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

Véhicules routiers — Aspects ergonomiques des systèmes d'information et de commande du transport — Spécifications et méthodes d'essai pour la présentation visuelle 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.

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 15008 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 15008:2003), which has been technically revised.

Introduction

Driver and vehicle form an integrated system that includes the environment, the primary vehicle controls, the instrumentation and the transport information and control systems (TICS). The task of driving, as well as human capabilities and limitations, are other important factors in the performance of this system.

TICS are intended to support drivers in their primary task, and it is therefore expected that the overall workload of the driver will not be negatively influenced by the use of TICS, while performance and comfort are increased.

The visual characteristics of display systems are only one set of factors influencing this process. They therefore need to be considered, along with human capabilities, in connection with the other elements of the driving environment.

Visual specifications fall within a wide range of environmental conditions and constitute only one necessary condition for adequate performance, comfort and workload. They refer to the relevant range of illumination conditions and to the location of the display with respect to the driver.

The following substantial changes have been made compared with the first edition of this International Standard:

— extension of the scope,

— updating of normative and bibliographic references, and terms and definitions,

— clarification of design viewing positions,

— referencing of contrast measurement methods and angles to SAE J1757/1:2007,

— changing of illumination ranges, addition of twilight condition,

— inclusion of outlined characters,

— exclusion of colour contrast,

— changing of minimum character heights,

— inclusion of Chinese and Japanese characters, and

— clarification of character dimension specifications.

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

1 Scope

This International Standard specifies minimum requirements for the image quality and legibility of displays containing dynamic (changeable) visual information presented to the driver of a road vehicle by on-board transport information and control systems (TICS) used while the vehicle is in motion. These requirements are intended to be independent of display technologies, while reference to test methods and measurements for assessing compliance with them have been included where necessary.

This International Standard is applicable to mainly perceptual, and some basic cognitive, components of the visual information, including character legibility and colour recognition. It is not applicable to other factors affecting performance and comfort, such as coding, format and dialogue characteristics, or to displays using

— characters presented as a part of a symbol or pictorial information,

— superimposed information on the external field (e.g. head-up displays),

— pictorial images (e.g. rear view camera),

— maps and topographic representations (e.g. those for setting navigation systems), or

— quasi-static information.

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 4513, *Road vehicles — Visibility — Method for establishment of eyellipses for driver's eye location*

CIE 17.4:1987, *International lighting vocabulary*

CIE 85:1989, *Solar spectral irradiance*

SAE J1757/1:2007, *Standard Metrology for Vehicular Displays*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE 17.4:1987 and the following apply.

3.1
adaptation
adjustment of the eye's sensitivity to the brightness of the observed visual field

NOTE Dark adaptation occurs at a slower rate than does light adaptation.

3.2
blink
intended periodic variation of the luminance of a light or visual information, normally from “OFF” to a given value, typically used for attracting attention

NOTE Terms and definitions related to photometric quantities (e.g. illuminance, luminance, luminance contrast and saturation) are given in CIE 17.4:1987.

3.3
brightness
subjective attribute of light sensation by which a stimulus appears to be more or less intense or to emit more or less light

3.4
critical specular line
CSL
line from the centre of the display to the centre of the eyellipse

3.5
chromatic
having hue or being coloured, appearing different in quality from a neutral grey having the same brightness

NOTE It is related to the colour properties of a visual stimulus.

3.6
contrast
C
ratio between the difference of the luminance, L_{high}, of an area in its “bright” state (e.g. the strokes of a character in the case of negative polarity) minus the luminance, L_{low}, of the same area in its “dark” state and the luminance L_{low}

NOTE 1 $$C = \frac{L_{\text{high}} - L_{\text{low}}}{L_{\text{low}}}$$

NOTE 2 Terms and definitions related to photometric quantities (e.g. illuminance, luminance, luminance contrast and saturation) are given in CIE 17.4:1987.

3.7
contrast ratio
R_{C}
ratio between the luminance L_{high} and the luminance L_{low}

NOTE 1 $$R_{\text{C}} = \frac{L_{\text{high}}}{L_{\text{low}}}$$

NOTE 2 Terms and definitions related to photometric quantities (e.g. illuminance, luminance, luminance contrast and saturation) are given in CIE 17.4:1987.

3.8
cyclopean eyellipse
elliptical volume combining the left and the right eyellipse of the driver into one single volume located in the centre between them

3.9
day condition
condition with diffuse ambient light

3.10
direct sunlight condition
condition under which the viewing conditions are mainly influenced by direct light from the sun on the display surface

3.11
dynamic information
information that has more than two stages of change

3.12
eyellipse
elliptical shape of the driver eye range, as defined in ISO 4513

NOTE 1 See definition of 95th percentile eyellipse in ISO 4513.

NOTE 2 It is the contraction of the words “eye” and “ellipse”.

3.13
flicker
unintended perceived temporal variation of the brightness of a visual stimulus, usually generated by refresh process of the display content or by variation of the luminance of the backlight

NOTE Terms and definitions related to photometric quantities (e.g. illuminance, luminance, luminance contrast and saturation) are given in CIE 17.4:1987.

3.14
disability glare
dazzling or disabling effect produced by a bright light

NOTE This is a retinal effect, primarily caused by light scatter in the eye, which produces a luminous veil over the retinal image and thus reduces contrast.

3.15
discomfort glare
distracting or disrupting effect of bright point sources in the field of view

NOTE This is a perceptual effect, interfering with visual attention and selection.

3.16
jitter
unintended periodic movement of an image or parts of it

3.17
legibility
visual properties of a character or graphics representation that determine the ease with which it can be recognized

3.18
map
representation on plane surface of the features of a connected part of the earth surface (especially of the road and traffic environment), shown in their representative forms, sizes and relationship in accordance with some convention of representation

3.19
night condition
condition of low ambient illumination under which the adaptation level of the driver is mainly influenced by the portion of the road ahead covered by the vehicle's own headlights and surrounding street lights, and display and instrument brightness

NOTE Low ambient illumination is less than 50 lx.

3.20
pixel
smallest selectively addressable element of the display surface capable of reproducing the full range of luminance and colours

NOTE 1 "Pixel" is an abbreviation for "picture element".

NOTE 2 Terms and definitions related to photometric quantities (e.g. illuminance, luminance, luminance contrast and saturation) are given in CIE 17.4:1987.

3.21
quasi static information
⟨reconfigurable displays⟩ information that has a limited number of states, where one or other state is always displayed and does not change frequently

EXAMPLE AM/PM, km/miles, kPa/PSI, On/Off information.

3.22
redundantly presented information
information which is presented in parallel by different means or at different positions

EXAMPLE 1 Speed can be displayed in both analogue and digital format.

EXAMPLE 2 Turn-by-turn navigation can be displayed on a central display and in parallel in the instrument cluster.

3.23
segment
pre-defined geometric form that can be used to create a character or symbol in whole or in part

EXAMPLE Stroke.

3.24
twilight condition
condition between night condition and day condition

NOTE In twilight condition, the setting of the display illumination might be in day or night setting.

4 Requirements and measurement methods

4.1 General

The following requirements shall be complied with to ensure that images on the visual displays used in on-board TICS equipment are legible.

Conformity of the presented images to the requirements specified in this International Standard shall be tested at a temperature within the range of 18 °C to 28 °C. The test shall not start until the illumination has reached a stable state. The requirements are accompanied by standard measurement conditions in terms of ambient illuminance and observer positions. Methods for measurement of contrast shall be in accordance with SAE J1757/1:2007.

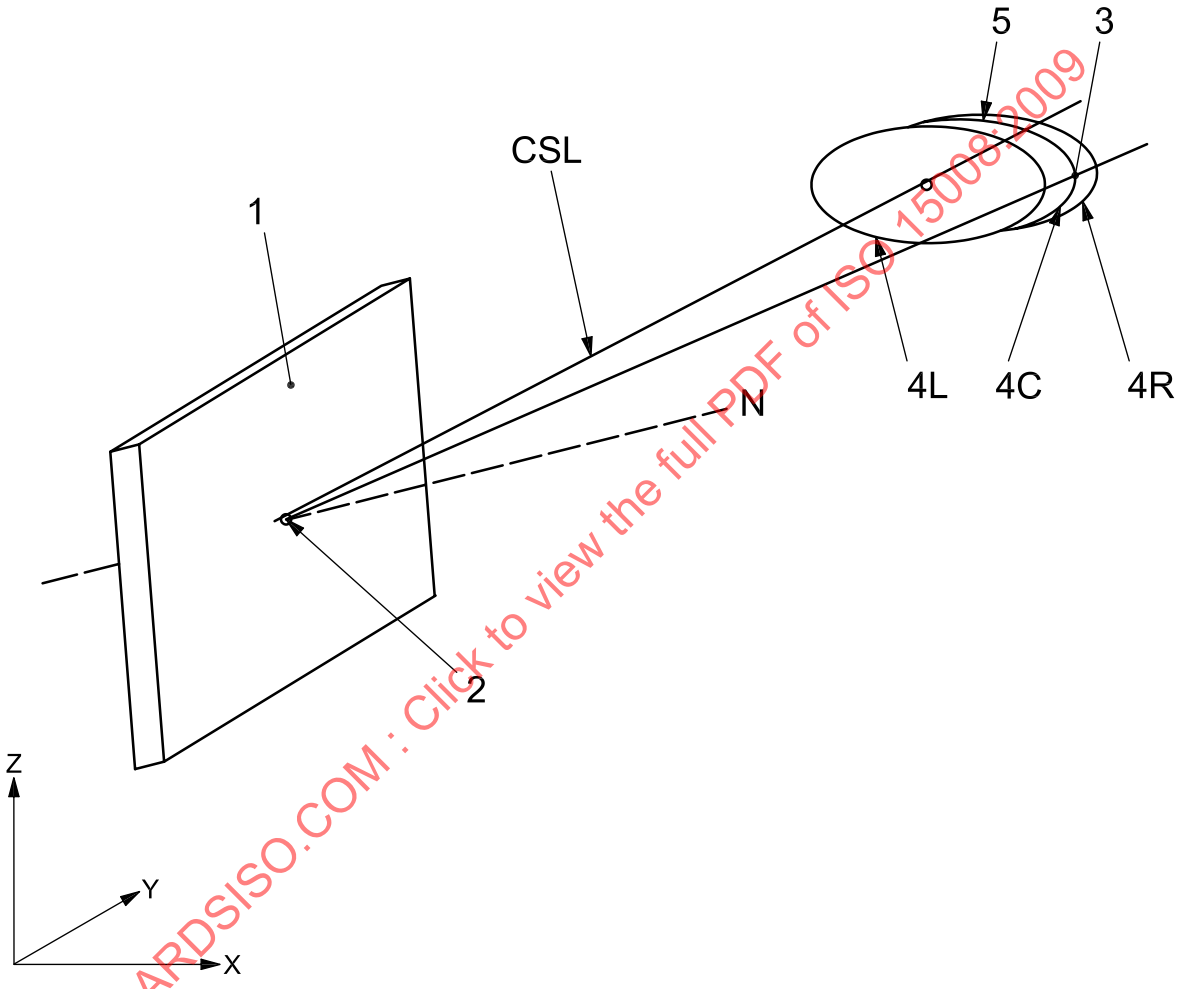
4.2 Design viewing position and illumination range

4.2.1 Design viewing position

The requirements in this subclause are applicable to displays in their installed vehicle locations, as seen from any point in the driver eyellipses according to ISO 4513 (for passenger vehicles only).

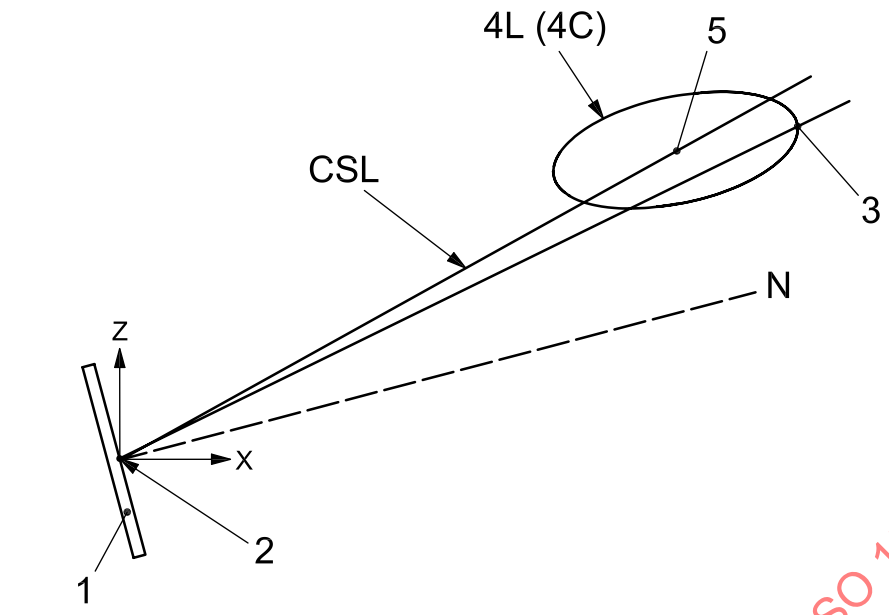
If the display is fixed to the vehicle, the relevant requirements shall be complied with from the rearmost point of the cyclopean eyellipse. If the position of the display is adjustable, the display may be adjusted so that a position can be found in which all the relevant requirements are complied with simultaneously. For direct sunlight conditions, the requirements of contrast (see 4.3.2) shall only be fulfilled in the direction of the critical specular line (CSL) (see Figure 1).

Standard default values for angles (45°/30°) as an alternative for direct sunlight measurements are acceptable (see SAE J1757/1:2007).

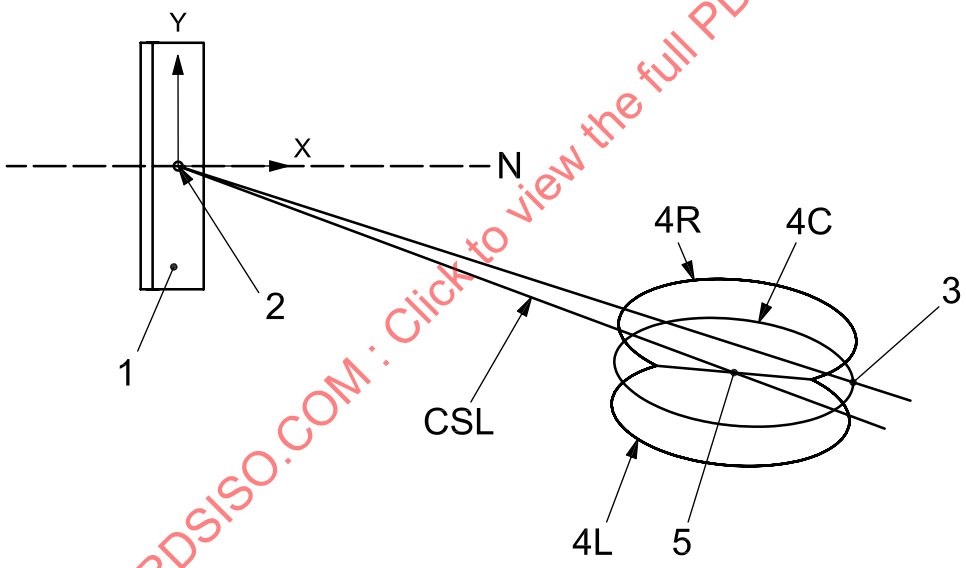


a) Display at right-hand side of driver

Figure 1 (*continued*)



b) **Side view**



c) **Plan view**

Key

1	display	4L	left eyellipse
2	centre of the display	4R	right eyellipse
3	rearmost point of the cyclopean eyellipse	5	centre of the cyclopean eyellipse
4C	cyclopean eyellipse	N	display perpendicular direction

Figure 1 — Design viewing position

4.2.2 Illumination range

4.2.2.1 The design illumination range establishes the four conditions of:

— night,

— twilight,

— day with diffuse ambient light, and

— day with direct sunlight.

4.2.2.2 **Night condition** is replicated in a dark environment such that the maximum illuminance on the object to be measured shall not exceed 10 lx, with a relative tolerance of ± 5 %. For the measurement procedure, see SAE J1757/1:2007, Table 1.

4.2.2.3 **Twilight condition** is replicated with a measurement condition specified in SAE J1757/1:2007, 4.1.2.4 and Table 1. The ambient light measured on the surface of the display (on the standard diffuse reflector) shall be 250 lx, with a relative tolerance of ± 5 %. If the display setting is brought into the night-time setting manually or automatically (e.g. triggered by the head lamp switch or a sun load sensor), the displayed information shall meet the twilight requirements in 4.3.2 in the night-time setting. If the driver can manually change the setting of the display to a higher contrast, the measurement may be made in that display setting.

4.2.2.4 **Day condition with diffuse ambient light** is replicated with ambient light omni-directional to the point of measurement. The ambient light measured on the surface of the display (on the standard diffuse reflector) shall be 5 klx, with a relative tolerance of ± 5 %. For the measurement procedure, see SAE J1757/1:2007, 4.1 and Table 1.

4.2.2.5 **Direct sunlight condition** is replicated with a standard measurement condition. The illuminance at the point of measurement shall be 45 klx, with a relative tolerance of ± 5 %. For the measurement procedure, see SAE J1757/1:2007, 4.1 and Table 1.

4.2.2.6 For day and direct sunlight and for twilight conditions in the measurement procedure in accordance with SAE J1757/1:2007, an artificial illumination system with light type similar to that of CIE 85:1989, Table 4 (± 20 %) shall be used. Light sources with large spikes in the spectrum (e.g. fluorescent lamps) should be avoided; metal halide lamps are more appropriate due to their energy in the blue part of the spectrum. The colour temperature is secondary to this issue.

4.3 Display illumination, minimum contrast, luminance and polarity

4.3.1 Display illumination

Due to the very wide range of ambient illuminations that determine the adaptation level of the driver, the display illumination should have a brightness control which allows adjustment over a suitable range.

4.3.2 Minimum contrast

4.3.2.1 Requirements

The minimum contrast ratio between symbol and background shall be

— 5:1 for night condition,

— 3:1 for twilight condition,

— 3:1 for day condition, and

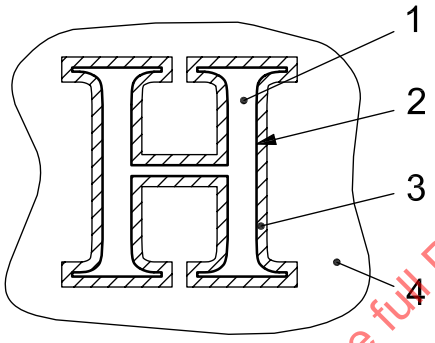
— 2:1 for direct sunlight condition.

This is especially important if characters are close to the minimum requirements for the dimensions (see 4.5). Lower contrast should be excluded except for characters that are intentionally grey-shaded or desaturated in colour to indicate some inactive status.

4.3.2.2 Character outlining

If sufficient contrast between the character and its background cannot be provided (e.g. with a dynamic background), additional means shall be applied. This can be an outline around the character, in which case a minimum contrast shall be provided between the body of the character/unfilled area and its outline.

The stroke width of the outline by character height ratio should be less than 0,04 for characters with serifs and less than 0,08 for characters without serifs. If the size of a character is so small that the stroke width of the outline would be less than 0,35 mm, an outline should be avoided to ensure readability (see Figure 2).



Key

1 body of the character/unfilled area
2 outline
3 borderline
4 background area

Figure 2 — Outlined character

Words or phrases written in outlined unfilled character (transparent body) fonts should not be used.

4.3.2.3 Changing background

If the background around the text or symbol is spatially changing in luminance or colour, minimum contrast should be reached with the worst case background in the area adjacent to text or symbol. The contrast ratio shall be calculated from at least two measurements in different areas of the display. If the background is dynamic, an additional borderline should be applied around the characters to provide sufficient contrast (see Figure 2). In this case, contrast should be measured between the outline and the borderline.

4.3.2.4 Contrast measurement

All contrast measurements shall be carried out at the centre point of the cyclopean eyellipse, as shown in Figure 1. For bench top measurements, standard values for angles (45°/30°) may be used for direct sunlight measurement (see SAE J1757/1:2007).

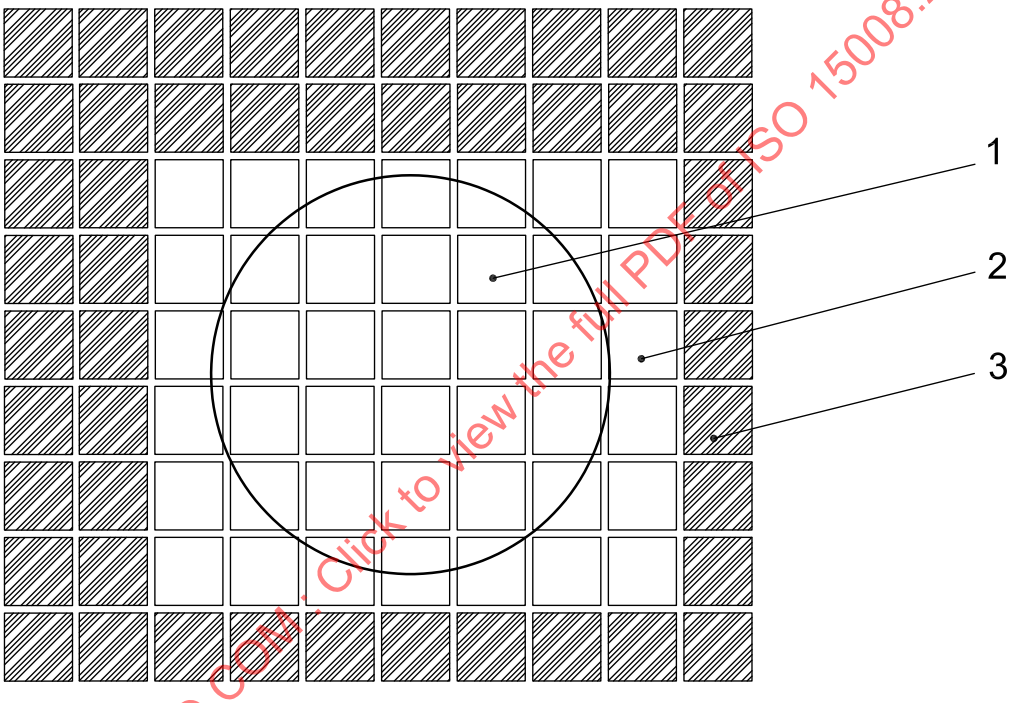
For matrix displays, the measurements shall be taken over a collection area covering at least (3 × 3) pixels (see Figure 3). The measurement accuracy will be reduced if the measurement area is less than (3 × 3) pixels. If the area of the character to be measured does not contain at least (3 × 3) pixels or the photometer spot size is larger than the area of the character, find a larger area on the character that has at least (3 × 3) pixels and that appears visually to have the same luminance. Measure this area.

For segment displays, the measurement shall be taken within a single segment. The diameter of the collection area shall be less than 80 % of the relevant dimension of the segment to be measured.

During the contrast measurement, the display luminance should be adjusted in the night-time condition to “night maximum” and in daylight or direct sunlight condition to “maximum brightness”. In twilight condition, at least one display illumination setting (e.g. day/night setting) shall be provided that meets the specified requirement when the headlamps/parking lamps are in an “ON” (or activated) state.

For a common display that delivers different images to a driver and passengers, the contrast of the driver's images shall be measured with passenger's image in fully white and in fully black. Required contrast shall be fulfilled in the worse condition.

NOTE Any ghost image from dynamic crosstalk is not covered by this International Standard.



Key

1 collection area (photometer measurement spot)
2 pixel in bright state
3 pixel in dark state

Figure 3 — Contrast measurement on matrix displays

4.3.3 Display mode

If a display shows light symbols on a dark background, this is called a negative display mode; if dark symbols are shown on a light background, this is called a positive display mode. Both display modes are known to give satisfactory performance. The choice is determined by the average luminance of those areas frequently viewed in sequence. Therefore, negative display mode should be used under the night condition. In day condition, either may be used, while taking into account the often dark immediate surroundings of displays in vehicles (e.g. the dashboard). For non-sheltered displays, positive display mode should be used for reducing the visibility of reflections.

4.4 Colour combinations

Regardless of the colour and colour combinations between a symbol or character and its background, minimum luminance contrast shall be provided (see 4.3.2).

For physiological and psychological reasons, not all symbol/background colour combinations are acceptable. Because of this, when selecting colours in full colour displays, certain symbol/background colour combinations should be chosen. For information regarding colour combinations, see Annex B.

4.5 Alphanumerical character dimensions

4.5.1 General

See Annex A for further information on the definition and measurement of character dimensions.

4.5.2 Height

For alphanumeric characters, the character height, H, shall be measured using the character “H” as reference (see Figure A.1). It shall be measured as the subtended angle from the rearmost point of the cyclopean eyellipse and it shall be in accordance with Table 1.

If a font meets the requirement above for the capital letter “H”, then all other characters associated with this font, such as smaller subscripts and superscripts, may also be used.

Letters imbedded in a symbol shall be excluded from the height requirements.

Table 1 — Character heights

Subtended angle dimension		Suitability level
in arc minutes	in radians [a]	
$\geqslant 20$	$\geqslant 5{,}815 \times 10^{-3}$	Recommended
$\geqslant 16$	$\geqslant 4{,}652 \times 10^{-3}$	Acceptable
$\geqslant 12$	$\geqslant 3{,}489 \times 10^{-3}$	Minimum [b]

[a] If multiplied by the viewing distance, it gives (in the same units) the actual character height.

[b] In situations when requirements for accuracy and speed of reading are modest.

4.5.3 Width by height ratio

The alphanumeric character width by height ratio should be between 0,6 and 0,8. A wider range from 0,5 to 1 may be used, especially if factors such as line length or proportional spacing are important.

4.5.4 Stroke width by height ratio

If the font uses different stroke width, S, an average stroke width should be used. The average stroke width, S_{AVG}, can be found by averaging the maximum stroke width, S_{MAX}, and the minimum stroke width, S_{MIN}, of a character, measured for a capital character “A”. The alphanumeric characters' stroke width by character height ratio shall be between 0,08 and 0,2. It shall be measured using the character “H” as reference (see Figure A.1). With certain fonts, higher values may be used.

4.5.5 Spacing

For adjacent characters with parallel lines next to each other, a minimum distance, P, of one minimum stroke width, S_{MIN}, shall be maintained. For characters without adjacent parallel lines next to each other, a minimum perceptible distance, M, of 0,5 × S_{MIN} shall be maintained between their closest points.

A minimum width, W_{MIN}, of one character, lower case “o”, shall be maintained between words.

Line spacing shall be maintained at a minimum of one average stroke width. Text line spacing, T, is defined by the distance between the descender line of the current text line and the ascender line of the following text line.

4.6 Pixel matrix character format

4.6.1 Upper and lower case of alphanumeric characters

A (5 × 7) pixel (width by height) character matrix shall be the minimum used for alphanumeric characters.

If legibility of an individual alphanumeric character is important for the task, a (7 × 9) pixel (width by height) character matrix should be the minimum.

If characters with descenders are used, a (7 × 11) pixel (width by height) character matrix should be the minimum.

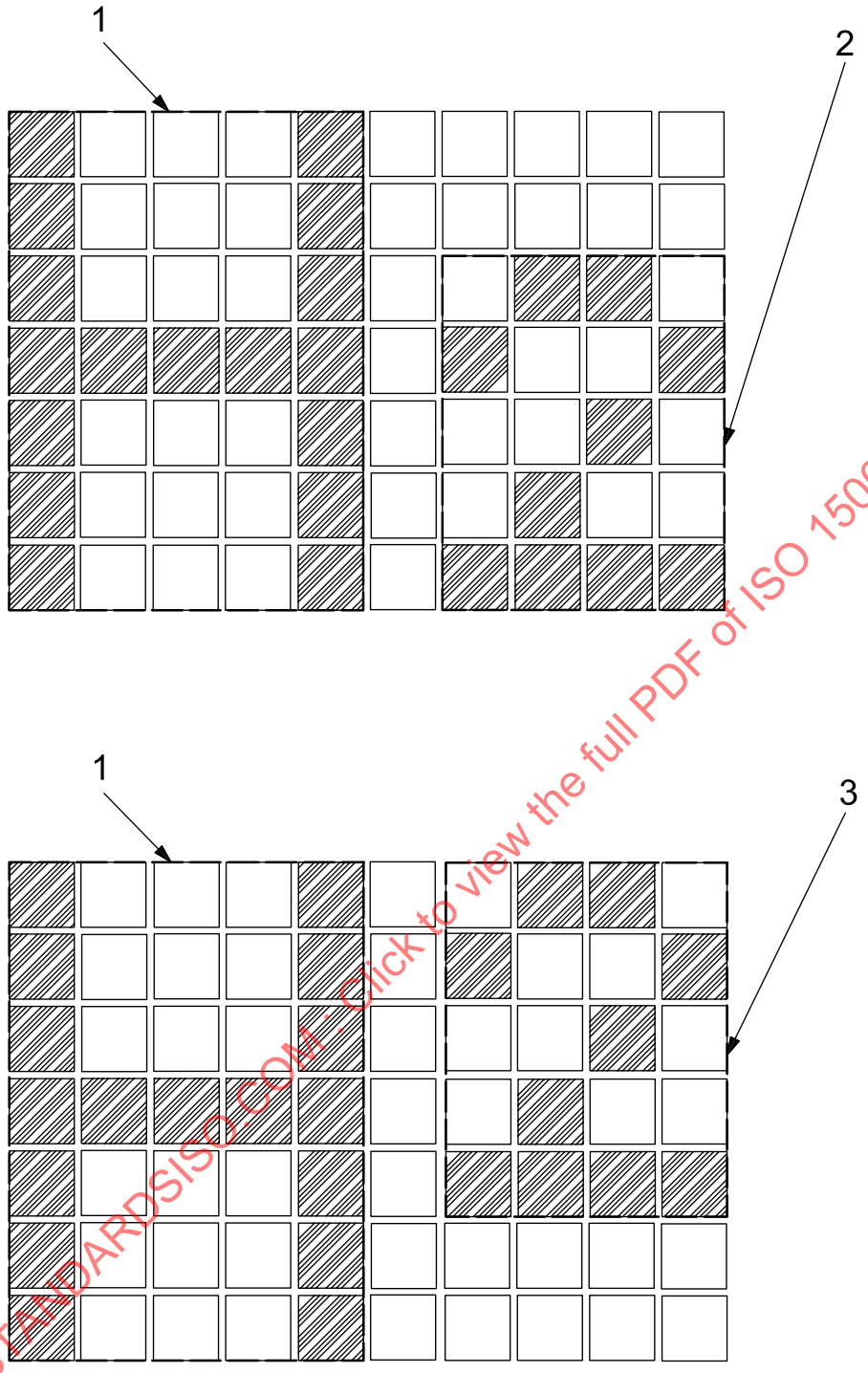
A (4 × 5) pixel (width by height) alphanumeric character matrix shall be the minimum for

— subscripts and superscripts,

— numerators and denominators of fractions displayed in a single-character position, and

— information unrelated to the task (e.g. the copyright symbol, ©).

It is not necessary for the subscript or superscript to extend below or above the main character (see Figure 4).



Key

1 (5 × 7) pixel matrix for alphanumeric character
2 (4 × 5) pixel matrix for subscript
3 (4 × 5) pixel matrix for superscript

Figure 4 — Matrix for alphanumeric character, subscript and superscript

4.6.2 Automotive symbols

For automotive symbols in accordance with ISO 2575, or similar, a (32 × 32) pixel matrix should be the minimum. A smaller matrix, e.g. (24 × 24) pixels, may be used if the display is capable of grey shades.

The number of pixels shall be determined by counting them on a suitable set of characters and symbols.

4.6.3 Chinese and Japanese characters

A (16 × 16) pixel (width by height) character matrix shall be the minimum used for Chinese characters (traditional and simplified) and Japanese characters.

NOTE 1 Examples for (16 × 16) pixel matrices can be found in JIS X 9051.

If the legibility of an individual Chinese character or Japanese character is key to the interpretation of the message, a (24 × 24) pixel (width by height) character matrix should be the minimum, or modification of characters should be used.

NOTE 2 Examples for (24 × 24) pixel matrices can be found in JIS X 9052.

If only a limited and predefined set of characters is used, and these characters are clearly discriminable from one another, a smaller pixel matrix may be used.

4.7 Reflections and glare

Reflections and glare visible by the driver should be minimized. Additional reflection- and glare-reduction or contrast-enhancement techniques, if used, shall not cause the display to deviate from the requirements of this International Standard.

4.8 Characteristics of presentation

4.8.1 Image instability

The image should be free from temporal instability (flicker) and spatial instability.

One factor of spatial instability is peak-to-peak variation in the geometric location of the image within the display (jitter): this shall not exceed 0,000 2 × d, where d is the viewing distance between the centre of the cyclopean eyellipse and the centre of the display.

NOTE Additional factors contributing to spatial image stability, e.g. display vibrations generated by the vehicle, are not considered in this International Standard.

For displays with pixels having continuous luminance distributions only, jitter can be measured using a measuring microscope with a magnification of at least 20. The movement is determined by visual alignment of the microscope cursor, or comparator reticle, with the extreme positions of the centroid, or the edge of a character, or test object, during the observation period.

For any display type, a special display-measuring device may be used. This device shall be used to determine, on a scan-by-scan basis, the relative location of a character or test object. If the device used determines movement along the horizontal and vertical axes separately, the extent of the jitter shall be defined as the square root of the sum of the squares of the maximum horizontal and vertical differences.

Observations shall continue at least for 4 s.

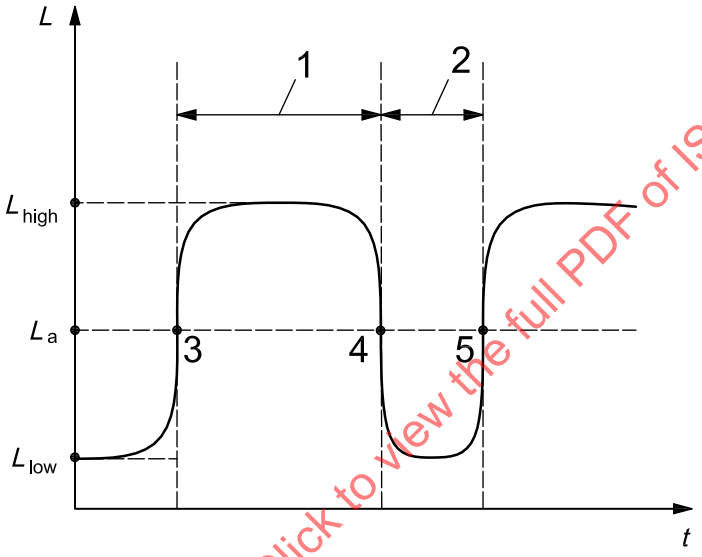
4.8.2 Image blinking

Image blinking should be used only to attract attention and inform about critical conditions requiring an immediate action. In order to attract attention, a single blink frequency of 1 Hz to 5 Hz with a duty cycle of

50 % should be used. If legibility of the displayed information content is required, a single blink rate of 1/3 Hz to 1 Hz with a duty cycle of 70 % should be used.

The blinking rate should be measured using a luminance meter aimed at the blinking picture element (i.e. a pixel or segment) located in the display centre. The meter should be capable of delivering the time varying luminance values with a low-pass cut-off frequency of at least 10 times the highest frequency to be measured. The signal should be processed with an oscilloscope or similar instrument with adequate bandpass in order to obtain the "ON" and "OFF" durations.

In order to measure the "ON" and "OFF" durations (points 1 and 2 in Figure 5), the switching times (points 3, 4 and 5 in Figure 5) are established at which the luminance is equal to the average luminance between the minimum and the maximum luminance values (L_{low} and L_{high} in Figure 5). The "ON" duration is the time between points 3 and 4, and the "OFF" duration is the time between points 4 and 5.



Key

1	"ON" duration	L	luminance
2	"OFF" duration	L_a	average luminance
3	switch-on time	L_{high}	maximum luminance
4	switch-off time	L_{low}	minimum luminance
5	next switch-on time	t	time

Figure 5 — Blinking frequency measurement

The equivalent frequency (in hertz) should be obtained from the duration (in seconds). For pulse width modulated backlight, the effect of the backlight variation should be considered (e.g. triggering of oscilloscope). Alternatively, a continuous stable backlight should be used for these measurements.

4.9 Redundant information displays

If the same information is presented in more than one display, at least one of the information displays shall meet the requirements of this International Standard. Other, redundant, information displays should also meet the requirements of this International Standard.