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Road vehicles — Visibility — Specifications and test procedures for ~~Head~~head-up displays (HUD)

~~PDTS stage~~

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Foreword

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This document was prepared by Technical Committee ~~*[for Project Committee]*~~ ISO/TC ~~*[for ISO/PC]*~~ 22, *Road Vehicles*, Subcommittee SC 35, *Lighting and visibility*~~]~~.

~~This second/third/... edition cancels and replaces the first/second/... edition (ISO #####:####), which has been technically revised.~~

~~The main changes compared to the previous edition are as follows:~~

~~— xxx xxxxxxx xxx xxxx~~

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Introduction

This document outlines ~~Ergonomic~~ergonomic specifications, evaluations and test methods for the design and laboratory assessment measurement of ~~Head~~head-up ~~Display~~display (HUD) displayed image qualities like virtual image distance (X), aspect ratio (Y~~&~~ and Z), luminance, contrast~~,~~ and image height adjustment ranges. This document also outlines procedures for measuring HUD images for the purpose of laboratory assessments, as measured from observation areas defined by an ~~Eyebox~~eyebox, and provides the definition of the ~~Eyebox~~eyebox from the locating the driver's ~~Eyellipse (See~~eyellipse (see ISO 4513~~:2022~~).

This document also provides a standard measurement practice of HUD virtual images for HUD bench testing, static and dynamic laboratory test, as well as methods for documenting HUD virtual image attributes such as size, luminance, contrast, field of view, image location adjustment ranges~~,~~ and HUD ~~Eyebox~~eyebox attributes using image readability standards from SAE ~~1757~~J1757-1, SAE ~~1757~~J1757-2, ISO 15008 or other applicable standards where required.

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Road vehicles — Visibility — Specifications and test procedures for ~~Head~~head-up displays (HUD)

1 Scope

This document provides a common framework of definitions and measurement methods for the design, and ergonomics testing of automotive head-up displays (HUDs) independent of technologies except where noted. Applications in both passenger cars (including sport utility vehicles and light trucks) and commercial vehicles (including heavy trucks and buses) are covered. This document does not include helmet-mounted HUDs or other head carried gear such as glasses.

Areas covered in this ~~standard~~document include:

- guidance on how to establish reference points and representative viewing conditions based on vehicle coordinates and ranges of ~~driver / passenger~~driver's/passenger's eye points;
- descriptions of the HUD image geometry and optical properties measurements;
- definitions of the HUD virtual image and driver vision measurements;
- static and dynamic laboratory tests, and dynamic field operational assessments that include suggested vehicle setup procedures in order to measure HUD image attributes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4130, *Road vehicles — Three-dimensional reference system and fiducial marks — Definitions*

ISO 4513, *Road vehicles — Visibility — Method for establishment of ~~Eyellipsee~~vellipses for driver's eye location*

ISO ~~6549~~ 16750-2:—[1], *Road vehicles ~~— Procedure for H- and R-point determination~~*

~~ISO 16750-2, 3, 4, and 5[2], *Road vehicles —*~~ — *Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads*

[1] ~~Under~~Fifth edition under preparation. Stage at the time of publication: ISO/~~DIS 6549~~FDIS 16750-2:2023.

[2] ~~Part 2 and Part 3 under preparation. (Stage at the time of publication, ISO/DIS 16750-2, -3)~~

ISO 16750-3:— [3], *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 3: Mechanical loads*

ISO 16750-4:— [4], *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

ISO 16750-5:— [5], *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 5: Chemical loads*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 ~~3.1 Vehicular~~ Terms related ~~terms~~ to vehicules

3.1.1
vehicular coordinate system
three-dimensional reference coordinate system showing the supporting surface of the vehicle as the zero Z plane (horizontal zero plane), the zero Y plane (vertical longitudinal zero plane), and the zero X plane (vertical transverse zero plane) at non-operational conditions

Note 1 to entry: It is defined on a right-handed coordinate system having the x-axis positive pointing opposite of the forward movement direction, z-axis positive being orthogonal to the ground plane and pointing upwards, and the y-axis positive pointing to the right seen in forward movement direction. (See also ~~(~~3.1.2~~)~~ for reference grid under operational condition~~).)~~

3.1.2
three-dimensional reference grid
longitudinal plane X-Z, a horizontal plane X-Y and a vertical transverse plane Y-Z which ~~is~~are used to determine the dimensional relationships between the positions of design points on drawings and their positions on the actual vehicle when the vehicle coordinates is in operational condition

Note 1 to entry: There can be national regulation applicable which specifies the vehicle operation condition affecting the three-dimensional reference grid which is used in the evaluation procedure of this document. For example, in countries adopting the UN Regulation No. 125, the operation condition determining the three-dimension reference grid is given in the UN Regulation No. 125, 2.3 (See also ~~(~~3.1.1~~)~~.).

3.1.3
V point
vision point positions in the passenger compartment determined as a function of vertical longitudinal planes passing through the centres of the outermost designated seating positions on the front seat and in

[3] Fourth edition under preparation. Stage at the time of publication: ISO/FDIS 16750-3:2023.

[4] Fourth edition under preparation. Stage at the time of publication: ISO/FDIS 16750-4:2023.

[5] Third edition under preparation. Stage at the time of publication: ISO/FDIS 16750-5:2023.

relation to the "R" point and the design angle of the seat-back, and are used for verifying compliance with driver's fields of view requirements

3.1.4
H point
pivot centre of the torso and thigh of the 3-D H machine installed in the vehicle seat, and located in the centre of the centre line of the device which is between the 'H' point sight buttons on either side of the 3-D H machine

Note 1 to entry: The H point is detailed in ISO 6549 and it is used to determine the location of the *eyellipse*~~.~~ (3.2.1). The "H point" corresponds theoretically to the "R" point.

3.1.5
SgRP
seating reference point
R point
design point defined by the vehicle manufacturer for each seating position and established with respect to the three-dimensional reference system

Note 1 to entry: The R point is detailed in ISO 6549 and it is used to determine the location of the *eyellipse*~~.~~ (3.2.1).

3.1.6
windscreen datum point
point situated at the intersection with the *windscreen* (3.3.13) of lines radiating forward from the *V points* (3.1.3) to the outer surface of the windscreen

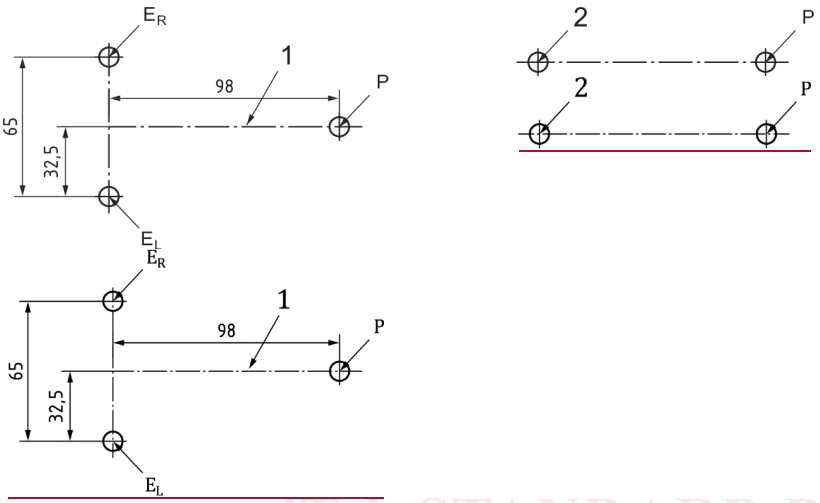
3.1.7
P point
point about which the driver's head rotates when driver views objects on a horizontal plane at eye level

Note 1 to entry: ~~HUD~~*Head-up display* (*HUD*) (3.3.1) images are presented to the driver intended to be observed with the head oriented in a forward direction (for P3 and P4, see Figure 7). Nevertheless, small head rotation may occur while accessing device for indirect vision with some minor residual head turn around this point (for P1 and P2, see Figure 7).

3.1.8
E point
point representing the centre of the driver's eyes and used to assess the extent to which "A" pillars obscure the field of vision

Note 1 to entry: The E ~~points are~~points' definition ~~is~~ adopted ~~in~~from UN Regulation 125 when observing the direction of "A" pillar while the driver's ocular reference point (ORP) defined in 3.~~16 are~~3.17 is the ~~center~~centre at forward-facing driver head orientation. See Figure 1 for the correlation of E point to with *P point*~~.~~ (3.1.7).

Dimensions in millimetres



a) Plan view **b) Side view**

Key

E_L left eye
E_R right eye
P neck pivot point
1 driver head centre line
2 line, viewed end on, between E_L and E_R

Figure 1 — Neck pivot point and associated eye points

3.1.9
seat-back angle
angle measured between a vertical line through the *H point* (3.1.4) and the torso line using the back-angle quadrant on the 3-D H machine

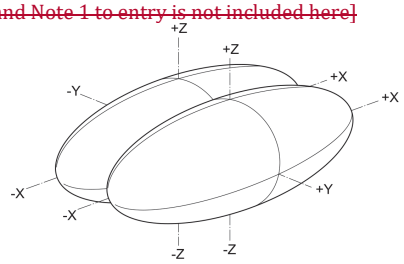
3.1.~~14~~10
A pillar
roof support forward of the vertical transverse plane located 68 mm in front of the *V points* (3.1.3) and includes non-transparent items such as *windscreen* (3.3.13) mouldings and door frames, attached or contiguous to such a support

~~3.3~~3.2 ~~3.2 Eyellipse and Eyebox~~Terms related ~~terms~~to the eyellipse and ~~definitions~~eyebox

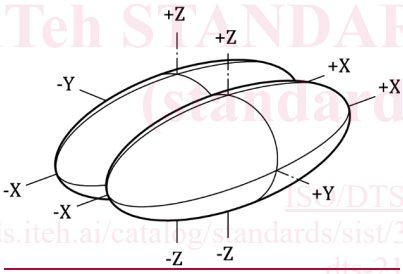
3.2.1
~~**Eyellipse**~~
eyellipse

statistical distribution of eye locations in three-dimensional space located relative to defined vehicle interior reference points

~~[SOURCE: ISO 4513:2022,, 3.1, modified — explanation on "contraction of the words “eye” and “ellipse” used to describe" is deleted, and Note 1 to entry is not included here]~~



Note 1 to entry: Eyellipse is a term derived as a contraction of the words “eye” and “ellipse” and it is defined in ISO 4513. Unless otherwise specified, the eyellipse space in this document refers to the specific eyellipse representing the distribution of the 95 % percentile of driver population as seated in the drive seat. Figure 2 shows an eyellipse model which would be located as shown in Figure 3.



Key

X, ellipse axes

Figure 2 — Eyellipse

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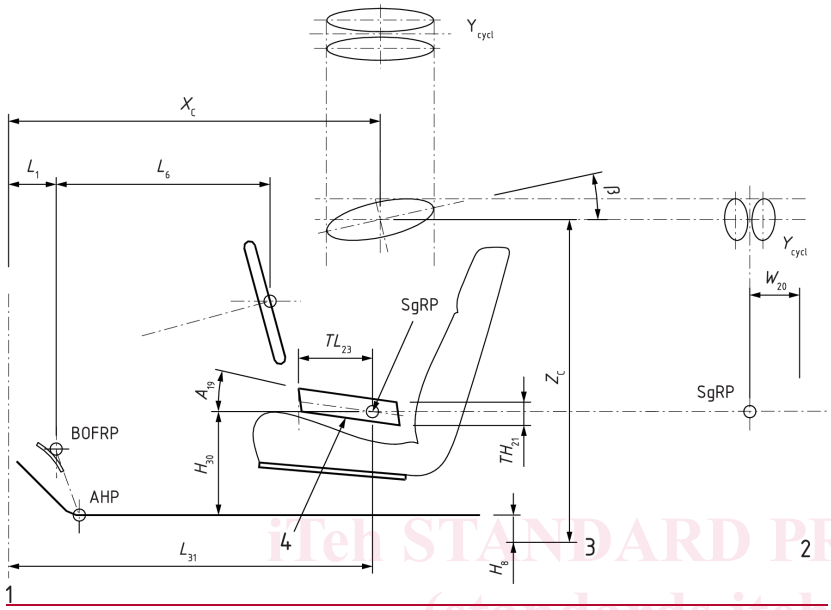

Key

A_{19}	seat track rise	TL_{23}	seat track travel
AHP	accelerator heel point	W_{20}	y-coordinate of the SgRP
BOFRP	ball of foot reference point	X_C	x-coordinate of the eyellipse centroid location
H_8	z-coordinate of the AHP	Y_{cycl}	mid-eye y-coordinate
H_{30}	z distance of the *SgRP* (3.1.5) from the AHP	Z_C	z-coordinate of the eyellipse centroid location
L_1	x-coordinate of the BOFRP	β	side view angle
L_6	x distance from the steering wheel centre to BOFRP	1	zero X grid
L_{31}	x-coordinate of the SgRP	2	zero Y grid
SgRP	seating reference point	3	zero Z grid
TH_{21}	H-point vertical adjustment	4	H-point travel path

Figure 3 — Location of the ~~Eyellipse~~eyellipse relative to ~~Driver Packaging Dimensions~~driver packaging dimensions

~~Note to entry: Eyellipse is a term derived as a contraction of the words "eye" and "ellipse" and it is defined under ISO 4513. Unless otherwise specified, the eyellipse space in this document refer to the specific eyellipse representing the distribution of the 95 % percentile of driver population as seated in the drive seat. Figure 2 show an eyellipse model which would be located as shown in Figure 3.~~

~~3~~[SOURCE: ISO 4513:2022, 3.1, modified — Explanation on "contraction of the words "eye" and "ellipse" used to describe" has been deleted, Figure 3 was added and Note 1 to entry has been replaced.]

3.2.2.~~2~~
~~Eyebox~~
eyebox

simplified two-dimensional rectangular box model providing the representative distribution range of the ~~driver~~driver's eye reference point for evaluation, encapsulation and having its frame line tangential to the *eyellipse* (3.2.1)

Note 1 to entry: The ~~Eyebox~~eyebox is an area covering the entire range of driver with different physical characteristics and a *device under test* (*DUT*) (3.3.25) may not necessarily be capable ~~to convey~~of conveying visual information within the entire ~~Eyebox~~eyebox range without personal adjustment. See also ~~"Adjusted~~*adjusted viewable HUD window*~~"~~ (3.2.3). It is rather a rectangular vertical plane defined at the ~~center~~centre of the eyellipse and actually it is not a three-dimensional box.

3.2.3
adjusted viewable HUD window
observation eyebox window at adjusted condition
range designed to convey the visual information to the viewer at adjusted condition, within which the image generated by the ~~DUT shall satisfy~~*device under test* (*DUT*) (3.3.25) satisfies the required image quality condition

Note 1 to entry: The ~~driver~~driver's eye position is expected to come somewhere within the ~~Eyellipse~~*eyellipse* (3.2.1) range. A *head-up display* (*HUD*) (3.3.1) system is often composed ~~with~~of a reflective device transferring image from the imaging device towards the ~~driver~~driver's eye, and its visibility ~~affect~~is affected by the observation point. To satisfy needs of ~~driver~~drivers with different ~~gender~~genders or anthropometric characteristics, a system may provide adjustability to satisfy those different needs. A DUT adjusted to a specific eye position shall provide satisfactory image within ~~a~~an expect range of driver head movement.

Note 2 to entry: An HUD system ~~capable~~is a system ~~to provide~~expected to be capable of providing a uniform image quality to the entire eyellipse range without ~~any~~ deterioration of the image quality, and this implies to cover a certain acceptable range of eye movement coverage ~~does~~while in operation that may not ~~need to be cared. Otherwise, the~~ cause a drastical degradation on the perceived image quality by the driver normal head movements within this specified window. The DUT shall be capable ~~to~~of properly ~~convey~~conveying the visual information to at least a defined range characterized according to this constrained window once adjusted by each driver. This auxiliary observation ~~Eyebox~~*eyebox* (3.2.2) range is defined as complementary range for image quality evaluation.

Note 3 to entry: If the quality of the image conveyed to the viewer drastically ~~vary~~varies within this range, it may induce discomfort. ~~But~~On the other hand, if the quality of the image gradually degrades with the driver head displacement going beyond this adjusted viewable HUD window position, the degradation of the image caused by the displacement of head position will motivate the driver to return his head position to within this window, therefore, to enable such design strategy which may motivate the driver to return his head position within the adjusted viewable HUD window, but it does not prevent to cause degradation when the driver may move his/her eyes beyond this range as a mean to motivate the driver to maintain their head to a certain limited range to be able to access to the visual information conveyed by the HUD. the image quality beyond this range does not necessarily need to fulfil the same image quality as required with driver eye at nominal position.

3.2.4
eye position tracker
equipment to localize the dynamic positioning of the ~~driver~~driver's eye

Note 1 to entry: The detected position of the eye serves to dynamically control and generate augmented reality ~~image~~images of intended information according to geometrical positional configuration of the ~~driver~~driver's eye point of observation. Other ~~adaptation~~adaptations or ~~adjustment~~adjustments according to detected ~~driver~~driver's eye position may apply.

~~3.5~~3.3 ~~3.3~~Terms related to an HUD system ~~related terms and definitions~~

3.3.1