INTERNATIONAL STANDARD

ISO 4513

Second edition
2003-10-15

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

Véhicules routiers — Visibilité — Méthode de détermination des ellipses oculaires correspondant à l'emplacement des yeux des conducteurs

Reference number
ISO 4513:2003(E)

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Published in Switzerland

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Foreword

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ISO 4513 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 17, *Visibility*.

This second edition cancels and replaces the first edition (ISO 4513:1978), which has been technically revised.

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

1 Scope

This International Standard specifies a method for establishing an eyellipse for locating driver's eyes inside a road vehicle for the purpose of measuring the driver's field of view. Elliptical (eyellipse) models in both two and three dimensions are used to represent 95th and 99th percentiles of driver eye locations. Its procedures, which differ depending on the type of vehicle considered, are applicable to passenger cars (and light trucks), and to buses and heavy vehicles, as defined in ISO 3833. The statistical representation of the driver's eye locations it provides can be used as a design tool for passenger cars (although V-points can be used in lieu of the complete eyellipse to standardize the driver's field of view for regulation purposes).

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 3833, *Road vehicles — Types — Terms and definitions*

ISO 4130, *Road vehicles — Three-dimensional reference system and fiducial marks — Definitions*

ISO 4131, *Road vehicles — Dimensional codes for passenger cars*

ISO 7397-2:1993, *Passenger cars — Verification of driver's direct field of view — Part 2: Test method*

SAE J 1516:1987, *Accommodation Tool Reference Point*

SAE J 1517:1987, *Driver Selected Seat Position*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4130 and ISO 4131 and the following apply.

3.1
eyellipse
statistically derived elliptical model representing driver eye locations in road vehicles

See Figure B.1.

NOTE 1 For background on the development of the eyellipse, see Annex A.

NOTE 2 A contraction of the words “eye” and “ellipse”, *eyellipse* is the sole term to be used in this application.

3.2
eyellipse template
two-dimensional drafting tool for drawing plan and side-view eyellipses at the correct location and orientation

See Figure B.2.

NOTE 1 See Annex B.

NOTE 2 The co-ordinates of eyellipse tangent points can be located in the actual vehicle three-dimensional reference system to determine design verification.

3.3
eyellipse locator line
line in the side view defining eyellipse X and Z location as a function of design seat torso

See Figure B.3.

NOTE See Annex B.

3.4
eyellipse and head position locator template
drafting tool for positioning the eyellipse and head clearance contour as a function of design torso angle

See Figure B.3.

NOTE See Annex B.

4 Mathematical description of 3-D eyellipses

In this International Standard, 95th and 99th percentile eyellipses are defined for each of two different ranges of fore/aft seat track travel (ISO-L23). Eyellipses shall be constructed in three dimensions in accordance with the following (see Figure B.4).

4.1 Axes lengths

Dimensions for the lengths of the three axes in true view for the four eyellipses shall be in accordance with Table 1.

Table 1 — Three axes in true view for the four eyellipses

Dimensions in millimetres

	Eyellipse			
	95th		99th	
Seat track travel (ISO-L23)	**100 to 133**	**>133**	**100 to 133**	**>133**
Axis				
X	173,8	198,9	242,1	268,2
Y	105,0	104,9	149,0	148,9
Z	86,0	86,0	122,0	122,0
NOTE The X-axis of both 95th and 99th eyellipses is about 25 mm longer for seat track travel in excess of 133 mm. The effect of the longer track travel is to stretch the front of the eyellipse forward in the workspace without changing the location of the rear.				

4.2 Centroid

The centroid of each eyellipse shall be located at the midpoint of the three axes.

4.3 Left and right eyes

Eyellipses for the left and right eyes shall be identical except that their centroids shall be separated horizontally by 65 mm. A single, mid eye centroid (cyclopean eye) shall be located 32,5 mm from the centroid of either eyellipse.

4.4 Ellipsoid surface versus three axial sections

The user may construct either a complete ellipsoidal surface or a 3-D eyellipse containing only the three axial sections defining plan, side and rear views. Use of the ellipsoidal surface gives the greatest accuracy.

5 Procedure for passenger cars and light trucks

This procedure is applicable to passenger cars and light trucks with the following range of driver workspace dimensions as shown in Table 2.

Table 2 — Range of driver workspace dimensions — Passenger cars and light trucks

Code No.	Description	Dimension
ISO-H30	SgRP to heel — Vertical	127 mm to 405 mm
ISO-H59	H-point rise	0 to 50 mm
ISO-L23	Seat track travel	> 100 mm
ISO-D9	Steering wheel diameter	< 450 mm
ISO-L40	Torso angle	5° to 40°

5.1 3-D eyellipse locating procedure

See Figure B.5.

NOTE All values in the following equations have units of millimetres, except ISO-L40 which is expressed in degrees. Equation coefficients provide accuracy to ± 0,05 mm.

5.1.1 Locate R-Point

Determine a design H-Point (R-Point or SgRP). The X, Y and Z coordinates of the SgRP are ISO-L31, ISO-W20 and ISO-H70. ISO-W20 shall be made a negative number for left-hand drive vehicles.

5.1.2 Determine ISO-L40

The design torso angle (ISO-L40) shall be as specified by the manufacturer.

5.1.3 Select an eyellipse

Determine the seat track travel and select the appropriate 95th or 99th eyellipse.

5.1.4 Locate centroid

Locate the eyellipse centroid in the vehicle's three-dimensional reference system. Calculate the left and right eyellipse centroids as follows.

a) For seat track travel (ISO-L23) greater than 133 mm:

$$X = (\text{ISO-L31}) - 259{,}914\ 72 + 10{,}281\ 641 \times (\text{ISO-L40}) - 0{,}032\ 032 \times (\text{ISO-L40})^2 \quad (1)$$

$$\text{(left eye) } Y = (\text{ISO-W20}) - 32{,}5 \quad (2)$$

$$\text{(right eye) } Y = (\text{ISO-W20}) + 32{,}5 \quad (3)$$

$$Z = (\text{ISO-H70}) + 653{,}717\ 57 + 0{,}398\ 747 \times (\text{ISO-L40}) - 0{,}059\ 301 \times (\text{ISO-L40})^2 \quad (4)$$

b) For seat track travel (ISO-L23) from 100 mm to 133 mm:

$$X = (\text{ISO-L31}) - 247{,}714\ 72 + 10{,}281\ 641 \times (\text{ISO-L40}) - 0{,}032\ 032 \times (\text{ISO-L40})^2 \quad (5)$$

$$\text{(left eye) } Y = (\text{ISO-W20}) - 32{,}5 \quad (6)$$

$$\text{(right eye) } Y = (\text{ISO-W20}) + 32{,}5 \quad (7)$$

$$Z = (\text{ISO-H70}) + 655{,}017\ 57 + 0{,}398\ 747 \times (\text{ISO-L40}) - 0{,}059\ 301 \times (\text{ISO-L40})^2 \quad (8)$$

5.1.5 Orient axes

Separately rotate each eyellipse about its centroid so the X-axis is inward 5,4° (looking forward) in plan view and down 6,4° (looking forward) in side view.

6 Procedure for heavy trucks and buses

This procedure is applicable to heavy trucks and buses with the range of driver workspace dimensions shown in Table 3.

Table 3 — Range of driver workspace dimensions — Heavy trucks and buses

Code no.	Description	Dimension
ISO-H30	SgRP to heel — vertical	405 mm to 530 mm
ISO-H59	H-point rise	0 mm
ISO-L23	Seat track travel	> 100 mm
ISO-D9	Steering wheel diameter	450 mm to 560 mm
ISO-L40	Torso angle	11° to 18°

6.1 3-D eyellipse locating procedure

See Figure B.6.

6.1.1 Locate ATRP

Determine the accommodation tool reference point (ATRP). Normally, this is the midpoint of the design H-point travel path. It may also be located using the procedure for Class B vehicles given in SAE J 1516 and SAE J 1517. The X and Z coordinates of the ATRP are X(ATRP) and Z(ATRP).

6.1.2 Determine ISO-L40

The design torso angle (ISO-L40) shall be as specified by the manufacturer.

6.1.3 Select an eyellipse

Determine the seat track travel ISO-L23 and select the appropriate 95th or 99th eyellipse.

6.1.4 Locate centroid

The eyellipse centroid is located to the vehicle's three-dimensional reference system. The following equations locate the centroid as a function of design torso angle for three different male/female mixes (50/50, 75/25, 90/10 to 95/5) in the driver population. Select the same male/female mix that was used in determining the ATRP. All values are in millimetres except ISO-L40, which is expressed in degrees.

a) For a 50/50 male/female ratio:

$$X = X(ATRP) - 175{,}26 + 12{,}68 \times (ISO\text{-}L40) \quad (9)$$

$$Z = Z(ATRP) + 691{,}09 - 3{,}57 \times (ISO\text{-}L40) \quad (10)$$

b) For a 75/25 male/female ratio:

$$X = X(ATRP) - 201{,}05 + 13{,}65 \times (ISO\text{-}L40) \quad (11)$$

$$Z = Z(ATRP) + 699{,}66 - 3{,}82 \times (ISO\text{-}L40) \quad (12)$$

c) For a 90/10 to 95/5 male/female ratio:

$$X = X(ATRP) - 184{,}44 + 12{,}23 \times (ISO\text{-}L40) \quad (13)$$

$$Z = Z(ATRP) + 707{,}52 - 4{,}17 \times (ISO\text{-}L40) \quad (14)$$

In each case the Y coordinate of the left and right eyellipse centroids is given by:

$$(\text{left})\ Y = (ISO\text{-}W20) - 32{,}5 \quad (15)$$

$$(\text{right})\ Y = (ISO\text{-}W20) + 32{,}5 \quad (16)$$

ISO-W20 shall be made a negative number for left-hand drive vehicles.

6.1.5 Orient axes

Separately rotate each eyellipse about its centroid so the X-axis is inward 5,4° (looking forward) in plan view and down 11,6° (looking forward) in side view.

Annex A
(informative)

Development of the eyellipse

A.1 Historical background

This International Standard is based on an original study involving over 2 300 US drivers performing a straight-ahead viewing task without head-turning, sitting in seats having fore/aft adjustment and fixed back angles[6]. Elliptical contours were developed by the statistical analysis of the stereophotogrammetric data, using a male-to-female ratio of one-to-one. These contours were given the name eyellipse, a contraction of the words eye and ellipse. An eyellipse affords a convenient way to represent driver eye locations in a driver workspace in order to determine what drivers can see. In a subsequent study a procedure was developed to position an eyellipse in the driver workspace for various design torso (back) angles ranging from 5° to 40°.

A.2 Three-dimensional eyellipse

A typical three-dimensional eyellipse is shown in Figure B.1. Four different eyellipses are described in this document. Each eyellipse was derived as the perimeters of an envelope formed by an infinite number of planes dividing the eye positions so that (P) % of the eyes are on one side of the plane and (100 – P)% are on the other.

It should be noted that the 95th percentile eyellipse does not include 95 % of the drivers' eye locations. To illustrate this, consider the side view of the eyellipse shown in Figure B.7. If a plane seen as a straight line in the side view is drawn tangent to the upper edge of the 95th percentile eyellipse, then 95 % of the driver eye locations will be below the line and 5 % of the driver eye locations will be above the line. Further, if a plane seen as a straight line in the side view is drawn tangent to the lower edge of the 95th percentile eyellipse, then 95 % of the driver eye locations will be above the line and 5 % of the driver eye locations will be below the line. The 95th and the 99th percentile eyellipses are defined in this document and are shown in plan and side view in Figure B.8.

A.3 Fixed seat eyellipses

The eyellipses defined in this document are valid for seats having horizontal track travel of at least 100 mm. Eyellipses have been developed for seats having no horizontal adjustment (fixed seats), but are not defined here[7] [8].

A.4 Passenger cars and heavy trucks

In this document there are two different procedures for locating an eyellipse, depending on whether or not the driver workspace is that found in a passenger car or a heavy truck. The rationale for a different locating procedure for heavy trucks is based on an SAE study of truck driver eye locations in three heavy truck cab configurations having 381 mm of horizontal seat travel. It was found that an elliptical model having the same axes lengths as the eyellipses previously developed for passenger cars provided a good fit to the truck driver eye position data, regardless of the population mix of male or female truck drivers. However, the location of the eyellipse centroid and the slope of the major axis in side view would not be predicted using the location procedure for passenger cars. Therefore, a different eyellipse locating procedure was developed for heavy trucks and buses (see Clause 6).

A.5 Lean factor

Recent studies in contemporary vehicles have indicated a need to remove the lean factor from the eyellipse lateral procedure and to reduce from 6 to 2 the number of eyellipses for different lengths of horizontal seat track travel[8].