

	SURFACE VEHICLE RECOMMENDED PRACTICE	SAE	J941 MAR2010
		Issued Revised	1965-11 2010-03
		Superseding	J941 OCT2008
Motor Vehicle Drivers' Eye Locations			

RATIONALE

This revision contains editorial changes to improve the document structure and clarity. No technical changes were made.

FOREWORD

This SAE Recommended Practice describes the eyellipse, a statistical representation of driver eye locations, which is used to facilitate design and evaluation of vision in motor vehicles. Examples of eyellipse applications include rearview mirror size and placement, wiped and defrosted areas, pillar size and location, and general exterior field of view. These applications are covered in other SAE and ISO practices.

The 2002 revision of the eyellipse was the most significant update to SAE J941 since its inception. The 2002 eyellipses differed from the previous eyellipses in the following ways:

- a. The axis angles in plan view and rear view are parallel to vehicle grid.
- b. The side view X axis angle is tipped down more at the front.
- c. For the 95th percentile eyellipse (99th shown in parentheses):
 1. The X axis length is 7.5 (18.9) mm longer.
 2. The Y axis is 44.6 (63.6) mm shorter.
 3. The Z axis is 7.4 (10.1) mm longer.
- d. The centroid location is generally higher and more rearward.
- e. The centroid location in side view is a function of packaging geometry (SgRP, steering wheel location, seat cushion angle, and the presence or absence of a clutch pedal).
- f. The eyellipse is no longer positioned according to the drivers' torso angle.
- g. The eyellipse for seat tracks shorter than 133 mm in length has an X axis length unchanged from the prior SAE J941. The Y and Z axis lengths, and the centroid location, are based on the new values/ equations given in this document.
- h. Neck pivot (P) and eye (E) points are based on the previous plan view sight lines to rearview mirrors and A-pillars, but are adjusted to the shape and location of the new eyellipses.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2010 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
 Tel: 724-776-4970 (outside USA)
 Fax: 724-776-0790
 Email: CustomerService@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

Full document details: SAE J941_201003

SAE values your input. To provide feedback
 on this Technical Report, please visit
http://www.sae.org/technical/standards/J941_201003

Documents

Document Sharing Hub

New additions, incorporated as appendices to this document, are summarized as follows:

- a. Fixed seat eyellipses for an adult user population at a 50/50 gender mix and 95th and 99th percentile tangent cutoffs (Appendix B).
- b. A procedure for calculating adjustable and fixed seat eyellipses for any user population stature and gender mix at selected percentile tangent cutoffs (Appendices A and C).
- c. Tables providing comparisons between tangent cutoff eyellipses and inclusive eyellipses. An inclusive eyellipse can be constructed using these tables (Appendix D).

Eyellipses for Class B vehicles are unchanged from prior versions of SAE J941 (Appendix E).

Appendices are informative only and are not normative requirements of this document.

TABLE OF CONTENTS

1.	SCOPE.....	4
2.	REFERENCES.....	4
2.1	Applicable Publications	4
2.1.1	SAE Publications.....	4
2.2	Related Publications	5
2.2.1	SAE Publications.....	5
2.2.2	Other Publication.....	5
3.	DEFINITIONS	5
3.1	Eyellipse	5
3.2	Cyclopean Eye or Mid-Eye Point	6
3.3	Tangent Cutoff Plane	6
3.4	Tangent Cutoff Eyellipse	6
3.5	Neck Pivot Points (P points)	6
3.6	Neck Pivots, P1 and P2	6
3.7	Neck Pivots, P3 and P4	7
3.8	Eye Points (E points).....	7
3.9	Inclusive Eyellipse.....	8
3.10	Dimensions and Definitions in SAE J1100	8
4.	ADJUSTABLE SEAT 95TH AND 99TH PERCENTILE TANGENT CUTOFF EYELLIPSES FOR A 50/50 MALE/FEMALE GENDER MIX	9
4.1	Reference anthropometry	9
4.2	Axis Lengths.....	9
4.3	Axis Angles	10
4.3.1	Rear and Plan View Angles	10
4.3.2	Side View Angle, β	10
4.4	Centroid Locations	11
4.4.1	Locating Equations	11
4.4.2	Seats with Vertical Adjustment	11
4.4.3	Left, Right, Mid-Eye Centroids	12
5.	EYELLIPSE LOCATING PROCEDURE, CLASS A VEHICLES.....	12
5.1	Determine seat characteristics A19, W20, H30, TL23.....	12
5.2	Determine H8 and L6.....	12
5.3	Determine t based on the percentage of vehicle production that has a clutch pedal.....	12
5.4	Construct identical left and right eyellipses based on the axes given in Table 2.	12
5.5	Locate the centroids using Equations 2 through 5.	12
5.6	Tilt the front of the eyellipse X axis down in side view according to Equation 1.....	12

6.	NECK PIVOT (P) AND EYE (E) POINTS: LOCATING PROCEDURE, CLASS A VEHICLES	13
6.1	Background	13
6.2	Neck Pivot (P) Points	13
6.3	Eye (E) Points	13
7.	NOTES	14
7.1	Marginal Indicia	14
APPENDIX A	ADJUSTABLE SEAT TANGENT CUTOFF EYELLIPSES FOR ANY USER POPULATION STATURE DISTRIBUTION AND GENDER MIX [INFORMATIVE]	15
APPENDIX B	FIXED SEAT 95TH AND 99TH PERCENTILE TANGENT CUTOFF EYELLIPSES FOR AN ADULT POPULATION AT A 50/50 GENDER MIX [INFORMATIVE]	21
APPENDIX C	FIXED SEAT TANGENT CUTOFF EYELLIPSES FOR ANY USER POPULATION STATURE DISTRIBUTION AND GENDER MIX [INFORMATIVE]	25
APPENDIX D	TANGENT CUTOFF EYELLIPSES AND INCLUSIVE EYELLIPSES [INFORMATIVE]	29
APPENDIX E	EYELLIPSES FOR CLASS B VEHICLES [INFORMATIVE]	32
APPENDIX F	BACKGROUND FOR THIS REVISION OF SAE J941 [INFORMATIVE]	35
FIGURE 1	TYPICAL THREE-DIMENSIONAL TANGENT CUTOFF EYELLIPSES FOR THE LEFT AND RIGHT EYES	6
FIGURE 2	P POINT LOCATIONS RELATIVE TO 95TH PERCENTILE EYELLIPSE MID-EYE CENTROID WITH SEAT TRACK TRAVEL >133 MM	7
FIGURE 3	NECK PIVOT POINT AND ASSOCIATED EYE POINTS	8
FIGURE 4	ADJUSTABLE SEAT TANGENT CUTOFF EYELLIPSE FOR ONE EYE, THREE VIEWS	10
FIGURE 5	EYELLIPSE PACKAGE FACTORS, SIDE VIEW AXIS ANGLE, AND CENTROID LOCATION	12
FIGURE A1	SIDE VIEW LOCATION OF THE MALE AND FEMALE EYE CENTROIDS RELATIVE TO THE REFERENCE CENTROID	16
FIGURE A2	DETERMINATION OF EYELLIPSE X AXIS END POINTS AND LENGTH	16
FIGURE B1	FIXED SEAT EYELLIPSE SIDE VIEW AXIS ANGLE AND CENTROID LOCATION	21
FIGURE B2	FIXED SEAT TANGENT CUTOFF EYELLIPSE FOR ONE EYE - TRUE VIEWS	23
FIGURE C1	FIXED SEAT EYELLIPSE SIDE VIEW, (X, Z) AXIS AND AXIS ANGLE, δ	27
FIGURE D1	TWO DIMENSIONAL TANGENT CUTOFF DESCRIPTION	29
FIGURE E1	EYELLIPSE LOCATION IN CLASS B VEHICLES	33
TABLE 1	REFERENCE ANTHROPOMETRY (NHANES III) ⁽¹⁾	9
TABLE 2	LEFT AND RIGHT EYELLIPSE AXIS LENGTHS (TRUE VIEW)	9
TABLE 3	NECK PIVOT POINTS RELATIVE TO THE 95TH PERCENTILE EYELLIPSE MID-EYE CENTROID	13
TABLE A1	POPULATION ANTHROPOMETRY ⁽¹⁾	19
TABLE A2	LEFT AND RIGHT EYELLIPSE AXIS LENGTHS (MM)	19
TABLE A3	CHANGE IN EYELLIPSE CENTROID LOCATION ⁽¹⁾ (50% MALE POPULATION)	20
TABLE B1	FIXED SEAT EYELLIPSE AXIS LENGTHS	22
TABLE D1	TANGENT CUTOFF EYELLIPSE PERCENTILES AND CORRESPONDING 2-D AND 3-D INCLUSIVE EYELLIPSE PERCENTILES, ADJUSTABLE SEAT	30
TABLE D2	TANGENT CUTOFF EYELLIPSE PERCENTILES AND CORRESPONDING 2-D AND 3-D INCLUSIVE EYELLIPSE PERCENTILES, FIXED SEAT	31
TABLE E1	LENGTH OF 3 AXES IN TRUE VIEW FOR THE FOUR EYELLIPSES (MM)	32

1. SCOPE

This SAE Recommended Practice establishes the location of drivers' eyes inside a vehicle. Elliptical (eyellipse) models in three dimensions are used to represent tangent cutoff percentiles of driver eye locations.

Procedures are provided to construct 95th and 99th percentile tangent cutoff eyellipses for a 50/50 gender mix, adult user population.

Neck pivot (P) points are defined in Section 6 to establish specific left and right eye points for direct and indirect viewing tasks described in SAE J1050. These P points are defined only for the adjustable seat eyellipses defined in Section 4.

This document applies to Class A Vehicles (Passenger Cars, Multipurpose Passenger Vehicles, and Light Trucks) as defined in SAE J1100. It also applies to Class B vehicles (Heavy Trucks), although these eyellipses have not been updated from previous versions of SAE J941.

The appendices are provided for information only and are not a requirement of this document.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J826	Devices for Use in Defining and Measuring Vehicle Seating Accommodation
SAE J1100	Motor Vehicle Dimensions
SAE J1516	Accommodation Tool Reference Point
SAE J4002	H-Point Machine (HPM-II) Specifications and Procedure for H-Point Determination—Auditing Vehicle Seats
SAE J4004	Positioning the H-Point Design Tool—Seating Reference Point and Seat Track Length

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this specification.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

- | | |
|------------------|---|
| SAE J1050 | Describing and Measuring the Driver's Field of View |
| SAE J1517 | Driver Selected Seat Position |
| SAE Paper 650464 | Automobile Driver Eye Position, J. F. Meldrum (1965) |
| SAE Paper 680105 | The Eyellipse and Considerations in the Driver's Forward Field of View, W. A. Devlin and R. W. Roe (1968) |
| SAE Paper 720200 | Driver Head and Eye Positions, D. C. Hammond and R. W. Roe (1972) |
| SAE Paper 750356 | Describing the Driver's Workspace Eye, Head, Knee, and Seat Positions, R. W. Roe (1975) |
| SAE Paper 852317 | Describing the Truck Driver Workspace, N. L. Philippart and T. J. Kuechenmeister (1985) (in SAE SP-712) |
| SAE Paper 980012 | Development of an Improved Driver Eye Position Model, M.A. Manary, et al (1998) (in SAE SP-1358) |
- M. S. Sanders (1983), "U.S. Truck Driver Anthropometric and Truck Workspace Data Survey," Final Report submitted to SAE, Warrendale, PA
- B. E. Shaw and M. S. Sanders (1984), "Female U.S. Truck Driver Anthropometric and Truck Workspace Data Survey," Final Report submitted to SAE, Warrendale, PA

2.2.2 Other Publication

Available from UMTRI, RIPC, 2901 Baxter Road, Ann Arbor, MI 48109-2150, Tel: 734-764-6504, www.umtri.umich.edu.

W. A. Devlin (1975), "Visibility Design Guide," Proposed SAE Recommended Practice (also, ISO/TC159/SC4(USA1)6), SAE Driver Vision Committee, Troy, MI

3. DEFINITIONS

3.1 EYELLIPSE

A contraction of the words eye and ellipse used to describe the statistical distribution of eye locations in three-dimensional space located relative to defined vehicle interior reference points. See Figure 1.

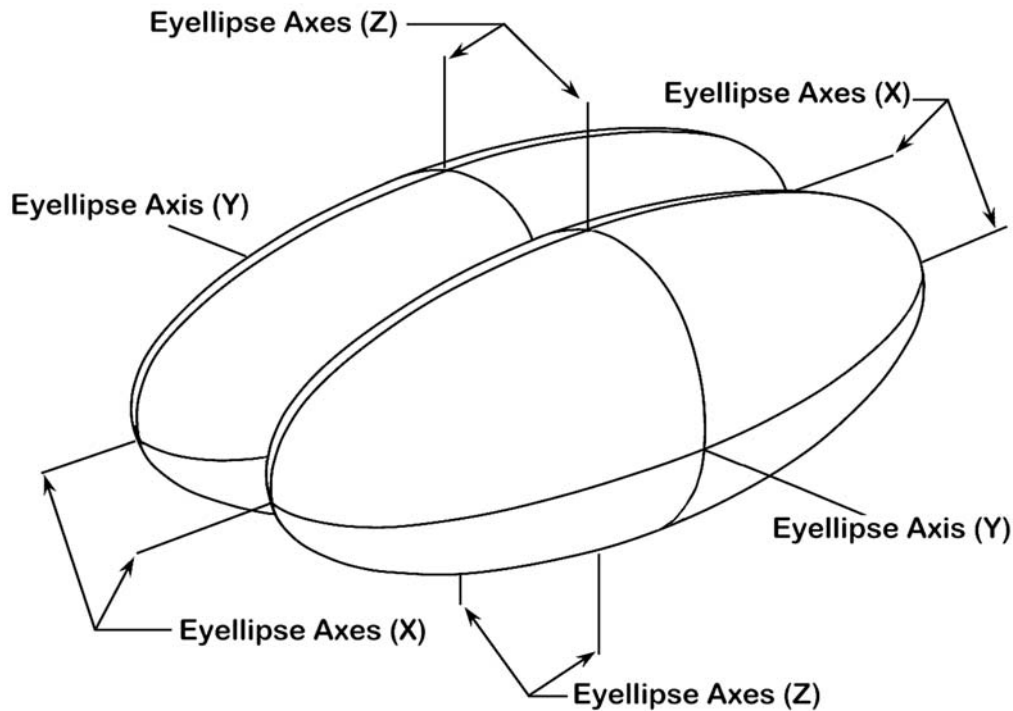


FIGURE 1 - TYPICAL THREE-DIMENSIONAL TANGENT CUTOFF EYELLIPSES FOR THE LEFT AND RIGHT EYES

3.2 CYCLOPEAN EYE OR MID-EYE POINT

Midpoint between left and right eye points and/or left and right eyellipse centroids at centerline of occupant.

3.3 TANGENT CUTOFF PLANE

Plane tangent to an eyellipse.

NOTE: When projected at a specified angle or to a specific target, a tangent cutoff plane may be considered a sight plane. In a two-dimensional view, a sight plane may be considered a sight line. See Figure D1 in Appendix D.

3.4 TANGENT CUTOFF EYELLIPSE

Three dimensional eyellipse derived as the perimeter of an envelope formed by an infinite number of planes dividing the eye locations so that P percent of the eyes are on one side of the plane and (100 – P) percent are on the other. See Appendix D.

3.5 NECK PIVOT POINTS (P POINTS)

Points about which a driver's head turns on a horizontal plane. See Figure 2.

3.6 NECK PIVOTS, P1 AND P2

Neck (head) pivot points used to position eye points for measuring the driver binocular obstruction due to A-pillars at the left and right side of the vehicle. See Figure 2.

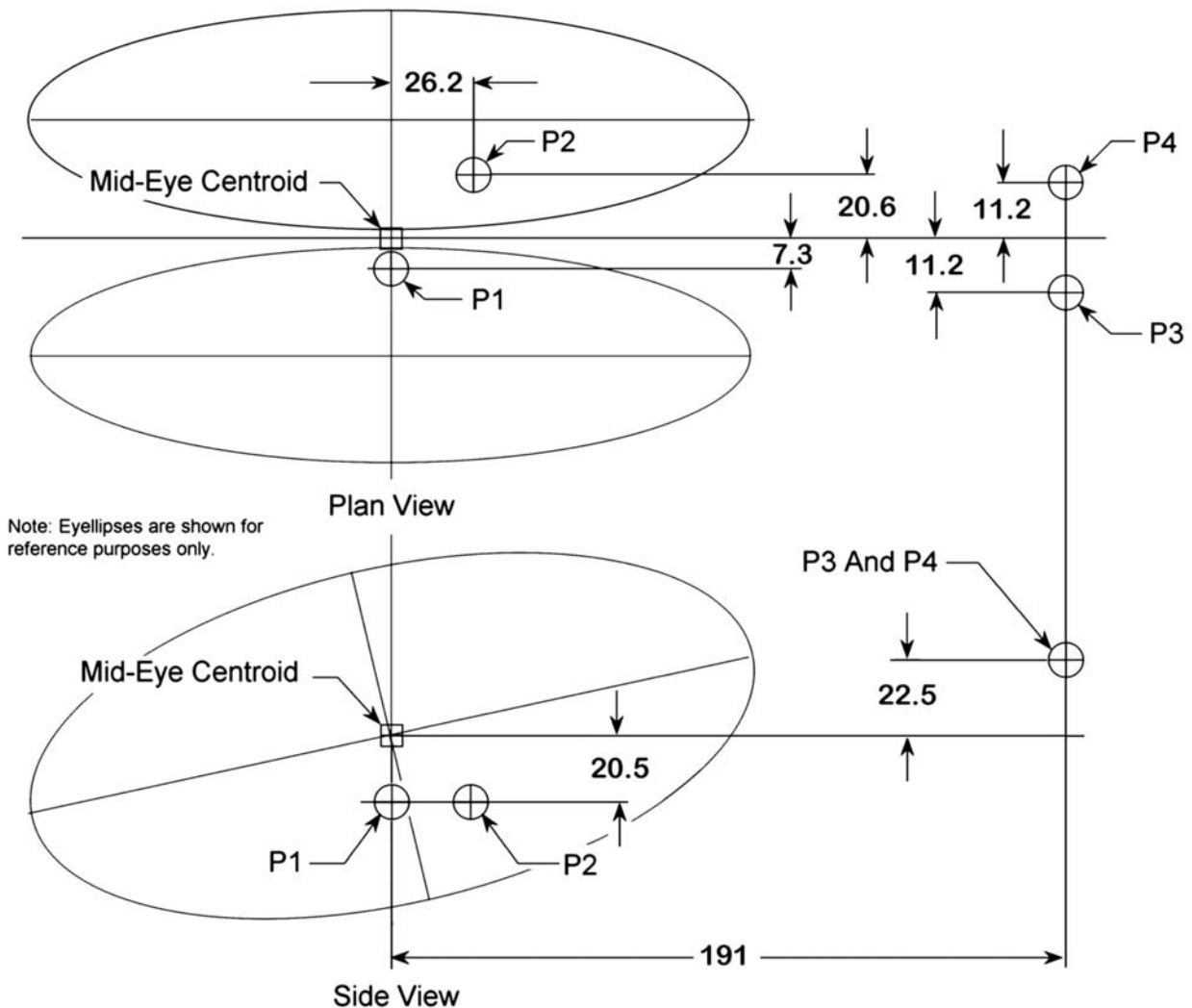


FIGURE 2 - P POINT LOCATIONS RELATIVE TO 95TH PERCENTILE EYELLIPSE MID-EYE CENTROID WITH SEAT TRACK TRAVEL >133 mm

3.7 NECK PIVOTS, P3 AND P4

Neck (head) pivot points used to position eye points for measuring driver field of view from rearview mirrors located to the left and right of the driver. See Figure 2.

3.8 EYE POINTS (E POINTS)

Two points representing the left and right eyes of the driver, used in conjunction with a Neck Pivot Point to describe specific viewing tasks. See Figure 3.

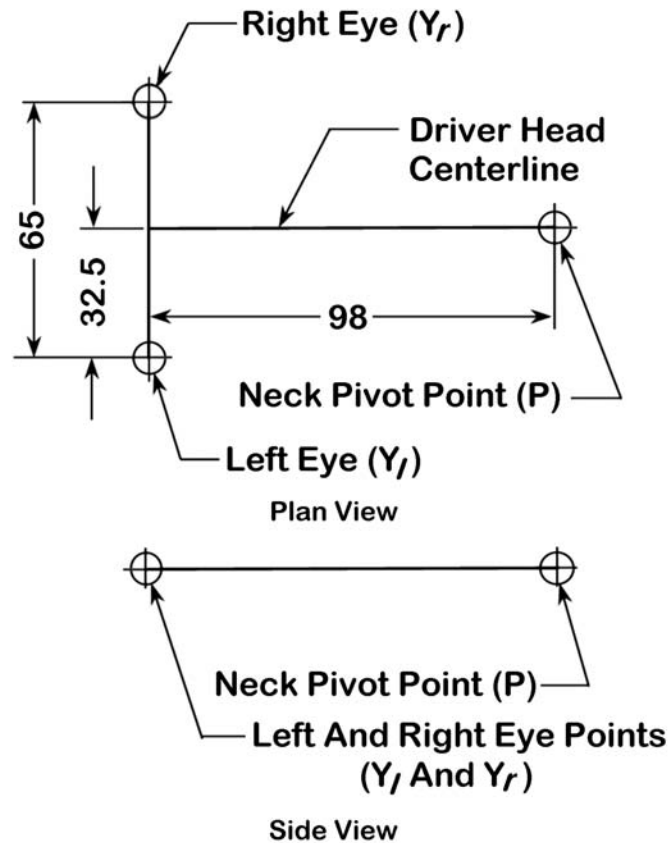


FIGURE 3 - NECK PIVOT POINT AND ASSOCIATED EYE POINTS

3.9 INCLUSIVE EYELLIPSE

Eyellipse that contains a specified percentage of drivers' eyes inside its boundaries.

3.10 Dimensions and Definitions in SAE J1100

- a. H-POINT
- b. SEATING REFERENCE POINT, SgRP
- c. BALL OF FOOT REFERENCE POINT (BOFRP)
- d. ACCELERATOR HEEL POINT (AHP)
- e. H-POINT TRAVEL PATH, TH21, TL23
- f. A19 — SEAT TRACK RISE
- g. H30 — SEAT HEIGHT
- h. L6 — BALL OF FOOT REFERENCE POINT (BOFRP) TO STEERING WHEEL CENTER
- i. CLASS A and CLASS B VEHICLES

4. ADJUSTABLE SEAT 95TH AND 99TH PERCENTILE TANGENT CUTOFF EYELLIPSES FOR A 50/50 MALE/FEMALE GENDER MIX

4.1 Reference Anthropometry

These eyellipses are based on the user populations described in Table 1. Driver eyellipses for a 50/50 gender mix shall be used for designing Class A vehicles.

TABLE 1 - REFERENCE ANTHROPOMETRY (NHANES III)⁽¹⁾

Gender	Mean Stature mm	Standard Deviation of Stature mm
Males	1755	74.2
Females	1618	68.7

1. Source: U.S. National Health and Nutrition Examination Survey (NHANES III). Height for males (and females) 20 years and older, number of examined persons, standard error of the mean, and selected percentiles, by ethnicity/race, age: United States, 1988-1994, obtained from <http://www.cdc.gov/nchs/>. Standard deviations for each gender were estimated by dividing the difference between the 95th and 5th percentiles by the difference in z scores (3.29).

The 95th and 99th percentile tangent cutoff eyellipses for a 50/50 gender mix are constructed from tables and equations given in 4.2 through 4.3.2. These eyellipses are applicable to driver and front outboard passenger seat locations.

4.2 Axis Lengths

Axis lengths are given in Table 2. See Figure 4.

TABLE 2 - LEFT AND RIGHT EYELLIPSE AXIS LENGTHS (TRUE VIEW)

Seat Track Travel (TL23) mm	Percentile	X Axis Lengths mm	Y Axis Lengths mm	Z Axis Lengths mm
>133	95	206.4	60.3	93.4
	99	287.1	85.3	132.1
1-133	95	173.8 ⁽¹⁾	60.3	93.4
	99	242.1 ⁽¹⁾	85.3	132.1

1. For seat track travels of 100 to 133 mm, the eyellipse X axis length was retained from the prior SAE J941. No new eye position data was collected for these shortened seat track travels.

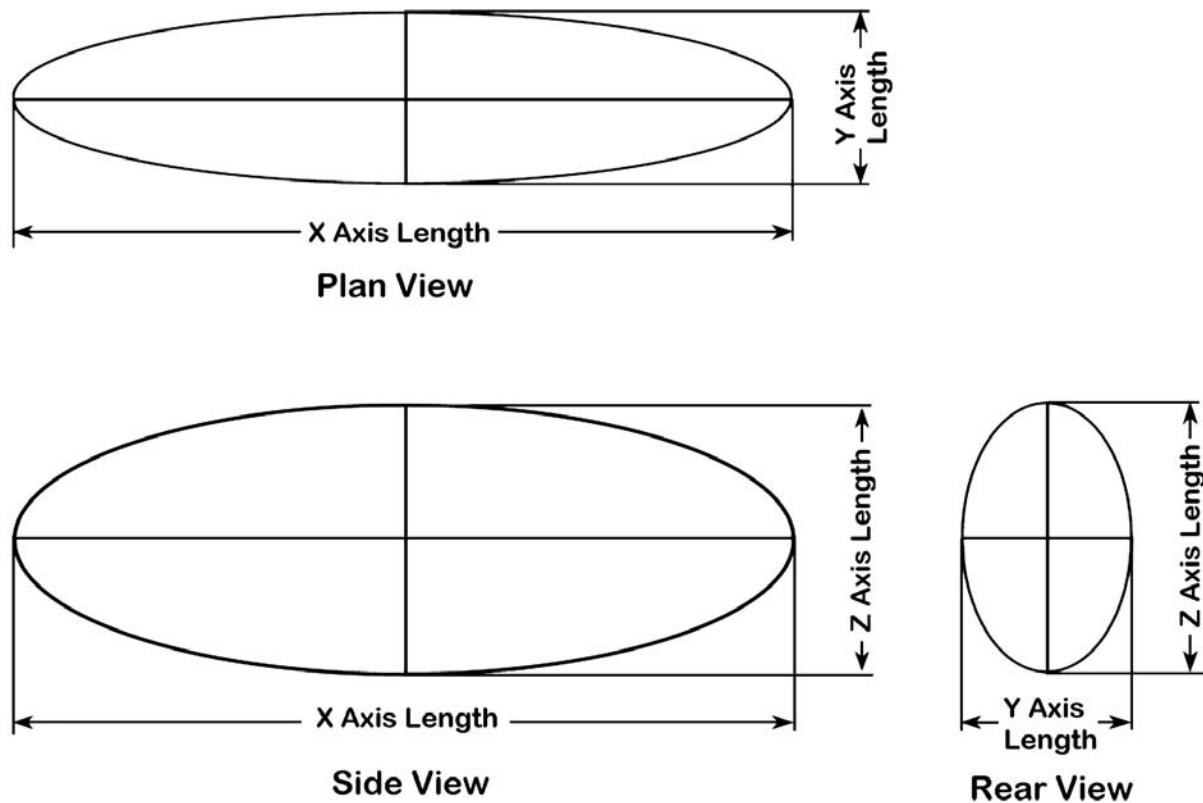


FIGURE 4 - ADJUSTABLE SEAT TANGENT CUTOFF EYELLIPSE FOR ONE EYE, THREE VIEWS

4.3 Axis Angles

4.3.1 Rear and Plan View Angles

The eyellipse is aligned with the vehicle axes in plan view (Z-plane) and rear view (X-plane), but it is tilted down at the front in side view (Y-plane).

4.3.2 Side View Angle, β

In side view the angle of the eyellipse is

$$\beta = 12.0 \quad (\text{Eq. 1})$$

where:

β is in degrees (positive, tipped down at the front from horizontal)

4.4 Centroid Locations

4.4.1 Locating Equations

Equations 2 through 5 are used to calculate the eyellipse centroid location. See Figure 5.

$$X_c = L1 + 664 + 0.587(L6) - 0.176(H30) - 12.5t \quad (\text{Eq. 2})$$

$$Y_{cl} = W20 - 32.5 \quad (\text{Eq. 3})$$

$$Y_{cr} = W20 + 32.5 \quad (\text{Eq. 4})$$

$$Z_c = H8 + 638 + H30 \quad (\text{Eq. 5})$$

where:

L1 is the BOFRP x coordinate,
L6 is the x distance from steering wheel center to BOFRPx
H30 is the z distance of the SgRP from the AHP
t is the transmission type (1 with clutch pedal, 0 without clutch pedal)
W20 is the SgRP y coordinate and
H8 is the AHP z coordinate

4.4.2 Seats with Vertical Adjustment

For driver seats that provide vertical adjustment, Equations 2 to 5 were developed with H30 (and SgRP) positioned at the middle of the vertical adjustment range. Typically this was 20 to 25 mm vertically above the full down H-point travel path (Figure 5). If manufacturers define their SgRP so it is not at 20 mm above the driver's full down H-point travel path, the accuracy in locating the vertical position of the eyellipse using the manufacturer's H30 dimension in Equation 5 will be reduced. If the H-point vertical adjustment (TH21) is less than 40 mm, then H30 and the eyellipse Z centroid should be located from a point midway between the full up and full down travel path.