

Motor Vehicle Driver and Passenger Head Position

RATIONALE

The side view angle of the adjustable seat head contour shown in Figure 3 was corrected to 12 degrees, the value it was in the 2005 version of SAE J1052.

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1. SCOPE

This SAE Standard describes head position contours and procedures for locating the contours in a vehicle. Head position contours are useful in establishing accommodation requirements for head space and are required for several measures defined in SAE J1100. Separate contours are defined depending on occupant seat location and the desired percentage (95 and 99) of occupant accommodation.

This document is primarily focused on application to Class A vehicles (see SAE J1100), which include most personal-use vehicles (passenger cars, sport utility vehicles, pick-up trucks). A procedure for use in Class B vehicles can be found in Appendix B.

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 J941 Motor Vehicle Drivers' Eye Locations

SAE J1100 Motor Vehicle Dimensions

SAE J1516 Accommodation Tool Reference Point

SAE J1517 Driver Selected Seat Position

3. USING THE HEAD POSITION CONTOURS IN DESIGN

The following considerations should be kept in mind when applying head position contours during design. Head position contours are models that describe occupant head locations for a population, not an individual. In this document, the head contours for Class A vehicles are based on a USA population having an equal number of males and females. Head position contours are constructed as tangent cutoff tools by applying a mean head profile (SAE Paper 750356) to the appropriate tangent cutoff eyellipse. (See Figure 1.) This means that a plane drawn tangent to the surface of a 95 percentile head position contour will result in 95% of the head locations lying on one side of the plane, while 5% will be on the other. It does not mean that the 95th percentile head position contour contains 95 percent of occupant head locations inside its surface.

The surface of a head position contour represents the surface of the population of heads with hair. If the top of the 95% head contour is just touching a vehicle surface, this means that 5% of a population consisting of half males/half females would have their head or hair contacting a vehicle surface when sitting in their preferred seating posture. Designers will need to add additional clearance around the head contours in order to prevent occupants' head or hair from touching vehicle surfaces and structures in normal driving or riding postures.

4. SELECTING THE CORRECT HEAD POSITION CONTOUR

Three factors determine which head contour to use: seat track travel length (TL23), desired accommodation percentile value, and occupant seat location.

4.1 Seat Track Travel, TL23

The size and location of the head position contour varies depending on the amount of fore/aft seat track travel available. There are three categories of seat track travel: 0 mm (fixed seat), up to 133 mm, and greater than 133 mm.

Seat track travel also determines the side view angle of the contour. For adjustable seats (track travel greater than 0 mm), the head contour is tipped down in front 12 degrees. Head contours for fixed seats are not tipped.

4.2 Accommodation Percentile Values

Head position contours for 95th and 99th accommodation percentiles are provided. Percentile value affects the size of the contour, with the 99th percentile contour larger than the 95th. Only the 95th percentile head position contours are required for dimensions given in SAE J1100.

4.3 Occupant Seat Location

4.3.1 Front Row

For the driver and front outboard passenger, the head position contours are 23 mm wider in rear view than for other occupants. The additional 23 mm is located outboard of occupant centerline. There are 6 possible head position contours available for the driver and front outboard passenger depending on the amount of seat track travel available and the desired accommodation percentile value. Adjustable seat head position contours are also used for the center occupant in the front row. In this case, the 23 mm segment should not be incorporated into the adjustable seat head contour.

4.3.2 Second and Succeeding Rows

For occupant seat locations behind the front row, only two contours are provided – 95th percentile fixed seat and 99th percentile fixed seat.

If the 2nd or succeeding row seat has fore/aft H-point adjustment, with a seat back angle that is either fixed or adjustable, there are no field data available on which to base a procedure for selecting or locating a head contour. Until such data are available, select the 95% or 99% fixed seat head contour, locate it from the manufacturer's SgRP and design torso angle, and then sweep the head contour along the range of normal riding fore/aft seat adjustment. The swept volume defines the range of rider head locations. If the manufacturer's SgRP or design torso angle is unknown, use the rearmost, lowest normal riding position and a torso angle of 25 degrees to position the contour.

5. HEAD POSITION CONTOUR GEOMETRY

Head position contours are constructed by modifying 3-D ellipsoids. The size of the initial ellipsoid, defined by the length of the X, Y, and Z axes, depends on the desired accommodation percentile value and amount of seat track travel. The centroid of the initial ellipsoid is the point used for positioning the completed head contour.

The size and shape of the completed head contour depends on the desired percentile value, amount of seat track travel, and occupant seat location.

5.1 Construct an Ellipsoid

Construct the appropriate ellipsoid using the values in Table 1. Identify the centroid of the ellipsoid and maintain this point.

TABLE 1 - ELLIPSOID AXES DIMENSIONS (mm)

Percentile Value	Seat Track Travel (TL23)	Axis Length from Centroid X	Axis Length from Centroid Y	Axis Length from Centroid Z
95th	>133 mm	± 211.25	± 143.75	± 133.50
	< or = 133 mm	± 198.76	± 143.75	± 133.50
	0 mm (fixed seat)	± 161.45	± 143.41	± 147.07
99th	>133 mm	± 246.04	± 166.79	± 151.00
	< or = 133 mm	± 232.40	± 166.79	± 151.00
	0 mm (fixed seat)	± 181.25	± 165.20	± 171.20

5.2 Discard Lower Half

The lower half of the ellipsoid is not used in any of the contours and should be discarded. The centroid identified in 5.1 will now be centered at the bottom of the completed contour.

NOTE: This completes construction of the head contours for fixed seat rear passengers. (See Figure 2.)

5.3 Extend Contour, Driver and Front Row Outboard Passenger Only

Head position contours used for driver and front row outboard passengers are asymmetrical in rear view. The contours extend 23 mm farther on the outboard side than on the inboard side. Note in this case the ellipsoid centroid will not be at the center of the completed head contour. See Figure 3.

Divide the contour in half along the lateral (Y) centerplane, while maintaining the position of the ellipsoid centroid relative to the *inboard* section. Following the x,z curve of the ellipsoid centerline section, create a lateral segment 23 mm wide. Put this in the middle of the divided contour. The inboard edge of the 23 mm segment is located at the same Y as the ellipsoid centroid. Dimensions for the completed head position contours are provided in Table 2 (95th percentile contours) and Table 3 (99th percentile contours).

TABLE 2 - 95TH PERCENTILE HEAD POSITION CONTOUR DIMENSIONS: DISTANCE FROM ELLIPSOID CENTROID TO OUTER EDGE OF THE HEAD POSITION CONTOUR (mm)

Occupant Seat Location	Seat Track Travel (TL23)	X	Y		Z
			INBOARD	OUTBOARD	
Driver and Front Outboard Passenger	>133 mm	± 211.25	143.75	166.75	+ 133.50
	< or = 133 mm	± 198.76	143.75	166.75	+ 133.50
	0 mm (fixed seat)	± 161.45	143.41	166.41	+ 147.07
Front Center Passenger	>133 mm	± 211.25	143.75	143.75	+ 133.50
	< or = 133 mm	± 198.76	143.75	143.75	+ 133.50
All Other Passengers	0 mm (fixed seat)	± 161.45	143.41	143.41	+ 147.07

TABLE 3 - 99TH PERCENTILE HEAD POSITION CONTOUR DIMENSIONS: DISTANCE FROM ELLIPSOID CENTROID TO OUTER EDGE OF THE HEAD POSITION CONTOUR (mm)

Occupant Seat Location	Seat Track Travel (TL23)	X	Y		Z
			INBOARD	OUTBOARD	
Driver and Front Outboard Passenger	>133 mm	± 246.04	166.79	189.79	+ 151.00
	< or = 133 mm	± 232.40	166.79	189.79	+ 151.00
	0 mm (fixed seat)	± 181.25	165.20	188.20	+ 171.20
Front Center Passenger	>133 mm	± 246.04	166.79	166.79	+ 151.00
	< or = 133 mm	± 232.40	166.79	166.79	+ 151.00
All Other Passengers	0 mm (fixed seat)	± 181.25	165.20	165.20	+ 171.20

5.4 Orient Axes

For adjustable seat contours, the front of the head position contour is angled down in side view 12 degrees. Other axes are parallel to vehicle grid.

For fixed seats, all head position contour axes are parallel to vehicle grid.

6. LOCATING HEAD POSITION CONTOURS IN CLASS A VEHICLES

The head contours may be located relative to the cyclopean eyellipse centroid or directly from vehicle grid. For adjustable front row seats, the reference point for locating a head position contour is its centroid in the SgRP Y-plane (Figure 3). The location of the head contour relative to eyellipse centroid depends only on the amount of seat track travel. For all head contours and conditions, the centroid of the head ellipsoid is located at the same y coordinate as the cyclopean eyellipse centroid, which is at the SgRP y coordinate (W20, occupant centerline).

6.1 Locating from Cyclopean Eyellipse Centroid

To locate the head contour, move its ellipsoid centroid in X, Y, Z space relative to the centroid of the cyclopean eyellipse using the values provided in Table 4.

TABLE 4 - DISTANCE FROM CYCLOPEAN EYELLIPSE CENTROID (SAE J941) TO HEAD CONTOUR ELLIPSOID CENTROID (mm)

Seat Track Travel (TL23)	X _h	Y _h	Z _h
> 133 mm	90.6	0	52.6
< or = 133 mm	89.5	0	45.9
0 mm (fixed seat)	96.7	0	44.8

6.2 Locating from Vehicle Grid

Alternatively, the head position contours may be located directly from vehicle grid without first locating the cyclopean eyellipse centroid. These locating equations are provided in Table 5.

TABLE 5 - HEAD CONTOUR ELLIPSOID CENTROID RELATIVE TO VEHICLE GRID (mm)

Seat Track Travel (TL23)	Head Ellipsoid Centroid Location	
Greater than 0 mm	$X = L1 + 664 + 0.587(L6) - 0.176(H30) - 12.5t + X_h$	Eq. 1
	$Y = W20$	Eq. 2
	$Z = H8 + 638 + H30 + Z_h$	Eq. 3
0 mm (fixed seat)	$X = L31 + 619 \sin \delta + X_h$	Eq. 4
	$Y = W20$	Eq. 5
	$Z = H70 + 619 \cos \delta + Z_h$	Eq. 6

where

$$\delta = 0.689(A40) - 9.09$$

and

X_h and Z_h are selected from the appropriate row of Table 4,

L1 is the BOFRP x coordinate,

L6 is the x-distance from steering wheel center to BOFRP,

H30 is the z coordinate of the SgRP, measured vertically from AHP,

t is transmission type (1 with clutch pedal, 0 without clutch pedal),

W20 is SgRP y coordinate,

H8 is AHP z coordinate,

δ is the side view fixed seat eyellipse angle in degrees (z-axis tipped back at the top from vertical), and

A40 is the design torso angle.

Determine t based on the percentage of vehicle production that has a clutch pedal. If 50% or more of anticipated production has a clutch pedal, set t=1. Otherwise, set t=0.

7. ASSESSING HEAD CLEARANCE

Head clearance is established as the closest distance between the head position contour and any protrusion or interior surface. This distance is measured normal (90 degrees) to the head position contour. (See Figure 4.) To accommodate the percentage of occupants represented by a given percentile head position contour, there must be some space between that head position contour and the vehicle interior surfaces. Otherwise, some occupants would have their head or hair contacting a vehicle interior surface.

Head clearance dimensions defined in SAE J1100 are based on side and rear view sections cut normal to grid through the top of contour (the highest point on the SgRP Y-plane of a head position contour). See Figures 2 and 3.

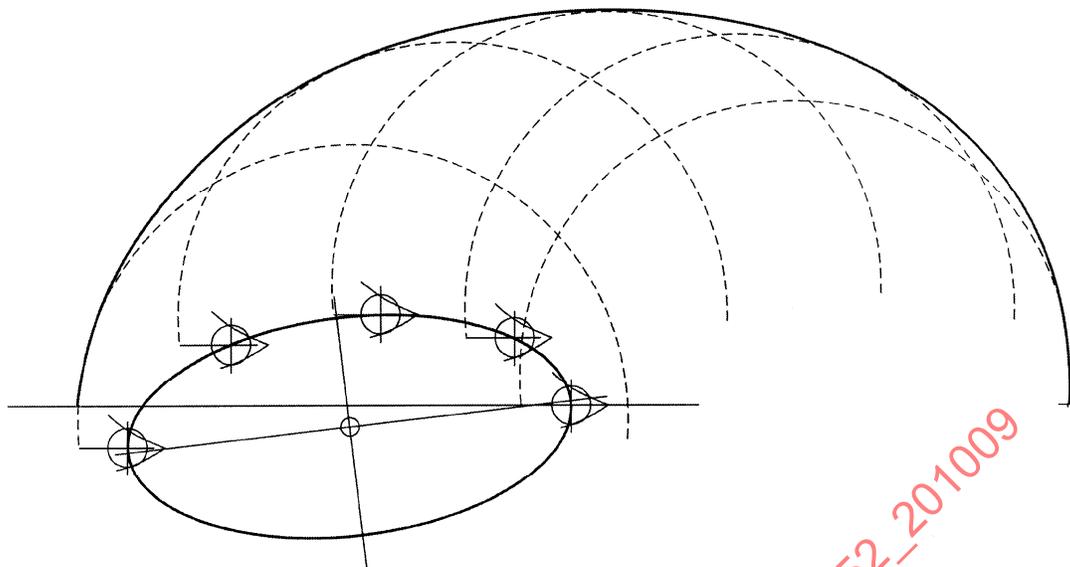


FIGURE 1 - DEVELOPMENT IN SIDE VIEW OF HEAD POSITION CONTOUR BY SPOTTING EYE REFERENCE OF MEAN HEAD AROUND EYELLIPTSE

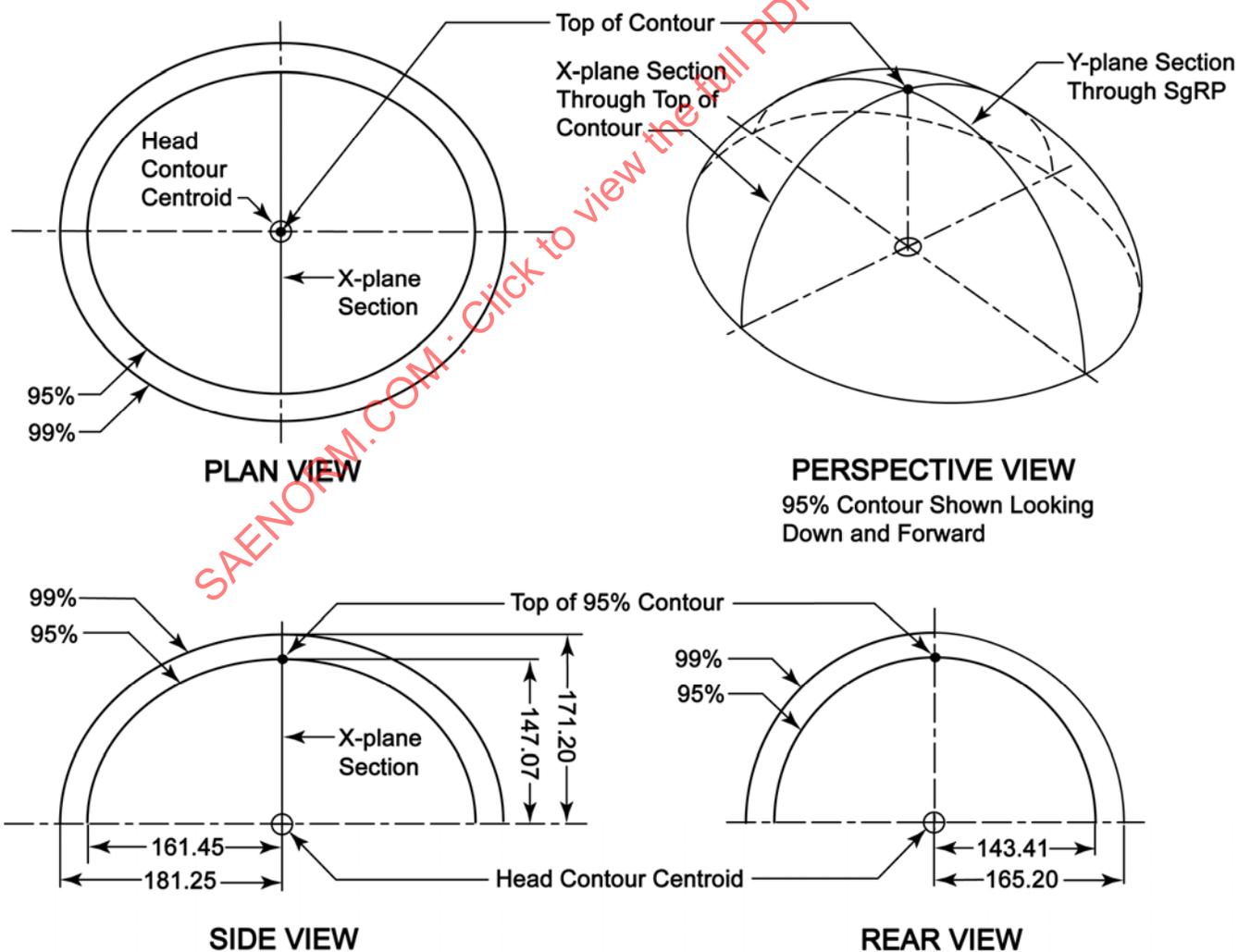


FIGURE 2 - HEAD POSITION CONTOURS FOR CLASS A VEHICLES WITH FIXED SEATS

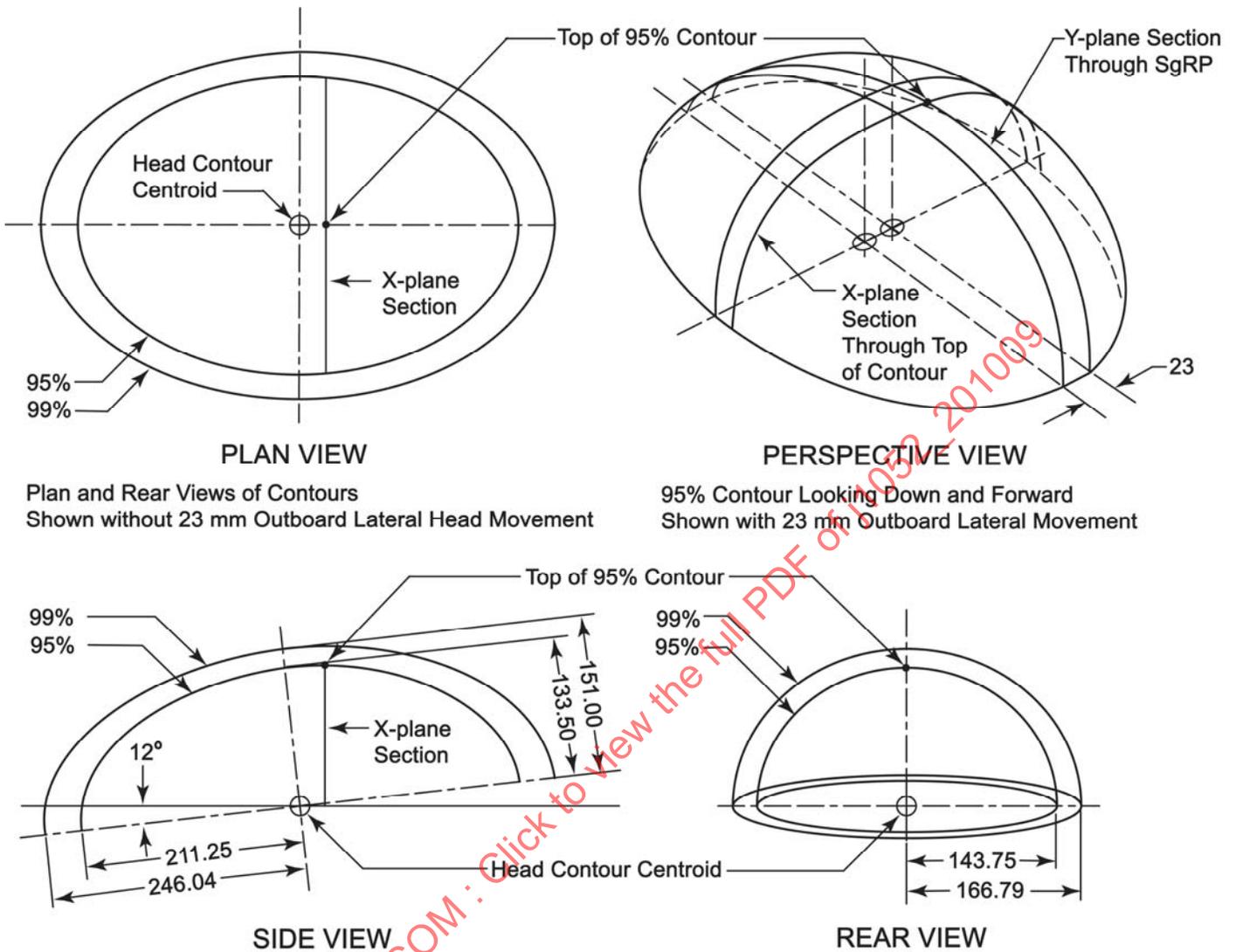


FIGURE 3 - DRIVER HEAD POSITION CONTOURS FOR CLASS A VEHICLES WITH SEAT TRACK TRAVEL GREATER THAN 133 mm

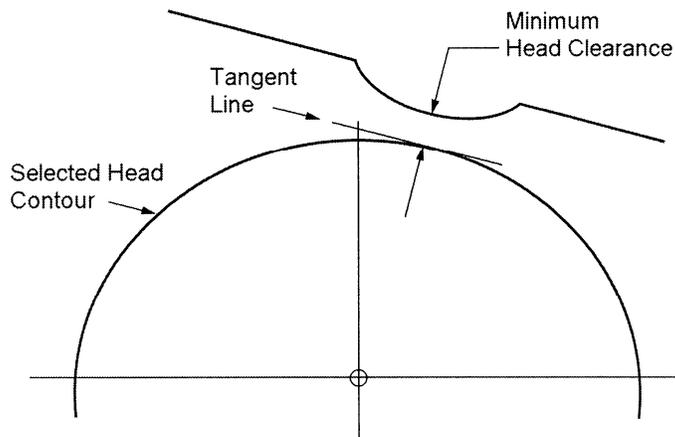


FIGURE 4 - MINIMUM HEAD CLEARANCE

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- CAESAR (Civilian American and European Surface Anthropometry Resource) Final Report, November 2002 (Available from SAE at <http://store.sae.org/caesar>)

9. NOTES

9.1 Marginal Indicia

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APPENDIX A - DEVELOPMENT OF HEAD POSITION CONTOURS

A.1 PRIOR SAE J1052 HISTORICAL INFORMATION

A.1.1 Driver Head Locations in Class A Vehicles

Previous driver head position contours were developed using data gathered from head and eye position studies (SAE Papers 650464, 720200) and anthropometric data of the head (SAE Paper 750356). Mean top of head (including hair) and back of head (including hair) were determined relative to the eye from these studies. The mean front and side of head was determined relative to the eye from anthropometric data. This information was used to develop a mean head profile in side and rear view referenced to a cyclopean eye (SAE Paper 750356).

Driver head position contours were developed by placing the mean head profile over the side view eyellipses and tracing the head contours as the eye was spotted around the eyellipses. (See Figure 1.) A rear view driver head location contour for the adjustable seat was generated from a rear view eyellipse taken from the original driver's eye position study (SAE Paper 720200). This was a rear view composite of the data from the Ford, Chevrolet and Plymouth convertibles (SAE Paper 650464). Only the upper half of the eyellipses was used. Lateral shift of the outboard side of the driver head contour was made to account for lateral head movement (see A.1.2). This resulted in a 23 mm flat segment between the left and right side of the driver head position contours.

To simplify the mathematical definition of the head position contours, the two-dimensional side and rear views were approximated as ellipses which allows the three dimensional model to be a simple ellipsoid. The Driver Seat Head Position contours defined in SAE J1052 MAY87 differed slightly from the ellipsoid model in SAE J1052 APR97. The differences varied with location around the contour and did not exceed 6 mm. In addition, to simplify the model, the plan view and rear view tilt of the eyellipses were not reflected in the head position contour geometry. Only the downward side view tilt was retained. The resulting simple ellipsoid models provided sufficient statistical accuracy to define head location.

The head contours can be interpreted as parameters of envelopes formed by an infinite number of planes dividing head positions so that (P) percent of the heads are on one side of the plane and (100-P) percent are on the other. For example, if a plane seen as a straight line in the side view is drawn tangent to the upper edge of the 95th percentile head position contour, then 95% of the heads will be below the line and 5% will be above. Head clearance is established as the closest distance between the head position contour and any protrusion or surface. This distance is typically measured normal (90 degrees) to the head contour surface. (See Figure 4.)

These head locations were based on a 50/50 male/female population mix, with heads positioned for straight-ahead viewing. 99% and 95% driver head position contours were defined for vehicles with shorter seat track travels (less than 133 mm) and for vehicles with longer seat track travels (greater than 133 mm). (See Figure 3.) Previously head location was modeled as a function of design torso angle for adjustable seats, so a locator function based on Seating Reference Point (SgRP) and design torso angle was used to position the head contours (SAE Paper 750356).

A.1.2 Driver Lateral Head Excursions

The original head position contours were based on eye locations looking straight ahead in open top vehicles with bench seats without shoulder restraint (unrestricted lateral positioning). Subsequently, vehicle designs having more contoured seats and shoulder restraints restricted lateral variability of driver position in the seat, and as a result, the width of the head position contour was reduced. However, lateral movement caused by driver's need to look to the left and right had to be included in determining the width of the head clearance contours in order to meaningfully represent the true lateral head clearance needs of drivers. Vertical and longitudinal movements were not considered since movement in these directions was assumed to be less frequent and less pronounced. Data on driver mean lateral head movement (Lee, 1988) were used to define the width and lateral placement of the driver head position contour. These data shifted the outboard side of the 95% driver's head contour outboard 23 mm (167 mm from seat centerline). The inboard side (144 mm from seat centerline) was not widened, because it's unlikely there will be clearance problems on that side. The result was an asymmetrical rear view. The widened 95% and 99% contours provided an allowance for a mean maximum head turn excursion. Practically, the 23 mm shift of the 95% contour outboard approximately aligned with the head contours generated previously using the lean equation ($0.85 W7 + 0.075 W3$). This meant that dimensional comparisons made with the 1987 and 1997-based driver head clearance contours would be generally similar.

A.1.3 Passenger (Fixed Seat) Head Locations in Class A Vehicles

Fixed-seat head position contours were developed by placing the mean head profile over the side and rear view fixed seat eyellipses developed in SAE Paper 750356 and tracing the head contours as the eye is spotted around the fixed seat eyellipses. Only the upper half of the fixed seat eyellipse was used. These head position contours were used to describe seated passenger head locations in any seat that is not adjustable for Class A vehicles. All applications are limited to a 50/50 male/female population mix. A locator function was used to position the contour according to design torso angle.

The fixed seat head position contours were approximated as true ellipsoids in side and rear view so that the three dimensional model was a simple ellipsoid. The fixed seat ellipsoid model in J1052 APR97 differed very slightly from the previous fixed seat contours given in SAE J1052 MAY87. In addition, the ellipsoid axes were aligned parallel to horizontal, vertical, and lateral vehicle axes. (See Figure 2.)

A.1.4 Driver Head Locations in Class B Vehicles

Truck driver head location data were collected in the SAE Truck Driver Anthropometric and Workspace Study in three heavy truck cab configurations with 381 mm of horizontal seat travel (SAE Paper 852317). Top-of-head and rear-of-head points (including hair) were determined relative to the eye for each driver. These data were used to construct boundaries that contained 95 and 99% of heads for various truck driver population mixes of males and females.

The same procedures and the head forms in A.1.1 for developing head contours from the eyellipse were used to generate contours to compare with the experimentally determined boundaries. The mean head profile was rotated around the upper halves of the experimental eyellipses generated from eye location data collected in the same study. In all cases, contours generated from eyellipses approximated the experimental boundaries with less than 15 mm difference. These head contours were also similar in size and shape to the SAE head contours for adjustable seats described in A.1.1 regardless of proportions of males and females in the truck driver population. However, truck driver head contours were located farther forward, higher, and with greater side view slope than would be predicted using the locating procedure in A.1.1, because of differences in user populations and seating package geometry. Therefore, although head contours described in A.1.1 are appropriate for use in Class B vehicles, a new locating procedure and reference system was developed. Locator equations were provided to position head contours in Class B workspaces for a range of back angles between 11 and 18 degrees. A separate equation is used for each of the populations representing the following ratios of males to females: 50/50, 75/25, and 90/10 to 95/5. See B.1.4.

A.2 DEVELOPMENT OF HEAD POSITION CONTOURS FOR THE 2002 REVISION

SAE J1052 was modified in 2002 to define head position contours that were consistent with the changes made to SAE J941 eyellipses. The method used to develop the head position contours was similar to the method described in Section A.1 and illustrated in Figure 1. In addition to the mean head profile, three 3-dimensional average-size male head forms, scanned as part of the CAESAR data collection in The Netherlands, were used. Various 3-dimensional surfaces were fitted to the head position data. An acceptable fit to the data was provided by the existing elliptical surfaces defined in SAE J1052 APR97, after they were translated up and rearward. As a result, the size and shape of the adjustable seat contours were not changed.

The adjustable seat head position contours are based on a 50/50 male/female population mix. There are 99th and 95th percentile driver head position contours defined for vehicles with shorter seat track travels (less than 133 mm) and for vehicles with longer seat track travels (greater than 133 mm). (See Figure 3.) The width of the contours includes the same 23 mm flat section to provide some allowance for driver outboard head turn. (See 5.3.)

The procedure for positioning the contours in Class A vehicles was modified from the 1997 procedure. In the 1997 version of this practice, contours were located relative to SgRP as a function of manufacturer's design torso angle. In this version, contours are positioned either relative to the centroid of the corresponding eyellipse, or relative to vehicle grid. The adjustable seat head contours are no longer located as a function of design torso angle. Also, the side view angle of the adjustable seat head contour is inclined more downward at the front. For the first time, head position contours have been defined for the front center seat location, and for a front outboard seat location having fixed (non fore/aft adjustable) seats. The procedure for Class B vehicles was not changed.