

Issued 1974-08
Revised 2002-08

Superseding J1052 APR97

(R) Motor Vehicle Driver and Passenger Head Position

Foreword—Changes for this Revision—This document has been modified to reflect the changes to SAE J941 eyellipses. The actual geometry – size and shape – of the head position contours remains the same. However, the location of the head contours in Class A vehicles has been shifted upward and rearward, and the procedure for positioning the contours has been modified. In the prior version of this practice, contours were located relative to SgRP as a function of manufacturer's design back 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 back 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. Information about the development of the head position contours is given in Appendix A.

TABLE OF CONTENTS

| | | |
|----|---|----|
| 1. | Scope | 2 |
| 2. | References | 2 |
| 3. | Using the Head Position Contours in Design | 2 |
| 4. | Selecting the Correct Head Position Contour | 3 |
| 5. | Head Position Contour Geometry | 3 |
| 6. | Locating Head Position Contours in Class A Vehicles | 4 |
| 7. | Assessing Head Clearance | 5 |
| 8. | Notes | 8 |
| | Appendix A Development of Head Position Contours | 9 |
| | Appendix B Procedure for Class B Vehicles | 12 |

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 ©2002 Society of Automotive Engineers, Inc.

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: custsvc@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

1. **Scope**—This SAE Recommended Practice 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 Publications**—The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

- 2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J941—Motor Vehicle Drivers' Eye Locations
 SAE J1052 MAY87—Motor Vehicle Driver and Passenger Head Position
 SAE J1052 APR97—Motor Vehicle Driver and Passenger Head Position
 SAE J1100—Motor Vehicle Dimensions
 SAE J1516—Accommodation Tool Reference Point
 SAE J1517—Driver Selected Seat Position
 SAE Paper 650464—J.F. Meldrum (1965), "Automobile Driver Eye Position," SAE Mid-Year Meeting, Chicago, IL
 SAE Paper 720200—D.C. Hammond and R.W. Roe (1972), "Driver Head And Eye Positions," SAE Annual Congress, Detroit, MI
 SAE Paper 750356—R.W. Roe (1975), "Describing the Driver's Workspace: Eye, Head, Knee, and Seat Positions," SAE Annual Congress, Detroit, MI
 SAE Paper 852317 (in SAE Special Pub. 712)—N.L. Philippart and T.J. Keuchenmeister (1985), "Describing the Truck Driver Workspace", SAE Truck & Bus Meeting, Chicago, IL

- 2.1.2 UMTRI PUBLICATION—Available from UMTRI, RIPC, 2901 Baxter Road, Ann Arbor, MI 48109-2150. Email: umtridocs@umich.edu, 734-764-2171.

Lee, N.S. and Schneider, L.W. "A Preliminary Investigation of Driver Lean in Late Model Vehicles with Bench and Bucket Seats," UMTRI Report No. UMTRI-88-49, November 1988

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—For the driver and front outboard passenger, the head position contours are 23mm 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.

For all other occupant seat locations, only two contours are provided – 95th percentile fixed seat and 99th percentile fixed seat. For rear seats that allow occupants to adjust the fore/aft seat travel and/or the back angle, there is no data from which a head position contour can be developed, located, and selected. Until such data are available, use of the fixed seat head contour is recommended.

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) | ± 173.31 | ± 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) | ± 198.00 | ± 165.20 | ± 169.66 |

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 | 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) | ± 173.31 | 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) | ± 173.31 | 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 | 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) | ± 198.00 | 165.20 | 188.20 | + 169.66 |
| 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) | ± 198.00 | 165.20 | 165.20 | + 169.66 |

- 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. 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) | 85.4 | 0 | 42.0 |

- 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) | $X = L31 + 640\sin\delta + X_h$ | Eq. 4 |
| | $Y = W20$ | Eq. 5 |
| | $Z = H70 + 640\cos\delta + Z_h$ | Eq. 6 |

where

$$\delta = 0.719(A40) - 9.6$$

and

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

L1 is the PRP x coordinate,

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

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 occupant back angle.

- 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 head contour ellipsoid centroid.

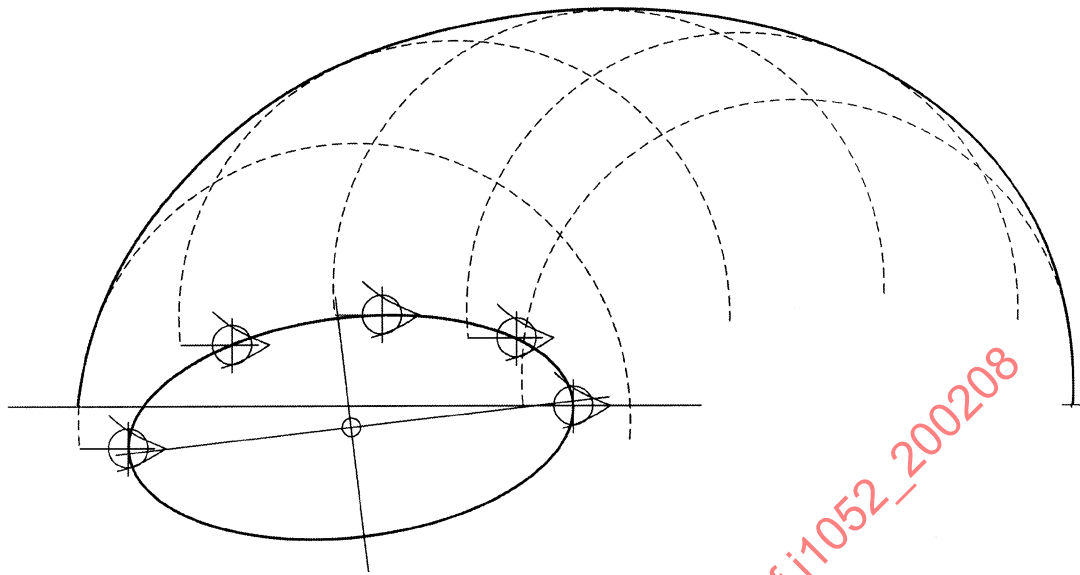


FIGURE 1—DEVELOPMENT IN SIDE VIEW OF HEAD POSITION CONTOUR BY SPOTTING EYE REFERENCE OF MEAN HEAD AROUND EYELLIPSE

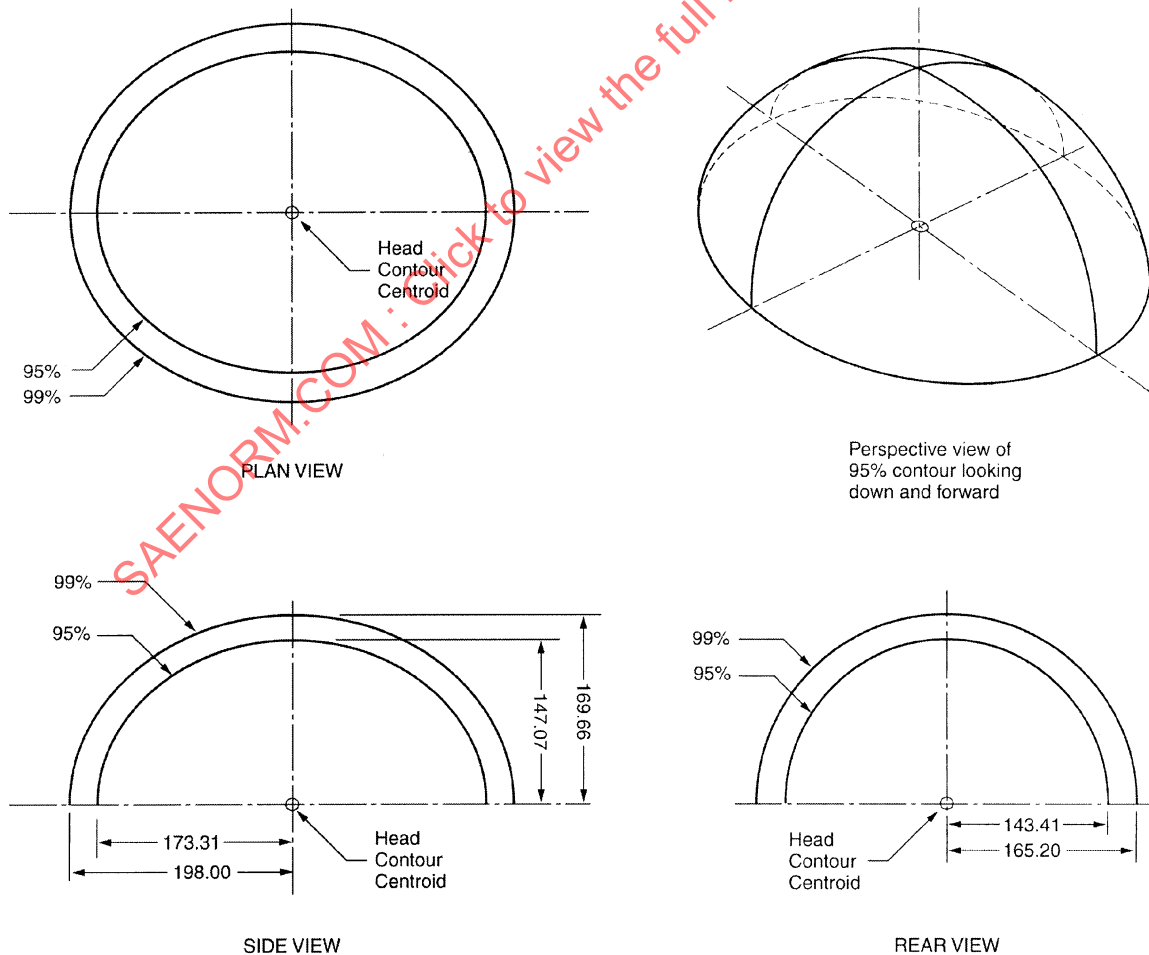


FIGURE 2—HEAD POSITION CONTOURS FOR CLASS A VEHICLES WITH FIXED SEATS

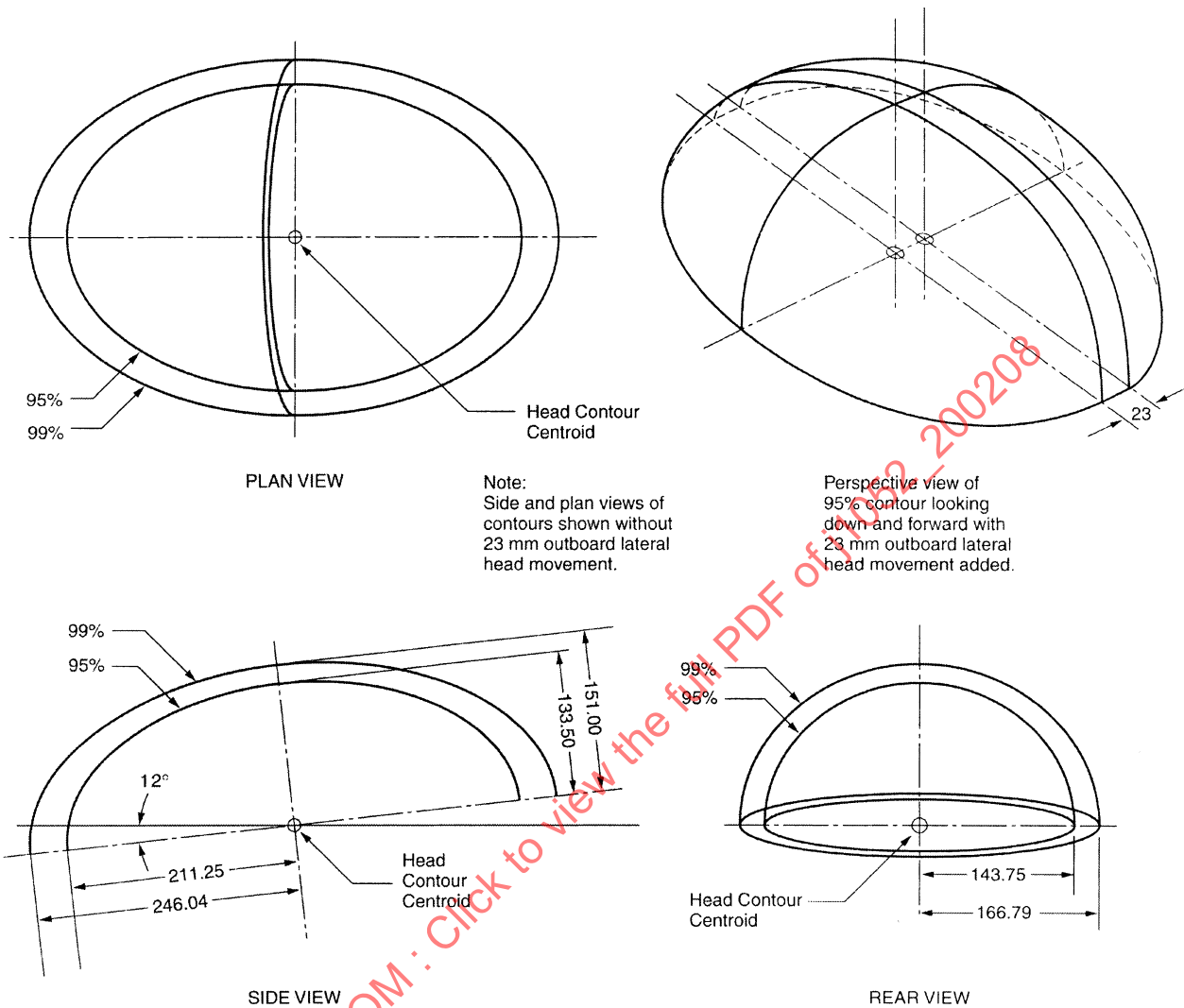


FIGURE 3—DRIVER HEAD POSITION CONTOURS FOR CLASS A VEHICLES WITH SEAT TRACK TRAVEL GREATER THAN 133 mm

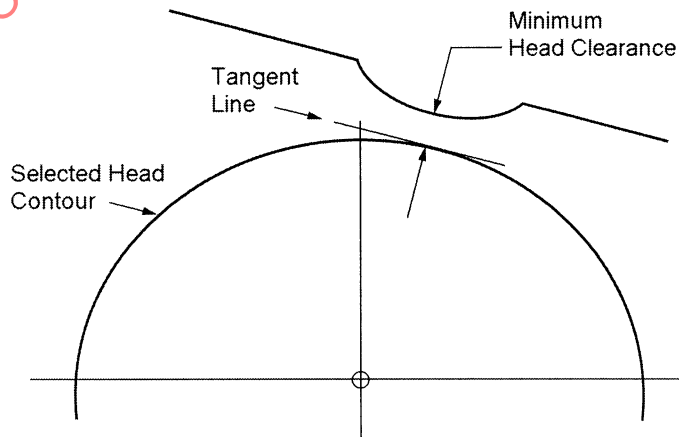


FIGURE 4—MINIMUM HEAD CLEARANCE

8. Notes

- 8.1 Marginal Indicia**—The change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE HUMAN ACCOMMODATIONS AND
DESIGN DEVICES STANDARDS COMMITTEE

SAENORM.COM : Click to view the full PDF of j1052_200208

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 seat back angle for adjustable seats, so a locator function based on Seating Reference Point (SgRP) and design back 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 movement 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 seat back 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 this Revision—The method used to develop the head position contours was similar to the previous 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. The adjustable seat contours were also rotated down at the front in side view from their prior location in the driver workspace.

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.)