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SAE J1516 OCT85

Accommodation Tool Reference Point

SAE Recommended Practice
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RATIONALE:

Previously, manufacturers used a seating reference point (SgRP) to locate driver workspace accommodation tools. Definition of the location of this reference point was left to a manufacturer's discretion. Consequently, the SgRP could vary among competitors' vehicles for similar seating arrangements leading to different indications of accommodation provided by commonly used tools. A more consistent reference point across vehicles based on how drivers used the seat travel was required to eliminate those differences.

Data to define the reference line to be used in Class A vehicles were collected from fourteen different workspace studies. Workspaces included a range of vehicles from sports cars with 145-180mm H-point heights through vans and multipurpose vehicles with 300-405mm H-point heights. Steering wheel diameters were between 330 and 442mm. Driver selected seat position of subjects stratified by stature and sex to represent the general driving population (assuming a 50/50 male/female mix) were collected in these workspaces. Data were converted to H-point locations relative to a manikin ball of foot reference for each package.

The median H-point location, a statistically stable reference point, was determined for each package and plotted as a function of package H-point height (H30). A second degree polynomial was fit to the data. This line which gives a horizontal reference location as a function of H-point height for a driver population composed of 50% males and 50% females is the Accommodation Tool Reference Line for vehicles defined as belonging to Class A.

Data to define the reference line to be used in Class B vehicles were collected from a heavy truck workspace study. The workspace simulated three truck cab configurations with H-point heights of 405, 468 and 530mm and steering wheel diameters of 457, 508 and 560mm. All configurations had a treadle accelerator pedal and suspended clutch. Driver selected seat position of male and female heavy truck drivers were collected in the workspace. Data were converted to H-point locations relative to a manikin heel point reference for each package.

Pedal configuration determined the reference points chosen for both classes of vehicles. Most Class A vehicles have suspended accelerator pedals. With a suspended pedal, the manikin's ball of foot reference is less likely to change due to the amount of seat travel provided in a workspace. The heel point location however changes with the amount of available travel. Most Class B vehicles have treadle pedals. With this configuration pedal, the manikin's heel point has a physical stop to rest against making it less likely to change as a function of pedal depression angle.

A statistical technique was used to generate four populations from the original truck workspace data with the following ratios of males and females; 50/50, 75/25, 90/10 and 95/5. Median H-point locations were determined for the three H-point height configurations by population mix and plotted as a function of H-point height (H30). Straight lines were fit to each of the four mixes of data. (Second degree expressions were not used due to paucity of data). Separate equations define horizontal reference points as a function of H-point height for truck driver populations with 50/50 and 75/25 male/female ratios. The linear expressions for populations with 90/10 and 95/5 male/female ratios were very similar. Therefore, one equation, appropriate for both mixes, was developed to define a horizontal reference point as a function of H-point height. These three lines which give horizontal H-point location as a function of H-point height for populations with male/female ratios of 50/50, 75/25, and 90/10 to 95/5 are the Accommodation Tool Reference Lines for vehicles defined as belonging to Class B.

REFERENCE SECTION:

SAE J941 OCT85, Motor Vehicle Driver's Eye Range

SAE J1052 OCT85, Motor Vehicle Driver and Passenger Head Position

SAE J1100, Motor Vehicle Dimensions

SAE J1517 OCT85, Driver Selected Seat Position

SAE J1521 OCT85, Truck Driver Shin-Knee Position for Clutch and Acceleration

SAE J1522 OCT85, Truck Driver Stomach Position

SAE Paper No. 840508, Driver Selected Seat Position Model

SAE U.S. Truck Driver Anthropometric and Truck Workspace Data Survey

SAE Female U.S. Truck Driver Anthropometric and Truck Workspace Data Survey

APPLICATION:

Reference lines have been developed to which driver workspace accomodation tools can be located in vehicle space. The lines describe horizontal reference point locations as a function of vehicle H-point height (H30). One reference line has been established for use in vehicles with H-point heights (H 30) and steering wheel diameters (W9) less than 405mm and 450mm, respectively. (Class A Vehicles) This point can be used to reference appropriate workspace tools to accommodate a driver population with a male to female ratio of one to one. Separate reference lines have been established for use in vehicles with H-point heights (H30) between 405 and 530mm and steering wheel diameters (W9) between 450 and 560mm with treadle type pedals. (Class B Vehicles) Three lines are available for use in Class B vehicles depending on the percentages of males and females in the population the designer wishes to accommodate. Separate points can be used to reference appropriate workspace tools to accommodate driver populations with male/female ratios of 50/50, 75/25 and 90/10 to 95/5. Different procedures for locating Class A and Class B Accommodation Tool Reference Lines in vehicle space have been established based on unique packaging considerations of the two categories of vehicles.

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TRUCK AND BUS PRACTICE

American National Standard

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ACCOMMODATION TOOL REFERENCE POINT

1. SCOPE: Reference lines have been developed to which driver workspace accomodation tools can be located in vehicle space. The lines describe horizontal reference point locations as a function of vehicle H-point height (H30). One reference line has been established for use in vehicles with H-point heights (H 30) and steering wheel diameters (W9) less than 405mm and 450mm, respectively. (Class A Vehicles) This point can be used to reference appropriate workspace tools to accommodate a driver population with a male to female ratio of one to one. Separate reference lines have been established for use in vehicles with H-point heights (H30) between 405 and 530mm and steering wheel diameters (W9) between 450 and 560mm with treadle type pedals. (Class B Vehicles) See Fig. 1. Three lines are available for use in Class B vehicles depending on the percentages of males and females in the population the designer wishes to accommodate. Separate points can be used to reference appropriate workspace tools to accommodate driver populations with male/female ratios of 50/50, 75/25 and 90/10 to 95/5. Different procedures for locating Class A and Class B Accommodation Tool Reference Lines in vehicle space have been established based on unique packaging considerations of the two categories of vehicles.

2. REFERENCE DOCUMENTS:

SAE J941 OCT85, Motor Vehicle Driver's Eye Range
SAE J1052 OCT85, Motor Vehicle Driver and Passenger Head Position
SAE J1100, Motor Vehicle Dimensions
SAE J1517 OCT85, Driver Selected Seat Position
SAE J1521 OCT85, Truck Driver Shin-Knee Position for Clutch and Acceleration
SAE J1522 OCT85, Truck Driver Stomach Position

3. BACKGROUND: Previously, manufacturers used a seating reference point (SgRP) to locate driver workspace accommodation tools. Definition of the location of this reference point was left to a manufacturer's discretion. Consequently, the SgRP could vary among competitors' vehicles for similar seating arrangements leading to different indications of accommodation provided by commonly used tools. A more consistent reference point across vehicles based on how drivers used the seat travel was required to eliminate those differences.

Data to define the reference line to be used in Class A vehicles were collected from fourteen different workspace studies(1). Workspaces included a range of vehicles from sports cars with 145-180mm H-point heights through vans and multipurpose vehicles with 300-405mm H-point heights. Steering wheel diameters were between 330 and 442mm. Driver selected seat position of subjects stratified by stature and sex to represent the general driving population (assuming a 50/50 male/female mix) were collected in these workspaces. Data were converted to H-point locations relative to a manikin ball of foot reference for each package.

The median H-point location, a statistically stable reference point, was determined for each package and plotted as a function of package H-point height (H30). A second degree polynomial was fit to the data. This line which gives a horizontal reference location as a function of H-point height for a driver population composed of 50% males and 50% females is the Accommodation Tool Reference Line for vehicles defined as belonging to Class A.

Data to define the reference line to be used in Class B vehicles were collected from a heavy truck workspace study(2,3). The workspace simulated three truck cab configurations with H-point heights of 405, 468 and 530mm and steering wheel diameters of 457, 508 and 560mm. All configurations had a treadle accelerator pedal and suspended clutch. Driver selected seat position of male and female heavy truck drivers were collected in the workspace. Data were converted to H-point locations relative to a manikin heel point reference for each package.

Pedal configuration determined the reference points chosen for both classes of vehicles. Most Class A vehicles have suspended accelerator pedals. With a suspended pedal, the manikin's ball of foot reference is less likely to change due to the amount of seat travel provided in a workspace. The heel point location however changes with the amount of available travel. Most Class B vehicles have treadle pedals. With this configuration pedal, the manikin's heel point has a physical stop to rest against making it less likely to change as a function of pedal depression angle. Application of this practice (Class B) supposes a reasonable, typical accelerator pedal angle.

A statistical technique was used to generate four populations from the original truck workspace data with the following ratios of males and females; 50/50, 75/25, 90/10 and 95/5. Median H-point locations were determined for the three H-point height configurations by population mix and plotted as a function of H-point height (H30). Straight lines were fit to each of the four mixes of data. (Second degree expressions were not used due to paucity of data). Separate equations define horizontal reference points as a

3. (Continued)

function of H-point height for truck driver populations with 50/50 and 75/25 male/female ratios. The linear expressions for populations with 90/10 and 95/5 male/female ratios were very similar. Therefore, one equation, appropriate for both mixes, was developed to define a horizontal reference point as a function of H-point height. These three lines which give horizontal H-point location as a function of H-point height for populations with male/female ratios of 50/50, 75/25 and 90/10 to 95/5 are the Accommodation Tool Reference Lines for vehicles defined as belonging to Class B.

4. DEFINITIONS: In addition to the definitions listed below, reference is made to the following definitions given in SAE J1100:

H-point
H-point height (H30)
Steering wheel diameter (W9)
Accelerator heel point (AHP)
Seating reference point (SgRP)

4.1 Class A Vehicles: Vehicles with H-point heights (H30) less than 405mm and steering wheel diameters (W9) less than 450mm. This class of vehicles includes passenger cars, multipurpose passenger vehicles and vans.

4.2 Class B Vehicles: Vehicles with H-point heights (H30) between 405 and 530mm and steering wheel diameters (W9) between 450 and 560mm with treadle accelerator pedals. This class of vehicles includes heavy trucks, some medium duty trucks and some buses.

4.3 The following definitions pertain to locating procedures for vehicles defined as belonging to Class A.

4.3.1 Class A Vehicles' Accommodation Tool Reference Line: Two dimensional side view curve which defines a horizontal reference point as a function of H-point height to which driver workspace accommodation tools can be located in vehicle space. The line is appropriate to reference workspace tools to accommodate a driver population with a male to female ratio of one to one. The reference line can be determined from the following equation:

$$x = 793.7 + 0.903387z - 0.00225518z^2$$

where x is the horizontal reference location in mm aft of the Accommodation Ball of Foot Reference and z is the height of the H-point above the Accommodation Heel Reference (H30) in millimeters.

4.3.2 Pedal Plane: A plane viewed as a line in side view which is tangent to the accelerator pedal and represents the bottom of the two dimensional manikin's shoe.

4.3.3 Pedal Plane Angle: The angle between the pedal-plane and the horizontal floor which is a function of manikin geometry - the 95th Percentile leg links and an 87° foot angle with the H-point on the 95th Percentile Selected Seat Position Curve at a specified H-point height (H30). The pedal plane angle, θ, can be determined from the equation:

$$\theta = 78.96 - 0.15z - 0.0173z^2$$

where z is the height of the H-point above the accelerator heel point (H30) in centimeters. The equation was derived by placing the manikin's H-point on the 95th Percentile Selected Seat Position Curve, moving the manikin along the curve and measuring the angle its shoe (pedal plane) made with the horizontal floor while keeping the heel on the floor and the ball of foot on the pedal.

4.3.4 Ball of Foot: A point on a straight line 203mm from the Accelerator Heel Point tangent to the bottom of the manikin's shoe at the ball of foot.

4.3.5 95th Percentile Selected Seat Position Curve: A two dimensional side view curve which expresses driver selected seat position aft of the ball of foot reference for 95th percentile accommodation as a function of vehicle H-point height. The curve can be determined from the following equation:

$$x_{95} = 913.7 + 0.672316z - 0.0019553z^2$$

where x is the location in millimeters of the 95th percentile H-point aft of the ball of foot and z is the height of the H-point above the accelerator heel point (H30) in millimeters.

4.3.6 Accommodation Heel Reference Point: A point on the pedal plane that intersects the depressed floor covering below the accelerator pedal. This point is defined when the pedal plane is set up at the appropriate angle, θ, as a function of H-point height and placed tangent to a point on the pedal surface with heel on the floor. This point defines the horizontal reference plane in side view for positioning the Class A Accommodation Tool Reference Line.

4.3.7 Accommodation Ball of Foot Reference Point: A point on the pedal plane 203mm from the accommodation heel reference point. The point is defined when the pedal plane is set up at the appropriate angle, θ, as a function of H-point height and placed tangent to a point on the pedal surface with the heel on the depressed floor covering. This point defines the vertical reference plane in side view for positioning the Class A Accommodation Tool Reference Line.

4.4 The following definitions pertain to locating procedures for vehicles defined as belonging to Class B.

4.4.1 Class B Vehicles' Accommodation Tool Reference Line: Two dimensional side view line which defines a horizontal reference point as a function of H-point height to which driver workspace accommodation tools can be located in vehicle space. Three different lines are provided to reference workspace tools to accommodate truck driver populations with male/female ratios of 50/50, 75/25 and 90/10 to 95/5. The reference lines can be determined from the following equations.

For 50/50 male/female ratio:
$x = 798.74 - 0.446z$

For 75/25 male/female ratio:
$x = 822.44 - 0.460z$

For 90/10 to 95/5 male/female ratio:
$x = 855.31 - 0.509z$

where x is the horizontal reference location in mm aft of the Accommodation Heel Reference and z is the height of the H-point above the Accommodation Heel Reference (H30) in millimeters.

4.4.2 Pedal Plane: A plane viewed as a line in side view that is parallel to the treadle pedal surface and represents the bottom of the two dimensional manikin's shoe.

4.4.3 Pedal Plane Angle: The angle between the pedal plane and the horizontal floor that represents the attitude of the two dimensional manikin's shoe (manikin ankle angle can exceed 87°) with heel on the floor in contact with the base of the treadle accelerator pedal.

4.4.4 Accommodation Heel Reference Point: A point on the pedal plane that intersects the depressed floor covering below the accelerator pedal. This point is defined when the pedal plane parallels the surface of the undepressed treadle pedal. This point defines both the horizontal and vertical reference planes in side view for positioning the Class B Accommodation Tool Reference Line.

5. DESCRIPTION:

5.1 Equations: Equations are given that define horizontal reference points in vehicle space as a function of H-point height. One second degree equation defines the Accommodation Tool Reference Line for Class A vehicles. The line is appropraite to reference workspace tools to accommodate a driver population with a one to one male to female ratio. Three first degree equations define the Accommodation Tool Reference Lines for Class B vehicles. One line is appropriate to reference workspace tools to accommodate truck driver populations with 50% males and 50% females; the second line, populations with 75% males and 25% females; the third line, populations with 90% to 95% males and 10% to 5% females. All Accommodation Tool Reference Lines are located in vehicle space relative to vertical and horizontal side view planes. In Class A vehicles, these planes are defined from the Accommodation Ball of Foot and the Accommodation Heel Reference Points. In Class B vehicles, these planes are defined from the Accommodation Heel Reference Point only. Procedures for establishing these planes differ for Class A and Class B vehicles.

5.2 Application Table: A table is given that provides information for defining the Accommodation Heel and Ball of Foot Reference Points for Class A vehicles only to which the Accommodation Tool Reference Line can be located. The table provides the following:

- The horizontal distance between the Accommodation Ball of Foot Reference Point and the Accommodation Heel Reference Point (referred to as L in Application Table).

- The vertical distance between the Accommodation Heel Reference Point and the Accommodation Ball of Foot Reference Point (referred to as H in Application Table).

Use of the table eliminates the necessity of computing the pedal plane angle, θ, since L and H values can be used to define the pedal plane and its angle, θ.

6. LOCATING PROCEDURES: Different procedures are used to locate Accommodation Tool Reference Lines in Class A and Class B vehicles. Procedures are based on a given H-point height and given accelerator pedal hardware.

6.1 Use the following procedure to define Accommodation Heel and Ball of Foot Reference Points to locate the Accommodation Tool Reference Line in Class A workspaces.

6.1.1 Construct a right triangle using the L and H values from the Application Table for the given or measured H-point height, z. The hypotenuse represents the pedal plane. The corner of the triangle point where the hypotenuse meets the horizontal leg represents the Accommodation Heel Reference Point. The corner of the triangle where the hypotenuse meets the vertical leg represents the Accommodation Ball of Foot Reference Point. The angle between the hypotenuse and horizontal leg of the triangle represents the pedal plane angle, θ.

6.1.2 Determine the shape of the accelerator pedal in side view and any associated pivots that allow the pedal angle to adapt to the driver's foot.

6.1.3 Set the hypotenuse of the triangle (pedal plane) tangent to the pedal. Rock the pedal if geometry allows movement. the pedal plane may extend beyond the fall of foot for pedal contact. The horizontal leg of the triangle must be aligned with the depressed heel.

6.1.4 Locate the Accommodation Tool Reference Line to the Accommodation Heel and Ball of Foot Reference Points. Since these points do not lie in the same horizontal and vertical planes, horizontal and vertical side view lines should be constructed through the reference points. The intersection of these lines defines the side view station to which the Accommodation Tool Reference Line is located.

6.1.5 For certain treadle pedal configurations in Class A vehicles, the following situations may occur:

6.1.5.1 If the angle the treadle pedal surface makes with the floor is less than the pedal plane angle, θ, the Accommodation Heel Reference Point will contact the pedal surface, but the Accommodation Ball of Foot Reference Point will not. (See Figure 2). In this case, set the Accommodation Heel Reference Point in contact with the pedal, then pivot the pedal plane around this point until the Accommodation Ball of Foot Vertical Reference Point contacts the pedal surface. Locate the Accommodation Tool Reference Line to these points using the same procedure outlined in 5.1.4.

6.1.5.2 If the angle the treadle pedal surface makes with the floor is greater than the pedal plane angle, θ, the Accommodation Ball of Foot Reference Point will contact the pedal surface, but the Accommodation Heel Reference Point will not. (See Figure 3). In this case, define the Accommodation Ball of Foot Reference at pedal contact, even though the pedal plane may go through the pedal surface, and the Accommodation Heel Reference does not contact the pedal surface. Locate the Accommodation Tool Reference Line to the Accommodation Heel and Ball of Foot Reference using the same procedure outlined in 5.1.4.

6.2 Use the following procedure to define the Accommodation Heel Reference Point to locate the Accommodation Tool Reference Line in Class B vehicles.

6.2.1 For treadle pedal, define the pedal plane and pedal plane angle, from the treadle pedal surface and the angle the pedal makes with the floor, and proceed to 6.2.2. If a suspended pedal is used in a Class B vehicle, the following procedure should be used to define the Accommodation Heel Reference Point.

6.2.1.1 Determine the pedal plane angle, as defined by the equation given in Paragraph 4.3.3. Construct a line (pedal plane) tangent to the undepressed accelerator pedal in the side view which intersects the floor at the determined angle). Rock the pedal as necessary if geometry allows movement to adapt to the driver's foot. Proceed to 6.2.2.

6.2.2 Define the Accommodation Heel Reference Point as the point where the pedal plane intersects the depressed floor coverings. This point also represents the vertical station to which the Accommodation Tool Reference Line is to be located.

6.2.3 Determine population mix for design. Locate the appropriate Accommodation Tool Reference Line to the Accommodation Heel Reference Point.

7. REFERENCES:

(1) N. L. Philippart, R. W. Roe, A. J. Arnold, T. J. Kuechenmeister (1984), "Driver Selected Seat Position Model," SAE Paper No. 840508, Detroit, MI.

(2) M. S. Sanders (1983), "U.S. Truck Driver Anthropometric and Truck Workspace Study," Final Report Submitted to: Society of Automotive Engineers, Inc., Warrendale, PA.

(3) B. E. Shaw and M. S. Sanders (1984), "Female U. S. Truck Driver Anthropometric and Truck Workspace Study," Final Report Submitted to: Society of Automotive Engineers, Inc., Warrendale, PA.

4.2 APPLICATION TABLE

CHAIR HEIGHT (Z) MM	95% H-POINT AFT OF BALL OF FOOT (X) MM	BALL OF FOOT LENGTH TO HEEL POINT (L) MM	BALL OF FOOT HEIGHT ABOVE HEEL POINT (H) MM
100	961.4	50.0	196.7
105	962.7	50.9	196.5
110	964.0	51.8	196.3
115	965.2	52.7	196.0
120	966.2	53.7	195.8
125	967.2	54.7	195.5
130	968.1	55.7	195.2
135	968.8	56.7	194.9
140	969.5	57.8	194.6
145	970.1	58.9	194.3
150	970.6	60.0	193.9
155	970.9	61.1	193.6
160	971.2	62.3	193.2
165	971.4	63.5	192.8
170	971.5	64.7	192.4
175	971.5	66.0	192.0
180	971.4	67.3	191.5
185	971.2	68.6	191.1
190	970.9	69.9	190.6
195	970.5	71.2	190.1
200	970.0	72.6	189.6
205	969.4	74.0	189.0
210	968.7	75.5	188.5
215	967.9	76.9	187.9
220	967.0	78.4	187.3
225	966.0	79.9	186.6
230	964.9	81.4	186.0
235	963.7	83.0	185.3
240	962.4	84.5	184.6
245	961.1	86.1	183.8
250	959.6	87.7	183.1
255	958.0	89.4	182.3
260	956.3	91.0	181.5