SURFACE VEHICLE RECOMMENDED PRACTICE

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Driver Seating Accommodation and Steering Wheel Location Models

RATIONALE

This revision removes an outdated equation that provided an adjustment to account for the difference in length of the AHP to BOFRP between HPM-I and HPM-II, for finding SgRP. BOFRP has been common between HPM-I and HPM-II since SAE J4002 was revised in 2010.

INTRODUCTION

This document describes recommended methods for laying out important dimensions of the driver workstation. These design tools assume that a design seat height value (H30) is available, along with pedal and floor geometry.

The seating reference point (SgRP) is defined in SAE J1100 as “the rearmost normal design driving or riding position of each designated seating position in a vehicle.” For a driver seating position with an adjustable seat, the SgRP is one H-point location within the H-point travel path. This document describes the industry practice for locating SgRP using the SgRP curve referenced to the Ball of Foot Reference Point (BOFRP) and Accelerator Heel Point (AHP). The SgRP curve is the 95% accommodation curve from SAE J1517, which contained the original SAE seating accommodation model. SAE J1517 is no longer applicable to Class-A vehicles, and the seating accommodation model in SAE J1517 has been completely superseded by the seating accommodation model in the current practice. However, to maintain compatibility with decades of practice, the SgRP equation is retained.

Similarly, an updated version of an equation presented in SAE J1516 has been retained to define the Shoe Plane Angle (SPA) as a function of H30. During the development of SAE J1516 and SAE J1517, an equation for an accelerator “pedal plane angle” (denoted by theta) was derived by moving the H-point of the SAE J826 2D template along the SgRP locator curve while holding the ankle angle at 87 degrees, maintaining the ball of foot at a constant X-location and maintaining the template heel at a constant Z-location. To maintain compatibility with previous practice, the SPA is defined using an updated version of the equation that more accurately replicates the kinematics of the template. Note that SAE J1516 and SAE J1517 are no longer applicable to Class-A vehicles.

After computing SPA, the profile of the shoe of the SAE J826 template is placed at the appropriate angle against the profile of the undepressed accelerator pedal with the heel resting on the floor. When the shoe profile is appropriately positioned, BOFRP and AHP are established.

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Prediction of the distribution of driver-selected seat position on the seat adjuster path is important to ensure that a large percentage of drivers can comfortably reach and operate vehicle hand and foot controls. This document provides a method for determining driver seat track length and for positioning the seat track in the vehicle package to achieve the desired level of accommodation. This seating accommodation model (SAM) is based on statistical models developed at the University of Michigan Transportation Research Institute (UMTRI) based on data from hundreds of drivers in dozens of vehicles. This new method completely supersedes the model presented in SAE J1517. The recommended position of the driver seat track in the vehicle is based on H30, L6, and the presence or absence of a clutch pedal. The seat track length is independent of vehicle seat or package variables. Background details of the new method are given in Appendix A. Historical information about the prior procedure is given in Appendix B.

This practice also introduces a recommended procedure for establishing a design steering wheel position. The steering wheel preference model is based on driver preference data gathered and analyzed at UMTRI and confirmed by reference to benchmarking data.

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1. SCOPE

This practice presents methods for establishing the driver workspace. Methods are presented for:

- Establishing accelerator reference points, including the equation for calculating the shoe plane angle
- Locating the SgRP as a function of seat height (H30)
- Establishing seat track dimensions using the seating accommodation model
- Establishing a steering wheel position

Application of this document is limited to Class-A Vehicles (Passenger Cars, Multipurpose Passenger Vehicles, and Light Trucks) as defined in SAE J1100.

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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J826 Devices for Use in Defining and Measuring Vehicle Seating Accommodation

SAE J826/2 2-D CAD Template for SAE J826 H-point Machine

SAE J1100 Motor Vehicle Dimensions

SAE J1516 Accommodation Tool Reference Point for Class B Vehicles

SAE J1517 Driver Selected Seat Position for Class B Vehicles - Seat Track Length and SgRP

SAE J4002 H-Point Machine (HPM-II) Specifications and Procedure for H-Point Determination - Auditing Vehicle Seats

Philippart, N., Roe, R., Arnold, A., and Kuechenmeister, T., “Driver Selected Seat Position Model,” SAE Technical Paper 840508, 1984, https://doi.org/10.4271/840508.

Reed, M., “Driver Preference for Fore-Aft Steering Wheel Location,” *SAE Int. J. Passeng. Cars - Mech. Syst.* 6(2):629-635, 2013, https://doi.org/10.4271/2013-01-0453.

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2.2 Related Publications

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

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 +1 724-776-4970 (outside USA), www.sae.org.

Flannagan, C., Schneider, L., and Manary, M., "Development of a New Seating Accommodation Model," SAE Technical Paper 960479, 1996, https://doi.org/10.4271/960479.

Flannagan, C., Manary, M., Schneider, L., and Reed, M., "An Improved Seating Accommodation Model with Application to Different User Populations," SAE Technical Paper 980651, 1998, https://doi.org/10.4271/980651.

2.2.2 Other Publications

Abraham, S., Johnson, C.L., and Najjar, M.F. (1979). Weight and height of adults 18-74 years of age. *Vital and Health Statistics*, Series 11, No. 211.

U.S. National Health and Nutrition Examination Survey (NHANES III), Height for males and females 20 years and older, 1988-1994.

3. DEFINITIONS

3.1 SAE J1100 Definitions

3.1.1 Accelerator Heel Point (AHP)

3.1.2 Ball of Foot (BOF)

3.1.3 Ball of Foot Reference Point (BOFRP)

3.1.4 Floor Reference Point (FRP)

3.1.5 Heel of Shoe (HOS)

3.1.6 H-point

3.1.7 H-Point Travel Path

3.1.8 Pedal Contact Point (PCP)

3.1.9 Seating Reference Point (SgRP)

3.1.10 A27 - Cushion Angle

3.1.11 A47 - Shoe Plane Angle (SPA)

3.1.12 H30 - Seat Height

3.1.13 L6 - BOFRP to Steering Wheel Center

3.1.14 PW86 - AHP to BOFRP Lateral Offset

3.1.15 H17 - Accelerator Heel Point (AHP) to Steering Wheel Center

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4. DRIVER LAYOUT REFERENCES

The SAE Recommended Practice for establishing the driver layout is based on the three key reference points: Seating Reference Point (SgRP), Ball of Foot Reference Point (BOFRP), and the Accelerator Heel Point (AHP). The position of these points relative to one another determines critical measurements defined in SAE J1100 within the Driver's space, specifically:

- Seat Height (H30) - vertical distance from SgRP to AHP
- Shoe plane - plane normal to the Y-axis that passes through the BOFRP and the AHP
- L99 - longitudinal distance from the driver's BOFRP and SgRP

The manufacturer positions any one of these reference points within the Driver's space and uses a defined relationship between the reference points combined with an 87-degree ankle angle requirement to complete the layout of the HPD 2D template. This relationship is set by the SAE SgRPx Curve and defined below:

4.1 $SgRP_x$ Curve

The $SgRP_x$ curve expresses the driver seat H-point position aft of the ball of foot reference (L99) as a function of Seat Height (H30). See Equation 1.

$$SgRP_X = 913.7 + 0.672316(H30) - 0.0019553(H30)^2 = \text{Distance (in mm) rearward of BOFRP} \qquad \text{(Eq. 1)}$$

The result of applying this equation to the HPD 2D Template is a bounding box that constraints the position of the remaining key reference points. See Figure 1.

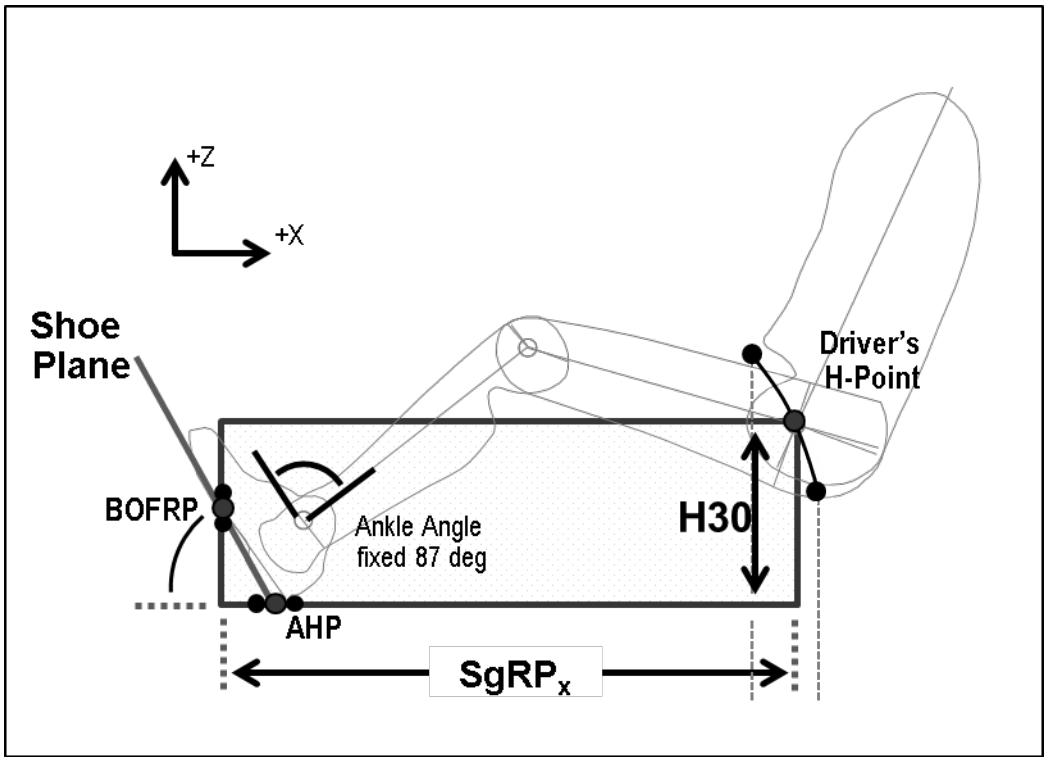

Figure 1 - Driver's SgRP curve and reference point constraints

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4.2 Driver's SPA Equation

In some design practices, it is beneficial to only work with the pedal and shoe geometry. The Driver's SPA equation provides a simple method for directly estimating the angle of the Driver's shoe plane as a function of seat height (H30) without the need to determine the complete HPD layout using the $SgRP_x$ equation (see Equation 2).

$$SPA_{driver} = 2.522(10^{-7})(H30^3) - 3.961(10^{-4})(H30^2) + 4.644(10\text{-}^{2})(H30) + 74.374 \text{ degrees from horizontal} \quad \text{(Eq. 2)}$$

The resulting output of the equation is within 0.007 degree of the solution determined by the kinematics of the SAE J826 2D template when applying the $SgRP_x$ methodology for defined Class-A vehicle packages.

4.2.1 Driver Shoe Plane Location Derived from Accelerator Pedal Geometry

If the accelerator pedal has already been designed, driver shoe plane may be located using the existing accelerator pedal geometry per the following:

- Non-pivoting, suspended pedal: Position the driver shoe so that the bottom of the shoe contacts the lateral centerline of the pedal surface with the heel on the depressed floor covering.

- Flat, suspended pedal with a pivoting pedal pad: Position the driver shoe so that the bottom of the shoe contacts the lateral centerline of the pedal pad surface with the heel on the depressed floor covering. The pedal pad should be pivoting within its range of motion as needed to allow the shoe plane to be moved as far forward as possible without depressing the pedal.

- Treadle (pivot at floor) pedal: Position the driver shoe so that the bottom of the shoe contacts the lateral centerline of the pedal pad surface with the heel on the depressed floor covering. Three types of contact can occur with a treadle pedal: at the heel of the shoe with the pedal at a flatter angle than the bottom of the shoe, tangent to the bottom of the shoe, or contact at the upper portion of the shoe with the heel of the shoe rearward of the bottom of the pedal.

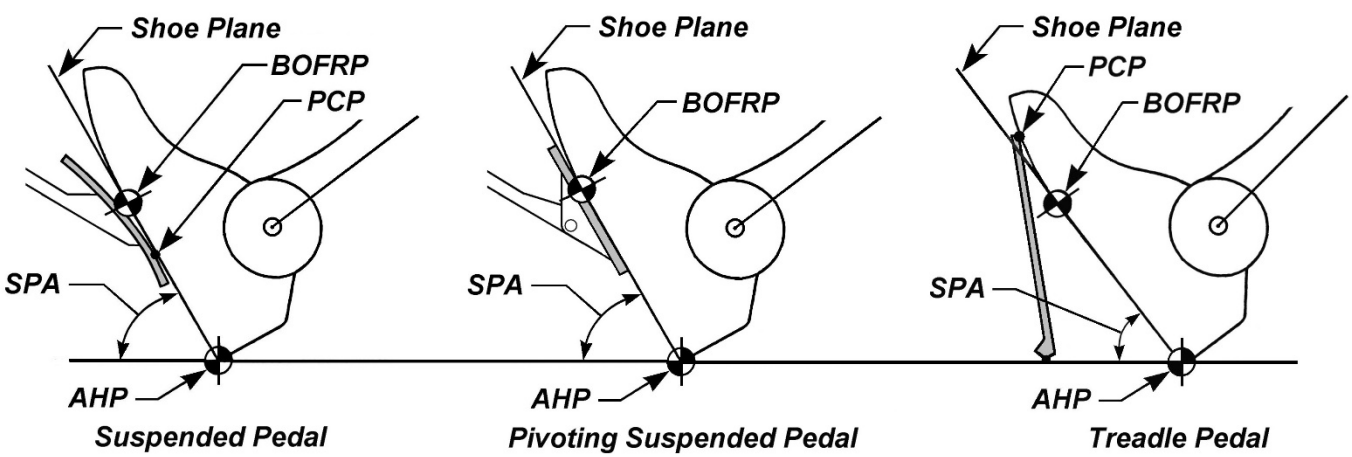

Figure 2 - Examples of the HPD-II driver's shoe plane used with different accelerator pedal geometry

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