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SURFACE VEHICLE RECOMMENDED PRACTICE

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Superseding J4003 AUG2005

H-Point Machine (HPM-II)—Procedure for H-Point Determination—Benchmarking Vehicle Seats

RATIONALE

The 2008 revision of this Practice relates to revisions in SAE J4004 (2008) that change the way foot and pedal reference points are established. The PRP is replaced with the BOFRP which is now a point on the shoe when the shoe is in contact with the accelerator pedal. The AHP to BOF distance was changed from 200 mm to 203 mm for better agreement with the previous SAE J826 and SAE J1100:2008.

NOTE: Some key differences from the previous version of SAE J4003 are:

– Use of the SAE 95th SgRP equation with an 87 degree driver ankle angle is recommended.
– When H30-1 is known, it potentially reduces the number of iterative calculations that may be required to complete the Benchmarking procedure.
– Even though manufacturers are encouraged to report the driver seat height (H30), a procedure for determining H30 is now provided. When applied to seats with vertical adjustment (H21) of 40 mm or greater, H30 (and the SgRP) is established at 20 mm directly above the full down H-point travel path in order to make consistent comparisons of seating packages across vehicles. For vertical adjustment less than 40 mm, the SgRP should be established on the SgRP curve at mid-vertical H-point travel height.

This document should yield similar results to those from the SAE J826 (2008) design tool, provided that the flat shoe defined in SAE J826 is used.

FOREWORD

The tools and procedures for H-point determination given in this standard are based on the SAE H-Point Machine (HPM-II), which is described in SAE J4002. Compared to the H-point machine described in SAE J826, the changes made to HPM-II have resulted in improved repeatability, greater ease of use, and additional features and measurement capabilities. All efforts were made to achieve these improvements while minimizing their impact on the location of reference points and measurements.

H-point devices are used for the design, audit, and benchmarking of seats. SAE J4002 describes the use of the HPM-II in auditing vehicle seats and other interior compartment dimensions. SAE J4003 describes the use of the HPM-II in benchmarking. Audits are conducted by regulatory agencies and OEMs to assess how closely the vehicle is manufactured to its design intent. Although serving different purposes, auditing and benchmarking procedures are very similar. The most significant difference between them is that audits use actual design intent values to set up the vehicle and position the seat, whereas benchmarking is used to discover the design intent values for competitor vehicles.

SAE J4004 describes the use of the H-Point Design tool (HPD) for establishing key vehicle interior reference points used in designing vehicle interior compartments. The HPD is a simplified CAD representation of the HPM. It replaces the 2-D H-point template. The HPD is often used in CAD in conjunction with the physical installation of the HPM during the auditing and benchmarking process.

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INTRODUCTION

H-point devices are used (1) during vehicle design and development to establish interior reference points and dimensions for occupant packaging, (2) to validate (audit) the location of these key reference points and dimensions on physical properties, and (3) to measure competitive vehicles for benchmarking. The procedures employed for each usage vary somewhat. This document describes the use of the HPM-II for benchmarking.

H-point devices are also used for designing, auditing, and benchmarking seats independent of the vehicle. However, in these instances, the reference points and dimensions are defined relative to the seat structure and/or surface, rather than the vehicle's interior. The procedures for positioning the H-point devices in seats do not require the use of the shoe tool or leg segments.

For convenience and simplicity, many terms associated with H-point devices use human body parts in their name. However, they should not be construed as measures that indicate occupant accommodation, human capabilities, or comfort. H-point devices do not represent the size or posture of any category of occupant.

1. SCOPE

Benchmarking is used to discover the design intent measurements for seating compartments in vehicles when these measurements are either unknown or are specified using differing measurement procedures.

This document provides the specifications and procedures to establish consistent measurements for benchmarking vehicle seating positions using the H-Point Machine (HPM-II[1]) described in SAE J4002 and the H-Point Design tool (HPD) described in SAE J4004. The HPM-II is a physical tool used to establish key reference points and measurements in a vehicle (Figure 1). The HPD is a CAD tool that aids in the benchmarking process (see Appendix A and SAE J4004).

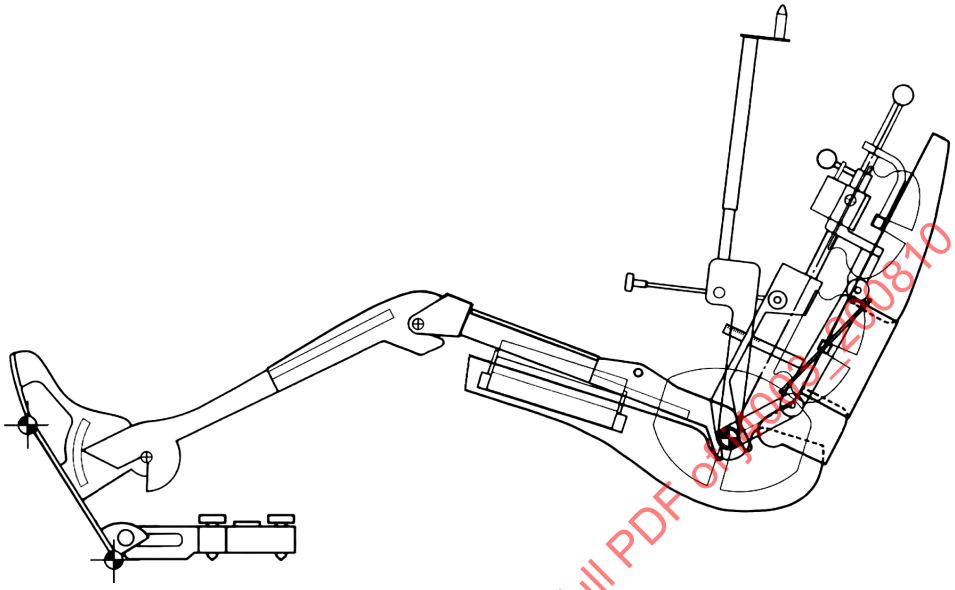


FIGURE 1 - SIDE VIEW OF THE HPM

2. REFERENCES

This document contains provisions which reference the following documents. The latest edition of the reference applies.

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version 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 J182 Motor Vehicle Fiducial Marks and Three-Dimensional Reference System

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

SAE J1100 Motor Vehicle Dimensions

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

[1] In this document the terms H-point machine, HPM, and HPM-II are used interchangeably to refer to the new H-point machine that is described in SAE J4002. The older H-point machine described in SAE J826 uses the term H-point machine.

3. DEFINITIONS

See SAE J1100 for definitions of H-point, SgRP (seating reference point), LSP (lumbar support prominence), AHP (accelerator heel point), BOFRP (ball of foot reference point), SPA (shoe plane angle) and FRP (floor reference point).

See SAE J4002 for a complete description and specifications for the HPM, as well as dimensional verification procedures for the HPM elements.

4. HPM BENCHMARKING—OVERVIEW AND PREPARATIONS

These procedures can be used to measure and assess vehicle interiors of physical properties whenever design intent information is not available. Most often, benchmarking is used to reliably quantify competitive vehicles.

4.1 Use of the Physical Tool (HPM) and the CAD Tool (HPD)

Benchmarking usually involves a mix of CAD and physical assessment; different users rely more on one type of assessment or the other. The extent that CAD is used will depend on the individual company, organization, and/or particular goals of the benchmarking activity.

The HPM is a physical tool used in physical properties. By using the HPM in conjunction with CMM equipment and the HPD, key reference points in the vehicle's interior can be established (e.g. SgRP, AHP, BOFRP, FRP). With this information, other design devices can then be used in the CAD environment (e.g. eyellipses, head contours, reach curves). These measurements are described in more detail in Appendix C.

4.1.1 Use of HPM

At minimum, the HPM shall be installed to determine the following seat measurements:

- H-point location
- Torso angle
- Cushion angle
- Lumbar support prominence - The back pan of the HPM is articulated to fit various seat back contours. LSP is measured with a scale attached to the HPM back pan linkage (Figure 2).

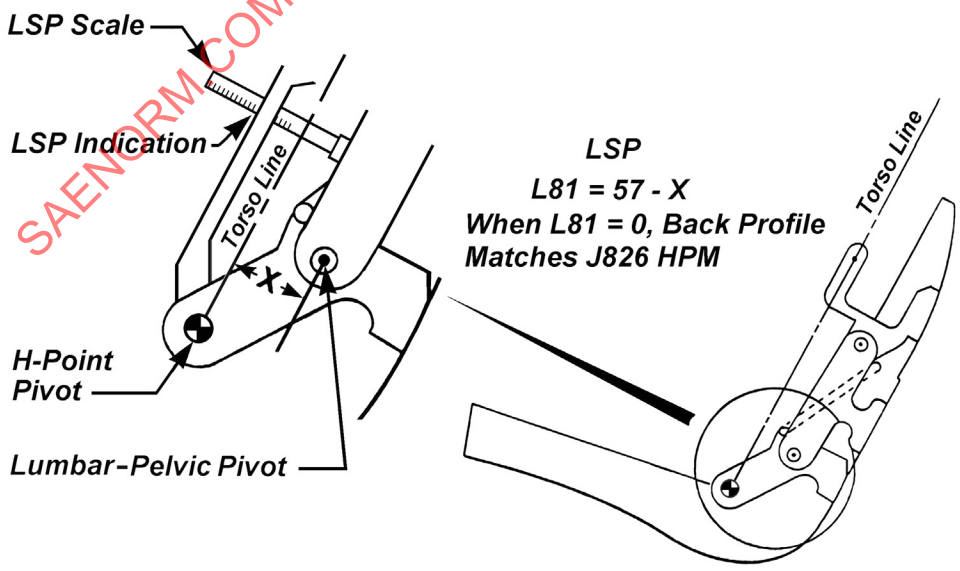


FIGURE 2 - LUMBAR SUPPORT PROMINENCE (LSP)

These four seat measurements can be determined without installing the HPM shoe, lower leg and thigh assemblies.

Additional measurements that are taken using the HPM or the HPD in CAD are as follows:

- SgRP location
- Shoe Plane and Floor Plane Angles
- BOFRP, FRP, and AHP coordinates
- Hip, Knee, Thigh, and Ankle Angles
- Head room
- Leg room
- Knee clearance
- Leg clearance

Often users will find it helpful to physically install the HPM shoe tool in order to directly obtain pedal and floor measurements. Setting the seat (with the HPM or HPD in it) to the driver SgRP position, and installation of the leg assemblies, will often be done in CAD.

When using the H-Point Machine (HPM), interactions can occur between adjacent seating positions (i.e. having two HPMs installed in adjacent seating positions can change the results obtained for both seating positions). Therefore, only one machine should be installed in a particular row of seats during each test.

4.1.2 Use of HPD in CAD

Except for the four seat measurements cited in 4.1.1, it is possible to take all other measurements in CAD using the HPD. Following is a list of data that will need to be digitized in order to benchmark in CAD with the HPD:

- geometry of the accelerator pedal pad at pedal centerline
- floor surface (depressed floor covering) around the approximate location of the heel of shoe
- tunnel surface near accelerator pedal, if it could interfere with the HPM shoe
- seat travel window, for positions with adjustable seats
- an H-point location, obtained by installing the HPM
- divot points on the cushion and back pans to aid in posturing the HPD
- floor and seatback profile of preceding seat, for 2nd and 3rd row passenger positions
- headliner surface in the area where head room will be measured

4.2 Prepare the Property for HPM Installation

When the HPM is used for benchmarking of vehicles, bucks (vehicle mock-ups), seats or seat assemblies, the following considerations apply.

4.2.1 Temperature and Relative Humidity

Seat coverings and foam may respond differently to the weight of the HPM depending on their temperature and humidity. Sufficient time (at least 4 h) shall be allowed to ensure that the seat material reaches room temperature. Room temperature shall be 19 to 26 °C (66 to 79 °F). Room relative humidity should be within a range of 50% ± 5%. If this relative humidity is not met, record both relative humidity and room temperature.

4.2.2 Leveling

The property (e.g., vehicle) shall be leveled prior to any HPM installation or measurement. Once the property is leveled, care should be taken to not lean on it, rock it, or in some other way knock it off level. Usually the top or bottom of the vehicle rocker structure is level with grid.

4.2.3 Grid Reference

Unlike auditing, benchmarking will not have fiducial points available to establish vehicle grid references. Arbitrary grid references will need to be determined. Measurements can then be determined relative to this arbitrary three-dimensional reference system. These references should be established from hard points on the test property such as weld flanges on the rocker panel or seat attachment points.

4.2.4 Accelerator Pedal

The accelerator pedal shall be held in an undepressed position by some means. For example, use blocks, or clamp the accelerator cable to prevent the pedal from moving. If the pedal rotates about a pivot, independent of throttle movement, fix or block the pedal arm movement but allow pivoting of the pad. If pedals adjust fore/aft, the pedals shall be set at the most-forward adjustment position in the vehicle.

4.2.5 Seat Break-in

If the seat to be checked has never been sat upon, a 70 to 80 kg person or device shall sit on the seat to flex the cushion and back prior to installing the HPM.

4.2.6 Seat Recovery

Prior to the installation of the HPM, seats should remain unloaded for 30 minutes. This is to allow the seat and seat materials (e.g., foam) to recover from compression.

4.2.7 Muslin Cloth

Muslin cloth should be placed over the seat prior to installing the HPM. The cloth should be large enough to prevent the HPM from contacting the seat. The muslin cloth may be a single piece fitting across both seat cushion and seat back, or two pieces, one for the cushion and one for the seat back. Use of the muslin cloth ensures a constant friction surface across seat fabrics.

4.2.8 Seat Attitude and Location

The attitude and location of the benchmark seat and the seat immediately in front (cushion angle, lumbar support, and torso angle) should be properly adjusted prior to beginning the installation of the HPM. (See Table 1 for specifications.)

- A seat providing both vertical and fore/aft adjustment is normally positioned initially in the lowest most-rearward location because it is easiest to install the HPM with the seat in this position.
- Adjustable seat backs shall be oriented at the angle specified in Table 1. See 5.4.4.
- The seat shall be positioned so its H-point is at SgRP as follows:
  - For driver seats, after the HPM cushion and back pans are installed and loaded, and an H-point (usually the full down, full rear H-point) has been determined, the seat shall be repositioned to the SgRP location specified in 5.7.2 and 5.7.3.
  - For rear passenger seats, the seat immediately in front of the test seat shall be set at its benchmarked attitude and location (SgRP, torso and cushion angle). If the rear passenger seat has fore/aft seat travel adjustment, set the seat to the rearmost and lowest position that can be used by a passenger.
- If a seat back or seat track adjustment has discrete detents, or has insufficient adjustment to attain the specified torso angle or SgRP, it shall be adjusted to the detent setting closest to the specified value.

4.2.8.1 Specifications for Seat Settings and Locations Before and After HPM Installation

Table 1 describes required seat settings and locations before and after HPM installation. These adjustments provide consistency for comparing measurements between properties.

TABLE 1 - SEAT ATTITUDE AND LOCATION

Feature	Setting/Location	When
HPM Torso Angle	Driver - 22 degrees (for adjustable recliners). Initially set so unloaded back pan is approximately 20 degrees and check periodically while loading the manikin to achieve a final reading of 22 degrees. Rear Passenger – 25 degrees (if adjustable). Initially set so unloaded back pan is approximately 23 degrees and check periodically while loading the manikin to achieve a final reading of 25 degrees. If a rear passenger seat cannot be adjusted to 25 degrees, set it at the value closest to 25 degrees.	Achieved by the completion of HPM loading
Cushion Angle	Set to the middle of its adjustment range	Prior to measuring the seat travel path and installing the HPM
Lumbar Support Prominence	Full-off, minimum setting (fully deflated, least intrusive, etc.)	Prior to installing the HPM
Initial Seat Location	Driver - At one of the four 'corners' of the seat travel path digitized in 5.2. The lowest most-rearward position is usually easiest. Rear Passenger – At lowest most-rearward riding position, if adjustable	Prior to installing the HPM
Final Seat Location	Driver - At the intersection of the SgRP curve and the design H-point travel path. If the seat has vertical adjustment of 40 mm or more, on the SgRP curve at 20 mm above the full down H-point travel path. If the adjustment is less than 40 mm, at mid-height of the H-point travel window. (If seat track is detented, use the nearest detent.) Rear Passenger – At lowest most-rearward riding position, if adjustable	After the initial installation and loading of the HPM, but before attaching the legs
Preceding row seat attitude and location – Rear Passenger installation only	Set preceding row seat to its benchmarked torso angle, cushion angle and SgRP location.	Prior to installing the HPM

5. BENCHMARKING THE DRIVER SEAT

The procedures described in this section focus on the use of the HPM in the physical environment. Some steps may vary depending on how much CAD will be used. See Appendix B for a summary of benchmarking procedures for the driver seat position.

5.1 Prepare the Physical Property

See 4.2 and Table 1.

5.2 Digitize Interior Components

Information regarding the seat's travel path shall be determined before the HPM is installed. Other interior components are also most easily digitized prior to the installation of the HPM.

5.2.1 Seat Travel Path

In order to calculate the SgRP, the seat's travel path shall be digitized, and later translated into the H-point travel path. First, adjust the seat cushion to the middle of the cushion angle adjustment range. Next, place one or more registration marks on the side of the seat. The registration mark(s) can be located anywhere along the side of the seat that can be easily accessed by the CMM equipment. Finally, digitize the location of the registration mark(s) with the seat in each of four positions: lowest most-rearward, highest most-rearward, highest most-forward, lowest most-forward. By connecting these four points, the seat's travel path can be readily seen (Figure 3).

NOTE 1: For seats without vertical adjustment, only two points need to be taken, most forward and most rearward, provided the seat track follows a linear path.

NOTE 2: If the seat track travel path is curved, additional points (between foremost and rearmost) need to be taken. A second registration mark must be added to the side of the seat cushion in order to measure how cushion angle changes with seat track position. The two registration marks should be widely separated (one high and one low) on the seat back to permit an accurate measurement of the angular change that would result from the curved seat track.

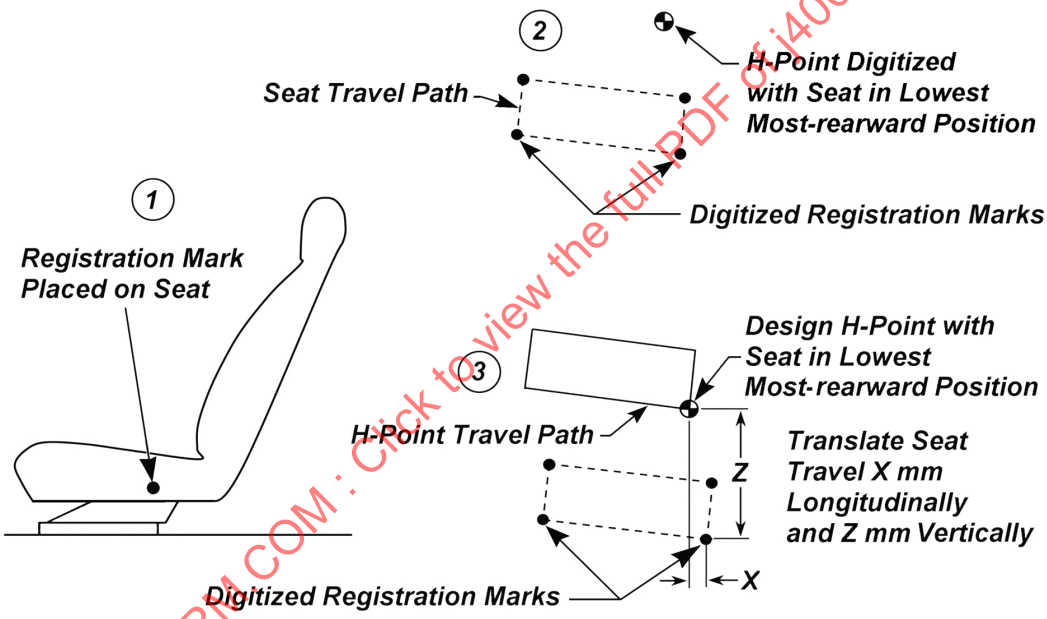


FIGURE 3 - SEAT TRAVEL PATH

5.2.2 Other Interior Features

Profiles of the seat cushion and seat back, the floor surface beneath the accelerator pedal, and the side view profiles and rear view outlines of the accelerator, brake, and clutch pedals should be digitized prior to installing the HPM. Some additional features that are useful to digitize include other floor surfaces, the steering wheel rim, interior surface of the door, headliner, roof and floor consoles, and knee bolsters.

5.3 Establish BOFRP, AHP, PCP and Shoe Plane

The shoe tool is used to establish the Ball of Foot Reference point (BOFRP), Accelerator Heel Point (AHP), Pedal Contact Point (PCP) and shoe plane (Figure 4). It is easiest to install the shoe tool and fixture before the rest of the HPM. Before installing, check that the centerline of the accelerator pedal was previously marked. If pedals adjust fore/aft, check that the pedals are set at the most-forward adjustment position in the vehicle.

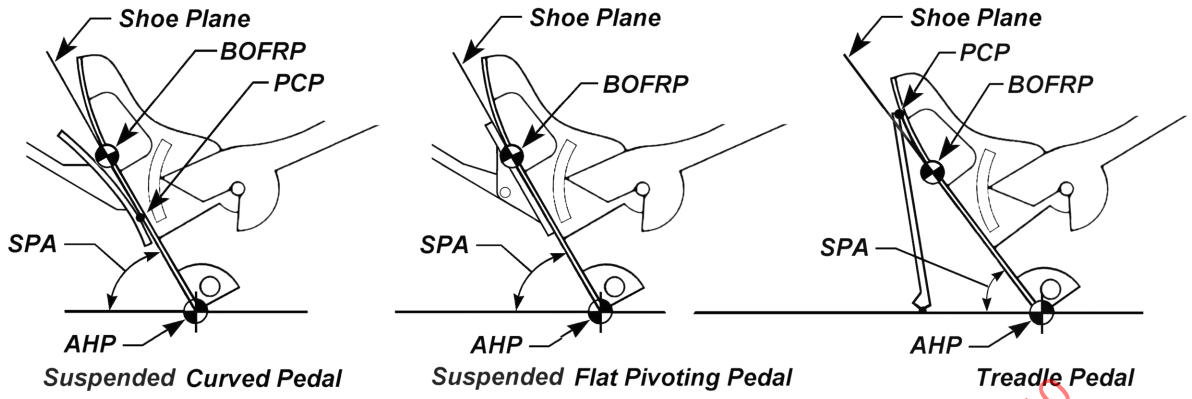


FIGURE 4 - BALL OF FOOT REFERENCE AND PEDAL CONTACT POINTS

NOTE: The BOFRP, PCP, and AHP can be determined in CAD using the HPD shoe if the accelerator pedal pad, floor, and tunnel surfaces are digitized. See A.2.

5.3.1 Install the Shoe Fixture

The shoe fixture is used to hold the shoe level and in place on the pedal. Since the accelerator pedal centerline may be angled in plan view, the lateral location of the fixture may have to be adjusted once the BOFRP is determined. Position the forward edge of the shoe fixture approximately 100 to 150 mm rearward of the accelerator pedal such that the fork that will hold the shoe tool is in line with the accelerator centerline. The fixture should be square to the grid reference. Adjust the screws on the shoe fixture until it is level (Figure 5).

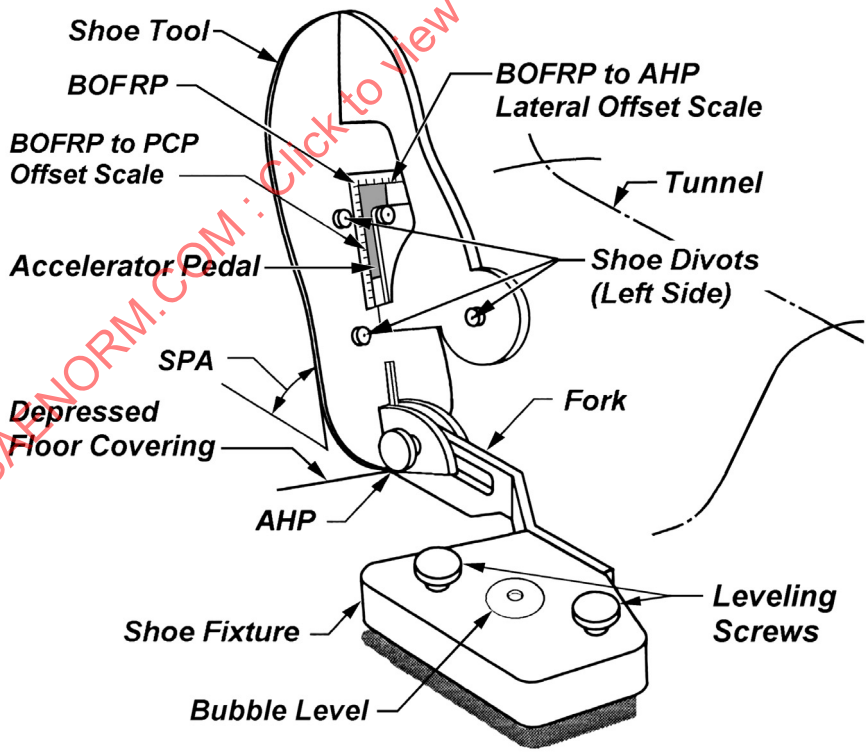


FIGURE 5 - SHOE TOOL INSTALLATION FOR DRIVER SEAT POSITION

5.3.2 Install the Shoe Tool

Use Equation 1 to determine the initial Shoe Plane Angle (SPA) based on either the published or estimated Manufacturer's Seat Height (H30).

$$SPA = 2.522(10^{-7})(H30^{3}) - 3.961(10^{-4})(H30^{2}) + 4.644(10^{-2})(H30) + 73.374 \text{ degrees from horizontal} \quad \text{(Eq. 1)}$$

Place the shoe tool in the fixture. Then place the inclinometer on the rearward-facing surface of the shoe 'sole' to set the SPA value. Tighten the shoe locking screw to hold the shoe in place. Slide the shoe forward. The shoe shall be positioned so that the heel is on the depressed floor covering and the bottom of the shoe contacts the pedal face at centerline. For flat, free-pivoting or spring-loaded pivoting pedals, the bottom of the shoe will be flush with the face of the pedal. The BOFRP on the shoe tool is located at the zero marking (corner) of the 2 scales on the top surface of the shoe.

5.3.2.1 Interference with the Shoe

Occasionally, some aspect of the vehicle's structure – such as the tunnel, rocker, center console, etc. – prevents the positioning of the shoe tool and fixture. If the interference prevents the shoe tool from being properly positioned at the accelerator centerline, the shoe and fixture shall be shifted laterally until the interference is cleared. The amount of lateral offset should be read from the ball of foot lateral offset scale (Figure 5) and recorded (PW86). The BOFRP is defined at the centerline of the accelerator pedal, even though the BOF may not be at the centerline (Figure 6). The AHP is defined at the location of the heel of shoe after the shoe tool is moved to clear the interference.

In some cases the shoe tool may fit properly, but the shoe fixture cannot. The tool and fixture will still need to be moved to clear the interference, but the AHP location is defined as if the shoe were aligned at the pedal centerline. In other words, the AHP coordinates are defined as if the shoe had remained positioned on the pedal centerline with no interference. This translation is most easily done in CAD.

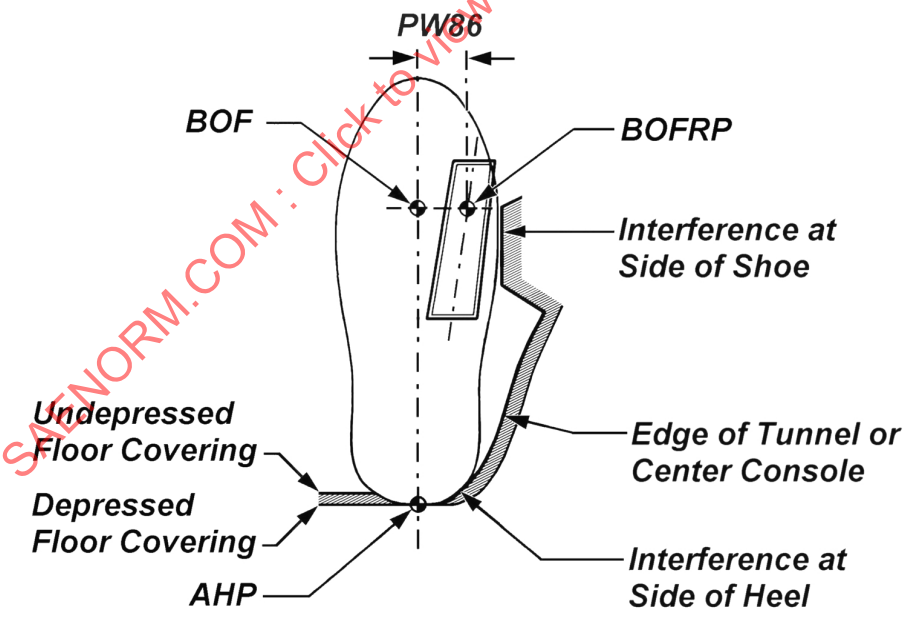


FIGURE 6 - LATERAL OFFSET OF SHOE ON ACCELERATOR PEDAL (PW86)

5.3.3 Record Pedal Reference Points

The reference points and dimensions listed in Table 2 can now be determined.

TABLE 2 - HPM PEDAL REFERENCE POINTS

Dimension	Location or Description	Location w/ Interference	Notes
BOFRP (L1, W1, H1)	The intersection of the BOF and the accelerator pedal centerline when the centerline is projected to the shoe plane.	The intersection of the accelerator centerline projected to the shoe plane and the BOF lateral scale.	Digitize directly or digitize shoe divot points and calculate.
AHP (L8, W8, H8)	The intersection of the heel of shoe and the depressed floor covering	L8, W8, and H8 are defined at the intersection of the heel of shoe and the depressed floor covering *after* the shoe has been laterally adjusted to clear the interference.	Digitize divot points on shoe, and calculate location.
Shoe Plane Angle (A47)	The side view angle of the bottom of the shoe (BOF to heel), measured from horizontal	Same	Calculate using Eq. 1. Verify by reading inclinometer placed on the shoe land, or digitize shoe divot points and calculate.
AHP to BOFRP Lateral Offset (PW86)	(No offset)	The lateral distance from BOFRP to AHP	Read from the AHP to BOFRP lateral offset scale.

The BOF point when the shoe is in contact with the pedal surface is the BOFRP, and the point contacted by the heel of shoe on the depressed floor covering is the AHP. Although the BOFRP can be directly digitized, the AHP cannot. AHP can be calculated using the shoe divot points (S1, S2 and S3), and Equations 2 and 3 (see Figure 7). Equations for BOFRP coordinates are also provided.

$$AHP_X = S3_X + 175 * \cos(SPA) - 5 * \sin(SPA) \quad \text{(Eq. 2)}$$

$$AHP_Z = S3_Z - 175 * \sin(SPA) - 5 * \cos(SPA) \quad \text{(Eq. 3)}$$

$$BOFRP_X = S3_X - 25 * \cos(SPA) - 5 * \sin(SPA) \quad \text{(Eq. 4)}$$

$$BOFRP_Z = S3_Z + 25 * \sin(SPA) - 5 * \cos(SPA) \quad \text{(Eq. 5)}$$

$BOFRP_Y$ is defined at the accelerator pedal centerline and AHP_Y is defined at the shoe centerline. Both can be determined from the divot point locations. The S1, S2, and S3 divot points are offset 10 mm either side of the shoe centerline. The direction of the 10 mm correction to an S_Y location will depend on which side of the shoe was digitized (Figure 7).

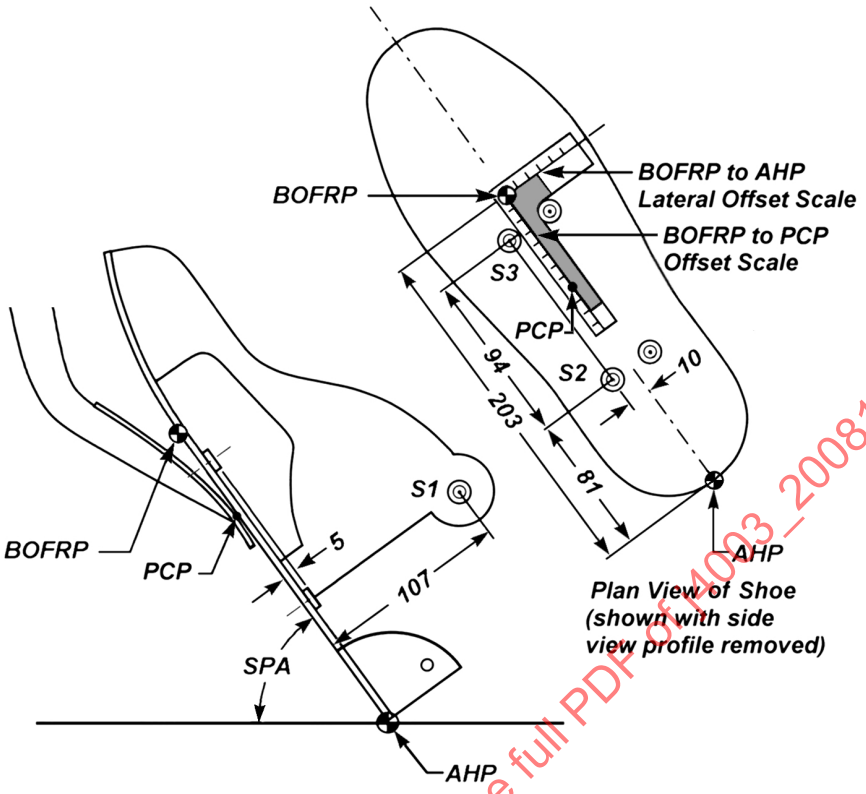


FIGURE 7 - SHOE DIVOT POINTS

5.4 Install HPM Cushion and Back Pan Assembly

Before installing the HPM in the driver's seat, place an inclinometer on the seatback and set the seatback angle to the detent nearest to 20 degrees. Rotate the seatback one or more detents forward and rearward from this setting to determine the angular spacing between recliner detents. Spacing between seatback detents typically ranges from 1 to 3 degrees. Some seatback recliners, such as those that are power-actuated, provide infinite adjustability in torso angle.

Using CMM, locate and mark the lateral centerline of the seat cushion and seat back.

5.4.1 Install the Cushion Pan

Place the cushion pan (Figure 8) on the seat with the back of the pan resting lightly against the seat back. Visually center the cushion pan laterally within the seat trim.

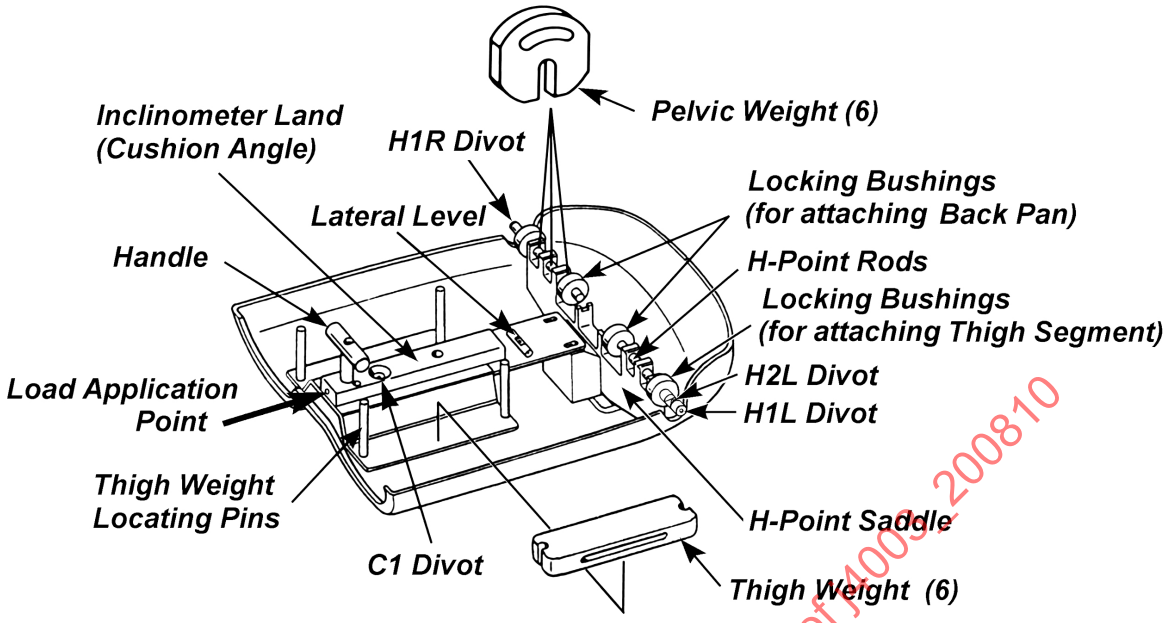


FIGURE 8 - CUSHION PAN

5.4.2 Install the Back Pan

To protect the shells of the cushion and back pans, the back pan should be locked in a slouched position before installing it. Articulate the back pan into a slouched position (LSP < 0) and lock.

Place the H-point pivot shaft, located at the base of the back pan, on the H-point saddle of the cushion pan (Figures 8 and 9). The upper portions of the back pan should not contact the seat back. Secure by sliding the brass locking bushings inwards over the H-point shaft.

Unlock the torso articulation. Put one hand firmly on the cushion pan T-handle to maintain the position of the cushion pan. Put the other hand on the back pan T- handle and gently rotate the back pan assembly against the seat back to allow the back pan assembly to conform to the seat back contour. Ensure that the top and bottom corners at each side of the lumbar segment remain outside the thoracic and pelvic segments. Also ensure that the muslin cloth is not caught between the back segments.

Visually center the back pan laterally within the seat back trim. CMM may be used to verify that cushion and back pans are centered laterally in the seat.

NOTE: The cushion and back pan can be connected and installed as a single unit if preferred. Follow the same steps as above, centering the cushion pan lightly against the seat back with the back pan rotated forward and locked in the slouched position.

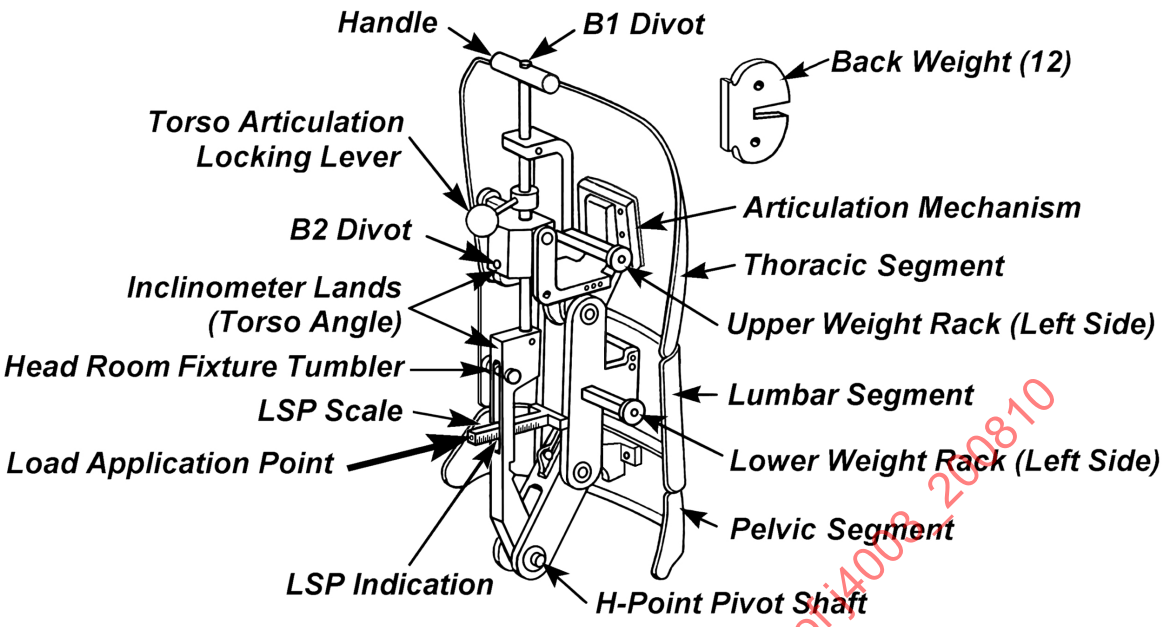


FIGURE 9 - BACK PAN

5.4.3 Install the Head Room Fixture (optional)

Install the head room fixture if head room is to be measured. Slide the forks at the end of the head room fixture into the grooves on the brass locking bushings of the cushion pan. With the adjuster screw full out, snap the end of the screw into the rotating tumbler on the back pan (Figures 9 and 10). Ensure the fixture is fully against the stop on the back pan.

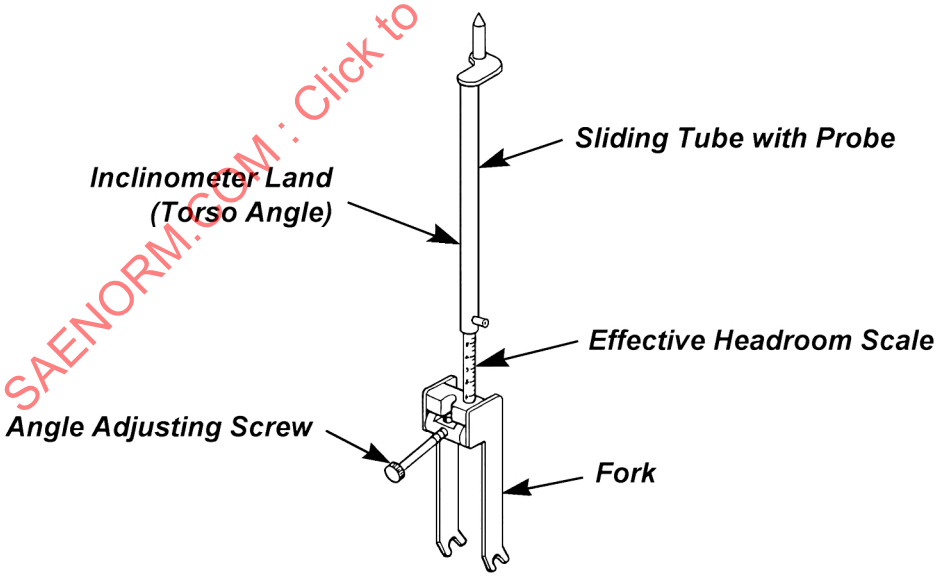


FIGURE 10 - HEAD ROOM FIXTURE

5.4.4 Set Initial Torso Angle

As the HPM is loaded, torso angle will tend to increase. Therefore, the initial torso angle reading needs to be less than the desired final torso angle reading. An initial setting of approximately 20 degrees should result in a final reading close to 22 degrees. A better way to estimate the amount the seatback will deflect after the HPM is loaded is to:

1. Place an inclinometer on the torso angle land and set the torso angle at the detent nearest to 20 degrees.
2. Punch the back twice.
3. Hold the cushion pan in place manually or by adding 1 round of cushion pan weights, and
4. Apply and hold a 4 kg (10 lb) load at the middle of the upper weight rack; read the torso angle.
5. If the torso angle is as close to 22 degrees as the detent settings allow, unload any cushion pan weights and proceed with the HPM installation. If not, readjust the seatback recliner detent and repeat steps 2 - 5.

Follow a similar procedure for a rear passenger seat, if it is equipped with an adjustable torso angle.

5.4.5 Level the HPM

Referring to the bubble level on the cushion pan, dither and adjust the HPM to level laterally on the seat. Make sure the HPM is in firm contact with the seat back.

5.5 Load the HPM

Installing weights on the HPM is referred to as 'loading.' The HPM is loaded with the torso articulation mechanism unlocked. Weights are installed from the H-point outward and from the H-point upward to prevent the HPM from toppling out of the seat. Prior to each round of weights being loaded, an 89 N (20 lb) force is applied twice by 'punching' the appropriate load application site with the spring-loaded probe. After each 'punch' the operator shall immediately release any applied force once the punch probe reaches its spring loading. This procedure ensures the HPM remains fully nested into the seat during the loading.

The HPM shall be checked for level, and the torso angle monitored and adjusted as needed during the loading process. The sequence of actions for loading the HPM, summarized in Table 3, shall be followed.

TABLE 3 - LOADING THE HPM

Round	Apply 89 N (20 lb force)	Load 2 Weights	THEN Load 2 Weights	Check for:
1	Punch twice	2 Pelvic - innermost positions	2 Thigh	Level
2	Punch twice	2 Pelvic - next innermost positions	2 Thigh	Level
3	Punch twice	2 beveled Pelvic - outermost positions	2 Thigh	Level
4	Punch twice	2 Lower rack - innermost positions	2 Upper rack - innermost positions	Level and torso angle
5	Punch twice	2 Lower rack - next innermost position	2 Upper rack - next innermost positions	Level and torso angle
6	Punch twice	2 Lower rack - outermost positions	2 Upper rack - outermost positions	Level
7	Lock Torso Articulation			

5.5.1 Load the Cushion Pan

There are two types of weights for loading the cushion pan; pelvic weights, which are positioned in slots along the H-point axis, and thigh weights that are held in place by the pins in the thigh area.

Punch the HPM twice at the cushion pan load application site. Install two pelvic weights in the innermost pelvic weight slots (one to either side of the H-point). Install two thigh weights (one to either side). Check for level.

Repeat these steps (punch twice, load two pelvic weights, load two thigh weights, and level) two more times to complete the loading of the cushion pan.

5.5.2 Load the Back Pan

There are two areas for loading weights on the back pan assembly, the lower and upper racks. However, the same type of weight is used in both areas.

Punch the HPM twice at the back pan load application site. Install two weights on the lower racks – one on either side of centerline. Push the weights toward the centerline as far as possible. Install two weights on the upper racks, one on either side of centerline, and push towards the centerline. Check for level. Check lateral level and torso angle.

Repeat these steps (punch twice, load two weights on the lower rack, load two weights on the upper rack, level, and check torso angle) two more times. During the loading, adjust the seat recliner if necessary to obtain a final torso angle reading as close as possible to 22 degrees. No adjustment in torso angle should be made once loading is completed.

If the final torso angle is within ±1 degree from 22 degrees after the HPM is fully loaded, the installer can proceed to 5.5.3. If the final torso angle is outside this range and a different seatback recliner setting would yield a torso angle closer to 22 degrees, unload and remove the HPM, readjust the recliner setting, wait 30 minutes, and reinstall the HPM.

After the back pan is fully loaded and level, lock the torso articulation mechanism.

5.5.3 Soak Time

After installation, the HPM can continue to 'settle' into a seat, depending on the type of seat being used. Therefore, it is recommended to wait 5 minutes after completing the HPM installation before recording data.

5.6 Digitize HPM Points

5.6.1 H-point

The H-point is located at the centerline of the HPM. Therefore, this point cannot be directly digitized. Rather, divot points H1L and H1R are provided for digitizing at either end of the H-point rods (Figure 8). If either H1L or H1R is not readily accessible by the CMM, use divots H2L and H2R. Both H1L and H1R or H2L and H2R should be digitized. The H-point is midway between these two points. Divot points B1, B2 and C1 may also be used to establish the HPM longitudinal centerline in CAD to check the Y coordinate of the H-point.

5.6.2 Cushion Angle, Torso Angle, LSP

Record cushion angle, torso angle, and LSP. If benchmarking is to be completed in CAD, the posture of the HPD can be determined by reading LSP from a scale on the HPM and either:

- digitizing the torso angle and cushion angle divot points, or
- measuring the torso angle and cushion angle directly with the inclinometer.

5.7 Calculate SgRP

Several measurements cannot be taken until the HPM (or HPD) is positioned at SgRP, including: knee angle, thigh angle, ankle angle, and head room. Many other measurements also require positioning at SgRP, including: leg room, elbow room, hip room, shoulder room, and hip angle.

5.7.1 Translate Seat Travel to H-Point Travel Path

Determine the difference (in X and Z coordinates) between the measured H-point and the seat registration mark that corresponds to the seat position used for H-point measurement. Translate the seat travel path to the H-point travel path in CAD by adding these differences to each of the measured registration mark coordinates at the extremes of the seat adjustment path (Figure 3). The resulting window is the H-point travel path.

5.7.2 SgRP for Seats with No Fore/Aft Adjustment

If the seat does not have fore/aft or vertical adjustment, the measured H-point is the SgRP.

If the seat only has vertical adjustment one of two conditions applies:

Condition 1 - For adjustment of 40 mm or more, the SgRP is 20 mm above the full down position.
or
Condition 2 - For adjustment less than 40 mm, SgRP is at the middle of the adjustment range.

5.7.3 SgRP for Seats with Fore/Aft Adjustment

In order to calculate the SgRP for a driver seat having fore/aft adjustment, the following data are needed.

- H-point travel path (for positions with adjustable seats)
- H-point location (obtained by installing the HPM)
- BOFRP X coordinate
- AHP (accelerator heel point), Z coordinate

Using the BOFRP X coordinate and the AHP Z coordinate, plot the SgRP curve from SAE J1517:1990 given in Eq. 6.

$$SgRP_X = 913.7 + 0.672316(H30) - 0.0019553(H30)^2 = \text{horizontal distance (mm) rear of BOFRP} \qquad \text{(Eq. 6)}$$

5.7.3.1 Determine the SgRP Location

If the seat does not have vertical adjustment, SgRP is located at the intersection of the H-point travel path and the SgRP curve.

For seats with vertical adjustment (TH21) of 40 mm or more, establish the intersection with the SgRP curve using an H-point travel path line 20 mm above the full down position; if the vertical adjustment is less than 40 mm, use a fore/aft H-point travel path midway between the full down and full up travel path (Figures 11 and 12). Determining the point of intersection is best done in CAD (see A.2.4.1), but could be solved analytically, if desired.

If the measured SgRP location is not at the proper vertical height within the H-point travel box, one or two iterations may be needed to locate SgRP_z at 20 mm above full down or at mid-height.

Determine the X, Y, Z coordinate of the SgRP location, and calculate the distance dX, dY, and dZ between the SgRP and the lowest most-rearward corner of the H-point travel path. The dY distance will be zero except when the seat track is not parallel to the longitudinal axis of the vehicle (i.e. the seat track is angled in plan view). These dX and dZ values can be used to reposition the seat (see 5.8) such that the measured seat H-point is at the SgRP location.

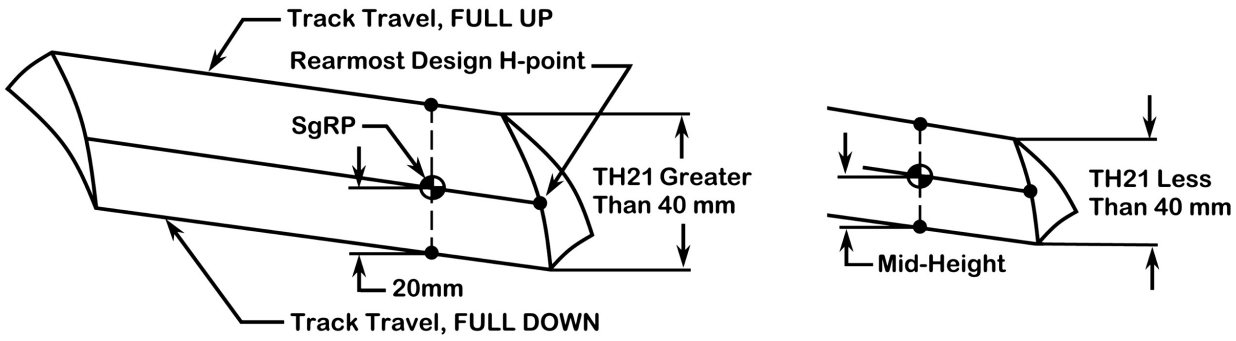


FIGURE 11 - LOCATION OF THE SGRP WITHIN THE TRAVEL PATH FOR VERTICAL SEAT ADJUSTERS

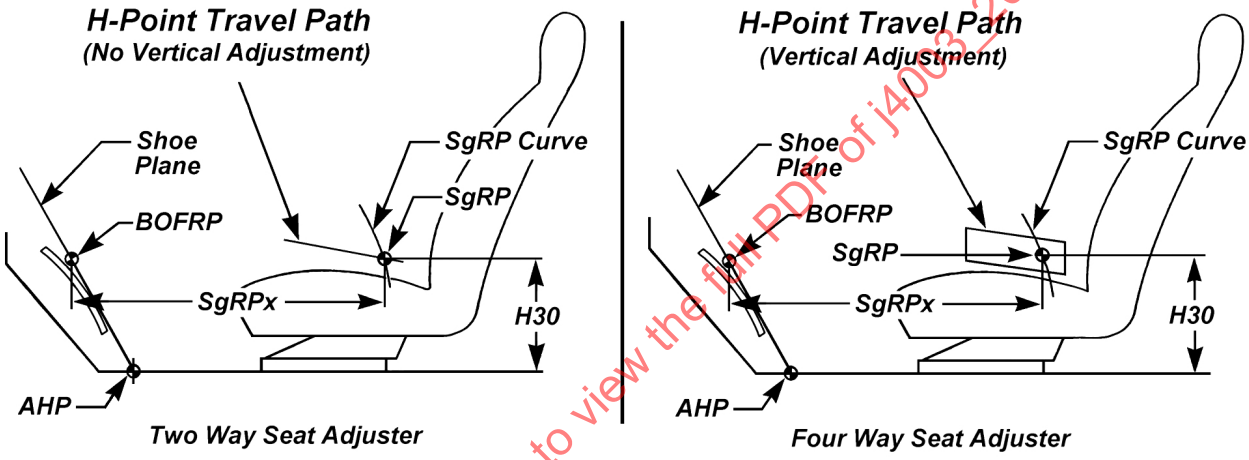


FIGURE 12 - H-POINT TRAVEL PATH AND SGRP LOCATION

5.7.3.2 SgRP for Short Seat Track Travel

If the H-point travel path is not long enough to include the SgRP calculated from the SgRP equation, the SgRP shall be defined and positioned at the rearmost point of the H-point travel path. If a seat has vertical adjustment, this is the point indicated in Figure 11.

5.8 Reposition Seat to SgRP

Before the legs are attached, the seat shall be repositioned so that the H-point of the HPM is at SgRP using the information obtained in 5.7.3.1 (Figure 13). Verify the seat is positioned at SgRP using the CMM equipment. If the seat track has detented positions, move the seat to the detent position nearest to the calculated SgRP. If the seat track is curved, move the seat to SgRP position and re-adjust seat recliner so the HPM torso angle is 22 degrees, if necessary.

NOTE: It is recommended that this step and the leg segment installation be done in CAD (see A.2).

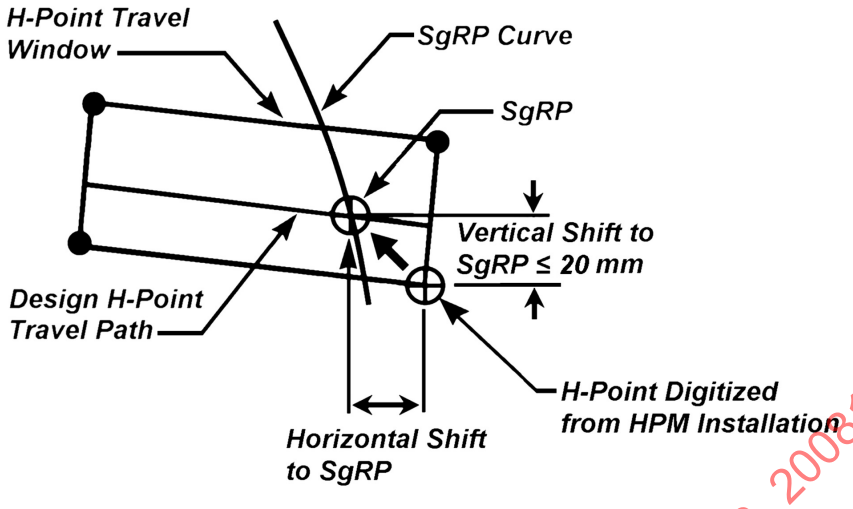


FIGURE 13 - REPOSITIONING THE SEAT TO SGRP – SHOWN FOR SEAT HAVING BOTH VERTICAL AND FORE/AFT ADJUSTMENT

5.9 Install Leg Segments (optional)

Adjust the thigh length to 456 mm and the lower leg to 459 mm. Pin the leg segments at these lengths.

Install the thigh segment by placing the forks on the H-point rods. Slide the locking bushings inward and rotate until the pins lock into place. Install the lower leg at the ankle pivot without moving the shoe. Join the thigh and lower leg segments, raising the thigh segment if necessary. Use the bushing on the knee pivot rod to secure the lower leg in place.

NOTE: Manufacturers may have special applications for which other leg lengths may be used.

5.10 Record Measurements

Measurements listed in Table 4 are obtained by combinations of direct readouts on the HPM (divot points, inclinometer, angle and linear scales) and/or from digitized data applied using the HPD in CAD. For the head room measurement (H61) the torso angle shall be set to 8 degrees. See Appendix C and SAE J1100 for additional details.

TABLE 4 - DRIVER MEASUREMENTS

SAE J1100 Code	Dimension
L1, W1, and H1	BOFRP X, Y, and Z coordinates
L8, W8, and H8	AHP X, Y, and Z coordinates
PW86	AHP to BOFRP lateral offset
A47	Shoe Plane Angle
L31, W20, and H70	SgRP X, Y, and Z coordinates
H30	Seat Height
A40	Torso Angle
A27	Cushion Angle
A57	Thigh Angle
A42	Hip Angle
A44	Knee Angle
A46	Ankle Angle
L81	Lumbar Support Prominence
H61	Effective Head Room

5.11 Remove the HPM

To aid in removing the HPM, seats may be moved, unless a subsequent HPM installation will be made in the succeeding row.

- Remove the lower leg and the thigh segment, if installed.
- Unload the HPM. Weights are removed from the HPM in the reverse order that they were installed. See Table 5 for the order of removal.

TABLE 5 - UNLOADING THE HPM

Round	Remove 2 Weights from:	THEN Remove 2 Weights from:
1	Outermost Upper Rack	Outermost Lower Rack
2	Next outermost Upper Rack	Next outermost Lower Rack
3	Innermost Upper Rack	Innermost Lower Rack
4	Thigh	Outermost Pelvic
5	Thigh	Next outermost Pelvic
6	Thigh	Innermost Pelvic

- Remove head room fixture, if installed.
- Remove cushion and back pans: Unlock the torso articulation mechanism, position the back pan in a slouched posture, and re-lock the mechanism. Slide the brass locking bushings outward and remove the back pan. Remove the cushion pan.

NOTE: The cushion and back pans can be removed as a single unit if preferred.

- Remove shoe tool and shoe fixture, if installed.

6. BENCHMARKING 2ND OR SUCCEEDING ROWS, OUTBOARD PASSENGER POSITIONS

The procedures that follow describe the use of the HPM in the physical environment. However, as was the case for the driver's position, much of the work can be done in CAD using the HPD if preferred. See Appendix B for a summary of procedures for benchmarking rear passenger seat positions.

6.1 Prepare the Physical Property

See 4.2 and Table 1.

6.2 Position Seats

For rear passenger seat positions, the seat immediately in front of the seat to be evaluated must be considered because it affects the knee, leg and foot room measured by the HPM.

If the seat to be evaluated is adjustable, place it at the lowest most-rearward position that can be used by a seated passenger. The seat in front of it should either be at SgRP (if it is the front seat) or at its lowest most-rearward position (see Table 1). If the test seat has an adjustable recliner, adjust the seat back so that the final HPM torso angle will be 25 degrees (see 5.4.4 and use 25 degrees instead of 22). If the maximum torso angle is less than 25 degrees, set the torso angle to the maximum. Set the cushion angle at the middle value (if it's adjustable), and the lumbar support at the minimum value.

Using the CMM, scan the cushion and back of the test seat and the back surface of the seat in front if CAD is to be used for taking some measurements.

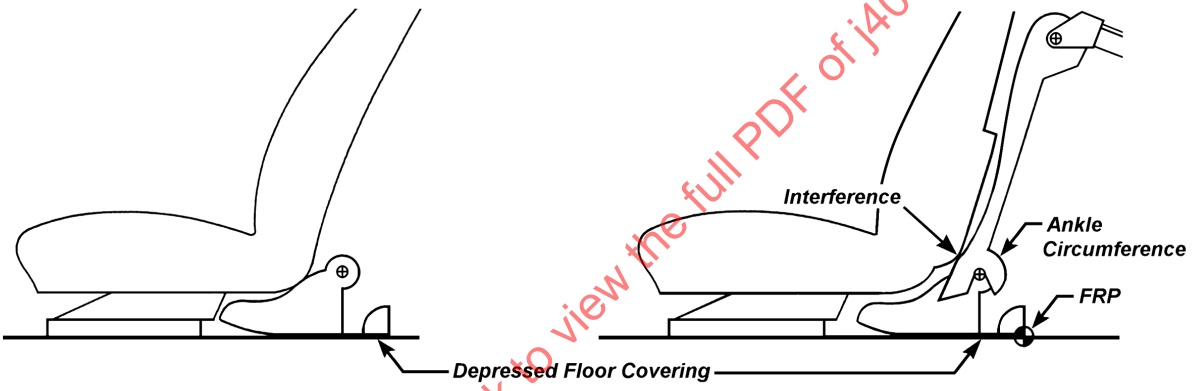
6.3 Install the Shoe Tool

Place the shoe tool on the floor and slide it forward, beneath the seat in front, until it reaches an obstruction. Move the shoe laterally to find the most forward location of the shoe, keeping the shoe centerline within ±127 mm of occupant centerline (SgRP-y). See Figure 14a. There are two conditions where the shoe will have to be moved rear of this location: interference at the ankle circumference when the lower leg is attached (see 6.3.1), and a long-coupled seating condition (see 6.5.2). If the shoe does not fit between the seats, see 6.3.2.

NOTE: The shoe fixture is not needed for passenger seating positions.

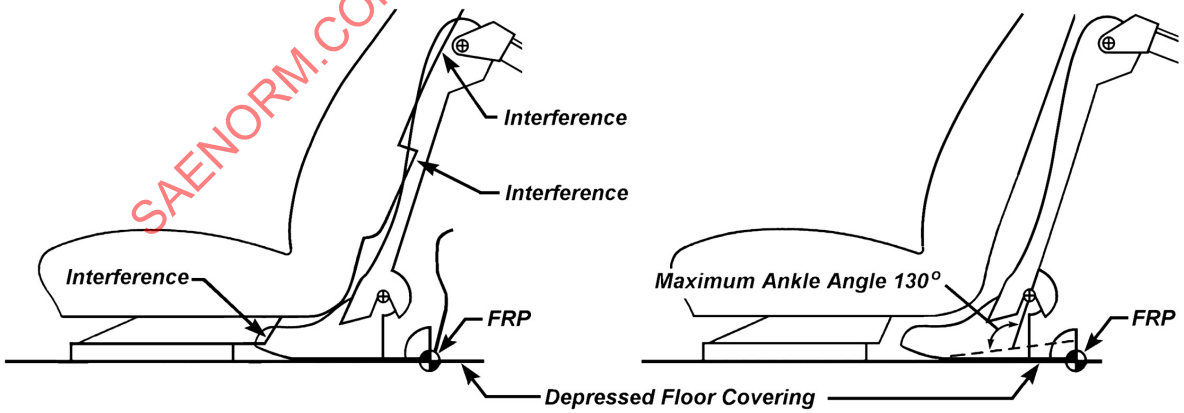
6.3.1 Interference at the Ankle Circumference

Temporarily attach only the lower leg to the shoe to determine if there is shoe interference in the area of the ankle pivot circumference on the lower leg (Figure 14b). If there is interference at the ankle circumference, move the shoe rearward to just clear the interference. Interference above the ankle pivot circumference is not considered for positioning the shoe but will be considered when determining leg interference with short-coupled seating (see 6.5.1). Use this shoe position to define the FRP, floor plane angle, and all other dimensions.



(a) Shoe is first positioned as far forward as possible

(b) Shoe may need to be moved rearward to eliminate ankle interference with lower seat back trim



(c) Short-coupled seating: the seat interferes with the knee, leg, or shoe, requiring the seat be moved forward to allow installation of the leg and shoe

(d) Long-coupled seating: the shoe must be moved rearward so the lower leg reaches the shoe with an ankle angle no more than 130 degrees

FIGURE 14 - SHOE AND LEG INSTALLATION FOR REAR PASSENGER SEATS

6.3.2 Interference at the Front of the Shoe with Short-Coupled Seating

If the shoe cannot be fitted on the floor between the seats, measurement of knee clearance (L48), leg clearance (L58), and leg room (L51) is best done in CAD. If a physical installation of the HPM shoe and legs is desired, move the preceding seat forward along its seat adjustment path until the shoe just fits between the seats (Figure 14c). Move the shoe laterally within ±127 mm of occupant centerline, keeping the rear of the shoe against the trim under the test seat, to find the location that requires the least amount of preceding seat movement. Record the seat movement. This movement shall be subtracted from the measured knee clearance, leg clearance, and leg room. See Figures 15 and 17.

If the shoe cannot be fitted and the preceding seat does not have fore/aft adjustment, then L48, L58, and L51 must be measured in CAD.

NOTE: The HPD shoe, along with the lower leg and thigh, can be installed in CAD, if the preceding seat back and seat recliner pivot, trim under the test seat, and the floor were digitized.

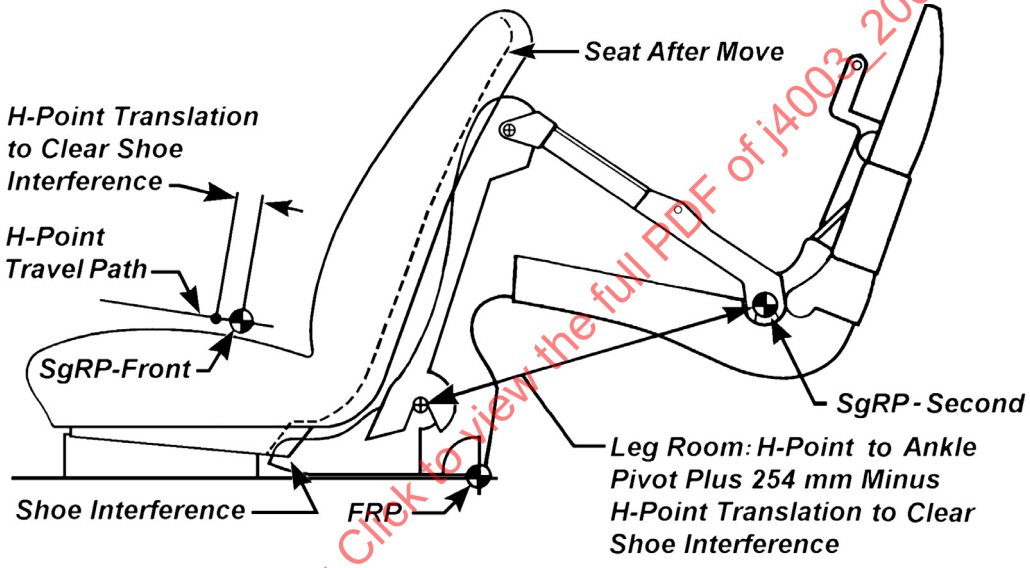


FIGURE 15 - SHOE INTERFERENCE WITH SHORT-COUPLED SEATING

6.4 Install and Load Cushion Pan, Back Pan, and Head Room Fixture

Follow the same installation procedure as described for the driver's position except, if the torso angle is adjustable, set the HPM torso angle to 25 degrees for the rear seat. See 5.4, 5.5, and Table 1.

6.5 Install Leg Segments (optional)

Attach the thigh and lower leg segments. It may be necessary to move the preceding seat forward to allow enough room to install the HPM lower leg and thigh. In this case mark the SgRP location of the preceding seat, then move the preceding seat forward along its seat track until the thigh and lower leg can be installed. If the preceding seat does not have fore/aft adjustment but does have seat back adjustment, mark the initial seat back location and rotate the seat back to allow leg and thigh installation. Mark the location of the shoe so its initial position can be maintained. Return the seat and seat back to its original location. Measure L48, L58 and L51. If the preceding seat or seat back cannot be returned to its original location, the L48 and L58 measurements will be more accurate if done in CAD. A field measurement method is given in 6.5.1. See Figure 16.

If the preceding seatback cannot be adjusted to a torso angle of 22 degrees, L48, L58 and L51 shall be measured in CAD. If the preceding seat has neither fore/aft nor recline adjustment, use CAD to determine clearances and other measurements. See SAE J1100.

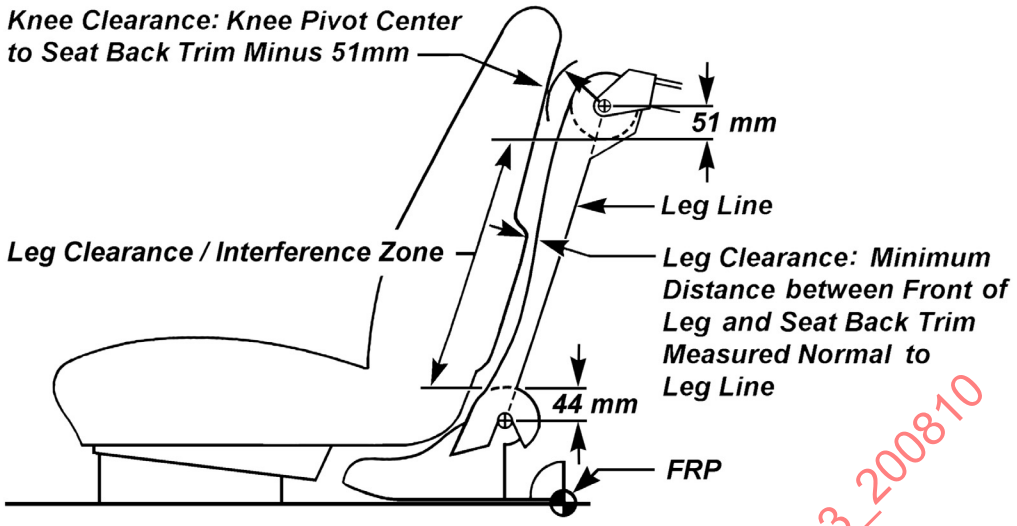


FIGURE 16 - KNEE AND LEG CLEARANCE ZONES

6.5.1 Short-Coupled Seating

If the preceding seat cannot re-attain its original location because its seat back contacts the HPM knee or lower leg, the seating arrangement is called "short-coupled" (Figure 14c). In this case mark the SgRP location of the preceding seat. Move the preceding seat forward to allow the lower leg and thigh to be installed. Do not move the shoe. Then move the preceding seat rearward until the seat back just contacts the HPM knee or lower leg (Figure 17). If the seat track is detented, move the preceding seat to the detent that brings the seat back as close as possible to the HPM knee or leg.

To determine L48 and L58, measure the minimum value of any remaining knee and leg clearance and subtract the distance the preceding seat was moved forward of its SgRP location. If the preceding seat has a curved fore/aft seat track adjustment path or seat back recliner adjustment, subtract the chordal (vector) movement distances at the points on the seat where the minimum knee and leg clearance were measured. Either or both L48 and L58 will be a negative value for short-coupled seating. See SAE J1100:2005.

NOTE: Field measurement of L48, L58, and L51 may produce slightly different measured values than those determined in CAD. Measurement in CAD is recommended.

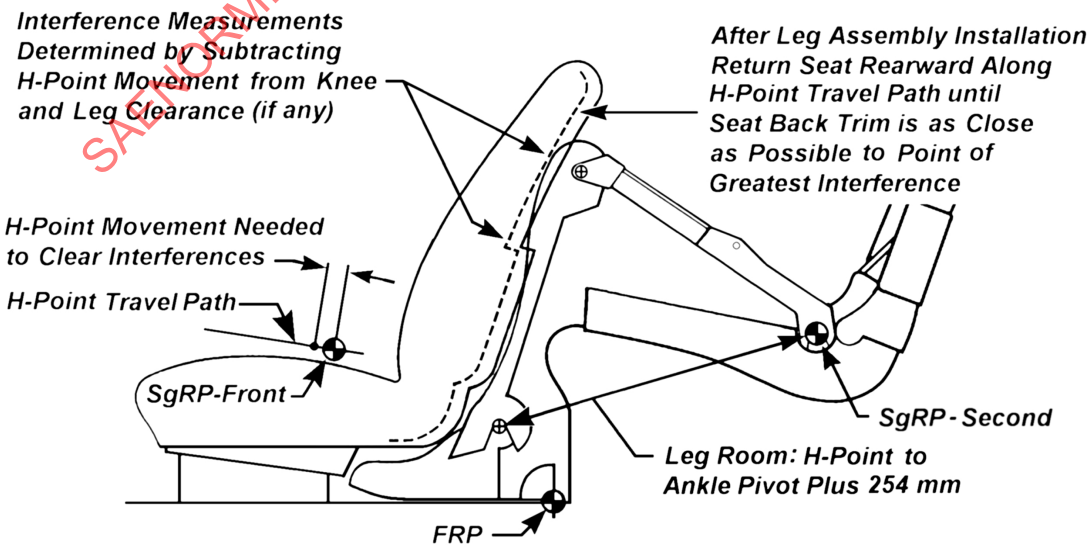


FIGURE 17 - KNEE AND LEG INTERFERENCE WITH SHORT-COUPLED SEATING (SHOWN FOR A LINEAR H-POINT TRAVEL)

6.5.2 Long-Coupled Seating

Some vehicles have seating arrangements where the lower leg segment either does not reach the shoe tool, or, if it does reach, the ankle angle exceeds 130 degrees (Figure 14d). These seating arrangements are called "long-coupled".

Measure leg room (L51) to this ankle pivot point location. Then move the shoe rearward until an ankle angle of 130 degrees is achieved with the thigh assembly attached to the H-point and the lower leg assembly attached to the shoe tool. Use this position to establish the floor reference point, floor plane angle, knee clearance (L48), leg clearance (L58), and all other dimensions except leg room.

6.6 Record Measurements

6.6.1 Digitize HPM Points

See 5.6 for determining the H-point. For benchmarking purposes this H-point is recorded as the SgRP. Other divot points can be digitized if desired.

If benchmarking measurements will be taken in CAD, the posture of the HPD can be determined by reading LSP from a scale on the HPM and either:

- digitizing the torso angle and cushion angle divot points, or
- measuring the torso angle and cushion angle directly with the inclinometer.

6.6.2 Floor Reference Points

The point contacted by the heel of the shoe on the depressed floor covering is the FRP (floor reference point). The FRP should be calculated using the shoe divot points (S1, S2 and S3) and Equations 7 and 8. Floor plane angle can be measured with the inclinometer or calculated from divot points as shown in Equation 9. See Figure 18.

$$FRP_X = S3_X + 175 * \cos(FPA) - 5 * \sin(FPA) \quad \text{(Eq. 7)}$$

$$FRP_Z = S3_Z - 175 * \sin(FPA) - 5 * \cos(FPA) \quad \text{(Eq. 8)}$$

$$FPA = \text{Floor Plane Angle} = \arcsin[(S3_Z - S2_Z) / 94] \quad \text{(Eq. 9)}$$

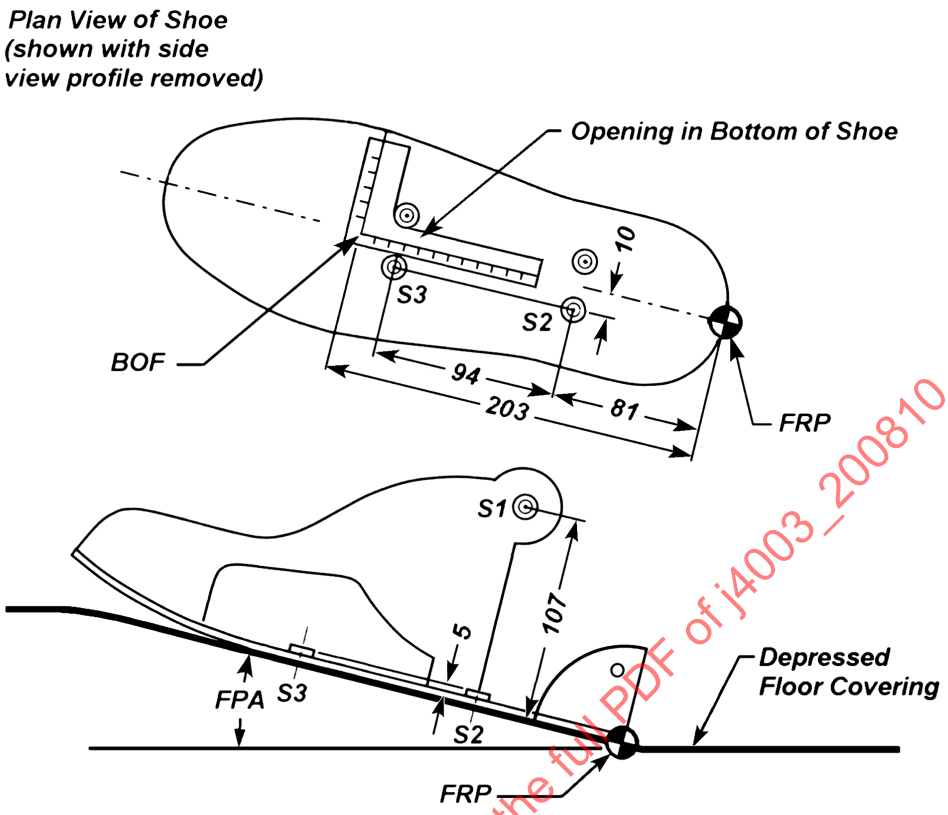


FIGURE 18 - SHOE DIVOT POINTS AND FLOOR REFERENCE POINTS

Measurements are obtained by combinations of direct readouts on the HPM (divot points, inclinometer, angle and linear scales) and/or from digitized data applied using the HPD in CAD. Table 6 lists the key passenger measurements. See Appendix C for additional details.

TABLE 6 - REAR PASSENGER MEASUREMENTS

SAE J1100 Code[a]	Dimension
L31, W20, H70	SgRP X, Y, and Z coordinates
H30	Seat Height
L98 and H98	Floor Reference Point X and Z coordinates
A48	Floor Plane Angle
A40	Torso Angle
A27	Cushion Angle
A57	Thigh Angle
A42	Hip Angle
A44	Knee Angle
A46	Ankle Angle
L81	LSP
H61	Effective Head Room
L48	Knee Clearance
L58	Leg Clearance
L51	Effective Leg room

[a] A suffix (-2, -3, …) that denotes the seat row must be added to each dimension code.

6.7 Remove the HPM

Follow the procedures described in 5.11.

7. NOTES

7.1 Marginal Indicia

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE HUMAN ACCOMMODATION AND DESIGN DEVICES COMMITTEE

APPENDIX A - (INFORMATIVE)
CAD PROCEDURES USING HPD IN BENCHMARKING

A.1 OVERVIEW OF CAD PROCEDURES

In benchmarking the HPM must be used to determine the seat H-point, cushion angle, torso angle and lumbar support prominence. The H-point design tool (HPD, see Figure A1) may be used in CAD as part of the benchmarking process in the following ways:

- CAD is normally used to establish the driver SgRP and H-point travel path.
- CAD is often used to position the HPD thigh and lower leg in order to measure additional reference points and dimensions of the vehicle seating package (maximizing the use of the HPD and CAD).
- CAD may at times be used to position the shoe tool.

The HPD shall use the SgRP leg lengths of 456 mm for the thigh and 459 mm for the lower leg for the procedures described in this appendix.

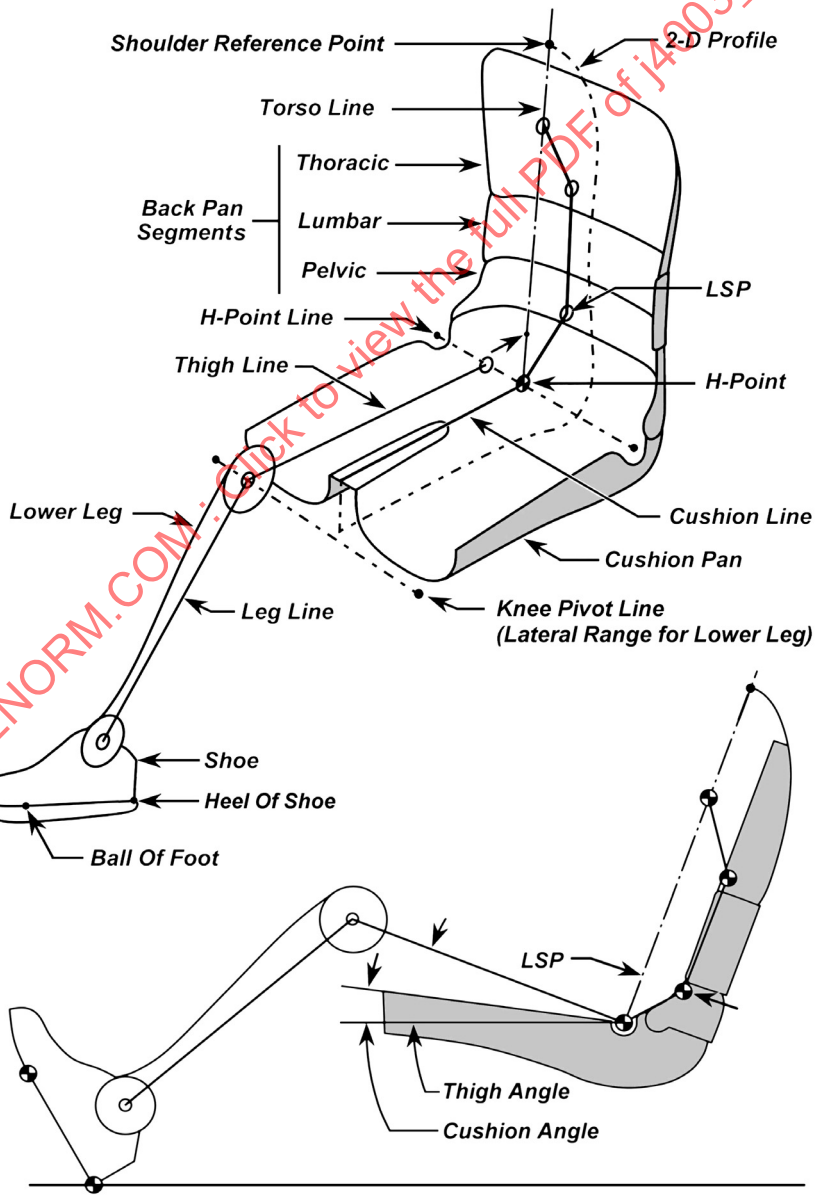


FIGURE A1 - H-POINT DESIGN TOOL (HPD)

A.2 DRIVER SEAT POSITION

This procedure is used to establish the driver seating reference point (SgRP-Front) and to position the HPD at the driver SgRP location. It also describes how to establish the Ball of Foot Reference Point (BOFRP) and accelerator heel point (AHP) in CAD.

A.2.1 Establish Shoe Plane, Shoe Plane Angle (SPA), BOFRP, and AHP

If pedals adjust fore/aft, set the pedals at the most-forward adjustment position.

In CAD the shoe plane is used to orient the flat part of the HPD shoe bottom (Figure A2). Users could construct the shoe plane in the shape of the flat part of the HPM shoe, so that in side view the shoe plane would appear as a line 203 mm long. The shoe plane angle defines the attitude of the HPD shoe.

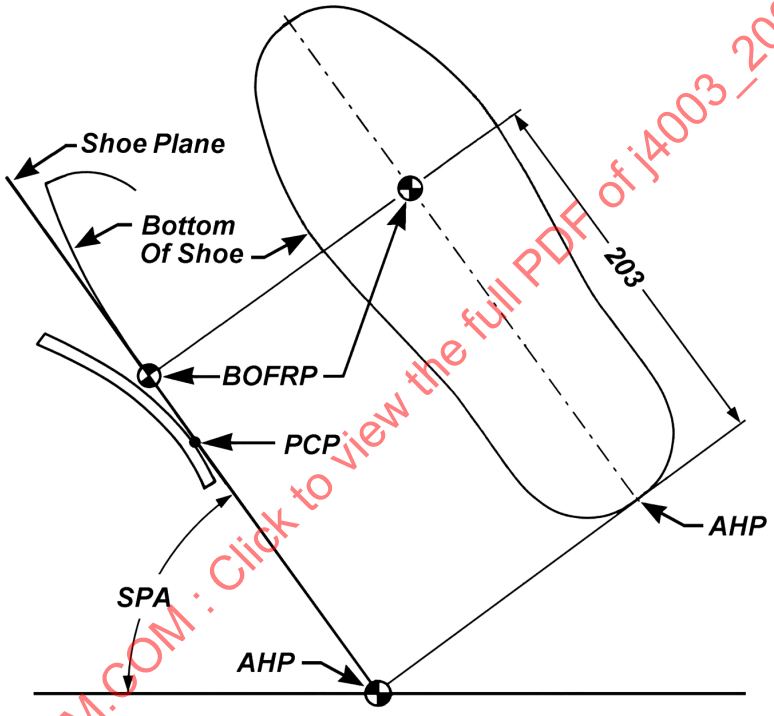


FIGURE A2 - SHOE PLANE CONSTRUCTION USING A PORTION OF THE HPD SHOE

The shoe plane is defined at the longitudinal centerline of the undepressed accelerator pedal. The following two methods may be used to establish shoe plane in order to position the HPD shoe on the undepressed accelerator pedal.

A.2.1.1 Directly from HPM Measurements

If the AHP and BOFRP were determined from installation of the HPM shoe tool, these values can be used in CAD to locate and orient the shoe plane.

A.2.1.2 Derived from Accelerator Pedal Geometry

If the accelerator pedal surface was digitized but the shoe tool was not installed, the shoe plane can be determined in CAD as follows:

a. Calculate the shoe plane angle (SPA) form the manufacturer's published Seat Height (H30) using the following equation and use it to set the attitude of the CAD shoe tool.

$$SPA = 2.522(10^{-7})(H30^{3}) - 3.961(10^{-4})(H30^{2}) + 4.644(10^{-2})(H30) + 73.374 \quad \text{(Eq. A1)}$$

b. Position the shoe plane per the following pedal configurations:

1. Non pivoting pedal – Position the driver shoe plane CAD tool so that the bottom of the shoe contacts the longitudinal centerline of the pedal pad surface with the heel on the depressed floor covering
2. Pivoting pedal pad – Position the driver shoe plane CAD tool so that the bottom of the shoe contacts the longitudinal centerline of the pedal pad surface with the heel on the depressed floor covering, allowing the pedal to pivot to achieve the most forward position of the shoe plane .
3. Treadle pedal – Position driver shoe plane CAD tool so that the bottom of the shoe contacts the lateral centerline of the pedal pad surface with the heel on the depressed floor covering (same as for # 2 just above) Three types of contact can occur with a treadle pedal; at the heel of shoe with the pedal at a flatter angle than the bottom of shoe, tangent to the bottom of the shoe or contact at the upper portion of the shoe with the heel of shoe rearward of the bottom of the pedal.

In side view the angle of the shoe plane from horizontal is the shoe plane angle. In rear view the segment from BOF to the heel of the shoe shall be vertical and square to grid (yaw is not permitted). If the accelerator pedal is angled in top view, align the shoe plane to the pedal (roll is permitted).

If there is interference from a center console, the contour of the tunnel, etc., which prevents the shoe from being positioned at the same Y coordinate as the pedal centerline, translate the AHP to the left until the shoe clears the interference (Figure 6). The lateral offset between AHP and BOFRP should be recorded (PW86).

A.2.2 Translate Seat Travel to H-Point Travel Path

In CAD establish the H-point travel path from the seat travel path that was determined in 5.2.1 (Figure 3). To do this, determine the difference (in X and Z coordinates) between the H-point and the seat registration mark corresponding to the seat position used for H-point measurement. Add these differences to each of the other seat registration mark coordinates measured at the extremes of the seat adjustment path. The resulting window is the H-point travel path.

If the seat adjusts vertically, establish an H-point travel line 20 mm vertically above the full down travel path if the vertical adjustment is 40 mm or more, or at the middle of the vertical adjustment range if it is less than 40 mm. (Figures 11 and 12).

A.2.3 Determine SgRP for Adjustable Seats

Depending on the X,Z location of SgRP, W20 may be somewhat different than the measured W20. This can happen when the seat track travel is not parallel to the longitudinal axis of the vehicle (i.e. the track travel is angled in plan view).

A.2.3.1 Position the SgRP Curve and Determine SgRP

The SgRP curve is positioned aft of the BOFRP using the following equation from SAE J1517:

$$SgRP_X = 913.7 + 0.672316(H30) - 0.0019553(H30)^2 = \text{Distance (in mm) rearward of BOFRP} \qquad \text{(Eq. A2)}$$

SgRP is the location where the SgRP curve intersects the H-point travel line. The vertical (z) distance between the AHP and the SgRP is the H30 for benchmarking (Figure 11).

A.2.3.2 Short Seat Track Travel

If the design H-point travel path is not long enough to include the SgRP determined by equation A1, then the SgRP shall be defined and positioned at the rearmost point of the design H-point travel.

A.2.4 Position HPD at SgRP

Position the HPD at the H-point, torso angle, cushion angle, and LSP values measured in 5.6. If the seat is adjustable, translate the HPD and the scan of the seat cushion and back contours (determined in 5.2.2) to the SgRP location. If the torso angle from the HPM field installation was not 22 degrees, in CAD rotate the seat back and HPM torso about the seat back pivot to achieve a torso angle of 22 degrees.