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**Road vehicles — H-point machine  
(HPM II) — Specifications and  
procedure for H-point determination**

*Véhicules routiers — Machine point H (HPM II) — Spécifications  
et mode opératoire pour la détermination du point H*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 20176 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 13, *Ergonomics applicable to road vehicles*.

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## Introduction

The tools and procedures for H-point determination given in this International Standard are based on the new SAE H-Point Machine (HPM-II).

H-point devices are used during vehicle design and development to establish interior reference points and dimensions for occupant packaging, and to validate the location of these key reference points and dimensions on physical properties during audits.

H-point devices are also used for the design and validation of seats. 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 are abridged, and 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.

### a) Key Differences from ISO 6549

Compared to the H-point machine described in ISO 6549, the changes made 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. Several of the changes are discussed below.

#### 1) Separate Components

For the HPM-II, the legs (upper and lower), shoe, cushion pan and back pan are all separate pieces. This greatly improves the ease of installation.

#### 2) "Legless" Manikin

The new tools allow the H-point location to be defined without having to attach the legs. This is a major advantage of the HPM-II. The new procedure is based on installing the HPM-II without legs. Use of legs is optional.

#### 3) Shoe Tool

Several improvements were made to the shoe tool and how it is positioned in the vehicle, including:

- changing the location of the ball of foot to 200 mm from heel of shoe,
- establishing a new pedal reference point (PRP), and
- defining a more complete procedure for positioning the shoe.

#### 4) Cushion Angle

The cushion angle can now be measured independently of thigh angle, and at the same time the other measurements are made. Previously, cushion angle was measured off the thigh line, and required a separate installation of the HPM.

#### 5) Lumbar Support

The articulation of the back pan assembly allows the HPM-II to be better seated in contoured seats. It also provides a new measurement called lumbar support prominence (LSP). This measurement provides an indication of the amount the seatback is contoured to provide support for the lumbar spine. The contour of the new back pan assembly is most similar to the original H-point machine when the HPM-II is in a neutral posture (LSP equals zero).

### b) Time period for coexistence of ISO 6549 and ISO 20176

ISO 20176 and ISO 6549 will co-exist for a transition period of at least 10 years, preferably no longer, from the first publication date of ISO 20176. Following this transition period, ISO 6549 will be withdrawn. During the transition period, it remains up to the vehicle designers to decide which HPM to use. Regulatory bodies and other parties that need to know are informed regarding which HPM was used.

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# Road vehicles — H-Point Machine (HPM-II) — Specifications and procedure for H-point determination

## 1 Scope

This International Standard provides the specifications and procedures for using the H-point machine [HPM<sup>1)</sup>] to audit vehicle seating positions. The HPM is a physical tool used to establish key reference points and measurements in a vehicle (see Figure 1 and Annex A). The H-point design tool (HPD) is a simplified CAD<sup>2)</sup> version of the HPM, which can be used in conjunction with the HPM to take the optional measurements specified in this document, or used independently during product design (see Annex D) .

These H-point devices provide a method for reliable layout and measurement of occupant seating compartments and/or seats. This document specifies the procedures for using the H-point machine (HPM) to audit (verify) key reference points and measurements in a vehicle.

The devices are intended for application at designated seating positions. They are not to be construed as tools that measure or indicate occupant capabilities or comfort. They are not intended for use in defining or assessing temporary seating, such as folding jump seats.

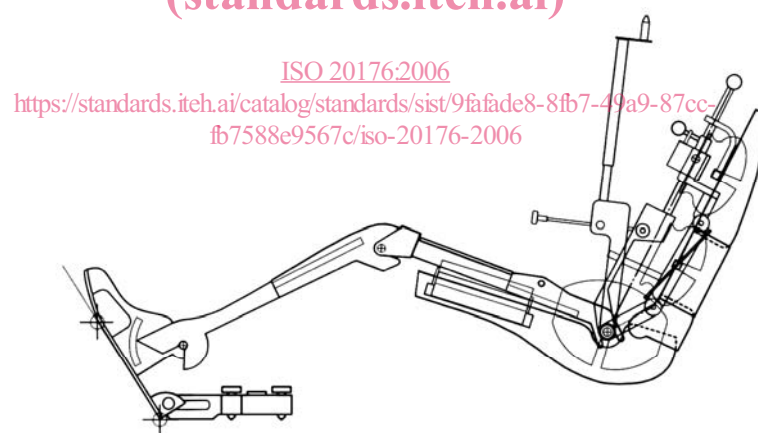


Figure 1 — Side view of HPM

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

1) All references to H-point machine or HPM in this standard refer to the new SAE H-point machine (HPM-II), unless otherwise noted.

2) CAD is an acronym for computer-aided design. In a general sense, it has come to encompass any software system/approach to automotive design and development, and is often used to refer to CAE (computer-assisted engineering) and CAM (computer-assisted manufacturing) software systems as well.

### 3 Definitions

For the purposes of this International Standard, the following definitions apply. Several of the reference points established with an H-point device are required for the subsequent positioning of other design devices, such as head contours, eyellipses, and reach curves. The most important reference points established by an H-point device are the H-point, the H-point travel path, the SgRP (seating reference point), the AHP (accelerator heel point), and the PRP (pedal reference point).

#### 3.1 H-point

point at the pivot centre of the back pan and cushion pan assemblies, located on the lateral centreline of the H-point device (HPM or HPD).

NOTE 1— The H-point is also the intersection of the cushion line and the torso line. When an H-point device is properly positioned within a vehicle — either in CAD or in an actual physical property — the location of the H-point relative to the vehicle is used as a vehicle reference point. If the seat is moved, the location of the H-point within the vehicle is changed. Therefore, adjustable seats will have more than one H-point location, while fixed seats will have only one H-point location.

NOTE 2— H-points are often referred to as hip points or hip pivot points. However, they do not accurately represent the location of the human hip joint.

#### 3.2 H-point travel path

all possible locations of the H-point provided by the full range of seat adjustments (horizontal, vertical or tilt) for a given designated seating position.

#### 3.3 SgRP (Seating Reference Point), R-point, design H-point

manufacturer's intended location for a design H-point, which is specifically designated as R-point or SgRP, and which:

- a) is the fundamental reference point used to establish occupant accommodation tools and dimensions;
- b) simulates the position of the pivot centre of the human torso and thigh;
- c) has coordinates established with respect to the designed vehicle structure;
- d) establishes the rearmost normal design driving or riding H-point of each designated seating position, which accounts for all modes of adjustment: horizontal, vertical and tilt that are available for the seat, but does not include seat travel used for purposes other than normal driving and riding

#### 3.4 AHP (Accelerator Heel Point)

point located at the intersection of the heel of shoe and the depressed floor covering, with the ball of foot contacting the lateral centreline of the undepressed accelerator pedal, and the bottom of shoe on the pedal plane.

#### 3.5 PRP (Pedal Reference Point)

point on the accelerator pedal lateral centreline where the ball of foot contacts the pedal, with the heel of shoe at AHP and bottom of shoe on the pedal plane.

### 3.6 FRP (Floor Reference Point, rear passenger)

point located at the intersection of the heel of shoe and the depressed floor covering, with the HPM shoe and/or lower leg segment resting against the seat immediately in front, and the bottom of foot positioned flat on the depressed floor covering.

## 4 Measurement procedure for the three-dimensional H-point machine

A complete description of the three-dimensional H-point machine is given in Annex A. Specifications and tolerances are given in Annex B. A field checking procedure for the HPM is given in Annex C.

### 4.1 Summary of installation procedure

Table 1 – Summary of Installation Procedure

| Driver Position  | 2 <sup>nd</sup> & 3 <sup>rd</sup> Row Passenger Positions   |
|--|---|
| Prepare the physical property. If possible, calibrate the CMM equipment to vehicle grid coordinates.   |   |
| Position seat to design intent location and attitude.  | Position the test seat and (if the HPM legs will be installed) the seat in front of the test seat to design intent location and attitude. |
| Install shoe fixture and shoe tool, if measuring leg and shoe dimensions. Record shoe-based measurements. See 5.1.   | Install shoe tool, if measuring leg and shoe dimensions. Record shoe-based measurements. See 6.1.   |
| Install and load the cushion pan, and back pan.<br>If measuring head room, install head room fixture before loading the pans. See 7.1.<br>Determine H-point, torso angle, cushion angle, and LSP. See 4.8. |   |
| Attach thigh and lower leg segments, if measuring leg-based dimensions. See 5.1.   | Attach thigh and lower leg segments, if measuring leg-based dimensions. See 6.1.  |
| Determine optional measurements. See 5.2 and 7.1.  | Determine optional measurements. See 6.2 and 7.1.   |

#### 4.1.1 Measured versus design values

When verifying or auditing a particular designated vehicle seating position, measurements taken with the three-dimensional HPM are normally compared to the design values indicated by the vehicle manufacturer. If any measured value is sufficiently close to the manufacturer's design value, the vehicle/seat is considered to meet the manufacturer's design intent for that measurement. The vehicle manufacturer or a regulatory agency may provide specifications for the term "sufficiently close". Two HPM measurements of particular interest are H-point (SgRP) and torso angle.

### 4.2 Prepare vehicle and seat

#### 4.2.1 Vehicle

Dimensions are measured relative to the vehicle three-dimensional reference system by setting up the vehicle relative to the fiducial marks (see ISO 4130) as specified by the manufacturer. The property (e.g., vehicle) shall be levelled prior to any HPM installation or measurement. Once the property is levelled, care should be taken to not lean on it, rock it, or in some other way knock it off level.

If the accelerator pedal is needed for the measurements, 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 freely rotates about a pivot, independent of pedal travel, fix or block the pedal at the middle of the free rotation range. If the pedal rotates, but is held at a given angle with a spring, block the

pedal at the given angle to maintain its position. If the accelerator pedal has fore/aft adjustment, the pedal shall be positioned as specified by the manufacturer. If no specification is provided, the pedal shall be adjusted to its most forward position in the vehicle.

**4.2.2 Seat**

The vehicle shall be preconditioned at the manufacturer's discretion, at a temperature of  $(20 \pm 10)$  °C to ensure that the seat material reaches room temperature. 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.

The following considerations will help ensure that stable, reliable measurements are made across seat types. Prior to the installation of the HPM, seats should remain unloaded for 30 minutes at the manufacturer's request. This is to allow the seat and seat materials (e.g., foam) to recover from compression.

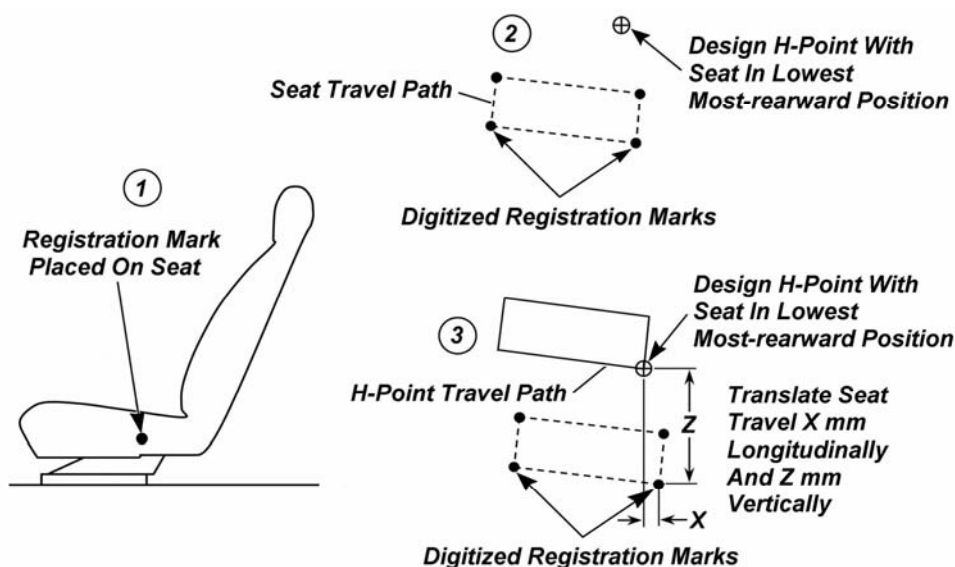
At the request of the manufacturer muslin cloth should be placed over the seat prior to installing the HPM. The muslin cloth may be a single piece fitting across both seat cushion and seat back, or two pieces, one for the cushion and one for the seat back. This ensures a constant friction surface across seat fabrics. See B.11.

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

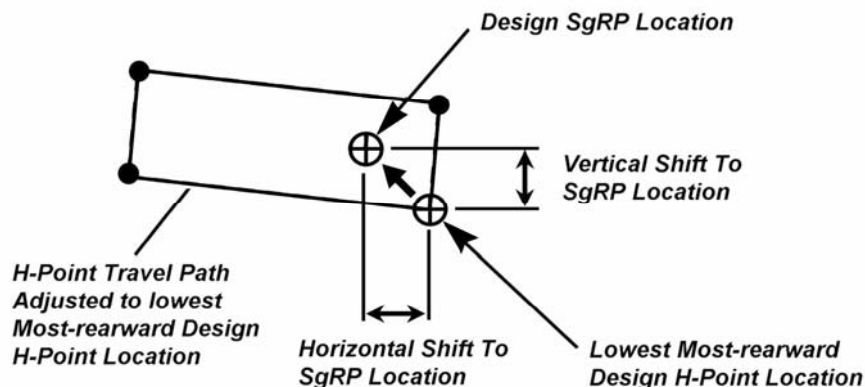
**4.3 Determine the H-point travel path (optional)**

If verification of the H-point travel path is desired, the seat's travel path must be digitised, and then translated to 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, digitise 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 seen more readily. See Figure 2A, steps 1 and 2.

NOTE: 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. If the seat track travel path is curved, additional points (between foremost and rearward) need to be taken.



(a) Translate seat travel path to H-point travel path



(b) Move seat to SgRP location

Figure 2 — Locating SgRP from the seat travel path

## 4.4 Adjust seat to design intent

### 4.4.1 Move seat to design intent position

All adjustable features of the seat shall be set to manufacturer's design intent attitude or position before installing the HPM.

For seats with an independent vertical adjustment or suspension, the vertical position shall be rigidly fixed in a position specified by the manufacturer.

The seat registration mark is helpful in positioning the seat at design intent relative to one of the seat's extreme locations (usually the rearmost, lowest position) determined in 4.3. Normally the design intent position specified by the vehicle manufacturer is the seating reference point (SgRP). Figures 2A and 2B illustrate a typical way to translate seat travel to H-point travel, and then to SgRP. After an adjustable seat is positioned at design intent, digitise the seat cushion registration mark(s).

### 4.4.2 Torso angle and cushion angle

The location of the H-point is influenced by a number of factors, including how the seat cushion and seat back are adjusted. Therefore, for accurate results, the seat shall be adjusted to the design intent torso angle and cushion angle before installing the HPM.

Seat torso and cushion angle adjustment procedures for auditing differ depending on whether or not variance in seat build is of interest.

#### 4.4.2.1 Audit of seat and vehicle build

If the purpose of the audit is to evaluate both the seat build and the vehicle build, then the seat structure shall be adjusted to the design attitude.<sup>3</sup> If the seat and seat assembly do not match their design intent values, this will affect the measured torso and cushion angles, and could result in a displacement of the H-point. The vehicle manufacturer (or seat supplier) will need to provide information regarding the location and attitude of the discernable seat structure (e.g., the seat frame), other hard points (e.g., seat controls, pivot points, head restraint rods, etc), or the amount of adjustment required to attain the desired seat attitude.

#### 4.4.2.2 Audit of vehicle build

If the purpose of the audit is to evaluate vehicle build independent of seat construction, then the seat shall be positioned to the design intent torso angle and cushion angle using either the method in 4.4.2.2.1 or 4.4.2.2.2.

<sup>3</sup> Note that the seat can also be verified independent of the vehicle.

(Since both torso and cushion angles measure how the seat impacts the HPM, the HPM needs to be installed in order to set the seat to the design intent values of these angles).

**4.4.2.2.1 Position seat at design intent: Method 1**

Install the HPM twice. The first installation allows the seat to be positioned at the design intent values of torso and cushion angle. Then, remove the HPM, wait 30 minutes to allow the seat materials to recover, and install the HPM a second time for the audit.

**4.4.2.2.2 Position seat at design intent: Method 2**

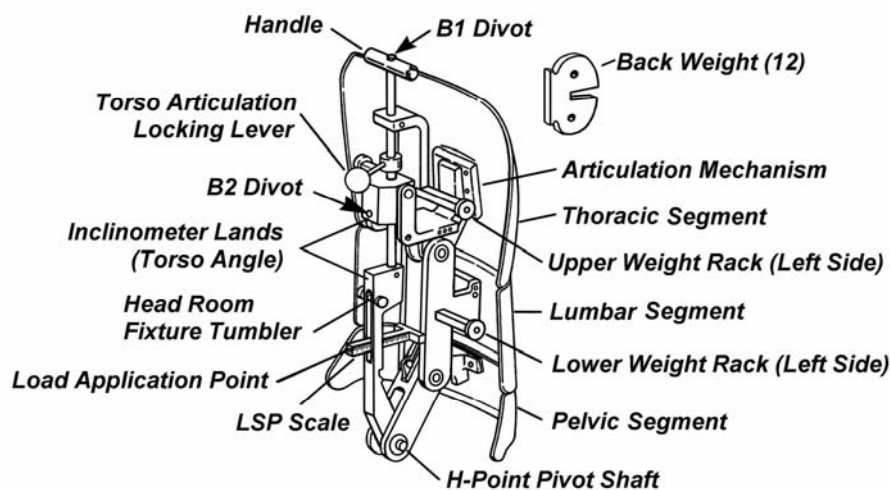
Monitor and adjust cushion angle and torso angle during the installation and loading of the HPM according to Table 2 and Table 3.

As the HPM is loaded, torso angle will increase. Therefore, as a guide, the initial (unloaded) torso angle reading should be approximately 2 degrees less than the desired final torso angle reading after loading. For example, an initial setting of approximately 20 degrees should result in a final reading of 22 degrees.

Check the initial torso angle using an inclinometer placed on the torso angle land of the back pan inclinometer land (Figure 3). Adjust the seat recliner as necessary to achieve a reading of approximately 2 degrees less than design intent torso angle.

**Table 2 – Adjusting Torso and Cushion Angles during HPM Loading**

|                          | <b>Driver Position</b>   | <b>2<sup>nd</sup> or 3<sup>rd</sup> Row Passenger Positions</b>  |
|--------------------------|--|--|
| <b>Torso Angle A40</b>   | Initially set the torso angle to approximately 2 degrees more vertical than design intent. Monitor and adjust if needed during HPM loading to achieve design intent.   | If the seat recliner is adjustable, initially set the torso angle to approximately 2 degrees more vertical than design intent. Monitor and adjust if needed during HPM loading to achieve design intent. |
| <b>Cushion Angle A27</b> | If the seat cushion is adjustable, initially set the cushion angle to be slightly greater than design intent value. Monitor and readjust as necessary during HPM installation to achieve the design intent cushion angle as the final reading. |  |



**Figure 3 — Back pan**

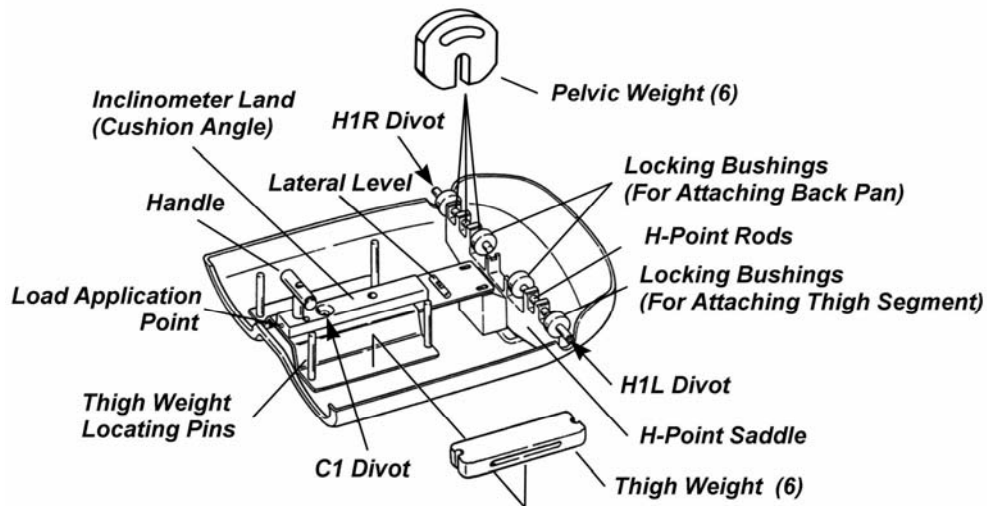
**4.4.3 Seat in front of test seat**

If leg positions, leg room, foot room, and knee clearance are planned to be measured, the seat in front of the test seat should be positioned to its SgRP or R-point and design intent torso angle.

## 4.5 Install HPM cushion and back pan assembly

### 4.5.1 Install the cushion pan

Place the cushion pan (Figure 4) on the seat with the back of the pan resting lightly against the seat back. Visually centre the cushion pan laterally in the seat.



**Figure 4 – Cushion pan**  
(standards.iteh.ai)

### 4.5.2 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. (see Figures 3 and 4) 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.

Note 1 – The cushion and back pan can be connected and installed as a single unit if preferred. Follow the same steps as above, centring the cushion pan lightly against the seat back with the back pan rotated forward and locked in the slouched position.

Note 2 – If measuring head room, install the head room fixture now (see 7.1).

### 4.5.3 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.

## 4.6 Load the HPM

Installing weights on the HPM is referred to as 'loading'. The HPM shall be loaded with the torso articulation mechanism unlocked. Weights shall be 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 force shall be applied twice by 'punching' the appropriate load application site with the spring-loaded probe. After