

# Dummy Seating Procedure for Rear Outboard Positions

## Version II

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**Insurance Institute for Highway Safety**

988 Dairy Road

Ruckersville, VA 22968

[researchpapers@iihs.org](mailto:researchpapers@iihs.org)

+1 434 985 4600

[iihs.org](http://iihs.org)



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## DOCUMENT REVISION HISTORY

### Revisions to Version II

In November 2023, the procedure was revised in following ways:

Step 1 was modified to allow seat track positions midtrack or rearward only.

Step 8 was updated to clarify the torso rotation measurement method.

In December 2022, the procedure was revised in following ways:

Step 7 was updated to clarify the foot-positioning steps.

Step 8 was updated to add details about torso rotation.

Step 12 was updated to clarify the hand position for dummies with full arms.

Photographs were added to steps 8, 11, and 12.

In October 2020, the procedure was revised in following ways:

Steps 3, 8.2.3, and 10 were updated to improve the procedure's repeatability and reproducibility.

Step 7.2 was updated to clarify the final position of the feet.

In April 2020, the procedure was revised in following ways:

Step 1 was updated to include the initial upper anchor position for the shoulder belt.

Step 2 (2.2) procedure to center the dummy on bench seats was changed and the pelvis lateral alignment was added.

Step 3 was updated to specify the pushback and the tibia-thigh angle.

Steps 6 and 7 were interchanged in sequence.

Step 8 (8.3) was updated to specify the number of repetitions if the pelvic angle is above the specified range.

Step 9 was changed to specify the priority between the head level and pelvic angle if both cannot be achieved within specified tolerances.

Step 10 was added to address situations where the rear-occupant space and rear-occupant's knees prevent the front seat from being placed in the UMTRI position.

Step 11 (11.1 and 11.2) were interchanged in sequence. (11.2 and 11.3) were updated to address the unnatural belt placement of the lower and upper portions of the safety belt.



## **Revisions to Version I**

In April 2012, the Version I procedure was revised in the following way:

Step 3 was updated to clarify the tibia-thigh angle when a pelvic and seatback gap exceeds 50 mm.

In August 2005, the Version I procedure was revised in the following ways:

Steps 8 and 9 were updated to address vehicles with adjustable seatbacks in rear outboard positions.

## POSITIONING PROCEDURE

The following rear-occupant seating procedure is intended for use with small female dummies. It also may be used as a guideline for seating midsize and large male dummies.

1. Adjust the rear seat, if applicable. Set the rear seat to the rearmost position in the fore-aft adjustment range, unless another position (mid-track or rearward) is specified by the test vehicle manufacturer. If a seat is vertically adjustable, place it in its full-down position. Set the seatback angle to 23 degrees, as measured by an H-point manikin torso angle, or to the angle specified by the manufacturer. If adjustable, the shoulder belt upper anchor should be initially placed at a position recommended by the manufacturer.
2. Place the dummy in the seat.
  - 2.1 On bucket or contoured seats, center the dummy on the seat cushion so that its midsagittal plane is vertical and coincides with the vertical longitudinal plane through the center of the seat cushion.
  - 2.2 On bench seats, center the dummy on the seat cushion so that its midsagittal plane is vertical and coincides with the vertical longitudinal plane through the center of the head restraint. If no head restraint exists, align the midsagittal plane evenly between the lap belt anchor points.

Align the pelvis so that it is parallel to the vehicle's lateral axis.
3. Place the lower legs at 90 degrees to the thighs and the feet on and/or level with the floor pan. Set the initial transverse distance between the longitudinal centerline of the dummy's knees approximately at 160–170 mm, with the thighs and legs of the dummy in vertical planes. If the driver seat, when positioned according to the UMTRI procedure (IIHS, 2022), contacts the rear-occupant's knees or feet when the lower legs are positioned at 90 degrees to the thighs and the rear seat track is adjustable, move the rear seat to the rearmost fore-aft position. If the rear seat track is not adjustable, then the driver seating position should be modified temporarily in order to conduct the rear-occupant seating procedure without interference.
  - 3.1 Push rearward on the dummy's knees to force the pelvis into the seat, so there is no gap between the pelvis and the seatback or until contact occurs between the back of the dummy's calves and the front of the seat cushion, without allowing the angle between the thighs and lower legs to change. If the back of the heels contact the seat structure first, preventing both the pelvis and the calves from contacting, continue pushing rearward on the dummy's knees to force the pelvis into the seat while allowing the angle between the thighs and lower legs to change just until there is no gap between the pelvis and the seatback or until contact occurs between the back of the dummy's calves and the front of the seat cushion.
4. Hold the dummy's thighs down and push rearward on the upper torso to maximize the dummy's pelvic angle.

5. Gently rock the upper torso relative to the lower torso laterally in a side-to-side motion three times through a  $\pm 5$ -degree arc (approximately 50 mm side to side) to reduce friction between the dummy and the seat.
6. In this and the following steps, the tibia-thigh angle will be dictated by the steps of the procedure and no longer needs to remain at 90 degrees or the final angle achieved in step 3. Rest the dummy's thighs against the seat cushion and ensure that the transverse distance between the longitudinal centerline of the dummy's knees is 160–170 mm, with the thighs and legs of the dummy in vertical planes.
7. Position the feet.
  - 7.1. Plantar flex the foot joints and move them rearward until the heels contact the floorpan or the back of the calves or the feet contact the seat/seat structure. Place the feet parallel to the floorpan. If the feet achieve maximum plantar flexion, rotate them just enough to not achieve maximum plantar flexion. After the initial positioning, it should be possible to lift the legs behind the ankles and, when slowly released, the legs should return to the original position. The upper and lower legs should have centerlines that are close to longitudinal and vertical planes, respectively.
8. Measure the dummy's pelvic angle. The angle should be set to  $20 \pm 2.5$  degrees for small female dummies and  $22.5 \pm 2.5$  degrees for midsize and large male dummies.
  - 8.1. If the dummy's pelvic angle is within the specified range, proceed to step 9.
  - 8.2. If the measured pelvic angle is below the specified range, complete the following steps:
    - 8.2.1. Hold the dummy's knees down to minimize movement of the feet and push rearward on the upper torso to maximize the dummy's pelvic angle. If the pelvic angle is within the specified range, proceed to step 9.
    - 8.2.2. If the pelvic angle is still below the specified range and the seatback is adjustable, adjust the seatback rearward one notch (or 2 degrees for infinitely adjustable seatbacks) and repeat steps 8.2.1 and 8.2.2 until the pelvic angle is within the specified range, or until the seatback is in the full-rearward position.
    - 8.2.3. If the driver seat was temporarily modified in step 3, proceed to step 9. If the driver seat was not modified in step 3 and the pelvic angle is still below the specified range or the seatback is not adjustable, lift the thighs and pelvis and move them forward (away from the seatback) the minimum amount necessary to achieve the correct pelvic angle. Then hold the dummy's thighs down and push rearward on the upper torso to maximize the dummy's pelvic angle. Repeat this until the pelvic angle is within the specified range or until

the knees/feet cannot be moved further forward without contacting the front seat. Proceed to step 9.

- 8.3. If the measured pelvic angle is above the specified range, complete the following steps:
  - 8.3.1 Hold the dummy's knees down to minimize movement of the feet (do not push the knees longitudinally towards the seatback) and rotate the torso forward, as shown in Figure 1, approximately 90 to 110 degrees with respect to horizontal, measured using tilt sensors mounted on dummy's thorax (An alternate method to measure this angle using CMM data instead of tilt sensors is described in the appendix). Doing this will push the pelvis rearward naturally and decrease the pelvic angle. Holding the dummy's knees down, slowly rotate the torso rearward until it is supported by the seatback. If the pelvic angle is within the specified range, proceed to step 9.
  - 8.3.2 If the pelvic angle is above the specified range, repeat step 8.3.1 up to a total of three times. If the pelvic angle remains above the specified range and the seatback is fixed, record the pelvic angle and proceed to step 9.
  - 8.3.3 If the seatback is adjustable, adjust the seatback forward one notch (or 2 degrees for infinitely adjustable seatbacks) and repeat step 8.3.1 for each notch until the pelvic angle is within the specified range or until the seatback is in the full-forward position. Proceed to step 9.

**Figure 1**  
**Example of torso rotation**



9. Measure the head transverse instrumentation platform angle. The anterior-posterior and medial-lateral angle should be level to within  $\pm 0.5$  degrees. Adjust the lower neck bracket to level the head in the anterior-posterior direction. If it is not possible to achieve the head level within  $\pm 0.5$  degrees and the seatback is adjustable, minimize the angle by moving the seatback one notch (or 2 degrees for infinitely adjustable seatbacks) at a time in the appropriate direction to achieve the head level, ensuring that the pelvic angle remains either within the specified tolerance or no further out of the tolerance than was achieved in step 8. If it is not possible to achieve both the head level and the specified pelvic angle, priority goes to achieving the pelvic angle within or as close as possible to the specified tolerance.
10. If the driver seat position was temporarily modified in step 3, reset the driver seat by first moving the rear-occupant's feet rearward until the back of the calves or feet contact the rear seat and then adjusting the driver seat longitudinally forward of the calculated UMTRI position (IIHS, 2022) just until there is no contact between the driver seatback and the rear-occupant's knees or feet. If there is room for the rear-occupant's feet to move forward after the driver seat has been positioned, they should be placed flat on the floorpan and beneath the front seat as far as possible without interference.

11. Place the seat belt around the dummy and fasten the latch.
  - 11.1 Remove all slack from the lap belt and pull all webbing out of the retractor just enough to not activate the automatic locking retractor (if equipped) and allow it to retract while holding the belt by the webbing and maintaining tension in the belt. Repeat this operation three times.
  - 11.2 Apply an estimated 8-18 Newton (2–4 pound) load to the lap belt by pulling the upper torso belt adjacent to the latch plate. The lap belt should lie as low as possible across the pelvis, touching the top of the thighs. If placing the belt so that it touches the tops of the thighs creates an unnatural belt position (e.g., gaps or hammocks across the abdomen), allow the belt to slide upward just until the belt lays smoothly and naturally across the abdomen, as shown in Figure 2.

**Figure 2**  
**Example of lap belt position**



- 11.3. The upper portion of the belt should lie flat on the dummy's chest. Pull the belt 50–100 mm from the chest and allow it to retract on its own. If the manufacturer's-recommended upper belt anchor position creates an unnatural belt placement (e.g., offset on the sternum (Figure 3A) or clavicle ), move the upper belt anchor in the appropriate direction until the belt lies naturally across the sternum and mid-clavicle, as shown in Figure 3B. If not adjustable, proceed to step 12.

**Figure 3**  
**Example of unnatural and natural shoulder belt position (frontal test)**



**Figure 3A.** Unnatural shoulder belt position



**Figure 3B.** Natural shoulder belt position

12. Position the dummy's arms and hands.

For dummies with half arms (SID-IIs, ES-2, WorldSID), adjust the upper arm to the stop position 45 degrees forward of the neutral (down) position.

For dummies with full arms (Hybrid III, THOR), bend and lower each upper arm until the elbow touches the seatback. Lower the hands, palm down onto the thigh, with the tip of the middle finger aligned with the longitudinal centerline of the thigh, as shown in Figure 4.

**Figure 4**  
**Hand placement for dummies with full arms**



## **REFERENCE**

Insurance Institute for Highway Safety. (2022). *Guidelines for using the UMTRI ATD positioning procedure for ATD and seat positioning (Version VI)*.

Insurance Institute for Highway Safety. (2023). *Moderate overlap crashworthiness evaluation 2.0 crash test protocol (Version I)*.

## APPENDIX: MEASURING THE TORSO ANGLE

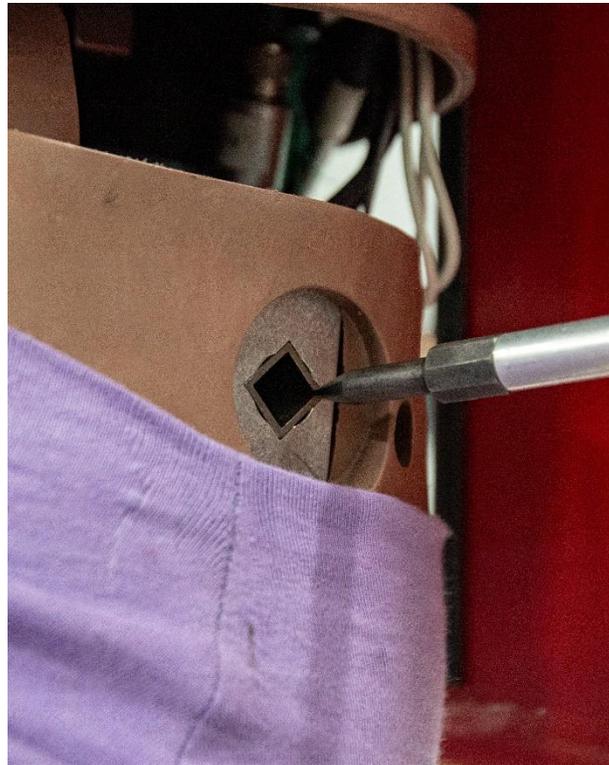
During the step 8.3.1, the torso angle is measured using tilt sensor (DTS tilt/positioning sensors 15108-00040 or similar) mounted on the rear of dummy's thorax. Alternatively, a CMM based method (equation 1) can be used instead of the tilt sensors. This method results in similar torso measures as the tilt sensors but estimates the torso angle by measuring the angle made by the line joining two points, the rear corner on the H-point tool insert location and the rear base of the neck along dummy centerline (as shown in figures 5a and 5b), with respect to horizontal. The CMM measures are recorded in the vehicle coordinate system (*Moderate overlap crashworthiness evaluation 2.0 crash test protocol (Version I) (IIHS, 2023)*).

$(x_1, y_1, z_1)$ : CMM location of rearward corner of the H – point tool insert location

$(x_2, y_2, z_2)$ : CMM location of base of the neck along dummy centerline

$$\text{Torso angle} = \begin{cases} \tan^{-1} \left( \frac{z_2 - z_1}{x_2 - x_1} \right), & \text{if } \theta < 90^\circ \\ 180 + \tan^{-1} \left( \frac{z_2 - z_1}{x_2 - x_1} \right), & \text{if } \theta > 90^\circ \end{cases} \quad (1)$$

**Figure 5a CMM point 1: Rear corner of the H-point tool insert location**



**Figure 5b CMM point 2: Rear base of neck along dummy centerline**

