



Shoulder Belt Comfort Evaluation Part B: Belt Routing Procedure

Section 1: Shoulder Belt Comfort Prediction

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To predict the comfort of safety belt systems based on shoulder belt routing.

1.2 Applicability. All of the safety belt restraint systems with a retracting shoulder belt.

1.3 Remarks. This evaluation is based on the measurement of shoulder belt routing relative to the Belt Restraint Technical Committee (BRTC) landmarks established on University of Michigan Transportation Research Institute (UMTRI) torso-based routing assessment tools. This is an objective evaluation whose measurements correlate to subjective ratings from the 1991 Comfort Survey performed by the Occupant Restraints group at GM's Safety Research and Development Laboratory; Milford Proving Ground. The result is a prediction of customer complaints based on the distance of the shoulder belt from the BRTC landmarks.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

SAE J826

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- 1991 Comfort Survey.
- Belt Restraint Technical Committee (BRTC).
- Computer graphics package (e.g., Computer Graphics System (CGS), Computer Aided Design (CAD), etc.).
- Coordinate Measuring Machine (CMM) manufacturer's instructions.
- Owner's Manual.
- Seating arrangement drawings showing H-point and Centerline of Occupant coordinates for desired seating locations.
- University of Michigan Transportation Research Institute (UMTRI).
- Vectoron CMM. (tbts.co.jp)
- Vehicle drawings.

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

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3.1.3 Any facility containing a Three Dimensional (3-D) Coordinate Measuring Machine (CMM) capable of measuring points to an accuracy of ± 0.5 mm within a vehicle interior compartment. The Vectoron CMM (see Appendix A, Figure A6) is an example of a recommended device because the flexibility of its robot-arm allows accurate measurement of points throughout the vehicle passenger compartment.

3.1.4 A facility capable of maintaining an ambient temperature sufficient to sustain the normal operating characteristics of the seat and restraint systems.

3.2 Equipment.

3.2.1 Test Equipment.

3.2.1.1 Three Dimensional (3-D) Coordinate Measuring Machine (CMM). See 3.1.3.

3.2.1.2 A 95th, 50th, and 5th percentile UMTRI torso-based Belt Routing Assessment Tools.

3.2.1.3 Seating arrangement drawings showing H-point and Centerline of Occupant coordinates for desired seating locations or a 3-D; H-point machine (see Appendix A, Figure A7) to determine these coordinates.

3.2.1.4 A 12 V power supply to operate power accessories (i.e., motorized belt restraint, guideloop or seat adjustments) if the vehicle electrical system is inoperative.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Vehicle. Vehicle or 3-D vehicle mock-up with the intended environment for safety belt system(s) to be evaluated including seating characteristics, belt anchorage locations, and any components which may affect belt routing or belt tension.

3.4 Test Time.

Calendar time: 6 h

Test hours: 4 h

Coordination hours: 2 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Level and stabilize the vehicle or 3-D vehicle mock-up to eliminate motion and to ensure the belt system operates per design intent.

4.1.2 Align the CMM coordinate system to the vehicle coordinate system according to the CMM manufacturer's instructions using only hard, fixed points on the surface of the vehicle or mock-up as references.

4.1.3 Determine coordinates for the H-point and Centerline of Occupant for all seating locations to be tested, using the seating arrangement drawings for the subject vehicle. If vehicle drawings are not available, use the 3-D; H-point machine to determine these coordinates by applying the procedure outlined in SAE J826. Adjust articulating seat contours (e.g., lumbar support, etc.) to the fully retracted position throughout the evaluation.

4.1.4 The following configurations represent the minimum conditions for a testing matrix. Other conditions should be tested as deemed necessary to ensure the proper routing for various sized occupants.

4.1.4.1 Use the 95th percentile belt routing assessment tool with the seat in the full rear position of its longitudinal adjustment. For seats that have vertical adjustment, test in the full down position.

4.1.4.2 Use the 50th percentile belt routing assessment tool with the seat in the mid position of its longitudinal adjustment. For seats that have vertical adjustment, test in the mid position.

4.1.4.3 Use the 5th percentile belt routing assessment tool with the seat in the full forward position of its longitudinal adjustment. For seats that have vertical adjustment, test in the full up position. The belt routing assessment tools are shown in Appendix A, Figure A4.

4.1.4.4 Position adjustable belt guide features according to manufacturer's instructions as described in the Owner's Manual. If no instructions are given, position the guides such that the belt routes midway between the neck and acromion landmarks on the routing assessment tool.

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4.1.4.5 Position adjustable head restraints according to manufacturer's instructions as they may influence the routing of the shoulder belt. If no instructions are given, position the top of the head restraint closest to the appropriate distance above the seat H-point as follows; 690 mm for the 95th, 658 mm for the 50th, 590 mm for the 5th, in the vehicle coordinates established in 4.1.2.

4.1.5 Torso Positioning.

Note: All specified measurements should be achieved to a tolerance of ± 3 mm.

4.1.5.1 With the selected Belt Routing Assessment Tool in the appropriate vehicle setup (see 4.1.4), align the midsagittal plane of the routing tool with the Centerline of Occupant coordinates for the seating position as determined in 4.1.3. Use the scribed line defining the median plane of the torso to check lateral positioning near the top and bottom of the routing assessment tool. Maintain this alignment throughout the evaluation.

4.1.5.2 Adjust the H-point of the assessment tool to a point 25 mm forward (i.e., subtract 25 mm from longitudinal coordinate) and 12 mm above (i.e., add 12 mm to vertical coordinate) the H-point coordinates derived in 4.1.3. Maintain this positioning throughout the evaluation.

4.1.5.3 Obtain the proper routing tool torso angle by locating the acromion landmark at the appropriate distance rearward of the H-point, see Standard Positioning (SP) as follows, in the vehicle coordinates established in 4.1.2. If the design seat back angle does not allow proper torso angle, position the acromion landmark according to:

$$P = SP - (7.6 \times (26.0 - DA))$$

Where:

Positioning (P): The positioning (in millimeters) of the acromion landmark rearward of the H-point.

SP: The standard positioning value for the acromion landmark; 201 mm for the 95th, 199 mm for the 50th, 180 mm for the 5th.

Design angle (DA): The design angle of the torso as given by the seating arrangement drawing or 3-D; H-point machine. Maintain the proper torso angle throughout the evaluation.

4.1.5.4 Obtain the proper routing tool lap angle by pivoting the adjustable lap section such that its spirit-level indicates level. Maintain the proper lap angle throughout the evaluation.

4.1.5.5 Align the torso in the longitudinal-lateral plane (plan view) by adjusting the torso such that the shoulder points on either side of the assessment tool have the same longitudinal coordinate. Maintain this alignment throughout the evaluation.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions.

4.3.1 Using the CMM, measure and record the coordinates of the neck, acromion and clavicle landmarks.

4.3.2 Route the safety belt over the assessment tool using the following procedure:

4.3.2.1 Extract enough belt webbing from the retractor spool(s) to route around the torso shell. While holding the webbing away from the torso, engage the latch plate in the buckle. Route the belt across the torso while allowing excess webbing to retract onto the spool(s). Be careful not to affect the positioning of the assessment tool while routing the belt. When extracting the belt from the spool(s), be certain not to engage cinching features not designed for normal occupant use (i.e., child restraint provisions, etc.) If comfort features that provide belt slack, reduced belt tension, or belt re-routing are to be evaluated, they should be engaged according to manufacturer's instructions.

4.3.2.2 The routing of the belt will be largely determined by the natural tendency of the belt to follow the shortest, straight line path from the latch plated to the guideloop or intermediate guide.

Route the belt on the torso shell midway between the neck and acromion landmarks and between the breasts.

Note: Adjustable features should be positioned according to 4.1.4.4 and 4.1.4.5.

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For belt systems with an articulating inboard buckle, allow the buckle to move to a position which most naturally accommodates proper lap belt routing (the lap belt should be positioned low on the pelvic region of the torso).

4.3.2.3 Rotate the torso about its pivot point through a (15 ± 2) degree arc repeatedly until routing stabilizes. Each oscillation should take no < 1.5 s to complete.

Note: Belt systems with a mechanical tension reduction feature (e.g., dual mode retractor, etc.) may require a decreased torso rotation angle to avoid unintended activation of the feature.

4.3.3 Verify the positioning of the torso as expressed in 4.1.5.

4.3.4 Using the CMM, measure and record the position of the centerline of the belt in the vehicle coordinate system.

4.3.5 Determine the minimum (perpendicular) distance between the belt centerline and the torso landmarks in the lateral-vertical plane (front view) and the longitudinal-lateral plane (plan view). This can be accomplished by using the features of a computer graphics package (e.g., Computer Graphics System (CGS), Computer Aided Design (CAD), etc.) or by using geometric equations. The average distance from the belt centerline to a landmark in the front and plan views is the basis for predicting shoulder belt routing complaints using Comfort Survey data.

Note: Only the path of the belt that is forward of the neck landmark should be used for determining the distance between the belt centerline and the torso landmarks. Using the belt path rearward of this point can lead to computational errors.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation.

5.3.1 Record pertinent test results on Appendix A, Data Sheet A1.

5.3.2 Shoulder Belt Routing Complaint Predictions (all calculations assume a nominal 50 mm belt width).

The predicted complaint level of a belt system based on shoulder belt routing, are determined from the measurements taken in 4.3.5 using the following correlation equations:

- Shoulder belt routing at clavicle: Percent complaints = $0.00667x_2 - 1.0333x + 42.0$ for $(-43 < x < 73)$.
- Shoulder belt routing at neck: Percent complaints = $-0.005x_2 - 0.895x + 34.354$ for $(-55 < x < 55)$.
- Shoulder belt routing at acromion: Percent complaints = $0.00140x_2 - 0.288x + 13.0$ for $(-40 < x < 66)$.

Where x is the average distance (in millimeters) from the belt centerline to the landmark as determined in 4.3.5.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

Acromion Landmark: A reference point on the surface of the routing torso named for its close proximity to the acromion, a bone in the shoulder (see Appendix A, Figures A1, A2 and A3).

Clavicle Landmark: A reference point on the surface of the routing torso named for its close proximity to the inboard uppermost surface of the clavicle bone (see Appendix A, Figures A1, A2 and A3).

Design Angle: The design angle of the torso as given by the seating arrangement drawing or 3-D; H-point machine.

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