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16. Abstract

The National Highway Traffic Safety Administration is considering upgrades to FMVSS No. 213 to include a side impact test for child restraint systems and to make the existing frontal impact test representative of current real world conditions. In order to determine the representative nature of the current FMVSS No. 213 sled bench assembly to the newer vehicle fleet and to develop a representative environment for the side impact test protocol, the agency contracted with Alpha Technology Associates Inc. (Alpha) to conduct a survey of rear seat geometry in newer vehicles. Accordingly, Alpha conducted a survey of 24 MY 2010 vehicles. In addition, Alpha surveyed the vehicle Lower Anchor and Tethers for Children (LATCH) systems to support the agency's efforts to address issues related to LATCH. This report summarizes the results of the measurements performed for the rear seating position in these vehicles.

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I. EXECUTIVE SUMMARY

The National Highway Traffic Safety Administration is considering upgrades to Federal Motor Vehicle Safety Standard (FMVSS) No. 213 to include a side impact test for child restraint systems and to make the existing frontal impact test representative of current real world conditions.[1] In order to determine the representative nature of the current FMVSS No. 213 sled bench assembly to the newer vehicle fleet and to develop a representative environment for the side impact test protocol, the agency contracted with Alpha Technology Associates Inc. (Alpha) to conduct a survey of rear seat geometry in newer vehicles. Accordingly, Alpha conducted a survey of 24 Model Year (MY) 2010 vehicles. In addition, Alpha surveyed the vehicle Lower Anchor and Tethers for Children (LATCH) systems to support the agency's efforts to address issues related to LATCH.

In 2003, an upgrade to FMVSS No. 213 was executed based on a survey conducted by the Naval Air Systems Command, Patuxent River (PAX River) of the geometry of rear seats in MY 2001 vehicles. In the current study, measurements were taken following a modified version of the procedure used by PAX River for its 2001 Vehicle Rear Seat Geometry Study.[2] Similar to the PAX River study, a Seat Geometry Measuring Fixture (SGMF) was used in this study to create a reference point on each vehicle rear seat. Measurements were taken with respect to point A (near the seat bight) on the SGMF for consistency. In addition to the rear seat geometry measurements, measurements and observations were made for the vehicles' lower anchor and tether systems, and for the vehicles' seat belt systems. This procedure was also performed on the current FMVSS No. 213, Economic Commission for Europe (ECE), and New Programme for the Assessment of Child restraint Systems (NPACS) test benches to permit a direct comparison of results to existing bench designs.

[1] Docket No. NHTSA-2009-0108-0001
[2] Docket No. NHTSA-02-11707-0009

II. BACKGROUND

In 2000, the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act mandated that the National Highway Traffic Safety Administration (NHTSA) initiate a rulemaking for the purpose of improving the safety of child restraints. As a result of this Act, the agency issued a Notice of Proposed Rulemaking (NPRM) to upgrade Federal Motor Vehicle Safety Standard (FMVSS) No. 213, *Child Restraint Systems*. Proposed revisions for the FMVSS No. 213 standard included: updating the bench seat used to dynamically test add-on child restraint systems (CRS), establishing a wider test corridor for the sled pulse, incorporating improved child test dummies, adding or revising injury criteria to assess CRS dynamic performance, and expanding applicability to child restraint systems recommended for use by children weighing up to 65 pounds.[3]

To ensure that an updated sled bench would reflect designs for the then-current fleet of passenger motor vehicles, the agency funded the Naval Air Systems Command, Patuxent (PAX) River to conduct a rear seat geometry study on Model Year (MY) 2001 vehicles. PAX collected rear seat geometry data including seat back angle, seat pan angle, seat pan length, tether anchor locations, child restraint anchorage system anchor locations, seat belt locations, and seat clearance measurements from 35 MY 2001 vehicles tested by NHTSA's New Car Assessment Program (NCAP).

The purpose of repeating PAX's 2001 study was to determine whether the current FMVSS No. 213 bench remains representative of the rear seats in today's modern vehicles and if an upgrade of the FMVSS No. 213 test bench should be considered. Measurements were collected not only for vehicle rear seats, but were also taken for vehicle armrests and windowsills in the event a side door structure design could be considered for inclusion into a future side impact dynamic test for FMVSS No. 213. Observations were also made for vehicle restraints, including components related to Lower Anchors and Tethers for Children (LATCH), as they also pertain to the FMVSS No. 213 test bench.

This report summarizes the results of the measurements performed for the rear seating positions in MY 2010 vehicles. This report also compares the data collected to dimensions taken from the Economic Commission for Europe (ECE) Regulation 44 and New Programme for the Assessment of Child-restraint Systems (NPACS) test benches.

III. METHODS

The rear seat measuring procedure used for this study was based on the methods developed by PAX and used in its study of MY 2001 vehicles. The procedure, in its entirety, is included as Appendix A. The study was performed for each unique rear seating position for 24 MY 2010 vehicles tested by NCAP. The subject vehicles were from frontal NCAP tests and were visually inspected to ensure there was no damage to either the rear seats or the rear seating compartment. The following rear seat measurements were made: seat back and seat pan cushion height, length, width, angle, and thickness; shoulder belt and tether anchor distances; shoulder belt and lower anchor spacing; rear seat clearance;

[3] Docket No. NHTSA-02-11707

windowsill dimensions; and armrest dimensions. Additionally, observations were made for the shoulder belt retractor, tether anchor, and lower anchor locations.[4]

Measurements were consistently taken using a Seat Geometry Measuring Fixture (SGMF), which was fabricated using two 2x4 wood blocks (600 mm x 88 mm x 38 mm) and a three inch hinge (See Figure 1 in Appendix A). The SGMF was positioned on the centerline of each unique rear seating position and measurements were taken with respect to point A on the SGMF (which was located at the center of the hinge, near the seat bight). The SGMF in the center seating position can be seen in Photo No. 1 of Appendix D. To directly relate measurements from this survey to dimensions from test benches that are currently in use or under development, the procedure was repeated for the current FMVSS No. 213 bench, as well as for the ECE and NPACS benches. Tables 1, 2, and 3 in Appendix C compare the measurements taken for each test bench to those of the surveyed vehicles.

IV. DATA RESULTS AND DISCUSSION

A. Seat Cushion Observations and Measurements

Observations and measurements were taken for the seat back and seat pan using point A on the SGMF as a reference point. When looking at the seat fabric for the 24 MY 2010 vehicles under study, 79% were found to be cloth and 21% were leather. The current FMVSS No. 213 bench has a vinyl fabric.

i. Seat Back

Seat back angle, height, cushion thickness, and width measurements were taken for 43 individual rear seating positions in 24 MY 2010 vehicles.[5]

Angle

The average seat back angle was 20°, from the vertical, with a standard deviation of 4°. The angle ranged from a minimum of 9° to a maximum of 28° (See Figure 1 in Appendix B). As shown in Table 1 of Appendix C, the current FMVSS No. 213 standard specifies a bench back angle of 20°. This is comparable to what PAX collected, an average seat back angle of 22°. Also, note that only one vehicle had an adjustable rear seat back and the other 23 vehicles had fixed rear seat backs. The current FMVSS No. 213 bench has a fixed seat back.

Height

The average seat back height was 688 mm with a standard deviation of 76 mm when the head restraint was included in the measurement. The range consisted of a minimum height of 540 mm and a maximum height of 849 mm (See Figure 2 in Appendix B). The average seat back height when the head restraint was not included in the measurement was 578 mm with a standard deviation of 60 mm. The range consisted of a minimum height of 450 mm and a maximum height of 778 mm (See Figure 3 in Appendix B). As indicated in Table 1 of Appendix C, the height of the current FMVSS No. 213 seat back (which does not have a head restraint) is 517 mm. Since PAX did not collect similar measurements

[4] LATCH is an abbreviation for Lower Anchors and Tethers for CHildren. It is appropriate to use LATCH when referring to both lower anchors and tether anchors.

[5] Individual rear seating positions are defined by each unique outboard position (positions 4 and 6) and the center seating position (position 5) if applicable.

during the 2001 study, no direct comparisons to older MY vehicles could be made. Of note, the range of seat back heights (measurements taken from the base to the top of the child restraint) for a selection of forward-facing child restraints available in 2010 was 587 mm to 724 mm, and the average was 683 mm (See Table 1 in Appendix E).

Cushion Thickness

The average outboard seat back cushion thickness was determined by taking measurements on the centerline of each unique outboard seating position at points A, B, C, D and E (if applicable) on the SGMF. The overall average seat back cushion thickness at the outboard seat was 76 mm with a standard deviation of 20 mm. The overall average seat back cushion thickness at the center seat was 76 mm with a standard deviation of 37 mm. The thicknesses at each point for both the outboard and center seating positions are illustrated in Figure 4 of Appendix B. Photo Nos. 23 and 24 of Appendix D provide an example of a seat back cushion that was removed from one of the surveyed vehicles. Points at which thickness measurements were collected are also shown.

The overall average seat back cushion thickness for both outboard and center seating positions was 76 mm with a standard deviation of 29 mm. The current FMVSS No. 213 seat back cushion thickness is 152.4 mm (See Table 1 in Appendix C). Since PAX did not collect similar measurements, no direct comparisons could be made to the 2001 study.

Width

The seat back width of each unique outboard and center seating position was measured at points A, B, C, D, and E (if applicable) on the SGMF. Measurements were performed twice, at each of the five points, once in which side bolsters were included, and once in which they were not. The measurements taken at each of the points in both the outboard and center seating positions can be found in Table 5 of Appendix C.

The overall average seat back cushion width for the outboard seating position when the side bolsters were included was 495 mm with a standard deviation of 63 mm. The overall average when the side bolsters were not included was 315 mm with a standard deviation of 57 mm. The overall average seat back cushion width for the center seating position when the side bolsters were included was 398 mm with a standard deviation of 32 mm. The overall average when the side bolsters were not included was 254 mm with a standard deviation of 58 mm. As the current FMVSS No. 213 bench has two seating locations, it was also of interest to determine the total width of the outboard and center seating positions in the subject vehicles. The overall averages for the outboard and center seating positions (including the side bolsters) were compiled to obtain a "total" width of 893 mm with a standard deviation of 65 mm. The "total" width (not including the side bolsters) was 569 mm with a standard deviation of 64 mm. PAX did not collect seat back width measurements for either the outboard or center seating positions. Consequently, no direct comparisons to the 2001 study could be made. The current seat back width of the current FMVSS No. 213 bench was measured to be 813 mm.

ii. Seat Pan

Measurements pertaining to the seat pan angle, length, cushion thickness, width, and height above the floor were taken for 43 individual seating positions in the 24 MY 2010 vehicles.

Angle

The average seat pan angle was 13° with a standard deviation of 4°. The angle ranged from a minimum of 7° to a maximum of 23° (See Figure 5, Appendix B). As shown in Table 2 of Appendix C, this is comparable to what PAX collected, an average seat pan angle of 15°. The current FMVSS No. 213 test bench specifies a seat pan angle of 15°.

Length

The average seat pan length was 406 mm with a standard deviation of 38 mm and there was a maximum of 514 mm and minimum of 330 mm (See Figure 6 in Appendix B). As indicated in Table 2 of Appendix C, the current FMVSS No. 213 seat pan length is 416 mm. PAX recorded an average seat pan length of 461 mm with a standard deviation of 46 mm; this is not comparable to the current vehicle measurements.

Cushion Thickness

Many more points were measured for the seat pan cushion thickness than for the seat back cushion. Measurements were collected at points A, B, C, and D on the centerline of all unique seating positions as well as on parallel lines, spaced at 50 mm intervals until the edge of the seat was reached to the left and right (See Figure 7 in Appendix B and Photo Nos. 25 and 26 in Appendix D). The average outboard seat pan cushion thicknesses on the centerline at points A, B, and C were: 79 mm with a standard deviation of 20 mm, maximum of 124 mm and a minimum of 48 mm; 80 mm with a standard deviation of 22 mm, maximum of 113 mm and a minimum of 32 mm; and 94 mm with a standard deviation of 48 mm, maximum of 192 mm and a minimum of 26 mm, respectively. There was only one vehicle that had a seat pan length which extended to point D; the seat pan cushion thickness at that point was 70 mm. The measurements taken on the parallel lines that intersect the perpendicular lines through points A, B, C, and D for the outboard seating position can also be found in Figure 7 of Appendix B.

As shown in Figure 8 of Appendix B, the average seat pan cushion thicknesses on the centerline at points A, B, and C for the center seat were: 79 mm with a standard deviation of 23 mm, maximum of 119 mm and a minimum of 28 mm; 96 mm with a standard deviation of 32 mm, maximum of 153 mm and a minimum of 40 mm; and 109 mm with a standard deviation of 48 mm, maximum of 209 mm and a minimum of 56 mm, respectively. The measurements taken on the parallel lines that intersect with the perpendicular lines through points A, B, and C can also be found in Figure 8 of Appendix B (See Photo No. 25 of Appendix D as well). As the length of the seat pan in the center seating position did not extend beyond point C in any vehicles, there were no measurements taken at points D and E.

As shown in Table 7 of Appendix C, the overall average seat pan cushion thickness was 87 mm with a standard deviation of 39 mm for the outboard seating position, and was 95 mm with a standard deviation of 40 mm for the center seating position. The overall average seat pan cushion thickness for both seating positions was 90 mm with a standard deviation of 40 mm. The current FMVSS No. 213 test bench seat pan cushion has a thickness of 152.4 mm (See Table 2 in Appendix C). A comparison could not be made to PAX's 2001 study, as PAX did not collect this measurement.

Width

The seat pan width of each unique outboard and center seating position was measured at points A, B, C, and D (if applicable) on the SGMF. Since the length of the seat pan did not extend beyond point D in either seating position in any of the vehicles, there were no measurements taken at point E. Measurements were performed twice at each of the four SGMF points, once in which side bolsters were included and once when they were not. The measurements taken at each of the points in both the outboard and center seating positions can be found in Table 6 of Appendix C.

The overall average seat pan cushion width for the outboard seating position when the side bolsters were included was 506 mm with a standard deviation of 48 mm. The overall average when the side bolsters were not included was 327 mm with a standard deviation of 41 mm. The overall average seat pan cushion width for the center seating position when the side bolsters were included was 418 mm with a standard deviation of 105 mm. The overall average when the side bolsters were not included was 268 mm with a standard deviation of 63 mm. As mentioned previously in relation to the seat back cushion width measurements, it was of interest to determine the total width of the outboard and center seating positions in the subject vehicles. Accordingly, the overall averages for the outboard and center seating positions (including the side bolsters) were compiled to obtain a "total" width of 924 mm with a standard deviation of 77 mm. The "total" width (not including the bolsters) was 595 mm with a standard deviation of 60 mm. PAX did not collect measurements of the seat pan width for neither the outboard nor center seating positions. Consequently, no direct comparisons to the 2001 study could be made. The current FMVSS No. 213 seat pan bench width was measured to be 825 mm.

Height Above Floor

The distance from the lip of the underside of the seat pan to the floor was measured for each vehicle to find the average seat pan cushion height. As shown in Table 2 of Appendix C, it was found that in the outboard seating position, the average height was 211 mm with a standard deviation of 37 mm. For the center seating position, the average height was 134 mm with a standard deviation of 66 mm. The outboard seating position had a maximum seat pan height of 260 mm and a minimum height of 130 mm. The center seating position had a maximum seat pan height of 290 mm and a minimum height of 40 mm. The overall (combined) average seat pan height was 177 mm with a standard deviation of 64 mm, a maximum of 290 mm, and a minimum of 40 mm. PAX did not collect measurements of the distance from the lip of the underside of the seat pan to the floor. Thus, no direct comparison to the 2001 study could be made. The current FMVSS No. 213 bench has a seat pan height of 286 mm above the floor of the sled, but no simulated vehicle floor structure exists.

B. Seat Belt Observations and Measurements

Observations and measurements were made for the seat belt retractor, latchplate, shoulder belt, and lap belt on 43 individual seating positions in the 24 MY 2010 vehicles.

i. Belt Retractor and Latchplate

It was observed that all of the retractor types were switchable and contained the retractor mechanism in the shoulder belt. In addition, it was found that all of the latchplates were sliding.

ii. Shoulder Belt

Figure 9 of Appendix B shows that overall, the shoulder belt was observed to be predominantly mounted on the package (hat) shelf (37%) or side post (35%). In the outboard seating position, the shoulder belt was only mounted on the side post (62%) and package (hat) shelf (38%). In the center seating position, the shoulder belt was mounted in various locations including the package (hat) shelf (37%), seat (37%), roof (21%), and rear wall (5%).

Measurements were also gathered on the shoulder belt anchor location in the fore-aft (x-plane), lateral (y-plane), and vertical (z-plane) directions for the 43 individual seating positions. All measurements were reported from point A on the SGMF. The overall average aft, lateral, and vertical distances for the outboard and center seating positions, as shown in Table 9 of Appendix C, was 350 mm with a standard deviation of 118 mm, 247 mm with a standard deviation of 57 mm, and 581 mm with a standard deviation of 72 mm, respectively. The ranges of these measurements were correspondingly 155 mm to 618 mm, 179 mm to 457 mm, and 442 mm to 825 mm. The values for these measurements at the outboard and center seating positions are also individually listed in Table 8 of Appendix C.

As indicated in Table 3 of Appendix C, the location of the shoulder belt on the current FMVSS No. 213 test bench in the aft, lateral, and vertical directions as measured from point A on the SGMF are 350 mm, 385 mm, and 690, respectively. PAX recorded average aft, lateral, and vertical shoulder belt distances of 295 mm with a standard deviation of 122 mm, 247 mm with a standard deviation of 81 mm, and 632 mm with a standard deviation of 80 mm, respectively, for the MY 2001 vehicles.

iii. Lap Belt

This section addresses the distance between lap belt anchors for 43 individual seating positions. Measurements are provided separately for the outboard and center seat due to a significant difference in the size of the seating positions. For the outboard seating position, the average distance was 450 mm with a standard deviation of 36 mm, and for the center seating position, the average distance was 356 mm with a standard deviation of 60 mm. Ranges for the outboard and center seating positions were 390 mm to 515 mm and 232 mm to 455 mm, respectively. The average overall distance between lap belt anchors for both seating positions was 407 mm with a standard deviation of 67 mm. Data for individual vehicles is shown in Figure 10 of Appendix B.

As shown in Table 3 of Appendix C, the lap belt anchor distance for the outboard seating position on the current FMVSS No. 213 bench is 427 mm; it is 400 mm for the center seating position. PAX recorded an average lap belt anchor distance of 433 mm overall (for both outboard and center seating positions) and also noted that the average lap belt anchor distance for the center seating position was 392 mm. PAX did not record an individual measurement for the outboard seating position.

C. Lower Anchor and Tether Anchor Observations and Measurements

For 43 individual seating positions, observations and measurements were made relative to: lower anchor and tether anchor locations; labeling, visibility, and accessibility of lower anchors and tether anchors; distance from the center of the seating position to the lower anchors; distance between lower anchors; lower anchor interference with belt anchors; and depth, angle, and ease of connection of the lower anchors. Additional observations were made for vehicles having designated lower anchors in the

center seating position, and for vehicles permitting the creation of center LATCH positions by allowing the sharing of one or more inboard lower anchors from the outboard LATCH positions.

i. Tether Anchors

Location

Tether anchors were present in all of the 43 seating positions studied. Overall, as depicted in Figure 13 of Appendix B, the study showed that 45% of the tether anchors were found on the rear shelf location, 40% were found on the top, mid, and bottom of the seat back, 10% were located on the roof, and 5% were observed in another location. It was also noted that the location of the tether anchor varied depending on the seating position and type of vehicle.

Figures 11 and 12 of Appendix B, respectively, show the apparent differences in the location of the tether anchor when looking at the data for the outboard and center seating positions individually. The majority of the tether anchors were located on the rear shelf and on the bottom or middle of the seat back for the outboard seating position. For the center seating position, the majority of the tether anchors were located on the rear shelf, the top of the seat back, or the roof.

When looking at the data for each type of vehicle (passenger car, truck, or multi-purpose vehicle (MPV)), there was a prominent difference in the location of the tether anchors. Tether anchors were predominantly found on the rear shelf in passenger cars, whereas for trucks and MPVs, the tether anchors were found primarily on the seat back. The frequency of each location for each type of vehicle can be found in Table 10 of Appendix C.

In order to obtain a quantitative representation of the tether anchor location in the vehicle, a measurement was taken from the center of the tether anchor, where the tether clip is attached, to point A on the SGMF. The measurement was taken twice, once routed over the head restraint for 39 seating positions and once under the head restraint for 31 seating positions. Table 11 of Appendix C shows that the average distance measured when routed over the head restraint was 1067 mm with a standard deviation of 194 mm. The distances measured ranged from a maximum of 1693 mm to a minimum of 760 mm. The average distance when routed under the head restraint was 892 mm with a standard deviation of 228 mm. The distances measured ranged from a maximum of 1660 mm to a minimum of 108 mm.

Measurements were also taken to gauge the average length of tethers seen for a selection of forward-facing child restraints available in 2010. The average maximum tether length for forward-facing CRSs available in 2010 was measured as 1407 mm, and the average minimum tether length was measured as 141 mm (See Table 1 in Appendix E). These tether lengths ranged from an absolute maximum of 2896 mm to an absolute minimum of 64 mm. To determine whether CRS tethers were of sufficient length to attach to the tether anchors in today's vehicles, it was necessary to adjust the measured CRS tether lengths to reflect the additional distance from where the tether feeds out of the CRS back to the bottom of the CRS. It was also then necessary to subtract the height of the lower leg of the SGMF from this adjusted tether length so that, similar to the vehicles' tether anchor distances, the adjusted CRS tether lengths would also be referenced from point A on the SGMF. Adjusting the measured CRS tether lengths in this manner permitted a one-to-one comparison to the tether anchor distance measurements

recorded for the vehicles. Tether lengths (and adjusted tether lengths) for individual child restraints surveyed can be seen in Table 2 of Appendix E.

Comparing the tether anchor location distance measurements (when taken both over and under the head restraint) to the adjusted CRS tether lengths for MY 2010 child restraints, shows that the range for the maximum adjusted tether lengths, 3315 mm (max.) to 1473 mm (min.), does not completely meet the maximum tether anchor location distances for the surveyed vehicles when measurements were taken both over and under the head restraint, 1693 mm and 1660 mm, respectively. As shown, CRSs having tethers that extend only to a maximum adjusted length of 1473 mm, will not permit attachment in those vehicles having the maximum tether anchor location distances of 1693 mm and 1660 mm. Furthermore, the range for the minimum tether lengths, 730 mm (max.) to 559 mm (min.), does not completely meet the minimum tether anchor location distances for the surveyed vehicles when measurements were taken under the head restraint, 108 mm. The data suggests that it will not be possible to install a CRS having a minimum tether length such that it will be sufficiently tight in the vehicle having the minimum tether anchor location distances of 108 mm, as this distance is shorter than the shortest possible tether length for the related CRS. It is likely, however, that this same CRS could be installed tightly in this same vehicle if the tether was routed over the head restraint instead of under the head restraint.

Labeling, Visibility, and Accessibility

Of the 43 seating positions, 88% of the tether anchors were labeled with the ISOFIX tether icon (See Photo No. 2 in Appendix D). To determine the visibility of the tether anchor, observations were made to distinguish whether or not the tether anchor was exposed. It was found that 33% of tether anchors were exposed and 67% were not exposed (unexposed tether anchors had a plastic cover over the anchor).

To determine the accessibility of the tether anchor, three classifications were established: direct access, easy access, and difficult access. These classifications were defined as requiring no steps, one step (lifting the plastic tether anchor cover), and multiple steps to access the tether anchor (such as folding down the vehicle seat and lifting the plastic cover), respectively. Observations revealed that 63% of the tether anchors were easily accessible, 32% of the tether anchors were directly accessible, and 5% were considered difficult to access. Examples of the different accessibility classifications for the tether anchors can be seen in Photo No. 3 through Photo No. 5 in Appendix D.

ii. Lower Anchors

Dimensions and Location

Measurements were taken to determine the anchor bracket width (measurements taken with respect to the outside of the anchor bracket), distance between the center of one anchor to the center of the other anchor, and distance between the center of one anchor to the centerline of the seat for each allowable LATCH seating position. Allowable LATCH positions included designated outboard LATCH positions, designated center LATCH positions, shared center LATCH positions, and created center LATCH positions. Similar measurements were also taken for created center LATCH positions that were not permitted by the vehicle manufacturer. (See Photo No. 16, 17, and 18 of Appendix D for owner's manual examples of instructions for use of LATCH in the center seating position.) Values for the

measurements recorded are reported in Table 4 of Appendix C. The measurements are also depicted visually in Photo No. 6 and Photo No. 7 of Appendix D.

For designated outboard LATCH positions, measurements were taken for the two lower anchors which were designated solely for an outboard LATCH seating position. Of the 24 vehicles surveyed, each vehicle had designated lower anchors in both outboard seating positions.[6] The average anchor bracket width for the right anchor was 45 mm with a standard deviation of 8 mm and the average anchor bracket width for the left anchor was 46 mm with a standard deviation of 9 mm. The average distance from the center of the right anchor to the center of the left anchor was 281 mm with a standard deviation of 32 mm and a range from 260 mm to 420 mm. The average distance from the center of the right anchor to the centerline of the seat was 132 mm with a standard deviation of 25 mm and the average distance from the center of the left anchor to the centerline of the seat was 141 mm with a standard deviation of 31 mm.

For designated center LATCH positions, measurements were taken on the two lower anchors which were designated solely for the center LATCH seating position. Of the 24 vehicles surveyed, 4% (one vehicle) had a pair of lower anchors designated for the center seating position. The anchor bracket width for the right and left anchors was 50 mm. The distance between the centers of the right anchor and left anchor was 290 mm. The distance from the center of the right anchor to the centerline of the seat was 148 mm and the distance from the center of the left anchor to the centerline of the seat was 142 mm.

For shared center LATCH positions, measurements were taken for one lower anchor that was designated solely for the center LATCH seating position and one inboard lower anchor from an outboard LATCH position. Of the 24 vehicles, 8% (two vehicles) permitted the use of one designated center lower anchor and one shared outboard lower anchor to create a center LATCH position.[7] The average anchor bracket width for the right and left lower anchors was 66 mm with a standard deviation of 11 mm, and 57 mm with a standard deviation of 10 mm, respectively. The average distance between the centers of the anchors was 285 mm with a standard deviation of 1 mm and range from 284 mm to 285 mm. The average distance from the center of the right anchor to the centerline of the seat was 128 mm with a standard deviation of 18 mm and the average distance from the center of the left anchor to the centerline of the seat was 174 mm with a standard deviation of 54 mm.

For created center LATCH positions, measurements were taken on the inboard anchors from both outboard LATCH positions to create a center LATCH position. Of the 24 vehicles, 8% (two vehicles) allowed the use of the inboard anchors from the outboard LATCH positions to form a center LATCH position. The average anchor bracket width for the right and left lower anchors was 48 mm with a standard deviation of 1 mm. The average distance between the centers of the lower anchors was 360 mm with a standard deviation of 85 mm and range from 300 mm to 420 mm. The average distance from the center of the right anchor to the centerline of the seat was 167 mm with a standard deviation

[6] Only one outboard LATCH position was surveyed per vehicle unless the two outboard LATCH positions were not symmetrical.

[7] At any time, only one CRS was permitted to be attached to any one lower anchor.

of 17 mm and the average distance from the center of the left anchor to the centerline of the seat was 147 mm with a standard deviation of 6 mm.

As expected, these measurements are comparable to the specifications outlined in the FMVSS No. 225, *Child Restraint Anchorage Systems*. The specified anchor bracket width is 25-60 mm; the center to center anchor bracket distance is 280 mm.[8]

As mentioned previously, measurements were also collected for created center LATCH positions that were otherwise prohibited by vehicle manufacturers. As shown in Table 4 of Appendix C, the average distance between the lower anchors for created center LATCH positions that were prohibited by vehicle manufacturers was 438 mm with a standard deviation of 109 mm and a range from 270 mm to 675 mm. This distance is much greater than the average distance measured between anchors for all allowable center LATCH positions (designated center, shared center, and allowable created center), 316 mm with a standard deviation of 52 mm. The average distance between lower anchors for all center LATCH positions, be they prohibited or allowable, was 416 mm with a standard deviation of 111 mm and a range from 270 mm to 675 mm. As mentioned previously, the average distance between lower anchors in designated outboard LATCH positions was 281 mm with a standard deviation of 32 mm and a range from 260 mm to 420 mm. The overall average distance between lower anchors for both outboard and center LATCH positions (regardless of whether a created center LATCH position was prohibited) was 343 mm with a standard deviation of 105 mm.

Interference with Belt Anchors

The findings show that the average distance between lower anchor brackets (from center to center) in outboard LATCH positions, 281 mm, falls within the average distance between the lower lap belt anchors for outboard seating positions, 448 mm. Similarly, the average distance between designated, shared, and allowable created center lower anchor brackets, 316 mm, is within the average center distance between the lower lap belt anchors, 356 mm. However, it was observed that 42% of the 24 vehicles had potential for interference between the belt stalk and lower anchors.

Interference was determined by attaching the child restraint lower anchor connectors to the vehicle lower anchors and visually inspecting the overlap between the belt stalks, shoulder/lap belt webbing, and child restraint lower anchor connectors. For such instances in which interference occurred when the CRS connectors were attached to a pair of designated lower anchors in the outboard seating position, the lap/shoulder belt for the center seating position was either hard to access or it intersected the lower anchor connection for the outboard LATCH position. Interference also occurred when the lower anchors from the outboard LATCH positions were used to create a center LATCH position even when it was permitted by the vehicle manufacturer. In such instances, the created center LATCH position caused potential obstruction between the seat belt and belt buckle stalk for the outboard seating positions (See Photos No. 9 and 10 in Appendix D). For cases in which the vehicle owner's manuals prohibited an occupant in the center seat when the lower anchors in the outboard seating position(s) were in use, interference was not documented.

[8] Docket No. 98-3390, Notice 2

Depth

Vertical measurements were taken for each lower anchor in individual seating positions. Averages are included in Table 12 of Appendix C. For the outboard position, the average vertical distance from the right anchor to point A on the SGMF was 23 mm, and the average vertical distance from the left anchor to point A was 21 mm. For the center position, the average vertical distance from the right anchor to point A was 12 mm, and the average vertical distance from the left anchor to point A was 11 mm. The overall anchor depth was 21 mm with a standard deviation of 16 mm. The average vertical distances for the anchors in the outboard seating position were inconsistent with the anchors in the center seating position. It was observed that the pair of lower anchors for the center seating position was significantly closer to point A than the pair of anchors for the outboard seating position.

Angle

The angle of the lower anchors was reported from the horizontal plane for each lower anchor in each individual seating position. As indicated in Table 12 of Appendix C, the average angle of the right anchor in the outboard position was 21°, and the average angle of the left anchor in the outboard position was 20°. The average angle of the right anchor in the center position was 44°, and the average angle of the left anchor in the center position was 48°. The overall average angle of the lower anchors was 23° with a standard deviation of 20°. It can be concluded that there is no consistency in the angles between anchors for a given seating position (See Photo No. 8 in Appendix D). For the lower anchors which angled downward, it was more difficult to connect the child restraints using LATCH because the lower anchors were below the seat cushion.

Labeling and Ease of Connection

The type of labeling for the lower anchors was also observed. Of the 24 vehicles, 23 had lower anchors that were labeled with the ISOFIX lower anchor icon (See Photo No. 12 in Appendix D). This icon was most often found on a plastic dot or tag, or was printed on a plastic cover or flap. It was apparent that the lower anchors were most commonly labeled using a plastic dot. The plastic dot is 15 mm in diameter and was located on the seat back an average of 64 mm above the lower anchor brackets. As expected, this is comparable to the specification for lower anchor labeling in FMVSS No. 225. As shown in Figure 14 of Appendix B, observations showed that 87% of the vehicles were labeled using a plastic dot, 9% were labeled using a printed diagram on a plastic cover, and 4% were labeled using a tag. Examples of each type of label can be seen in Photo Nos. 13, 14, and 15 of Appendix D.

Four types of CRS connectors were used to determine the ease of connection to the vehicle lower anchors in each seating position. The types of connectors were the SureLATCH®, push button, and two different sizes of hooks. Photos and dimensions of these lower anchor connectors can be seen in Photo No. 19 through Photo No. 22 in Appendix D. Overall, no one type of connector was found to permit easier attachment than the others.

D. Windowsill Dimensions

Windowsill dimensions were collected for the 24 MY 2010 vehicles to determine the lateral and vertical location of the windowsill in relation to the centerline of the outboard seat as measured from the SGMF. Measurements taken are shown in Figure 15 of Appendix B. Measurements were taken from the top of the windowsill along the corresponding points A, B, C, D and E on the SGMF. The overall average lateral

distance was 399 mm with a standard deviation of 29 mm and a range from 297 mm to 478 mm. The overall average vertical distance was 440 mm with a standard deviation of 77 mm and a range from 225 mm to 600 mm. The average measurements collected at points A, B, C, D and E are shown in Table 13 of Appendix C.

E. Armrest Dimensions

Armrest dimensions were collected in the 24 MY 2010 vehicles to determine the length, height, thickness, and also the lateral and vertical location of the armrest in relation to the centerline of the outboard seat as measured from the SGMF. Measurements taken are shown in Figure 15 of Appendix B. Because of the wide variation in armrest designs (incorporated door handles, door panels, cup holders, and speakers), it was difficult to collect consistent measurements. Applicable measurements were taken for both the top and bottom of the armrests along the corresponding points A, B, C, D, and E on the SGMF.

As shown in Table 16 of Appendix C, the overall (combined top and bottom) average lateral distance for the armrest was 311 mm with a standard deviation of 31 mm and a range from 177 mm to 390 mm. The overall average vertical distance was 136 mm with a standard deviation of 69 mm and a range from 40 mm below the SGMF to 309 mm above. The overall average width of the armrest was 52 mm with a standard deviation of 29 mm and a range from 0 mm to 152 mm. The average height was 64 mm with a standard deviation of 33 mm and a range from 0 mm to 158 mm. The overall average length of the armrest was 487 mm with a standard deviation of 141 mm and a range from 160 mm to 730 mm. The average angle along the top of the armrest was 3° with a standard deviation of 2° and a range from 0° to 6°. The averages for the top and bottom of the armrest are shown independently in Tables 14 and 15 of Appendix C.

F. Rear Seat Clearance

Rear seat clearance measurements were taken for a separate set of 20 MY 2010 vehicles[9]. It was necessary to take these measurements separately because the frontal NCAP vehicles used for the aforementioned rear seat geometry measurements had inoperable passenger seat tracks and seat back adjustments. As it was desirable to take the clearance measurements with the front passenger seat in the rearmost position, and the seat back adjusted to the nominal riding position as well as the most upright position, it was necessary that the front passenger seat track and seat back be operable.

For each vehicle, a longitudinal measurement was made from a point located 572 mm[10] vertically above point A on the SGMF to the back of the front passenger seat back when it was set to the two seat back recline angles mentioned. The average longitudinal distance measured when the seat back was reclined in its nominal riding position was 457 mm with a standard deviation of 74 mm. The average longitudinal

[9] Toyota Prius, Toyota Venza, Toyota Highlander, Toyota RAV 4, Toyota Camry, Kia Optima, Kia Soul, Kia Sportage, Kia Forte, Kia Sorento, Ford Mustang Convertible, Ford F150 Crew Cab, Ford Edge, Ford Flex, Ford F250, Dodge Charger, Chrysler Sebring, Acure RL, Hyndai Elantra, Honda Pilot.

[10] This distance represents the typical location of a child's head when seated in the CRS. It was calculated by summing the average CRS seat height to the average seating height of a 3 year-old, minus the distance from the top of the head to the forehead.

distance measured when the seat back was in its most upright position was 687 mm with a standard deviation of 90 mm.

Similar measurements were collected in the PAX study (2001). In that study, however, the longitudinal distance was taken from the vertical plane at the rear seat bight to the back of the front passenger seat when it was positioned in the mid fore-aft position with the seat back reclined to the nominal upright position. The longitudinal average obtained during that study was 712 mm with a standard deviation of 87 mm. A schematic of each method can be seen in Figure 16 of Appendix B. Because the measurements were taken differently, it is not feasible to directly compare the results of this study with those from the PAX study.

Rear seat clearance is not considered a primary measurement when determining the geometry of the test bench, but is an important parameter to consider when establishing the overall crash envelope available for the CRS occupant. FMVSS No. 213 head excursion limits are based on a horizontal measurement taken from the Z-point of the test bench; 813 mm for untethered seats and 720 mm for tethered seats. Therefore, in order to compare the data collected in this study to FMVSS No. 213 head excursion limits, the limits must be reduced by 152 mm to account for the horizontal distance from the Z-point to point A on the SGMF. The corresponding reduced FMVSS No. 213 head excursion limits are then 661 mm for untethered CRS and 568 mm for tethered CRS. The average clearance measured when the front seat back was in the nominal riding position, 457 mm, is significantly less than both tethered and untethered excursion limits once reduced. Recall, however, that this measurement was collected when the front seat was set to the rearmost seating position. The average seat track length was 240 mm with a standard deviation of 32 mm. Adjusting the average clearance measurement recorded for the nominal riding position to reflect a mid-track position results in an adjusted average clearance measurement of 577 mm. This adjusted clearance measurement is comparable to the reduced head excursion limit for tethered CRS. The average clearance measured when the front seat back was in the upright position, 687 mm, is greater than the maximum permissible head excursion.

V. ALTERNATIVE BENCHES

A comparison between the measurements for the current FMVSS No. 213, ECE, and NPACS test benches is provided in Tables 1, 2, and 3 of Appendix C for the seat back, seat pan, and belt anchor locations, respectively. These measurements were taken in an effort to support the agency in evaluating the merits of other existing benches.

APPENDIX A

Rear Seat Geometry Measurement Procedure

Vehicle Rear Seat Geometry Study

This study is intended to gather seat and restraint geometry data from the rear outboard and rear center occupant positions of model year 2010 vehicles tested under the New Car Assessment Program (NCAP). This data will be used by the Department of Transportation for modeling and to develop a new seat fixture for Federal Motor Vehicle Safety Standard (FMVSS) No. 213. The data collected are critical to insure that the seat fixture developed reasonably represents the occupant positions of contemporary vehicles frequently used to transport children.

Some of the methods may not appear to be the most conventional, but have been developed to minimize variation by both the specifics of the seat design and the person taking the measurements. These methods were revised from the "Technical Report on the FMVSS 213 Crash Pulse and Test Bench Analysis" by William Glass of the Naval Air Warfare Center Aircraft Division in Patuxent River, MD.

Please record all distance measurements in millimeters (mm).

Materials Needed

To conduct this study the following tools are required:

- Seat Geometry Measuring Fixture (SGMF) – Instructions on fabrication to follow
- 450 millimeter long flat ruler
- Standard tape measure
- Inclinometer
- Calipers
- An adjustable square
- Two 24 inch levels with ruled edge

Fabrication of the Seat Geometry Measuring Fixture

Build a SGMF fixture as follows:

1. Acquire the following materials
   - 2 lengths of standard 2"x 4" lumber, each 600 mm long
   - One 3 inch wide hinge (with appropriate attaching hardware)
2. Draw a centerline on each 2x4 on the nominal 4 inch wide side the full 600 mm.
3. Starting at one end, mark each 2x4 in 150 mm increments (number these 0, 150, 300, 450).
4. Mark an "A" at point 0
5. Mark a "B" at point 150
6. Mark a "C" at point 300
7. Mark a "D" at point 450
8. Mark a "E" at point 600
9. Assemble the 2 lengths of 2x4 so that the hinge joins the two 2x4's at the zero (0) or "A" point and so that the increments are on the inside of the boards.

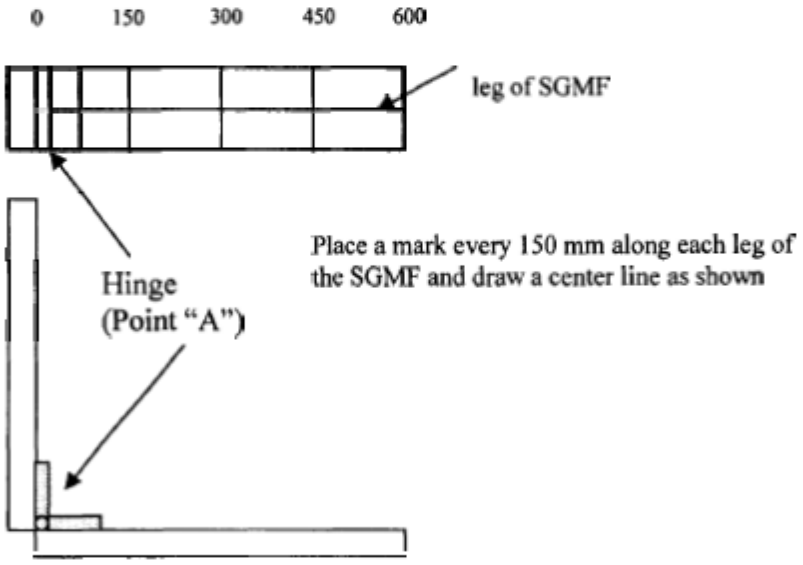


Figure 1
Seat Geometry Measuring Fixture SGMF

Separate data sheets are provided at the end of this document that should be reproduced and used to record the required data at each occupant position being measured.

Vehicle Information

First, fill in the sections of the data table related to basic vehicle information and record the exact dimensions of the 2" x 4" sections of the SGMF.

Photographs

Please take the photographs listed below. It may be easier to take these as the measurements are being taken. If appropriate, the text includes a note when a photo should be taken. Include a set of these photos with the appropriate data submissions.

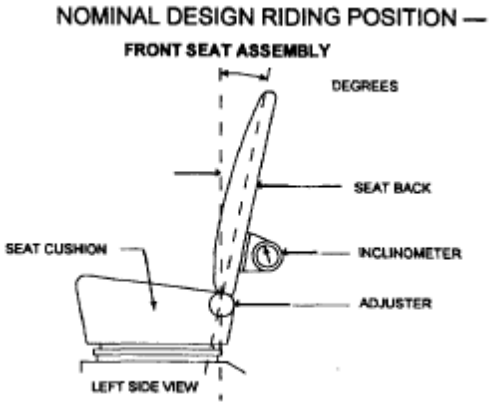
* An asterisk notes that a photograph should be taken.

1. Front and side view of each seat position to be measured.
2. Any warning or instruction about the use of the restraint system with a child restraint.
3. Front view of each seat position that is being measured with the SGMF installed.
4. The latchplate and buckle assembly in a buckled configuration with the SGMF installed.
5. Each belt anchor, including shoulder belt anchors, if applicable (the photo should be as close up as possible but include the entire visible anchor area and the SGMF in the view).
6. Each lower anchor (photo should include the lower anchors and the SGMF in the view).
7. Each tether anchor in relation to the applicable seating location.
8. Close-up view of each **exposed** tether anchor.
9. Front view of each head restraint, if adjustable, in relation to the applicable seating position.
10. Side view of armrest (with door closed) through opposite side of vehicle.
11. The seat back cushion and seat pan cushion after their removal from the seat frame (photos should show top, bottom, side, front, and rear views of each cushion).
12. The seat frame with the cushions removed.
13. Any areas in which a problem occurred while taking a measurement.
14. Close-up view of each **unexposed** tether anchor (photo should adequately show any labeling).
15. Close-up view of each pair of lower anchors (photo should show the lower anchors in relation to any forms of labeling (button or tag)). If appropriate, a close-up view of the related button or tag should also be provided.
16. Close-up view of location of seat belt stalk in relation to LATCH lower anchors (photo should adequately show overlapping or interference if present).
17. Front view of overlapping lower anchorages, if present.
18. Front view of created LATCH positions, if possible.
19. Side view of front seat back in relation to rear seat when front seat back angle is set to the nominal design position.
20. Side view of front seat back in relation to rear seat when front seat back angle is set to the forward-most locking position or 0^{o}, whichever is greater.
21. Sections of the owner's manual containing head restraint use with CRS and also LATCH locations.

Nominal Seat Position

These measurements will need to be taken for each subject position. If an adjustment does not exist, you do not need to identify a range or an adjusted position. All directions are from the vantage point of a person sitting, facing forward.

1. Place the vehicle on a level surface. Make sure that the seat back angle and seat bottom angle and/or height adjustment (if applicable) are set to the prescribed angle/position used in the respective NCAP test. Do not move the seats from this position until all dimensions and photographs are taken.
2. Measure the recline angle of the seat back for the nominal design riding position. Record the exact location of the inclinometer when the measurement is taken. When feasible, set the inclinometer 150 mm above the bottom of the seat back along the outboard edge.



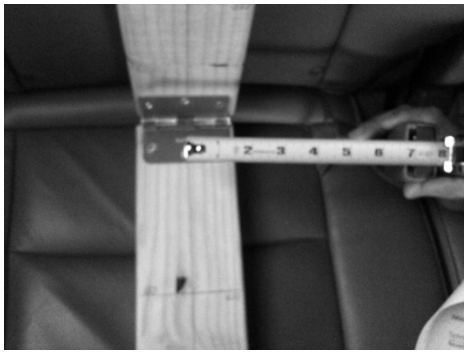
Rear Seat Dimensions

This section is intended to gather general seat and anchor location geometry. Measurements should be taken for each unique, forward-facing, rear seat occupant position of the vehicle being assessed. Some of the measurements may not be able to be made precisely due to cushioning material or other factors. A best approximation should be made and any dimension that is an approximation should be recorded and chosen from the drop down tabs. All of the measurements taken in this section should be recorded on a single data table located with the data submissions.

1. Make sure the vehicle is sitting on a level surface and that the seat is set to its prescribed NCAP test position prior to taking these measurements.
2. Measure and mark the centerline of the vehicle seat on the seat pan, seat back, and head restraint.
3. Use a square to measure the vertical distance from the floor to the underside of the vehicle seat pan cushion at the vehicle seat centerline.
4. Open the SGMF to approximately 90 degrees.
5. Position the bottom leg of the SGMF at the centerline of the occupant position to be measured. Open the SGMF so that the back leg is against the seat back (The hinge point should be as close to the seat bight as possible). Adjust the SGMF and head restraint, if necessary, to maximize the amount of each leg making contact with the seating surfaces. Photograph this position with the SGMF installed*.
6. Buckle the available seat belt for this position and photograph the latchplate and buckle junction*. For center seats, note whether it is necessary to connect two buckles to form the lap belt portion. Unbuckle the seat belt and proceed.

7. Place the inclinometer on the bottom leg of the SGMF and record the angle from horizontal. Place the inclinometer on the back leg of the SGMF and record the angle from vertical.


8. Measure the distance along the SGMF from point A to the top of the seat back (excluding the head restraint, if it is adjustable). If the seat incorporates an adjustable head restraint, it should be set to its highest position, according to the NCAP laboratory test procedures. Place it in the full down (lowest) position at this time and measure from point A to the top of the head restraint. Record both measurements in the data table.
9. Measure the distance along the SGMF from point A to the front edge of the seat pan.
10. Measure the width of the seat pan cushion, not including side bolsters, at points A, B, C, D, and E for the seating location. Repeat this step to measure the width of the seat pan cushion, including side bolsters.
11. Measure the width of the seat back cushion, not including side bolsters, at points A, B, C, D, and E for the seating location. Repeat this step to measure the width of the seat back cushion, including side bolsters.
12. Measure the location for the seat belt anchors for the lap belt section relative to point A on the SGMF. Attempts should be made to measure to the actual attachment of webbing or the stalk to the anchor bracket as opposed to measuring to the anchor bolt location; this may require an approximation as to the actual anchor point. Measurements for the lateral, fore/aft, and vertical positions of these anchors should be taken. Also, note which side of the seating position the buckle is located by choosing the appropriate position in the drop down tab on the data table. Record the lateral distance between the anchors. Photograph each lower seat belt anchor at this position with the SGMF installed*.




13. Measure the length of the buckle stalk. This measurement shall be the distance from the anchor to the top of the buckle along its centerline.
14. Measure the shoulder belt anchor point in relation to point A on the SGMF and complete the data table in relation to the location and type of retractor. Measurements for the lateral, fore/aft, and vertical positions of this anchor should be taken. Retractor types (ALR, switchable, ELR, none) are identified in accordance with FMVSS No. 209. This measurement is intended to

measure the location where the shoulder belt load will be carried. Photograph the shoulder belt anchor point in relation to point A on the SGMF*. Also record the latchplate type (locking, switchable, sliding, sewn-on).

15. Measure the location of the lower anchors of the LATCH system using the method described above for the seat belt anchors. Measure the lateral, fore/aft, and vertical location of the lower anchors relative to the centerline of the SGMF at point A. Take these measurements to the center of the lower anchor bracket. Measure and record the width of this lower anchor bracket. Measure the lateral, fore/aft, and vertical positions of these anchors. Also record the lateral distance between the anchors (from the center of one anchor to the center of the other). Photograph each anchor at this position with the SGMF installed*.
16. Measure the angle of the lower anchors by placing the flat ruler flush with the sides of the anchor, if necessary. Place the inclinometer on top of the ruler and record the angle.
17. Measure the clearance around the LATCH anchorages at the seat bight.
18. Use the tape measure to measure the distance from point A on the SGMF to the tether anchor for the applicable LATCH positions. For vehicles with adjustable head restraints, two measurements should be taken. The first measurement should be taken when the head restraint is in its full down (lowest) adjustment position. (Route the tape measure over the head restraint when taking this measurement.) The second measurement should be taken when the head restraint is in its highest adjustment position. (Route the tape measure under the head restraint when taking this measurement). Also measure the lateral, fore/aft, and vertical location of the tether anchor relative to the centerline of the SGMF at point A. Photograph the location of the tether anchor with respect to the applicable seating position and photograph the exposed tether anchor itself close-up.*
19. For separately adjustable head restraints, use the tape measure to measure the maximum width, length, and height of the head restraint. Draw a dashed line vertically along the head restraint to denote its centerline. If this centerline does not coincide with the seat centerline, measure the lateral distance from the seat centerline to the head restraint centerline and note whether the center of the head restraint is positioned to the left or to the right of the seat centerline. Photograph the head restraint with respect to the seating location in the vehicle.*
20. If possible, move the front seat to its rearmost full-down position and set the front seat back angle to the angle used in the respective Frontal NCAP test. Use an inclinometer to measure the recline angle of the seat back for this position and record this angle in the data table. Also record the exact location of the inclinometer when the measurement is taken in the data table. When feasible, set the inclinometer 150 mm above the bottom of the seat back along the outboard edge. Photograph the position of the front seat back with respect to the rear seat.* Also record the front seat track length, as specified in the Frontal NCAP test report.
21. In the plane that passes vertically through the rear seat centerline, as indicated on the SGMF, use an adjustable square (or two 24 inch levels (with a ruled edge) positioned perpendicular to each other to measure the distance (horizontal to ground) from a point that is 572 mm directly above point A to the back of the front seat. Record this measurement in the data table.
22. With the front seat set to its rearmost full-down position, set the front seat back angle to its forward-most locking position, or to 0^{o}, whichever is greater. Use an inclinometer to measure the recline angle of the seat back for this position and record this angle in the data table. Also record the exact location of the inclinometer when the measurement is taken in the data table. When feasible, set the inclinometer 150 mm above the bottom of the seat back along the outboard edge. Then, repeat step 21 and record the measurement taken in the data table. Also photograph the position of the front seat back with respect to the rear seat.*

Armrest and Windowsill Dimensions

These measurements should be taken for the right rear outboard seating position, and separately for the left rear outboard seating position if the lateral distance from the center of the right rear outboard LATCH position to the door differs from a similar measurement taken for the left rear outboard LATCH position. Measurements for LATCH positions that are offset (are not centered over the rear outboard seat pan) should also be taken, if applicable.

1. Place the inclinometer on the top of the armrest and measure the angle. If necessary, a ruler may be placed on the armrest to achieve a flat surface.
2. Using an adjustable square (or two 24 inch levels (with a ruled edge) positioned perpendicular to each other), place the horizontal piece of the square (or horizontal level) on point A, level to the ground. Measure the lateral and vertical position of the top and bottom of the armrest in relation to point A on the SGMF. Repeat this step for SGMF positions B, C, D, and E. If the rearmost or forwardmost point on the armrest does not coincide with any of the five points designated on the SGMF, additional lateral and vertical measurements should also be taken at those rearmost and forwardmost points, along with the corresponding fore/aft measurements, referenced from point A.

Figure 2. Depiction of tool placement when measuring lateral and vertical distances of armrest to point A.

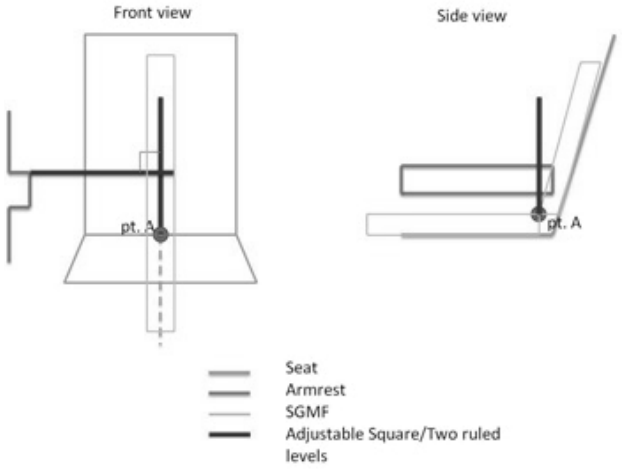


Figure 3. Depiction of how measurements should be taken.

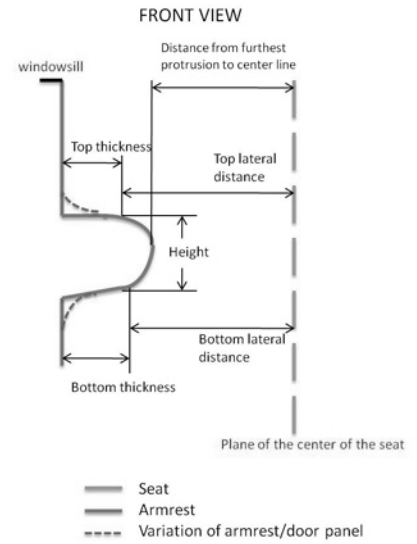
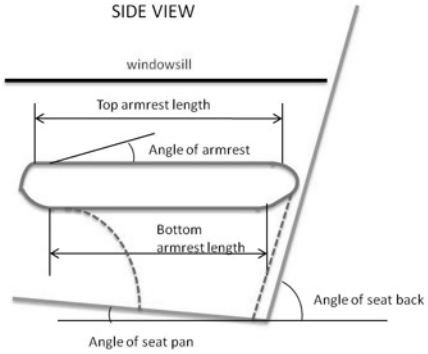


Figure 4. Depiction of how measurements should be taken.



3. The total length of the armrest at the top and bottom should also be noted. Using a ruler or tape measure, also measure the thickness (if protruding) or depth (if sunken) of the top and bottom of the armrest at the points that correspond with point A on the SGMF. Repeat this step for points B, C, D, and E, and also for the rearmost and forwardmost points on the armrest if the rearmost and forwardmost points on the armrest do not coincide with any of the five points designated on the SGMF. Use a tape measure to also measure the height of the armrest at each of the 5 points, and also at the rearmost and forwardmost points on the armrest if those rearmost and forwardmost points do not coincide with any of the five points designated on the SGMF.
4. Using an adjustable square (or two 24 inch levels (with a ruled edge) positioned perpendicular to each other), place the intersection of the levels on point A, level to the ground. Measure the lateral and vertical position of the windowsill from point A, B, C, D, and E on the SGMF. If the rearmost or forwardmost point on the armrest does not coincide with any of the five points designated on the SGMF, additional lateral and vertical measurements should also be taken at those rearmost and forwardmost points, along with corresponding fore/aft measurements, referenced from point A. Photograph the armrest in relation of the vehicle seat with the door closed*. This photograph should be taken from the opposite side of the vehicle.

<u>Rear Seat Adjustments</u>

1. Determine the range of recline angles of the rear seat back from vertical. Record the exact location of the inclinometer when the measurements are taken. When feasible, set the inclinometer 150 mm above the bottom of the seat back along the outboard edge.
2. If the seat to be measured has a seat bottom angle and/or height adjustment, measure the range of angles of tilt from horizontal and/or the height, as measured along the seat bottom's centerline.
3. If the seat to be measured has an adjustable head restraint (height adjustment and/or tilt), measure the height and/or the angle of tilt from vertical at the prescribed NCAP test position, as measured along the centerline of the head restraint's face. Also, note whether the head restraint is adjustable and whether it can be removed.
4. If there are other seat adjustments of the seats involved, record associated measurements in the "other" block.

Seat Pan Cushion Thickness

These measurements will require the removal of the seat cushion from the frame. Please ensure that all previous measurements and pictures have been adequately taken prior to removing the cushion. Please note any issues that arise when taking measurements in the notes section at the bottom of the table.

1. With the SGMF on the centerline of the seat as previously described, mark and label points A, B, C, D, and E on the seat pan cushion to both the right and left of the SGMF. Remove the SGMF and use the 450 mm ruler to draw a line to connect the corresponding points.
2. Remove the seat pan cushion from the frame.
3. Using the calipers, measure the thickness of the seat cushion at the midpoint of the AA line (this should be marked by the intersection of the centerline and the AA line). Record this measurement in the appropriate table as the thickness at the centerline, under the A column.
4. Place the 450 mm ruler perpendicular to the centerline at point A (collinear with line AA) and mark points every 50 mm from the seating position's centerline as listed in the contour table. Measure the thickness of the seat pan cushion at each of these points and record the measurement on the data table.
5. Repeat steps 3 through 4 for each point B, C, D, and E.

Seat Back Cushion Thickness

These measurements will require the removal of the seat cushion from the frame. Please ensure that all previous measurements and pictures have been adequately taken prior to removing the cushion. Please note any issues that arise when taking measurements in the notes section at the bottom of the table.

1. With the SGMF on the centerline of the seat as previously described, mark and label points A, B, C, D, and E on the seat back cushion to both the right and left of the SGMF. Remove the SGMF and use the 450 mm ruler to draw a line to connect the corresponding points.
2. Remove the seat back cushion from the frame.
3. Using the calipers, measure the thickness of the seat back cushion at the midpoint of the AA line (this should be marked by the intersection of the centerline and the AA line). Record this measurement as the thickness at position A.
4. Repeat step 3 for each point B, C, D, and E.

LATCH Observations and Measurements

Please make and record the required LATCH measurements and observations in the related data table. Record all measurements in millimeters.

Vehicle Owner's Manual

Photograph or copy sections of the vehicle owner's manual containing information regarding head restraint use with CRS and also LATCH locations within the vehicle.*

APPENDIX B

Figures

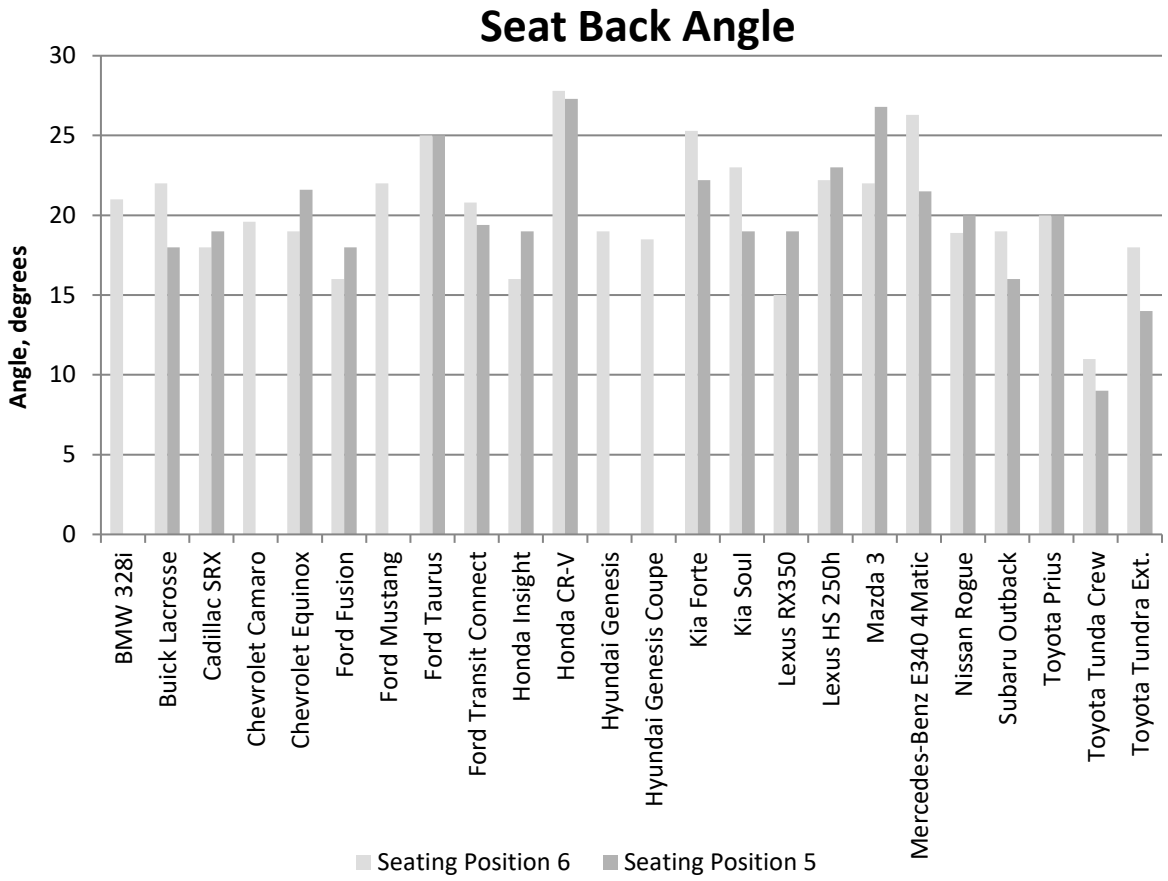


Figure 1: Seat Back Angle

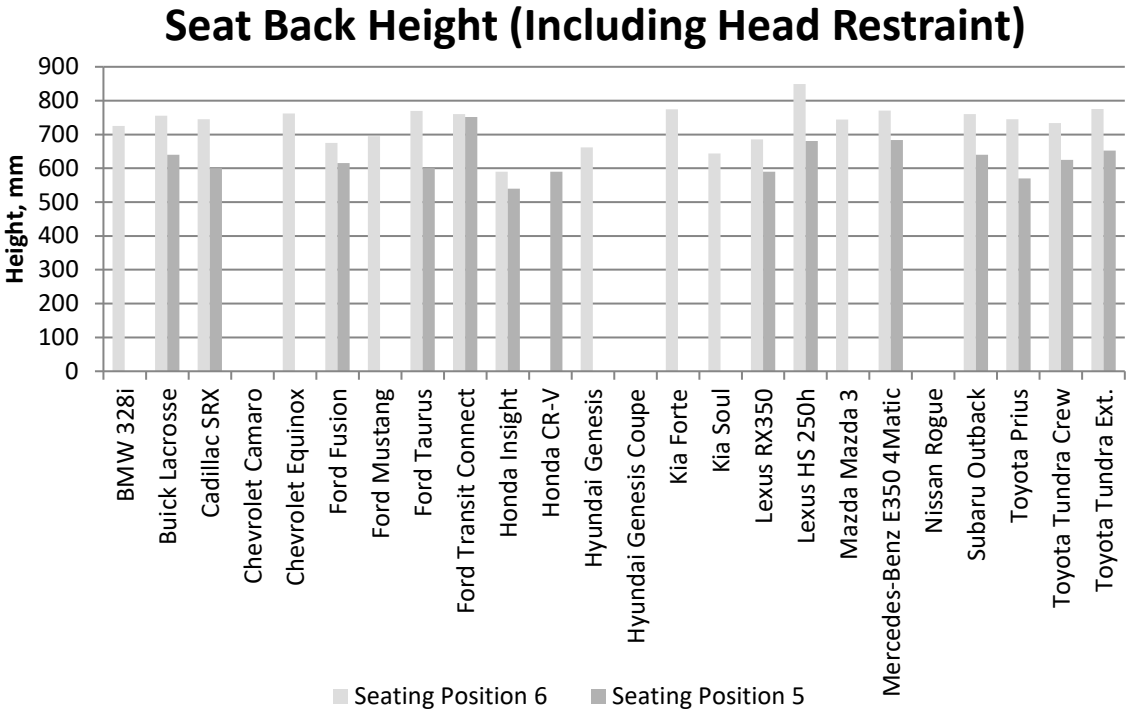


Figure 2: Seat Back Height Including Head Restraint

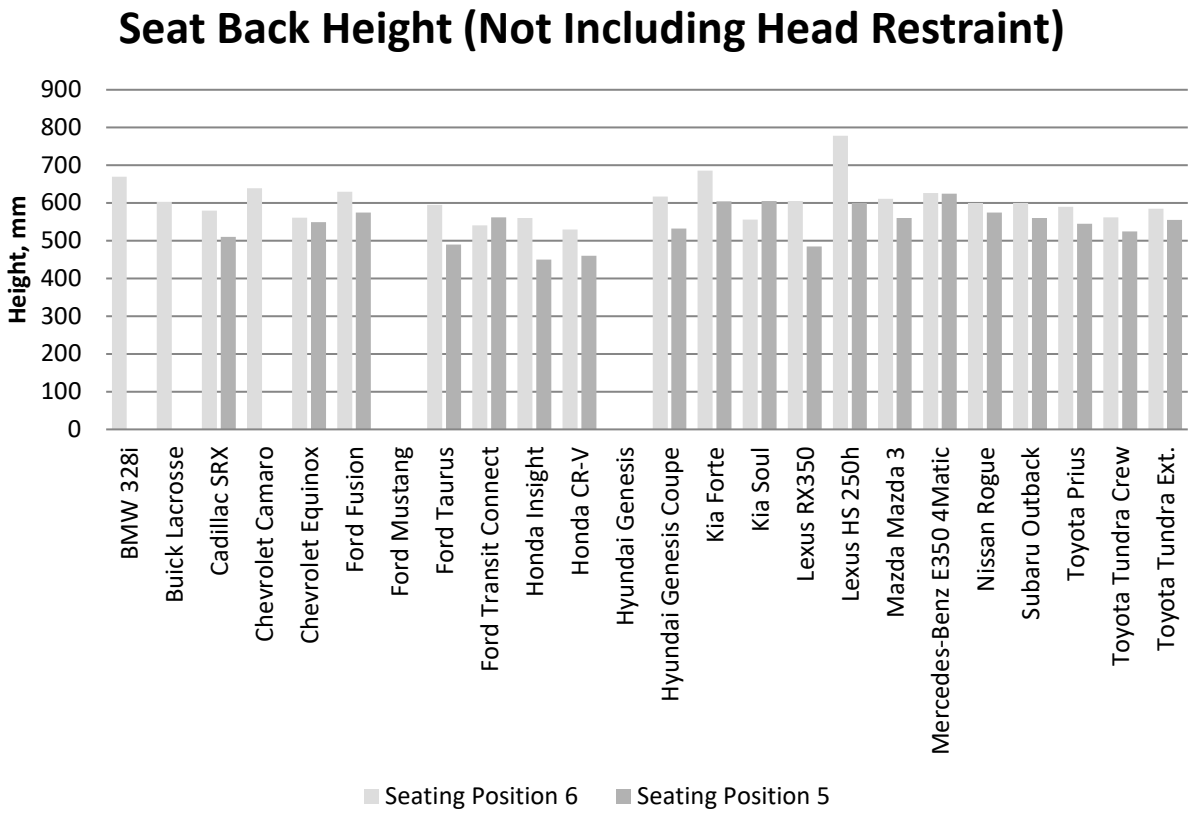


Figure 3: Seat Back Height Not Including Head Restraint

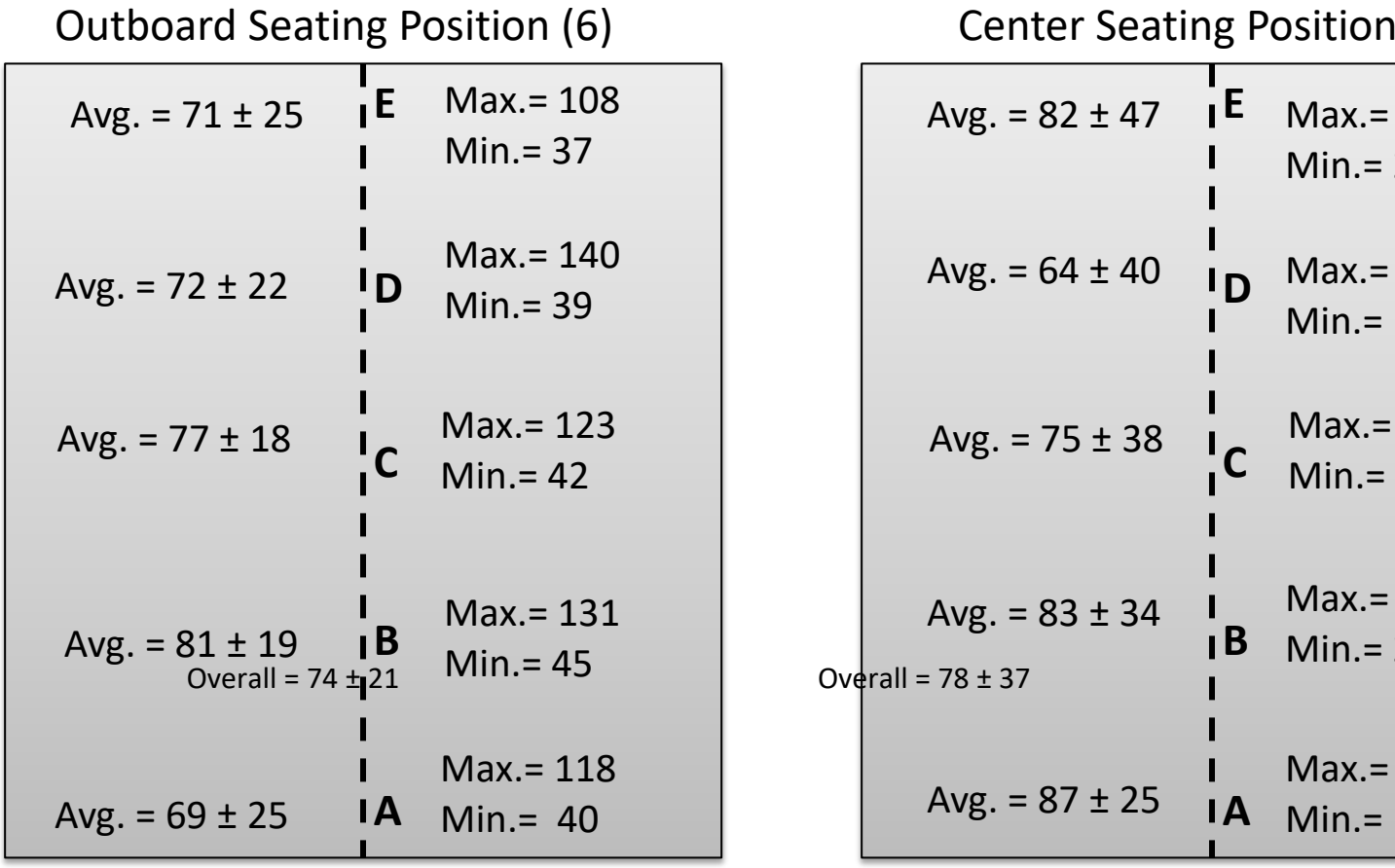


Figure 4: Seat back cushion thickness at points A, B, C, D, and E along the centerline of the seat. Measurements are shown on a "seat back cushion" schematic to illustrate the location of the points. (Measurements in mm.)

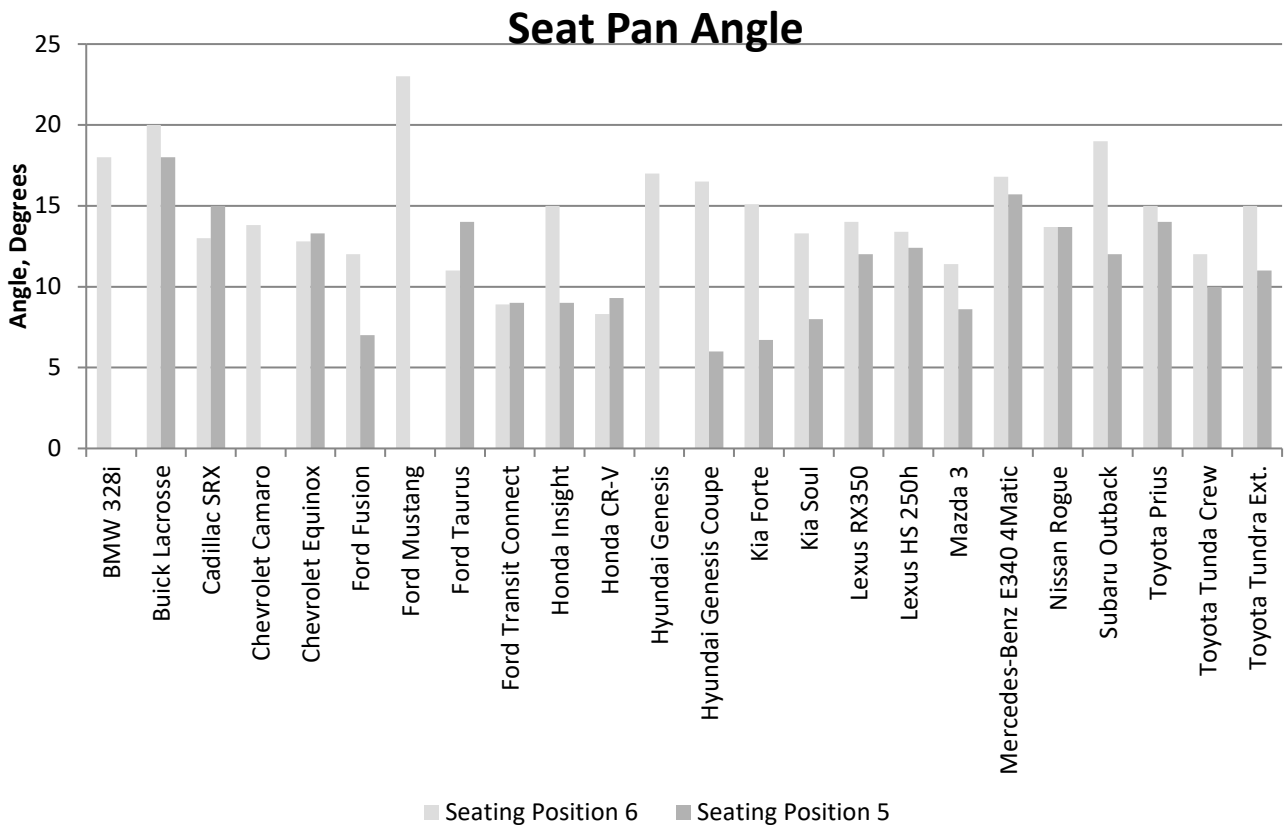


Figure 5: Seat Pan Angle

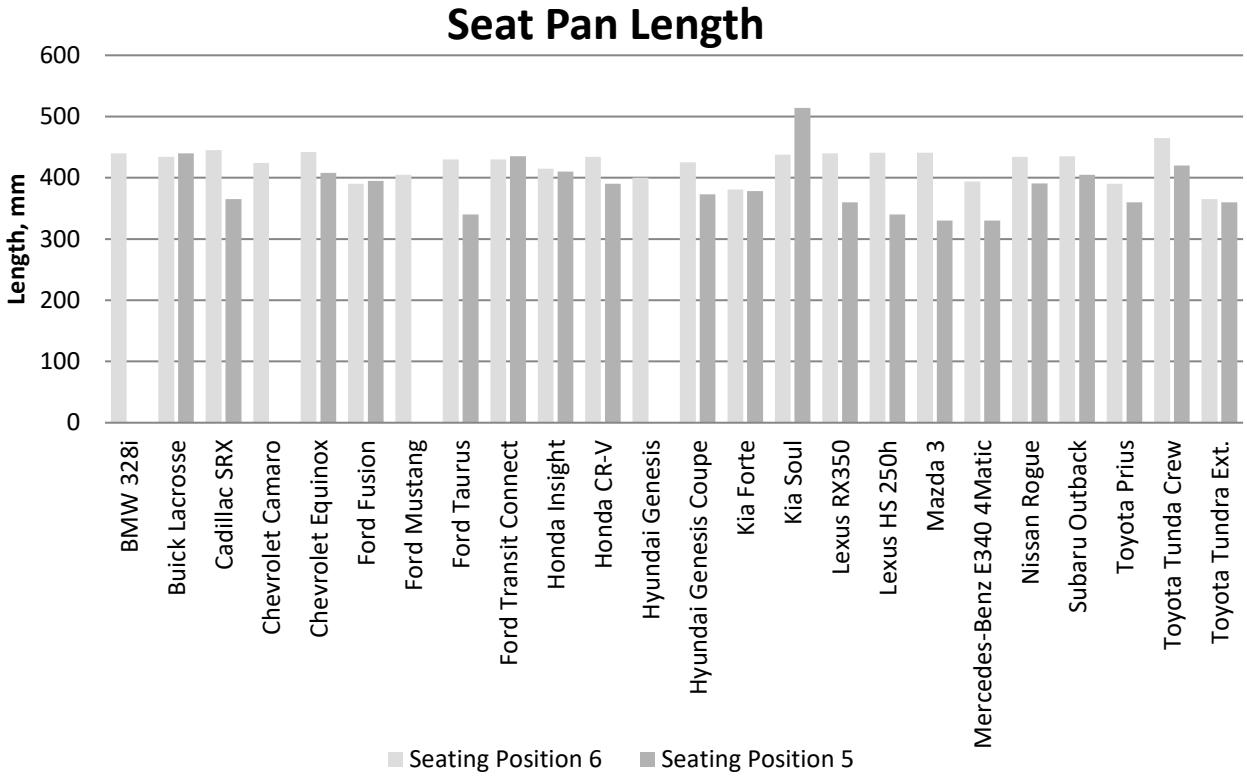


Figure 6: Seat Pan Length

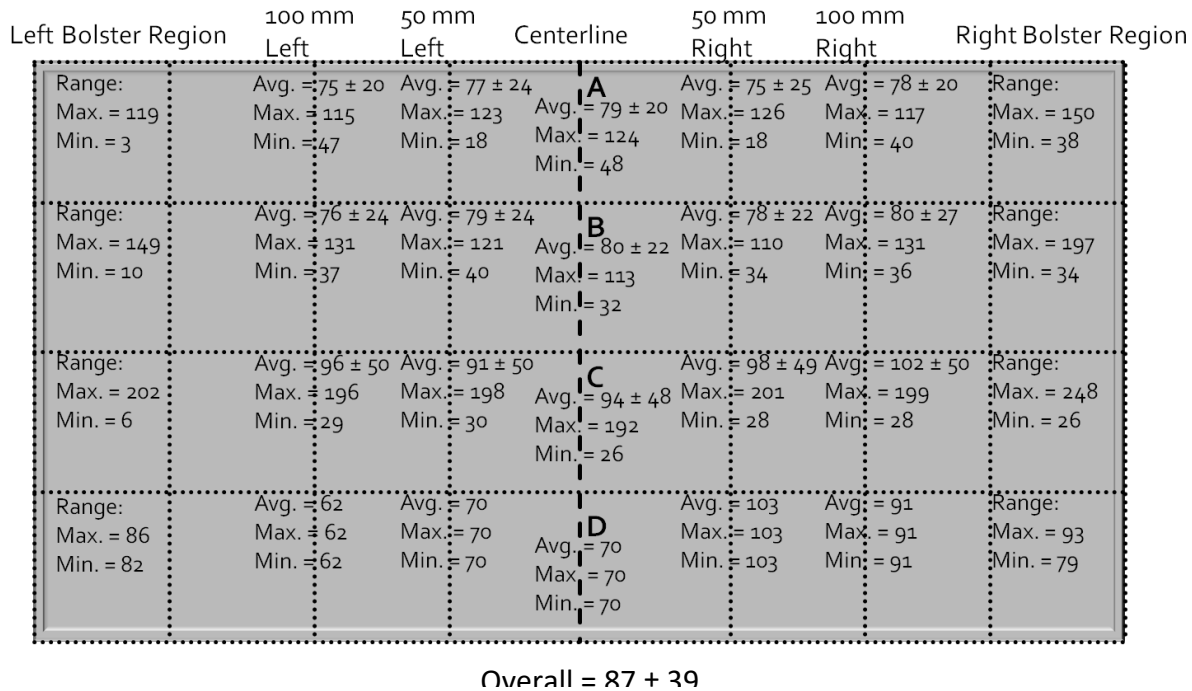


Figure 7: Seat pan cushion thicknesses in the outboard seating position at points A, B, C, and D along the centerline and lines parallel. Measurements are shown on a "seat pan cushion" schematic in a grid arrangement to illustrate the location of the points. (Measurements in mm.)

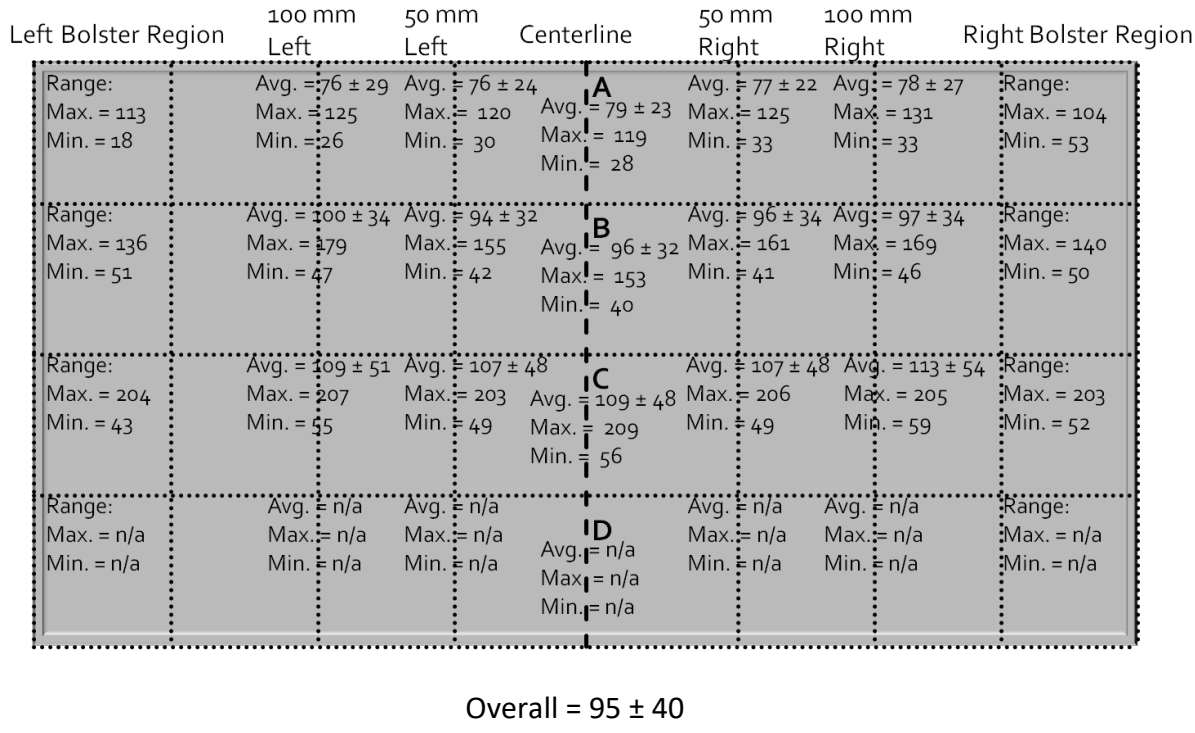


Figure 8: Seat pan cushion thicknesses in the center seating position at points A, B, C, and D along the centerline and lines parallel. Measurements are shown on a "seat pan cushion" schematic in a grid arrangement to illustrate the location of the points. (Measurements in mm.)

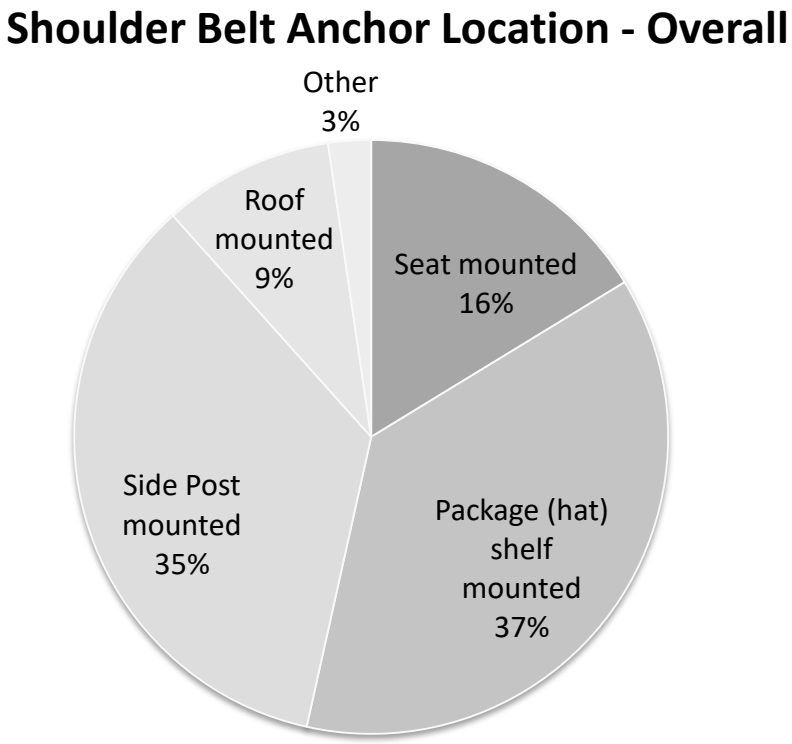


Figure 9: Overall Shoulder Belt Anchor Location

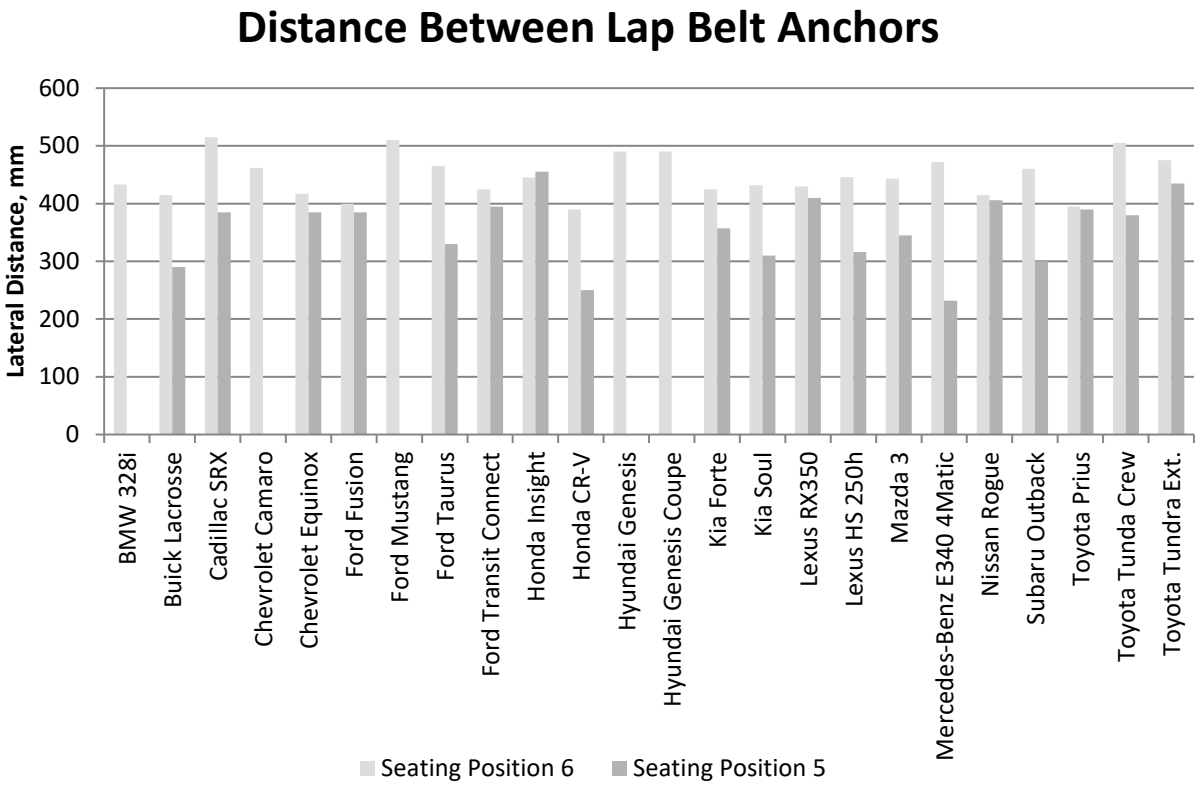


Figure 10: Distance Between Lap Belt Anchors

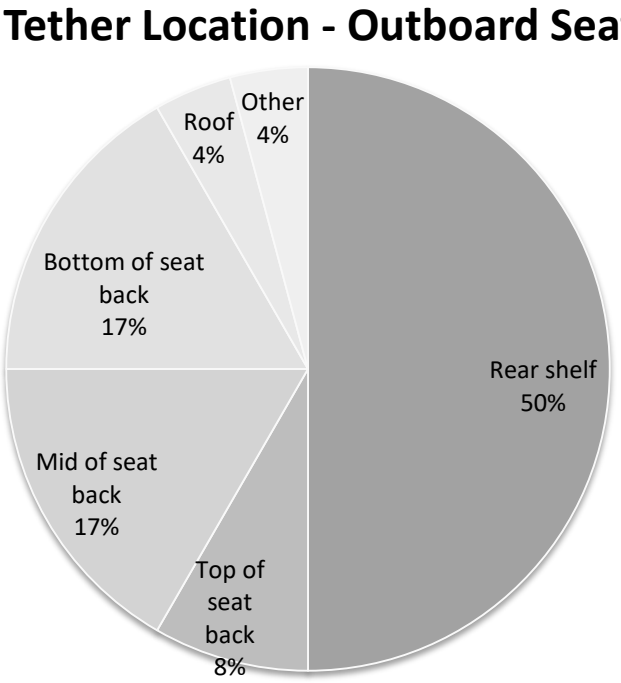


Figure 11: Outboard Seat Tether Location

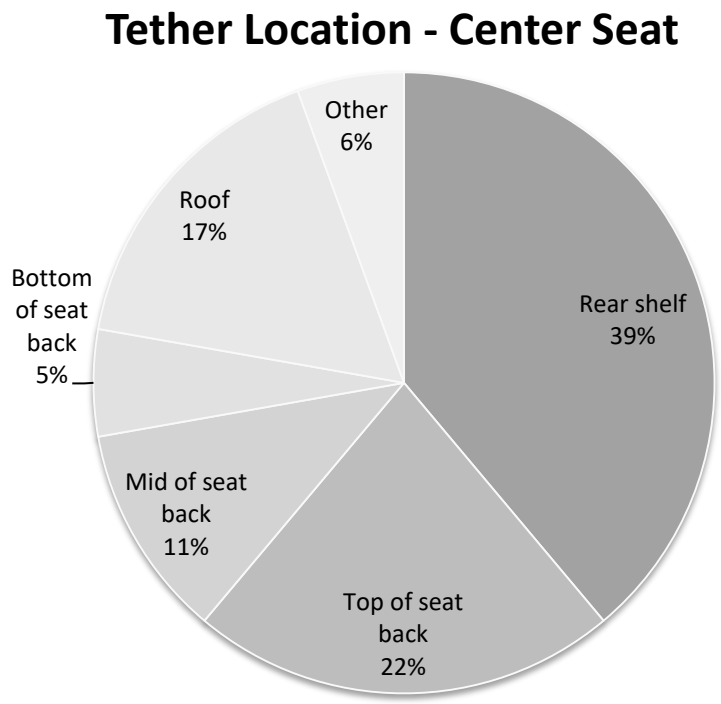


Figure 12: Center Seat Tether Location

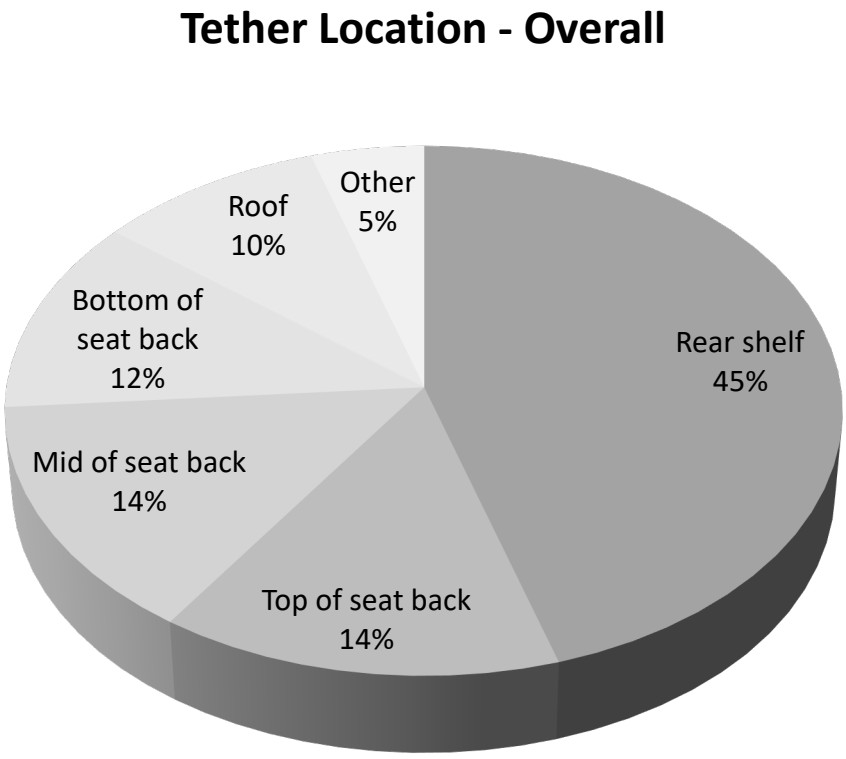


Figure 13: Overall Tether Location

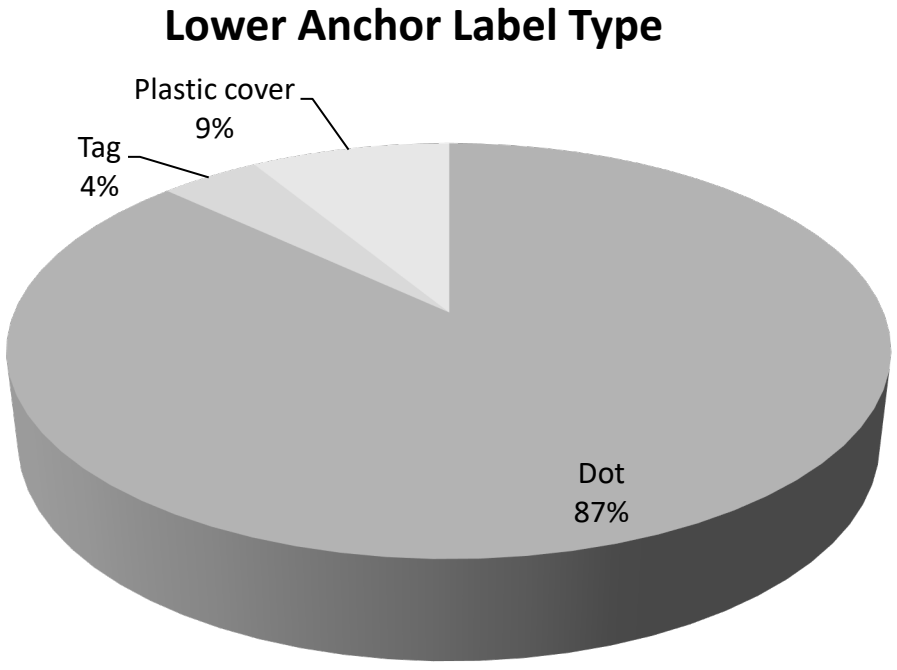
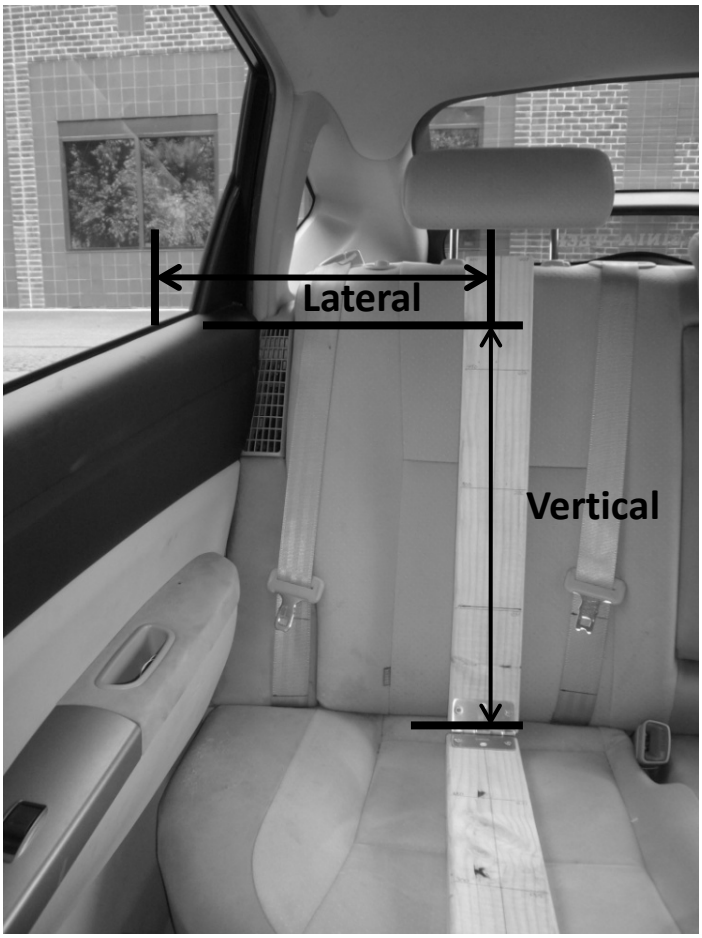


Figure 14: Lower Anchor Labeling

Windowsill



Armrest

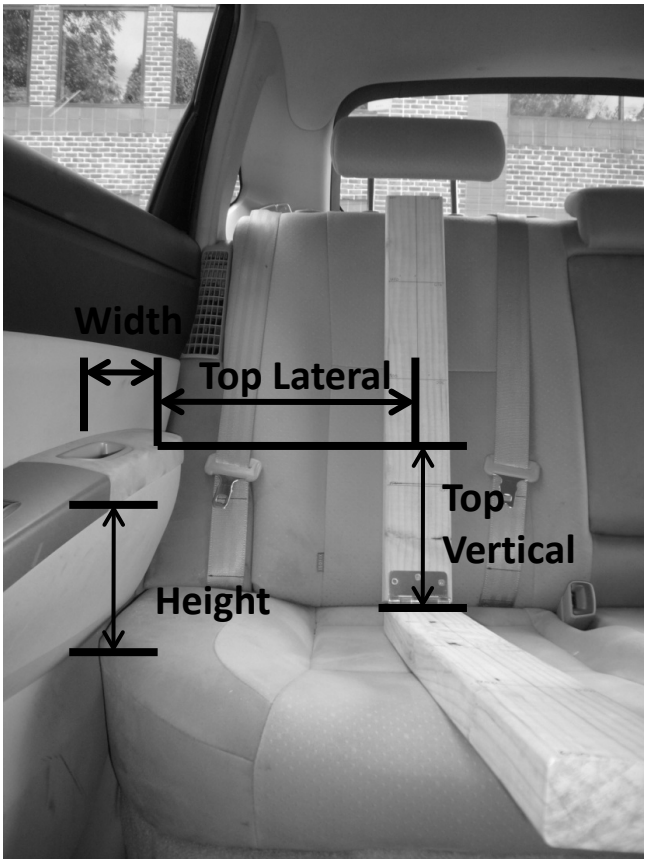


Figure 15: Windowsill and Armrest Measurements

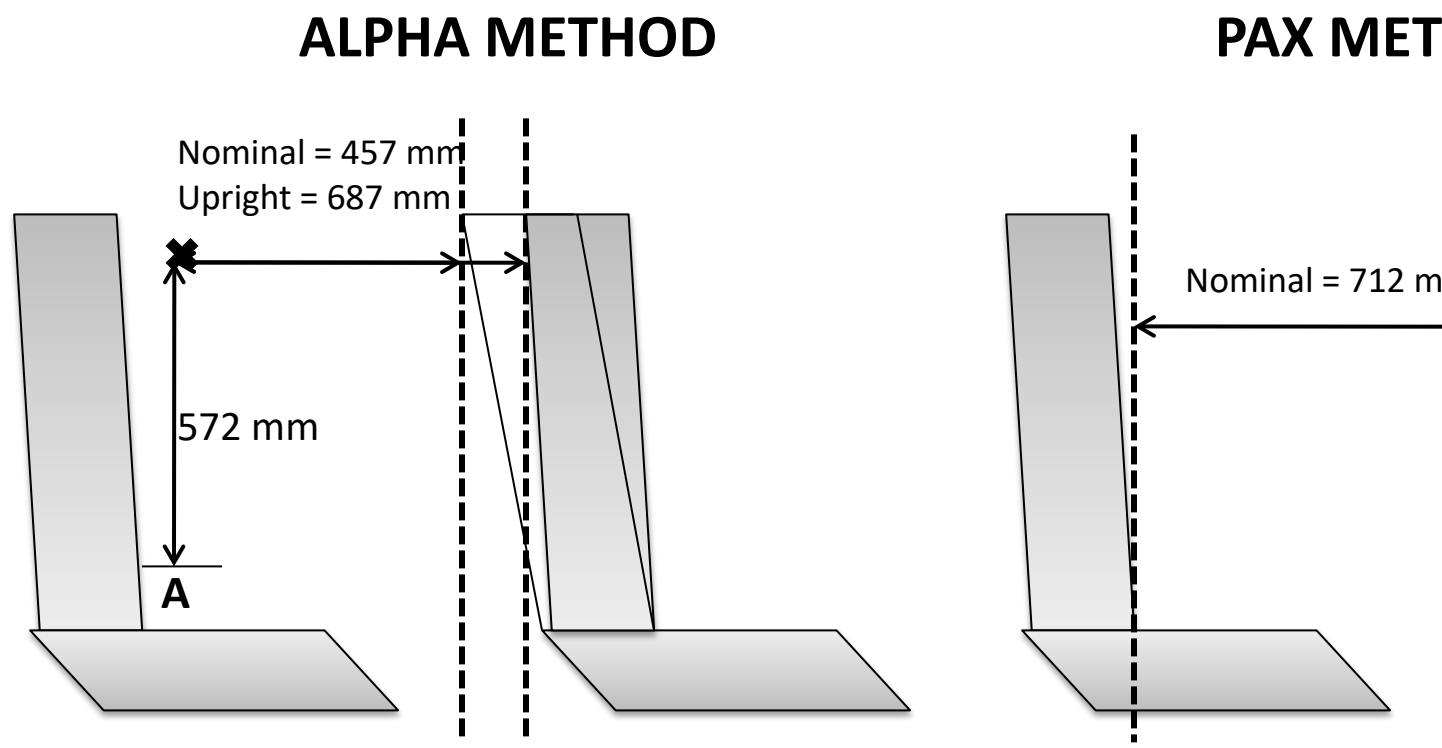


Figure 16: Rear Seat Clearance Measurements Schematic Comparison

APPENDIX C

Tables

Measurements recorded in millimeters unless otherwise specified.

Table 1: Seat back measurements compared to the current FMVSS No. 213, ECE, and NPACS test benches. Referenced from point A on the SGMF.

			Alpha			213	ECE	NPACS	PAX
			Overall	Outboard	Center				
Seat Back	ANGLE		20° ± 4°	20° ± 4°	20° ± 4°	20°	20°	20°	22°
	HEIGHT	w/ headrest	688 ± 76	-	-	517	432	432	-
		w/o headrest	578 ± 60	-	-				-
	THICKNESS		76 ± 29	76 ± 20	76 ± 37	152.4	70	70	-
	WIDTH	w/ bolsters	893 ± 65	495 ± 63	398 ± 32	813	800	-	-
		w/o bolsters	569 ± 64	315 ± 56	254 ± 58				-

Table 2: Seat pan measurements compared to the current FMVSS No. 213, ECE, and NPACS test benches. Referenced from point A on the SGMF.

			Alpha			213	ECE	NPACS	PAX
			Overall	Outboard	Center				
Seat Pan	ANGLE		13° ± 4°	15° ± 4°	12° ± 4°	15°	15°	15°	15°
	LENGTH		406 ± 38	422 ± 24	387± 44	416	438	454	461
	THICKNESS		90 ± 40	87 ± 39	95 ± 40	152.4	140	130	-
	WIDTH	w/ bolsters	924 ± 77	506 ± 48	418 ± 105	825	800	-	-
		w/o bolsters	595 ± 60	327 ± 41	268 ± 63				-
	HEIGHT ABOVE FLOOR		177 ± 64	211 ± 37	134 ± 66	286	279	279	-

Table 3: Shoulder belt anchor location compared to the current FMVSS No. 213, ECE, and NPACS test benches. Referenced from point A on the SGMF.

		Alpha	213	ECE	NPACS	PAX
Shoulder Belt Location	Aft	350 ± 118	350	216	213	295 ± 122
	Lateral	247 ± 57	385	302	298	247 ± 81
	Vertical	581 ± 72	690	500	514	632 ± 80
Distance Between Lap Belt Anchors	Outboard	450 ± 36	427	-	-	-
	Center	356 ± 60	400	-	-	392

Table 4: Average lower anchor measurements.

		Allowable Positions					Prohibited	Allowable & Prohibited	Allowable & Prohibited
		Designated Outboard	Designated Center	Shared Center	Created Center	Center (All)	Created Center	Center (All)	Outboard & Center (All)
Distance Between Centers of Anchors		281 ± 32	290	285 ± 1	360 ± 85	316 ± 52	438 ± 109	416 ± 111	343 ± 105
Anchor Bracket Width	**Right**	45 ± 8	50	66 ± 11	48 ± 1	55 ± 10	-	-	46 ± 8
	Left	46 ± 9	50	57 ± 10	48 ± 1	52 ± 6	-	-	47 ± 9
Distance From Center of Anchor to Centerline of Seat	**Right**	132 ± 25	148	128 ± 18	167 ± 17	147 ± 21	-	-	132 ± 27
	Left	141 ± 31	141	174 ± 54	147 ± 6	156 ± 28	-	-	141 ± 35

Table 5: Seat back widths at points A, B, C, D, and E.

	Outboard Seating Position						Center Seating Position					
	With Bolsters			W/O Bolsters			With Bolsters			W/O Bolsters		
	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min
A	414 ± 78	564	310	296 ± 36	366	220	423	423	423	265 ± 60	390	195
B	496 ± 69	625	342	298 ± 31	355	245	399 ± 41	428	370	249 ± 62	425	194
C	517 ± 40	625	426	305 ± 37	405	260	400 ± 42	430	370	258 ± 58	415	195
D	510 ± 38	610	412	325 ± 69	505	235	365	365	365	256 ± 62	420	186
E	507 ± 39	550	419	394 ± 80	527	299	N/A	N/A	N/A	236 ± 23	270	217
Overall	495 ± 63			315 ± 57			398 ± 32			254 ± 58		

Table 6: Seat pan widths at points A, B, C, D and E.

	Outboard Seating Position						Center Seating Position					
	With Bolsters			W/O Bolsters			With Bolsters			W/O Bolsters		
	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min
A	474 ± 28	560	355	308 ± 57	369	240	296 ± 65	377	175	253 ± 89	415	175
B	530 ± 27	585	452	320 ± 29	388	272	368 ± 62	425	325	258 ± 42	415	175
C	515 ± 53	593	424	351 ± 38	527	260	404 ± 64	520	300	260 ± 82	420	186
D	520	520	520	350	350	350	N/A	N/A	N/A	275	275	275
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overall	506 ± 48			327 ± 41			418 ± 105			268 ± 63		

Table 7: Overall Seat Pan Cushion Thickness

	Outboard	Center	Overall
A	77	77	77
B	79	97	88
C	96	109	103
D	79	109	94
E	N/A	N/A	N/A
Overall	87 ± 39	95 ± 40	90 ± 40

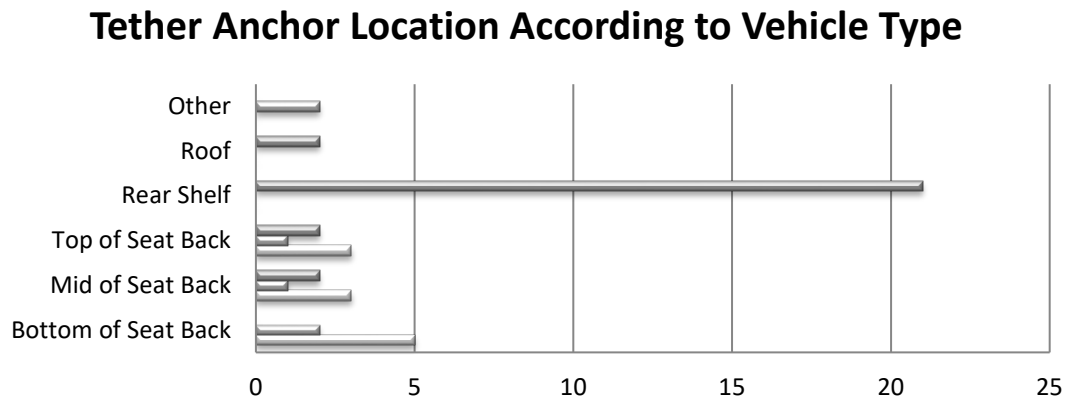
Table 8: Shoulder belt location for the outboard and center seating positions individually

	Outboard Seating Position			Center Seating Position		
	Aft Distance	**Lateral Distance**	**Vertical Distance**	**Aft Distance**	**Lateral Distance**	**Vertical Distance**
Average	329 ± 124	258 ± 51	594 ± 41	377 ± 109	233 ± 63	563 ± 98
Maximum	618	457	700	565	380	825
Minimum	155	200	545	190	179	442

Table 9: Overall shoulder belt location

	Aft Distance	Lateral Distance	Vertical Distance
Average	350 ± 118	247 ± 57	581 ± 72
Maximum	618	457	825
Minimum	155	179	442

Table 10: Frequency of tether anchor location per vehicle type



	Bottom of Seat Back	Mid of Seat Back	Top of Seat Back	Rear Shelf	Roof	Other
Passenger Car (n=27)	0	2	2	21	2	0
Truck (n=6)	2	1	1	0	0	2
MPV (n=11)	5	3	3	0	0	0

Table 11: Tether anchor distances

	Routed Over Head Restraint	Routed Under Head Restraint
Average	1067 ± 194	892 ± 228
Maximum	1693	1660
Minimum	760	108

Table 12: Depth and angle of lower anchors

	Outboard		Center		Overall
	Right	Left	Right	Left	
Average Depth	23	21	12	11	-
Overall Average Depth	22		11		21 ± 16
Average Angle	21°	20°	44°	48°	-
Overall Average Angle	21°		46°		23° ± 20°

Table 13: Lateral and vertical measurements for windowsill at points A, B, C, D, and E.

	Lateral	Vertical
A	390 ± 24	506 ± 46
B	396 ± 19	462 ± 41
C	403 ± 15	410 ± 48
D	409 ± 19	374 ± 33
E	412 ± 35	329 ± 21
Overall	399 ± 29	440 ± 77

Table 14: Top of armrest measurements

	Rearmost	A	B	C	D	E	Forwardmost	Overall
Lateral Distances from Armrest to Point, mm	302 ± 30	290 ± 37	304 ± 17	307 ± 17	305 ± 19	275	337 ± 25	308 ± 29
Vertical Distances from Armrest to Point, mm	209 ± 41	222 ± 47	193 ± 35	155 ± 21	117 ± 18	66	116 ± 36	173 ± 53
Width, mm	41 ± 20	59 ± 23	73 ± 16	67 ± 19	65 ± 11	80	38 ± 22	59 ± 23
Armrest length, mm	-	-	-	-	-	-	-	503 ± 128
Armrest angle, degrees	-	-	-	-	-	-	-	3° ± 2°

Table 15: Bottom of armrest measurements

	Rearmost	A	B	C	D	E	Forwardmost	Overall
Lateral Distances from Armrest to Point, mm	315 ± 24	301 ± 37	304 ± 35	313 ± 23	311 ± 32	329 ± 47	341 ± 23	315 ± 32
Vertical Distances from Armrest to Point, mm	147 ± 55	141 ± 67	119 ± 54	84 ± 46	42 ± 32	38 ± 54	50 ± 52	101 ± 65
Width, mm	28 ± 23	40 ± 35	55 ± 35	61 ± 35	64 ± 20	40 ± 57	32 ± 23	46 ± 32
Armrest length, mm	-	-	-	-	-	-	-	466 ± 155

Table 16: Overall (top and bottom combined) armrest measurements

	Overall
Lateral Distances	311 ± 31
Vertical Distance	136 ± 69
Width	52 ± 29
Height	64 ± 33
Length	487 ± 141

APPENDIX D

Photographs

Seat Geometry Measuring Fixture

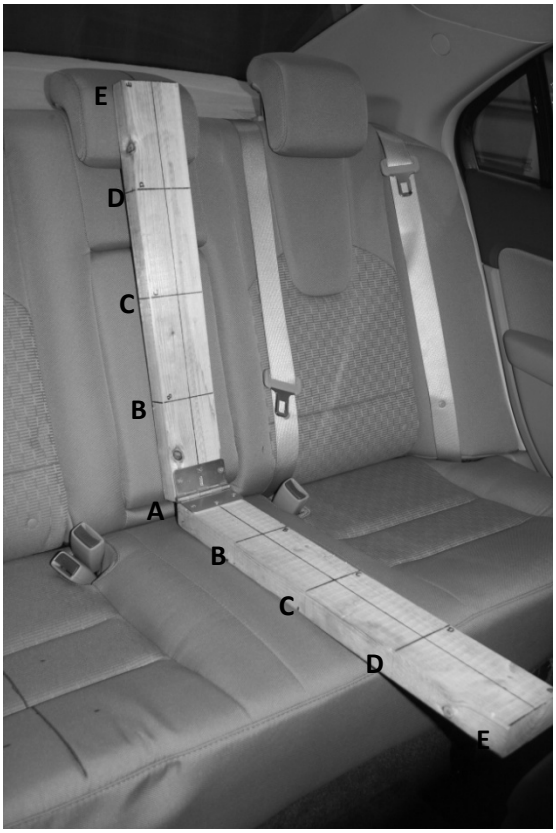


Photo No. 1: Seat Geometry Measuring Fixture in Center Seating Position

Tether Labeling

Photo No. 2: ISOFIX Tether Anchor Label

Tether Accessibility

Photo No. 3: Direct access

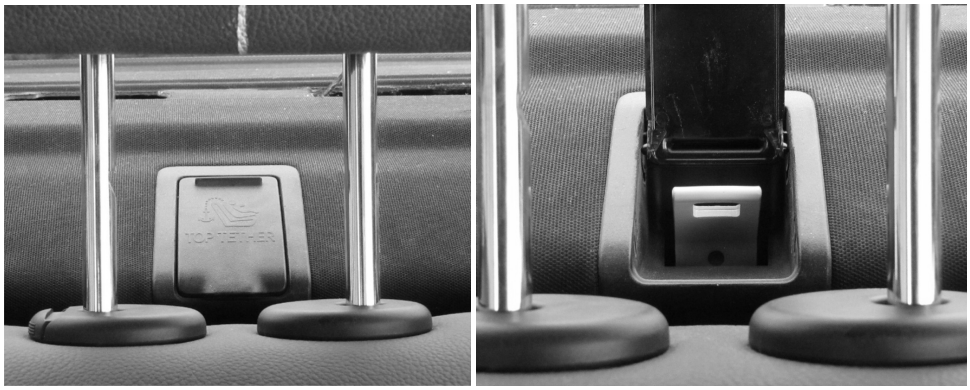


Photo No. 4: Easy to access

Photo No. 5: Difficult to access

Lower Anchor Measurements Schematic

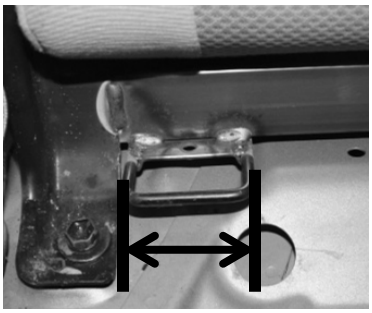


Photo No. 6: Lower Anchor Width

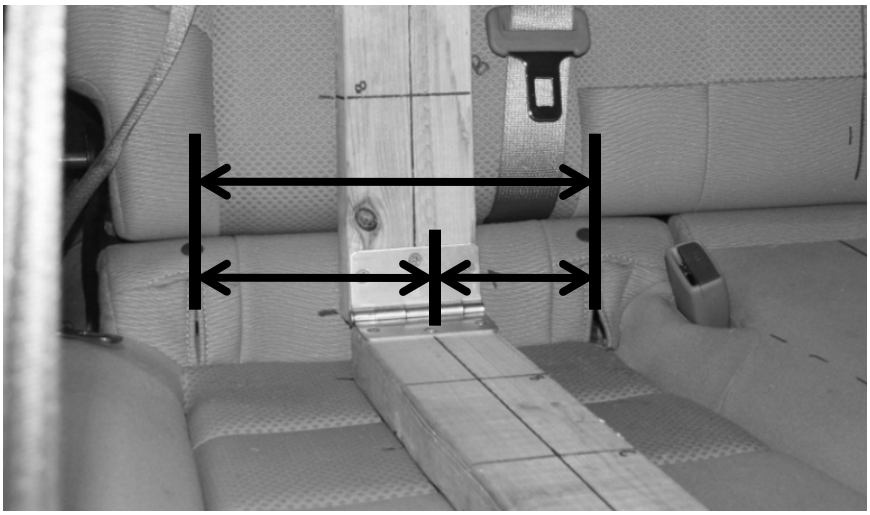


Photo No. 7: Distance from Center of Anchor to Centerline of the Seat and Center of Anchor to Center of Anchor

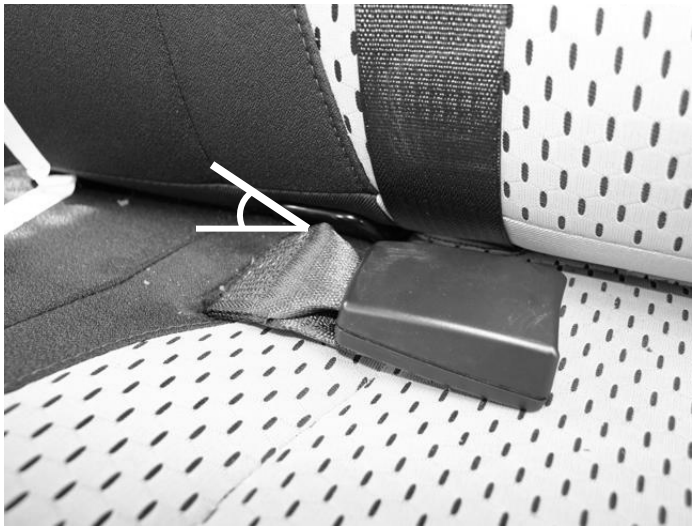


Photo No. 8: Lower Anchor Angle

Interference Between Lower Anchors and Belt Stalk

Photo No. 9: Example in the Outboard Seating Position

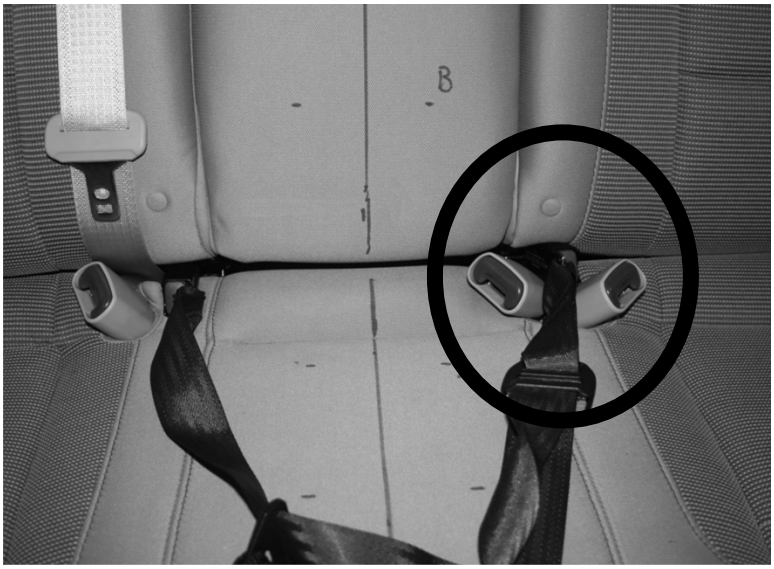
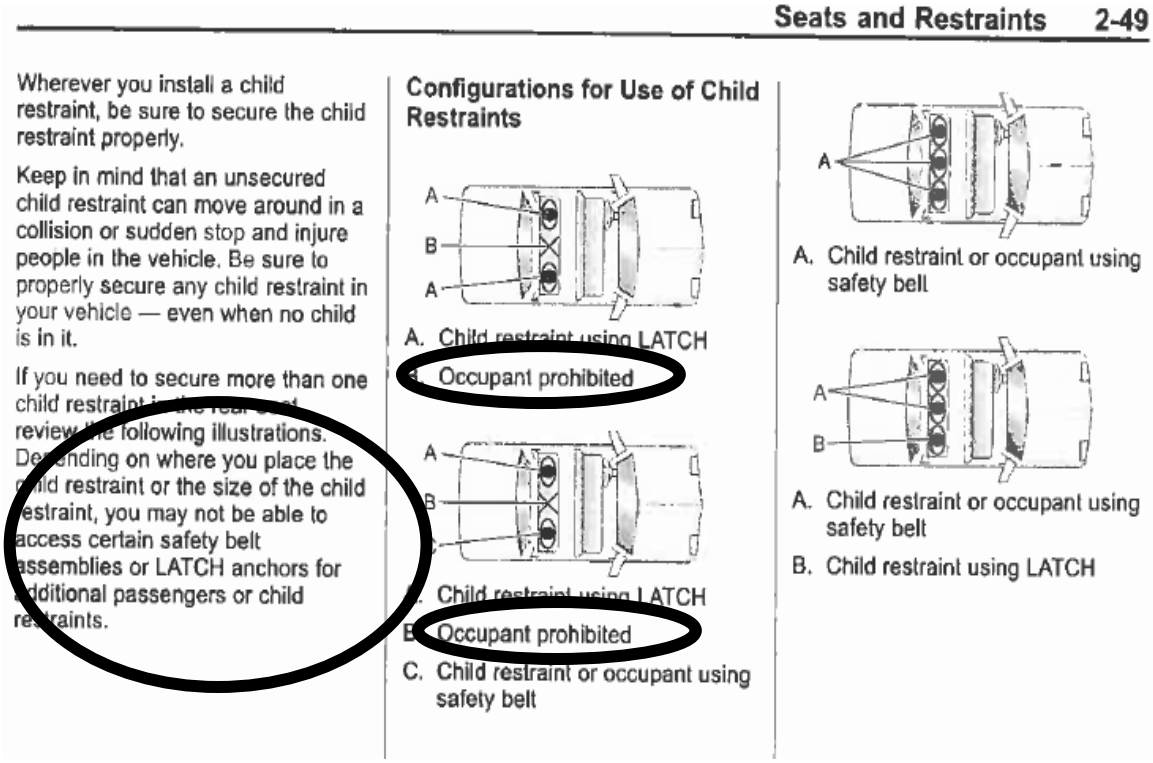


Photo No. 10: Example in the Center Seating Position



Seats and Restraints 2-49

Wherever you install a child restraint, be sure to secure the child restraint properly.

Keep in mind that an unsecured child restraint can move around in a collision or sudden stop and injure people in the vehicle. Be sure to properly secure any child restraint in your vehicle — even when no child is in it.

If you need to secure more than one child restraint [illegible] review the following illustrations. Depending on where you place the child restraint or the size of the child restraint, you may not be able to access certain safety belt assemblies or LATCH anchors for additional passengers or child restraints.

Configurations for Use of Child Restraints

A
B
A

A. Child restraint using LATCH
Occupant prohibited

A
B
A

Child restraint using LATCH
Occupant prohibited
C. Child restraint or occupant using safety belt

A

A. Child restraint or occupant using safety belt

A
B

A. Child restraint or occupant using safety belt
B. Child restraint using LATCH

Photo No. 11: Example of Owner's Manual Prohibiting Use Due to Interference

Lower Anchor Labeling

Photo No. 12: ISOFIX Lower Anchor Label

Photo No. 13: Dot

Photo No. 14: Printed on plastic cover

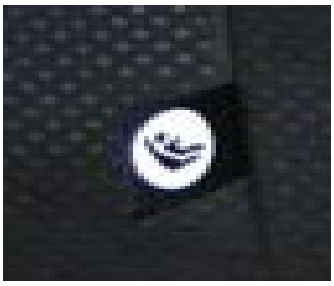


Photo No. 15: Tag

Owner's Manual Guidance on Using Lower Anchors in the Center Seating Position

Photo No. 16: One Designated Center Lower Anchor

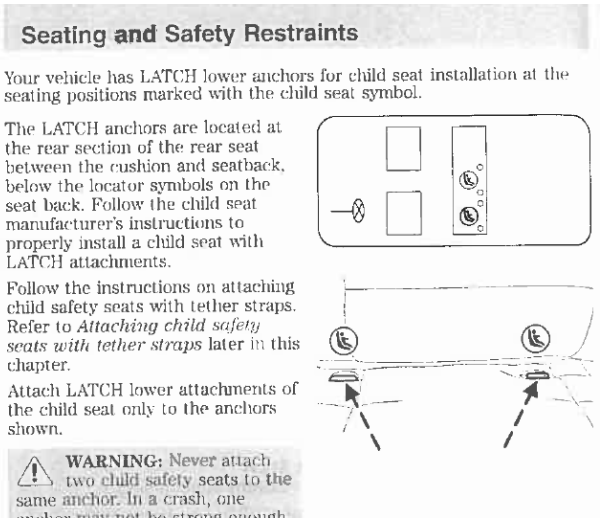
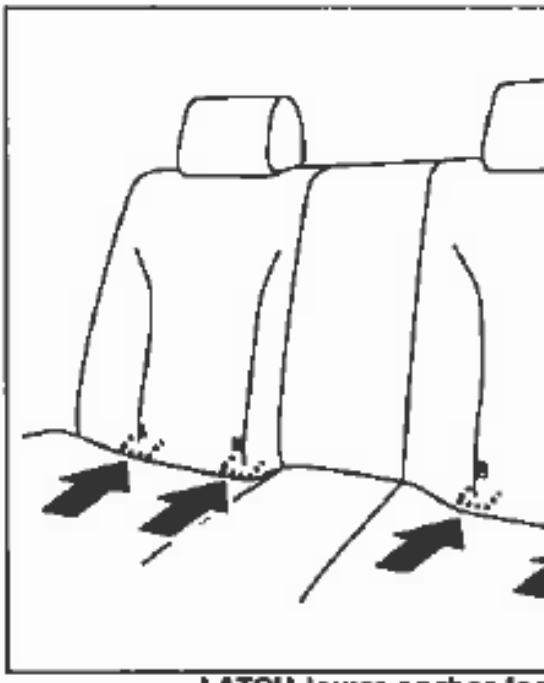


Photo No. 17: Two Designated Center Lower Anchors

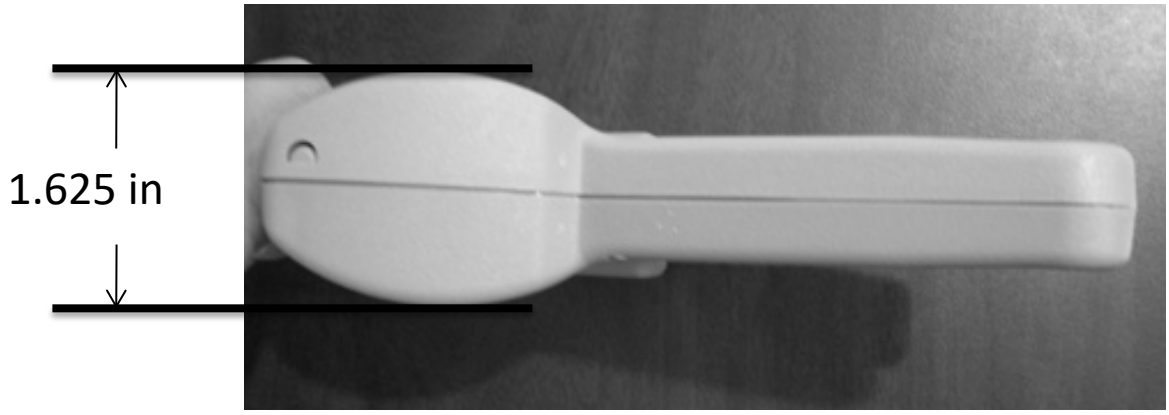
positions only. Do not attempt to install a child restraint in the center position using the LATCH anchors.



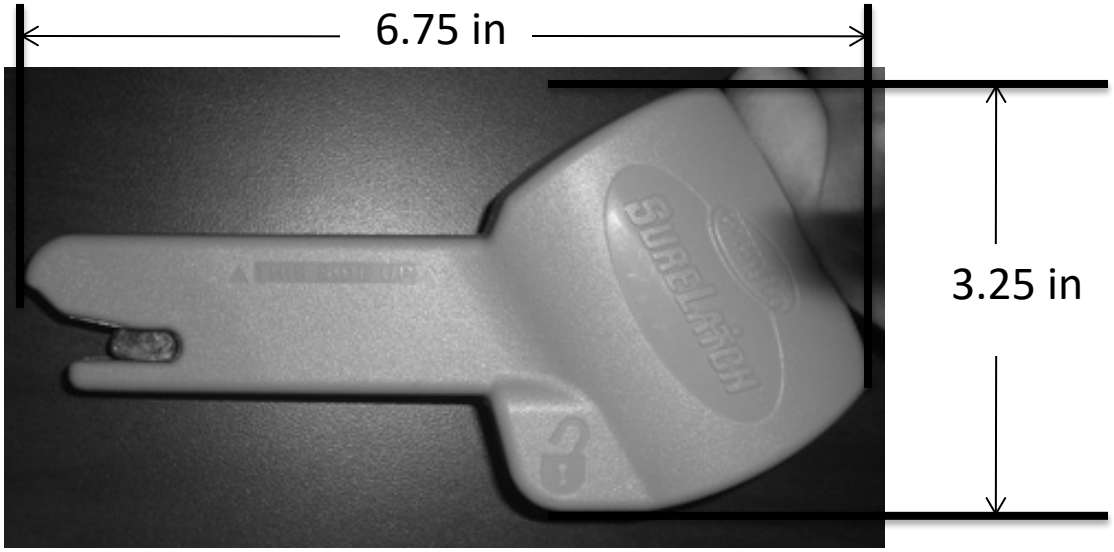
LATCH lower anchor loc

Photo No. 18: Prohibits Installation of CRS in Center Seating Position

Different Types of Child Restraint Connectors

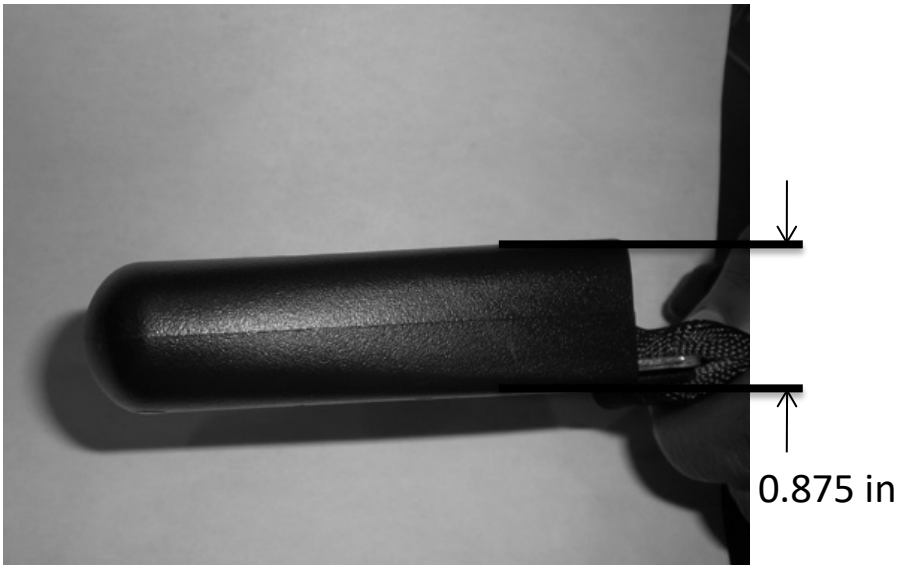


Top View



Side View

Photo No. 19: SureLATCH®



Top View

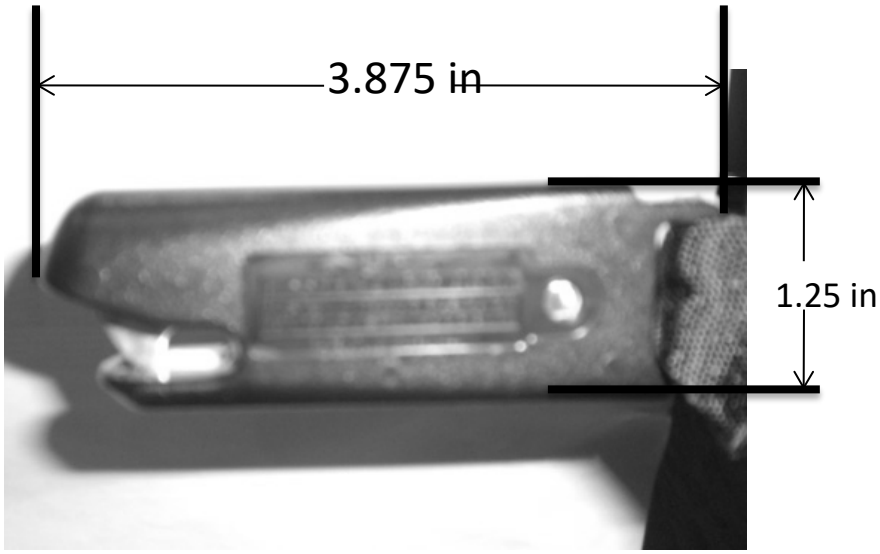
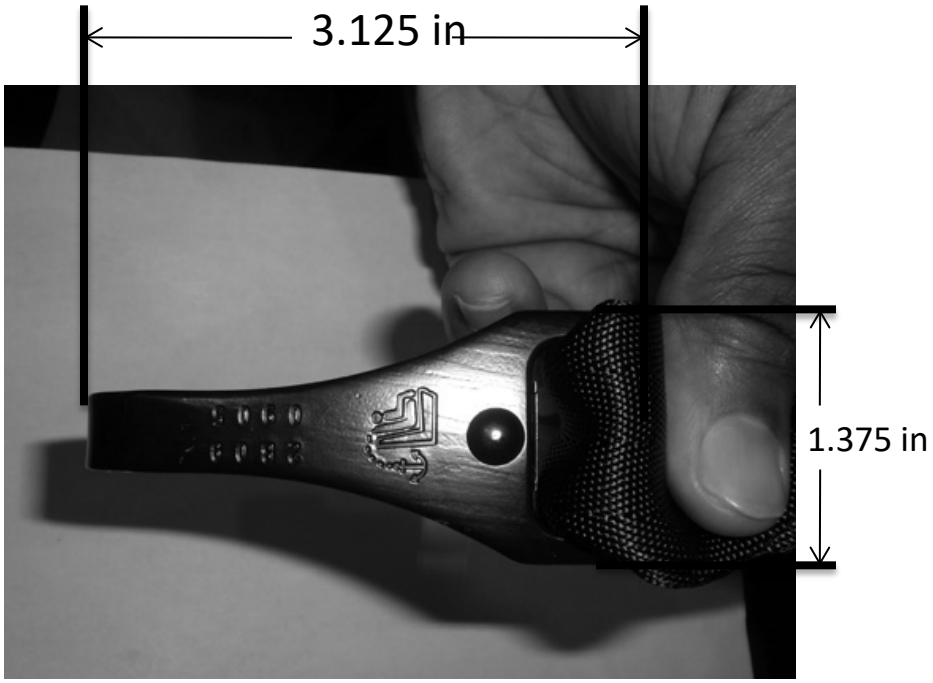


Photo No. 20: Push Button
Side View



Top View

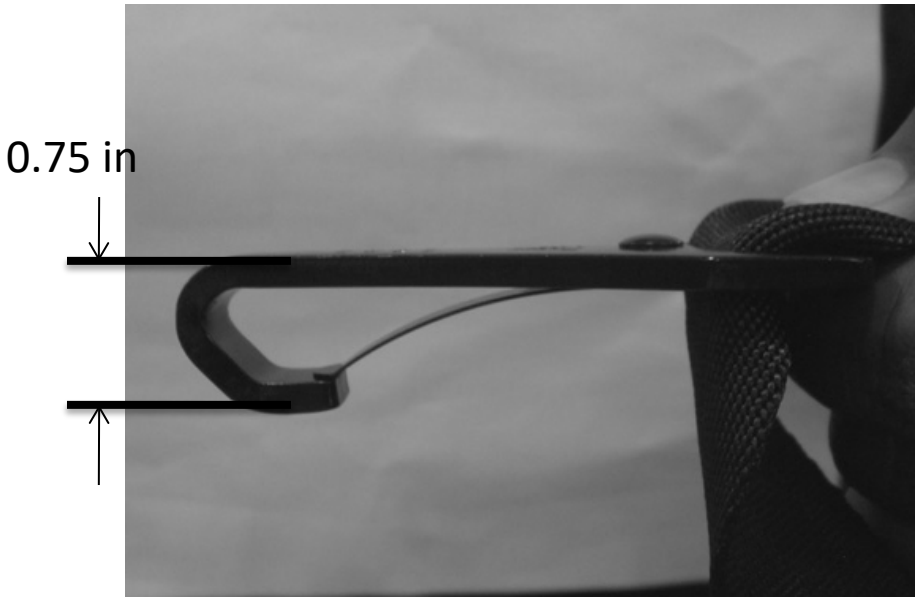


Photo No. 21- Hook Connector

Side View

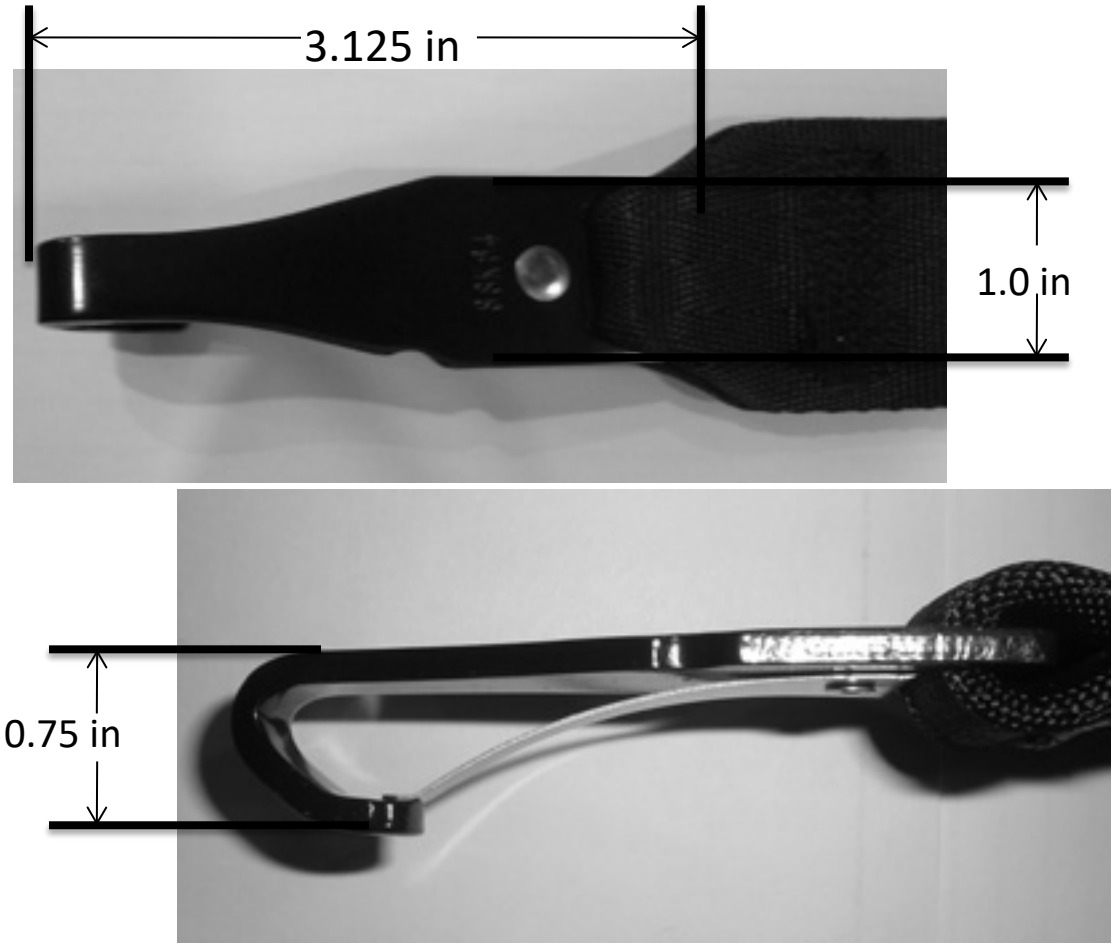


Photo No. 22: Skinny Hook Connector

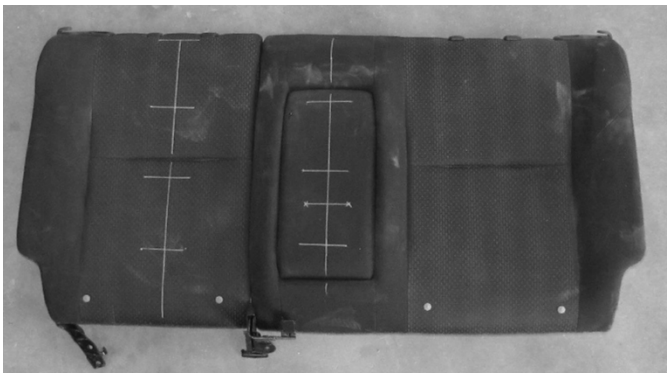


Photo No. 23: Seat Back Cushion – Front View

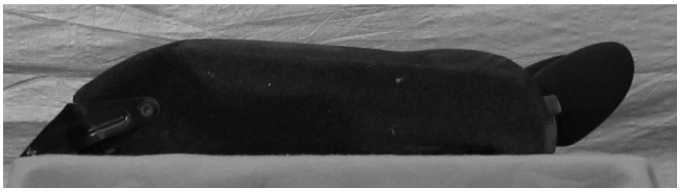


Photo No. 24: Seat Back Cushion – Side View

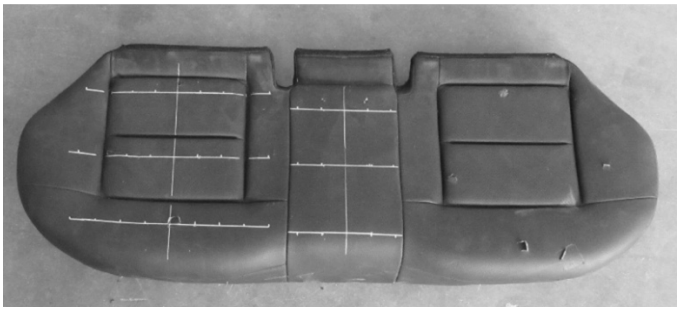


Photo No. 25: Seat Pan Cushion – Front View

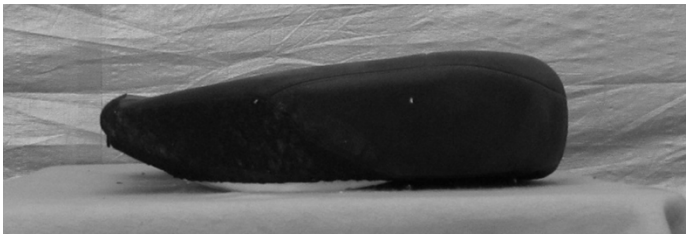


Photo No. 26: Seat Pan Cushion – Side View

APPENDIX E

Related Child Restraint Measurement Tables

Measurements recorded in millimeters unless otherwise stated.

Table 1: Seat back heights for MY 2010 child restraints in forward-facing mode

Child Restraint		Unreclined	Reclined
Britax	**Frontier 85**	673	587
Combi	**Zeus 360**	724	692
Evenflo	**Maestro**	705	-
Evenflo	**Generations 65**	686	673
Graco	**ComfortSport**	686	-
Graco	**MyRide 65**	699	-
Graco	**Nautilus Elite**	699	686
Safety 1st	**Intera (with base)**	686	-
Safety 1st	**Intera (without base)**	660	-
Average		691 ± 19	660 ± 49
OVERALL AVERAGE		683 ± 33	

Table 2: Tether lengths for MY 2010 child restraints in forward-facing mode

Child Restraint		Maximum	Minimum	Adjusted Max.*	Adjusted Min.*
Britax	**Frontier**	1581	64	2108	591
Combi	**Zeus 360**	2896	140	3315	559
Evenflo	**Maestro**	908	165	1473	730
Evenflo	**Generations 65**	1073	165	1531	623
Graco	**ComfortSport**	1003	140	1575	712
Graco	**MyRide 65**	1117	114	1702	699
Graco	**Nautilus Elite**	1187	165	1721	699
Safety 1st	**Intera**	1492	171	1937	616
Average		1407 ± 645	141 ± 36	1920 ± 602	653 ± 64

* The adjusted maximum and minimum tether lengths are derived by adding the distance from where the tether feeds out of the back of the CRS to the bottom of the CRS to the original tether lengths, and then subtracting the height of the lower leg of the SGMF. (These adjustments will scale the original point of reference from whether the tether exits the back of the CRS to point A on the SGMF instead.)