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NHTSA Research Procedure for the Proposed FMVSS No. 213 Frontal Impact Test

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Purpose

This research test procedure was drafted for the use with the upgraded Federal Motor Vehicle Safety Standard No. 213 (FMVSS 213) frontal sled buck assembly in support of the notice of proposed rulemaking (NPRM). It details procedures used for the following: high speed imagers, instrumentation, seat cushion foam certification, seat cushion assembly, child restraint system (CRS) installation, and anthropomorphic test device (ATD) positioning. This test procedure was used by the research team at the Vehicle Research and Test Center (VRTC) at the Transportation Research Center Inc. (TRC). These test procedures will be evaluated by the Office of Vehicle Safety Compliance (OVSC) to determine what test requirements would be needed to update the existing test procedure (FMVSS No. 213) at the appropriate time of final rulemaking.

1.0 Equipment

1.1 Test Buck Equipment

1. The test device used for research consists of two seat assemblies representing a rear seat of modern vehicles.[1] These seat assemblies are mounted to a dynamic test platform that is securely mounted on an impact sled. The entire assembly will be referred to as the frontal sled buck assembly.[2] The orientation should simulate a vehicle frontal impact. The overall set-up of the FMVSS No. 213 frontal impact test is shown in Figure 1.
2. A child restraint system (CRS) is attached to the frontal impact seat assembly by lower anchor attachments with or without top tether, or 3-point seat belt system with or without top tether.
3. Separating the two assemblies is a white painted wall made of plywood and PVC. This board should be rigidly mounted and parallel to the longitudinal center line of the seat. Numerous targets of different sizes are placed on the wall so that excursion measurements can be calculated using photogrammetric analysis. The targets all lay on the same reference plane and are spread out so that not all targets fall in a straight line.

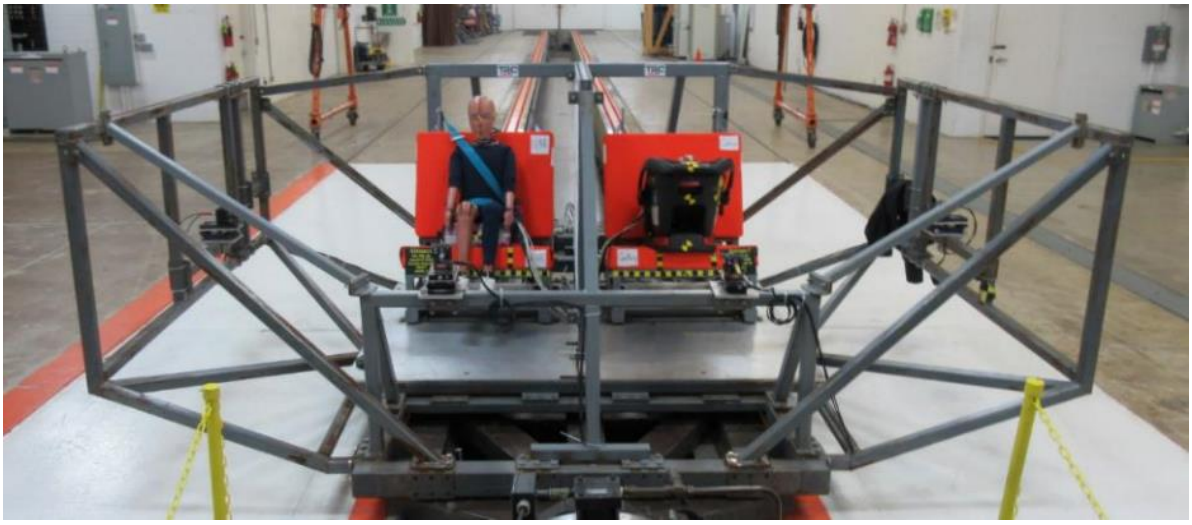


Figure 1: FMVSS No. 213 Frontal Sled Buck Assembly with Camera Wings

1.2 Buck Set Up

1.2.1 Cameras

1. Position a minimum of four high-speed imagers (minimum 1000 fps), two on each seat of the frontal sled buck assembly, onboard in the following locations to record occupant and CRS kinematics during the sled test (Figure 2):[3]
    a. Front View of Dummy (#1): This view includes the entire seat and front view of the CRS. The camera is parallel to and in-line with the longitudinal centerline of the seat.

[1] Aram, M.L., Rockwell, T., "Vehicle Rear Seat Study," Technical Report, July 2012. Docket No. NHTSA-2014-0012, Item No. 0005.
[2] Seat assembly was built to latest 213 frontal drawing package May 2019.
[3] IDT/Redlake N3 cameras were used with 12.5 mm focal length lenses at tests conducted at the Transportation Research Center Inc.

b. Lateral View (#2): This view includes the ATD, seat, and full view of the wall and targets. The camera is perpendicular to the longitudinal centerline of the seat. The camera should be positioned to track the head and knee for the entire event. This camera view will be used to measure the dummy excursions.

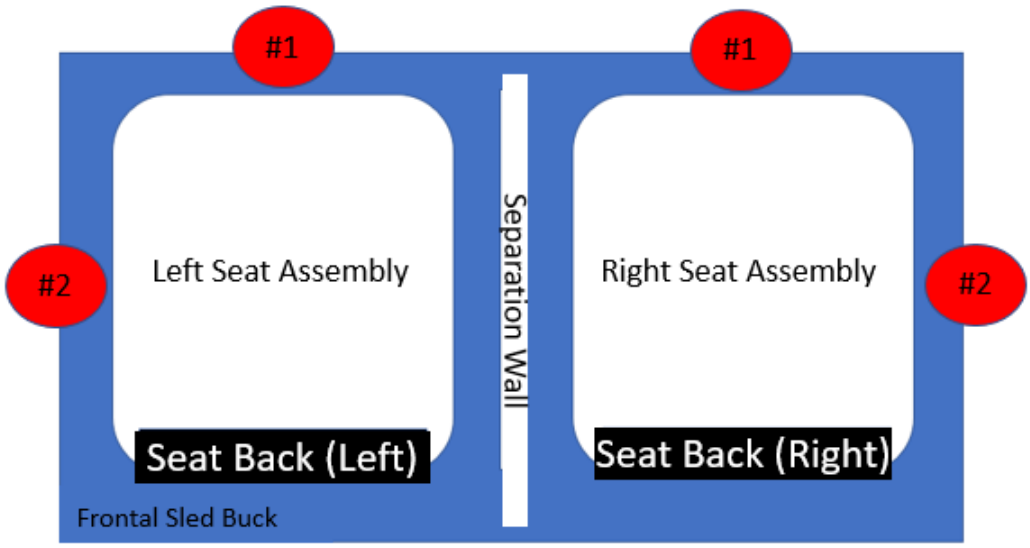


Figure 2: Camera Schematic for the Frontal Sled Buck Assembly

1.2.2 Targets and Measurements[4]

1. Set up the targets and inch tape on seat bench (Figure 3).
    a. Place inch tape on the seat frame along the seat back and seat pan.
    b. Mark the Z-point with a target. This will be the origin for all measurements. The location of the Z-point is specified in the drawing package.
2. Set up the targets on the separation wall for camera #2; these targets will be used for photogrammetric analysis.
    a. Randomly place a minimum of four targets on the separation wall.
    b. Ensure that a minimum of four targets are visible in the first frame (note: more than four targets are recommended for steps a and b).[5]
    c. Avoid having all four targets positioned in a straight line.
3. Measure camera locations using a 3D coordinate measurement machine (CMM), such as a FaroArm, with reference to the Z-point prior to the first test run of each series.
    a. Identify and measure four points on the camera around the lens and on the same plane where the lens connects to the camera body.
    b. Use those four points to generate a center point where the lens attaches to the camera, resulting in the lens center point.

[4] The Vehicle Research and Test Center (VRTC) uses TEMA software for photogrammetric analysis utilizing a 4-point method. The target and inch tape placement, measurements, camera calibration, and analysis procedures described in this section and in Appendices A and B are specific to that software. Different target/tape placements, measurements, and procedures may be needed for use with other photogrammetric analysis software.
[5] VRTC used approximately 9 targets.

c. Repeat steps a. and b. if a camera being used for photogrammetric analysis (i.e., Camera #2) is moved at any time during testing.[6]

4. Conduct lens calibration on the cameras being used for the photogrammetric analysis, which typically is Camera #2.
    a. Re-calibrate the camera anytime a lens is changed.

See Appendices A and B for lens calibration and post-test dummy excursion measurement procedures for the TEMA software used by VRTC.

Figure 3: Seat Bench and Separation Wall Targets

1.3 Test Conditions

Sled testing with the frontal sled buck assembly is conducted per the FMVSS No. 213 specification for sled acceleration. Table 1 lists the upper and lower limit times and accelerations, and Figure 4 plots the boundary corridor. The required velocity of the sled pulse is 48, +0, -3.2 kilometers per hour (30, +0, -2 mph).

[6] Typically, the camera is moved when the CRS has changed from forward-facing to rear-facing.

Table 1: Acceleration Upper and Lower Limits

Upper Limit		Lower Limit	
Time (msec)	Acceleration (G's)	Time (msec)	Acceleration (G's)
0	3	4	0
10	25	13	19
52	25	46	19
90	0	75	0

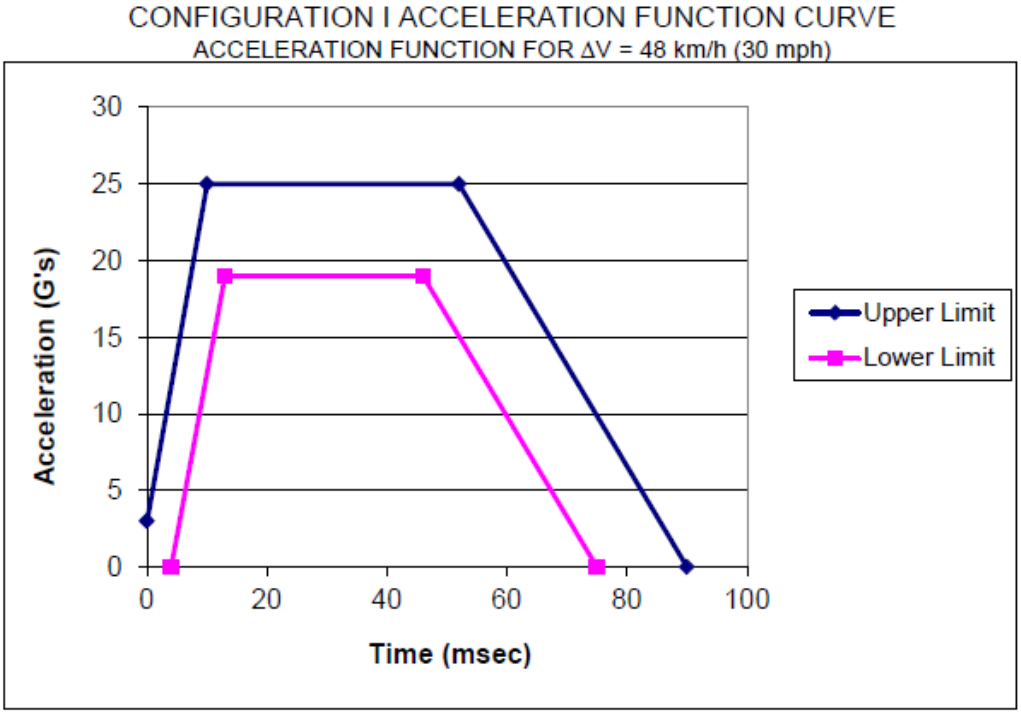


Figure 4: Seat Acceleration Corridor

1.4 Instrumentation

1. Instrumentation of the frontal sled buck assembly
    a. Measure seat acceleration in the direction of motion using accelerometers mounted on the bottom of the sled buck interface.
        i. Primary and Redundant X-axis.
2. Instrumentation of the ATDs
    a. The ATDs used with the CRSs are the following:
        i. 12-month-old CRABI (CRABI 12 MO)
        ii. Hybrid III 3YO (3YO)
        iii. Hybrid III 6YO (6YO)
        iv. Hybrid III 10YO (10YO)
    b. The CRABI 12 MO and the Hybrid III 3YO ATDs can be used in both forward-facing (FF) and rear-facing (RF) configurations.

c. The ATDs must be calibrated per the existing specifications listed in Part 572.[7]
d. Table 2 lists the instrumentation used during testing for each ATD.

Table 2: Summary of Instrumentation for ATDs

Location	Measurement	Instrument	Channels	ATDs			
				12MO	3YO	6YO	10YO
Head	Head C.G. Acceleration	Tri-Axial Accelerometer	3	✓	✓	✓	✓
Neck	Upper Neck Forces & Moments	6-Axis Load Cell	6	✓	✓	✓	✓
	Lower Neck Forces & Moments	6-Axis Load Cell	6	✓	✓	✓	✓
Thorax	Chest Acceleration	Tri-Axial Accelerometer	3	✓	✓	✓	✓
	Chest Displacement	Rotary Potentiometer	1		✓	✓	✓
Lumbar Spine	Forces & Moments	6-Axis Load Cell	6	✓	✓	✓	✓
	Velocity	Angular Rate Sensor	1			✓	
Pelvis	Pelvis Acceleration	Tri-Axial Accelerometer	3	✓	✓	✓	✓
Total Channels				27	28	29	28

3. Additional instrumentation for measuring belt loads during dynamic testing.
   a. When using the 3-point seat belt for CRS installation, use two seat belt load cells to measure loads (one at shoulder area and one at lap area at buckle location).[8]
   b. When using the lower anchors for CRS installation, place one load cell on the outboard side of the lower anchor belt, if it does not interfere with the CRS.
   c. When using the top tether as an additional attachment of the CRS, use one seat belt load cell to measure top tether dynamic loads.

[7] CRABI 12 MO per CFR Title 49, Part 572, Subpart R; Hybrid III 3YO per CFR Title 49, Part 572, Subpart P; 6YO to CFR Title 49, Part 572, Subpart S; and 10YO to CFR Title 49, Part 572, Subpart T.
[8] Load cells used were Measurement Specialties, model number EL20-S458-16KN.

1.5 Seat Bench Cushion Set Up

1. Foam used for testing must have specifications that meet those listed in Table 3. Certification sheets should be acquired from the foam manufacturer for all foam used in testing.

Table 3: Procurement Specifications for Seat Back and Seat Pan Foams

	Density kg/m^3 (lb/ft^3)	**50% CFD kPa (lb/in^2)**	**IFD 25% N (lb)**	**IFD 50% N (lb)**	**IFD 65% N (lb)**
Seat Pan (102 mm)	47 (2.9) ±10%	6.6 (0.96) ±10%	237 (53.3) ± 15% For reference	440 (98.9) ±10% [396-484]	725 (162.9) ±15% For reference
Seat Back (51 mm)	47 (2.9) ±10%	6.6 (0.96) ±10%	157 (35.3) For reference	300 (67.4) ±15% [255-345]	480 (107.9) For reference

2. Before the foam sets can be installed and used on the frontal seat assembly, test each foam piece to measure the indentation force-deflection (IFD) characteristics of the foam per the test procedure detailed in Appendix C.
    a. The IFD values of the foam must fall within the testing specifications listed in Table 4. Note that the seat pan foam 50 percent IFD procurement specification listed in Table 3 is different than that of the testing specification.

Table 4: Test Specifications Required for the Seat Back and Seat Pan Foams

	IFD 25% N (lb)	**IFD 50% N (lb)**	**IFD 65% N (lb)**
Seat Pan (102 mm)	237 (53.3) ±15% For reference	440 (98.9) ±15% [374-506]	725 (162.9) ±15% For reference
Seat Back (51 mm)	157 (35.3) For reference	300 (67.4) ±15% [255-345]	480 (107.9) For reference

3. During testing, the seat foams must rest for approximately one hour prior to the next sled use. The test matrix will determine the frequency for re-certification testing.[9]
4. Monitor the temperature and humidity in the lab during the test series. Record the temperature and relative humidity at the time of the test.

[9] During research testing, the foams were alternated after each dynamic sled test and re-certified after approximately five test uses.

5. When the foam sets are not being used for testing, store them in a humidity monitored area with a temperature range of 20.3 ± 4.7 degrees Celsius (67.5 ±7.5 degrees Fahrenheit).

1.5.1 Assembly of the Seat Foam Cushion Sets

1. Seat foam cushion assembly dimensions are detailed in the May 2019 FMVSS No. 213 frontal drawing package (Seat bench pan: 3021-230, 3021-233 and seat bench back: 3021-245, 3021-248).[10]
2. Wrap the seat foams in fabric (drawings# 3021-234 and 3021-249) and install them on both the seat bench back and seat bench pan. Appendix D shows the steps for wrapping the foam.
3. Install the 51-millimeter thick foam on the seat bench back and the 102-millimeter thick foam on the seat bench pan. Hand tighten the nuts on the bolts when the foams are installed for both the seat bench back and seat bench pan.
    a. When installing the foam cushion on the seat bench back, ensure the foam cushion does not slip on the metal plate; the top of the foam cushion should be in line with the top of the seat bench back. If the foam does slip, undo the fabric and re-wrap the cushion and the plate.
4. Ensure the seat bench back and seat bench pan cushion assemblies have been installed correctly by measuring the gap between them (Figure 5). The gap should measure 65 ± 5 millimeters.

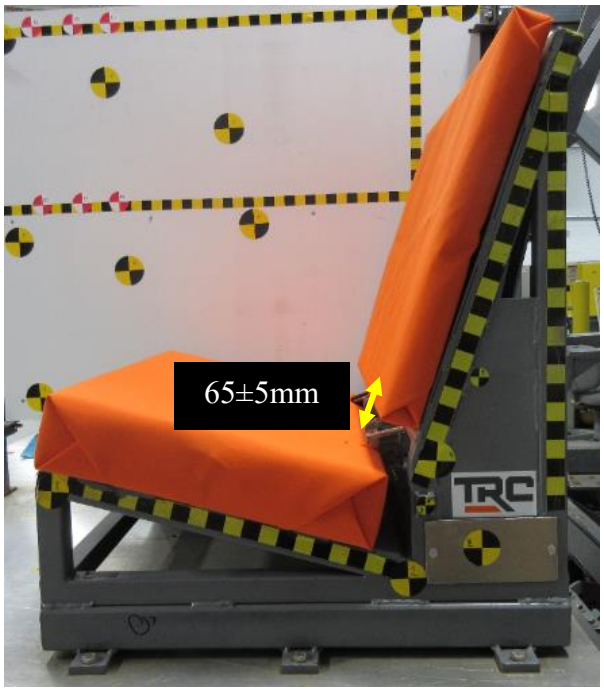


Figure 5: Gap Measurement Between Cushions

[10] Dimensions and other details regarding the cushion assembly can be found in Child Frontal Impact Sled-V2, NHTSA Standard Seat Assembly; FMVSS No. 213, No. NHTSA-213-2016, Drawing Package, May 2019.

1.6 ATD and CRS Targets

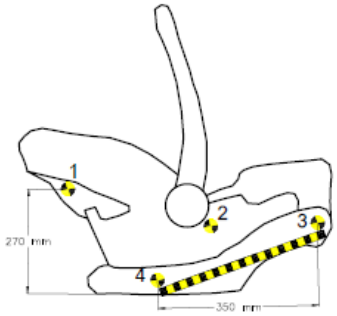
1. Each CRS and ATD are targeted in specific locations for analysis and seating comparisons. Table 5 and Figure 6 list and illustrate the locations of targets for both the CRS and ATD in rear-facing and forward-facing orientations. Positive X, Y, and Z axes are defined as forward, right, and down, respectively, with respect to the Z-point on the seat assembly. These targets are measured with a 3D CMM and recorded. For reference on the physical locations of the target locations, refer to Appendix E. Many of the reference targets are located on the centerline of the ATD. CRS Targets 1 through 4 are shown in Figure 6 for the different seat configurations. This target application is done prior to the CRS being installed on the seat assembly and is done on a flat surface.

Table 5: Target Location Descriptions

Point	Target Description: Infant	Target Description: Rear-Facing CRS	Target Description: Convertible/HB Booster	Target Description: NB Booster
1	Z-Point (should be 0,0,0)	Z-Point (should be 0,0,0)	Z-Point (should be 0,0,0)	Z-Point (should be 0,0,0)
2	Center of Seat Frame Back (on buck)	Center of Seat Frame Back (on buck)	Center of Seat Frame Back (on buck)	Center of Seat Frame Back (on buck)
3	Top of CRS	Top of CRS	Top of CRS	NA
4	CRS Bottom Center (near strap adjuster)	CRS Bottom Center (near strap adjuster))	NA	NA
5	NA	CRS Top of Headrest (if applicable)	CRS Top of Headrest (if applicable)	NA
6	CRS Top of the Base (on base - if it has a base)	NA	NA	NA
7	CRS Handle Center (if applicable)	NA	NA	NA
8	Top of Head at CG	Top of Head at CG	Top of Head at CG	Top of Head at CG
9	Bridge of Nose	Bridge of Nose	Bridge of Nose	Bridge of Nose
10	Head CG Outboard	Head CG Outboard	Head CG Outboard	Head CG Outboard
11	NA	Neck Center (center mark on neck if applicable)	Neck Center (center mark on neck if applicable)	Neck Center (center mark on neck if applicable)
12	NA	NA	NA	Shoulder Belt Upper
13	NA	NA	NA	Lap Belt Upper
14	NA	NA	NA	Shoulder Belt Lower
15	NA	NA	NA	Lap Belt Lower
16	Chest Clip	Chest Clip	Chest Clip	NA
17	Buckle	Buckle	Buckle	NA
18	Knee Pivot Center	Knee Pivot Center	Knee Pivot Center	Knee Pivot Center
19	NA	Ankle Pivot	Ankle Pivot	Ankle Pivot

20	CRS mid height (on back of CRS)	NA	NA	NA
21	CRS Base Center or bottom of CRS at centerline	CRS Base Center or bottom of CRS at centerline	CRS Base Center (on front of seat)	Booster Base Center (on front of seat)
22	Center of Seat Frame Bottom (on seat buck)	Center of Seat Frame Bottom (on seat buck)	Center of Seat Frame Bottom (on seat buck)	Center of Seat Frame Bottom (on seat buck)
23	CRS Side Handle (if applicable)	NA	NA	NA
24	Target 1 - Seat Side Upper (see schematic in Figure 6)	Target 1 - Seat Side Upper (see schematic in Figure 6)	NA	NA
25	Target 2 - Seat Base H-Point (see schematic in Figure 6)	Target 2 - Seat Base H-Point (see schematic in Figure 6)	Target 2 - Seat Base H-Point (see schematic in Figure 6)	Target 2 (see schematic in Figure 6)
26	Target 3 - Seat Base Side (see schematic in Figure 6)	Target 3 - Seat Base Side (see schematic in Figure 6)	Target 3 - Seat Base Side (see schematic in Figure 6)	Target 3 (see schematic in Figure 6)
27	Target 4 - Seat Side Lower (see schematic in Figure 6)	Target 4 - Seat Side Lower (see schematic in Figure 6)	Target 4 - Seat Side Lower (see schematic in Figure 6)	NA

Infant Seats



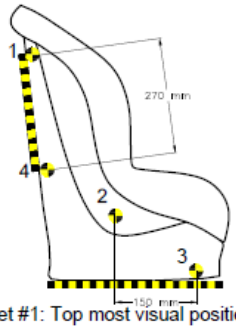
Target #1: Top most visual position. ~270 mm vertical from bottom of CRS

Target #2: H-point location

Target #3: Place in flat surface within 20-50 mm of seat edge.

Target #4: 350 mm rearward horizontally from #3

RF Convertible



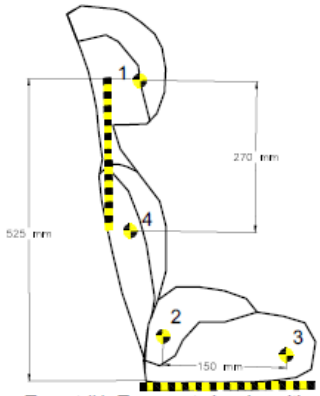
Target #1: Top most visual position.

Target #2: H-point location

Target #3: 150 mm forward horizontally from #2

Target #4: 270 mm at seatback angle from #1

FF Convertible & Boosters



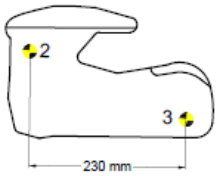
Target #1: Top most visual position. ~525 mm vertically from bottom of CRS.

Target #2: H-point location

Target #3: 150 mm forward horizontally from #2

Target #4: 270 mm vertically from #1. Near belt opening.

Low Back Boosters



Target #2: H-point location

Target #3: 230 mm forward horizontally from #2

Figure 6: Targeting Schematic for Different CRS Configurations

2. For the rear-facing convertible CRSs, three additional large targets are used to calculate the angle of the seat back (Figure 7).
    a. The targets are placed along the side of the CRS in view of the lateral camera, parallel to the CRS seatback when installed on the seat bench. The initial angle is measured with an inclinometer on the CRS seatback and the targets are placed such that the three targets form a line representing the CRS seatback.
    b. During post-test analysis, the three targets are tracked to determine how much the rear-facing CRS has rotated. The angle between the system's back support surface for the child and the vertical shall not exceed 70 degrees.

Figure 7: Target Locations for Rear-Facing CRS for Angle Calculation

2.0 Test Set Up

1. Select the CRS, CRS configuration, and ATD as indicated by the test matrix.
2. Before installing the CRS on the seat bench, weigh the CRS and record the mass in the tested configuration (including any accessories as applicable for dummy configuration).
3. Install each CRS per the manufacturer's instructions, as applicable.
4. Install the CRS on the seat bench first, then appropriately seat and position the ATD in the CRS. Confirm the ATD's joints are properly adjusted to the 1-2 g requirement per each of the ATD's qualification manual.
5. Measure the ATDs, the seat bench, and the CRSs with a 3D CMM. The origin of the measurements should be at the Z-point of the seat bench, as shown in Figure 8 (drawing# 3021-1000).

Figure 8: Z-Point Location on Sled Buck Assembly

6. When conducting repeat tests, match all corresponding measurements for the ATD and CRS targets as closely as possible.[11]

2.1 CRS Installation with Lower Tethers

1. Place the CRS on the seat pan cushion assembly and push the CRS until the back of the CRS (front of CRS for rear-facing) contacts the seat back cushion. Be sure that the footprint of the CRS is in full contact with the seat pan cushion.
2. Check that the center of the CRS is aligned with the center of the seat bench frame.
3. Attach the CRS lower tethers to the LATCH assembly (drawing# 3021-750). If required, per the test matrix, attach the top tether to the top tether anchor assembly (drawing# 3021-345).
4. Place weight (body weight) with hand on the inside of the CRS at the bottom edge of the CRS seat back while tightening the restraints.
5. Tighten the lower tethers, making sure that the CRS does not move or tilt while tightening. Tighten to the appropriate specifications, as shown in Table 6, Section 2.3.

2.2 CRS Installation with a 3-point Belt[12]

1. Connect the correct anchorage hardware (drawings# 3201-120 and 3201-121) to the LATCH assembly (drawing# 3021-750).
    a. Be sure the inboard lap belt anchor, outboard lap belt anchor, rear locking belt anchor, and D-ring are installed in the correct orientation per the drawing package.

[11] On all repeat measurements, a tolerance of ± 10 mm is targeted for x and z coordinates and a ± 5 mm is targeted for the y-axis coordinates.
[12] Seven panel seat belt webbing (Seatbelt Plus) www.seatbeltsplus.com/product/7Panel_Webbing.html

2. Before installing the CRS on the seat bench, weigh the CRS and record the mass in the tested configuration (including any accessories as applicable for dummy configuration).
3. Install each CRS per the manufacturer's instructions, as applicable.
4. When using the 3-point seat belt orientation, route the seat belt webbing as shown in Figures 9 through 15. Follow the CRS manufacturer's instructions to verify the belt path for each respective CRS.
    a. Install seat belt webbing starting with the rear locking belt anchor.
    b. Pull the end of the webbing straight through the back of the rear locking belt anchor, and then loop it around the knurled rod and back through the slot (Figure 9 and Figure 10).

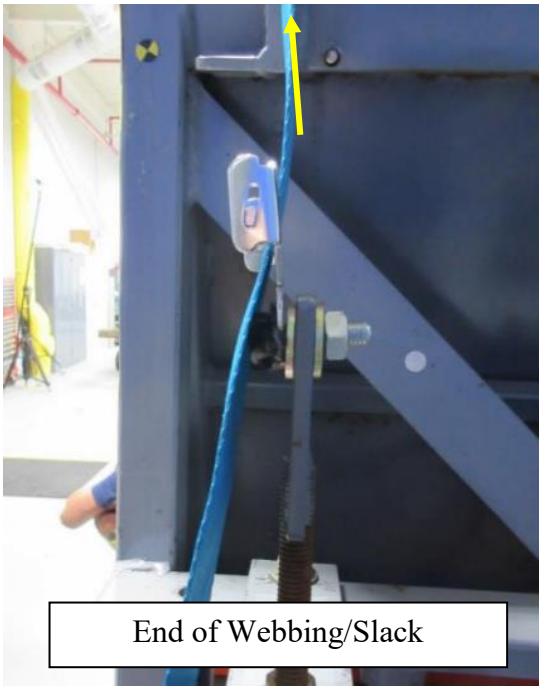


Figure 9: Webbing Through the Rear Locking Belt Anchor

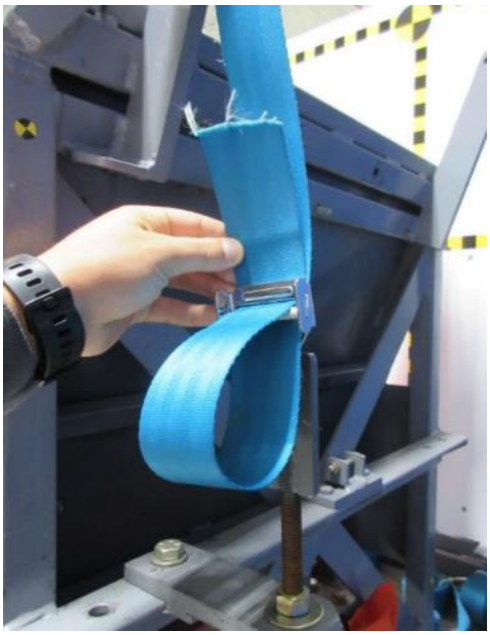


Figure 10: Loop Webbing Back Through the Rear Locking Belt Anchor

c. Pull at least 200 millimeters (8 inches) of slack through the slot, and let it hang off the side of the rear locking belt anchor (Figure 11).

Figure 11: Slack Pulled Through the Slot

d. Route the rest of the belt through the D-ring ensuring there are no twists in the webbing.

e. Route the webbing over the shoulder of the ATD and/or through the correct belt path on the CRS to the inboard lap belt anchor, as appropriate for the type of CRS and per the CRS manufacturer's instructions (Figure 12).

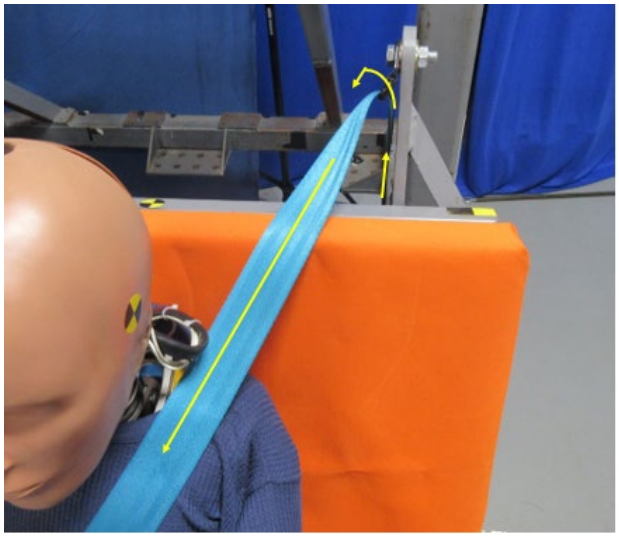


Figure 12: Belt Routed Through the D-ring and Over the Shoulder of ATD

f. Once the webbing is over the shoulder and chest of the ATD, or through rear of the CRS, route the webbing through the inboard lap belt anchor (Figure 13).

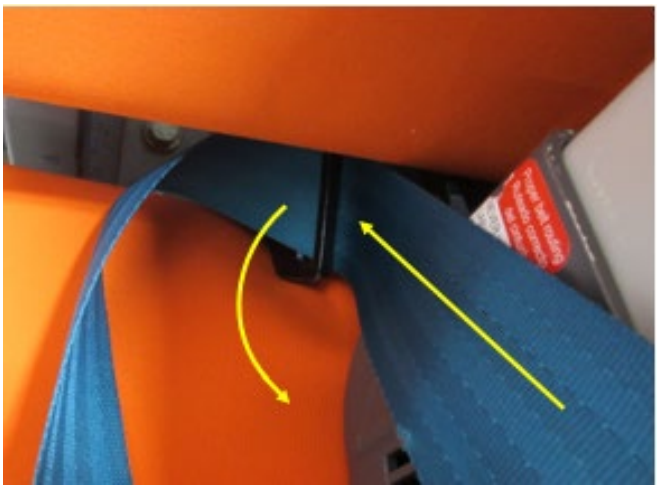


Figure 13: Belt Routed Through the Inboard Lap Belt Anchor

g. Pull the end of the webbing back over the lap of the ATD or back through CRS, as appropriate for the type of CRS and per the CRS manufacturer's instructions, to the outboard lap belt anchor (Figure 14). Pull slack from the rear locking belt anchor as needed to accomplish this.

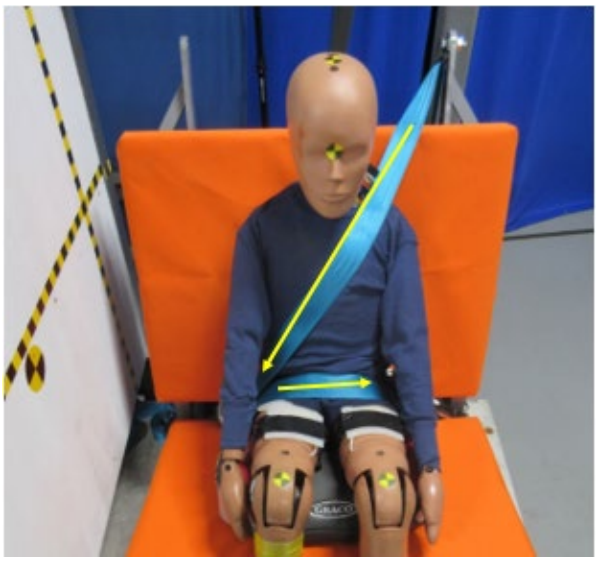


Figure 14: Belt Routed Over Shoulder, Through Inboard Anchor, and Over Lap

h. Once the webbing is over the lap of the ATD or through the back of the CRS, pull the webbing through the slot underneath the knurled rod (knurled rod at maximum position).

i. Once all slack is pulled through, wrap the webbing back through the slot over top of the knurled rod (Figure 15).

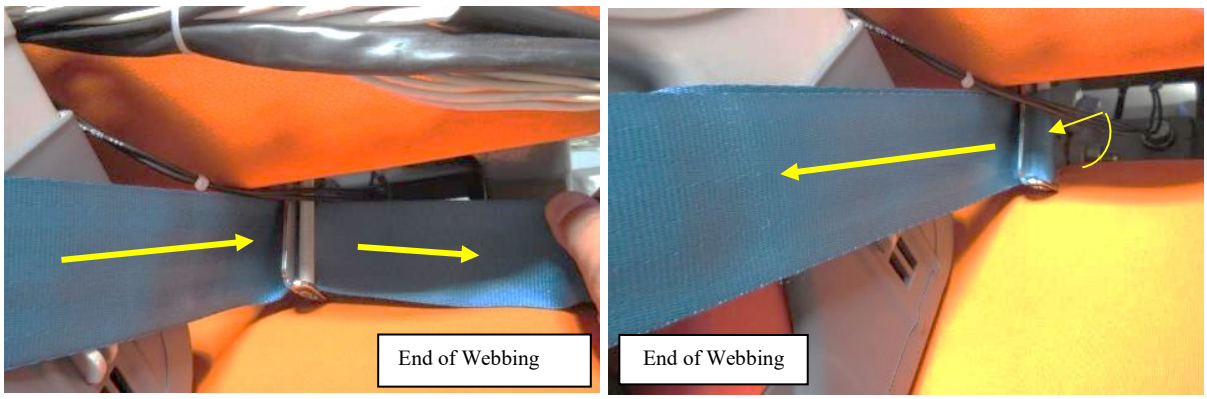


Figure 15: Belt Route Through the Outboard Anchor

j. Pull all the slack out of the webbing.

k. Add seat belt load cells, if required.

l. Tension belts to the desired range for the test configuration (Section 2.3).

2.3 Tension Verification of the CRS

2.3.1 Seat Belt Tension Specifications

1. After the ATD is seated per its test configuration, measure and verify the tensions of the seat belt webbing and harnesses per the tension specifications listed in Table 6.
2. Check the belt tensions using a belt tensioning device such as the one shown in Figure 16.[13]

Table 6: Belt Tension Specifications

	Lower Anchor Tethers	Top Tether	Internal Harness	3PT Seat Belt with CRS	3PT Belt with BPB
Tension Requirements	54-67 N (12-15 lb)	45-54 N (10-12 lb)	9-18 N (2-4 lb)	54-67 N (12-15 lb)	9-18 N (2-4 lb)

Figure 16: Tension Gauge

2.3.2 Alternate Tension Adjustment Method

If the tension gauge cannot be placed on the seat belt, use this method to verify the tension on the CRS is correct.

1. Check at the belt path that the CRS cannot move more than 25 millimeters (1 inch) in either the fore/aft or lateral directions. Make this measurement using the following steps:

[13] VRTC uses a BT-3329-S manufactured from Kent-Moore, a division of Bosch. Tension gauge is calibrated at a range of 2-15 pounds.

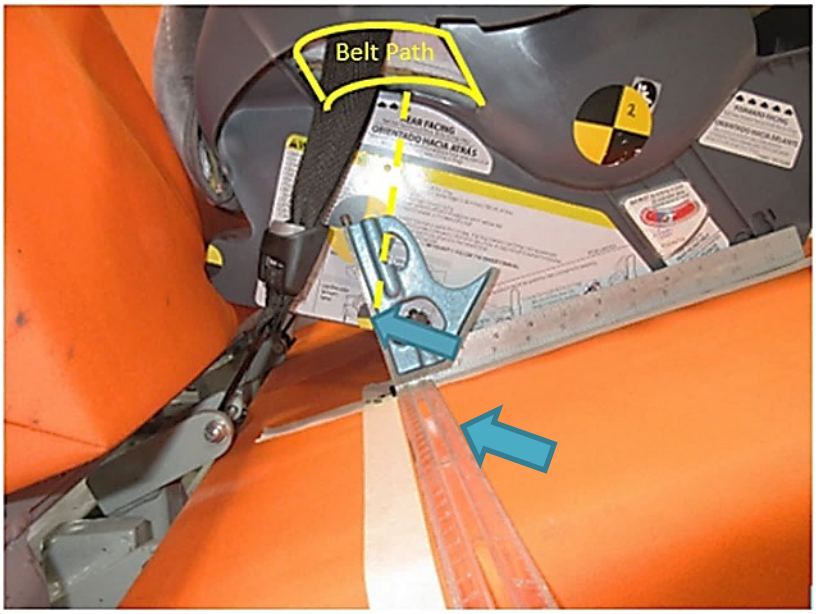


Figure 17: Reference Point on Base of CRS

a. Mark a reference point on the base of the CRS in line with the belt path. Mark another reference point on the seat bench cushion in the same lateral plane as the CRS target. This is the starting reference point location (Figure 17).
b. Stand, facing the seat, grab the CRS at the belt path, and firmly pull laterally on the CRS left and right two times. Pull first on the side opposite the reference target and then on the same side as the reference target. Mark the seat reference point on the lateral tape.
c. While in the same position, grab the CRS at the belt path, and firmly pull the CRS forward, away from the seat bench back, and then push it back. This is performed twice. Mark the final location of the reference point on the CRS in the for-aft direction.
d. The reference point should not have moved more than 25 millimeters (1 inch) from the starting location in the fore-aft or lateral direction when moving the CRS. If it exceeds 25 millimeters in either direction, tighten the belts and repeat steps a through d.

3.0 ATD Installation

Place the ATD in the CRS such that the midsagittal plane is aligned in the same lateral plane as the center of the seat assembly. Confirm the lateral distances (y-coordinate) of the centerline targets (described in Section 1.6, Table 4) are aligned using the 3D CMM, and confirm they are within ±5 millimeters of each other (Figure 18). Adjust where necessary. The positioning of the ATDs is based on the FMVSS No. 213-10 Test Procedure.[14]

[14] FMVSS No. 213-10; www.nhtsa.gov/vehicle-manufacturers/test-procedures.

Figure 18: Lateral Alignment of ATD

3.1 CRABI 12-Month-Old

3.1.1 Rear-Facing CRS Installation

1. Place the ATD in the CRS with the back of the torso and pelvis in contact with the back of the support surface and the bottom of the pelvis in contact with the bottom of the support surface of the CRS.
    a. Place harness straps at or below the shoulder of the ATD in accordance with the manufacturer's instructions.
    b. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.
2. If applicable, position CRS handle per manufacturer's instructions.
    a. If nothing is noted or multiple locations are provided, place the handle in the first locked position rearward on the seat, as shown in Figure 19.
3. Raise the arms of the ATD vertically above the head.
4. Make sure all the cable routing is gathered and routed under the harness and out the side towards the separating wall of the frontal sled buck assembly.
5. Push the knees of the ATD to ensure contact with the back of the CRS.
6. Fasten the harness on the ATD per manufacturer's instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.
7. Verify the chest clip is placed at armpit level.
8. Slowly lower the arms, without bending, until the arms contact a CRS surface.
9. Verify that the arms are not restrained from any movement other than in the downward direction.
10. Straighten the legs out from the body without bending.
11. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame. Verify the belt tensions are within specifications

12. Measure and record the angle of the line connecting the three large targets (see Figure 7) relative to horizontal.

Figure 19: CRABI 12 MO Installed in Rear-Facing CRS

3.1.2 Forward-Facing Installation

1. Place the ATD in the CRS while holding the ATD torso upright.
    a. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.
2. Gently push the ATD rearward along the CRS seat bottom until the back of the ATD contacts the CRS seat back.
    a. Confirm that the ATD's clothing is not gathered into joints prior to positioning it.
3. Verify the ATD is centered, aligning the midsagittal plane of the dummy's head with the centerline of the seat bench.
4. Raise the arms of the ATD vertically above the head as far as possible.
5. Straighten the legs of the ATD outward from body without bending.
6. Using a flat surface with an area of 2580 square millimeters (4 in^2), apply a force of 178 Newtons (40 lb) perpendicular to the plane of the seat bench back.
    a. First, apply the force against the ATD crotch.
    b. Second, apply the force to the ATD thorax in the midsagittal plane of the ATD.
7. Verify the harness straps on the ATD are positioned at or above the shoulder, in accordance with the manufacturer's instructions.
8. Make sure all the cable routing is gathered and routed under the harness and out the side towards the separating wall of the frontal sled buck assembly.
9. Fasten the harness on the ATD per manufacturer's instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.

10. Verify the chest clip is placed at armpit level.
11. Slowly lower the arms, without bending, until the arms contact a CRS surface.
    a. Verify that the arms are not restrained from any movement other than in the downward direction.
12. Verify ankles, knees, and legs are in line.
13. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame. Verify the belt tensions are within specifications.

3.2 Hybrid III 3YO

3.2.1 Rear-Facing Installation

This procedure will be used for seats with a rear-facing weight limit of up to 15.9 kilograms (35 lb). Remove the ATD knee stops for the rear-facing configuration.

1. Place the ATD in the CRS making sure the back of the torso is in contact with the back of the support surface of the CRS.
    a. Place harness straps at or below the shoulder of the ATD, in accordance with the manufacturer's instructions.
    b. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.
2. If applicable, position CRS handle per manufacturer's instructions.
    a. If nothing is noted or multiple locations are provided, place the handle in the first locked position, rearward on the seat, as shown in Figure 19.
3. Raise the arms of the ATD vertically above the head.
4. Make sure all the cable routing is gathered and routed under the harness and out the side towards the separating wall of the frontal sled buck assembly.
5. Push the knees of the ATD to ensure contact with the back of the CRS.
6. Fasten the harness on the ATD per manufacturer's instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.
7. Verify the chest clip is placed at armpit level.
8. Slowly lower the arms, without bending, until the arms contact a CRS surface.
    a. Verify that the arms are not restrained from any movement other than in the downward direction.
9. Straighten the legs out as well as possible against the seat back without bending, as seen in Figure 20.
10. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame. Verify the belt tensions are within specifications.
11. Measure and record the angle of the line connecting the three large targets (see Figure 7) relative to horizontal.

Figure 20: Hybrid III 3YO Installed in Rear-Facing CRS

3.2.2 Forward-Facing Installation

1. Place the ATD in the CRS while holding the ATD torso upright. Gently push the ATD rearward along the CRS seat bottom until the back of the ATD contacts the CRS seat back.
    a. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.
    b. Confirm that the ATD's clothing is not gathered into joints prior to positioning.
2. Verify the ATD is centered, aligning the midsagittal plane of the dummy's head with the centerline of the seat bench.
3. Raise the arms of the ATD vertically above the head as far as possible.
4. Straighten the legs of the ATD outward from body without bending, with the dummy feet perpendicular to the centerline of the lower legs.
5. Using a flat surface with an area of 2580 square millimeters (4 in^2), apply a force of 178 Newtons (40 lb) perpendicular to the plane of the seat bench back.
    a. First, apply the force against the ATD crotch.
    b. Second, apply the force to the ATD thorax in the midsagittal plane of the ATD.
6. Verify the harness straps on the ATD are positioned at or above the shoulder, in accordance with the manufacturer's instructions.
7. Make sure all the cable routing is gathered and routed under the harness and out the side towards the separating wall of the frontal sled buck assembly.
8. Fasten the harness on the ATD per manufacturers' instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.
9. Verify the chest clip is placed at armpit level.
10. Slowly lower the arms, without bending, until the arms contact a CRS surface.

a. Verify that the arms are not restrained from any movement other than in the downward direction.

11. Verify ankles, knees, and legs are in line (Figure 21). Bend the legs over the CRS if applicable (knees are at the edge of the CRS and ATD can remain where placed).
12. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame. Verify the belt tensions are within specifications.

Figure 21: Hybrid III 3YO Installed in Forward-Facing CRS

3.3 Hybrid III 6YO

3.3.1 Forward-Facing Installation

1. Place the ATD in the CRS while holding the ATD torso upright. Gently push the ATD rearward along the CRS seat bottom until the back of the ATD contacts the CRS seat back.
    a. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.
    b. Confirm that the ATD's clothing is not gathered into joints prior to positioning.
2. Verify the ATD is centered, aligning the midsagittal plane of the dummy's head with the centerline of the seat bench.
3. Raise the arms of the ATD vertically above the head as far as possible.
4. Straighten the legs of the ATD outward from body without bending, with the dummy feet perpendicular to the centerline of the lower legs.
5. Using a flat surface with an area of 2580 square millimeters (4 in^2), apply a force of 178 Newtons (40 lb) perpendicular to the plane of the seat bench back.
    a. First, apply the force against the ATD crotch.
    b. Second, apply the force to the ATD thorax in the midsagittal plane of the ATD.

6. Verify the harness straps on the ATD are positioned at or above the shoulder, in accordance with the manufacturer's instructions.
7. Make sure all the cable routing is gathered and routed under the harness and out the side towards the separating wall of the frontal sled buck assembly.
8. Fasten the harness on the ATD per manufacturer's instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.
9. Verify the chest clip is placed at armpit level.
10. Slowly lower the arms, without bending, until the arms contact a CRS surface.
    a. Verify that the arms are not restrained from any movement other than in the downward direction.
11. Bend the legs at knees to bring the legs down until they touch the CRS or foam cushion. (Figure 22).
12. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame. Verify the belt tensions are within specifications.

Figure 22: Hybrid III 6YO Installed in Forward-Facing CRS

3.3.2 Belt Position Booster Installation

1. Confirm that the lap shield is installed, with the top edge aligned with the top of the pelvis and the lower flaps resting on top of the thighs of the ATD (see Figure 23), secured around the thighs and towards the top of the pelvis with strips of tape.[15]
2. Place the ATD in the CRS while holding the ATD torso upright. Gently push the ATD rearward along the CRS seat bottom until the back of the ATD contacts the seat back of

[15]The use of duct tape deviates from the current FMVSS 213 procedure to affix the lap shield with double-sided tape. During the research testing series, it was observed that the double-sided tape would not stay adhered to the material of the lap shield, therefore duct tape was used.

the CRS or the back of the seat bench while also keeping the bottom of the pelvis in contact with the bottom of the CRS.

   a. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.
   b. Confirm that the ATD's clothing is not gathered into joints prior to positioning.

Figure 23: Lap Shield Installed

3. Verify the ATD is centered, aligning the midsagittal plane of the dummy's head with the centerline of the seat bench.
4. Raise the arms of the ATD vertically above the head as far as possible.
5. Straighten the legs of the ATD outward from body without bending.
6. Using a flat surface with an area of 2580 square millimeters (4-in^2), apply a force of 178 Newtons (40 lb) perpendicular to the plane of the seat bench back.
   a. First, apply the force against the ATD crotch,
   b. Second, apply the force to the ATD thorax in the midsagittal plane of the ATD.
7. Slowly lower the arms, without bending, until the arms contact a CRS surface.
   a. Verify that the arms are not restrained from any movement other than in the downward direction.
8. Bend the legs at the knees to bring the legs down until they touch the CRS or foam cushion.
9. Position the knees so that the center-of-knee to center-of-knee distance measures 180 ± 5 millimeters.
10. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame.
11. Position the seat belt on the ATD per manufacturer's instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.
    a. The lap belt should be over the thighs of the dummy, while the shoulder belt shall come across the chest, as shown in Figure 24.

Figure 24: Hybrid III 6YO Installed in Backless Booster

3.4 Hybrid III 10YO

3.4.1 ATD Setup

1. Verify the 10YO neck bracket is positioned in SP-16 (Figure 25) setting and the lumbar spine is in SP-12 setting (Figure 26).[16]

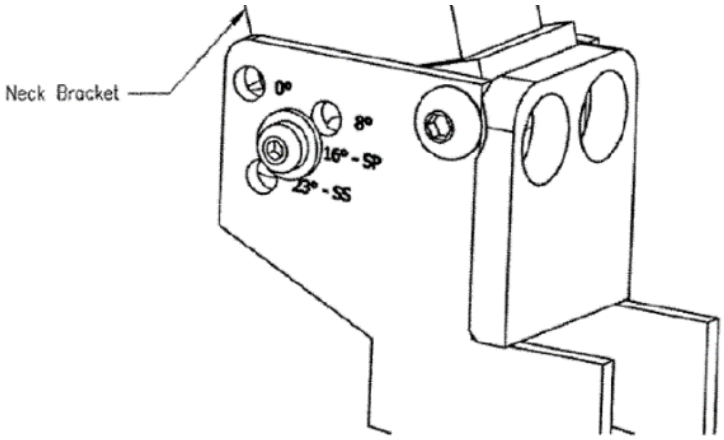


Figure 25: HIII 10YO Neck Angle Setting Adjustment

[16] Per FMVSS 213-10 NHSTA Test Procedure; https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/tp-213-10_tag.pdf

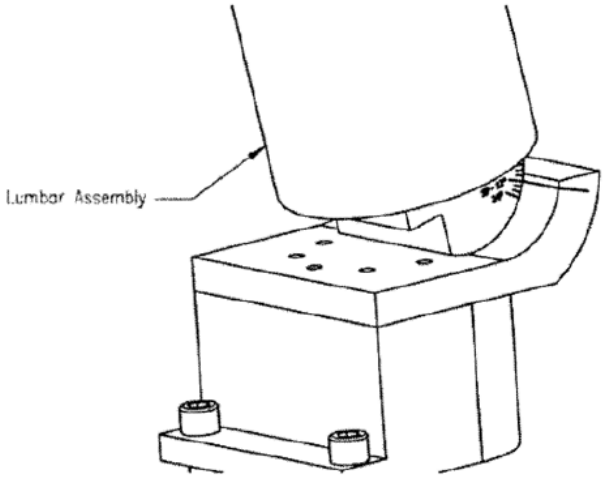


Figure 26: HIII 10YO Lumbar Angle Setting

3.4.2 Forward-Facing Installation

1. Place the ATD in the CRS while holding the ATD torso upright. Gently push the ATD rearward along the CRS seat bottom until the back of the ATD contacts the CRS seat back.
    a. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.
    b. Confirm that the ATD's clothing is not gathered into joints prior to positioning.
2. Verify the ATD is centered, aligning the midsagittal plane of the dummy's head with the centerline of the seat bench.
3. Raise the arms of the ATD vertically above the head as far as possible.
4. Straighten the legs of the ATD outward from body without bending.
5. Using a flat surface with an area of 2580 square millimeters (4 in^2), apply a force of 178 Newtons (40 lb) perpendicular to the plane of the seat bench back.
    a. First, apply the force against the ATD crotch.
    b. Second, apply the force to the ATD thorax in the midsagittal plane of the ATD.
6. Verify the harness straps on the ATD are positioned at or above the shoulder, in accordance with the manufacturer's instructions.
7. Make sure all the cable routing is gathered and routed under the harness and out the side towards the separating wall of the frontal sled buck assembly.
8. Fasten the harness on the ATD per manufacturer's instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.
9. Verify the chest clip is placed at armpit level.
10. Slowly lower the arms, without bending, until the arms contact a CRS surface.
11. Verify that the arms are not restrained from any movement other than in the downward direction.
12. Bend the legs at the knees to bring the legs down until they touch the CRS or foam cushion. (Figure 27).
13. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame. Verify the belt tensions are within specifications.

Figure 27: Hybrid III 10YO Installed in Forward-Facing CRS

3.4.3 Belt Position Booster Installation

1. Confirm that the lap shield is installed with the top edge aligned with the top of the pelvis and the lower flaps resting on top of the thighs of the ATD, as seen for the 6YO in Figure 23.
2. Confirm the pelvis pad is installed (Figure 28). The pelvis pad is a square foam that should be placed on the lower back of the 10YO ATD at the top edge of the pelvis. This typically contacts the seat back of the CRS or the back of the seat bench after the dummy is positioned.
3. Position the ATD in accordance with the manufacturer's instructions provided with the system, as applicable.

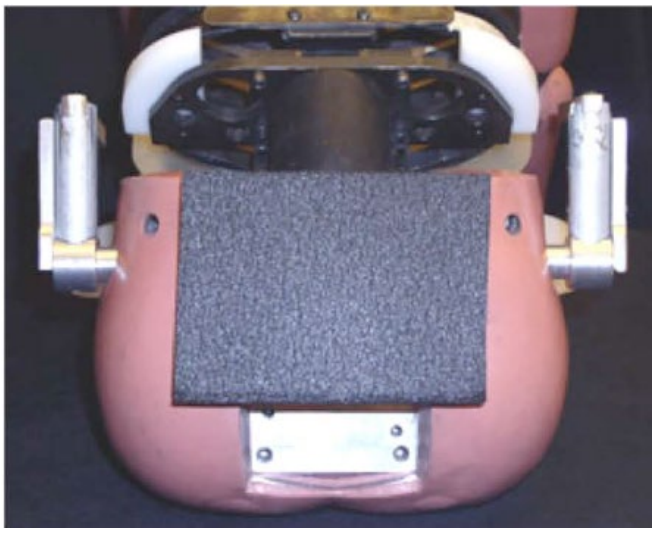


Figure 28: Pelvis Pad Installed on ATD

4. Place the ATD in the CRS while holding the ATD torso upright. Gently push the ATD rearward along the CRS seat bottom until the back of the ATD contacts the seat back of the CRS or back of the seat bench.
    a. Confirm that the ATD's clothing is not gathered into joints prior to positioning.
5. Verify the ATD is centered, aligning the midsagittal plane of the dummy's head with the centerline of the seat bench.
6. Raise the arms of the ATD vertically above the head as far as possible.
7. Straighten the legs of the ATD outward from body without bending, with the dummy feet perpendicular to the centerline of the lower legs.
8. Using a flat surface with an area of 2580 square millimeters (4 in^2), apply a force of 178 Newtons (40 lb) perpendicular to the plane of the seat bench back.
    a. First, apply the force against the ATD crotch.
    b. Second, apply the force to the ATD thorax in the midsagittal plane of the ATD.
9. Slowly lower the arms, without bending, until the arms contact a CRS surface.
    a. Verify that the arms are not restrained from any movement other than in the downward direction.
10. Bend the legs at the knees to bring the legs down until they touch the CRS or foam cushion.
11. Position the knees so that the center-of-knee to center-of-knee distance measures 210 ± 5 millimeters.
12. Re-check that the centerlines of the CRS and ATD align with the center of the seat bench frame.
13. Position the seat belt on the ATD per manufacturer's instructions and tighten the belt to the recommended tension range shown in Table 6, Section 2.3.
    a. The lap belt should be over the thighs of the dummy, while the shoulder belt shall come across the chest, as shown in Figure 29.

Figure 29: Hybrid III 10YO Installed in Booster

4.0 Testing

1. Conduct the test with the CRS and ATD installed, making sure the frontal sled buck assembly acceleration is within the corridor and the velocity within the tolerance of 48, +0, -3.2 kilometers per hour (30, +0, -2 mph), as described in Section 1.3.
2. Disconnect and remove the CRS from the seat bench, recording any damage to the CRS, ATD structure, or foam cushions.
3. If the foam cushions are used consecutively, make sure there is ample time (minimum of 1 hour) for the seat foam cushion to rest between tests.

4.1 Head Paint

1. After each of the ATDs is positioned and the targets measured, apply chalk to the head of the ATD to allow visual indication of any contact with the seat bench, CRS, or other part of ATD. Figure 30 illustrates the painting scheme to be used for all ATDs.

Figure 30: ATD Head Chalk Example as shown on CRABI 12 MO

4.2 Photography

1. Add the appropriate signage identifying the CRS make/model, ATD type, test number and date, and pre- or post-test information to the test apparatus and sign boards.
2. Take photographs of the set-up, CRS, ATD, and separation wall for both seat assemblies. The following pictures should be taken before (pre) and after (post) testing for each CRS:
    a. Overall sled buck and seat assembly.
    b. Wide front view of seat assembly with the dummy.
    c. Tight front view on seat assembly with the dummy.
    d. Side view of seat assembly with the dummy.
    e. Rear view of seat assembly with the dummy.
    f. Up close of ATD installed in CRS.
    g. Overhead view of seat assembly with the dummy.
    h. View over wall of seat assembly with the dummy.
    i. Inclinometer showing RF angle, if applicable.
    j. Restraint connections of CRS and seat assembly.
3. Additional post-test photographs:
    a. If the ATD head contacted either the CRS or another part of the ATD, take a photograph capturing the chalk mark left behind.
    b. With a permanent marker, document the test date, test number, and manufacturer on the CRS. Take a photograph of the information written on the CRS along with the manufacturing label.

Appendix A: Camera Lens Calibration

The lens calibration used by VRTC is **Planar Target Lens Calibration** using a printed target board (Figure A1) from the recommended image supplied by TEMA (below). More detailed instructions for lens calibration can be found in the TEMA user manual.[17] This Appendix details the general steps for conducting the calibration.

Place the board in the field of view in which the ATD will move during testing.

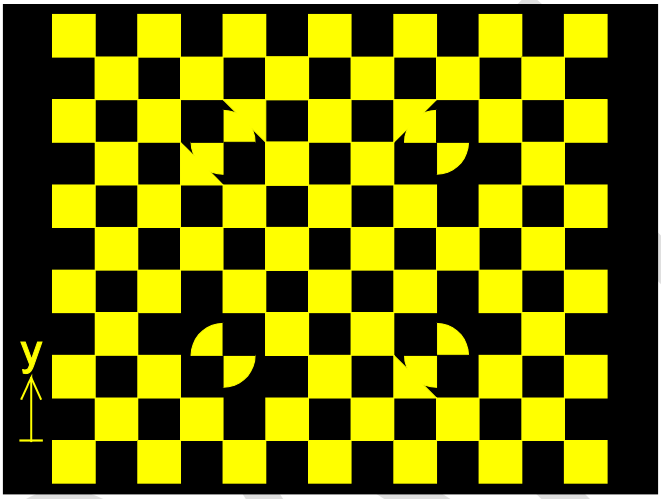


Figure A1: Printed Target Board

A recommended set of calibration images are described and shown below for Figure A2:

1. Images 1-3: Different positions between camera and calibration target.
2. Images 4-7: Sloped images with different angels between the camera and the calibration target. Recommended slope is approximately 45º.
3. Images 1-5 are the minimum needed for calibration, although additional images are recommended. The accuracy of the calibration generally improves if more images are added, up to a maximum of about 20 images.

Images should be saved as individual frames directly from the video file. They cannot be screen captures of the images. Images should be saved as a *.jpeg.

It is important that the reference points (target markers) on the calibration target are close to the edge of the image. It does not matter if some parts of the target are out of the image view.

[17] http://www.imagesystems.se/tema/automotive/,

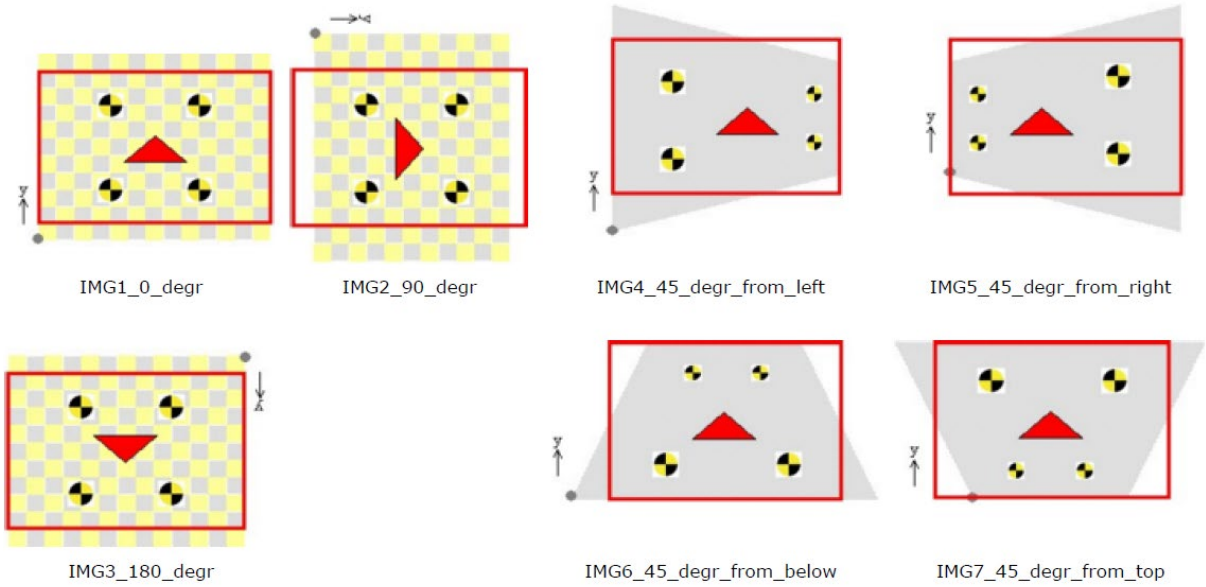


Figure A2: Lens Calibration Board Orientation Angles

Explanations of illustrations above:

1. The red square illustrates the camera view/captured image of the calibration target.
2. The red arrow points towards the topside of the calibration target.

Appendix B: Post-Test Measurements in TEMA

1. VRTC uses a 4-point method in TEMA to measure head and knee excursions.
2. The analysis includes a lens calibration. The lens calibration aids in getting more accurate results and reducing the lens distortion near the edges of the frame of view. Reference for lens calibration can be found in Appendix A.
3. Input the values collected in Section 1.2.2 (back wall target points, ATD and CRS target points, and camera location) into TEMA.
4. For the 4-point method, select four (4) visible points from the separation wall to use as reference points in TEMA. Create a new coordinate system with the most central separation wall target as a new zero point. This target also functions to remove camera bounce when used in dynamic mode.
5. Calculate the offsets and input them into the software using wall and dummy measurements. This step ensures the scaling of the targets in the different planes.
6. For head excursion:
    a. Track head CG target.
    b. When head CG reaches the maximum excursion point in time, identify the furthest point on the contour of the head in the video and place a constant point on the furthest most point (FMP) of the head.
    c. Report the FMP at the maximum head excursion.
7. For knee excursion:
    a. Track knee target.
    b. Report the value of maximum knee excursion from TEMA.

Figure B1: TEMA Analysis with Wall Targets and Additional Targets Identified

Appendix C: Indention Force Deflection (IFD) Test Procedure

1. Before the foam sets are installed and used on the frontal seat assembly, test each foam piece to measure their indentation force-deflection (IFD) characteristics.
    a. Prior to conducting the IFD test, store the foam set in a temperature and humidity-controlled chamber with a temperature range of 21.1 ± 2.8 degrees Celsius (70 ±5 degrees Fahrenheit) and a relative humidity range of 55 ±5 percent for a minimum of 24 hours.
    b. Record the temperature and relative humidity of the storage location.
2. Test each foam specimen at 25%, 50%, and 65% compression, consecutively, using ASTM Standard D3574-11 Test B1 as a guideline.
3. Test each foam sample on the side that will interact with the CRS during sled testing.
    a. Mark the foams "Top" or "Bottom" for consistency. If the foam cushion has a skin, face the skin side up (i.e. the side interacting with the CRS).
4. Use an apparatus having a flat circular indenter foot 200 +3/-0 mm (7.87 +0.12/-0 in) in diameter to deflect the specimen.
5. Insure the apparatus is on a horizontal plate which is perforated with approximately 6.5 mm holes on approximately 20 mm centers to allow for rapid escape of air during the test.
6. Test Procedure
    a. Place the specimen on the tensile test machine.
    b. Identify the test height of the specimen by having the indenter apply a force of 4.5 N to the specimen.
    c. Pre-flex the specimen by compressing it to 75% of its test height, two times at 250 ± 25 mm/min.
        i. The indenter should completely clear the top of the specimen after each pre-flex.
    d. Rest the specimen at least 6 minutes.
    e. Compress the specimen to 25% of its test height at a rate of 50 ± 5 mm/min and hold one minute once the correct deflection is met.
    f. Record the IFD value at the end of this minute.
    g. Immediately compress the specimen to 50% of its test height at a rate of 50 ± 5 mm/min and hold one minute once the correct deflection is met.
    h. Record the IFD value at the end of this minute.
    i. Immediately compress the specimen to 65% of its test height at a rate of 50 ± 5 mm/min and hold one minute once the correct deflection is met.
    j. Record the IFD value at the end of this minute.
    k. Return the indenter to the starting position, clearing the top of the specimen.
7. IFD values of the foam must fall within the test specifications per Table C1.
    a. If the foam does not fall within test specifications after the initial 24-hour temperature and humidity-controlled soak, a minimum of 30 minutes must pass before re-testing the foam for certification.
        i. During the 30 minutes, two potential methods to help the specimen fall within the test specification could include but are not limited to the following:
            1. Soak the specimen for more than the 30-minute minimum timeframe (within temperature and humidity tolerances).

2. Manually compress or knead the foam.

ii. If foam does not fall within the test specifications after step (i), re-soak the specimen for an additional 24 hours or longer within the temperature and humidity tolerances.

1. Specimen is unusable if it does not fall within the test specifications after repeating the steps detailed in step (i).

b. When the foam sets are not being used for testing, store them in an area with a temperature range of 20.3 ± 4.7 degrees Celsius (67.5 ± 7.5 degrees Fahrenheit) and that is humidity-monitored.

8. Record the temperature and relative humidity at the time of the test.

Table C1: Test Specifications for the Seat Back and Seat Pan Foams

	IFD 25% N (lb)	**IFD 50% N (lb)**	**IFD 65% N (lb)**
Seat Pan (102 mm)	237 (53.3) ± 15% For reference	440 (98.9) ±15% [374-506]	725 (162.9) ±15% For reference
Seat Back (51 mm)	157 (35.3) For reference	300 (67.4) ±15% [255-345]	480 (107.9) For reference

Appendix D: Foam Wrapping Procedure for the Frontal Sled Buck Assembly

1. Wrap each foam and metal plate for the seat bench pan and seat bench back with the appropriate fabric (drawings# 3021-234 and 3021-249).[18]
    a. Dimensions of the seat bench back and seat bench pan foam and plate assemblies are in the FVMSS No. 213 frontal drawing package.[19]

2. Adhere 120 grit sandpaper to the side of the plate that contacts the foam (side without the bolts). Adhere the sandpaper by spraying the reverse side of the paper with spray adhesive. Use two pieces of sandpaper (Figure D1).

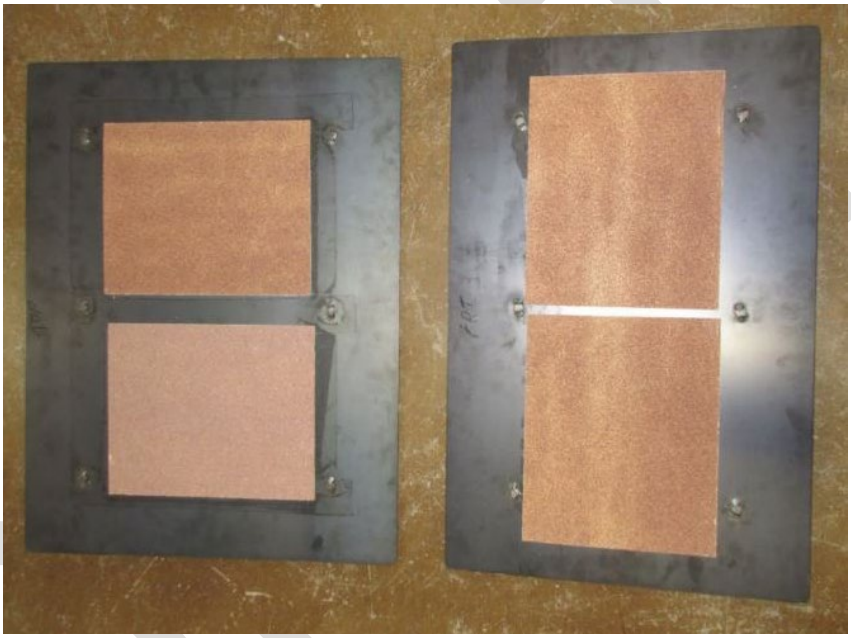


Figure D1: Two Pieces of Sandpaper Adhered to the Back of Metal Plate

3. Cut two fabric[20] pieces of the following dimensions[21] to wrap around the foams.
    a. Seat bench pan: 1080 mm x 1270 mm (42.5 in x 50 in).
    b. Seat bench back: 1118 mm x 1118 mm (44 in x 44 in).
4. Place the plate on the foam with approximately 25 mm (1 in) on each side (Figure D2).

[18] Polyacrylate Fiber, Weight: 90z/yd, Break Strength: 285 lb Warp, 180 lb Filling
[19] Assembly Drawings Numbers: Dated May 2019.
[20] Woven fabric is anisotropic; warp is the stronger direction of the threads.
[21] Second dimension refers to the Warp of the material, while the first refers to the filling

Figure D2: Foam Placed on Plate with 25 mm of Foam on Each Side

5. Stretch the material over the bolts, and mark on the fabric the location of the bolts. Use a soldering iron to burn through the material at those marked locations (for first use).
    a. Install size 1 grommets at each of the hole locations created in step 4.

6. Place the bolts through the grommet holes in the fabric and adhere the edge of the fabric to the plate using 3-inch preservation tape. (Figure D3).[22]

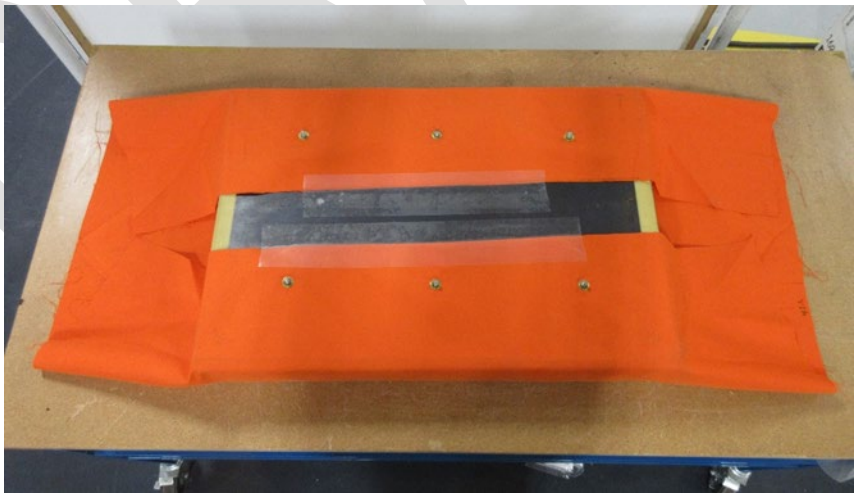


Figure D3: Material Wrapped Around Foam with Bolts Going Through Grommet Holes

[22] Dr. Shrink brand preservation tape was used throughout the research testing and was determined to be the best product to stick to the Sunbrella fabric, due to its adhesive bond that sticks to most surfaces and leaves little residue. https://dr-shrink.com/wp-content/uploads/2019/04/tape-specs.pdf.

7. Push fabric into the thickness of the foam (Figure D4), and then fold the top piece of the fabric down in a triangular method (Figure D5). Repeat step 6 for both ends of the fabric.

Figure D4: Fabric Pushed into Thickness of Foam

Figure D5: Top Piece of Fabric Folded Down

8. Pull the fabric upwards and secure the edge of the fabric with the preservation tape (Figure D6).

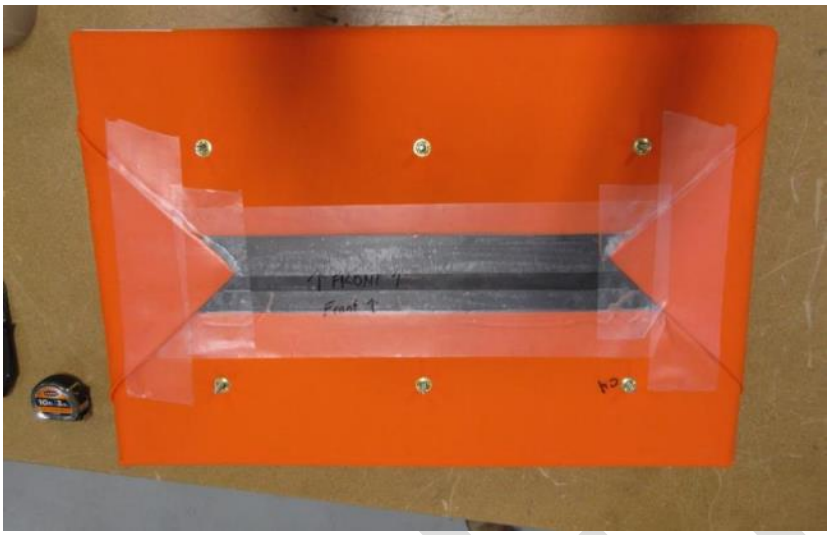


Figure D6: Finished Final Foam Wrapped Foam Set

Appendix E: CRS Target Schematics

Figure E1: Target Schematic for CRABI 12 MO/ Infant Seat

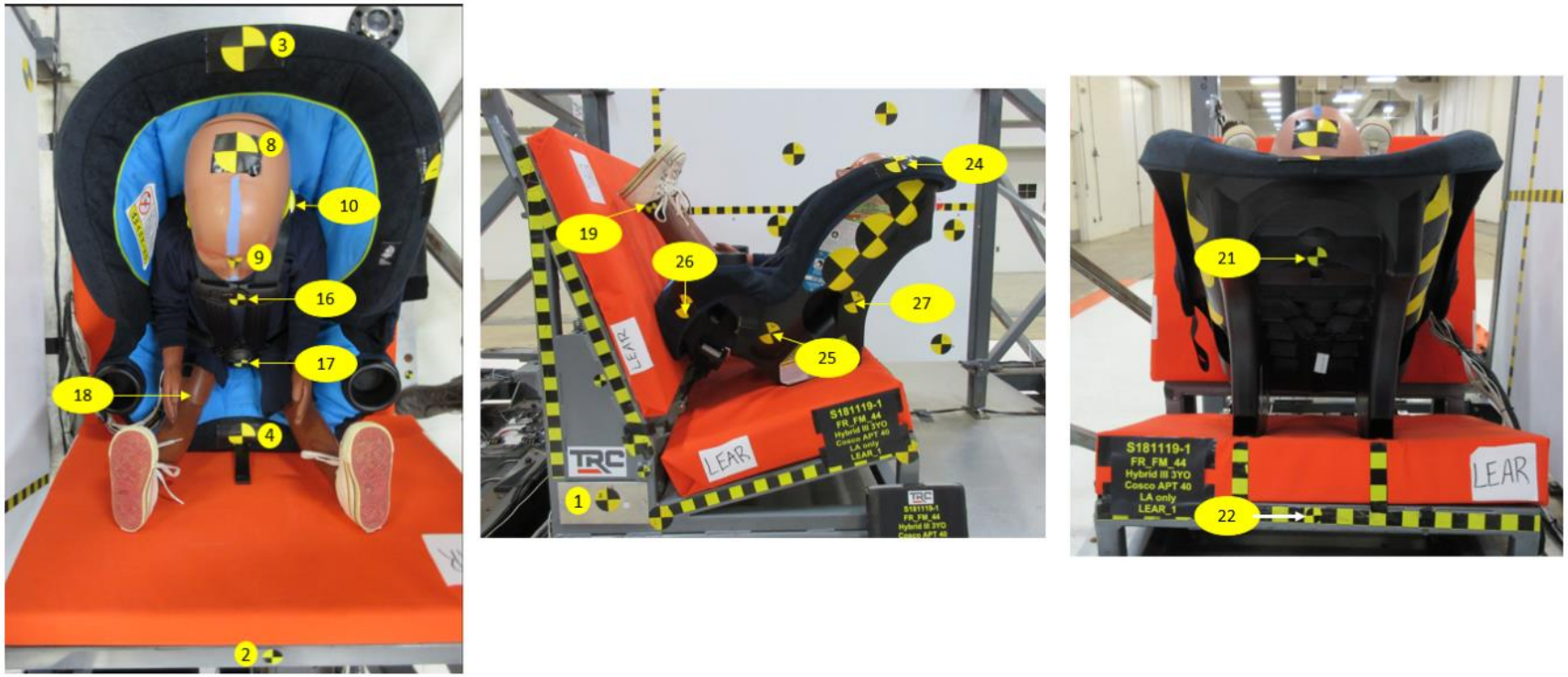


Figure E2: Target Schematic for RF 3YO

Figure E3: Target Schematic for Frontal Convertible/High Back Booster 6YO and 10YO

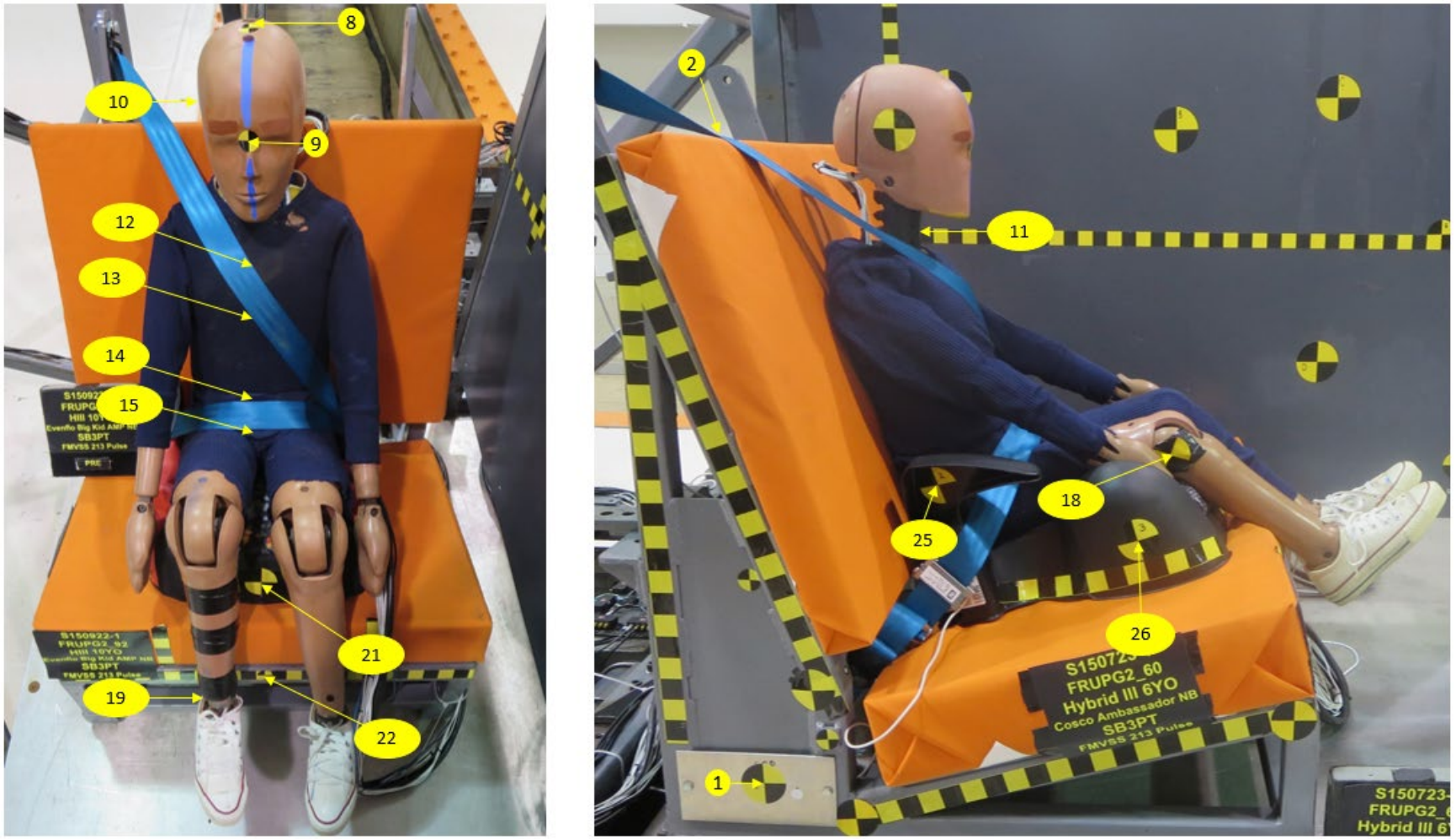


Figure E4: Target Schematic for No Back Booster 6YO and 10YO