US Department
Of Transportation

National Highway
Traffic Safety
Administration

Memorandum

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Subject: Docket Submission of Technical Report "Repeatability And Reproducibility Analysis of the SID-IIs FRG Dummy In the Certification Test Environment"

Date: SEP 14 2004

From: Joseph N. Kanianthra, Ph.D.
Associate Administrator for Vehicle Safety Research

Reply to Attn. Of: NVS-300

To: Docket # NHTSA-2004-17694

Thru: Jacqueline Glassman
Office of Chief Counsel

Attached is a technical report titled, "Repeatability and Reproducibility Analysis of the SID-IIs FRG Dummy in the Certification Test Environment," that we are submitting to Docket number NHTSA-2004-17694. This report documents the repeatability and reproducibility analysis of the SID-IIs FRG dummy in the certification environment and is being submitted as supporting information for the FMVSS 214 NPRM.

Attachment

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Repeatability and Reproducibility Analysis of the SID-IIs FRG Dummy in the Certification Test Environment

April 2004

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Introduction

As part of the National Highway Traffic Safety Administration (NHTSA) evaluation of the SID-IIs FRG dummy, repeatability and reproducibility (R&R) of the SID-IIs FRG dummy were analyzed. In the winter of 2003, two SID-IIs dummies of the FRG design configuration (described in detail in "Development of the SID-IIs FRG," Rhule et al, 2003) were tested in certification tests at the Vehicle Research and Test Center (VRTC).

Methods

The test matrix of all R&R certification tests performed at VRTC is shown in Table 1. The procedures that were followed for the SID-IIs FRG Head Drop and Lateral Neck Pendulum certification tests are documented in "SID-IIs Small Side Impact Crash Test Dummy User's Manual" Revision 3, February 2002, by First Technology Safety Systems. The draft procedures that were followed for the SID-IIs FRG whole-body certification tests are included in Appendices A-E.

Table 1. SID-IIs FRG Certification R&R Test Matrix

Test Type	Description	Test Speed (m/s)	Probe mass (kg)	Probe face diameter (mm)	Number of Tests	
					Dummy 032	Dummy 056
Head Drop	200 mm head drop onto rigid surface				5	5
Lateral Neck Pendulum	Neck & head form on pendulum	5.57			5	6
Shoulder Impact	Whole body test on bench seat	4.3	13.97	120.7	5	4
Thorax Impact With Arm		6.7	13.97	120.7	5	4
Thorax Impact Without Arm		4.3	13.97	120.7	5	5
Abdomen Impact		4.3	13.97	76.2*	5	6
Pelvis Impact		6.7	13.97	120.7	5	5

*Abdomen Impact tests utilize a smaller diameter probe face.

The Head Drop test procedure is a standard 200 mm drop onto a rigid surface, with the D-plane of the head at a 35º angle relative to vertical. The Lateral Neck Pendulum test is a standard neck pendulum test using a head form in place of the head. Figure 1 shows a photograph of the head form used in the SID-IIs Lateral Neck Pendulum certification tests. The head form/neck assembly is attached to a pendulum that is dropped from a height such that the impact velocity of the pendulum with a honeycomb block is 5.57 m/s. The whole-body tests for the shoulder, thorax with and without arm, abdomen and pelvis are performed with the dummy positioned on a bench seat. Figure 2 shows a schematic of the rigid bench seat, whose seat and seatback surfaces are covered with near frictionless material. For all of the whole-body impact tests the appropriate component of the dummy is impacted with a probe with a face diameter of 120.7 mm, except for the Abdomen Impact test, in which the abdomen is impacted with a probe with a face diameter of 76.2 mm. The probe specified in the Code of Federal Regulations Title 49 Part 572 for impacting the thorax of a Hybrid III Fifth Percentile Small Female dummy was modified for the SID-IIs by fabricating two new probe faces to match those specified for the SID-IIs (see

Table 1) and adjusting the probe mass accordingly.

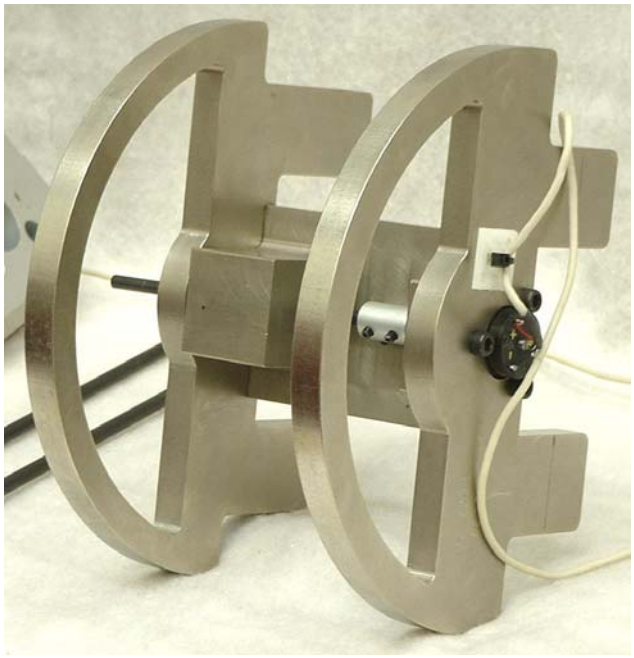

Figure 1. Head form used in place of SID-IIs head during Lateral Neck Pendulum Certification Tests.

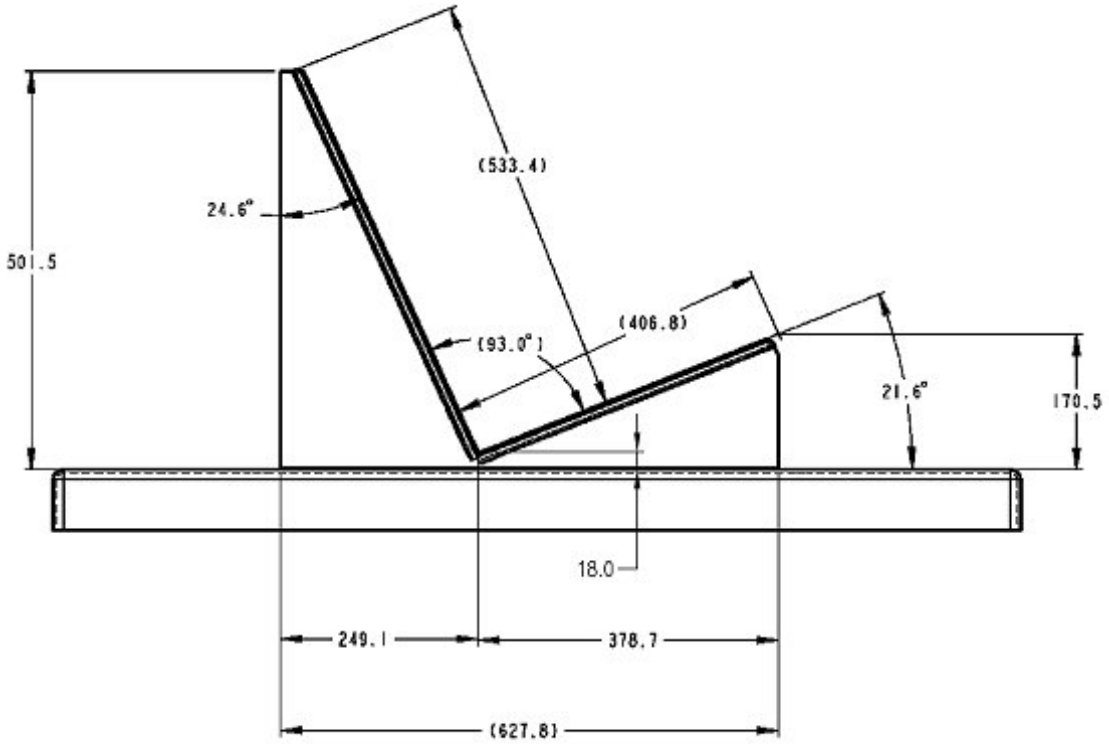

Figure 2. Sketch of rigid bench seat used for all SID-IIs whole-body certification tests.

Results and Discussion

Table 2 shows the average, standard deviation and percent coefficient of variation (%CV) for each dummy's peak responses individually, and both dummies' responses together, for each certification test type. The dummy rating practice of the ISO/TC22/SC12/WG5 indicates that a CV between 0 and 5% is considered excellent; between 5% and 10% is good, with the CV becoming borderline acceptable as it approaches 10%. Any CV above 10% is considered poor. The CV's are color-coded in the table for easy identification: green indicates a CV between 0 and 5%; yellow indicates a CV between 5.1 and 10%; and pink indicates a CV above 10%. Tables F.1 through F.7 in Appendix F contain peak responses and statistical analysis for each certification test type. Blue text in Tables F.1 through F.7 indicates the response requirements from the FTSS User's Manual (FTSS, 2002). Bold type in the dummy response data for the Head Drop and Lateral Neck Pendulum tests indicates responses that did not meet the FTSS required response criteria. Response corridors for the whole-body certification tests are not included in Appendix F as the procedure using the bench is relatively new and response corridors are still under development. Overlay plots of the pertinent data traces for both dummies are contained in Figures F.1 through F.32 in Appendix F.

Head

Table 2 shows that both dummies exhibit excellent repeatability and reproducibility with CV's well below 5% for the peak head resultant acceleration response.

Neck

Table 2 shows that both dummies exhibit excellent repeatability and reproducibility with CV's below 5%, except for the time between the peak moment and peak rotation parameter for dummy 056, which had a CV of 5.14%.

Shoulder

Table 2 shows that both dummies exhibit excellent repeatability and reproducibility with CV's below 5% for the peak probe force and shoulder rib deflection responses.

Thorax

In the Thorax Without Arm tests, each dummy demonstrates excellent repeatability and reproducibility for all responses, with the exception of the peak lower spine acceleration response for both dummies combined, which had a CV of 5.62%, demonstrating good reproducibility.

In the Thorax With Arm tests, each dummy demonstrates excellent repeatability. Both dummies exhibit excellent reproducibility for all responses, with the exception of peak probe force, which had a CV of 7.29%, demonstrating good reproducibility.

Table 2. Statistical Analysis for Certification Test Responses

	S/N 032			S/N 056			S/N 032 & 056 Combined		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
Head									
Head Resultant Acceleration (g)	136.1	2.36	**1.74**	135.0	2.38	**1.76**	135.6	2.31	**1.70**
Neck									
Peak D-Plane Rotation (deg)	75.5	0.13	**0.17**	77.0	0.21	**0.28**	76.4	0.80	**1.04**
Peak Rotation Decay to zero degree (ms)	69.6	0.30	**0.43**	72.8	0.35	**0.48**	71.4	1.70	**2.39**
Peak Occipital Condyle Moment (N-m)	43.5	0.19	**0.43**	42.4	0.36	**0.84**	42.9	0.63	**1.46**
Peak Moment Decay to 10 N-m (ms)	92.2	0.20	**0.22**	93.5	0.48	**0.52**	92.9	0.77	**0.83**
Time Between Peak Moment and Peak Rotation (ms)	8.4	0.41	**4.86**	8.7	0.44	**5.14**	8.5	0.43	**5.00**
Front Pot Peak Rotation (deg)	61.3	0.15	**0.24**	60.4	0.43	**0.71**	60.8	0.59	**0.97**
Time of Front Pot Peak Rotation (ms)	63.8	0.30	**0.47**	62.5	0.31	**0.49**	63.1	0.71	**1.13**
Rear Pot Peak Rotation (deg)	50.2	0.15	**0.31**	50.3	0.33	**0.65**	50.3	0.25	**0.50**
Time of Rear Pot Peak Rotation (ms)	63.9	0.72	**1.12**	62.8	0.55	**0.87**	63.3	0.82	**1.30**
Shoulder									
Probe Force (kN)	2.26	0.03	**1.29**	2.23	0.03	**1.28**	2.25	0.03	**1.42**
Shoulder Rib Deflection (mm)	28.2	0.94	**3.33**	27.3	0.67	**2.45**	27.8	0.91	**3.29**
Thorax With Arm									
Probe Force (kN)	4.27	0.06	**1.44**	4.89	0.07	**1.45**	4.54	0.33	**7.29**
Shoulder Rib Deflection (mm)	30.4	0.33	**1.09**	31.7	0.93	**2.94**	31.0	0.92	**2.95**
Upper Thoracic Rib Deflection (mm)	24.7	0.39	**1.58**	26.9	0.47	**1.75**	25.7	1.23	**4.79**
Middle Thoracic Rib Deflection (mm)	30.4	0.20	**0.67**	31.1	0.49	**1.57**	30.7	0.46	**1.51**
Lower Thoracic Rib Deflection (mm)	33.2	0.26	**0.78**	33.1	0.63	**1.92**	33.1	0.44	**1.32**
Upper Spine Acceleration (g)	41.7	0.35	**0.84**	44.6	0.79	**1.76**	43.0	1.66	**3.87**
Lower Spine Acceleration (g)	38.9	0.38	**0.99**	38.6	0.11	**0.28**	38.8	0.32	**0.84**
Thorax Without Arm									
Probe Force (kN)	2.34	0.03	**1.49**	2.36	0.05	**2.23**	2.35	0.04	**1.84**
Upper Thoracic Rib Deflection (mm)	34.6	1.08	**3.11**	37.5	0.63	**1.68**	36.1	1.74	**4.82**
Middle Thoracic Rib Deflection (mm)	40.9	0.28	**0.68**	40.7	0.58	**1.41**	40.8	0.44	**1.07**
Lower Thoracic Rib Deflection (mm)	37.0	0.72	**1.94**	37.3	0.66	**1.77**	37.2	0.66	**1.78**
Upper Spine Acceleration (g)	16.6	0.33	**1.97**	15.7	0.15	**0.96**	16.1	0.53	**3.29**
Lower Spine Acceleration (g)	10.4	0.26	**2.49**	9.5	0.35	**3.70**	10.0	0.56	**5.62**
Abdomen									
Probe Force (kN)	1.89	0.03	**1.73**	2.06	0.05	**2.30**	1.98	0.09	**4.77**
Upper Abdominal Rib Deflection (mm)	39.0	0.37	**0.95**	39.7	1.40	**3.53**	39.4	1.07	**2.72**
Lower Abdominal Rib Deflection (mm)	39.0	1.33	**3.42**	37.6	0.63	**1.67**	38.2	1.19	**3.12**
Upper Spine Acceleration (g)	6.6	0.22	**3.39**	7.7	0.24	**3.07**	7.2	0.58	**8.04**
Lower Spine Acceleration (g)	12.3	0.24	**1.95**	13.3	0.61	**4.56**	12.8	0.70	**5.41**
Pelvis*									
Probe Force (kN)	5.92	0.03	**0.55**	6.27	0.01	**0.20**	6.10	0.18	**3.00**
Pelvis Lateral Acceleration (g)	54.3	2.58	**4.75**	46.4	1.36	**2.93**	50.3	4.58	**9.10**

*new plug used for each test

Abdomen

Each dummy shows excellent repeatability for the Abdomen test responses. All responses demonstrate excellent reproducibility as well, with the exception of the upper and lower spine acceleration responses, which exhibit good reproducibility with CV's of 8.04% and 5.41%, respectively. Figures 3 and 4 show the upper and lower spine acceleration data traces for dummies 032 and 056, respectively, during the Abdomen Impact certification tests. The data traces appear to be reasonably repeatable. Figure 5 shows the upper and lower spine accelerations for both dummies, which shows the reproducibility of the responses to be reasonable as well. The relatively large CV values can be misleading when the magnitude of the mean response is small, as in the upper and lower spine accelerations in the Abdomen Impacts. For such low average responses, (i.e., 7.2 g and 12.8 g for T1 and T12, respectively) a small standard deviation (i.e., 0.58 g for T1 and 0.70 g for T12) results in a large coefficient of variation. Instead of simply looking at the value of the CV to assess the dummy's repeatability and reproducibility, it is also important to consider the magnitude of the average response in order to interpret the CV. Since T1 is relatively far away from the region of impact, it makes sense that the T1 response of both dummies is small.

Pelvis

Table 2 shows that each dummy exhibits excellent repeatability for the peak probe force and lateral pelvis acceleration responses. With the data from both dummies combined, the peak probe force displays excellent reproducibility, but the lateral pelvis acceleration response indicates elevated variability with a CV of 9.10%. Figures 6 and 7 show the lateral pelvis acceleration data traces for the repeat pelvis impact tests for dummies 032 and 056, respectively. The sled tests that were performed for R&R analysis of the SID-IIs FRG dummy also showed some variability in the pelvis acceleration response (Rhule, H., Hagedorn, A., 2004). Unfortunately, no additional data (such as lumbar loads and moments, acetabulum or iliac wing forces) was collected during the certification tests in order to ascertain the causes of the variability. As per the FTSS User's Manual (FTSS, 2002), the foam pelvis plug must be replaced after each impact, including after certification tests, prior to crash tests. The disposable plug procedure was followed for the certification tests so that a new plug was used in each test. It is suspected that this uncertified, protruding plug may be related to the elevated variability of responses observed in the pelvis. The agency is exploring development of a test procedure that would allow the selection of replacement plugs on an objective rather than subjective basis.

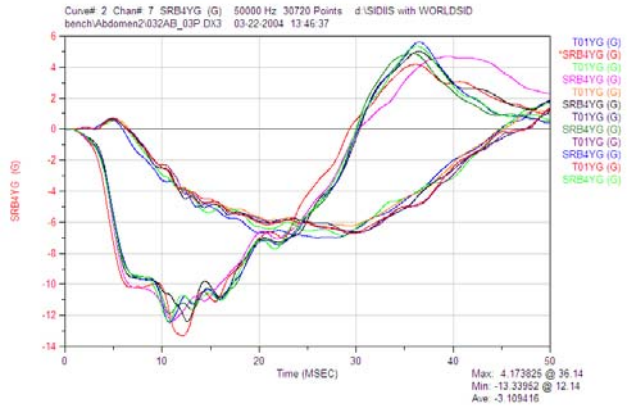

Figure 3. Upper and lower spine acceleration responses for dummy 032 during Abdomen Impact certification tests.

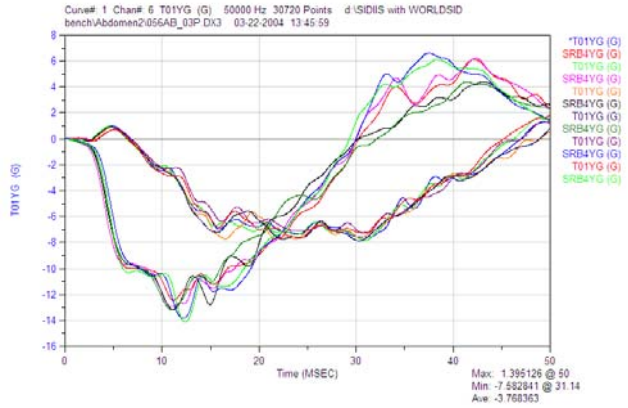

Figure 4. Upper and lower spine acceleration responses for dummy 056 during Abdomen Impact certification tests.

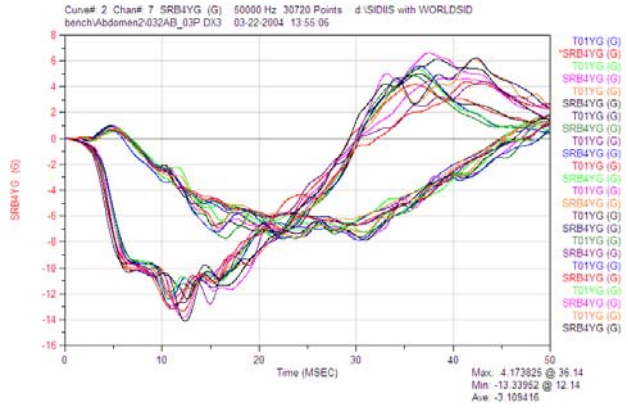

Figure 5. Upper and lower spine acceleration responses for dummies 032 and 056 during Abdomen Impact certification tests.

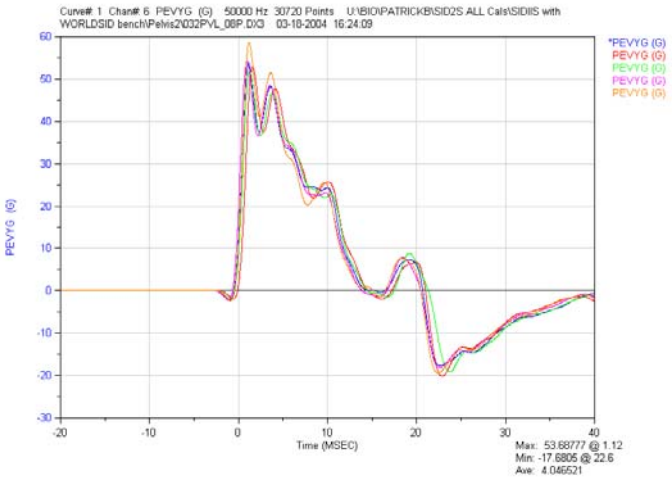

Figure 6. Lateral pelvis acceleration data traces for dummy 032 during Pelvis Impact Certification tests.

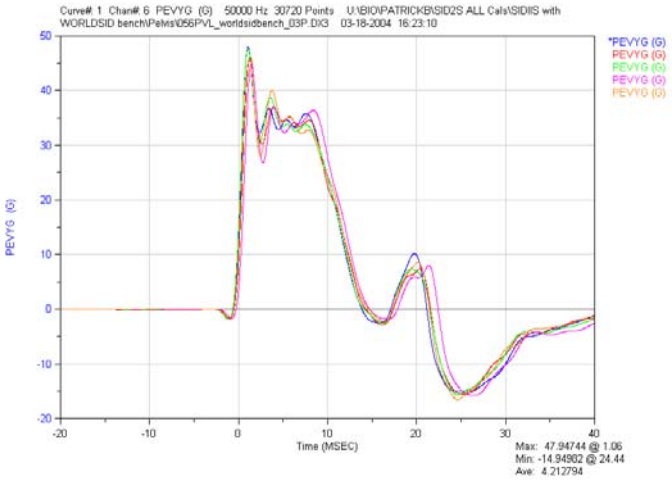

Figure 7. Lateral pelvis acceleration data traces for dummy 056 during Pelvis Impact Certification tests.

Conclusions

The head, neck, shoulder, thorax and abdomen of the SID-IIs FRG dummy exhibit quite good R&R. However, the lateral pelvis acceleration response shows elevated variability during the Pelvis Impact certification tests, much like it did during the R&R sled tests. The agency is exploring development of a test procedure that would allow the selection of replacement plugs on an objective basis, and thereby, bring about a reduction of the plug-related pelvis response variability

References

Code of Federal Regulations Title 49 Part 572 Subpart O - Hybrid III 5th Percentile Female Test Dummy, Alpha Version.

First Technology Safety Systems, "SID-IIs Small Side Impact Crash Test Dummy User's Manual" Revision 3, February 2002.

Rhule, H., Hagedorn, A., "Development of the SID-IIs FRG" November 2003, NHTSA docket #NHTSA-2004-17694.

Rhule, H., Hagedorn, A., "Repeatability and Reproducibility Analysis of the SID-IIs FRG Dummy in the Sled Test Environment" March 2004, NHTSA docket #NHTSA-2004-17694.

Appendix A. Draft Shoulder Certification Procedure

Shoulder Certification Procedure

Required Instrumentation

- Shoulder linear potentiometer
- Test probe accelerometer
- Speed Trap

Pretest Preparation

- Install the thoracic and abdominal pads using cable ties[1].
- Place the chest jacket on the dummy.
- The dummy should wear cotton underwear pants, cut off just above the knees, for this procedure. No shirt or shoes should be worn.
- The dummy should be grounded using a cable between the dummy and ground.
- Align the upper and lower neck brackets so that the top edges are flush.
- Be sure that the rubber arm plug is completely inserted into the arm and secured to the arm bone with screws.
- Place the certification bench (Figure A.1.) in the pendulum's impact area so that the dummy can be impacted on the shoulder.

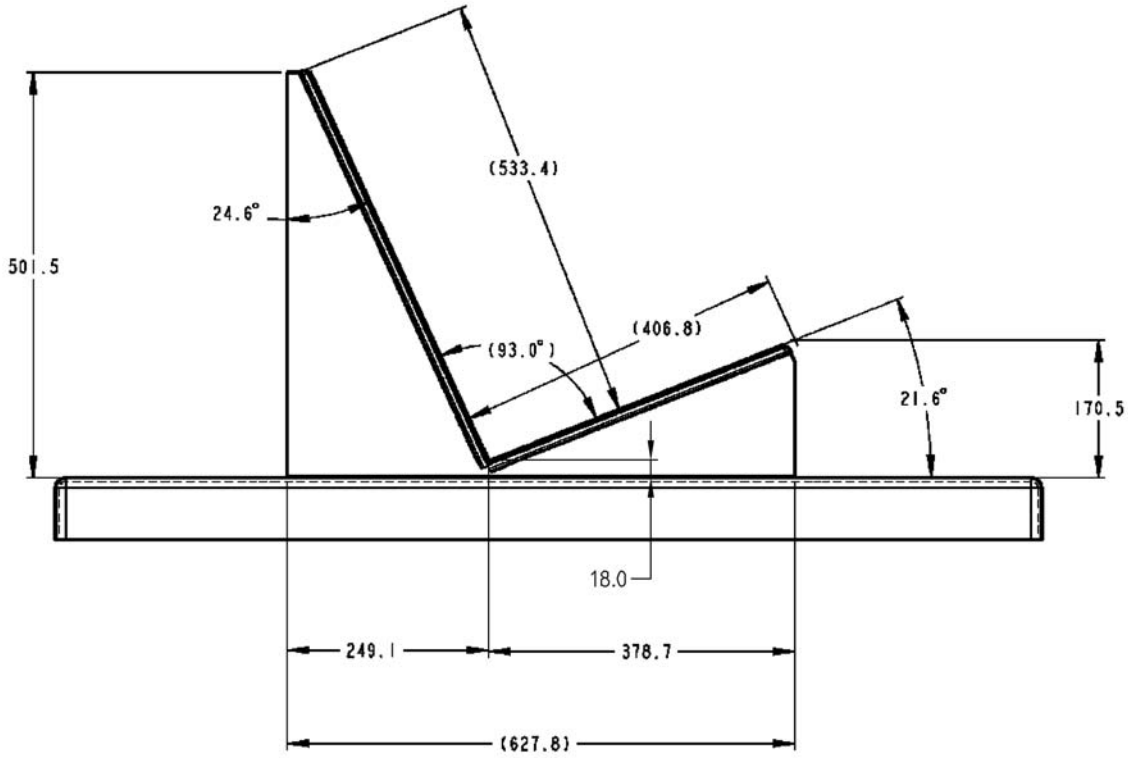

Figure A.1. Certification bench seat specifications for SID-IIs certification tests.

[1] See Appendix G.: *Attachment of Thoracic and Abdominal Pads in the SID-IIs*.

- Seat the dummy on a sheet of 387 x 521 mm Teflon (2 mm thick) on the bench. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seat pan (Figure A.2.).
- Place a sheet of 514 x 514 mm Teflon (2 mm thick) between the seatback and the dummy's posterior thorax. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seatback (Figure A.2.).
- Position the impact arm so that it points forward at 90 ± 2° relative to the centerline of the dummy's thorax (Figure A.2.).

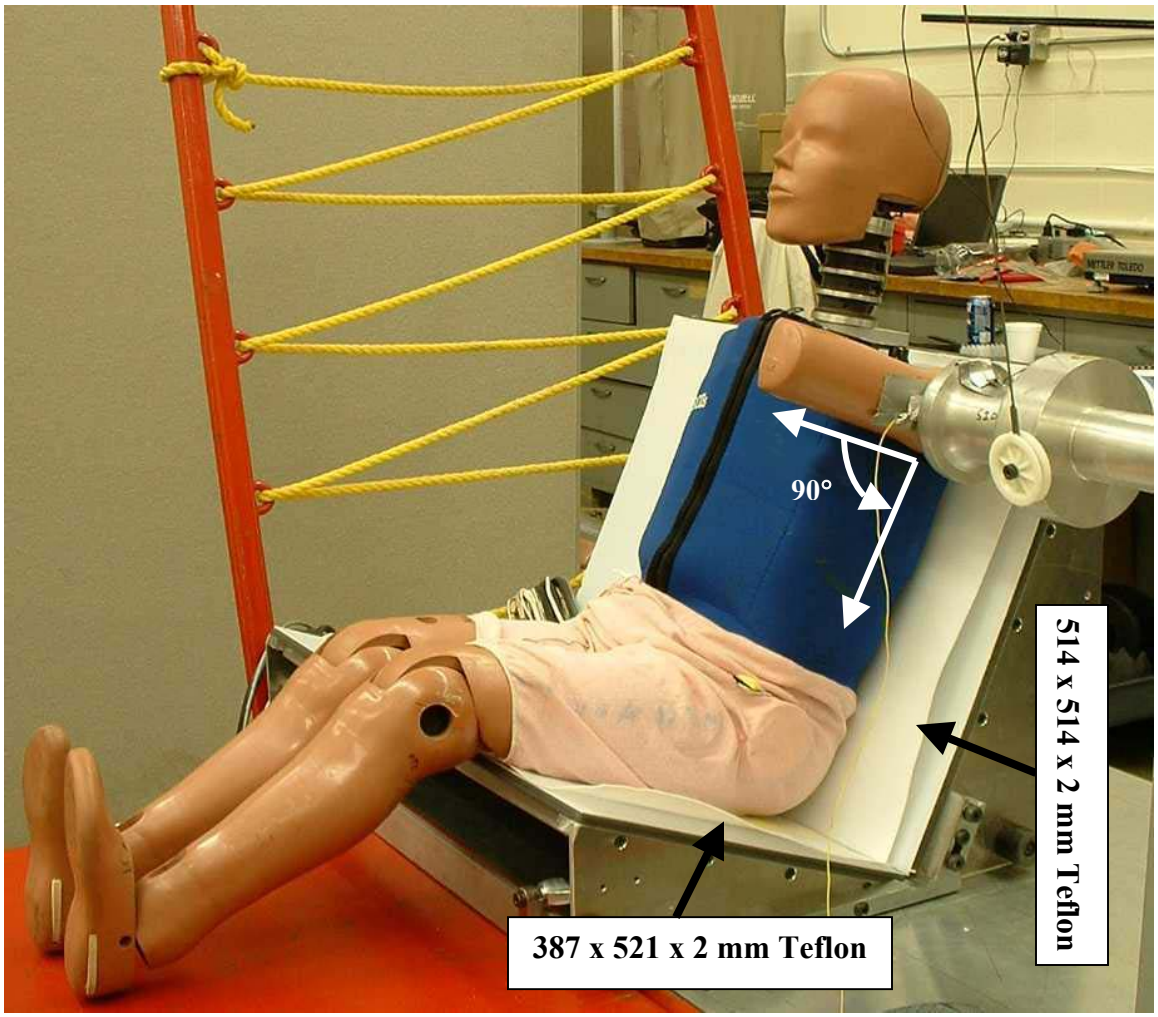

Figure A.2. Shoulder impact test configuration for SID-IIs.

- Position the dummy so that the centerline of the arm bolt is centered on the centerline of the impact probe within 2mm. The face of the pendulum should be parallel to, and just touching, the surface of the rubber shoulder plug, when the pendulum probe is at its lowest position during travel (Figures A.2. and A.3.).
- Push the dummy's chest towards the seatback, so that the back of the thorax is touching the seat (Figure A.3.).

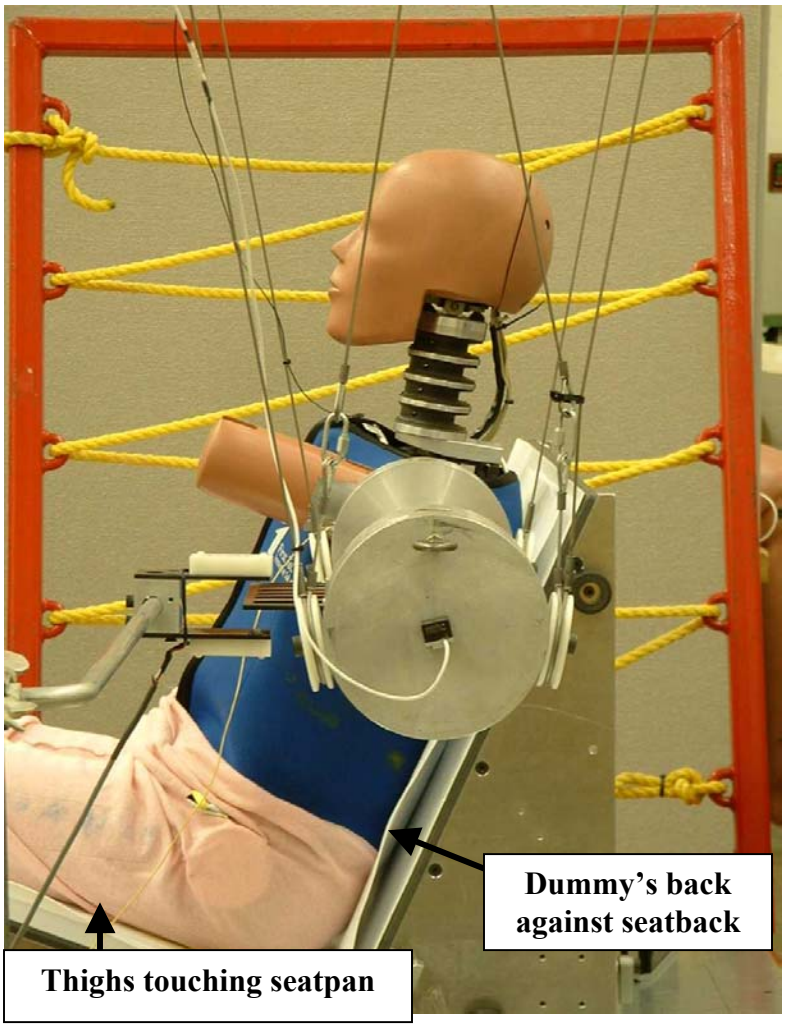

Figure A.3. Impact probe and dummy seating position for the SID-IIs shoulder certification test.

- Push the femurs towards the seatpan so that the thighs are in contact with the seat (Figures A.3. and A.4.).
- Move the legs together so that the knees are touching (Figure A.4.).

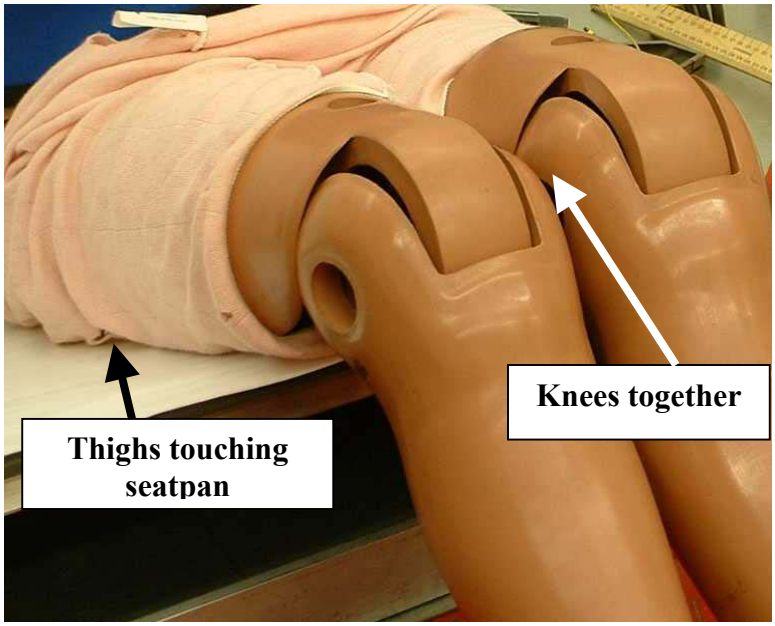

Figure A.4. SID-IIs leg positioning for shoulder certification tests.

- Position the feet so that they are vertical, with the heels touching the surface of the support table (Figure A.5.).

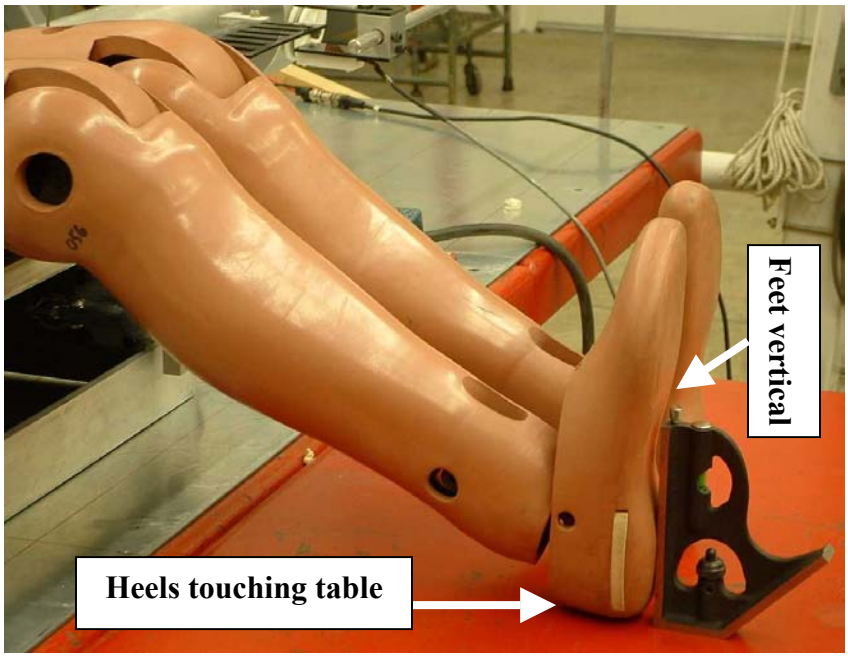

Figure A.5. Feet positioning for SID-IIs shoulder certification tests.

- Adjust the dummy so that the thoracic lateral plane is 0° ± 1 relative to horizontal Figure A.6.).

Figure A.6. Adjusting the SID-IIs dummy in the lateral direction for shoulder certification tests.

Adjust the dummy so that the thoracic fore/aft plane measures 24.6° ± 1 relative to horizontal (Figure A.7.).

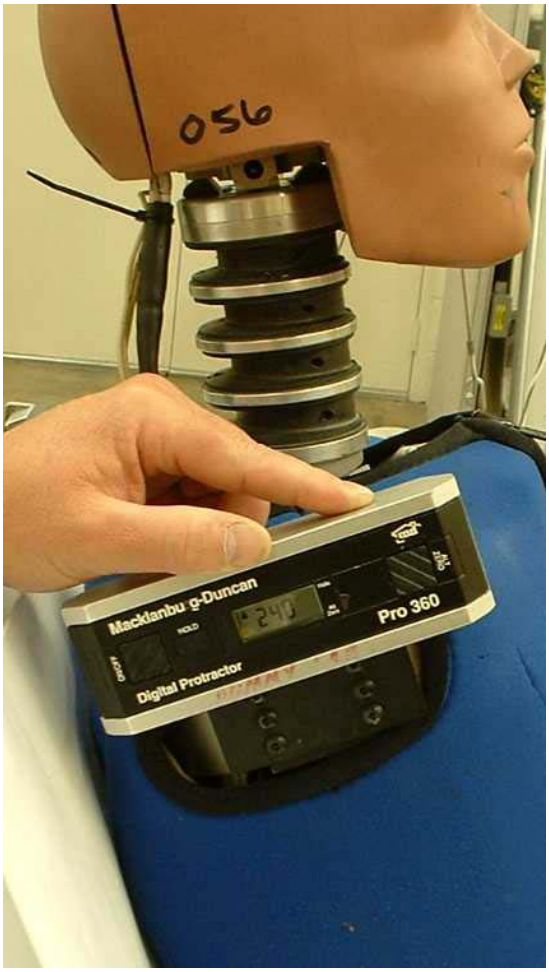

Figure A.7. Adjusting the SID-IIs in the fore/aft plane for shoulder certification tests.

Shoulder Certification Test Procedure

- The test probe should have a mass of 13.97 ± 0.23 kg [2] with a 120.7 mm face diameter, and a 12.7 mm radius.
- Mount an accelerometer on the test probe with its sensitive axis in line with the longitudinal centerline of the test probe.
- Release the test probe at an impact speed between 4.20 - 4.40 m/s, at a temperature between 20.6-22.2º C and a relative humidity between 10.0-70.0%.
- The data acquisition system should conform to SAE Recommended Practice J211.
- The pendulum acceleration is collected and filtered using a Channel Class 180 phaseless filter.

[2] Mass includes probe mass and all rigidly attached hardware, plus 1/3 of supporting cable weight.

- The shoulder deflection is collected and filtered using a Channel Class 600 phaseless filter.
- Time zero is defined as the time of contact between the impact probe and the shoulder. All channels should be at a zero level at this point.
- Calculate the test probe force by multiplying the mass of the pendulum by the test probe acceleration.
- Wait at least 30 minutes between successive shoulder impact tests (on the same shoulder).

Appendix B. Draft Thorax With Arm Certification Procedure

Thorax With Arm Certification Procedure

Required Instrumentation

- Shoulder linear potentiometer
- Upper thorax linear potentiometer
- Middle thorax linear potentiometer
- Lower thorax linear potentiometer
- Upper spine (Y) accelerometer (T1)
- Lower spine (Y) accelerometer (T12)[1]
- Test probe accelerometer
- Speed Trap

Pretest Preparation

- Install the thoracic and abdominal pads using cable ties[2].
- Place the chest jacket on the dummy.
- The dummy should wear cotton underwear pants, cut off just above the knees, for this procedure. No shirt or shoes should be worn.
- The dummy should be grounded using a cable between the dummy and ground.
- Align the upper and lower neck brackets so that the top edges are flush.
- Place the certification bench (Figure B.1.) in the probe's impact area so that the dummy can be impacted in the thorax.

[1] This is the accelerometer aligned with the first abdominal rib on the non-struck side.
[2] See Appendix G.: *Attachment of Thoracic and Abdominal Pads in the SID-IIs*.

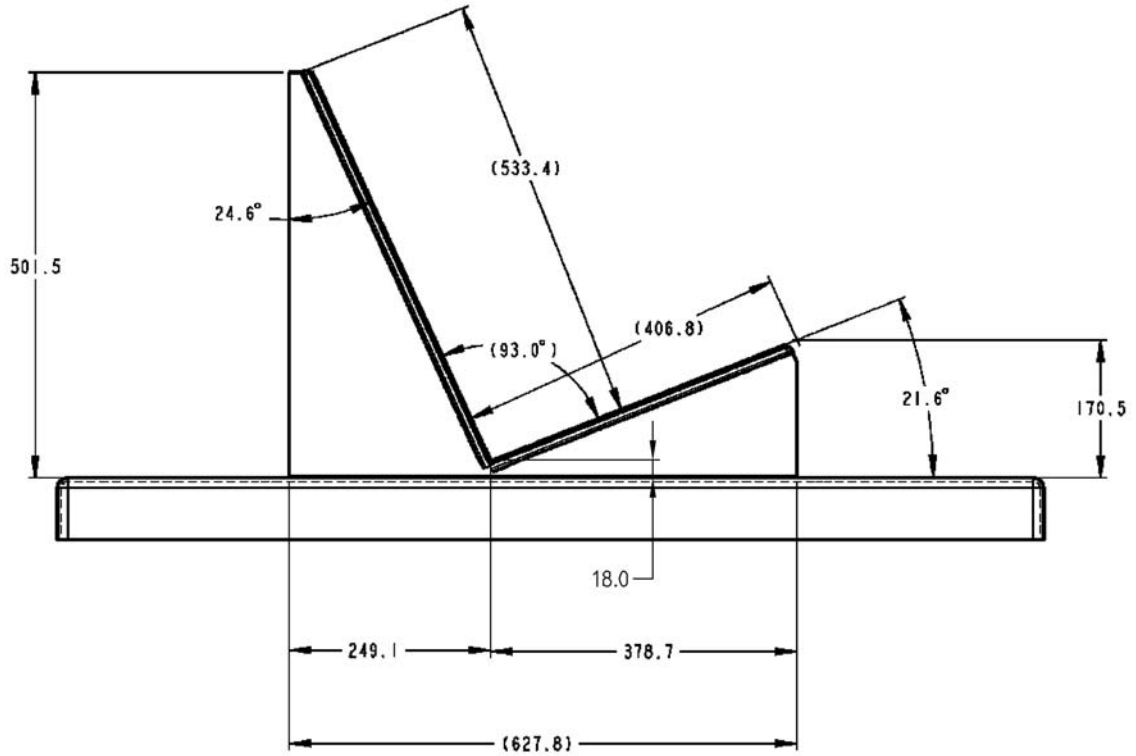

Figure B.1. Certification bench seat specifications for SID-IIs certification tests.

- Seat the dummy on a sheet of 387 x 521 mm Teflon (2 mm thick) on the bench. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seat pan (Figure B.2.).
- Place a sheet of 514 x 514 mm Teflon (2 mm thick) between the seatback and the dummy's posterior thorax. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seatback (Figure B.2.).
- Position the impact arm so that it points downward, perpendicular to the seatpan (Figure B.2.).
- Push the dummy's chest towards the seatback, so that the back of the thorax is touching the seat (Figure B.2.).

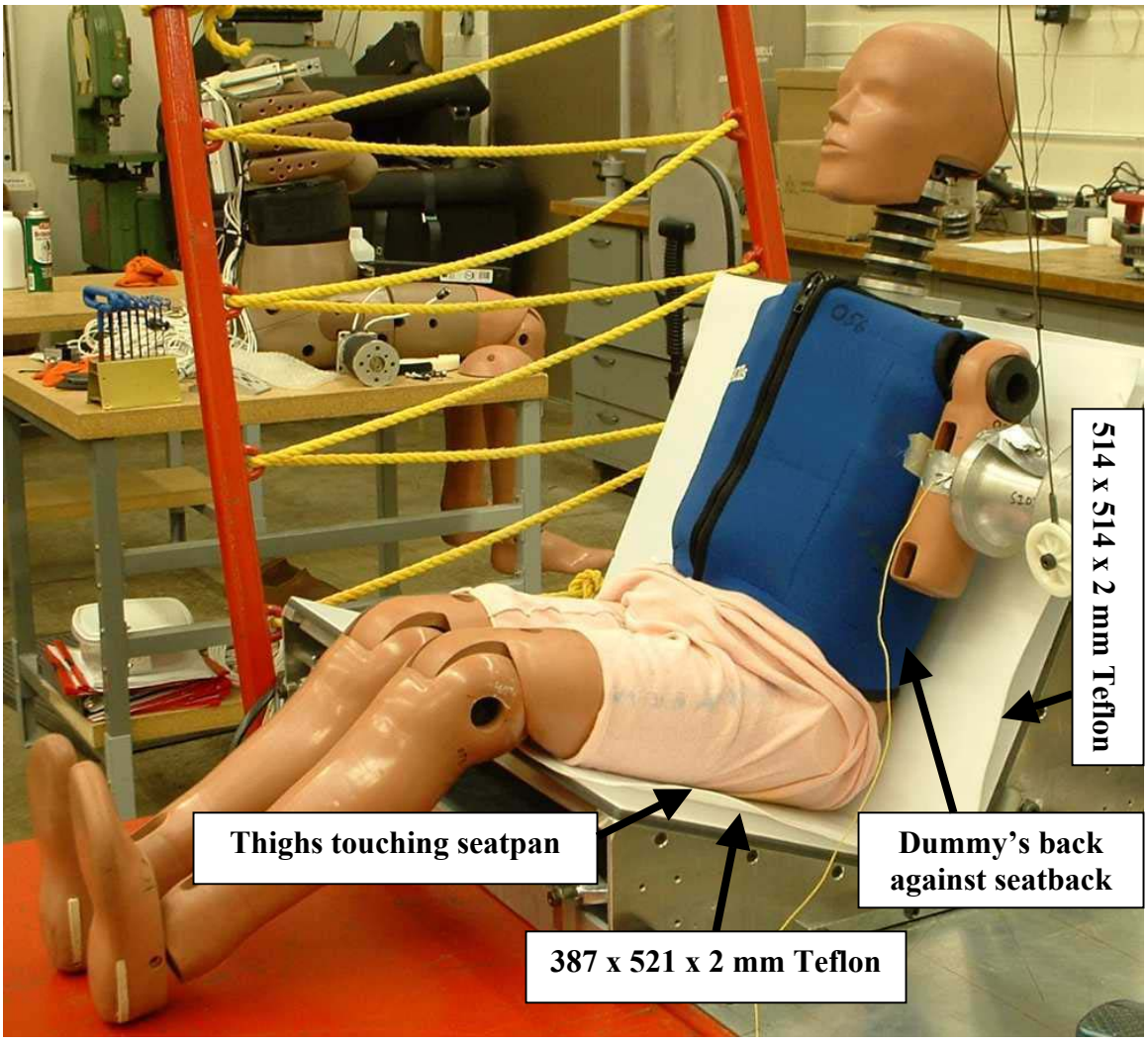

Figure B.2. Thorax With Arm certification test configuration for SID-IIs.

- Position the dummy so that the centerline of impact probe is centered on the centerline of the middle rib within 2 mm. This corresponds to a measurement of 93 ± 2 mm below the centerline of the shoulder bolt when measured along the length of the arm. The face of the probe should be parallel to, and just touching, the surface of the arm, when the probe is at its lowest position during travel (Figure B.3.).

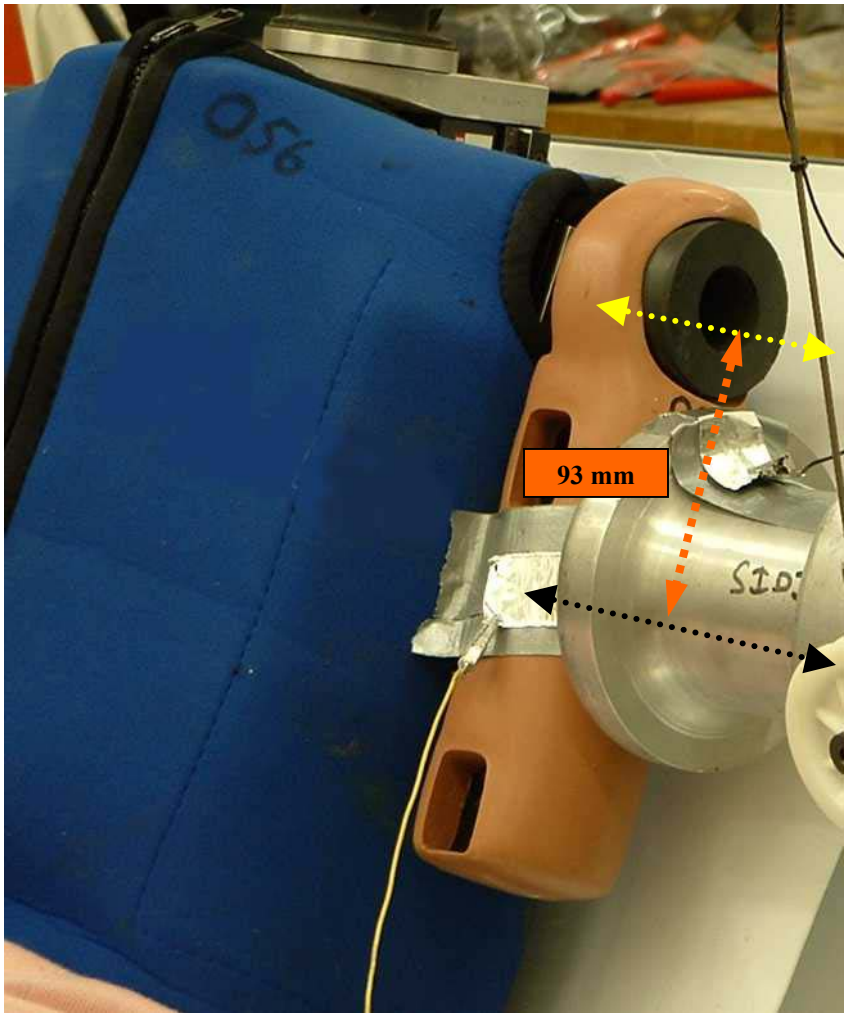

Figure B.3. Position of impact probe for the SID-IIs Thorax With Arm certification test.

- Push the femurs towards the seatpan so that the thighs are in contact with the seat (Figures B.2. and B.4.).
- Move the legs together so that the knees are touching (Figure B.4.).

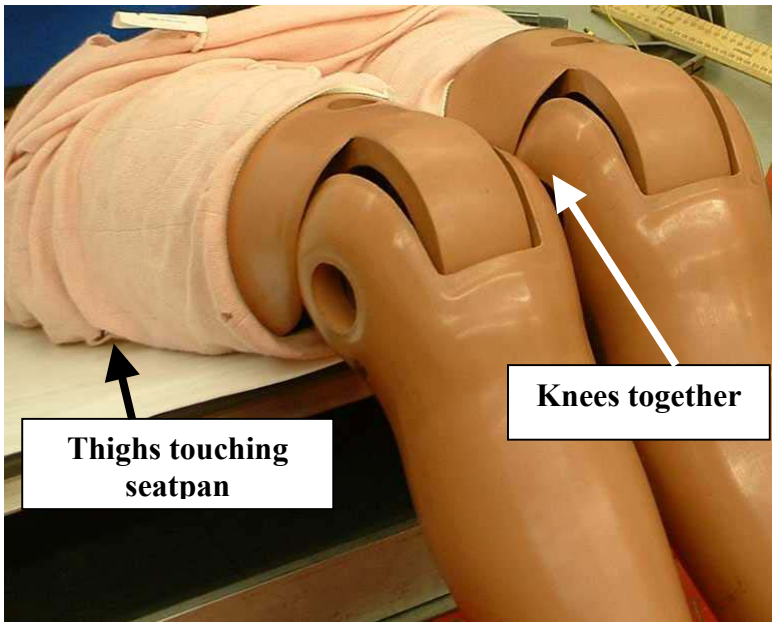

Figure B.4. SID-IIs leg positioning for Thorax With Arm certification tests.

- Position the feet so that they are vertical, with the heels touching the surface of the support table (Figure B.5.).

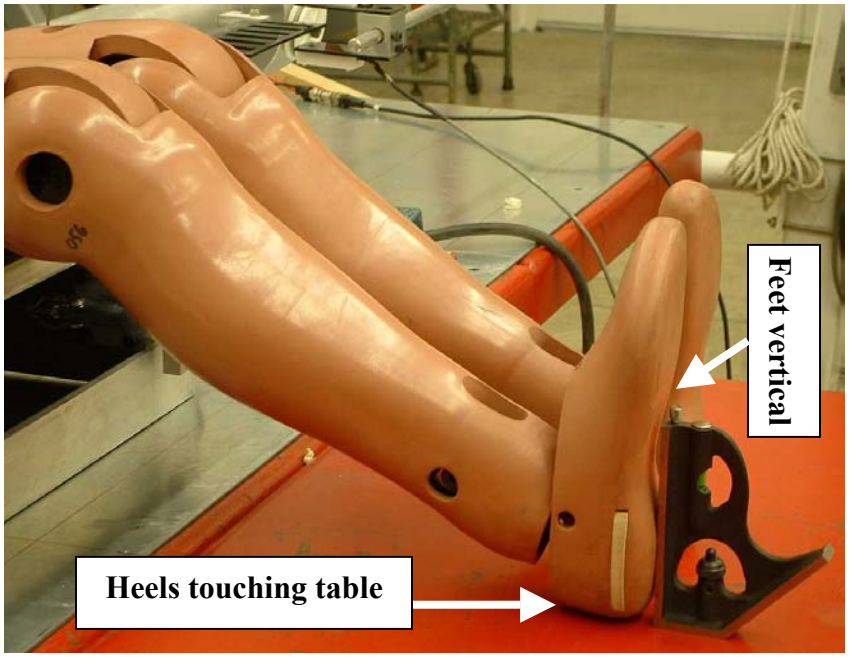

Figure B.5. Feet positioning for SID-IIs Thorax With Arm certification tests.

- Adjust the dummy so that the thoracic lateral plane is 0° ± 1 relative to horizontal (Figure B.6.).

Figure B.6. Adjusting the SID-IIs dummy in the lateral direction for Thorax With Arm certification tests.

- Adjust the dummy so that the thoracic fore/aft plane measures 24.6° ± 1 relative to horizontal (Figure B.7.).

Figure B.7. Adjusting the SID-IIs in the fore/aft plane for Thorax With Arm certification tests.

Thorax With Arm Certification Test Procedure

- The test probe should have a mass of 13.97 ± 0.23 kg [3] with a 120.7 mm face diameter, and a 12.7 mm radius.
- Mount an accelerometer on the test probe with its sensitive axis in line with the longitudinal centerline of the test probe.
- Release the test probe at an impact speed between 6.60 – 6.80 m/s, at a temperature between 20.6-22.2º C and a relative humidity between 10.0-70.0%.
- The data acquisition system should conform to SAE Recommended Practice J211.
- The probe and spine accelerations are collected and filtered using a Channel Class 180 phaseless filter.
- The shoulder and thoracic deflections are collected and filtered using a Channel Class 600 phaseless filter.
- Time zero is defined as the time of contact between the impact probe and the arm. All channels should be at a zero level at this point.
- Calculate the test probe force by multiplying the mass of the probe by the test probe acceleration.
- Wait at least 30 minutes between successive thorax impact tests on the same thorax assembly.

[3] Mass includes probe mass and all rigidly attached hardware, plus 1/3 of supporting cable weight.

Appendix C. Draft Thorax Without Arm Certification Procedure

Thorax Without Arm Certification Procedure

Required Instrumentation

- Upper thorax linear potentiometer
- Middle thorax linear potentiometer
- Lower thorax linear potentiometer
- Upper spine Y accelerometer (T1)
- Lower spine Y accelerometer (T12)[1]
- Test probe accelerometer
- Speed Trap

Pretest Preparation

- Remove the arm on the impact side.
- Install the thoracic and abdominal pads using cable ties[2].
- Place the chest jacket on the dummy.
- The dummy should wear cotton underwear pants, cut off just above the knees, for this procedure. No shirt or shoes should be worn.
- The dummy should be grounded using a cable between the dummy and ground.
- Align the upper and lower neck brackets so that the top edges are flush.
- Place the certification bench (Figure C.1.) in the probe's impact area so that the dummy can be impacted in the thorax.

[1] This is the accelerometer aligned with the first abdominal rib on the non-struck side.
[2] See Appendix G.: *Attachment of Thoracic and Abdominal Pads in the SID-IIs*.

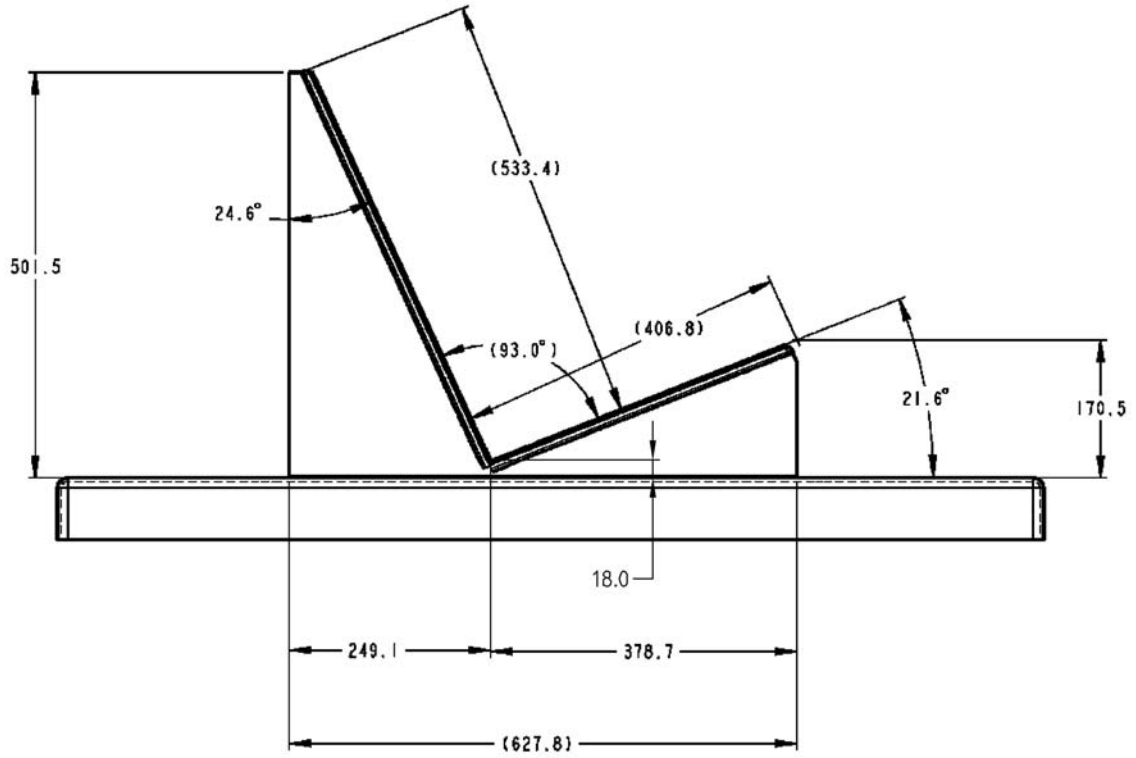

Figure C.1. Certification bench seat specifications for SID-IIs certification tests.

- Seat the dummy on a sheet of 387 x 521 mm Teflon (2 mm thick) on the bench. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seat pan (Figure C.2.).
- Place a sheet of 514 x 514 mm Teflon (2 mm thick) between the seatback and the dummy's posterior thorax. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seatback (Figure C.2.).

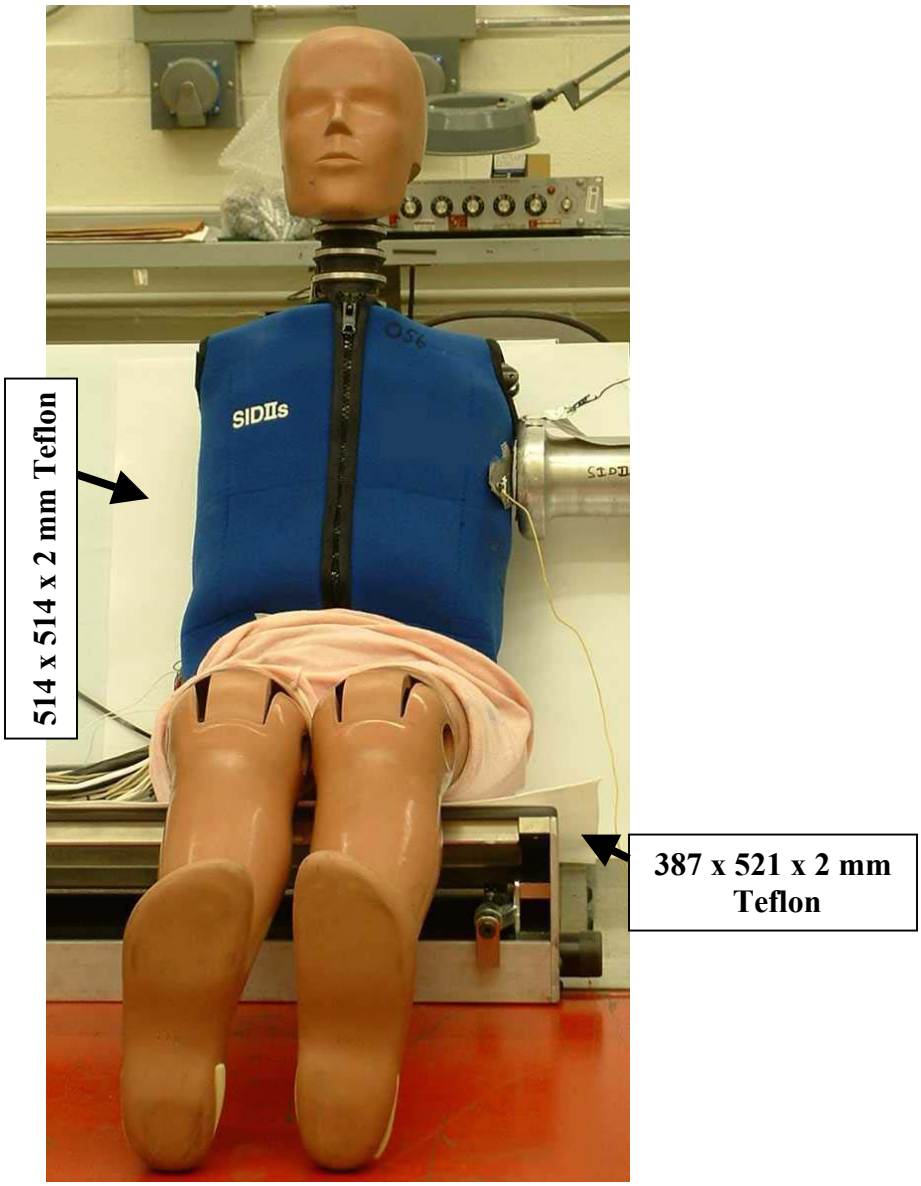

Figure C.2. Thorax Without Arm certification test configuration for SID-IIs.

- Position the dummy so that the centerline of impact probe is centered on the centerline of the middle rib within 2 mm. This corresponds to a measurement of 93 ± 2 mm below the centerline of the shoulder bolt when measured along the centerline of the thorax. The face of the probe should be parallel to, and just touching, the surface of the thorax, when the probe is at its lowest position during travel (Figure C.3.).
- Push the dummy's chest towards the seatback, so that the back of the thorax is touching the seat (Figure C.3.).

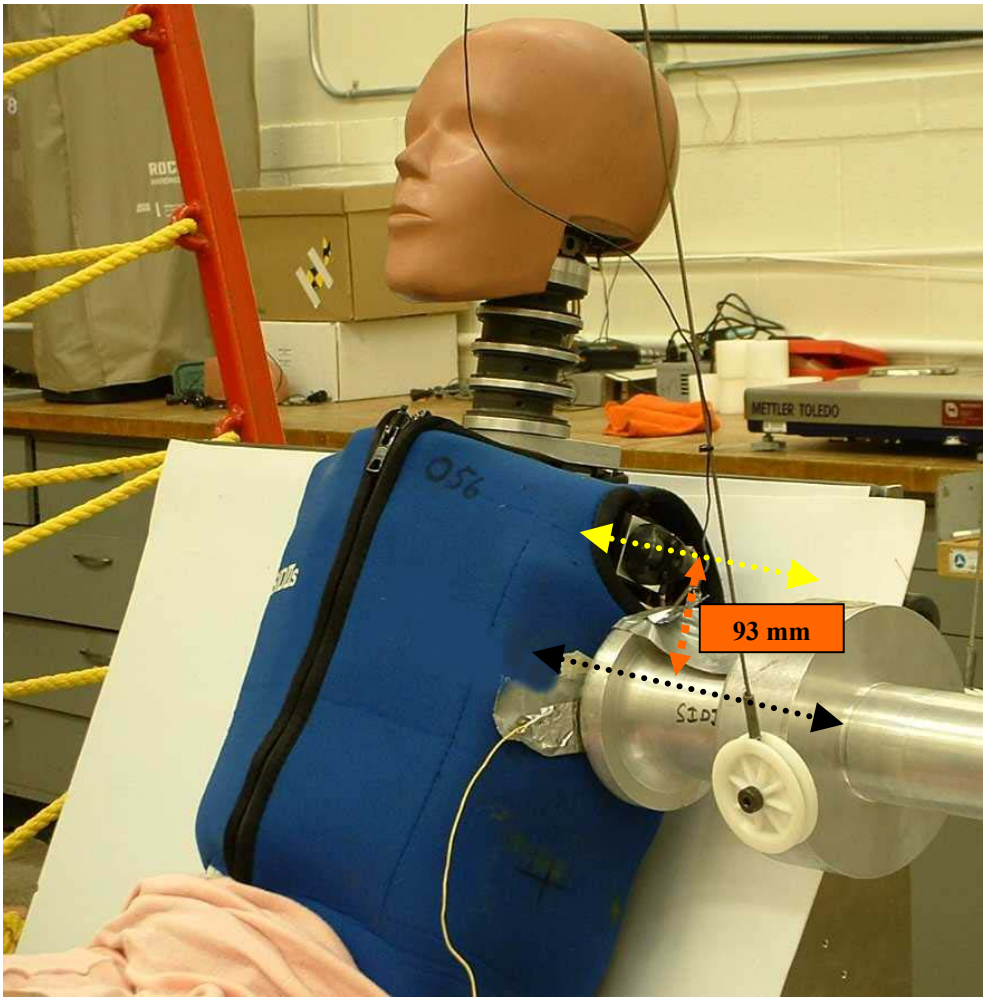

Figure C.3. Impact probe position for the SID-IIs Thorax Without Arm certification test.

- Push the femurs towards the seatpan so that the thighs are in contact with the seat (Figure C.4.).
- Move the legs together so that the knees are touching (Figure C.4.).

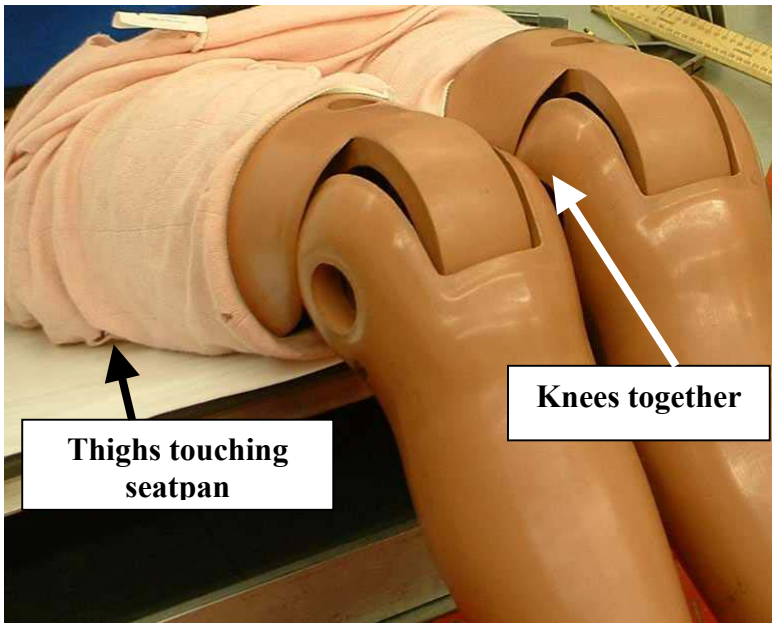

Figure C.4. SID-IIs leg positioning for Thorax Without Arm certification tests.

- Position the feet so that they are vertical, with the heels touching the surface of the support table (Figure C.5.).

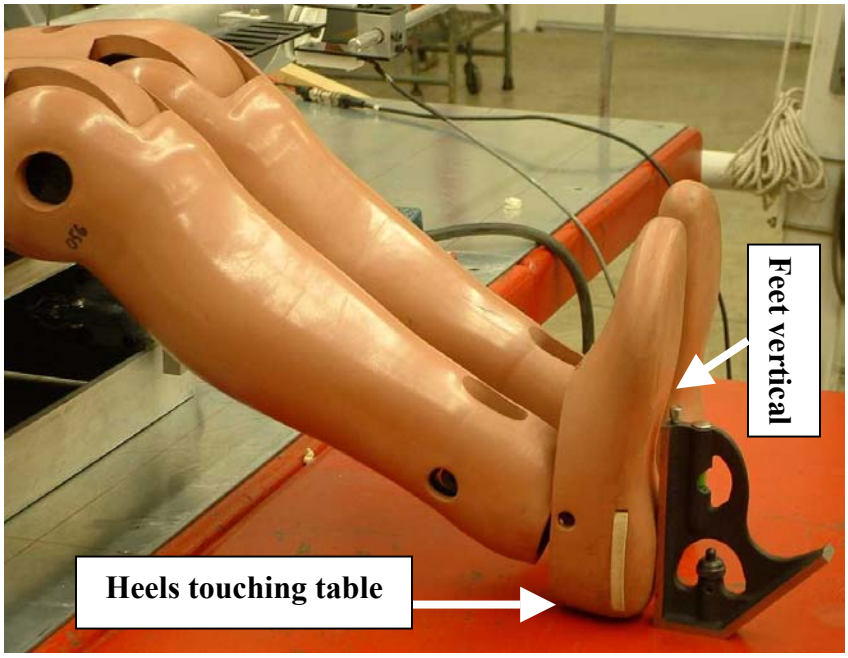

Figure C.5. Feet positioning for SID-IIs Thorax Without Arm certification tests.

- Adjust the dummy so that the thoracic lateral plane is 0° ± 1 relative to horizontal (Figure C.6.).

Figure C.6. Adjusting the SID-IIs dummy in the lateral direction for Thorax Without Arm certification tests.

- Adjust the dummy so that the thoracic fore/aft plane measures 24.6° ± 1 relative to horizontal (Figure C.7.).

Figure C.7. Adjusting the SID-IIs in the fore/aft plane for Thorax Without Arm certification tests.

Thorax Without Arm Certification Test Procedure

- The test probe should have a mass of 13.97 ± 0.23 kg [3] with a 120.7 mm face diameter, and a 12.7 mm radius.
- Mount an accelerometer on the test probe with its sensitive axis in line with the longitudinal centerline of the test probe.
- Release the test probe at an impact speed between 4.20 - 4.40 m/s, at a temperature between 20.6-22.2º C and a relative humidity between 10.0-70.0%.
- The data acquisition system should conform to SAE Recommended Practice J211.
- The probe and spine accelerations are collected and filtered using a Channel Class 180 phaseless filter.
- The thoracic deflections are collected and filtered using a Channel Class 600 phaseless filter.
- Time zero is defined as the time of contact between the impact probe and the thorax. All channels should be at a zero level at this point.
- Calculate the test probe force by multiplying the mass of the probe by the test probe acceleration.
- Wait at least 30 minutes between successive thorax impact tests on the same thorax assembly.

[3] Mass includes probe mass and all rigidly attached hardware, plus 1/3 of supporting cable weight.

Appendix D. Draft Abdomen Certification Procedure

Abdomen Certification Procedure

Required Instrumentation

- Upper abdominal linear potentiometer
- Lower abdominal linear potentiometer
- Upper spine (Y) accelerometer (T1)
- Lower spine (Y) accelerometer (T12)[1]
- Test probe accelerometer
- Speed Trap

Pretest Preparation

- Remove the arm on the impact side.
- Install the thoracic and abdominal pads using cable ties[2].
- Place the chest jacket on the dummy.
- The dummy should wear cotton underwear pants, cut off just above the knees, for this procedure. No shirt or shoes should be worn.
- The dummy should be grounded using a cable between the dummy and ground.
- Align the upper and lower neck brackets so that the top edges are flush.
- Place the certification bench (Figure D.1.) in the pendulum's impact area so that the dummy can be impacted in the abdomen.

[1] This is the accelerometer aligned with the first abdominal rib on the non-struck side.
[2] See Appendix G.: *Attachment of Thoracic and Abdominal Pads in the SID-IIs*.

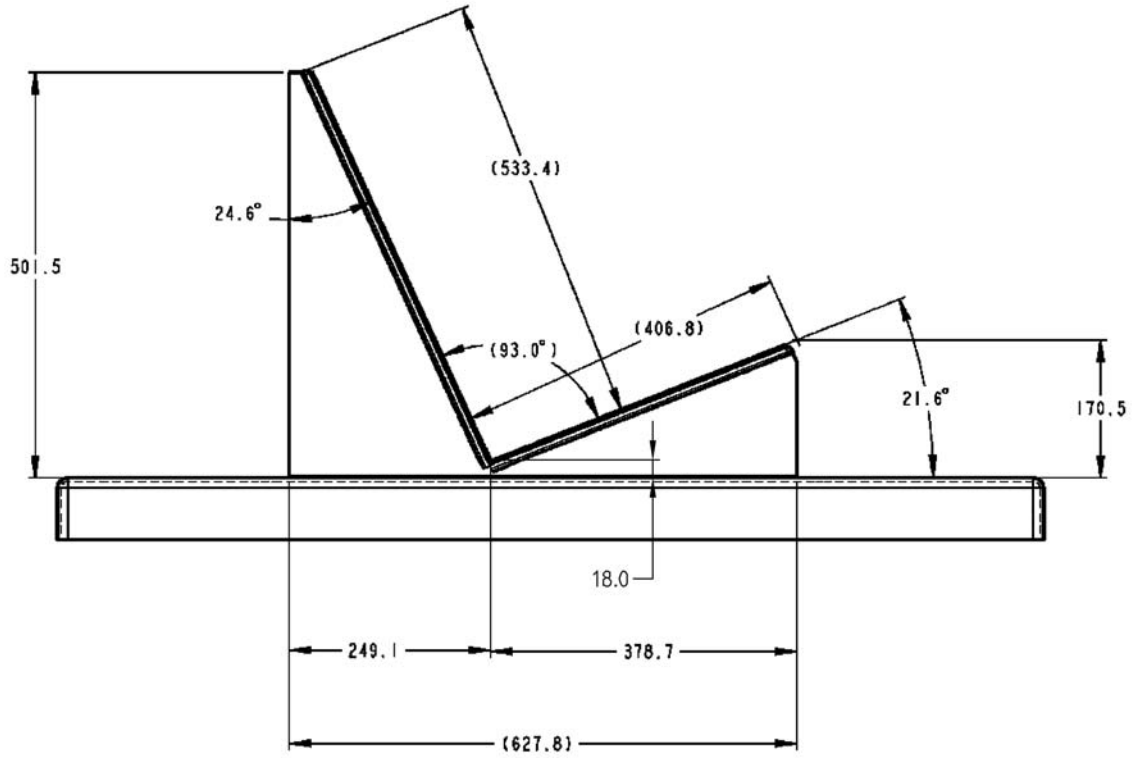

Figure D.1. Certification bench seat specifications for SID-IIs certification tests.

- Seat the dummy on a sheet of 387 x 521 mm Teflon (2 mm thick) on the bench. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seat pan (Figure D.2.).
- Place a sheet of 514 x 514 mm Teflon (2 mm thick) between the seatback and the dummy's posterior thorax. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seatback (Figure D.2.).

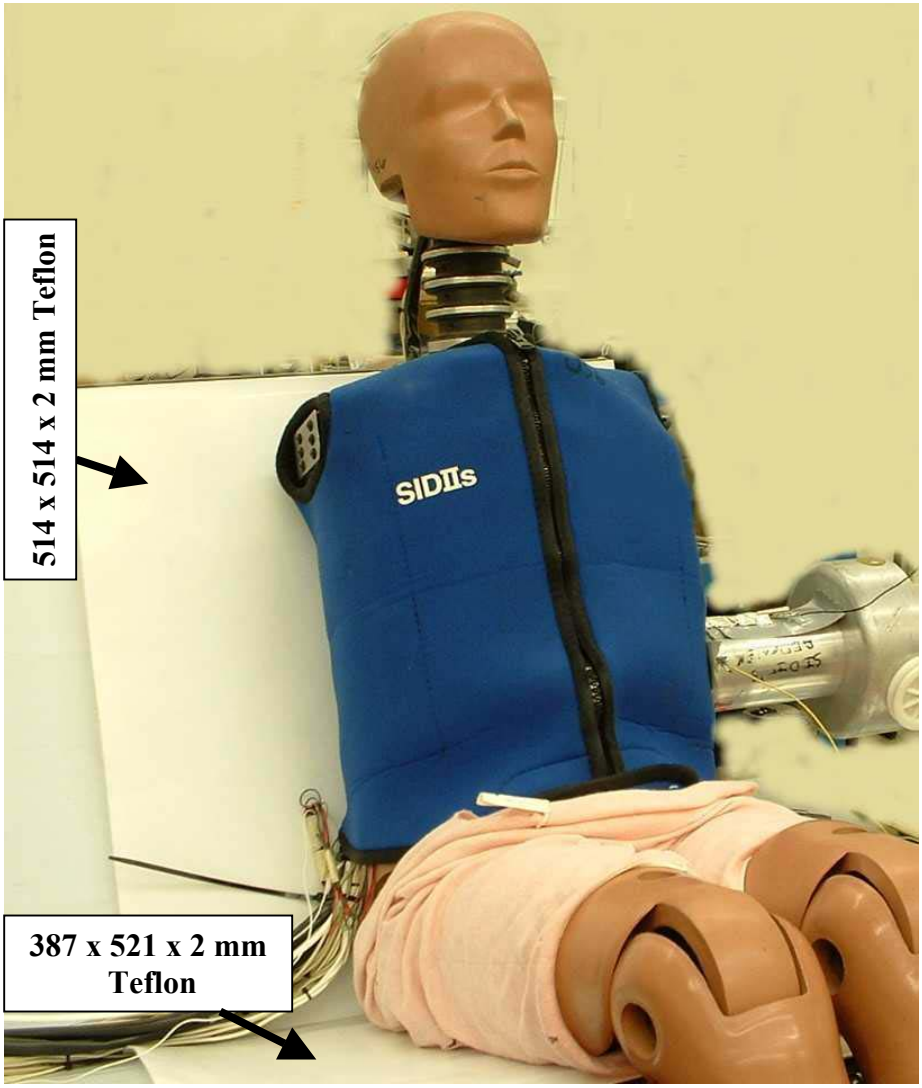

Figure D.2. Abdomen certification test configuration for SID-IIs.

- Position the dummy so that the centerline of impact probe is centered on the midpoint between the two abdominal ribs within 2 mm. This corresponds to a measurement of 208 ± 2 mm below the centerline of the shoulder bolt when measured along the centerline of the thorax (Figure D.3.). The face of the pendulum should be parallel to, and just touching, the surface of the abdomen, when the pendulum probe is at its lowest position during travel.
- Push the dummy's chest towards the seatback, so that the back of the thorax is touching the seat (Figure D.3.).

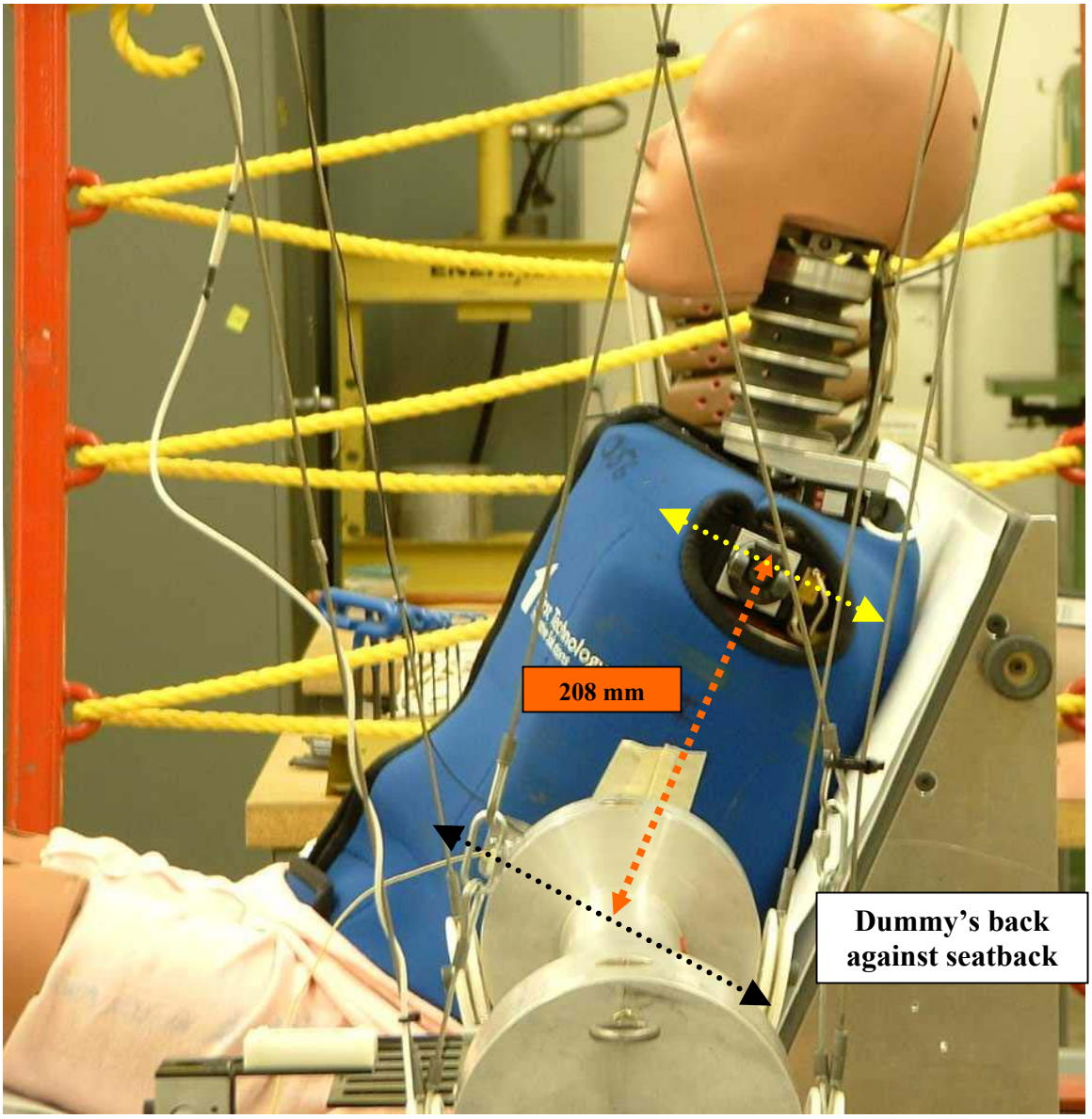

Figure D.3. Impact probe position for the SID-IIs Abdomen certification test.

- Push the femurs towards the seatpan so that the thighs are in contact with the seat (Figure D.4.).
- Move the legs together so that the knees are touching (Figure D.4.).

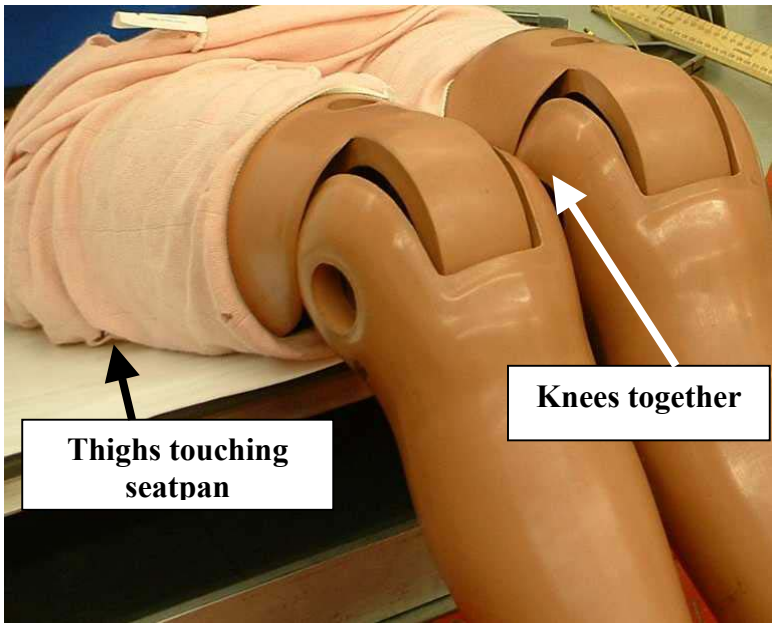

Figure D.4. SID-IIs leg positioning for Abdomen certification tests.

- Position the feet so that they are vertical, with the heels touching the surface of the support table (Figure D.5.).

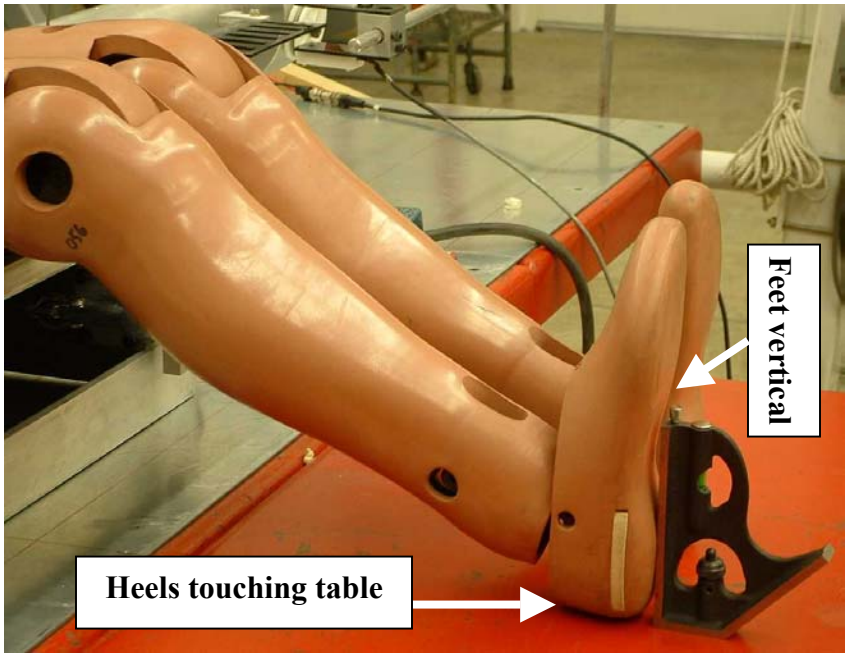

Figure D.5. Feet positioning for SID-IIs Abdomen certification tests.

- Adjust the dummy so that the thoracic lateral plane is 0° ± 1 relative to horizontal (Figure D.6.).

Figure D.6. Adjusting the SID-IIs dummy in the lateral direction for Abdomen certification tests.

- Adjust the dummy so that the thoracic fore/aft plane measures 24.6° ± 1 relative to horizontal (Figure D.7.).

Figure D.7. Adjusting the SID-IIs in the fore/aft plane for Abdomen certification tests.

Abdomen Certification Test Procedure and Specifications

- The test probe should have a mass of 13.97 ± 0.23 kg [3]. The probe tip[4] should have a 76.2 mm face diameter and a 12.7 mm radius.
- Mount an accelerometer on the test probe with its sensitive axis in line with the longitudinal centerline of the test probe.
- Release the test probe at an impact speed between 4.20 - 4.40 m/s, at a temperature between 20.6-22.2º C and a relative humidity between 10.0-70.0%.
- The data acquisition system should conform to SAE Recommended Practice J211.
- The probe and spine accelerations are collected and filtered using a Channel Class 180 phaseless filter.
- The abdominal deflections are collected and filtered using a Channel Class 600 phaseless filter.
- Time zero is defined as the time of contact between the impact probe and the abdomen. All channels should be at a zero level at this point.
- Calculate the test probe force by multiplying the mass of the probe by the test probe acceleration.
- Wait at least 30 minutes between successive abdomen impact tests on the same abdomen assembly.

[3] Mass includes probe mass and all rigidly attached hardware, plus 1/3 of supporting cable weight.
[4] Note that this probe tip differs from the probe tip used in the other certification tests.

Appendix E. Draft Pelvis Certification Procedure

Pelvis Certification Test Procedure

Required Instrumentation

- Pelvis (Y) accelerometer
- Test probe accelerometer
- Speed Trap

Pretest Preparation

- Remove the chest jacket from the dummy.
- Be sure the thoracic and abdominal pads are installed using cable ties[1].
- Install a new pelvis plug
- Position the arm on the impact side down and perpendicular to the seatpan.
- The dummy should not wear clothing for this procedure. No shoes should be worn.
- The dummy should be grounded using a cable between the dummy and ground.
- Align the upper and lower neck brackets so that the top edges are flush.
- Place the certification bench (Figure E.1.) in the probe's impact area so that the dummy can be impacted in the pelvis.

[1] See Appendix G.: *Attachment of Thoracic and Abdominal Pads in the SID-IIs*.

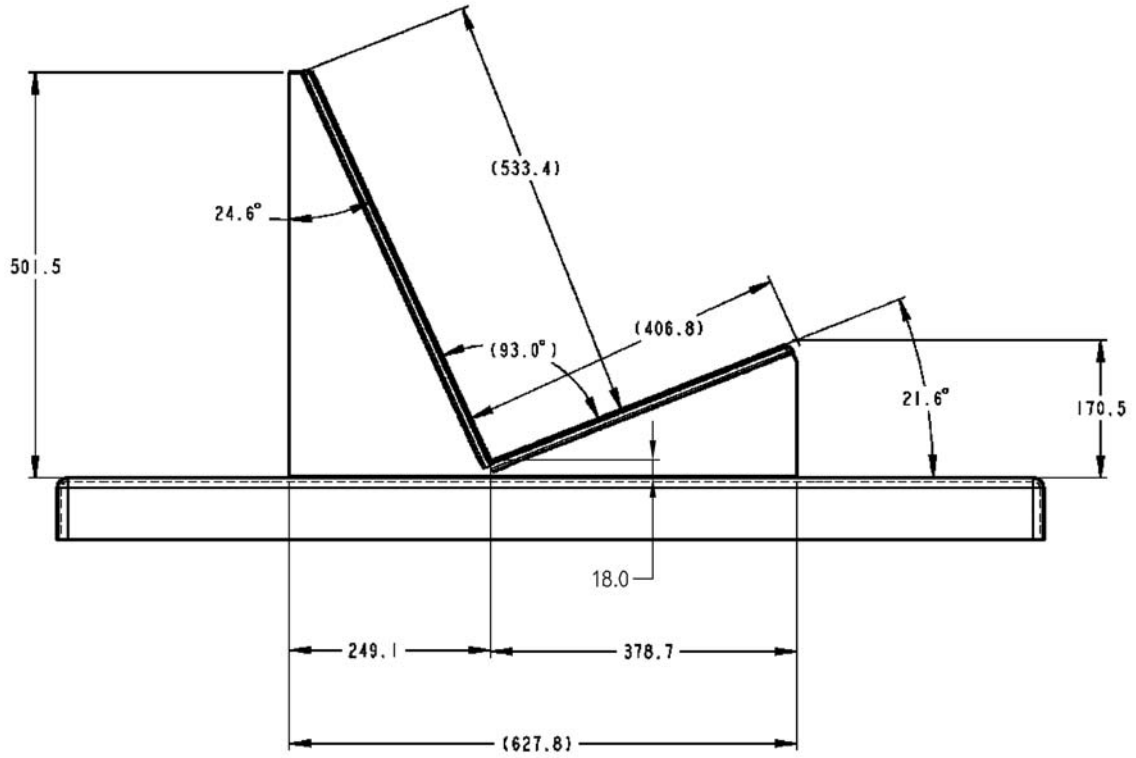

Figure E.1. Certification bench seat specifications for SID-IIs certification tests.

- Seat the dummy on a sheet of 387 x 521 mm Teflon (2 mm thick) on the bench. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seat pan (Figure E.2.).
- Place a sheet of 514 x 514 mm Teflon (2 mm thick) between the seatback and the dummy's posterior thorax. Center the dummy on the Teflon sheet, and position the edge of the sheet along, or parallel to, the impact side of the bench's seatback (Figure E.2.).
- Move the legs together so that the knees are touching (Figure E.2.).

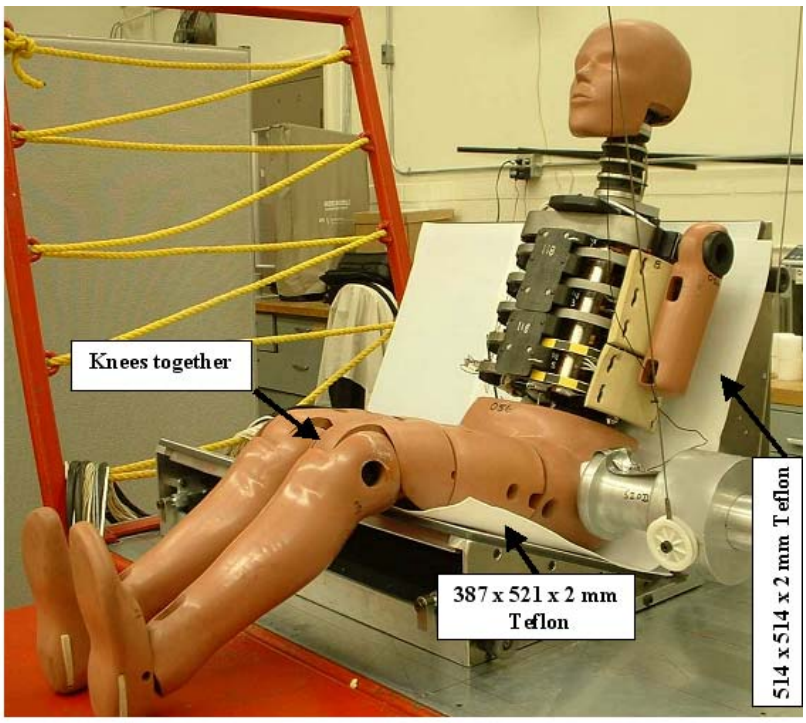

Figure E.2. Pelvis certification test for SID-IIs.

- Position the dummy so that the centerline of impact probe is centered on the centerline of the pelvis plug within 2 mm. The face of the probe should be parallel to, and just touching, the surface of the pelvis plug, when the probe is at its lowest position during travel (Figure E.3.).

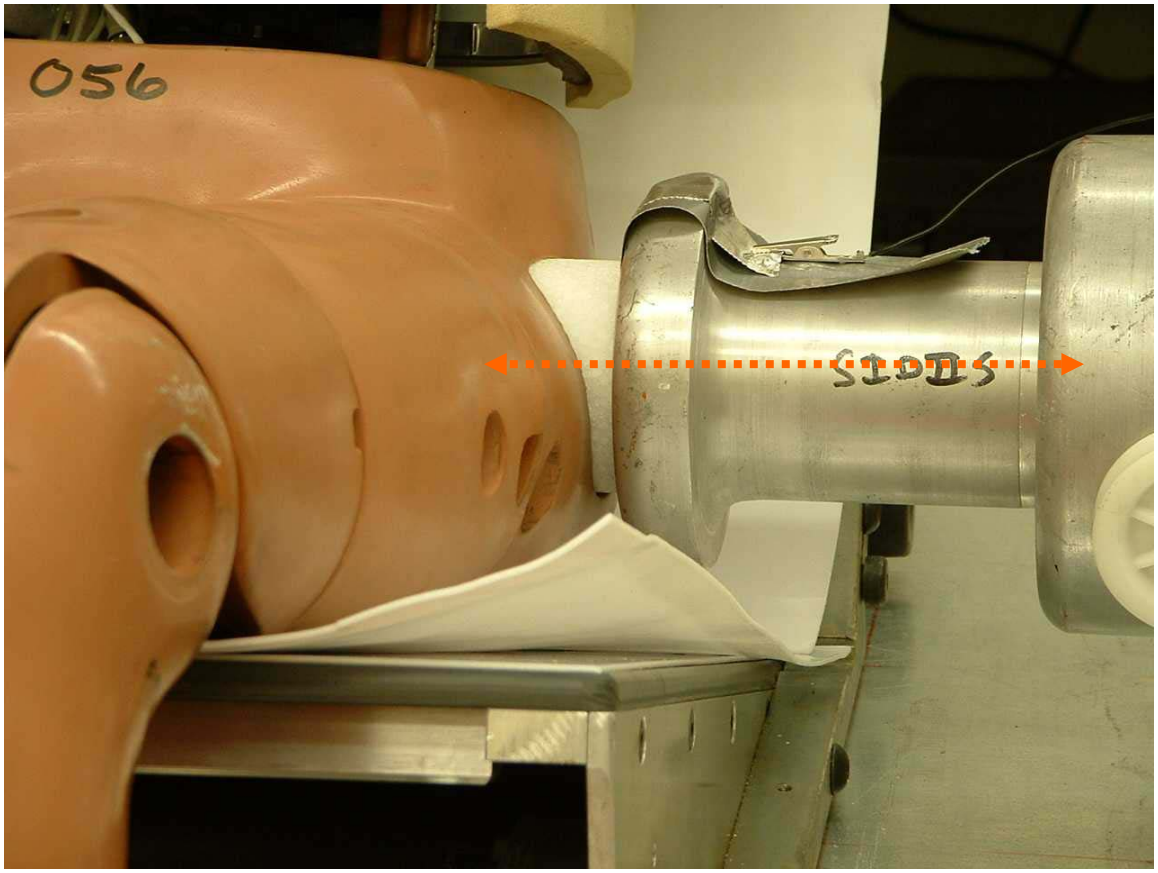

Figure E.3. Impact probe position for the SID-IIs Pelvis certification test.

- Push the dummy's chest towards the seatback, so that the back of the thorax is touching the seat (Figure E.4.).
- Push the femurs towards the seatpan so that the thighs are in contact with the seat (Figure E.4.).

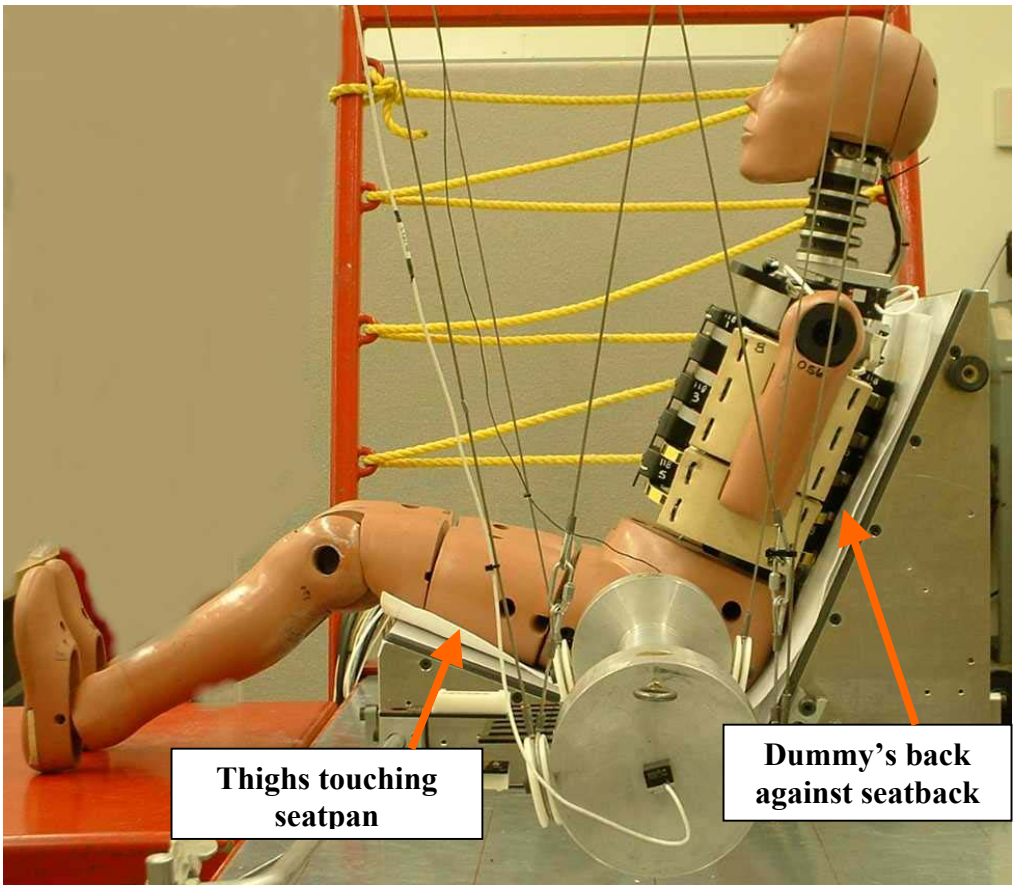

Figure E.4. SID-IIs leg and back positioning for Pelvis certification tests.

- Push the femurs towards the seatpan so that the thighs are in contact with the seat (Figure E.5.).
- Move the legs together so that the knees are touching (Figure E.5.).

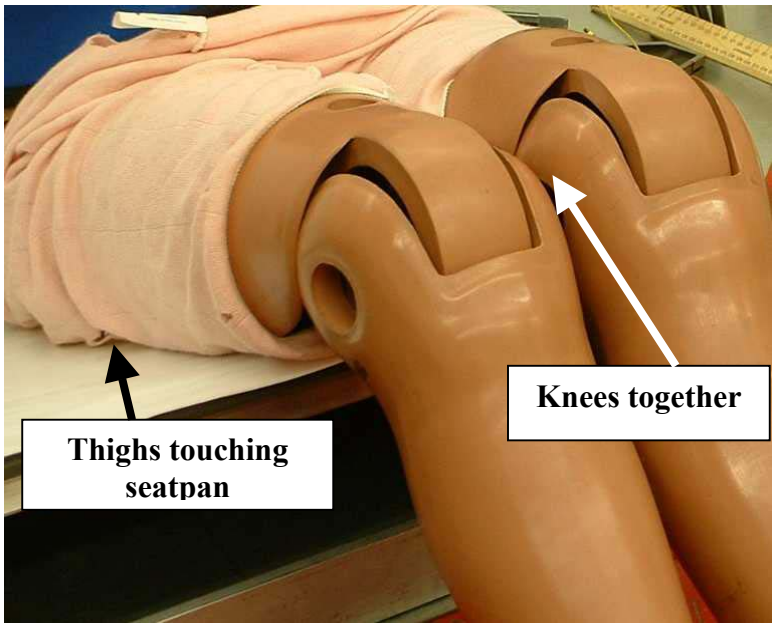

Figure E.5. SID-IIs leg positioning for Pelvis certification tests.

- Position the feet so that they are vertical, with the heels touching the surface of the support table (Figure E.6.).

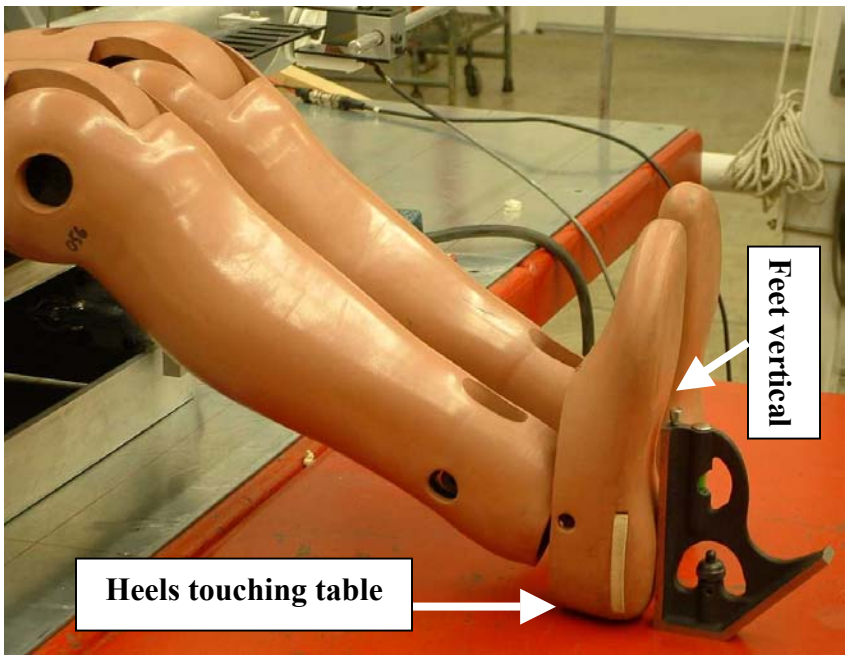

Figure E.6. Feet positioning for SID-IIs Pelvis certification tests.

- Adjust the dummy so that the thoracic lateral plane is 0° ± 1 relative to horizontal (Figure E.7.).

Figure E.7. Adjusting the SID-IIs dummy in the lateral direction for Pelvis certification tests.

- Adjust the dummy so that the thoracic fore/aft plane measures 24.6° ± 1 relative to horizontal (Figure E.8.).

Figure E.8. Adjusting the SID-IIs in the fore/aft plane for Pelvis certification tests.

Pelvis Certification Test Procedure

- The test probe should have a mass of 13.97 ± 0.23 kg [2]. The probe tip should have a 120.7 mm face diameter and a 12.7 mm radius.
- Mount an accelerometer on the test probe with its sensitive axis in line with the longitudinal centerline of the test probe.
- Release the test probe at an impact speed between 6.60 – 6.80 m/s, at a temperature between 20.6-22.2º C and a relative humidity between 10.0-70.0%.
- The data acquisition system should conform to SAE Recommended Practice J211.
- The probe and pelvis accelerations are collected and filtered using a Channel Class 180 phaseless filter.
- Time zero is defined as the time of contact between the impact probe and the pelvis. All channels should be at a zero level at this point.
- Calculate the test probe force by multiplying the mass of the probe by the test probe acceleration.
- Wait at least 30 minutes between successive pelvis impact tests on the same pelvis.

[2] Mass includes probe mass and all rigidly attached hardware, plus 1/3 of supporting cable weight.

Appendix F. Certification Data Tables And Plots

Table F.1. Peak Responses and Statistical Analysis for Head Drop Certification Tests

Head Drop Tests		Peak Resultant Acceleration (g)	Peak A-P Acceleration (g)
Test # / Statistical Parameter	**Dummy**	115-145	-/+15
032HDL_01	32	132.1	-2.3
032HDL_02	32	136.3	-2.6
032HDL_03	32	136.4	3.0
032HDL_04	32	137.9	-2.3
032HDL_05	32	137.8	-2.7
056HDL_01	56	137.8	-2.7
056HDL_02	56	132.2	7.5
056HDL_03	56	135.5	6.4
056HDL_04	56	136.7	-3.0
056HDL_05	56	132.9	-3.2
Average		136.11	
Standard Deviation	32	2.36	
%CV		**1.74%**	
Average		135.02	
Standard Deviation	56	2.38	
%CV		**1.76%**	
Average		135.56	
Standard Deviation	Both	2.31	
%CV		**1.70%**	

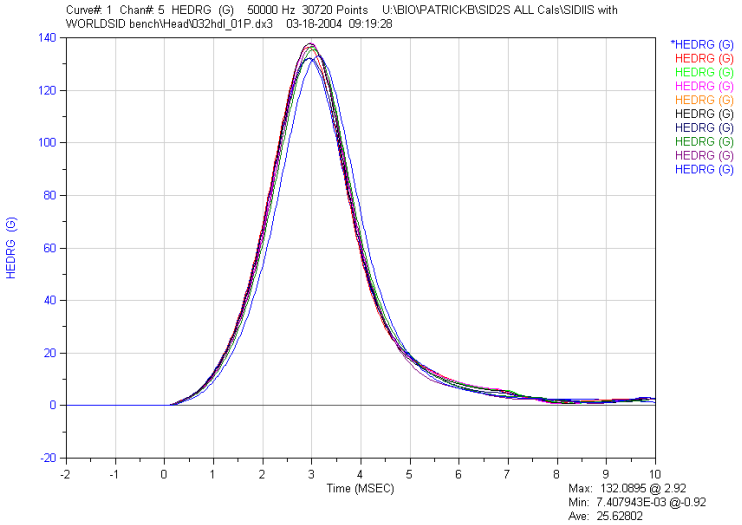

Figure F.1. Head Resultant Acceleration (g)

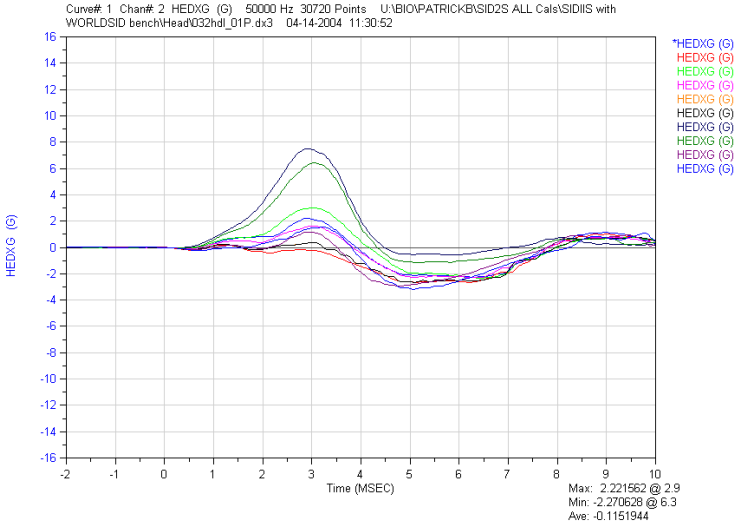

Figure F.2. Head A-P Acceleration (g)

Table F.2. Peak Responses and Statistical Analysis for Lateral Neck Certification Tests

Lateral Neck		Impact Velocity	Delta Velocity (m/s)					Peak D-Plane Rotation	Decay Time of D-Plane Rotation Peak to Zero Degree	Peak Occipital Condyle Moment	Time at 10 Nm after peak moment	Time of last Moment Peak to Max Rotation	Front Pot Peak Rotation	Time of Front Pot Peak Rotation	Rear Pot Peak Rotation	Time of Rear Pot Peak Rotation
		(m/s)	10 ms	15 ms	20 ms	25-60 ms		(deg)	(m/s)	(Nm)	(ms)	(ms)	(deg)	(ms)	(deg)	(ms)
Test # / Statistical Parameter	Dummy	5.51 - 5.63	2.10 - 2.70	3.00 - 3.80	4.20 - 5.20	5.00 - 6.40 min > 5.00 max < 6.40 min	max	72 - 82	60 - 83	[-43] - [-36]	90 - 98	<14	59-72	61-73	47-56	62-73
032NL_02	32	5.528	2.443	3.676	4.921	5.470	5.955	75.3	69.1	**-43.6**	92.2	7.9	61.2	63.4	50.2	64.6
032NL_03	32	**5.506**	2.455	3.641	4.879	5.481	5.939	75.6	69.6	**-43.3**	91.9	8.6	61.3	63.8	50.3	63.3
032NL_04	32	**5.506**	2.460	3.616	4.840	5.469	5.922	75.5	69.9	**-43.6**	92.4	8.1	61.1	63.7	50.1	64.4
032NL_05	32	**5.506**	2.502	3.653	4.897	5.470	5.919	75.7	69.5	**-43.5**	92.2	8.6	61.4	63.8	50.2	63.0
032NL_06	32	5.528	2.402	3.569	4.809	5.479	5.919	75.6	69.9	**-43.2**	92.4	8.8	61.5	64.2	50.5	64.2
056NL_09	56	5.528	2.516	3.659	4.914	5.474	5.928	77.1	72.7	-42.6	93.0	9.0	60.9	62.4	50.5	63.1
056NL_10	56	5.528	2.442	3.629	4.829	5.476	5.925	76.7	72.3	-42.4	93.4	8.7	60.2	62.5	50.3	63.0
056NL_11	56	**5.506**	2.379	3.556	4.760	5.497	5.916	77.1	72.7	-42.8	94.0	8.0	60.8	62.5	50.8	62.8
056NL_12	56	5.528	2.336	3.447	4.622	5.322	5.901	77.2	73.3	-41.8	94.2	9.3	60.3	63.1	50.2	63.3
056NL_13	56	**5.506**	2.429	3.569	4.801	5.493	5.924	76.8	73.1	-42.1	93.3	8.3	59.8	62.4	49.8	**61.8**
056NL_14	56	**5.506**	2.512	3.695	4.975	5.483	5.945	77.2	72.7	-42.5	93.1	8.6	60.1	62.3	50.1	63.1
Average	32	5.51	2.45	3.63	4.87	5.47	5.93	75.54	69.61	-43.45	92.21	8.40	61.31	63.79	50.24	63.91
Std Dev		0.01	0.04	0.04	0.04	0.01	0.02	0.13	0.30	0.19	0.20	0.41	0.15	0.30	0.15	0.72
%CV		**0.22%**	**1.46%**	**1.13%**	**0.92%**	**0.10%**	**0.27%**	**0.17%**	**0.43%**	**-0.43%**	**0.22%**	**4.86%**	**0.24%**	**0.47%**	**0.31%**	**1.12%**
Average	56	5.52	2.44	3.59	4.82	5.46	5.92	77.03	72.82	-42.38	93.50	8.65	60.35	62.54	50.30	62.83
Std Dev		0.01	0.07	0.09	0.12	0.07	0.01	0.21	0.35	0.36	0.48	0.44	0.43	0.31	0.33	0.55
%CV		**0.22%**	**2.93%**	**2.47%**	**2.56%**	**1.23%**	**0.24%**	**0.28%**	**0.48%**	**-0.84%**	**0.52%**	**5.14%**	**0.71%**	**0.49%**	**0.65%**	**0.87%**
Average	Both	5.52	2.44	3.61	4.84	5.46	5.93	76.35	71.36	-42.86	92.91	8.53	60.79	63.11	50.27	63.32
Std Dev		0.01	0.06	0.07	0.10	0.05	0.01	0.80	1.70	0.63	0.77	0.43	0.59	0.71	0.25	0.82
%CV		**0.21%**	**2.29%**	**1.96%**	**1.98%**	**0.88%**	**0.25%**	**1.04%**	**2.39%**	**-1.46%**	**0.83%**	**5.00%**	**0.97%**	**1.13%**	**0.50%**	**1.30%**

Blue text indicates response corridors from FTSS User's Manual (FTSS, 2002).

Bold text indicates dummy responses outside FTSS response corridors.

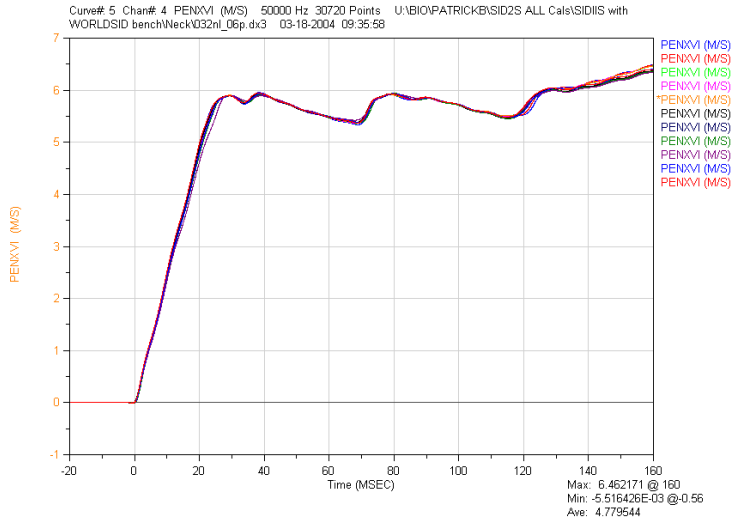

Figure F.3. Neck Pendulum Velocity (m/s)

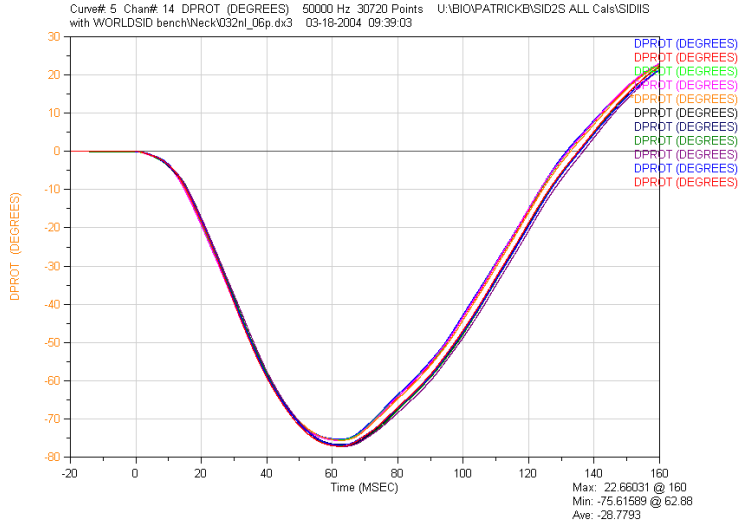

Figure F.4. D-Plane Rotation (deg)

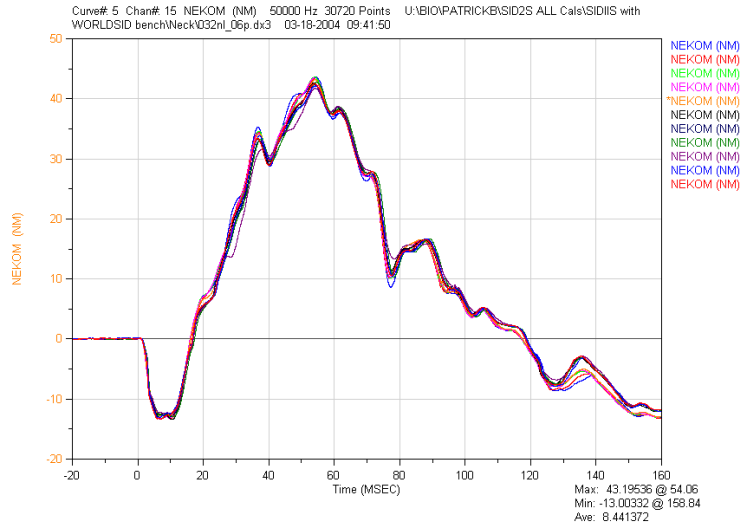

Figure F.5. Upper Neck Lateral Bending Moment about Occipital Condyle (N-m)

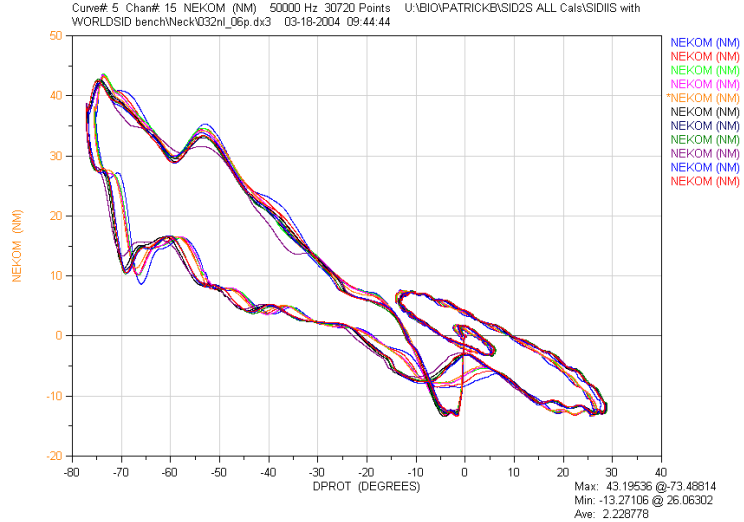

Figure F.6. O-C Moment (N-m) vs. D-Plane Rotation (deg)

Table F.3. Peak Responses and Statistical Analysis for Shoulder Certification Tests

Shoulder		Impact Velocity (m/s)	Probe Force (kN)	Shoulder Deflection (mm)
Test # / Statistical Parameter	Dummy	4.20 – 4.40		
032SH_07	32	4.29	2.24	27.1
032SH_08	32	4.32	2.30	28.8
032SH_09	32	4.33	2.29	28.8
032SH_10	32	4.31	2.25	28.9
032SH_11	32	4.32	2.25	27.2
056SH_12	56	4.31	2.21	28.2
056SH_13	56	4.31	2.21	26.7
056SH_14	56	4.31	2.25	27.1
056SH_15	56	4.29	2.26	26.9
Average	32	4.31	2.26	28.15
Standard Deviation		0.01	0.03	0.94
%CV		**0.34%**	**1.29%**	**3.33%**
Average	56	4.30	2.23	27.25
Standard Deviation		0.01	0.03	0.67
%CV		**0.16%**	**1.28%**	**2.45%**
Average	Both	4.31	2.25	27.75
Standard Deviation		0.01	0.03	0.91
%CV		**0.30%**	**1.42%**	**3.29%**

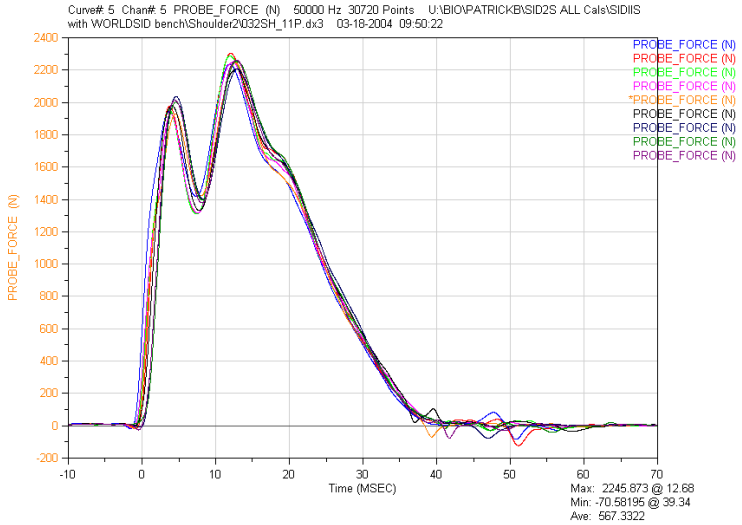

Figure F.7. Shoulder Probe Force (N)

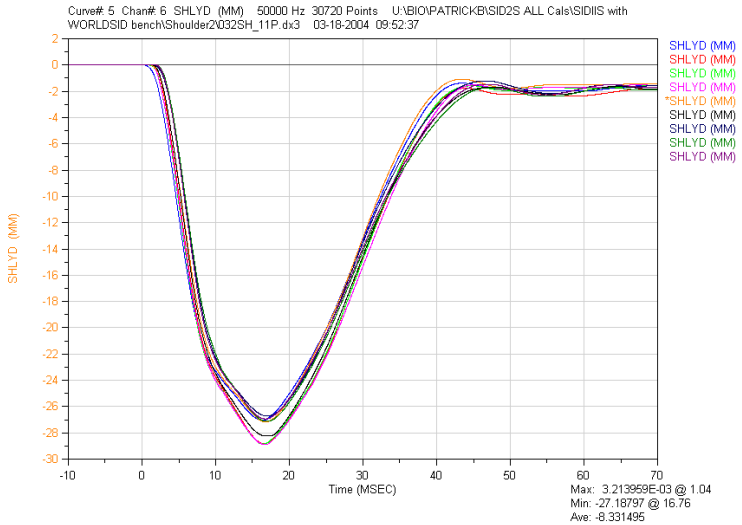

Figure F.8. Shoulder Rib Deflection (mm)

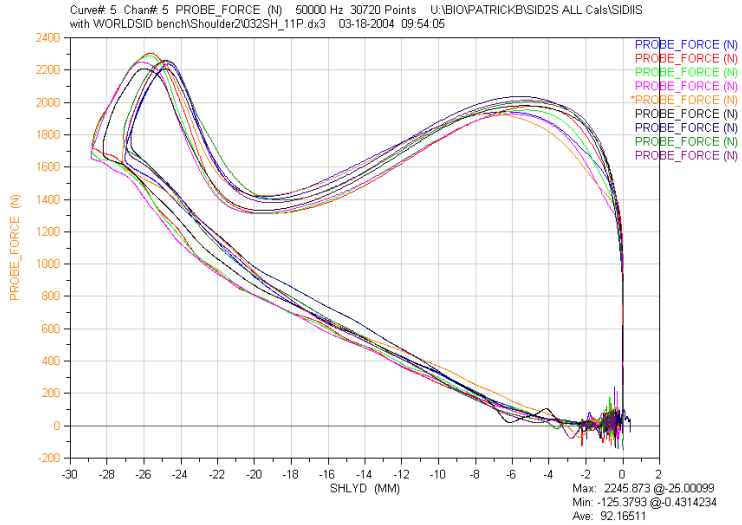

Figure F.9. Shoulder Probe Force (N) vs. Shoulder Rib Deflection (m

Table F.4. Peak Responses and Statistical Analysis for Thorax With Arm Certification Tests

Thorax Test With Arm		Impact Velocity (m/s)	Probe Force (kN)	Shoulder Deflection (mm)	Upper Rib Deflection (mm)	Middle Rib Deflection (mm)	Lower Rib Deflection (mm)	Upper Spine Acceleration (g)	Lower Spine Acceleration (g)
Test # / Statistical Parameter	**Dummy**	**6.60 – 6.80**							
032Thoraxwitharm32l_01P	32	6.72	4.37	30.5	24.1	30.2	33.2	41.6	39.2
032Thoraxwitharmnewshoulder32l_01P	32	6.72	4.27	30.7	24.7	30.5	33.0	42.1	39.3
032Thoraxwitharmnewshoulder32l_02P	32	6.72	4.23	29.9	24.5	30.2	32.9	41.5	38.7
032Thoraxwitharmnewshoulder32l_03P	32	6.72	4.23	30.4	24.9	30.6	33.4	41.2	38.4
032Thoraxwitharmnewshoulder32l_04P	32	6.72	4.24	30.7	25.1	30.6	33.5	41.8	39.1
056TWA_07	56	6.72	4.83	32.0	27.1	31.8	34.0	43.7	38.6
056TWA_08	56	6.72	4.83	32.8	27.4	31.0	32.7	44.4	38.7
056TWA_09	56	6.72	4.91	30.5	26.4	30.7	32.9	44.9	38.5
056TWA_10	56	6.72	4.98	31.5	26.5	30.7	32.7	45.6	38.7
Average		6.72	4.27	30.42	24.67	30.44	33.20	41.66	38.94
Standard Deviation	32	0.00	0.06	0.33	0.39	0.20	0.26	0.35	0.38
%CV		**0.00%**	**1.44%**	**1.09%**	**1.58%**	**0.67%**	**0.78%**	**0.84%**	**0.99%**
Average		6.72	4.89	31.70	26.88	31.05	33.06	44.64	38.63
Standard Deviation	56	0.00	0.07	0.93	0.47	0.49	0.63	0.79	0.11
%CV		**0.00%**	**1.45%**	**2.94%**	**1.75%**	**1.57%**	**1.92%**	**1.76%**	**0.28%**
Average		6.72	4.54	30.99	25.65	30.71	33.14	42.98	38.80
Standard Deviation	Both	0.00	0.33	0.92	1.23	0.46	0.44	1.66	0.32
%CV		**0.00%**	**7.29%**	**2.95%**	**4.79%**	**1.51%**	**1.32%**	**3.87%**	**0.84%**

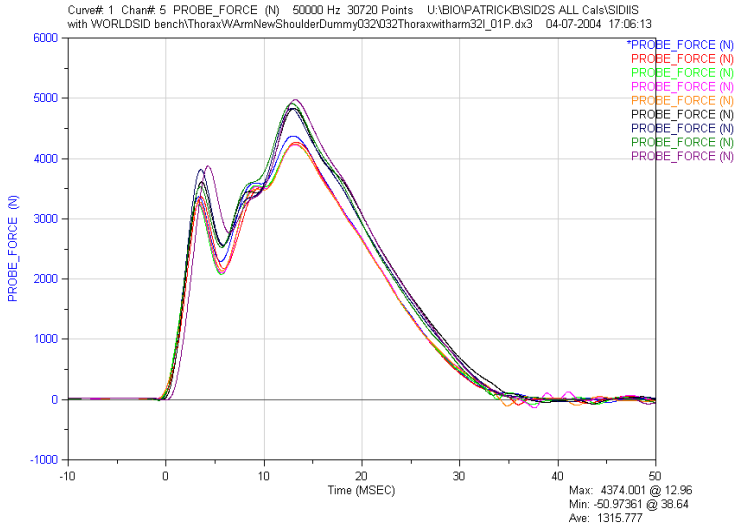

Figure F.10. Thorax Probe Force (N)

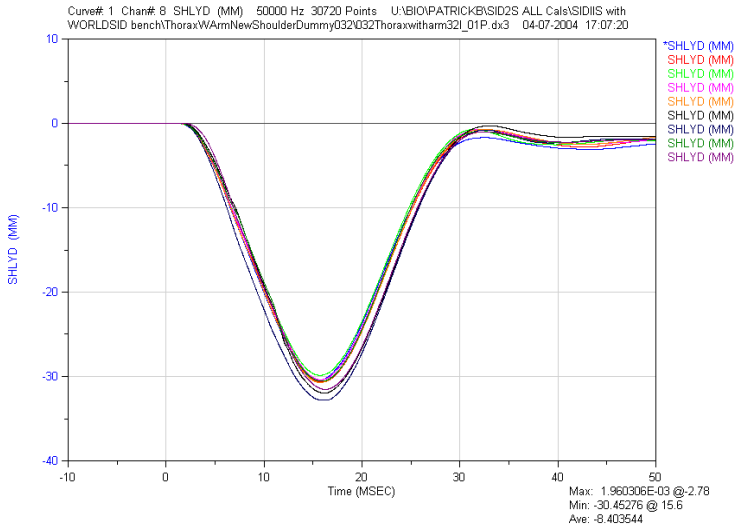

Figure F.11. Shoulder Rib Deflection (mm)

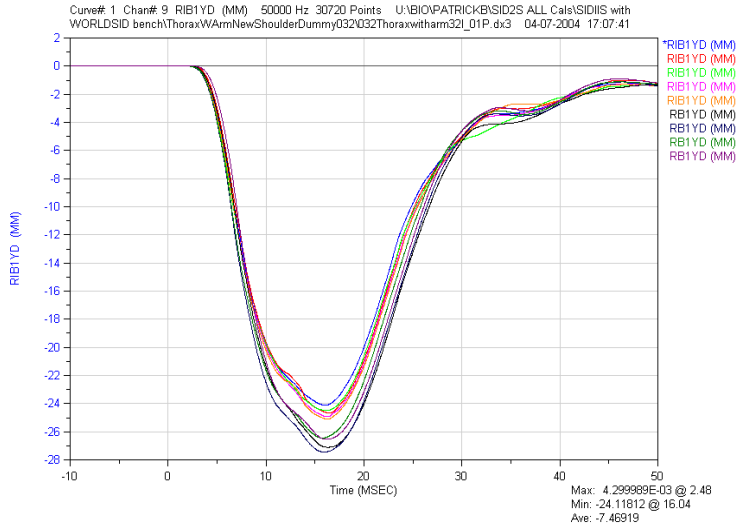

Figure F.12. Upper Thorax Rib Deflection (mm)

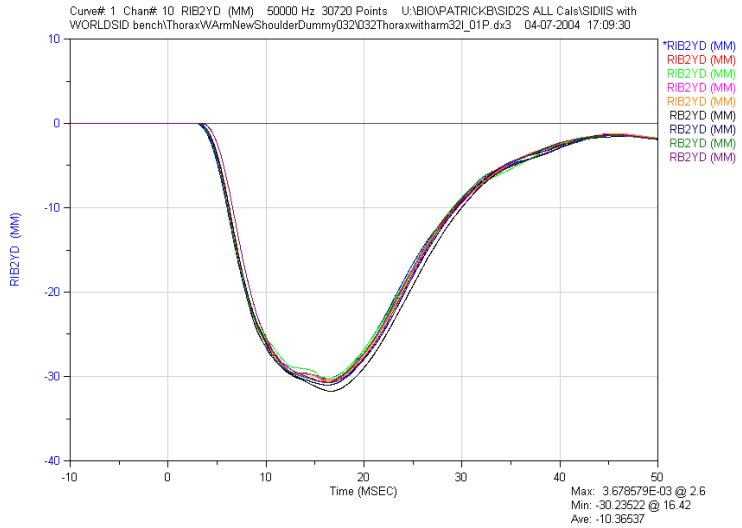

Figure F.13. Middle Thorax Rib Deflection (mm)

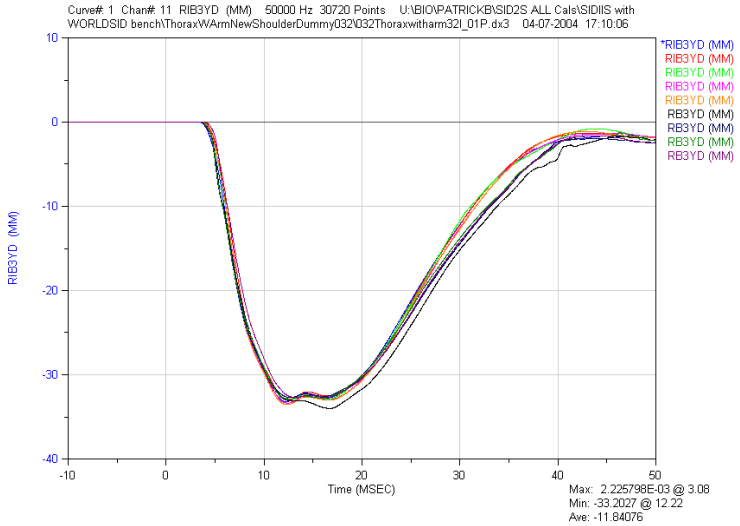

Figure F.14. Lower Thorax Rib Deflection (mm)

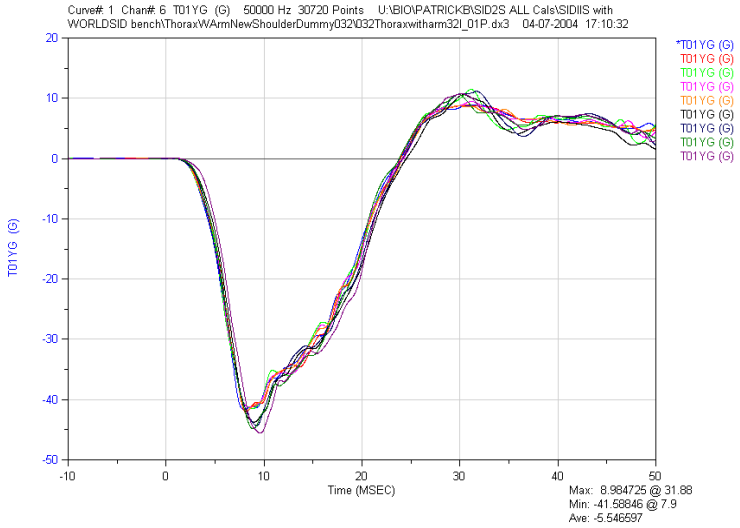

Figure F.15. Upper Spine (T1) Acceleration (g)

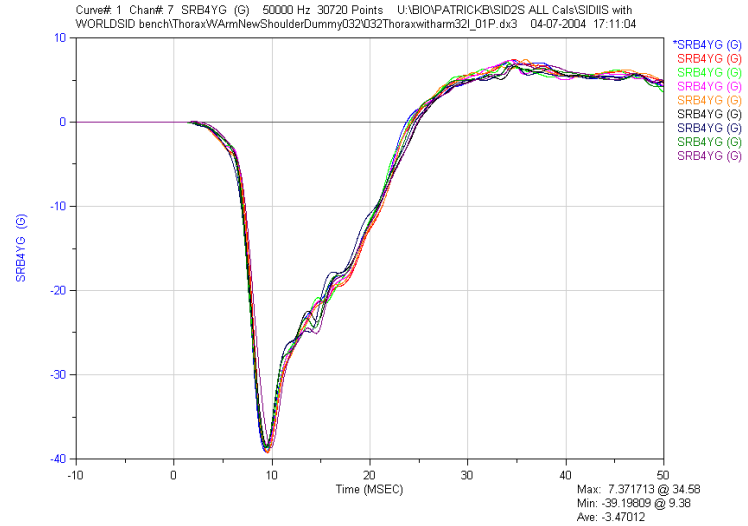

Figure F.16. Lower Spine (T12) Acceleration (g)

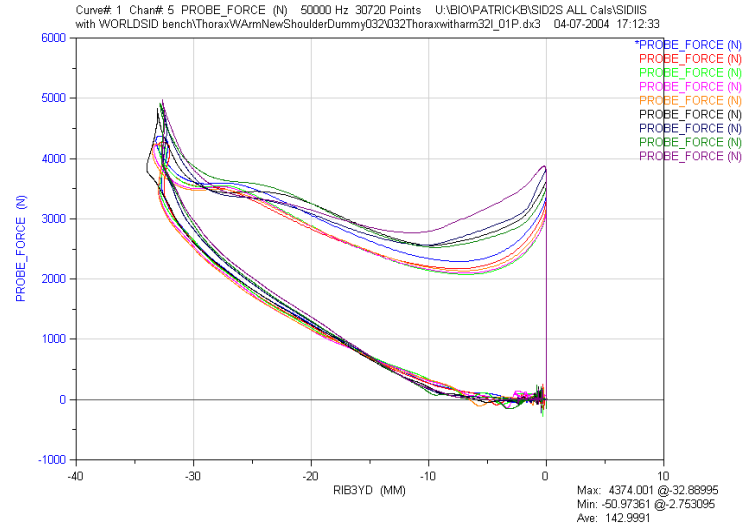

Figure F.17. Thorax Probe Force (N) vs. Lower Thorax Rib Deflection (mm)

Table F.5. Peak Responses and Statistical Analysis for Thorax Without Arm Certification Tests

Thorax Test Without Arm		Impact Velocity	Probe Force	Upper Rib Deflection	Middle Rib Deflection	Lower Rib Deflection	Upper Spine Acceleration	Lower Spine Acceleration
		(m/s)	(kN)	(mm)	(mm)	(mm)	(g)	(g)
Test # / Statistical Parameter	**Dummy**	**4.20 - 4.40**						
032TWOA_05	32	4.305	2.35	34.2	40.7	36.9	16.7	10.3
032TWOA_06	32	4.305	2.37	34.0	40.8	37.6	17.0	10.7
032TWOA_07	32	4.320	2.33	35.2	41.0	36.5	16.4	10.5
032TWOA_08	32	4.305	2.29	36.2	41.3	36.3	16.1	10.0
032TWOA_09	32	4.320	2.38	33.5	40.6	38.0	16.6	10.6
056THWOA_WorldSIDBench_01	56	4.291	2.36	37.2	40.2	36.7	15.6	10.0
056THWOA_WorldSIDBench_02	56	4.291	2.35	37.7	40.8	37.1	15.7	9.4
056THWOA_WorldSIDBench_03	56	4.305	2.32	38.3	41.1	37.1	15.7	9.2
056THWOA_WorldSIDBench_07	56	4.291	2.45	36.7	40.0	36.9	15.8	9.8
056THWOA_WorldSIDBench_08	56	4.305	2.32	37.8	41.4	38.4	15.5	9.2
Average		4.31	2.34	34.63	40.88	37.04	16.55	10.42
Standard Deviation	32	0.01	0.03	1.08	0.28	0.72	0.33	0.26
%CV		**0.19%**	**1.49%**	**3.11%**	**0.68%**	**1.94%**	**1.97%**	**2.49%**
Average		4.30	2.36	37.52	40.70	37.26	15.66	9.51
Standard Deviation	56	0.01	0.05	0.63	0.58	0.66	0.15	0.35
%CV		**0.18%**	**2.23%**	**1.68%**	**1.41%**	**1.77%**	**0.96%**	**3.70%**
Average		4.30	2.35	36.08	40.79	37.15	16.11	9.96
Standard Deviation	Both	0.01	0.04	1.74	0.44	0.66	0.53	0.56
%CV		**0.25%**	**1.84%**	**4.82%**	**1.07%**	**1.78%**	**3.29%**	**5.62%**

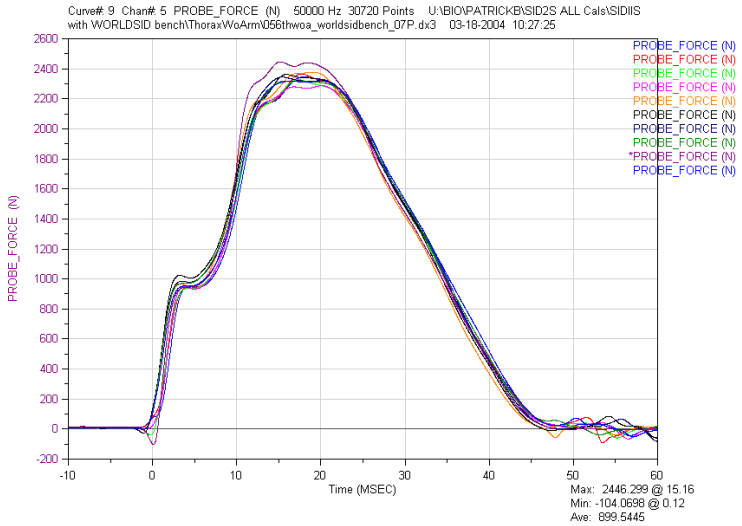

Figure F.18. Thorax Probe Force (N)

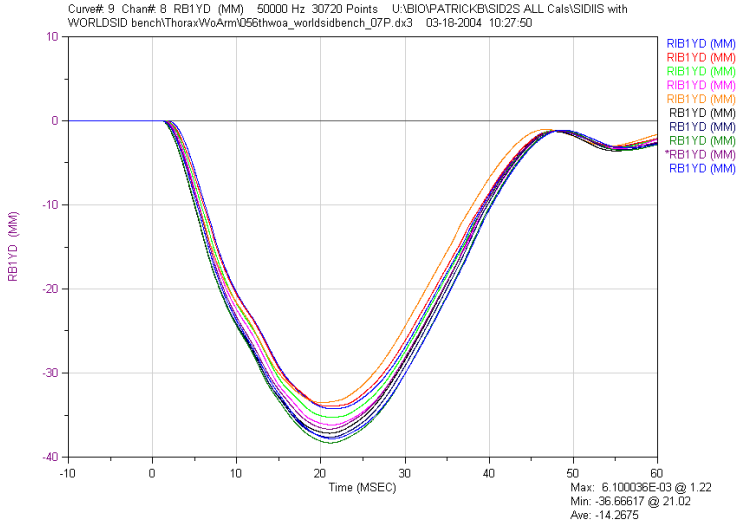

Figure F.19. Upper Thorax Rib Deflection (mm)

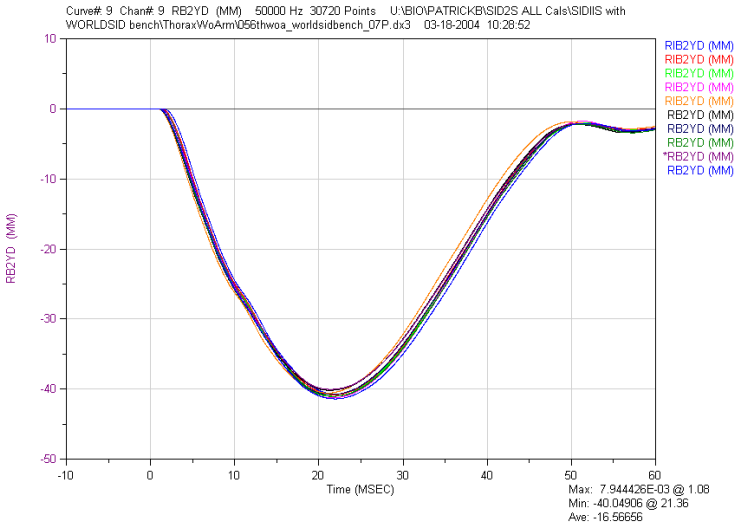

Figure F.20. Middle Thorax Rib Deflection (mm)

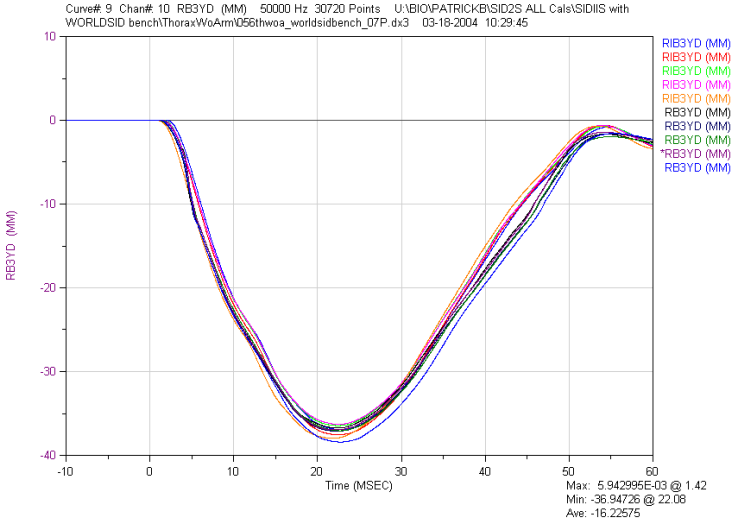

Figure F.21. Lower Thorax Rib Deflection (mm)

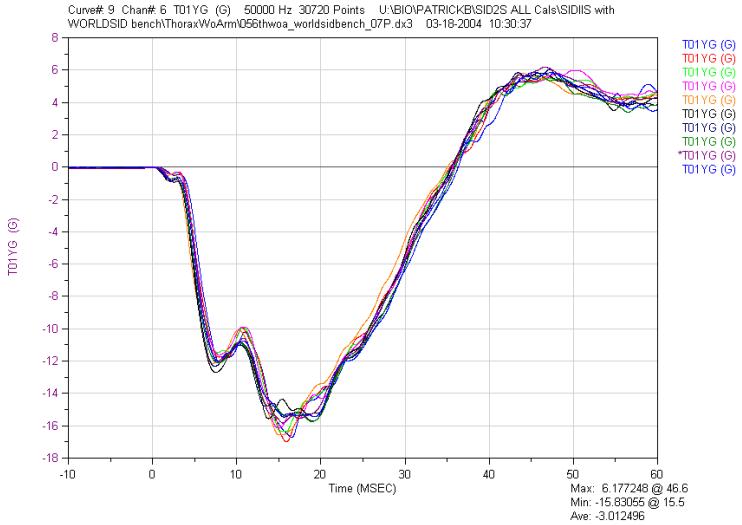

Figure F.22. Upper Spine (T1) Acceleration (g)

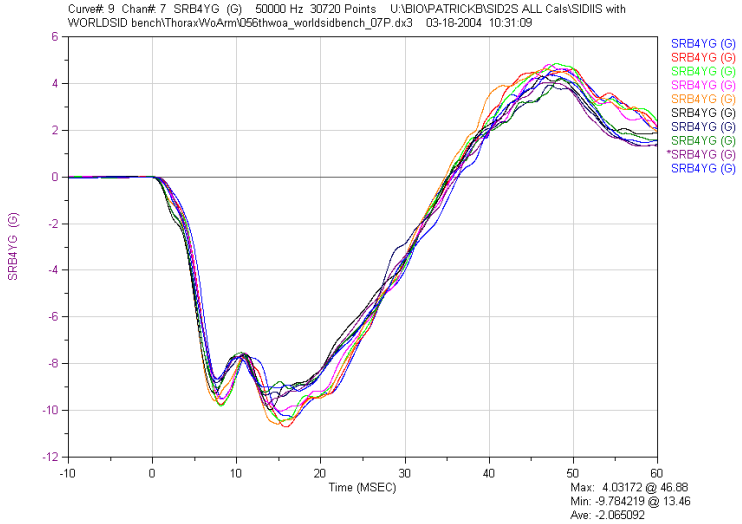

Figure F.23. Lower Spine (T12) Acceleration (g)

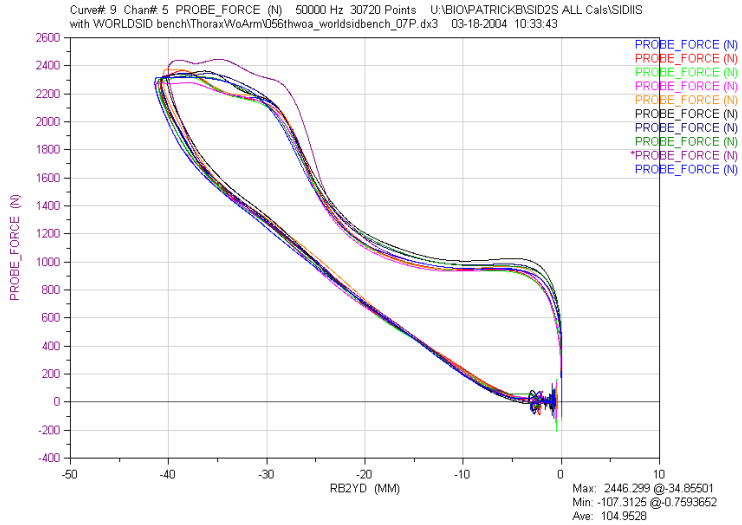

Figure F.24. Thorax Probe Force (N) vs. Middle Thorax Rib Deflection (mm)

Table F.6. Peak Responses and Statistical Analysis for Abdomen Certification Tests

Abdomen		Impact Velocity	Probe Force	Upper Rib Deflection	Lower Rib Deflection	Upper Spine Acceleration	Lower Spine Acceleration
		(m/s)	(kN)	(mm)	(mm)	(g)	(g)
Test # / Statistical Parameter	**Dummy**	**4.2 - 4.4**					
032AB_04	32	4.31	1.87	39.2	36.6	6.9	12.3
032AB_05	32	4.31	1.85	38.6	39.4	6.3	12.4
032AB_06	32	4.32	1.93	38.6	40.0	6.6	11.9
032AB_07	32	4.31	1.91	39.1	39.5	6.7	12.5
032AB_08	32	4.31	1.90	39.4	39.1	6.7	12.4
056AB_03	56	4.29	2.10	40.0	38.0	7.6	12.5
056AB_04	56	4.31	2.10	40.0	38.0	7.8	12.9
056AB_05	56	4.29	2.10	41.0	37.0	7.8	13.2
056AB_06	56	4.31	2.00	41.0	37.0	7.9	13.2
056AB_09	56	4.31	2.02	38.2	38.4	7.2	13.9
056AB_10	56	4.31	2.03	37.7	37.0	7.7	14.1
Average		4.31	1.89	39.01	38.95	6.64	12.29
Standard Deviation	32	0.01	0.03	0.37	1.33	0.22	0.24
%CV		**0.16%**	**1.73%**	**0.95%**	**3.42%**	**3.39%**	**1.95%**
Average		4.30	2.06	39.65	37.57	7.67	13.30
Standard Deviation	56	0.01	0.05	1.40	0.63	0.24	0.61
%CV		**0.17%**	**2.30%**	**3.53%**	**1.67%**	**3.07%**	**4.56%**
Average		4.30	1.98	39.36	38.20	7.20	12.84
Standard Deviation	Both	0.01	0.09	1.07	1.19	0.58	0.70
%CV		**0.18%**	**4.77%**	**2.72%**	**3.12%**	**8.04%**	**5.41%**

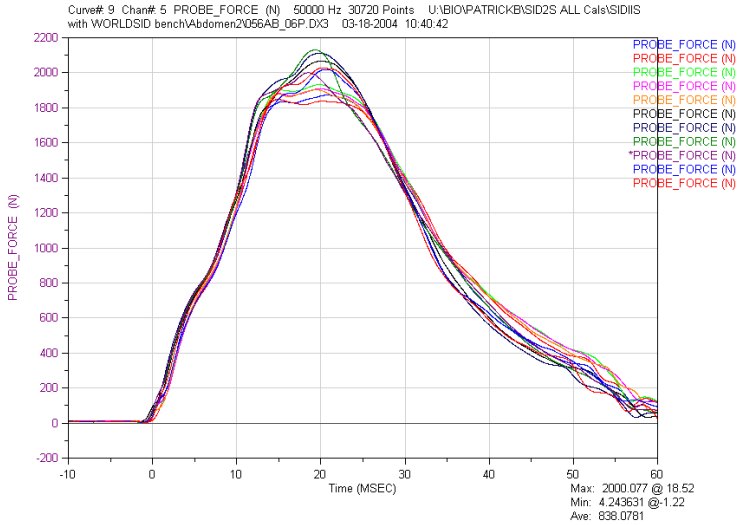

Figure F.25. Abdomen Probe Force (N)

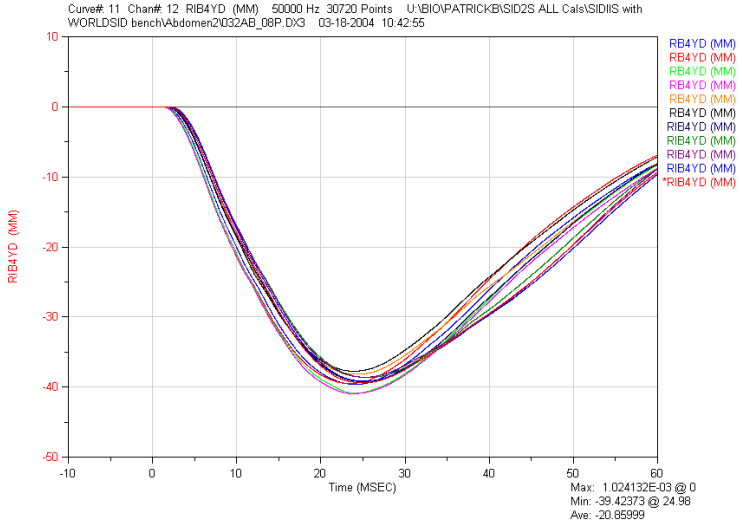

Figure F.26. Upper Abdomen Rib Deflection (mm)

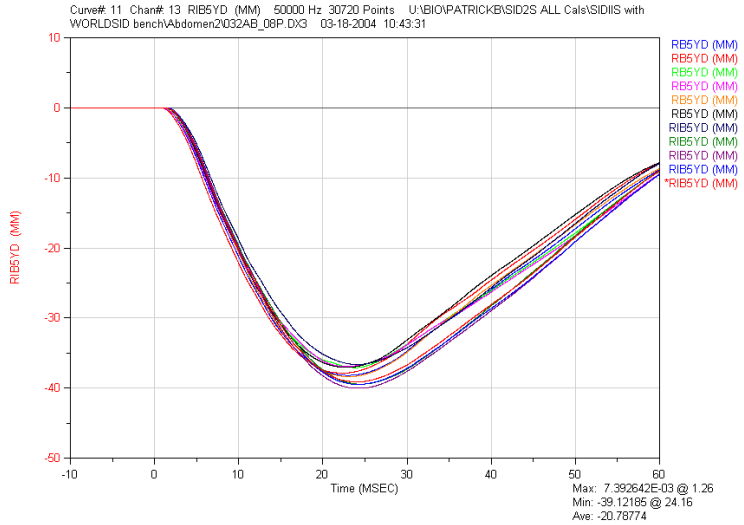

Figure F.27. Lower Abdomen Rib Deflection (mm)

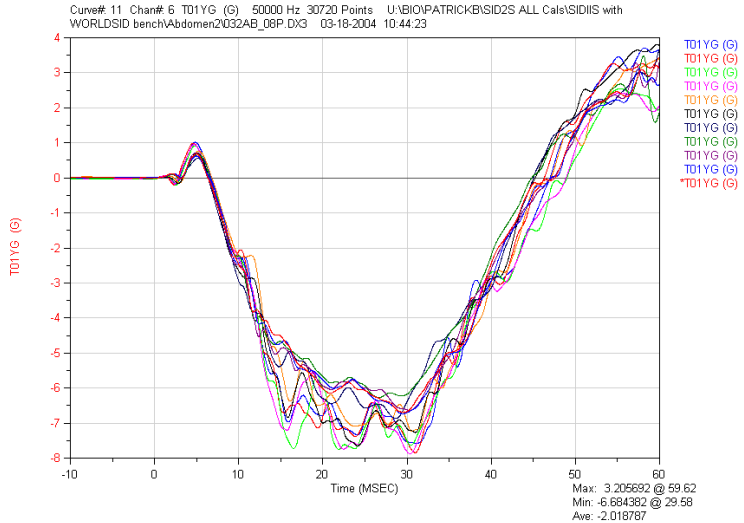

Figure F.28. Upper Spine (T1) Acceleration (g)

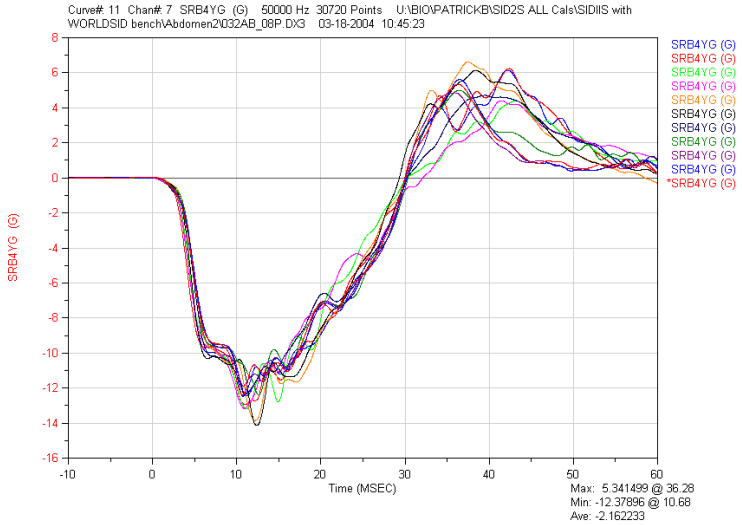

Figure F.29. Lower Spine (T12) Acceleration (g)

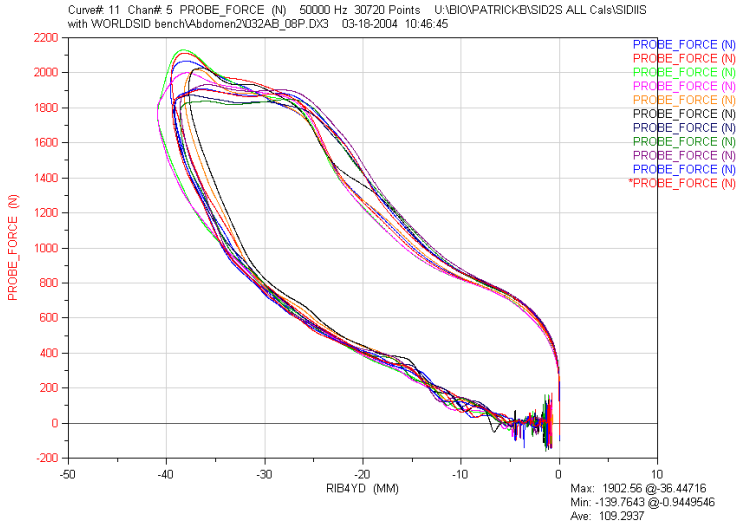

Figure F.30. Abdomen Probe Force (N) vs. Upper Abdomen Rib Deflection (mm)

Table F.7. Peak Responses and Statistical Analysis for Pelvis Certification Tests

Pelvis - new plug used every time		Impact Velocity (m/s)	Probe Force (kN)	Lateral Pelvis Acceleration (g)
Test # / Statistical Parameter	**Dummy**	**6.6 - 6.8**		
032PVL_08	32	6.76	5.90	53.7
032PVL_09	32	6.76	5.95	52.9
032PVL_10	32	6.76	5.89	51.9
032PVL_11	32	6.76	5.91	54.3
032PVL_12	32	6.76	5.97	58.6
056PLV_WorldSIDBench_03	56	6.72	6.26	47.9
056PLV_WorldSIDBench_04	56	6.76	6.29	46.0
056PLV_WorldSIDBench_06	56	6.76	6.26	47.6
056PLV_WorldSIDBench_07	56	6.76	6.26	44.7
056PLV_WorldSIDBench_08	56	6.72	6.28	45.6
Average	32	6.76	5.92	54.26
Standard Deviation		0.00	0.03	2.58
%CV		**0.00%**	**0.55%**	**4.75%**
Average	56	6.74	6.27	46.38
Standard Deviation		0.02	0.01	1.36
%CV		**0.28%**	**0.20%**	**2.93%**
Average	Both	6.75	6.10	50.32
Standard Deviation		0.02	0.18	4.58
%CV		**0.24%**	**3.00%**	**9.10%**

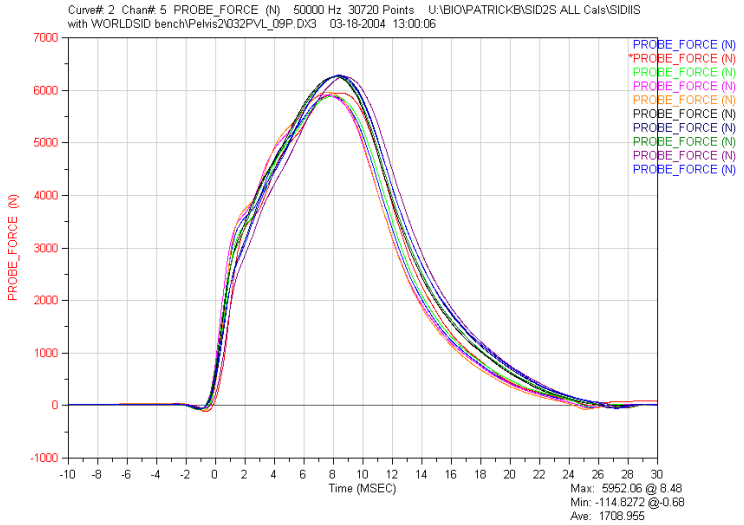

Figure F.31. Pelvis Probe Force (N)

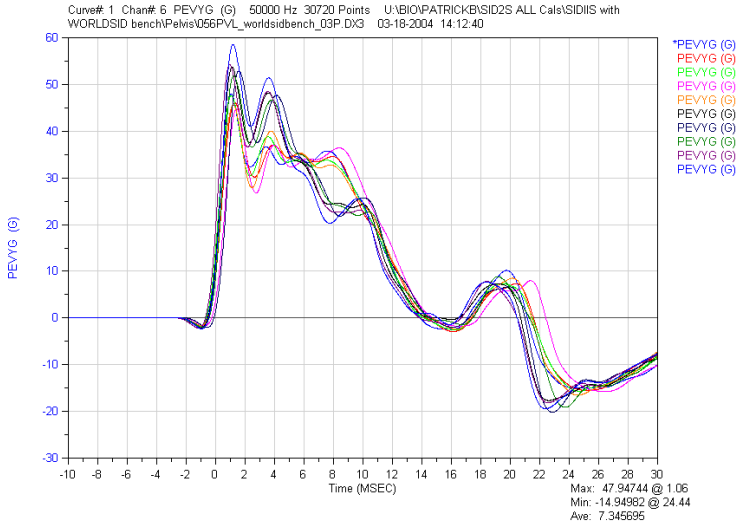

Figure F.32. Pelvis Lateral Acceleration (g)

Appendix G. Attachment of Thoracic and Abdominal Pads in the SID-IIs FRG

Attachment of Thoracic and Abdominal Pads in the SID2s

Use approximately 185mm (7.31”) long, 4.67mm (0.184”) wide, 1.33mm thick cable ties to attach the pads to the ribs. The cable ties should be used at each rib on both the left and right edges of the pad. Route the cable ties through the holes punched into the pad and around the rib making certain that the cable tie locking apparatus is at the back side of the rib. Be sure not to wrap over rib damping material or over the larger flared out portion of the ribs near the red urethane. Tighten the cable tie so that pad is pulled against the rib and the pad becomes compressed by the cable tie. Once the cable tie is tightened, the cable “tail” (excess which was pulled through the locking mechanism) should be approximately 125mm long. About 55 mm of the tie will be utilized on the loop around the ribs (*Note: about 5 mm of the tie remains inside the locking mechanism*). An indication of the proper “tightness” can be identified in Figure G.1. After tightening the cable tie the proper amount, cut off the excess “tail” so that no further tightening will occur and any interference will be prevented.

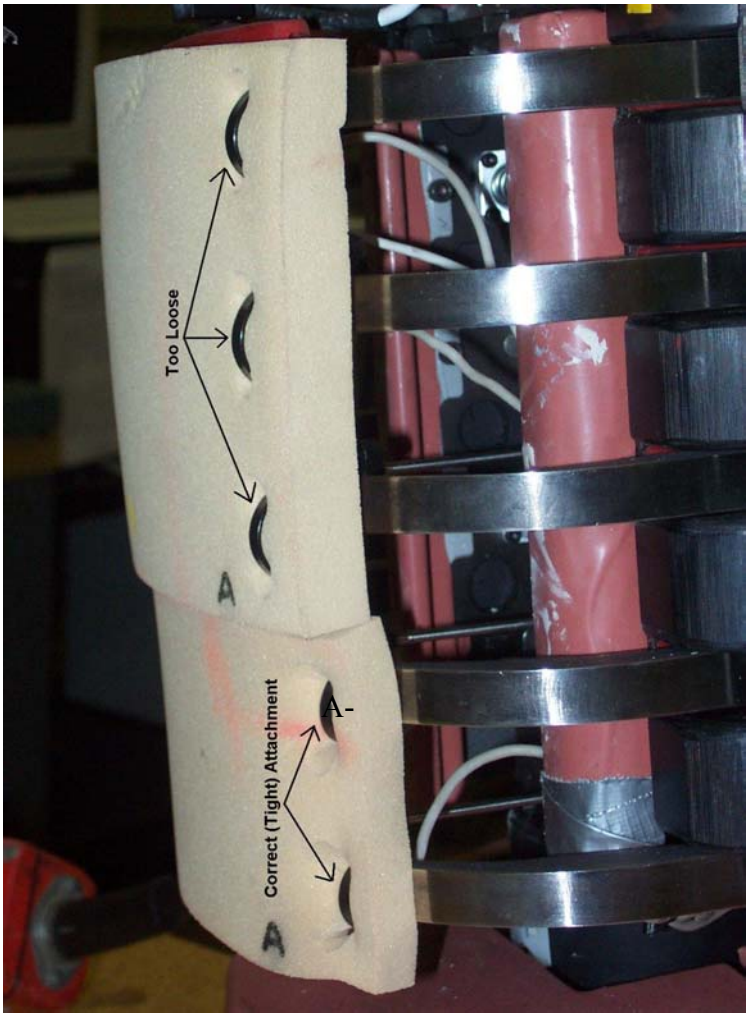

Figure G.1. Cable tie attachment to hold the rib pads for the SID-IIs FRG.