WorldSID 50th Percentile Male (WorldSID-50M) Qualification Procedures and Requirements

January 2024

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1 QUALIFICATION TEST MATRIX

The complete WorldSID-50M qualification test matrix, with test descriptions, is shown in Table 1-1. The order of operations is shown in Table 1-2. First, the sub-assembly component (head assembly and neck assembly) qualification tests are performed. These tests can be performed in parallel. After the component tests are completed, the dummy is assembled, and the full-body qualification tests are performed. The full-body tests do not need to be performed in the order shown in Table 1-2. Any order is acceptable.

Table 1-1. Qualification Test Matrix

Body Region	Test	Test Description
Head	Frontal Drop	376 mm drop onto the forehead using a 49 CFR Part 572.32 head drop fixture
	Left Lateral Drop	200 mm drop onto the left side of the head using a 49 CFR Part 572.32 head drop fixture
	Right Lateral Drop	200 mm drop onto the right side of the head using a 49 CFR Part 572.32 head drop fixture
Neck	Left Lateral Flexion	3.40 m/s left side impact of the neck/headform assembly using a 49 CFR Part 572.33 neck pendulum
	Right Lateral Flexion	3.40 m/s right side impact of the neck/headform assembly using a 49 CFR Part 572.33 neck pendulum
	Left Torsion	5.2 m/s left side impact of the neck/torsion fixture assembly using a 49 CFR Part 572.33 neck pendulum
	Right Torsion	5.2 m/s right side impact of the neck/torsion fixture assembly using a 49 CFR Part 572.33 neck pendulum
Thorax	Shoulder Impact	4.3 m/s impact to the shoulder using a 49 CFR Part 572.36(a) 23.36 kg (51.50 lb.) pendulum impactor
	Thorax With Arm Impact	6.7 m/s impact to the thorax with arm using a 49 CFR Part 572.36(a) 23.36 kg (51.50 lb.) pendulum impactor
	Thorax Without Arm Impact	4.3 m/s impact to the thorax without arm using a 49 CFR Part 572.36(a) 23.36 kg (51.50 lb.) pendulum impactor with modified face
Abdomen	Abdomen Impact	4.3 m/s impact to the abdomen using a 49 CFR Part 572.36(a) 23.36 kg (51.50 lb.) pendulum impactor with armrest simulator
Pelvis	Pelvis Impact	6.7 m/s impact to the pelvis using a 49 CFR Part 572.36(a) 23.36 kg (51.50 lb.) pendulum impactor

Table 1-2. Order of Operations for Qualification Procedures

1 Component Tests	Head	Head Lateral Head Drop	Left
			Right
		Head Frontal Head Drop	
	Neck	Neck Lateral Flexion	Left
			Right
		Neck Torsion	Left
			Right
2 Full-Body Tests		Shoulder	Left or Right Based on Dummy Configuration
		Thorax With Arm	
		Thorax Without Arm	
		Abdomen	
		Pelvis	

2 NORMATIVE DOCUMENTS

(a) SAE International, 400 Commonwealth Drive, Warrendale, PA, 15096.

1) SAE Recommended Practice J211-1, Instrumentation for impact test – Part 1: Electronic Instrumentation, August 2022.

2) SAE Information Report J1733, Sign Convention for Vehicle Crash Testing, November 2018.

3) SAE Information Report J2570, Performance Specifications for Anthropomorphic Test Device Transducers, November 2019.

(b) International Organization for Standardization, ISO-MME task force, part of ISO TC12/SC22/WG3, https://www.iso-mme.org.

1) ISO/TS 13499 – RED B:2020 E, 2020-06-17.

2) ISO-MME Task Force Discussion Forum, Dummy Certification, Proposed Codes for Lab Equipment, 2022-02-28.

(c) 49 CFR Part 572

1) §572.32, Subpart E, Hybrid III Test Dummy, Head.

2) §572.33, Subpart E, Hybrid III Test Dummy, Neck.

3) §572.36, Subpart E, Hybrid III Test Dummy, Test conditions and instrumentation.

(d) www.Regulations.gov

1) WorldSID-50M Drawing Package, Document ID NHTSA-20##-####-####.

2) WorldSID-50M Procedures for Assembly, Disassembly, and Inspection (PADI), Document ID NHTSA-20##-####-####.

(e) https://one.nhtsa.gov/Research/Databases-and-Software/NHTSA-Test-Reference-Guides

1) Version 5 Test Reference Guide, Volume II: Biomechanical Tests (Revision) November 2014.

3 GENERAL DATA COLLECTION GUIDELINES

3.1 Sign Conventions

The sign conventions of signals conform to SAE J1733 (Section 2, (a)2) and are defined in the WorldSID-50M PADI (Section 2, (d)2).

3.2 Signal Naming Conventions

In data processing steps prescribed herein, standard signal names are used to identify signals. Standard codes are also used to identify signal characteristics, such as axes and polarities. The signal naming convention for the WorldSID-50M follows ISO-MME (Section 2, (b)1). The signal naming convention for the lab equipment follows ISO-MME (Section 2, (b)2). The characteristic codes are identified in NHTSA's Test Reference Guide (Section 2, (e)1). Names and codes are applied herein only to provide clarity. Any signal naming and coding convention may be used.

3.3 Required Recorded Channels

Throughout these procedures, the *Required Recorded Channels* tables show the channels that are required to be recorded by the data acquisition system when performing the qualification tests. All data must be recorded in accordance with SAE J211-1 (Section 2, (b)1). Except for the RibEye data channels, all required recorded data channels are shown with an ISO-MME filter code “P”, indicating that the data is pre-filtered by the data acquisition anti-aliasing filter at a frequency higher than SAE J211 Channel Frequency Class (CFC) 1000. It is acceptable for the recorded data to be pre-filtered by the data acquisition system at CFC1000. In this case, the ISO-MME filter code of the recorded data should be changed to an “A” and no post-test filtering is required to obtain CFC1000 data. The RibEye recorded data channels are not prefiltered prior to recording, so they are shown with an ISO-MME filter code “0”.

3.4 Required Measurements

Throughout these procedures, the *Required Measurements* tables show the measurements that are used in the qualification specifications. Measurements denoted as AM (As Measured) in the DASTAT column are used in the qualification specifications and/or are used to calculate qualification specifications. A qualification specification that is calculated from other measurements is denoted as CM (Calculated Measure) in the DASTAT column.

4 ATD ADJUSTMENT

For the full-body qualification tests, the neck angle should be set to 0 degrees and the joint torques should be set to 1 g as described in the WorldSID-50M PADI (Section 2, (d)2).

5 HEAD QUALIFICATION

5.1 Description

The head qualification test is a dynamic test performed to examine the acceleration-time characteristics of the head when dropped onto a rigid impact surface in three orientations, right-side lateral, left-side lateral and frontal. The lateral response is tested by dropping the head onto both the left and right sides from 200 mm. The frontal response is tested by dropping the head from 376 mm onto the forehead. The x, y and z-axis acceleration-time responses are recorded at the head CG and the resultant acceleration is calculated.

5.2 Materials

- WorldSID-50M head assembly as shown in drawing W50-10000. The instrumented head core assembly is shown in Figure 5-1 and the complete head assembly is shown in Figure 5-2. The complete head assembly includes the upper neck load cell, a linear tri-axial accelerometer, three angular rate sensors and a tilt sensor. Except for the required tri-axial accelerometer, it is recommended that the other sensors be substituted with structural or mass replacements to minimize the possibility of sensor cabling affecting the head drop test.
- Head impact test fixture as described in 49 CFR Part 572.32.

Figure 5-1. Head core and upper neck load cell structural replacement.

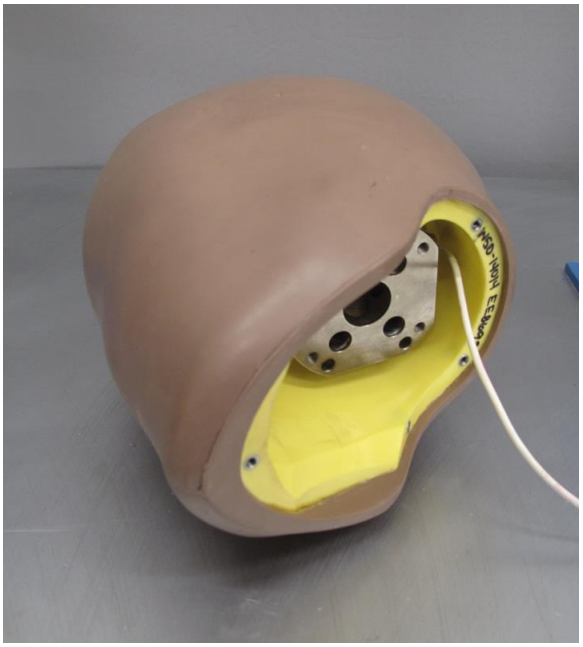

Figure 5-2. Complete head assembly.

5.3 Instrumentation

- Linear tri-axial accelerometer (SA572-S48) at the head CG.

5.4 Pre-Test Procedure

5.4.1 Remove the molded head and head core assembly from the ATD (see WorldSID-50M PADI). It is acceptable to remove only the molded head and test the molded head with a different head core assembly with its own tri-axial accelerometer and mass replacements for the other sensors. This simplifies the head qualification by making it unnecessary to unplug the ATD's head sensors from the onboard data acquisition system.

5.4.2 Soak the head in a controlled environment with a temperature of 20.6 to 22.2 °C and a relative humidity (RH) of 10 to 70% for at least 4 hours prior to a test. The test environment should have the same temperature and humidity requirements as the soak environment.

5.4.3 Clean the head skin surface and the surface of the impact plate with isopropyl alcohol, or equivalent.

5.5 Test Procedure

5.5.1 Lateral

The lateral head drop tests are performed on both the right side and the left side of the head. The photographs in the test procedure show the head positioned for a right-side lateral test. Other than repositioning the head so that the left side of the head contacts the impact surface, the left-side lateral test procedure is the same as shown for the right-side lateral test.

5.5.1.1 Suspend the head above the horizontal impact surface so that the head midsagittal plane (x-z plane) is at an angle of 35° ± 1° to the impact surface (Figure 5-3) and the anterior-posterior axis (x axis) is within 1° of horizontal. The angles can be measured using an inclinometer on the base of the load cell structural replacement, as shown in Figure 5-4 and Figure 5-5.

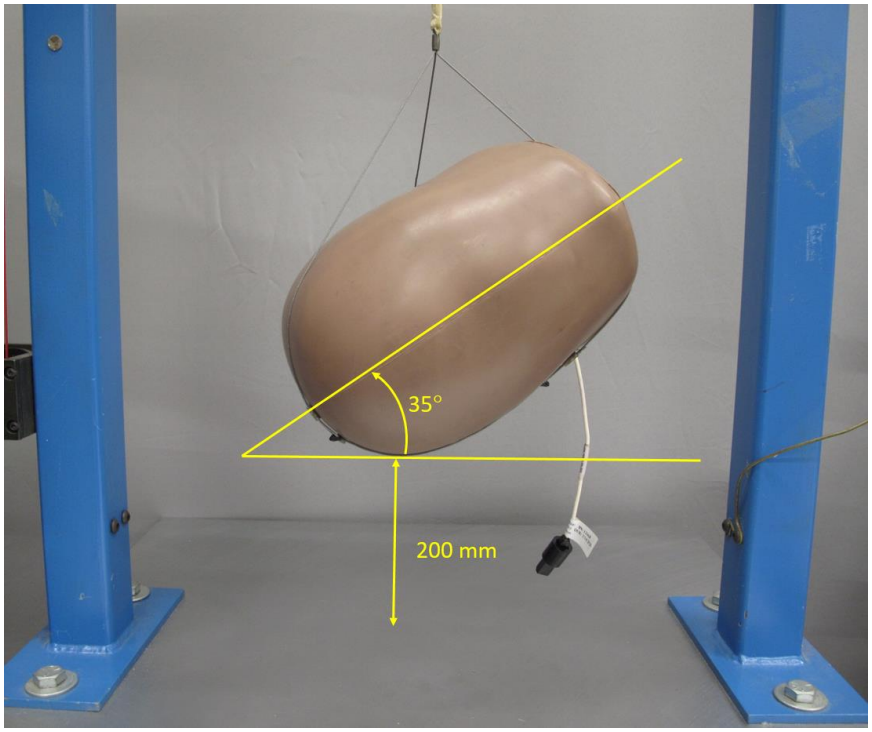

Figure 5-3. Head assembly positioned at 35° ± 1° for a right lateral head drop.

Figure 5-4. Midsagittal (x-z) plane angle measured at the base of the load cell structural replacement.

Figure 5-5. Anterior-posterior axis (x-axis) measured at the base of the load cell structural replacement.

5.5.1.2 Raise the head so that its lowest point is 200 mm ± 0.25 mm above the impact surface (Figure 5-3).

5.5.1.3 Verify that the test setup parameters are within the specification shown in Table 5-1.

5.5.1.4 Arrange the instrumentation cables to ensure that they will not influence the motion of the head while it is falling. Make sure that the head suspension sling is not in the impact region of the head.

5.5.1.5 Ensure that at least two hours have elapsed between previous impacts on the same head location.

5.5.1.6 Record the required channels listed in Table 5-2 in accordance with SAE J211-1.

5.5.1.7 Using a quick release mechanism, drop the head onto the impact surface.

Table 5-1. Left and Right Lateral Head Qualification Test Setup Parameters

Parameter	Requirement
Head midsagittal plane (x-z plane)	35° ± 1°
Head interior-posterior axis (x-axis)	Horizontal ± 1°
Drop height	200 mm ± 0.25 mm
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Wait time between tests	2 hours minimum

Table 5-2. Required Recorded Channels for the Lateral Head Qualification Test

Channel Description	ISO MME Code
Head Acceleration X	D0HEAD0000WSACXP
Head Acceleration Y	D0HEAD0000WSACYP
Head Acceleration Z	D0HEAD0000WSACZP

5.5.2 Frontal

5.5.2.1 Suspend the head above the horizontal impact surface so that the head coronal plane (y-z plane) is at an angle of 35° ± 1° to the impact surface (Figure 5-6) and the lateral axis (y axis) is within 1° of horizontal. The angles can be measured using an inclinometer on the base of the load cell structural replacement, as shown in Figure 5-7 and Figure 5-8.

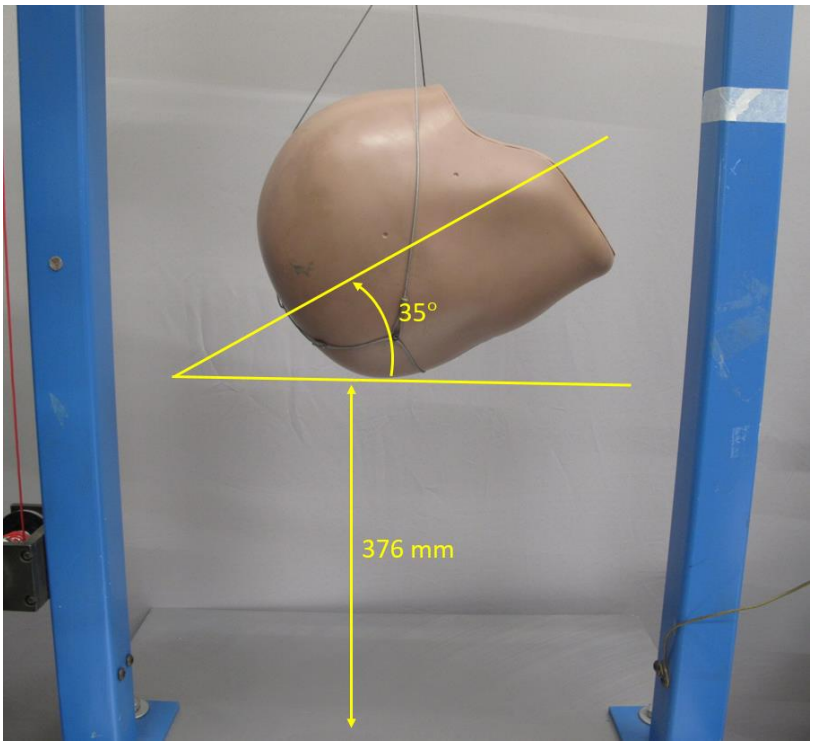

Figure 5-6. Head assembly positioned at 35° ± 1° for a frontal head drop.

Figure 5-7. Coronal (y-z) plane angle measured at the base of the load cell structural replacement.

Figure 5-8. Lateral axis (y-axis) measured at the base of the load cell structural replacement.

5.5.2.2 Raise the head so that its lowest point is 376 mm ± 0.25 mm above the impact surface (Figure 5-6).

5.5.2.3 Verify that the test setup parameters are within the specification shown in Table 5-3.

5.5.2.4 Arrange the instrumentation cables to ensure that they will not influence the motion of the head while it is falling. Make sure that the head suspension sling is not in the impact region of the head.

5.5.2.5 Ensure that at least two hours have elapsed between previous impacts on the same head location.

5.5.2.6 Record the required channels listed in Table 5-4 in accordance with SAE J211-1.

5.5.2.7 Using a quick release mechanism, drop the head onto the impact surface.

Table 5-3. Frontal Head Qualification Test Setup Parameters

Parameter	Setting
Head coronal plane (y-z plane)	35° ± 1°
Head left-right axis (y axis)	Horizontal ± 1°
Drop height	376 mm ± 0.25 mm
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Wait time between tests	2 hours minimum

Table 5-4. Required Recorded Channels for the Frontal Head Qualification Test

Channel Description	ISO MME Code
Head Acceleration X	D0HEAD0000WSACXP
Head Acceleration Y	D0HEAD0000WSACYP
Head Acceleration Z	D0HEAD0000WSACZP

5.6 Data Processing

5.6.1 Set T0 (Time Zero) to the time when the head contacts the impact surface. First contact can be determined by the initial rise in channel D0HEAD0000WSACZP.

5.6.2 Perform bias removal of the recorded channels listed in Table 5-4 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0.

5.6.3 Filter channels based on the channel filter classes (CFC) listed in Table 5-5.

5.6.4 Calculate Head Resultant Acceleration.

$$HDCG_R(t) = \sqrt{HDCG_X^2 + HDCG_Y^2 + HDCG_Z^2}$$

Where: $HDCG_R(t)$ = *D0HEAD0000WSACRA*
$HDCG_X$ = *D0HEAD0000WSACXA*
$HDCG_Y$ = *D0HEAD0000WSACYA*
$HDCG_Z$ = *D0HEAD0000WSACZA*

5.6.5 Perform calculation to verify that the head CG resultant acceleration time-history is unimodal (any peak).

$$\left(\frac{HDCG_R\,(t)\ 2nd\ highest\ peak\ value}{HDCG_R\,(t)\ peak\ value}\right) \times 100$$

Where: $HDCG_R(t)$ = *D0HEAD0000WSACRA*

Table 5-5. Required Measurements for the Head Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Head Acceleration X	1000	D0HEAD0000WSACXA	XL	AM	HDCG	AC	G′S
Head Acceleration Y	1000	D0HEAD0000WSACYA	YL	AM	HDCG	AC	G′S
Head Acceleration Z	1000	D0HEAD0000WSACZA	ZL	AM	HDCG	AC	G′S
Head Resultant Acceleration	N/A	D0HEAD0000WSACRA	RS	CM	HDCG	PP	G′S

5.7 Performance Specifications

Table 5-6. Left and Right Lateral Head Drop Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Temperature	°C	20.6	22.2
Relative humidity	%	10.0	70.0
Peak resultant acceleration	g	107	126
Peak acceleration, x-axis	g	-15	+15
Unimodal (resultant acceleration time-history)	%	<10	

Table 5-7. Frontal Head Drop Response Requirements

Parameter	**Units**	**Specification**	
		Min.	**Max.**
Temperature	°C	20.6	22.2
Relative humidity	%	10.0	70.0
Peak resultant acceleration	g	211	261
Peak acceleration, y-axis	g	-15	+15
Unimodal (resultant acceleration time-history)	%	<10	

6 NECK LATERAL FLEXION QUALIFICATION

6.1 Description

The left and right lateral neck flexion qualification tests for the WorldSID-50M are performed to examine the dynamic response characteristics of the neck assembly in lateral flexion. The base of the neck is rigidly attached to the bottom of the head-neck pendulum, and the top of the neck is attached to a WorldSID headform. The pendulum arm is dropped from a height to achieve the specified velocity and then the motion of the pendulum arm is decelerated with aluminum honeycomb to achieve the specified pulse. The simulated head rotation directions for the right and left neck flexion tests are shown in Figure 6-1.

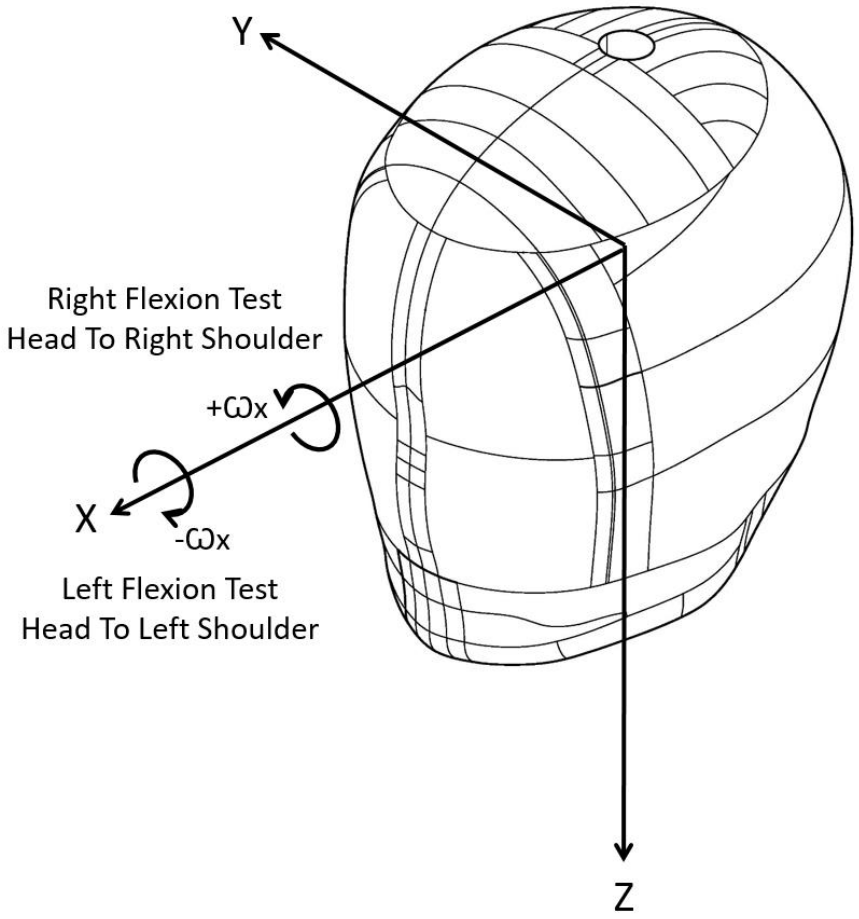

Figure 6-1. Simulated head rotation directions for right and left flexion tests.

6.2 Materials

- WorldSID-50M neck assembly (drawing W50-21001).
- Neck pendulum as described in 49 CFR Part 572, Subpart E.
- 76.2 mm deep aluminum honeycomb (28.8 kg/m^3 recommended)
- WorldSID-50M headform fixture (drawing W50-83000).

6.3 Instrumentation

- WorldSID-50M 6-axis upper neck load cell (SA572-S146).
- Angular rate sensor for headform x axis rotation rate (SA572-S58).
- Instrumentation to measure the impact velocity.
- Pendulum accelerometer.
- Three rotational potentiometers (forward, rearward, and headform).

6.4 Pre-Test Procedure

6.4.1 Remove the neck assembly (P/N W50-21001) from the ATD (see WorldSID-50M PADI for removal procedure). Since the neck assembly is symmetrical front-to-rear and top-to-bottom, it can be installed on the dummy and tested in multiple orientations (front-to-rear rotation or top-to-bottom rotation). Make sure that the neck is labeled to identify the intended top, bottom, front and rear so that it will be qualified and assembled on the dummy using the same orientation.

6.4.2 Using the neck compression tool, remove the half-spherical screws from interface plates at each end of the neck assembly (Figure 6-2). Verify that the half-spherical screws are lubricated with an anti-seize lubricant. Reinstall the half-spherical screws and tighten them to 10 Nm using the neck compression tool.

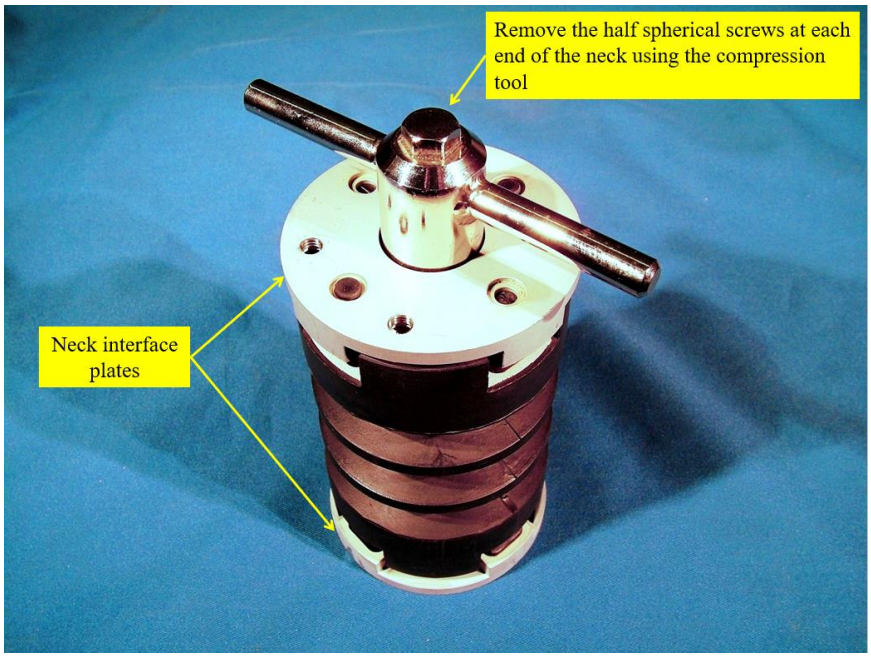

Figure 6-2. Removing the half-spherical screws.

6.4.3 Soak the neck assembly in a controlled environment with a temperature of 20.6 to 22.2 °C and a relative humidity of 10 to 70% for at least 4 hours prior to a test. The test environment should have the same temperature and humidity requirements as the soak environment.

6.4.4 Install the neck assembly (W50-21001) to the WorldSID-50M headform assembly (W50-83000) as shown in Figure 6-3 and instructed in the following steps.

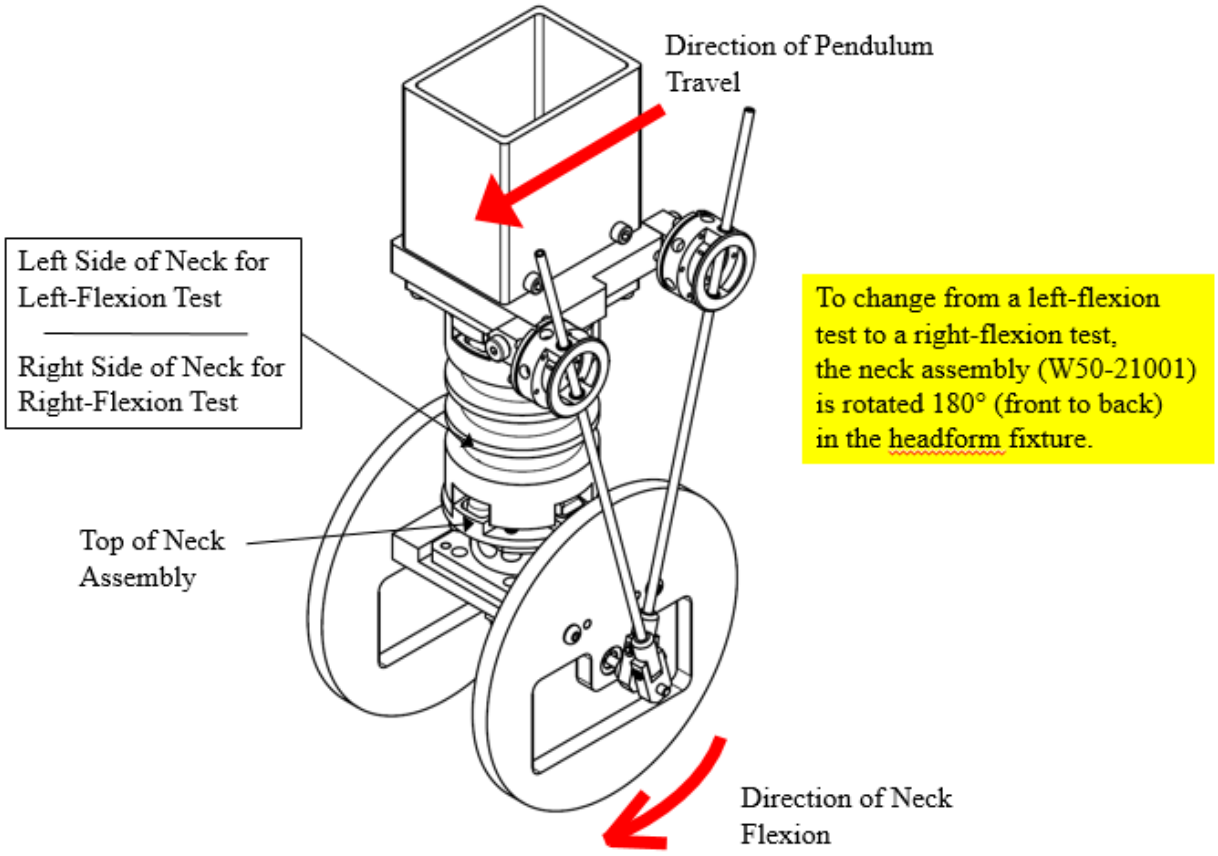

Figure 6-3. WorldSID-50M neck (W50-21001) installed in headform (W50-83000) fixture.

1. Fasten the upper neck interface plate (W50-83104) to the upper neck load cell using four M6 x 12 SHCS, as shown in Figure 6-4.

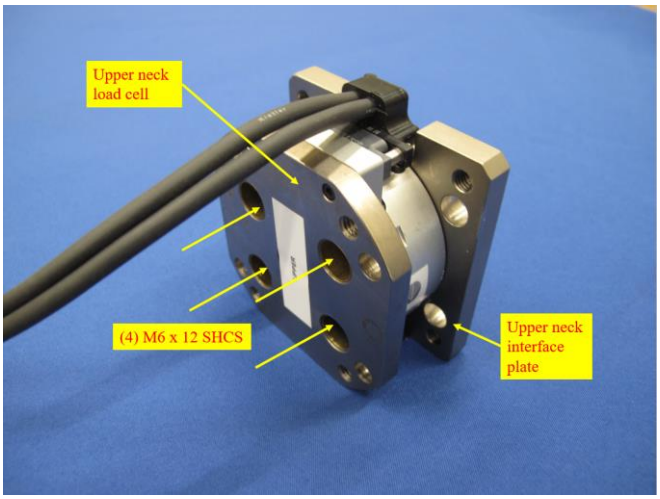

Figure 6-4. Attaching the upper neck interface plate to the upper neck load cell.

Caution: In steps 2 & 3 (Figure 6-5 & Figure 6-6), fasteners longer than 12 mm will protrude into the rubber neck and affect neck performance.

2. As shown in Figure 6-5, fasten the upper neck load cell to the top of the WorldSID-50M neck assembly using four M6 x 12 SHCS. The left and right sides of the neck should be oriented based on the test being performed, left lateral or right lateral. The neck orientations are shown in the Figure 6-3 drawing and the Figure 6-5 photograph.

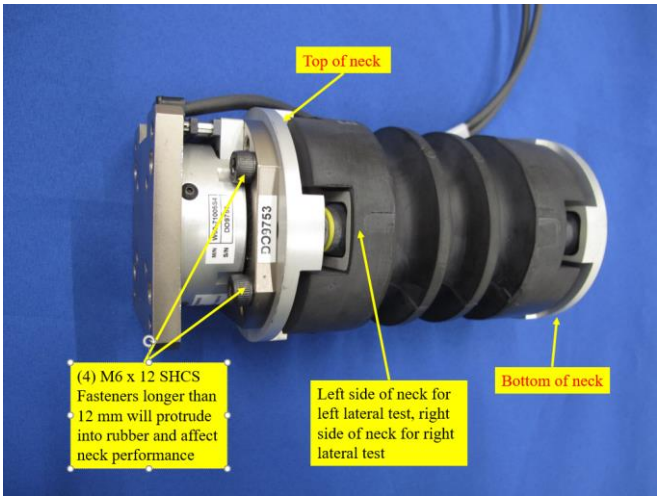

Figure 6-5. Fastening the upper neck load cell to the neck assembly.

3. Fasten the lower neck interface plate (W50-83201) to the bottom of the neck assembly using four M6 x 12 SHCS (Figure 6-6).

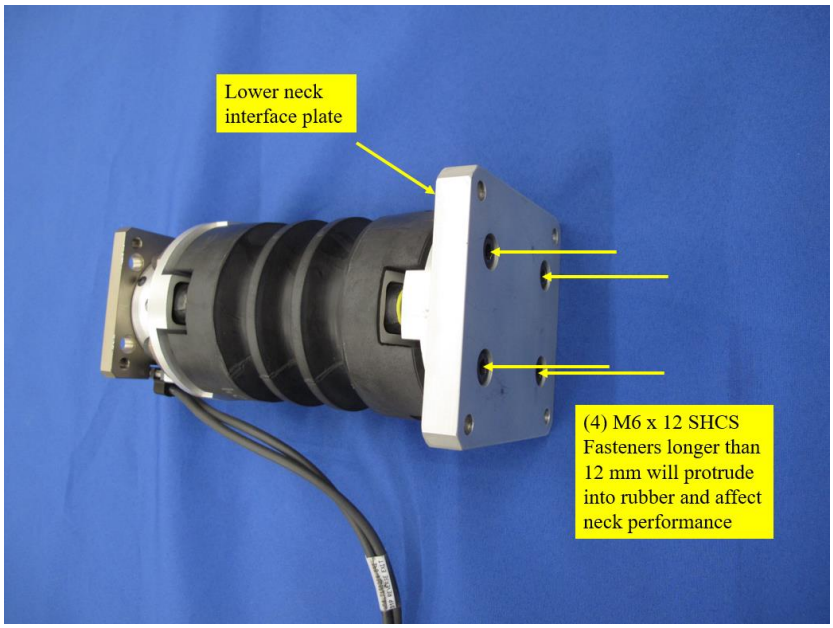

Figure 6-6. Fastening the lower neck interface to the bottom of the neck assembly.

4. Attach the neck pendulum mounting base (W50-83206), with forward and rearward potentiometers to the lower neck interface plate (W50-83201) using four M6 x 22 SHCS, as shown in Figure 6-7.

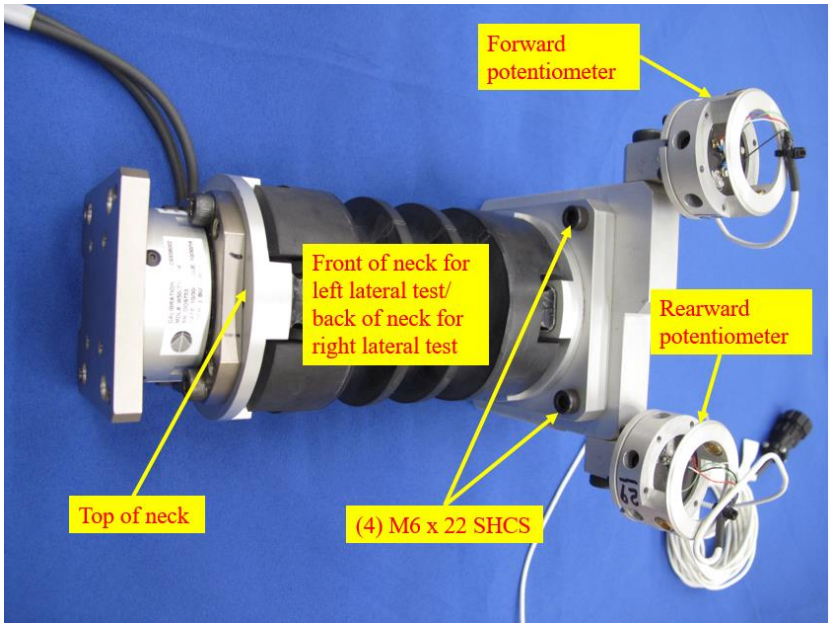

Figure 6-7. Attaching neck pendulum mounting base.

5. Attach the headform assembly central plate (W50-83101) to the upper neck interface plate (W50-83104) by inserting four M6 x 16 SHCS through the central plate of the headform and screwing them into the upper neck interface plate (Figure 6-8). Attach the angular rate sensor to the headform assembly central plate (Figure 6-8).

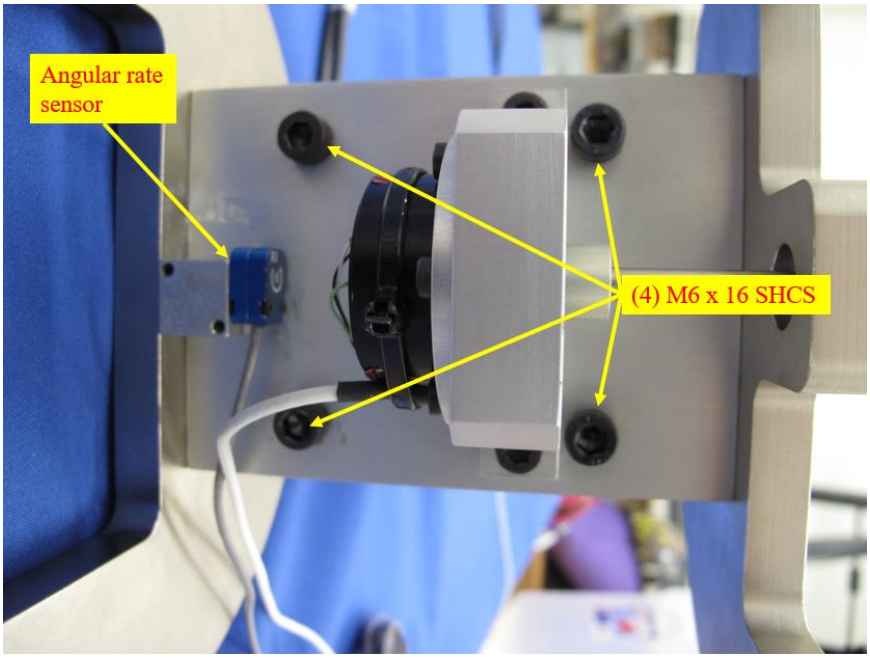

Figure 6-8. Attaching the headform to the upper neck interface plate.

6. Mount the completed assembly to the pendulum arm of the neck pendulum using four M6 x 16 SHCS. The WorldSID-50M neck installed in the lateral flexion test headform fixture is shown in Figure 6-9. Note that the forward potentiometer is always oriented toward the aluminum honeycomb. For a left-lateral test, the left side of the neck will be installed toward the aluminum honeycomb. For a right-lateral test, the right side of the neck will be installed toward the aluminum honeycomb.

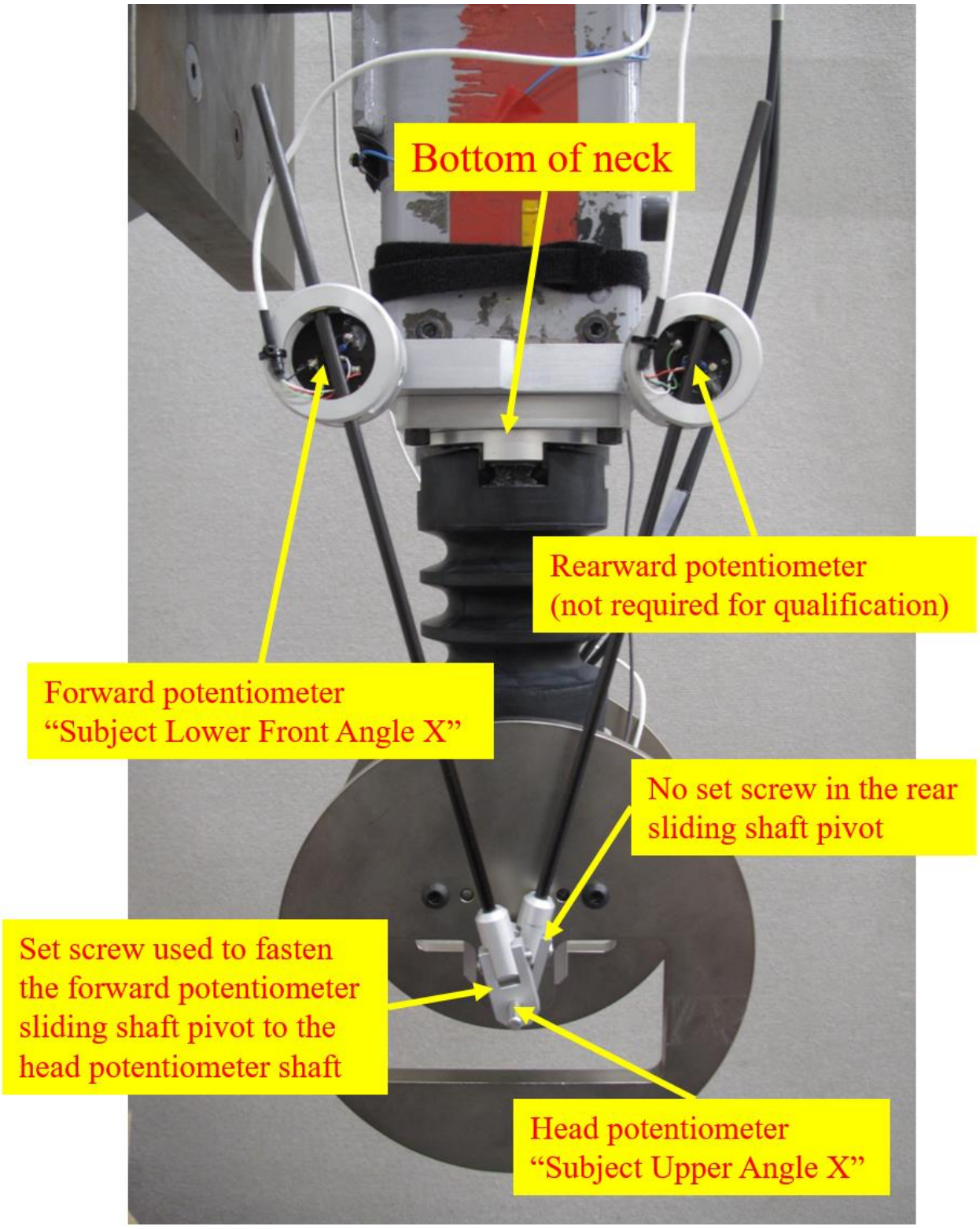

Figure 6-9. Neck/headform assembly for lateral flexion qualification test.

6.5 Test Procedure

6.5.1 Install the appropriate 76.2 mm (3 inch) deep aluminum honeycomb to meet the pendulum pulse specified in Table 6-1, where the pendulum velocity is calculated as described in Section 6.6. Confirm that the contact area of the aluminum honeycomb engages the pendulum's impactor plate upon impact.

Table 6-1. Pendulum Pulse for Lateral Neck Test

Parameter	Units	Specification	
		Min.	Max.
Pendulum velocity at 4 ms after time zero	m/s	0.87	1.09
Pendulum velocity at 8 ms after time zero	m/s	1.72	2.10
Pendulum velocity at 12 ms after time zero	m/s	2.63	3.17

6.5.2 Verify that the test setup parameters are within the specifications shown in Table 6-2.

6.5.3 Ensure that at least 30 minutes have elapsed between consecutive impacts on the same neck

6.5.4 Record the required channels listed in Table 6-3 in accordance with SAE J211-1.

6.5.5 Release the pendulum from a height to generate an impact velocity of 3.40 ± 0.1 m/s, as measured at the center of the pendulum accelerometer. No more than five minutes shall elapse between the time that the pendulum is raised and the time that the pendulum is released.

Table 6-2. Lateral Neck Flexion Qualification Test Setup Parameters

Parameter	Setting
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Aluminum honeycomb	76.2 mm deep
Wait time between tests	30 minutes minimum

Table 6-3. Required Recorded Channels for the Lateral Neck Flexion Qualification Test

Channel Description	ISO MME Code
Pendulum Acceleration X	T0PEND000000ACXP
Upper Neck Force Y	D0NECKUP00WSFOYP
Upper Neck Moment X	D0NECKUP00WSMOXP
Subject Upper Angle X	D0SUBJUP0000ANXP
Subject Lower Front Angle X	D0SUBJLOFR00ANXP
Subject Angular Velocity X	D0SUBJ000000AVXP

6.6 Data Processing

6.6.1 Set T0 (Time Zero) to the time when the pendulum first contacts the aluminum honeycomb. First contact can be determined using a contact switch during testing or by initial rise in pendulum acceleration (T0PEND000000ACXP).

6.6.2 Perform bias removal of the pendulum acceleration (T0PEND000000ACXP) by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0.

6.6.3 Filter the bias removed pendulum acceleration (T0PEND000000ACXP) to CFC1000.

6.6.4 Reset T0 to the first data sample where the filtered pendulum acceleration (T0PEND000000ACXA) exceeds 5 g.

6.6.5 Perform the bias removal of the remaining recorded (unfiltered) data channels shown in Table 6-3 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0.

6.6.6 Filter the remaining recorded and bias removed data channels as indicated in Table 6-4.

6.6.7 Using the trapezoid rule, integrate T0PEND000000ACXA from 0.00 s to the end of the sample period to obtain pendulum velocity (T0PEND000000VAXA).

6.6.8 Calculate the Headform (Subject) Flexion Angle X (β) by summing Subject Lower Front Angle X (θ_f) and Subject Upper Angle X (θ_h).

$$\beta\ (Headform\ Flexion\ Angle) = \theta_f + \theta_h$$

$$Where:\ \beta = D0SUBJ000000ANXC$$
$$\theta_f = D0SUBJLOFR00ANXC$$
$$\theta_h = D0SUBJLO0000ANXC$$

6.6.9 Calculate the Neck Moment X at the occipital condyle (MOCx)

$$MOC_X = M_X + (F_Y \times 0.0195)$$

$$Where:\ MOC_X = X\ Moment\ at\ Occipital\ Condyle$$
$$M_X = D0NECKUP00WSMOXB$$
$$F_Y = D0NECKUP00WSFOYB$$

Table 6-4. Required Measurements for the Lateral Neck Flexion Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Pendulum Acceleration X	1000	T0PEND000000ACXA	XG	AM	PEND	AC	G'S
Pendulum Velocity X	N/A	T0PEND000000VAXA	XG	CM	PEND	PP	MPS
Upper Neck Force Y	600	D0NECKUP00WSFOYB	YL	AM	NEKU	LC	NWT
Upper Neck Moment X	600	D0NECKUP00WSMOXB	XL	AM	NEKU	LC	NWM
Subject Lower Front Angle X (θ_f)	1000	D0SUBJLOFR00ANXC	XL	AM	PEND	AD	DEG
Subject Upper Angle X (θ_h)	180	D0SUBJUP0000ANXC	XL	AM	PEND	AD	DEG
Subject Flexion Angle X (β)	180	D0SUBJ000000ANXC	XL	CM	HDFR	PP	DEG
Subject Angular Velocity X	60	D0SUBJ000000AVXD	XL	AM	HDFR	AV	DPS
Neck Moment at Occipital Condyle X	180	D0NECKOC00WSMOXB	XL	CM	NEKU	PP	NWM

6.7 Performance Specifications

Table 6-5. Lateral Neck Test Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Temperature	°C	20.6	22.2
Relative humidity	%	10.0	70.0
Impact velocity	m/s	3.30	3.50
Pendulum velocity at 4 ms after time zero	m/s	0.87	1.09
Pendulum velocity at 8 ms after time zero	m/s	1.72	2.10
Pendulum velocity at 12 ms after time zero	m/s	2.63	3.17
Left Lateral Flexion Test			
Peak headform flexion angle (β)	deg	-61.0	-50.0
Peak headform flexion angle decay time to 0 degrees	ms	58.0	72.0
Peak x-axis moment at occipital condyle (MOCx)	Nm	54.0	67.0
Peak x-axis moment at occipital condyle decay time to 0 Nm	ms	71.0	87.0
Peak headform x-axis angular rate	deg/s	-2503	-2047
Right Lateral Flexion Test			
Peak headform flexion angle (β)	deg	50.0	61.0
Peak headform flexion angle decay time to 0 degrees	ms	58.0	72.0
Peak x-axis moment at occipital condyle (MOCx)	Nm	-67.0	-54.0
Peak x-axis moment at occipital condyle decay time to 0 Nm	ms	71.0	87.0
Peak headform x-axis angular rate	deg/s	2047	2503

7 NECK TORSION QUALIFICATION

7.1 Description

The left and right neck torsion qualification tests for the WorldSID-50M are performed to examine the dynamic response characteristics of the neck assembly in a twisting motion about the z-axis. The WorldSID neck assembly is installed in the neck torsion fixture (Figure 7-1) and then the torsion fixture is attached to the base of the 49 CFR Part 572, Subpart E neck pendulum. The neck pendulum is dropped from a height to achieve the specified velocity and the motion of the neck pendulum arm is decelerated with aluminum honeycomb to achieve the specified input pulse. A secondary pendulum attached to the neck torsion fixture continues to rotate to simulate head rotation about the z-axis. The simulated head rotation directions for the right and left torsion tests are shown in Figure 7-2.

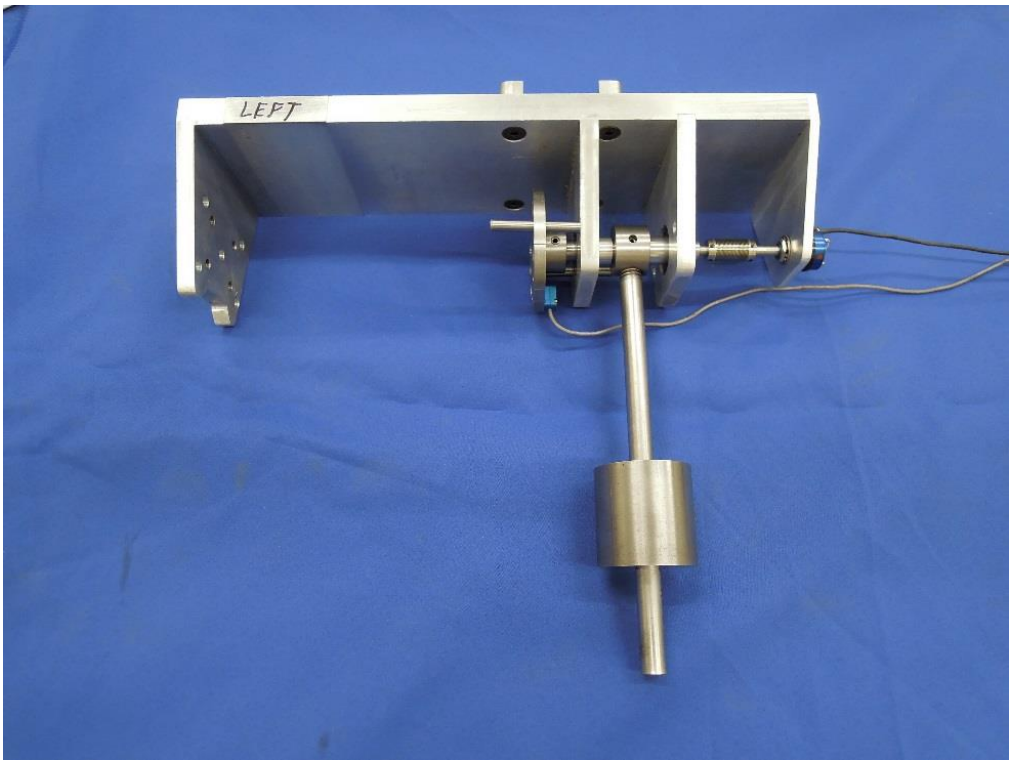

Figure 7-1. WorldSID-50M neck torsion test fixture.

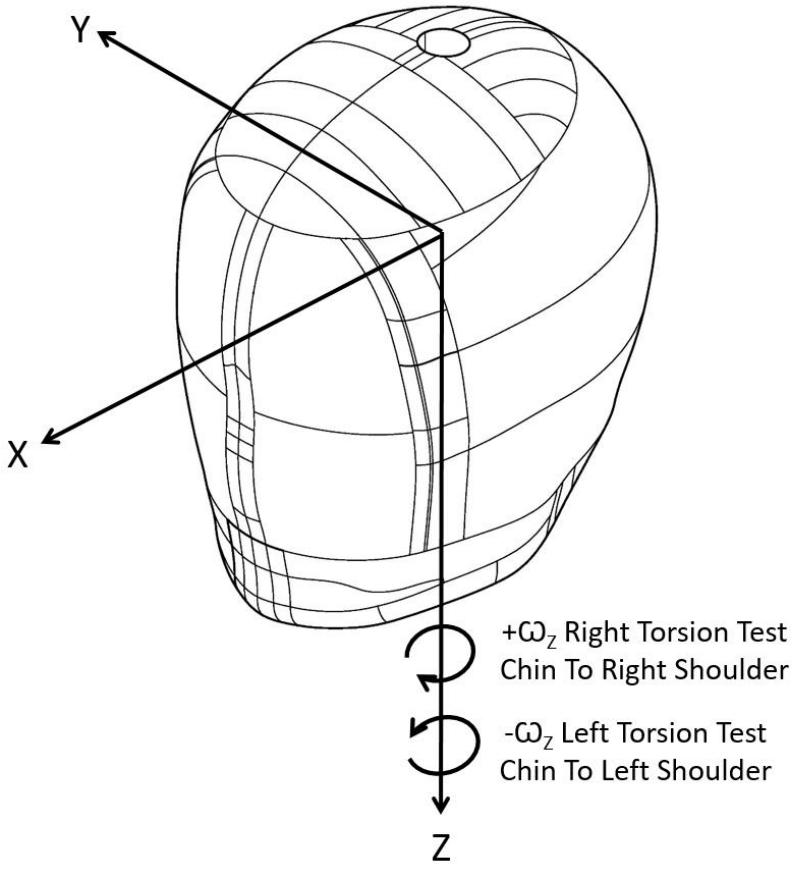

Figure 7-2. Simulated head rotation directions for right and left torsion tests.

7.2 Materials

- WorldSID-50M ATD neck assembly (drawing W50-21001).
- Head-neck Pendulum (as defined in 49 CFR Part 572, Subpart E).
- 152.4 mm deep aluminum honeycomb (28.8 kg/m^3 recommended).
- WorldSID-50M neck torsion fixture (DL210-400).

7.3 Instrumentation

- WorldSID-50M 6-axis lower neck load cell (SA572-S147).
- Angular rate sensor attached to the torsion fixture neck mounting plate to measure neck z-axis rotation rate (SA572-S58).
- Rotary potentiometer to measure neck z-axis rotation angle.
- Instrumentation to measure the impact velocity.
- Pendulum accelerometer.

7.4 Pre-Test Procedure

7.4.1 Remove the neck assembly from the ATD (see WorldSID-50M PADI). Since the neck assembly is symmetrical front-to-rear and top-to-bottom, it can be installed on the dummy and tested in multiple orientations (front-to-rear rotation or top-to-bottom rotation). Make sure that the neck is labeled to identify the intended top, bottom, front and rear so that it will be qualified and assembled on the dummy using the same orientation.

7.4.2 Using the neck compression tool, remove the half-spherical screws from interface plates at each end of the neck assembly (Figure 7-3). Verify that the half-spherical screws are lubricated with an anti-seize lubricant. Reinstall the half-spherical screws and tighten them to 10 Nm using the neck compression tool.

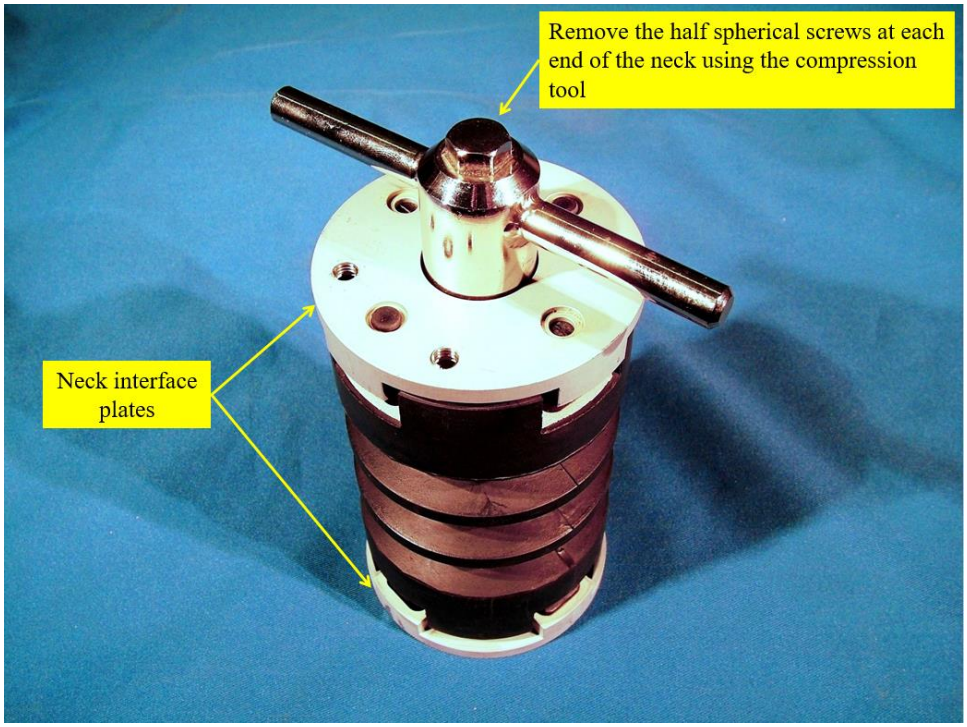

Figure 7-3. Removing the half-spherical screws.

7.4.3 Soak the neck in a controlled environment with a temperature of 20.6 to 22.2 °C and a relative humidity of 10 to 70% for at least 4 hours prior to a test. The test environment should have the same temperature and humidity requirements as the soak environment.

7.4.4 Install the neck assembly (W50-21001) into the WorldSID-50M neck torsion fixture (DL210-400) as instructed below.

1. Attach the lower neck load cell to the end plate (DL210-410) using four M6 x 14 socket head cap screws (SHCS), as shown in Figure 7-4.

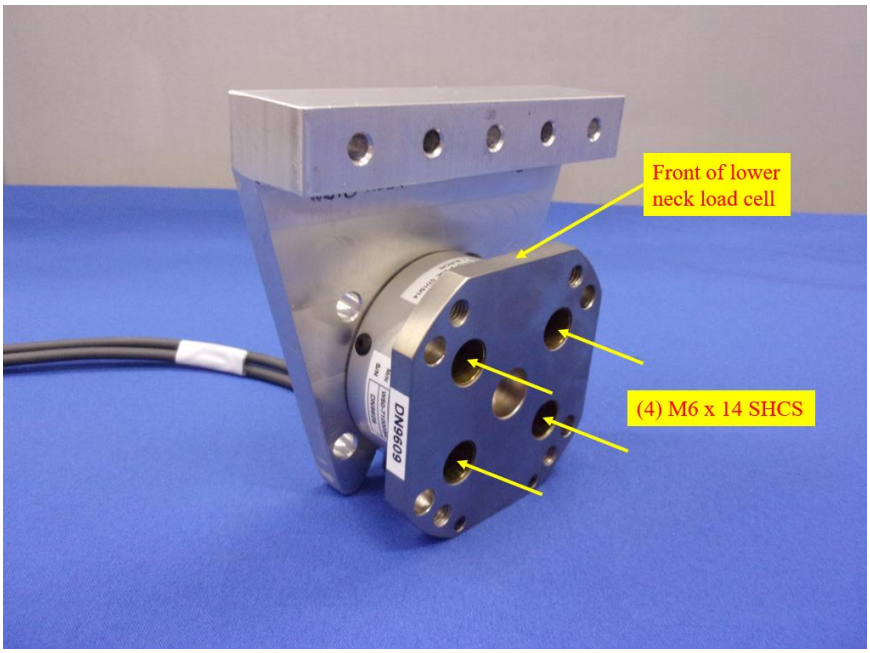

Figure 7-4. Load cell fastened to fixture end plate.

Caution: In steps 2 & 3 (Figure 7-5 & Figure 7-6), fasteners longer than specified will protrude into the rubber neck and affect neck performance.

2. Using the through-holes in the end plate and making sure the neck is correctly oriented, fasten the bottom of the neck assembly to the lower neck load cell using four M6 x 12 SHCS (Figure 7-5).

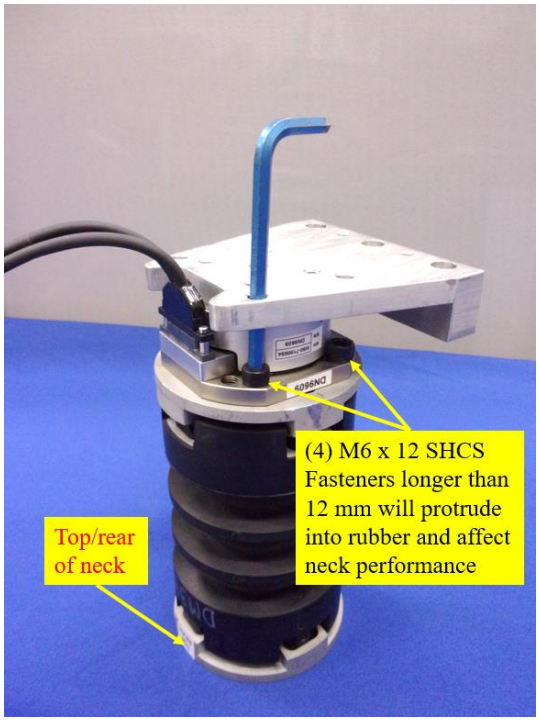

Figure 7-5. Neck assembly fastened to load cell.

3. Fasten the neck mounting adapter (DL210-420) to the top of the neck assembly using four M6 x 10 button head cap screws (BHCS), as shown in Figure 7-6.

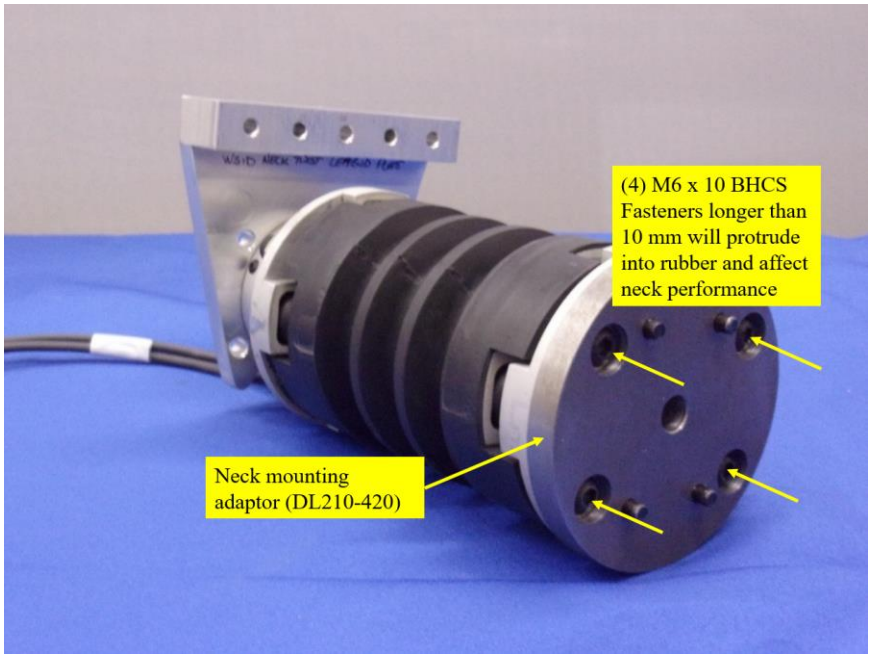

Figure 7-6. Neck mounting adapter fastened to neck assembly.

4. As shown in Figure 7-7, mount the neck torsion fixture to the bottom of the head-neck pendulum. Note that prior to testing, to prevent damage to the fixture, the locking pins must be removed.

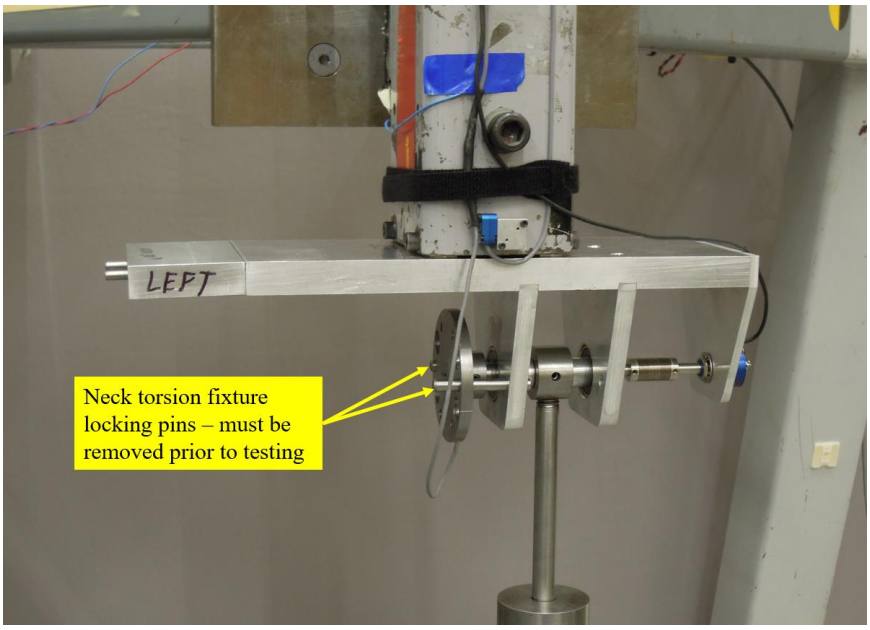

Figure 7-7. Torsion fixture mounted to neck pendulum arm.

5. Attach the neck assembly to the torsion fixture by aligning the two locator pins on the end of the fixture with the holes in the end plate while simultaneously aligning the four locator pins on the neck mounting adapter with the holes in the fixture's neck attachment plate. To aid with the alignment and insertion of the four pins, rotate the torsion fixture's pendulum rod back and forth until the pins are properly seated (Figure 7-8).

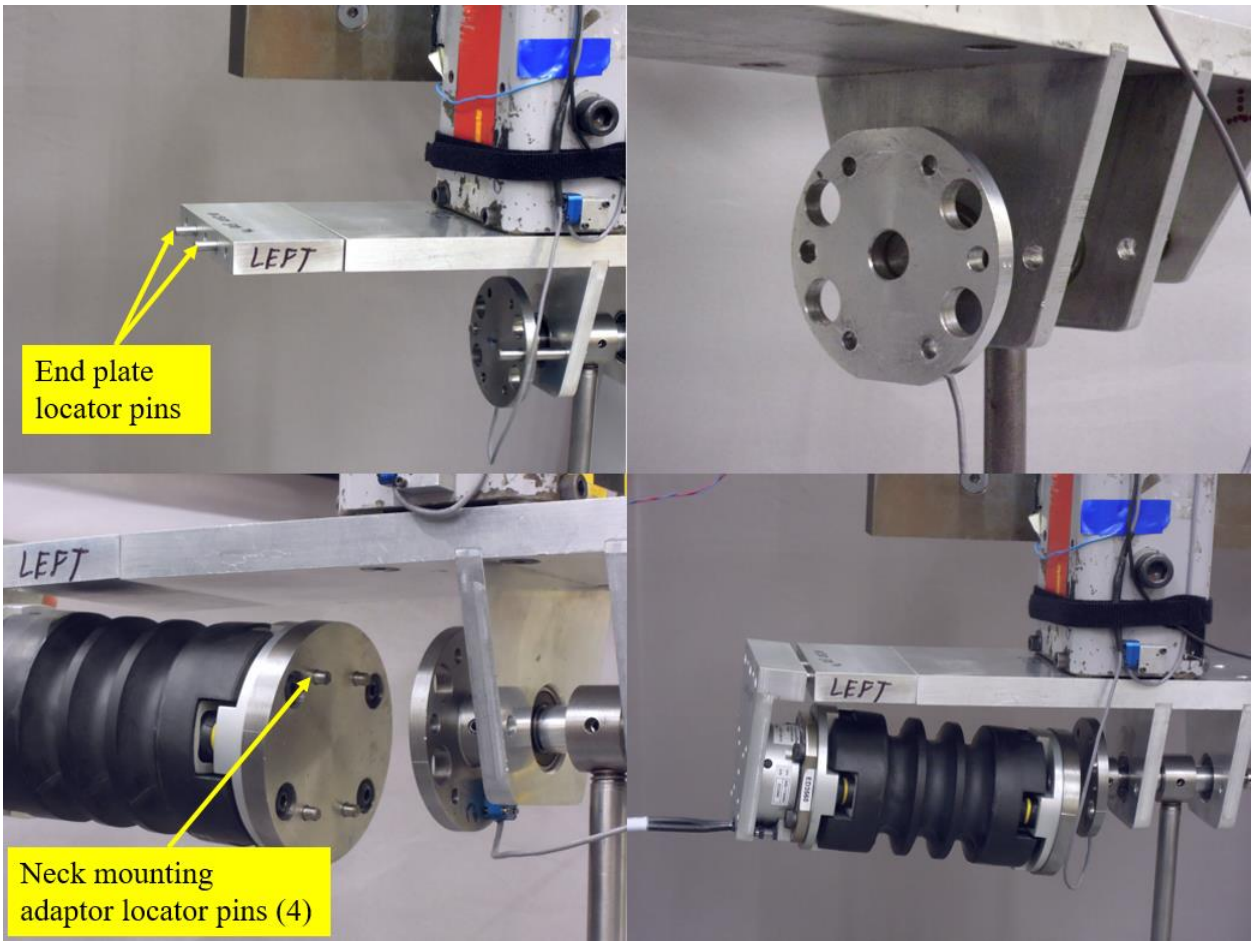

Figure 7-8. Torsion fixture pin alignment.

6. Once all pins have been properly aligned and inserted, fasten the full neck assembly to the torsion fixture using three #10-24 x 3-inch SHCS (Figure 7-9).

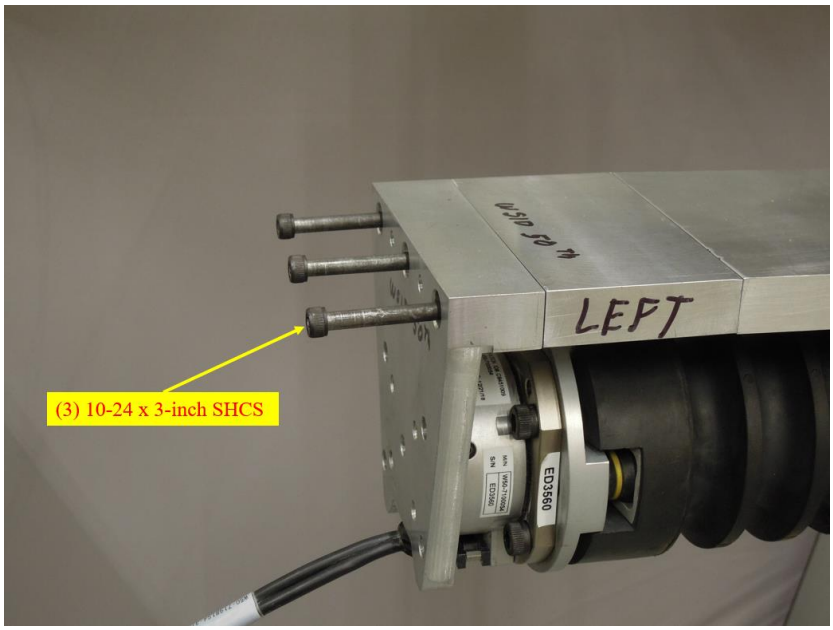

Figure 7-9. Neck assembly attached to torsion fixture.

7. When the neck assembly is completely installed in the neck torsion fixture, a small gap should exist between the neck mounting adaptor and the fixture, as shown in Figure 7-10. This gap allows for changes in neck assembly length that may occur during the torsion test.

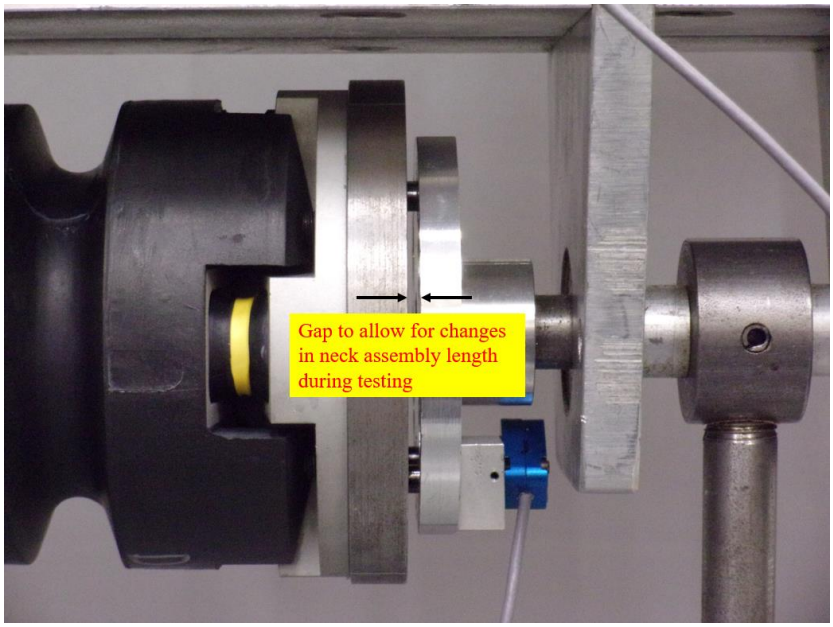

Figure 7-10. Gap to allow for changes in neck assembly length.

8. Fasten the 0.75 ± 0.05 kg pendulum weight to the fixture pendulum rod so that it is 152.4 mm from the center of the weight to the center of the shaft, as shown in Figure 7-11 and Figure 7-12. Fasten the mass to the rod using a 10-24 set screw in the mass.

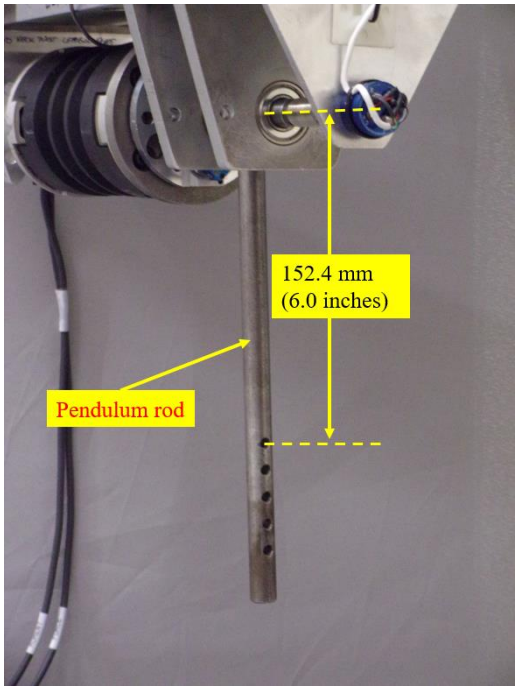

Figure 7-11. Location of pendulum weight.

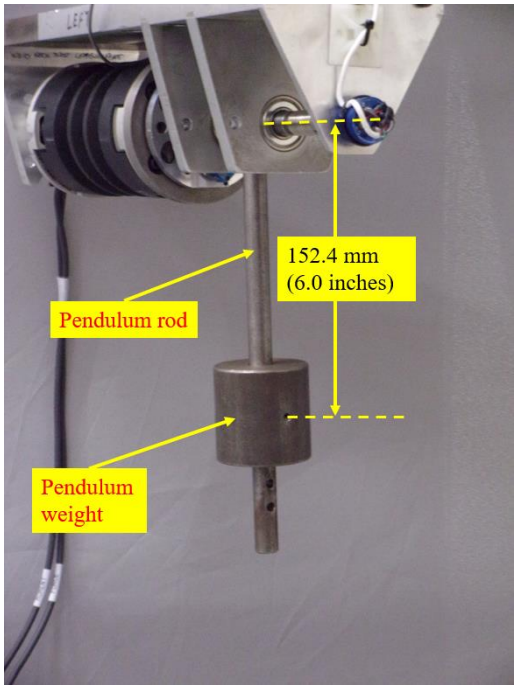

Figure 7-12. Pendulum weight install on the pendulum rod.

9. The neck torsion fixture completely assembled for a left torsion qualification test is shown in Figure 7-13.

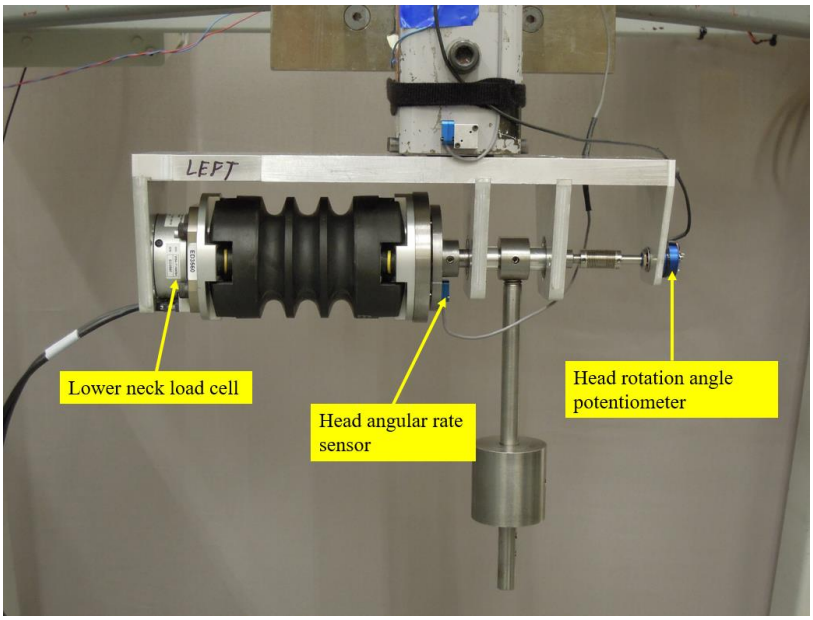

Figure 7-13. Neck torsion fixture configured for a left torsion test.

10. To perform a right torsion qualification test, remove the entire torsion fixture from the 49 CFR Part 572, Subpart E neck pendulum arm, rotate it 180 degrees, and then reattach the torsion fixture to the neck pendulum arm. The neck torsion fixture completely assembled for a right torsion qualification test is shown in Figure 7-14.

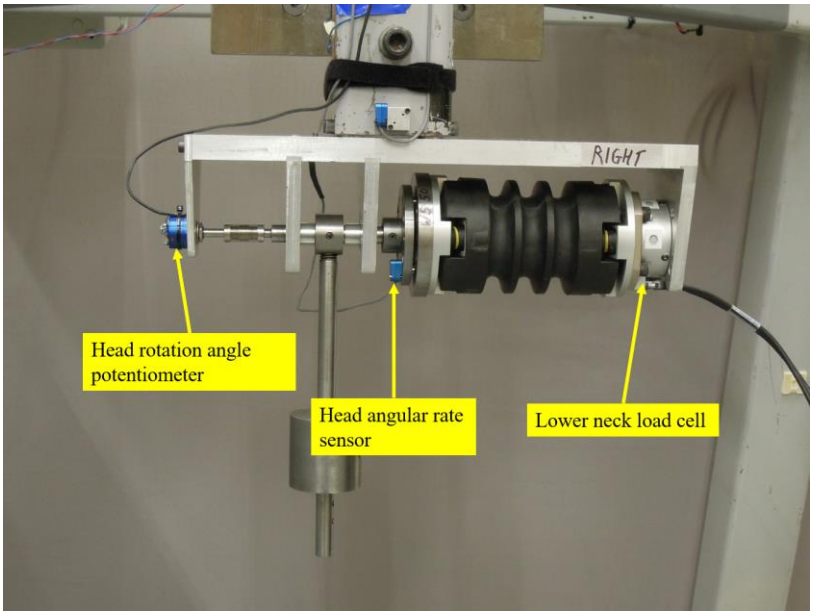

Figure 7-14. Neck torsion fixture configured for a right torsion test.

7.5 Test Procedure

7.5.1 Install the appropriate 152.4 mm deep aluminum honeycomb to meet the pendulum velocity pulse specified in Table 7-1, where the pendulum velocity is calculated as described in Section 7.6. Confirm that the contact area of the aluminum honeycomb engages the pendulum's impactor plate upon impact.

Table 7-1. Pendulum Pulse for Neck Torsion Qualification Test

Parameter	Units	Specification	
		Min.	Max.
Pendulum velocity at 10 ms after time zero	m/s	2.09	2.37
Pendulum velocity at 15 ms after time zero	m/s	3.19	3.63
Pendulum velocity at 20 ms after time zero	m/s	4.27	4.87

7.5.2 Verify that the test setup parameters are within the specifications shown in Table 7-2.

7.5.3 Ensure that at least 30 minutes have elapsed between consecutive impacts on the same neck.

7.5.4 Record the required channels listed in Table 7-3 in accordance with SAE J211-1.

7.5.5 Raise the pendulum from a height to generate an impact velocity of 5.20 ± 0.1 m/s, as measured at the center of the pendulum accelerometer. No more than five minutes shall elapse between the time that the pendulum is raised and the time that the pendulum is released.

Table 7-2. Neck Torsion Qualification Test Setup Parameters

Parameter	Setting
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Aluminum honeycomb	152.4 mm deep
Wait time between tests	30 minutes minimum

Table 7-3. Required Recorded Channels for the Neck Torsion Qualification Test

Channel Description	ISO MME Code
Pendulum Acceleration X	T0PEND000000ACXP
Lower Neck Moment Z	D0NECKLO00WSMOZP
Subject Angle Z	D0SUBJ000000ANZP
Subject Angular Velocity Z	D0SUBJ000000AVZP

7.6 Data Processing

7.6.1 Set T0 (Time Zero) to the time when the pendulum first contacts the aluminum honeycomb. First contact can be determined using a contact switch during testing or by initial rise in pendulum acceleration (T0PEND000000ACXP).

7.6.2 Perform bias removal of the pendulum acceleration (T0PEND000000ACXP) by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0.

7.6.3 Filter the bias removed pendulum acceleration (T0PEND000000ACXP) to CFC1000.

7.6.4 Reset T0 to the first data sample where the filtered pendulum acceleration (T0PEND000000ACXA) exceeds 5 g.

7.6.5 Perform the bias removal of the remaining recorded (unfiltered) data channels shown in Table 7-3 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0.

7.6.6 Filter the remaining recorded and bias removed data channels as indicated in Table 7-4.

7.6.7 Using the trapezoid rule, integrate T0PEND000000ACXA from 0.00 s to the end of the sample period to obtain pendulum velocity (T0PEND000000VAXA).

Table 7-4. Required Measurements for the Neck Torsion Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Pendulum Acceleration X	1000	T0PEND000000ACXA	XG	AM	PEND	AC	G'S
Pendulum Velocity X	N/A	T0PEND000000VAXA	XG	CM	PEND	PP	MPS
Lower Neck Moment Z	600	D0NECKLO00WSMOZB	ZL	AM	NEKL	LC	NWM
Subject Angle Z	60	DOSUBJ000000ANZD	ZL	AM	PEND	AD	DEG
Subject Angular Velocity X	60	D0SUBJ000000AVZD	ZL	AM	NEKU	AV	DPS

7.7 Performance Specifications

Table 7-5. Neck Torsion Qualification Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Temperature	°C	20.6	22.2
Relative humidity	%	10.0	70.0
Impact velocity	m/s	5.10	5.30
Pendulum velocity at 10 ms after time zero	m/s	2.09	2.37
Pendulum velocity at 15 ms after time zero	m/s	3.19	3.63
Pendulum velocity at 20 ms after time zero	m/s	4.27	4.87
Left Torsion Test			
Peak torsion fixture rotation, z-axis	deg	-51.0	-41.5
Torsion fixture rotation decay time to 0 deg	ms	35.0	43.0
Peak fixture angular rate, z-axis	Deg/s	-1655	-1345
Peak lower neck moment, z-axis	Nm	34.0	42.0
Right Torsion Test			
Peak torsion fixture rotation, z-axis	deg	41.5	51.0
Torsion fixture rotation decay time to 0 deg	ms	35.0	43.0
Peak fixture angular rate, z-axis	Deg/s	1345	1655
Peak lower neck moment, z-axis	Nm	-42.0	-34.0

8 FULL-BODY QUALIFICATIONS

8.1 Description

The left or right lateral full-body qualification tests include dynamic impacts of the shoulder, thorax with half-arm, thorax without half-arm, abdomen, and pelvis. Since the dummy can be configured for either a left-side or right-side impact, the full-body qualification tests are performed on only one side of the dummy. In the shoulder, thorax with half-arm and pelvis tests, the dummy is impacted with a 23.36 kg rigid impactor. For the thorax without arm qualification test, a modified face (Figure 8-2) is attached to the face of the 23.36 kg impactor. The modified face is made from a rigid material and has a mass of 0.5 kg, increasing the total impactor mass to 23.86 kg. For the abdomen qualification test, a simulated armrest consisting of a 1 kg rigid block, as described in Section 8.2, is attached to the face of the 23.36 kg impactor, increasing the total impactor mass to 24.36 kg. The shoulder, thorax without half-arm and abdomen tests are performed at 4.3 m/s while the thorax with half-arm and pelvis tests are performed at 6.7 m/s.

For all full-body qualification tests, the dummy is positioned on the qualification test bench (see Section 8.2) in the standard test posture, as described in Section 8.5. Only the position of the half-arm on the impact side of the dummy is changed for some body region impacts. For each body region test, the qualification bench is repositioned in front of the impactor so that the center of the impactor is aligned with the desired impact location on the dummy.

8.2 Materials

All Full-Body Qualification Tests

- Fully assembled WorldSID-50M ATD.
- Impactor conforming to the requirements of 49 CFR Part 572.36. The impactor is a 152.4 ± 0.25 mm diameter cylinder that has a rigid flat impacting face with an edge radius of 12.7 ± 0.25 mm. The mass of the impactor is 23.36 ± 0.02 kg including instrumentation, rigid attachments, and the mass of the lower 1/3 of the suspension cables.
- Qualification test bench conforming to the requirements 49 CFR Part 572, Subpart V, Appendix A, Figure V3 (Figure 8-1). The bench has two layers of 2 mm thick PTFE (Teflon) on the seat base and the seat back. The first layer covers the entire seat and is affixed to the seat base and seat back. The second layer is a 387 mm x 521 mm unaffixed section on the seat base and a 514 mm x 514 mm unaffixed section on the seat back.

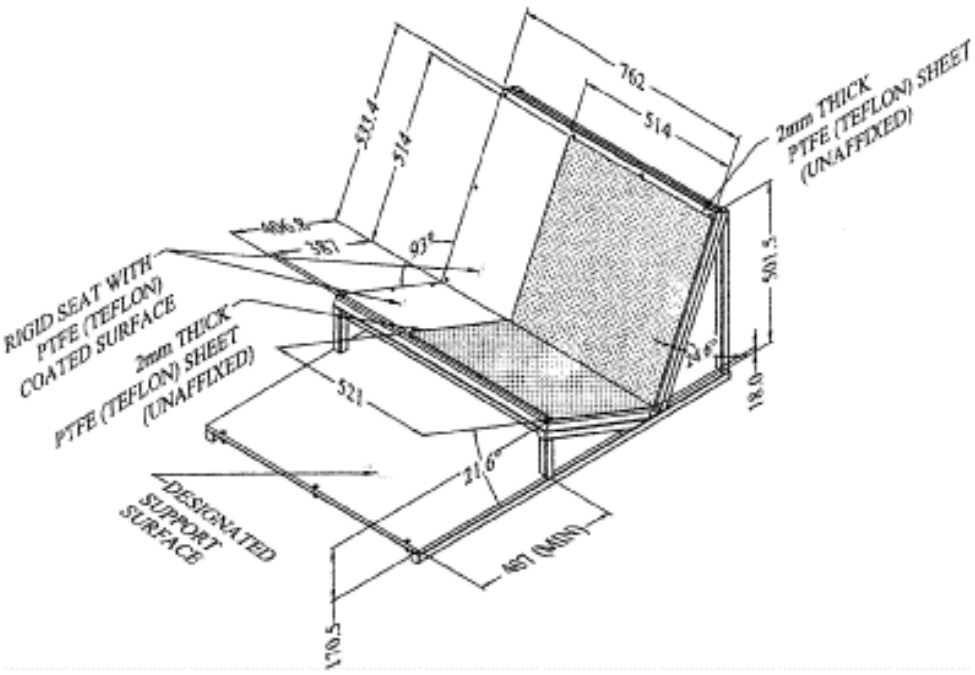

Figure 8-1. Qualification test bench.

- H-Point tool (drawing W50-82500).

Thorax Without Half-Arm Qualification Test

- Modified impactor face as shown in Figure 8-2.

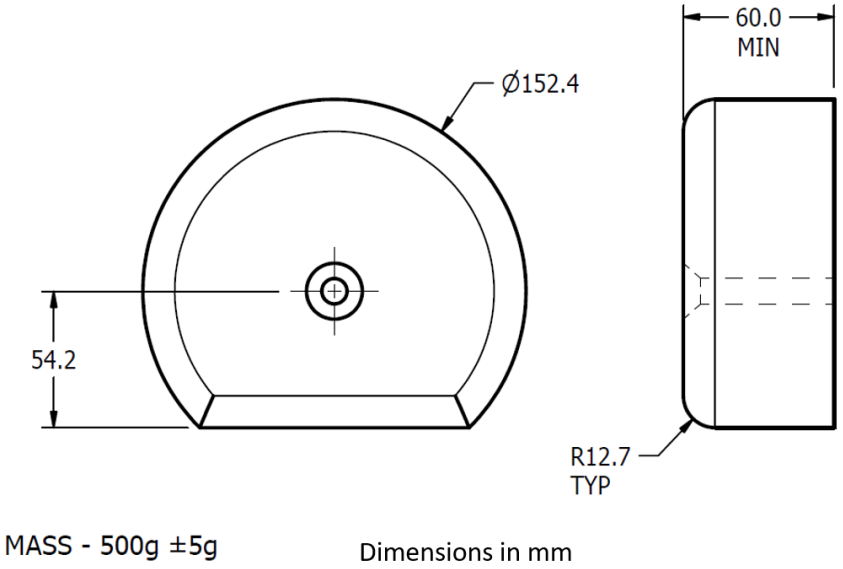

Figure 8-2. Thorax without half-arm modified impactor face.

Abdomen Qualification Test

- For the abdomen impact test, a simulated armrest, as described in 49 CFR Part 572.186, is added to the front of the impactor. The simulated armrest is a rigid block that is 150 ± 0.5 mm wide, 70 ± 0.5 mm high and 60 to 80 mm deep with an edge radius of 4 to 5 mm. The mass of the simulated armrest is 1.00 ± 0.01 kg.

8.3 Instrumentation

All Full-Body Qualification Tests

- Accelerometer mounted on the longitudinal centerline of the impactor with the sensitive axis of the accelerometer parallel to the impactor longitudinal centerline.
- Instrumentation to measure the impact velocity.
- A dual-axis tilt sensor (SA572-S44) fastened to the head cone (see WorldSID-50M PADI) to measure the angle of the head about the x-axis and y-axis.
- A dual-axis tilt sensor (SA572-S44) fastened to the spine box (see WorldSID-50M PADI) to measure the angle of the thorax about the x-axis and y-axis.
- A dual-axis tilt sensor (SA572-S44) fastened to the pelvis instrumentation bracket (see WorldSID-50M PADI) to measure the angle of the pelvis about the x-axis and y-axis.

Shoulder Qualification Test

- RibEye rib deflection measurement system (see WorldSID-50M PADI) to measure shoulder rib deflection.
- 3-axis shoulder load cell (SA572-S148 for left-side qualification or SA572-S149 for right-side qualification).

Thorax With and Without Half-Arm Qualification Test

- RibEye rib deflection measurement system (see WorldSID-50M PADI) to measure thorax ribs 1, 2 and 3 deflections.
- Linear tri-axial accelerometer at T4 to measure y-axis acceleration (SA572-S48).
- Linear tri-axial accelerometer at T12 to measure y-axis acceleration (SA572-S48).

Abdomen Qualification Test

- RibEye rib deflection measurement system (see WorldSID-50M PADI) to measure abdomen ribs 1 and 2 deflections.
- Linear tri-axial accelerometer at T12 to measure y-axis acceleration (SA572-S48).

Pelvis Qualification Test

- Linear tri-axial accelerometer in the pelvis to measure y-axis acceleration (SA572-S48).
- Pubic load cell to measure y-axis force (SA572-S150).
- 12-axis sacroiliac load cell to measure y-axis force (SA572-S152).

8.4 Pre-Test Procedure

8.4.1 Soak the dummy in a controlled environment with a temperature of 20.6 to 22.2 °C and a relative humidity of 10 to 70% for at least 4 hours prior to a test. The test environment should have the same temperature and humidity requirements as the soak environment.

8.4.2 Set the lower neck bracket angle to 0 degrees (see Figure 8-3).

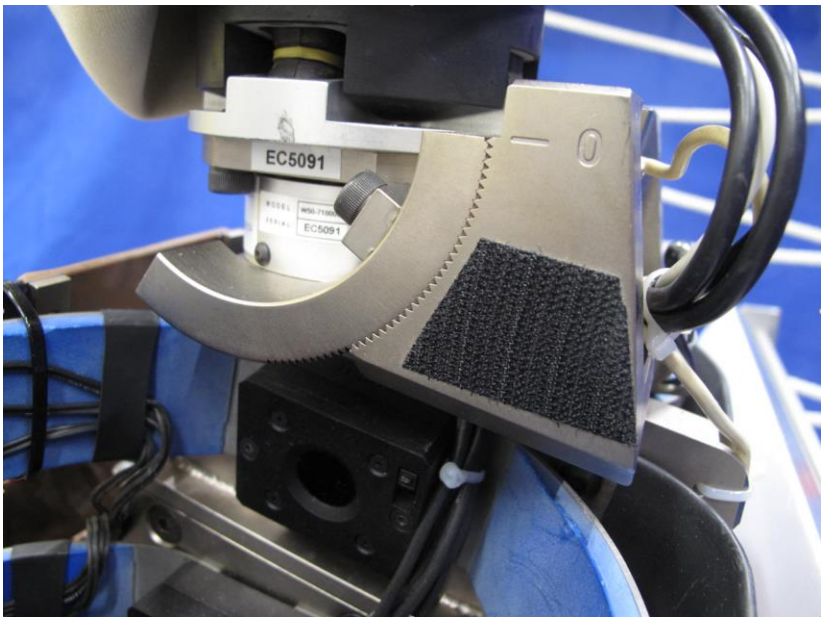

Figure 8-3. Neck bracket angle set to 0 degrees.

8.4.3 Make sure that the temperature sensor installed on the thorax rib is between 20.6 to 23.8 °C prior to testing. Depowering the onboard data acquisition and rib deflection measurement systems between tests will aid in keeping the temperature within the required test specifications. Also, unzipping the suit and blowing air into the thorax cavity using a fan can prevent an excessive buildup of heat during consecutive tests.

Prior to performing qualification tests that require RibEye displacement measurements (shoulder, thorax with & without arm, and abdomen), the six RibEye sensors must be cleaned to prevent any debris or smudges on the lenses from interfering with the light signal measured by the sensors. The lenses can be cleaned by wiping them with a lens cleaning wipe that is pre-moistened with alcohol. Make sure that the wipes being used do not leave any cleaning solution residue on the lenses. Never use cotton-tipped swabs or other materials that may leave fibers on the lenses.

8.5 Dummy Positioning

8.5.1 Place the qualification test bench, described in Section 8.2, onto the lift table in front of the impactor and position the bench for the body region to be impacted. Make sure that front edge of the bench is parallel with the longitudinal centerline of the impactor. The precise location of the bench may change after positioning the dummy so that the impactor face aligns precisely with the desired impact location on the dummy.

8.5.2 Place the unaffixed Teflon sheets onto the seat base and seat back of the test bench along the edge of the bench on the impact side (Figure 8-1) and seat the dummy on the Teflon sheets. To minimize the chance of the impact probe contacting the bench during testing, position the dummy so that its impact side is near the outermost edge of the bench, as shown in Figure 8-4.

Figure 8-4. Dummy positioned at edge of the qualification bench.

8.5.3 While rotating the torso forward around the lumbar by pulling on the dummy's neck, push the pelvis rearward so that the pelvis fully engages the seat back. Verify that the pelvis of the dummy is square to the back of the test bench by ensuring the distance between the back of the test bench and the left and right sides of the pelvis flesh are within 10 mm (Figure 8-5 and Figure 8-6).

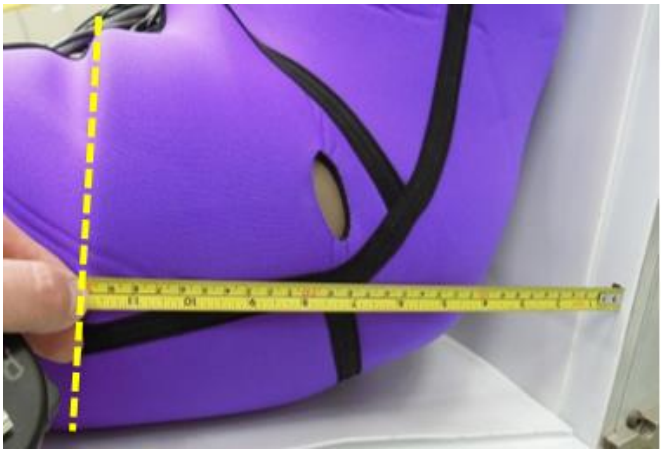

Figure 8-5. Left-side pelvis measurement.

Figure 8-6. Right-side pelvis measurement.

8.5.4 Using the in-dummy tilt sensors, position the angles of the head, thorax, and pelvis body segments, as shown in Table 8-1. Where available, mechanical reference measurement locations and angles are also provided in Table 8-1. The mechanical reference angles can be checked with an inclinometer as shown in Figure 8-7 through Figure 8-9.

Table 8-1. Dummy Segment Angles

Location	Axis	Tilt Sensor Angle	Dummy Component Mechanical Reference	Component Angle
Head	x	0 ± 2°	NA	NA
	y	0 ± 2°	NA	NA
Thorax	x	0 ± 2°	Top of lower neck bracket (Figure 8-7)	0 ± 2°
	y	0 ± 2°	Top of lower neck bracket (Figure 8-8)	0 ± 2°
Pelvis	x	0 ± 2°	NA	NA
	y	5 ± 2°	H-point tool (Figure 8-9)	40 ± 2°

Figure 8-7. Thorax x-axis angle measurement using an inclinometer.

Figure 8-8. Thorax y-axis angle measurement using an inclinometer.

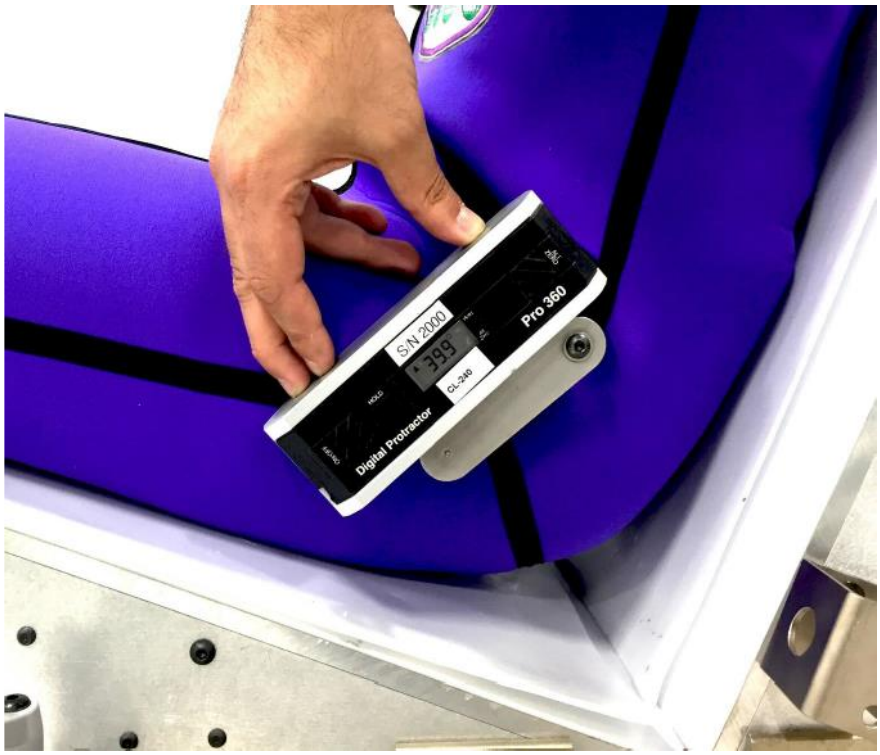

Figure 8-9. Pelvis y-axis angle measurement using H-point tool and an inclinometer.

8.5.5 Position the legs so that the knee centers are 279 ± 50 mm apart (Figure 8-10).

Figure 8-10. Knee centers spaced at 279 ± 50 mm.

8.5.6 For all full-body qualification tests, place the non-impact side arm into the detent that places the arm in the most-raised position (near horizontal). Place the impact side arm into the position specified in the procedure for the body region being tested.

8.5.7 While being careful to maintain the position of the dummy achieved in the previous steps, reposition the test bench vertically and in the fore-aft direction so that the longitudinal centerline of the impactor is aligned with the desired impact location on the dummy. See the specific body region procedures for details on impact location. Position the test bench/dummy laterally so that the impactor face first contacts the dummy when at the lowest point of its travel arc. Impact point alignment for the shoulder and pelvis qualification tests can be performed without unzipping the dummy's suit. Aligning the impact point for the thorax, thorax with arm and abdomen qualifications requires the suit to be unzipped and the thorax pad removed to expose the impact locations on the thorax and abdomen ribs. This requires the use of reference measurements and/or laser alignment tools to ensure that the impact point remains at the correct location after reinstalling the thorax pad and suit.

8.5.8 After the test bench is in the correct position for the desired impact location, verify that the dummy segment angle measurements are still within the tolerances specified in Table 8-1. Make any required adjustments so that the dummy segment angles and impact location are correct. Also, verify that the front of the test bench is still parallel to the longitudinal centerline of the impactor. After all measurements have been verified, secure the test bench to the lift table.

8.5.9 Proceed to the procedure for the body region being qualified.

8.6 Shoulder Qualification

8.6.1 Description

The left or right shoulder qualification test is a dynamic impact to the center of the arm pivot joint using a 23.36 kg rigid impactor, as described in Section 8.2, at 4.30 m/s. Since the dummy can be configured for either a left-side or right-side impact, the shoulder qualification test is performed on only one side of the dummy.

8.6.2 Materials

Refer to Section 8.2 for material requirements for full-body qualification tests.

8.6.3 Instrumentation

Refer to Section 8.3 for instrumentation requirements for full-body qualification tests.

8.6.4 Pre-Test Procedures

Refer to Section 8.4 for pre-test procedure for full-body qualification tests.

8.6.5 Test Procedure

8.6.5.1 Ensure that the Ribeye sensor lenses have been cleaned as described in Section 8.4.

8.6.5.2 Position the test bench and dummy as described in Section 8.5 with the impact side arm in the detent that places the arm in the most-raised position (nearly horizontal). Align the longitudinal centerline of the impactor with the center of the arm pivot joint.

8.6.5.3 Position the test bench/dummy laterally so that the impactor face first contacts the dummy when the impactor is at the lowest point of its travel arc. The dummy positioned for a shoulder qualification test is shown in Figure 8-11.

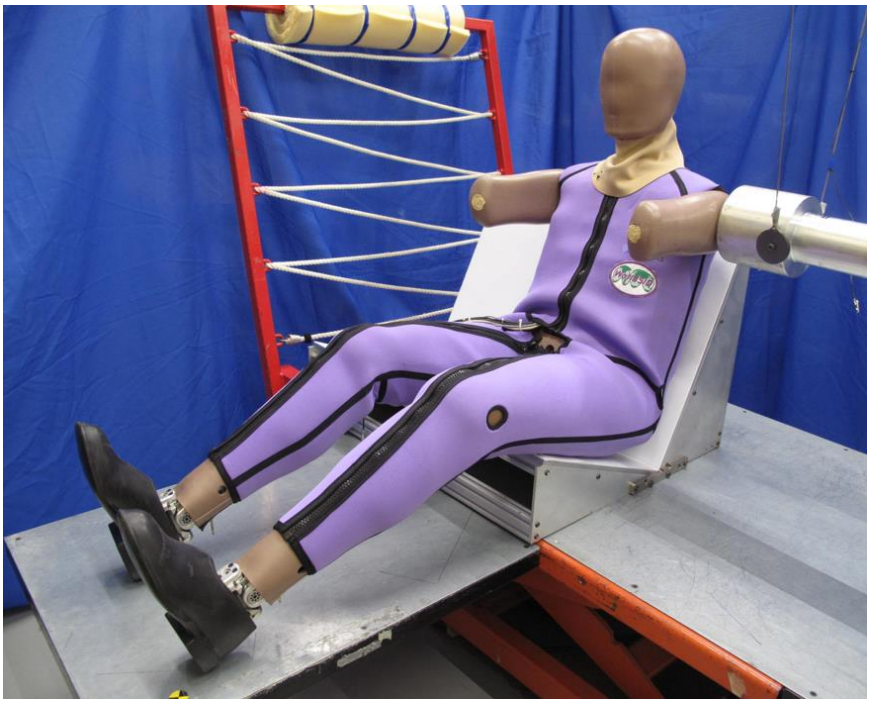

Figure 8-11. Dummy positioned for left side shoulder qualification test.

8.6.5.4 Verify that the test setup parameters are within the specifications shown in Table 8-2.

8.6.5.5 Ensure that at least thirty minutes have elapsed between previous impacts.

8.6.5.6 Record the required channels listed in Table 8-3 in accordance with SAE J211-1.

8.6.5.7 Impact the dummy at 4.3 m/s ± 0.1 m/s.

Table 8-2. Shoulder Qualification Test Setup Parameters

Parameter	Setting
Neck bracket	0°
Head angle	0° ± 2° (x and y-axis)
Thorax angle	0° ± 2° (x and y-axis)
Pelvis angle	0° ± 2° (x-axis), 5° ± 2° (y-axis)
Knee spacing	279 ± 50 mm (center-to-center)
Impact side arm position	Most-raised detent position (nearly horizontal)
Impact location	Center of arm pivot joint
Thorax rib temperature sensor	20.6 to 23.8 °C
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Wait time between tests	30 minutes minimum

Table 8-3. Required Recorded Channels for the Shoulder Qualification Test

Impact Side	Channel Description	ISO MME Code
Left	Impactor Acceleration X	T0IMPA000000ACXP
	Shoulder Left Force Y	D0SHLDLE00WSFOYP
	Shoulder Rib Left Middle Position X	D0SHRILEMIWSDSX0
	Shoulder Rib Left Middle Position Y	D0SHRILEMIWSDSY0
Right	Impactor Acceleration X	T0IMPA000000ACXP
	Shoulder Right Force Y	D0SHLDRI00WSFOYP
	Shoulder Rib Right Middle Position X	D0SHRIRIMIWSDSX0
	Shoulder Rib Right Middle Position Y	D0SHRIRIMIWSDSY0

8.6.6 Data Processing

8.6.6.1 Set T0 (Time Zero) to the time when the impactor first contacts the dummy. First contact can be determined using a contact switch during testing or by the initial rise in impactor acceleration. To keep all data synchronized in time, any adjustment in time to set T0 must be performed on the data from all data systems (in-dummy DAS, test lab DAS and RibEye DAS).

8.6.6.2 Perform bias removal of the recorded channels listed in Table 8-3 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0. Since any required bias removal of the deflection data is performed by the RibEye software as part of the rib length change calculation, no post-test bias removal is required for the RibEye data.

8.6.6.3 Filter channels based on the channel filter classes (CFC) listed in Table 8-4. Since required rib deflection data filtering is performed by the RibEye software, no post-test filtering is required for shoulder rib deflection data.

8.6.6.4 Calculate the time-history of the impactor force.

$$F_{IMP}(t) = m_{IMP} \times a_{IMP}(t)$$

Where: $F_{IMP}(t)$ = *T0IMPA000000FOXC (N)*
m_{IMP} = *mass of impactor (kg)*
$a_{IMP}(t)$ = *T0IMPA000000ACXC (m/s²)*

8.6.6.5 Shoulder rib length change at the middle shoulder LED is calculated by the RibEye software.

Table 8-4. Required Measurements for the Shoulder Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Impactor Acceleration X	180	T0IMPA000000ACXC	XG	AM	PEND	AC	G'S
Impactor Force X	N/A	T0IMPA000000FOXC	XG	CM	PEND	PP	NWT
Left Side Impact							
Shoulder Left Force Y	600	D0SHLDLE00WSFOYB	YL	AM	SHLL	LC	NWT
Shoulder Rib Left Middle Length Change	N/A	D0SHRILEMIWSDSLB	CH	CM	SHLLMI	PP	MM
Right Side Impact							
Shoulder Right Force Y	600	D0SHLDRI00WSFOYB	YL	AM	SHLR	LC	NWT
Shoulder Rib Right Middle Length Change	N/A	D0SHRIRIMIWSDSLB	CH	CM	SHLRMI	PP	MM

8.6.7 Performance Specifications

Table 8-5. Shoulder Qualification Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Laboratory temperature	°C	20.6	22.2
Laboratory relative humidity	%	10.0	70.0
Thorax rib temperature sensor	°C	20.6	23.8
Impact velocity	m/s	4.20	4.40
Peak impactor force	kN	2.62	3.20
Peak shoulder load cell force, y-axis	kN	-1.84	-1.51
Peak shoulder rib length change	mm	34.8	42.5

8.7 Thorax With Arm Qualification

8.7.1 Description

The left or right thorax with arm qualification test is a dynamic impact to the arm/thorax using a 23.36 kg rigid impactor, as described in Section 8.2, at 6.70 m/s. For this test the center of the impactor is aligned with the center of thorax rib 2, and then the half-arm is positioned so that it is interposed between the impactor and the thorax ribs. Since the dummy can be configured for either a left-side or right-side impact, the thorax with arm qualification test is performed on only one side of the dummy.

8.7.2 Materials

Refer to Section 8.2 for material requirements for full-body qualification tests.

8.7.3 Instrumentation

Refer to Section 8.3 for instrumentation requirements for full-body qualification tests.

8.7.4 Pre-Test Procedures

Refer to Section 8.4 for pre-test procedure for full-body qualification tests.

8.7.5 Test Procedure

8.7.5.1 Ensure that the Ribeye sensor lenses have been cleaned as described in Section 8.4.

8.7.5.2 Position the test bench and dummy as described in Section 8.5. Remove the suit and thorax pad on the impact side and align the longitudinal centerline of the impactor with the center of thorax rib 2, as shown in Figure 8-12. While being careful not to move the dummy, reinstall the thorax pad and suit.

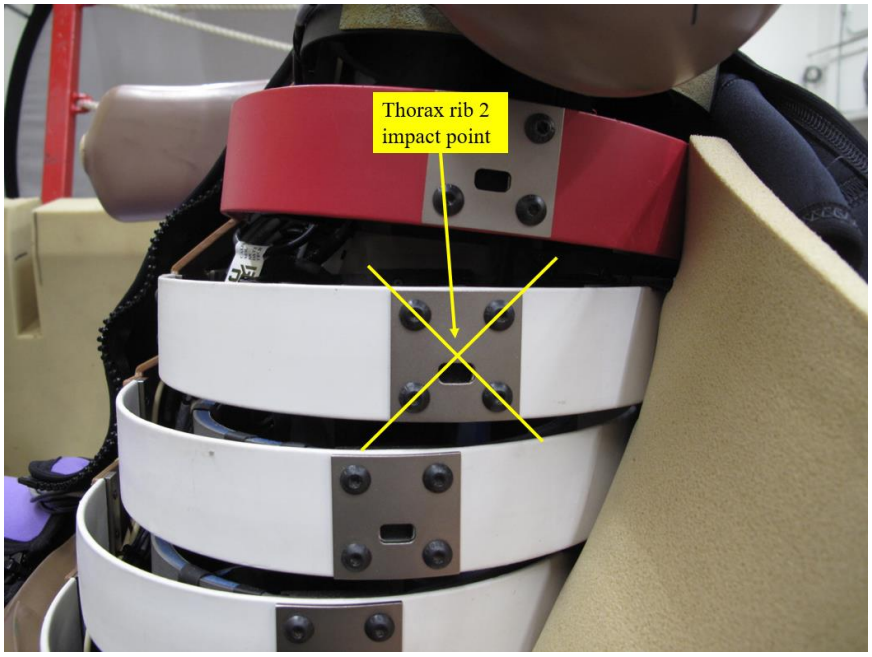

Figure 8-12. Thorax with arm qualification impact point at thorax rib 2.

8.7.5.3 Position the impact side arm in the detent that places the arm in the most lowered position (parallel to thorax). Position the test bench/dummy laterally so that the impactor face first contacts the dummy when the impactor is at the lowest point of its travel arc. The dummy positioned for a left side thorax with arm qualification test is shown in Figure 8-13.

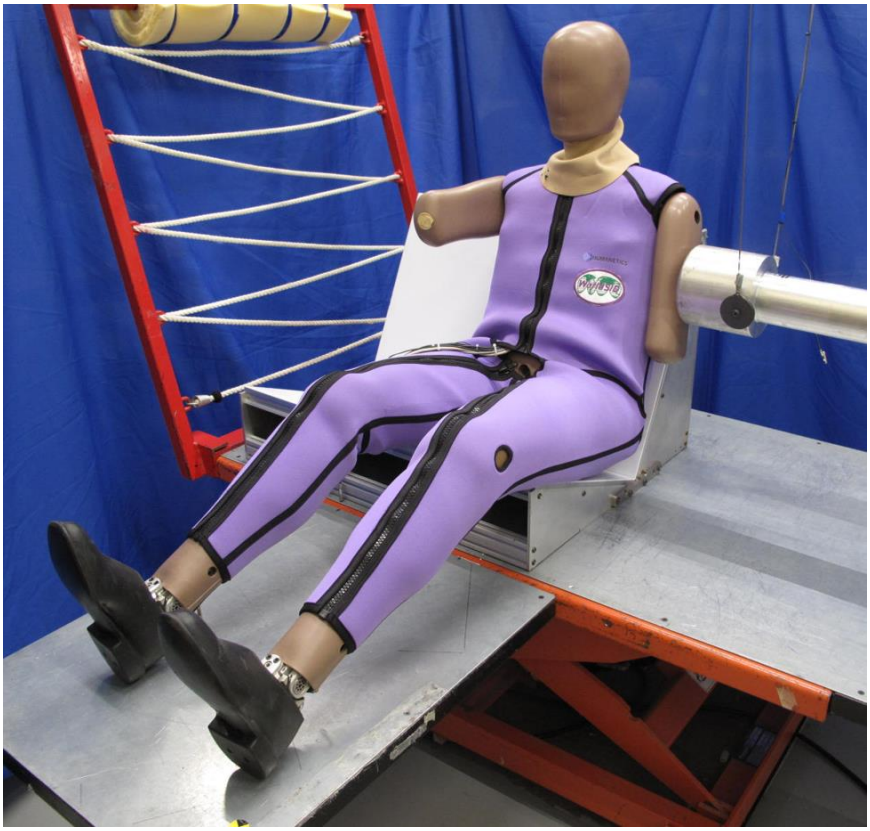

Figure 8-13. Dummy positioned for left side thorax with arm qualification test.

8.7.5.4 Verify that the test setup parameters are within the specifications shown in Table 8-6.

8.7.5.5 Ensure that at least thirty minutes have elapsed between previous impacts.

8.7.5.6 Record the required channels listed in Table 8-7 in accordance with SAE J211-1.

8.7.5.7 Impact the dummy at 6.7 m/s ± 0.1 m/s.

Table 8-6. Thorax With Arm Qualification Test Setup Parameters

Parameter	Setting
Neck bracket	0°
Head angle	0° ± 2° (x and y-axis)
Thorax angle	0° ± 2° (x and y-axis)
Pelvis angle	0° ± 2° (x-axis), 5° ± 2° (y-axis)
Knee spacing	279 ± 50 mm (center-to-center)
Impact side arm position	Most lowered detent position (arm parallel to the thorax)
Impact location	Center of thorax rib 2
Thorax rib temperature sensor	20.6 to 23.8 °C
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Wait time between tests	30 minutes minimum

Table 8-7. Required Recorded Channels for the Thorax with Arm Qualification Test

Impact Side	Channel Description	ISO MME Code
Left	Impactor Acceleration X	T0IMPA000000ACXP
	T4 Acceleration Y	D0THSP0400WSACYP
	T12 Acceleration Y	D0THSP1200WSACYP
	Thorax Rib 1 Left Middle Position X	D0TRRILUMIWSDSX0
	Thorax Rib 1 Left Middle Position Y	D0TRRILUMIWSDSY0
	Thorax Rib 2 Left Middle Position X	D0TRRILMMIWSDSX0
	Thorax Rib 2 Left Middle Position Y	D0TRRILMMIWSDSY0
	Thorax Rib 3 Left Middle Position X	D0TRRILLMIWSDSX0
	Thorax Rib 3 Left Middle Position Y	D0TRRILLMIWSDSY0
Right	Impactor Acceleration X	T0IMPA000000ACXP
	T4 Acceleration Y	D0THSP0400WSACYP
	T12 Acceleration Y	D0THSP1200WSACYP
	Thorax Rib 1 Right Middle Position X	D0TRRIRUMIWSDSX0
	Thorax Rib 1 Right Middle Position Y	D0TRRIRUMIWSDSY0
	Thorax Rib 2 Right Middle Position X	D0TRRIRMMIWSDSX0
	Thorax Rib 2 Right Middle Position Y	D0TRRIRMMIWSDSY0
	Thorax Rib 3 Right Middle Position X	D0TRRIRLMIWSDSX0
	Thorax Rib 3 Right Middle Position Y	D0TRRIRLMIWSDSY0

8.7.6 Data Processing

8.7.6.1 Set T0 (Time Zero) to the time when the impactor first contacts the dummy. First contact can be determined using a contact switch during testing or by the initial rise in impactor acceleration. To keep all data synchronized in time, any adjustment in time to set T0 must be performed on the data from all data systems (in-dummy DAS, test lab DAS and RibEye DAS).

8.7.6.2 Perform bias removal of the recorded channels listed in Table 8-7 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0. Since any required bias removal of the deflection data is performed by the RibEye software as part of the rib length change calculation, no post-test bias removal is required for the RibEye data.

8.7.6.3 Filter channels based on the channel filter classes (CFC) listed in Table 8-8. Since required rib deflection data filtering is performed by the RibEye software, no post-test filtering is required for shoulder rib deflection data.

8.7.6.4 Calculate the time-history of the impactor force.

$$F_{IMP}(t) = m_{IMP} \times a_{IMP}(t)$$

Where: $F_{IMP}(t)$ = *T0IMPA000000FOXC (N)*
m_{IMP} = *mass of impactor (kg)*
$a_{IMP}(t)$ = *T0IMPA000000ACXC (m/s²)*

8.7.6.5 Thorax ribs 1, 2 and 3 length changes at the middle LED are calculated by the RibEye software.

Table 8-8. Required Measurements for the Thorax with Arm Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Impactor Acceleration X	180	T0IMPA000000ACXC	XG	AM	PEND	AC	G'S
Impactor Force X	N/A	T0IMPA000000FOXC	XG	CM	PEND	PP	NWT
T4 Acceleration Y	180	D0THSP0400WSACYC	YL	AM	SPNM	AC	G'S
T12 Acceleration Y	180	D0THSP1200WSACYC	YL	AM	SPNL	AC	G'S
Left Side Impact							
Thorax Rib 1 Left Middle Length Change	N/A	D0TRRILUMIWSDSLB	CH	CM	RBLUMI	PP	MM
Thorax Rib 2 Left Middle Length Change	N/A	D0TRRILMMIWSDSLB	CH	CM	RBLMMI	PP	MM
Thorax Rib 3 Left Middle Length Change	N/A	D0TRRILLMIWSDSLB	CH	CM	RBLLMI	PP	MM
Right Side Impact							
Thorax Rib 1 Right Middle Length Change	N/A	D0TRRIRUMIWSDSLB	CH	CM	RBRUMI	PP	MM
Thorax Rib 2 Right Middle Length Change	N/A	D0TRRIRMMIWSDSLB	CH	CM	RBRMMI	PP	MM
Thorax Rib 3 Right Middle Length Change	N/A	D0TRRIRLMIWSDSLB	CH	CM	RBRLMI	PP	MM

8.7.7 Performance Specifications

Table 8-9. Thorax With Arm Qualification Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Laboratory temperature	°C	20.6	22.2
Laboratory relative humidity	%	10.0	70.0
Thorax rib temperature sensor	°C	20.6	23.8
Impact velocity	m/s	6.60	6.80
Peak impactor force	kN	5.58	6.82
Peak thorax rib 1 length change	mm	36.9	45.1
Peak thorax rib 2 length change	mm	40.4	49.3
Peak thorax rib 3 length change	mm	32.8	40.1
Left Side Impact			
Peak T4 acceleration, y-axis	g	31.3	38.2
Peak T12 acceleration, y-axis	g	23.6	28.9
Right Side Impact			
Peak T4 acceleration, y-axis	g	-38.2	-31.3
Peak T12 acceleration, y-axis	g	-28.9	-23.6

8.8 Thorax Without Arm Qualification

8.8.1 Description

The left or right thorax without arm qualification test is a dynamic impact to the thorax using a 23.86 kg rigid impactor with the modified face attachment, as described in Section 8.2, at 4.30 m/s. The impactor mass of 23.86 kg includes the standard impactor mass of 23.36 kg and the modified face attachment with a mass of 0.5 kg. For this test the center of the impactor is aligned with the center of thorax rib 2 and the impact side half-arm is raised so that the impactor directly contacts the thorax ribs. Since the dummy can be configured for either a left-side or right-side impact, the thorax with arm qualification test is performed on only one side of the dummy.

8.8.2 Materials

Refer to Section 8.2 for material requirements for full-body qualification tests.

8.8.3 Instrumentation

Refer to Section 8.3 for instrumentation requirements for full-body qualification tests.

8.8.4 Pre-Test Procedures

Refer to Section 8.4 for pre-test procedure for full-body qualification tests.

8.8.5 Test Procedure

8.8.5.1 Ensure that the Ribeye sensor lenses have been cleaned as described in Section 8.4.

8.8.5.2 Position the test bench and dummy as described in Section 8.5. Attach the modified impactor face to the front of the impactor making sure that the bottom surface of the impactor face is level within ± 0.2° (Figure 8-14). Remove the suit and thorax pad on the impact side and align the longitudinal centerline of the impactor with the center of thorax rib 2, as shown in Figure 8-15. While being careful not to move the dummy, reinstall the thorax pad and suit.

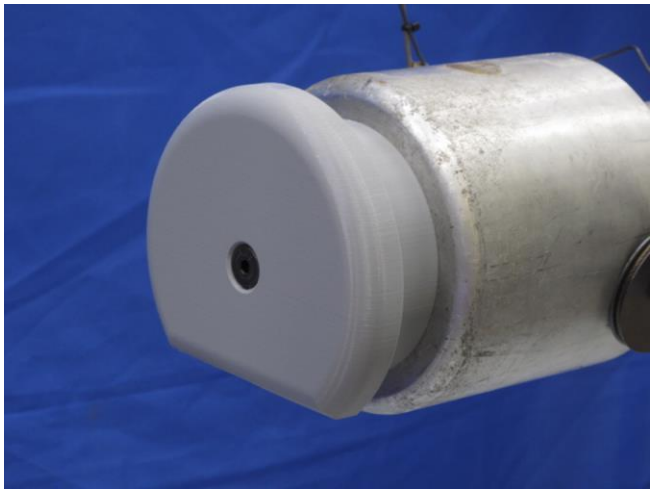

Figure 8-14. Modified impactor face attached to front of impactor.

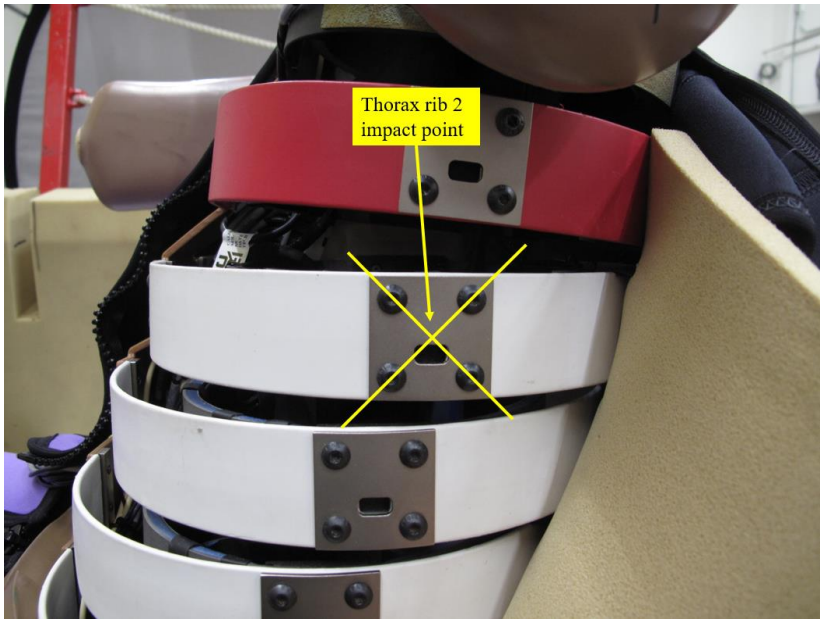

Figure 8-15. Thorax without arm qualification impact point at thorax rib 2.

8.8.5.3 Position the impact side arm vertically upward to completely expose the thorax ribs to the impactor as shown in Figure 8-16. To prevent the impactor from striking the arm, it may be necessary to tape the arm to the head to provide enough clearance between the top of the impactor and the arm. If the arm is taped to the head, the head angle setup parameters shown in Table 8-10 are not applicable.

8.8.5.4 Position the test bench/dummy laterally so that the modified impactor face first contacts the dummy when the impactor at the lowest point of its travel arc. The dummy positioned for a left side thorax without arm qualification test is shown in Figure 8-16.

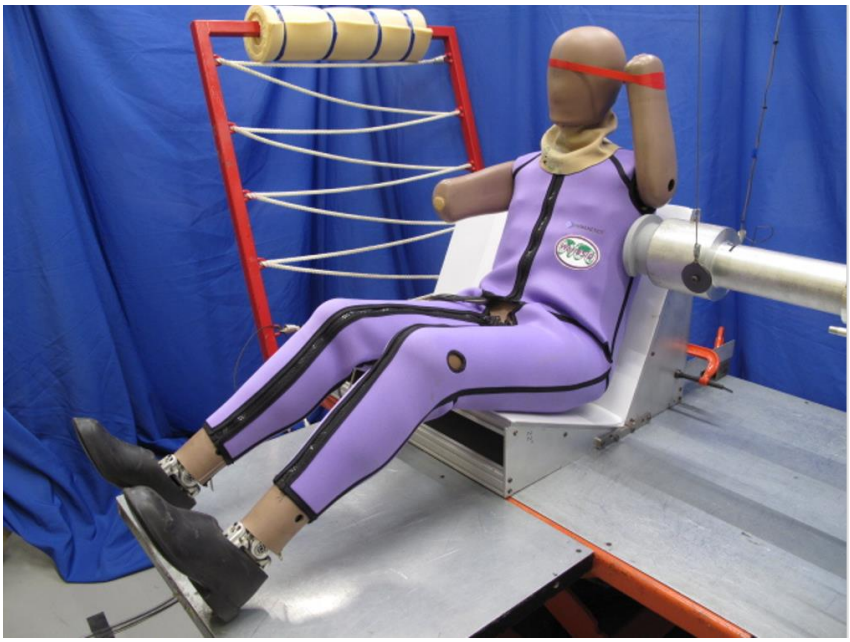

Figure 8-16. Dummy positioned for left side thorax without arm qualification test.

8.8.5.5 Verify that the test setup parameters are within the specifications shown in Table 8-10

8.8.5.6 Ensure that at least thirty minutes have elapsed between previous impacts.

8.8.5.7 Record the required channels listed in Table 8-11 in accordance with SAE J211-1.

8.8.5.8 Impact the dummy at 4.3 m/s ± 0.1 m/s.

Table 8-10. Thorax Without Arm Qualification Test Setup Parameters

Parameter	Setting
Neck bracket	0°
Head angle	0° ± 2° (x and y-axis) N/A if the arm is taped to the head
Thorax angle	0° ± 2° (x and y-axis)
Pelvis angle	0° ± 2° (x-axis), 5° ± 2° (y-axis)
Knee spacing	279 ± 50 mm (center-to-center)
Impact side arm position	Vertical (taped to the head if required for clearance)
Impact location	Center of thorax rib 2
Thorax rib temperature sensor	20.6 to 23.8 °C
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Wait time between tests	30 minutes minimum

Table 8-11. Required Recorded Channels for the Thorax Without Arm Qualification Test

Impact Side	Channel Description	ISO MME Code
Left	Impactor Acceleration X	T0IMPA000000ACXP
	Thorax Rib 1 Left Middle Position X	D0TRRILUMIWSDSX0
	Thorax Rib 1 Left Middle Position Y	D0TRRILUMIWSDSY0
	Thorax Rib 2 Left Middle Position X	D0TRRILMMIWSDSX0
	Thorax Rib 2 Left Middle Position Y	D0TRRILMMIWSDSY0
	Thorax Rib 3 Left Middle Position X	D0TRRILLMIWSDSX0
	Thorax Rib 3 Left Middle Position Y	D0TRRILLMIWSDSY0
Right	Impactor Acceleration X	T0IMPA000000ACXP
	Thorax Rib 1 Right Middle Position X	D0TRRIRUMIWSDSX0
	Thorax Rib 1 Right Middle Position Y	D0TRRIRUMIWSDSY0
	Thorax Rib 2 Right Middle Position X	D0TRRIRMMIWSDSX0
	Thorax Rib 2 Right Middle Position Y	D0TRRIRMMIWSDSY0
	Thorax Rib 3 Right Middle Position X	D0TRRIRLMIWSDSX0
	Thorax Rib 3 Right Middle Position Y	D0TRRIRLMIWSDSY0

8.8.6 Data Processing

8.8.6.1 Set T0 (Time Zero) to the time when the impactor first contacts the dummy. First contact can be determined using a contact switch during testing or by the initial rise in impactor acceleration. To keep all data synchronized in time, any adjustment in time to set T0 must be performed on the data from all data systems (in-dummy DAS, test lab DAS and RibEye DAS).

8.8.6.2 Perform bias removal of the recorded channels listed in Table 8-11 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0. Since any required bias removal of the deflection data is performed by the RibEye software as part of the rib length change calculation, no post-test bias removal is required for the RibEye data.

8.8.6.3 Filter channels based on the channel filter classes (CFC) listed in Table 8-12. Since required rib deflection data filtering is performed by the RibEye software, no post-test filtering is required for shoulder rib deflection data.

8.8.6.4 Calculate the time-history of the impactor force.

$$F_{IMP}(t) = m_{IMP} \times a_{IMP}(t)$$

Where: $F_{IMP}(t)$ = *T0IMPA000000FOXC (N)*
m_{IMP} = *mass of impactor (kg)*
$a_{IMP}(t)$ = *T0IMPA000000ACXC (m/s²)*

8.8.6.5 Thorax ribs 1, 2 and 3 length changes at the middle LED are calculated by the RibEye software.

Table 8-12. Required Measurements for the Thorax Without Arm Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Impactor Acceleration X	180	T0IMPA000000ACXC	XG	AM	PEND	AC	G'S
Impactor Force X	N/A	T0IMPA000000FOXC	XG	CM	PEND	PP	NWT
Left Side Impact							
Thorax Rib 1 Left Middle Length Change	N/A	D0TRRILUMIWSDSLB	CH	CM	RBLUMI	PP	MM
Thorax Rib 2 Left Middle Length Change	N/A	D0TRRILMMIWSDSLB	CH	CM	RBLMMI	PP	MM
Thorax Rib 3 Left Middle Length Change	N/A	D0TRRILLMIWSDSLB	CH	CM	RBLLMI	PP	MM
Right Side Impact							
Thorax Rib 1 Right Middle Length Change	N/A	D0TRRIRUMIWSDSLB	CH	CM	RBRUMI	PP	MM
Thorax Rib 2 Right Middle Length Change	N/A	D0TRRIRMMIWSDSLB	CH	CM	RBRMMI	PP	MM
Thorax Rib 3 Right Middle Length Change	N/A	D0TRRIRLMIWSDSLB	CH	CM	RBRLMI	PP	MM

8.8.7 Performance Specifications

Table 8-13. Thorax Without Arm Qualification Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Laboratory temperature	°C	20.6	22.2
Laboratory relative humidity	%	10.0	70.0
Thorax rib temperature sensor	°C	20.6	23.8
Impact velocity	m/s	4.20	4.40
Peak impactor force	kN	3.25	3.97
Peak thorax rib 1 length change	mm	34.1	41.7
Peak thorax rib 2 length change	mm	36.5	44.6
Peak thorax rib 3 length change	mm	31.6	38.6

8.9 Abdomen Qualification

8.9.1 Description

The left or right abdomen qualification test is a dynamic impact to the abdomen using a 24.36 kg rigid impactor with the armrest simulator face attachment, as described in Section 8.2, at 4.30 m/s. The impactor mass of 24.36 kg includes the standard impactor mass of 23.36 kg and the armrest simulator face attachment with a mass of 1.0 kg. For this test, the center of the impactor is aligned with the center of the space between abdomen rib 1 and abdomen rib 2. The impact side half-arm is positioned in the detent that places the arm in the most-raised position (nearly horizontal). Since the dummy can be configured for either a left-side or right-side impact, the thorax with arm qualification test is performed on only one side of the dummy.

8.9.2 Materials

Refer to Section 8.2 for material requirements for full-body qualification tests.

8.9.3 Instrumentation

Refer to Section 8.3 for instrumentation requirements for full-body qualification tests.

8.9.4 Pre-Test Procedures

Refer to Section 8.4 for pre-test procedure for full-body qualification tests.

8.9.5 Test Procedure

8.9.5.1 Ensure that the Ribeye sensor lenses have been cleaned as described in Section 8.4.

8.9.5.2 Position the test bench and dummy as described in Section 8.5. Attach the armrest simulator to the front of the impactor making sure that the top surface of the impactor face is level within ± 0.2° (Figure 8-17). Remove the suit and thorax pad on the impact side and align the center of the impactor face with the center of the space between abdomen ribs 1 & 2, as shown in Figure 8-18. While being careful not to move the dummy, reinstall the thorax pad and suit.

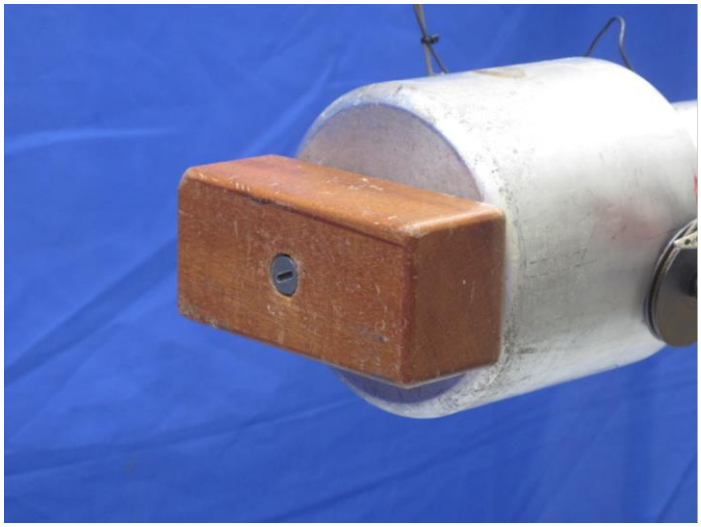

Figure 8-17. Armrest simulator attached to front of impactor

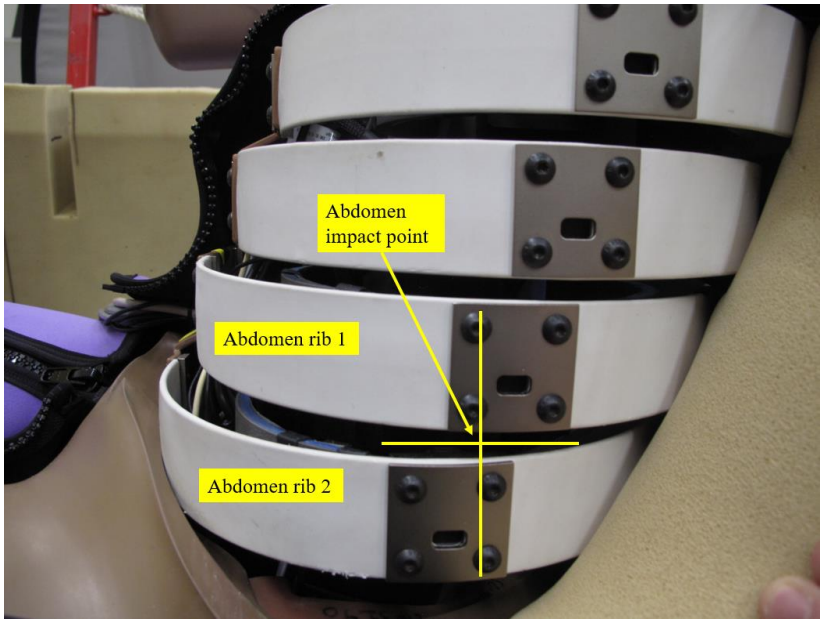

Figure 8-18. Abdomen qualification impact point between abdomen ribs 1 and 2.

8.9.5.3 Position the impact side arm in the detent that places the arm in the most-raised position (nearly horizontal). Position the test bench/dummy laterally so that the armrest simulator face first contacts the dummy when the impactor is at the lowest point of its travel arc. The dummy positioned for a left side abdomen qualification test is shown in Figure 8-19.

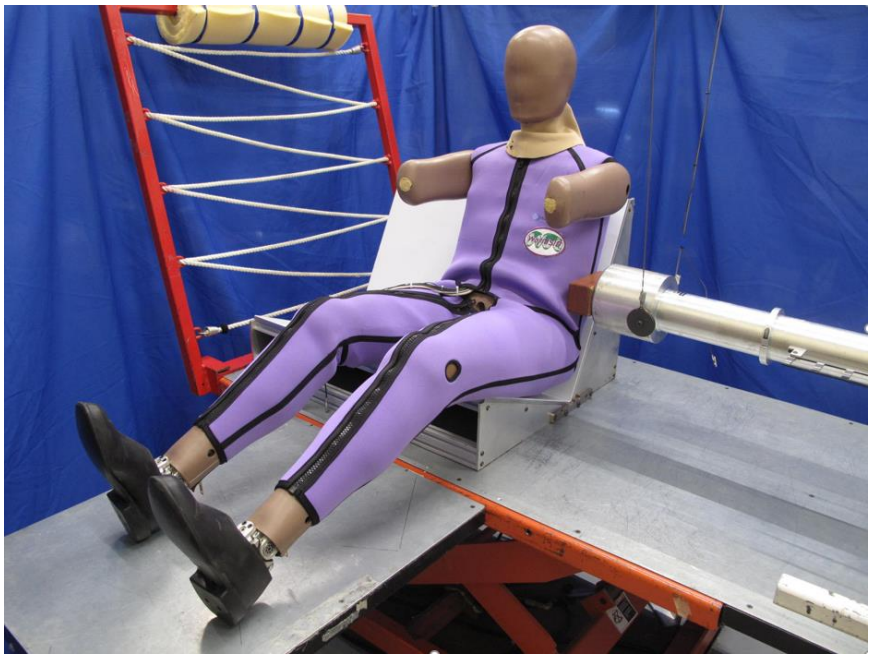

Figure 8-19. Dummy positioned for left side abdomen qualification test.

8.9.5.4 Verify that the test setup parameters are within the specifications shown in Table 8-14.

8.9.5.5 Ensure that at least thirty minutes have elapsed between previous impacts.

8.9.5.6 Record the required channels listed in Table 8-15 in accordance with SAE J211-1.

8.9.5.7 Impact the dummy at 4.3 m/s ± 0.1 m/s.

Table 8-14. Abdomen Qualification Test Setup Parameters

Parameter	Setting
Neck bracket	0°
Head angle	0° ± 2° (x and y-axis)
Thorax angle	0° ± 2° (x and y-axis)
Pelvis angle	0° ± 2° (x-axis), 5° ± 2° (y-axis)
Knee spacing	279 ± 50 mm (center-to-center)
Impact side arm position	Most-raised detent position (nearly horizontal)
Impact location	Midway between abdomen ribs 1 & 2
Thorax rib temperature sensor	20.6 to 23.8 °C
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Wait time between tests	30 minutes minimum

Table 8-15. Required Recorded Channels for the Abdomen Qualification Test

Impact Side	Channel Description	ISO MME Code
Left	Impactor Acceleration X	T0IMPA000000ACXP
	T12 Acceleration Y	D0THSP1200WSACYP
	Abdomen Rib 1 Left Middle Position X	D0ABRILUMIWSDSX0
	Abdomen Rib 1 Left Middle Position Y	D0ABRILUMIWSDSY0
	Abdomen Rib 2 Left Middle Position X	D0ABRILLMIWSDSX0
	Abdomen Rib 2 Left Middle Position Y	D0ABRILLMIWSDSY0
Right	Impactor Acceleration X	T0IMPA000000ACXP
	T12 Acceleration Y	D0THSP1200WSACYP
	Abdomen Rib 1 Right Middle Position X	D0ABRIRUMIWSDSX0
	Abdomen Rib 1 Right Middle Position Y	D0ABRIRUMIWSDSY0
	Abdomen Rib 2 Right Middle Position X	D0ABRIRLMIWSDSX0
	Abdomen Rib 2 Right Middle Position Y	D0ABRIRLMIWSDSY0

8.9.6 Data Processing

8.9.6.1 Set T0 (Time Zero) to the time when the impactor first contacts the dummy. First contact can be determined using a contact switch during testing or by the initial rise in impactor acceleration. To keep all data synchronized in time, any adjustment in time to set T0 must be performed on the data from all data systems (in-dummy DAS, test lab DAS and RibEye DAS).

8.9.6.2 Perform bias removal of the recorded channels listed in Table 8-15 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0. Since any required bias removal of the deflection data is performed by the RibEye software as part of the rib length change calculation, no post-test bias removal is required for the RibEye data.

8.9.6.3 Filter channels based on the channel filter classes (CFC) listed in Table 8-16. Since required rib deflection data filtering is performed by the RibEye software, no post-test filtering is required for shoulder rib deflection data.

8.9.6.4 Calculate the time-history of the impactor force.

$$F_{IMP}(t) = m_{IMP} \times a_{IMP}(t)$$

Where: $F_{IMP}(t)$ = *T0IMPA000000FOXC (N)*
m_{IMP} = *mass of impactor (kg)*
$a_{IMP}(t)$ = *T0IMPA000000ACXC (m/s²)*

8.9.6.5 Abdomen ribs 1 and 2 length changes at the middle LED are calculated by the RibEye software.

Table 8-16. Required Measurements for the Abdomen Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Impactor Acceleration X	180	T0IMPA000000ACXC	XG	AM	PEND	AC	G'S
Impactor Force X	N/A	T0IMPA000000FOXC	XG	CM	PEND	PP	NWT
T12 Acceleration Y	180	D0THSP1200WSACYC	YL	AM	SPNL	AC	G'S
Left Side Impact							
Abdomen Rib 1 Left Middle Length Change	N/A	D0ABRILUMIWSDSLB	CH	CM	RBLUMI	PP	MM
Abdomen Rib 2 Left Middle Length Change	N/A	D0ABRILLMIWSDSLB	CH	CM	RBLLMI	PP	MM
Right Side Impact							
Abdomen Rib 1 Right Middle Length Change	N/A	D0ABRIRUMIWSDSLB	CH	CM	RBRUMI	PP	MM
Abdomen Rib 2 Right Middle Length Change	N/A	D0ABRIRLMIWSDSLB	CH	CM	RBRLMI	PP	MM

8.9.7 Performance Specifications

Table 8-17. Abdomen Qualification Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Laboratory temperature	°C	20.6	22.2
Laboratory relative humidity	%	10.0	70.0
Thorax rib temperature sensor	°C	20.6	23.8
Impact velocity	m/s	4.20	4.40
Peak impactor force	kN	2.88	3.53
Peak abdomen rib 1 length change	mm	31.3	38.3
Peak abdomen rib 2 length change	mm	31.1	38.0
Left Side Impact			
Peak T12 acceleration, y-axis	g	15.6	19.0
Right Side Impact			
Peak T12 acceleration, y-axis	g	-19.0	-15.6

8.10 Pelvis Qualification

8.10.1 Description

The left or right pelvis qualification test is a dynamic impact to the pelvis H-point using a 23.36 kg rigid impactor, as described in Section 8.2, at 6.70 m/s. The impact side half-arm is positioned in the detent that places the arm in the most-raised position (nearly horizontal). Since the dummy can be configured for either a left-side or right-side impact, the pelvis qualification test is performed on only one side of the dummy.

8.10.2 Materials

Refer to Section 8.2 for material requirements for full-body qualification tests.

8.10.3 Instrumentation

Refer to Section 8.3 for instrumentation requirements for full-body qualification tests.

8.10.4 Pre-Test Procedures

Refer to Section 8.4 for pre-test procedure for full-body qualification tests.

8.10.5 Test Procedure

8.10.5.1 Position the test bench and dummy as described in Section 8.5. Insert the H-point tool into the impact side of the pelvis. Align the longitudinal centerline of the impactor with the H-point, as indicated by the locator pin in the H-point tool (Figure 8-20).

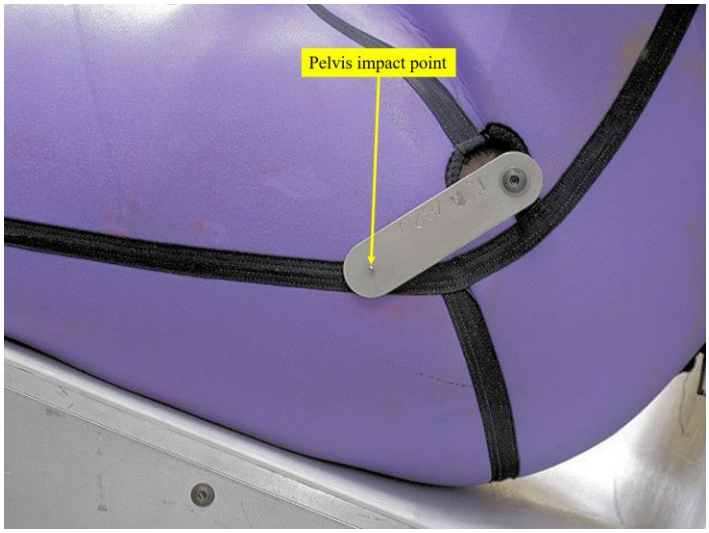

Figure 8-20. Pelvis qualification impact point at H-point.

8.10.5.2 Position the impact side arm in the detent that places the arm in the most-raised position (nearly horizontal). Position the bench/dummy laterally so that the impactor face first contacts the dummy when the impactor is at the lowest point of its travel arc. The dummy positioned for a left side pelvis qualification test is shown in Figure 8-21

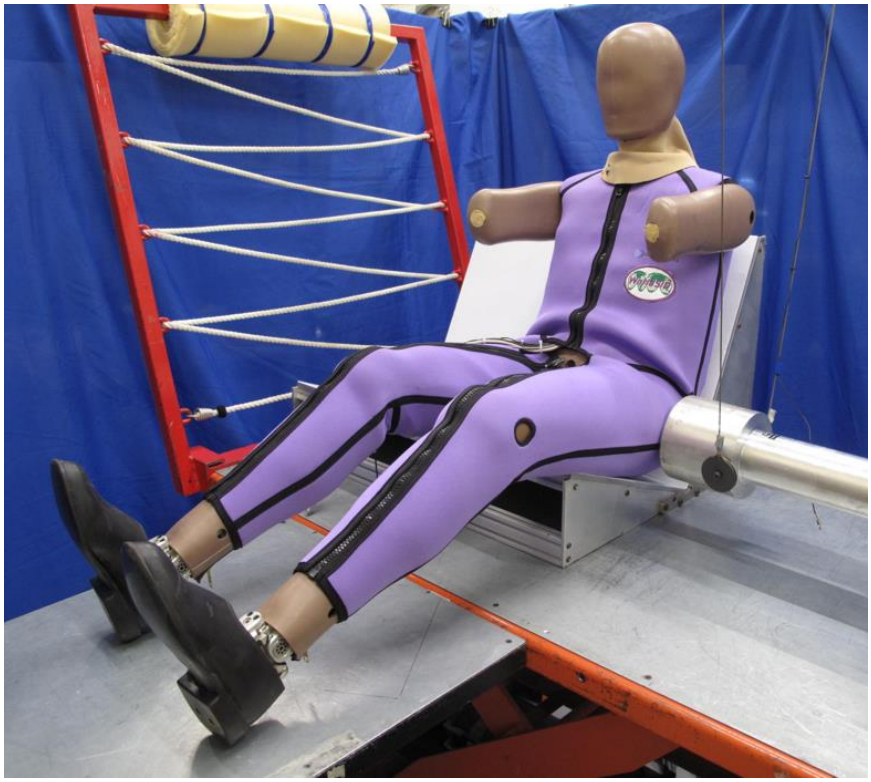

Figure 8-21. Dummy positioned for left side pelvis qualification test.

8.10.5.3 Verify that the test setup parameters are within the specifications shown in Table 8-18.

8.10.5.4 Ensure that at least thirty minutes have elapsed between previous impacts.

8.10.5.5 Record the required channels listed in Table 8-19 in accordance with SAE J211-1

8.10.5.6 Impact the dummy at 6.7 m/s ± 0.1 m/s.

Table 8-18. Pelvis Qualification Test Setup Parameters

Parameter	Setting
Neck bracket	0°
Head angle	0° ± 2° (x and y-axis)
Thorax angle	0° ± 2° (x and y-axis)
Pelvis angle	0° ± 2° (x-axis), 5° ± 2° (y-axis)
Knee spacing	279 ± 50 mm (center-to-center)
Impact side arm position	Most-raised detent position (nearly horizontal)
Impact location	H-point
Thorax rib temperature sensor	20.6 to 23.8 °C
Environmental soak period prior to testing	4 hours minimum at 20.6 to 22.2 °C, 10 to 70% RH
Test environment	20.6 to 22.2 °C, 10 to 70% RH
Wait time between tests	30 minutes minimum

Table 8-19. Required Recorded Channels for the Pelvis Qualification Test

Impact Side	Channel Description	ISO MME Code
Left	Impactor Acceleration X	T0IMPA000000ACXP
	Pelvis Acceleration Y	D0PELV0000WSACYP
	Pubic Symphysis Force Y	D0PUBC0000WSFOYP
	Sacroiliac Left Force Y	D0SACRLE00WSFOYP
Right	Impactor Acceleration X	T0IMPA000000ACXP
	Pelvis Acceleration Y	D0PELV0000WSACYP
	Pubic Symphysis Force Y	D0PUBC0000WSFOYP
	Sacroiliac Right Force Y	D0SACRRI00WSFOYP

8.10.6 Data Processing

8.10.6.1 Set T0 (Time Zero) to the time when the impactor first contacts the dummy. First contact can be determined using a contact switch during testing or by the initial rise in impactor acceleration. To keep all data synchronized in time, any adjustment in time to set T0 must be performed on the data from all data systems (in-dummy DAS and test lab DAS).

8.10.6.2 Perform bias removal of the recorded channels listed in Table 8-19 by subtracting the average value of the data samples over the period between (-.050 s) and (-.010 s) prior to T0.

8.10.6.3 Filter channels based on the channel filter classes (CFC) listed in Table 8-20.

8.10.6.4 Calculate the time-history of the impactor force.

$$F_{IMP}(t) = m_{IMP} \times a_{IMP}(t)$$

Where: $F_{IMP}(t)$ = *T0IMPA000000FOXC (N)*
m_{IMP} = *mass of impactor (kg)*
$a_{IMP}(t)$ = *T0IMPA000000ACXC (m/s²)*

Table 8-20. Required Measurement for the Pelvis Qualification Test

Channel Description	CFC	ISO-MME Code	Axis	DASTAT	SENATT	SENTYP	YUNITS
Impactor Acceleration X	180	T0IMPA000000ACXC	XG	AM	PEND	AC	G'S
Impactor Force X	N/A	T0IMPA000000FOXC	XG	CM	PEND	PP	NWT
Pelvis Acceleration Y	180	D0PELV0000WSACYC	YL	AM	PVSA	AC	G'S
Pubic Symphysis Force Y	600	D0PUBC0000WSFOYB	YL	AM	PVPS	LC	NWT
Left Side Impact							
Sacroiliac Left Force Y	600	D0SACRLE00WSFOYB	YL	AM	PVIL	LC	NWT
Right Side Impact							
Sacroiliac Right Force Y	600	D0SACRRI00WSFOYB	YL	AM	PVIL	LC	NWT

8.10.7 Performance Specifications

Table 8-21. Pelvis Qualification Response Requirements

Parameter	Units	Specification	
		Min.	Max.
Laboratory temperature	°C	20.6	22.2
Laboratory relative humidity	%	10.0	70.0
Thorax rib temperature sensor	°C	20.6	23.8
Impact velocity	m/s	6.60	6.80
Peak impactor force	kN	7.12	8.70
Peak pubic force, y-axis	kN	-1.53	-1.25
Peak sacroiliac force, impact side, y-axis	kN	-2.43	-1.98
Left Side Impact			
Peak pelvis acceleration, y-axis	g	38.0	46.5
Right Side Impact			
Peak pelvis acceleration, y-axis	g	-46.5	-38.0