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Hybrid III Ten-Year Old Child Dummy
User's Manual

RATIONALE

This user's manual is being stabilized because it covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

STABILIZED NOTICE

This document has been declared "STABILIZED" by SAE Dummy Testing and Equipment Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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FOREWORD

Government and industry researchers identified a need for a large-sized child dummy in 2000. An average ten-year-old was selected as the most appropriate size based on a study by Klinich et al., (Klinich, K. D.; Pritz, H. B.; Beebe, M. S.; Welty, K. E. 1994. Survey of older children in automotive restraints. *Thirty-eighth Stapp Car Crash Conference Proceedings*. pp. 245-264. SAE Report No. SAE 942222.) The Hybrid III Family Task Group met to define the size, weight, impact response characteristics and response measurements for a 10-year-old child dummy which would be similar in design to the midsize adult male Hybrid III dummy. Some variations from this design were included to address the multiple applications expected for this size of dummy, which include:

- testing child restraint systems at the upper end of the weight limits
- studying performance of restraint systems in vehicles with and without additional child restraint systems
- evaluating airbag deployment scenarios
- school-bus testing
- pedestrian impact testing

The size and weight specifications of the Hybrid III 10-year-old dummy are generally based on the average characteristic dimensions taken from anthropometry studies of 10-year-old boys and girls. The biofidelic impact response requirements for head, neck, chest, and knees were extrapolated from the corresponding Hybrid III adult male responses taking into account the differences in size, weight, and tissue material properties that exist between children and adults.

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1. SCOPE

This user's manual covers the Hybrid III 10-year old child test dummy. The manual is intended for use by technicians who work with this test device. It covers the construction and clothing, assembly and disassembly, available instrumentation, external dimensions and segment masses, as well as certification and inspection test procedures. It includes guidelines for handling accelerometers, guidelines for flesh repair, and joint adjustment procedures. Finally, it includes drawings for some of the test equipment that is unique to this dummy.

1.1 Manual Overview

1.1.1 Appendices

Several guidelines and procedures apply to various parts throughout the dummy, and are included in the appendices for easier reference. First, when handling an instrumented dummy, improper techniques can damage instrumentation, particularly accelerometers. Appendix A contains guidelines for safe handling of instrumented dummies. Second, the vinyl flesh of dummies can be damaged, but is often repairable. Appendix B contains instructions for repairing dummy flesh. Third, procedures for adjusting the joints throughout the dummy are included in Appendix C.

1.1.2 Other SAE Documents

In addition to the attached appendices, other SAE publications are particularly useful when working with the Hybrid III dummies. SAE J211-1 provides the most recent guidelines and procedures for dummy instrumentation and filtering. SAE Information Report J1733 illustrates the instrumentation available for the Hybrid III dummies, along with descriptions of how to apply the positive right-hand rule sign convention.

1.1.3 Test Definitions

Test procedures are classified as either Certification Tests or Inspection Tests. Certification tests are specified for dummy responses which could affect dummy measurements that are used by governments and safety engineers to assess occupant injury potential. Certification tests are performed by the dummy manufacturer to assure that a new component or assembly meets the SAE specified response requirements. The crash dummy user will periodically perform the certification tests to assure the dummy is maintained at the SAE specified performance levels. Inspection tests are supplemental to the certification tests to ensure that a component meets its design intent. They are performed by the dummy manufacturer on new parts. The dummy user may conduct inspection tests when a part is damaged or replaced.

1.1.4 Part Numbers

All part numbers in this manual refer to the drawing package in the docket of the National Highway Traffic Safety Administration. Copies of the drawing package for this dummy can be obtained from Reprographic Technologies, www.repro-tech.com, 18810 Woodfield Rd., Gaithersburg MD 20879, (301)-670-7874.

1.2 Construction

- One-piece cast aluminum skull with removable vinyl head and cap skins. The vinyl skin has been tuned to give human-like response for forehead impacts. The head is the same one used in the Hybrid III small female dummy.

- A rubber segmented neck that has been tuned to give human-like angle versus moment response in dynamic flexion (forward bending) and extension (rearward bending) articulations.

- Neck can be adjusted to four different positions from 0 to 22°.

- Cable through the neck's longitudinal axis to increase the neck's durability to high axial loads.

- Six spring steel ribs with polymer-based damping materials to provide the chest with a human-like force-deflection response and a minimum deflection space of 60 mm.

- Top and bottom rib stops to control the vertical movement of the rib cage.

- Two methods available for chest deflection measurement: a traditional ball-slider rotary potentiometer mechanism, as well as the IR-TRACC.

- More humanlike shoulder shape.

- Zippered chest jacket for easy removal.

- Cylindrical rubber lumbar spine.

- Pelvis and abdominal assembly has a seated design with vinyl skin and foam flesh molded over an aluminum pelvis casting. Features have been incorporated to allow the dummy to be seated in a humanlike slouched posture when appropriate.

- The thighs contain ball-jointed femurs and retaining rings for hip pivot joint. A knee insert under a vinyl knee impact surface controls impact response. The flesh has a more realistic seated cross section.

1.3 Clothing

When used in testing, the dummy should wear shirt (children's size 10 to 12) and pants (children's 14 to 16) which are thermal knit, waffle weave, 50%/50% polyester and cotton underwear or equivalent. The neckline should be small enough to prevent contact between a shoulder belt and the dummy's skin. The pants should end above the dummy's knee. The shirt and pants should each weigh no more than 0.14 kg (0.31 pound). The shoes should be children's size 2-1/2 wide leather athletic shoe. Each shoe weighs 0.59 kg ± 0.05 kg (1.30 pounds ± 0.10 pound).

1.4 Instrumentation

The following is the instrumentation which the SAE Task Group agreed would be needed to evaluate child restraints and air bag interactions with children of this size, also illustrated in Figure 1:

- Three uniaxial accelerometers in the head

- Two tilt sensors in the head

- Six-channel upper neck load cell

- Six-channel lower neck load cell

- Chest Deflection Rotary Potentiometer or IR-TRACC

- Two accelerometers on the sternum

- Two accelerometers at the back of the spine box

- Triaxial accelerometers in the upper torso and pelvis

- Two-channel shoulder load cells

- Six-channel lumbar spine load cell

- Two-channel anterior superior iliac spine load cells

- Six-channel femur load cell (single axis available)

- Six-channel leg load cells at mid shaft (single axis available)

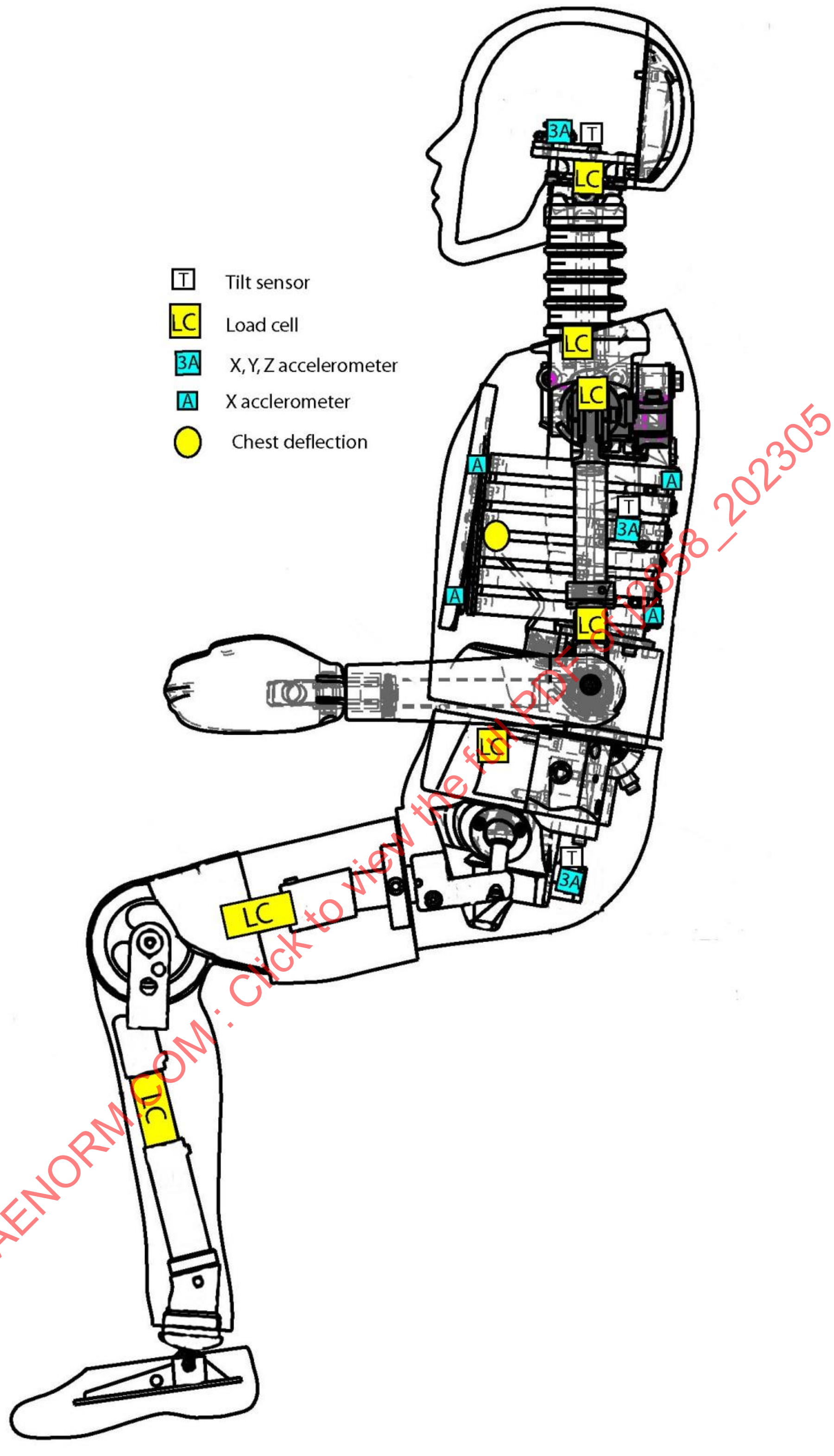

Figure 1 - Instrumentation locations

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J211-1-1 Instrumentation for Impact Test - Part 1 - Electronic Instrumentation

SAE J211-1-2 Instrumentation for Impact Test—Part 2: Photographic Instrumentation

SAE J1733 Sign Convention for Vehicle Crash Testing

SAE J2517 Hybrid III Family Chest Potentiometer Calibration Procedure

3. ABBREVIATIONS

Threaded fastener abbreviations used in manual:

3.1 SHCS

Socket Head Cap Screw

3.2 FHCS

Flat Head Cap Screw

3.3 BHCS

Button Head Cap Screw

3.4 SHSS

Socket Head Shoulder Screw

3.5 SSCP

Socket Screw, Cup Point

4. DISASSEMBLY AND ASSEMBLY PROCEDURES

4.1 Dummy Posture

The Hybrid III 10YO has an adjustable neck and lumbar spine to allow a variety of postures. The neck angle can be set to 0, 8, 16, or 23° relative to the spine box. The lumbar spine can be adjusted from 0 to 24° relative to the top of the pelvis in increments of 4°. Standard upright dummy posture, shown in Figures 2 and 3, is achieved by setting the neck angle at 16° and the lumbar angle at 12°. A standard slouched posture, shown in Figure 4, is achieved by setting the neck angle to 23° and the lumbar angle to 0°. Other slouched postures are also possible.

Figure 2 - Front view of Hybrid III 10YO

Figure 3 - Side view of Hybrid III 10YO in upright posture

Figure 4 - Side view of Hybrid III 10YO in slouched posture

4.2 Head

The head of the 10YO dummy is the same one used on the Hybrid III small female dummy. The small female accelerometer block may be used with the 10YO. However, there is a different accelerometer block available for the 10YO that allows mounting of tilt sensors (Figure 5).

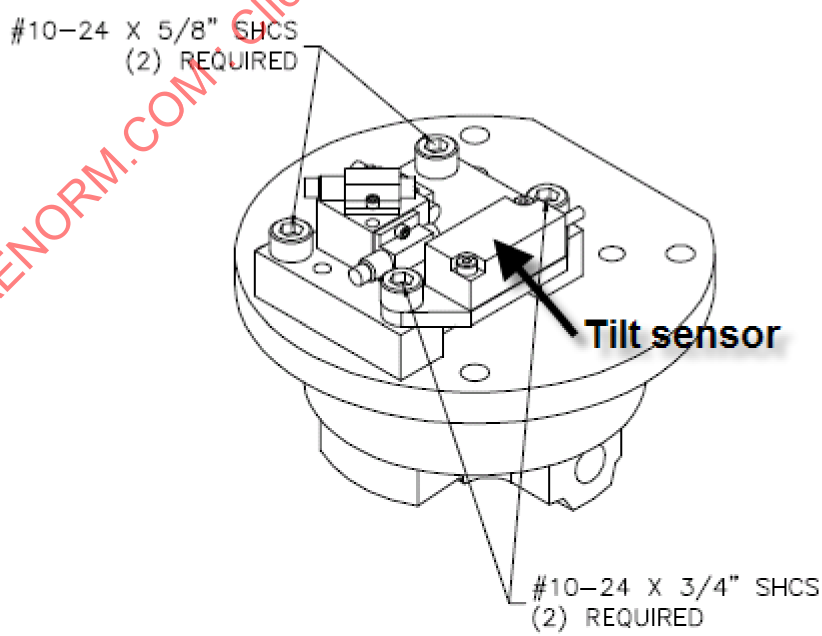

Figure 5 - Optional accelerometer block for the 10YO dummy head

4.3 Neck

Before the neck can be removed, the chest jacket, and the arm/shoulder assemblies should be removed (Figure 6). To reassemble this joint, slip the pivot nut into the bottom part of the shoulder support bracket. Place the shoulder washer into the recess of the pivot nut. Put the shoulder pivot washers on either side of the hole on the shoulder assembly. Place the shoulder assembly and pivot washers into the shoulder support. Insert the SHSS through the flat washer and into the partially assembled shoulder.

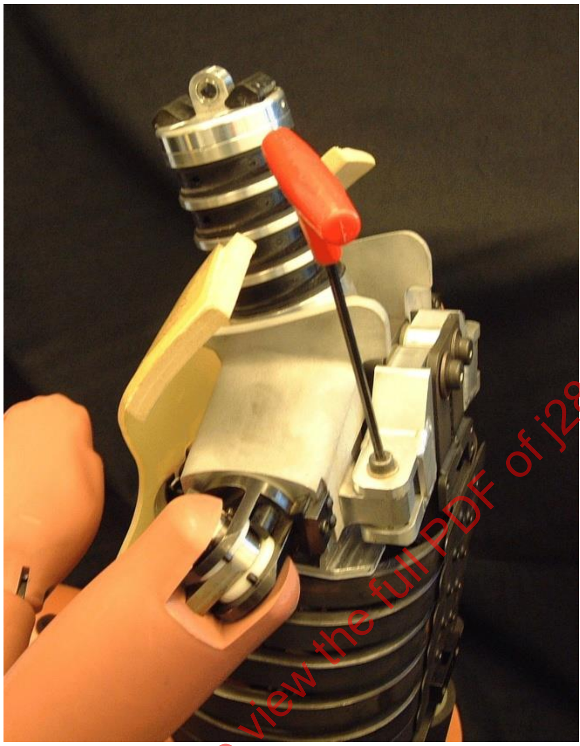

Figure 6 - Remove arm/shoulder assembly to gain access to neck

To adjust the neck angle, loosen the two BHCS shown in Figure 7 - for the left and Figure 8 - for the right. Select the neck angle by removing the shoulder bolt, washers, and nut shown in these figures. Different angles are achieved by inserting the shoulder bolt into different holes as indicated in Figure 9.

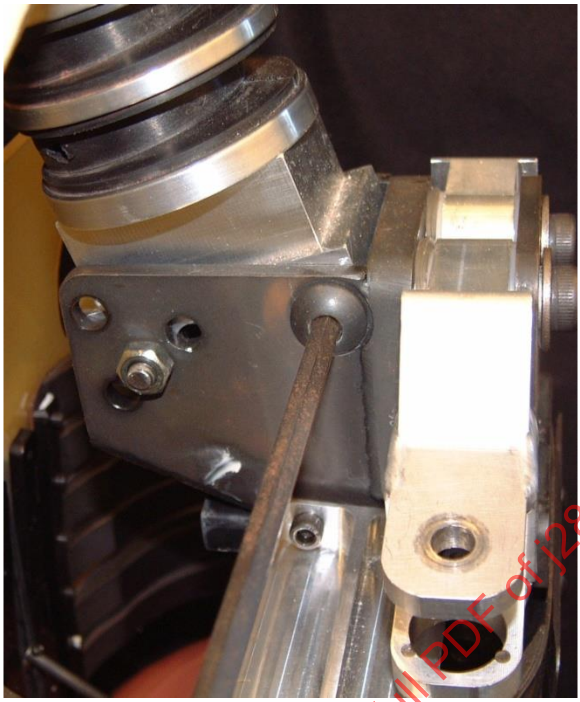

Figure 7 - Left BHCS attaching neck assembly to spine box

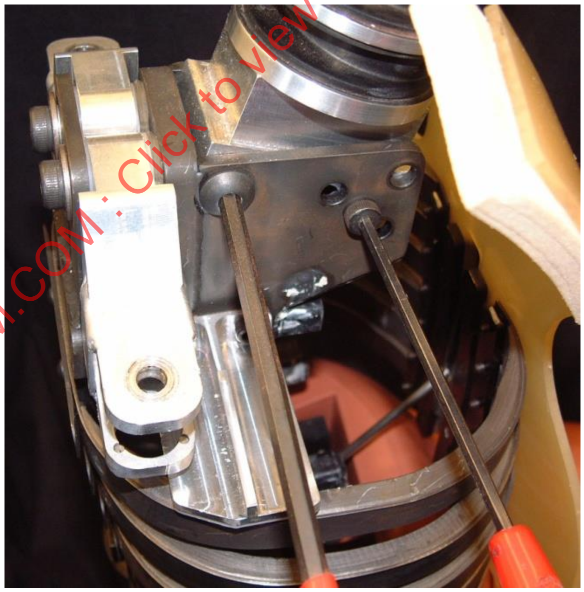

Figure 8 - Right BHCS and adjusting shoulder bolt attaching neck assembly to spine box

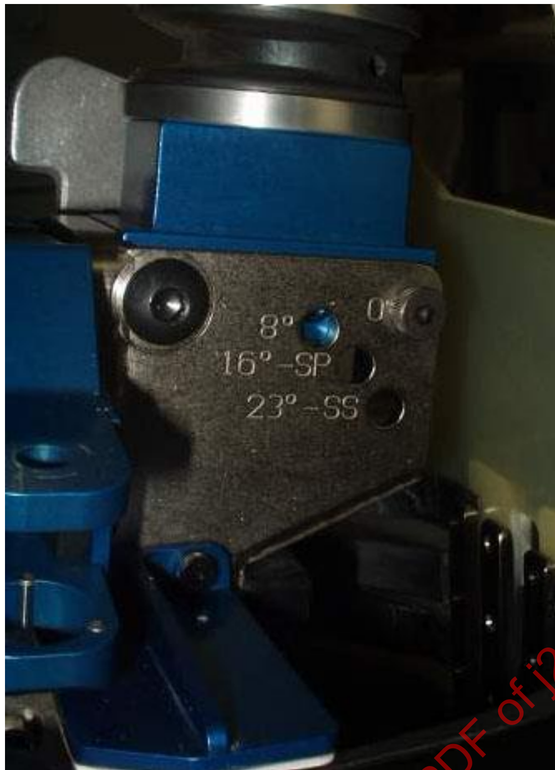

Figure 9 - Right view showing neck angles achieved when placing adjusting shoulder bolt in different positions

To remove the neck assembly, remove the two BHCS and the adjusting shoulder bolt shown in Figure 7 - and Figure 8 -. The components of the neck assembly are shown in Figure 10. To assemble, place the upper bushing on the neck cable, insert the neck cable into the neck, attach the lower bushing, then the washer, and a jam nut. Torque the neck cable to 0.9 Nm ± 0.2 Nm (8 in-lb ± 2 in-lb) using a screwdriver to hold the end of the cable. Add another jam nut. Attach the lower neck load cell with four SHCS; dowel pins orient it so you can't put it on backwards. Place the nodding blocks (same fore and aft) in the nodding joint, and attach the nodding joint with 4 FHCS.

Figure 10 - Components of neck assembly

4.4 Upper Torso/Arms

Remove two modified SHCS that attach the left and right shoulder support assemblies to the spine box. The components of one joint are shown in Figure 11. When reassembling, slip the pivot nut into the spine box weldment. Place the shoulder pivot washers on either side of the shoulder support assembly, and slide them into place on the spine box. Insert the sternum washer between the pivot nut and shoulder pivot washer. Insert the modified screw through the flat washer, spine box, washers, and pivot nut already assembled.

Figure 11 - Components of joint between spine box and shoulder support assembly

Remove upper rib guides, each attached with two SHCS. To remove upper torso from lower torso, take out the abdomen component. Then remove 4 SHCS and washers from either side of the chest deflection transducer assembly as shown in Figure 12.

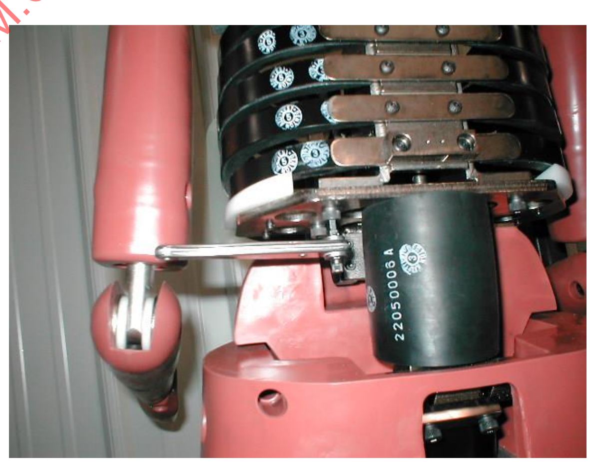

Figure 12 - Removing upper torso from lower torso

Remove left and right plate front rib end stiffener by removing the six BHCS that attach each side (Figure 13); the threaded rib strip on the inside of the ribs (Figure 14) will fall off. Remove the twelve BHCS from the sternum plate to allow the bib to lift off.

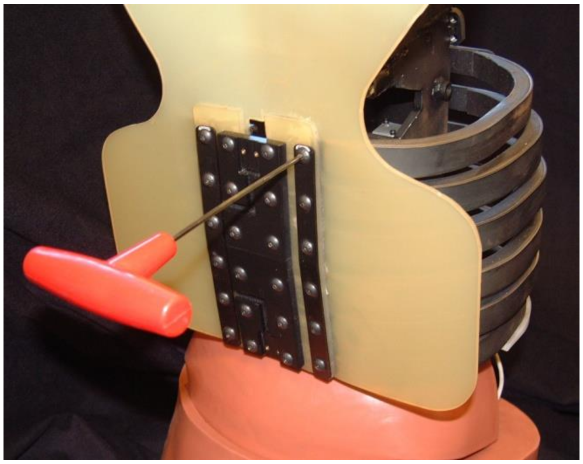

Figure 13 - Removal of front rib end stiffener

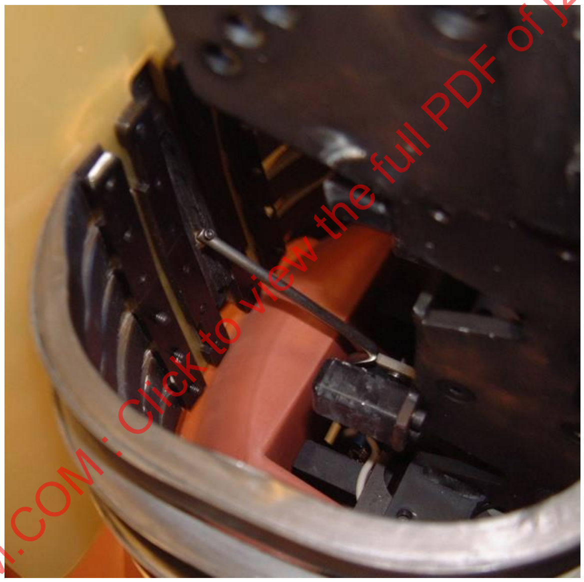

Figure 14 - Threaded rib strip on interior of ribs

Remove back stiffeners by removing the six rib stiffeners attached with twelve BHCS. On the lowest rib, there is a lower thorax accelerometer mount (Figure 15). The upper thorax accelerometer mount is located in the spine box as shown in Figure 16. It is attached with two FHCS accessible on the back of the spine box.

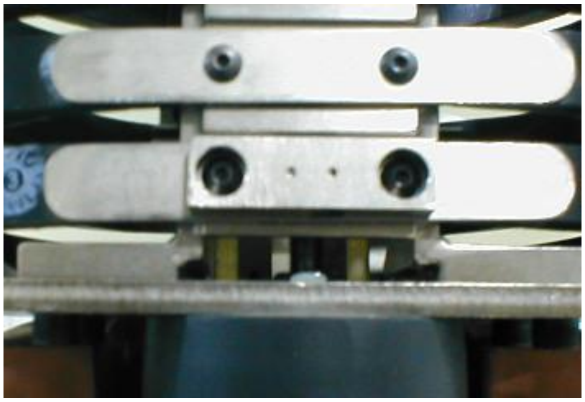

Figure 15 - Back rib stiffeners and posterior lower thorax accelerometer mount

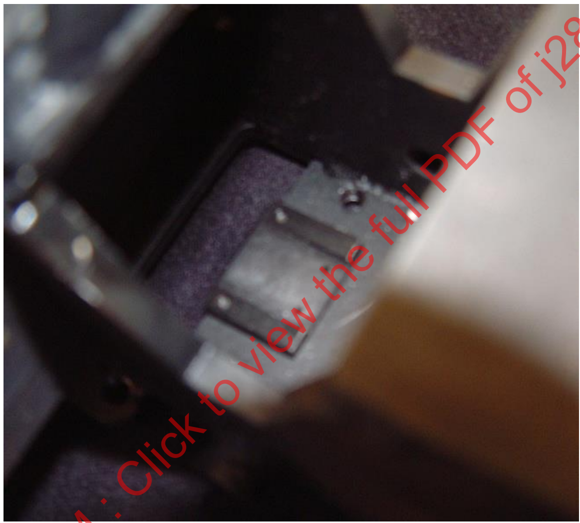

Figure 16 - Location of upper posterior thorax accelerometer

On the front of the sternum, accelerometers can be mounted on the top and bottom of the sternum plate. Slots for the wiring are included in the sternum plate. The upper and lower pairs of accelerometers on the front and back of the thorax need to be oriented the same way so the CG lines up correctly.

4.4.1 Spine Box Disassembly

Detach lower sternum stops from spine box by removing two SHCS each. Detach upper sternum stops by accessing two SHCS through the hole in the back of the spine box.

Remove the stops from the chest deflection transducer assembly by removing 2 SHCS each (Figure 17). Remove thorax instrumentation insert using two FHCS on either side of the spine box. The triaxial accelerometer mount is on top, and also includes a place for a tilt sensor as shown in Figure 18.

Figure 17 - Removing stops from chest deflection transducer assembly

Figure 18 - Thorax instrumentation block used with chest deflection transducer assembly

To disassemble the shoulder (Figure 19), remove the curved piece of the arm stop attached with a SHCS first. Then remove two BHCS to take off square part.

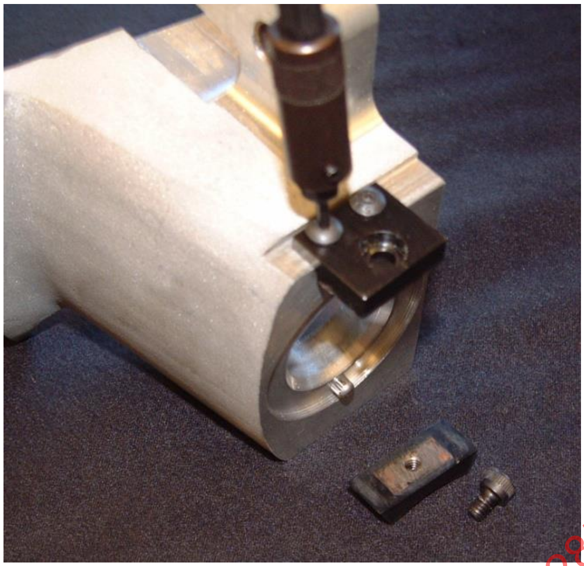

Figure 19 - Removal of shoulder stop components

Begin shoulder assembly by attaching the shoulder stop bracket to the clavicle link assembly using two BHCS. Attach the shoulder stop assembly to the shoulder stop bracket using a SHCS. Attach the steel stop to the shoulder yoke assembly with two SHCS. Insert the shoulder yoke assembly through one of the shoulder yoke pivot bushings. Insert the shoulder yoke assembly through the milled hole in the clavicle link assembly. Place the other shoulder yoke pivot bushing over the shoulder yoke assembly. Then place the retaining washer, the shoulder joint spring washer, and the flat washer over the shoulder yoke assembly, securing it with the hex jam nut.

Figure 20 - Shoulder assembly

The components of the joint between the shoulder assembly and upper arm are shown in Figure 21. This joint has the same components as the elbow joint. To reassemble, place the Delrin hat bushing and Delrin washer on either side of the upper arm. Place the urethane washer into the recess of the Delrin hat bushing. Slide this assembly into the shoulder clevis, with the urethane washer against the large clevis hole. Insert the round threaded nut in the hole of the shoulder clevis closest to the urethane washer. Place the SHSS through the steel washer and through the rest of the joint into the nut. Dowel pins in the shoulder clevis orient the Delrin washers.

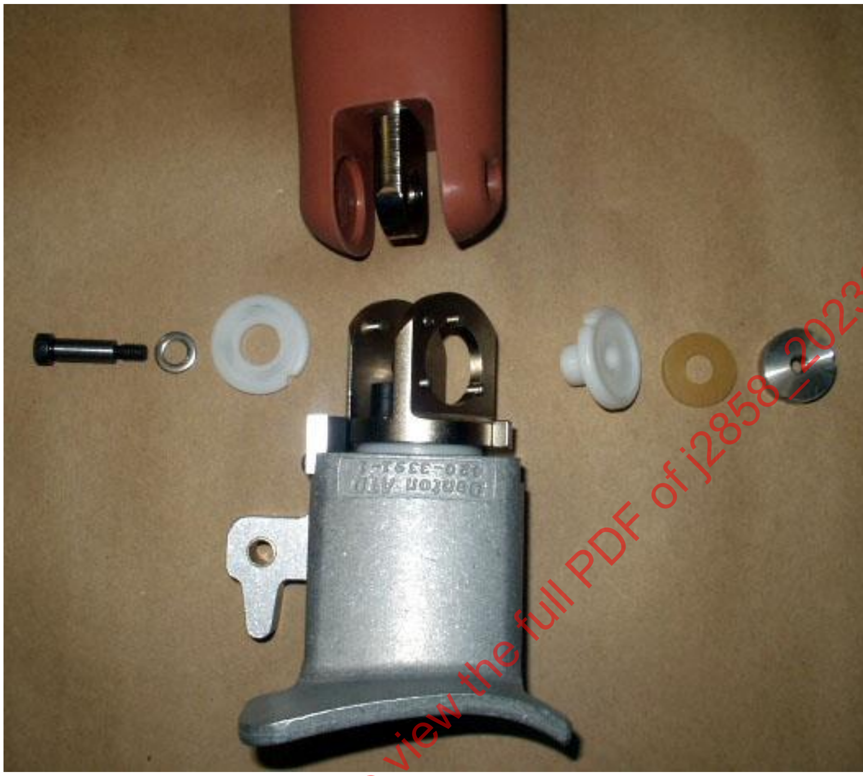

Figure 21 - Components of arm to shoulder joint

A SHCS attaches the hand to the forearm clevis. The clevis, part of the wrist rotation weldment, attaches to the forearm with a SHCS.

4.5 Lower Torso/Legs

To disassemble the pelvis, remove two SHCS from the front of the lower lumbar load cell as shown in Figure 22. Remove pelvis instrumentation block from back of pelvis as shown in Figure 23 by detaching two SHCS. Finish removing the lumbar spine assembly by removing the two SHCS from the bottom of the lumbar load cell, with access through pelvis instrumentation cavity (Figure 23).

Figure 22 - Remove lumbar spine from pelvis using two SHCS accessible from the top

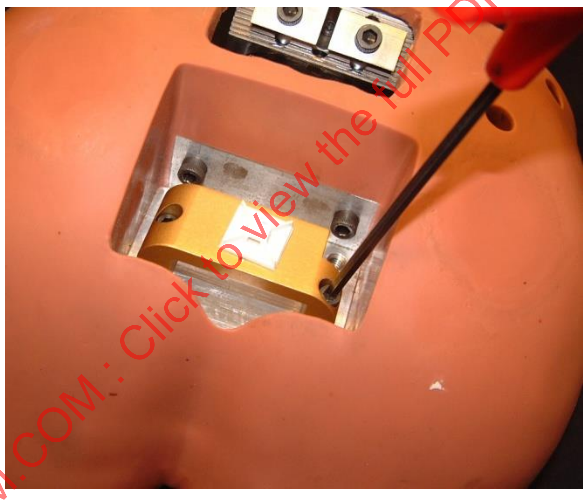

Figure 23 - Removal of pelvic instrumentation block.
The two remaining SHCS that attach the lumbar spine assembly are also shown.

An exploded view of the lumbar spine assembly is shown in Figure 24. To assemble it, place the bushing on the ball end of the cable, insert the cable into the bottom of lumbar spine, add the plastic hat bushing, and add one jam nut. Torque the lumbar cable to 0.9 ± 0.2 (8 in-lb ± 2 in-lb) and attach the second jam nut. The nut end of the lumbar spine is on top. The lumbar attachment bracket connects to the base of the lumbar spine with two SHCS in front and a modified BHCS in back. The lumbar load cell attaches to the lumbar adjustment bracket with four SHCS from the bottom. As shown in Figure 25, the lumbar adjustment bracket is connected to the lumbar attachment bracket with two SHCS and the adjustment bracket nut. A complete lumbar spine assembly shown in Figure 26 shows that angles of adjustment marked from 0 to 24° .

Figure 24 - Exploded view of lumbar spine assembly

Figure 25 - Adjustment of the lumbar spine angle

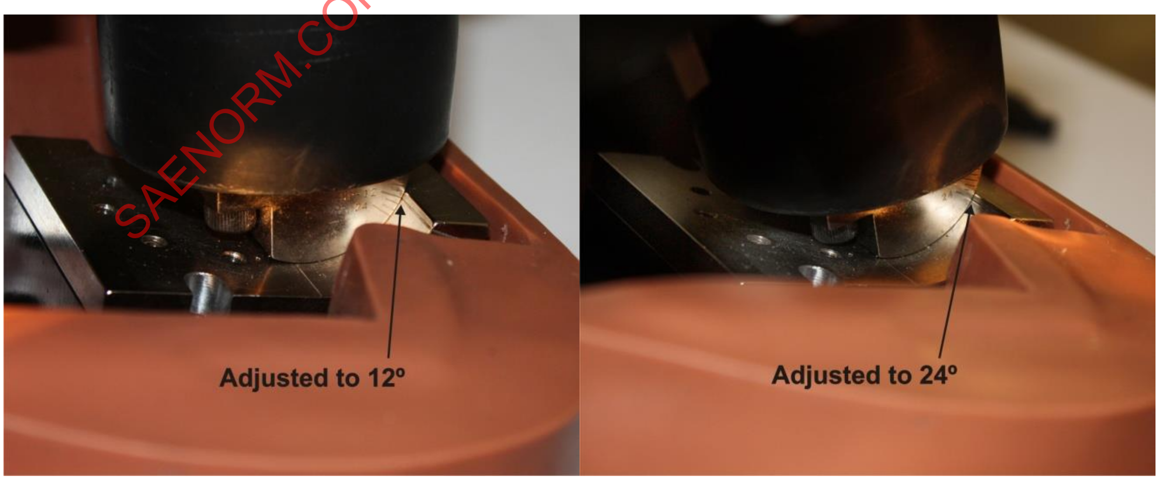

Figure 26 - Lumbar spine assembly, with lumbar adjustment angles marked, and designations for Standard Posture (SP) and Standard Slouched (SS) indicated

Iliac load cells are located in the pelvis and oriented as shown in Figure 27. Each one is attached with two SHCS accessed from the rear of the pelvis as shown in Figure 28.

Figure 27 - Orientation of right iliac load cell

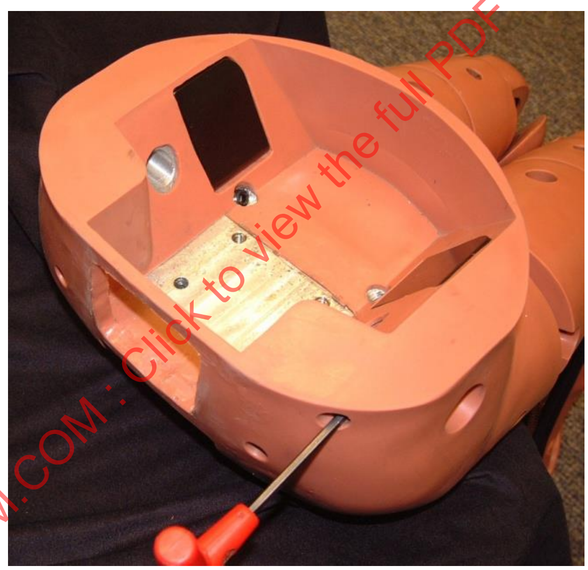

Figure 28 - Access for installing iliac load cells

The friction on the femur joint is set using a nylon-tipped set screw accessible from the pelvis interior. To disassemble the lower extremity, remove the shoulder bolt connecting the thigh to the femur component (Figure 29.) Loosen the set screw on the hip joint. As shown in Figure 30, remove the hip joint from the pelvis by taking out three SHCS, accessible through the three most posterior holes on the side of the dummy pelvis. Access to the bottom SHCS is gained when the femur is twisted inboard.

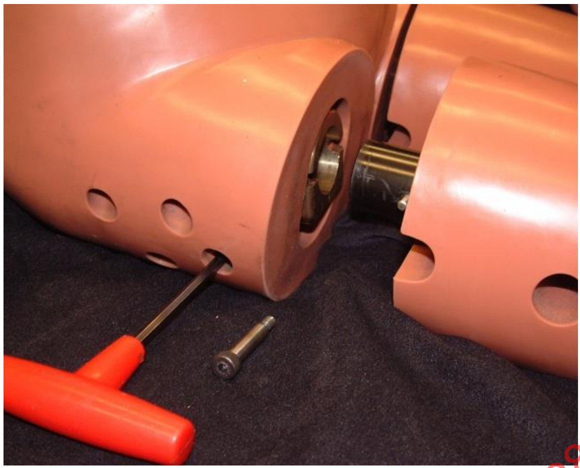

Figure 29 - Shoulder bolt connects thigh to the femur component

Figure 30 - Three SCHS, accessible through three rearmost holes in dummy flesh, connect the hip joint to the pelvis

The thigh and knee assembly are connected by the femur load cell replacement (Figure 31). A SHCS connects the thigh component, while a shoulder bolt connects the knee assembly. If necessary, the bone can be removed from thigh flesh; use alcohol as a lubricant.

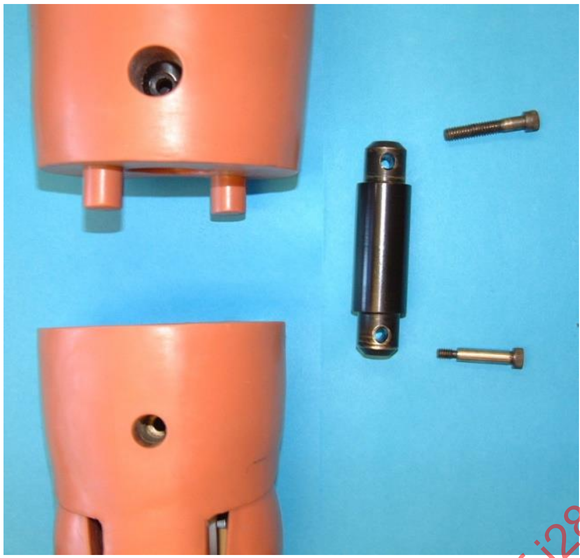

Figure 31 - The thigh and knee assembly are connected by the femur load cell replacement

The lower leg flesh can be kept on when disassembling the knee. An exploded view of the knee joint is shown in Figure 32. The knee joint is assembled in the following order: shoulder bolt, clevis of lower leg, Delrin washer, kneecap, Delrin hat bushing, urethane yoke spring washer, clevis of lower leg, and round threaded nut. Insert a nylon covered screw for the knee rotation stop nylon covered screw.

Figure 32 - Exploded view of knee assembly

An exploded view of the lower leg is shown in Figure 33. The lower leg load cell replacement attaches to the upper and lower parts of the lower leg bone with SHCS.

Figure 33 - Exploded view of lower leg

An exploded view of the ankle joint appears in Figure 34. To assemble, insert the ankle ball into the ankle shell. Attach the lower ankle shell using three FHCS, retaining the ball. Drop the pin in through the slot of the ankle shell so it falls in the track of the ankle ball; the curvier end is in ball. Press the brass stop pin retainer into the ankle shell. Secure it by tightening the two set screws in the lower ankle shell. Attach the ankle bumper to the ankle shell assembly with four BHCS. Use a modified shoulder bolt to connect the ankle shaft to the foot. Insert the nylon bearing and set screw to control friction in the joint.

Figure 34 - Exploded view of ankle joint

5. CERTIFICATION TEST PROCEDURES

DEFINITION: Certification tests are specified for dummy responses which could affect dummy measurements that are used by governments and safety engineers to assess occupant injury potential. Certification tests are performed by the dummy manufacturer to assure that a new component or assembly meets the SAE specified response requirements. The crash dummy user will periodically perform the certification tests to assure the dummy is maintained at the SAE specified performance levels.

5.1 Head Drop Test

A. The test measures the forehead response to frontal impacts with a hard surface.

B. The head assembly consists of:

-- head assembly (880105-100x)

-- 6-channel neck transducer or a structural replacement (78051-383X)

-- head-to-neck pivot pin (78051-339)

-- three accelerometers

The mass of the head assembly is 3.73 kg ± 0.05 kg (8.23 pounds ± 0.10 pound).

C. The test fixture consists of a structure to suspend the head assembly and a rigidly supported, flat, horizontal, steel plate. The square plate should be 50.8 mm ± 2 mm (2.0 inches ± 0.08 inch) thick, with a length and width of 610 mm ± 10 mm (24 inches ± 0.4 inch), and have a smooth surface finish of 8 to 80 microinches/inch rms. A surface finish close to 8 microinch/inch rms is preferred. The suspension system and accelerometer cable masses should be as light as possible to minimize the external forces acting on the head.

D. The Data Acquisition System, including transducers, must conform to the specifications of the latest revision of SAE Recommended Practice J211-1. Filter all data channels using Channel Class 1000 phaseless filters.

E. Test Procedure

1. Visually inspect the head skin for cracks, cuts, or abrasions, etc. Replace the head skin if abrasions or cuts to the frontal area are more than superficial, or repair any minor damage. Torque the 10-24 skull cap screws to 7.5 N·m (66 in-lbf) and the 10-24 accelerometer mount cap screws to 7.5 N·m (66 in-lbf).

2. Soak the head assembly in a controlled environment with a temperature of 18.9 to 25.6 °C (66 to 78 °F) and a relative humidity from 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.

3. Mount the accelerometers in the head on the horizontal transverse bulkhead so the sensitive axes intersect at the Center of Gravity point as defined in drawing number 880105-100x. One accelerometer is aligned with the sensitive axis perpendicular to the horizontal bulkhead in the midsagittal plane ("Z" axis). The second accelerometer is aligned with the sensitive axis parallel to the horizontal bulkhead in the midsagittal plane ("X" axis). The third accelerometer is aligned with the sensitive axis parallel to the horizontal bulkhead and perpendicular to the midsagittal plane ("Y" axis). Ensure that all transducers are properly installed, oriented and calibrated.

4. Prior to the test, clean the impact surface of the skin and the impact plate surface with isopropyl alcohol or an equivalent. The impact surface and the skin must be clean and dry for testing.

5. Suspend the head assembly in a manner similar to that shown in Figure 35. The lowest point on the forehead is 376 mm ± 1.0 mm (14.8 inches ± 0.04 inch) from the impact surface. The lowest point on the forehead is 12.7 mm ± 1 mm (0.5 inch ± 0.04 inch) below the lowest point on the dummy's nose when the midsagittal plane is vertical. The 1.57 mm (0.062 inch) diameter holes located on either side of the dummy's head may be used to ensure that the head is level with respect to the impact surface.

6. Drop the head assembly from a height of 376 mm ± 1 mm (14.8 inches ± 0.04 inch) by a means that ensures a smooth, instant release onto the impact surface.

7. Wait at least 2 hours between successive tests on the same head assembly.

8. Time-zero is defined as the point of contact between the head and the impact surface. All data channels should be at the zero level at this time.

F. Performance Specifications

1. The peak resultant acceleration should be not less than 250 G and not more than 300 G.

2. The resultant acceleration versus time history curve should be unimodal; oscillations occurring after the main pulse should be less than 10% of the peak resultant acceleration.

3. The lateral acceleration should not exceed 15 G.

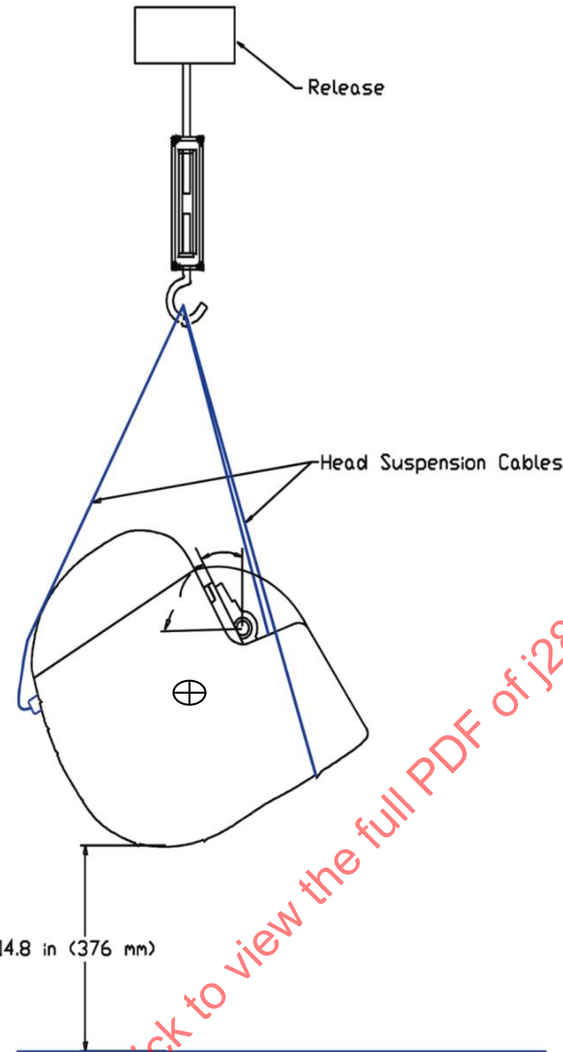

Figure 35 - Head Drop Test Set-Up Specifications

5.2 Neck Tests

A. The components required for the neck tests are:

- -- head assembly (880105-100x)
- -- neck assembly (420 to 2000), with lower neck load cell (420 to 2070) removed
- -- a six-channel neck transducer to measure the "X" axis force and the "Y" axis moment
- -- transducers to measure the rotation of the "D" plane (horizontal plane parallel to the base of the skull) with respect to the pendulum's longitudinal centerline
- -- three actual or simulated accelerometers in the head to maintain the proper weight and center of gravity location; data from the accelerometers are not required.
- -- neck pendulum accelerometer

B. The test fixture pendulum arm with specifications appears in Figure 36. The aluminum honeycomb material is commercial grade, 152.4 mm (6.0 inches) thick, 0.8 kg (1.8 pounds) per ft^3 with 19 mm (0.75 inch) diameter cells. Mount the accelerometer with its sensitive axis aligned with the arc formed at a radius 1657.4 mm (65.25 inches) from the pivot point.

C. The Data Acquisition System, including transducers, must conform to the specifications of the latest revision of SAE Recommended Practice J211-1. Using phaseless filters, filter the neck "force" data channel using Channel Class 1000, the neck "moment" data channel using Channel Class 600, the pendulum acceleration data channel using Channel Class 180, and the neck rotation data channels using Channel Class 180.

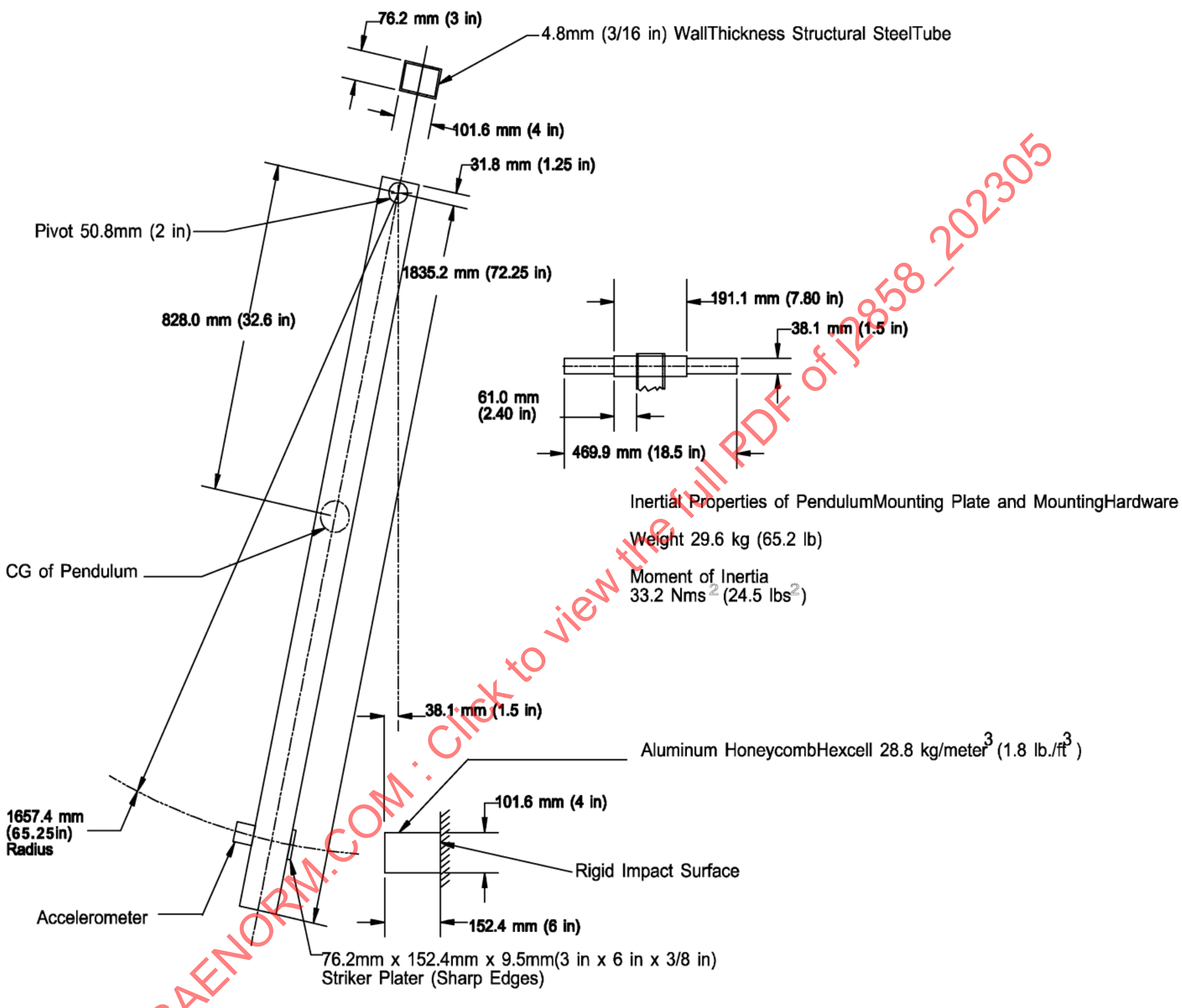

Figure 36 - Neck pendulum arm specifications

D. Test Procedure

1. Soak the neck assembly in a controlled environment at a temperature between 20.6 to 22.2 °C (69 to 72 °F) and a relative humidity from 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. Monitor the temperature of the neck by placing a thermo-sensor into one of the holes in the neck.

2. Inspect the neck assembly for cracks, cuts and separation of the rubber from the metal segments.

3. Inspect the nodding blocks for any deterioration and replace as necessary. The durometer should be 80 to 90 Shore A. Ensure that the nodding blocks are installed correctly.

4. Inspect the nodding joint washers for an interference fit. Adjust or replace as required.

5. Mount the head-neck assembly, with the lower neck bracket removed, so the midsagittal plane of the head is vertical. As shown in Figure 37 for the Flexion test, the midsagittal plane should coincide with the plane of motion of the pendulum's longitudinal centerline.

6. Install the transducers or other devices for measuring the "D" plane rotation with respect to the pendulum longitudinal centerline. These measurement devices should be as light as possible to minimize their influence on the performance of the head-neck assembly.

7. Torque the hex nut on the neck cable to 0.9 N·m ± 0.2 N·m (8 in-lbf ± 2 in-lbf) before each test on the same neck.

8. The number of cells in the honeycomb material required to produce the pendulum input pulse will be different for the flexion and extension tests. The number of cells required may also vary for each sheet and/or batch of material. Prior to the test, pre-crush the honeycomb material by lightly impacting it so the desired honeycomb surface contacts the pendulum striker plate.

9. With the pendulum resting against the honeycomb material, adjust the neck bracket until the longitudinal centerline of the pendulum is perpendicular ±1° to the D-plane on the dummy's head.

10. Wait at least 30 minutes between successive tests on the same neck.

11. Calculate the moment about the occipital condyles for both flexion and extension tests using the formulae:

    Metric Units: Moment (N·m) = [My (N·m) - [0.01778m] [Fx (N)]
    English Units: Moment lbf-ft = {My (ft-lbf)} - {0.05833 ft} {Fx (lbf)}

NOTE: The formulae are based on the sign convention contained in the latest revision of SAE Recommended Practice J211-1, and SAE Information Report J1733.

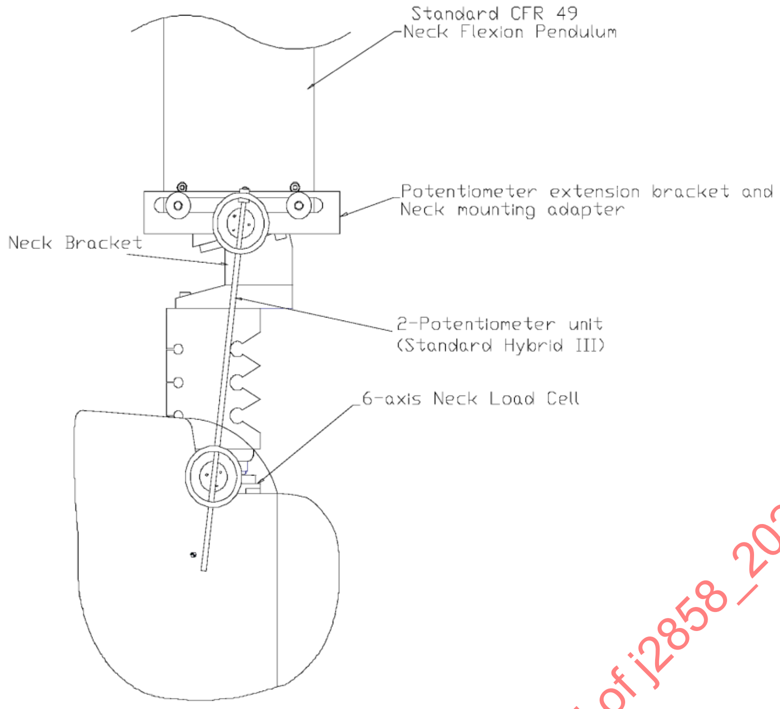

Figure 37 - Instrumentation setup for neck flexion test

E. Performance Specifications - Neck Flexion

1. Release the pendulum and allow it to fall freely from a height to achieve an impact velocity of 6.1 m/s ± 0.12 m/s (20.0 ft/s ± 0.4 ft/s), measured at the center of the accelerometer on the pendulum.

2. Time-zero is defined as the time of initial contact between the pendulum striker plate and the honeycomb material. All data channels should be at the zero level at this time.

3. Stop the pendulum from the initial velocity with an acceleration versus time pulse which meets the velocity change as specified below. Integrate the pendulum acceleration data channel to obtain the velocity versus time curve:

Table 1 - Pendulum impulse specification for neck flexion test

TIME	PENDULUM IMPULSE	
ms	m/s	ft/s
10	1.64-2.04	5.38- 6.69
20	3.04-4.04	9.97-13.25
30	4.45-5.65	14.60-18.53

4. The maximum rotation of the "D" plane of the head should be between 76.5 and 88.5° with respect to the pendulum.

5. The moment about the “Y” axis of the head, measured with respect to the occipital condyles, should have a maximum value during the rotation interval between 50 and 62 N·m (36.9 and 45.7 ft-lbf). The decaying moment versus time curve should cross 10 Nm between 91 and 101 ms after time zero.

F. Performance Specifications - Neck Extension

1. Release the pendulum and allow it to fall freely from a height to achieve an impact velocity of 5.03 m/s ± 0.12 m/s (16.50 ft/s ± 0.40 ft/s), measured at the center of the accelerometer on the pendulum.

2. Time-zero is defined as the time of initial contact between the pendulum striker plate and the honeycomb material. All data channels should be at the zero level at this time.

3. Stop the pendulum from the initial velocity with an acceleration versus time pulse which meets the velocity change as specified below. Integrate the pendulum acceleration versus time curve to determine the velocity versus time curve.

Table 2 - Pendulum impulse specification for neck extension test

TIME	PENDULUM IMPULSE	
ms	m/s	ft/s
10	1.49-1.89	4.89- 6.20
20	2.88-3.68	9.45-12.07
30	4.20-5.20	13.78-17.06

4. The maximum rotation of the "D" plane of the head should be between 96 and 115° with respect to the pendulum.

5. The moment about the “Y” axis of the head, measured with respect to the occipital condyles should have a peak value during the rotation interval between -47 and -36 N·m (-34.7 to -26.6 ft-lbf). The decaying moment versus time curve should first cross the -10 N·m (-7.4 ft-lbf) level between 100 and 114 ms after time zero.

5.3 Thorax Impact Test

A. The complete assembled dummy (420-0000) is required, including the clothing [shirt and pants], but without the shoes.

B. The fixture consists of a smooth, clean, dry, steel seating surface and a rigid test probe. The test probe mass is 6.89 kg ± 0.05 kg (15.2 pounds ± 0.1 pound) including instrumentation, rigid attachments, and the lower 1/3 of the suspension cable mass. The diameter of the impacting face is 121 mm ± 0.13 mm (4.76 inches ± 0.005 inch) and has a flat, right angle face with an edge radius of 12.7 mm (0.5 inch). The minimum moment of inertia for the thorax probe should be 500 lb-in^2 (1463 kg-cm^2). Mount an accelerometer to the probe with its sensitive axis in line with the longitudinal centerline of the test probe.

C. The data acquisition system, including transducers, must conform to the specifications of the latest revision of SAE Recommended Practice J211-1. Filter the pendulum acceleration data channel using Channel Class 180 phaseless filters and the chest deflection data channels using Channel Class 600 phaseless filters.

D. Test Procedure

1. Remove the chest skin and visually inspect the thorax assembly for cracks, cuts, or abrasions. Pay particular attention to the rib damping material on each rib assembly, the chest displacement transducer assembly, and the rear rib supports. Torque the spine cables to 0.9 N·m ± 0.2 N·m (8 in-lbf ± 2 in-lbf). Set the lumbar adjustment angle to 12°. Set the neck angle to 16°.

2. Soak the test dummy in a controlled environment with a temperature of 20.6 to 22.2 °C (69 to 72 °F) and a relative humidity from 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.

3. Check that all transducers are properly installed, oriented and calibrated.

4. Seat the dummy (without the chest skin) on the test fixture surface. The surface must be long enough to support the pelvis and outstretched legs. Level the ribs.

5. Use the chest depth gage to measure the chest depth at rib #1. Insert the gage arm between ribs #1 and #2 with the gage oriented so the RIB1&2 marking is visible. Place the gage so the contact surface touches the spine box near where rib #1 is attached. If the gage touches the threaded strip on the back of the chest bib, the chest depth at rib #1 has decreased below the acceptable range. If so, the ribs should be replaced before continuing with the impact test.

6. Use the chest depth gage to measure the chest depth at rib #5. Insert the gage arm between ribs #5 and #6 with the gage oriented so the RIB5&6 marking is visible. Place the gage so the contact surface touches the spine box near where rib #5 is attached. If the gage touches the threaded strip on the back of the chest bib, the chest depth at rib #5 has decreased below the acceptable range. If so, the ribs should be replaced before continuing with the impact test.

7. Place the arm assemblies horizontal (±2°) and parallel to the midsagittal plane. Using procedure in Appendix C, tighten all limbs to a 1 g setting. Level the ribs both longitudinally and laterally ±0.5° and adjust the pelvis so the D plane angle is 18° with respect to horizontal.

   The midsagittal plane of the dummy is vertical ±1° and within 2° of being parallel to the centerline of the test probe. The longitudinal centerline of the test probe is centered on the midsagittal plane of the dummy within ±3 mm (0.12 inch). Align the test probe so its longitudinal centerline is 12.7 mm ± 1.02 mm (0.5 inch ± 0.04 inch) below the horizontal centerline of the No. 3 rib and is within 0.5° of a horizontal line in the dummy's midsagittal plane.

   After completing the initial setup, record reference measurements from locations such as the rear surfaces of the thoracic spine and the lower neck bracket. These reference measurements are necessary to ensure that the dummy remains in the same position after installing the chest skin. When using a cable-supported test probe, the dummy must be moved rearward from the test probe to account for the thickness of the chest skin, so the probe will impact at the lowest point on its arc of travel. The test set-up appears in Figure 38.

8. Install the chest skin and reposition the dummy as described in the preceding paragraph using the recorded reference measurements. The reference locations must be accessible after installation of the chest skin, so it may be necessary to leave the chest skin unzipped until the references are checked, and then fasten it just prior to the test.

9. Impact the thorax with the test probe so the probe's longitudinal centerline is ±1° of a horizontal line in the dummy's midsagittal plane at the moment of impact.

10. Guide the probe so no significant lateral, vertical or rotational motion takes place during the impact.

11. The test probe velocity at the time of impact is 6.00 ms ± 0.12 ms (22.0 ft/s ± 0.4 ft/s).

12. Time-zero is defined as the time of initial contact between the test probe and the chest skin. All data channels should be at the zero level at this time.

13. Wait at least 30 minutes between successive tests on the same thorax.

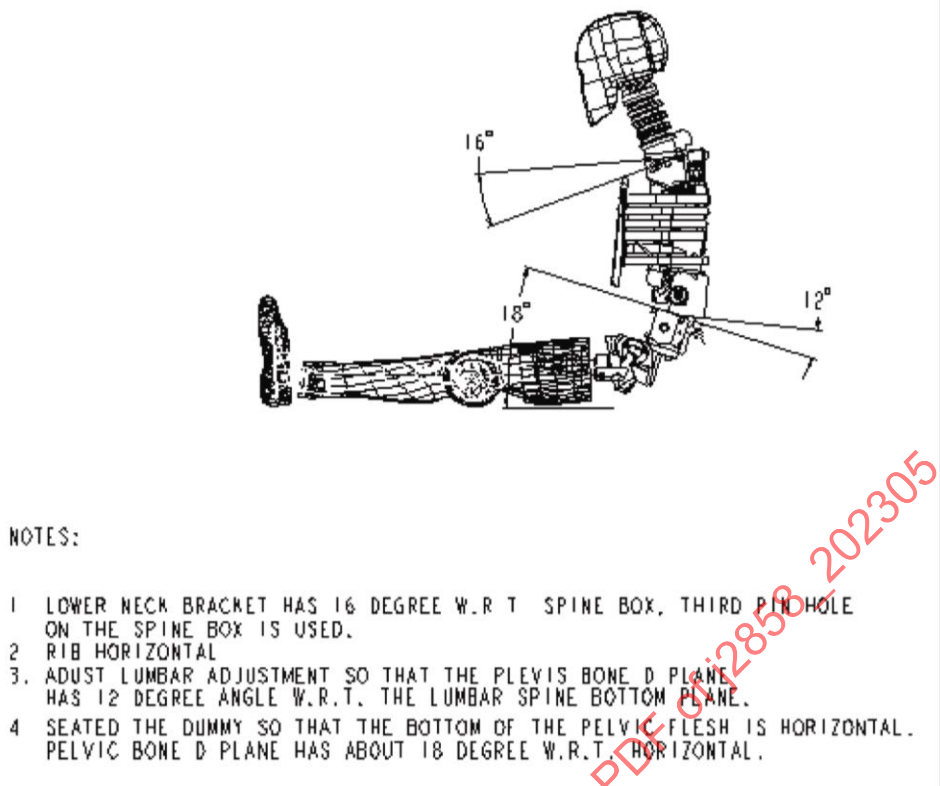

Figure 38 - Thorax impact test setup

E. Performance Specifications

1. The maximum sternum-to-spine deflection, as measured by the chest displacement transducer, should lie between 38.5 and 48.5 mm (1.52 and 1.91 inches).

2. The maximum force within the deflection corridor should be no less than 1.95 kN (438 lbf) and not more than 2.45 kN (551 lbf). Calculate this force by multiplying the test probe acceleration by its mass. The maximum force when the deflection is between 20 and 38.5 mm should be less than 2.45 kN (551 lbf).

3. The internal hysteresis should be greater than 69%, but less than 85%. The hysteresis, determined from the force versus displacement curve, is the ratio of the area between the loading and unloading portions of the curve to the area under the loading portion of the curve as shown in Figure 39.

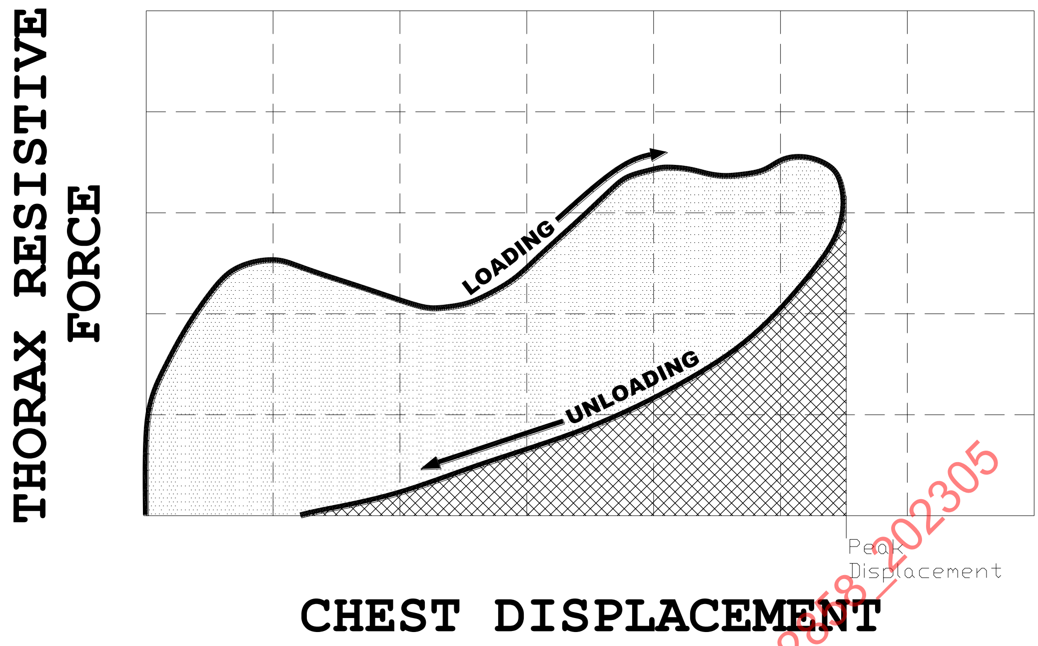

Figure 39 - Hysteresis calculation

6. INSPECTION TEST PROCEDURES

DEFINITION: Inspection tests are supplemental to the certification tests to ensure that a component meets its design intent. They are performed by the dummy manufacturer on new parts. The dummy user may conduct inspection tests when a part is damaged or replaced.

6.1 External Measurements

Procedure:

A. Remove the dummy's chest skin and abdominal insert.

B. Place the dummy on a flat, rigid, smooth, clean, dry, horizontal surface, as shown in Figure 40. The seating surface must be at least 406 mm (16 inches) wide and 406 mm (16 inches) deep, with a vertical section at least 406 mm (16 inches) wide and 914 mm (36 inches) high attached to the rear of the seating fixture.

C. Set the lumbar spine angle so it is 12°. Adjust the neck angle so it is 0°.

D. The D-plane of the pelvis bone is set to 18° with respect to horizontal.

E. Position the dummy so its midsagittal plane should be vertical.

F. Position the dummy's H-point so it is 84.0 mm ± 5.1 mm (3.31 inches ± 0.2 inch) above the seat surface and 138.2 mm ± 5.1 mm (5.44 inches ± 0.2 inch) forward of the rear vertical surface of the fixture. The H-point is located 38 mm (1.497 inches) forward and 55.2 mm (2.172 inches) downward from the center of the pelvic angle reference hole when the pelvis D-plane is horizontal. There will be a gap between the rear surface of the pelvis and the vertical surface.

G. The rear surface of the skull cap should be 48.3 mm ± 2.5 mm (1.9 inches ± 0.10 inch) from the vertical surface of the test fixture. Secure the head in this position.

H. Position the upper and lower legs parallel to the midsagittal plane so the knee and ankle pivot centerlines are parallel, forming a 90° angle between the tibia and femur.

I. Position the feet parallel to the dummy's midsagittal plane, with the bottoms horizontal and parallel to the seating surface.

J. Position the upper arms vertically so the centerlines of the shoulder and elbow pivots are parallel.

K. Position the lower arms horizontally so the centerlines of the elbow and wrist pivots are parallel.

L. Record the following dimensions. Dimensions C, D, and H are set-up dimensions. (The symbols and description for each measurement are indicated.)

Designations:

A. Total Sitting Height - Seat Surface to highest point on top of the head.

B. Shoulder Pivot Height - Centerline of shoulder pivot bolt to the seat surface.

C. Hip Pivot Height - H-point height above seat surface.

D. Hip Pivot from Backline - H-point from seat's rear vertical surface.

E. Shoulder Pivot from Backline with Jacket- Center of the shoulder clevis to the fixture's rear vertical surface.

F. Thigh Clearance - Seat surface to highest point on the upper femur segment.

G. Back of Elbow to Wrist Pivot - The back of the elbow flesh to the wrist pivot, in line with the elbow and wrist pivots.

H. Head Back from Backline - Skull cap skin to seat rear vertical surface.

I. Shoulder to Elbow Length - The highest point on top of the shoulder yoke to the lowest part of the flesh on the elbow, in line with the elbow pivot bolt.

J. Elbow Rest Height - The flesh below the elbow pivot bolt to the seat surface.

K. Backline to Knee Length - The most forward part of the knee flesh to the rear vertical surface of the seat back.

L. Popliteal Height - Seat surface to the horizontal plane at the bottom of the feet, with knee pivot and ankle joint vertical.

M. Knee Pivot to Floor Height - The knee pivot to the horizontal plane at the bottom of the feet.

N. Backline to Calf Length - The rearmost part of the lower leg to the rear vertical surface of the seat back.

O. Chest Depth - The depth of the chest measured at rib #3 without the jacket.

P. Foot Length - Tip of toe to rear of heel.

Q. Backline to Knee Pivot Length - The rear vertical surface of the seat back to the knee pivot bolt.

R. Head Breadth - The widest part of the head.

S. Head Depth - Back of the head to the forehead.

T. Hip Breadth - The widest location of the hips.

U. Shoulder Breadth - Between the outside shoulder edges at the pivot pin, not including flesh.

V. Foot Breadth- The widest part of the foot.

W. Head Circumference - The circumference of the head measured at the point as in measurement "T".

M. Reinstall the chest skin and abdominal insert. Reposition the dummy on the test fixture. Mark the locations and record the chest and waist circumference dimensions.

AA - Reference location for chest circumference measurement – at the center of rib #3.
BB - Reference location for waist circumference measurement – 1 cm below top rear surface of pelvis flesh, parallel to pelvis rim.
Y - Chest Circumference with Jacket – measured at location AA.
Z - Waist Circumference – measured at location BB.

N. Compare the measured dimensions to dimensions in the following table to determine conformance to specifications.

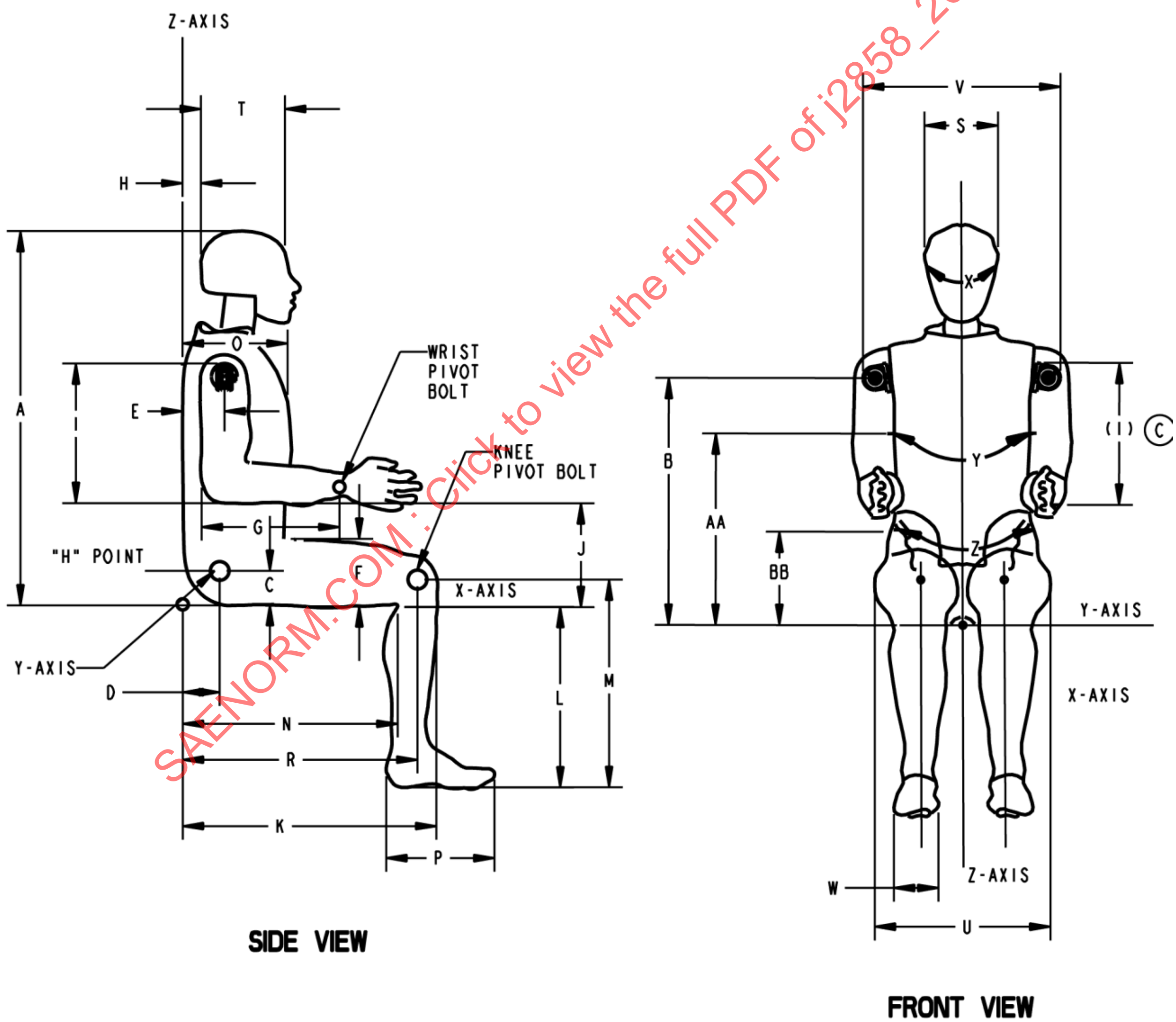

Figure 40 - External dimensions

Table 3 - External dimensions

TEST PARAMETER	DESIGNATION	MM	INCHES
Total Sitting Height	(A)	716 ± 13	28.20 ± 0.50
Shoulder Pivot Height	(B)	395 ± 10	15.55 ± 0.40
Hip Pivot Height	(C)	84 ± 5	3.31 ± 0.20
Hip Pivot from Backline	(D)	138 ± 5	5.44 ± 0.20
Shoulder Pivot from Backline with Jacket	(E)	90 ± 5	3.55 ± 0.20
Thigh Clearance	(F)	113 ± 5	4.45 ± 0.20
Back of Elbow to Wrist Pivot	(G)	235 ± 5	9.25 ± 0.20
Head Back from Backline	(H)	48 ± 5	1.90 ± 0.20
Top of Shoulder to Elbow Length	(I)	277 ± 5	10.90 ± 0.20
Elbow Rest Height	(J)	147 ± 5	5.80 ± 0.20
Backline to Knee Length	(K)	474 ± 5	18.65 ± 0.20
Bottom of Seating Surface to Bottom of Foot	(L)	332 ± 5	13.05 ± 0.20
Knee pivot to Floor Height	(M)	381 ± 8	15.00 ± 0.30
Backline to Rearmost Point of Calf	(N)	377 ± 10	14.85 ± 0.40
Chest Depth without jacket	(O)	165 ± 8	6.50 ± 0.30
Foot Length	(P)	196 ± 8	7.70 ± 0.30
Backline to Knee Pivot Length	(R)	424 ± 10	16.70 ± 0.40
Head Breadth	(S)	142 ± 5	5.60 ± 0.20
Head Depth	(T)	193 ± 5	7.20 ± 0.20
Hip Breadth	(U)	264 ± 5	10.40 ± 0.20
Shoulder Breadth Bone to Bone	(V)	315 ± 8	12.40 ± 0.30
Foot Breadth	(W)	76 ± 8	3.00 ± 0.30
Head Circumference	(X)	539 ± 10	21.20 ± 0.40
Chest Circumference with Jacket	(Y)	704 ± 13	27.70 ± 0.50
Waist Circumference	(Z)	709 ± 13	27.90 ± 0.50
Reference Location for Chest Circumference	(AA)	343 ± 5	13.50 ± 0.20
Reference Location for Waist Circumference	(BB)	See description	

NOTE: *These external dimensions are based upon measurements of production dummies.*