USER MANUAL

Harmonized Hybrid III 50th Male

78051-218-H

Harmonized Hybrid III 50th Male User Manual
78051-9900-H [Rev. A]

HUMANETICS
Innovative Solutions

Left View

Front View

Iso View

Right View

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Section 1. Introduction

1.1. Introduction

1.1.1. History of the User Manual

A group of Hybrid III users met at an SAE workshop held in June, 1984 to learn more about the design and use of the Hybrid III 50th percentile male anthropomorphic test device (ATD or "dummy"). They noted that a user's manual would be helpful. In response, the SAE Dummy Testing Equipment Subcommittee of the Human Biomechanics and Simulation Standards Committee prepared a User's Manual which became SAE Engineering Aid 23, published in June 1986. This manual has since become the basis for manuals on the entire Hybrid III family of dummies. This 1998 revision of Engineering Aid 23 (EA-23) includes modifications which are based on many years' experience with the Hybrid III, and addresses changes incorporated into the dummy. In 2009, J2856 replaced EA-23.

Previous versions of the user manual focused on differences between the Hybrid III and its predecessor, the Part 572 (Hybrid II) dummy. Presented in the user manual is the current accepted practice for calibration procedures.

1.1.2. Hybrid III Development and Features

The most significant user manual differences result from some changes in the Hybrid III dummy itself. One change now calls for using feet with a 45° range of motion rather than 30°; the feet also have a prescribed force-deflection characteristic. The other major change is a redesigned upper femur, which makes the hip joint range of motion more symmetric and biofidelic, and also prevents metal-to-metal contact between the hip bone and the femur. These part changes require additional procedures to ensure the proper range of motion at the hip joint.

The General Motors (GM) Hybrid III dummy shown below in **Figure 1.2.1** was an advancement of the ATD-502 dummy, developed in 1973 by GM under a NHTSA contract.

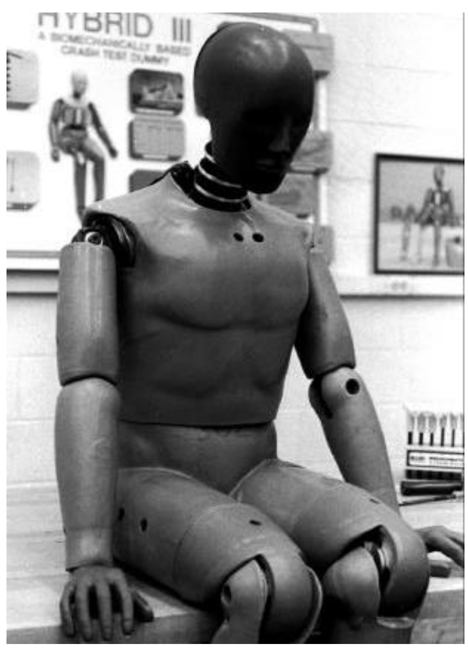

Figure 1.2.1: The GM Hybrid III crash test dummy

The objective of the Hybrid III program was to produce a practical test dummy that would respond to an impact environment approximately as a human, based on the biomechanical data then available. The first version of this dummy became available in 1976 and was documented by Foster, Kortge and Wolanin in a 1977 Stapp Conference paper entitled "Hybrid III -- A Biomechanically Based Crash Test Dummy." A number of improvements have followed.

The head of the Hybrid III dummy is anthropometrically shaped and responds in a similar manner to cadaver heads dropped on rigid surfaces. The head skin thickness is constant over the skull surface. The neck matches neck angle-torque response data in forward (flexion) and rearward (extension) directions for humans seated in automotive posture. Although not required, many users choose to use a neck shield during out-of-position testing to prevent possibly non-biofidelic interaction with air bags. Several styles of neck shield have been used, but none is yet universally accepted. If used, the neck shield should not change the neck bending response or provide a load path that bypasses the neck load cell. The shoulders show durability under shoulder belt loading. The shoulder joint torque remains essentially constant after adjustment. Most movable joints are of the constant friction type, and most have Delrin™-on-steel (or aluminum) surfaces. The adjustments should be checked before each test.

The chest matches the force-deflection characteristics (with rib fracture) of human cadavers from blunt chest impacts, with the force levels increased by 700 N to compensate for the cadavers' lack of muscle tone. The knee also matches cadaver response data. The lumbar spine is curved forward to add humanlike "slouch" to the seated dummy. The spine uses two laterally spaced cables which help stabilize the dummy in the lateral direction. An elastomeric insert over the machined knee and under the outer knee flesh simulation helps provide a soft, humanlike response. The abdomen is constructed of vinyl encased foam. The ankle assemblies now incorporate an ankle bumper which prevents metal to metal contact and controls moment vs. angle in plantar and dorsiflexion as well as in lateral motion. The feet now have 45° range of motion, which matches human ankle range of motion in dorsiflexion. They also have a new construction which controls the response of the sole of the foot to loading. The Hybrid III hip joint range of motion also matches the range of a human hip joint. In addition, the hip joint incorporates a bumper that prevents metal-to-metal contact between the femur and hip bone. Test procedures for the foot and ankle compliance have been added as inspection procedures.

1.2. Getting Familiar with the User's Manual

1.2.1. Reference Materials

Appendices - Several guidelines and procedures apply to various parts throughout the dummy, and are included in Section 13, "Appendices", for easy reference.

- When handling an instrumented dummy, improper techniques can damage instrumentation, particularly accelerometers. **Appendix A** contains guidelines for safe handling of instrumented dummies.
- The vinyl flesh of dummies can be damaged, but is often repairable. **Appendix B** contains instructions for repairing dummy flesh.
- The procedure for validating the axial integrity of the neck is provided in **Appendix C**.

SAE Documents - In addition to the attached appendices, other SAE publications are particularly useful when working with the Hybrid III dummies.

- **SAE J211** provides the most recent guidelines and procedures for dummy instrumentation and filtering.
- **SAE Information Report J1733** illustrates the instrumentation available for the Hybrid III dummy, along with descriptions of how to apply the positive right-hand rule sign convention.

1.2.2. Conventions Used in this Manual

Test and Design Reference Definitions

- **Calibration tests** are specified for dummy responses which could affect dummy measurements that are used by government and safety engineers to assess occupant injury potential. Calibration 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 calibration tests to assure the dummy is maintained at the SAE specified performance levels.

- The additional **European calibration tests** of the Hybrid III 50th percentile male dummy are included in the latest version of the document originally titled EC Directive 96/79/EC, "On the protection of occupants of motor vehicles in the event of a frontal impact." This document can be obtained from the following sources:

    - ✓ European Union Law
      http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Al21251

    - ✓ Global Engineering Documents
      https://global.ihs.com/

- **Inspection tests and design references** are supplemental to the calibration tests to insure 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.

Abbreviations: The following threaded fastener abbreviations are used in this manual:

- **SHCS**: Socket Head Cap Screw
- **FHCS**: Flat Head Cap Screw
- **BHCS**: Button Head Cap Screw
- **SHSS**: Socket Head Shoulder Screw
- **SSCP**: Socket Screw, Cup Point
- **RHMS**: Round Head Machine Screw

Section 2. Dummy Preparation and Use

2.1. General

Every newly purchased Hybrid III dummy should be completely disassembled and compared against the latest engineering drawing package. Pay particular attention to parts critical to the performance of the dummy qualification tests. The following procedures will help verify that the newly purchased dummy conforms to the engineering drawing package. These procedures will also provide the basis to validate the dynamic component responses of the dummy.

Several guidelines and procedures apply to various parts throughout the dummy, and are included in the following sections for easy 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. Appendix C contains procedures for adjusting the joints throughout the dummy.

In addition to the material in this manual, numerous SAE publications are particularly useful when working with the Hybrid III dummy. 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 dummy, along with descriptions of how to apply the positive right-hand rule sign convention.

2.1.1. Recommended Tools

The following tools are recommended to assemble, disassemble and calibrate the Hybrid III 50th percentile male dummy. For information concerning tool availability, contact the dummy manufacturers.

- Neck compression tool
- Ball hex wrench set
- Lumbar cable nut wrench
- Pelvis angle measurement tool (78051-532)
- Head skin thickness gauge
- Chest depth gauge (83-5006-007)
- Clavicle washer alignment tool
- (Submarining pelvis only) Iliac bolt removal tool

2.1.2. Disassembling the Body Assemblies

The process of disassembling the various dummy sub-assemblies and components is explained in detail within the major sections for each body segment assembly.

2.1.3. Assembling the Body Assemblies

Assembling the various dummy sub-assemblies and components is just a reversal of the disassembly process. Remarks within the sections for each assembly are confined to special considerations that are unique to that assembly.

2.2. Joint Resistive Torque Adjustments

The joints of the Hybrid III dummies are adjusted to a “1 G suspended setting.” This is defined as a torque level on the joint where the friction will allow an assembly to move toward the earth when a small force is applied to the unsupported end of the assembly. For example, when the dummy’s arm is fully extended laterally so it is perpendicular to the body, the shoulder yoke clevis bolt should be tight enough to support the weight of the arm, but loose enough so when you tap the dummy's wrist, the whole arm will slowly fall towards the dummy.

The following sections describe how to position the body parts and which joints to tighten to allow a 1.0 G setting.

2.2.1. Hands and Arms

Refer to **Figure 2.2.1.1** while completing the steps below.

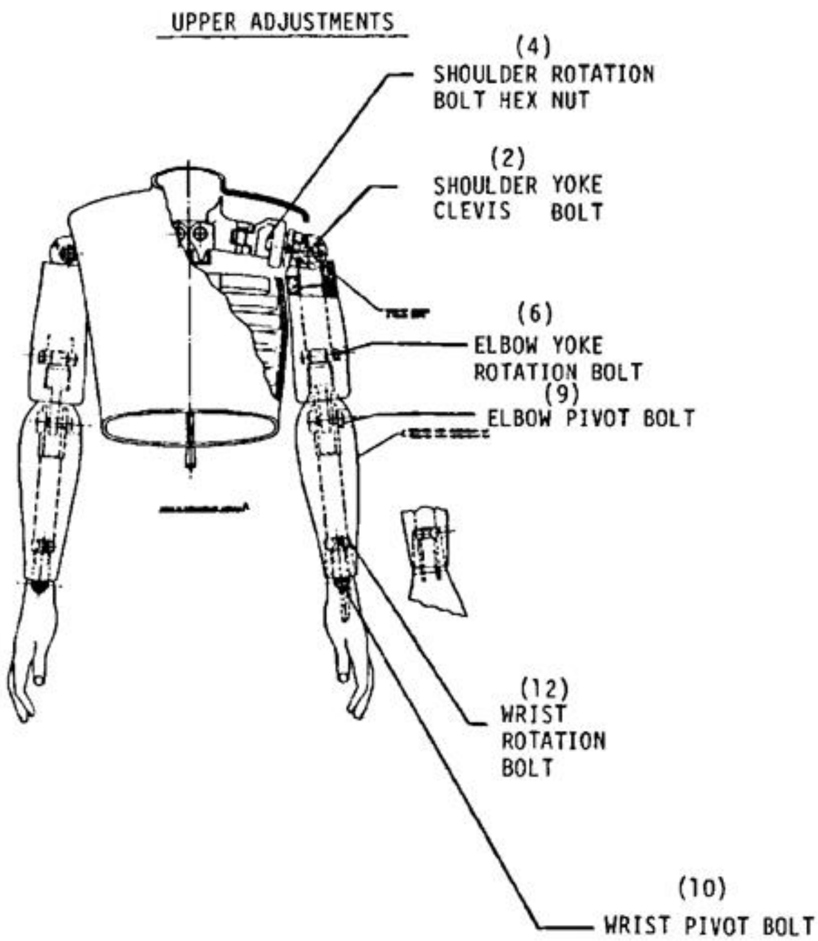

Figure 2.2.1.1: Hybrid III hand and arm joints requiring adjustment

Step 1. Extend complete arm laterally outward to a horizontal position. Twist the arm so the elbow cannot rotate downward. Tighten the shoulder yoke clevis bolt so the arm is suspended at 1.0 G.

Step 2. Rotate the complete arm assembly so it points forward and is horizontal. Twist the arm so the elbow cannot rotate downward. Adjust the shoulder yoke rotation hex nut so the arm is suspended at 1 G.

Step 3. Bend the elbow 90 degrees so the hand moves toward the chest. Adjust the elbow rotation bolt through access in the upper arm to hold the lower arm horizontally suspended at 1 G.

Step 4. Reposition the arm so it points forward and is horizontal. Twist the lower arm at the elbow, so the lower arm can pivot downward to vertical.

Step 5. Adjust the elbow pivot bolt through access holes in the lower arm flesh at the elbow to hold the lower arm suspended at 1 G.

Step 6. Extend the arm and twist the palm so it faces down. Adjust the wrist pivot bolt at the base of the hand so it is suspended at 1 G.

Step 7. Adjust the wrist rotation bolt through access in the wrist flesh to suspend it at 1 G.

Step 8. Repeat this procedure for the other hand and arm.

2.2.2. Legs and Feet

Refer to **Figure 2.2.2.1** while completing the steps below.

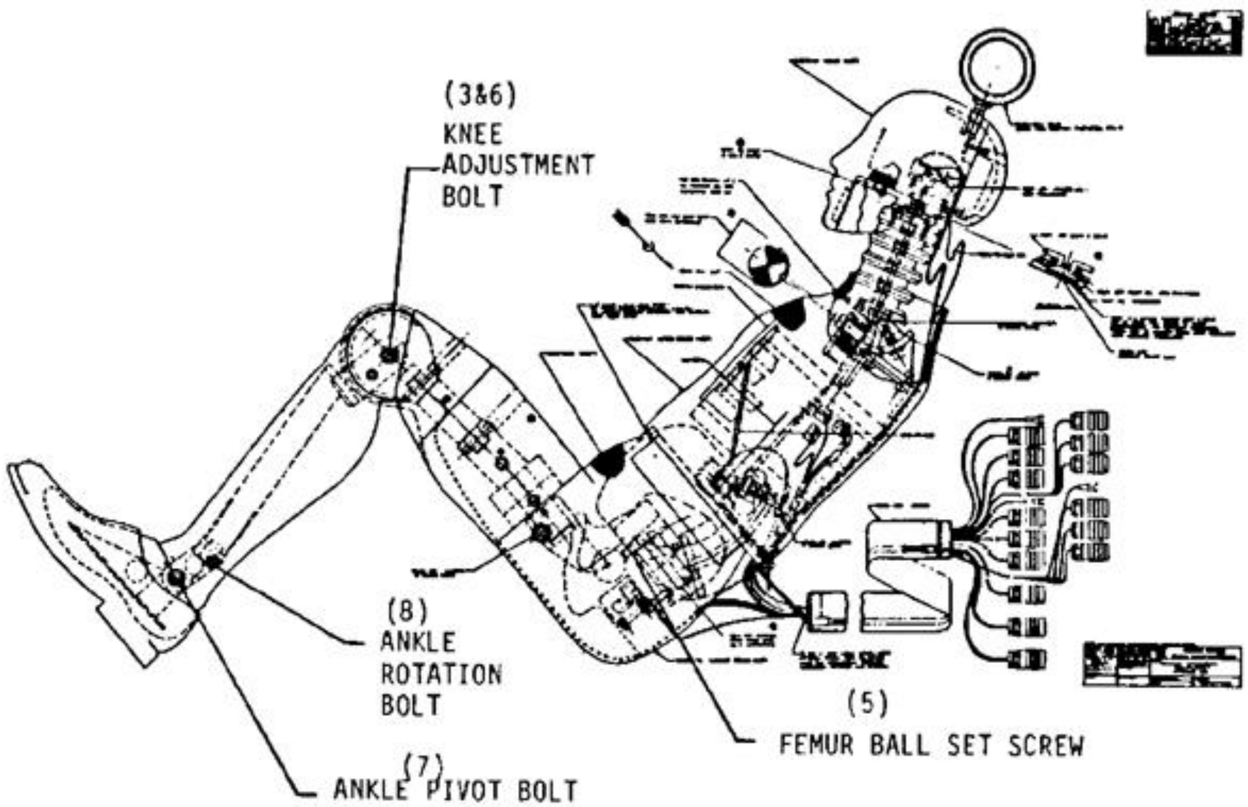

Figure 2.2.2.1: Hybrid III leg and feet joints requiring adjustment

Step 1. Remove the abdominal insert.

Step 2. With the lower leg at 90 degrees to the upper leg, and the dummy in a seated position, lift the upper leg assembly above the horizontal.

Step 3. Adjust the femur ball set screw so the upper leg is held suspended at 1 G.

Step 4. Rotate the lower leg assembly so it is horizontal.

Step 5. Adjust the knee clevis bolt so the lower leg is held suspended at 1 G.

Step 6. Adjust the ankle ball joint set screw so the foot is held suspended at 1 G (The ankle adjustment is not critical and is determined by individual feel).

Step 7. Repeat this procedure for the other foot and leg.

Section 3. External Measurement Procedure

3.1. External Measurement Procedure

Complete and record the following physical measurements in preparation for conducting any calibration tests.

Step 1. Remove the dummy's chest flesh and abdominal insert.

Step 2. Place the dummy on a flat, rigid, smooth, clean, dry, horizontal surface as shown in **Figure 3.1.1** below.

- The seating surface must be at least 406 mm (16 in) wide and 406 mm (16 in) deep, with a vertical section at least 406 mm (16 in) wide and 914 mm (36 in) high attached to the rear of the seating fixture.
- The dummy's midsagittal plane is vertical and centered on the test surface.

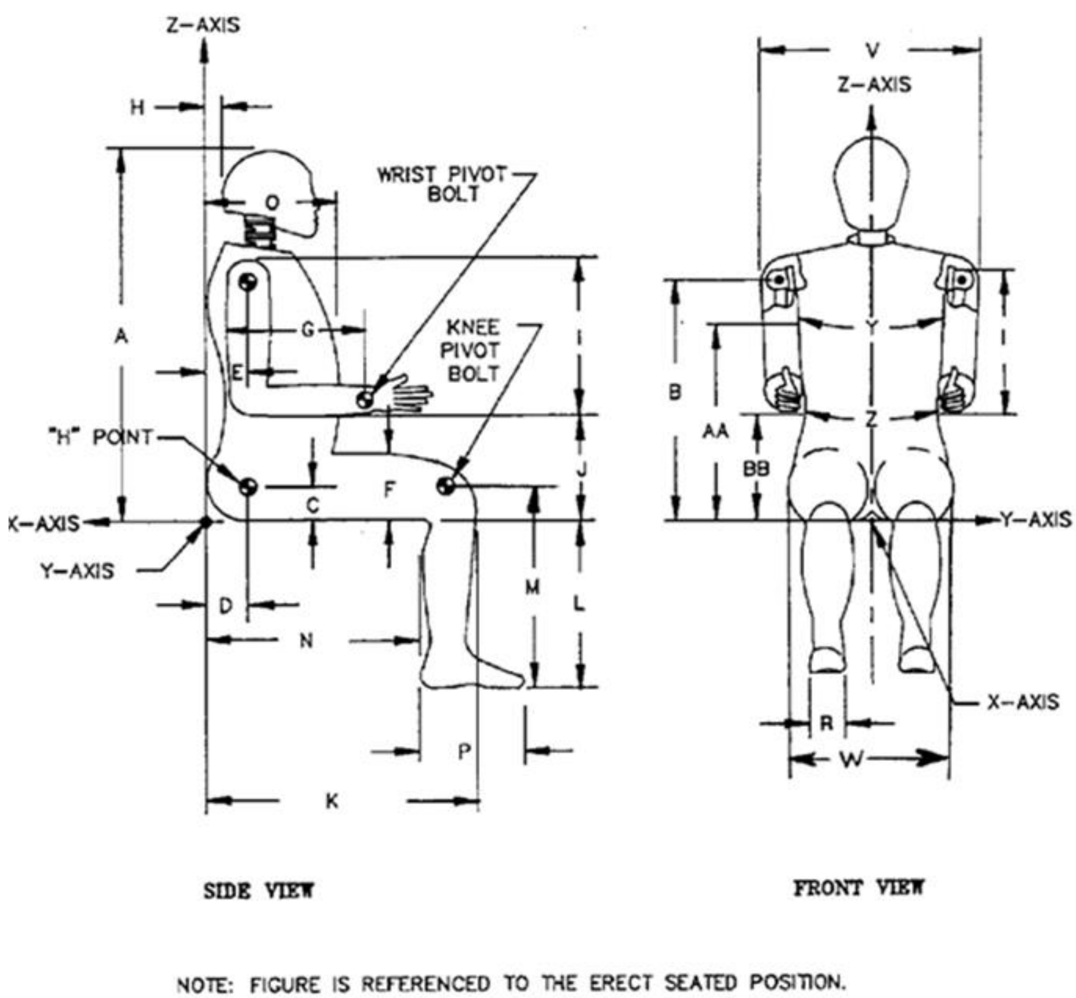

Figure 3.1.1: External Measurements

Step 3. Remove the four socket head cap screws which attach the lumbar spine to the thoracic spine. Torque the two lumbar cables to 1.1 to 1.4 N·m (10 to 12 in·lbf).

Note: At this point, inspect the thorax for damage. If required, remove the thorax displacement transducer for calibration. Use extreme caution to avoid damaging the instrumentation cables.

Step 4. Reassemble the lumbar spine to the thoracic spine.

Step 5. Secure the dummy to the test fixture so the rear surfaces of the upper thorax and buttocks are tangent to the rear vertical surface of the fixture (or as near tangent as possible). The dummy's midsagittal plane should be vertical.

Step 6. Secure the upper thorax to hold the dummy in position. Extend the neck to position the dummy's head so the occiput is 43.2 mm (1.7 in) ± 2.5 mm (0.1 in) forward of the test fixture's rear vertical surface. Secure the head in this position.

Step 7. Position the upper and lower legs parallel to the midsagittal plane so the centerline between the knee pivot and the screw attaching the ankle to the lower tibia is vertical.

Step 8. Position the feet parallel to the dummy's midsagittal plane, with the bottoms horizontal and parallel to the seating surface.

Step 9. Position the upper arms vertically so the centerline between the shoulder and elbow pivots is parallel to the rear vertical surface of the fixture.

Step 10. Position the lower arms horizontally so that the centerline between the elbow and wrist pivots is parallel to the seat surface.

Step 11. Record the following external dimensions. The letter designation for each dimension is indicated in **Figure 3.1.1.1** above. These letter designations also correspond to the specifications listed in **Table 3.3.1.2** below.

A. Total Sitting Height: From the seat surface to highest point on top of the head.

B. Shoulder Pivot Height: From the centerline of shoulder pivot bolt to the seat surface.

C. Hip Pivot (H-Point) Height: From above seat surface (reference).

D. Hip Pivot (H-Point) from Backline: From the seat rear vertical surface (reference).

E. Shoulder Pivot from Backline: From the center of the shoulder clevis to the rear vertical surface of the fixture.

F. Thigh Clearance: From the seat surface to highest point on the upper femur segment.

G. Back of Elbow to Wrist Pivot: From the back of the elbow flesh to the wrist pivot bolt.

H. Head Back (Skull Cap Skin) from Backline: To the seat rear vertical surface (reference).

I. Shoulder to Elbow Length: From the highest point on top of the shoulder clevis to the lowest part of the flesh on the elbow, in line with the elbow pivot bolt.

J. Elbow Rest Height: From the flesh below the elbow pivot bolt to the seat surface.

K. Buttock to Knee Length: From the most forward surface of the knee flesh to the rear surface of the buttocks, in line with the knee pivot and hip pivot.

L. Popliteal Height: From the seat surface to the horizontal plane at the bottom of the feet.

M. Knee Pivot Height: From the knee pivot to the horizontal plane of the bottom of the feet.

N. Buttock Popliteal Length: From the rearmost surface of the lower leg to the same point on the rear surface of the buttocks as used for dimension “K”.

O. Chest depth without chest flesh: Measured 345.4 mm ± 12.7 mm (13.6 in ± 0.50 in) above the seat surface (AA).

P. Foot Length: From tip of toe to rear of heel.

R. Foot Breadth: The widest part of the foot.

V. Shoulder Breadth: Between outside edges of shoulder clevises, in line with the shoulder pivot bolt.

W. Hip Breadth: The width of the hips at the H-Point.

Y. Chest Circumference: -Measured 431.8 mm (17 in) above the seat surface (AA), approximately at the top of the 5th rib.

Z. Waist Circumference - Measured 228.6 mm (9 in) above the seat surface (BB).

AA. Reference location for Chest Circumference (Y).

BB. Reference location for Waist Circumference (Z).

Step 12. Reinstall the chest flesh and abdominal insert.

Step 13. Reposition the dummy on the test fixture.

Note: You do not need to level the head as specified for the previous measurements.

Step 14. Mark the locations and record the chest and waist circumference dimensions (Items “Y” and “Z”, respectively, in **Figure 3.1.1.1** above).

Step 15. **Table 3.3.1.2** below summarizes the descriptions, specifications, and tolerances for each of the external dimensions listed and shown above in **Figure 3.1.1.1**. Compare the measured external dimensions to the specified external dimensions in **Table 3.3.1.2** below to determine the conformance to specifications.

Table 3.1.1: External dimension descriptions, specifications, and tolerances

Test Parameter	Designation	in	mm
Total Sitting Height	A	34.8±0.2	883.9±5.1
Shoulder Pivot Height	B	20.2±0.3	513.1±7.6
H-Point Height (ref.)	C	3.4±0.1	86.4±2.5
H-Point from Seat Back (ref.)	D	5.4±0.1	137.2±2.5
Shoulder Pivot from Backline	E	3.5±0.2	88.9±5.1
Thigh Clearance	F	5.8±0.3	147.3±7.6
Back of Elbow to Wrist pivot	G	11.7±0.3	297.2±7.6
Skull Cap to Backline	H	1.7±0.1	43.2±2.5
Shoulder to Elbow Length	I	13.3±0.3	337.8±7.6
Elbow Rest Height	J	7.9±0.4	200.7±10.2
Buttock to Knee Length	K	23.3±0.5	591.8±12.7
Popliteal Height	L	17.4±0.5	442.0±12.7
Knee Pivot to Floor Height	M	19.4±0.3	492.8±7.6
Buttock Popliteal Length	N	18.3±0.5	464.8±12.7
Chest Depth	O	8.7±0.3	221.0±7.6
Foot Length	P	10.2±0.3	259.1±7.6
Foot Width	R	3.9±0.3	99.1±7.6
Shoulder Width	V	16.9±0.3	429.3±7.6
Hip Width at H-Point	W	14.3±0.3	363.2±7.6
Chest Circumference	Y	38.8±0.6	985.5±15.2
Waist Circumference	Z	33.5±0.6	850.9±15.2
Reference Location for Chest Circumference (ref.)	AA	17.0±0.1	431.8±2.5
Reference Location for Waist Circumference (ref.)	BB	9.0±0.1	228.6±2.5

Section 4. Mass Measurements

4.1. Summary of Mass Specifications

Table 4.1.1 below summarizes the specified assembly mass for the different segment assemblies. Measure and record the mass of the various dummy segment assemblies on initial inspection and in preparation for conducting any calibration tests, and confirm that they meet the assembly mass specified in **Table 4.1.1**.

Table 4.1.1: Table of body segment assembly masses

ASSEMBLY	MASS	
	lb.	kg
Head Assembly	10.00 $\pm$ 0.10	4.54 $\pm$ 0.05
Neck Assembly	3.40 $\pm$ 0.10	1.54 $\pm$ 0.05
Upper Torso Assembly with Chest Flesh (includes from lower neck bracket to bottom of spine box)	37.90 $\pm$ 0.30	17.19 $\pm$ 0.14
Lower Torso Assembly (includes femurs and lower lumbar adapting plate)	50.80 $\pm$ 0.30	23.04 $\pm$ 0.14
Upper Leg Assembly, Left	13.20 $\pm$ 0.20	5.99 $\pm$ 0.09
Upper Leg Assembly, Right	13.20 $\pm$ 0.20	5.99 $\pm$ 0.09
Lower Leg Assembly, Left	9.45 $\pm$ 0.15	4.29 $\pm$ 0.07
Lower Leg Assembly, Right	9.45 $\pm$ 0.15	4.29 $\pm$ 0.07
Foot Assembly, Left	2.55 $\pm$ 0.15	1.16 $\pm$ 0.07
Foot Assembly, Right	2.55 $\pm$ 0.15	1.16 $\pm$ 0.07
Upper Arm Assembly, Left	4.40 $\pm$ 0.20	2.00 $\pm$ 0.09
Upper Arm Assembly, Right	4.40 $\pm$ 0.20	2.00 $\pm$ 0.09
Lower Arm Assembly, Left	3.75 $\pm$ 0.10	1.70 $\pm$ 0.05
Lower Arm Assembly, Right	3.75 $\pm$ 0.10	1.70 $\pm$ 0.05
Hand Assembly, Left	1.25 $\pm$ 0.10	0.57 $\pm$ 0.05
Hand Assembly, Right	1.25 $\pm$ 0.10	0.57 $\pm$ 0.05
Total Dummy Mass	171.30 $\pm$ 2.60	77.70 $\pm$ 1.18

Note: After replacing any parts, accelerometers, or other hardware, **always** recheck the mass of the pertinent segment.

4.2. Summary of Body Segment Centers of Gravity

The center of gravity for each of the dummy's 16 body segments is listed on drawing number 78051-338, sheets 1 and 2. Origins and axis locations are shown on the assembly drawing for each component. For convenience and increased clarity, **Table 4.2.1** summarizes the center of gravity information.

Table 4.2.1: Table of body segment assembly centers of gravity

Center of Gravity Segment	Axis	Location (mm)	Location (in)	Tolerance (mm)	Tolerance (in)	Reference
Head	X	63.5	2.50	±2.5	±0.10	Interface surface between skull and skull cap
	Y					Midsagittal plane
	Z	35.6	1.40	±2.5	±0.10	Bottom surface of skull
Neck & Upper Neck Bracket	X	-5.1	-0.20	±2.5	±0.10	CL of hole in UNB for neck cable
	Y					CL of hole in UNB for neck cable
	Z	50.8	2.00	±2.5	±0.10	Top surface of the UNB which contacts the bib simulator
Upper Torso	X	94.0	3.70	±5.1	±0.20	Rear surface of spine box upper back plate (78051-187)
	Y					Midsagittal plane
	Z	-50.8	-2.00	±5.1	±0.20	CL of bottom holes on spine box upper back plate (78051-187)
Lower Torso	X	-7.6	-0.30	±5.1	±0.20	Line connecting centers of two front lumbar to pelvic adapter mounting holes in the pelvic bone
	Y					Midsagittal plane
	Z	7.6	0.30	±5.1	±0.20	Top surface of the pelvic bone where the lumbar to pelvic adapter attaches
Upper Arm *Left & Right	X	-1.5	-0.06	±5.1	±0.20	Line connecting the shoulder pivot point and elbow pivot point
	Y					Line connecting the shoulder pivot point & elbow pivot point
	Z	-132.1	-5.20	±5.1	±0.20	Shoulder pivot point

Center of Gravity						
Segment	Axis	Location		Tolerance		Reference
		(mm)	(in)	(mm)	(in)	
Lower Arm *Left & Right	X	87.9	3.46	±5.1	±0.20	Elbow pivot point
	Y					Line connecting elbow pivot point and wrist pivot point
	Z	-5.3	-0.21	±5.1	±0.20	Line connecting elbow pivot point and wrist pivot point
Hand Left & Right	X	57.2	2.25	±5.1	±0.20	Center of wrist pivot
	Y					Center of wrist pivot
	Z	-1.5	-0.06	±5.1	±0.20	Midpoint between the two sides of the wrist clevis
Upper Leg Left & Right	X	-159.0	-6.26	±5.1	±0.20	Knee pivot point
	Y					Line passing through knee pivot point parallel to the axis of upper leg bone and midsagittal plane
	Z	19.3	0.76	±5.1	±0.20	Line passing through knee pivot point parallel to the axis of upper leg bone and midsagittal plane
Lower Leg *Left & Right	X	-5.1	-0.2	±5.1	±0.20	Line connecting knee pivot and ankle pivot
	Y					Line connecting knee pivot and ankle pivot
	Z	-200.7	-7.9	±5.1	±0.20	Knee pivot point
Foot Left & Right	X	55.9	2.20	±5.0	±0.20	Center of ankle pivot
	Y					Center of ankle pivot
	Z	-55.9	-2.20	±5.0	±0.20	Center of ankle pivot

NOTE: Left and Right are interchangeable.

Section 5. Top Level Dummy Assembly

5.1. Top Level Assembly

5.1.1. Exploded View

An exploded view of the top level dummy assembly (78051-218) is shown below in **Figure 5.1.1.1**.

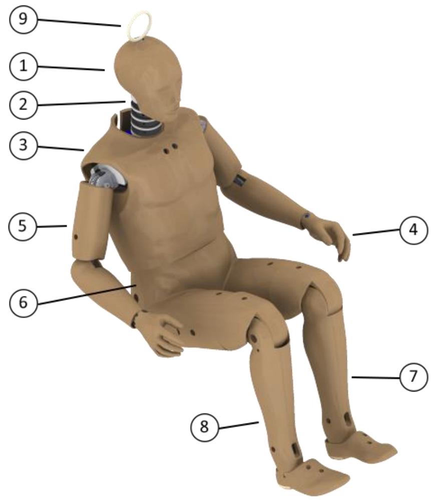

Figure 5.1.1.1: Top level assembly exploded view

5.1.2. Parts List

Table 5.1.2.1 below gives a general description of each item in the top level assembly (refer to top level assembly drawing 78051-218).

Table 5.1.2.1: Top level assembly parts list

Item	Quantity	Part Number	Description
1	1	78051-61X	Head Assembly
2	1	78051-90	Neck Assembly
3	1	78051-89	Upper Torso Assembly
4	1	78051-123	Left Arm Assembly
5	1	78051-124	Right Arm Assembly
6	1	78051-70	Lower Torso Assembly
7	1	86-5001-001	Leg Assembly, Complete, Left
8	1	86-5001-002	Leg Assembly, Complete, Right
9	1	78051-231	Lifting Ring

Section 6. Head and Neck Assembly

6.1. Head Assembly

6.1.1. Exploded View

An exploded view of the head assembly (78051-61X) is shown below in **Figure 6.1.1.1**.

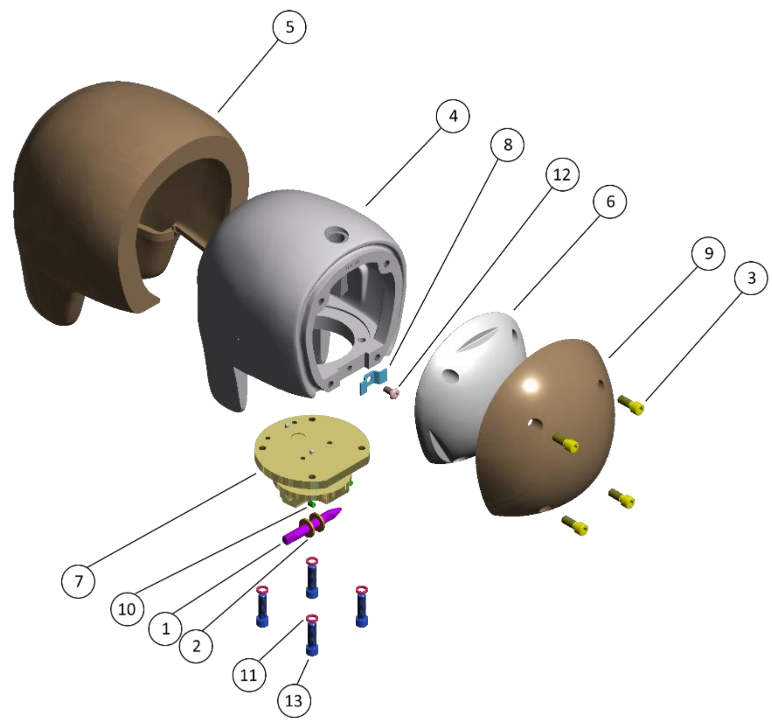

Figure 6.1.1.1: Head assembly exploded view

6.1.2. Parts List

Table 6.1.2.1 below gives a general description of each item in the head assembly (refer to head assembly drawing 78051-61X.

Table 6.1.2.1: Head assembly parts list

Item	Quantity	Part Number	Description
1	1	1717	Pivot Pin, Neck
2	2	78051-253	Washer, Nodding Joint
3	4	9000005	Screw, SHCS 1/4-20 x 5/8 LG. Nylok®
4	1	78051-77X	Skull, Machined, Six-Axis Neck
5	1	78051-228	Head Skin
6	1	78051-220	Skull Cap

Item	Quantity	Part Number	Description
7	1	78051-383X	Neck Transducer Assembly
8	1	83-5006-001	Skull Cable Clip
9	1	78051-229	Cap Skin, Molded
10	2	9000452	Screw, SSSCP #8-32 X 1/4 LG.
11	4	9000677	Shoulder Screw Shim, 1/4 X 1/16 Thick
12	1	9000538	Screw, BHCS #10-32 X 3/8 LG.
13	4	9000264	Screw, SHCS 1/4-28 X 7/8 LG.

6.2. Neck Assembly

Although not required nor universally recommended, some generic suggestions regarding neck shields are included here. Neck shields have usually been constructed of foam or another material that wraps around the dummy's neck and fills in or covers the gap in the chin. The seam of the neck shield is then secured with duct tape, rubber bands, or Velcro, but is generally not connected to the head or neck to avoid changing the neck's response.

Note: Begin the head and neck disassembly by removing the neck shield.

6.2.1. Exploded View

An exploded view of the neck assembly (78051-90) is shown below in **Figure 6.2.1.1**.

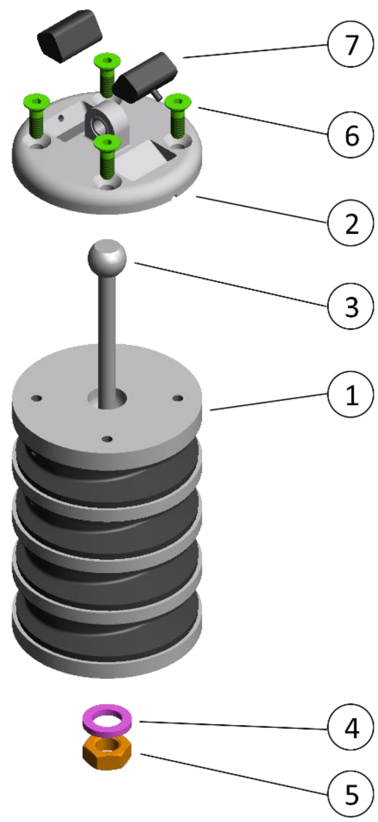

Figure 6.2.1.1: Neck assembly exploded view

6.2.2. Parts List

Table 6.2.2.1 below gives a general description of each item in the neck assembly (refer to neck assembly drawing 78051-90.

Table 6.2.2.1: Neck assembly parts list

Item	Quantity	Part Number	Description
1	1	78051-336	Molded Neck Assembly
2	1	78051-297	Nodding Joint, Neck
3	1	78051-301	Cable - Neck
4	1	9008007	Washer, Flat 0.515 ID X 0.875 OD
5	1	9000018	Nut, Jam 12-20
6	4	9000447	Screw, FHCS 1/4-20 X 3/4
7	2	78051-351-8550	Nodding Blocks*

*Note: The nodding blocks are included and tested with the molded neck assembly, and must be kept with it to ensure proper calibration.

6.2.3. Disassembling the Head and Neck

Step 1. Remove the chest flesh to permit easier access to the base of the neck bracket.

Step 2. Remove the 3/8-16 X 1 SHCS and washer that hold the upper neck bracket to the lower portion neck bracket and permit adjustment of the neck angle, as shown below in **Figure 6.2.3.1**.

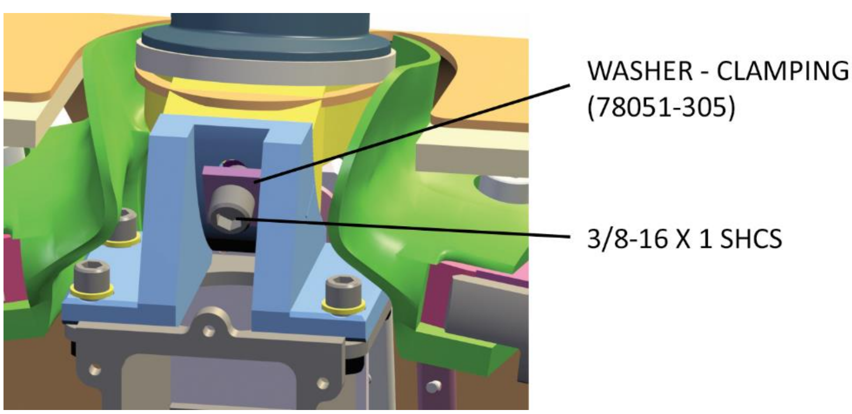

Figure 6.2.3.1: Neck angle adjustment screw and washer

Step 3. Check the condition of the curved steel washer, 78051-305 and note how it fits on the neck bracket.

Step 4. Tilt the head and neck forward and remove the neck cable nut and four 1/4-20 x 5/8" socket head cap screws that hold the upper neck bracket to the base of the neck, as shown in **Figure 6.2.3.2**.

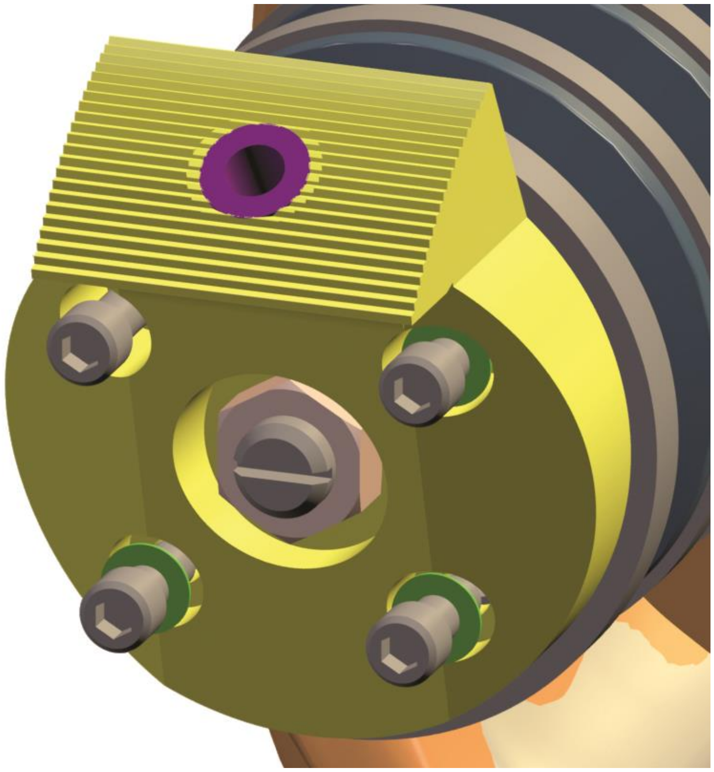

Figure 6.2.3.2: Neck to upper neck bracket attachment

Step 5. If they are missing, install steel washers between these four socket head cap screws and upper neck bracket on reassembly. The neck and head assembly is now disconnected from the plastic sternum-to-rib cage bib assembly.

Step 6. Remove four 1/4-20 x 5/8 SHCS from the rear skull cap.

Step 7. For the three-axis neck transducer or its structural replacement, remove the three ¼-20 x 3/4" socket head cap screws underneath the skull.

Step 8. Separate the head from the transducer or its structural replacement.

Note: Do not stress the neck transducer cable.

Step 9. Loosen the two #10-32 x 1/4" set screws and reinstall the transducer to the head.

Step 10. Fasten the neck compression tool, shown below in **Figure6.2.3.3**, to the back of the skull.

Figure 6.2.3.3: Neck compression tool

Step 11. Slip the round end of the tool over the cable and turn the knob until the neck is just being compressed, as shown below in **Figure 6.2.3.4**.

Figure 6.2.3.4: Neck compression tool installed on head and neck assembly

Step 12. For the six-channel neck transducer or its structural replacement, loosen two small 8-32 x 1/4" socket head set screws, as shown in **Figure 6.2.3.5**, which secure the head-to-neck pivot pin, as shown in **Figure 6.2.3.6**.

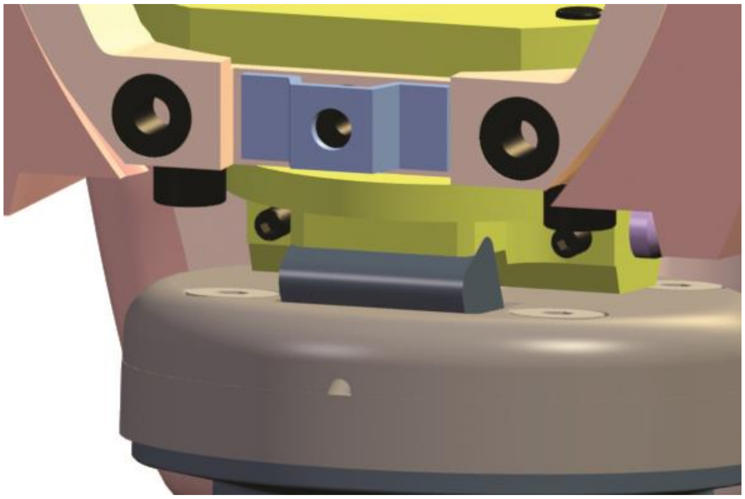

Figure 6.2.3.5: Neck pivot pin set screw

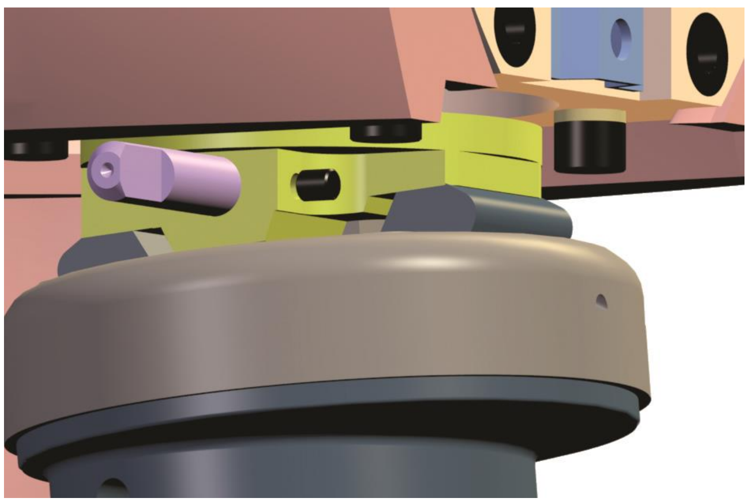

Figure 6.2.3.6: Installing the neck pivot pin

Step 13. Slowly increase the compression on the neck until the pivot pin, 1717 can be pushed or lightly tapped out with a minimum of effort with either transducer.

Note: Be careful not to drop the neck pivot pin washers, 78051-253 which will become loose when the pin is removed.

Step 14. Remove the nodding joint, 78051-297 and disassemble the neck. The rubber sections of the neck are permanently bonded to the aluminum spacers and cannot be disassembled.

Step 15. Check the two rubber neck nodding blocks, 78051-351-8550 shown in **Figure 6.2.3.7** on the top of the nodding joint. The blocks must conform to the drawing, which specifies a durometer between 80-90 Shore A. The 90° surfaces of the nodding blocks fit opposite, rather than inside, the 90° grooves of the head-to neck adaptor bracket. A drawing of the nodding block orientation appears in **Figure 6.2.3.8**.

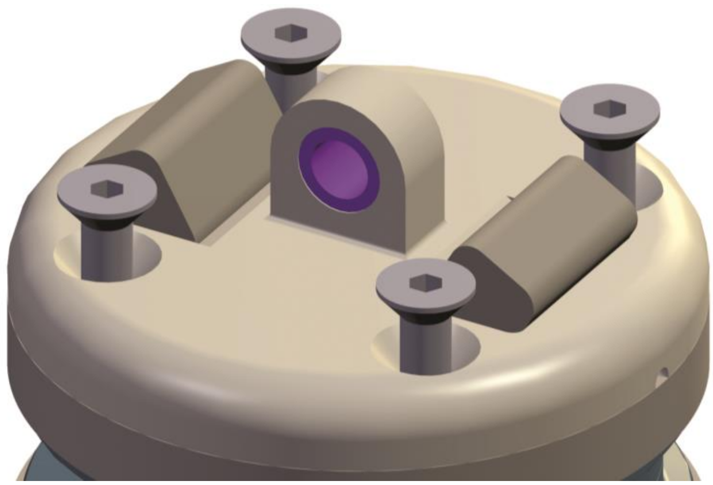

Figure 6.2.3.7: Rubber neck nodding blocks on nodding joint

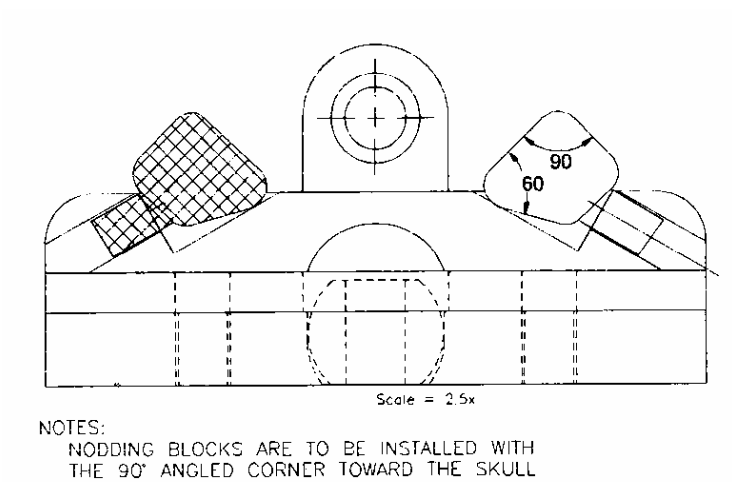

Figure 6.2.3.8: Nodding block orientation

Step 16. Inspect the neck cable for imperfections. No evidence of the cable pulling through the end fittings should exist. Examine the machined metal parts and compare the rubber sections of the neck against the drawing.

Step 17. Remove the lower portion of the neck bracket. A steel washer under each of the cap screws helps to protect the aluminum from being galled by the steel screws. If the axial integrity of the neck is in question, the neck without its cable can be pull tested to 7kN (1575 lbf). No separation is allowed to occur. Replace damaged or questionable parts and materials as required.

Step 18. Assemble the two sections of the neck bracket with the adjustment set to 0° and measure the bracket angle. The angle should be 13° 45' ± 30' relative to the bottom surface of the lower neck bracket.

Step 19. When using either optional neck transducer (3- or 6- channel), the lug on the nodding joint must fit very tightly in the slot in the bottom of the neck load cell, as shown in **Figure 6.2.3.9**. The tightness is controlled by a brass washer on each side of the yoke. These washers must be lapped to produce a 0.000 to 0.025 mm (0.000 to 0.001 in) interference fit at assembly. Because the inside diameter of these washers is also critical, validate this dimension against drawing number 78051-253.

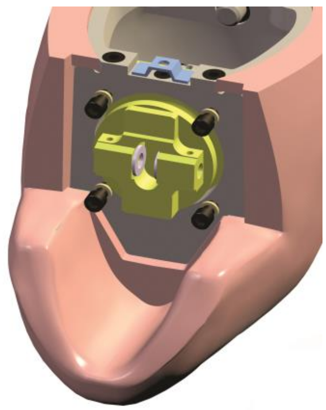

Figure 6.2.3.9 Neck load cell pivot joint and screws

Step 20. In separating the six-channel load cell from the head, remove the four 1/4 X 28-7/8" long cap screws from the bottom, as shown below in **Figure 6.2.3.10**. Special 1/4 ID x 3/8 OD x 1/16" washers are provided and must be used under the load cell attachment bolts. Larger washers will interfere with load cell operation. The use of ball hex wrenches is recommended.

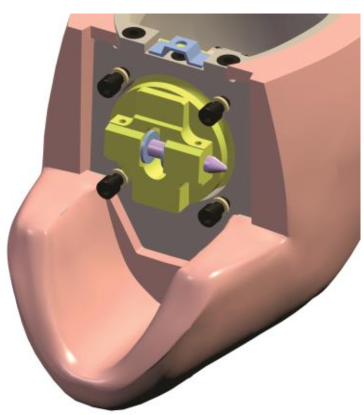

Figure 6.2.3.10: Special washers for six channel neck transducer

Step 21. Remove the skin from the skull and skull cap and check for tears and general quality. Inspect the skull for smoothness and freedom from flat spots and pits. Examine the bond of the skull ballast. If the ballast must be reinstalled or changed, see drawing number 78051-61X for instructions.

Note: It is recommended to have weight and center of gravity (C. G.) adjustments and securing of the ballast done by Humanetics Innovative Solutions, Inc.

Step 22. Replace the skin on the skull and cap. Measure the thickness of the skin in the locations shown in drawing 78051-61X. The thickness must be 11.2 ± 0.8 mm (0.441 ± 0.031 in) as measured by the special thickness tool.

Step 23. Install the neck transducer and accelerometer block with simulated accelerometers as shown in drawing 78051-61X. Install the skull cap. Weigh the assembly. The weight and center of gravity (C.G.) must conform to drawing 78051-338.

Note:

- If the head assembly does not comply with these weight and C.G. requirements, see drawing 78051-61X for instructions.
- In addition, **Table 2.3.3.1** (shown previously in this manual) summarizes the C.G. specifications for the whole dummy.

Section 7. Upper Torso Assembly

This section on the upper torso assembly includes the thoracic spine assembly, the sternum assembly, the ribs, and the shoulder and clavicle assemblies and links.

7.1. Disassembling, Inspecting, and Reassembling the Upper Torso

7.1.1. Exploded View

An exploded view of the upper torso assembly (78051-89) is shown below.

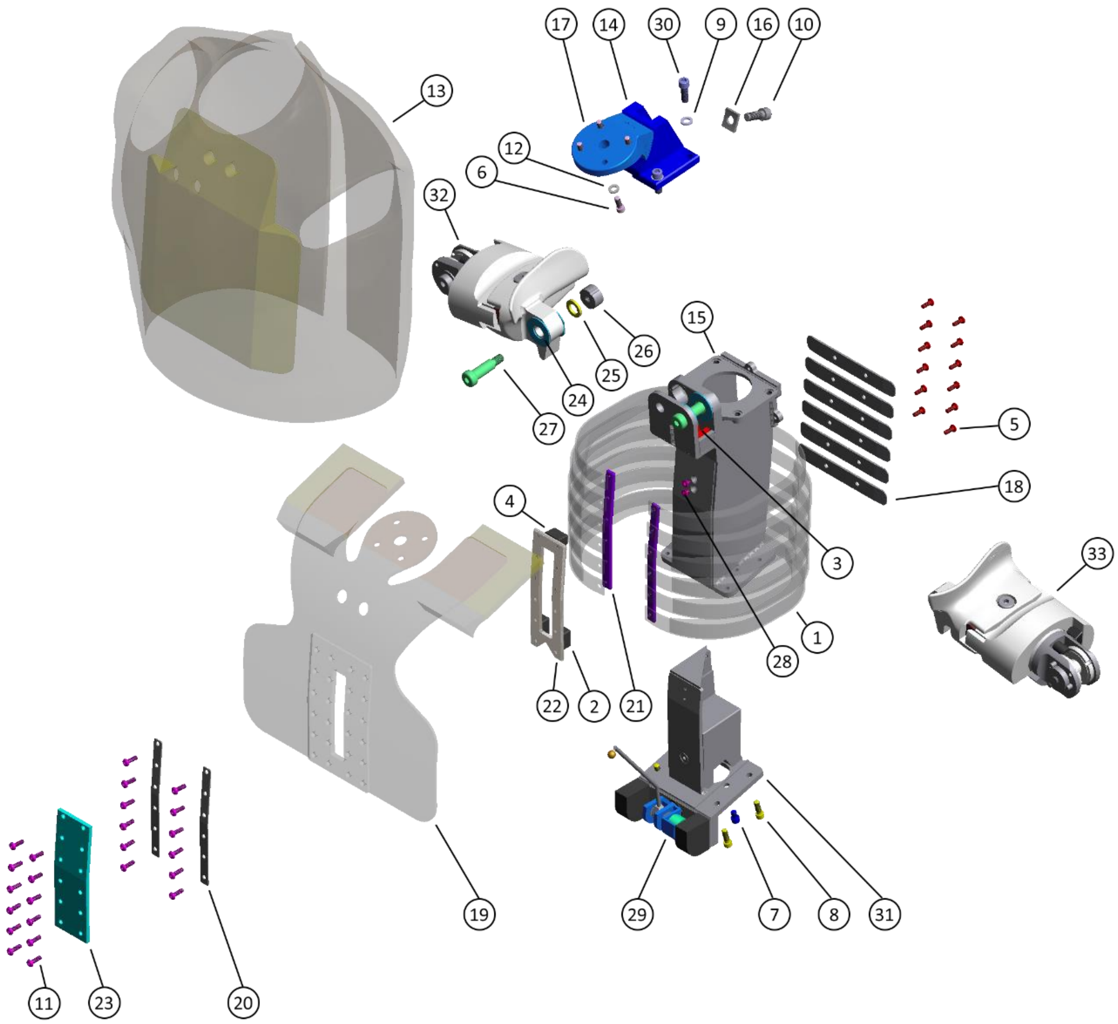

Figure 7.1.1.1: Upper torso assembly exploded view

7.1.2. Parts List

Table 7.1.2.1 below gives a general description of each item in the upper torso assembly (refer to upper torso assembly drawing 78051-89).

Table 7.1.2.1: Upper torso assembly parts list

Item	Quantity	Part Number	Description
1	1	78051-RS	Rib Set, Complete
2	2	78051-356	Stop, Sternum
3	2	78051-235	Bumper, Shoulder
4	1	78051-9	Stop, Sternum
5	12	900026	BHCS, #10-32 X 1/2” Lg.
6	4	9000144	SHCS, 1/4”-20 X 5/8” Lg.
7	2	9000597	SHCS, 1/4”-20 X 3/8” Lg.
8	4	9000454	SHCS, 1/4”-20 X3/4” Lg.
9	4	900022	Flat washer, 5/16” Plain A SS
10	1	900079	SHCS, 3/8”-16 X 1.0” Lg.
11	24	9000025	BHCS, #10-32 X 5/8” Lg.
12	4	9003843	Flat washer, 1/4” Plain A SS
13	1	78051-169	Chest Flesh and Skin Assembly
14	1	78051-303	Bracket, Neck, Adjusting Lower
15	1	78051-179	Thoracic Spine Assembly
16	1	78051-305	Washer, Clamping
17	1	78051-307	Bracket Assembly, Neck Adjusting Upper
18	6	78051-304	Support, Rib, Rear
19	1	78051-215	Bib Assembly, Sternum to Rib
20	2	78051-233	Plate, Front End Stiffener
21	2	78051-234	Strip, Front End
22	1	78051-232	Sternum

Item	Quantity	Part Number	Description
23	1	78051-316	Slider, Chest Deflector
24	4	78051-236	Washer, Clavicular Link
25	2	78051-237	Washer, Nut Clavicular
26	2	78051-238	Nut, Clavicle Link Pivot
27	2	78051-239	Clavicular Link, Pivot Screw
28	2	78051-225	Screw, Hex Socket Flat
29	1	78051-317	Transducer Assembly
30	4	9000113	SHCS, 5/16”-24 X 7/8” Lg.
31	1	78051-88	Adapter Assembly
32	1	78051-420	Shoulder Assembly, Right
33	1	78051-410	Shoulder Assembly, Left

7.1.3. Disassembling and Inspecting the Thoracic Spine

Step 1. Remove the four 1/4-20 X 3/4” cap screws that attach the lumbar spine to the thoracic spine assembly and lift off the thoracic spine.

Step 2. From the bottom of the thoracic spine, remove the two 1/4-20 X 5/8” long cap screws that hold the chest accelerometer adapter assembly, ballast weight, and chest displacement potentiometer assembly to the bottom of the spine box, as shown below in **Figure 7.1.3.1**.

Note: Before separating this unit from the spine box, remove the two #10-32 X 1/2” long flat head cap screws located about midway up the front of the box.

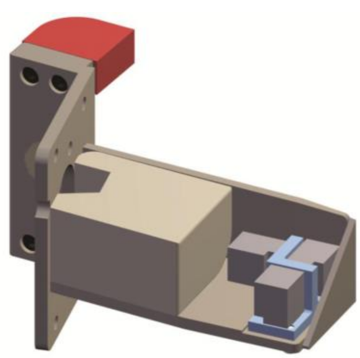

Figure 7.1.3.1: Thoracic instrumentation adaptor

Step 3. Slide the assembly out of the bottom of the spine box.

Note:

- On earlier versions of the Hybrid III dummy, this is the only way to reach the chest accelerometer package.
- Dummies built more recently should have a series of holes on the side of the spine, as shown below in **Figure 7.1.3.2**, to allow removal of the accelerometer block mounting screws.
- This allows removal of the block from the upper rear spine opening.
- These holes have been incorporated into the drawing package.

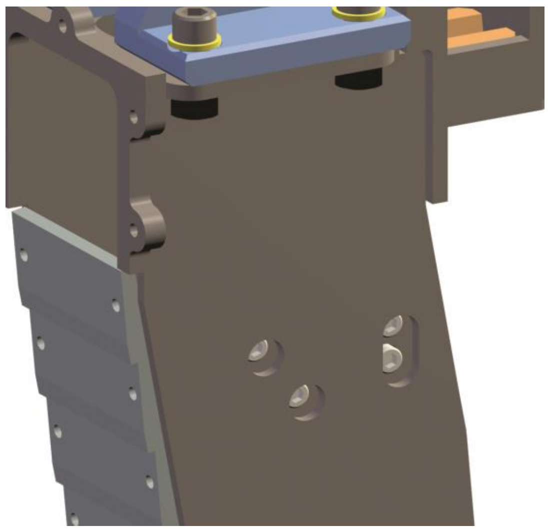

Figure 7.1.3.2: Spine box holes for removal of accelerometer block screws

Step 4. Install the accelerometer block package and make sure no interference with the accelerometers occurs. Check the two larger rubber bumpers protecting the chest displacement potentiometer, as shown below in **Figure 7.1.5.5**, sub-Section 7.1.5, “Disassembling and Inspecting the Ribs and Sternum”.

Step 5. Carefully remove the chest deflection transducer assembly from its bearing. A 1/4-20 X 1/2” long button head cap screw and washer shown in assembly drawing 78051-317, hold it in place. The assembly should easily push out.

Step 6. The chest deflection transducer assembly appears below in **Figure 7.1.3.3**. Check the bearing for smooth operation.

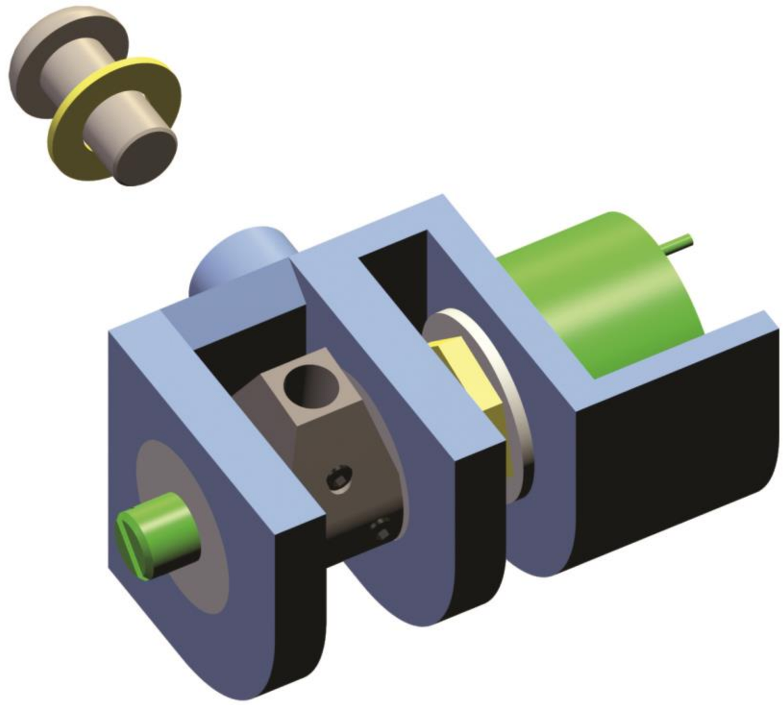

Figure 7.1.3.3: Chest deflection transducer assembly

7.1.4. Reassembling the Thoracic Spine

Assembling the thoracic spine assembly and its components is just a reversal of the disassembly process. Remarks in this section will be confined to special considerations that are unique to that assembly.

Step 1. If the dummy does not have the holes drilled in the side of the spine box to aid in the chest accelerometer mount installation, drill the holes shown in **Figure 7.1.3.2** above and in the drawing package.

Step 2. Torque the lumbar cables to 1.1 to 1.4 N·m (10 to 12 in·lbf).

Step 3. Install the lumbar adaptor assembly (with the thorax weight and transducers) into the bottom of the thoracic spine. Install the thoracic spine, with adaptor assembly, to the lumbar spine.

Step 4. When mounting the lower neck bracket to the top of the spine, ensure that the cap screws have metal washers to protect the aluminum.

7.1.5. Disassembling and Inspecting the Ribs and Sternum

Step 1. Remove the (12) #10-32 X 5/8" long button head cap screws holding the front of the ribs to the bib.

Step 2. Inspect the thin steel strips under the bolt heads for cracks. Check the thicker, slightly bent strips behind the rib ends for cracks. Note the way the strips fit the chest. The bend is not symmetrical; the upper portion is shorter than the lower.

Step 3. Detach the bib assembly.

__Do not__ loosen the set screw, shown below in **Figure 7.1.5.1**, because this will invalidate the chest pot calibration of SAE Recommended Practice J-2517.

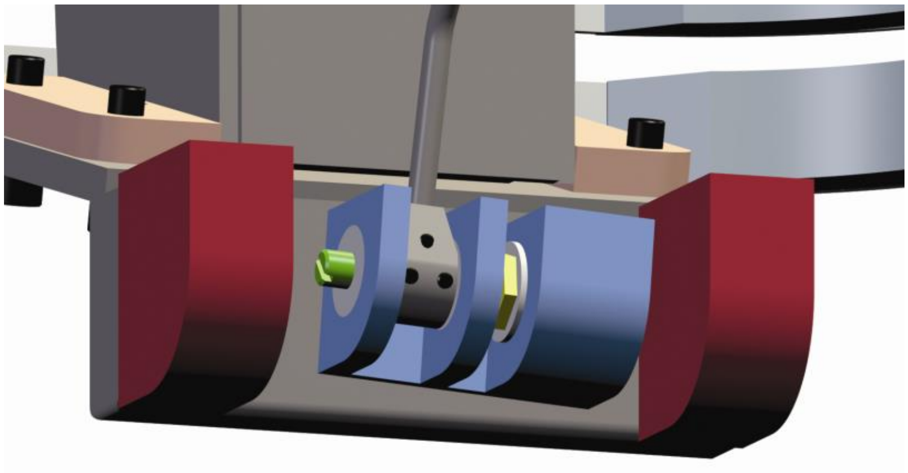

Figure 7.1.5.1: Displacement transducer and set screw

Step 4. Remove the (12) #10-32 X 5/8" long screws holding the DelrinTM slider assembly to the bib, as shown below in **Figure 7.1.5.2**.

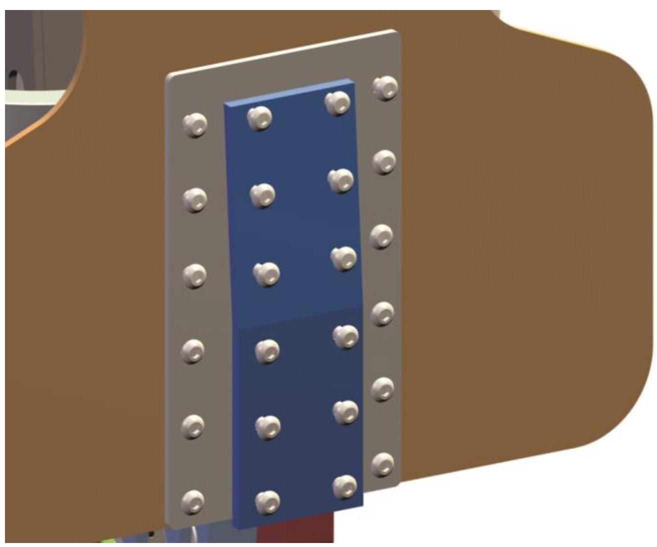

Figure 7.1.5.2: Slider assembly attached to bib

Step 5. Examine the slider for damage and ensure that the slider ball moves freely in its track. Inspect the aluminum plate to which the slider assembly bolts. Check that the "V" shaped groove is at the bottom, as shown below in **Figure 7.1.5.3**.

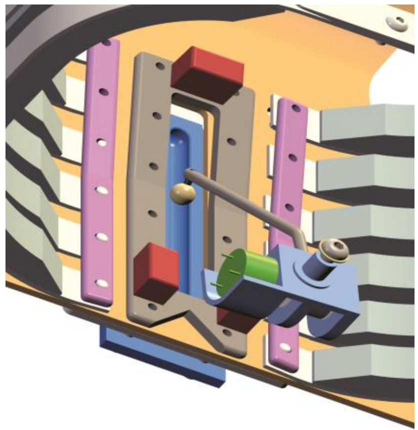

Figure 7.1.5.3: Sternum installed

Step 6. Three rubber bumps stops prevent the sternum assembly from striking the spine box during testing. The two lower stops can be mounted to either the sternum assembly, as shown in **Figures 7.1.5.3** (above) and 7**.1.5.4** (below), or to the spine box, as shown in **Figure 7.1.5.5** (also below). Mounting the stops to the spine box reduces the possibility of interaction with the sternal deflection rod

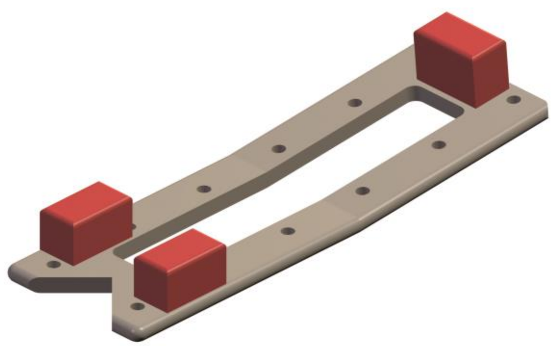

Figure 7.1.5.4: Sternum assembly with rubber stops

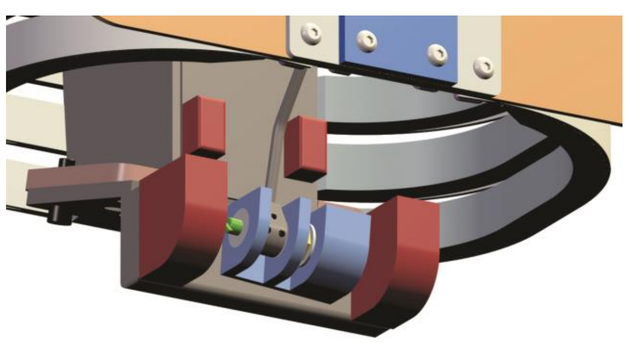

Figure 7.1.5.5: Sternum stops mounted to the spine

Step 7. Inspect the bib for cracks, tears and imperfections. Compare the shape to the drawing. Clean all parts with isopropyl alcohol or an equivalent.

Step 8. Detach the six ribs in the rib assembly shown below in **Figure 7.1.5.6,** and their rear rib supports shown below in **Figure 7.1.5.7** by removing the (12) #10-32x1/2" long screws at the rear of the thoracic spine assembly.

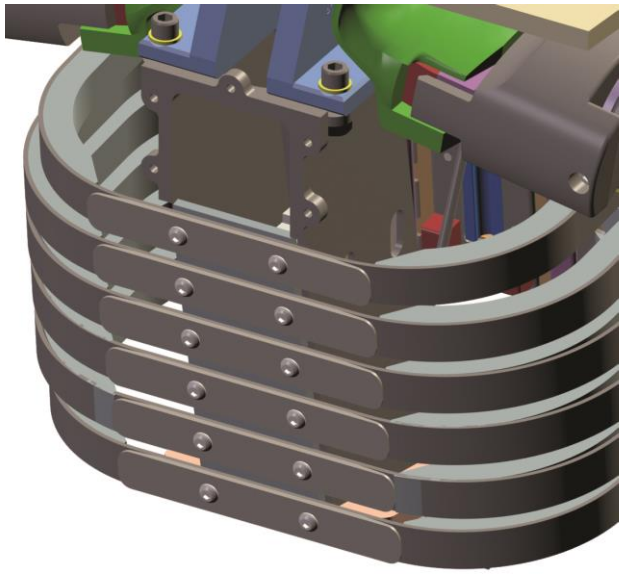

Figure 7.1.5.6: Rib assembly

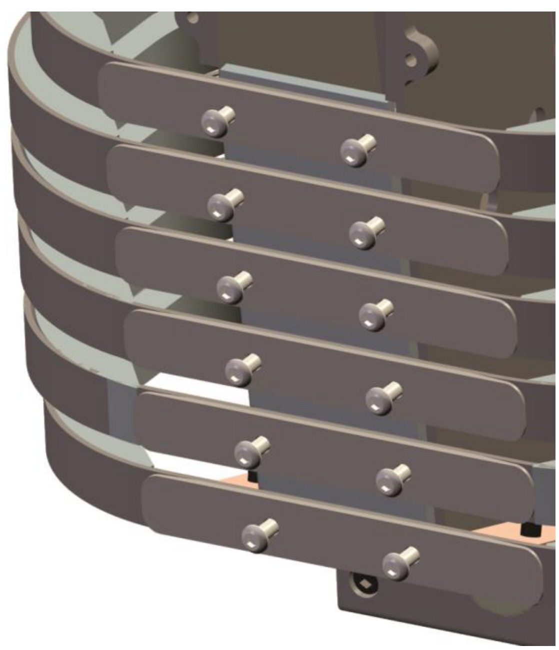

Figure 7.1.5.7: Rear rib supports

Step 9. Carefully examine each rib and the rib damping material for cracks. Check for gaps or other failures of the epoxy bond between the rib damping material and the rib metal, as shown below in **Figure 7.1.5.8**.

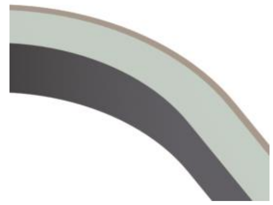

Figure 7.1.5.8: Steel rib and bonded damping material

Step 10. Verify the contours of each rib against a template made from the information obtained from the rib drawings. When the rib ends are matched to the template, the rib contour should be within ±1.50 mm (.060 in) of the template. Minor reshaping of the ribs may be done by hand.

Step 11. Measure the rib thickness.

Step 12. The Rockwell C hardness of each rib and rib support shall fall between 44 and 46 at the center of the metal between the two screw holes.

Step 13. When reassembling, make sure the rib supports (PN 78051-304) are not bent or damaged and are mounted the correct way with the beveled ends facing the front of the dummy.

Step 14. After assembling the ribs, or when checking rib condition, use the special tool (83-5006-007) to check for correct chest depth, as shown in **Figure 7.1.5.9**.

- The gauge is used to check the chest cavity depth at ribs number 1 and number 6.
- The gauge has two separate calibrated surfaces for ribs number 1 and number 6.
- The gauge should be pressed against the back edge of the spine box (not the rear rib supports).

Note: If the gauge probe contacts the front rib end threaded strip (PN 78051-234), the condition is unacceptable and the ribs should be replaced.

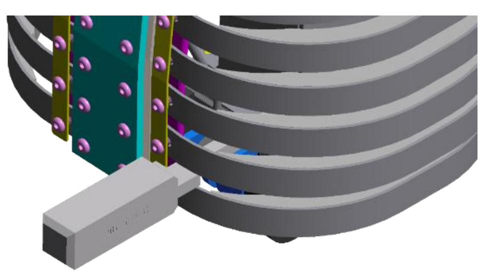

Figure 7.1.5.9: Chest depth gauge

7.1.6. Reassembling the Ribs and Sternum

Reassembling the ribs and sternum assembly and its components is just a reversal of the disassembly process. Remarks in this section will be confined to special considerations that are unique to that assembly.

Step 15. Attach the ribs and rear rib supports to the thoracic spine assembly. Do not tighten the screws. Attach the bib to the ribs using the rib stiffeners shown below in **Figure 7.1.6.1**.

Figure 7.1.6.1: Thick and thin rib stiffeners at the bib

Step 1. Install the aluminum sternum to the inside surface of the bib and attach the Delrin™ track. Ensure that the chest displacement rod ball engages the Delrin™ track properly (see **Figure 7.1.5.3** above).

Step 2. Check the spacing and alignment of the ribs and then tighten the screws. A 3/8" diameter rod can be used to control the space between the ribs.

7.1.7. Description and Features of the Shoulder-Clavicle and Link Assemblies

The right and left shoulder-clavicle and link assemblies consist of three main sections that bolt to each other and then to the thoracic spine. These three sections permit arm rotation, up-down motion at the shoulder, forward-rear excursion (hunching), and up-down motion of the entire shoulder-clavicle unit. See drawing 78051-89 for details of this assembly.

7.1.8. Disassembling and Inspecting the Shoulder and Clavicle Assemblies and Links

Note: Disassembly of the arm at the shoulder yoke is discussed below in sub-Section 9.1.3, "Disassembling the Arm." This same yoke provides shoulder rotation by rotating at the outer end of the clavicle.

Step 1. Detach the shoulder-clavicle unit from the thoracic spine assembly by reaching through a hole in the plastic chest "bib" and removing the socket head shoulder screw at the extreme top of the thoracic spine, as shown below in **Figure 7.1.8.1**.

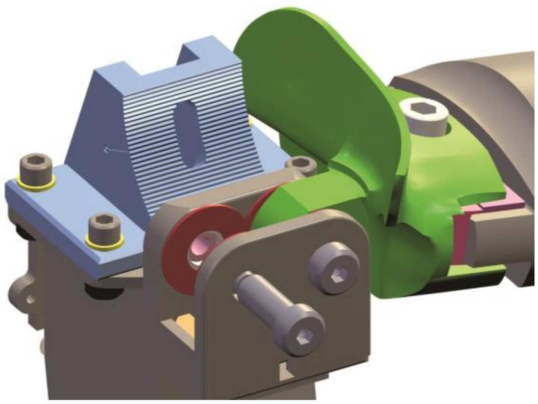

Figure 7.1.8.1: Clavicle link to spine attachment screws

Step 2. Pull the clavicle unit straight up.

Step 3. Check for the urethane washer at the rear of the cavity in the thoracic spine and for two Delrin™ washers isolating the clavicle from the spine. Make sure the pivot nut slides out freely. A Delrin™ bushing should also be present in the hole through the clavicle link.

Step 4. At this time, use a pair of needle nose pliers to remove the rubber bump stop from the thoracic cavity, as shown below in **Figure 7.1.8.2**. The stop must be free from tears or permanent deformation, and must be symmetrical in cross section. The durometer of this bump stop must fall between 75 - 85 Shore A.

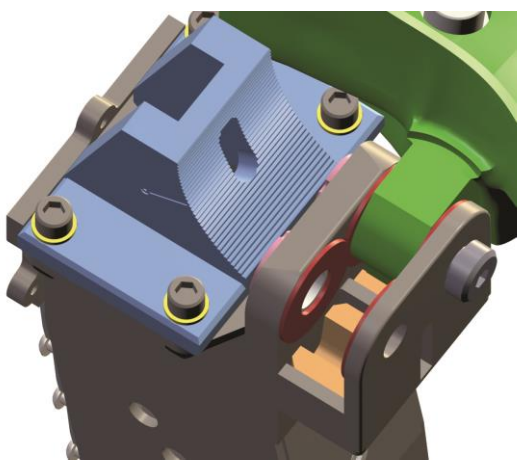

Figure 7.1.8.2: Thoracic rubber bump stop

Step 5. Remove the 1/2” X 1” long shoulder clavicle link screw and its steel washer that holds the two aluminum sections of the clavicle and its link together, as shown below in **Figure 7.1.8.3**.

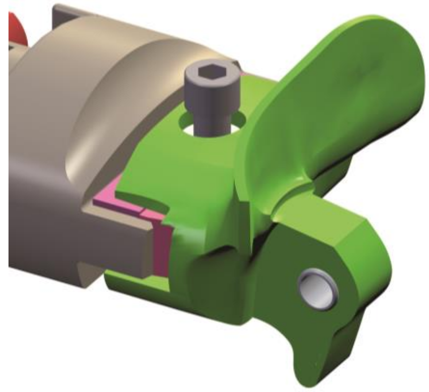

Figure 7.1.8.3: Clavicle to clavicle link screw

Step 6. Top and bottom thin Delrin™ strips should isolate the two sections, as shown below in **Figure 7.1.8.4**. A urethane spring "stop" should be located at the back of the cavity in the inner clavicle section, as shown below in **Figure 7.1.8.5**.

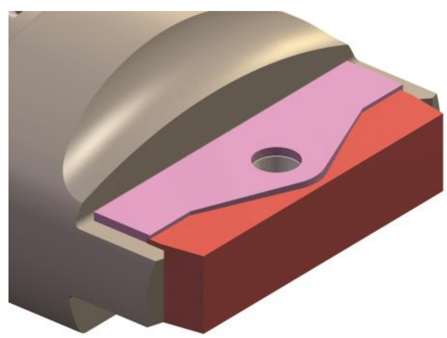

Figure 7.1.8.4: Clavicle, Delrin™ strip, and urethane spring stop

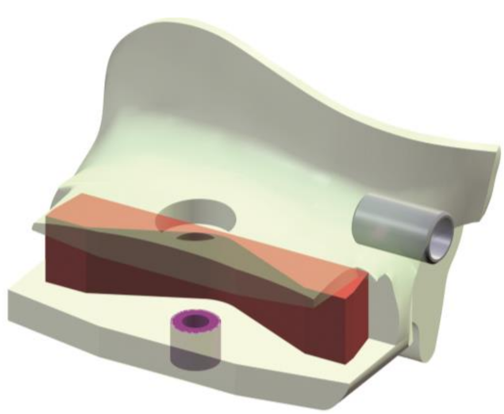

Figure 7.1.8.5: Urethane spring stop

7.1.9. Reassembling the Shoulder and Clavicle Assemblies and Links

Note: Reassembling the arm to the shoulder yoke is discussed below in sub-Section 7.1.5, "**Connecting the Arm Assembly to the Shoulder**." This same yoke provides shoulder rotation by rotating at the outer end of the clavicle.

Assembling the shoulder, clavicle, and clavicle links and their components is just a reversal of the disassembly process. Remarks in this section will be confined to special considerations that are unique to that assembly.

Step 1. Assemble the shoulder yokes, clavicles, and clavicle links. The long flat Delrin™ strips are easily damaged during assembly. An alignment tool will assist in this operation.

Step 2. Assemble the clavicles to the thoracic spine assembly. As shown below in **Figure 7.1.9.1**, insert the clavicular link nuts (PN 78051-238) followed by the urethane washer nuts (PN 78051-237) into the holes provided on the spine box.

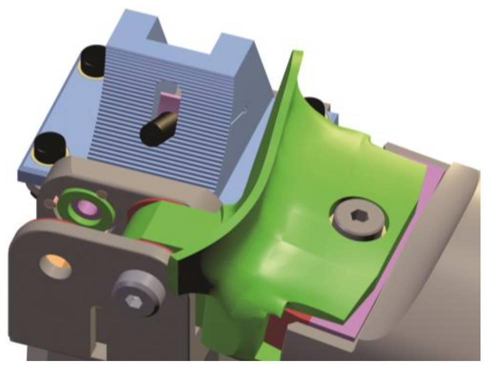

Figure 7.1.9.1: Installing clavicular link nuts and urethane washer nuts

Step 3. Place the clavicular washers (PN 78051-236) onto the clavicular link (PN 78051-188, 78051-189) with the flats in a vertical position toward the center, as shown below in **Figure 7.1.9.2**. The flat spots on the flat Delrin™ washers are on the side nearest the centerline of the spine.

Figure 7.1.9.2: Adding clavicular washers

Note: The following steps use two 15 cm (6 in) C-clamps to assemble the clavicles more easily.

Step 4. With the upper neck bracket removed, and the clavicle (PN 78051-141, 78051-142) and clavicular link already assembled, place the clavicular link into the slot provided on the spine box and position the C-clamp.

Step 5. If the holes on the clavicular link and the spine box are not aligned after the previous step, use a second C-clamp.

Step 6. Mount the head and neck assembly. The neck cable should be torqued to 1.36 N·m ± 0.27 N·m (1.0 ft·lbf ± 0.2 ft·lbf).

Step 7. Install the chest flesh.

7.1.10. Further Inspection of the Shoulder and Clavicle Assemblies and Links

Step 1. The durometer of the fore and aft rubber bump stop is 40-45 Shore A. Be careful not to install this stop backwards. Examine the plastic parts for physical damage. Check the shoulder-clavicle yoke for a rubber shoulder rotation bump stop, shown below in **Figure 7.1.10.1**, at the rear outer edge of the outer clavicle section for control of arm rotation.

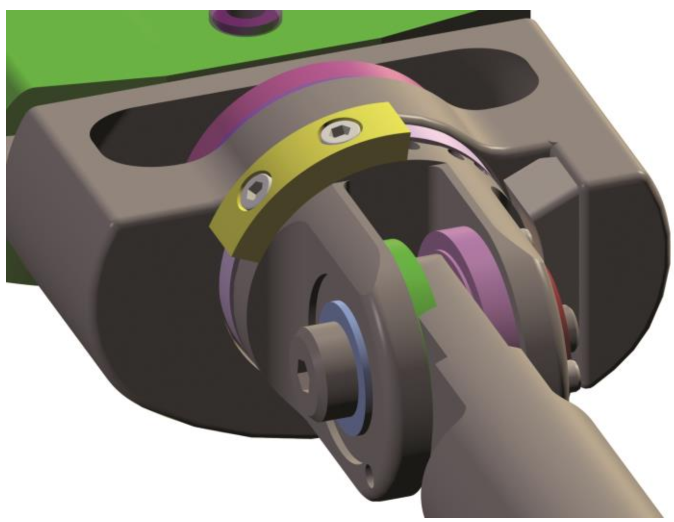

Figure 7.1.10.1: Rubber shoulder rotation bump stop

Step 2. Remove the shoulder-clavicle yolk to clavicle nut from the cavity on the bottom side of the outer clavicle section, shown below in **Figure 7.1.10.2**

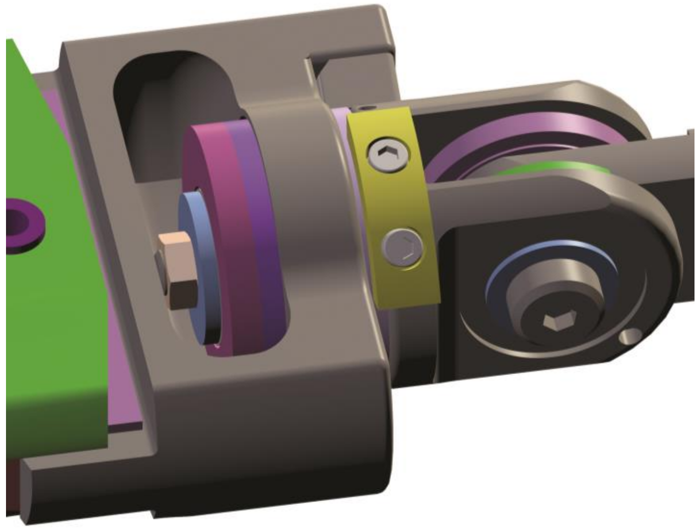

Figure 7.1.10.2: Shoulder yolk to clavicle nut

Step 3. Pull out the shoulder-clavicle yoke and check for its two-piece Delrin™ bushing, elastomeric washer, and large and small steel washers upon which the nut tightens, as shown below in **Figure 7.1.10.3.**

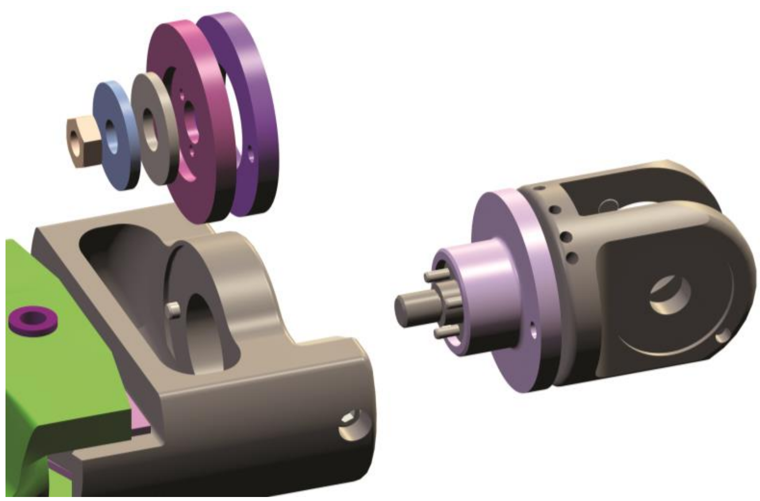

Figure 7.1.10.3: Exploded view of the shoulder-clavicle yolk

Step 4. Confirm that eight dowel pins are present.

Step 5. Check for a steel stop on the rim of the shoulder yoke, held by two #10-24 X 3/8" long screws, as shown above in **Figure 7.1.10.1**. The stop can be installed in two positions: one for the right side and the other for the left.

Step 6. Inspect clavicle aluminum parts for porosity and cracks.

Step 7. During reassembly, the steel shoulder yoke stop is installed on two of the four holes on the rim of the shoulder yoke, different on each side, to produce human like arm rotation. Confirm that arm rotation in the saggratal plane approximates human motion.

Section 8. Lower Torso Assembly

This section on the lower torso assembly includes the lumbar spine assembly, the abdominal insert, and the pelvic assembly.

8.1. Disassembling, Inspecting, and Reassembling the Lower Torso

8.1.1. Exploded View

An updated exploded view of the lower torso (78051-70) is shown below.

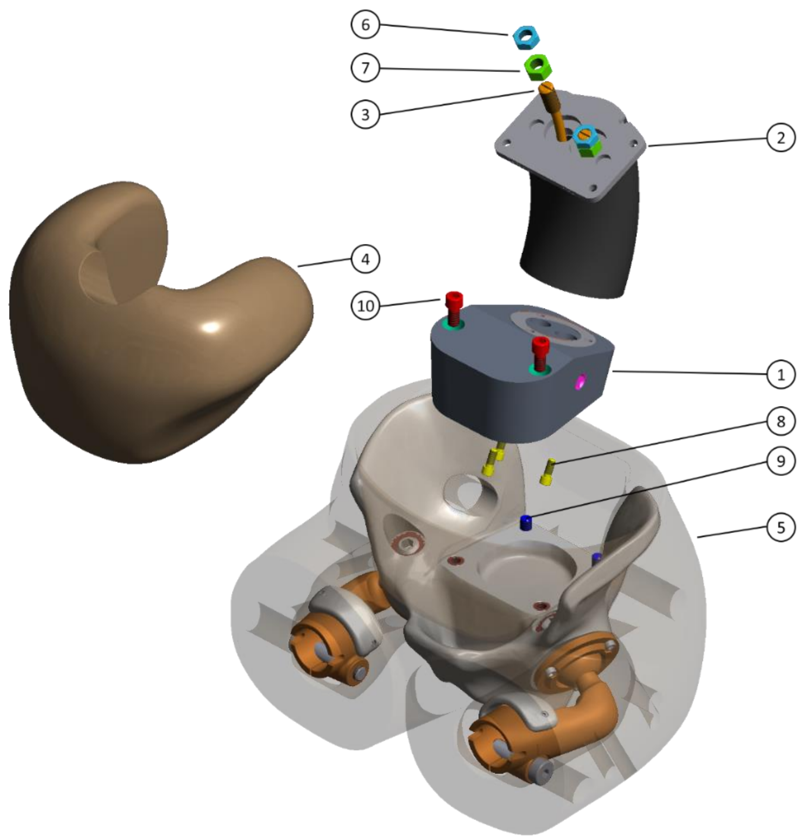

Figure 8.1.1.1: Lower torso assembly exploded view

8.1.2. Parts List

Table 8.1.2.1 below gives a general description of each item in the lower torso assembly (refer to lower torso assembly drawing 78051-70).

Table 8.1.2.1: Lower torso assembly parts list

Item	Quantity	Part Number	Description
1	1	78051-53	Lumbar Spine Bracket, Molded
2	1	78051-66	Lumbar Spine Assembly, Molded
3	2	78051-69	Lumbar Cable
4	1	78051-52	Abdominal Insert
5	1	78051-59	Pelvic Assembly
6	2	9000018	1/2-20 Hex Jam Nut, Zinc
7	2	9000057	1/2-20 Hex Nut, Zinc
8	3	9000144	SHCS, 1/4-20 X 5/8 Lg.
9	2	9000633	SHCS, 3/8-16 X 1 1/4 Lg.
10	2	9000490	SHCS, 3/8-16 X 3/4 Lg.

8.1.3. Disassembling and Inspecting the Lumbar Spine

Note: The lumbar spine is more easily accessed if the legs are detached.

Step 1. Remove the 5/8 X 1-3/4” long shoulder screw (one per leg) holding the rear of the upper leg to the brass femur. These bolts are located through holes in the flesh at the side and front of the pelvis, as shown in **Figure 8.1.3.1**. Detach the leg assemblies.

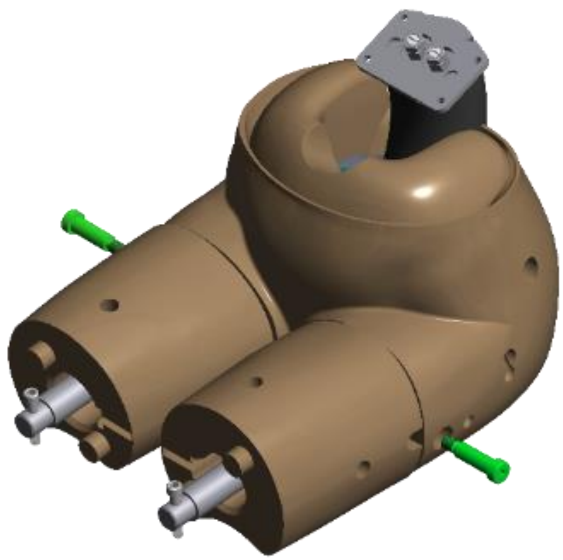

Figure 8.1.3.1: Upper leg access hole to femur

Step 2. Remove the four #10-24 X 3/8” long screws holding the pelvic instrument cavity cover.

Step 3. Separate the lumbar spine and its lumbar-to-pelvic adaptor from the pelvis by removing two 3/8-16 X 3/4" long cap screws from the front of the adaptor, as shown below in **Figure 8.1.3.2,** and two 3/8-16 X 1-1/4" long cap screws through the pelvic instrumentation cavity, as shown below in **Figure 8.1.3.3**.

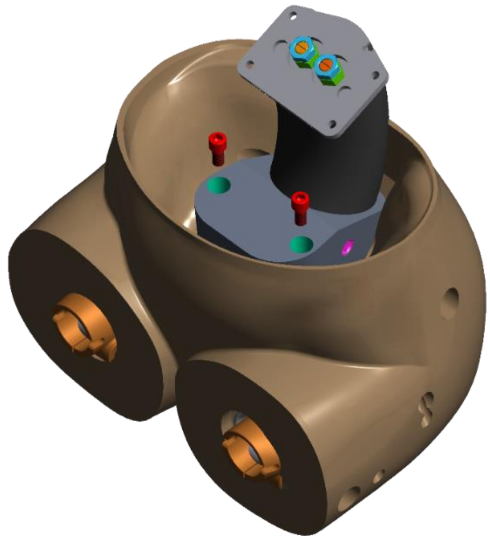

Figure 8.1.3.2: Lumbar spine assembly

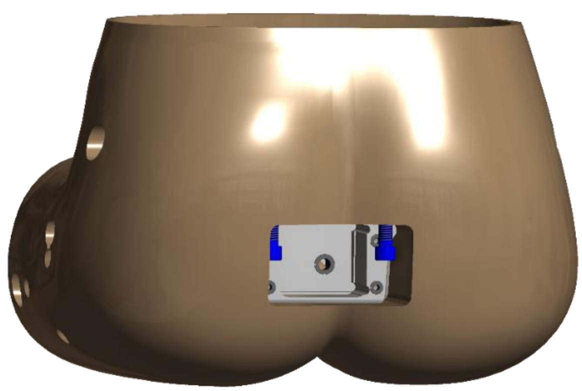

Figure 8.1.3.3: Pelvic instrumentation cavity with the cover removed

Step 4. Separate the lumbar spine from the adaptor by removing three 1/4-20 X 5/8" long cap screws from the bottom of the lumbar adaptor.

Step 5. Check the upper and lower surfaces of the lumbar spine adaptor. The lower surface must be flat and smooth. The upper surface for mounting the lumbar spine must be flat and smooth and have two hemispherical clearance depressions for the ends of the lumbar cables, as shown in **Figure 8.1.3.4**.

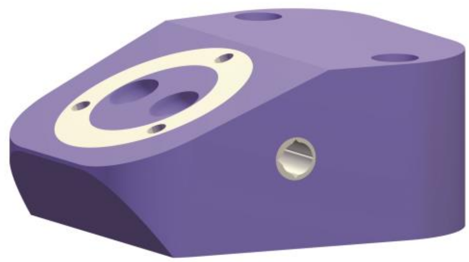

Figure 8.1.3.4: Lumbar spine adaptor

Step 6. Confirm that the corners formed by the square holes are parallel and perpendicular with the bottom of the bracket within ± 0.5°. Verify this by inserting the pelvis angle gauge and using a protractor or inclinometer.

Step 7. Detach the two lumbar cables by removing the two 1/2-20 hex and jam nuts on the top of each cable, as shown above in **Figure 8.1.3.2**, and pulling the cables through the spine. A special thin wrench is required for this job. These cables are not interchangeable with the neck cable.

Step 8. Check the top and bottom lumbar end plates for flatness and for complete adhesion to the rubber. Make sure sufficient clearance between the swaged balls and the hemispherical seats exists.

Step 9. Measure the included angle between the two plates of the spine, which must be 45.5° ± 0.5°, as shown in **Figure 8.1.3.5**.

NOTE: The spine must be allowed to sit free of the dummy for at least 24 hours before measuring the included angle between the two plates of the spine.

Figure 8.1.3.5: Measuring the lumbar spine angle

8.1.4. Inspecting the Abdomen Assembly

- Examine the abdominal insert (PN 78051-52) for skin-to-foam separation, for tears and/or cuts in the vinyl skin, and for air tightness.
- Air-shipped inserts are only partially sealed and must be fully sealed by the user.

8.1.5. Disassembling and Inspecting the Pelvis and Upper Femur Assemblies

Step 1. Remove the femur ball and flange assembly (PN 78051-114, 78051-115), as shown below in **Figure 8.1.5.1**, from each side of the pelvis by unscrewing three 1/4-20 X 3/4" long socket cap screws per side. Access to the screws is gained through the three one-half inch diameter holes in each side of the pelvic flesh.

Figure 8.1.5.1: Femur ball and flange assembly

Step 2. First remove the two rear screws and then rotate the femur assembly towards the pelvic center to allow access to the third screw. A tool made to fit in place of the upper leg bone will simplify this task.

Note: When removing the femurs, be careful not to tear the urethane bumpers (PN 78051-498-1, 78051-498-2) on the top of each femur. A small amount of talcum powder can be used on the bumpers to reduce friction.

Step 3. Remove the two #8-32 X 3/8" button head cap screws holding the bumpers in place, as shown below in **Figure 8.1.5.2**.

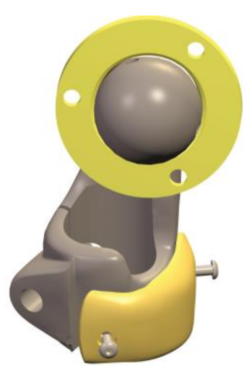

Figure 8.1.5.2: Removal of upper femur bumpers for inspection

Step 4. Inspect the bumpers for tears or cracks and replace if necessary.

Step 5. The new upper femur (PN 78051-110, 78051-111) is designed to prevent metal-to-metal contact between the femur and the flange/screws that hold the femur, when the femur is rotated towards the pelvis. This holds true when the femur is parallel to the midsagittal plane, as well as 7° inboard and outboard of this plane.

Step 6. Remove the accelerometer block; ensure that the accelerometer mount will properly house the desired accelerometers.

Step 7. Confirm that the lead ballast in the top of the pelvic casting (see **Figure 8.1.5.3**) does not project above the surrounding aluminum structure.

Figure 8.1.5.3: Potted lead shot (ballast) in cavity on top of pelvis

Step 8. Check the femur sockets and femur ball for galling. Confirm that the nylon-tipped femur friction adjusting screws are not damaged.

Step 9. Examine the pelvis for flesh tears and/or cuts, and the skin for foam separation. If the pelvis cavity for the femur shows signs of deterioration such as these, it will probably not pass the range of motion calibration test, and the pelvis should be remolded.

Step 10. Check the buttock compression by mounting an adaptor to the top of the pelvis. Invert the pelvis and apply a 334 N (75 lbf) force to the bottom of the pelvis, perpendicular to the ground, through a 400x400 mm (16x16 in.) plate covering the entire buttock area.

Step 11. After five minutes, the distance between the adaptor-to pelvic interface and the 400x400 mm plate must be 90.4 to 93.5mm (3.56 to 3.68 in).

Section 9. Arm Assembly

9.1. Disassembling, Inspecting, and Reassembling the Arm

9.1.1. Exploded View

An exploded view of the arm assembly (78051-123, left and 78051-124, right) is shown in the figure below.

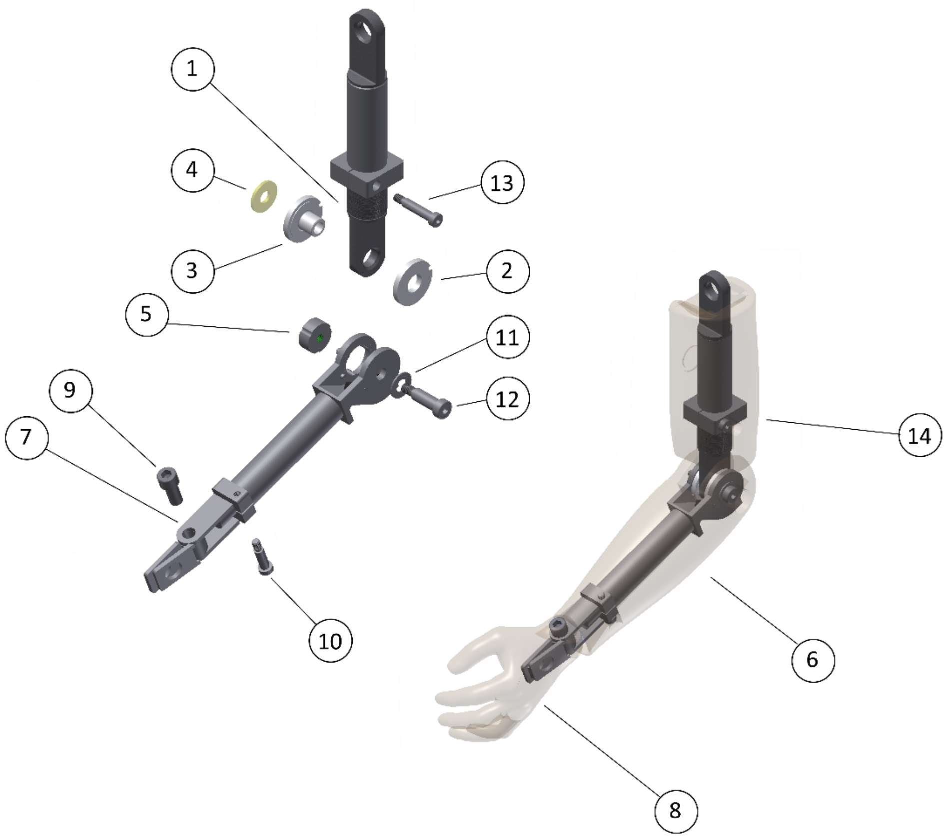

Figure 9.1.1.1: Arm assembly exploded view

9.1.2. Parts List

Table 9.1.2.1 below gives a general description of each item in the arm assembly (refer to arm assembly drawing 78051-123, left and 78051-124, right.

Table 9.1.2.1: Arm assembly parts list

Item	Quantity	Part Number	Description
1	1	78051-191	Weldment, Upper Arm, Lower Part
2	1	78051-200	Washer, Upper Arm and Elbow Pivot
3	1	78051-199	Bushing, Upper Arm and Elbow Pivot

Item	Quantity	Part Number	Description
4	1	78051-249	Washer, Shoulder Joint Spring
5	1	78051-202	Nut, Elbow Pivot
6	1	78051-194	Lower Arm Assembly, Molded
7	1	78051-204	Wrist Rotation
8	1	78051-208	Hand, Molded, Left
	1	78051-209	Hand, Molded, Right (Not Shown)
9	1	78051-214	Screw, Wrist Pivot
10	1	9000074	SHSS, 3/8" 1.0" Lg.
11	1	9001260	1/2" Flat Washer Plain Steel Cadmium
12	1	9000055	SHSS, 1/2" X 1 1/4" Lg.
13	1	9000082	SHSS, 3/8" X 1 1/2" Lg.
14	1	78051-174	Upper Arm, Molded

9.1.3. Disassembling the Arm

Step 1. Remove each arm from the shoulder yoke assembly at the shoulder by unscrewing the 1/2 X 1-1/4 long socket head shoulder screw (SHSS), as shown below in **Figure 9.1.3.1**.

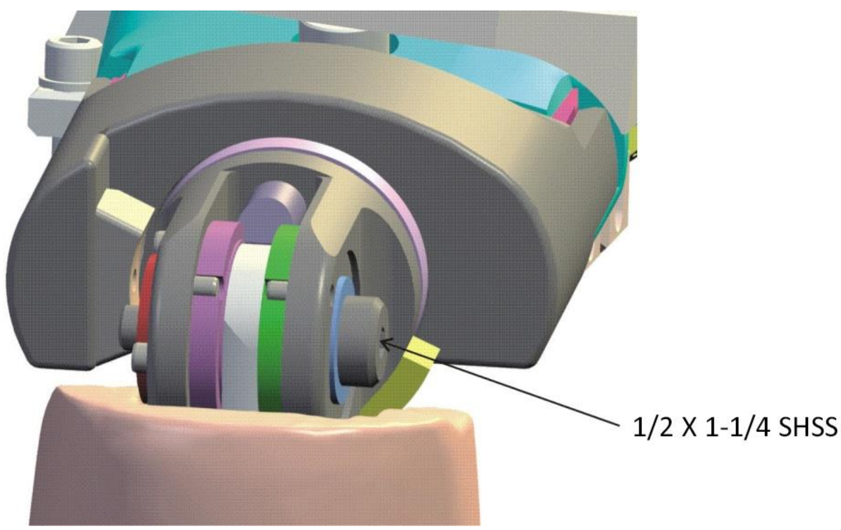

Figure 9.1.3.1: Remove the arm from the shoulder yoke assembly

Step 2. If necessary, clean the Delrin™ bushing and washers with a safety approved chlorinated solvent. Never lubricate any of the plastic bushings.

Step 3. Push out the steel pivot nut in each shoulder yoke, as shown below in **Figures 9.1.3.2** and **9.1.3.3.** If the nut does not slide out freely, use the just-removed shoulder screw to help pull it out. Make sure the nut slides freely in its hole.

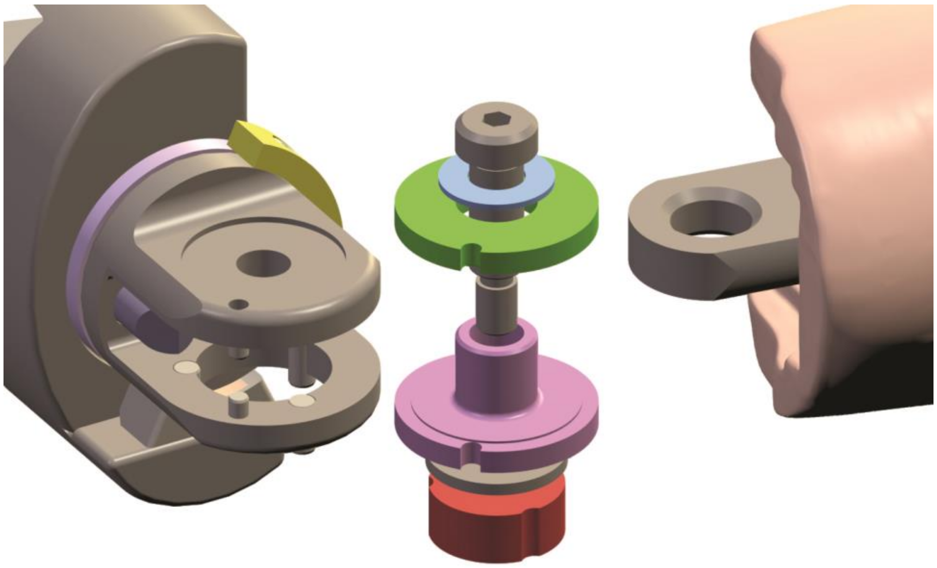

Figure 9.1.3.2: Exploded view of the shoulder yoke assembly

Figure 9.1.3.3: Shoulder yoke pivot nut

9.1.4. Inspecting the Arm Components

- Inspect each yoke to make sure each one contains five alignment dowel pins and one rubber bumper, as shown above in Figures 9.1.3.1 and 9.1.3.2).
- Examine all metal parts for burrs and sharp edges and remove them as necessary.
- Inspect vinyl-to-foam adhesion, cracked or cut vinyl skin, cracked or damaged bushings, and the condition of the threaded holes.

- Separate the lower arms from the upper arms and examine the elbow joints, noting the condition and position of the various parts as for the shoulder joints. Look to see that the two elbows with rubber stops (PN 78051-198) are in place.
- Remove the elbow pivot size nut (PN 78051-202) and check that the nut slides freely in the hole.
- Detach the hands from the lower arms and disconnect the wrist rotation joint. The elbow and wrist rotation joints have no stops.
- Lubricate the two rotation joints.

9.1.5. Connecting the Arm Assembly to the Shoulder

Step 1. Assemble the upper and lower arms and attach the arms to the shoulder yokes. The upper arm has a cutout on the upper inner side.

Step 2. The correct sequence of shoulder and elbow washers is:

1) Shoulder bolt
2) Steel flat washer
3) One half of yoke
4) Delrin™ bushing
5) Arm boss
6) Delrin™ bushing
7) Urethane washer
8) Other half of yoke
9) Steel sliding pivot/nut

9.1.6. Adjusting the Arm and Hand Joints

The procedure for adjusting the arm and hand joints is given in sub-Section 2.2, "**Joint Resistive Torque Adjustments**."

Section 10. Leg Assembly

10.1. Description and Features of the Leg Assembly

10.1.1. Non-Instrumented (Standard) and Instrumented (Optional) Lower Leg and Knee

Each Hybrid III lower leg assembly consists of the sliding knee (with an optional potentiometer to measure displacement), a lower leg (either standard or an optional instrumented one), and a 45° foot. Another knee design with a ball-slider mechanism is also available. The instrumented lower leg option can measure knee (tibia-to-femur) shear, knee clevis axial loads (inside and outside the knee), upper leg fore-aft and lateral moments plus shear and axial forces, and lower leg fore-aft and lateral moments plus shear. Load cells with four channels to measure various combinations of forces and moments are available for the upper and lower tibias.

The knees can be attached so the potentiometer mounts either inboard or outboard. **Figure 10.1.1.1** below shows the knees configured to hold the potentiometer inboard, while **Figure 10.1.1.2** below shows the knees set up to place the potentiometer outboard.

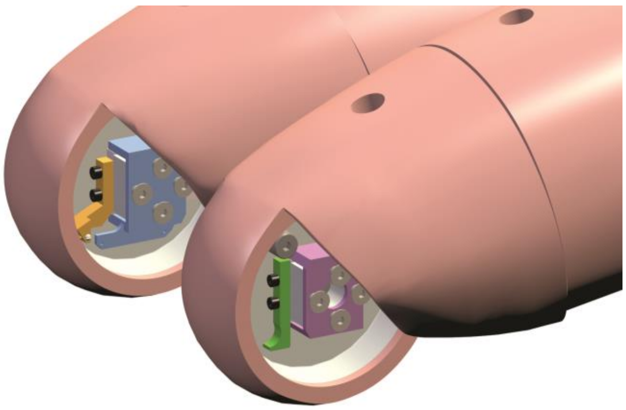

Figure 10.1.1.1: Knees assembled to allow inboard potentiometer placement

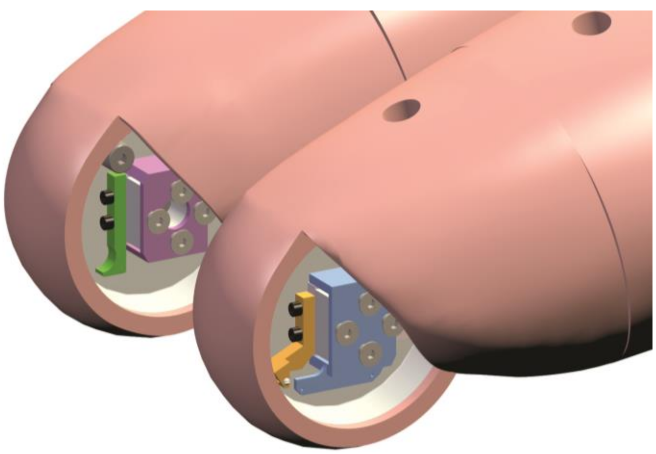

Figure 10.1.1.2: Knees assembled to allow outboard potentiometer placement

Mounting the potentiometer inboard provides easier access to the knee adjustment screw when seating the dummy. However, some test conditions may be more likely to damage the potentiometers when they are located inboard, so the test engineer can specify an outboard mounting location.

10.2. Disassembling, Inspecting, and Reassembling the Leg Assembly

10.2.1. Exploded View

An exploded view of the leg assembly (86-5001-001, left and 86-5001-002, right) is shown in the figure below.

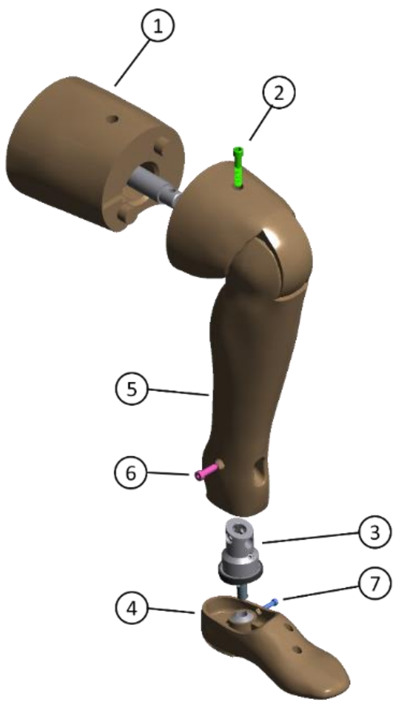

Figure 10.2.1.1: Leg assembly exploded view

10.2.2. Parts List

Table 10.2.2.1 below gives a general description of each item in the leg assembly (refer to leg assembly drawing (86-5001-001, left and 86-5001-002, right).

Table 10.2.2.1: Leg assembly parts list

Item	Quantity	Part Number	Description
1	1	78051-46	Upper Leg Assembly, Left
	1	78051-47	Upper Leg Assembly, Right (Not Shown)
2	1	9000066	Screw, SHCS, 3/8-16 X 2.0 Lg.
3	1	B-1889-DN	Ankle Assembly
4	1	78051-600	Foot Assembly, Left
	1	78051-601	Foot Assembly, Right (Not Shown)
5	1	86-5001-003	Knee & Lower Leg Assembly, Left
	1	86-5001-004	Knee & Lower Leg Assembly, Right (Not Shown)

10.2.3. Disassembling the Upper Leg and Knee

Step 1. Separate the upper leg sections by removing the two 3/8-16 screws (one is 1-3/4" long and the other is 2" long) that secure the load cell or the femur load cell simulator to the femur and the knee cap. The longer screw is nearest to the knee.

Step 2. Detach the lower leg from the machined knee by removing eight 1/4-28 X 7/16" long flat head cap screws. Refer to **Figures 10.2.3.1** and **10.2.3.2** below.

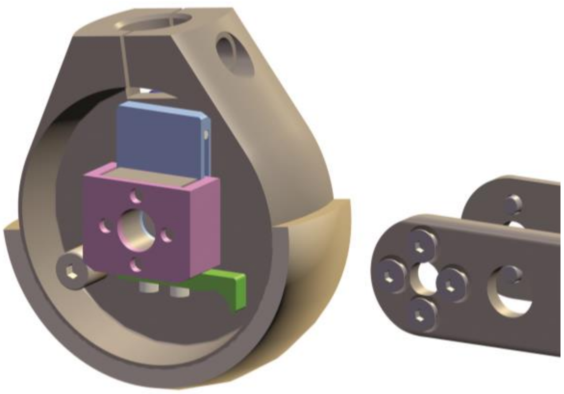

Figure 10.2.3.1: Side of knee with adjustment screw and stop

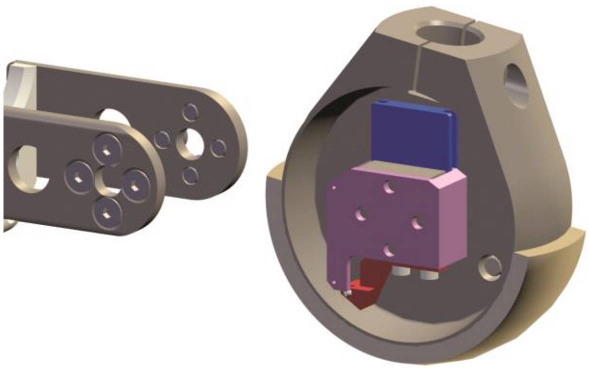

Figure 10.2.3.2: Side of knee that holds optional potentiometer

10.2.4. Disassembling and Inspecting the Knee

Note: The drawings dealing with the potentiometer location (PN 79051-16, -24, and -25) differ with respect to the "inboard" and "outboard" sides of the knee.

Step 1. Separate the lower leg from the machined knee by removing eight 1/4-28 X 7/16" long flat head cap screws from the clevis. This exposes the knee slider assembly.

Step 2. The slider is detached by removing the 3/8 X 3/8 inch long shoulder screw which has a metal and a urethane washer, as shown below in **Figure 10.2.4.1**. The two parts of the slider assembly then can be taken off of the machined knee, as shown below in **Figures 10.2.4.2, 10.2.4.3**, and 10**.2.4.4**).

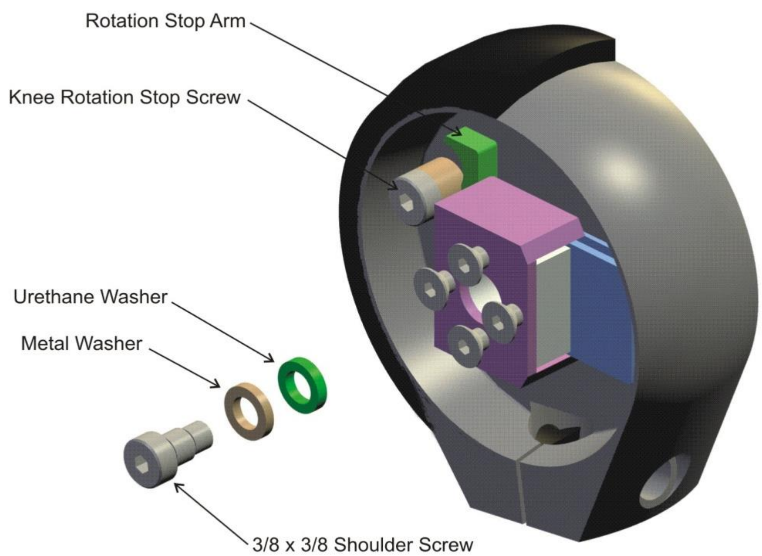

Figure 10.2.4.1: Knee slider assembly and lower leg rotation stop

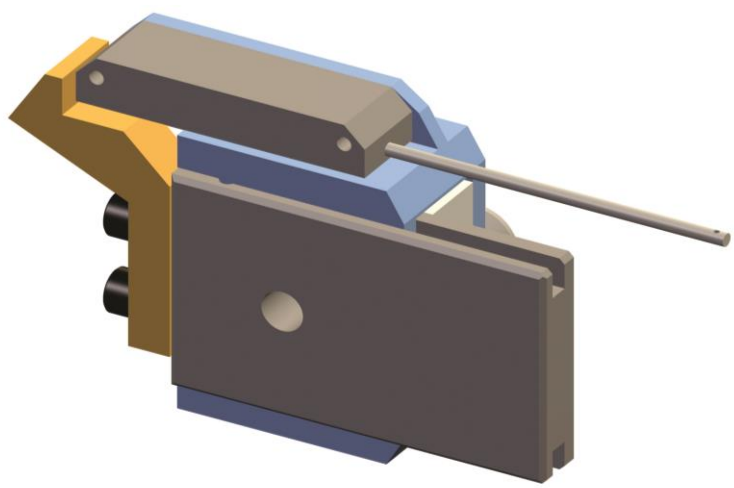

Figure 10.2.4.2: Half of the sliding knee transducer assembly and optional linear potentiometer

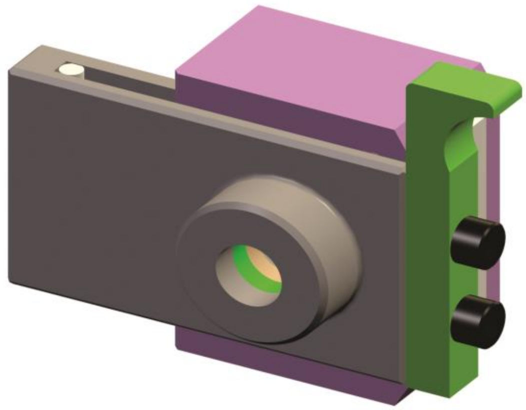

Figure 10.2.4.3: Remaining half of the sliding knee transducer assembly

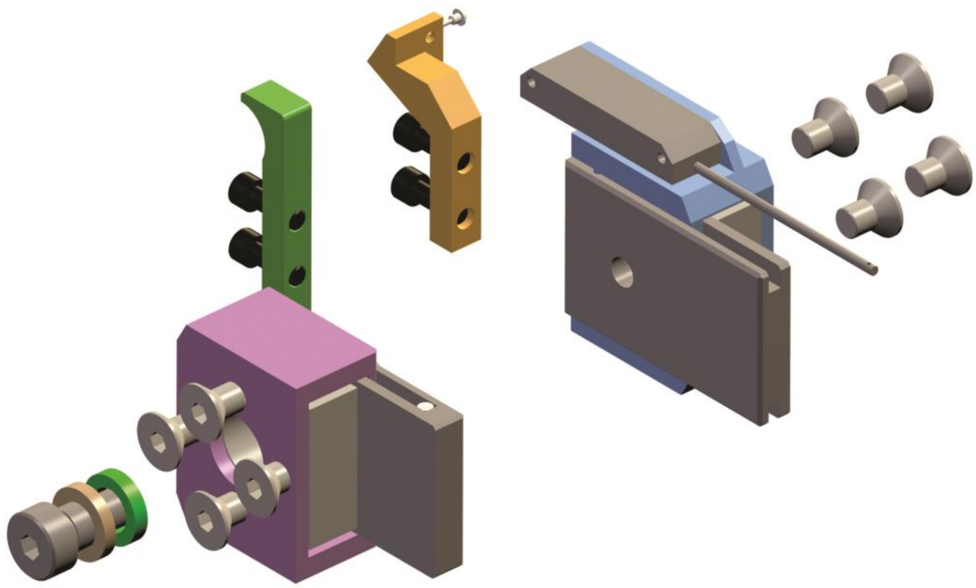

Figure 10.2.4.4: Exploded view of the knee slider assembly

Step 3. Ensure that the knee rotation stop is in place, as shown above in **Figure 10.2.4.1**.

Step 4. Add a graphite-based dry film lubricant or equivalent to the sliding tracks shown above in **Figures 10.2.4.2** and **10.2.4.3** above). The pin that holds the optional displacement potentiometer displacement-rod to the slider should be tight.

Step 5. Take off the knee skin and rubber knee insert, as shown below in **Figure 10.2.4.5**

- Examine these flesh parts for cuts and tears.
- Clean the inside and outside of the insert and adjoining knee skin with isopropyl to alcohol or equivalent.

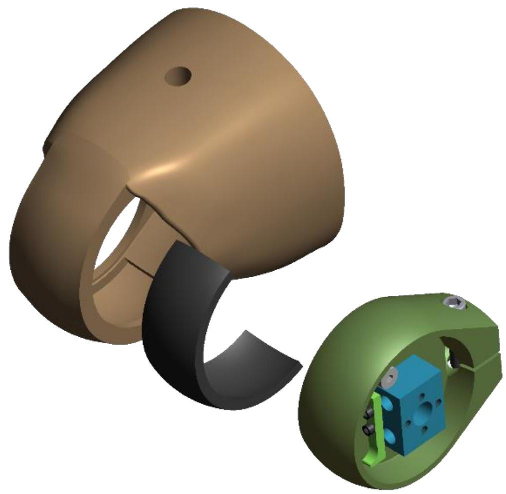

Figure 10.2.4.5: Knee, skin, and insert

10.2.5. Disassembling the Standard (Non-Instrumented) Lower Leg and Foot

Step 1. Remove the 45° foot from the ankle by unscrewing the foot attachment bolt, A-1886, shoulder screw from the side of the foot.

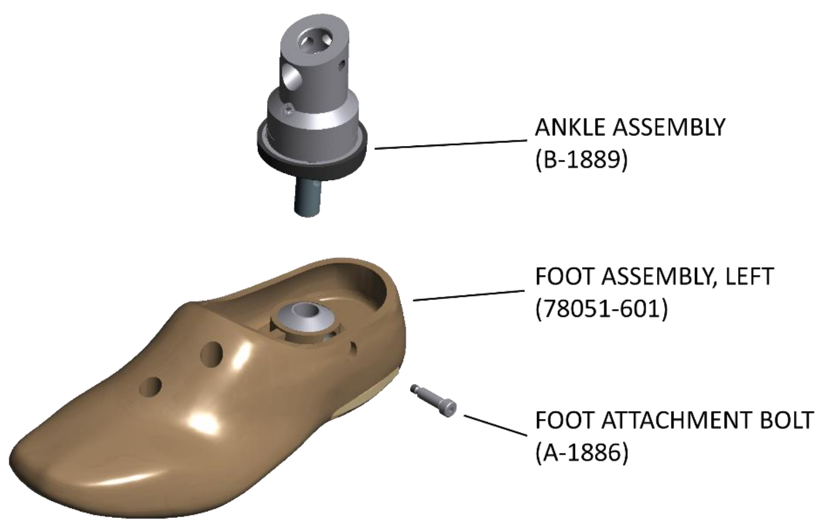

Figure 10.2.5.1: Foot, ankle assembly, and foot attachment bolt

Step 2. Remove the heel pad foam and inspect for deterioration, as shown in **Figure 10.2.5.2.** Make sure that the ankle bumper is in place and inspect for deterioration.

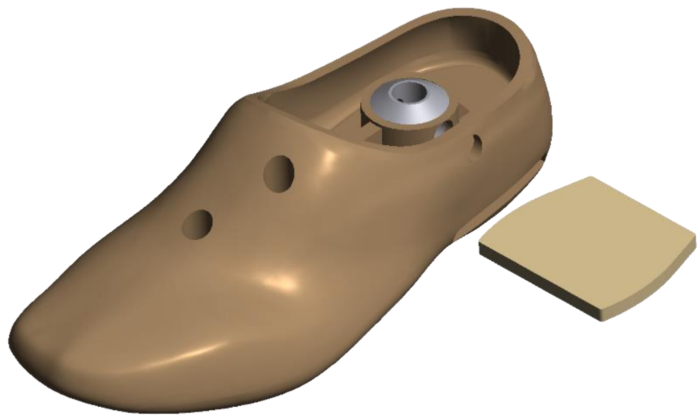

Figure 10.2.5.2: Foot and heel pad foam

10.2.6. Reassembling the Standard (Non-Instrumented) Lower Leg and Foot

- When assembling the knees with the standard, non-instrumented lower legs, the shoulder bolt head can be on the inboard or outboard side of both knees, as shown above in **Figures 10.1.1.1** and **10.1.1.2**, respectively..
- The modified 3/8" diameter shoulder bolt with a rubber sleeve mounted in the machined knee acts as a control for the motion between the lower leg and knee.

10.2.7. Adjusting the Leg and Foot Assemblies

The procedure for adjusting the leg and foot assemblies is given in sub-Section 2.2, "**Joint Resistive Torque Adjustments**."

Section 11. Optional Instrumented Lower Leg Assembly

11.1. Description and Features of the Instrumented Lower Leg

The standard lower leg can be replaced with an optional instrumented lower leg. The instrumented lower leg can measure knee (tibia-to-femur) shear, knee clevis axial loads (inside and outside the knee), upper leg fore-aft and lateral moments plus shear and axial forces, and lower leg fore-aft and lateral moments plus shear.

Load cells with four channels to measure various combinations of forces and moments are available for the upper and lower tibias. These optional upper and lower tibia load cells are separated by a heavy wall, aluminum tube that protects the load cell connectors. The upper and lower tibia load cells are each attached to the tube by four modified BHCS. The lower load cell may be rotated 90°, if lateral shear and moment are preferred, by using the second slot in the ankle-to-tibia adapter, or this load cell may be purchased with both moment measurements built in. No adjustments are needed except for a friction adjustment at the ankle ball.

The following sections describe the disassembly and reassembly of the optional instrumented lower leg.

11.2. Disassembly and Reassembly of the Optional Instrumented Lower Leg

11.2.1. Disassembling the Optional Instrumented Lower Leg

The optional instrumented lower leg, shown below in **Figures 11.2.1.1, 11.2.1.2,** and **11.2.1.3**, replaces the standard (non-instrumented) lower leg, which is the welded assembly shown in **Figure 11.2.1.4**.

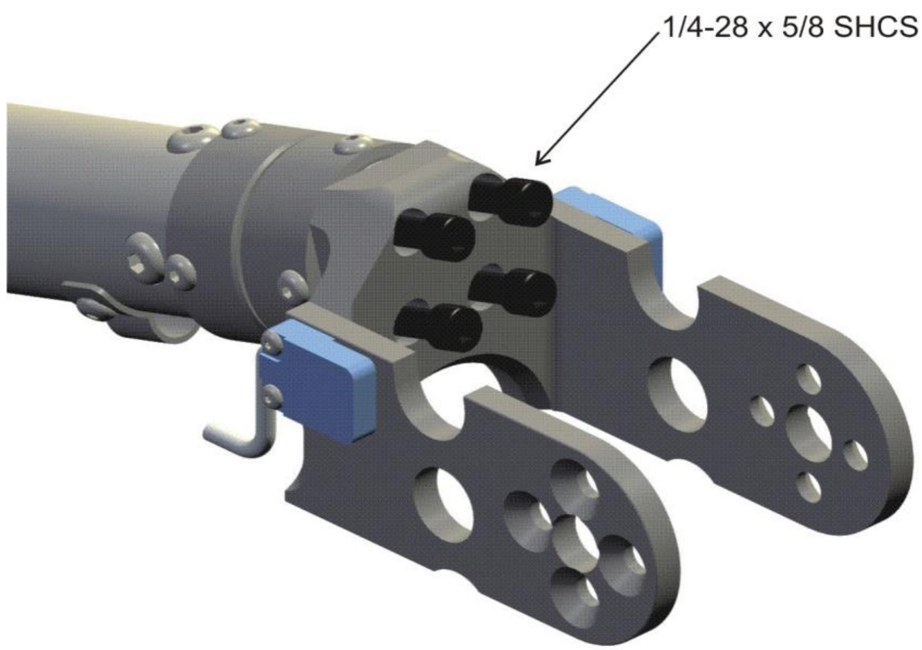

Figure 11.2.1.1: Optional instrumented lower leg

Figure 11.2.1.2: Optional heavy-wall aluminum tube and tibia multi-axis load cells

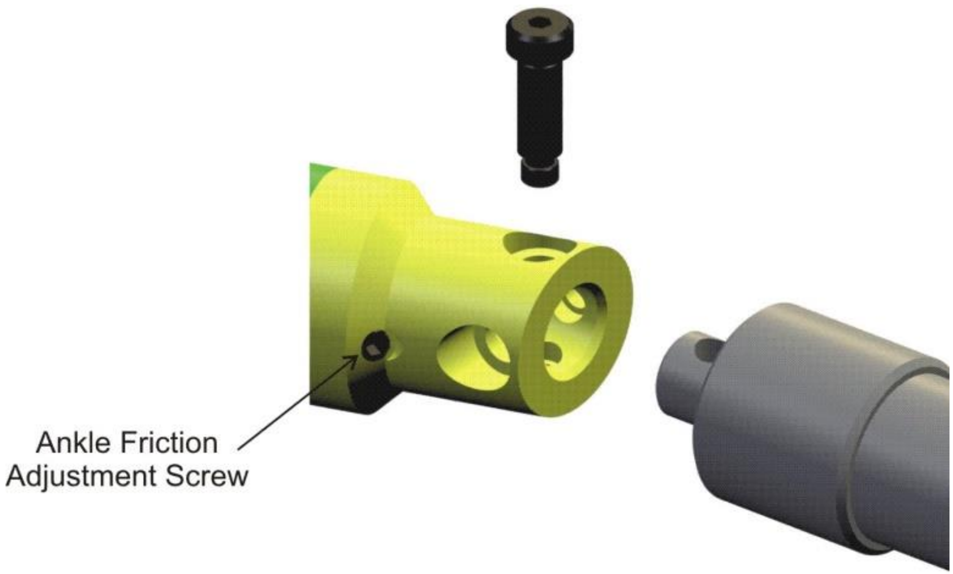

Figure 11.2.1.3: Lower tibia transducer with second bottom slot for 90° rotation of transducer

Figure 11.2.1.4: Standard (non-instrumented) lower leg

11.2.2. Reassembling the Knee and Optional Instrumented Lower Leg

Step 1. The upper part of the lower leg consists of the clevis with two Fz load cells. The clevis is bolted to the upper tibia load cell by four 1/4-28 x 5/8” long socket head cap screws, as shown in **Figure 11.2.1** above.

Step 2. The optional upper and lower tibia load cells are separated by a heavy wall aluminum tube which protects the load cell connectors, as shown in **Figure 11.2.2** above.

Step 3. The upper and lower tibia load cells are each attached to the tube by four modified 1/4 x 28 button head cap screws. The lower load cell may be rotated 90° if lateral shear and moment are preferred, by using the second bottom slot in the ankle-to-tibia adaptor, as shown in **Figure 11.2.3** above, or this load cell may be purchased with both moment measurements built in. However, no adjustments are possible except for a friction adjustment at the ankle ball.

Section 12. Jacket and Clothing Assembly

12.1. Description and Features of the Jacket and Clothing Assembly

- When used in testing, the dummy should wear snug-fitting cotton knit T-shirt and pants.
- 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 T-shirt and pants should each weigh no more than 0.27 kg (0.6 lbs). Garments similar to thermal underwear (trimmed to be short-sleeved and above the knee) usually meet these requirements.
- To improve the quality of high-speed films taken of the dummy during testing (by avoiding excessive glare), the garments are usually dyed light pink.
- The shoes used with the 50th percentile male dummies are men's dress oxfords, size 11XW that meet military specification MIL-S-13192P and whose weight each is 1.25± 0.2 lbs.

Section 13. Instrumentation

13.1. Overview

13.1.1. Recommendations when Ordering and/or Purchasing an ATD (Dummy)

When ordering a new test dummy, inform Humanetics of the type and model of accelerometer you intend to use. This will ensure that you obtain the correct accelerometer mounts for the head, chest and pelvis.

When purchasing a new head (or an original dummy), inform Humanetics which neck transducer (three or six channel) you intend to use. The skulls are not interchangeable. A six channel upper neck load cell may be furnished with only three channels active and it will fit in the six axis head.

13.1.2. Optional Instrumentation Availability

The Hybrid III dummy has many optional but recommended transducers that are listed below in **Table 13.1.2.1**. On the lower extremities, they allow measurement of knee shear (tibia-femur displacement), knee clevis axial load (relative to the knee and ankle joints), and tibia-ankle shear and bending moments, plus three forces. For the neck (both top and bottom) spine, six channel transducers that measure three moments and three forces are becoming preferred.

Table 13.1.2.1: Required and optional instrumentation availability

Instrumentation Location	Measurement	Number of Channels	Required	Optional
Head C.G.	Acceleration	3	X	
Head	Angular Acceleration	9 or 12		X
Head	Angular Rate	3		X
Head-Neck Interface	Force & Moment	3	X	
Head-Neck Interface	Force & Moment	6		X
Thorax C.G.	Acceleration	3	X	
Thoracic Spine	Force & Moment	5		X
Sternum	Displacement	1	X	
Sternum	Displacement	8		X
Lumbar Spine	Force & Moment	5		X
Pelvis	Acceleration	3		X
Pelvis	Lap Belt Position	6		X
Upper Femur	Force & Moment	6 each		X
Lower Femur	Force	1 each	X	

Instrumentation Location	Measurement	Number of Channels	Required	Optional
Lower Femur	Force & Moment	6 each		X
Knee-Tibia	Displacement	1 each		X
Knee-Clevis	Force	2 each		X
Upper Tibia	Force & Moment	4 each		X
Lower Tibia	Force & Moment	4 each		X
Foot/Ankle/Toe	Force & Moment	6 each		X
Shoulder	Force	2 each		X
Sternum	Acceleration	2		X

Section 14. Calibration Tests

14.1. Overview

Calibration tests are specified for dummy responses that could affect the measurements that are used by governments and safety engineers to assess occupant injury potential. Calibration 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 shall periodically perform the calibration tests to assure the dummy is maintained at the SAE specified performance levels.

As a supplement to the calibration procedures included in this manual, European regulations include some additional calibration tests. They essentially involve dynamic impacts to the lower extremities. Users should be aware of these additional tests when using dummies to certify vehicles in Europe. Sources of information regarding these European regulations and test procedures and be found in **Section 1.2.2**, "Conventions Used in this Manual."

14.2. Head Drop Test

14.2.1. Test Purpose

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

14.2.2. Required Test Parts

The head assembly, the mass of which must be 4.54 kg ± 0.05 kg (10.0 lb ± 0.1 lb), and other assemblies and parts required for this calibration test include the following:

- Head assembly 78051-61 (3 axis) or 78051-61X (6 axis)
- Neck transducer or a structural replacement; can be 3-channel (78051-383) or 6-channel (78051-383X)
- Head-to-neck pivot pin (78051-339)
- Three accelerometers

14.2.3. Test Fixture

The test fixture consists of a structure to suspend the head assembly and a rigidly supported, flat, horizontal, steel plate. A sample test setup is shown below in **Figure 14.2.5.1**.

- The square plate should be 50.8 mm ± 2 mm (2.0 in ± 0.08 in) thick, with a length and width of 610 mm ± 10 mm (24 in ± 0.4 in), and have a smooth surface finish of 8 to 80 micro inches/inch rms. A surface finish close to 8 micro inches/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.
- Effective suspension cable and accelerometer cable masses are to be less than 25 g (0.05 lb).
- Effective mass can be estimated by multiplying the mass/unit length of the cable by the length of cable between the head and the first support.

14.2.4. Data Acquisition

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 phase-less filters.

Note:

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

14.2.5. Test Procedure

Step 1. Visually inspect the head skin for cracks, cuts, abrasions, etc. Replace or repair the head skin if abrasions or cuts to the frontal area are more than superficial.

Step 2. Torque the 1/4-20 skull cap screws to 18 N·m (160 in-lbf) and the 10-24 accelerometer mount cap screws to 7.5 N·m (66 in-lbf).

Step 3. Soak the head assembly in a controlled environment with a temperature of 18.9 to 25.6 °C (69 to 72 °F) and a relative humidity from 10 to 70% for at least four hours prior to a test. The test environment must have the same temperature and humidity requirements as the soak environment.

Step 4. Mount the accelerometers in the head on the horizontal transverse bulkhead so the sensitive axes intersect at the center of gravity point as defined by Drawing 78051-338, Page 2 of 2.

- 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 its 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.

Step 5. The impact surface and the skin must be clean and dry for testing. Prior to the test, clean the impact surface of the skin and the impact plate surface with isopropyl alcohol or an equivalent.

Step 6. Suspend the head assembly in a manner similar to that shown below in **Figure 14.2.5.1**.

- The lowest point on the forehead is 12.7 mm ± 1 mm (0.5 in ± 0.04 in) below the lowest point of the dummy's nose when the midsagittal plane is vertical.
- The 1.6 mm (0.062 in) diameter holes located on either side of the head are used to ensure that the head is level with respect to the impact surface.

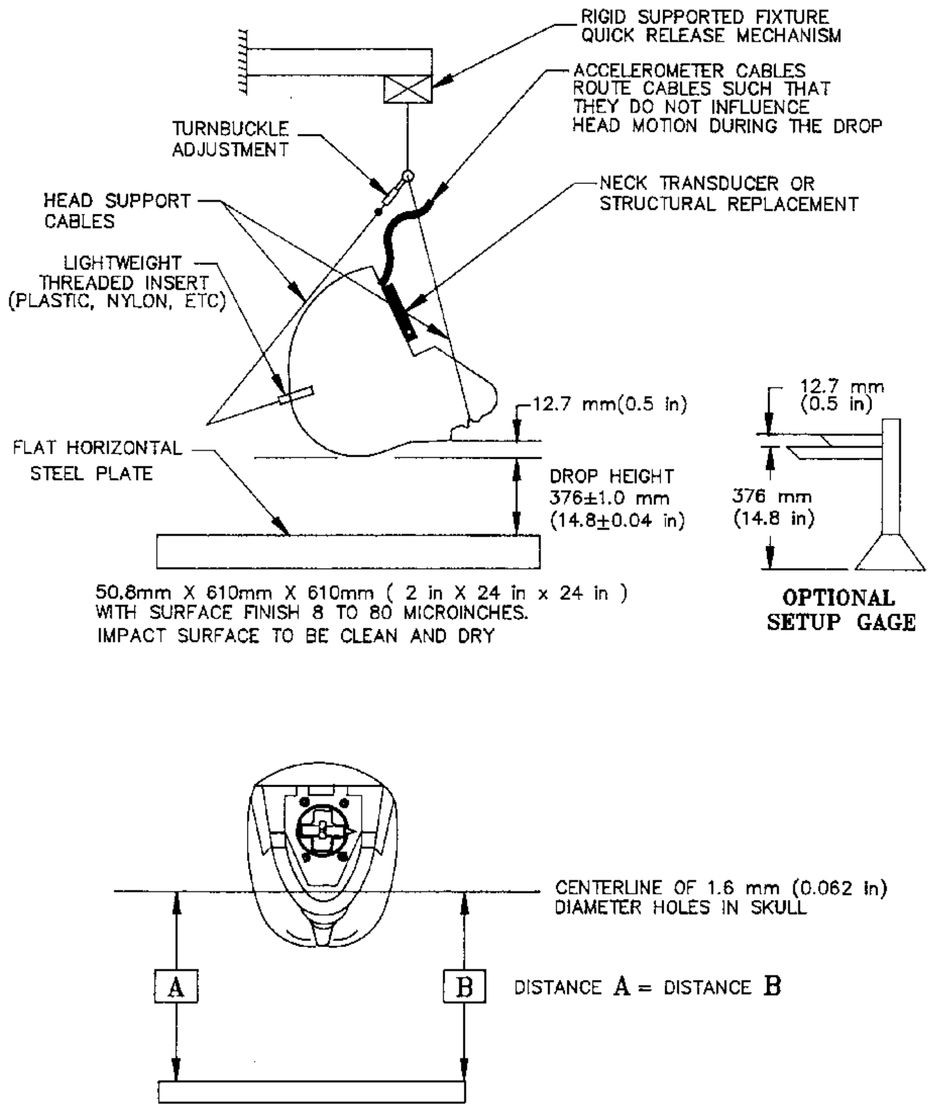

Figure 14.2.5.1: Head drop test/calibration setup specification

Step 7. Drop the head assembly from a height of 376 mm ± 1 mm (14.8 in ± 0.04 in) by a means that ensures a smooth, clean release onto the impact surface.

Step 8. Wait at least two hours between successive tests on the same head assembly.

14.2.6. Performance Specifications

- The peak resultant acceleration shall be between 225.0 G and 275.0 G, inclusive.
- The resultant acceleration versus time history curve shall be unimodal so that oscillations occurring after the main acceleration pulse are less than 10% (zero to peak) of the main pulse.
- The peak lateral acceleration vector shall be between (-15.0) and (+15.0) G's, inclusive.

14.3. Neck Test

14.3.1. Required Test Parts

The following assemblies and parts are required for this test:

- Head assembly (78051-61X)
- Neck assembly (78051-90)
- Upper neck bracket (78051-307)
- Lower neck bracket (78051-303)
- Bib simulator (78051-84)
- Three- or 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 through 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.

14.3.2. Test Fixture

The test fixture pendulum arm with specifications appears below in **Figure 14.3.2.1**.

- The aluminum honeycomb material is commercial grade, 0.8 kg (1.8 lb.) per cubic ft. with 19 mm (0.75 in) diameter cells.
- Mount the accelerometer with its sensitive axis aligned with the arc formed at a radius 1657.4 mm (65.25 in) from the pivot point.

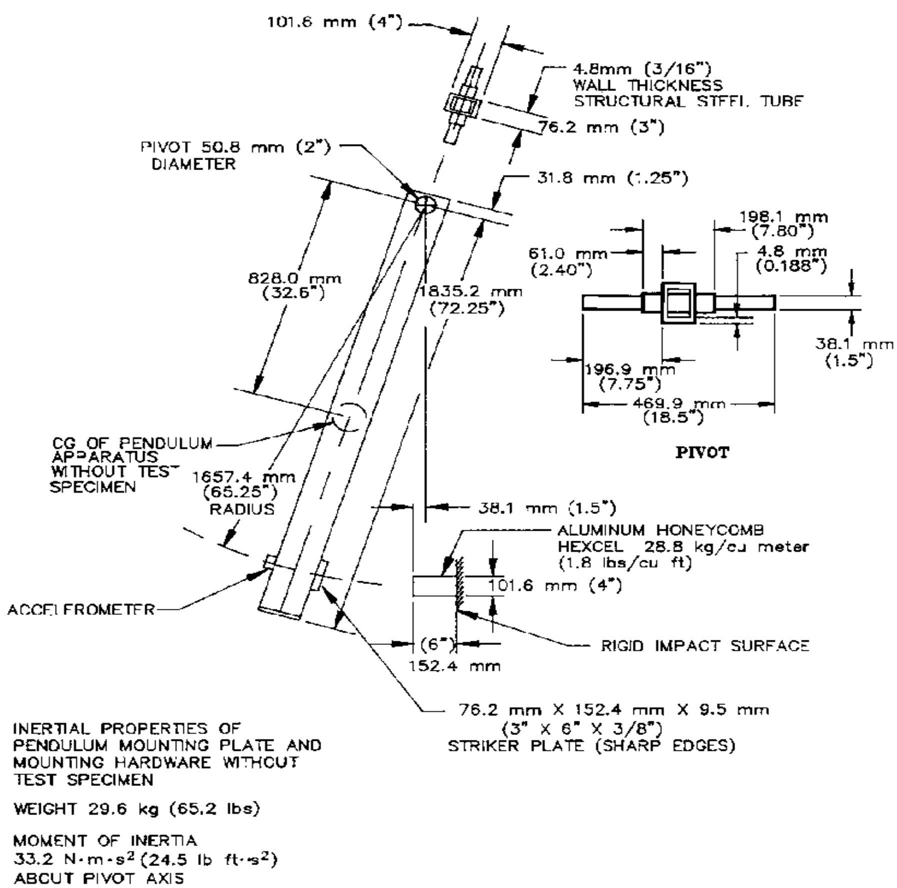

Figure 14.3.2.1: Neck test fixture pendulum arm and specifications

14.3.3. Data Acquisition

The data acquisition system, including transducers, must conform to the specifications of the latest revision of SAE Recommended Practice J211-1. Use phaseless filters to 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 60, and
- The neck rotation data channels using Channel Class 60.

Note:

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

14.3.4. Test Procedure

Step 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 four hours prior to a test. The test environment must have the same temperature and humidity requirements as the soak environment. Check that internal neck temperature reaches the soak temperature by placing a thermo-sensor into one of the holes in the neck.

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

Step 3. Inspect the nodding blocks for any deterioration and replace as necessary. Replace the blocks if they are less than 80% of their original height. The durometer should be 80 to 90 Shore A. Ensure that the nodding blocks are installed correctly, as shown in **Figure 6.2.3.8**.

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

Step 5. Mount the head-neck assembly on the pendulum so the midsagittal plane of the head is vertical. As shown below in **Figure 14.3.4.1** for the flexion test and **Figure 14.3.4.2** for the extension test, the midsagittal plane must coincide with the plane of motion of the pendulum's longitudinal centerline.

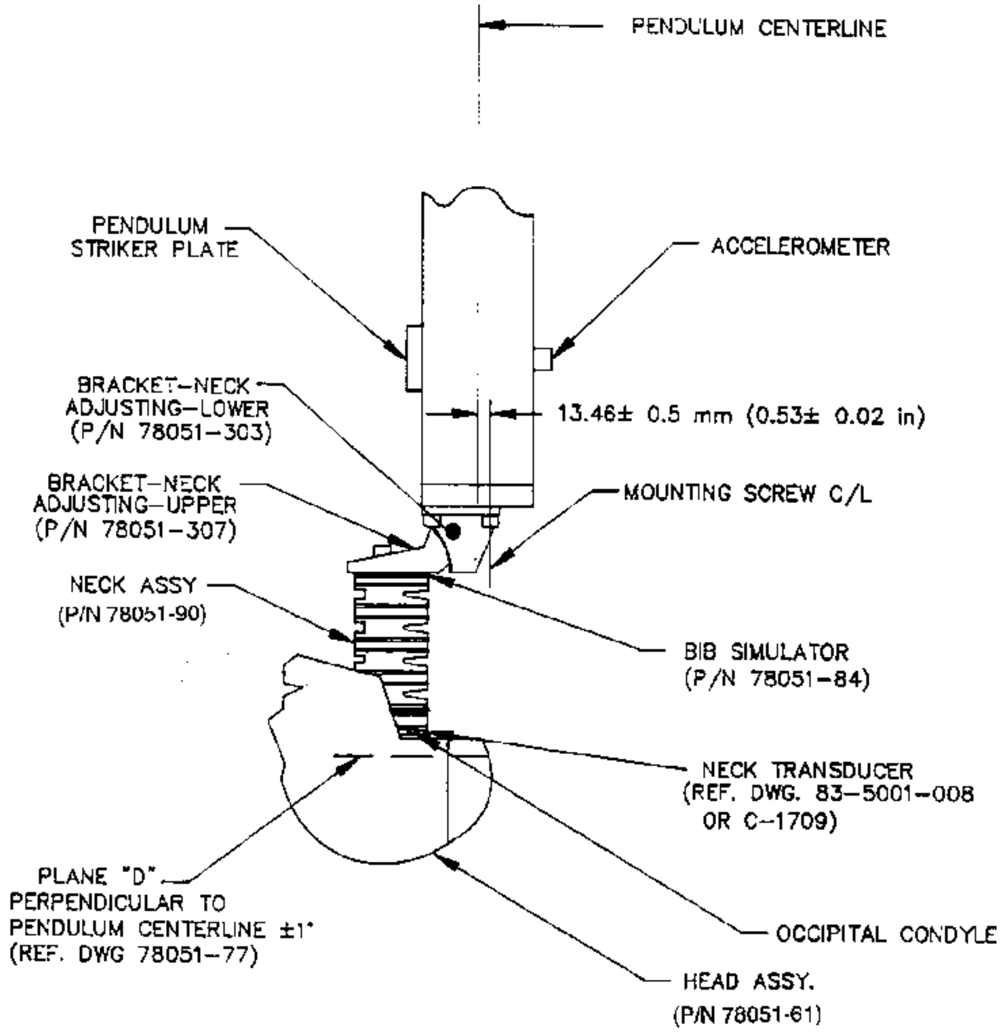

Figure 14.3.4.1: Neck flexion test set-up specification

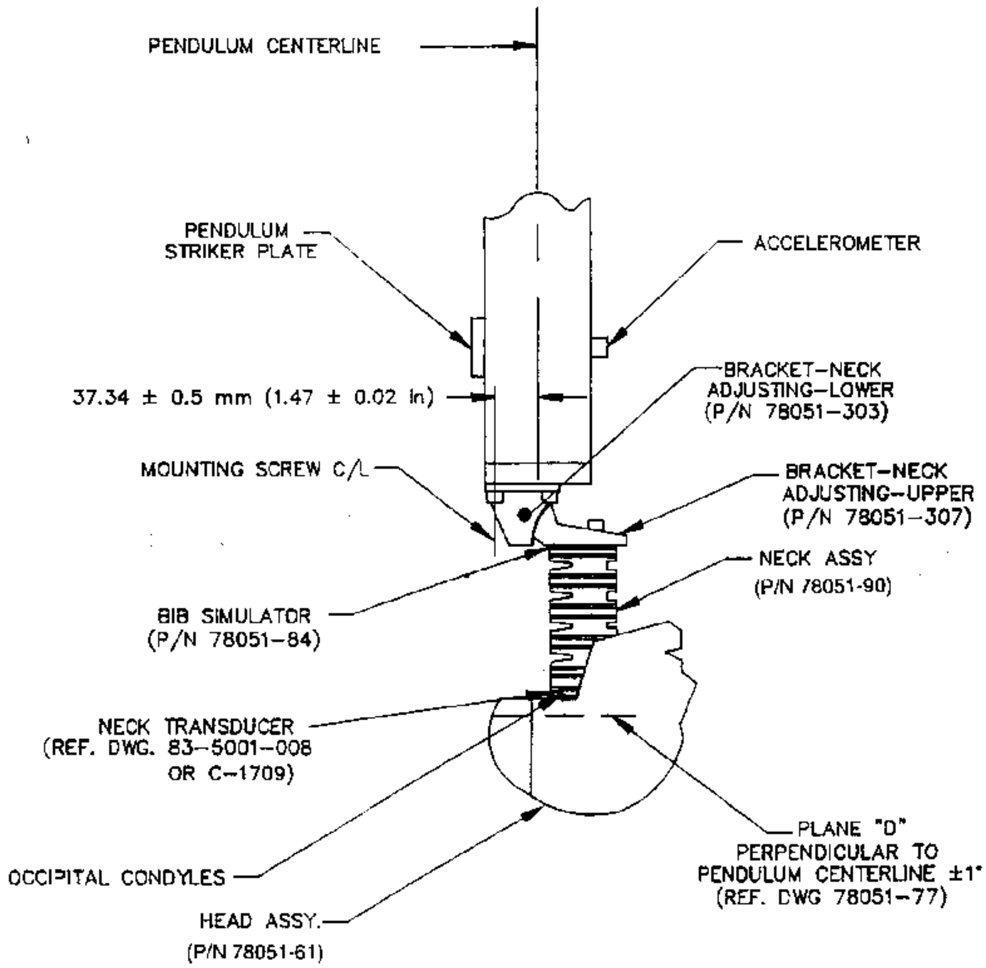

Figure 14.3.4.2: Neck extension test set-up specification

Step 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 designed to minimize their influence on the performance of the head-neck assembly.

Step 7. Torque the ½-20 jam nut on the neck cable to 1.36 N·m ± 0.27 N·m (1.0 lb-ft ± 0.2 lb-ft) before each test on the same neck.

Step 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, it is an option to pre-crush the honeycomb material by lightly impacting it so 90 to 100% of the projected honeycomb surface contacts the pendulum strike plate.

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

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

Step 11. Calculate the moment about the occipital condyles for both flexion and extension tests using the appropriate formulas from below.

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

For a three-channel neck transducer:

- **Metric units:** Moment (N·m) = [M_y (N·m)] - [0.008763 m] [F_x (N)]
- **English Units:** Moment (ft-lbf) = [M_y (ft-lbf)] - [0.02875 ft] [F_x (lbf)]

For a six-channel neck transducer:

- **Metric Units:** Moment (N·m) = [M_y (N·m)] - [0.01778 m] [F_x (N)]
- **English Units:** Moment (ft-lbf) = [M_y (ft-lbf)] - [0.05833 ft] [F_x (lbf)]

14.3.5. Test Procedure and Performance Specifications: Neck Flexion

Step 1. Release the pendulum and allow it to fall freely from a height to achieve an impact velocity of 6.89 to 7.13 m/s (22.6 to 23.4 ft/s), measured at the center of the accelerometer.

Step 2. Stop the pendulum from the initial velocity with an acceleration vs. time pulse which meets the velocity change as specified below in **Table 12.3.5.1**. Integrate the pendulum acceleration data channel to obtain the velocity vs. time curve.

Table 14.3.5.1: Neck flexion pendulum deceleration

Time (msec)	Pendulum Deceleration (g)
10.00	22.5 - 27.5
20.00	17.6 - 22.6
30.00	12.5 - 18.5
After 30.00	29.0 max

Step 3. The maximum rotation of the head D-plane must be 64.0 to 78.0 degrees with respect to the pendulum and must occur between 57.0 and 64.0 milliseconds after time zero. The decaying head rotation versus time curve must cross the zero angle between 113.0 and 128.0 milliseconds after time-zero.

Step 4. The moment about the Y-axis of the head, measured with respect to the occipital condyles, must have a maximum value between 88.1 and 108.4 N·m (65 and 80 ft-lbf) and must occur between 47.0 and 58.0 milliseconds. The decaying moment versus time curve must first cross zero between 97.0 and 107.0 milliseconds after time-zero.

14.3.6. Test Procedure and Performance Specifications: Neck Extension

Step 1. Release the pendulum and allow it to fall freely from a height to achieve an impact velocity of 5.95 to 6.19 m/s (19.5 to 20.3 ft/s), measured at the center of the accelerometer.

Step 2. Stop the pendulum from the initial velocity with an acceleration versus time pulse which meets the values specified in **Table 12.3.6.1**. Integrate the pendulum acceleration data channel to obtain the velocity versus time curve.

Table 14.3.6.1: Test parameters and performance specifications: Neck extension

Time (msec)	Pendulum Deceleration (g)
10.00	17.2 - 21.2
20.00	14.0 - 19.0
30.00	11.0 - 16.0
After 30.00	22.0 max

Step 3. The maximum rotation of the head D-plane must be 81.0 to 106.0 degrees with respect to the pendulum and must occur between 72.0 and 82.0 milliseconds after time-zero. The decaying head rotation versus time curve must cross the zero angle between 147.0 and 174.0 milliseconds after time-zero.

Step 4. The moment about the Y-axis of the head, measured with respect to the occipital condyles, must have a maximum value between -53.0 and -80.0 N·m (-39 to -59 ft-lbf) and must occur between 65.0 and 79.0 milliseconds. The decaying moment versus time curve must first cross zero between 120.0 and 148.0 milliseconds after reaching its peak value.

14.4. Thorax Impact Test

14.4.1. Required Test Parts

The complete dummy assembly is required for this test, including the clothing (shirt and pants), but not including the shoes.

14.4.2. Test Fixture

The fixture consists of a smooth, clean, dry, steel seating surface and a test probe. The positioning of the dummy for testing purposes is shown below in **Figure 14.4.4.1**.

- The test probe mass is 23.36 kg ± 0.02 kg (51.5 lb ± 0.05 lb), including instrumentation, rigid attachments, and the lower 1/3 of the suspension cable mass.
- The diameter of the impacting face is 152.4 mm ± 0.25 mm (6.0 in ± 0.01 in) and has a flat, right angle face with an edge radius of 12.7 mm ± 0.3 mm (0.5 in ± 0.01 in).
- Mount an accelerometer to the probe with its sensitive axis in line with the longitudinal centerline of the test probe.

14.4.3. Data Acquisition

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 600 phaseless filters.

Note:

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

14.4.4. Test Procedure

Step 1. Remove the chest flesh and visually inspect the thorax assembly for cracks, cuts, abrasions, etc. Pay particular attention to the rib damping material, chest displacement transducer assembly, and the rear rib supports.

Step 2. Torque the two lumbar cables to 1.1 to 1.4 N·m (10 to 12 in·lbf).

Step 3. 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 four hours prior to the test, until the rib temperature has reached the soak temperature. The test environment should have the same temperature and humidity requirements as the soak environment.

Step 4. Check that all transducers are properly installed, oriented, and calibrated.

Note: For the remainder of the steps in this procedure, please refer to **Figure 14.4.4.1 below.**

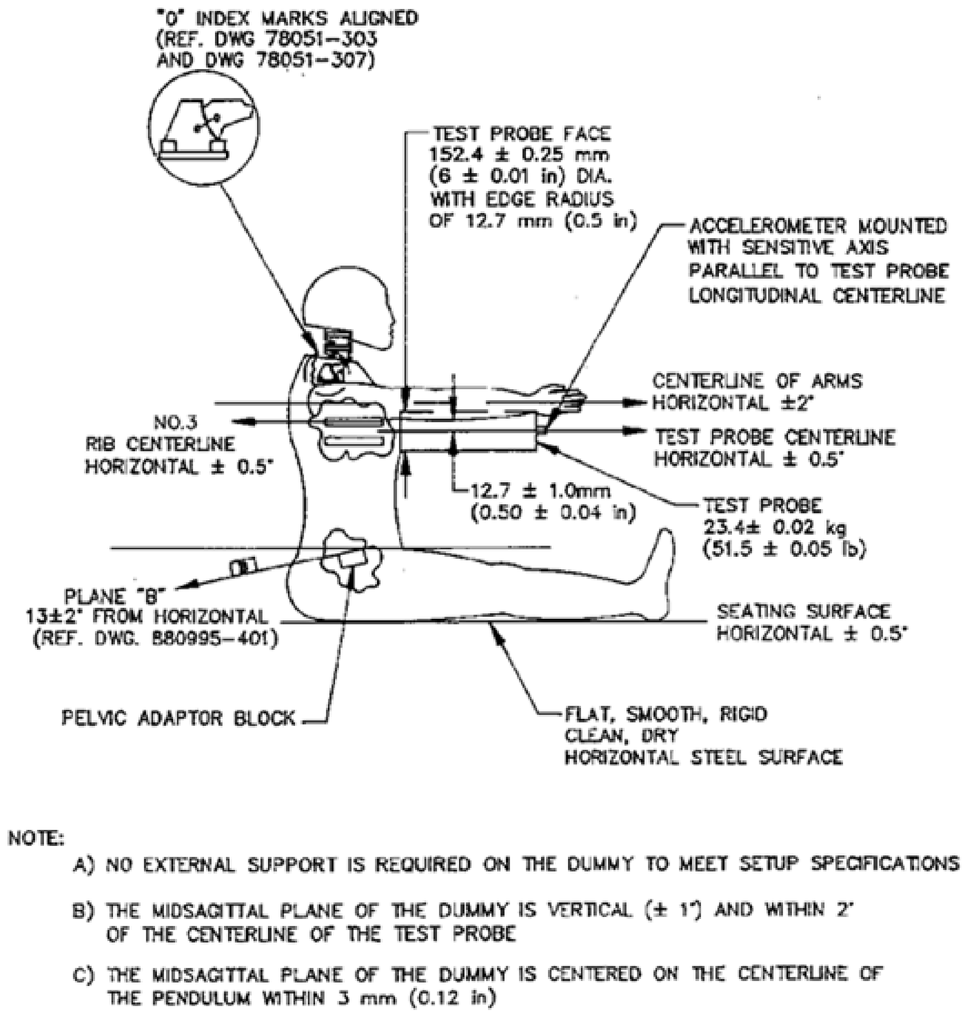

Figure 14.4.4.1: Thorax impact test setup specifications

Step 5. Seat the dummy (without the chest flesh but with the pants) on the test fixture surface. The surface must be long enough to support the pelvis and outstretched legs.

Step 6. Align the upper and lower neck bracket index marks to the zero position.

Step 7. Place the arm assemblies horizontal (± 2°) and parallel to the midsagittal plane. Secure the arms in position by tightening the adjustment nut which holds the arm yoke to the clavicle assembly. If necessary, prop the arms up with a rod that will fall away during the test.

Step 8. Level the ribs both longitudinally and laterally to within ±0.5° and adjust the pelvis angle to 13 ± 2°. (Use the special tool which inserts into the pelvic structure and extends outward beyond the pelvic skin surface. The tool permits the use of an angle measurement device to determine the pelvis angle.)

Step 9. The midsagittal plane of the dummy must be within ± 1° of vertical and within ± 2° of being parallel to the centerline of the test probe.

Step 10. The longitudinal centerline of the test probe is centered on the midsagittal plane of the dummy within 3 mm ± 0.25 mm (0.12 in ± 0.01 in).

Step 11. Align the test probe so its longitudinal centerline is 12.7 mm ± 1 mm (0.5 in ± 0.04 in) below the horizontal centerline of the No. 3 rib and is within 0.5 degree of a horizontal line in the dummy's midsagittal plane.

Step 12. 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 flesh.

Step 13. 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 flesh, so the probe will impact at the lowest point on its arc of travel.

Step 14. Install the chest flesh and shirt 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 flesh, so it may be necessary to leave the chest flesh unzipped until the references are checked, and then fasten it just prior to the test.

Step 15. Impact the thorax with the test probe so the probe's longitudinal centerline is within 2 degrees of a horizontal line in the dummy's midsagittal plane at the moment of impact.

Step 16. Guide the probe so no significant lateral, vertical or rotational motion takes place during the impact.

Step 17. Test probe velocity at the time of impact shall be 6.59 to 6.83 m/s (21.6 to 22.4 ft/s).

Step 18. Wait at least 30 minutes between successive tests on the same thorax.

14.4.5. Performance Specifications

- The maximum sternum-to-spine deflection, as measured by the chest displacement transducer, must be (-73.0) to (-64.0) mm (2.50 to 2.86 in).
- The maximum force applied to the thorax by the test probe must be (-5894) to (-5160) N (-1325 to -1160 lb).
- The hysteresis ratio, determined from the force versus deflection 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. The internal hysteresis ratio for this test must be greater than 69% but less than 85%.

14.5. Knee Impact Test

14.5.1. Required Test Parts

The required assemblies and parts for the knee impact test are the:

- Knee cap (79051-22)
- Knee flesh and skin assembly (78051-5 & 78051-6)
- Knee insert (78051-27)

14.5.2. Optional Test Parts

The optional assemblies and parts for the knee impact test are the:

- Knee slider assembly (79051-16)
- Lower leg assembly (87-5001-001 & 87-5001-002)
- Femur load cell or structural replacement

14.5.3. Test Fixture

The test fixture consists of a rigid test probe and a method of rigidly supporting the knee and lower leg assembly. The test setup is shown below in **Figure 14.5.3.1**.

- The test probe mass is 5.0 kg ± 0.01 kg (11.0 lb ± 0.02 lb), including instrumentation, rigid attachments, and the lower 1/3 of the suspension cable mass.

- The diameter of the impacting face is 76.2 mm ± 0.25 mm (3.0 in ± 0.01 in) with an edge radius of 0.5 mm (0.02 in).
- Mount an accelerometer on the end opposite the impacting face, with its sensitive axis collinear to the longitudinal centerline of the test probe.

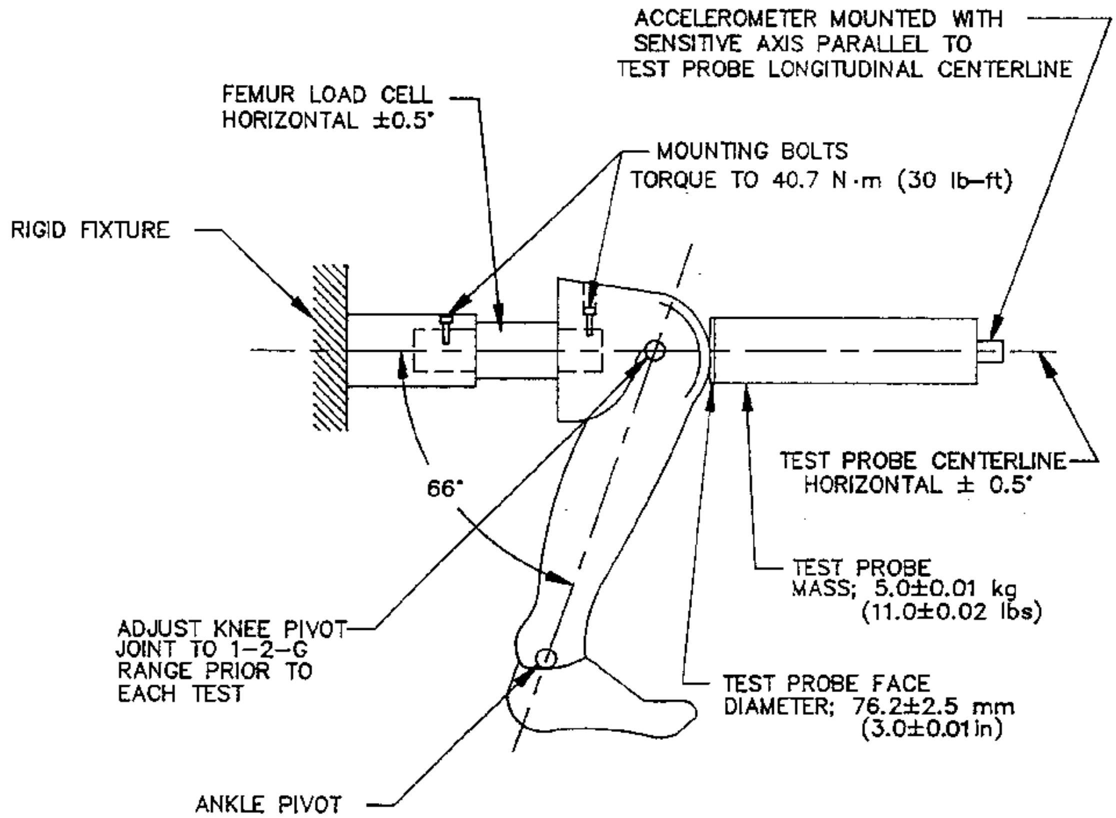

Figure 14.5.3.1: Knee impact test setup and specifications

14.5.4. Data Acquisition

The data acquisition system, including transducers, must conform to the requirements of the latest revision of SAE Recommended Practice J211-1. Filter all data channels using Channel Class 600 phaseless filters.

Note:

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

14.5.5. Test Procedure

Step 1. Inspect the knee assembly for cracks, cuts, abrasions, etc. If the machined knee is cracked or broken in the impact area, replace the machined knee. If the insert is cut, replace the insert.

Step 2. Soak the knee 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 four hours prior to a test. The test environment should have the same temperature and humidity requirements as the soak environment.

Step 3. Mount the knee/lower leg assembly to the fixture using a femur load cell or load cell simulator. Torque the load cell simulator bolts to 40.7 N·m (30 ft-lbf) to prevent slippage of the assembly during the impact. When using the lower leg assembly, adjust the lower leg so the line between the knee and ankle pivots is at an angle of 24 ± 1 degree rearward of vertical. Do not let the foot contact any exterior surface.

Step 4. Align the longitudinal centerline of the test probe so it is collinear (within ± 2.0 degrees) with the longitudinal centerline of the load cell simulator at the time of impact.

Step 5. Guide the probe so no significant lateral, vertical or rotational movement occurs at time-zero.

Step 6. Impact the knee so the longitudinal centerline of the test probe is within 0.5 degree of a horizontal line parallel to the load cell simulator at time-zero.

Step 7. The test probe velocity at the time of the impact must be 2.07 to 2.13 m/s (6.8 to 7.0 ft/s).

Step 8. Wait at least 30 minutes between successive tests on the same knee.

14.5.6. Performance Specifications

The peak impact force (defined as the product of the test probe mass and the deceleration) must be between 4715 and 5782 N (1060 and 1300 lbf).

14.6. Knee Slider Test

14.6.1. Required Test Parts

The required assemblies and parts for the knee slider test are the:

- The left and right knee assemblies (79051-16)
- A displacement transducer (79051-29)
- A femur load cell (78051-265)

14.6.2. Test Fixture

The test fixture consists of a rigid test probe and a method of rigidly supporting the knee assembly. The test setup is shown below in **Figure 14.6.2.1**.

- The test probe mass is 12.00 kg ± 0.020 kg (26.46 lb ± 0.044 lb), including instrumentation, rigid attachments, and the lower 1/3 of the suspension cable mass.
- The diameter of the impacting face is 76.2 mm ± 0.3 mm (3.0 in ± 0.01 in) with an edge radius of 0.5 mm (0.02 in).
- A load distribution bracket is required to transmit the impact energy into the slider assembly.

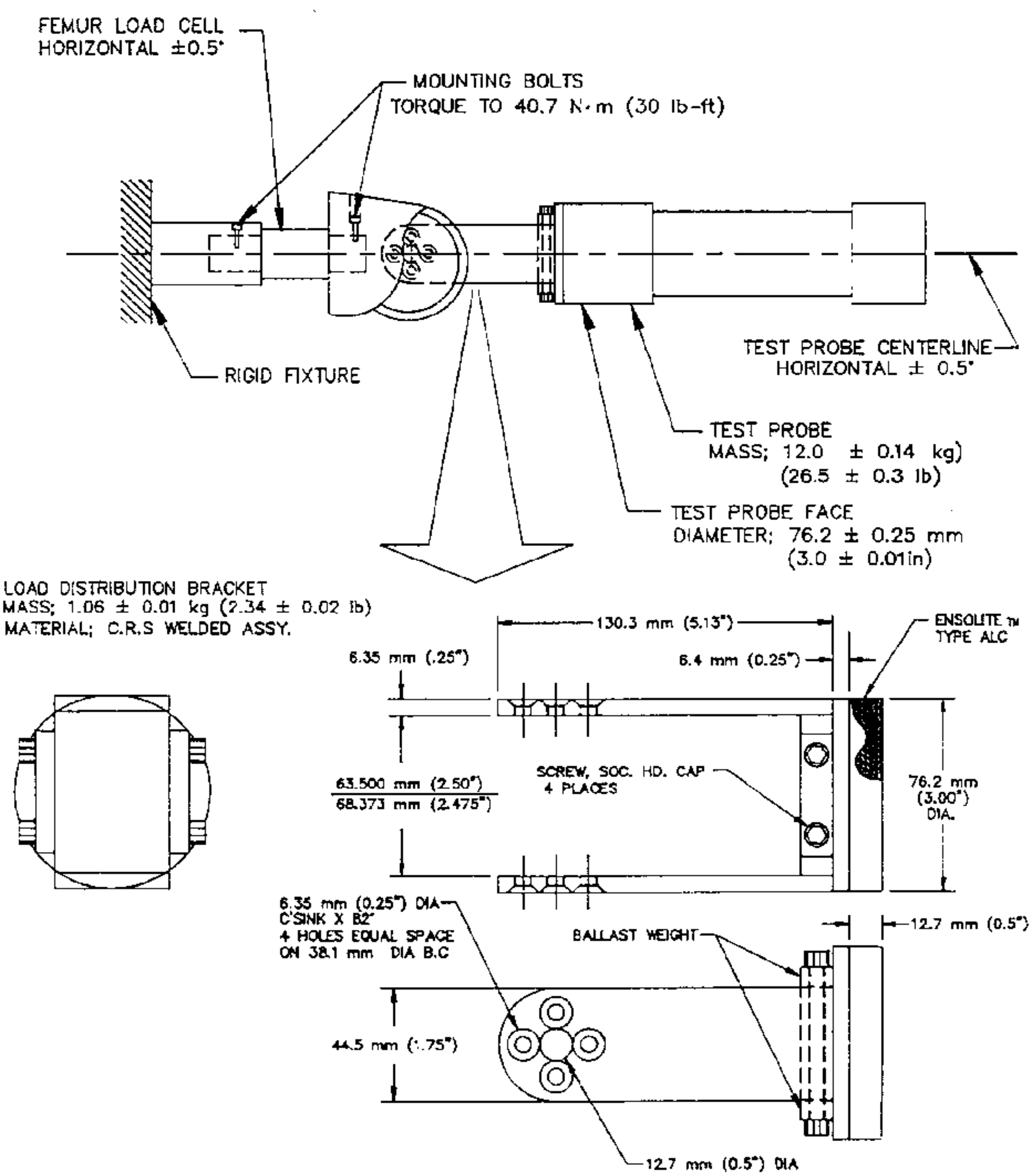

Figure 14.6.2.1: Knee slider test setup and specifications

14.6.3. Data Acquisition

The data acquisition system, including transducers, must conform to the specifications of the latest revision of SAE Recommended Practice J211-1. Filter the displacement data channel using Channel Class 180 phaseless filters.

Note:

- Time-zero is defined as the time of initial contact between the test probe and the load distribution bracket.
- All data channels shall be at zero level at this time.

14.6.4. Test Procedure

Step 1. Inspect the knee assembly for damage. Pay particular attention to the left and right side slider assemblies to ensure the tracks are clean and free from damage which could affect the operation. The potentiometer shaft should slide freely when the potentiometer is installed.

Step 2. Soak the knee 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.

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

Step 4. Mount the knee assembly to the fixture using a femur load cell. Torque the two mounting bolts to 40.7 N·m (30 ft-lbf) to prevent slippage of the assembly during impact.

Step 5. Attach the load distribution bracket to the slider assembly. The bracket is attached to the inboard and outboard slider assemblies in the same manner as the knee clevis, so the impacted bracket will slide rearward in the track.

Step 6. Align the longitudinal centerline of the test probe to ensure that at the time of impact, it is collinear (within 2°) of the longitudinal centerline between the load cell and the load distribution bracket. The test probe longitudinal centerline should be horizontal within 0.5°. Refer to the test setup that appears in **Figure 14.6.2.1** above.

Step 7. Guide the probe to ensure that no significant lateral, vertical or rotational motion occurs at the time of contact between the test probe face and the load distribution bracket.

Step 8. The test probe velocity at the time of impact shall be 2.70 70 2.80 m/s (8.84 to 9.20 ft/s). Allow one break-in test before the calibration test.

Step 9. Wait at least 20 minutes between successive tests on the same knee slider assembly.

14.6.5. Performance Specifications

A summary of force versus knee slider displacement is specified below in **Table 14.6.5.1**.

Table 14.6.5.1: Force vs. displacement specification for the knee slider test

Displacement	Minimum Force	Maximum Force
10.0 mm (0.4 in)	-1.26 kN (-283 lbf)	-1.72 kN (-387 lbf)
18.0 mm (0.7 in)	-2.27 kN (-510 lbf)	-3.10 kN (-697 lbf)

14.7. Hip Joint Range of Motion Test

14.7.1. Test Purpose

This test monitors the moment versus angle relationship of the upper femur and pelvis when each femur is rotated toward the pelvis.

14.7.2. Required Test Parts

The required assemblies and parts for the hip joint range of motion test are:

- The left and right upper femur assemblies (PN 78051-114 and PN 78051-115).
- The pelvis assembly (PN 78051-59).

14.7.3. Test Fixture

The test fixture consists of a structure to hold the pelvis and upper femur assembly, and a device to apply a moment through each upper femur. A generalized test set-up is shown below in **Figure 14.7.3.1**.

- The fixture's structure must be secured to prevent movement during the test.
- An adaptor mounted to the pelvis instrument cavity should mount the pelvis to the fixture and align it. The fixture should hold the pelvis so the bottom and rear skin of the pelvis do not contact the fixture. The fixture should hold the pelvis rigidly and prevent motion throughout the test.
- To ensure that the pelvis is restrained, an additional clamp to the fixture that is mounted through the two front bolt holes for the lumbar adaptor should be used.
- The moment arm should extend straight out of the upper femurs and have a disk (PN 78051-23) the same size and mass as that on the femur bone (PN 78051-43 or 78051-44). The disk should also be in the same location relative to the upper femurs as it is on the femur bone.
- The fixture should compensate for the effect of the mass of the moment arm, or include the effect when determining the applied torque. A guiding system is required to keep the moment arm aligned throughout the test.

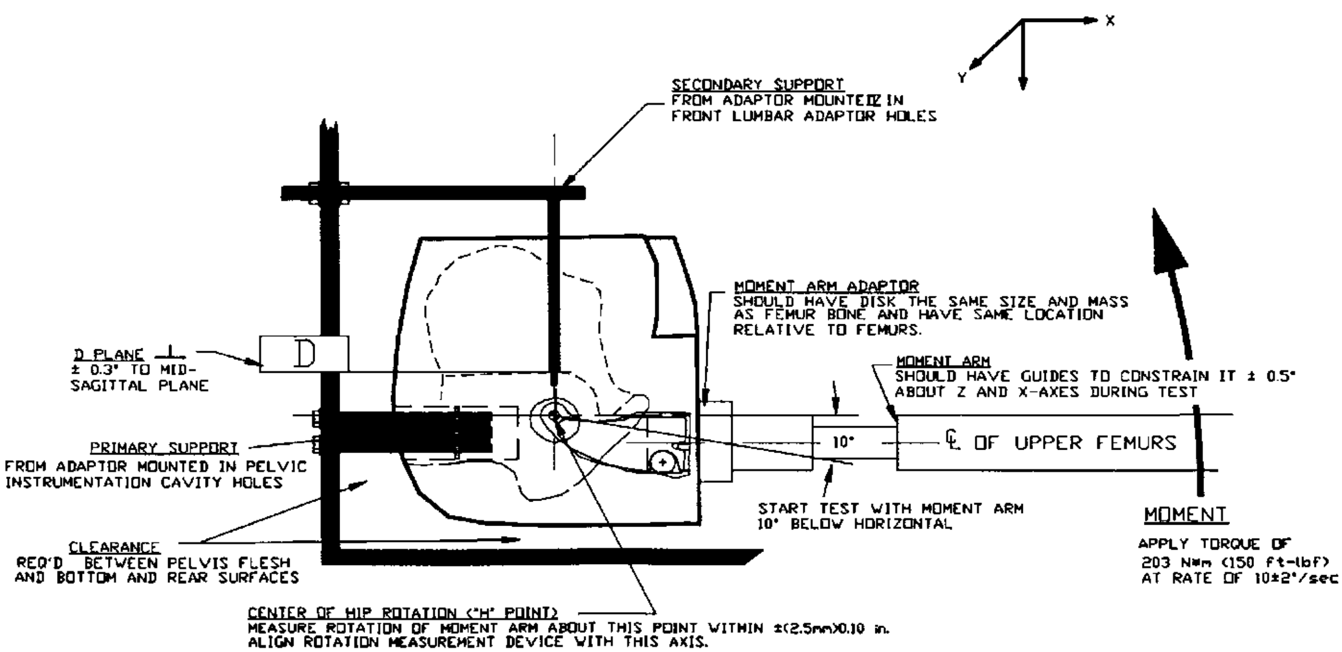

Figure 14.7.3.1: Hip joint range of motion calibration fixture setup

14.7.4. Data Acquisition

The Data Acquisition System, including transducers, must conform to the requirements of the latest version of SAE Recommended Practice J211-1. Filter the data with SAE Class 60 phaseless filters.

Note:

- Time zero is defined as the point at which the moment arm is parallel to the D surface of the pelvis.
- All data channels shall be at the zero level at this time after filtering.
- However, the test must begin at a location approximately 10° below horizontal to eliminate any static friction effects and allow time to achieve the correct load rate.

14.7.5. Test Procedure

Step 1. Clean the inside and front flesh of the pelvis with isopropyl alcohol or equivalent before initial assembly.

Step 2. Inspect the urethane stops (PN 78051-498-1, 78051-498-2) for damage. Replace if necessary.

Step 3. Inspect the pelvis flesh inside and outside the femur cavity for tears. If the pelvis flesh or foam is torn or disintegrated in this area, it should be replaced.

Step 4. Insert the urethane stops into the upper femurs. Use a small amount of talcum powder applied to the pelvis flesh and urethane bumper as a lubricant (to prevent tearing of the urethane bumper) and insert the upper femurs (PN 78051-110, 78051-111) into the pelvis.

Step 5. Remove the instrument cavity cover (PN 78051-13) and femur friction adjustment screws (PN 78051-259).

Step 6. Soak the knee 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.

Step 7. Mount the pelvis assembly on the fixture. Surface D on drawing 78051-60 should be perpendicular to the midsagittal plane within $\pm 0.3^{\circ}$.

Step 8. Insert the moment arm into one of the upper femurs, and place the moment arm within the guiding system. The moment arm and upper femur should be parallel to the midsagittal plane within $\pm 0.5^{\circ}$ initially and throughout the test. The moment arm should also be initially positioned so the bolt connecting the moment arm to the femur is perpendicular to the midsagittal plane within $\pm 0.5^{\circ}$. The guiding system should constrain the moment arm to prevent twist about the moment arm axis of more than $\pm 0.5^{\circ}$.

Step 9. Install the moment and angle measuring transducers. All measurements should be taken relative to the D surface of the pelvis. The origin of the angle measurement should be located at the H-point within 2.5 mm (0.1 in) as referenced on the drawing package. Marking the H-point on the pelvis flesh to use as a reference is not sufficient for this test.

Step 10. Apply a torque to the loading arm until a torque of at least 203 N·m (150 ft-lbf) is achieved. The applied torque should not be significantly above this value to prevent damage to the pelvis flesh. The rate of application should be between 5 and 10^{o}/second.

Step 11. Testing shall be performed on each femur separately. Each femur shall be tested with the moment arm parallel to the midsagittal plane.

Step 12. Wait at least 10 minutes between successive tests on the same femur.

14.7.6. Performance Specifications

The measured angle shall be between 40.0 and 50.0 degrees, inclusive, at an applied torque of 203.0 N·m (150.0 ft-lbf). In addition, the torque must remain below 95.0 N·m (70.0 ft-lbf) at angles up to 30.0 degrees.

14.8. Foot Test

14.8.1. Required Test Parts

The required assemblies and parts for the foot test are:

- The foot assembly (PN 78051-612).
- The heel pad foam (PN 78051-608).

14.8.2. Test Fixture

The test fixture consists of a compression testing machine equipped with a load cell and displacement gage. An example set-up appears below in **Figure 14.8.2.1**.

- An ankle adaptor bracket is needed to attach the foot to the compression testing machine.
- To allow adjustment of the foot angle, two standoffs are inserted into the bolt holes in the foot weldment provided for this purpose.

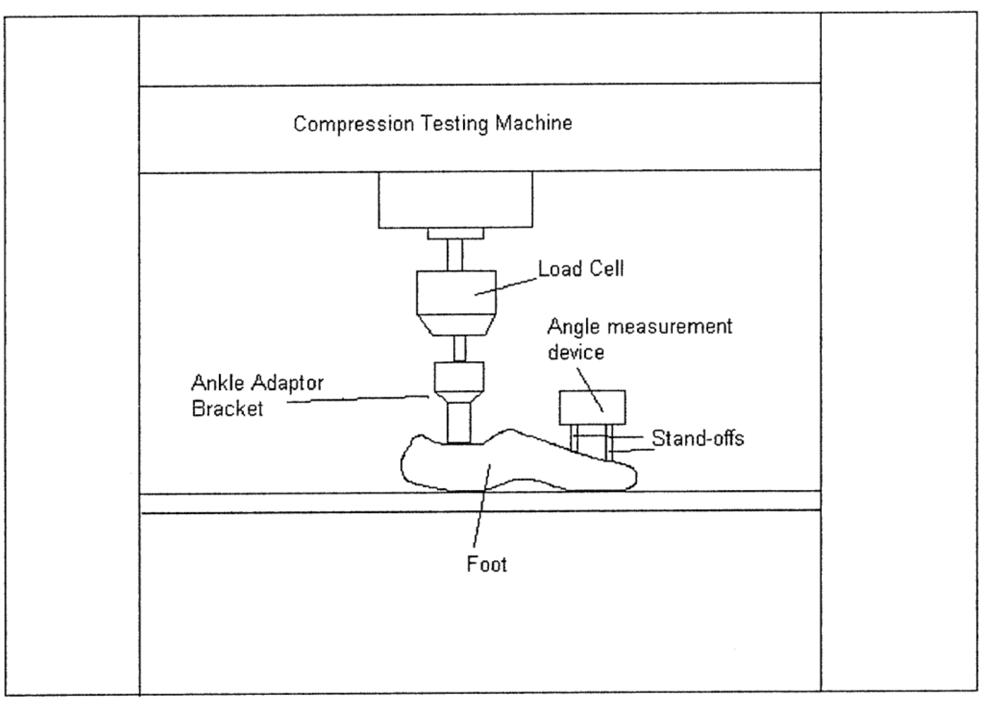

Figure 14.8.2.1: Foot test setup

14.8.3. Data Acquisition

The data acquisition system, including transducers, must conform to the specifications of the latest revision of SAE Recommended Practice J211-1. Use phaseless filters to filter the force and displacement channels using Channel Class 60.

Note:

- Time-zero is the time when the loading force measures 4.45 N (1 lbf).
- The displacement channels should be at the zero level at this time.

14.8.4. Test Procedure

Step 1. Soak the foot assembly in a controlled environment at a temperature between 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.

Step 2. Inspect the foot assembly for cracks, cuts, and separation of the rubber from the metal segment.

Step 3. Inspect the heel pad foam for signs of deterioration.

Step 4. Attach the standoffs on the foot.

Step 5. Install the ankle adaptor bracket to the foot, and attach it to the compression testing machine.

Step 6. Lower the foot until it first contacts the base of the test fixture. Using an angle measurement device positioned on the standoffs, position the foot so it is level (relative to the test fixture) in the transverse and longitudinal directions within ±1°.

Step 7. Load the foot at a rate of 15 mm/min ± 1 mm/min (0.59 in/min ± .04 in/min) until the deflection reaches 8.9 mm (0.35 in).

Step 8. Wait at least 30 minutes between tests on the same foot.

14.8.5. Performance Specifications

The force versus displacement characteristics must fall within the corridor plotted below in **Figure 12.8.5.1**.

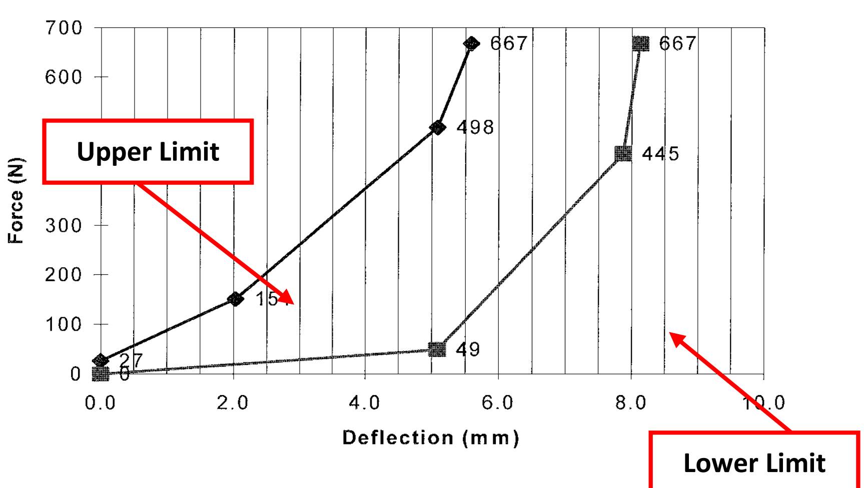

Figure 14.8.5.1: Foot compression test performance specifications

14.9. Ankle Motion Test

14.9.1. Test Purpose

This test monitors the range of motion and resistance to motion of the ankle joint in dorsiflexion, plantar flexion, eversion, and inversion.

14.9.2. Required Test Parts

The ankle assembly (PN 78051-614 & 78051-615) is required for this test.

14.9.3. Test Fixture

The test device consists of a rigid fixture that will hold the ankle shell.

- Two standoffs are mounted into the foot.
- Attached to the standoffs is a plate or bar that will allow a reference for angle measurement and a means for transmitting moment to the ankle joint.

14.9.4. Data Acquisition

The Data Acquisition System, including transducers, must conform to the requirements of the latest version of SAE Recommended Practice J211-1.

Note:

- Time zero is defined as the point at which the initial angles meet the requirements specified below in sub-Section 11.9.5, Step 6.
- All data channels should be at the zero level at this time.

14.9.5. Test Procedure

Step 1. Inspect the ankle bumper for uneven wear, tears, or other damage. Replace if necessary.

Step 2. Ensure that the ankle bumper is installed correctly, with the front part visibly thicker than the rear part.

Step 3. Adjust the ankle ball joint set screw so it applies no friction to the ball joint.

Step 4. Check for smooth rotation of the ankle shell on the ball. If rotation is not smooth, replace the ankle assembly.

Step 5. Conduct the tests with the ankle set screw loose.

Step 6. As shown below in **Figures 14.9.5.1 and 14.9.5.2**, an ankle reference plane is defined as the plane parallel to the sole plate of the foot that passes through the ankle ball joint center. This plane is 47.7 mm ± 0.2 mm (1.88 in ± 0.01 in) above the bottom of the standoff holes.

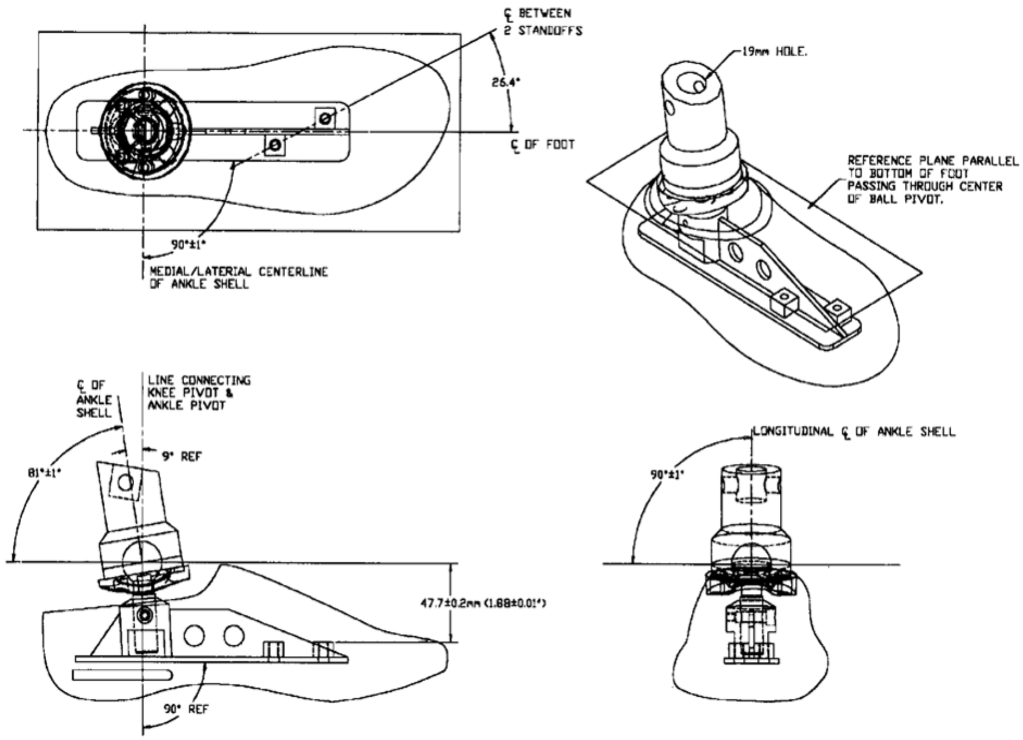

Figure 14.9.5.1: Pertinent dimensions for ankle motion test

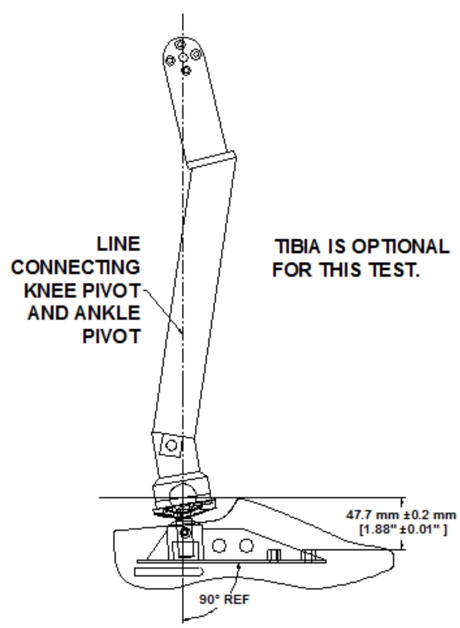

Figure 14.9.5.2: Initial position of foot for ankle test

Step 7. Mount the ankle shell to a rigid fixture using the existing 19 mm hole intended for attaching the ankle to the tibia.

Step 8. Insert the standoffs into the foot. Attach a device to the standoffs for applying the moment and providing an angle measurement reference surface.

Step 9. Soak the ankle assembly in a controlled environment with a temperature between of 20.6 to 22.2 °C (69 to 72 °F) and a relative humidity between 10 and 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.

Step 10. Install the moment and angle transducers. Angle and moment data shall be measured continually throughout all tests.

Step 11. Adjust the foot so that the angle between an anterior/posterior line on the ankle reference plane and the longitudinal centerline of the ankle shell is $81.0^{o} \pm 1.0^{o}$.

Step 12. In addition, adjust the foot so that a lateral/medial line on the ankle reference plane is perpendicular $\pm 1.0^{o}$ to the ankle shell longitudinal centerline.

Step 13. The medial/lateral centerline of the ankle shell shall be perpendicular to the centerline of the foot within $\pm 1.0^{o}$. (The centerline of the foot is 26.4 degrees from a centerline through the two standoffs.)

Step 14. Testing should be performed on each ankle joint separately.

Step 15. **For the Dorsiflexion test:** Apply a moment through the standoffs that rotates the toe towards the ankle shell about the ankle's medial/lateral axis until a moment of at least 40 N·m (29.5 lbf-ft) is reached at a rate of 1 rad/min (.95°/sec).

Step 16. **For the Plantar Flexion test:** Apply a moment through the standoffs that rotates the toe away from the ankle shell about the ankle's medial/lateral axis until a moment of at least 4 N·m (2.95 lbf-ft) is reached at a rate of 1 rad/min (.95°/sec).

Step 17. **For the Inversion test:** Apply a moment through the standoffs that rotates the foot inward relative the ankle shell about the ankle's anterior/posterior axis until a moment of at least 4 N·m (2.95 ft-lbf) is reached at a rate of 1 rad/min (.95°/sec).

Step 18. **For the Eversion test:** Apply a moment through the standoffs that rotates the foot outward relative the ankle shell about the ankle's anterior/posterior axis until a moment of at least 4 N·m (2.95 ft-lbf) is reached at a rate of 1 rad/min (.95°/sec).

Step 19. Wait at least 5 minutes between successive tests on the same ankle.

14.9.6. Performance Specifications

- **For the Dorsiflexion test:** At a moment of 50.0 N·m (37 ft-lbf), the angle shall measure 45.0^{o} +/-2.0^{o}. The moment in dorsiflexion up to 37 degrees must be between 1.3 and 8.1 N·m (1-6 ft-lbf).
- **For the Plantar Flexion test:** At a moment of 4.0 N·m (2.95 ft-lbf), the angle should measure 33.0^{o} +/- 2.0^{o}.
- **For the Inversion test:** The ankle should rotate 22.0^{o} +/- 1.0^{o} before contacting the bumper stop.
- **For the Eversion test:** : The ankle should rotate 22.0^{o} +/- 1.0^{o} before contacting the bumper stop.

Section 15. Appendices

15.1. Appendix A: Accelerometer Handling Guidelines

15.1.1. General Information

The accelerometers used in anthropomorphic test dummies, such as the Hybrid III dummy family, are small, low mass piezoresistive accelerometers. Because of their design and inherent mechanics, certain precautions must be observed when handling and mounting accelerometers to avoid damaging them.

When handling and mounting the accelerometer, avoid dropping or striking it against hard surfaces. Keep the unit in its protective sleeve until the unit is installed.

15.1.2. Preliminary Check-Out

Before installing any accelerometer into the dummy, check that it operates properly. Three simple tests that require minimal test equipment should be conducted:

1) **Impedance Test:** Read the input impedance (red to black) and output impedance (green to white) with an ohmmeter. Compare the measured values to those on the accelerometer calibration data sheet. The measured impedance should be within ±25% of the calibrated value.
2) **Insulation Resistance:** If the input and output impedances are within acceptable limits, use a multi-meter, ohmmeter, or mega-ohmmeter set at 50 volts maximum to measure the insulation resistance between:
    - All leads connected together and the cable shield.
    - All leads connected together and the accelerometer case.
    - The cable shield and the transducer case.

    All three readings should be at least 100 megohms. Be careful when connecting 50 VDC to eliminate the possibility of voltage spikes.
3) **Zero Measurand Output:** After the impedance and insulation resistance tests, measure the output of the accelerometer with 0 G acceleration.
    - With the unit still in its sleeve, turn the unit on its side so the accelerometer mounting surface is perpendicular to the table top (sensitive axis horizontal and perpendicular to the gravity field.)
    - After letting the accelerometer warm up for two minutes, apply the specified excitation voltage to it and measure its output with a DC millivolt meter.
    - The accelerometer should have a zero measurand output (ZMO) within the manufacturer's specified limits.

If any of these initial checks do not give proper readings, indicating a possible malfunction, remove the excitation source immediately and take the following measurements:

Step 1. Check and record leg 1, leg 2, leg 3, and leg 4 resistances.

Step 2. Disconnect, check and record excitation voltage from the source.

Step 3. Reconnect, check, and record excitation with the unit connected.

Step 4. Check and record ZMO again.

Step 5. Check and record static outputs +1 G and -1 G and compare to calibrated sensitivity.

Step 6. Check that the temperature and environment fall within accelerometer specification.

Step 7. Check to see if the accelerometer case is under stress.

Step 8. Check leads for abrasion or cuts.

If the reason for the erroneous reading cannot be found after completing all of the above checks, contact the accelerometer manufacturer.

15.1.3. Installation

When mounting or removing the accelerometer, you must use the proper techniques and tools. The mounting surface should be clean and free of burrs. A recommended surface roughness is 32 micro inch rms or less. Make sure that no dirt or particles can be clamped between the unit and mounting surfaces.

Remove the unit from the protective sleeve. With the sleeve absent, handle the unit by the case, not the cable. This will prevent the unit from slapping the mounting surface during installation. Place the unit on the mounting surface and align the mounting holes.

Correct torque is important to ensure correct mounting and performance. When mounting the accelerometer, use only the materials and parts which are supplied with the accelerometer. Always use the proper mounting torque recommended by the accelerometer manufacturer. If applicable, use the supplied mounting washers and screws, or mounting stud. Using the supplied wrench, turn the screws in the mounting holes to the recommended torque. Usually, this is roughly equivalent to finger tight with the supplied wrench. Installation of the unit with higher torque values, dry threads, or thread adhesives is not recommended as excessive torque will be required to break the screw loose when the accelerometer is removed.

Note:

- Excessive torque can create an over-range transient shock pulse when removing the unit, with sufficient high frequency content to damage or destroy the unit.
- Do not over torque the screws. Do not use snap type torque wrenches. Do not cement the unit to the mounting structure.

Where practical, tie down the cable within 4 to 6 cm (1.6 to 2.4 in) of the unit. Whipping of the cable due to vibration and shock will strain the cable unnecessarily at the unit.

Connect the unit to the signal conditioner and check for proper functioning through the use of standard techniques such as shunt calibration across the passive arms of the accelerometer.

15.1.4. Recalibration

Sensitivity and Zero Measurand Output calibrations should be performed at 6 to 12 month intervals, depending on usage. Usually, 12 month intervals are sufficient if you know the accelerometer has not been used beyond its rated specifications. If the unit is used under severe environments, the shorter calibration interval may be desirable.

15.1.5. Cleaning

Dirty units may be wiped clean using a damp cloth and a solvent such as acetone.

Note:

- DO NOT SOAK OR IMMERSE the unit in any solvent or water.
- Do not use any sharp tool such as a screwdriver to remove dirt or contaminants.
- If tools such as pliers are needed to handle the accelerometer, cover the jaws with masking tape to prevent unwanted metal to metal contact.

15.2. Appendix B: Guidelines for Repairing Flesh

Dummy flesh is often damaged, but can be repaired. The most common types or flesh damage are punctures, tears, and scrapes. Scrapes can be fixed by rubbing an iron, at low temperature, over the affected area several times. Punctures and tears require patching.

To repair the flesh, use an iron to bond the dummy's flesh to patches of repair materials. The iron is similar to a standard electronic soldering iron. Its output should range from 60 to 90 watts. The best tip is a broad, flat paddle tip like the one in the dummy tool kit provided by the dummy manufacturers. For best results, a variable power supply should be used to control the heat output from the iron. Without this control, repairs will be more difficult and may be unsightly from black flakes of burnt flesh imbedded in the flesh. These flakes are caused by overheating the flesh, which happens when an iron is too hot or remains in one position too long. Another cause of black residue in the flesh is improper or infrequent cleaning of the iron tip. The tip should be cleaned frequently during the repair job, between each melting of flesh if possible. The best method for doing this is to tap the iron quickly on a buffing wheel.

Conduct all flesh preparations and repairs in a well-ventilated area. When patching, first clear away any loose material which may be hanging from the damaged areas, such as shredded vinyl or foam. Clean the area with 99% solution isopropyl alcohol and dry for 15 minutes. Any residue from tape or chalk must be removed. If it remains after the initial cleaning, continue to clean with isopropyl alcohol until the area is completely clean. Since isopropyl alcohol is flammable, make sure the surface is dry before applying heat. Do not use soldering flux or any other chemical on the flesh or repair iron.

After preparation, a patch can be bonded to the flesh. Cut a patch of adequate size from the material provided in the dummy tool kit. The patch should be approximately 10 mm (0.5 in) wider than the damaged area on all sides. To check that the iron is at a usable temperature, test it on a small piece of patch material. The flesh should easily melt but not instantly burn. With the patch held over the damaged area, slide the iron between the patch and dummy flesh. Hold the iron in position until you see both materials melting. When both the patch and the flesh look like a gel, move the iron to a new point while holding the patch in place until they have both cooled. Continue this all the way around the damaged area until the patch is completely bonded to the flesh.

For large areas, or areas where the patch must bend to conform to the dummy part, it may be easier to "tack" a few points around the edge of the patch to hold it in place, then return to fill in the unbonded sections. Once you bond the patch to the flesh, you need to blend the patch into the flesh. This will eliminate any protruding edges that may later snag and ruin the repair. To blend the patch, work the iron tip around the patch edges in a circular motion, blending the patch material into the flesh as you work your way around the patch. If the iron is too hot, black flakes will appear; if it is too cold, the patch will not readily melt, and the patch is probably not very well bonded to the flesh. Continue working the patch into the flesh until the repair is fairly well hidden and let it cool. After the area cools, you can return to touch-up any areas.

If a certain area of flesh is frequently damaged and is not expected to contribute significantly to dummy response, duct tape can be placed on the flesh but under the clothing to help protect it. Tape should not be used on any area which directly affects the test data, such as head, neck, ribs, or spine. The engineer running the test should approve use of additional reinforcement such as tape before conducting tests.

15.3. Appendix C: Axial Integrity of the Neck

If the axial integrity of the neck is in question, the neck without its cable can be pull tested to 5.34kN (1200 lbf). No separation should occur. Replace as required.

Section 16. Legal Disclaimers and Notices

16.1. Disclaimer

The information in this manual is furnished for informational use only, and is subject to change without notice. Humanetics Innovative Solutions Inc. assumes no responsibility for liability on errors or inaccuracies that may appear in this manual.

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Section 17. User Manual Update Log

Table 17.1: User manual update log

Revision Level	Revision Date	Revision Author	Revision Description
A	May 2017	M. Tran	Initial release of harmonized user manual.