User Manual

THOR-50M

472-0000

THOR-50th Percentile Male Dummy User Manual 472-9900 [Rev. F]

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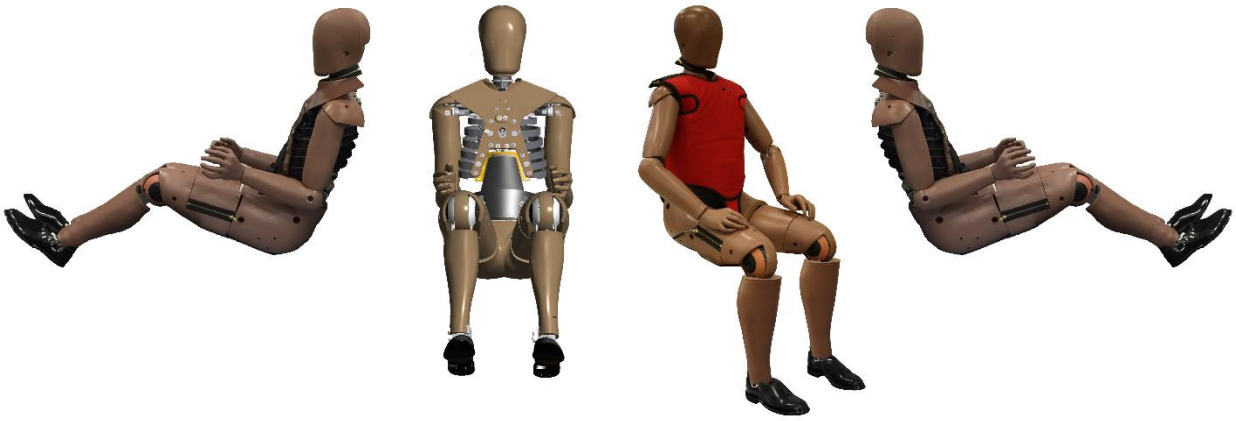

Left View Front View Iso View Right View

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Section 1. **Introduction**

1.1 **Introduction**

For several years, Humanetics, the National Highway Traffic Safety Administration (NHTSA), and European safety initiatives like FIT, APROSYS, and THORAX have all worked to update the THOR with much improved and anticipated modernizations to its design, usability, and handling. The first development program, undertaken by GESAC in 1995, resulted in the design and development of a test device for whole-body trauma assessment in a variety of occupant restraint environments. The new advanced frontal crash test dummy was named THOR (Test Device for Human Occupant Restraint). The primary design objectives of the development effort were as follows:

- Bio-fidelity in mass, size, surface geometry, and dynamic response
- Incorporation of specific instrumentation relevant to injury assessment
- Repeatability of performance
- Minimization of damage in severe test environment, i.e. overload protection
- User friendliness and modularity in design, for ease of assembly and disassembly

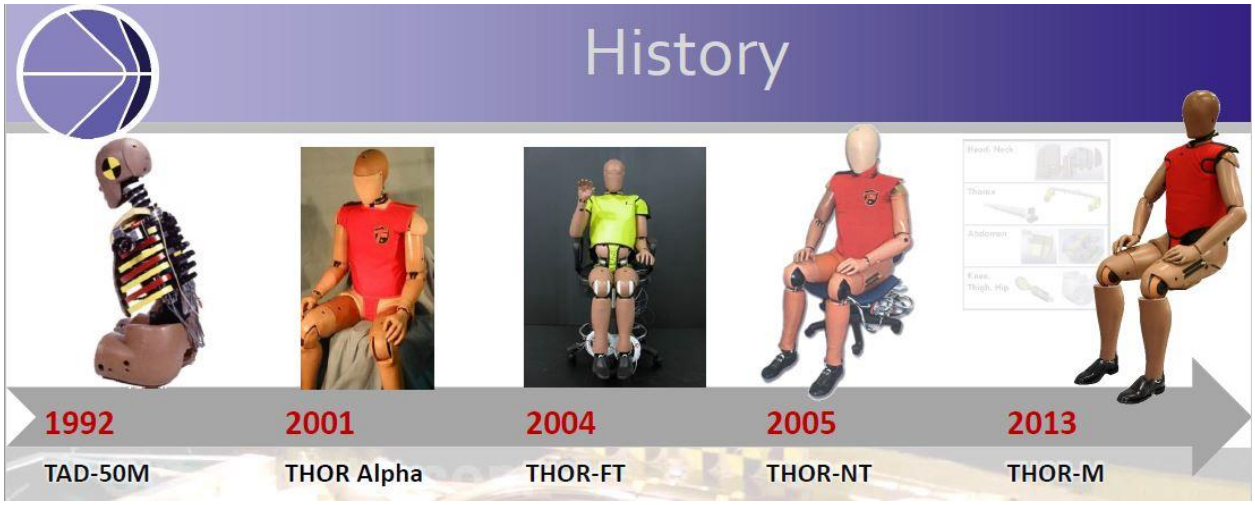

Figure 1.1 THOR History

The approach undertaken during the design of the THOR dummy was to first review the design elements which had been incorporated in the TAD-50M (the NHTSA funded predecessor to the THOR dummy). This review was conducted to identify needed improvements in bio-fidelity, dynamic response, and instrumentation. A systematic evaluation of design requirements for each body region was then accomplished. The facial region of the dummy has been instrumented with unidirectional load cells to assess the probability of facial fracture. The THOR neck assembly features multidirectional kinematic bio-fidelity, which results in more accurate head trajectories, velocities and accelerations for front, side and rear impacts. The thorax region utilized elliptical ribs which greatly enhance the bio-fidelity and geometry. In addition, a new thorax deflection sensor was designed which measures the dynamic three-dimensional compression of the ribcage at four distinct points. A newly designed abdominal segment can directly measure belt intrusion in three dimensions at two distinct points. The pelvis has been instrumented with a three-axis acetabular load cell at each hip joint and belt load sensors on each iliac notch. The THOR femur assembly includes a compliant element to provide the correct force transmission for axial loading through the femur into the pelvic assembly. A new lower extremity has been developed which provides increased injury sensing capabilities in the foot, ankle and lower leg, as well as,

greatly improving the torque versus angle relationship for the primary ankle rotation joints. In addition, the THOR dummy features many advances in sensors and instrumentation and is capable of measuring over one hundred channels of data for injury assessment.

Following the development of the prototype dummy, the first production level dummy was manufactured and was called THOR Alpha. Extensive revisions were undertaken on the THOR Alpha to further improve durability, usability, bio-fidelity, and anthropometry. The latest revision is known as THOR-50M.

In 2006, SAE formed THOR Task Force to evaluate feedback from tests conducted in North America, Europe and Asia/Pacific regions and to produce a list of recommendations for improvements. In fall 2009, NHTSA initiated a program to implement these recommendations along with European task group work into the THOR-NT. In 2012, the first fully Metric version (THOR-M) was produced incorporating the SD3 shoulder design.

In January 2017, Humanetics offers the THOR-50M Standard Build Level A (SBL-A) with minor part upgrades. One of the upgrades is the THOR-50M Molded Shoe. The THOR-50M Molded Shoe has better durability, geometry, and biofidelity. The figure below shows the latest THOR-50M.

Figure 1.2 The Latest THOR-50M

1.2 Getting Familiar with the User Manual

This manual is designed to serve as a reference book for technical people working with the THOR-50M Crash Test Dummy. Each assembly of the THOR-50M dummy has been described in great detail to assist the technical personnel in the proper set-up and adjustment of the dummy for testing. The user manual has been divided into sections as outlined below:

- Introduction
- Dummy Preparation and Use
- Top Level Dummy Assembly
- Head Assembly
- Face Assembly
- Neck Assembly
- Thorax Assembly
- SD3 Shoulder and Arm Assembly
- Lower Arm and Hand Assembly
- Spine Assembly
- Upper Abdomen Assembly
- Lower Abdomen Assembly
- Pelvis Assembly
- Upper Leg Assembly
- Lower LX Leg Assembly
- Jacket and Clothing
- Instrumentation and Wiring

1.2.1 Section Organization

Each section of this manual has been divided into the following subsections to provide a complete overview of each assembly.

- Description of Features
- Parts Lists
- Assembly Procedure
- Assembly of Component into THOR-50M
- Adjustments
- Wire Routing and Electrical Connections
- Calibration/Certification
- Inspection and Repairs

The assembly section of the manual assumes that the components have been disassembled to inspect or service the instrumentation or wear items. This assembly procedure is not designed for a complete strip-down of the component.

1.2.2 **Conventions Used throughout this Manual**

Right-hand and Left-Hand

The references to the right-hand and left-hand side of a component or assembly are made with the assumption that the component is installed within the dummy. Reference is made as if the laboratory personnel is oriented in the same position as the test dummy.

Front and Back

The reference to front and back refer to the anterior and posterior sides of the part or assembly based on the dummy reference system.

Top and Bottom

The reference to top and bottom refers to the superior and inferior sides of the part of assembly based on the dummy reference system.

Dummy Coordinate System

All references made to the coordinate system of X, Y, and Z will be based on the SAE Information Report J1733 – Sign Convention for Vehicle Crash Testing. This SAE sign convention is provided below:

+X is toward the anterior (front) of the dummy

+Y is laterally toward the right

+Z is toward the inferior (bottom) of the dummy

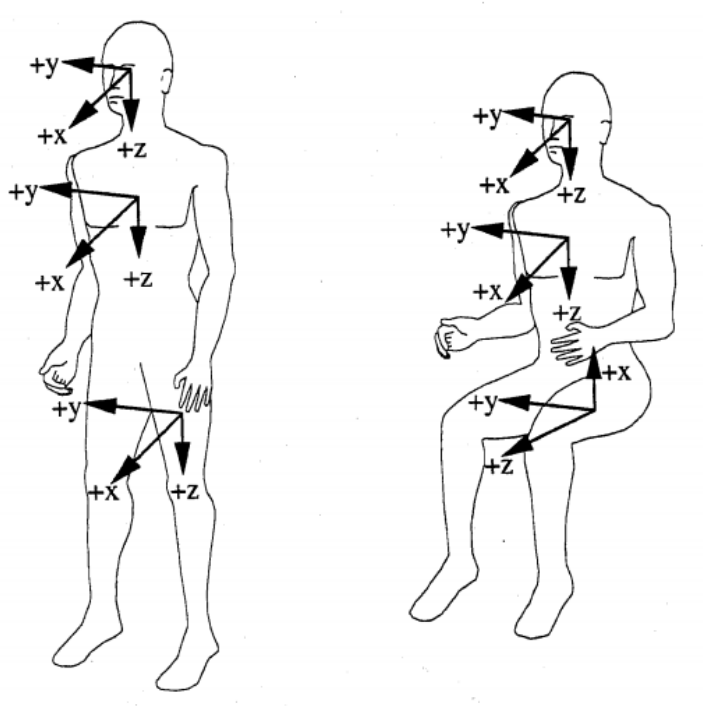

Figure 1.3 Dummy Coordinate System ***(SAE J1733 Issued DEC94)***

Section 2. Dummy Preparation and User

2.1 General

2.1.1 Hardware and Fasteners

All hardware and fasteners used on the THOR-50M crash test dummy are standard metric sizes. The following abbreviations are used throughout this manual.

Table 2-1 Hardware and Fastener Abbreviations

Abbreviation	Description
FHCS	Flat Head Socket Cap Screw
BHCS	Button Head Socket Cap Screw
SHCS	Socket Head Cap Screw
SSS	Socket Set Screw
NP	Nylon Pellet (Used in conjunction with one of the above designations)

2.1.2 Recommended Tools

The following tool list includes the recommended standard tools which should be available at the test labs using the THOR-50M dummy. This list will allow the laboratory personnel to make any necessary adjustments and to perform the standard disassembly and assembly procedures. These tools are listed in the table below.

Table 2-2 List of Recommended Tools

Tool Description	Size or Range
Set of “T” Handle Hex Wrenches (Ball End)	2, 2.5, 3, 4, 5, 6, 8 and 10 mm
Set of “L” Handle Hex Wrenches (Ball End)	1.5, 2, 2.5, 3, 4, 5, 6, 8 and 10 mm
Set of Straight Hex Wrenches (Screwdriver Style)	0.7, 0.9, 1.3, 1.5, 2, 2.5, and 3mm
Socket Set 3/8 Drive	6 mm to 19 mm
Torque Wrench 3/8 Drive	10-98 Nm
Hex Bit Socket Set	4, 5, 6, 7, 8, and 10 mm
Needle Nose Pliers	-
Diagonal Wire Cutters	-
Flat Head Screwdriver	3/16” Slotted, 4” Shaft Length

2.1.3 **Bolt Torque Values**

The following table indicates the recommended torque values for the various bolt sized used in the THOR-50M dummy assemblies. For fastener sizes smaller than those listed, engineering judgment should be used to arrive at a “reasonably snug” torque which will prevent the fastener from vibrating loose during impact.

Table 2-3 Recommended Fastener Torque Specifications (SHCS)

Metric Fastener	Recommended Torque Range (N-m)
M2	0.5 Nm
M2.5	0.8 Nm
M3	1.5 Nm
M4	3.5 Nm
M5	7.0 Nm
M6	13.0 Nm
M8	30.0 Nm
M10	55.0 Nm
M12	100.0 Nm
M14	160.0 Nm
M16	250.0 Nm

Table 2-4 Recommended Fastener Torque Specifications (BHCS & FHCS)

Metric Fastener	Recommended Torque Range (N-m)
M2	0.3 Nm
M2.5	0.5 Nm
M3	1.0 Nm
M4	2.5 Nm
M5	5.0 Nm
M6	10.0 Nm
M8	22.0 Nm
M10	40.0 Nm
M12	75.0 Nm
M14	120.0 Nm
M16	190.0 Nm

2.2 **Dummy Serial Number**

A serial number is labeled on each THOR-50M dummy on the upper thoracic spine box weldment. This serial number should be used as a reference during any correspondence regarding the use of the THOR-50M dummy.

2.3 **Dummy Storage**

The storage bracket attaches to both the upper portion of the spine box and the pelvis assembly in order to stabilize the flexible rubber lumbar segments in between (not shown in photo below). Handles are also provided to assist in finer positioning during storage. The lower spine pitch angle must be set to slouched to use the storage bracket. See Section 10.3, Adjustments for the Spine Assembly.

	**NOTE: THAT THE INSTRUMENTATION WIRE BUNDLE SHOULD BE PROPERLY STRAIN RELIEVED TO THE BOTTOM OF THE SPINE ASSEMBLY.**

Figure 2.1 Proper Storage Position of Dummy in Storage Locker

2.4 **Dummy Handling**

The THOR-50M dummy cannot be lifted by the head or neck assemblies as the dummy's neck was not designed to support the full weight of the dummy in tension. The lifting strap assembly should be used to transport the dummy as well as support/lift the dummy during assembly or disassembly processes. The assembly utilizes a lifting strap that attaches to a bracket mounted on the back of the spine box with two M5x10mm SHCS as shown in the figure below. It is important to store the THOR-50M dummy with the neck in a vertical position. If the neck is not vertical, permanent set can occur quickly. Vertical neck position can be achieved by adjusting the turnbuckle that controls the forward and backward tilt of the dummy (see Figure 2.1 above).

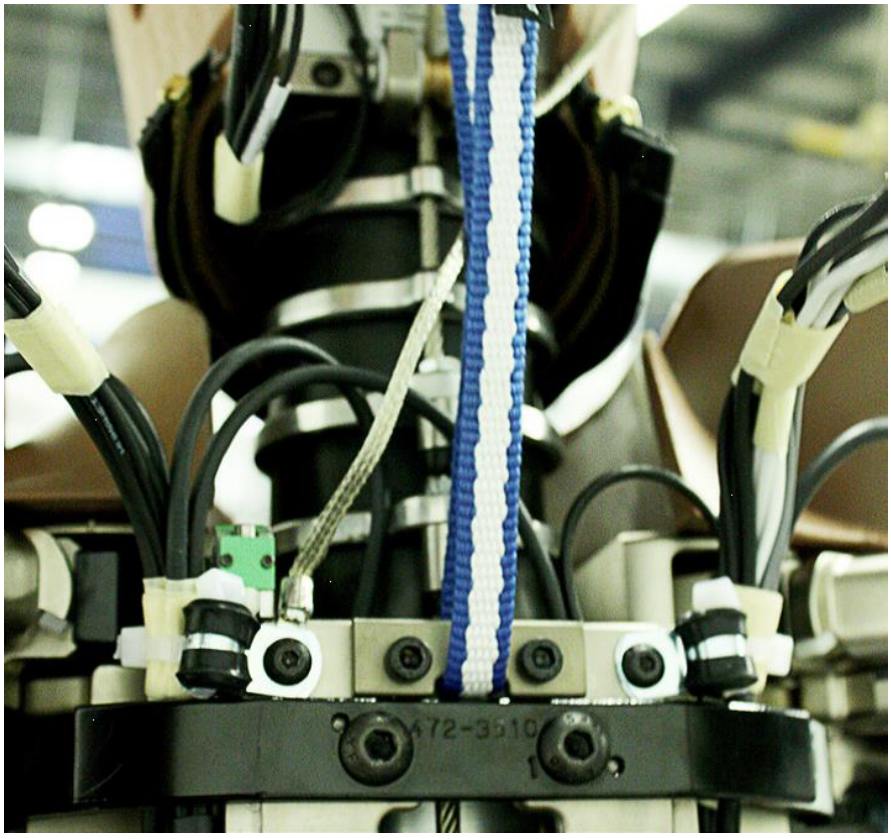

Figure 2.2 Lifting Strap and Bracket with two M5x10mm SHCS

2.5 H-Point Tool Assembly and Use

The assembly of the H-point tool is shown in Figure 2.3. The placement of the H-point tool into the access hole in the pelvis is shown in Figure 2.4.

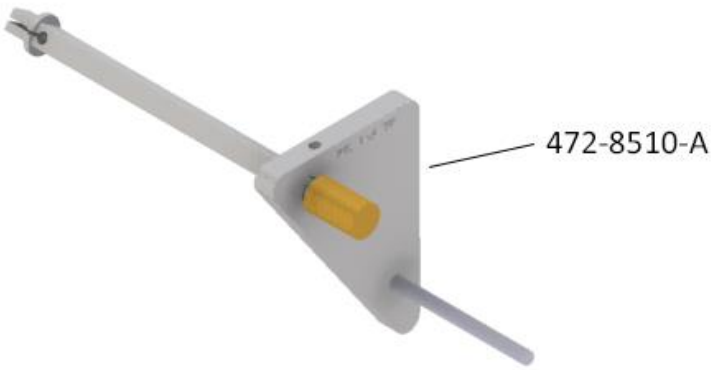

Figure 2.3 Assembled H-Point Tool

Figure 2.4 H-Point Tool Attached to Iliac

Ensure the front of the H-point tool is not expanded, then the tool shaft is inserted through the opening in the pelvis skin and into the access hole in the pelvis. The flange on the tool should be seated against the metal iliac wing. Once inserted, the brass knob should be turned until the tool is firmly interacting with the iliac wing. The smaller shaft should then point directly at the center of the H-point. The H-point tool plate is reversible for use on the dummy's left and right sides. The plate marking (left or right) should be visible to the user from the side of the dummy when the plate is positioned correctly. The configuration for the use of the H-point tool from the dummy's right side is shown in Figure 2.5. The location of the dummy's H-point is then indicated by the position of the center of the H-point shaft.

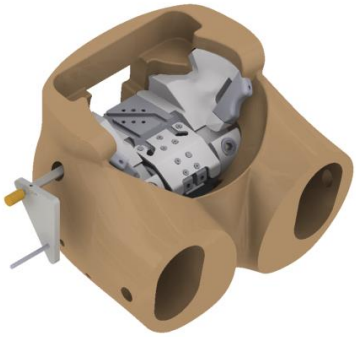

Figure 2.5 H-point Tool in Use

2.6 Joint Resistive Torque Adjustments

The joint resistive torque for the THOR-50M dummy are described under the various sections to which they apply. The joints in the dummy which require adjustments are the Shoulder (2), Elbow (2), Hip, and Knee. Generally, most of these adjustments are made in the same manner as the adjustments to a Hybrid III dummy. The goal of the adjustment is to provide a 1 g joint friction torque. For example, the dummy's shoulder joint should have just enough torque to maintain the position of the arms when they are raised to the front and the side.

2.7 Additional Reference Materials

The following reference materials are included with the THOR-50M dummy shipment to provide specific information about various aspects of the THOR-50M dummy performance and operation.

Certification Performance Graphs – The graphs for the various THOR-50M certification tests are included to show the response of the dummy relative to the known corridor boundaries.

Serial Number Reference Sheet – This data sheet provides serial number information on various dummy components which allows for traceability.

THOR-50M Calibration Sheets – These sheets contain all of the calibration information for the THOR-50M dummy instrumentation.

Section 3. Top Level Dummy Assembly

3.1 Top Level Assembly

The following figure refers to the top level THOR-50M assembly, 472-0000.

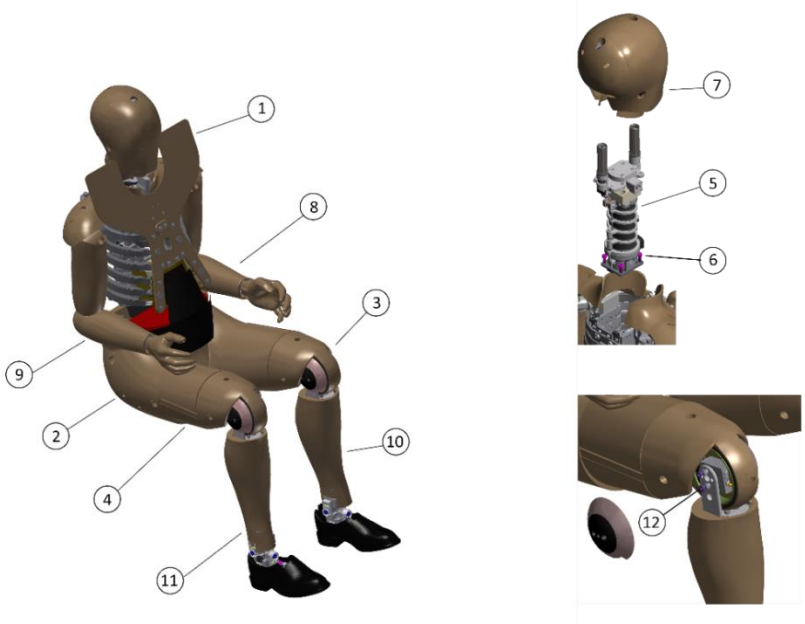

Figure 3.1 THOR-50M Top Level Assembly

Table 3-1 lists the parts in Top Level Dummy Assembly, 472-0000. The exploded view is shown in Figure 3.1.

Table 3-1 THOR-50M Top Level Assembly Parts Lists

Item	Qty.	Part Number	Description
1	1	472-3010	THORAX MECHANICAL ASSEMBLY, SD3
2	1	472-4000	PELVIS ASSEMBLY
3	1	472-5100-1	LEFT UPPER LEG ASSEMBLY
4	1	472-5100-2	RIGHT UPPER LEG ASSEMBLY
5	1	472-2000-B	MECHANICAL ASSEMBLY, NECK
6	4	5000604	M6 X 1 X 14 LG. SHCS
7	1	472-1000	HEAD ASSEMBLY
8	1	472-6500-1	LOWER ARM ASSEMBLY, LEFT
9	1	472-6500-2	LOWER ARM ASSEMBLY, RIGHT
10	1	472-7000-1	LEG ASSEMBLY, LEFT, THOR LX
11	1	472-7000-2	LEG ASSEMBLY, RIGHT, THOR LX
12	8	5000204	M6 X 1 X 10 LG. FHCS
13	1	6004278	PANTS, THERMAL, LARGE (NOT SHOWN)
14	1	472-3901-A	FRONT/REAR PANEL ASSEMBLY, JACKET (NOT SHOWN)
15	1	472-2900	NECK FOAM ASSEMBLY (NOT SHOWN)
16	1	472-2901	NECK SKIN ASSEMBLY (NOT SHOWN)
17	1	472-TOOL-KIT	TOOL KIT FOR THOR-M (NOT SHOWN)

3.2 **Disassembly of Body Segments**

This section describes how to disassemble body segments from the dummy and assemble them back. For further work on each body segment, refer to the relevant body segment section of this manual. Please keep in mind, it may not always be necessary to remove a particular body segment as described below, for instance, the head assembly can be worked on when it is mounted on the dummy. The reader should decide which is the best way to handle any particular job. As a first precaution, make sure to sit the dummy on a stable surface. A stable sitting dummy may become unstable during disassembly by removing consecutive parts. It is recommended to keep the dummy stable by securing the top of the spine of the dummy, preferably to an overhead crane or tackle using the lifting strap at the top of the spine.

Remove the jacket assembly by unzipping the shoulder and side zippers. To release the buttock strap, release the Velcro strap on the back of the jacket, lift the dummy's buttocks by slightly leaning the dummy to one side and pulling the strap in the front of the crotch. Put on the jacket in the reverse order. Start with pulling the buttock strap underneath the dummy from the front to the back.

For better access to the head and neck assemblies, first remove skull cap and skin by removing four M6x16 SHCS. Then remove the head skin. This will give easier access to the four M6x16 SHCS. Use a long 5mm hex T-wrench with a ball drive and access the screw heads alongside of the neck. Unscrew the M6x14 cap heads, and once the threads are released leave the screws in the holes of the lower neck load cell. When all screws are released, lift the head/neck assembly with the screws from the spine and gather the screws in a little box for safe keeping. Assemble the head and neck in reverse order, starting with placing the M6x14 screws in the lower neck load cell flange. For further work refer to the head and neck sections.

If the shoulder segment is to be worked on, first remove the head and neck assemblies to access the screws holding the shoulder segment on the inside of the upper spine. Remove the arms and rib #1. See thorax section for further instructions.

Most work on the chest section can be done after removing the dummy jacket. If the storage bracket is attached to the dummy, first remove it, as this will be in the way for all chest, spine and pelvis work. If spine work is necessary, first remove the head, the neck, the arms, and shoulders, (see above) and strip the thorax. Refer to the thorax section of the manual for details.

To access the lower abdomen, release the four M6 screws from the back of the dummy in the flexible spine area, through the rectangular hole in the Pelvis Skin. Unscrew the screws and pull out the complete lower abdomen assembly to the front. Gather the screws in a little box for safe keeping. Assembly is in the reverse order.

To work on the Pelvis, remove the femurs by unscrewing and pulling out the M16x40 shoulder screws through the sides of the Pelvis Skin. Use an 8mm hex T-wrench. Next split the dummy above the pelvis by removing four M6 screws at the bottom of the Flexible Lumbar Spine and top of Pelvis/Lumbar Mounting Block. It may be difficult to pull screws out, as the top half of the dummy is leaning on the screws. Access the four M6 FHCS with a long hex T-wrench with a ball end. Gather the screws in a little box for safe keeping. Assembly is in reverse order.

The lower legs and shoe can be disassembled from the knee. First remove the outer and inner kneecaps (2x2 M6x18 screws). Then remove 2x2 M6 FHCS from the knee clevis. Gather the screws in a little box for safe keeping. Assembly is in the reverse order. Make sure to use the correct length of screws, as longer screws will protrude into the rubber of the knee slider.

Section 4. **Head Assembly**

4.1 **Description of Head Assembly and Features**

The head assembly includes the head casting, skull cap, internal mounting plates, instrumentation, instrumentation mounting plates, and skins. The internal ballast weight has been pre-installed within the skull cavity to adjust the CG location and overall mass of the assembly to meet human requirements. The head is instrumented with three uniaxial accelerometers at the CG of the head; two pairs of uniaxial accelerometers, a pair of uniaxial accelerometers at the top of the skull, and a dual axis tilt sensor. The tilt sensor is attached on the right side of the skull cavity and is used to measure the angular orientation of the head about the X and Y axes in a static (pre or post-test) mode. The mounting holes in the accelerometer fixture are currently designed for the Endevco 7264C accelerometer in order to have the head CG match the human location. The three bi-axial accelerometer arrays along with the CG accelerometers are oriented to provide the data required to compute the head angular accelerations.

The CG accelerometer fixture is also configured for the installation of angular rate sensor, such as the Diversified Technical System (DTS), which can be used in conjunction with three accelerometers at the CG track six-degree-of-freedom motion of the head.

The face assembly includes the face foam, face plate, and 5 compression load cells with impact plates. The load cells are distributed across the entire face plate, one at each eye, cheek, and one at the center of the chin. The load cells are provided to measure the total load applied to the face. Human soft tissue over the face is represented by foam. The impact stiffness of the foam was selected to match human impact loading characteristics. The load cells must be substituted with the mock equivalent (472-1417) when face load measurements are not required.

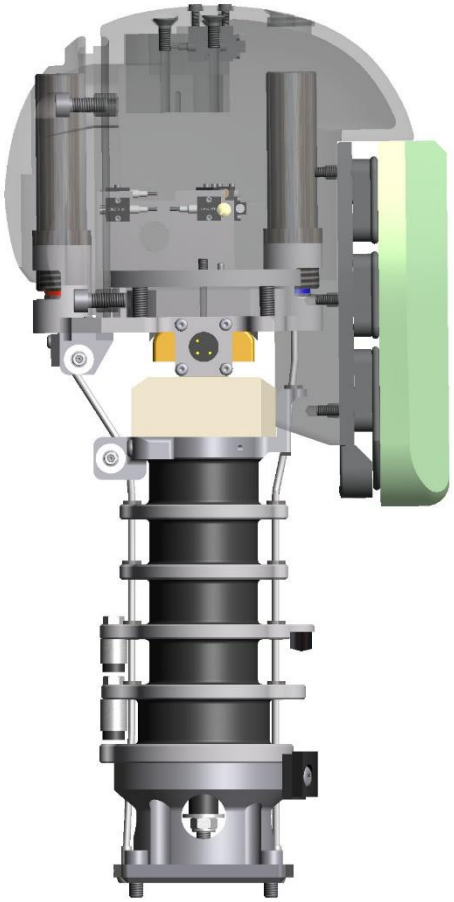

Figure 4.1 Side Section View of Head Accelerometers

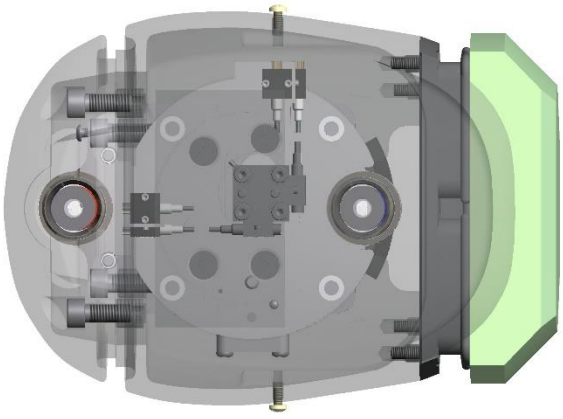

Figure 4.2 Top Section View of Head Showing Accelerometers

4.2 Assembly of the Head

4.2.1 Parts List

Figure 4.3 shows an exploded view of the head assembly, 472-1000 and table below shows the parts list.

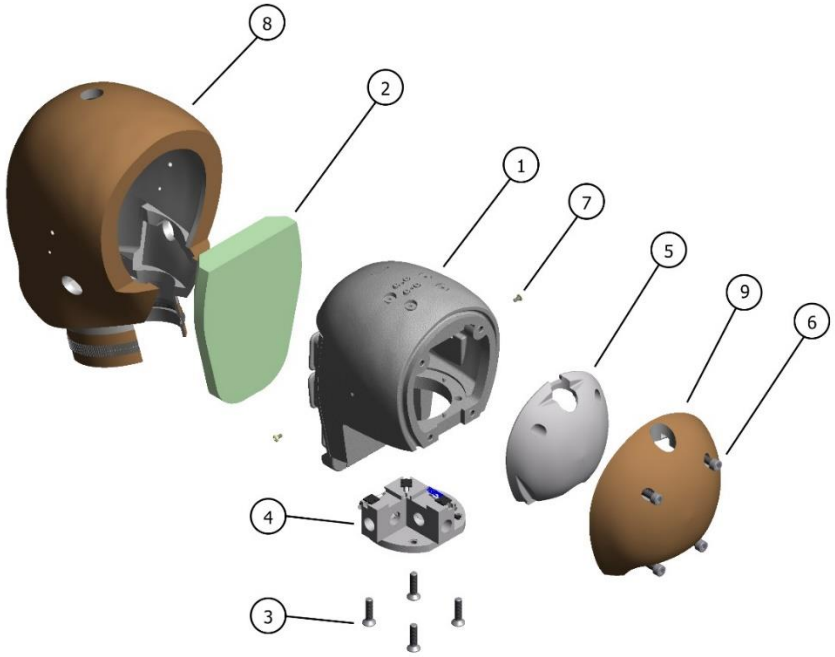

Figure 4.3 Head Assembly Exploded View

Table 4-1 Head Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-1100	SKULL ASSEMBLY
2	1	472-1401	CONFOR FOAM, FACE
3	4	5000135	M6 X 1 X 25 LG. FHCS
4	1	472-1200	ACCELEROMETER MOUNTING PLATE ASSEMBLY, HEAD
5	1	472-1110	HEAD CAP
6	4	5000081	M6 X 1 X 16 LG. SHCS
7	2	5001116	SCREW, PHILLIPS NYLON M3 X .5 X 6
8	1	472-1320	HEAD SKIN ASSEMBLY
9	1	472-1310	CAP SKIN

4.2.2 **Assembly of Head Components**

The following procedure is a step-by-step description of the assembly procedure for the head components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Remove the head skin if necessary. The orientation of the top head accelerometers is +X to the front and +Y to the right. Mount two uniaxial accelerometers to the Top Biaxial Accelerometer Mount (472-1119) using four M1.4x3 SHCS so that the desired orientation will be obtained when it is installed in the dummy. Mount the Top Biaxial Accelerometer Mounting Insert (472-1119) on the interior of the Head Casting using four M3x12 SHCS and two M3x12 dowel pins so that the accelerometer orientation is correct. The mounting bolts are passed through the skull from the outside and tighten the mounting block in place. Figure 4.4 shows a photograph of the top biaxial mount.

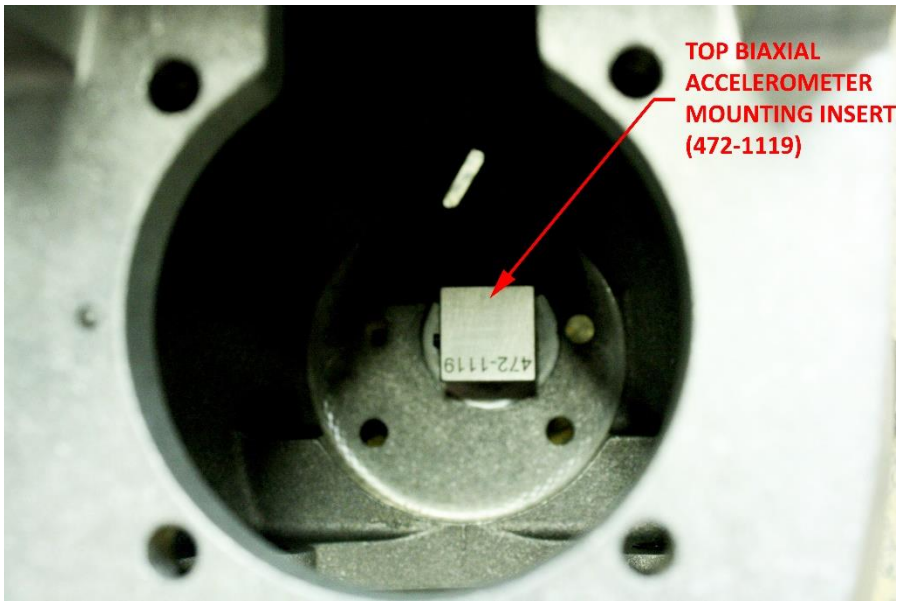

Figure 4.4 Top Biaxial Accelerometer Location

2. The seven accelerometer-array fixture (472-1212) holds seven uniaxial accelerometers. Three are at the CG of the head, two at the rear, and two at the side, attached using fourteen M1.4x3 SHCS.

    2.1 The orientation of the two side accelerometers is +X is to the front; +Z is down.
    2.2 The orientation of the two rear head accelerometers is +Y is to the right, +Z is down.
    2.3 The orientation of the three Head CG accelerometer units is +X is to the front, +Y is to the right, and +Z is down.

3. Mount the seven Accelerometer Array Fixture to the Head Accelerometer Mounting plate using four M6x16 FHCS, as shown in Figure 4.5. Accelerometers must be mounted in orientation shown in Figure 4.5 below.

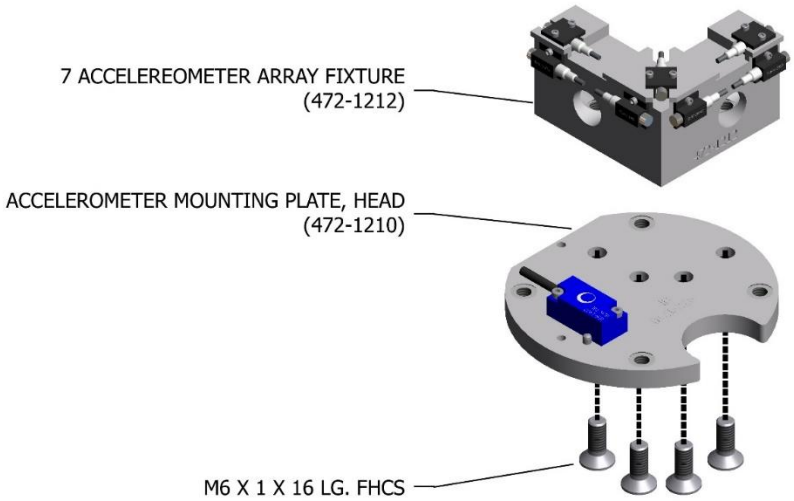

Figure 4.5 Array Fixture mounted on the Head Accelerometer Mounting Plate

4. The Head Tilt Sensor is attached to the interior of the Skull Assembly (472-1100) and to the Head Accelerometer Mounting Plate Assembly (472-1200).

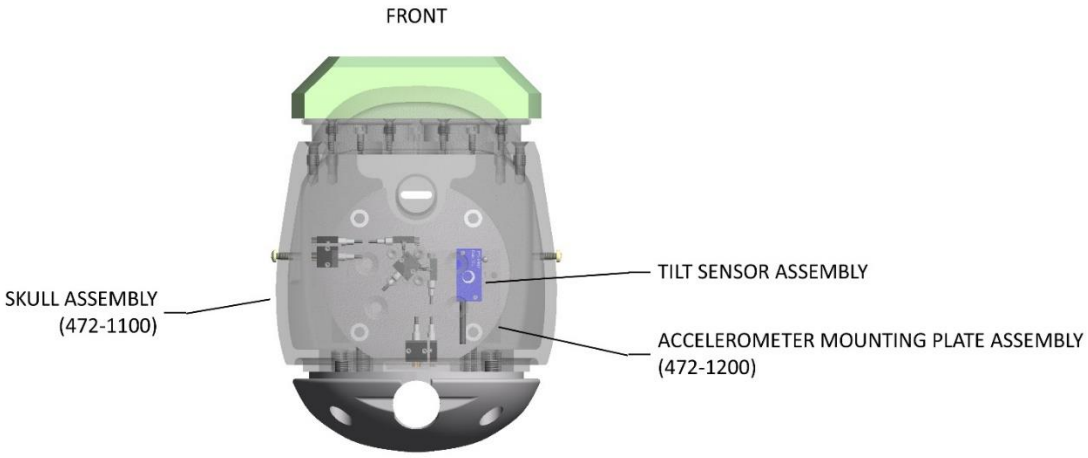

Figure 4.6 Attach Head Tilt Sensor

5. The IES sensor is attached using two M2x12 SHCS. Figure 4.6 and Figure 4.7 shows the head tilt sensor mounted in the head casting.

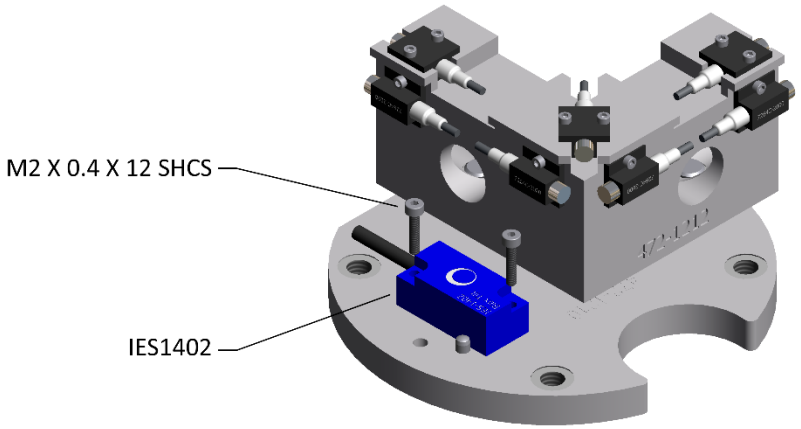

Figure 4.7 Tilt Sensor Location Showing IES1402

6. ARS Assembly: To mount the angular rate sensors to the Accelerometer Array Fixture, it is necessary to remove the head top X and Y accelerometers, and the head side and rear X and Z accelerometers. The ARS sensors are mounted as shown in Figure 4.8 with two M1.4x8 SHCS each.

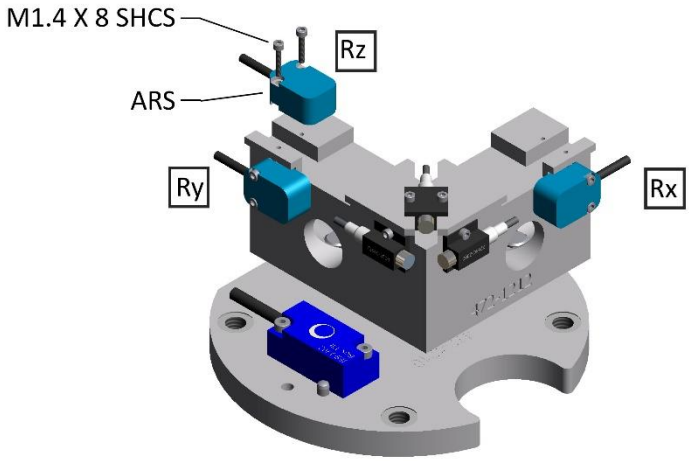

Figure 4.8 ARS Mount Location

7. To attach the head to the neck assembly, insert the completed Head/Neck Mounting Platform Assembly (472-2200) up through the bottom of the Head Assembly (472-1000). Tighten the four M6x16 FHCS. These mounting screws are typically inserted through the Head/Neck Mounting Platform Assembly (472-2200) prior to assembling the condyle bolt (see Section 6 Neck Assembly Neck for further details).

	**NOTE: THE NECK MUST BE ORIENTED SO THAT THE FRONT CABLE AND SPRING ARE POSITIONED TOWARD THE FRONT OF THE DUMMY. CHECK CABLES, MAKE SURE THEY ARE NOT PINCHED. REFER TO THE NECK SECTION FOR FURTHER DETAILS.**

8. The head angle is now adjusted as described in Section 4.3.1, Head Angle Adjustment. After the adjustment is completed, the Head Plug (472-1116) is tightened into the front hole in the top of the casting, as shown in Figure 4.9. This Head Plug prevents the spring assembly from ejecting in the event of a front cable failure.

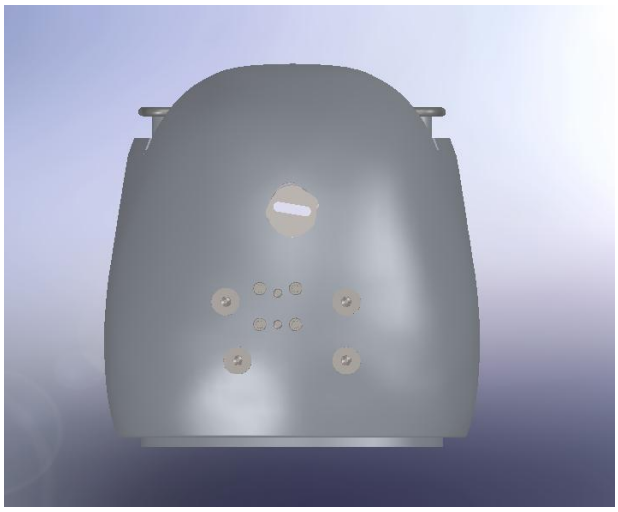

Figure 4.9 Head Plug Location

9. Position the Head Cap Skin (472-1310) onto the Head Cap (472-1110). The head cap assembly can be placed on the rear of the skull and slid down into position while routing the wire bundles out through the bottom sides of the cap. The cap is secured in place using four M6x16 SHCS as shown in Figure 4.10.

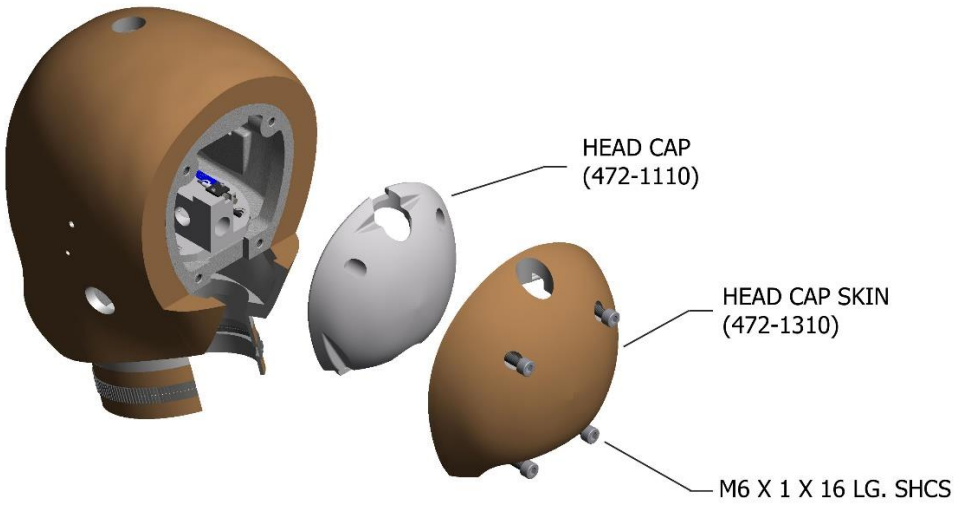

Figure 4.10 Properly Installed Skull Cap

10. An M3x6 Nylon SHCS is placed on both sides of the Machined Head Skull (472-1111) to mark the location of the Head CG. Figure 4.11 shows the CG location.

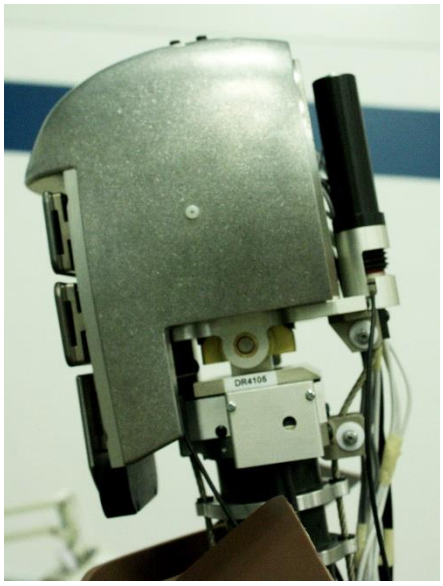

Figure 4.11 CG Marker Location on Head

The head skin (472-1320) can now be pulled into position over the head casting assembly. The head skin has a number of landmarks marked on the skin. The CG location corresponding to the equivalent point on the skull is marked with a hole. Positive engagement of the skin on the skull will be indicated by the Nylon SHCS being visible inside the CG hole. The EAM landmark is also indicated by a hole, while the Nasion and IOP are indicated by small dimples on the anterior part of the skin. The positions of the landmarks are shown in Figure 4.12.

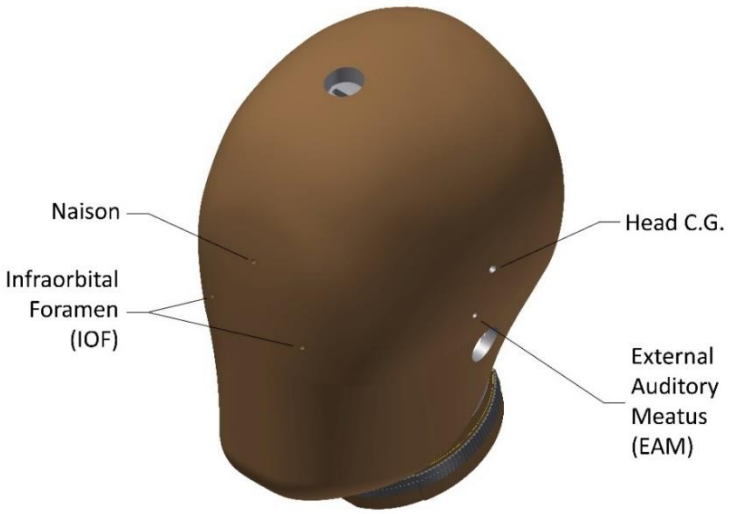

Figure 4.12 CG Marker Location on Head Skin

4.3 Adjustments for the Head Assembly

4.3.1 Head Angle Adjustment

The following procedure is a step-by-step description of the procedure for the head angle adjustment. This adjustment procedure is used to set the angle or attitude of the head relative to the ground plane. (This is also referred to as the eye level or eye plane adjustment in some literature.) All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Loosen the M5 hex jam nut located at the top of the front and rear neck cable assemblies. This nut location is shown in Figure 4.13.

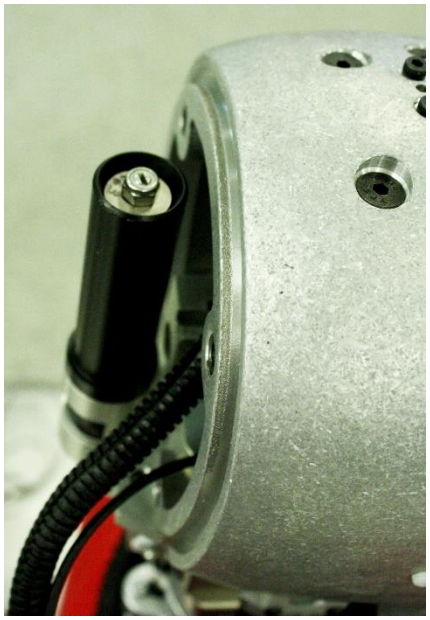

Figure 4.13 Rear Spring Adjustment Locknut Location

2. Adjust the hex nuts (M8 deep well socket) to obtain the proper head angle. The head angle will vary depending on the desired test set-up; however, most set-ups require that the eyes be directed straight ahead – parallel to the ground.

	**NOTE: THE PROPER TORQUE ADJUSTMENT OF THE SPRING ADJUSTMENT NUTS IS TO REMOVE THE SLACK FROM THE CABLE SYSTEMS WITHOUT PRE-COMPRESSING THE SPRING ASSEMBLIES. AFTER CERTIFICATION, HEAD SPRINGS SHOULD NOT BE ADJUSTED, AS THIS WILL REQUIRE RECERTIFICATION.**

3. Tighten the M5 hex jam nut, two on each side, located at the top of the front and rear cable assemblies.

4.4 Wire Routing and Electrical Connections

Note: Wire routing and strain relief can be completed per the customer's preference, the important aspect is to ensure that there is enough slack in the wires and that they are strain relieved in a location where they will not be damaged. The instructions below describe Humanetics' procedure.

The instrumentation wires from the head are first zip tied to the rear spring cover, this bundle is then routed to the right side of the back of the dummy exiting through the hole on the right on head cap (Figure 4.14). It is secured to the Upper Thoracic Spine Back Plate (472-3623) with a rubber-cushioned steel loop strap and an M3x8 BHCS. A small amount of slack should be provided between the instruments and the wire clamps to prevent stress on the instruments themselves.

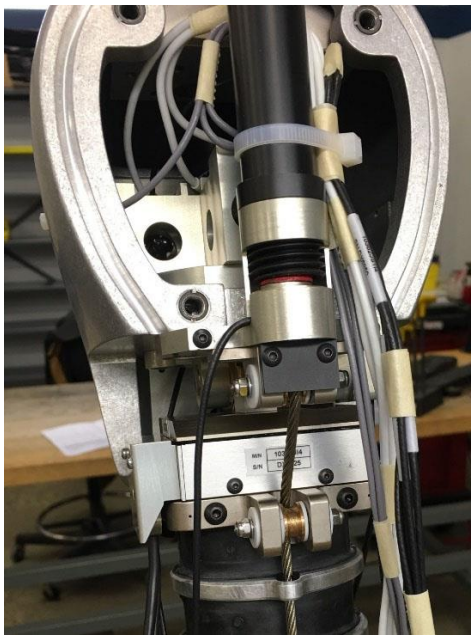

Figure 4.14 Head Instrumentation Wires Bundled to Rear Spring Cover

4.5 Head Qualification

Qualification procedures for the head are described in the *THOR-50M Qualification Procedures Manual* as a separate publication.

4.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgement should be used to determine the frequency of these inspections, a thorough inspection after every twenty tests. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. These inspections include both electrical and mechanical inspections. This inspection is most easily carried out during a disassembly of the dummy. The disassembly of the head components can be performed by simply reversing the procedure used during the assembly.

4.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the head instrumentation. The wires should be inspected for nicks, cuts pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

4.6.2 Mechanical Inspection

Several components in the head assembly will need an inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below.

General: The following checklist should be used when inspecting the dummy's head instrumentation for post-test damage:

- ✓ Check the tightness of all instrumentation mounting bolts.

Head Adjustments: The following checklist should be used when inspecting the dummy's head angle during the post-test inspection:

- ✓ Check the head angle adjustment as described in Section 4.3.1, Head Angle Adjustment.

Head Skin: The following checklist should be used when inspecting the dummy's head skin for post-test damage:

- ✓ Check the head skin for tears and damage.

Section 5. **Face Assembly**

5.1 **Face Assembly Description and Features**

The face assembly includes the foam assembly, face plate, and five compression load cells with impact plates. The load cells are distributed across the entire face plate, one at each eye, cheek, and one at the center of the chin. The load cells are provided to measure the total load applied to the face. Human soft tissue over the face is represented by a foam layer. The impact stiffness of the foam/rubber was selected to match human impact loading characteristics.

Figure 5.1 Face Assembly

The load cells can be substituted with the mock equivalent (472-1417) when face load measurements are not required.

5.2 Assembly of the Face

5.2.1 Parts List

Figure 5.2 is an exploded view of the skull assembly, 472-1100 and Table 5-1 shows the parts list.

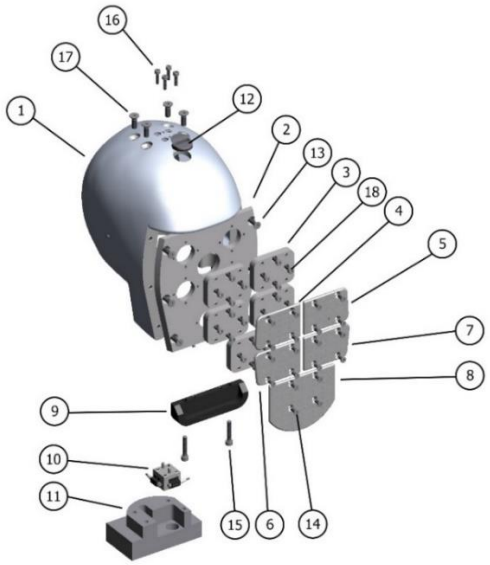

Figure 5.2 Skull Assembly Exploded View

Table 5-1 Skull Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-1111	HEAD, MACHINED
2	1	472-1410	FACE PLATE
3	5	472-1417	FACE LOAD CELL, MOCK
4	1	472-1412-2	RIGHT EYE LOAD CELL PLATE
5	1	472-1412-1	LEFT EYE LOAD CELL PLATE
6	1	472-1414-2	RIGHT CHEEK LOAD CELL PLATE
7	1	472-1414-1	LEFT CHEEK LOAD CELL PLATE
8	1	472-1416	CHIN LOAD CELL PLATE
9	1	472-1411	CHIN GUARD
10	1	472-1101	BIAXIAL ACCELEROMETER ASSEMBLY, HEAD
11	1	472-1120	HEAD BALLAST
12	1	472-1116	PLUG, HEAD
13	6	5001082	M4 X 0.7 X 16 LG. FHCS
14	20	5000116	M3 X 0.5 X 8 LG. FHCS
15	2	5001117	M4 X 0.7 X 22 LG. SHCS
16	4	5001103	M3 X 0.5 X 12 LG. SHCS
17	4	5000864	M5 X 0.8 X 14 LG. FHCS
18	20	5000388	M3 X 0.5 X 8 LG. SHCS

5.2.2 **Assembly of Face Components**

The following procedure is a step-by-step description of the assembly procedure for the face components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Attach the Face Plate (472-1410) to the Head Skull Assembly (472-1111) using six M4x16 FHCS. Then attach the Chin Guard by using two M4x22 SHCS.

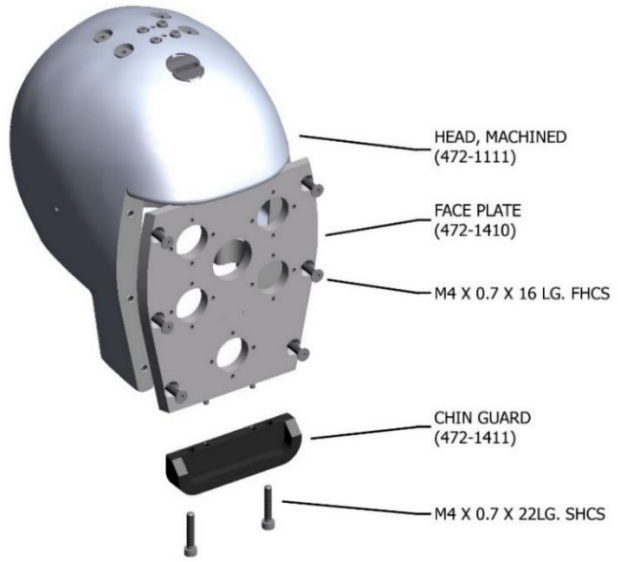

Figure 5.3 Assemble Face Plate and Chin Guard

2. Attach five Face Load Cells (10382JI4) or the load cell substitutes (472-1417) to the Face Plate using twenty M3x8 SHCS as shown in Figure 5.4.

Figure 5.4 Assemble Face Load Cells

3. Install the respective load cell plates (472-1412-1, 472-1412-2, 472-1414-1, 472-1414-2, 472-1416) onto the face load cells using four M3x8 FHCS per plate, total of twenty. Each load cell plate is shaped differently to match the contour of the front of the head casting. The load cell plates are labeled, l-eye, r-eye, l-cheek, r-cheek, and chin according to the location on the face, where the load cell plates are attached. Figure 5.5 is an illustration of the attachment of the load cell plates to the face load cells.

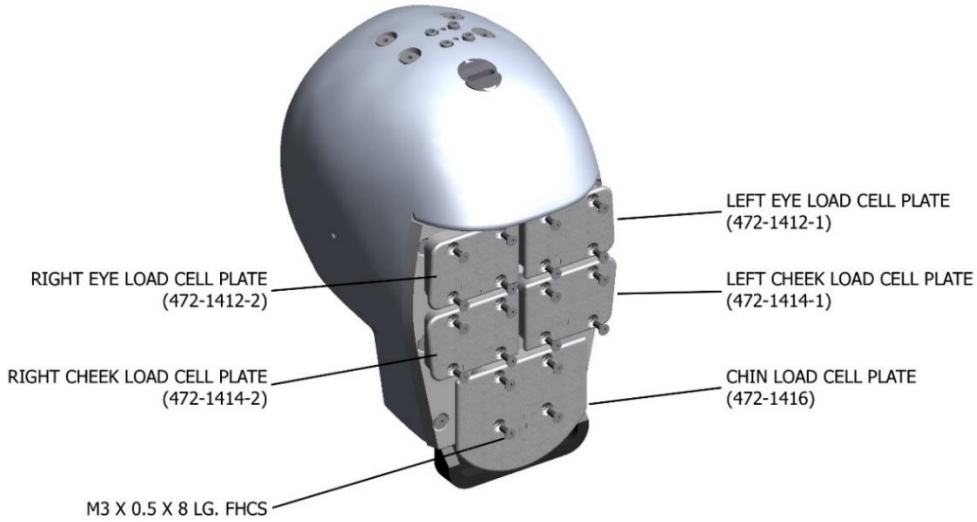

Figure 5.5 Load Cell Plates Attached to Load Cells

4. Position the Confor Face Foam Assembly (472-1401) inside the cavity in the Head Skin (472-1320). Mount the Head Skin to the Head Skull and proceed to the Head assembly, detailed in Section 4, Head Assembly.

5.3 Adjusting the Face Assembly

No adjustments are required for the face assembly.

5.4 Wiring Routing and Electrical Connections

Note: Wire routing and strain relief can be completed per the customer's preference, the important aspect is to ensure that there is enough slack in the wires and that they are strain relieved in a location where they will not be damaged. The instructions below describe Humanetics' procedure.

The face load cell wires are grouped with the wires from the head tilt sensor and wires from the fore and aft neck spring compression load cells. The bundle of wires is routed out through the left side of the back of the head. This bundle is secured to the Upper Thoracic Spine Back Plate (472-3623) with a rubber-cushioned steel loop strap and an M3x8 BHCS. A small amount of slack should be provided between the instruments and the wire clamps to prevent stress on the instruments themselves.

5.5 Face Qualification

Qualification procedures for the face are described in the THOR-50M Qualification Procedures Manual as a separate publication.

5.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgment should be used to determine the frequency of these inspections; however, a thorough inspection is recommended after every twenty tests. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. This inspection is most easily carried out during a disassembly of the dummy. The disassembly of the face components can be performed by simple reversing the procedure used during the assembly.

5.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all instrument wires from the face instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to data acquisition system. The instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

5.6.2 Mechanical Inspections

Several components in the face assembly will need an inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below.

Face Foam Assembly Inspection: The following checklist should be used when inspecting the dummy's face form assembly for post-test damage.

- ✓ Check the foam for tears and rips.
- ✓ Check the foam for permanent compression.

NOTE: Face foam will degrade over time.

Section 6. **Neck Assembly**

6.1 **Description of the Neck Assembly and Features**

The THOR-50M neck assembly is made from a series of aluminum disks and rubber pucks which are molded together using an epoxy resin system. The rubber pucks are elliptically shaped to provide the desired frontal and lateral bending responses for the neck assembly. Compression springs are located in the front and rear regions of the skull. In addition, rubber soft stops are attached at the base of the neck to achieve the desired bending characteristics in both front and rear motion.

The instrumentation for the neck assembly includes a pair of miniature load cells to measure the compression at the front and rear spring locations, six axis load cells at the top and base of the neck to measure the forces and moments developed at these locations, and a rotary potentiometer used at the condyle pin to measure the relative rotation between the head and top of the neck. Figure 6.1 shows a drawing of the THOR-50M neck assembly.

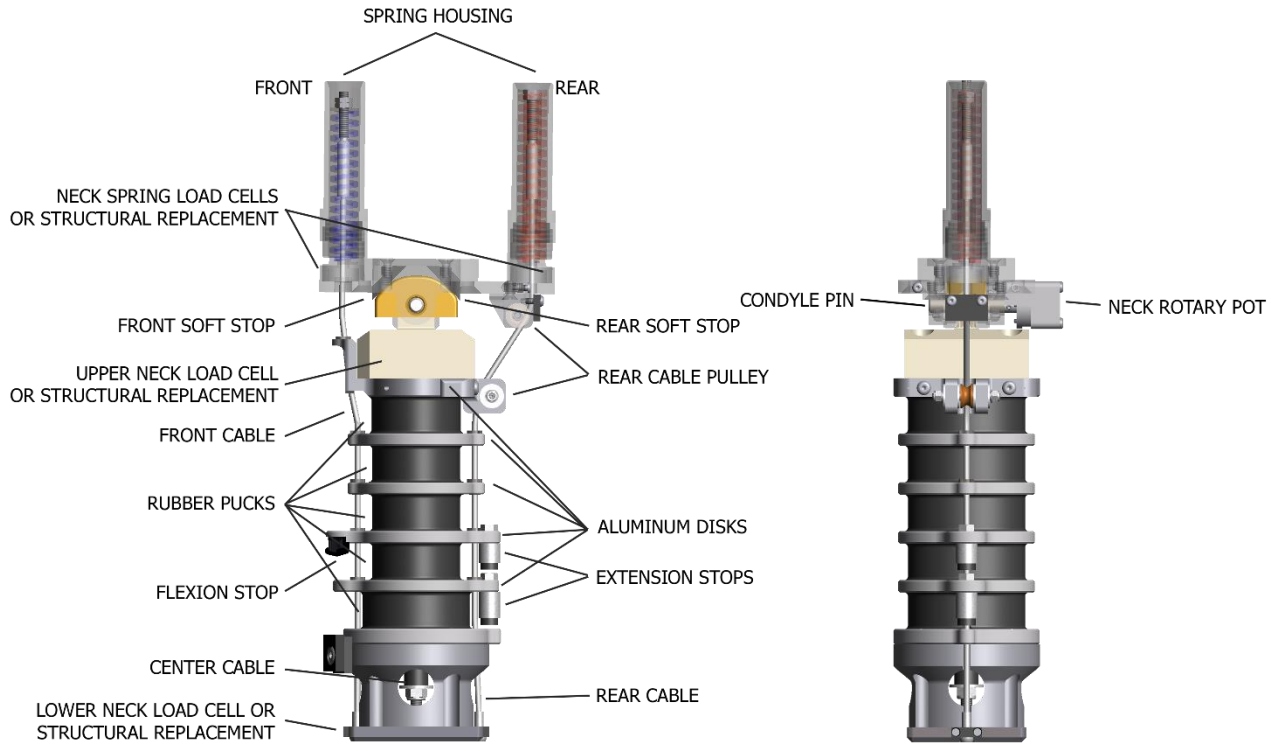

Figure 6.1 Neck Assembly

6.2 **Assembly of the Neck**

6.2.1 **Parts List**

The following figure is an exploded view of the neck assembly, 472-2000-B.

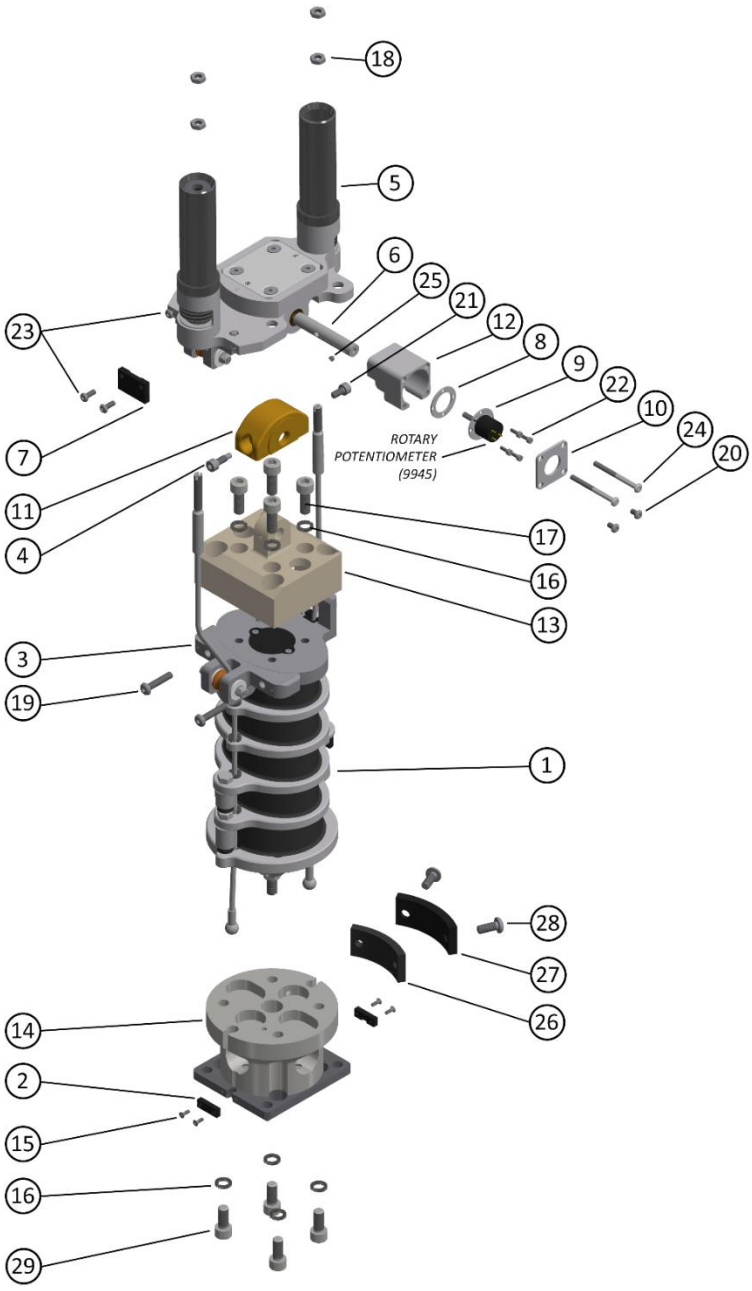

Figure 6.2 Neck Assembly Exploded View

Table 6-1 Neck Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-2100-B	CABLE ASSEMBLY, NECK
2	2	472-2015	CABLE SEAT COVER, NECK
3	1	472-2300	NECK PULLEY BRACKET ASSEMBLY
4	1	472-2016	OCCIPITAL CONDYLE SCREW
5	1	472-2200	MOUNTING PLATFORM ASSEMBLY, NECK
6	1	472-2011	OCCIPITAL CONDYLE PIN, NECK
7	1	472-2012	NECK PULLEY PLATE
8	1	472-2021	ROTARY POTENTIOMETER WASHER, NECK
9	2	472-2020	ROTARY POTENTIOMETER CLAMP, NECK
10	1	472-2014	ROTARY POTENTIOMETER COVER, NECK
11	1	472-2019	OCCIPITAL CONDYLE CAM, NECK
12	1	472-2013	ROTARY POTENTIOMETER HOUSING, NECK
13	1	472-2700	UPPER NECK LOAD CELL STRUCTURAL REPLACEMENT
14	1	472-2600	LOWER NECK LOAD CELL STRUCTURAL REPLACEMENT
15	4	5000469	M2 X 0.4 X 6 LG. FHCS
16	8	5001110	M6 HI-COLLAR LOCK WASHER S.S.
17	4	5000081	M6 X 1 X 16 LG. SHCS
18	4	5000596	M5 X 0.8 HEX JAM NUT ZINC
19	2	5000007	M4 X 0.7 X 20 LG. BHCS
20	2	5000674	M3 X 0.5 X 5 LG. BHCS
21	1	5000989	M4 X 0.7 X 8 LG. SHCS
22	4	5000082	M2 X 0.4 X 6 LG. SHCS
23	3	5000410	M3 X0.5 X 8 LG. BHCS
24	2	5001313	M3 X 0.5 X 35 LG. BHCS SS
25	1	5001112	M3 X 0.5 X 3 LG. SSS CONE PT.
26	1	472-2002	LOWER NECK LOAD CELL BUMPER
27	1	472-2001	LOWER NECK LOAD CELL BUMPER COVER
28	2	5000654	M5 X 0.8 X 12 LG. BHCS
29	4	5000604	M6 X 1 X 14 LG. SHCS

6.2.2 **Assembly of Neck Components**

The following procedure is a step-by-step description for the assembly procedure of the neck components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. The front/top of the neck is identified by the top neck plate with the vertical bracket.

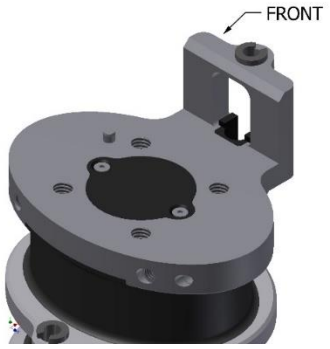

Figure 6.3 Front/Top of Neck

2. Pass the threaded end of the Front Cable Assembly (472-2150-B) through the load cell and each of the neck plate holes at the front side of the neck. Repeat with the Rear Cable Assembly (472-2130) on the rear side of the neck. Assembly the Cable Guides (472-2105) at the ten locations shown in figure below. The guides are cut on one side to allow them to be stretched open and pressed onto the cable at each location. Once the guide is on the cable, press it into the hole in each plate.

   NOTE: To minimize friction on the cable during testing, it is recommended to assemble the cable guides at a 45-degree angle from the front/back of the neck. This is shown in Figure 6.4.

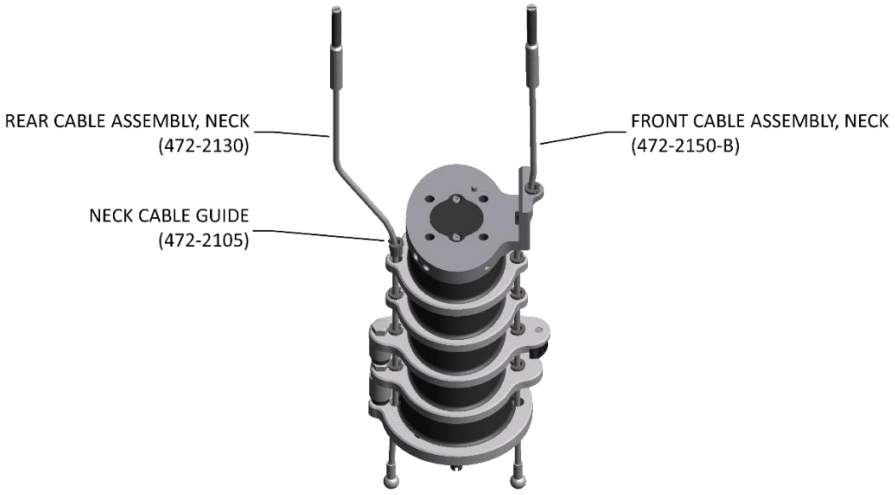

Figure 6.4 Front & Rear Cable Assembled Secured with Neck Cable Guide

3. Attach the lower neck load cell to the bottom of the neck with the sensor wires toward the rear of the neck using four M6x16 SHCS and M6 collar lock washers. Note: The holes at the front (cylindrical section) of the load cell are closer together than the rear holes.

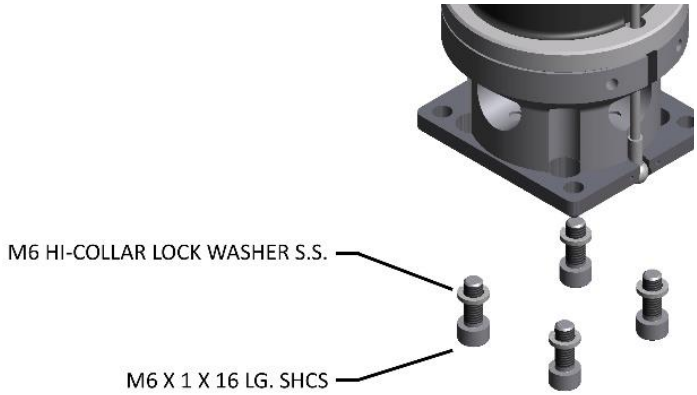

Figure 6.5 Secure Lower Neck LC with M6x16 SHCS and M6 Collar Lock Washer

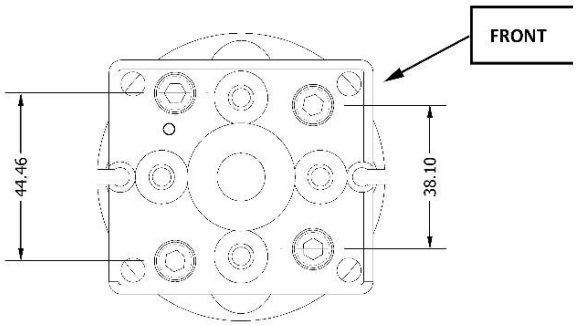

Figure 6.6 Lower Neck Load Cell (Bottom View)

4. The ball end of the cables rest in the base of the lower neck load cell and are secured with a Neck Cable Seat Cover (472-2015) and two M2X6 FHCS on the front and rear load cell base faces.

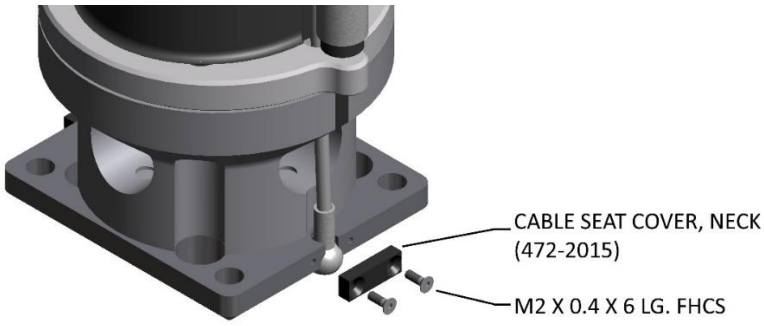

Figure 6.7 Secure Cable Seat Cover in the Front and Rear

5. Place the Lower Neck Load Cell Bumper (472-2002) against the front of the lower neck load cell. Position the Lower Neck Load Cell Bumper Cover (472-2001) over the Bumper and secure in position with two M5x12 BHCS.

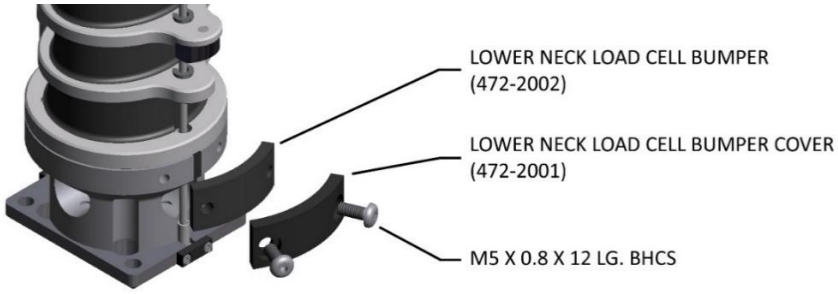

Figure 6.8 Lower Neck Load Cell Bumper

6. Pass the threaded end of the Neck Center Cable Assembly (472-2140) through the top side of the Neck Center Cable Fixture (472-2102). Pass the cable through the hole in the center of the Cable Assembly (472-2100-B) from the top side and position the Neck Center Cable Fixture (472-2102) in the recessed hole in the center of the top plate of the molded neck assembly. Secure the cable into position in the counter bore in the lower neck load cell using the Center Cable Lower Bushing 2, Neck (472-2108), the Neoprene spacer (472-2018), and an M6 Fender Washer S.S. Secure the center cable assembly with a M6 Hex Lock Nut by holding the threaded end of the cable with a standard tip screwdriver inserted through the 8mm socket. Tightening the nut 1/2 turn past finger tight. Secure the top by covering with the Cable Cover (472-2103) and two M2x6 FHCS.

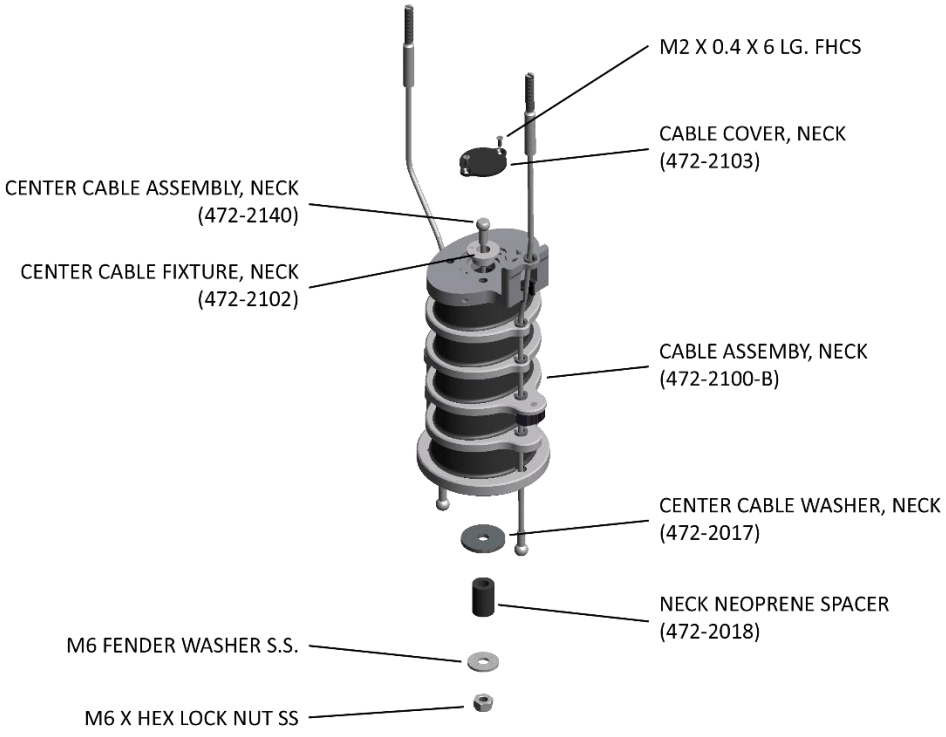

Figure 6.9 Neck Cable Assembly

7. Place a Teflon washer on each side of the Rear Cable Pulley (472-2312) and position it between the arms of the Rear Pulley Bracket (472-2310). Push the Pulley Shaft (472-2311) through the arm bearings, pulley wheel and washers. Center the shaft on the pulley assembly and secure each end of the shaft using a Neck Teflon Washer, a M3 Flat Washer, and M3 Nylock Nut. Tighten the nylock nuts until contact is achieved. An exploded view of this assembly is shown in Figure 6.10.

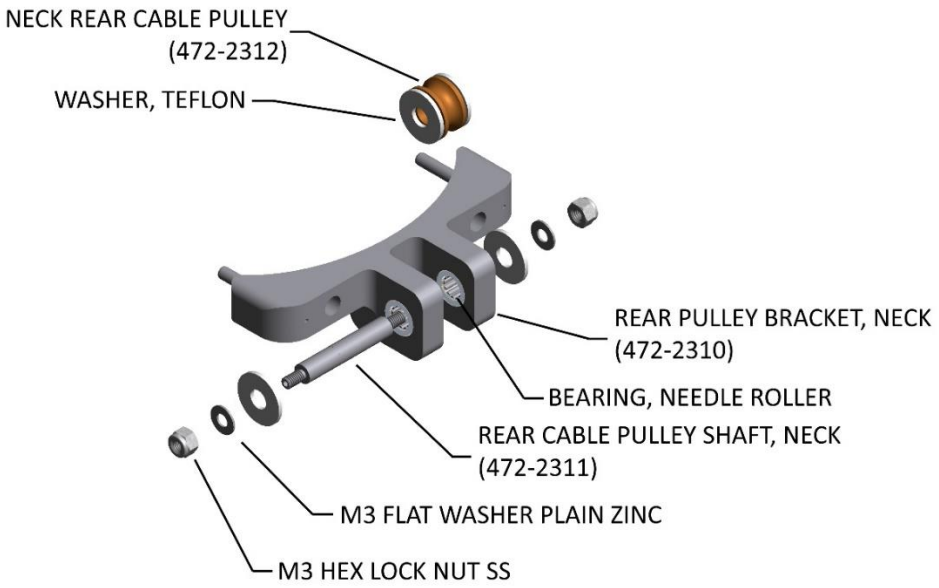

Figure 6.10 Rear Cable Pulley Assembly

8. Secure the Neck Pulley Bracket Assembly with two M4x20 BHCS.

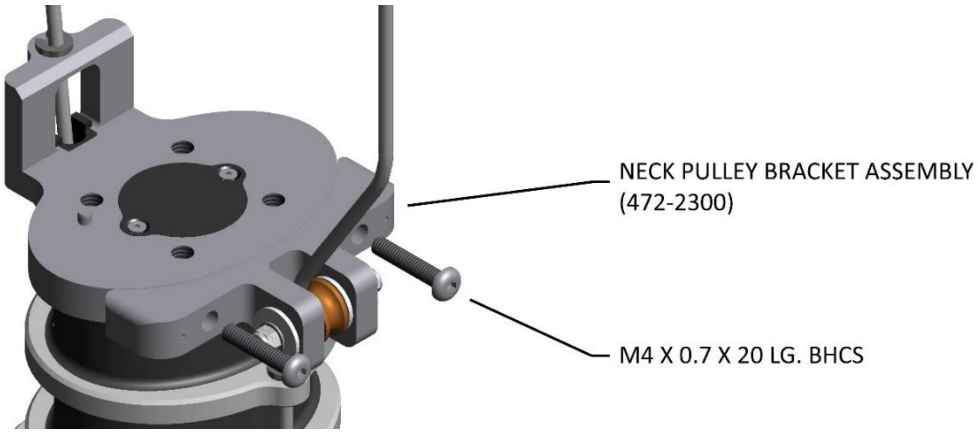

Figure 6.11 Secure the Neck Pulley Bracket Assembly

9. Install the Upper Neck Load Cell (or structural replacement) to the top using four M6x16 SHCS and four M6 collar lock washers (5001110).

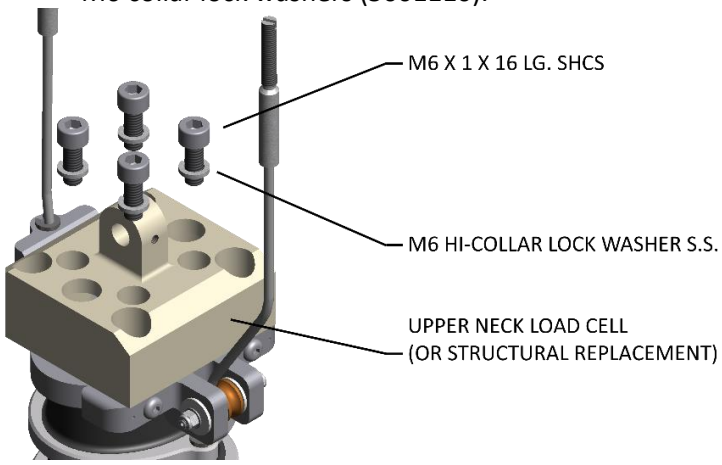

Figure 6.12 Upper Load Cell Attachment

10. Insert the Occipital Condyle Cam (472-2019) onto the Upper Neck Load Cell with the threaded counter bore hole aligned with the hole on the Upper Neck Load Cell. Install the Occipital Condyle Cam using the Occipital Condyle Set Screw (472-2016) on the threaded counter bore hole and an M4x8 SHCS on the opposite side (front) of the Cam.

	**NOTE: THE OCCIPITAL CONDYLE SCREW SHOULD NOT PROTRUDE INTO THE CENTER BORE FOR THE OCCIPITAL CONDYLE PIN AT THIS POINT. IT WILL BE TIGHTENED ONCE THE OCCIPITAL CONDYLE PIN IS IN PLACE.**

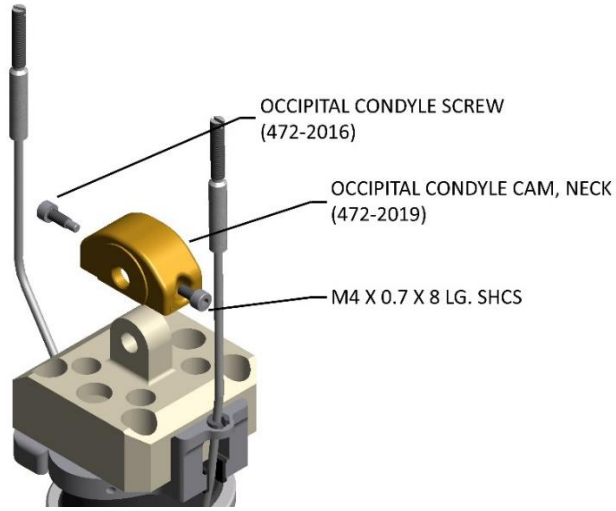

Figure 6.13 Insert the Occipital Condyle Cam

11. Assemble the front and rear neck spring load cells (or structural replacements) into the Head/Neck Mounting Platform (472-2210).

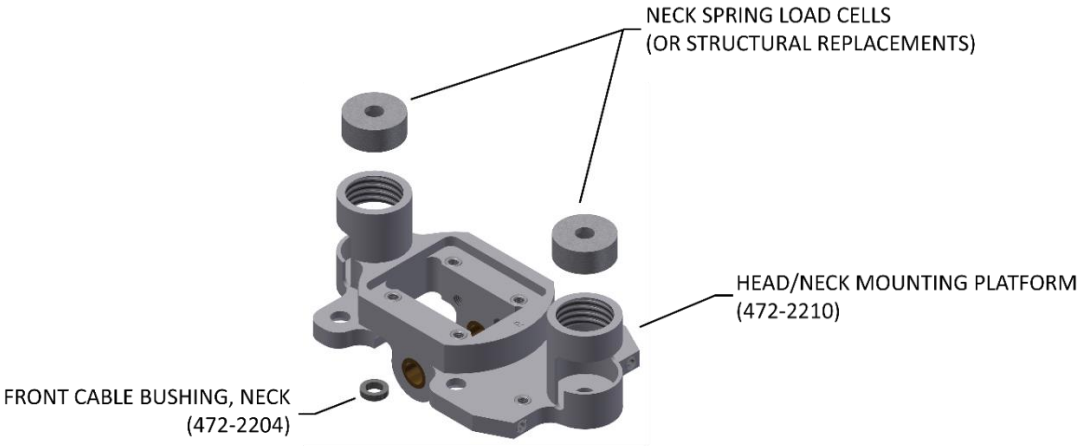

Figure 6.14 Assembling Neck Spring Load Cells (or Structural Replacements)

NOTE: WHEN REPLACING FRONT CABLE BUSHING (472-2204), CHEMICALLY CLEAN THE BUSHING AND MATING PART, MOUNTING PLATFORM, (472-2210). BOND WITH CYANOACRYLATE, MAKING SURE THE BOTTOM SURFACE IS FLUSH WITH ITS MATING PART.

12. The O.C. Stop Assembly (472-2230) is assembled using four M4x10 FHCS. Ensure the sides labeled F & R are facing the front and rear of the neck assembly accordingly.

NOTE: To help ensure repeatable results for the neck certification tests, clean the OC stop bumpers with acetone prior to assembly.

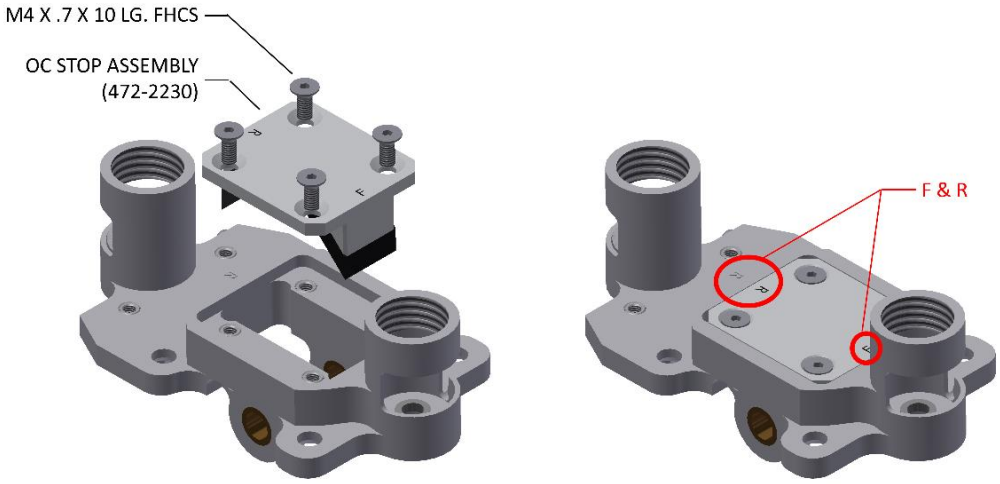

Figure 6.15 Assemble the OC Stop Assembly

13. Place a Teflon washer on each side of the Rear Cable Pulley (472-2312) and position it between the arms of the Head/Neck Pulley Bracket, Neck (472-2410). Push the Pulley Shaft (472-2311) through the arm bearings, pulley wheel and washers. Center the shaft on the pulley assembly and secure each end of the shaft using a Neck Teflon Washer, a M3 Flat Washer, and M3 Nylock Nut. Tighten the nylock nuts until contact is achieved. An exploded view of this assembly is shown in Figure 6.16.

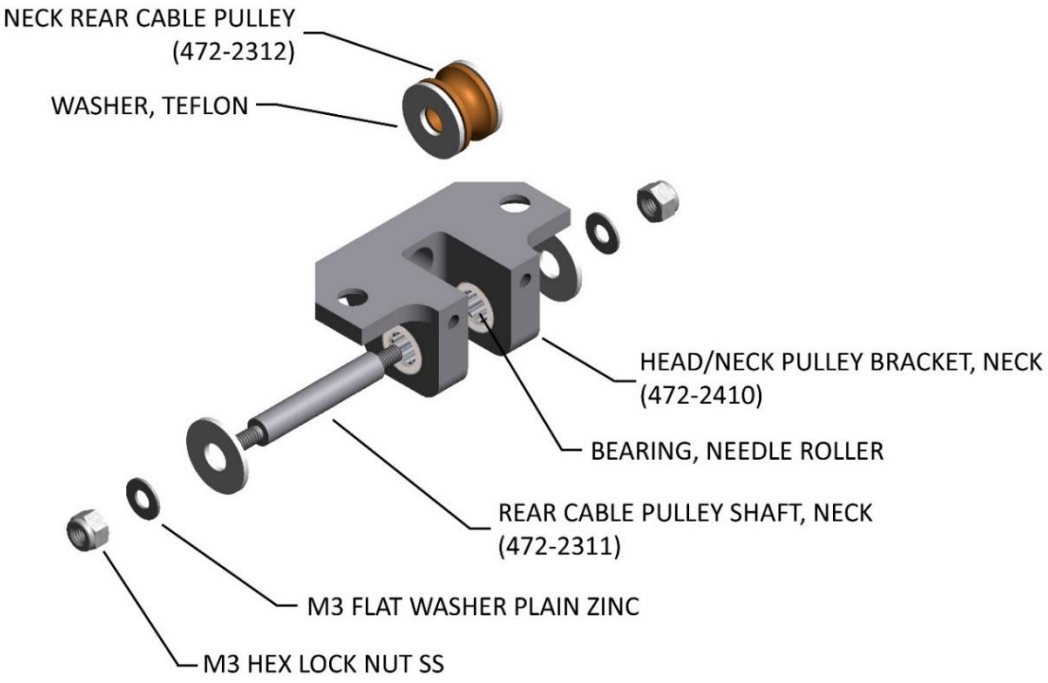

Figure 6.16 Head/Neck Pulley Bracket Assembly

14. Attach the Head/Neck Pulley Bracket Assembly (472-2400) to the Head/Neck Mounting Platform using two M4x10 FHCS.

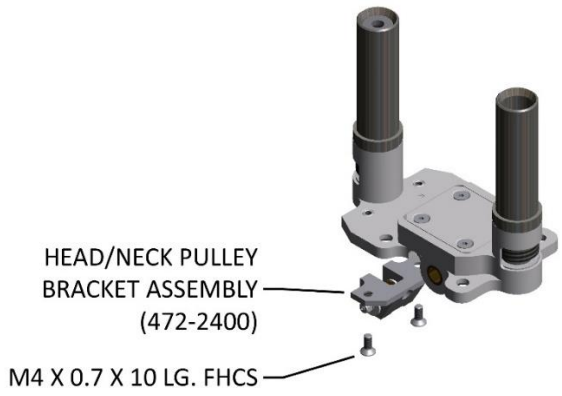

Figure 6.17 Attach Head/Neck Pulley Bracket to Head/Neck Mounting Platform

15. Put the front and rear cables through the Neck Mounting Platform Assembly (472-2200).

Figure 6.18 Neck Mounting Platform Assembly

16. Insert four M6x25 FHCS from the Head Assembly (472-1000) into the mounting holes of the Neck Mounting Platform Assembly from the Neck Assembly (472-2000-B) from the bottom side.

	**NOTE: A SMALL PIECE OF TAPE CAN BE USED TO HOLD THESE MOUNTING BOLTS IN PLACE DURING THE REST OF THE ASSEMBLY UNTIL THE NECK IS READY TO MATE WITH THE HEAD ASSEMBLY.**

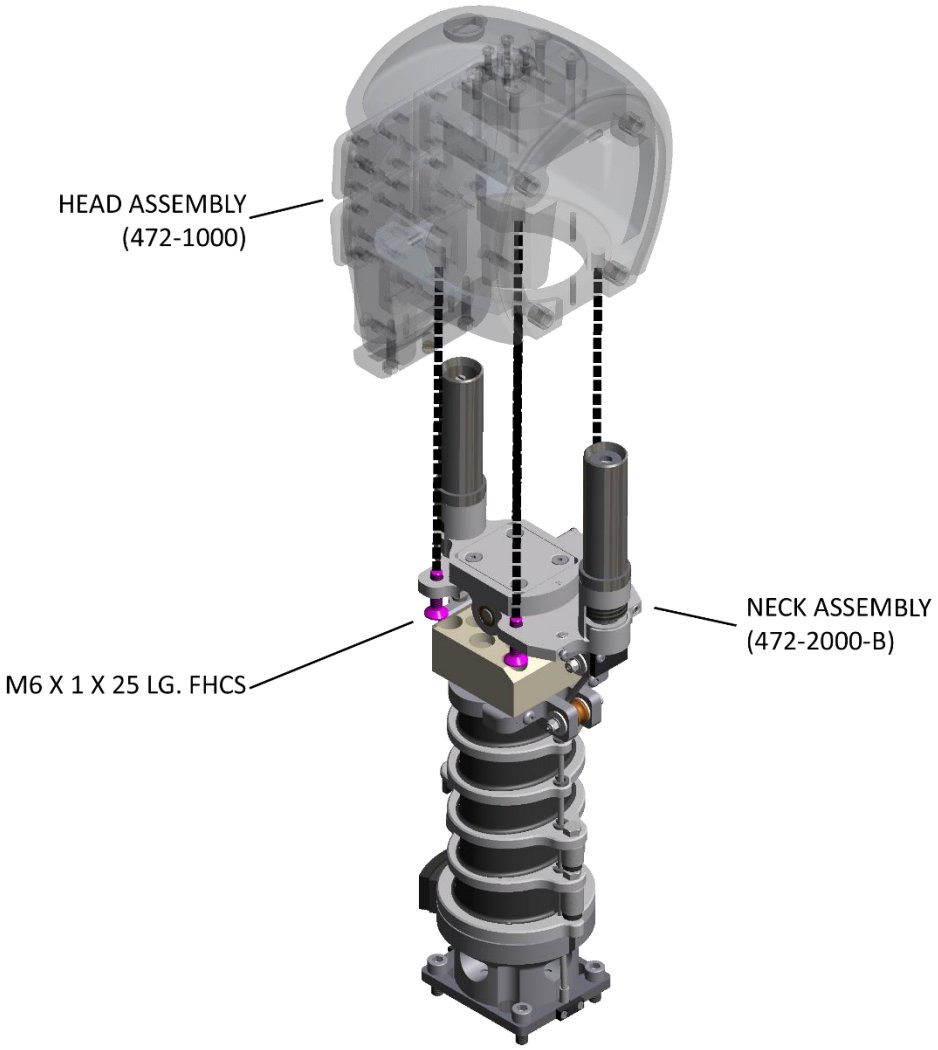

Figure 6.19 Head/Neck Mounting Bolt Locations

17. Pass the threaded end of the front and rear neck cable assemblies up through the front and rear spring tube assemblies in the Neck Mounting Platform Assembly (472-2200). Secure the cables with two M5 Hex Jam Nut Zinc on each side. The adjustment of these Cable Retaining nuts is described in Section 6.3, Adjustments for the Neck Assembly.

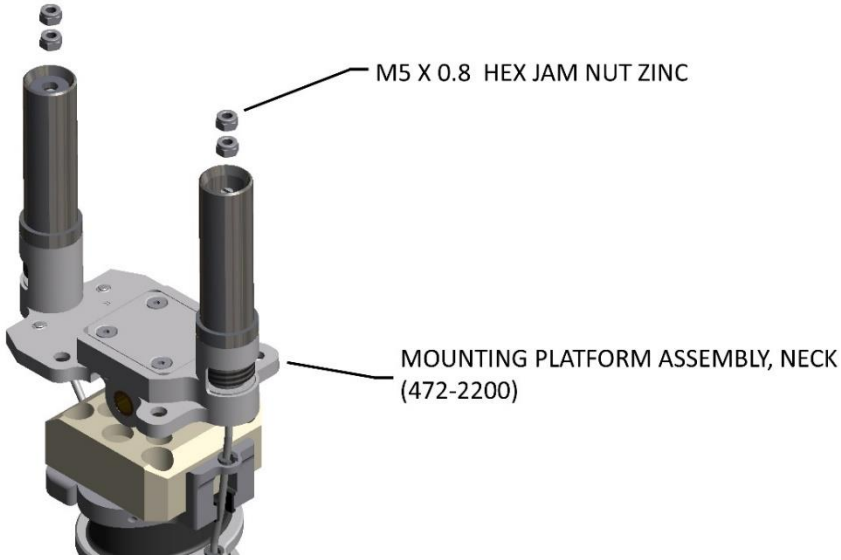

Figure 6.20 Secure Cables with M5 Hex Jam Nut

18. Pass the Occipital Condyle pin (472-2011) through the Neck/Head Mounting Platform Assembly (472-2200) and Upper Neck Load Cell (or structural replacement).

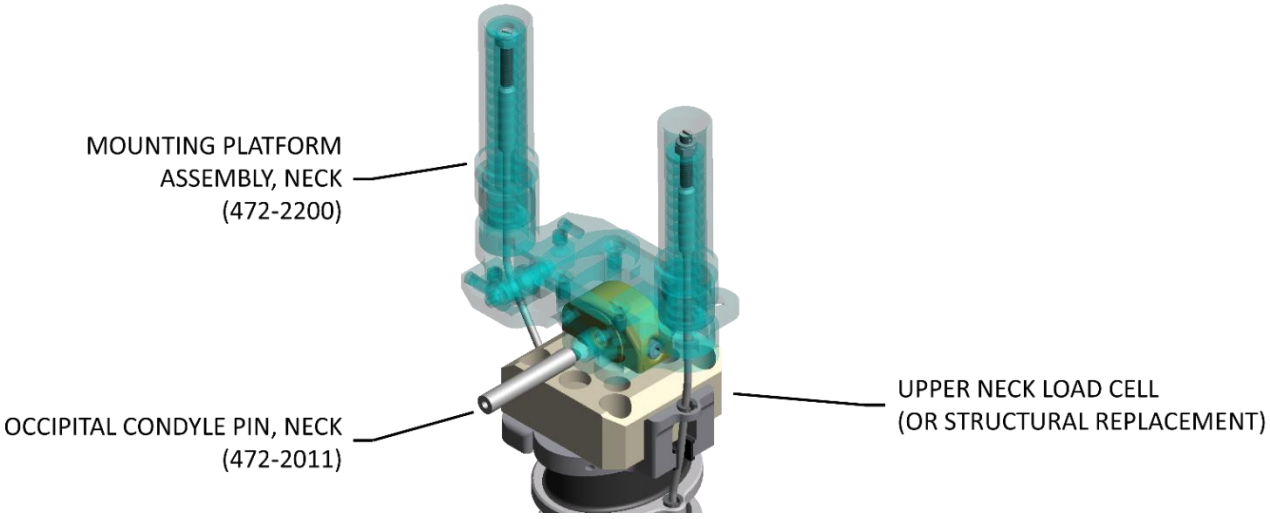

Figure 6.21 Pass OC Pin through Neck/Head Mounting Platform Assembly and Upper Neck LC

19. The O.C. pin (472-2011) is locked laterally by the O.C. screw (472-2016), which goes through the O.C. cam (472-2019) and through the Upper Neck Load Cell (or structural replacement). The end of the O.C. screw is turned down into a shaft that slip fits into a hole on the O.C. pin.

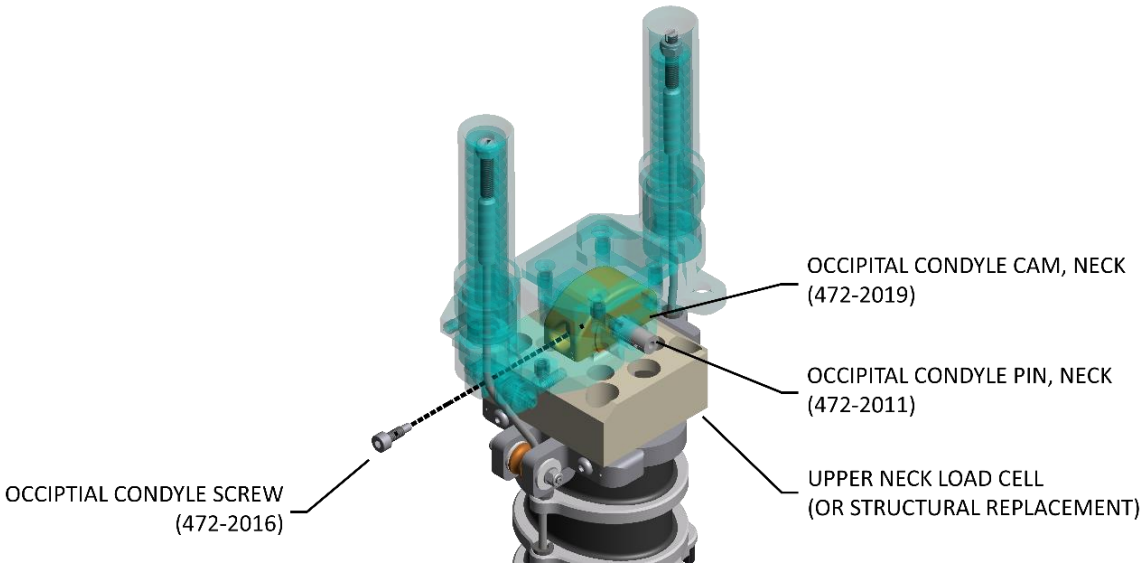

Figure 6.22 OC Pin Locked by OC Screw

20. The rotary potentiometer is mounted onto the rotary pot housing (472-2013) using a washer (472-2021), two split rings (472-2020), and four M2x6 SHCS.

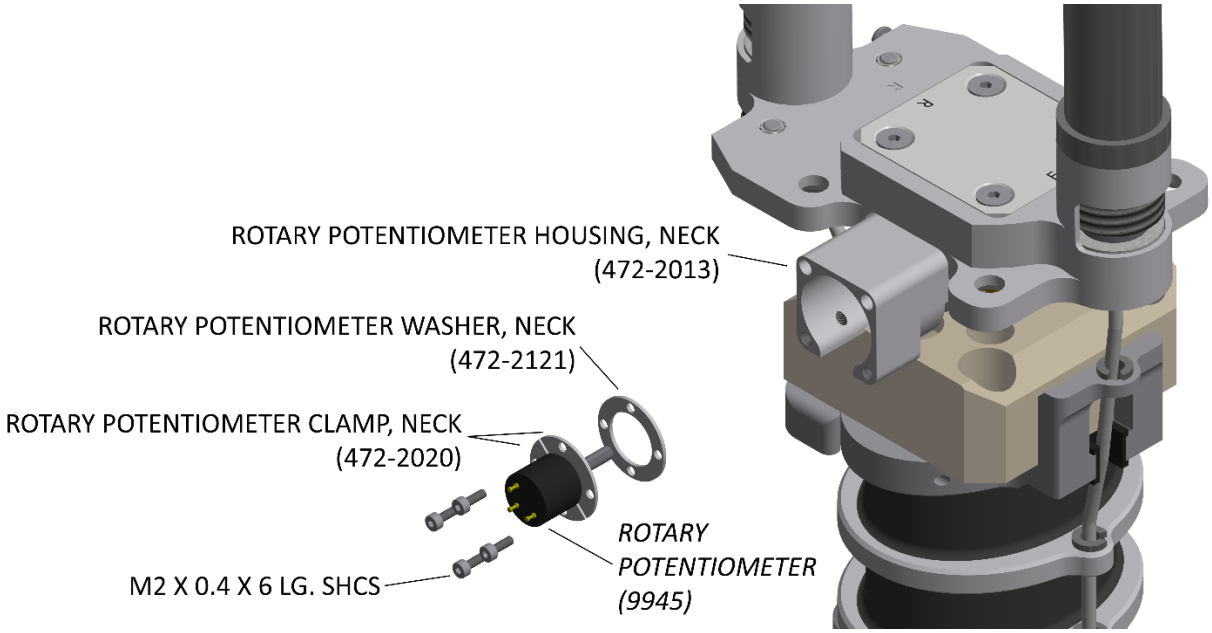

Figure 6.23 Mounting the Rotary Potentiometer Housing, Neck

21. The Rotary Potentiometer Housing and the Rotary Pot Cover (472-2014) are attached to the head neck mounting platform with two M3x35 BHCS and two M3x5 BHCS on the top and bottom holes respectively.

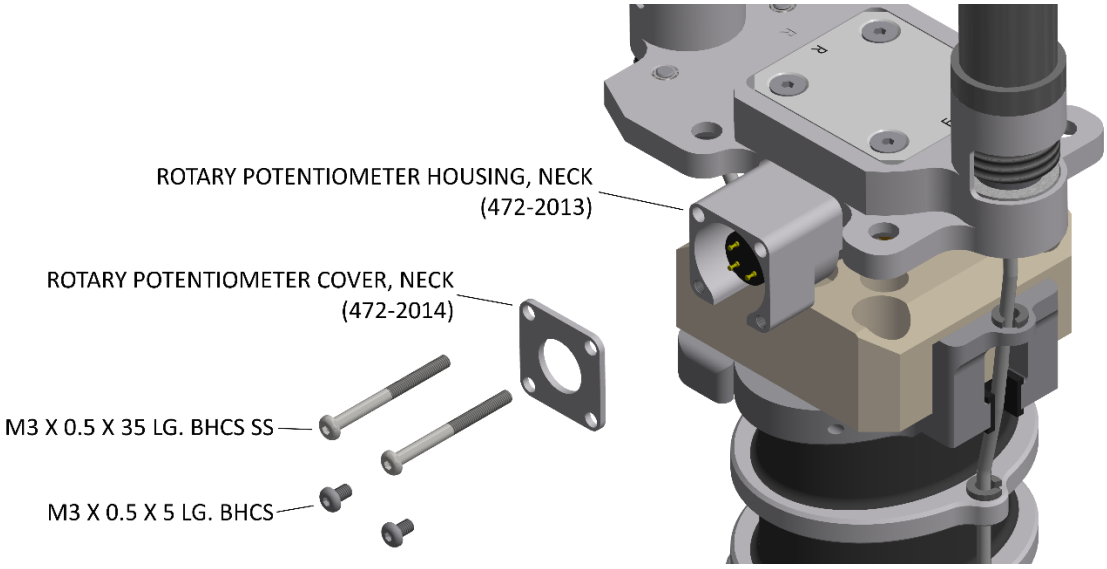

Figure 6.24 Installation of Rotary Pot Housing to Head/Neck Platform

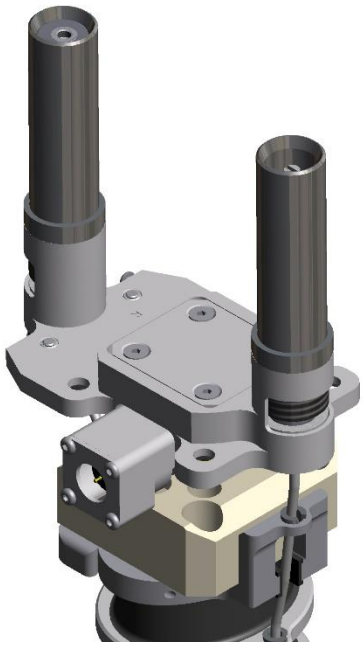

Figure 6.25 Completed Assembly of O.C. Pin and Rotary Potentiometer

22. The end of the O.C. pin that mates with the rotary potentiometer has a threaded hole for a set screw (M3 x 3 SSCP) that locks the potentiometer shaft.

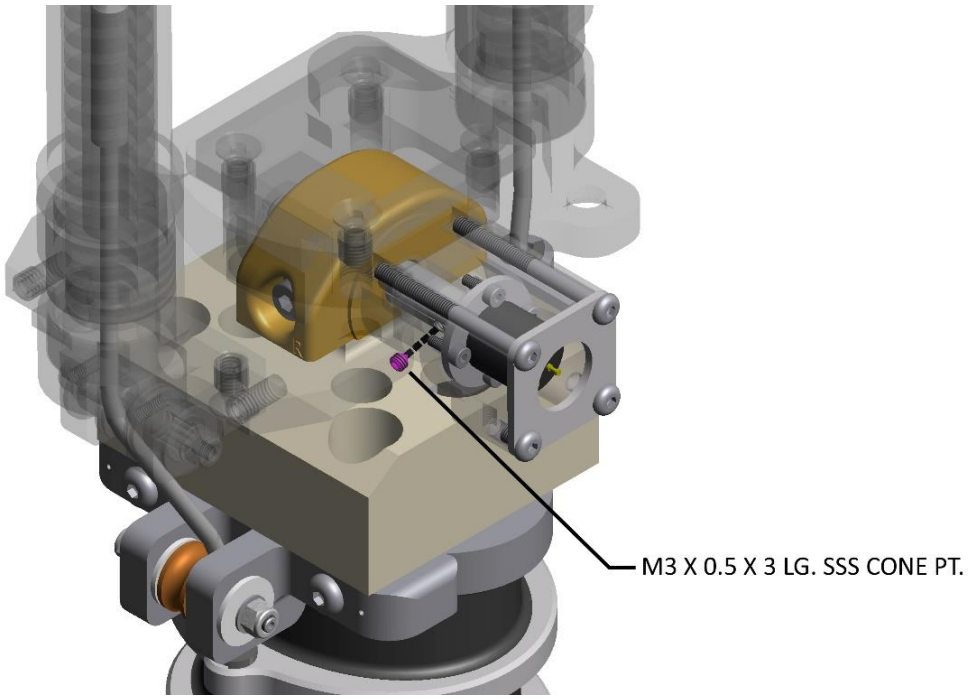

Figure 6.26 Lock the O.C. Pin with the M3x3 SSCP

6.2.3 Ground Strap Attachment

The Head/Neck Ground Strap (472-8700) connects the Spine at the Upper Thoracic Spine Back Plate (472-3623) to the Neck at the Neck/Head Mounting Platform (472-2210). Mount the Head/Neck Ground Strap to the Neck/Head Mounting Platform using a M3x8 BHCS, as shown on Figure 6.27.

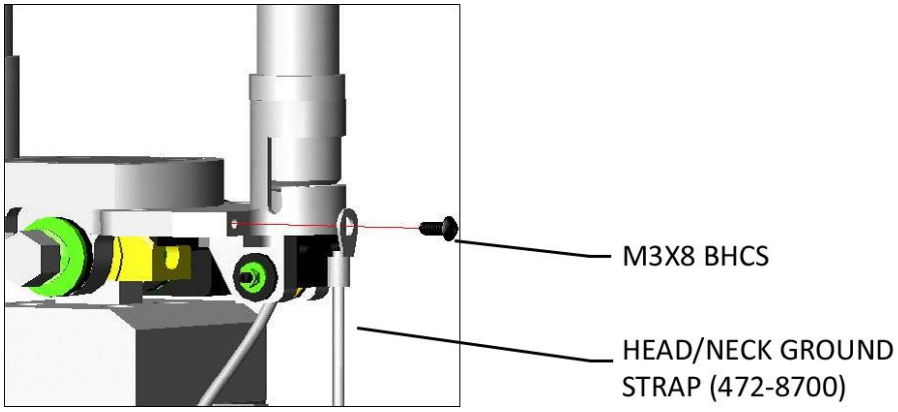

Figure 6.27 Head/Neck Ground Strap Attachment to Neck/Head Mounting Platform

6.2.4 **Assembly of the Neck to the Head**

The following procedure is a step-by-step description of the assembly procedure used to attach the head to the neck. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Insert the completed Head/Neck Mounting Platform Assembly (472-2200) up through the bottom of the Head Casting Assembly (472-1000). Tighten the four mounting bolts M6x25 FHCS. (These mounting bolts are typically inserted through the Head/Neck Mounting Platform Assembly (472-2000-B) prior to assembling the condyle bolt, see Section 6.2.2 Step 10.

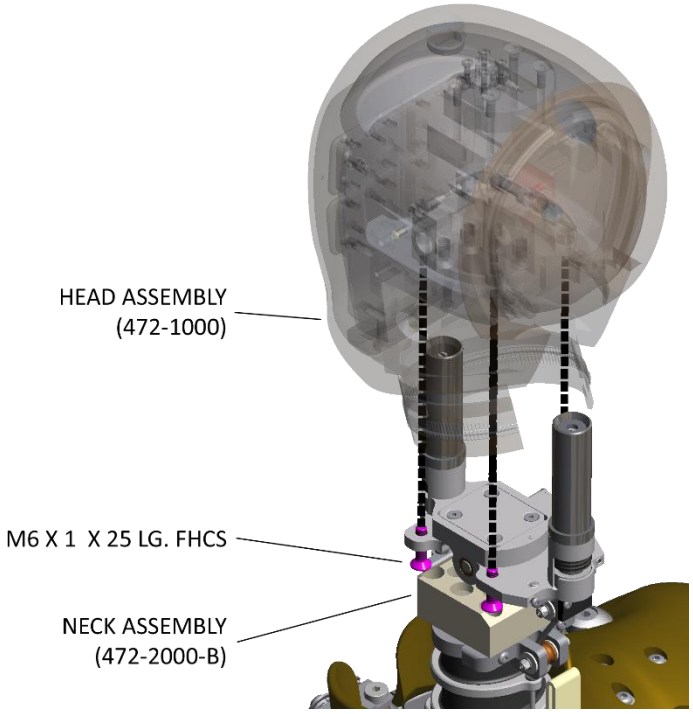

Figure 6.28 Neck Assembly Mounted to Head Assembly

	**NOTE: THE NECK MUST BE ORIENTED SO THAT THE FRONT CABLE AND SPRING ARE POSITIONED TOWARD THE FRONT OF THE DUMMY. REFER TO THE NECK SECTION FOR FURTHER DETAILS.**

6.2.5 **Assembly of the Neck to the Spine**

The following procedure is a step-by-step description used to install the head/neck assembly to the top plate of the neck pitch change mechanism assembly (472-3630). All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Secure the Neck Assembly (472-2000-B) to the Spine Assembly (472-3600) using four M6x14 SHCS.

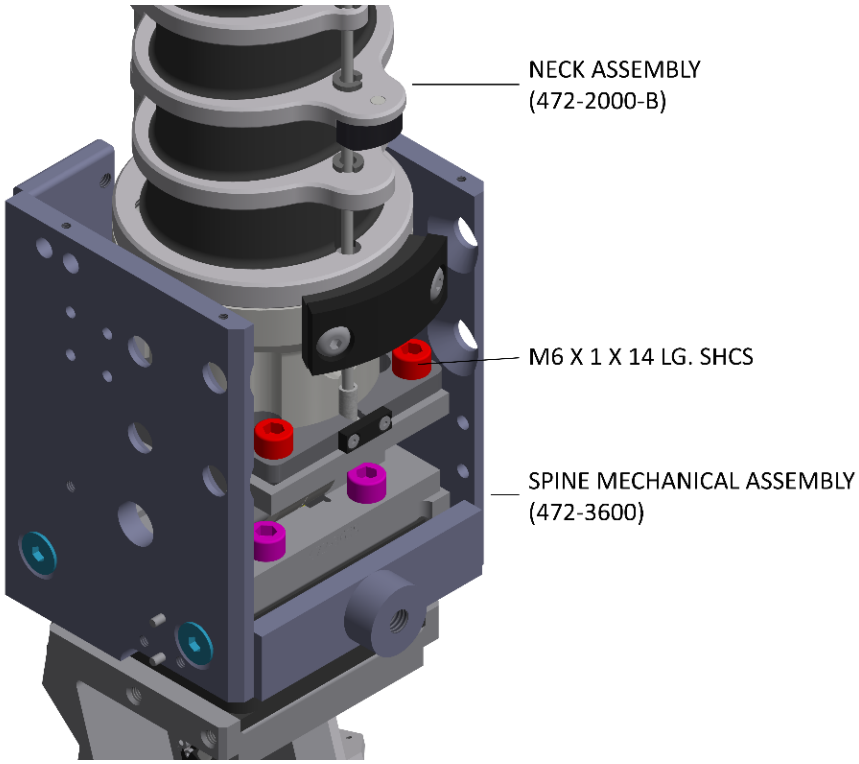

Figure 6.29 Attach the Neck Assembly to the Spine Assembly

2. Place the Neck Foam Assembly (472-2900) around the Neck Assembly and route the Upper Neck Load Cell wires at the back of the neck along the inside of the Neck Skin. The remaining wires from the head and the neck rotary potentiometer are routed outside of the Neck Skin as shown in Figure 6.30. Before securing the Neck Skin in place with Velcro, follow step 7 in Section 7.2.2Assembly of Thorax Components, in order to provide the correct amount of slack in the wires.

6.2.6 Neck Shield Installation Procedure

The user should check the test protocol (for example, US NCAP) if the neck shield or neck skin is needed in a specific test. If the neck skin or neck shield is needed, follow the steps below.

1. Remove head skin (472-1320) and slide Neck Foam Assembly (472-2900) under chin as shown in Figure 6.30.

Figure 6.30 Slide Neck Foam Assembly under Chin

2. Zip the Neck Skin Assembly (472-2901) to the disassembled Head Skin (472-1320) as shown in Figure 6.31.

Figure 6.31 Zip Neck Foam Assembly to Head Skin

3. When reassembling the head skin with Neck Skin Assembly (472-2900 and 472-2901), tuck the Neck Skin Assembly behind the shoulder pads as shown in Figure 6.32.

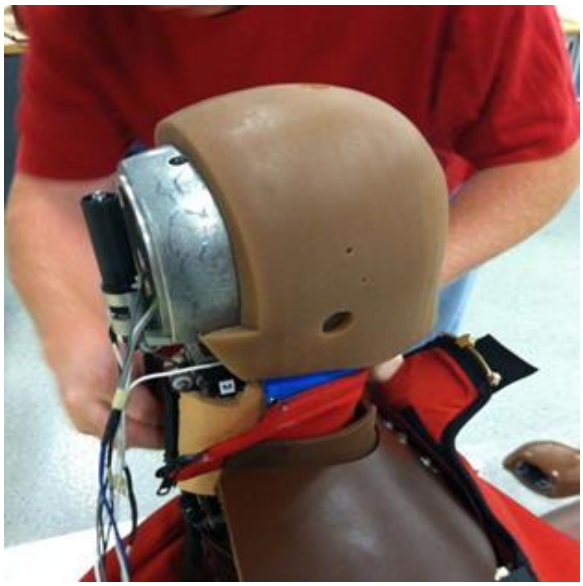

Figure 6.32 Tuck the Neck Skin Assembly Behind Shoulder Pads

4. Push the head skin under the chin and pull back into place. Install the skull cap and close the Neck Skin zipper down. See figure below.

	**NOTE: BEFORE SECURING SKIN IN PLACE WITH VELCRO, FOLLOW STEP 7 IN SECTION 9.2.2, ASSEMBLING THE THORAX COMPONENTS, IN ORDER TO PROVIDE THE CORRECT AMOUNT OF SLACK IN THE WIRES.**

Figure 6.33 Close Neck Skin Zipper Down

6.3 Adjustments for the Neck Assembly

The following adjustments affect the function of the neck assembly but are described in other sections where they fit into the procedures described.

Head Angle Adjustment: This adjustment changes the angle of the head relative to the neck assembly, it describes the procedure for properly adjusting the cable tension on the front and rear neck spring assemblies. This adjustment procedure is described in Section 4.3.1, Head Angle Adjustment.

Neck Pitch Change Mechanism Adjustment: This adjustment changes the angle of the head and neck assemblies relative to the spine at the approximate anthropomorphic landmark defined by the T6/T7 joint. This adjustment procedure is described in Section 10.3.2, Adjustment Procedure for Neck Pitch Change Mechanism.

6.4 Wire Routing and Electrical Connections

Note: Wire routing and strain relief can be completed per the customer's preference, the important aspect is to ensure that there is enough slack in the wires and that they are strain relieved in a location where they will not be damaged. The instructions below describe Humanetics' procedure.

The neck has five primary instruments: front and rear spring load cells, upper neck load cell, lower neck load cell, and the neck rotary potentiometer. The instrument wires from the lower neck load cell are routed through the along the right side of the back of the dummy and secured to the back of the spine using two Rubber Cushioned Steel Loop Straps.

The instrument wires from the upper neck load cell and neck rotary potentiometer are bundled together with the instrumentation wires from the head assembly.

1. Make two bundles: one with the wires from the Head Accelerometers and the Neck Spring Load Cells, the other with the wires from the Head Tilt Sensor, Neck Rotary Potentiometer, and Face Load Cells. Holding each bundle, measure 340mm down along the wire bundle. Centered at this point, wrap the wire bundles with electrical tape to provide enough thickness to allow the spine wire cover to hold it securely in place. This measurement will create the necessary slack in the wires.

2. Clamp each taped portion of the bundles using a Rubber Cushioned Steel Loop Strap and bolt each Loop Strap to the Upper Thoracic Spine Back Plate using M5x6 BHCS. This will clamp the wire bundle in position and provide the proper amount of slack in the cable to prevent damage to the instrumentation.

Additional details are provided in the Thorax and Instrumentation sections.

6.5 Neck Qualification

Qualification procedures for the neck are described in the THOR-50M Qualification Procedures Manual as a separate publication.

6.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgement should be used to determine the frequency of these inspections; however, a thorough inspection is recommended after every twenty tests. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. These inspections include both electrical and mechanical inspections. These inspections are most easily carried out during a disassembly of the dummy. The disassembly of the neck components cab be performed by simply reversing the procedure used during the assembly.

6.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the neck instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

6.6.2 Mechanical Inspection

Several components in the neck assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each of mechanical inspection will be covered in detail below.

General: The following checklist should be used when inspecting the dummy's neck instrumentation for post-test damage:

- ✓ Check the tightness of all instrumentation mounting bolts.

Cables: The following checklist should be used when inspecting the dummy's neck cables for post-test damage:

- ✓ Check the tightness of the neck cable, Section 6.2.2, Assembly of Neck Components, Step 7.
- ✓ Inspect the front, rear, and center cable assemblies for signs of fraying, broken strands, and kinking.

Adjustments: The following checklist should be used when inspecting the dummy's neck adjustments during the post-test inspection:

- ✓ Check the head angle adjustment, including cable tension adjustments, Section 4.3.1, Head Angle Adjustment.

Molded Neck Assembly: The following checklist should be used when inspecting the dummy's neck for post-test damage:

- ✓ Mechanically inspect the neck assembly for signs of debonding between the aluminum disks and the rubber puck, particularly along the rear of the neck.

- ✓ Inspect the front and rear neck soft stop assemblies for signs of debonding or permanent compression.

Section 7. **Thorax Assembly**

7.1 **Description of Thorax Assembly and Features**

The thorax assembly of the THOR-50M dummy is an integrated assembly which includes components from the shoulder, spine, ribcage, and abdomen assemblies. This section of the manual will describe the correct procedure to assemble the entire thorax of the THOR-50M dummy and will bring several subassemblies together. The thorax assembly with abdomen is shown in Figure 7.1.

Figure 7.1 Thorax Assembly

The advanced thorax assembly features extensive instrumentation which is used to measure and record the deflections, forces and accelerations that this region experiences during testing, as shown in Figure 7.2. The deflection of the ribcage is measured at four distinct points. These points are measured using the IR-TRACC's which capture the three-dimensional position time-history of the ribs relative to the appropriate spine segment. The forces on the thorax assembly are measured at the T12 location using a five-axis load cell. (This load cell is considered part of the Spine Assembly, Section 10). An accelerometer tri-pack or equivalent is located on the spine, but near the vertical level of the center of gravity of the thorax to measure the acceleration along the three principle axes. A uniaxial accelerometer is positioned on the sternal plate to measure acceleration at this location. Other instrumentation includes a T1 accel tri-pack, T12 accel tri-pack, Upper abdomen Accel, and four tilt sensors.

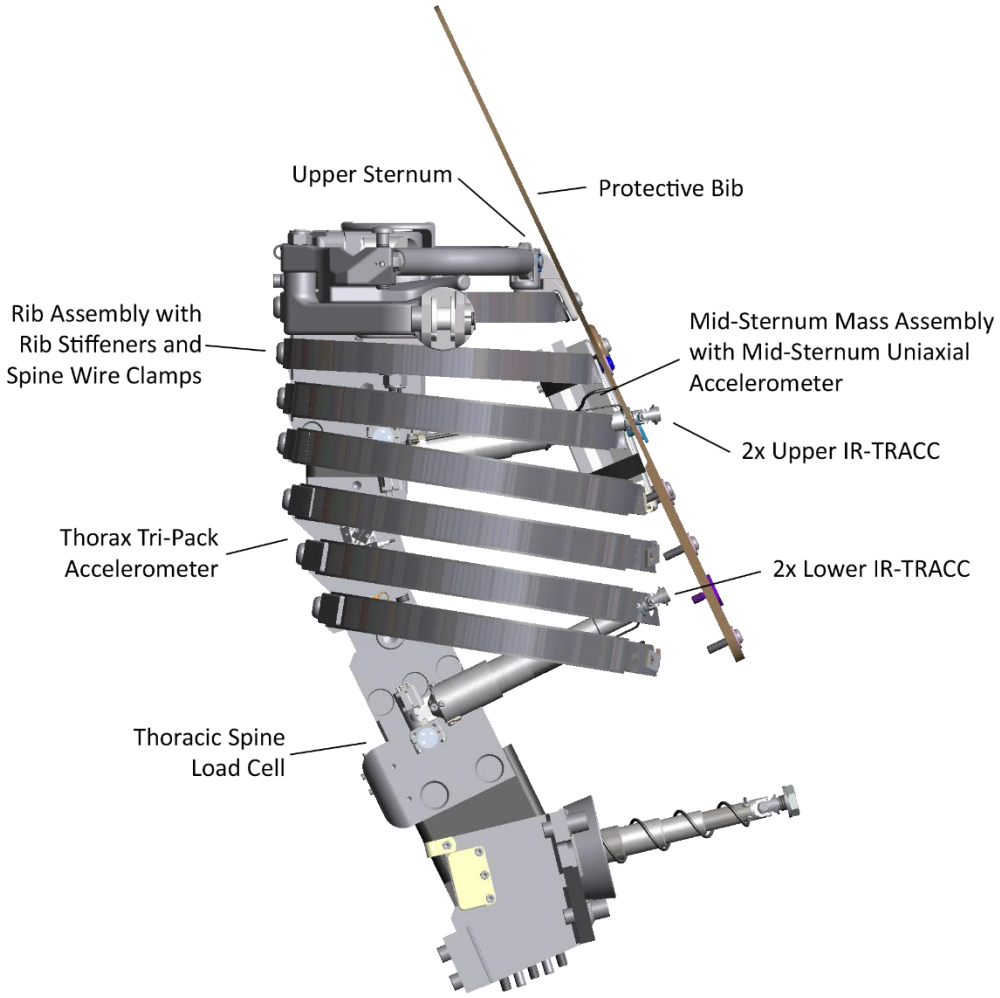

Figure 7.2 Thorax Instrumentation Locations

7.2 Assembly of the Thorax

7.2.1 Parts List

Figure 7.3 shows an exploded assembly of the thorax, 472-3010.

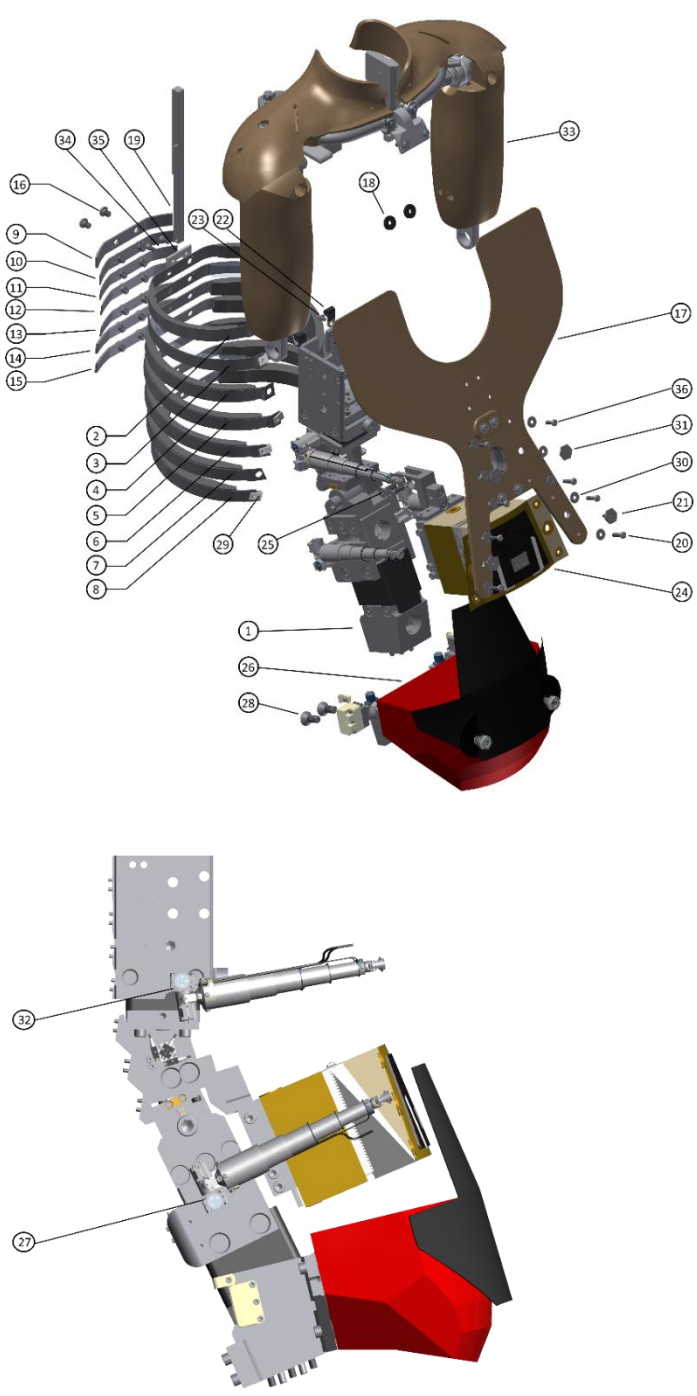

Figure 7.3 Thorax Assembly Exploded View

Table 7-1 Thorax Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-3600	SPINE MECHANICAL ASSEMBLY
2	1	472-3310	THORAX ELLIPTICAL RIB #1 – ASSEMBLY
3	1	472-3320	THORAX ELLIPTICAL RIB #2 - ASSEMBLY
4	1	472-3330	THORAX ELLIPTICAL RIB #3 - ASSEMBLY
5	1	472-3340	THORAX ELLIPTICAL RIB #4 - ASSEMBLY
6	1	472-3350	THORAX ELLIPTICAL RIB #5 - ASSEMBLY
7	1	472-3360	THORAX ELLIPTICAL RIB #6 - ASSEMBLY
8	1	472-3370	THORAX ELLIPTICAL RIB #7 - ASSEMBLY
9	1	472-3510	THORAX ELLIPTICAL RIB STIFFENER #1
10	1	472-3511	THORAX ELLIPTICAL RIB STIFFENER #2
11	1	472-3512	THORAX ELLIPTICAL RIB STIFFENER #3
12	1	472-3513	THORAX ELLIPTICAL RIB STIFFENER #4
13	1	472-3514	THORAX ELLIPTICAL RIB STIFFENER #5
14	1	472-3515	THORAX ELLIPTICAL RIB STIFFENER #6
15	1	472-3516	THORAX ELLIPTICAL RIB STIFFENER #7
16	14	5000454	M8 X 1.25 X 10 LG. BHCS
17	1	472-3400	THORAX BIB ASSEMBLY
18	2	9003743	WASHER, 1/4 X 3/4 X 1/8 REINFORCED RUBBER
19	1	472-3116	THOR LIFT STRAP
20	6	5000210	M5 X 0.8 X 20 LG. BHCS
21	2	472-3530	IRTRACC CONNECTING BOLT, LOWER THORAX
22	2	9003723	1/4 COATED CABLE CLAMP
23	2	5000214	M5 X 0.8 X 6 LG. BHCS
24	1	472-4600	UPPER ABDOMEN ASSEMBLY
25	2	5000117	M8 X 1.25 X 25 LG. FHCS
26	1	472-4700	LOWER ABDOMEN MECHANICAL ASSEMBLY
27	4	5000989	M4 X 0.7 X 8 LG. SHCS
28	2	5001127	M10 X 1.5 X 25 LG. FHCS
29	10	5000513	CLIP NUT, M5
30	10	5001126	M5 FLAT WASHER LARGE OD SS
31	2	472-3518	IRTRACC CONNECTING BOLT, UPPER THORAX
32	4	5000151	M4 X 0.7 X 10 LG. SHCS
33	1	AXSDM000	SD3 SHOULDER AND ARMS ASSEMBLY
34	2	5000291	M5 X 0.8 X 10 LG. SHCS
35	1	472-3115	BRACKET, LIFTING STRAP
36	2	5000416	M5 X 0.8 X 16 LG. BHCS

7.2.2 Assembly of Thorax Components

The following procedure is a step-by-step description of the assembly procedure for all of the thorax components. All bolts should be tightened to the torque specification provided in Section 2.1.3 Bolt Torque Values.

1. The thorax assembly includes: The Shoulder Assembly (AXSDM000), Spine Mechanical Assembly (472-3600), Elliptical Rib Assemblies, the Thorax Bib Assembly (472-3400), the Upper Abdomen Mechanical Assembly (472-4600), and the Lower Abdomen Mechanical Assembly (472-4700).

2. There are four IR-TRACC assemblies in the thorax assembly. Each position in the thorax requires a different assembly.

Table 7-2 IR-TRACC Assemblies for Thorax Assembly

IR-TRACC Position	Part Number
Upper Right	472-3560
Upper Left	472-3550
Lower Right	472-3570
Lower Left	472-3580

3. Assembly of the IR-TRACC is mentioned below. Note: Every time the IR-TRACC assembly is disassembled the Zero position for the two rotary potentiometers must be adjusted. This is detailed in *THOR-50M 3D IR-TRACC User Manual*.

4. To attach each of the Lower Thoracic IR-TRACCs to the Thoracic Spine Load Cell Flex Joint Adaptor Plate Assembly (472-3733-B), use two M4X8 SHCS.

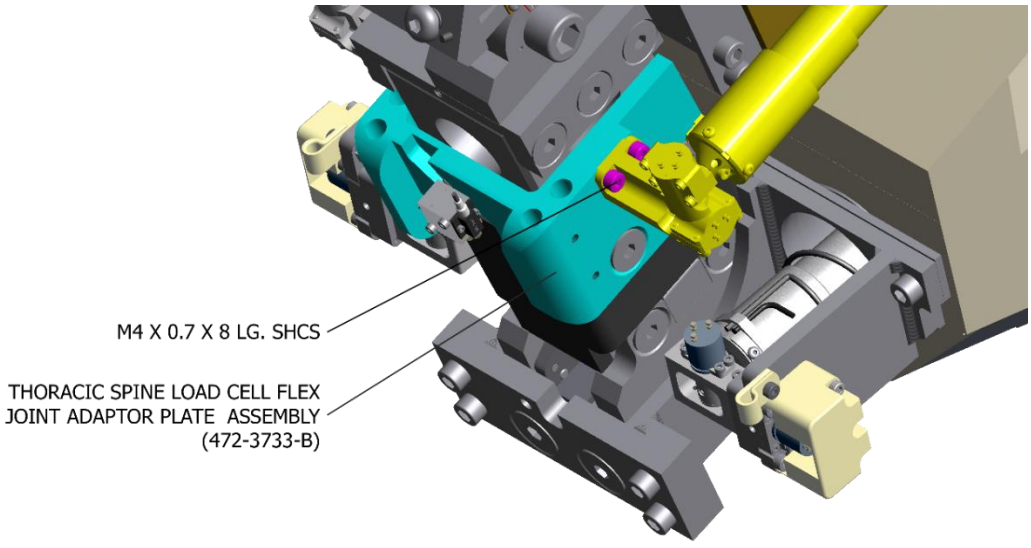

Figure 7.4 Mount Lower Thoracic IR-TRACCs to Thoracic Spine Load Cell Adaptor Plate

5. To attach each of the Upper Thoracic IR-TRACCs to the Upper Thoracic Spine Mechanical Assembly (472-3620-B), use two M4 X 10 SHCS.

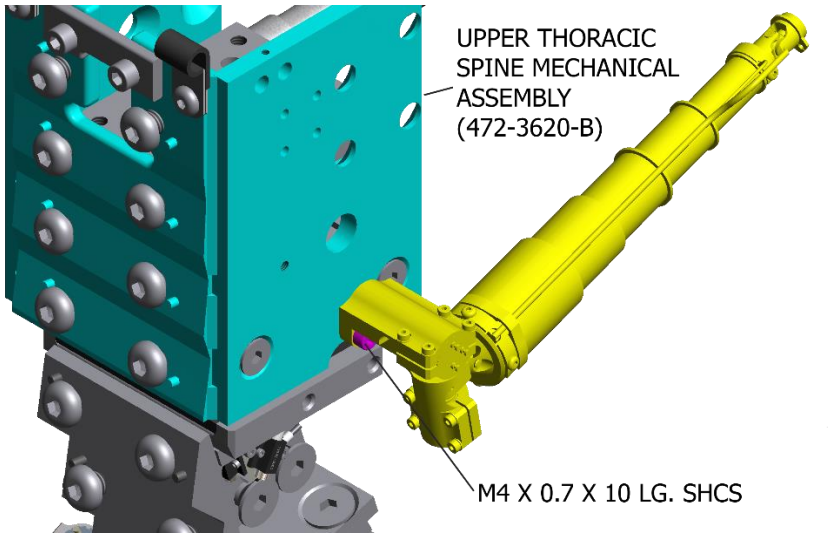

Figure 7.5 Mount Upper Thoracic IR-TRACCs to Upper Spine Mechanical Assembly

6. Install the Upper Abdomen assembly (472-4600) on to the Lower Thoracic Spine Assembly (472-3655) using two M8 X 25 FHCS.

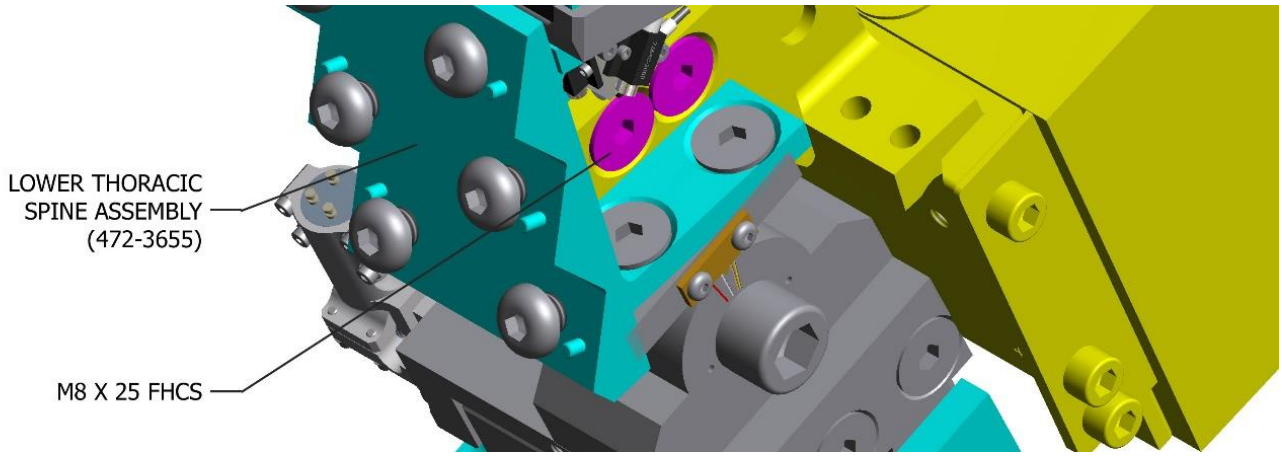

Figure 7.6 Install Upper Abdomen Assembly to Lower Thoracic Spine Assembly

7. The SD3 Shoulder Assembly (AXSDM000) attaches to Rib #1 (472-3310) using two of the M5 x 22 BHCS and M5 (15mm OD) flat washers from step 10. These bolts attach through the Thorax Bib and Rib #1 and are threaded into the Sternum Bracket (AXSDM040). Two more M5 x 22 BHCS and M5 (15mm OD) flat washers are also used, and these attach through the Bib and into the Sternum Bracket (AXSDM040).

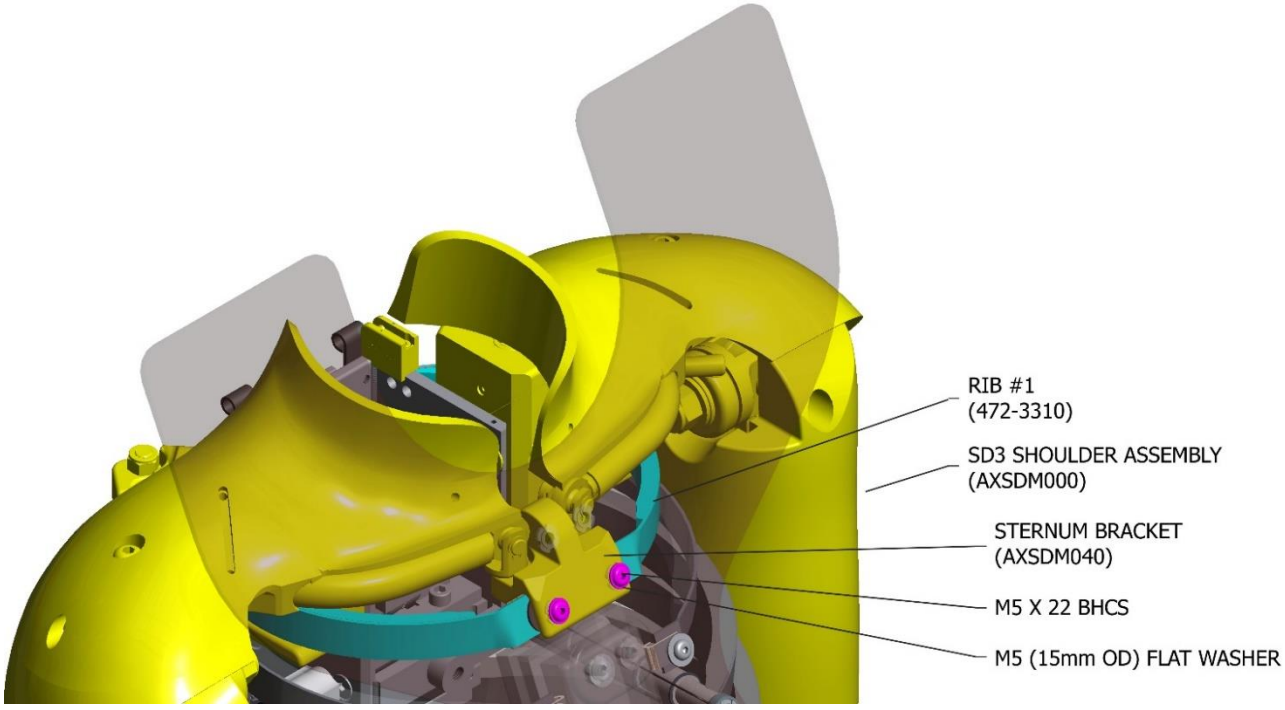

Figure 7.7 Attach the SD3 Shoulder Assembly

8. The Mid-Sternum Mass Assembly (472-3410-A) is attached to the Thorax Bib Assembly (472-3400) using four M5 X 10 BHCS and four M10 (15mm OD) flat washer.

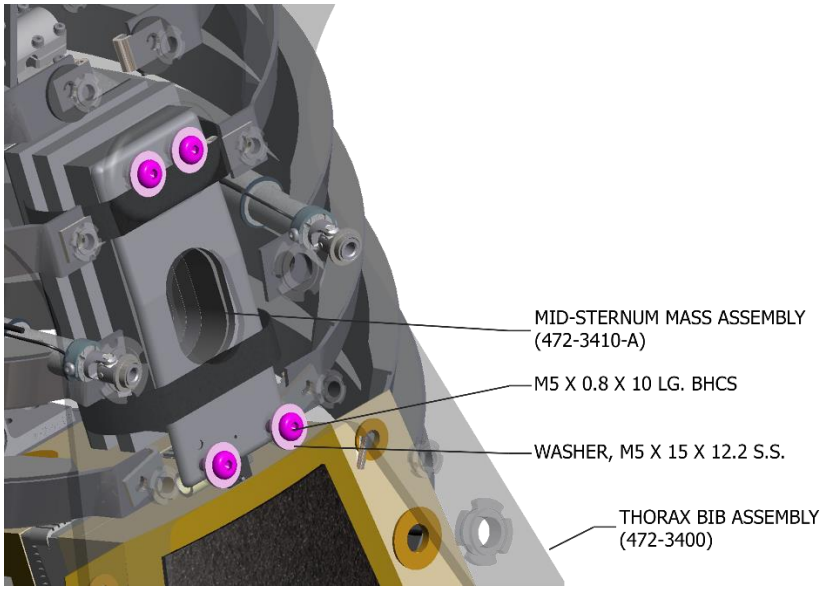

Figure 7.8 Attach the Mid-Sternum Mass Assembly to the Thorax Bib Assembly

9. Attach the individual ribs, numbered 1 through 7 (top to bottom) to the Spine Assembly (472-3600) with their respective Rib Stiffeners (each part is stamped with its respective position number) and two M8 X 10 BHCS per rib assembly. The following table describes which Rib uses which Stiffener and fastener. **Note: For ease in assembly, fully install the Thoracic IR-TRACC ribs (3 and 5) prior to assembling ribs 2, 4, and 6.**

Table 7-3 Rib, Stiffener, and Fastener List for Rib Positions 1-7

Rib Position	Rib Part Number	Stiffener Part Number	Attachment Screw
1	472-3310	472-3510	M8 x 10
2	472-3320	472-3511	M8 x 10
3	472-3330	472-3512	M8 x 10
4	472-3340	472-3513	M8 x 10
5	472-3350	472-3514	M8 x 10
6	472-3360	472-3515	M8 x 10
7	472-3370	472-3516	M8 x 10

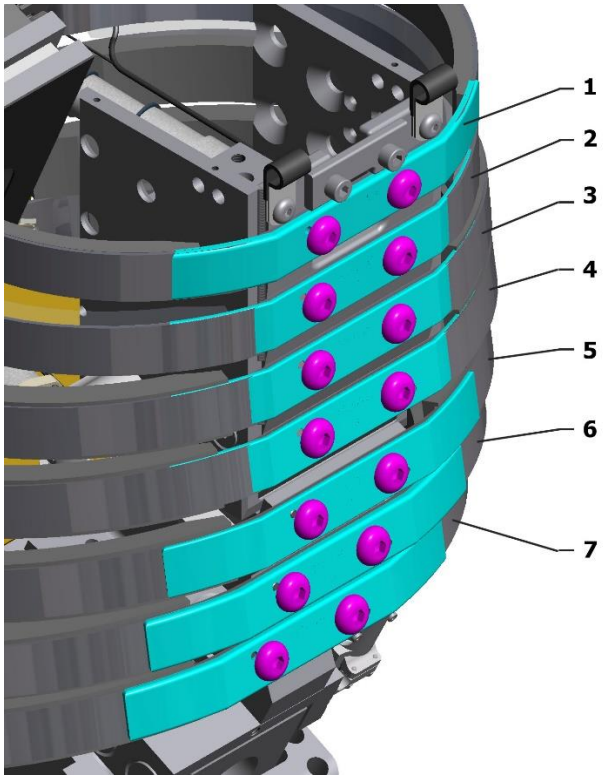

Figure 7.9 Attach the Ribs to the Spine Assembly

10. The Thorax Bib Assembly is attached to the Rib Assemblies using six M5 x 20 BHCS, two M5 x 16 BHCS, and ten M5 (15mm OD) flat washer. The four thoracic IR-TRACCs attach through the ribs No. 3 and 6 and are secured using Rib Connecting Bolts (472-3518 and 472-3530). The two lower thoracic IR-TRACCs connect to the rib No. 6 through the lower abdomen assembly flange.

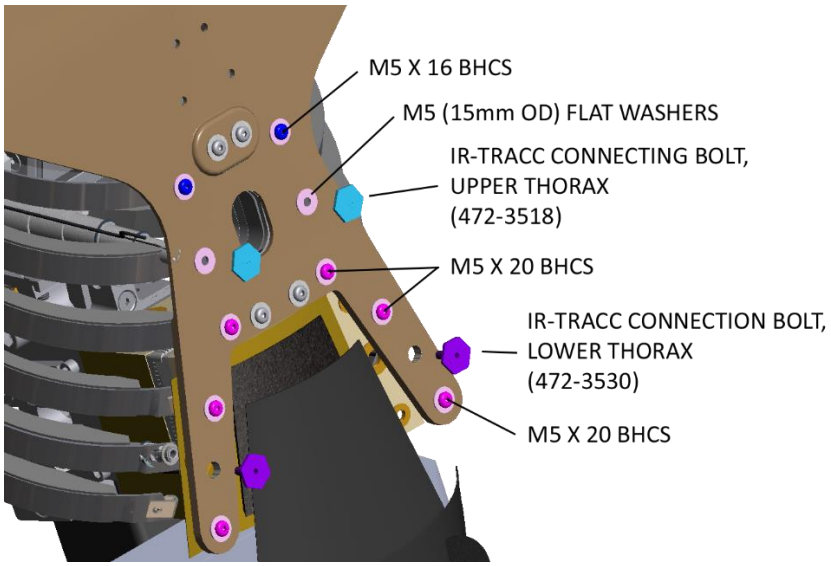

Figure 7.10 Attach the Thorax Bib Assembly to the Rib Assemblies

11. Attach the Lower Abdomen Assembly (472-4700) to the Spine Assembly at the Pelvis/Lumbar Mounting Block (472-3765) using two M10 X 1.5 X 25 mm FHCS through the Rear Attachment Plate (472-4761-A). The Rear Attachment plate is secured to the Lower Abdomen assembly using four M6 X 10 SHCS.

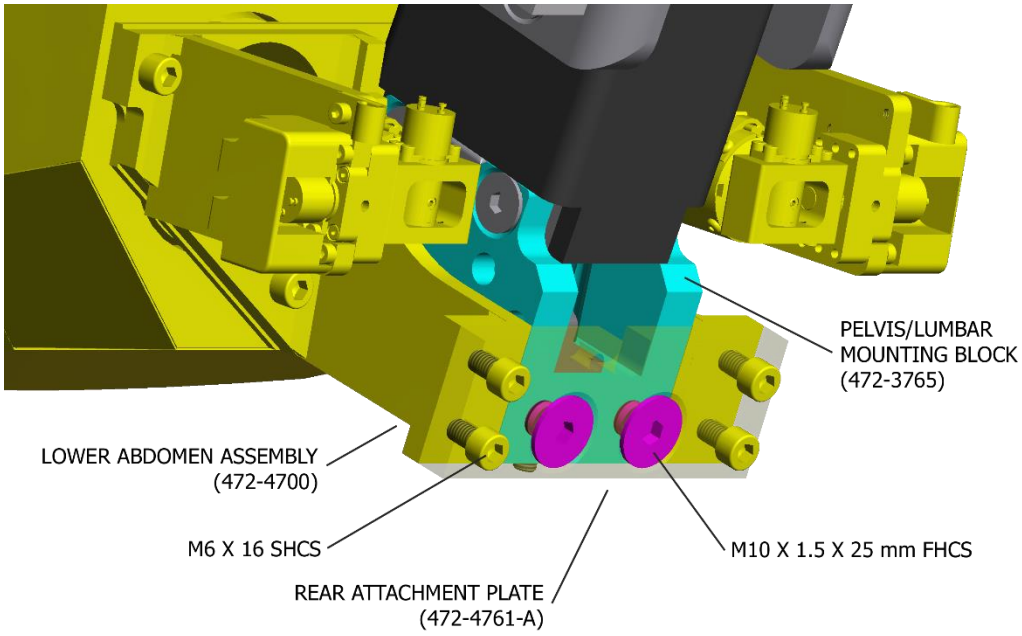

Figure 7.11 Attach the Lower Abdomen Assembly to the Spine Assembly

7.2.3 Assembly of Thorax into THOR-50M

The assembly of the thorax with the neck and pelvis assemblies is described in Section 10, Spine Assembly. The assembly of the thorax with the upper and lower abdomen assemblies is described in Section 11, Upper Abdomen Assembly, and Section 12, Lower Abdomen Assembly.

7.3 Adjustments for the Thorax Assembly

The thorax does not require any adjustments for testing.

7.4 Wire Routing and Electrical Connections

Instructions for wire routing are contained in each corresponding subassembly's section.

7.5 Thorax Qualification

Qualification procedures for the thorax are described in the THOR-50M Qualification Procedures Manual as a separate publication.

7.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgment should be used to determine the frequency of these inspections; however, a thorough inspection is recommended after every twenty tests. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. These inspections include both electrical and mechanical inspections. These inspections are most easily carried out during a disassembly of the dummy. The disassembly of the thorax components can be performed by simply reversing the procedure used during the assembly. Some comments are provided below to assist in the process.

7.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

7.6.2 **Mechanical Inspection**

Several components in the thorax assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below.

Ribs: The following checklist should be used when inspecting the dummy's ribs for post-test damage:

- ✓ Check each end of the damping material for debonding or cracking. This check should involve a visual inspection with the aid of a magnifying lens if possible.
- ✓ Check rib steel for deformation (spine attachment, side and bib attachment.
- ✓ Deformation needs to be checked in the X, Y, and Z directions.
- ✓ Drawings may be used as reference for comparison.
- ✓ Check rib stiffeners for bending.
- ✓ Check damping material for physical damage (top, bottom and interior surface)
- ✓ Check for cuts, nicks, deformation.

Bib: The following checklist should be used when inspecting the dummy's bib for post-test damage:

- ✓ Check all bolt locations for tearing/washer penetration.

Mid-Sternum Plate: The following checklist should be used when inspecting the dummy's mid-sternal plate for post-test damage:

- ✓ Check plate for excessive bending using the drawings as a reference.
- ✓ Check uniaxial accelerometer bolts for tightness and tighten if necessary.

Section 8. SD3 Shoulder and Arm Assembly

8.1 Description of the SD3 Shoulder Assembly and Features

The shoulder assembly for the THOR-50M dummy includes the mechanical components which connect the arms to the spine and thorax assemblies. The shoulder was designed to replicate the geometry and motion of the human shoulder/clavicle complex. A separate human-like clavicle linkage was used to provide a more bio-fidelic interaction between the shoulder assembly and the belt restraint systems. This separate clavicle can load the sternum and ribcage directly to produce a more human like loading condition. A pair of dedicated upper arms was developed, and the dummy jacket was tailored to allow the increased shoulder range of motion unimpeded.

The complete shoulder assembly can be seen in Figure 8.1.

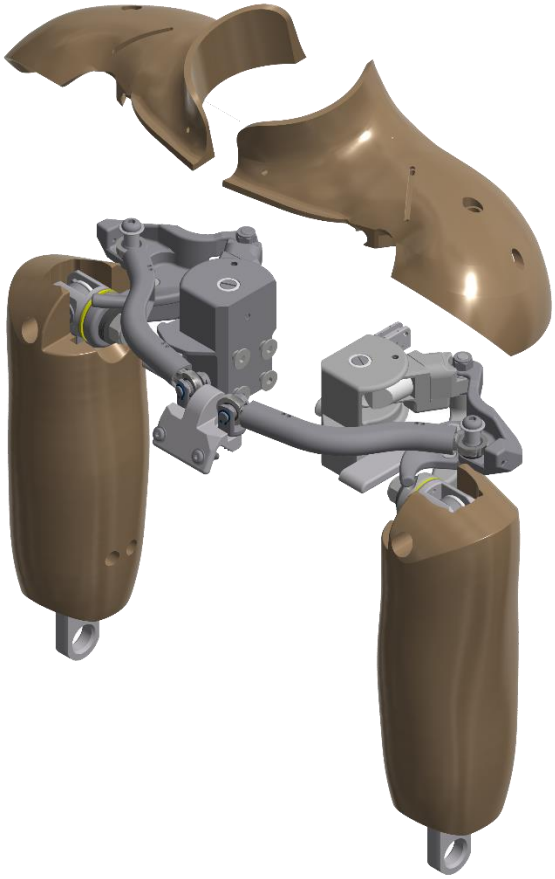

Figure 8.1 Shoulder and Upper Arms Assembly

8.2 Assembly of the Shoulder and Upper Arm

8.2.1 Assembly of Arm Clevis

The exploded view of the Arm Clevis Assembly, AXSDM500 is shown in Figure 8.2. Table 8-1 lists the parts in the Arm Clevis Assembly.

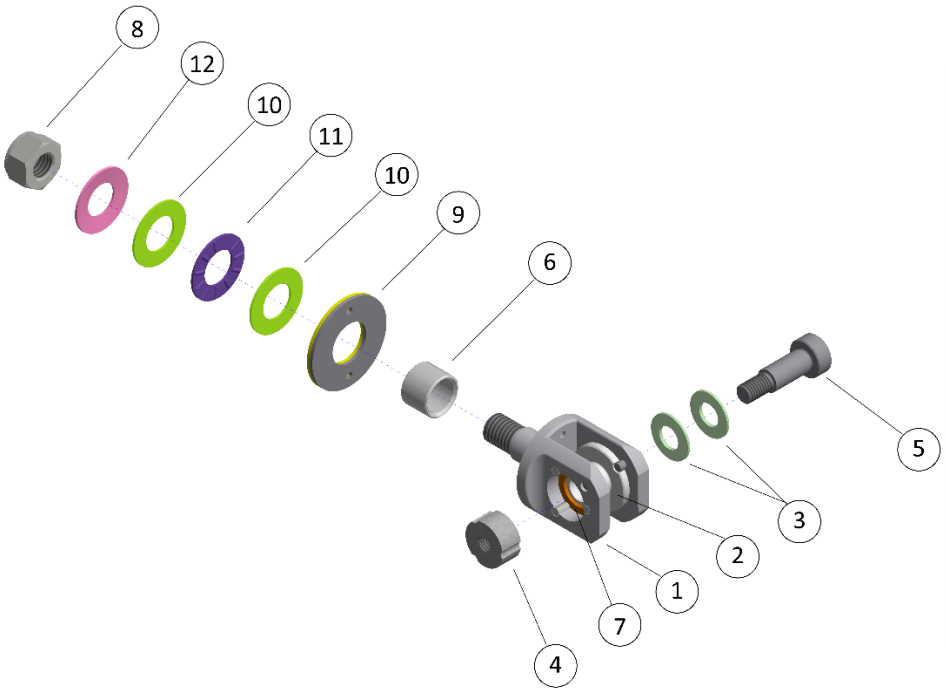

Figure 8.2 Arm Clevis Assembly Exploded View

Table 8-1 Arm Clevis Assembly Parts List

Item	Qty.	Part Number	Description
1	1	AXSDM044	ARM CLEVIS
2	1	AXSDM045	BUSHING UPPER ARM
3	2	5001232	SPRING WASHER, M10
4	1	AXSDM043	NUT, UPPER ARM PIVOT
5	1	5001237	SCREW, SHSS M10 x 20 (M8)
6	1	AXSDM032	BUSH, ARM PIVOT
7	1	AXSDM046	WASHER UPPER ARM
8	1	5000462	M12 X 1.75 HEX LOCK NUT ZINC
9	1	AXSDM027	BRAKE WASHER ASSEMBLY
10	2	5001518	WASHER NEEDLE THRUST 15 X 28 X 1 THK
11	1	5001517	BEARING NEEDLE THRUST 15 X 28 X 2 THK
12	1	5001502	WASHER BELLEVILLE M14 (14.2 X 28 X 1)

Assembly of the left and right arm clevis assemblies is identical, however, there is a difference in assembly orientation of the shoulder bolt. Upon assembly, the M10x20 SHSS hex head should face forward so that it can be easily accessed for friction adjustment (Figure 8.3).

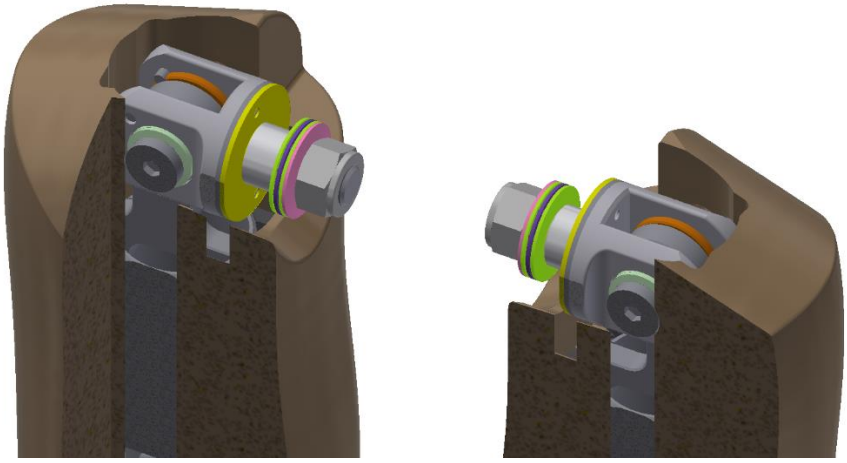

Figure 8.3 Right and Left Upper Arm Seen from the Front of the Dummy (Section View)

1. Orient the M10 Spring Washer with the small diameter touching the screw head; see Figure 8.4.

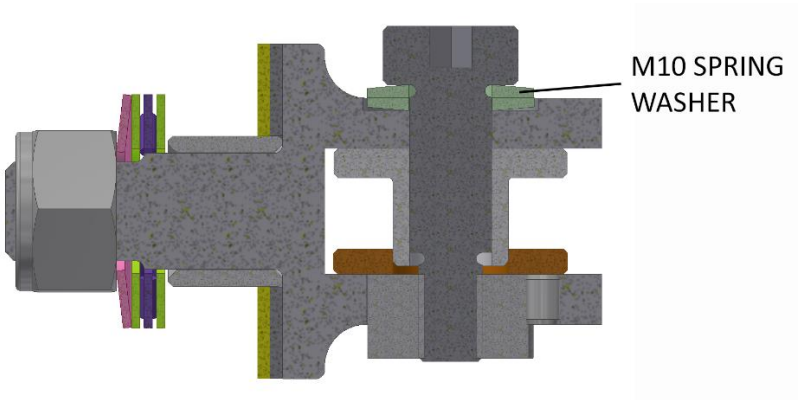

Figure 8.4 Check Protruded Length of the Dowels and Orientation of Spring Washers

2. Place the Upper Arm Bushing (AXSDM045) into the hole of the Upper Arm Washer (AXSDM046), then place into the Arm Clevis (AXSDM044). Align the cut-outs on the Upper Arm Bushing and Upper Arm Washer with the M4x8 dowels on the inside of the clevis.

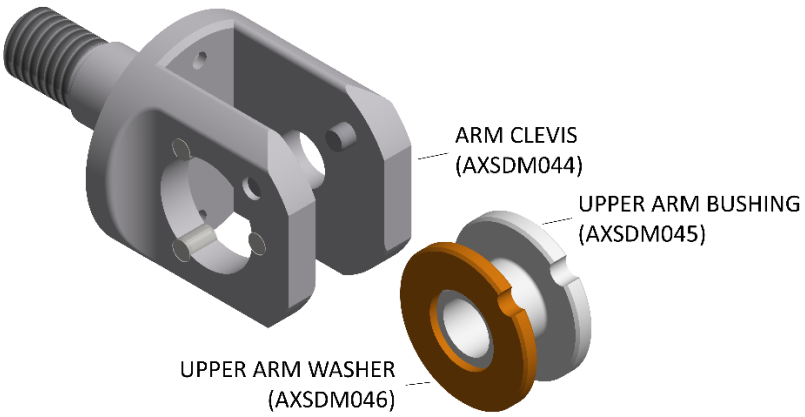

Figure 8.5 Placing the Upper Arm Bushing and Washer

3. To assemble the upper arm, assemble the upper arm onto AXSDM045, then, repeating step 2, ensure that the large hole with three dowel pins faces the rear. Align the Upper Arm Bushing (AXSDM045) and Upper Arm Washers (AXSDM046) with the hole for the M10x20 SHSS and push the shoulder screw and two M10 Spring Washers in. Orient the spring washers with the small diameters facing the arm clevis and the head of the bolt. On the opposite side insert the Upper Arm Pivot Nut (AXSDM043) with the grooves aligned with the M4x6 S.S. dowels and turn the M10x20 SHSS to engage the thread.

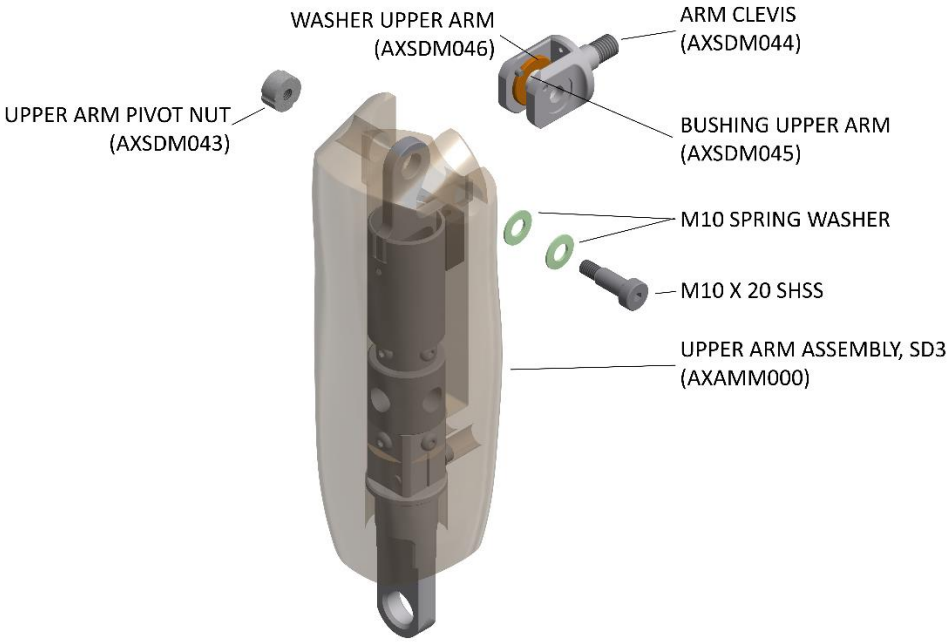

Figure 8.6 Assemble Upper Arm to Clevis

4. Place the Bush, Arm Pivot (AXSDM032) and the Brake Washer Assembly (AXSDM027) on the arm clevis stub as shown. Insert the clevis into the arm link, then place the Washer Needle Thrust, Bearing Needle Thrust, Washer Belleville M14, and M12 lock nut onto the clevis. Orient the Brake Washer Assembly with the steel surface contacting the Arm Clevis. Replace the lock nut if the locking function is worn out.

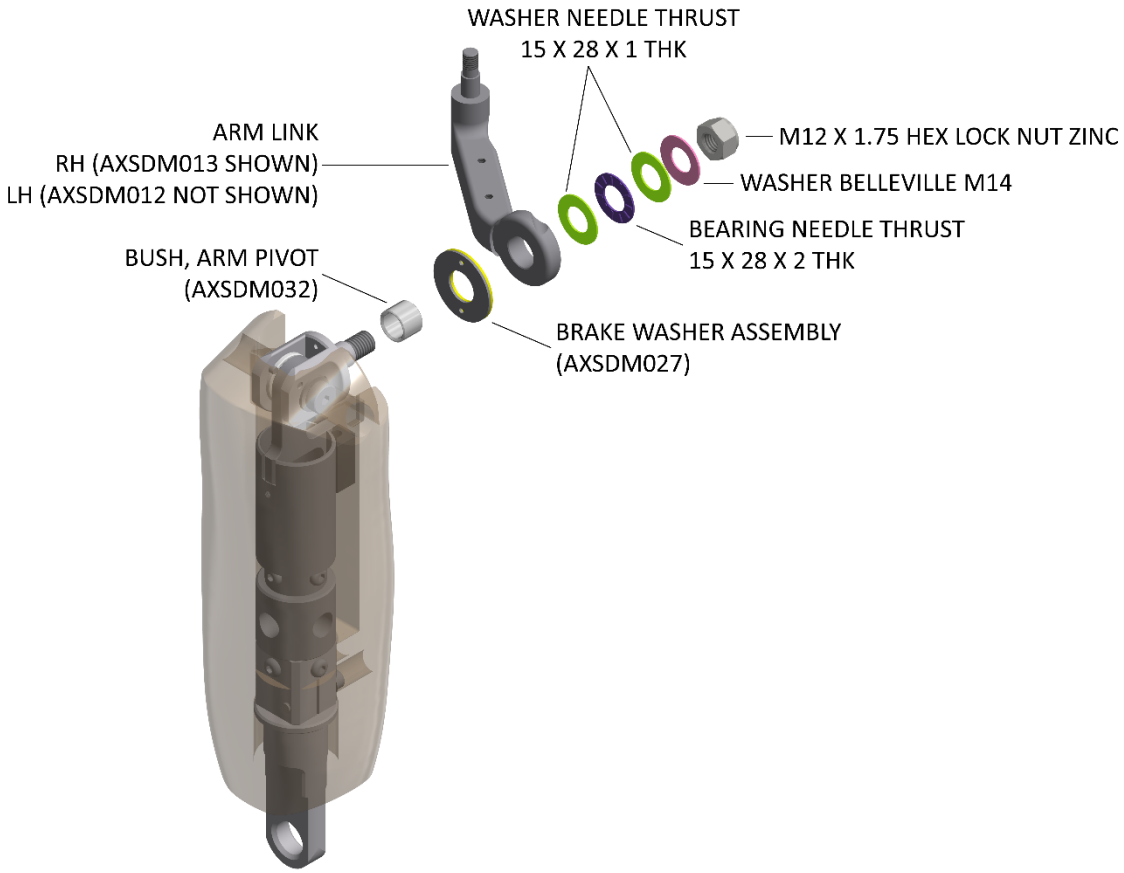

Figure 8.7 Placing Arm Pivot Bushing, Washers, and Nut on the Clevis

8.2.2 **Upper Arm Assembly, SD3**

The exploded view is shown below and the parts list of the Upper Arm Assembly, AXAMM000, is listed in Table 8-2.

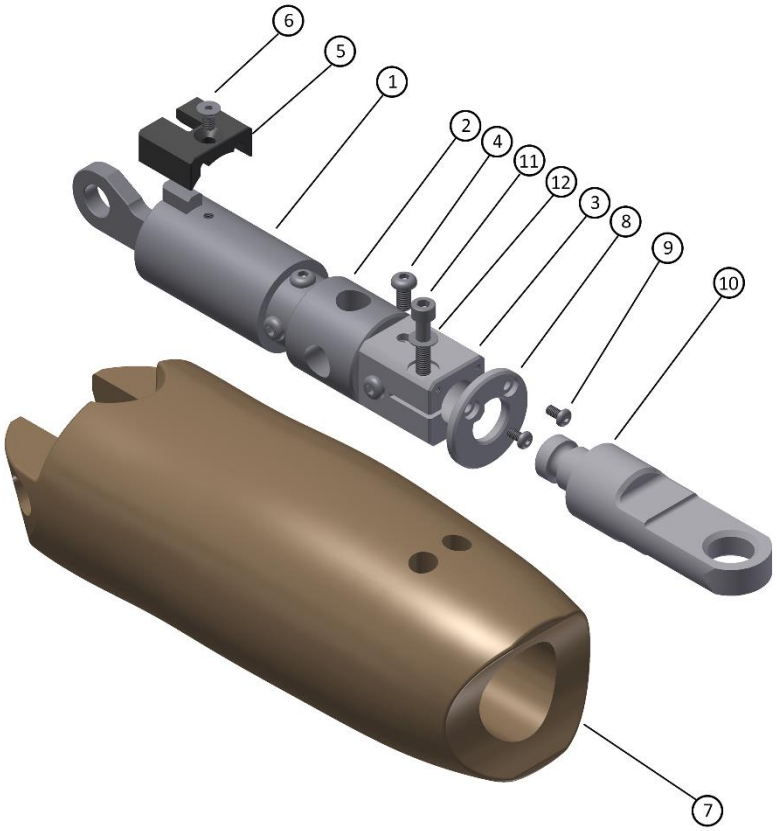

Figure 8.8 Upper Arm Assembly, SD3 Exploded View

Table 8-2 Upper Arm Assembly, SD3 Parts List

Item	Qty.	Part Number	Description
1	1	AXAMM010	UPPER HUMERUS ASSEMBLY
2	1	W50-61041	STRUCTURAL REPLACEMENT, UNIVERSAL ARM LOAD CELL
3	1	AXAMM001	LOADCELL INTERFACE LOWER
4	8	5000356	M6 X 1 X 12 LG. BHCS
5	1	AXAMM005	ARM FLESH SPACER
6	1	5000084	M5 X 0.8 X 10 LG. FHCS
7	1	AXAMM004	UPPER ARM FLESH
8	1	AXAMM002	END PLATE, ARM
9	2	5000103	M4 X 0.7 X 8 LG. BHCS
10	1	AXAMM003	UPPER ARM LOWER SECTION
11	1	AXAMM014	M6 SHCS S.S. MODIFIED
12	1	5001228	SPRING WASHER, M6

1. Install the Upper Humerus Assembly (AXAAM010) and the Load Cell Interface Lower (AXAMM001) to the Load Cell (or structural replacement) using eight M6x12 BHCS.

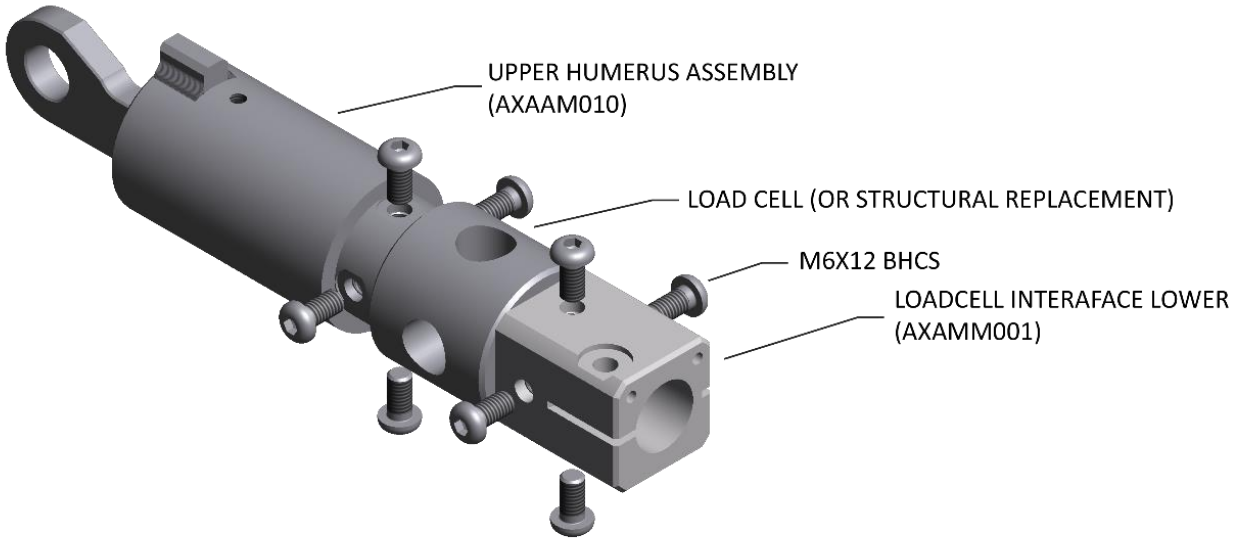

Figure 8.9 Install Upper Humerus Asm., L.C. S.R., and L.C. Interface Lower

2. Install the Arm Flesh Spacer (AXAAM005) to the Upper Humerus Assemby using an M5x10 FHCS. Place this assembly into the Upper Arm Flesh (AXAMM004).

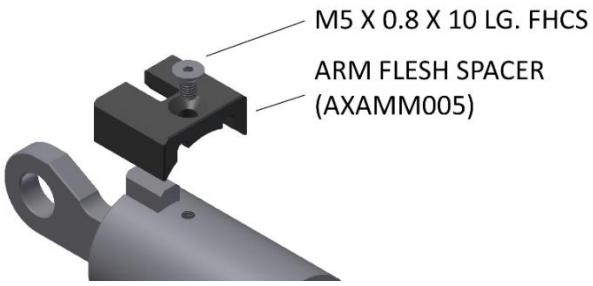

Figure 8.10 Installing Arm Flesh Spacer

3. Install the End Plate (AXAMM002) to the Load Cell Interface Lower using two M4x8 BHCS. **Note: Ensure that the length of these bolts are correct; if they are too long, they will cause assembly issues.**

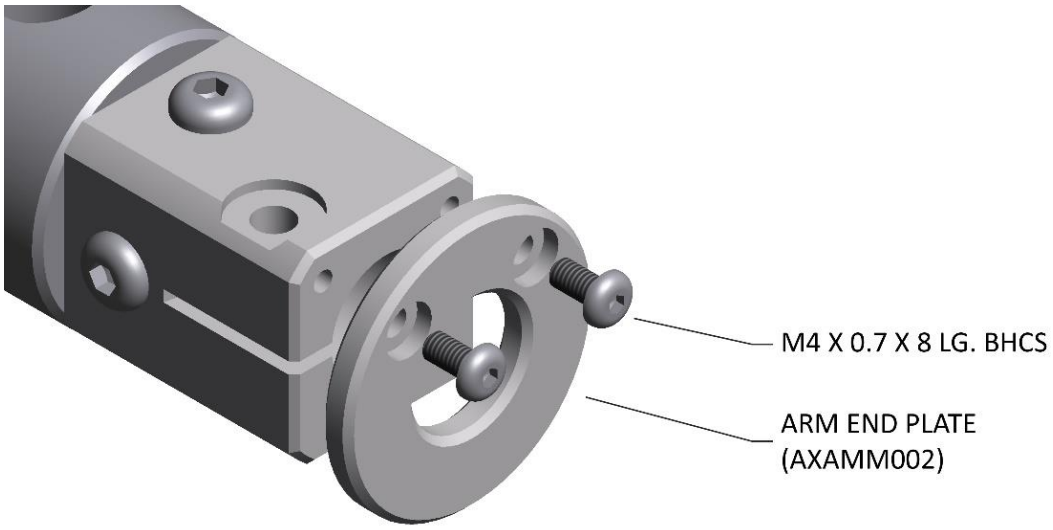

Figure 8.11 Installing Arm End Plate

4. Insert the Upper Arm Lower Section (AXAMM003) into the Load Cell Interface Lower, then, placing the spring washer with the small diameter facing the head of the Modified M6 SHCS (AXAMM014), install the bolt into the Load Cell Interface Lower through the hole in the flesh, locking the Upper Arm Lower Section into place.

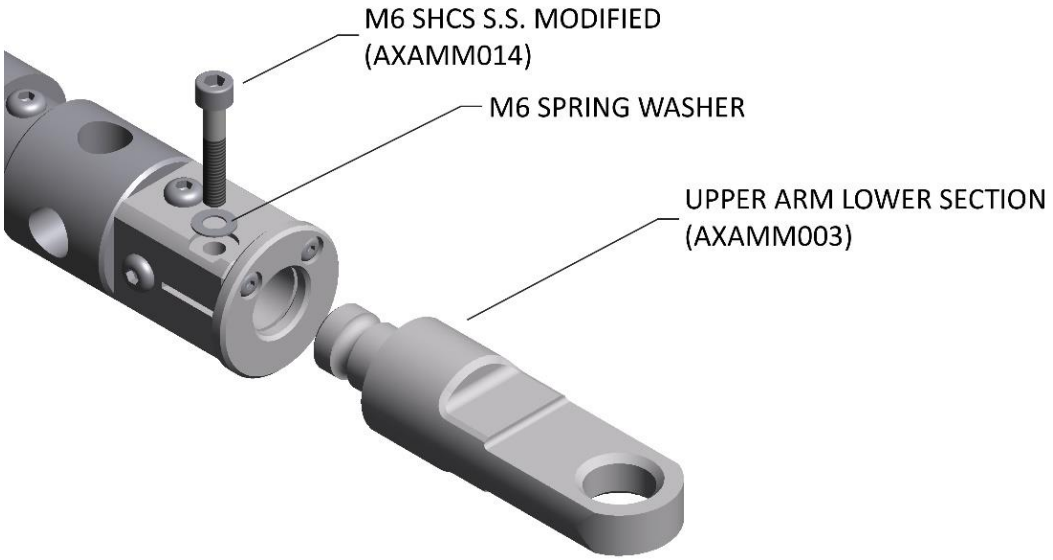

Figure 8.12 Installing Upper Arm Lower Section

8.2.3 **Clavicle Assembly**

The parts list for the left- and right-hand Clavicle Assembly, AXSDM100/AXSDM200 is shown in

Table 8-3. Figure 8.13 shows the left-hand Clavicle. Figure 8.14 shows the right-hand Clavicle.

Disassembly and assembly of the Clavicles is considered an expert operation. It should not be necessary as part of day to day service or maintenance of the SD3 shoulder. In the event that repair, or maintenance is necessary, it is recommended to have this serviced by Humanetics.

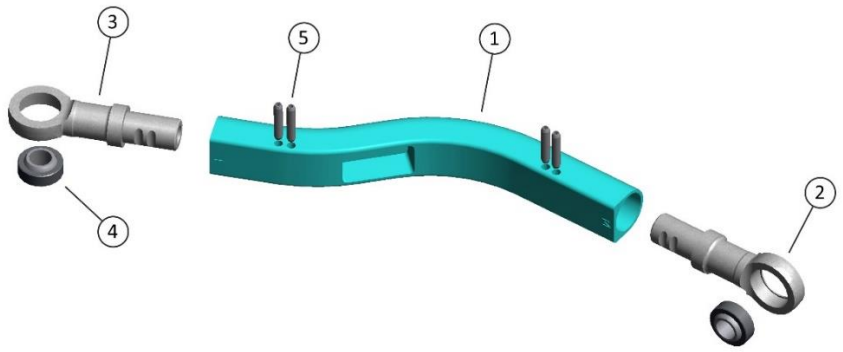

Figure 8.13 Left Hand Clavicle Assembly

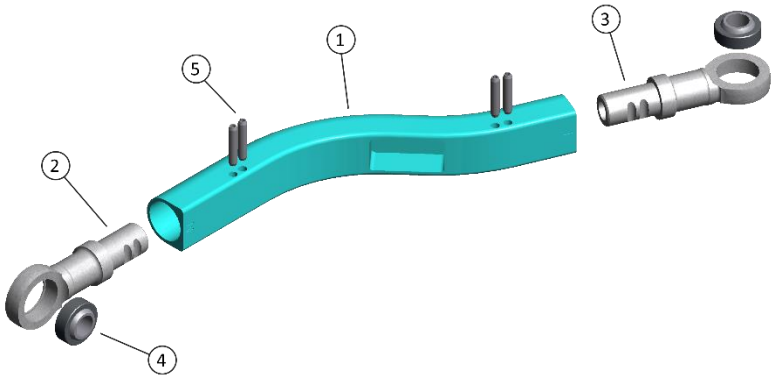

Figure 8.14 Right Hand Clavicle Assembly

Table 8-3 Left- and Right-Hand Clavicle Assembly Parts List

Item	Qty.	Part Number	Description
1	1	AXSDM101	CLAVICLE BONE STRUCTURAL REPLACEMENT
2	1	AXSDM104	MEDIAL SENSOR STRUCTRUAL REPLACEMENT
3	1	AXSDM103	LATERAL STRUCTURAL REPLACEMENT
4	2	5000946	METRIC SPHERICAL BEARING
5	4	9002330	1/8 X 5/8 LG. ROLL PIN

The right hand and left-hand Clavicles look very similar. The difference between left and right is in the orientation of the Lateral Structural Replacements (AXSDM103). The counter bore for the spherical bearing has a small recess on one side. The recess should be facing up when assembling the Clavicle on the dummy, See Figure 8.15.

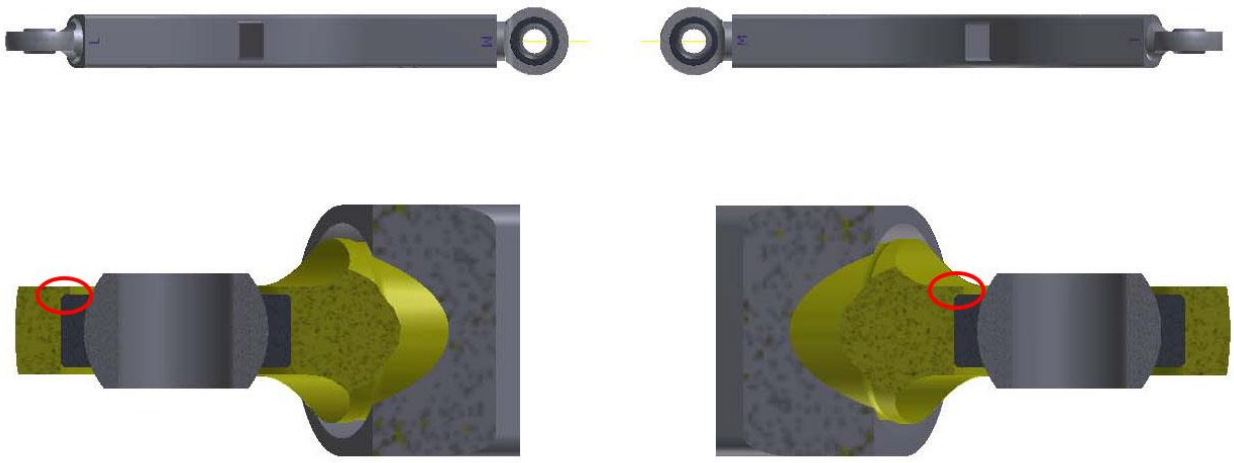

Figure 8.15 Detail of Left & Right Lateral S.R. (thru spherical bearing) seen from inside dummy

8.2.4 **SD3 Shoulder Assembly**

Table 8-4 lists the parts required for the top level SD3 THOR-50M Shoulder and Arms Assembly, AXSDM000.

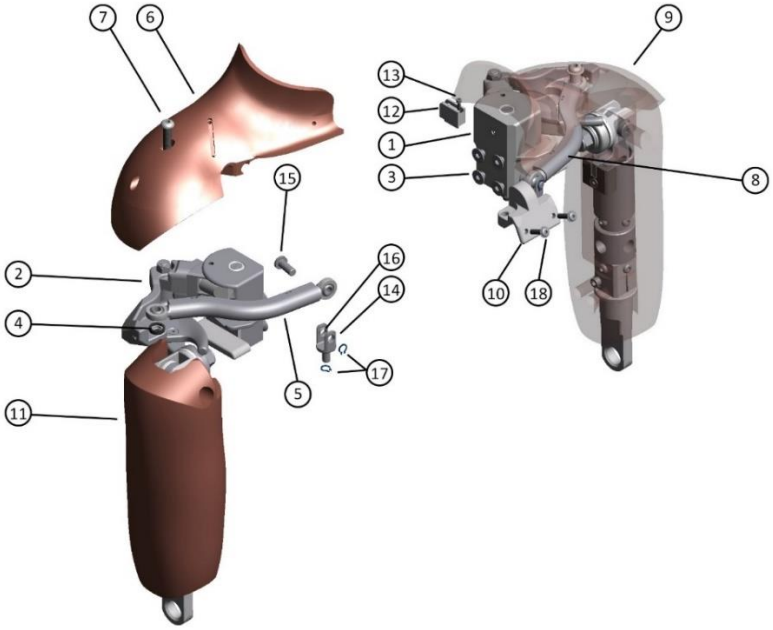

Figure 8.16 SD3 Shoulder and Arms Assembly Exploded View

Table 8-4 SD3 Shoulder and Arms Assembly Parts List

Item	Qty.	Part Number	Description
1	1	AXSDM300	SD3 LEFT SHOULDER ASSEMBLY
2	1	AXSDM400	SD3 RIGHT SHOULDER ASSEMBLY
3	8	5001090	M8 X 1.25 X 12 LG. FHCS
4	2	AXSDM038	ROD END SPACER ASSEMBLY
5	1	AXSDM200	RIGHT CLAVICLE STRUCTURAL REPLACEMENT, ASSEMBLY
6	1	AXSDM036	SHOULDER COVER, MOLDED RH
7	2	5000767	M8 X 1.25 X 35 L.G. BHCS
8	1	AXSDM100	LEFT CLAVICLE ASSEMBLY
9	1	AXSDM035	SHOULDER COVER, MOLDED LH
10	1	AXSDM040	STERNUM BRACKET
11	2	AXAMM000	UPPER ARM ASSEMBLY, SD3
12	1	AXSDM053-B	ACCEL MOUNT SHOULDER
13	1	5000437	M3 X 0.5 X 16 LG. SHCS
14	2	10933	MEDIAL CLEVIS
15	2	10934	MEDIAL CLEIVS PIN
16	4	10938	CLEVIS SPACER
17	4	5001250	SNAP RING, 8mm SHAFT
18	2	5000639	SCREW, BHCS FLANGE M5 X 20
19	4	6002121	CABLE TIE, 3.5 x 280 (NOT SHOWN)

8.2.4.1 LH and RH Shoulder Assemblies

1. To install the left and right SD3 Shoulder Assemblies (AXSDM300, AXSDM400) you need to access the M8x12 FHCS screws on the inside of the upper spine. In order to reach these, the Neck Assembly must be removed which is fixed at the bottom of the lower neck load cell (or structural replacement) with four M6 screws (refer to section 6.2.5, Assembly of the Neck to the Spine for full details). You would also need to remove rib one to prevent damage to the rib. Bolt the shoulder to the spine using four M8x12 FHCS on each side.

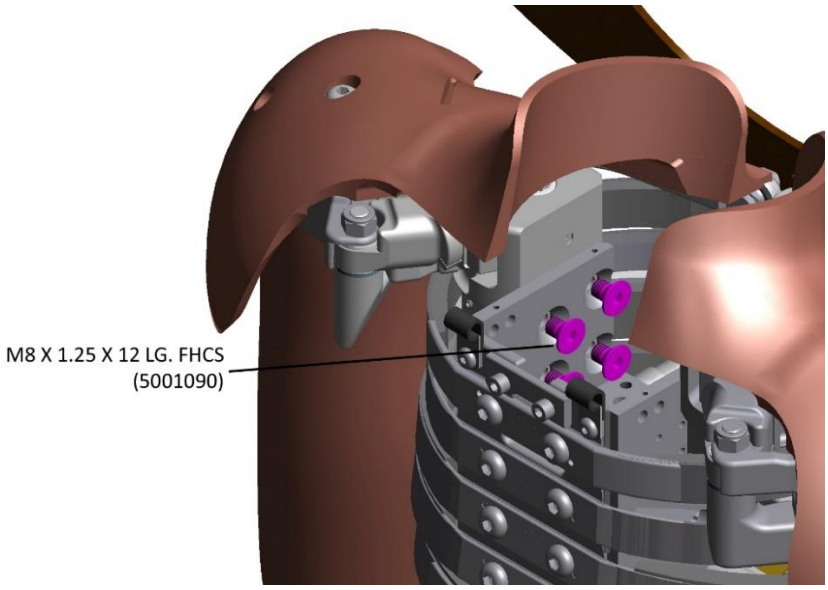

Figure 8.17 Bolt Shoulder to Spine Using M8x12 FHCS

2. The T1 Accelerometer Mount (AXSDM053-B) is mounted at the left rear top of the spine by one M3x16 SHCS. It must be mounted to the spine using that bolt before the z-axis accelerometer can be installed on the mount. Assemble the part as shown in Figure 8.18 with the large fillet to the rear of the dummy.

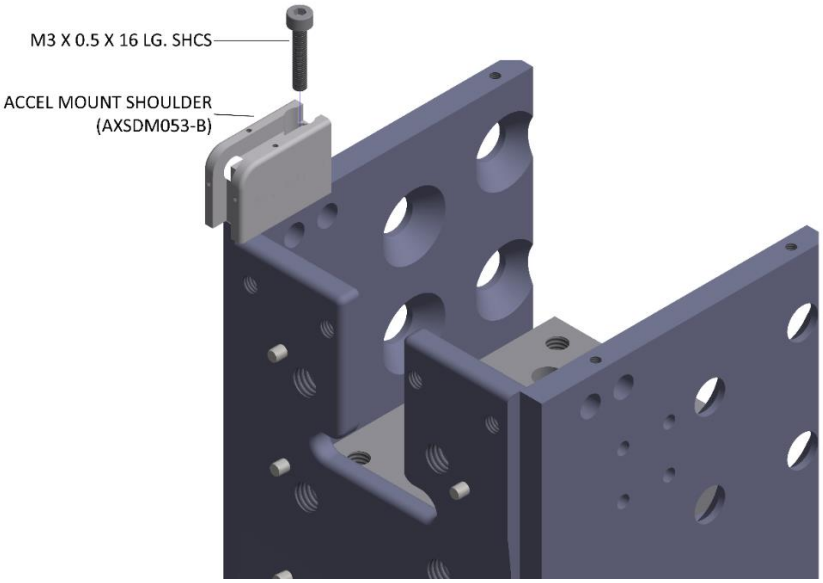

Figure 8.18 Mounting Accel Mount Shoulder

8.2.4.2 Sternum and Clavicles

1. The assembly of the left and right clavicle to the sternum follows the same steps for both sides. Place medial side of clavicle (labeled with an M) into the Medial Clevis (10933) and place a Clevis Spacer (10938) on each side of the load cell. Install the Medial Clevis Pin (10934) through all four parts with the head of the pin facing the rear.

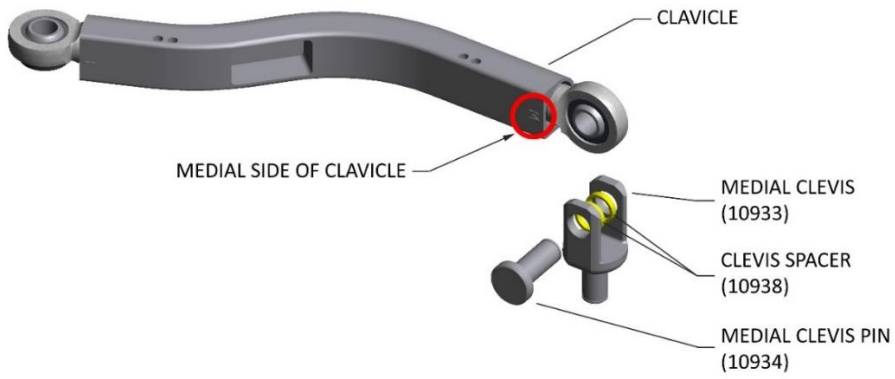

Figure 8.19 Placing the Medial Clevis on Clavicle

2. Place the Snap Ring onto the end of the Medial Clevis Pin to hold the assembly together. Insert this into the left or right side of the Sternum Bracket (AXSDM040) depending on which Clavicle is being installed. Once the Medial Clevis is installed, place a snap ring on the end to keep the clevis assembly attached to the bracket (Figure 8.20). If snap rings do not tightly fit in grooves, discard them and use new ones.

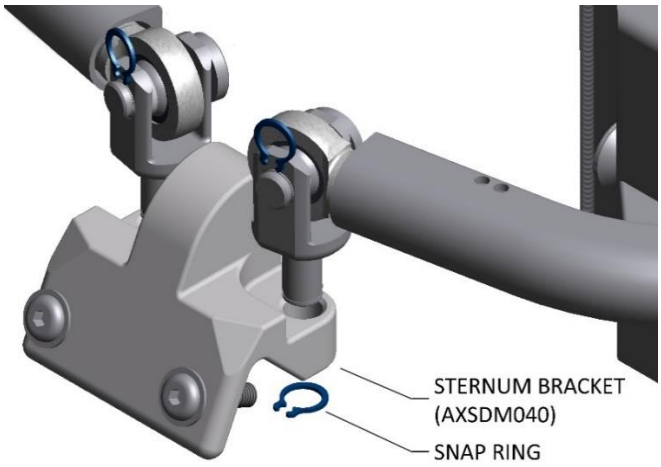

Figure 8.20 Place the Snap Rings

8.2.4.3 Shoulder Covers

Assemble the shoulder covers in the following order:

1. Put the Rod End Spacer (AXSDM038) on the scapula in line with the threaded hole, manipulate the scapula to align its hole with the Clavicle Lateral rod end (marked ‘L’) and push in and tighten the M8 X 35 BHCS.

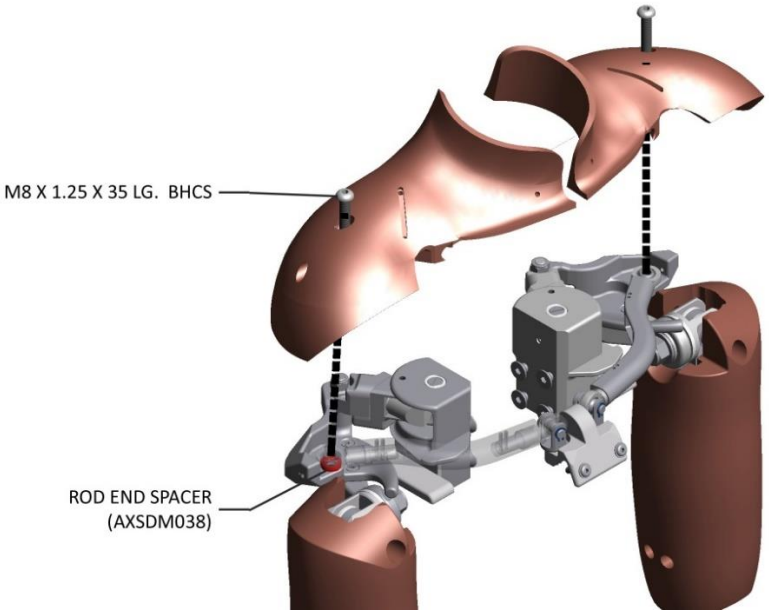

Figure 8.21 Put Rod End Spacer on Scapular and tighten with M8x35 BHCS

2. Place the LH or RH Shoulder Cover (AXSDM036 and AXSDM035) over the clavicle and feed the cable ties through the holes in the shoulder cover, loop them around the clavicle and mind that the thick section of the tie is on the underside of the cover. Make sure to push the tie inside the groove below the top surface of the shoulder cover.

3. The Shoulder Covers are tied down with two cable ties each.

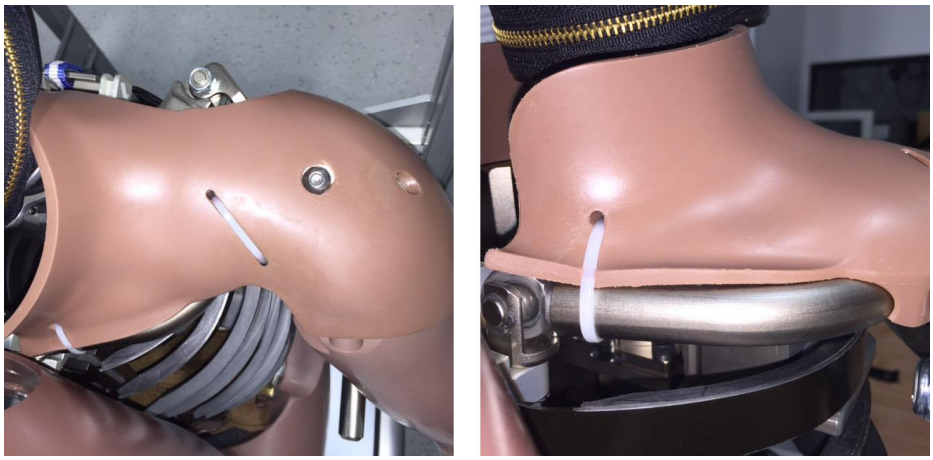

Figure 8.22 Shoulders tied down with cable ties

8.2.4.4 Shoulder Spring Assembly

Disassembly and assembly of the spring box and shaft requires special tools and is considered an expert operation. It should not be necessary as part of day to day service or maintenance. In case repair or maintenance is necessary it is recommended to have this done by Humanetics.

The only operation to be done by the users is the replacement of the buffers. Mount the left- or right-hand Lower Buffer (AXSDM026, AXSDM025) with an M3 X 8 FHCS. Mount Lower Buffer by means of cyano-acrylate super glue (it is recommended to wear gloves for this step). Before gluing, clean the surfaces with a solvent. If necessary, carefully remove old glue residue with fine sandpaper. On the Rearward Buffer (AXSDM017) apply only a small amount of glue such that the bond can be broken at a later occasion. After bonding wipe off excessive glue with cloth. These instructions apply to both Right Hand and Left-Hand Assemblies.

8.2.4.4.1 Left- and Right-Hand Shoulder Spring Assembly

Table 8-5 lists the parts required for the Left and Right Hand Shoulder Spring Assembly, AXSDM700/AXSDM800, which is illustrated in Figure 8.23**.**

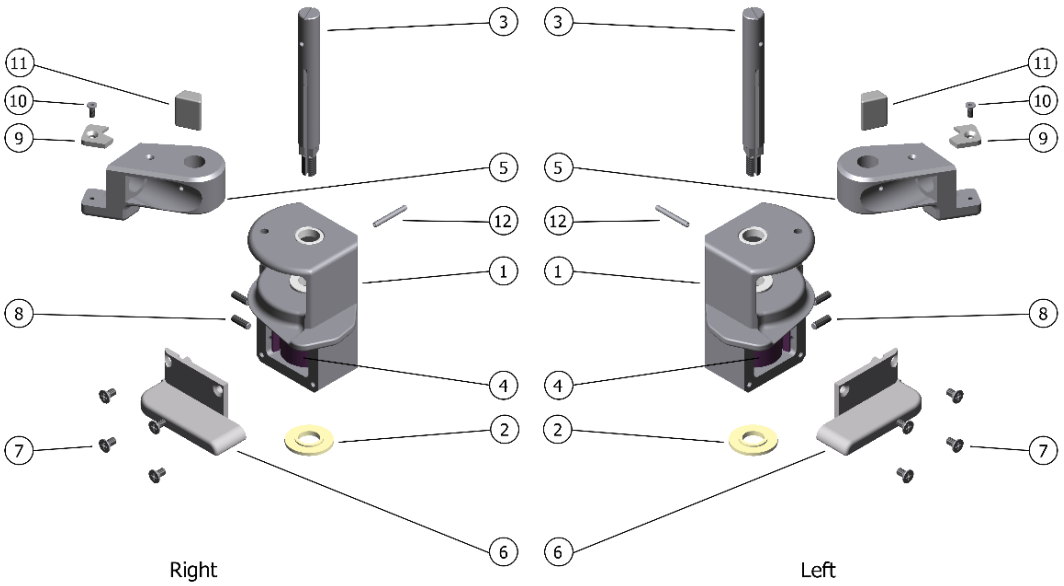

Figure 8.23 Left- and Right-Hand Shoulder Spring Assembly

Table 8-5 Left- and Right-Hand Shoulder Spring Assembly Parts List

Item	Qty.	Part Number	Description
1	1	AXSDM060	SPRING HOUSING COVER ASSY, LH
1	1	AXSDM070	SPRING HOUSING COVER ASSY, RH
2	1	AXSDM005	WASHER LOWER SPRING HOUSING
3	1	AXSDM001	SPRING SHAFT
4	1	AXSDM018	SPRING, SHOULDER
5	1	AXSDM006	SHOULDER SUPPORT LH
5	1	AXSDM007	SHOULDER SUPPORT RH
6	1	AXSDM014	RIB GUIDE LOWER LH
6	1	AXSDM015	RIB GUIDE LOWER RH
7	4	5000699	M4 X 0.7 X 8 LG. FHMSP ZINC
8	2	5001229	SCREW, FPSS M4 X 12
9	1	AXSDM025	BUFFER LOWER, LEFT
9	1	AXSDM026	BUFFER LOWER, RIGHT
10	1	5000116	M3 X 0.5 X 8 LG. FHCS
11	1	AXSDM017	LINK 1 ROM REARWARD BUFFER
12	1	5000140	M3 X 24 LG. ROLL PIN

8.2.5 **Assembly of Shoulder Pivot**

While the Shoulder Pivot Assembly is disassembled from the dummy, the free position of the shoulder can be checked. Unscrew the M8 X 1.25 Lock Nut until the Friction Washer (AXSDM004) and Spring Washer are loose. The edge of the Shoulder Support Arm should match the alignment mark on the rear of the Spring Housing, see Figure 8.24.

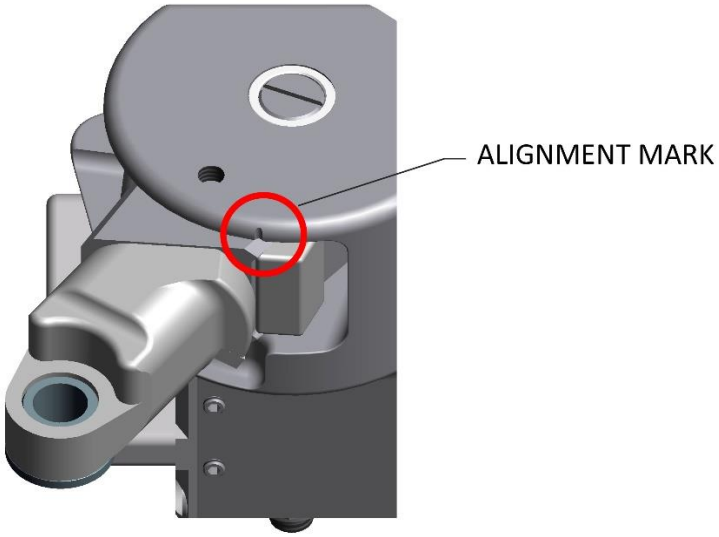

Figure 8.24 Alignment mark on the edge of the Spring Housing

The friction washer (AXSDM004), M8 (20 OD) spring washer, and M8 lock nut are used to set the friction of the shoulder support arm rotation. It may be necessary to replace the lock nut as it wears during adjustment. Make sure that the smaller diameter of the M8 spring washer faces the lock nut. Inspect the bearings and the washer (AXSDM031) and replace if necessary. In case of excessive play in the support link (AXSDM009) the M8 SNEP lock nut must be adjusted. If the Range of Motion Buffer (AXSDM016) is glued onto the shoulder support arm (AXSDM007), break the bond carefully by prying the buffer off from the bonding surface with a small screwdriver. Check that the lock nut has not lost its locking function. If that is the case replace the lock nut. Readjust the lock nut and, if this corrects the play, assemble according to instructions in the next section of this chapter.

Table 8-6 lists the parts required for the Left and Right Hand Shoulder Pivot Assembly, AXSDM600/AXSDM900, which is illustrated in Figure 8.25**.**

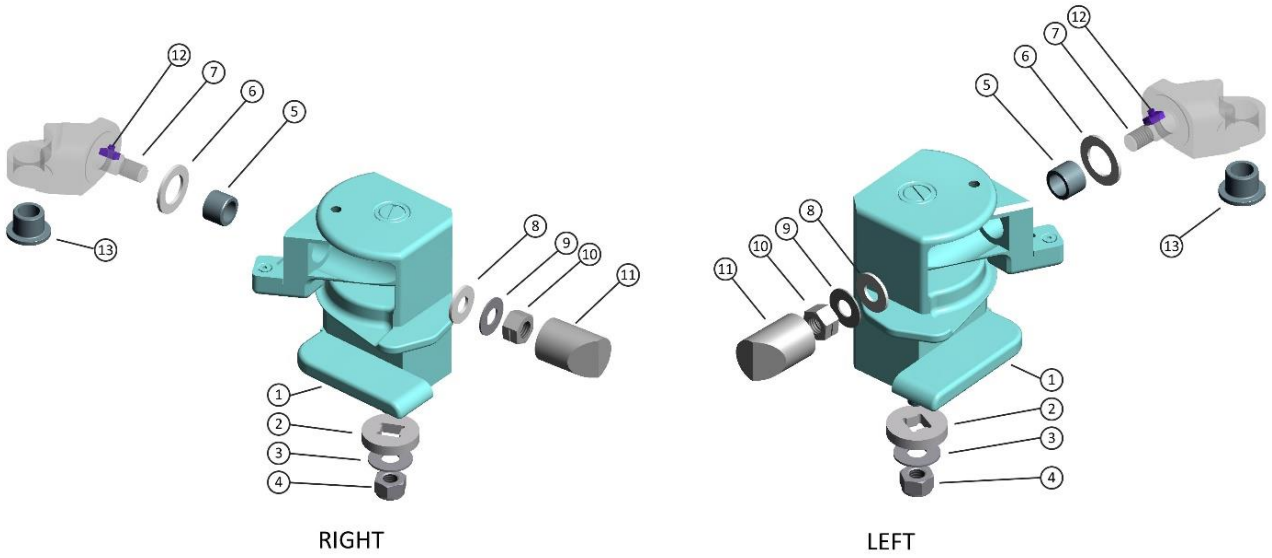

Figure 8.25 Left- and Right-Hand Shoulder Pivot Assembly

Table 8-6 Left- and Right-Hand Shoulder Pivot Assembly Parts List

Item	Qty.	Part Number	Description
1	1	AXSDM700	LEFT SHOULDER SPRING ASSEMBLY
1	1	AXSDM800	RIGHT SHOULDER SPRING ASSEMBLY
2	1	AXSDM004	WASHER FRICTION
3	1	5001234	SPRING WASHER, M8 (20 OD)
4	1	5000486	M8 X 1.25 HEX LOCK NUT ZINC
5	1	5001230	BEARING, IGUS SLEEVE 14 OD x 10 ID x 10
6	1	AXSDM031	LINK WASHER 23 X 14.2 X 1.5
7	1	AXSDM008	SHOULDER SUPPORT PIVOT LH
7	1	AXSDM009	SHOULDER SUPPORT PIVOT RH
8	1	AXSDM030	WASHER LINK 18 X 8 X 1.5
9	1	5001233	SPRING WASHER, M8 (18 OD)
10	1	5001235	M8 SNEP LOCKNUT
11	1	AXSDM016	LINK 1 ROM REARWARD BUFFER, MOLDED
12	1	AXSDM024	BUFFER, VERTICAL
13	1	5001231	BEARING, IGUS FLANGE 14 OD x 10 ID x 12

Assemble the Shoulder Support Pivot (left or right) in the following order.

1. Check that 3mm roll pin is present and is flush or below the surface of the Shoulder Support Arm (AXSDM006).

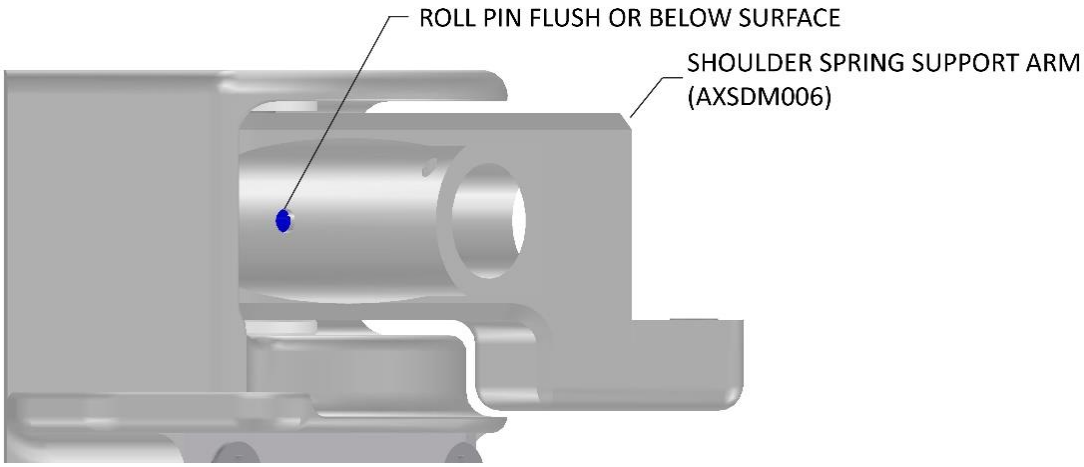

Figure 8.26 Check 3mm Roll Pin flush or below surface of Shoulder Support Arm (AXSDM006)

2. Fit bearings in their counterparts preferably using special tools AXSDT002 and AXSDT003.

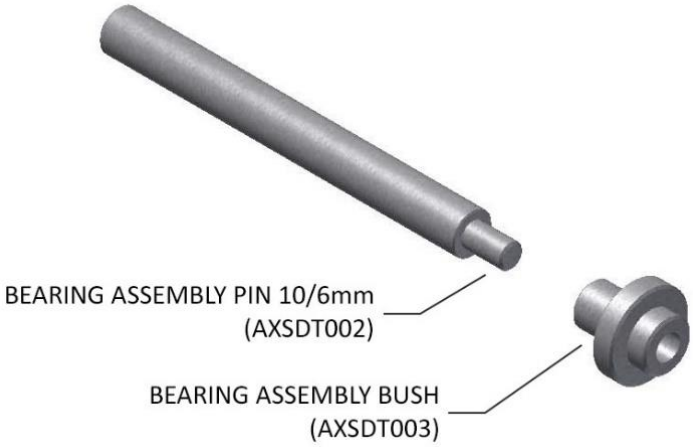

Figure 8.27 Fit Bearings using Special Tools AXSDT002 and ASXDT003

3. Push bearing (14 OD x 10 ID x 10) into Shoulder Support Arm (AXSDM006) until opposite side is flush.

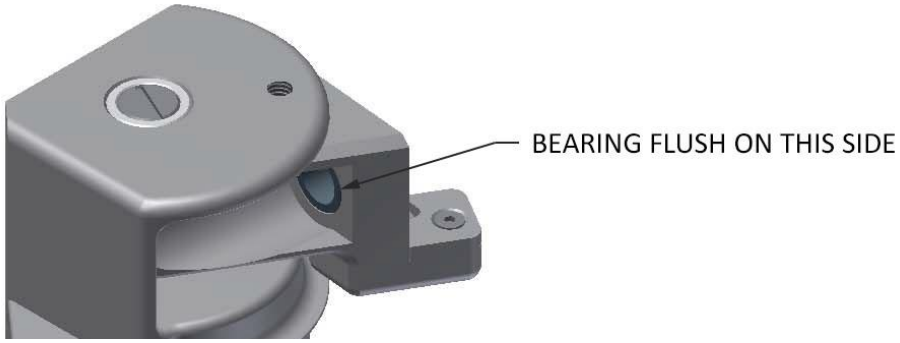

Figure 8.28 Push Bearing into Shoulder Support Arm

4. Assemble the Link Washer (AXSDM031), Shoulder Support Arm (AXSDM006), Washer Link (AXSDM030) and M8 (18 OD) Spring washer as shown in Figure 8.29, and tighten the M8 Lock Nut to compress the disc spring 1/3 turn (~120deg). Orient M8 spring washer with small diameter facing the nut.

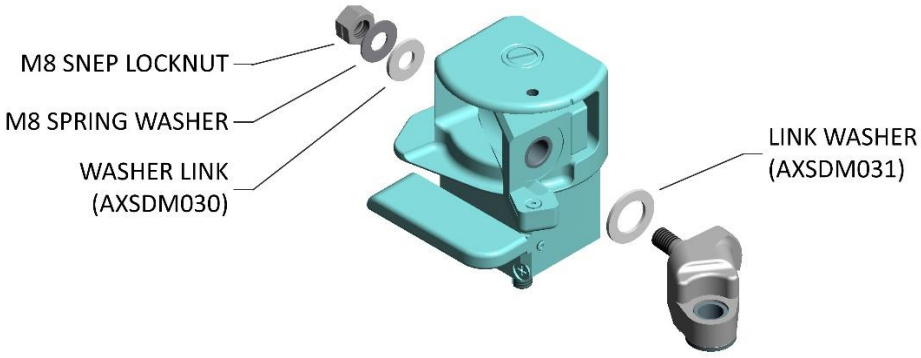

Figure 8.29 Assemble Washers and Nut

5. To tighten the lock nut, push back the Shoulder Support Pivot to allow better access.

6. Check the Shoulder Support Pivot (LH AXSDM008; RH AXSDM009) for smooth and free of play rotation and apply Loctite 290 on the thread close to the M8 SNEP lock nut.

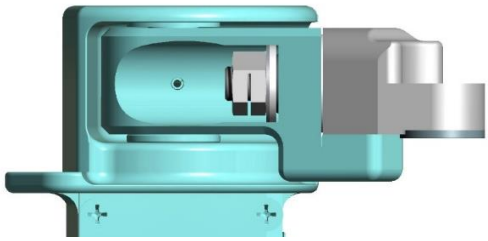

Figure 8.30 Apply Loctite 290 on Thread close to M8 SNEP Lock Nut

7. Assemble the friction washer (AXSDM004), M8 spring washer and the second M8 hex lock nut and tighten about 1/3 turn (~120°) after mating with the disc spring. Orient the M8 (20 OD) spring washer with small diameter facing the nut.

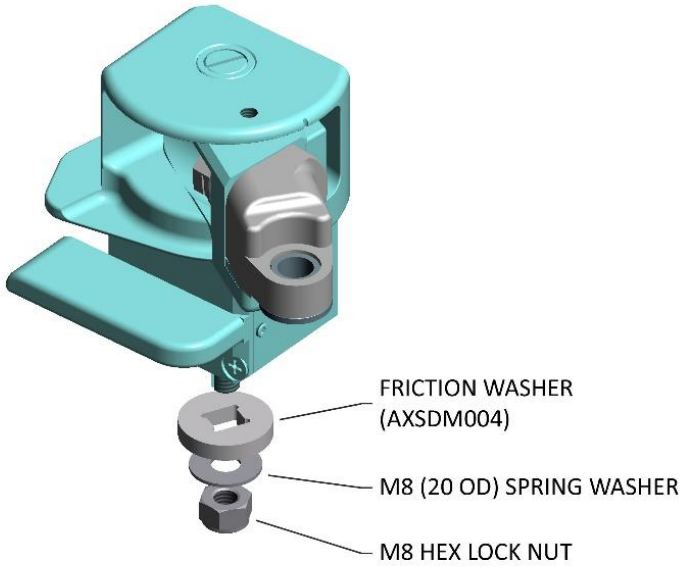

Figure 8.31 Assemble the Washers and Lock Nut

8. Fix buffers (AXSDM016, AXSDM024) with cyano-acrylate super glue. It is recommended to wear gloves for this step. Before gluing, clean the surfaces with a solvent. If necessary, carefully remove old glue residue with fine sandpaper. On the rearward buffer (AXSDM016) apply only a small amount of glue such that the bond can be broken at a later occasion. After bonding wipe off excessive glue with cloth.

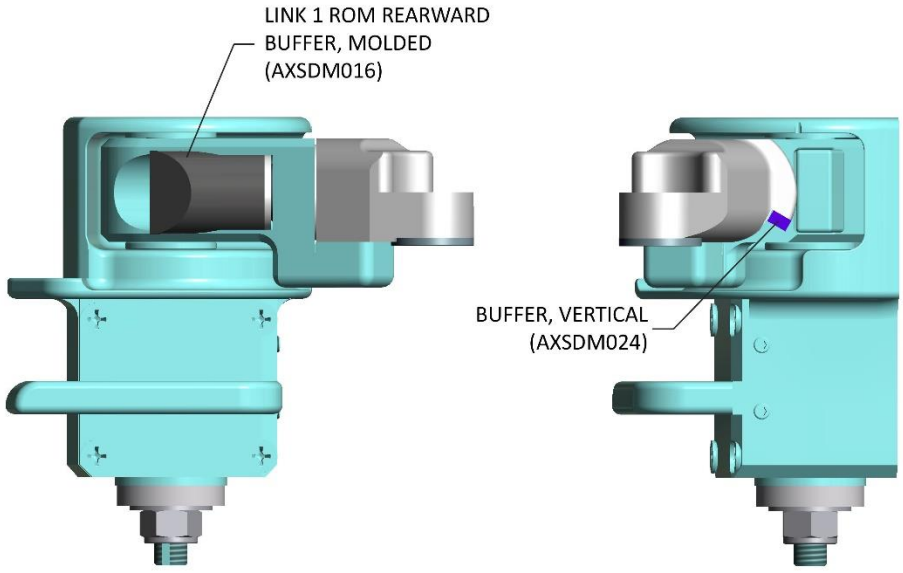

Figure 8.32 Glue Buffers, AXSDM016 and AXSDM024

8.2.6 **Assembly of the Shoulder**

The parts list of the Left and Right Shoulder Assembly, AXSDM300/AXSDM400, is given in Table 8-7.

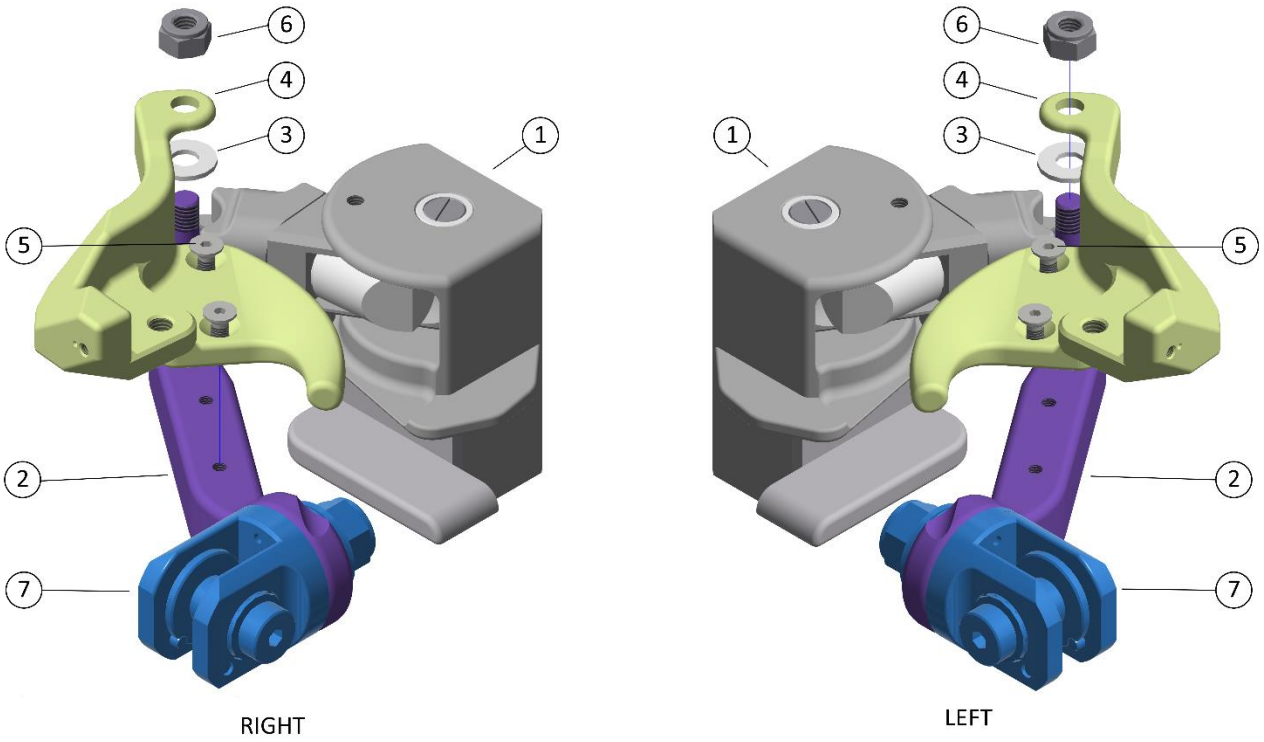

Figure 8.33 SD3 Left and Right Shoulder Assembly

Table 8-7 SD3 Left and Right Shoulder Assembly Parts List

Item	Qty.	Part Number	Description
1	1	AXSDM600	LEFT SHOULDER PIVOT ASSEMBLY
1	1	AXSDM900	RIGHT SHOULDER PIVOT ASSEMBLY
2	1	AXSDM012	ARM LINK LH
2	1	AXSDM013	ARM LINK RH
3	1	AXSDM030	WASHER LINK 18 X 8 X 1.5
4	1	AXSDM010	SCAPULA LH
4	1	AXSDM011	SCAPULA RH
5	2	5000467	M5 X 0.8 X 16 LG. FHCS
6	1	5000486	M8 X 1.25 HEX LOCK NUT ZINC
7	1	AXSDM500	ARM CLEVIS ASSEMBLY

Assemble the Left- and Right-Hand Scapula Assemblies in the following order.

1. Insert the tapped portion of the Arm Link (RH AXSDM013; LH AXSDM012) into the Shoulder Pivot Assembly (RH AXSDM900; LH AXSDM600). Place the washer (AXSDM030) over the tapped post and place the scapula (RH AXSDM011; LH AXSDM010) onto the Arm Link. Bolt this down using two M5 x 16mm FHCS.

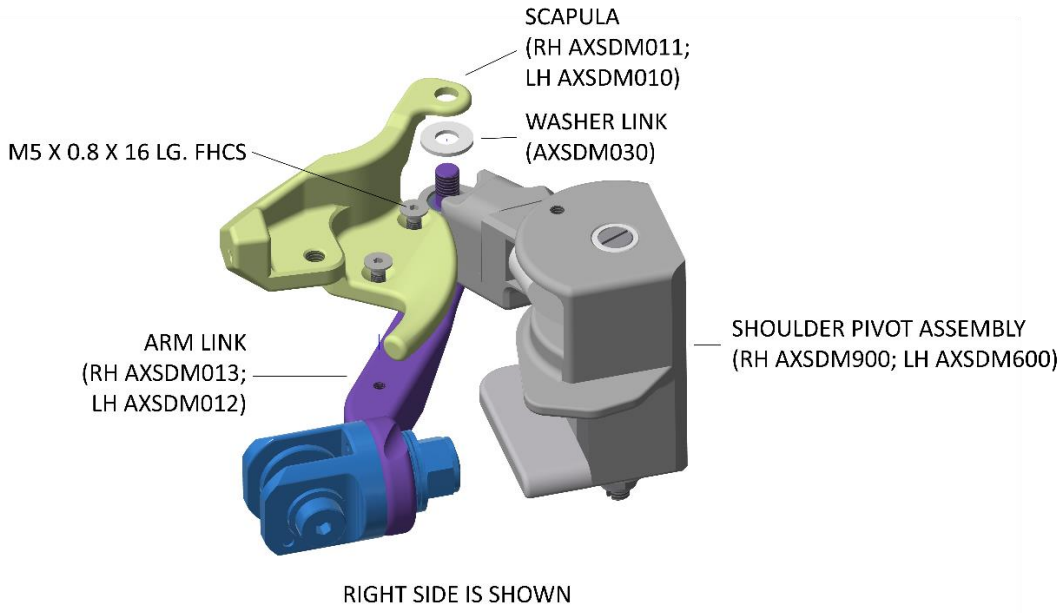

Figure 8.34 Insert Arm Link into Shoulder Pivot Assembly

2. Tighten the M8 lock nut such that the joint rotates freely without play. Replace the lock nut if the locking function is worn.

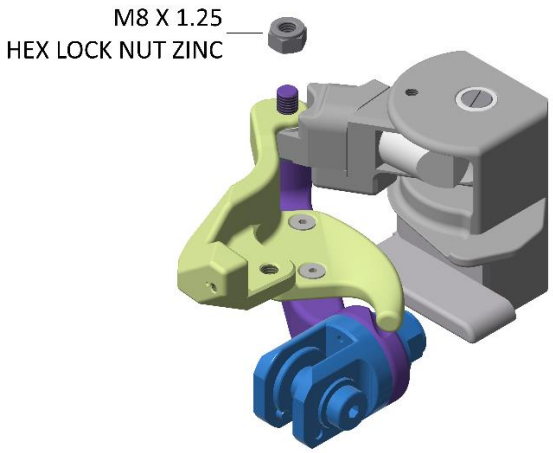

Figure 8.35 Tighten M8 Lock Nut

8.3 Adjustment for the SD3 Shoulder and Arm Assembly

8.3.1 Introduction

The current procedure was written to achieve a reference for adjustment of the SD3 shoulder and arm joint friction for use during prototype evaluations. The procedure is intended to have a suitable friction for stable positioning of the dummy in a test environment and aimed at intermediate friction level (i.e. lower than the '1G' settings of HIII). Therefor the friction shall be adjusted just below 1G level (slowly dropping body segment). Bending back the lower arm and hand during friction adjustment further reduces the target friction moment on the joints. On all joints (except elbow and wrist) the adjustment of the friction relies on two items, a conical spring washer and a lock nut. In case the friction adjustment on any of the joints is not well retained these two items are suspected. Check that the lock nut is not worn and, if so, replace it. Check that the spring washer is oriented with the smaller diameter facing the lock nut or the screw head.

8.3.2 Step by step procedure

1. Place the dummy in a stable upright position, with shoulders and clavicles in a horizontal plane and the jacket removed (or unzipped at the sides and shoulders). Both sides are adjusted the same way.
2. Shoulder z-axis friction, Figure 8.36. Lift the arm up for access. The nut is on the side of the spine in the arm pit area, access is between the 2nd and 3rd rib. Adjust the friction for smooth forward and backward motion of the shoulder. The shoulder spring should be able to bring the shoulder back close to its zero position (alignment hole and mark are visible below the shoulder molding).

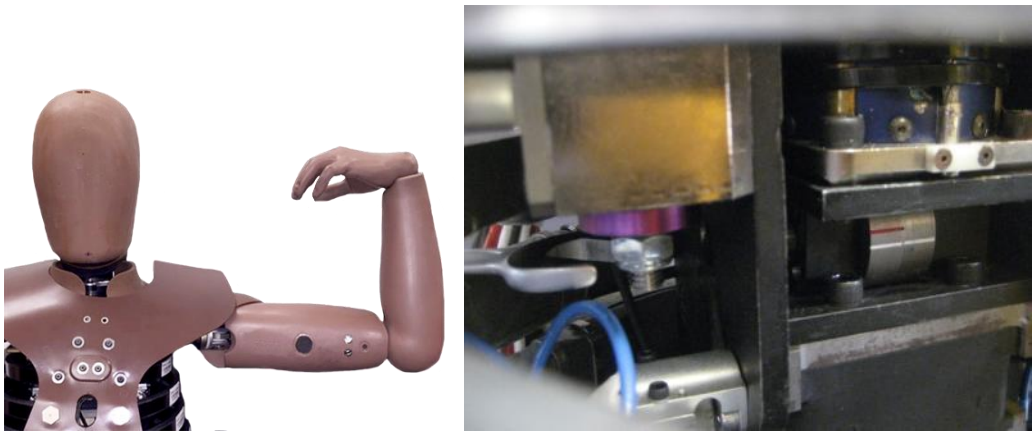

Figure 8.36 Shoulder Z-Axis Adjustment

3. Wrist. Adjust the wrist joint in two directions to a practical friction for a stable hand.

4. To adjust the elbow pin joint (Figure 8.37) rotate the lower arm about the vertical axis sideways for easy access to the bolt. With the upper arm shaft hanging vertically hold the lower arm horizontal and bend back the hand. Adjust the elbow joint friction such that forearm drops slowly after release.

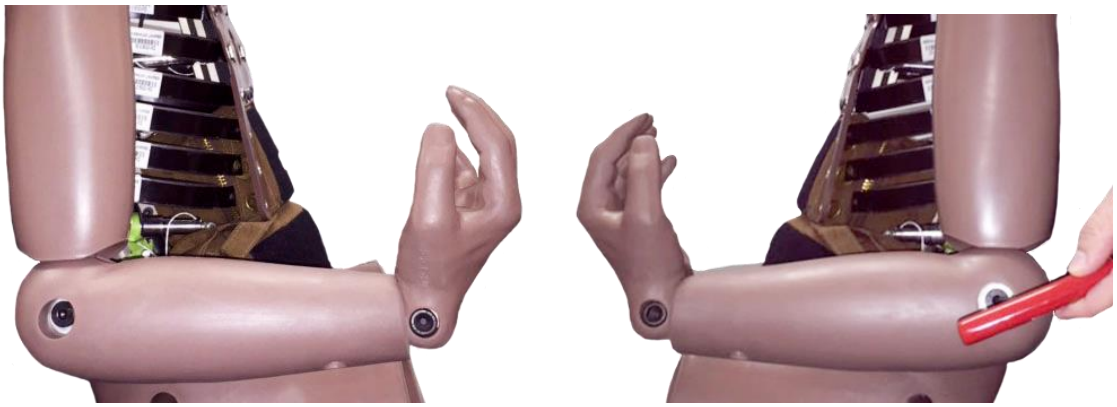

Figure 8.37 Elbow Pin Joint Adjustment

5. To adjust the humerus (upper arm) Y-axis joint, start with the upper arm hanging vertically (Figure 8.38). Rotate the upper arm up (forward about y-axis) until horizontal and then bend the lower arm and hand back. Adjust the friction on the M12 nut immediately (i.e. not attached to the spine) in the arm pit area so that the arm drops slowly after release (see also Figure 8.36).

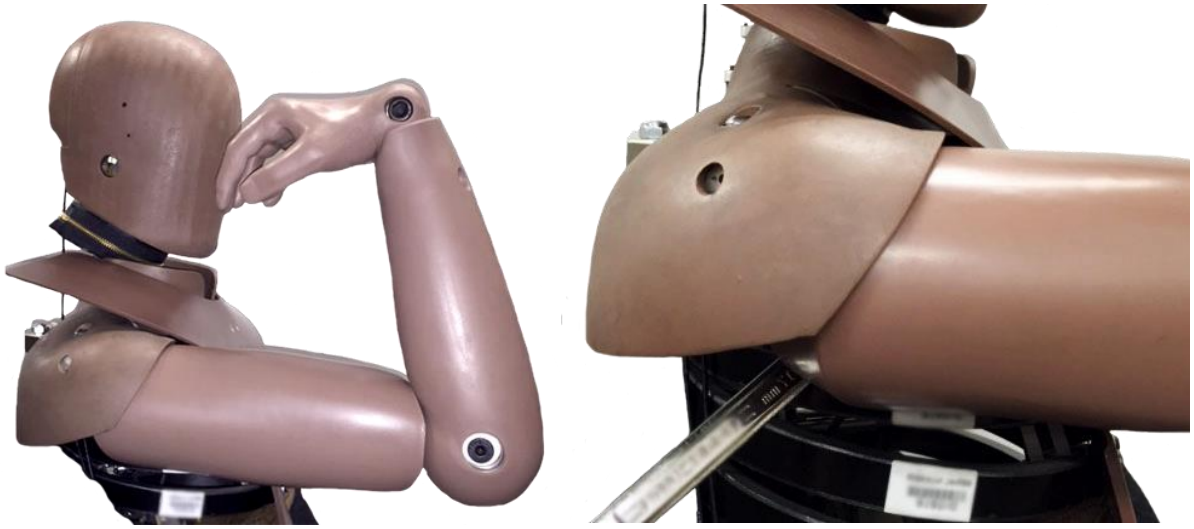

Figure 8.38 Upper Arm Y-Axis Adjustment

6. To adjust the humerus (upper arm) X-axis joint, see Figure 8.39. Start with the upper arm hanging down vertically and the lower arm forward horizontally. Rotate the upper and lower arm up and laterally while bending the hand back towards the head. Adjust the friction on shoulder bolt by tightening or loosening as appropriate. The friction is properly adjusted when the arm drops slowly from horizontal after release. Note that the shoulder can also lift during this motion; ensure that it is not by pushing down on the shoulder so that it remains on the stop.

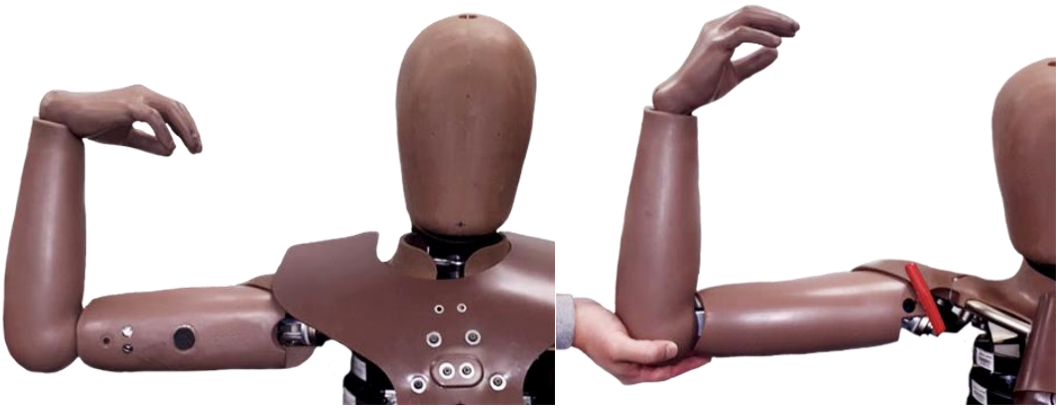

Figure 8.39 Upper Arm X-Axis Adjustment

7. To adjust the lower arm z-axis friction (moment along upper arm shaft), start with the upper arm hanging down vertically and lower arm and hand horizontally forward (~90° angle). Rotate the upper and lower arm up laterally to horizontal and hold the upper arm by the elbow in that position (Figure 8.40). Adjust z-axis friction by tightening or loosening, as appropriate, the bolt through a hole in the upper arm flesh. Adjust the friction such that the lower arm and hand drop slowly after release.

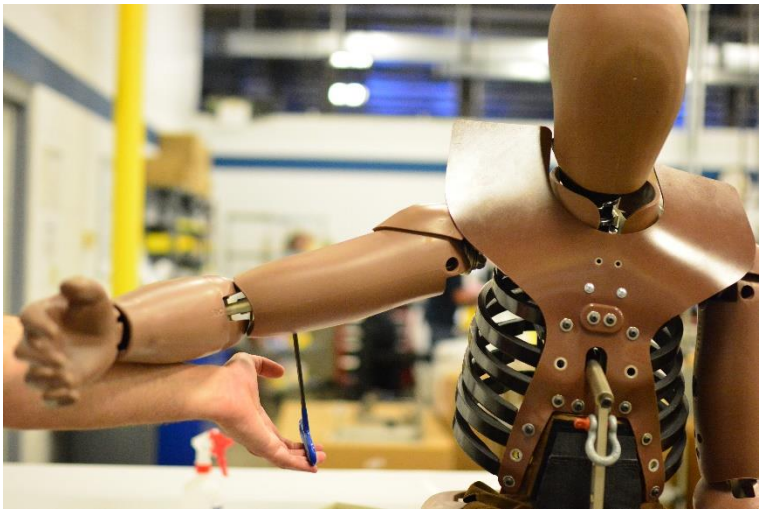

Figure 8.40 Lower Arm Z-Axis Adjustment

8.4 Wire Routing and Electrical Connections

Note: Wire routing and strain relief can be completed per the customer's preference, the important aspect is to ensure that there is enough slack in the wires and that they are strain relieved in a location where they will not be damaged. The instructions below describe Humanetics' procedure.

The only instruments in the shoulder are two Clavicle Load Cells on each side. Cables are routed around the Lower Neck Load Cell and bundled with the head and neck cables in rear of dummy.

The upper arms can be instrumented with a 6-channel load cell to measure forces and moments in 3 directions. The cables are routed up the arm to the Lower Neck Load Cell and bundled with the head and neck cables in the rear of the dummy.

8.5 Shoulder Qualification

There are no qualification requirements for the shoulder assembly.

8.6 Inspection and Repairs

After a test or test series has been performed, electrical and mechanical inspections must be made to ensure that the dummy's integrity has remained intact. These inspections are most easily carried out during disassembly of the dummy.

8.6.1 Electrical Inspections (Instrumentation Check)

Clavicle load cells may be installed in the shoulder assembly. The upper arms may be instrumented with a 6-channel load cell. This inspection should begin with the visual and tactile inspection of all of the instrument wires from the shoulder instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

8.6.2 **Mechanical Inspection**

Several components in the shoulder assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below.

Shoulder Joint Friction

- ✓ Check the shoulder and arm joint friction adjustment frequently according instructions in Section 8.3, Adjustment for the SD3 Shoulder and Arm Assembly.

Shoulder joint linkages

- ✓ The shoulder assembly consists of various linkages which should be able to rotate freely. Check all linkages for excessive play, and where found the locknut should be adjusted to minimize play. If the play is not corrected by this inspection of the joint is necessary, the polymer slide bearings may need to be replaced.

Shoulder Buffers

- ✓ There are 4 End Stop Buffers in the SD3 Shoulder Assembly that should be inspected regularly for wear and tear, see red highlighted parts in Figure 8.41.

Figure 8.41 End Stop Buffers for Inspection

Shoulder Covers

- ✓ Check the shoulder covers for damage (tearing, cuts, etc.) which may be caused by the belt. Check that the M8 screws in the shoulder covers are tightened.

Clavicles

- ✓ The Clavicles are linked with spherical bearings which are bonded inside the bores. Although not expected, these bonds could become loose. Check bearings for excessive play. On the sternum side check that the snap rings of the clevis and clevis pin are in good shape and are properly retaining the shaft and pin.

8.7 Handling

The SD3 shoulder has two addition features on each side of the shoulder. On the outer face of the scapula there is an indent intended for shoulder position measurement.

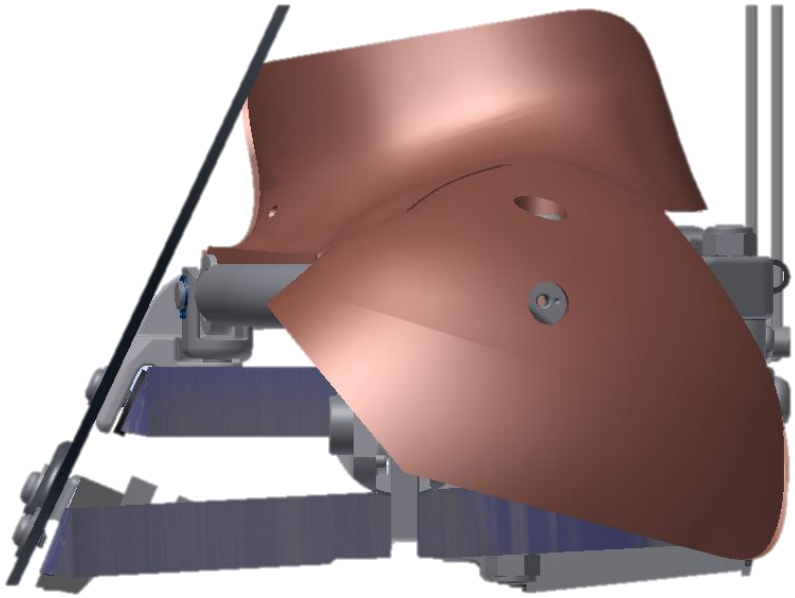

Figure 8.42 Indent Position Measurement, M4 Thread Access thru Lateral Hole in Shoulder Cover

Section 9. **Lower Arm and Hand Assembly**

9.1 **Description of the Lower Arm Assembly and Features**

The lower arm and hand assemblies are defined as the region below the elbow. The THOR-50M assembly is based on the Hybrid III 50th Male design with minor differences, including the use of metric hardware. A figure of the complete left and right lower arm assembly is shown below in Figure 9.1.

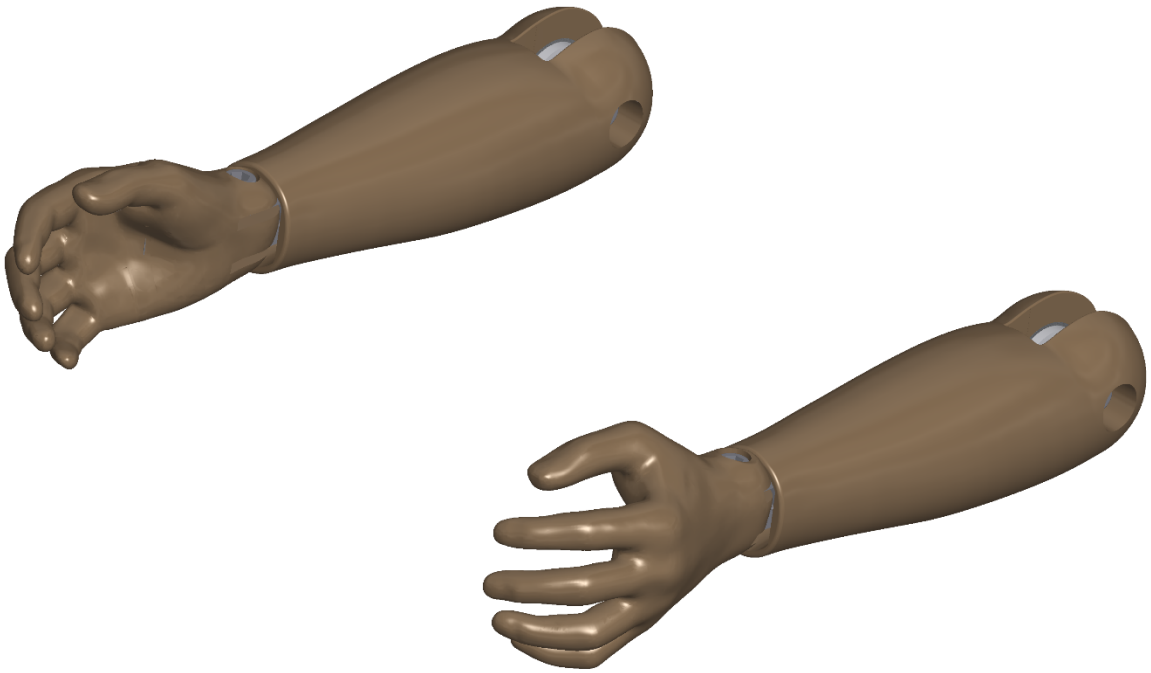

Figure 9.1 Lower Arm Assemblies, Left and Right

9.2 Assembly of the Lower Arm

9.2.1 Parts List

Figure 9.2 is an exploded view of the left and right lower arm assemblies, 472-6500-1/472-6500-2.

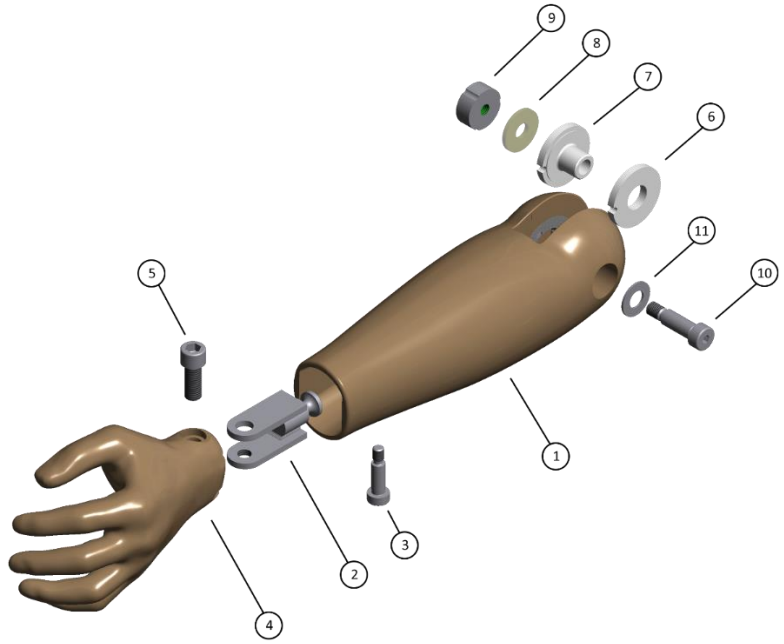

Figure 9.2 Lower Arm Assembly Exploded View

Table 9-1 Lower Arm and Hand Parts List

Item	Qty.	Part Number	Description
1	1	472-6520	LOWER ARM MOLDED
2	1	472-6700	LOWER WRIST ROTATION ASSEMBLY
3	1	5000492	M10 X 25 LG. SHSS
4	1	472-6900-1	HAND ASSEMBLY MOLDED, LEFT
	1	472-6900-2	HAND ASSEMBLY MOLDED, RIGHT (NOT SHOWN)
5	1	5000441	M12 X 1.75 X 30 LG. SHCS
6	1	472-6600	WASHER – UPPER ARM & ELBOW PIVOT
7	1	472-6590	BUSHING, UPPER ARM & ELBOW PIVOT
8	1	472-6950	WASHER – SHOULDER JOINT SPRING
9	1	472-6610	NUT – ELBOW PIVOT
10	1	5000506	M12 X 30 LG. SHSS
11	1	9001260	WASHER, 1.06 OD X .53 ID X .06 THK.

9.2.2 **Assembly of the Lower Arm Components**

The following procedure is a step-by-step description of the assembly procedure for the Left Lower Arm components. The Right Lower Arm assembly procedure is identical except it contains the Right Molded Hand.

1. Insert the Lower Wrist Rotation assembly (472-6700) in the bottom of the Molded Lower Arm (472-6520) and attach with one M10x25 SHCSS as shown in Figure 9.3 below.

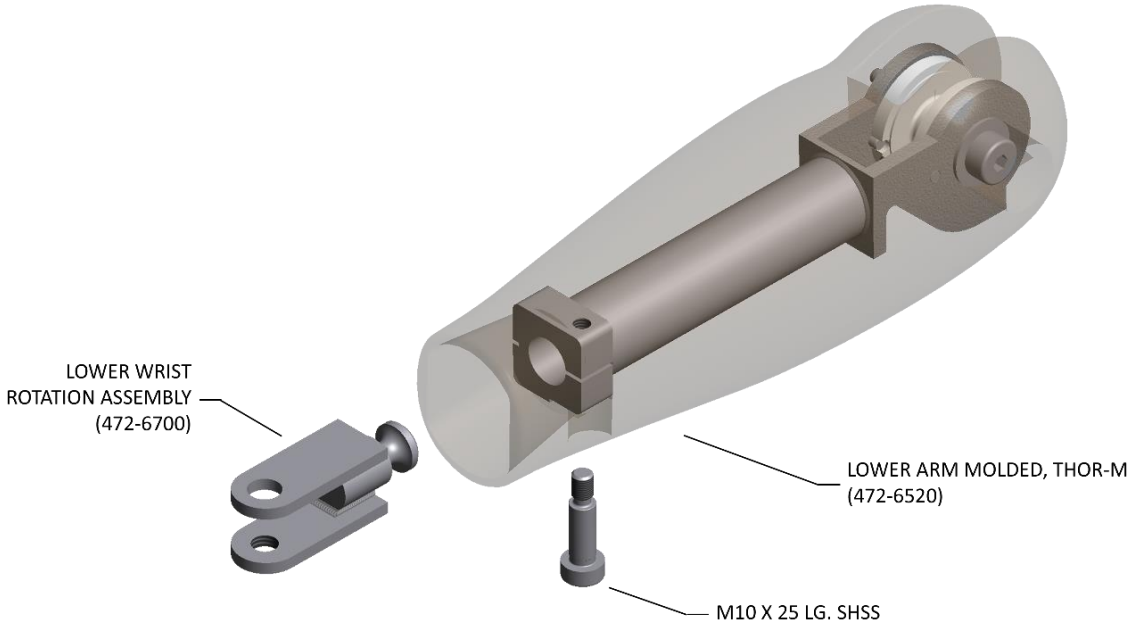

Figure 9.3 Lower Wrist Rotation Assembly Attached to Lower Arm Molded with M10x25 SHSS

2. Place the Molded Hand (472-6900-1) into the Wrist Rotation Assembly (472-6700) and secure it with one M12x30 SHCS as shown in Figure 9.4 below.

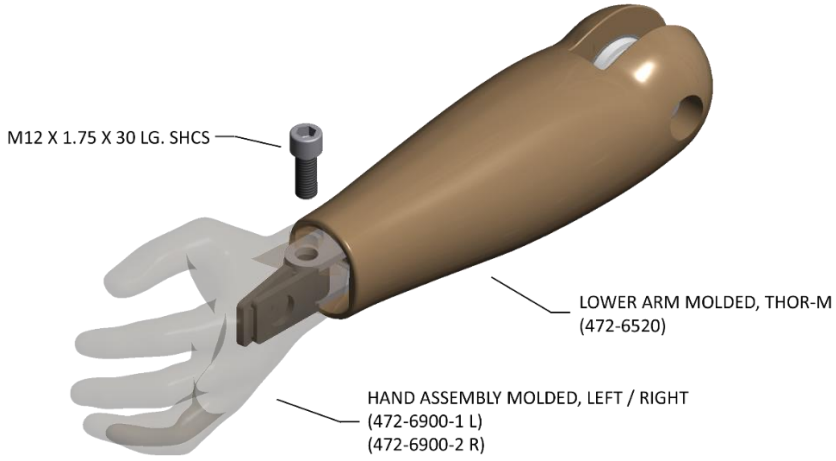

Figure 9.4 Hand Molded Secured to Lower Arm Molded with M12x30 SHCS

9.2.3 **Assembly of the Lower Arm into the Upper Arm**

Place the Upper Arm and Elbow Pivot Bushing (472-6590) into the hole on the Upper Arm Lower Section (AXAMM003). Place this assembly along with the Upper Arm and Elbow Pivot Washer (472-6600) into the elbow yoke at the top of the Upper Arm (472-6520). Secure the Upper Arm and Lower Arm together with the Shoulder Spring Washer (472-6950), 1.06OD X .53ID Washer, M12 x 30 SHSS, and the Elbow Pivot Nut (472-6610). This is shown in Figure 9.5 below.

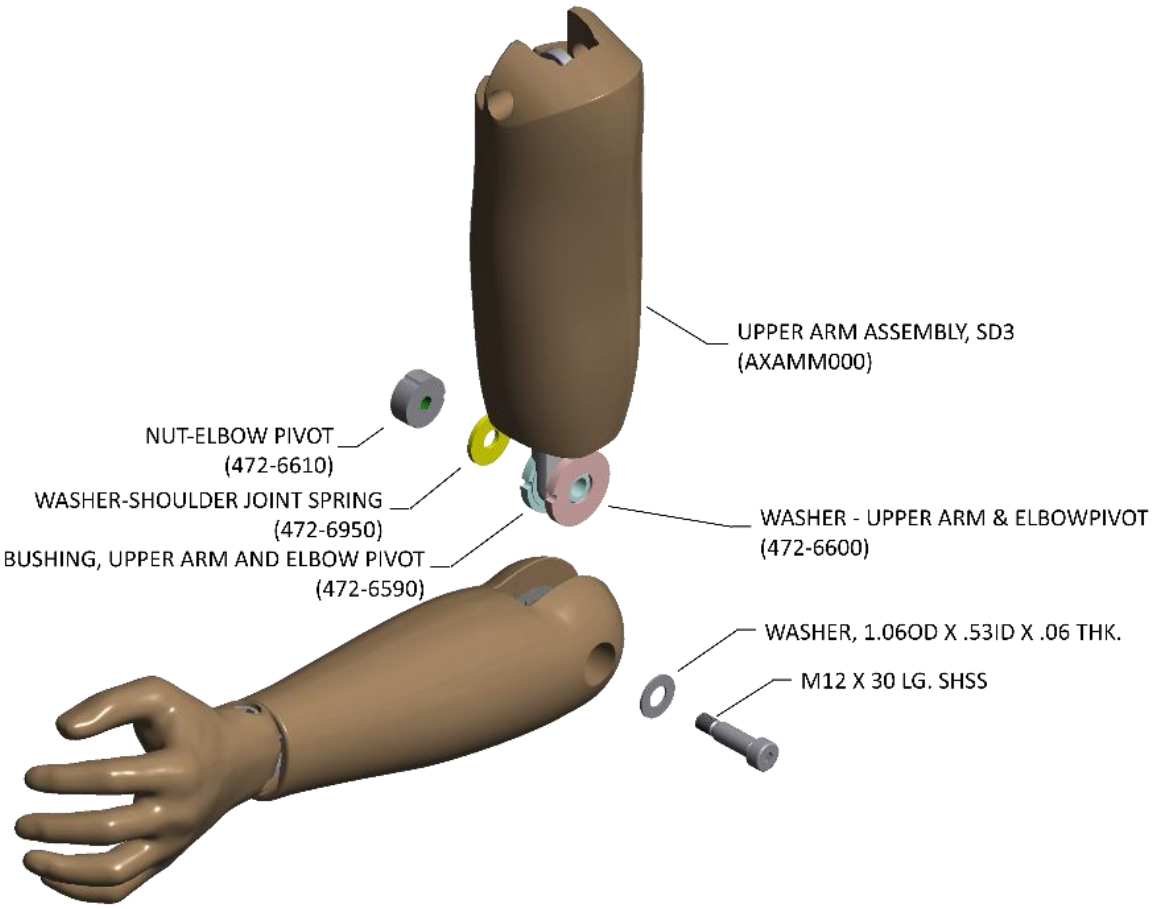

Figure 9.5 Exploded View of 472-6500-1 with AXAMM000

9.3 **Adjustments of Lower Arm**

The wrist and elbow should be adjusted to a “1 G suspended setting.” The steps below describe how to make these adjustments.

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

- Reposition the arm so it points forward and is horizontal. Twist the lower arm at the elbow, so that lower arm can pivot downward to vertical. Adjust the elbow pivot bolt through access holes in the lower arm flesh at the elbow to hold the lower arm suspended at 1G.

- 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 1G.

- Adjust the wrist rotation bolt through the access in the wrist flesh to hold it suspended at 1G.

- Repeat procedure for other hand and arm.

9.4 Wire Routing and Electrical Connections

There is no instrumentation included in the lower arm and hand assembly on the standard THOR-50M dummy.

9.5 Lower Arm Qualification

There are no qualification requirements for the lower arm and hand assembly.

9.6 Inspection and Repairs

- ✓ Check for holes, tears and cuts in the lower arm and hand skin.

Section 10. **Spine Assembly**

10.1 **Description of Spine Assembly and Features**

The spine assembly for the THOR-50M dummy includes the mechanical components from the neck pitch change mechanism to the pelvis/lumbar mounting block. This advanced spine assembly includes the following features: two pitch change mechanisms; two flex joints; and instrumentation including a thoracic spine load cell, tri-pack assemblies at T1, at the vertical level of the thorax CG, and at T12, and four angular orientation (tilt) sensors. The complete spine assembly can be seen in Figure 10.1.

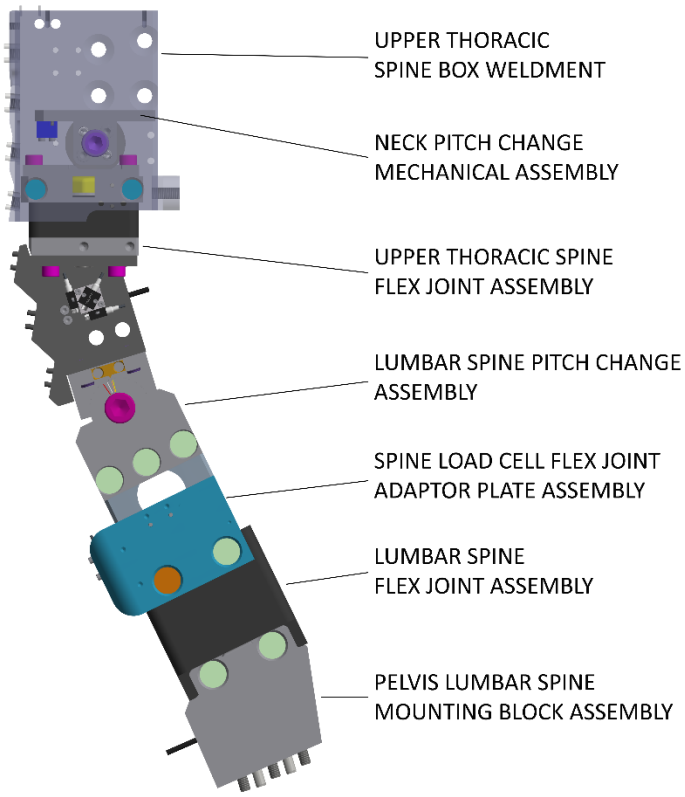

Figure 10.1 Complete Spine Assembly

One of the primary goals of the new spine assembly is to provide the ability for the dummy to assume several different seated postures for testing. The range of seating postures allows the dummy to accommodate various automotive environments. Four major seating postures have been defined through a postural study, and the THOR-50M spine assembly is capable of adjusting each one of these postures. The adjustment capability is provided by the neck and lower thoracic spine pitch change mechanisms. The neck pitch change mechanism is centered at the approximate location of the anthropomorphic landmark defined by the T6/T7 joint. The lower thoracic spine pitch change mechanism is centered at the approximate location of the anthropomorphic landmark defined by the T11/T12 joint. The seating posture of the THOR-50M dummy can be adjusted in 3-degree increments by rotating the spine segments with the pitch change mechanisms.

The second feature of the THOR-50M spine assembly is the integration of two flexible joints into the assembly to provide a degree of bending and flexibility. The lumbar spine flex joint has been redesigned to reduce the amount of space required for this joint. The upper thoracic flex joint has been added to provide additional flexibility to the spine.

The final feature of the THOR-50M spine assembly is the integration of several sensors to provide data about the orientation, acceleration, forces and moments of the spine assembly, as shown Figure 10.2. The Thoracic Spine Load Cell has been incorporated into the spine assembly at the approximate location of the anthropomorphic landmark defined by the T12/L1 joint. This load cell provides the forces about all three primary axes and the moments about the X and Y axes. Tri-pack Accelerometer Assemblies (T1NM100) are attached to the spine assembly at the approximate location of the anthropomorphic landmark T1, vertical level of Thorax CG, and T12. These accelerometers can be used to provide information about the spine acceleration along three perpendicular axes. In addition, four static tilt sensors have been attached to various components of the spine assembly to provide information on the posture of the dummy prior to testing. The angular orientation of the dummy spine is processed through a tilt sensor read-out box which provides the laboratory technician with two-dimensional orientation of the various spine components during the test setup.

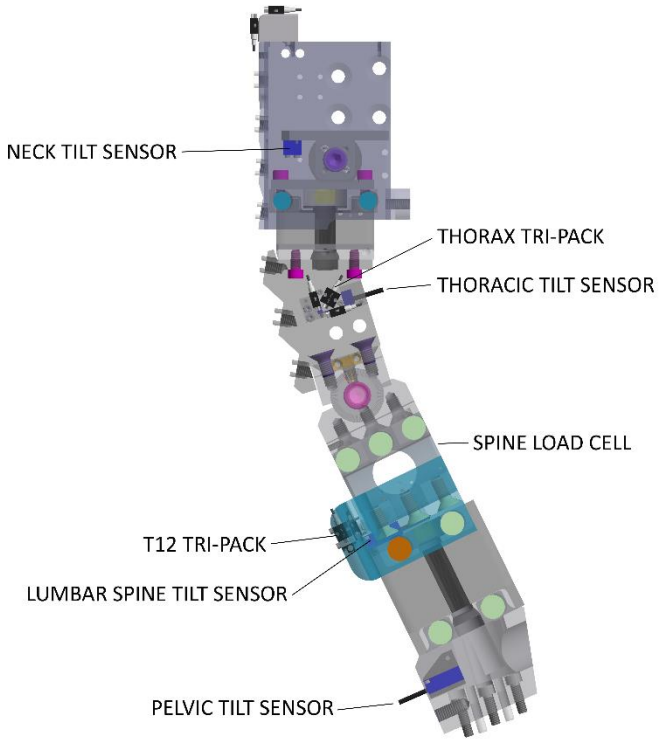

Figure 10.2 Spine Instrumentation Locations

10.2 Assembly of the Spine

10.2.1 Parts List

Refer to drawing 472-3600 in the THOR-50M drawing set for a detailed mechanical assembly drawing. Figure 10.3 shows an exploded assembly of the spine.

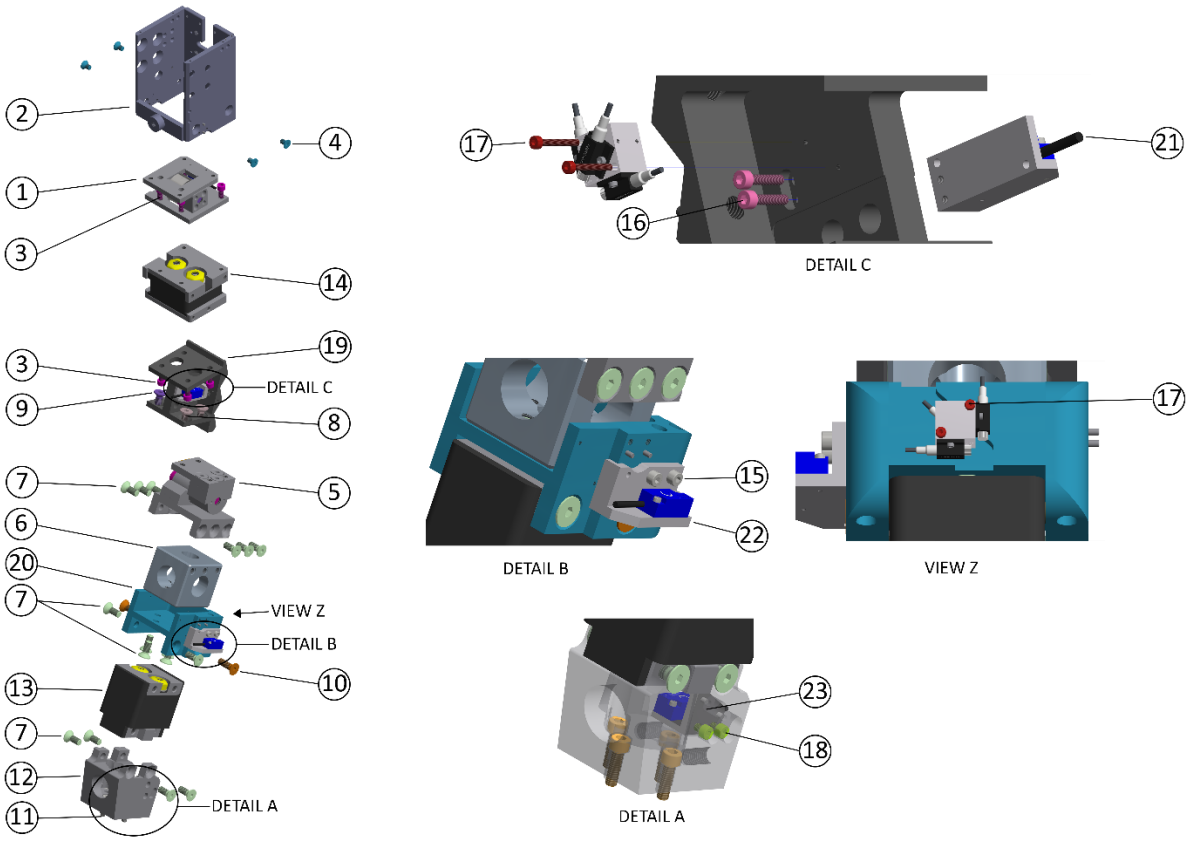

Figure 10.3 Spine Assembly Exploded View

Table 10-1 Spine Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-3630	NECK PITCH CHANGE MECHANISM ASSEMBLY
2	1	472-3620-B	UPPER THORACIC SPINEBOX WELDMENT
3	8	5000281	M6 X 1 X 12 LG. SHCS
4	4	5000204	M6 X 1 X 10 LG. SHCS
5	1	472-3670	LUMBAR SPINE PITCH CHANGE ASSEMBLY
6	1	472-3720	THORACIC SPINE LOAD CELL STRUCTURAL REPLACEMENT
7	16	5000868	M8 X 1.25 X 20 LG. FHCS
8	2	5001090	M8 X 1.25 X 12 LG. FHCS
9	2	5001091	M8 X 1.25 X 16 LG. FHCS

Item	Qty.	Part Number	Description
10	2	5000117	M8 X 1.25 X 25 LG. FHCS
11	4	5000001	M6 X 1 X 20 LG. SHCS
12	1	472-3765	PELVIS/LUMBAR MOUNTING BLOCK ASSEMBLY
13	1	472-3746	LUMBAR SPINE FLEX JOINT ASSEMBLY
14	1	472-3646	UPPER THORACIC SPINE FLEX JOINT ASSEMBLY
15	2	5000152	M4 X 0.7 X 12 LG. SHCS
16	2	5000252	M3 X 0.5 X 14 LG. SHCS
17	4	5000985	M2 X 0.4 X 16 LG. SHCS
18	2	5000151	M4 X 0.7 X 10 LG. SHCS
19	1	472-3655	LOWER THORACIC SPINE ASSEMBLY
20	1	472-3733-B	THORACIC SPINE LOAD CELL FLEX JOINT ADAPTOR PLATE ASSEMBLY
21	1	472-3783	TILT SENSOR MOUNT, LOWER THORAX
22	1	472-3781	TILT SENSOR MOUNT, LUMBAR SPINE
23	1	472-3787	TILT SENSOR ASSEMBLY, PELVIS

10.2.2 **Assembly of Spine components**

The following procedure is a step-by-step description of the assembly procedure for all of the spine components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. The Pelvic Tilt Sensor Assembly (472-3777) is attached to the rear of the Pelvis/Lumbar Mounting Block Assembly (472-3750) using two M4x10 SHCS

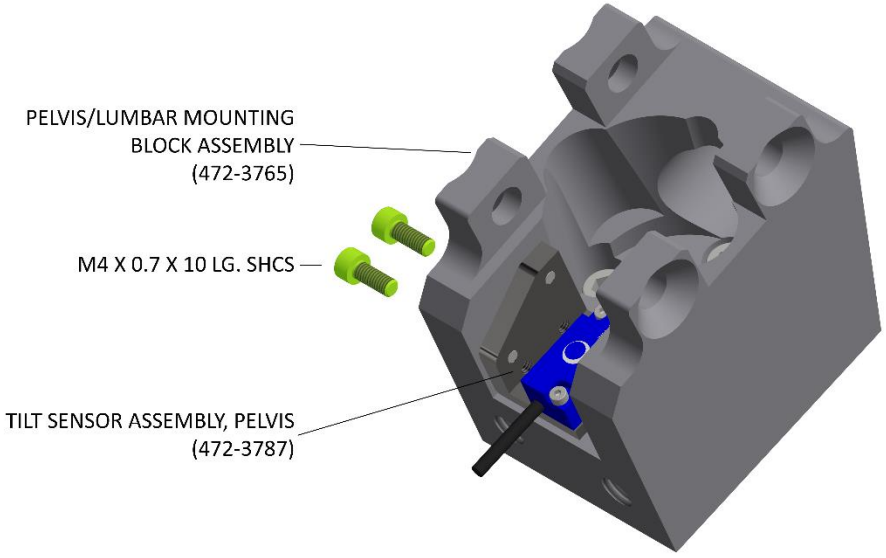

Figure 10.4 Pelvis/Lumbar Mounting Block Assembly

2. The Lumbar Spine Flex Joint (472-3746) is attached to the top of the Pelvis/Lumbar Spine Mounting Block (472-6765) using four M8x20 FHCS, as shown in Figure 10.5. The flex joint may be inserted into the mounting block with either side facing toward the front.

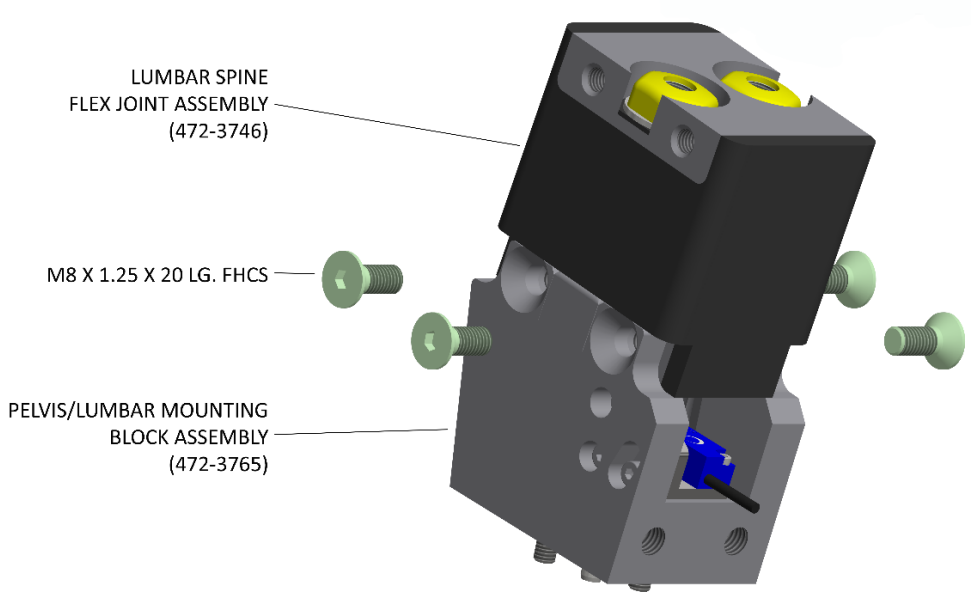

Figure 10.5 Lumbar Flex Joint Assembled to Pelvis/Lumbar Mounting Block

3. The Thoracic Load Cell Flex Joint Adaptor Plate Assembly (472-3733-B) is attached to the bottom of the Thoracic Spine Load Cell (or the non-active thoracic spine load cell, 472-3720) using four M8x20 FHCS, as shown in Figure 10.6. The Thoracic Spine Load Cell Flex Joint Adaptor Plate Assembly should be oriented so that the two M3 tapped holes are positioned toward the rear of the load cell where the instrumentation cables exit.

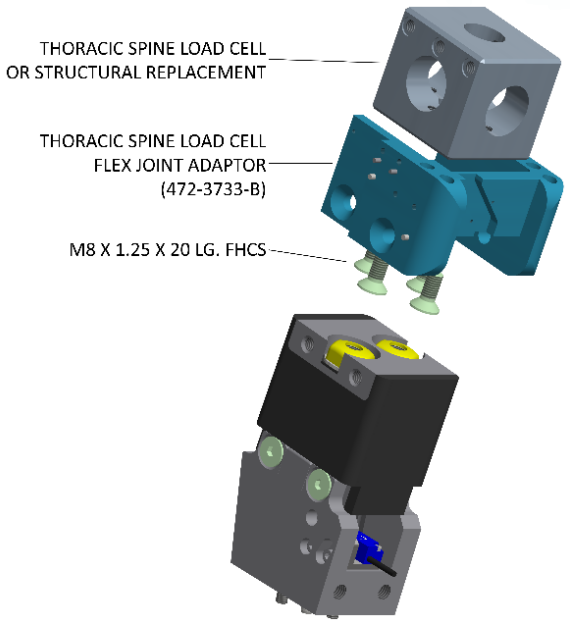

Figure 10.6 Thoracic Spine LC or S.R. Attach to Thoracic Spine LC Flex Joint Adaptor

4. The Thoracic Spine Load Cell Adaptor Plate Instrumentation Assembly/Thoracic Spine Load Cell, completed in Step 3, is attached to the Lumbar Spine Flex Joint using four M8x20 FHCS and two M8x25 FHCS, as shown in Figure 10.7.

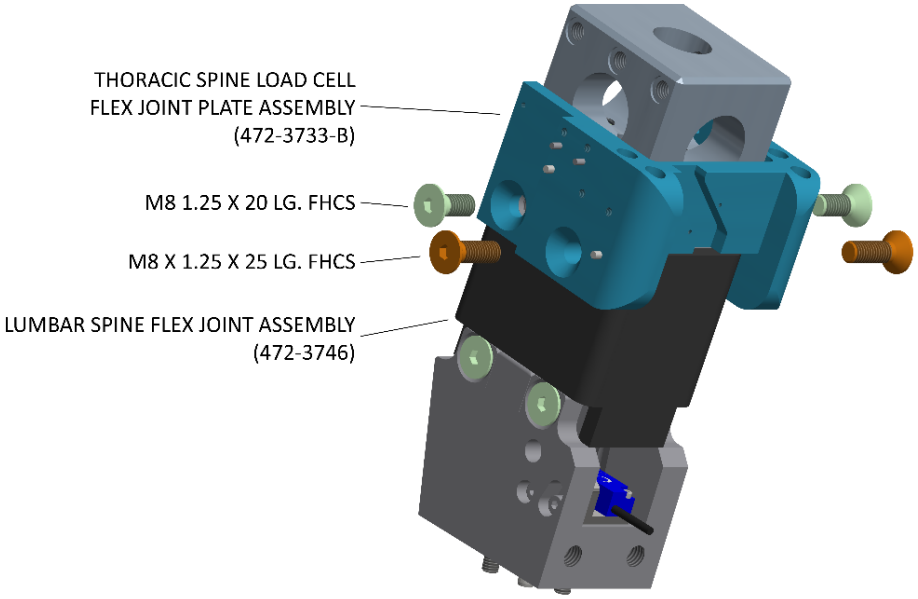

Figure 10.7 Attach Adaptor Plate Assembly to Lumbar Spine Flex Joint Assembly

5. The tilt sensor is attached to the Thoracic Spine Load Cell Flex Joint Adaptor Plate Assembly (472-3733-B) using the Lumbar Spine Tilt Sensor plate (472-3781) and two M4x12 SHCS.

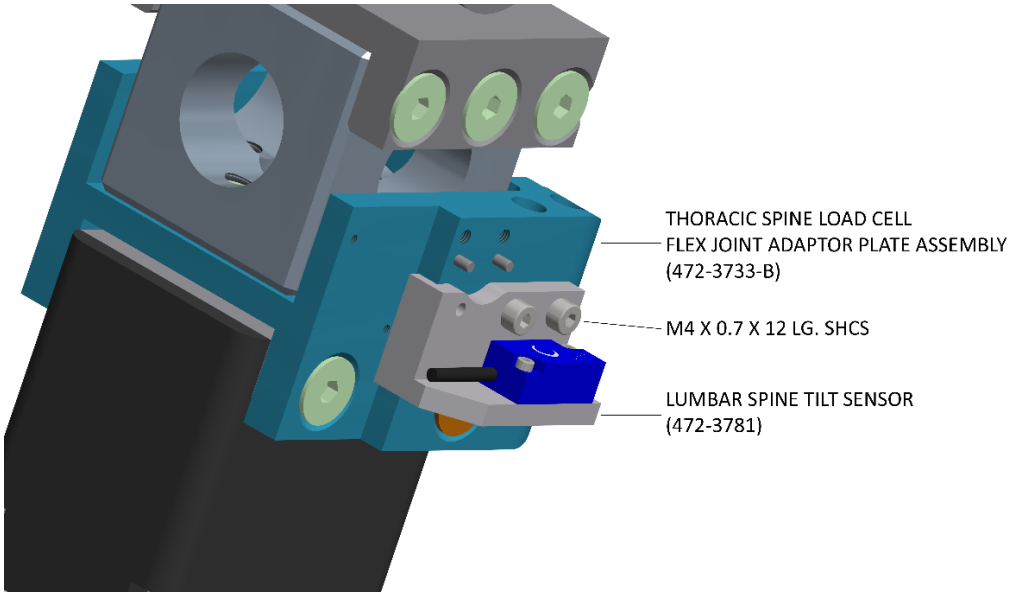

Figure 10.8 Load Cell Adaptor Plate attached to T12 Load Cell

6. The Lower Thoracic Spine Pitch Change Mechanism (472-3670) is attached to the Thoracic Spine Load Cell using six M8x20 FHCS, as shown in Figure 10.9. The head of the M12x60 SHCS adjustment bolt in the pitch change mechanism should be oriented to the right-hand side of the spine assembly.

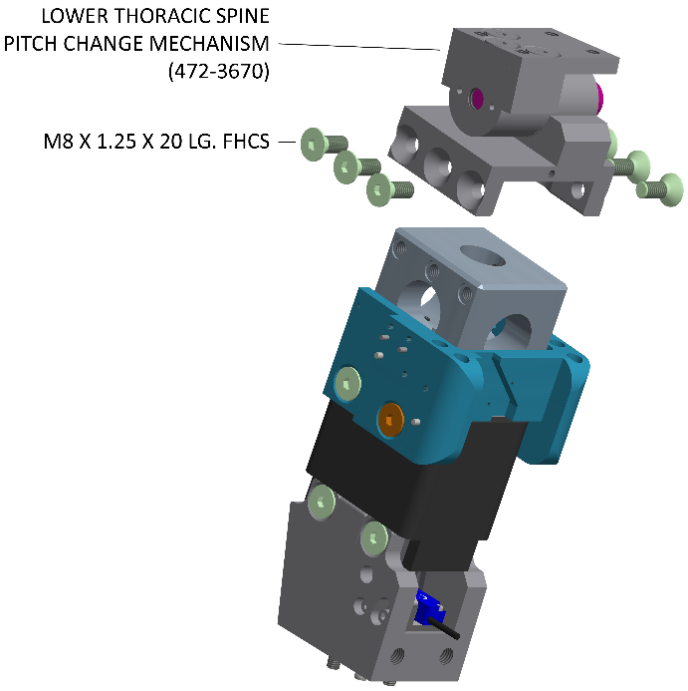

Figure 10.9 Lower Pitch Mechanism to T12 Load Cell

7. The head of the M12x60 SHCS adjustment bolt in the pitch change mechanism should be oriented to the right-hand side of the spine assembly.

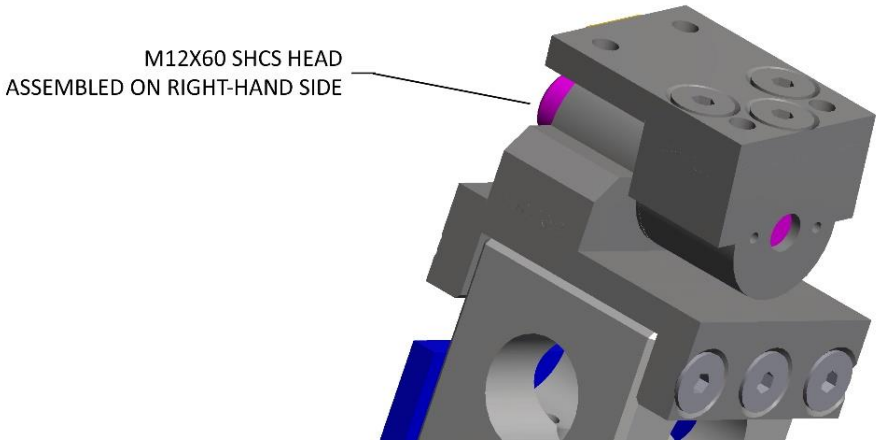

Figure 10.10 M12 x 60 SHCS Assembly on Right-Hand Side

8. The Lower Thoracic Spine Assembly (472-3655) is attached to the top plate of the Lower Thoracic Spine Pitch Change Mechanism using two M8x16 FHCS on right-hand side and two M8x12 FHCS on left-hand side, as shown in Figure 10.11.

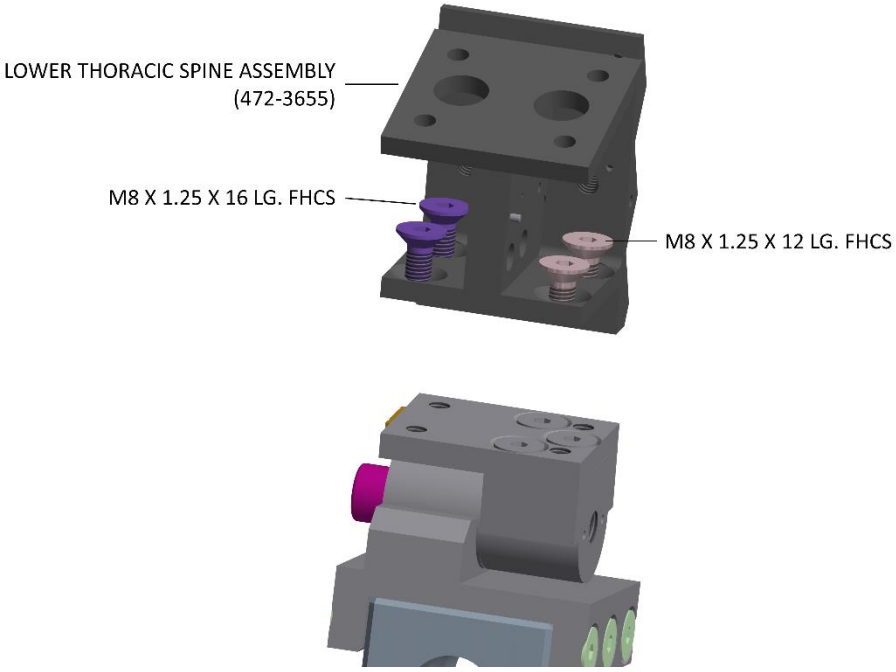

Figure 10.11 Attach Lower Thoracic Spine to Top Plate of Spine Pitch Change Mechanism

9. The Upper Thoracic Spine Flex Joint (472-3646) is attached to the Lower Thoracic Spine Assembly (472-3655) using four M6x12 SHCS. The flex joint must be oriented with the smaller bottom plate (472-3642) toward the Lower Thoracic Spine Assembly and the M5 tapped holes on the side closer to the front of the dummy, as shown in Figure 10.12.

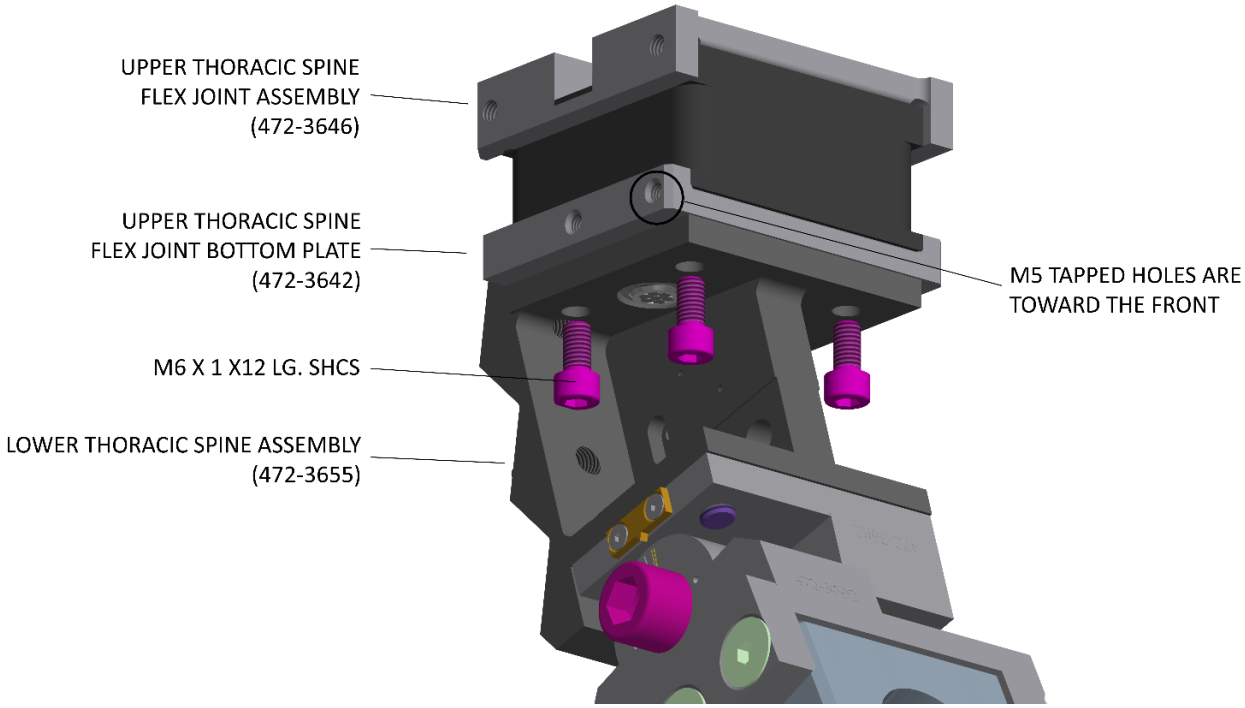

Figure 10.12 Upper Flex Joint Assembled to Lower Thoracic Spine Assembly

10. The Lower Thoracic Spine Tilt Sensor (IES1402) is attached on the Lower Thoracic Tilt Sensor Mount, and that assembly is attached to the left side of the spine to the Lower Thoracic Spine Assembly (472-3655) using two M3x12mm FHCS.

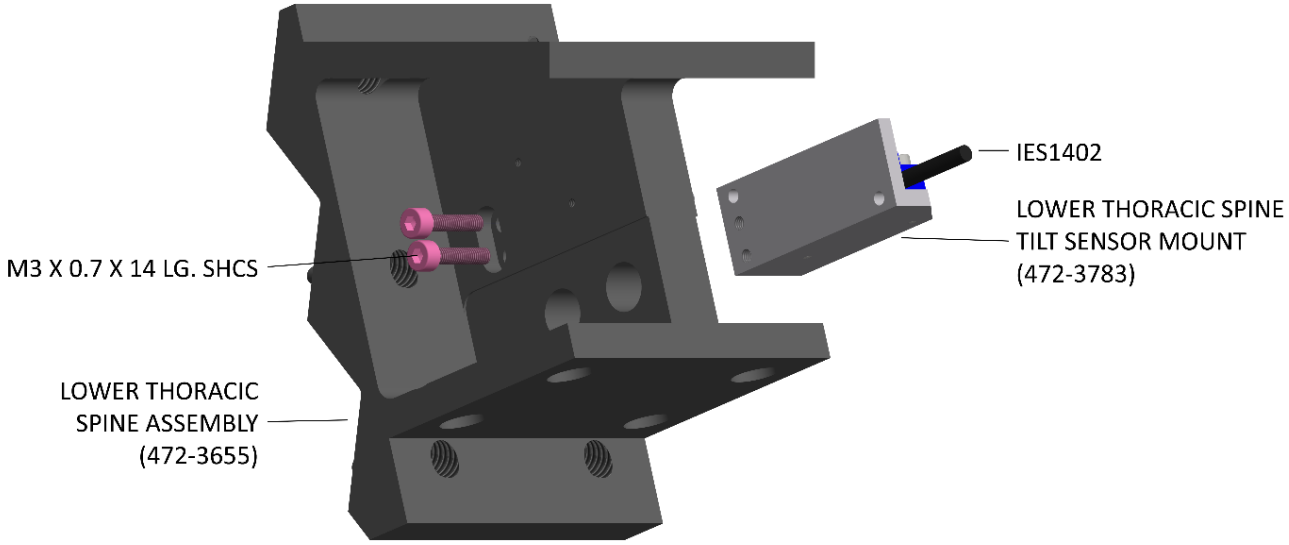

Figure 10.13 Lower Thoracic Spine Tilt Sensor Mount Assembled to Lower Thoracic Spine Assembly

11. Thoracic CG accelerometer tri-pack is attached to the Lower Thoracic Spine Assembly on the right side of the spine using two M2x16 SHCS.

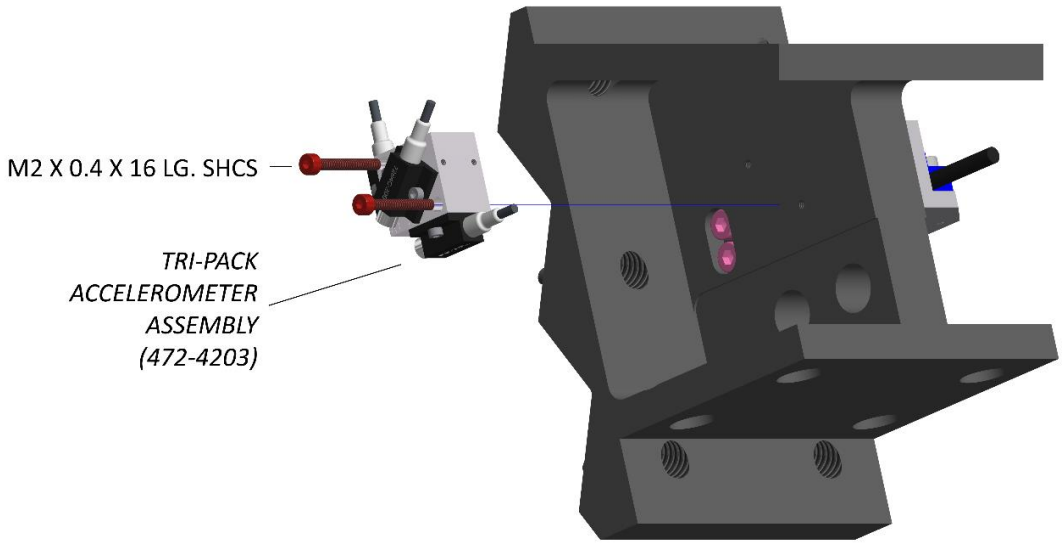

Figure 10.14 Tri-Pack Attached Using Two M2x16 SHCS

12. The Neck Tilt Sensor is attached to the Neck Pitch Change Mechanism Assembly (472-3630) using two M42x14 SHCS. See Figure 10.15.

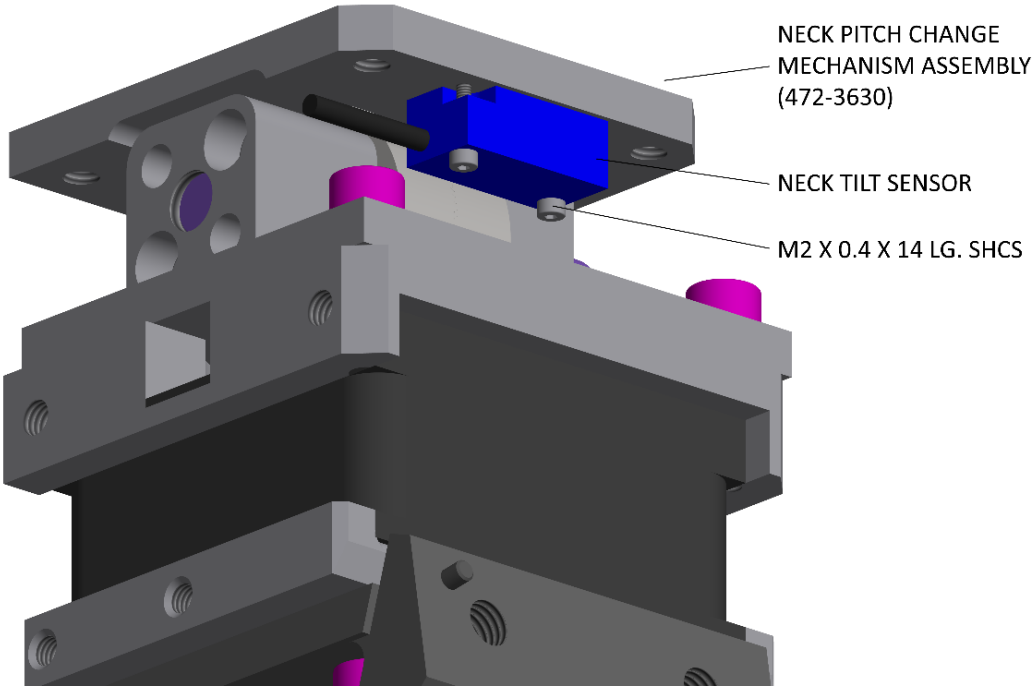

Figure 10.15 Attachment of Tilt Sensor to Neck Pitch Change Mechanism

13. The Neck Pitch Change Mechanism Assembly (472-3630) is attached to the Upper Thoracic Spine Flex Joint Assembly (472-3646) using four M6x12 SHCS. The pitch change mechanism must be oriented with the adjustment bolt toward the right side of the dummy, as shown in Figure 10.16. It may be necessary to loosen the pitch change mechanism to allow rotation of the upper plate, thus providing access to all the mounting holes.

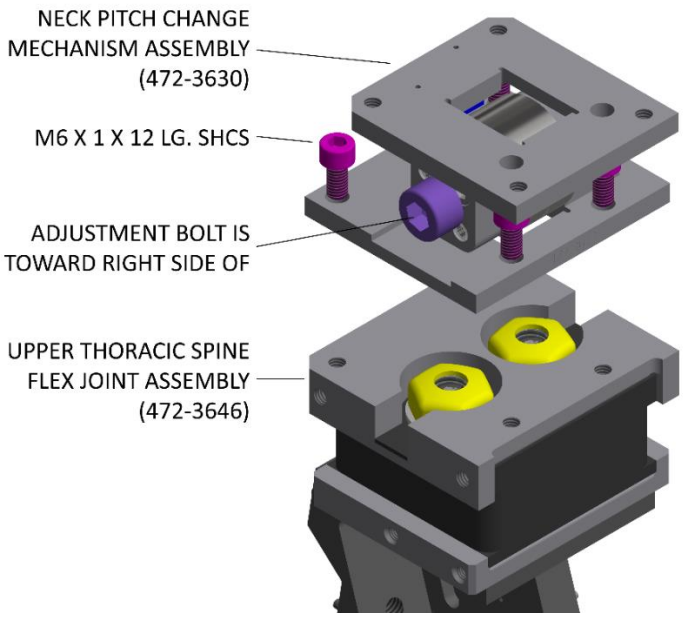

Figure 10.16 Neck Pitch Change Mechanism Assembled to Upper Flex Joint

14. The Upper Thoracic Spine Mechanical Assembly (472-3620-B) is attached to the Upper Thoracic Spine Flex Joint using four M6x10 FHCS, as shown in Figure 10.17.

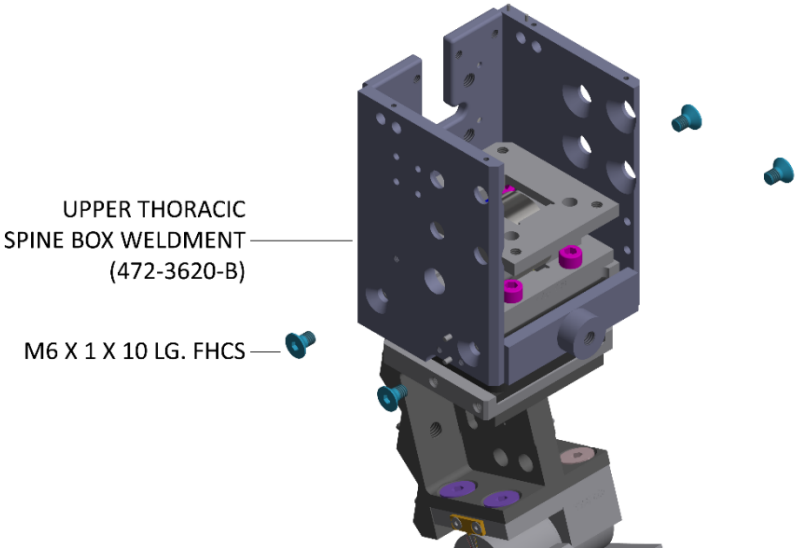

Figure 10.17 Complete Upper Thoracic Assembled to the Upper Flex Joint

10.2.3 **Assembly of the Spine to the Pelvis**

The following procedure is a description used to install the spine assembly to the completed pelvis assembly (472-4000). All bolts should be tightened to the torque specification provided in Section 2.1.3 Bolt Torque Values. **Note: In order to provide access to the mounting hardware, it is important to install the Pelvis/Lumbar Mounting Block Assembly to the Pelvis before building up the spine assembly.**

1. The Pelvis/Lumbar Spine Mounting Block Assembly (472-3675) is attached to the Pelvis Assembly (472-4200) using four M6x20 SHCS, as shown in Figure 10.18.

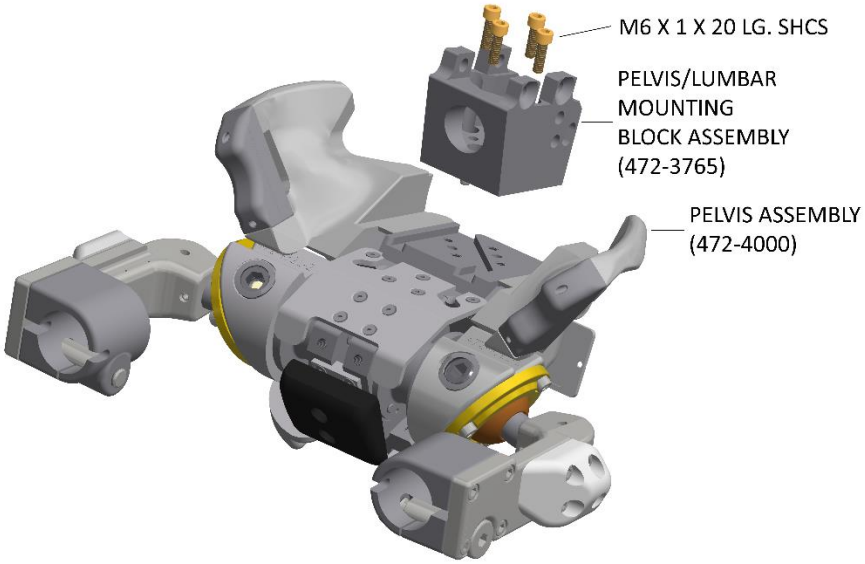

Figure 10.18 Attachment of Pelvis/Lumbar Mounting Block to Pelvis

2. The wires from the Pelvic Acetabular Load Cells need to be routed in the grooves provided in the pelvis assembly which lie under this mounting block's mounting surface.

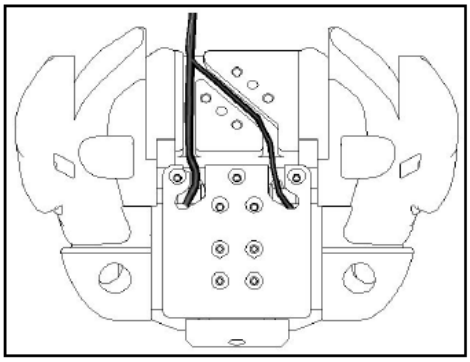

Figure 10.19 Acetabular Load Cells Wires Routing Under Pelvis/Lumbar Spine Mounting Block

10.2.4 **Assembly of the Neck to the Spine**

The following procedure is a step-by-step description used to install the neck assembly to the completed spine assembly at the top plate of the neck pitch change mechanism assembly (472-4300). All bolts should be tightened to the torque specification provided in Section 2.1.3 Bolt Torque Values.

1. Pass the Lower Neck Load Cell instrumentation wires up and out of the top of the spine assembly and clip at the left.

2. Secure the Lower Neck Load Cell to the Neck Pitch Change Mechanism Assembly (472-3630) using four M6 x 14 SHCS.

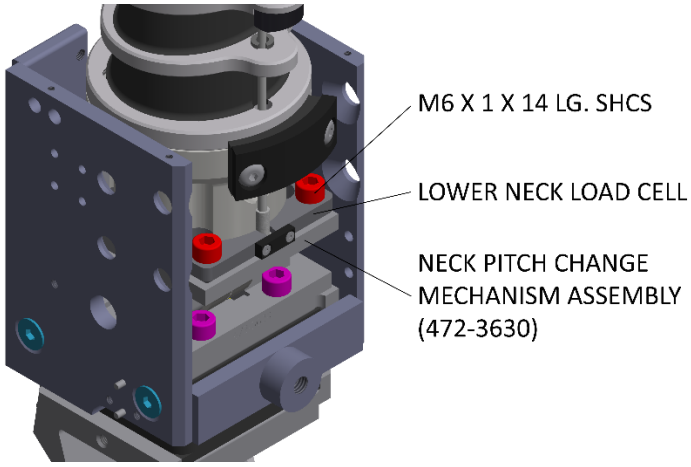

Figure 10.20 Secure Lower Neck Load Cell to Neck Pitch Change Mechanism Assembly

10.3 **Adjustments for the Spine Assembly**

10.3.1 **Adjustment Procedure for Lower Thoracic Spine Pitch Change Mechanism**

The following is a step-by-step procedure for adjusting the seating posture of the THOR-50M dummy using the Lower Thoracic Spine Pitch Change Mechanism. This adjustment changes the angle between the lumbar spine components and the lower thoracic spine components. The adjustment is made in three-degree increments by disengaging the teeth and rotating the two halves of the unit.

Disengage the teeth of the two halves of the “star-pattern” by loosening the central M12x60 SHCS thru bolt. This bolt can be accessed from the right-hand side of the dummy using the long “T-handle” Hex wrench. Unzip the right jacket zipper and insert the hex wrench into the bolt head, just below the level of rib #7. This bolt must be loosened enough to completely disengage the teeth from the mating halves of the “star-pattern”. **A visual inspection from the rear of the dummy may be made to determine if the teeth have been successfully disengaged.**

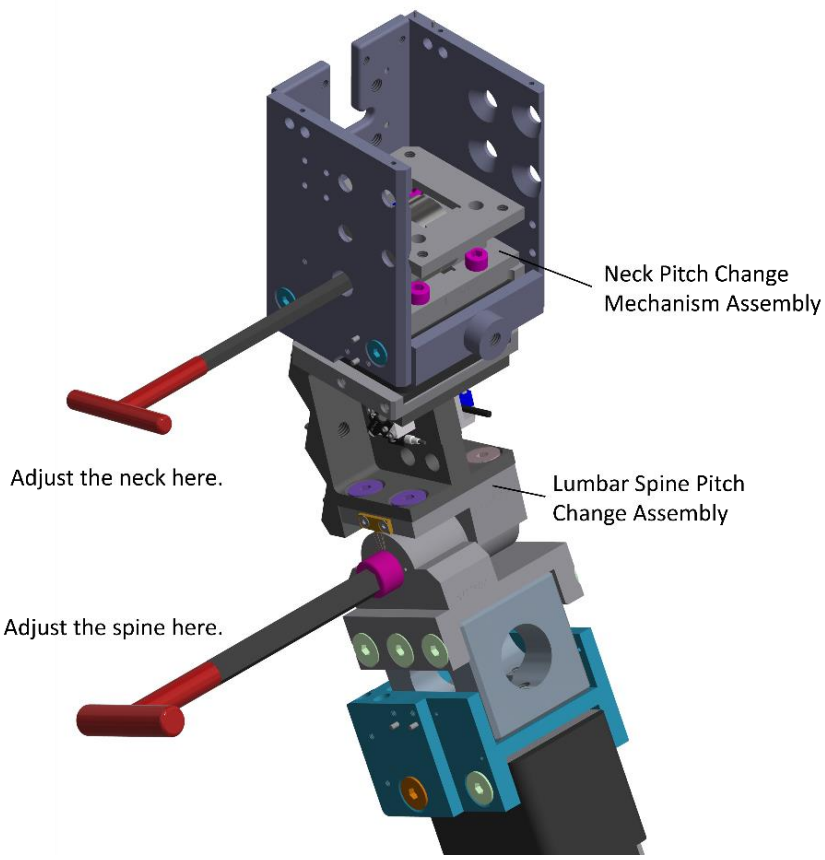

Figure 10.21 Lumbar Spine Adjustments

1. Adjust the posture to the desired setting by rotating the two halves of the pitch change mechanism with respect to one another. The desired posture setting can be determined by aligning the color coded marks on the right of the pitch change mechanism with the Lumbar Pitch Change Indicator (472-3713-A), as shown in Figure 10.22.

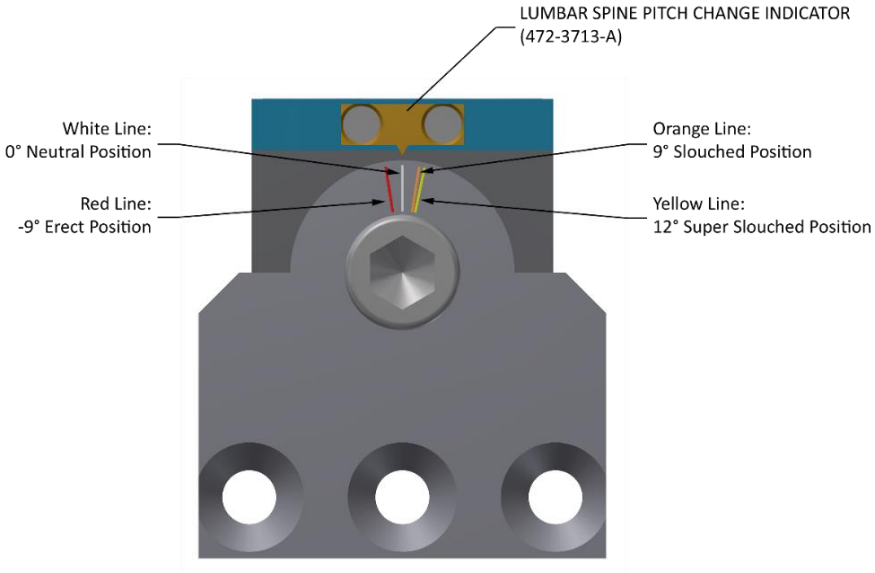

Figure 10.22 Adjustment Marks and Locations

2. Tighten the central M12x60 SHCS thru bolt to 68 Nm. to engage the teeth and lock the mechanism into place. **A visual inspection from the rear of the dummy is important to determine if the teeth have been successfully re-engaged, as the teeth are prone to damage.**

10.3.2 Adjustment Procedure for Neck Pitch Change Mechanism

The following is a step-by-step procedure for adjusting the head and neck position of the THOR-50M dummy using the Neck Pitch Change Mechanism. This adjustment changes the angle between the neck and the upper thoracic spine components. The adjustment is made in three-degree increments by disengaging the teeth and rotating the two halves of the unit.

1. Disengage the teeth of the two halves of the "star-pattern" by loosening the M10x55 SHCS as shown in Figure 10.23. This bolt can be accessed from the right side of the dummy using the long M8 "T-Handle" ball end Hex wrench. This bolt must be loosened enough to disengage the teeth from the mating halves of the "star-pattern". The head and neck will rotate freely fore and aft when the bolt is sufficiently loosened.

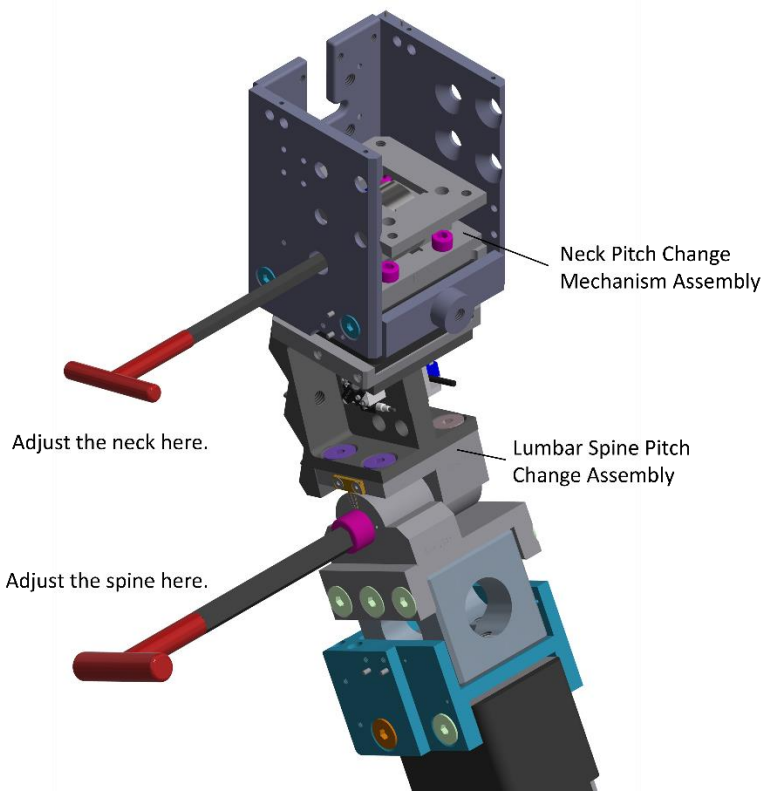

Figure 10.23 Neck Adjustments

2. Adjust the head and neck to the desired position by rotating the two halves of the pitch change mechanism with respect to one another. The desired posture setting can be determined by using the tilt sensors mounted on the neck pitch change mechanism and the Lower Thoracic Spine to determine the change in relative angle.

3. Tighten the central, M10x55 SHCD to a torque of 50.8 Nm. to engage the teeth and lock the mechanism into place. **A visual inspection is important to determine if the teeth have been successfully re-engaged, as the teeth are prone to damage.**

10.3.3 Adjustment Procedure for Tightening Flex Joint Cables

The adjustment procedure for correctly tightening the cables on the Upper Thoracic Joint (472-3646) and the Lumbar Spine Flex Joint (472-3746) is identical. Both joints use two 8mm steel cable assemblies which have a ball and shank on the one end and a M12 threaded swage on the other end. The cables for both units are oriented so that the ball and shank end are down (i.e. toward the pelvis) and the threaded end is up to allow access from the top. The only difference between these cable assemblies is the length: the lumbar cables are 71.1mm and the upper thoracic cables are 48.3mm. The cables must be adjusted so that they are snug (i.e. no slack in the cable), but the preload on the flex joint should be very minimal.

1. Insert the two cables through the holes provided in the flex joints. The threaded ends should exit from the top of the joints. Fasten each threaded end of the cable assemblies using a M12 Nylon Hex Nut and a steel washer.

2. Using a ¾" socket with a cutout to allow a wide chapman bit to hold the cable, tighten the nut onto the cable assemblies one half turn past contact between the nut and the top of the flex joint plate.

3. Cover the nuts and washers using the Upper Thoracic Spine Nut Cover (472-3647).

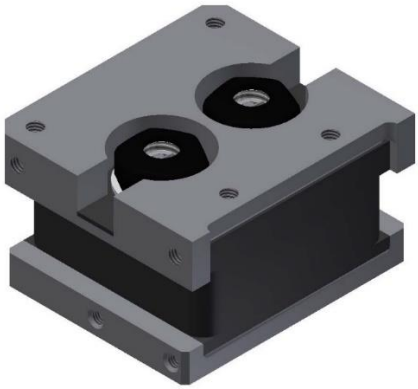

Figure 10.24 Tightening the Flex Joint Cables

10.4 Wire Routing and Electrical Connections

Note: Wire routing and strain relief can be completed per the customer's preference, the important aspect is to ensure that there is enough slack in the wires and that they are strain relieved in a location where they will not be damaged. The instructions below describe Humanetics' procedure.

The wire routing for the instrumentation on the spine assembly is fairly straightforward and each instrument in this assembly will be covered individually. It may also be necessary to refer to the Sections on the Thorax assembly and instrumentation to develop a complete understanding of these instrumentation systems. Refer to Figure 10.25 for a graphical representation of the wire routing for these instruments.

- **T1 tri-pack Accelerometer**: The wires follow the bundle down the left side of the spine and secured to the 3/16" clamp on the Lower Thoracic Tilt Sensor bracket.

- **Neck Tilt Sensor Assembly**: If wire is long enough, it is routed along the side of the neck pitch mechanism and is joined with the bundle of wires running down from the head and neck.

- **Thoracic (CG) Accelerometer**: These wires are strain relieved on the side of the Upper Thoracic Flex Joint Assembly using a ¼" coated clamp and M5x6 BHCS and exit between Ribs #4 and #5.

- **Lower Thoracic Spine Tilt Sensor Assembly:** This wire follows the left spine bundle.

- **Lumbar Spine Tilt Sensor Assembly:** This wire is bundled with the rest of the wires running down along the side of the spine.

- **T12 tri-pack Accelerometer**: The wires from this unit are routed to join the wires which run along the side of the spine.

- **Pelvic Tilt Sensor Assembly**: This wire is clamped by a ¼" coated clamp attached to the 472-4761-A, using the button head that holds the thoracic grounding cable.

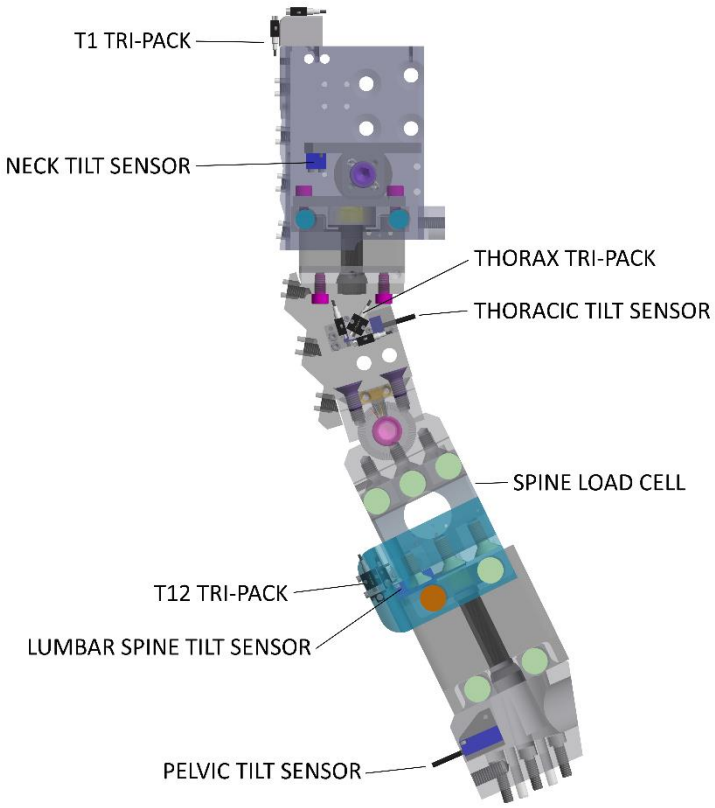

Figure 10.25 Spine Instrumentation Wire Routing

All the above wires get strain relieved at the base at the lumbar spine flex joint assembly, see Section 10.3.3, Adjustment Procedure for Tightening Flex Joint Cables for further details.

10.5 Calibration of Thoracic Spine Load Cell

The Thoracic Spine Load Cell is recommended for recalibration at yearly intervals. In addition to the recommended recalibration interval, recalibration is required if the “zero load” output signal from the unloaded load cell is significantly different than that stated on the calibration sheet.

10.6 Inspection and Repairs

After a test or test series has been performed, there are several inspections which need to be made to ensure that the dummy integrity has remained intact. These inspections include both electrical and mechanical inspections. This inspection is most easily carried out during a disassembly of the dummy. The disassembly of the spine components can be performed by simply reversing the procedure used during the assembly.

10.6.1 **Electrical Inspections (Instrumentation Check)**

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the spine instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

10.6.2 **Mechanical Inspection**

Several components in the spine assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below.

Neck Pitch Change Mechanism: The following checklist should be used when inspecting the dummy's neck pitch change mechanism for post-test damage:

- ✓ The assembly should be inspected to ensure that the teeth of the mating "star-patterns" are still engaged and held tightly against one another. If the teeth are loose, the mechanism must be disassembled and inspected for damage to the mating teeth.
- ✓ The center adjusting bolt should be checked for a proper torque of 50.8 Nm.

Upper Thoracic Spine Flex Joint: The following checklist should be used when inspecting the dummy's upper thoracic flex joint for post-test damage:

- ✓ The unit should be inspected for proper cable tension as describe in Section 10.3.3, Adjustment Procedure for Tightening Flex Joint Cables.
- ✓ Inspect for debonding between the metal plates and the urethane. If there is evidence of severe debonding (greater than 3mm of debonding along a surface), the unit should be replaced.

Lower Thoracic Spine Pitch Change Mechanism: The following checklist should be used when inspecting the dummy's lower thoracic spine pitch change mechanism for post-test damage:

- ✓ This assembly should be inspected to ensure that the teeth of the mating "star-patterns" are still engaged and held tightly against one another. If the teeth are loose, the mechanism must be disassembled and inspected for damage to the mating teeth.
- ✓ The M12x60 SHCS center bolt should be checked for a proper torque of 68 Nm.

Lower Thoracic Spine Flex Joint: The following checklist should be used when inspecting the dummy's lower thoracic spine flex joint for post-test damage:

- ✓ This unit should be inspected for proper cable tension as described in Section 10.3.3, Adjustment Procedure for Tightening Flex Joint Cables.

- ✓ Inspect for debonding between the metal plates and the urethane. If there is evidence of severe de-bonding (greater than 3mm of debonding along a surface), the unit should be replaced.

Section 11. **Upper Abdomen Assembly**

11.1 **Description of Upper Abdomen Assembly and Features**

The Upper abdomen is the region on the dummy that represents the lower thoracic cavity. Physically, this component fills the volume that exists between the lowest three ribs, above the lower abdomen and in front of the spine. The component is primarily constructed of deformable materials to produce a compression response similar to human cadaver test data. Instrumentation is incorporated into the component to measure the impact acceleration. An ISO view of the complete upper abdominal assembly is provided in Figure 11.1.

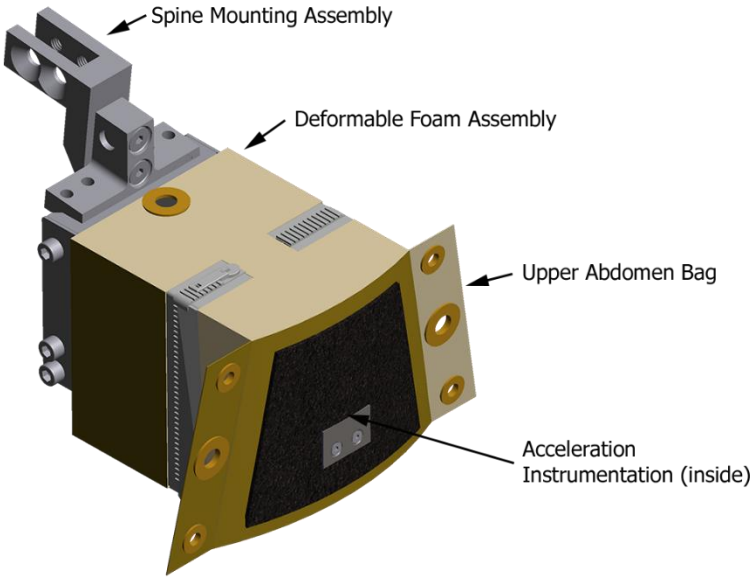

Figure 11.1 Upper Abdomen Assembly

The upper abdomen assembly consists of a Cordura nylon bag that encloses a series of layered foams. Two flaps extend laterally from the front surface of the upper abdomen to allow it to be bolted to the ribs and bib layers. A zipper provides access to the interior of the bag for inspecting the foams and instrumentation. There are three different layers of foam that are used to obtain the proper compression response.

There is a uniaxial accelerometer that is mounted onto a Delrin block on the front surface of the Upper Abdomen bag assembly. The mounting surface has been cut to roughly direct the active axis of the accelerometer in the –X direction. This sensor measures the acceleration generated during impacts by objects, such as an airbag or a loose shoulder belt slapping against the upper abdomen of the dummy.

11.2 Assembly of the Upper Abdomen

11.2.1 Parts List

Below is an exploded view of the upper abdomen assembly, 472-4600, and hardware.

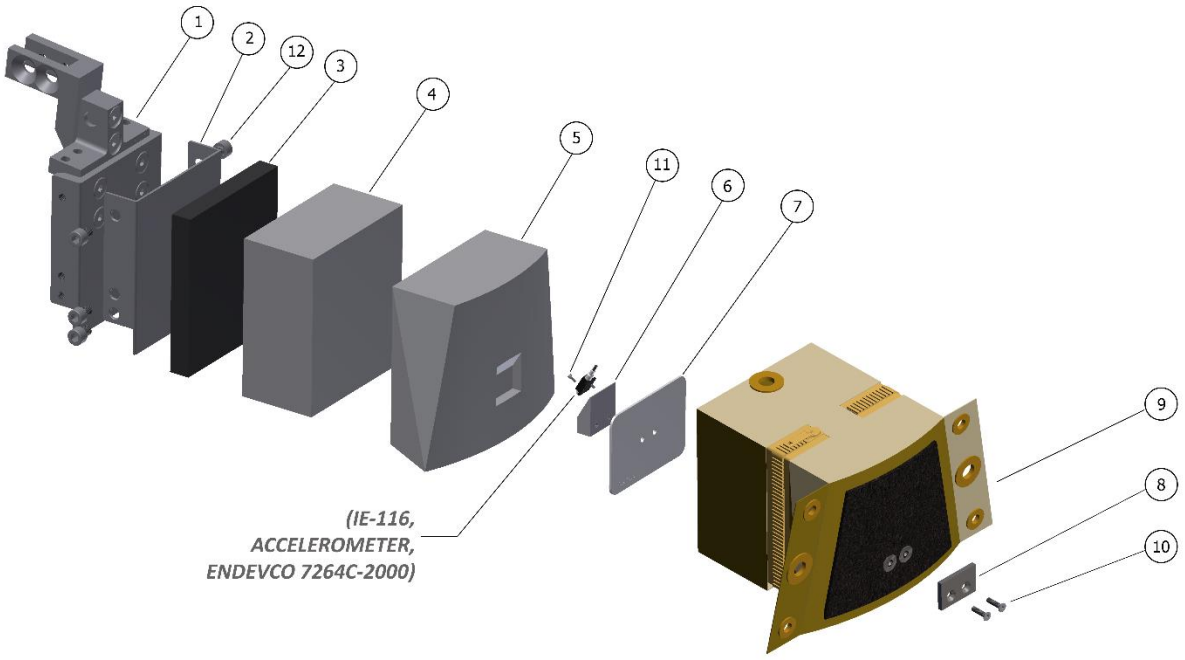

Figure 11.2 Upper Abdomen Assembly Exploded View

Table 11-1 Upper Abdomen Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-4610	SPINAL MOUNT BRACKET ASSEMBLY
2	1	472-4620	UPPER ABDOMEN INTERNAL MOUNT PLATE FRONT
3	1	472-4621	INTERNAL FOAM REAR LAYER
4	1	472-4628	INTERNAL FOAM MIDDLE LAYER
5	1	472-4623	INTERNAL FOAM FRONT LAYER
6	1	472-4624	ACCELEROMETER MOUNT, UPPER ABDOMEN
7	1	472-4625	LOAD DISTRIBUTION PLATE
8	1	472-4626	ACCELEROMETER MOUNT PLATE
9	1	472-4627-A	GROMMET ASSEMBLY, UPPER ABDOMEN BAG
10	2	5000377	M3 X 0.5 X 12 LG. FHCS SS
11	2	5000375	M1.4 X 0.3 X 4 LG. SHCS
12	6	5000085	M6 X 1 X 8 LG. SHCS

11.2.2 **Assembly of Upper Abdomen Components**

The following procedure is a step-by-step description of the assembly procedure for all of the upper abdomen components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Slip the Internal Mounting Plate (472-4620) through the slits in the Bag Assembly (472-4627-A) shown in Figure 11.3.

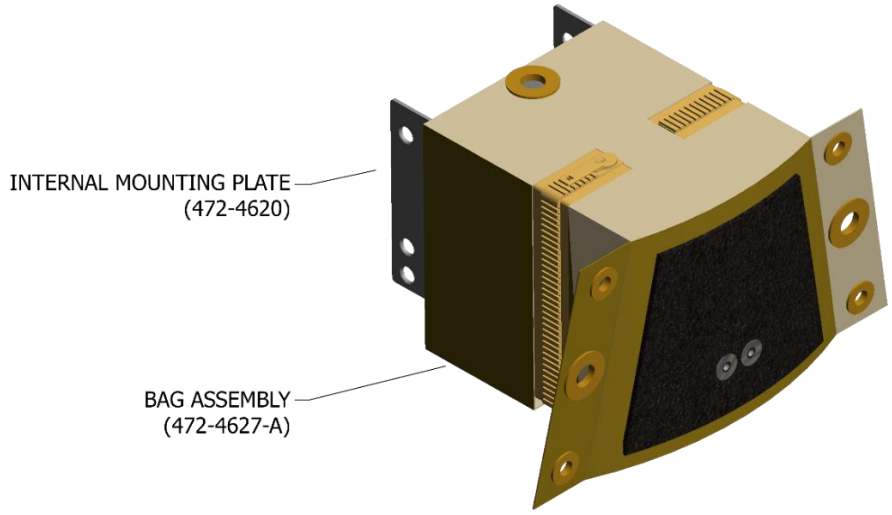

Figure 11.3 Fabric Bag Assembled to Mounting Plate

2. Insert the Rear Foam Layer (472-4621) into the bag. Ensure that the orientation of the layer matches the dimensions of the Internal Mounting Plate.

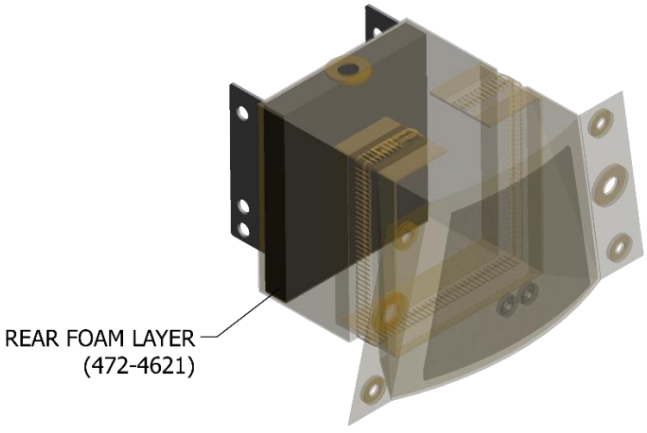

Figure 11.4 Rear Foam Layer Inserted into Bag

3. The Upper Abdomen can be instrumented with a uniaxial accelerometer 2000g to measure the acceleration of the bag face during impact. Mount the Uniaxial Accelerometer to the Accelerometer Mount (472-4624) using two M1.4x4 SHCS as shown in figure below. The electrical cable from the uniaxial accelerometer unit should be oriented toward the narrow end of the Accelerometer Mount wedge.

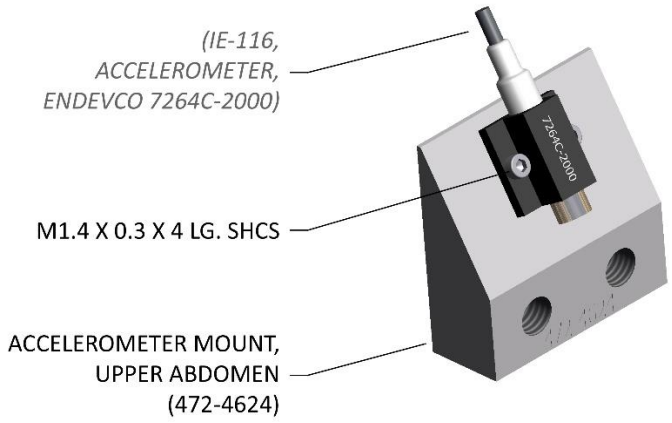

Figure 11.5 Uniaxial Accelerometer on Accelerometer Mount

4. Thread the accelerometer's electrical cable above the foam layers in the bag assembly and through the small hole at the rear of the top of the bag from the inside to the outside.

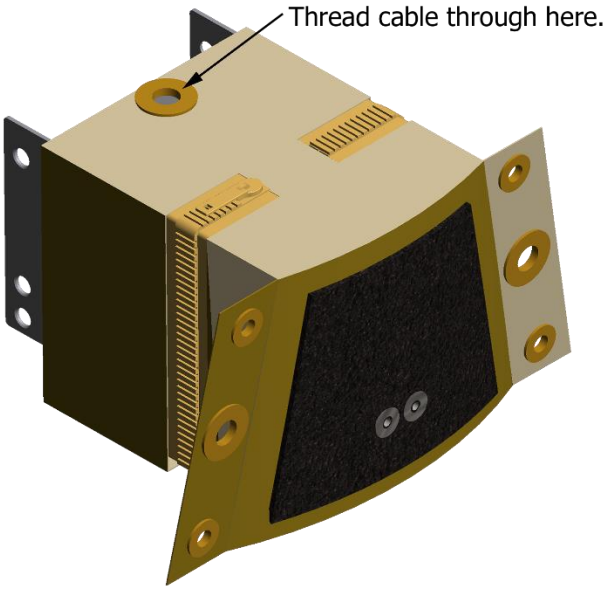

Figure 11.6 Accelerometer Wire Routing

5. Place two M3 x 12 FHCS through the holes in the Accelerometer Mount Plate (472-4626). Align the bolts with the holes on the front of the Upper Abdomen bag and push the bolts through the holes.

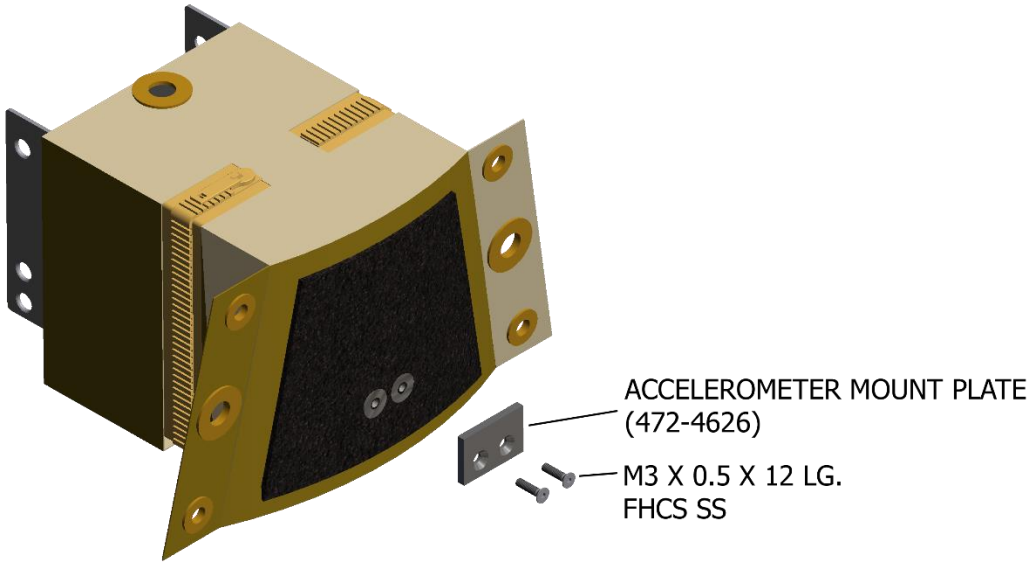

Figure 11.7 Accelerometer Mounting Plate

6. Position the Load distribution Plate (472-4625) on the inside front surface of the Upper Abdomen Bag and push the holes of the plate onto the protruding bolts from Step 5, as shown in Figure 11.8.

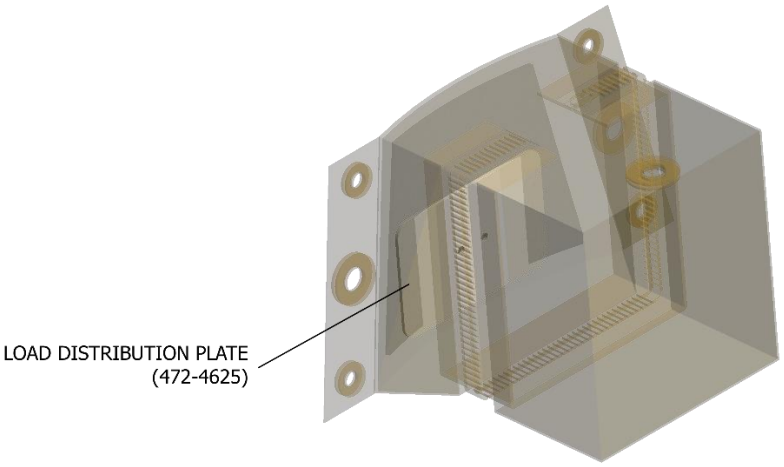

Figure 11.8 Load Distribution Plate Inside of Bag

7. Align the bolts with the threaded holes in the Accelerometer Mount and thread the M3 bolts from the front plate into the corresponding threaded hole of the Accelerometer Mount. Repeat this step for the second bolt after the first bolt has been secured. Position the Front Foam Layer (472-4623), so that the notch cut in the front of the foam is placed on the angled surface of the Accelerometer Mount as shown in Figure 11.9.

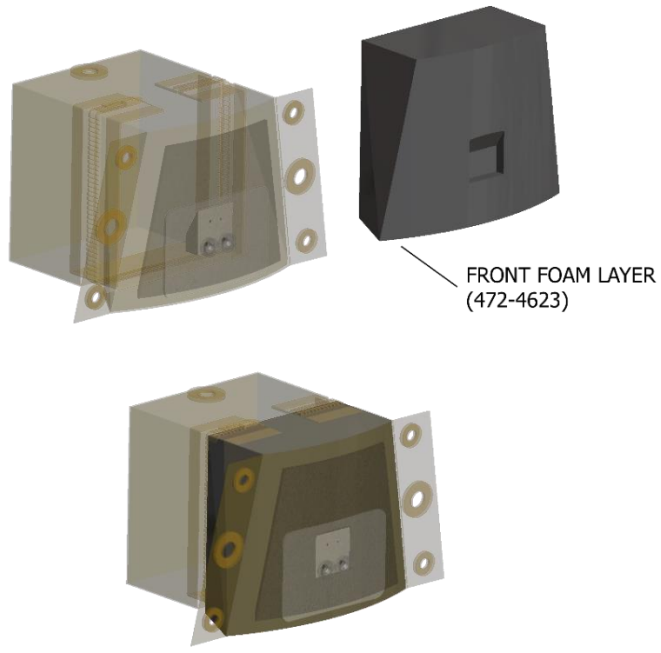

Figure 11.9 Front Foam Layer Inserted into Bag After Attachment of Accelerometer Mount

8. Insert the Middle Foam Layer (472-4628), such that the wider end is lined up with the wider part at the front of the bag. The foam will have to be pushed in during the procedure.

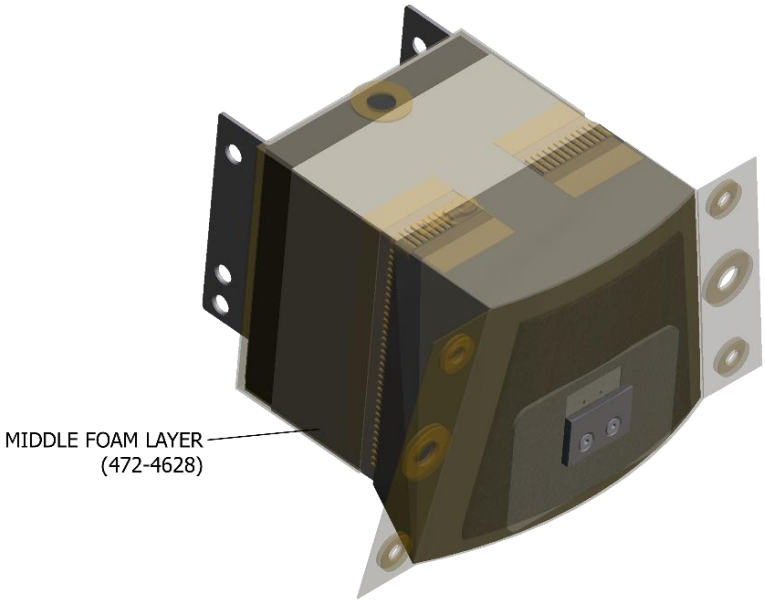

Figure 11.10 Middle Foam Layer Inserted into Bag

9. Close the front and rear flaps of the bag, making sure that the rear foam layer does not get displaced. The zipper half on the rear flap will be pulled over the middle foam layer (472-4628). Close the zipper. Figure 11.11 shows the Upper Abdomen Spinal Mount Assembly (472-4610) inserted into the rear of the Internal Mounting Plate (472-4620).

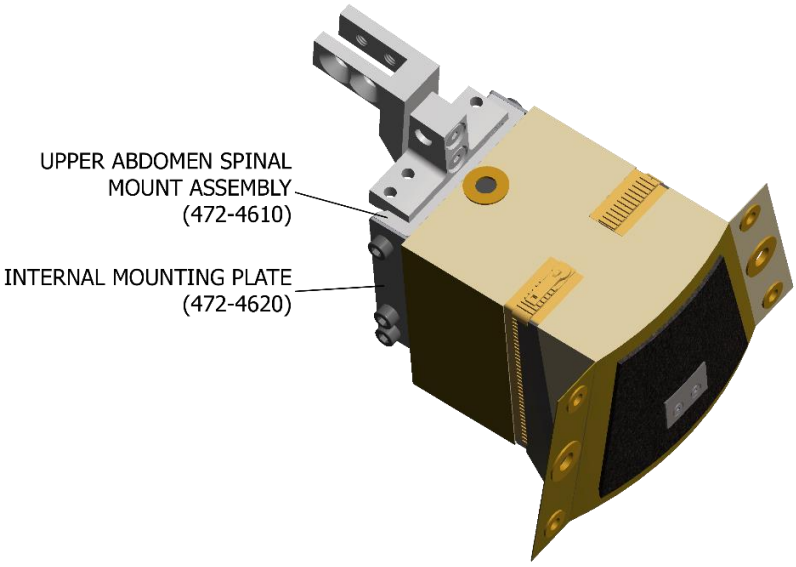

Figure 11.11 Bag Attached to Spine Mounting Bracket

11.2.3 **Assembly of Upper Abdomen into THOR-50M**

The following procedure is a step-by-step description of the assembly procedure used to attach the upper abdomen to the completed thorax assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values. The upper abdomen can be installed either before or after the thorax assembly is complete. This procedure assumes that the spine of the dummy with the ribs and bib is already assembled and that ribs #5, 6, and 7 are not attached to the bibs.

1. Loosen the center bolt of the Lower Thoracic Spine Pitch Change Mechanism (472-3670) as described in Section 10.3.1, Adjustment Procedure for Lower Thoracic Spine Pitch Change Mechanism. Rotate the upper thorax and spine rearwards to open the thoracic cavity and allow easy access. This will provide space between the upper and lower abdomen assemblies.
2. Position the Spinal Mounting Bracket arms on either side of the Lower Thoracic Spine Weldment and carefully slide the Upper Abdomen into the dummy's thorax.
3. Align the holes and fasten the Spinal Mounting Bracket to the Lower Thoracic Spine Weldment using two M8x25 FHCS into the two mounting holes in the Spinal Mounting Bracket arms from the right side, as shown in Figure 11.12.

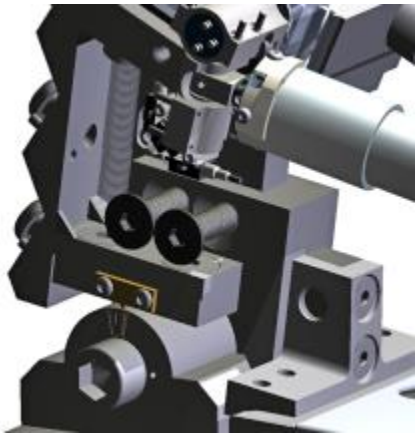

Figure 11.12 Upper Abdomen Mounting to Spine

4. Insert the U-Joint of each lower IR-TRACC unit through the 3/8" holes of rib #6. Then pass the U-Joint through the 3/8" grommet of the upper abdomen flaps. Push the separate layers of the bib over the end of the U-Joint. Screw the Rib Connecting Bolt into the U-Joint to secure the upper abdomen and the bib layers together. For additional details, refer to Section 7, Thorax Assembly.
5. Readjust the Lower Thoracic Pitch Change Mechanism to the desired setting, Section 10.3.1, Adjustment Procedure for Lower Thoracic Spine Pitch Change Mechanism.

6. After the installation of the lower abdomen is complete, cover the front surfaces of the upper and lower abdomen assemblies with the Upper and Lower Abdomen Velcro Cover as shown in Figure 11.13.

Figure 11.13 Proper Location of Upper and Lower Abdomen Cover

11.3 Adjustments for the Upper Abdomen Assembly

The upper abdomen assembly does not require any adjustments for testing.

11.4 Wire Routing and Electrical Connections

The upper abdomen has one primary instrument: the uniaxial accelerometer. The instrument wire from the mid-sternum uniaxial accelerometer is routed with the upper abdomen instrumentation.

Upper Abdomen Uniaxial Accelerometer: This wire is routed through the upper abdomen bag and is used to the top of the bag with a strip of Velcro. The wire from the mid-sternum uniaxial accelerometer is bundled with this wire and secured to the same Velcro strip. These wires are then routed to the left of the spine and secured to the same wire clamp as the Left Side upper thoracic IR-TRACC. Finally, the wires exit the thorax to join the other wires running down the spine.

IR-TRACC: The wires from the upper and lower units are strain relieved with a wire clamp attached to each side of the Upper Abdomen Spine Mount (472-4610) with a M6 BHCS. The wires are then routed on the left and right sides of the spine assembly and exit the thorax below rib #7 to join the bundle of wires running down the dummy's spine.

Mid-sternum Uniaxial Accelerometer: Bundle the instrument wire from the mid sternal uniaxial accelerometer with the upper abdomen uniaxial accelerometer wire. Pass these wires around the left side of the spine and secure it into the wire clamp, located on the upper abdomen assembly, used to fasten the upper and lower left IR-TRACC wires. The cables are routed out the left side of the dummy to join the bundle of cables running down the spine.

11.5 Upper Abdomen Qualification

Qualification procedures for the upper abdomen are described in the THOR-50M Qualification Procedures Manual as a separate publication.

11.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgement should be used to determine the frequency of these inspections; however, a thorough inspection is recommended after twenty tests have been performed. Inspection frequency should increase if the tests are particularly severe or unusual data signals are being recorded. These inspections include both electrical and mechanical inspections. These inspections are most easily carried out during dummy disassembly. Disassembly of the upper abdomen components can be performed by simply reversing the assembly procedure.

11.6.1 **Electrical Inspections (Instrumentation Check)**

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the upper abdomen instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure they are properly strain relieved. A more detailed check on the individual instruments will be covered in

11.6.2 **Mechanical Inspection**

Several components in the upper abdomen assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below.

Bag and Zipper Inspection: The following checklists should be used when inspecting the dummy's upper abdomen bag and zipper for post-test damage.

- ✓ Check the bag for tears, cuts and broken stitches. Repair or replace as necessary.

Foam Inspection: The following checklist should be used when inspecting the dummy's upper abdomen foam for post-test damage.

- ✓ Check the foam for tearing, rips, and permanent compression.

Section 12. **Lower Abdomen Assembly**

12.1 **Description of the Lower Abdomen Assembly and Features**

The lower abdomen is defined as the region of the human body between the lower thoracic rib cage and the pelvic girdle. The component is primarily constructed of deformable materials to produce a compression response similar to human cadaver test data. This region of the dummy is subjected primarily to belt loading, however interaction with the steering wheel and airbag is also possible. Instrumentation has been incorporated into the lower abdomen assembly to measure the three-dimensional displacement of the region at two distinct points. Figure 12.1 shows the complete lower abdomen assembly.

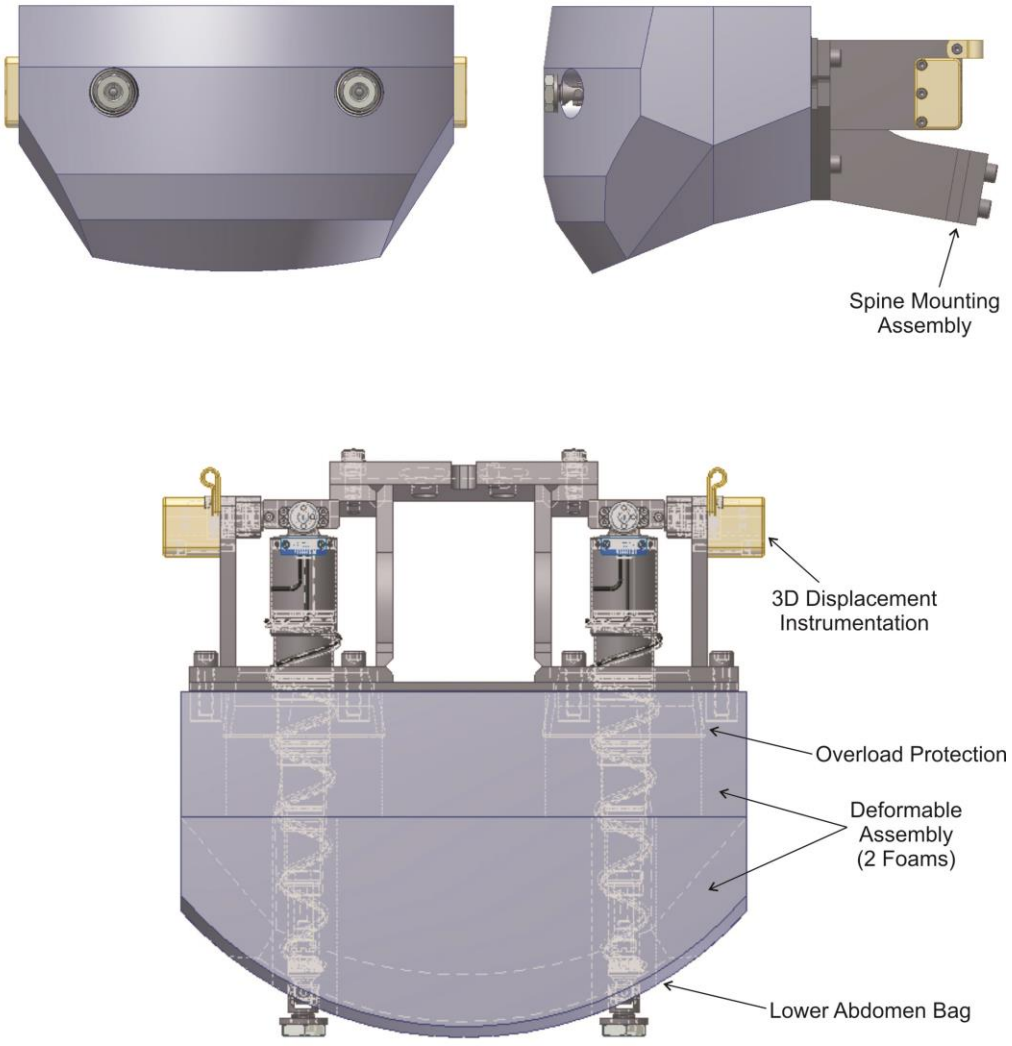

Figure 12.1 Lower Abdomen Assembly

The lower abdomen assembly consists of a Cordura nylon bag that encloses a series of layered foams, which have been contoured to the geometry of the abdominal section. The Cordura is a very durable fabric and the seams of the bag are sewn with a Kevlar thread to prevent tearing. A zipper provides access to the interior of the bag for inspecting the foams and instrumentation. There are two different layers of foams that are used to obtain the proper compression response. Two holes are cut through each layer to allow the IR-TRACC units to pass through to the front cover. The lower abdomen assembly is secured to the base of the spine assembly through a series of mounting plates which rest on either side of the lumbar spine region.

The instrumentation for the lower abdomen unit consists of two IR-TRACC units. These units provide complete deflection data for the assembly at distinct points on the abdominal surface during the impact event. The operation and function of these units are covered in greater detail in Section 17 Instrumentation and Wiring.

12.2 Assembly of the Lower Abdomen

12.2.1 Parts list

Figure 12.2 is an exploded view of the lower abdomen assembly, 472-4700.

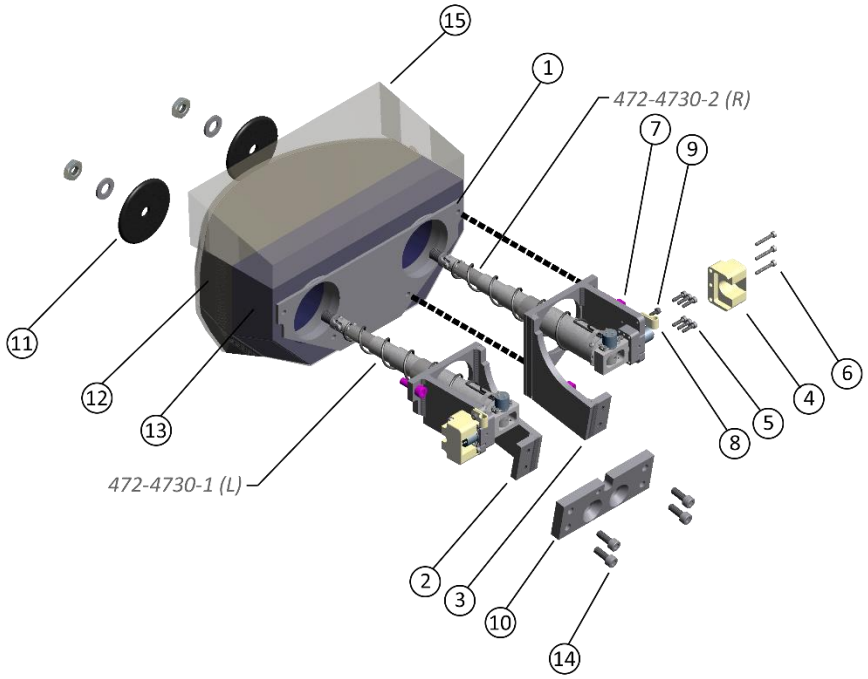

Figure 12.2 Lower Abdomen Exploded View

Table 12-1 Lower Abdomen Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-4710	INTERNAL MOUNTING WELD ASSEMBLY
2	1	472-4720-1-B	ATTACH BRACKET WELD ASSEMBLY, LEFT
3	1	472-4720-2-B	ATTACH BRACKET WELD ASSEMBLY, RIGHT
4	2	472-4760	POTENTIOMETER COVER
5	8	5001103	M3 X 0.5 X 12 LG. SHCS
6	6	5000312	M3 X 0.5 X 20 LG. SHCS
7	4	5000001	M6 X 1 X 20 LG. SHCS
8	2	6004191	3/16 CABLE CLAMP
9	2	5000388	M3 X 0.5 X 8 LG. SHCS
10	1	472-4761-A	REAR ATTACHMENT PLATE
11	2	472-4762	LOWER ABDOMEN DISTRIBUTION PLATE
12	1	472-4764	LOWER ABDOMEN FRONT FOAM LAYER
13	1	472-4766	LOWER ABDOMEN REAR FOAM LAYER
14	4	5000081	M6 X 1 X 16 LG. SHCS
15	1	472-4763-A	LOWER ABDOMEN SEWING ASSEMBLY

12.2.2 **Assembly of the Lower Abdomen Components**

The following procedure is a step-by-step description of the assembly procedure for all of the Lower abdomen components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Position the Internal Mounting Welded Assembly (472-4710) into the interior of the Lower Abdomen Sewing Assembly (472-4763-A). Insert the Lower Abdomen Rear Foam Layer, 472-4766, inside the Lower Abdomen Bag, 472-4763-A. Then attach the Lower Front Foam Layer, 472-4764, to the Rear Foam, 472-4766, using double sided tape. Cover the entire rear surface of 472-4764 with tape strips and cut out Ø21.1 hole and assemble to the front surface of 472-4766.

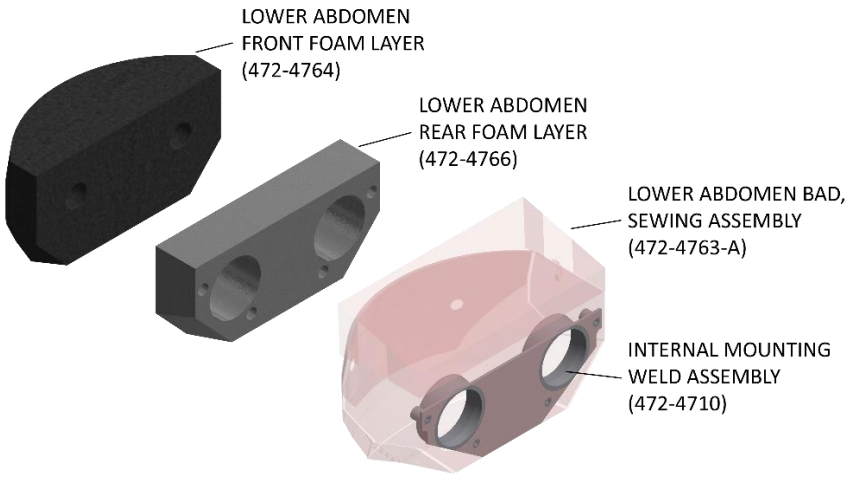

Figure 12.3 Internal Mounting Weld Assembly Positioned Properly Inside of the Bag

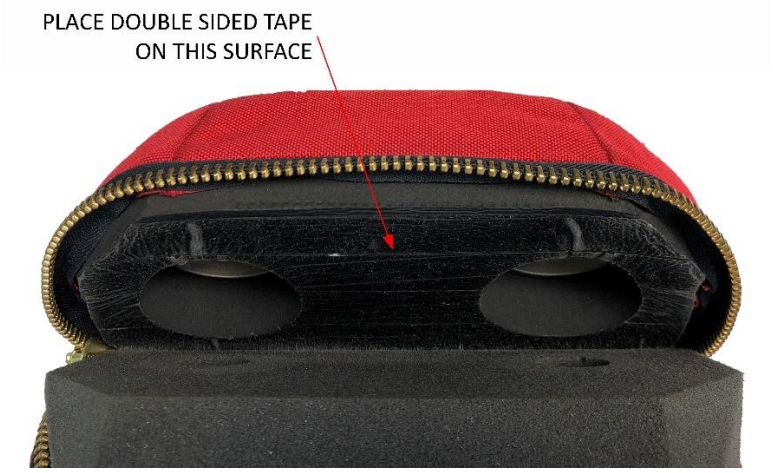

Figure 12.4 Internal Mounting Weld Assembly Positioned Properly Inside of the Bag

2. Secure the Left Attachment Bracket (472-4720-1-B) to the left rear side of the lower abdomen assembly using two M6 X 1 X 16 LG. SHCS. Secure the Right Attachment Bracket (472-4720-2-B) to the right rear side of the lower abdomen assembly using two M6 X 1 X 16 LG. SHCS.

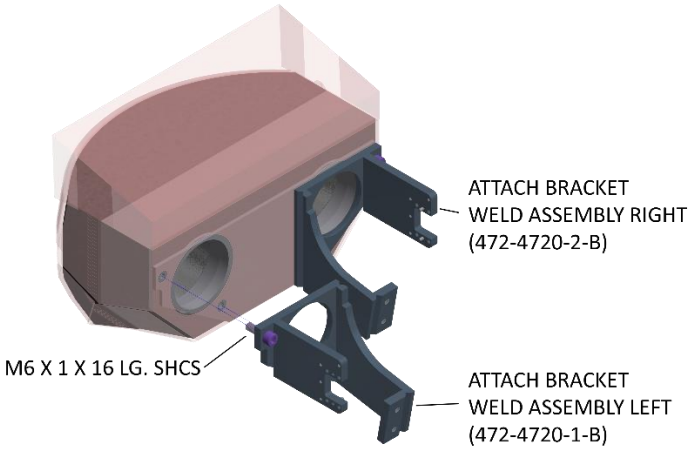

Figure 12.5 Left Attachment Bracket Assembled to Internal Plate

3. Check the IR-TRACC units for calibration date, if a calibration is due, the units must be calibrated prior to assembly.
4. The IR-TRACC sensors used in the Lower Abdomen right and left sides are the same.
5. Attach the 3D IR-TRACC assembly to the Attachment Bracket Weld Assembly (472-4720-1-B, left; 472-4720-2-B, Right) using four M3 x 12 SHCS, each side.

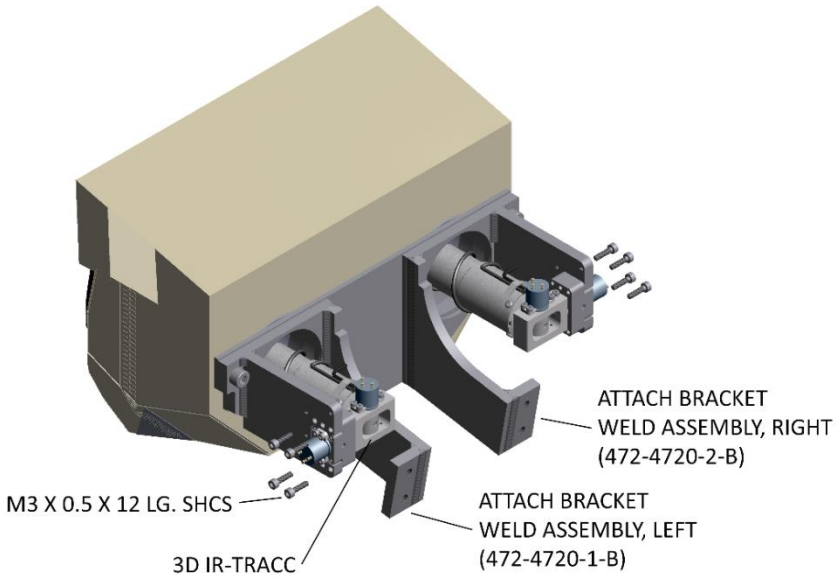

Figure 12.6 Attach 3D IR-TRACC with M3 X 0.5 X 12 LG. SHCS

6. The Potentiometer Cover attaches to the Attachment Bracket Welded Assembly using three M3 x 20 SHCS.

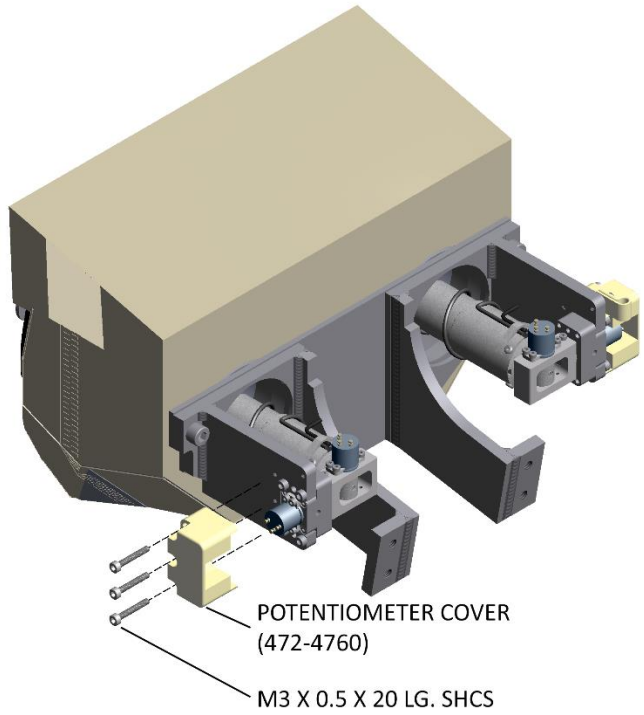

Figure 12.7 Attach the Potentiometer Cover Using M3 X 0.5 X 20 LG. SHCS

7. Secure the three cables from each 3D IR-TRACC assembly in the 3/16” cable clamp on each Attachment Bracket.

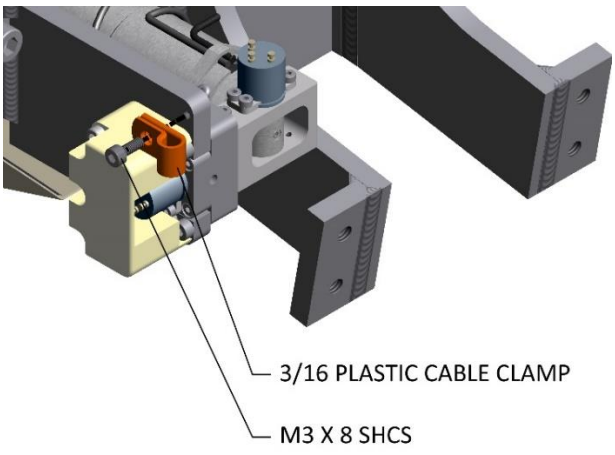

Figure 12.8 Secure Cable Clamp with a M3 X 8 SHCS – CAD Model

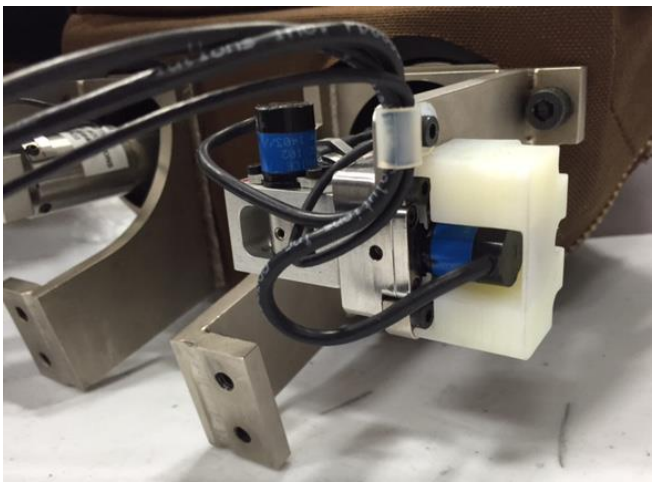

Figure 12.9 Secure Cable Clamp with a M3 X 8 SHCS – Physical Model

8. Line up the four, 1/2" diameter bores in the Rear Abdominal Foam Layer (472-4766) with the posts protruding from the inside face of the Internal Mounting Plate. Position the front of the U-joints attached to the IR-TRACC assemblies within the opening of the cones and the hole in the foam. Press the rear layer of foam over the cones and against the Internal Mounting Plate, as shown in Figure 12.10. The foam should be on the inside of the abdominal bag.

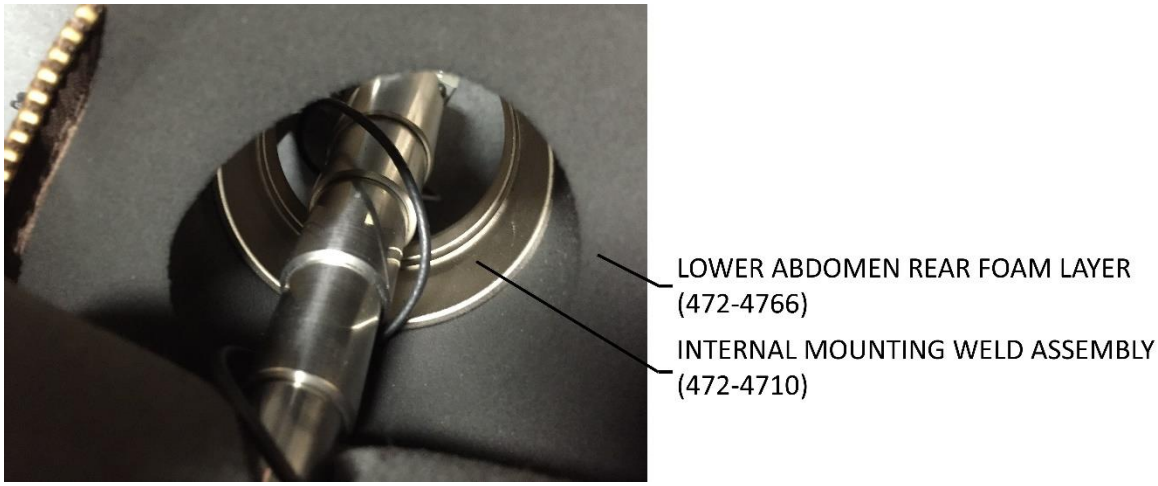

Figure 12.10 Rear Foam Layer Inserted into Bag

9. Examine the Front Abdominal Foam Layer (472-4764), position the flat face against the exposed surface of the rear foam layer. Route the U-joint through the hole in the front layer.

Figure 12.11 Internal Front Foam Layer

10. Place a Load Distribution Plate (472-4762) over the front of the U-joint as shown in Figure 12.12. The small counter bore in one side of the distribution plate must be oriented toward the IR-TRACC assembly. These load distribution plates will rest inside the Lower Abdomen Bag and distribute the impact force over a larger area of the foam.

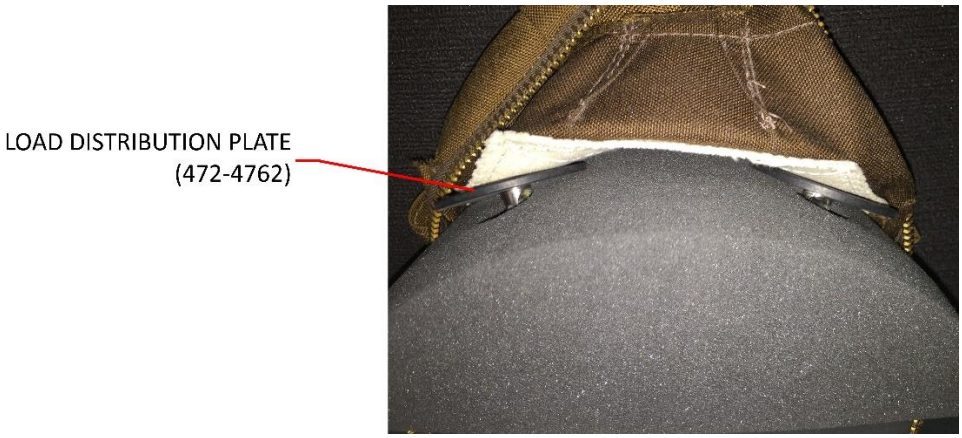

Figure 12.12 Load Distribution Plate over U-Joint End

11. Thread each IR-TRACC assembly U-joint through their respective holes in the front of the abdominal bag.
12. Close the Lower Abdominal Bag and adjust the foam within the bag geometry. Zip the bag closed.
13. Thread the M10 stainless steel washer and M10 x 1.5 panel nut onto each IR-TRACC assembly U-joint.
14. Grasp the left-hand IR-TRACC Assembly (using the shaft screwed into the front of the U-joint) and pull the IR-TRACC telescope into an extended position. Change the angle of pull as necessary to “steer” the IR-TRACC U-joint through the Load Distribution Washer and Lower Abdomen Bag.
15. Secure the IR-TRACC unit to the front of the Lower Abdomen assembly using the washer and panel nut. Tighten the panel nut until it is flush with the threaded end of the U-joint, as shown in Figure 12.13.

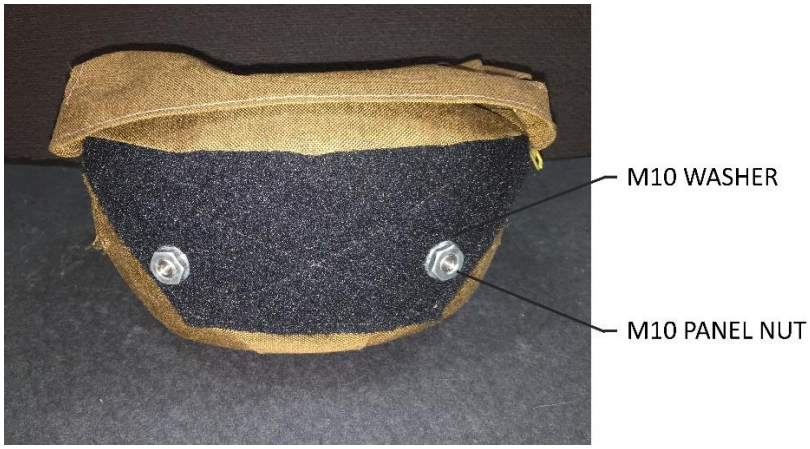

Figure 12.13 Securing of Nut and Washer to Outside of Bag

16. Repeat steps #13 and 14 for the Right-hand IR-TRACC. The completed Lower Abdomen Assembly is shown inFigure 12.14.

Figure 12.14 Completed Lower Abdomen Assembly

12.2.3 Attaching the Lower Abdomen to THOR-50M Dummy

The following procedure is a step-by-step description of the assembly procedure used to attach the lower abdomen to the THOR-50M Dummy. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values. The lower abdomen can be installed at any time after the spine is connected to the pelvis assembly.

1. Loosen the center bolt of the Lower Thoracic Spine Pitch Change Mechanism as described in Section 10.3.1, Adjustment Procedure for Lower Thoracic Spine Pitch Change Mechanism, for Lower Thoracic Spine Pitch Change Mechanism. Rotate the upper thorax and spine rearwards to open the thoracic cavity and allow easy access.
2. Align the gap between the Left and Right Attachment Brackets (472-4720-1-B and 472-4720-2-B) with the Lumbar/Pelvis Mounting Block (472-3761).

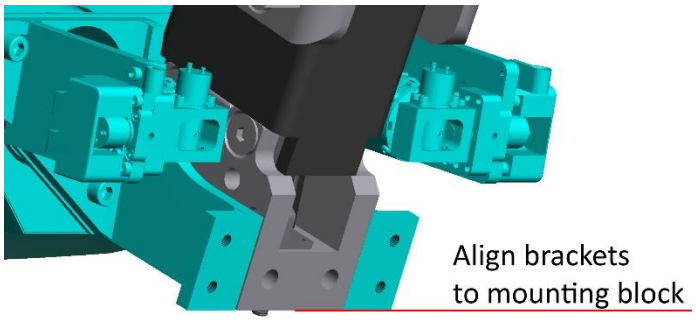

Figure 12.15 Align Brackets with Mounting Block

3. Tilt the top of the lower abdomen forward and insert the abdomen into the cavity of the dummy. Carefully guide the IR-TRACC and their wires around the proper sides of the spine. See Figure 12.16.

Figure 12.16 Insertion of Lower Abdomen into Dummy

4. Attach the Rear Attachment Plate (472-4761-A) to the rear of the Pelvis/Lumbar Mounting Block using two M10 x 1.5 x 25mm FHCS, as shown in Figure 12.17. The bottom surface of the plate should be flush with the bottom surface of the block.

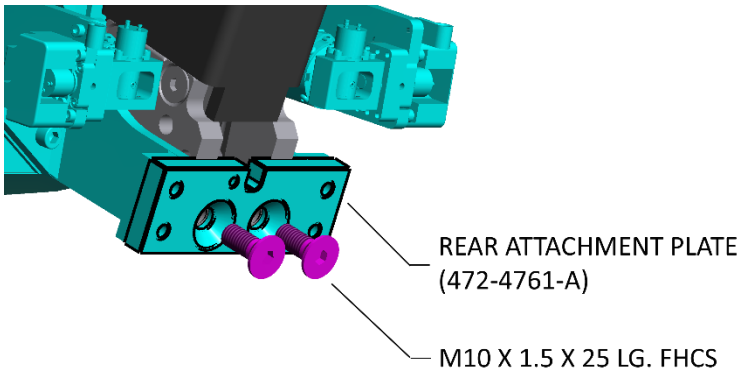

Figure 12.17 Rear Attachment Plate to Spine

5. The Lumbar Spine Ground Strap (472-8703) connects the Lower Abdomen at the Rear Attachment (472-4761-A) to the Spine at the Thoracic Spine Load Cell/Flex Joint Adaptor Plate (472-3761-A). The Lumbar Spine Ground Strap is mounted to the Rear Attachment (472-4761-A) using M6 x 10 SHCS.

6. Attach the rear flange of the Lower Abdomen assembly to the Rear Support Plate using four M6 x 16 SHCS.

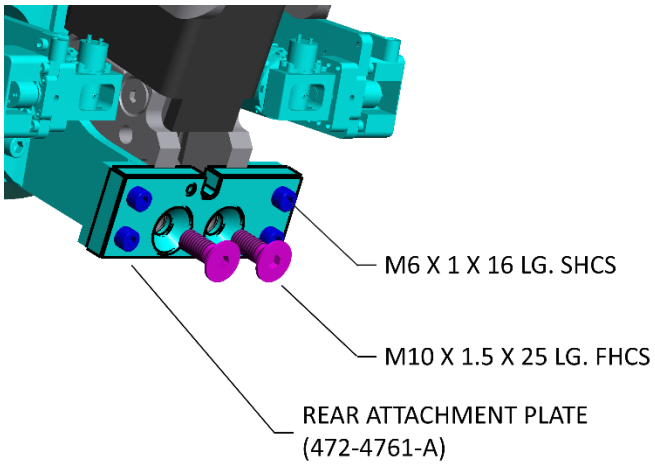

Figure 12.18 Attached to Lower Abdomen Rear Attachment with M6X16 SHCS.

7. Re-adjust the Lower Thoracic Pitch Change Mechanism to the desired setting. Refer to Section 10.3.1, Adjustment Procedure for Lower Thoracic Spine Pitch Change Mechanism for detailed instructions on this procedure.
8. After the installation of the lower abdomen is complete, cover the front surfaces of the upper and lower abdomen assemblies with the Upper and Lower Abdomen Velcro Cover as shown in Figure 12.19.

Figure 12.19 Upper and Lower Abdomen Cover

12.3 Adjustments for the Lower Abdomen Assembly

The lower abdomen assembly does not require any adjustments for testing.

12.4 Storage and Handling

Care should be taken to ensure there is no compression or deformation of the foam sections during storage periods.

12.5 Wire Routing and Electrical Connection

The lower abdomen has two primary instruments: the left and right IR-TRACC assemblies.

Left IR-TRACC Unit: These wires exit the IR-TRACC unit at the rear of the tube and are routed on the left side of the spine to join the bundle of wires running down the back of the spine.

Right IR-TRACC Unit: These wires exit the IR-TRACC unit at the rear of the tube and are routed on the right side of the spine to join the bundle of wires running down the back of the spine.

12.6 Lower Abdomen Qualification

Qualification procedures for the lower abdomen are described in the THOR-50M Qualification Procedures Manual as a separate publication.

12.6.1 IR-TRACC Calibration

The calibration of the IR-TRACC sensors should be performed prior to the installation into the Lower Abdominal Assembly. The IR-TRACC calibration sheets are included with the shipment of the instruments.

12.7 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgment should be used to determine the frequency of these inspections; however, a thorough inspection is recommended after twenty tests have been performed. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. Both electrical and mechanical inspections are most easily carried out during dummy disassembly. The disassembly of the lower abdomen components can be performed by simply reversing the assembly procedure.

12.7.1 **Wire Routing and Electrical Connections**

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the lower abdomen instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

12.7.2 **Mechanical Inspection**

Several Components in the lower abdomen assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below.

Bag and Zipper Inspection: The following checklist should be used when inspecting the dummy's lower abdomen bag and zipper for post-test damage:

- ✓ Check the bag for tears, cuts, and broken stitches. Repair or replace as necessary.
- ✓ Check the zipper, for broken or damaged teeth and/or slider mechanism.

Foam Inspection: The following checklist should be used when inspecting the dummy's lower abdomen foam for post-test damage:

- ✓ Check the foam for tearing and rips and permanent compression.

IR-TRACC Unit Inspection: The procedure for inspecting the dummy's IR-TRACC units for post-test damage is in *THOR-50M 3D IR-TRACC User Manual*.

Section 13. **Pelvis Assembly**

13.1 **Description of Pelvis Assembly and Features**

The pelvis assembly of the THOR-50M dummy is a mechanical representation of the human pelvis. The assembly consists of a Base Module and two aluminium wings, designed to approximate the geometry of the human pelvic bone structure. The locations of two important anthropomorphic landmarks have been carefully maintained; they are the H-points and the ASIS points. These landmarks provide locations that can be directly related to the human pelvis. The front of the iliac wing has been machined to accept the Pelvic Box Assembly which holds the Acetabular Load Cells. The top of the pelvis Base Module is machined to accept the lumbar/pelvis mounting block to allow attachment of the spine assembly.

There are several different types of instrumentation that have been incorporated into the pelvic region. A tri-pack accelerometer mounting location is provided in the rear cavity of the pelvis to measure the accelerations of the approximate pelvic center of gravity in three axes. Two acetabular load cells were designed to measure the loads that are transferred through the femurs to the pelvic structure. The Iliac Wings accept a dual axis anterior-superior iliac spine (ASIS) load cell attached to the front. The ASIS load cell is designed to provide a measurement of the force of a lap belt against the iliac spine of the pelvis. This force is measured as Fx and is insensitive to the position of the belt on the iliac. The moment channel (My) is designed to provide an indication of the position of the belt on the iliac. A reading of zero output would occur if the center of pressure of the belt is on the load cell neutral axis. If the belt is above the neutral axis a positive moment reading would occur, and a belt positioned below the neutral axis would produce a negative bending moment output.

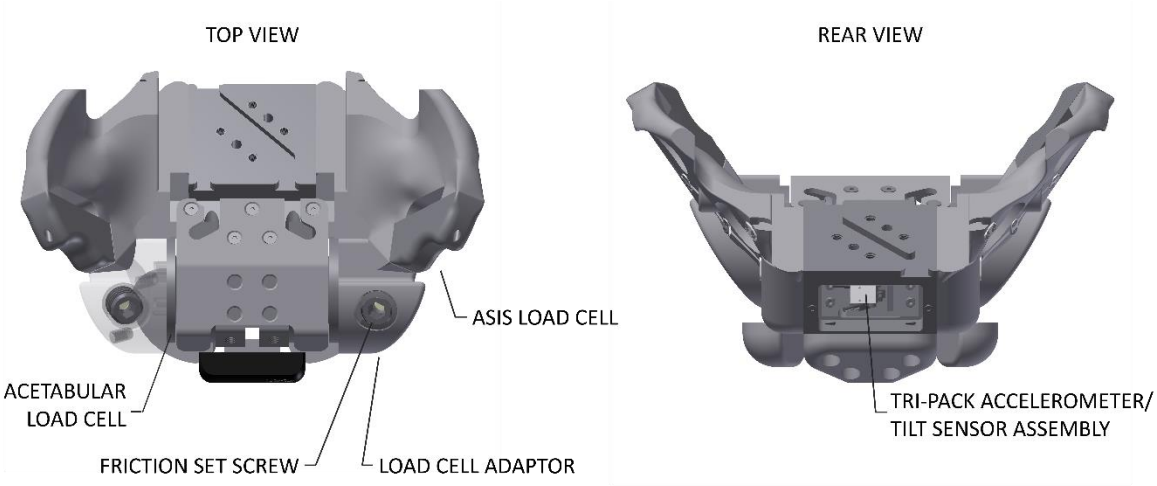

Figure 13.1 Pelvis Assembly

13.2 Assembly of the Pelvis

13.2.1 Parts List

Figure 13.2 is the exploded pelvis assembly, 472-4000.

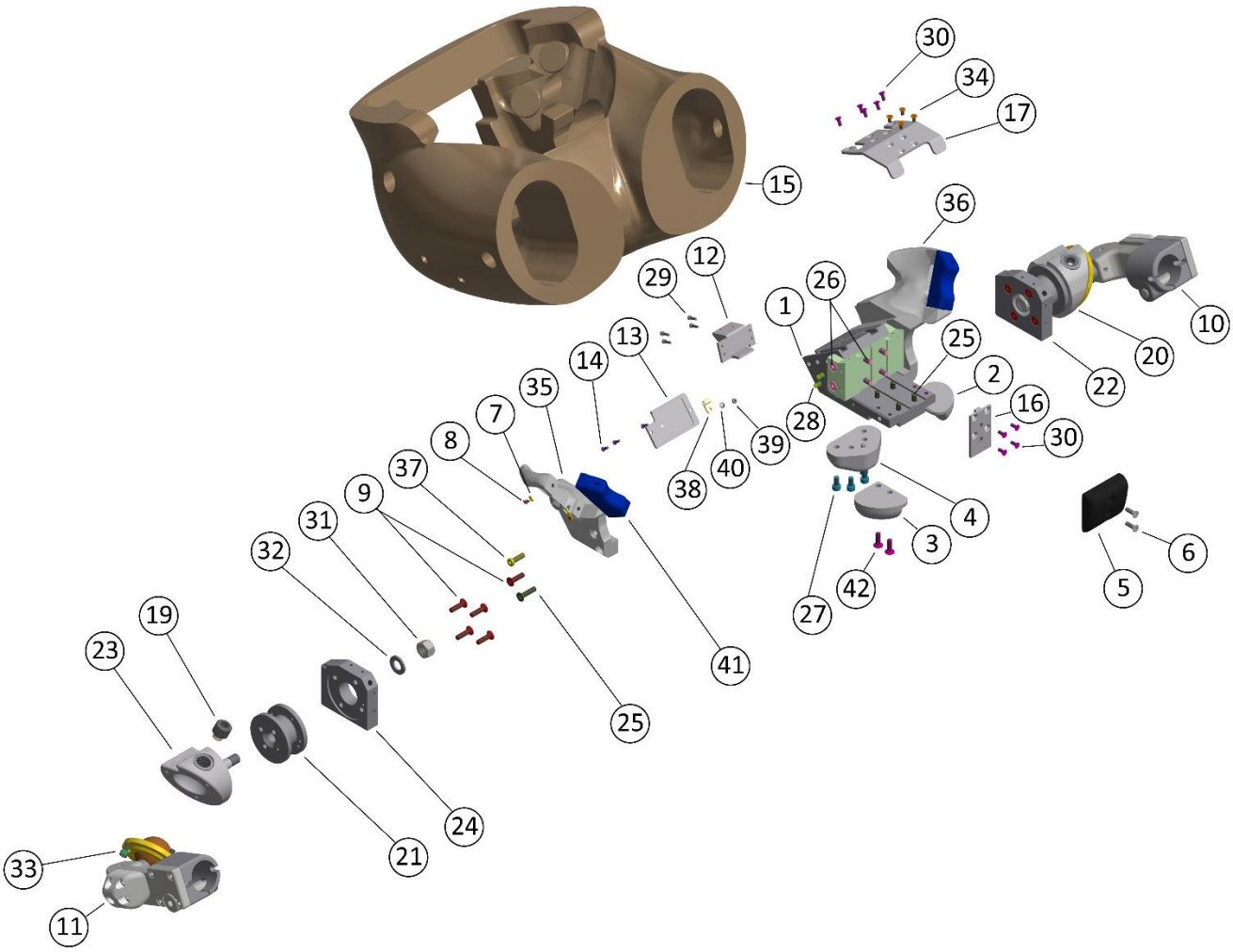

Figure 13.2 Pelvis Assembly Exploded View

Table 13-1 Pelvis Assembly Parts List

Item	Qty.	Part Number	Description
1	1	472-4212	PELVIS BASE MODULE
2	1	472-4340-1	PELVIS LEFT D-PT
3	1	472-4340-2	PELVIS RIGHT D-PT
4	1	472-4350	PELVIS COCCYX
5	1	472-4370	MACHINED FRONT PELVIC CASTING
6	2	5000467	M5 X 0.8 X16 LG. FHCS
7	8	472-4372	ILIAC CABLE COVER, PELVIS
8	16	5000723	M2.5 X 0.45 X 5 LG. FHCS
9	10	5000572	M6 X 1 X 22 LG. FHCS
10	1	472-4800-1	LEFT FEMUR BALL JOINT ASSEMBLY
11	1	472-4800-2	RIGHT FEMUR BALL JOINT ASSEMBLY
12	1	472-4361	PELVIS TRI-PACK MOUNTING BRACKET
13	1	472-4371	PELVIS ACCELEROMETER COVER
14	3	5000203	M3 X 0.5 X 10 LG. FHCS
15	1	472-4100	PELVIS FLESH, MOLDED
16	1	472-4330	FRONT PELVIC PLATE
17	1	472-4204	PELVIS TOP PLATE
18	1	472-4205	PELVIS, REAR PLATE
19	2	472-4310	FRICTION ADJUSTMENT SET SCREW ASSEMBLY
20	1	472-4321-1	PELVIS SOCKET ADAPTOR (LEFT)
21	2	472-4323	ACETABULAR LOAD CELL STRUCTURAL REPLACEMENT
22	1	472-4325-1	PELVIS LOAD CELL MOUNTING PLATE (LEFT)
23	1	472-4321-2	PELVIS SOCKET ADAPTER (RIGHT)
24	1	472-4325-2	PELVIS LOAD CELL MOUNTING PLATE (RIGHT)
25	8	5000135	M6 X 1 X 25 LG. FHCS
26	12	5001089	M6 X 1 X 20 LG. FHCS
27	4	5000281	M6 X 1 X 12 LG. SHCS
28	4	5000090	M6 X 1 X 16 LG. FHCS
29	4	5000119	M3 X 0.5 X 10 LG. SHCS
30	9	5000023	M4 X 0.7 X 10 LG. FHCS
31	2	5000462	M12 X 1.75 HEX LOCK NUT ZINC
32	2	5000267	M12 FLAT WASHER PLAIN ZINC
33	6	5000604	M6 X 1 X 14 LG. SHCS
34	4	5000646	M4 X 0.7 X 8 LG. FHCS
35	1	472-4390-2	ILIAC WING RIGHT
36	1	472-4390-1	ILIAC WING LEFT
37	2	5001316	M6 X 1 X 20 LG. LHCS
38	1	9002655	WIRE CLAMP, NYLON 1/8 DIA.
39	1	5001096	M3 X 0.5 HEX NUT ZINC
40	1	5001441	WASHER BELLEVILLE 3.2 ID x 7 OD SS
41	2	472-4375-A	S.R. THOR A.S.I.S.
42	4	5000108	M6 X 1 X 18 LG. FHCS

13.2.2 **Assembly of Pelvis Components**

The following procedure is a step-by-step description of the assembly procedure for the pelvis components. Complete and integration of several sub-assemblies is required to create the Pelvis assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Attach the Left Load Cell Mounting Plate (472-4325-1) to the Left Acetabulum Load Cell (or structural replacement) using four M6 x 22 FHCS. Orient the load cell wiring to the mounting plate as shown in Figure 13.3.

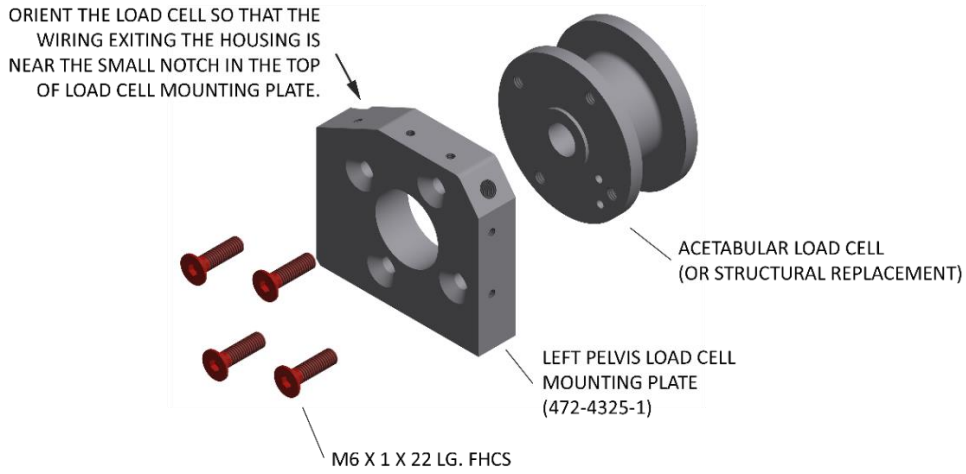

Figure 13.3 Orientation of Load Cell on Plate

2. Insert the shaft of the Left Pelvic Socket Adaptor (472-4321-1) into the Left Acetabulum Load Cell (or structural replacement). The orientation of the pelvic socket adaptor and the load cell (or structural replacement) is shown in Figure 13.4. Align the dowel pin holes of the Load Cell (or structural replacement) with the dowel pins in the Socket Adaptor. Insert the M12 ID flat washer onto the adaptor shaft. Use a M12 nylon lock hex jam nut to secure the Socket Adaptor to the Acetabulum Load Cell or structural replacement. Make sure both nut threads and 472-4321-1 threads are clean and free of grease. Tighten M12 nut to 75±3 Nm.

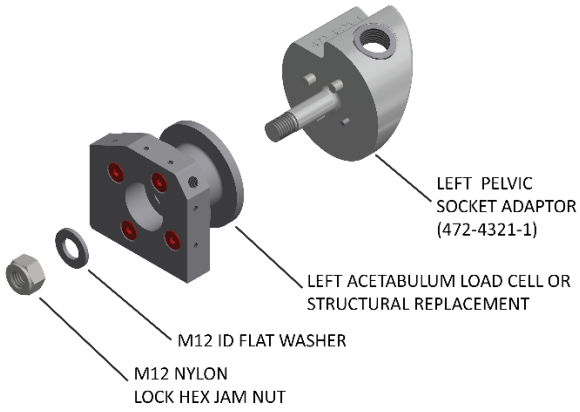

Figure 13.4 Orientation of Socket Adaptor to Load Cell

3. Attach the Right Load Cell Mounting Plate (472-4325-2) to the Right Acetabulum Load Cell (or structural replacement) using four M6 x 22 FHCS Orient the load cell wiring to the mounting plate as shown in Figure 13.5.

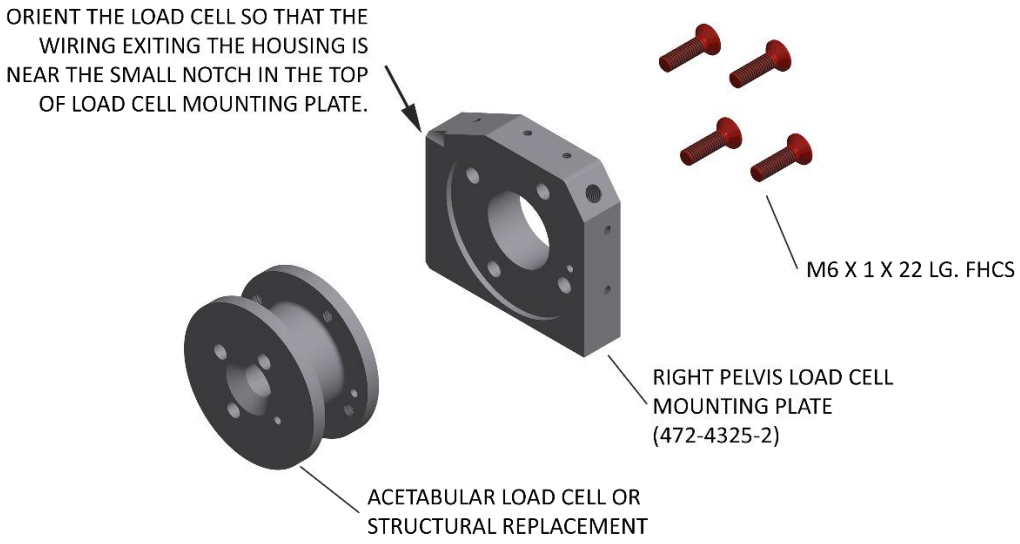

Figure 13.5 Orientation of Load Cell on Plate

4. Insert shaft of the Right Pelvic Socket Adaptor (472-4321-2) into the Right Acetabulum Load Cell (or structural replacement). The orientation of the Pelvic Socket Adaptor and the Load Cell (or structural replacement) is shown in Figure 13.6. Align the dowel pin holes of the Load Cell (or structural replacement) with dowel pins in the Socket Adaptor. Place the M12 ID flat washer onto the adaptor shaft. Use M12 nylon lock hex jam nut to secure the Socket Adaptor to the Acetabulum Load Cell. Make sure both nut threads and 472-4321-2 threads are clean and free of grease. Tighten M12 nut to 75±3 Nm.

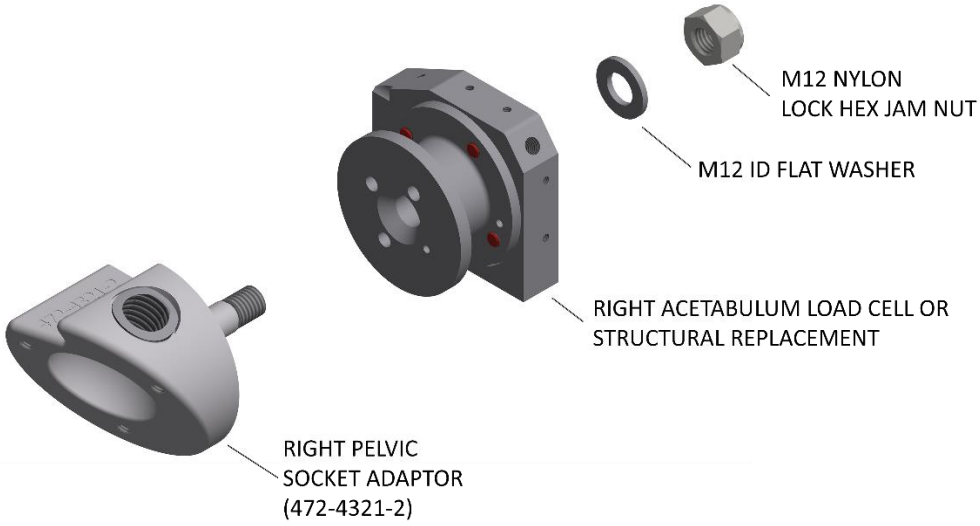

Figure 13.6 Orientation of Socket Adaptor to Load Cell

5. Bolt the Left and Right Socket/Load Cell Assemblies to the Rear Plate using four M6x20 FHCS, as shown in Figure 13.7.

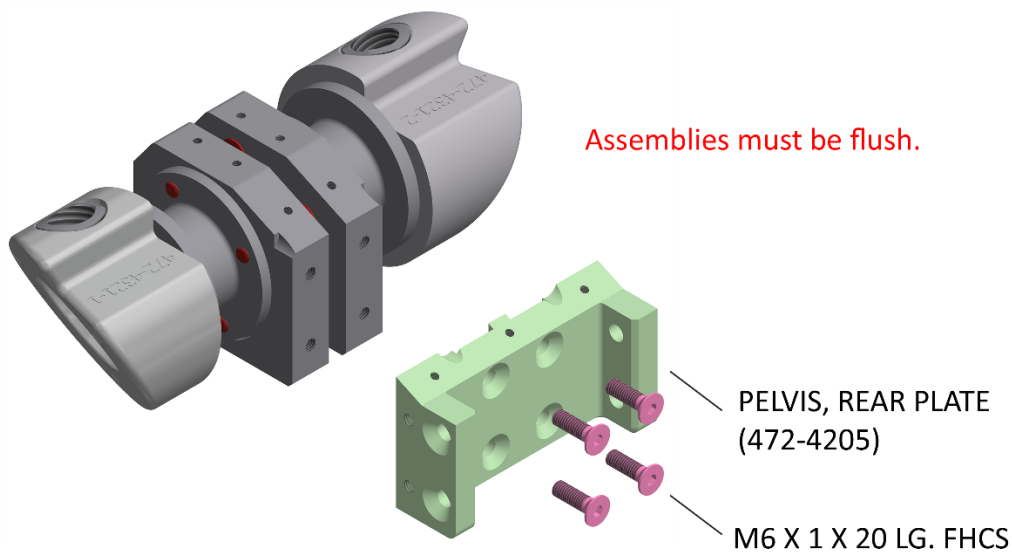

Figure 13.7 Left Socket Assembly Attached to Rear Plate

6. Mount the Pelvis Base Module (472-4212) on the opposite side of the Top Plate (472-4204), and to the Rear Plate (472-4205), Left (472-4325-1) and Right (472-4325-2) Load Cell Mounting Plates, using six M6x25 FHCS and four M6 x 20 FHCS respectively on the bottom and sides of the Pelvis Base Module.

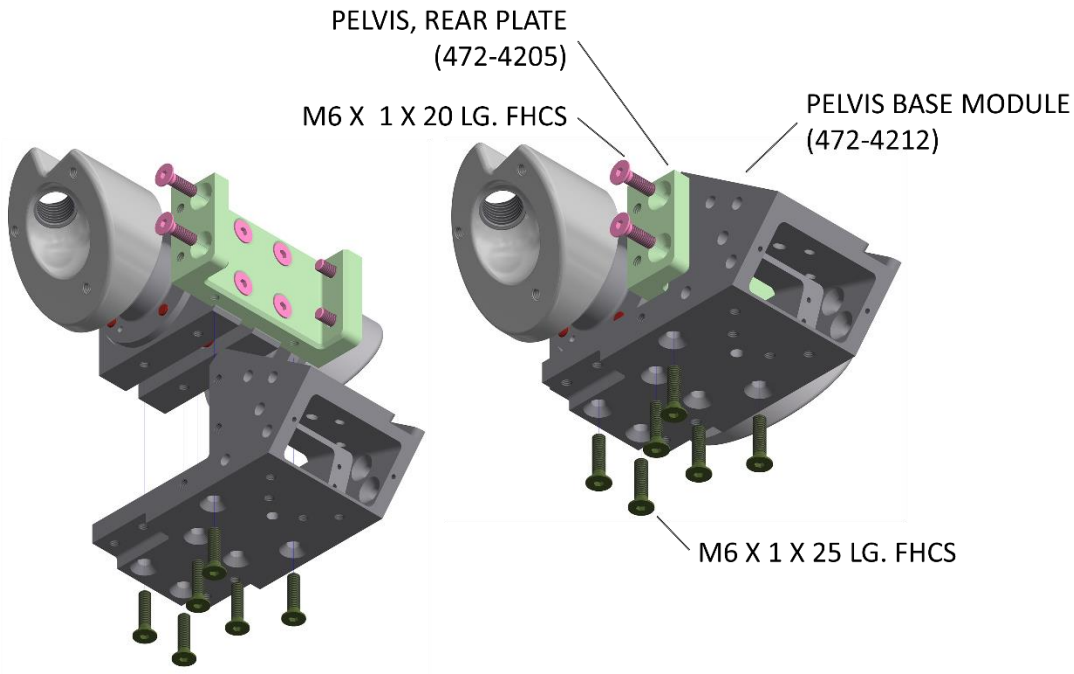

Figure 13.8 Pelvis Base Module/Load Cell Mounting Plates Assembly

7. Mount a Friction Adjustment Set Screw Assembly (472-4310) on each top hole of the Left and Right Acetabular Assemblies, as shown in Figure 13.9.

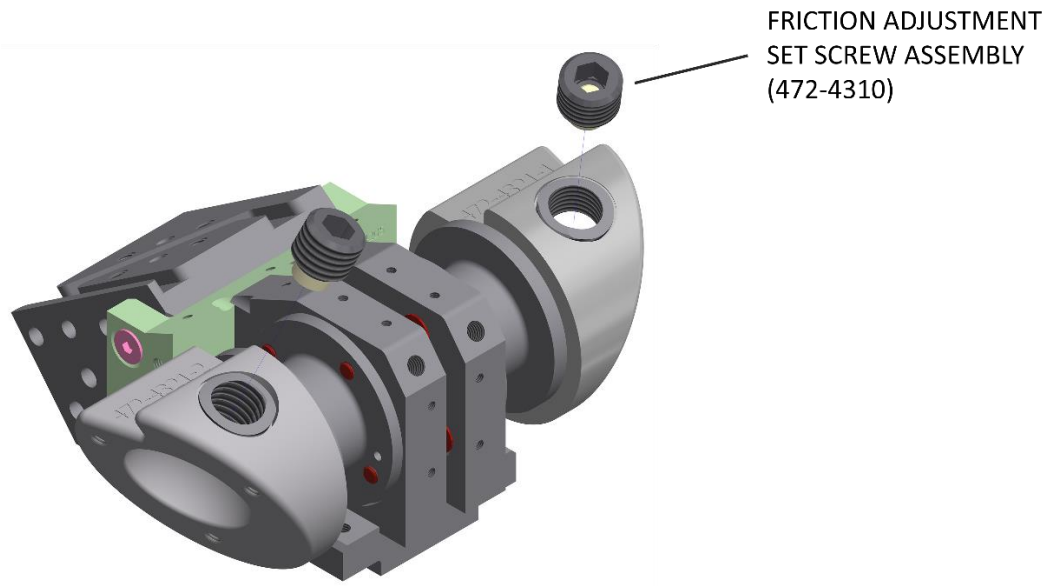

Figure 13.9 Friction Adjustment Set Screw

8. Bolt Top Plate (472-4204) to the top of the Left and Right Load Cell Mounting Plates, using nine M4x10 FHCS, as shown in Figure 13.10. The Acetabular Load Cell wires must exit through the grooves at the rear of the top plate.

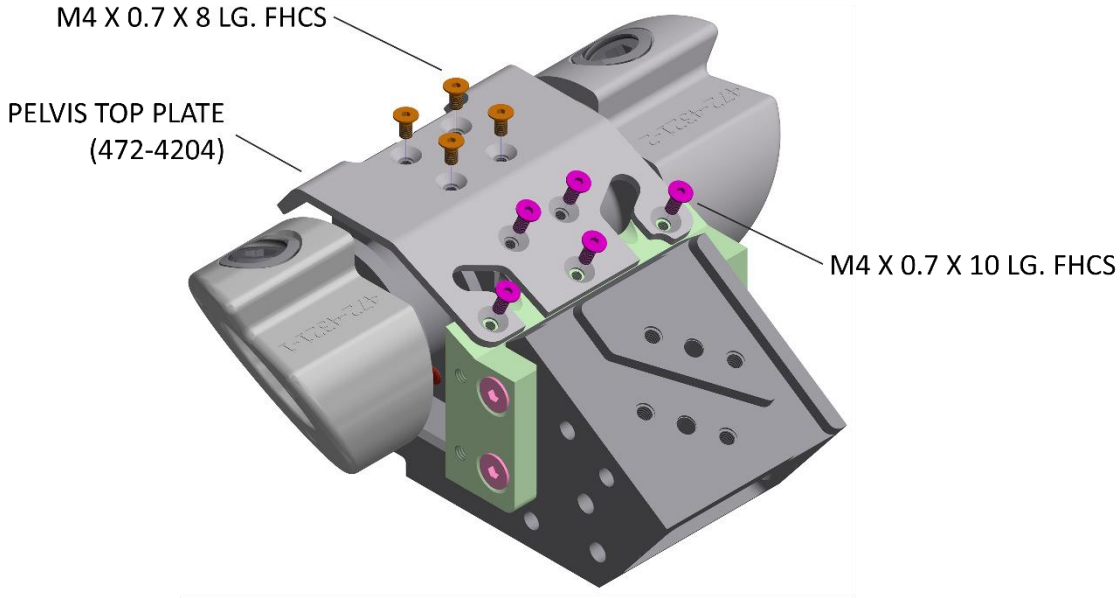

Figure 13.10 Top Plate Assembled to Pelvic Box

9. Bolt the Front Plate (472-4330) on to the front of the Left and Right Load Cell Mounting Plates using four M4x10 FHCS, as shown in Figure 13.11.

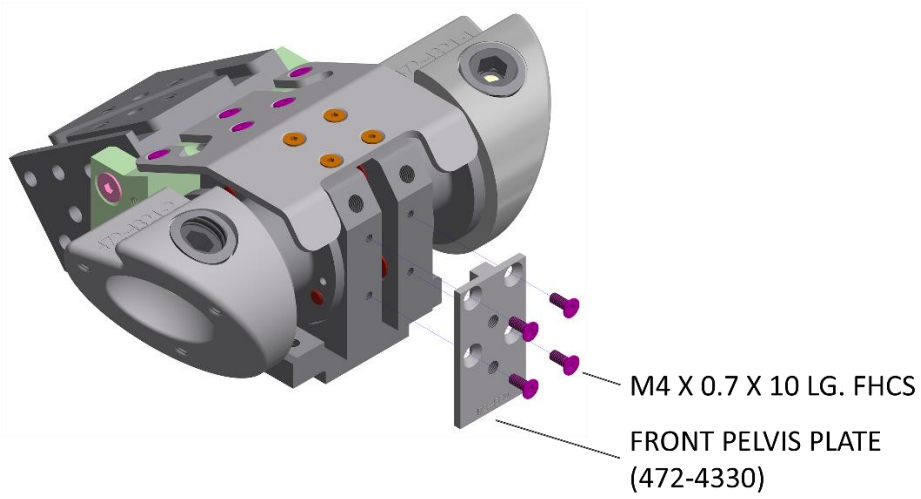

Figure 13.11 Front Plate Attached to Pelvic Box

10. Attach the Front Pelvic Casting (472-4370) to the Front Plate using two M5 x 16 FHCS. At this stage, this assembly is referred to as the Pelvic Box Assembly.

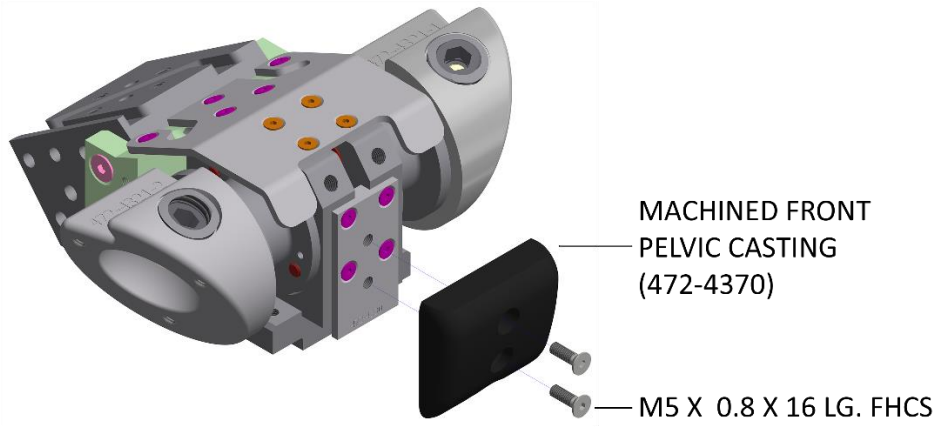

Figure 13.12 Front Casting

11. Attach the Left (472-4340-1) and Right (472-4340-2) D-Points to the front corners of Pelvis Base Module, using four M6x18 FHCS. See Figure 13.13.

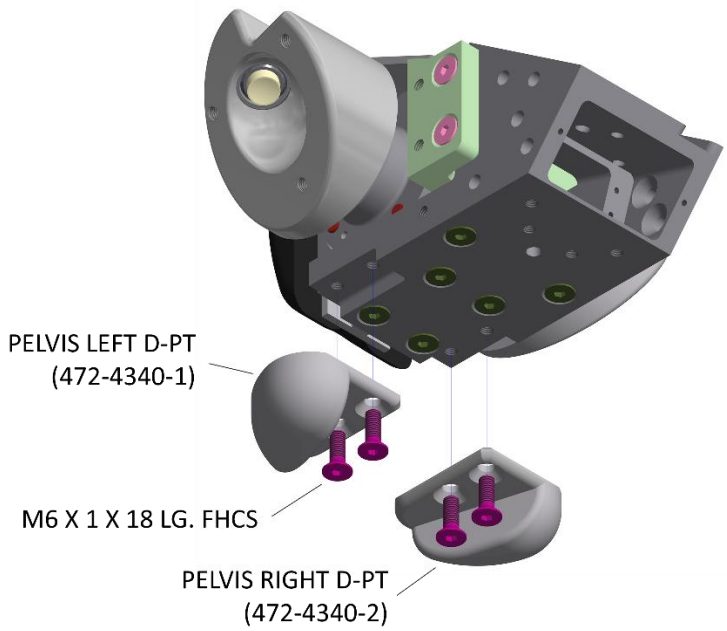

Figure 13.13 D-Points/Base Module

12. Align the holes of the Pelvis Coccyx (472-4350) with the holes on the rear of the Pelvis Base Module, and attach the former to the latter using four M6x12 SHCS and a M6x20 dowel pin, as shown in the Figure 13.14.

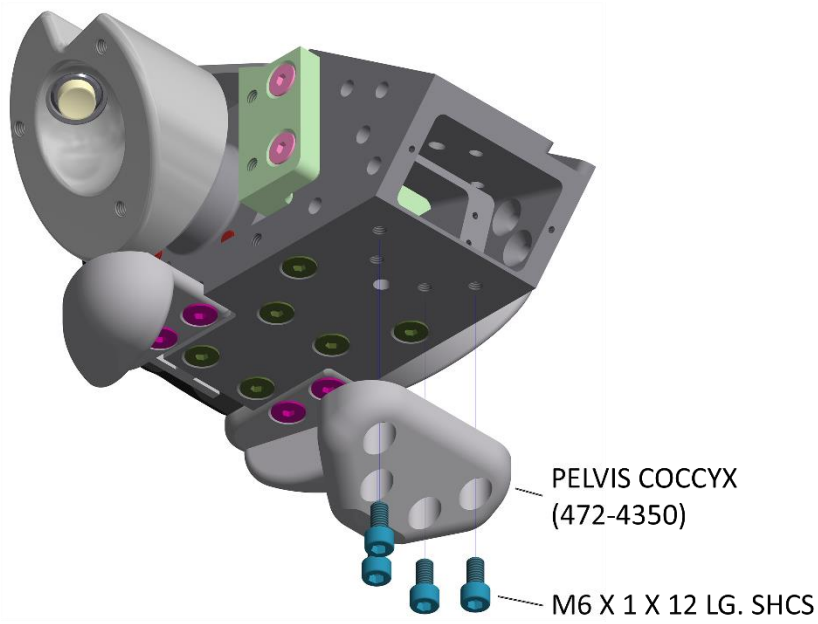

Figure 13.14 Pelvis Coccyx

13. Attach the Left (472-4390-1) and Right (472-4390-2) Pelvis Wings to the left and right of the Pelvis Base Module using one M6 x 25 FHCS, two M6 x 22 FHCS, one M6x20 LHCS, and four M6x16 FHCS, as shown in Figure 13.15.

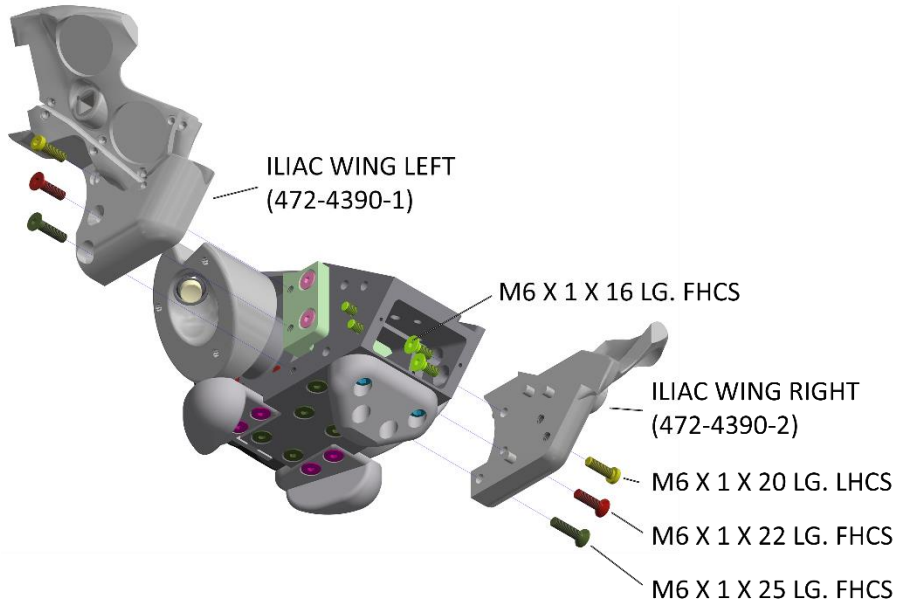

Figure 13.15 Pelvis Wing

14. Mount the Pelvic tri-pack Assembly (472-4360) at the Pelvis C.G. located in the cavity at the rear of the Pelvis Base Module, using four M3x10 SHCS. The stamped markings on the unit are oriented in the following manner: +X forward, +Y is right, +Z down.

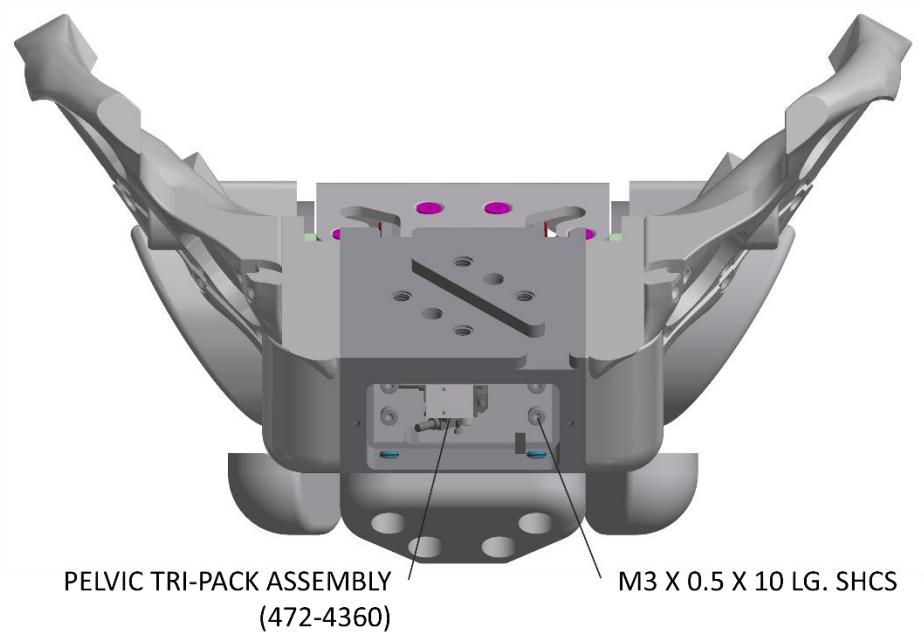

Figure 13.16 Pelvic Tri-Pack Assembly Mounted in Pelvis

15. Optional ARS Assembly: Mount one ARS on a piggyback mount with two M1.4 x 10 SHCS. Mount the side and back ARS with two M1.4 x 8 SHCS each as shown in figure below.

NOTE: Due to space limitation, when mounting ARS in pelvis location, it is necessary to remove the wire clamp and hardware provided with the standard pelvis shown in Figure 13.18.

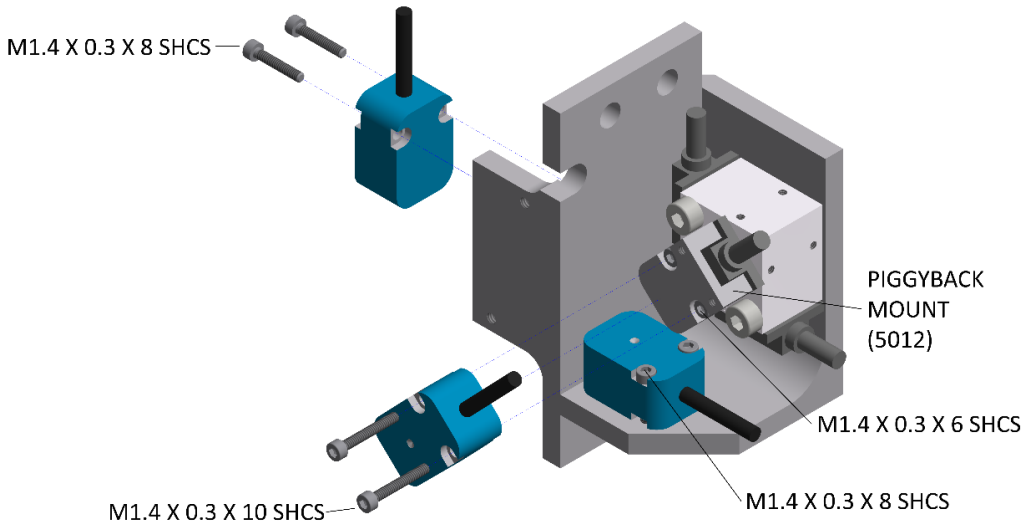

Figure 13.17 Pelvis ARS Mount Location

16. Assemble the wire clamp to the Pelvis Accelerometer Cover, 472-4371, with an M3 X 10 FHCS, Washer 3.2 ID X 7 OD SS and an M3 X 0.5 Hex Nut Zinc. Then install the Pelvis Accelerometer Cover (472-4371) over the cavity in the pelvis casting using two M3x10 FHCS. The cover must be oriented with the wire exit hole at the top right corner as shown.

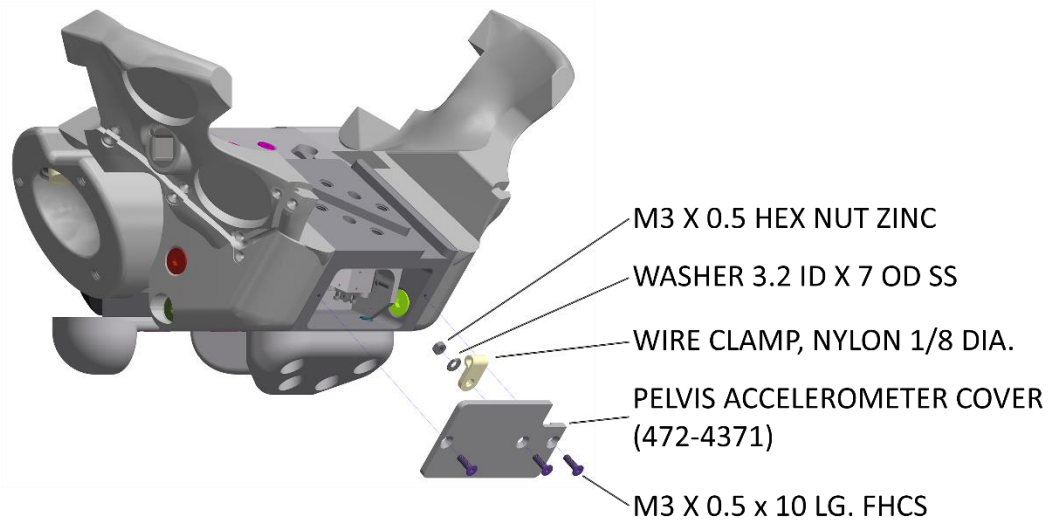

Figure 13.18 Pelvis Accelerometer Cover

17. Position one of the ASIS load cells as shown in Figure 13.19 and attach it to the left iliac wing using the supplied M5x16 BHCS.

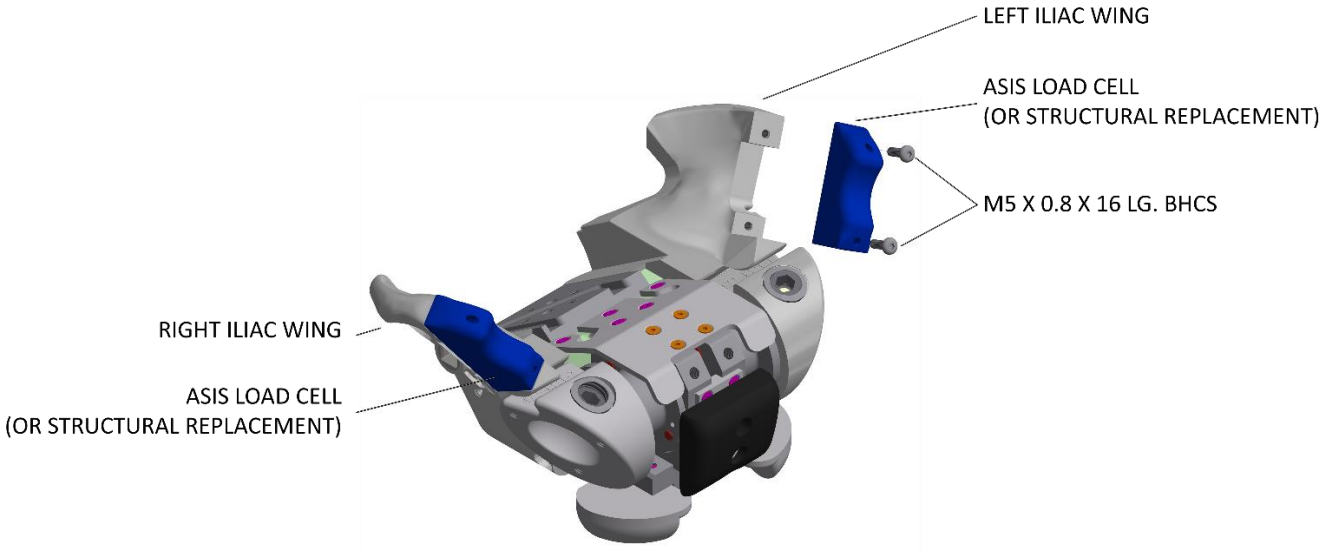

Figure 13.19 ASIS Load Cell and Iliac Cable Covers

18. Repeat step 17 for the right iliac wing load cell.

19. Install the completed mechanical pelvis assembly into the Molded Pelvis Skin (472-4100) as shown in Figure 13.20.

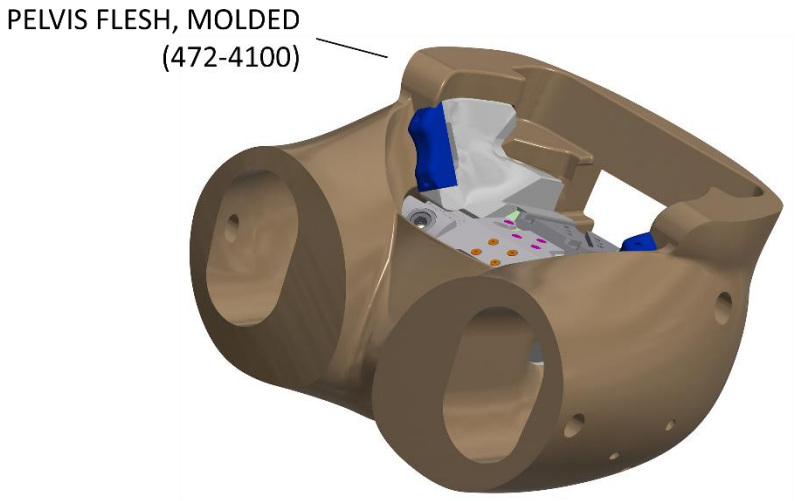

Figure 13.20 Pelvis Installed in Pelvis Skin

20. Install the Left and Right Femur Ball Joint Assembly (472-4800-1/-2) with three M6 x14 SHCS on each side.

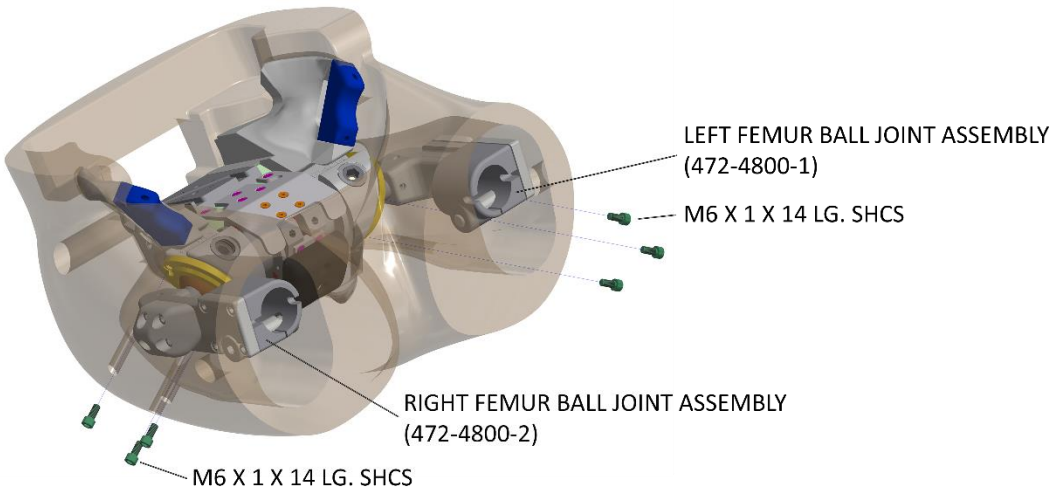

Figure 13.21 Installing the Left and Right Femur Ball Joint Assembly

13.2.3 **Assembly of the Pelvis of the Spine**

The following procedure is a step-by-step description used to install the completed spine assembly (472-3600) to the completed pelvis assembly (472-4000). All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Remove the Pelvis/Lumbar Mounting Block Assembly (472-3765) from the Lumbar Flex Joint Assembly (472-3740) by removing the four M8 x 20 FHCS.

2. The Pelvis/Lumbar Spine Mounting Block is attached to the Pelvis Assembly (472-4000) using the four M6 x 20 SHCS.

3. Reverse step 1 to reattach the Pelvis Lumbar Mounting Block Assembly (472-3761) to the Lumbar Flex Joint Assembly (472-3740).

13.3 Adjustments for the Pelvis Assembly

The pelvis assembly requires a joint resistive torque adjustment for each acetabular cup. The goal of the adjustment is to provide a 1g joint friction torque by turning the femur plunger downward to press against the femur ball.

Check the adjustment by straightening the leg of the dummy and raising it in front of the dummy. The leg should remain in position but move easily under external force. If needed, adjust the Friction Adjustment Set Screw Assemblies (femur plunger, 472-4310) in Figure 13.9 in order to achieve 1g joint friction torque.

13.4 Wire Routing and Electrical Connections

Note: Wire routing and strain relief can be completed per the customer's preference, the important aspect is to ensure that there is enough slack in the wires and that they are strain relieved in a location where they will not be damaged. The instructions below describe Humanetics' procedure.

Acetabular Load Cells: The wires from the Pelvic Acetabular Load Cells need to be routed in the grooves provided in the pelvis assembly which lie under the Pelvis/Lumbar Spine Mounting Block. These wires are joined to the main wire bundle at the rear of the spine.

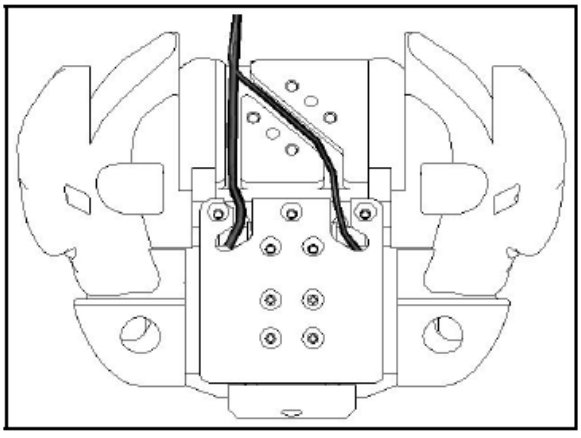

Figure 13.22 Acetabular Load Cells Wires Routing Under Pelvis/Lumbar Spine Mounting Block

ASIS Load Cells: The wires for the load cells should be placed in the machined grooves on the outside surface of the iliac wings. Once the wires are in the groove, install the four Cable Cover Plates (472-4372) using eight M2.5 x 5 FHCS per wing. Finally, the wire is routed to join the bundle of wires at the base of the dummy's spine.

Pelvis CG tri-pack Accelerometer: The wire(s) from the pelvis CG tri-pack cube and tilt sensor exit the rear cover at the upper right corner. They are attached to the inside of the rear cover with a cable clamp to provide strain relief. The wire is routed to join the bundle of wires at the base of the spine.

13.5 Pelvis Qualification

Qualification procedures for the pelvis are described in the THOR-50M Qualification Procedures Manual as a separate publication.

13.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the integrity of the dummy. Good engineering judgment should be used to determine the frequency of these inspections, however a thorough inspection after every twenty tests is recommended. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. Both electrical and mechanical inspections are most easily done during dummy disassembly. Disassembly of the pelvis components can be performed by simply reversing the assembly.

13.6.1 Electrical Inspections (Instrumentation Check)

Begin with the visual and tactile inspection of all of the instrument wires. The wires should be checked for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. Instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

13.6.2 Mechanical Inspection

Several components in the pelvis assembly will need a visual inspection to determine if they are still functioning properly. At this time, perform a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact the manufacturer regarding questions about parts which fail the mechanical inspection.

ASIS Load Cells: The following checklist should be used when inspecting for post-test damage:

- ✓ Check the wiring for proper routing.

Acetabular Socket Adaptors: The following checklist should be used when inspecting for post-test damage:

- ✓ Check the inside surface of the cup joint for wear and scuffing.
- ✓ Check the fit and condition of the pelvis Friction Adjustment Set Screw (472-4310).

Pelvis Skin: The following checklist should be used when inspecting for post-test damage:

- ✓ Check the pelvic skin for cuts, nicks, and tears.

Section 14. **Upper Leg Assembly**

14.1 **Description of the Upper Leg Assembly and Features**

The upper leg assembly of the THOR-50M dummy is a representation of the human upper leg. This assembly extends from the femur ball joint to the knee. At the upper end of the femur is a ball which mates with the socket in the pelvis assembly to form the hip joint. At the lower end of the femur is a standard six axis femur load cell which will connect the femur assembly to the machined knee. Figure 14.1 shows a drawing of the complete femur assembly without the Femur Ball Joint Assembly (472-5100/5601) that connects the femur shaft hub to the pelvis.

The THOR-50M femur has been designed with an axially compliant bushing which has been tuned to create a biofidelic response along the axis of the femur during a knee impact. The compliant section is constrained on a square shaft that slides linearly within a square bushing. The square shaft and bushing assure a purely linear motion. There are end stop bumpers fixed to both ends of the shaft to prevent over-travel.

Each femur is instrumented with a six-axis femur load cell. This load cell is also used in the WorldSID dummy. This sensor produces output for three axes of applied forces and three axes of moments.

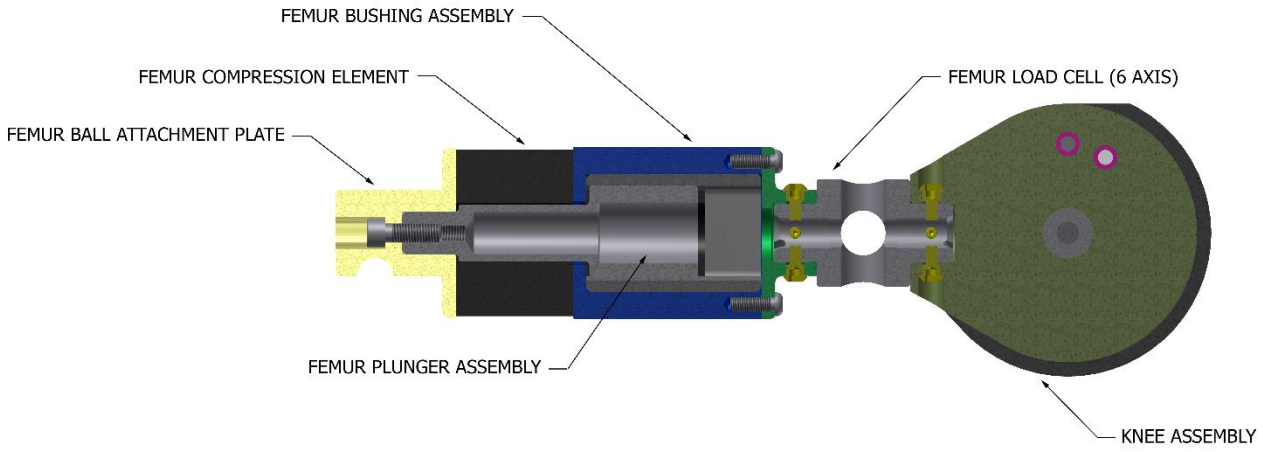

Figure 14.1 Upper Leg Assembly

14.2 Assembly of the Upper Leg

14.2.1 Parts List

The following figure shows the exploded view of the Left and Right Upper Leg Assembly, 472-5100-1/472-5100-2. The table lists the parts in the Upper Leg Assembly.

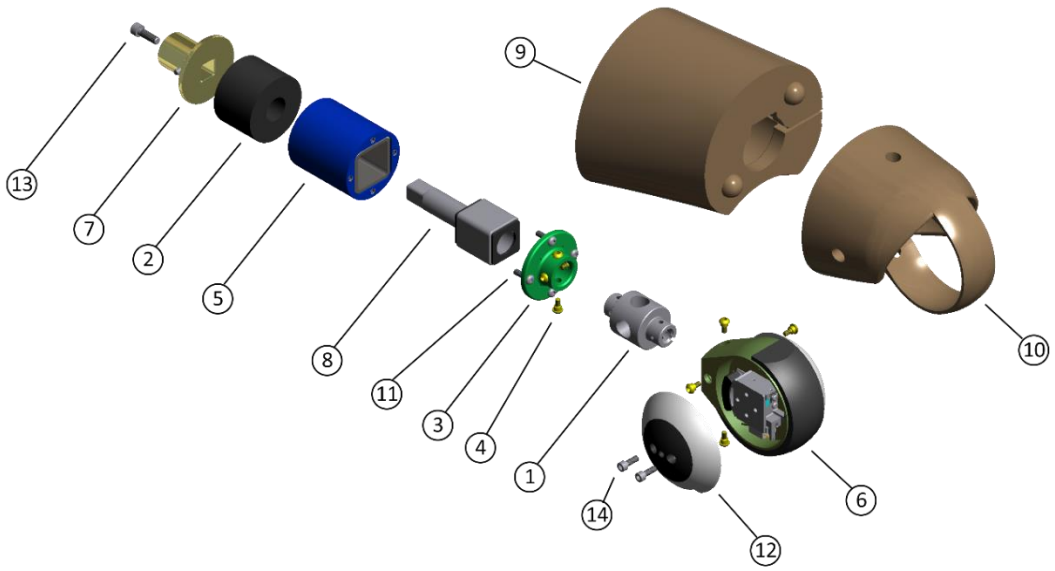

Figure 14.2 Left Upper Leg Assembly Exploded View

Table 14-1 Left and Right Upper Leg Parts List

Item	Qty.	Part Number	Description
1	1	W50-51060	UNIVERSAL LEG L.C. S.R. BODY
2	1	472-5206	COMPRESSION ELEMENT – UPPER LEG
3	1	472-5203	END CAP - FEMUR
4	8	W50-61042	MODIFIED BHSS M6 THREAD
5	1	472-5200	FEMUR BUSHING ASSEMBLY
6	1	472-5300	KNEECAP ASSEMBLY, LEFT
	1	472-5700	KNEECAP ASSEMBLY, RIGHT (NOT SHOWN)
7	1	472-5410	FEMUR BALL ATTACHMENT PLATE ASSEMBLY
8	1	472-5420	FEMUR PLUNGER ASSEMBLY
9	1	472-5503-1-6	THIGH FLESH - LEFT
	1	472-5503-2-6	THIGH FLESH – RIGHT (NOT SHOWN)
10	1	472-5502-6	KNEE FLESH LEFT/RIGHT
11	4	5000438	SCREW, BHCS M6 X 1 X 20 MM
12	2	472-5353	KNEE COVER
13	1	5000037	M8 X 1.25 X 25 LG. SHCS
14	4	5000285	M6 X 1 X 18 LG. SHCS

14.2.2 **Assembly of Upper Leg Components**

The following procedure is a step-by-step description of the assembly procedure for the femur components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values. The order starts form the top to the bottom of the dummy.

1. Verify that the end stops are in the correct position on the Femur Plunger Assembly (472-5420), as shown in Figure 14.3. Slide the Femur Plunger Assembly into the Femur Bushing Assembly (472-5200). Be sure that the Femur Plunger Assembly is completely seated into the Femur Bushing Assembly.

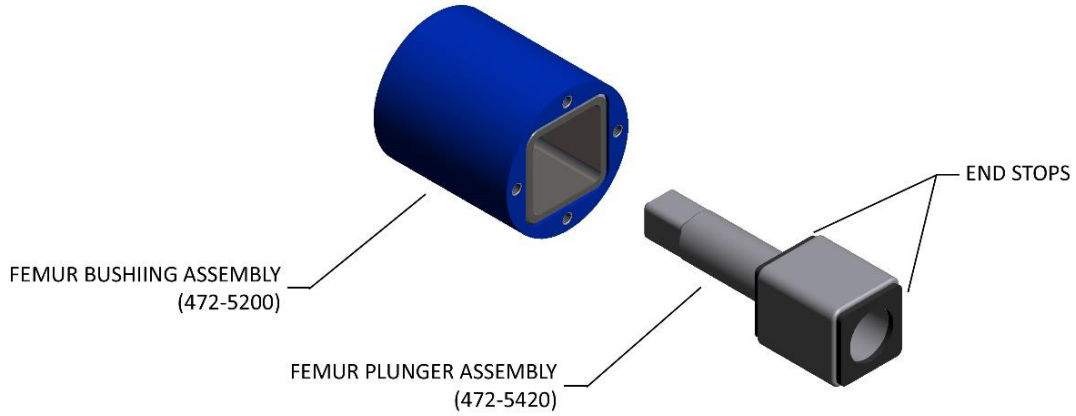

Figure 14.3 Femur Plunger Assembly Installed into Femur Bushing Assembly

2. Slide the Femur Compression Element (472-5206) over the shaft of the Femur Plunger Assembly as shown in Figure 14.4.

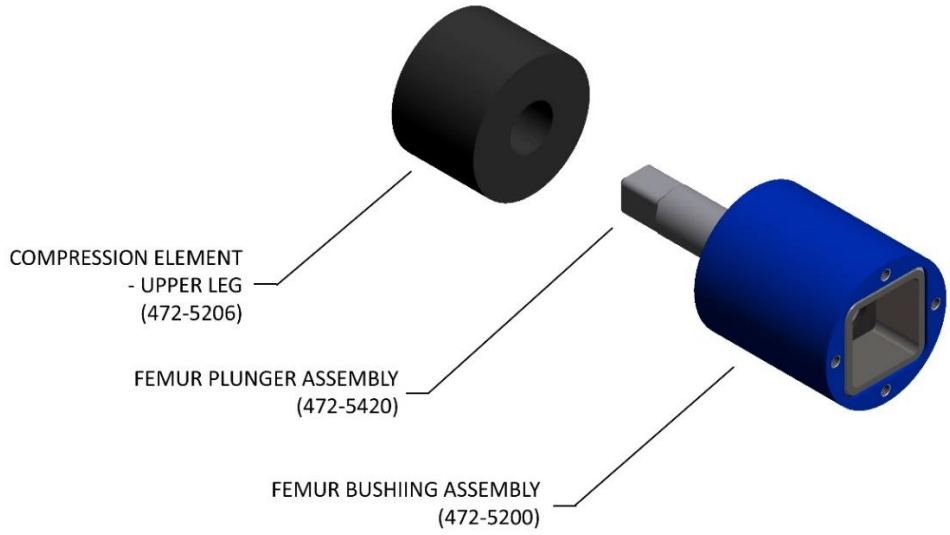

Figure 14.4 Femur Compression Element Installation

3. Assemble the Femur Ball Attachment Plate Assembly (472-5410) to the square end of the Femur Plunger Assembly (472-5420) by sliding the plate over the shaft and inserting the M8x25 SHCS.

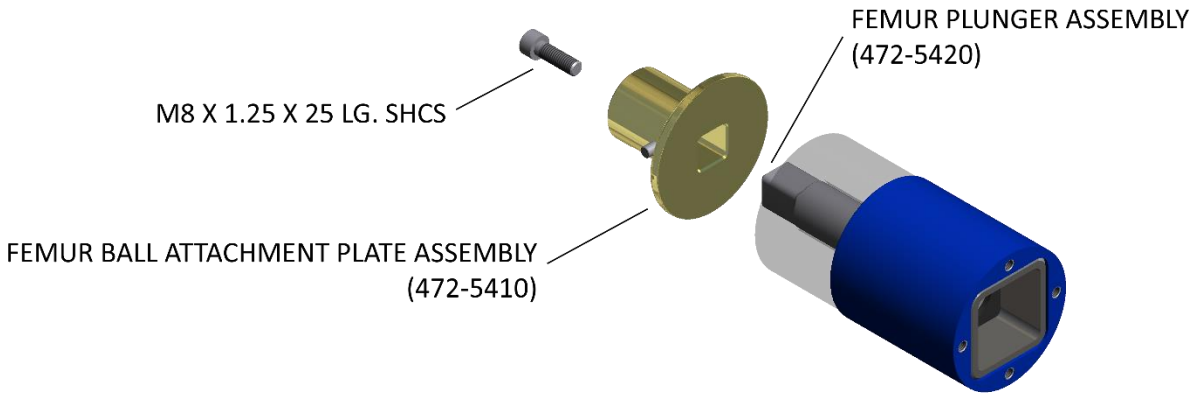

Figure 14.5 Femur Ball Attachment Plate Installation

4. Place the Femur End Cap (472-5203) onto the Femur Bushing Assembly and attach using four M6x20 BHCS as shown in Figure 14.6.

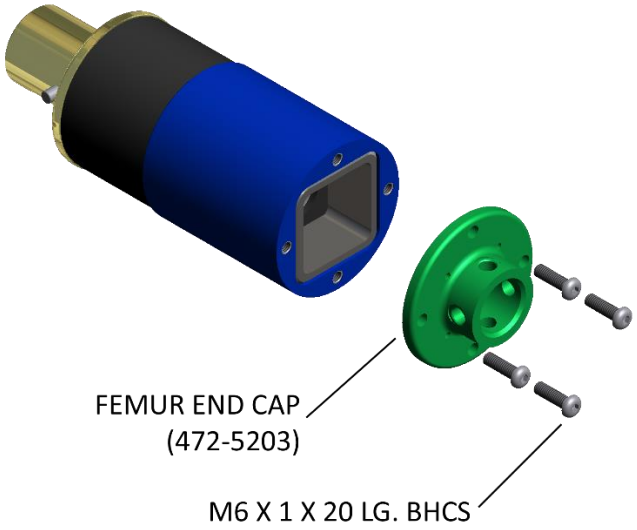

Figure 14.6 Femur End Cap Installation

5. Install the Rotation Stop Assembly (472-5306) to the Molded Inboard Slider Assembly (472-5320) using two M4x6 BHCS, as shown in Figure 14.7.

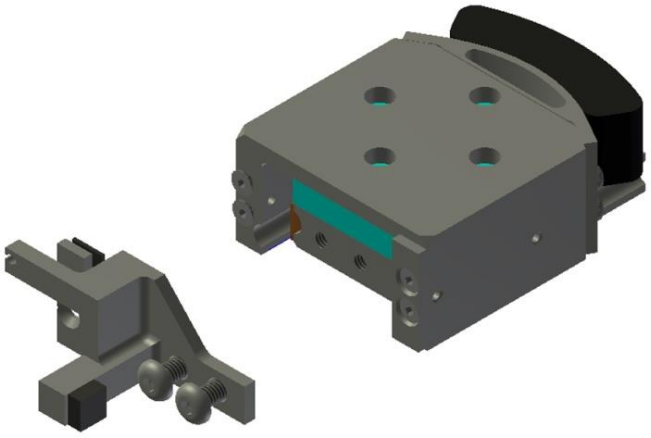

Figure 14.7 Rotation Stop Assembly Installation

6. Install the String Pot Assembly to the Mounting Plate (472-5305) using two M2.5x4 FHCS as shown in Figure 14.8.

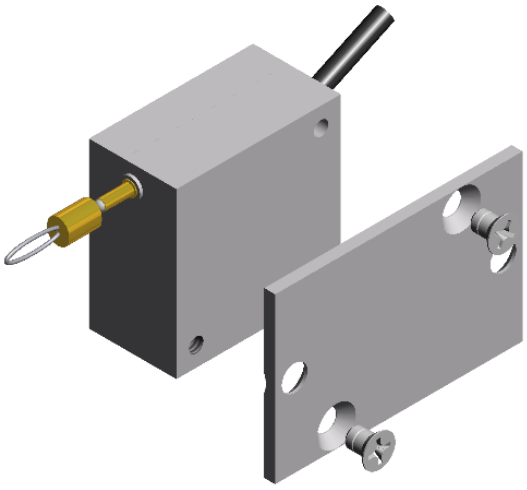

Figure 14.8 String Pot Mounting Plate Installation

7. Install the String Pot and Plate Assembly to the Molded Inboard Knee Slider using two M2.5x4 FHCS as shown in Figure 14.9. Be sure to place the loop of the String Pot into the slot on the Pot String Holder (472-5306/472-5307).

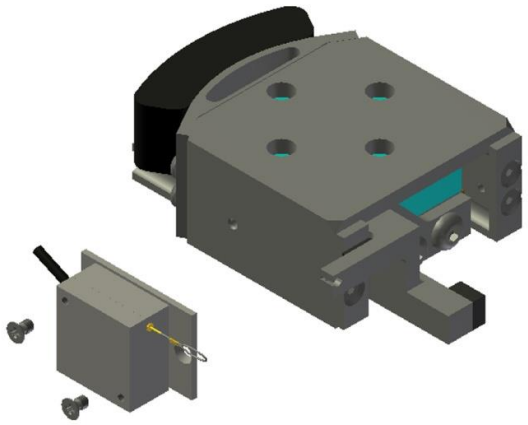

Figure 14.9 String Pot Assembly Installation

8. Install the Inboard (472-5320) and Outboard (472-5330) Knee Sliders to the Knee Bone Assembly (472-5350) using the modified shoulder bolt (472-5302), the compression washer (472-5304) and the regular washer (472-5303). Orient the sliders so that the travel is rearward, as shown in Figure 14.10.

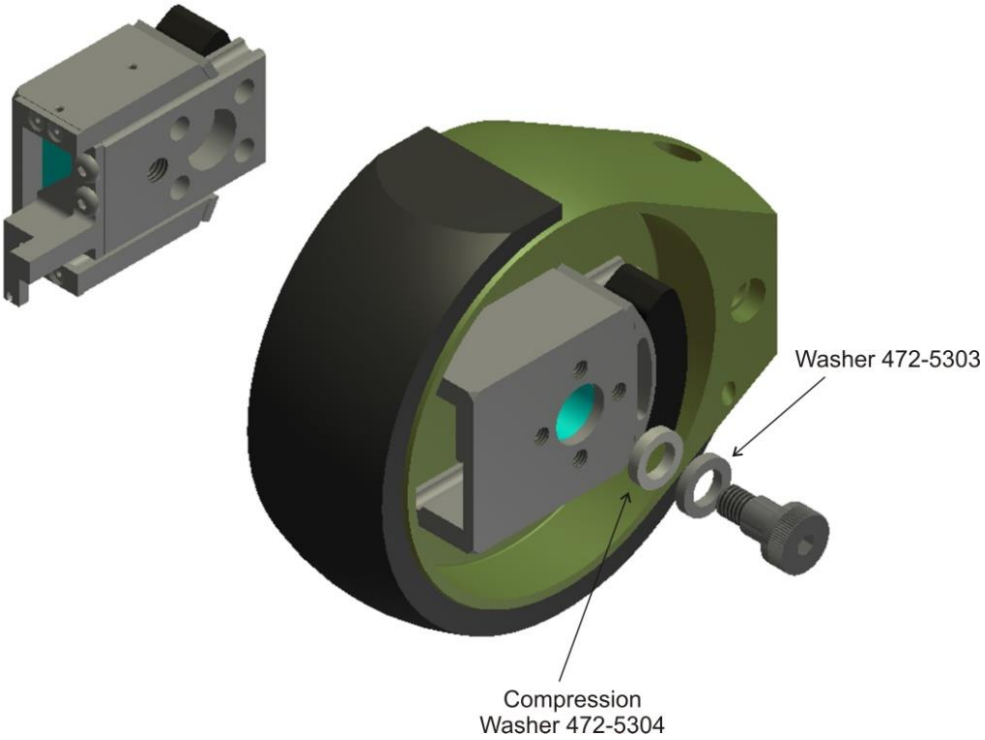

Figure 14.10 Knee Slider Installation

9. Install the Knee Stop Pin (472-5763) into the rear hole in the Knee Bone Assembly. The pin should protrude out on the same side as the Inboard Knee Slider, as shown in Figure 14.11.

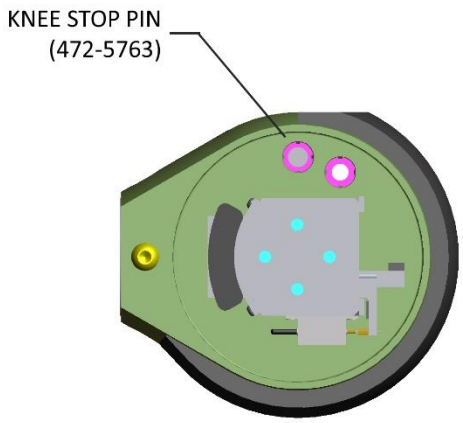

Figure 14.11 Knee Stop Pin Installation

10. Place the Left Knee Flesh (472-5502-6) over the Left Kneecap Assembly (472-5300). Install rubber insert (472-5301) between flesh and knee cap. The end of the structural replacement with the larger keyway slot (4.5mm) is the end that goes into the kneecap assembly. With the roll pin protruding into the counter bore, the structural replacement or load cell can only be installed in one position, down and to the left when looking at the top of the Kneecap Assembly

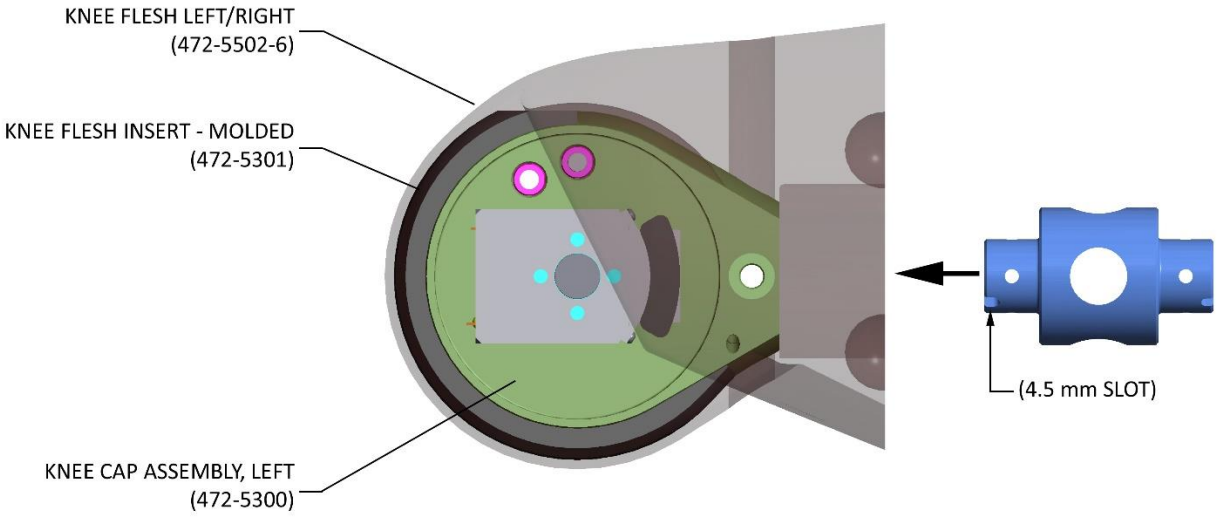

Figure 14.12 Assembling the Knee Flesh and Structural Replacement

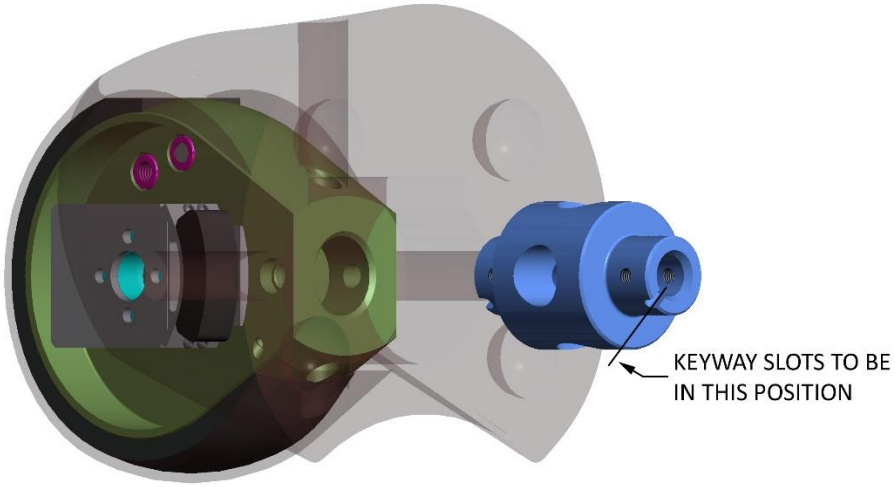

Figure 14.13 Keyway Slot Position

11. Assemble the Femur Load Cell (or structural replacement) to the Left Kneecap Assembly (472-5300) using four of the modified shoulder screws (W50-61042).

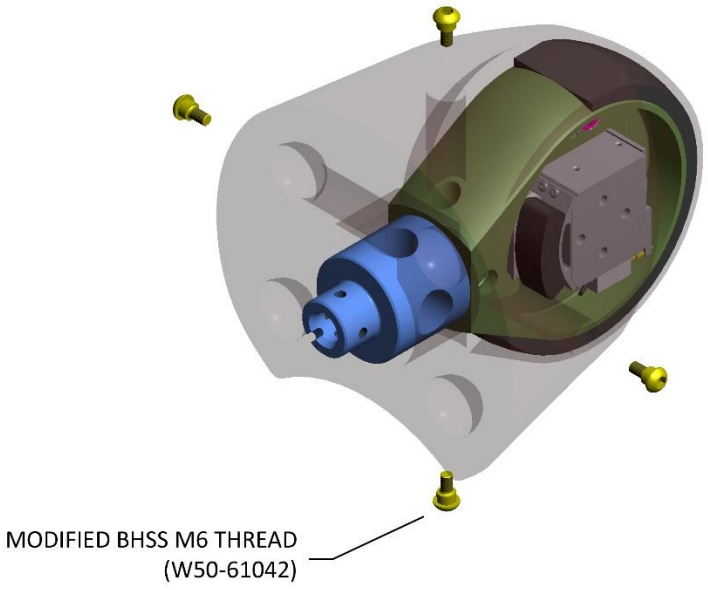

Figure 14.14 Femur Load Cell (or Structural Replacement)/Knee Flesh Installation

12. Install the Left Knee Assembly to the Femur Bushing assembly using four of the modified shoulder screws (W50-61042) as shown in Figure 14.15.

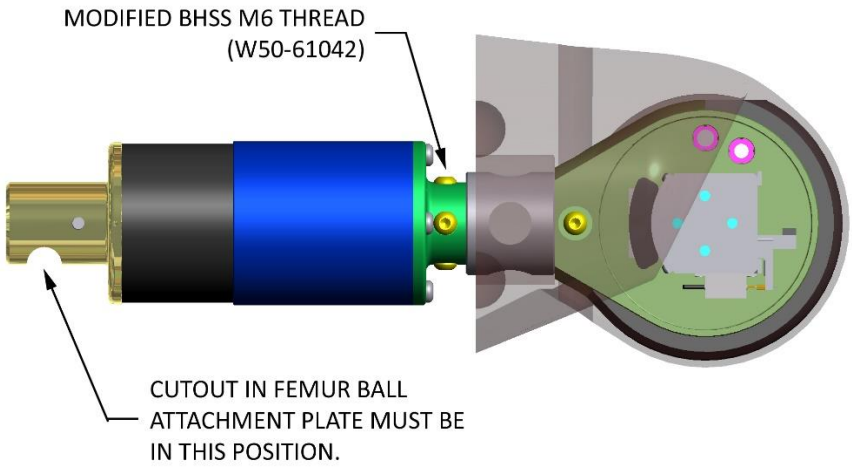

Figure 14.15 Knee Assembly to Femur Bushing Assembly Installation.

13. Install the Left Thigh Flesh (472-5503-1-6) over the Femur Assembly by aligning the knobs on the end of the Thigh Flesh with the holes in the Knee Flesh (472-5502-6). Wrap the flesh around the Femur Assembly and secure it closed with the zipper. When installed correctly, the zipper should be facing down as shown in Figure 14.16.

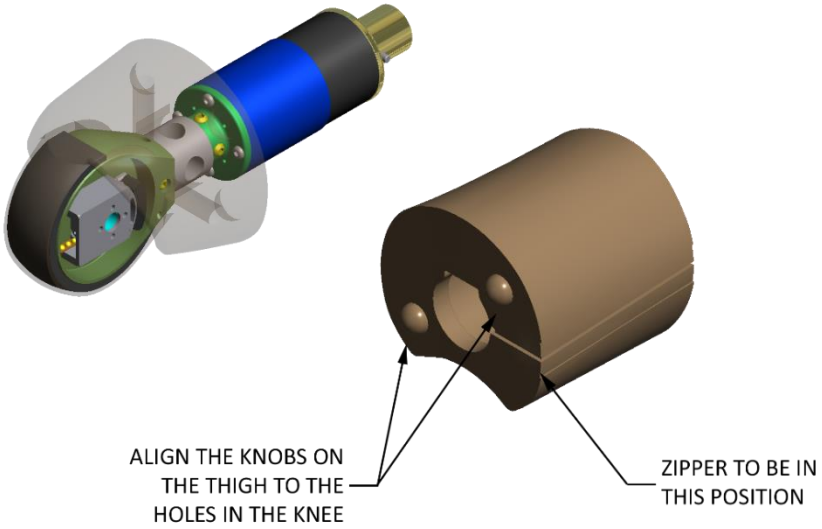

Figure 14.16 Thigh Flesh Installation

14. Slide the Left Femur Ball Joint Assembly (472-5100) so that dowel pins on the Femur Ball Attachment Plate lock into the slots on the ball joint assembly. The ball should be facing up and to the right side if installed correctly as shown in Figure 14.17. Once the Ball Joint Assembly is in the correct position, install M16x40 LG. SHSS.

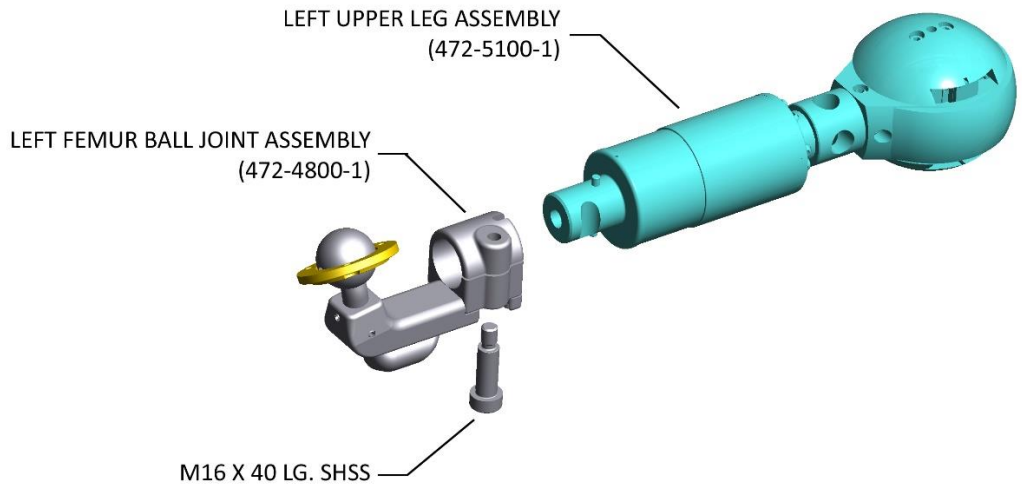

Figure 14.17 Femur Ball Joint Installation

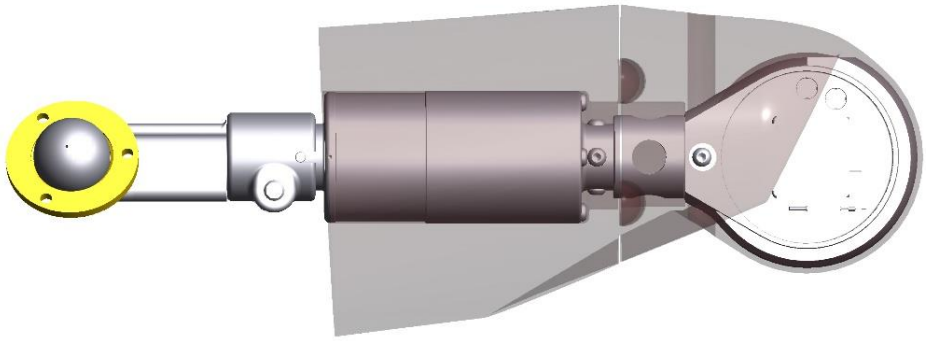

Figure 14.18 Upper Leg/Knee and Skins Assemblies

15. Repeat the process for the Right Upper Leg Assembly.

14.2.3 **Assembly of the Lower LX Leg to the Knee**

The following procedure is a step-by-step description used to install the completed Lower LX Leg Assembly (472-7000-1, left / 472-7000-2, right or Hybrid III) to the completed Femur/Knee Assembly (472-5000). All bolts should be tightened to the torque specifications provided in Section 17 Instrumentation and Wiring.

1. Rotate the Knee Sliders so both the inner and outer slider are aligned to slide rearward as shown in Figure 14.19.

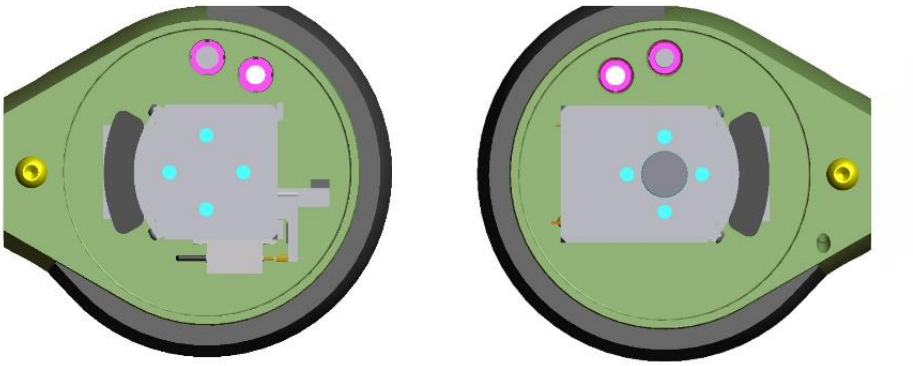

Figure 14.19 Knee Slider Position

2. With the foot pointing away from the dummy, slide the Lower Leg Knee Clevis over the Knee Sliders.

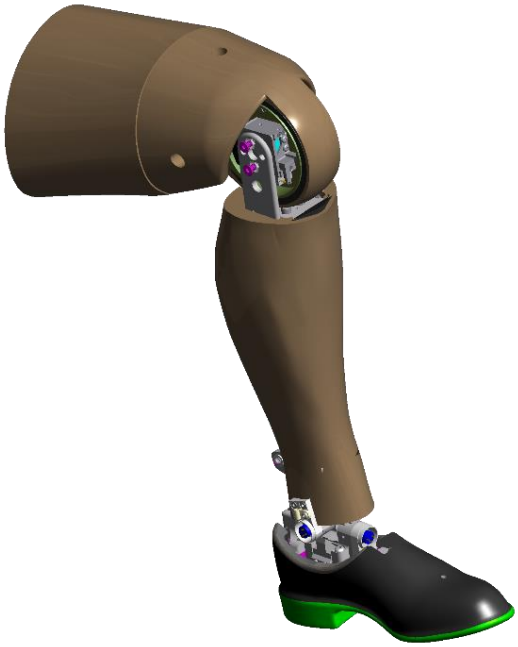

Figure 14.20 Knee Clevis over Knee Slider with Foot Pointing Away

3. Align the holes of the knee clevis (attached to the Lower Leg) with the holes of the Knee Slider and secure using four M6 x 10 FHCS.

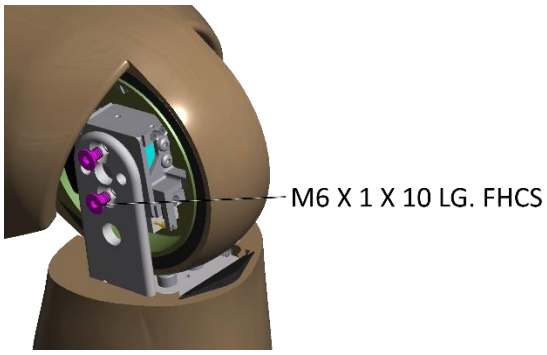

Figure 14.21 Knee Clevis to Kneecap Assembly

4. Install the knee cover plates so that holes in the covers line up with the two remaining holes on each side of the knee clevis and secure using four M6 x 16 SHCS.

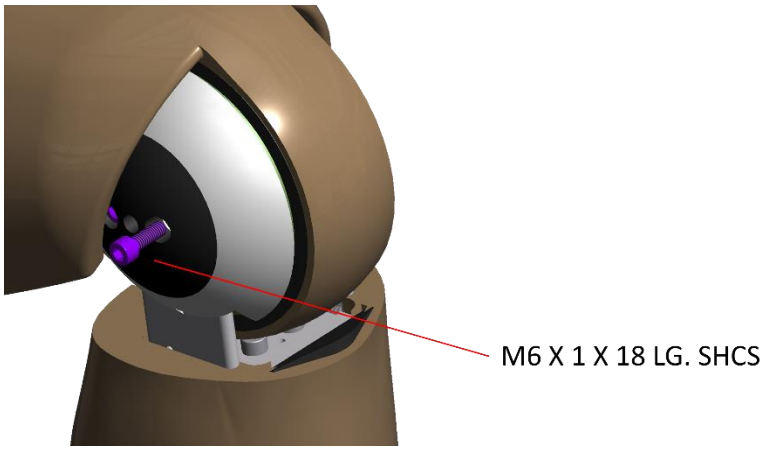

Figure 14.22 Knee Cover Installation

NOTE: WHEN THE LOWER LEG IS ATTACHED CORRECTLY, THE INNER AND OUTER KNEE SLIDERS ARE BOTH ALIGNED TO SLIDE REARWARD WHEN THE FRONT OF THE TIBIA IS IMPACTED. ALSO, THE RANGE OF MOTION STOP ENGAGES WHEN THE LEG IS STRAIGHT, PREVENTING HYPEREXTENSION.

5. Repeat the procedure for the Right Lower Extremity Assembly.

14.3 Adjustments for the Femur Assembly

The femur assembly does not require any adjustments.

14.4 Wire Routing and Electrical Connections

The wire routing for the instrumentation in the femur assembly is fairly straight forward. Each instrument in this assembly will be covered individually.

Six Axis Femur Load Cells – The wires from the Femur Load Cells need to be routed in the grooves provided in the femur flesh at the Knee/Femur Interface. These wires are routed to the backside of the femur assembly.

14.5 Upper Leg Qualification

Qualification procedures for the upper leg are described in the THOR-50M Qualification Procedures Manual as a separate publication.

14.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgement should be used to determine the frequency of these inspections; however, a thorough inspection after every twenty tests is recommended. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. These inspections include both electrical and mechanical inspections. These inspections are most easily carried out during a disassembly of the dummy. The disassembly of the femur components can be performed by simply reversing the procedure used during the assembly.

14.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all the instrument wires from the neck instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from transferred properly to the data acquisition system. The instrument wires should be checked to ensure that they are properly stain relieved. A more detailed check on the individual instruments will be covered in Section 17 Instrumentation and Wiring.

14.6.2 **Mechanical Inspection**

Several components in the femur assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact the manufacturer regarding questions about parts which fail the mechanical inspection.

Compliant Bushing: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for permanent compression, nicks, or tears.

Femur Shaft: The following checklist should be used when inspecting for post-test damage:

- ✓ Check alignment and correct motion in the femur bearing housing.
- ✓ Check the condition of the linear bearing lining on the ID.
- ✓ Check the two end stop bumpers.

Femur Skin: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for holes, tears, and cuts.

Knee Skin: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for holes, tears, and cuts.

Section 15. **Lower LX Leg Assembly**

15.1 **Description of the Lower Leg Assembly and Features**

The THOR-LX was also updated with many new sensors to increase the ability of the dummy to measure injury and trauma, including a pair of tibia load cells, to measure the force and moment data for the tibia shaft. (The upper tibia load cell is a five-channel unit, while the lower one provides five channel capability). Three rotary potentiometers were used to measure the rotation of the individual ankle joints, thereby providing complete kinematic data. A pair of uniaxial accelerometers on the tibia shaft provide the acceleration in the X and Y axes to allow the transformation of the measured tibia moment to the calculated ankle moment. Finally, a single triaxial accelerometer unit on the foot was included to enable correlation with prior foot/ankle injury tolerance studies. The instrumentation in the THOR-LX leg assembly is shown below in Figure 15.1.

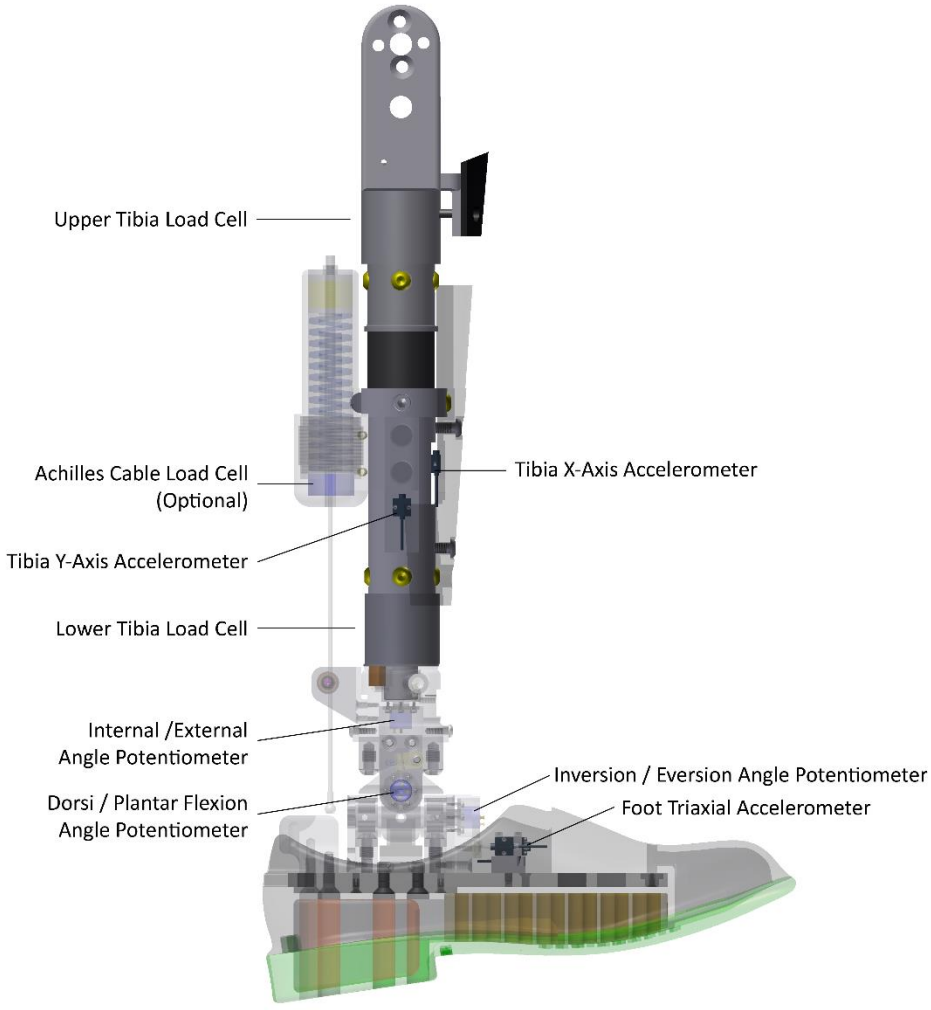

Figure 15.1 THOR-LX Leg Assembly Instrumentation

The THOR-50M dummy has been designed to accept either the standard Hybrid III 50% male lower leg or the advance lower extremity known as the THOR-LX.

15.2 Assembly of the LX Lower Leg

15.2.1 Parts List

Refer to drawing 472-7000-1 and 472-7000-2 in the THOR-50M drawing set for a detailed mechanical assembly drawing. Figure 15.2 shows an exploded view of the assembly and hardware.

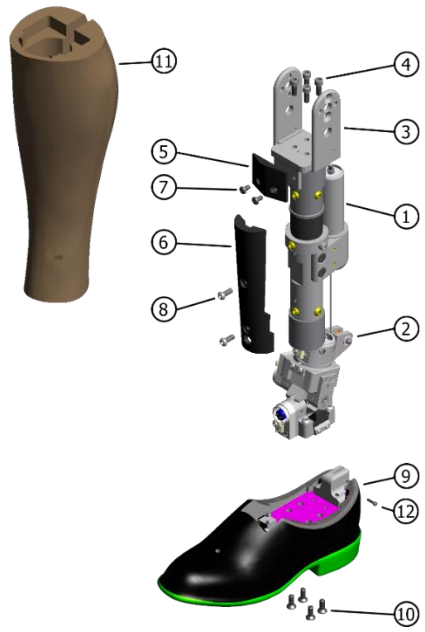

Figure 15.2 Left Lower LX Leg Assembly Exploded View

Table 15-1 Left and Right Lower LX Leg Parts List

Item	Qty.	Part Number	Description
1	1	472-7300	LOWER LEG MECHANICAL ASSEMBLY
2	1	472-7500-1	ANKLE ASSEMBLY, LEFT
	1	472-7500-2	ANKLE ASSEMBLY, RIGHT (NOT SHOWN)
3	1	472-7200	KNEE CLEVIS WELDMENT
4	4	5000081	M6 X 1 X 16 LG. SHCS
5	1	472-7110	KNEE BUMPER, MOLDED
6	1	472-7115	TIBIA GUARD
7	2	5000003	M5 X 0.8 X 10 LG. BHCS
8	2	5000072	M6 X 1 X 16 LG. BHCS
9	1	472-7800-1	MOLDED SHOE ASSEMBLY, LEFT
	1	472-7800-2	MOLDED SHOE ASSEMBLY, RIGHT (NOT SHOWN)
10	4	5000090	M6 X 1 X 16 LG. FHCS
11	1	472-7370-1	LOWER LEG FLESH, LEFT
	1	472-7370-2	LOWER LEG FLESH, RIGHT (NOT SHOWN)
12	1	5001103	M3 X 0.5 X 12 LG. SHCS

15.2.2 **Assembly of Lower Leg Components**

The following procedure is a step-by-step description of the assembly procedure for the THOR-LX components. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. The Ankle Assembly is attached to the Molded Shoe Assembly (472-7800-1, Left, or 472-7800-2, Right) using four M6 x 16 FHCS.

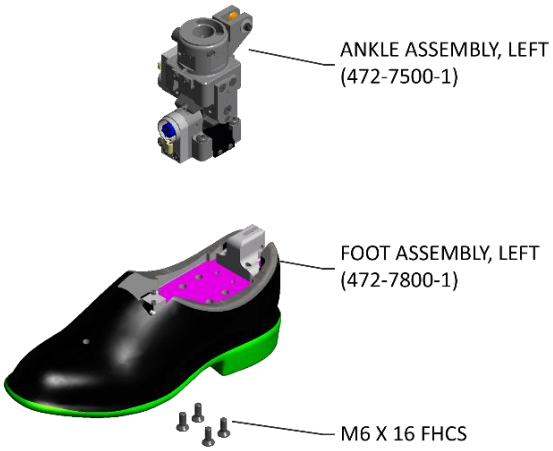

Figure 15.3 Ankle Assembly Attached to Foot Assembly with Four M6x16 FHCS

2. Secure the wedge and Lower Tibia Load Cell of the Lower Leg Mechanical Assembly (472-7300) into the counter bored hole in the Mechanical Ankle Assembly (472-7500-1 for left leg, 472-7500-2 for right leg). Center the Z-rotation wedge between the soft stops (if required) and slide the assemblies together as shown in the bottom figure below.

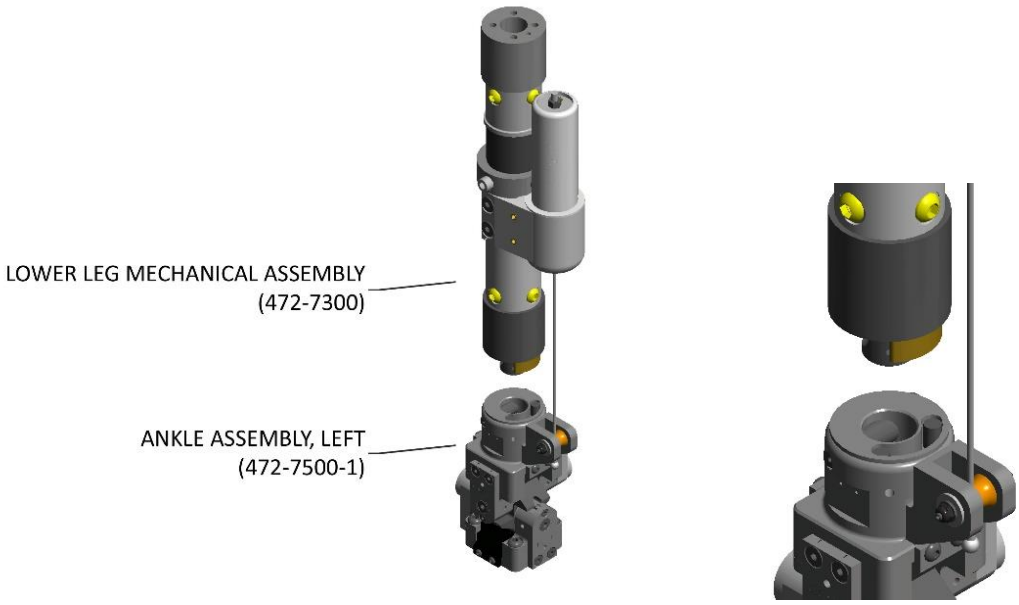

Figure 15.4 Lower Leg Mechanical Assembly Inserted into Ankle Assembly

3. A uniaxial accelerometer unit can be attached directly to the mounting location provided on the front of the Tibia Tube to measure the X-axis acceleration. Use two M1.4 x 0.3 x 3 LG SHCS to attach the uniaxial accelerometer to the flat mounting area on the front of the Lower Tibia Tube.

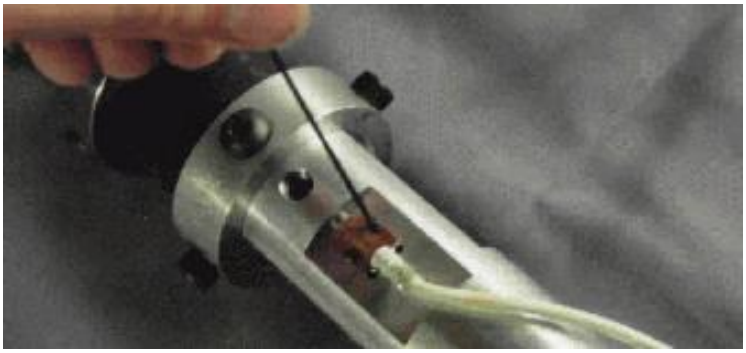

Figure 15.5 Attaching X-Axis Accelerometer to Front of 472-7311

4. A uniaxial accelerometer unit can be attached directly to the mounting location provided on the right side of the Tibia Tube to measure the Y-axis acceleration. Use two M1.4 x 0.3 x 3 LG SHCS to attach the uniaxial accelerometer to the flat mounting area on the right-hand side of the Lower Tibia Tube.

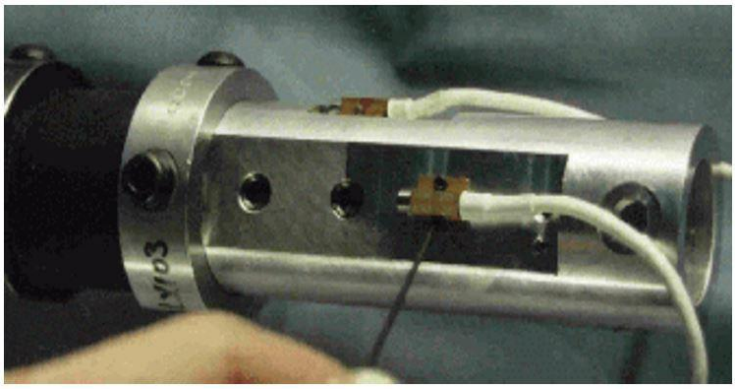

Figure 15.6 Attaching the Y-Axis Accelerometer

5. The Tibia Guard (472-7115) is mounted to the front of the Lower Leg Assembly using two M6 x 16 BHCS in the mounting hole**.** The uniaxial accelerometer wire is routed out the hole in the Tibia Guard on the right side.

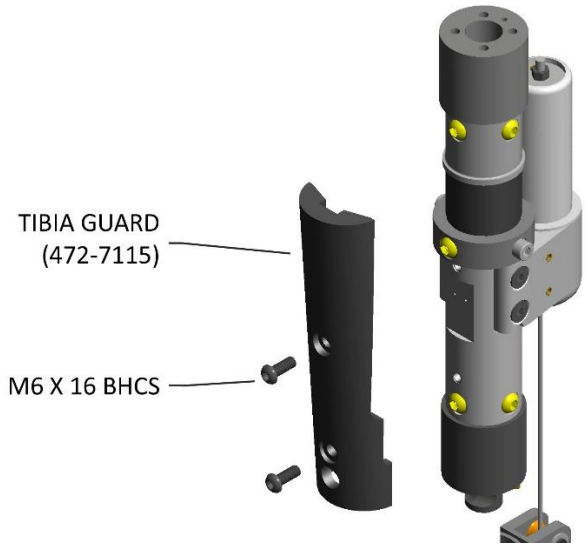

Figure 15.7 Mounting the Tibia Guard

6. Attach the Knee Clevis Weldment (472-7200) to the top of the Upper Tibia Load Cell using four M6 x 16 SHCS.

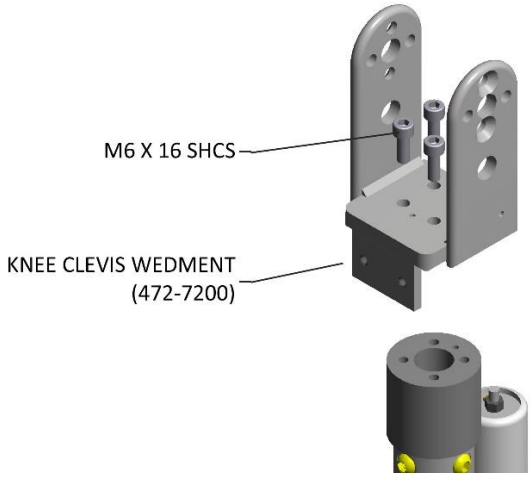

Figure 15.8 Attach Knee Clevis Weldment with Four M6x16 SHCS

7. Attach the Molded Knee Bumper (472-7110) to the front of the Knee Clevis Assembly using two M5 x 10 BHCS

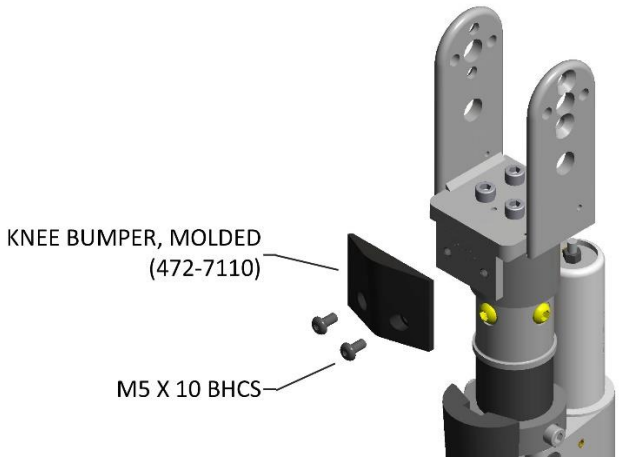

Figure 15.9 Attaching the Molded Knee Bumper

8. The Foot Tri-Pack Mounting Plate (472-7710) is mounted onto the composite Sole Plate using two M3 x 16 FHCS. The instrumented Tri-Pack Block is mounted to the front of the Foot Tri-PackMounting Plate using two M2.5 x 16 SHCS

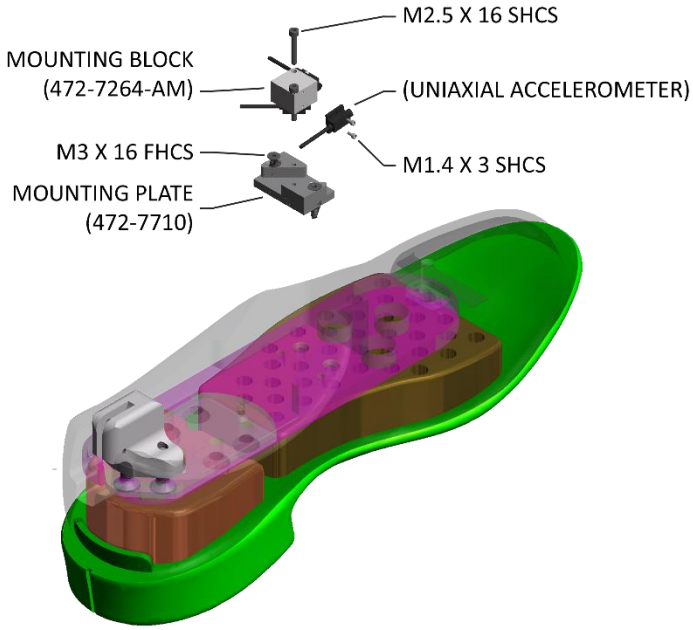

Figure 15.10 Mount the Foot Tri-Pack Mounting Plate, Accelerometer Block and Accelerometers

9. Pass the Achilles Cable behind the Achilles Pulley Wheel which is mounted to the rear of the Lower Tibia Load Cell. Attach the ball end of the Achilles Cable Assembly to the Lower Achilles Mounting Post by sliding the cable section above the ball into the slot on the back of the mounting post.

Figure 15.11 Slide Achilles Cable Assembly into Mounting Post Slot

10. Allow the ball to move up to the top of the recessed area in the mounting post and secure the cable in place by inserting a M3 x 12 SHCS locking screw into the hole on the side of the mounting post.

Figure 15.12 Secure Cable with Locking Screw

11. Position the Molded Knee Bumper (472-7110) of the Knee Clevis Assembly (472-7200) into the molded pocket located on the upper front interior surface of the Lower Leg Skin (472-7370-1 for left leg and 472-7370-2 for right leg).

Figure 15.13 Insert Knee Bumper and Clevis into the Molded pocket of the Lower Leg Skin

12. Route the wires from the instruments into the two wire channels provided within the Lower Leg Skin as shown in Figure 15.14. The wires are designed to exit the skin at the top - behind the knee assembly.

Figure 15.14 Route the Wiring in Lower Leg Skin

13. Zip the Lower Leg Skin around the Leg to Complete the Assembly.

Figure 15.15 Completed THOR-LX Foot, Ankle and Lower Leg Assembly

15.2.3 **Assembly of the THOR-LX Leg to the Knee**

The following procedure is a step-by-step description to install the completed THOR-LX to the knee assembly. This unit was designed to be installed on the Hybrid III 50th percentile kneeassembly which has been upgraded to the ball bearing slider, as specified in the drawing package andbill of materials (BOM). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. All bolts should be tightened to the torque specifications provided in Section 2.1.3 Bolt Torque Values.

1. Insert the Knee Assembly into the modified THOR-LX Knee Skin (472-5502-6) prior to attaching the Knee Clevis.

2. Position the corresponding Knee Cover over each side of the Knee Assembly and secure the covers with four M6 x 18 SHCS. The screws pass through the covers, through the holes in the Knee Clevis and into the Ball Bearing Slider Block for the outside and inside of the Right Knee Assemblies.

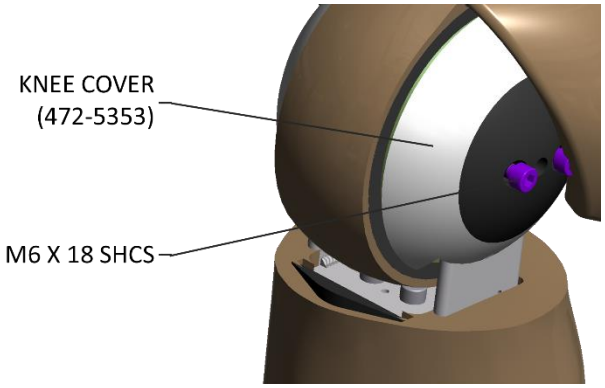

Figure 15.16 Installed Knee Covers

3. Repeat the procedure for the Left THOR-LX Leg Assembly.

4. The completed THOR-LX Leg Assembly is shown in Figure 15.17**.**

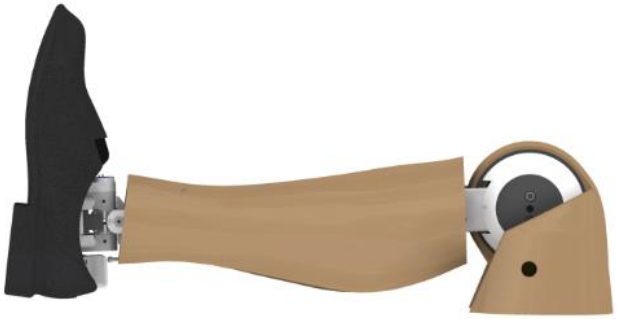

Figure 15.17 Completed THOR-LX Leg Assembly

15.3 Adjustments for the THOR-LX Leg Assembly

Refer to the THOR-50M Qualification Procedures Manual for the Achilles adjustments.

15.4 THOR-LX Leg Qualification

Qualification procedures for the LX leg are described in the THOR-50M Qualification Procedures Manual as a separate publication.

15.5 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure that the dummy integrity has remained intact. Good engineering judgment should be used to determine the frequency of these inspections; however, the manufacturer recommends a thorough inspection after every 20 tests. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. These inspections include both electrical and mechanical inspections. These inspections are most easily carried out during a disassembly of the dummy. The disassembly of the THOR-LX leg assembly components can be performed by simply reversing the procedure used during the assembly. The area of inspection is covered in detail below. Please contact the manufacturer regarding questions about parts which fail the inspection.

Lower Leg Skin and Foot Skin: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for holes, tears, and cuts.

15.5.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the wires. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments is provided in Section 17 Instrumentation and Wiring.

15.5.2 Mechanical Inspection

Several components in the THOR-LX assembly will need a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection is covered in detail below. Please contact the manufacturer regarding questions about parts which fail the mechanical inspection.

Achilles Tendon Cable: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for kinks and broken strands.

Ankle Soft Stops: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for permanent compression, nicks or tears.

Ankle Torque Cylinders: The following checklist should be used when inspecting for post- test damage; these can be viewed with the potentiometers and bearing housings removedfrom each side of the ankle assembly:

- ✓ Check for permanent compression, nicks or tears.

Tibia Compliant Bushing Assembly: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for alignment and correct motion in the lower tibia bearing housing.
- ✓ Check the condition of the linear bearing lining.
- ✓ Check the rubber bushing for signs of permanent compression, de-bonding.

Tibia Skin: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for holes, tears and cuts.

Foot Skin: The following checklist should be used when inspecting for post-test damage:

- ✓ Check for holes, tears and cuts.

Section 16. Jacket and Clothing Assembly

16.1 Description of Jacket Assembly, Clothing, and Features

The THOR-50M Jacket assembly is comprised of the front panel assembly, rear panel assembly, crotch strap, and rib stiffeners. Internal side foam inserts have been installed along the sides of the ribs just below the shoulder yoke assembly to closely resemble the human anthropometry in the thorax region.

Made from a flexible elastic material, the jacket assembly stretches and conforms easily to the dummy's movements. Reinforcements have been added to 1) the shoulder areas to reduce wear from belt burn and belt load and 2) the lower section of the front panel to keep the rib stiffeners in place. The rib stiffeners play a crucial role in preventing the lap belt from intruding into the voids between the upper and lower abdomen assemblies. The crotch strap assists in keeping the jacket in place and prevents bunching of the jacket due to belt loading.

An added feature of the jacket is the strategic location of the four zippers. The locations allow the jacket to be opened from either side for internal inspection and, if needed, to remove the entire Jacket assembly from the dummy with little movement of the dummy. The zippers have a Velcro covering that aids in keeping the zippers in place and provide a smooth, continuous surface over the entire Jacket assembly.

As an integral part of the thorax assembly, the jacket enhances the response of the thorax during testing. The design of the jacket also prevents metal to metal contact between THOR-50M instrumentation and the testing environment.

16.2 Assembly of the Jacket

16.2.1 Parts List

The following table shows the parts associated with the Front/Rear Panel Assembly, Jacket drawing, 472-3901-A.

Table 16-1 Jacket Parts List

Item	Qty.	Part Number	Description
1	1	472-3930-A	FRONT PANEL ASSEMBLY, JACKET
2	1	472-3951	REAR PANEL ASSEMBLY, JACKET

Figure 16.1 and Figure 16.2 are photographs of the outside and inside of the jacket assembly.

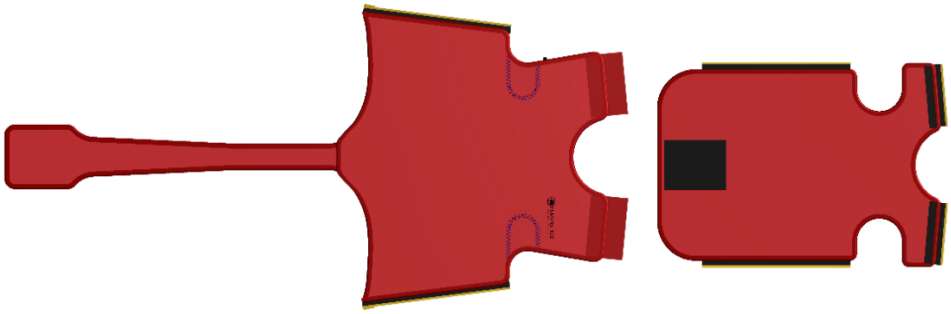

Figure 16.1 Jacket Assembly (Outside View)

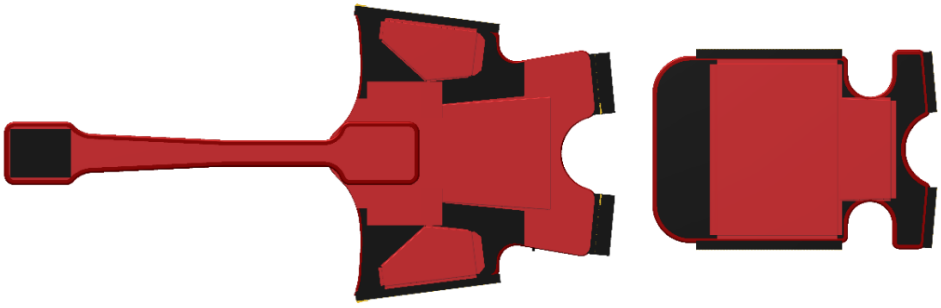

Figure 16.2 Jacket Assembly (Inside View)

16.2.2 **Assembly of Jacket Components**

The following procedure is a step-by-step description of the assemble procedure for the jacket assembly.

1. Locate the rib stiffener pockets (472-3913) on the lower inside of the front panel (472-3911). Insert one rib stiffener (472-3926) into each of the four rib stiffener pockets as shown in Figure 16.3.

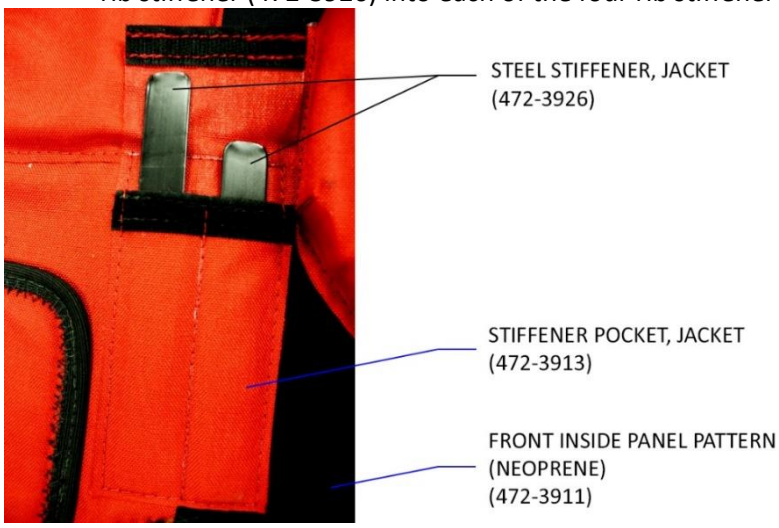

Figure 16.3 Rib Stiffener Inserted into Pocket

2. The jacket is assembled onto the thorax of the dummy by draping the inside front panel (472-3930-A) and inside rear panel (472-3951) of the jacket over the front and rear of the dummy's thorax as shown in Figure 16.4.

Figure 16.4 Jacket Assembled onto Thorax

3. Locate and close the front panel zipper (472-3917) on the Left shoulder, and cover with the attached Velcro as shown in Figure 16.5.

Figure 16.5 Left Shoulder Zipped

4. Similarly, locate and close the front panel zipper (472-3917) on the Left Shoulder, and cover with the attached Velcro as shown in Figure 16.6.

Figure 16.6 Right Shoulder Zipped

5. Locate and close the front panel zipper (472-3918) on the left side of the jacket as shown in Figure 16.7.

Figure 16.7 Left Side Zipped

6. Similarly, locate and close the front panel zipper (472-3918) on the right side of the jacket as shown in Figure 16.8.

Figure 16.8 Right Side Zipped

7. Lift the dummy using the procedure outlined in Section 2.4 Dummy Handling. While the dummy is suspended, have an assistant slide the crotch strap assembly (472-3922-A) between the legs underneath the pelvis. Lower the dummy and attach the Velcro on the crotch strap to the Velcro on the bottom of the jacket rear panel (472-3953). The front and rear views of the complete jacket assembly are shown in Figure 16.9 and Figure 16.10.

Figure 16.9 Properly Installed Jacket, Front

Figure 16.10 Properly Installed Jacket Assembly, Rear

16.3 Adjustments for the Jacket Assembly

The jacket assembly does not require any adjustments.

16.4 Wire Routing and Electrical Connections

The jacket assembly does not require any electrical connections.

16.5 Jacket Qualification

There are no qualification requirements for the jacket assembly.

16.6 Inspection and Repairs

After a test series has been performed, the Jacket assembly should be inspected for wear or damage. Good engineering judgment should be used to determine the frequency of these inspections; however, a thorough inspection is recommended after every twenty tests. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. The disassembly of the jacket components can be performed by simple reversing the procedure used during the assembly.

16.6.1 Mechanical Inspection

The following checklist should be used when inspecting the dummy's jacket for post-test damage:

- ✓ Check the rib stiffeners to ensure no permanent deformation has occurred and that the stiffeners are securely in place.
- ✓ Check fabric for tears or holes, especially in areas where lap and shoulder belts contact the fabric surface.
- ✓ Examine Velcro and zippers for broken hardware or stitching.

Section 17. **Instrumentation and Wiring**

17.1 **Overview of Instrumentation and Wiring**

The THOR-50M dummy when fully instrumented has 157 separate sensor channels. These include 18 channels of data for each THOR-LX. In addition, there are 5 tilt sensors that are used to establish the orientation of the dummy. Table 17-1 shows the location of the instrumentation for THOR-50M and the figure below shows the relative location. Each instrument has an individual lead wire to allow for easy removal and insertion for calibration and inspection.

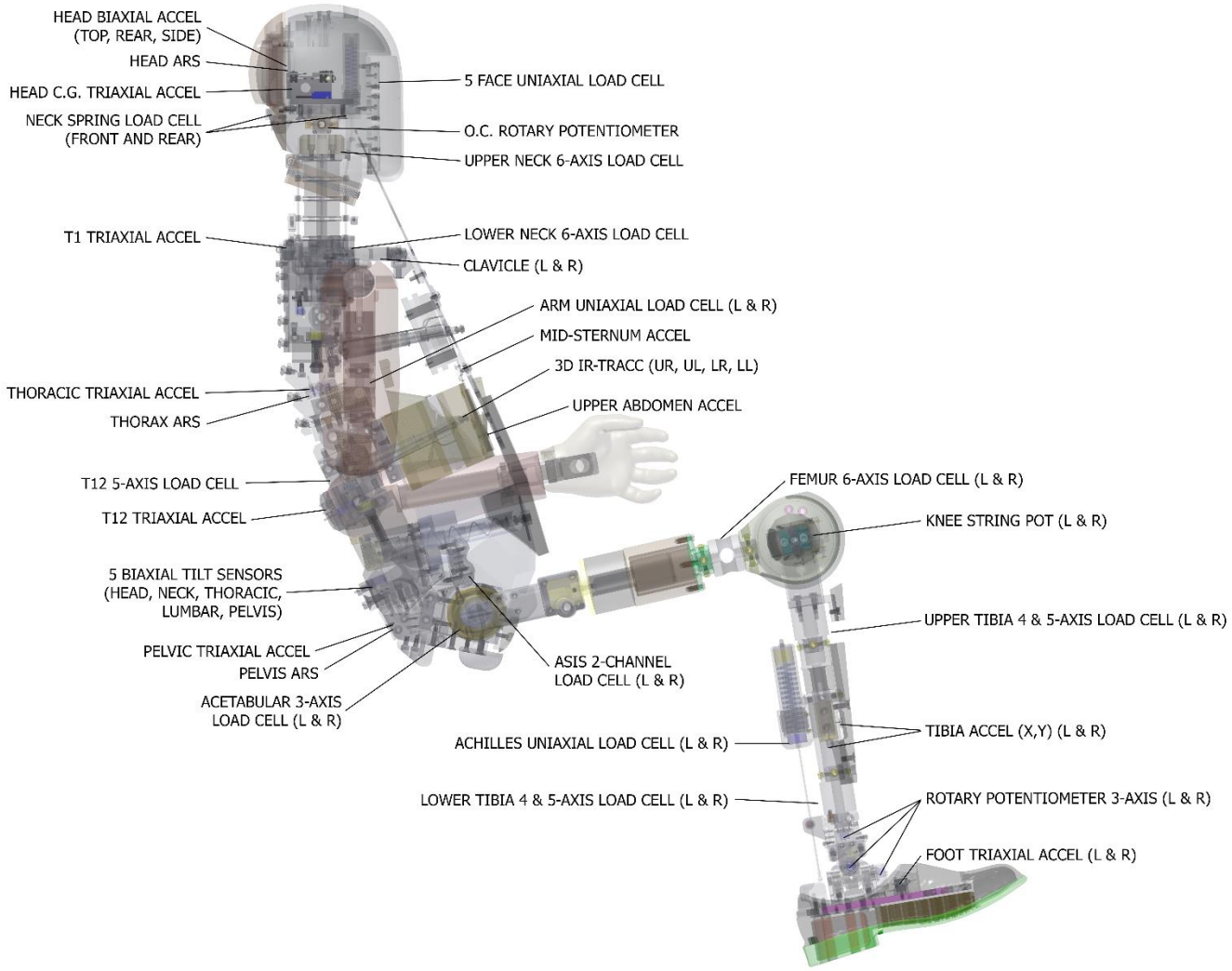

Figure 17.1 Relative Location of THOR-50M Instrumentation

17.1.1 **Available Instrumentation**

The THOR-50M dummy is currently capable of supporting the following instrumentation.

Table 17-1 THOR-50M Instrumentation

Location	Description
Head & Neck	Head Accelerometers (CG)
	Head Accelerometers (Top)
	Head Accelerometers (Side)
	Head Accelerometers (Rear)
	Head CG Angular Rate Sensor
	Head Tilt Sensor
	Neck Tilt Sensor
	Face Load Cell -Left Eye
	Face Load Cell -Right Eye
	Face Load Cell -Left Cheek
	Face Load Cell - Right Cheek
	Face Load Cell - Chin
	Upper Neck Load Cell
	Lower Neck Load Cell
	Skull Spring Load Cell (Front)
	Skull Spring Load Cell (Rear)
	O.C. Rotary Potentiometer
Shoulder & Arm	Clavicle Load Cell SD3 (Left)
	Clavicle Load Cell SD3 (Right)
	Arm Load Cell (Left)
	Arm Load Cell (Right)
Spine & Thorax	T1 Accelerometer (Tri-pack)
	Mid Sternum Accelerometer
	Thorax Accelerometer (Tri-pack)
	T12 Accelerometer (Tri-pack)
	Thoracic Tilt Sensor
	Thorax Angular Rate Sensor
	Lumbar Tilt Sensor
	T12 Load Cell
	3D IR-TRACC Upper Thorax (Left)
	3D IR-TRACC Upper Thorax (Right)
	3D IR-TRACC Lower Thorax (Left)
	3D IR-TRACC Lower Thorax (Right)
Abdomen	Upper Abdomen Accelerometer
	3D IR-TRACC Abdomen (Left)
	3D IR-TRACC Abdomen (Right)

Location	Description
Pelvis	Pelvis CG Accelerometer (Tri-pack)
	Pelvis Tilt Sensor
	Pelvis Angular Rate Sensor
	Acetabulum Load Cell (Left)
	Acetabulum Load Cell (Right)
	A.S.I.S Load Cell (Left)
	A.S.I. S Load Cell (Right)
Femur	Femur Load Cell (Left)
	Femur Load Cell (Right)
Lower Extremity (Left)	Knee Shear Displacement Potentiometer
	Upper Tibia Load Cell
	Lower Tibia Load Cell
	Tibia Accelerometer
	Achilles Load Cell
	Ankle Rotation Potentiometer X Y Z
	Foot Acceleration
Lower Extremity (Right)	Knee Shear Displacement Potentiometer
	Upper Tibia Load Cell
	Lower Tibia Load Cell
	Tibia Accelerometer
	Achilles Load Cell
	Ankle Rotation Potentiometer X Y Z
	Foot Acceleration

17.1.2 Instrumentation Description

Head:

The THOR-50M head assembly is instrumented with three uniaxial accelerometers at the CG of the head; two pairs of uniaxial accelerometers, mounted on a 7-acclerometer array fixture, a pair of uniaxial accelerometers at the top of the skull and a biaxial tilt sensor. The purpose of the accelerometers is to allow the reconstruction of the head kinematics. The purpose of the dual-axis tilt sensor is described in the Spine section. The CG accelerometer fixture is also configured for the installation of angular rate sensors.

Face:

Five uniaxial load cells are positioned at five distinct points to measure impacts to the facial region. The load cell positions include left and right orbital regions (eye sockets), left and right maxillae (upper jaw bones), and mandible (lower jawbone).

Neck:

The neck instrumentation consists of a pair of six-axis load cells located at the top and bottom of the flexible neck assembly. These load cells provide the primary loading data for the neck structure, which includes the forces in the X, Y, and Z directions, as well as the moments in the X, Y, and Z directions. In addition, a pair of uniaxial load cells is used to measure the cable tension (or spring force) on the front and rear neck cables. Finally, a rotary potentiometer is centered at the condyle bolt to measure the rotation of the head relative to the top of the neck.

Thorax:

The thorax assembly is instrumented with four 3D IR-TRACC units. The units are located at the level of rib #3 and rib #6 on the left and right sides. Each of these units measures the three-dimensional deflection of the rib cage at the attachment point. This system provides a four-point measurement system for thoracic deflection. There are also left and right Clavicle Load cells, 4 channels each, to measure shoulder loading.

Mid Sternum:

The mid-sternum assembly is instrumented with a uniaxial accelerometer on the backside of the plate. This unit is designed to measure the sternal accelerations, such as those caused by an airbag or steering wheel impact.

Upper Abdomen:

A Uniaxial accelerometer is mounted inside the upper abdomen assembly. This unit is designed to measure the uni-directional acceleration of the bag, such as those caused by an airbag or steering wheel impact.

Lower Abdomen:

The lower abdomen assembly is instrumented with a pair of 3D IR-TRACCs. These units consist of an IR-TRACC and 2 rotary pots which provides three-dimensional deflection data for two points (left and right) in the lower abdomen assembly.

Spine:

The spine is instrumented with the five-axis thoracic load cell located at the anthropomorphic level of T12. This load cell provides the primary loading data for the spine structure, which includes the forces in the X, Y, and Z directions, as well as the moments in the X and Y directions. In addition, the spine is instrumented with three tri-pact accelerometers – located at the anthropomorphic levels of T1 and T12 and at the vertical level of the thorax CG. Three additional dual-axis tilt sensors are located along the spine between the head and the pelvis. The tilt sensors are capable of measuring the relative angular orientation of the dummy in the anterior-posterior and in the lateral directions. These allow very repeatable posture setups between tests.

Pelvis:

The pelvis assembly is instrumented with a pair of acetabular load cells located at the ball joint of the hip. These load cells measure the forces in the three primary directions of the loads transferred from the femur to the pelvis. A pair of 2 channel load cells are built into the iliac ASIS region of the pelvic casting. The purpose of these load cells is to determine whether or not the belt is loading the pelvis in the iliac notch region. Lack of load reading on these iliac load cells may indicate a condition of submarining. In addition, a tri-pack accelerometer is located at the pelvis CG to measure the accelerations in the three principal directions.

Femur:

The femur assemblies are each instrumented with a six-axis femur load cell located between the knee and the compliant femur bushing. These load cells provide the primary loading data for the femur

structure which includes the forces in the X, Y, and Z directions, as well as the moments in the X, Y, and Z directions.

Knee:

The knee assemblies are each instrumented by miniature string potentiometers which measure the shear displacement of the tibia relative to the femur.

Tibia:

Each tibia assembly contains a 5-axis upper tibia load cell and a 5-axis lower tibia load cell. These provide data on the forces at the top and bottom of the tibia in the Fx, Fy, Fz directions and moments in the Mx, My directions. In addition, two accelerometers are attached to the tibia which measure accelerations in the X and Y directions in the tibia coordinate system. These can be used with the tibia load cell data and the ankle rotation data (below) to compute the moment and forces acting at the ankle joints.

Ankle:

Each ankle assembly contains three rotary potentiometers which measure the rotation of the foot relative to the tibia in the three principal directions: dorsiflexion/plantarflexion, inversion/eversion, and internal/external rotations.

Foot:

Each foot assembly contains a tri-pack accelerometer which measures the accelerations of the foot in three perpendicular directions in the foot coordinate system.

17.2 Wire Routing

Note: Wire routing and strain relief can be completed per the customer's preference, the important aspect is to ensure that there is enough slack in the wires and that they are strain relieved in a location where they will not be damaged. The instructions below describe Humanetics' procedure.

17.2.1 Wire Bundle from the Head and Neck

After the completed head and neck assemblies have been properly attached on the THOR-50M thorax and spine assemblies, the bundle of wires from all the instrumentation needs to be properly restrained. Details of this procedure are covered in Section 7.2.2, Assembly of Thorax Components. The instrumentation wires from the head and neck instrumentation should be bundled together.

1. Gather the wire bundle from the head and neck instrumentation. Holding the bundle together, measure 13.5" down along the wire bundle from the bottom of the head mounting plate. Centered at this point, wrap the wire bundle with electrical tape to provide enough thickness to allow the spine wire cover to hold it securely in place. This measurement will provide the necessary slack in the wires.
2. Repeat the above procedure for the Neck Spring Load Cells, Head Tilt Sensor, Neck Rotary Potentiometer, and Face Load cells wires.
3. The wire bundles are clamped on each side of the Upper Thoracic Spine Back Plate using ¼" Steel Loop Strap and a M5 BHCS.

17.2.2 Wire Routing for THOR-50M Instrumentation

Wire routing for the individual instruments in the THOR-50M dummy is discussed in detail in their associated assembly sections.

17.3 Strain Relief for THOR-50M Instrumentation Wires

17.3.1 Individual Instruments

Strain relief for the instrumentation wires has been provided in several manners to prevent damage to the wiring during testing. This initial strain relief is provided in various ways, depending upon the instrument. Some instruments use a zip-tie to attach the wire to a solid structure, some use a special wire clamp to hold the wire in position.

A second method of strain relief, which is used throughout the dummy, is the use of plastic wire crimp clamps. These clamps use a thru-bolt to compress the clamp around wires and hold them in place. Instructions on how to use these clamps is described throughout this manual, as necessary, to hold various groups of wires in place.

17.3.2 Main Dummy Strain Relief at Base of Spine

The final strain relief is provided at the base of the spine where all of the instrumentation wires (except the femurs and lower extremities) are grouped together to run to the data acquisition system. The procedure for securing the wires at this point is described in detail below.

1. Position the bundle of instrumentation wires, and secure to the lumbar spine flex joint assembly using several zip-ties.

2. Cover all the wires using the Nylon Wire Cover. Zip the cover shut and secure it to the mesh using two zip-ties through the grommets at the end of the cover, as shown in Figure 17.2.

Figure 17.2 Mesh Cover Properly Positioned

17.4 Wire Markers

In order to keep track of the instrumentation wiring used for the THOR-50M dummy, labels have been put in place on each instrument wire.

Table 17-2 Instrumentation Labels

Instrument Type
LOAD CELLS
ACCELEROMETERS
POTENTIOMETERS
IR-TRACC
TILT SENSORS

17.5 Instrumentation Excitation and Ground Requirements

For all the instrumentation on the THOR-50M dummy, the excitation voltage and ground requirements are supplied below. All instrumentation for this dummy was designed for the same excitation requirements, thus simplifying the power requirements. The current requirements are minimal, i.e. 100 mA per instrument is more than enough, but lower currents can be utilized. The excitation voltage is at the discretion of the laboratory and can be unipolar or bipolar. The following is the standard excitation used for developing the sensitivity tables that are supplied to the user.

All + Excitation Terminals are connected to a 10.00 (+/- 0.05) V DC power supply (except: IR TRACC and Tilt Sensors: 5V DC).

All – Excitation Terminals are connected to a ground (i.e. 0.0 V DC) source.

All Ground Terminals are connected to a ground (i.e. 0.0 V DC) source.

Section 18. **Appendix**

18.1 **Appendix A – Sign Conventions and Polarity Tests**

The tables below compare the polarity for the THOR-50M dummy to the SAE-J211 standard for each sensor. All instruments to be checked are assumed to be properly assembled into the dummy as specified in this user's manual. The T1, T12, Chest CG, and Pelvis CG accelerometers listed are the tri-pack configuration. The tri-pack configuration uses three uniaxial accelerometers mounted onto a tri-pack block (472-4202) to measure accelerations. The z-axis rotation manipulations are as seen from above; the x-axis rotation manipulations are as seen facing forward from the dummy perspective.

Appendix Table 18-1 Head and Neck

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Head Accelerometers (CG)	Ax	Impact rear of head in forward direction	+		
	Ay	Impact left side of head in rightward direction	+		
	Az	Impact top of head in downward direction	+		
Head CG Angular Rate Sensor	ωx	Rotate right ear toward right shoulder	+		
	ωy	Rotate chin toward sternum	-		
	ωz	Rotate chin toward right shoulder	+		
Upper Neck Load Cell	Fx	Move head rearward, chest forward	+		
	Fy	Move head leftward, chest rightward	+		
	Fz	Move head upward, chest downward	+		
	Mx	Rotate left ear toward left shoulder	+		
	My	Rotate chin toward sternum	+		
	Mz	Rotate chin toward left shoulder	+		
Lower Neck Load Cell	Fx	Move head rearward, chest forward	+		

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
	Fy	Move head leftward, chest rightward	+		
	Fz	Move head upward, chest downward	+		
	Mx	Rotate left ear toward left shoulder	+		
	My	Rotate chin toward sternum	+		
	Mz	Rotate chin toward left shoulder	+		
Front Neck Spring	Fz	Rotate head rearward	+		
Rear Neck Spring	Fz	Rotate chin toward chest	+		
O.C. Rotary Pot	θ_y	Rotate chin toward chest	-		
Face Eye Right	Fx	Hold back of head, push face rearward	-		
Face Eye Left	Fx	Hold back of head, push face rearward	-		
Face Cheek Right	Fx	Hold back of head, push face rearward	-		
Face Cheek Left	Fx	Hold back of head, push face rearward	-		
Face Chin	Fx	Hold back of head, push face rearward	-		

Appendix Table 18-2 Spine and Thorax

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
	Ax	Impact rear of thorax in forward direction	+		
	Ay	Impact left side of thorax in rightward direction	+		

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
T1 Accelerometer (Tri-pack)[a]	Az	Impact top of thorax in downward direction	+		
Mid Sternum Accelerometer	Ax	Impact rear of thorax in forward direction	+		
Thorax Accelerometer (Tri-pack)[a]	Ax	Impact rear of thorax in forward direction	+		
	Ay	Impact left side of thorax in rightward direction	+		
	Az	Impact top of thorax in downward direction	+		
T4/Thorax ARS	ωx	Rotate thorax rightward	+		
	ωy	Rotate thorax rearward	+		
	ωz	Rotate right shoulder backward and left shoulder forward	+		
T12 Accelerometer (Tri-pack)[a]	Ax	Impact rear of thorax in forward direction	+		
	Ay	Impact left side of thorax in rightward direction	+		
	Az	Impact top of thorax in downward direction	+		

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
T12 Load Cell	Fx	Move chest rearward, pelvis forward	+		
	Fy	Move chest leftward, pelvis rightward	+		
	Fz	Move chest upward, pelvis downward	+		
	Mx	Rotate left shoulder toward left hip	+		
	My	Rotate sternum towards front of legs	+		

Appendix Table 18-3 Shoulder and Arm

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Left Clavicle Load Cell	Fx - Medial	Push center of clavicle bone rearward towards spine	-		
	Fz - Medial	Push center of clavicle bone downward towards pelvis	+		
	Fx - Lateral	Push center of clavicle bone rearward towards spine	-		
	Fz - Lateral	Push center of clavicle bone downward towards pelvis	+		
Right Clavicle Load Cell	Fx – Medial	Push center clavicle bone rearward towards spine	-		
	Fz - Medial	Push center of clavicle bone downward towards pelvis	+		
	Fx - Lateral	Push center of clavicle bone rearward towards spine	-		
	Fz - Lateral	Push center of clavicle bone downward towards pelvis	+		

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Upper Left Arm Load Cell	Fx	Move shoulder rearward, elbow forward	+		
	Fy	Move shoulder leftward, elbow rightward	+		
	Fz	Move shoulder upward, elbow downward	+		
	Mx	Rotate elbow leftward	+		
	My	Rotate elbow forward	+		
	Mz	With upper arm vertical and lower arm horizontal, rotate hand rightward	+		
Upper Right Arm Load Cell	Fx	Move shoulder rearward, elbow forward	+		
	Fy	Move shoulder leftward, elbow rightward	+		
	Fz	Move shoulder upward, elbow downward	+		
	Mx	Rotate elbow leftward	+		
	My	Rotate elbow forward	+		
	Mz	With upper arm vertical and lower arm horizontal, rotate hand rightward	+		

Appendix Table 18-4 Abdomen

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Upper Abdomen Accelerometer	Ax	Impact front of abdomen in rearward direction	-		

Appendix Table 18-5 Pelvis

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Pelvis CG Accelerometer (Tri-pack)[a]	Ax	Impact rear of pelvis in forward direction	+		
	Ay	Impact left side of pelvis in rightward direction	+		
	Az	Impact top of pelvis in downward direction	+		
Pelvis ARS	ωx	Move left leg upward and right leg downward	+		
	ωy	Rotate pelvis rearward	+		
	ωz	Move upper legs rightward	+		
L Acetabular LC	Fx	Move femur forward, pelvis rearward	-		
	Fy	Move femur rightward, pelvis leftward	-		
	Fz	Move femur downward, pelvis upward	-		
R Acetabular LC	Fx	Move femur forward, pelvis rearward	+		
	Fy	Move femur rightward, pelvis leftward	+		
	Fz	Move femur downward, pelvis upward	+		
L ASIS	Fx	Push inward towards back of pelvis	-		
	My	Push top of ASIS towards back of pelvis	+		
R ASIS	Fx	Push inward towards back of pelvis	-		
	My	Push top of ASIS towards back of pelvis	+		

Appendix Table 18-6 Femur

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Left Femur Load Cell[b]	Fx	Move knee upward, upper femur downward	+		
	Fy	Move knee rightward, upper femur leftward	+		
	Fz	Move knee forward, femur rearward	+		
	Mx	Rotate knee leftward, hold upper femur	+		
	My	Rotate knee upward, hold upper femur	+		
	Mz	Rotate tibia leftward, hold pelvis	+		
Right Femur Load Cell[b]	Fx	Move knee upward, upper femur downward	+		
	Fy	Move knee rightward, upper femur leftward	+		
	Fz	Move knee forward, femur rearward	+		
	Mx	Rotate knee leftward, hold upper femur	+		
	My	Rotate knee upward, hold upper femur	+		
	Mz	Rotate tibia leftward, hold pelvis	+		

Appendix Table 18-7 Lower Extremity Left

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Knee Shear Displacement	Dx	Hold femur, move tibia forward	+		

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Upper Tibia Load Cell[b]	Fx	Move tibia forward, knee rearward	+		
	Fy	Move tibia rightward, knee leftward	+		
	Fz	Move tibia downward, knee upward	+		
	Mx	Rotate tibia leftward, hold knee	+		
	My	Rotate tibia forward, hold knee	+		
Lower Tibia Load Cell[b]	Fx	Move ankle forward, knee rearward	+		
	Fy	Move ankle rightward, knee leftward	+		
	Fz	Move ankle downward, knee upward	+		
	Mx	Rotate ankle leftward, hold knee	+		
	My	Rotate ankle forward, hold knee	+		
Tibia Accelerometer	Ax	Impact back of tibia in forward direction	+		
	Ay	Impact left of tibia in rightward direction	+		
Achilles Load Cell	Fz	Hold tibia, move toes upward	+		
Ankle Rotation	θ_x	Hold tibia, rotate bottom of foot leftward	+		
	θ_y	Hold tibia, pull toe upward	+		
	θ_z	Hold tibia, rotate toe rightward	+		
Foot Acceleration	Ax	Impact back of foot in forward direction	+		
	Ay	Impact left of foot in rightward direction	+		
	Az	Impact top of foot in downward direction	+		

Appendix Table 18-8 Lower Extremity Right

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Knee Shear Displacement	Dx	Hold femur, move tibia forward	+		
Upper Tibia Load Cell[b]	Fx	Move tibia forward, knee rearward	+		
	Fy	Move tibia rightward, knee leftward	+		
	Fz	Move tibia downward, knee upward	+		
	Mx	Rotate tibia leftward, hold knee	+		
	My	Rotate tibia forward, hold knee	+		
Lower Tibia Load Cell[b]	Fx	Move ankle forward, knee rearward	+		
	Fy	Move ankle rightward, knee leftward	+		
	Fz	Move ankle downward, knee upward	+		
	Mx	Rotate ankle leftward, hold knee	+		
	My	Rotate ankle forward, hold knee	+		
Tibia Accelerometer	Ax	Impact back of tibia in forward direction	+		
	Ay	Impact left of tibia in rightward direction	+		
Achilles Load Cell	Fz	Hold tibia, move toes upward	+		
Ankle Rotation	θ_x	Hold tibia, rotate bottom of foot leftward	+		
	θ_y	Hold tibia, pull toe upward	+		
	θ_z	Hold tibia, rotate toe rightward	+		
Foot Acceleration	Ax	Impact back of foot in forward direction	+		
	Ay	Impact left of foot in rightward direction	+		
	Az	Impact top of foot in downward direction	+		

Appendix Table 18-9 IR-TRACC Polarity

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Upper Left IR-TRACC	Dx	Push front of rib where IR-TRACC mounts inward toward spine	-		
	Ry	Push front of rib where IR-TRACC mounts downward	-		
	Rz	Push front of rib where IR-TRACC mounts rightward	+		
Upper Right IR-TRACC	Dx	Push front of rib where IR-TRACC mounts inward toward spine	-		
	Ry	Push front of rib where IR-TRACC mounts downward	-		
	Rz	Push front of rib where IR-TRACC mounts rightward	+		
Lower Left IR-TRACC	Dx	Push front of rib where IR-TRACC mounts inward toward spine	-		
	Ry	Push front of rib where IR-TRACC mounts downward	-		
	Rz	Push front of rib where IR-TRACC mounts rightward	+		
Lower Right IR-TRACC	Dx	Push front of rib where IR-TRACC mounts inward toward spine	-		
	Ry	Push front of rib where IR-TRACC mounts downward	-		
	Rz	Push front of rib where IR-TRACC mounts rightward	+		
Abdomen Left IR-TRACC	Dx	Push front of abdomen where IR-TRACC mounts inward toward spine	-		
	Ry	Push front of abdomen where IR-TRACC mounts downward	-		
	Rz	Push front of abdomen where IR-TRACC mounts rightward	+		
Abdomen Right IR-TRACC	Dx	Push front of abdomen where IR-TRACC mounts inward toward spine	-		
	Ry	Push front of abdomen where IR-TRACC mounts downward	-		
	Rz	Push front of abdomen where IR-TRACC mounts rightward	+		

NA = Not Applicable

a = Tri-pack refers to three uniaxial accelerometers mounted onto a tri-pack block

b = Motions are to be applied with the knee bent 90 degrees

Section 19. **Legal Disclaimer and Notices**

19.1 **Disclaimer**

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Section 20. **User Manual Update Log**

Revision Level	Revision Date	Revision Author	Revision Description
A	Dec. 2012		Manual updated to Thor NT / Metric with Mod Kit
B	JULY 2016	MGT, BLB, JQG	THOR-50M content update
C	JAN. 2017	MGT	Update for SBL-A and other changes and updates; Removed section Spine Calibration/Certification; Updated Recommended Tools Table 2-2; H-Point Tool, Figure 2-3, 2-4, 2-5: 472-8510-A was 472-8510; Angular Measurement Values Table 3-2: A4, 24.6 was -33.6; A6 & A7, Lumbar spine was Lower thoracic flex joint; A7, 33.6 was -24.6; A9, 31.3 was -31.2; A10, 31.3 was 23.6 in two places; Linear Measurement Values Table 3-3: L5 dimension 582±7 was 505±7 for left and right; THOR-50M Top Level Assembly Parts List Table 5-1: 472-2000-A was 472-2000; 472-3901-A was 472-3901; Thorax Assembly Parts List Table 9-1: 5000210 QTY 6 was 4; 5000416 QTY 2 was 4; Updated text 'four M5 x 20 BHCS, four M5 x 16 BHCS, and ten M5 (15mm OD) flat washer' was 'eight M5 x 20 BHCS and twelve M5 (15mm OD) flat washer' and updated Figure 9.10; SD3 Shoulder and Arms Assembly Parts List Table 10-4: Typo, 5000767 was 5000676; Removed 9000380; Updated Figure 12.22 Caption; Upper Abdomen Assembly Parts List Table 13-1: 472-4627-A was 472-4627; Lower Abdomen Assembly Parts List Table 14-1: 472-4763-A was 472-4763; 472-4761-A was 472-4761; Removed M10 flat washer; Pelvis Assembly Parts List Table 15-1: Added 9002655, 5001096, 5001441; 5000203 QTY 3 was 2; 472-4375-A was 472-4375; Updated Figure 15.4, Left Acetabulum was Right Acetabulum; Left and Right Upper Leg Parts List Table 16-1: 472-5502-6 was 472-5502; 472-5503-1-6 was 472-5503-1; 472-5503-2-6 was 472-5503-2; Left and Right Lower LX Leg Parts List Table 17-1:

Revision Level	Revision Date	Revision Author	Revision Description
			472-7300 was 472-7300-1/-2; 472-7800-1 and 472-7800-2 was 472-7740-1 and 472-7740-2; Added M3 X 12 SHCS; 18.2.1 Parts List: 472-3901-A was 472-3901; Jacket Parts List Table 18-1: 472-3930-A was 472-3930; Page 218: 472-3930-A was 472-3910; Added back Relative location of THOR-50M instrumentation figure 19-1; Updated Figures; Added Appendix A – Sign Conventions and Polarity Tests
D	MAR. 2017	MGT	Removed External Measurement Procedure and Mass Measurements Sections
E	JUL. 2018	MGT	Update to SBL-B changes and various updates; Update address
F	JUN. 2020	MGT	Section 13.2.2, Step 2, added “Make sure both nut threads and 472-4321-1 threads are clean and free of grease. Tighten M12 nut to 75±3 Nm.”, Step 4, added “Make sure both nut threads and 472-4321-2 threads are clean and free of grease. Tighten M12 nut to 75±3 Nm.”