THOR 50th Percentile Male (THOR-50M)

Procedures for Assembly, Disassembly, and Inspection (PADI)

AUGUST 2018

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THOR-50M PADI Manual
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Section 1. **Introduction**

1.1 Introduction

This manual describes the procedures for assembly, disassembly, and inspection (PADI) of the Test device for Human Occupant Restraint 50th percentile male (referred to as THOR-50M herein) anthropomorphic test device (ATD). This manual applies to the THOR-50M defined in the THOR-50M drawing package[1].

1.2 Getting Familiar with the PADI Manual

This manual serves as a technical reference book for the THOR-50M. This manual contains the following Sections:

- Introduction
- Dummy Preparation and Use
- Head Assembly
- Neck Assembly
- Spine Assembly
- Thorax Assembly
- Shoulder Assembly
- Upper Abdomen Assembly
- Lower Abdomen Assembly
- Pelvis Assembly
- Upper Leg Assembly
- Lower Extremity Assembly
- Arm Assembly
- Jacket and Clothing Assembly
- Instrumentation and Wiring
- 3D IR-TRACC Calibration Overview
- THOR-50M IR-TRACC Processing
- THOR-50M Tester's Checklist
- External Dimensions

[1] "Parts List and Drawings THOR-50M Advanced Frontal Crash Test Dummy: THOR-50M Male," (August 2018).

1.2.1 **Section Organization**

Each section of this manual contains the following subsections to provide a complete overview of each assembly:

- Description of Features
- Assembly of Component or Assembly
- Parts List
- Assembly Procedure
- Assembly of Component into THOR-50M
- Adjustments
- Wire Routing and Electrical Connections
- Inspection and Repairs

The assembly section of the manual assumes that the components have been disassembled to inspect or refurbish. Please refer to the THOR-50M Drawing Package for any details not covered in this manual.

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 relative to the dummy's right-hand or left-hand.

Front and Back
The references 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 refer to the superior and inferior sides of the part or assembly based on the dummy reference system.

Dummy Coordinate System
All references made to the coordinate system and instrumentation polarities are based on the SAE Information Report SAE J1733[2]. Manipulations to check instrumentation polarities are located in Section 15.5 THOR-50M Instrumentation Polarity Check. The SAE sign convention utilized includes:

- + X is toward the anterior or front of the dummy
- + Y is laterally toward the right
- + Z is toward the inferior (towards the bottom (feet) of the dummy)

[2] SAE J1733: Sign Convention for Vehicle Crash Testing, SAE Surface Vehicle Recommended Practice, November 2007.

Section 2. **Dummy Preparation and Use**

2.1 General

2.1.1 Hardware and Fasteners

With very few exceptions, all hardware and fasteners used on the THOR-50M crash test dummy are metric sizes.

The following abbreviations used throughout this manual include:

<u>SCREW ABBREVIATIONS:</u>

FHCS	**F**lat **H**ead **C**ap **S**crew
BHCS	**B**utton **H**ead **C**ap **S**crew
SHCS	**S**ocket **H**ead **C**ap **S**crew
SSS	**S**ocket **S**et **S**crew
HHCS	**H**ex **H**ead **C**ap **S**crew
SSFP	**S**et **S**crew **F**lat **P**oint

<u>MATERIAL ABBREVIATIONS:</u>

CRS	**C**old **R**olled **S**teel
SS	**S**tainless **S**teel
AL	**Al**uminum

2.1.2 Tools Required

The following tool list includes the recommended standard tools necessary for assembling the THOR-50M dummy (Figure 2-1). This list will allow the laboratory personnel to make any necessary adjustments and to perform standard disassembly and assembly procedures.

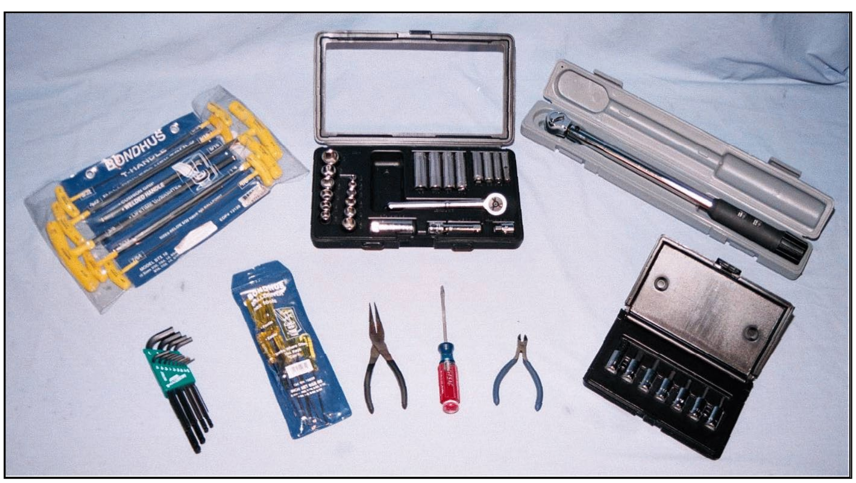


Figure 2-1. Required tools for assembly of the THOR-50M

- Set of “T” Handle Hex Wrenches (Ball End) Sizes: M1.5 to M8
- Set of “L” Handle Hex Wrenches (Ball End) Sizes: M1.5 to M8
- Set of Straight Hex Wrenches (Screwdriver Style) Sizes: M1.3 to M6
- Metric Socket Set
- Torque Wrench Sizes: Range 1.5 N-m to 70 N-m (1 to 52 ft-lb)
- Hex Bit Socket Set Size: M1.5 to M8
- Needle Nose Pliers
- Diagonal Cutters
- Flat Head Screwdriver

2.1.3 Bolt Torque Values

Table 2-1 indicates the recommended torque setting values for the various bolt sizes used in the THOR-50M dummy assemblies. Unless otherwise specified, utilize the torque settings below. For bolt sizes smaller than those listed, use engineering judgment to tighten enough to prevent the fastener from vibrating loose during impact.

Table 2-1. Recommended Torque Values for THOR-50M Bolts.

Note: Torque settings are for SHCS only. Use guidance provided in manual and best engineering judgement for modified bolts or bolts other than SHCS. For shoulder bolts, use torque associated with bolt thread size.

Bolt Size Metric	Torque (N-m)
M3	2.45
M4	5.85
M5	12.0
M6	20.3
M8	48.8
M10	97.5
M12	165.0
Neck Pitch Change Mechanism	50.8
Lumbar Pitch Change Mechanism	68.0

2.2 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. Instead, a lifting strap is installed on back of the dummy above the first rib.

2.2.1 Installing Lifting Strap

2.2.1.1 Insert the Dummy Lifting Strap (472-3517) through the Lifting Strap Bracket (472-3115) (Figure 2-2).

Figure 2-2. THOR-50M lifting strap and mounting bracket

2.2.1.2 Install the two M5 x 0.8 x 10 BHCS through the lifting strap bracket into the Upper Thoracic Spine Box Weldment (472-3620) above the first rib (Figure 2-3).

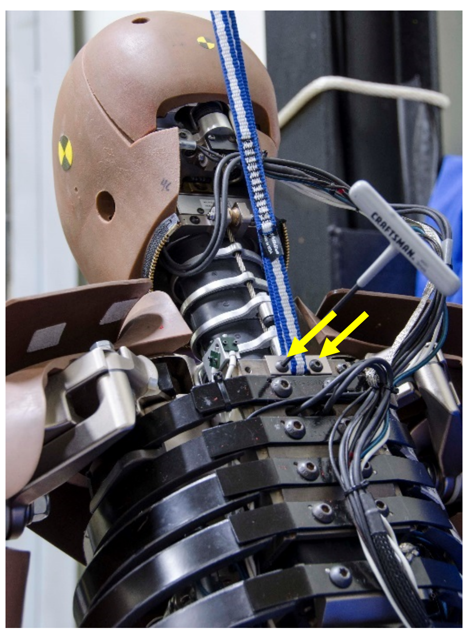


Figure 2-3. Install lifting strap bracket to upper thoracic spine box weldment

2.2.1.3 Use the THOR-50M lifting strap when handling and/or lifting the dummy (Figure 2-4).

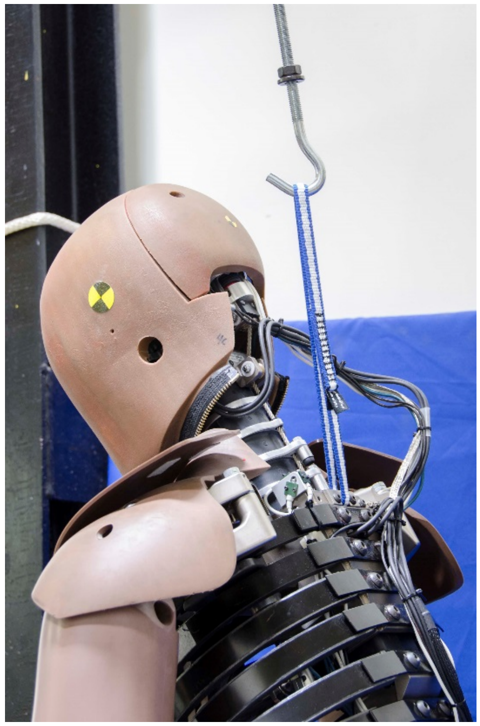


Figure 2-4. Lifting THOR-50M

2.3 Dummy Storage

Figure 2-5 illustrates an example of a storage chair for the THOR-50M (DL110-0000). This storage chair is also used for the WorldSID ATD. The chair positions the THOR-50M with the dummy upright to minimize stress on the neck as well as the pelvis and lumbar spine areas.

Figure 2-5. Example of THOR-50M storage chair

2.3.1 Installation of THOR-50M into Storage Chair

2.3.1.1 A storage bracket assembly (472-8100) is attached to THOR-50M through the sternum area into the spine box using an M8 x 1.25 x 200 SHCS. Two M8 x 1.25 x 160 SHCS are secured just under the lower abdomen (Figure 2-6 and Figure 2-7). The lumbar spine pitch change assembly (472-3670) joint must be set to the NEUTRAL position to attach the storage bracket. See Section 5.3.1 for instructions.

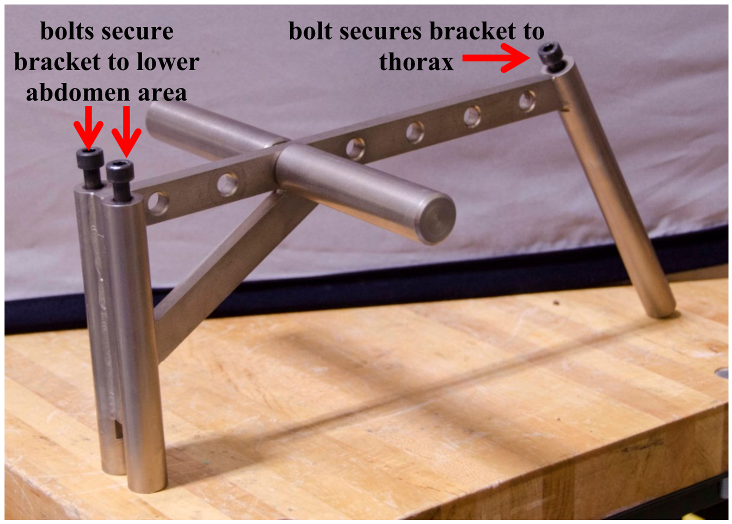


Figure 2-6. THOR-50M storage bracket assembly which attaches to THOR-50M

Figure 2-7. Storage bracket assembly secured to THOR-50M

2.3.1.2 The hanger assembly (DL110-0700), which slides into the top of the storage chair, is illustrated in Figure 2-8. Attach the hanger assembly to the lifting bracket by sliding the hanger assembly over the main bar (472-8102) of the lifting bracket assembly using two self-locking T-handles (3/8” diameter x 2” long) (Figure 2-8 and Figure 2-9).

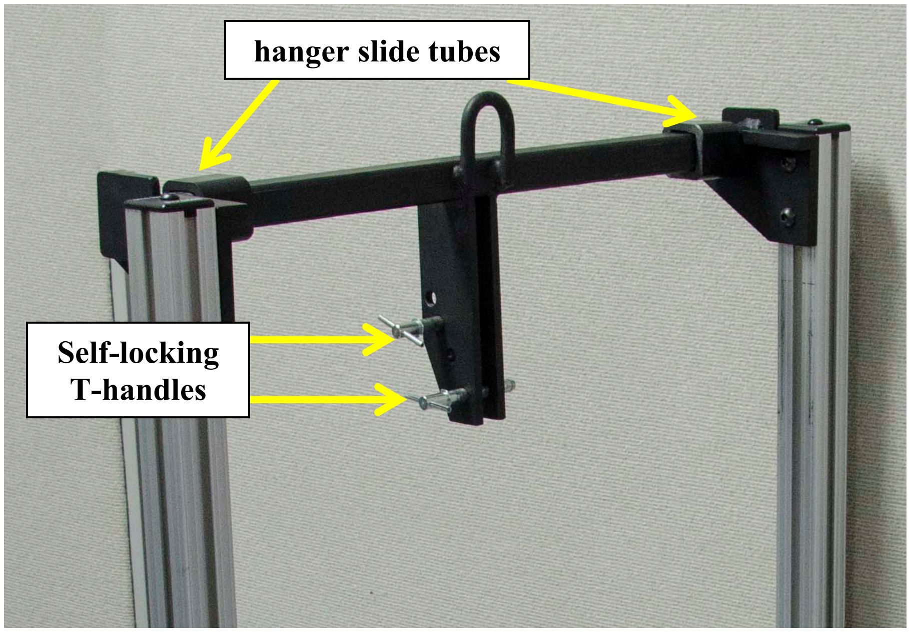


Figure 2-8. Hanger assembly which fits onto storage chair

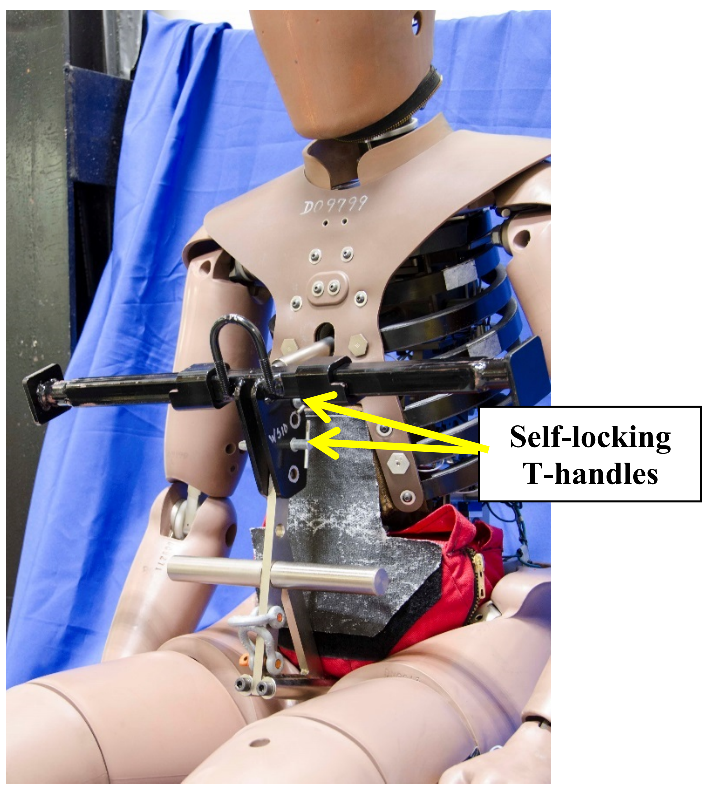


Figure 2-9. Hanger assembly installed onto rod storage bracket

2.3.1.3 Lift the THOR-50M over the storage chair using the hanger assembly and install to the storage chair brackets (Figure 2-10). Slide the hanger slide tubes (DL110-0720) towards the ends of the hanger tube to lock the hanger assembly into place on the chair. Position the heels behind the bar on the floor of the chair.

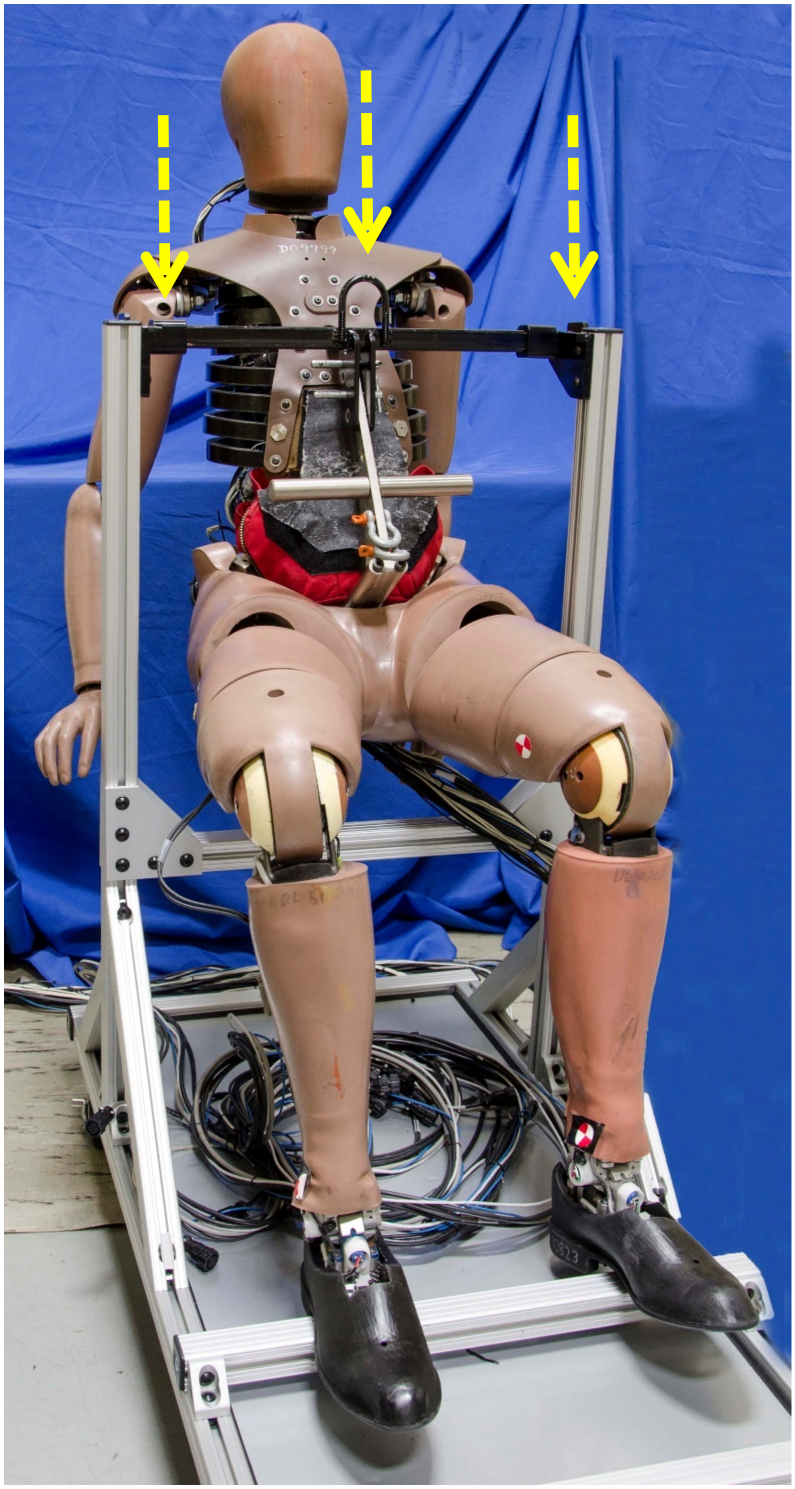


Figure 2-10. THOR-50M installed in storage chair

2.4 H-Point Tool Assembly and Use

The THOR-50M H-Point Tool (472-8510-A) provides a quick, accurate method to determine the location of the H-Point.

2.4.1 Parts List

Figure 2-11 shows an exploded view of THOR-50M H-Point Tool Assembly (472-8510-A) hardware. Table 2-2 lists the components that are included in the H-Point tool assembly.

Table 2-2. H-Point Gage Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
H-Point Tool, Expander	1	472-8511-A	Figure 2-11	1
H-Point Tool, Plate	1	472-8512-A	Figure 2-11	2
H-Point Tool, Pin Assembly	1	472-8515-A	Figure 2-11	3
Screw, SSNP M4 x 0.7 x 6	1	5001472	Figure 2-11	4
H-Point Pin	1	472-8516-A	Figure 2-11	5

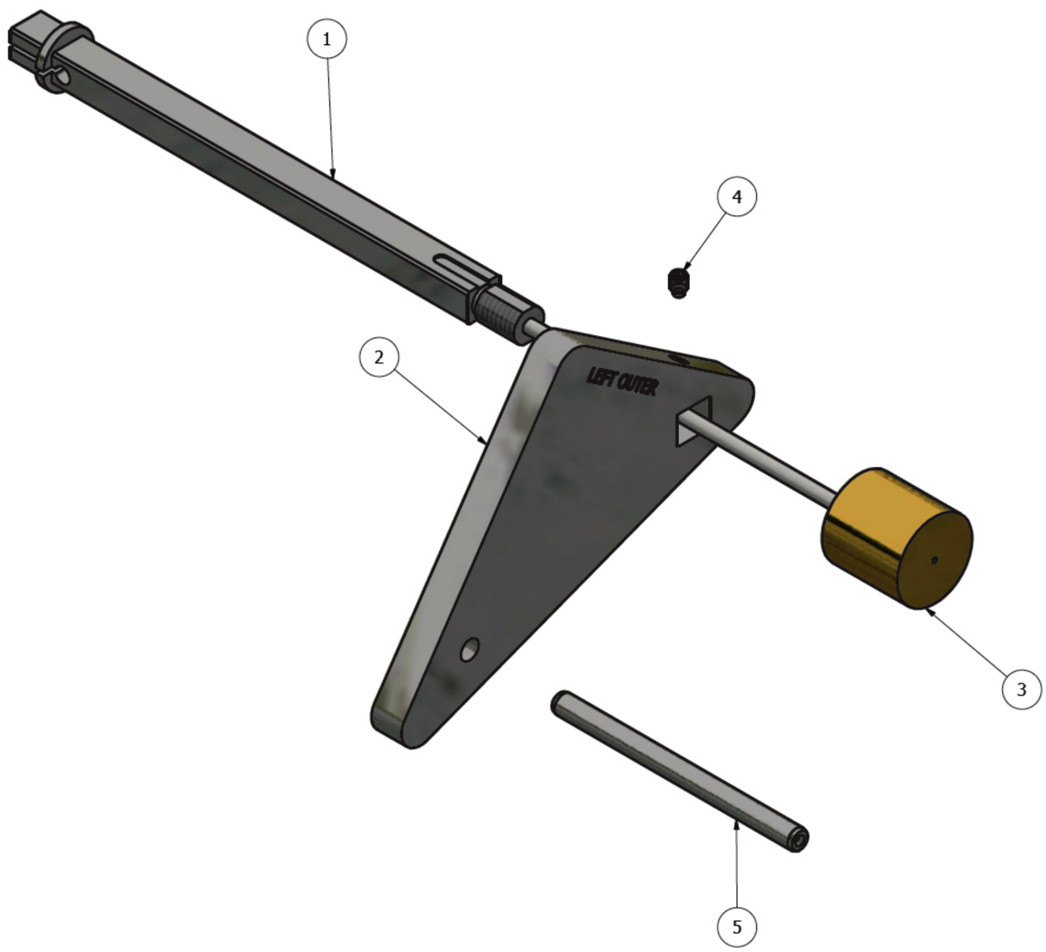


Figure 2-11. THOR-50M H-point tool (left-hand)

2.4.2 Installing the H-Point Tool

2.4.2.1 Figure 2-12 shows the components of the H-point tool.

Figure 2-12. H-point tool components

2.4.2.2 To assemble, insert the H-Point Tool Expander (472-8511-A) into the square hole in the H-Point Tool Plate (472-8512-A) on the opposite side of the plate than the intended measure. Align the set screw recess on the expander with the set screw in the plate (Figure 2-13). Tighten the SSNP M4 x 0.7 x 6 set screw through the edge of the plate into the expander tool (Figure 2-14).

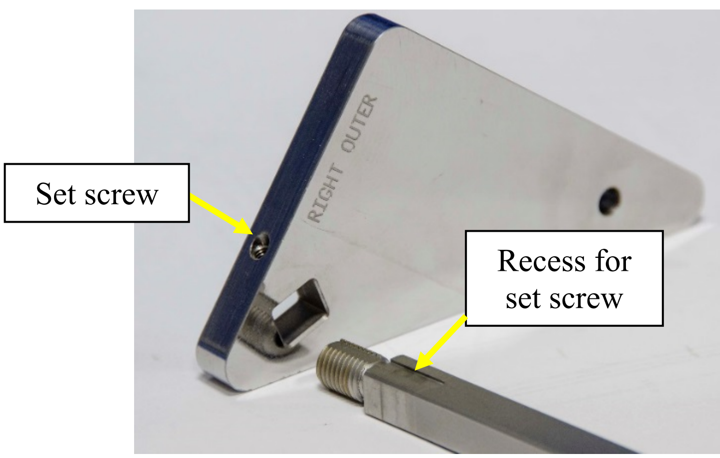


Figure 2-13. Install H-point tool expander into H-point tool plate

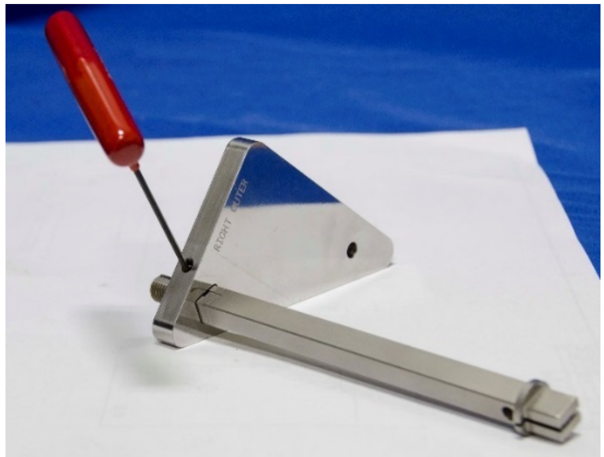


Figure 2-14. Tighten set screw into tool expander

2.4.2.3 Install the H-Point Tool Pin Assembly (472-8516-A) into the expander end. Insert the H-Point Pin (472-8516-A), dimpled end out, into the circular hole on the plate (Figure 2-15).

Figure 2-15. THOR-50M H-point tool assembled

2.4.2.4 With the pin assembly fully unscrewed, insert the expander end of the H-point tool into the pelvis H-point opening until the collar above the expander is fully seated internally against the pelvis. Turn the pin assembly clockwise until the expander engages firmly with the pelvis. Note that the top edge of the H-point tool is parallel to the pelvis angle (Figure 2-16).

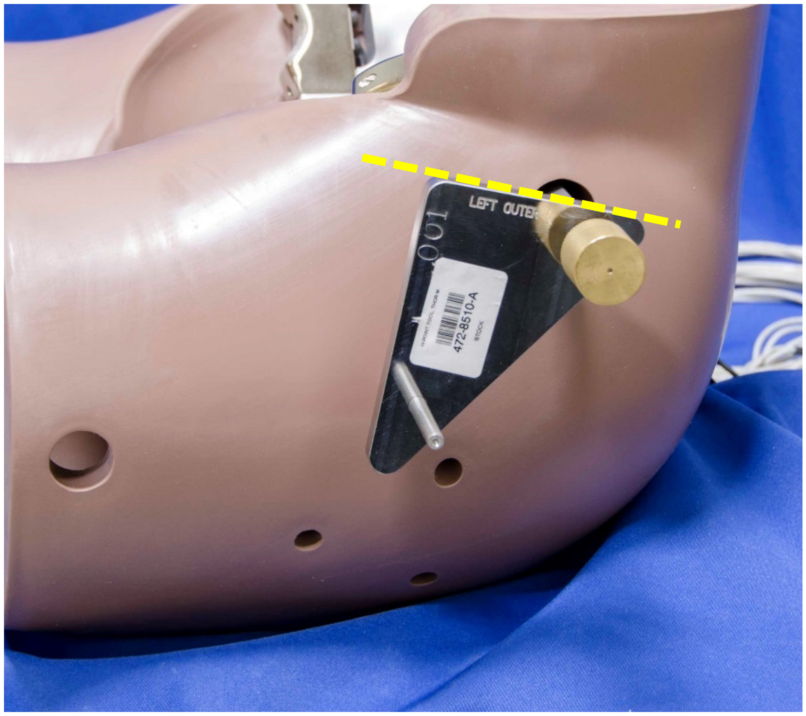


Figure 2-16. Top edge of H-Point tool is parallel to pelvis angle

2.5 Dummy Posture Adjustments and Positioning

The adjustment of the dummy's posture is largely dependent upon the specific positioning requirements of the test lab and the test series being performed. The positioning of the dummy normally begins by marking the location of the H-Point and moving this point to the desired location in the testing environment. When installed into the pelvis, the top surface of the gage plate is parallel with the measurement plane (Figure 2-16) of the pelvis tilt sensor. The operation and function of the tilt sensors is explained in each assembly which includes a tilt sensor.

Anatomically, the angle measured by the tilt sensor about the Y-axis relates to line between the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) landmarks by **Equation 2.1**.

Equation 2.1
ASIS-PSIS Angle = Pelvis Tilt Sensor Reading (About Y Axis) + 10°

where ASIS-PSIS Angle is defined by the line between the ASIS and the PSIS anatomical landmarks and the Pelvis Tilt Sensor Reading (About Y Axis) is measured using either a) the pelvis tilt sensor assembly (472-3777-1 or 472-3777-2), or b) the angle of the H-Point Gage Assembly (472-8510-A), as measured by reading an inclinometer placed on the edge of the tool above the text "[Right/Left] Outer."

At this point, the dummy can be placed in a "standard seating posture," or the dummy posture can be further manipulated to accommodate various seating geometries or testing environments. Four major seating postures have been defined through a postural study (Reynolds), and the THOR-50M spine assembly is capable of adjusting into any one of these postures (or other positions if desired). The adjustment capability is provided by the neck and lumbar 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 lumbar spine pitch change assembly is centered at the approximate location of the anthropomorphic landmark defined by the T11 / T12 joint. The locations of these pitch change mechanisms are shown in Figure 2-17.

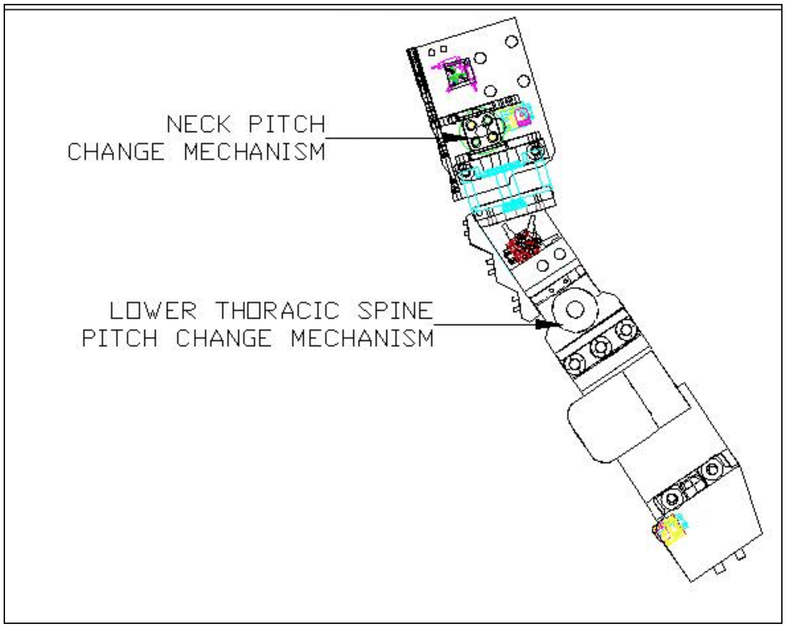


Figure 2-17. Pitch change locations

The seating posture of the THOR-50M dummy can be adjusted in 3° increments by rotating the spine segments with the pitch change mechanisms. The orientation of the lower thoracic pitch change mechanism is normally set in the "Slouched" position and the neck pitch change mechanism is normally set in the "Neutral" position; the procedure for adjusting the pitch change mechanisms is described in detail in Section 5.3 of this manual.

2.6 Joint Resistive Torque Adjustments

The joint resistive torque adjustments for the THOR-50M dummy are described under the various Sections to which they apply. The joints in the dummy which require adjustments include the shoulders, elbows, hips, and knees. Most of these adjustments are made in the same manner as those in the Hybrid III dummy. The goal of the adjustment is to provide a 1G joint friction torque. For example, the knee joint should be adjusted such that the dummy's lower leg has just enough torque to maintain an extended position of the lower leg.

Section 3. **Head Assembly**

3.1 Description of Head Assembly and Features

The head assembly includes the head casting, skull cap, internal mounting plates, instrumentation, instrumentation mounting plates, and skin. The internal ballast weight has been pre-installed within the skull cavity to adjust the CG location and overall mass of the assembly. The head instrumentation includes three uniaxial accelerometers at the CG of the head, three angular rate sensors, and a dual axis tilt sensor. The tilt sensor is attached on the left 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-test or post-test) mode. The angular rate sensors are used in conjunction with the three accelerometers at the CG to track six-degree-of-freedom motion of the head.

The face assembly includes the foam assembly, face plate, and 5 compression load cells with impact plates (SA572-S124). The load cells are distributed across the entire face plate, one at each eye, cheek, and one at the center of the chin to measure the total load applied to the face.

3.2 Assembly of the Head

3.2.1 **Parts List**

Table 3-1 through Table 3-3 list the components that are included in the head and skull assemblies. Figure 3-1 through Figure 3-3 illustrate the head assembly components.

Table 3-1. Head Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Skull Assembly	1	472-1100	Figure 3-1	1
Confor Foam, Face	1	020-1025	Figure 3-1	2
Accelerometer Mounting Plate Assembly, Head	1	472-1200	Figure 3-1	3
Head Cap	1	472-1110	Figure 3-1	4
M6 x 1 x 16 Lg. SHCS	4	5000081	Figure 3-1	5
Screw, Phillips Nylon M23 x 0.5 x 6	2	5001116	Figure 3-1	6
Skin Assembly	1	472-1320	Figure 3-1	7
Cap Skin	1	472-1310	Figure 3-1	8

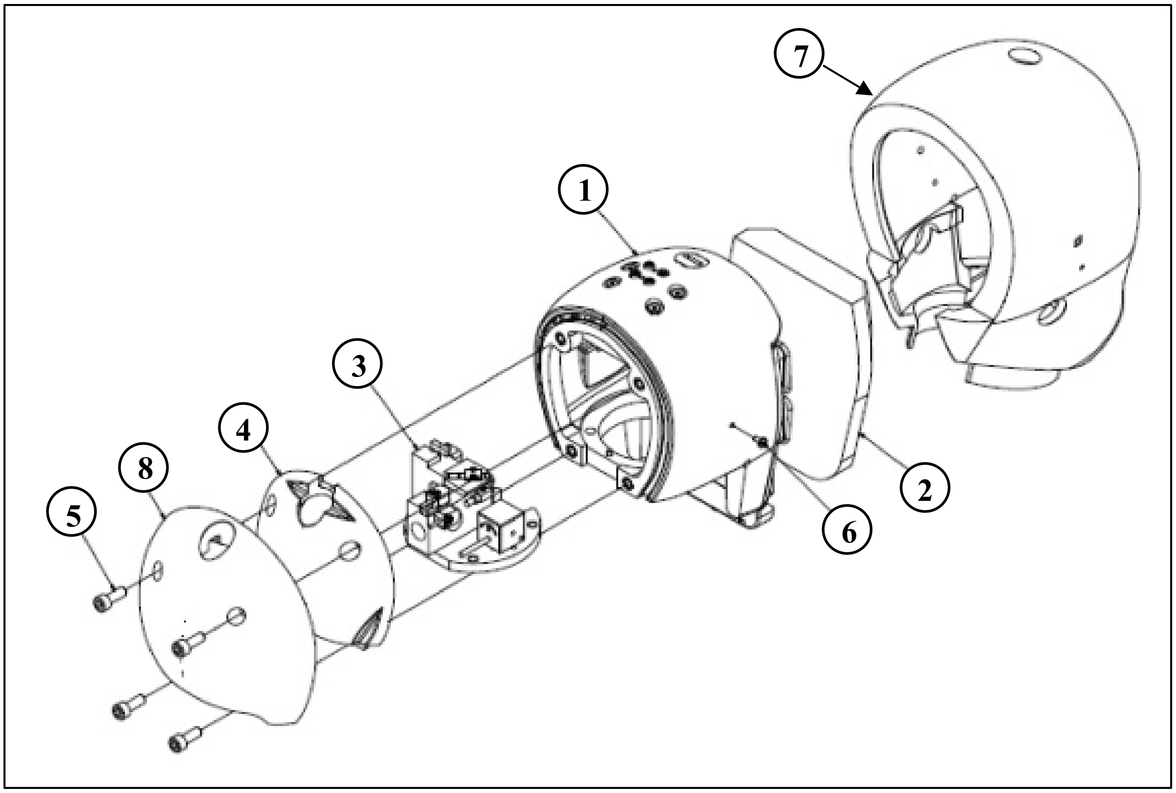


Figure 3-1. Head assembly components

Table 3-2. Skull Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Head, Machined	1	472-1111	Figure 3-2	1
Face Plate	1	472-1410	Figure 3-2	2
Face Load Cell, Mock	5	472-1417	Figure 3-2	3
Right Eye Load Cell Plate	1	472-1412-2	Figure 3-2	4
Left Eye Load Cell Plate	1	472-1412-1	Figure 3-2	5
Right Cheek Load Cell Plate	1	472-1414-2	Figure 3-2	6
Left Cheek Load Cell Plate	1	472-1414-1	Figure 3-2	7
Chin Load Cell Plate	1	472-1416	Figure 3-2	8
Chin Guard	1	472-1411	Figure 3-2	9
Biaxial Accelerometer Assembly, Head	1	472-1101	Figure 3-2	10
Head C.G. Part group for Ballast Weight Design	1	472-1115	Figure 3-2	11
Head Ballast	1	472-1120	Figure 3-2	12
Head Plug	1	472-1116	Figure 3-2	13
Screw, FHCS M4-0.7 x 16	10	5000025	Figure 3-2	14
Screw, FHCS M4-0.7 x 16	40	5000116	Figure 3-2	15
Screw, FHCS M4-0.7 x 16	2	5001117	Figure 3-2	16
M3 x 0.5 x 12 LG, SHCS	4	5001103	Figure 3-2	17

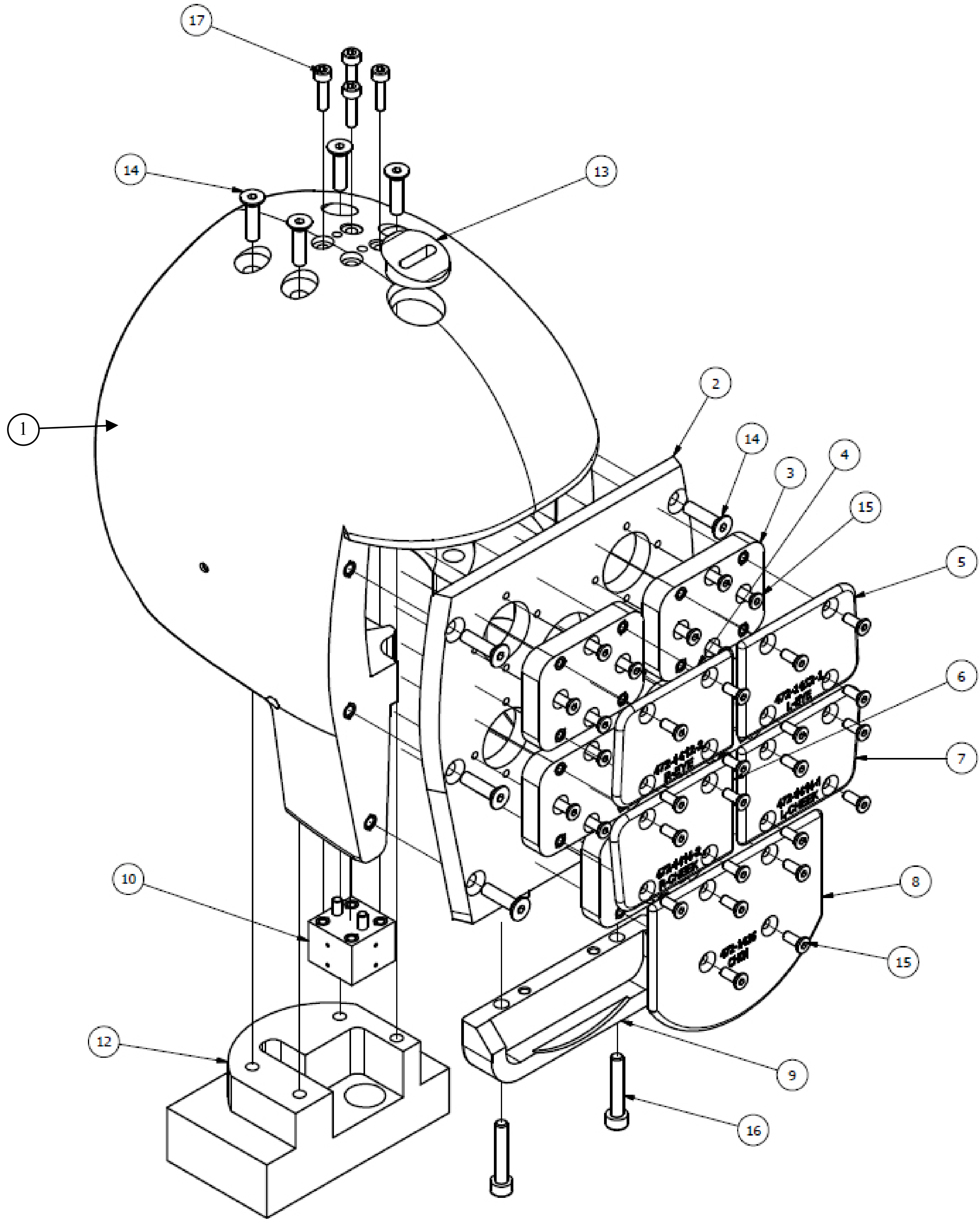


Figure 3-2. Skull assembly components

Table 3-3. Head Accelerometer Mounting Plate Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Accelerometer Mounting Plate	1	472-1210	Figure 3-3	1
7 Accelerometer Array Fixture	1	472-1212	Figure 3-3	2
Screw, FHCS M6 x 1.0 x 16	4	9000826	Figure 3-3	3
Screw, SHCS M1.4 x 0.3 x 3	6	5000068	Figure 3-3	4
Screw, Cheese Head M1.4 x 0.3 x 8	6	6000000	Figure 3-3	5

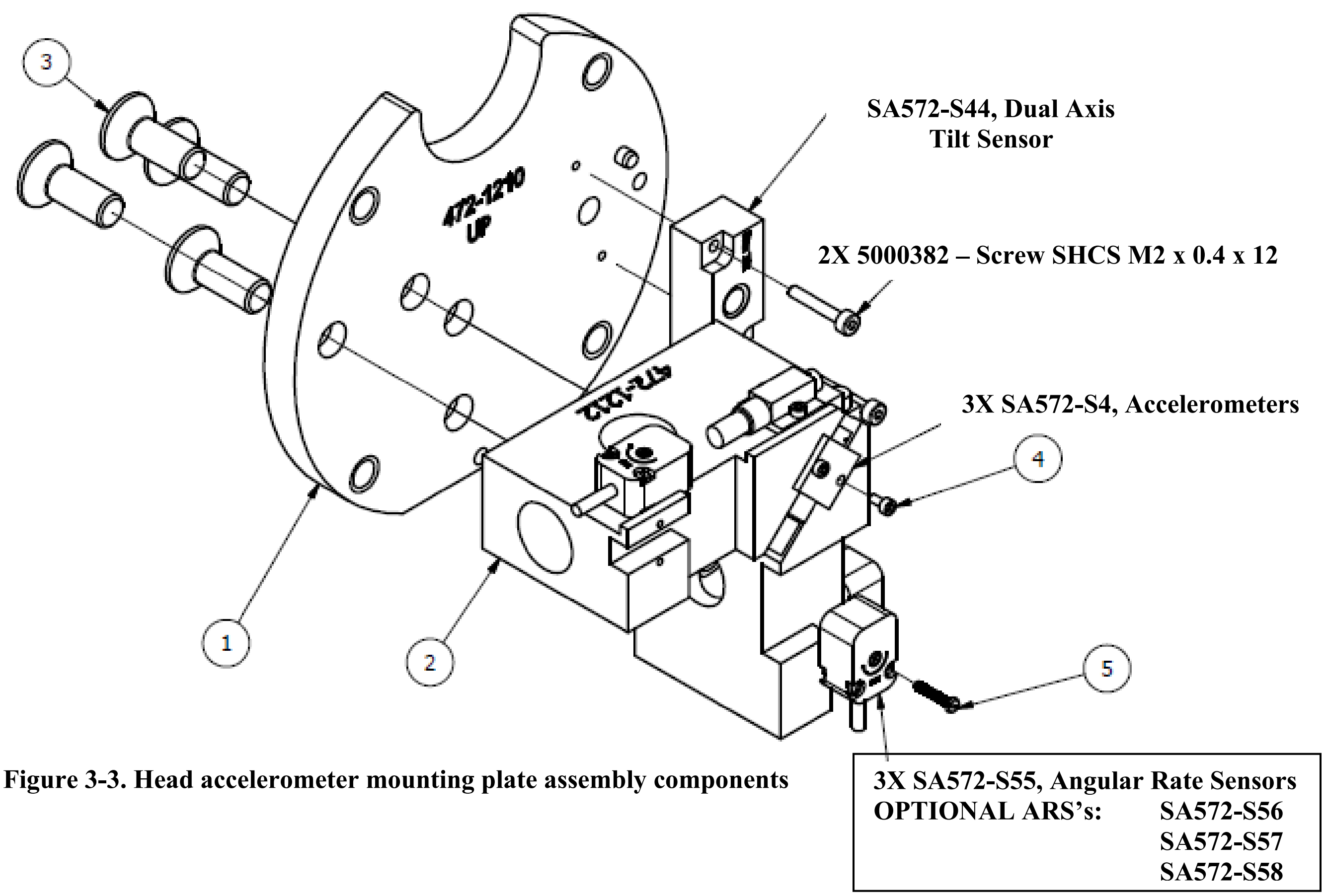


Figure 3-3. Head accelerometer mounting plate assembly components

3.2.2 Assembly of Head Components

The following is a step-by-step description of the assembly procedure for the head components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

3.2.2.1 The 7 accelerometer-array fixture (472-1212) holds three angular rate sensors (Figure 3-4); mount each sensor to the fixture using two M1.4 x 0.3 x 8 Cheesehead Screws.

3.2.2.2 The 7 accelerometer-array fixture (472-1212) holds three uniaxial accelerometers at the CG of the head (Figure 3-5). Install each accelerometer using two M1.4 x 0.3 x 3 SHCS. Orient the three head CG accelerometer units: +X to the front, +Y to the right, and +Z down.

3.2.2.3 Attach the Head Tilt Sensor (SA572-S44) to the Head Accelerometer Mounting Plate (472-1210) using two M2 x 0.4 x 12 SHCS (Figure 3-4). A dowel pin ensures that the proper position of the tilt sensor unit.

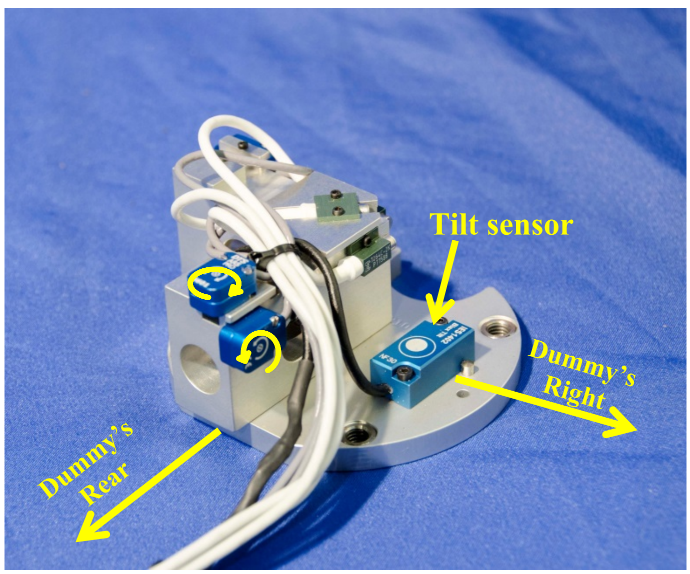


Figure 3-4. Head angular rate sensors installed

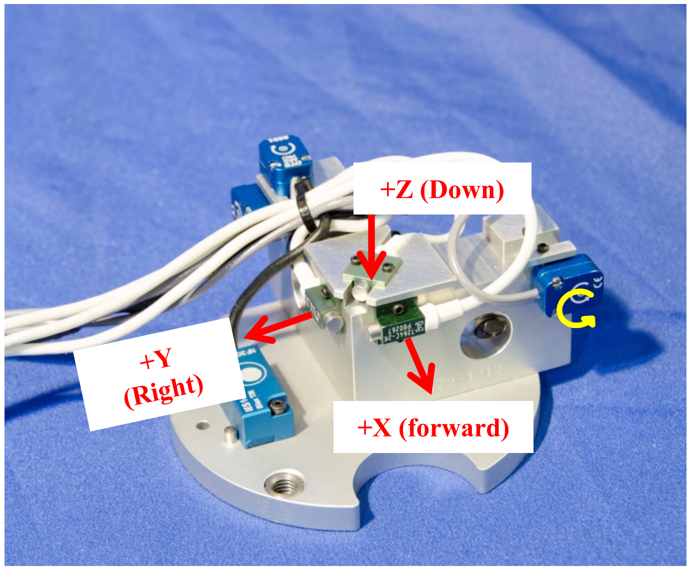


Figure 3-5. Accelerometer and angular rate sensor configuration

3.2.2.4 Mount the 7 Accelerometer Array Fixture to the Head Accelerometer Mounting Plate (472-1210) using four M6 x 1 x 16 FHCS on the underside of the mounting plate, as shown on Figure 3-6.

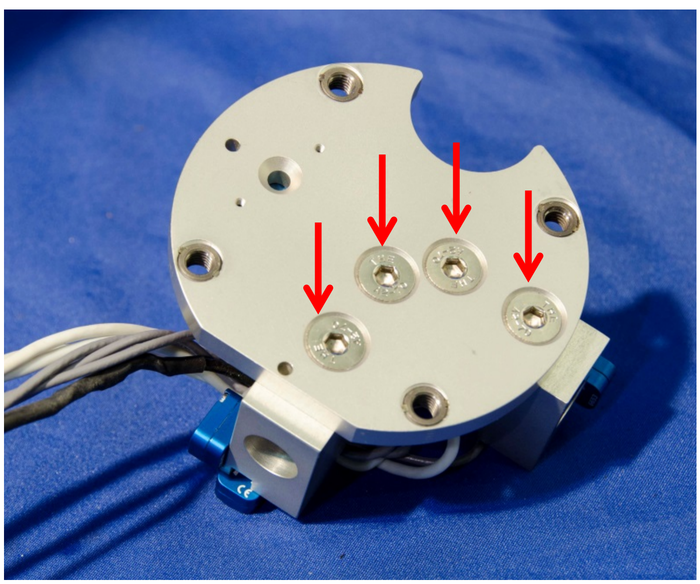


Figure 3-6. Secure the 7 accelerometer array fixture to the head accelerometer mounting plate

3.2.2.5 Attach the Chin Guard (472-1411) to the Face Plate (472-1410) with the angled side downwards and out using two M4 x 0.7 x 22 SHCS (Figure 3-7).

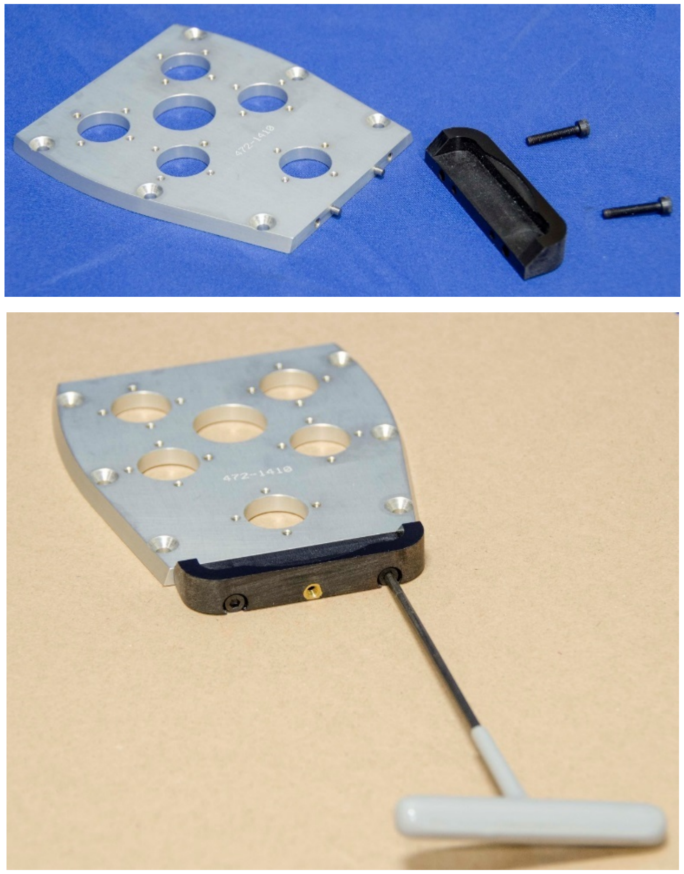


Figure 3-7. Assemble the chin guard to the face plate

3.2.2.6 Attach the Face Plate (472-1410) to the Head Skull assembly (472-1111) using six M4 x 0.7 x 16 FHCS as shown in Figure 3-8.

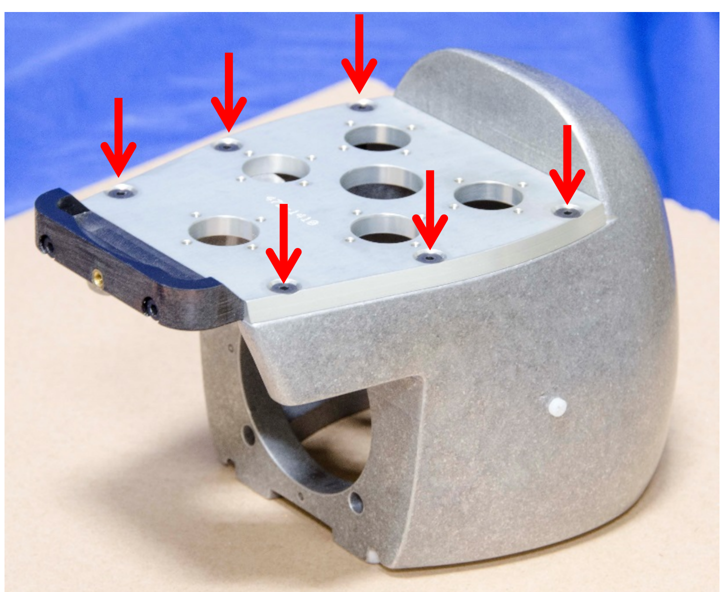


Figure 3-8. Face plate assembly

3.2.2.7 Attach five Face Load Cells (SA572-S124) or the load cell substitutes (472-1417) to the Face Plate using twenty M3 x 0.5 x 10 SHCS (Figure 3-9 and Figure 3-10).

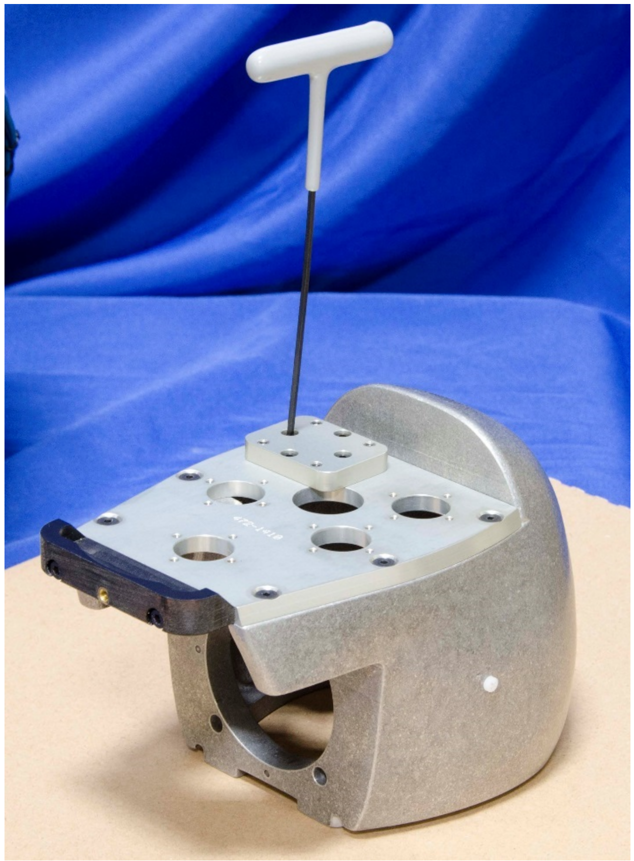


Figure 3-9. Secure the face load cells to face plate

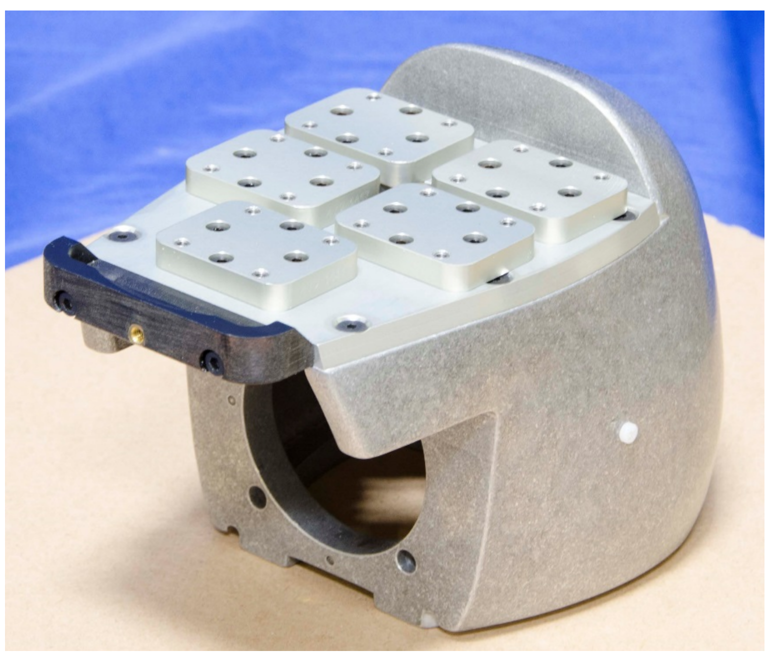


Figure 3-10. Face load cells fully assembled

3.2.2.8 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 M3 x 0.5 x 8 FHCS per plate (total of 20) (Figure 3-11). Each load cell plate is shaped differently to match the contour of the front of the head casting. Labels on the load cell plates: “L-EYE”, “R-EYE”, “L-CHEEK”, “R-CHEEK”, and “CHIN” describe the load cell attachment location on the face.

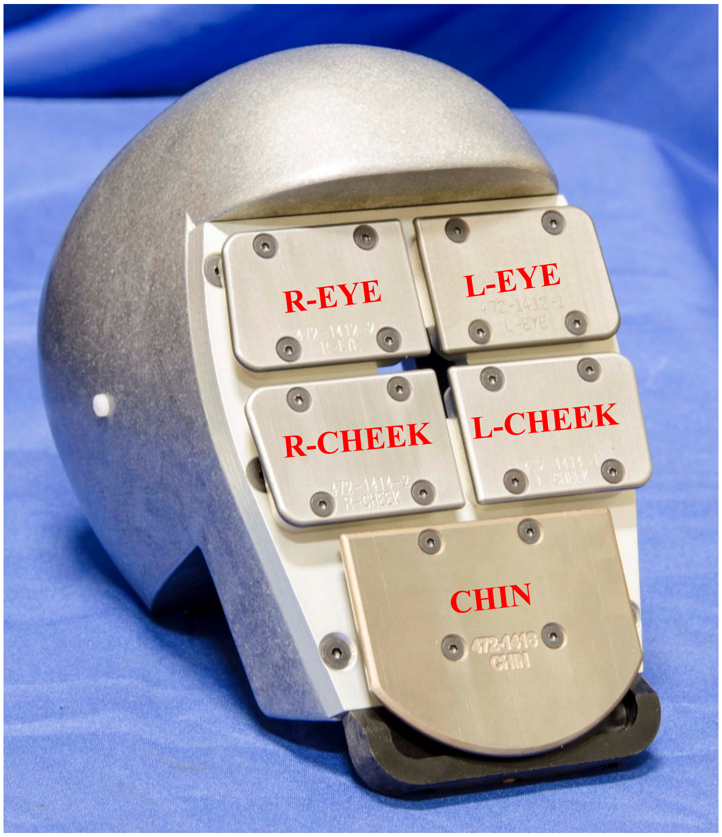


Figure 3-11. Face load cell plates

3.2.2.9 Install the Head Biaxial Accelerometer Assembly (472-1101) to the skull using four M3 x 0.5 x 12 SHCS through the exterior top of the skull (Figure 3-12).

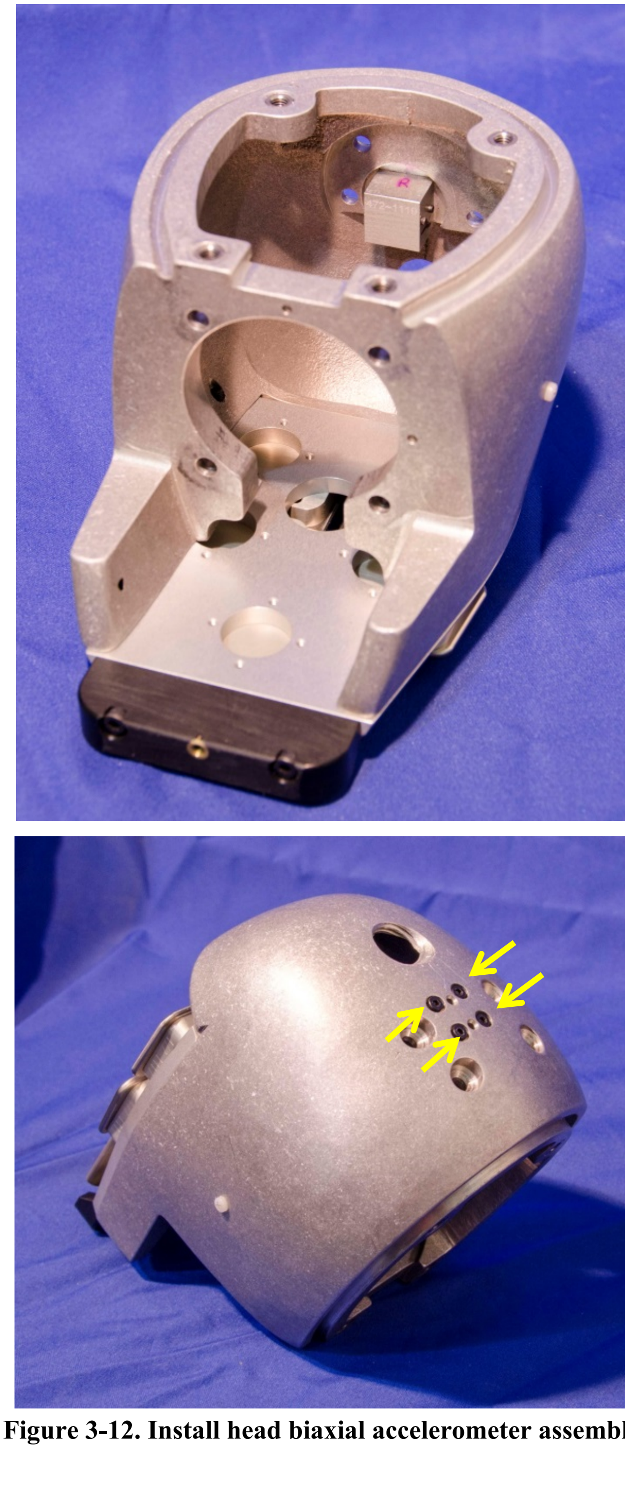


Figure 3-12. Install head biaxial accelerometer assembly

3.2.2.10 Position the Head Ballast (472-1120) over the Head Biaxial Accelerometer Assembly inside the skull. Install the ballast using four M4 x 0.7 x 16 FHCS. Insert the screws through the exterior top of the skull (Figure 3-13 and Figure 3-14).

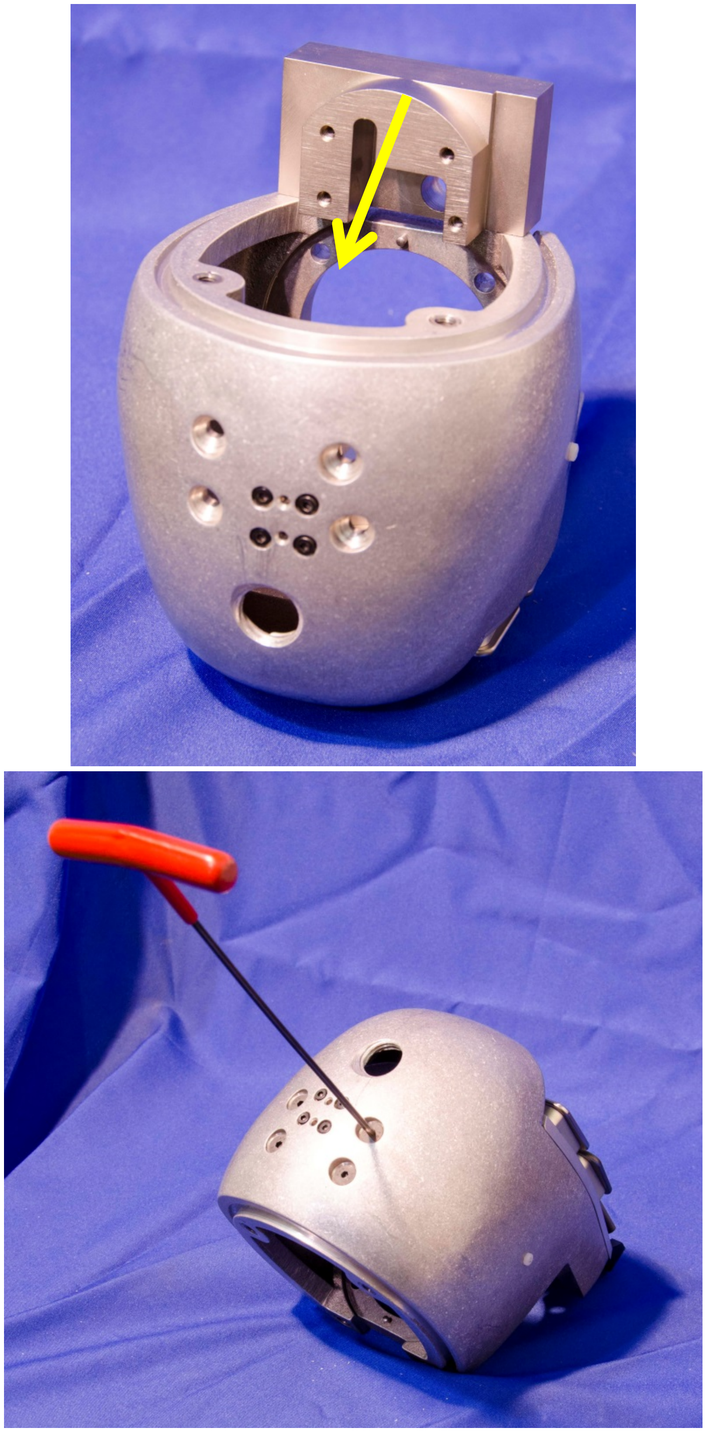


Figure 3-13. Install head ballast

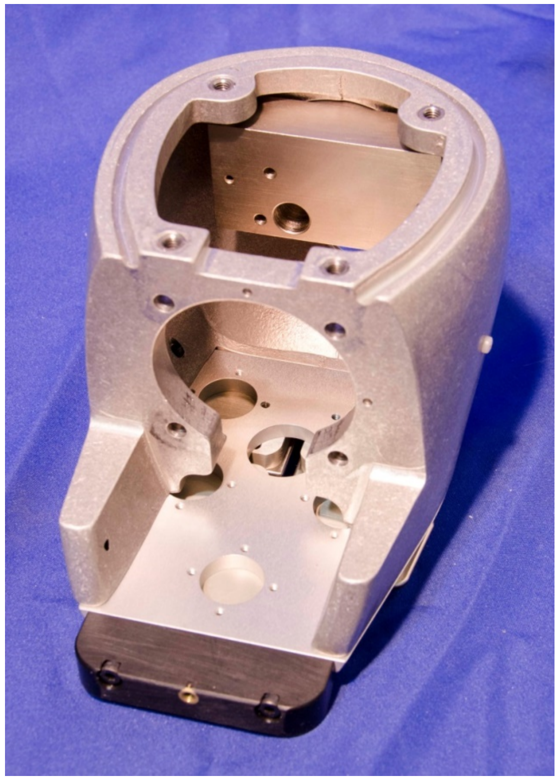


Figure 3-14. Head ballast installed

3.2.2.11 Install the Head Plug (472-1116) into the top of the skull so that it is flush with the skull surface (Figure 3-15).

Figure 3-15. Install the head plug

3.2.2.12 Position the Face Foam Assembly (472-1400) inside the cavity in the Head Skin (472-1320) (Figure 3-16).

Figure 3-16. Install face foam

3.2.2.13 Insert the completed Head Accelerometer Mounting Plate Assembly (472-1200) into the Head Casting (472-1111) and orient the plate so that the Dual Axis Tilt Sensor (SA572-S44) is towards the right of the dummy (Figure 3-17).

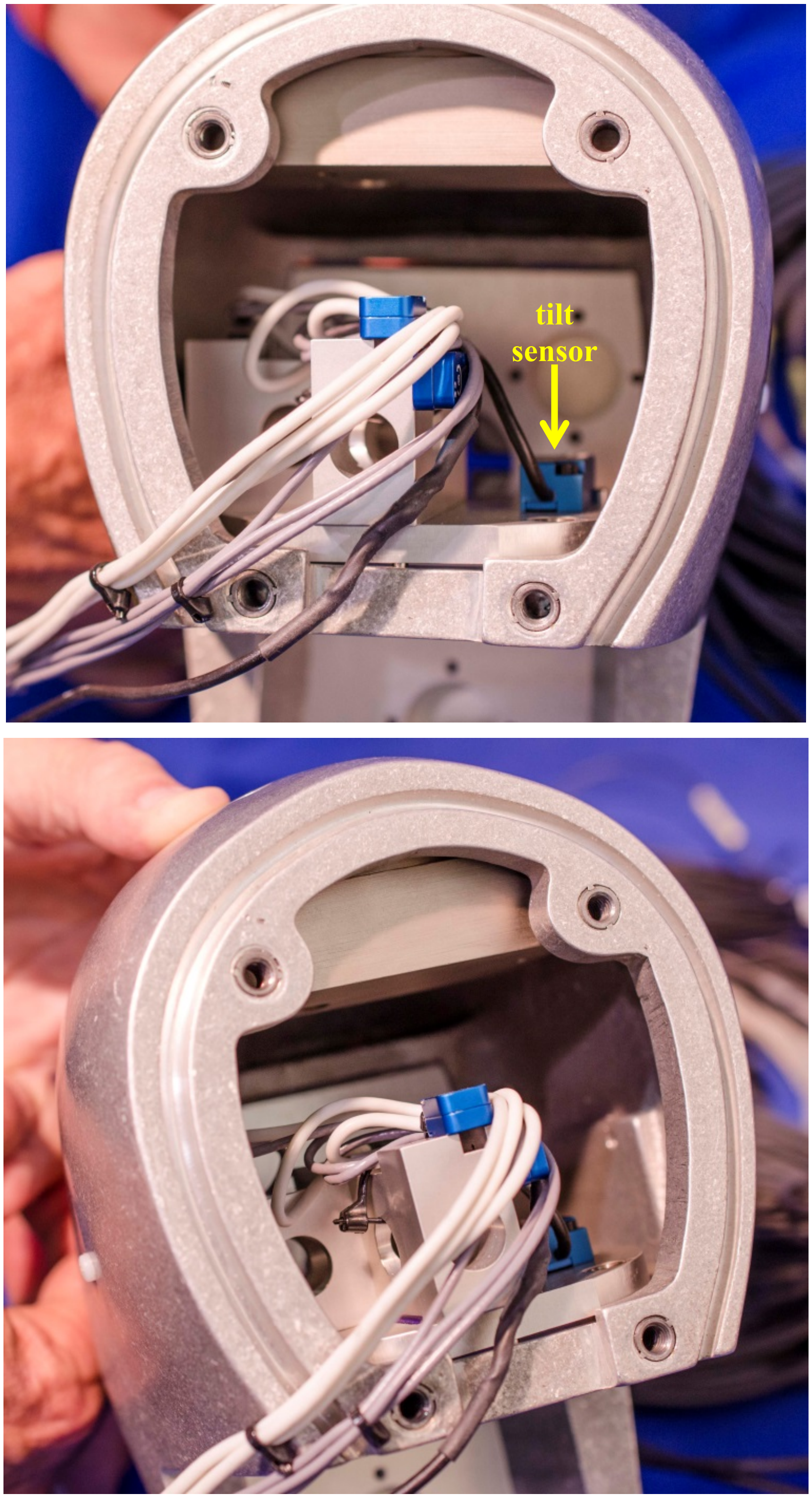


Figure 3-17. Install the head accelerometer mounting plate into the head

3.2.2.14 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 M6 x 1 x 25 FHCS from the underside of the head (Figure 3-18 and Figure 3-19).

NOTE: The neck must be oriented properly for installation within the head. The rear cable is easily identifiable by the presence of the cable pulley.

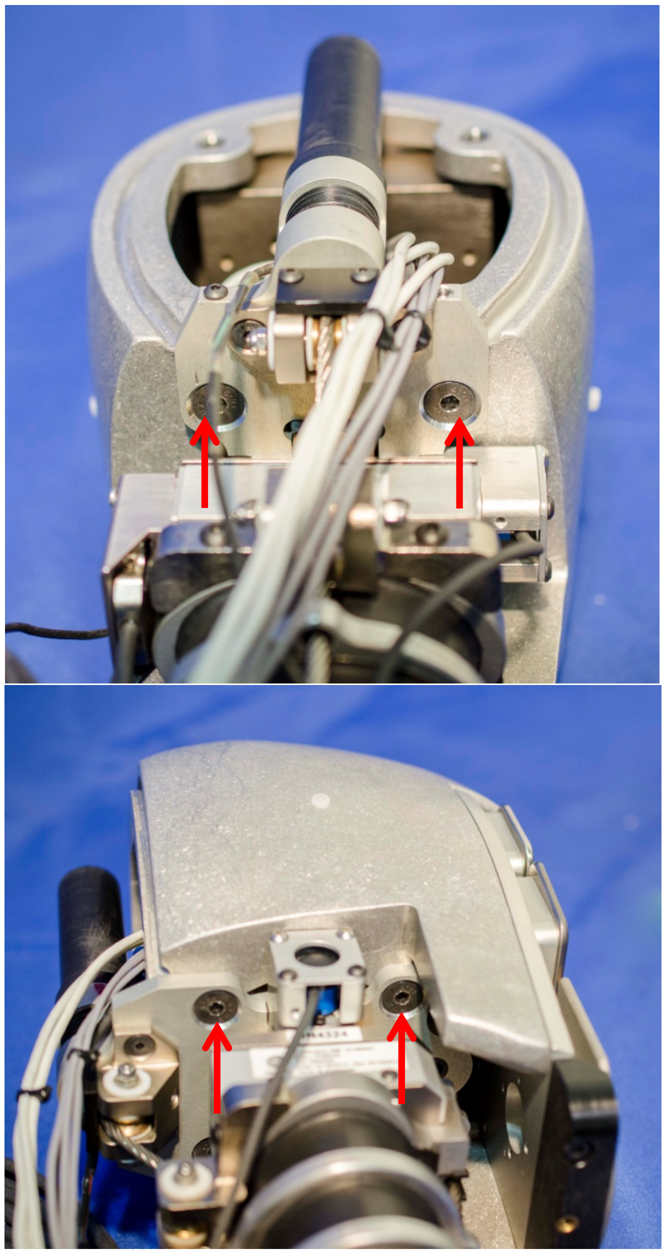


Figure 3-18. Attach the head to the neck

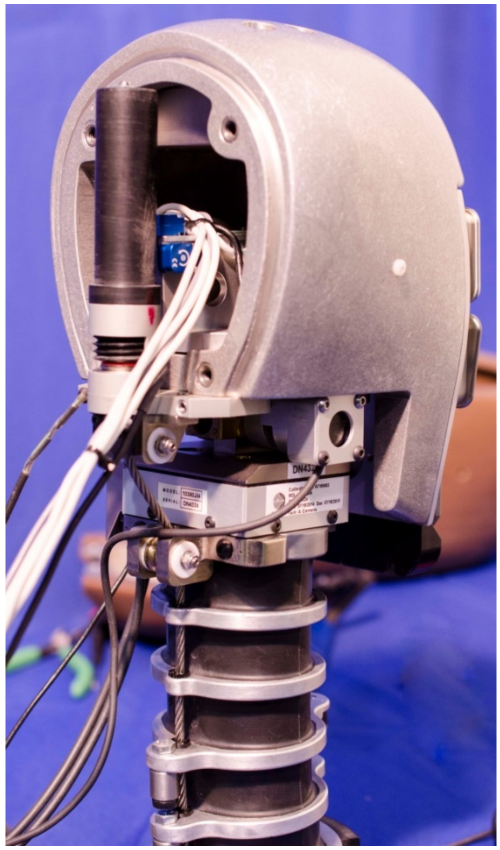


Figure 3-19. Head attached to neck

3.2.2.15 An M3 x 0.5 x 6 Nylon Phillips Screw installed on both sides of the skull marks the location of the Head C.G. (Figure 3-20). The head skin has a number of landmarks marked on the skin (Figure 3-21). The C.G. location on the Molded Head Skin corresponds to the equivalent points on the skull marked with a hole. The EAM landmark is also indicated by a hole, while the Nasion and IOF are indicated by small dimples on the anterior part of the skin.

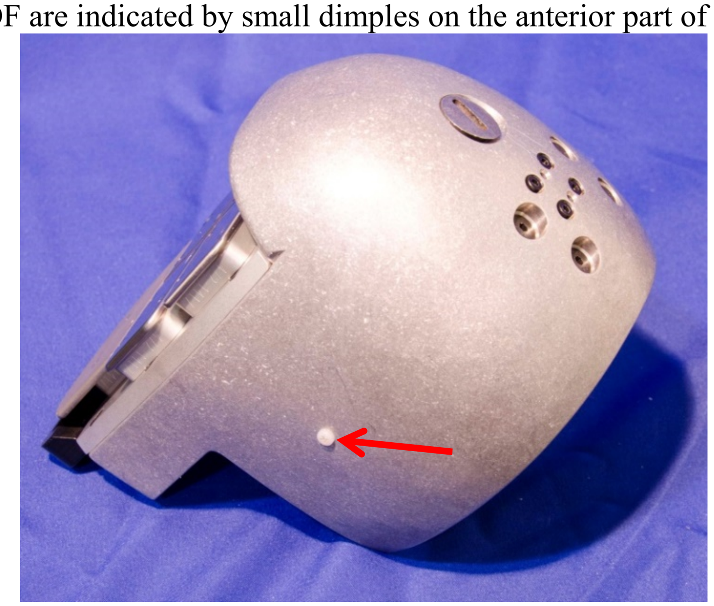


Figure 3-20. CG locators on skull

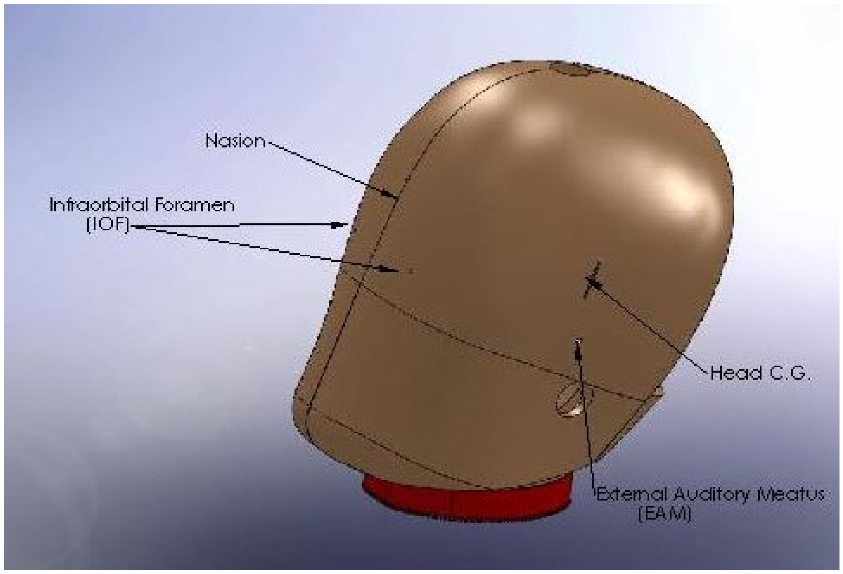


Figure 3-21. Landmarks on the head skin

3.2.2.16 Install the head skin (with face foam inserted) over the skull assembly. Position the posterior skin at the skull cap interface so that the skin seats into the grooved contour on the skull (Figure 3-22). Confirm positive engagement of the skin on the skull by visibility of the Nylon SHCS inside the C.G. hole in the head skin.

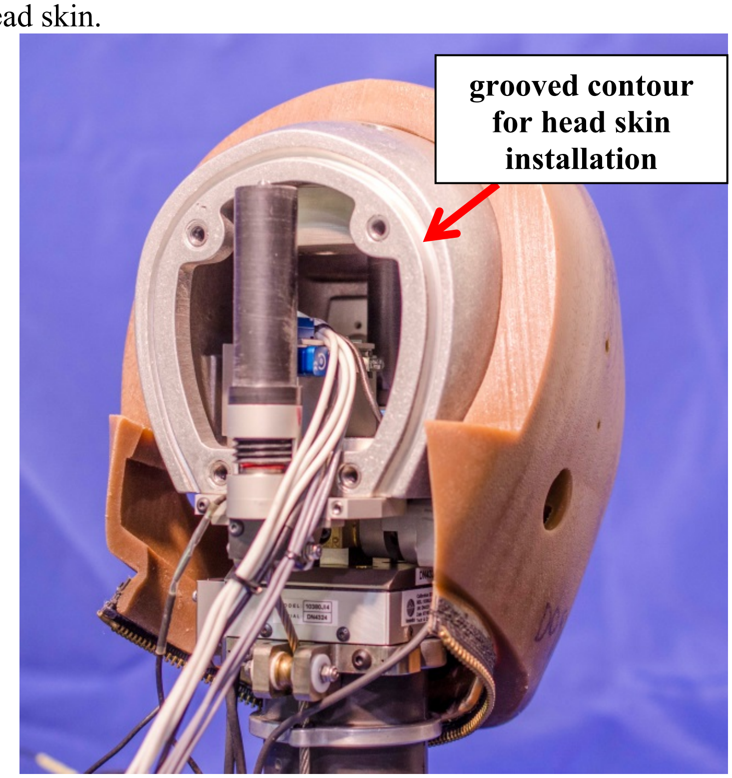


Figure 3-22. Install head skin into grooved contour on skull

3.2.2.17 Route the instrumentation wires from the head and upper neck load cell as shown in Figure 3-23.

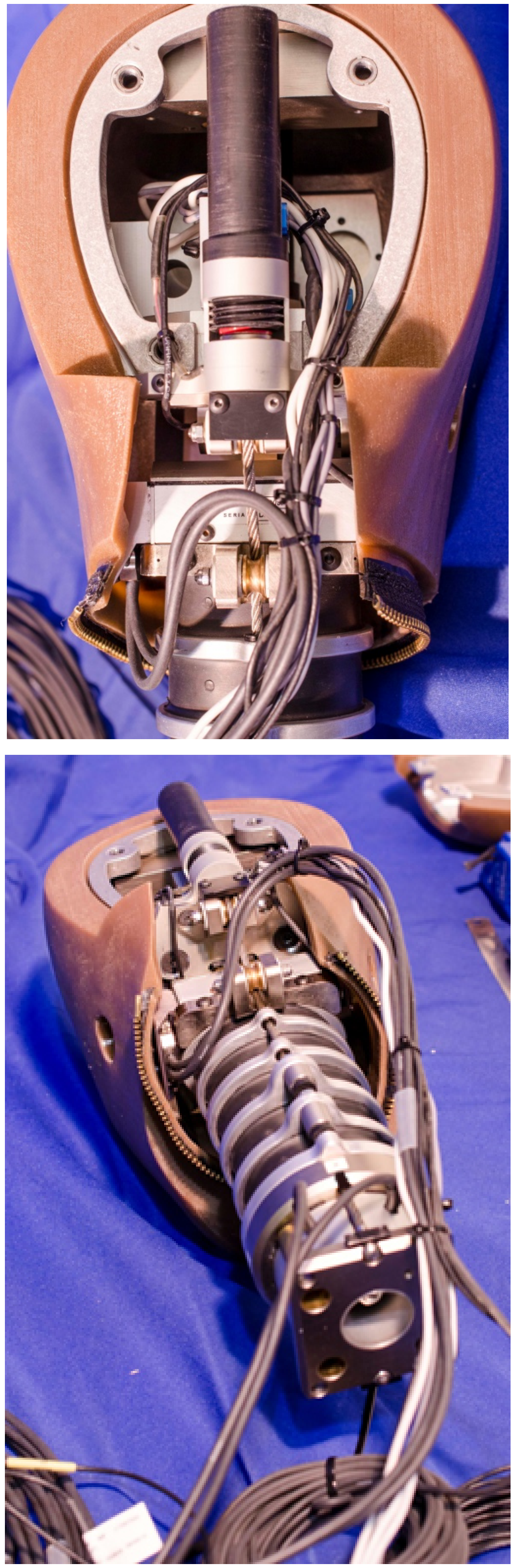


Figure 3-23. Routing cables for the head

3.2.2.18 Position the Head Cap Skin (472-1310) onto the Head Cap (472-1110). Slide the head cap assembly on the rear of the skull while carefully routing the wire bundles out through the bottom sides of the cap (Figure 3-24). Take caution not to pinch any of the instrumentation wiring between the skull cap assembly and the skull during installation. Secure the cap into place using four M6 x 1 x 16 SHCS.

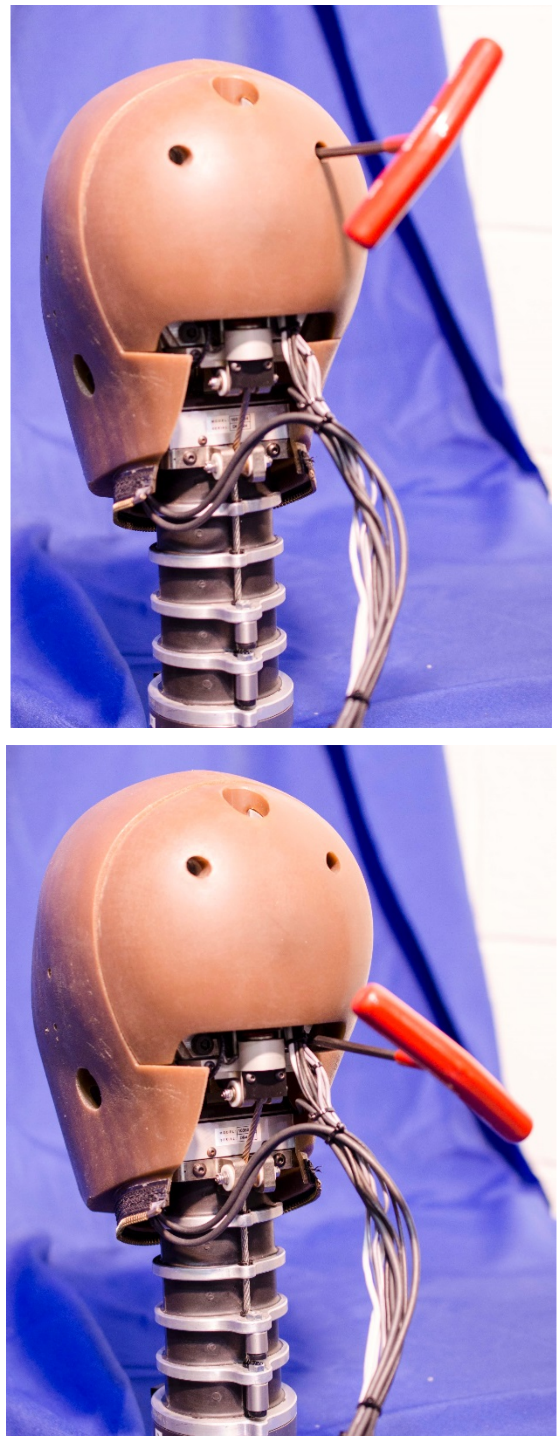


Figure 3-24. Install the skull cap

3.3 Adjustments for the Head and Face Assemblies

No adjustments are required for the head and face assemblies.

3.4 Electrical Connections and Requirements

Section 15.3 includes grounding information. Section 15.4 describes cable routing instructions.

3.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the head and neck, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

3.5.1 Electrical Inspections (Instrumentation Check)

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from head instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief (see Section 15.4.1).

Specific areas to examine:

- Ensure that no wires are in the pinch points between the Head Cap (472-1110) and the Skull Assembly (472-1100). If wires are pinched, remove the head cap and relieve the pinch point; follow the steps above to verify signal integrity.

- Check the security of all head instrumentation mounting bolts.

3.5.2 Mechanical Inspection

Several components in the head assembly require inspection post-test.

Specific areas to examine:

- Check the Skin Assembly (472-1320) for tears and damage. Replace the skin assembly if the damage compromises fit of the skin on the skull or if the damage is located in a critical impact area.
- Confirm positive engagement of the skin assembly on the skull by visibility of the Nylon SHCS inside the C.G. hole in the head skin (Section 3.2.2.16). Also, ensure that the skin seats into the grooved contour on the skull. Adjust the skin if necessary to maintain fit.
- Check the Confor Face Foam (472-1025) for tears, rips, or permanent deformation. Replace the confor face foam if damaged or deformed.

Section 4. **Neck Assembly**

4.1 Description of the Neck Assembly and Features

The THOR-50M neck assembly consists of a series of aluminum plates and rubber pucks which are molded together using an epoxy resin system. The elliptical rubber pucks provide the desired frontal, lateral, and torsional bending responses for the neck assembly. Compression springs are located in the fore and aft regions of the skull. In addition, rubber soft stops at the base of the neck aid in achieving the desired bending characteristics in both front and rear motion.

The instrumentation for the neck assembly includes a pair of skull spring load cells (SA572-S112), which measure the compression at the front and rear spring locations. In addition, six-axis load cells at the top (SA572-S110) and base (SA572-S111) of the neck measure the forces and moments developed at these locations, while a rotary potentiometer (SA572-S114) at the condyle pin measures the relative rotation between the head and top of the neck. Figure 4-1 illustrates the THOR-50M neck assembly.

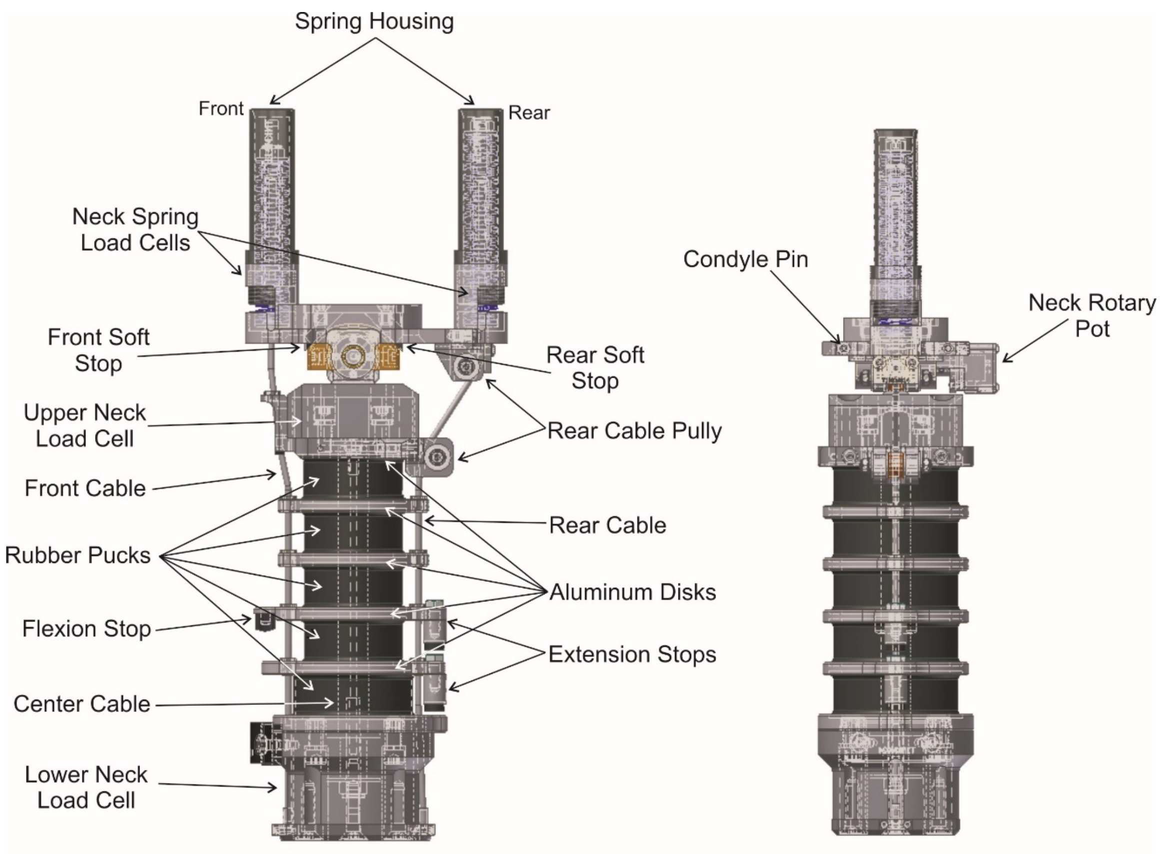


Figure 4-1. Neck assembly

4.2 Assembly of the Neck

4.2.1 Parts List

Table 4-1 through Table 4-5 list the components that are included in the neck.
Figure 4-2 through Figure 4-7 show drawings of the neck assemblies and hardware.

Table 4-1. Neck Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Neck Cable Assembly	1	472-2100	Figure 4-2	1
Neck Cable Seat Cover	2	472-2015	Figure 4-2	2
Neck Pulley Bracket Assembly	1	472-2300	Figure 4-2	3
Occipital Condyle Screw	1	472-2016	Figure 4-2	4
Neck Mounting Platform	1	472-2200	Figure 4-2	5
Neck Occipital Condyle Pin	1	472-2011	Figure 4-2	6
Neck Pulley Plate	1	472-2012	Figure 4-2	7
Neck Rotary Potentiometer Washer	1	472-2021	Figure 4-2	8
Neck Rotary Potentiometer Clamp	2	472-2020	Figure 4-2	9
Neck Rotary Potentiometer Cover	1	472-2014	Figure 4-2	10
Neck Occipital Condyle Cam	1	472-2019	Figure 4-2	11
Neck Rotary Potentiometer Housing	1	472-2013	Figure 4-2	12
Upper Neck Load Cell Structural Replacement	1	472-2700	Figure 4-2	13
Lower Neck Load Cell Structural Replacement	1	472-2600	Figure 4-2	14
M2 X 0.4 X 6 LG. FHCS	4	5000469	Figure 4-2	15
M6 Hi-Collar Lock Washer S.S.	8	5001110	Figure 4-2	16
M6 X 1 X 14 LG. SHCS	8	5000604	Figure 4-2	17
M5 Hex Jam Nut	4	5000380V	Figure 4-2	18
M4 X 0.7 X 20 LG. BHCS	2	5000007	Figure 4-2	19
M3 X 0.5 X 5 LG. BHCS	2	5000674	Figure 4-2	20
M4 X 0.7 X 6 LG. SHCS	1	5000076	Figure 4-2	21
M2 X 0.4 X 6 LG. SHCS	4	5000082	Figure 4-2	22
M3 X 0.5 X 8 LG. BHCS	3	5000410	Figure 4-2	23
M3 X 0.5 X 30 LG. BHCS SS	2	5000749	Figure 4-2	24
M3 X 0.5 X 3 LG. SSS CONE PT.	1	5001112	Figure 4-2	25
Lower Neck Load Cell Bumper	1	472-2002	Figure 4-2	26
Lower Neck Load Cell Bumper Cover	1	472-2001	Figure 4-2	27
M5 X 0.8 X 12 LG. BHCS	2	5000654	Figure 4-2	28
Upper Neck Load Cell (Optional)	1	SA572-S110	Figure 4-2	29
Lower Neck Load Cell (Optional)	1	SA572-S111	Figure 4-2	30

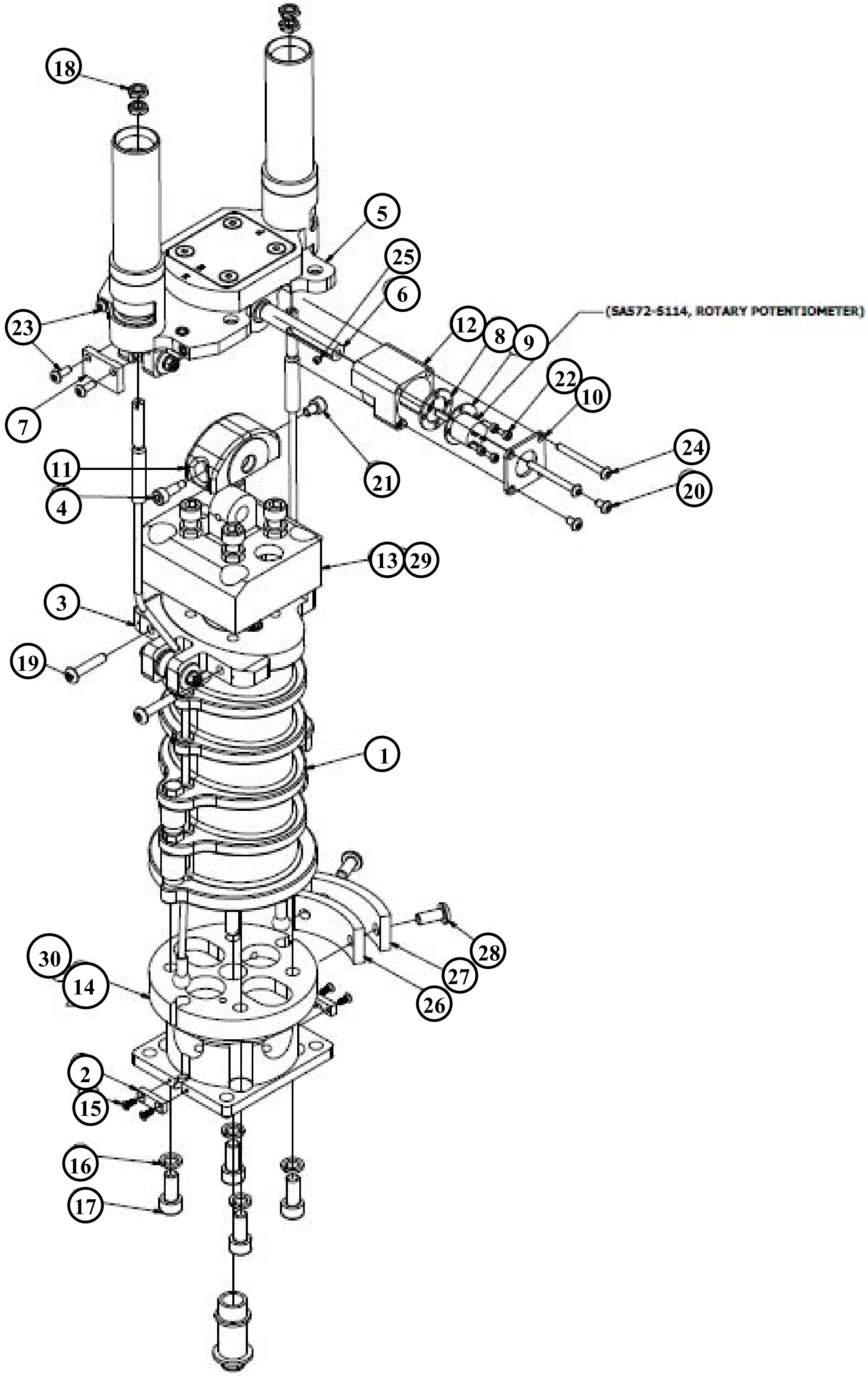


Figure 4-2. Neck assembly components

Table 4-2. Neck Cable Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Neck Assembly	1	472-2110	Figure 4-3	1
Neck Cable Guide	8	472-2105	Figure 4-3	2
Neck Cable Guide	1	472-2106	Figure 4-3	3
Neck Center Cable Fixture	1	472-2102	Figure 4-3	4
Neck Cable Cover	1	472-2103	Figure 4-3	5
Neck Center Cable Assembly	1	472-2140	Figure 4-3	6
Neck Rear Cable Assembly	1	472-2130	Figure 4-3	7
Neck Front Cable Assembly	1	472-2150	Figure 4-3	8
M2 x 0.4 x 6 LG FHCS	2	5000469	Figure 4-3	9
Upper Neck Stop Assembly	1	472-2500	Figure 4-3	10
Lower Neck Stop Assembly	1	472-2520	Figure 4-3	11
M5 x 0.8 x 12 HHCS	2	5001109	Figure 4-3	12
Neck Neoprene Spacer	1	472-2018	Figure 4-3	13
M6 Fender Washer S.S.	1	5001113	Figure 4-3	14
M6 x 1 Hex Lock Nut S.S.	1	5000503	Figure 4-3	15
Neck Center Cable Lower Bushing 2	1	472-2108	Figure 4-3	16

Table 4-3. Neck Pulley Bracket Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Neck Rear Pulley Bracket	1	472-2310	Figure 4-4	1
Neck Rear Cable Pulley Shaft	1	472-2311	Figure 4-4	2
Needle Roller (3/16 bore) Bearing	2	9002597	Figure 4-4	3
Neck Rear Cable Pulley	1	472-2312	Figure 4-4	4
Teflon Washer 0.187 x 0.5 x 0.04	4	9002595	Figure 4-4	5
Dowel Pin S.S. M3 x 18 LG.	2	5000391	Figure 4-4	6
Plain Zinc M3 Flat Washer	2	5001095	Figure 4-4	7
M3 x 0.3 Hex Lock Nut S.S.	2	5001106	Figure 4-4	8

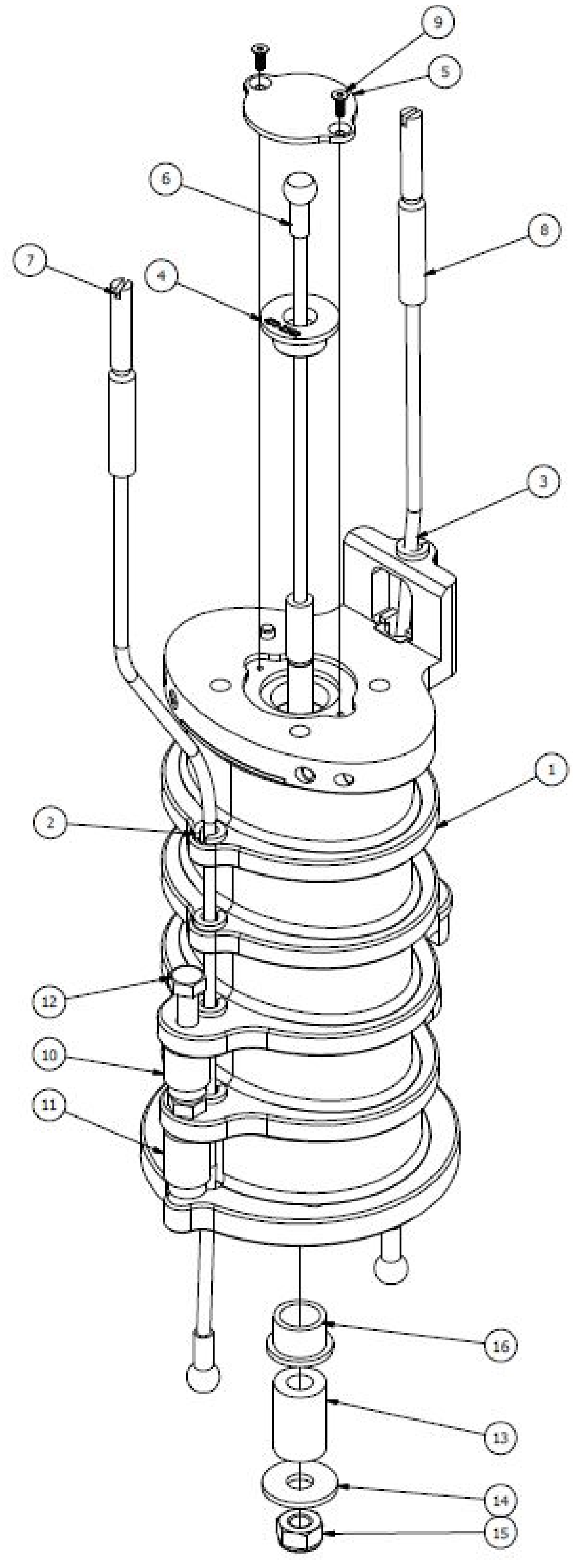


Figure 4-3. Neck cable assembly components

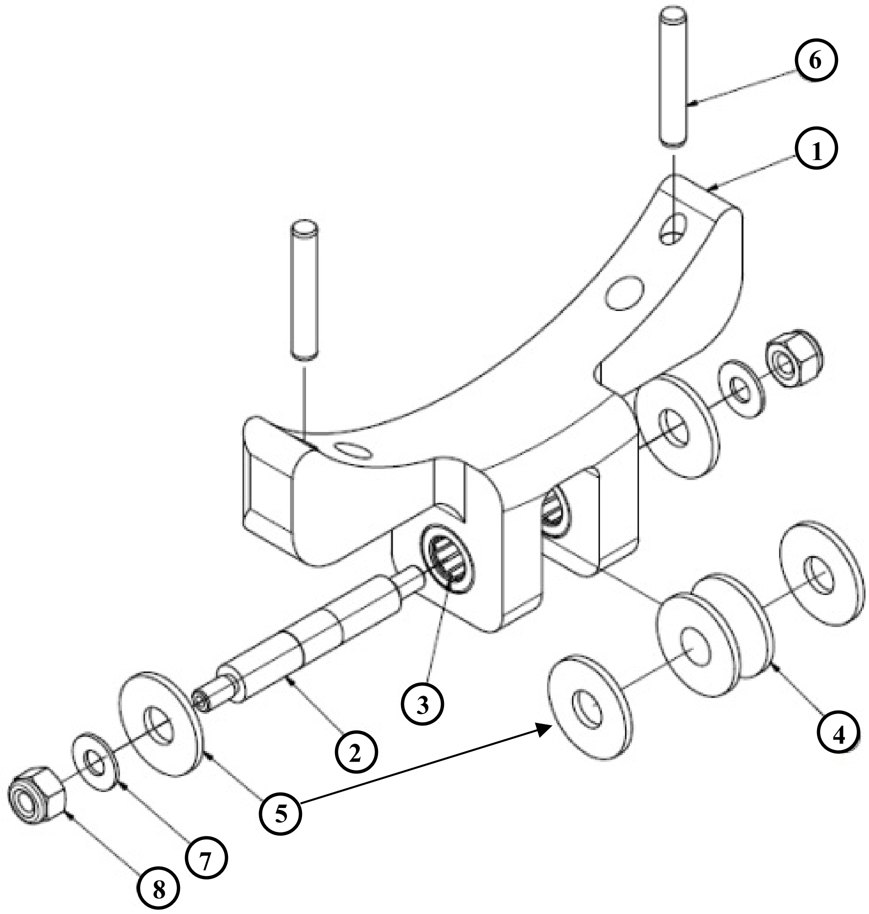


Figure 4-4. Neck pulley bracket components

Table 4-4. Neck Mounting Platform Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Head/Neck Mounting Platform	1	472-2210	Figure 4-5	1
OC Stop Assembly	1	472-2105	Figure 4-5	2
Head/Neck Pulley Bracket Assembly	1	472-2106	Figure 4-5	3
Neck Spring Load Cell Structural Replacement	2	472-2102	Figure 4-5	4
Neck Front/Rear Spring Tube	2	472-2103	Figure 4-5	5
Front Spring Assembly	1	472-2140	Figure 4-5	6
Rear Spring Assembly	1	472-2130	Figure 4-5	7
Neck Front Cable Bushing	1	472-2150	Figure 4-5	8
Screw, M4 x 10 FHCS	6	5000469	Figure 4-5	9
0.085 dia. Skull Spring Load Cell (Optional)	2	SA572-S112	Figure 4-5	10

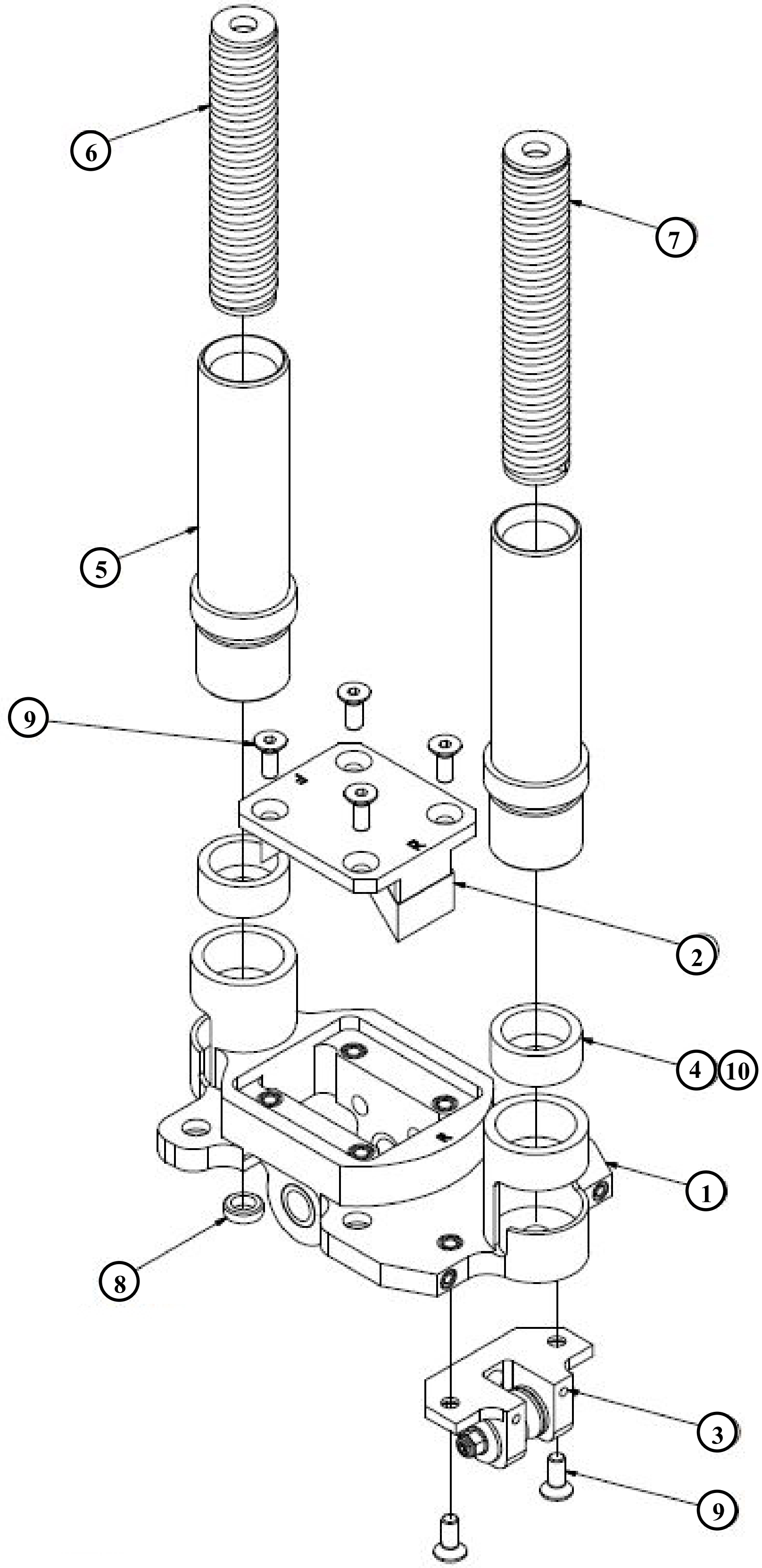


Figure 4-5. Neck mounting platform components

Table 4-5. Neck Spring Assemblies Components

Part Description	Quantity	Part Number	Figure #	Item #
Rear Spring Assembly				
Spring, 16 x 8 I.D. x 89	1	50000516	Figure 4-6	1
Neck Spring Bushing	2	472-2221	Figure 4-6	2
Neck Rear Spring Damping Tube	1	472-2241	Figure 4-6	3
Front Spring Assembly				
Spring, 16 x 8 I.D. x 76	1	50000517	Figure 4-7	1
Neck Spring Bushing	2	472-2221	Figure 4-7	2
Neck Front Spring Damping Tube	1	472-2222	Figure 4-7	3

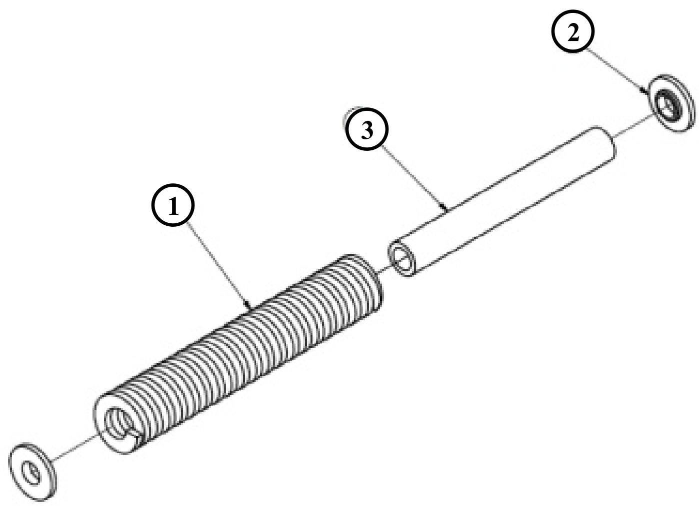


Figure 4-6. Rear spring assembly components

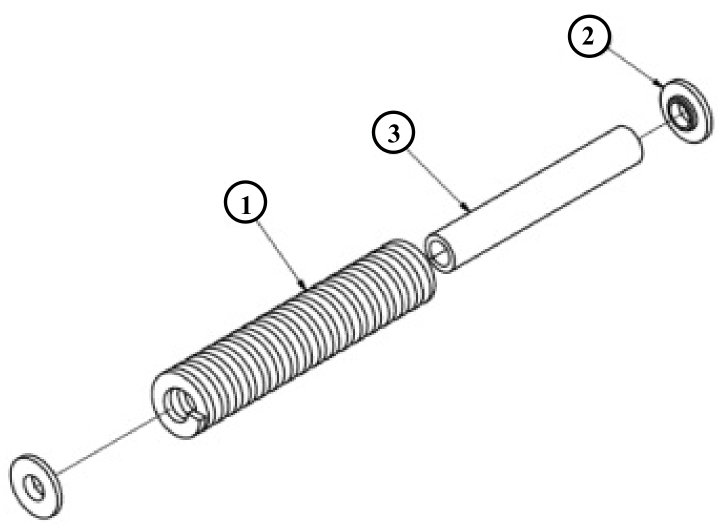


Figure 4-7. Front spring assembly components

4.2.2 **Assembly of Neck Components**

The following procedure is a step-by-step description of the assembly procedure for the neck components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

4.2.2.1 The anterior/top of the neck can be identified by the surface containing the machined vertical bracket. Install the Rear Pulley Bracket (472-2300) to the posterior top of the neck using two M4 x 0.7 x 20 BHCS (Figure 4-8).

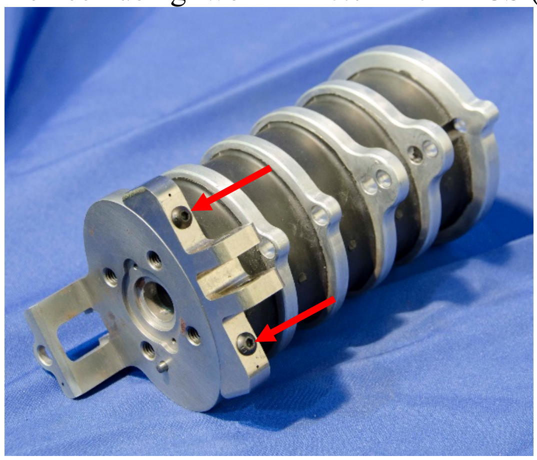


Figure 4-8. Install rear pulley bracket to neck

4.2.2.2 Insert the Neck Center Cable Assembly (472-2140) through the Neck Center Cable Fixture (472-2102) and into the top of the neck (Figure 4-9).

Figure 4-9. Insert neck center cable assembly

4.2.2.3 Install the Neck Cable Cover (472-2103) over the top of the neck center cable fixture using two M2 x 0.4 x 6 FHCS (Figure 4-10 and Figure 4-11).

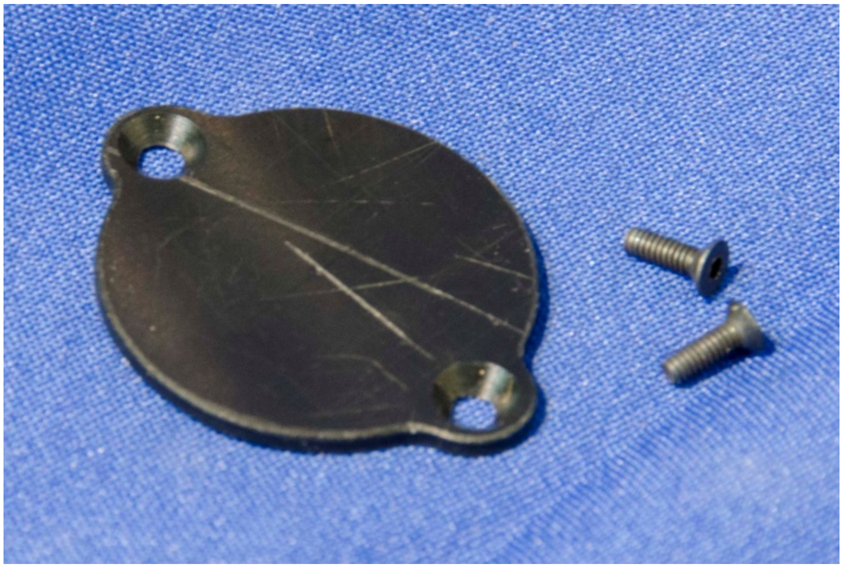


Figure 4-10. Neck cable cover

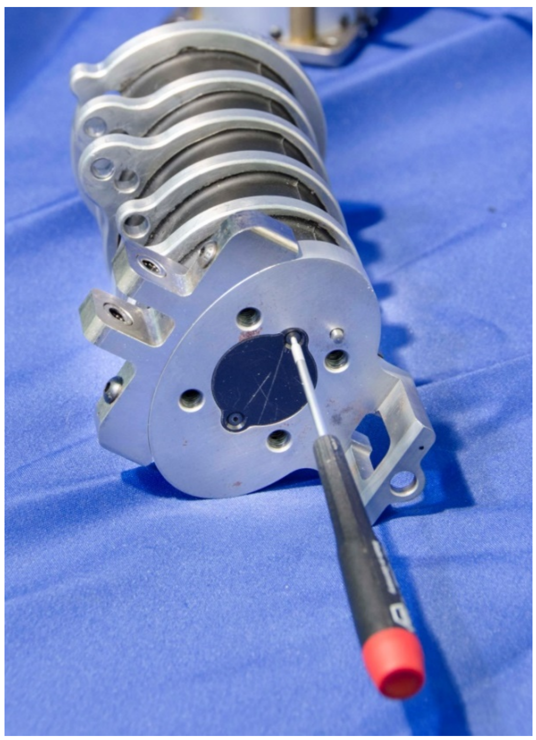


Figure 4-11. Install neck cable cover

4.2.2.4 Pass the threaded end of the Neck Front Cable Assembly (472-2150) through the Lower Neck Load Cell (SA572-S111) and through each of the neck plate holes at the front side of the neck. Repeat with the Neck Rear Cable Assembly (472-2130) on the rear side of the neck (Figure 4-12).

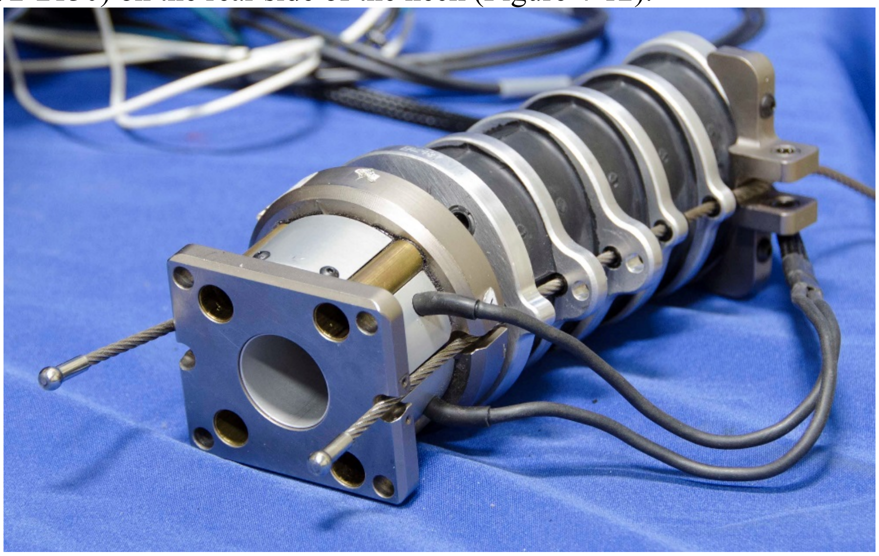


Figure 4-12. Assemble front and rear cable assemblies to neck

4.2.2.5 Attach the lower neck load cell to the bottom of the neck with the sensor wires toward the rear of the neck using four M6 x 1 x 14 SHCS and M6 hi-collar lock washers (Figure 4-13). Note that the holes at the top-front (cylindrical section) of the load cell are closer together than the rear holes (Figure 4-14).

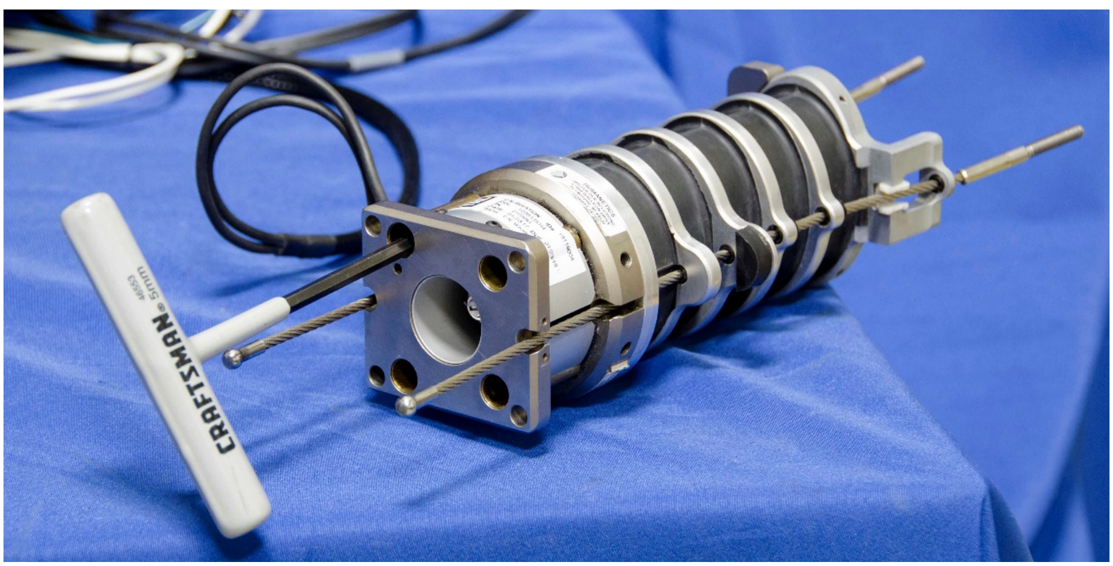


Figure 4-13. Attach lower neck load cell to neck

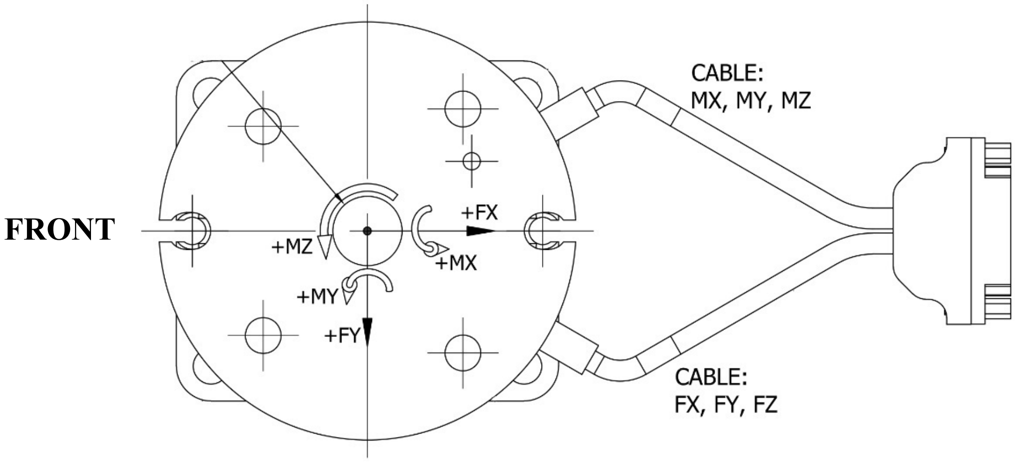


Figure 4-14. Lower neck load cell (top view)

4.2.2.6 The ball end of each cable rests in the base of the lower neck load cell and is secured with a Neck Cable Seat Cover (472-2015) and two M2 x 0.4 x 6 FHCS on the front and rear load cell base faces (Figure 4-15). Orient the recessed area on the cover inwards to accommodate the ball end of the cable.

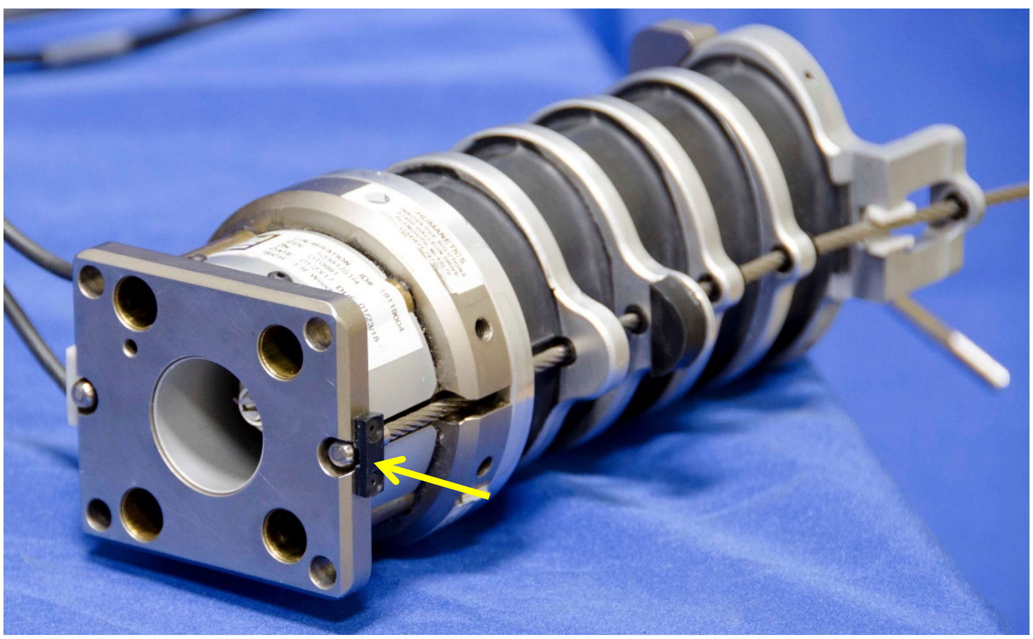


Figure 4-15. Install neck cable seat covers

4.2.2.7 Assemble and install the neck center cable at the threaded end. The order of installation is as follows (Figure 4-16[3]):

1. Neck Center Cable Lower Bushing 2 (472-2108)
2. Neck Neoprene Spacer (472-2018)
3. M6 fender washer
4. M6 x 1 hex lock nut

[3] Figure includes drawing rendition of Neck Center Cable Lower Bushing 2 since part was not yet available

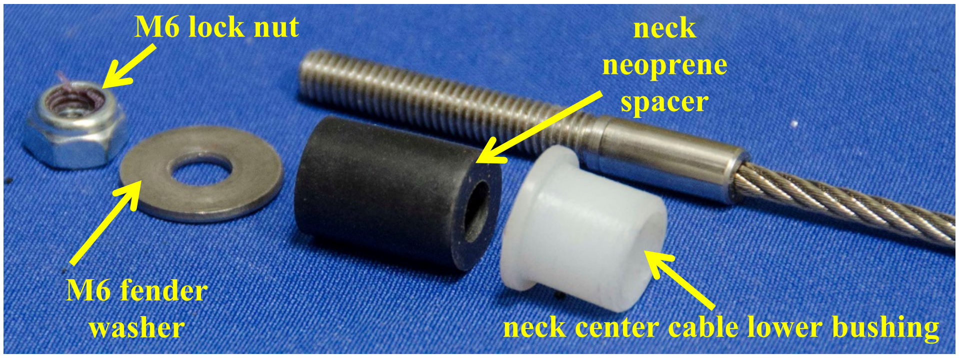


Figure 4-16. Hardware for securing neck center cable

4.2.2.8 For ease of installation of the M6 x 1 hex lock nut, insert a screwdriver into the 10 mm socket while the socket tightens the nut (Figure 4-17 and Figure 4-18). The hex lock nut should be tightened 1/2 turn beyond contact.

Figure 4-17. Technique for installing center neck cable

Figure 4-18. Install hardware for neck center cable

4.2.2.9 There are nine cable guides in the neck (Figure 4-19). Eight of the guides are 7.9 mm long (472-2105) which fit into neck plates 1, 2, and the two neck plate 3 locations. Install the other 4.7 mm long cable guide (472-2106) into the neck top plate.

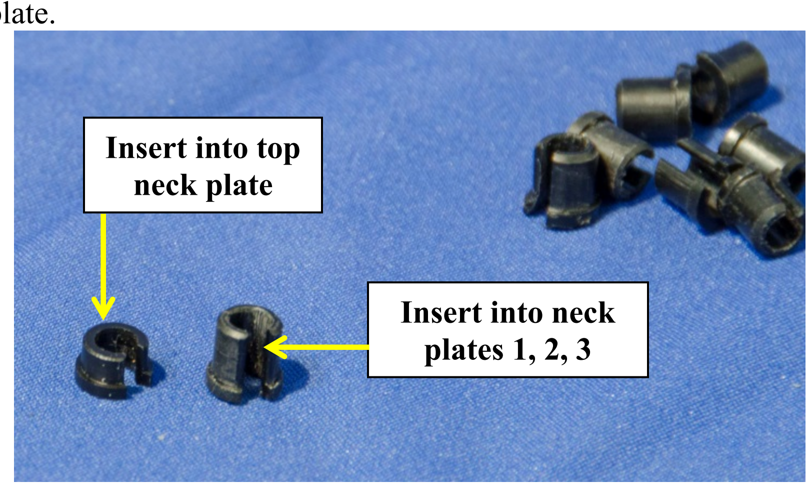


Figure 4-19. Neck cable guides

4.2.2.10 Insert the shorter (4.7 mm) cable guide (472-2106) into the neck top plate around the front cable (Figure 4-20). There is a slit in the guide on one side to stretch the guide open and press it onto the front cable. Once the guide is on the cable, press it into the hole in the top neck plate.

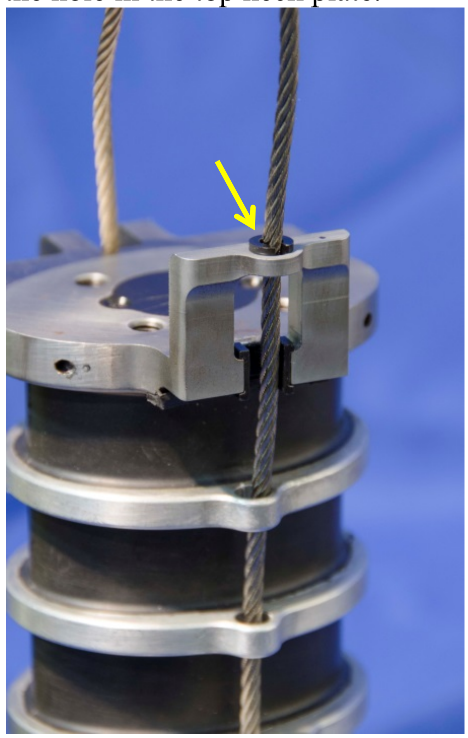


Figure 4-20. Install top plate cable guide

4.2.2.11 Assemble the Cable Guides (472-2105) at the eight locations shown in Figure 4-21. Slits on one side of guides allow them to be stretched open and pressed onto the cable at each location. Once each guide is on the cable, press it into the hole in each plate.

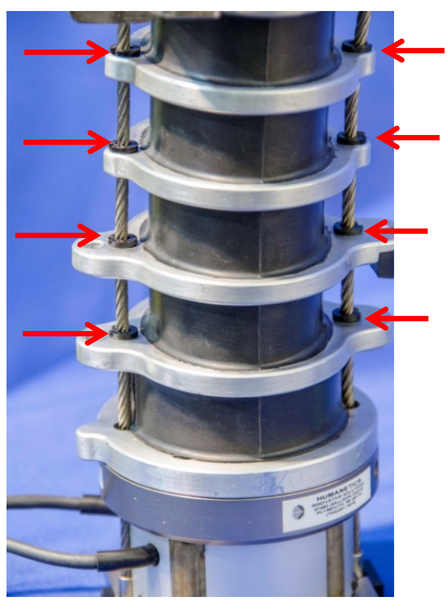


Figure 4-21. Install cable guides

4.2.2.12 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 M5 x 0.8 x 12 BHCS (Figure 4-22 and Figure 4-23).

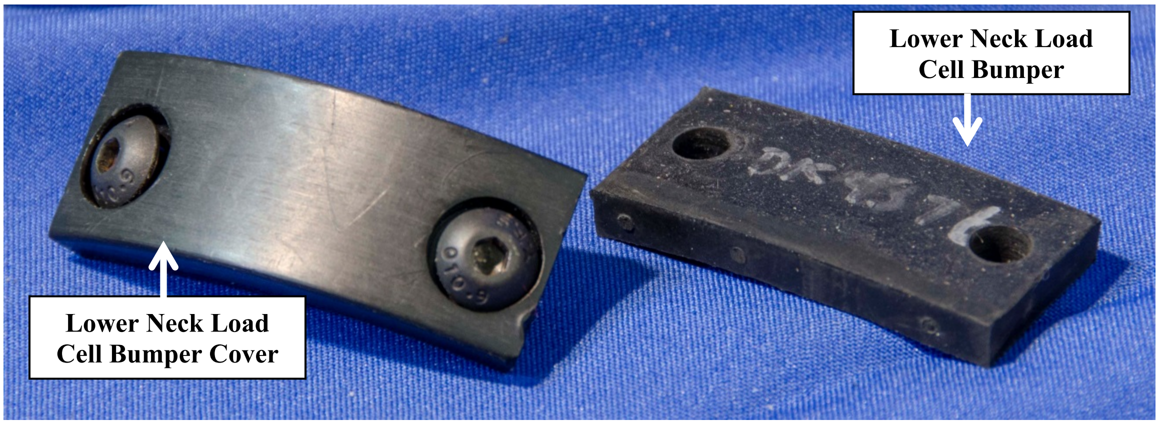


Figure 4-22. Lower neck load cell bumper and bumper cover

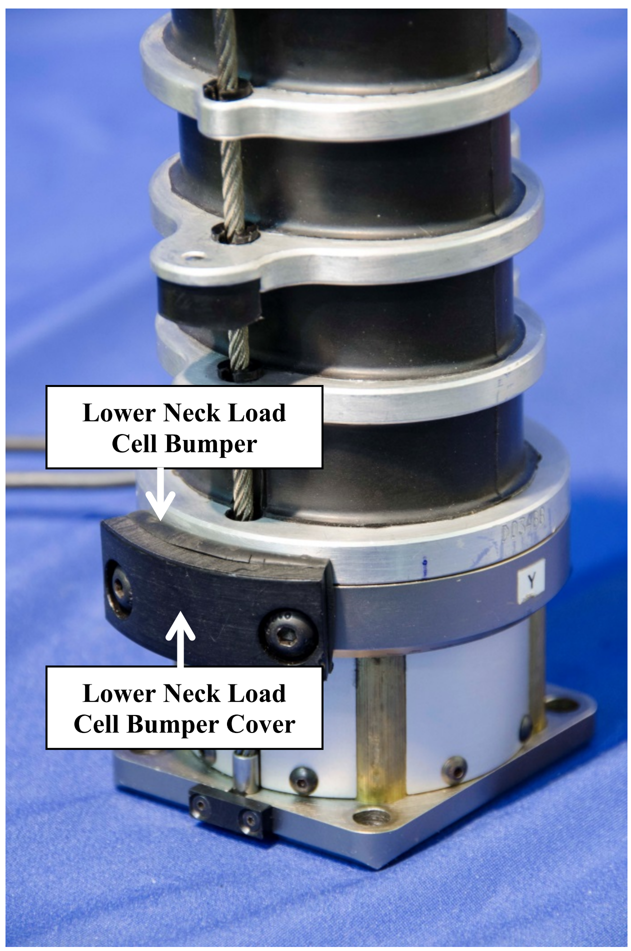


Figure 4-23. Neck load cell bumpers installed

4.2.2.13 There are two neck stop assemblies in the THOR-50M neck (Figure 4-24). The Lower Neck Stop Assembly (472-2520) is approximately 17 mm long and the Upper Neck Stop Assembly (472-2500) is approximately 14 mm in length.

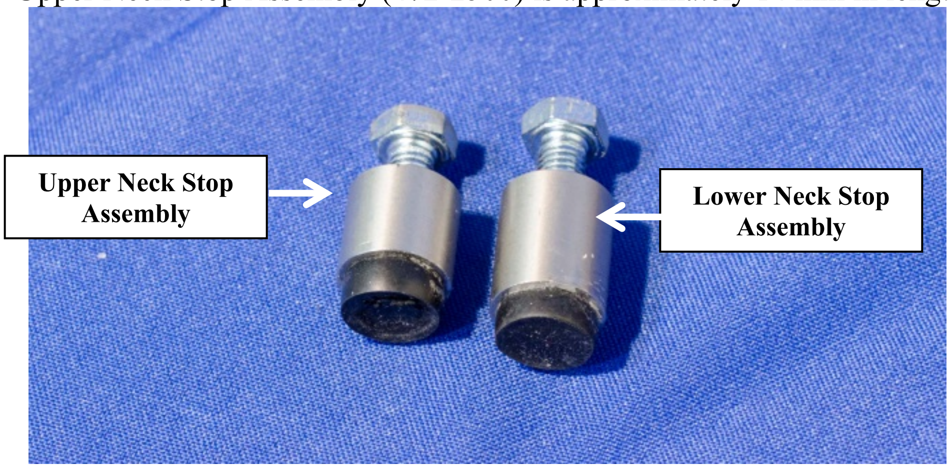


Figure 4-24. Upper and lower neck stop assemblies

4.2.2.14 Install the lower neck stop assembly using an M5 x 0.8 x 12 HHCS (Figure 4-25).

Figure 4-25. Install lower neck stop assembly

4.2.2.15 Install the upper neck stop assembly using an M5 x 0.8 x 12 HHCS (Figure 4-26).

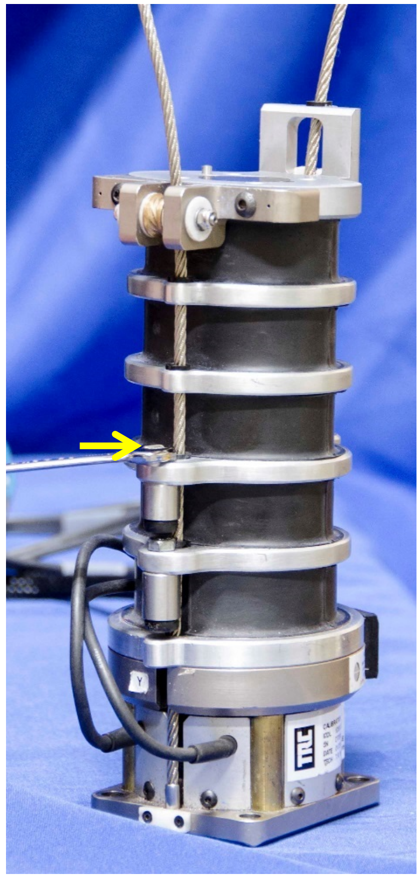


Figure 4-26. Install upper neck stop assembly

NOTE: During the assembly of the Neck Rear Pulley Bracket (472-2300), it is important to keep the Rear Neck Cable (472-2130) positioned between the Rear Cable Pulley (472-2312) and the Neck Top Plate (472-2125).

4.2.2.16 To install the Rear Cable Pulley (472-2312), place a Teflon washer 0.187 x 0.50 x 0.04 on each side of the rear cable pulley 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 Teflon washer, an M3 Flat Washer, and a M3 x 0.3 Hex Lock Nut (Figure 4-27). Tighten the nuts until contact.

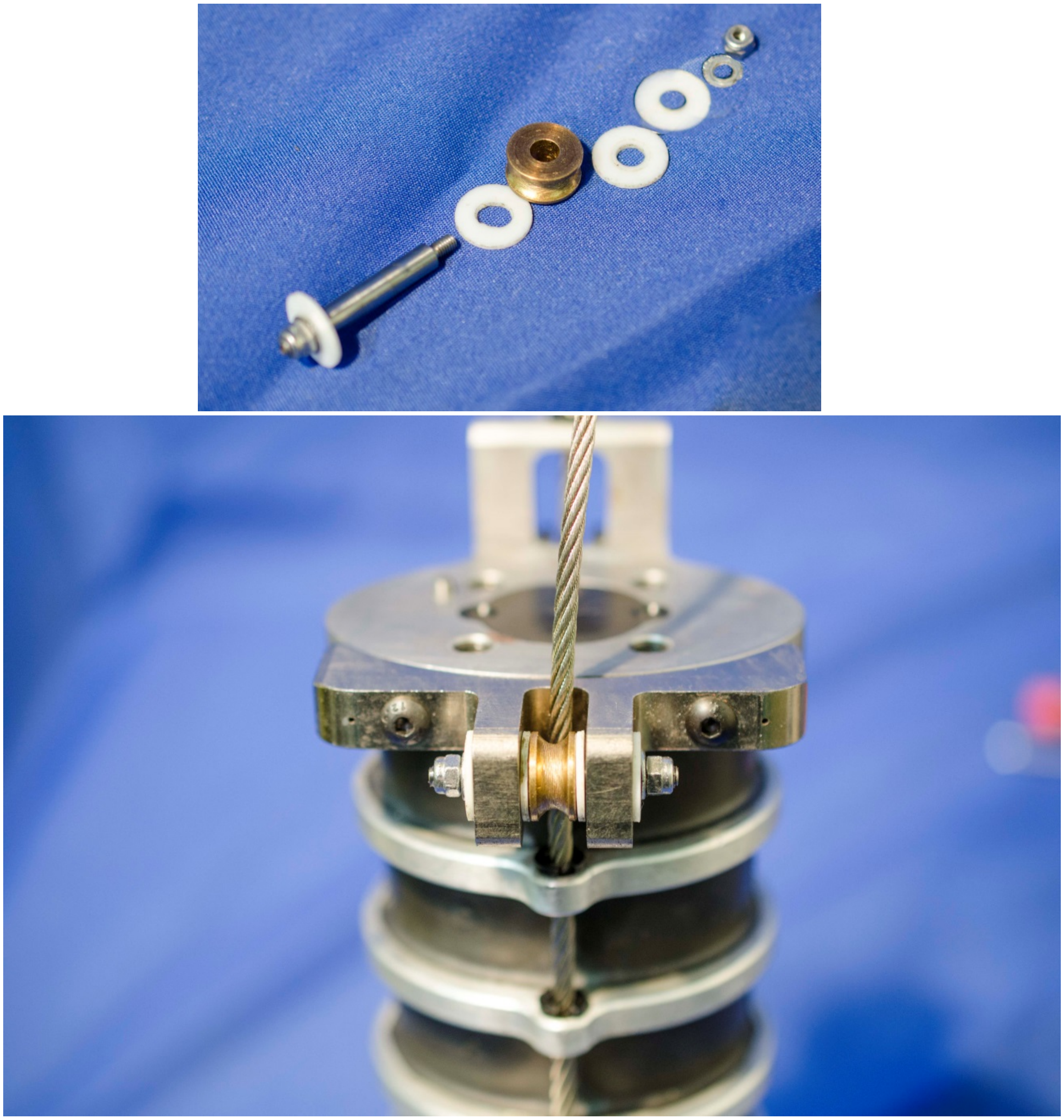


Figure 4-27. Assemble and install pulley

4.2.2.17 Install the Upper Neck Load Cell (SA572-S110) (or Upper Neck Load Cell Structural Replacement 472-2700) to the top plate of the Molded Neck Assembly (472-2100) using four M6 x 14 SHCS and four M6 hi-collar lock washers (Figure 4-28).

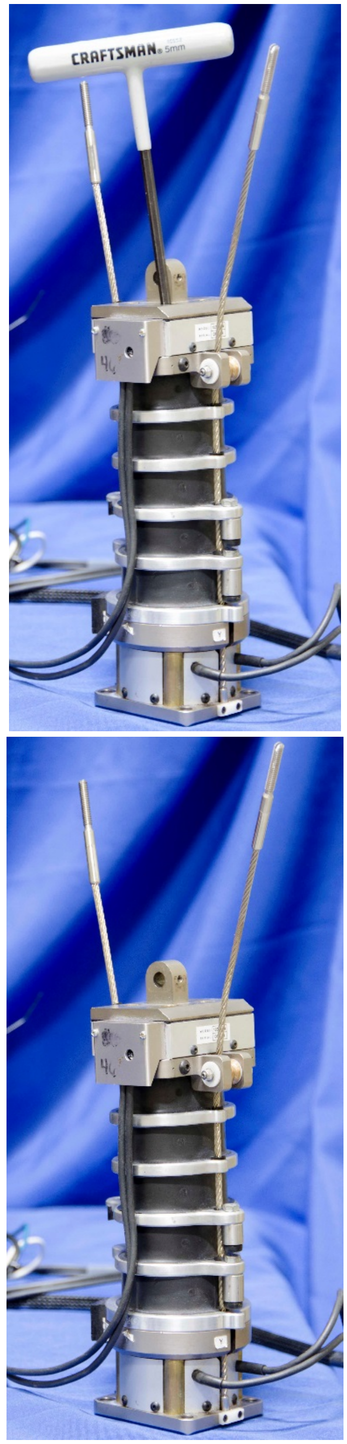


Figure 4-28. Install the upper neck load cell

4.2.2.18 Install the 0.850 diameter Skull Spring Load Cells (SA572-S112) into the Head/Neck Mounting Platform (472-2210) at the base of the front and rear spring towers (Figure 4-29).

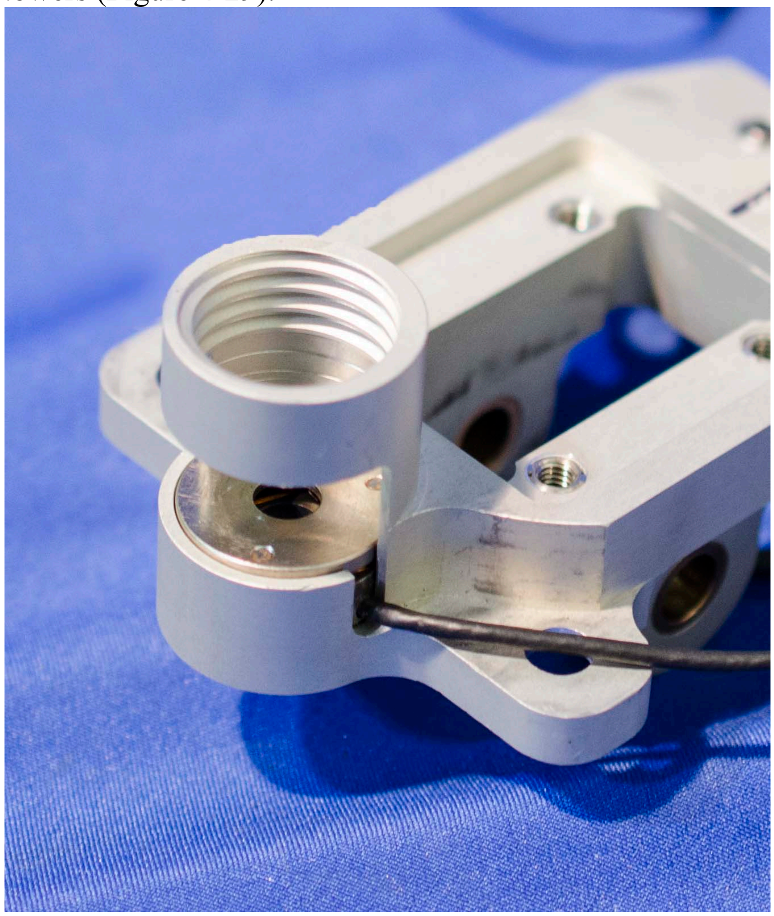


Figure 4-29. Insert skull spring load cells into neck mounting plate

4.2.2.19 Place the Neck Occipital Condyle Cam (472-2019) over the upper neck load cell (Figure 4-30). Note that the cam must be properly oriented; the cam ends are engraved to aid in correct positioning. Loosely attach the cam to the upper neck load cell using the Occipital Condyle Screw (472-2016) on the rear and an M4 x 0.7 x 6 SHCS on the front.

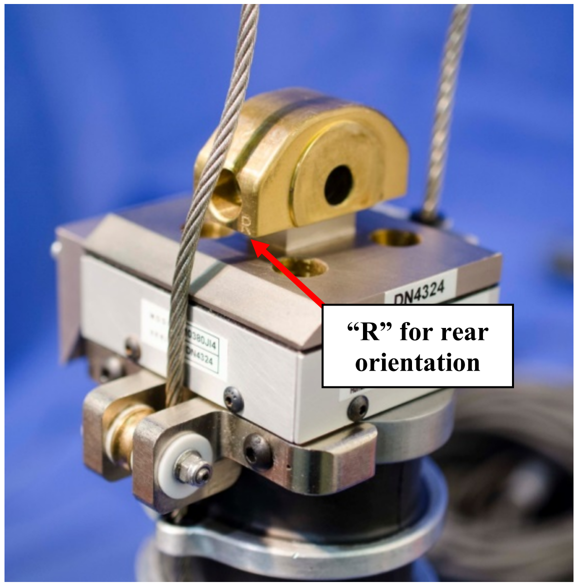


Figure 4-30. Install occipital condyle cam

4.2.2.20 Install the neck mounting platform on top of the neck occipital condyle cam (Figure 4-31). Pass the front and rear neck cables up through the Skull Spring Load Cells (SA572-S112).

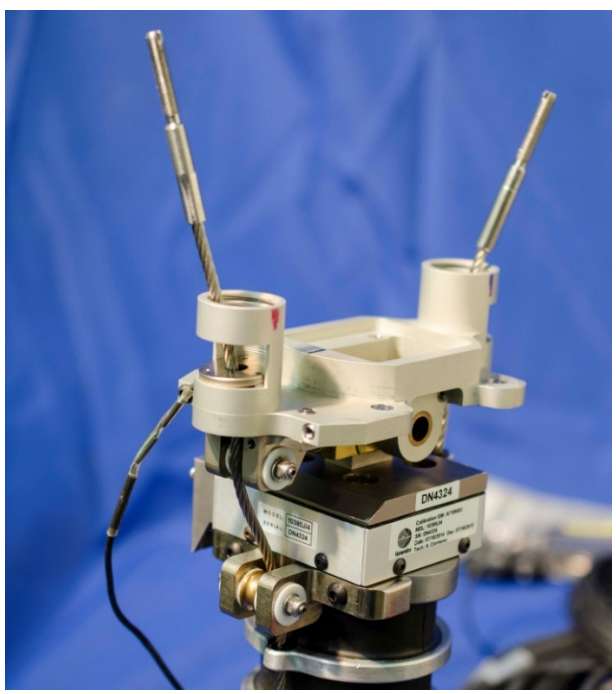


Figure 4-31. Secure neck mounting plate assembly to neck O.C. cam

4.2.2.21 Insert the Neck Occipital Condyle Pin (472-2011) into the cam hole (Figure 4-32). Be certain that the pin is properly oriented within the hole so that the holes in the pin aligns with the occipital condyle screw in the rear.

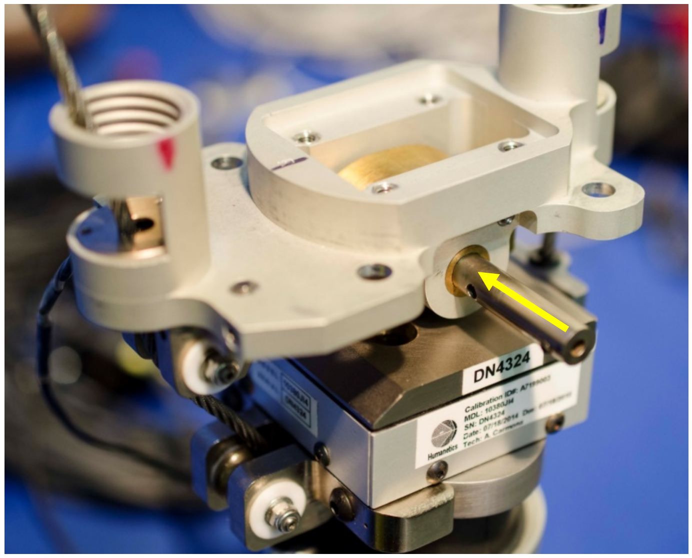


Figure 4-32. Insert O.C. pin into cam

4.2.2.22 Tighten the occipital condyle screw on the rear (Figure 4-33) and then the M4 x 0.7 x 8 SHCS on the front to secure the cam to the upper neck load cell (Figure 4-34).

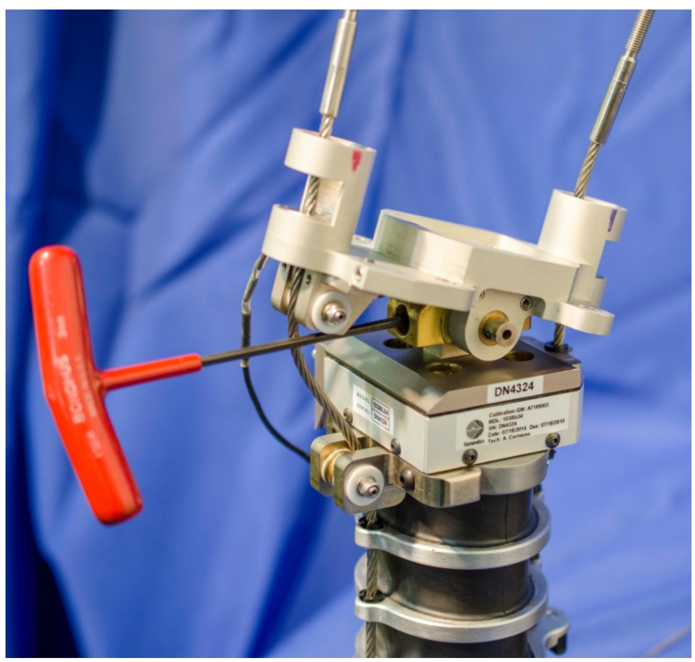


Figure 4-33. Tighten occipital condyle screw to secure O.C. cam in rear

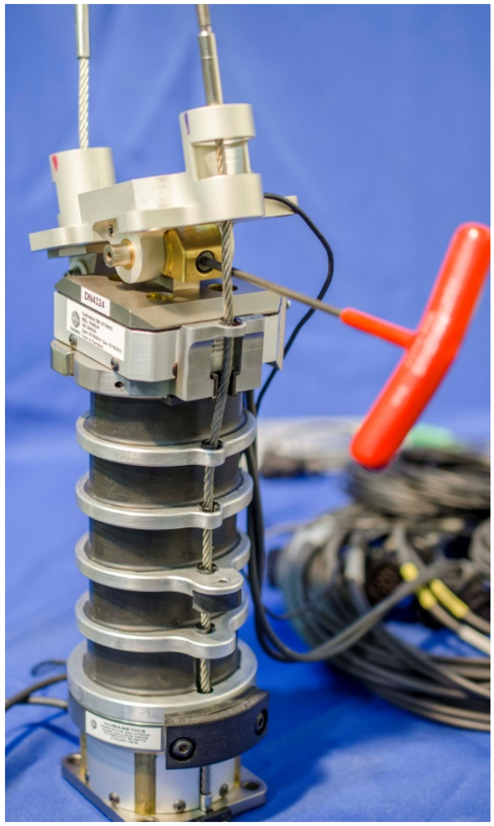


Figure 4-34. Tighten screw to secure O.C. cam in front

4.2.2.23 Install the Neck Pulley Plate (472-2012) to the rear side of the Neck Mounting Platform (472-2200) using two M3 x 0.5 x 8 BHCS (Figure 4-35).

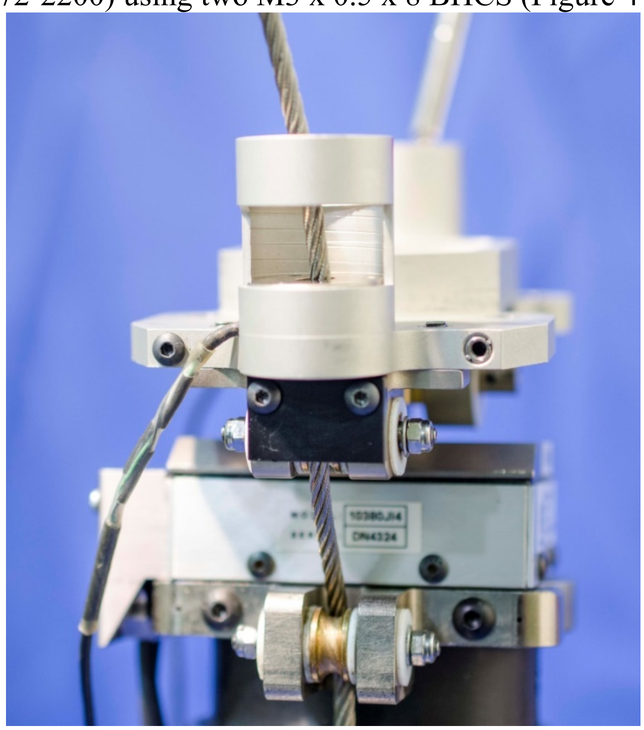


Figure 4-35. Install neck pulley plate to neck mounting plate

4.2.2.24 Insert the O.C. Stop Assembly (472-2105) into the head/neck mounting platform and secure with four M4 x 10 FHCS (Figure 4-36 and Figure 4-37). Assure that the assembly is properly oriented (the thicker nodding block is towards the rear).

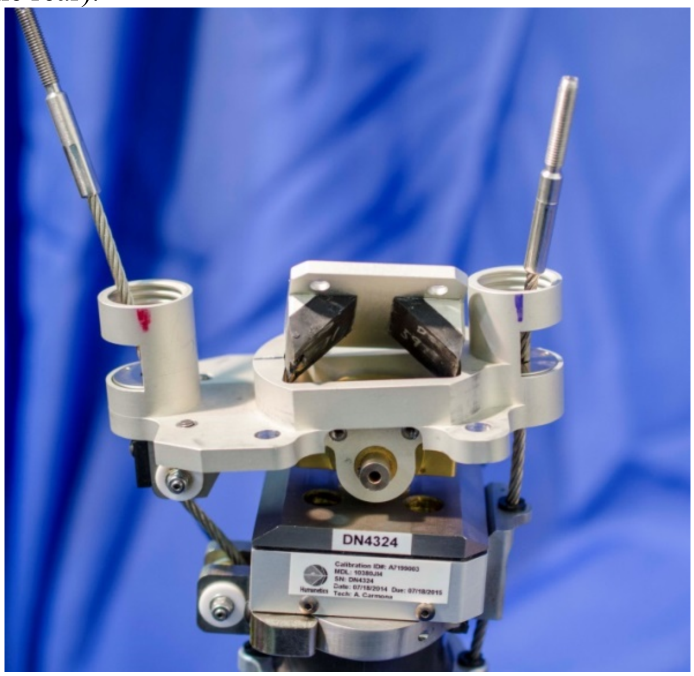


Figure 4-36. Place O.C. stop assembly into head/neck mounting platform

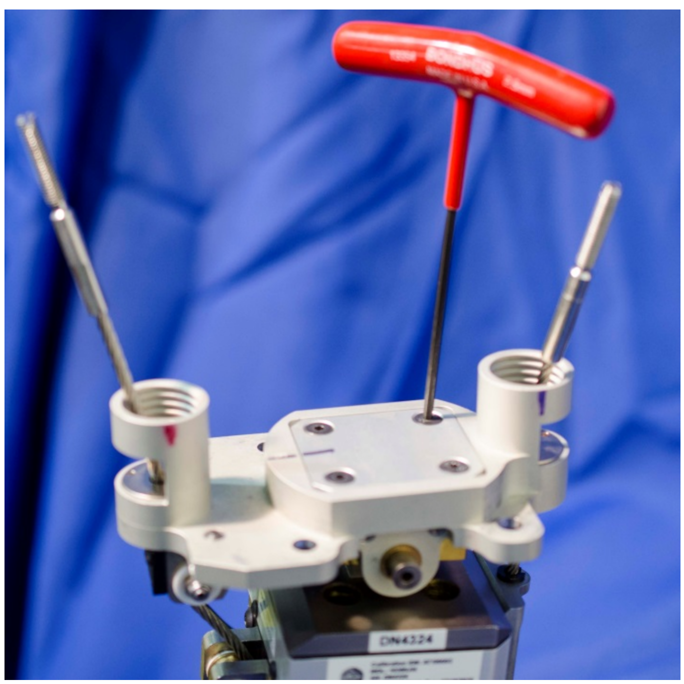


Figure 4-37. Secure nodding block screws

4.2.2.25 Insert the Neck Rotary Potentiometer Washer (472-2021) into the Neck Rotary Potentiometer Housing (472-2013), then install the Occipital Condyle Rotary Potentiometer (SA572-S114) into the housing (Figure 4-38). Secure the two Neck Rotary Potentiometer Clamps (472-2020) over the base of the potentiometer and into the housing using four M2 x 0.4 x 6 SHCS.

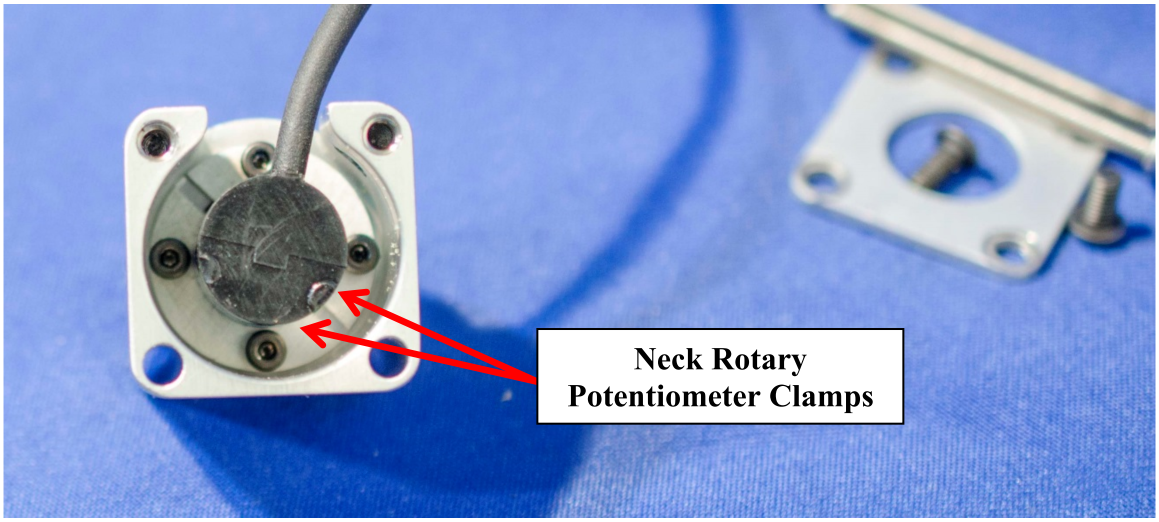


Figure 4-38. Install neck rotary potentiometer

4.2.2.26 Attach the Neck Rotary Potentiometer Cover (472-2014) with two M3 x 0.5 x 5 BHCS at the bottom of the housing (Figure 4-39).

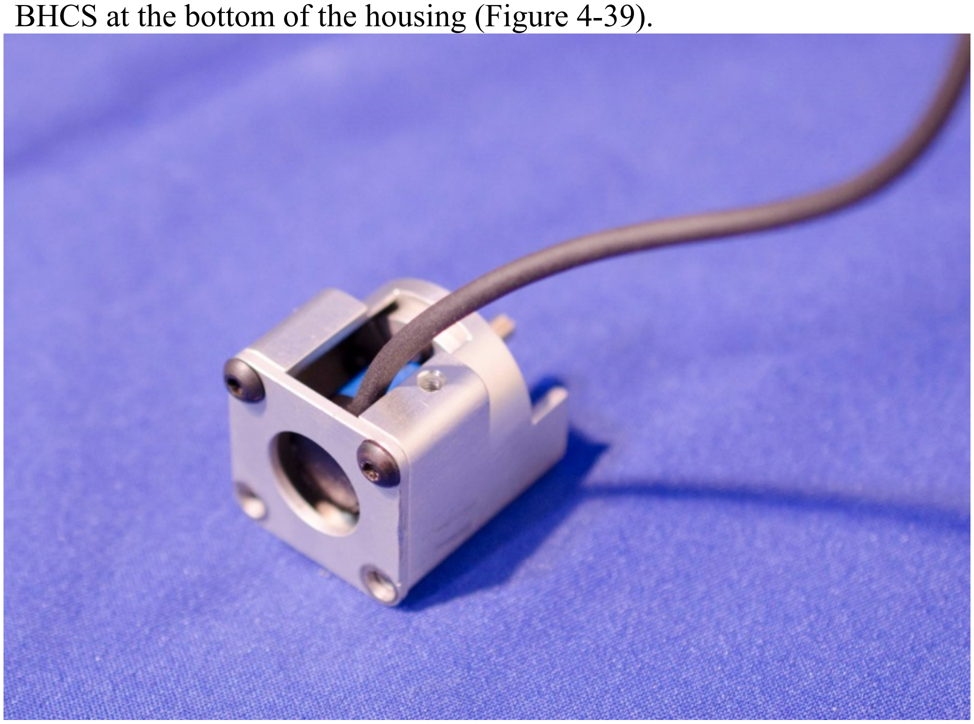


Figure 4-39. Attach rotary potentiometer cover

4.2.2.27 Loosely install the M3 x 0.5 x 3 mm SSS cone point set screw into the Neck Occipital Condyle Pin (472-2011) (Figure 4-40). The set-screw should not enter the shaft opening at this point in the assembly.

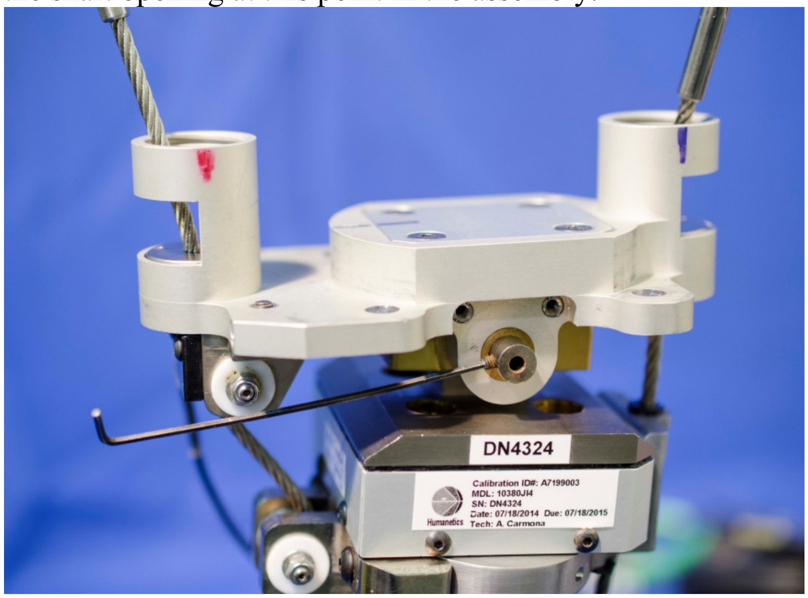


Figure 4-40. Loosely install set-screw into O.C pin

4.2.2.28 Before inserting the rotary potentiometer shaft into the O.C. pin, assure that the potentiometer will not pass through a dead band when moved through its range of motion in the neck. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range.

4.2.2.29 Once this is complete, insert the potentiometer shaft into the O.C. pin. Tighten the M3 x 0.5 x 3 mm SSS cone point set screw against the potentiometer shaft. Attach the rotary potentiometer housing to the head neck mounting platform with two M3 x 0.5 x 30 BHCS at the top of the housing (Figure 4-41).

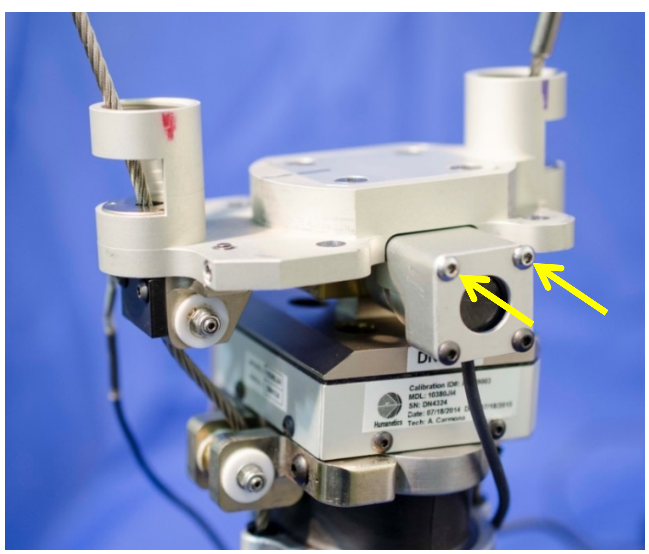


Figure 4-41. Attach rotary potentiometer housing to head neck mounting platform

4.2.2.30 Pass the threaded end of the front and rear neck cable assemblies up through the front and rear spring tube assemblies in the Neck / Head Mounting Platform (472-2210) (Figure 4-42).

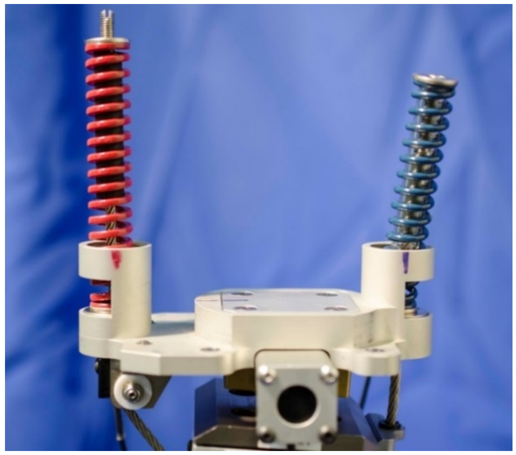


Figure 4-42. Insert cables into neck springs

4.2.2.31 Proceed to the *THOR 50th Percentile Male (THOR-50M) Qualification Procedures Manual* (April 2018) Section entitled *Pre-Test Neck Setup Procedure* for spring tower tension and neck setup procedures. Once the neck cables are adjusted, the neck is ready for qualification testing. The cables must not be adjusted <u>after</u> qualification testing as this may invalidate the qualification results.

4.2.2.32 Screw on the Front and Rear Spring Tubes (472-2103) (Figure 4-43).

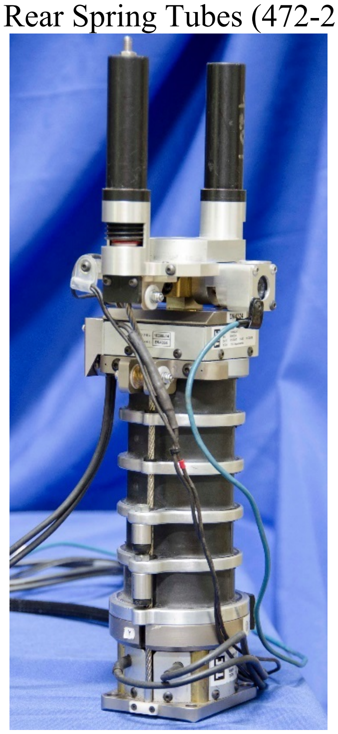


Figure 4-43. Screw on neck spring tubes

4.2.3 **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 M3 x 8 BHCS, as shown on Figure 4-44.

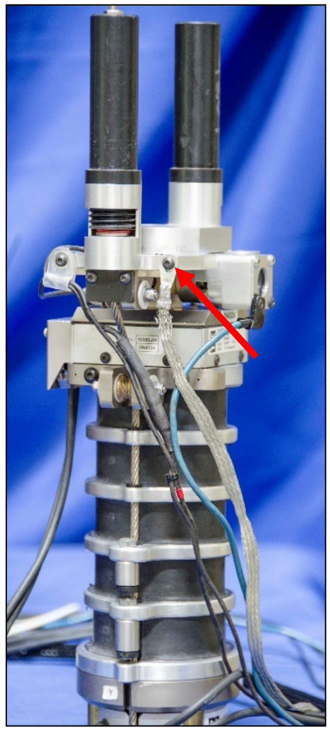


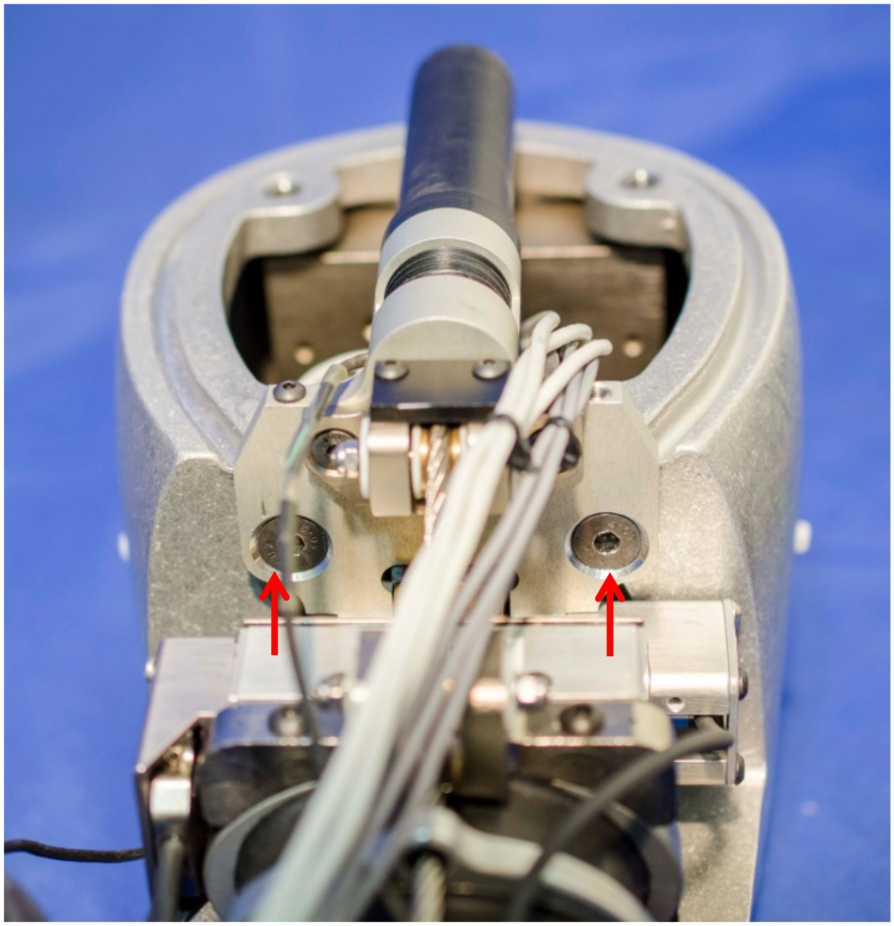
Figure 4-44. Head/neck ground strap attachment to head/neck mounting platform

4.2.4 **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. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

4.2.4.1 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 M6 x 1 x 25 FHCS from the underside of the head (Figure 4-45 and Figure 4-46).

NOTE: The neck must be oriented properly for installation within the head. The rear cable is easily identifiable by the presence of the cable pulley.



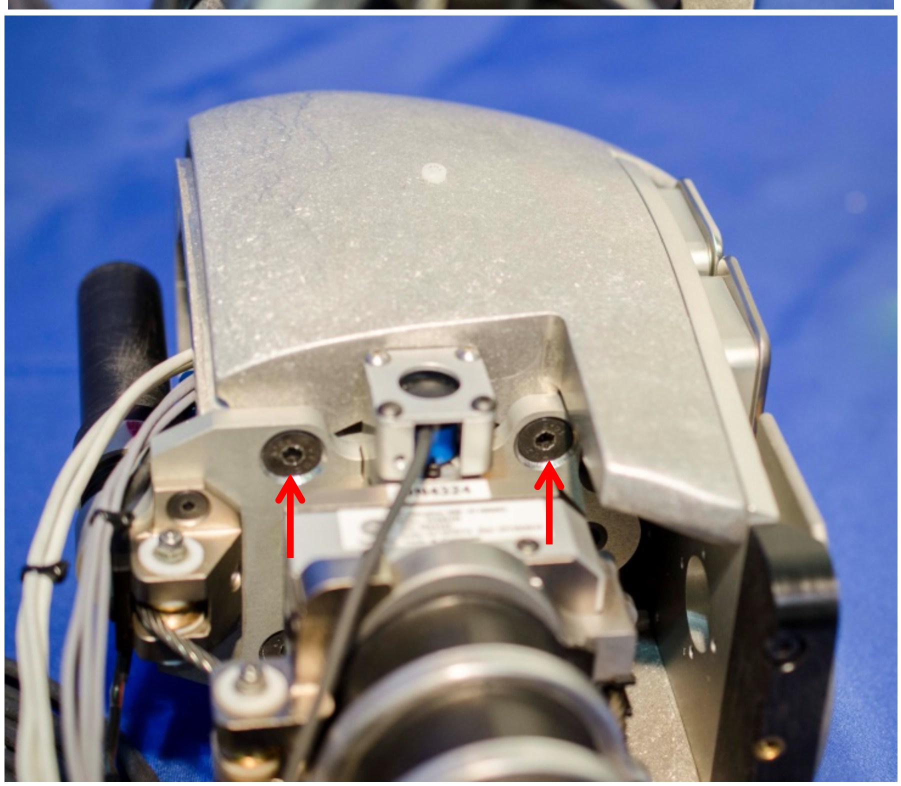


Figure 4-45. Install head/neck mounting platform to head

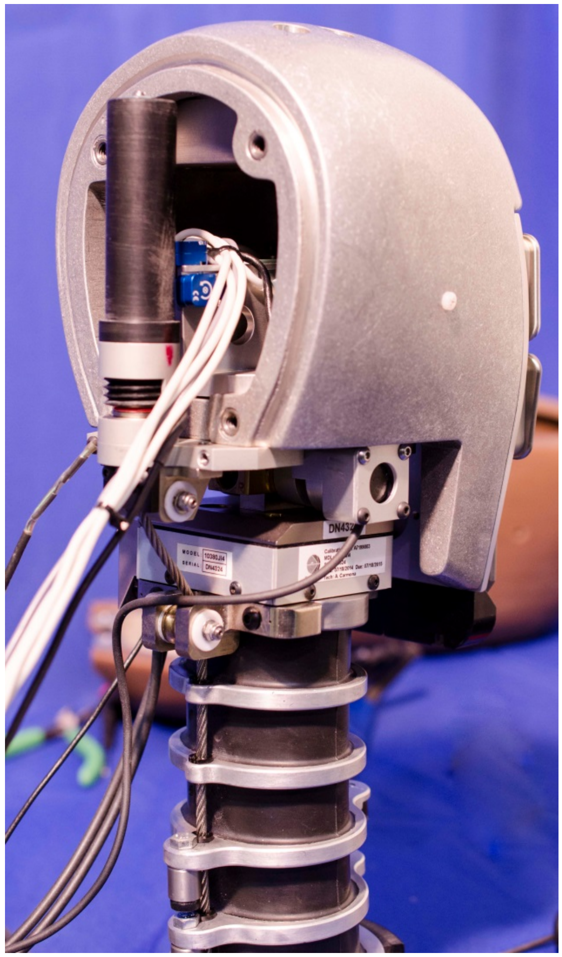


Figure 4-46. Head/neck mounting platform installed in head

4.2.5 **Assembly of the Neck to the Spine**

The following procedure is a step-by-step description to install the head/neck assembly to the top plate of the neck pitch change mechanism assembly (472-3630). For simplicity, only the spine elements involved in the assembly are illustrated. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

4.2.5.1 Secure the Lower Neck Load Cell to the top plate (472-3636) of the Neck Pitch Change Mechanism using four M6 x 1 x 14 SHCS as shown in Figure 4-47.

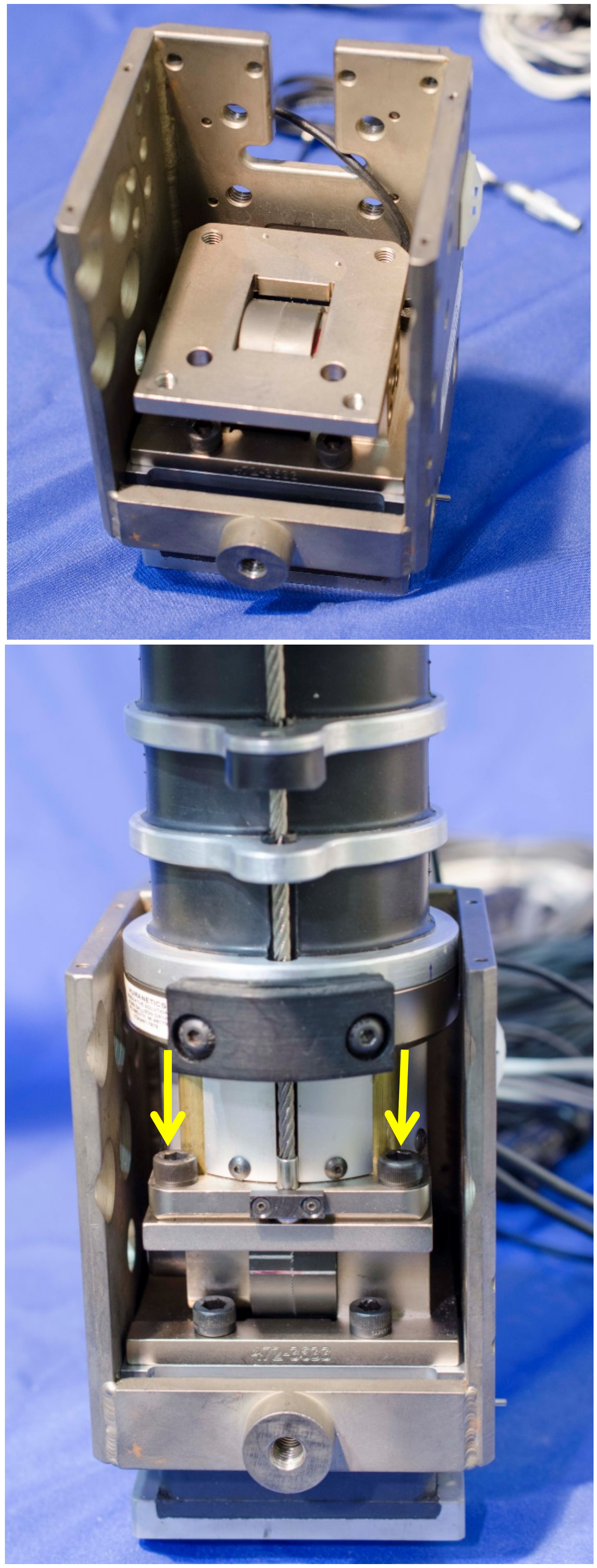


Figure 4-47. Secure lower neck load cell to neck pitch change mechanism

4.2.5.2 Route the lower neck load cell wires out through the holes at the top of the Upper Thoracic Spine Weldment (Figure 4-48). Rib #1 and the accompanying rib stiffener must be removed prior to routing the wire.

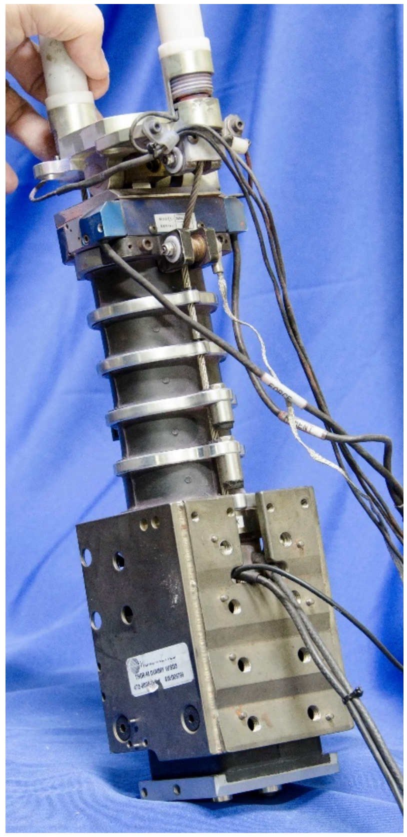


Figure 4-48. Routing wires for the lower neck load cell

4.2.5.3 OPTIONAL: 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. Route the remaining wires from the head and the neck rotary potentiometer on the outside of the Neck Skin as shown in Figure 4-49. Wrap the Neck Skin Assembly (472-2901) around the Neck Foam Assembly, such that the zipper in the Neck Skin Assembly closes down, as shown in Figure 4-50.

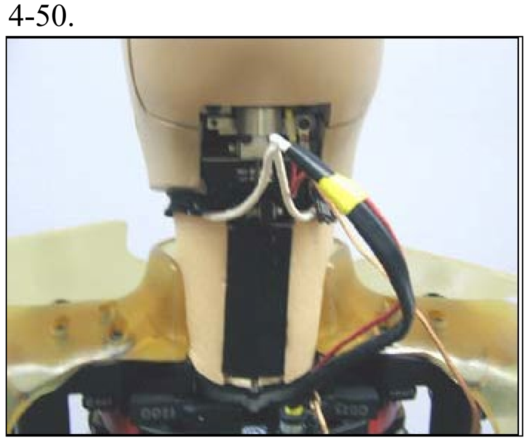


Figure 4-49. Neck foam assembly installed

Figure 4-50. Neck skin assembly

4.3 Adjustments for the Neck Assembly

Before the neck qualification procedures are performed, the neck spring towers must be properly installed, adjusted, and locked in place using a jam nuts at the top of the front and rear towers (Figure 4-51). *Once the spring tower adjustment has been made and neck qualification tests have been performed, do not adjust the spring towers again or new neck qualification tests must be performed.*

4.3.1 Spring Tower Adjustment

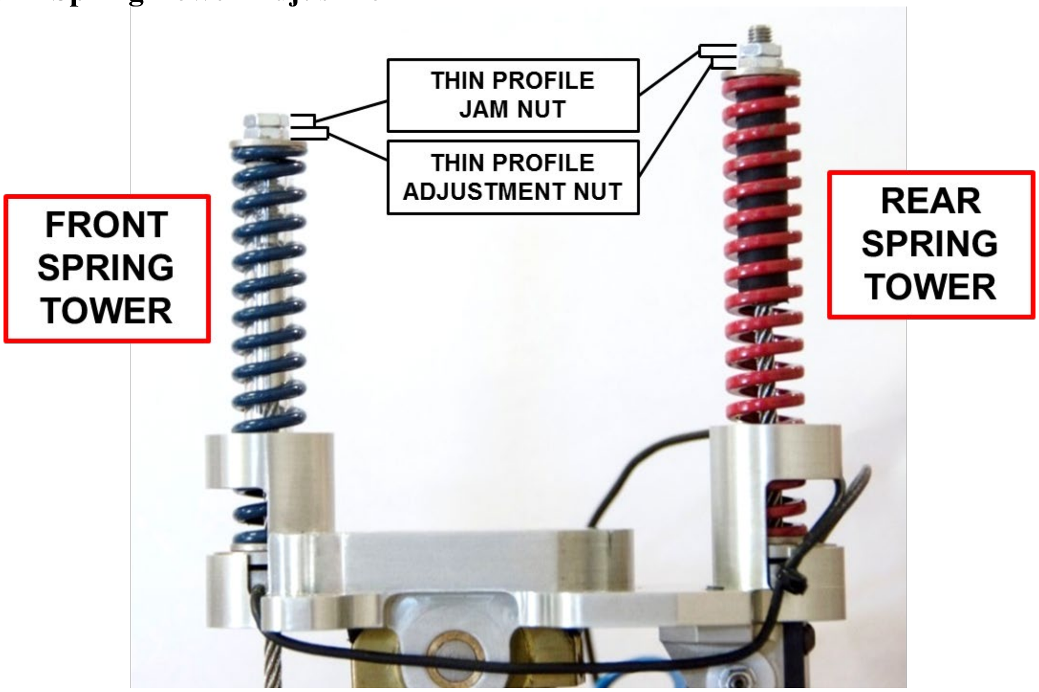


Figure 4-51. Neck spring tower jam nut configuration

4.3.1.1 Remove the head from the neck by removing four M6 FHCS from the bottom of the head/neck mounting platform (472-2210). Remove the front and rear spring tubes (472-2203) by unscrewing by hand from the head/neck mounting platform.

4.3.1.2 Remove *both* M5 x 0.8 thin profile nuts from the top of the rear spring cable.

4.3.1.3 Remove *both* M5 x 0.8 thin profile nuts from the top of the front spring cable.

4.3.1.4 Proceed to the *THOR 50th Percentile Male (THOR-50M) Qualification Procedures Manual* (April 2018) Section entitled *Pre-Test Neck Setup Procedure* for spring tower tension and neck setup procedures.

4.3.1.5 Once the neck cables are adjusted as above, the neck is ready for qualification testing. *The cables must not be adjusted after qualification testing as this may invalidate the qualification results.*

4.3.2 Neck Pitch Change Mechanism Adjustment

The neck pitch change mechanism connects the lower neck load cell to the upper thoracic spinebox (472-3620). It allows adjustment of the angle of the base of the neck in 3° increments. There are two scribe lines marked on the right sprocket, which rotates with the neck, and one scribe line setting marked on left sprocket, which is fixed to the upper thoracic spine. To achieve a neutral setting, align the fixed scribe line with the inferior scribe line on the right sprocket, as shown in Figure 4-52. The default posture is the neutral setting, which most closely resembles the Anthropometry of Motor Vehicle Occupants (AMVO)[4] seated posture for a 50th percentile male occupant.

To adjust the angle of the neck pitch change mechanism, follow the steps below.

4.3.2.1 Unzip the zippers on the right shoulder and the right side of the jacket. If desired or convenient, remove the jacket completely.

4.3.2.2 Locate the M10 x 1.5 x 55 mm SHCS on the right side of the upper thoracic spine, as indicated in Figure 4-52. With the dummy fully assembled, the SHCS can be accessed by inserting an M10 T-handle between ribs #2 and #3, through the access hole in the upper thoracic spinebox, and into the head of the adjustment bolt (Figure 4-53 and Figure 4-54).

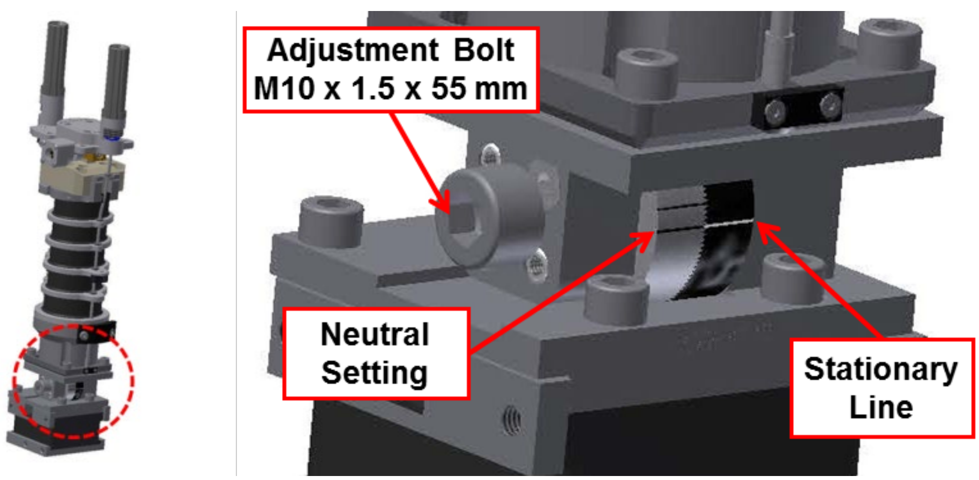


Figure 4-52. Neck pitch change assembly (472-3630) posture setting. Diagram shows neck in "neutral" position.

[4] Schneider, L.W., Robbins, D.H., Pflug, M.A., Snyder, R. G., "Development of Anthropometrically Based Design Specifications for an Advanced Adult Anthropomorphic Dummy Family; Volume 1-Procedures, Summary Findings and Appendices, "U.S. Department of Transportation, DOT-HS-806-715, 1985.

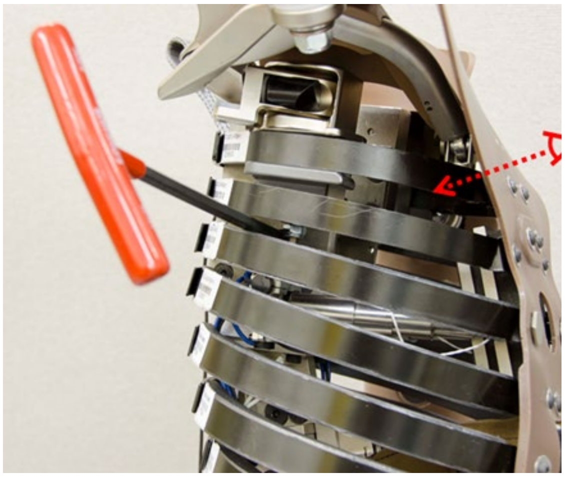


Figure 4-53. Access to the neck pitch change mechanism through the upper thoracic spinebox.

Figure 4-54. View of neck pitch change joint scribe lines through ribcage

4.3.2.3 Unscrew the M10 x 1.5 x 55 mm SHCS bolt at least two complete turns (720°) to disengage the sprockets.

WARNING: The sprockets of the pitch change unit will be seriously damaged if the adjustment is made *BEFORE* the teeth are <u>completely</u> disengaged.

4.3.2.4 Manipulate the neck to achieve the desired posture setting. Set the default position ("neutral" as shown in Figure 4-52 right and Figure 4-54) by aligning the lower/inferior scribe line on the sprocket attached to the neck with the scribe line on the fixed sprocket. With the dummy fully-assembled, the scribed lines can be viewed by looking between ribs #1 and #2 from the front of the dummy (see direction indicated in Figure 4-53 and expected view in Figure 4-54).

4.3.2.5 Re-tighten the M10 x 1.5 x 55 mm SHCS and torque to 50.8 N-m (37.5 ft-lbf).

4.4 Electrical Connections and Requirements

Section 15.3 includes grounding information. Section 15.4 describes cable routing instructions.

4.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the neck, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

4.5.1 Electrical Inspections (Instrumentation Check)

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the neck instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief (see Section 15.4).

Specific areas to examine:

- Ensure that the O.C. potentiometer will not pass through dead band while head is rotating. If it does, set the potentiometer so that it is at approximately zero. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range.
- Ensure that O.C. set screw is tight.
- Ensure instrumentation cable slack will allow full forward flexion and rearward extension.

4.5.2 **Mechanical Inspection**

Several components in the head assembly require inspection post-test.

Specific areas to examine:

- If the neck has a bend greater than 2° from the head mounting platform relative to the base of the neck, consider replacing the neck.
- Check the neck center cable nut is ½ turn beyond contact. If the nut is loose, readjust to ½ turn beyond contact.
- Ensure spring tower outer jam nut is tight (at least 1.5 N-m torque).
- Inspect the O.C. bumpers on the O.C. Stop Assembly (472-2105). If the bumpers are excessively deformed or torn, replace the assembly.
- Ensure that all three neck cables (front spring neck cable, rear spring neck cable, and Neck Center Cable) are not frayed or pulling through the swages.
- Check that the front and rear neck cables are installed in the correct locations.
- Ensure that the head instrumentation plane and the upper neck load cell are parallel.
- Ensure that the upper and lower neck load cell bolts are of the correct length and have proper washers installed. If the bolts are too long, or lack the proper washers, then the bolts will protrude into the rubber.
- Ensure rubber neck stops, two in the back and one in the front, are installed and tight.
- Inspect the front and rear neck soft stop assemblies for signs of debonding or permanent compression.
- Check that all neck cable guide inserts are installed and firmly seated.
- Ensure that the neck pitch is set to neutral.
- Mechanically inspect the neck assembly for signs of debonding between the aluminum disks and the rubber pucks, particularly along the rear of the neck. Replace the neck if it is debonded.

Section 5. **Spine Assembly**

5.1 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 (Figure 5-1). This advanced spine assembly includes the following features: two pitch change mechanisms; two flex joints; and instrumentation including a thoracic spine load cell, triaxial accelerometer assemblies at T1, at the vertical level of the thorax C.G., and at T12, and four angular orientation (tilt) sensors.

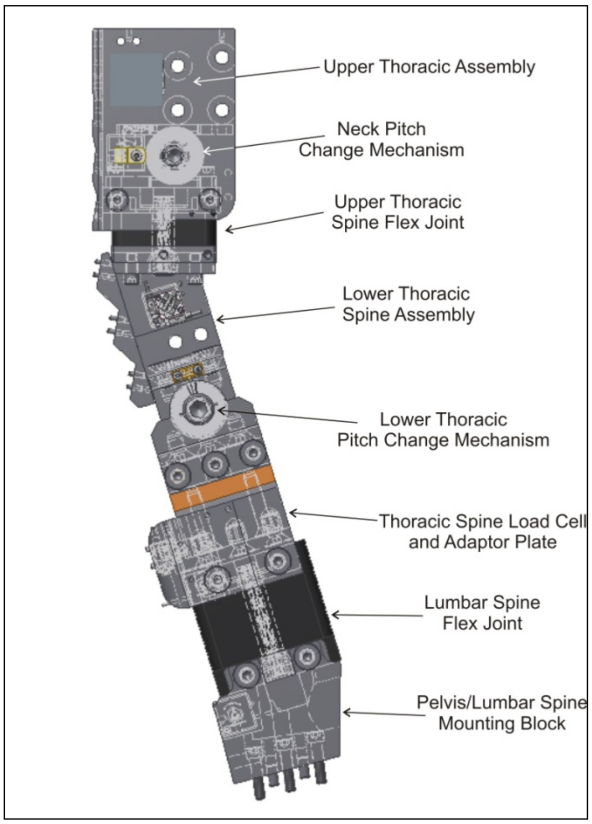


Figure 5-1. Complete spine assembly

As a primary goal, the spine assembly provides the ability for the dummy to assume several different seated postures for testing. The THOR-50M adjusts to four major seating postures defined through a postural study. The neck and lumbar spine pitch change mechanisms allow this adjustment capability. The neck pitch change mechanism is centered at the approximate location of the anthropomorphic landmark defined by the T6/T7 joint; the lumbar spine pitch change assembly 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 by rotating the spine segments with the pitch change mechanisms.

Another feature of the THOR-50M spine assembly includes the integration of lumbar and upper thoracic flexible (flex) joints to provide a degree of bending and flexibility to the spine. Each of these flexible rubber joints are strengthened by tightening two internal cable assemblies to a predetermined torque.

The THOR-50M spine assembly includes several sensors, which measure the orientation, acceleration, forces and moments of the spine assembly (Figure 5-2). The Thoracic Spine Load Cell (SA572-S127) 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 attached to the spine assembly at the approximate location of the anthropomorphic landmark T1, vertical level of the thorax C.G., and T12. In addition, four static tilt sensors attached to various components of the spine assembly 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 two-dimensional orientation of the various spine components during the test setup.

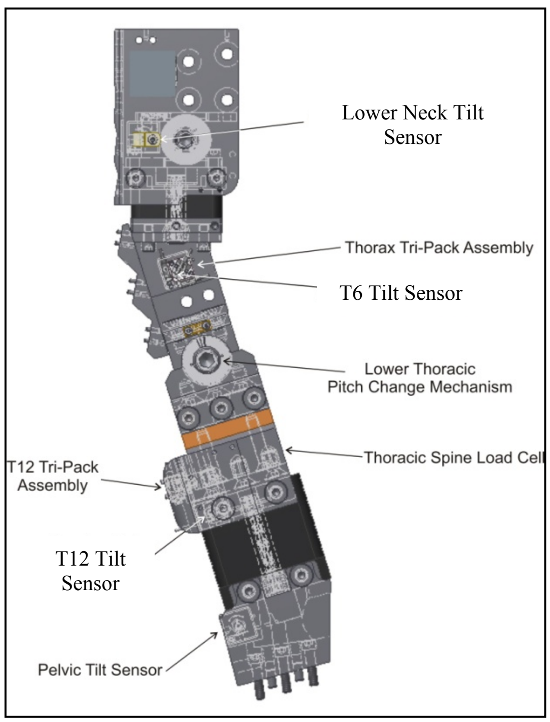


Figure 5-2. Spine instrumentation locations

5.2 Assembly of Spine

5.2.1 Parts List

Figure 5-3 through Figure 5-8 show illustrations of spine assembly components and hardware. Table 5-1 through Table 5-5 lists the components that are included in the spine assembly.

Table 5-1. Spine Mechanical Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Neck Pitch Change Mechanism	1	472-3630	Figure 5-3	1
Upper Thoracic Spinebox Weldment	1	472-3620	Figure 5-3	2
Screw, SHCS M6 x 1 x 12	8	5000281	Figure 5-3	3
Screw, FHCS M6 x 1 x 10	4	5000204	Figure 5-3	4
Lumbar Spine Pitch Change Mechanism Assembly	1	472-3670	Figure 5-3	5
Thoracic Spine Load Cell Structural Replacement	1	472-3720	Figure 5-3	6
Screw, FHCS M8 x 1.25 x 20	16	5000868	Figure 5-3	7
Screw, FHCS M8 x 1.25 x 14	2	5001092V	Figure 5-3	8
Screw, FHCS M8 x 1.25 x 25	2	5000117	Figure 5-3	9
Lower Thoracic Spine Assembly	1	472-3650	Figure 5-3	10
Screw, SHCS M6 x 1 x 20	4	5000001	Figure 5-4	11
Pelvis/Lumbar Mounting Block Assembly	1	472-3760	Figure 5-3	12
Lumbar Spine Flex Joint Assembly	1	472-3746	Figure 5-3	13
Upper Thoracic Spine Flex Joint Assembly	1	472-3646	Figure 5-3	14
Tilt Sensor Mount, T12	1	472-3781	Figure 5-3	15
Tilt Sensor Mount, T6	1	472-3783	Figure 5-3	16
Screw, SHCS M3 x 0.5 x 14	1	5000252	Figure 5-3	17
Screw, SHCS M2 x 0.4 x 16	4	5000985	Figure 5-4	18
Tilt Sensor Mount Assembly, Pelvis	1	472-3787	Figure 5-3	19
Screw, FHCS M8 x 1.25 x 12	2	5001090	Figure 5-3	20
Thoracic Spine Load Cell Flex Joint Adaptor Plate Assembly	1	472-3733	Figure 5-3	21
Screw, SHCS M4 x 0.7 x 10	2	5000151	Figure 5-3	22
Screw, SHCS M4 x 0.7 x 8	2	5000024	Figure 5-3	23
Screw, SHCS M2 x 0.4 x 10	8	5000215	Figure 5-3	24
Tilt Sensor, Dual Axis	4	SA572-S44	Figure 5-3	25
Tri-Pack Accelerometer Assembly	2	472-4203	Figure 5-4	26
T1 Accelerometer Mount Assembly	1	472-3857	Figure 5-3	27
Screw, FHCS M3 x 0.5 x 12	2	5000568	Figure 5-3	28
Thoracic Spine Load Cell (optional)	1	SA572-S127	Figure 5-3	29

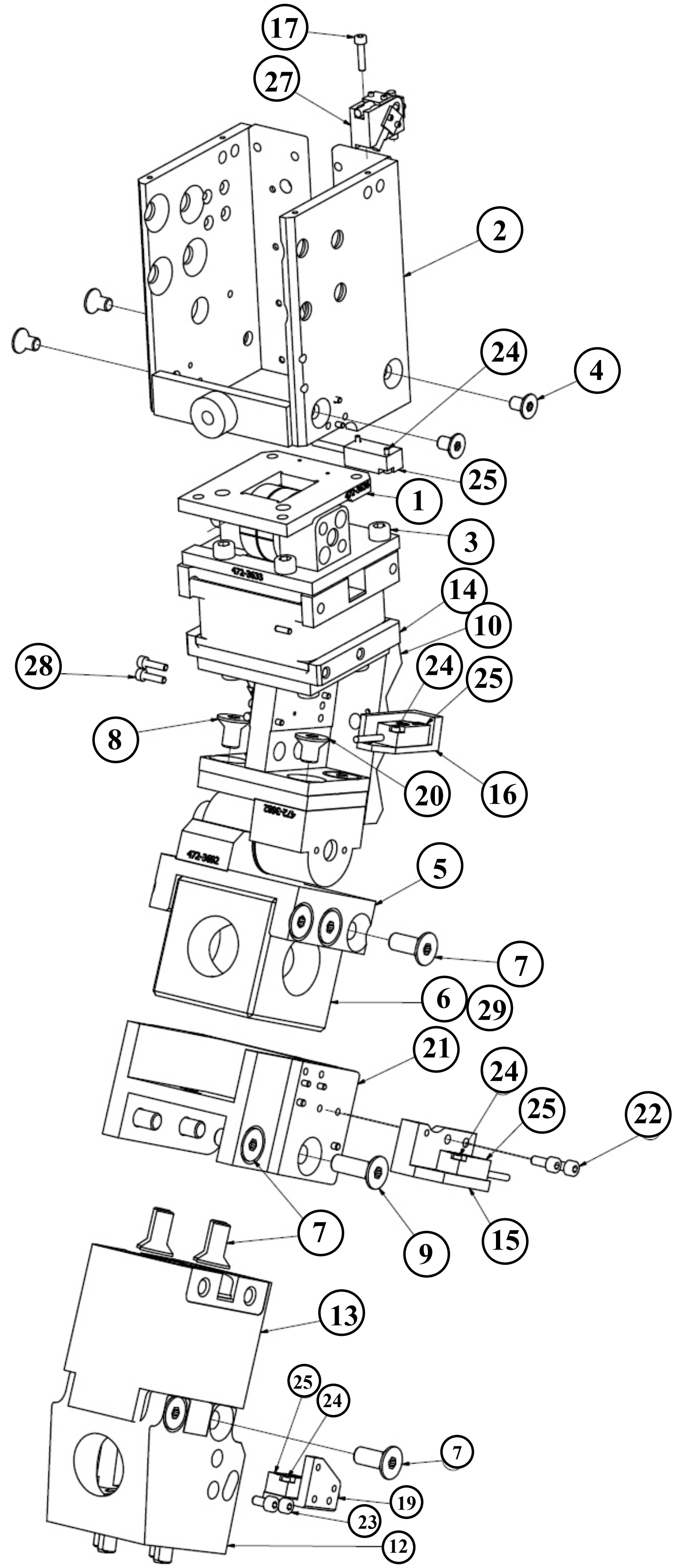


Figure 5-3. Spine mechanical assembly components (1 of 2)

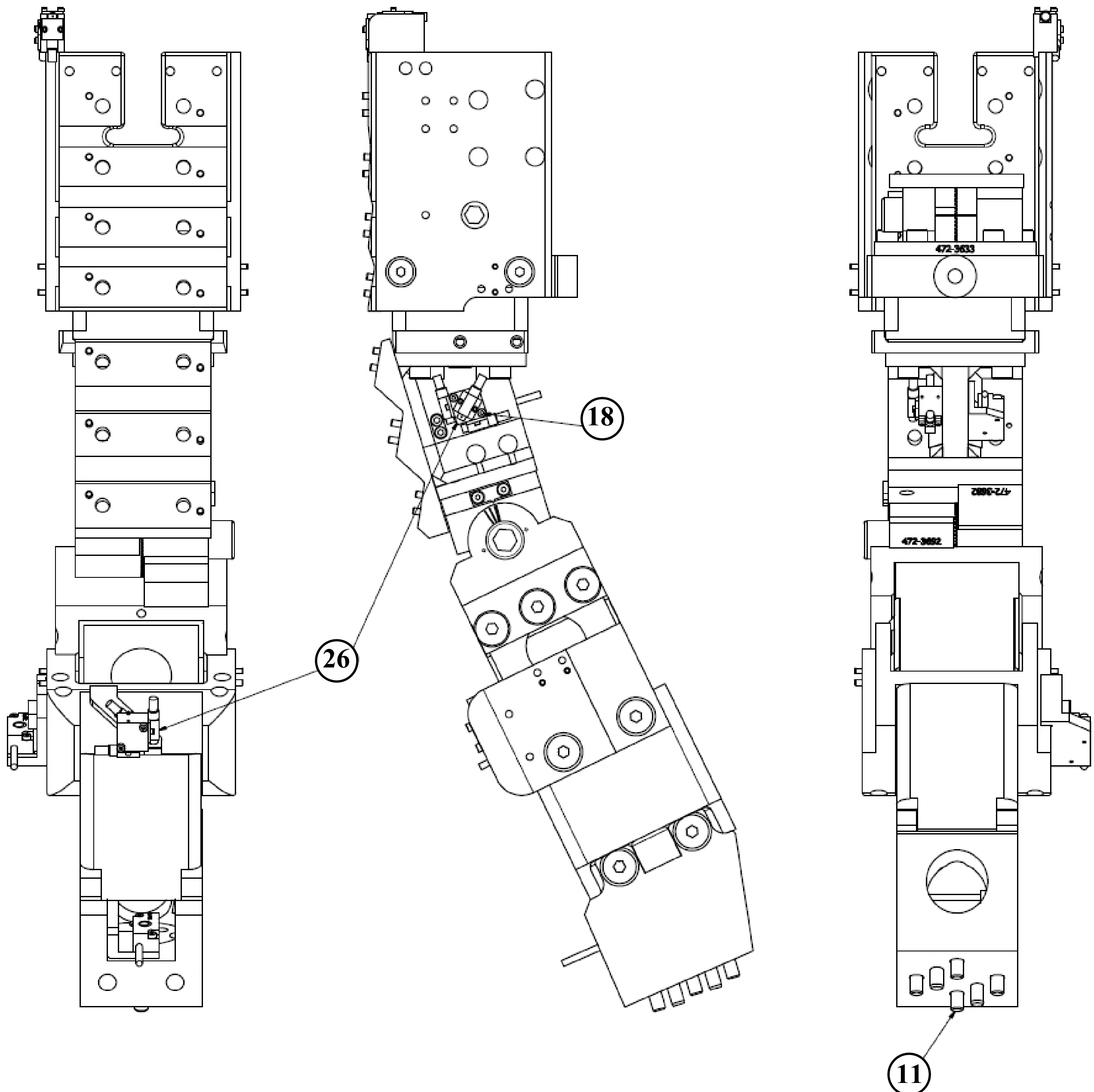


Figure 5-4. Spine mechanical assembly components (2 of 2)

Table 5-2. Lumbar Spine Flex Joint Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Lumbar Spine Flex Joint Molded Assembly	1	472-3740	Figure 5-5	1
Lumbar Spine Flex Joint Cable Assembly	2	472-3745	Figure 5-5	2
½ SAE Flat Washer Type-B Zinc	2	9003938	Figure 5-5	3
M12 x 1.75 Modified Locknut	2	472-3747	Figure 5-5	4
M12 Vinyl Nut Cover	2	472-3647	Figure 5-5	5

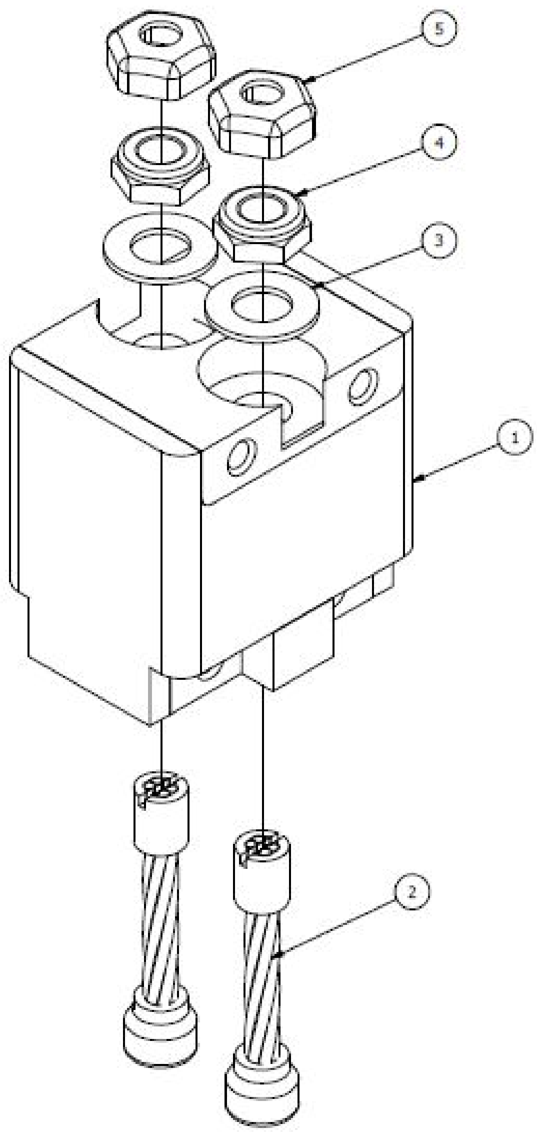


Figure 5-5. Lumbar spine flex joint components

Table 5-3. Upper Thoracic Spine Flex Joint Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper Thoracic Spine Flex Joint Molded Assembly	1	472-3640	Figure 5-6	1
½ SAE Flat Washer Type-B Zinc	2	9003938	Figure 5-6	2
M12 x 1.75 modified locknut	2	472-3747	Figure 5-6	3
M12 Vinyl Nut Cover	2	472-3647	Figure 5-6	4
Upper Thoracic Spine Flex Joint Cable Assembly	2	472-3645	Figure 5-6	5

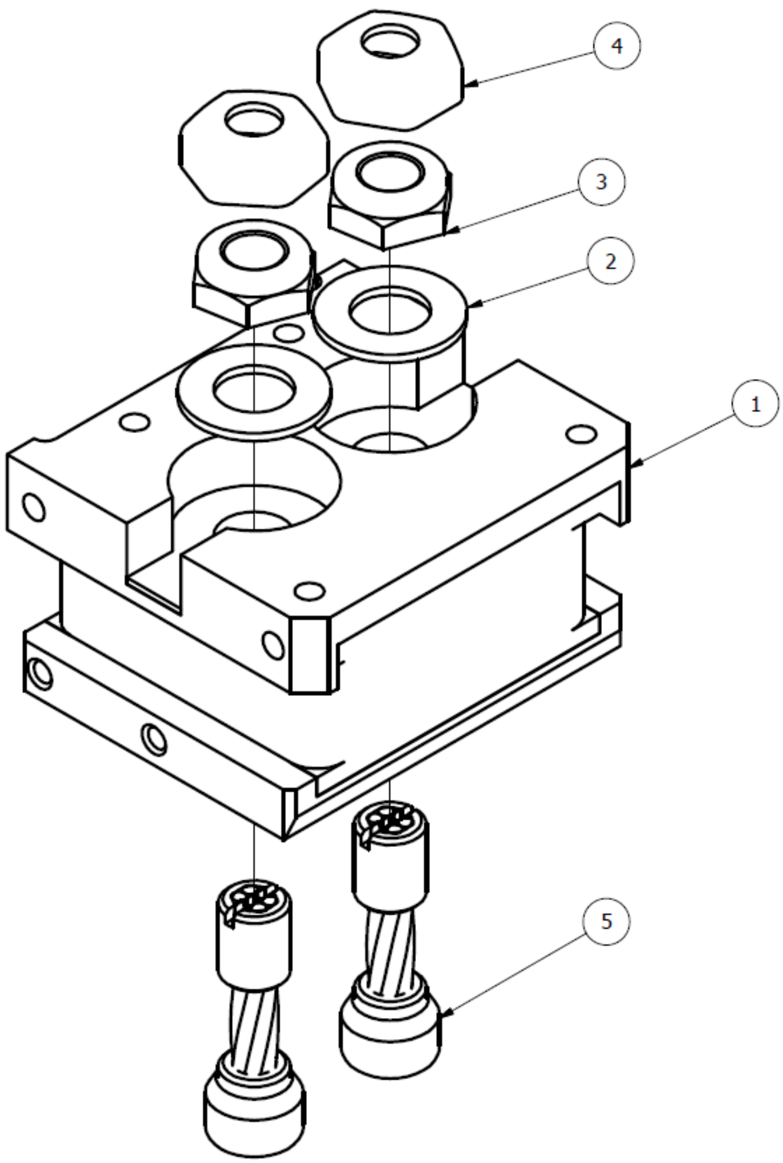


Figure 5-6. Upper thoracic spine flex joint components

Table 5-4. Neck Pitch Change Mechanism Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Neck Pitch Change Mechanism Star Pattern 1	1	472-3632	Figure 5-7	1
Neck Pitch Change Mechanism Star Pattern 2	1	472-3631	Figure 5-7	2
Neck Pitch Change Mechanism Star Pattern 1	1	472-3633	Figure 5-7	3
Neck Pitch Change Mechanism Star Pattern 1	4	472-3634	Figure 5-7	4
Neck Pitch Change Mechanism Star Pattern 1	1	472-3636	Figure 5-7	5
Dowel Pin, Pull Out M6 x 20	4	50000445	Figure 5-7	6
Screw, SHCS M10 x 1.5 x 55	1	50011332	Figure 5-7	7

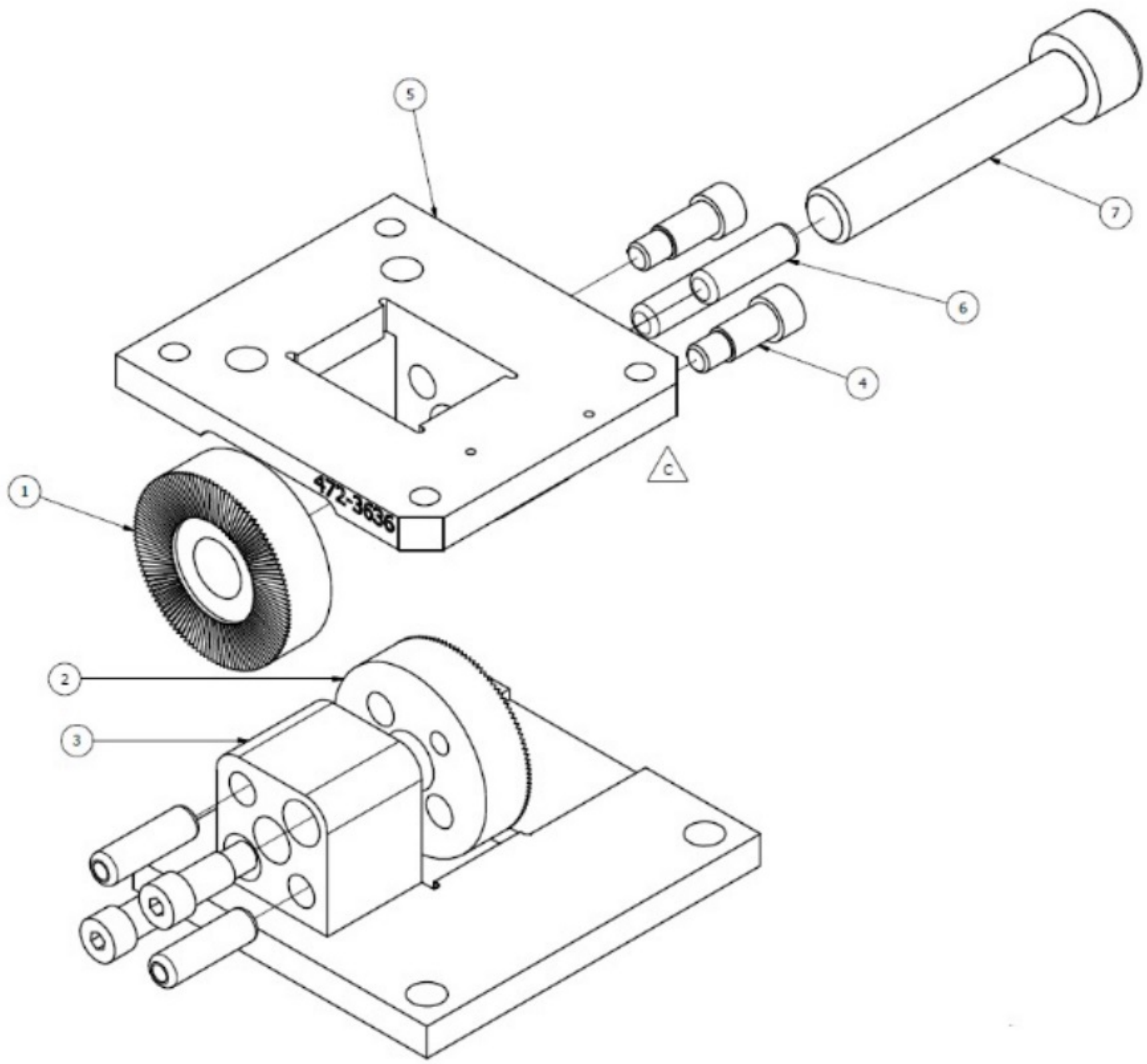


Figure 5-7. Neck pitch change mechanism components

Table 5-5. Lumbar Spine Pitch Change Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Lumbar Spine Pitch Change Lower Half Assembly	1	472-3690	Figure 5-8	1
Lumbar Spine Pitch Change Upper Half Assembly	1	472-3680	Figure 5-8	2
M12 x 1.75 x 60 LG. SHCS	1	5000442	Figure 5-8	3
Lumbar Spine Pitch Change Indicator	1	472-3713	Figure 5-8	4
Screw, FHCS M3-0.5 x 10	2	5000203	Figure 5-8	5

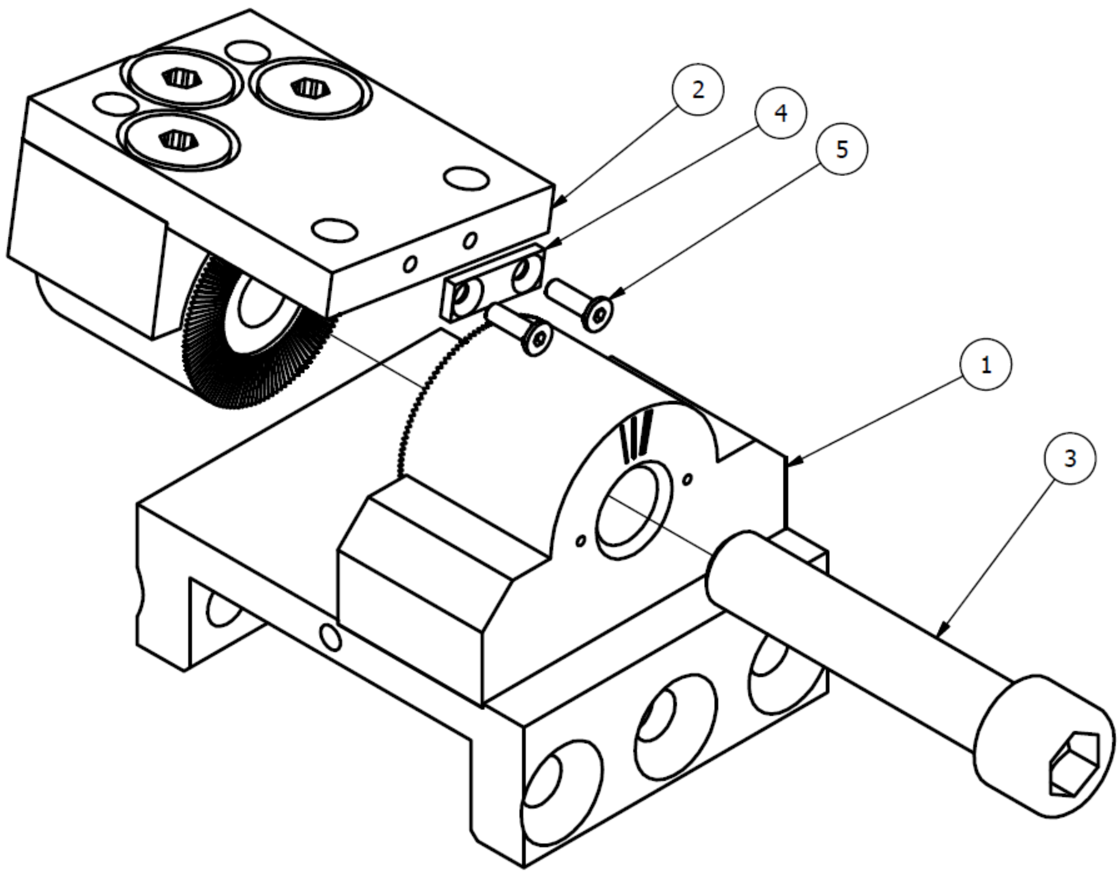


Figure 5-8. Lumbar spine pitch change assembly components

5.2.2 Assembly of Spine Components

The following is a step-by-step description of the assembly procedure for the spine components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

5.2.2.1 Install a Lumbar Spine Flex Joint Cable Assembly (472-3745) into the Lumbar Spine Flex Joint Molded Assembly (472-3740) (Figure 5-9). At this point, it is useful to loosely install a large cable-tie around the lumbar spine flex joint and loop 2 small cable-ties though it as illustrated. These will be used for wire routing when instrumentation is installed (Section 15.4.3.3). Note the installation of the cables ties on the lumbar flex joint is much easier to complete in this step than on the fully assembled dummy.

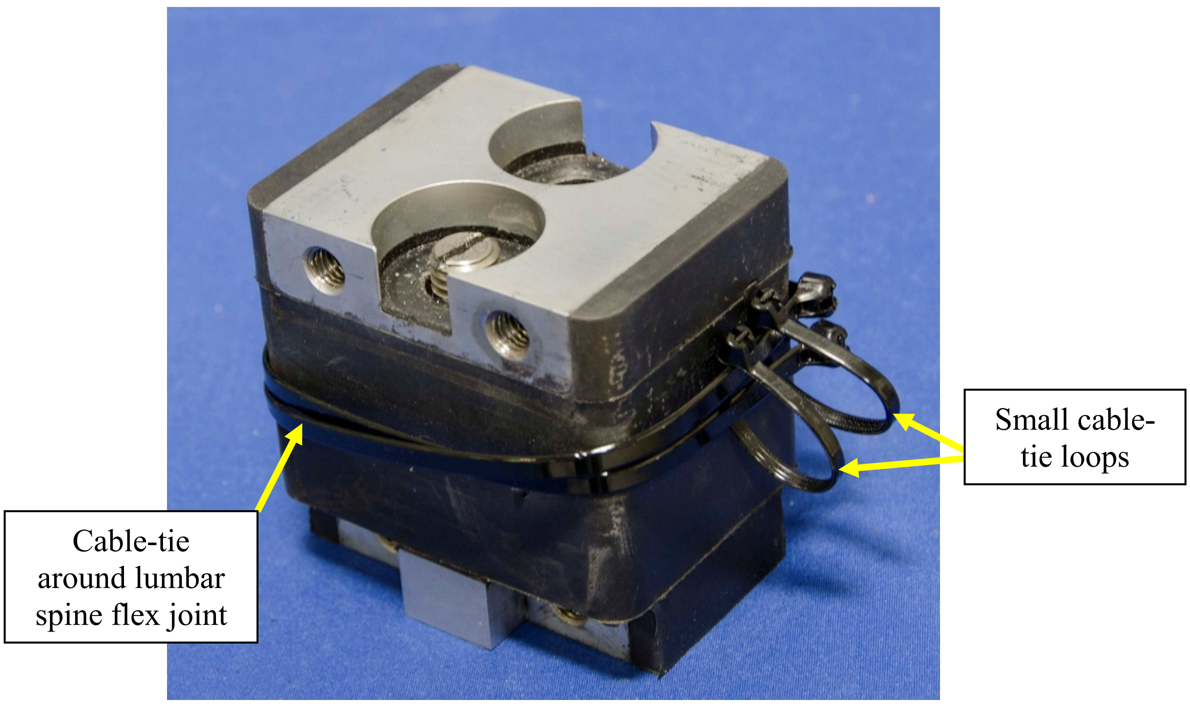


Figure 5-9. Install lumbar flex joint cable assembly into molded lumbar spine flex joint

5.2.2.2 Place a ½ SAE Flat Washer Type-B Zinc (9003938) over the threaded end of the cable (Figure 5-10).

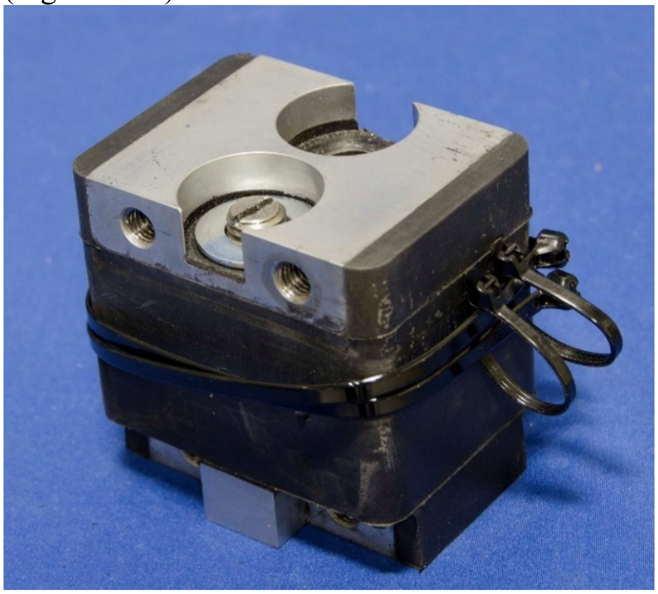


Figure 5-10. Washer placement for lumbar cable

5.2.2.3 Install an M12 x 1.75 Modified Locknut (472-3747) onto the threaded end of the lumbar cable (Figure 5-11). Position a screwdriver through the socket head in order to tighten the nut without turning the cable. Tighten the nut to contact plus half of a turn.

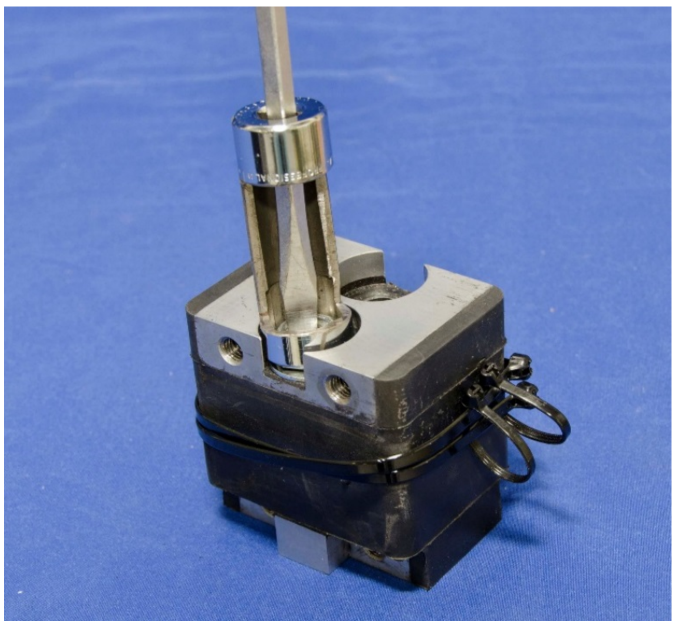


Figure 5-11. Install locknut to lumbar cable

5.2.2.4 Place the M12 Vinyl Nut Cover (472-3647) over the modified locknut (Figure 5-12).

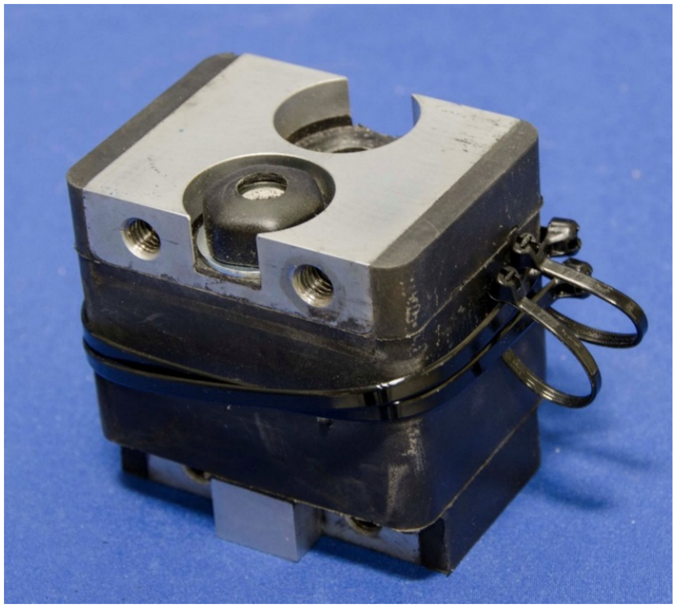


Figure 5-12. Vinyl nut cover over lumbar locknut

5.2.2.5 Repeat steps 5.2.2.1 to 5.2.2.4 for the second Lumbar Spine Flex Joint Cable Assembly.

5.2.2.6 Secure the Pelvis/Lumbar Mounting Block (472-3760) to the Pelvis as described in Section 10.2.3.

5.2.2.7 Install the Lumbar Flex Joint Assembly (472-3746) to the Pelvis/Lumbar Mounting Block using four M8 x 1.25 x 20 FHCS, two on each side of the Flex Joint (Figure 5-13).

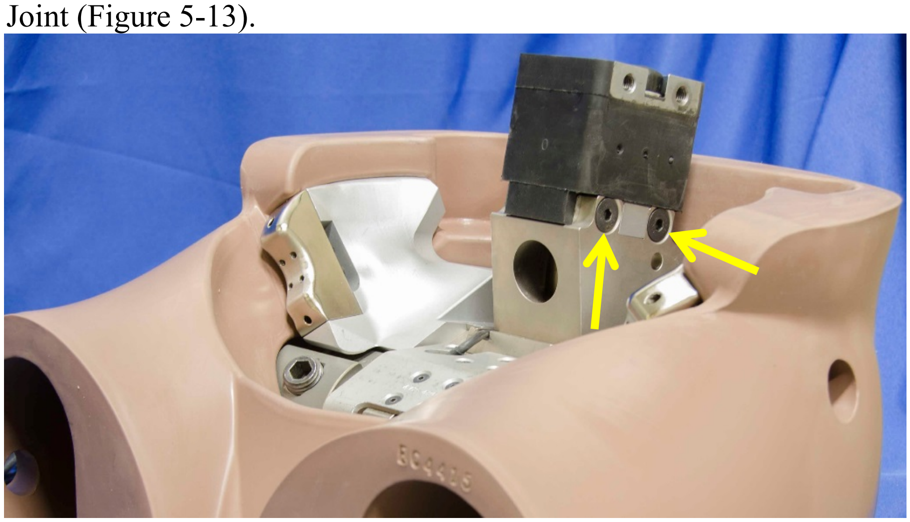


Figure 5-13. Attach lumbar flex joint to pelvis/lumbar mounting block

5.2.2.8 Install the Thoracic Spine Load Cell (SA572-S127) into the Thoracic Spine Load Cell Flex Joint Adaptor Plate (472-3731) using M8 x 1.25 x 20 FHCS on the bottom of the plate (Figure 5-14). Secure the lumbar spine ground strap (472-8703) to the Thoracic Spine Load Cell Flex Joint Adaptor Plate using an M4 x 8 BHCS on the right side of the plate.

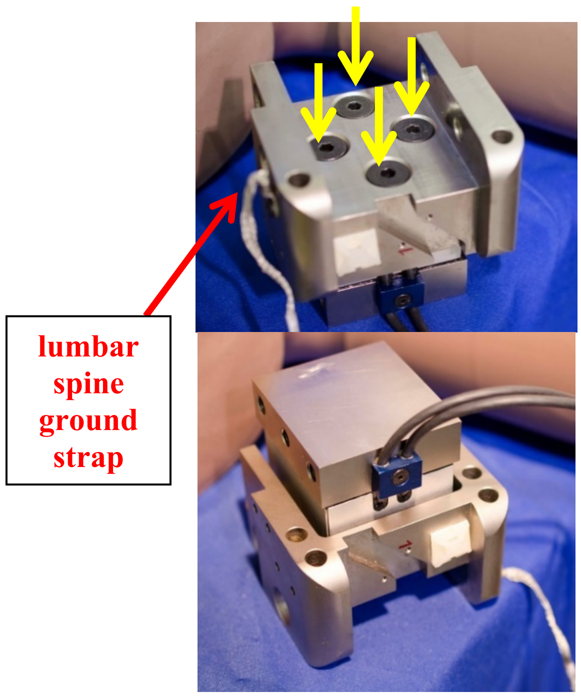


Figure 5-14. Install thoracic spine load cell to thoracic spine load cell flex joint adaptor plate

5.2.2.9 Attach the Thoracic Spine Load Cell Adaptor Plate Instrumentation Assembly / Thoracic Spine Load Cell, completed in Step 5.2.2.7, to the Lumbar Spine Flex Joint using two M8 x 1.25 x 20 FHCS (front) and two M8 x 1.25 x 25 FHCS (rear) (Figure 5-15).

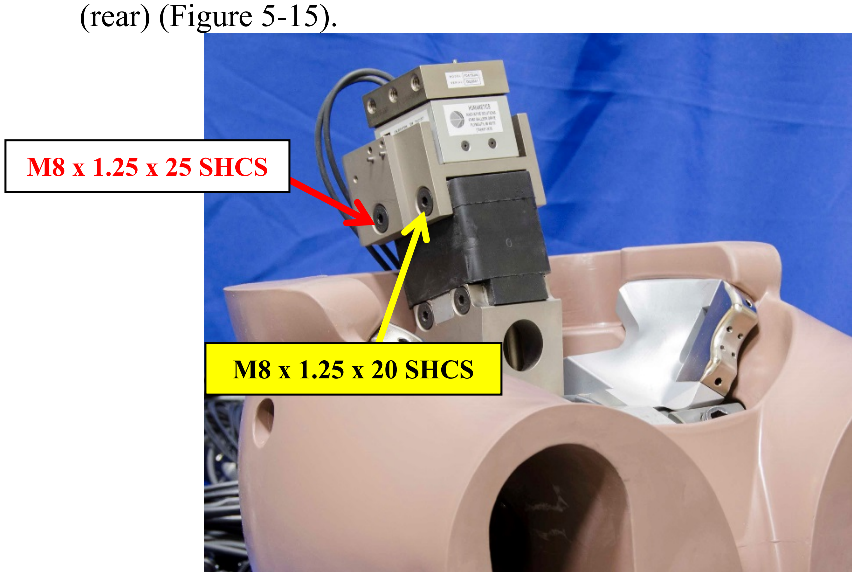


Figure 5-15. Attach thoracic spine load cell to lumbar flex joint

5.2.2.10 Attach the Lumbar Spine Pitch Change Mechanism (472-3670) (Figure 5-16) to the Thoracic Spine Load Cell using six M8 X 1.25 x 20 FHCS (Figure 5-17). Orient the head of the M12 1.75 x 60 mm SHCS adjustment bolt in the pitch change mechanism to the right-hand side of the spine assembly. After achieving the desired lumbar angle, re-tighten the M12 adjustment bolt torque to 68.0 N-m (50.5 ft-lbf). For detailed instructions to set the lumbar angle, see Section 5.3.1.

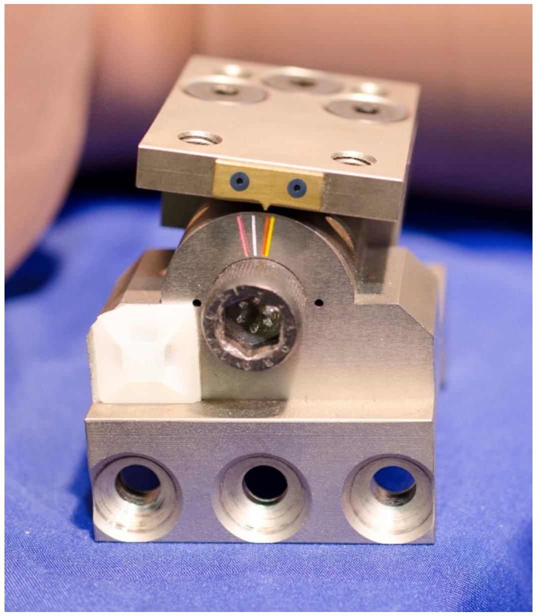


Figure 5-16. Lumbar spine pitch assembly

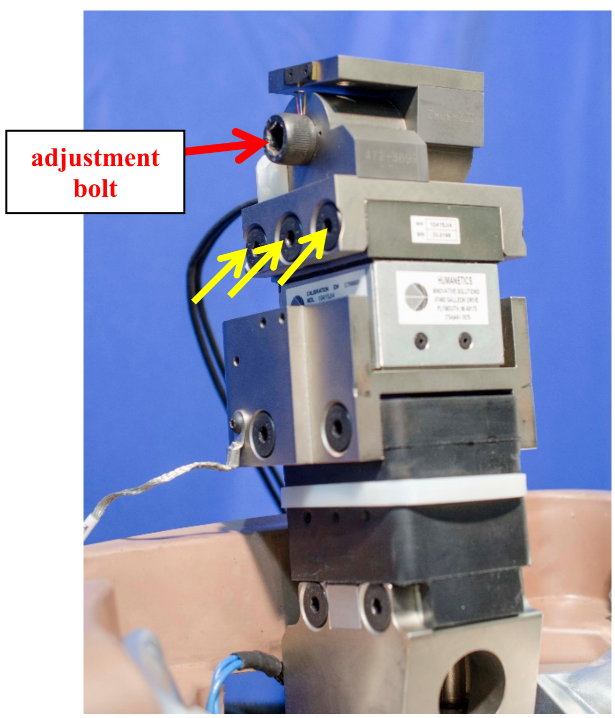


Figure 5-17. Secure lumbar spine pitch assembly to thoracic spine load cell

5.2.2.11 Attach the Lower Thoracic Spine Assembly (472-3650) to the top plate of the Lumbar Spine Pitch Change Assembly using two M8 x 1.25 x 12 FHCS on the left side and two M8 x 1.25 x 14 on the right side (Figure 5-18).

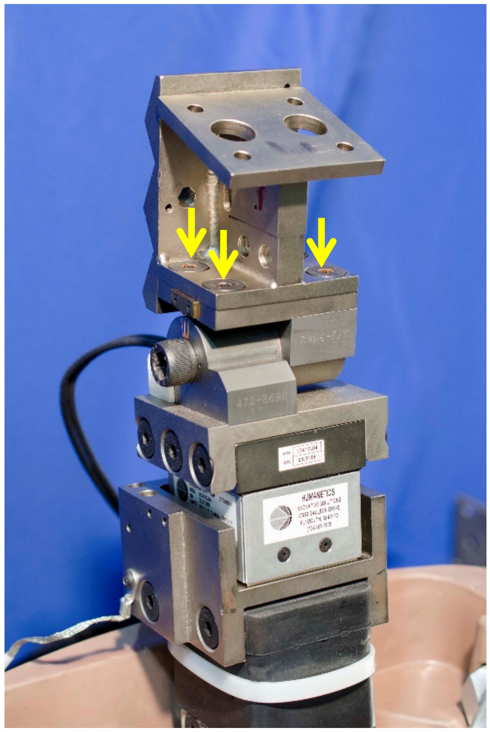


Figure 5-18. Install lower thoracic spine assembly to lumbar spine pitch change assembly

5.2.2.12 Insert the two Upper Thoracic Spine Flex Joint Cable Assemblies (472-3645) through the Upper Thoracic Spine Flex Joint Molded Assembly (472-3640). Install a ½ SAE Type-B Zinc Flat Washer (9003938) over the threaded portion of the cable (Figure 5-19 and Figure 5-20).

Figure 5-19. upper thoracic spine flex joint cable hardware

Figure 5-20. Install upper thoracic spine flex joint cable and associated washer

5.2.2.13 Install an M12 x 1.75 Modified Locknut (472-3747) onto the threaded end of each of the spine flex joint cables. Use a screwdriver positioned through the socket head in order to tighten the nut without turning the cable (Figure 5-21). Tighten the nut to contact plus half of a turn. Cover the nut with M12 vinyl nut covers (Figure 5-22).

Figure 5-21. Install locknuts to spine flex joint cables

Figure 5-22. Vinyl covers for spine flex joint locknuts

5.2.2.14 Attach the Upper Thoracic Spine Flex Joint (472-3640) to the Lower Thoracic Spine Assembly (472-3650) using four M6 x 1 x 12 SHCS on the underside of the Lower Thoracic Spine Assembly (Figure 5-23). The flex joint must be oriented with the smaller bottom plate (472-3642) against the Lower Thoracic Spine Assembly and the M5 tapped holes on the side closer to the front of the dummy.

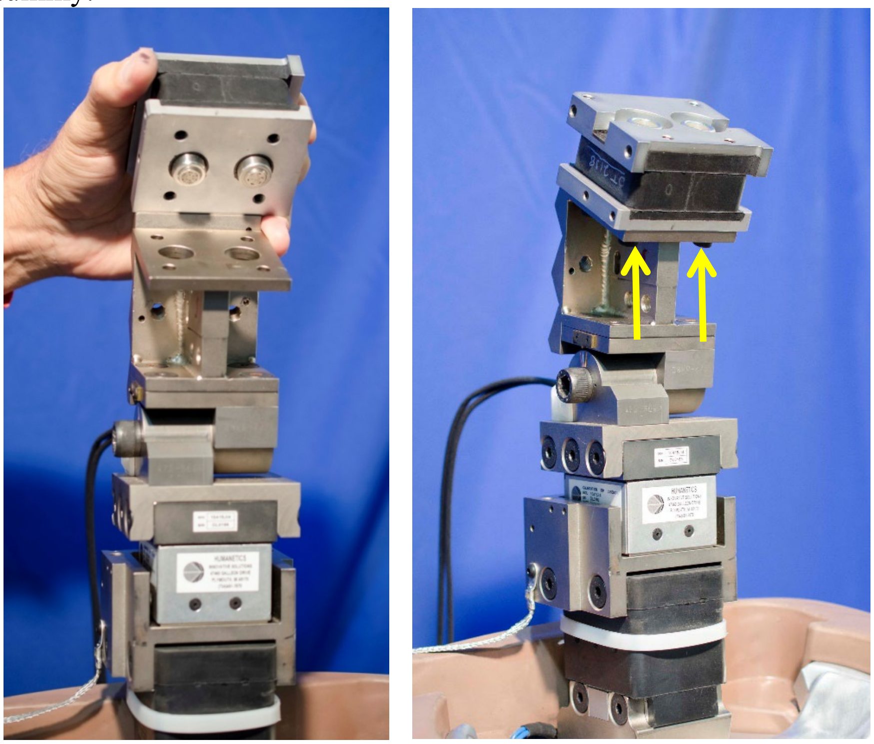


Figure 5-23. Upper flex joint assembled to lower thoracic spine assembly

5.2.2.15 Assemble the Neck Pitch Mechanism Assembly (472-3630). Install the Neck Pitch Change Mechanism Star Pattern 2 (472-3631) over the two Pull Out M6 x 20 Dowel Pins (5000445) on the Neck Pitch Change Mechanism Base Plate (472-3633). Secure the star pattern 2 using two Neck Pitch Change Mechanism Bolts (472-3634) (Figure 5-24).

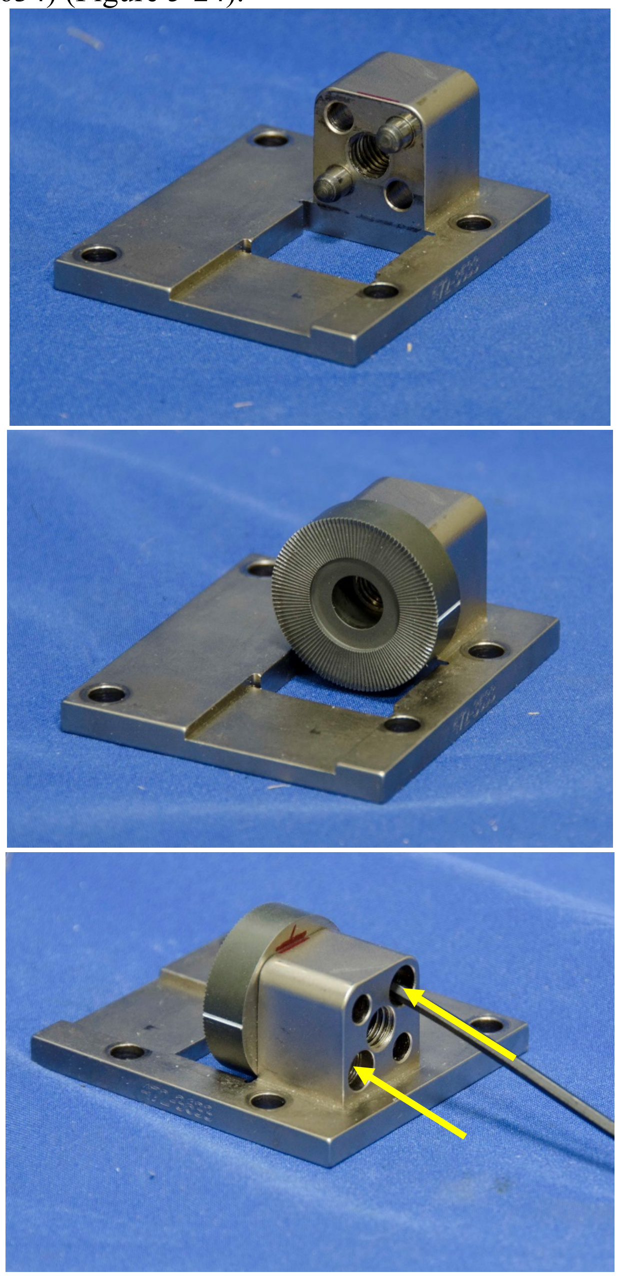


Figure 5-24. Install neck pitch change mechanism star pattern 2 to base plate

5.2.2.16 Install the Neck Pitch Change Mechanism Star Pattern 1 (472-3632) over the two Pull Out M6 x 20 Dowel Pins (5000445) on the Neck Pitch Change Mechanism Top Plate (472-3636). Secure the star pattern 1 using two Neck Pitch Change Mechanism Bolts (472-3634)

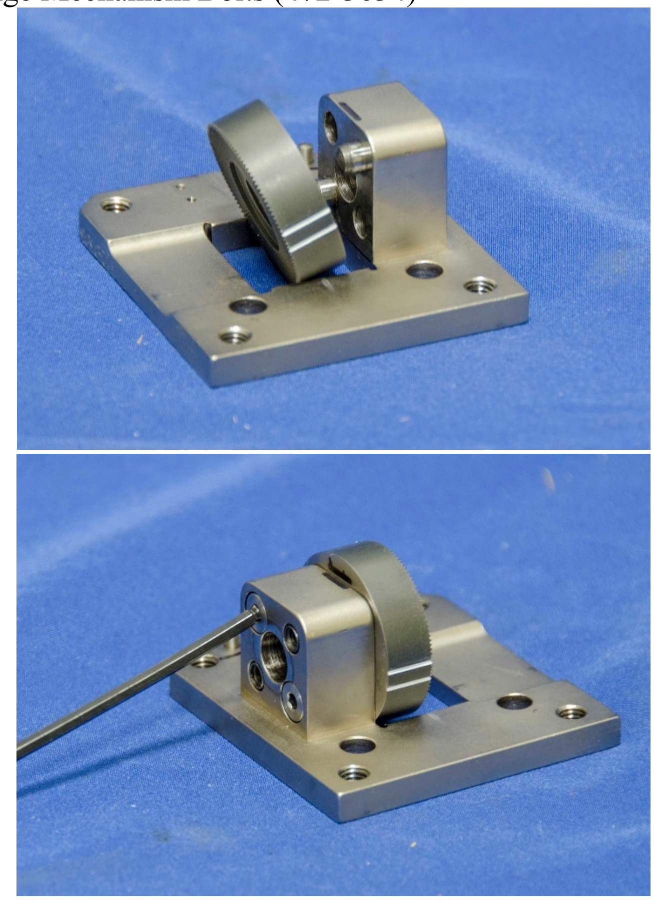


Figure 5-25. Install neck pitch change mechanism star pattern 1 to top plate

5.2.2.17 Assemble the top and bottom plates together. Align the indicator lines on each star pattern part to the desired position (the standard position is set to “neutral as shown in Figure 5-26). Be certain that the star patterns properly mate together so as not to damage the parts. Insert the M10 x 1.5 x 55 SCHS through the star pattern parts and tighten to 50.8 N-m (37.5 ft-lbf).

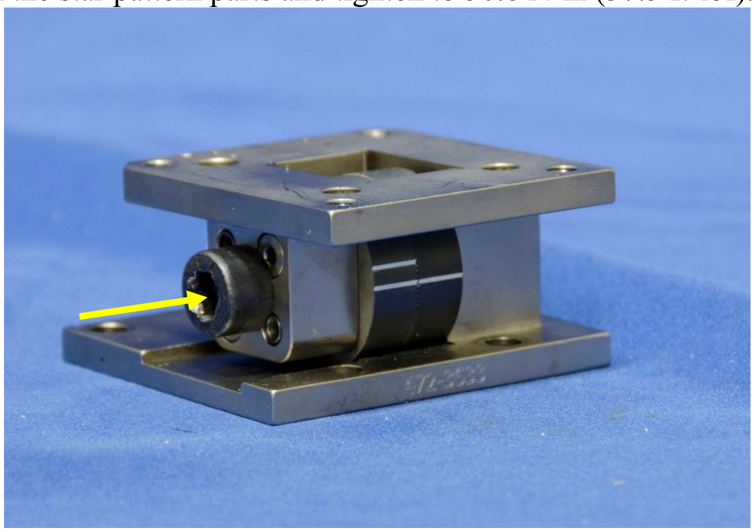


Figure 5-26. Align star pattern parts and install center bolt into neck pitch change mechanism

5.2.2.18 Secure the Dual Axis Tilt Sensor (SA572-S44) to the Neck Pitch Change Mechanism Top Plate (472-3636) using two M2 x 0.4 x 10 SHCS (Figure 5-27).

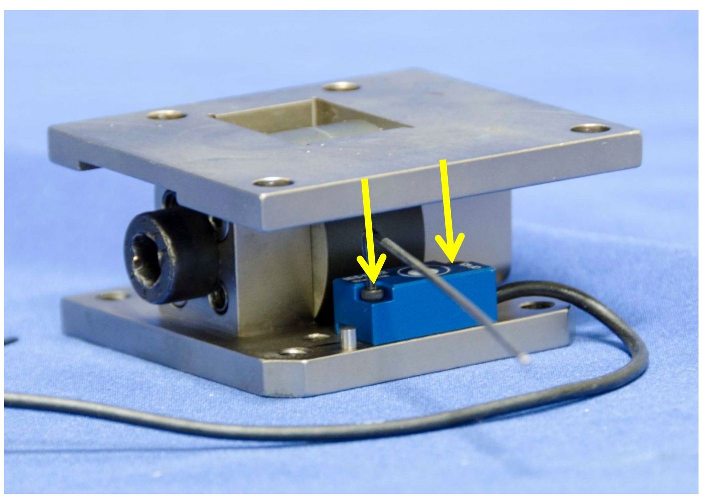


Figure 5-27. Attach tilt sensor to neck pitch change mechanism

5.2.2.19 Attach the Neck Pitch Change Mechanism (472-3630) to the Upper Thoracic Spine Flex Joint using four M6 x 1 x 12 SHCS (Figure 5-28). The pitch change mechanism must be oriented with the adjustment bolt toward the right side of the dummy**.**

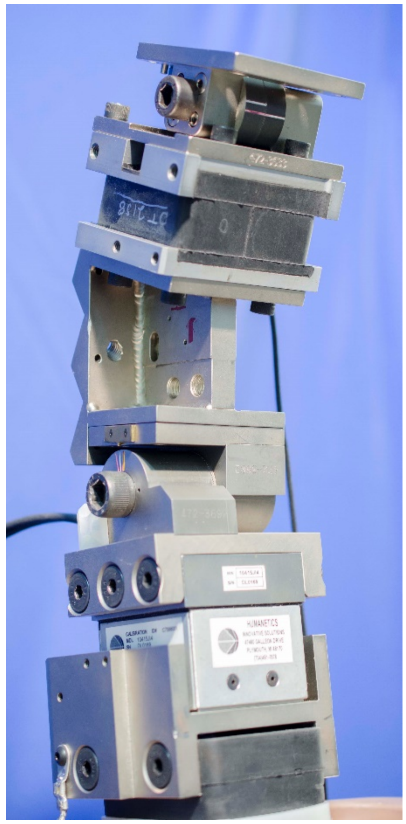


Figure 5-28. Neck pitch change mechanism assembled to upper spine flex joint

5.2.2.20 Figure 5-29 below shows the neck pitch mechanism set to "neutral." See Section 4.3.2 for details on adjusting the neck pitch.

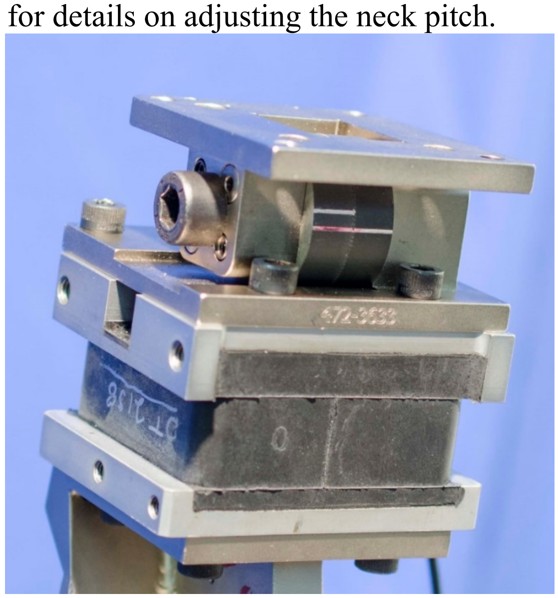


Figure 5-29. Neck pitch mechanism at "neutral" setting

5.2.2.21 Attach the Upper Thoracic Spinebox Weldment (472-3620) to the Upper Thoracic Spine Flex Joint using four M6 x 1 x 10 FHCS (Figure 5-30).

Figure 5-30. Secure upper thoracic spinebox weldment to upper thoracic spine flex joint

5.2.3 Assembly of the Spine to the Pelvis

For the procedure to assemble the pelvis to the spine, see Section 10.2.3.

5.2.4 Assembly of the Neck to the Spine

For the procedure to assemble the neck to the spine, see Section 4.2.5.

5.3 Adjustments for the Spine Assembly

5.3.1 Adjustment Procedure for Lumbar Spine Pitch Change Assembly

The following is a step-by-step procedure for adjusting the seating posture of the THOR-50M dummy using the Lumbar Spine Pitch Change Assembly (472-3670). The lumbar spine pitch change mechanism connects the upper (thoracic) and lower (lumbar) spine segments. It allows adjustment of the spine angle to four settings marked on the pitch change assembly, representing erect, neutral, slouched, and super-slouched postures. Slouched posture represents the default posture, as this most closely resembles the AMVO seated posture for a 50th percentile male occupant.

To adjust the lumbar spine pitch change mechanism angle, follow the steps below.

5.3.1.1 Unzip the zippers on the right shoulder and the right side of the jacket. If desired or convenient, remove the jacket completely.

5.3.1.2 Locate the M12 x 1.75 x 60 mm SHCS on the right side of the lower spine, as indicated in Figure 5-31.

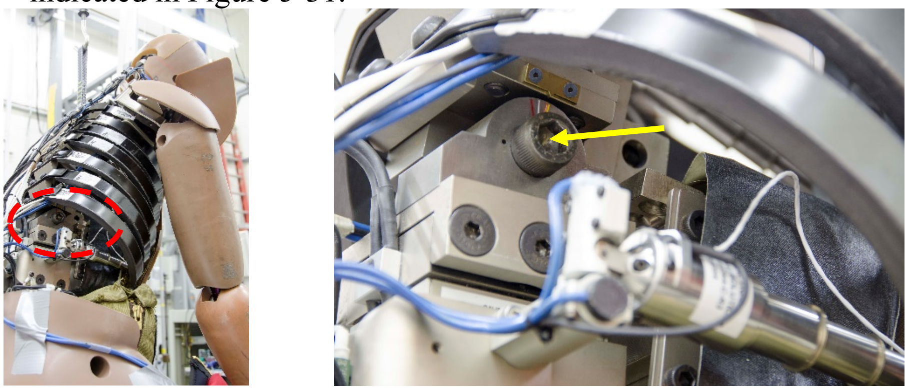
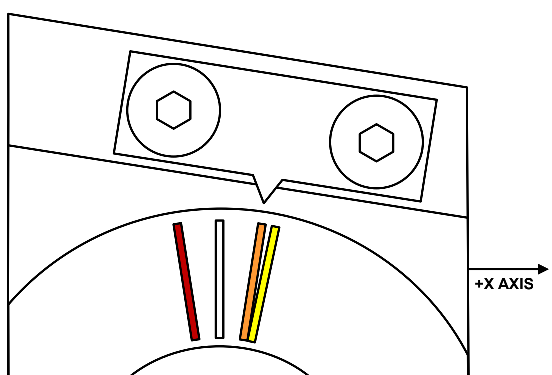


Figure 5-31. Lumbar spine pitch change mechanism adjustment SHCS (M12)

5.3.1.3 Loosen the M12 x 1.75 x 60 mm SHCS *at least* two complete turns (720°) to disengage the sprockets.

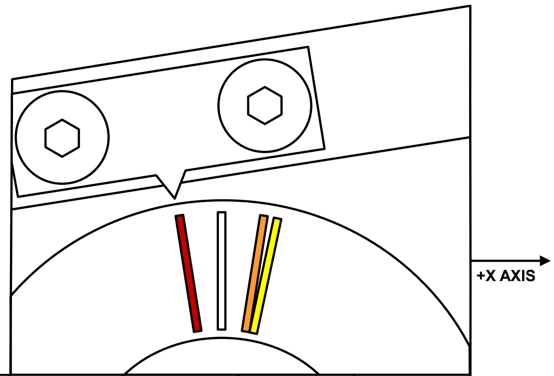
WARNING: The sprockets of the pitch change unit will be seriously damaged if the adjustment is made *BEFORE* the teeth are <u>completely</u> disengaged.

5.3.1.4 Manipulate the upper portion of the spine to achieve the desired posture setting, as shown in either Figure 5-32 or Figure 5-33.



COLOR	RED	WHITE	ORANGE	YELLOW
POSTURE	ERECT	NEUTRAL	SLOUCHED	SUPER SLOUCHED
ANGLE	-9°	0°	9°	12°

Figure 5-32. Lumbar spine pitch change assembly (472-3670) posture settings. Diagram indicates the "slouched" position.



COLOR	RED	WHITE	ORANGE	YELLOW
POSTURE	ERECT	NEUTRAL	SLOUCHED	SUPER SLOUCHED
ANGLE	-9°	0°	9°	12°

Figure 5-33. Lumbar spine pitch change assembly (472-3670) posture settings. Diagram indicates the "erect" position.

WARNING: Be certain to properly mesh and engage the sprockets of the pitch change mechanism before proceeding.

5.3.1.5 Re-tighten the M12 x 1.75 x 60 mm SHCS and torque to 68.0 N-m (50.5 ft-lbf).

5.3.2 Adjustment Procedure for Neck Pitch Change Mechanism

5.3.2.1 For the procedure to adjust the neck pitch, see Section 4.3.2.

5.3.3 Adjustment Procedure for Tightening Flex Joint Cables

5.3.3.1 Section 5.2.2.3 details the adjustment procedure for correctly tightening the cables on the Lumbar Spine Flex Joint Assembly (472-3746).

5.3.3.2 Section 5.2.2.13 details the adjustment for the Upper Thoracic Spine Flex Joint Assembly (472-3646).

5.4 Electrical Connections and Requirements

Section 15.3 includes grounding information. Section 15.4.2 describes cable routing instructions.

5.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the spine, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

5.5.1 Electrical Inspections (Instrumentation Check)

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the spine instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief (see Section 15.4.2).

Specific areas to examine:

- Check the security of all spine instrumentation mounting bolts.

5.5.2 Mechanical Inspection

Several components in the spine assembly require inspection post-test.

Specific areas to examine:

- Inspect the Upper Thoracic Spine Flex Joint Cables (472-3645) for damage such as frays, and ensure that the cable is not pulling through the swages (Figure 5-34); replace the cable if this damage is observed.
- Ensure that the lumbar spine pitch is set to the desired position for test; slouch is the orientation most often utilized. However, for face qualification testing, the "erect" orientation is used.

- Check the Upper Thoracic Spine Flex Joint Molded Assembly (472-3640) for delamination, a separation between the rubber and metal upper and lower plates. If this joint is severely (if the cable is visible between the rubber and either of the plates) delaminated, it must be replaced. If the joint is partially delaminated, it should be monitored and replaced when practical.
- Check Lumbar Spine Flex Joint Molded Assembly (472-3740) for tears; replace the assembly if tears are observed (Figure 5-35).

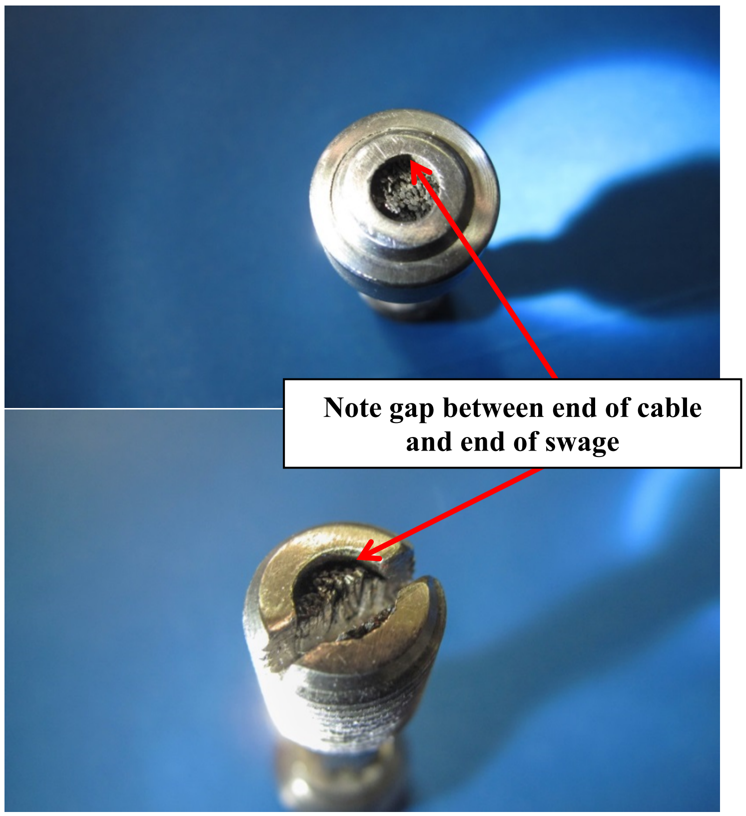


Figure 5-34. Upper thoracic spine flex joint cable pulling through swage

- Ensure that the M12 x 1.75 modified locknut (472-3747) on the upper thoracic spine flex joint cable is 1/2 turn beyond contact.
- Inspect the Lumbar Spine Flex Joint Cables (472-3745) for damage such as frays, and ensure that the cable is not pulling through the swages; replace the lumbar as well as the cable if this damage is observed.
- Ensure that the M12 x 1.75 modified locknut (472-3747) on the lumbar spine flex joint cable is 1/2 turn beyond contact.

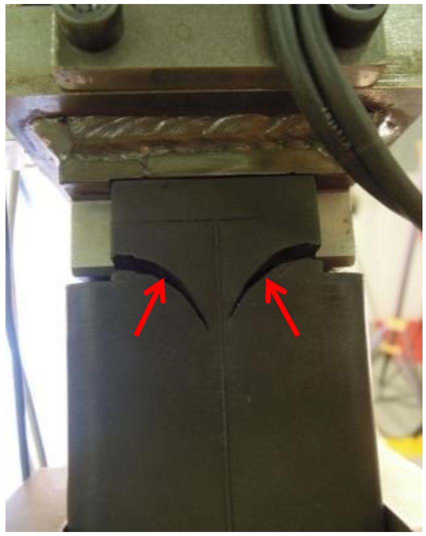


Figure 5-35. Tears in lumbar spine flex joint

- Inspect the Thorax Rib#1 Dummy Lift Strap (472-3517) and replace if frayed or damaged.
- Inspect the Neck Pitch Change Mechanism (472-3630) to ensure that the teeth of the mating “star patterns” are still tightly engaged against one another. If the sprocket’s teeth are worn and the fit is loose, disassemble the mechanism and inspect for damage to sprockets. Replace the neck pitch change assembly if damaged to the extent that proper alignment of the teeth is not possible.
- Inspect the Lumbar Pitch Change Mechanism (472-3670) to ensure that the teeth of the mating “star patterns” are still tightly engaged against one another. If the teeth are loose, disassemble the mechanism and inspect for damage to sprockets. Replace the lumbar pitch change assembly if damaged to the extent that proper alignment of the teeth is not possible.
- Ensure that the Lumbar Spine Pitch Assembly M12 x 1.75 x 60 mm SHCS adjustment bolt torque is 68.0 N-m (50.5 ft-lbf).
- Ensure that the Neck Pitch Assembly M10 x 1.5 x 55 mm SHCS adjustment bolt torque is 50.8 N-m (37.5 ft-lbf).

Section 6. **Thorax Assembly**

6.1 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 upper abdomen assemblies. This Section of the manual describes the procedures to assemble the entire thorax of the THOR-50M dummy. Figure 6-1 illustrates the thorax.

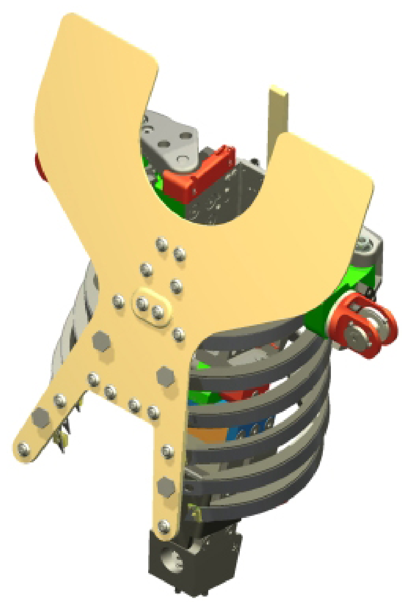


Figure 6-1. Thorax assembly

The advanced thorax assembly features extensive instrumentation to measure and record deflections, forces, and accelerations to the thorax (Figure 6-2). IR-TRACCs measure deflection of the ribcage at four distinct locations. These IR-TRACCs capture the three-dimensional position time-history of the ribs relative to the attached spine segment. Forces are measured at the T12 location, and a triaxial accelerometer array near the vertical center of gravity of the thorax measures acceleration of the spine. A uniaxial accelerometer positioned on the sternal plate measures acceleration at this location.

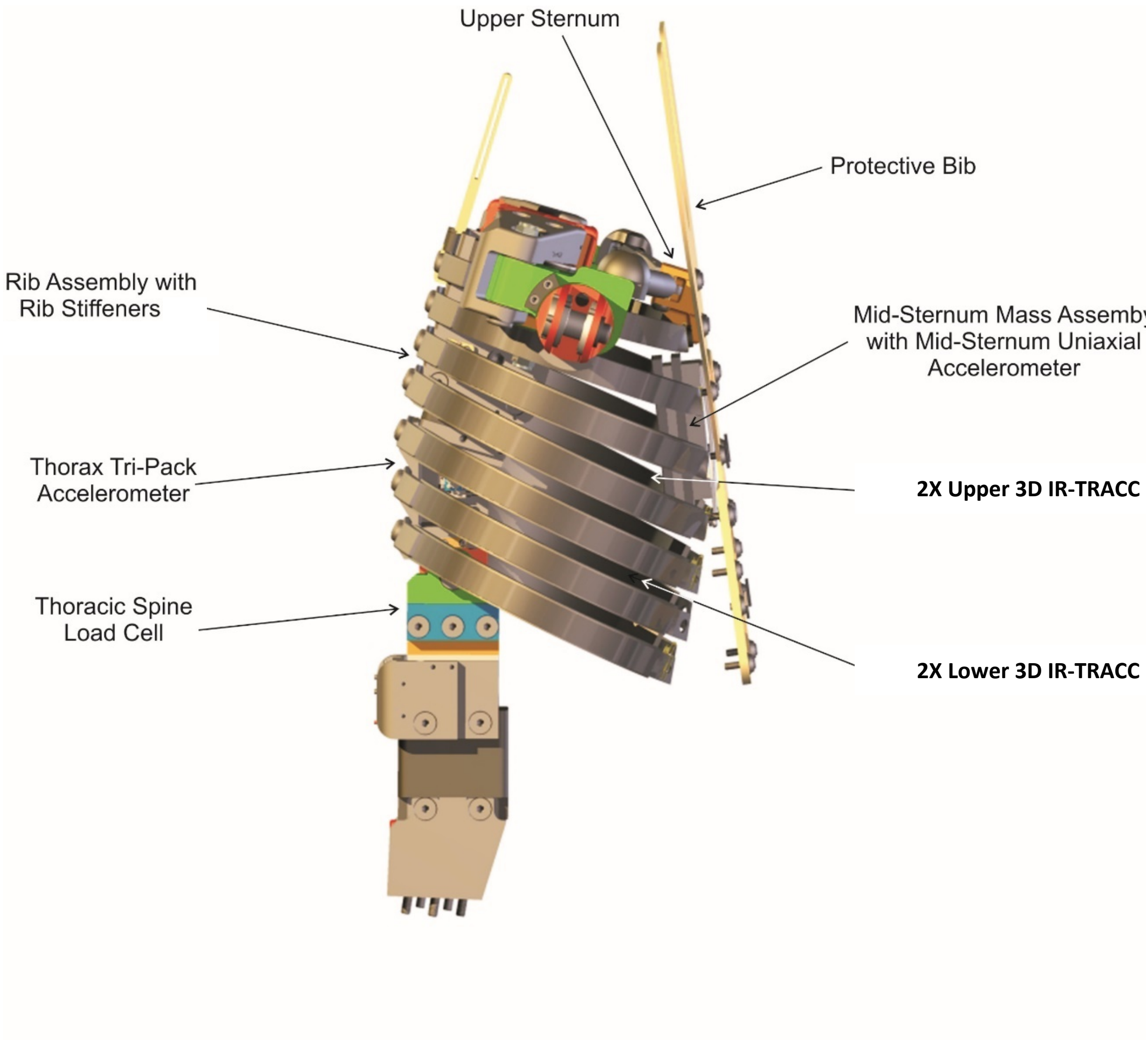


Figure 6-2. Thorax instrumentation locations

6.2 Assembly of the Thorax

6.2.1 Parts List

Table 6-1 through Table 6-5 list the components that are included in the Thorax Assembly. Figure 6-3 through Figure 6-7 show exploded views of the thorax assemblies and hardware.

Table 6-1. Thorax Mechanical Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Spine Mechanical Assembly	1	472-3600	Figure 6-3	1
Thorax Elliptical Rib #1 - Assembly	1	472-3310	Figure 6-3	2
Thorax Elliptical Rib #2 - Assembly	1	472-3320	Figure 6-3	3
Thorax Elliptical Rib #3 - Assembly	1	472-3330	Figure 6-3	4
Thorax Elliptical Rib #4 - Assembly	1	472-3340	Figure 6-3	5
Thorax Elliptical Rib #5 - Assembly	1	472-3350	Figure 6-3	6
Thorax Elliptical Rib #6 - Assembly	1	472-3360	Figure 6-3	7
Thorax Elliptical Rib #7 - Assembly	1	472-3370	Figure 6-3	8
Thorax Elliptical Rib Stiffener #1	1	472-3510	Figure 6-3	9
Thorax Elliptical Rib Stiffener #2	1	472-3511	Figure 6-3	10
Thorax Elliptical Rib Stiffener #3	1	472-3512	Figure 6-3	11
Thorax Elliptical Rib Stiffener #4	1	472-3513	Figure 6-3	12
Thorax Elliptical Rib Stiffener #5	1	472-3514	Figure 6-3	13
Thorax Elliptical Rib Stiffener #6	1	472-3515	Figure 6-3	14
Thorax Elliptical Rib Stiffener #7	1	472-3516	Figure 6-3	15
Shoulder Assembly	1	472-3800	Figure 6-3	16
M8 x 1.25 x 10 LG. BHCS	14	5000454	Figure 6-3	17
Thorax Bib Assembly	1	472-3400	Figure 6-3	18
Dummy Lifting Strap	1	472-3517	Figure 6-3	19
M5 x 0.8 x 22 LG. BHCS	2	5000571	Figure 6-3	20
M5 x 0.8 x 12 LG. BHCS	2	5000654	Figure 6-3	21
M5 x 0.8 x 20 LG. BHCS	6	5000210	Figure 6-3	22
IR-TRACC Connecting Bolt, Lower Thorax	2	472-3520	Figure 6-3	23
¼ Coated Cable Clamp	2	9003723	Figure 6-3	24
M5 x 0.8 x 6 LG. BHCS	2	5000214	Figure 6-3	25
Upper Abdomen Assembly	1	472-4600	Figure 6-3	26
M8 x 1.25 x 25 LG. FHCS	2	5000117	Figure 6-3	27
IR-TRACC Assembly, Upper Left	1	472-5350	Figure 6-3	28
IR-TRACC Assembly, Upper Right	1	472-3560	Figure 6-3	29
IR-TRACC Assembly, Lower Right	1	472-3570	Figure 6-3	30
IR-TRACC Assembly, Lower Left	1	472-3580	Figure 6-3	31
Lower Abdomen Mechanical Assembly	1	472-4700	Figure 6-3	32

M4 x 0.7 x 8 LG. SHCS	4	5000989	Figure 6-3	33
M10 x 1.5 x 25 LG. FHCS	2	5001127	Figure 6-3	34
Clip Nut, (Monadnock #130300-M5-1)	10	5000513	Figure 6-3	35
Washer, M5 x 15 x 1.2 S.S.	12	5001126	Figure 6-3	36
IR-TRACC Connecting Bolt, Upper Thorax	2	472-3518	Figure 6-3	37
M4 x 0.7 x 10 LG. SHCS	4	50000151	Figure 6-3	38
Bracket, Lifting Strap	1	472-3115	Figure 6-3	39
Screw, BHCS M5 x 0.8 x 10	2	5000003	Figure 6-3	40

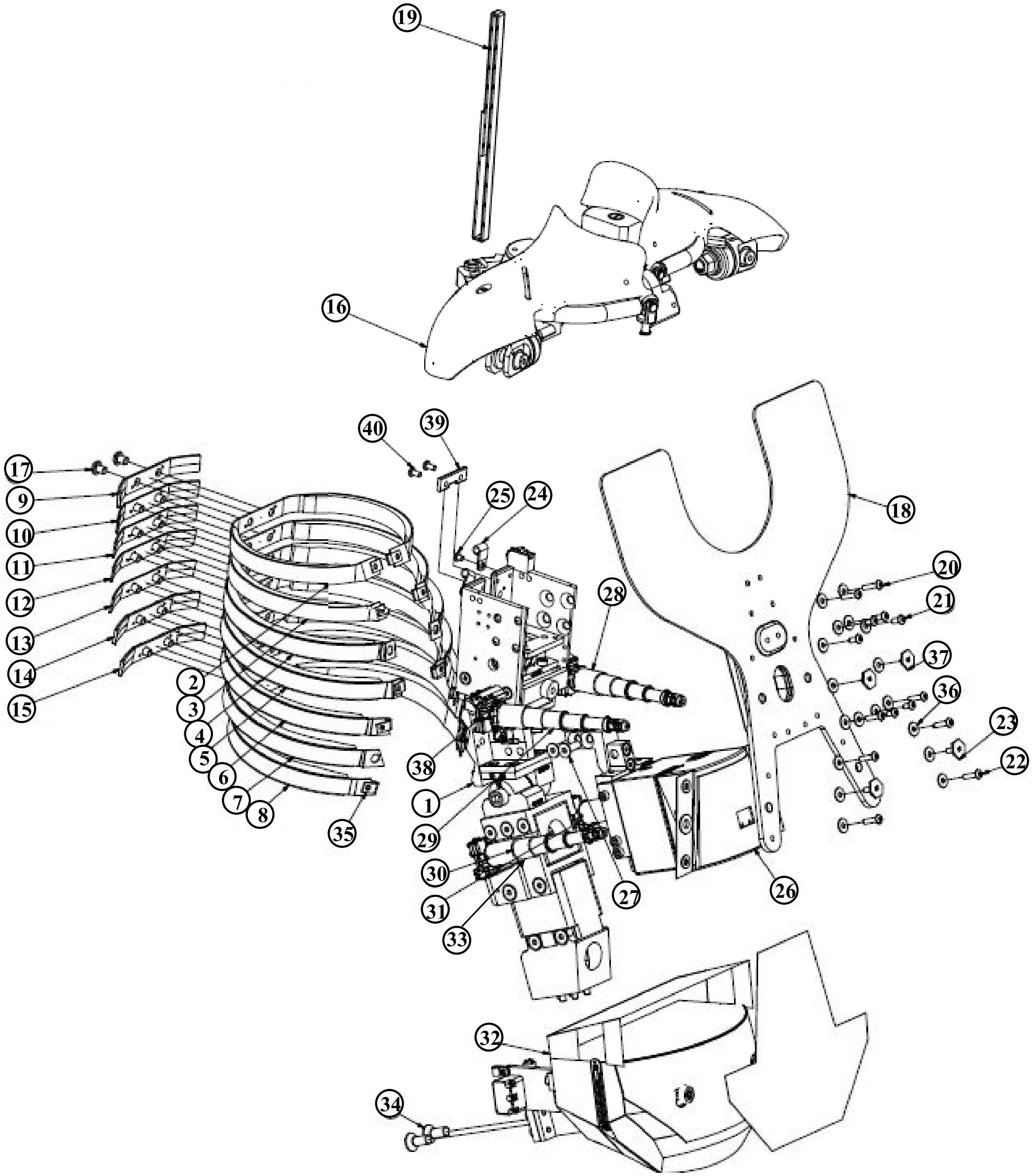


Figure 6-3. Thorax mechanical assembly components

Table 6-2. Upper (Left) IR-TRACC Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper IR-TRACC Base	1	472-3551	Figure 6-4	1
Rotary Potentiometer	2	SA572-S114	Figure 6-4	2
Flange Bearing (1/4” O.D. x 1/8” I.D.)	2	9002201	Figure 6-4	3
M3 Flat Washer Large OD SS	2	5000378	Figure 6-4	4
IR-TRACC Arm Mounting Bracket, Right	1	472-3552	Figure 6-4	5
Servo/IR-TRACC Adaptor	1	472-3553	Figure 6-4	6
IR-TRACC Clamp	2	472-3554	Figure 6-4	7
M2.5 x 0.45 x 3 LG. SSCP	2	5000578	Figure 6-4	8
IR-TRACC Chest	1	SA572-S117	Figure 6-4	9
M2.5 x 0.45 x 10 LG. SHCS	1	5000456	Figure 6-4	10
M2 x 0.4 x 8 LG. SHCS	8	5000083	Figure 6-4	11
M2 Split Lock Washer SS	8	5001216	Figure 6-4	12

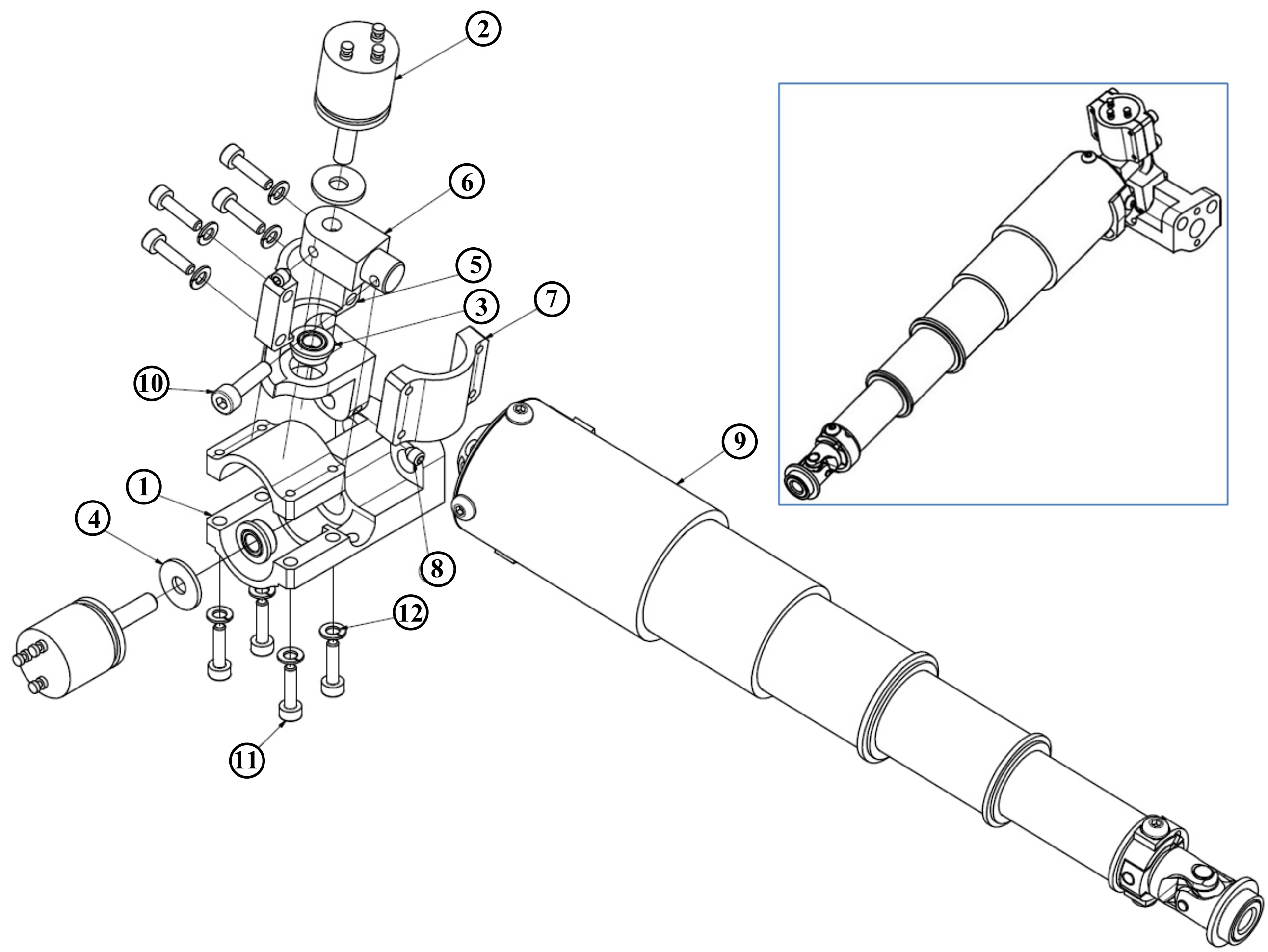


Figure 6-4. Upper (left) IR-TRACC assembly components

Table 6-3. Lower (Left) IR-TRACC Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper IR-TRACC Base	1	472-3571	Figure 6-5	1
Rotary Potentiometer	2	SA572-S114	Figure 6-5	2
Flange Bearing (1/4" O.D. x 1/8" I.D.)	2	9002201	Figure 6-5	3
M3 Flat Washer Large OD SS	2	5000378	Figure 6-5	4
IR-TRACC Arm Mounting Bracket, Left	1	472-3562	Figure 6-5	5
Servo/IR-TRACC Adaptor	1	472-3553	Figure 6-5	6
IR-TRACC Clamp	2	472-3554	Figure 6-5	7
M2.5 x 0.45 x 3 LG. SSCP	2	5000578	Figure 6-5	8
IR-TRACC Chest	1	SA572-S117	Figure 6-5	9
M2.5 x 0.45 x 10 LG. SHCS	1	5000456	Figure 6-5	10
M2 x 0.4 x 8 LG. SHCS	8	5000083	Figure 6-5	11
M2 Split Lock Washer SS	8	5001216	Figure 6-5	12

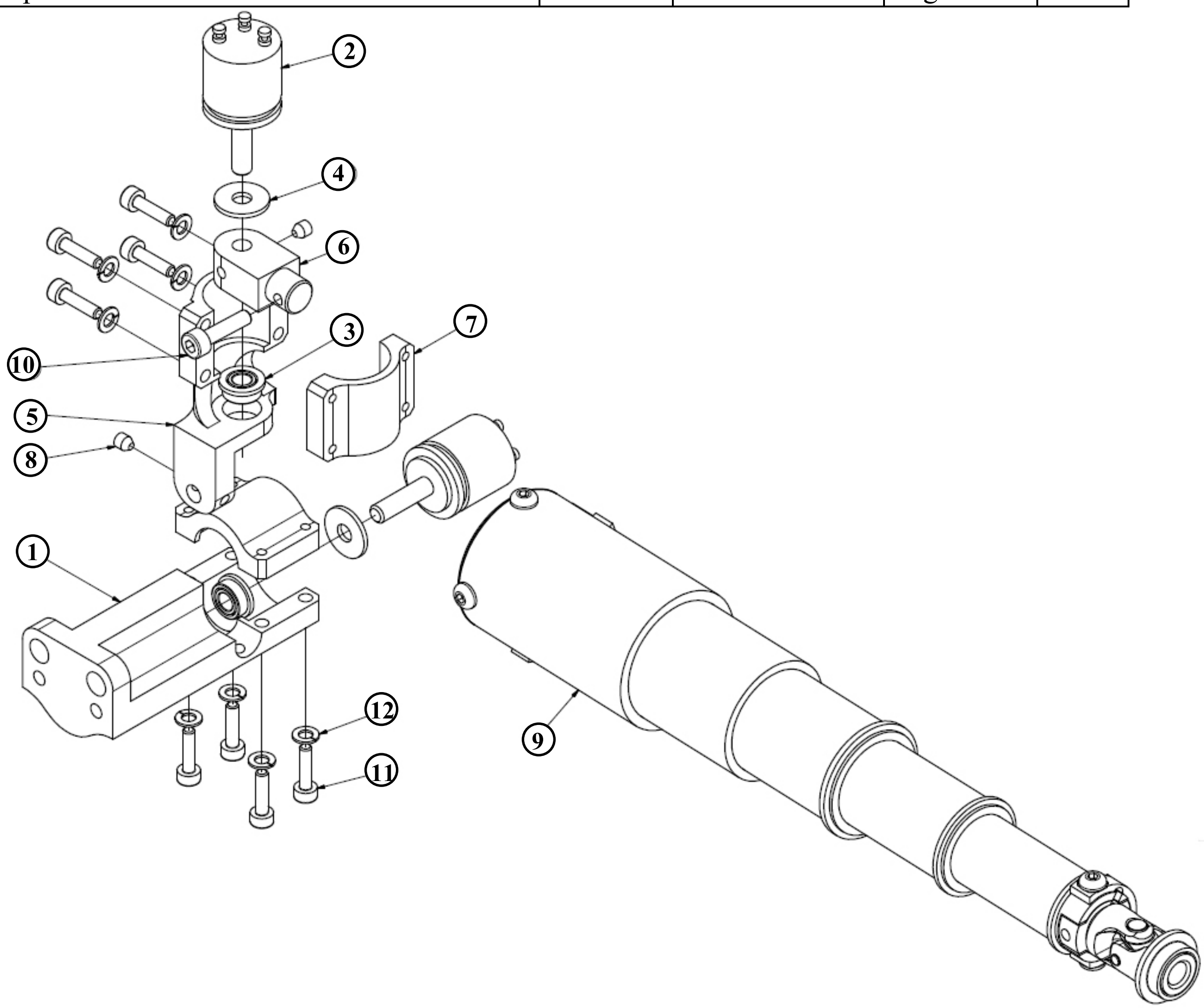


Figure 6-5. Lower (left) IR-TRACC assembly components

Table 6-4. Thorax Bib Assembly Components

Part Description	Quantity	Part Number	Figure #	Item#
Mid-Sternum Bonding Assembly	1	472-3410	Figure 6-6	1
Thorax Outer Bib	1	472-3420	Figure 6-6	2
M5 x 0.8 x 10 LG. BHCS	4	5000003	Figure 6-6	3
M1.4 x 0.3 x 3 LG. SHCS	2	5000068	Figure 6-6	4
Washer, M5 x 15 x 1.2 S.S.	4	5001126	Figure 6-6	5
Nylon Wire Clamp 1/8” DIA.	1	9002655	Figure 6-6	6
M4 x 0.7 x 8 BHCS	1	5000103	Figure 6-6	7
Sternum Mass Strap	2	472-3431	Figure 6-6	8

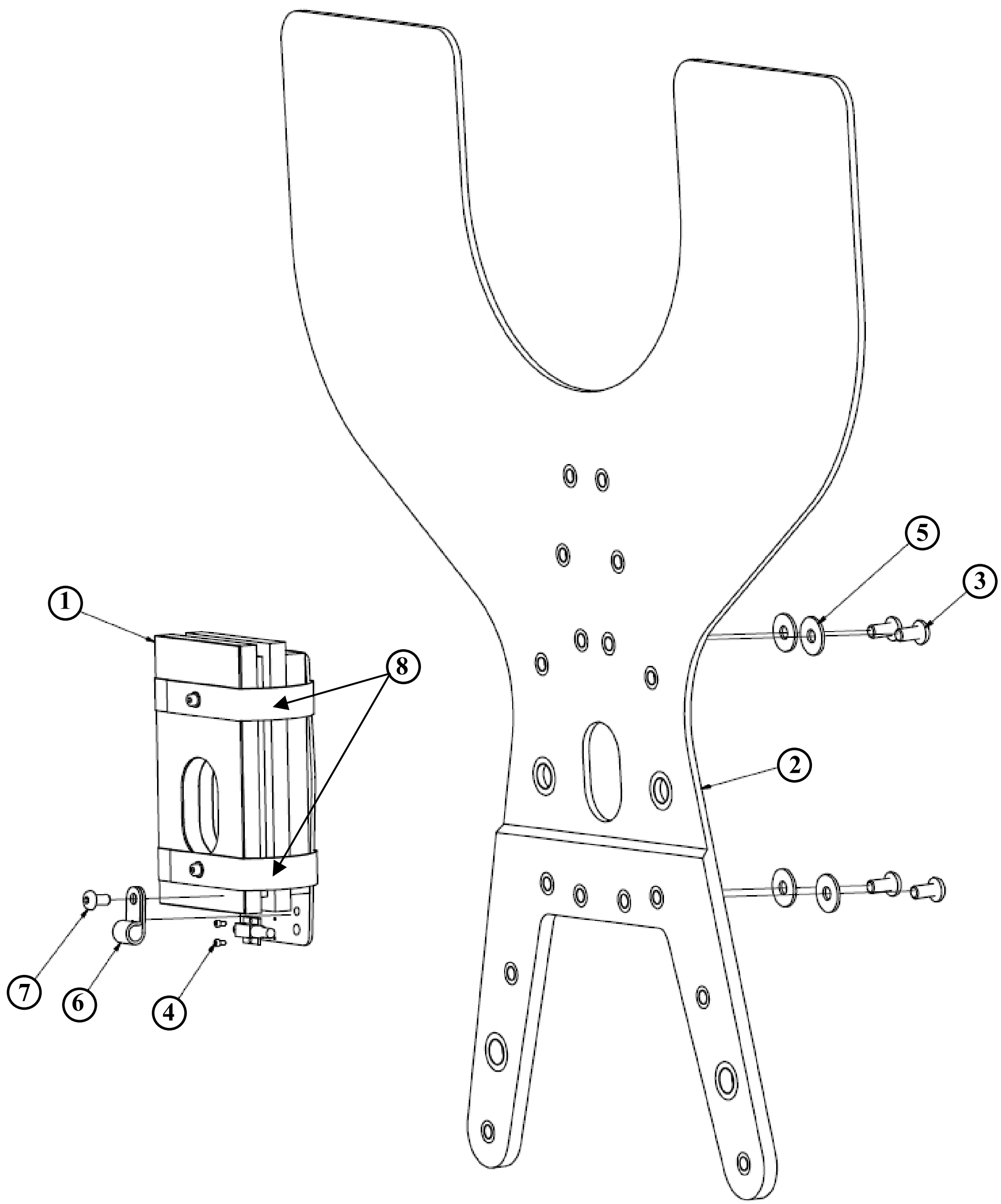


Figure 6-6. Thorax bib assembly components

Table 6-5. Mid-Sternum Bonding Assembly

Part Description	Quantity	Part Number	Figure #	Item#
Mid-Sternum Plate	1	472-3413	Figure 6-7	1
Mass Damping Foam #1, Mid-Sternum	1	472-3414	Figure 6-7	2
Mid-Sternum Mass	1	472-3411	Figure 6-7	3
Mass Damping Foam #2, Mid-Sternum	1	472-3412	Figure 6-7	4
Mid-Sternum Rubber Pad	1	472-3415	Figure 6-7	5
Mid-Sternum Mass #2	1	472-3411-A	Figure 6-7	6
Sternum Mass Strap	2	472-3431	Figure 6-7	7
M2.5 Flat Washer Plain Zinc	2	5001094	Figure 6-7	8
M2.5 x 0.45 x 8 LG. SHCS	2	5000458	Figure 6-7	9

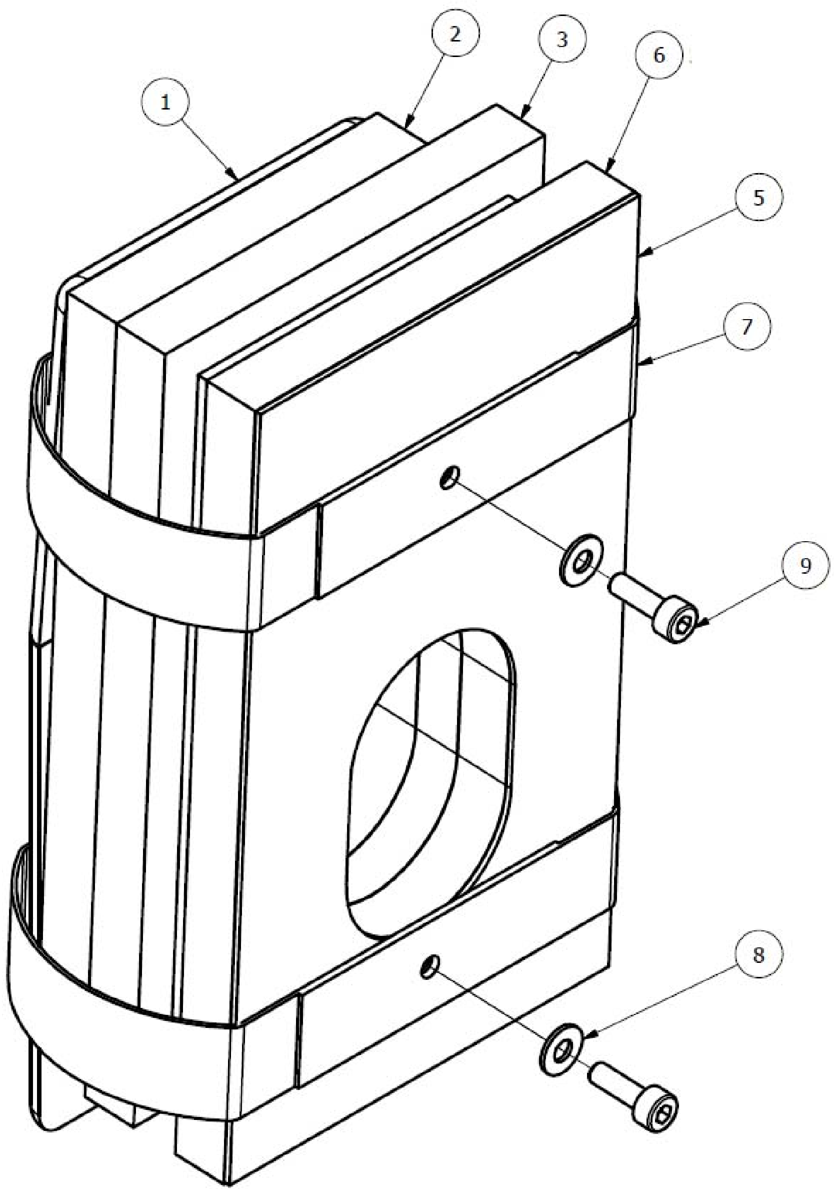


Figure 6-7. Mid-sternum bonding assembly components

6.2.2 **Assembly of Thorax Components**

The following procedure is a step-by-step description of the assembly procedure for the thorax components. Unless otherwise specified, tighten all bolts to the torque specification provided in Section 2.1.3.

- The thorax assembly includes: The Shoulder Assembly (472-3800), Spine Mechanical Assembly (472-3600), Upper Abdomen Assembly (472-4600) and the Lower Abdomen Mechanical Assembly (472-4700).

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

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

6.2.2.1 Assemble the Upper (Left) IR-TRACC Assembly (472-3550) by installing the Y-axis potentiometer with large M3 flat washer into the Upper IR-TRACC Base (472-3551) (Figure 6-8 and Figure 6-9).

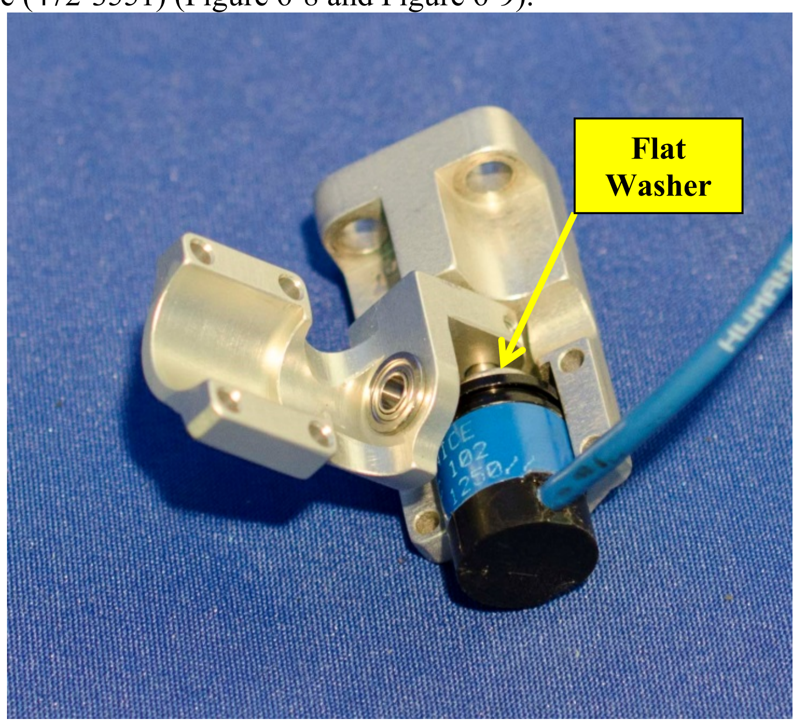


Figure 6-8. Upper thorax IR-TRACC assembly details

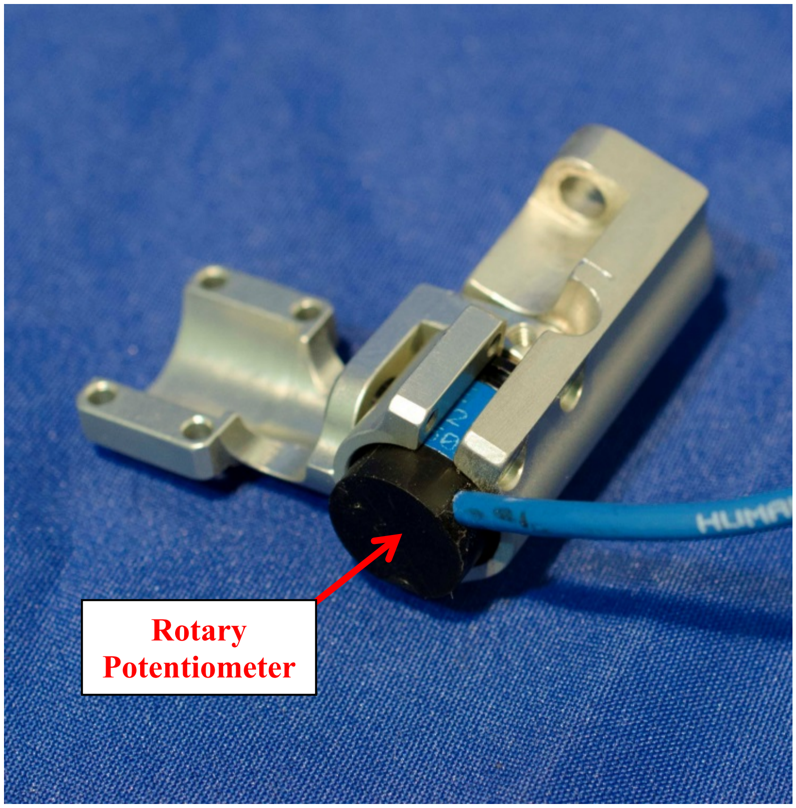


Figure 6-9. Upper IR-TRACC installation of rotary potentiometer

6.2.2.2 Install the IR-TRACC Clamp (472-3554) to the assembly using four M2 split lock washers and accompanying M2 x 0.4 x 8 SHCS (Figure 6-10).

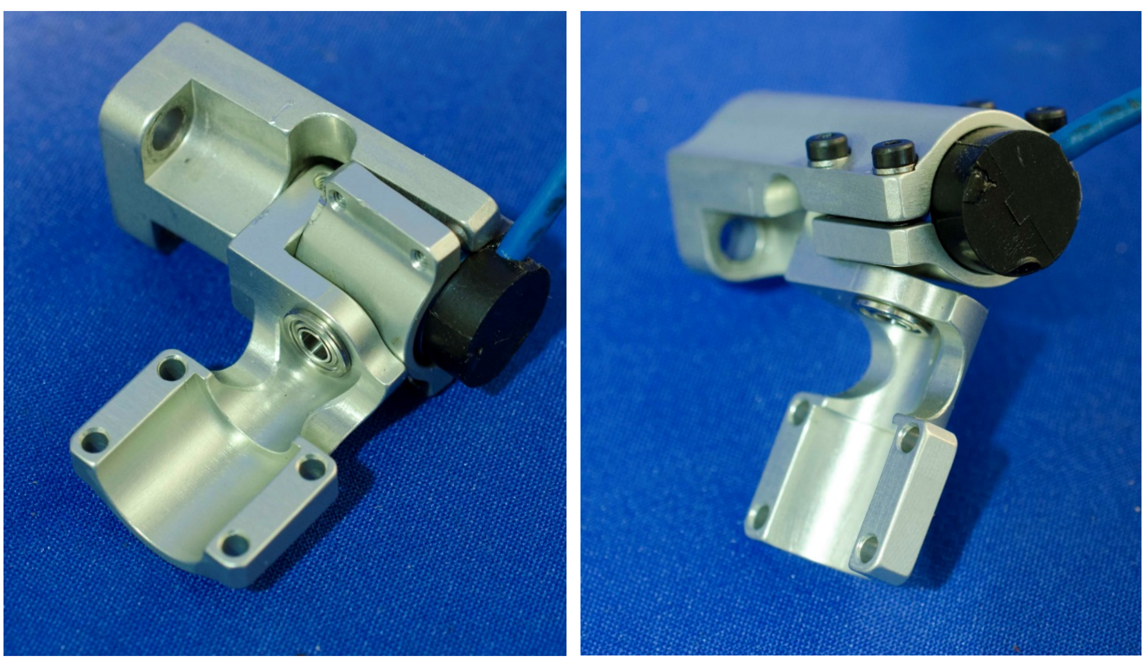


Figure 6-10. Install IR-TRACC clamp

6.2.2.3 Assure that the Y-axis rotary potentiometer will not pass through a dead band when moved through its range of motion in the thorax. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Once this is complete, insert and tighten the M2.5 x 0.45 x 3 SSCP against the Y-axis potentiometer shaft (Figure 6-11).

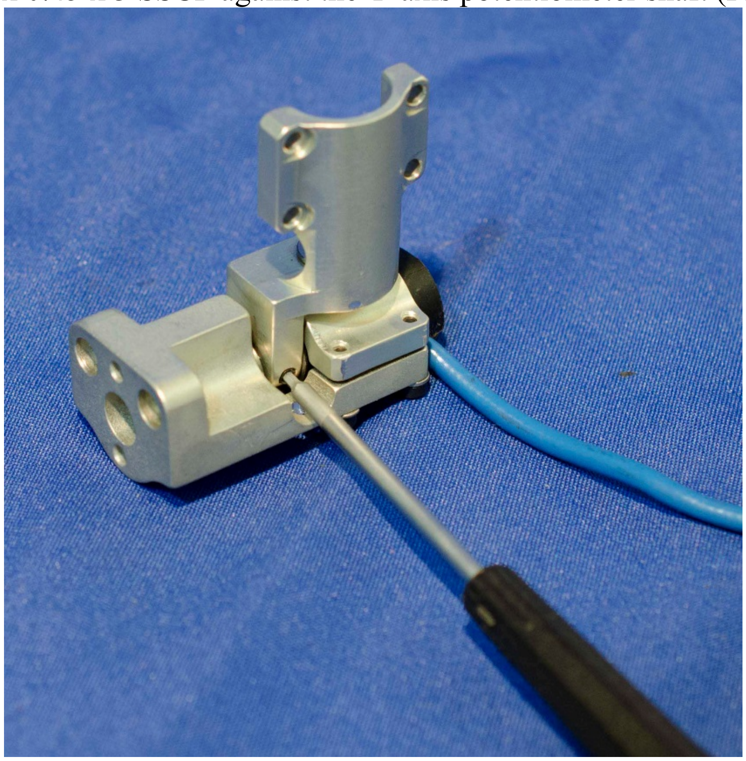


Figure 6-11. Tighten set screw on the Y-axis potentiometer

6.2.2.4 Insert the Z-axis potentiometer through the end of the THOR-M Chest IR-TRACC (SA572-S117) (Figure 6-12) and install the IR-TRACC Clamp (472-3554) using four M2 split lock washers and M2 x 0.4 x 8 SHCS (Figure 6-13).

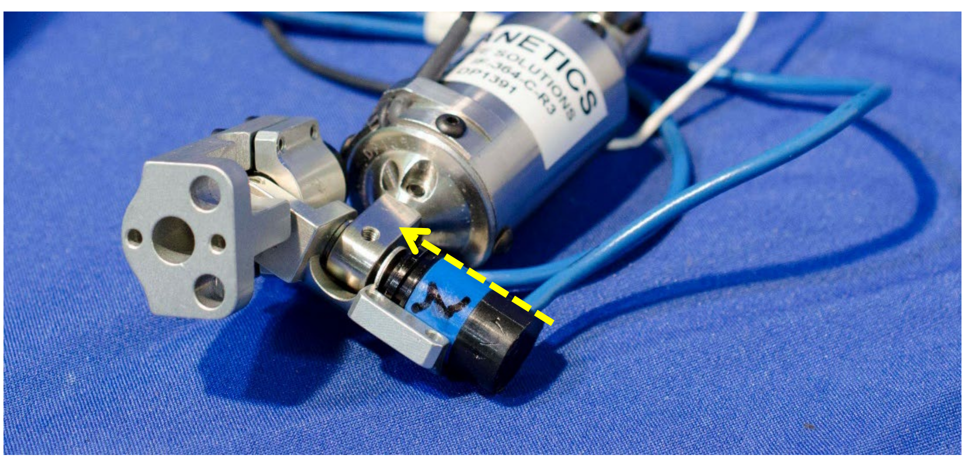


Figure 6-12. Install Z-axis potentiometer

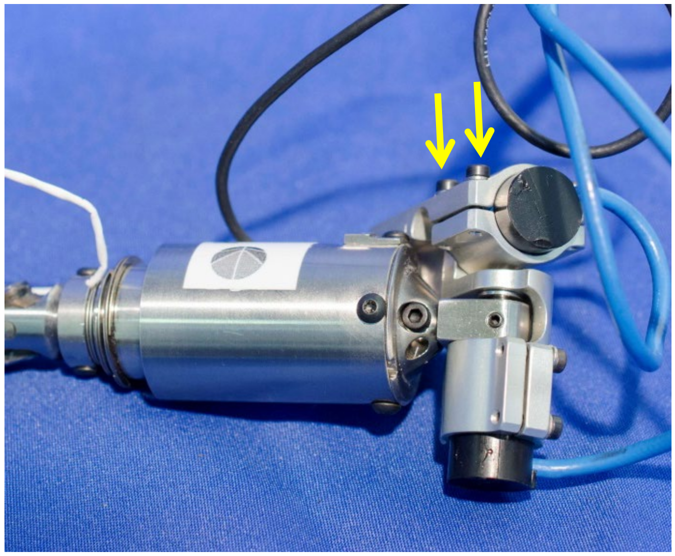


Figure 6-13. Install Z-axis IR-TRACC clamp

6.2.2.5 Assure that the Z-axis rotary potentiometer will not pass through a dead band when moved through its range of motion in the thorax. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Once this is complete, insert and tighten the M2.5 x 0.45 x 3 SSCP against the Z-axis potentiometer shaft (Figure 6-14).

Figure 6-14. Tighten set screw against Z-axis potentiometer

6.2.2.6 Tie off the transducer wires to the housing leaving approximately 140 mm of cable slack.

6.2.2.7 Repeat Steps 6.2.2.1 through 6.2.2.6 for the Upper Right IR-TRACC Assembly (472-3560).

6.2.2.8 Each time the 3D IR-TRACC assembly is re-assembled, the zero position for the Y-axis and Z-axis rotary potentiometers must be adjusted and the initial position offsets recorded (Section 16.3).

6.2.2.9 Assemble the Lower (Left) IR-TRACC Assembly (472-3580) by installing the Y-axis potentiometer with large M3 flat washer into the Upper IR-TRACC Base (472-3571) (Figure 6-14). Install the IR-TRACC Clamp (472-3554) to the assembly using four M2 split lock washers and accompanying M2 x 0.4 x 8 SHCS.

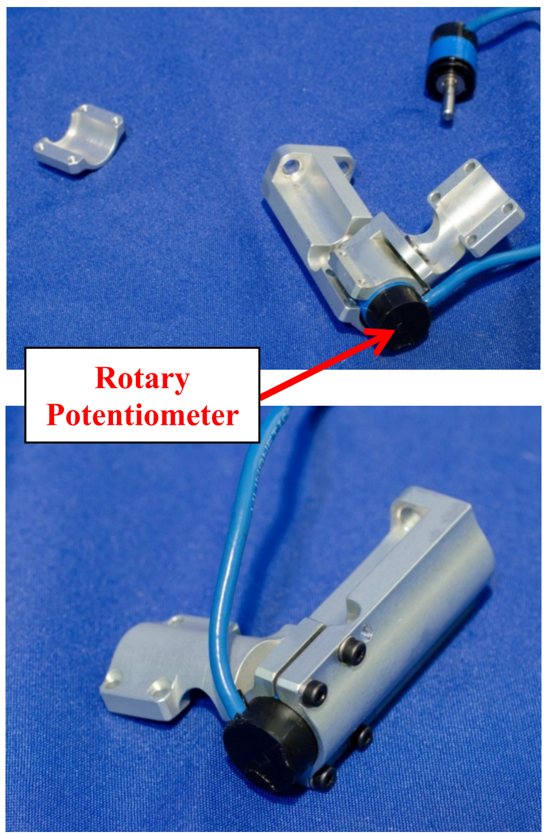


Figure 6-15. Assemble lower thorax IR-TRACC Y-axis potentiometer

6.2.2.10 Assure that the Y-axis rotary potentiometer will not pass through a dead band when moved through its range of motion in the thorax. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Once this is complete, insert and tighten the M2.5 x 0.45 x 3 SSCP against the Y-axis potentiometer shaft (Figure 6-16).

Figure 6-16. Tighten set-screw for Y-axis lower thorax IR-TRACC

6.2.2.11 Insert the Z-axis potentiometer through the end of the THOR-M Chest IR-TRACC (SA572-S117) and install the IR-TRACC Clamp (472-3554) using four M2 split lock washers and M2 x 0.4 x 8 SHCS (Figure 6-17).

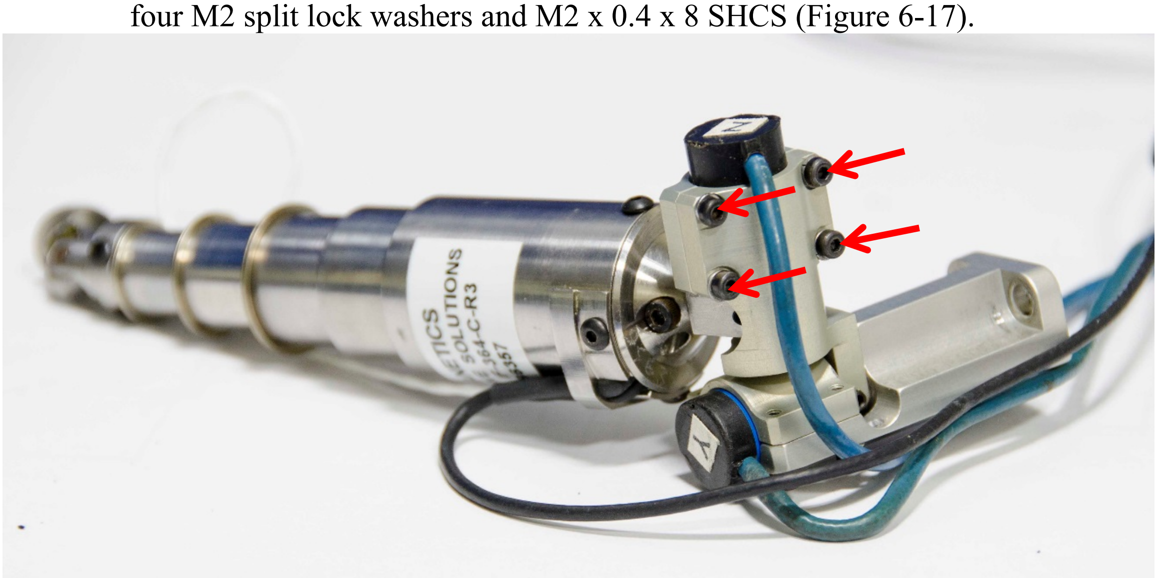


Figure 6-17. Install Z-axis potentiometer and clamp for lower thorax IR-TRACC

6.2.2.12 Tie off the transducer wires leaving approximately 140 mm of cable slack (Figure 6-18). In addition, tie the wiring to the lower IR-TRACC base.

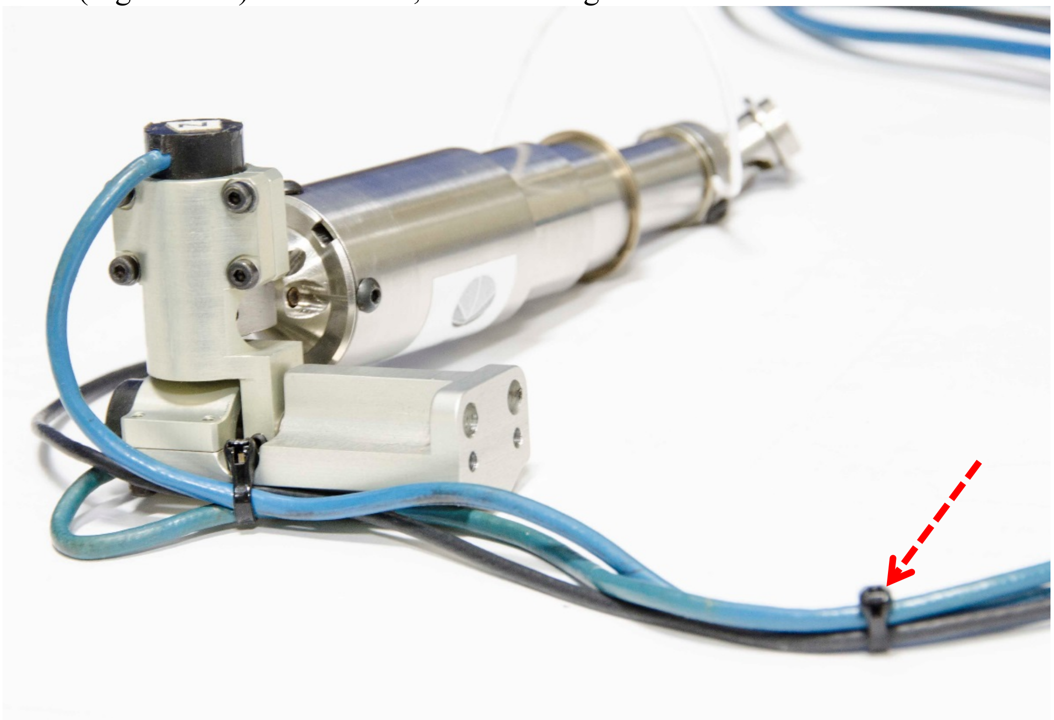


Figure 6-18. Tie off IR-TRACC wires for strain relief

6.2.2.13 Assure that the Z-axis rotary potentiometer will not pass through a dead band when moved through its range of motion in the thorax. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Once this is complete, insert and tighten the M2.5 x 0.45 x 3 SSCP against the Z-axis potentiometer shaft (Figure 6-19).

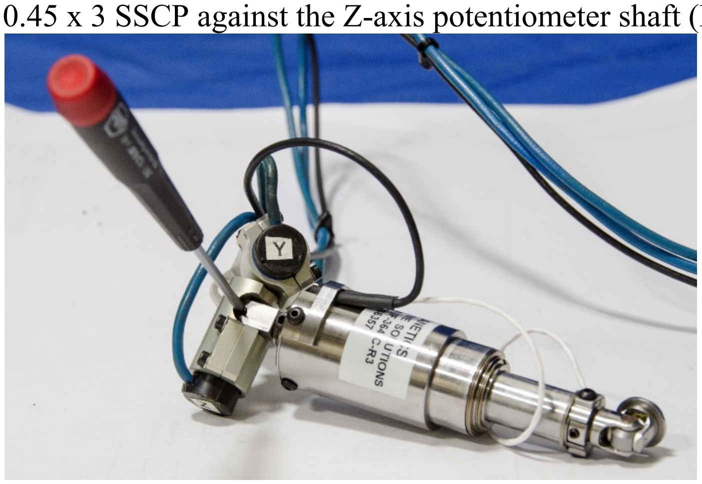


Figure 6-19. Tighten set-screw for Z-axis potentiometer for Lower thorax IR-TRACC

6.2.2.14 Repeat Steps 6.2.2.1 through 6.2.2.6 for the Lower Right IR-TRACC Assembly (472-3570).

6.2.2.15 It is critical that each time the 3D IR-TRACC assembly is re-assembled, the zero position for the Y-axis and Z-axis rotary potentiometers must be adjusted and the initial position offsets recorded (Section 16.3).

6.2.2.16 To attach each of the Lower Thoracic IR-TRACC Assemblies to the Thoracic Spine Load Cell Adaptor Plate (472-3730) use two M4 X 0.7 X 8 mm SHCS per assembly (Figure 6-20 and Figure 6-21).

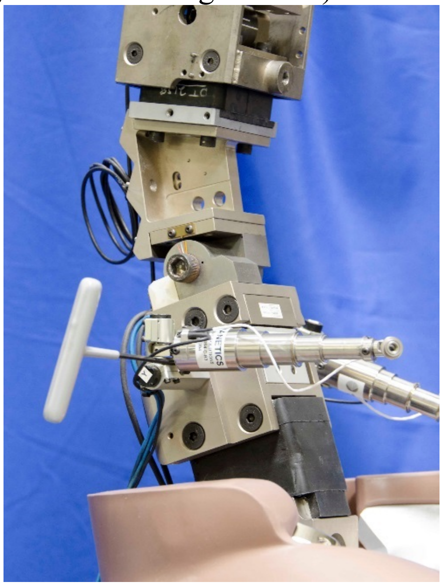


Figure 6-20. Attach lower thoracic IR-TRACCs to thoracic spine

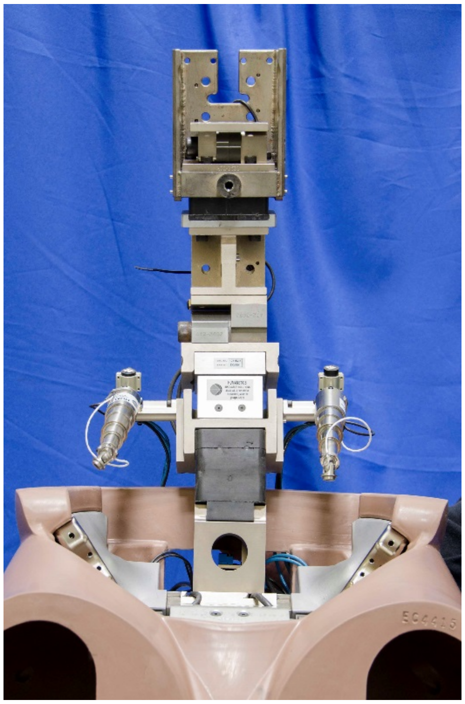


Figure 6-21. Lower thoracic IR-TRACCs installed

6.2.2.17 To attach each of the Upper Thoracic IR-TRACC Assemblies to the Upper Thoracic Spine Mechanical Assembly (472-3610) use two M4 X 0.7 X 10 mm SHCS per assembly (Figure 6-22 and Figure 6-23).

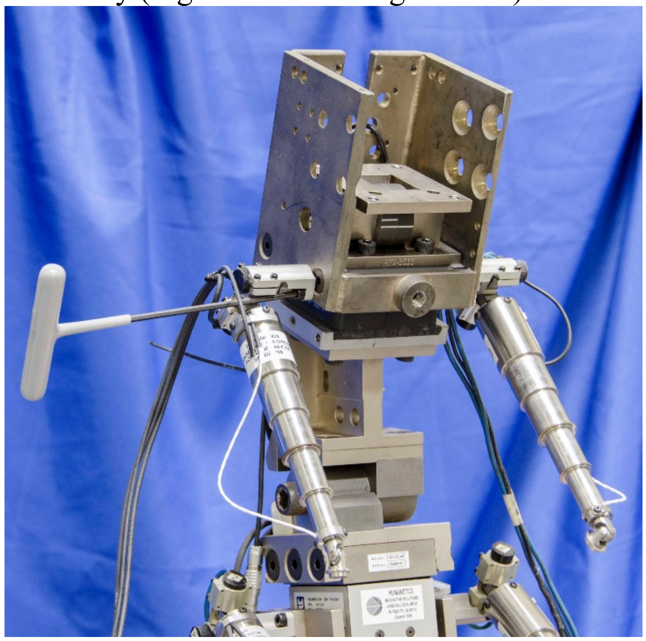


Figure 6-22. Attach upper thoracic IR-TRACCs to upper thoracic spine

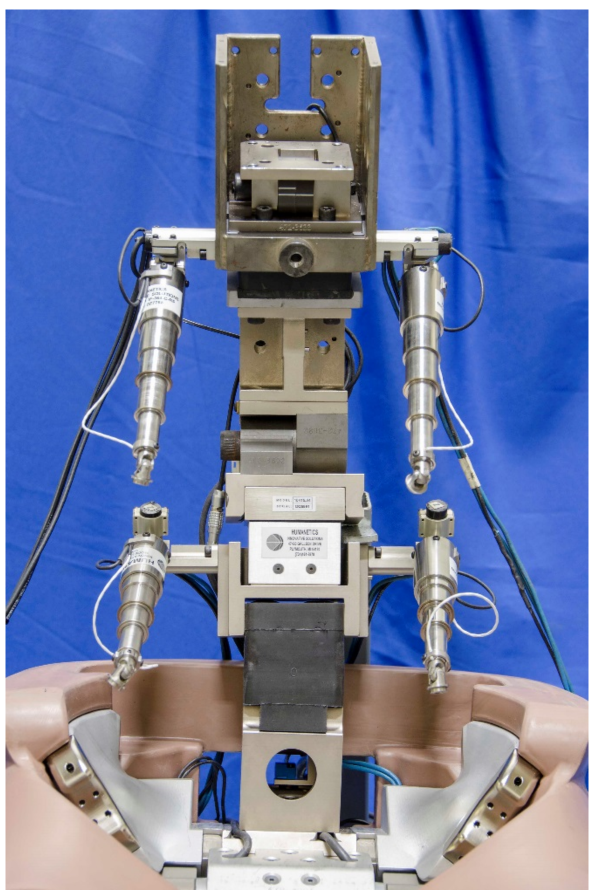


Figure 6-23. Upper and lower thoracic IR-TRACCs installed

6.2.2.18 Install the Dual Axis Tilt Sensor (SA572-S44) to the T6 Tilt Sensor Mount (472-3783), using two M2 x 0.4 x 10 SHCS (Figure 6-24).

Figure 6-24. Install T6 tilt sensor to mount

6.2.2.19 Install the T6 Tilt Sensor Assembly to the left spine using two M3 x 0.5 x 16 FHCS which are inserted through the right side of the spine (Figure 6-25 and Figure 6-26).

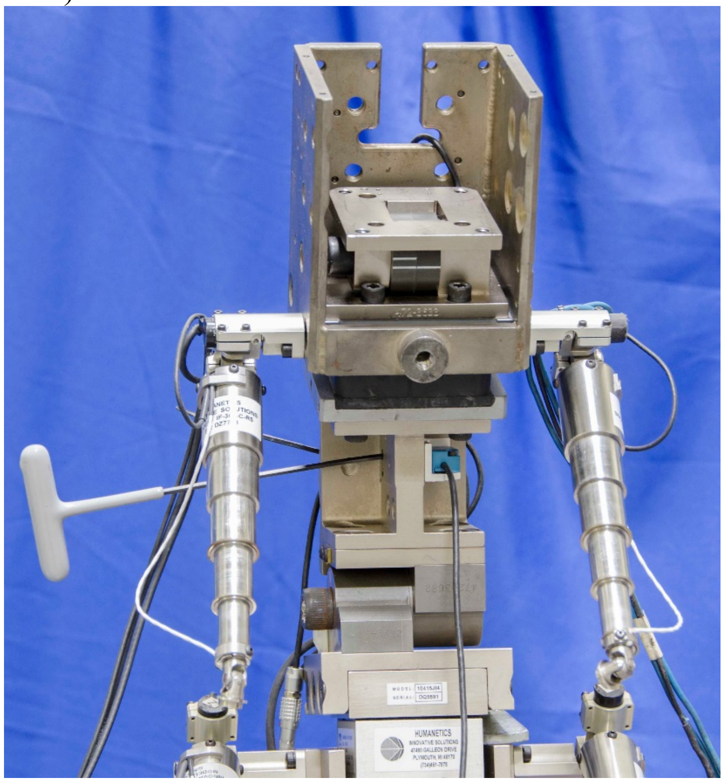


Figure 6-25. Install T6 tilt sensor to spine

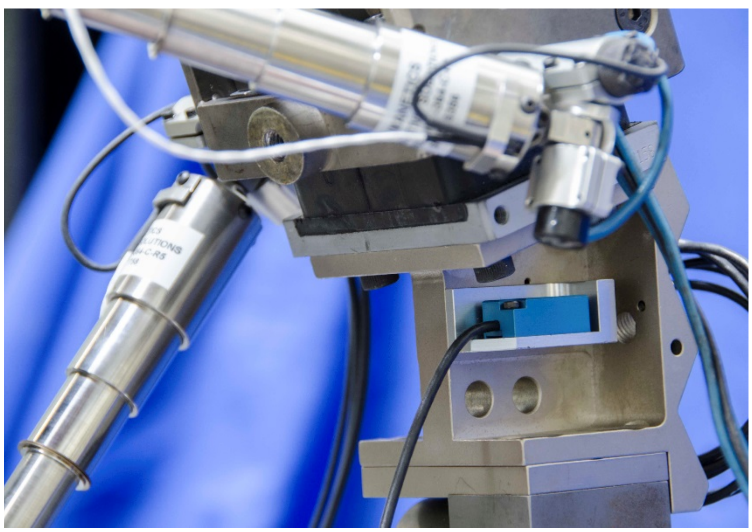


Figure 6-26. T6 tilt sensor installed on spine

6.2.2.20 Install the Dual Axis Tilt Sensor (SA572-S44) to the T12 Tilt Sensor Mount (472-3781), using two M2 x 0.4 x 10 SHCS (Figure 6-27).

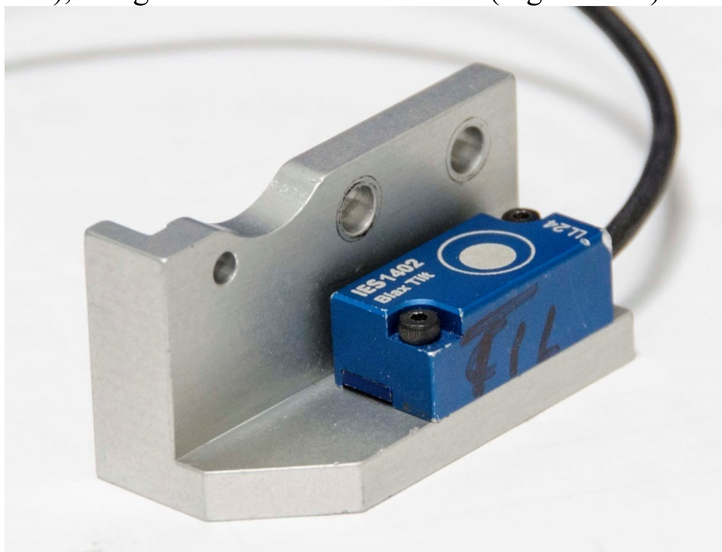


Figure 6-27. Install T12 tilt sensor to mount

6.2.2.21 Secure the T12 Tilt Sensor Assembly to the Thoracic Spine Load Cell Flex Joint Adaptor Plate (472-3731) with two M4 x 0.7 x 10 SHCS (Figure 6-28).

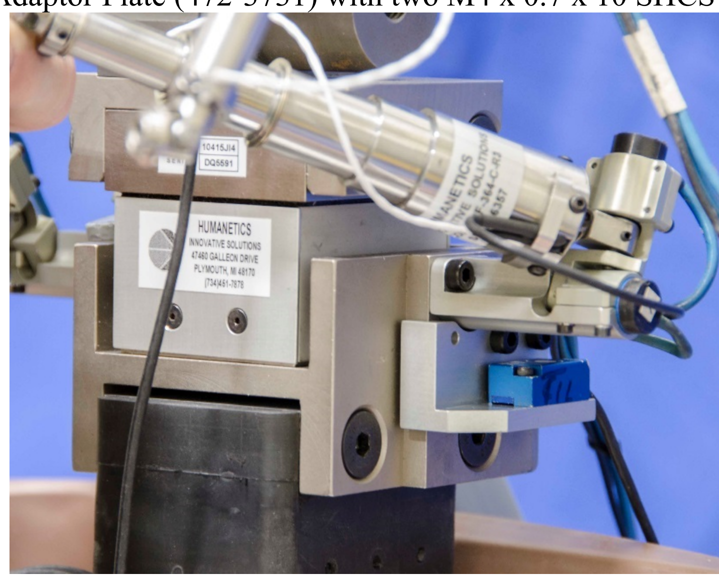


Figure 6-28. Install T12 tilt sensor to spine

6.2.2.22 Attach three uniaxial accelerometers (SA572-S4) to an S4 Triaxial Accelerometer Metric Mounting Block (SA572-S80M) using two M1.4 x0.3 x 3 SHCS per accelerometer (Figure 6-29).

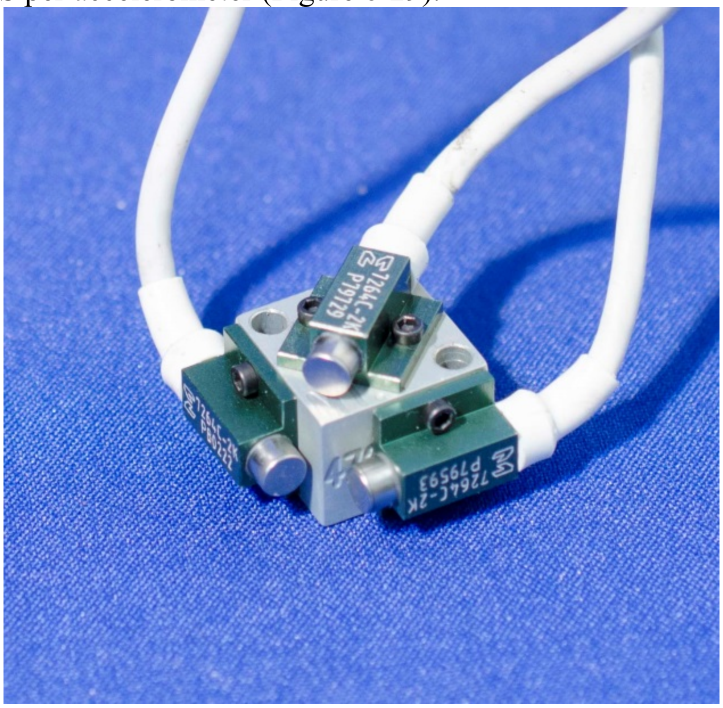


Figure 6-29. Attach accelerometers to mounting block

6.2.2.23 Secure the Tri-Pack Accelerometer Assembly (472-4203) to the Thoracic Spine Load Cell Flex Joint Adaptor Plate (472-3731) using two M2 x 0.4 x 16 SHCS (Figure 6-30).

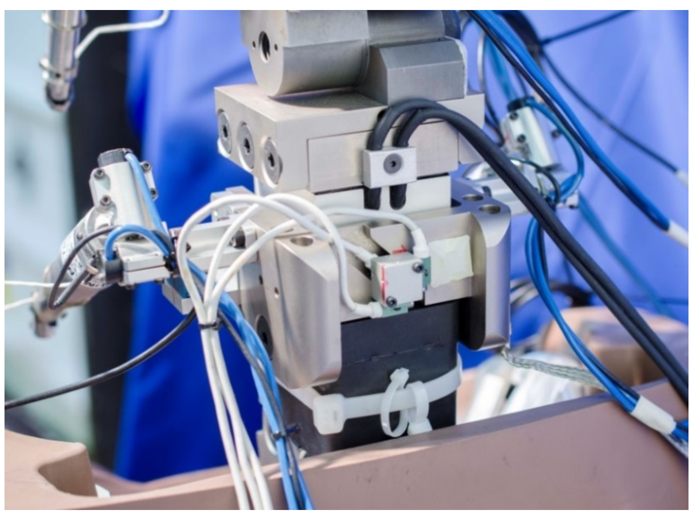


Figure 6-30. Install tri-pack accelerometer block to thoracic spine load cell flex joint adaptor plate

6.2.2.24 Attach three uniaxial accelerometers (SA572-S4) to an S4 Triaxial Accelerometer Metric Mounting Block (SA572-S80M) using two M1.4 x0.3 x 3 SHCS per accelerometer (Figure 6-29).

6.2.2.25 Install the accelerometer block to the right side of the spine using two M2 x 0.4 x 16 SHCS (Figure 6-31).

Figure 6-31. Install accelerometer block to right side of spine

6.2.2.26 Secure the T1 Accelerometer Mount (472-3858) to the upper left rear top edge of the Upper Thoracic Spinebox Weldment (472-3620) with one M3 x 0.5 x 14 SHCS (Figure 6-32).

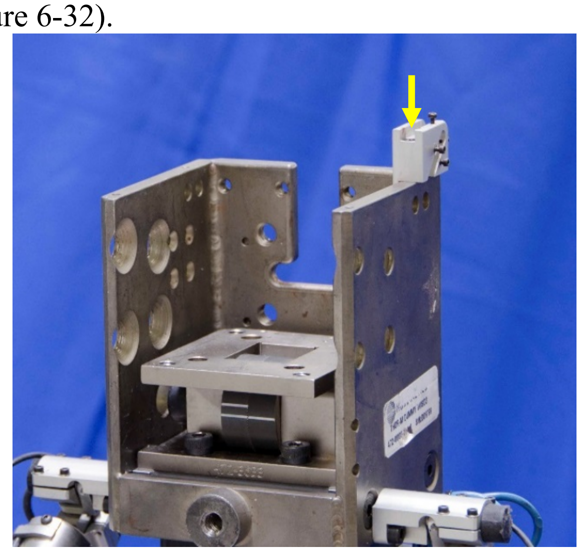


Figure 6-32. Secure T1 accelerometer mount assembly to upper spinebox

6.2.2.27 Mount the X-axis, Y-axis, and Z-axis accelerometers to the T1 Accelerometer Mount using two M1.4 x 0.3 x 3 SHCS (Figure 6-33) for each accelerometer.

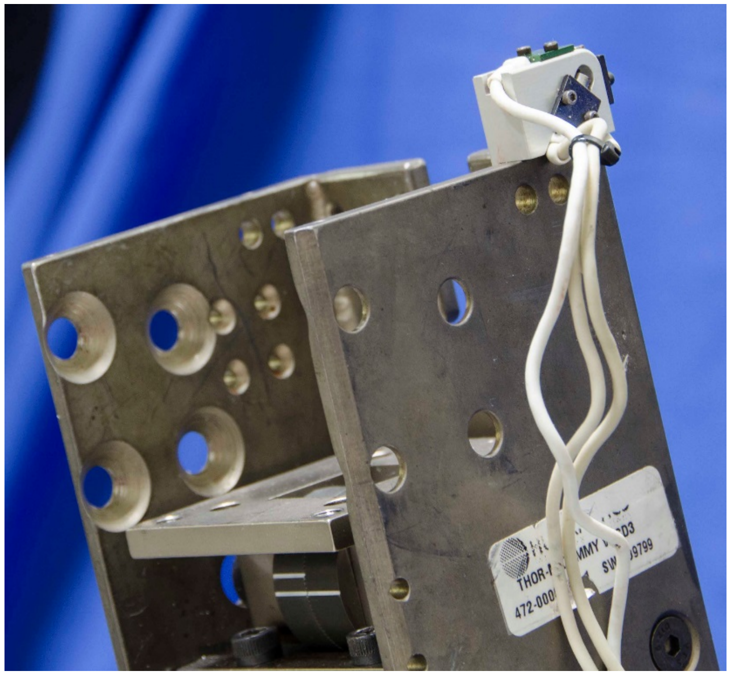


Figure 6-33. Install Z-axis accelerometer to T1 mount

6.2.2.28 Attach the shoulder to the dummy using four M8 x 1.25 x 12 FHCS (Figure 6-34 and Figure 6-35).

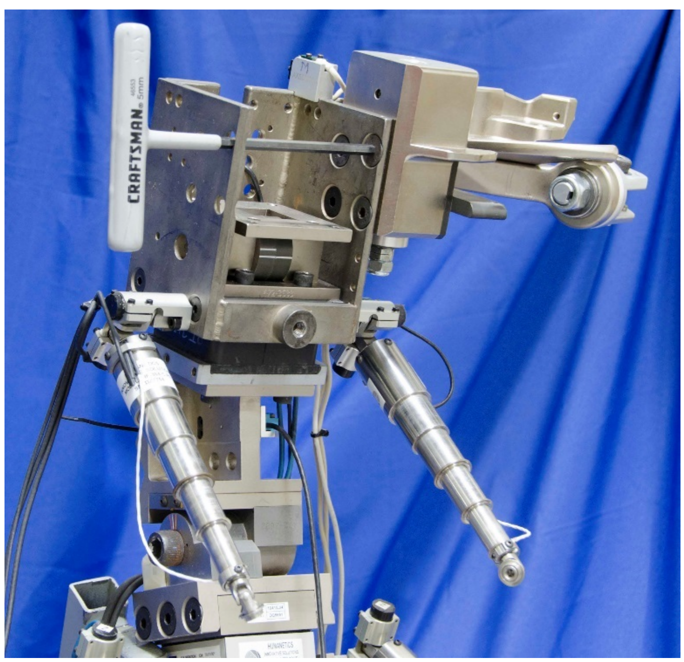


Figure 6-34. Install (left) shoulder to thorax

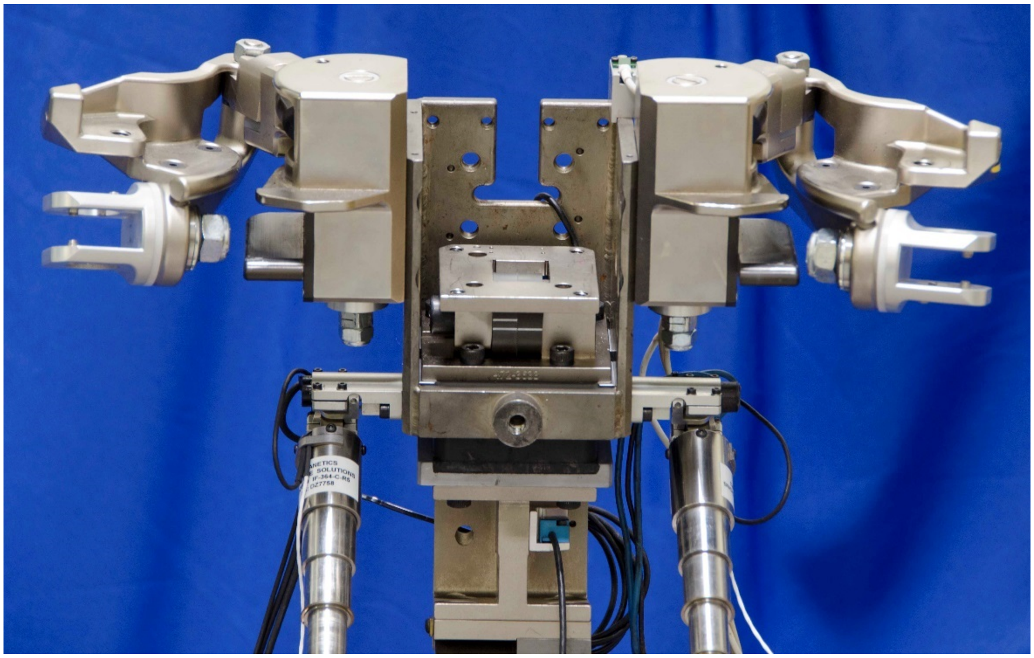


Figure 6-35. Shoulders installed

6.2.2.29 Place the Rod End Spacer Assembly (472-3880) onto the Left Hand Scapula (472-3830-1, Figure 7-3) (Figure 6-36 and Figure 6-37).

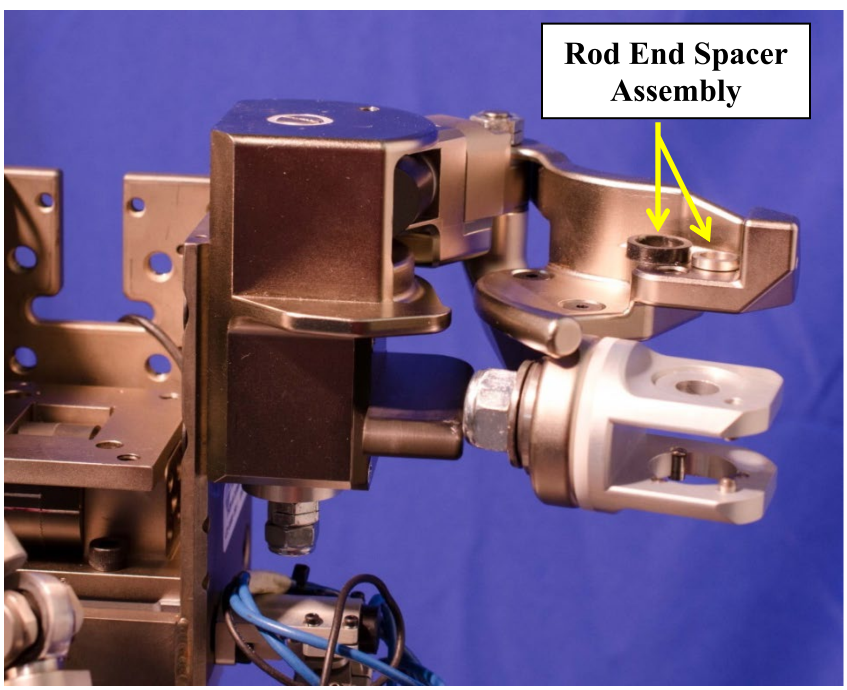


Figure 6-36. Placement of rod end spacer assembly on shoulder

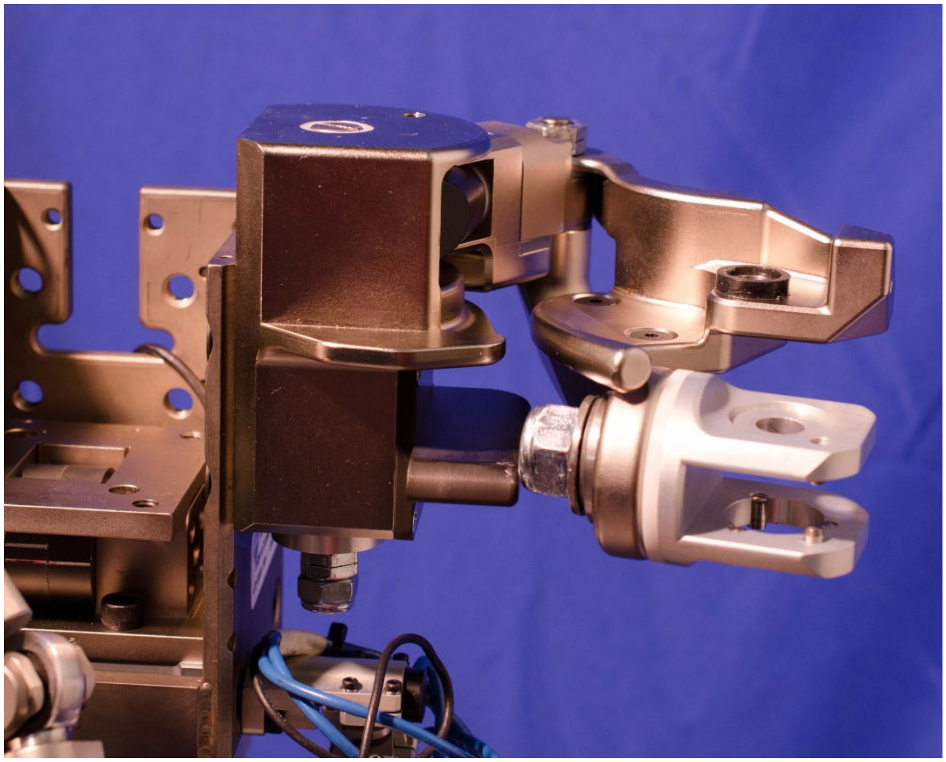


Figure 6-37. Rod end spacer installed on shoulder

6.2.2.30 Install the Shoulder Cover Bushing (472-3890) into the Left Shoulder Cover (472-3895-1) (Figure 6-38 and Figure 6-39).

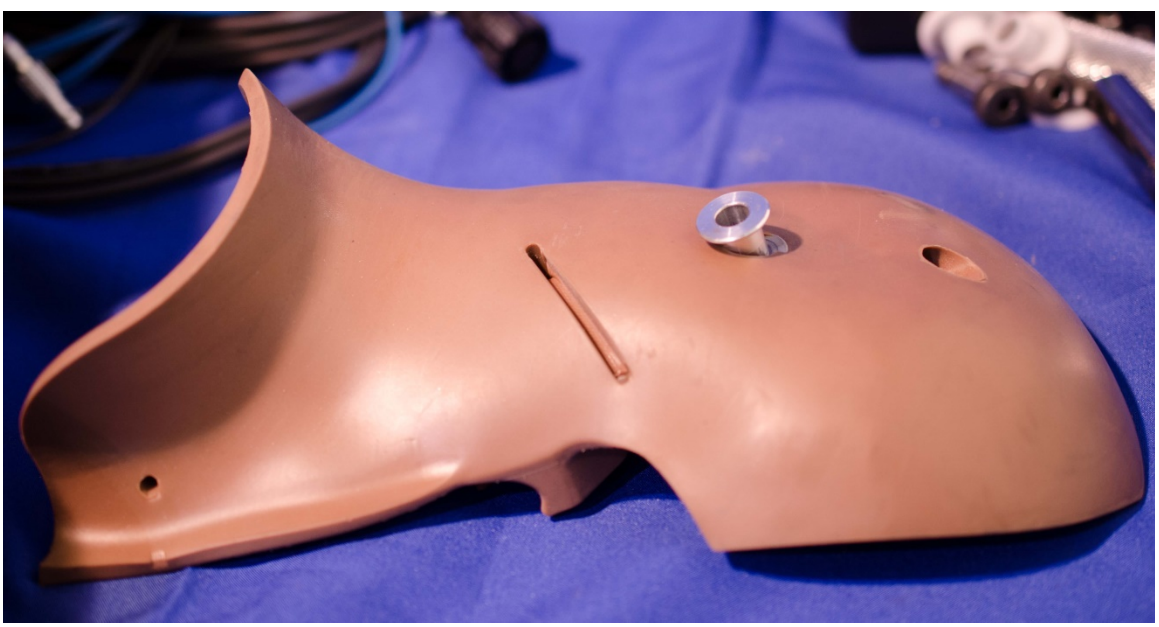


Figure 6-38. Install shoulder cover bushing

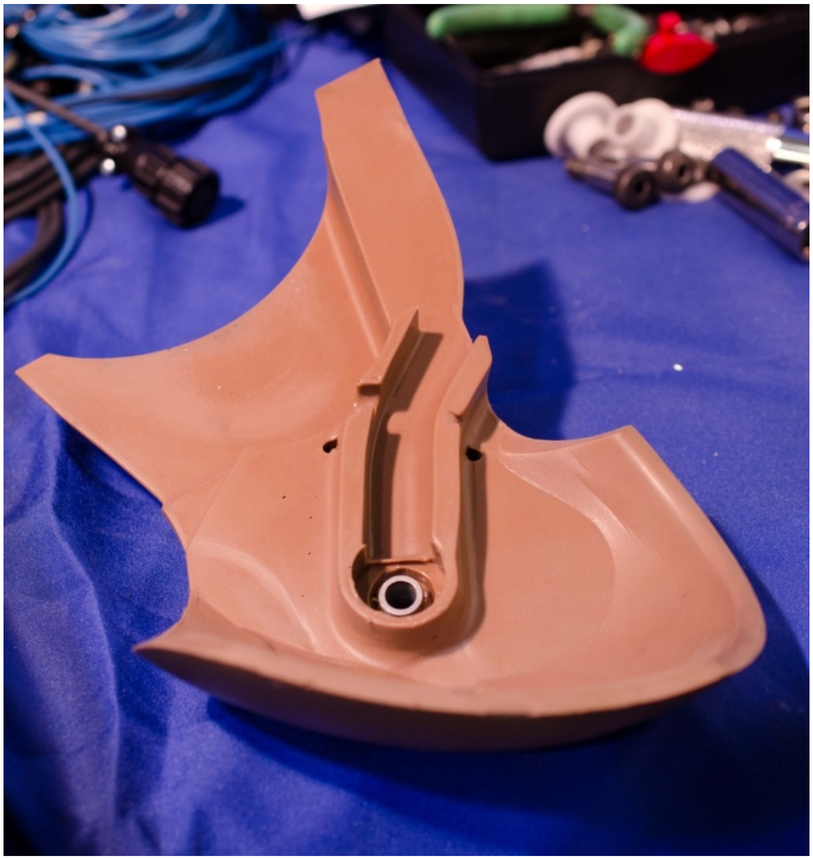


Figure 6-39. Underside view of installed shoulder cover bushing

6.2.2.31 Place the Left Clavicle Assembly (472-3850) into the underside of the Left Shoulder Cover (472-3895-1) (Figure 6-40). Use a tie wrap (approximately 4 mm wide and 210 mm long) to wrap around the clavicle through the shoulder cover. Insert the Modified M8 Bolt (472-3891) through the Shoulder Cover Bushing (472-3890).

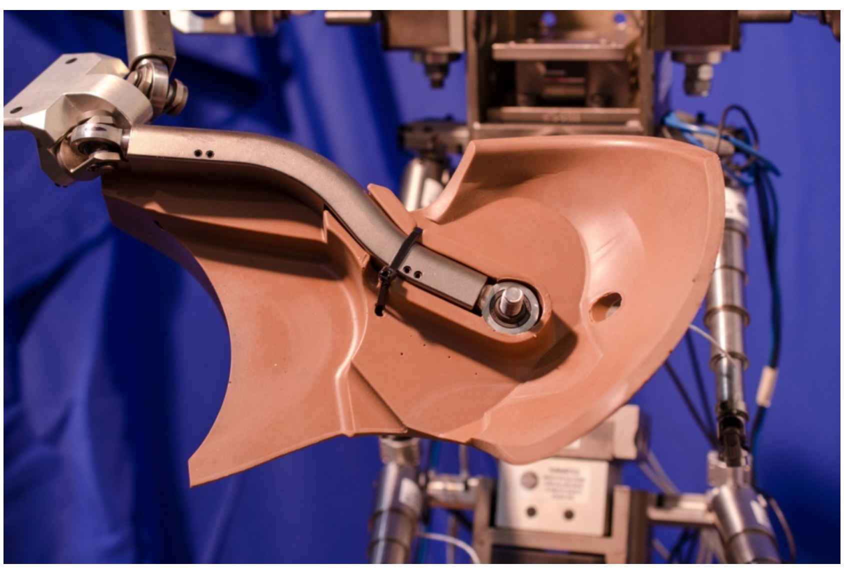


Figure 6-40. Install clavicle into underside of shoulder cover

6.2.2.32 Place the shoulder cover on top of the clavicle and rod end spacer assembly and secure with a modified M8 BHCS (Figure 6-41).

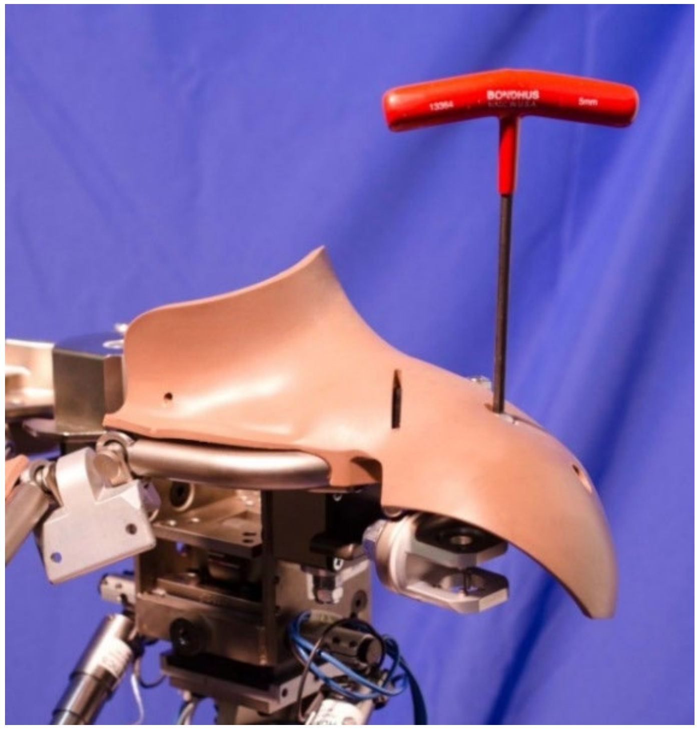


Figure 6-41. Secure shoulder cover to clavicle

6.2.2.33 Attach the Left Shoulder Pad Assembly (472-3120) using the modified shoulder screw for each pad (Figure 6-42). Repeat steps 6.2.2.29 to 6.2.2.32 for the right side.

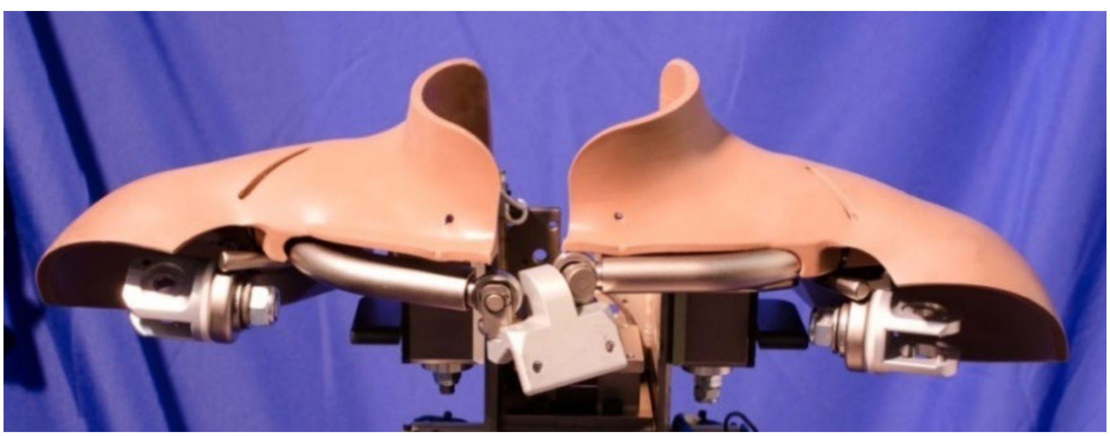


Figure 6-42. Attach shoulder pad assemblies

6.2.2.34 Install the Lower Abdomen Assembly (472-4700) to the pelvis (see Section 9.2.3).

6.2.2.35 Install the Upper Abdomen Assembly (472-4600) to the thorax (see Section 8.2.3).

6.2.2.36 Insert the Dummy Lifting Strap (472-3517) through the Lifting Strap Bracket (472-3115) (Figure 6-43).

Figure 6-43. THOR-50M lifting strap and mounting bracket

6.2.2.37 Install the two M5 x 0.8 x 10 BHCS through the lifting strap bracket into the Upper Thoracic Spine Box Weldment (472-3620) above the first rib (Figure 6-44). Attach the remainder of the individual ribs, numbered 2 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 1.2 x 10 BHCS per rib assembly for all ribs (Figure 6-44 and Table 6-6).

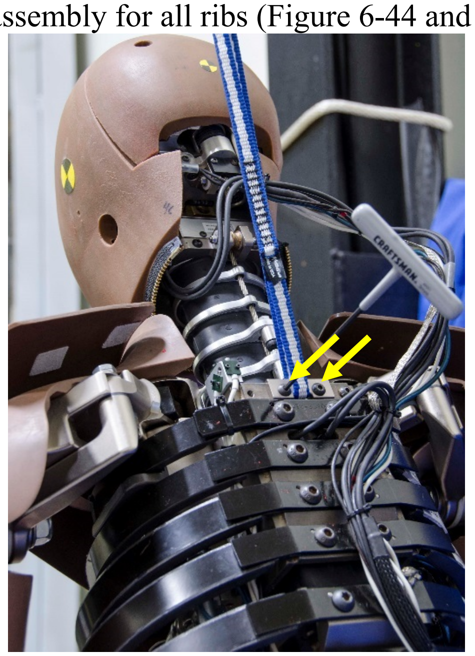


Figure 6-44. Install lifting strap bracket to upper thoracic spine box weldment

Table 6-6. Rib and Stiffener Part Number Summary

Rib Position	Rib Part Number	Stiffener Part Number	Attachment Screw
1	472-3310	472-3510	M8 x 1.2 x 10 BHCS
2	472-3320	472-3511	M8 x 1.2 x 10 BHCS
3	472-3330	472-3512	M8 x 1.2 x 10 BHCS
4	472-3340	472-3513	M8 x 1.2 x 10 BHCS
5	472-3350	472-3514	M8 x 1.2 x 10 BHCS
6	472-3360	472-3515	M8 x 1.2 x 10 BHCS
7	472-3370	472-3516	M8 x 1.2 x 10 BHCS

6.2.2.38 Assemble the two Sternum Mass Straps (472-3431) to the Mid-Sternum Bonding Assembly (472-3410) using M2.5 x0.45 x 8 SHCS and associated M2.5 plain zinc flat washers (Figure 6-45). There should be no pre-compression of the foams once assembly is complete.

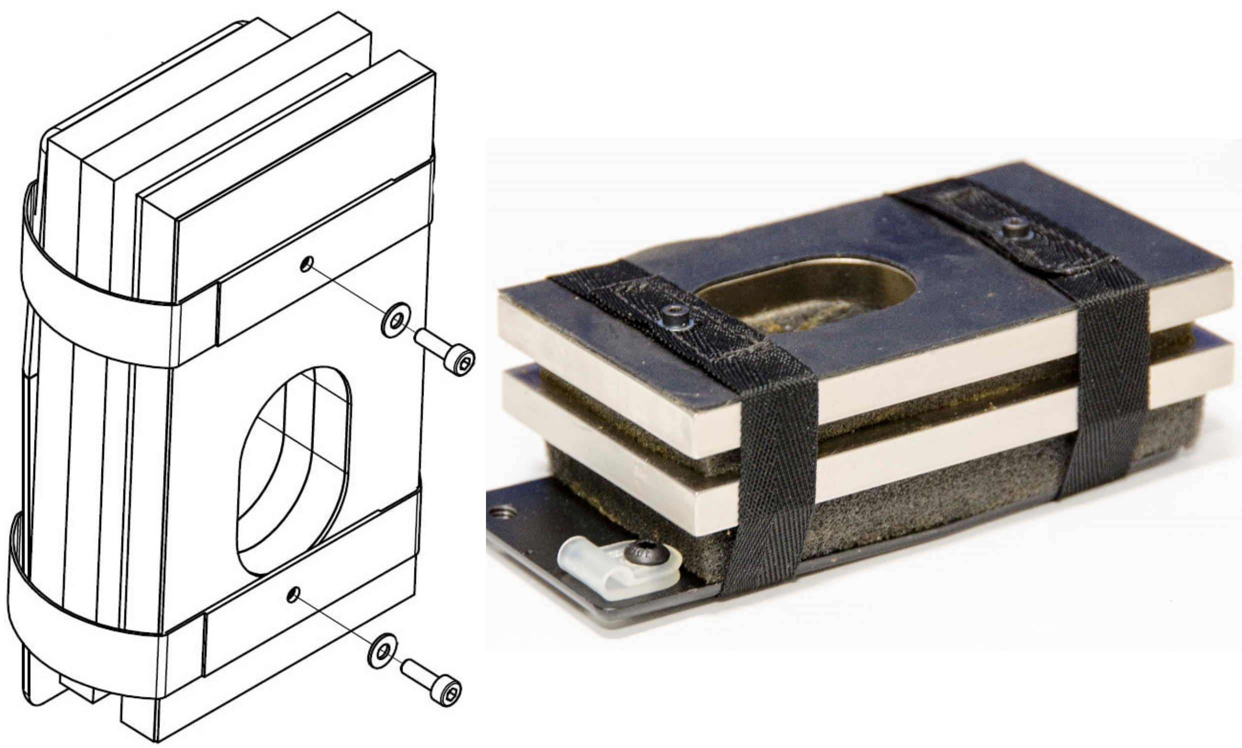


Figure 6-45. Attach sternum straps to the mid-sternum bonding assembly

6.2.2.39 Attach the Mid-Sternum Bonding Assembly (472-3410) to the Thorax Bib Assembly (472-3400) using four M5 x 0.8 x 10 BHCS with associated M5 x 15 x 1.2 washers (Figure 6-46). Install the screws through the front of the bib.

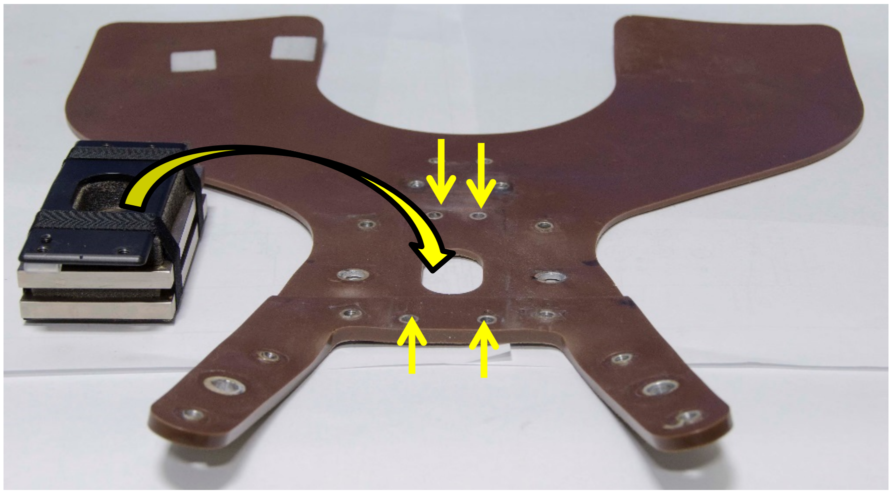


Figure 6-46. Attach mid-sternum mass assembly to bib

6.2.2.40 Install a uniaxial accelerometer to the sternum mass using two M1.4 x 0.3 x 3 SHCS (Figure 6-47).

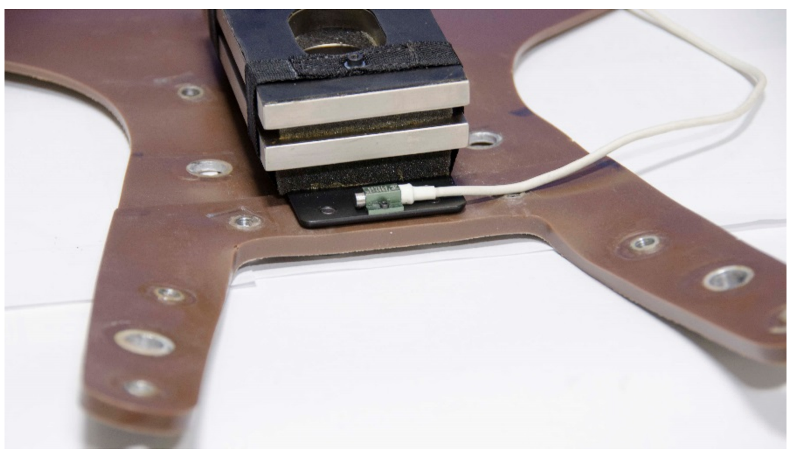


Figure 6-47. Install accelerometer to sternum mass

6.2.2.41 Route the accelerometer wire through the 1/8" Nylon Wire Clamp (9002655). Install the ground strap between the wire clamp and the sternum mass and secure with an M4 x 0.7 x 8 BHCS (Figure 6-48).

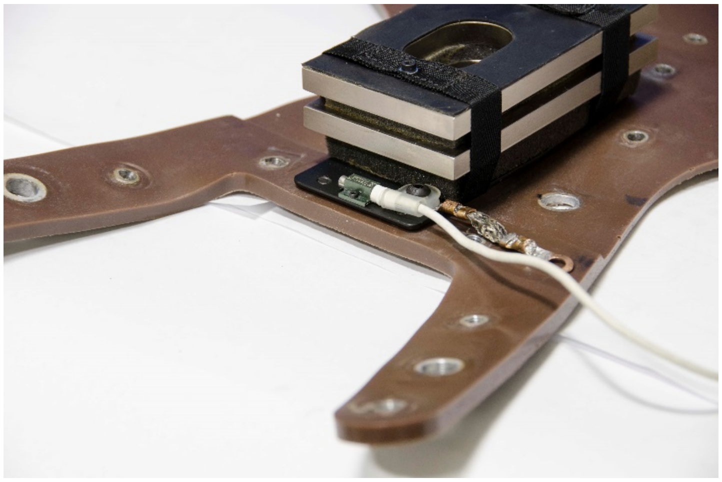


Figure 6-48. Install wire clamp with ground strap to sternum accelerometer

6.2.2.42 Install M5 Clip Nuts (5000513) to the ends of Rib #1 and slide into the Sternum Bracket (472-3870) (Figure 6-49).

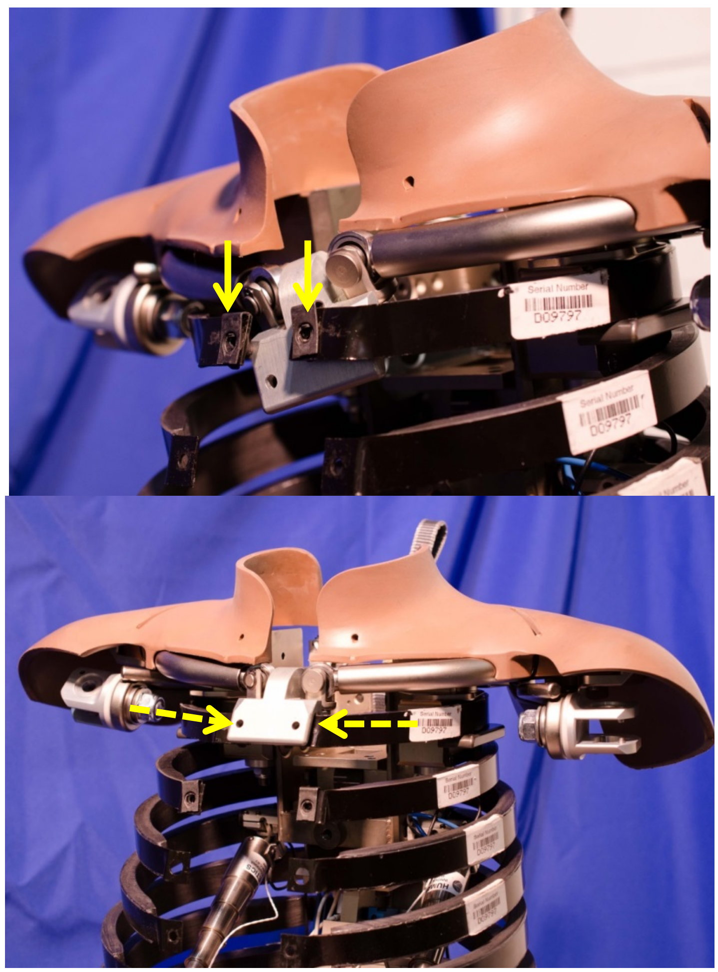


Figure 6-49. Install clip nuts on Rib #1 and slide into sternum bracket

6.2.2.43 The M5 x 15 x 1.2 flat washers and M5 x 0.8 x 22 BHCS should initially be loosely installed into the sternum bracket in order to ease alignment of the remaining ribs (Figure 6-50).

Figure 6-50. Install Rib #1 at sternum

6.2.2.44 Install M5 clip nuts on the ends of Rib #2. Insert the M5 x 15 x 1.2 flat washers and M5 x 0.8 x 12 BHCS through the rib ends and loosely tighten (Figure 6-51).

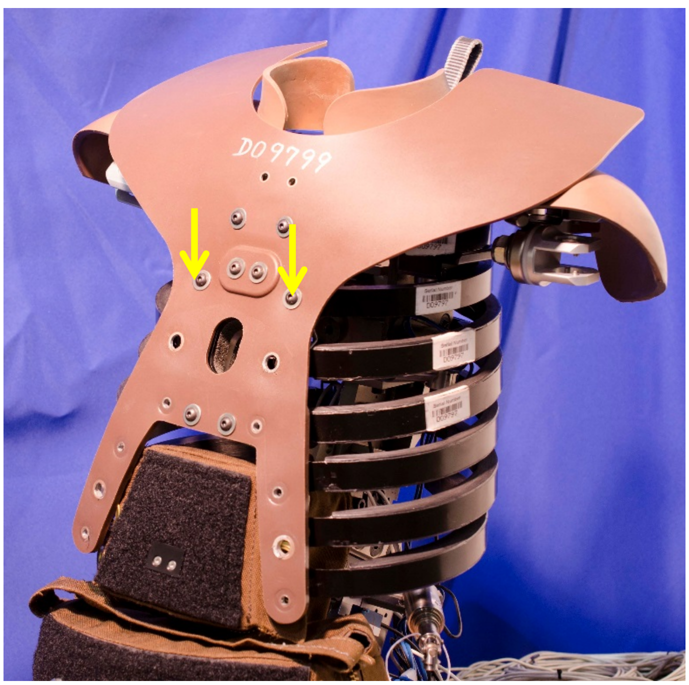


Figure 6-51. Install Rib #2 at sternum

6.2.2.45 To attach Rib #3, no clip nut is utilized. Instead, loosely secure an Upper Thorax IR-TRACC Connecting Bolt (472-3518) through an M5 x 15 x 1.2 flat washer and into the end of each upper IR-TRACC assembly (Figure 6-52). Ensure that the wire that attaches the two ends of the IR-TRACC is aligned in the same plane at each end. The pins in the universal joints where the thorax IR-TRACCs attach to the bib should be configured vertically and horizontally to prevent binding (Figure 6-53 and Figure 6-54).

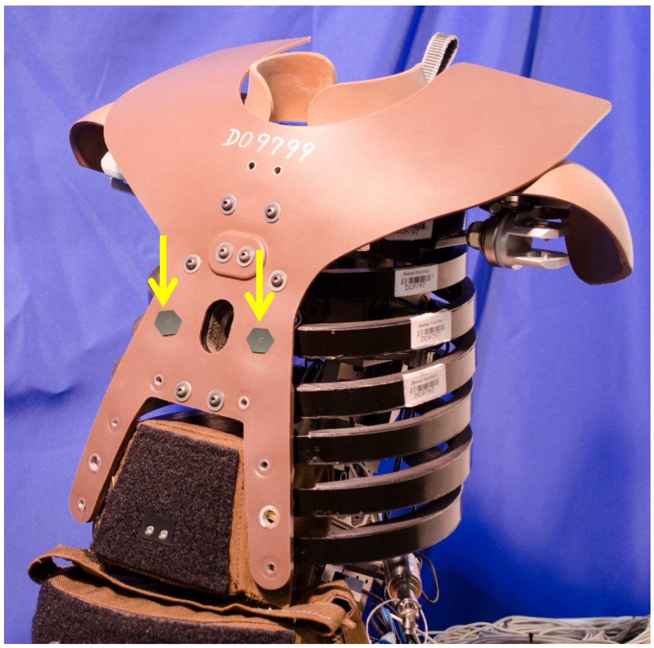


Figure 6-52. Install Rib #3 at sternum

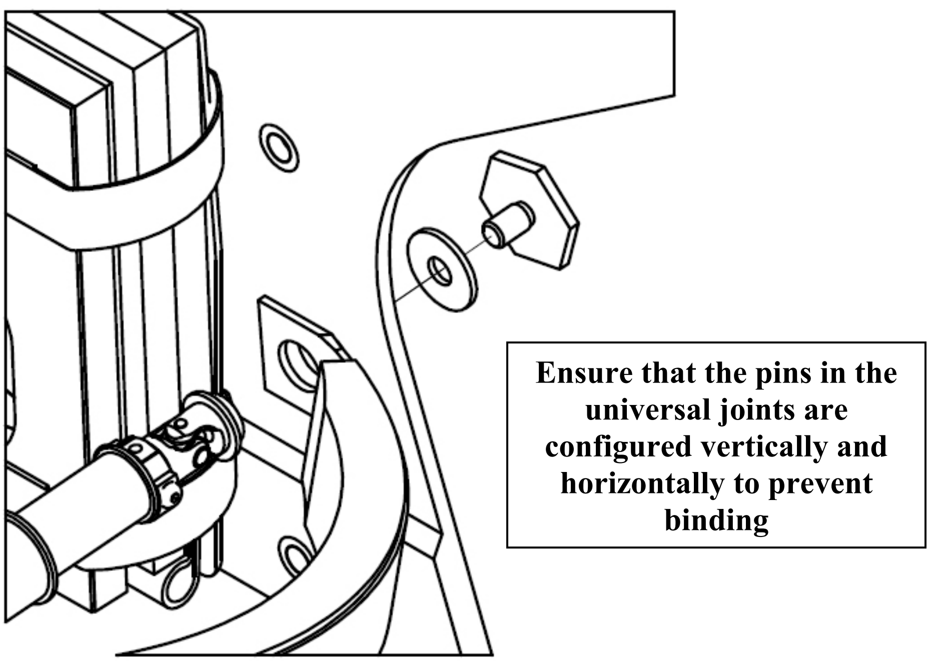


Figure 6-53. Details of universal joint for IR-TRACCs

Figure 6-54. Rib attachment for IR-TRACC

6.2.2.46 To attach Rib #4, install M5 clip nuts on both rib ends. The ground strap for the sternum mass (Section 6.2.2.41) should be between the bib and the rib. Loosely secure the rib to the bib using M5 x 15 x 1.2 flat washers and M5 x 0.8 x 20 BHCS (Figure 6-55).

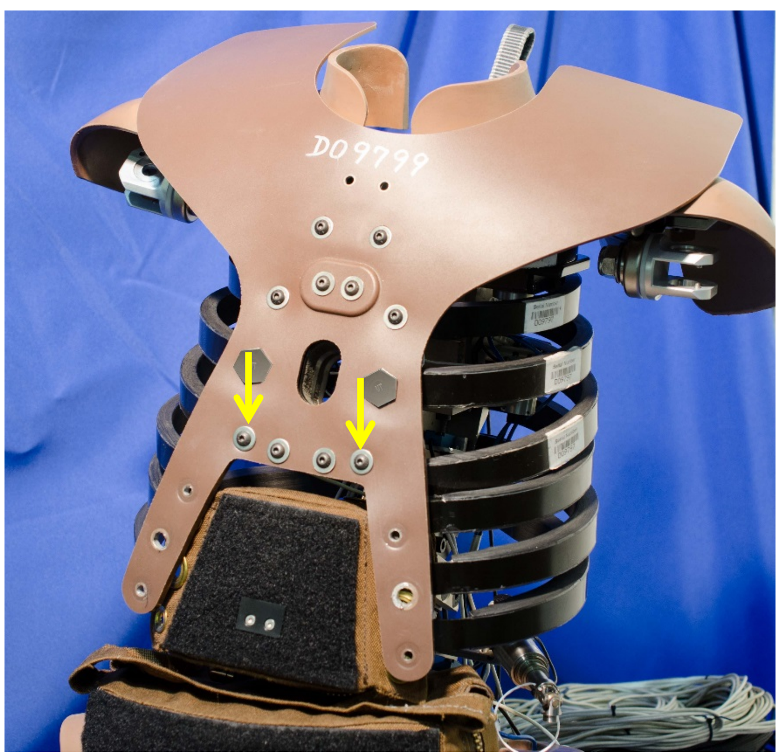


Figure 6-55. Install Rib #4 at sternum

6.2.2.47 To attach Rib #5, install M5 clip nuts on both rib ends. The top grommet of the Upper Abdomen Bag should be between the bib and the rib. Loosely secure the rib to the bib using M5 x 15 x 1.2 flat washers and M5 x 0.8 x 20 BHCS (Figure 6-56).

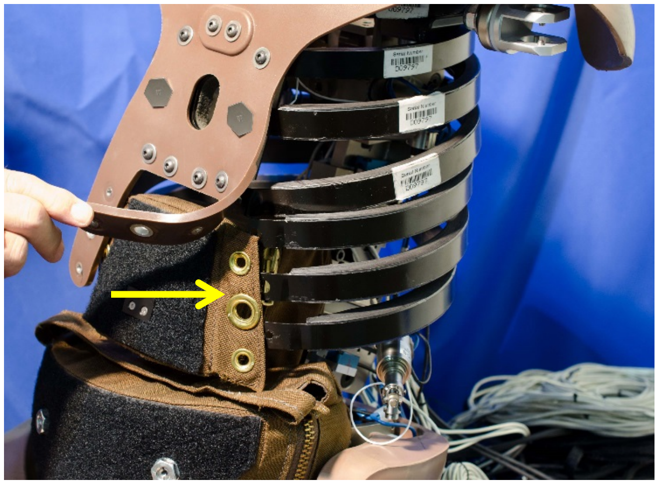


Figure 6-56. Install Rib #5 at sternum

6.2.2.48 To attach Rib #6, no clip nut is utilized. Instead, loosely secure a Lower Thorax IR-TRACC Connecting Bolt (472-3520) through an M5 x 15 x 1.2 flat washer and into the end of each lower IR-TRACC assembly (Figure 6-57). The middle grommet of the Upper Abdomen Bag should be between the bib and the rib. Ensure that the wire that attaches the two ends of the IR-TRACC is aligned in the same plane at each end. The pins in the universal joints where the thorax IR-TRACCs attach to the bib should be configured vertically and horizontally to prevent binding (See photos in Section 6.2.2.45).

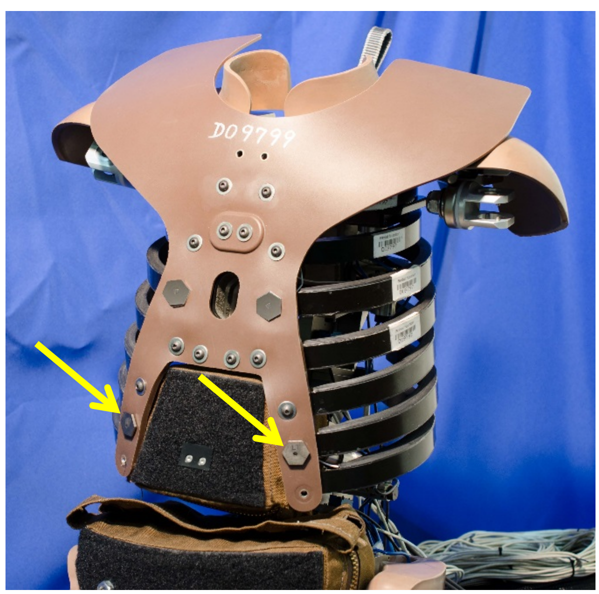


Figure 6-57. Install Rib #6 at sternum

6.2.2.49 To attach Rib #7, install M5 clip nuts on both rib ends. The bottom grommet of the Upper Abdomen Bag should be between the bib and the rib. Loosely secure the rib to the bib using M5 x 15 x 1.2 flat washers and M5 x 0.8 x 20 BHCS (Figure 6-58).

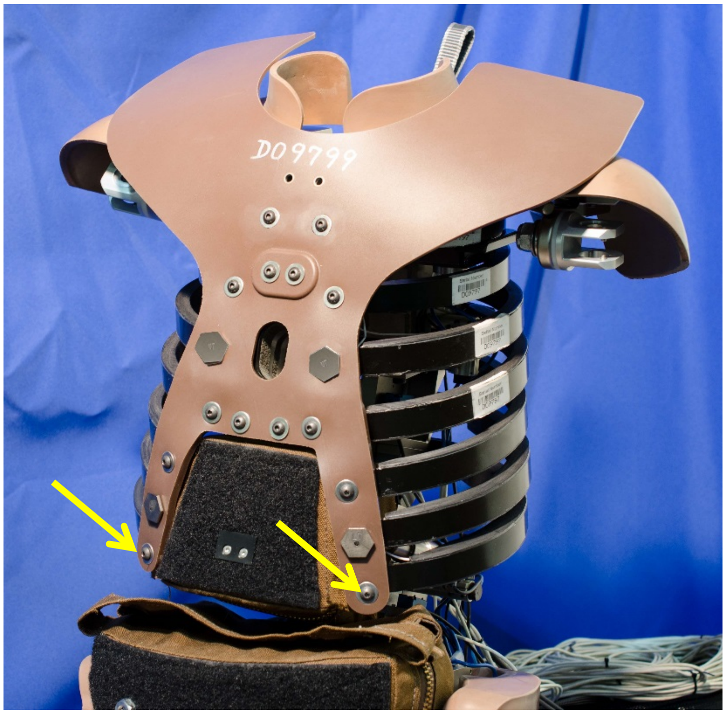


Figure 6-58. Install Rib #7 at sternum

6.2.2.50 Securely tighten all rib screws in Sections 6.2.2.43 through 6.2.2.49.

6.2.2.51 Install the Lower Abdomen Assembly (472-4700) on to the Lower Thoracic Spine Assembly (472-3650), beneath the Thorax Accelerometer Tri-Pack, using two M10 x 25 FHCS.

6.2.2.52 Install the Upper Abdomen Assembly (472-4600) on to the Lower Thoracic Spine Assembly (472-3650) using two M8 x 25 FHCS.

6.3 Electrical Connections and Requirements

Section 15.3 includes grounding information. Section 15.4.2 describes cable routing instructions.

6.4 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the thorax, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

6.4.1 **Electrical Inspections (Instrumentation Check)**

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the thorax instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief (see Section 15.4.2).

Specific electrical areas to examine:

- Check the security of all thorax instrumentation mounting bolts.
- Ensure that the wire that attaches the two ends of each IR-TRACC is aligned in the same plane at each end (Section 6.2.2.45)
- Inspect the set-screws locking the rotary potentiometer shafts in place on the 3D IR-TRACC assemblies. If the set-screws are loose, re-tighten. Inspect the IR-TRACC and potentiometer wiring for physical damage including broken connectors, pinched wires, missing insulation, etc. Repair the wiring or replace the IR-TRACC unit if necessary. There are no user-serviceable parts in the IR-TRACC unit itself. Return the IR-TRACC sensor to the manufacturer for repair or replacement.

6.4.2 Mechanical Inspection

Several components in the thorax assembly require inspection post-test.

Specific mechanical areas to examine:

- Check each rib end of the damping material for delamination, particularly near the stiffeners and the attachment point near the sternum. If delaminated, the ribs may be re-bonded with glue (check with manufacturer for specifics) or sent back to the manufacturer for repair.
- Check each rib's damping material for cracking. Replace any ribs with cracks in the damping material.
- Check rib steel for deformation (spine attachment, sides and bib attachment). Inspect in the X, Y, and Z directions using drawings as a comparison reference. Scuffs or small indents in the damping material are acceptable, however if the ribs are bent or delaminated they should be replaced.
- Check rib stiffeners for bending. There should not be any visible gaps between the ribs and the rib stiffeners.
- Check bib at all bolt locations for tearing/washer penetration of the Thorax Bib Assembly (472-3400). Repair or replace the bib assembly as necessary.
- Check Mid-Sternum Plate (472-3413) for excessive bending using the drawings as a reference. Replace the Mid-Sternum Bonding Assembly (472-3410) if it is bent.
- Ensure that the Mid-Sternum Mass Damping Foam #1 (472-3414) and Mid-Sternum Mass Damping Foam #2 (472-3412) are not torn or debonding from the steel plates. Check with the manufacturer for glue recommendations for re-bonding. If the foam is torn, replace the Mid-Sternum Bonding Assembly (472-3410)
- Inspect the telescoping column of each IR-TRACC for structural damage which might inhibit the movement (extension and retraction) of the telescoping column.
- Ensure that the pins in the universal joints where the thorax IR-TRACCs attach to the bib are configured vertically and horizontally to prevent binding.
- Inspect the rotary potentiometers and brackets in the 3D IR-TRACC assembly for damage. Replace or repair the rotary potentiometers if necessary.

  NOTE: There are no user serviceable parts in the IR-TRACC unit. The IR-TRACC sensor should be returned to the manufacturer for repair or replacement.

Section 7. **Shoulder Assembly**

7.1 Description of Shoulder Assembly and Features

The shoulder assembly for the THOR-50M dummy includes the mechanical components to connect the arms to the spine and thorax assemblies (Figure 7-1). A primary goal of the shoulder assembly includes providing a human-like interaction between the shoulder belt restraint and the dummy. As such, the shoulder design resembles the geometry and motion of the human shoulder/clavicle complex. An integrated shoulder pad conforms closely to the human shoulder geometry. A separate human-like clavicle linkage provides a more biofidelic interaction between the shoulder assembly and seat belt restraint systems. The clavicle loads the sternum and ribcage directly to produce more human-like loading conditions. The shoulder joint and linkage provides fore and aft, as well as "shrugging" motions similar to the human shoulder joint. Soft stops limit the range of motion to meet specifications on human range of motion. The shoulder assembly design for THOR-50M accepts a redesigned upper arm and the standard Hybrid III 50% male dummy lower arms.

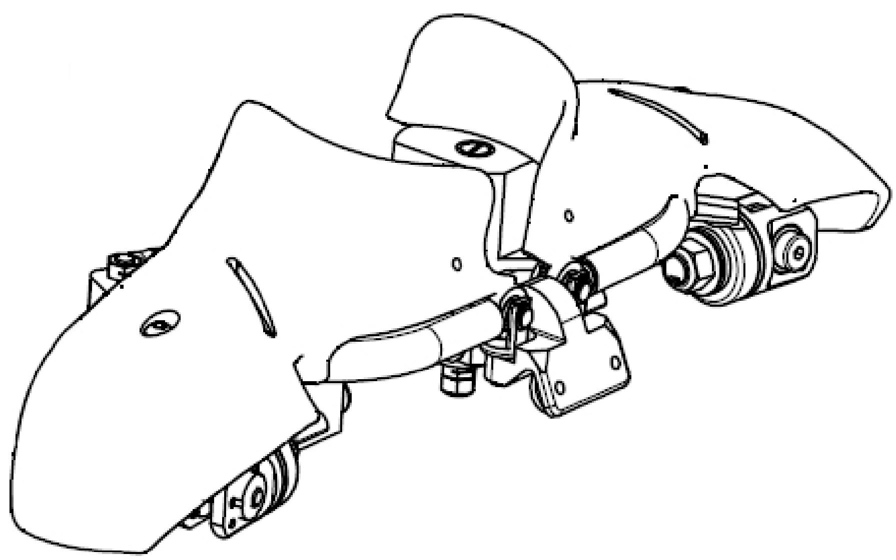


Figure 7-1. Shoulder assembly

7.2 Assembly of Shoulder

7.2.1 Parts List

Figure 7-2 through Figure 7-6 show assemblies and hardware for the shoulder. Table 7-1 though Table 7-5 lists the components that are included in the shoulder assembly.

Table 7-1. Shoulder Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Left Shoulder Assembly	1	472-3810	Figure 7-2	1
Right Shoulder Assembly	1	472-3840	Figure 7-2	2
Left Clavicle Assembly	1	472-3850	Figure 7-2	3
Right Clavicle Assembly	1	472-3860	Figure 7-2	4
Sternum Bracket	1	472-3870	Figure 7-2	5
Rod End Spacer Assembly	2	472-3880	Figure 7-2	6
Shoulder Cover Bushing	2	472-3890	Figure 7-2	7
Modified M8 Bolt	2	472-3891	Figure 7-2	8
Left Shoulder Cover	1	472-3895-1	Figure 7-2	9
Right Shoulder Cover	1	472-3895-2	Figure 7-2	10
Rubber Spacer Washer	2	472-3898	Figure 7-2	11
Screw, FHCS M8 x 1.25 x 12	8	5001090	Figure 7-2	12

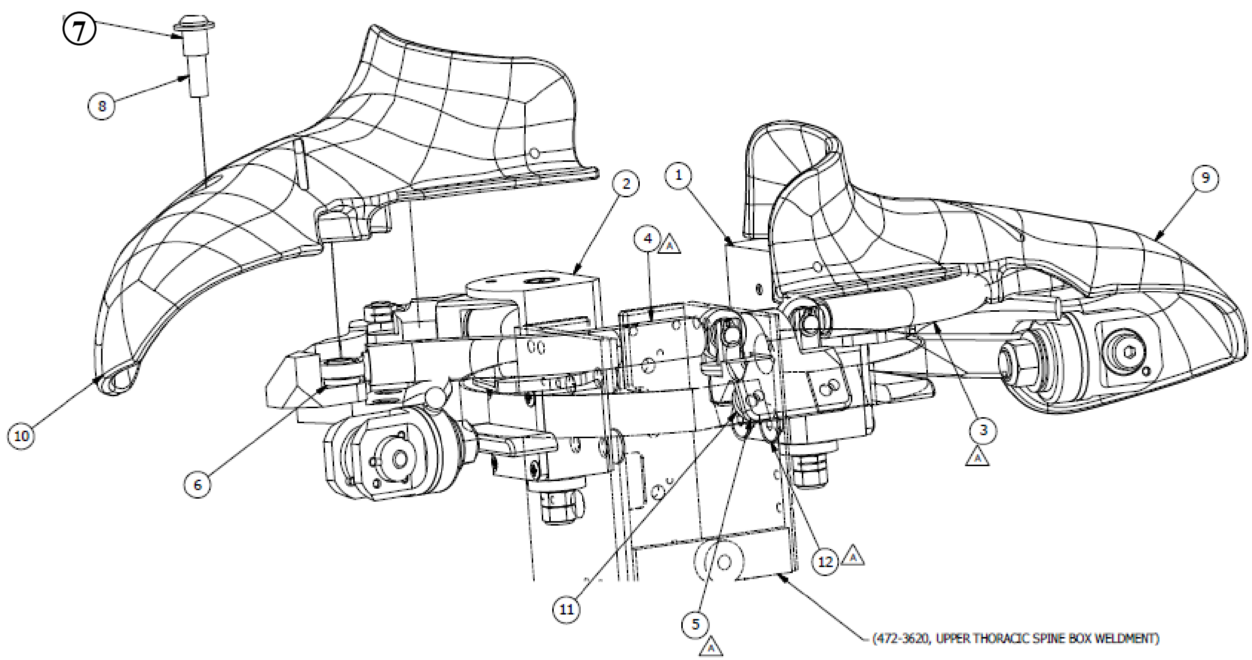


Figure 7-2. Shoulder assembly components

Table 7-2. Left Shoulder Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Left Shoulder Pivot Assembly	1	472-3811	Figure 7-3	1
Left Arm Link	1	472-3829-1	Figure 7-3	2
Washer Link, 18 x 8 x 1.5	1	472-3818	Figure 7-3	3
Screw, FHCS M5 x 0.8 x 16	2	5000467	Figure 7-3	4
Left Scapula	1	472-3830-1	Figure 7-3	5
Locknut, M8 x 1.25, SNEP #ESN H100	1	5001164V	Figure 7-3	6
Arm Clevis Assembly	1	472-3831	Figure 7-3	7

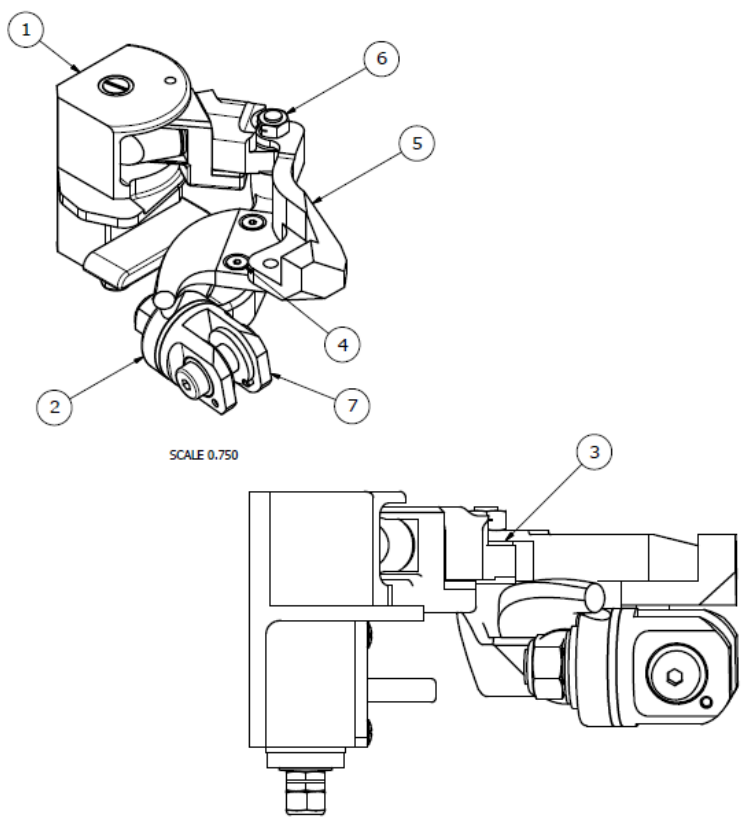


Figure 7-3. Left shoulder assembly components

Table 7-3. Left Shoulder Pivot Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Left Spring Housing Cover	1	472-3812-1	Figure 7-4	1
Left Shoulder Support Assembly	1	472-3813-1	Figure 7-4	2
Upper Spring Housing Bushing	1	472-3822	Figure 7-4	3
Lower Spring Housing Bushing	2	472-3823	Figure 7-4	4
Spring Disc Washer, 20 x 8.2 x 1.0	1	5001170V	Figure 7-4	5
Spring Shaft	1	472-3824	Figure 7-4	6
Roll Pin, M3 x 24	1	5000140	Figure 7-4	7
Lower Spring Housing Washer	1	472-3825	Figure 7-4	8
Washer	1	472-3826	Figure 7-4	9
Spring	1	472-3827	Figure 7-4	10
Left Lower Rib Guide	1	472-3828-1	Figure 7-4	11
Screw, FHMS M4 x 0.7 x 8 Phillips	4	5000699	Figure 7-4	12
Screw, SSFP M4 x 12	2	5000292V	Figure 7-4	13
Locknut, M8 x 1.25, SNEP #ESN H100	1	5001164V	Figure 7-4	14
Nylock, M8 x 1.25	1	5001165V	Figure 7-4	15

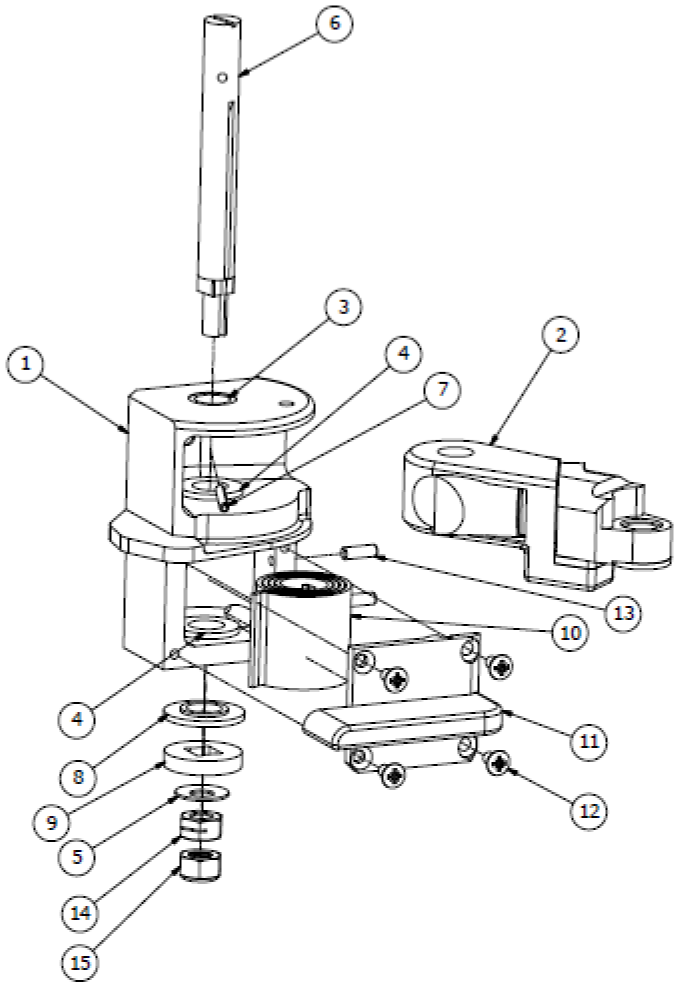


Figure 7-4. Left shoulder pivot assembly components

Table 7-4. Left Shoulder Support Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Left Shoulder Support	1	472-3814-1	Figure 7-5	1
Left Shoulder Support Pivot	1	472-3815-1	Figure 7-5	2
Forward ROM Buffer	1	472-3816	Figure 7-5	3
Lower Left Buffer	1	472-3817-1	Figure 7-5	4
Flange Bearing, 14OD x 20FL x 10ID x 12LG	1	5001168V	Figure 7-5	5
Washer Link, 18 x 8 x 1.5	1	472-3818	Figure 7-5	6
Spring Disc Washer, 20 x 8.2 x 1.0	1	5001170V	Figure 7-5	7
Rear Rom Buffer	1	472-3819	Figure 7-5	8
Vertical Buffer	1	472-3820	Figure 7-5	9
Screw, FHCS, M3 x 0.5 x 8	1	5000116	Figure 7-5	10
Bearing, IGLIDUR 14 x 10 x 10LG	1	5001168V	Figure 7-5	11
Link Washer, 23 x 14.2 x 1.5	1	472-3821	Figure 7-5	12
Locknut, M8 x 1.25, SNEP #ESN H100	1	5001164V	Figure 7-5	13

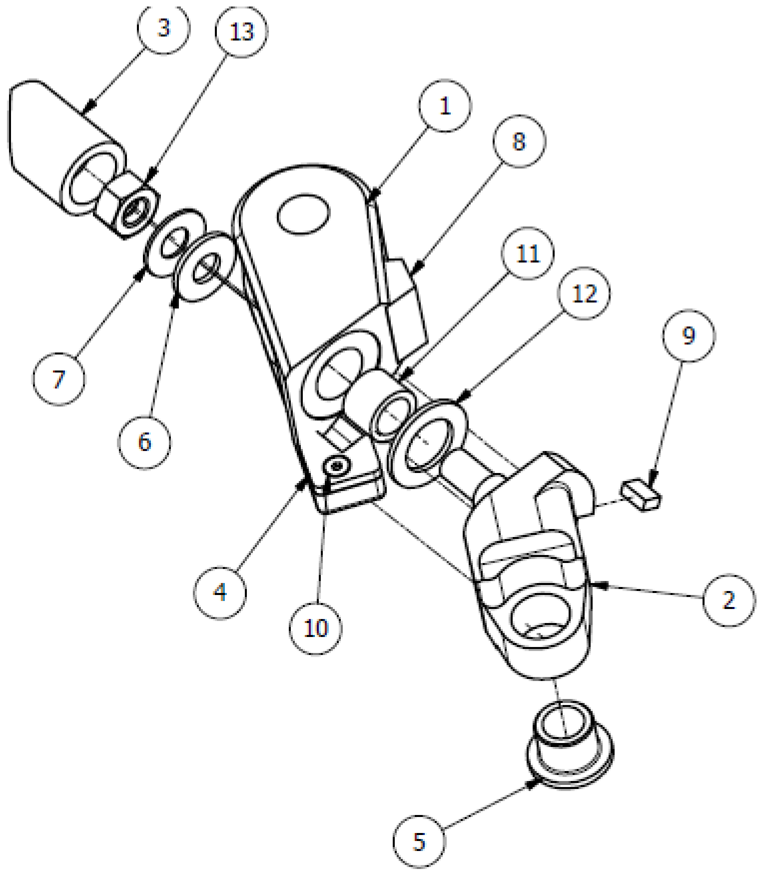


Figure 7-5. (Left) shoulder support assembly components

Table 7-5. Arm Clevis Assembly Components

Part Description	**Quantity**	**Part Number**	**Figure #**	**Item #**
Arm Clevis	1	472-3832	Figure 7-6	1
Pin, Dowel M4 x 6	3	5000680	Figure 7-6	2
Pin, Dowel M4 x 8	2	5000524	Figure 7-6	3
Nut, Upper Arm Pivot	1	472-3833	Figure 7-6	4
Washer, Upper Arm	1	472-3834	Figure 7-6	5
Bushing, Upper Arm	1	472-3837	Figure 7-6	6
Bushing, Arm Pivot	1	472-3836	Figure 7-6	7
Washer, Arm Clevis	1	472-3837	Figure 7-6	8
Disc Spring Washer, 20 x 10.2 x 1.1	1	5000763V	Figure 7-6	9
Disc Spring Washer, 25 x12.2 x 1.25	1	5000764V	Figure 7-6	10
Tabbed Washer	1	472-3838	Figure 7-6	11
Locknut, Nylon, M12 x 1.75	1	5010638	Figure 7-6	12
Screw, SHSS M10 x 20mm LG	1	5001172V	Figure 7-6	13

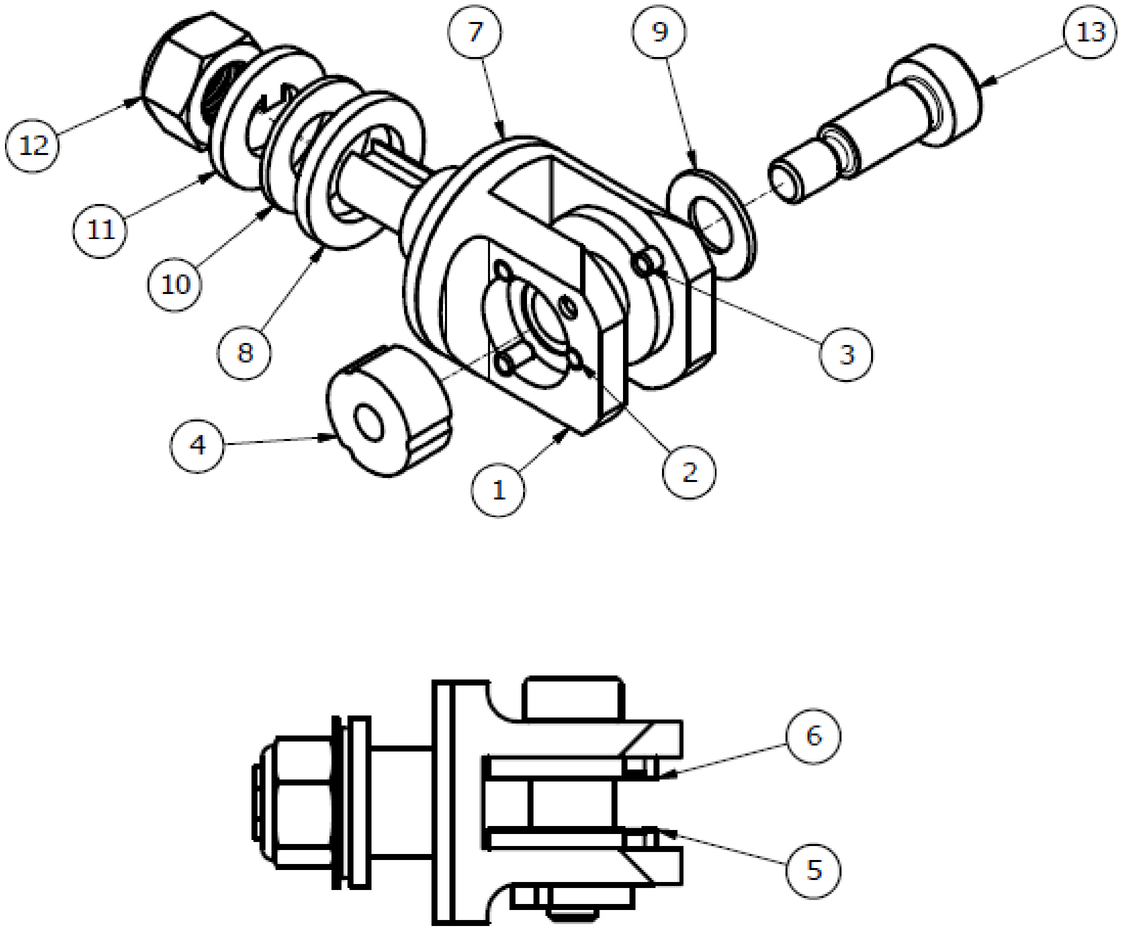
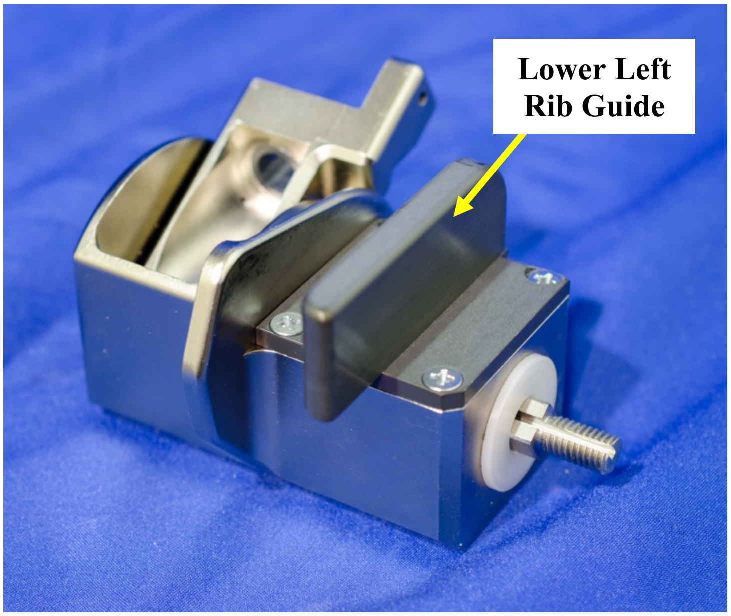


Figure 7-6. Arm clevis assembly components

7.2.2 Assembly of Shoulder Components

The following procedure is a step-by-step description of the assembly procedure for the shoulder components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

7.2.2.1 Install the Lower Left Rib Guide (472-3828-1) to the Left Spring Housing Cover (472-3812-1) using four M4 x 0.7 x 8 Phillips screws (Figure 7-7).



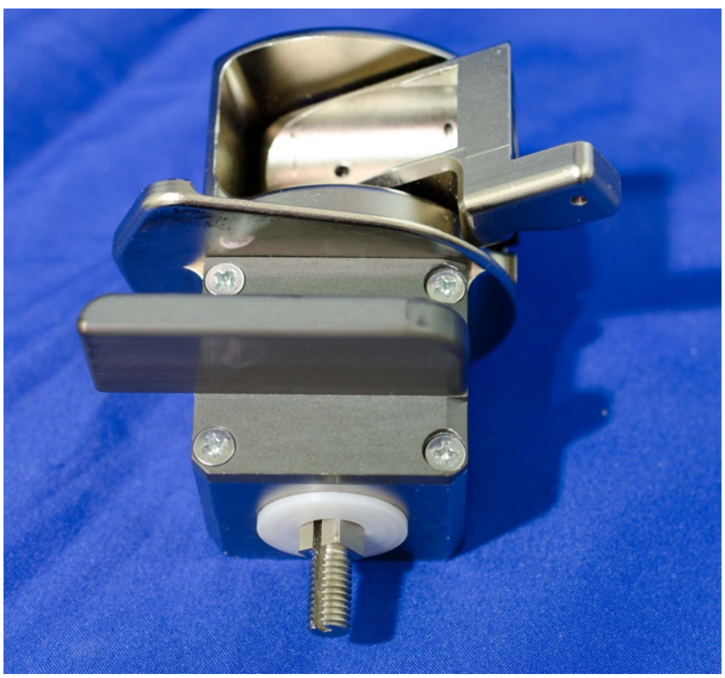


Figure 7-7. Install lower rib guide

7.2.2.2 Install the Lower Left Buffer (472-3817-1) using one M3 x 0.5 x 8 FHCS (Figure 7-8).

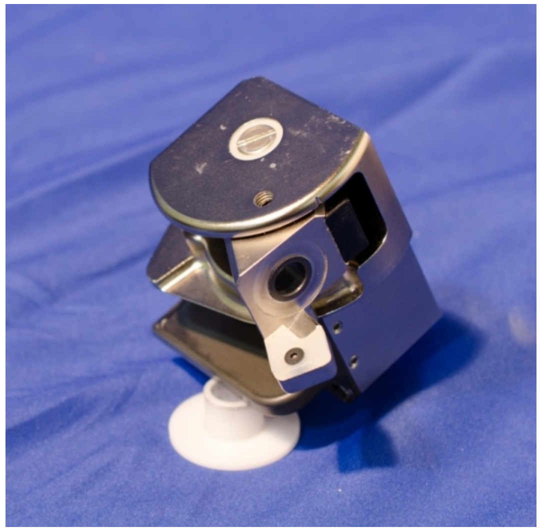


Figure 7-8. Install lower left buffer

7.2.2.3 Assemble the 23 x 14.2 x 1.5 link washer (472-3821) over the threaded portion of the Shoulder Support Pivot (472-3815-1) (Figure 7-9).

Figure 7-9. Assemble link washer on shoulder support pivot

7.2.2.4 Assemble the Left Shoulder Support Pivot (472-3815-1) into the Left Shoulder Support (472-3814-1). Install the 18 x 8 x 1.5 Washer Link (472-3818), the 20 x 8.2 x 1.0 spring disc washer, and M8 x 1.25 locknut (SNEP #ESN H100) onto the threaded shaft of the shoulder support pivot (Figure 7-10).

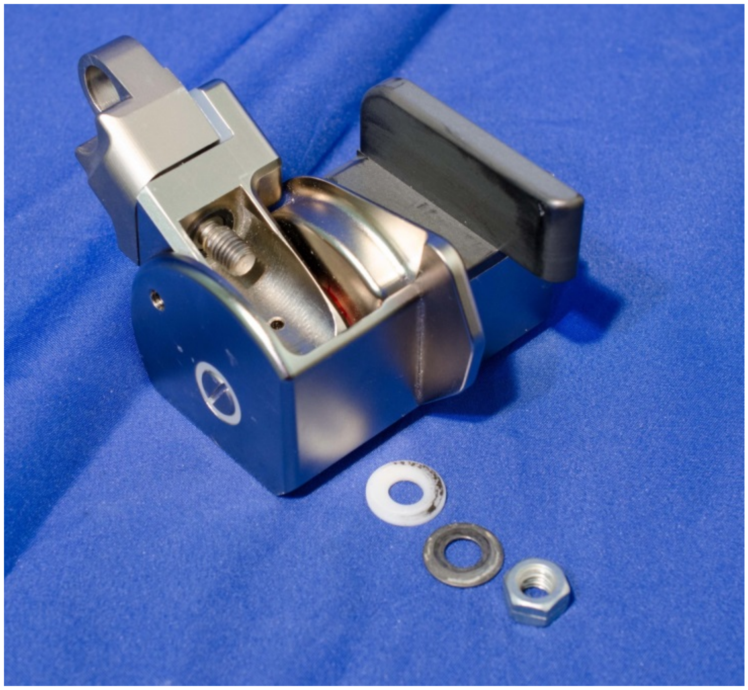


Figure 7-10. Assemble shoulder support pivot into shoulder support

7.2.2.5 Install the Forward ROM Buffer (472-3816) (Figure 7-11).

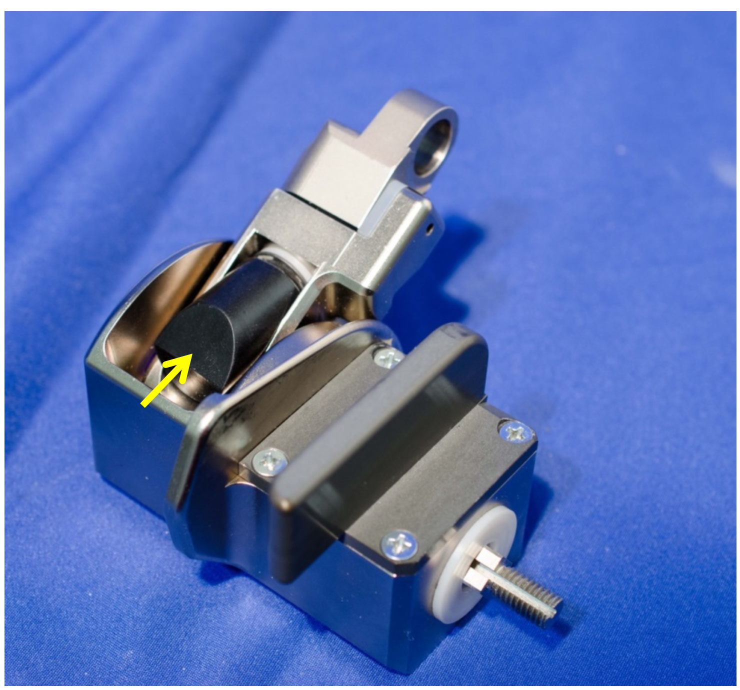


Figure 7-11. Install forward ROM buffer

7.2.2.6 Insert the Flange Bearing (14OD x 20FL x 10ID x 12LG) into the shoulder support pivot hole (Figure 7-12).

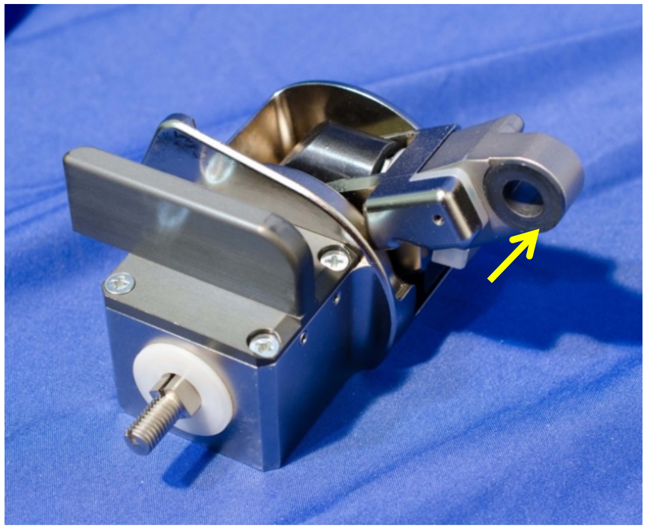


Figure 7-12. Install flange bearing into shoulder support pivot

7.2.2.7 Install Lower Spring Housing Washer (472-3825), Washer (472-3826), shaft washers and nuts (Figure 7-13).

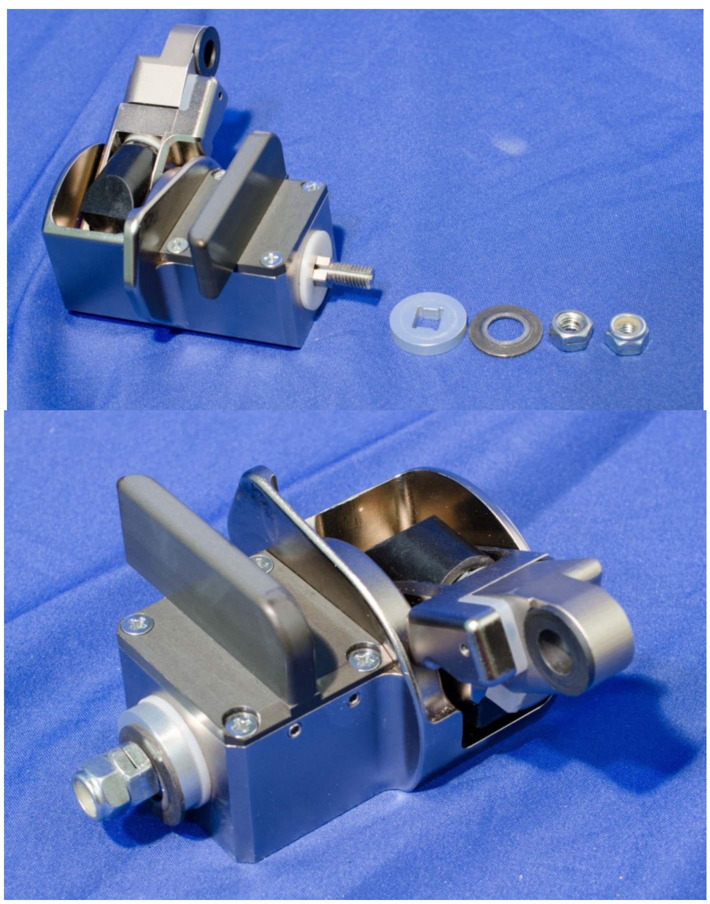


Figure 7-13. Install washers and nut for shoulder

7.2.2.8 Insert the shaft of the Left Arm Link (472-3829-1) into the shoulder assembly (Figure 7-14).

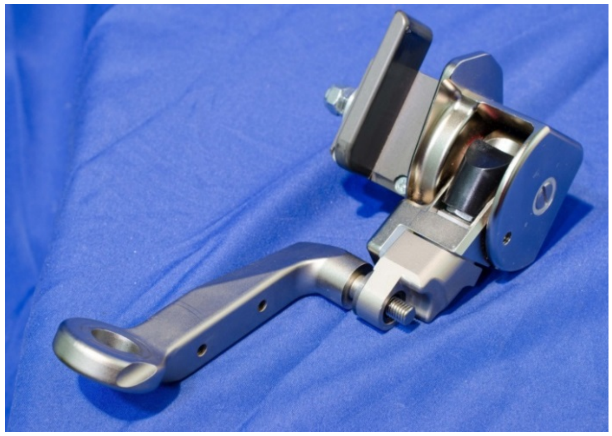


Figure 7-14. Insert arm link into shoulder assembly

7.2.2.9 Place the 18 x 8 x 1.5 Link Washer (472-3818) on the threaded shaft of the Left Arm Link. Install the scapula and secure with the M8 x 1.25 Locknut (SNEP #ESN H100) loosely (Figure 7-15).

Figure 7-15. Install scapula to arm link

7.2.2.10 Secure the scapula to the arm link using two M5 x 0.8 x 16 FHCS (Figure 7-16).

Figure 7-16. Secure scapula to arm link

7.2.2.11 Install the upper arm pivot bushing onto the arm clevis (Figure 7-17). Insert into the shoulder assembly.

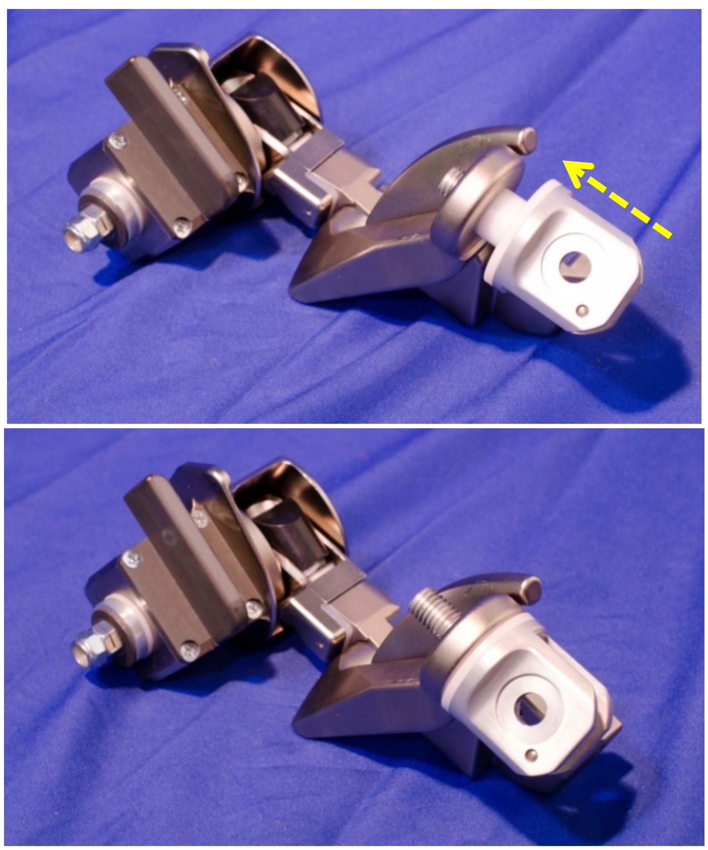


Figure 7-17. Install upper arm pivot bushing onto arm clevis

7.2.2.12 Assemble the Arm Clevis Assembly (472-3831) by installing the Arm Clevis Washer (472-3837), Disc Spring Washer 25 x 12.2 x 1.25, Tabbed Washer (472-3838) and Nylon Locknut M12 x 1.75 (Figure 7-18 and Figure 7-19).

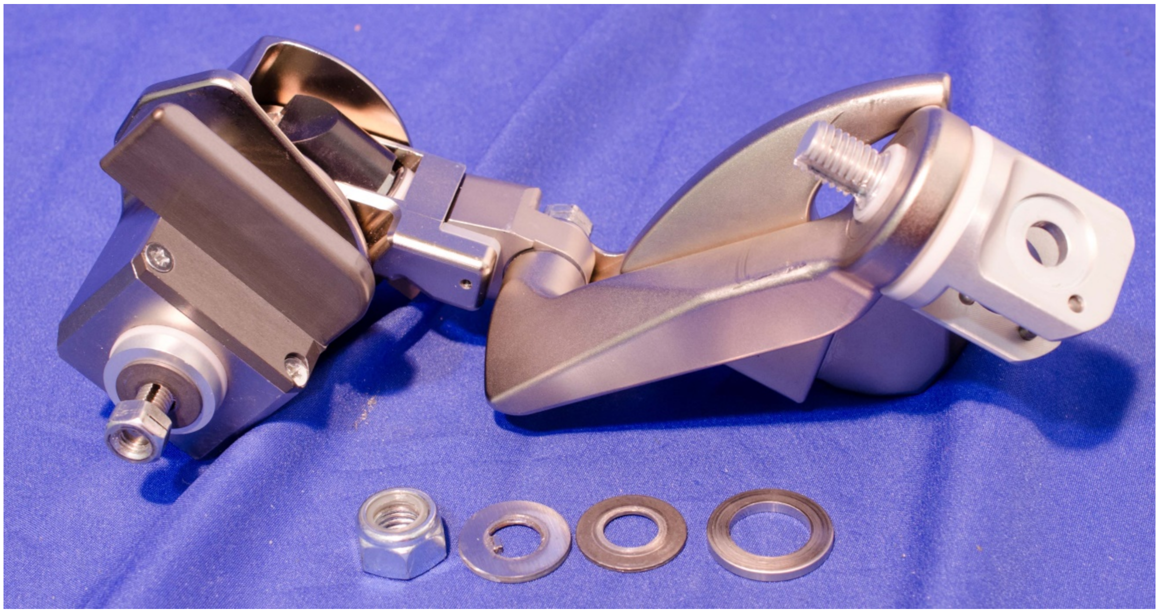


Figure 7-18. Arm clevis hardware

Figure 7-19. Install arm clevis

7.2.3 **Connecting the Arms to the Shoulders**

The procedure for connecting the arm to the shoulder is located in Section 13.2.3

7.3 Adjustments for the Shoulder Assembly

7.3.1 **Shoulder Joint Torque Settings**

7.3.1.1 Disconnect both clavicles at the shoulder by removing the modified M8 bolt (472-3891; Figure 7-20). Do not remove the cable ties holding the shoulder pad to the clavicle.

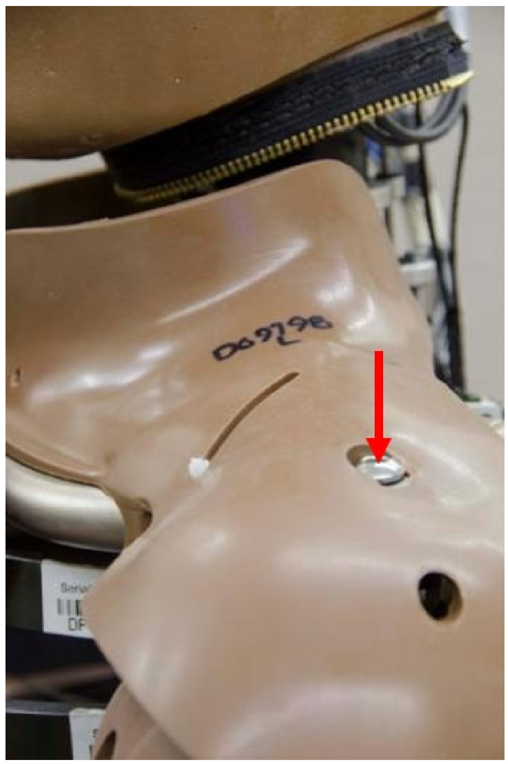


Figure 7-20. Disconnect clavicles at shoulders (shoulder pad cable ties may be left intact)

7.3.1.2 Locate the M10 x 20mm SHSS attaching the left upper humerus assembly (472-6200) to the arm clevis (472-3831). This screw may be located through either the anterior or posterior hole in the upper arm flesh (472-6270), as indicated in (Figure 7-21), With the elbow bent at 90°, rotate upper arm about the X-axis shoulder joint until the arm is in the horizontal plane. Adjust the torque of the M10 bolt such that the arm remains in this position under its own mass but falls once any additional mass or force is added. Repeat for right arm.

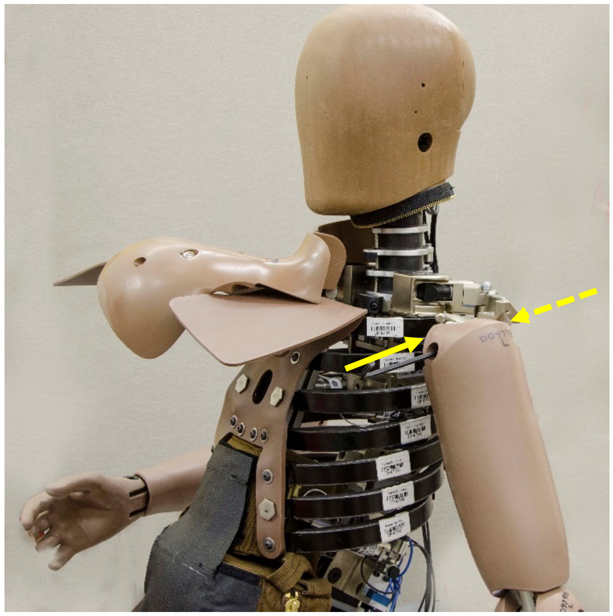


Figure 7-21. Upper arm orientation for setting joint torque about shoulder X-axis to 1G

7.3.1.3 Set the torque on the M8 locknut connecting the left shoulder support assembly (472-3813) to the left arm link (472-3829) to 15 N-m (Figure 7-22). Repeat for right arm.

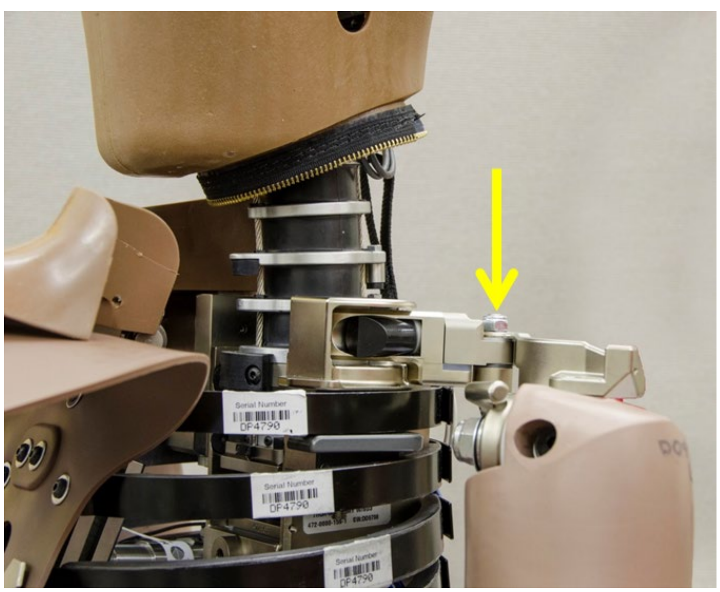


Figure 7-22. Locknut on joint connecting shoulder support assembly to arm link.

7.3.1.4 Locate the M12 x 1.75 mm locknut at the medial aspect of the left arm clevis assembly (472-3831), indicated by arrow in Figure 7-23. Straighten the elbow, extend the arm fully forward in the horizontal plane, and rotate the lower arm about the global X-axis to prevent bending at the elbow joint. Adjust the torque on the M12 nut such that the arm remains in this position under its own mass but falls once any additional mass or force is added. If this cannot be achieved, inspect the tabbed washer (472-3838) and replace if damaged. Repeat for right arm.

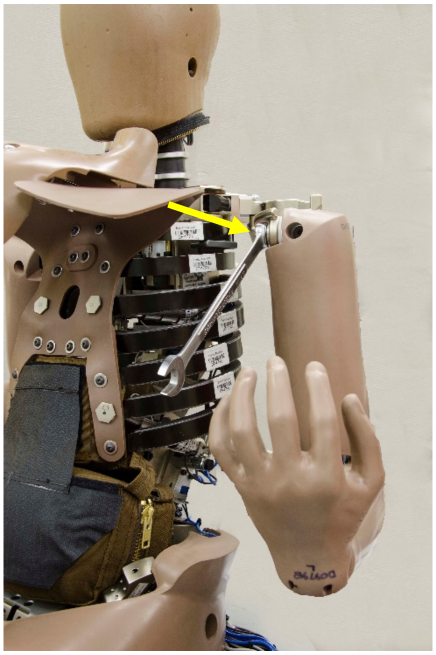


Figure 7-23. Upper arm orientation for setting joint torque about shoulder Y-axis to 1G

7.3.1.5 Remove the left forward range of motion (ROM) buffer cover (472-3816) to reveal the locknut behind it (Figure 7-24). Repeat for right arm.

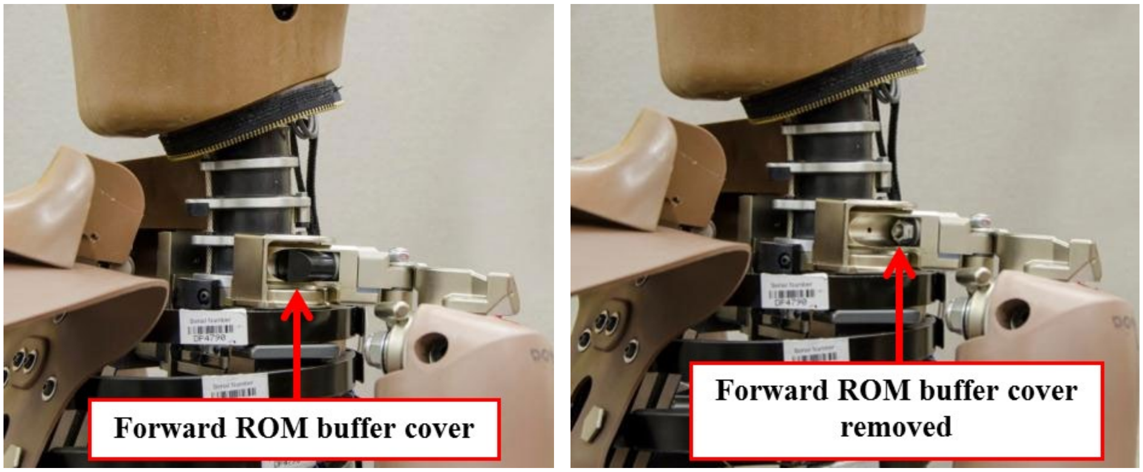


Figure 7-24. Removal of shoulder forward ROM buffer cover to reveal locknut

7.3.1.6 Set the torque on the M8 x 1.25 mm nut under the forward ROM buffer to 10 N-m (Figure 7-25). Repeat for right arm.

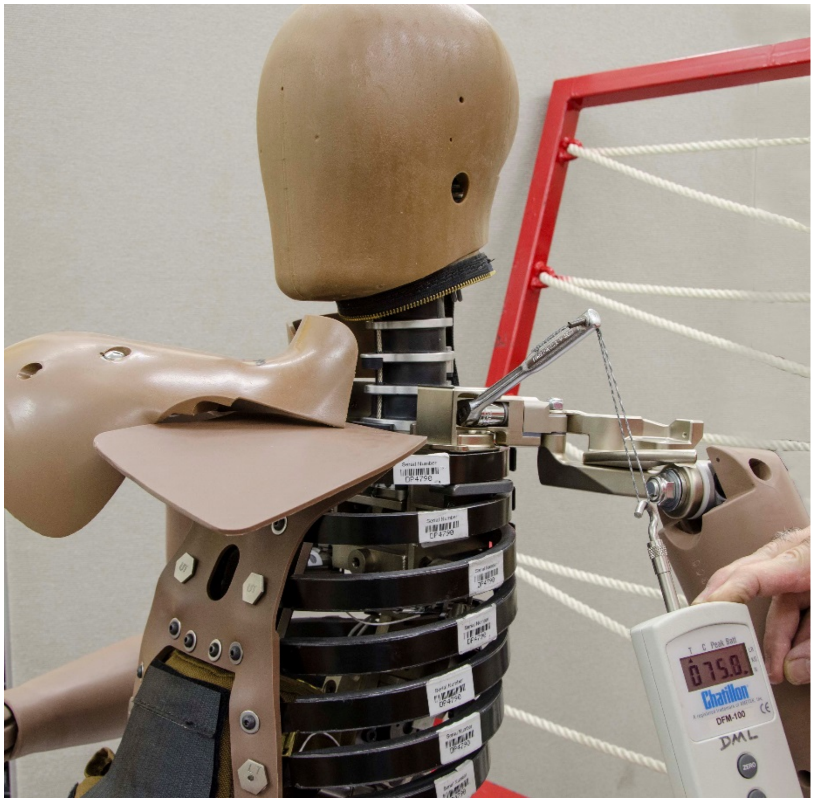


Figure 7-25. Shoulder pivot joint torque setting

7.3.1.7 Reinstall the forward ROM buffer (472-3816) so that the line formed between the two beveled surfaces of the ROM buffer is vertical, and the beveled surface faces away from the body of the shoulder support (472-3814), as shown in Figure 7-26. Repeat for right arm.

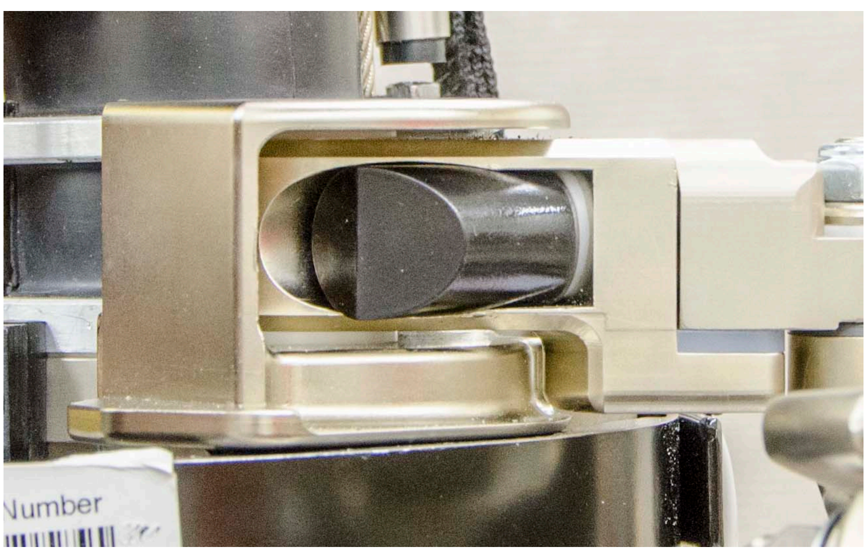


Figure 7-26. Reinstallation of forward ROM buffer

7.3.1.8 Reinstall the left and right clavicles by replacing the modified M8 bolts (472-3891) on both the left and right shoulders (Figure 7-20).

7.4 Electrical Connections and Requirements

Section 15.3 includes grounding information.

7.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. Since the shoulder contains no instrumentation, only mechanical inspections are noted. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the shoulder, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

7.5.1 Electrical Inspections (Instrumentation Check)

There is no instrumentation in the shoulder assembly.

7.5.2 Mechanical Inspection

Several components in the shoulder assembly require inspection post-test.

Specific mechanical areas to examine:

- Check the inner soft shoulder stop assemblies for debonding between the rubber and the steel mounting plates
- Check both soft stops for tearing or permanent compression
- Inspect the Tabbed Washer (472-3838) to ensure that the tab is intact (Section 7.2.2.12).
- Check the Shoulder Covers (472-3895-1 and 472-3895-2) for damage (tearing, cuts, etc.) in particular if subjected to belt loading.
- Ensure that the shoulder joints have been adjusted according to the procedures in Section 7.3.

Replace damaged parts as needed to restore the dummy to an acceptable condition.

Section 8. **Upper Abdomen Assembly**

8.1 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 upper abdomen is primarily constructed of deformable materials in order to produce a biofidelic compression response. Optional instrumentation includes an accelerometer near the anterior surface (Figure 8-1).

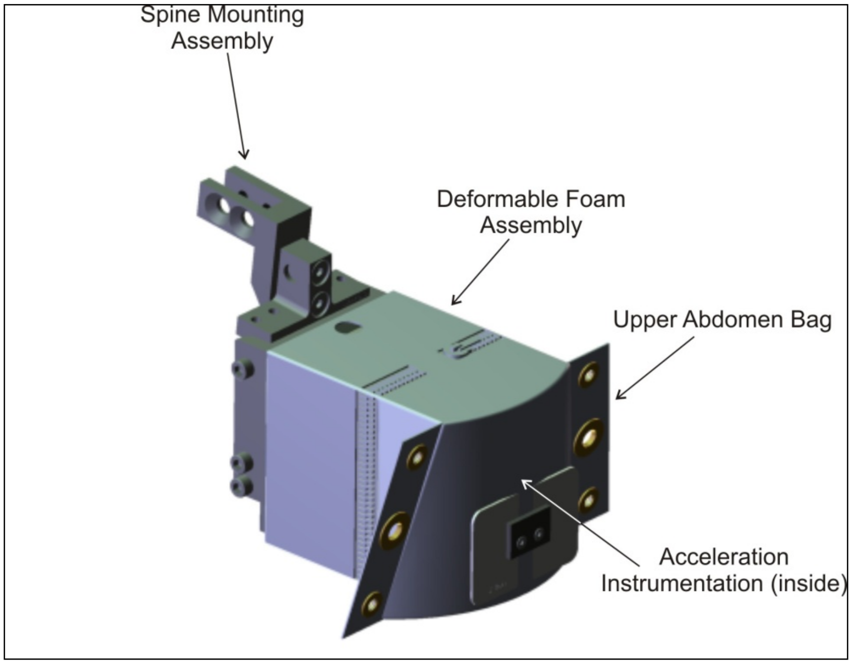


Figure 8-1. Upper abdomen assembly

The upper abdomen assembly consists of a Cordura nylon bag that encloses a series of layered foams. The durable Cordura bag includes seams sewn with Kevlar thread to prevent tearing. Two flaps extend laterally from the front surface of the upper abdomen to allow attachment to the ribs and bib layers. A zipper provides access to the interior of the bag for inspecting the foams. The abdomen utilizes three different layers of various foams to obtain the proper compression response.

The optional uniaxial accelerometer mounts onto a Delrin block on the front surface of the Upper Abdomen bag assembly. The mounting surface roughly directs the active axis of the accelerometer in the X-axis direction.

8.2 Assembly of the Upper Abdomen

8.2.1 Parts List

Figure 8-2 and Figure 8-3 show component views of upper abdomen assembly and hardware; Table 8-1 and Table 8-2 list the upper abdomen components.

Table 8-1. Upper Abdomen Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Spinal Mount Bracket Assembly	1	472-4610	Figure 8-2	1
Front Upper Abdomen Internal Mount Plate	1	472-4620	Figure 8-2	2
Internal Foam Rear Layer	1	472-4621	Figure 8-2	3
Internal Middle Foam Layer	1	472-4622	Figure 8-2	4
Internal Foam Front Layer	1	472-4623	Figure 8-2	5
Upper Abdomen Accelerometer Mount	1	472-4624	Figure 8-2	6
Load Distribution Plate	1	472-4625	Figure 8-2	7
Accelerometer Mount Plate	1	472-4626	Figure 8-2	8
Grommet Assembly, Upper Abdomen Bag	1	472-4627	Figure 8-2	9
M3 x 0.5 x 12 LG. FHCS SS	2	5000377	Figure 8-2	10
M1.4 x 0.3 x 4 LG. SHCS	2	5000375	Figure 8-2	11
M6 x 1 8 LG. SHCS	6	5000085	Figure 8-2	12

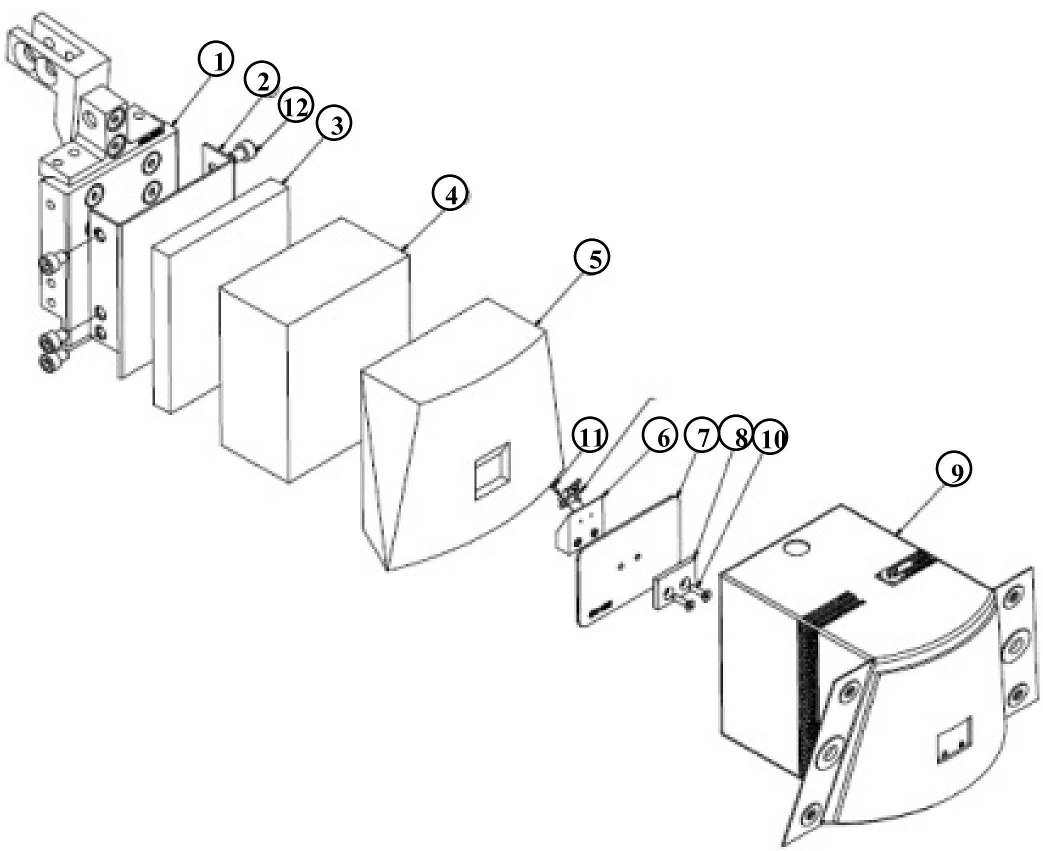


Figure 8-2. Upper abdomen assembly components

Table 8-2. Spinal Mount Bracket Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Thoracic Instrumentation Bracket Base Plate	1	472-4612	Figure 8-3	1
Upper Abdomen Thoracic Instrumentation Bracket	1	472-4611	Figure 8-3	2
Upper Abdomen Spinal Mount Bracket	1	472-4613	Figure 8-3	3
M6 X 1 X 12 LG. FHCS	4	5000139	Figure 8-3	4
M6 X 1 X 30 LG. FHCS	2	5000265	Figure 8-3	5

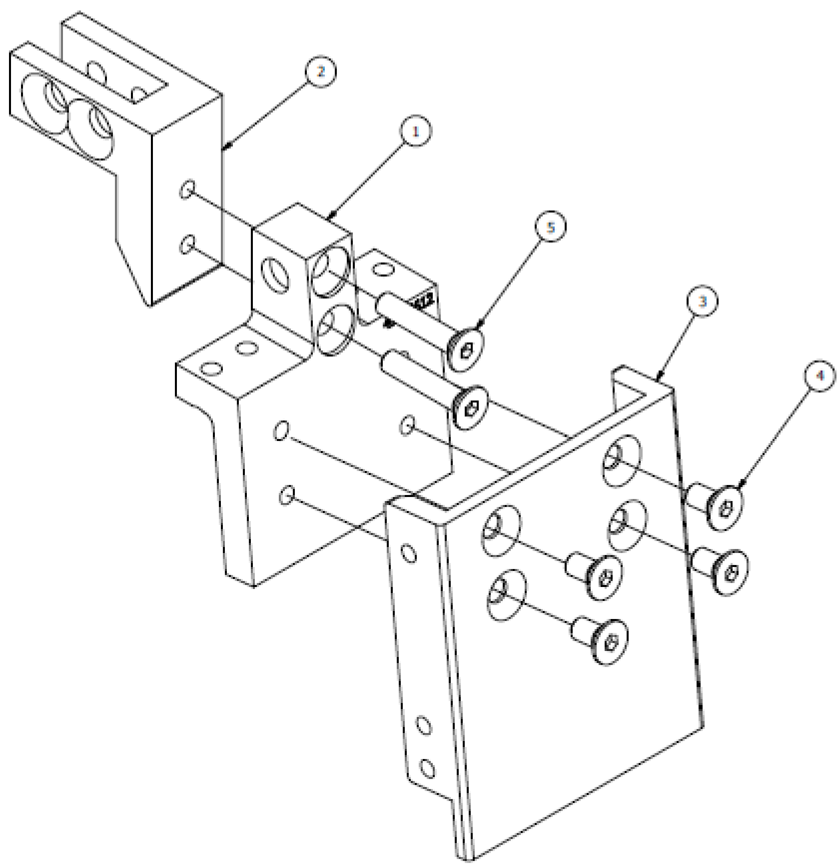


Figure 8-3. Spinal mount bracket assembly components

8.2.2 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. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

8.2.2.1 Slip the Front Upper Abdomen Internal Mount Plate (472-4620) through the slits in the Upper Abdomen Bag Grommet Assembly (472-4627) shown in Figure 8-4.

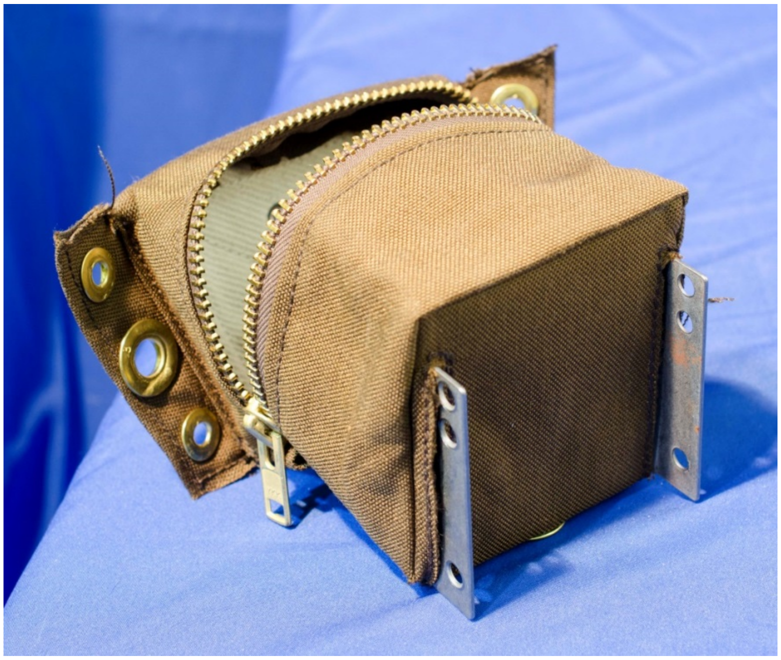


Figure 8-4. Install internal mount plate inside of upper abdomen bag

8.2.2.2 Insert the Internal Foam Rear Layer (472-4621) into the bag **(**Figure 8-5**)**. Ensure that the orientation of the layer matches the dimensions of the Internal Mounting Plate. Next, install the Internal Foam Middle Layer (472-4622) over the rear foam.

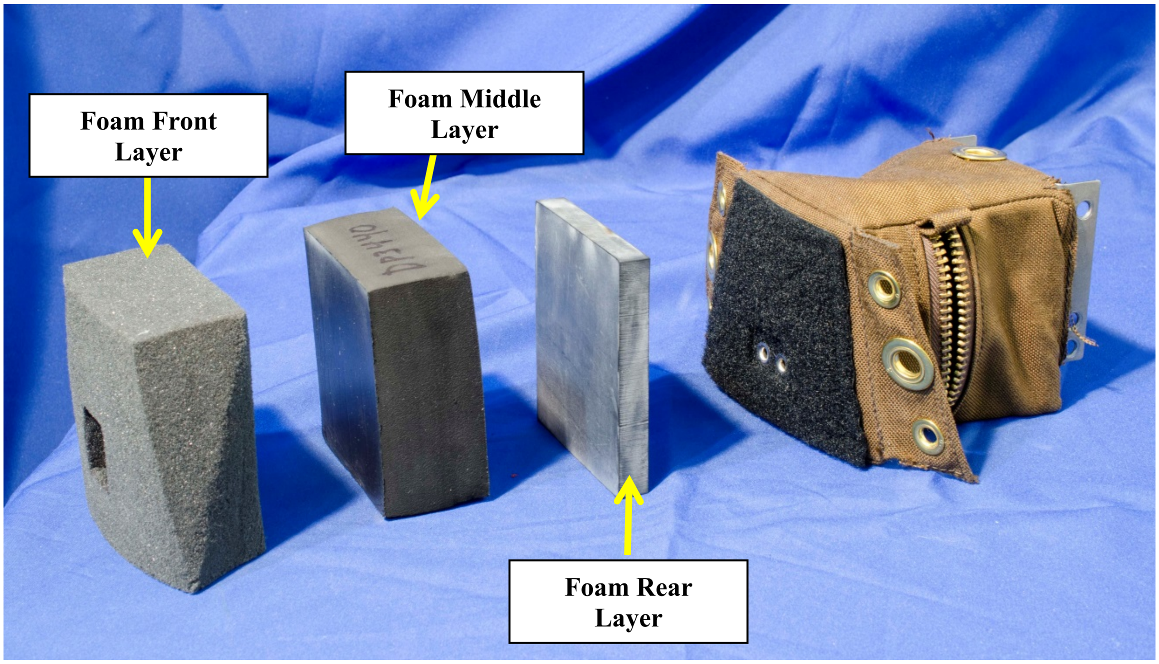


Figure 8-5. Insert internal rear and middle foam into upper abdomen bag

8.2.2.3 An optional uniaxial accelerometer (SA572-S4) measures the acceleration of the anterior bag face during impact. 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, as shown in Figure 8-6 and Figure 8-7.

Figure 8-6. Insert accelerometer into upper abdomen bag

Figure 8-7. Route accelerometer along inside top of upper abdomen bag

8.2.2.4 Mount the uniaxial accelerometer to the Upper Abdomen Accelerometer Mount (472-4624) using two M1.4 X 4 SHCS as shown in Figure 8-8. The screws should be snug but be careful not to over-tighten. Orient the electrical cable from the uniaxial accelerometer unit toward the narrow end of the accelerometer mount wedge.

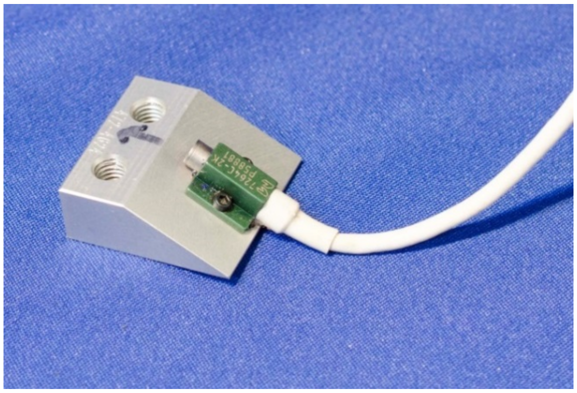


Figure 8-8. Upper abdomen accelerometer installed to mount

WARNING: Do not over-tighten the M1.4 as this may damage the accelerometer! A snug fit is adequate to secure the sensor.

8.2.2.5 Position the Load Distribution Plate (472-4625) on the front inside flap of the upper abdomen bag and the Accelerometer Mount Plate (472-4624) on the outside of the bag aligned with the two holes in the bag. Place two M3 X 0.5 X 12 FHCS through the holes in the accelerometer mount plate. From the outside of the bag, push the bolts through the holes in the bag, then through the load distribution plate. Secure the screws to the upper abdomen accelerometer mount (Figure 8-9 and Figure 8-10).

Figure 8-9. Securing upper abdomen accelerometer inside bag

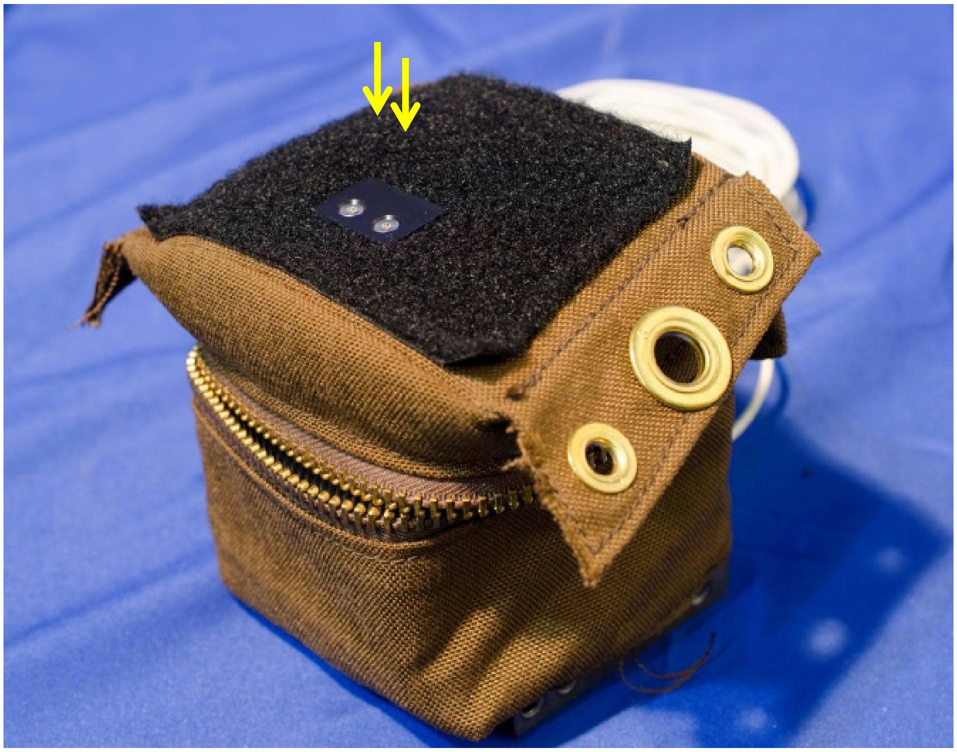


Figure 8-10. Bolts through accelerometer mount plate

8.2.2.6 Position the Internal Foam Front Layer (472-4623) with the notch cut in the front of the foam, on the angled surface of the accelerometer mount as shown in Figure 8-11.

Figure 8-11. Front foam layer inserted into bag after attachment of accelerometer mount

8.2.2.7 Zip close the front and rear of the bag, making sure that the foam layers do not displace. The zipper half of the rear of the bag should be over the middle foam layer (Figure 8-12).

Figure 8-12. Upper abdomen after foams inserted

8.2.2.8 Assemble the Spinal Mount Bracket Assembly (472-4610) by attaching the Thoracic Instrumentation Bracket Base Plate (472-4612) to the Upper Abdomen Spinal Mount Bracket (472-4613) using four M6 X 1 X 12 FHCS (Figure 8-13).

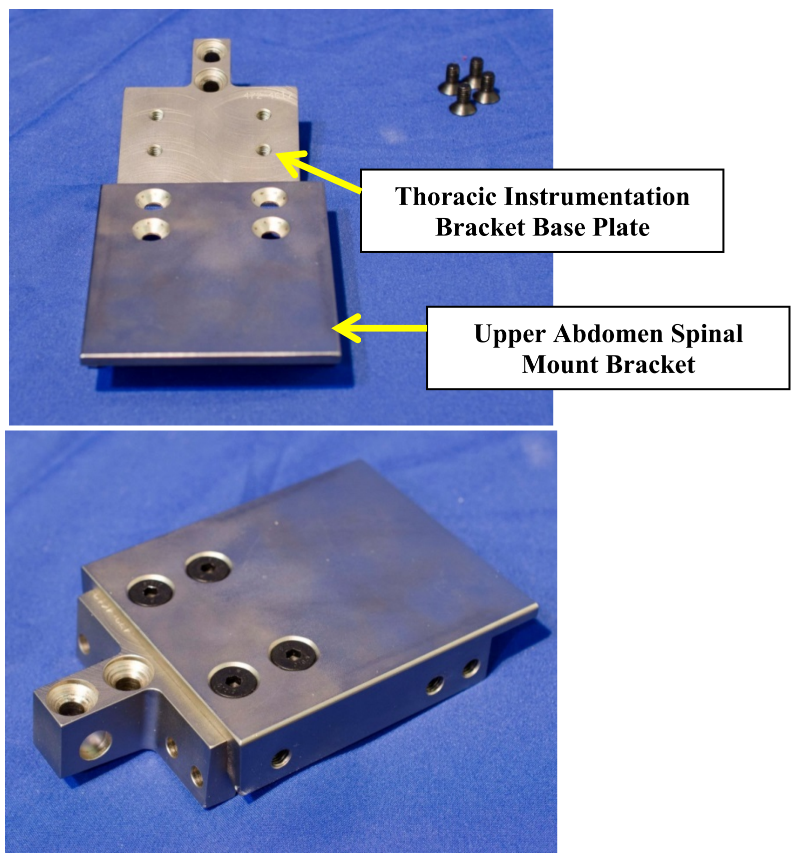


Figure 8-13. Assemble spinal mount bracket to thoracic instrumentation bracket base plate

8.2.2.9 Secure the Upper Abdomen Thoracic Instrumentation Bracket to the Thoracic Instrumentation Bracket Base Plate using two M6 X 1 X 30 FHCS (Figure 8-14).

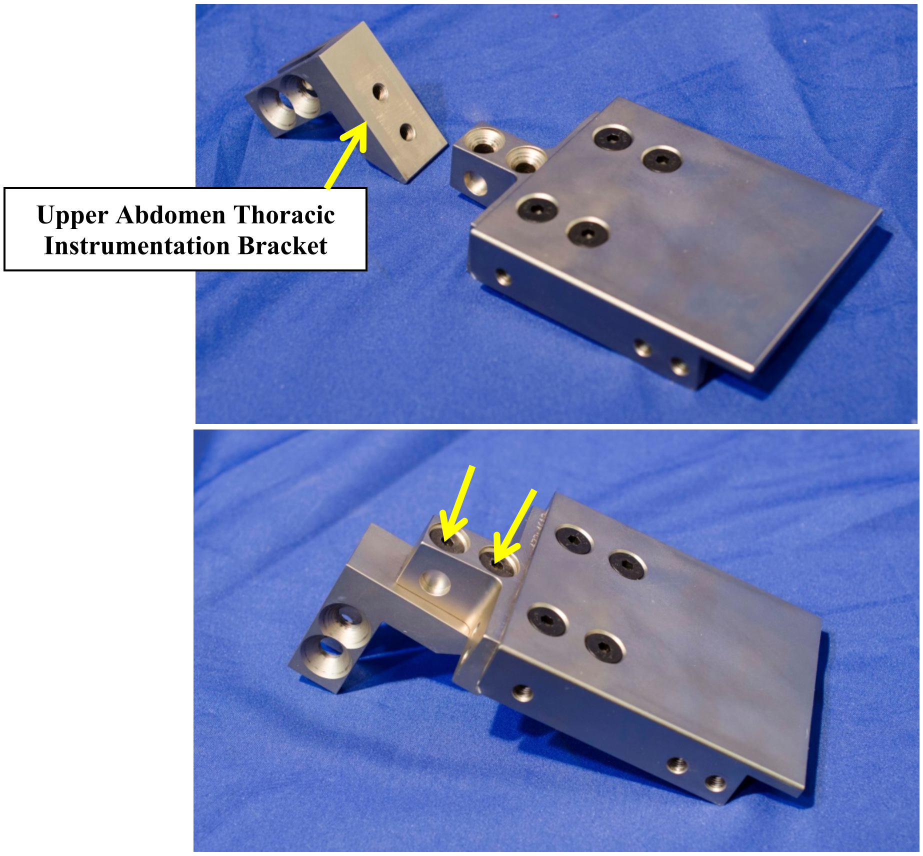


Figure 8-14. Spinal Mount Bracket Assembly

8.2.2.10 Install the Upper Abdomen Bag to the Spinal Mount Bracket Assembly using six M6 X 1 X 8 SHCS (Figure 8-15).

Figure 8-15. Secure Upper Abdomen Bag to Spinal Mount Bracket Assembly

8.2.3 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. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3. Install the upper abdomen either before or after the completing the thorax assembly.

8.2.3.1 Position the Spinal Mount Bracket Assembly (472-4610) arms on either side of the Lower Thoracic Spine Welded Assembly (472-3660) and carefully slide the upper abdomen into the dummy's thorax (Figure 8-16).

WARNING: Take care not to pinch the instrumentation wiring during the upper abdomen installation.

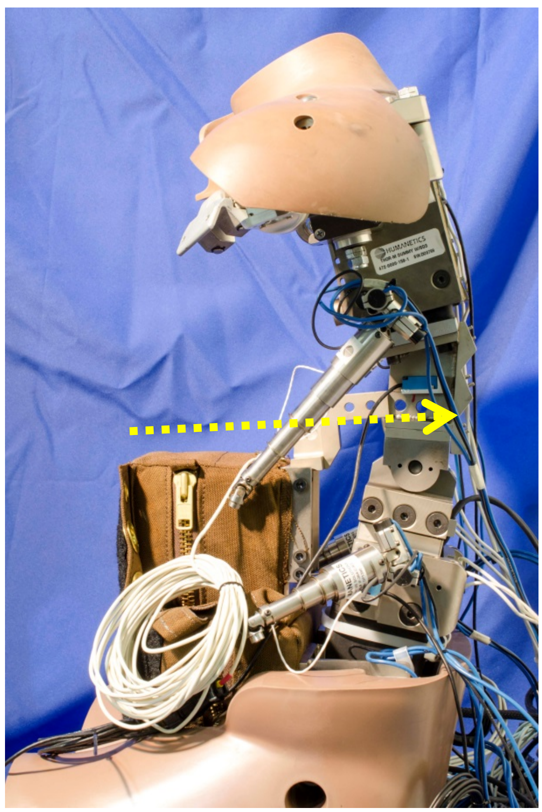


Figure 8-16. Slide upper abdomen into thorax

8.2.3.2 Align the holes and fasten the spinal mounting bracket to the lower thoracic spine weldment using two M8 X 1.25 X 25 FHCS into the two mounting holes in the spinal mounting bracket arms from the right side (Figure 8-17). The T6 tilt sensor mount may need to be loosened to install the upper abdomen.

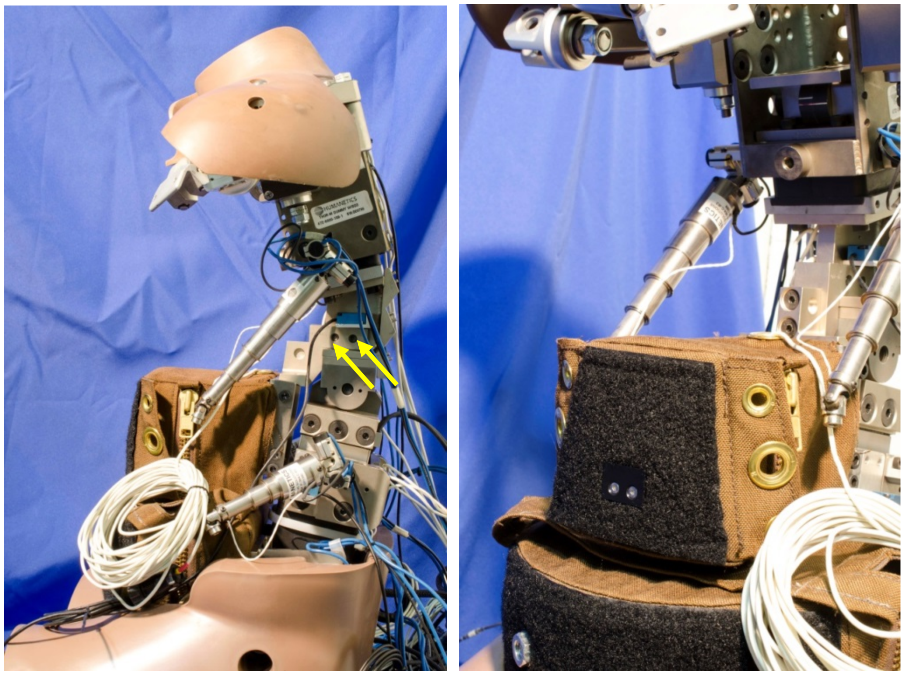


Figure 8-17. Upper abdomen installed to spine

8.2.3.3 See Sections 6.2.2.47 through 6.2.2.50 to assemble the ribs and IR-TRACCs to the upper abdomen.

8.2.3.4 After completing the installation of ribs and IR-TRACCs, cover the front surfaces of the upper and lower abdomen assemblies with the Upper and Lower Abdomen Velcro® Cover (472-4763-8) as shown in Figure 8-18.

Figure 8-18. Abdomen cover installed

8.3 Adjustments for the Upper Abdomen Assembly

The upper abdomen assembly does not require any adjustments prior to testing.

8.4 Electrical Connections and Requirements

Section 15.3 includes grounding information. Section 8.2.2.2 through 8.2.2.3 describes cable routing instructions for the uniaxial accelerometer in the upper abdomen.

8.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the upper abdomen, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

8.5.1 **Electrical Inspections (Instrumentation Check)**

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the spine instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief.

Specific electrical areas to examine:

- Check the security of the upper abdomen accelerometer mounting bolts.

8.5.2 **Mechanical Inspection**

Several components in the upper abdomen assembly require inspection post-test.

Specific mechanical areas to examine:

- Check the bag for tears, cuts and broken stitches. Repair or replace as necessary.
- Inspect the zipper. If the zipper is damaged to the point it will not fully contain the foams, replace.
- Check each foam insert for tearing, rips, and permanent compression. Replace any damaged foams.

Section 9. **Lower Abdomen Assembly**

9.1 Description of the Lower Abdomen Assembly and Features

The lower abdomen region of the human body lies between the lower thoracic rib cage and the pelvic girdle. The lower abdomen component of THOR-50M is primarily constructed of deformable materials to produce a compression response similar to Post Mortem Human Subject (PMHS) test data. This region of the dummy is primarily subjected to belt loading, however interaction with the steering wheel and air bag is also possible. Instrumentation has been incorporated into the lower abdomen assembly to measure the three-dimensional displacement of the lower abdomen region at two distinct points (Figure 9-1).

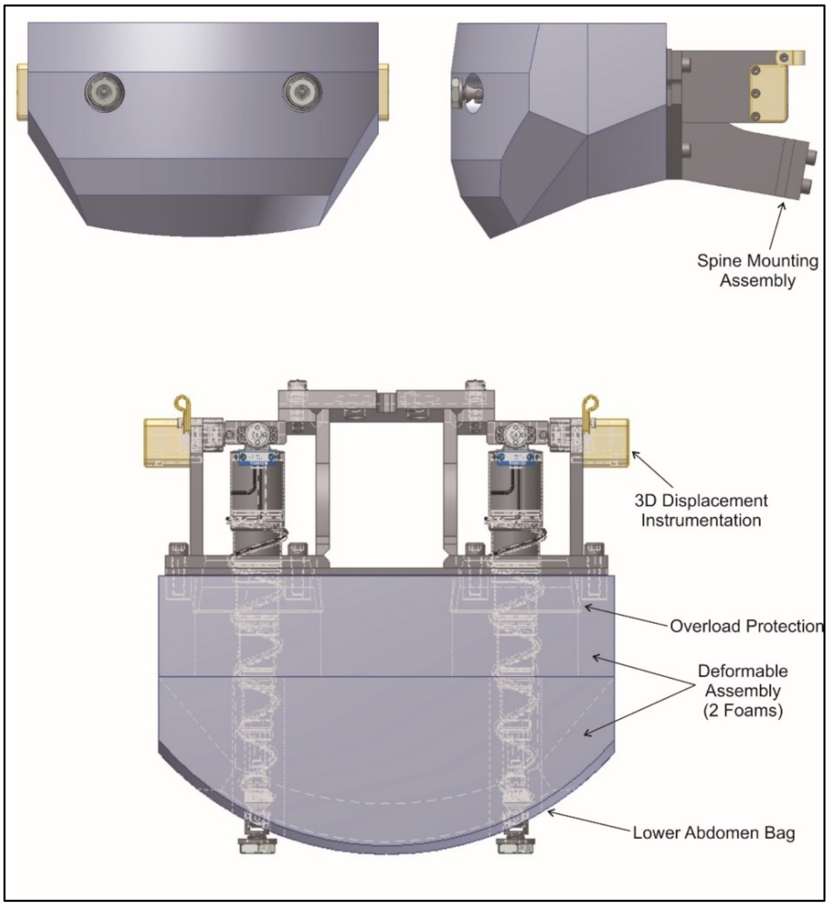


Figure 9-1. Lower abdomen assembly

The lower abdomen assembly includes a Cordura nylon bag that encloses two layered contoured foams. A zipper provides access to the interior of the bag for inspecting the foams and instrumentation. Two holes cut through each layer allow the IR-TRACC units to pass through to the anterior cover of the lower abdomen bag. Mounting plates secure the lower abdomen assembly to the base of the spine assembly on either side of the lumbar spine region. Two 3D IR-TRACC units, each consisting of an IR-TRACC and two rotary potentiometers mounted in a gimbal assembly, provide deflection data for the abdomen assembly at two distinct points on the abdominal surface.

9.2 Assembly of the Lower Abdomen

9.2.1 Parts List

Figure 9-2 through Figure 9-4 show assemblies and hardware for the lower abdomen. Table 9-1 through Table 9-3 lists the components that are included in the lower abdomen assembly.

Table 9-1. Lower Abdomen Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Internal Mounting Weld Assembly	1	472-4710	Figure 9-2	1
Left Attach Bracket Weld Assembly	1	472-4720-1	Figure 9-2	2
Right Attach Bracket Weld Assembly	1	472-4720-2	Figure 9-2	3
Left THOR Abdomen Metric 3D IR-TRACC Assembly	1	472-4730-1	Figure 9-2	4
Right THOR Abdomen Metric 3D IR-TRACC Assembly	1	472-4730-2	Figure 9-2	5
Potentiometer Cover	2	472-4760	Figure 9-2	6
M3 x 0.5 x 12 LG. SHCS	8	5001103	Figure 9-2	7
M3 x 0.5 x 20 LG. SHCS	6	5000312	Figure 9-2	8
M6 x 1 x 20 LG. SHCS	4	5000001	Figure 9-2	9
3/16 Cable Clamp	2	6004191	Figure 9-2	10
M3 x 0.5 x 8 LG. SHCS	2	5000388	Figure 9-2	11
Rear Attachment Plate	1	472-4761	Figure 9-2	12
Lower Abdomen Distribution Plate	2	472-4762	Figure 9-2	13
Lower Abdomen Front Foam Layer	1	472-4764	Figure 9-2	14
Lower Abdomen Rear Foam layer	1	472-4765	Figure 9-2	15
Lower Abdomen Bag, Sewing Assembly	1	472-4763	Figure 9-2	16
M6 x 1 x 16 LG. SHCS	4	5000081	Figure 9-2	17

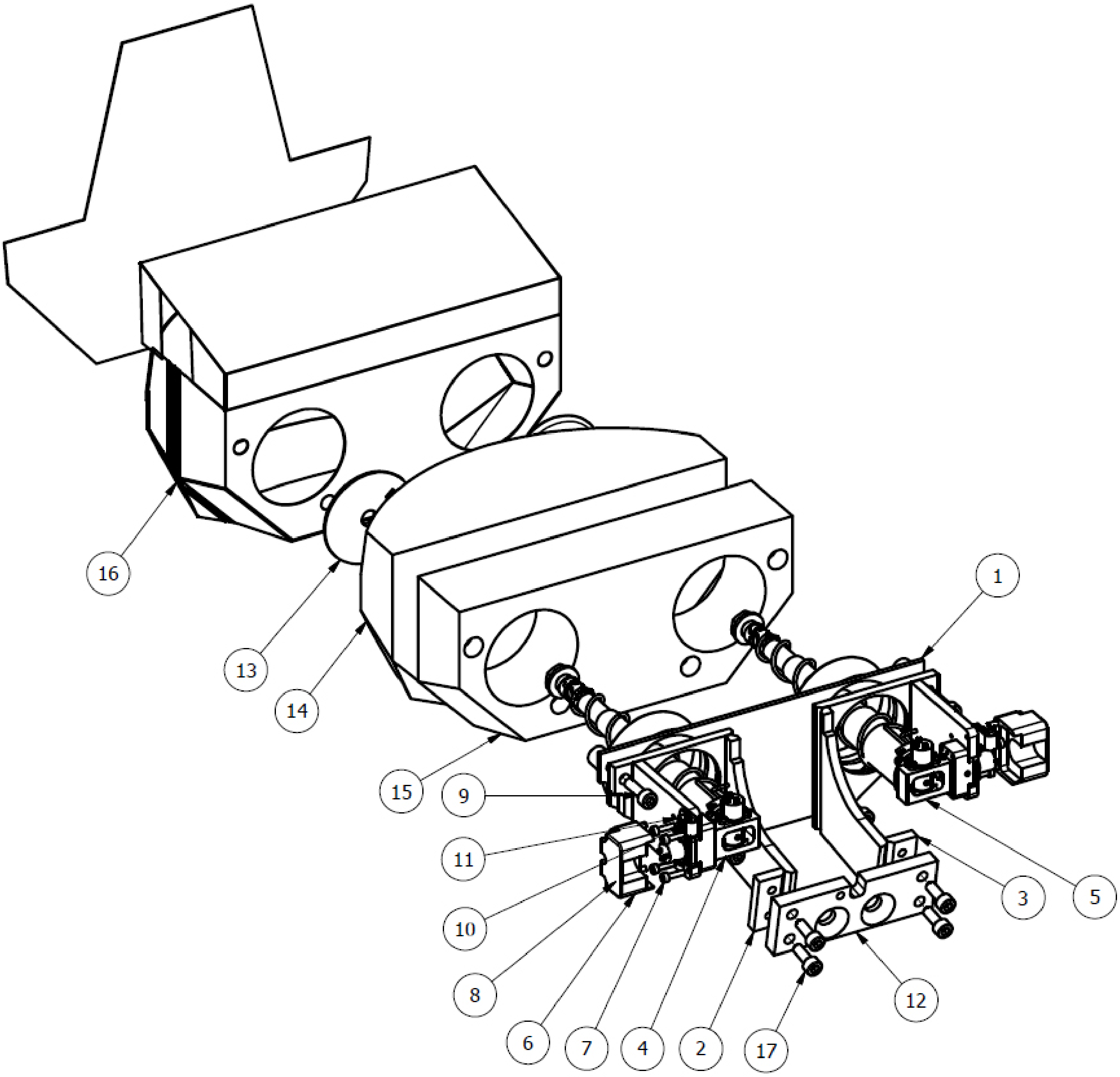


Figure 9-2. Lower abdomen assembly components

Table 9-2. Lower Abdomen IR-TRACC Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
120mm IR-TRACC Assembly – Metric	1	SA572-S121	Figure 9-3	1
Left Pivot Assembly	1	472-4740-1	Figure 9-3	2 (top figure)
Right Pivot Assembly	1	472-4740-2	Figure 9-3	2 (bottom figure)

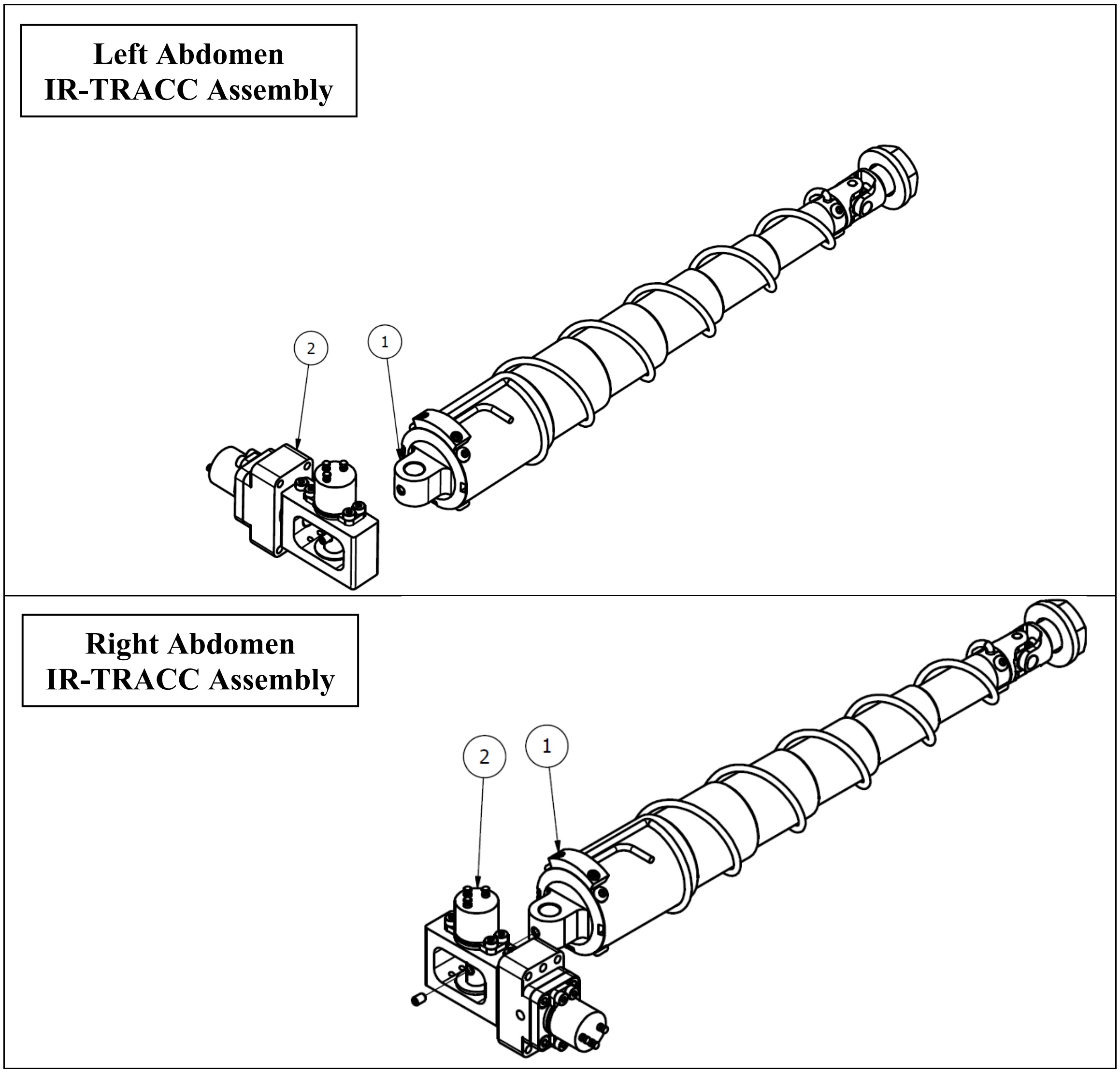


Figure 9-3. Lower left and right abdomen IR-TRACC assembly components

Table 9-3. Lower Abdomen IR-TRACC Pivot Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Mounting Block	1	472-4741	Figure 9-4	1
Cover	1	472-4742	Figure 9-4	2
Pivot Block	1	472-4743	Figure 9-4	3
Horizontal Shaft	1	472-4744	Figure 9-4	4
Vertical Shaft	1	472-4745	Figure 9-4	5
Pot Clamp	4	472-4746	Figure 9-4	6
Flange Bearing 6 x 8 x 4 LG.	5	5000949	Figure 9-4	7
M2 x 0.4 x 5 LG. SHCS	8	5001079	Figure 9-4	8
M1.5 x 12 LG. Dowel SS	1	5000514	Figure 9-4	9
M2.5 x 0.45 x 4 LG. SSSCP SS	1	5001043	Figure 9-4	10
M2 x 0.4 x 3 LG. SSSCP SS	2	5001136	Figure 9-4	11
Screw, M2.5 x 0.45 x 5 SHCS	4	5000641	Figure 9-4	12
Rotary Potentiometer	2	SA572-S114	Figure 9-4	13

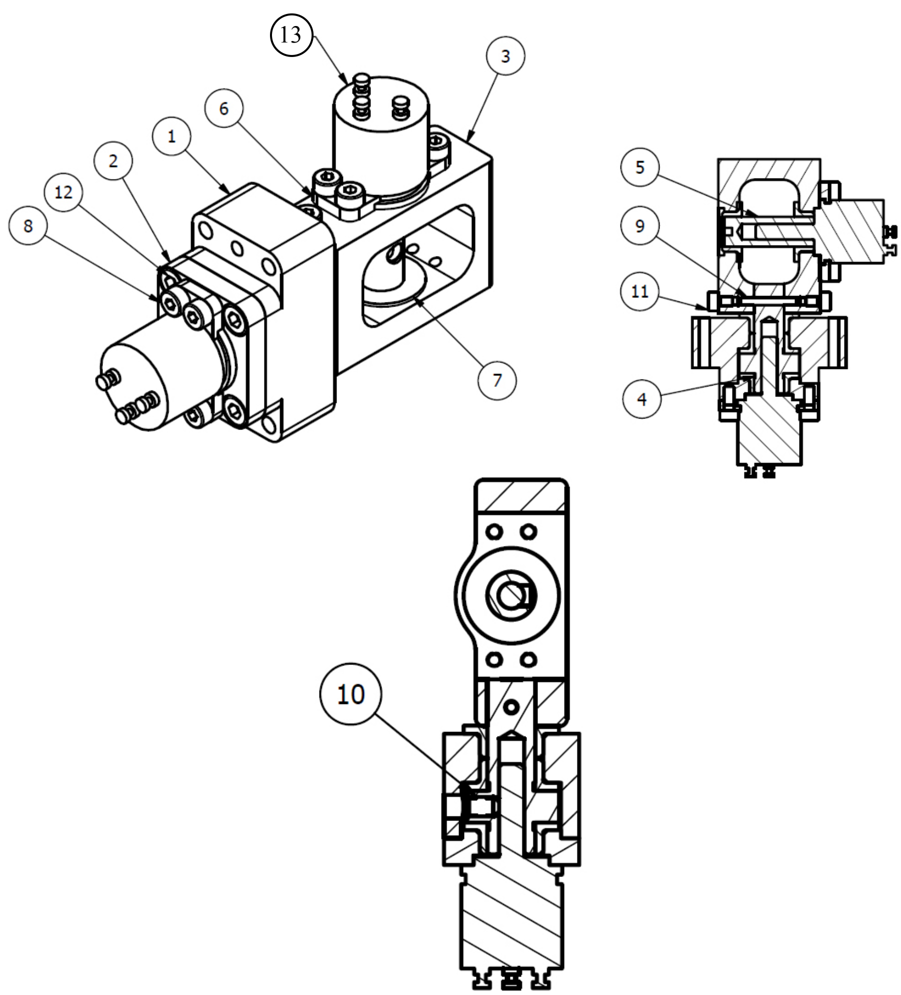
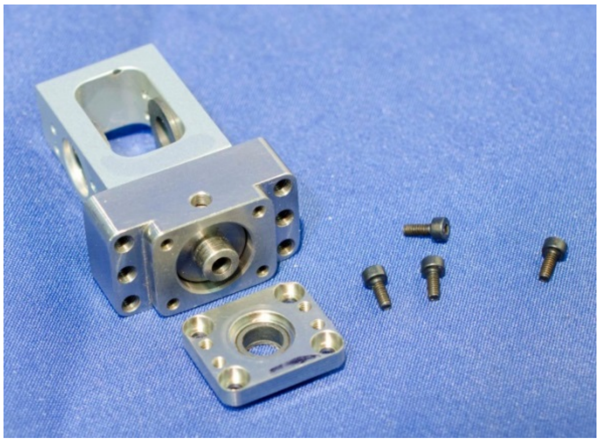


Figure 9-4. Lower (left) abdomen IR-TRACC pivot assembly components

9.2.2 Assembly of Lower Abdomen Components

The following procedure is a step-by-step description of the assembly procedure for the lower abdomen. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

9.2.2.1 Configure the (Left) Pivot Assembly (472-4740-1) by installing the Cover (472-4742) on the Mounting Block (472-4741) using four M2.5 x 0.4 x 5 SHCS (Figure 9-5).



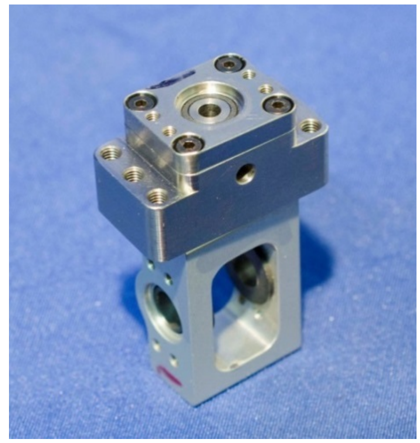


Figure 9-5. Install cover on mounting block

9.2.2.2 Align the hole for the set-screw in the block pivot with the set screw hole in the mounting block. Before inserting the Y-axis rotary potentiometer shaft into the Horizontal Shaft (472-4744), assure that the potentiometer will not pass through a dead band when moved through its range of motion in the lower abdomen. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Once this is complete, insert the potentiometer shaft into the horizontal shaft (Figure 9-6).

Figure 9-6. Insert Y-axis potentiometer

9.2.2.3 Install an M2.5 x 0.45 x 4 SSSCP set-screw through the mounting block against the Y-axis potentiometer shaft (Figure 9-7).

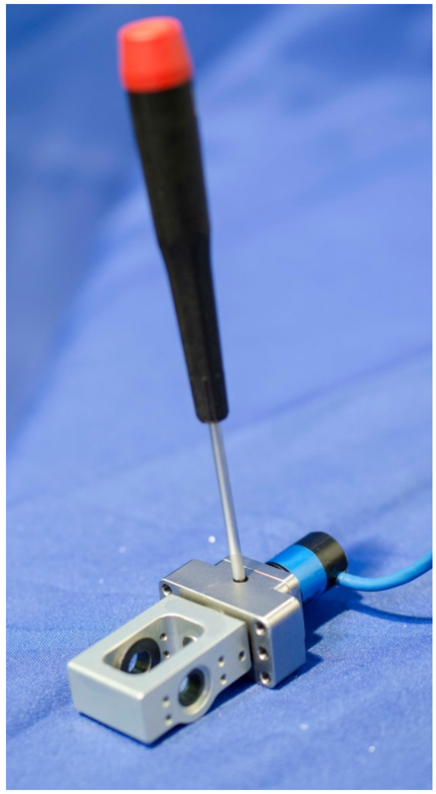


Figure 9-7. Install set-screw against Y-axis potentiometer shaft

9.2.2.4 Install the two Pot Clamps (472-4746) using two M2 x 0.4 x 5 SHCS per clamp (Figure 9-8).

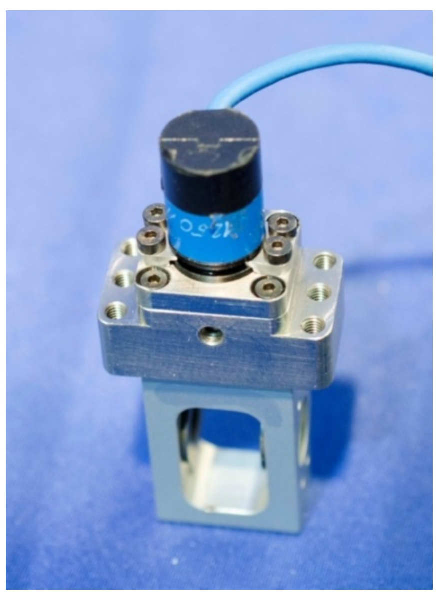


Figure 9-8. Install Y-axis potentiometer pot clamps

9.2.2.5 To install the Z-axis potentiometer, insert the IR-TRACC pivot end into the pivot assembly (Figure 9-9).

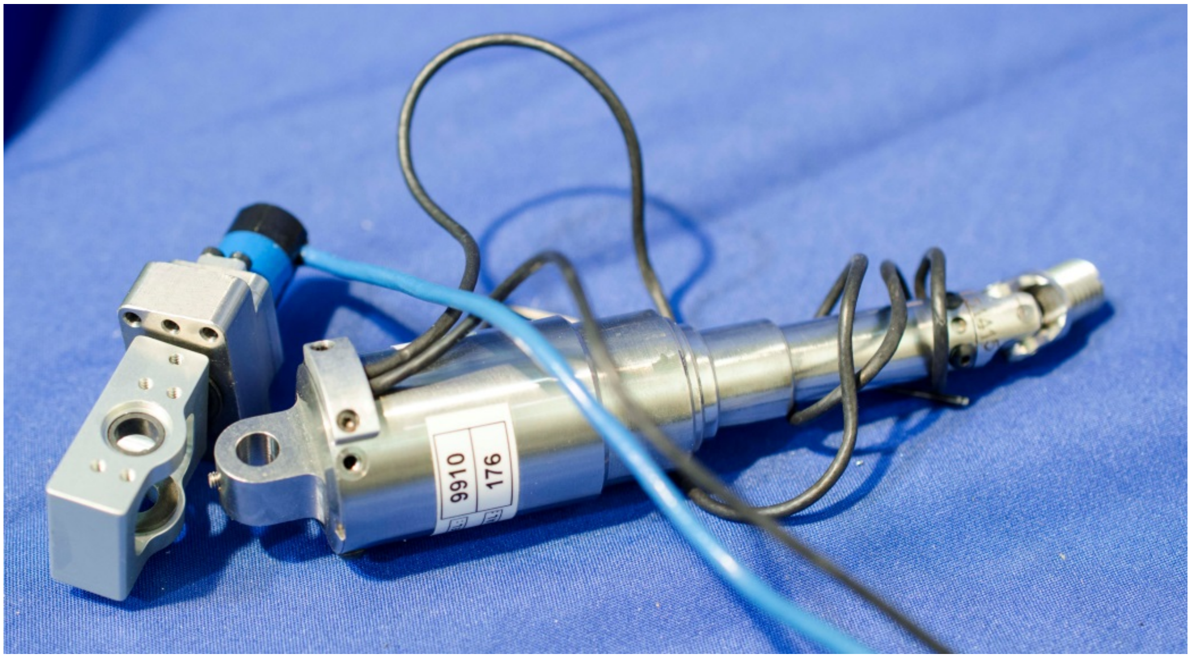


Figure 9-9. Install Z-axis potentiometer to IR-TRACC pivot end

9.2.2.6 Insert the Vertical Shaft (472-4745) through the Block Pivot (472-4743) (Figure 9-10).

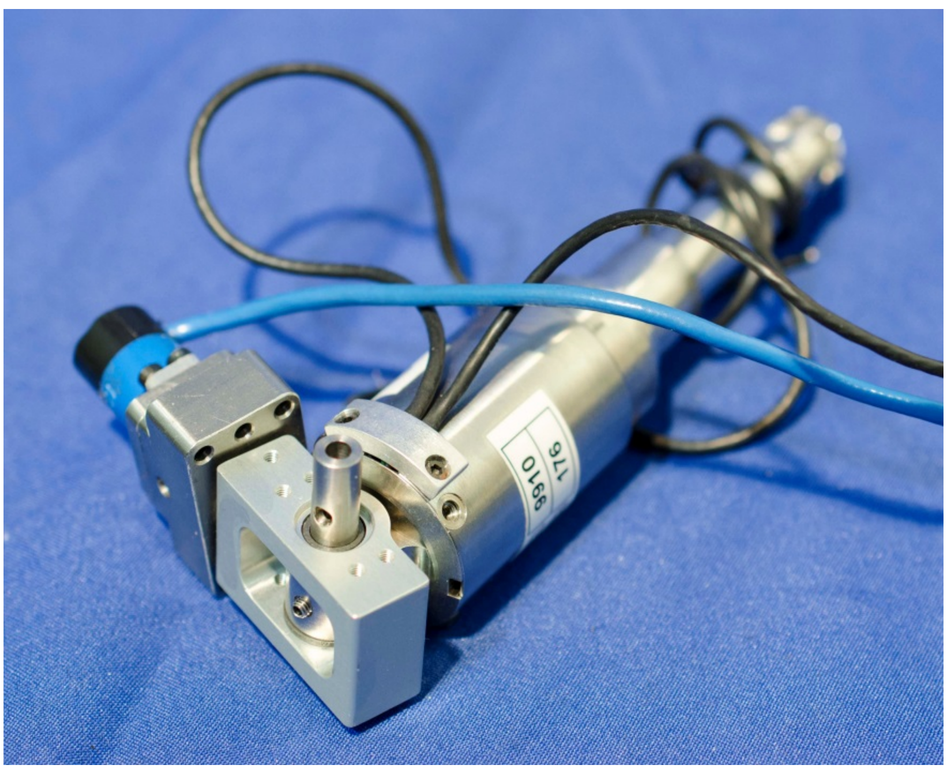


Figure 9-10. Insert vertical shaft through pivot block

9.2.2.7 Before inserting the Z-axis rotary potentiometer shaft into the vertical shaft, assure that the potentiometer will not pass through a dead band when moved through its range of motion in the lower abdomen. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Once this is complete, insert the potentiometer shaft into the vertical shaft. Tighten the set-screw (472-4740) against the potentiometer shaft (Figure 9-11).

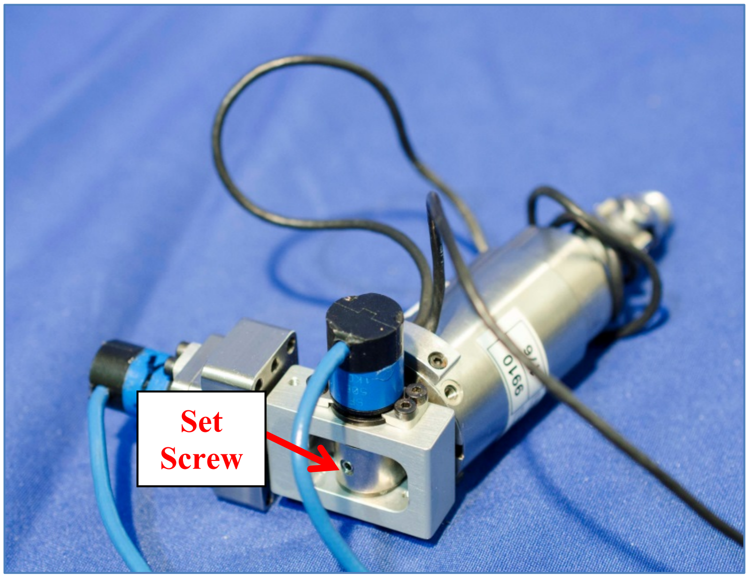


Figure 9-11. Install Z-axis rotary potentiometer

9.2.2.8 Install the pot clamps on both sides of the rotary potentiometer using two M2 x 0.4 x 5 SHCS per clamp (Figure 9-12).

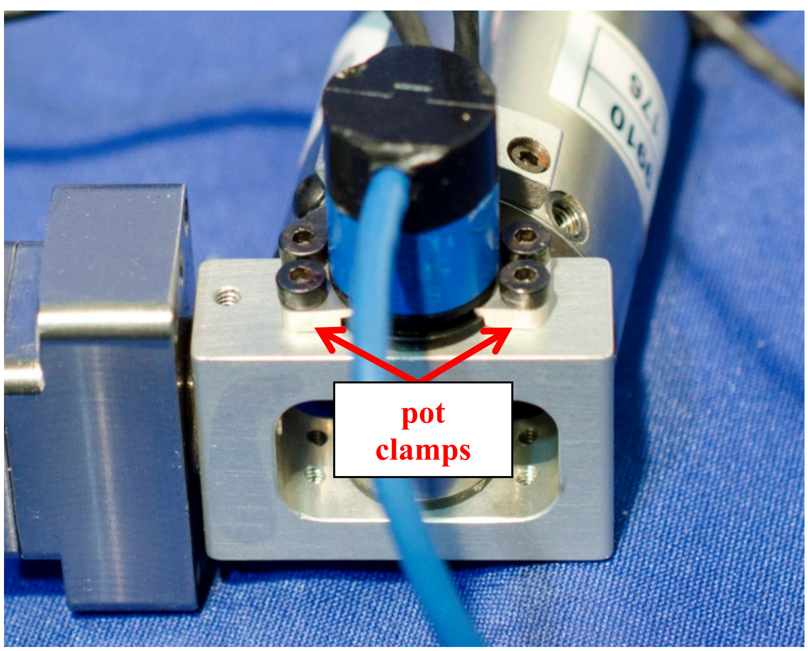


Figure 9-12. Install Z-axis potentiometer pot clamps

9.2.2.9 Repeat steps 9.2.2.1 through 9.2.2.8 for the right side lower abdomen IR-TRACC.

9.2.2.10 Each time the 3D IR-TRACC assembly is re-assembled, the zero position for the Y-axis and Z-axis rotary potentiometers must be adjusted and the initial position offsets recorded (Section 16.3).

9.2.2.11 Position the Internal Mounting Welded Assembly (472-4710) into the interior of the Lower Abdomen Sewing Assembly (472-4763) (Figure 9-13).

Figure 9-13. Position internal weldment assembly into lower abdomen bag

9.2.2.12 Secure the Left Attachment Bracket (472-4720-1) to the left rear side of the lower abdomen assembly using two M6 x 1 x 20 SHCS (Figure 9-14).

Figure 9-14. Left bracket assembled to internal plate

9.2.2.13 Repeat step 9.2.2.12 for the Right Attachment Bracket (472-4720-2) (Figure 9-15).

Figure 9-15. Left and right attachment brackets installed on lower abdomen

9.2.2.14 Install the lower abdomen frontal (472-4764) and rear foams (472-4765) (adhered together with double-sided tape) into the Lower Abdomen Bag Sewing Assembly (472-4763) (Figure 9-16). Press the rear layer of foam over the cones and against the Internal Mounting Weld Assembly (472-4710), but do not zipper the bag (Figure 9-17).

Figure 9-16. Align lower abdomen foams with cones

Figure 9-17. Lower abdomen foams installed

9.2.2.15 Install the left side lower abdomen IR-TRACC assembly into the Left Attach Bracket Weld (472-4720-1) using four (per side) M3 x 0.5 x12 LG. SHCS (Figure 9-18).

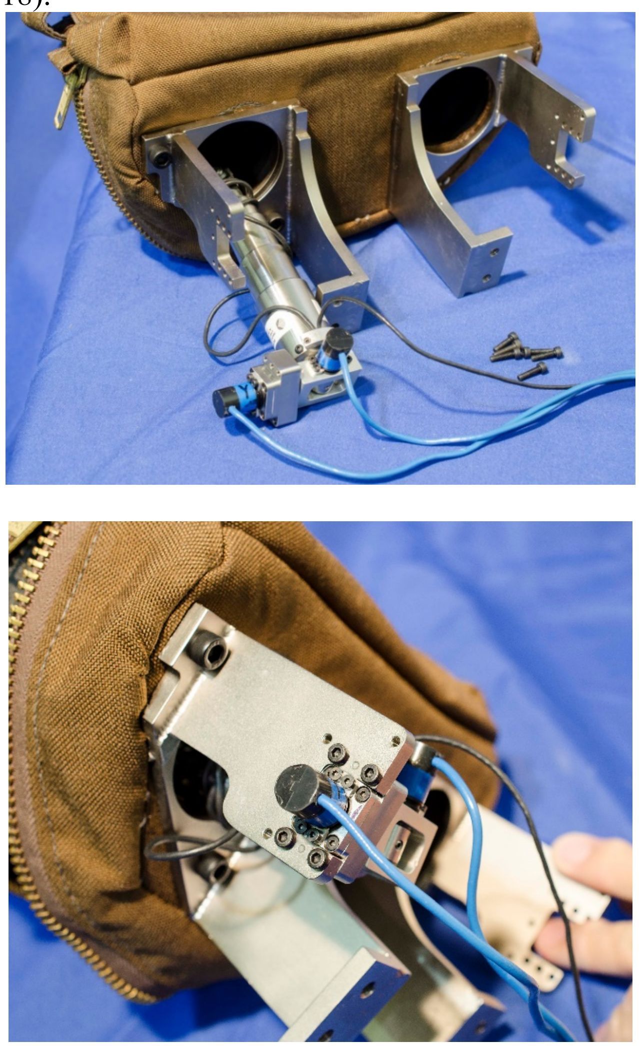


Figure 9-18. Install IR-TRACC into lower abdomen

9.2.2.16 Install three M3 x 0.5 x 20 SHCS to hold the Potentiometer Cover (472-4760) to the left attach bracket weld assembly (Figure 9-19).

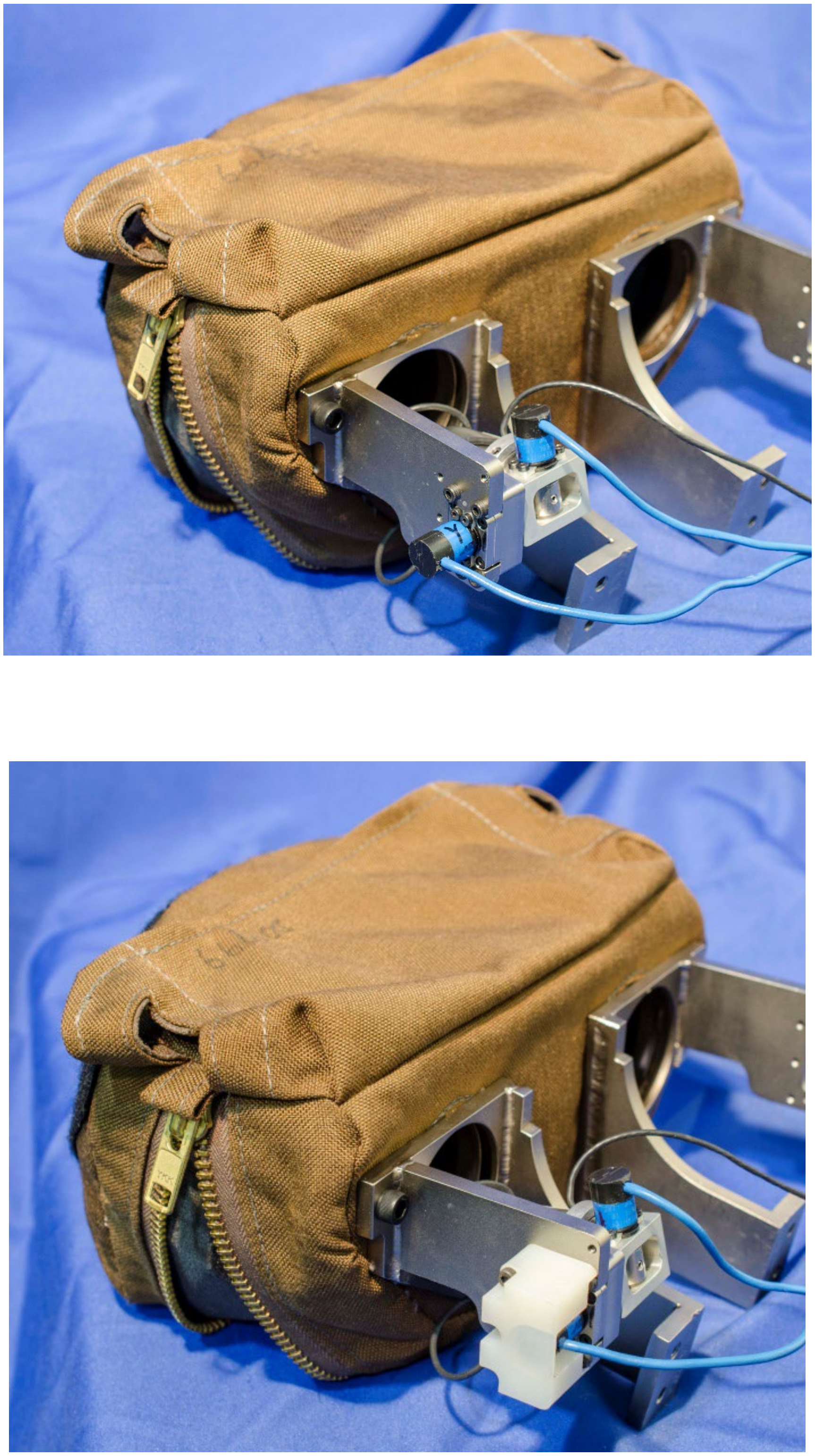


Figure 9-19. Install potentiometer cover to bracket weld assembly

9.2.2.17 To provide cable strain relief, pass the instrumentation wires from the IR-TRACC and pots through a 3/16" wire clamp and attach the clamp to the left attach weld bracket assembly using an M3 x 0.5 x 8 SHCS (Figure 9-20).

Figure 9-20. Cable strain relief for the lower abdomen IR-TRACCs

9.2.2.18 Repeat procedures 9.2.2.15 to 9.2.2.17 for the right IR-TRACC installation.

9.2.2.19 Place a Load Distribution Plate (472-4762) over each IR-TRACC U-joint between the abdomen bag and front foam (Figure 9-21). These load distribution plates rest inside the lower abdomen bag and distribute the impact force over a larger area of the foam. Place the rounded edge against the foam.

Figure 9-21. Install load distribution plate

9.2.2.20 For the following procedures, a tool with M5 threads as show in Figure 9-22 will greatly facilitate the procedure. Install a 10.5 ID x 20 OD flat washer and M10 x 1.5 hex jam nut over the threaded tool (Figure 9-23).

Figure 9-22. Example of threaded tool for aiding lower abdomen IR-TRACC installation

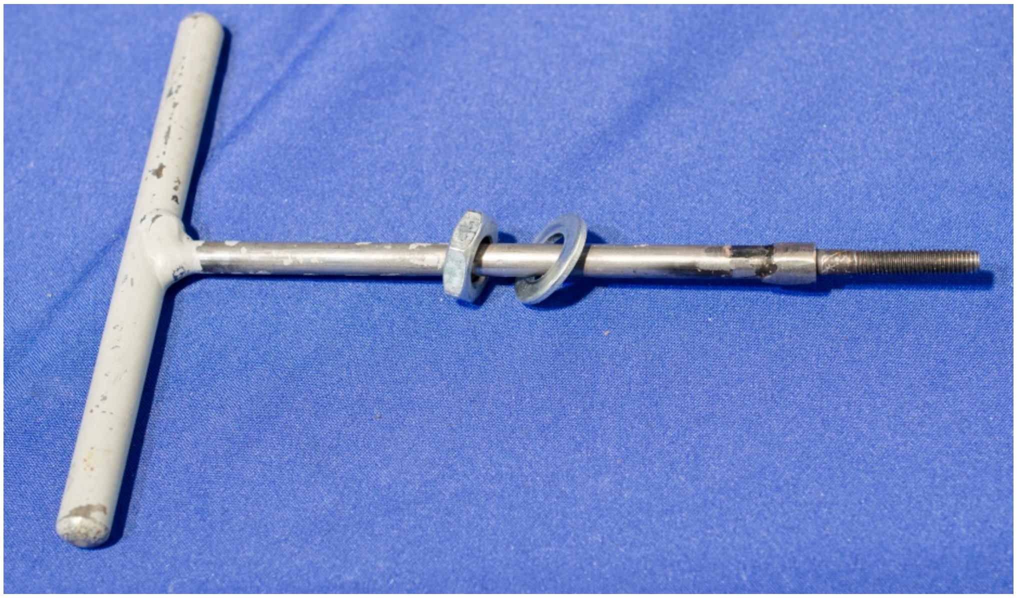


Figure 9-23. Insert washer and nut over threaded tool

9.2.2.21 Thread the tool into the Universal Joint Assembly (472-4751) and pull the end of the IR-TRACC through the abdomen foam (Figure 9-24). Start threading the hex jam nut onto the external threads on the Universal Joint Assembly and remove the threaded tool.

Figure 9-24. Install threaded tool into end of lower abdomen IR-TRACC

9.2.2.22 Use a screwdriver inserted into the slot on the IR-TRACC to restrict rotation of the IR-TRACC to install the hex jam nut with a wrench (Figure 9-25).

Figure 9-25. Use a screwdriver to prevent IR-TRACC rotation

WARNING: Do not rotate the IR-TRACC unit during installation as this may cause damage to the IR-TRACC cable connections in the unit.

9.2.2.23 Repeat Steps 9.2.2.21 and 9.2.2.22 for the right side. Zipper the abdomen bag closed (Figure 9-26).

Figure 9-26. Fully assembled lower abdomen

9.2.3 Attaching the Lower Abdomen to THOR-50M Dummy

The following procedure is a step-by-step description of the procedure to attach the lower abdomen to the THOR-50M. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3. Install the lower abdomen after connecting the spine to the pelvis assembly.

9.2.3.1 Attach the Rear Attachment Plate (472-4761) to the rear of the pelvis/lumbar mounting block using two M10 x 1.5 x 25mm FHCS (Figure 9-27). The bottom surface of the plate should be flush with the bottom surface of the block.

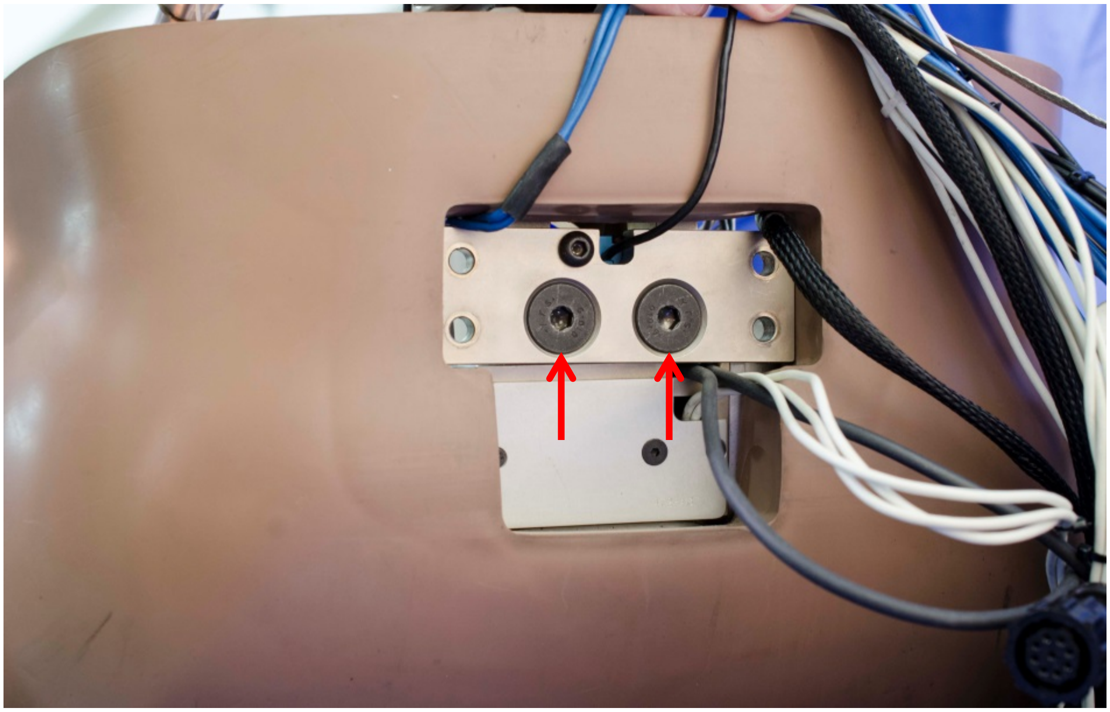


Figure 9-27. Secure rear attachment plate to pelvis

9.2.3.2 Slightly *loosen* (but do not remove) the M6 x 1 x 20 SHCS bolts (two per side) which hold the Left and Right Attachment Brackets (472-4720-1 & 472-4720-2) to the abdomen bracket (Figure 9-28). This will make it easier to install the abdomen assembly to the pelvis mounting block. Take care to tighten these bolts at the end of the assembly.

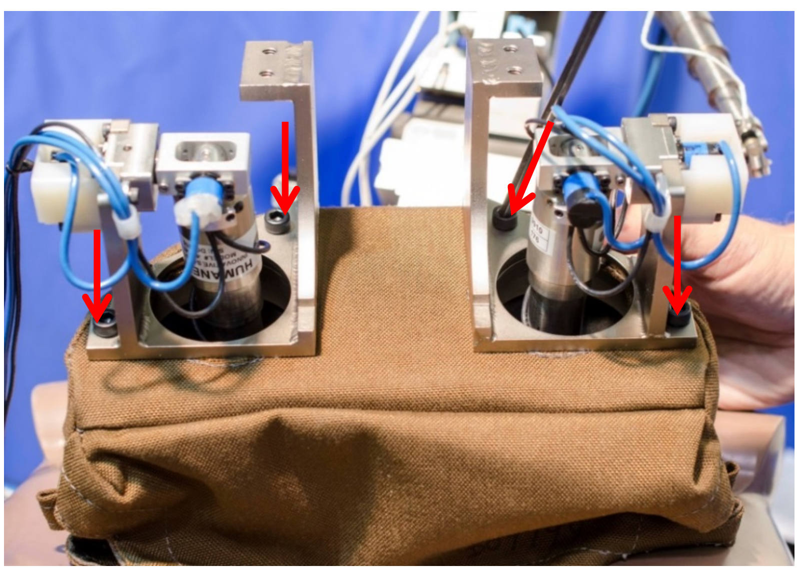


Figure 9-28. Loosely install left and right IR-TRACC attachment brackets to abdomen

9.2.3.3 Tilt the top of the lower abdomen forward and insert the abdomen into the cavity of the dummy. Carefully guide the IR-TRACC and wires around the proper sides of the spine. Use caution not to pinch the ASIS load cell wires.

9.2.3.4 The Lumbar Spine Ground Strap (472-8703) connects the Lower Abdomen at the Rear Attachment (472-4761) to the Spine at the Thoracic Spine Load Cell/ Flex Joint Adaptor Plate (472-3761). Place the Lumbar Spine Ground Strap over the upper right bolt before inserting the bolt (Figure 9-29). *Loosely* install four M6 x 1 x 16 SHCS to the rear attachment plate to hold the abdomen to the pelvis (Figure 9-30).

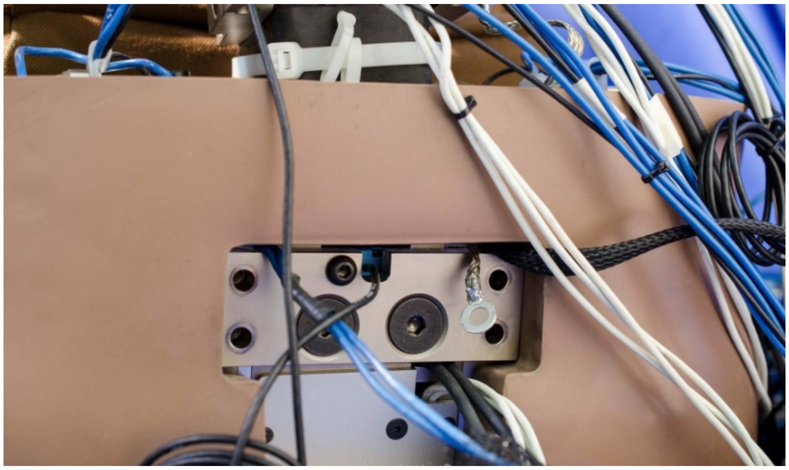


Figure 9-29. Lumbar ground strap attachment to pelvis

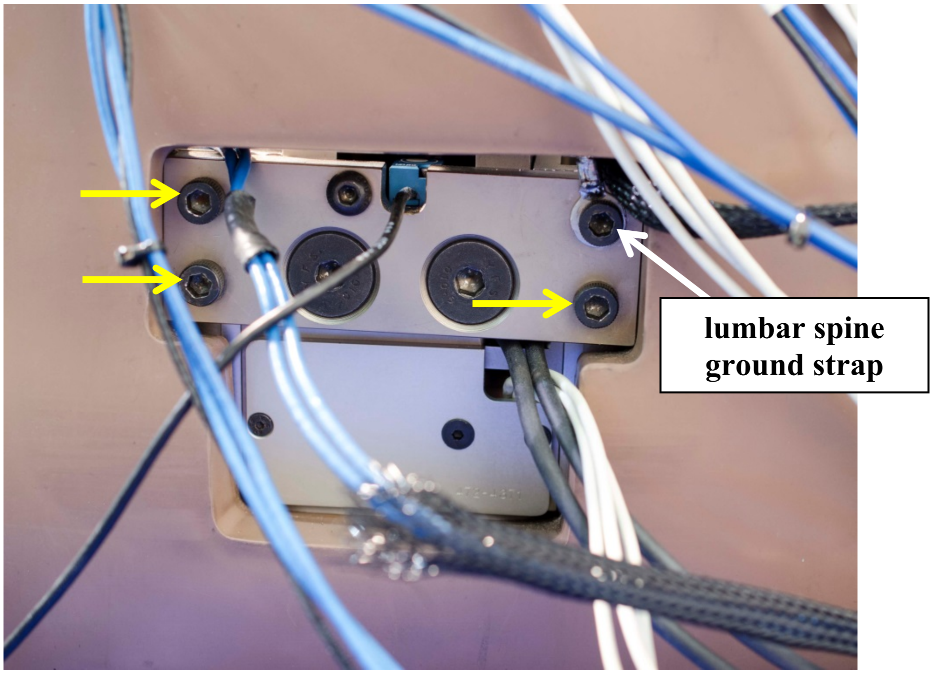


Figure 9-30. Loosely install rear attachment plate to hold lower abdomen to pelvis

9.2.3.5 Tighten the bolts Left and Right Attachment Brackets (Section 9.2.3.2).

9.2.3.6 Tighten the M6 x 1 x 16 SHCS on the pelvis Section 9.2.3.4.

9.2.3.7 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 (472-4763-8) as shown in Figure 9-31.

Figure 9-31. Abdomen cover installed

9.3 Adjustments for the Lower Abdomen Assembly

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

9.3.1 Storage and Handling:

Take care to ensure there is no compression or deformation of the foam sections during storage periods. Removing the foam inserts may help alleviate damage due to prolonged storage.

9.4 Electrical Connections and Requirements

Section 15.3 includes grounding information. Section 15.4.3 describes cable routing instructions.

9.4.1 IR-TRACC Calibration

Perform calibration of the IR-TRACC sensors prior to the installation into the lower abdomen assembly. See Section 16.

9.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the lower abdomen, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

9.5.1 Electrical Inspections (Instrumentation Check)

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the spine instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief (see Section 15.4.3).

Specific electrical areas to examine:

- Check the security of instrumentation mounting bolts for the IR-TRACC assemblies.
- Ensure that the wire that attaches the two ends of each IR-TRACC is aligned in the same plane at each end (Section 6.2.2.45)
- Inspect the set-screws locking the rotary potentiometer shafts in place on the 3D IR-TRACC assemblies. If the set-screws are loose, re-tighten.
- Inspect the IR-TRACC and potentiometer wiring for physical damage including broken connectors, pinched wires, missing insulation, etc. Repair the wiring or replace the IR-TRACC unit if necessary. There are no user-serviceable parts in the IR-TRACC unit itself. Return the IR-TRACC sensor to the manufacturer for repair or replacement.

9.5.2 Mechanical Inspection

Several components in the lower abdomen assembly require inspection post-test.
Specific mechanical areas to examine:

- Ensure that upper and lower abdomen Velcro® cover is installed over abdomen bags.
- Check the bag for tears, cuts and broken stitches. Repair or replace the bag if it is damaged to the point it will not fully contain the foams.
- Inspect the zipper. If the zipper is damaged to the point it will not fully contain the foams, repair or replace the bag.
- Ensure that the correct abdomen foams are installed.
- Check each foam for tearing, rips, and permanent compression. Replace any damaged foams.
- Inspect the telescoping column of each 3D IR-TRACC for structural damage which might inhibit the movement (extension and retraction) of the telescoping column.
- Ensure that the pins in the universal joints where the thorax IR-TRACCs attach to the bib are configured vertically and horizontally to prevent binding.
- Inspect the rotary potentiometers and brackets in the 3D IR-TRACC assemblies for damage. Replace of repair the rotary potentiometers if necessary.
- Ensure that the wire that attaches the two ends of the abdominal IR-TRACCs is wrapped around the collapsible tubes.
- Ensure that the lower abdominal Y-axis potentiometer exit cable points toward the rear of the dummy.
- Ensure that the wire that attaches the two ends of the IR-TRACC aligns in the same plane at each end.

  NOTE: There are no user serviceable parts in the IR-TRACC unit. Return the IR-TRACC sensor to the manufacturer for repair or replacement.

Section 10. **Pelvis Assembly**

10.1 Description of Pelvis Assembly and Features

The pelvis assembly of the THOR-50M dummy consists of a cold rolled steel base module and two aluminum wings, designed to approximate the geometry of the human pelvic bone structure. The locations of two important anthropomorphic landmarks have been carefully maintained: the H-points and the ASIS points. These landmarks provide locations that can be directly related to the human pelvis. The iliac wing accepts the pelvic box assembly, which holds the acetabular load cells and acetabular cups. The top of the pelvis base module accepts the lumbar/pelvis mounting block to allow attachment of the spine assembly. Figure 10-1 illustrates a drawing of the completed pelvic assembly with and without the pelvis skin.

There are several different types of instrumentation sensors incorporated into the pelvic region. A tri-pack accelerometer in the rear cavity of the pelvis measures the accelerations of the (approximate) pelvic center of gravity in three axes. A dual-axis tilt sensor measures the static position of the pelvis about the X- and Y-axes. Two acetabular load cells measure the loads transferred through the femurs to the pelvic structure. Each anterior iliac wing accepts a dual-axis ASIS load cell. The ASIS load cell measures the force of a lap belt against the iliac spine of the pelvis. The ASIS force (FX) is insensitive to the position of the belt on the iliac, while the moment channel (MY) provides an indication of the position of the belt on the iliac. A moment measurement reading of zero output occurs if the center of pressure of the belt lies on the load cell neutral axis. If the belt is above the neutral axis, the moment measures a positive output; a belt positioned below the neutral axis produces a negative bending moment.

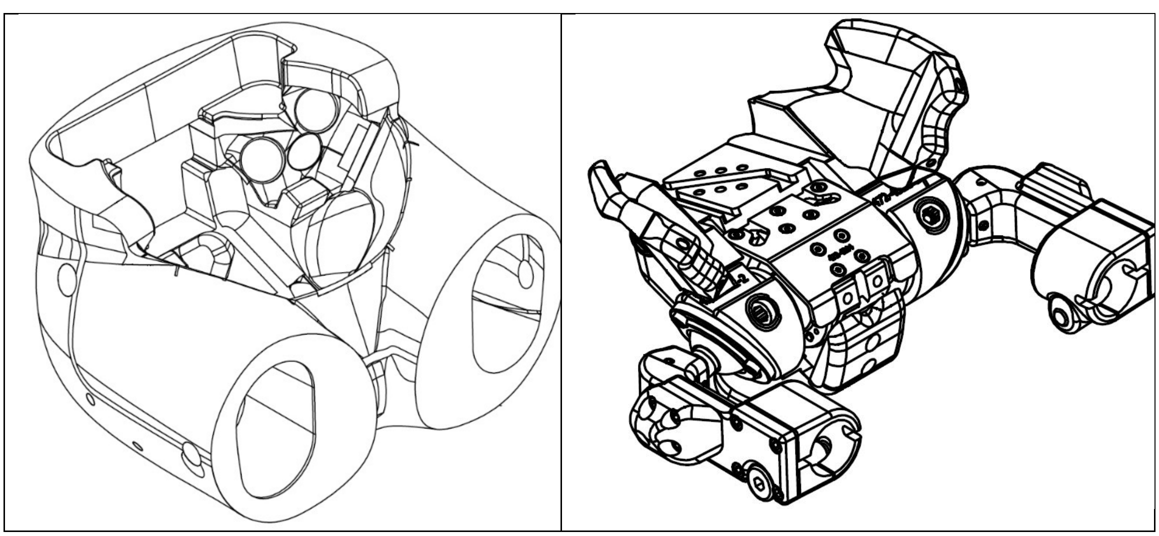


Figure 10-1. Pelvis assembly

10.2 Assembly of the Pelvis

10.2.1 Parts List

Figure 10-2 and Figure 10-3 show assemblies and hardware for the pelvis assembly. Table 10-1 and Table 10-2 list the components that are included in the pelvis assembly.

Table 10-1. Left Femur Ball Joint Assembly Components

Part Description	**Quantity**	**Part Number**	**Figure #**	**Item #**
Femur Retaining Ring	1	472-3830	Figure 10-2	1
Hip Shaft	1	472-4819	Figure 10-2	2
Femur Ball	1	472-4820	Figure 10-2	3
Left Trochanter	1	472-4812-1	Figure 10-2	4
Left Hip Cylinder	1	472-4814-1	Figure 10-2	5
Left Hip Arm	1	472-4815-1	Figure 10-2	6
M6 x 35mm Roll Pin	2	5001119	Figure 10-2	7
M6 x 40mm Roll Pin	1	5001118	Figure 10-2	8
M6 x 1 x 16 LG. SHCS	8	5000081	Figure 10-2	9
M16 x 40 LG. SHSS	1	5000298	Figure 10-2	10

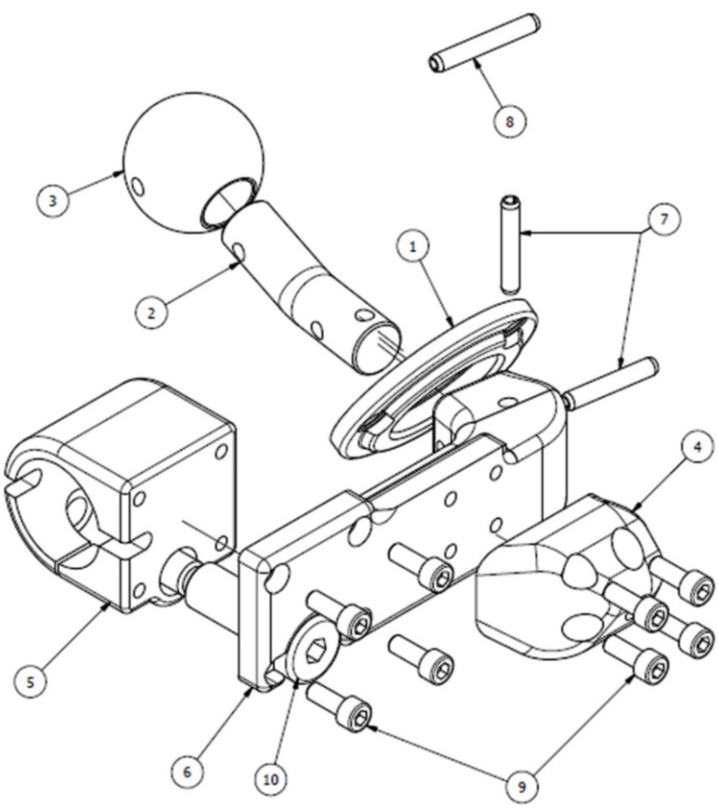


Figure 10-2. Left femur ball joint assembly components

Table 10-2. Pelvis Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Pelvis Base Module	1	472-4211	Figure 10-3	1
Pelvis Left D-Pt	1	472-4340-1	Figure 10-3	2
Pelvis Right D-Pt	1	472-4340-2	Figure 10-3	3
Pelvis Coccyx	1	472-4350	Figure 10-3	4
Machined Front Pelvic Casting	1	472-4370	Figure 10-3	5
Screw, FHCS M5 x 0.8 x 10	2	5000084	Figure 10-3	6
Right Iliac Assembly	1	472-4380-2	Figure 10-3	7
Left Iliac Assembly	1	472-4830-1	Figure 10-3	8
Iliac Cable Cover, Pelvis	8	472-4372	Figure 10-3	9
Screw, FHCS M2.5 x 0.45 x 5	16	5000723	Figure 10-3	10
Screw, FHCS M6 x 1 x 22	10	5000572	Figure 10-3	11
S.R. THOR A.S.I.S.	2	472-4375	Figure 10-3	12
Left Femur Ball Joint Assembly	1	472-4800-1	Figure 10-3	13
Right Femur Ball Joint Assembly	1	472-4800-2	Figure 10-3	14
Pelvis Tri-Pack Mounting Bracket	1	472-4361	Figure 10-3	15
Pelvis Accelerometer Cover	1	472-4371	Figure 10-3	16
Screw, FHCS M3 x 0.5 x 10	3	5000203	Figure 10-3	17
Pelvis Flesh, Molded	1	472-4100	Figure 10-3	18
Pelvis Front Plate	1	472-4330	Figure 10-3	19
Pelvis Top Plate	1	472-4204	Figure 10-3	20
Pelvis Rear Plate	1	472-4205	Figure 10-3	21
Friction Adjustment Set Screw Assembly	2	472-4310	Figure 10-3	22
Pelvis Socket Adaptor (Left)	1	472-4321-1	Figure 10-3	23
Acetabular Load Cell Structural Replacement	2	472-4323	Figure 10-3	24
Pelvis Load Cell Mtg. Plate Left	1	472-4325-1	Figure 10-3	25
Pelvis Socket Adaptor (Right)	1	472-4321-2	Figure 10-3	26
Pelvis Load Cell Mtg. Plate (Right)	1	472-4325-2	Figure 10-3	27
Screw, FHCS M6 x 1 x 25	8	5000135	Figure 10-3	28
Screw, FHCS M6 x 1 x 20	8	5001089	Figure 10-3	29
Screw, SHCS M6 x 1 x 12	4	5000281	Figure 10-3	30
Screw, FHCS M6 x 1 x 16	4	5000090	Figure 10-3	31
Screw, SHCS M3 x 0.5 x 10	4	5000119	Figure 10-3	32
Screw, FHCS M4 x 0.7 x 10	9	5000023	Figure 10-3	33
M12 x 1.75 Hex Lock Nut Zinc	2	5000462	Figure 10-3	34
M12 Flat Washer Plain Zinc	2	5000267	Figure 10-3	35
Screw, SHCS M6 x 1 x 14	6	5000604	Figure 10-3	36
Screw, FHCS M4 x 0.7 x 8	9	5000646	Figure 10-3	37
A.S.I.S. Load Cell (optional)	2	SA572-S119	Figure 10-3	38
Right Acetabular Load Cell Assembly	1	SA572-S129	Figure 10-3	39
Left Acetabular Load Cell Assembly	1	SA572-S128	Figure 10-3	40

Part Description (continued)	Quantity	Part Number	Figure #	Item #
Wire Clamp, Nylon 1/8 DIA.	1	9002655	Figure 10-3	41
Spring Lock M3 Washer	1	5001111V	Figure 10-3	42
Nut, Hex M-0.5	1	9009248V	Figure 10-3	43
Screw, M6 x 22 Low Profile SHCS	2	9010566V	Figure 10-3	44
Tri-Pack Accel. Assy.	1	472-4203	Figure 10-3	45
M2 x 0.4 x 16 LG. SHCS	2	5000985	Figure 10-3	46
Screw, M6 x 1 x 18 FHCS	4	5000285	Figure 10-3	47

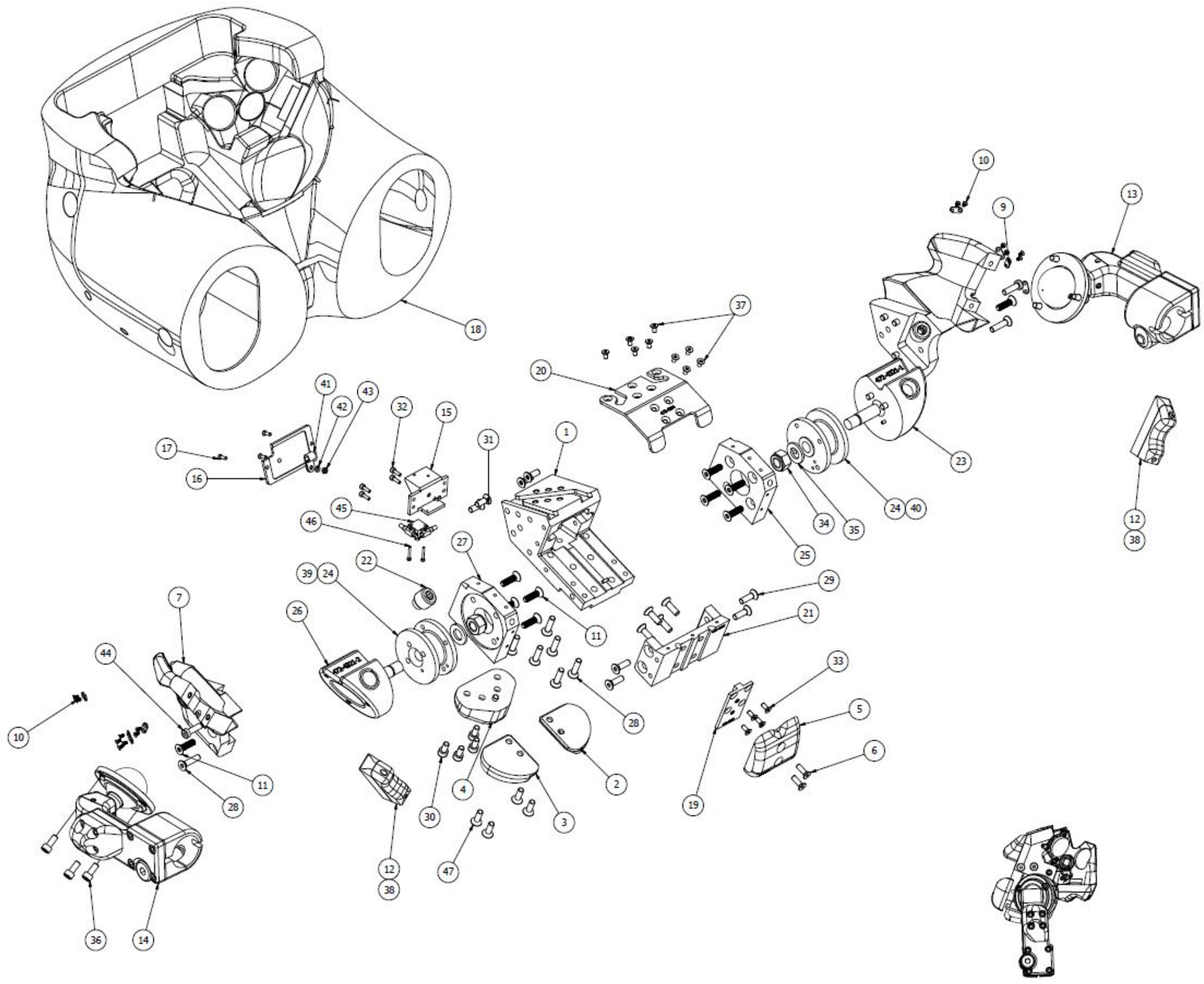


Figure 10-3. Pelvis assembly components

10.2.2 **Assembly of Pelvis Components**

The following procedure is a step-by-step description of the assembly procedure for the pelvis components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

10.2.2.1 Attach the Left Load Cell Mounting Plate (472-4325-1) to the Left Acetabulum Load Cell (472-4390) using four M6 x 22 FHCS (Figure 10-4). Orient the load cell wiring to the mounting plate as shown in Figure 10-5.

NOTE: The orientation of the acetabulum load cell axes and wiring is critical to proper assembly of the pelvis. Improper orientation will prevent the load cell from installation within the pelvis.

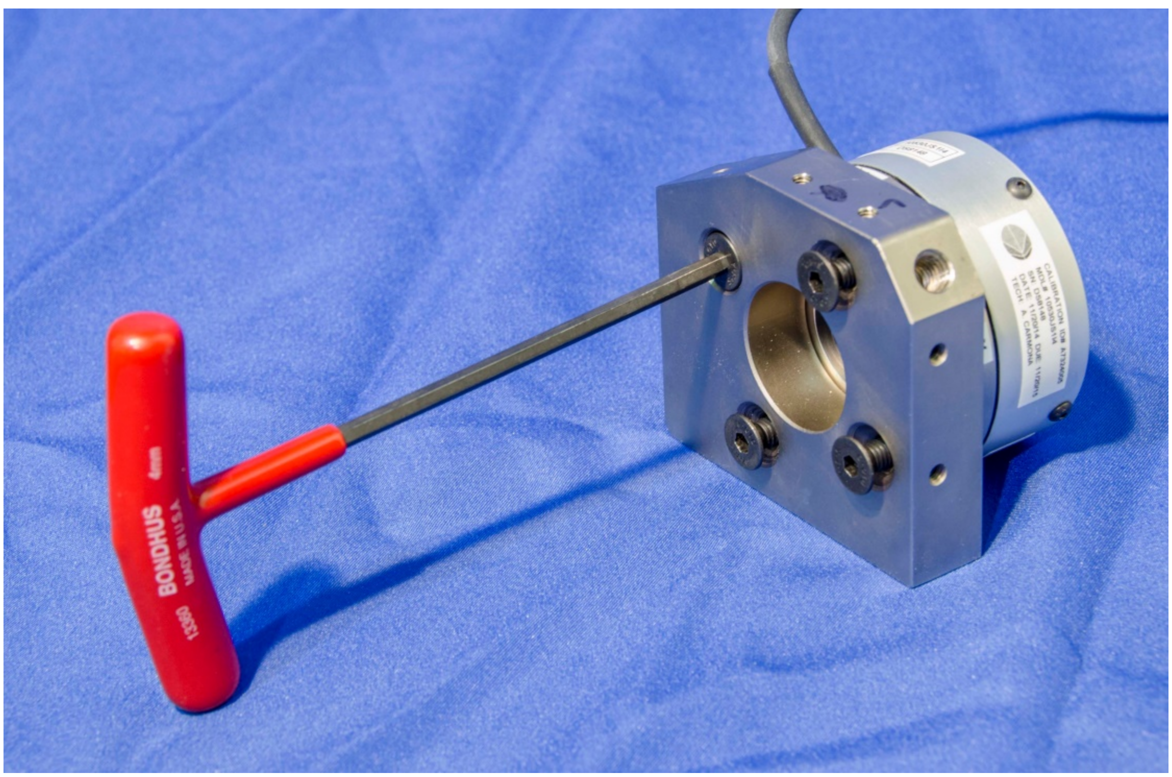


Figure 10-4. Attach load cell mounting plate to acetabulum load cell

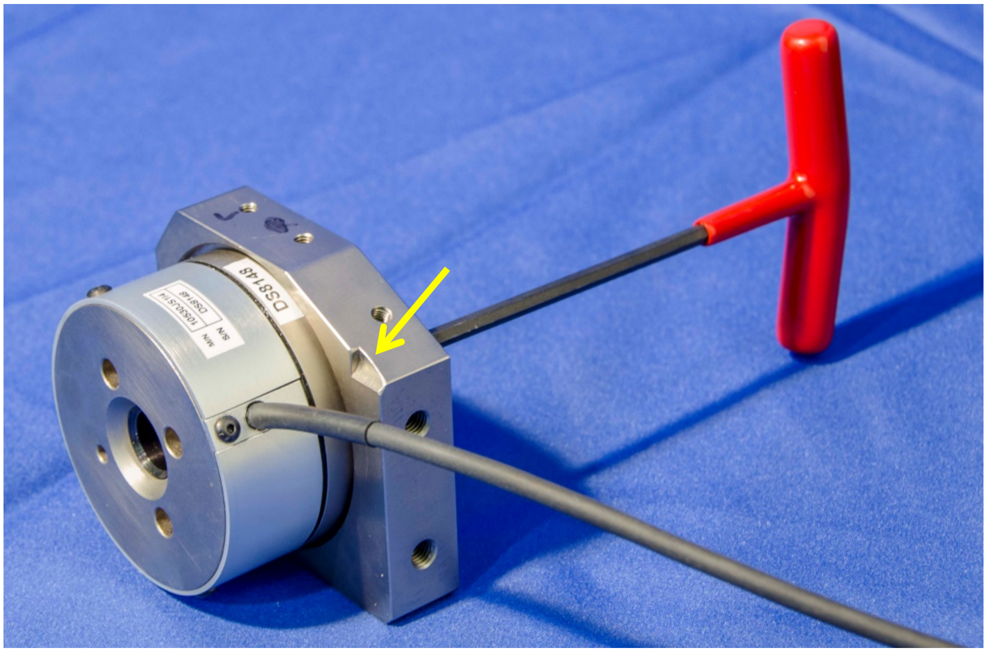


Figure 10-5. Ensure proper orientation of acetabulum load cell

10.2.2.2 Insert the shaft of the Left Pelvic Socket Adaptor (472-4321-1) into the left acetabulum load cell. Figure 10-6 indicates the orientations of the pelvic socket adaptor and the load cell. Align the dowel pin holes of the load cell with the dowel pins in the socket adaptor.

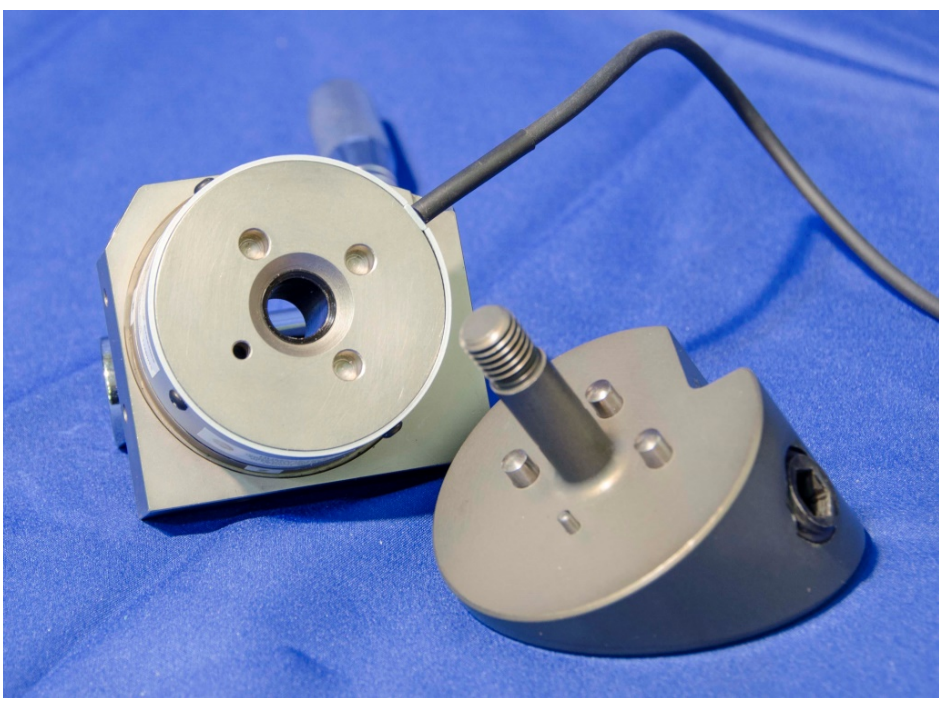


Figure 10-6. Insert pelvic socket adaptor into acetabulum load cell aligning pins

10.2.2.3 Insert the M12 ID flat washer onto the adaptor shaft (Figure 10-7). Use an M12 nylon lock hex jam nut with torque of 11.3 N-m (100 in-lb) to secure the socket adaptor to the acetabulum load cell (Figure 10-8 and Figure 10-9).

Figure 10-7. Install M12 flat washer

Figure 10-8. Secure pelvis socket adaptor to acetabulum load cell

Figure 10-9. Acetabulum load cell installed to pelvic socket adaptor

10.2.2.4 Repeat steps 10.2.2.1 and 10.2.2.3 for the right side.

10.2.2.5 Bolt the Left and Right Socket/Load Cell Assemblies to the Pelvis Rear Plate (472-4205) using four M6 x 20 FHCS, as shown in Figure 10-10.

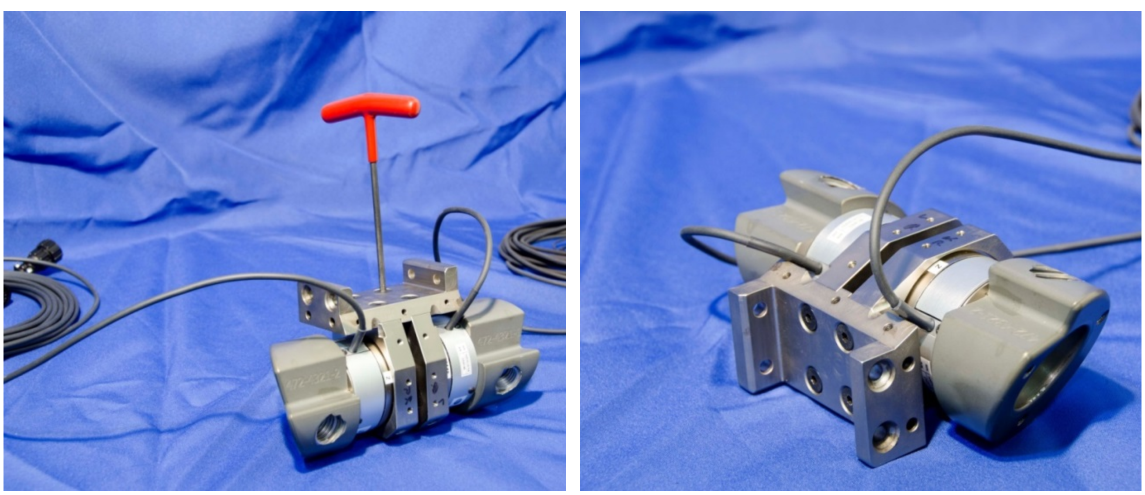


Figure 10-10. Bolt left and right load cell assemblies to rear plate

10.2.2.6 Mount a Friction Adjustment Set Screw Assembly (472-4310) on each top hole of the Left and Right Acetabular Load Cell Assemblies (SA572-S128 and SA572-S129) (Figure 10-11).

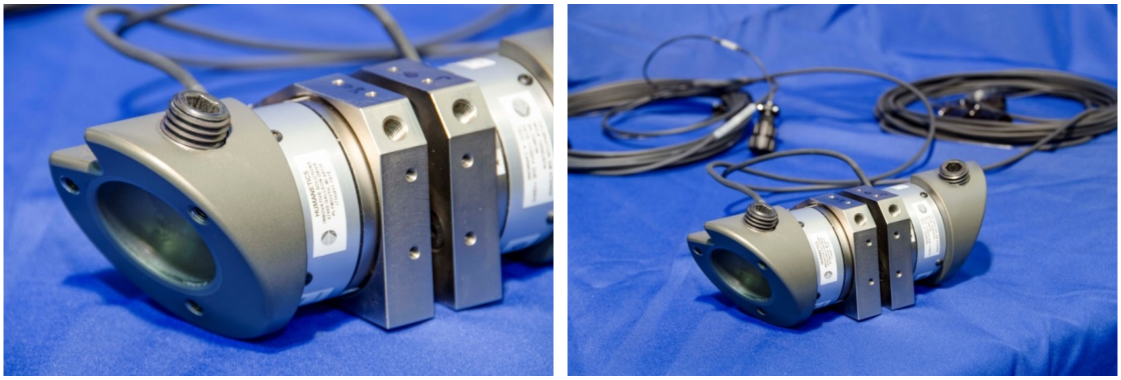


Figure 10-11. Friction adjustment set screws

10.2.2.7 Bolt the Top Plate (472-4204) to the top of the left and right load cell mounting plates, using five M4 x 8 FHCS (angled edge), and four M4 x 8 FHCS (top surface) (Figure 10-12). The Acetabular load cell wires must exit through the grooves at the rear of the top plate.

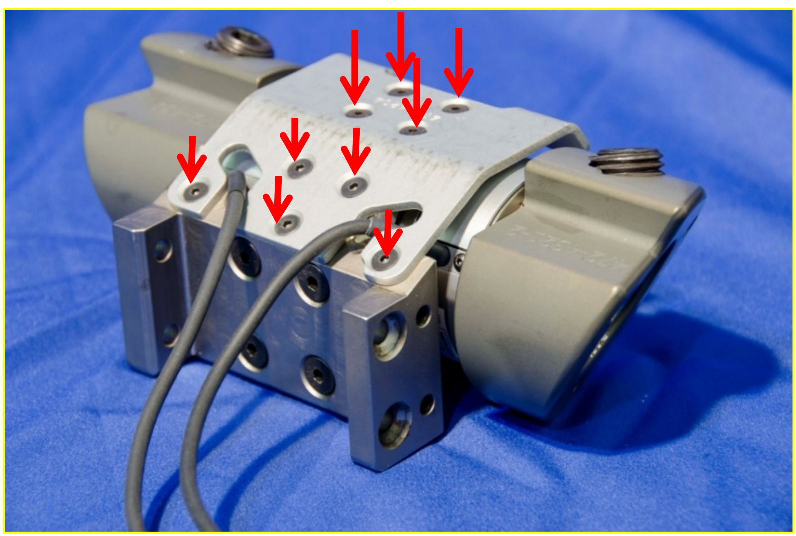


Figure 10-12. Top plate assembled to load cell mounting plates

10.2.2.8 Bolt the Front Plate (472-4330) on to the front of the left and right load cell mounting plates using four M4 x 10 FHCS (Figure 10-13).

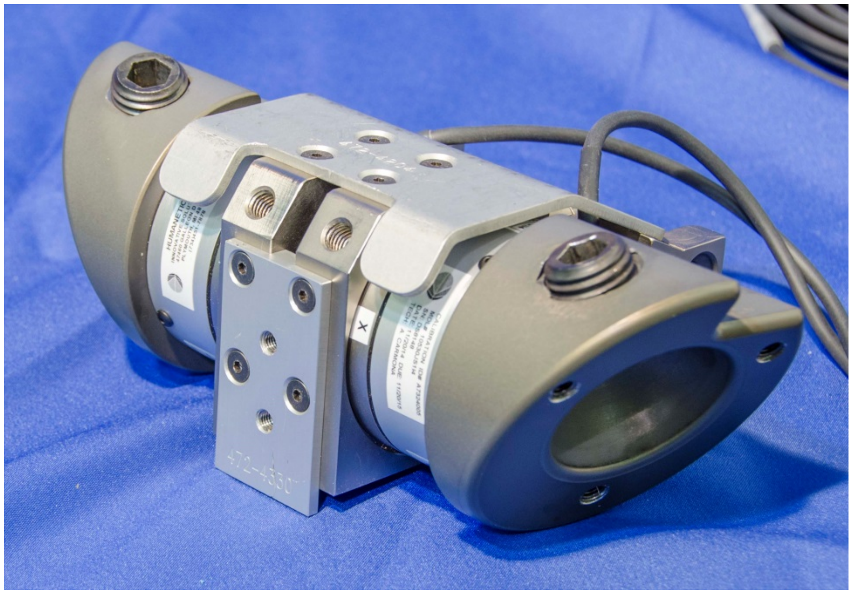


Figure 10-13.Front plate attached to load cell mounting plate

10.2.2.9 Attach the Machined Front Pelvic Casting (472-4370) to the Front Plate (472-4330) using two M5 x 16 FHSCS, as shown in Figure 10-14. At this stage, this assembly is referred to as the pelvic box assembly.

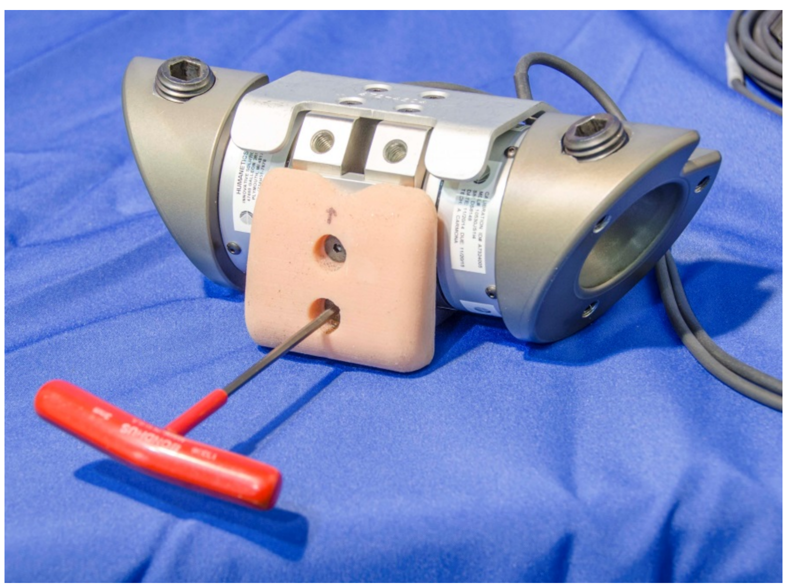


Figure 10-14. Attach the machined front pelvic casting

10.2.2.10 Mount the Pelvis Base Module (472-4211) to the pelvic box assembly using four M6 x 20 FHCS on the sides of the pelvis base module (Figure 10-15).

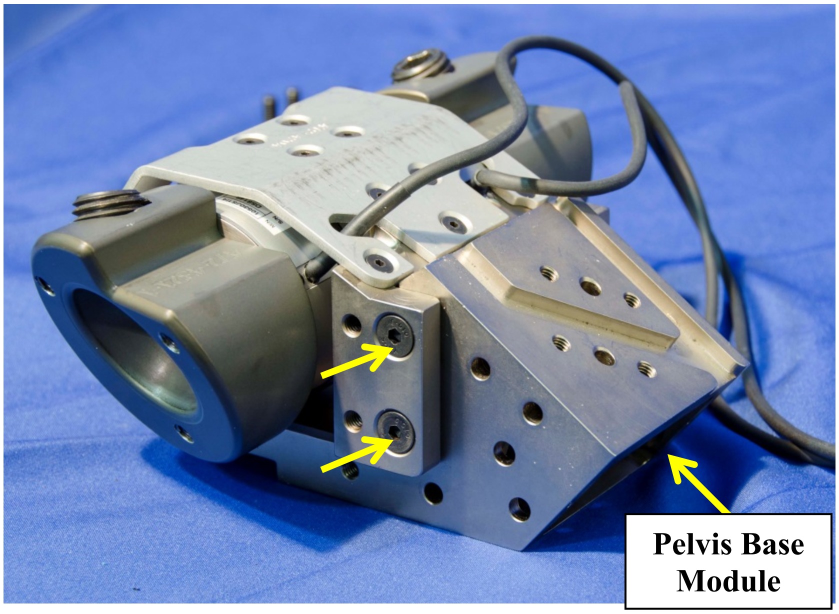


Figure 10-15. Mount sides of pelvis base module to pelvic box assembly

10.2.2.11 Secure with six M6 x 25 FHCS on the bottom of the pelvis base module (Figure 10-16 and Figure 10-17).

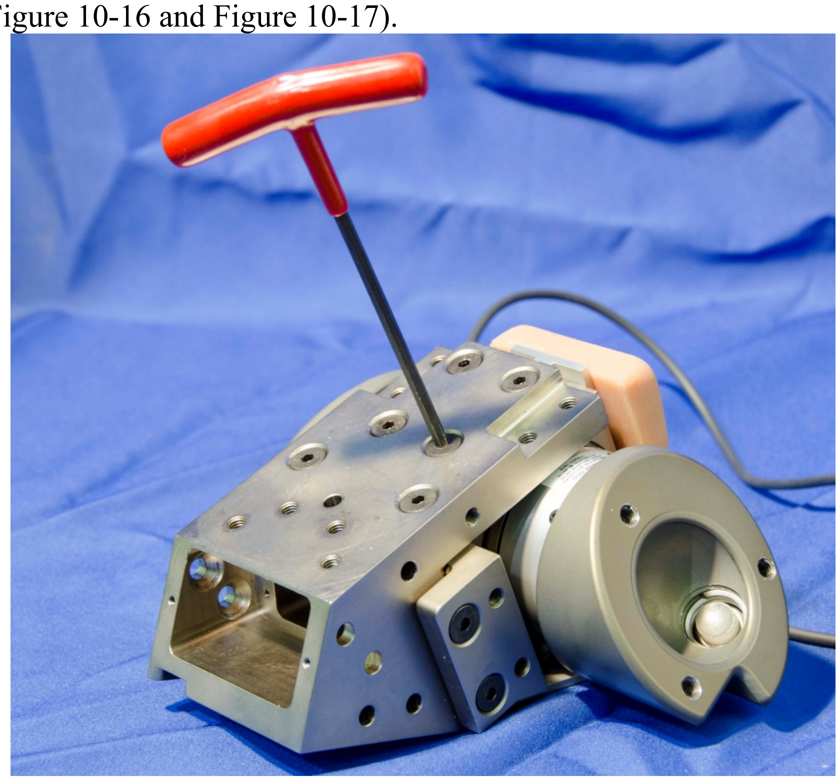


Figure 10-16. Secure pelvis base module to bottom of pelvic box assembly

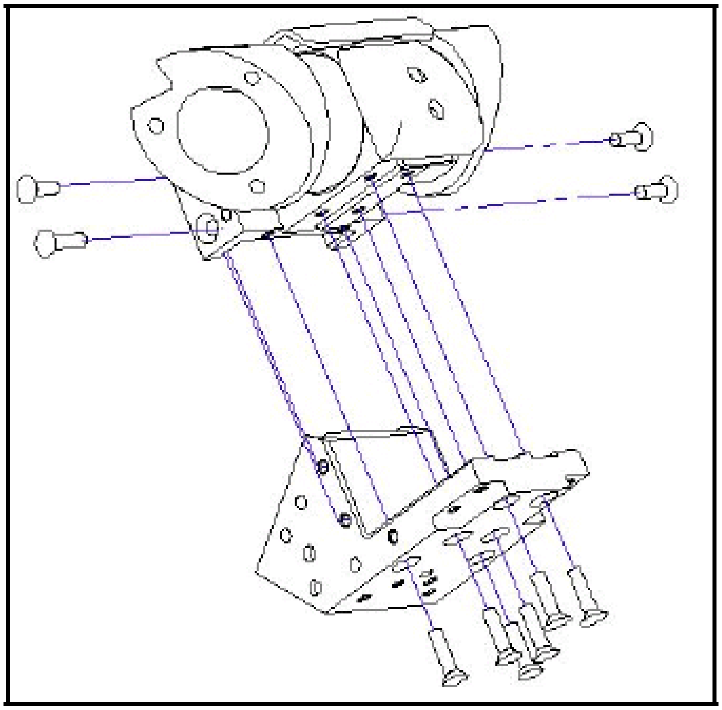


Figure 10-17. Details for assembling pelvis base module to pelvic box assembly

10.2.2.12 Attach the Left (472-4340-1) and Right (472-4340-2) D-Points to the front corners of pelvis base module, using four M6 x 1 x 20 FHCS (Figure 10-18).

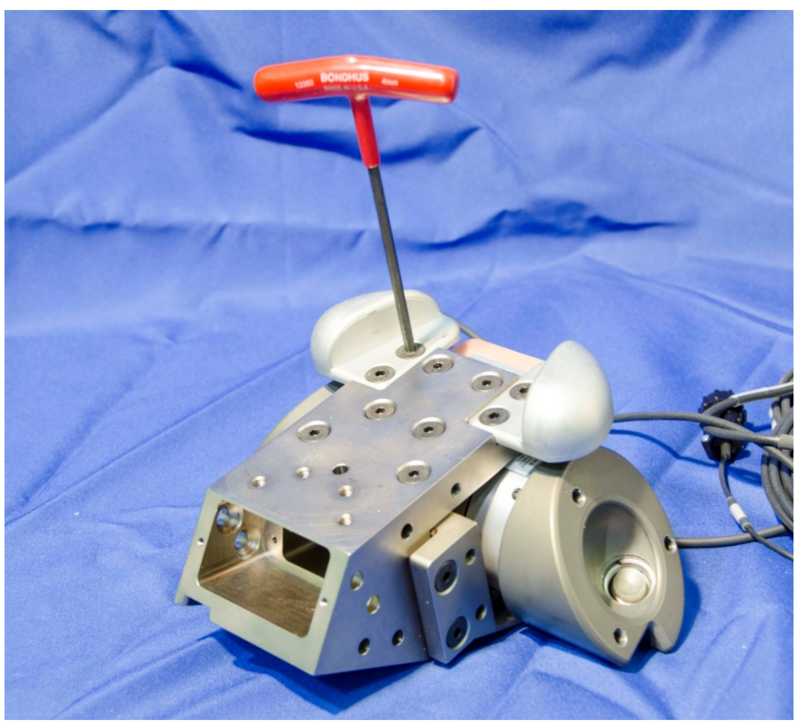


Figure 10-18. Attach D-points to pelvis base module

10.2.2.13 Align the holes of the Pelvis Coccyx (472-4350) with the holes on the rear of the Pelvis Base Module, and attach the coccyx to the base module using four M6 x 1 x 12 SHCS and an M6 x 20 dowel pin (Figure 10-19 and Figure 10-20).

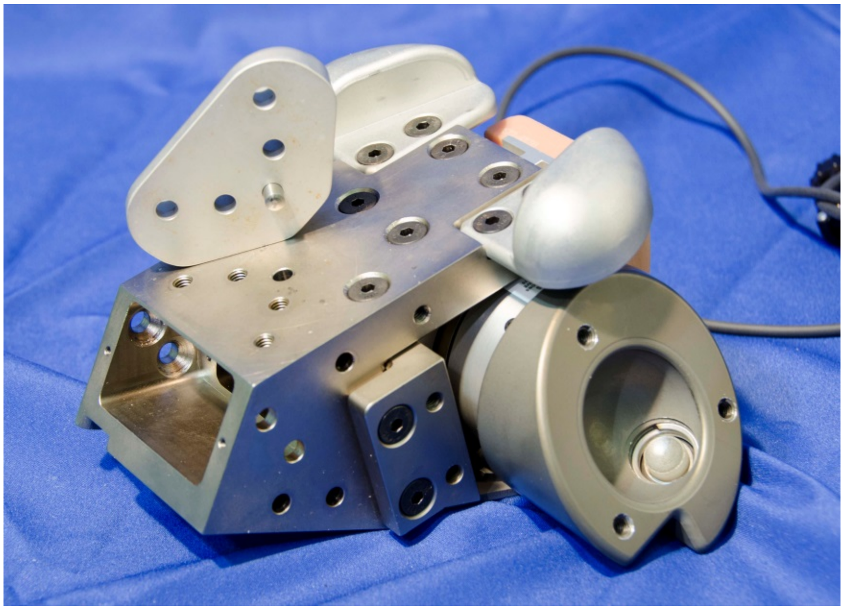


Figure 10-19. Align holes in pelvis coccyx to pelvis base module

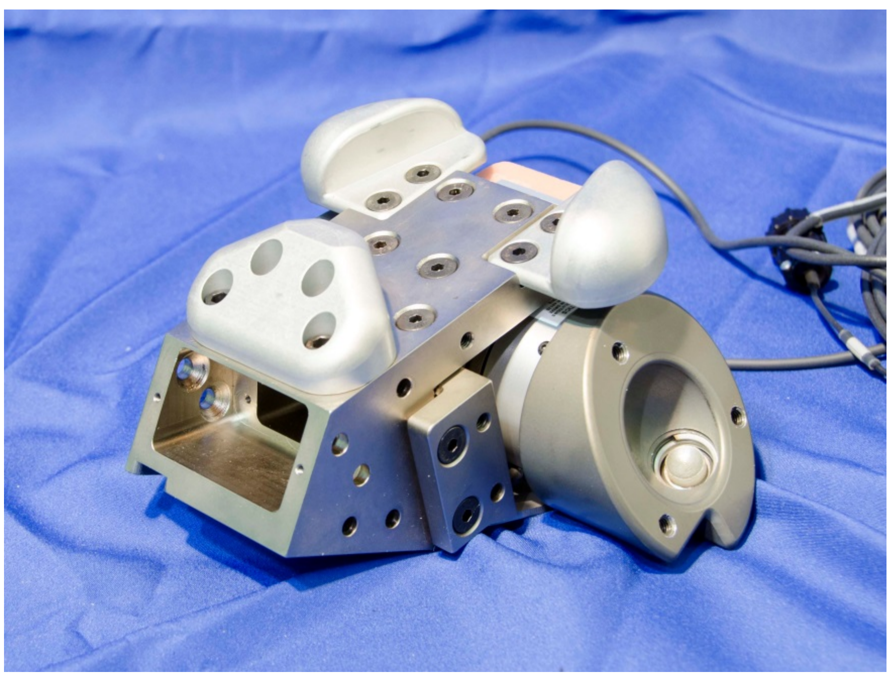


Figure 10-20. Pelvis coccyx installed

10.2.2.14 Attach the Left (472-4382-1) and Right (472-4382-2) Pelvis Wings to the left and right sides of the pelvis base module using one M6 x 20 low profile SHCS, one M6 x 1 x 22 FHCS, and one M6 x 1 x 25 FHCS on each side (Figure 10-21 and Figure 10-22).

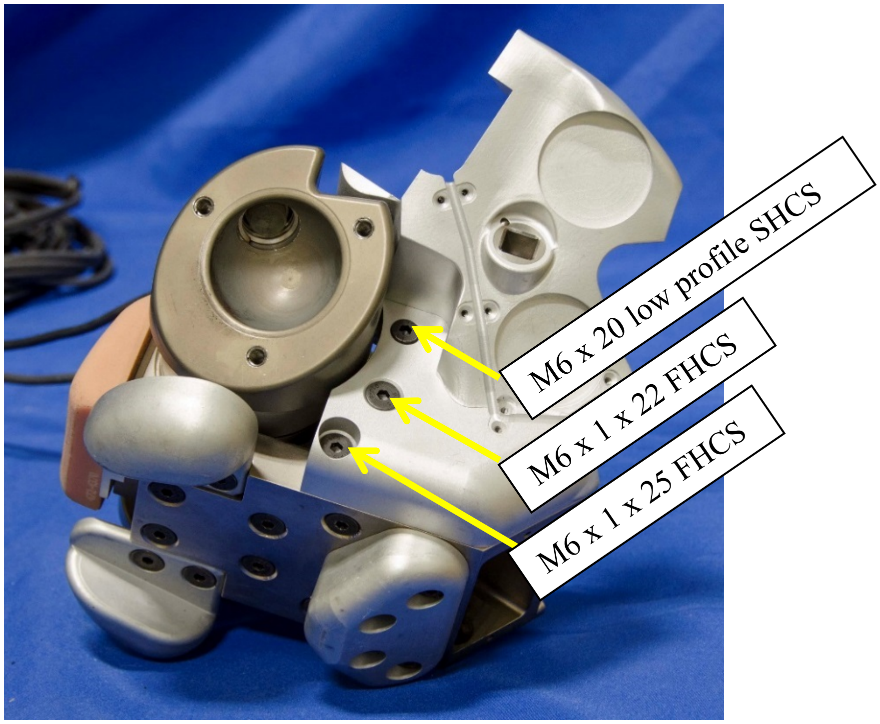


Figure 10-21. Attach screws through pelvis iliac wings into pelvis base module

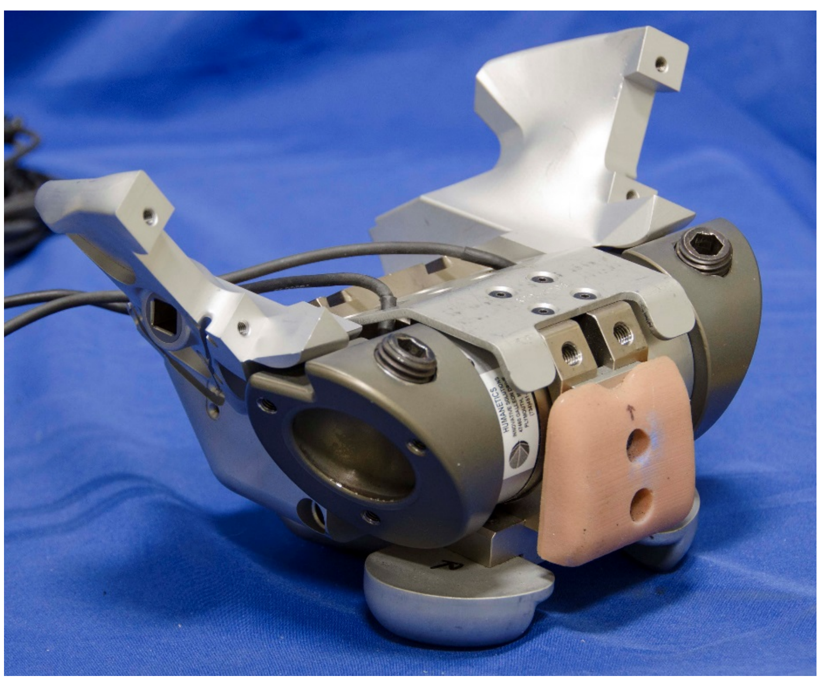


Figure 10-22. Iliac wings attached to pelvis base module

10.2.2.15 Install two M6 x 1 x 16 FHCS per side through the pelvis base module and into the iliac wing (Figure 10-23 and Figure 10-24).

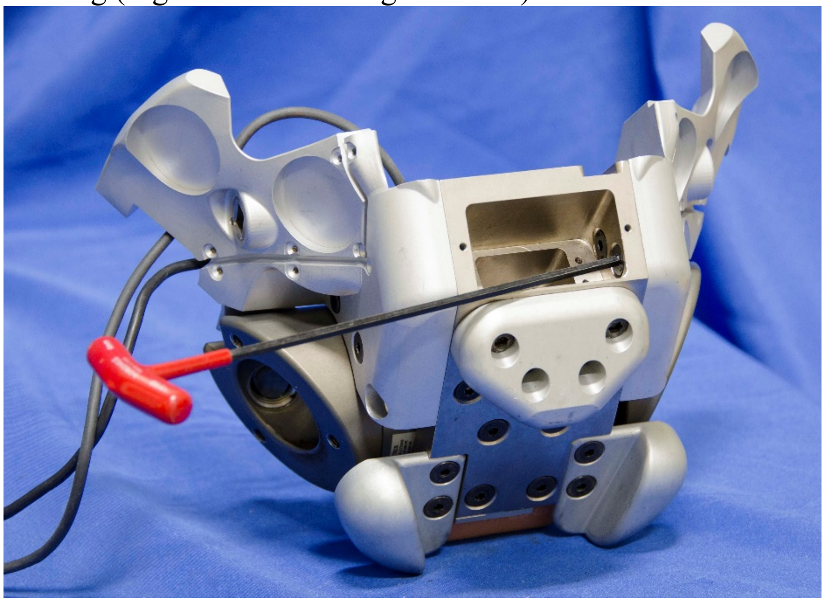


Figure 10-23. Secure interior screws through pelvis base module into iliac wing

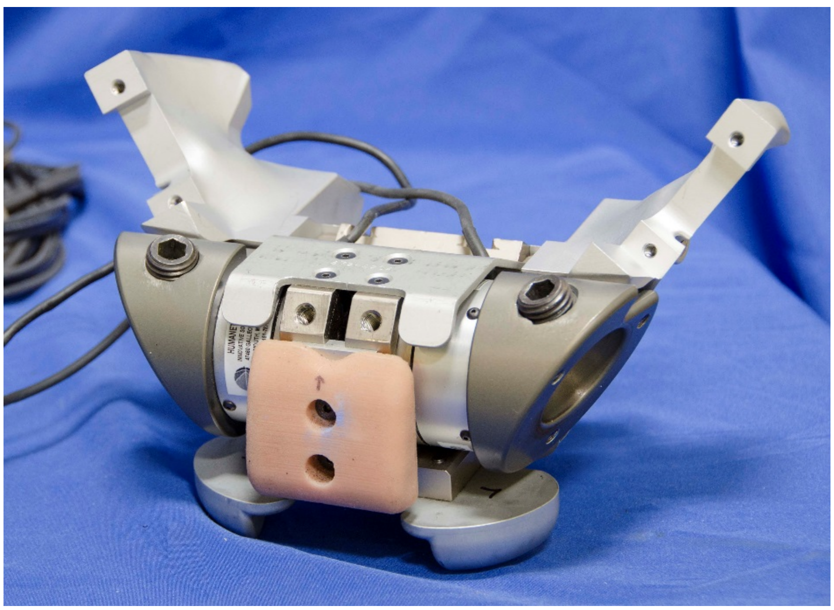


Figure 10-24. Pelvis with iliac wings installed

10.2.2.16 Mount the X, Y, and Z accelerometers to the accelerometer block using two M1.6 x 3 SHCS per accelerometer. Secure the accelerometer block to the Pelvis Tri-Pack Mounting Bracket with two M2 x 16 SHCS (Figure 10-25).

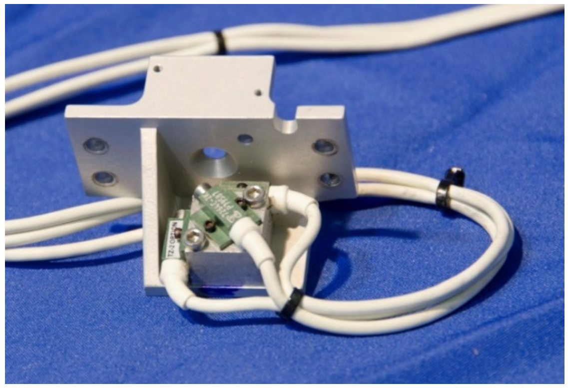


Figure 10-25. Attach accelerometers to block and secure to pelvis tri-pack mounting bracket

10.2.2.17 Mount the Pelvic Tri-Pack Assembly (472-4360) at the Pelvis C.G. (cavity at the rear of the Pelvis Base Module), using four M3 x 0.5 x 10 SHCS (Figure 10-26). The accelerometers are oriented in the following manner: +X forward, +Y right, +Z down. This sign convention agrees with the SAE coordinate system.

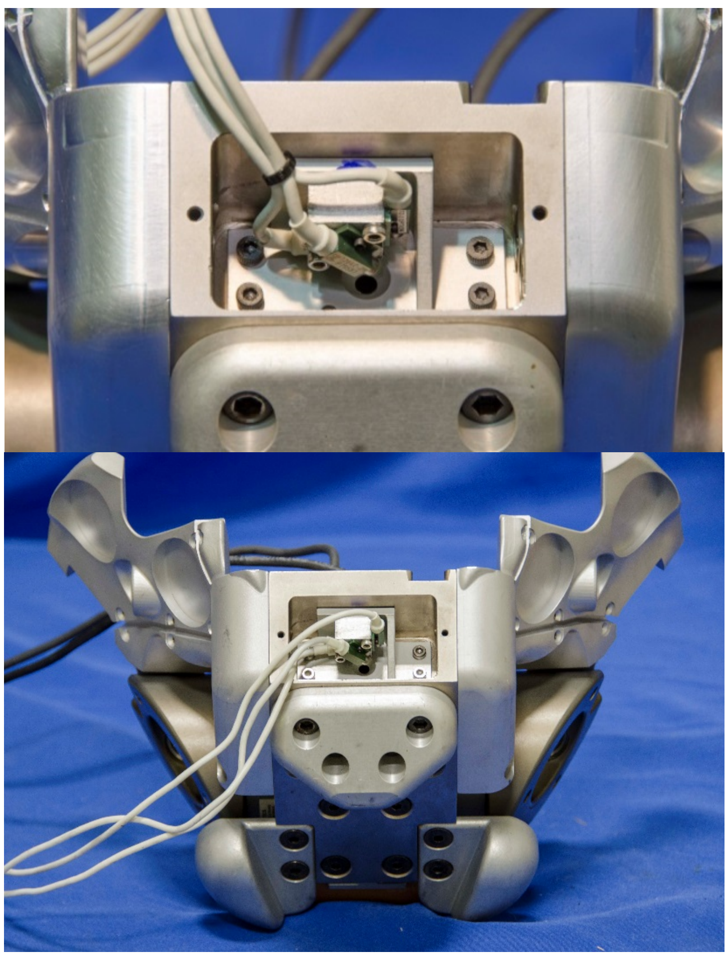


Figure 10-26. Mount pelvis tri-pack assembly to pelvis

10.2.2.18 Secure the triaxial accelerometer wires (and tilt sensor wire if used) to the inside of the Pelvis Triaxial Cover (472-4371) using a 1/8" Wire Clamp, M4 x 12 FHCS and a M4 Nylock nut (Figure 10-27 and Figure 10-28). Be sure to install a new nylock nut each time the nut is removed. Leave at least 100 mm of slack between the accelerometers and strain relief clamp.

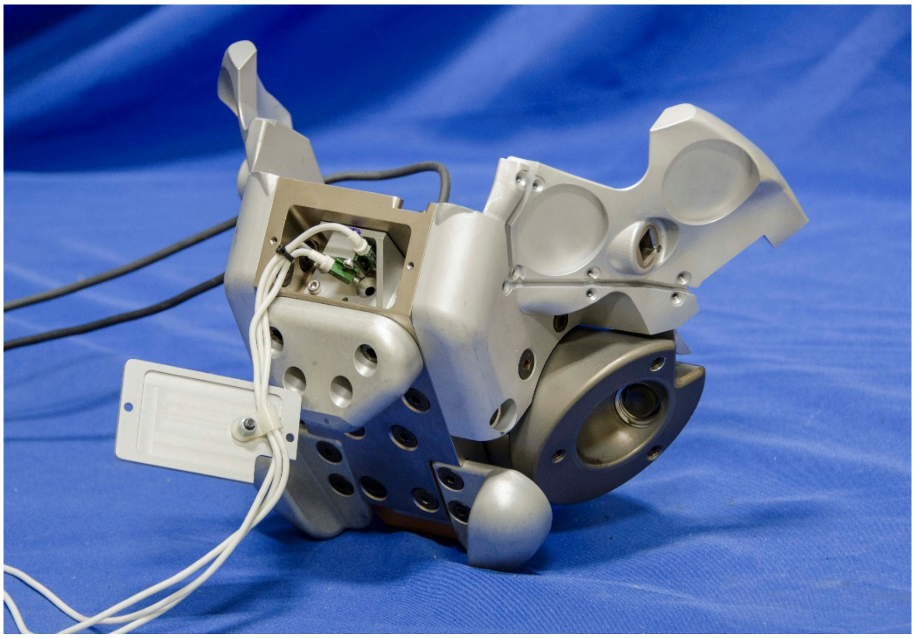


Figure 10-27. Provide strain relief for pelvic transducers

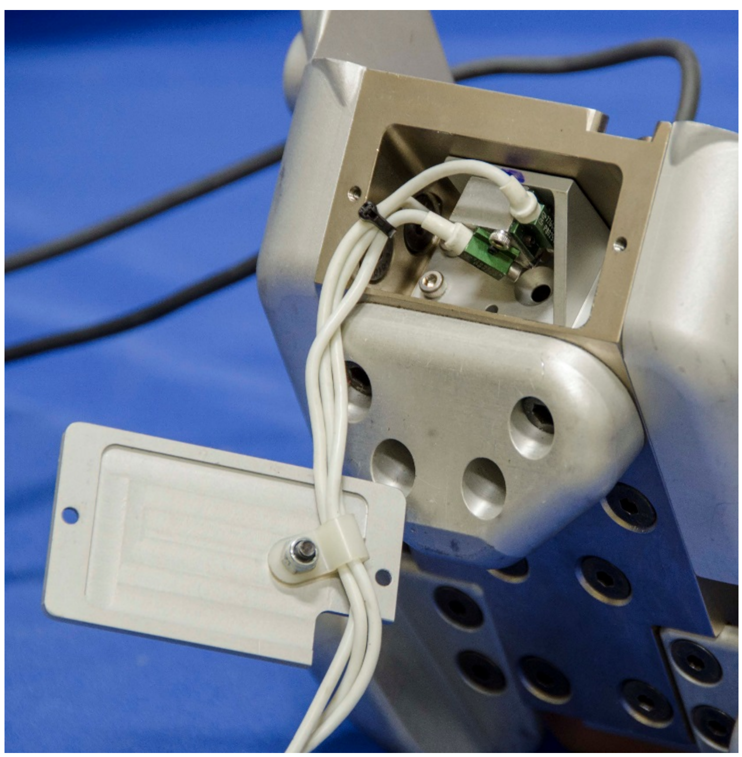


Figure 10-28. Details of pelvic strain relief wire clamp

10.2.2.19 Install the Pelvis Accelerometer Cover (472-4371) over the cavity in the pelvis casting using two M3 x 10 FHCS (Figure 10-29). The cover must be oriented with the wire exit hole at the top right corner as shown. Use caution so that the wires are not crimped beneath the plate edges during installation.

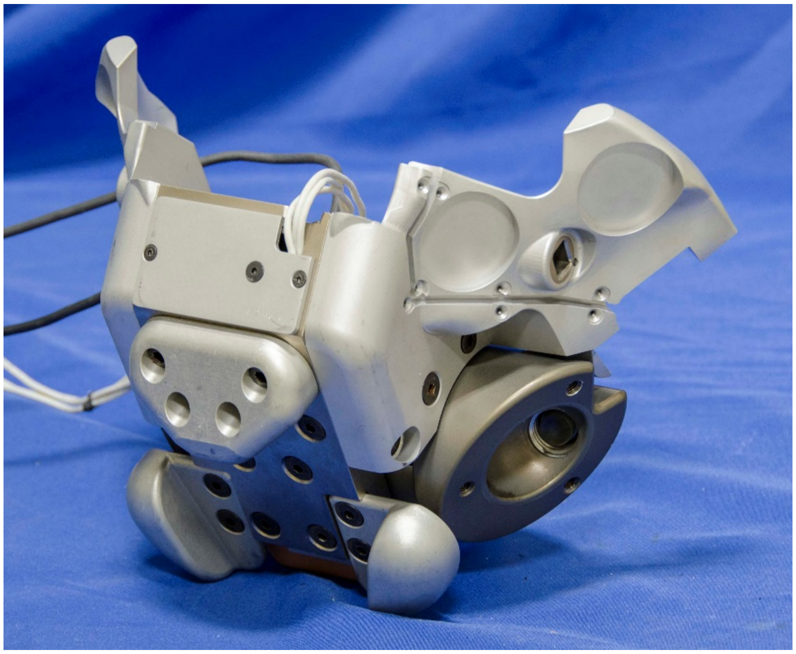


Figure 10-29. Install pelvis accelerometer cover

10.2.2.20 Position the ASIS load cell as shown in Figure 10-30 and attach it to the left iliac wing using two M5 x 16 BHCS (Figure 10-30). Repeat this procedure to attach the right side ASIS load cell to the right iliac wing.

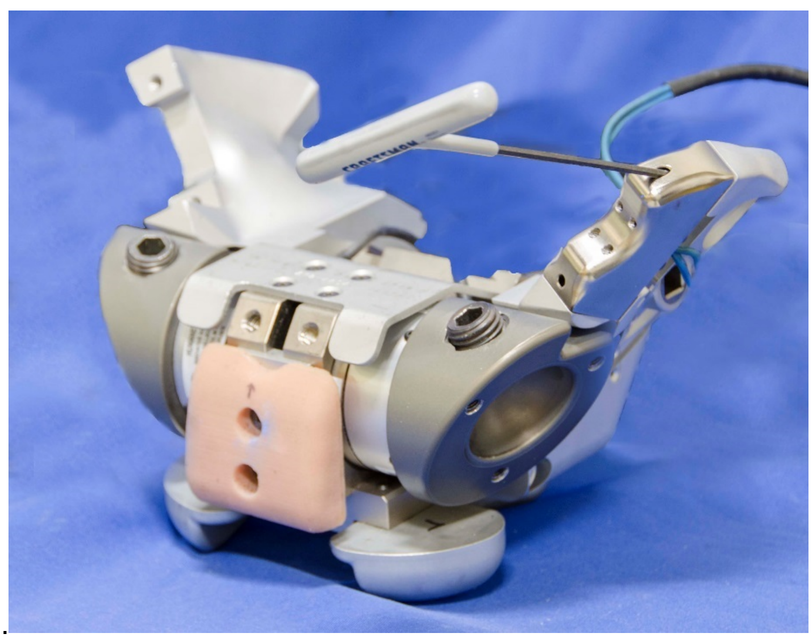


Figure 10-30. Install ASIS load cell

10.2.2.21 For each iliac wing, the wires from the ASIS load cell should be placed in the machined groove on the outside surface of the iliac wing; secure the wiring using four iliac cable covers (472-4372) and eight M2.5 x 0.45 x 5 FHCS (Figure 10-31). Figure 10-32 and Figure 10-33 show the completed internal pelvis structure.

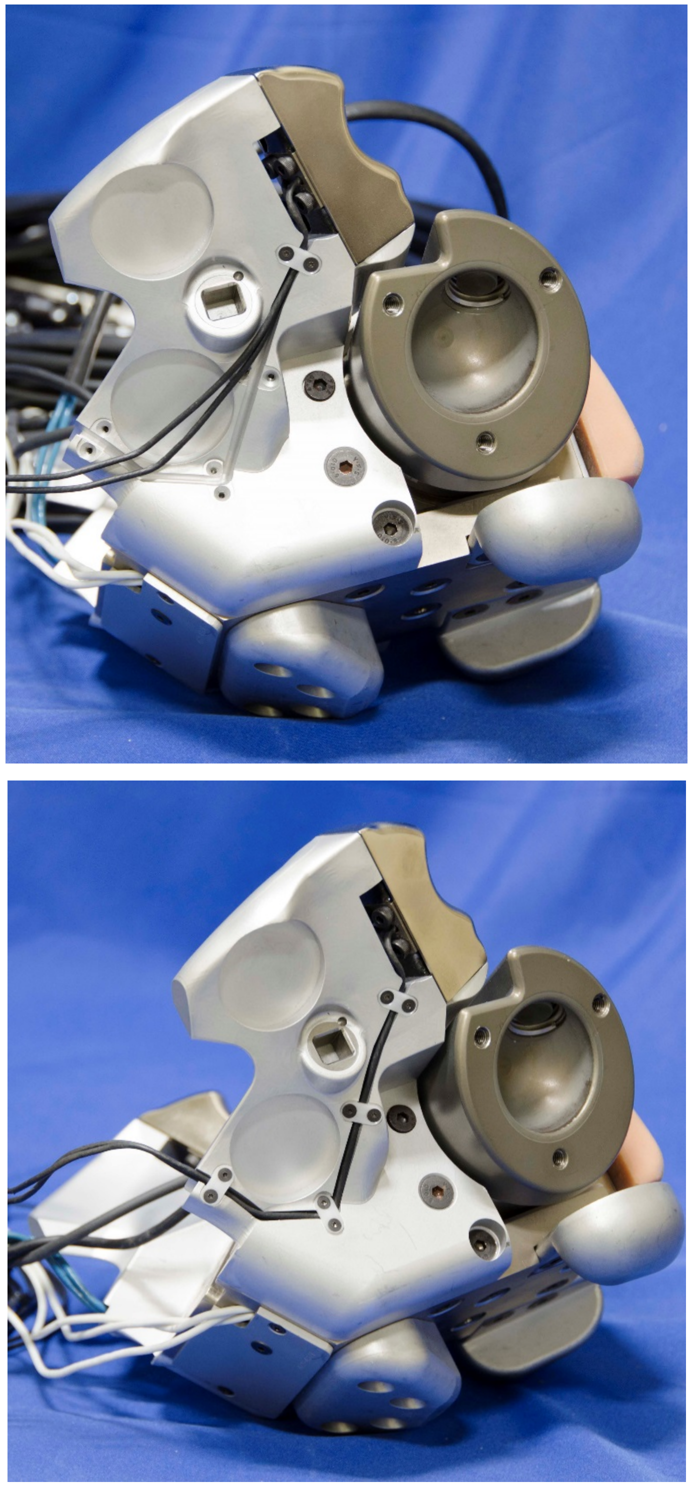


Figure 10-31. Route ASIS load cell wiring into groove on iliac wing (right side illustrated)

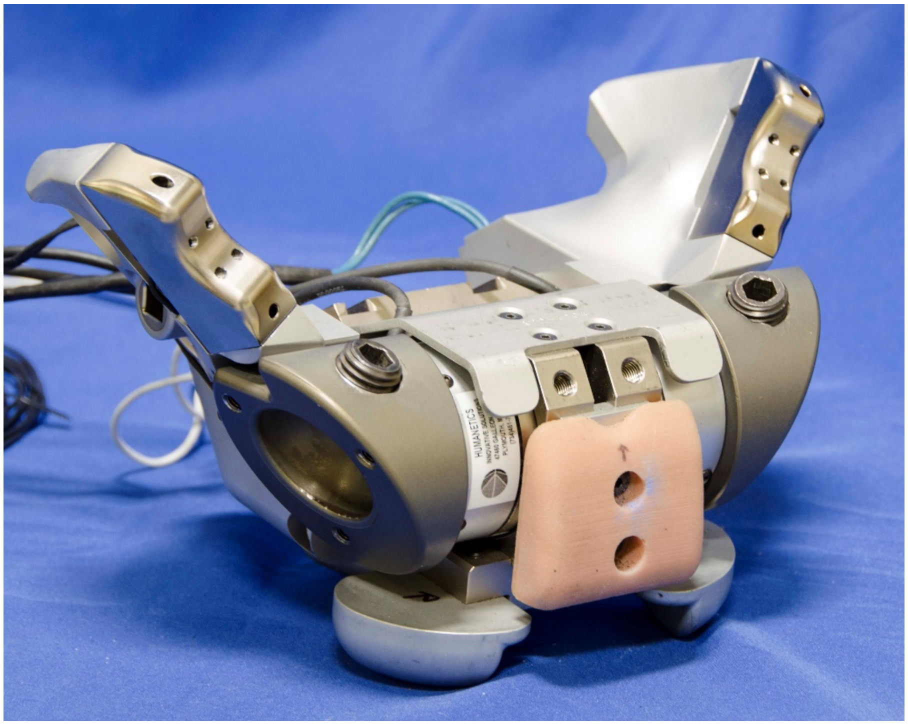


Figure 10-32. Complete pelvis internal structure (front view)

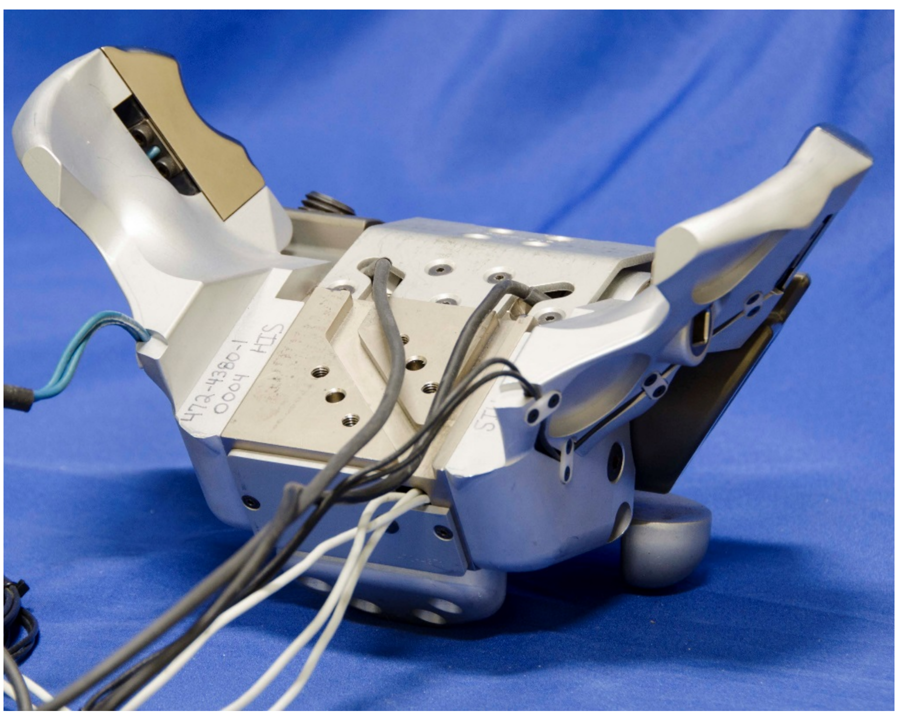


Figure 10-33. Complete pelvis internal structure (back view)

10.2.2.22 Install the completed mechanical pelvis assembly into the Molded Pelvis Skin (472-4100). Except for the ASIS wires which are routed over the skin, route the wiring (from inside to outside) through the hole in the back of the pelvis flesh (Figure 10-34 and Figure 10-35).

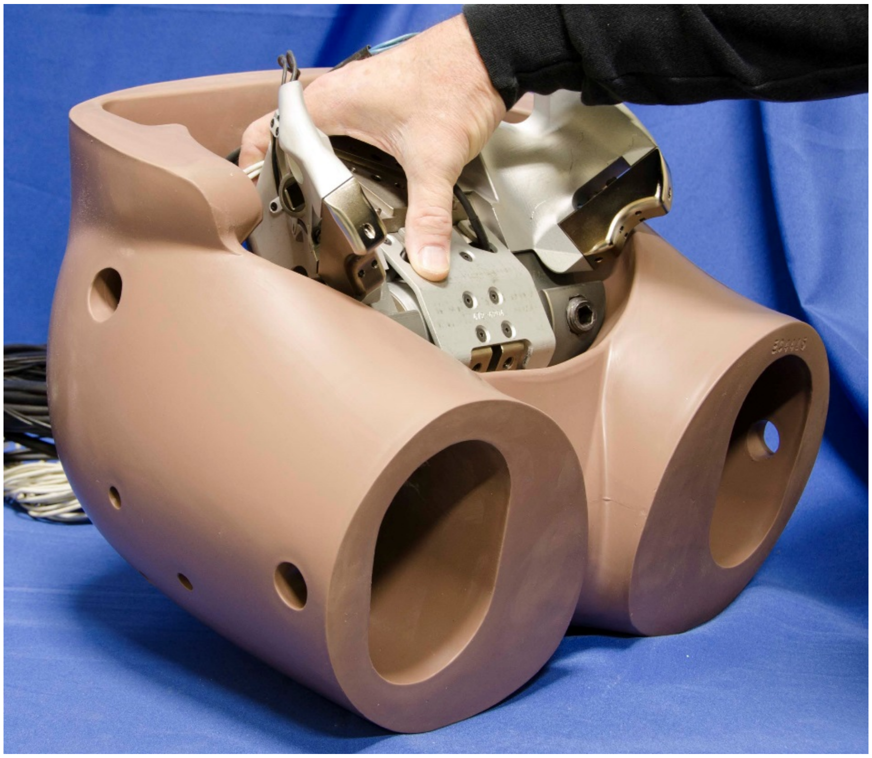


Figure 10-34. Insert mechanical pelvis assembly into molded pelvis skin

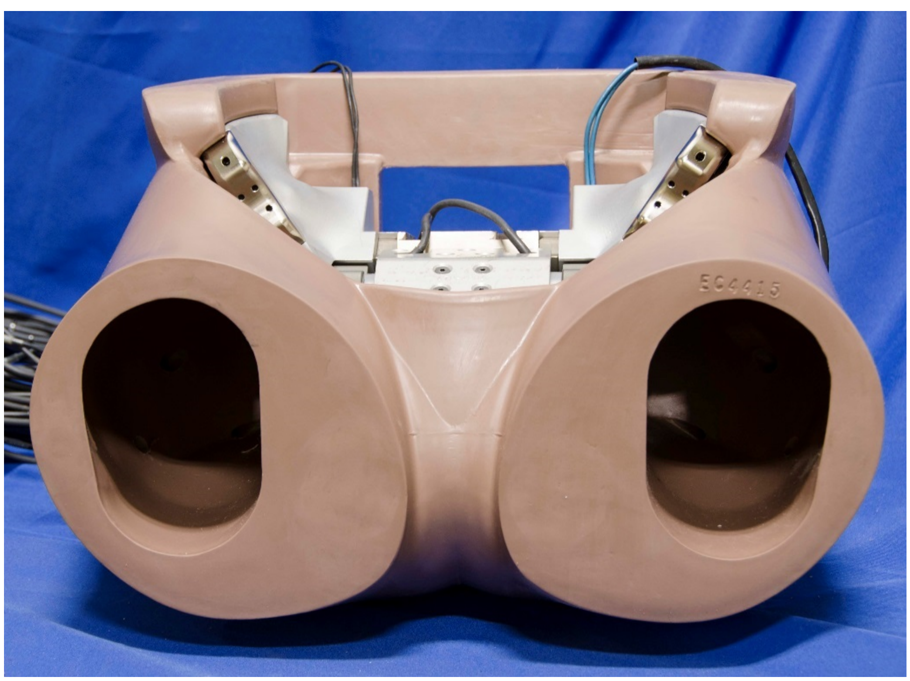


Figure 10-35. Pelvis mechanical assembly seated into pelvis skin

10.2.2.23 Install the Left Trochanter (472-4812-1) to the Left Hip Arm (472-4815-1) with four M6 x 1 x 16 SHCS (Figure 10-36).

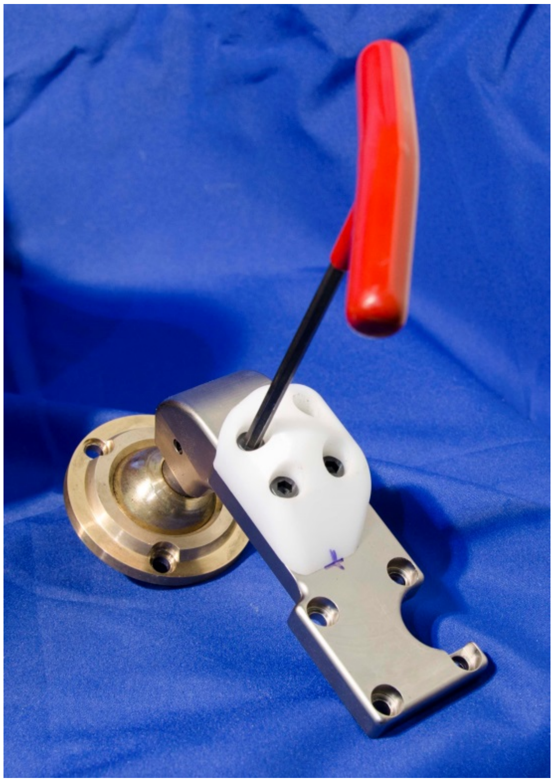


Figure 10-36. Install trochanter to hip arm

10.2.2.24 Secure the Left Hip Cylinder (472-4814-1) to the Left Hip Arm with four M6 x 1 x 16 SHCS (Figure 10-37).

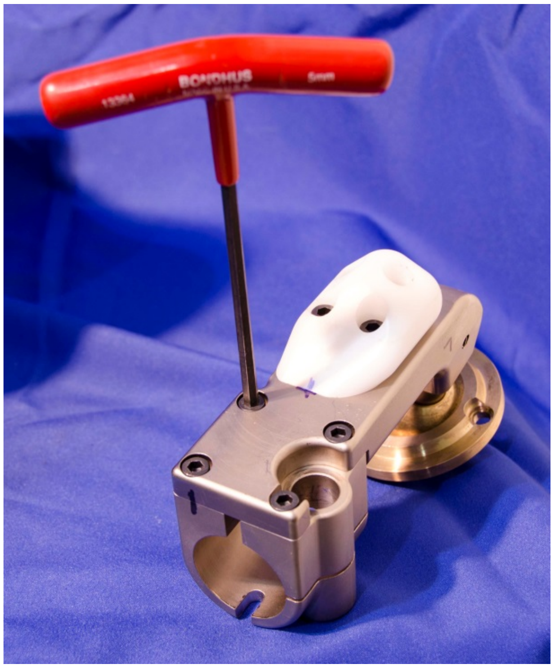


Figure 10-37. Secure hip cylinder to hip arm

10.2.2.25 Insert the Left Femur Ball Joint Assembly (472-4800-1) into the femur pelvic flesh (Figure 10-38).

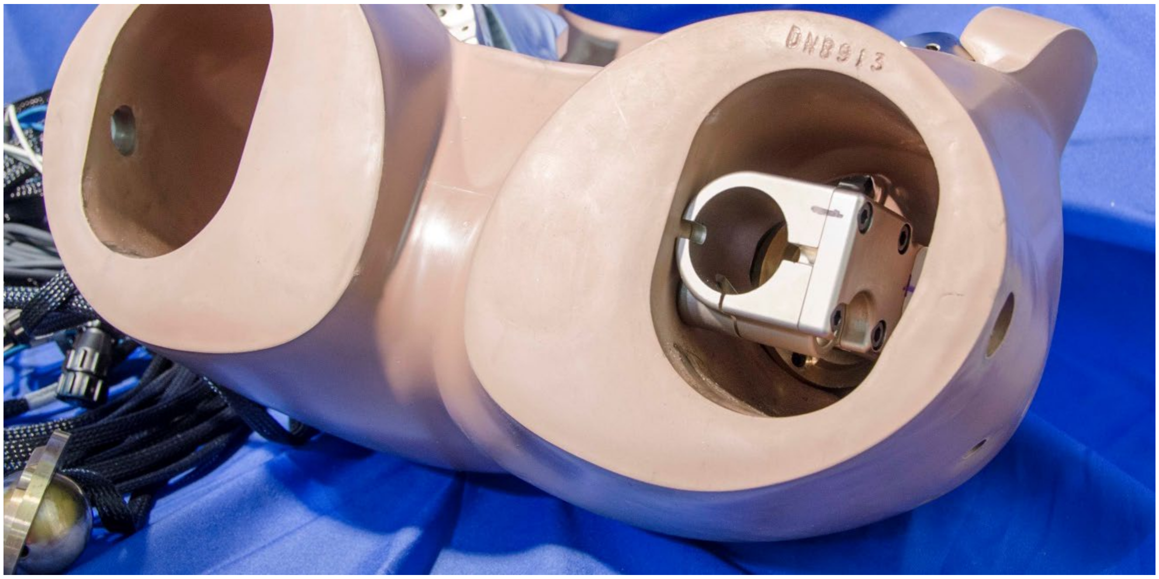


Figure 10-38. Insert femur ball joint assembly into pelvic flesh

10.2.2.26 Attach the femur ball joint assembly to the pelvis with three M6 x 1 x 14 SHCS. Access the screws through the external openings on the pelvis flesh (Figure 10-39 and Figure 10-40).

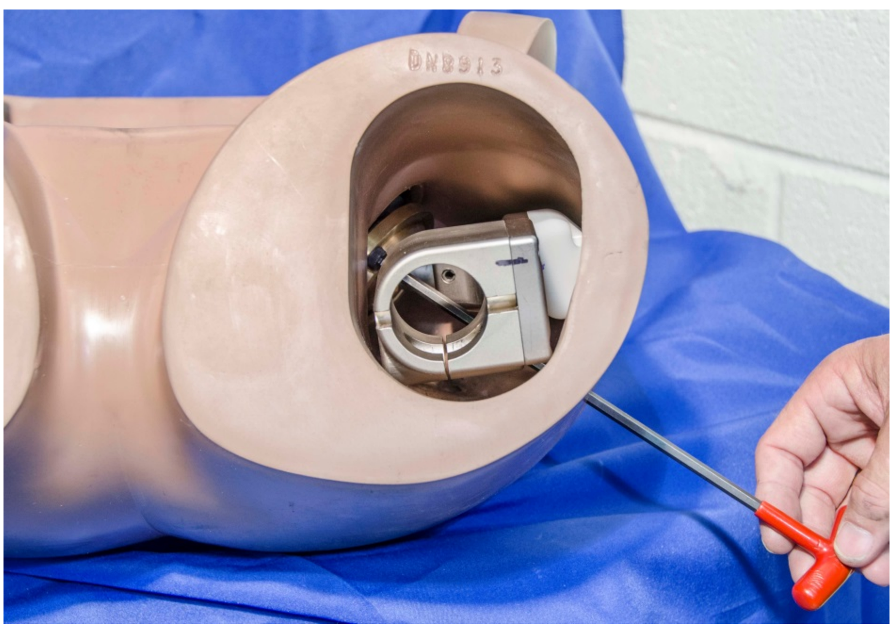


Figure 10-39. Attach femur ball joint to pelvis

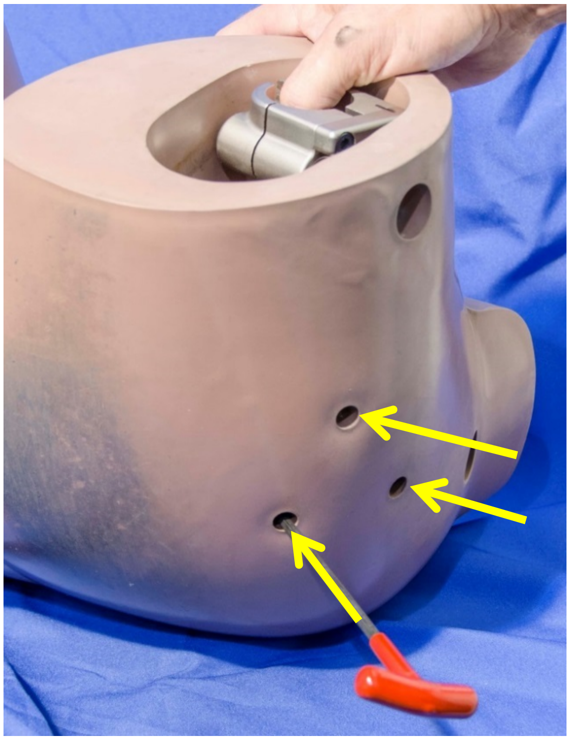


Figure 10-40. Access holes for installing femur ball joints

10.2.3 Assembly of the Pelvis to 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). Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

10.2.3.1 Route the acetabulum load cell wires in the grooved area on the pelvis/lumbar spine mounting block (Figure 10-41).

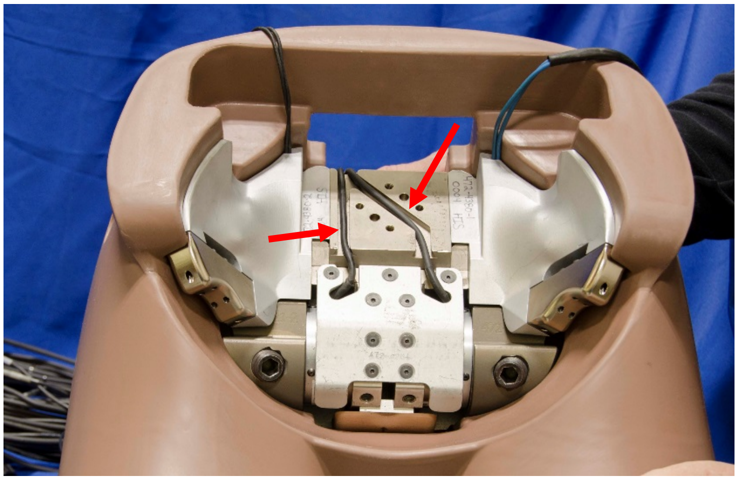


Figure 10-41. Route acetabulum wires through grooves in pelvis/lumbar mounting block

10.2.3.2 Install the Pelvis/Lumbar Mounting Block Assembly (472-3760) to the Pelvis Base Module (472-4211) using four M6 x 1 x 20 SHCS (Figure 10-42 and Figure 10-43). Note that the pelvis/lumbar mounting block assembly cannot be installed into the pelvis if the tilt sensor mounts are already in place.

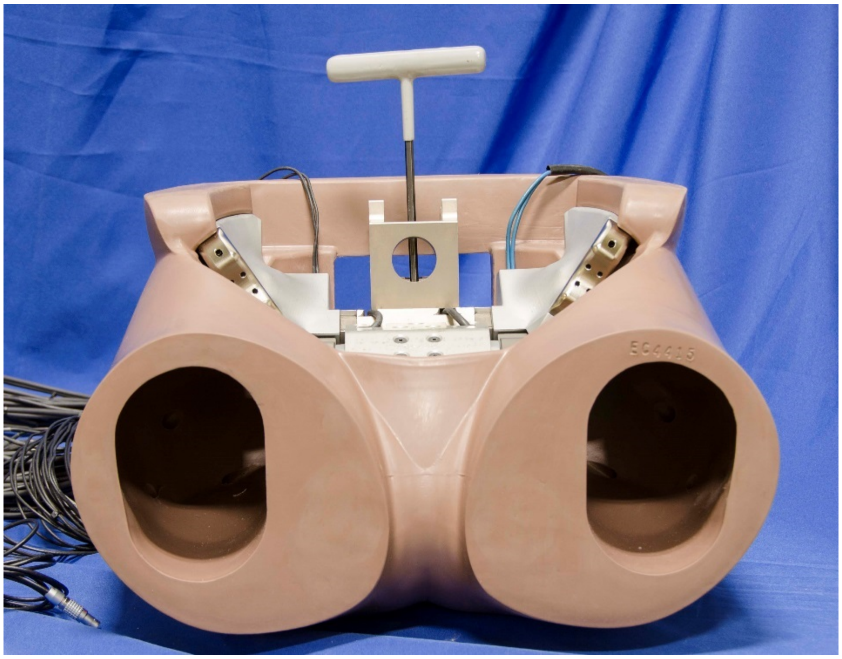


Figure 10-42. Install pelvis/lumbar mounting block to pelvis base module

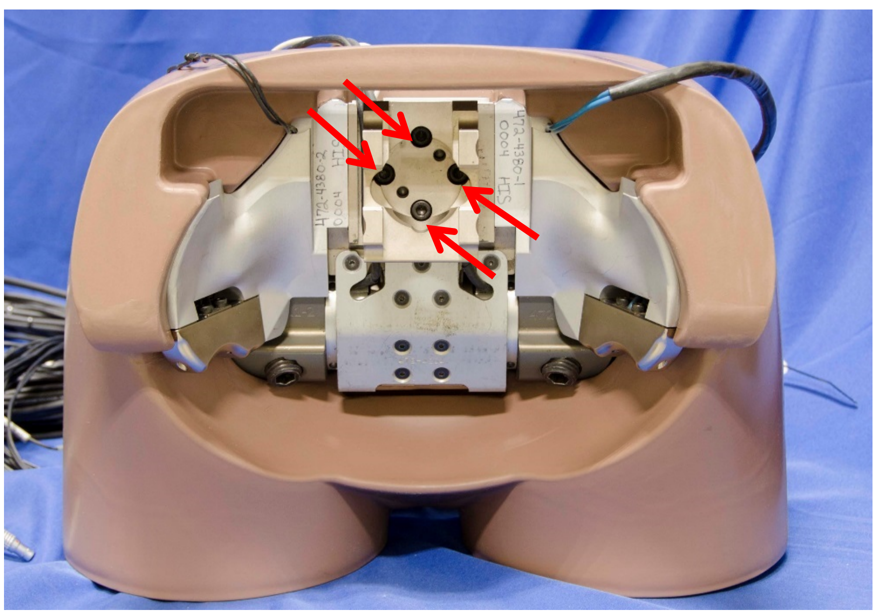


Figure 10-43. Mounting locations

10.2.3.3 Install the Dual Axis Tilt Sensor (SA572-S44) to the Pelvis Tilt Sensor Mount Assembly (472-3787) using two M2 x 0.4 x 10 SHCS. (Figure 10-44).

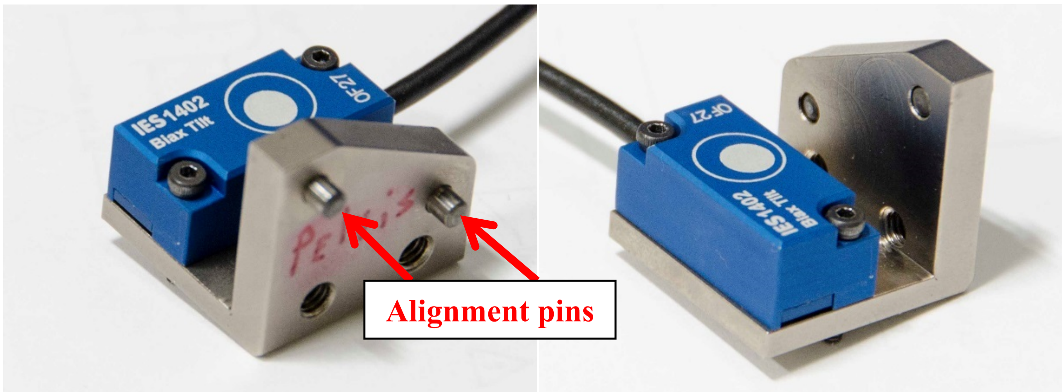


Figure 10-44. Pelvis tilt sensor installed to mount

10.2.3.4 Insert the pelvis tilt mount assembly into the pelvis/lumbar mounting block; align the tilt sensor mount pins with the holes on the left side of the pelvis block (Figure 10-44 and Figure 10-45). Note that Figure 10-45 shows the lumbar mounting block uninstalled from the pelvis for illustrative purposes; the tilt sensors cannot be installed prior to securing the pelvis/lumbar mounting block to the pelvis. Secure the pelvis tilt sensor mount assembly to the pelvis/lumbar mounting block using two M4 x 0.7 x 8 SHCS (Figure 10-46) through the left side of the mounting block. Pass the wiring through the back of the pelvis opening.

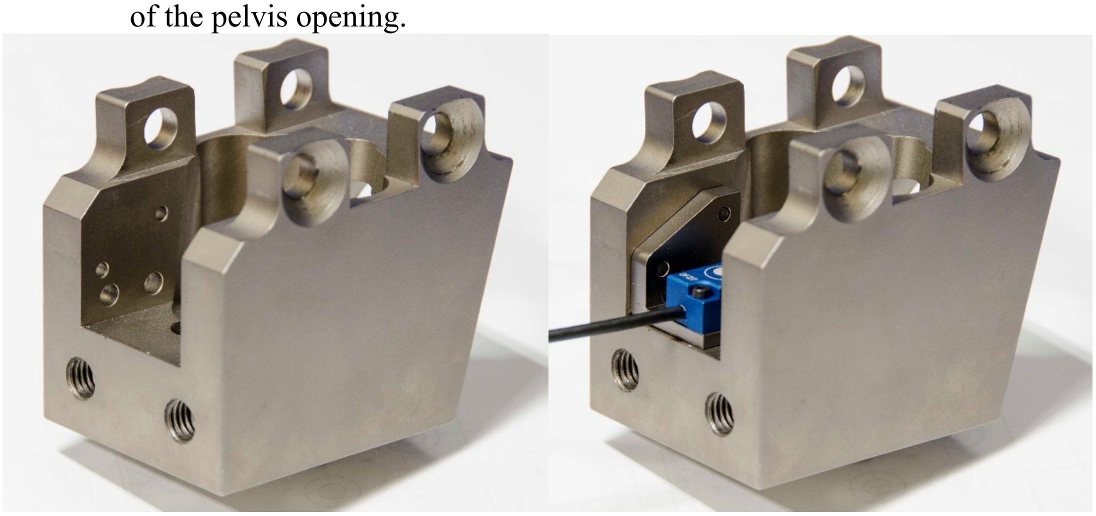


Figure 10-45. Installing pelvis tilt mount assemblies (lumbar mounting block uninstalled for illustrative purposes)

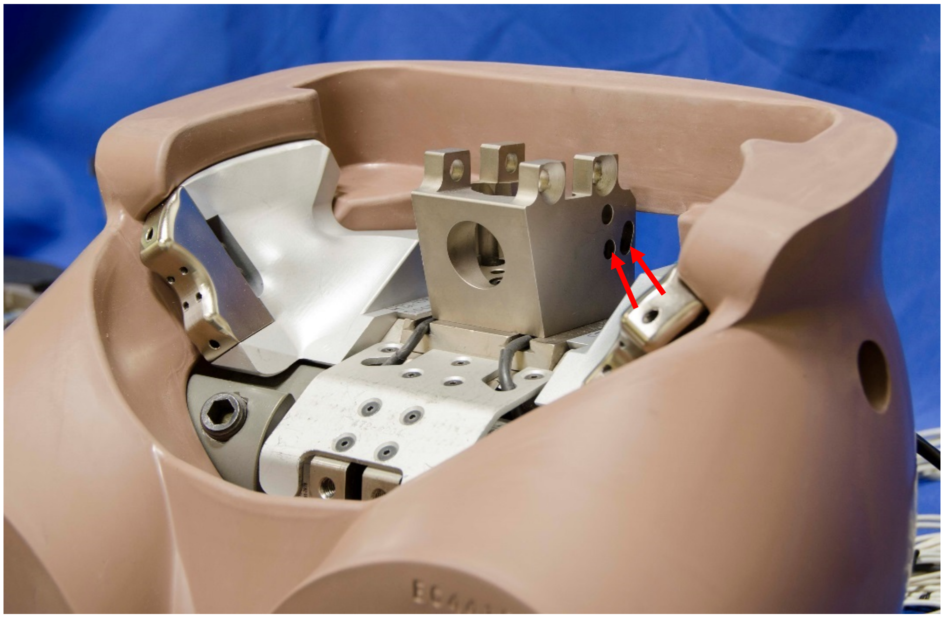


Figure 10-46. Secure pelvis tilt sensor mount assembly to pelvis

10.2.3.5 Install the Lumbar Flex Joint Assembly (472-3746) to secure the spine to the pelvis/lumbar mounting block using four M8 x 1.25 x 20 FHCS, two on each side of the flex joint (Figure 10-47).

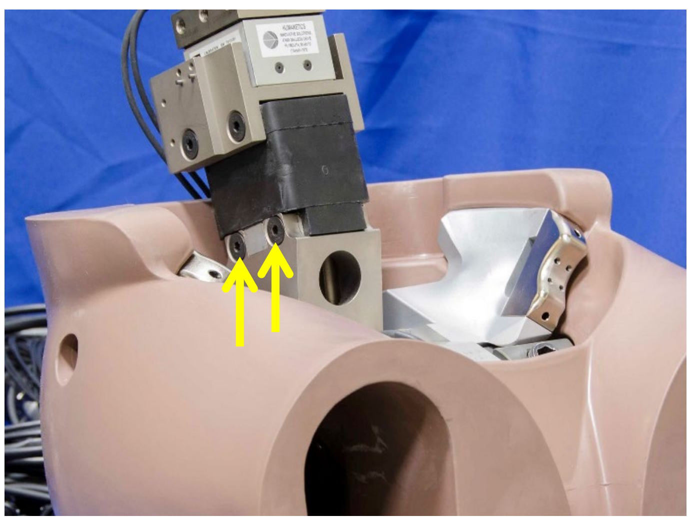


Figure 10-47. Install lumbar flex joint assembly to pelvis mounting block

10.3 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 order to achieve 1G joint friction torque.

10.4 Wire Routing and Electrical Connections

Section 15.3 includes grounding information. Section 15.4.3 describes cable routing instructions. Section 10.2.2.21 also shows cable routing instructions for the ASIS load cells.

10.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the pelvis, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

10.5.1 Electrical Inspections (Instrumentation Check)

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the spine instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief (see Section 15.4.3).

Specific electrical areas to examine:

- Ensure proper routing for the ASIS load cell wiring (Sections 10.2.2.21 and 15.4.3)
- Ensure that the acetabulum load cells are installed and oriented correctly (Sections 10.2.2.1to 10.2.2.4).

- Ensure that the pelvic socket adapter (threaded shaft through load cell) has a flat washer and a nylock nut torqued to 11.3 N-m (100 in-lb) (Section 10.2.2.3). Be sure to install a new nylock nut each time the nut is removed.
- Check the security of all pelvic instrumentation mounting bolts.

10.5.2 Mechanical Inspection

Several components in the pelvis assembly require inspection post-test.

Specific mechanical areas to examine:

- Check the pelvic skin for cuts and tears; replace the skin if the damage causes poor fit of the pelvic bone assembly.
- Ensure that the four M6 x 22 FHCS bolts that mount the Acetabulum Load Cell (472-4390) to the Load Cell Mounting Plate (472-4325-1 and 472-4325-2) are not broken or stretched; replace the bolts if damaged. Also, examine the threaded holes for damage and repair or replace the load cell or mounting plate if needed.
- Check the inside surface of the cup on the left and right Pelvic Socket Adaptors (472-4231-1 and 472-4231-2) joint for wear and scuffing; replace the pelvic socket adaptors if wear inhibits smooth function of the joint.
- Check the fit and condition of the pelvis Friction Adjustment Set Screw Assembly (472-4310); replace the set-screw if it no longer adequately adjusts the friction level of the joint.

Section 11. **Upper Leg Assembly**

11.1 Description of the Upper Leg Assembly and Features

The upper leg assembly of the THOR-50M dummy extends from the femur ball joint to the knee. At the upper end of the femur, a ball mates with the socket in the pelvis assembly to form the hip joint. At the lower end of the femur, a standard six-axis femur load cell connects the femur assembly to the machined knee. Figure 11-1 shows the femur assembly without the Femur Ball Joint Assemblies (472-4800-1 and 472-4800-2) which connect the femur shaft to the pelvis.

The THOR-50M femur axial compliant bushing design has been tuned to create a biofidelic response along the axis of the femur during a knee impact. The axial compression of the femur simulates the compressive response of human PMHS femurs. The compliant section is constrained on a square shaft that slides linearly within a square bushing. The square shaft and bushing assures a purely linear motion. There are end stop bumpers fixed to both ends of the shaft to prevent over-travel.

The upper leg instrumentation includes a six-axis femur load cell (SA572-S120) also utilized in the WorldSID dummy. This sensor produces three output forces and three output moments.

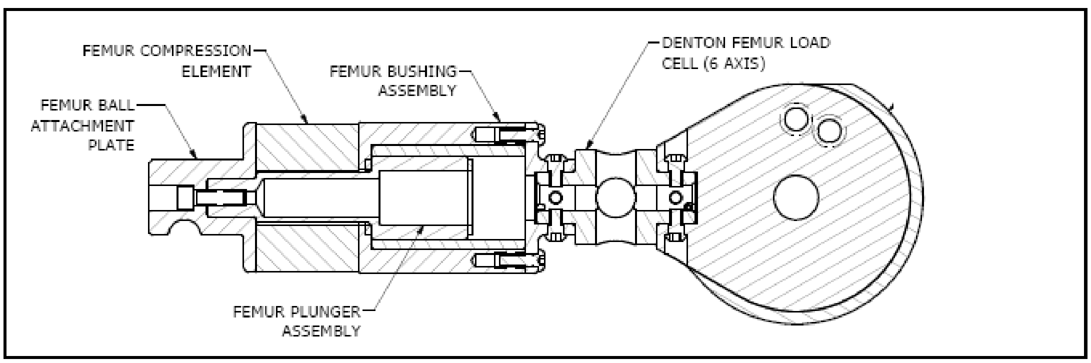


Figure 11-1. Femur assembly

11.2 Assembly of the Upper Leg

11.2.1 **Parts List**

Table 11-1 lists the components that are included in the upper leg assembly. Figure 11-2 illustrates the upper leg assembly and hardware.

Table 11-1. Upper Leg Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Universal Leg L.C. Structural Replacement	1	W50-51060	Figure 11-2	1
Compression Element – Upper Leg	1	472-5206	Figure 11-2	2
End Cap – Femur	1	472-5203	Figure 11-2	3
Modified BHSS M6 Thread	8	W50-61042	Figure 11-2	4
Femur Bushing Assembly	1	472-5200	Figure 11-2	5
Left Knee Cap Assembly Right Knee Cap Assembly (not shown)	1 1	472-5300 472-5700	Figure 11-2	6
Femur Ball Attachment Plate Assembly	1	472-5410	Figure 11-2	7
Femur Plunger Assembly	1	472-5420	Figure 11-2	8
Left Thigh Flesh Right Thigh Flesh (not shown)	1 1	472-5503-1 472-5503-2	Figure 11-2	9
Knee Flesh Left/Right Modified	1	470-5502	Figure 11-2	10
Screw, BHCS M6 x 1 x 20	4	5000438	Figure 11-2	11
Knee Cover	2	472-5353	Figure 11-2	12
Screw, SHCS M8 x 1.25 x 25	1	5000037	Figure 11-2	13
SHCS M6 x 18	4	9005217	Figure 11-2	14
Femur Load Cell (optional)	1	SA572-S120	Figure 11-2	15

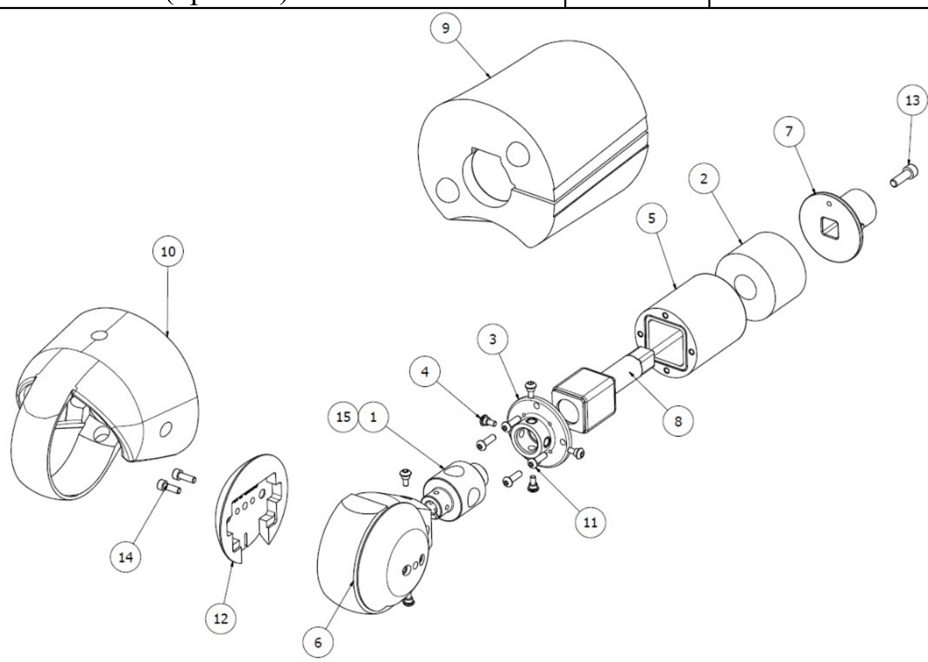


Figure 11-2. Upper leg assembly components

11.2.2 **Assembly of Upper Leg Components**

The following procedure is a step-by-step description of the assembly procedure for the upper leg (femur) components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

11.2.2.1 Slide the Femur Plunger Assembly (472-5420) into the Femur Bushing Assembly (472-5200) (Figure 11-3 and Figure 11-4)**.** Completely seat the femur plunger assembly into the femur bushing assembly.

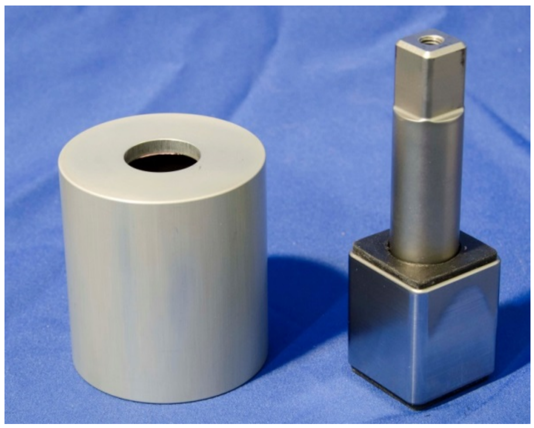


Figure 11-3. Femur bushing assembly and femur plunger

Figure 11-4. Femur plunger assembled

11.2.2.2 Slide the Upper Leg Compression Element (472-5206) over the shaft of the femur plunger assembly (Figure 11-5).

Figure 11-5. Assemble upper leg compression element to femur plunger assembly

11.2.2.3 Assemble the Femur Ball Attachment Plate (472-5410) to the square end of the femur plunger assembly by sliding the plate over the shaft and inserting the M8 x 25 SHCS into the hole in the bottom of the femur ball attachment plate **(**Figure 11-6 and Figure 11-7**).**

Figure 11-6. Assemble femur ball attachment plate to femur plunger assembly

Figure 11-7. Secure femur ball joint attachment plate

11.2.2.4 Place the Femur End Cap (472-5203) onto the femur bushing assembly; attach the end cap using four M6 x 1 x 20 BHCS (Figure 11-8).

Figure 11-8. Attach femur end cap

11.2.2.5 Install the Femur Load Cell (SA572-S120) to the femur end cap with four modified BHSS M6 thread screws (Figure 11-9).

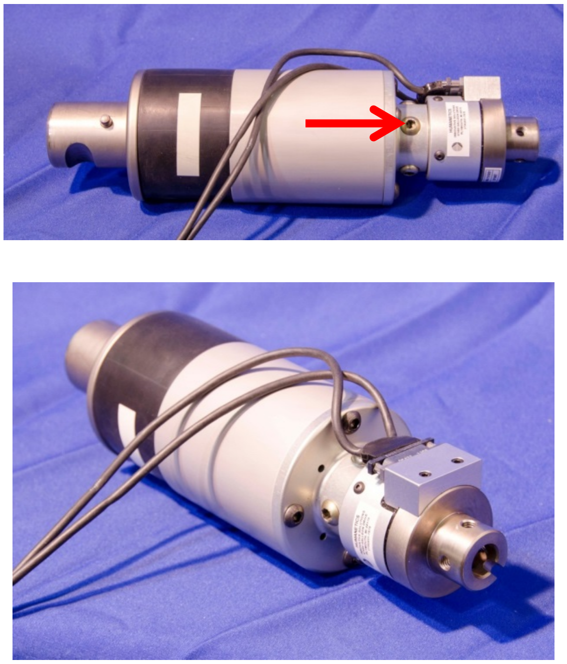


Figure 11-9. Install femur load cell to femur end cap

11.2.2.6 Install the String Pot Holder Assembly (472-5306) to the Molded Inboard Slider Assembly (472-5320) using two M4 x 6 BHCS, as shown in Figure 11-10**.**

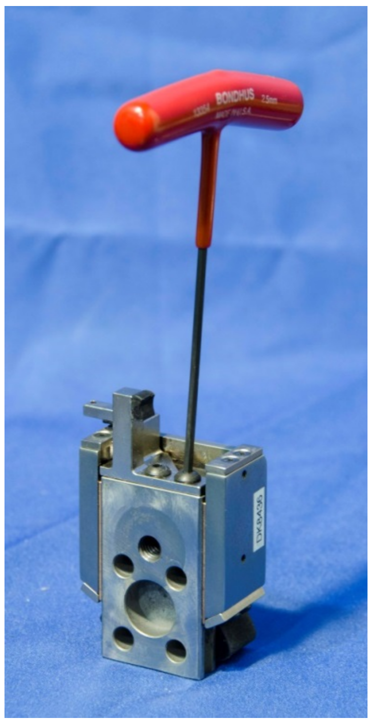


Figure 11-10. Install string pot holder assembly to inboard slider

11.2.2.7 Install the String Pot (SA572-S90-L) to the Mount Plate (472-5305) using two #2-56 x 1/8" phillips head FHCS as shown in Figure 11-11.

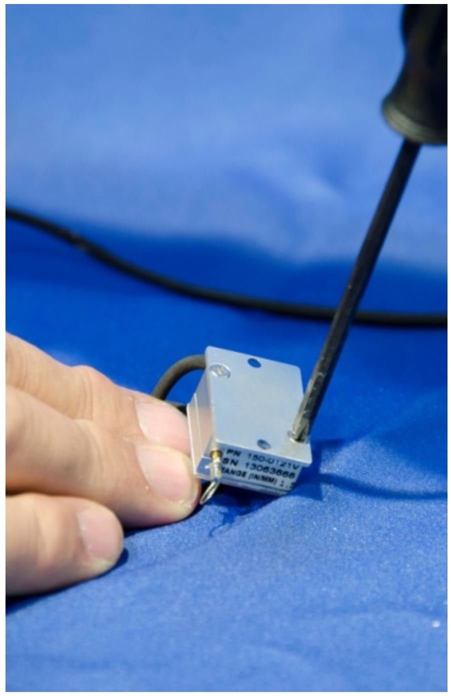


Figure 11-11. Install mount plate to string pot assembly

11.2.2.8 Secure a strain-relief adhesive clamp to the string pot housing and install the pot wiring through it leaving some slack for strain-relief (Figure 11-12). Attach the string pot and plate assembly to the molded inboard knee slider using two M2.5 x 0.45 x 5 FHCS as shown in Figure 11-13.

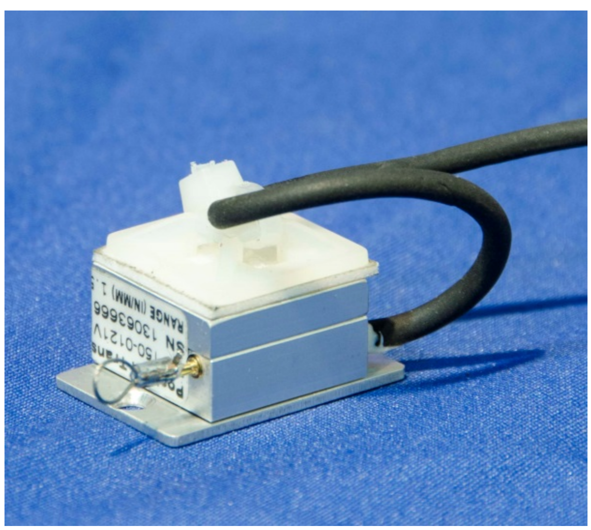


Figure 11-12. Strain relief for string pot

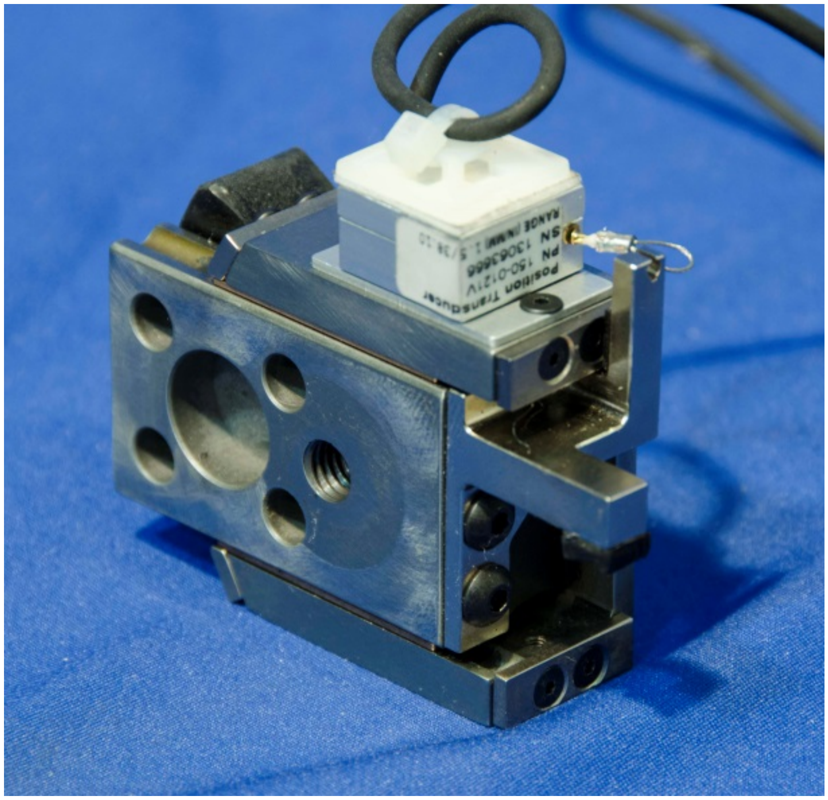


Figure 11-13. Attach string pot assembly to molded inboard knee slider

11.2.2.9 Place the wire into the slot on the Pot String Holder (472-5306) so that the looped end will not return back against the pot housing (Figure 11-14).

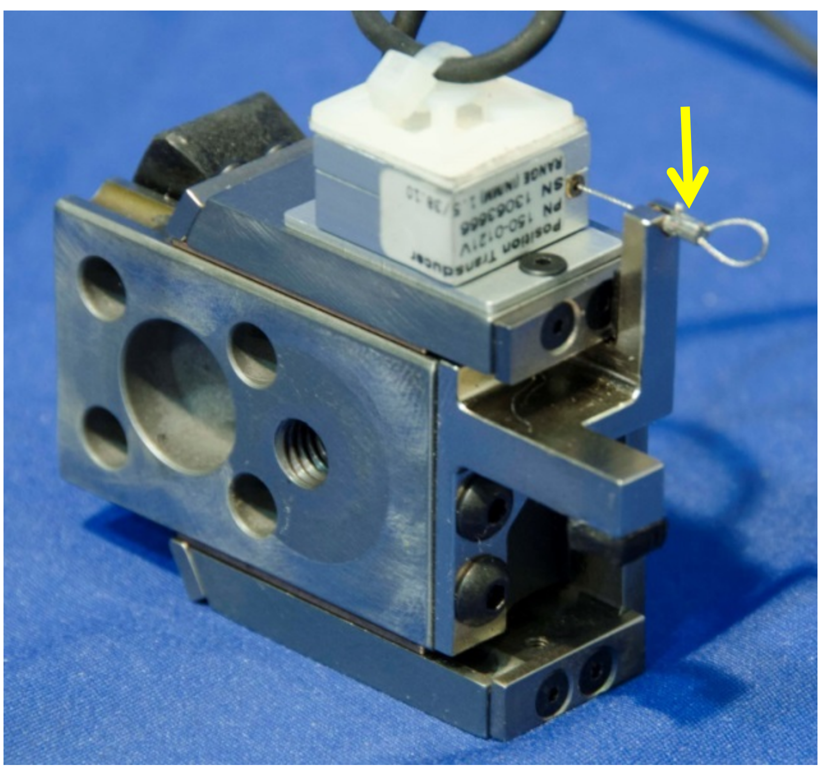


Figure 11-14. String pot in pot string holder

11.2.2.10 Install the Inboard (472-5320) and Outboard (472-5330) Knee Sliders to the Knee Bone Assembly (472-5350) using the Shoulder Bolt (472-5302), the Compression Washer (472-5304) and the Sliding Knee Washer (472-5303) (Figure 11-15 to Figure 11-17).

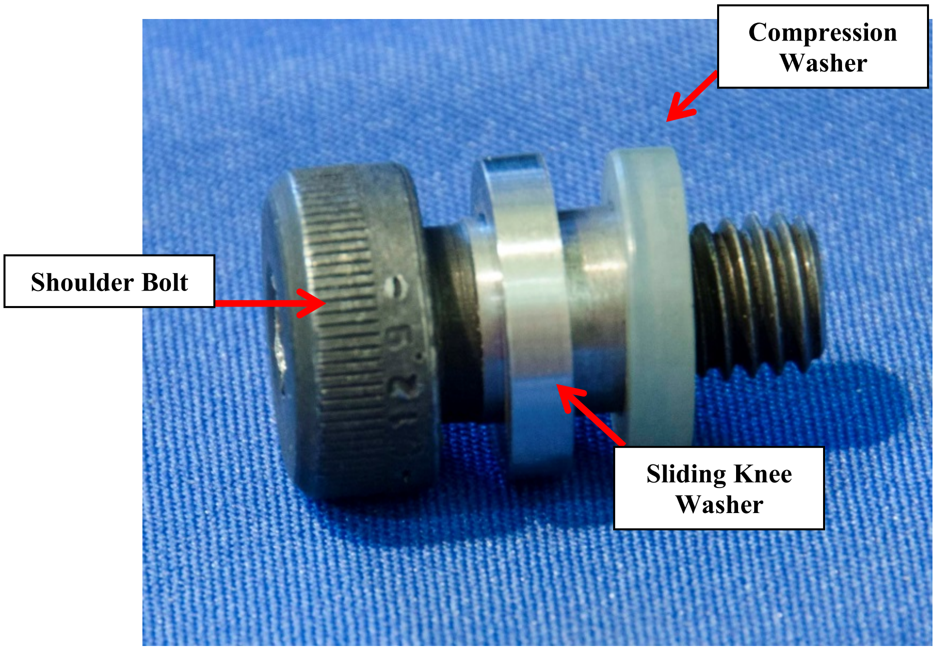


Figure 11-15. Shoulder bolt and washers for knee slider installation

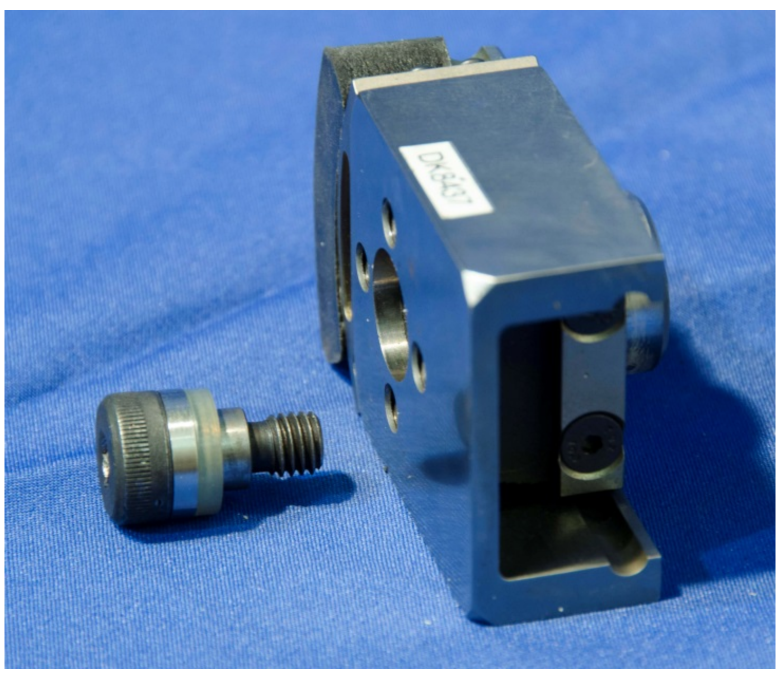


Figure 11-16.Install shoulder bolt

Figure 11-17. Install knee slider to knee

11.2.2.11 Install the Knee Stop Pin (472-5763) into the rear hole in the Left Knee Cap Assembly (472-5300). The pin should protrude out on the same side as the inboard knee slider (Figure 11-18).

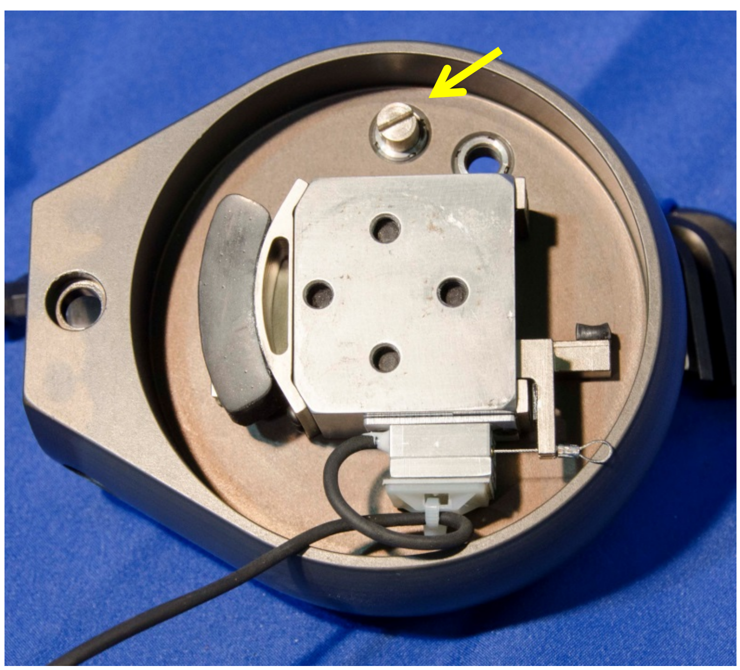


Figure 11-18. Install knee stop pin

11.2.2.12 Place the Left Knee Flesh (472-5502) over the left knee cap assembly. (472-5300) (Figure 11-19).

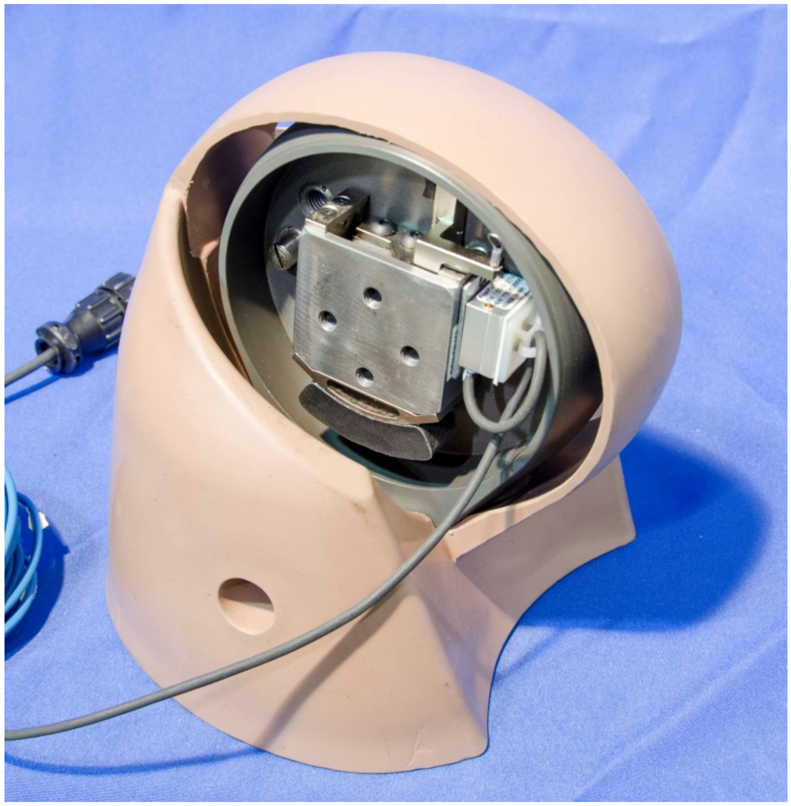


Figure 11-19. Install knee flesh

11.2.2.13 Install Molded Knee Flesh Insert (472-5301) between flesh and knee cap. Position the “flat” end of the insert at the top of the knee (Figure 11-20 through Figure 11-22).

Figure 11-20. Orientation of molded knee flesh insert

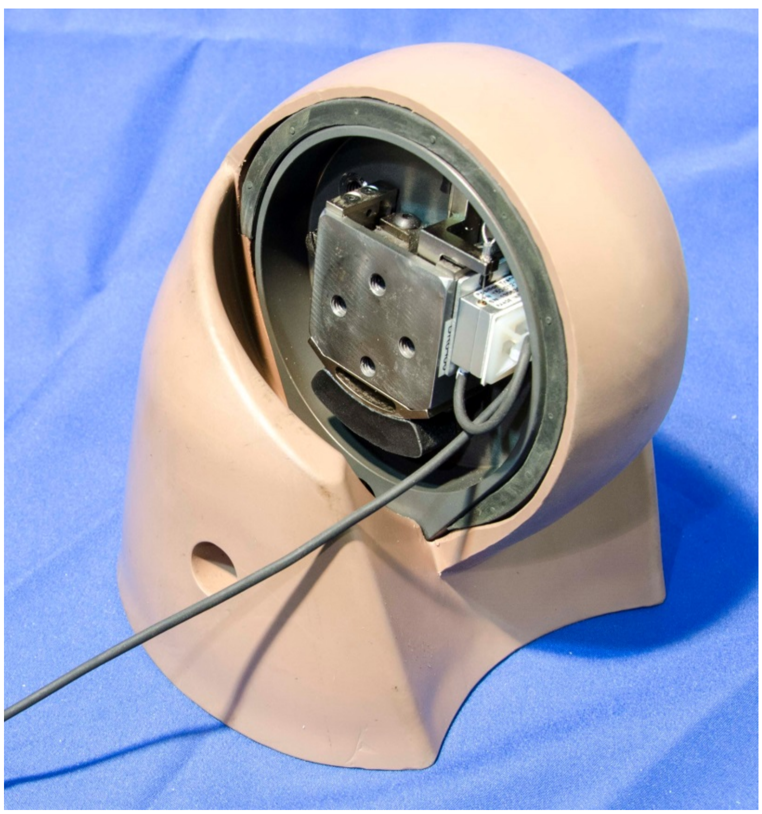


Figure 11-21. Install molded knee flesh insert

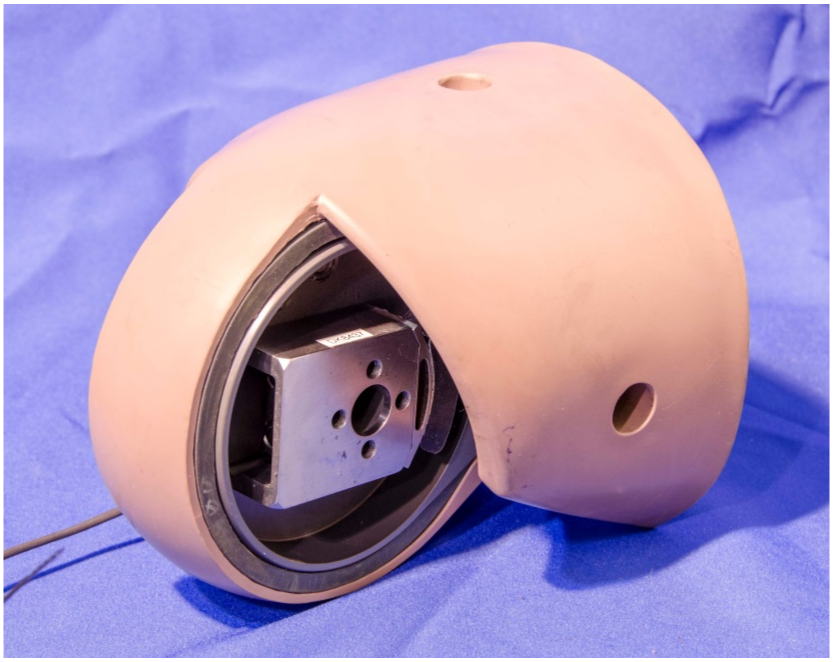


Figure 11-22. Complete knee assembly

11.2.2.14 Assemble the Femur Load Cell (SA572-S120) (or Structural Replacement (W50-51060)) to the Left Knee Cap Assembly (472-5300) using four of the modified shoulder screws (W50-61042) (Figure 11-23). 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 knee cap assembly.

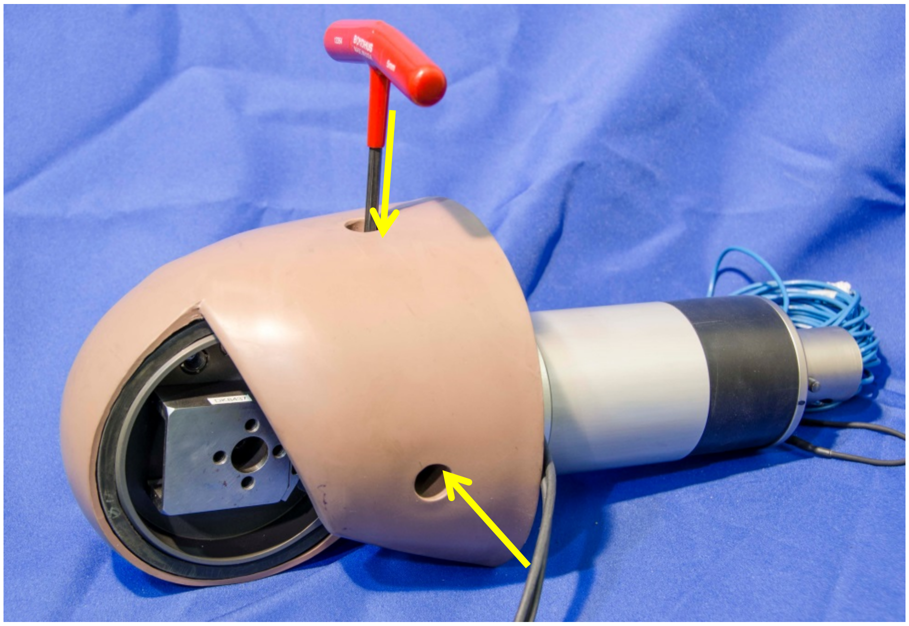


Figure 11-23. Connect femur load cell to knee cap assembly

11.2.2.15 Install the femur ground strap; tape the femur load cell wires in a loop onto the surface of the femur for strain-relief as shown in Figure 11-24. The wiring exits the upper leg at the interface between the thigh flesh and knee flesh.

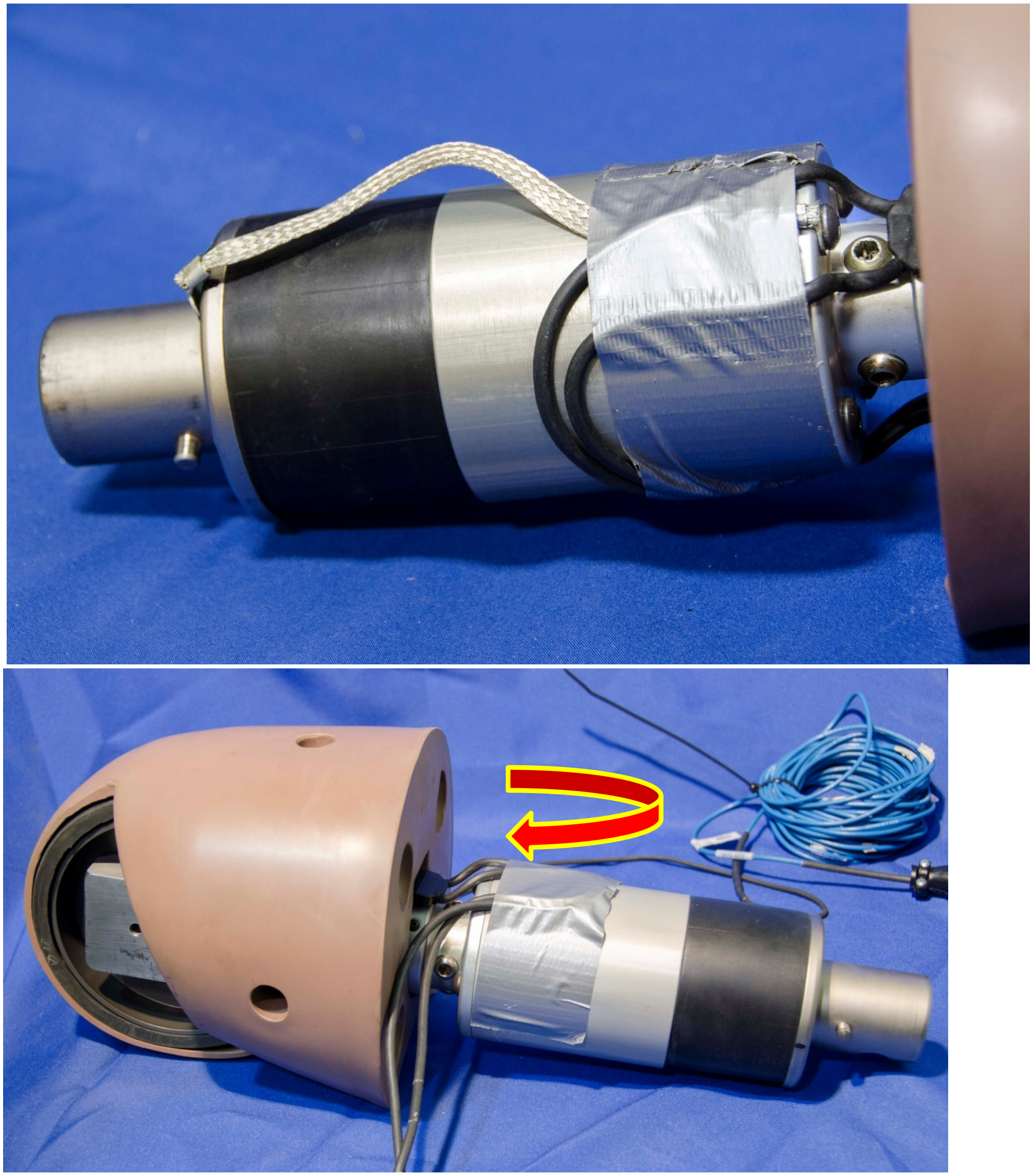


Figure 11-24. Tape femur load cell wiring in a loop for strain-relief

11.2.2.16 Install the Left Femur Thigh Flesh (472-5503-1) over the femur assembly by aligning the knobs on the end of the thigh flesh with the holes in the Knee Flesh (472-5502). Wrap the flesh around the femur assembly and secure it closed with the zipper. When installed correctly, the zipper should be outboard (Figure 11-25). Install the knee cover (472-5353) after attaching the lower leg.

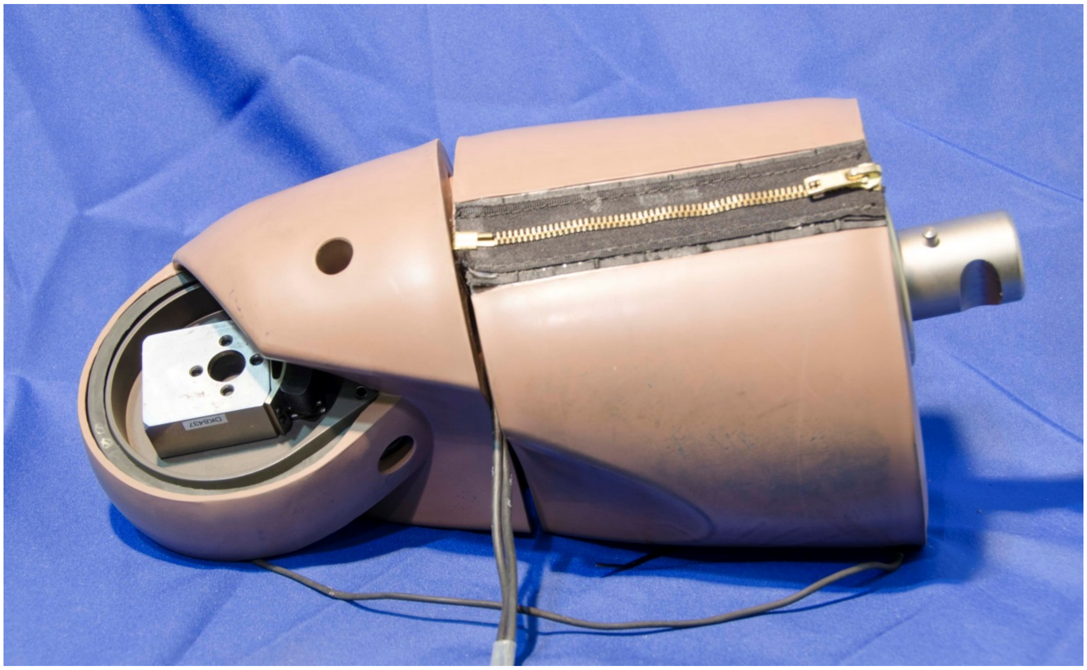


Figure 11-25. Thigh flesh installed

11.2.2.17 Repeat the process for the Right Upper Leg Assembly (472-5100-2).

11.2.3 Assembly of the Upper Leg to the Pelvis

The following procedure is a step-by-step description used to install the Upper Leg Assembly (472-5100-2) to the Pelvis Assembly (472-4000). Unless otherwise specified, tighten to the torque specifications provided in Section 2.1.3.

11.2.3.1 Slide the Left Femur Ball Attachment Plate Assembly (472-5410) into the Left Hip Cylinder (472-4814-1) so that dowel pins on the attachment plate lock into the slots on the hip cylinder (Figure 11-26). Secure the upper leg with an M16 x 40 SHSS (5000298) inserted on the outer pelvis flesh (Figure 11-27).


Figure 11-26. Insert upper leg into pelvis for attachment

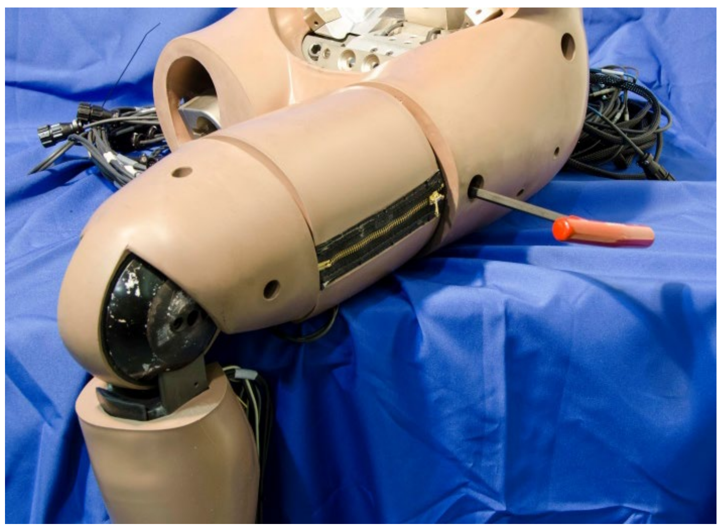


Figure 11-27. Install upper leg to pelvis

11.2.4 Assembly of the Lower Extremity to the Knee

The assembly of the lower extremity to the knee can be found in Section 12.2.3.

11.3 Adjustments for the Femur Assembly

The femur assembly does not require any adjustments.

11.4 Electrical Connections and Requirements:

Section 15.3 includes grounding information. Section 15.4.3 describes cable routing instructions.

11.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the upper leg, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

11.5.1 **Electrical Inspections (Instrumentation Check)**

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the spine instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief (see Section 11.2.2.15).

Specific areas to examine:

- Ensure that the left and right side knee slider assembly tracks are clean and free from damage which could affect the operation. The potentiometer string should move freely; if not, replace the unit (Sections 11.2.2.6 through 11.2.2.10).

11.5.2 Mechanical Inspection

Several components in the upper leg assembly require inspection post-test.

Specific areas to examine:

- Check the Knee Flesh (472-5502) and Molded Knee Flesh Insert (472-5301) for tears and damage, particularly on the anterior end which covers the Knee Cap Assembly (472-5300); replace the flesh if it is severely damage or it does not pass knee qualification tests (see *THOR 50th Percentile Male (THOR-50M) Qualification Procedures Manual, April 2018).*
- Check the Thigh Flesh (472-5503-1 and 472-5503-2) for tears and damage on the skin or zipper
- Check the Upper Leg Compression Element (472-5206) for permanent compression, nicks or tears; replace the element if damaged.
- Check for proper alignment of the Femur Plunger Assembly (472-5420) which should slide easily into the Femur Bushing (472-5200) (Section 11.2.2.1).
- Inspect the knee slider rubber stops for tears and delamination. Repair the stops or replace the unit (Sections 11.2.2.6 through11.2.2.10).

Section 12. **Lower Extremity Assembly**

12.1 Description of the Lower Extremity Assembly and Features

The mechanical design of the THOR-50M lower extremity provides several advances over previous lower extremity designs. A compliant section in the tibia shaft, similar to the THOR-50M compliant femur section, provides more biofidelic force transmission from the heel to the knee complex. The spring damper Achilles tendon system aids in producing the desired ankle motion and torque characteristics. The ankle design provides correct range of motion, joint axes placement, and biofidelic torque vs. angle response for the two primary axes (dorsi/plantar-flexion and inversion/eversion). Soft stop elements provide more biofidelic stiffness at the extremes of motion. Figure 12-1 illustrates the THOR-50M lower extremity assembly.

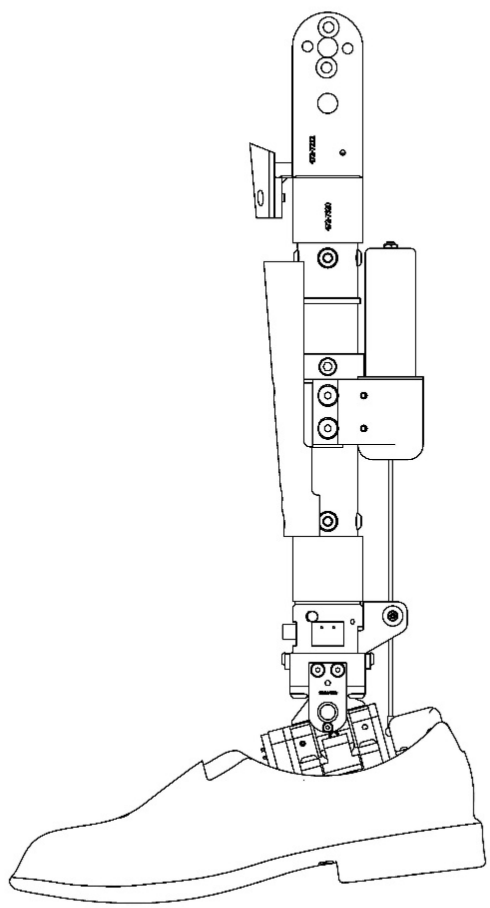


Figure 12-1. Lower extremity assembly (depicted without leg flesh)

The lower extremity includes sensors to measure injury parameters. Five-channel upper (SA572-S32) and lower tibia load cells (SA572-S33) are incorporated into the design to provide force and moment data of the tibia shaft. A uniaxial compression load cell (SA572-S127) implemented into the Achilles tendon housing provides a direct measurement of the contribution of the Achilles to the overall ankle joint torque. Three rotary potentiometers measure the rotation of the individual ankle joints, thereby providing kinematic data. Finally, two uniaxial accelerometers on the tibia and a tri-pack accelerometer assembly on the upper shoe allow the transformation of the measured tibia moment to the calculated ankle moment.

12.2 Assembly of the Lower Extremity

12.2.1 **Parts List**

Table 12-1 through Table 12-4 list the components included in the lower leg assembly. Figure 12-2 through Figure 12-6 illustrate the components of lower leg assembly and hardware.

Table 12-1. Lower Leg Complete Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Lower Leg Mechanical Assembly	1	472-7300	Figure 12-2	1
Left Ankle Assembly Right Ankle Assembly (not shown)	1 1	472-7500-1 472-7500-2	Figure 12-2	2
Knee Clevis Weldment	1	472-7200	Figure 12-2	3
Screw, SHCS M6 x 1.0 x 16	4	9000852	Figure 12-2	4
Left Molded Shoe Assembly (Right Molded Shoe Assembly - not shown)	1 (1)	472-7800-1 (472-7800-2)	Figure 12-2	5
Screw, FHCS M6 x 1.0 x 16	4	9000826	Figure 12-2	6
Knee Bumper Molded	1	472-7110	Figure 12-2	7
Tibia Guard	1	472-7115	Figure 12-2	8
Screw, BHCS M5 x 10	2	9003042	Figure 12-2	9
Screw, BHCS M6 x 1.0 x 16	2	9010453	Figure 12-2	10
Left Lower Leg Flesh (Right Lower Leg Flesh - not shown)	1 (1)	472-7370-1 (472-7370-2)	Figure 12-2	11
Uniaxial Piezoresistive Accelerometer	2	SA572-S4	Figure 12-2	12
Screw, M1.4 x 0.3 x 3 SHCS	4	9010407	Figure 12-2	13

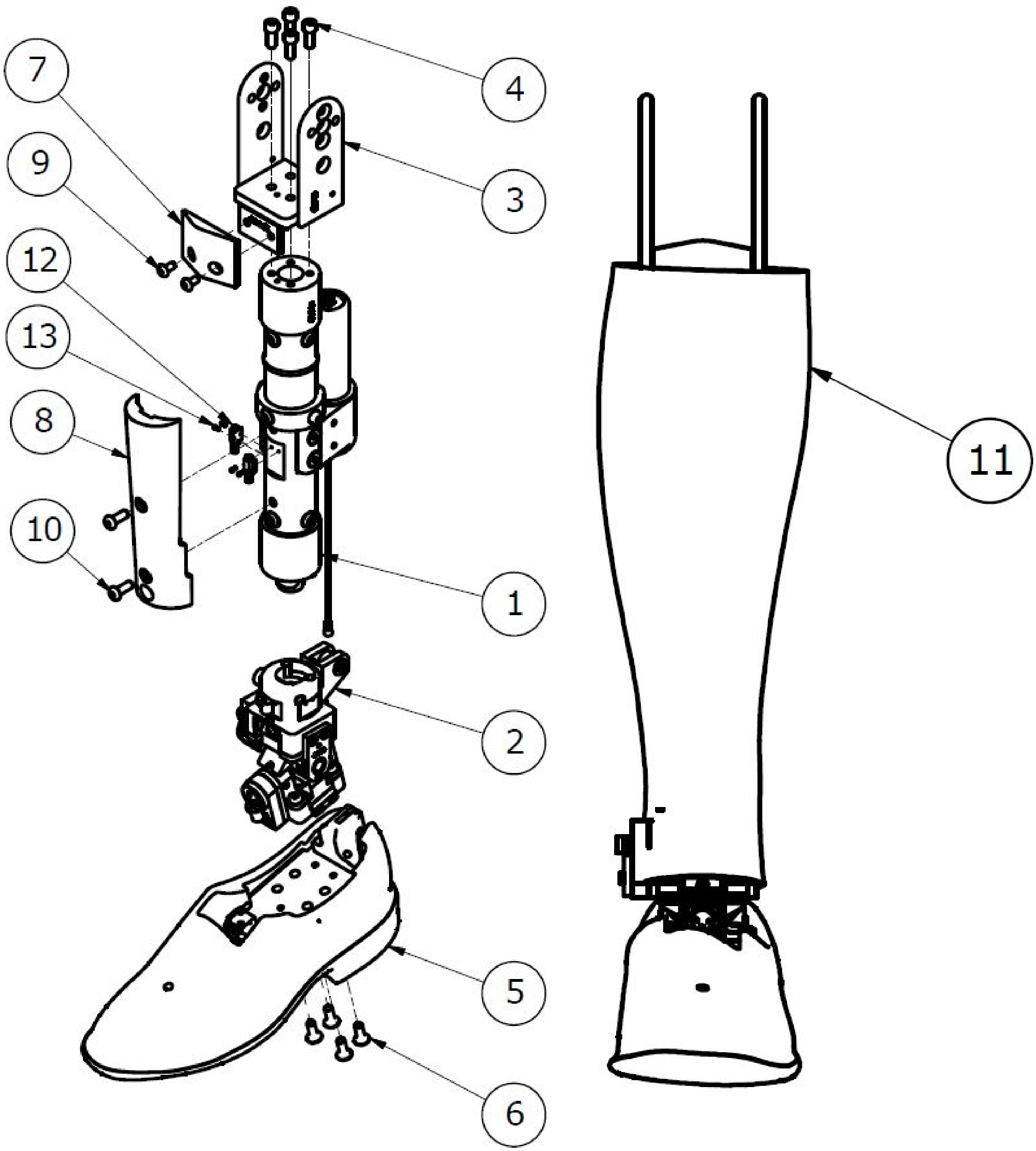


Figure 12-2. Lower leg complete assembly components

Table 12-2. Lower Leg Mechanical Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Lower Tibia Tube Assembly	1	472-7310	Figure 12-3	1
Upper Tibia Load Cell Blank	1	472-7320	Figure 12-3	2
Tibia Compliant Bushing	1	472-7315	Figure 12-3	3
Lower Tibia Load Cell Blank	1	472-7325	Figure 12-3	4
Modified BHSS M6 Thread	9	W50-61042	Figure 12-3	5
Achilles Spring Tube Mechanical Assembly	1	472-7350	Figure 12-3	6
Plunger Retaining Bolt	2	472-7335	Figure 12-3	7
Screw, FHCS M6 x 1 x 12	5	9001445	Figure 12-3	8
Z Rotation Wedge Assembly	1	427-7330	Figure 12-3	9
Screw, SHCS M3 x 0.5 x 12	1	9000058	Figure 12-3	10
Screw, SHSS M3 x 0.5 x 3	1	9010447	Figure 12-3	11
Five Channel Upper Tibia Load Cell (Optional)	1	SA572-S32	Figure 12-3	12
Five Channel Lower Tibia Load Cell (Optional)	1	SA572-S33	Figure 12-3	13

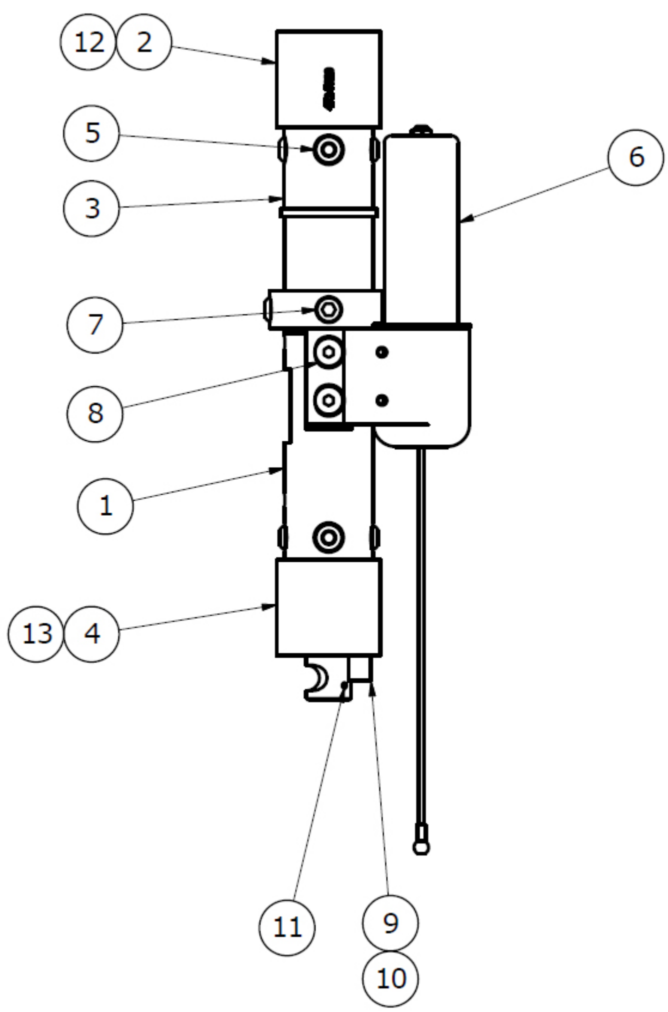


Figure 12-3. Lower leg mechanical assembly components

Table 12-3. Achilles Spring Tube Mechanical Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Achilles Spring Tube Base	1	472-7351	Figure 12-4	1
Achilles Load Cell Blank	1	472-7359	Figure 12-4	2
Achilles Spring Base Cap	1	472-7356	Figure 12-4	3
Compression Spring	1	9000540	Figure 12-4	4
Elastomeric Spring Element	1	472-7357	Figure 12-4	5
Achilles Spring Tube	1	472-7360	Figure 12-4	6
Foam Compression Element	1	472-7358	Figure 12-4	7
Achilles Primary Washer	1	472-7354	Figure 12-4	8
Achilles Spring Cap	1	472-7355	Figure 12-4	9
Achilles Cable Assembly	1	472-7352	Figure 12-4	10
M5 Hex Jam Nut	2	50000380V	Figure 12-4	11

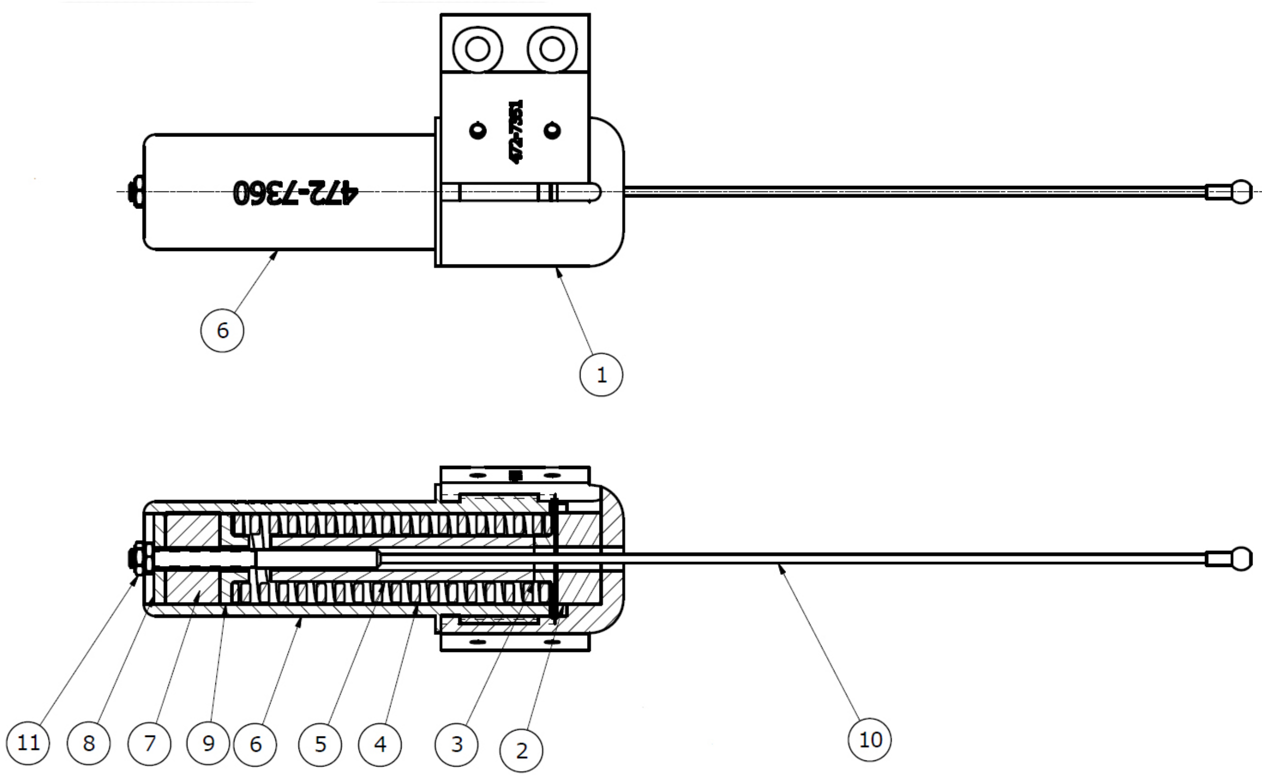


Figure 12-4. Achilles spring tube mechanical assembly components

Table 12-4. Ankle Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Ankle Center Block Assembly	1	472-7510	Figure 12-5	1
Retaining Washer	4	472-7515	Figure 12-5	2
Base Torque Cap	4	472-7522	Figure 12-5	3
Screw, BHCS M6 x 1 x 12	8	9010445	Figure 12-5	4
Bottom Torque Base	1	472-7523	Figure 12-5	5
Torque Cylinder	18	472-7524	Figure 12-5	6
Dorsi Stop Assembly	1	472-7530	Figure 12-5	7
Ankle Bushing Plate Assembly – Free End	2	472-7540	Figure 12-5	8
Screw, FHCS M3 x 0.5 x 16	4	9010446	Figure 12-5	9
Screw, SHSS M3 x 0.5 x 3	2	9010447	Figure 12-5	10
Screw, FHCS M4 x 0.7 x 12	4	9000873	Figure 12-5	11
Screw, FHCS M4 x 0.7 x 20	4	9010448	Figure 12-5	12
Achilles Pulley Bracket	1	472-7560	Figure 12-5	13
Screw, FHCS M3 x 12	2	9010449	Figure 12-5	14
Achilles Cable Pulley Shaft	1	472-7561	Figure 12-5	15
Needle Roller Bearing	2	9000509	Figure 12-5	16
Achilles Washer	2	9000508	Figure 12-5	17
Flat Washer, #4 Type B Narrow	2	9000510	Figure 12-5	18
Achilles Cable Pulley	1	472-7562	Figure 12-5	19
Nylock M3 x 0.5 Nut	2	9010450	Figure 12-5	20
Eversion Stop Assembly	1	472-7533	Figure 12-6	21
Inversion Stop Assembly	1	472-7534	Figure 12-5	22
Screw, BHCS M4 x 0.7 x 8	7	5000103	Figure 12-5	23
Ankle Bolt and Sleeve Assembly	1	472-7563	Figure 12-5	24
Nylon Loop Clamp	3	9005135	Figure 12-5	25
Plantar Stop Assembly	1	472-7527	Figure 12-6	26
Torque Ankle Top Base	1	472-7580	Figure 12-5	27
Pot End Ankle Bushing Plate Assembly	2	472-7582	Figure 12-5	28
Potentiometer Retainer	2	472-7585	Figure 12-5	29
Potentiometer	3	SA572-S114	Figure 12-5	30
Potentiometer Clamp	3	472-7581	Figure 12-5	31
Screw, SHCS M2 x 0.4 x 4	6	9010559	Figure 12-5	32
Screw, SHCS M2 x 0.2 x 6	12	9010560	Figure 12-5	33
Screw, BHCS M3 x 0.5 x 8	4	5000410	Figure 12-5	34

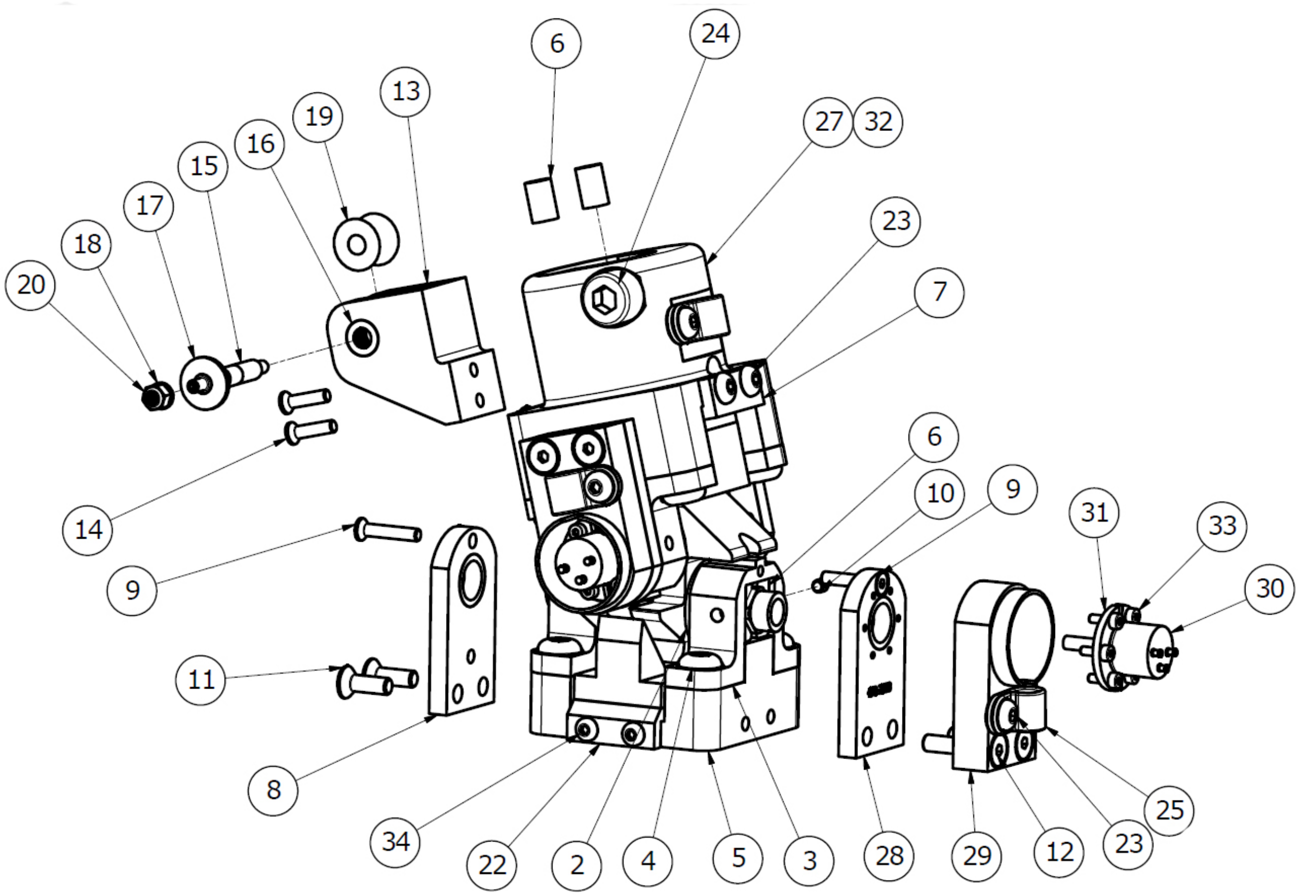


Figure 12-5. Ankle (left) assembly components

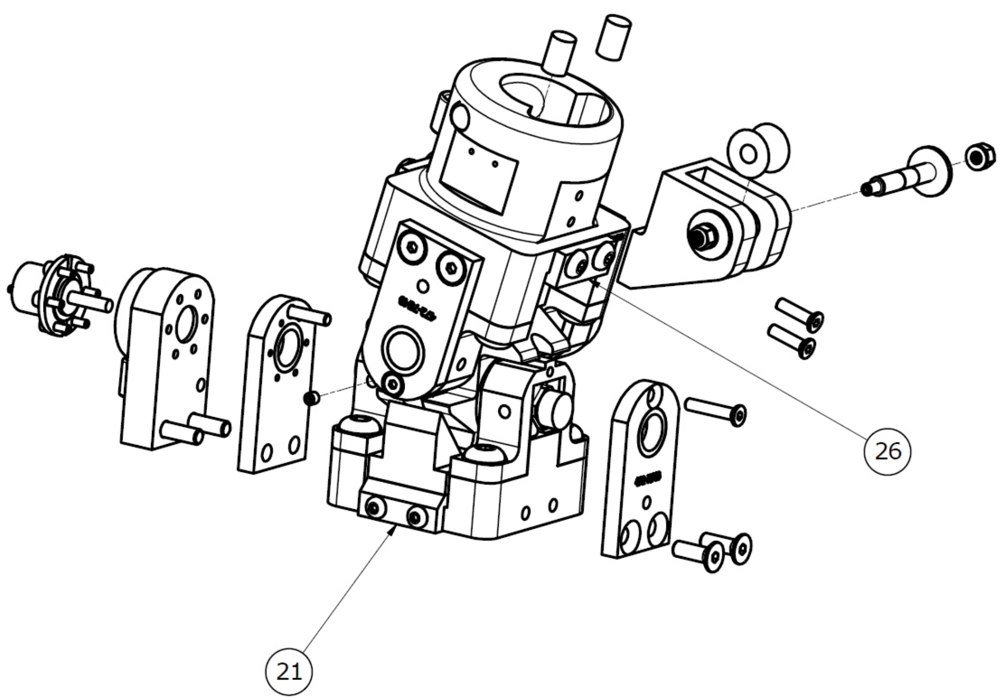


Figure 12-6. Ankle (left) assembly components – additional view

Table 12-5. Molded Shoe Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Shoe Upper - Left	1	472-7802-1	Figure 12-7	1
Heel Pad Molded - Left	1	472-7804-1	Figure 12-7	2
Ball of Foot Pad Molded - Left	1	472-7803-1	Figure 12-7	3
Shoe Sole - Left	1	472-7801-1	Figure 12-7	4
Mounting Post, Lower Achilles	1	472-7744	Figure 12-7	5
Screw, FHCS M6x1 X 20	3	5001089	Figure 12-7	6
Plate Mounting, Tri Pack Accel	1	472-7710	Figure 12-7	7
Tri-Pack Block	1	SA572-S80M	Figure 12-7	8
Screw, FHCS M3x0.5 X 16	2	9010446	Figure 12-7	9
Screw, SHCS M2.5x0.45 X 16	2	9000863	Figure 12-7	10
SCREW, SHCS M1.4 X 0.3 X 3 LG.	6	9010407	Figure 12-7	11
Uniaxial Piezoresistive Accelerometer	3	SA572-S4	Figure 12-7	12
Screw, SHCS M3-0.5 X 12	1	9000058	Figure 12-7	13

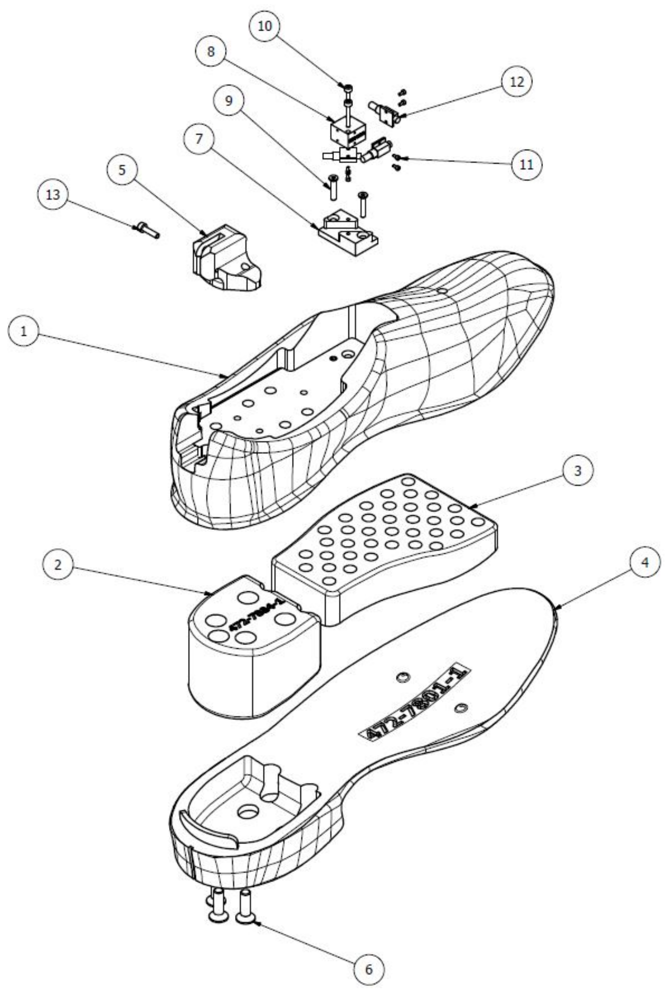


Figure 12-7. Molded shoe (left) assembly components

12.2.2 **Assembly of the Lower Extremity Components**

The following procedure is a step-by-step description of the assembly procedure for the lower extremity components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

12.2.2.1 Install the Knee Clevis Weldment (472-7200) on the Upper Tibia Load Cell (SA572-S32) using four M6 x 1 x 16 SHCS (Figure 12-8).

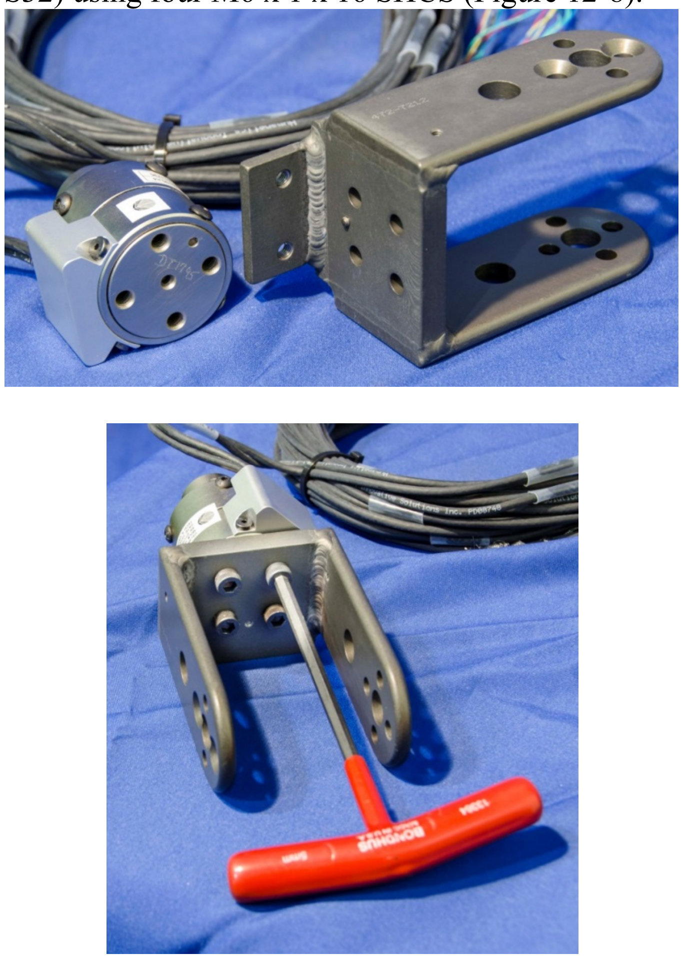


Figure 12-8. Install knee clevis to upper tibia load cell

12.2.2.2 Attach the five-channel upper tibia load cell to the Tibia Compliant Bushing Assembly (472-7315) using four Modified M6 Thread BHSS (W50-61042) (Figure 12-9 and Figure 12-10).

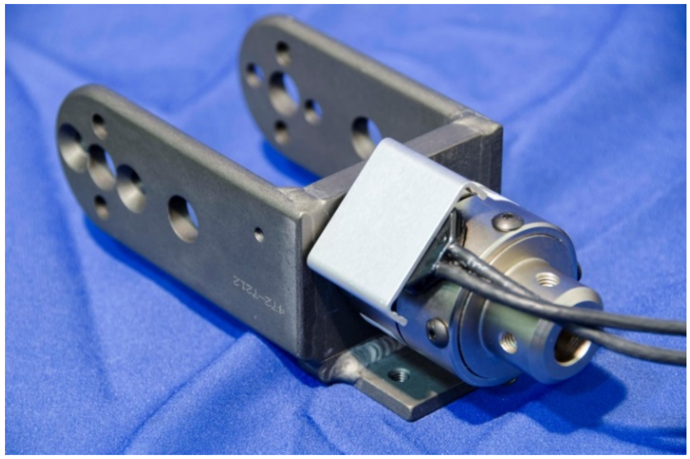


Figure 12-9. Upper tibia load cell connected to knee clevis

Figure 12-10. Install tibia compliant bushing assembly to upper tibia load cell

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NOTE: The upper tibia load cell X-axis MUST be oriented towards the anterior (front) of the lower extremity as it is assembled.

12.2.2.3 The Lower Tibia Tube Assembly (472-7310) connects to the Lower Flange (472-7317) of the Tibia Compliant Bushing Assembly (472-7315) using a Modified BHSS M6 Thread on the anterior (front) side (Figure 12-11 and Figure 12-12).

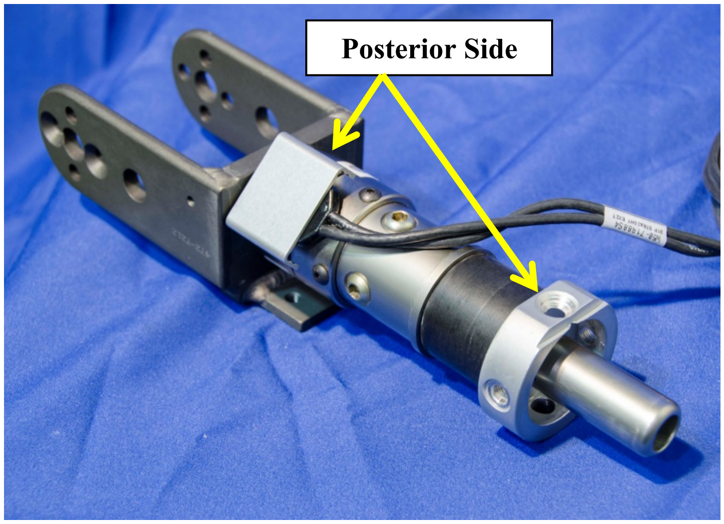


Figure 12-11. Connect lower tibia tube assembly to lower flange of tibia compliant bushing (posterior view)

Figure 12-12. Connect lower tibia tube assembly to lower flange of tibia compliant bushing (anterior view)

12.2.2.4 Mount two Plunger Retaining Bolts (472-7335) on the left and right sides of the lower flange (Figure 12-13).

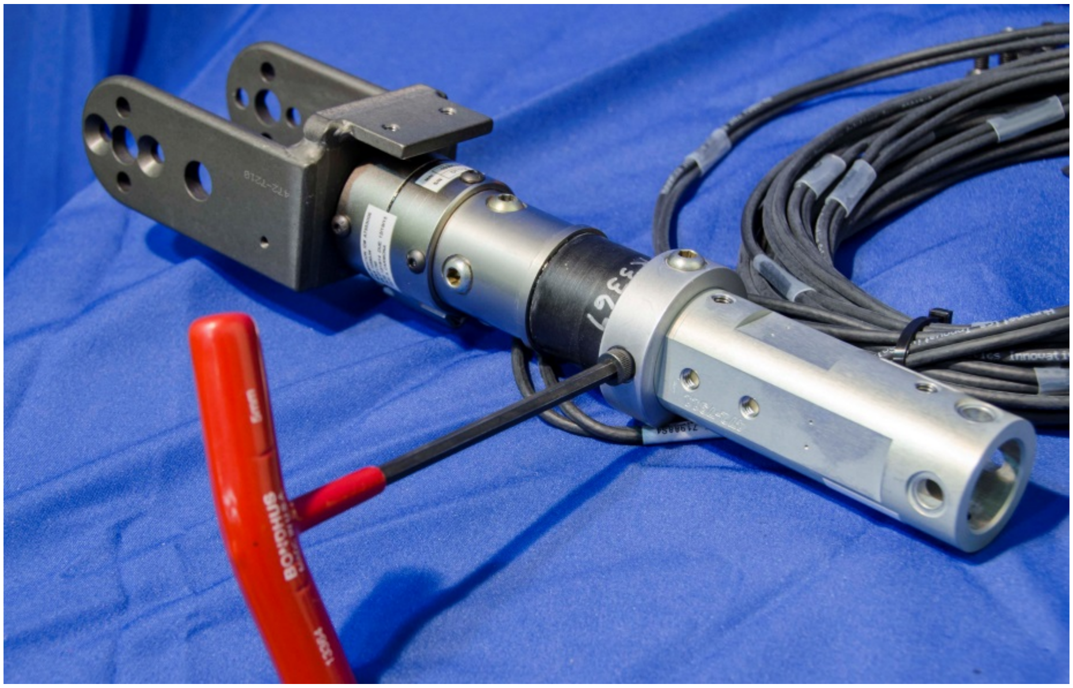


Figure 12-13. Mount plunger retaining bolts

12.2.2.5 Mount an M6 x 1 x 12 FHCS to the posterior (rear) of the lower flange (Figure 12-14).

Figure 12-14. Secure lower flange

12.2.2.6 Install the Z-Rotation Wedge Assembly (472-7330) to the lower tibia load cell using an M3 x 0.5 x 12 SHCS (Figure 12-15).

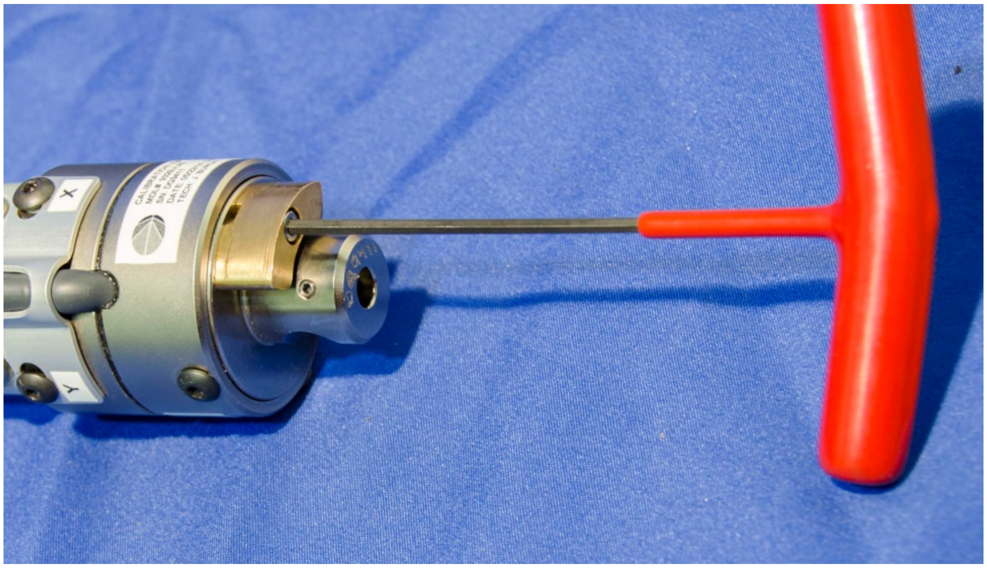


Figure 12-15. Install Z-rotation wedge to lower tibia load cell

12.2.2.7 Connect the lower tibia load cell to the bottom of the Lower Tibia Tube Assembly (472-7310) using four Modified BHSS M6 Thread Bolts (W50-61042) (Figure 12-16 and Figure 12-17). Orient the notch on the lower tibia load cell toward the anterior (front) of the leg.

Figure 12-16. Connect lower tibia load cell to lower tibia tube assembly

Figure 12-17. Lower leg assembled (without ankle)

12.2.2.8 Place the Achilles Load Cell (SA572-S126) or Achilles Load Cell Blank (472-7359) into the counterbore at the bottom of the Achilles Spring Tube Base (472-7351), as shown in Figure 12-18. Orient the load cell with the flat side facing up (Figure 12-19). Use the Groove on the side of the Spring Tube Base for wire routing (Figure 12-20).

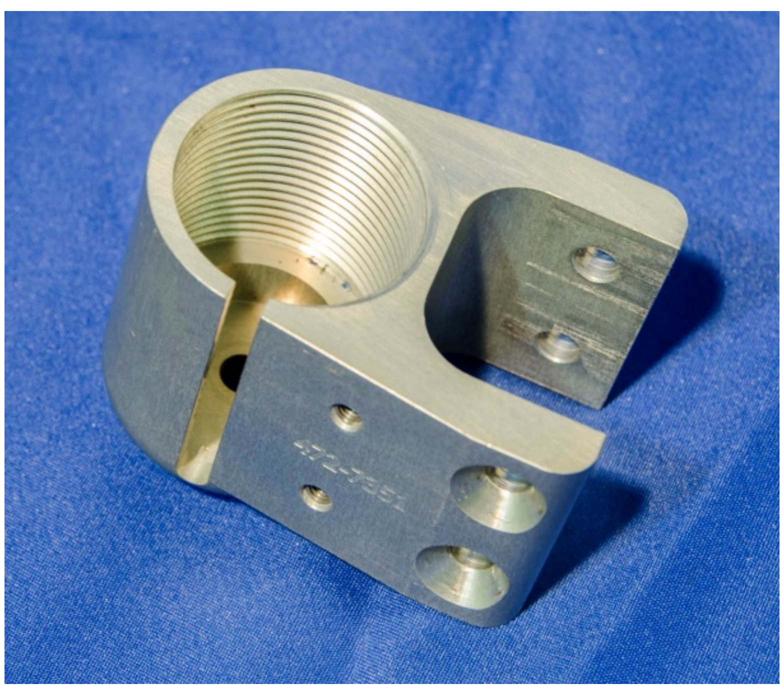


Figure 12-18. Achilles spring tube base

Figure 12-19. Achilles load cell orientation

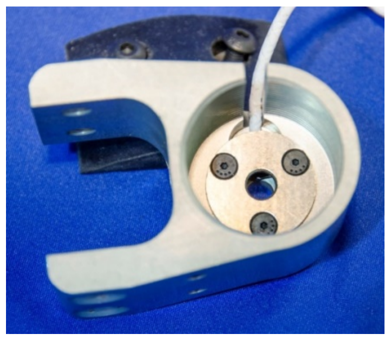


Figure 12-20. Insert Achilles load cell into Achilles spring tube base

12.2.2.9 Place the Achilles Spring Base Cap (472-7356) on top of the load cell with the raised button facing away from the load cell (Figure 12-21).

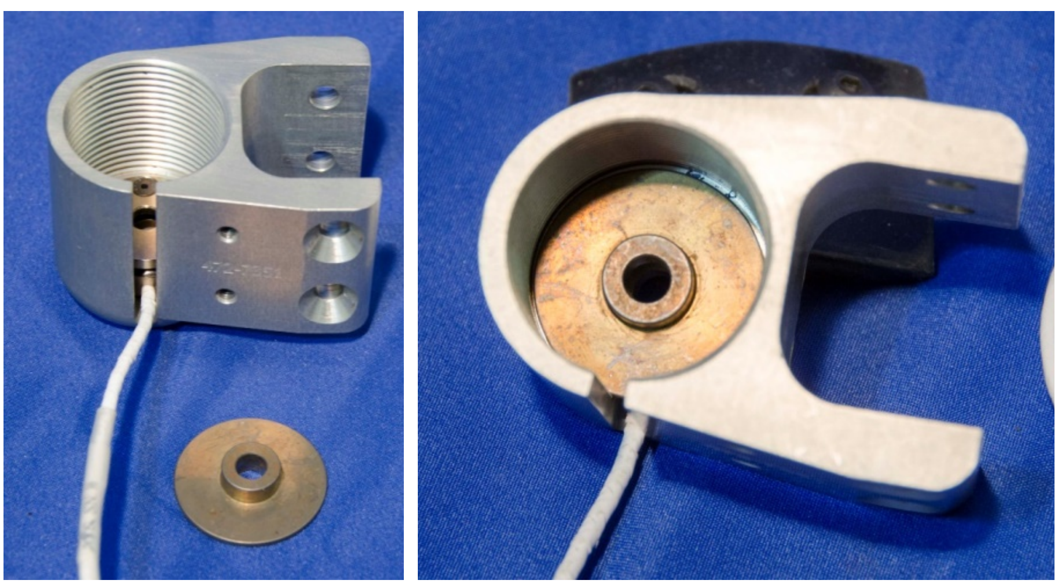


Figure 12-21. Install Achilles spring base cap

12.2.2.10 Screw the Achilles Spring Tube (472-7360) into the top of the spring tube base and tighten securely (Figure 12-22).

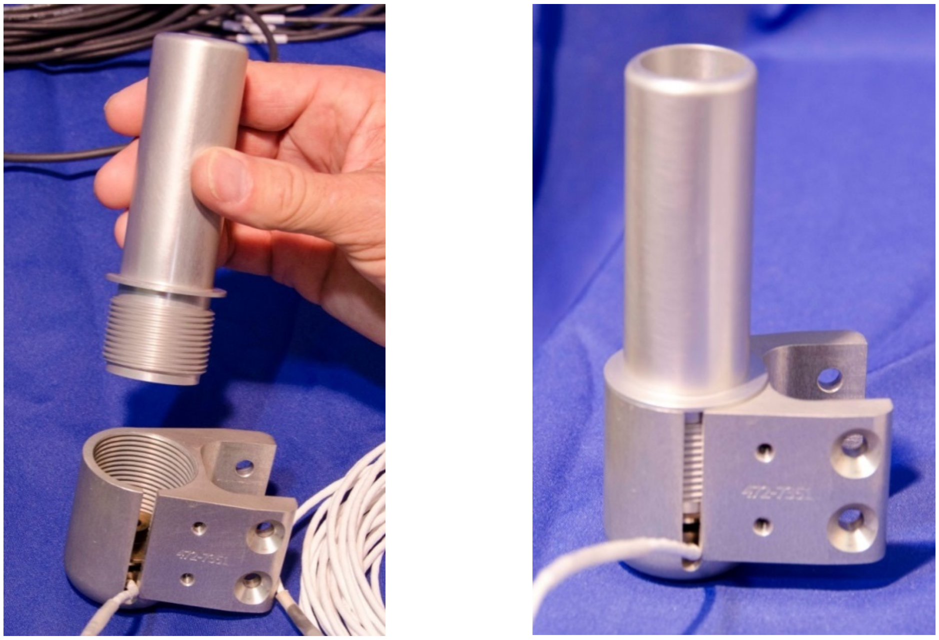


Figure 12-22. Install Achilles spring tube into spring tube base

12.2.2.11 Insert the Elastomeric Spring Element (472-7357) into the Compression Spring (9000540) (24 N/mm) (Figure 12-23).

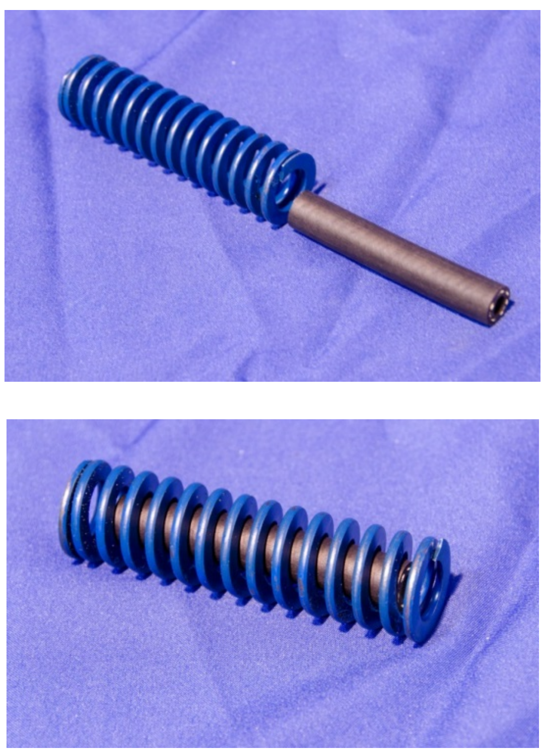


Figure 12-23. Assemble compression spring with elastomer spring element

12.2.2.12 Slide the Compression Spring Assembly into the Spring Tube (Figure 12-24), and place the Achilles Spring Cap (472-7355) toward the open end (Figure 12-25).

Figure 12-24. Install front compression tube assembly into spring tube

Figure 12-25. Install Achilles spring cap

12.2.2.13 Position the Foam Compression Element (472-7358) above the Achilles Spring Cap (Figure 12-26). Next, insert the Achilles Primary Washer (472-7354) (Figure 12-27).

Figure 12-26. Assemble foam compression element into Achilles

Figure 12-27. Insert Achilles primary washer

12.2.2.14 Pass the threaded end of the Achilles Cable (T1LLM319) up through the spring tube assembly from the bottom side, as shown in Figure 12-28.

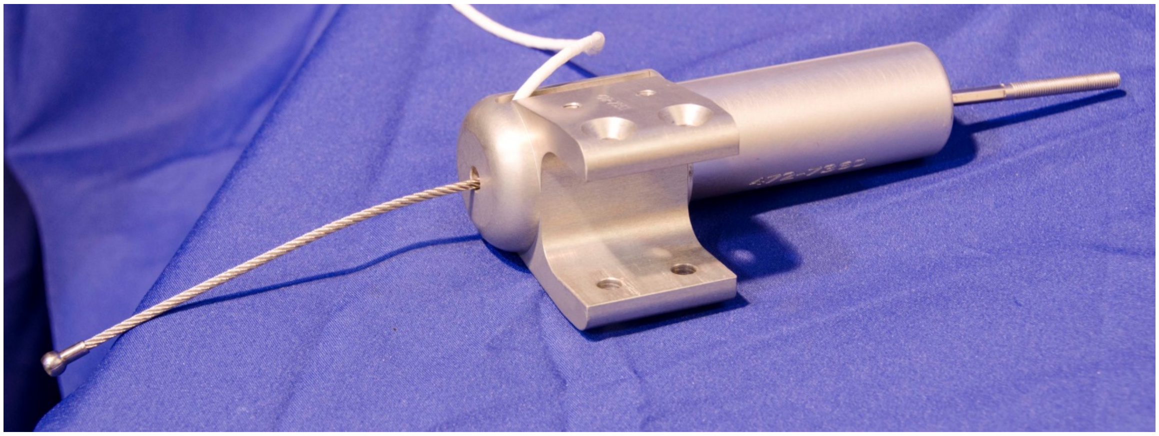


Figure 12-28. Insert Achilles cable into spring tube assembly

12.2.2.15 Secure the cable with the two M5 Hex Jam Nuts (5000380V) **(**Figure 12-29**)**. The adjustment of the Achilles cable is in Section 12.3.2.

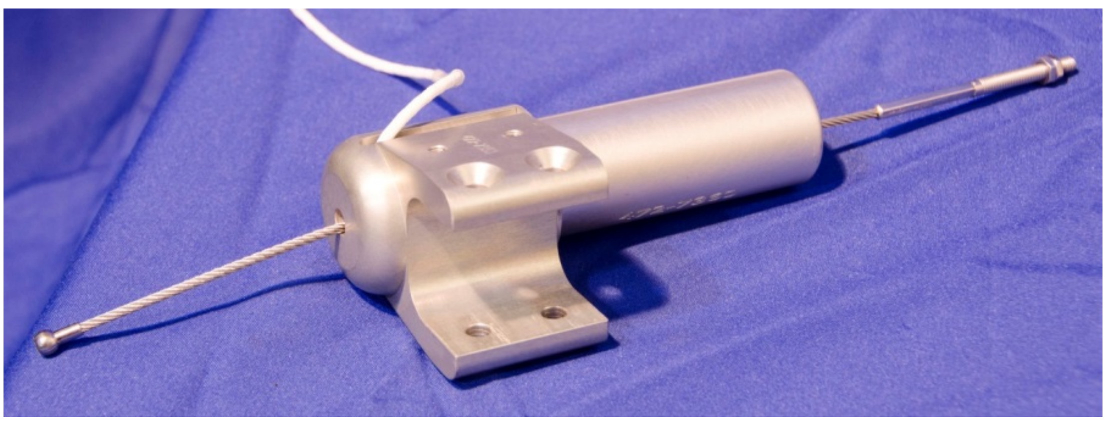


Figure 12-29. Secure Achilles cable with hex jam nuts

12.2.2.16 Attach the Achilles Spring Tube assembly to the rear of the lower tibia tube using four M6 x 1 x 12 FHCS (Figure 12-30 and Figure 12-31).

Figure 12-30. Attach Achilles spring tube to lower tibia tube

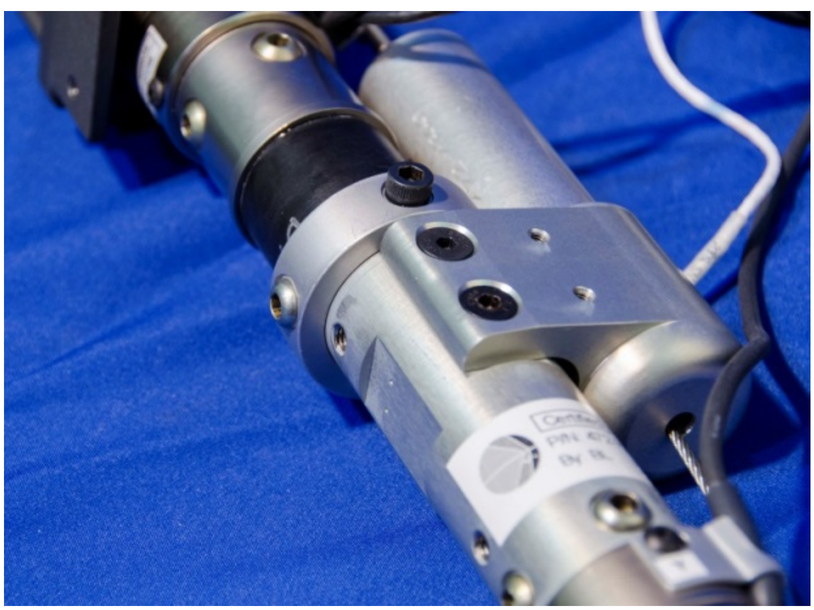


Figure 12-31. Achilles spring tube attached to lower tibia tube

12.2.2.17 Install the four Retaining Washers (472-7515) over each end of the Upper (472-7512) and Lower (472-7513) Torque Shafts on the Ankle Center Block (472-7511) (Figure 12-32).

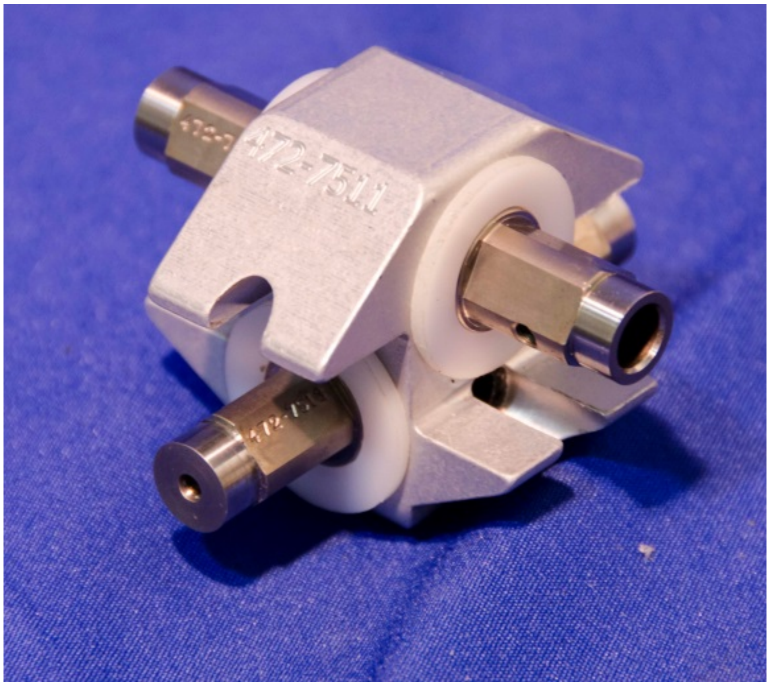


Figure 12-32. Install retaining washers in upper and lower torque shafts

12.2.2.18 Install the four Base Torque Caps (472-7522) onto the Upper and Lower Torque Shafts. The rounded corners of the torque cap should face outwards (Figure 12-33).

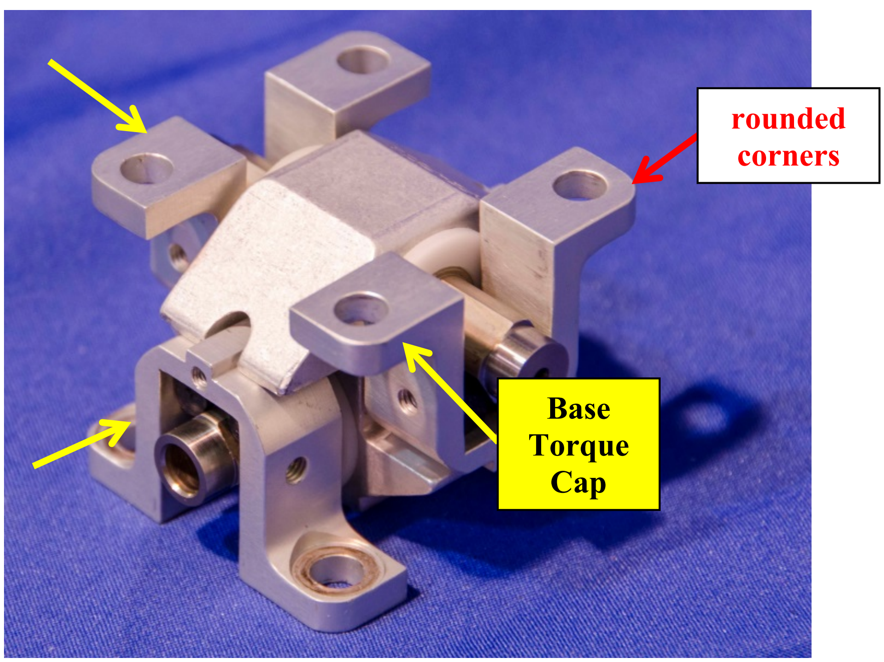


Figure 12-33. Install base torque caps on upper and lower torque shafts

12.2.2.19 For ease of assembly, initially only insert two of the Torque Cylinders (472-7524), at the most interior corners of each torque cap (Figure 12-34).

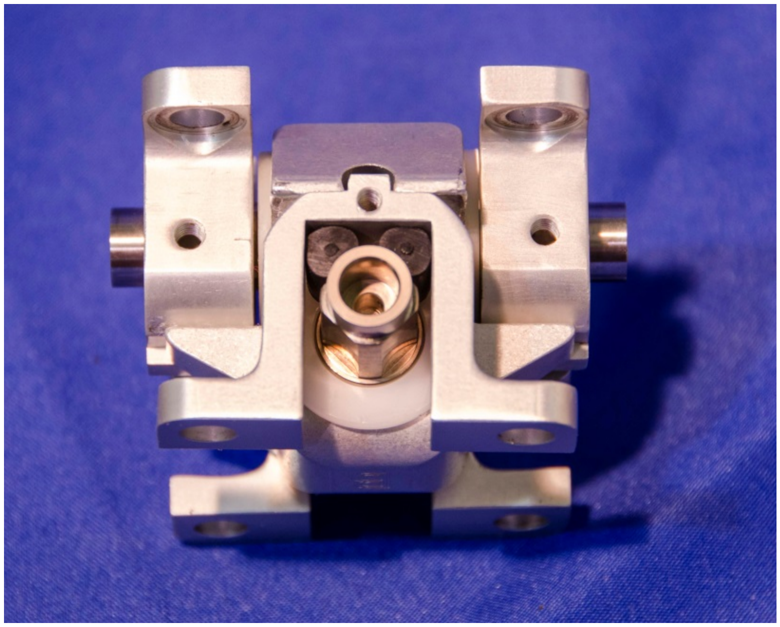


Figure 12-34. Insert torque cylinders into interior corners of torque cap

12.2.2.20 Install the Inversion Stop Assembly (472-7534) and Eversion Stop Assembly (472-7533) to the Torque Bottom Base (472-7523) using two M3 x 0.5 x 8 BHCS for each stop assembly (Figure 12-35 and Figure 12-36). The inversion stop is the thinner of the two stop assemblies.

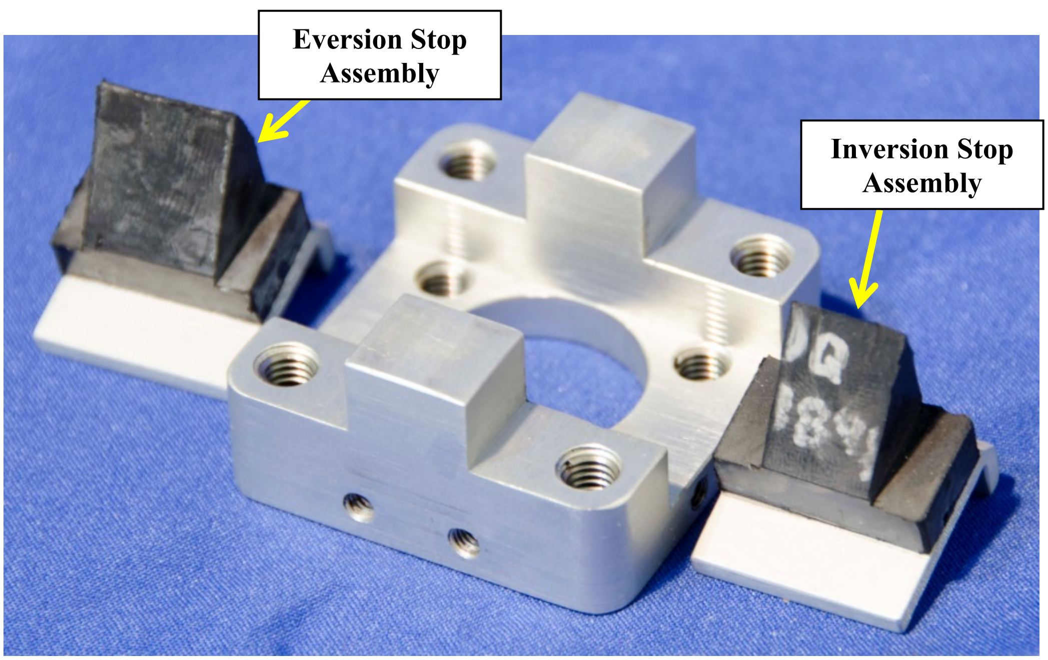


Figure 12-35. Eversion and inversion stop assemblies

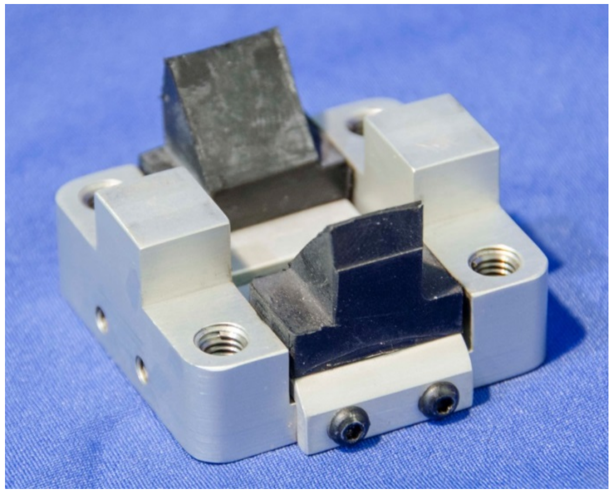


Figure 12-36. Install inversion and eversion stops

12.2.2.21 Secure the center block shaft assembly to the torque bottom base with four M6 x 1 x 12 BHCS (Figure 12-37 and Figure 12-38).

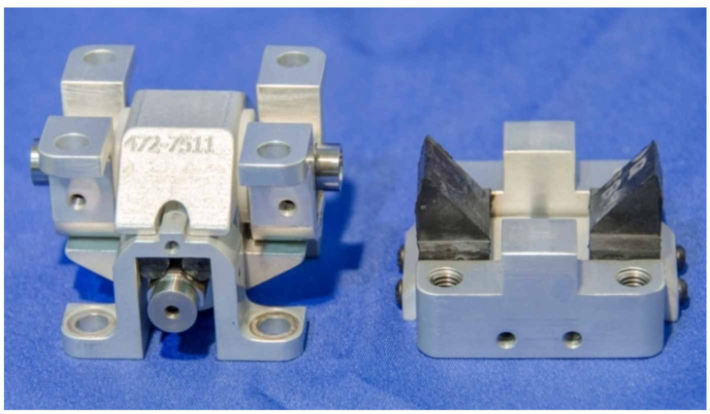


Figure 12-37. Center block shaft assembly and torque bottom base

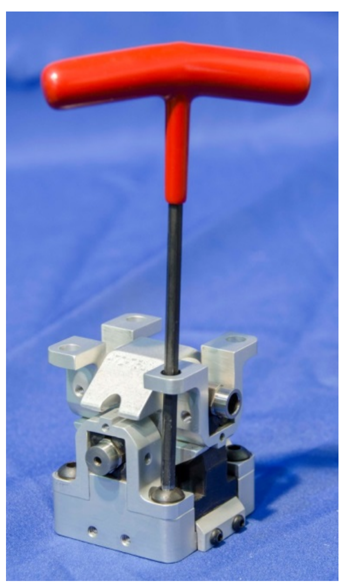


Figure 12-38. Install center block shaft assembly to torque bottom base

12.2.2.22 Before inserting the rotary potentiometer into the torque ankle top base, assure that the potentiometer will not pass through a dead band when moved through its range of motion in the ankle. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Once this is complete, insert the rotary potentiometer (SA572-S114) inside the Torque Ankle Top Base (472-7580) so that the wiring routes through the groove, and secure using a Potentiometer Clamp (472-7581) with six M2 x 0.2 x 4 SHCS (9010559) (Figure 12-39). Insert the potentiometer wiring through a nylon loop clamp, then install the clamp to the torque ankle top base using a M4 x 0.7 x 8 BHCS (9003049).

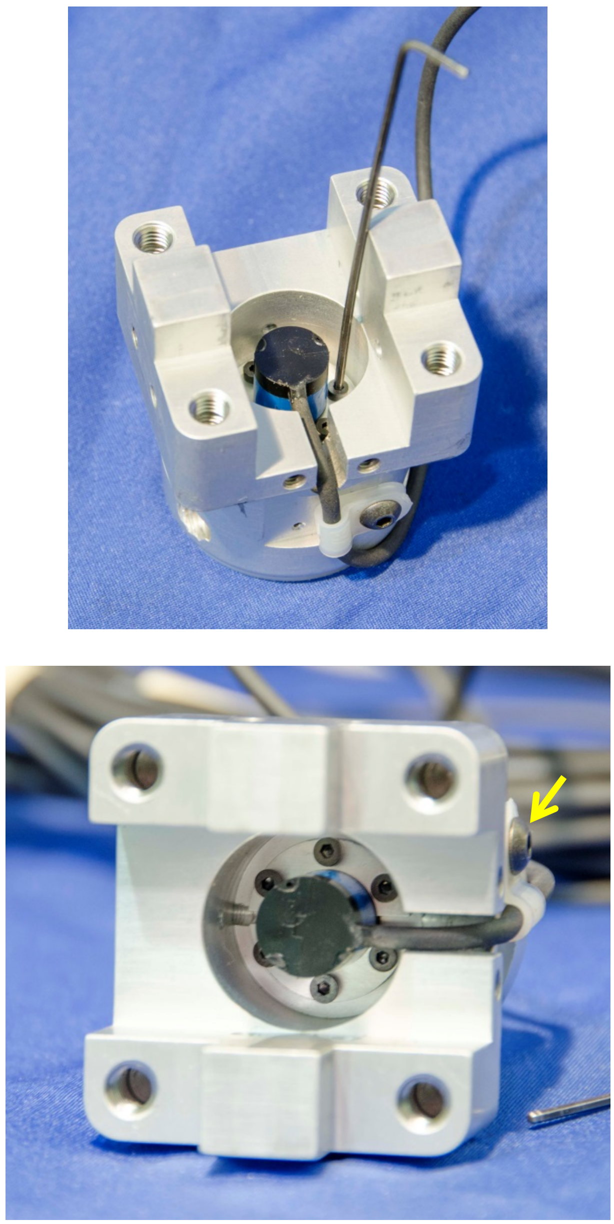
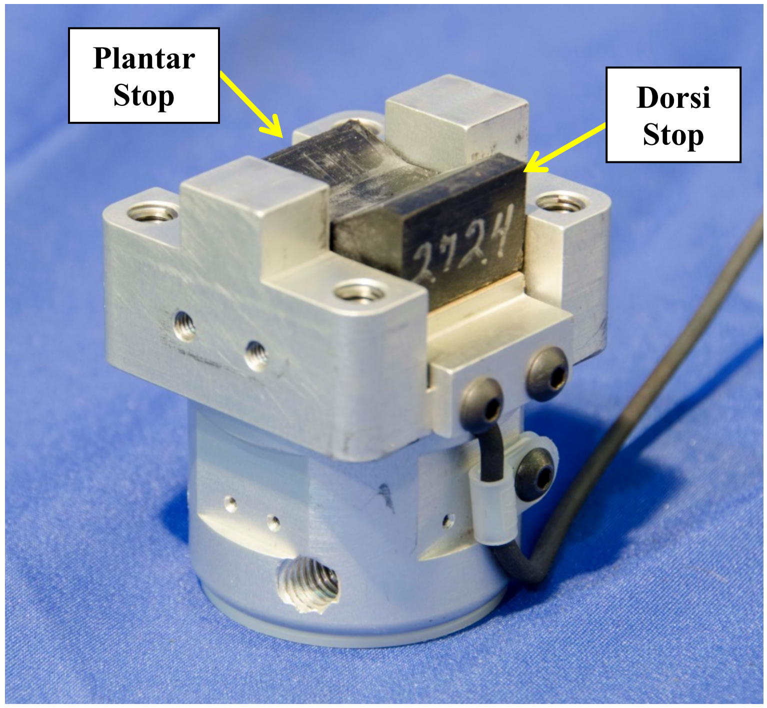


Figure 12-39. Install rotary potentiometer into torque ankle top base

12.2.2.23 Install the Dorsi Stop Assembly (472-7530) on the front and the Plantar Stop Assembly (472-7527) on the back of the Torque Ankle Top Base (472-7580) (Figure 12-40). Note that the dorsi stop assembly is taller than the plantar stop. Use M4 x 0.7 x 8 BHCS to secure the Front Stop Dorsi Bracket (472-7531) and Rear Stop Plantar Bracket (472-7528).



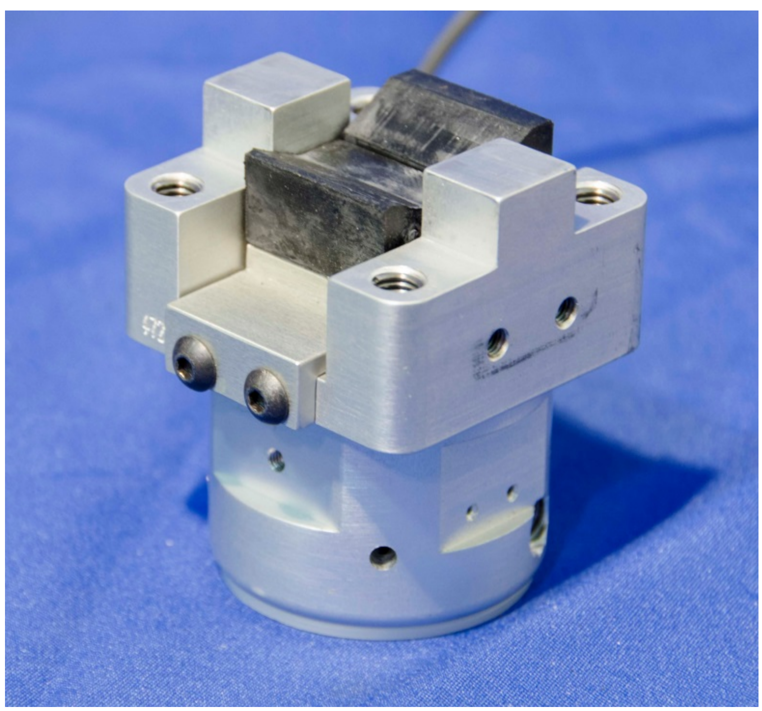


Figure 12-40. Install dorsi stop assembly

12.2.2.24 Install two Torque Cylinders per side into the top of the torque caps (Figure 12-41).

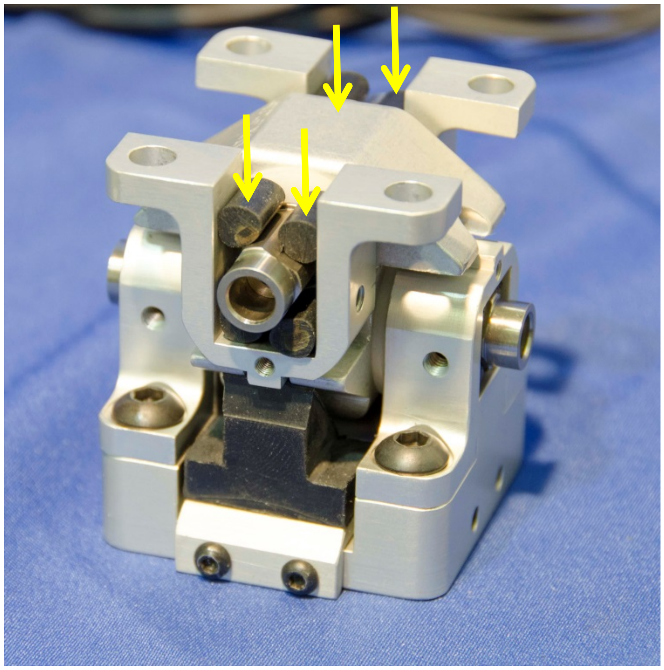


Figure 12-41. Install torque cylinders into top torque caps

12.2.2.25 Secure the bottom base unit assembly to the top base with four M6 x 1 x12 BHCS (Figure 12-42).

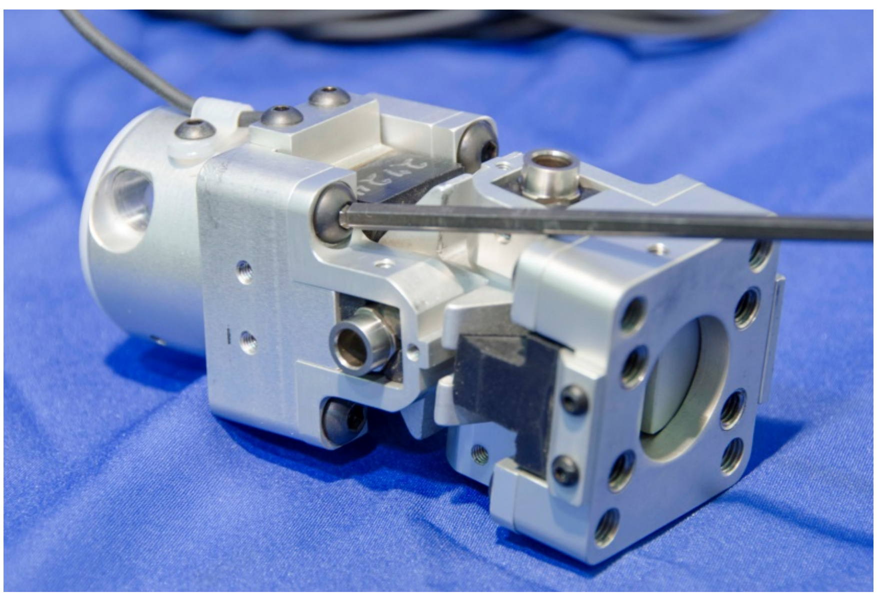


Figure 12-42. Secure bottom base unit assembly to top base

12.2.2.26 Insert two Torque Cylinders into the Ankle Top Torque Base (472-7580) (Figure 12-43).

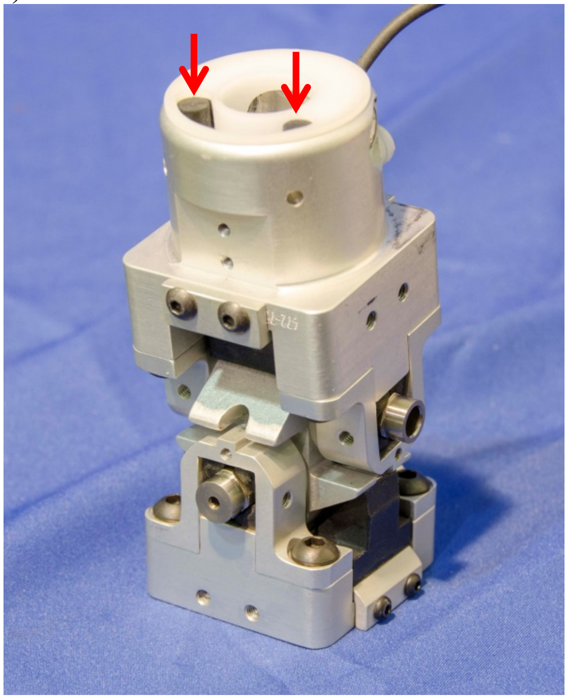


Figure 12-43. Insert torque cylinders into ankle top torque base

12.2.2.27 Attach the Pot End Ankle Bushing Plate Assembly (472-7582) to the Torque Bottom Base (472-7523) with one M3 x 0.5 x 12 FHCS near the rounded end of the bushing plate (Figure 12-44).

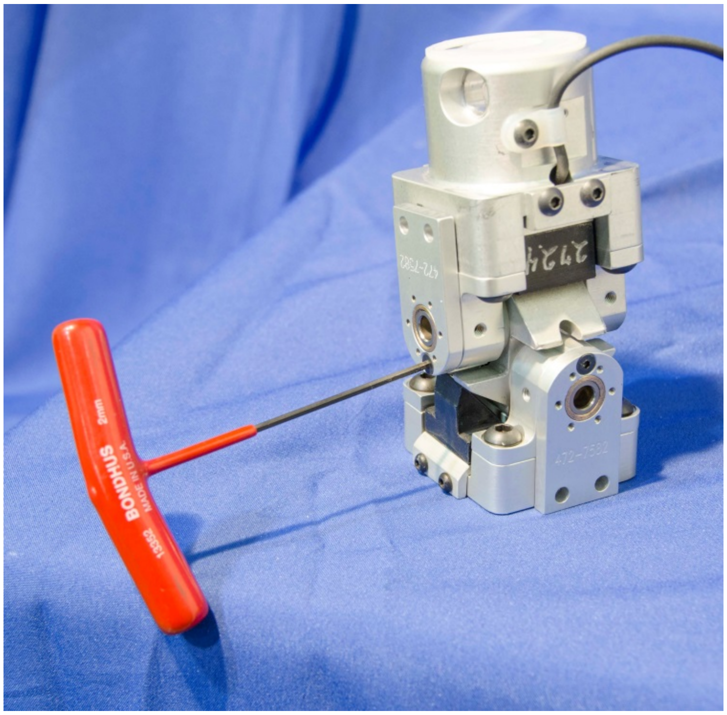


Figure 12-44. Install pot end ankle bushing plate assembly to torque bottom base

12.2.2.28 Install Potentiometer Retainers (472-7585) on the front and right sides of the ankle using two M4 x 0.7 x 20 FHCS per installation (Figure 12-45). Nylon Loop Clamps are also installed using M4 x 0.7 x 8 BHCS (9003049) to provide strain relief for the potentiometer wires.

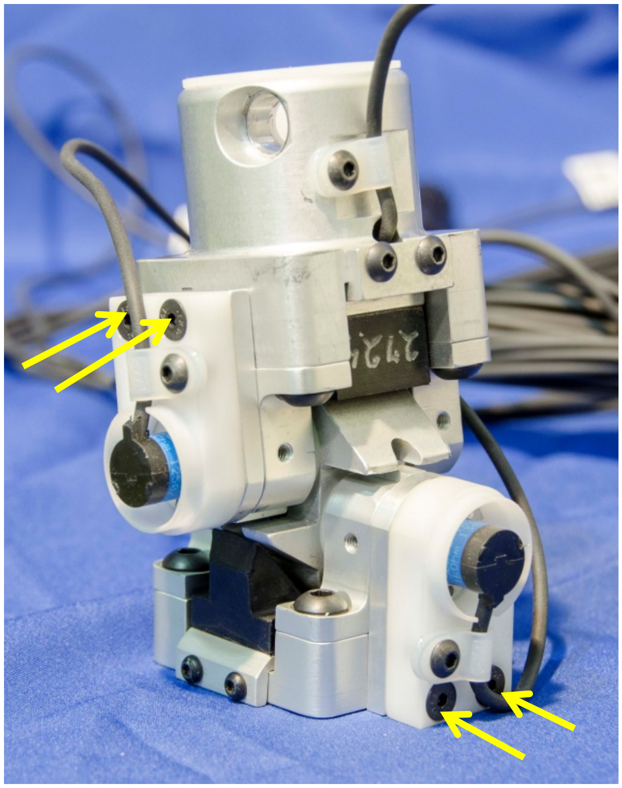


Figure 12-45. Install potentiometer retainers

12.2.2.29 Install six (per potentiometer) M2 x 0.4 x 6 SHCS into each potentiometer clamp to secure the potentiometer to the Ankle Bushing Plate Assembly (Figure 12-46 and Figure 12-47).

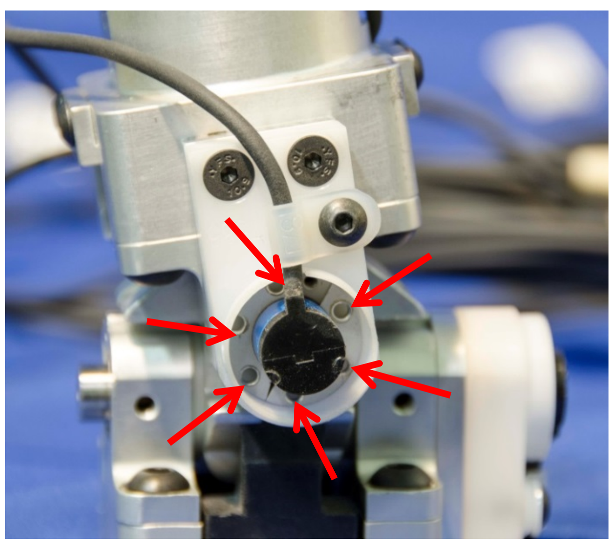


Figure 12-46. Align potentiometer to ankle bushing plate

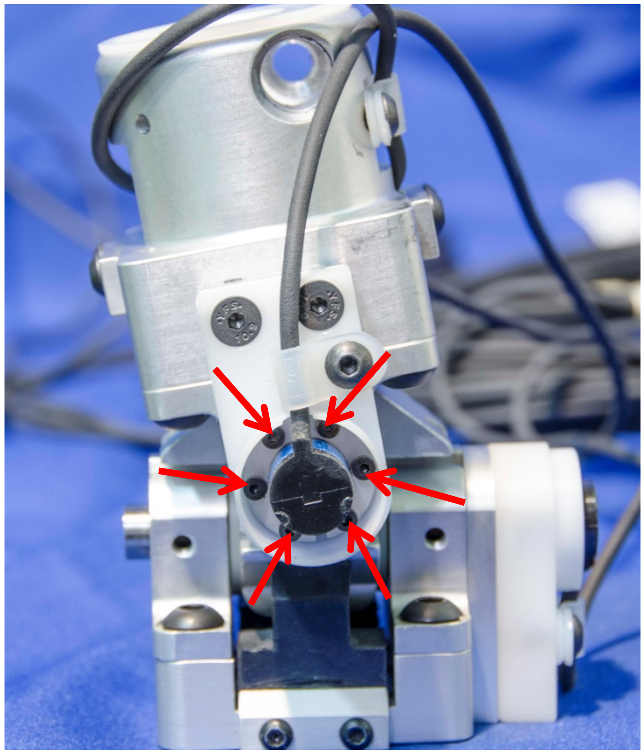


Figure 12-47. Install potentiometer clamps to hold pot to ankle bushing plate

12.2.2.30 Install an M3 x 0.5 x 3 SHSS against the X-axis potentiometer through the left side access hole (Figure 12-48).

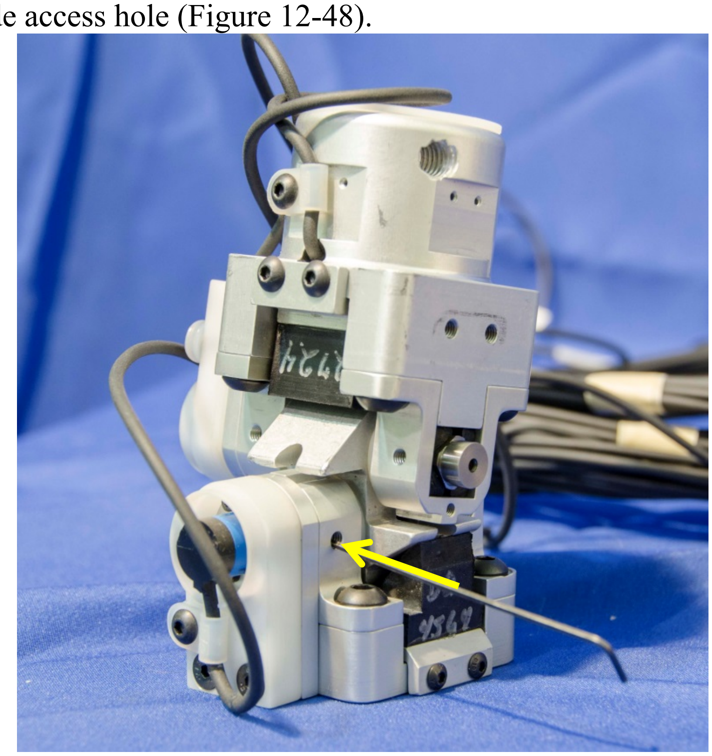


Figure 12-48. Install X-axis potentiometer set-screw

12.2.2.31 Install an M3 x 0.5 x 3 SHSS against the Y-axis potentiometer through the rear access hole (Figure 12-49).

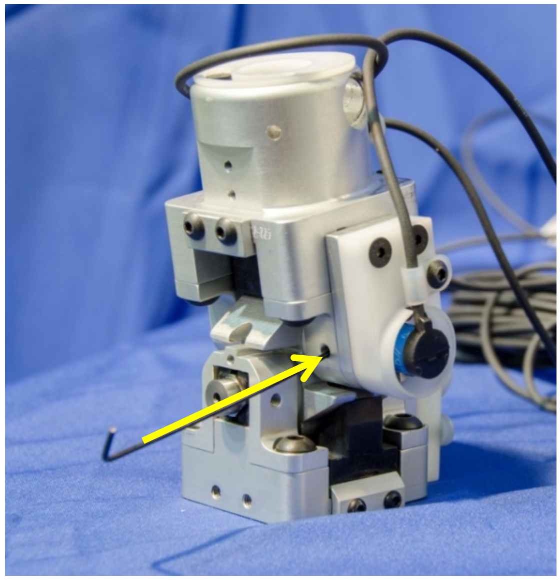


Figure 12-49. Install Y-axis set-screw

12.2.2.32 Install two Ankle Bushing Plate Free End Assemblies (472-7540) using one M3 x 0.5 x 16 FHCS in the hole closest to the rounded edge and two M4 x 0.7 x 12 FHCS in the holes near the straight edge of the plate (Figure 12-50).

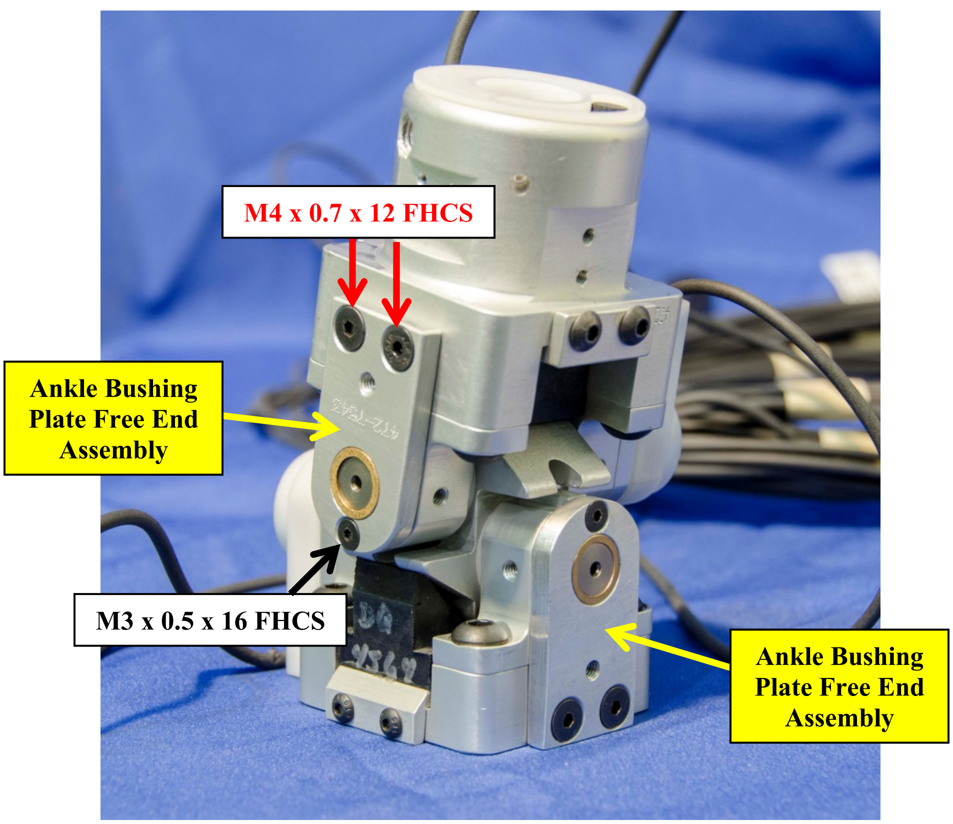


Figure 12-50. Install ankle busing plate free end assemblies

12.2.2.33 Install the Achilles Cable Pulley (472-7562) into the Achilles Pulley Bracket (472-7560). Insert the Achilles Cable Pulley Shaft (472-7561) through the cable pulley assembly. Install an Achilles Washer (9000508) and a #4 type B Narrow Flat Washer (9000510) on each end of the shaft. Secure the shaft on each end with an M3 x 0.5 nylock nut. Be sure to install a new nylock nut each time the nut is removed.

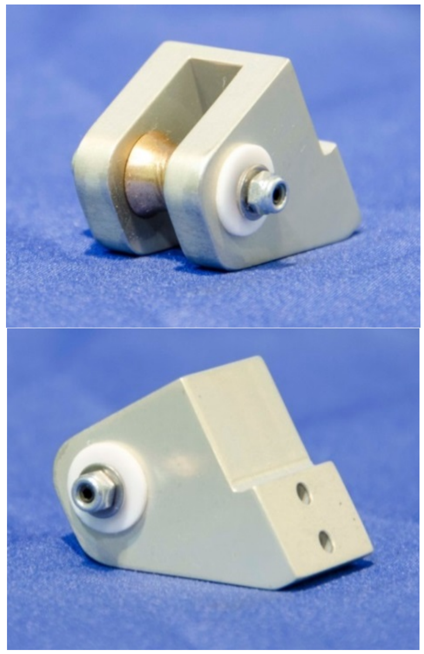


Figure 12-51. Install Achilles cable pulley into pulley bracket

12.2.2.34 Attach the Achilles pulley bracket assembly to the ankle assembly using two M3 x 12 FHCS (Figure 12-52).

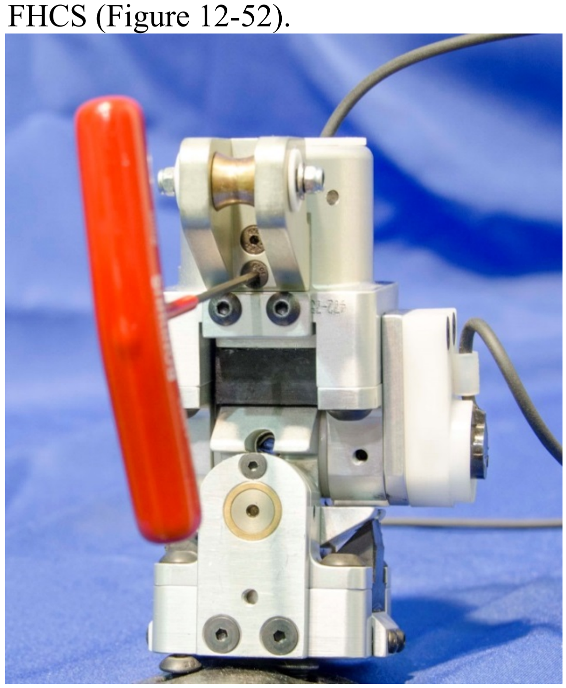


Figure 12-52. Attach Achilles pulley bracket to ankle

12.2.2.35 Slide the mounting post of the lower tibia load cell into the counter bored hole in the Ankle Top Torque Base (472-7580) of the Mechanical Ankle Assembly (472-7500) (Figure 12-53). Secure the ankle to the lower tibia using the Ankle Bolt and Sleeve Assembly (472-7563).

Figure 12-53. Attach lower tibia load cell to ankle top torque base

12.2.2.36 Insert the Achilles cable through the Achilles pulley bracket (Figure 12-54). Secure the potentiometer shaft by installing the M3 x 0.5 x 3 SHSS.

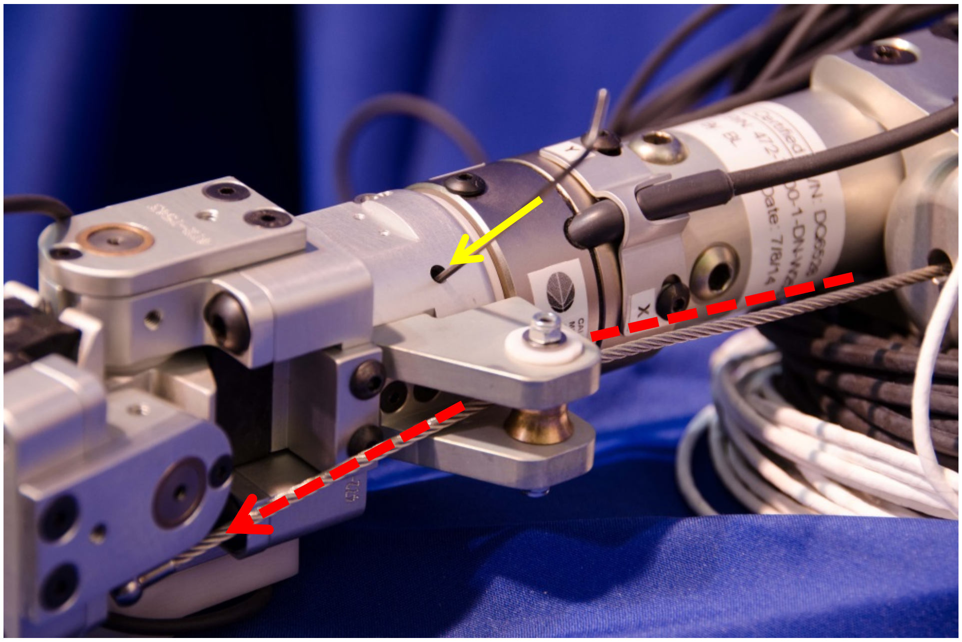


Figure 12-54. Insert Achilles cable through pulley

12.2.2.37 Attach Tri-Pack Accel Mounting Plate (472-7710) to the Shoe Upper (Left) (472-7802-1) using two M3 x 0.5 x 16 SHCS (Figure 12-55).

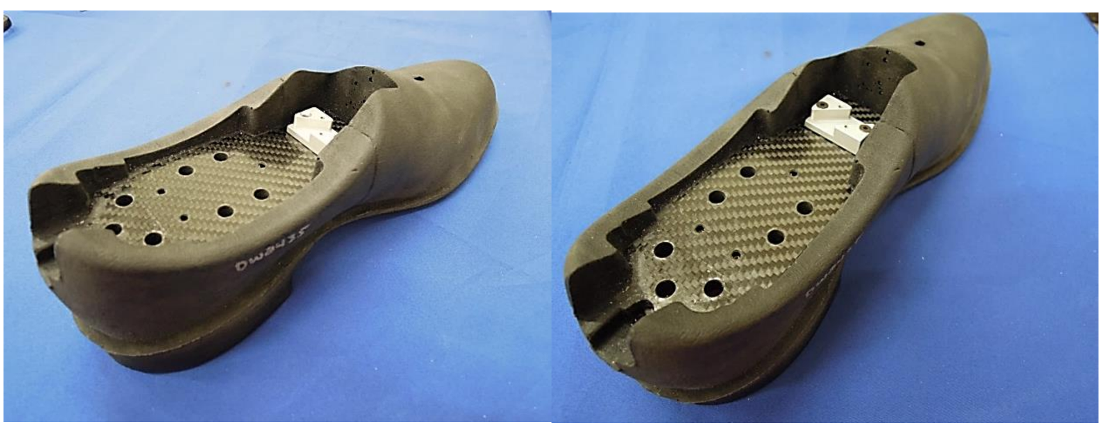


Figure 12-55. Install tri-pack accelerometer mounting plates to molded shoe

12.2.2.38 Mount three Uniaxial Piezoresistive Accelerometers (SA572-S4) on the Tri-Pack Block (SA572-S80M) using six M1.4 x 0.3 x 3 SHCS (Figure 12-56).

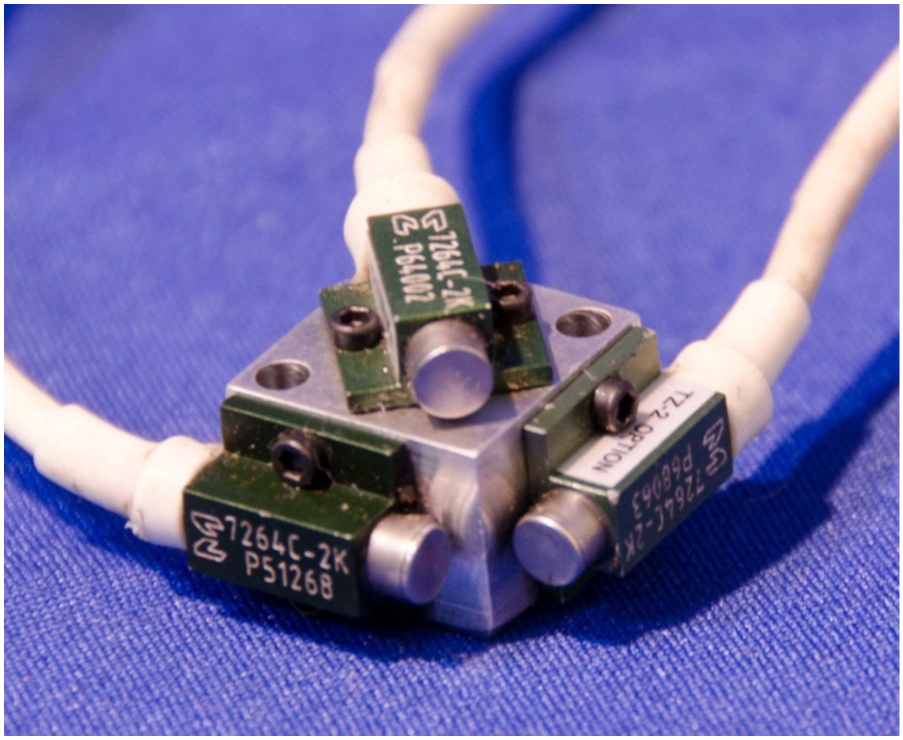


Figure 12-56. Mount accelerometers to Tri-Pack block

12.2.2.39 Attach the Tri-Pack Block to the Tri-Pack Accel Mounting using two M2.5 x 0.45 x 16 SHCS (Figure 12-57).

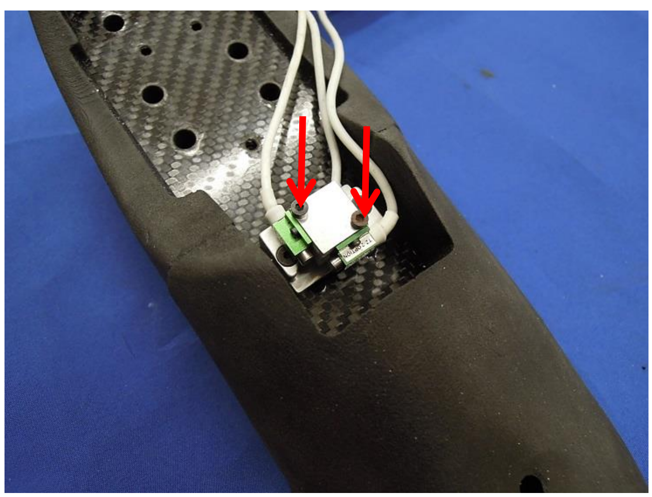


Figure 12-57. Attach Tri-Pack block to mounting

12.2.2.40 Place the Achilles Mounting Post (472-7744) on the upper shoe (Figure 12-58). Install three M6 x 1 x 20 FHCS through the heel and into the Achilles mounting post (Figure 12-59 and Figure 12-60).

Figure 12-58. Achilles mounting post and molded shoe

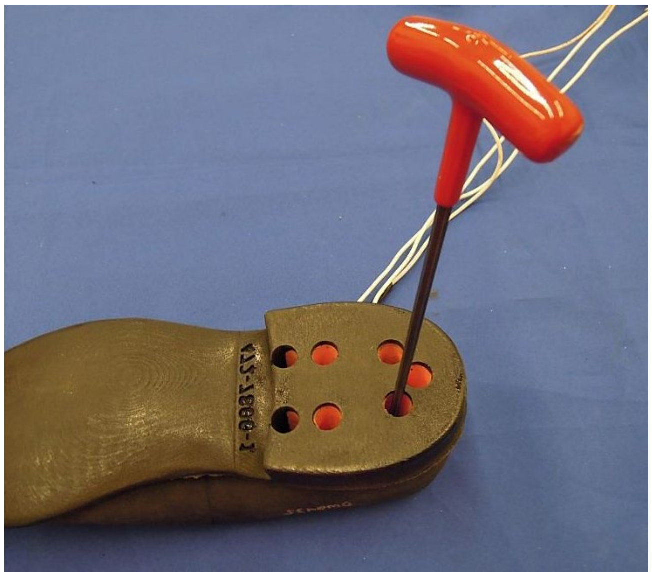


Figure 12-59. Install Achilles mounting post to molded shoe

Figure 12-60. Achilles mounting post installed to molded shoe

12.2.2.41 Mount the molded shoe assembly to the ankle with four M6 x 1 x 16 FHCS (Figure 12-61).

Figure 12-61. Mount molded shoe assembly to ankle

12.2.2.42 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 12-62).

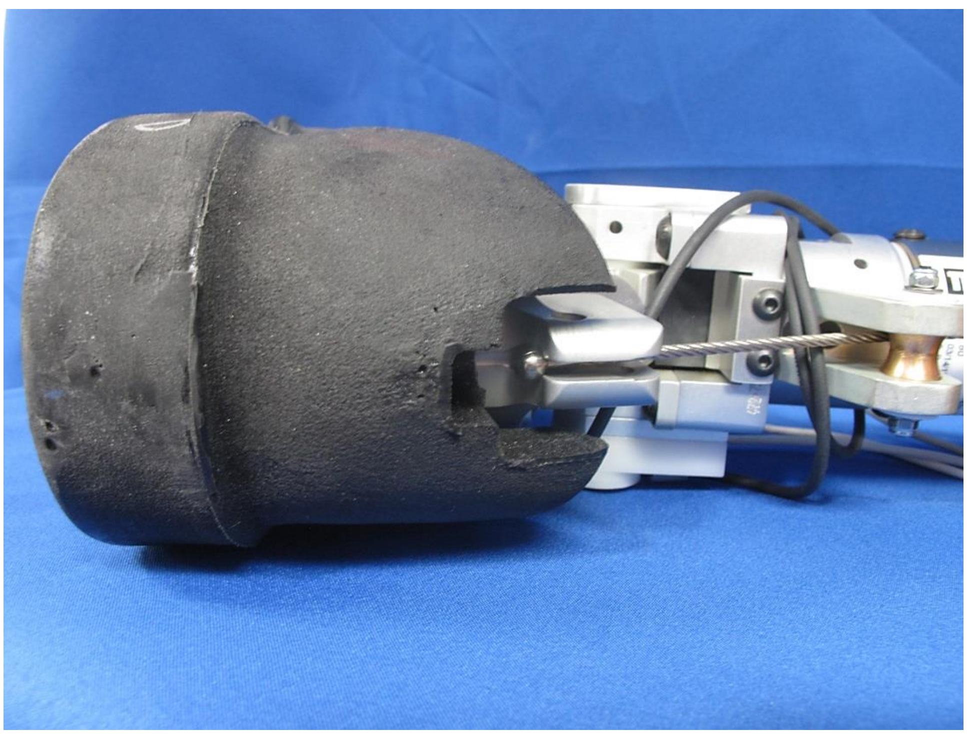


Figure 12-62. Attach ball end of Achilles cable to lower Achilles mounting post

12.2.2.43 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 an M3 x 0.5 x 12 SHCS into the hole on the side of the mounting post (Figure 12-63).

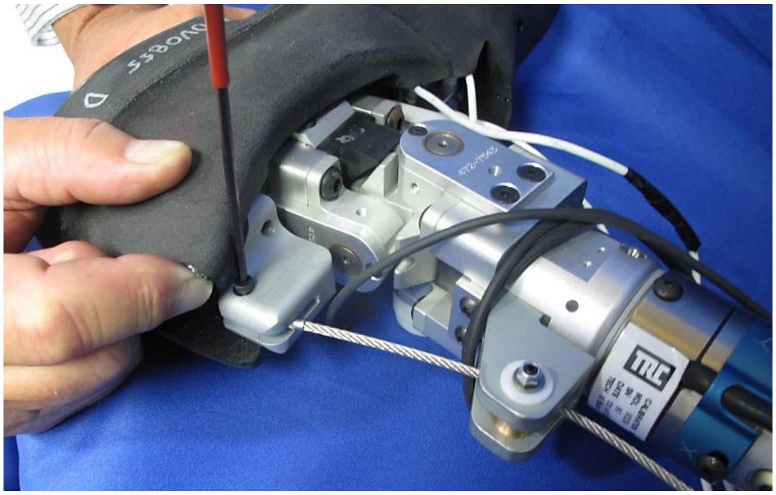


Figure 12-63. Secure Achilles cable at ankle

12.2.2.44 See Section 12.3.2 for instructions on properly setting Achilles tension.

12.2.2.45 Mount two uniaxial accelerometers on the front and right sides of the Lower Tibia Tube Assembly (472-7310), using two M1.4 x 0.3 x 3 SHCS per accelerometer (Figure 12-64).

Figure 12-64. Mount accelerometers to lower tibia

12.2.2.46 Mount the Tibia Guard (472-7115) to the front of the lower leg assembly using a two M6 x 1 x 16 BHCS (Figure 12-65). Take care not to pinch the tibia accelerometer wires routed on the right rear side of the tibia guard.

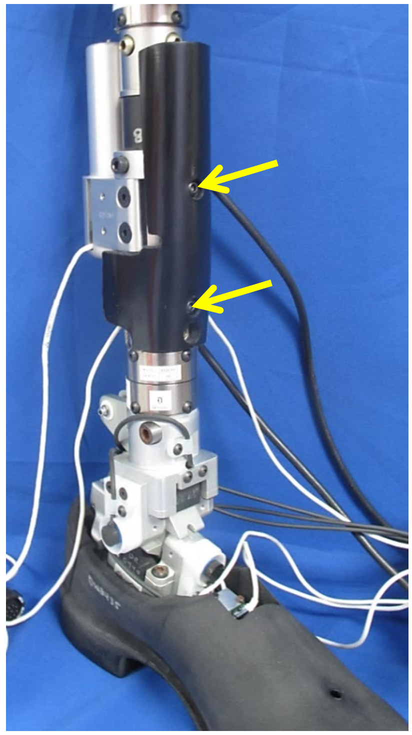


Figure 12-65. Mount tibia guard

12.2.2.47 Secure the Molded Knee Bumper (472-7110) to the Knee Clevis Weldment (472-7200) with two M5 x 10 BHCS (Figure 12-66).

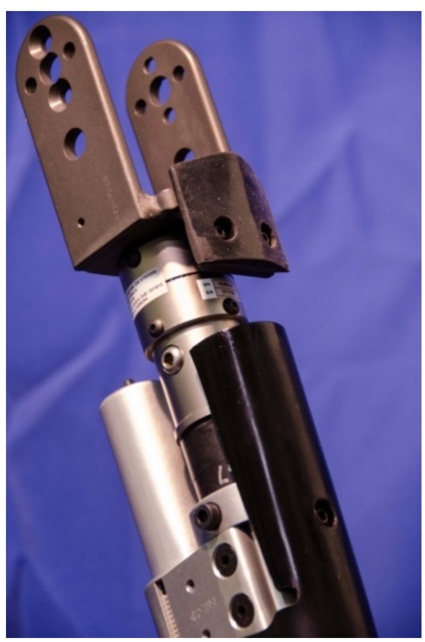


Figure 12-66. Secure molded knee bumper

12.2.2.48 Bundle the lower leg transducer wires and route upwards along the inner tibia and out at the upper tibia (Figure 12-67).

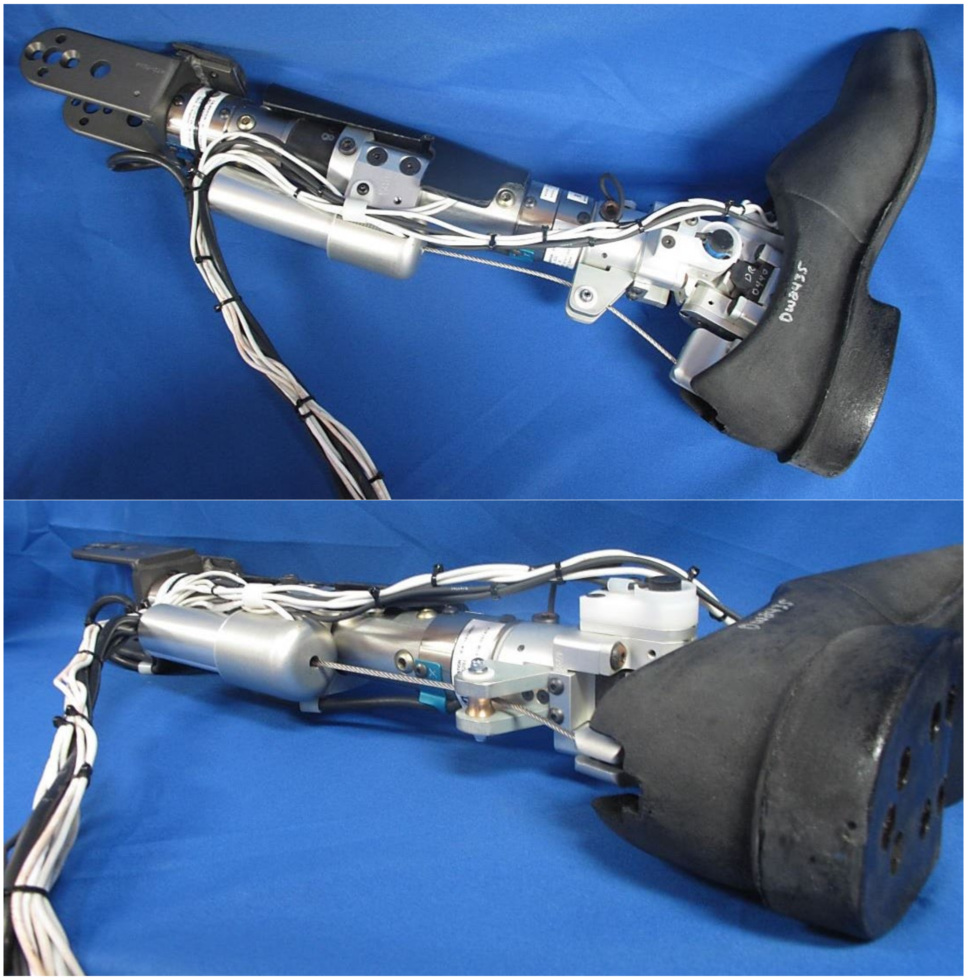


Figure 12-67. Bundle and route wires for lower leg

12.2.2.49 Install the Tibia Instrumentation Ground Strap (472-8705) (Figure 12-68).

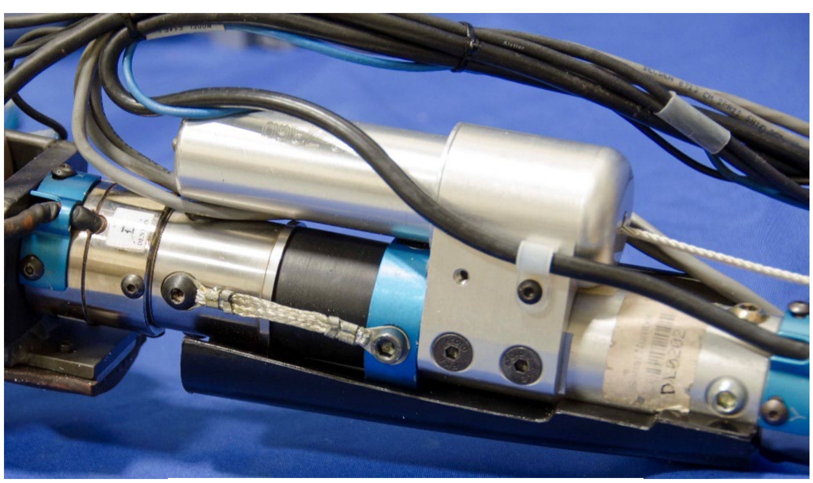


Figure 12-68. Install tibia ground strap

12.2.2.50 Loosely install the (Left) Lower Leg Flesh (472-7370-1) with the zipper to the back (Figure 12-69).

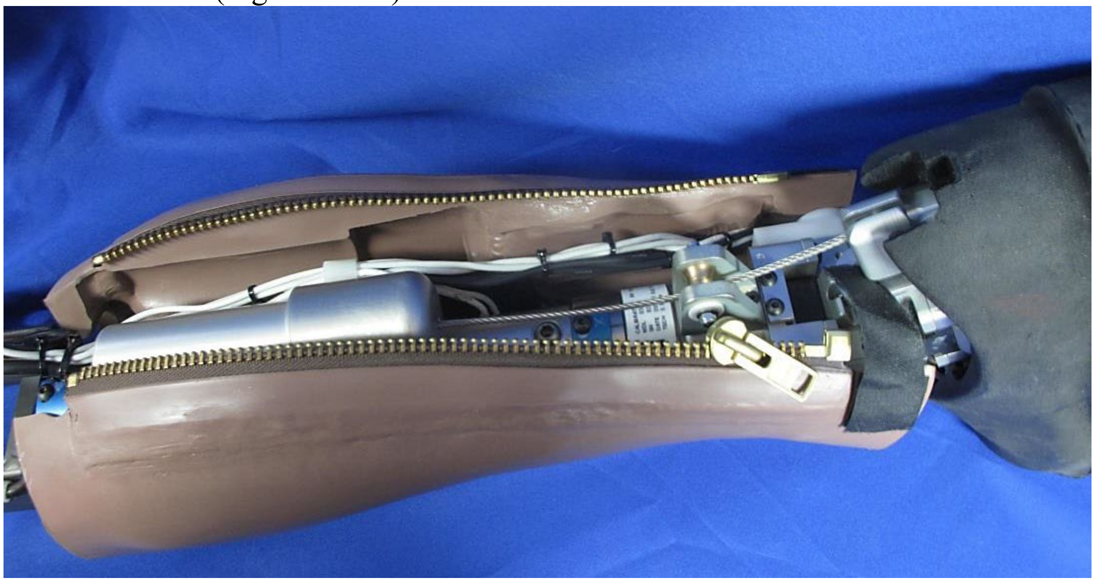


Figure 12-69. Loosely install the lower leg flesh

12.2.2.51 Position the Molded Knee Bumper (472-7110) into the molded pocket located on the upper front interior surface of the tibia skin (Figure 12-70).

Figure 12-70. Position molded knee bumper into molded pocket on tibia skin

12.2.2.52 Zip the tibia skin around the lower leg to complete the assembly. Route the lower extremity wiring out at the top of the zipper (Figure 12-71).

Figure 12-71. Zip tibia skin

12.2.2.53 Attach the hook and loop fastener over the end of the zipper near the ankle (Figure 12-72).

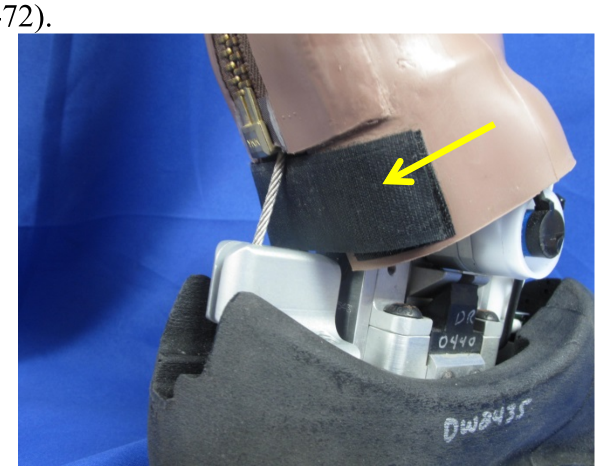


Figure 12-72. Attach hook and loop fastener at ankle

12.2.3 Assembly of the Lower Extremity to the Knee

The following procedure is a step-by-step description used to install the (Left) Lower Extremity Assembly (472-7000-1) to the completed femur/knee assembly. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

12.2.3.1 With the lower leg perpendicular to the upper leg, align the holes of the knee clevis (attached to the Lower Extremity) with the threaded holes in the knee assembly (Figure 12-73).

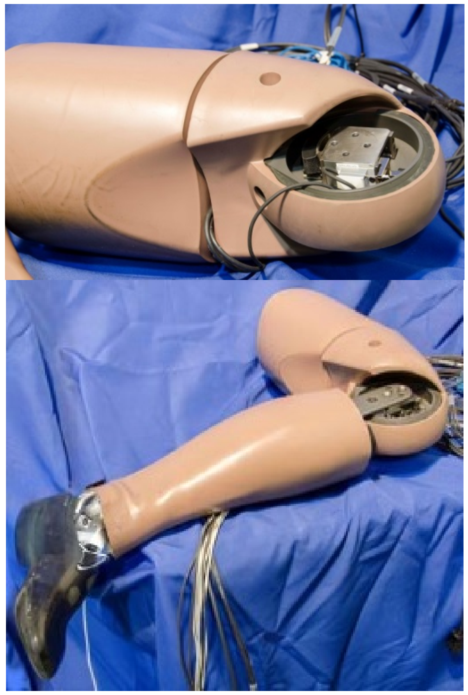


Figure 12-73. Align knee clevis to holes in knee assembly

12.2.3.2 Secure the clevis to the knee using four M6 x 1.0 x 10 FHCS (two per side) (Figure 12-74).

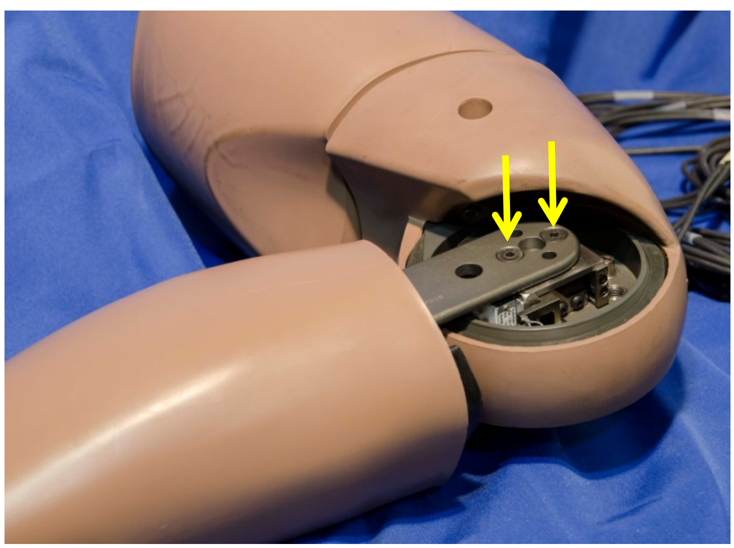


Figure 12-74. Secure clevis to knee

12.2.3.3 Install the Knee Covers (472-5353) and both sides of the knee with two M6 x 18 SHCS per side (Figure 12-75).

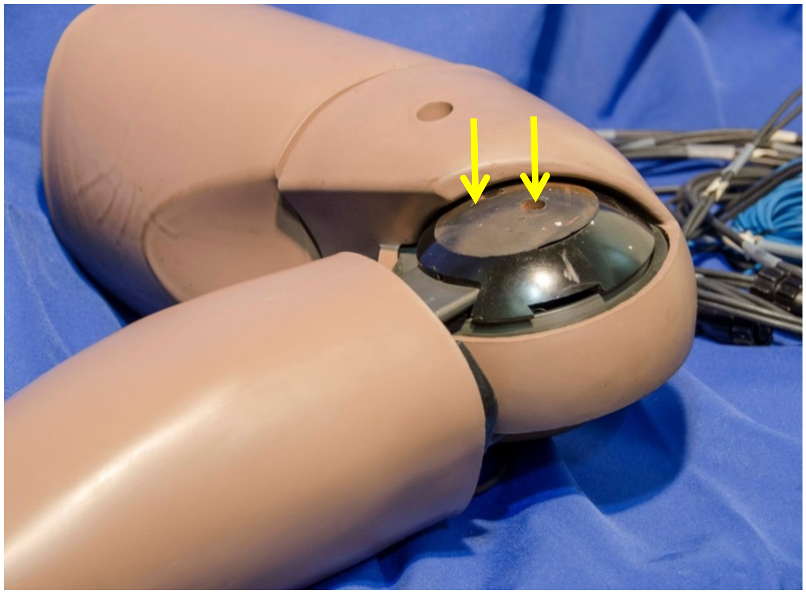


Figure 12-75. Install knee covers

12.2.3.4 Repeat the procedure for the Right Lower Extremity Assembly (472-7200-2).

12.3 Adjustments for the Lower Extremity Assembly

12.3.1 **Ankle Rotary Potentiometer Zeroing Procedure**

Proceed to the *THOR 50th Percentile Male (THOR-50M) Qualification Procedures Manual* (April 2018) Section entitled *Ankle Rotary Potentiometer Zeroing Procedure* for ankle zeroing procedures.

12.3.2 **Achilles Cable Adjustment Procedure**

Proceed to the *THOR 50th Percentile Male (THOR-50M) Qualification Procedures Manual* (April 2018) Section entitled *Achilles Cable Adjustment Procedure* for Achilles tension procedures.

12.3.3 **Knee Joint Torque Settings**

The lower leg assembly requires a joint resistive torque adjustment for each knee joint. Check the adjustment by straightening the lower leg of the dummy and raising it in front of the dummy (Figure 12-76). The leg should remain in position, but move easily under external force. If needed, adjust the Shoulder Bolt (472-5302) on the outboard side of the knee to achieve 1G joint friction torque.

Figure 12-76. Setting the knee to 1G

12.4 Electrical Connections and Requirements:

Section 12.2.2.49 includes grounding information. Sections 12.2.2.48 through 12.2.2.52 describe cable routing instructions.

12.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. These inspections include both electrical and mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the lower leg, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

12.5.1 **Electrical Inspections (Instrumentation Check)**

Proper handling, along with proper wire routing, can go a long way towards preventing unnecessary cable damage. This inspection should begin with the visual and tactile check of all wires from the lower leg instrumentation. Inspect the wires for nicks, cuts, pinch-points, wiring pulling out of transducer housing, and damaged electrical connections, all of which may prevent data signals from proper transfer to the data acquisition system. If damage is evident, check for signal output by manipulating the transducer such as in a polarity check described in Section 15.5. Move the wiring around to check for intermittent signals. Check the bridge arm resistances and ensure that they are within the manufacturer's specifications. When checking the bridge arm resistances, it is important to also ensure that none of the arms are shorted to the shield. If they are out of specification, repair the wiring (if possible) or replace the transducer. If wiring is pulling out of the transducer's housing, in addition to checking the signal and repairing/replacing the transducer, re-check the instrumentation wires to ensure proper strain relief.

Specific electrical areas to examine:

- Ensure that the upper tibia load cell's X-axis is facing toward the front of the leg.
- Ensure that the M3 x 0.5 x 3 SHSS ankle pot set screws are tight (see Section 12.2.2.30 and 12.2.2.31).

12.5.2 Mechanical Inspection

Several components in the lower leg assembly require inspection post-test.

Specific mechanical areas to examine:

- Check the Achilles Cable Assemblies (472-7352) for kinks and broken strands and replace cable if damaged.
- Ensure that Achilles cable tension is 77.8 ± 4.4N (17.5 ± 1 lb) (this is *not* to be adjusted after qualification of the leg).
- Ensure Achilles cable jam nuts are tight.
- Check for permanent compression or tears in the Dorsi Stop Assembly (472-7530), Plantar Stop Assembly (472-7527), Inversion Stop Assembly (472-7534) and Eversion Stop Assembly (472-7533); replace stop if damaged.
- Inspect the knee slider rubber bumpers (472-5357) for tears and delamination; repair if delaminated or replace if damaged.
- Inspect the Knee Flesh Molded Inserts (472-5301) for tears; replace if damaged.
- Inspect the pot string holder assembly (472-5306) in the knee to check if the extension stop bumper (472-5735) has become unglued from the pot string holder (472-5737-1 and 472-5737-2). This part should be monitored and glued if it is not properly adhered.
- Check Tibia Compliant Bushing (472-7315) for signs of debonding or permanent compression; replace if damaged.

Section 13. **Arm Assembly**

13.1 Description of Arm Assembly and Features

The THOR-50M arm is comprised of an upper humerus assembly, lower molded arm, and molded hand.

13.2 Assembly of the Arm

13.2.1 **Parts List**

Table 13-1 and Table 13-2 list the components that are included in the arm assembly. Figure 13-1 and Figure 13-2 show components of (left) arm assembly and hardware.

Table 13-1. Arm Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper Humerus Assembly	1	472-6200	Figure 13-1	1
THOR-M Upper Arm & Elbow Pivot Washer	1	472-6600	Figure 13-1	2
Upper Arm and Elbow Pivot Bushing	1	472-6590	Figure 13-1	3
Shoulder Joint Spring Washer	1	472-6950	Figure 13-1	4
THOR-M Elbow Pivot Nut	1	472-6610	Figure 13-1	5
THOR-M Lower Arm Molded	1	472-6520	Figure 13-1	6
Lower Wrist Rotation Assembly	1	472-6700	Figure 13-1	7
Left THOR-M Molded Hand (Right THOR-M Molded Hand (not shown))	1	472-6900-1 (472-6900-2)	Figure 13-1	8
Washer, 1.06 OD x 0.53 ID x 0.06 THK	1	9001260	Figure 13-1	9
M12 x 30 LG. SHSS	1	5000506	Figure 13-1	10
M10 x 25 LG. SHSS	1	5000492	Figure 13-1	11
M12 x 1.75 x 30 LG. SHCS	1	5000441	Figure 13-1	12

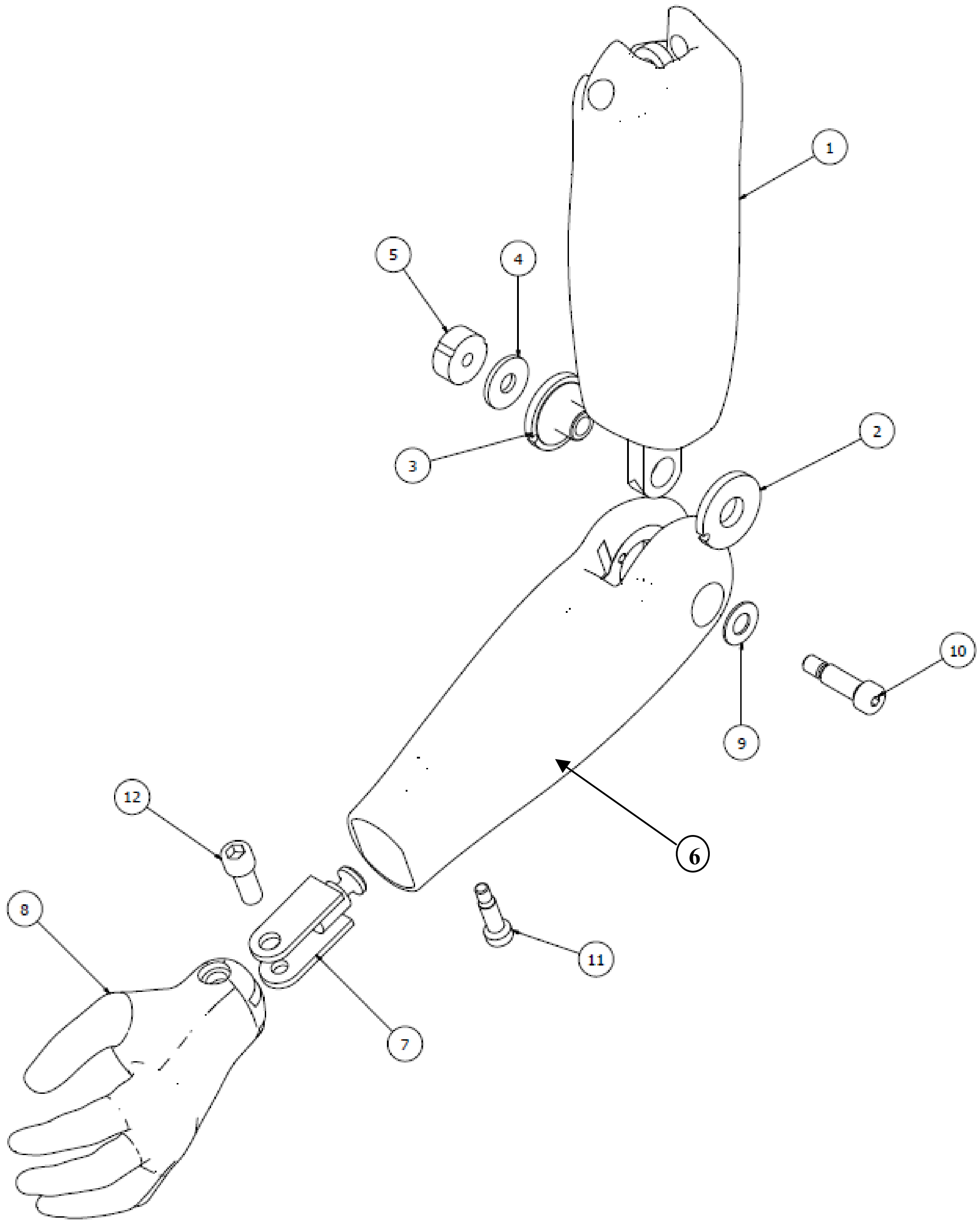


Figure 13-1. Arm assembly components

Table 13-2. Upper Humerus Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper Humerus Weldment	1	472-6210	Figure 13-2	1
Structural Replacement	1	W50-61041	Figure 13-2	2
Lower Load Cell Interface	1	472-6220	Figure 13-2	3
Arm End Plate	1	472-6230	Figure 13-2	4
Screw, BHCS M4 x 0.7 x 8	2	5000103	Figure 13-2	5
Lower Section Upper Arm	1	472-6240	Figure 13-2	6
Spring Disc Washer 12.5 x 6.2 x 0.5	1	5001176V	Figure 13-2	7
M6 Modified SHCS	1	472-6250	Figure 13-2	8
M6 x 1 x 12 BHCS	8	5000356	Figure 13-2	9
Arm Flesh Spacer	1	472-6260	Figure 13-2	10
M5 x 0.8 x 10 FHCS	1	50000084	Figure 13-2	11
Upper Arm Flesh	1	472-6270	Figure 13-2	12

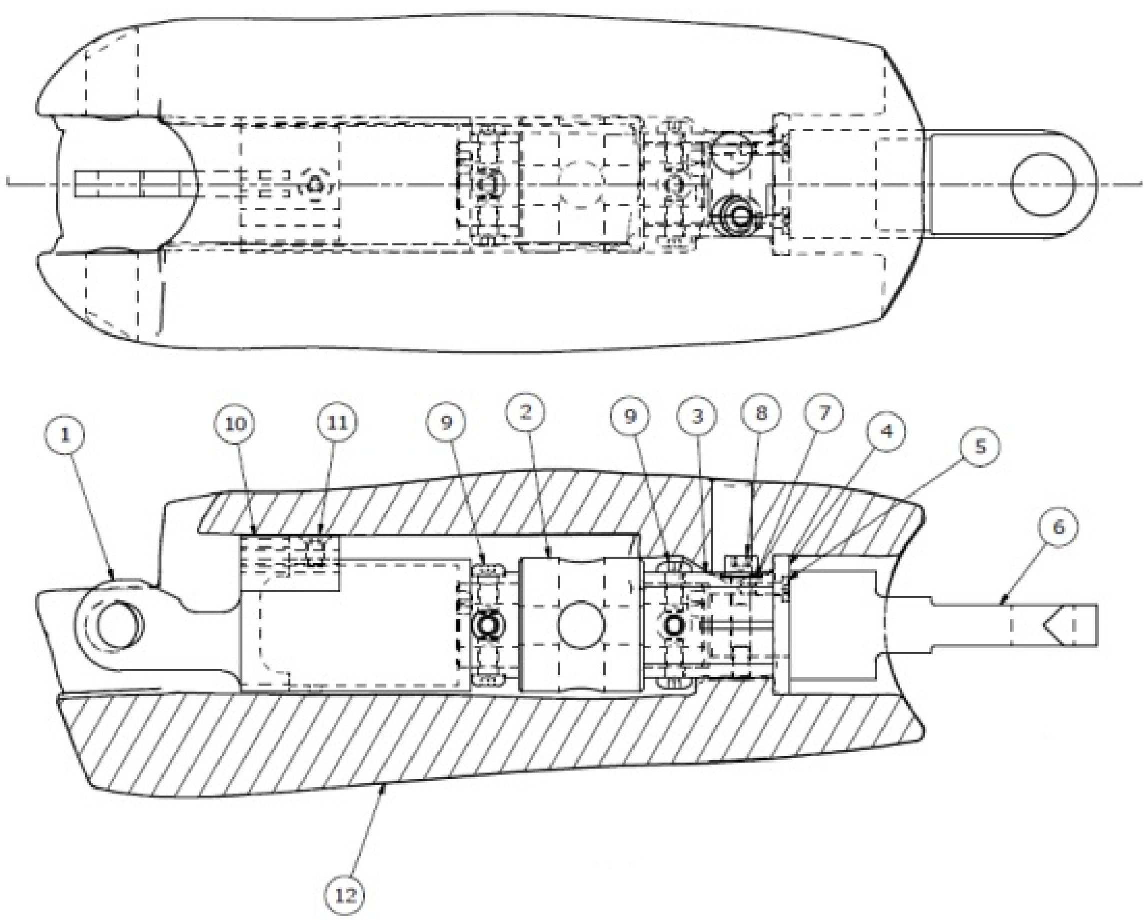


Figure 13-2. Upper humerus assembly components

13.2.2 **Assembly of Arm Components**

The following procedure is a step-by-step description of the assembly procedure for the arm components. Only the left arm assembly is illustrated. The right arm assembly follows identical procedures. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

13.2.2.1 Install Lower Wrist Rotation Assembly (472-6700) into Molded Lower Arm (472-6520) using M10 x 25 SHSS (Figure 13-3 and Figure 13-4).

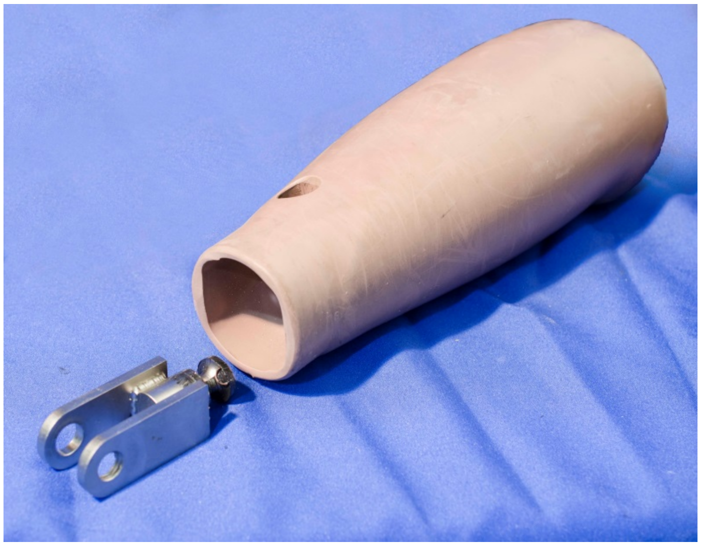


Figure 13-3. Install lower wrist rotation assembly into molded lower arm

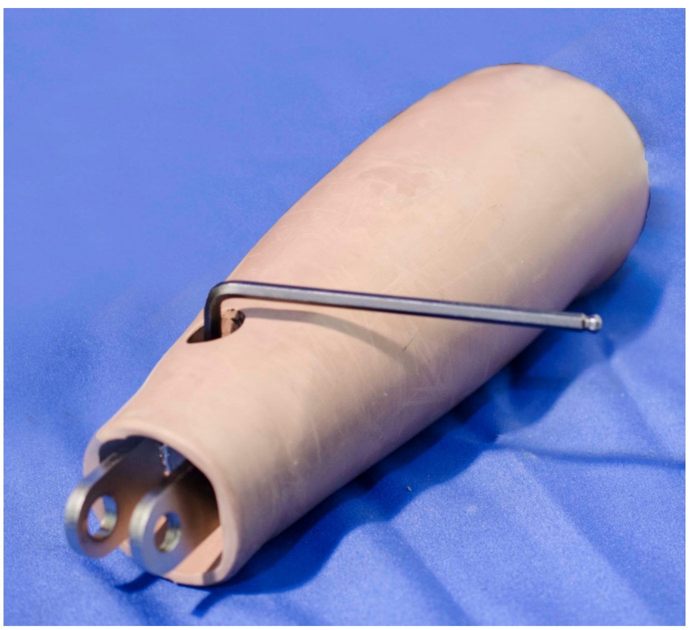


Figure 13-4. Secure lower wrist rotation assembly to lower arm

13.2.2.2 Attach Molded Hand (472-6900-1) to the lower wrist rotation assembly using M12 x 1.75 x 30 SHCS installed from the thumb side of the hand (Figure 13-5).

Figure 13-5. Attach molded hand to lower wrist rotation assembly

13.2.2.3 Insert the Upper Arm Lower Section (472-6240) into the Upper Humerus Assembly (472-6200); secure using the M6 modified SHCS (Figure 13-6 and Figure 13-7).

Figure 13-6. Insert upper arm lower section into humerus

Figure 13-7. Secure upper arm lower section to humerus

13.2.2.4 Insert the Upper Arm and Elbow Pivot Bushing (472-6590) into the upper arm lower section hole located on the surface of the arm nearest the body (Figure 13-8).

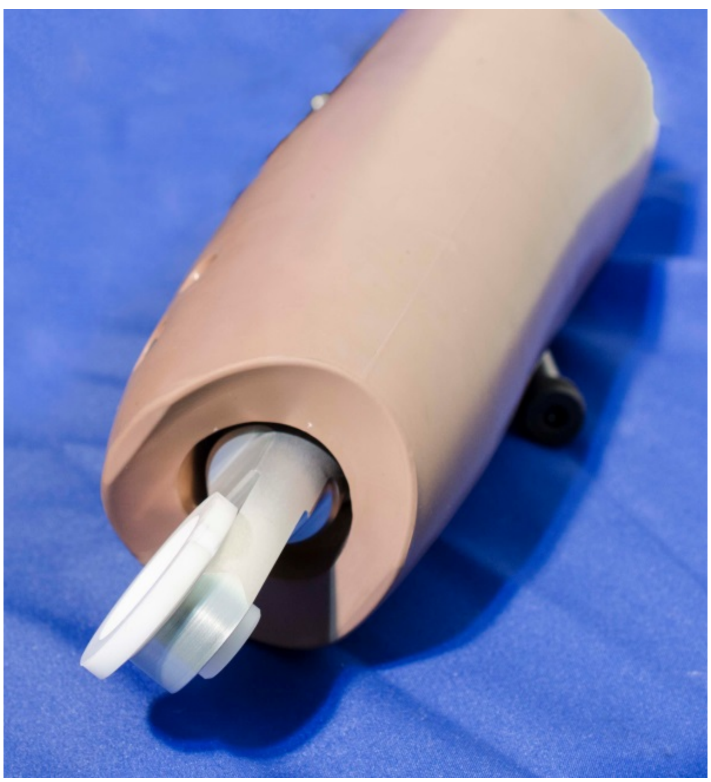


Figure 13-8. Insert upper arm and elbow pivot bushing into upper arm

13.2.2.5 Insert the Upper Arm and Elbow Pivot Washer (472-6600) into the upper arm lower section hole located on the opposite side of the bushing (Figure 13-9).

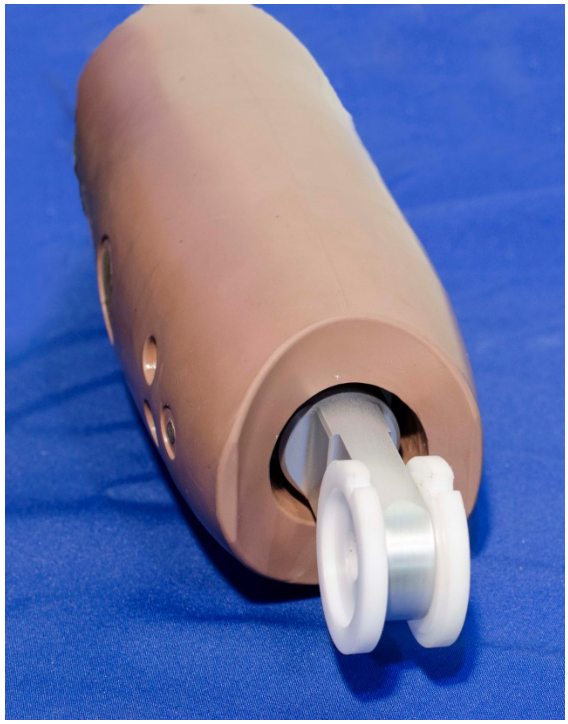


Figure 13-9. Install upper arm and elbow pivot washer into upper arm

13.2.2.6 Place the Shoulder Joint Spring Washer (472-6950) into the recess located in the upper arm and elbow pivot bushing (Figure 13-10).

Figure 13-10. Place shoulder joint spring washer into upper arm and elbow pivot bushing

13.2.2.7 Align the Elbow Pivot Nut (472-6610) in the lower arm with the pins so that it is flush within the recess (Figure 13-11 and Figure 13-12).

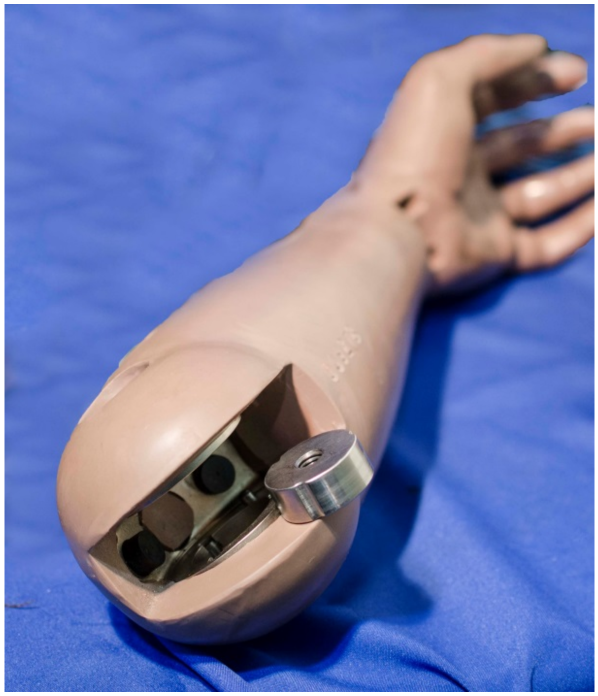
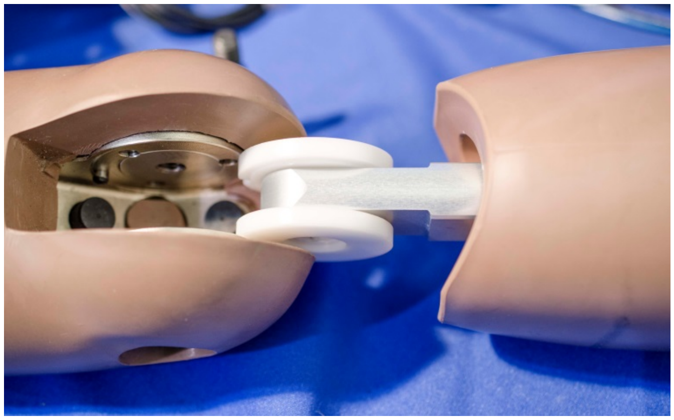


Figure 13-11. Align elbow pivot nut in recess

Figure 13-12. Elbow pivot nut installed

13.2.2.8 Slide the assembly into the lower arm (Figure 13-13).



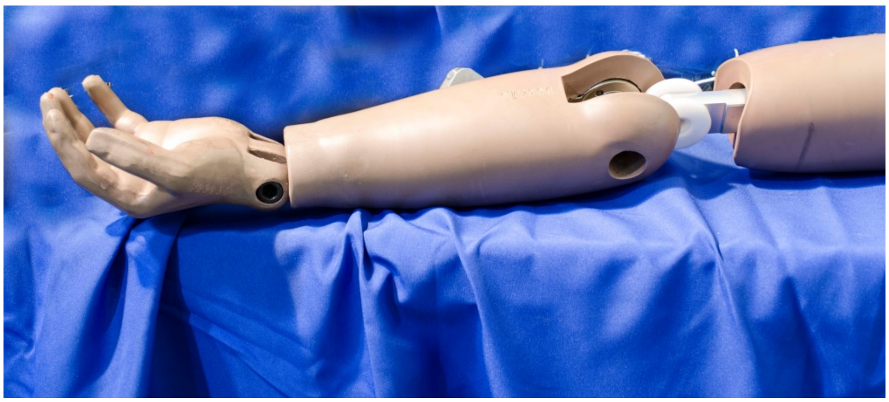


Figure 13-13. Attach lower and upper arm

13.2.2.9 Secure the M12 x 30 SHSS and 1.06 OD x 0.53 ID x 0.06 THK washer to join the upper arm and humerus at the elbow (Figure 13-14).

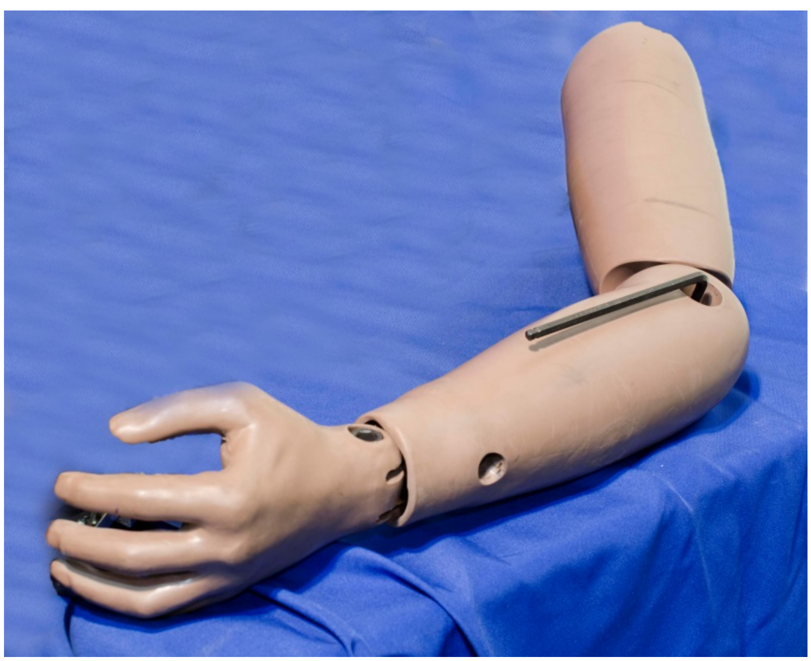


Figure 13-14. Secure upper arm and humerus at elbow

13.2.3 **Attaching the Arm to the Shoulder**

The following procedure is a step-by-step description used to install the arm assembly to the shoulder. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

13.2.3.1 Insert the Upper Arm Bushing (472-3834) into the Upper Humerus Weldment (472-6210) on the outer side of the arm (Figure 13-15 and Figure 13-16).

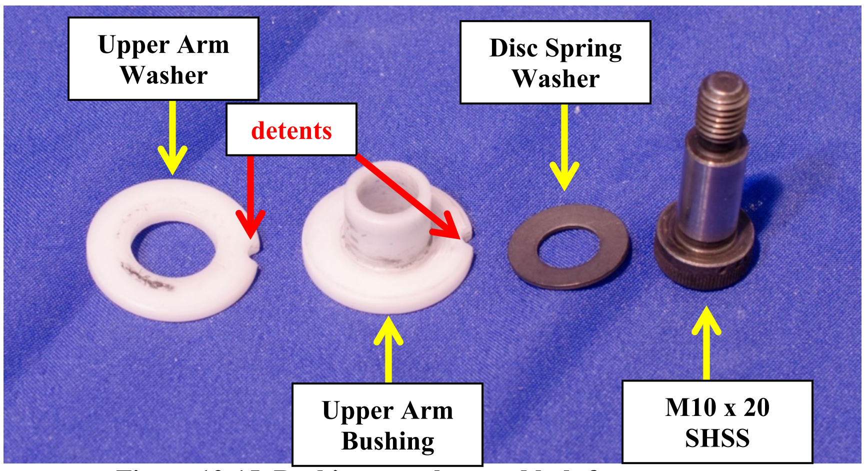


Figure 13-15. Bushings, washer, and bolt for upper arm

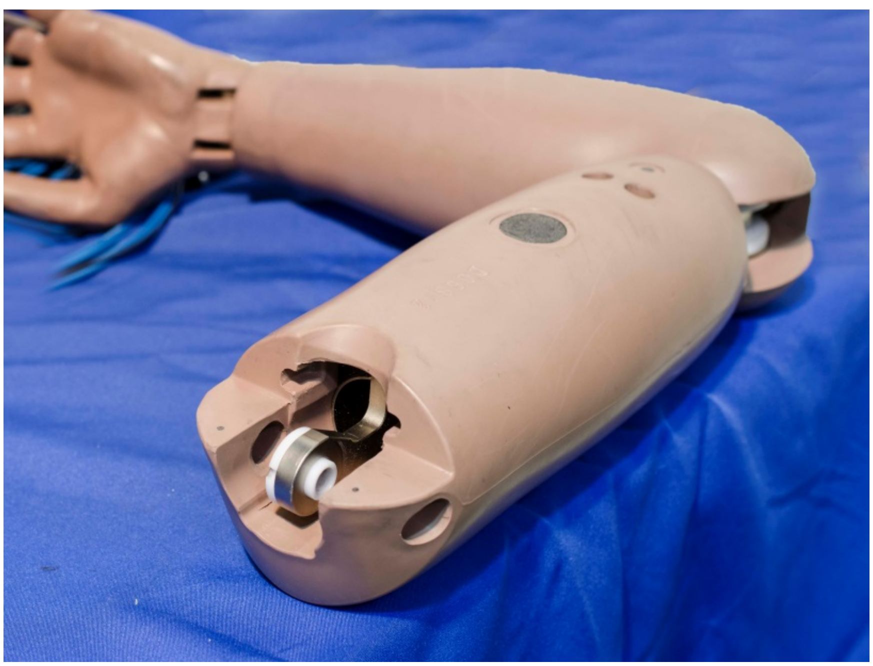


Figure 13-16. Insert upper arm bushing into humerus

13.2.3.2 Install the Upper Arm Washer (472-3834) on the opposite side of the upper humerus weldment (Figure 13-17).

Figure 13-17. Install upper arm washer

13.2.3.3 Insert the Upper Arm Pivot Nut (472-3833) into the Arm Clevis (472-3832) and align the recess in the pivot nut with the dowel pin (Figure 13-18).

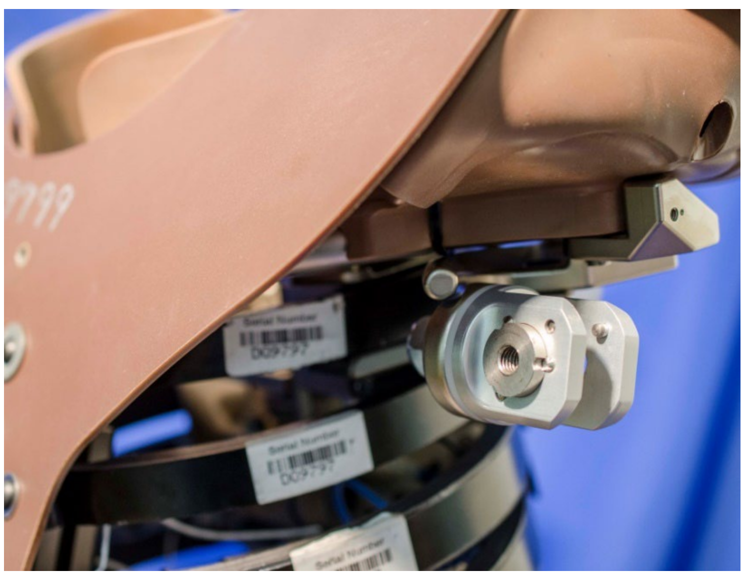


Figure 13-18. Insert upper arm pivot nut into arm clevis

13.2.3.4 Insert the arm into the arm clevis so that the detents in upper arm bushing and upper arm washer align with the pins (Figure 13-19. Rotate the arm within the clevis using the detents and pins to guide the arm into place.

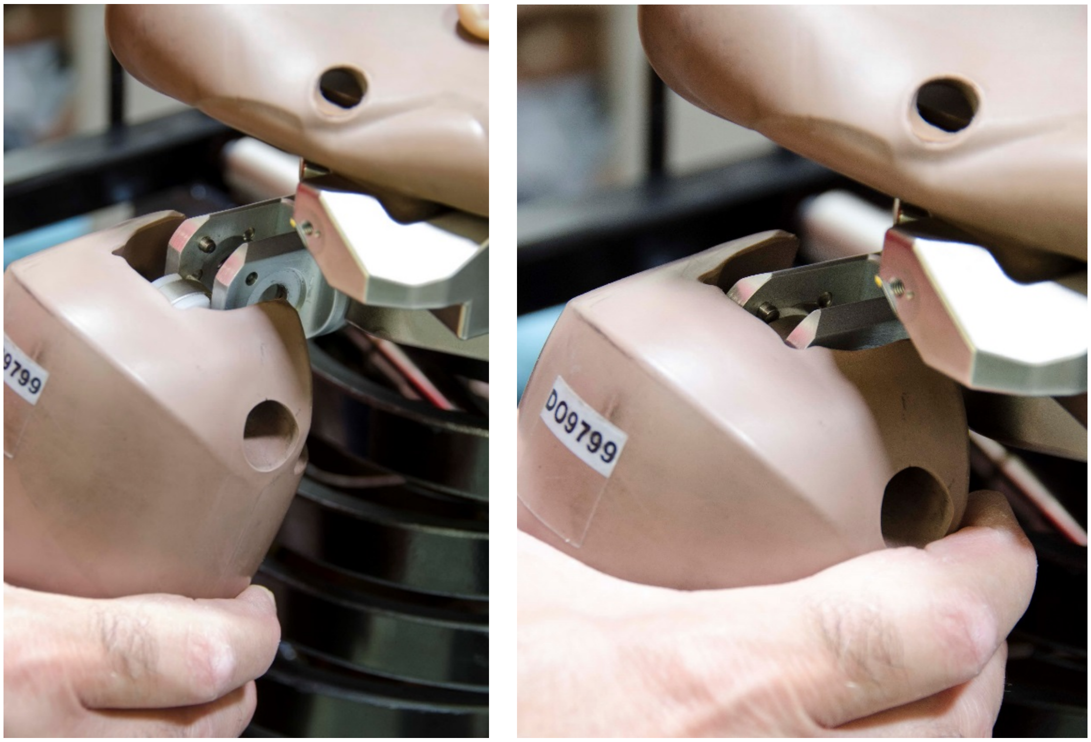


Figure 13-19. Insert arm into clevis and align pins

13.2.3.5 Use pliers to insert the disc spring washer into the recess and against the posterior clevis (Figure 13-20). Align the washer hole with the hole and install the M10 x 20 SHSS. The installed arm is illustrated in Figure 13-21.

Figure 13-20. Install spring washer and shoulder bolt

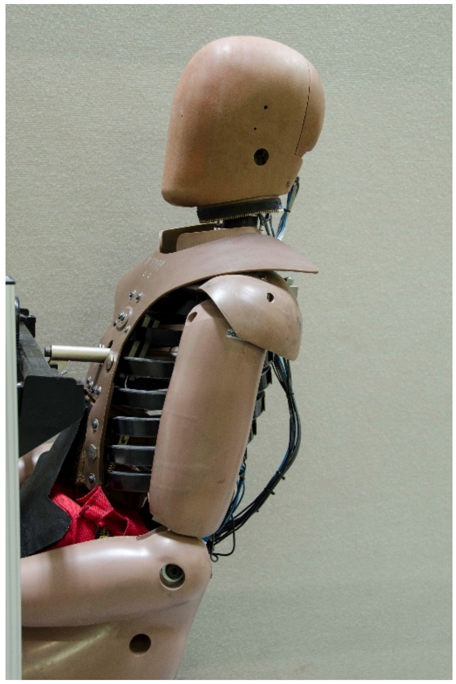


Figure 13-21. Arm installed on THOR-50M

13.3 Adjustments for the Arm Assembly

13.3.1 Arm and Elbow Joint Torque Settings

13.3.1.1 Position the left hand as shown in Figure 13-22. Adjust the torque of the M12 x 1.75 x 30 mm SHCS at the wrist joint such that the hand remains in this position under its own mass but falls once any additional mass or force is added. Repeat for right hand.

Figure 13-22. Wrist orientation for setting joint torque to 1G

13.3.1.2 Position the left lower arm as shown in Figure 13-23. Adjust the torque of the M12 x 30 mm SHSS at the elbow joint such that the lower arm remains in this position under its own mass but falls once any additional mass or force is added. Repeat for right elbow.

Figure 13-23. Elbow orientation for setting joint torque to 1G

13.4 Electrical Connections and Requirements

There is no instrumentation in the arm assembly.

13.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. Since there is no instrumentation, the arm inspections include only mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the arm, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

13.5.1 Electrical Inspections (Instrumentation Check)

There is no instrumentation in the arm assembly.

13.5.2 Mechanical Inspection

Several components in the arm assembly require inspection post-test.

Specific mechanical areas to examine:

- Check 1G settings on wrist and elbow (Section 13.3).

Section 14. **Jacket and Clothing Assembly**

14.1 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 steel jacket stiffeners. Internal side foam inserts installed along the sides of the ribs, just below the shoulder yoke assembly and 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 open from either side for internal inspection; if needed, the entire jacket assembly can be removed from the dummy with little movement of the dummy. The zippers have Velcro® coverings that aid 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 jacket design also prevents metal-to-metal contact between THOR-50M instrumentation and the testing environment.

14.2 Assembly of the Jacket

14.2.1 **Parts List**

Table 14-1 and Table 14-2, Figure 14-1 through Figure 14-3 show the components of the jacket assembly.

Table 14-1. Jacket Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Front Inside Panel Pattern (Neoprene)	1	472-3911	Figure 14-1	1
Front Interior Shoulder Patch	1	472-3927	Figure 14-1	2
Front Interior Abdomen Patch, Jacket	1	472-3921	Figure 14-1	3
Crotch Strap Assembly, Jacket	1	472-3922	Figure 14-1	4
Chest Foam Pocket	1	472-3914	Figure 14-1	5
Upper Left Foam Pocket	1	472-3915-1	Figure 14-1	6
Upper Right Foam Pocket	1	472-3915-2	Figure 14-1	7
Stiffener Pocket, Jacket	2	472-3913	Figure 14-1	8
Steel Stiffener, Jacket	4	472-3926	Figure 14-1	9
Weighted Bib, Jacket	1	472-3920	Figure 14-1	10
Front Outside Panel Pattern (Cordura)	1	472-3912	Figure 14-1	11
Front Panel Zipper, Jacket	2	472-3918	Figure 14-1	12
Front Panel Shoulder Zipper, Jacket	2	472-3917	Figure 14-1	13
Upper Side Foam	2	472-3919	Figure 14-1	14

Table 14-2. Jacket Panel Assemblies

Part Description	Quantity	Part Number	Figure #	Item #
Jacket Front Panel Assembly	1	472-3910	Figure 14-2	-
Jacket Rear Panel Assembly	1	472-3951	Figure 14-3	-

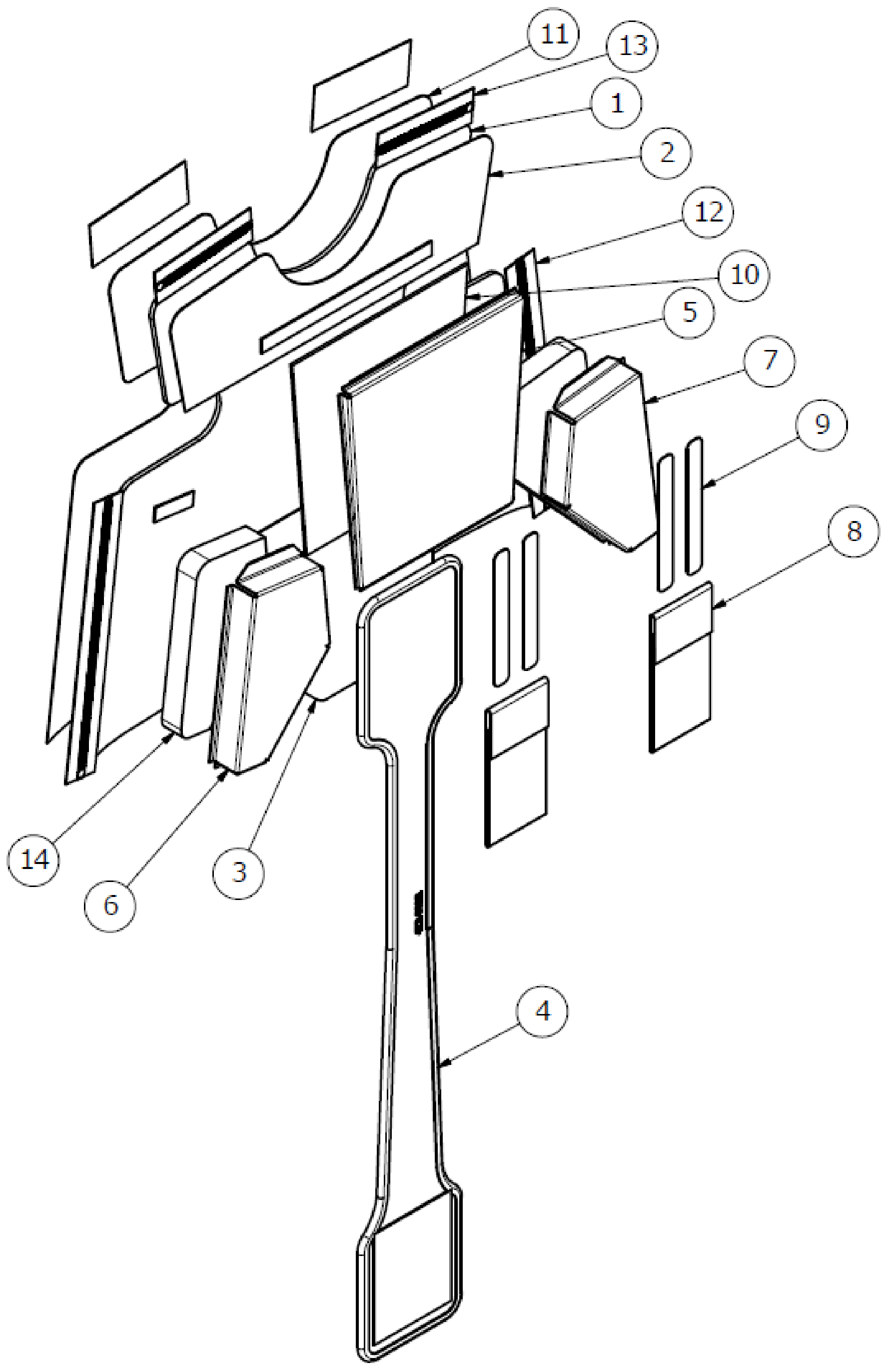


Figure 14-1. Jacket front panel assembly components

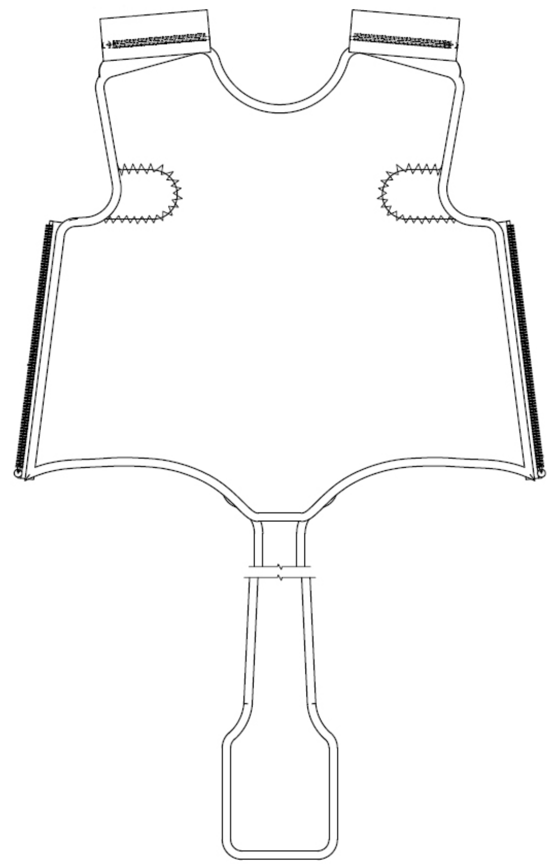


Figure 14-2. Front jacket panel

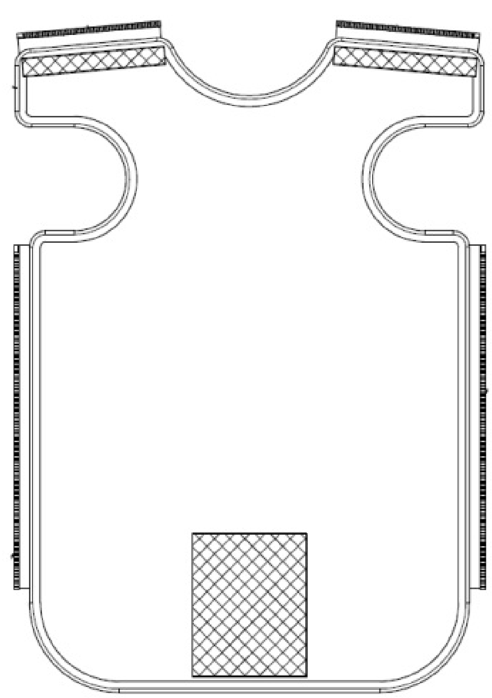


Figure 14-3. Rear jacket panel

14.2.2 **Assembly of Jacket Components**

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

14.2.2.1 Install the pads into the front and rear pockets in the jacket (Figure 14-4 and Figure 14-5).

Figure 14-4. Jacket front assembly

Figure 14-5. Jacket rear assembly

14.2.2.2 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 (Figure 14-6).

Figure 14-6. Install rib stiffeners

14.2.2.3 Install the Jacket onto the thorax of the dummy by draping the Inside Front Panel (472-3910) and Inside Rear Panel (472-3951) of the jacket over the front and rear of the dummy's thorax and closing the left and right shoulder zippers. Adhere the hook and loop fastener on the shoulders to cover the zippers (Figure 14-7).

Figure 14-7. Drape front and rear panels over dummy then zipper shoulders

14.2.2.4 Zipper the left and right sides of the jacket (Figure 14-8).

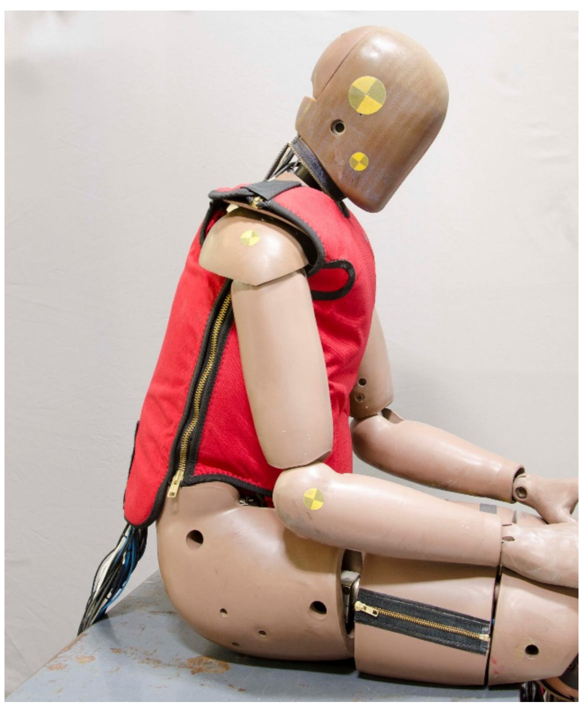


Figure 14-8. Zipper left and right sides of jacket

Warning: The following step requires lifting of the dummy by the dummy lift strap. Avoid lifting by the head/neck area to prevent damage.

14.2.2.5 Lift the dummy. While the dummy is suspended, slide the crotch strap assembly (472-3922) 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) (Figure 14-9).

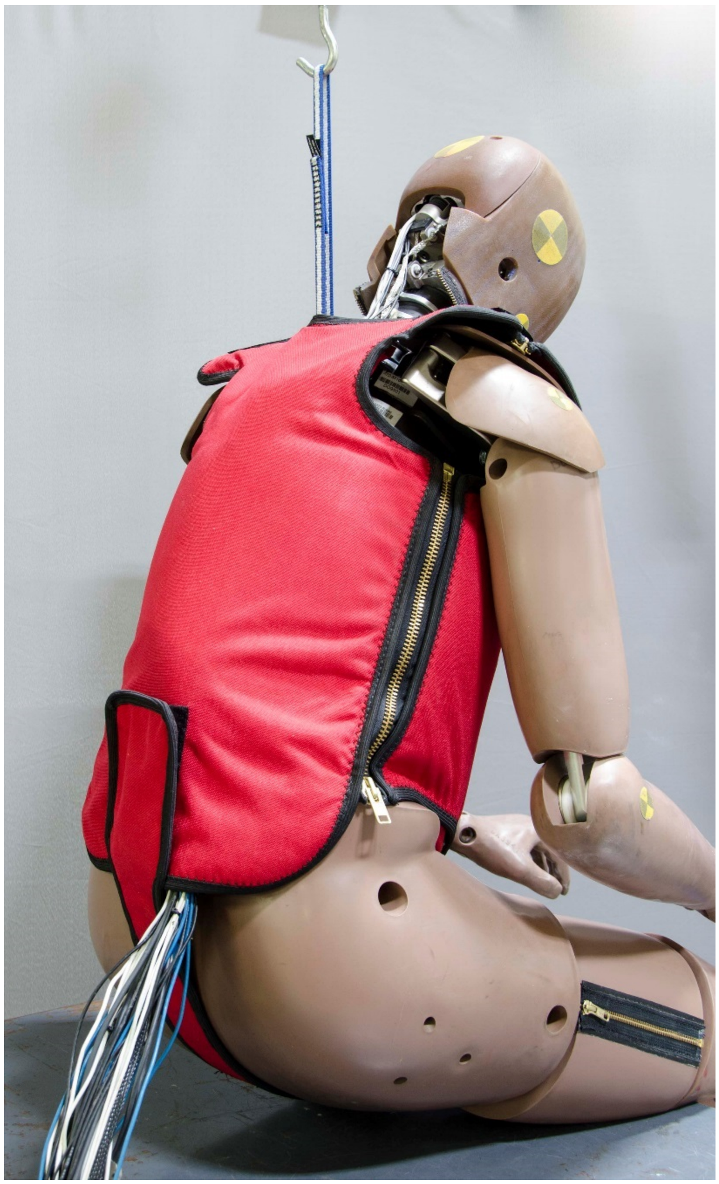


Figure 14-9. Lift dummy and install crotch strap

14.3 Adjustments for the Jacket Assembly

The jacket assembly does not require any adjustments.

14.4 Electrical Connections and Requirements

The jacket assembly does not require any electrical connections.

14.5 Inspection and Repairs

After a test series using THOR-50M, several inspections ensure that the dummy integrity remains intact. Use good engineering judgment to determine the frequency of these inspections, which are dependent on the severity of test conditions. The frequency of the inspections should increase if the tests are particularly severe or in tests which display unusual data signal outputs. Since there is no instrumentation, the jacket inspections include only mechanical aspects. For ease of inspection, perform inspections during disassembly of the dummy. To disassemble the jacket, simply reverse the procedures described in the assembly instructions. Additional comments below may further assist in the disassembly process.

14.5.1 **Electrical Inspections (Instrumentation Check)**

There is no instrumentation in the jacket assembly.

14.5.2 **Mechanical Inspection**

Several components in the jacket assembly require inspection post-test.

Specific mechanical areas to examine:

- Check the rib stiffeners to ensure no permanent deformation has occurred and that the stiffeners are securely in place. If the stiffeners are bent, bend them back into shape using a hammer and a hard flat surface. If bending back into shape results in material separation, replace with new stiffeners.
- Check fabric for tears or holes, especially in areas where lap and shoulder belts contact the fabric surface. Repair or replace any damaged panels.
- Examine Velcro® and zippers for broken hardware or stitching. Repair or replace any panels where the zipper will not function.
- The integrity of the jacket foams should be checked on a regular basis and replaced if any deterioration is observed.

Section 15. **Instrumentation and Wiring**

15.1 Overview of Instrumentation

When fully instrumented, the THOR-50M measures 115 separate (dynamic measurement) sensor channels. In addition, five tilt sensors establish the static orientation of the dummy. Table 15-1 and Figure 15-1 through Figure 15-3 show locations of the instrumentation for THOR-50M. Table 15-2 describes the instrumentation.

Table 15-1. THOR-50M Sensor/Load Cell Locations

Part Description	Quantity	Part Number	Figure #	Item #
Head Accelerometer Mounting Plate	1	472-1200	Figure 15-1	1
Skull Spring Load Cell	2	SA572-S112	Figure 15-1	2
Upper Neck Load Cell	1	SA572-S110	Figure 15-1	3
Lower Neck load Cell	1	SA572-S111	Figure 15-3	4
Thoracic Spine Load Cell	1	SA572-S127	Figure 15-1	5
Acetabulum Load Cell (Left)	1	SA572-S128	Figure 15-2	6
ASIS Load Cell	2	SA572-S119	Figure 15-1	7
Femur Load Cell	2	SA572-S120	Figure 15-1	8
IR-TRACC Assembly, Upper Left	1	472-3550	Figure 15-2	9
IR-TRACC Assembly, Upper Right	1	472-3560	Figure 15-2	10
IR-TRACC Assembly, Lower Right	1	472-3570	Figure 15-2	11
IR-TRACC Assembly, Lower Left	1	472-3580	Figure 15-2	12
Tri Pack Accel Assembly	1	472-4203	Figure 15-2	13
Acetabulum Load Cell, Right	1	SA572-S129	Figure 15-2	14
Tilt Sensor, Dual Axis	1	SA572-S44	Figure 15-1	15
Stringpot, Mini (Left)	1	SA572-S90-L	Figure 15-1	16
Stringpot, Mini (Right)	1	SA572-S90-R	Figure 15-1	17
Five Channel Upper Tibia Load Cell	2	SA572-S32	Figure 15-1	18
Five Channel Lower Tibia Load Cell	2	SA572-S33	Figure 15-1	19
Achilles Load Cell (1.0” diameter)	2	SA572-S126	Figure 15-1	20
Rotary Potentiometer	7	SA572-S114	Figure 15-1	21
Uniaxial Piezoresistive Accelerometer	5	SA572-S4	Figure 15-1	22
T1 Accel. Mount Assembly	1	472-3857	Figure 15-1	23

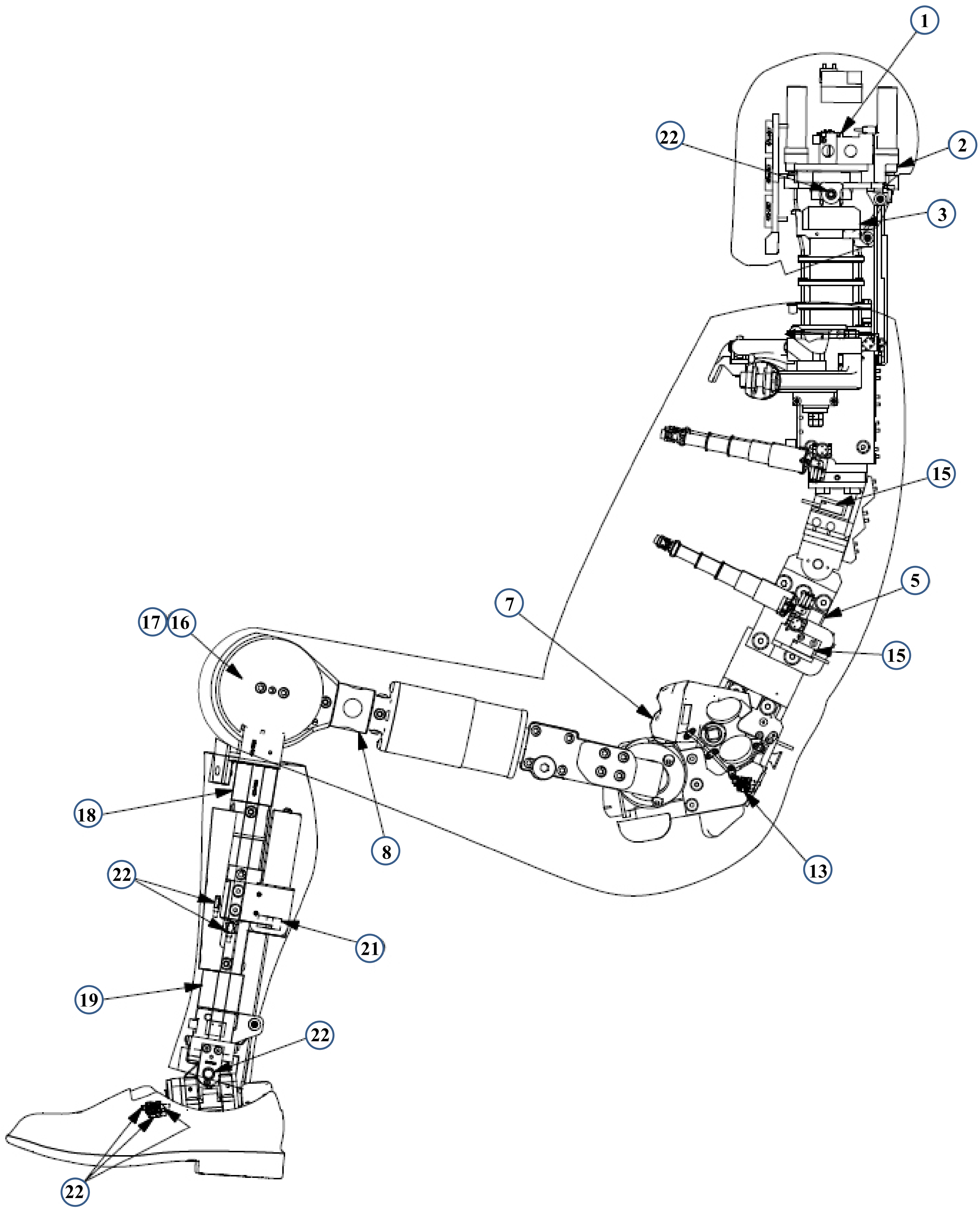


Figure 15-1. THOR-50M sensor locations (1 of 3)

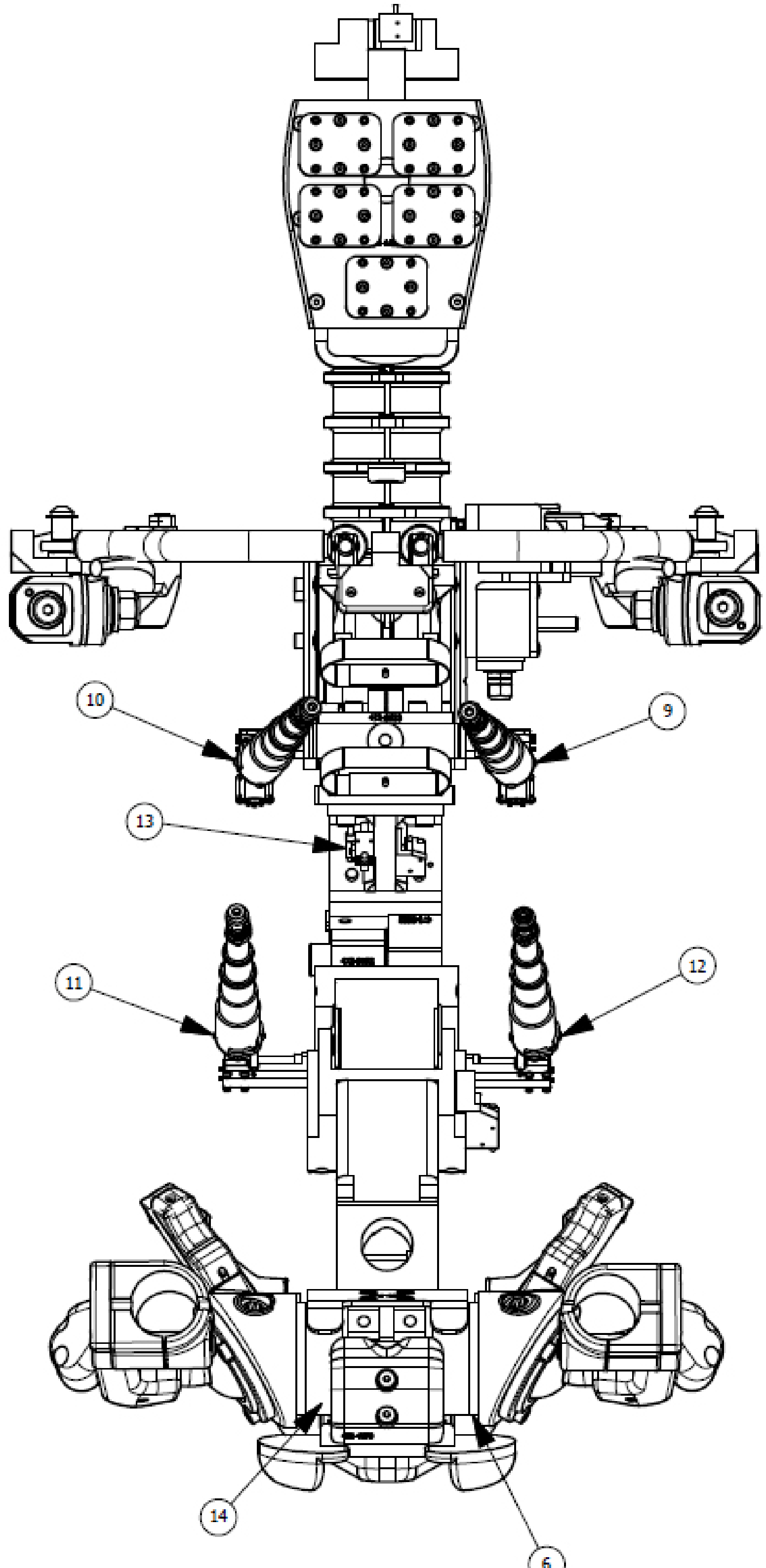


Figure 15-2. THOR-50M sensor locations (2 of 3)

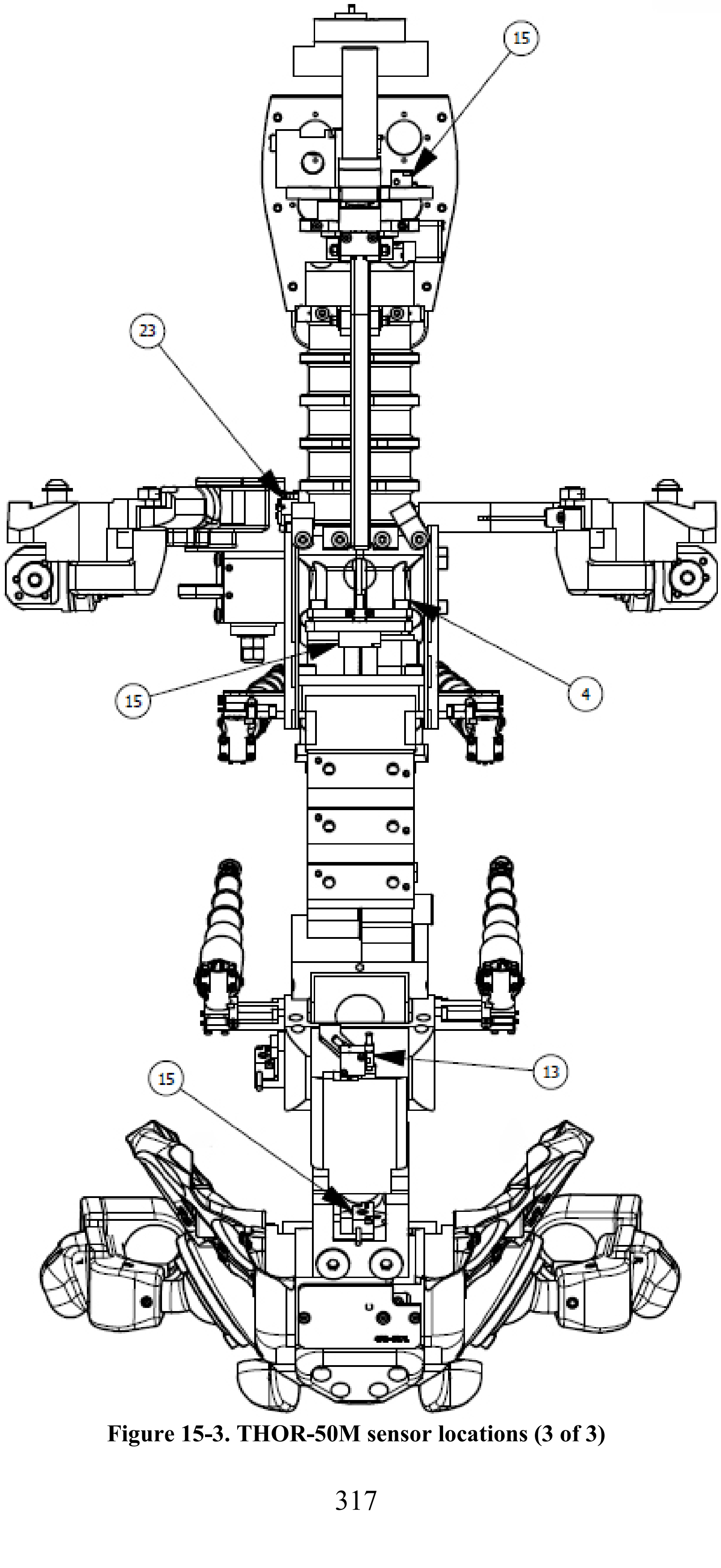


Figure 15-3. THOR-50M sensor locations (3 of 3)

Table 15-2. THOR-50M Available Instrumentation

Head:	3 Uniaxial Accelerometers at the C.G 3 Angular Rate Sensors 1 Biaxial Tilt Sensor
Face:	Five Uniaxial Load Cells
Neck:	Upper Neck Load Cell (6-axis) Lower Neck Load Cell (6-axis) Front Neck Spring Load Cell Rear Neck Spring Load Cell Head Rotation Potentiometer 1 Biaxial Tilt Sensor
Thorax:	3D IR-TRACC Deflection Units - 3D Thoracic Deflection Measurement (4 units - 3 channels each)
Mid Sternum:	1 Uniaxial Accelerometer
Upper Abdomen:	1 Uniaxial Accelerometer
Lower Abdomen:	3D IR-TRACC Deflection Units – 3D Lower Abdomen Measurement (2 units - 3 channels each)
Spine:	1 tri-pack Accelerometer at the T1 location 1 tri-pack Accelerometer at the T12 location Thoracic Load Cell (5-axis) 1 tri-pack Accelerometer at the level of the thorax C.G. 3 Biaxial Tilt Sensors
Pelvis:	Acetabular Load Cell (left and right, 3-axis each) ASIS Load Cells (left and right) 1 Triaxial Accelerometer at the C.G.
Femur:	Femur Load Cell (left and right, 6-axis each)
Knee:	Displacement string potentiometer (left and right)
Lx:	Upper Tibia Load Cell (left and right, 5-axis each) Lower Tibia Load Cell (left and right, 5-axis each) Tibia Accelerometer (left and right, biaxial each) Achilles' Load Cell (left and right) Ankle Joint Rotation Potentiometers (left and right, 3 each) Foot tri-pack Accelerometer (left and right, 3 each)

15.2 Instrumentation Cable Routing

The THOR-50M dummy contains provisions for mounting numerous electronic instruments to evaluate various types of occupant restraint systems. Typically, the instruments are connected to the data acquisition system using long cables. The instrumentation cables must be routed in and around the dummy in a manner that ensures that the dummy's motion is not affected by the cables while also being careful not to place the cables in a position where they are susceptible to damage from the test event. While there may be other acceptable methods of cable routing, especially in different loading environments or instrumentation configurations, this guide provides best practices for cable routing in frontal and frontal oblique test modes with a fully-instrumented THOR-50M dummy.

15.3 Grounding

To reduce the possibility of static electricity discharge and subsequent noise in the data acquisition system, it is necessary to provide electrical conductivity between sections of the dummy that are electrically isolated from the primary grounding cable exiting the dummy. Figure 15-4 shows an example of an instrumentation channel which is not properly grounded. The signal is characterized by spikes which have very short duration. Although poor grounding will not likely damage either instrumentation or harm the user, the signal output will include unwanted static spikes.

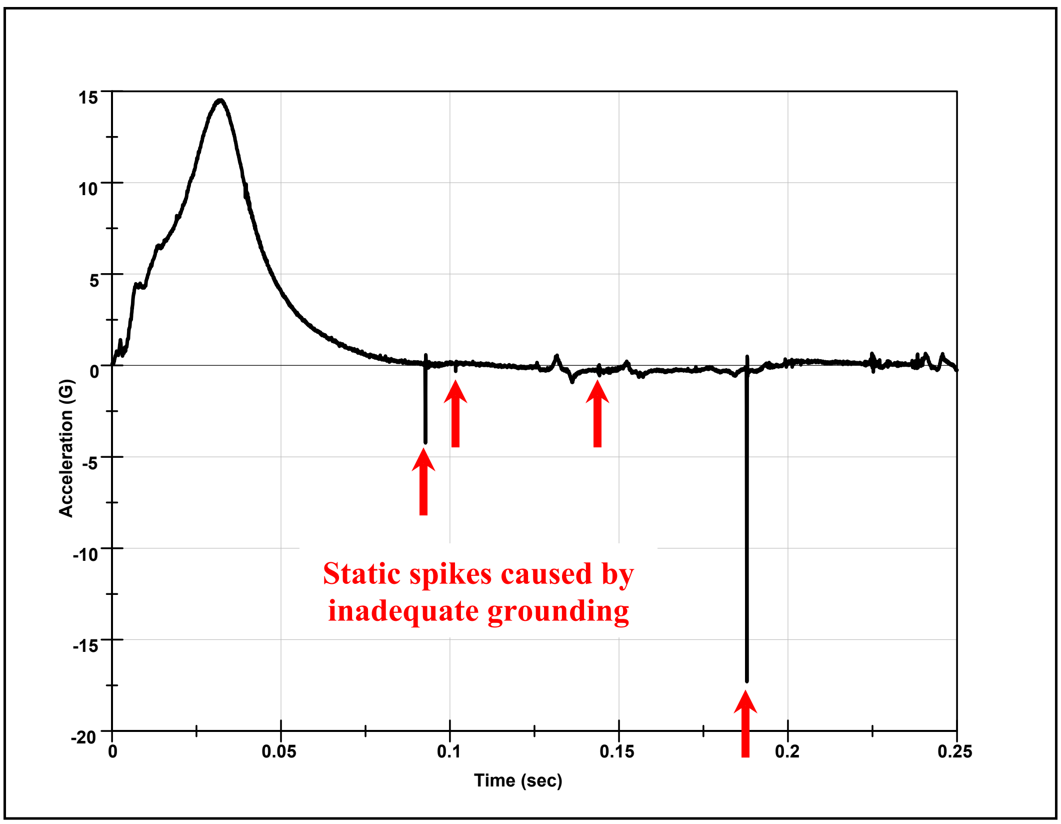


Figure 15-4. Example of instrumentation channel with poor grounding

Grounding is achieved by using multiple ground cables typically placed on the head/neck, lumbar/pelvis, between ribs 4 and 5 on the thoracic spine, at mid sternum, on the femurs, and tibias. These grounding straps are included in the drawing package (Figure 15-5 and Table 15-3). Note that the Main Ground Strap (472-8706) is required but is not shown in the Figure. It attaches to the dummy at the lower abdomen rear attachment plate using the same M6 screw that attaches the Lumbar Spine Instrument Ground Strap (472-8703).

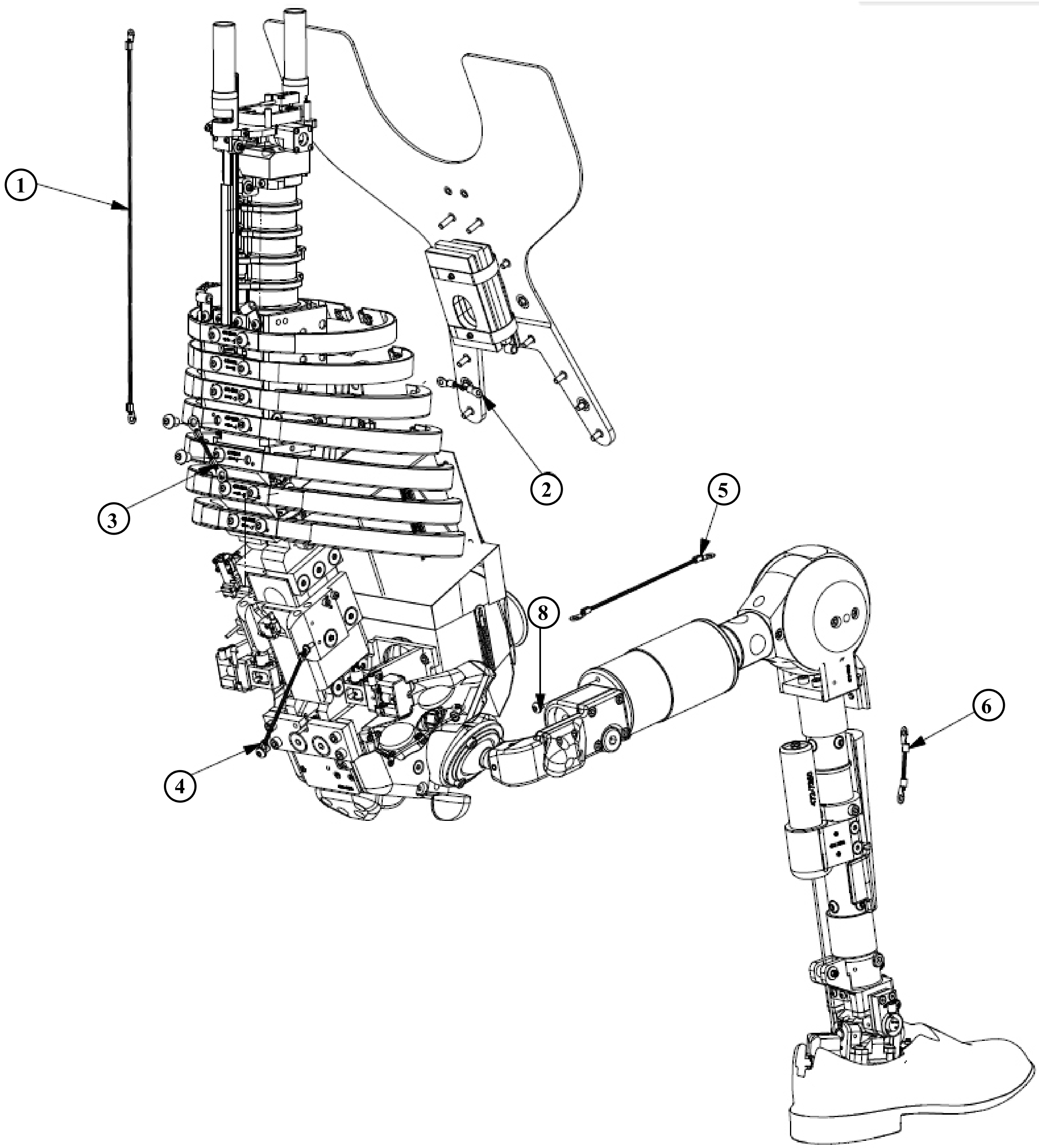


Figure 15-5. Ground straps on the THOR-50M

Table 15-3. THOR-50M Sensor/Load Cell Locations

Part Description	Quantity	Part Number	Figure #	Item #
Head/Neck Instrument Ground Strap	1	472-8700	Figure 15-5	1
Mid Sternum Instrument Ground Strap	1	472-8701	Figure 15-5	2
Thoracic Spine Instrument Ground Strap	1	472-8702	Figure 15-5	3
Lumbar Spine Instrument Ground Strap	1	472-8703	Figure 15-5	4
Femur Instrument Ground Strap	2	472-8704	Figure 15-5	5
Tibia Instrument Ground Strap	2	472-8705	Figure 15-5	6
Instrument Ground Strap, Main Ground (not shown)	1	472-8706	Figure 15-5	7
Screw, BHCS M6 x 1 x 6 mm	1	5000357V	Figure 15-5	8

Illustrations of the grounding straps installed on the THOR-50M are shown in Figure 15-6 through Figure 15-8. Figure 15-6 shows the head/neck grounding cable. This ground strap should be bundled with the instrumentation cables from the head and neck. A small ground strap is also placed between the rib and sternum plates on rib #4 (Figure 15-7). The strap is secured between the rib and bib using the two screws indicated in Figure 15-7. The lumbar ground strap connects between the pelvis and lumbar spine (Figure 15-8). Route the strap under the pelvis skin to attach to the lumbar. The thoracic spine grounding strap is attached between rib #4 and rib #5 (Figure 15-8).

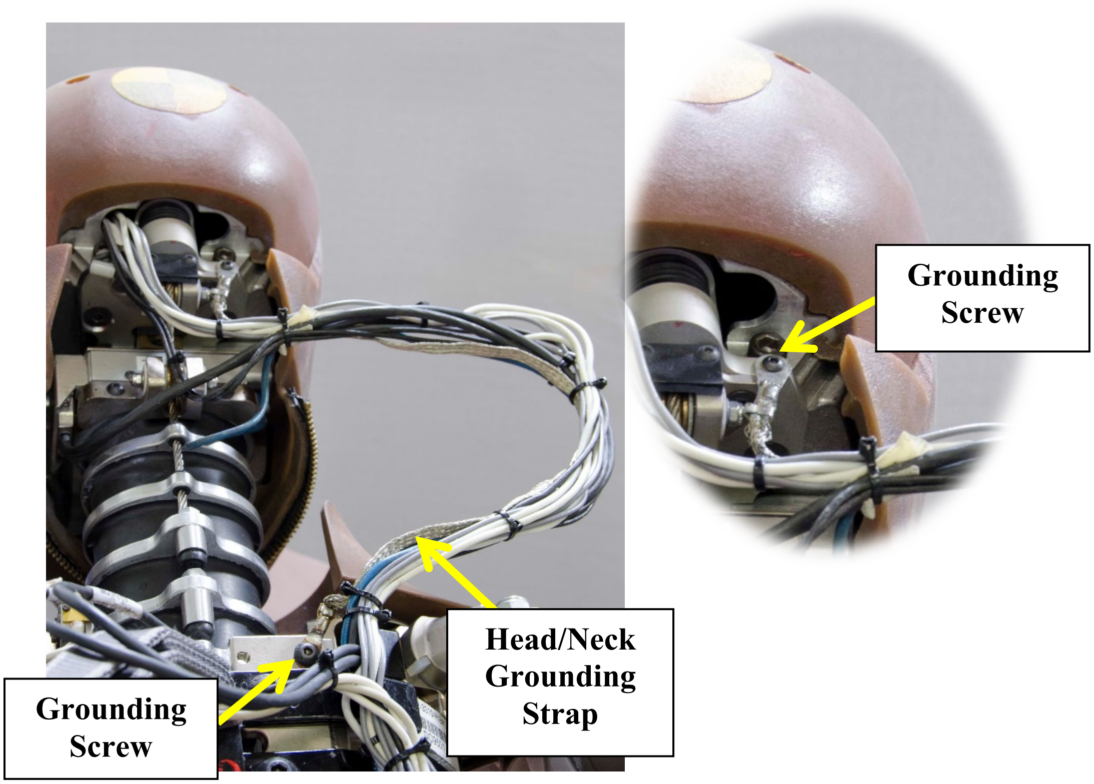


Figure 15-6. Head and neck grounding strap

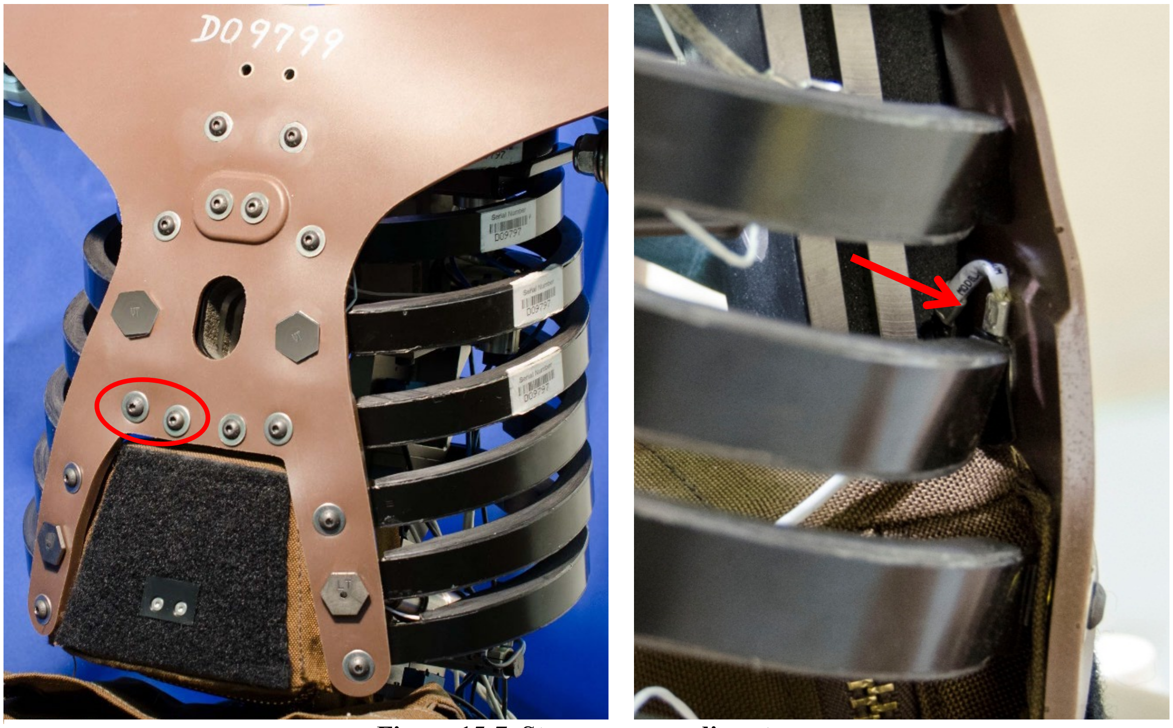


Figure 15-7. Sternum grounding strap

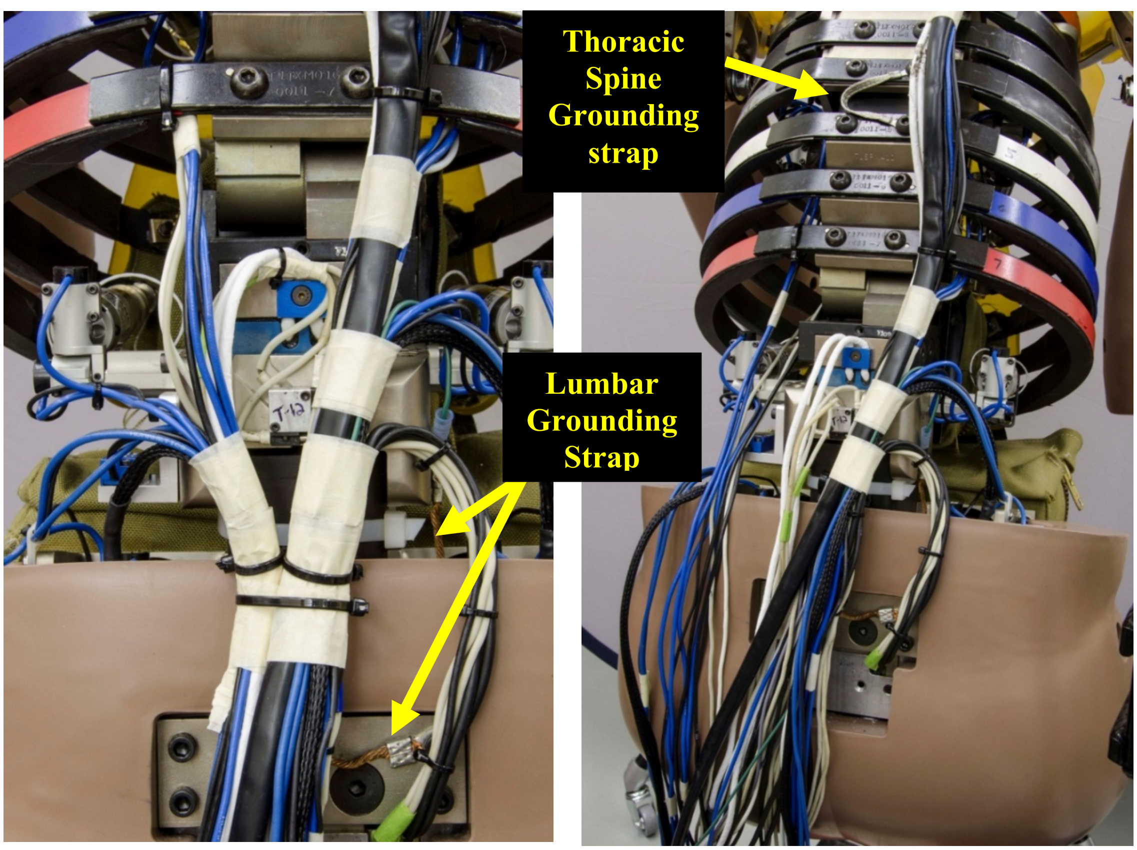
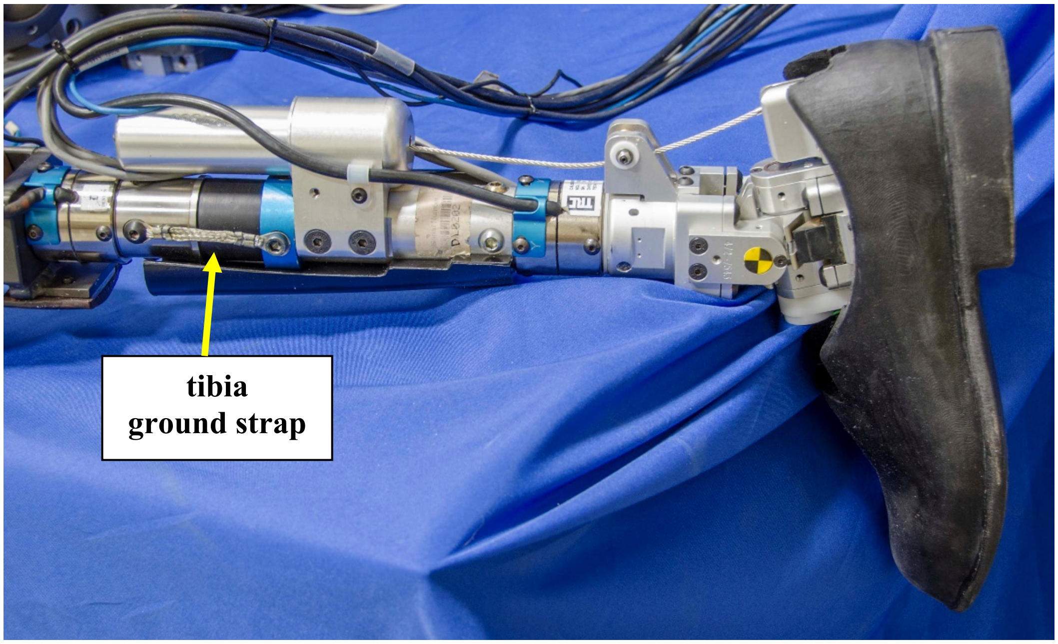


Figure 15-8. Grounding wires on lumbar/pelvis and thoracic spine

A femur ground strap attaches to the femur load cell using an M6 x 1 x 6 mm BHCS if the load cell is installed. A tibia ground strap (Figure 15-9) is necessary if there is any instrumentation installed in the lower tibia, ankle, or foot.



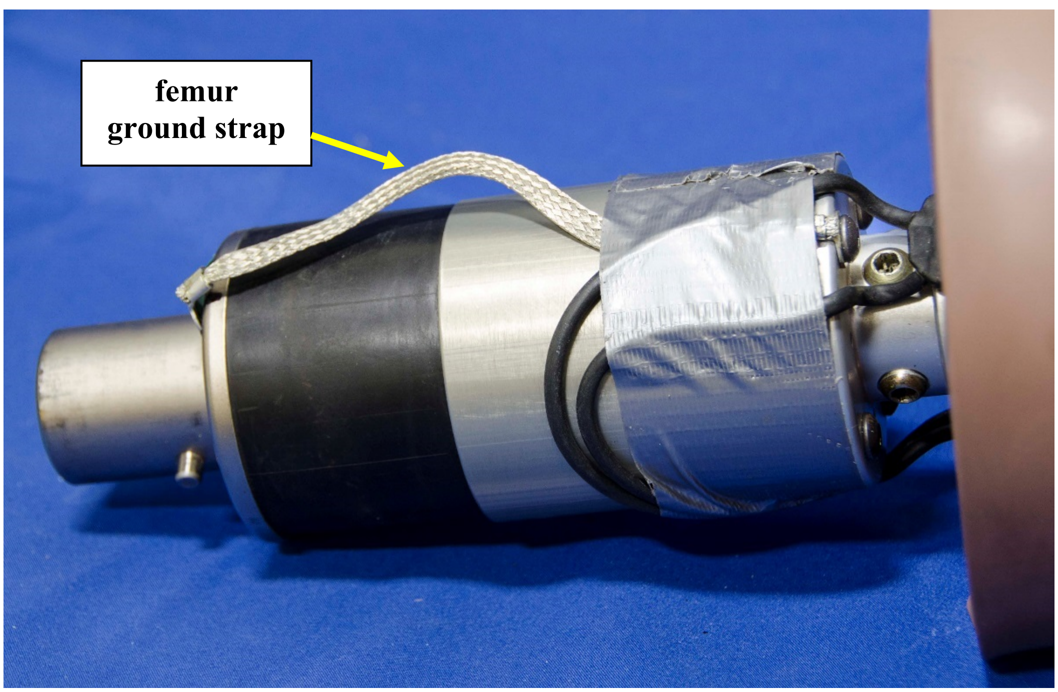


Figure 15-9. Additional ground straps required for instrumented legs

A primary grounding cable which extends from the lumbar spine to the data acquisition system provides a path from the dummy to ground (Figure 15-10). Bundle this wire with the dummy umbilical (Figure 15-35).

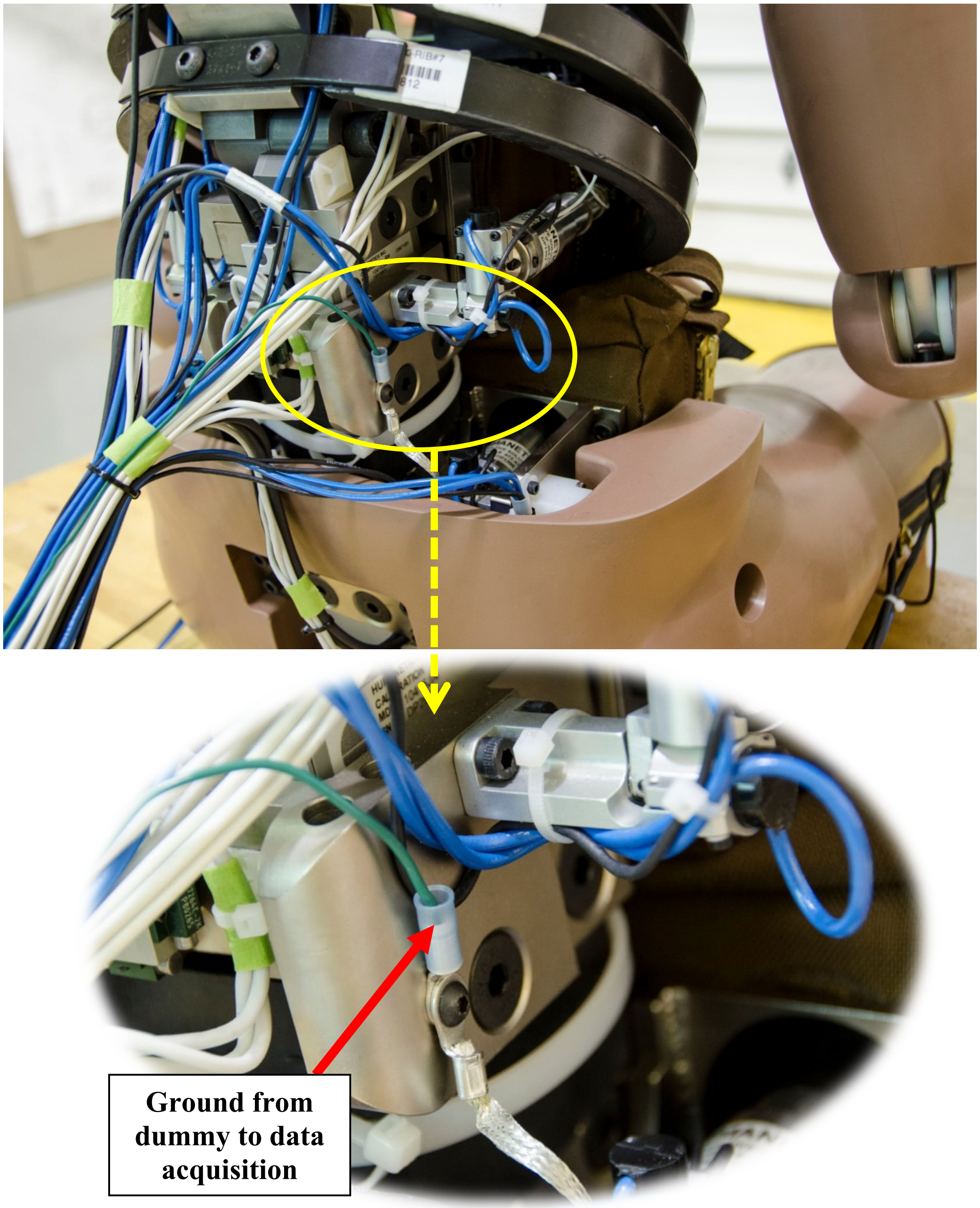


Figure 15-10. Primary grounding cable from dummy to data acquisition system

15.4 Cable Routing

15.4.1 Head and Neck Cable Routing (head accelerometers, ARS sensors, upper and lower neck load cells, head tilt sensor, front and rear spring tower load washers, occipital condyle pot)

15.4.1.1 After installing the accelerometers and ARS sensors on the head plate, install a tie-wrap around the mount as shown (Figure 15-11); be sure that it is loose enough to insert another tie-wrap underneath it.

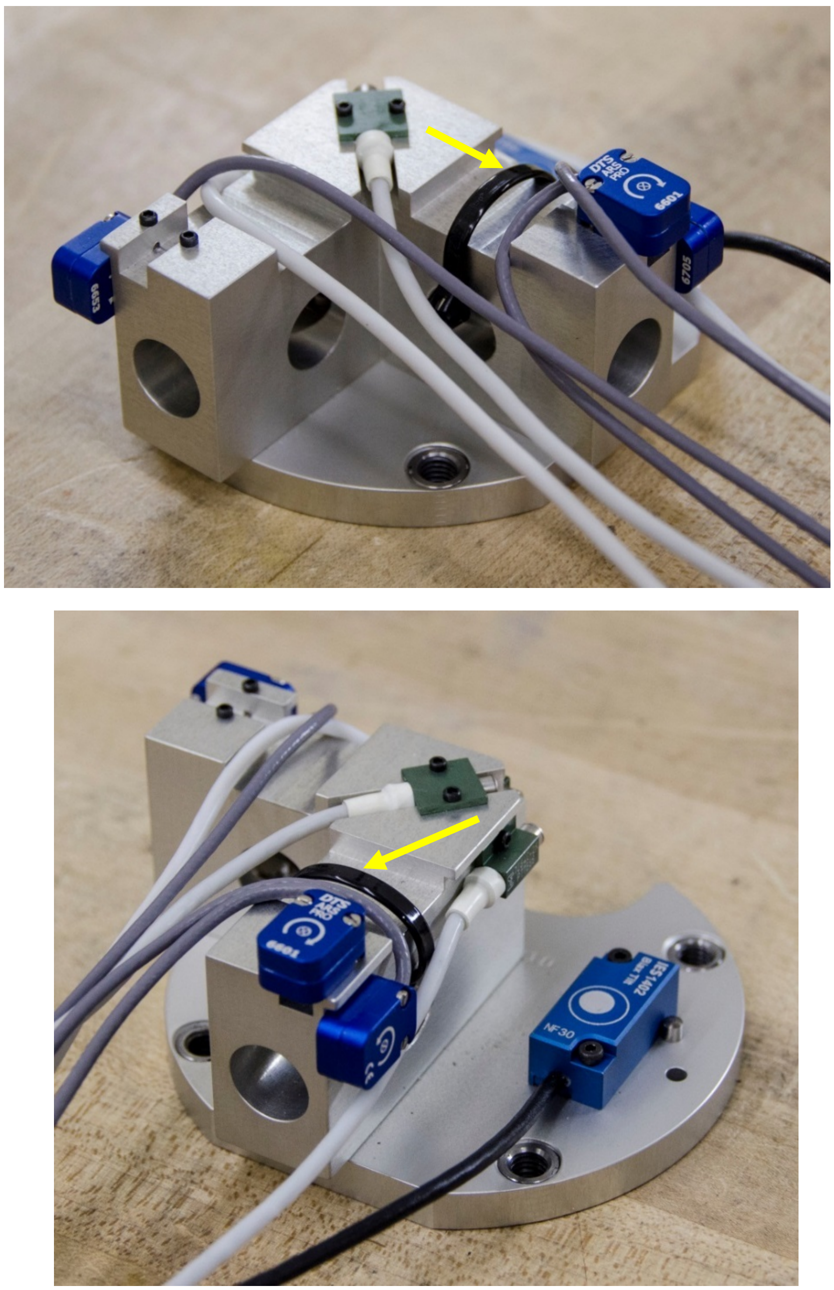


Figure 15-11. Installing anchor on head mounting plate

15.4.1.2 Gather the wiring and bundle as shown, leaving enough slack so that the wires don't turn sharply from the base of each sensor and cause damage (Figure 15-12). Figure 15-12 indicates references for approximate slack between the instrumentation housing and the strain relief tie-wrap. Using the installed tie-wrap (Figure 15-11), loop another tie underneath and around the wire bundle to complete the strain relief.

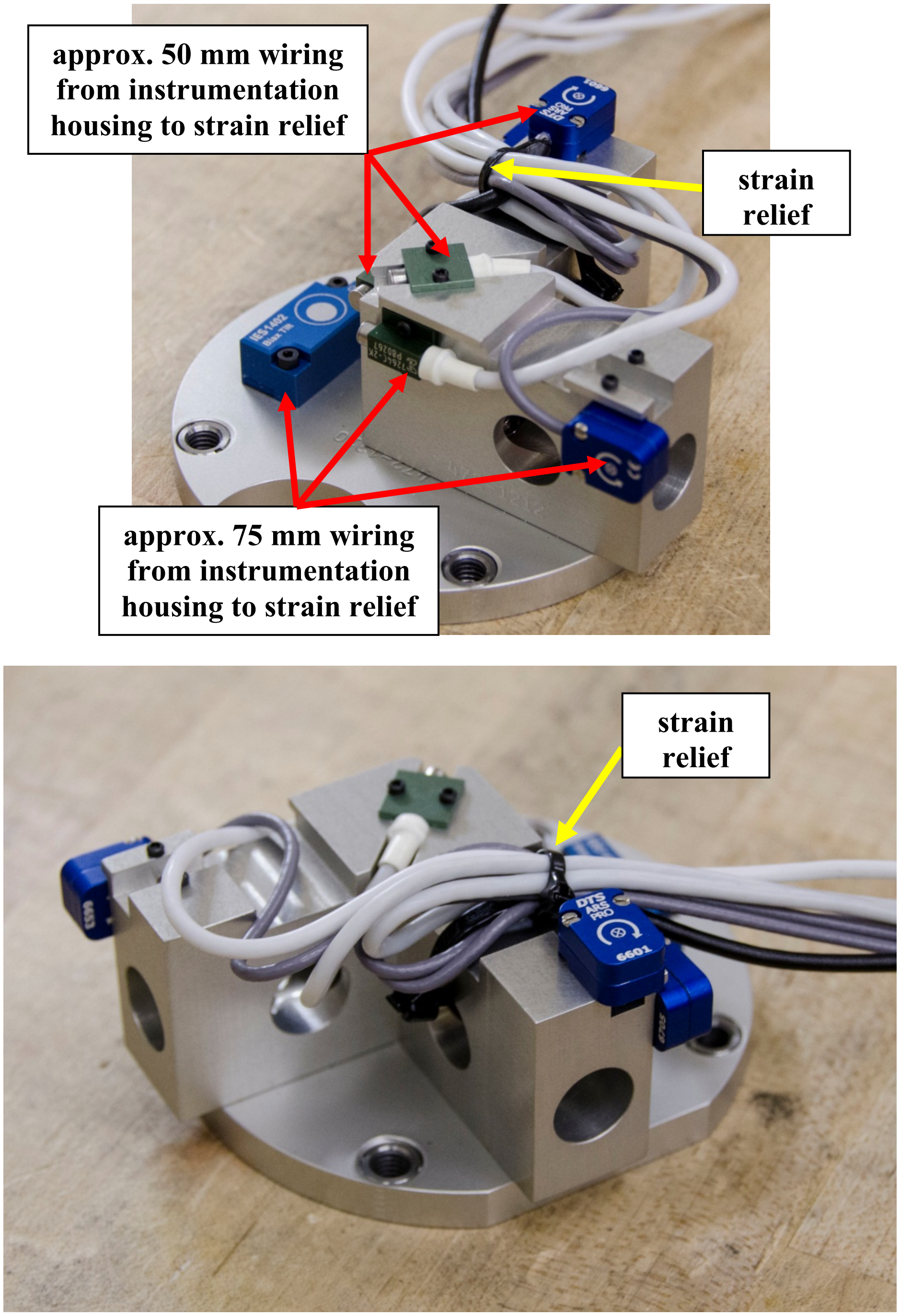


Figure 15-12. Bundle and tie down head instrumentation cables

15.4.1.3 Install the head instrumentation into the head. Next, install the rear neck cable/spring assembly (Figure 15-13). Place the internal instrumentation wires from the head to the dummy's right, behind the spring tower.

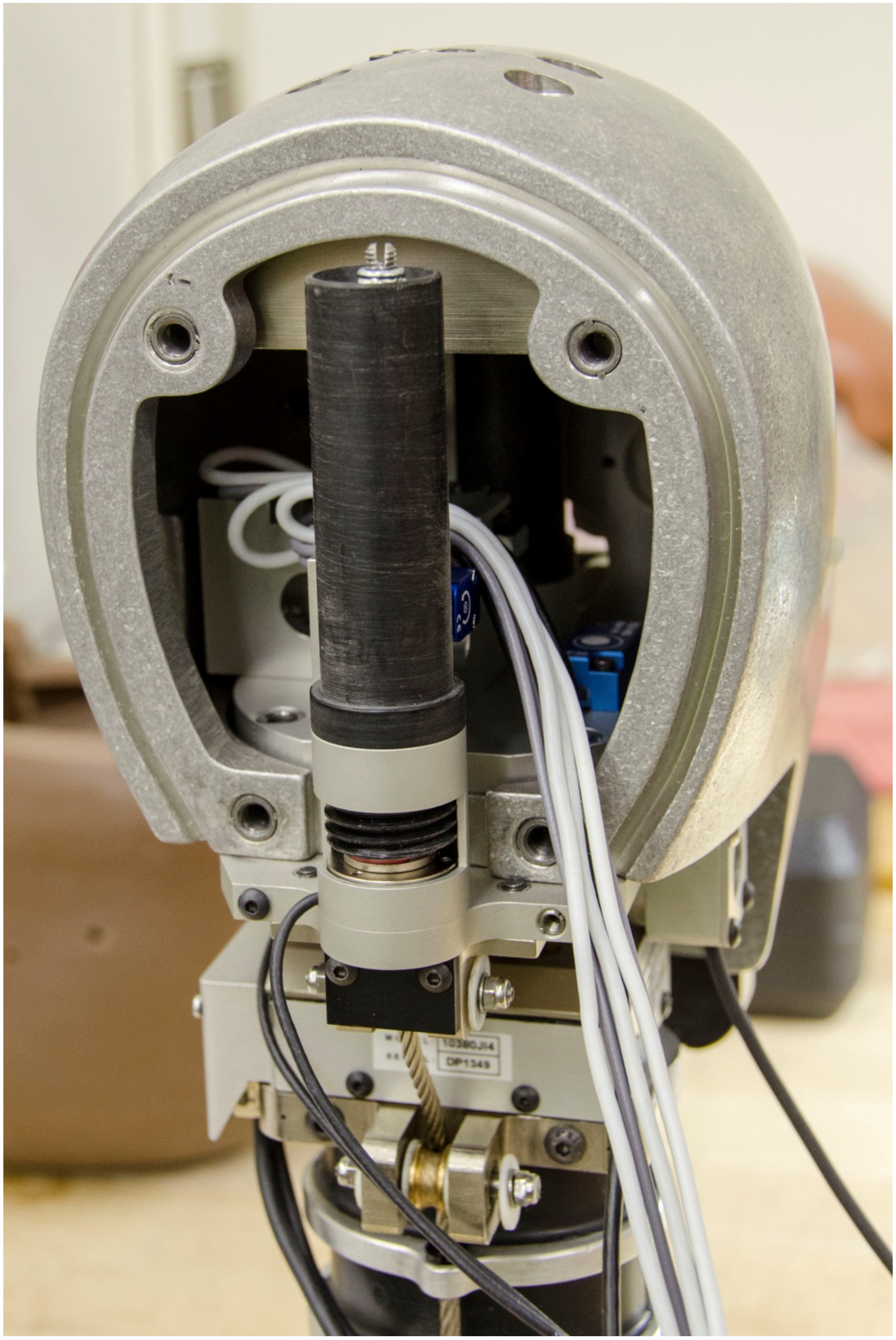


Figure 15-13. Install rear neck cable/spring assembly

15.4.1.4 Route the wire from the front spring tower load cell under the head as shown in Figure 15-14. Locate the wire from the rear spring load cell and cable-tie both front and rear load cell cables together.

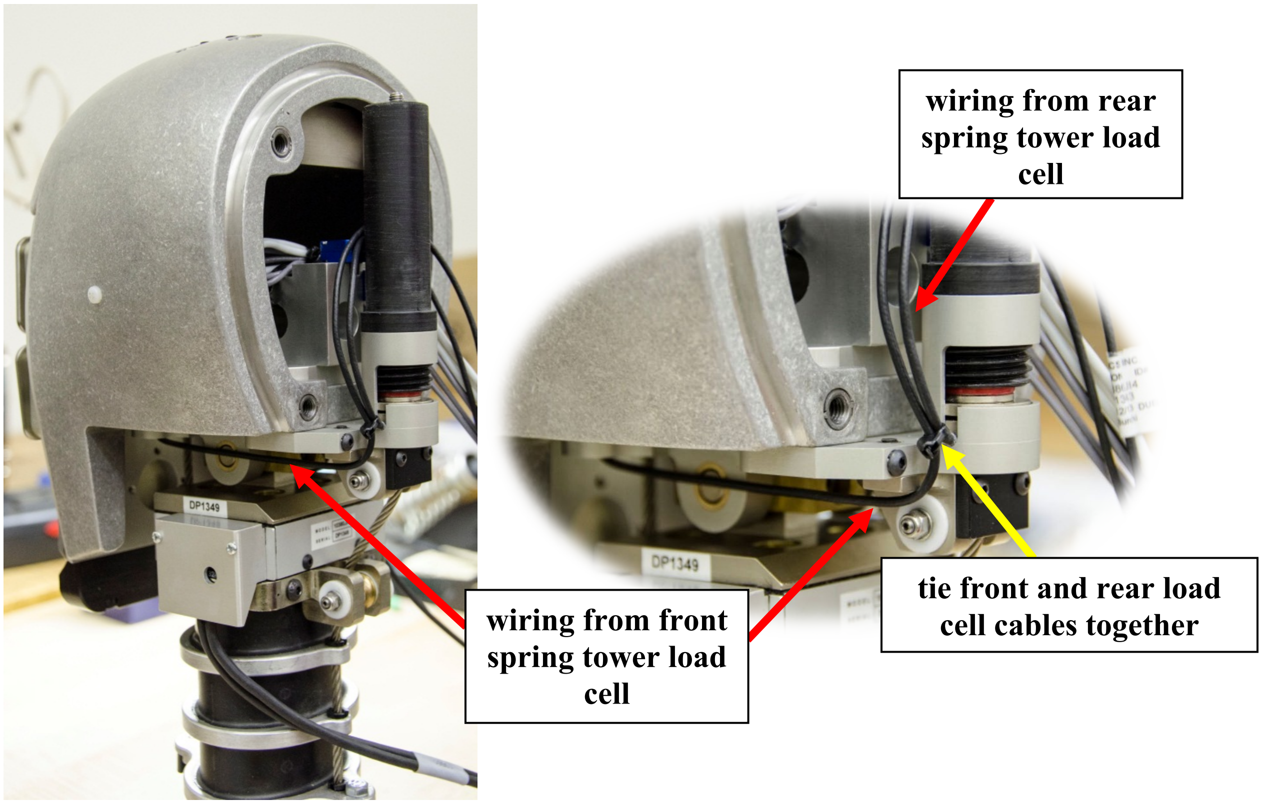


Figure 15-14. Route wires from spring load towers

15.4.1.5 Gather the bundle from the internal head instrumentation, occipital condyle pot, head tilt sensor, along with the front and rear spring tower load cells; use masking tape to secure the cable bundle. Use of masking tape is recommended over duct tape since it will tear if the cable is tugged, preventing damage to instrumentation (Figure 15-16).

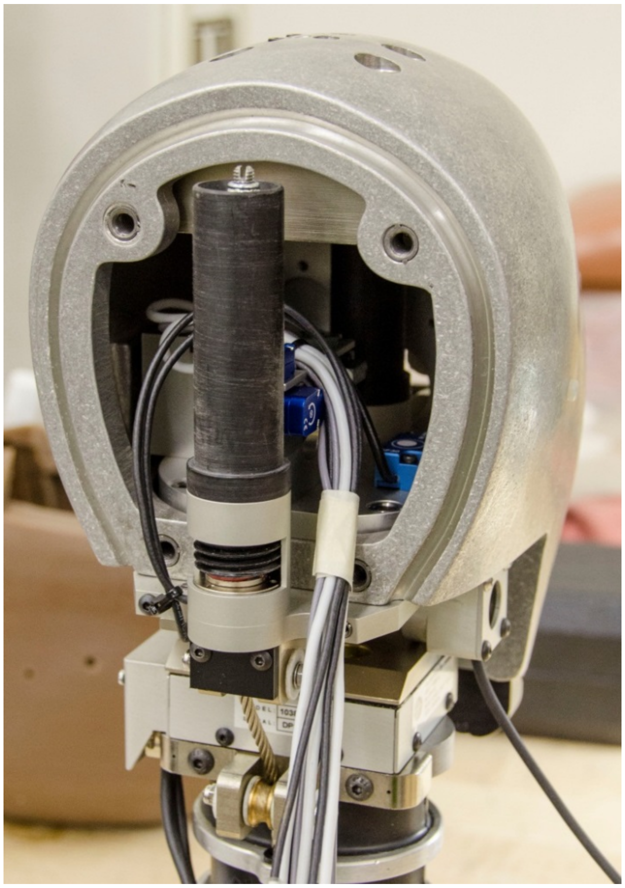


Figure 15-16. Secure head bundle with masking tape

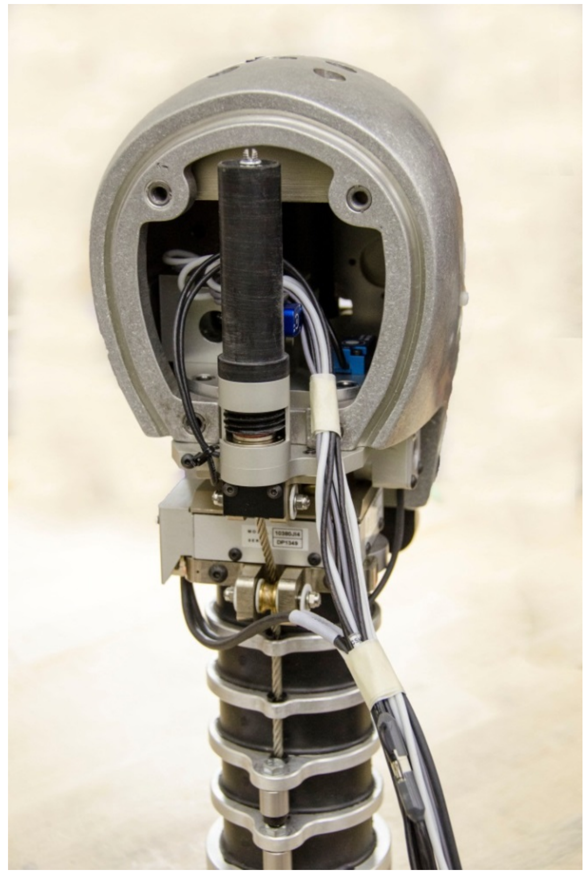


Figure 15-15. Secure wiring from upper neck load cell and occipital condyle to head bundle

15.4.1.6 Add the wires from the upper neck load cell and occipital condyle pot to the bundle using masking tape (Figure 15-15 and Figure 15-17). Leave sufficient slack in the wiring to allow for neck flexion or extension.

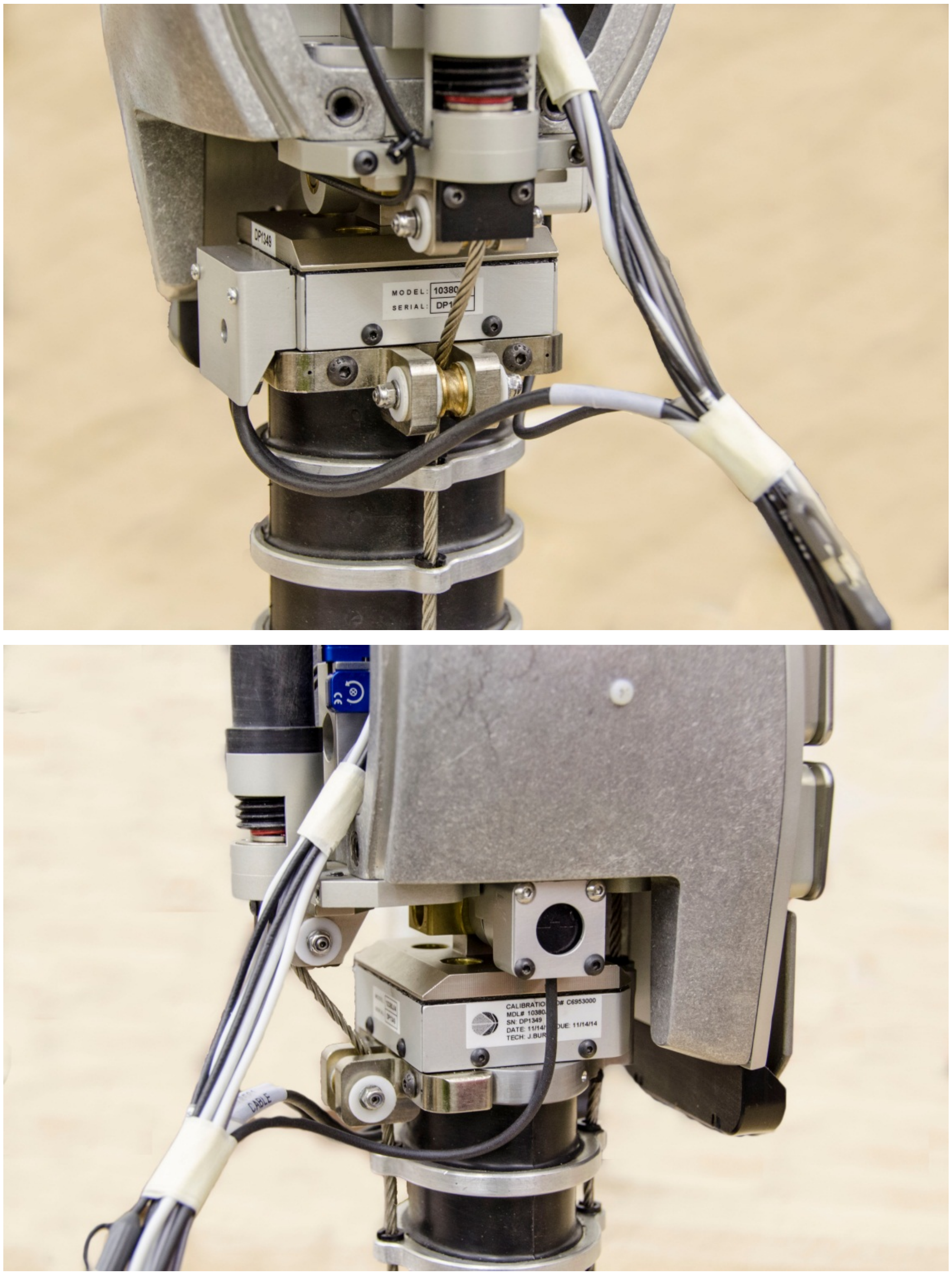


Figure 15-17. Routing Occipital Condyle and upper neck load cell wires

15.4.1.7 To install the skull cap, move any cable wiring towards the neck spring tower, away from the area where the skull cap screws into the skull; this will ensure that the cables exiting the head are not pinched by the skull cap (Figure 15-18). After installing the skull cap, use masking tape to hold the bundle of wires together.

Figure 15-18. Install skull cap

15.4.1.8 Route the lower neck load cell cable through the thorax interior behind rib #1; exit out to the exterior through the recess in the spine between rib #1 and #2 (Figure 15-19). If the cable is hard wired with a connector on the end, it may not fit between the two ribs. If this is the case, it is necessary to first remove the shoulder then uninstall rib #1 to route the cable between the ribs. After passing the cable between ribs #1 and #2, include the wiring in the bundle with the wiring from the head (see next Section). Reinstall rib #1 and the shoulder after completing the cable routing.

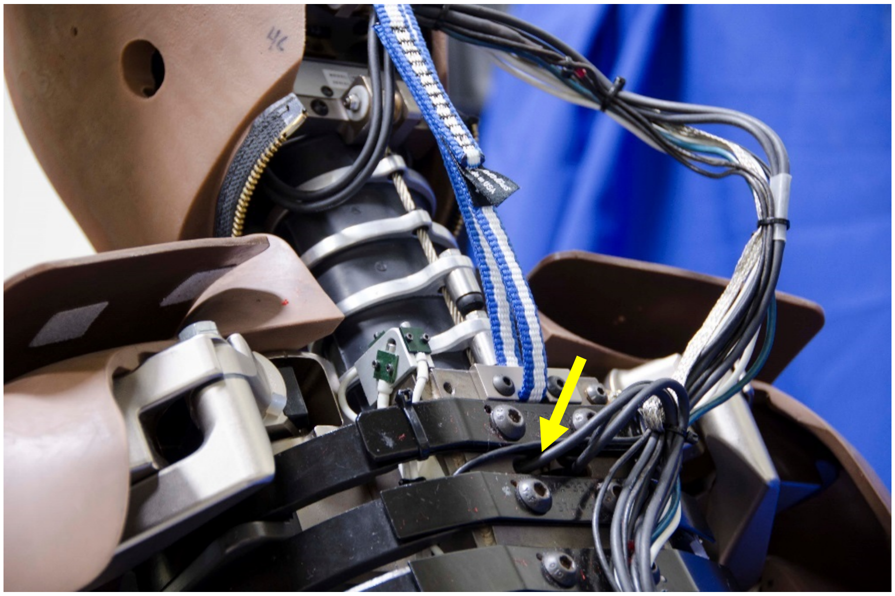


Figure 15-19. Route the lower neck load cell wiring between rib #1 and #2

15.4.2 Thorax Cable Routing (T1 accelerometers, T6 accelerometers, Upper Thorax IR-TRACCs, Tilt Sensors: Lower Neck, T6, and T12)

15.4.2.1 Direct the wiring for the T1 accelerometers behind the ribs and straight down the left side of the dummy and out of the bottom of the ribcage (Figure 15-20).

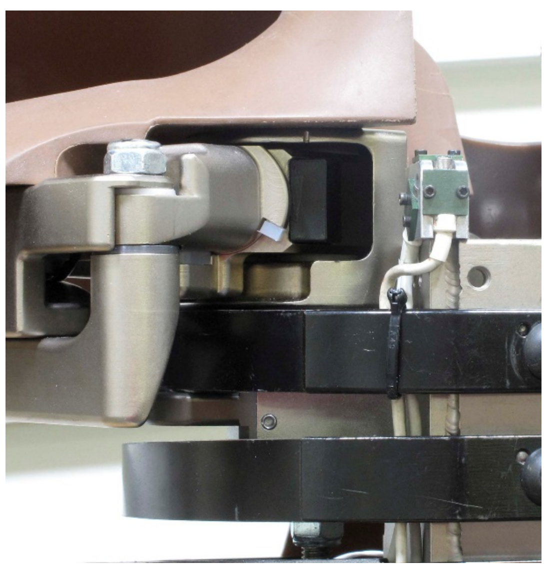


Figure 15-20. Routing T1 accelerometer wires

15.4.2.2 Create a tie-down for the cable bundle coming from the head by looping a tie-wrap around rib #1 and the associated stiffener; use this loop to hold the tie-wrap for the neck cable bundle (Figure 15-21).

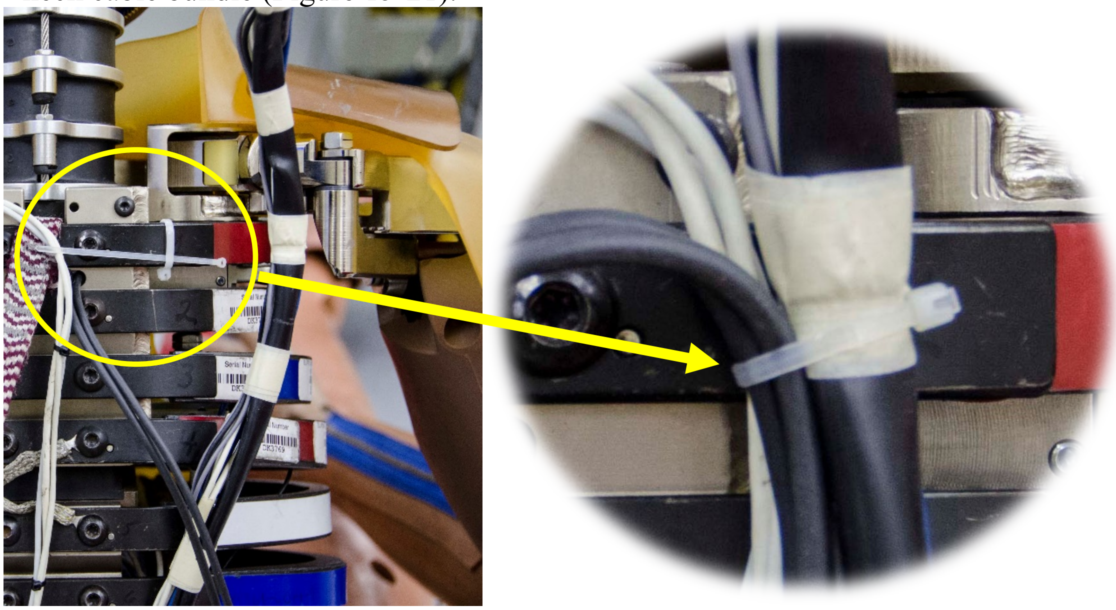


Figure 15-21. Create an anchor on rib #1 for the neck cable bundle

15.4.2.3 Use the cable-tie on rib #1 to bundle the neck cable, the T1 accelerometer wires, lower neck tilt sensor, and the lower neck load cell cables (Figure 15-22). Route the cabling posterior to the hanger strap to avoid cable damage when the dummy is suspended. To check that there is enough slack in the head cable for neck flexion and extension, pull the bundle (gently) away from the neck; there should be approximately 100 mm – 115 mm of space between the instrumentation cable and the neck. Attach the cables to the anchor on rib #1 (Figure 15-23).

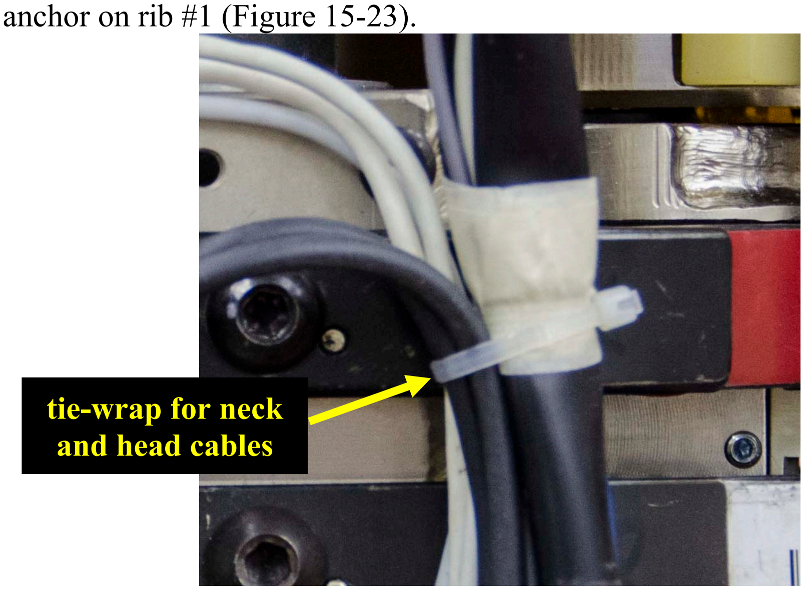


Figure 15-22. Bundle the neck cable, T1 accelerometer wires, lower neck tilt sensor and lower neck load cell cables and attach to Rib #1

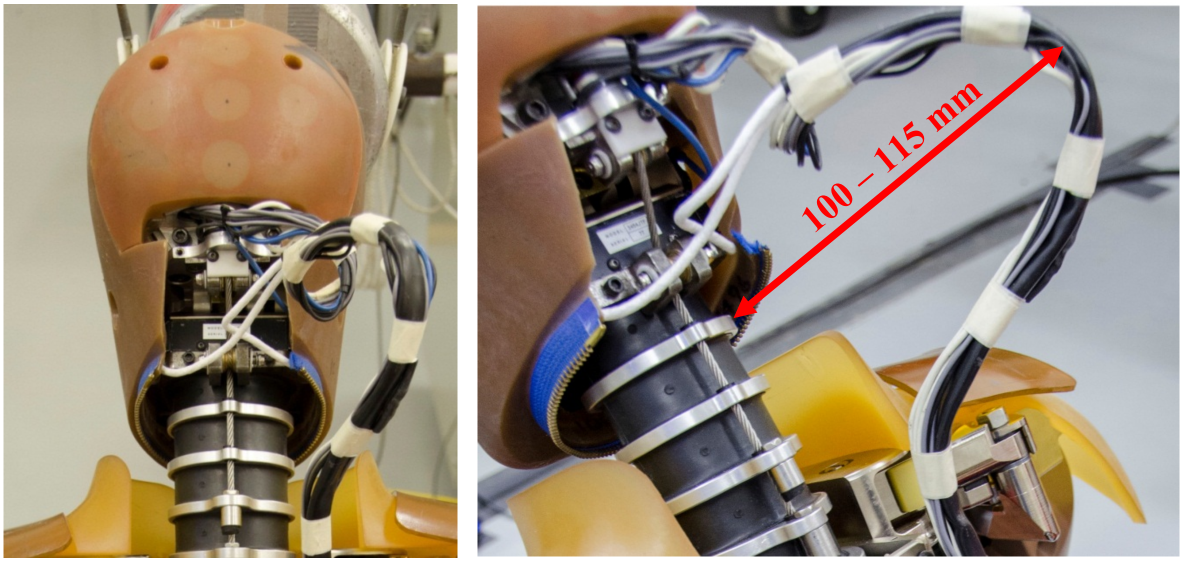


Figure 15-23. Assure sufficient slack in head cable

15.4.2.4 Wrap the bundle with tape about mid thorax level. Install a tie-wrap near the rib stiffener on rib #7 (Figure 15-24). Feed another tie through this loop to hold the bundle down the spine along the rib stiffeners.

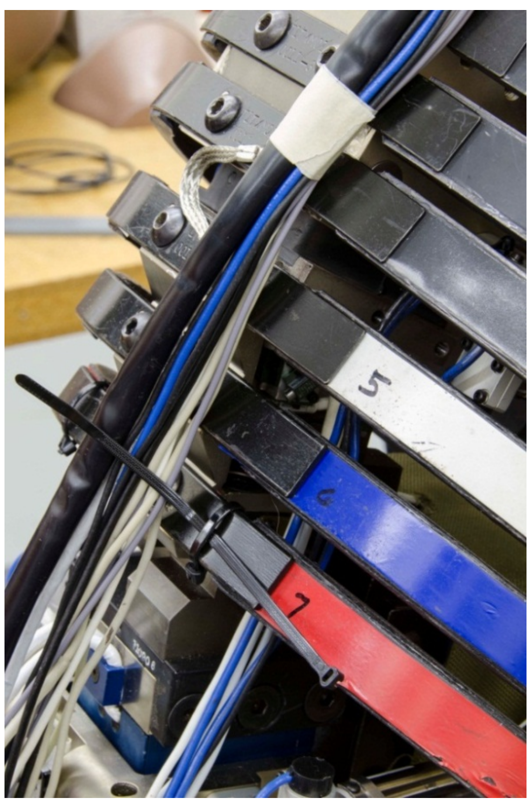


Figure 15-24. Install anchor on rib #7

15.4.2.5 Anchor the neck cable bundle at rib #7 (Figure 15-25). Route the wiring for the left and right upper thorax IR-TRACCs, the T6 accelerometer, and the T6 tilt sensor on the inside of the thorax close to the spine on its respective side. For wiring routed down the inside of the thorax on the left side, attach a tie-wrap to rib 7 on the left side. Use this tie-wrap to loop another one through to hold the internal wires.

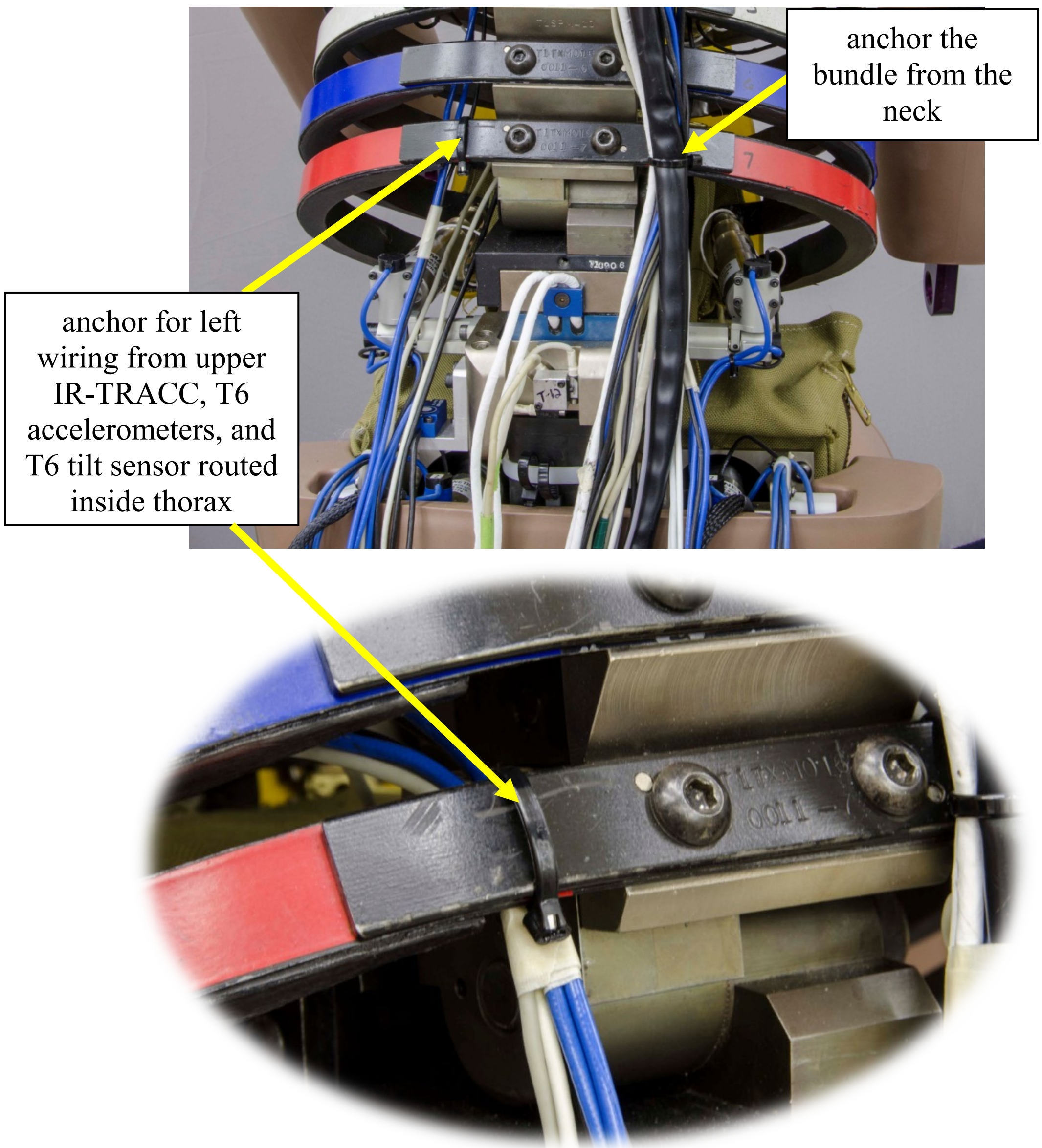


Figure 15-25. Gather and tie-wrap wiring on rib #7

15.4.2.6 To check that there is sufficient slack to allow for flexion of the spine (Figure 15-26), pull the bundle (gently) away from the spine, there should be approximately 60 mm of space between the instrumentation cable and the spine.

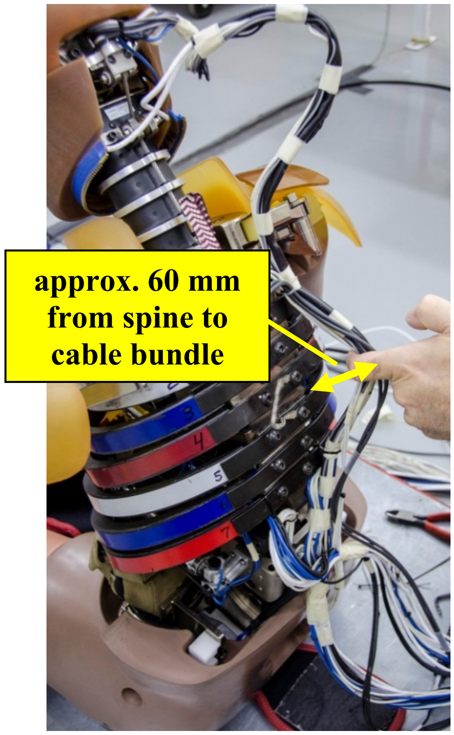


Figure 15-26. Assure sufficient slack for spine flexion

15.4.2.7 Wiring protruding from each 3D IR-TRACC should have strain-relief as shown in Figure 15-27. Be sure to leave enough slack so that the 3D IR-TRACC can move freely about the Y and Z rotational axes without binding. As a guide for sufficient slack, Figure 15-27 shows reference lengths from the instrumentation housing to the strain relief.

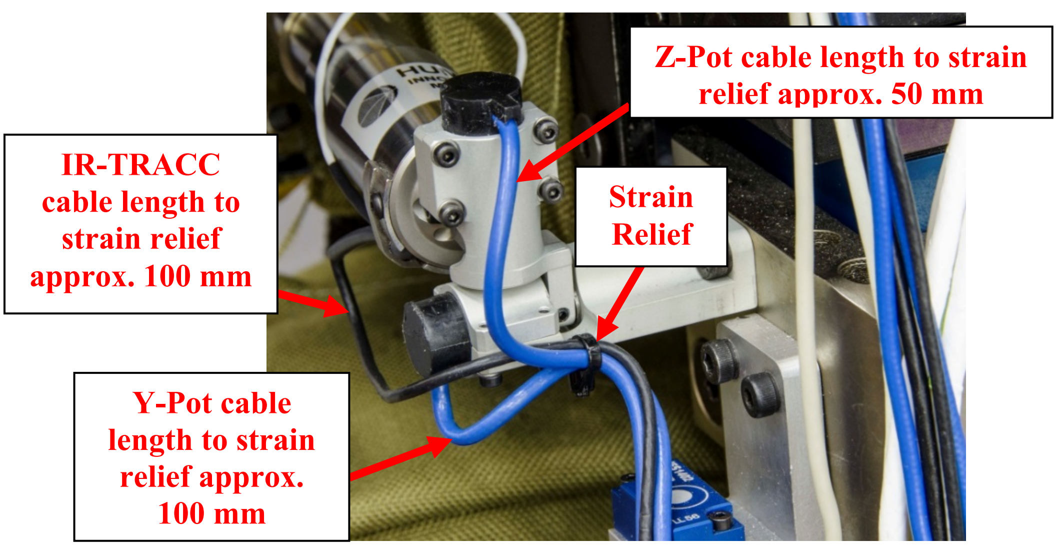


Figure 15-27. Strain relief for 3D IR-TRACCs
(lower thorax IR-TRACC shown for illustration)

15.4.3 **Pelvis Cable Routing (Lower Thorax IR-TRACCs, Abdomen IR-TRACCs, T12 Accelerometers, Pelvis Accelerometers, Acetabulum Load Cells, Thoracic Spine Load Cell, ASIS Load Cells, Pelvis Tilt Sensor)**

15.4.3.1 Gather the cables for the lower right thorax IR-TRACC. As illustrated in Figure 15-27, the wiring from each lower thorax IR-TRACC and abdomen IR-TRACCs should be sufficiently strain-relieved to their respective 3D IR-TRACC units. The cables from the abdomen IR-TRACC potentiometers are held in place by nylon cable holders secured to the abdomen bracket (Figure 15-28). Use masking tape to hold the lower thorax 3D IR-TRACC and abdomen 3D IR-TRACC wires to the cable bundle from the spine.

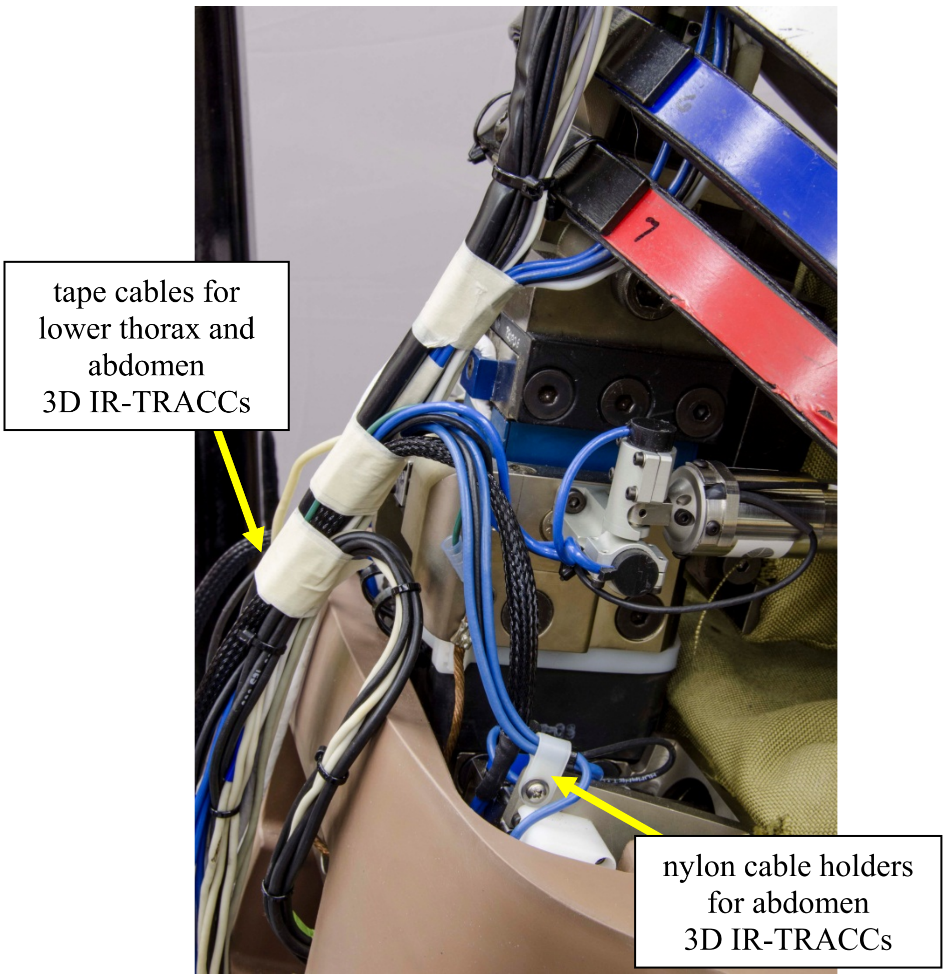


Figure 15-28. Secure wiring for abdomen and lower thorax 3D IR-TRACCs

15.4.3.2 Cable-tie the cables from the pelvis accelerometers, right ASIS load cell, right acetabulum load cell, and pelvis tilt sensor together on the right side of the dummy. Use masking tape to hold these wires to the cable bundle from the spine (Figure 15-29).

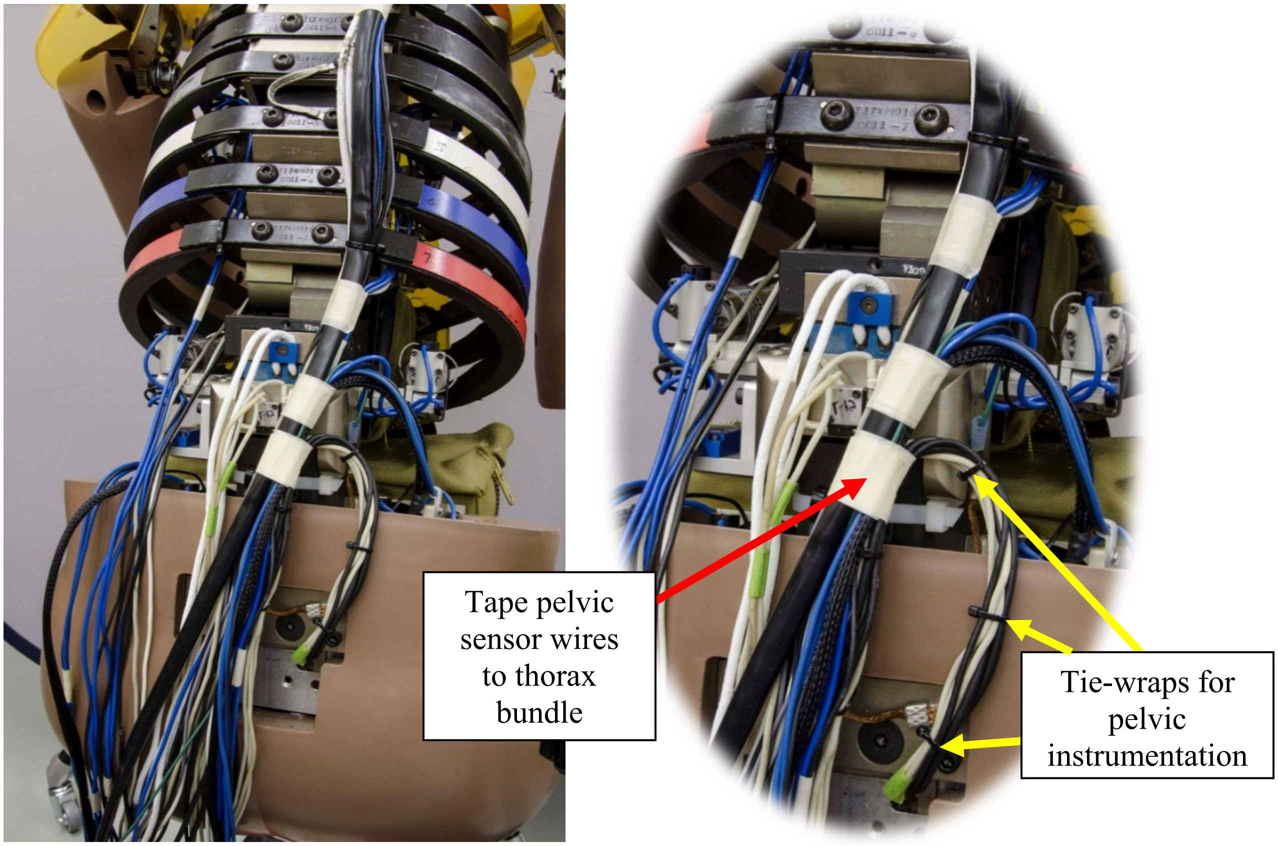


Figure 15-29. Tie-wrap pelvis accelerometer, ASIS, acetabulum, and pelvis tilt sensor cables together

15.4.3.3 If it is not already installed, loosely secure a large cable-tie around the lumbar spine and loop 2 small cable-ties around it as illustrated in Figure 15-30. Note that this step is easier to perform prior to installing the lumbar spine.

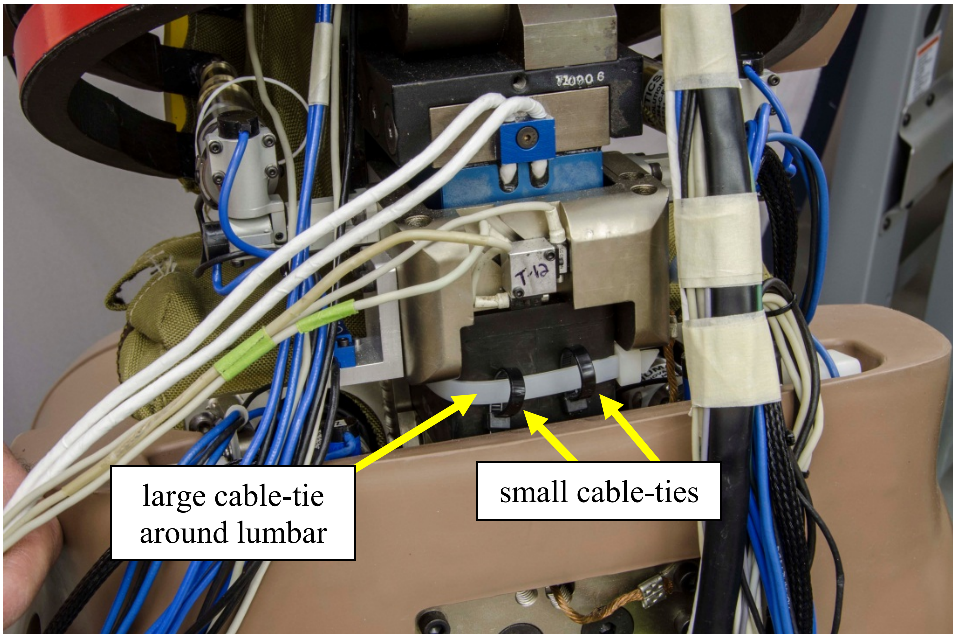


Figure 15-30. Install cable-ties to lumbar spine

15.4.3.4 To protect the wires, wrap the wiring bundle with tape at the level of the lumbar spine cable-tie. Cable-tie the large bundle of wires to the lumbar spine as illustrated in Figure 15-31.

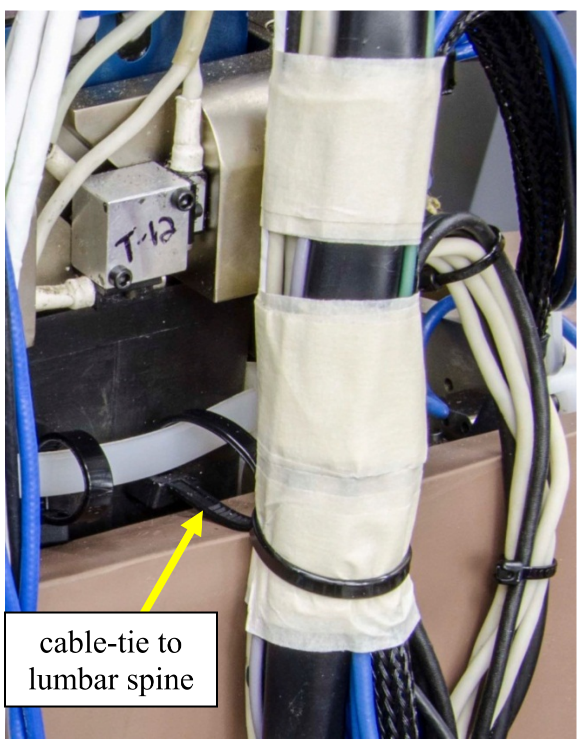


Figure 15-31. Cable-tie large bundle to lumbar spine

15.4.3.5 Gather the wires from the thoracic spine load cell and the T-12 accelerometers and fasten them together with a tie-wrap (Figure 15-32). Position them towards the left side of the dummy.

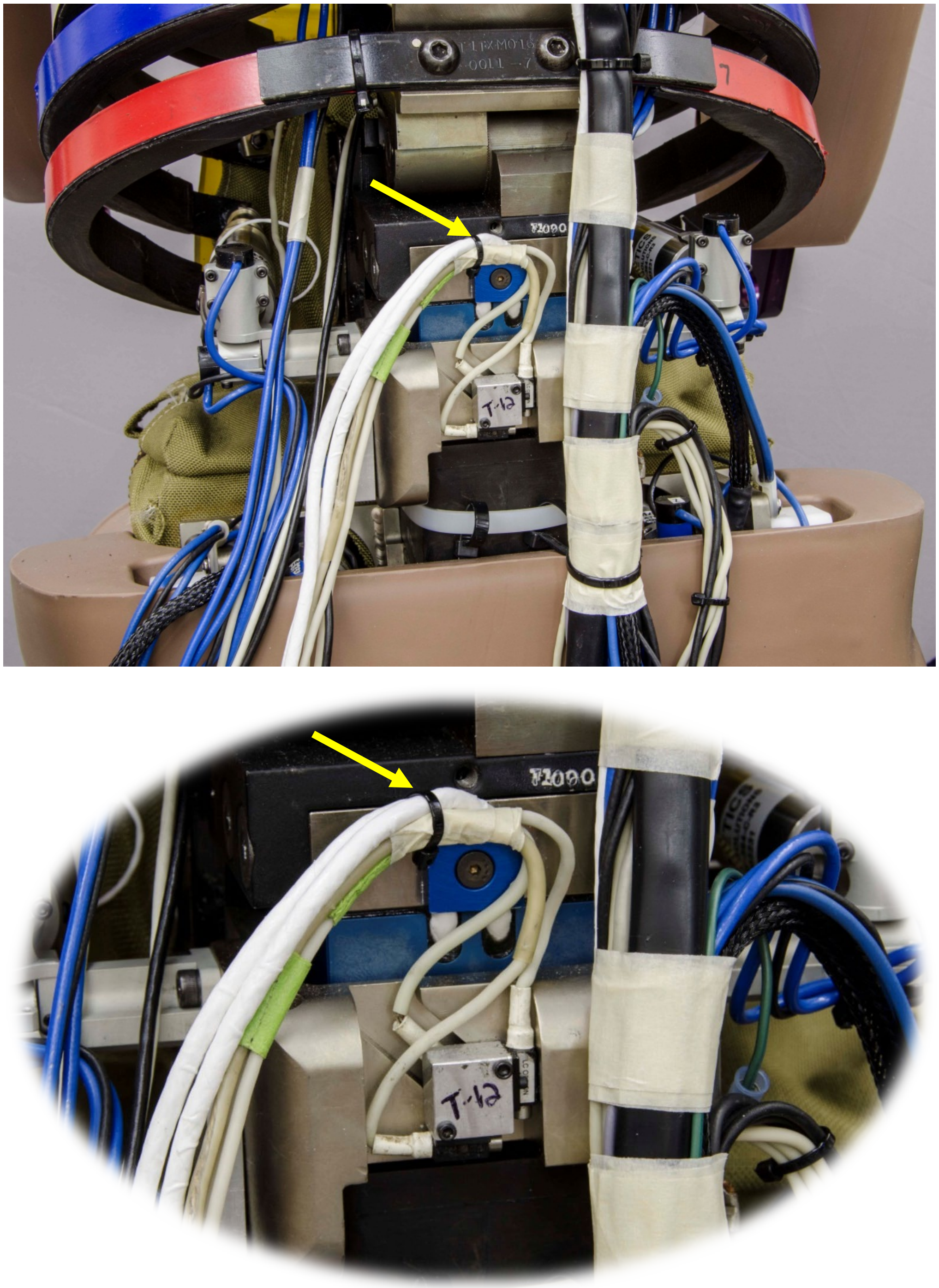


Figure 15-32. Thoracic spine load cell and T-12 accelerometer wiring bundle

15.4.4 **Overall Cable Routing**

15.4.4.1 Bundle wiring from the left side of the dummy with masking tape (Figure 15-33). Use a small tie-wrap to anchor this bundle to the left side of the spine in similar fashion to Figure 15-31.

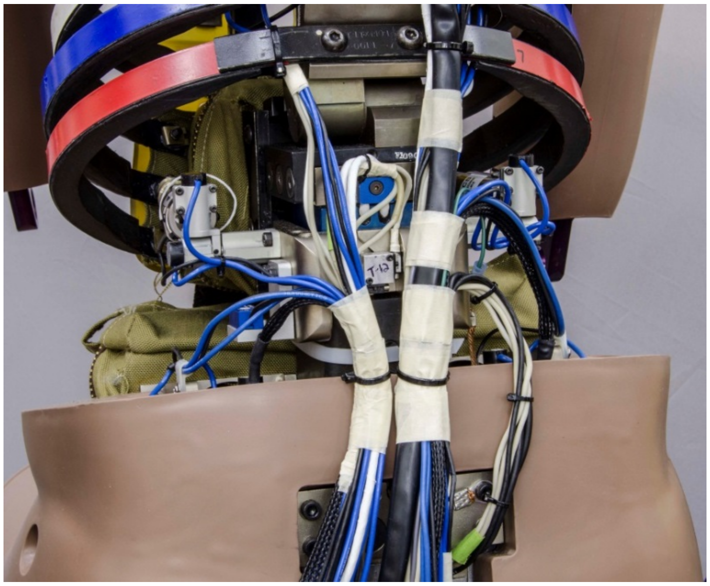


Figure 15-33. Bundle the left side wiring together

15.4.4.2 Gather the wiring bundles from the left and right sides of the dummy and tie-wrap them together (Figure 15-34).

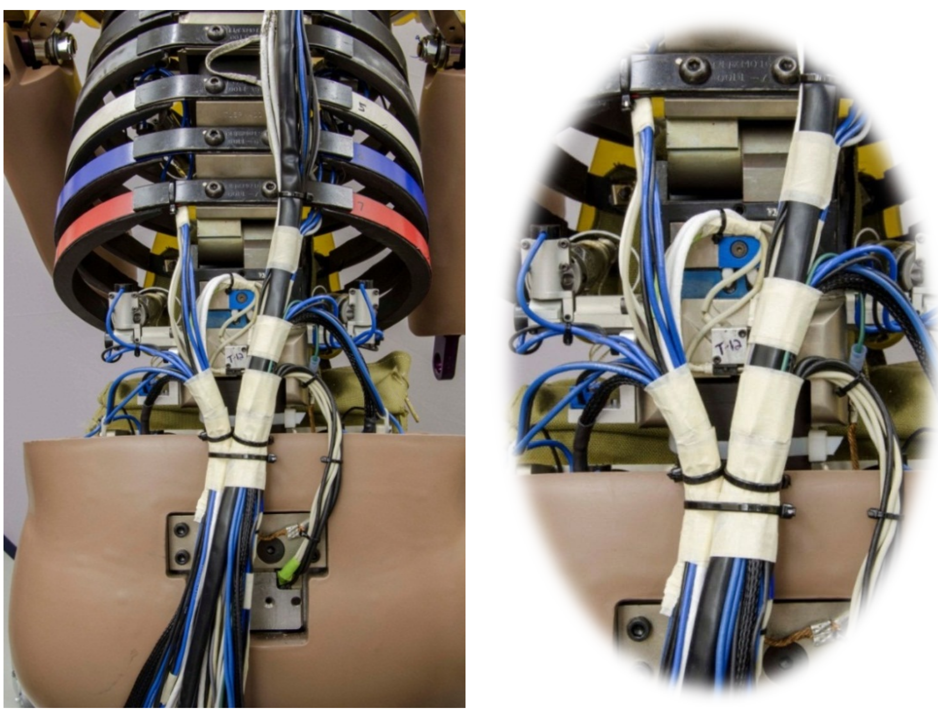


Figure 15-34. Tie the left and right cable bundles together

15.4.4.3 Additional masking tape and/or tie-wraps should be used along the cable bundle to hold the wiring in the "umbilical" cable together (Figure 15-35).

Figure 15-35. Final bundling of the "umbilical" cable

15.5 THOR-50M Instrumentation Polarity Check

A polarity check should be conducted each time the THOR-50M is connected to a data acquisition system. Polarity checks are important because not all of the instrumentation in the THOR-50M is oriented, as installed, in accordance with SAE-J1733. Furthermore, conducting a pre-test polarity check will rule out wiring errors to ensure proper data collection.

To conduct the polarity check, connect the instrumentation to the data acquisition system, ideally in the same plugin configuration used for the test series. Open a live view of the data channel in question (see the manual for your data acquisition system's interface software for more information). Apply the manipulation listed in the "Motion" column for each row in the Polarity Checklist table and observe the response (Table 15-4 through Table 15-10). If the response does not match the "SAE-J1733 Polarity" column, the channel must be inverted in your data acquisition system's software or test setup file. You might find it useful to print this section to facilitate this procedure.

The complexity of the 3D IR-TRACC assemblies in the chest and abdomen requires a more detailed polarity check procedure (see Section 15.5.1).

Table 15-4. Head and Neck Polarity Check for THOR-50M

Instrument	Direction	Motion	SAE-J1733 Polarity	Recorded Polarity	Flip?
Head Accelerometers (CG)	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy to left (right side up)	+		
	Az	Rotate dummy back (face up)	+		
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 rear, chest forward	+		
	Fy	Move head left, chest right	+		
	Fz	Move head up, chest down	+		
	Mx	Rotate left ear toward left shoulder	+		
	My	Rotate chin toward sternum	+		
	Mz	Rotate chin toward left shoulder	+		
Lower Neck Load Cell	Fx	Move neck rear, chest forward	+		
	Fy	Move neck left, chest right	+		
	Fz	Move neck up, chest down	+		
	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 Load Cells	Fx	Hold back of head, push face rearward	-		

Table 15-5. Spine and Thorax Polarity Check for THOR-50M

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
T1 Accelerometer	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy to left (right side up)	+		
	Az	Rotate dummy back (face up)	+		
Mid Sternum Accelerometer	Ax	Rotate dummy back (face up)	+		
T6 Accelerometer (Chest CG)	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy to left (right side up)	+		
	Az	Rotate dummy back (face up)	+		
T12 Accelerometer	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy to left (right side up)	+		
	Az	Rotate dummy back (face up)	+		
T12 Load Cell	Fx	Move chest rear, pelvis forward	+		
	Fy	Move chest left, pelvis right	+		
	Fz	Move chest up, pelvis down	+		
	Mx	Rotate left shoulder toward left hip	+		
	My	Rotate sternum towards front of legs	+		

Table 15-6. Abdomen Polarity Check for THOR-50M

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Upper Abdomen Accelerometer	Ax	Rotate dummy back (face up)	+		

Table 15-7. Pelvis Polarity Check for THOR-50M

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Pelvis CG Accelerometer (tri-pack)	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy to left (right side up)	+		
	Az	Rotate dummy back (face up)	+		
L Acetabular LC	Fx	Move femur rearward, pelvis forward	+		
	Fy	Move femur leftward, pelvis rightward	+		
	Fz	Move femur upward, pelvis downward	+		
R Acetabular LC	Fx	Move femur forward, pelvis rear	+		
	Fy	Move femur right, pelvis left	+		
	Fz	Move femur down, pelvis up	+		
L ASIS	Fx	Push in towards back of pelvis	-		
	My	Push top of ASIS towards back of pelvis	+		
R ASIS	Fx	Push in towards back of pelvis	-		
	My	Push top of ASIS towards back of pelvis	+		

Table 15-8. Femur Polarity Check for THOR-50M

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Left Femur Load Cell	Fx	Move knee upward, upper femur down	+		
	Fy	Move knee right, upper femur left	+		
	Fz	Move knee forward, femur rear	+		
	Mx	Rotate knee left, hold upper femur	+		
	My	Rotate knee up, hold upper femur	+		
	Mz	Rotate tibia left, hold pelvis	+		
Right Femur Load Cell	Fx	Move knee upward, upper femur down	+		
	Fy	Move knee right, upper femur left	+		
	Fz	Move knee forward, femur rear	+		
	Mx	Rotate knee left, hold upper femur	+		
	My	Rotate knee up, hold upper femur	+		
	Mz	Rotate tibia left, hold pelvis	+		

Table 15-9. Left Lower Extremity Polarity Check for THOR-50M

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Knee Shear Displacement	Dx	Hold femur, move tibia forward	+		
Upper Tibia Load Cell	Fx	Move tibia forward, knee rearward	+		
	Fy	Move tibia right, knee left	+		
	Fz	Move tibia down, knee up	+		
	Mx	Rotate tibia left, hold knee	+		
	My	Rotate tibia up, hold knee	+		
Lower Tibia Load Cell	Fx	Move ankle forward, knee rearward	+		
	Fy	Move ankle right, knee left	+		
	Fz	Move ankle down, knee up	+		
	Mx	Rotate ankle left, hold knee	+		
	My	Rotate ankle up, hold knee	+		
Tibia Accelerometer	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy left (right side up)	+		
Achilles Load Cell	Fz	Rotate foot forward	+		
Ankle Rotation	θ_x	Hold tibia, rotate foot leftward	+		
	θ_y	Hold tibia, pull toe upward	+		
	θ_z	Hold tibia, rotate foot CW	+		
Foot Acceleration	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy left (right side up)	+		
	Az	Rotate dummy back (face up)	+		

Table 15-10. Right Lower Extremity Polarity Check for THOR-50M

Instrument	Direction	Motion	SAE-J211 Polarity	Recorded Polarity	Flip?
Knee Shear Displacement	Dx	Hold femur, move tibia forward	+		
Upper Tibia Load Cell	Fx	Move tibia forward, knee rearward	+		
	Fy	Move tibia right, knee left	+		
	Fz	Move tibia down, knee up	+		
	Mx	Rotate tibia left, hold knee	+		
	My	Rotate tibia up, hold knee	+		
Lower Tibia Load Cell	Fx	Move ankle forward, knee rearward	+		
	Fy	Move ankle right, knee left	+		
	Fz	Move ankle down, knee up	+		
	Mx	Rotate ankle left, hold knee	+		
	My	Rotate ankle up, hold knee	+		
Tibia Accelerometer	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy left (right side up)	+		
Achilles Load Cell	Fz	Rotate foot forward	+		
Ankle Rotation	θ_x	Hold tibia, rotate foot leftward	+		
	θ_y	Hold tibia, pull toe upward	+		
	θ_z	Hold tibia, rotate foot CW	+		
Foot Acceleration	Ax	Rotate dummy back (face up)	+		
	Ay	Rotate dummy left (right side up)	+		
	Az	Rotate dummy back (face up)	+		

15.5.1 IR-TRACC Polarity

In order to reduce the risk of damage to instrumentation, do not disconnect the 3D IR-TRACC units from the rib cage to conduct the polarity tests. This Section describes an alternate procedure for checking the 3D IR-TRACC polarity. Note that due to the use of a standardized IR-TRACC setup fixture to determine potentiometer offsets, the polarity of the rotational potentiometers in the IR-TRACC assemblies as installed in the THOR will not correspond with SAE J211 polarity. Instead, potentiometer polarities will match those measured as installed in the *THOR 3D IR-TRACC Setup Fixture*, which in turn match the inherent polarity of the potentiometers. The expected polarities are for the thorax are shown in Figure 15-36 and expected polarities for the abdomen are shown in Figure 15-37.

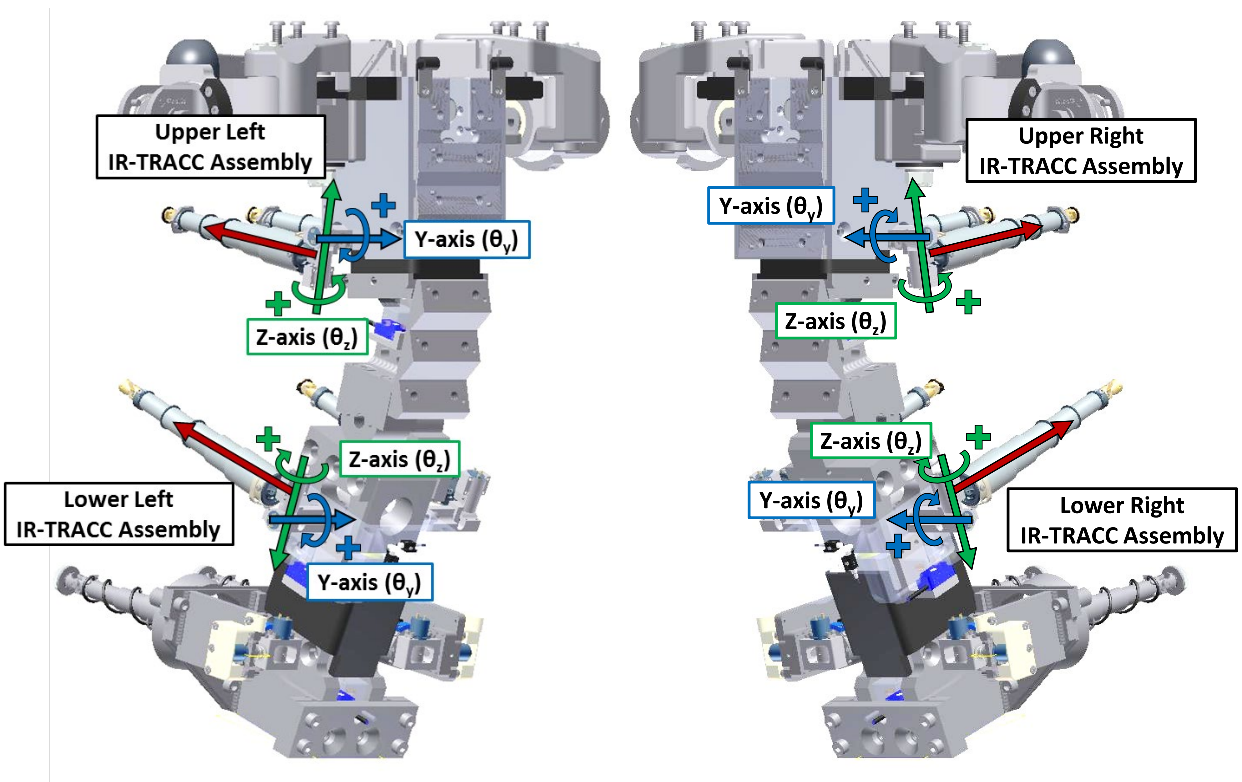


Figure 15-36. Sign conventions for 3D IR-TRACCs installed in THOR-50M thorax

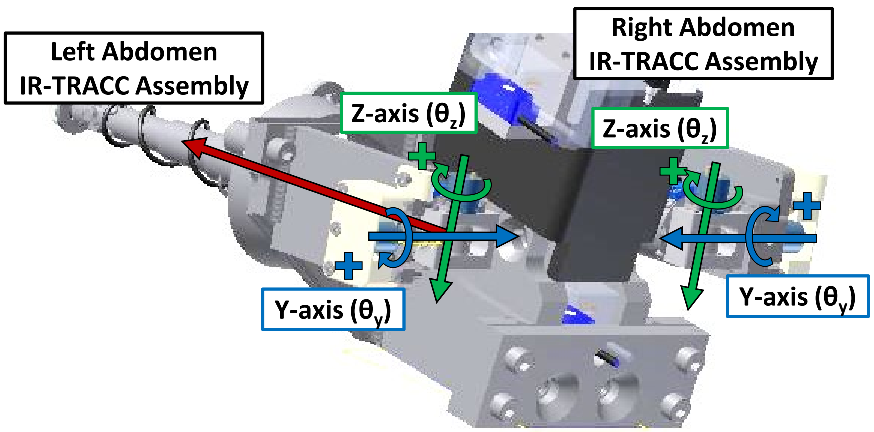


Figure 15-37. Sign conventions for 3D IR-TRACCs installed in the THOR-50M abdomen.

15.5.1.1 Using the data acquisition system control software, open a live view of each channel. If possible, view the DX, RY, and RZ components of a given quadrant simultaneously.

15.5.1.2 Record the initial reading of each channel.

15.5.1.3 Perform the following motions on each of the four thoracic rib attachment locations and two abdomen attachment locations (Table 15-11).

Table 15-11. Polarity Manipulations for 3D IR-TRACC Assemblies

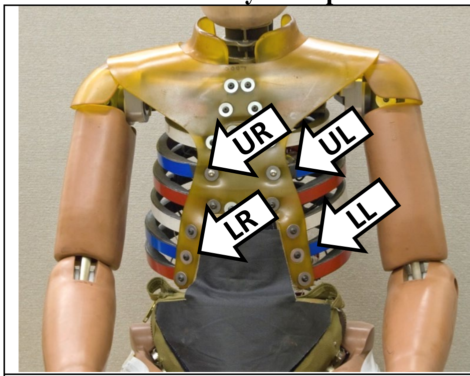
Location	Instrumentation	Motion
DX	IR-TRACC	Push inward (front-to-back)
RY	Rotational potentiometer	Push downward (head-to-pelvis)
RZ	Rotational potentiometer	Push rightward (left-to-right)

15.5.1.4 Record the final reading of each channel (Table 15-12 and Table 15-13).

15.5.1.5 If the final reading represents an increase from the initial reading, record “Increase” in the box to the right. If the final reading represents a decrease from the initial reading, record “Decrease” in the box to the right.

15.5.1.6 If the “Measured” value (increase or decrease) does not match the “Expected” value, invert the polarity of the channel.

Table 15-12. Polarity Manipulation Results for Thoracic 3D IR-TRACCs

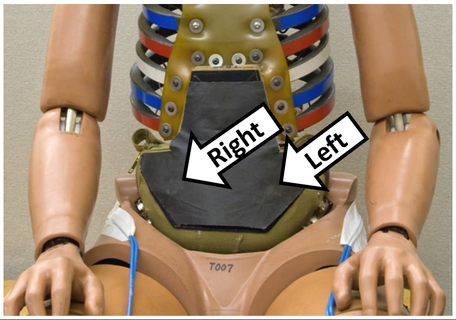


Note that due to the use of a standardized IR-TRACC setup fixture to determine potentiometer offsets, the polarity of the rotational potentiometers in the IR-TRACC assemblies as installed in the THOR will not necessarily correspond with SAE J211 polarity.

UR					UL				
Channel	**Initial**	**Final**	**Measured**	**Expected**	**Channel**	**Initial**	**Final**	**Measured**	**Expected**
DX (V)				**Increase**	DX (V)				**Increase**
RY (Deg)				**Increase**	RY (Deg)				**Decrease**
RZ (Deg)				**Decrease**	RZ (Deg)				**Decrease**

LR					LL				
Channel	**Initial**	**Final**	**Measured**	**Expected**	**Channel**	**Initial**	**Final**	**Measured**	**Expected**
DX (V)				**Increase**	DX (V)				**Increase**
RY (Deg)				**Increase**	RY (Deg)				**Decrease**
RZ (Deg)				**Increase**	RZ (Deg)				**Increase**

Table 15-13. Polarity Manipulation Results for Abdomen 3D IR-TRACCs



Abdomen Right				Abdomen Left			
Channel	**Initial**	**Final**	**Measured** / **Expected**	**Channel**	**Initial**	**Final**	**Measured** / **Expected**
DX (V)			/ **Increase**	DX (V)			/ **Increase**
RY (Deg)			/ **Increase**	RY (Deg)			/ **Decrease**
RZ (Deg)			/ **Increase**	RZ (Deg)			/ **Increase**

15.6 Tilt Sensors and Readout Display

Tilt sensors mounted to the head, lower neck, T6, T12, and pelvis provide a complete orientation of the dummy's posture in static (pre- or post-test) mode.
Connect the tilt sensors to a digital device such as a laptop, etc. with the tilt sensor software installed, via the interface, which accepts the signals from the five tilt sensors. The serial number, ID, and calibration information for each tilt sensor are stored in the software in order to display the appropriate angles.

Section 16. **IR-TRACC Calibration Overview**

This Section describes the calibration procedures for the chest deflection instrumentation of the THOR-50M. Prior to installation in the dummy, each 3D IR-TRACC assembly must be calibrated. Each of the three sensors (IR-TRACC and two rotary potentiometers) are calibrated separately. The entire assembly is then installed into the 3D IR-TRACC Setup Fixture to zero the rotary potentiometers and determine the initial offset values.

The THOR-50M chest deflection measurement uses an IR-TRACC and two rotary potentiometers (Y-axis and Z-axis) installed in a double-gimbaled assembly to measure IR-TRACC compression and IR-TRACC Y-axis and Z-axis rotations (Figure 16-1). Post-test processing of these three measurements can then be used to calculate X-axis, Y-axis and Z-axis displacement of the pivoting end of the IR-TRACC. The gimbaled end of the assembly attaches to the spine and the pivoting end of the IR-TRACC attaches to the component to be measured. Six of these IR-TRACC assemblies are used in the THOR-50M dummy including two in the upper thorax (left and right), two in the lower thorax (left and right) and two in the abdomen (left and right).

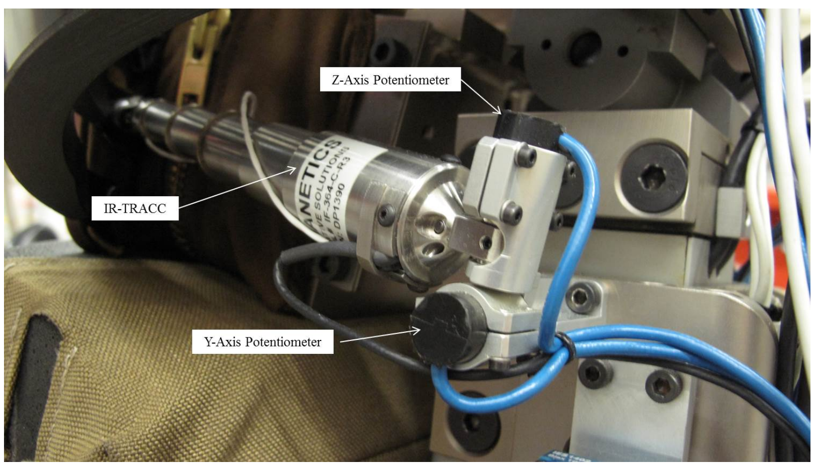


Figure 16-1. THOR-50M 3D IR-TRACC assembly

Before the 3D IR-TRACC assembly can be used in a dummy, it must be disassembled so that the three transducers (IR-TRACC, Y-axis rotary potentiometer and Z-axis rotary potentiometer) can be individually calibrated. The rotary potentiometers are each calibrated in a rotary potentiometer calibration fixture to determine their sensitivity in engineering units (mV/V/°). The IR-TRACC is calibrated in a linear displacement calibration fixture to determine the relationship between output voltage and compression distance. Since the IR-TRACC operates according to the inverse-square law where the intensity of light at the receiver end of the IR-TRACC is inversely proportional to the square of the distance from the light source end of the IR-TRACC, the relationship between output voltage and IR-TRACC compression distance will be non-linear. Therefore, the IR-TRACC output voltage must first be linearized using a linearization exponent before the IR-TRACC sensitivity (mm/V) can be calculated. The IR-TRACC calibration process includes the following steps:

1. Record IR-TRACC voltage output vs. compression distance in a linear displacement calibration fixture.
2. Determine the *optimized linearization exponent* that best linearizes the IR-TRACC voltage output vs. IR-TRACC compression distance relationship (16.2.2.4).
3. Calculate the IR-TRACC sensitivity (mm/V).

After calibrating the transducers, they are re-assembled into the 3D double-gimbaled assembly. Before the assembly can be installed in the dummy, it must be installed in the *THOR 3D IR-TRACC Setup Fixture* to determine reference (intercept) values. These intercept values account for the geometry and orientation of the sensors in their as-installed configuration and allow calculation of the absolute 3D position of the anterior attachment point in the local spine coordinate system. The IR-TRACC intercept converts the measured compression to a pivot-to-pivot length (Figure 16-2) and the Y-axis and Z-axis rotational potentiometer intercepts zero the measured angles when the assembly is oriented such that the pivot-to-pivot measurement is parallel to the X-axis of the local spine coordinate system (Figure 16-3) for the upper spine coordinate system).

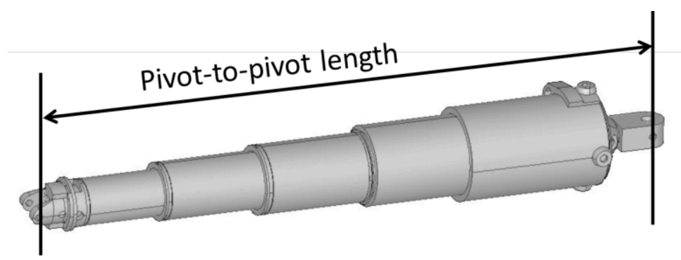


Figure 16-2. Pivot-to-pivot length of IR-TRACC sensor

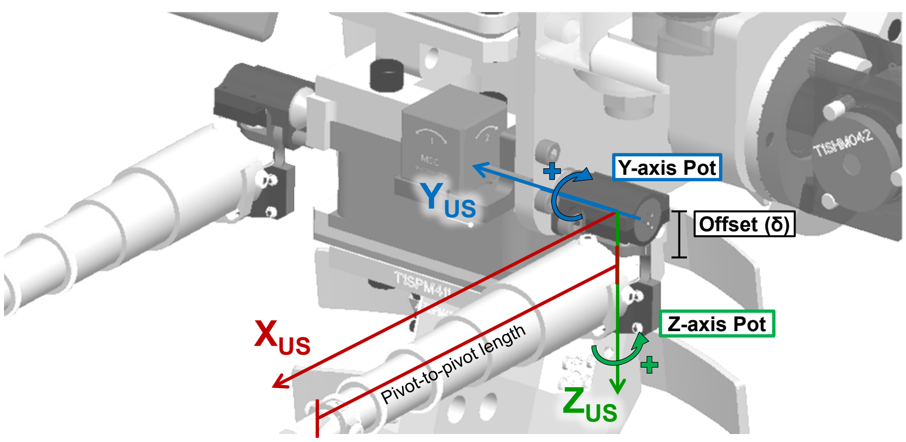


Figure 16-3. Orientation of IR-TRACC assembly parallel to local spine coordinate system

These intercepts, along with IR-TRACC calibration parameters, are documented on the "THOR 3D IR-TRACC Calibration Summary Sheet" (Figure 16-18). These values are then used in conjunction with the equations in Section 17, to output 3D position time-histories of thoracic and abdominal deflection in the local spine coordinate system.

16.1 Instrument Wiring

A consistent transducer wiring scheme is required to maintain standardized 3D IR-TRACC assembly polarities. Polarity checks should still be performed prior to testing to verify expected data channel polarities (see Section 15.5.1).

16.1.1 **Potentiometer Wiring**

The Y-axis and Z-axis potentiometers should be wired so that a counter-clockwise rotation of the potentiometer shaft (looking from the shaft end of the potentiometer) produces a more positive voltage output. Completion resistors should be added to the potentiometer so that it operates as a full-bridge transducer. A schematic diagram is shown in Figure 16-4. The wiring pin-outs for the IR-TRACC are included in Table 16-1.

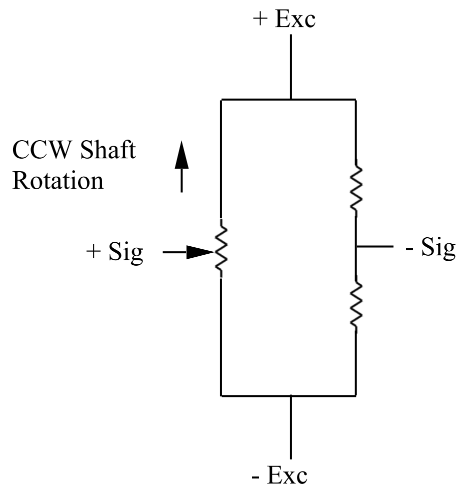


Figure 16-4. Potentiometer wiring schematic

Table 16-1. Potentiometer Wiring Pin-Outs

Wire Color	Pin
Red	+Excitation
Green	+Signal
Orange	Channel ID
Shield	Ground
White	-Signal
Black	-Excitation

16.1.2 **IR-TRACC Wiring**

The IR-TRACC should be wired and powered according to the manufacturer's instructions. The IR-TRACC un-scaled and non-linearized output should be a positive voltage that increases as the IR-TRACC is compressed. The wiring pin-outs for the IR-TRACC are included in Table 16-2.

Table 16-2. IR-TRACC Wiring Pin-Outs

Wire Color	Pin
Red	+Excitation
Green	+Signal
Orange	Channel ID
Shield	Ground
White	-Signal
Black	-Excitation

16.2 Transducer Calibration

16.2.1 **Potentiometer Calibration**

16.2.1.1 Remove the potentiometer from the double-gimbaled assembly and install it into the rotary potentiometer calibration fixture. A typical rotary potentiometer calibration fixture is shown in Figure 16-5.

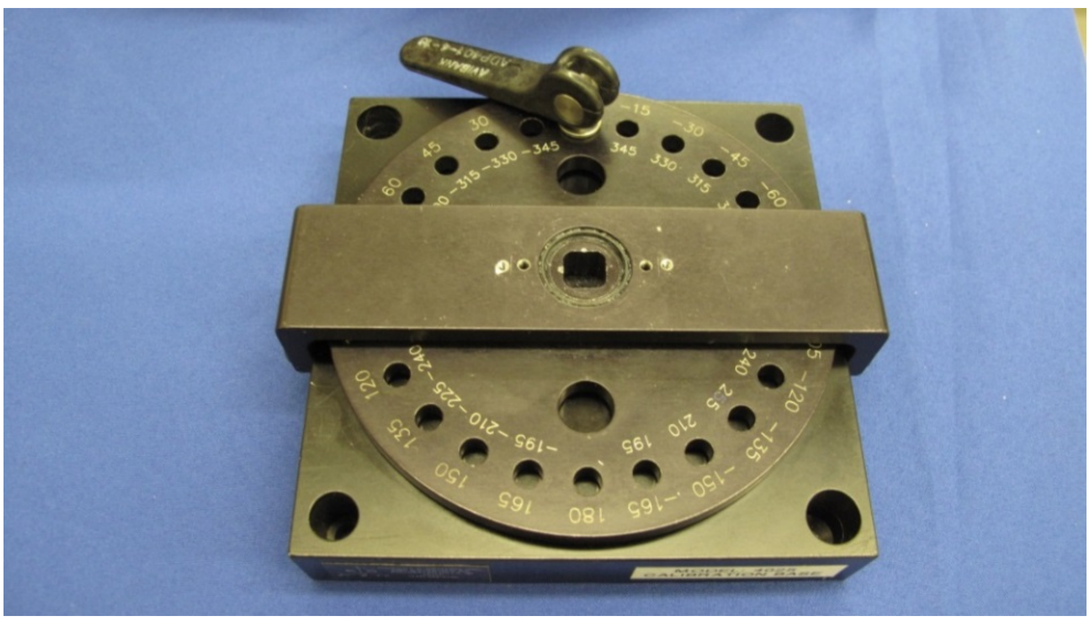


Figure 16-5. Example potentiometer calibration fixture

16.2.1.2 Set the calibrator to the 0° position. Before the potentiometer is fastened into the fixture, rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Fasten the potentiometer body and shaft into the fixture in this position.

16.2.1.3 Record the potentiometer output voltage at 15° increments from -75° to +75°. Calculate the slope (Potentiometer Sensitivity) of the potentiometer output voltage vs. potentiometer rotation angle using a linear regression function. Using the results of the linear regression function and the recorded calibration voltages, calculate the angle at each of the calibration positions. Determine the non-linearity error as a percentage of the full-scale range. Refer to SA572-S114 for performance requirements. An example rotary potentiometer calibration summary is shown in Figure 16-6.

16.2.1.4 Repeat this procedure for both potentiometers and then re-install them into the 3D IR-TRACC assembly. Before tightening the potentiometer shaft set-screw, see the assembly Section for the IR-TRACC location, for potentiometer shaft positioning instructions.

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Rotary Potentiometer Calibration

$$\frac{|Rotation - Calculated\ Rotation|}{Range\ (150)} \times 100$$

Model Number: PD210-4B
Serial Number: DG5916
Technician: R. Waldeck

Date: 11/7/2013
Temperature: 71 F
Humidity: 50 %
Excitation: 10 V

Rotation (Degrees)	Sensor Output (V)	Sensor Output Zeroed (V)	Calculated Rotation (Degrees)	% F.S. Error
-75	-2.3360	-2.3019	-75.2	0.14
-60	-1.8834	-1.8493	-60.4	0.28
-45	-1.4202	-1.3861	-45.3	0.19
-30	-0.9465	-0.9124	-29.8	0.12
-15	-0.4875	-0.4534	-14.8	0.12
0	-0.0341	0.0000	0.0	0.00
15	0.4187	0.4528	14.8	0.14
30	0.8707	0.9048	29.6	0.29
45	1.3304	1.3645	44.6	0.28
60	1.7953	1.8294	59.8	0.15
75	2.2619	2.2960	75.0	0.02

$$SensorOutput - SenorOutput\ @\ 0\ degrees$$

$$\frac{Sensor\ Output\ Zeroed \times 1000}{Sensitivity \times Excitation}$$

Max. Linearity Error (Max. Allowable is .5 %): 0.29 %

Sensitivity: 3.0604 mV/V/deg

Approved By: ____________________

Figure 16-6. Example rotary potentiometer calibration sheet

16.2.2 **IR-TRACC Calibration**

16.2.2.1 Remove the IR-TRACC from the double-gimbaled assembly and install it into a linear displacement calibration fixture DL472-6000 as shown in Figure 16-7.

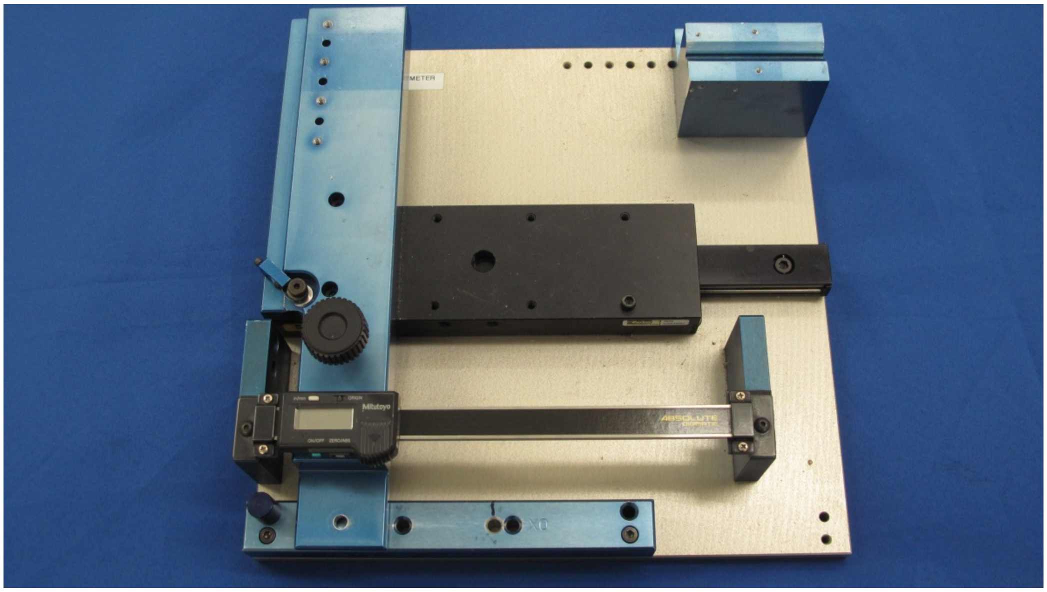

Figure 16-7. IR-TRACC linear displacement calibration fixture

16.2.2.2 Fully extend the IR-TRACC and zero the measurement reference at the fully extended position. Compress the IR-TRACC to 5 mm. The 5 mm position will be the first calibration data point. Record the IR-TRACC voltage output in this position.

16.2.2.3 Record the IR-TRACC output voltage at 5 mm increments until it is fully compressed (87 mm for thorax IR-TRACCs and 117 mm for abdomen IR-TRACCs).

16.2.2.4 Calculate the linearization exponent and sensitivity that minimize the error between the actual value and the value measured by the IR-TRACC. Refer to instrumentation drawings (SA572-S117 for thorax IR-TRACCs or SA572-121 for abdomen IR-TRACCs) or manufacturer's instructions for allowable linearity and full-scale error requirements. See Table 16-3 for more information. An example rotary IR-TRACC calibration sheet is shown in Figure 16-8.

16.2.2.5 Re-install the IR-TRACC into the 3D IR-TRACC assembly.

Table 16-3. IR-TRACC calibration process details

Parameter	Description	Calculation
IR-TRACC Calibration		
IR-TRACC Known Displacement (mm)	Known displacement (compression) of IR-TRACC tube as measured by fixture or caliper. The origin of displacement occurs when the IR-TRACC tube is fully-extended	D_{known}
IR-TRACC Output (V)	Voltage measured from the IR-TRACC	V_{IR}
Linearization Exponent	Exponent which minimizes full-scale error. Minimum value is -0.500 based on inverse square law.	LE
Linearized Output (V)	Voltage calculated by raising the sensor output to the power of the linearization exponent	$V_L = (V_{IR})^{LE}$
IR-TRACC Calibration Slope (V/mm) & Intercept (V)	Linear Regression of $V_L\ vs.\ D_{known}$ calculated using the LE which minimizes full-scale error	S_{cal} I_{cal}
IR-TRACC Sensitivity (mm/V)	Inverse of the IR-TRACC slope	$IR_{sens} = -\frac{1}{S_{cal}}$
IR-TRACC Calculated Displacement (mm)	Displacement (compression) of IR-TRACC tube calculated using the IR-TRACC calibration slope and intercept	$D_{IR} = \frac{V_L - I_{cal}}{S_{cal}}$
% F.S. Error	Error between calculated displacement and known displacement, expressed as a percentage of full measurement (87 mm for thorax IR-TRACCs and 117 mm for abdomen IR-TRACCs)	$\%\,F.S.\ Error = \frac{\lvert D_{known} - D_{IR}\rvert}{\begin{cases} 87mm\ (thorax) \\ 117mm (abdomen)\end{cases}} \times 100\%$
Offsets From Reference Fixture		
IR-TRACC Absolute Intercept (mm)	Calculated offset such that when IR-TRACC assembly is in Position #1 in *THOR 3D IR-TRACC Setup Fixture*, D_{abs} equals the known fixture length (139.8 mm for thorax IR-TRACC and 150.9 mm for abdomen IR-TRACC)	$I_{abs} = \begin{cases} 139.8\ (thorax) \\ 150.9\ (abdomen)\end{cases} - IR_{sens} * (V_{IR\ @P1})^{LE}$
Y-axis Potentiometer Intercept (deg)	Calculated offset such that when IR-TRACC assembly is in Position #1 in *THOR 3D IR-TRACC Setup Fixture*, Y-axis potentiometer angle equals zero	$I_Y = \frac{-Y_{meas@P1}}{Y_{sens} \times Y_{excitation}}$
Z-axis Potentiometer Intercept (deg)	Calculated offset such that when IR-TRACC assembly is in Position #1 in *THOR 3D IR-TRACC Setup Fixture*, Z-axis potentiometer angle equals zero	$I_Z = \frac{-Z_{meas@P1}}{Z_{sens} \times Z_{excitation}}$
Post-Test Processing Software		
Non-coincident potentiometer correction	Where the Y-axis and Z-axis potentiometers are not coincident an offset correction must be applied to the coordinate systems.	Upper thorax 3D IR-TRACC (δ) = 15.65 mm Lower thorax 3D IR-TRACC (δ) = 15.65 mm Abdomen 3D IR-TRACC (δ) = 0 mm
IR-TRACC absolute compression	The absolute distance from the center pin of the universal joint at the anterior attachment point to the intersection of the IR-TRACC tube with the Z-axis potentiometer (see Figure 16-2)	$r_t = V_L \times \lvert IR_{sens}\rvert + I_{abs}$
Absolute Position (mm)	Resulting position of the anterior attachment point of the IR-TRACC assembly with respect to the intersection between the Z-axis and Y-axis potentiometers in the local spine coordinate system; example shown for lower left thorax IR-TRACC assembly.	$X_{abs} = r_{t*} cos([\theta_Z + I_Z]) * cos([\theta_Y + I_Y]) + \delta * sin([\theta_Y + I_Y])$ $Y_{abs} = r_t * sin([\theta_Z + I_Z])$ $Z_{abs} = -r_t * cos([\theta_Z + I_Z]) * sin([\theta_Y + I_Y]) + \delta * cos\ ([\theta_Y + I_Y])$

NHTSA Vehicle Research and Test Center

IR-TRACC Calibration

$$\% \, F.S.\, Error = \frac{|D_{known} - D_{IR}|}{\begin{cases} 87mm\ (thorax) \\ 117mm (abdomen) \end{cases}} \times 100\%$$

Model Number:
Serial Number:
Technician:

Date: 11/7/2013
Temperature: 71.0 F
Humidity: 50 %
Excitation: 5 V

Displacement (mm) D_{known}	Sensor Output (V) V_{IR}	Linearized Output (V) V_L	Calculated Displacement (mm) D_{IR}	% F.S. Error
5	0.0759	2.8390	4.88	-0.13
10	0.0846	2.7170	9.88	-0.14
15	0.0950	2.5924	14.98	-0.02
20	0.1071	2.4697	20.01	0.01
25	0.1219	2.3436	25.17	0.20
30	0.1384	2.2263	29.98	-0.03
35	0.1594	2.1026	35.04	0.05
40	0.1852	1.9787	40.12	0.13
45	0.2165	1.8575	45.08	0.09
50	0.2559	1.7360	50.05	0.06
55	0.3063	1.6142	55.04	0.05
60	0.3715	1.4929	60.01	0.01
65	0.4573	1.3725	64.94	-0.07
70	0.5749	1.2511	69.91	-0.10
75	0.7425	1.1280	74.95	-0.05
80	0.9841	1.0065	79.93	-0.08
85	1.3469	0.8865	84.85	-0.18
87	1.5859	0.8298	87.17	0.20

$$V_L = (V_{IR})^{LE}$$

$$D_{IR} = \frac{V_L - I_{cal}}{S_{cal}}$$

Max. Linearity Error (Max. Allowable is 2%): 0.20 %

Sensitivity (IR_{sens}): 40.9547 mm/V

Linearization Exponent (LE): -0.4047

Approved By: ____________________

Figure 16-8. Example IR-TRACC calibration sheet

16.3 Measuring 3D IR-TRACC Assembly Reference (Intercept) Values

After the potentiometers and the IR-TRACC are calibrated using the procedures described in Section 16.2.1, Potentiometer Calibration, and Section 16.2.2, IR-TRACC Calibration, the 3D double-gimbaled assembly is installed in the *THOR 3D IR-TRACC Setup Fixture* (Humanetics P/N TF-472-6000), as shown in Figure 16-9, to obtain intercept values, verify calibration/setup parameters and to check sensor wiring polarities.

Figure 16-9. THOR-50M 3D IR-TRACC setup fixture

The setup fixture uses both sides of the base plate to accommodate all six of the THOR-50M 3D IR-TRACC positions. The top side of the plate is used for the upper right thorax, lower left thorax and right abdomen 3D IR-TRACC assemblies and the bottom side is used for upper left thorax, lower right thorax and left abdomen assemblies (see Figure 16-10 and Figure 16-11, respectively).

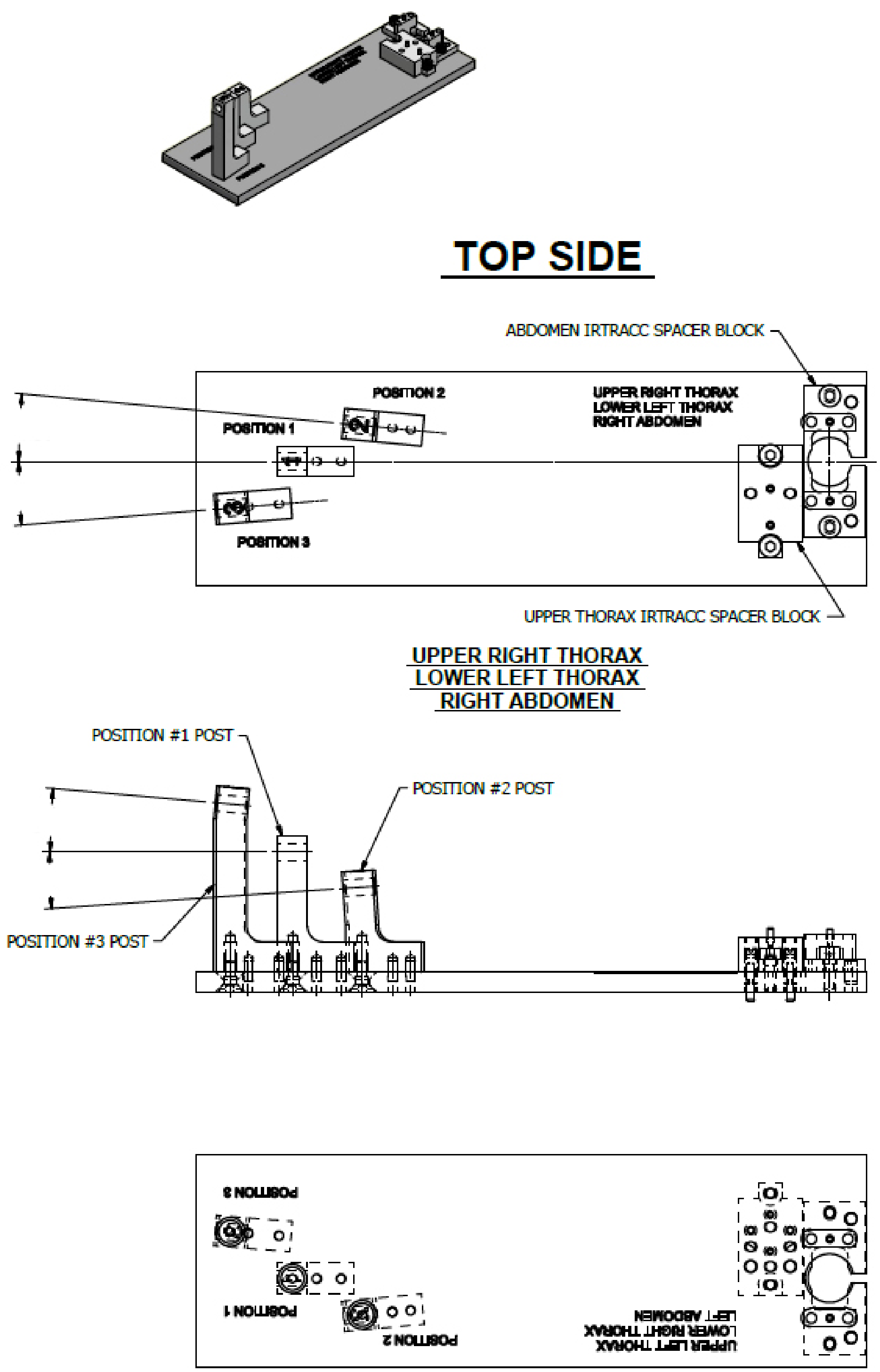

Figure 16-10. Top side IR-TRACC zero fixture

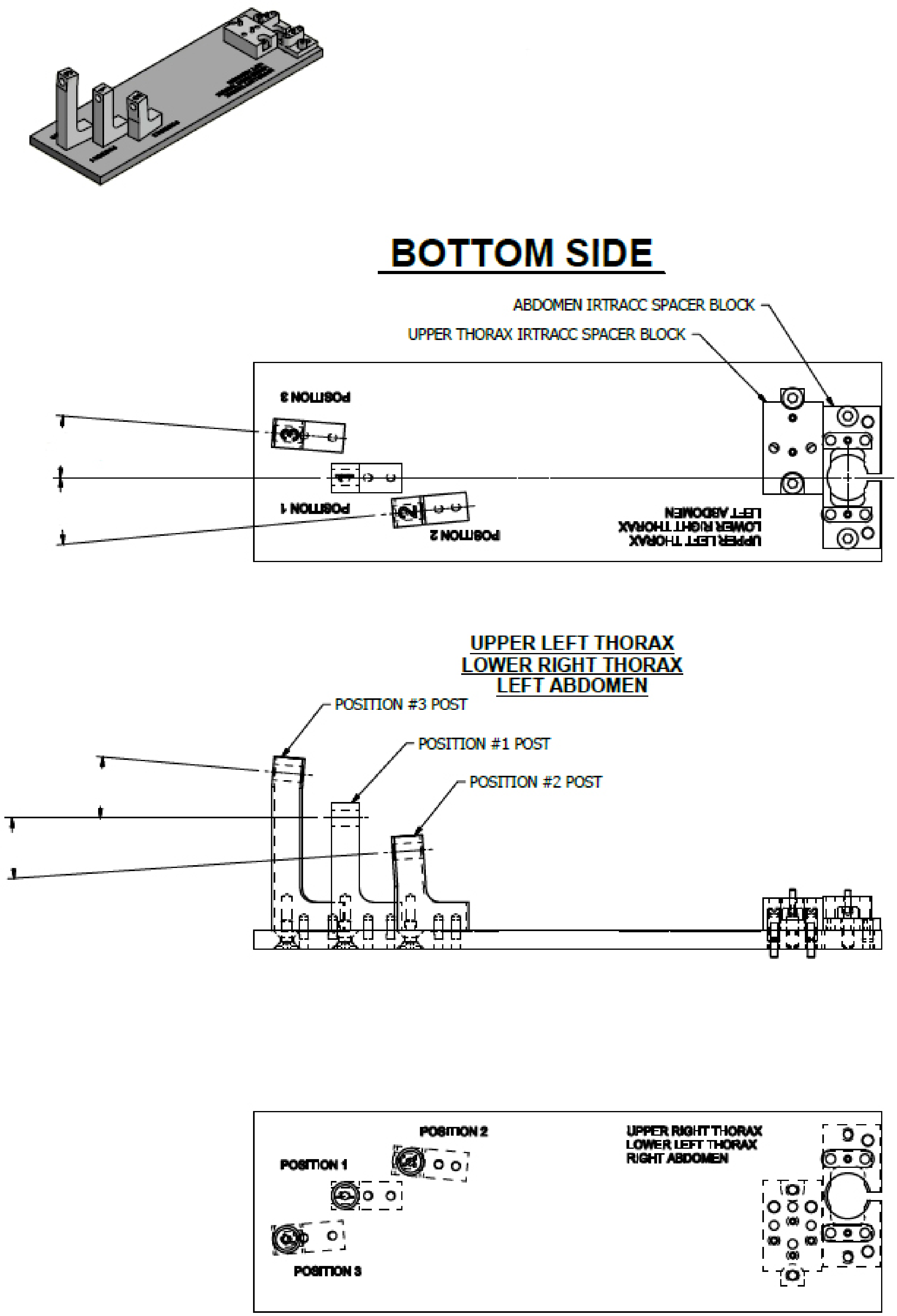

Figure 16-11. Bottom side IR-TRACC zero fixture

Figure 16-12 thru Figure 16-17 below show each of the six THOR-50M 3D IR-TRACC assembly types installed in the setup fixture. Note that since the bases used in the upper thorax IR-TRACC assemblies are shorter than those used in the lower thorax assemblies, a spacer block under the upper thorax bases is required, as shown in Figure 16-12 and Figure 16-13. All of the setup fixture posts and spacers use dowel pins with unique spacing to ensure that they can be installed only in the correct location and orientation.

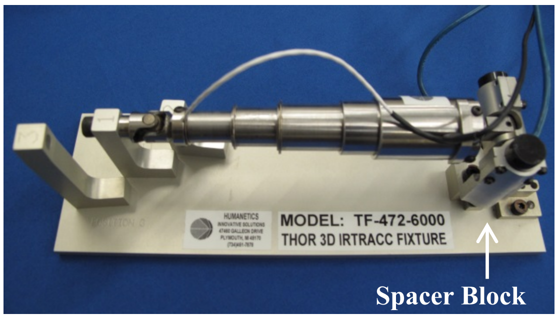

Figure 16-12. Upper right thorax

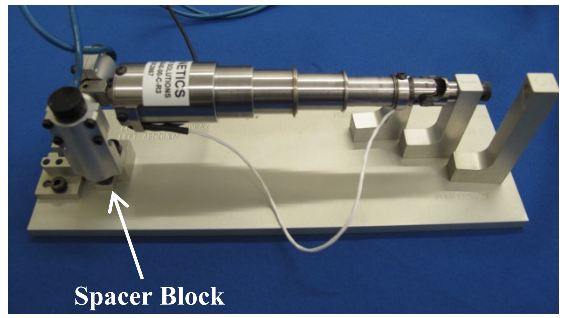

Figure 16-13. Upper left thorax

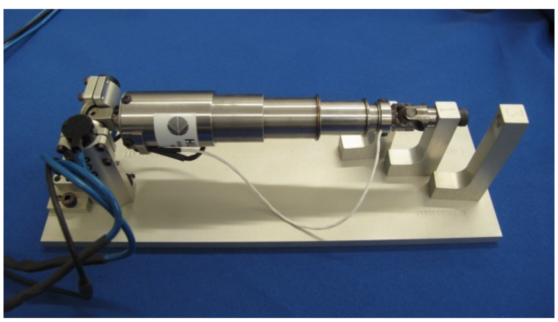
Figure 16-14. Lower right thorax

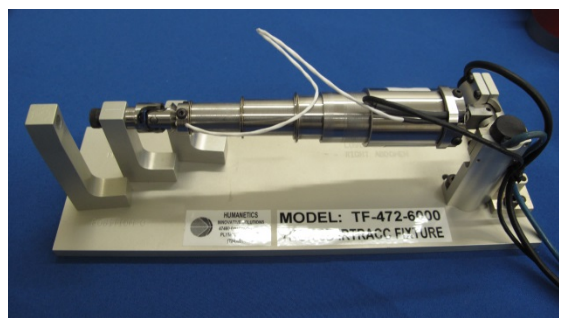
Figure 16-15. Lower left thorax

Figure 16-16. Right abdomen

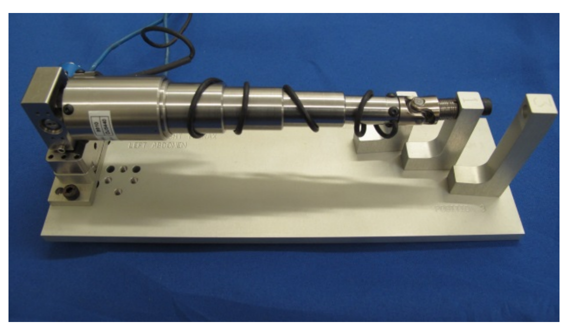
Figure 16-17. Left abdomen

After the 3D IR-TRACC assembly is installed in the setup fixture, the *THOR 3D IR-TRACC Calibration Summary* spreadsheet, shown in Figure 16-18, can be used to record all required information. The spreadsheet fields that require user input are shaded in blue. The information fields for **3D IR-TRACC Location in THOR** use drop-down menus to provide all applicable field entry choices. The information fields in the **Calibration Factors** section can be copied from the individual sensor calibration sheets obtained in Sections 16.2.1 and 16.2.2 (see Figure 16-6 and Figure 16-8). The sensor output voltages are recorded in the **THOR 3D IR-TRACC Setup Fixture Calibration** section of the spreadsheet. First, place the IR-TRACC in Position 1 on the fixture and record the IR-TRACC and potentiometer output voltages in the appropriate spreadsheet fields (Figure 16-19). Repeat this process in Position 2 and Position 3 of the fixture. Using the sensor calibration factors, the spreadsheet will calculate the sensor output in engineering units. These outputs will be compared with expected outputs based on sensor location and a pass/fail indication will be shown. The expected outputs for each 3D IR-TRACC assembly in each position on the fixture is shown in Table 16-4.

A failing test could result from a scaling error or an incorrect polarity. If the calculated engineering output has the correct sign but incorrect magnitude, check the sensitivity and excitation voltage being used. If the calculated engineering output has the correct magnitude, but incorrect sign, check the sensor wiring for possible polarity issues. Note that the *THOR 3D IR-TRACC Calibration Summary* spreadsheet polarity check only checks the sensor for correct wiring. Depending on the location of the 3D IR-TRACC assembly within the THOR-50M dummy, some sensors will require a polarity change to conform to SAE J1733polarity requirements (Section 15.5).

The **Processing Software Setup Values** section of the *THOR 3D IR-TRACC Calibration Summary* spreadsheet contains all of the information that should be required for post-test processing software. Using the equations in Section 17, 3D position time-histories of thoracic and abdominal deflection in the local spine coordinate system can be calculated.

16.4 Calibration Summary

1. Remove the potentiometers and IR-TRACC from the 3D assembly
2. Calibrate both potentiometers
3. Calibrate the IR-TRACC
4. Re-install the potentiometers and IR-TRACC into the assembly
5. Install 3D assembly into the *THOR 3D IR-TRACC Setup Fixture*
6. Record information in the *THOR 3D IR-TRACC Calibration Summary* spreadsheet to verify sensitivities, polarities and to obtain intercept (setup) values.

THOR 3D IR-TRACC Calibration Summary

Date	
Technician	

3D IR-TRACC Location in THOR	
Left or Right Side	Left
Upper or Lower (n/a for Abdomen)	Upper
Thorax or Abdomen	Thorax

$|IR_{sens}|$

LE

Calibration Factors					
IR-TRACC Model Number		Y Pot Model Number		Z Pot Model Number	
IR-TRACC Serial Number		Y Pot Serial Number		Z Pot Serial Number	
IR-TRACC Excitation	5	Y Pot Excitation (V)	5	Z Pot Excitation (V)	5
IR-TRACC Sensitivity (mm/V)	29.6587	Y Pot Sensitivity (mV/V/°)	3.0369	Z Pot Sensitivity (mV/V/°)	3.0461
IR-TRACC Exponent	-0.4981				

$(V_{IR\,@\,Pn})^{LE} * |IR_{sens}| - (V_{IR\,@\,P1})^{LE} * |IR_{sens}|$

$(V_{Y@Pn} - V_{Y@P1})/(Y_{sens} * Y_{Vex}/1000)$

$(V_{Z@Pn} - V_{Z@P1})/(Z_{sens} * Z_{Vex}/1000)$

Where:
Pn is the fixture postion number

$V_{Y@Pn}$ is the output voltage of Y-potentiometer at the designated fixture position

Y_{sens} is the sensitivity of the Y-potentiometer

Y_{Vex} is the excitation Voltage of the Y-potentiometer

Z_{sens} is the sensitivity of the Z-potentiometer

Z_{Vex} is the excitation Voltage of the Z-potentiometer

$V_{Z@Pn}$ is the output voltage of Z-potentiometer at the designated fixture position

THOR 3D IR-TRACC Setup Fixture Calibration

Fixture	IR-TRACC				Y-Axis Potentiometer				Z-Axis Potentiometer			
Position	Out (V)	Actual	Expected	Pass/Fail	Out (V)	Actual	Expected	Pass/Fail	Out (V)	Actual	Expected	Pass/Fail
1	0.0980		0		0.0762		0		0.0107		0	
2	0.1587	-20.13	-20	Pass	-0.0011	-5.09	-5	Pass	-0.0646	-4.94	-5	Pass
3	0.0669	19.76	20	Pass	0.1530	5.06	5	Pass	0.0883	5.10	5	Pass

Processing Software Setup Values

Transducer	Exponent	Sensitivity (mm/V)	Intercept
IR-TRACC	-0.4981	29.6587	45.48
Y-Axis Potentiometer			-5.02
Z-Axis Potentiometer			-0.70

I_{abs}

I_Y

I_Z

IR-TRACC Processing

IR-TRACC Length (pivot-to-pivot) = $((V_{IR\text{-}TRACC})^{Exponent}$ * Sensitivity) + Intercept

Potentiometer Processing

Y Angle$_{(THOR)}$ = Y Angle$_{(recorded\ by\ DAS)}$ + Intercept

Z Angle$_{(THOR)}$ = Z Angle$_{(recorded\ by\ DAS)}$ + Intercept

Data Acquisition System Setup
IR-TRACC and potentiometer channels used in the THOR 3D IR-TRACC assembly should be setup in the DAS so that the transducer bias is not removed prior to testing since initial positions of these transducers are required to calculate X, Y and Z-axis displacements in post-test processing software

PASS/FAIL Requirements

Rotary Pots: Expected ± 0.75°
IR-TRACC: Expected ± 2.0 mm

Figure 16-18. THOR-50M 3D IR-TRACC Calibration Summary Spreadsheet

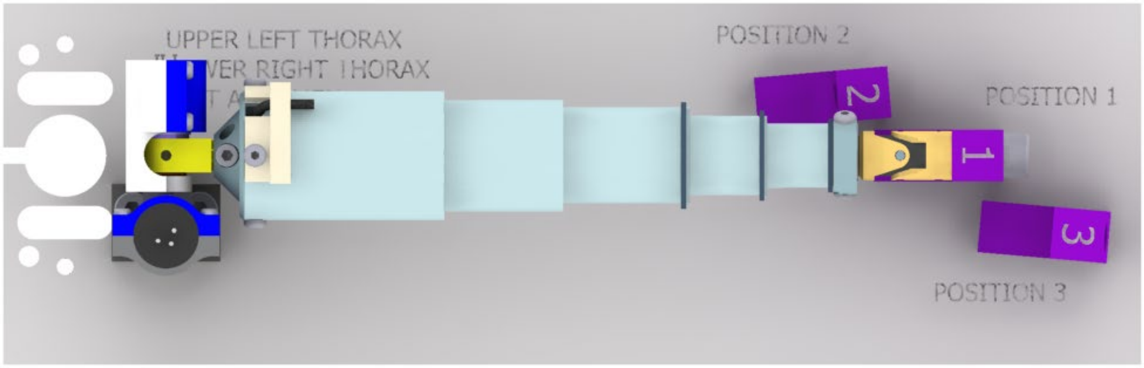

Figure 16-19. Setup to obtain expected sensor output

Table 16-4. Expected Sensor Output

3D IR-TRACC Assembly	Position 1			Position 2			Position 3		
	Θ_y (°)	Θ_z (°)	ΔL (mm)	Θ_y (°)	Θ_z (°)	ΔL (mm)	Θ_y (°)	Θ_z (°)	ΔL (mm)
Upper Left Thorax	0	0	0	-5	-5	-20	+5	+5	+20
Upper Right Thorax	0	0	0	+5	+5	-20	-5	-5	+20
Lower Left Thorax	0	0	0	+5	+5	-20	-5	-5	+20
Lower Right Thorax	0	0	0	-5	-5	-20	+5	+5	+20
Left Abdomen	0	0	0	+4.3	-4.3	-21.6	-4.3	+4.3	+21.6
Right Abdomen	0	0	0	-4.3	+4.3	-21.6	+4.3	-4.3	+21.6

Section 17. **THOR-50M IR-TRACC Processing**

17.1 IR-TRACC Deflection Calculations

The double gimbaled IR-TRACCs that are installed in the thorax and abdomen of the THOR dummy require special data collection and processing methods to calculate the X, Y, and Z linear displacements.

The axes of the Y-axis and Z-axis potentiometers that are mounted to the thorax 3D IR-TRACCs are offset from one another, and require an offset value (δ) to be applied during the calculations to shift the output displacements into the correct coordinate system. It should be noted that the potentiometers in the abdomen are coincident, and do not require the coordinate system to be shifted.

- Thorax 3D IR-TRACC (δ) = 15.65 mm
- Abdomen 3D IR-TRACC (δ) = 0 mm

***Note that all numbered equations must be followed to properly calculate the X, Y, and Z linear displacements, and the equations that are not numbered are intermediate steps that derive the numbered equations.**

17.2 Data Collection Considerations

Prior to performing any testing, verify that each 3D IR-TRACC assembly has been installed into the 3D IR-TRACC setup fixture, and that a calibration summary has been generated for each assembly within the specified calibration interval (Section 16.4).

The formulas in this Section require the IR-TRACCs to be recorded in raw voltage, and the pre-event bias of the IR-TRACCs ***must not*** be removed at any time during data collection. The potentiometers may be recorded in voltage, or in engineering units, but the pre-event bias ***must not*** be removed at any time from the channels during data collection.

17.3 Required Channels

At a minimum, the following channel time histories are required as inputs to calculate the displacements for a given 3D IR-TRACC assembly:

- IR-TRACC Voltage
- Y-Axis Angular Displacement
- Z-Axis Angular Displacement

17.4 Convert the channels to engineering units and filter

If the potentiometer time-history is output in engineering units from the DAS, then it is unnecessary to perform Equation 1 or Equation 2, but it is still necessary to convert the IR-TRACC (Equation 3) data because the time-history of the channel should be recorded in voltage.

17.4.1 **Convert the potentiometer voltage time-history to engineering units:**

where:
$V\theta_y$ is the raw Y-axis potentiometer voltage time-history
$V\theta_z$ is the raw Z-axis potentiometer voltage time-history
Y_{sens} is the sensitivity of the Y-axis potentiometer (in deg/V)
Z_{sens} is the sensitivity of the Z-axis potentiometer (in deg/V)
θ_y is the scaled time-history of the Y-axis potentiometer
θ_z is the scaled time-history of the Z-axis potentiometer

Equation 1

$$\theta_y = |Y_{sens}| * V\theta_y$$

Equation 2

$$\theta_z = |Z_{sens}| * V\theta_z$$

17.4.2 **Convert the IR-TRACC voltage time-history to engineering units:**

where:
V_{IR} is the raw IR-TRACC voltage time-history
IR_{sens} is the sensitivity for the IR-TRACC (in mm/V)
LE is the linearization exponent for the IR-TRACC
R is the linearized and scaled absolute time-history of the IR-TRACC

Equation 3

$$R = |IR_{sens}| * (V_{IR})^{LE}$$

17.4.3 Filter $\boldsymbol{\theta_y}$, $\boldsymbol{\theta_z}$, and $\boldsymbol{R}$ to the required filter class.

17.5 Data channel polarity

Prior to performing any calculations, ensure that the polarities of the time histories listed in the required channels list (Section 17.3) comply with the polarity requirements outlined in Section 15.5.1; if a channel does not comply with the polarity requirements then it must be inverted prior to performing any of the following calculations.

17.6 Calculate the relative changes from the Zero Position (3D IRTRACC setup fixture)

where:
I_Y is the "Intercept" value of the Y-axis potentiometer, as shown on the Calibration Summary (Section 16.4)
I_Z is the "Intercept" value of the Z-axis potentiometer, as shown on the Calibration Summary (Section 16.4)

I_{abs} is the "Intercept" value of the IR-TRACC, as shown on the Calibration Summary (Section 16.4)
θ_y' is the time-history of the relative change from the zero position of the Y-axis potentiometer
θ_z' is the time-history of the relative change from the zero position of the Z-axis potentiometer
r is the time-history of the relative change from the zero position of the IR-TRACC

Equation 4

$$\theta_y' = \theta_y \quad + I_Y$$

Equation 5

$$\theta_z' = \theta_z \quad + I_Z$$

Equation 6

$$r = R + I_{abs}$$

17.7 Calculate the IR-TRACC mount-to-sternum displacements

17.7.1 Upper Left Thorax

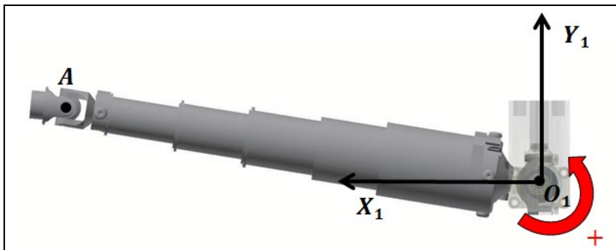

Figure 17-1. Overhead View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Z-axis potentiometer is positive.

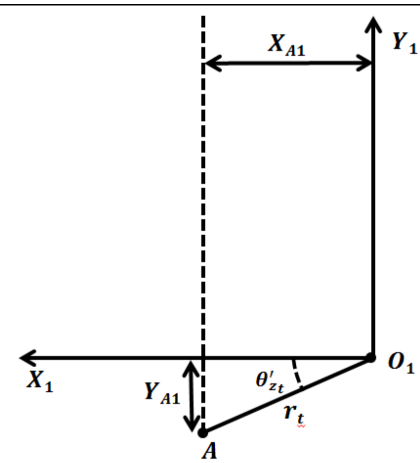

Figure 17-2. Overhead View

$$X_{A1} = r * \cos(\theta_z')$$

$$Y_{A1} = -r * \sin(\theta_z')$$

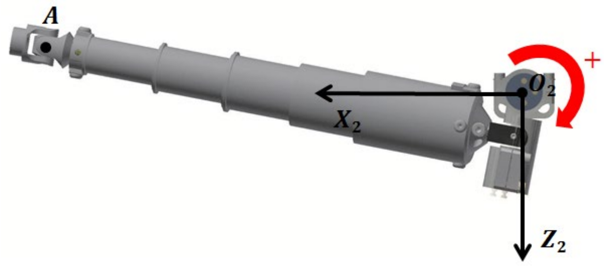

Figure 17-3. Lateral View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Y-axis potentiometer is positive.

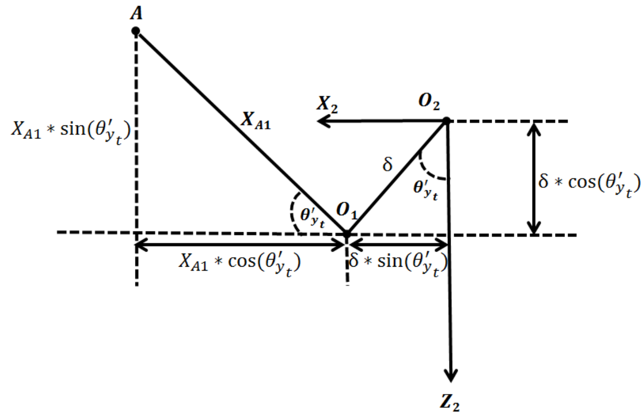

Figure 17-4. Lateral View

Equation 7- Upper Left Thorax X

$$X = \delta * sin(\theta'_y) + r \quad * cos(\theta'_z) * cos(\theta'_y)$$

Equation 8- Upper Left Thorax Y

$$Y = -r \quad * sin(\theta'_z)$$

Equation 9- Upper Left Thorax Z

$$Z = \delta * cos(\theta'_y) - r \quad * cos(\theta'_z) * sin(\theta'_y)$$

17.7.2 **Upper Right Thorax**

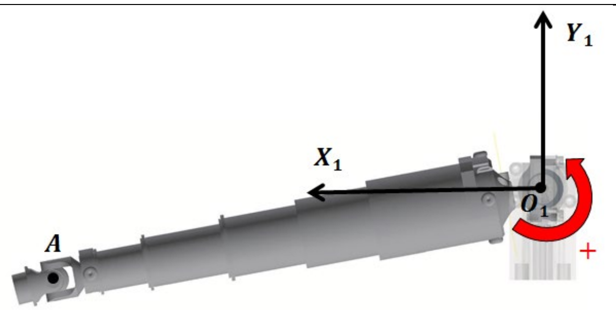

Figure 17-5. Overhead View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Z-axis potentiometer is positive.

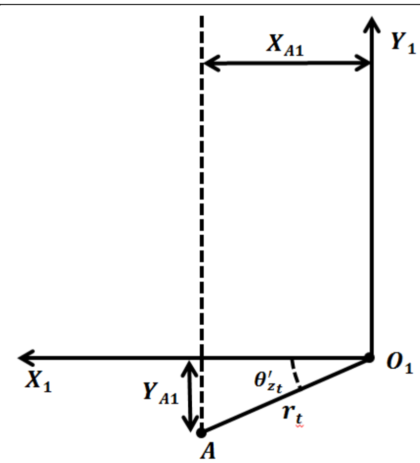

Figure 17-6. Overhead View

$$X_{A1} = r * \cos(\theta'_z)$$

$$Y_{A1} = -r * \sin(\theta'_z)$$

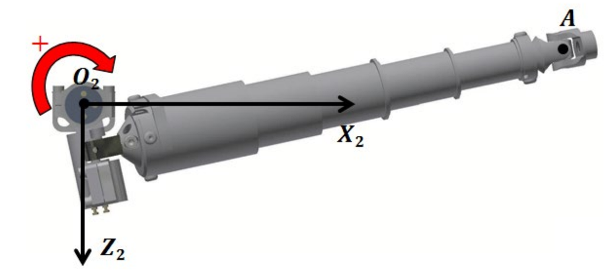

Figure 17-7. Lateral View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Y-axis potentiometer is negative.

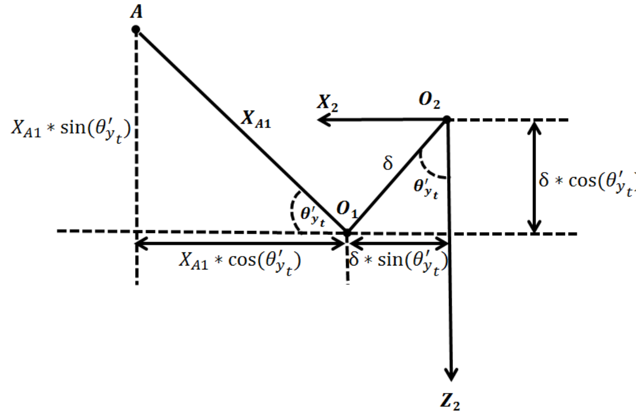

Figure 17-8. Lateral View

Equation 10- Upper Right Thorax X

$$X = -\delta * sin(\theta'_y) + r \quad * cos(\theta'_z) * cos(\theta'_y)$$

Equation 11- Upper Right Thorax Y

$$Y = -r * sin(\theta'_z)$$

Equation 12- Upper Right Thorax Z

$$Z = \delta * cos\left(\theta'_y\right) + r * cos(\theta'_z) * sin(\theta'_y)$$

17.7.3 **Lower Left Thorax**

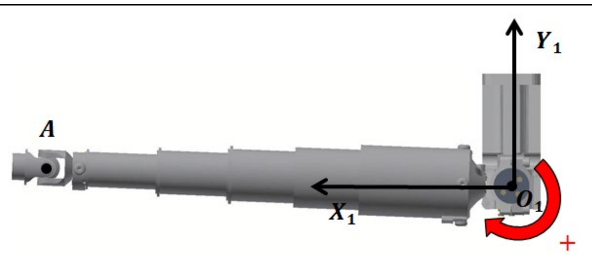

Figure 17-9. Overhead View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Z-axis potentiometer is negative.

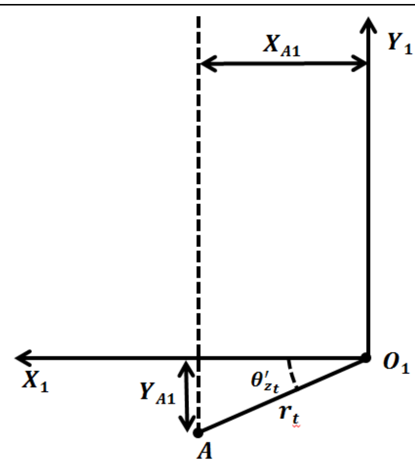

Figure 17-10. Overhead View

$$X_{A1} = r * \cos(\theta'_z)$$

$$Y_{A1} = r * \sin(\theta'_z)$$

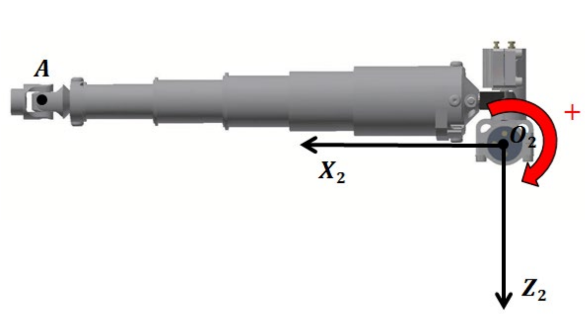

Figure 17-11. Lateral View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Y-axis potentiometer is negative.

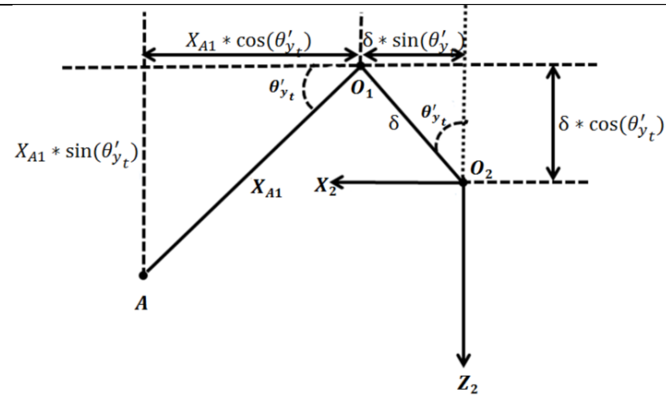

Figure 17-12. Lateral View

Equation 13- Lower Left Thorax X

$$X = -\delta * sin(\theta'_y) + r * cos(\theta'_z) * cos(\theta'_y)$$

Equation 14- Lower Left Thorax Y

$$Y = r * sin(\theta'_z)$$

Equation 15- Lower Left Thorax Z

$$Z = -\delta * cos(\theta'_y) - r * cos(\theta'_z) * sin(\theta'_y)$$

17.7.4 **Lower Right Thorax**

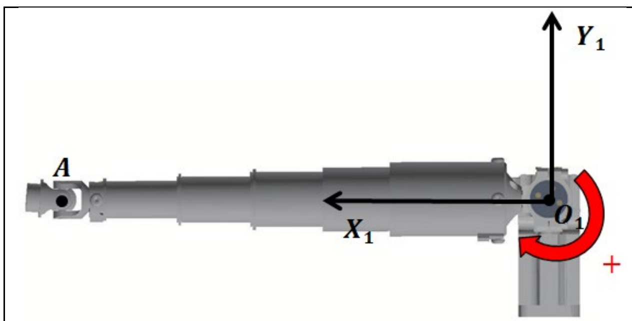

Figure 17-13. Overhead View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Z-axis potentiometer is negative.

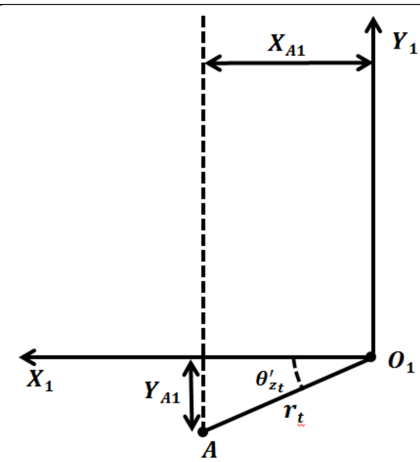

Figure 17-14. Overhead View

$$X_{A1} = r * \cos(\theta'_z)$$

$$Y_{A1} = r * \sin(\theta'_z)$$

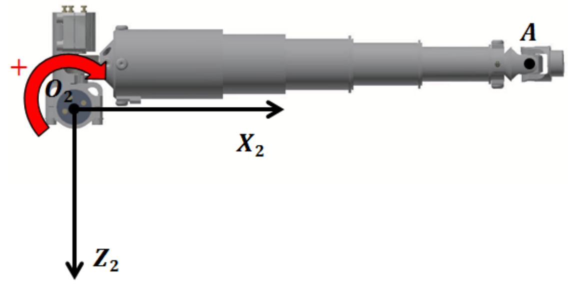

Figure 17-15. Lateral View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Y-axis potentiometer is positive.

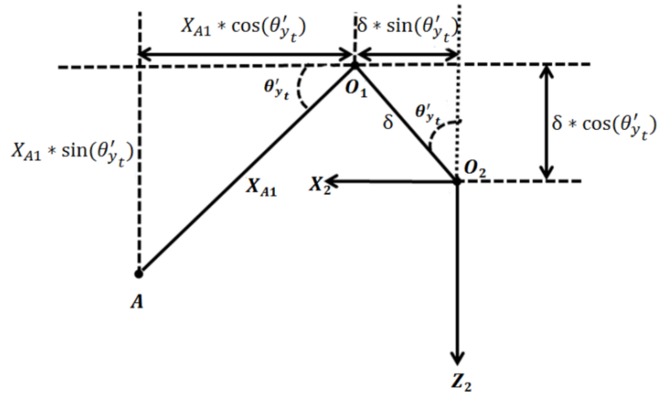

Figure 17-16. Lateral View

Equation 16- Lower Right Thorax X

$$X = \delta * sin(\theta'_y) + r * cos(\theta'_z) * cos(\theta'_y)$$

Equation 17- Lower Right Thorax Y

$$Y = r * sin(\theta'_z)$$

Equation 18- Lower Right Thorax Z

$$Z = -\delta * cos\left(\theta'_y\right) + r * cos(\theta'_z) * sin(\theta'_y)$$

17.7.5 Left Abdomen

The equations for the left abdomen match those of the lower left thorax. However, since the Y-axis potentiometer and the Z-axis potentiometer are coincident, the δ term is eliminated.

Equation 19- Left Abdomen X

$$X = r * cos(\theta'_z) * cos(\theta'_y)$$

Equation 20- Left Abdomen Y

$$Y = r * sin(\theta'_z)$$

Equation 21- Left Abdomen Z

$$Z = -r * cos(\theta'_z) * sin(\theta'_y)$$

17.7.6 Right Abdomen

The equations for the right abdomen match those of the lower right thorax. However, since the Y-axis potentiometer and the Z-axis potentiometer are coincident, the δ term is eliminated.

Equation 22- Lower Right Thorax X

$$X = r * cos(\theta'_z) * cos(\theta'_y)$$

Equation 23- Lower Right Thorax Y

$$Y = r * sin(\theta'_z)$$

Equation 24- Lower Right Thorax Z

$$Z = r * cos(\theta'_z) * sin(\theta'_y)$$

17.8 Remove pre-event bias of channels at time zero

where:

D_X is the time-history deflection in the X-axis
D_Y is the time-history deflection in the Y-axis
D_Z is the time-history deflection in the Z-axis
X_{t0} is the value of X at time-zero
Y_{t0} is the value of Y at time-zero
Z_{t0} is the value of Z at time-zero

Equation 25

$$D_X = X - X_{t0}$$

Equation 26

$$D_Y = Y - Y_{t0}$$

Equation 27

$$D_Z = Z - Z_{t0}$$

Section 18. **THOR-50M Tester's Checklist**

Important items to verify *during* dummy build	**Body Segment**	**Section**	**Check**
Ensure that the face foam is installed and is not torn	Head	Section 3	
Ensure skull locators are firmly seated in face flesh	Head	Section 3	
Ensure that the neck center cable nut is 1/2 turn beyond contact	Neck	Section 4	
Inspect rubber nodding joint for wear and tear	Neck	Section 4	
Ensure that all three neck cables are not frayed or pulling through the swages	Neck	Section 4	
Ensure that the front and rear neck cables are installed in their respective positions	Neck	Section 4	
Ensure that the O.C. pot will not pass through dead band while head is rotating	Neck	Section 4	
Ensure that O.C. set screw is tight	Neck	Section 4	
Ensure that the head instrumentation plane and the upper neck load cell are parallel	Neck	Section 4	
Ensure that the upper and lower neck load cell bolts are of the correct length and have proper washers installed. If the bolts are too long, or lack the proper washers, then the bolts will protrude into the rubber	Neck	Section 4	
Inspect the tabbed shoulder washer for damage	Shoulder	Section 7	
Inspect upper thoracic spine and lumbar spine flex joint cables for damage, and ensure that the cable is not pulling through the swages	Spine	Section 5	
Ensure that the thoracic spine flex joint cable nut is 1/2 turn beyond contact	Spine	Section 5	
Ensure that the lumbar flex joint cable nut is 1/2 turn beyond contact	Spine	Section 5	
Ensure that the wire that attaches the two ends of the abdominal IR-TRACCs is wrapped around the collapsible tubes	Lower Abdomen	Section 9	
Ensure that the correct abdomen foam is installed, and there isn't major damage	Lower Abdomen	Section 9	
Ensure that the lower abdominal Y-axis potentiometer exit cable is pointed toward the rear of the dummy	Lower Abdomen	Section 9	
Ensure that the acetabulum load cells are installed and oriented correctly	Pelvis	Section 10	
Ensure that pelvic socket adapter (threaded shaft through load cell) has flat washer and nylock nut torqued to 100 in-lbs; be sure to install a new nylock nut each time the nut is removed	Pelvis	Section 10	
Ensure that the bolts that mount the acetabulum load cell to the pelvis mounting plate are not broken or stretched	Pelvis	Section 10	
Ensure that the upper tibia load cell's X-axis is facing toward the front of the leg	Lower Extremity	Section 12	
Inspect the knee slider rubber stops for tears and delamination	Lower Extremity	Section 12	
Ensure that Achilles tension is 77.8 ± 4.4N, but this is not to be adjusted after qualification of the leg	Lower Extremity	Section 12	
Ensure that all tilt sensors are properly oriented and programmed	Head Spine	Section 3 Section 5	

Important items to verify *after* dummy build	Body Segment	Section	Check
Ensure that no wires are in the pinch points between the skull cap and the skull	Head	Section 3	
Ensure spring tower jam nuts are tight	Neck	Section 4	
Ensure rubber neck stops, two in the back and one in the front are installed and tight	Neck	Section 4	
Ensure instrumentation cable slack will allow full forward flexion and rearward extension	Neck	Section 4	
Ensure that all neck cable guide inserts are installed and firmly seated	Neck	Section 4	
Ensure that the neck pitch change angle is set to neutral	Neck	Section 4	
Ensure that the lumbar pitch change mechanism angle is set to slouch	Spine	Section 5	
Check upper thoracic spine flex joint for delamination	Spine	Section 5	
Check lumbar flex joint for tears	Spine	Section 5	
Check lifting strap for fraying and damage	Spine	Section 5	
Ensure that the sternal mass foam is not torn or debonding from the steel plates	Thorax	Section 6	
Ensure that the steel stiffeners are installed in the jacket, and are not bent	Thorax	Section 6	
Check ribs for delamination (pay additional attention to the areas near stiffeners and near attachment points at sternum)	Thorax	Section 6	
Ensure that the pins in the universal joints where the thorax IR-TRACCs attach to the bib are configured vertically and horizontally to prevent binding.	Thorax	Section 6	
Ensure that the wire that attaches the two ends of the IR-TRACC is aligned in the same plane at each end	Thorax Lower Abdomen	Section 6 Section 9	
Ensure that IR-TRACC potentiometer set screws are tight	Thorax Lower Abdomen	Section 6 Section 9	
Ensure that upper and lower abdomen Velcro® cover is installed	Lower Abdomen	Section 9	
Inspect the abdomen bags for tears	Lower Abdomen	Section 9	
Ensure Achilles jam nuts are tight (at least 1.5 N-m)	Lower Extremity	Section 12	
Ensure that the ankle pot set screws are tight	Lower Extremity	Section 12	
Ensure that all limbs joints are set to 1G	Joint Resistive Torques Shoulder Pelvis Lower Extremity Arm	Section 2.6 Section 7 Section 10 Section 12 Section 13	
Ensure that shoulder joints have been adjusted per the procedure	Shoulder	Section 7.3.1	

Section 19. **External Dimensions**

These measurements shall be taken prior to testing with the dummy in order to verify key external dimensions and identify possible deficiencies in the dummy molded parts or problems with the internal structural configuration. This procedure allows for checking these dimensions with or without instrumentation cabling. The description below uses an instrumented THOR-50M, but the same procedures would be applicable for an uninstrumented THOR-50M. Figure 19-1 through Figure 19-3 illustrate the external dimension details for the THOR-50M dummy. Table 19-1 describes the specifications for each of the THOR-50M external dimensions.

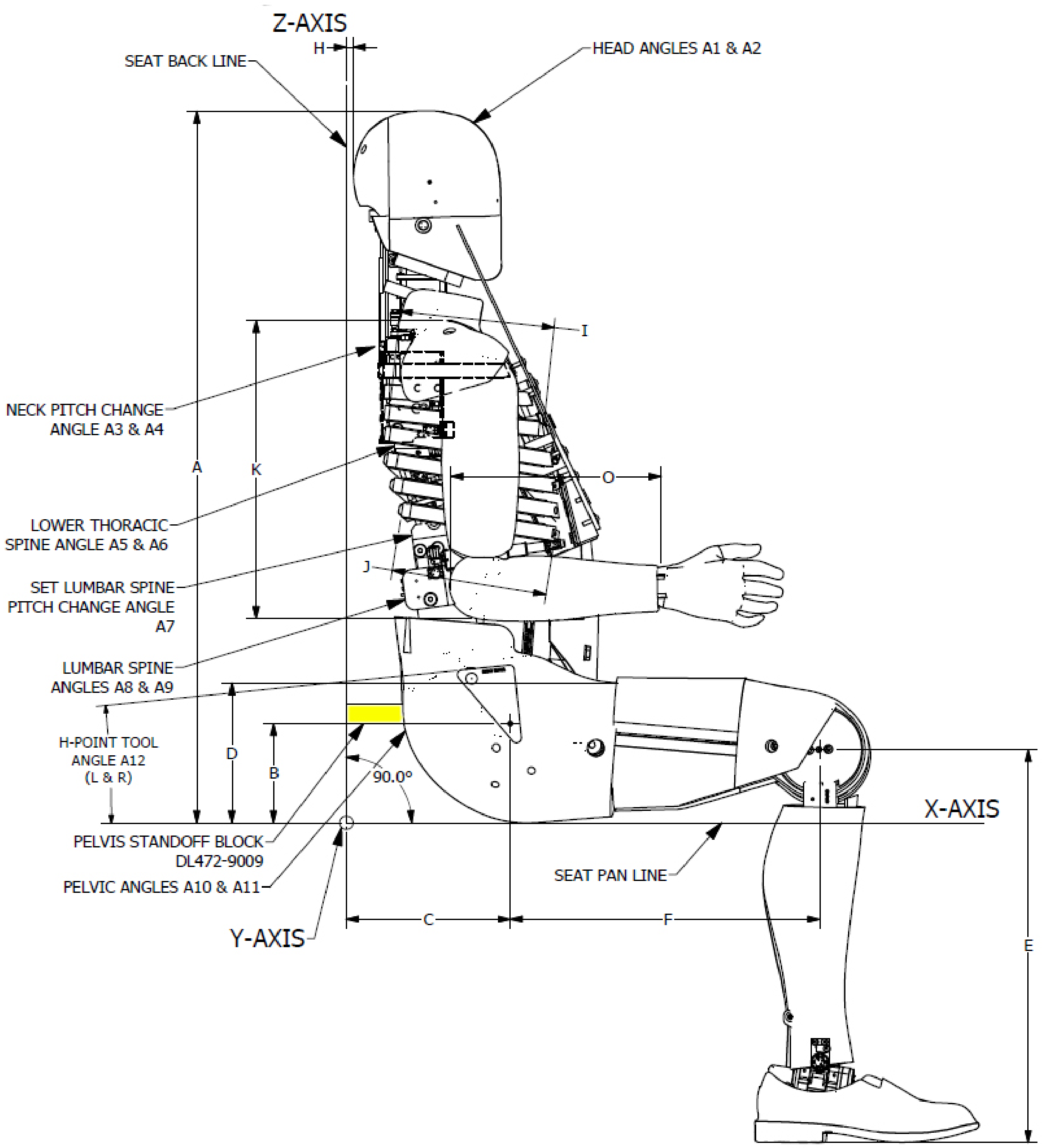

Figure 19-1. THOR-50M external dimensions (side view)

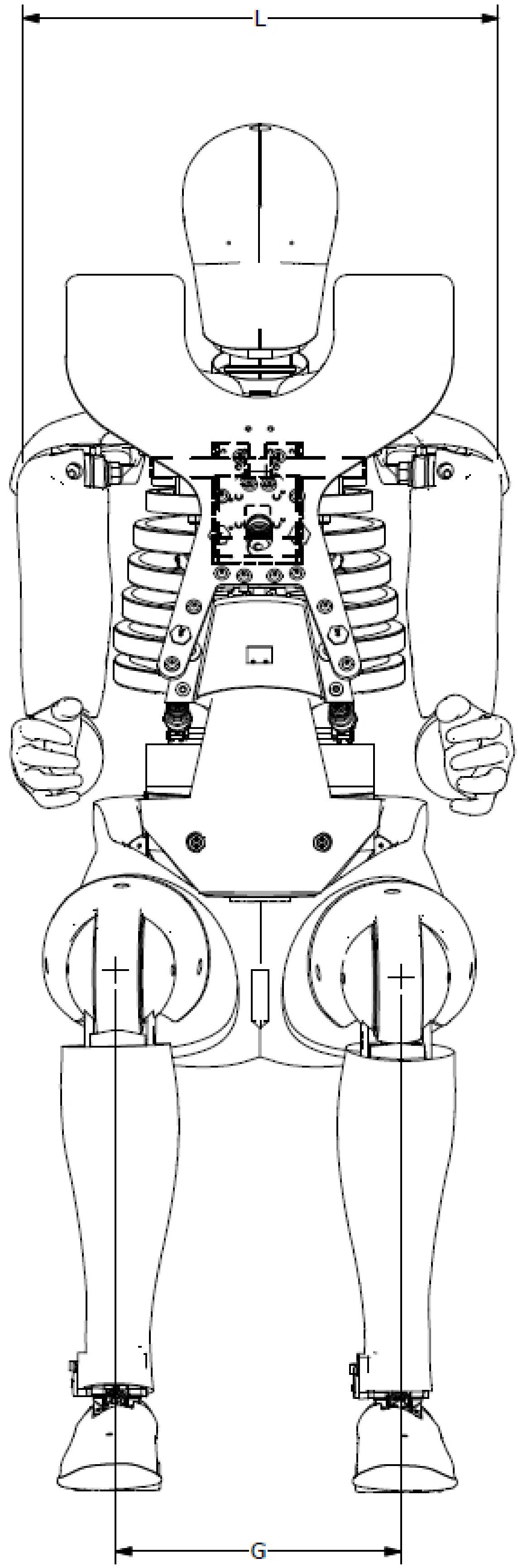

Figure 19-2. THOR-50M external dimensions (front view)

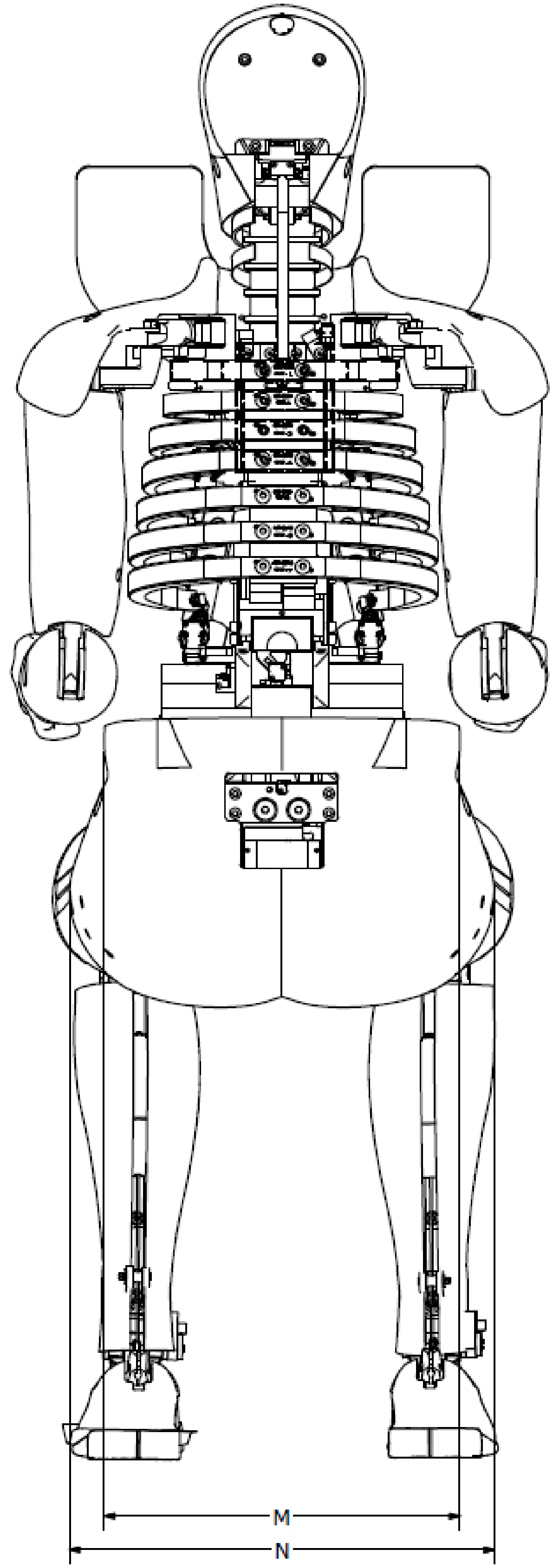

Figure 19-3. THOR-50M external dimensions (back view)

Table 19-1. THOR-50M External Dimension Details

Dim	Description	Details
A	Sitting Height	seat surface to highest point on top of head
B	Hip Pivot Height	SETUP - seat surface to H-point
C	Hip Pivot Seat Back	SETUP - seat back surface to H-point
D	Thigh Clearance	seat surface to top of thigh portion of pelvis flesh
E	Knee Pivot to Bottom of Foot	knee pivot bolt to horizontal plane of the bottom of the feet
F	Knee Pivot to Hip Pivot	distance from knee pivot centerline to center of H-point
G	Knee Centerline to Knee Centerline	distance between anterior knee vertical centerlines while upper legs parallel and lower legs perpendicular to upper leg
H	Head Back to Seat Back Line	rearmost surface of skull cap to seat back surface
I	Rib #3 Depth	center* of rib #3 anterior rib attachment bolt to rib #3 stiffener (flat portion near bolt)
J	Rib #7 Depth	center* of rib #7 anterior rib attachment bolt to rib #7 stiffener (flat portion near bolt)
K	Shoulder to Elbow Length	top of shoulder cover attachment screw to underside of forearm
L	Breadth Across Arms	breadth across arms just below shoulder cover
M	Minimum Waist Breadth	breadth at narrowest point of pelvis flesh above H-point locator holes
N	Maximum Hip Breadth	Breadth at widest area of hips
O	Back of Elbow to Wrist Pivot	length of each arm from back of elbow flesh to center of wrist pivot
A1	Head Angle about X-Axis	SETUP – measured with head X-axis tilt sensor
A2	Head Angle about Y-Axis	SETUP – measured with head Y-axis tilt sensor
A3	Neck Pitch Change Angle about X-Axis	measured with lower neck X-axis tilt sensor
A4	Neck Pitch Change Angle about Y-Axis	measured with lower neck Y-axis tilt sensor
A5	Lower Thoracic Spine Angle about X-Axis	measured with T6 X-axis tilt sensor
A6	Lower Thoracic Spine Angle about Y-Axis	measured with T6 Y-axis tilt sensor
A7	Lumbar Spine Pitch Change Setting	SETUP - set to ERECT prior to measuring
A8	Lumbar Spine Angle about X-Axis	SETUP - measured with T12 X-axis tilt sensor
A9	Lumbar Spine Angle about Y-Axis	measured with T12 Y-axis tilt sensor
A10	Pelvic Angle about X-Axis	SETUP - measured with pelvis X-axis tilt sensor
A11	Pelvic Angle about Y-Axis	SETUP - measured with pelvis Y-axis tilt sensor
A12	H-Point Tool Angle	measured with angle-finder on top of H-Point tool

* "center" refers to external surface of the bolt center rather than the bolt head tool recess

19.1 Procedures for Measuring External Dimensions

1. Assemble the dummy according to the procedures defined in the PADI. Assure that the neck spring cables are set according to the prescribed procedures.

2. Remove the jacket.

3. Set the lumbar spine pitch change to the erect position.

4. Insert the lower abdomen erect position foam (472-0011).

5. Remove the two M3 x 0.5 x 10 mm FHCS from the pelvis accelerometer cover (472-4371) on the posterior side of the pelvis. Install the pelvis standoff block (DL472-9010) in place of the pelvis accelerometer cover using two M3 x 0.5 x 16 mm SHCS (Figure 19-4 through Figure 19-6). The angled surface of the block is installed against the pelvis, with the longer (108.7 mm) edge of the block oriented downwards.

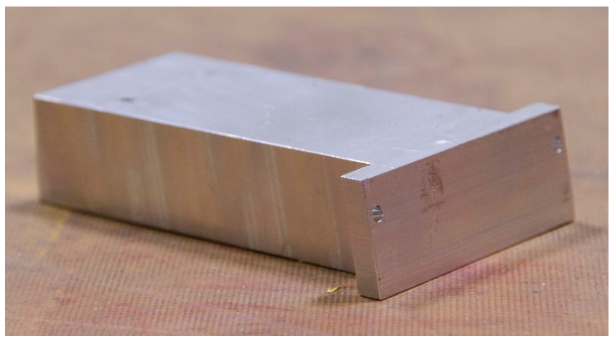

Figure 19-4. External dimension fixture pelvis standoff block

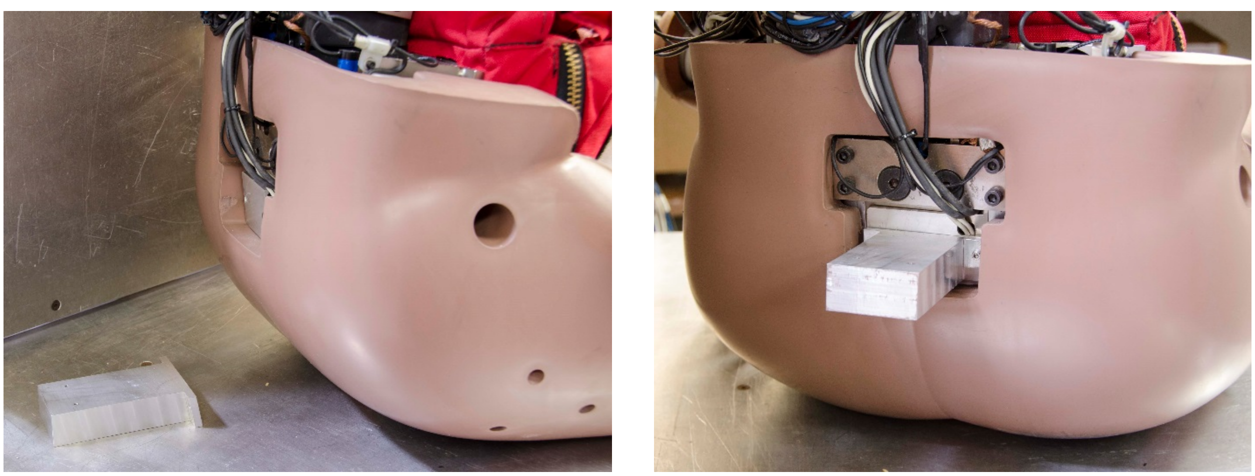

Figure 19-5. Installation of pelvis standoff block

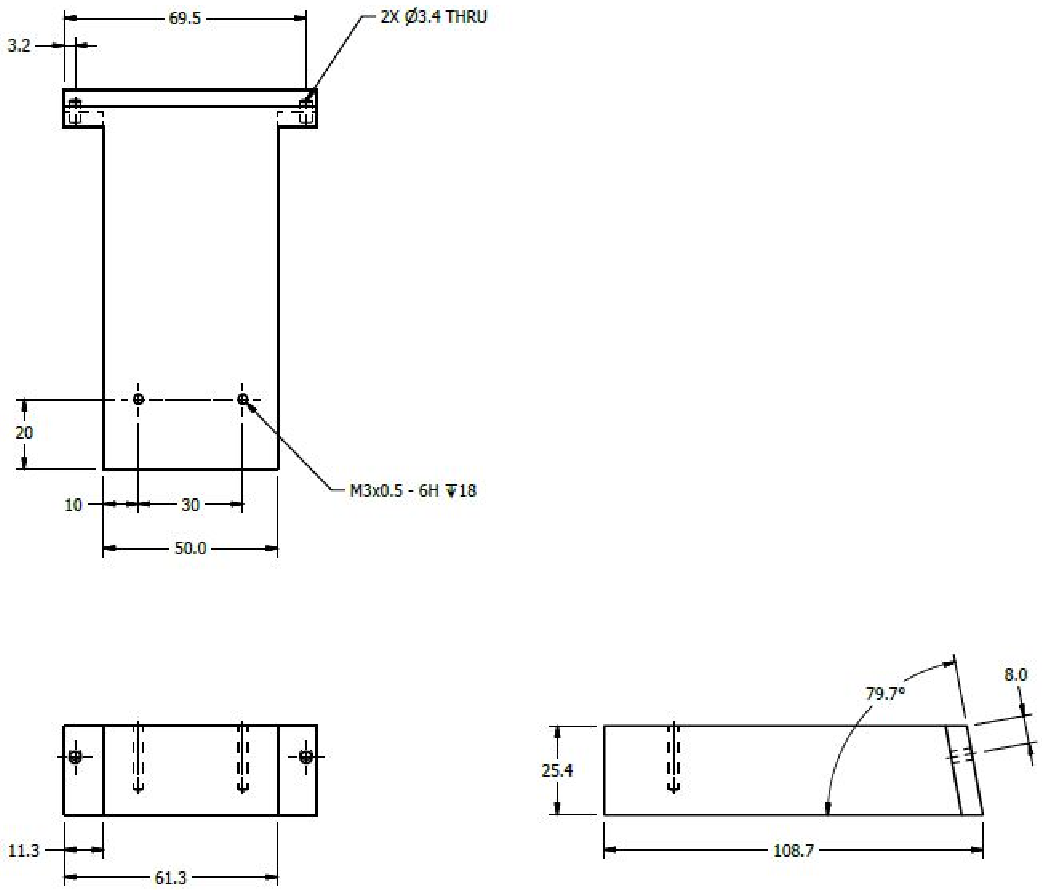

Figure 19-6. Pelvis standoff block dimensions

6. Seat the dummy on a flat, rigid, smooth, clean, dry, horizontal surface. The seating surface must be at least 406 mm (16 in) wide; the anterior edge of the seating surface to the seat back should be 560 ± 2 mm (22 in) deep. The vertical section should be at least 406 mm (16 in) wide and 914 mm (36 in) high and attached to the rear of the seating fixture. An adjustable head block (76 ± 5 mm deep) should be installed behind the rearmost portion (crown) of the head. A foot plate, which is parallel to the seating surface, is installed such that the top of the foot plate to the top of the seat pan is 450 ± 2 mm.

7. If instrumentation is installed in the dummy, hang the wiring from seat or over the seat back; adjust the cables so that they will be out of the way during measurement.

8. Seat the dummy in the test fixture so that the dummy's midsagittal plane is vertical and centered on the seating surface. The crown of the head should contact the head block; the pelvic block should contact the seat back.

9. Position the upper arms vertical with the lower arms perpendicular to the upper arms.

10. The upper legs should be against the seat surface such that the centerline of the femur is parallel to the seat surface; the upper legs should be parallel to one another.

11. The centerline of the lower legs should be vertical, with feet flat on the foot plate.

12. Install both left and right H-point tools.

13. Install an adjustable tension strap across the forehead such that the bottom edge of the strap is 20 ± 3 mm above the nasion indicator on the skin (Figure 19-7). The strap should *not* be across the face foam. Figure 19-8 shows the dummy positioned in the seat.

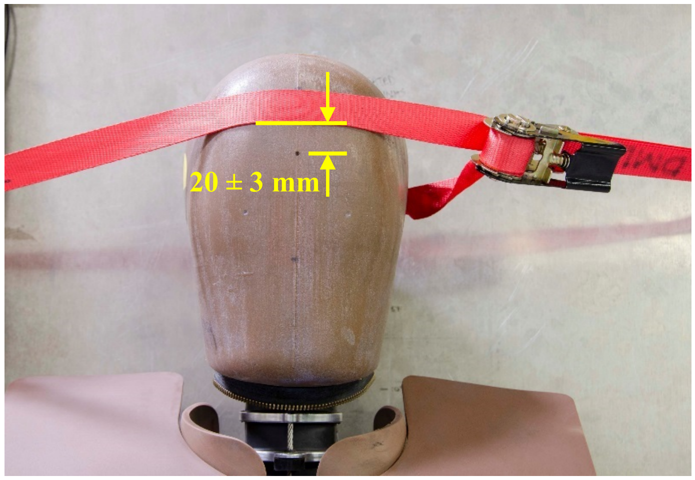

Figure 19-7. Placement of head strap

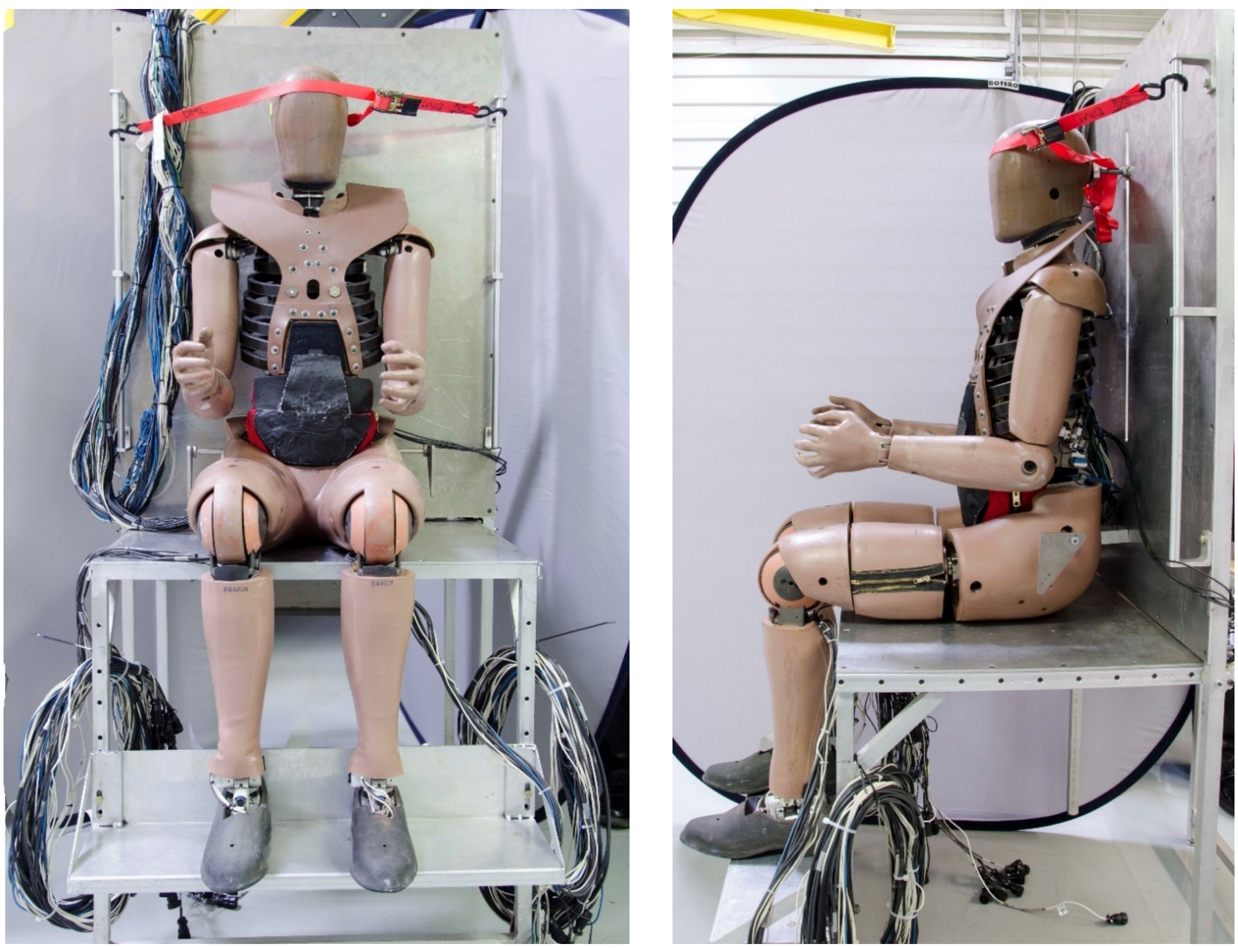

Figure 19-8. External dimension measurement setup for THOR-50M

14. Adjust the tension in the head strap so that the crown of the head is against the head block and the head angles, as indicated by the head tilt sensors, measure:
    Head angle about X-axis: 0 ± 2°
    Head angle about Y-axis: -5 ± 2°

15. Adjust the pelvic angle, as indicated by the pelvis tilt sensors, to read:
    Pelvis angle about X-axis: 0 ± 2°
    Pelvis angle about Y-axis: 0 ± 2°

16. Position the H-points (both left and right sides):
    H-point height from seating surface: 114 ± 5 mm
    H-point to seat back surface: 220 ± 5 mm

17. **Sitting Height (A)**: Measure the distance from the seat horizontal surface to a level placed on top of the head.

18. **Hip Pivot Height (B)**: This measurement is a setup parameter. With both left and right H-point tools installed, measure the vertical distance from the seat surface to the H-point.

19. **Hip Pivot Seat Back (C)**: This measurement is a setup parameter. With both left and right H-point tools installed, measure the horizontal distance from the seat back surface to the H-point.

20. **Thigh Clearance (D)**: Measure (perpendicular) from the horizontal seat surface to the top of thigh portion of pelvis flesh. Do not measure this value on top of the thigh portion of upper legs.

21. **Knee Pivot to Bottom of Foot (E):** Measure vertically from the knee pivot to the horizontal plane of the bottom of the foot (foot plate).

22. **Knee Pivot to Hip Pivot (F):** Measure the horizontal distance from the knee pivot centerline to the center of the H-point.

23. **Knee Centerline to Knee Centerline (G):** With upper legs parallel, measure the horizontal distance between the left inner kneecap to the right outer kneecap; this avoids determining the exact centerline of each kneecap (Figure 19-9).

24. **Head Back to Seat Back Line (H):** Horizontal measurement from the rearmost surface of the skull cap to the seat back.

25. **Rib #3 Depth (I)**: Measure from the center of rib #3 anterior rib attachment bolt to the rib #3 stiffener (flat portion near bolt).

26. **Rib #7 Depth (J)**: Measure from the center of rib #7 anterior rib attachment bolt to the rib #7 stiffener (flat portion near bolt).

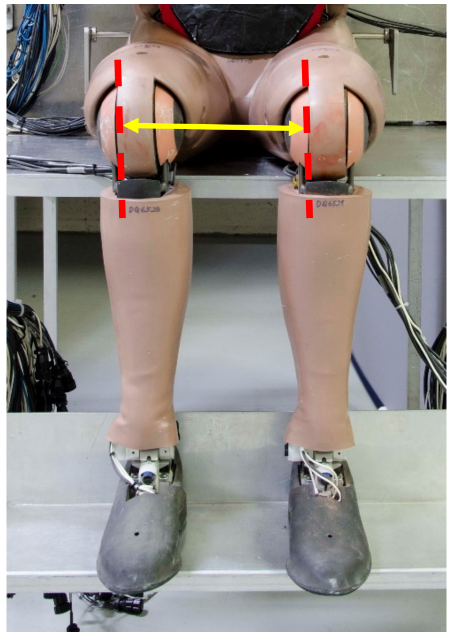

Figure 19-9. Technique to measure knee centerline distance

27. **Shoulder to Elbow Length (K)**: Measure from the top of the shoulder cover attachment screw to the underside of the forearm.

28. **Width Across Arms (L)**: Measure the width across the arms just below the shoulder cover.

29. **Waist Width (M):** Measure the narrowest point of pelvis flesh.

30. **Back of Elbow to Wrist Pivot (N):** Measure length of each arm from back of elbow to center of wrist pivot.

31. **Head Angle about X-axis (A1):** This measurement is a setup parameter. Measurement from X-axis head tilt sensor.

32. **Head Angle about Y-axis (A2)**: This measurement is a setup parameter. Measurement from Y-axis head tilt sensor.

33. **Neck Pitch Change Angle about X-axis (A3)**: Measurement from X-axis lower neck tilt sensor.

34. **Neck Pitch Change Angle about Y-axis (A4)**: Measurement from Y-axis lower neck tilt sensor.

35. **Lower Thoracic Spine Angle about X-axis (A5)**: Measurement from X-axis T6 tilt sensor.
36. **Lower Thoracic Spine Angle about Y-axis (A6)**: Measurement from Y-axis T6 tilt sensor.

37. **Lumbar Spine Pitch Change Setting (A7)**: Set to "erect" position.

38. **Lumbar Spine Angle about X-axis (A8)**: Measurement from X-axis T12 tilt sensor.

39. **Lumbar Spine Angle about Y-axis (A9)**: Measurement from Y-axis T12 tilt sensor.

40. **Pelvic Angle about X-axis (A10)**: This measurement is a setup parameter. Measurement from X-axis pelvis tilt sensor.

41. **Pelvic Angle about Y-axis (A11)**: This measurement is a setup parameter. Measurement from Y-axis pelvis tilt sensor.