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THOR-NT
User's Manual

50% Male Frontal Dummy

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NHTSA/GESAC, Inc.,

TRAUMA ASSESSMENT DEVICE DEVELOPMENT PROGRAM

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THOR NT User's Manual
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Section 1. Introduction

1.1 Introduction

For several years the National Highway Traffic Safety Administration (NHTSA) has actively supported the development of an advanced frontal crash test dummy that incorporates improved biofidelic features and significantly expanded instrumentation. This development program, undertaken by GESAC in 1995, resulted in the design and development of a test device for whole-body trauma assessment in a variety of occupant restraint environments. The new advanced frontal crash test dummy was named THOR (Test Device for Human Occupant Restraint). The primary design objectives of the development effort were as follows:

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

The approach undertaken during the design of the THOR dummy was to first review the design elements which had been incorporated in the TAD-50M (the NHTSA funded predecessor to the THOR dummy). This review was conducted to identify needed improvements in biofidelity, dynamic response, and instrumentation. A systematic evaluation of design requirements for each body region was then accomplished. The design of THOR resulted in improvements to all the dummy components except the arms (which remain Hybrid III stock pending conclusion of arm development efforts ongoing within the automotive industry). The facial region of the dummy has been instrumented with unidirectional load cells to assess the probability of facial fracture. The THOR neck assembly features multidirectional kinematic biofidelity, which results in more accurate head trajectories, velocities and accelerations for front, side and rear impacts. The thorax region utilizes elliptical ribs which greatly enhance the biofidelity and geometry. In addition, a new thorax deflection sensor was designed which measures the dynamic three dimensional compression of the ribcage at four distinct points. A newly designed abdominal segment can directly measure belt intrusion in three dimensions at two distinct points. The pelvis has been instrumented with a three axis acetabular load cell at each hip joint and belt load sensors on each Iliac notch. The THOR femur assembly includes a compliant element to provide the correct force transmission for axial loading through the femur into the pelvic assembly. A new lower extremity has been developed which provides increased injury sensing capabilities in the foot, ankle and lower leg, as well as, greatly improving the torque vs. angle relationship for the primary ankle rotation joints. In addition, the THOR dummy features many advances in sensors and instrumentation and is capable of measuring over one hundred channels of data for injury assessment.

Following the development of the prototype dummy, the first production level dummy was manufactured and was called THOR Alpha. Extensive revisions were undertaken on the THOR Alpha to further improve durability, usability, biofidelity, and anthropometry. The latest revision is known as THOR NT. **Figure 1.1** and **Figure 1.2** show oblique and side views of the THOR NT advanced frontal crash test dummy.

Figure 1.1- Oblique view of THOR NT

Figure 1.2- Side view of THOR NT

Figure 1.2 presents an assembly drawing of THOR indicating its primary features.

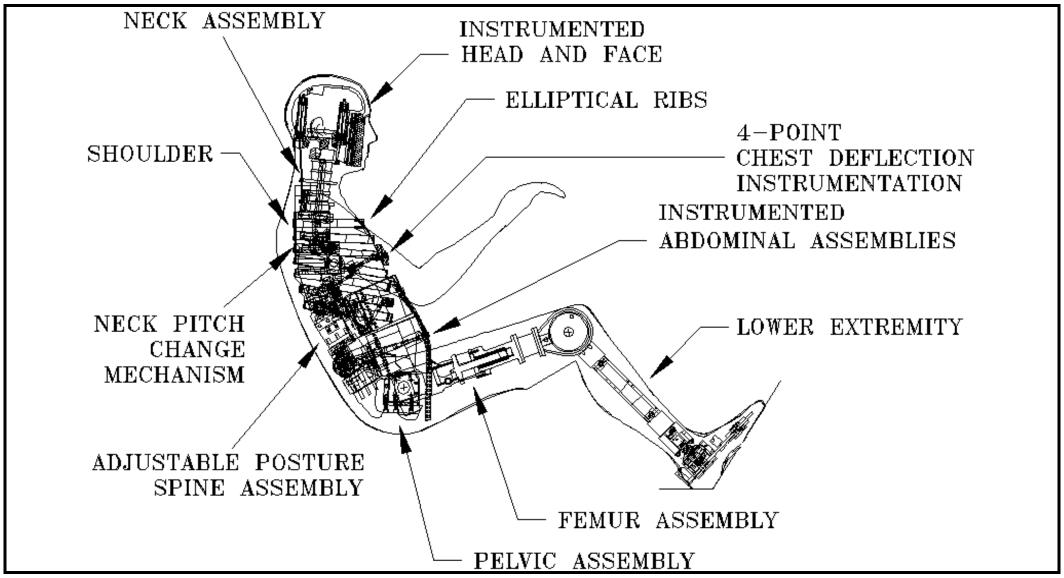

Figure 1.2- Primary features of the THOR dummy

1.2 Getting Familiar with the User's Manual

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

Introduction
Dummy Preparation and Use
Head
Face
Neck
Spine
Thorax
Shoulders
Upper Abdomen Assembly
Lower Abdomen Assembly
Pelvic Assembly
Femur Assembly
Lower Extremity
Jacket and Clothing
Instrumentation
CRUX Units
DGSP Units

1.2.1 Section Organization

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

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

The assembly section of the manual assumes that the components have been disassembled to inspect or service the instrumentation or wear items. This assembly procedure is not designed for a complete strip-down of the component. Please refer to the THOR NT Drawing Package for details which are not covered in this section of the user's 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 made with the assumption that the component is installed within the dummy. Reference is made as if the laboratory personnel is oriented in the same position as the test dummy.

Front and Back

The 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 of X, Y, and Z will be based on the SAE Information Report J1733 - Sign Convention for Vehicle Crash Testing. This SAE sign convention is provided below:
+X is toward the Anterior or front of the dummy
+Y is laterally toward the right
+ Z is toward the inferior or bottom of the dummy

Section 2. Dummy Preparation and Use

2.1 General

2.1.1 Hardware and Fasteners

All hardware and fasteners used on the THOR crash test dummy are standard “English” sizes. Depending on the function of a specific assembly, the thread sizes may be UNC or UNF in sizes ranging from 0-80 to 3/4". The following abbreviations are used throughout this manual.

SCREW ABBREVIATIONS:

F.H.S.C.S.	FLAT HEAD SOCKET CAP SCREW
B.H.S.C.S.	BUTTON HEAD SOCKET CAP SCREW
S.H.C.S.	SOCKET HEAD CAP SCREW
S.S.S	SOCKET SET SCREW
N.P.	NYLON PELLET (USED IN CONJUNCTION WITH ONE OF THE ABOVE ABBREVIATIONS)

MATERIAL ABBREVIATIONS:

CRS	COLD ROLLED STEEL
SS	STAINLESS STEEL
AL	ALUMINUM

Nylon Pellet bolts are used throughout the dummy assembly to prevent bolts from loosening during the impact and vibrations associated with a crash pulse. These bolts are used in assemblies where the threaded hole is in a steel part. The pellet bolts should be replaced with new ones when the dummy is disassembled for inspection or repair.

WARNING: DO NOT USE PELLET BOLTS IN ASSEMBLIES WHICH CONTAIN HELI-COILS OR THREADED INSERTS.

WARNING: REUSING NYLON PELLET BOLTS GREATLY DIMINISHES THEIR EFFECTIVENESS TO RESIST LOOSENING.

2.1.2 Tools Required

The following tool list includes the recommended standard tools which should be available at the test labs using the THOR dummy. This list will allow the laboratory personnel to make any necessary adjustments and to perform a standard through disassembly and assembly procedures. These tools are shown in **Figure 2.1.**

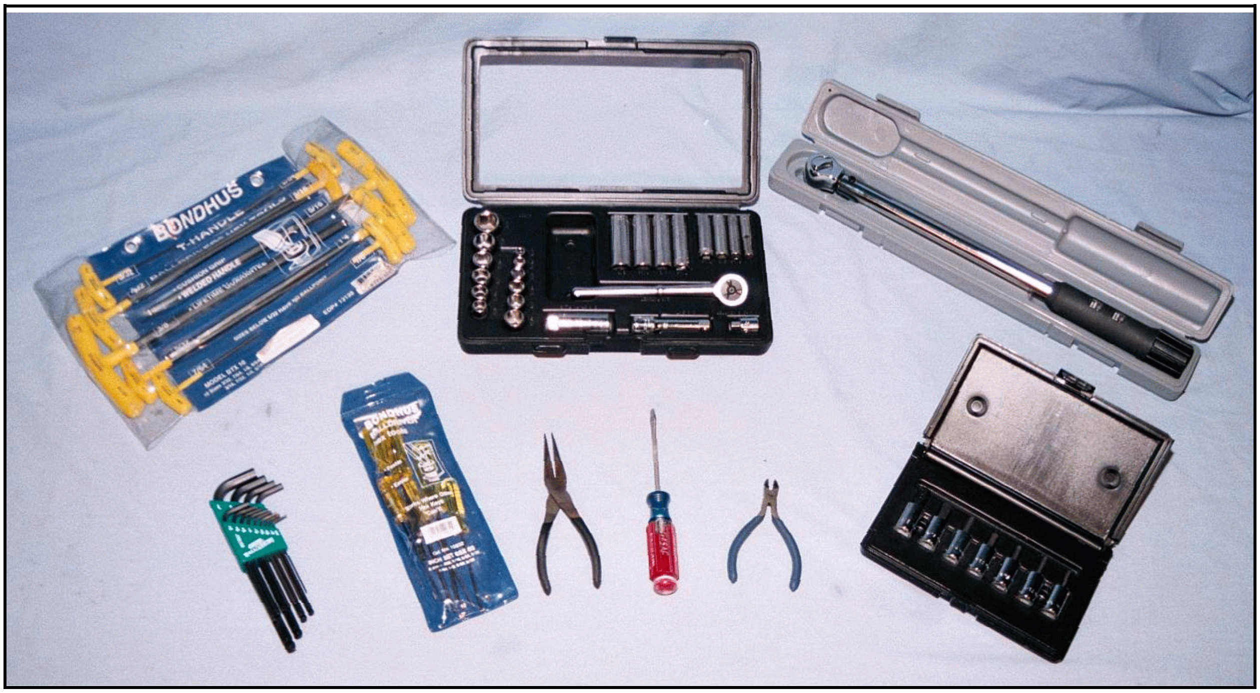

Figure 2.1- Required tools

Set of "T" Handle Hex Wrenches (Ball End)	Size:	3/32" to 3/8"
Set of "L" Handle Hex Wrenches (Ball End)	Size:	0.050" thru 3/8"
Set of Straight Hex Wrenches (Screwdriver Style)	Size:	0.050" thru 3/8"
Socket Set 1/4" Drive	Size:	1/4" thru 3/4" 1/4" thru 5/8" Deep
Torque Wrench	Range:	5 to 80 ft-lb
Hex Bit Socket Set	Size:	5/32" to 3/8"
Needle Nose Pliers		
Diagonal Cutters		
Flat Head Screwdriver		

2.1.3 Bolt Torque Values

The following table indicates the recommended torque values for the various bolt sizes used in the THOR dummy assemblies.

Bolt Size	Torque Range (Ft-lb)	Torque Range (N-m)
#4	10 to 16 (in-lb)	1.1 to 1.75
#6	19 to 29 (in-lb)	2.1 to 3.25
#8	2.5 to 3.8	3.4 to 5.1
#10	3.5 to 5.3	4.75 to 7.2
1/4	7 to 9	9.5 to 12
5/16	13 to 15	17 to 20
3/8	29 to 31	39 to 42
½	45 to 55	61 to 75
Neck Pitch Change Mechanism	37.5	50.8
Lumbar Pitch Change Mechanism	50.5	68

For bolt sizes smaller than those listed, common sense should dictate a "reasonably snug" torque which will prevent the fastener from vibrating use during impact.

2.2 Dummy Serial Number

A serial number is stamped on to each THOR dummy at the rear of the bottom plate of the thoracic pitch change mechanism. The serial number consists of a specific six digit number at the time of final assembly. The serial number begins with a two digit code for the dummy type (T1 for THOR 50% Male) followed by a four digit sequential serial number which is unique to each dummy. This serial number should be used as a reference during any correspondence regarding the use of the THOR dummy.

2.3 Part Numbers & Serial Numbers

Each major component of the THOR dummy is marked with a part number which is identical to the drawing number of the part in the THOR drawing package. Exceptions to this rule include very small components and rubber washers and bumpers. These part numbers will be referred to throughout the user's manual to aid in the disassembly, inspections, calibration, repair and assembly of any of the dummy components. The format for the part numbers follows the file naming **AABBCNNN**

AA - The first set of letters are used as the name given to the crash test dummy and will remain consistent through-out the entire package of drawing.

T1 = THOR 50th percentile male dummy.

BB - The second set of letters refers to the body area of the dummy. The two letter descriptor tags can be found in the chart labeled Two Letter Descriptor Tags For Body Areas.

FULL DUMMY ASSEMBLY	FD	THOR-LX	LX
ANKLE	AK	LOWER LEG	LL
ARMS	AM	MID-STERNUM	MS
CRUX	CX	NECK	NK
DGSP	DP	PELVIS	PL
FACE	FC	SHOULDER	SH
FEMUR	FM	SPINE	SP
FOOT	FT	THORAX	TX
HEAD	HD	UPPER ABDOMEN	UA
INSTRUMENTATION	IN		
JACKET	JK	CALIBRATION EQUIPMENT	CE
KNEE	KN	MOLDING EQUIPMENT	ME
LOWER ABDOMEN	LA	TEXT DOCUMENT	TD

C - A single letter noting the type of drawing.

M	Mechanical Drawing	P	Purchased Dummy Part
S	Skins	A	Drawing Arrangement
E	Electrical Drawing	I	Instrument Wire
T	Assembly Tools	X	Drawing Index
W	Welding Drawing	F	Fabric Pattern
C	Connector Wire	B	Bill of Materials

NNN - The last three digits is a numbering scheme for the different levels of drawings such as an assembly drawing, subassembly drawing, and part or detail drawing. In general, the examples given below applies to the majority of the drawings but due to the complexity of some of the parts in the dummy these may vary slightly.

000	Denotes an assembly drawing.
100, 200, ... 900	Denotes a subassembly drawing.
010, 011, ... 099	
110, 111, ... 199	
210, 211, ... 299	Denotes a part drawing.
....	
910, 911, ... 999	

In addition to the part numbers, several of the assemblies are given a serial number which is used to identify and track the manufacture and distribution of the parts. The following sub-assemblies are assigned unique serial numbers, which are marked on the parts at the time of manufacture, these serial numbers can be used to trace various parameters of the manufacturing process including date, chemical batch numbers, etc. The following assemblies have been marked with a serial number: rib set, face skin, neck assembly, femur bushings, shoulder pads, shoulder joint covers, upper thoracic flex joint, lumbar flex joint, upper and lower abdomen bags, upper and lower abdomen foam inserts, jacket, pelvis skin, front pelvic casting, upper femur skins, tibia shin guard, and knee bumper.

2.4 Dummy Storage

The increased instrument capacity and biofidelic features of the THOR dummy dictates some specific storage requirements which must be followed to avoid damage to the instruments or sub-assemblies. The dummy packing coffin makes an ideal storage container for the dummy - the coffins may be stacked to maximize the available floor space in the laboratory environment. The proper storage of the dummy is shown in **Figure 2.2.** During storage, the following recommendations apply:

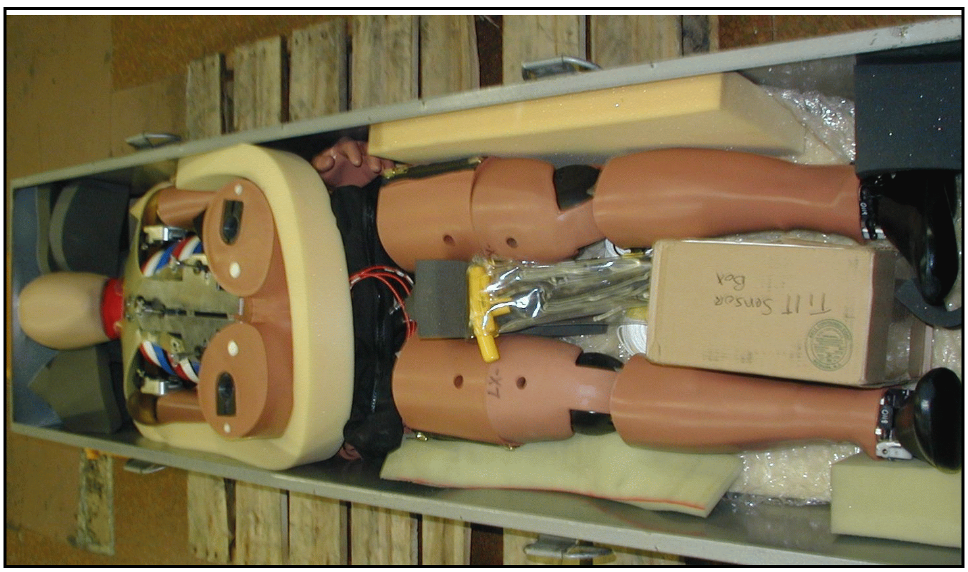

Figure 2.2- Proper storage position of dummy in storage locker.

- Whenever possible, the dummy should be stored laying supine to remove load from the flexible spine elements. (If this position is not possible, the dummy should be reclined in a seat or harness as far as possible.)

- The neck should be supported with a soft foam wedge to minimize the bending of an unsupported neck. Direct loading should not be applied to the neck structure (i.e. do not hang the dummy by the neck).

- The cable tension in the string potentiometer instruments of the upper abdomen and lower abdomen can cause permanent foam compression over a period of time. An

Abdomen Storage fixture has been designed to relieve the tension that these instruments place on the foam elements - the use of this fixture is described in Section 2.8. If the storage fixture is not available (it may be obtained as an option through GESAC T1FDT210), the tension on the instruments should be released as described in the DGSP and Upper Abdomen Sections.

- If the dummy is to be stored for extended periods, it should be placed on a soft foam pad to prevent permanent compression to the pelvic and femur flesh.

2.5 Dummy Handling

The THOR dummy has been designed to serve as a very robust test device and should not be damaged through handling provided that the following recommendations are followed:

- Do not hang the dummy from the head and neck assemblies, the dummy's neck was not designed to support the full weight of the dummy in tension and should not be used to transport the dummy. The recommended procedure is to attach a lifting hook to the strap which is located at the rear of rib #1, as shown in **Figure 2.3**.

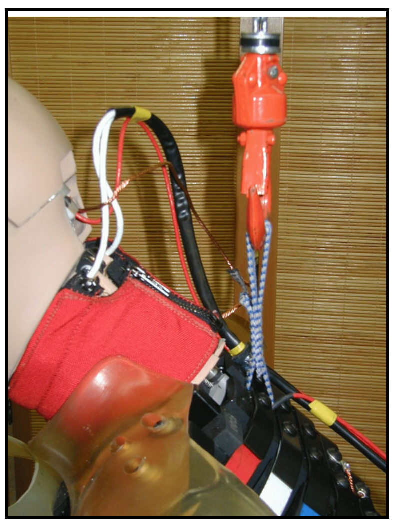

Figure 2.3- Proper lifting of the dummy

- The instrumentation wire bundle from the dummy must be properly strain relieved to the bottom of the spine assembly using the mesh cable clamp provided. This will prevent any of the individual wires from being loaded during the transport and positioning of the dummy.

2.6 H-Point Tool Assembly and Use

The THOR dummy is supplied with an H-Point Tool (T1FDT110) which provides a quick, accurate method to mark the location of the H-Point on the external skin surface. The assembly of the H-Point tool is shown in **Figure 2.4**. The placement of the H-Point tool into the access hole in the pelvis is shown in **Figure 2.5**.

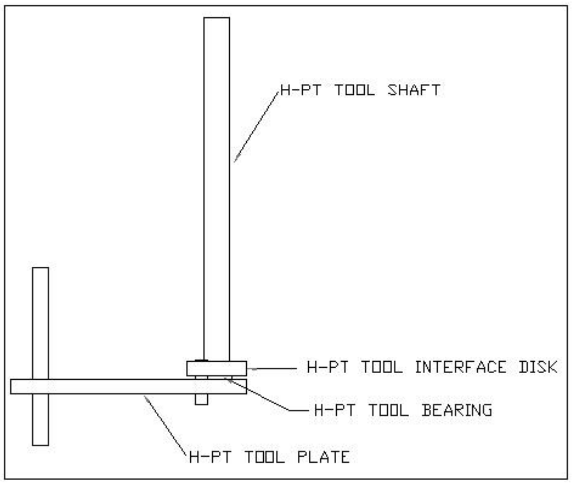

Figure 2.4- Assembled H-Point tool

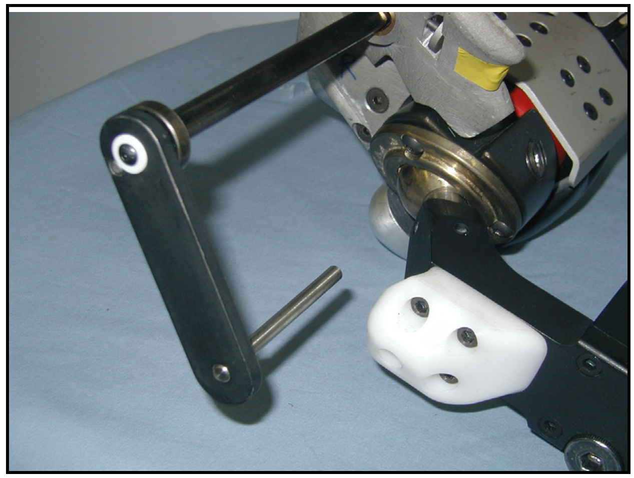

Figure 2.5- H-Point tool attached to pelvis

The H-point tool shaft is inserted through the opening in the pelvis skin and firmly into the access hole in the pelvis. The smaller shaft should then point directly at the center of the H-point. The H-Point tool plate is reversible for use on the dummy's left and right sides. The plate marking (left or right) should be visible to the user from the side of the dummy when the plate is positioned correctly. The configuration for the use of the H-Point tool from the dummy's left side is shown in **Figure 2.6**. The location of the dummy's H-Point is then indicated by the position of the center of the H-point shaft.

Figure 2.6- H-Point tool in use

2.7 Dummy Posture Adjustments and Positioning

The adjustment of the dummy posture is largely dependant upon the specific positioning requirements of the test lab and the test series being performed. GESAC has developed a recommended seating posture based on a study conducted by Reynolds, however, users are capable of changing this posture to suit their needs. 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.

The adjustments to the pelvic angle can then be made using the pelvic tilt sensor as a point of reference. The operation and function of the tilt sensors is explained in Section 15-Instrumentation. The tilt sensor readout box can be set to display the pelvic tilt sensor rotation about the Y axis which can be correlated to the pelvic angle as shown in **Equation 2.1**.

Equation 2.1
Pelvic Angle = Pelvic Tilt Sensor Reading (About Y Axis) + 10°

where Pelvic Angle is defined by the line between the ASIS and the PSIS pelvic landmarks, the Pelvic Tilt Sensor Reading (About Y Axis) is measured using the Tilt Sensor Readout Box provided with the THOR dummy.

At this point, the dummy can be placed in a "standard seating posture" recommended by GESAC, or the dummy posture can be further manipulated to accommodate various seating geometries or testing environments (the dummy can also stand straight up). Four major seating postures have been defined through a postural study (Reynolds), and the THOR 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 lower thoracic spine pitch change mechanisms. The neck pitch change mechanism is centered at the approximate location of the anthropomorphic landmark defined by the T6 / T7 joint. The lower thoracic spine pitch change mechanism is centered at the approximate location of the anthropomorphic landmark defined by the T11 / T12 joint. The locations of these pitch change mechanisms are shown in **Figure 2.7**.

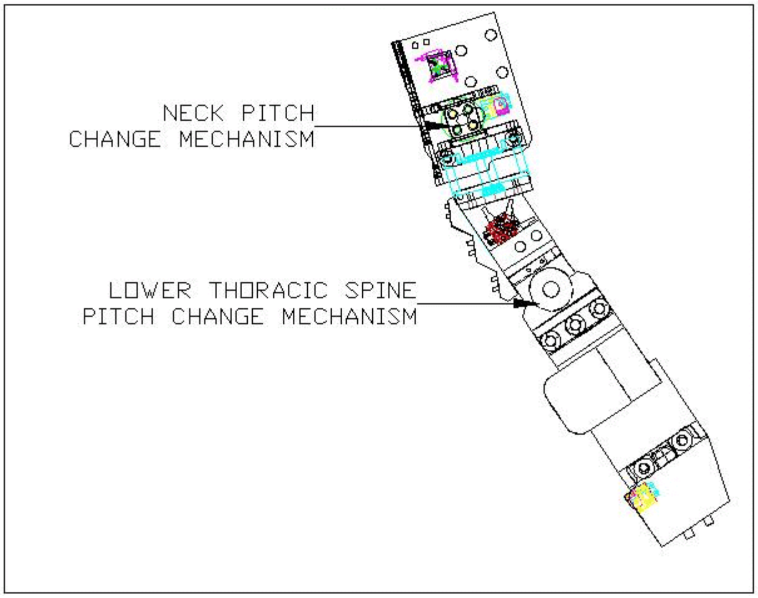

Figure 2.7- Pitch Change locations

The seating posture of the THOR dummy can be adjusted in 3 degree increments by rotating the spine segments with the pitch change mechanisms. Note: The procedure for adjusting the pitch change mechanisms is described in great detail in Section 6.3 - Spine of this manual. The orientation of the lower thoracic pitch change mechanism is normally set in the "Slouched" position, as described in the SPINE section. This mechanism may be adjusted to vary the seating posture of the dummy for a specific seating environments. The center adjustment bolt is accessed from the right side of the dummy by unzipping the right jacket zipper and inserting a 3/8" "T" handle wrench into the head of the bolt just below the level of rib 7, as shown in **Figure 2.8**. The adjustments are made be loosening the center bolt of the pitch change mechanism and repositioning the geared teeth into the desired setting. The mechanism is then tightened to 50.5 ft-lb as specified.

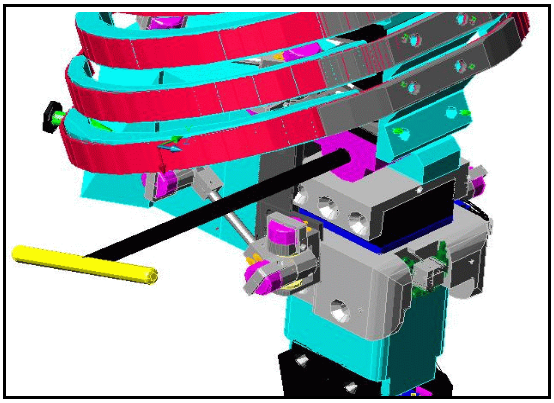

Figure 2.8- Lower Thoracic Pitch Change adjustment

After the lower thoracic pitch change mechanism has been adjusted and tightened, the neck pitch change mechanism can be adjusted to change the orientation of the head neck assembly. The orientation of the neck pitch change mechanism is normally set in the "Neutral" position with the upper and lower plates of the mechanism parallel to one another. This mechanism is adjusted by means of the center adjustment bolt which is accessed from the right side of the dummy by unzipping the right jacket zipper and inserting a 5/16" "T" handle wrench between ribs #2 and #3, through the access hole in the upper thoracic spine weldment into the head of the adjustment bolt, as shown in **Figure 2.9**. The adjustments can be made be loosening the center bolt of the pitch change mechanism and repositioning the geared teeth into the desired setting. The mechanism is then tightened to 37.5 ft-lb as specified.

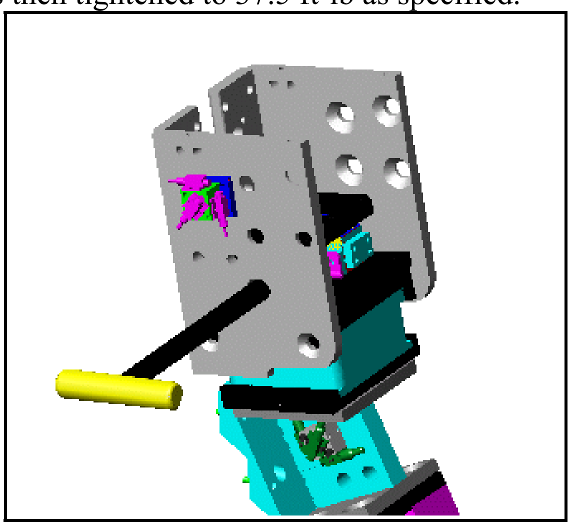

Figure 2.9- Neck Pitch Change adjustment

The final posture adjustment required is to set the head angle so that the dummy's eyes are facing straight forward (normal position). This can be adjusted by changing the position of the adjustment nuts on the front and rear neck cables. For the rear neck cable, remove the skull cap from the rear of the head and loosen the #10-32 Nylon Hex Locknut Nut. This nut location is shown in **Figure 2.10.** For the front cable, remove the Head Plug (T1HDM116) to access the front spring adjustment nut (**Figure 2.11**) . The spring adjustment nuts can now be adjusted using a 3/8" deep socket. To rotate the head back, loosen the front spring adjustment nut and tighten the rear adjustment nut. Note: The nuts are only tightened to remove the slack from the cable assemblies and are not designed to preload the spring assemblies. To obtain further details about this procedure, refer to **Section 3.3** in the manual (Adjustments of the Head Assembly).

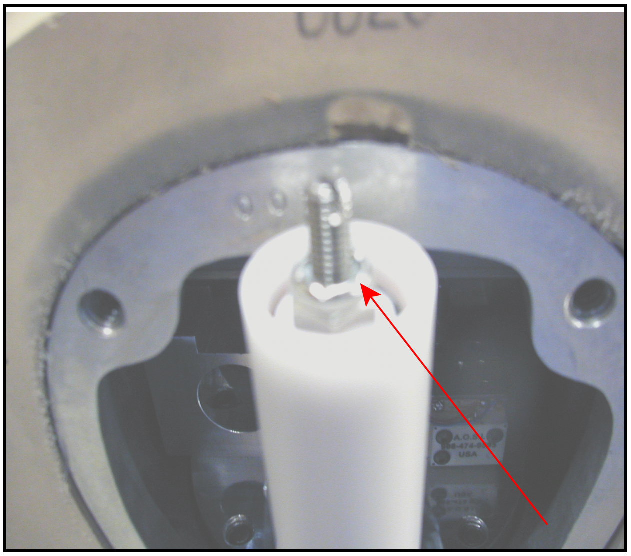

Figure 2.10- Rear head Locknut location

Figure 2.11- Front head angle adjustment

2.8 Abdomen Storage Fixture

The cable tension in the string potentiometer instruments of the upper abdomen and lower abdomen can cause permanent foam compression over a period of time. An Abdomen Storage fixture has been designed to relieve the tension that these instruments place on the foam elements. This storage fixture was designed to be used during storage, shipping, or other instances when the dummy will remain unused for a period of time. This fixture was designed to allow usage with the dummy in both the seated and reclined positions. The advantage of this fixture is that it allows the tension of the string potentiometers to be relieved without detaching the instruments from the dummy.

The abdomen storage fixture is shown in **Figure 2.12**, a photograph of the fixture mounted on the dummy is shown in **Figure 2.13**. The following procedure describes the use of the abdomen fixture.

- Remove the dummy testing jacket as described in Section 14.

- The Abdomen Fixture Plate (T1FDT212) is positioned over the upper and lower abdomen assemblies with the foam block resting on the bib assembly above the upper abdomen bag.

- Thread the 1/4-20 Round Thumb Nuts up against the head of each of the three Abdomen Fixture Bolts (T1FDT211).

- Insert the top Abdomen Fixture Bolt through a 1/4" ID washer, through the middle slot on the Abdomen Fixture Plate and thread the bolt into the hole in the upper abdomen Accelerometer Mount (T1UAM015).

- Insert the lower two Abdomen Fixture Bolts through a 1/4" ID washer, through the outer two slots on the Abdomen Fixture Plate and thread the bolts into the holes in the U-Joints of the Left and Right DGSP Units.

- Turn the 1/4-20 Round Thumb Nuts down to contact the fixture plate and continue turning to draw the string pot cables up toward the fixture plate. This will transfer the tension in the string pot cables from the abdomen foam to the fixture plate.

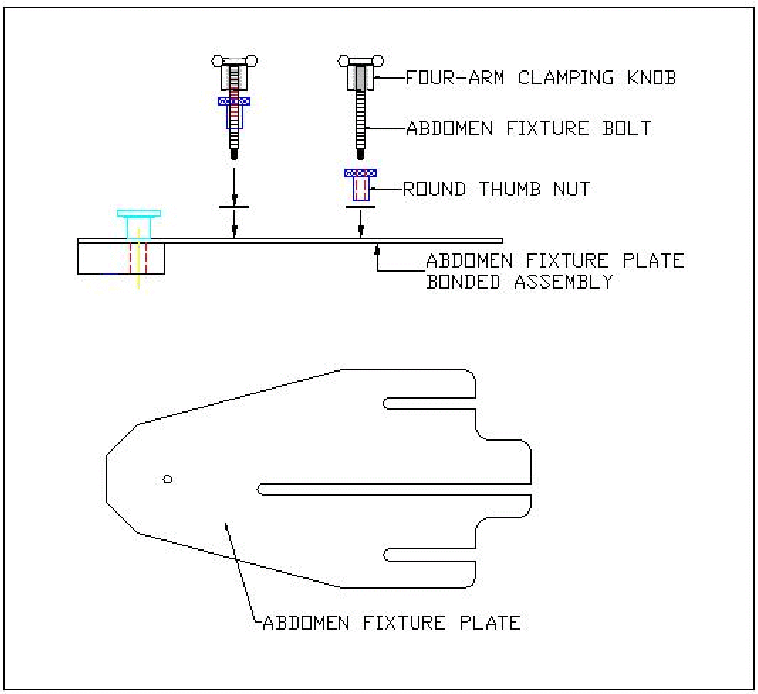

Figure 2.12- Abdomen Fixture Plate

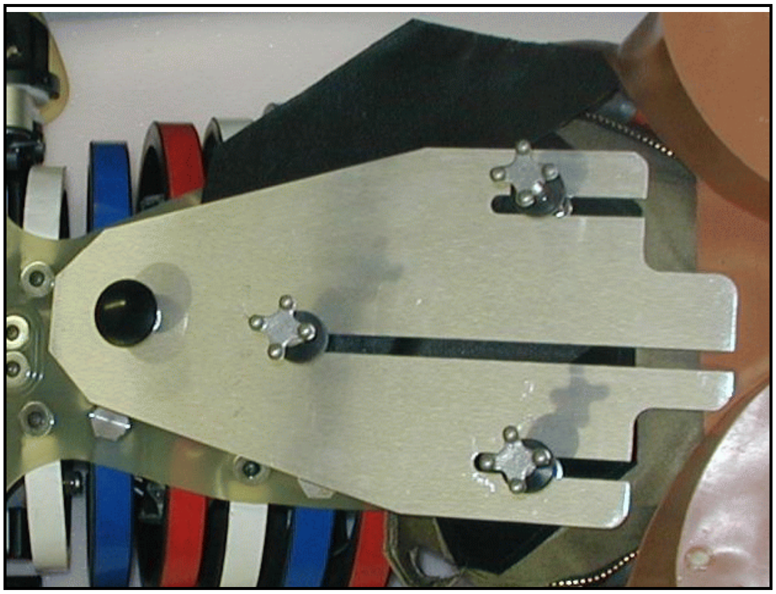

Figure 2.13- Proper use of Abdomen Fixture Plate

2.9 Joint Resistive Torque Adjustments

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

2.10 Packing and Shipping

The steel coffin shipping container which the dummy arrived in makes an ideal storage and shipping container. Dents in the coffin caused during shipping can easily be pounded out using a rubber mallet from the inside surface. The coffin is lined with a layer of soft foam to cushion and protect the dummy during shipment, in addition, blocks of foam should be positioned around the dummy to prevent lateral shifting within the container. There is a black dot on one end of the lid which corresponds to a similar mark on one end of the coffin - aligning these marks will align the bolt holes in the lid of the coffin. In addition to the machine screws which hold the lid in place, the use of fiber reinforced tape or packing straps is recommended for additional reinforcement.

2.11 Additional Reference Materials:

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

THOR NT Drawing Package - This document provides detailed assembly and parts drawings of all THOR components. The drawings should be referenced for detailed information on any part or assembly described in this manual and also for those components for which description is not given in this manual.

THORTEST Software Program and Manual - This is a custom program which was developed to analyze the data for the chest deflection instrumentation (CRUX), lower abdomen deflection instrumentation (DGSP), head / neck forces and moments, lower leg forces and moments, and head angular accelerations. The description of the use and manipulation of this program is included with the dummy in a separate documentation package. In addition a separate disk containing the input data files (modified for this specific dummy) is included for your use.

Biomechanical Response Requirements of the THOR NHTSA Advanced Frontal Dummy - This report describes the response requirements of selected components of the THOR NHTSA Advanced Frontal Dummy under specified dynamic conditions. It also describes the laboratory procedure for testing a specific requirement and the original biomechanical tests that were used to develop the requirement. This document is included with the dummy in a separate documentation package.

THOR Certification Manual - This document provides detailed procedures for performing the various certification tests on the dummy to establish whether the dummy is within calibration. This document is included with the dummy in a separate documentation package.

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

Serial Number Reference Sheet - This data sheet provides serial number information on various dummy components which allows us to track their performance.

THOR Calibration Sheets - These sheets contain all of the calibration information for the THOR dummy instrumentation. The sheets are customized to the particular dummy set-up which you are using. Separate sheets are included for the DGSP and CRUX units which are calibrated on a test fixture at GESAC prior to assembling the dummy.

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 skins. The internal ballast weights have been pre-installed within the skull cavity to adjust the CG location and overall mass of the assembly to meet human requirements. The head is instrumented with three uniaxial accelerometers at the CG of the head; two pairs of uniaxial accelerometers, mounted on a 7-accelerometer array fixture, a pair of uniaxial accelerometers at the top of the skull, 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 or post-test) mode. The head has been specifically designed for the Endevco accelerometer model number 7264C-2KTZ in order to have the head CG match the human location. The three bi-axial accelerometer arrays along with the CG accelerometers are oriented to provide the data required to compute the head angular accelerations. The accelerometers are arranged in the following manner: top (X and Y), rear (Y and Z), and side (X and Z). The distance from the point where the three axes of the C.G. accelerometers intersect to the point where the axes of the paired accelerometers intersect for each of the three sets of accelerometers is as follows: C.G. to the rear accelerometers = 2.00 inches, and C.G. to the side accelerometers = 1.90 inches, and C.G. to the top accelerometers = 2.82 inches. **Figure 3.1** shows a drawing of the THOR head assembly.

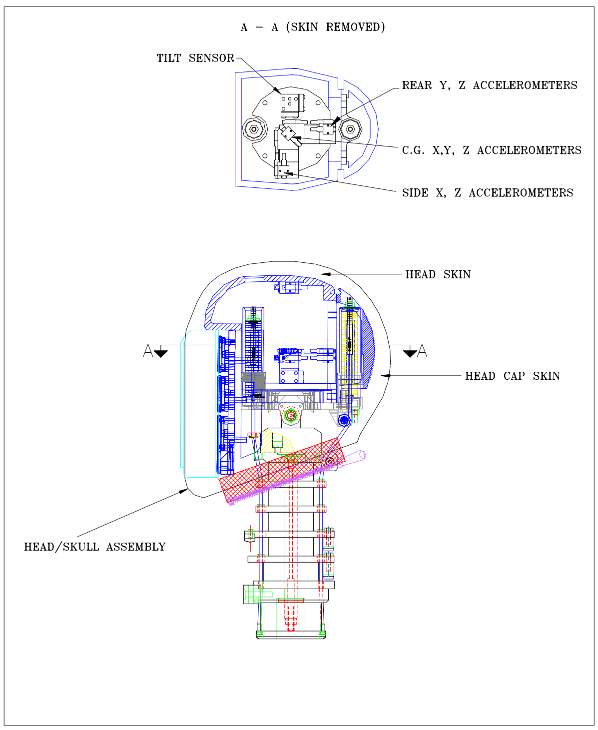

Figure 3.1- Head Assembly

3.2 Assembly of the Head

3.2.1 Parts List

The parts list for the head assembly is listed in Appendix I - Bill of Materials under the Head subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1HDM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 3.2** shows an exploded view of head assembly and hardware.

Figure 3.2- Head Exploded Assembly

3.2.2 Assembly of Head Components

The following procedure is a step-by-step description of the assembly procedure for the head components. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Remove the head skin if necessary. The orientation of the top head accelerometers is +X is to the front, +Y is to the right. Mount two uniaxial accelerometers (T1INM111) to the Top Biaxial Accelerometer Mount (T1HDM119) using four #0-80 x 1/8" S.H.C.S. {0.50}and four 18 SS washers so that the desired orientation will be obtained when it is installed in the dummy. Mount the Top Biaxial Accelerometer Mounting Insert

(T1HDM119) on the interior of the Head Casting (T1HDM130) using four #4-40 x 7/16" S.H.C.S. {3/32} and two 1/8 x ½" dowel pins so that the accelerometer orientation is correct. The dowel pins are pressed into the Head Casting from the outside until they become flush with the surface. The mounting bolts are passed through the skull from the outside and tighten the mounting block in place. **Figure 3.3** shows a photograph of the top biaxial mount.

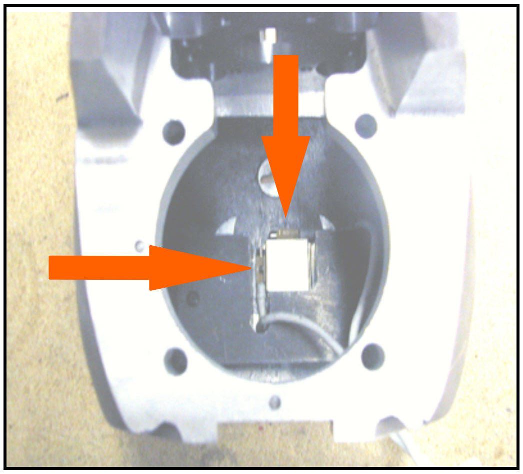

Figure 3.3- Top biaxial accelerometer location

2. The 7 accelerometer-array fixture (T1HDM212) holds 7 uniaxial accelerometers (T1INM111). Three are at the C.G. of the head, two at the rear, and two at the side, attached using fourteen # 0-80 X1/8" S.H.C.S. {0.50} and # 0 flat washers.

   2.1 The orientation of the two side accelerometers is +X is to the front, +Z is down.

   2.2 The orientation of the two rear head accelerometers is +Y is to the right, +Z is down.

   2.3 The orientation of the three Head CG accelerometer units is +X is to the front, +Y is to the right, and +Z is down.

3. Mount the 7 Accelerometer Array Fixture to the Head Accelerometer Mounting plate using four #1/4-28 X 5/8 F.H.S.C.S {5/32}), as shown on **Figure 3.4.**

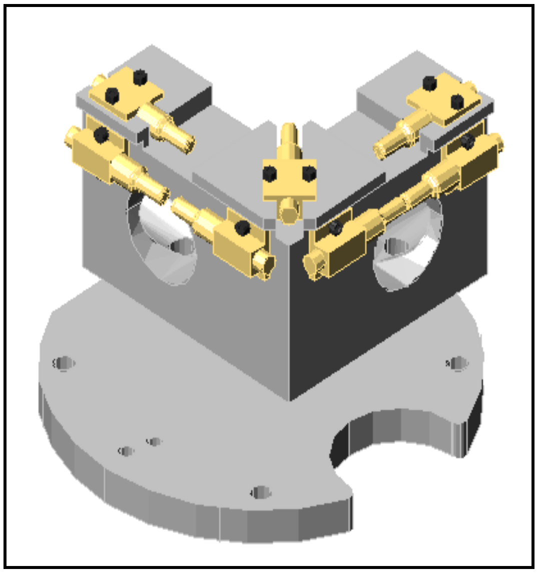

Figure 3.4- 7 Array Fixture mounted on
the Head Accelerometer Mounting Plate.

4. The Head Tilt Sensor Assembly (T1HDM501) is attached to the interior of the Head Casting (T1HDM111) and to the Head Accelerometer mounting plate (T1HDM210) using two #4-40 X ½" F.H.S.C.S {1/16}. The Tilt Sensor wires are clamped to the tilt sensor using a 1/8" cable clamp, a # 4-40 X 1/4" S.H.C.S {3/32}, and a #4 washer. **Figure 3.5** shows the head tilt sensor mounted in the head casting.

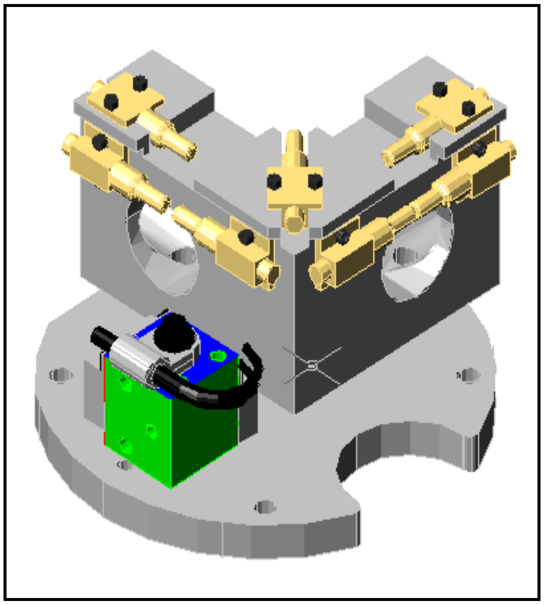

Figure 3.5- Tilt Sensor Location

5. Insert the completed Accelerometer Mounting Plate Assembly (T1HDM200) into the

Head Casting (T1HDM111) and orient the plate so that the Tilt Sensor Assembly is toward the right of the dummy.

6. To attach the head to the neck assembly, insert the completed Head / Neck Mounting Platform Assembly (T1NKM200) - See Neck Section 5 for further details - up through the bottom of the Head Casting Assembly (T1HDM000). Tighten the four 1/4-28 X 1" F.H.S.C.S. (These mounting screws are typically inserted through the Head / Neck Mounting Platform Assembly (T1NKM200) prior to assembling the condyle bolt - See Neck Section 5 for further details.

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

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7. The instrumentation wires from the head are split into two bundles and are secured to the Upper Thoracic Spine Assembly two 1/4" rubber-cushioned steel loop straps and two 10-24 1/4" B.H.S.C.S {1/8}. **Figure 3.6** shows the attachment of the wire routing for the head instruments.

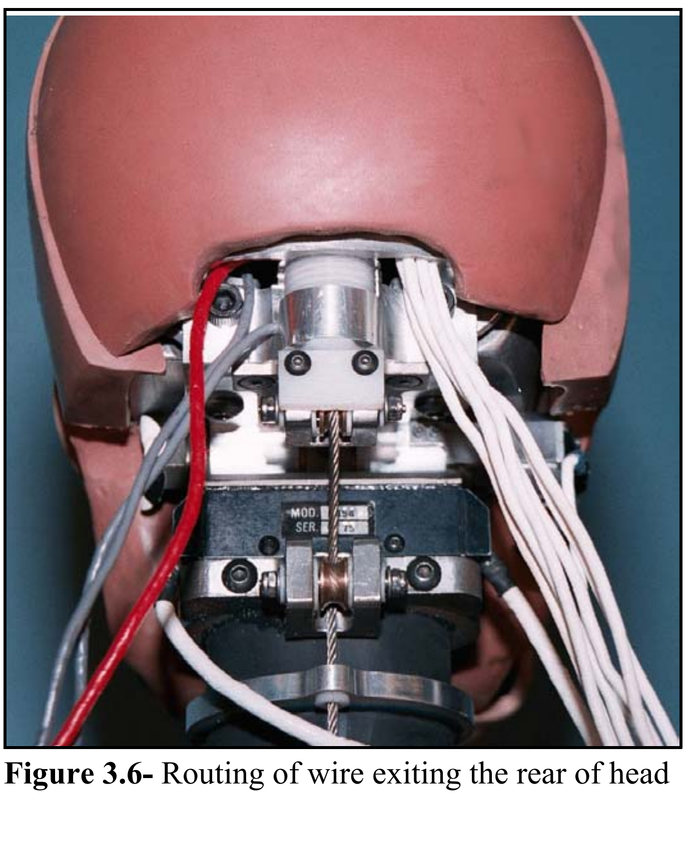

Figure 3.6- Routing of wire exiting the rear of head

8. The head angle is now adjusted as described in Section 3.3.1. After the adjustment is completed, the Head Plug (T1HDM116) is tightened into the front hole in the top of the head casting, as shown in **Figure 3.7**. This Head Plug prevents the spring assembly from ejecting in the event of a front cable failure.

Figure 3.7- Head Plug Location

9. Position the Head Cap Skin (T1HDS010) onto the Head Cap (T1HDM110). The head cap assembly can be placed on the rear of the skull and slid down into position while routing the wire bundles out through the bottom sides of the cap. The cap is secured in place using four 1/4-20 x 5/8" S.H.C.S. {3/16} as shown in **Figure 3.8**.

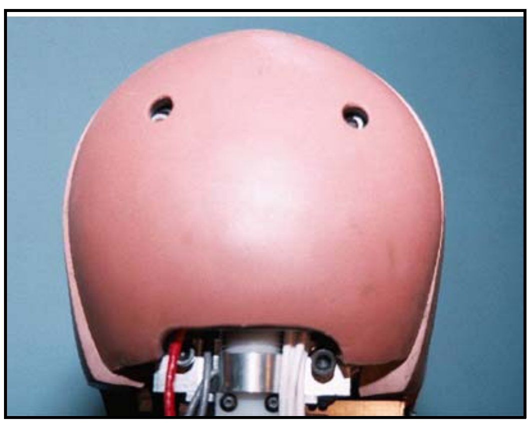

Figure 3.8- Properly installed skull cap

10. The head skin (T1HDS020) can now be pulled into position over the head casting assembly. A #4-40 x 1/4" Nylon S.H.C.S. {3/32} is placed on both sides of the Machined Head Skull (T1HDM111) to mark the location of the Head C.G. **Figure 3.9** shows the

C.G. location.

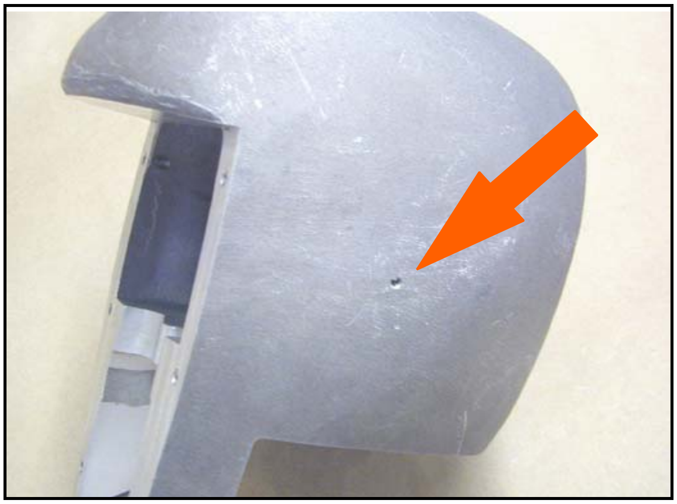

Figure 3.9- C.G. Marker Location

3.3 Adjustments for the Head Assembly

3.3.1 Head Angle Adjustment

The following procedure is a step-by-step description of the procedure for the head angle adjustment. This adjustment procedure is used to set the angle or attitude of the head relative to the ground plane. (This is also referred to as the eye level or eye plane adjustment in some literature.) The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2.

1. Loosen the #10-32 Nylon Hex Locknut Nut located at the top of the front and rear neck cable assemblies. This nut location is shown in **Figure 3.10.**

Figure 3.10- Rear Spring Adjustment Locknut Location

2. Adjust the hex nuts {3/8 deep well socket} to obtain the proper head angle. The adjustment for the front cable retaining nut is shown in **Figure 3.11**. The head angle will vary depending on the desired test set-up, however, most set-ups require that the eyes be directed straight ahead - parallel to the ground.

Note: The proper torquing adjustment of the spring adjustment nuts is to remove the slack from the cable systems without precompressing the spring assemblies.

Figure 3.11- Remove head plug to access front cable adjustment

3. Tighten the two # 10-32 Hex Nylon located at the top of the front and rear cable assemblies.

4. Continue from Step 11 in the Assembly of Head Components specified above.

3.4 Electrical Connections and Requirements

There are two wire loop clamps which provide strain relief for the head instrumentation wires. These two wire loop clamps are attached to the Upper Thoracic Spine Back Plate (T1SPM123). The wire bundles are split into two groups, one exiting through the holes in the head cap on each side of the rear spring tube assembly. A small amount of slack should be provided between the instruments and the wire clamps to prevent stress on the instruments themselves.

3.5 Head Calibration

The head assembly is subjected to the standard Hybrid III drop test calibration which is performed by the OEM supplier prior to modification at GESAC. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication.

3.6 Inspection and Repairs

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

Although this disassembly is very simple, some comments are provided below to assist in the process.

3.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the spine instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

3.6.2 Mechanical Inspection

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

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

- Check the tightness of all instrumentation mounting bolts.

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

- Check the head angle adjustment as described in Section 3.3.1

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

- Check the head skin for tears and damage.

Section 4. Face Assembly

4.1 Face Assembly Description and Features

The face assembly includes the foam assembly, face plate, and 5 compression load cells with impact plates. The load cells are distributed across the entire face plate, one at each eye, cheek, and one at the center of the chin. The load cells are provided to measure the total load applied to the face. Human soft tissue over the face is represented by foam sandwiched between two rubber sheets. The impact stiffness of the foam/rubber was selected to match human impact loading characteristics. **Figure 4.1** shows a drawing of the THOR face assembly.

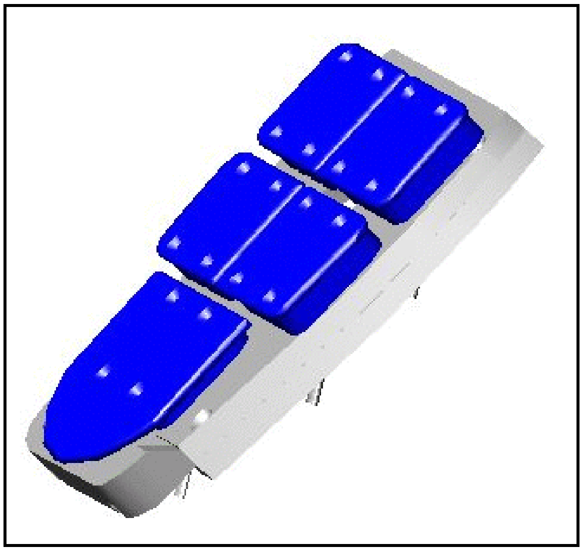

Figure 4.1- Face Assembly

4.2 Assembling the Face

4.2.1 Parts List

The parts list as well as all quantities for the face assembly are listed in Appendix I - Bill of Materials under the face section. Refer to drawing (T1FCM000) in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 4.2** is a drawing of the exploded head assembly and hardware.

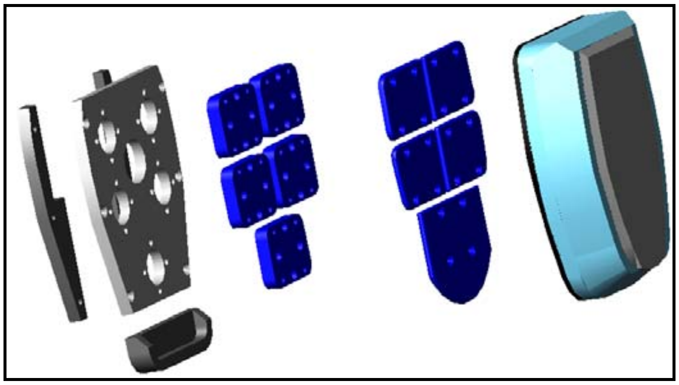

Figure 4.2- Exploded face assembly

4.2.2 Assembly of Face Components

The following procedure is a step-by-step description of the assembly procedure for the face components. The numbers provided in () refer to a specific drawing / part number of each particular part. The numbers noted in {} after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Install the face load cells (T1INM430) onto the face plate (T1FCM110) using four #6-32 x 3/8" SHCS {7/64} per load cell. The load cells are oriented onto the face plate so that the instrument wires can easily slide through the holes in the face plate. **Figure 4.3** can be used as a reference for proper rotation of the Load Cells.

2. Place the Right and Left Face Plate Spacers (T1FCM119) and (T1FCM120) on the Front face of the Head Skull (T1HDM111) as shown in **Figure 4.3.**

Figure 4.3- Face Plate Spacers/Head Skull Assembly

3. At this point, it is necessary to attach the Face plate (T1FCM110) to the Face Plate Spacers/ Head Skull assembly using eight six #6-32 X 3/4" F.H.S.C.S. {5/64} as shown in **Figure 4.4**.

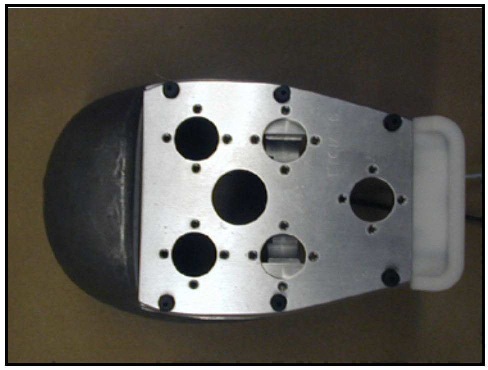

Figure 4.4- Face Plate Assembly

4. Attach five Face Load Cells (T1INM430) to the Face Plate using twenty #6-32 x 3/8" S.H.C.S {7/64}as shown in **Figure 4.5**.

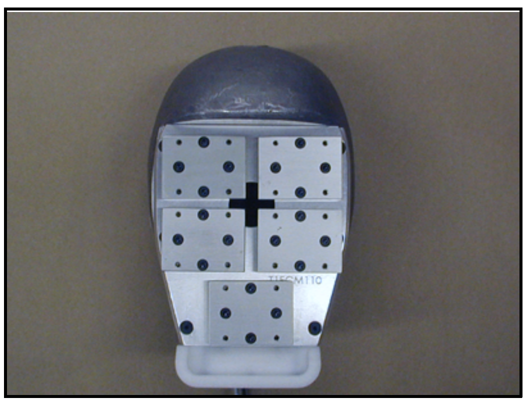

Figure 4.5- Face Load Cells Assembly

5. Install the respective load cell plates (T1FCM112, T1FCM113, T1FCM114, T1FCM115, & T1FCM116) onto the face load cells using four #6-32 x 3/8" FHSCS {5/64} per plate. Each load cell plate is shaped differently to match the contour of the front of the head casting. The load cell plates are labeled, "l-eye, r-eye, l-cheek, r-cheek, and chin according to the location on the face, that the load cell plates should be attached. **Figure 4.6** is an illustration of the attachment of the load cell plates to the face load cells.

Figure 4.6- Load Cell Plates attached to Load Cells

6. Locate the Chin Guard (T1FCM111), and attach it to the face plate with the angled side downwards and out using two #6-32 x 7/8" S.H.C.S {7/64}and two 1/8 x 3/8" Dowel Pins. **Figure 4.7** shows the Chin Guard assembled to the Face Plate.

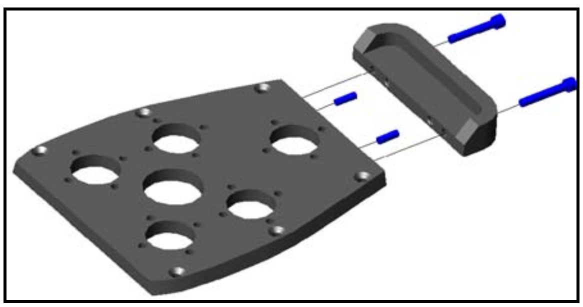

Figure 4.7- Chin Guard exploded assembly

7. Position the Face Foam Assembly (T1FCM060) inside the cavity in the Head Skin (T1HDS020). Velcro is located on both sides of the Head Skin to hold the foam in place. Mount the Head Skin to the Head Skull and proceed to the Head assembly, detailed in Section 3.

4.3 Adjusting the Face Assembly

No adjustments are required for the face assembly.

4.4 Electrical Connections and Requirements

The face load cell wires are grouped with the wire from the head tilt sensor and a wire from the fore and aft neck spring compression load cells. The bundle of wires are routed out the back of the head. Refer to Section 3, Head Assembly for further details.

4.5 Face Certification

The face assembly is certified at GESAC using two different dynamic impact tests. The impacts are done on the face with two different loading surfaces and impact speeds while the force is recorded by the load cells on the face and the load cell on the impact test machine. Certification procedures for these tests are described in the THOR Certification Manual which is available from GESAC as a separate publication.

4.6 Inspection and Repairs

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

Although this disassembly is very simple, some comments are provided below to assist in the process.

4.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all instrument wires from the face instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation and Wiring.

4.6.2 Mechanical Inspections

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

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

- Check the foam for tears and rips.
- Check the foam for permanent compression.
- Check the rubber sheet on both sides of the foam assembly for tears and other damage.

Section 5. Neck Assembly

5.1 Description of the Neck Assembly and Features

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

The instrumentation for the neck assembly includes a pair of miniature load cells to measure the compression at the front and rear spring locations (Denton: Model 6005), six component load cells at the top (Denton: Model B-3454) and base (Denton: Model 2357) of the neck to measure the forces and moments developed at these locations, and a rotary potentiometer (Contelec: PD210-4B) used at the condyle pin to measure the relative rotation between the head and top of the neck. **Figure 5.1** shows a drawing of the THOR NT neck assembly.

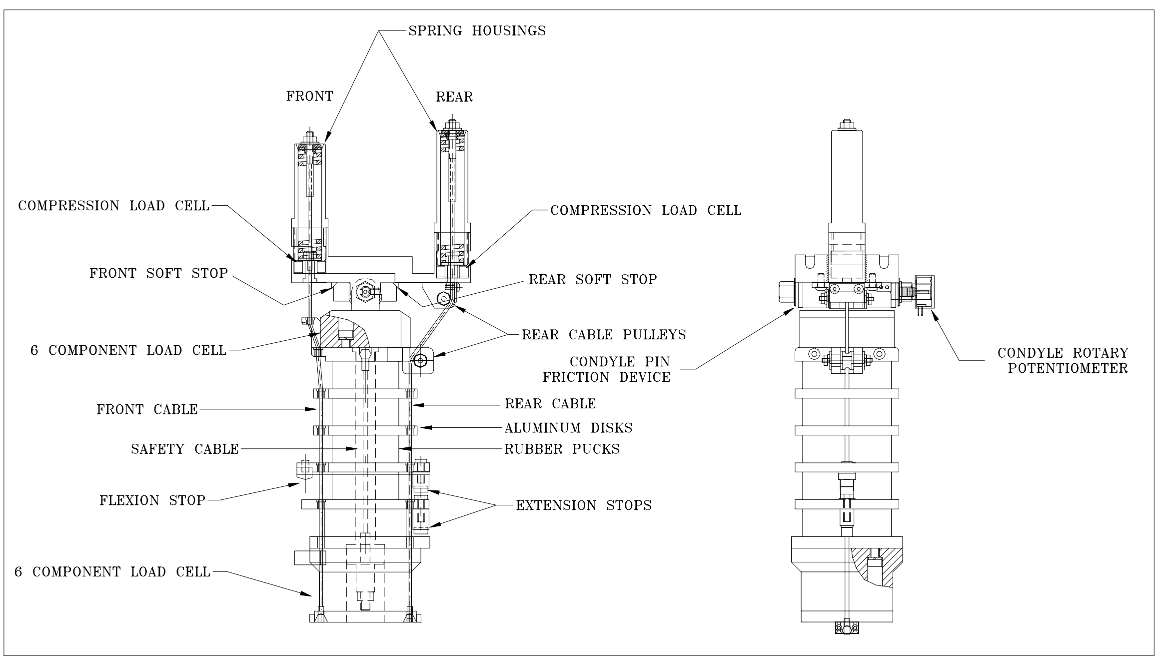

Figure 5.1- Neck Assembly

5.2 Assembly of the Neck

5.2.1 Parts List

The parts list for the neck assembly is listed in Appendix I - Bill of Materials under the Neck subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1NKM000 in the THOR NT drawing set for a detailed mechanical assembly drawing. **Figure 5.2** is a drawing of the exploded head assembly and hardware.

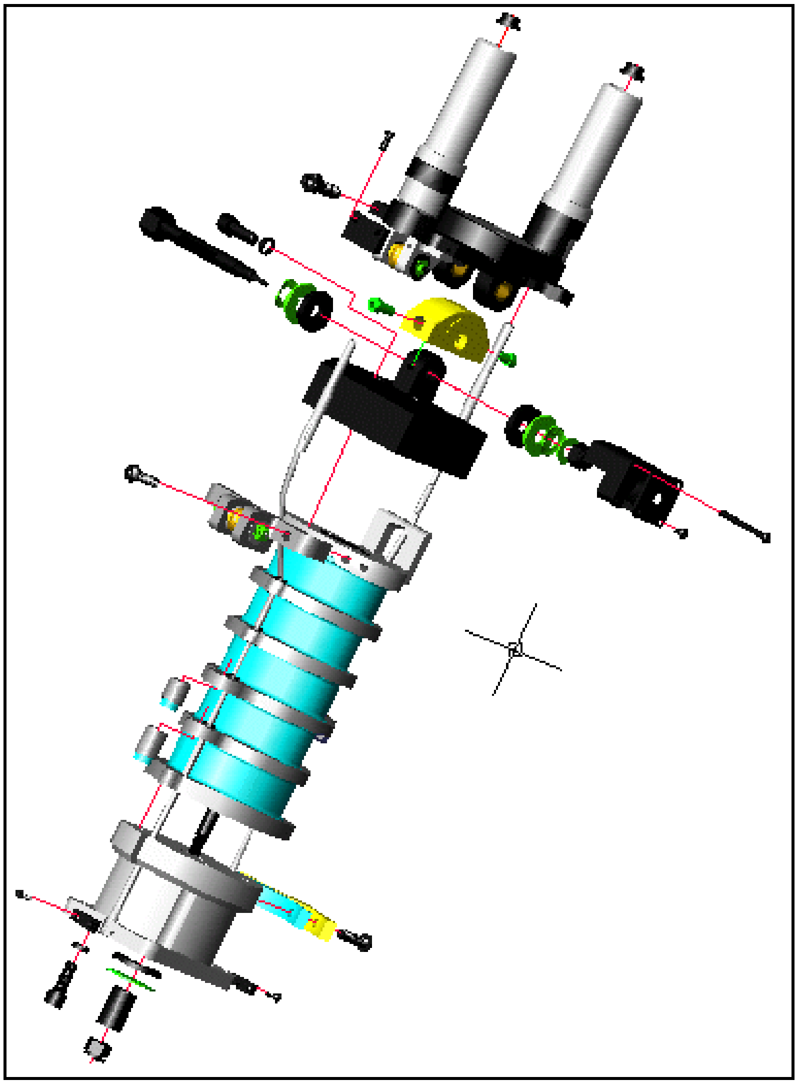

Figure 5.2- Neck Exploded Assembly

5.2.2 Assembly of Neck Components

The following procedure is a step-by-step description of the assembly procedure for the neck components. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Identify the front of the Neck Molded Assembly (T1NKM100) by looking at the top plate. The plate has a machined bracket which stands up and bends toward the front. Pass the Neck Front Cable Assembly (T1NKM122) through the holes in the front of the neck plates - starting at the top - ball end of the cable first. Perform the same procedure with the Neck Rear Cable Assembly (T1NKM117) on the holes in the rear of the neck plates.

2. Assemble the Cable Guide Halves (T1NKM118) at the ten locations shown in **Figure 5.3**. Two halves are positioned in each hole that the cable passes through and are pressed into the hole around the cable.

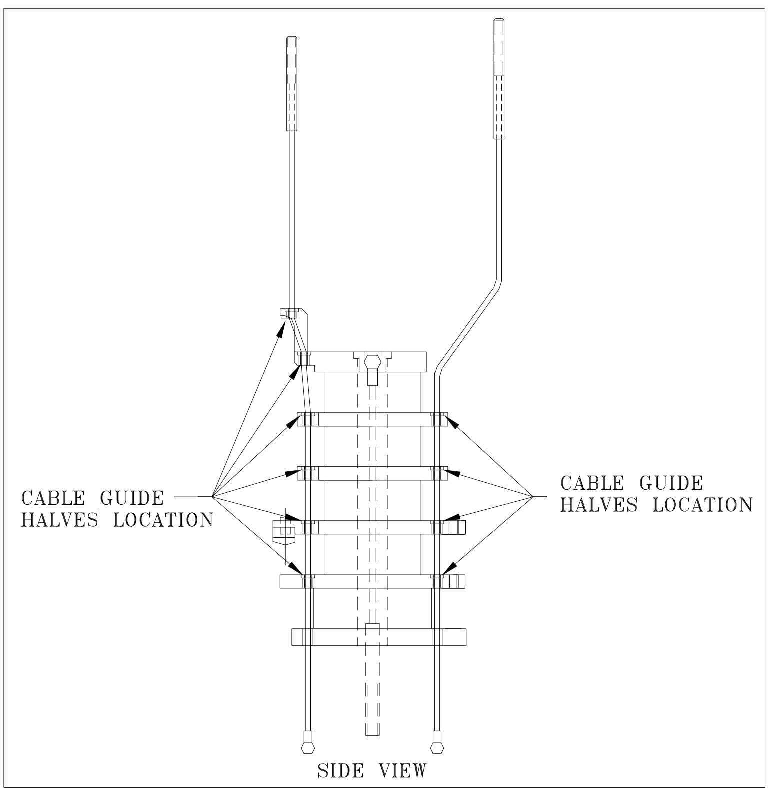

Figure 5.3- Cable guide locations

3. Identify the front of the Lower Neck Load Cell (T1INM320) by looking at the four main mounting holes. The holes are spaced closest together on the front side of the load cell. (Note: The instrumentation wires exit in the rear of the load cell.) Pass the front and rear

cable ball ends through the cable mounting holes in the front and rear of the lower neck load cell respectively. The cables should pass through the load cell top plate and out the slots in the side.

4. Attach the Lower Neck Load Cell (T1INM320) to the bottom plate of the Neck Molded Assembly (T1NKM100) using four 1/4-20 x 5/8" S.H.C.S. (3/16} with 1/4" split lock washers.

5. Pull the ball ends of the cables up into the cable retaining holes on the bottom of the load cell and at both the front and rear neck cable attachment points. To secure each ball, mount a Neck Cable Seat Cover (T1NKM022) and two #2-56 X 3/8" F.H.S.C.S {0.05}on the front and rear faces of the lower neck load cell bottom plate, as shown in **Figure 5.4**.

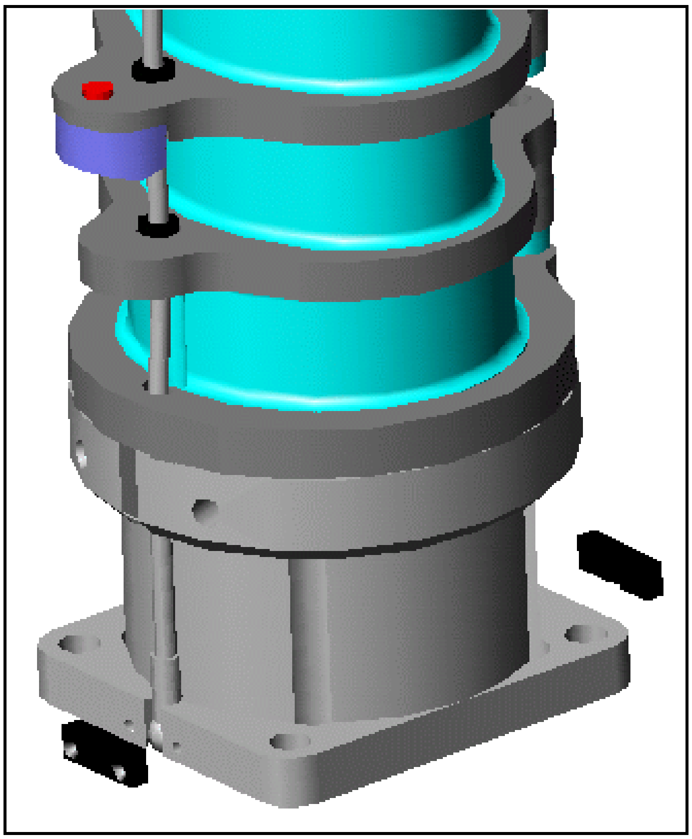

Figure 5.4- Proper placement of cables in Lower Load Cell

6. Place the Lower Neck Load Cell Bumper (T1NKM025) against the front of the Lower Neck Load Cell. Position the Lower Neck Load Cell Bumper Cover (T1NKM024) over the bumper and secure them to the load cell using two #10-32 x 3/4" B.H.S.C.S. {1/8} as

shown in **Figure 5.5**.

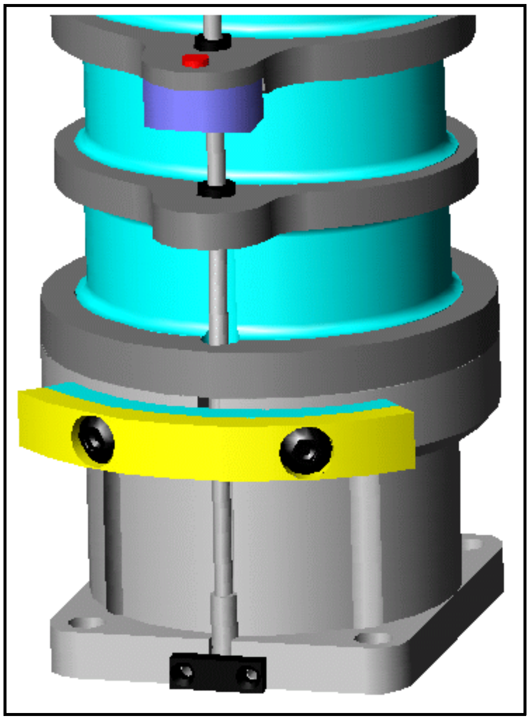

Figure 5.5- Lower Neck Load Cell Bumper

7. Pass the threaded end of the Neck Center Cable Assembly (T1NKM119) through the top side of the Neck Center Cable Fixture (T1NKM120). Pass the cable through the hole in the center of the Molded Assembly (T1NKM100) from the top side and position the Neck Center Cable Fixture (T1NKM120) in the recessed hole in the center of the top plate of the molded neck assembly. Secure the cable into position in the counter bore in the lower neck load cell using a flat washer and a nylon spacer. Secure the center cable assembly with a 1/4-28 Serrated Hex Nut {7/16 socket} by holding the top end of the cable with a flat head screwdriver and tightening the nut ½ turn past finger tight. The completed assembly is shown in **Figure 5.6**.

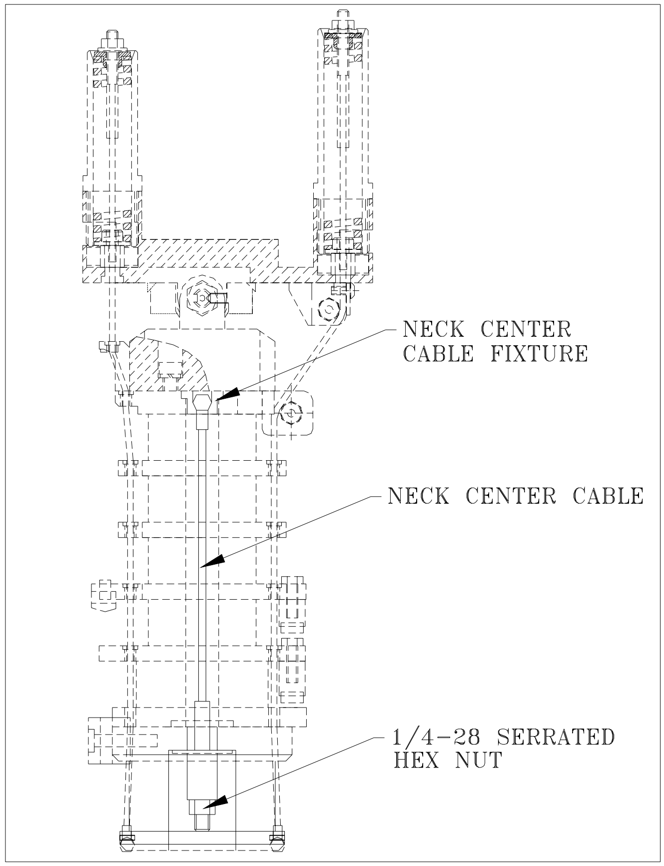

Figure 5.6- Neck Cable Assembly

NOTE: DURING THE ASSEMBLY OF THE NECK REAR PULLEY BRACKET (T1NKM300), IT IS IMPORTANT TO KEEP THE REAR NECK CABLE (T1NKM117) POSITIONED BETWEEN THE REAR CABLE PULLEY (T1NKM312) AND THE NECK TOP PLATE (T1NKM116).

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8. Place a Teflon washer on each side of the Rear Cable Pulley (T1NKM312) and position it between the arms of the Rear Pulley Bracket (T1NKM310). Lightly tap the Pulley Shaft (T1NKM311) through the arm bearings, pulley wheel and washers. Center the shaft on the pulley assembly and secure each end of the shaft using a Neck Teflon Washer (T1NKM313), a #4 Flat Washer, and a #4-40 Nylock Nut {1/4 socket}. Tighten the nylock nuts until contact is achieved. An exploded view of this assembly is shown in **Figure 5.7**.

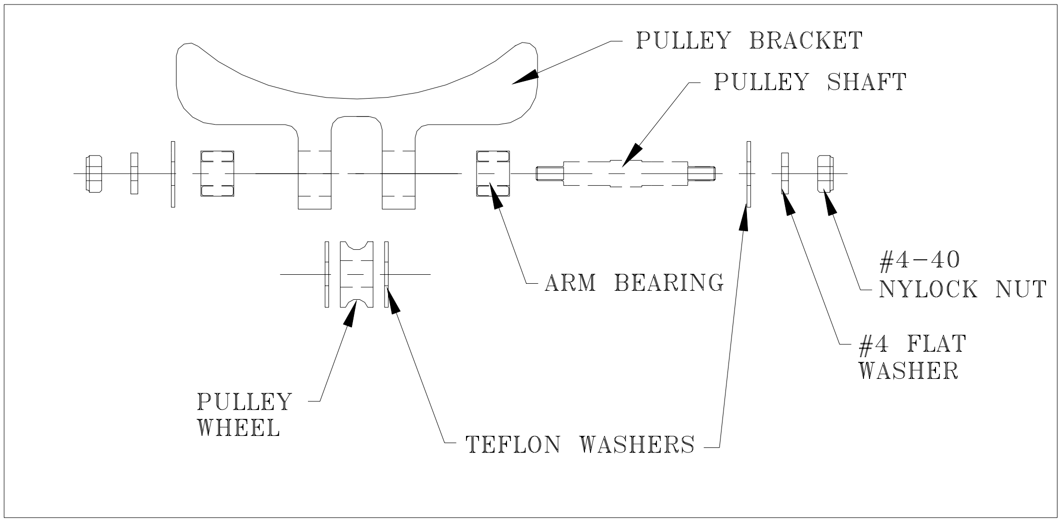

Figure 5.7- Rear cable pulley assembly

9. Install the Upper Neck Load Cell (T1INM310) to the top plate of the Molded Neck Assembly (T1NKM100) using four 1/4-20 x 5/8" S.H.C.S. {3/16} and four 1/4" split lock washers. Check to be sure that the Occipital Condyle Set Screw (T1NKM027) is in the condyle bolt hole on the Upper Neck Load Cell. **Figure 5.8** shows the attachment of the upper neck load cell.

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

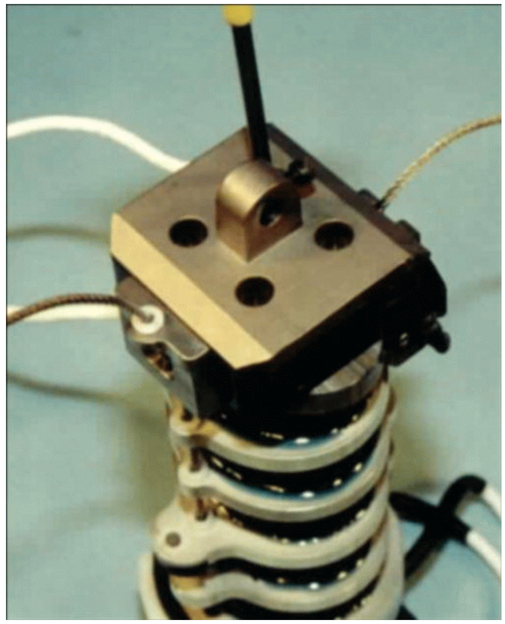

Figure 5.8- Upper load cell attachment

10. **Figure 5.9** shows an exploded view of the Neck/Mounting Platform. For further details, refer to drawing T1NKM200 in the THOR NT drawing package.

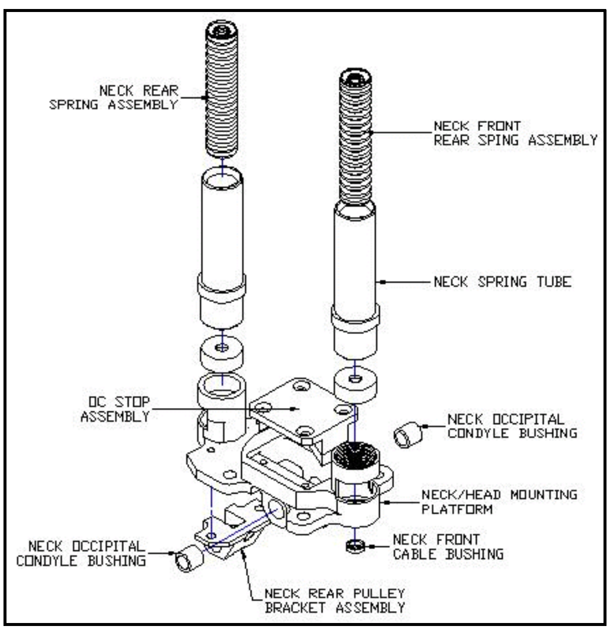

Figure 5.9- Neck/Head Mounting Platform exploded assembly

Drawings T1NKM030, T1NKM050, and T1NKM400 in the THOR NT drawing package describe respectively the assembly procedure of the Neck Front and Rear Spring Assemblies and the Neck Rear Pulley Bracket Assembly.

11. Insert four 1/4-28 x 1" F.H.S.C.S. {5/32} into the front and rear pair of mounting holes in the Neck / Head Mounting Platform (T1NKM210)) from the bottom side as shown in **Figure 5.10.**

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

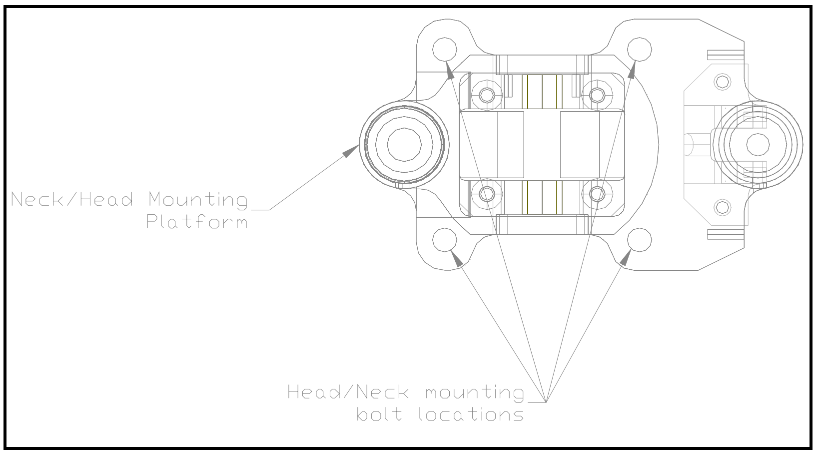

Figure 5.10- Head/Neck mounting bolt locations

12. 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 (T1NKM210). Secure the cables with a #10-32 Hex Nylon insert lock nut. The adjustment of these Cable Retaining nuts is described in Section 3.3

13. Prepare the Neck Occipital Condyle Bolt (T1NKM010) by placing hardware on the bolt in the following order: two Curved Disk Spring washers, a Neck Key Washer (T1NKM011) and a Friction Washer (T1NKM012) onto the Condyle bolt as shown in **Figure 5.11.**

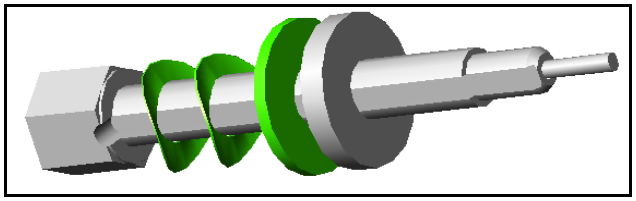

Figure 5.11- Occipital Condyle Bolt Assembly

14. Insert the Occipital Condyle Cam (T1NKM043) into the Upper Neck Load Cell with the threaded counter bore hole aligned with the hole on the Upper Neck Load Cell. Secure the Occipital Condyle Cam using the Occipital Condyle Set Screw (T1NKM027) on the threaded counter bore hole and a #8-32 X 1/4" S.H.S.C.S {3/32}on the opposite side of the Cam.

15. Pass the Condyle bolt through the Neck / Head Mounting Platform (T1NKM210) and Upper Neck Load Cell from the left side. Secure the Condyle bolt with the following hardware: Friction Washer (T1NKM012), Neck Key Washer (T1NKM011), two Curved Disk Spring washers, a #10 Flat Washer, and a 1/4-20 Nylock Nut and torque the nut to 7 ft-lb. This completed assembly is shown in **Figure 5.12.**

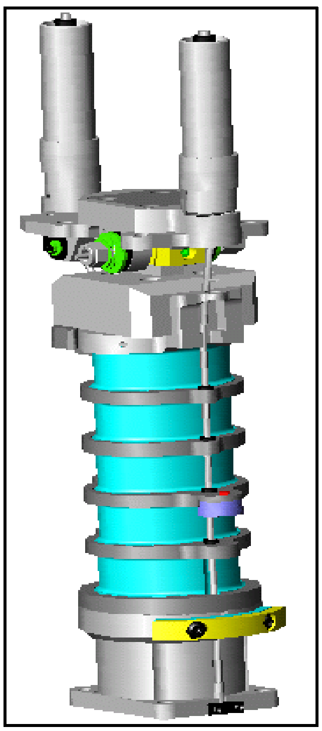

Figure 5.12- Completed Assembly to this point

16. Install the Neck Rotary Potentiometer into the Neck Rotary Potentiometer Housing (T1NKM017) by pressing it into place. Align the D-shaped hole in the potentiometer with the flat on the end of the Condyle Bolt.

WARNING: THE D-SHAPED HOLE IN THE POTENTIOMETER MUST BE ALIGNED WITH THE FLAT ON THE CONDYLE PIN OR THE POTENTIOMETER WILL BE PERMANENTLY DAMAGED.

17. Install the Rotary Potentiometer Housing Cover (T1NKM018) over the Neck Rotary Potentiometer Housing (T1NKM017) using two # 4-40 X 1 1/4" and two # 4-40 X 3/16" B.H.S.C.S. {0.050}on the top holes and bottom holes respectively, as shown on **Figure 5.13.**

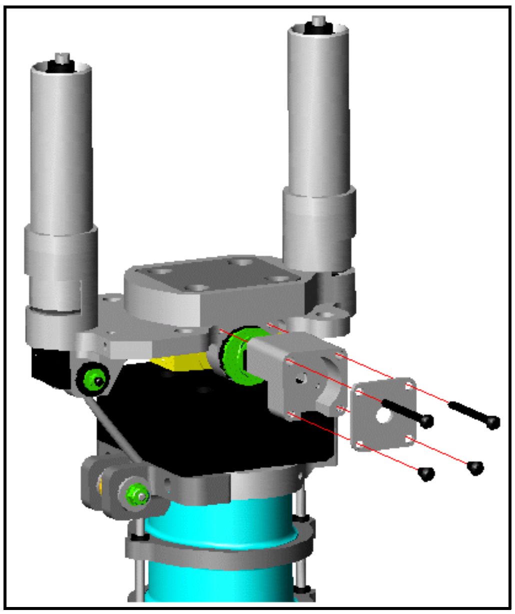

Figure 5.13- Neck Potentiometer Assembly

5.2.3 Ground Strap Attachment

The Head/Neck Ground Strap (T1INM011) connects the Spine at the Upper Thoracic Spine Back Plate (T1SPM123) to the Neck at the Neck/Head Mounting Platform (T1NKM210). Mount the Head/Neck Ground Strap to the Neck/Head Mounting Platform using a #6-32 x 5/16" B.H.S.CS. {5/64}, as shown on **Figure 5.14.**

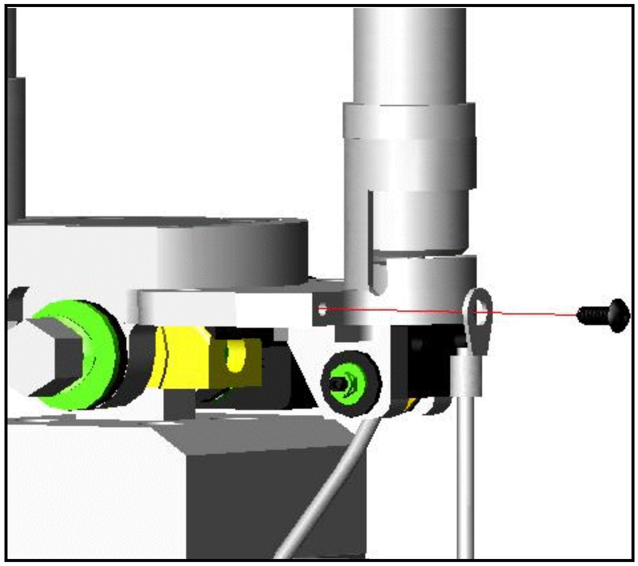

Figure 5.14- Head/Neck Ground Strap attachment to Neck/Head Mounting Platform

5.2.4 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. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2.

1. Insert the completed Head / Neck Mounting Platform Assembly (T1NKM200) up through the bottom of the Head Casting Assembly (T1HDM000). Tighten the four front and rear mounting bolts 1/4-28 x 1" F.H.S.C.S. {5/32}. (These mounting screws are typically inserted through the Head / Neck Mounting Platform Assembly (T1NKM200) prior to assembling the condyle bolt - See Section 5.2.2 - Step 14.

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

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2. Continue the assembly of the head and neck from the procedure given in Section 3.2.2 - Step 10.

5.2.5 Assembly of the Neck to the Spine

The following procedure is a step-by-step description used to install the lower neck load cell to the top plate of the neck pitch change mechanism assembly (T1SPM200). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2.

1. Pass the Lower Neck Load Cell instrumentation wires out through the hole at the top of the Upper Thoracic Spine weldment (T1SPM100) as shown in Figure 5.15.

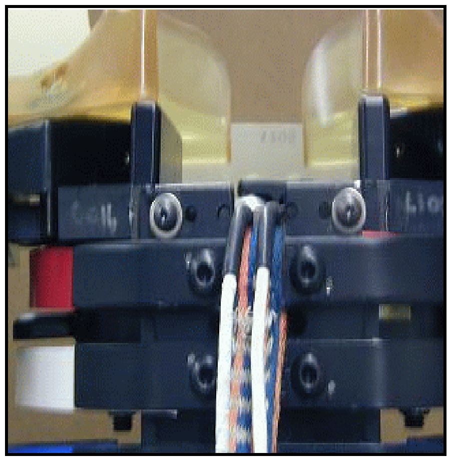

Figure 5.15- Lower Neck Load Cell wires routed through the rear of the Upper Thoracic Spine Mechanical Assembly

2. Secure the Lower Neck Load Cell to the top plate (T1SPM216) of the Neck Pitch change Mechanism using four 1/4-20 x ½" S.H.C.S.- N.P. {3/16}as shown in Figure 5.16.

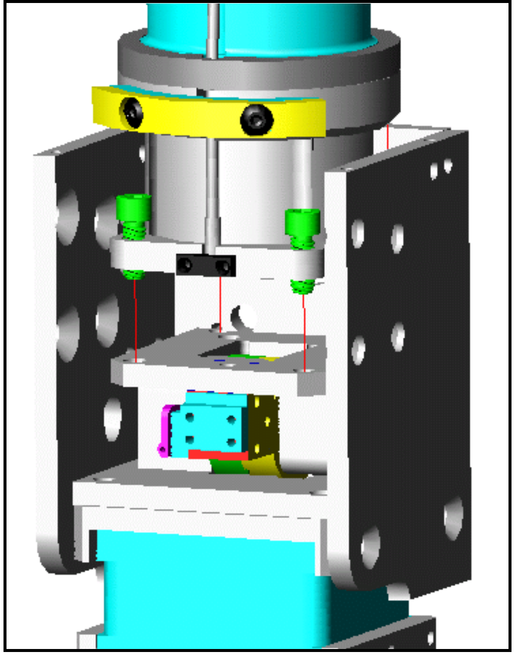

Figure 5.16- Attach the Neck Assembly to the Neck Pitch Mechanism

3. Place the Neck Foam Assembly (T1NKS100) around the Neck Assembly and route the Upper Neck Load Cell wires at the back of the neck along the inside of the Neck Skin. The remaining wires from the head and the neck rotary potentiometer are routed on the outside of the Neck Skin as shown in **Figure 5.17.** Before securing the Neck Skin in place with Velcro, follow step 7 in Section 7.2.2-Assembling the Thorax Components, in order to provide the correct amount of slack in the wires.

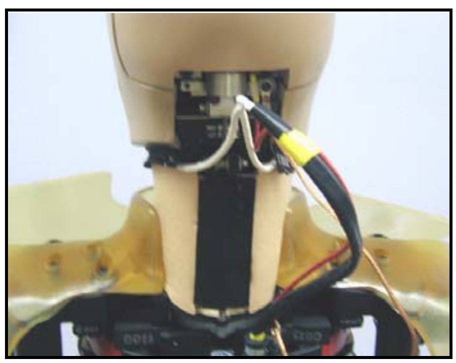

Figure 5.17- Neck/Neck Foam assembly

4. Wrap the Neck Skin Assembly (T1NKS200) around the Neck Foam Assembly, such that the zipper in the Neck Skin Assembly closes down, as shown in **Figure 5.18**. **Figure 5.19** shows the complete Neck Foam/Neck Skin Assemblies.

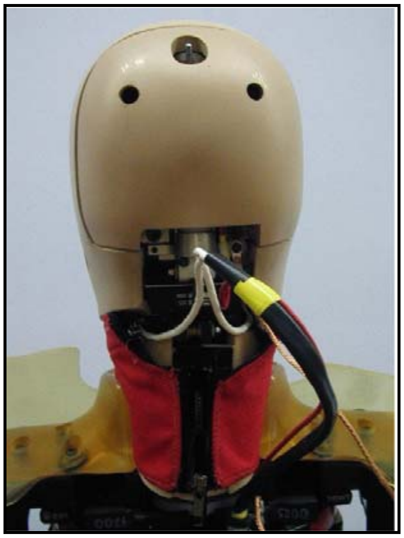

Figure 5.18- Neck Skin Assembly

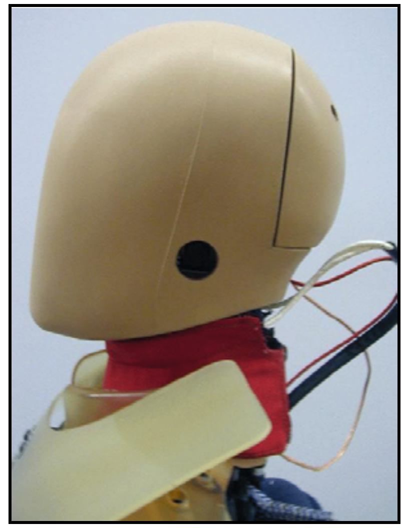

Figure 5.19- Neck Skin assembly

5.3 Adjustments for the Neck Assembly

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

Head Angle Adjustment - This adjustment changes the angle of the head relative to the neck assembly - it describes the procedure for properly adjusting the cable tension on the front and rear neck spring assemblies. This adjustment procedure is described in Section 3.3.1.

Neck Pitch Change Mechanism Adjustment - This adjustment changes the angle of the head and neck assemblies relative to the spine at the approximate anthropomorphic landmark defined by the T6 / T7 joint. This adjustment procedure is described in Section 6.3.2.

5.4 Electrical Connections and Requirements

The neck has three primary instruments: upper neck load cell, lower neck load cell, and the neck rotary potentiometer. The instrument wires from the lower neck load cell are routed through the hole in the back of the Upper Thoracic Spine Weldment and secured to the back of the spine using two Rubber Cushioned Steel Loop Straps.

The instrument wires from the upper neck load cell and neck rotary potentiometer are bundled together with the instrumentation wires from the head assembly. This wire bundle is clamped in place along the rear of the spine using the Aluminum Spine Wire Covers. The procedure for this wire routing is described briefly below. For additional details and pictures, refer to Section 6.4.

1. Make two bundles. One with the wires from the Head Accelerometers and the Neck Spring Load Cells. The other with the wires from the Head Tilt Sensor, Neck Rotary Potentiometer, and Face Load Cells. Holding each bundle, measure 13.5" down along the wire bundle. Centered at this point, wrap the wire bundles with electrical tape to provide enough thickness to allow the spine wire cover to hold it securely in place. This measurement will create the necessary slack in the wires.

2. Route out the two bundles to the holes in the Upper Thoracic Spine Back Plate (T1SPM123). (See Drawing T1TXM000 and T1TXM001 for details).

3. Clamp each taped portion of the bundles using a Rubber Cushioned Steel Loop Strap, and bolt each Loop Strap to the Upper Thoracic Spine Back Plate using a #10-24 X 1/4" B.H.S.C.S {1/8}. This will clamp the wire bundle in position and provide the proper amount of slack in the cable to prevent damage to the instrumentation.

   Additional details are provided in the Thorax and Instrumentation sections.

5.5 Neck Calibration

The neck assembly is calibrated at GESAC using a pendulum test. The neck is subjected to frontal, rearward, and lateral bending while measuring data for the neck angle and moment. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication.

5.6 Inspection and Repairs

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

5.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the neck instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

5.6.2 Mechanical Inspection

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

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

- Check the tightness of all instrumentation mounting bolts.

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

- Check the tightness of the center neck cable - Section 5.2.2 - Step 7.
- Inspect the front, rear and center cable assemblies for signs of fraying, broken strands, and kinking.

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

- Check the head angle adjustment - including cable tension adjustments - Section 3.3.1

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

- Mechanically inspect the neck assembly for signs of debonding between the aluminum disks and the rubber pucks - particularly along the first two pucks at the rear of the neck
- Inspect the front and rear neck soft stop assemblies for signs of debonding or permanent compression.

Section 6. Spine Assembly

6.1 Description of Spine Assembly and Features

The spine assembly for the THOR NT dummy includes the mechanical components from the neck pitch change mechanism to the pelvis / lumbar mounting block. This advanced spine assembly includes the following features: two pitch change mechanisms; two flex joints; and instrumentation including a thoracic spine load cell, triaxial accelerometer assemblies at T1, at the vertical level of the thorax C.G., and at T12, and four angular orientation (tilt) sensors. The complete spine assembly can be seen in **Figure 6.1**.

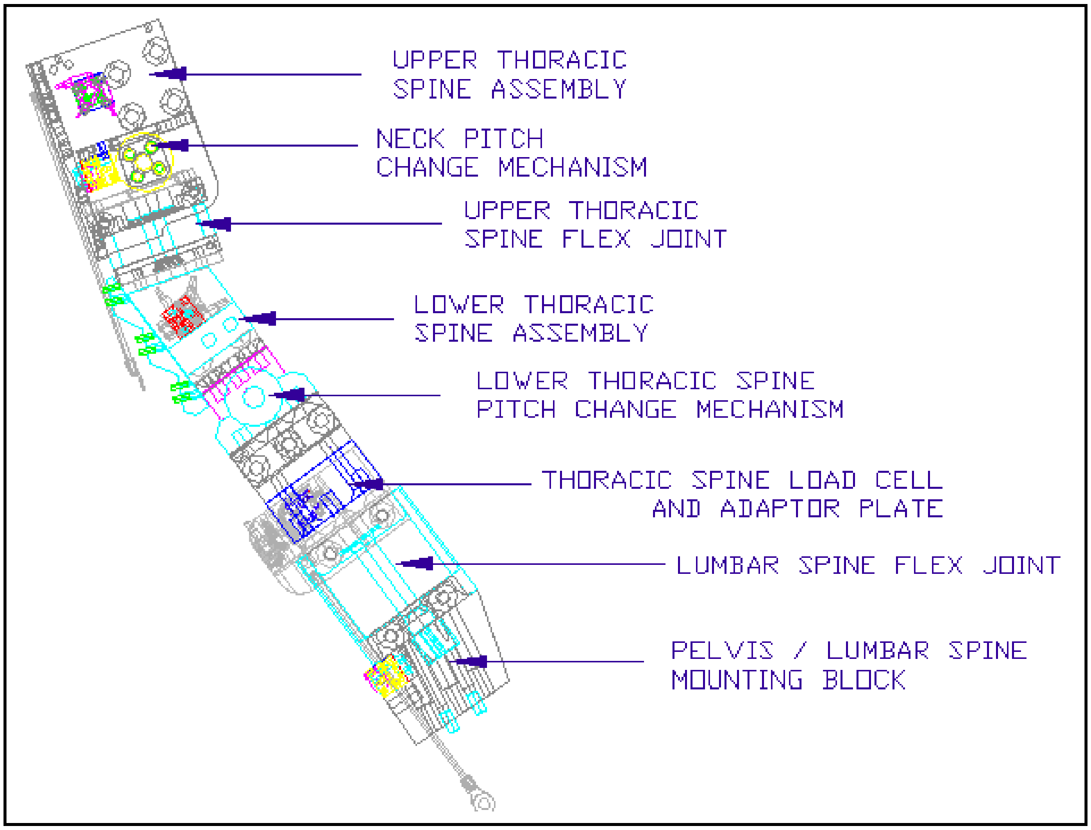

Figure 6.1- Complete Spine Assembly

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

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

The final feature of the THOR spine assembly is the integration of several sensors to provide data about the orientation, acceleration, forces and moments of the spine assembly, as shown in **Figure 6.2**. The Thoracic Spine Load Cell (Denton: Model B-1911J) 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 (T1INM100) are attached to the spine assembly at the approximate location of the anthropomorphic landmark T1, vertical level of Thorax C.G., and T12. These accelerometers can be used to provide information about the spine acceleration along three perpendicular axes. In addition, four static tilt sensors have been attached to various components of the spine assembly to provide information on the posture of the dummy prior to testing. The angular orientation of the dummy spine is processed through a tilt sensor read-out box which provides the laboratory technician with the two dimensional orientation of the various spine components during the test setup.

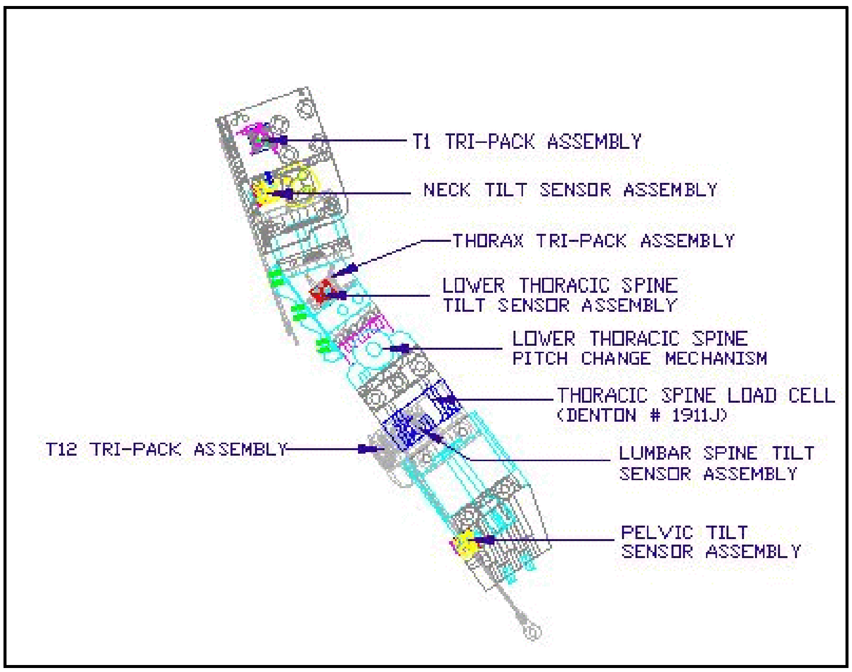

Figure 6.2- Spine Instrumentation Locations

6.2 Assembly of Spine

6.2.1 Parts List

The parts list for the spine assembly is listed in Appendix I - Bill of Materials under the Spine subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1SPM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 6.3** shows an exploded assembly of the spine.

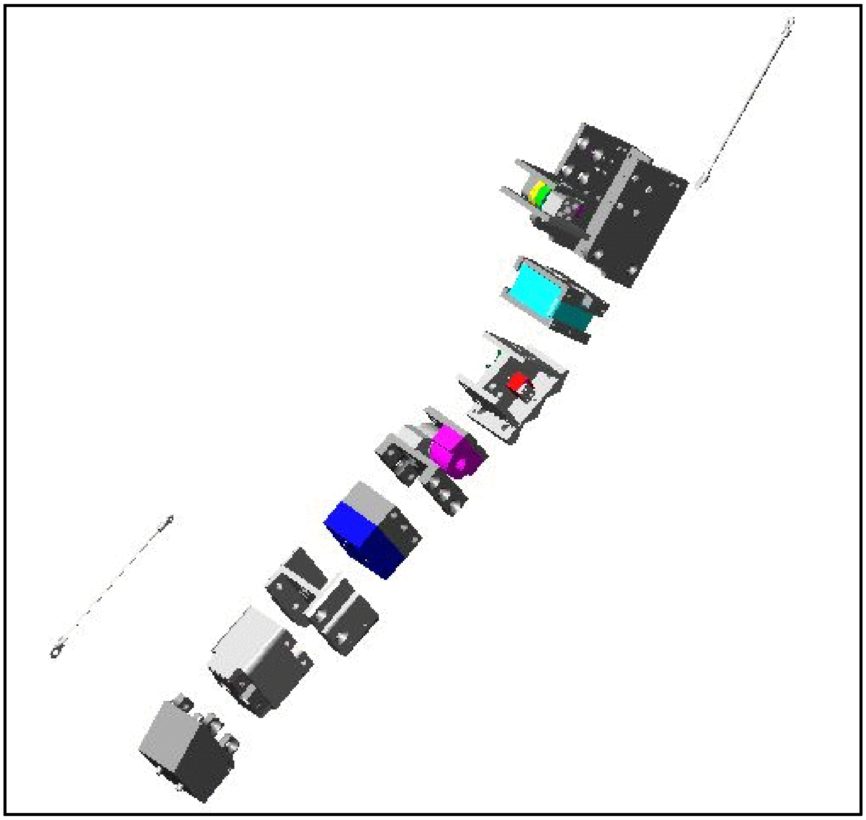

Figure 6.3- Spine Exploded Assembly

6.2.2 Assembly of Spine Components

The following procedure is a step-by-step description of the assembly procedure for all of the spine components. The numbers noted in ( ) refer to a specific drawing / part number for each particular part. The numbers noted in the { } indicate the size of Hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. The Pelvic Tilt Sensor Assembly (T1INM501-4) is attached to the rear of the Pelvis/Lumbar Mounting Block Assembly (T1SPM800) using a #4-40 X ½"

S.H.C.S.{1/16}and two 1/8 X 5/8" Dowel Pins. A 1/16" Nylon Cable Clamp is used to secure the tilt sensor wire to the rear of the Pelvis/Lumbar Spine Mounting Block Assembly using a #2-56 X ½" S.H.C.S {5/64}and a #2 washer.

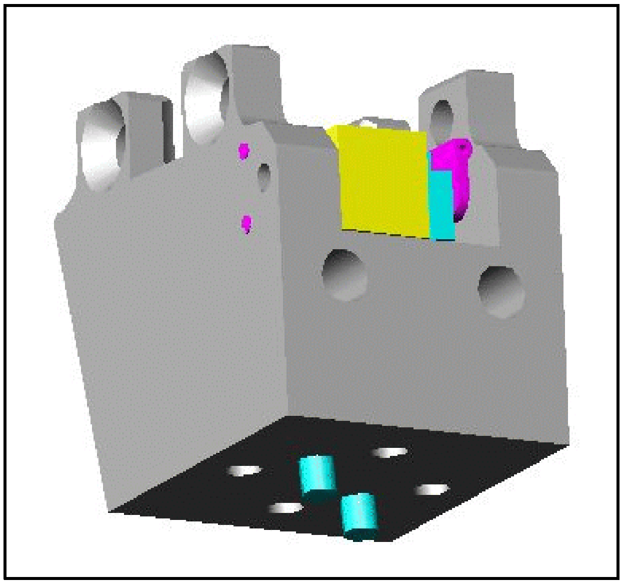

Figure 6.4- Pelvis/Lumbar Mounting Block Assembly

2. The Pelvis / Lumbar Spine Mounting Block Assembly is attached to the Pelvis Assembly (T1PLM000) using the four 1/4-20 x 1" SHCS {3/16}, as shown in **Figure 6.5**. The mounting block is positioned with the tilt sensor assembly toward the front of the pelvis assembly. The wires from the Pelvic Acetabular Load Cells need to be routed in the grooves provided in the pelvis assembly which lie under this mounting block's mounting surface.

WARNING: CARE MUST BE EXERCISED TO AVOID PINCHING ANY OF THE WIRES FROM THE PELVIC INSTRUMENTATION DURING THIS STEP.

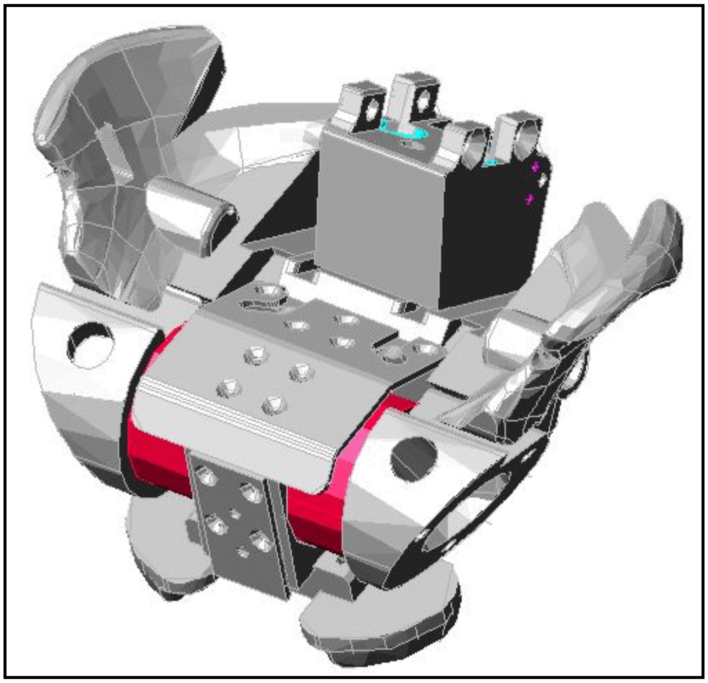

Figure 6.5- Attachment of Pelvis/Lumbar Mounting Bock to Pelvis

3. The Lumbar Spine Flex Joint (T1SPM710) is attached to the top of the Pelvis / Lumbar Spine Mounting Block using four 5/16-18 x 3/4" FHSCS-NP {3/16}, as shown in **Figure 6.6**. The flex joint may be inserted into the mounting block with either side facing toward the front.

NOTE: STEP 3 OF THE ASSEMBLY ASSUMES THAT THE CABLES IN THE FLEX JOINT HAVE BEEN PROPERLY ADJUSTED AS DESCRIBED IN SECTION 6.3.

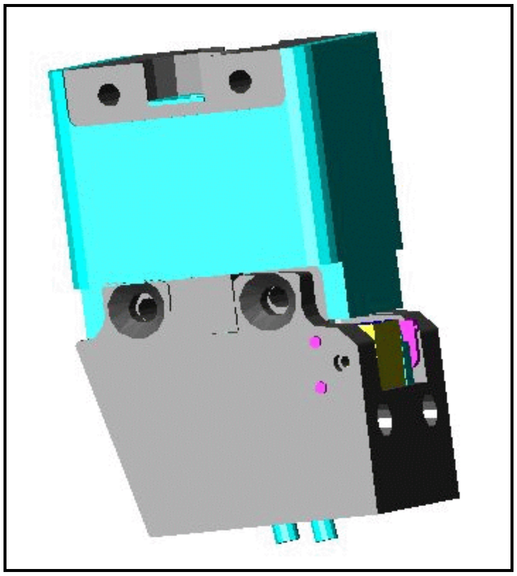

Figure 6.6- Lower Flex Joint assembled to Pelvis/Lumbar Mounting Block

4. The Thoracic Load Cell Adaptor Plate Instrumentation Assembly (T1SPM609) is attached to the bottom of the Denton Thoracic Spine Load Cell Model B-1911 (T1INM330) (or the non-active thoracic spine load cell - (T1SPM620)) using four 5/16-18 x 3/4" FHSCS-NP {3/16}, as shown in **Figure 6.7**. The Thoracic Load Cell Adaptor Plate Instrumentation Assembly should be oriented so that the two #4-40 tapped holes are positioned toward the rear of the load cell where the instrumentation cables exit.

NOTE: THE TWO #4-40 TAPPED HOLES WILL BE USED TO ATTACH THE T12 TRIAXIAL ACCELEROMETER COVER IN STEP 18.

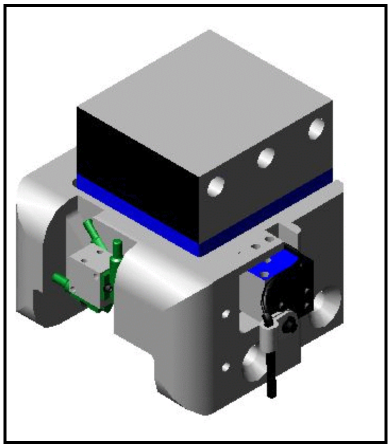

Figure 6.7- Load Cell Adaptor Plate attached to T12 Load Cell

5. The Thoracic Spine Load Cell Adaptor Plate Instrumentation Assembly / Thoracic Spine Load Cell, completed in Step 4, is attached to the Lumbar Spine Flex Joint using four # 5/16-18 x 3/4" FHSCS-NP {3/16}and two 5/16-18 X 1" F.H.S.C.S-NP, as shown in **Figure 6.8.**

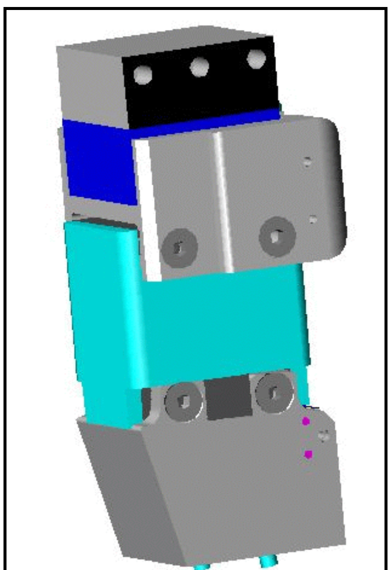

Figure 6.8- Lower Flex Joint attached to Load Cell Adaptor Plate

6. The Lower Thoracic Spine Pitch Change Mechanism (T1SPM500) is attached to the Thoracic Spine Load Cell using six 5/16-18 X 3/4" FHSCS-NP {3/16}, as shown in **Figure 6.9**. The head of the ½-20 x 2.5 SHCS adjustment bolt in the pitch change mechanism should be oriented to the right-hand side of the spine assembly.

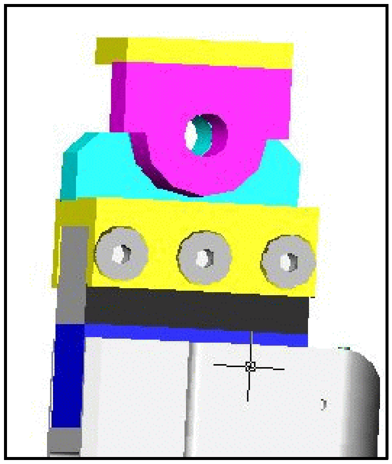

Figure 6.9- Lower Pitch Mechanism to T12 Load Cell

7. The Lower Thoracic Spine Assembly (T1SPM400) is attached to the top plate of the Lower Thoracic Spine Pitch Change Mechanism using two 5/16-18 x ½" FHSCS-NP {3/16} on the left side and two 5/16-18 X 5/8" FHSCS-NP {3/16} on the right side, as shown in **Figure 6.10**.

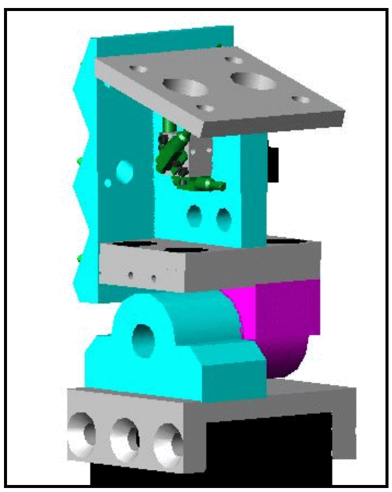

Figure 6.10- Lower Thoracic Spine Assembly mounted to Lower Pitch Change Mechanism

8. The Upper Thoracic Spine Flex Joint (T1SPM310) is attached to the Lower Thoracic Spine Assembly (T1SPM400) using four 1/4-20 x ½" SHCS-NP {3/16}. The flex joint must be oriented with the smaller bottom plate (T1SPM312) toward the Lower Thoracic Spine Assembly and the #10-32 tapped holes on the side closer to the front of the dummy, as shown in **Figure 6.11.**

NOTE: STEP 10 OF THE ASSEMBLY ASSUMES THAT THE CABLES IN THE FLEX JOINT HAVE BEEN PROPERLY ADJUSTED AS DESCRIBED IN SECTION 6.3.

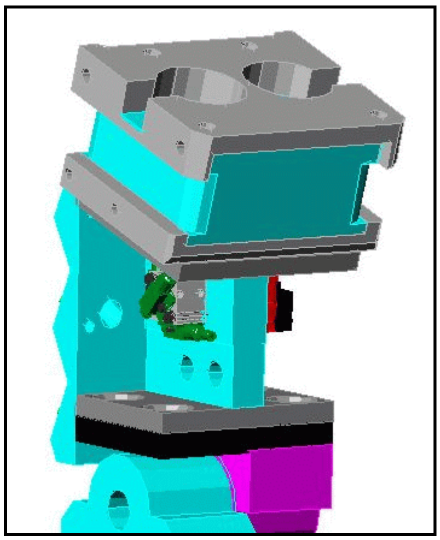

Figure 6.11- Upper Flex Joint assembled to Lower Thoracic Spine Assembly

9. The Neck Tilt Sensor Assembly (T1INM501) is attached to the Neck Pitch Mechanism (T1SPM200) using a #4-40 X .25 S.H.C.S {1/16}and two 1/8" X 3/8" dowel pins. The tilt sensor wire is clamped to the Tilt Sensor Assembly using a 1/8" Nylon Cable Clamp, a # 2 Washer, and a #2/56 x ½" S.H.C.S {5/64}. See **Figure 6.12**.

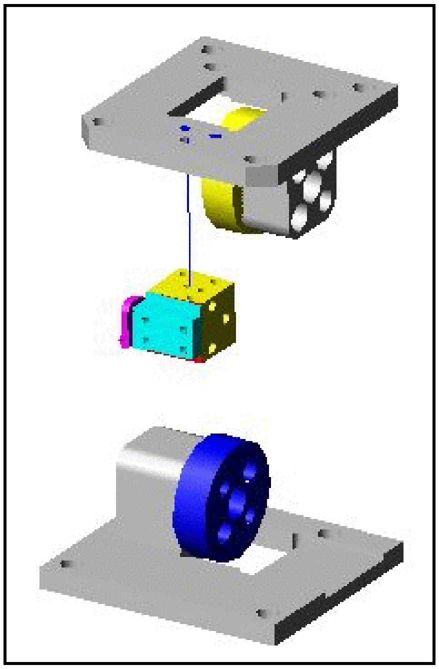

Figure 6.12- Attachment of Tilt Sensor to Neck Pitch Change Mechanism

10. The Neck Pitch Change Mechanism (T1SPM200) is attached to the Upper Thoracic Spine Flex Joint using four 1/4-20 x ½" SHCS-NP {3/16}. The pitch change mechanism must be oriented with the adjustment bolt toward the right side of the dummy, as shown in **Figure 6.13.** It may be necessary to loosen the pitch change mechanism to allow rotation of the upper plate, thus providing access to all of the mounting holes.

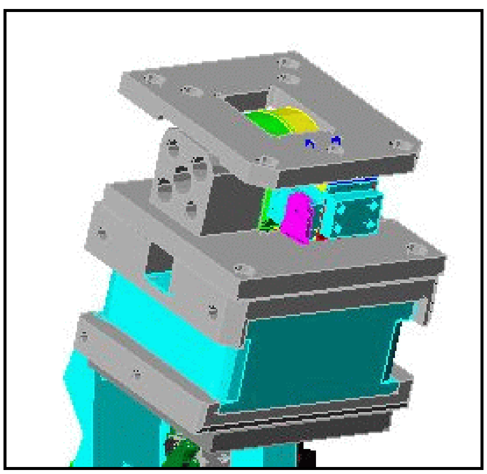

Figure 6.13- Neck Pitch Change Mechanism assembled to Upper Flex Joint

11. The Neck Tilt Sensor cable is routed through the hole in the rear of the Upper Thoracic Spine Assembly, as shown in **Figure 6.14.**

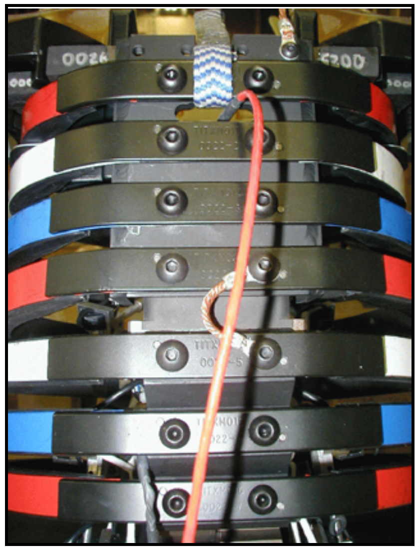

Figure 6.14- Neck Tilt Sensor wire routing

12. The Upper Thoracic Spine Mechanical Assembly - tri-pack accelerometer (T1SPM101) is attached to the Upper Thoracic Spine Flex Joint using four 1/4-20 x ½" FHSCS-NP {3/16}, as shown in **Figure 6.15**.

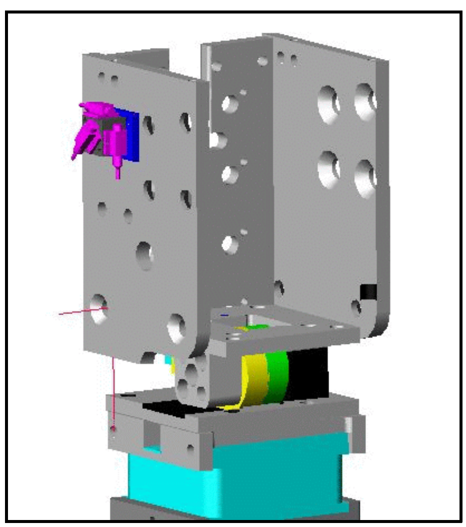

Figure 6.15- Complete Upper Thoracic assembled to the Upper Flex Joint

6.2.3 Assembly of the Spine to the Pelvis

The following procedure is a description used to install the spine assembly to the completed pelvis assembly (T1PLM000). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. For additional details, refer to steps 1-3 in Section 6.2.2.

1. The Pelvis / Lumbar Spine Mounting Block is attached to the Pelvis Assembly (T1PLM000) using four 1/4-20 x 1" SHCS {3/16}, as shown in **Figure 6.16**. The mounting block is positioned with the tilt sensor assembly toward the rear of the pelvis assembly. The wires from the Pelvic Acetabular Load Cells need to be routed in the grooves provided in the pelvis assembly which lie under this mounting block's mounting surface.

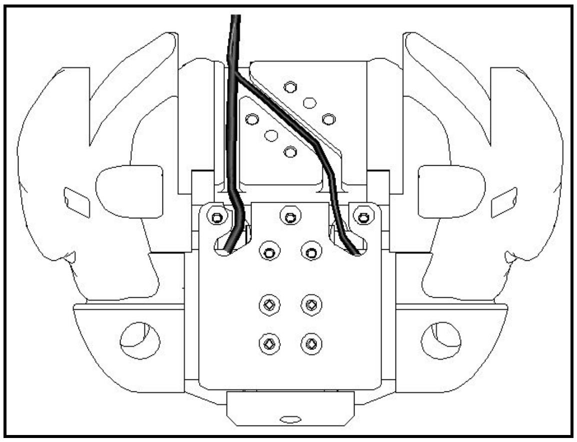

Figure 6.16- Acetabular Load Cells wires routing under Pelvis/Lumbar Spine Mounting Block

WARNING: CARE MUST BE EXERCISED TO AVOID PINCHING ANY OF THE WIRES FROM THE PELVIC INSTRUMENTATION DURING THIS STEP.

6.2.4 Assembly of the Neck to the Spine

The following procedure is a step-by-step description used to install the neck assembly to the completed spine assembly at the top plate of the neck pitch change mechanism assembly (T1SPM200). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. For additional details refer to Section 5.2.4.

1. Pass the Lower Neck Load Cell instrumentation wires out through the rear of the Upper Thoracic Spine Assembly (T1SPM101).

2. Secure the Lower Neck Load Cell to the of the Neck Pitch Change Mechanism top plate (T1SPM216) using four 1/4-20 x 5/8" SHCS.- N.P. {3/16}.

6.3 Adjustments for the Spine Assembly

6.3.1 Adjustment Procedure for Lower Thoracic Spine Pitch Change Mechanism

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

1. Disengage the teeth of the two halves of the "star-pattern" by loosening the central ½-20 x 2.5 SHCS thru bolt {3/8}. This bolt can be accessed from the right-hand side of the dummy using the long "T-Handle" ball end Hex wrench. Unzip the right jacket zipper and insert the hex wrench into the bolt head, just below the level of rib #7. This bolt must be loosened enough to disengage the teeth from the mating halves of the "star pattern". A visual inspection from the rear of the dummy may be made to determine if the teeth have been successfully disengaged.

WARNING: THE TEETH OF THE UNIT WILL BE SERIOUSLY DAMAGED IF THE ADJUSTMENT IS MADE BEFORE THE TEETH ARE COMPLETELY DISENGAGED.

2. Adjust the posture to the desired setting by rotating the two halves of the pitch change mechanism with respect to one another. The desired posture setting can be determined by aligning the color coded marks on the right of the pitch change mechanism with the Neck Pitch Change Indicator (T1SPM523), as shown in **Figure 6.17.**

WARNING: BE SURE THAT THE TEETH ARE MESHED AND ENGAGING PROPERLY BEFORE PROCEEDING.

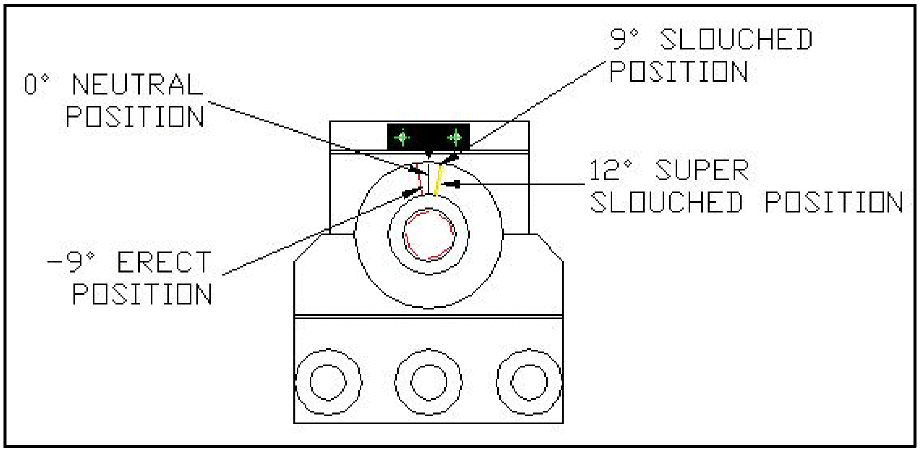

Figure 6.17- Adjustment marks and locations

3. Tighten the central ½-20 x 2.5 SHCS thru bolt {3/8} to 50 ft-lb to engage the teeth and lock the mechanism into place.

6.3.2 Adjustment Procedure for Neck Pitch Change Mechanism

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

1. Disengage the teeth of the two halves of the "star-pattern" by loosening the 3/8-24 SHCS {5/16} as shown in **Figure 6.18**. This bolt can be accessed from the right side of the dummy using the long 5/16 "T-Handle" ball end Hex wrench. This bolt must be loosened enough to disengage the teeth from the mating halves of the "star pattern". The head and neck will rotate freely fore and aft when the bolt is sufficiently loosened.

WARNING: THE TEETH OF THE UNIT WILL BE SERIOUSLY DAMAGED IF THE ADJUSTMENT IS MADE BEFORE THE TEETH ARE COMPLETELY DISENGAGED.

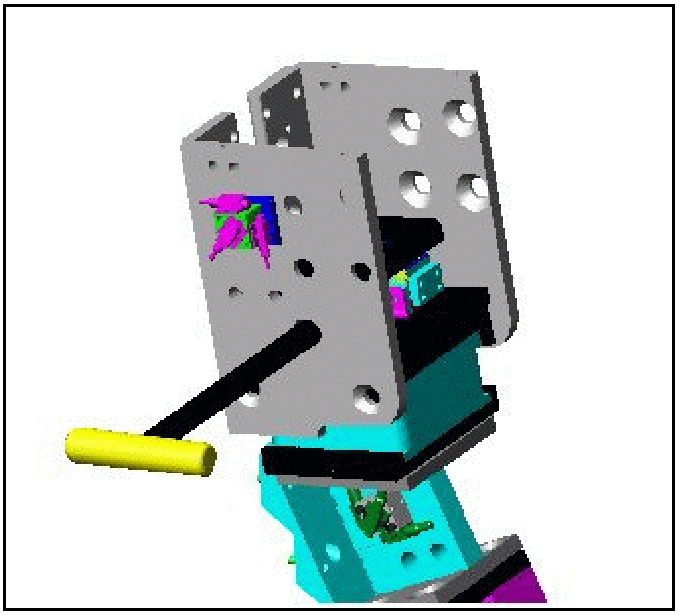

Figure 6.18- Neck pitch change adjustment

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

WARNING: BE SURE THAT THE TEETH ARE MESHED AND ENGAGING PROPERLY BEFORE PROCEEDING.

3. Tighten the central 3/8 - 24 S.H.C.S {5/16} to a torque of 37.5 ft-lb to engage the teeth and lock the mechanism into place.

6.3.3 Adjustment Procedure for Tightening Flex Joint Cables

The adjustment procedure for correctly tightening the cables on the Upper Thoracic and Lumbar Spine Flex Joints is identical. Both of these joints use two 5/16" steel cable assembly which has a ball and shank on one end and a ½-20 threaded swage on the other end. The cable for both units are oriented so that the ball and shank end are down (i.e. toward the pelvis) and the threaded end is up to allow access from the top. The only difference between these cable assemblies is the length: the lumbar cables are 3.0" and the upper thoracic cables are 2.0". The cables must be adjusted so that they are snug (i.e. no slack in the cables), but the preload on the flex joint should be very minimal.

1. Insert the two cables through the holes provided in the flex joints. The threaded ends should exit from the top of the joints. Fasten each threaded end of the cable assemblies using a #1/2-20 Nylon Hex Nut and a Teflon Washer (1" I.D., 0.5" O.D., .057" thick).

2. Using a 3/4 socket on a 3/8 socket driver, tighten the nut onto the cable assemblies one half turn past contact between the nut and the top of the flex joint plate.

3. Cover the nuts and washers using the Upper Thoracic Spine Nut Cover (TI1SPM313). See **Figure 6.19.**

Figure 6.19- Tightening the Flex Joint Cables

6.4 Wire Routing and Electrical Connections

The wire routing for the instrumentation on the spine assembly is fairly straightforward and each instrument in this assembly will be covered individually. It may also be necessary to refer to the Sections on the Thorax assembly and Instrumentation to develop a complete understanding of these instrumentation systems. Refer to **Figure 6.20** for a graphical representation of the wire routing for these instruments.

T1 tri-pack Accelerometer: The wires from this unit should run down the right-hand side of the spine assembly and exit between ribs 1 and 2 to joint the wire bundle running along the back of the spine.

Neck Tilt Sensor Assembly: This wire is routed along the side of the neck pitch mechanism and exits through the hole at the rear of the Upper Thoracic Spine Assembly to joint the bundle of wires running down from the head and neck.

Thoracic (CG) Accelerometer: These wires are strain relieved on the side of the Upper Thoracic Flex Joint Assembly using a 3/16" Nylon Cable Clamp and #10-32 x 3/8" B.H.S.C.S, and exit between Ribs #4 and 5.

Lower Thoracic Spine Tilt Sensor Assembly: This wire is clamped to the Tilt Sensor Assembly and exits between ribs #4 and #5 to join the wire bundle running along the back of the spine.

WARNING: GREAT CARE MUST BE USED WHEN INSERTING THE THORACIC INSTRUMENTATION BRACKET INTO PLACE TO AVOID PINCHING THIS WIRE.

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

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

Pelvic Tilt Sensor Assembly: This wire joins the rest of the wires running down from the Spine and Neck.

All the above wires get strain relieved at the base of the Pelvis, see **Section 15.3.2** for further details.

6.5 Calibration

6.5.1 Calibration of Lumbar Spine Flex Joint

The Lumber Spine Flex Joint calibration is a quasi-static bending test. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication. Recommended calibration intervals are every 3-6 months depending on the frequency of testing and the storage conditions of the dummy. The unit can be returned to GESAC for calibration when necessary.

6.5.2 Calibration of Upper Thoracic Spine Flex Joint

The Upper Thoracic Flex Joint calibration is a quasi-static bending test. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication. Recommended calibration intervals are every 3-6 months depending on the frequency of testing and the storage conditions of the dummy. The unit can be returned to GESAC for calibration when necessary.

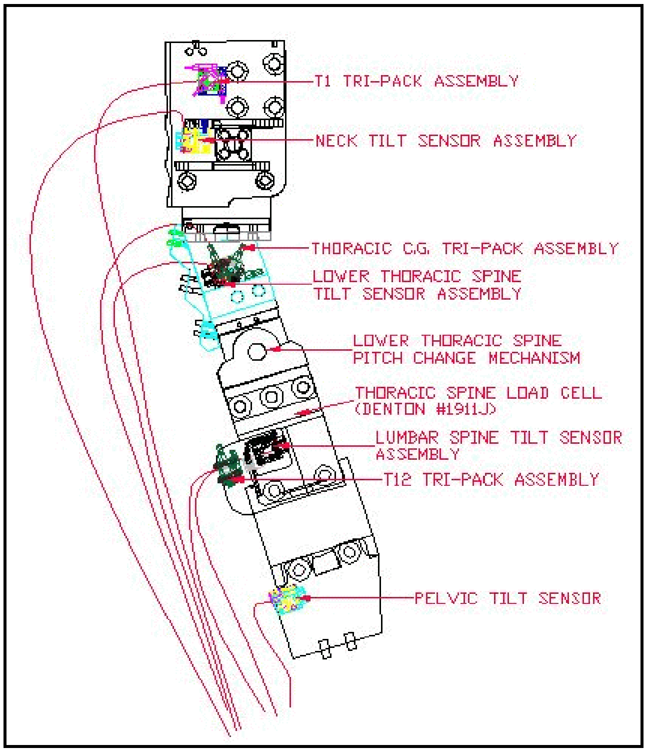

Figure 6.20- Spine Instrumentation wire routing

6.5.3 Calibration of Thoracic Spine Load Cell

The Thoracic Spine Load Cell (Denton Model B-1911J) is calibrated by the manufacturer and requires recalibration at yearly intervals. The unit may be returned to either GESAC or the manufacturer for recalibration as necessary. In addition to the recommended recalibration interval, recalibration is required if the "zero load" output signal from the unloaded load cell is significantly different than that stated on the calibration sheet.

6.6 Inspection and Repairs

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

Although this disassembly is very simple, some comments are provided below to assist in the process.

6.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the spine instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

6.6.2 Mechanical Inspection

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

NOTE: THE USE OF NYLON PELLET BOLTS WAS SPECIFIED FOR THE SPINE ASSEMBLY TO PREVENT BOLTS FROM LOOSENING DURING THE IMPACT AND VIBRATIONS ASSOCIATED WITH A CRASH PULSE. IF IT IS NECESSARY TO REPLACE A BOLT IN THE SPINE ASSEMBLY, IT IS ADVANTAGEOUS TO USE A NEW BOLT WITH A FRESH PELLET. REUSING OLD PELLET BOLTS WILL LESSEN THEIR EFFECTIVENESS.

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

- This assembly should be inspected to ensure that the teeth of the mating "star patterns" are still engaged and held tightly against one another. If the teeth are loose, the mechanism must be disassembled and inspected for damage to the mating teeth.
- The center adjusting bolt should be checked for a proper torque of 50.8 N-m (37.5 ft-lb).

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

- This unit should be inspected for proper cable tension as described in section 6.3.3.
- Inspect for debonding between the metal plates and the urethane. If there is evidence of severe debonding (greater than 1/8" of debonding along a surface), the unit should be replaced.

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

- This assembly should be inspected to ensure that the teeth of the mating "star patterns" are still engaged and held tightly against one another. If the teeth are loose, the mechanism must be disassembled and inspected for damage to the mating teeth.
- The ½-20 x 2.5 SHCS center bolt should be checked for a proper torque of 50 ft-lb.

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

- This unit should be inspected for proper cable tension as described in Section 6.3.3.
- Inspect for debonding between the metal plates and the urethane. If there is evidence of severe de-bonding (greater than 1/8" of debonding along a surface), the unit should be replaced.

Section 7. Thorax Assembly

7.1 Description of Thorax Assembly and Features

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

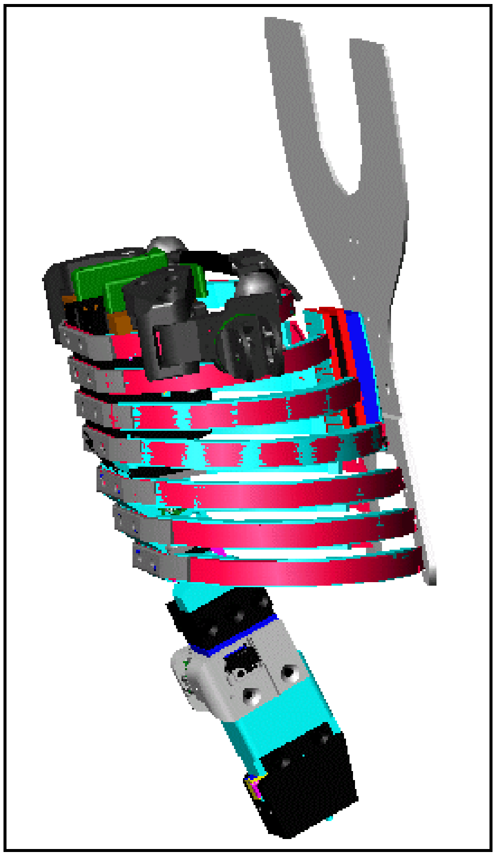

Figure 7.1- Thorax Assembly

The advanced thorax assembly features extensive instrumentation which is used to measure and record the deflections, forces and accelerations that this region experiences during testing, as shown in **Figure 7.2**. The deflection of the ribcage is measured at four distinct points. These points are measured using the CRUX units which capture the three-dimensional timewise deformation. The forces on the thorax assembly are measured at the T12 location using a five-axis load cell. (This load cell is considered part of the Spine assembly - Section 6.) A triaxial accelerometer is located on the spine, but near the vertical level of the center of gravity of the thorax to measure the acceleration along the three principle axes. A uniaxial accelerometer is positioned on the sternal plate to measure acceleration at this location.

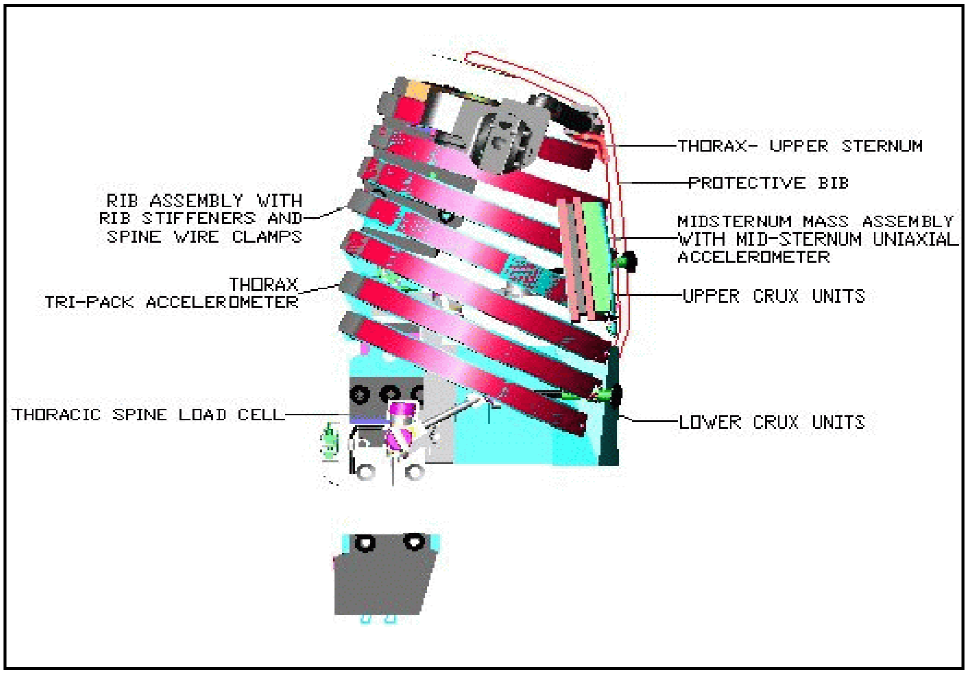

Figure 7.2- Thorax instrumentation locations

7.2 Assembly of the Thorax

7.2.1 Parts List

The part list for the thorax assembly is listed in Appendix I - Bill of Materials under the Thorax subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1TXM000 in the THOR NT drawing set for a detailed mechanical assembly drawing. **Figure 7.3** shows an exploded view of the thorax assembly.

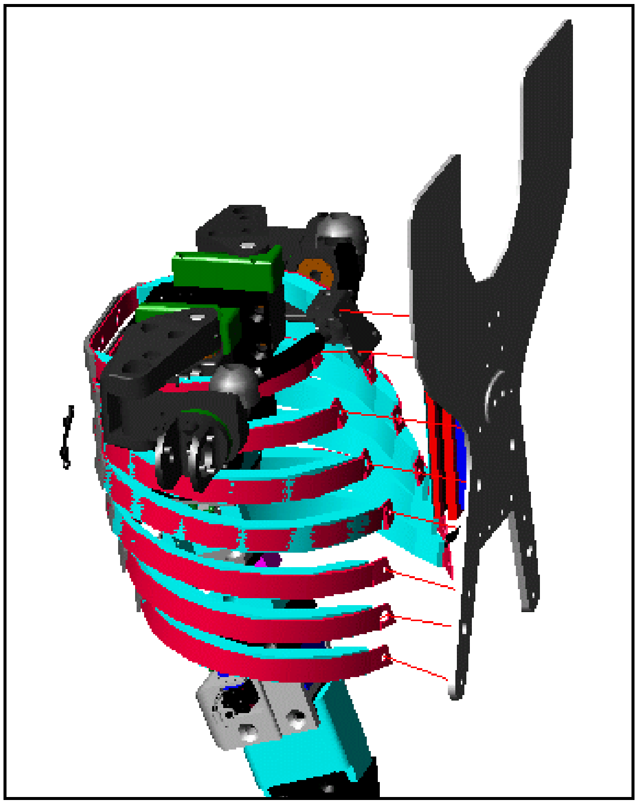

Figure 7.3- Thorax Exploded Assembly

7.2.2 Assembly of Thorax Components

The following procedure is a step-by-step description of the assembly procedure for the thorax components. This assembly requires the completion and integration of several sub-assemblies to create the thorax assembly. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Assemble the complete spine assembly as described in Section 6.2. The completed spine assembly should include all the mechanical components from the pelvis to the neck pitch change mechanism, as well as, all relevant instrumentation: 4 tilt sensors, T1 and T12 tri-pack accelerometers and the T12 load cell. The head and neck should not be mounted at this point.

2. Assemble the shoulder components onto the Upper Thoracic Spine Mechanical Assembly-tri-pack Accelerometer (T1SPM101) as described in Section 8.2. This assembly should include all related shoulder hardware for both the left and right-hand sides including rubber stops, rib #1 support and shoulder blocks.

3. Assemble the Upper Abdomen / CRUX / Thoracic Instrumentation Bracket onto the spine assembly as described in Sections 9 and 16 of the manual.

4. Pass the instrumentation cables from the lower neck load cell and the neck tilt sensor through hole at the rear of the Upper Thoracic Spine Mechanical Assembly- tri-pack Accelerometer. Mount the neck to the spine as described in Section 5.2.4.

5. Position the Elliptical Rib #1 Assembly (T1TXM310) as shown in **Figure 7.4**. This rib assembly is marked with the serial number followed by the number “1" and the mark is oriented correctly to denote the top and bottom of the rib. The rib must be located above the rib support bracket and the rear of the rib should be centered over the Upper Thoracic Spine Mechanical Assembly- tri-pack Accelerometer (T1SPM101) so that the holes line up. Since the shoulder hardware can make insertion of this rib troublesome, the following description may be helpful for positioning this rib: Pass the open end of rib around the right-hand clavicle rod at the front of the dummy and above the rib support on the right-hand side (with the open end facing the rear of the dummy). Rotate the rib (clockwise as viewed from the top) around the upper thoracic spine until the open end is again at the front (i.e. the rib must pass across the rear of the upper thoracic spine weldment and above the other rib support.)

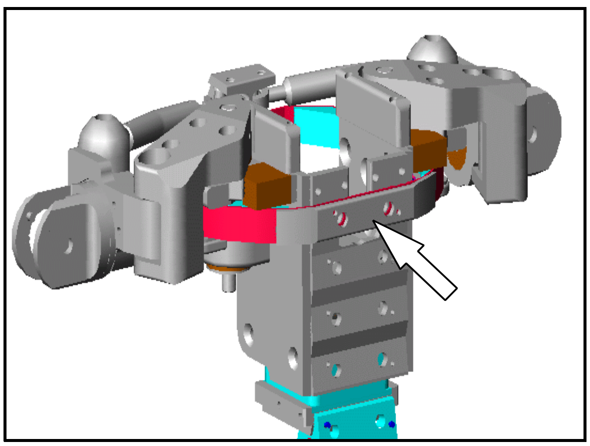

Figure 7.4- Rib #1 Assembly installation

6. Position the Elliptical Rib Stiffener #1 (T1TXM010) over the back of rib #1 and line up the mounting holes. Use two 5/16-24 X ½" B.H.S.C.S -NP {3/16}to mount the Elliptical rib and stiffener #1 to the Upper Thoracic Spine Mechanical- tri-pack Accelerometer (T1SPM101).

7. Gather the wire bundle from the head and neck instrumentation (except the lower neck

load cell wire). Holding the bundle together, measure 13.5" down along the wire bundle from the bottom of the head mounting plate. Centered at this point, wrap the wire bundle with electrical tape, as shown in **Figure 7.5**, to provide enough thickness to allow the spine wire cover to hold it securely in place. This measurement will create the necessary slack in the wires.

NOTE: IT IS CRITICAL TO PROVIDE THE CORRECT AMOUNT OF SLACK WIRE ABOVE THIS CLAMP TO ALLOW THE HEAD AND NECK TO HAVE FREE MOTION IN FLEXION AND EXTENSION.

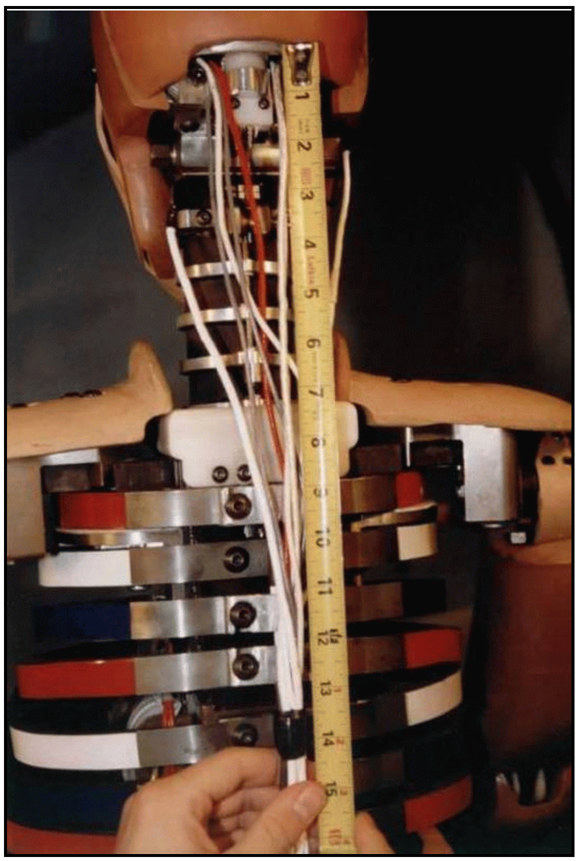

Figure 7.5- Measuring the wire bundle

NOTE: THE RIB STIFFENERS ON THE THOR NT DUMMY ARE NOT INTERCHANGEABLE. EACH STIFFENER IS DESIGNED FOR A SPECIFIC RIB POSITION. THEY ARE MARKED #1 - #7 TO CORRESPOND WITH THE RIBS.

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8. Position Elliptical Rib #2 Assembly (T1TXM320) and Elliptical Rib Stiffener #2 (T1TXM011) on the back of the Upper Thoracic Spine Mechanical- tri-pack Accelerometer (T1SPM101) and secure the assemblies using two 5/16-24 x ½" BHSCS-NP {3/16}, as shown in **Figure 7.6**.

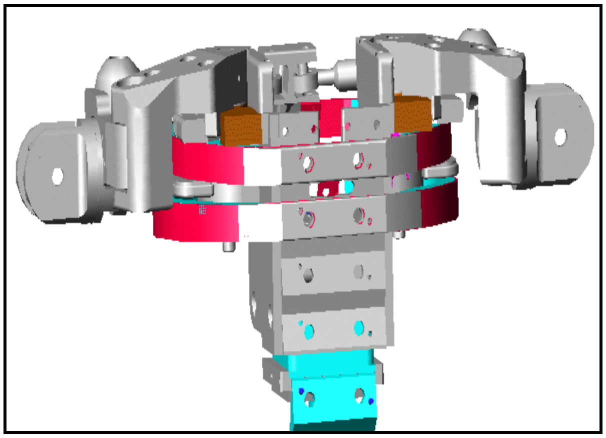

Figure 7.6- Proper Positioning of Rib # 2 Assembly

9. Position Elliptical Rib #3 Assembly (T1TXM330) and Elliptical Rib Stiffener #3 (T1TXM012) on the back of the Upper Thoracic Spine Mechanical- tri-pack Accelerometer (T1SPM101). Secure the rib assembly with two 5/16-24 x 7/8" BHSCS-NP {3/16}(5/16-24 X ½" B.H.S.C.S-NP {3/16}).

10. Attach Elliptical Rib #4 Assembly (T1TXM340) and Elliptical Rib Stiffener #4 (T1TXM013) on the back of the Upper Thoracic Spine Mechanical- tri-pack Accelerometer (T1SPM101) using a # 5/16-24 X 3/8" B.H.S.C.S-NP. Pass the wire bundle from the head and neck instruments, including the lower neck load cell.

11. Position Elliptical Rib #5 Assembly (T1TXM350) and Elliptical Rib Stiffener #5 (T1TXM014) on the back of the Lower Thoracic Spine Assembly (T1SPM400). Align the rear rib holes with the dowel pins on the Lower Thoracic Spine Assembly, and secure the # 5 Rib set using two 5/16-24 X 3/8" B.H.S.C.S. See **Figure 7.7.**

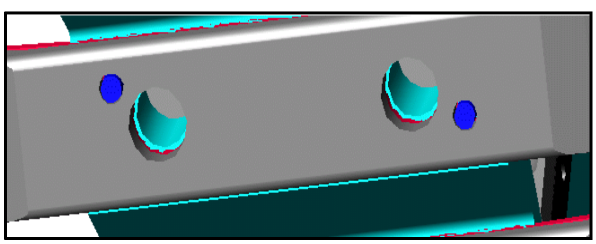

Figure 7.7- Position of Rib #5 Assembly

12. Position Elliptical Rib #6 Assembly (T1TXM360) and Elliptical Rib Stiffener #6 (T1TXM015) on the back of the Lower Thoracic Spine Assembly (T1SPM400) and secure with two 5/16-24 x ½" BHSCS-NP {3/16}.

13. Position Elliptical Rib #7 (T1TXM370) and Elliptical Rib Stiffener #7 (T1TXM016) on the back of the Upper Thoracic Spine Weldment and secure with two 5/16-24 x ½" BHSCS-NP {3/16}. The completed rib assembly is shown in **Figures 7.8** and **7.9**.

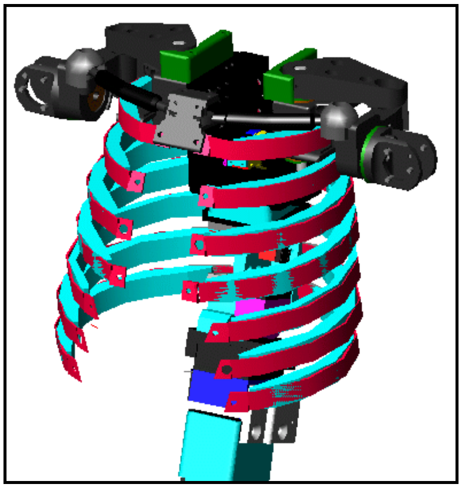

Figure 7.8- Complete Rib Assembly (Front)

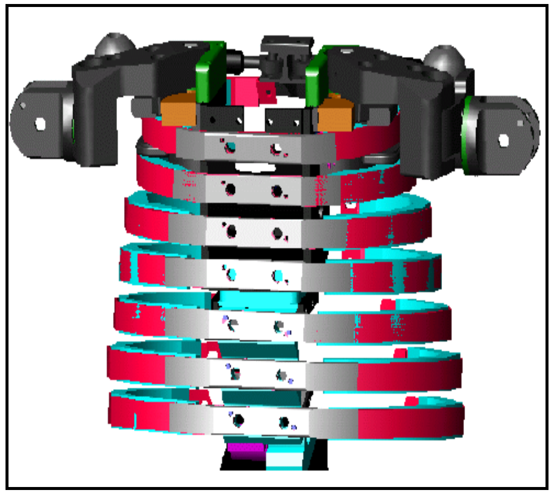

Figure 7.9- Complete Rib Assembly (Rear)

14. Attach the Thoracic Spine Ground Strap (T1INM013) to Ribs # 4 and 5 at the rib stiffeners, as shown in **Figure 7.10**.

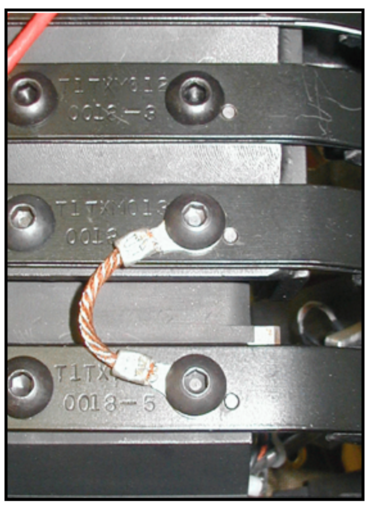

Figure 7.10- Thoracic Spine Ground Strap assembly

15. Attach the Mid-Sternum Assembly (T1MSM005) to the Urethane Outer Bib (T1TXM110), as shown in **Figure 7.11,** using four #10-32 X 3/8" {1/8}Flange B.H.S.C.S and #8-5/8 flanged washers.

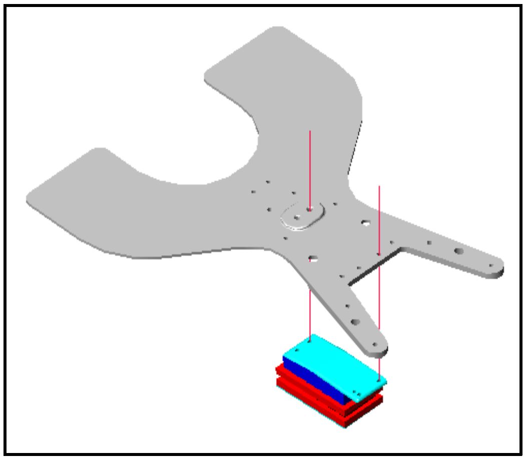

Figure 7.11- Mid-sternum assembled to Bib

16. The THOR NT dummy was designed with a set of mounting holes for a uniaxial accelerometer (T1INM110) on the Mid-Sternum Plate. This accelerometer can be mounted at this time using two #0-80 x 1/8" SHCS {0.050} and two #0-80 washers as shown in **Figure 7.12**. The bolts should be tightened securely, but excessive force is NOT required.

Warning: The application of excessive torque to the 0-80 accelerometer mounting bolts may cause permanent damage to the accelerometer and bolt threads.

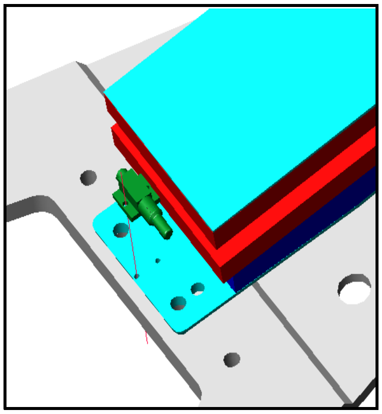

Figure 7.12- Mid-sternal uniaxial accelerometer attached to Mid-sternum

17. Verify that the #10-32 Clip Nuts have been installed onto the outer ends of ribs #1,2,4,5, and 7. These clip-nuts will be used to install the bib to the rib assembly.

18. Bolt the bib assembly to each side of Elliptical Rib #7 at the front of the dummy using two #10-32 x 3/4" Flanged B.H.S.C.S {1/8} and a #8-5/8 Flanged washers). For rib #7, the bolt should pass through the washer, the urethane outer bib, the upper abdomen flap hole, and into the clip nut on the end of rib #7. This needs to be done for both the left and right-hand sides of the rib.

19. The next attachment point for the bib is at Rib #6 where the lower CRUX units are connected. Using the Crux Insertion Tool Mechanical Assembly (T1CXT000), Pass the Universal Joint end from the Lower Right Crux unit (T1CXM003) through the hole in the end of the right hand side of the sixth rib, through the center hole in the right hand side Upper Abdomen Bag Flap, and through the outer urethane bib.

NOTE: A SIMPLE TRICK FOR FEEDING THE CRUX UNITS THROUGH THE BIB MATERIAL IS TO USE THE CRUX INSERTION TOOL (T1CXT000) TO PULL THE U-JOINT OUT THROUGH THE BIB MATERIAL. THE USE OF THIS TOOL IS SHOWN IN **FIGURE 7.13**

Use of the Crux Insertion Tool is shown below in **Figure 7-13.**

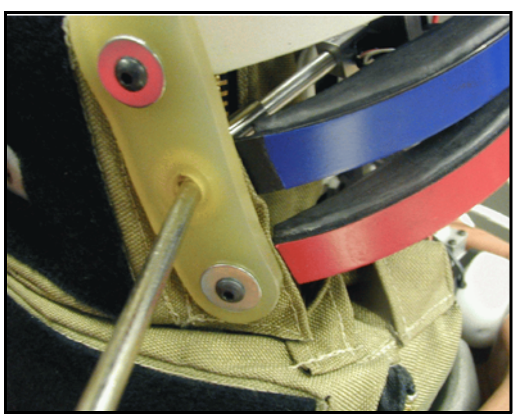

Figure 7.13- Using the Crux insertion tool to pull Crux unit through bib material

20. Place a 8 X 5/8" Flanged Washer on the end of the U-Joint and secure the U-Joint with a

CRUX Rib Connection Bolt (T1CXM010) {3/4}. The U-Joint is designed to have limited rotation on the end of the CRUX arm. The U-Joint rotation should be set to the middle of the rotation range for testing, as shown in **Figure 7.14**.

NOTE: A SIMPLE TRICK TO SET THE U-JOINT IN THE MIDDLE OF ITS RANGE OF MOTION IS TO TIGHTEN THE CRUX RIB CONNECTING BOLT USING A 3/4" WRENCH UNTIL CONTACT IS FELT - THE U-JOINT WILL BE AT ONE END OF ITS RANGE OF MOTION. TURN THE RIB BOLT COUNTERCLOCKWISE SLIGHTLY, CAUSING THE U-JOINT TO ROTATE ON THE CRUX ARM, UNTIL THE U-JOINT IS CENTERED. THE POSITION OF THE U-JOINT MUST BE VERIFIED VISUALLY.

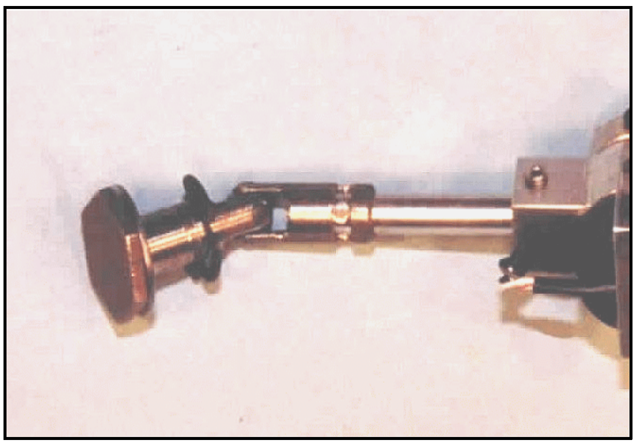

Figure 7.14- Proper positioning of the U-Joint in its range of motion

21. Repeat steps 20-21 on the left hand side for the Lower Left CRUX Unit (T1CXM004).

22. Bolt the bib assembly to Elliptical Rib #5 at the front of the dummy. The bolts to be used for connecting the bib to the ends of the ribs are #10-32 x 3/4" Flanged BHCS {1/8} with #8 x 5/8" Flanged Washers. For rib #5, the bolt should pass through the #8 Flanged Washers, the urethane outer bib, the upper abdomen flap hole and into the clip nut on the end of rib #5. This needs to be done for both the left and right-hand sides of the ribs.

23. Bundle the instrument wire from the mid sternal uniaxial accelerometer with the upper abdomen uniaxial accelerometer wire. Pass these wires around the left side of the spine and secure it into the 1/4" wire clamp and #1/4-20 X .25" B.H.S.C.S located on the upper abdomen assembly, used to fasten the upper and lower left CRUX wires, as shown in **Figure 7.15**. The cables are routed out the left side of the dummy to joint the bundle of cables running down the spine.

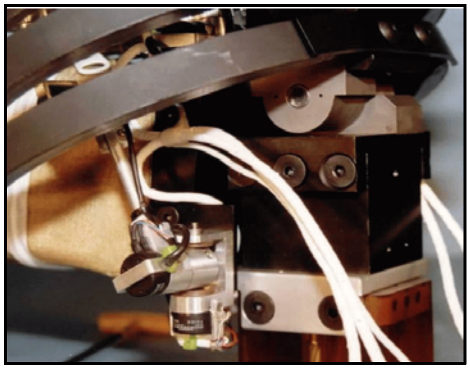

Figure 7.15- Wire routing for the CRUX and mid sternal accelerometer cables

24. Bolt the bib assembly to Elliptical Rib #4 at the front of the dummy. The bolts to be used for connecting the bib to the ends of the ribs are #10-32 x 3/4" Flanged BHSCS {1/8} with #8 Flanged Washers. For rib #4, the bolt should pass through the #8 Washer, the urethane outer bib, and into the clip nut on the end of rib #4. This needs to be done for both the left and right-hand sides of the ribs.

25. Pass the Universal Joint end from the Upper Right Crux unit (T1CXM001) through the hole in the end of the right hand side of the third rib and through the outer urethane bib using the CRUX Insertion Tool.

26. Place a #8 Flanged Washers on the end of the U-Joint and secure the U-Joint with a CRUX Rib Connection Bolt (T1CXM010) {3/4}. The U-Joint is designed to have limited rotation on the end of the CRUX arm. The U-Joint rotation should be set to the middle of the rotation range for testing.

27. Repeat steps 26 - 27 on the Left hand side for the Upper Left CRUX Unit (T1CXM002).

28. Bolt the bib assembly to Elliptical Rib #2 at the front of the dummy. The bolts to be used for connecting the bib to the ends of the ribs are #10-32 X ½" Flanged B.H.S.C.S{1/8} with #8 Flanged Washers. For rib #2, the bolt should pass through the #8 Flanged Washers, the urethane outer bib, and into the clip nut on the end of rib #2. This needs to be done for both the left and right-hand sides of the ribs.

29. Bolt the bib assembly to Elliptical Rib #1 at the front of the dummy. The bolts to be used for connecting the bib to the ends of the ribs are #10-32 X 5/8" Flanged B.H.S.C.S {1/8} with #8 Flanged Washers. For rib #1, the bolt should pass through the #8 Flanged Washers, the urethane outer bib, through the lower set of holes in the Thorax Upper Sternum Plate (T1SHM018), and into the clip nut on the end of rib #1. This needs to be

done for both the left and right-hand sides of the ribs.

30. Bolt the top of the Thorax Upper Sternum Plate to the bib assembly using two #10-32 x 3/8" Flanged B.H.S.C.S {1/8} and two #8 Flanged Washers, as shown in **Figure 7.16**. The bolts should pass through the #8 Flanged Washers, the urethane outer bib, and thread into the upper set of holes in the Thorax Upper Sternum Plate.

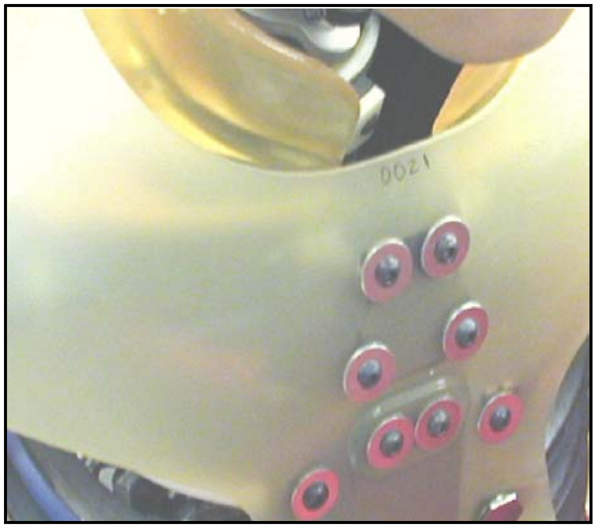

Figure 7.16- Attach bib to Upper Sternal Plate

The Jacket is assembled onto the thorax by draping the front panel (T1JKF110) and rear panel (T1JKF210) of the jacket over the front and rear of the thorax. See Section 14 of this manual for further details.

7.3 Adjustments for the Thorax Assembly

The thorax assembly does not require any adjustments.

7.4 Wire Routing and Electrical Connections

The wire routing for the instrumentation in the thorax assembly is fairly straightforward. Each instrument in this assembly will be covered individually. Since the thorax assembly involves several separate sub-assemblies, it may also be necessary to refer to the sections on the Spine, Upper Abdomen, and Instrumentation to develop a complete understanding of these instrumentation systems.

CRUX Units - The routing of the wires from the CRUX units is discussed in the CRUX Section 16. The wires from the upper and lower CRUX units are strain relieved with a wire clamp attached to each side of the Upper Abdomen Spine Mount (T1UAM100) with a #1/4-20 x 1/4" BHSCS {5/32}. The wires are then routed on the left and right sides of the spine assembly and exit the thorax below rib #7 to join the bundle of wires running down the dummy's spine.

Mid-Sternum Uniaxial Accelerometer - Bundle the instrument wire from the mid sternal uniaxial accelerometer with the upper abdomen uniaxial accelerometer wire. Pass these wires around the left side of the spine and secure it into the 1/4" wire clamp, located on the upper abdomen assembly, used to fasten the upper and lower left CRUX wires. The cables are routed out the left side of the dummy to joint the bundle of cables running down the spine.

Thorax CG Triaxial Accelerometer: The wire from the thorax CG triaxial cube exits to the left and is bundled with the LTS tilt sensor wire. These wires are secured with a #10-32 x ½" BHSCS {1/8} to the left front mounting bolt hole of the CG Accelerometer Bracket using a 3/16" wire clamp.

7.5 Calibration of Thorax Assembly

The thorax assembly is calibrated at GESAC using a dynamic impact test. The test is conducted at two locations on the thorax (upper and lower) with two test speeds at the upper location and one speed at the lower location. The thoracic load is plotted against the internal deflection of the thorax measured by the CRUX units. Calibration procedures for this test are described in the THOR NT Calibration Manual - available from GESAC as a separate publication.

7.6 Inspection and Repairs

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

7.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

7.6.2 Mechanical Inspection

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

NOTE: THE USE OF NYLON PELLET BOLTS WAS SPECIFIED FOR THE SPINE ASSEMBLY TO PREVENT BOLTS FROM LOOSENING DURING THE IMPACT AND VIBRATIONS ASSOCIATED WITH A CRASH PULSE. IF IT IS NECESSARY TO REPLACE A BOLT IN THE SPINE ASSEMBLY, IT IS ADVANTAGEOUS TO USE A NEW BOLT WITH A FRESH PELLET. REUSING OLD PELLET BOLTS WILL LESSEN THEIR EFFECTIVENESS.

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

- Check each end of the damping material for debonding or cracking. This check should involve a visual inspection with the aid of a magnifying lens if possible.
- Check rib steel for deformation (spine attachment, sides and bib attachment) Deformation needs to be checked in the X, Y, and Z directions.
  Drawings may be used as reference for comparison
- Check rib stiffeners for bending. There should not be any visible gaps between the ribs and the rib stiffeners.
  Drawings may be used as reference for comparison
- Check damping material for physical damage (top, bottom and interior surface) Check for cuts, nicks, deformation

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

- Check tightness of rib / bib connection bolts and CRUX Rib Connection Bolts
- Check that U-Joints for CRUX units are still positioned in the middle range of their allowable rotation.

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

- Check all bolt locations for tearing / washer penetration

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

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

Section 8. Shoulder Assembly

8.1 Description of Shoulder Assembly and Features

The shoulder assembly for the THOR NT dummy includes the mechanical components which connect the arms to the spine and thorax assemblies. The shoulder was designed to replicate the geometry and motion of the human shoulder / clavicle complex. A separate human-like clavicle linkage was used to provide a more biofidelic interaction between the shoulder assembly and the belt restraint systems. This separate clavicle can load the sternum and ribcage directly to produce a more human like loading condition. The shoulder was designed as a four part linkage in which the shoulder block acts like the scapula to connect the linkage to the spine. This block is connected to the shoulder joint through a rotation joint. The shoulder joint is also connected to the clavicle, which is in turn connected to the sternum. The shoulder joint has been designed as a two-axis of rotation system which provides similar motion to the human ball joint. Soft stops have been provided to limit the range of motion to meet the human design specifications provided by SAE.

Motion in the shoulder structure was provided in the fore and aft, as well as the shrugging directions. The shoulder assembly for THOR NT has been designed to accept the standard Hybrid III 50% male dummy arms which allow many test labs to retro-fit arms from older dummies onto the new units. The complete shoulder assembly can be seen in **Figure 8.1**.

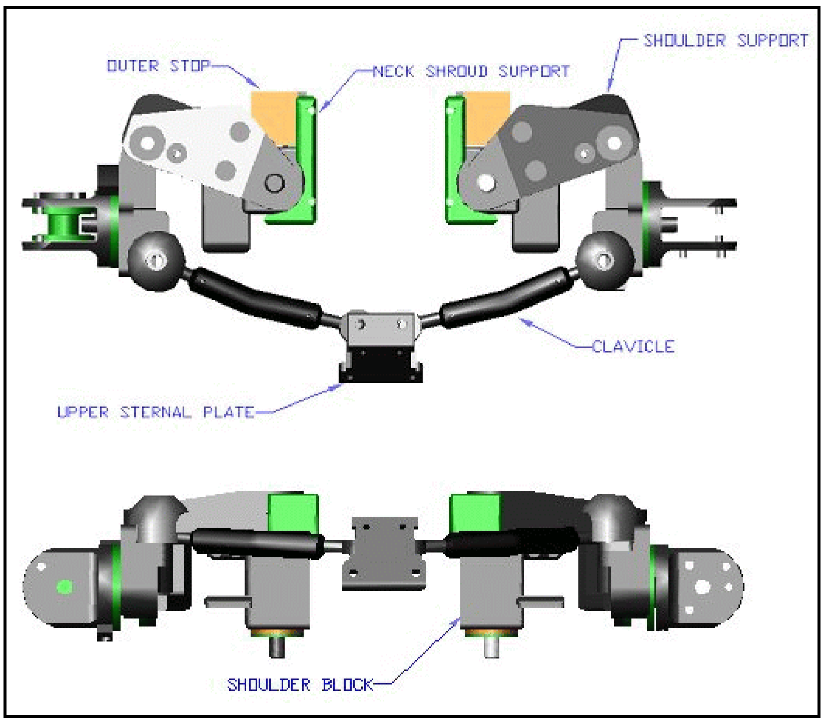

Figure 8 -1 Shoulder Assembly

One of the primary goals of the new shoulder assembly was to provide a more human like interaction between the shoulder belt restraint and the dummy. The shoulder was designed with an integrated shoulder pad which conforms closely to the human shoulder geometry and helps to create the proper interaction between the belt and the clavicle.

8.2 Assembly of Shoulder

8.2.1 Parts List

The parts list and all quantities for the shoulder assembly is listed in Appendix I - Bill of Materials under the Shoulder subsection. Refer to drawing T1SHM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 8.2** is an exploded view of the shoulder assembly.

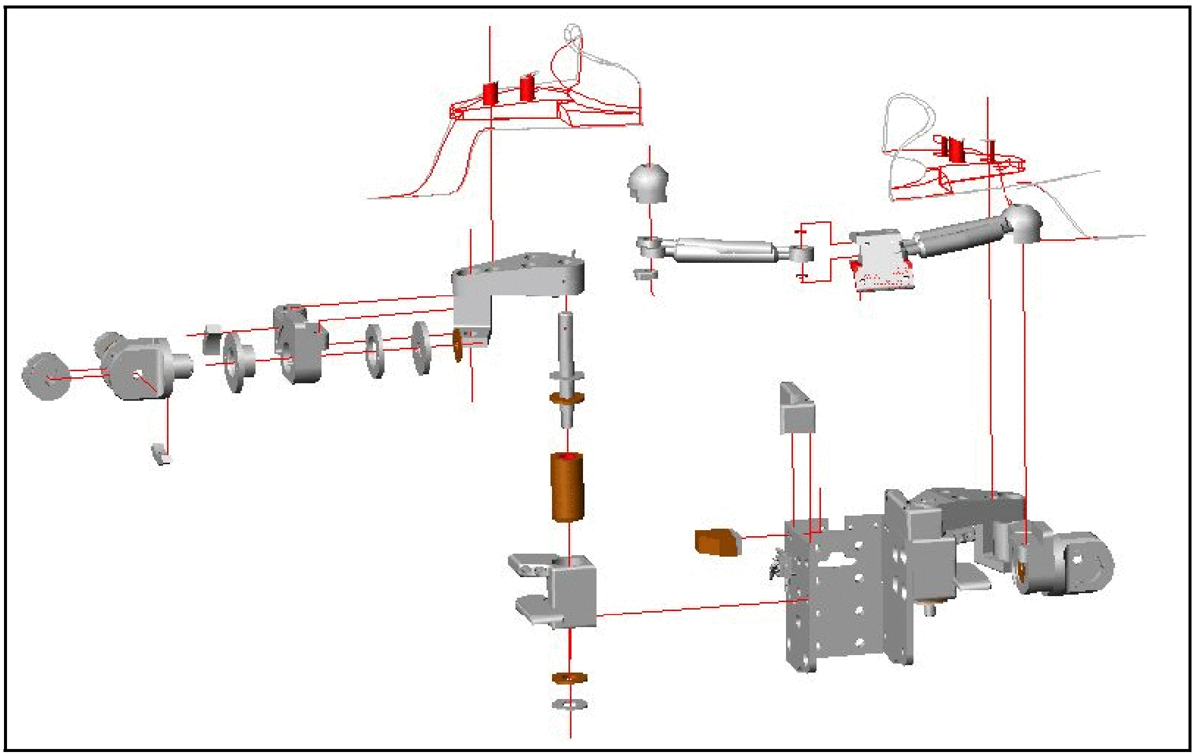

Figure 8 -2 Shoulder Exploded Assembly

8.2.2 Assembly of Shoulder Components

The following procedure is a step-by-step description of the assembly procedure for all of the shoulder components. The numbers noted in ( ) refer to a specific drawing / part number for each particular part. The numbers noted in the { } indicate the size of Hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.- Bolt Torque Values.

1. Attach the Right Neck Shroud Support (TISHM051) and the Outer Stop Assembly (T1SHM008) to the Upper Thoracic Spine (UTS) Right Side Plate (T1SPM121) using respectively two #6-32 x 3/8 S.H.C.S {7/64}and two # 10-32 x ½" B.H.S.C.S {1/8},as shown in **Figure 8.3.**

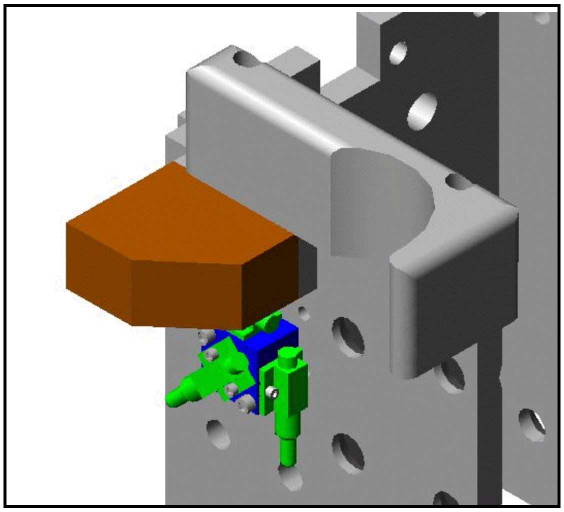

Figure 8-3 Neck Shroud Support and Outer Stop Assembly attached to UTS Assembly

2. Repeat the same procedure to mount the Left Neck Shroud Support (T1SHM052) and the Outer Stop Assembly to the Upper Thoracic Spine Left Side Plate (T1SPM122).

3. Insert in this order, the following hardware into the Right shoulder Block Assembly (T1SHM070): Yoke Washer (T1SHM028), Rubber Washer I (T1SHM030), Molded Rubber Sleeve Assembly (T1SHM003), Shoulder Shaft (T1SHM035), Rubber Washer I (T1SHM030), Yoke Washer (T1SHM028). See **Figure 8.4.**

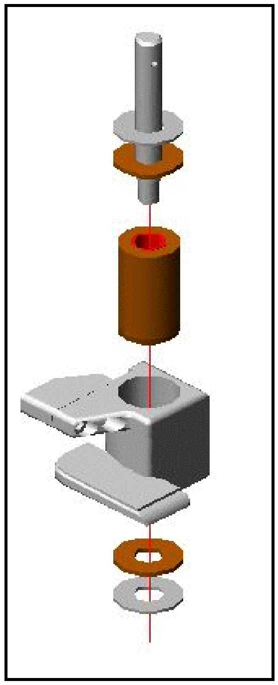

Figure 8-4 Shoulder Block exploded Assembly

4. Repeat the same procedure for the Left Shoulder Block Assembly (TISHM071).

5. Secure the assemblies completed in steps 3 and 4 using a # 3/8" washer and a 3/8"-16 Nylon Insert Locknut {½}. The completed assembly is shown in **Figure 8.5**.

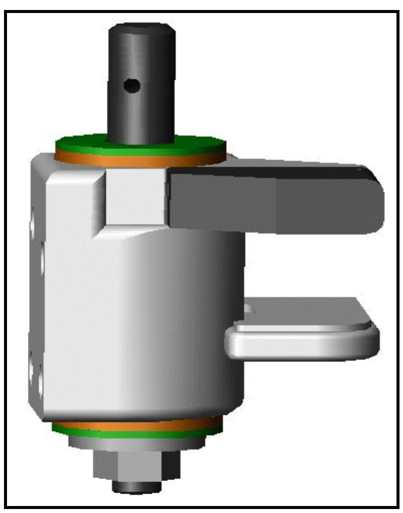

Figure 8-5 Shoulder Block with assembled hardware

6. Attach the Right Shoulder Support (T1SHM023) to the Shoulder Support, using a 1/8"x 1-1/4" Spring Pin, as shown in **Figure 8.6.**

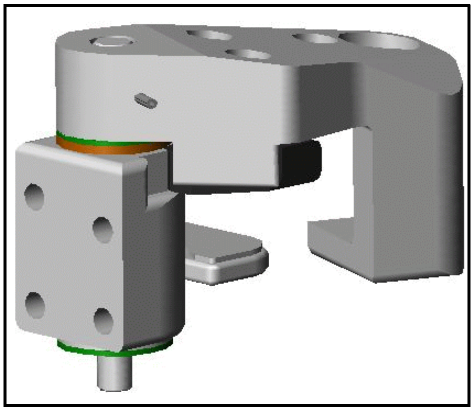

Figure 8-6 Shoulder Support assembled to Shoulder Block

7. Repeat the same procedure to mount the Left Shoulder Support (T1SHM022).

8. Mount the Right Shoulder Block Assembly to the Upper Thoracic Spine Right Side Plate, using four # 5/16-24 x ½" F.H.S.C.S {3/16}. The bolts are tightened from inside the Upper Thoracic Spine Assembly.

9. Repeat the above procedure for the Left Shoulder Block Assembly, as shown in **Figure 8.7**.

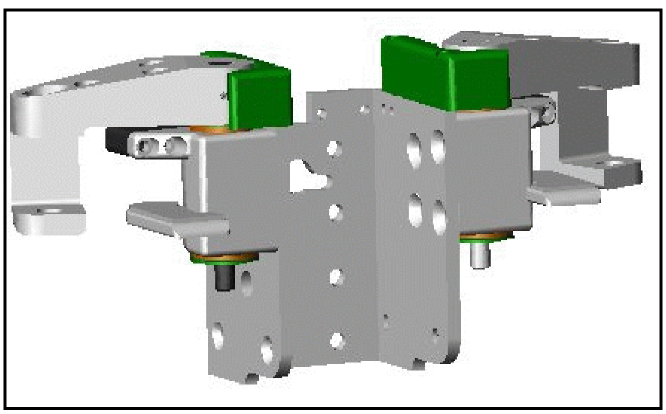

Figure 8-7 Shoulder Blocks assembled to UTS Assembly

10. Insert the following hardware into the Shoulder Yoke Assembly (T1SHM005): Upper Arm Pivot Washer (T1SHM041), Upper Arm Pivot Bushing (T1SHM040), Upper Arm Joint Spring Washer (T1SHM047), Pivot Nut (T1SHM042). Secure the assembly using a #3/8" Flat Washer and a # 3/8-1" Shoulder Screw. Fasten the Shoulder Pivot Stop

Assembly (T1SHM004) to the Right Shoulder Yoke Mount Assembly (T1SHM007) using two # 8-32 x 5/8" S.HC.S {9/64}. Mount the Shoulder Pivot Stop (T1SHM046) to the Shoulder Yoke Assembly using two # 8-32 x 3/8" S.HC.S {9/64}. Rotate the upper arm pivot bushing and the upper arm pivot washer until the notches are aligned with the dowel pins in the shoulder yoke. Align the grooves on the nut with the dowel pins and tighten the shoulder bolt into the pivot nut and adjust the arm to a 1 g resistive torque. An exploded view of the assembly is shown in **Figure 8.8**.

NOTE: The pivot nut should be placed directly over the joint spring washer to allow effective adjustment of the arm resistive torque.

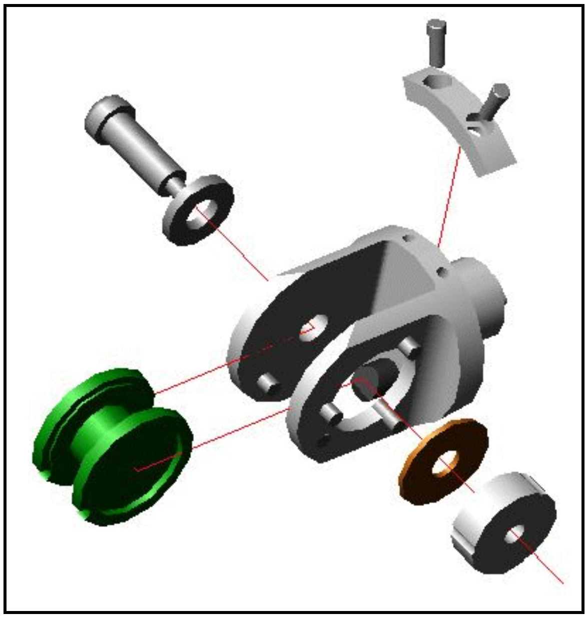

Figure 8-8 Shoulder Yoke exploded assembly

11. Repeat the above procedure for the Left Shoulder Yoke Mount Assembly (T1SHM006).

12. **Figure 8.9** shows an exploded view of: the assembly created in step 10, the Shoulder Yoke Pivot Bushing (T1SHM038), the Right Shoulder Yoke Mount Assembly (T1SHM007), the Shoulder Yoke Delrin Washer (T1SHM027), the Shoulder Yoke Steel Washer (T1SHM026), the Shoulder Joint Spring Washer (T1SHM037). Secure the assembly using a #5/16 -18 x 5/8" B.H.S.C.S {3/16} and two #5/16" Flat Washers. The two holes in the shoulder yoke pivot bushings should engage the dowel pins in the yoke mount assemblies.

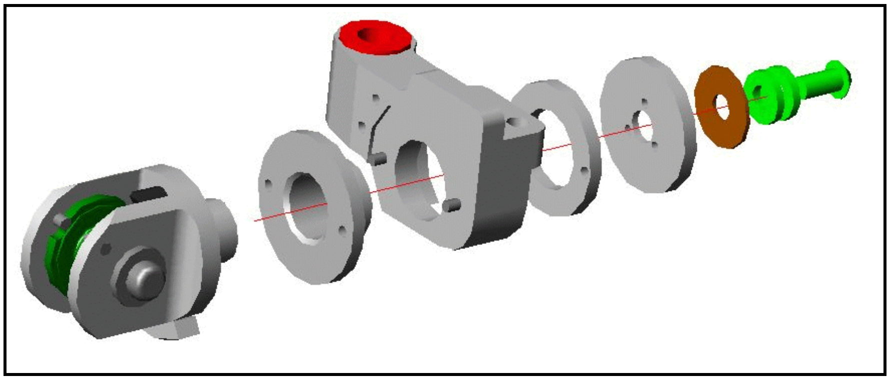

Figure 8-9 Shoulder Yoke/Shoulder Yoke Mount exploded assembly

13. Repeat the above procedure for the assembly created in step 11 and the Left Shoulder Yoke Mount Assembly (T1SHM006).

14. Mount the Shoulder Pivot Stop Assembly (T1SHM004) to the Left and Right Shoulder Yoke Mount Assemblies using four #8-32- 3/8 S.H.C.S{9/64}, as shown in **Figure 8.10**.

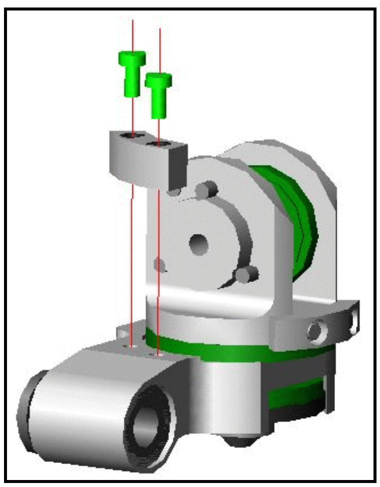

Figure 8-10 Yoke Mount / Pivot Stop exploded assembly

15. Slide the above assembly into the machine slot on the Right Shoulder Support (T1SHM023). Insert a ½" x 1 3/4" Shoulder Bolt {1/4} through the assembly and tighten into the left shoulder support. Secure the Shoulder Bolt using a 5/16" Flat Washer, and a 3/8-16" Nylon insert Locknut {9/16}. An exploded view of this assembly is shown in **Figure 8.11**. Tighten the nut to provide a joint resistive torque of 1 g.

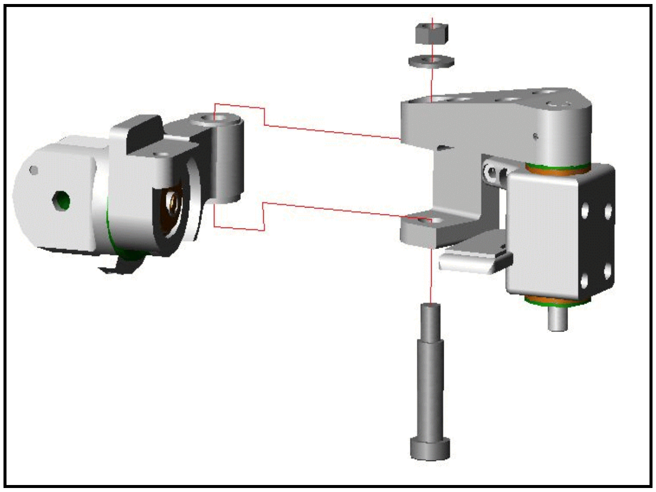

Figure 8-11 Shoulder Support / Yoke Mount
exploded assembly

16. Repeat the same procedure for the Left Shoulder Support (T1SHM022).

17. Position a Sternum / Clavicle Washer (T1SHM010) on both sides of the Clavicle Assembly (T1SHM002) ball end joints. Position the ball end joint and washers into the recess on the back right side of the Upper Sternal Plate (T1SHM018), and secure the clavicle with a Sternal / Clavicle Bolt (T1SHM011) {3/16}, inserted from the bottom. See **Figure 8.12**.

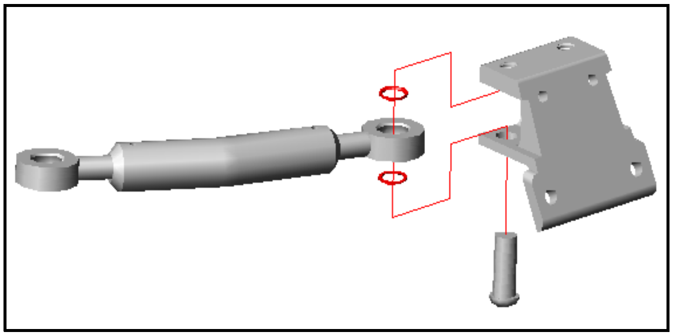

Figure 8-12 Clavicle exploded assembly

18. Repeat Step 17 for the Left of the Upper Sternal Plate.

19. Place the Clavicle End Cover (T1SHM992) and the Clavicle Spacer (T1SHM991) respectively above and below the Clavicle Assembly, and attach the assembly to the Left and Right Shoulder Yoke Mount Assemblies using a # 5/16-18 x 1 1/4" S.H.C.S {1/4}, as shown in **Figure 8.13**.

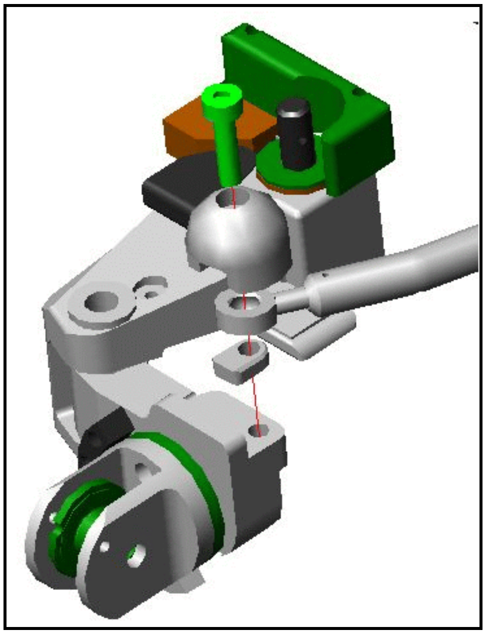

Figure 8-13 Clavicle / Cover exploded assembly

20. Mount the Right (T1SHS110) and Left (T1SHS111) Shoulder Pad Assemblies to the Right and Left Shoulder Supports using three # 1/4-20 x 1" B.H.S.C.S {5/32}on each side. See **Figure 8.14.**

Figure 8-14 Shoulder Pad assembly

8.2.3 Connecting the Arms to the Shoulders

The following procedure is a step-by-step description used to connect the Hybrid III 50% Male Arm Assemblies to the completed shoulder assembly. The numbers provided in ( ) refer to a specific drawing / part number of each part. The numbers noted in { } after the bolt size indicate the hex wrench size required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values.

Disassemble the assembly created in Step 10, and reassemble it with the upper arm between the Upper Arm Pivot Washer and Bushing, as shown in **Figure 8.15**.

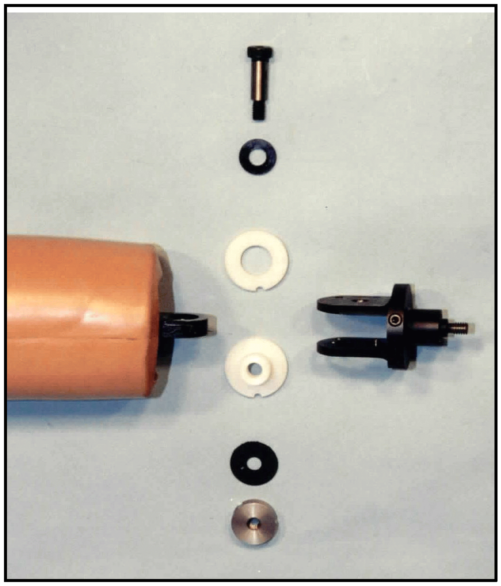

Figure 8-15 Exploded arm attachment assembly

8.3 Adjustments for the Shoulder Assembly

The shoulder assembly requires two joint resistive torque adjustments. The goal of the adjustment is to provide a 1 g joint friction torque.

- The adjustment of the flexion shoulder motion is described in Section 8.2.2, Step 15. Check the adjustment by straightening the arm and raising it in front of the dummy. The arm should remain in position, but move easily under external force.
- The adjustment of the abduction and adduction motion is described on the Shoulder Block Assembly drawing in the THOR NT drawing package. Check the adjustment by straightening the arm and raising it to the side of the dummy. The arm should remain in position, but move easily under external force.

8.4 Electrical Connections and Requirements

No electrical connections are required for the shoulder assembly.

8.5 Shoulder Certification

No certification is required for the shoulder assembly.

8.6 Inspection and Repairs

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

Although this disassembly is very simple, some comments are provided below to assist in the process.

8.6.1 Electrical Inspections (Instrumentation Check)

There are no instruments in the shoulder assembly.

8.6.2 Mechanical Inspection

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

Shoulder Soft Stops: The following checklist should be used when inspecting the shoulder soft stops for post-test damage:

- Check the inner soft stop assemblies for debonding between the rubber and the steel mounting plates
- Check both soft stops for tearing or permanent compression

Shoulder Pads: The following checklist should be used when inspecting the shoulder pads for post-test damage:

- Check the shoulder pads for damage (tearing, cuts, etc.) which may be caused by the belt loading.

Friction Joint Adjustments: The following checklist should be used when inspecting the shoulder pads for post-test damage:

- Check the two rotation joints at the shoulder for the proper resistive torque. Refer to Section 2.9- Joint Resistive Torque Adjustments for further details.

Section 9. Upper Abdomen Assembly

9.1 Description of Upper Abdomen Assembly and Features

The upper abdomen is the region on the dummy that represents the lower thoracic cavity. Physically, this component fills the volume that exists between the lowest three ribs, above the lower abdomen and in front of the spine. The component is primarily constructed of deformable materials to produce a compression response similar to human cadaver test data. Instrumentation is incorporated into the component to measure the impact penetration and acceleration. A drawing of the complete upper abdominal assembly is provided in **Figure 9.1**.

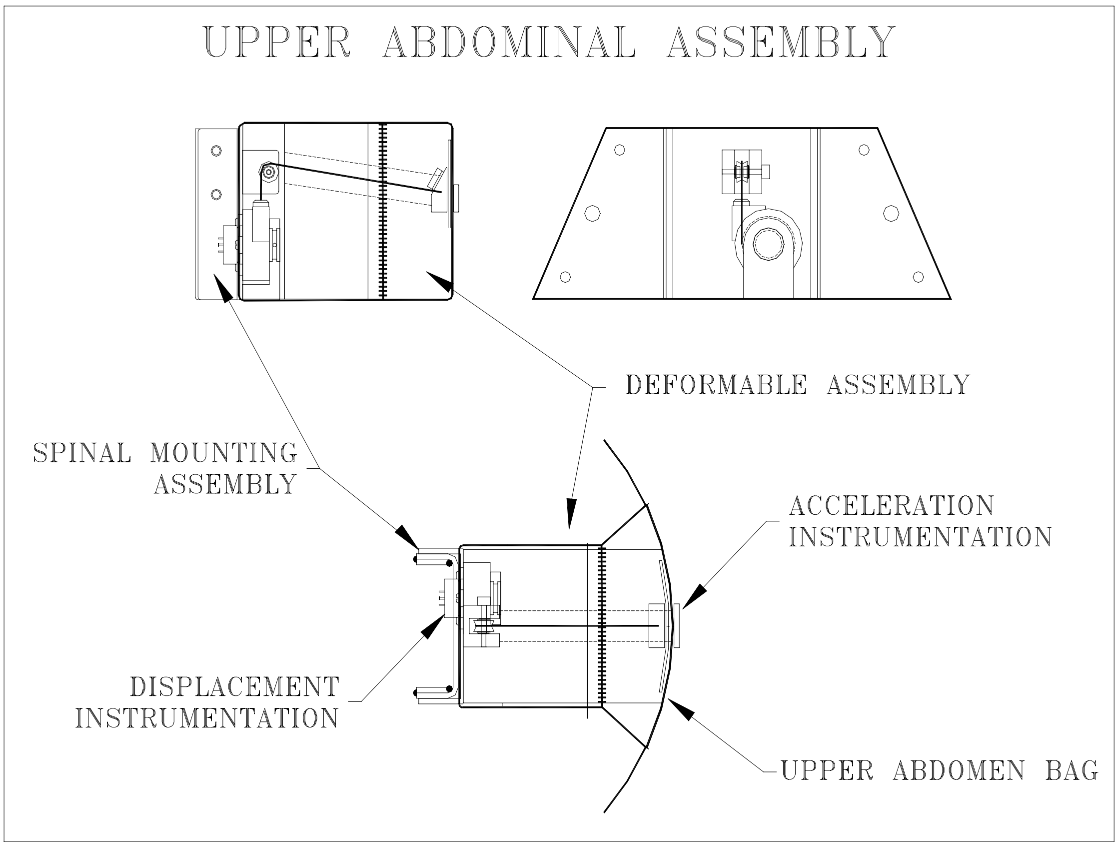

Figure 9.1- Upper abdomen assembly

The upper abdomen assembly consists of a Cordura nylon bag that encloses a series of layered foams. The Cordura is a very durable fabric and the seams of the bag are sewn with a Kevlar thread to prevent tearing. Two flaps extend laterally from the front surface of the upper abdomen to allow it to be bolted to the ribs and bib layers. A zipper provides access to the interior of the bag for inspecting the foams and instrumentation. There are two different layers of foams that are used to obtain the proper compression response. Each layer has a hole cut through it to allow the cable of the string transducer to pass through to the front cover.

There are two types of instrumentation installed into the Upper Abdomen. A String Potentiometer is installed to measure the abdominal penetration in the X-axis of the dummy's coordinate system. The String Potentiometer is mounted on the forward surface of the Internal Mounting Plate with the cable passing through the foams to the front surface of the fabric where it is connected. The second sensor is a uniaxial accelerometer that is mounted onto a Delrin block on the front surface of the bag assembly. The mounting surface has been cut to roughly direct the active axis of the accelerometer in the -X direction. This sensor measures the acceleration generated during impacts by objects, such as an airbag or a loose shoulder belt slapping against the upper abdomen of the dummy.

9.2 Assembly of the Upper Abdomen

9.2.1 Parts List

The parts list for the upper abdomen assembly is listed in Appendix I - Bill of Materials under the Upper Abdomen subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1UAM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 9.2** is a drawing of the exploded upper abdomen assembly and hardware.

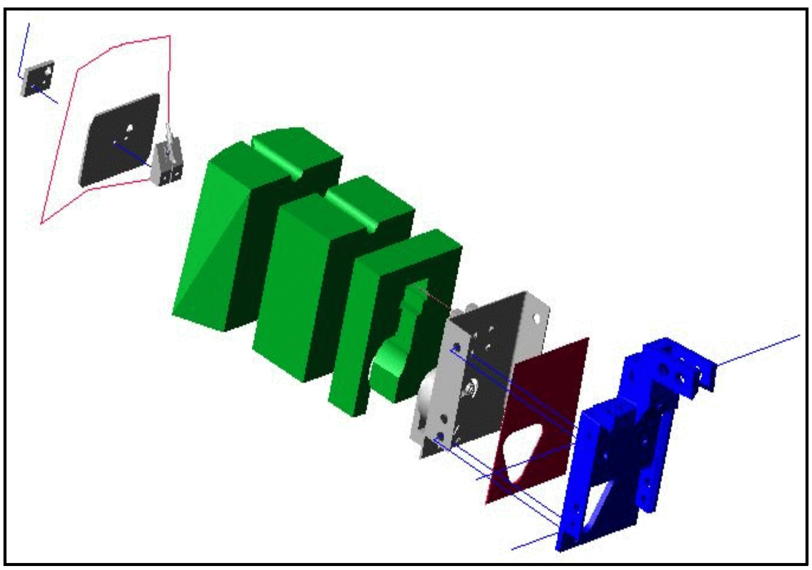

Figure 9.2- Upper abdomen exploded assembly

9.2.2 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. The numbers noted in ( ) refer to a specific drawing / part number for each particular part. The numbers noted in the { } indicate the size of Hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Bolt the Pulley Wheel Assembly (T1UAM210, T1UAM211, T1UAM212) to the forward facing surface of the Internal Mounting Plate Front (T1UAM252) using four #6-32 x 3/8" FHSCS {5/64}, as shown in **Figure 9.3**. (Note: The forward facing surface is on the same side opposite the flanges.)

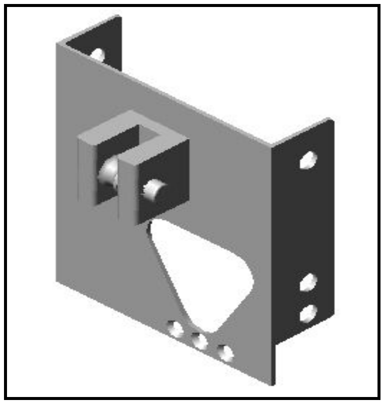

Figure 9.3- Pulley wheel assembled to internal plate assembly

2. Fit the cylindrical protrusion of the string transducer through the hole of the String Potentiometer Mounting Bracket (T1UAM213). Orient the bracket so that the body of the string potentiometer is nestled in the "L" of the bracket. Rotate the string transducer so that the string is pointed in a direction away from the end with the three mounting holes. Tighten the two #4-40 x 3/8" SSS {0.050} on each side of the holder just enough so that the string transducer cannot be removed, but still may be rotated within the holder. This is shown in **Figure 9.4**.

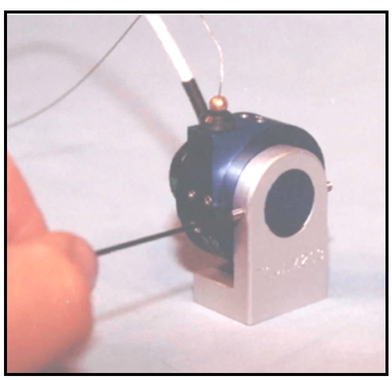

Figure 9.4- String pot in mounting bracket

3. Bolt the String Potentiometer Mounting Bracket to the same surface as the pulley wheel assembly using three #6-32 x 3/8" FHSCS {5/64}. The rotary potentiometer should protrude through the "clover- shaped" hole of the internal mounting bracket.

4. Rotate the string transducer in its holder, so that the string transducer cable passes from the black Delrin cable guide on the string transducer housing to the pulley wheel with the least resistance. The proper alignment of the string potentiometer is shown in **Figure 9.5**. (Note: This adjustment allows the cable to wind off of the drum tangentially.)

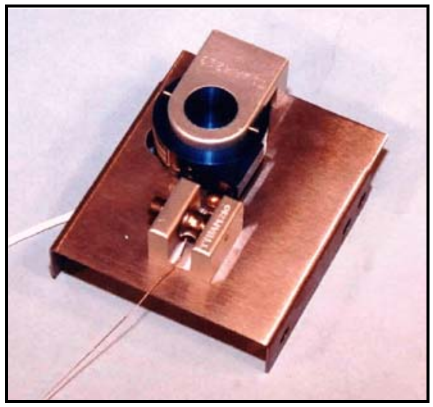

Figure 9.5- Proper alignment of string potentiometer

5. Pass the string transducer cable underneath the center of the pulley wheel.

6. Align the Internal Foam Rear Layer (T1UAM010), so that it matches the positions of the string transducer and pulley wheel assembly and push it into place around the potentiometer, as shown in **Figure 9.6**.

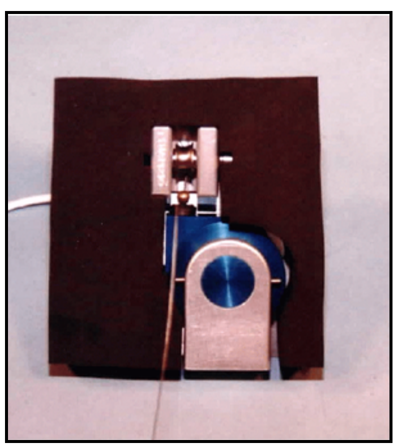

Figure 9.6- Internal foam rear layer installed

7. Pass the electrical cable for the string transducer through the “clover-shaped” hole in the rear of the Bag Assembly (T1UAF300) from the inside to the outside, until it is possible to insert the entire assembly into the rear of the bag. Pay attention to align the holes in the bag and the flanges of the bracket properly. Proper assembly of the fabric bag to the mounting plate is shown in **Figure 9.7**.

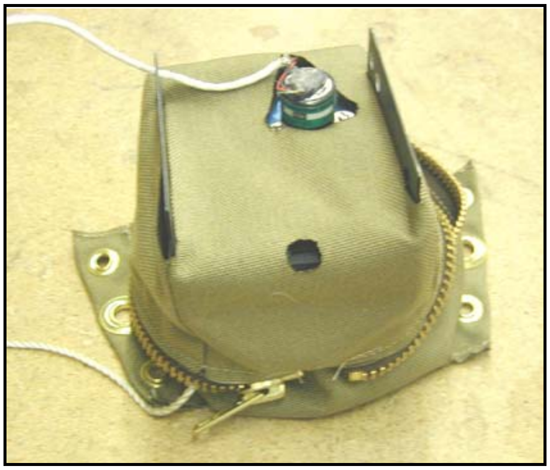

Figure 9.7- Fabric bag assembled to mounting plate

8. Thread the string transducer cable through the hole in the Internal Foam Middle Layer (T1UAM011). Insert this middle layer of the foam into the bag as shown in **Figure 9.8**.

Figure 9.8- Middle foam layer inserted into bag

9. Thread the string transducer cable through the hole in the Internal Foam Front Layer

(T1UAM012). Insert this front layer of the foam into the bag.

10. The Upper Abdomen can be instrumented with a uniaxial accelerometer 2000g (T1INM111) to measure the acceleration of the bag face during impact. Mount the Uniaxial Accelerometer to the Accelerometer Mount (T1UAM015) using two #0-80 x 1/4" SHCS {0.050} and two #0 washers as shown in **Figure 9.9**. The electrical cable from the uniaxial accelerometer unit should be oriented toward the narrow end of the Accelerometer Mount wedge.

WARNING: DO NOT OVER TIGHTEN THE #0-80 BOLTS. A SNUG FIT IS ADEQUATE TO SECURE THE SENSOR. OVER TIGHTENING MAY CAUSE DAMAGE TO THE ACCELEROMETER!!!

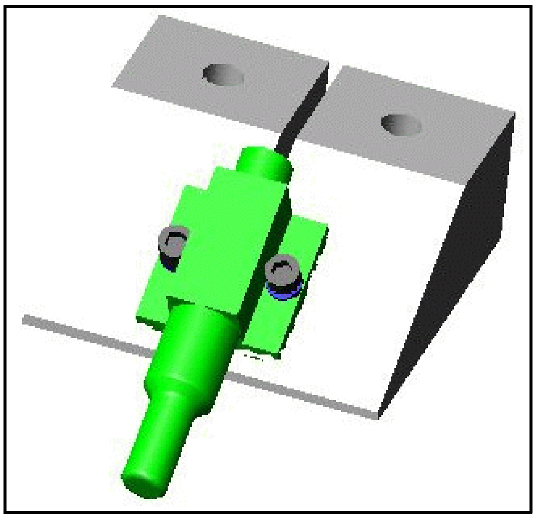

Figure 9.9- Uniaxial accelerometer on accelerometer mount

11. 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 **Fig 9.10**.

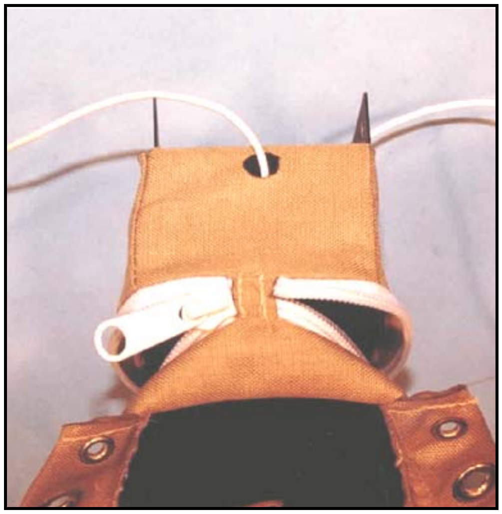

Figure 9.10- Accelerometer wire routing

NOTE: THE HOLE BORED IN THE FOAM LAYERS FOR THE STRING POTENTIOMETER CABLE IS ANGLED TO DIRECT THE CABLE FROM THE TOP OF THE BAG AT THE REAR TO THE MIDDLE OF THE BAG AT THE FRONT FACE.

12. Pull the string potentiometer cable through the foams using a pair of pliers until the swag ball appears.

WARNING: BE VERY CAREFUL NOT TO PULL THE STRING FURTHER THAN ONE INCH FROM THE SURFACE OF THE GREY POLYESTER FOAM. EXTENDING THE STRING ANY FURTHER MAY CAUSE DAMAGE TO THE STRING TRANSDUCER!!!

13. Position the Accelerometer mount at the front of the Internal Foam Front Layer and slide the slot of the Accelerometer Mounting block over the cable, with the swag ball socket facing the swag ball, as shown in **Figure 9.11**. Allow the string to retract with the ball seating into the ball socket. Slowly release the cable and allow the Accelerometer Mounting block to rest against the front foam layer. The uniaxial accelerometer is positioned directly against the front foam layer.

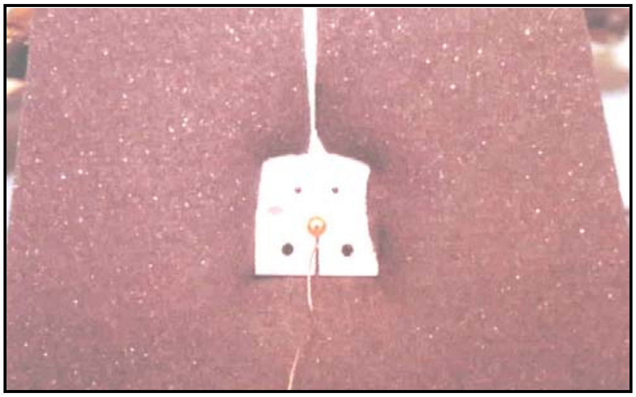

Figure 9.11- Cable inserted on accelerometer block

14. Place two #4-40 x ½" FHSCS {1/16} through the holes in the String / Accelerometer Mount Plate (T1UAM014). Align the bolts with the holes on the front of the Upper Abdomen bag and push the bolts through the holes. The plate should be oriented with the 1/4" through hole at the upper left side, as shown in **Figure 9.12**.

Figure 9.12- String potentiometer / accelerometer mounting plate

15. Position the Load distribution Plate (T1UAM013) on the inside front surface of the Upper Abdomen Bag and push the holes of the plate onto the protruding bolts from step 14, as shown in **Figure 9.13**.

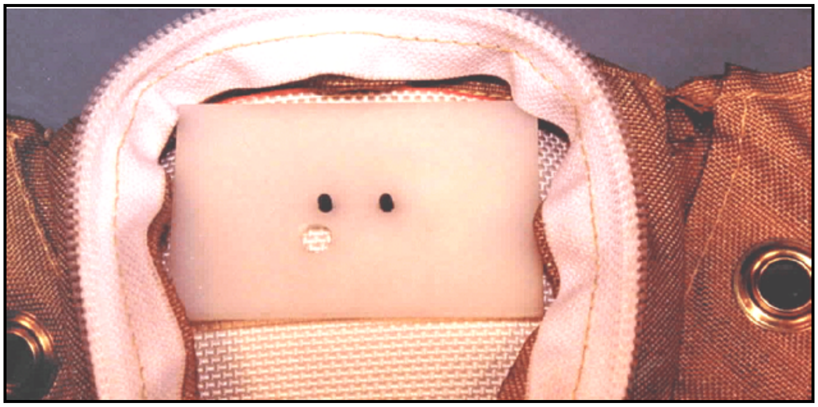

Figure 9.13- Load Distribution Plate inside of bag

16. Align the bolts with the threaded holes in the Accelerometer Mount and thread the #4-40 bolts from the front plate into the corresponding threaded hole of the mounting block. Repeat this step for the second bolt after the first bolt has been secured.

17. Position the foam layers into the bag and zip the bag assembly closed.

18. Pass the instrument wire from the String Potentiometer through the ½" diameter hole in the lower left side of the Spine Mounting Bracket Assembly (T1UAM100). Position the bag assembly into place over the Spine Mounting Bracket Assembly as shown in **Figure 9.14**. Secure the string potentiometer wire to the spine mounting bracket using a zip-tie.

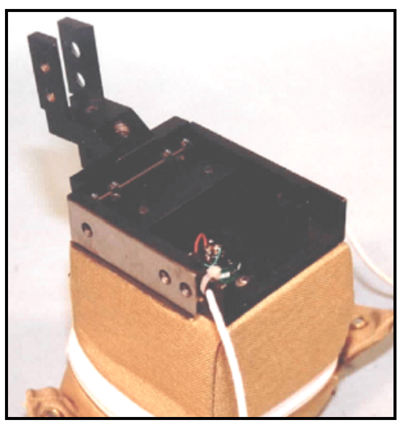

Figure 9.14- Bag attached to mounting bracket

19. Install the Upper and Lower CRUX units to the Upper Abdomen Assembly as described in Section 16 - CRUX. Secure the CRUX wires to the upper abdomen assembly with a 1/4-20 x ½" BHSCS {5/32} and a 1/4" nylon cable clamp on each side. These bolts are fastened through the top mounting hole of the Upper Abdomen assembly.

9.2.3 Assembly of Upper Abdomen into THOR NT

The following procedure is a step-by-step description of the assembly procedure used to attach the upper abdomen to the completed thorax assembly. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. The upper abdomen can be installed either before or after the thorax assembly is complete. This procedure assumes that the spine of the dummy with the ribs and bib is already assembled and that ribs #5,6 & 7 are not attached to the bibs.

1. Check the adjustment of the String Potentiometer as described in Section 9.5

2. Loosen the center bolt of the Lower Thoracic Spine Pitch Change Mechanism as described in Section 6.3.1. Rotate the upper thorax and spine rearwards to open the thoracic cavity and allow easy access. This will provide space between the upper and lower abdomen assemblies.

3. Position the Spinal Mounting Bracket arms on either side of the Lower Thoracic Spine Weldment and carefully slide the Upper Abdomen / CRUX assembly into the dummy's thorax.

WARNING: IT IS VERY EASY TO PINCH THE WIRE FROM THE LTS TILT SENSOR DURING THE INSTALLATION OF THE UPPER ABDOMEN. THIS WIRE IS ROUTED BETWEEN THE ARMS OF THE UPPER ABDOMEN SPINE MOUNTING BRACKET.

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4. Align the holes and fasten the Spinal Mounting Bracket to the Lower Thoracic Spine Weldment using two 5/16-18 x 1" FHSCS {3/16} into the two mounting holes in the Spinal Mounting Bracket arms from the right side, as shown in **Figure 9.15**.

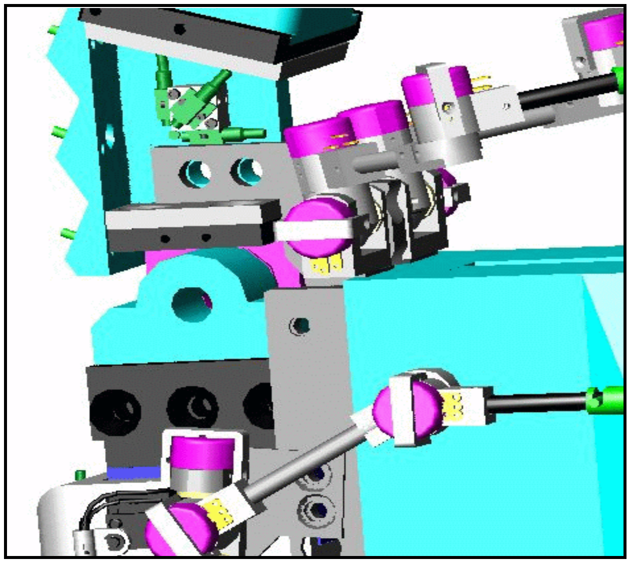

Figure 9.15- Upper abdomen mounting to spine

5. Insert the U-Joint of each lower CRUX unit through the 3/8" holes of rib #6. Then pass the U-Joint through the 3/8" grommet of the upper abdomen flaps. Push the separate layers of the bib over the end of the U-Joint. Screw the Rib Connecting Bolt into the U-Joint to secure the CRUXs, upper abdomen and the bib layers together. For additional details, refer to Section 7 - Thorax.

6. Readjust the Lower Thoracic Pitch Change Mechanism to the desired setting - Section 6.3.1.

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 (T1LAF117), as shown in **Figure 9.16**

Figure 9.16- Proper location of Upper and Lower Abdomen cover

9.3 Adjustments for the Upper Abdomen Assembly

The upper abdomen assembly does not require any adjustments for testing - except the initial adjustment of the rotary potentiometer as described in Section 9.5.

9.3.1 Storage and Handling

The storage of the Upper Abdomen unit can greatly effect the longevity of the unit. Due to the nature of the string potentiometer, the upper abdomen is subjected to a constant compressive loading. Over periods of time (storage and shipment), this loading can cause permanent compression of the upper abdomen foam. This loading can be eliminated in storage and shipping conditions by one of the following two methods:

- Release the string potentiometer cable from the accelerometer mount at the front of the upper abdomen bag and allow the cable to retract slowly into the bag. This will remove the cable tension from the assembly, but it will necessitate reattachment of the cable prior to further testing.

WARNING: THE STRING POTENTIOMETER CABLE WILL SNAP IF THE CABLE IS ALLOWED TO RETRACT QUICKLY INTO THE HOUSING. THE CABLE MUST BE LOWERED UNDER TENSION VERY SLOWLY DURING THE DISASSEMBLY.

- The use of the Abdomen Storage fixture, will relieve the tension placed on the foam by the string potentiometer. This fixture may be obtained as an option through GESAC. The part number for ordering is T1FDT210. The use of this fixture is described in Section 2.8.

9.4 Electrical Connections and Requirements

The upper abdomen has two primary instruments: the string potentiometer and the uniaxial accelerometer. In addition, the four CRUX units are attached to the upper abdomen prior to installation within the dummy. Finally, the instrument wire from the mid-sternum uniaxial accelerometer is routed with the upper abdomen instrumentation.

String Potentiometer Wire: This wire exits the string potentiometer from the rear of the upper abdomen bag assembly. The wire is passed through the lower left side of the Spine Mounting Bracket Assembly and secured using a zip-tie. This wire is then routed directly to the wire bundle running down the back of the spine.

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

CRUX Units - The routing of the wires from the CRUX units s discussed in the CRUX 16. The wires from the upper and lower CRUX units are strain relieved with a wire clamp attached to each side of the Upper Abdomen Spine Mount (T1UAM100) with a 1/4-20 x ½" BHSCS {5/32}. The wires are then routed on the left and right sides of the spine assembly and exit the thorax below rib #7 to joint the bundle of wires running down the dummy's spine.

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

9.5 Calibration of Upper Abdomen Assembly

The upper abdomen assembly is calibrated at GESAC using a dynamic impact test. This test is conducted with a steering wheel shaped impactor. The results of the dynamic testing produce a graph of impact force versus internal deflection measured by the string potentiometer unit. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication.

9.5.1 Calibration of the String Potentiometer

The string transducer requires an adjustment to properly set the initial position of the rotary potentiometer. This adjustment will produce a nearly zero voltage for the uncompressed condition of the abdomen. Measurements of the deflection are made from this starting point. This initial calibration was performed at GESAC during the assembly of the dummy. Use the following procedure if the string potentiometer does not appear to be correctly calibrated.

1. Connect the sensor to a power supply and voltage meter as described in the Instrumentation section. Power the sensor with 10 V DC and less than 100 mA.

2. Measure the initial output voltage of the uncompressed upper abdomen. The value should fall in a range between 0.000 and 0.020 mV/V_{EX}. If the uncompressed voltage falls within that range, the potentiometer is adjusted properly; do not proceed. If the value is outside of that range, continue with Steps 3 through 7.

3. Loosen the three slotted screws around the rotary potentiometer of the string transducer. They are accessible through the “clover-shaped” hole in the rear of the abdominal bag.

4. Rotate the rotary potentiometer a small amount. Measure the output voltage. If the output voltage is closer to the desired range, continue rotating the potentiometer in the same direction. If the voltage has changed further from the range, rotate the potentiometer in the opposite direction.

5. Repeat step #4 until the initial voltage is within the desired range.

6. Tighten the screws around the rotary potentiometer.

7. Measure the output voltage to ensure that the initial voltage did not change when the screws were tightened. If the initial value has fallen outside of the range, repeat Steps 3 through 7.

9.6 Inspection and Repairs

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

9.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the upper abdomen instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

9.6.2 Mechanical Inspection

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

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

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

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

- Check the foam for tearing and rips.
- Check the foam for permanent compression caused by the tension of the cable in the string potentiometer. This permanent compression can be eliminated through careful storage and handling, as described in Section 9.3.1

Section 10. Lower Abdomen Assembly

10.1 Description of the Lower Abdomen Assembly and Features

The lower abdomen is defined as the region of the human body between the lower thoracic rib cage and the pelvic girdle. The component is primarily constructed of deformable materials to produce a compression response similar to human cadaver test data. This region of the dummy is subjected primarily to belt loading, however interaction with the steering wheel and airbag is also possible. Instrumentation has been incorporated into the lower abdomen assembly to measure the three dimensional displacement of the region at two distinct points. A drawing of the complete lower abdomen assembly is provided in **Figure 10.1**.

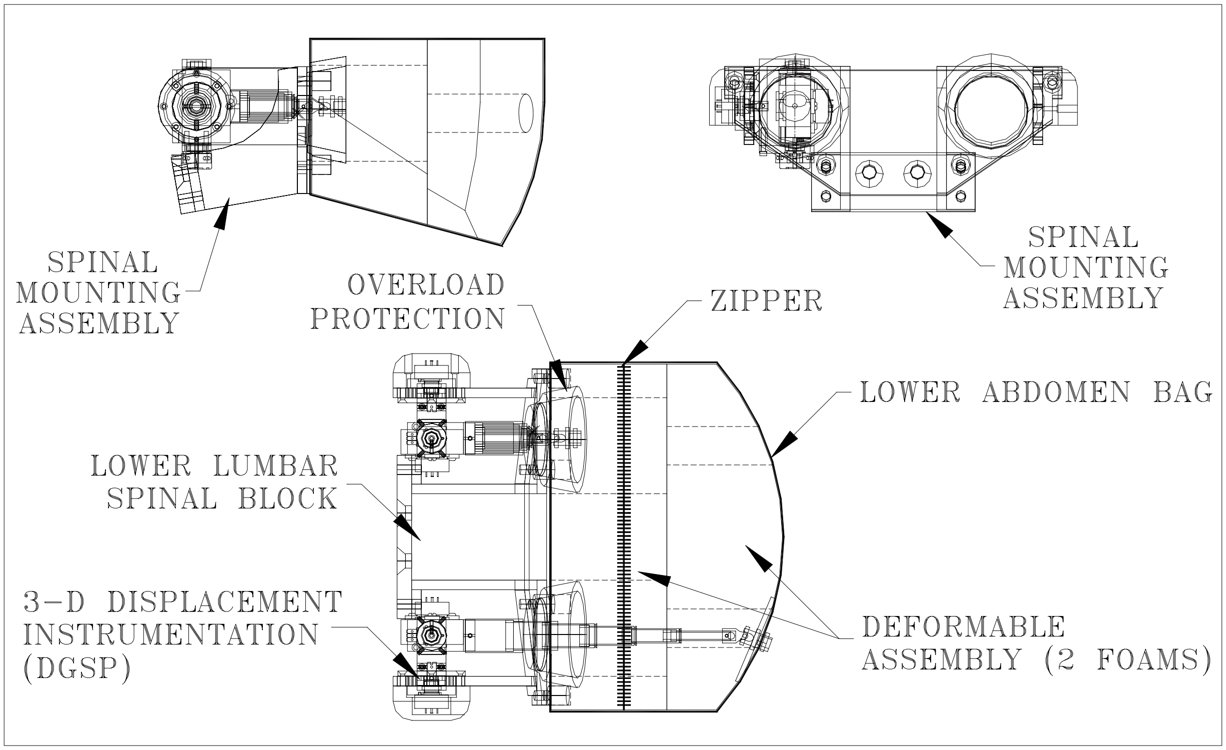

Figure 10.1- Lower abdomen assembly

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

The instrumentation for the lower abdomen unit consists of two DGSP (Double Gimballed String Potentiometer) units. These units provide complete deflection data for the assembly at two distinct points on the abdominal surface during the impact event. The operation and function of these units are covered in greater detail in Section 17 -DGSP Assembly.

10.2 Assembly of the Lower Abdomen

10.2.1 Parts List

The parts list for the lower abdomen assembly is listed in Appendix I - Bill of Materials under the Lower Abdomen subsection. Refer to drawing T1LAM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 10.2** is an exploded view of the lower abdomen assembly. The fine red lines represent the Bag Assembly location.

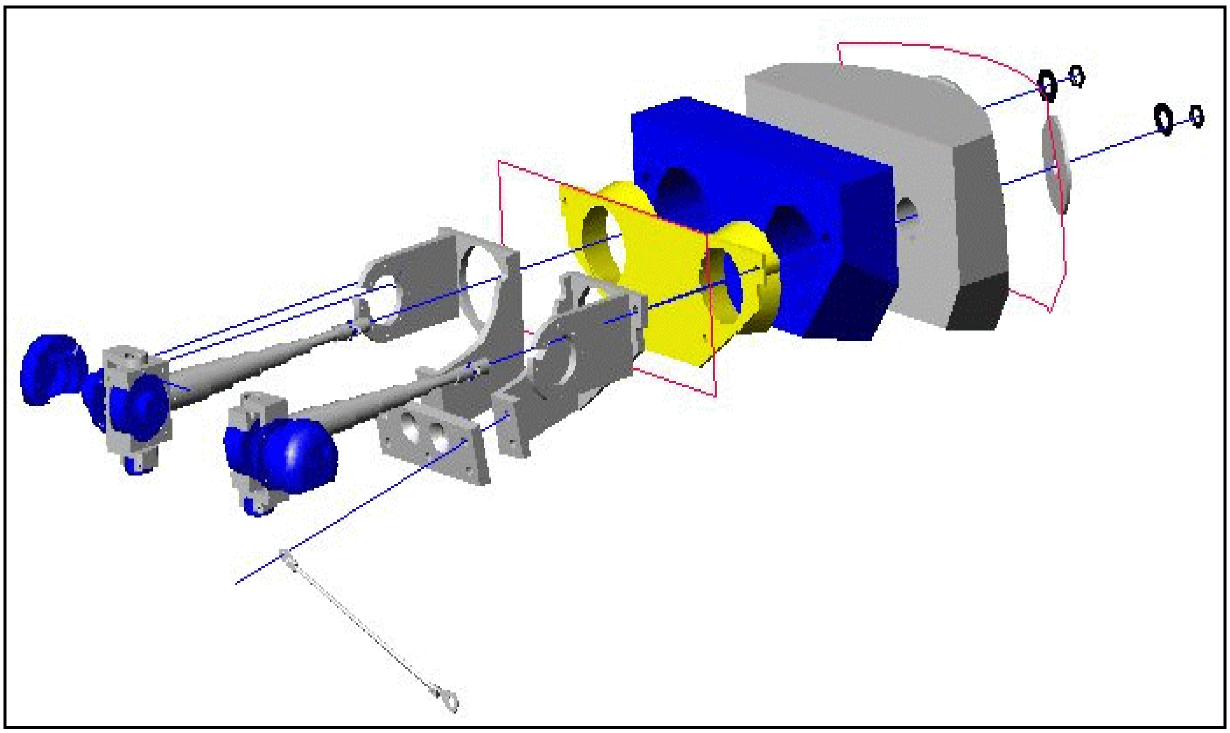

Figure 10.2- Lower abdomen exploded assembly

10.2.2 Assembly of Lower Abdomen Components

The following procedure is a step-by-step description of the assembly procedure for all of the Lower abdomen components. The numbers noted in ( ) refer to a specific drawing / part number for each particular part. The numbers noted in the { } indicate the size of Hex wrench required to perform that assembly step. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Position the Internal Mounting Welded Assembly (T1LAW080) into the interior of the Lower Abdomen Bag Assembly (T1LAF100), as shown in **Figure 10.3**.

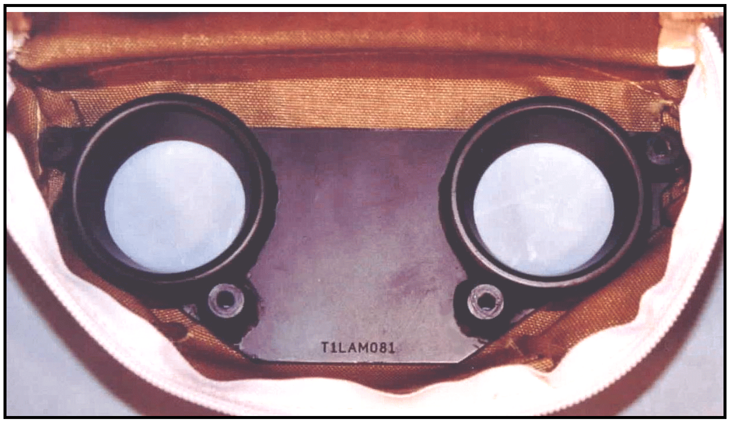

Figure 10.3- Internal Mounting Weld assembly positioned properly inside of bag

2. Secure the Left Attachment Bracket (T1LAW040) to the left rear side of the lower abdomen assembly using two 1/4-20 x 3/4" BHSCS-NP {5/32}, as shown in **Figure 10.4**.

Figure 10.4- Left Attachment Bracket assembled to internal plate

3. Repeat step 2 for the Right Attachment Bracket (T1LAM060). The lower abdomen mounting assembly should look like **Figure 10.5**.

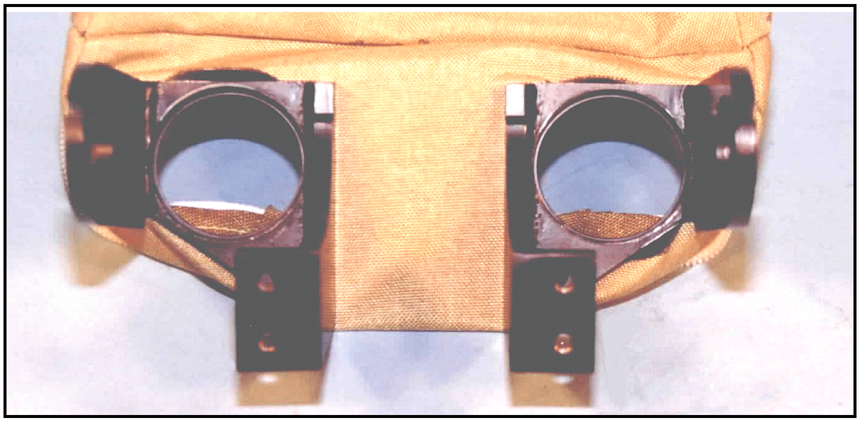

Figure 10.5- Right and Left Attachment Brackets installed

4. Check the DGSP units for calibration date - if a calibration is due, the units must be calibrated prior to assembly. The calibration procedure is described in Section 17.

NOTE: THE DGSP UNITS MUST BE CALIBRATED PRIOR TO INSERTION IN THE LOWER ABDOMEN ASSEMBLY.

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5. Identify the Left and Right DGSP units. Note that the left and right units are assembled differently. The difference involves the position of the Rotary Potentiometer #1 in the +final mounted position. On their perspective sides, the #1 Rotary Potentiometers are facing upward on the Yoke and Gimbal Assembly. If facing downward, they will interfere with the Side Support Brackets. **Figure 10.6** shows the left and right DGSP units for reference. Refer to Section 17 for further detail on the DGSP units.

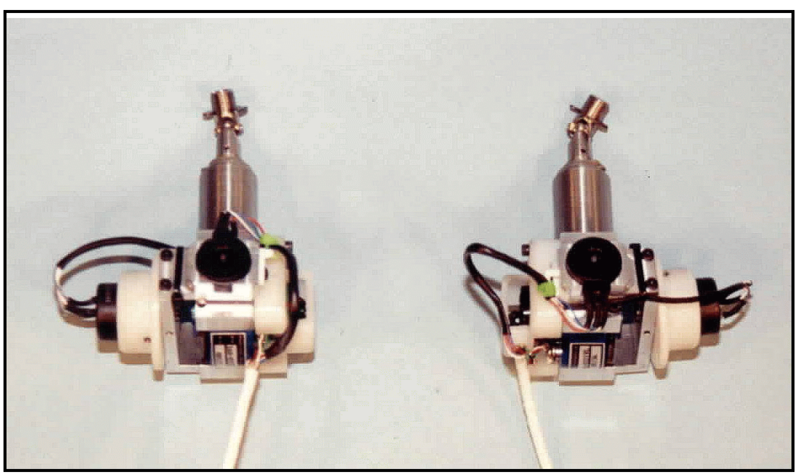

Figure 10.6- Left and Right DGSP assemblies

6. Locate the Left DGSP unit (T1DPM000). Remove the two #4-40 x 3/8" SHCS {3/32}

that hold the Right Yoke Arm (T1DPM213) to the Left Yoke Arm (T1DPM212) and Gimbal Assembly (T1DPM200), as shown in **Figure 10.7**.

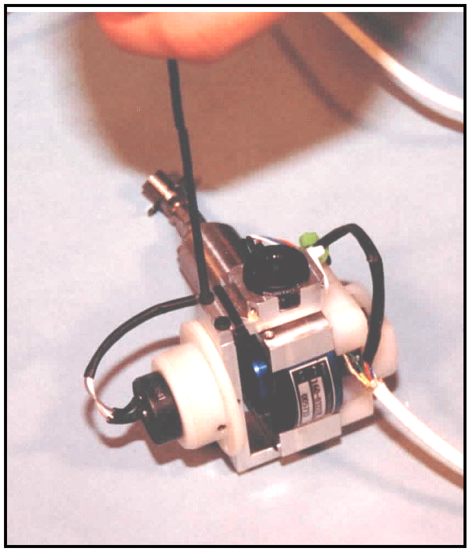

Figure 10.7- Yoke arm bolt location

WARNING: DUE TO THE SOLDERED CONNECTIONS, THERE IS ONLY A SMALL AMOUNT OF DISTANCE ALLOWED TO SEPARATE THE STRING POTENTIOMETER ASSEMBLY FROM THE YOKE LEFT ARM. IT IS IMPORTANT TO KEEP THE TWO ASSEMBLIES IN CLOSE PROXIMITY TO AVOID APPLYING TENSION TO THE WIRES.

---

7. Carefully separate the Rotary Potentiometer #1, DGSP Right Arm and String Potentiometer Assembly (T1DPM300) from the DGSP Yoke Left Arm, as shown in **Figure 10.8**. Two Teflon washers will fall off the lower trunnions of the string potentiometer assembly.

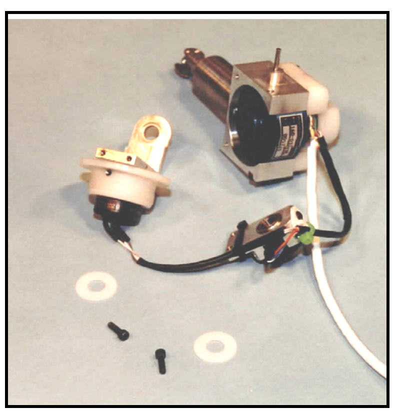

Figure 10.8- Separation of DGSP

8. Pass the wire which connects the Rotary Potentiometer #1 (T1INM210) to the Yoke Axis Rotary Potentiometer (T1DPM210) through the slot in the rear of the Lower Abdomen Attachment Bracket - Left (T1LAW040). The DGSP assembly should be oriented to the inside of the attachment bracket as shown in **Figure 10.9**.

Figure 10.9- Potentiometer wire routing through slot in rear of bracket

9. Insert the Left DGSP telescope into the left access hole in the rear of the lower abdominal bag mounting plate, as shown in **Figure 10.10**.

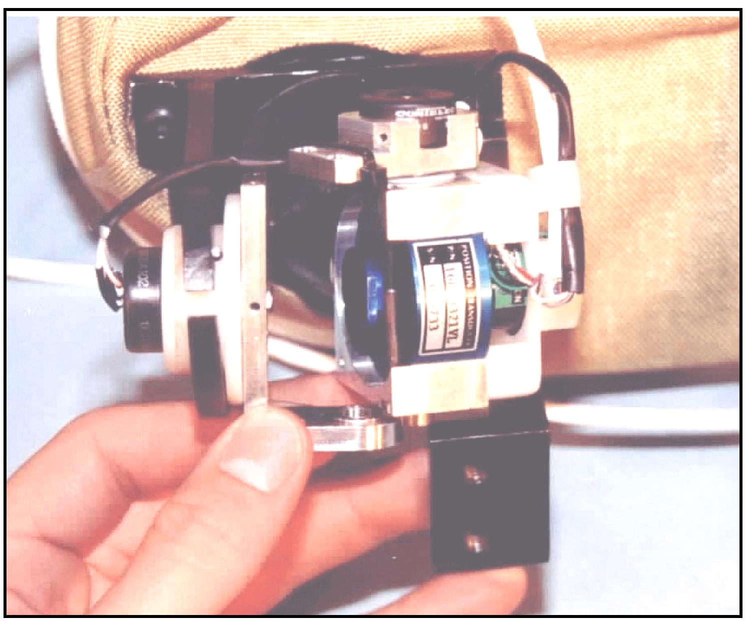

Figure 10.10- Insert DGSP telescope into access hole

10. Insert the Rotary Bushing (T1DPM211) and Yoke Axis Rotary Potentiometer (T1DPM210) through the 1.25" diameter hole of the Left Attachment Bracket, as shown in **Figure 10.11**.

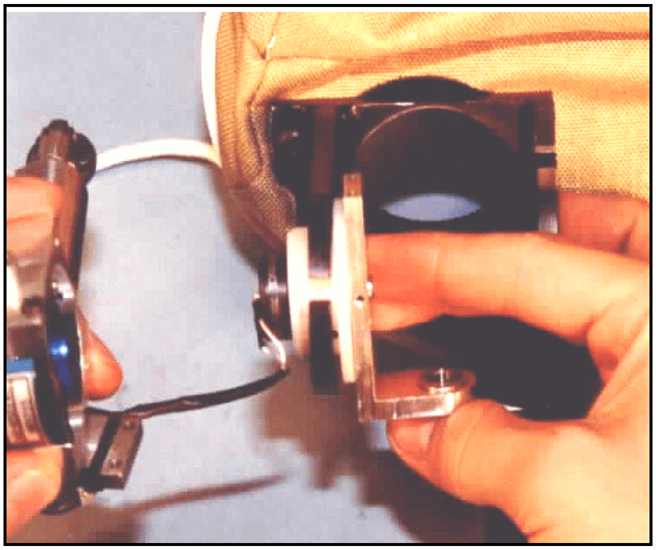

Figure 10.11- Insert Rotary bushing through 1.25" hole

11. Rotate the flanged surface of the bushing until the engraved arrow is pointing upwards as shown in **Figure 10.12**. The orientation of the arrow will insure proper operation of the Yoke Axis Rotary Potentiometer during the dynamic test event.

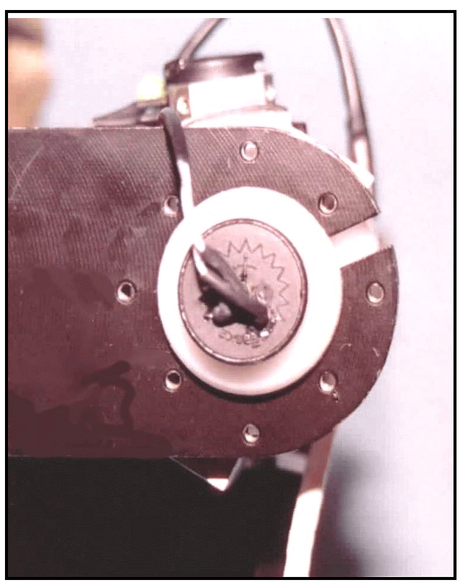

Figure 10.12- Align potentiometer so that the arrow is pointing up

12. Secure the Rotary Bushing to the Left Attachment Bracket using four #4-40 x 3/8" FHSCS {1/16}, as shown in **Figure 10.13**. Ensure that the engraved arrow is still oriented upwards.

NOTE: THERE ARE TWO PATTERNS OF #4-40 HOLES ON THE ATTACHMENT BRACKET. THE BUSHING WILL ONLY FIT ON THE BOLT PATTERN WITH THE SMALLER DIAMETER.

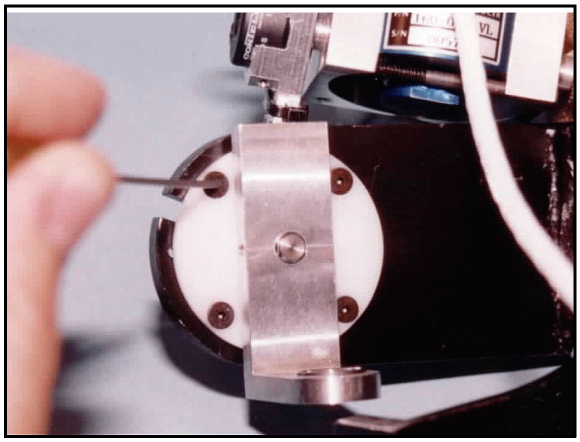

Figure 10.13- Attachment of rotary bushing to bracket

13. Place the Teflon washers onto the lower trunnions of the String Potentiometer Assembly (T1DPM300) and reinsert the trunnion into the bearings of the DGSP Yoke Left Arm. Replace the two #4-40 x 3/8" SHCS that hold the Right Yoke Arm (T1DPM213) to the Left Yoke Arm (T1DPM212) and Gimbal Assembly (T1DPM200) as shown in **Figure 10.14**.

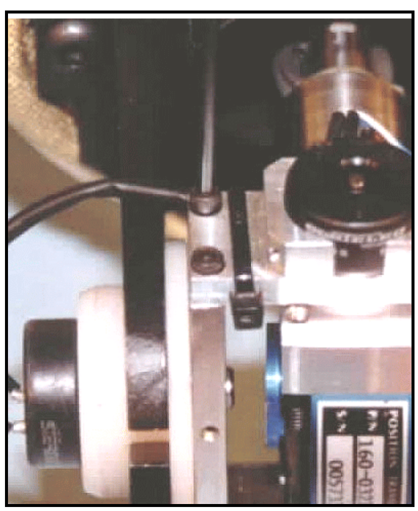

Figure 10.14- DGSP assembly

14. Place the Potentiometer Cover (T1LAM011) over the exposed terminals of the Yoke Axis rotary potentiometer, so that the small groove in the cover provides strain relief to the wire. Align the hole pattern of the cover with the pattern on the Side Support Bracket, and secure the covers to the brackets using three #4-40 X ½" SHCS {3/32}, as shown in **Figure 10.15**.

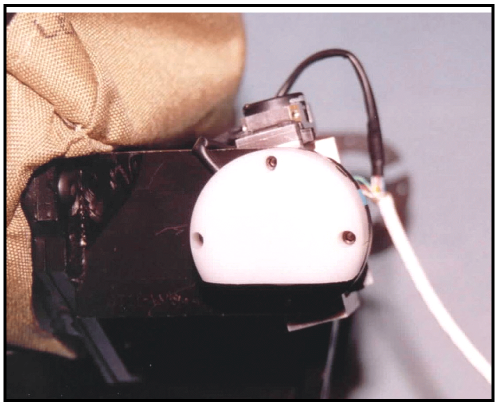

Figure 10.15- Potentiometer cover

15. Repeat the same steps for the Right hand DGSP unit.

16. At this time, make sure that the panel nut and stainless steel washer on the DGSP U-joints are removed. Attach the threaded end of a DGSP assembly cable to the tapped hole in the end of each DGSP unit.

17. Line up the four ½" diameter bores in the Rear Abdominal Foam Layer (T1LAM013) with the posts protruding from the inside face of the Internal Mounting Plate. Pass the DGSP assembly cables through the large bored holes in the rear foam layer. Press the rear layer of foam over the cones and against the Internal Mounting Plate, as shown in **Figure 10.16**. The foam should be on the inside of the abdominal bag.

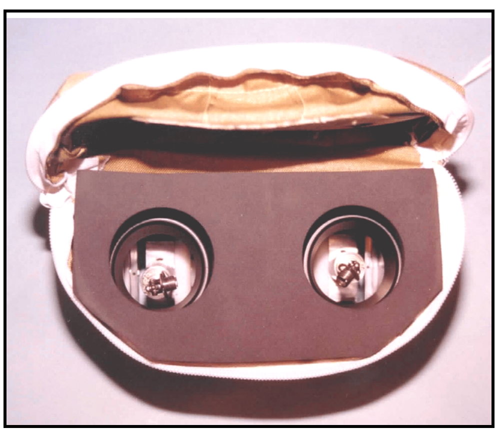

Figure 10.16- Rear foam layer inserted into bag

18. Examine the Front Abdominal Foam Layer (T1LAM012), position the flat face against the exposed surface of the rear foam layer, as shown in **Figure 10.17**. Again, pass the DGSP assembly cables through the large bored holes in the front foam layer.

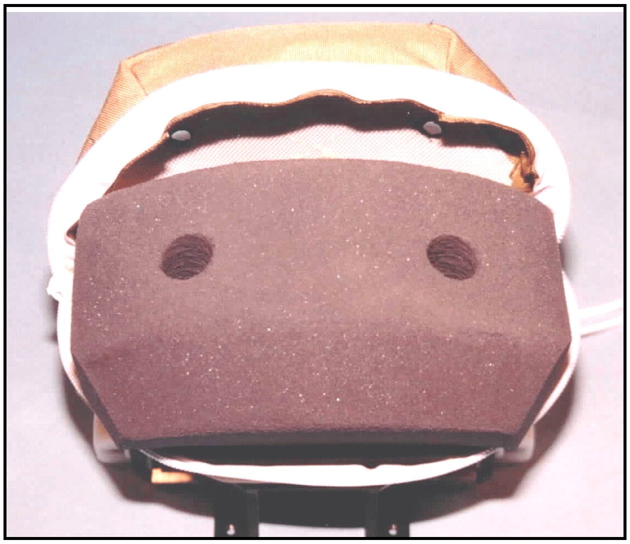

Figure 10.17- Internal front foam layer

19. Thread a Load Distribution Plate (T1LAM014) onto each DGSP assembly cable, as shown in **Figure 10.18.** The small counter bore in one side of the distribution plate must be oriented toward the DGSP assembly. These load distribution plates will rest inside the Lower Abdomen Bag and distribute the tension in the string potentiometer to a large area of the foam.

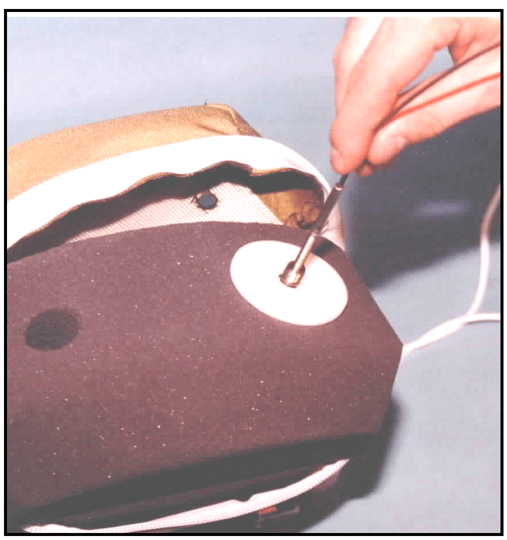

Figure 10.18- Load distribution plate over cable

20. Thread each DGSP assembly cable through their respective holes in the front of the abdominal bag.

NOTE: A GOOD TRICK IS TO USE A BINDER CLIP ON THE CABLES TO PREVENT THEM FROM PULLING BACK INTO THE LOWER ABDOMEN BAG accidentally.

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21. Close the Lower Abdominal Bag and adjust the foam within the bag geometry. Zipper the bag closed.

22. Thread a stainless steel washer and a panel nut onto each DGSP assembly cable.

23. Grasp the left hand DGSP Assembly Cable and pull the DGSP telescope into an extended position. Change the angle of pull as necessary to “steer” the DGSP U-Joint through the Load Distribution Washer and Lower Abdomen Bag. Continue holding tension on the cable.

24. Secure the DGSP unit to the front of the Lower Abdomen assembly using the washer and panel nut. Tighten the panel nut {½" crescent wrench} until it is flush with the threaded end of the U-Joint, as shown in **Figure 10.19**.

WARNING: DO NOT OVER TIGHTEN THE DGSP PANEL NUTS. THIS WOULD CAUSE THE U-JOINTS TO PROTRUDE FURTHER THAN NECESSARY FROM THE LOWER ABDOMEN ASSEMBLY.

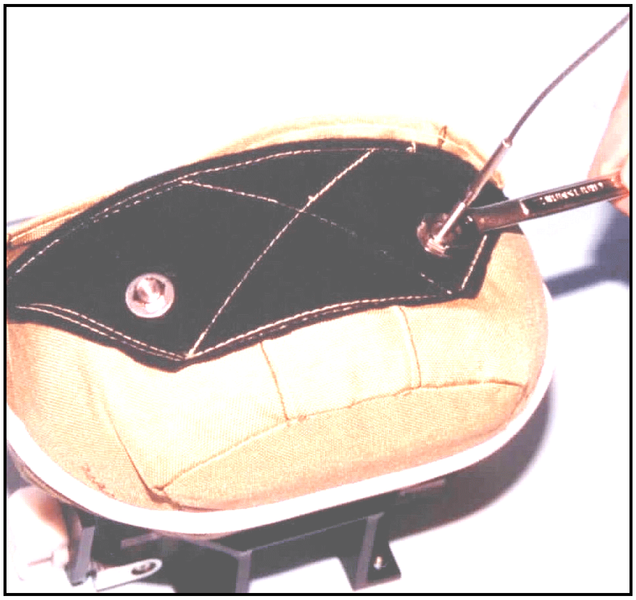

Figure 10.19- Securing of cable to outside of bag

25. Repeat steps #22 & 23 for the Right hand DGSP. The completed Lower Abdomen Assembly is shown in **Figure 10.20**.

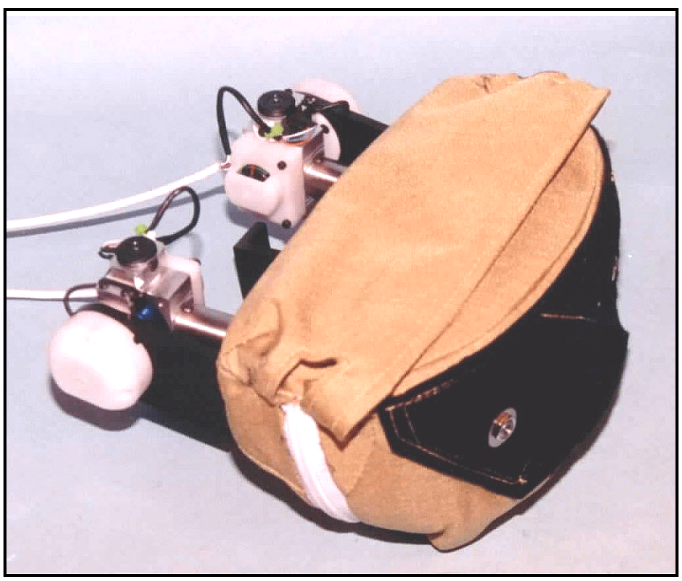

Figure 10.20- Completed Lower Abdomen assembly

10.2.3 Attaching the Lower Abdomen to THOR Dummy

The following procedure is a step-by-step description of the assembly procedure used to attach the lower abdomen to the THOR NT Dummy. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. The lower abdomen can be installed at any time after the spine is connected to the pelvis assembly.

1. Loosen the center bolt of the Lower Thoracic Spine Pitch Change Mechanism as described in Section 6.3.1, Adjustment procedure for Lower Thoracic Spine Pitch Change Mechanism. Rotate the upper thorax and spine rearwards to open the thoracic cavity and allow easy access.

2. Align the gap between the Left and Right Attachment Brackets (T1LAW040 & T1LAW060) with the Lumbar / Pelvis Mounting Block (T1SPM810).

NOTE: IF THE GAP BETWEEN THE ATTACHMENT BRACKETS IS TOO SMALL, SLIGHTLY LOOSEN THE LOWER 1/4-20 BHSCS {5/32} ON EACH BRACKET. THIS WILL PROVIDE A SMALL AMOUNT OF CLEARANCE THAT MAY BE NEEDED TO SLIP THE ABDOMEN INTO POSITION. REMEMBER TO TIGHTEN THE BOLTS AT THE END OF THE ASSEMBLY.

---

3. Tilt the top of the lower abdomen forward and insert the abdomen into the cavity of the dummy. Carefully guide the DGSP units and their wires around the proper sides of the spine. The insertion of the Lower Abdomen Assembly is shown in **Figure 10.21**.

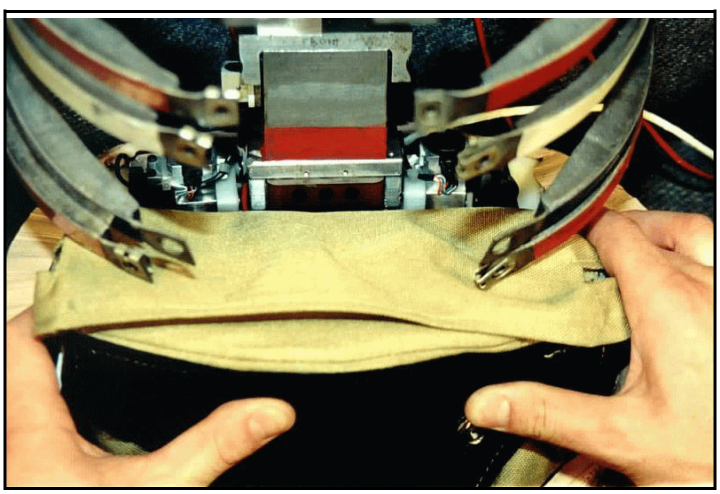

Figure 10.21- Insertion of Lower Abdomen into dummy

4. Attach the Rear Attachment Plate (T1LAM010) to the rear of the Pelvis / Lumbar Mounting Block using two 3/8-16 x 1" FHSCS {7/32}, as shown in **Figure 10.22**. The bottom surface of the plate should be flush with the bottom surface of the block.

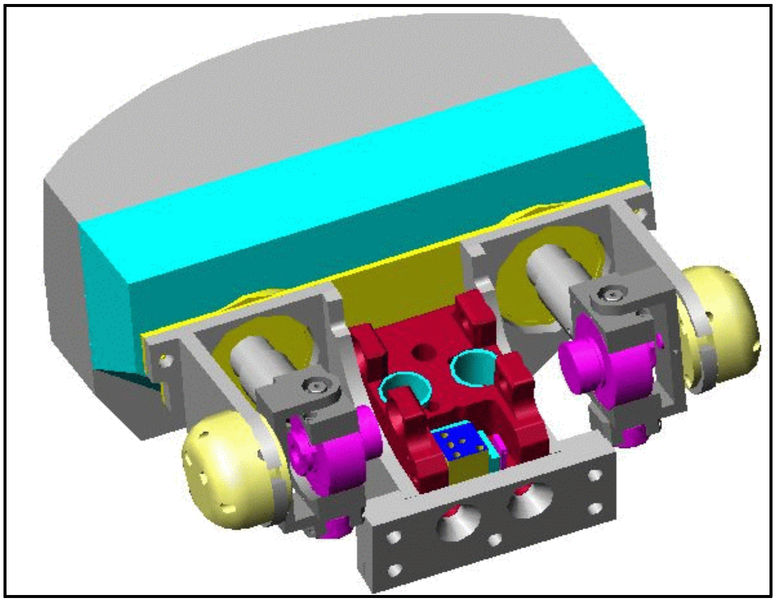

Figure 10.22- Rear attachment plate to spine

5. The Lumbar Spine Ground Strap (T1INM014) connects the Lower Abdomen at the Rear Attachment (T1LAM010) to the Spine at the Thoracic Spine Load Cell/ Flex Joint Adaptor Plate (T1SPM810). The Lumbar Spine Ground Strap is mounted to the Rear Attachment (T1LAM010) using a # 1/4-20 x 5/8" B.H.S.C.S-NP {5/64}as shown on **Figure 10.23.**

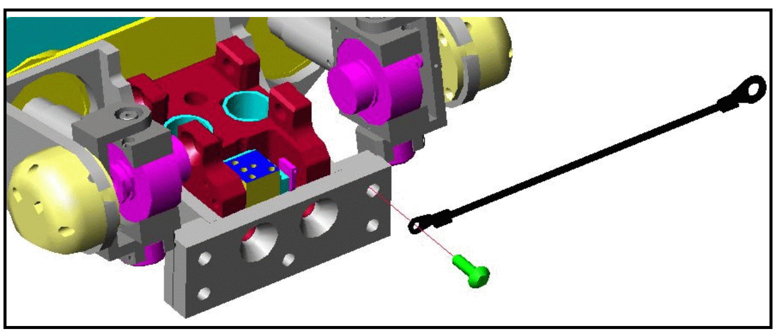

Figure 10.23- Lumbar Spine Ground attached to Lower Abdomen Rear Attachment

Attach the rear flange of the Lower Abdomen assembly to the Rear Support Plate using three 1/4-20 x 5/8" BHSCS-NP {5/32}, as shown in **Figure 10.24**.

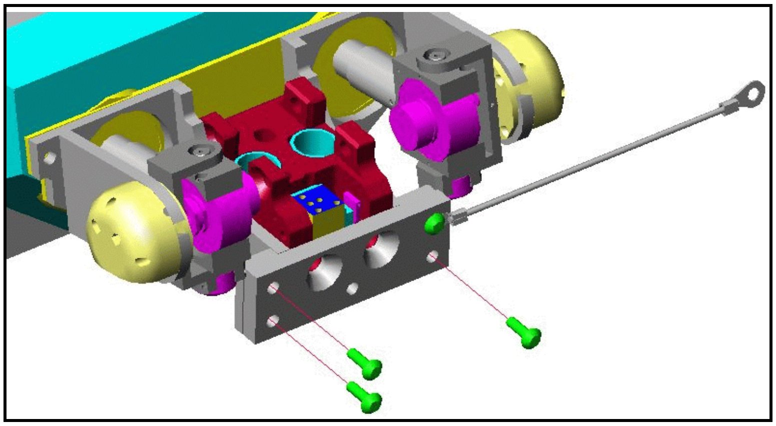

Figure 10.24- Lower Abdomen to Rear Attachment Plate

6. Readjust the Lower Thoracic Pitch Change Mechanism to the desired setting . Refer to Section 6.3.1 for detailed instructions on this procedure.

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 (T1LAF117), as shown in **Figure 10.25**.

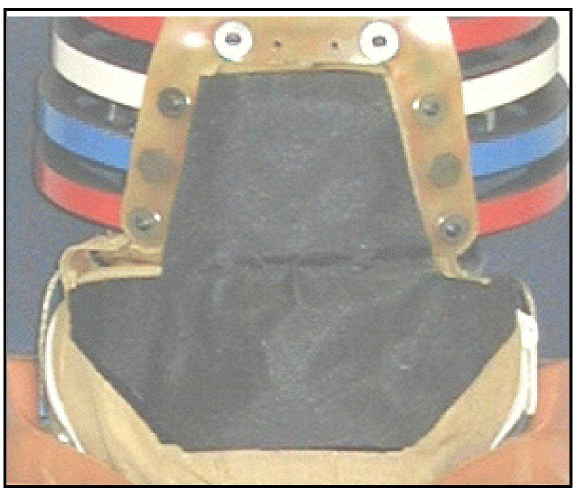

Figure 10.25- Upper and Lower abdomen cover

10.3 Adjustments for the Lower Abdomen Assembly

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

10.3.1 Storage and Handling:

The storage of the Lower Abdomen unit can greatly effect the longevity of the unit. Due to the nature of the string potentiometers in the DGSP units, the lower abdomen is subjected to a constant compressive loading. Over time, due to storage and shipment, this loading can cause permanent compression of the lower abdomen foam. This condition can be eliminated during storage and shipping conditions by using one of the following two techniques:

1. Release the DGSP units at the front of the lower abdomen bag assembly using the DGSP cables and allow the cable to retract slowly into the bag. This will remove the cable tension from the assembly, but requires reattachment of the cable prior to further testing.

WARNING: THE STRING POTENTIOMETER CABLE IN THE DGSP UNITS WILL SNAP IF THE CABLE IS ALLOWED TO RETRACT QUICKLY INTO THE HOUSING. THE CABLE MUST BE LOWERED UNDER TENSION VERY SLOWLY DURING THE DISASSEMBLY.

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2. Using the Abdomen Storage fixture will relieve the tension placed on the foam by the DGSP units. This optional fixture may be obtained from GESAC by ordering part number T1FDT210. The use of this fixture is described in Section 2.8-Abdomen Storage Fixture.

10.4 Electrical Connections and Requirements

The lower abdomen has two primary instruments: the left and right DGSP units.

Left DGSP Unit: This wire exits the string potentiometer at the rear of the DGSP unit and is routed on the left side of the spine to joint the bundle of wires running down the back of the spine.

Right DGSP Unit: This wire exits the string potentiometer at the rear of the DGSP unit and is routed on the right side of the spine to joint the bundle of wires running down the back of the spine.

10.5 Calibration of Lower Abdomen Assembly:

The lower abdomen assembly is calibrated at GESAC using a dynamic impact test. This test is conducted with a 1-inch diameter rigid rod with a total mass of 32.3 kg which is accelerated to 5.5 m/s. The results of the dynamic testing produce a graph of impact force versus internal deflection measured by the DGSP units. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication.

10.5.1 DGSP Calibration

The calibration of the DGSP sensors should be performed prior to the installation into the Lower Abdominal Assembly. The DGSP calibration sheets are included with the shipment of the instruments. In the event that the DGSP needs to be recalibrated, the procedure is described in detail in the DGSP Section 17.

10.6 Inspection and Repairs

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

10.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the lower abdomen instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

10.6.2 Mechanical Inspection

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

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

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

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

- Check the foam for tearing and rips.
- Check the foam for permanent compression caused by the tension of the cable in the string potentiometer. This permanent compression can be eliminated through careful storage and handling, as described in Section 10.3.1- Storage and handling

DGSP Unit Inspection: The procedure for inspecting the dummy's DGSP units for post-test damage is described in Section 17.6.2

Section 11. Pelvis Assembly

11.1 Description of Pelvis Assembly and Features

The pelvis assembly of the THOR NT dummy is a mechanical representation of the human pelvis. The assembly consists of a Cold Rolled Steel Base Module and two aluminum wing castings, designed to approximate the geometry of the human pelvic bone structure. The location of two important anthropomorphic landmarks have been carefully maintained; they are the D-points and the ASIS points. These landmarks provide locations that can be directly related to the human pelvis. The front of the casting has been machined to accept the Pelvic Box Assembly which holds the Acetabular Load Cells and Acetabular Cups. The top of the pelvis Base Module was machined to accept the lumbar/pelvis mounting block to allow attachment of the spine assembly. **Figure 11.1** shows a drawing of the completed pelvic assembly without the Pelvis Skin.

There are several different types of instrumentation that have been incorporated into the pelvic region. A tri-pack accelerometer mounting location is provided in the rear cavity of the pelvis to measure the accelerations of the approximate pelvic center of gravity in three axes. Two acetabular load cells (Denton: Model 3455) were designed to measure the loads that are transferred through the femurs to the pelvic structure. Finally, the Iliac Crest region of the pelvic casting was instrumented with a miniature compression load cell on both the left and right sides to indicate the presence of belt loading.

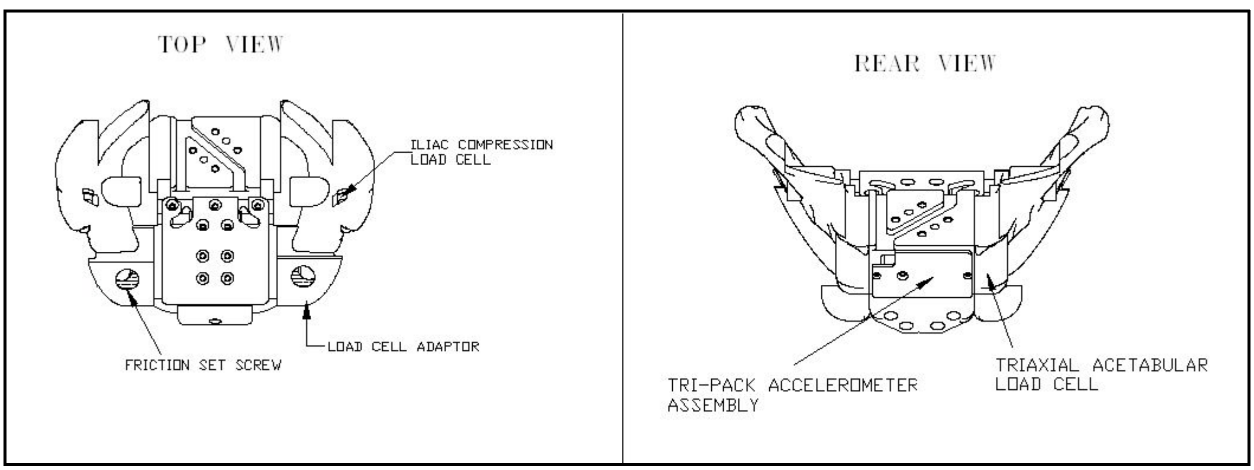

Figure 11.1- Pelvis assembly

11.2 Assembly of the Pelvis

11.2.1 Parts List

The part list for the pelvis assembly is listed in Appendix I - Bill of Materials under the Pelvis subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1PLM000 in the THOR NT drawing set for a detailed mechanical assembly drawing. **Figure 11.2** is a photograph of the exploded pelvis assembly and hardware.

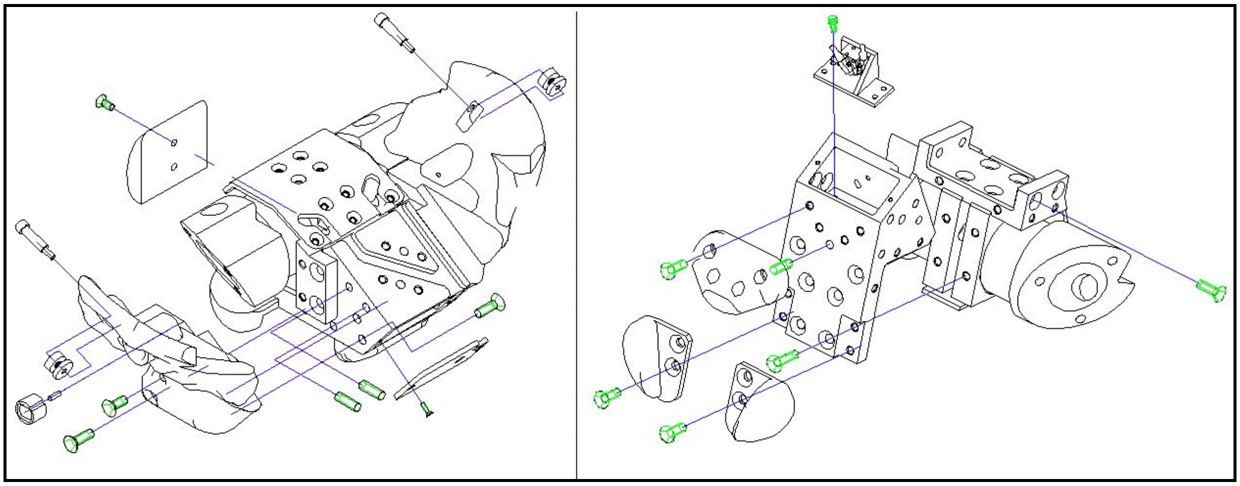

Figure 11.2- Pelvis exploded assembly

11.2.2 Assembly of Pelvis Components

The following procedure is a step-by-step description of the assembly procedure for the pelvis components. Completion and integration of several sub-assemblies is required to create the Pelvis assembly. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Attach the Left Load Cell Mounting Plate (T1PLM211) to the Left Acetabulum Load Cell (T1INM340) using four 1/4-20 x 7/8" FHSCS-NP {5/32}. Orient the load cell wiring to the mounting plate as shown in **Figure 11.3.**

NOTE: THE ORIENTATION OF THE ACETABULAR LOAD CELL AXES AND WIRING IS CRITICAL TO THE ASSEMBLY OF THE PELVIS. IMPROPER ORIENTATION WILL PREVENT THE LOAD CELL FROM FITTING WITHIN THE PELVIC CASTING.

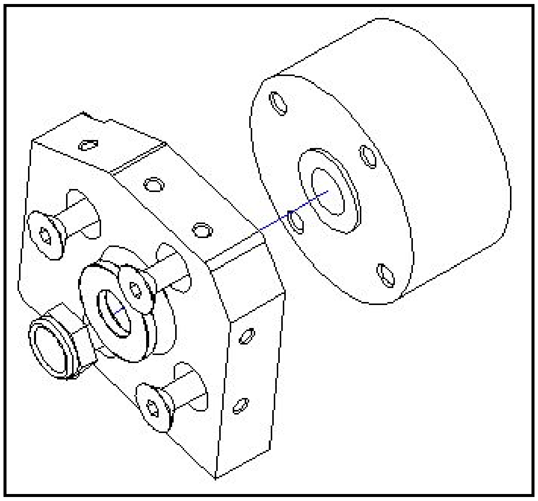

Figure 11.3- Orientation of Load Cell on plate

2. Insert the shaft of the Left Pelvic Socket Adaptor (T1PLM217) into the Left Acetabulum Load Cell. The orientation of the pelvic socket adaptor and the load cell is shown in **Figure 11.4**. Align the dowel pins holes of the Load Cell with the dowel pins in the Socket Adaptor. Insert the ½" ID flat washer onto the adaptor shaft. Use a ½" nylon lock hex jam nut to secure the Socket Adaptor to the Acetabulum Load Cell. Tighten securely to the torque range listed in section 2.1.3.

WARNING: THERE MUST BE FOUR 1/4" DOWELS BETWEEN THE PELVIC SOCKET ADAPTOR AND THE ACETABULUM LOAD CELLS TO PROVIDE CORRECT SHEAR AND ROTATIONAL LOAD TRANSFER.

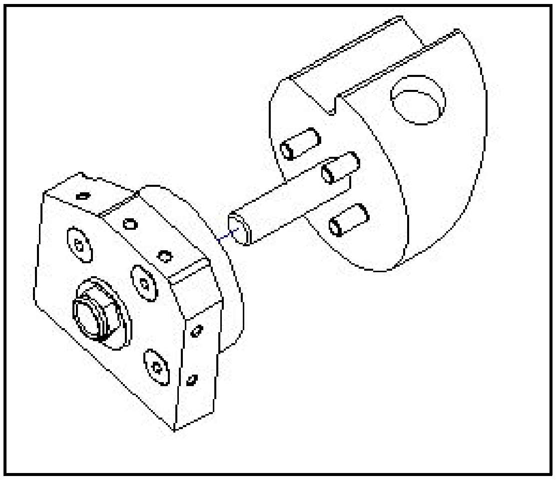

Figure 11.4- Orientation of socket adaptor to load cell

3. Attach the Right Load Cell Mounting Plate (T1PM212) to the Right Acetabulum Load Cell (T1INM341) using four 1/4"-20 x 7/8" FHSCS-NP {5/32}. Orient the load cell wiring to the mounting plate as shown in **Figure 11.5**.

NOTE: THE ORIENTATION OF THE ACETABULAR LOAD CELL AXES AND WIRING IS CRITICAL TO THE ASSEMBLY OF THE PELVIS. IMPROPER ORIENTATION WILL PREVENT THE LOAD CELL FROM FITTING WITHIN THE PELVIC CASTING.

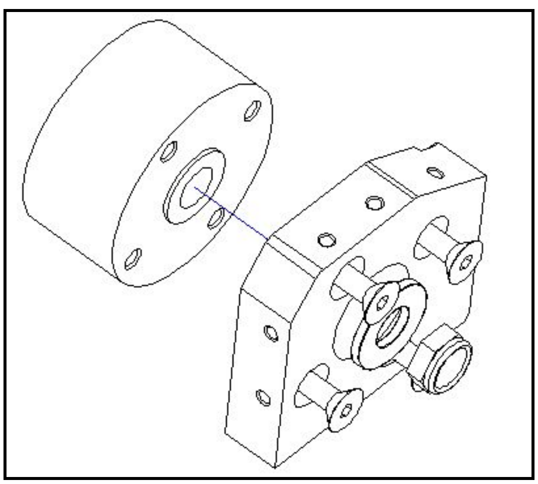

Figure 11.5- Orientation of Load Cell on plate

4. Insert the shaft of the Right Pelvic Socket Adaptor (T1PLM218) into the Right Acetabulum Load Cell. The orientation of the pelvic socket adaptor and the load cell is shown in **Figure 11.6**. Align the dowel pins holes of the Load Cell with the dowel pins in the Socket Adaptor. Place the ½" ID flat washer onto the adaptor shaft. Use ½" nylon lock hex jam nut to secure the Socket Adaptor to the Acetabulum Load Cell. Tighten securely to the torque range listed in section 2.1.3.

WARNING: THERE MUST BE FOUR 1/4" DOWELS BETWEEN THE PELVIC SOCKET ADAPTOR AND THE ACETABULUM LOAD CELLS TO PROVIDE CORRECT SHEAR AND ROTATIONAL LOAD TRANSFER.

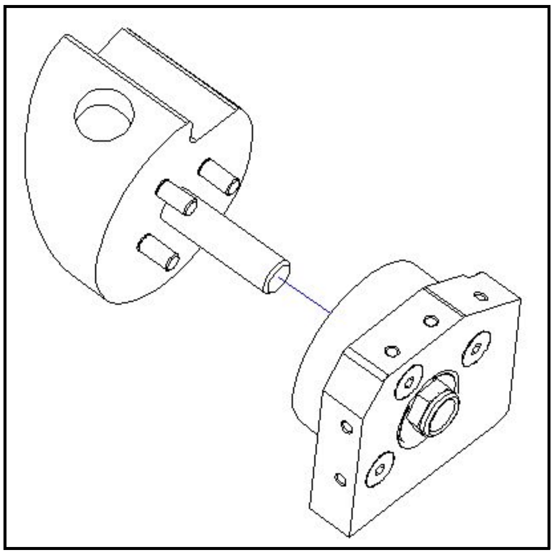

Figure 11.6- Orientation of socket adaptor to load cell

5. Bolt the Left and Right Socket / Load Cell Assemblies to the Rear Plate using two 1/4-20 x 3/4" FHSCS {5/32}, as shown in **Figure 11.7**.

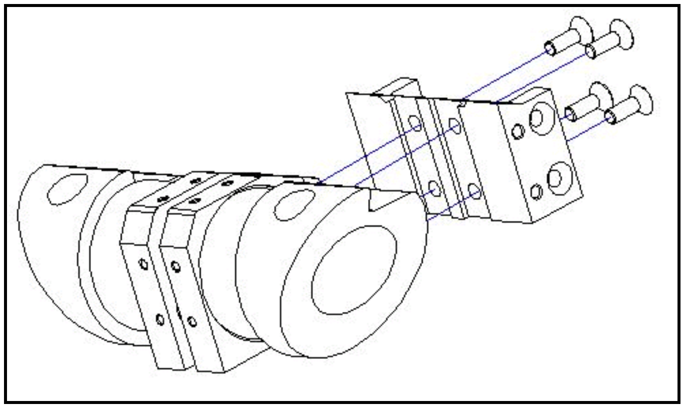

Figure 11.7- Left Socket assembly attached to Rear Plate

6. Mount a Friction Adjustment Set Screw Assembly (T1PLM300) on each top hole of the Left and Right Acetabular Assemblies, as shown in **Figure 11.8**.

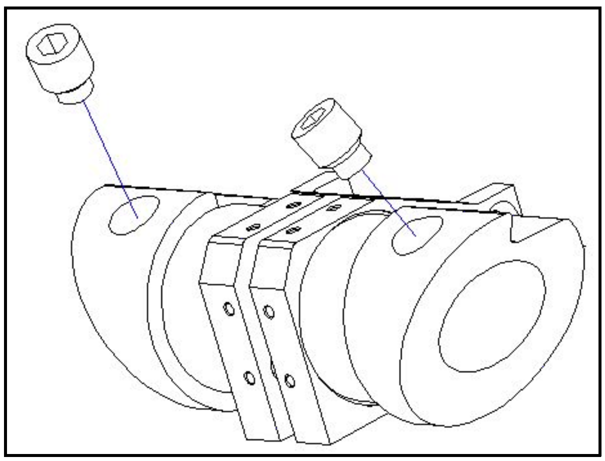

Figure 11.8- Friction Adjustment Set Screw

7. Bolt the Top Plate (T1PLM213) to the top of the Left and Right Load Cell Mounting Plates, using nine #10-24 x 3/8" FHSCS {1/8}, as shown in **Figure 11.9**. The Acetabular Load Cell wires must exit through the grooves at the rear of the top plate.

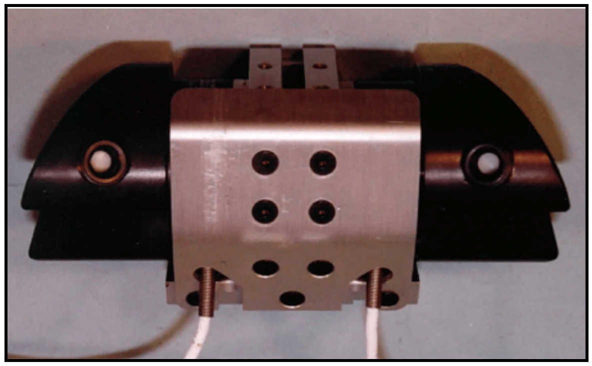

Figure 11.9- Top Plate assembled to Pelvic Box

8. Bolt the Front Plate (T1PLM215) on to the front of the Left and Right Load Cell Mounting Plates using four #10-24 x 3/8" FHSCS {1/8}, as shown in **Figure 11.10**.

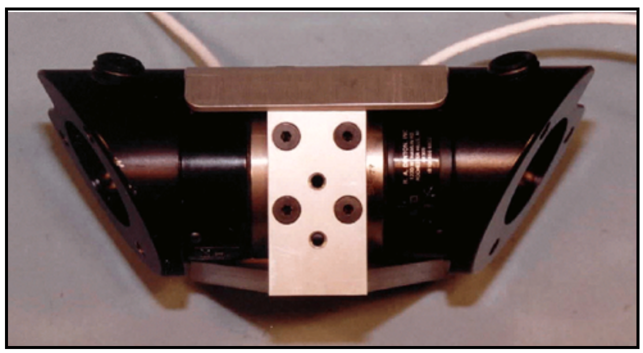

Figure 11.10- Front Plate attached to Pelvic Box

9. Attach the Front Pelvic Casting (T1PLM219) to the Front Plate using two 10-32 x 3/4" F.H.S.C.S{1/8}, as shown in **Figure 11.11**. At this stage, this assembly is referred to as the Pelvic Box Assembly.

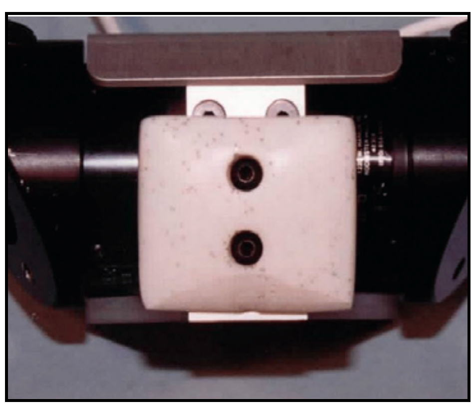

Figure 11.11- Front Casting assembly

10. Mount the Pelvis Base Module (T1PLM010) on the opposite side of the Top Plate (T1PLM213), and to the Rear Plate (T1PLM214), Left (T1PLM210) and Right (T1PLM211) Load Cell Mounting Plates, using six 1/4-20 x 1" F.H.S.C.S {5/32}and four 1/4-20 x 3/4" F.H.S.C.S respectively on the bottom and sides of the Pelvis Base Module. See **Figure 11.12**.

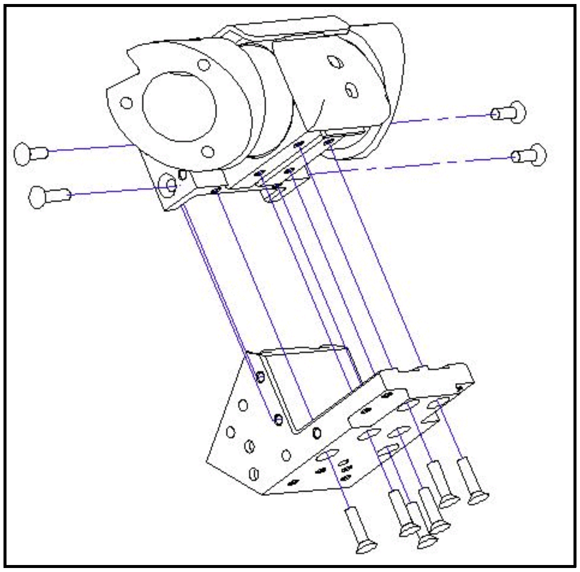

Figure 11.12- Pelvis Base Module/ Load Cell Mounting Plates assembly

11. Attach the Left (T1PLM014) and Right (T1PLM015) D-Points to the front corners of Pelvis Base Module, using four 1/4-20 x 3/4" F.H.S.C.S {5/32}. See **Figure 11.13.**

12. Align the holes of the Pelvis Coccyx (T1PLM013) with the holes on the rear of the Pelvis Base Module, and attach the former to the latter using four # 1/4-20 x ½" {5/32}and a 1/4 x 3/4" dowel pin, as shown in the **Figure 11.13.**

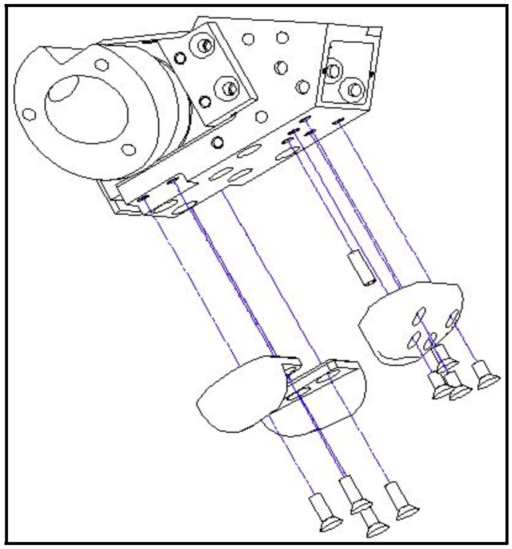

Figure 11.13- Pelvis Coccyx, D-Points/ Base Module exploded assembly

13. Attach the Left (T1PLM011) and Right (T1PLM012) Pelvis Wings to the left and right of the Pelvis Base Module using: one # 1/4- 20 x 1" F.H.S.C.S, two # 1/4-20 x 7/8" F.H.S.C.S,{5/32}, and three # 1/4 x 7/8" Dowel Pins on each side, as shown in **Figure 11.14**. Refer to the Pelvis Mechanical Assembly drawing (T1PLM000) in the THOR NT drawing package.

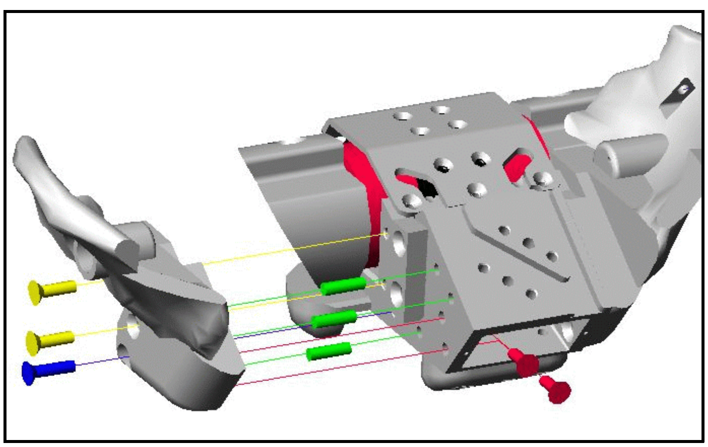

Figure 11.14- Pelvis Wing exploded assembly

14. Insert an H-P tool Bearing (T1PLM019) into each cavity located on the side of the Left and Right Wings and secure each one using a 1/8 x 3/8" Dowel Pin to hold it in place. See **Figure 11.15**.

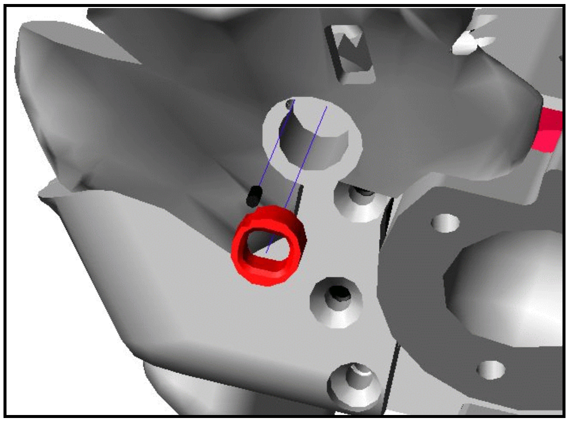

Figure 11.15- H-P Tool Bearing Location

15. Mount the Pelvic tri-pack Assembly (T1PLM101) at the Pelvis C.G. located in the cavity at the rear of the Pelvis Base Module, using two # 6-32 x 3/8 S.H.C.S {7/64}.The stamped markings on the unit are oriented in the following manner: +X forward, +Y is right, +Z down. This sign convention is in agreement with the SAE coordinate system, as shown in **Figure 11.16**.

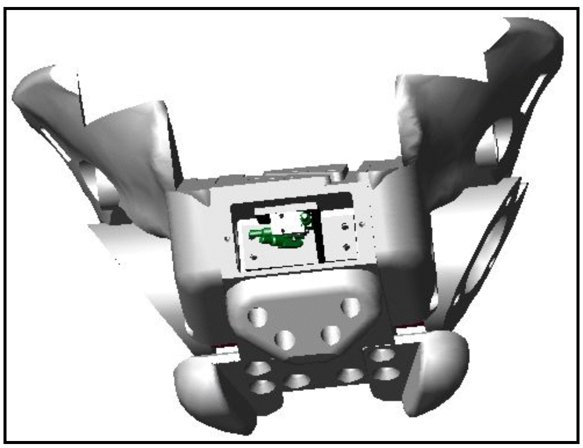

Figure 11.16- Pelvic tri-pack Assembly mounted in Pelvis

16. Secure the triaxial accelerometer wires to the inside of the Pelvis Triaxial Cover (T1PLM111) using a 1/8" Wire Clamp, a #6-32 x ½" FHSCS and a #6-32 Nylock nut, as shown in **Figure 11.17**. These wires are then joined to the bundle of wires at the base of the spine.

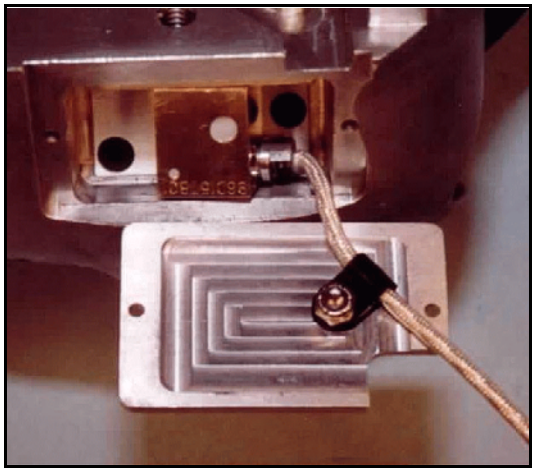

Figure 11.17- Pelvic tri-pack strain relief

17. Install the Pelvis Accelerometer Cover (T1PLM111) over the cavity in the pelvis casting using two #4-40 x 3/8" FHSCS {1/16}, as shown in **Figure 11.18**. The cover must be oriented with the wire exit hole at the top right corner as shown.

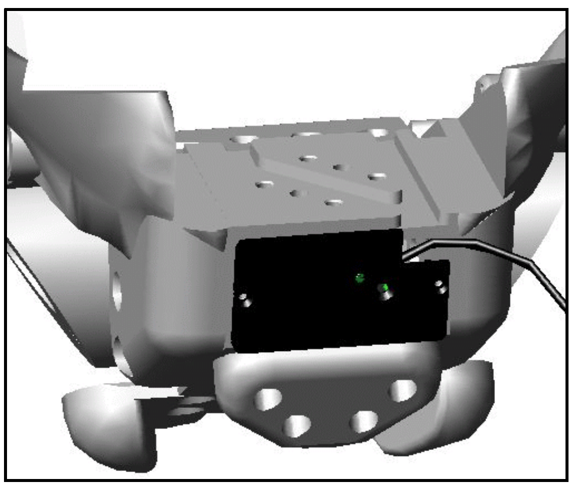

Figure 11.18- Pelvis Accelerometer cover

18. Position a Uniaxial Compression Load Cell (T1INM410) in the machined grove on the Left Iliac wing of the pelvis. Slide the Iliac Load Cell Washer (T1PLM017) behind the load cell and align the through holes in the washer and load cell. The placement of the washer and load cell is shown in **Figure 11.19**. The wires for the load cells are strain relieved with a 1/8" cable clamp and a #6-32 x ½ BHSCS {5/64} and joined to the bundle of wires running down the back of the spine.

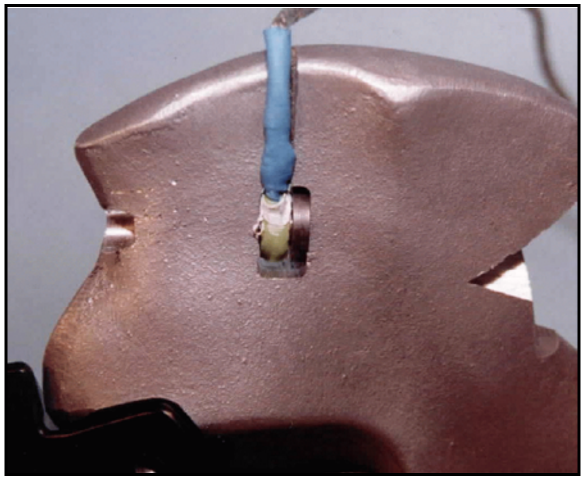

Figure 11.19- Iliac load cell and washer

19. Insert the Iliac Load Cell Plunger (T1PLM018) into the hole located at the Left Iliac Notch and push the plunger toward the rear to mate with the load cell and load washer, as shown in **Figure 11.20**.

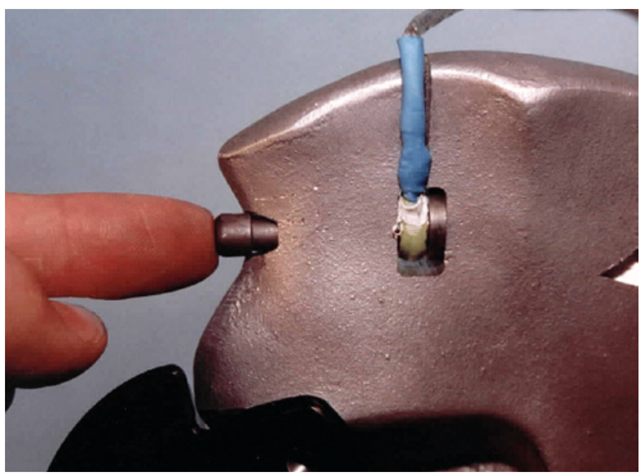

Figure 11.20- Iliac load cell plunger

20. Repeat steps 16 and 17 for the Right Iliac wing load cell.

21. At this point it is necessary to attach the Left Femur Ball Joint Assembly (T1FMM100) to the Left Pelvic Socket Adaptor (T1PLM217) using three 1/4"-28 x 5/8" SHCS {3/16} as shown in **Figure 11.21.**

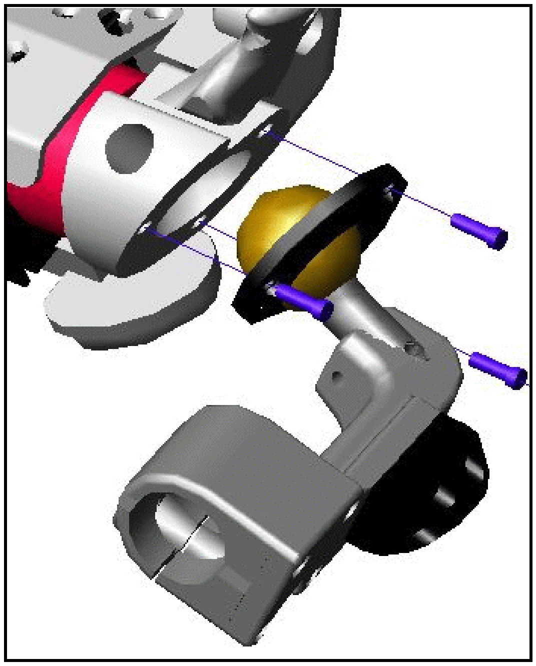

Figure 11.21- Pelvis Ball Joint/ Socket Adaptor exploded assembly

22. Repeat Step 19 for the Right Femur Ball Joint Assembly (T1FMM101).

23. Install the completed mechanical pelvis assembly into the Molded Pelvis Skin (T1PLS000), as shown in **Figure 11.22**.

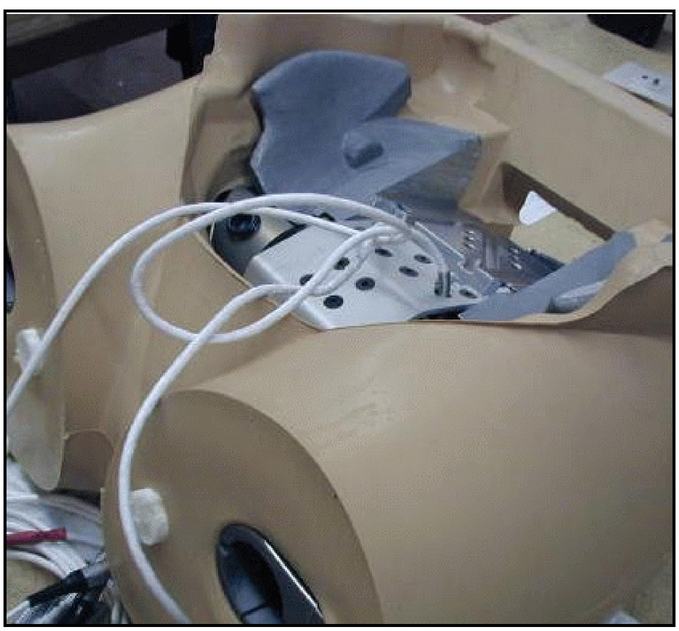

Figure 11.22- Pelvis installed in Pelvis skin

11.2.3 Assembly of the Pelvis to the Spine

The following procedure is a step-by-step description used to install the completed spine assembly (T1SPM000) to the completed pelvis assembly (T1PLM000). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. For additional details, refer to Section 6.2.2- Steps 1 through 3.

1. Remove the Pelvis / Lumbar Mounting Block Assembly (T1SPM810) from the Lumbar Flex joint Assembly (T1SPM710) by removing the four 5/16-18 x 3/4" FHSCS-NP {3/16}.

2. The Pelvis / Lumbar Spine Mounting Block is attached to the Pelvis Assembly (T1PLM000) using the four 1/4-20 x 1" SHCS {3/16}, as shown in **Figure 11.23**. The mounting block is positioned with the tilt sensor assembly toward the rear of the pelvis assembly. The wires from the Pelvic Acetabular Load Cells must be routed in the grooves provided in the pelvis assembly which lie under this mounting block's mounting surface. See **Figure 11.24.**

WARNING: CARE MUST BE EXERCISED TO AVOID PINCHING ANY OF THE WIRES FROM THE PELVIC INSTRUMENTATION DURING THIS STEP.

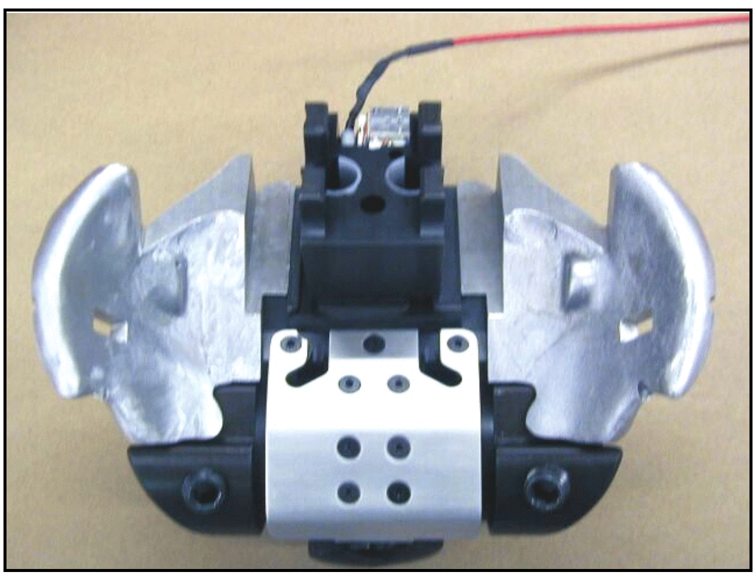

Figure 11.23- Lumbar / Spine Block attached to top of Pelvis

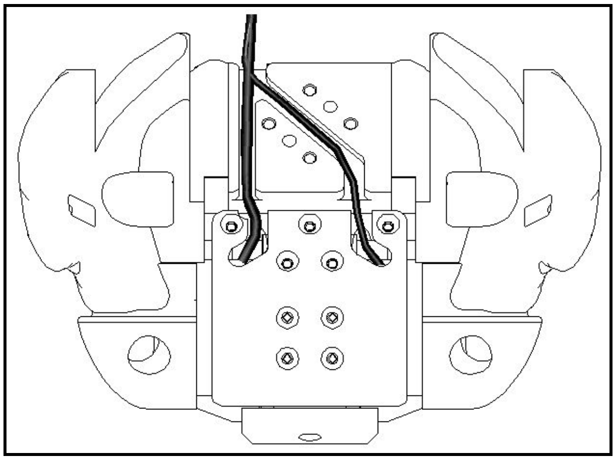

Figure 11.24- Acetabular Load Cells wires routing under Pelvis/Lumbar Spine Mounting Block

3. Reverse step 1 to reattach the Pelvis Lumbar Mounting Block Assembly (T1SPM810) to the Lumbar Flex joint Assembly (T1SPM710).

11.2.4 Assembly of the Pelvis to the Femur

The following procedure is a step-by-step description used to install the completed femur assembly (T1FMM000) to the completed pelvis assembly (T1PLM000). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. Refer to Section 12 for further details.

1. Loosen the Friction Adjustment Set Screw Assembly (T1PLM300) in the Pelvic Socket Adaptors (T1PLM217 & T1PLM218) so that they are not protruding into the ball socket.

2. Insert the ball end of the Left Femur Ball Joint Assembly (T1FMM100) into the socket of the Left Socket Adaptor (T1PLM217).

3. Bolt the Femur Retaining Ring (T1FMM130) to the Socket Adaptor using (3) 1/4"-28 x 5/8" SHCS.

4. Repeat step 1 through 3 for the Right Femur Ball Joint Assembly (T1FMM101).

5. Tighten the Friction Adjustment Set Screw Assembly (T1PLM300) in the Pelvic Socket Adaptors to provide a joint resistive torque of 1 g.

11.3 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 1 g joint friction torque.

- 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.

11.4 Wire Routing and Electrical Connections

The wire routing for the instrumentation in the pelvis assembly is fairly straightforward. Each instrument in this assembly will be covered individually.

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

Iliac Load Cells: The wires for the load cells are strain relieved with a 1/8" cable clamp and a #6-32 x ½ BHSCS {5/64} in the hole provided. These load cell wires are then routed around the external surface of the pelvic casting on the left and right sides. Finally, the wire is routed to join the bundle of wires at the base of the dummy's spine.

Pelvis CG tri-pack Accelerometer: The wire from the pelvis CG tri-pack cube exits the rear cover at the upper right corner. It is attached to the inside of the rear cover with a cable clamp to provide strain relief. The wire is routed to join the bundle of wires at the base of the spine.

11.5 Calibration of Pelvis Assembly

The pelvis assembly with skin is checked for the appropriate hip range of motion in flexion, extension, abduction, and adduction. The certification procedures for these tests are described in the THOR Certification Manual - available from GESAC as a separate publication.

11.6 Inspection and Repairs

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

11.6.1 Electrical Inspections (Instrumentation Check)

Begin with the visual and tactile inspection of all of the instrument wires. The wires should be checked for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. Instrument wires should be checked to ensure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation and Wiring.

11.6.2 Mechanical Inspection

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

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

- Check the wiring for proper routing.
- Check the position of the plunger to be sure that the tip is through both the load cell and the washer.

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

- Check the inside surface of the cup joint for wear and scuffing
- Check the fit and condition of the pelvis Friction Adjustment Set Screw (T1PLM300)

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

- Check the pelvic skin for cuts, nicks and tears

Section 12. Femur Assembly

12.1 Description of the Femur Assembly and Features

The femur assembly of the THOR NT dummy is a representation of the human femur, the largest bone in the human body. This assembly extends from the femur ball joint to the knee. At the upper end of the femur is a ball which mates with the socket in the pelvis assembly to form the hip joint. Since the ball joint is identical to the Hybrid III design, the THOR NT femur is interchangeable with the Hybrid III femur and can be used to retrofit to it. At the lower end of the femur is the standard femur load cell which will connect the femur assembly to the Hybrid III knee. **Figure 12.1** shows a drawing of the complete femur assembly without the Femur Ball Joint Assembly (T1FMM100/101) that connects the femur shaft hub to the pelvis.

The THOR NT femur has been designed with an axially compliant bushing which has been tuned to create a biofidelic response along the axis of the femur during an knee impact. The axial compression of the femur has been designed to simulate the compressive response of human cadaver femurs. The compliant section is constrained on a shaft that slides linearly within the bushing. Several perimeter bolts constrain the bushing to a purely linear motion within the bearing and resist torsion and rebound separation.

Each femur is instrumented with a six axis femur load cell (Denton: Model B-1953). This load cell is also used in the Hybrid III dummy. This sensor produces output for three degrees of applied forces and three moments around the orthogonal axes.

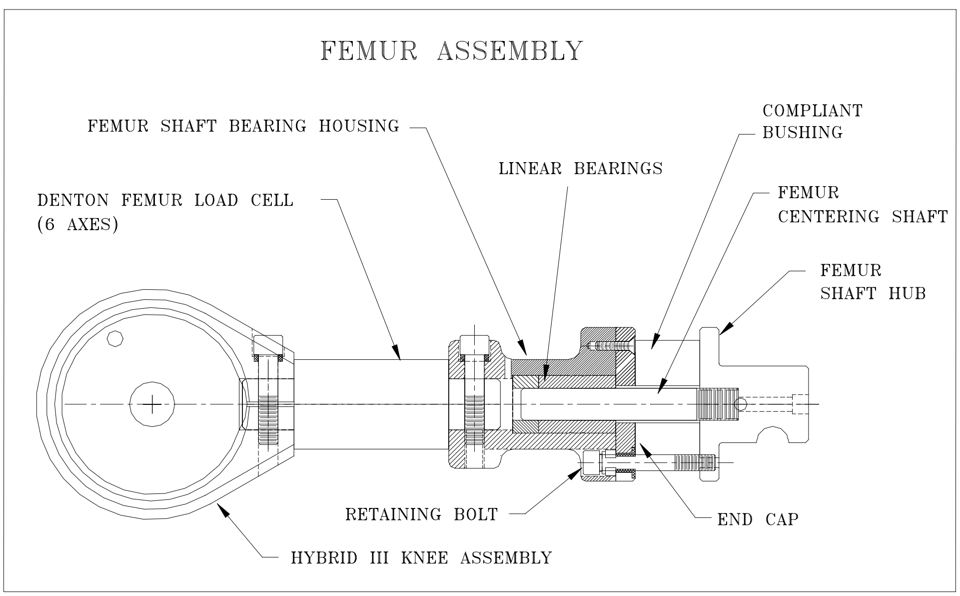

Figure 12.1- Femur assembly

12.2 Assembly of the Femur

12.2.1 Parts List

The part list and all quantities for the femur assembly is listed in Appendix I - Bill of Materials under the Femur subsection. Refer to drawing T1FMM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 12.2** shows an exploded femur assembly and hardware. For convenience, the Femur Skin is not shown on this Figure.

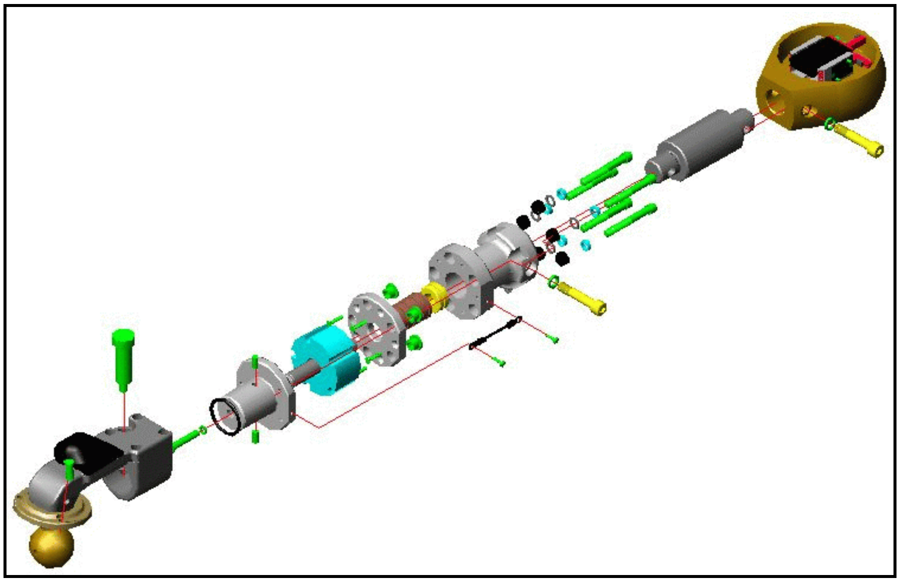

Figure 12.2- Femur exploded assembly

12.2.2 Assembly of Femur Components

The following procedure is a step-by-step description of the assembly procedure for the femur components. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3 -Bolt Torque Values. The order starts from the top to the bottom of the dummy.

1. Slide the Compliant Bushing (T1FMM014) over the Femur Shaft Assembly (T1FMM012 & T1FMM016) and seat it against the Femur Shaft Hub. Align the grooves in the Compliant Bushing with the corresponding holes in the Femur Hub. Secure the assembly using a # 1/4-28 x 1 ½" SHCS {3/16} and a # 1/4" Lockwasher, as shown in **Figure 12.3**.

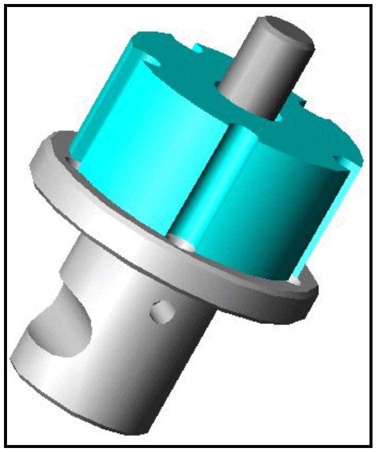

Figure 12.3- Femur bushing installed over Femur Shaft

2. On the Femur End Cap (T1FMM011), mount five linear bolt bushings (T1FMM018) into the counter bored holes and five #8-32 x 3/4" F.H.S.C.S {3/32} on the opposite side. Position the End Cap closest to the Femur shaft, and align the two flat edges. The 5/8" counter bored hole on the Femur Bearing Housing indicates the top of the assembly, as shown in **Figure 12.4**.

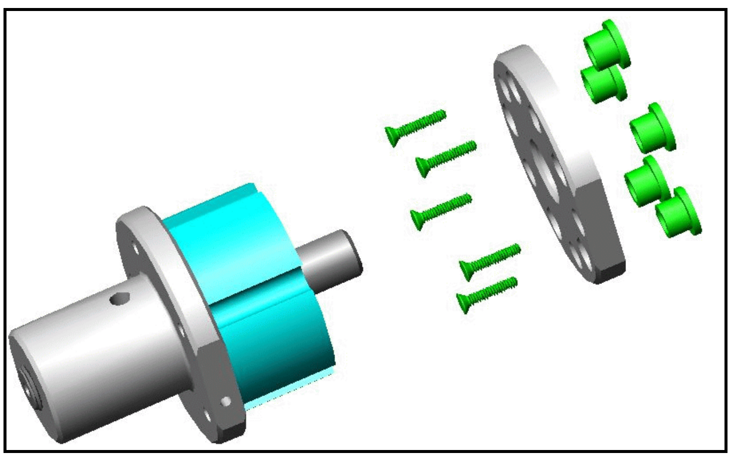

Figure 12.4- Femur End Cap exploded assembly

3. Insert a Linear Bearing and a Modified Linear Bearing (T1FMM015) into the Femur Shaft Bearing Housing (T1FMM010), as shown in **Figure 12.5**.

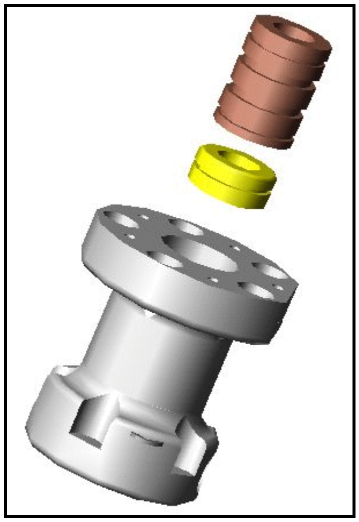

Figure 12.5- Femur Shaft Bearing Housing/Linear Bearings exploded assembly

4. Attach the Femur Shaft Bearing Housing (T1FMM010) to the End Cap using the # 8-32 x 3/4" F.H.S.C.S mounted previously. The end of the shaft bearing housing with the linear bearings should be positioned closest to the End Cap (T1FMM011). The orientation of the Femur Shaft Hub to the Shaft Bearing Housing is critical to proper assembly. The 5/8" counter bored hole on the femur bearing housing indicates the top of the assembly.

5. The Femur Ground Strap (T1INM015) connects the Femur Shaft Bearing House to the Femur Shaft hub. Attach each end of the Ground Strap to the respective parts using a # 6-32 x ½" B.H.S.CS {5/64}, as shown in **Figure 12.6.**

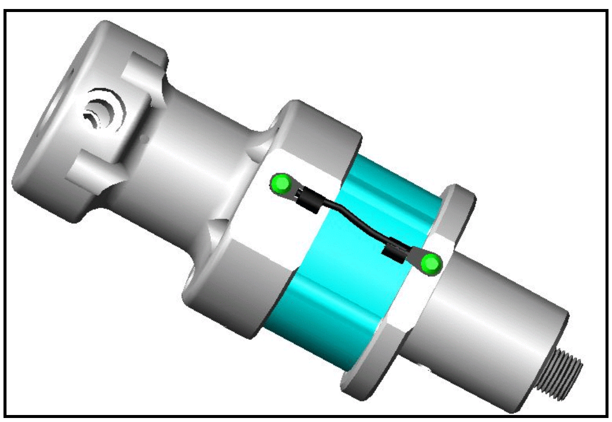

Figure 12.6- Femur Ground Strap attachment

6. Place the following hardware on each of five 5/16-24 x 2.25" SHCS in the order listed: a hard fiber washer (O.D. 7/16", I.D. 5/16") a steel flat washer (T1FMM021), and a Bolt

Bushing (T1FMM017). Insert each bolt through the counter bored holes of the Bearing Housing toward the Shaft Assembly. Tighten the five bolts {1/4} ½ a rotation past contact between the bolt head and the bore. This is shown in **Figure 12.7**.

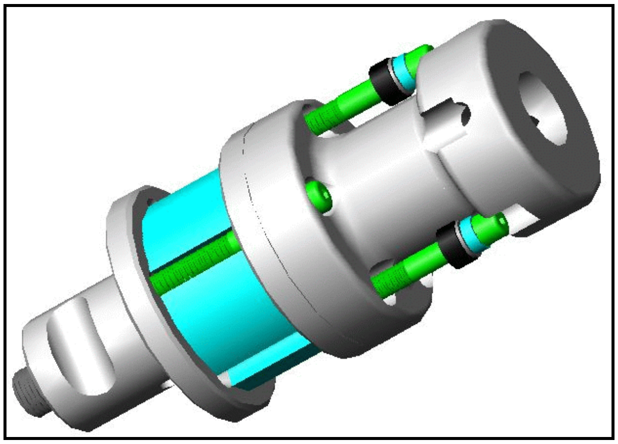

Figure 12.7- Bolt assembly and orientation

7. Insert one end of the 6 axis Femur Load Cell (T1INM350) into the Bearing Housing. Secure the Load Cell in the Bearing Housing using one Femur Load Cell Bolt (T1FMM019) {5/16} and a 3/8" Lockwasher, as shown in **Figure 12.8**.

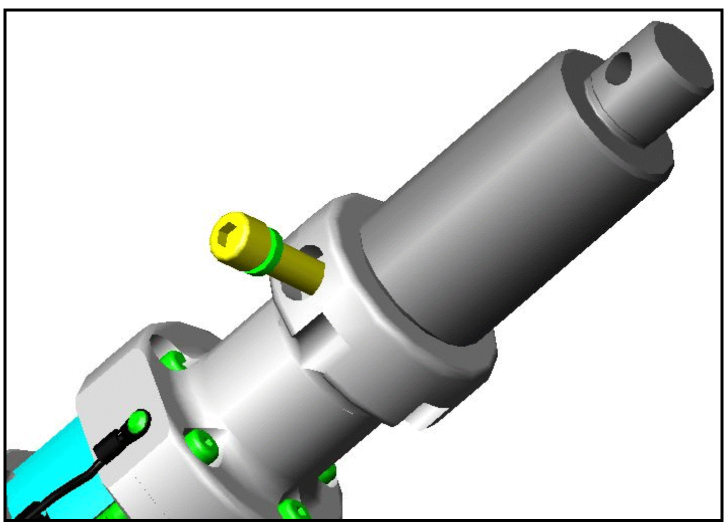

Figure 12.8- Femur Load cell attachment

8. Insert the Left Knee Assembly (EX 593-1) into the Left Knee Flesh (T1KNS010), and position the Knee Insert (78051-27) between the front of the knee hardware and the knee skin, as shown in **Figure 12.9**.

NOTE: THE LEFT AND THE RIGHT KNEE ASSEMBLY IS IDENTIFIED BY THE APPROPRIATE LETTER (L OR R)ENGRAVED ON THE TOP OF EACH KNEE ASSEMBLY.

Figure 12.9- Knee in Knee flesh

9. Repeat Step 6 for the Right Knee Assembly (EX 593-2) and the Right Knee Flesh (T1KNS011).

10. The other end of the Femur Load Cell is connected to the LX at the Knee using a Femur Load Cell Bolt (T1FMM019) {5/16} and a 5/16" Lockwasher, as shown in **Figure 12.10**.

Figure 12.10- Attachment of knee to load cell

11. Repeat the above procedure for the Right Femur, Right Knee Assembly, and Right Knee Flesh.

12. Insert the Left Femur/Knee assembly into the Left (T1FMS011) Leg Femur Skin, and rotate to align the holes and knobs at the knee skin interface. Secure the skin in place with the zipper facing the lateral side of the leg, as shown in **Figure 12.11**.

NOTE: THE END OF THE FEMUR SKIN WITH THE TWO KNOBS IS ORIENTED TOWARD THE KNEE FLESH. THE 1/4" WIRE GROOVE AT THE KNEE FLESH INTERFACE IS PROVIDED TO ROUTE THE FEMUR LOAD CELL WIRES DOWNWARD.

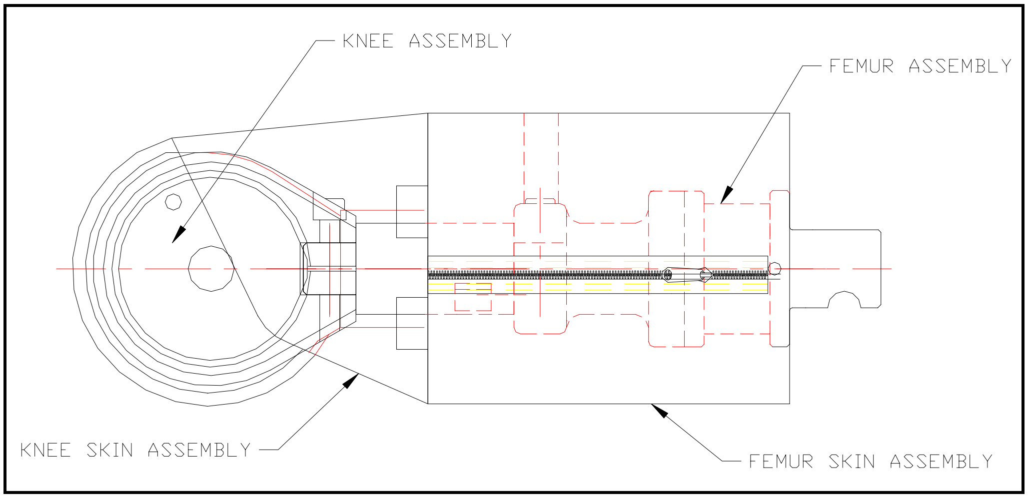

Figure 12.11- Femur/Knee and Skins Assemblies

NOTE: BE SURE TO ALIGN THE AIR VENT HOLE OF THE FEMUR ASSEMBLY WITH THE AIR VENT HOLE OF THE FEMUR SKIN.

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13. Assemble the left and right Femur Ball Joint Assembly (T1FMM100, T1FMM101) according to the corresponding assembly drawing in the THOR NT Drawing Package.

14. Insert a 1 ½ x 1 1/8" O-Ring into the Femur Shaft Hub and attach the left Femur/Knee assembly to the Left Femur Ball Joint Assembly (T1FMM100) in the Pelvis Skin (T1PLS010), using a Femur Ball Joint Bolt (T1FMM022) and two 1/4"D x ½" Dowel Pins, as shown in **Figure 12.12.** For clarity, the Pelvis Skin was omitted in the picture.

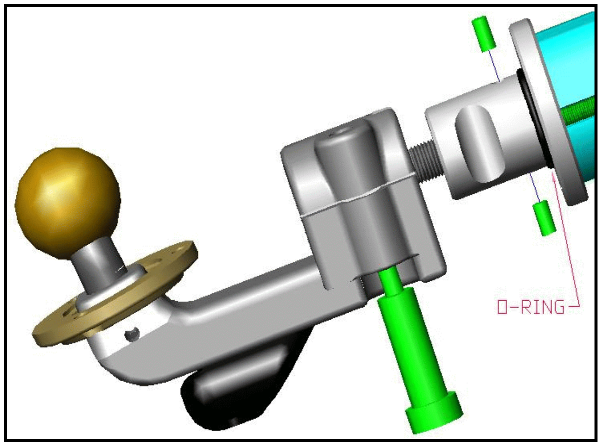

Figure 12.12- Femur Ball Joint Assembly

NOTE: THE O-RING IS NEEDED TO ELIMINATE NOISE CAUSED BY METAL TO METAL CONTACT DURING IMPACT AT THE FEMUR JOINT.

15. Repeat Steps 12 and 13 for the Right Leg Femur Skin (T1FMS010) and the Right Ball Joint Assembly (T1FMM101).

12.2.3 Assembly of the Femur to the Pelvis

This procedure is described in Section 11.2.2 Steps 21 and 22.

12.2.4 Assembly of the Lower Extremity to the Knee

The following procedure is a step-by-step description used to install the completed Lower Extremity Assembly (T1LXM000 or Hybrid III) to the completed Femur / Knee assembly (T1FMM000 & T1KNM000). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. Refer to Section 13.2.3 for further details.

1. Rotate the Rotary Knee Block located on the outer side of Left Knee Assembly so the hook mechanism touches the bottom of the shoulder bolt.

2. With the foot pointing away from the dummy, slide the Lower Extremity Knee Clevis over the rotary knee blocks.

3. Align the holes of the knee clevis (attached to the Lower Extremity) with the holes of the Rotary Knee Block and secure using eight 1/4" - 28 x 3/8" FHSCS {5/32}.

NOTE: WHEN THE FEMUR AND THE LOWER LEG IS ATTACHED TO THE KNEE, THE ENTIRE LEG SHOULD NOT EXCEED THE NORMAL RANGE OF MOTION OF A HUMAN KNEE. IF THIS OCCURS, DETACH THE LOWER LEG FROM THE KNEE ASSEMBLY AND ROTATE THE OUTER ROTARY KNEE BLOCK TO GIVE PROPER RANGE OF MOTION.

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

12.3 Adjustments for the Femur Assembly

The femur assembly does not require any adjustments.

12.4 Wire Routing and Electrical Connections:

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

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

12.5 Femur Calibration

The femur assembly is calibrated at GESAC using a dynamic impact test. The purpose of this test is to verify the performance of the Compliant Femur Bushing. The impact is targeted at the knee assembly of a fully assembled dummy. The direction of impact is in line with the femur assembly. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication.

12.6 Inspection and Repairs

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

12.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the neck instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

12.6.2 Mechanical Inspection

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

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

- Check for permanent compression, nicks or tears

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

- Check for alignment and correct motion in the femur bearing housing.
- Check the condition of the linear bearing lining on the ID.

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

- Check for holes, tears and cuts.

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

- Check for holes, tears and cuts.

.

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

- Check for holes, tears and cuts.

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Section 13. Lower Extremity Assembly

13.1 Description of the THOR-LX Lower Extremity Assembly and Features

The THOR dummy has been designed to accept either the standard Hybrid III 50% male lower extremities or the advanced lower extremity known as the THOR-LX. The mechanical design of the THOR-LX provides several advances over previous lower extremity designs. A compliant section, similar to the THOR compliant femur section, was designed in the tibia shaft which provides the correct force transmission from the heel to the knee complex. A spring damper Achilles tendon system was designed to aid in producing the desired ankle motion and torque characteristics. The new ankle design provides correct joint axes placement and biofidelic torque vs. angle response for the two primary axes (dorsi / plantar-flexion and inversion / eversion). The range of motion in all three principal directions of rotation was increased to the specifications provided by the NHTSA. Soft stop elements were used to provide human-like stiffness at the extremes of motion. **Figure 13.1** shows a drawing of the completed THOR-LX assembly.

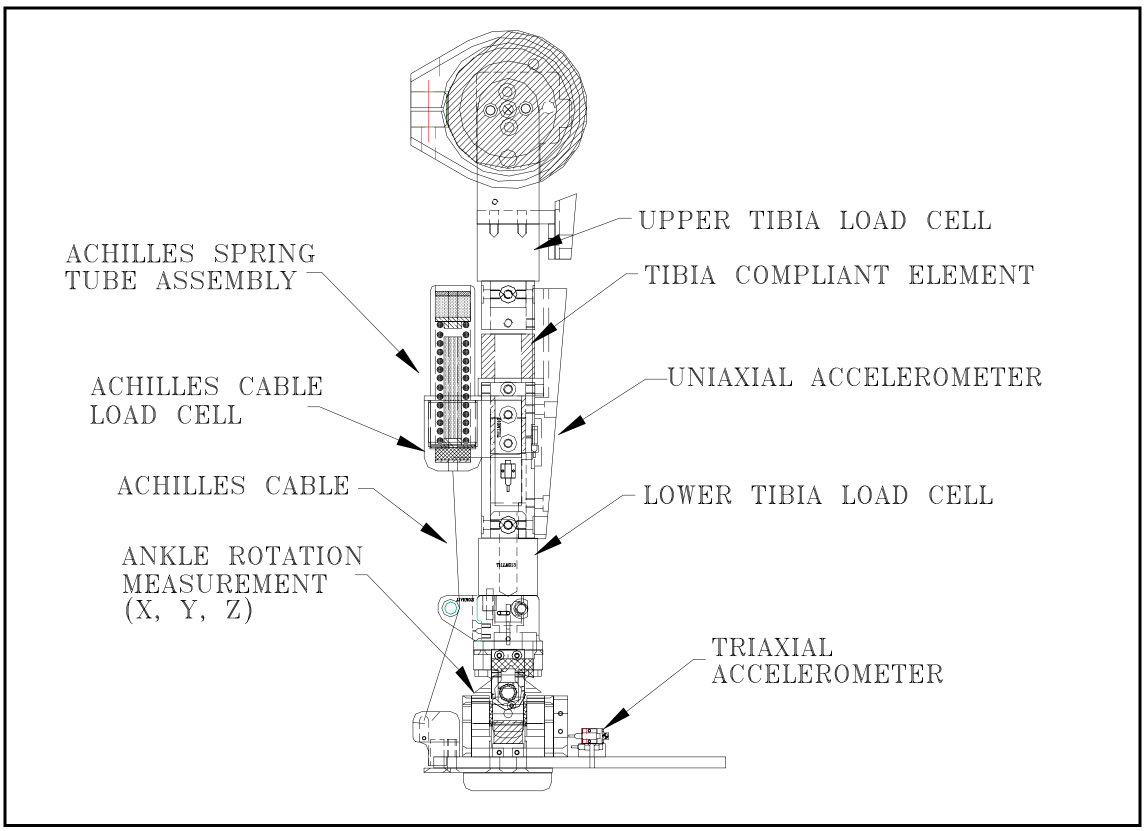

Figure 13.1- Lower Extremity Assembly

The THOR-LX was also updated with many new sensors to increase the ability of the dummy to measure injury and trauma. Four axes upper and lower tibia load cells (Denton: Model B-4929J & 4353J) are incorporated into the design. These load cells provide the force and moment data for the tibia shaft. A uniaxial compression load cell was implemented into the Achilles tendon housing which provides a direct measurement of the contribution of the Achilles to the overall ankle joint torque. Three rotary potentiometers were used to measure the rotation of the individual ankle joints, thereby providing complete kinematic data. Finally, two uniaxial accelerometers on the tibia and a tri-pack accelerometer assembly on the foot plate were included to allow the transformation of the measured tibia moment to the calculated ankle moment.

13.2 Assembly of the Lower Extremity

13.2.1 Parts List

The part list for the THOR-LX assembly is listed in Appendix I - Bill of Materials under the THOR-LX subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1LXM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 13.2** shows an exploded view of the LX assembly and hardware. The LX Skin was omitted for clarity.

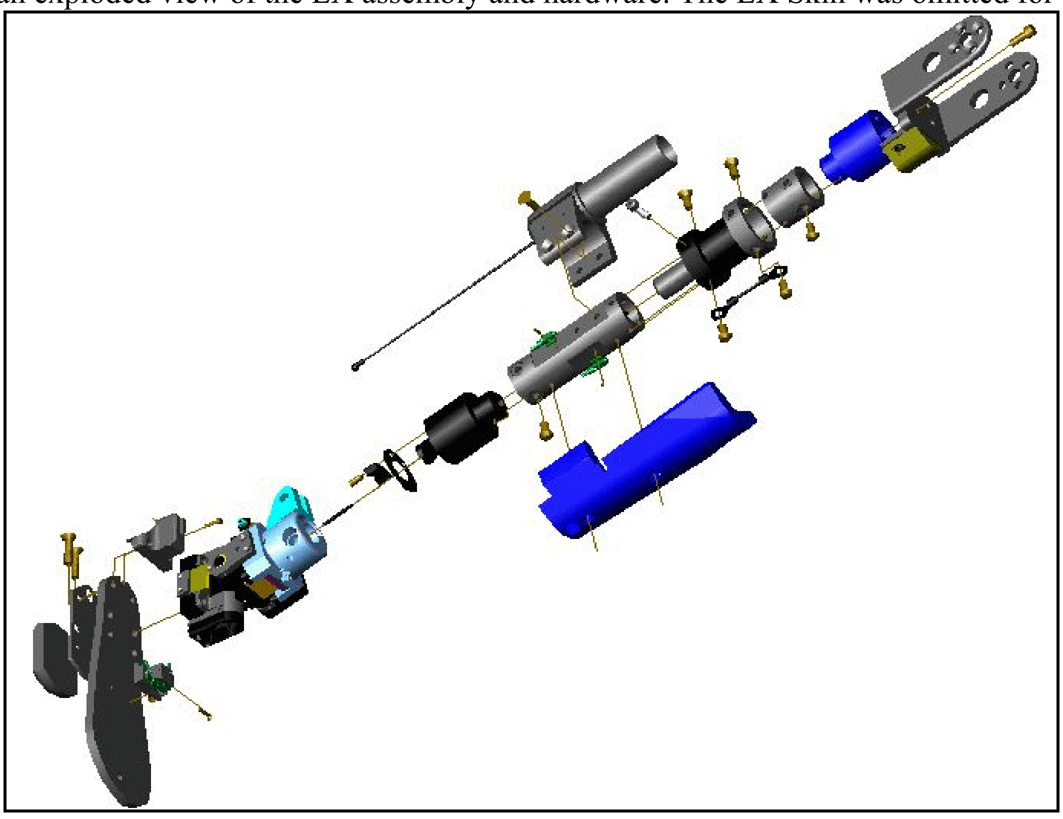

Figure 13.2- Lower Extremity exploded assembly

13.2.2 Assembly of THOR-LX Components

The following procedure is a step-by-step description of the assembly procedure for the THOR-LX components. The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. The Upper Tibia Load Cell (Denton: Model 4353) is connected to the Upper Tibia Tube (T1LLM011) using four 1/4-28 x ½" BHSCS {5/32}, as shown in **Figure 13.3**.

NOTE: THE UPPER LOAD CELL X-AXIS MUST BE ORIENTED TOWARD THE FRONT OF THE LOWER EXTREMITY ASSEMBLY AS IT IS PUT TOGETHER.

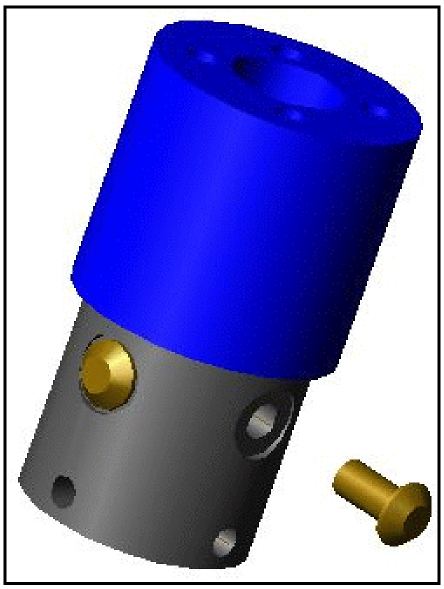

Figure 13.3- Upper Tibia Load cell attached to Upper Tibia Tube

2. The Upper Tibia Tube is connected to the Upper Flange of the Tibia Compliant Bushing Assembly (T1LLM400) using a # 1/4-28 x ½" F.H.S.C.S in the countersunk hole which is oriented to the rear of the Leg Assembly (-X axis). Mount three 1/4-28 x ½" B.H.S.C.S {5/32}on the remaining holes, using the B.H.S.C.S on the opposite side of the F.H.S.C.S to attach one end of the Tibia Ground Strap (T1INM018) to the assembly. See **Figure 13.4**, below.

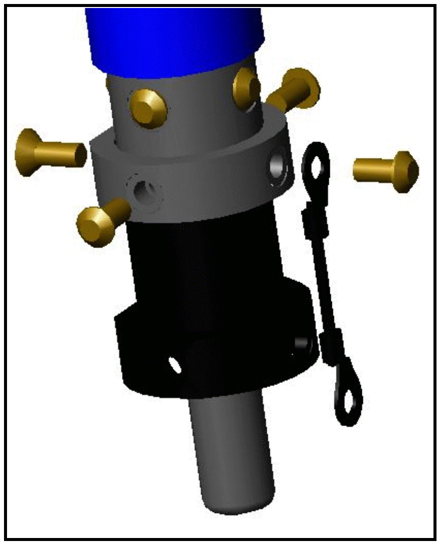

Figure 13.4- Upper Tibia Tube attached to Compliant Bushing

3. Insert the Compliant Bushing Plunger into the linear bearings within the Lower Tibia Tube Assembly (T1LLM002). Ensure that the Lower Tibia Tube Pin is present in the Lower Tibia Tube Assembly (See Drawing T1LLM002 in the THOR NT Drawing Package for details). Rotate the Lower Tibia Tube Assembly so that the Pin is aligned with the hole in the Compliant bushing Assembly, and there is a mounting surface on the left, right, and front sides, as shown in **Figure 13.5**.

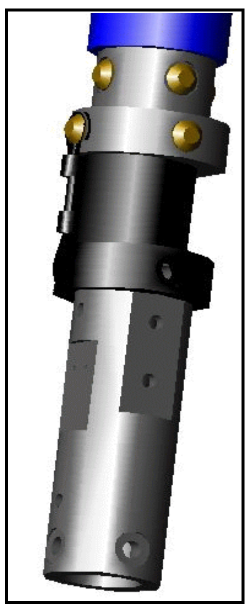

Figure 13.5- Proper orientation of Lower Tibia Tube

4. Secure the Compliant Bushing Assembly to the Lower Tibia Tube Assembly using two Plunger Retaining Bolts (T1LLM413) on the Left and Right Sides, one 1/4-28 x ½" FHSCS {5/32} in the rear. Mount the other end of the Tibia Ground Strap to the front using a #1/4-28 x ½" B.H.S.C.S. This assembly is shown in two views in **Figure 13.6** and **Figure 13.7**.

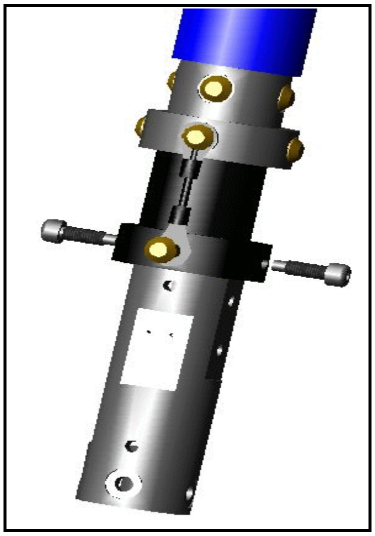

Figure 13.6- Securing the Compliant Bushing (Front)

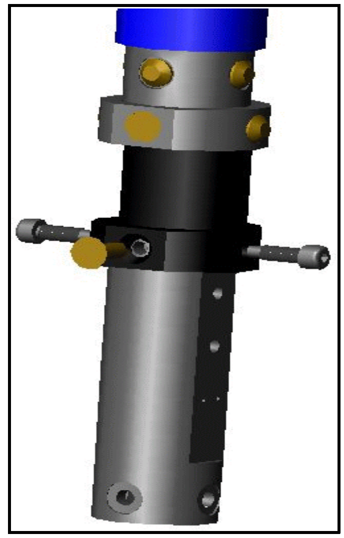

Figure 13.7- Securing the Compliant Bushing (Rear)

5. The Lower Tibia Load Cell (Denton: Model 4929J) is connected to the bottom of the Lower Tibia Tube using four 1/4-28 x ½" BHSCS {5/32}, as shown in **Figure 13.7**.

NOTE: THE LOWER TIBIA LOAD CELL X-AXIS MUST BE ORIENTED TOWARD THE FRONT OF THE LOWER EXTREMITY ASSEMBLY AS IT IS PUT TOGETHER. THE 3/8" RADIUS NOTCH IN THE LOWER FLANGE OF THE LOAD CELL INDICATES THE POSITIVE X AXIS AND IS ORIENTED TOWARD THE FRONT OF THE ASSEMBLY.

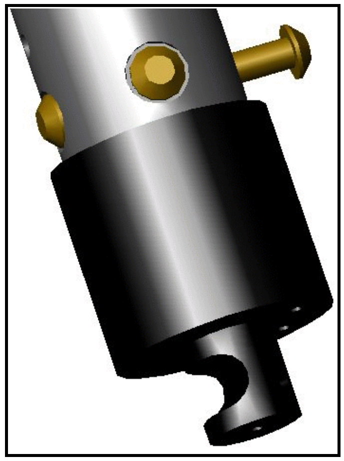

Figure 13.7- Lower Tibia
Load Cell attached to
Lower Tibia Tube

6. Mount two Uniaxial Accelerometers (T1INM110) on the front and right sides of the Lower Tibia Tube Assembly (T1LLM002), using four # 0-80 x 1/4" S.H.C.S {.050} and #0 washers, as shown on the **Figure 13.8**.

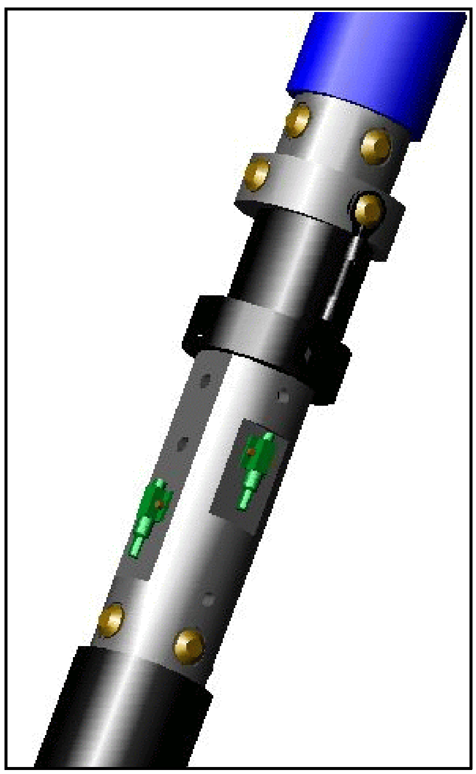

Figure 13.8- Uniaxial
Accelerometers Location

7. The Lower Extremity Tibia Guard (T1LLM014) is mounted to the front of the Lower Leg assembly using a 1/4-28 x 7/8" BHSCS {5/32} in the top mounting hole and a 1/4-28 x 5/8" BHSCS {5/32} in the lower mounting hole, as shown in **Figure 13.9**. The triaxial accelerometer wire is routed out the hole in the tibia guard on the right side.

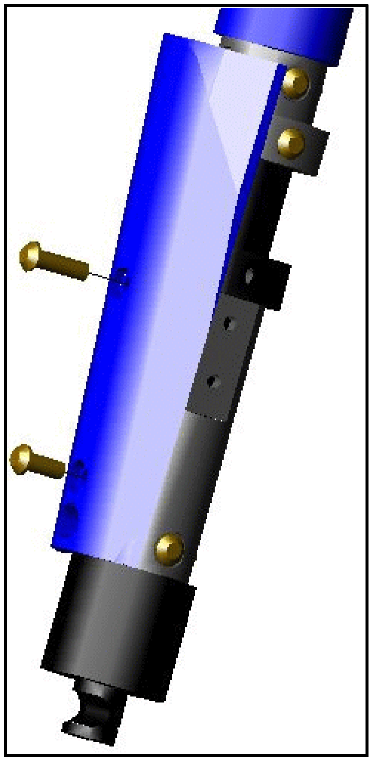

Figure 13.9- Tibia Guard assembly

8. An exploded view of the Achilles Spring Tube assembly is shown in **Figure 13.10**. Refer to drawing T1LLM300 for further details .

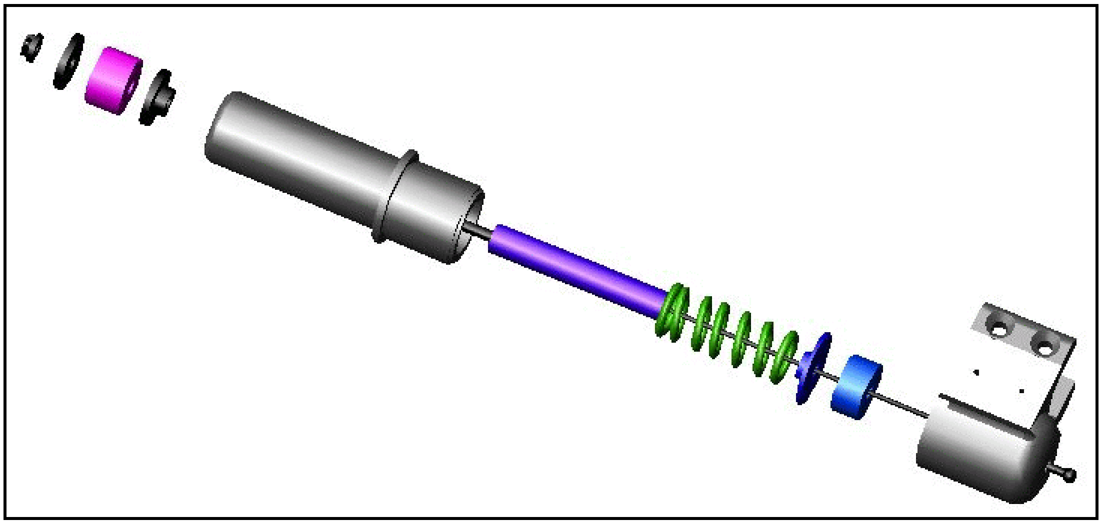

Figure 13.10- Achilles Spring Tube exploded assembly

9. Place the Denton Achilles Load Cell 1000 LBF (Model 5145) into the counterbore at the bottom of the Spring Tube Base (T1LLM310), as shown in **Figure 13.11**. Use the Groove on the side of the Spring Tube Base for wire routing.

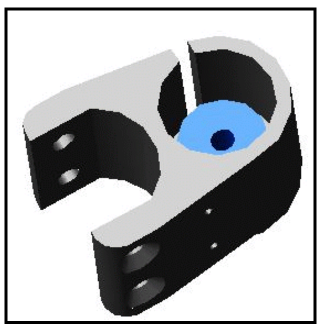

Figure 13.11- Insert
Load Cell Base Washer

10. Place the Achilles Spring Base Cap (T1LLM314) onto of the Load Cell with the raised button facing away from the load cell, as shown in **Figure 13.12**.

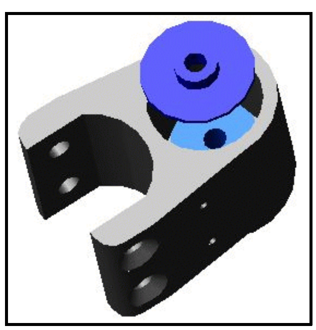

Figure 13.12- Insert
the Spring Base Cap

11. Screw the Achilles Spring Tube (T1LLM311) into the top of the Spring Tube Base and tighten securely as shown in **Figure 13.13**.

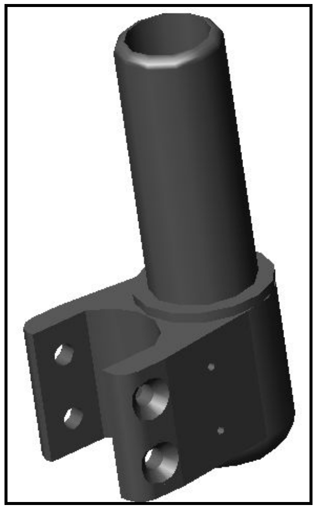

Figure 13.13- Thread Spring Tube into Base

12. Slide the 3.5" Compression Spring assembly (137 lb/in) and the Elastomeric Spring Element (T1LLM316) into the Spring Tube, and place the Achilles Spring Cap (T1LLM313) toward the open end, as shown in **Figure 13.14**.

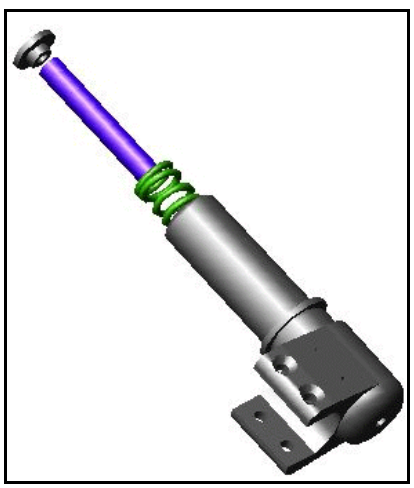

Figure 13.14- Slide compression spring into the Spring Tube

13. Position a Soft Foam Compression Element (T1LLM317) above the Spring Cap and a Primary Load Washer (T1LLM312) on top of the Soft Foam Compression Element, as

shown in **Figure 13.15**.

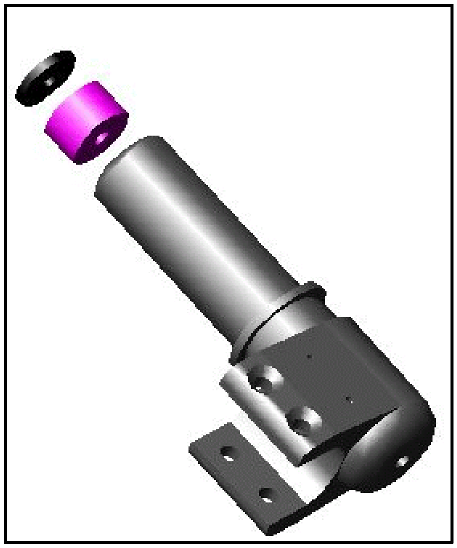

Figure 13.15- Insert the Primary Load Washer

14. Pass the threaded end of the Achilles Cable (T1LLM319) up through the Spring Tube Assembly from the bottom side, as shown in **Figure 13.16**.

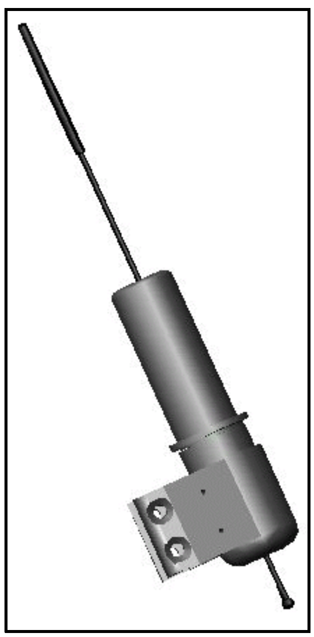

Figure 13.16- Pass Achilles cable through Spring Tube

15. Secure the cable with the Achilles Retaining Nut (T1LLM318) and tighten the #4-40 x 1/8" SSS in the retaining nut to secure the position of the nut on the cable, as shown in **Figure 13.17**. The adjustment of the Achilles cable will be discussed in Section 13.3.

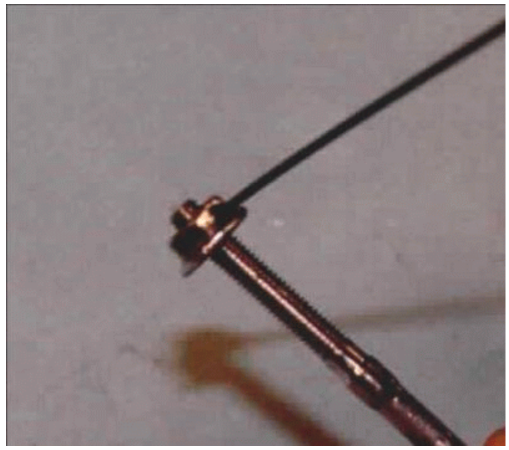

Figure 13.17- Tighten retaining nut

16. Attach the Achilles Spring Tube assembly to the rear of the Lower Tibia Tube using four 1/4-28 x ½" FHSCS {5/32}, as shown in **Figure 13.18**.

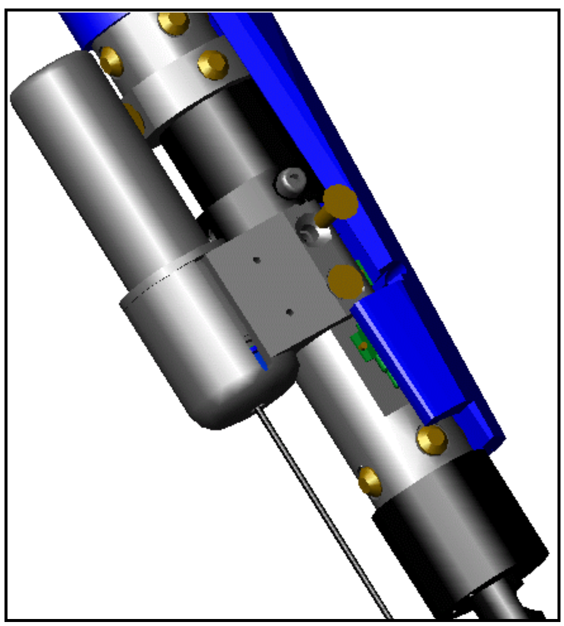

Figure 13.18- Attach the Spring Tube to the Lower Tibia Tube

17. Slide the mounting post of the lower tibia load cell into the counter bored hole in the Top Torque Base (T1AKM011) of the Mechanical Ankle Assembly (T1AKM000). Align the

D-shaped hole in the Z-axis potentiometer (located within the Top Torque Base) with the flat on the end of the tibia Rotary Potentiometer Shaft (T1LLM021), as shown in **Figure 13.19.**

WARNING: THE D-SHAPED HOLE IN THE POTENTIOMETER MUST BE ALIGNED WITH THE FLAT ON THE POTENTIOMETER SHAFT OR THE POTENTIOMETER WILL BE PERMANENTLY DAMAGED.

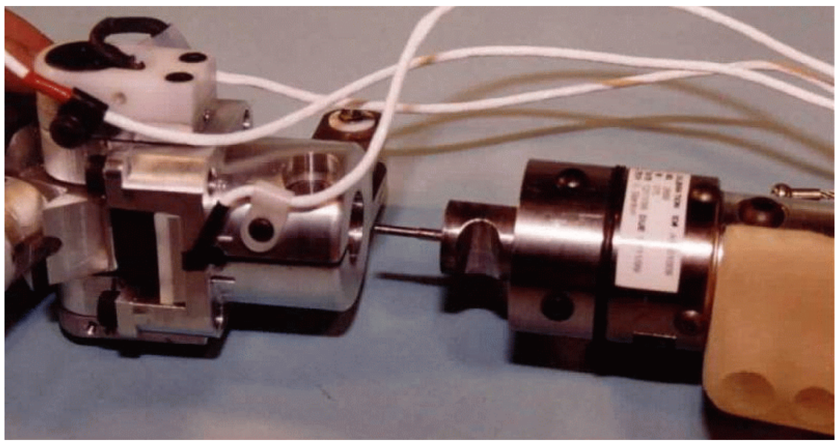

Figure 13.19- Proper Positioning of Lower Tibia Load Cell onto Ankle assembly

18. Secure the ankle assembly to the lower leg assembly using an Angle Retaining Bolt Assembly (T1AKM004), as shown in **Figure 13.20**.

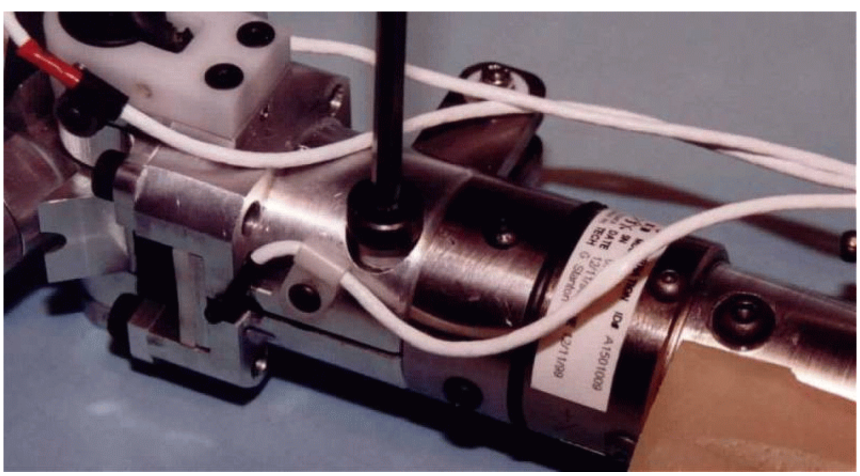

Figure 13.20- Secure the Lower Tibia to the Ankle assembly

19. Mount a Tri-Pack type accelerometers, which can be attached to a mounting plate which will be attached to the sole plate of the molded foot assembly. Mount three Uniaxial Accelerometers (T1INM111) on the Tri-Pack Block (T1INM130) using six #0-80 x 1/4" S.H.C.S {.050}and # 0 washers.

20. Attach the Tri-pack Mounting plate (T1FTM012) to the Foot-Composite Sole Plate (T1FTM010), using two # 4-40 x ½" F.H.S.C.S {1/16} as in **Figure 13.21**.

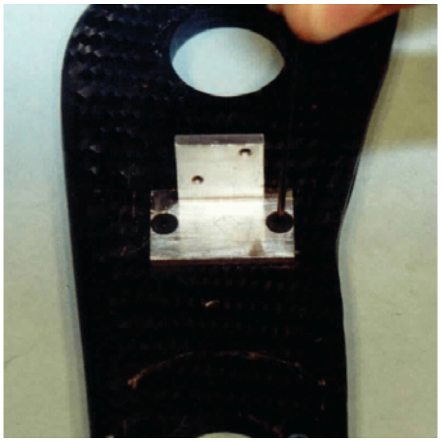

Figure 13.21- Attach Mounting Plate to foot assembly

21. The instrumented Tri-Pack block is mounted to the top of the Foot Tri-Pack Mounting Plate (T1FTM012) using two #2-56 x 9/16" S.H.C.S {5/64}, as shown in **Figure 13.22**. The axes must be corrected to the S.A.E convention in the DAQ system wiring.

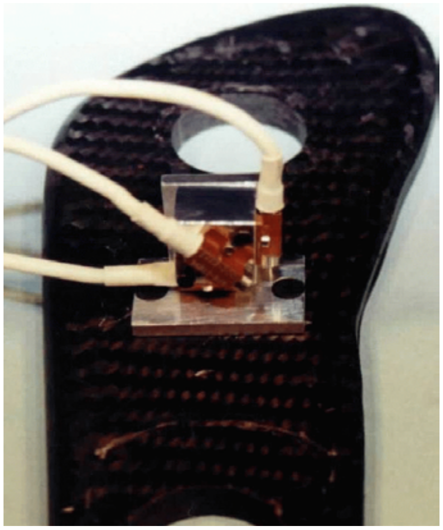

Figure 13.22- Mount the Tri-pack accelerometer to Mounting Plate

22. The skin of the molded foot assembly is not bonded to the Composite Sole Plate in the heel region. The heel skin can be carefully pried back from the sole plate to allow access to the mounting bolts for the ankle assembly. Pull back the heel section of the foot skin and insert the Ankle / Achilles Mounting Plate (T1FTM210) below the sole plate with the counter sinks toward the bottom of the foot skin, as shown in **Figure 13.23**. The pointed end of the plate indicates the heel section.

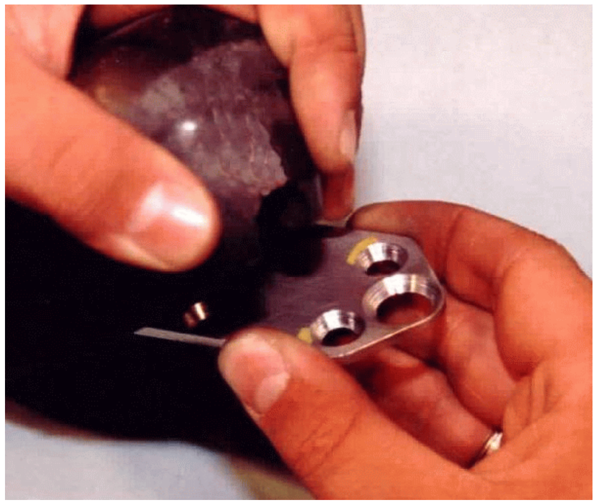

Figure 13.23- Insert the Ankle / Achilles Mounting Plate

23. Insert four 1/4-20 x 5/8" FHSCS {5/32} into the front four countersunk holes of the Ankle / Achilles Mounting Plate and the sole plate, as shown in **Figure 13.24**. This is done by holding the heel skin away from the bottom of the sole plate.

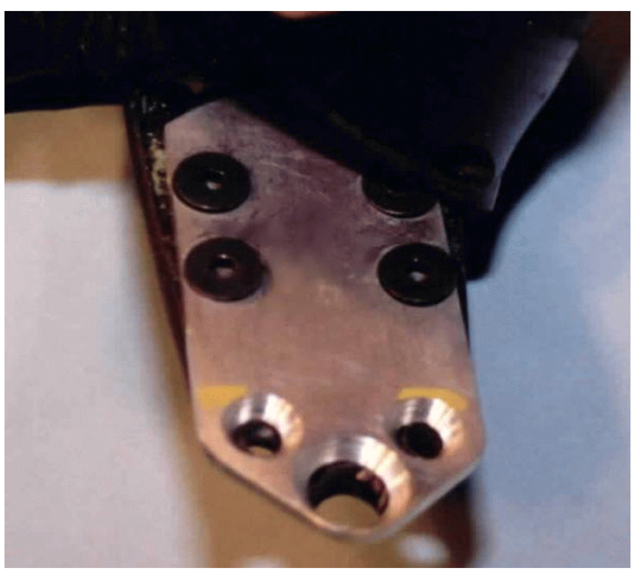

Figure 13.24- Insert four FHSCS into place

24. The mechanical ankle assembly is attached to the Composite Sole Plate (T1FTM010) of the Molded Foot Assembly by positioning the ankle assembly over the four mounting bolts and tightening the bolts using a hex wrench {5/32} inserted in the access holes at the bottom of the foot skin, as shown in **Figure 13.25**.

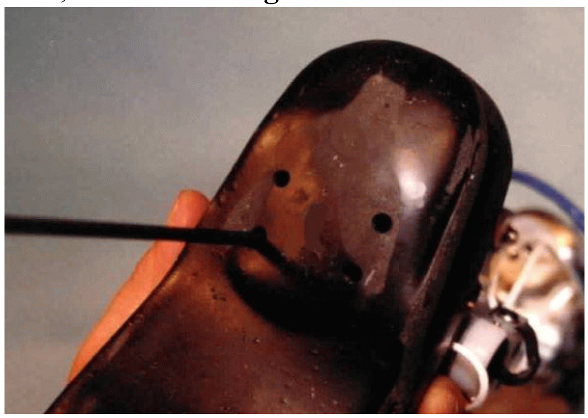

Figure 13.25- Tighten bolts via access holes

25. Attach the Lower Achilles Mounting Post (T1FTM311) to the top of the sole plate in the heel area using three 1/4-20 x 7/8" FHSCS {5/32}, as shown in **Figure 13.26**. The radius cut-out on the bottom of the Lower Achilles Mounting Post should fit tightly against the composite sole plate.

Figure 13.26- Attach the Achilles Cable Mount

26. Insert the rubber Heel Pad (T1FTM214) into the molded pocket on the inside of the foot skin under the ankle mounting area, as shown in **Figure 13.27**. The pad should be positioned with the rounded edge away from the sole plate.

Figure 13.27- Insert rubber heel pad

27. Pass the Achilles Cable behind the Achilles Pulley Wheel which is mounted to the rear of the Lower Tibia Load Cell. Attach the ball end of the Achilles Cable Assembly to the Lower Achilles Mounting Post by sliding the cable section above the ball into the slot on the back of the mounting post, as shown in **Figure 13.28**.

Figure 13.28- Slide cable ball into slot

28. Allow the ball to move up to the top of the recessed area in the mounting post and secure the cable in place by inserting a #4-40 x ½ " SHCS {3/32} into the hole on the side of the mounting post, as shown in **Figure 13.29**.

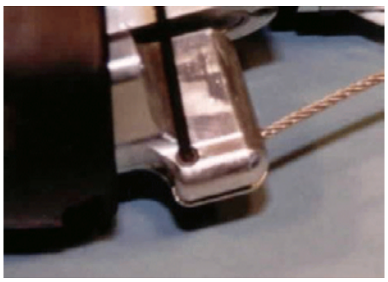

Figure 13.29- Insert cable locking screw

29. Position the Molded Knee Bumper (T1LLM025) of the Knee Clevis Assembly (T1LLM001) into the molded pocket located on the upper front interior surface of the tibia skin (T1LLS010 and T1LLS011), as shown in **Figure 13.30**.

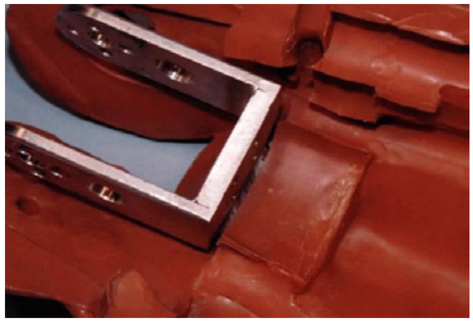

Figure 13.30- Insert Knee Bumper and Clevis into the molded pocket of the Tibia Skin

30. Position the tibia skin and knee clevis lower leg assembly and secure the Knee Clevis to the Upper Tibia Load Cell using four 1/4-28 x 5/8" SHCS {3/16}, as shown in **Figure 13.31**.

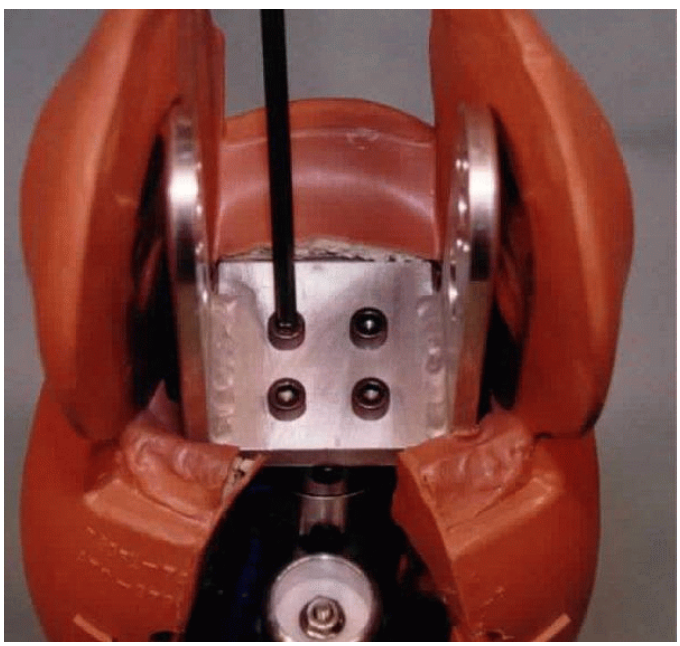

Figure 13.31- Attach Tibia to the Knee Clevis

31. Zip the tibia skin around the lower leg to complete the assembly, as shown in **Figure 13.32**.

Figure 13.32- Completed Lower Extremity assembly

13.2.3 Assembly of the Lower Extremity to the Knee

The following procedure is a step-by-step description used to install the completed Lower Extremity (T1LXM000 or Hybrid III) to the completed Femur / Knee assembly (T1FMM000 & T1KNM000). The numbers provided in ( ) refer to a specific drawing / part number of each particular part. The numbers noted in { } after the bolt size indicate the size of the hex wrench required to perform that step of the assembly. All bolts should be tightened to the torque specifications provided in Chapter 2. Refer to Section 12.2.4 for further details.

1. Rotate the Rotary Knee Block located on the outer side of Left Knee Assembly so the hook mechanism touches the bottom of the shoulder bolt head, as shown in **Figure 13.33**.

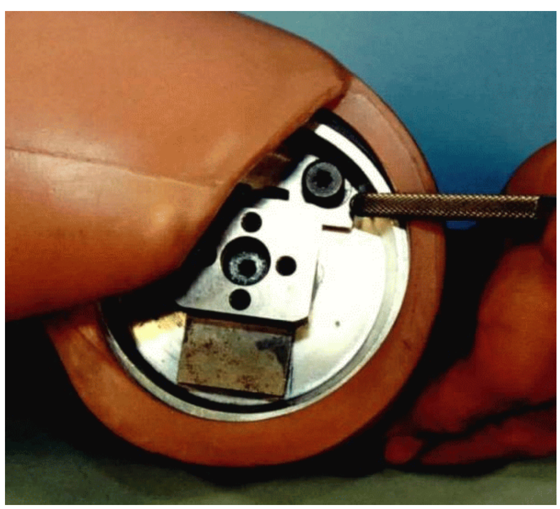

Figure 13.33- Proper positioning of the knee block

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

the rotary knee blocks, as shown in **Figure 13.34**.

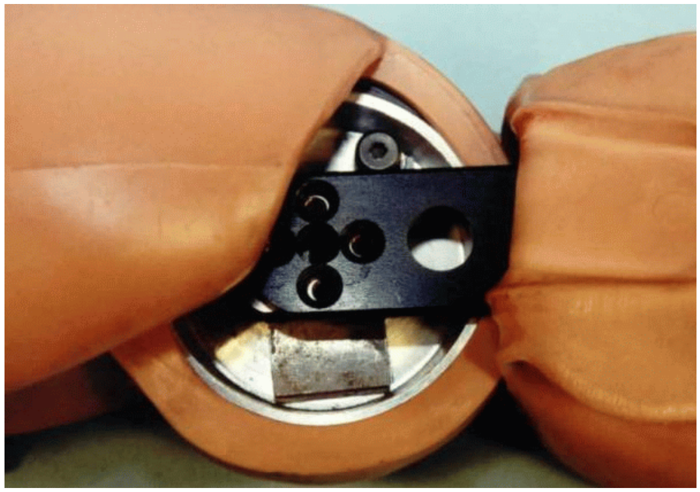

Figure 13.34- Slide knee clevis of rotary knee block

3. Align the holes of the knee clevis (attached to the Lower Extremity) with the holes of the Rotary Knee Block and secure using four 1/4" - 28 x 3/8" FHSCS {5/32}, as shown in **Figure 13.35**.

NOTE: WHEN THE FEMUR AND THE LOWER LEG ARE ATTACHED TO THE KNEE, THE ENTIRE LEG SHOULD NOT EXCEED THE NORMAL RANGE OF MOTION OF A HUMAN KNEE. IF THIS OCCURS, DETACH THE LOWER LEG FROM THE KNEE ASSEMBLY AND ROTATE THE OUTER ROTARY KNEE BLOCK TO GIVE PROPER RANGE OF MOTION.

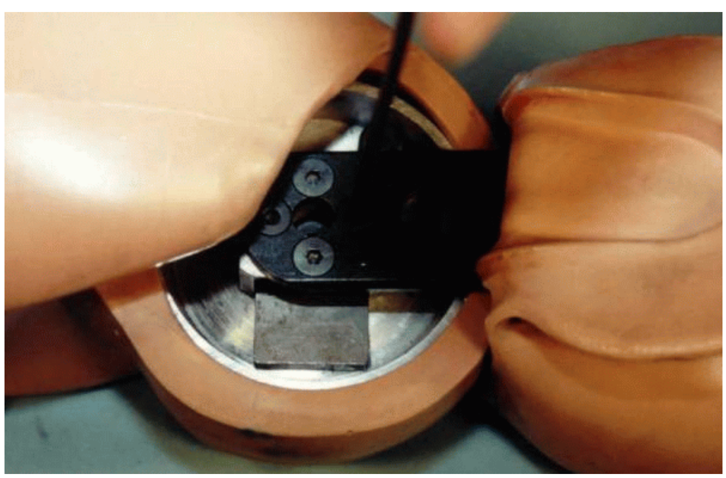

Figure 13.35- Attach the knee clevis to the knee block

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

13.3 Adjustments for the THOR-LX Assembly

The THOR-LX assembly was designed with an adjustable Achilles Tendon Cable which can change the engagement point of the Achilles relative to the ankle rotation angle. The THOR-LX was designed to have a neutral position (zero resistive torque in the ankle joints) at an angle of 15 degrees in plantar flexion. The motion of the foot from this neutral position to zero degrees dorsiflexion (tibia and foot are perpendicular) was designed with a minimum torque contribution from the Achilles tendon. This initial 15 degrees of rotation is allowed by the soft foam compression element of the Achilles Spring Tube. At the position of zero degrees dorsiflexion, the soft foam element must be fully bottomed and the Compression Spring should begin to load. The following steps will describe the correct adjustment of the Achilles Spring Cable tension.

1. Loosen the the #4-40 x 1/8" SSS in the Achilles Retaining Nut to allow the nut to be adjusted. This was shown in **Figure 13.22**.

2. Position the foot in the neutral position of 15 degrees plantar flexion as shown in **Figure 13.36**. Adjust the Achilles Retaining Nut to remove the slack from the cable and the spring tube assembly. The soft foam compression element should have a very small amount of compression at this time - just touching.

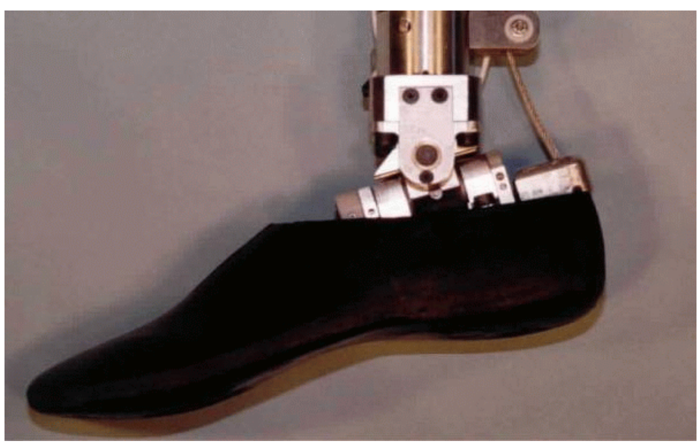

Figure 13.36- Neutral position of foot

3. Rotate the foot until it is perpendicular to the tibia assembly (0 degrees dorsiflexion or plantar flexion), as shown in **Figure 13.37**. The soft foam element should be fully compressed at this point and further dorsiflexion rotation should begin to load the compression spring. If the adjustment is incorrect, turn the Achilles Retaining Nut slightly to correct. If the soft foam is not fully compressed, tighten the retaining nut. If the soft foam compresses fully prior to reaching the 0 degree dorsiflexion position, loosen the

retaining nut.

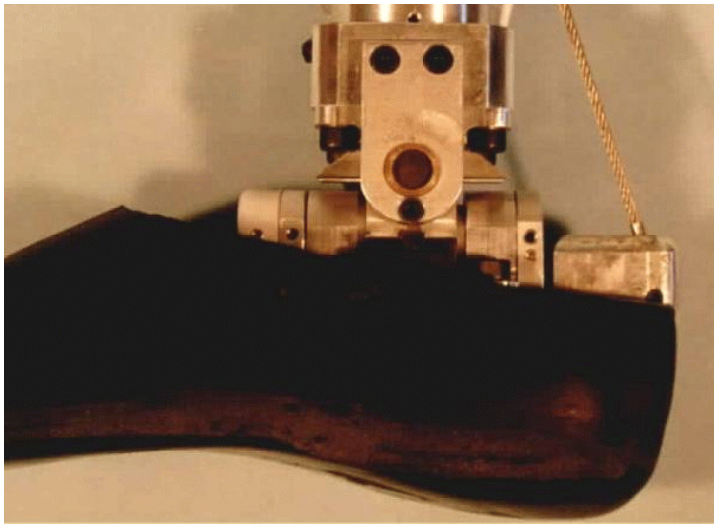

Figure 13.37- Relative position of foot and ankle for calibration

NOTE: A SIGNIFICANT INCREASE IN THE RESISTANCE OF THE ANKLE ROTATION WILL BE FELT WHEN THE SOFT FOAM ELEMENT IS FULLY COMPRESSED AND THE CABLE BEGINS O LOAD THE COMPRESSION SPRING. THIS TRANSITION SHOULD OCCUR AT THE POSITION OF ZERO DEGREES DORSIFLEXION WITH THE FOOT PERPENDICULAR TO THE TIBIA.

13.4 Wire Routing and Electrical Connections:

The wire routing for the instrumentation in the THOR-LX assembly is fairly straightforward. Each instrument in this assembly will be covered individually.

Upper Tibia Load Cell: The wire from this load cell exits through the hole provided at the rear of the tibia skin - just below the knee. The hole is at the top of the tibia skin zipper assembly.

Lower Tibia Load Cell: The wire from this load cell is routed up the right side of the lower leg and is bundled with the wires from the X & Z axis rotary potentiometers. These wires are strain relieved to the left side of the Achilles Spring Tube Base using a 3/16" wire clamp and a #6-32 x ½" BHSCS {5/64}. These wires continue up and exit through the hole provided at the rear of the tibia skin - just below the knee.

Tibia Triaxial Accelerometer: The wire from this accelerometer unit exits the right side of the tibia guard and is bundled with the wires from the foot triaxial accelerometer and the Y axis rotary potentiometers. These wires are strain relieved to the right side of the Achilles Spring Tube Base using a 3/16" wire clamp and a #6-32 x ½" BHSCS {5/64}. These wires continue up and exit through the hole provided at the rear of the tibia skin - just below the knee.

Foot Triaxial Accelerometer: The wire from this accelerometer unit exits the molded foot cavity to the right and is strain relieved to the front side of the Y axis rotary potentiometer housing with a 3/16" wire clamp using a #6-32 x 3/8" BHSCS {5/64}. A small amount of slack must be provided in this wire between the instrument and the strain relief to allow for dorsi / plantar flexion motion of the foot. This wire is then bundled with the wire from the Y axis rotary potentiometers. These wires are strain relieved to the right side of the Achilles Spring Tube Base using a 3/16" wire clamp and a #6-32 x ½" BHSCS {5/64}. These wires continue up and exit through the hole provided at the rear of the tibia skin - just below the knee.

Achilles Spring Load Cell: The wire from this load cell exits the right side of the Achilles Spring Tube Base and is strain relieved to the right side of the Achilles Spring Tube Base with a 1/8" wire clamp using a #6-32 x 3/8" BHSCS {5/64}. The wire then joins the wire bundle running up the right side of the lower leg and exits through the hole provided at the rear of the tibia skin - just below the knee.

X axis rotary potentiometer: This wire is strain relieved to the potentiometer housing with a 1/8"wire clamp using a #6-32 x 3/8" BHSCS {5/64}. This wire is strain relieved again at the front left side of the Y axis rotation joint with a 1/8" wire clamp using a #6-32 x 3/8" BHSCS {5/64}. A small amount of slack must be provided in this wire between the instrument and the strain relief to allow for dorsi / plantar flexion motion of the foot. This wire is then bundled with the wire from the lower tibia load cell. These wires are strain relieved to the left side of the Achilles Spring Tube Base using a 3/16" wire clamp and a #6-32 x ½" BHSCS {5/64}. These wires continue up and exit through the hole provided at the rear of the tibia skin - just below the knee.

Y axis rotary potentiometer: This wire is strain relieved to the potentiometer housing with a 1/8"wire clamp using a #6-32 x 3/8" BHSCS {5/64}. This wire then runs up the right side of the leg and is bundled with the wires from the foot triaxial accelerometer. These wires are strain relieved to the right side of the Achilles Spring Tube Base using a 3/16" wire clamp and a #6-32 x ½" BHSCS {5/64}. These wires continue up and exit through the hole provided at the rear of the tibia skin - just below the knee.

Z axis rotary potentiometer: This wire is strain relieved to the front of the Top Torque Base with a 1/8"wire clamp using a #6-32 x 3/8" BHSCS {5/64}. The wire is routed up the right side of the lower leg and is bundled with the wires from the X axis rotary potentiometer and the lower tibia load cell. These wires are strain relieved to the left side of the Achilles Spring Tube Base using a 3/16" wire clamp and a #6-32 x ½" BHSCS {5/64}. These wires continue up and exit through the hole provided at the rear of the tibia skin - just below the knee.

13.5 THOR-LX Calibration

The femur assembly is calibrated at GESAC using two dynamic impact tests. The purposes of these tests are to verify the performance of the Compliant Tibia Bushing and the Ankle Torque Characteristics. In the first test, the impact is targeted at the ball of the foot on a rigidly fixed lower extremity. A graph of Resistive Torque vs. Angle is generated for comparison with human response data. The second test consists of a heel impact test. In this test the force in the Z direction is plotted against time for comparison with human response data. The direction of impact is in line with the femur assembly. Calibration procedures for this test are described in the THOR Calibration Manual - available from GESAC as a separate publication.

13.6 Inspection and Repairs

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

13.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all of the instrument wires from the neck instrumentation. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to insure that they are properly strain relieved. A more detailed check on the individual instruments will be covered in Section 15 - Instrumentation.

13.6.2 Mechanical Inspection

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

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

- Check for kinks and broken strands

.

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

- Check for permanent compression, nicks or tears

.

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

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

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

- Check for holes, tears and cuts.

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

- Check for holes, tears and cuts.

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Section 14. Jacket and Clothing Assembly

14.1 Description of Jacket Assembly, Clothing, and Features

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

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

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

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

14.2 Assembly of the Jacket

14.2.1 Parts List

The parts list for the Jacket assembly is listed in Appendix I - Bill of Materials under the Jacket subsection. All quantities are listed in the Bill of Materials. Refer to drawing T1JKF000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 14.1** and **Figure 14.2** are photographs of the outside and inside of the Jacket assembly.

Figure 14.1- Jacket assembly (outside view).

Figure 14.2- Jacket assembly (inside view).

14.2.2 Assembly of Jacket Components

The following procedure is a step-by-step description of the assembly procedure for the Jacket assembly. The numbers provided in ( ) refer to a specific drawing / part number of each particular part.

1. Locate the rib stiffener pockets (T1JKF112) on the lower inside of the front panel (T1JKF110). Insert one rib stiffener (T1JKM010) into each of the four rib stiffener pockets as shown in **Figure 14.3.**

Figure 14.3- Rib stiffener inserted into pocket

2. The Jacket is assembled onto the thorax of the dummy by draping the inside front panel (T1JKF110) and inside rear panel (T1JKF210) of the jacket over the front and rear of the dummy's thorax as shown in **Figure 14.4.**

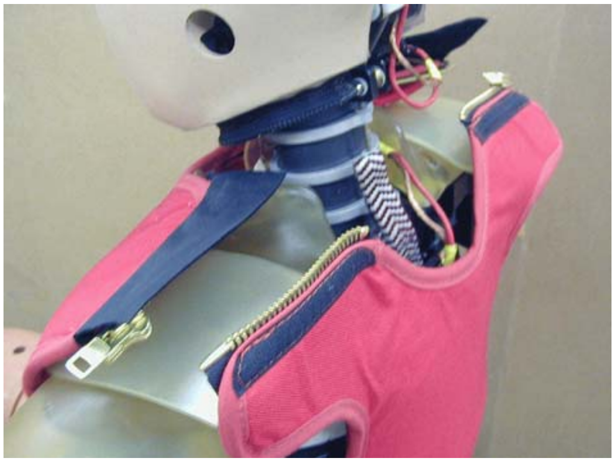

Figure 14.4- Jacket assembled onto thorax

3. Locate and close the front panel zipper (T1JKF116) on the Left shoulder, and cover with the attached velcro as shown in **Figure 14.5.**

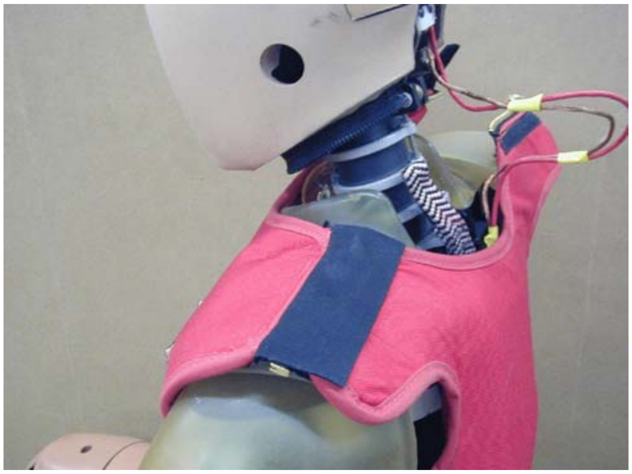

Figure 14.5- Left shoulder zipped

4. Similarly, locate and close the front panel zipper (T1JKF116) on the Left shoulder, and cover with the attached velcro as shown in **Figure 14.6.**

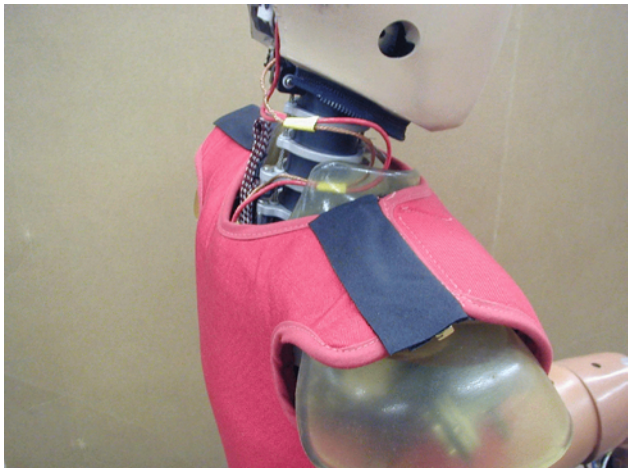

Figure 14.6- Right shoulder zipped

5. Locate and close the front panel zipper (T1JKF117) on the left side of the jacket as shown in **Figure 14.7.**

Figure 14.7- Left side zipped

6. Similarly, locate and close the front panel zipper (T1JKF117) on the right side of the jacket as shown in **Figure 14.8** .

Figure 14.8- Right side zipped

Warning: The following step requires lifting of the dummy by procedures outlined in Section 2.5. Care should be taken to avoid lifting by the head/neck area to prevent damage. Always have assistance when lifting or moving the dummy.

7. Lift the dummy using the procedure outlined in Section 2.5 and Figure #2.4. While the dummy is suspended, have an assistant slide the crotch strap assembly (T1JKF130) between the legs underneath the pelvis. Lower the dummy and attach the velcro (T1JKF122) on the crotch strap to the velcro (T1JKF214) on the bottom of the jacket rear panel (T1JKF210). The front and rear views of the complete jacket assembly are shown in **Figure 14.9** and **Figure 14.10**.

Figure 14.9- Properly installed Jacket assembly (front).

Figure 14.10- Properly installed Jacket assembly (rear).

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 Calibration

The Jacket assembly does not require any calibration.

14.6 Inspection and Repairs

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

14.6.1 Mechanical Inspection

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

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

Section 15. Instrumentation and Wiring

15.1 Overview of Instrumentation and Wiring

The THOR NT dummy when fully instrumented has 125 separate sensor channels. These include 18 channels of data for each THOR-Lx. In addition, there are 5 tilt sensors that are used to establish the orientation of the dummy. **Figure 15.1** is a plot showing the relative location of all the instrumentation for THOR. The layout of the instrumentation in the THOR dummy was designed to maintain a high degree of modularity, which was one of the main goals in the design of this dummy. Each instrument has an individual lead wire to allow for easy removal and insertion for calibration and inspection.

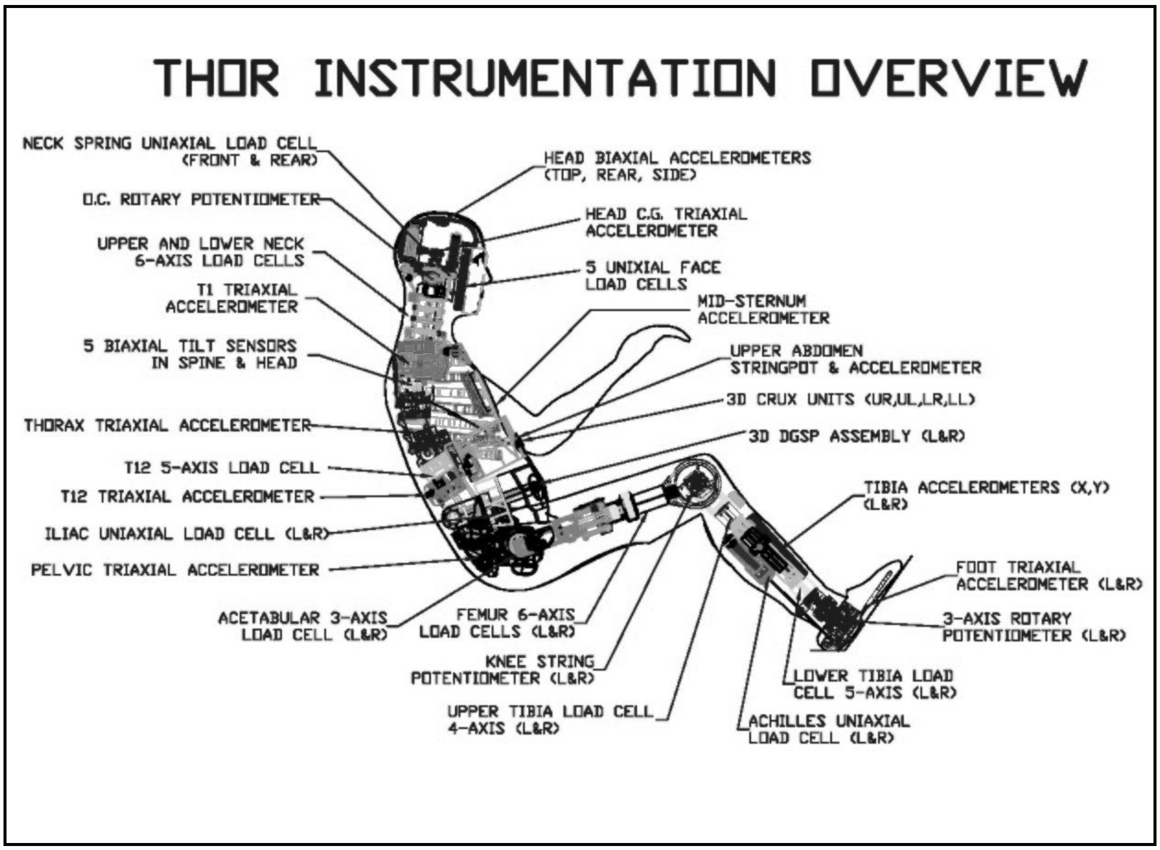

Figure 15.1- Relative location of THOR Instrumentation

15.1.1 Available Instrumentation

The THOR Dummy is currently capable of supporting the following instrumentation:

Head:	9 Uniaxial Accelerometers including 3 at the C.G. 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
Thorax:	CRUX Deflection Units - 3 Dimensional Thoracic Deflection Measurement (4 units - 3 channels each) Mid Sternum: 1 Uniaxial Accelerometer
Upper Abdomen:	Uni-directional Displacement String Potentiometer 1 Uniaxial Accelerometer
Lower Abdomen:	DGSP Deflection Units - 3 Dimensional Lower Abdomen Deflection Measurement (2 units - 3 channels each)
Spine:	1 tri-pack Accelerometer at the T1 location 1 tri-pack Accelerometer at the T12 location T12 Load Cell (5-axis) 1 tri-pack Accelerometer at the level of the thorax C.G. 4 Biaxial Tilt Sensors
Pelvis:	Acetabular Load Cell (left and right, 3-axis each) Iliac Load Cells (left and right) 1 Triaxial Accelerometer at the C.G.
Femur:	Femur Load Cell (left and right, 6-axis each)
Knee:	Displacement potentiometer (left and right)
Lx:	Upper Tibia Load Cell (left and right, 4-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)

15.1.2 Instrumentation Description

Head: The THOR NT head assembly is instrumented with a seven-accelerometer array (9 uniaxial units) and a biaxial tilt sensor. The purpose of the accelerometers is to allow the reconstruction of the head kinematics. The purpose of the dual-axis tilt sensor is described in this section under the Spine section.

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

Neck: The neck instrumentation consists of a pair of six-axis load cells located at the top and bottom of the flexible neck assembly. These load cells provide the primary loading data for the neck structure, which includes the forces in the X, Y, and Z directions, as well as the moments in the X, Y, and Z directions. In addition, a pair of uniaxial load cells is used to measure the cable tension (or spring force) on the fore and aft neck cables. Finally, a rotary potentiometer is centered at the condyle bolt to measure the rotation of the head relative to the top of the neck. The loading data from the head / neck assembly are analyzed using the THORTEST software program (supplied and documented separately).

Thorax: The thorax assembly is instrumented with four CRUX units. These units operate as a two-bar linkage system as described in Section 16 - CRUX Units. The units are located at the level of rib #3 and rib #6 on the left and right sides. Each of these units measures the three-dimensional deflection of the rib cage at the attachment point. This system provides a four-point measurement system for thoracic deflection. The data from the CRUX units are analyzed using the THORTEST software program (supplied and documented separately).

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

Upper Abdomen: The upper abdomen assembly is instrumented with a uni-directional displacement measuring device - the string potentiometer. This unit consists of a high strength miniature cable which is wound around a spring-tensioned drum. As the abdomen is compressed, the string is wound around the drum and the rotation is converted to a linear deflection. In addition, the upper abdomen assembly is instrumented with a uniaxial accelerometer, mounted in the interior of the front bag face. This unit is designed to measure the uni-directional acceleration of the bag, such as those caused by an airbag or steering wheel impact.

Lower Abdomen: The lower abdomen assembly is instrumented with a pair of double gimballed string potentiometer (DGSP) units. These units consist of a string potentiometer housed within a telescopic column which provides three-dimensional deflection data for two points (left and right) in the lower abdomen assembly. The data from the DGSP units are analyzed using the THORTEST software program (supplied and documented separately).

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

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

Femur: The femur assemblies are each instrumented with a six-axis femur load cell located between the knee and the compliant femur bushing. These load cells provide the primary loading data for the femur structure which includes the forces in the X, Y, and Z directions, as well as the moments in the X, Y, and Z directions.

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

Tibia: Each tibia assembly contains an 4-axis upper tibia load cell and a 5-axis lower tibia load cell. These provide data on the forces at the top and bottom of the tibia in the Fx, Fy, Fz directions and moments in the Mx, My directions. In addition, two accelerometers are attached to the tibia which measure accelerations in the X and Y directions in the tibia coordinate system. These can be used with the tibia load cell data and the ankle rotation data (below) to compute the moment and forces acting at the ankle joints.

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

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

15.1.3 Standard Instrumentation Specifications

Table 15.1 shows the THOR Drawing Number for each instrument (containing the sensitivity and performance data), as well as a typical vendor reference for the instrument.

Table 15.1

Instrument	**THOR Drawing Number**	**Vendor Reference**
Uniaxial Accelerometer	T1INM110 or T1INM111	Entran # EGE-73BQ-2000HD Endevco # 7264C-2K
Tri-pack Accelerometer	T1INM100	Endevco # 7264C-2K
CRUX	T1CXM000	GESAC
DGSP	T1DPM000	GESAC
Rotary Potentiometer #1	T1INM210	Contelec # PD210-4B
Rotary Potentiometer #2	T1INM220	Sfernice # 20x78RBA102-1K-9641
String Potentiometer	T1INM230	Space Age Controls # 160-0321-VL
*Upper Neck Load Cell	T1INM310	Denton # 3454J
*Lower Neck Load Cell	T1INM320	Denton # 4366J
*Thoracic Spine Load Cell	T1INM330	Denton # 1911J
*Acetabular Load Cell - Left	T1INM340	Denton # 3855J
*Acetabular Load Cell - Right	T1INM341	Denton # 3455J
*Femur Load Cell	T1INM350	Denton # 1914J
Iliac Uniaxial Compression Load Cell	T1INM410	AL Designs # ALD-MINI-T-3K
Neck Spring Load Cell	T1INM420	Denton # 6005
Face Uniaxial Compression Load Cell	T1INM430	Denton # 4168
Knee Shear String Potentiometer	-	Space Age Controls# 150-0121 VR, VL

Instrument	THOR Drawing Number	Vendor Reference
*Upper Tibia Load Cell	-	Denton #4353
*Lower Tibia Load Cell	-	Denton #4929
Achilles Load Cell	-	Denton #5145
Tilt Sensor	T1INM510	Advanced Orientation Systems # SX-60-LIN

* Load cell output polarity must conform to SAE J-211 standard.

15.2 Wire Routing

15.2.1 Wire Bundle from the Head and Neck

After the completed head and neck assemblies have been properly attached on the THOR thorax and spine assemblies, the bundle of wires from all the instrumentation needs to be properly restrained. Details of this procedure are covered in Section 7.2.2- Assembling the Thorax Components. The instrumentation wires from the head and neck instrumentation should be bundled together. This wire bundle should be clamped in place Upper Thoracic Spine Back Plate (T1SPM123) as described in the procedure below.

1. Gather the wire bundle from the head and neck instrumentation. Holding the bundle together, measure 13.5" down along the wire bundle from the bottom of the head mounting plate. Centered at this point, wrap the wire bundle with electrical tape to provide enough thickness to allow the spine wire cover (T1TXM040) to hold it securely in place. This measurement will provide the necessary slack in the wires.

NOTE: It is critical to provide the correct amount of slack wire above this clamp to allow the head and neck to have free motion in flexion and extension.

2. Repeat the above procedure for the Head Tilt Sensor, Neck Rotary Potentiometer, and Face Load cells wires. The wire bundles are clamped on each side of the Upper Thoracic Spine Back Plate using a 1/4" Steel Loop Strap and a #10-24 x 1/4 B.H.S.C.S.

15.2.2 Wire Routing for THOR Instrumentation

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

15.3 Strain Relief for THOR Instrumentation Wires

15.3.1 Individual Instruments

Strain relief for the instrumentation wires has been provided in several manners to prevent damage to the wiring during testing. Each instrument has some form of strain relief at the instrument housing to prevent the electrical connections from receiving any loading during movement of the wires. This initial strain relief is provided in various ways, depending upon the instrument. Some instruments use a zip-tie to attach the wire to a solid structure, some use a special wire clamp to hold the wire in position.

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

15.3.2 Main Dummy Strain Relief at Base of Spine

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

1. Attach the adjustable cable support grip (strain relief mesh grip) to the rear of the Lower Abdomen Rear Attachment Plate (T1LAM010) using the Strain Relief Mounting Plate (T1INM010) and a 5/16-18 x 1" FHSCS {3/16}, as shown in **Figure 15.2**.

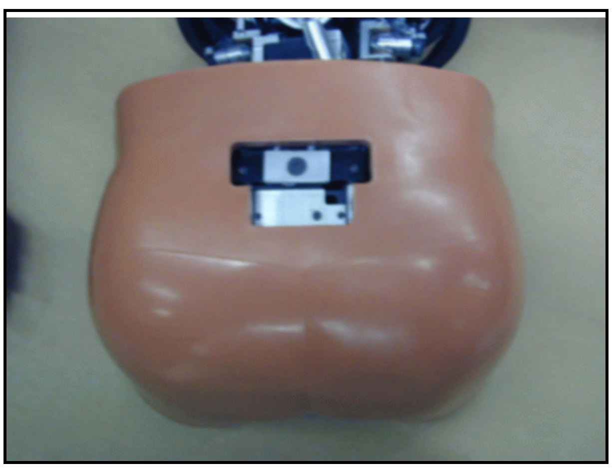

Figure 15.2- Abdomen Rear Attachment Plate

2. Position the bundle of instrumentation wires in the strain relief mesh, and secure the mesh using several zip-ties as shown in **Figure 15.3**.

Figure 15.3- Wire bundle secured in mesh

3. Cover all the wires and the mesh using the Nylon Wire Cover (T1INF000). Zip the cover shut and secure it to the mesh using two zip-ties through the grommets at the end of the cover, as shown in **Figure 15.4.**
.

Figure 15.4- Mesh cover properly positioned

15.4 Wire Markers

In order to keep track of the instrumentation wiring used for the THOR dummy, a wire marking system has been employed. This system involves an alpha-numeric marking strip for each instrument wire and connector wire, as well as, a color coded marker to denote the instrument type. **Table 15.2** provides a reference to the colors and their meanings.

Table 15.2

Wire Marker Color	Instrument Type
ORANGE	LOAD CELLS
RED	ACCELEROMETERS
BLUE	POTENTIOMETERS
BLACK	DGSP UNITS
YELLOW	TILT SENSORS

A complete listing of the instrumentation and related wire markers is listed in **Table 15.3** for reference. Please refer to the notes at the bottom of the table for further information.

Table 15.3

THOR COMPONENT AND SENSOR	WIRE MARKER
HEAD	
Uniaxial Accelerometer - CG (X axis)	HCGX{Red}1
Uniaxial Accelerometer - CG (Y axis)	HCGY{Red}1
Uniaxial Accelerometer - CG (Z axis)	HCGZ{Red}1
Uniaxial Accelerometer - Top (X axis)	HTX{Red}1
Uniaxial Accelerometer - Top (Y axis)	HTY{Red}1
Uniaxial Accelerometer - Side (X axis)	HSX{Red}1
Uniaxial Accelerometer - Side (Z axis)	HSZ{Red}1
Uniaxial Accelerometer - Rear (Y axis)	HRY{Red}1
Uniaxial Accelerometer - Rear (Z axis)	HRZ{Red}1
FACE	
Eye Uniaxial Compression Load Cell (Right)	FEER{Orange}LC
Eye Uniaxial Compression Load Cell (Left)	FEEL{Orange}LC
Cheek Uniaxial Compression Load Cell (Right)	FCKR{Orange}LC
Cheek Uniaxial Compression Load Cell (Left)	FCKL{Orange}LC
Chin Uniaxial Compression Load Cell (Middle)	FCNM{Orange}LC
NECK	
Lower Load Cell (6 axis)	LN{Orange}**
Upper Load Cell (6 axis)	UN{Orange}**

THOR COMPONENT AND SENSOR	WIRE
Neck Rear Spring Load Cell	NKR{Orange}LC
Neck Front Spring Load Cell	NKF{Orange}LC
Neck Condyle Pin Rotary Potentiometer	NKC{Blue}RP
MID-STERNUM	
Mid-Sternum Uniaxial Accelerometer	MID{Red}1
UPPER ABDOMEN	
Upper Abdomen Uniaxial Accelerometer	UA{Red}1
Upper Abdomen String Potentiometer	UA{Blue}SP
LOWER ABDOMEN	
Left Hand Side DGSP - 3 Dimensional Deflection	DP#{Black}L
Right Hand Side DGSP - 3 Dimensional Deflection	DP#{Black}R
THORAX	
Triaxial Accelerometer - Thorax	TX-*{Red}3
Upper Left CRUX Unit - 3 Dimensional Deflection	CX#-UL
Upper Right CRUX Unit - 3 Dimensional Deflection	CX#-UR
Lower Left CRUX Unit - 3 Dimensional Deflection	CX#-LL
Lower Right CRUX Unit - 3 Dimensional Deflection	CX#-LR
SPINE	
T12 - Thoracic Load Cell (Fx, Fy, Fz, Mx, My)	T12{Orange}**
Triaxial Accelerometer - T1 Location	T1-*{Red}3
Triaxial Accelerometer - T12 Location	T12*{Red}3
PELVIS	
Triaxial Accelerometer - Pelvis CG	PL-*{Red}3
Pelvic Acetabular Load Cell	PA@{Orange}F*
Pelvic Iliac Crest Load Indicator	IC@{Orange}LC
FEMUR	
Femur Load Cell	FM@Orange}**

THOR COMPONENT AND SENSOR	WIRE
KNEE	
Knee Shear Displacement	K@{Blue}SD
TIBIA	
Upper Tibia Load Cell (Fx, Fz, Mx, My)	UT@{Orange}**
Lower Tibia Load Cell (Fx, Fy, Fz, Mx, My)	LT@{Orange}**
Uniaxial Accelerometer (X axis)	TB@{Red}AX
Uniaxial Accelerometer (Y axis)	TB@{Red}AY
ANKLE	
Ankle Rotation	AK@{Blue}R*
FOOT	
Triaxial Accelerometer - Foot	FT@{Red}A*
TILT SENSORS	
Neck Tilt Sensor	T{Yellow}NECK
Thoracic Tilt Sensor	T{Yellow}LTS
Lumbar Tilt Sensor	T{Yellow}LUM
Pelvic Tilt Sensor	T{Yellow}PEL
Head Tilt Sensor	T{Yellow}HEAD

Notes:

Colors in { } indicate a blank space of the corresponding color.
* Indicates X, Y, or Z axis
** Indicates Force X,Y,Z or Moment X, Y, Z (i.e. FX, MX)
\# Indicates POT # 1, 2, or 3
@ Indicates L for left, R for right

15.5 THOR Instrumentation Wiring

15.5.1 Commercial Dummy Sales

The THOR units which are sold commercially are provided with the instrumentation requested in the sales agreement. The instrument wires on these units are left bare ended for the individual customers to attach the connector of their choice. This allows various customers to select the connector which will mate with the desired DAS system. All of the load cells and accelerometers will be provided with their own individual calibration sheets which contain the necessary wiring information. For the CRUX, DGSP, and String Potentiometer and Rotary Potentiometer Units, please refer to the wiring directions provided below.

Upper Abdomen String Potentiometer- (wire marker UA{Blue}SP)
Neck Condyle Pin Rotary Potentiometer- (wire marker NKC{Blue}RP)

Function	Wire Color
+ Excitation	Red
Ground	Black
+ Signal	Green

DGSP Assemblies- (wire marker DP#{Black}L and DP#{Black}R)
where # indicates Pot #1, 2, or 3

Potentiometer:	Function:	Wire Color:
String Pot (#1)	+ Excitation	Red
	Ground	Black
	+ Signal	Green
Top Pot (#2)	+ Excitation	Orange
	Ground	Black Stripe
	+ Signal	Blue
Side Pot (#3)	+ Excitation	Red Stripe
	Ground	Gray
	+ Signal	White

CRUX Assemblies- (wire marker CX*-UR, CX*-UL, CX*-LR, CX*-LL)
where * indicates Pot #1, 2, or 3

Potentiometer:	Function:	Wire Color:
Base Pot (#1)	+ Excitation	Red
	Ground	Black
	+ Signal	Green
Mid Pot (#2)	+ Excitation	Orange
	Ground	Black Stripe
	+ Signal	Blue
Elbow Pot (#3)	+ Excitation	Red Stripe
	Ground	Gray
	+ Signal	White

Ankle Rotary Potentiometers (wire marker AKL{Blue}R# and AKR{Blue}R* where * indicates X, Y, or Z pots)

Function	Wire Color
+Excitation	Red
-Excitation	Black
+Signal	Green

15.5.2 Leased Dummies

Initially, the method for adapting THOR's connectors to other laboratory data acquisition systems had been a point of concern. This problem has been solved with the use of THOR connector wires. The instrumentation from the THOR dummy is connected to the laboratory data acquisition system through the use of the Connector Wires. These connector wires feature a mating LEMO connector on one end to fit THOR's LEMO connectors and a bare ended wire at the other end. The blank end of the connector wire can be soldered to the appropriate connector necessary for mating with the testing laboratory data acquisition system. Each connector wire is individually marked to mate with a specific instrument on the dummy. **Table 15.4** describes the correct wire color assignments for the connector wires. This table should provide all the necessary information to correctly wire the appropriate mating connectors for the laboratory data acquisition system.

TABLE 15.4

Face Compression Load Cells- (wire marker F***{Orange}LC, where *** donates position)
Neck Spring Load Cells- (wire marker NKF{Orange}LC and NKR{Orange}LC)
Pelvic Iliac Load Indicators- (wire marker ICL{Orange}LC and ICR{Orange}LC)

Function	Wire Color
+ Excitation	Red
- Excitation	Black
+ Signal	Green
- Signal	White

Uniaxial Accelerometers- (wire marker ***{Red}1, where *** donates position)

Function	Wire Color
+ Excitation	Red
- Excitation	Black
+ Signal	Green
- Signal	White

Upper Neck Load Cell- (wire marker UN{Orange}**)

where ** indicates Force X, Y, Z or Moment X, Y, Z
<u>Lower Neck Load Cell</u>- (wire marker LN{Orange}**)
where ** indicates Force X, Y, Z or Moment X, Y, Z

Forces:

Axis:	Function:	Wire Color:
X,Y,Z	+ Excitation	Red
	- Excitation	Black
	+ Signal	Green
	- Signal	White

Moments:

Axis:	Function:	Wire Color:
X,Y,Z	+ Excitation	Red
	- Excitation	Black
	+ Signal	Green
	- Signal	White

<u>T12 Load Cell</u> - (wire marker T12{Orange}**)
where ** indicates Force X, Y, Z or Moment X, Y
<u>Lower Tibia Load Cell</u> - (wire marker LTL{Orange}** and LTR{Orange}**
where ** indicates Force X, Y, Z or Moment X, Y

Forces:

Axis:	Function:	Wire Color:
X,Y,Z	+ Excitation	Red
	- Excitation	Black
	+ Signal	Green
	- Signal	White

Moments:

Axis:	Function:	Wire Color:
X,Y	+ Excitation	Red
	- Excitation	Black
	+ Signal	Green
	- Signal	White

<u>Upper Tibia Load Cell</u> - (wire marker UTL{Orange}** and UTR{Orange}**
where ** indicates Force X, Y or Moment X, Y

Forces:

Axis:	Function:	Wire Color:
X,Y	+ Excitation	Red

	- Excitation	Black
	+ Signal	Green
	- Signal	White

Moments:

Axis:	Function:	Wire Color:
X,Y	+ Excitation	Red
	- Excitation	Black
	+ Signal	Green
	- Signal	White

<u>Pelvic Acetabular Load Cell</u>- (wire marker PAL{Orange}F*and PAR{Orange}F*) where * indicates Force X, Y, or Z

Forces:

Axis:	Function:	Wire Color:
X,Y,Z	+ Excitation	Red
	- Excitation	Black
	+ Signal	Green
	- Signal	White

<u>Upper Abdomen String Potentiometer</u>- (wire marker UA{Blue}SP)
and
<u>Neck Condyle Pin Rotary Potentiometer</u>- (wire marker NKC{Blue}RP)

Function	Wire Color
+ Excitation	Red
Ground	Black
+ Signal	Green

<u>DGSP Assemblies</u>- (wire marker DP#{Black}L and DP#{Black}R) where # indicates Pot #1, 2, or 3

Potentiometer:	Function:	Wire Color:
String Pot (#1)	+ Excitation	Red
	Ground	Black
	+ Signal	Green
Top Pot (#2)	+ Excitation	Red
	Ground	Black
	+ Signal	Green
Side Pot (#3)	+ Excitation	Red
	Ground	Black

	+ Signal	Green

CRUX Assemblies- (wire marker CX*-UR, CX*-UL, CX*-LR, CX*-LL)
where * indicates Pot #1, 2, or 3

Potentiometer:	Function:	Wire Color:
Base Pot (#1)	+ Excitation	Red
	Ground	Black
	+ Signal	Green
Mid Pot (#2)	+ Excitation	Red
	Ground	Black
	+ Signal	Green
Elbow Pot (#3)	+ Excitation	Red
	Ground	Black
	+ Signal	Green

Ankle Rotary Potentiometers (wire marker AKL{Blue}R* and AKR{Blue}R*)
where * indicates pots for X, Y, Z rotations

Function	Wire Color
+Excitation	Red
-Excitation	Black
+Signal	Green

15.6 Instrumentation Excitation and Ground Requirements

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

All + Excitation Terminals are connected to a 10.00 (+/- 0.05) V DC power supply.
All - Excitation Terminals are connected to a ground (i.e. 0.0 V DC) source.
All Ground Terminals are connected to a ground (i.e. 0.0 V DC) source.

15.7 Data Acquisition

Proper connection of the THOR instrumentation to the laboratory data acquisition system is essential to the correct measurement of the various forces, moments, accelerations, and deflections. **Table 15.5** provides a reference to the proper data acquisition requirements for each channel. These requirements include the channel configuration and range requirements for each of the THOR instruments.

The data acquisition channel configuration defines how to measure the voltage difference for the output of each channel. For all of the instruments of the THOR dummy, the channel configuration is either differential or referenced single-ended. The term DIFF denotes a differential configuration in which the + Signal lead is connected to a HI input channel and the - Signal lead is connected to a LO input channel. The data acquisition system is then configured as a differential input to measure the voltage difference between the HI and LO channel inputs.

WARNING: Do not connect the - Signal lead to ground or the instrumentation may be permanently damaged.

For typical data acquisition systems, differential input configurations require two channels of the data acquisition system for each instrument channel (i.e. a HI and LO channel for each axis of a load cell, etc.). All load cells and accelerometers used in the THOR instrumentation require a differential configuration for the proper data acquisition.

The term RSE denotes a referenced single-ended configuration in which the + Signal lead is connected to a HI input channel. The data acquisition system is then configured as a referenced single-ended input to measure the voltage difference between the HI channel input and the ground reference.

In addition to the channel configuration, the other critical information needed to set up the data acquisition for THOR is the expected output voltage range for each of the instruments. This output voltage range is used to adjust the individual channel sensitivity of the data acquisition system to obtain the highest possible data resolution. The use of the output voltage ranges listed in the table will ensure that none of the data is clipped for extreme loading that may occur.

In the following table, a ** indicates that additional information has been provided for these instruments and further details can be found immediately following the table. In addition, the instruments which have multiple channels have been noted in the table.

TABLE 15.5

THOR COMPONENT AND SENSOR	DAS Configuration	Output Voltage Range
HEAD		
Uniaxial Accelerometer - Head CG (X axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Head CG (Y axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Head CG (Z axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Top (X axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Top (Y axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Side (X axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Side (Z axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Rear (Y axis)	DIFF	-0.5 to 0.5 V
Uniaxial Accelerometer - Rear (Z axis)	DIFF	-0.5 to 0.5 V
FACE		
Face Compression Load Cells (5 load cells)	DIFF	-20 to 20 mV
NECK		
Lower Load Cell	DIFF (6 CH)	-30 to 30 mV
Upper Load Cell	DIFF (6 CH)	-30 to 30 mV
Neck Rear Spring Load Cell	DIFF	-20 to 20 mV
Neck Front Spring Load Cell	DIFF	-20 to 20 mV
Neck Condyle Pin Rotary Potentiometer	RSE	0 to 10 V
MID-STERNUM		
Mid-Sternum Uniaxial Accelerometer	DIFF	-0.5 to 0.5 V
UPPER ABDOMEN		
Upper Abdomen Uniaxial Accelerometer	DIFF	-0.5 to 0.5 V
Upper Abdomen String Potentiometer	RSE	0 to 10 V
LOWER ABDOMEN		
DGSP - 3D Deflection (Left and Right)	RSE (3 CH)	0 to 10 V

THOR COMPONENT AND SENSOR	DAS Configuration	Output Voltage Range
THORAX		
Triaxial Accelerometer - Thorax CG	DIFF (3 CH)	-.5 to .5 V
CRUX Units - 3D Deflection (UR, UL, LR, LL)	RSE (3 CH)	0 to 10 V
SPINE		
T12 Thoracic Load Cell (Fx, Fy, Fz, Mx, My)	DIFF (5 CH)	-30 to 30 mV
Triaxial Accelerometer - T1 Location	DIFF (3 CH)	-.5 to .5 V
Triaxial Accelerometer - T12 Location	DIFF (3 CH)	-.5 to .5 V
PELVIS		
Triaxial Accelerometer - Pelvis CG	DIFF (3 CH)	-.5 to .5 V
Pelvic Acetabular Load Cell (Left and Right)	DIFF (3 CH)	-30 to 30 mV
Pelvic Iliac Crest Load Indicator (Left and Right)	DIFF	-30 to 30 mV
FEMUR		
Femur Load Cell (Left and Right)	DIFF (6 CH)	-30 to 30 mV
KNEE		
Knee Shear Displacement (Left and Right)	RSE	0 to 10V
TIBIA		
Upper Tibia Load Cell (Left and Right)	DIFF (4 CH)	-30 to 30 mV
Lower Tibia Load Cell (Left and Right)	DIFF (5 CH)	-30 to 30 mV
Uniaxial Accelerometer -X Axis (Left and Right)	DIFF	-.5 to .5 V
Uniaxial Accelerometer -Y Axis (Left and Right)	DIFF	-.5 to .5 V
ANKLE		
Ankle Rotary Potentiometers	RSE (3 CH)	0 to 10V
FOOT		
Triaxial Accelerometer - Foot	DIFF (3 CH)	-.5 to .5 V

CRUX and DGSP Notes: The three output signals (+Signal) for each instrument are measured with reference to Ground for data acquisition. For additional information, refer to Section 16 for the CRUX units and Section 17 for the DGSP units.

Pelvic Iliac Load Indicator Notes: The purpose of the iliac load indicators are to indicate if the lap belt is correctly loading the iliac crest or if the belt has slipped out of position. This instrument was not designed to provide a measurement of belt load or provide a quantitative measurement of belt loading.

15.7.1 Thor Instrumentation Polarity Check

Table 15.6 compares the polarity for the Thor dummy to the SAE-J211 standard for each sensor. All instruments to be checked are assumed to be properly assembled into the dummy as specified in this user's manual. Although, in order to perform the Crux manipulations, as described in the table below, the front of each Crux unit should be detached from the front of the rib. The Crux manipulations should be performed with care to prevent over ranging the potentiometers when manipulated past the design range of motion of each unit (refer to Section 16 - Crux Units, for more details). There is a mechanical stop internal to the sensor that will become damaged if rotated past this point. The unit only needs to be rotated slightly to see a voltage change to check for its polarity. After the Crux manipulations are complete, the units should be reattached to the front of the rib cage. Refer to Section 9.2.3- Installing the Upper Abdomen in Thor, for detailed instructions on how to reattach the front of each Crux unit to the front of the rib cage.

WARNING: The Crux manipulations should be performed with care to prevent over ranging the potentiometers when manipulated past the design range of motion of each unit.

The T1, T12, Chest CG, and Pelvis CG accelerometers listed in **Table 15.6** are the tri-pack configuration. The tri-pack configuration uses three uniaxial accelerometers mounted onto a tri-pack block (T1INM130) to measure accelerations along the X, Y, and Z axes at the seismic center of the three units attached to the block.

TABLE 15.6: THOR INSTRUMENTATION POLARITY CHECK

Head & Neck

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
Head Accelerometers (CG, top, rear, & side)	Ax	Rotate dummy back (face up)	+	+
	Ay	Rotate dummy to left (right side up)	+	+
	Az	Rotate dummy back (face up)	+	+
Upper Neck Load Cell[c]	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	+	+

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
	My	Rotate chin toward sternum	+	+
	Mz	Rotate chin toward left shoulder	+	+
Lower Neck Load Cell[c]	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	+	+
Front Neck Spring	Fz	Rotate head rearward	NA	+
Rear Neck Spring	Fz	Rotate chin toward chest	NA	+
O.C. Rotary Pot	θ_y	Rotate chin toward chest	NA	+
Face Load Cells	Fx	Hold back of head, push face rearward	NA	+

Spine and Thorax

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
T1 Accelerometer (Tri-pack)[b]	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)	+	-
Thorax Accelerometer (Tri-pack)[b]	Ax	Rotate dummy back (face up)	+	-
	Ay	Rotate dummy to left (right side up)	+	+
	Az	Rotate dummy back (face up)	+	+
T12 Accelerometer (Tri-pack)[b]	Ax	Rotate dummy back (face up)	+	-
	Ay	Rotate dummy to left (right side up)	+	-
	Az	Rotate dummy back (face up)	+	-
T12 Load Cell[c]	Fx	Move chest rear, pelvis forward	+	+

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
	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	+	+
Upper Right Crux		Refer to **Figure 15.5** for illustration		
UR Base pot (Pot 1)	θ_1	Hold base, rotate rear arm upward	NA	+
UR Mid pot (Pot 2)	θ_2	Hold base, rotate rear arm CW[a]	NA	+
UR Elbow pot (Pot 3)	θ_3	Hold rear arm, rotate front arm CW[a]	NA	+
Upper Left Crux		Refer to **Figure 15.6** for illustration		
UL Base pot (Pot 1)	θ_1	Hold base, rotate rear arm downward	NA	+
UL Mid pot (Pot 2)	θ_2	Hold base, rotate rear arm CW[a]	NA	+
UL Elbow pot (Pot 3)	θ_3	Hold rear arm, rotate front arm CW[a]	NA	+
Lower Right Crux		Refer to **Figure 15.5** for illustration		
LR Base pot (Pot 1)	θ_1	Hold base, rotate rear arm CCW[a]	NA	+
LR Mid pot (Pot 2)	θ_2	Hold base, rotate rear arm downward	NA	+
LR Elbow pot (Pot 3)	θ_3	Hold rear arm, rotate front arm downward	NA	+
Lower Left Crux		Refer to **Figure 15.6** for illustration		
LL Base pot (Pot 1)	θ_1	Hold base, rotate rear arm CCW[a]	NA	+
LL Mid pot (Pot 2)	θ_2	Hold base, rotate rear arm upward	NA	+
LL Elbow pot (Pot 3)	θ_3	Hold rear arm, rotate front arm upward	NA	+

Abdomen

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
Upper Abdomen Accelerometer	Ax	Rotate dummy back (face up)	+	-
Upper Abdomen String pot	Dx	Move front face of upper abdomen rearward	-	+

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
Right DGSP		Refer to **Figure 15.7** for illustration		
R. string pot (Pot 1)	Dx	Move DGSP tube rearward	NA	+
R. Z-axis pot (Pot 2)	θ	Rotate DGSP tube CCW[a]	NA	+
R. Y-axis pot (Pot 3)	ψ	Rotate DGSP tube downward	NA	+
Left DGSP		Refer to **Figure 15.8** for illustration		
L. string pot (Pot 1)	Dx	Move DGSP tube rearward	NA	+
L. Z-axis pot (Pot 2)	θ	Rotate DGSP tube CCW[a]	NA	+
L. Y-axis pot (Pot 3)	ψ	Rotate DGSP tube upward	NA	+

Pelvis

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
Pelvis CG Accelerometer (Tri-pack)[b]	Ax	Rotate dummy back (face up)	+	+
	Ay	Rotate dummy to left (right side up)	+	+
	Az	Rotate dummy back (face up)	+	+
L Acetabular LC[c]	Fx	Move femur forward, pelvis rear	+	+
	Fy	Move femur right, pelvis left	+	+
	Fz	Move femur down, pelvis up	+	+
R Acetabular LC[c]	Fx	Move femur forward, pelvis rear	+	+
	Fy	Move femur right, pelvis left	+	+
	Fz	Move femur down, pelvis up	+	+
L & R Iliac LC	Fx	Apply load front to back to the Iliac	-	+

Femur (L&R)

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
Femur Load Cell[c]	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	+	+

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
	My	Rotate knee up, hold upper femur	+	+
	Mz	Rotate tibia left, hold pelvis	+	+

Lx - Lower Extremity (L&R)

Instrument	Direction	Motion	SAE-J211 Polarity	THOR Polarity
Knee Shear Displacement	Dx	Hold femur, move tibia forward	+	+
Upper Tibia Load Cell[c]	Fx	Move tibia forward, knee rearward	+	+
	Fy	Move tibia down, femur up	+	+
	Mx	Rotate ankle left, hold knee	+	+
	My	Rotate ankle up, hold knee	+	+
Lower Tibia Load Cell[c]	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	NA	+
Ankle Rotation	θx	Hold tibia, rotate foot leftward	NA	+
	θy	Hold tibia, rotate foot upward	NA	+
	θz	Hold tibia, rotate foot CW	NA	+
Foot Acceleration	Ax	Rotate dummy back (face up)	+	+
	Ay	Rotate dummy left (right side up)	+	+
	Az	Rotate dummy back (face up)	+	+

NA = Not Applicable
[a] = As seen from above, looking down
[b] = Tri-pack refers to three uniaxial accelerometers mounted onto a tri-pack block (T1INM130)
[c] = Output polarity has been adjusted to conform to SAE-J211

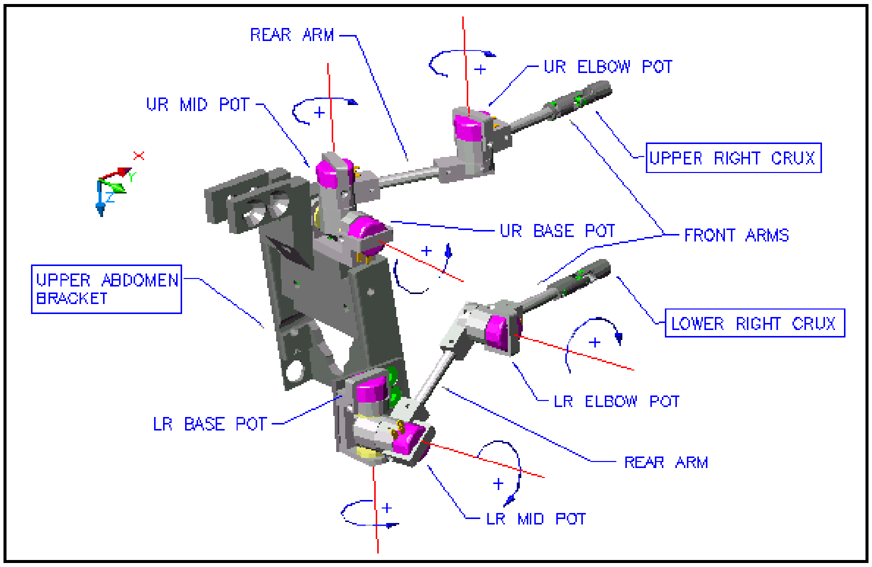

Figure 15.5- Thor polarity for UR and LR Cruxes

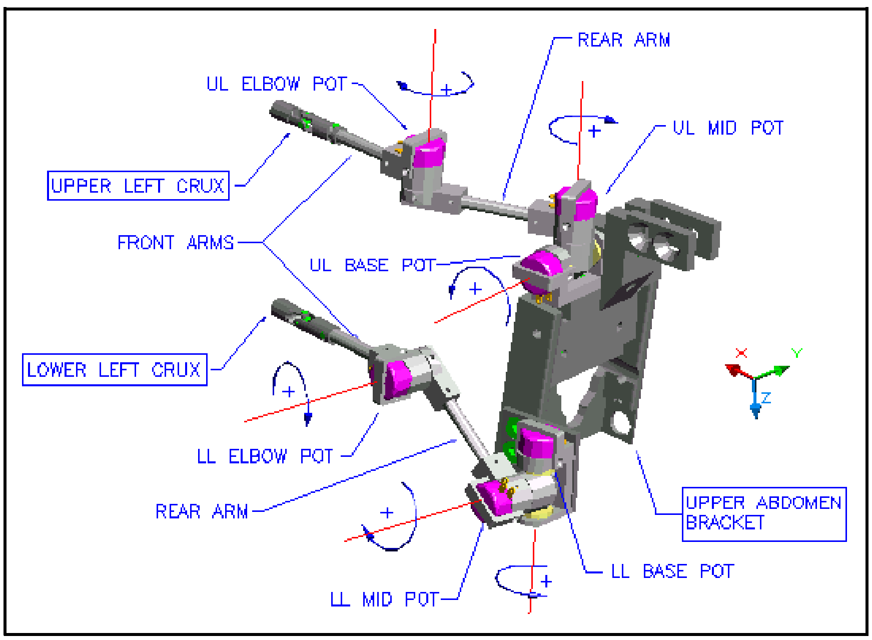

Figure 15.6- Thor polarity for UL and LL Cruxes

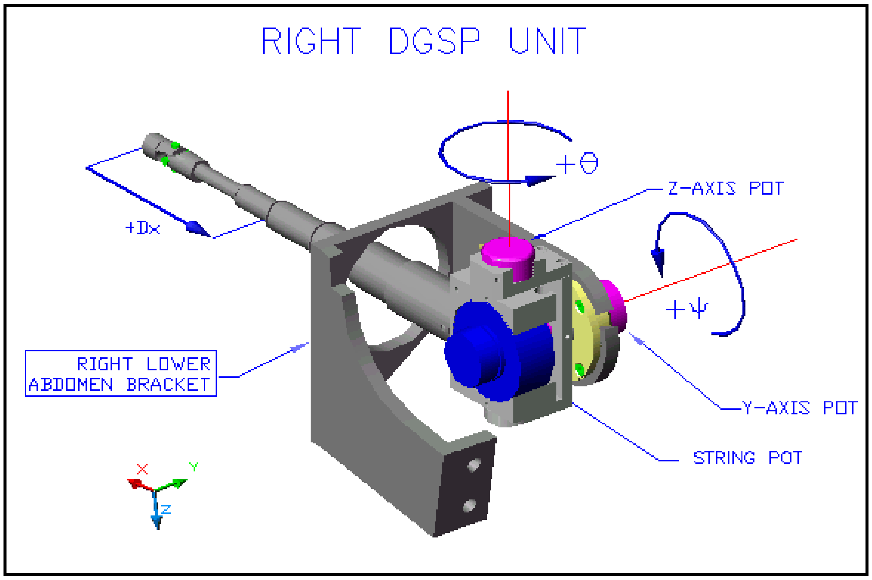

Figure 15.7- Thor polarity for right DGSP unit

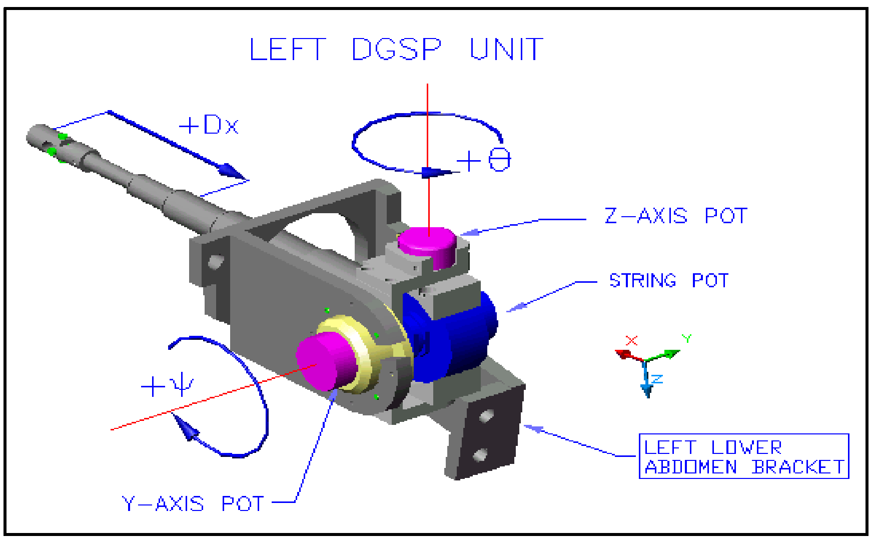

Figure 15.8- Thor polarity of left DGSP unit

15.8 THOR Instrumentation - Sensor Evaluation Device (SED)

A hand-held sensor evaluation device (SED) has been designed for use with the THOR dummy. The SED is typically supplied with leased dummies, and is available for purchase as an accessory for commercial sales. This device helps to identify trouble with the instruments and wiring in a laboratory setting. The device was constructed to operate at 120 V AC power, and is designed for use with standard LEMO connectors provided on the leased THOR dummies. Adaptor cables are available for connecting the commercial THOR units to the laboratory's preferred connector system. The SED panel is shown in **Figure 15.9.**

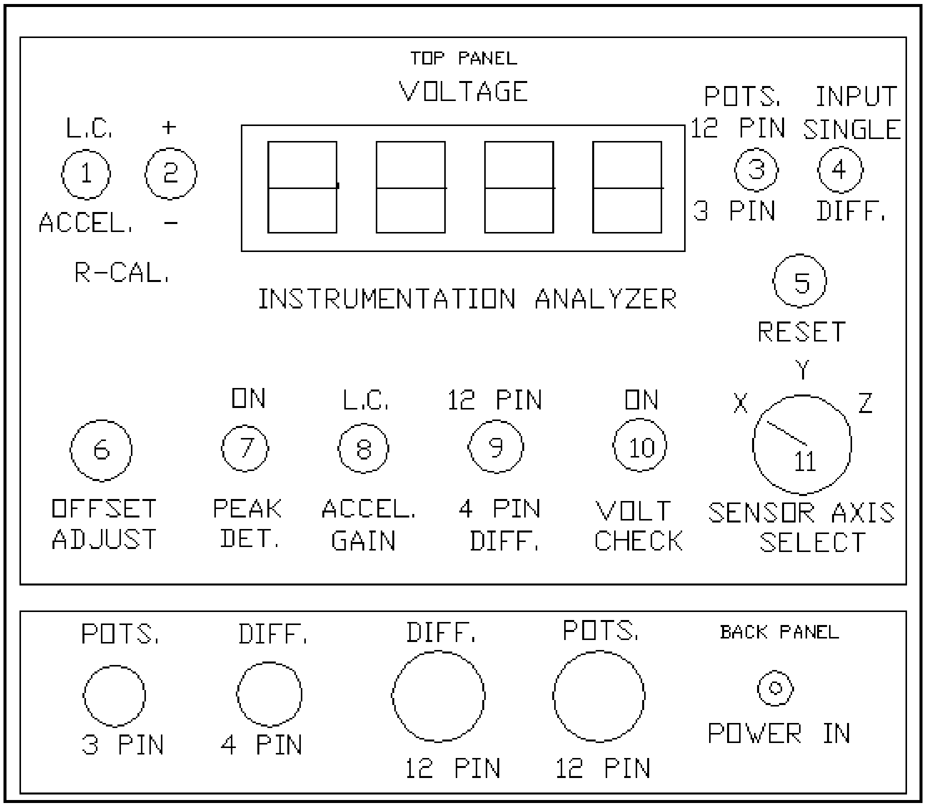

Figure 15.9- Sensor Evaluation Device (SED) panel

The following procedure details the use and function of the SED.

1. Applying Power: The instrument may be powered using the 120 volt AC to 15 volt DC wall adapter, or using the banana plug adapter cable, connect the instrument to 15-18 volt DC from a DC power supply. Allow a 5-10 minute warm-up period for best results.

2. Excitation Voltage: First, ensure the calibration toggle switch #2 is in the center (OFF) position, and that the peak detector toggle switch #7 is in the down (OFF) position.   The sensor bridge excitation voltage may be checked by placing toggle switch #10 in the up (ON) position. After the warm up-period, the display should read 10.00 ± .02 volts D.C. max. Switch #10 should normally be in the down (OFF) position.

3. Load Cells: To qualitatively check load cells, first place toggle switch # 9 in the position for a 4-pin or 12-pin connector after inserting the LEMO plug into the differential socket on the rear panel; be sure you are not in the 12-pin potentiometer LEMO socket if testing a tri-axial unit (see diagram on back).   Also, ensure the calibration toggle switch #2 is in the center, OFF, position, and that switch #7 is in the down (OFF) position. Make sure Toggle switch #4 is in the DIFF. (Differential)Position. The three- position rotary switch #11, alternately selects theX, Y, or Z axis. First, place toggle switch #8 in the UP position for load cell gains

and then adjust the output voltage to a nominal 5.00 volts DC using the offset rotary potentiometer, #6. Next, activate the peak detector circuit by placing toggle switch #7 in the on (UP) position. The voltage display may read a voltage greater than 5 volts so reset the circuit by depressing momentary reset switch #5. The display voltage will then drift toward 5 volts. Apply a moderate force or torque to the load cell and observe a significant voltage change on the output display. If the display does not change more than a few tenths of a volt, repeat applying a larger force. If the voltage still does not change significantly, the sensor may not be functioning correctly.

4. <u>Accelerometers:</u> After plugging in the LEMO to the appropriate 12-triaxial or 4-pin uniaxial rear panel connector, select the 4- or 12-pin position with toggle switch #9. Put toggle switch #8 in the accelerometer (DOWN) position. Ensure switch #2 is in the center (OFF) position and that the peak detector, switch #7, is OFF. Toggle switch #4 should again be set to the DIFF position. Adjust the output to a nominal 5 volts D.C. using the offset adjust rotary potentiometer #6. Turn on the peak detector circuit, switch #7 and reset any residual voltage using the reset button #5. Apply a significant acceleration to the sensor in the direction of sensitivity and observe a significant voltage change on the output. If the display does not change more than a few tenths of a volt apply a larger acceleration. If the voltage still does not change more than a few tenths of a volt, the sensor may be defective.

5. <u>Potentiometer Sensors:</u> Potentiometers should use the 12-pin Pot connector or the single 3-pin Pot connector on the back panel. Again, make sure toggle switch #2 is in the center, OFF, position and that the peak detector circuit is OFF, with toggle switch #7 down. Select switch #3 for 3- or 12-pin connectors, and place toggle switch #4 in the <u>Single</u>-ended UP position. The output voltage display will read the wiper voltage of the potentiometer in volts. Because the Pots signals are not amplified, there will be no need to use the offset adjust. Varying the post of the dummy part on which the sensor is mounted will change the output voltage from ground to 10 volts DC.

6. <u>Calibration:</u> The calibration function applies a resistive shunt between the positive and negative voltage and the positive bridge output. Set both switches #1 and #8 to the load cell or accelerometer position. Turn off the peak detector switch, #7. Adjust the output voltage to a nominal 5 volts DC output using the offset adjust, #6. Push toggle switch #2 to the UP position, observe a voltage increase of several volts, and record the reading. Next, push switch #2 to the DOWN position and record the decreased voltage reading. A perfectly balance bridge should be displaced by the same voltage in each direction. If the voltage is highly non-symmetric about the 5 volt value, the bridge could be outside of its specification tolerance. The instrument gains for the load cell and accelerometer switch positions are 5741.1 and 147.9 respectively. The shunt resistors for the load cell and accelerometer positions are 3.34 Meg. and 99.14K ohms respectively. Knowing the sensor sensitivity and shunt resistor loading from the sensor data sheet, the actual expected R-Cal offset voltage may be calculated.

15.9 Tilt Sensors and Readout Display

In the past, one of the most difficult problems with automotive crash testing has been the difficulty in reproducing the desired initial position of the dummies within the automobile. The task of positioning the THOR dummy within the test environment has been greatly simplified with the incorporation of five tilt sensors into the THOR dummy. One sensor has been mounted to each of the following segments of the dummy: the pelvis, the lumbar spine, the lower thoracic spine, the neck, and the head. These tilt sensors are used to provide a complete electronic orientation of the dummy's posture before and after the crash testing.

The tilt sensors must be installed into their mounting brackets with the proper orientation so the angular orientation of the components will be correctly displayed on the tilt sensor readout. Each tilt sensor is marked with a vertical line on the outside of the sensor housing. The tilt sensor must be positioned so this vertical line is toward the front (anterior) of the dummy. On each of the tilt sensor housings, there is a scribed line on the top surface to aid in aligning the vertical line on the tilt sensor with that the line on the tilt sensor housing. The tilt sensors have been correctly positioned within their mounting brackets during the initial assembly of the dummy at GESAC. However, if it becomes necessary to remove the sensors from their brackets, it will be necessary to align the tilt sensors correctly during the reassembly.

During the positioning of the dummy within the automobile, each of the five tilt sensors are connected to a hand-held display. The tilt sensor display has been designed to accept the LEMO connectors directly from the five THOR tilt sensors. Each LEMO receptacle has been labeled for a particular tilt sensor. The calibration for each tilt sensor is stored in the tilt sensor display for a specific tilt sensor therefore the correct LEMO must be plugged into the correct receptacle.

This display features an analog angle-conversion module and additional circuitry to convert the voltage output from the tilt sensor module to a display of the various angles in degrees. This tilt sensor unit was designed to make the task of repetitive dummy posture set-ups much easier. If the dummy is set into an initial desired posture - and the values for the various tilt sensors are recorded, then it is very easy to ensure that the same posture is used in a later test by positioning the dummy to obtain the same tilt sensor measurements. The tilt sensor wires are disconnected from the hand-held display prior to running the impact test. The use of the hand-held display is outlined in the process below.

1. Connect the five tilt sensor wires from the THOR dummy to the appropriate receptacle at the back of the hand-held display, as shown in **Figure 15.10**. (Note: All tilt sensor wires are marked with a yellow character in the marking strip to make identification easier.) Refer to the list below for the tilt sensor readout display instrumentation receptacle numbering scheme.

Sensor Wire Label	Tilt Sensor Readout Display Label
T{Yellow}HEAD	CH 0
T{Yellow}NECK	CH 1
T{Yellow}LTS	CH 2
T{Yellow}LUM	CH 3
T{Yellow}PEL	CH 4

Figure 15.10- Connecting tilt sensors to the display

2. Operate the tilt sensor readout display on a 9 V DC nominal power supply.

3. Press the power toggle switch, located at the front of the unit, to the "on" position. Rotate the centrally located knob to view the desired tilt sensor response. The tilt sensor numbering scheme for the various knob positions is the same as the instrumentation receptacle numbering scheme as described above. A picture of the front of the tilt sensor readout display is shown in **Figure 15.11**.

Figure 15.11- Front-view of tilt sensor readout display

NOTE: The tilt sensor readout display shows the rotation about the X and Y axis of the particular dummy component simultaneously.

4. Read the displayed angles (X and Y angular orientation) for all five tilt sensors and record for future reference. This information will provide a reference which can be used to correctly position the dummy for future tests.

NOTE: The angle values produced by the tilt sensor display are absolute. It measures the angle of the particular dummy component relative to ground.

Section 16 - CRUX Units

16.1 CRUX Units Description and Features

This section is intended to familiarize the user with the chest deflection measurement system which GESAC has developed for the THOR dummy. This instrumentation is known as the CRUX System - Compact Rotary Unit. Four CRUX units are used in the thorax of the THOR dummy to measure the three-dimensional deflection time histories at four distinct points of the rib cage. This measurement system is basically a two-bar linkage which features three measured degrees of freedom to provide a complete three-dimensional measurement at the end of the unit. The unit is attached to the rib of the dummy with a universal joint, which also provides three additional mechanical degrees of freedom. The measurement of the position of the unit is made with respect to the base and the center of the universal joint. **Figure 16.1** shows a detail drawing of the various parts of a CRUX unit for reference. The CRUX base is attached to the thoracic instrumentation bracket which bolts to the spine assembly. The U-joint assembly is mounted to the front of the thorax assembly and attaches to the bib and ribs.

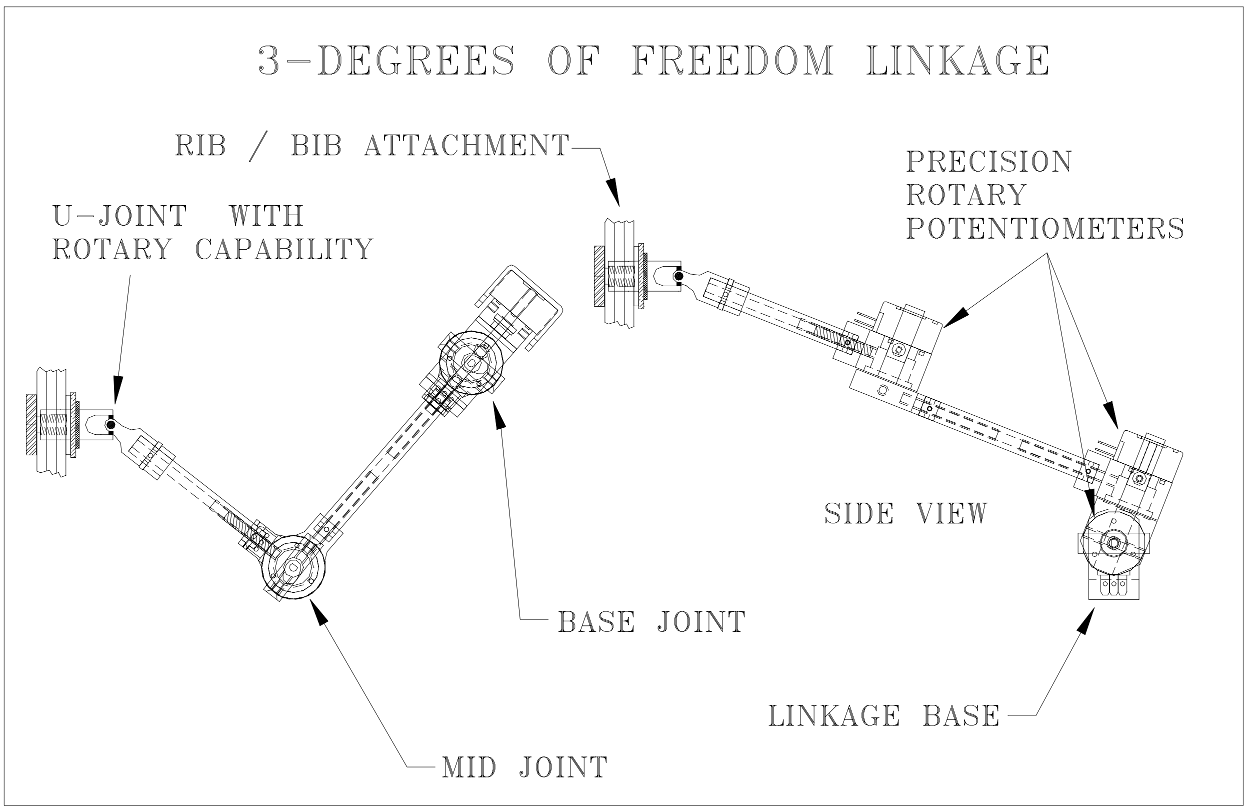

Figure 16.1- CRUX assembly

The CRUX system uses three precision rotary potentiometers to measure the position of the various link-arms. These potentiometers feature 0.25% linearity and 315 degrees of allowable rotation. The potentiometers have stops which prevent full rotation, thus it is necessary to set up the units for either the right- or left-hand side of the thorax.

WARNING: It is possible to damage the potentiometers of the CRUX unit with improper handling. Each unit is unique and is designed for a very specific range of motion. If the units are removed from the dummy, **the arms should not be rotated**. Keep the unit in the installation position.

These units have been designed and calibrated for a 10.0 V DC excitation. (Note: If a different excitation voltage is required for a specific testing application, contact GESAC and request the appropriate units. It is possible to provide custom calibrated units which can be calibrated for any DC excitation between five and twelve volts to allow for variations in excitation voltage at different testing facilities. It is necessary to match the excitation voltage used during testing with the excitation voltage used during calibration.)

The CRUX units are calibrated prior to insertion within the dummy thorax. Once the calibration has been performed, the unit may be inserted into the thorax and tested up to 25 times before recalibrating. (Note: If damage or suspicious output is discovered at any time during the testing, the units should be recalibrated.) During the calibration procedure, the output voltage from each of the three potentiometers is measured and recorded for various angular orientations of the unit. This calibration information is used to define the calibration and setup variables in the input parameter file to be used with the THORTEST software program. During impact testing, the output voltages from each of the three potentiometers are recorded with a data acquisition system. This data is processed post-test using the THORTEST program to convert the output voltages into actual three-dimensional coordinates (X, Y, Z displacement). Thus the initial, dynamic, and final positions of the unit can be determined directly from the potentiometer output voltage signals.

The CRUX units attach to the mounting plate of the upper abdomen assembly and feature a highly modular design. They can be inserted and removed from the thorax easily, with minimal disassembly of the spine or ribcage. Additional information in the CRUX assembly and disassembly can be found in Section 7 - Thorax and 9 - Upper Abdomen. In addition, the units themselves are modular, making it very simple to replace any parts that are damaged during testing.

16.2 Assembling CRUX Units

16.2.1 Parts List

The parts list and all quantities for the CRUX assembly are listed in Appendix I - Bill of Materials under the CRUX subsection. Refer to drawing T1CXM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 16.2** is a photograph of the exploded CRUX units and mounting hardware.

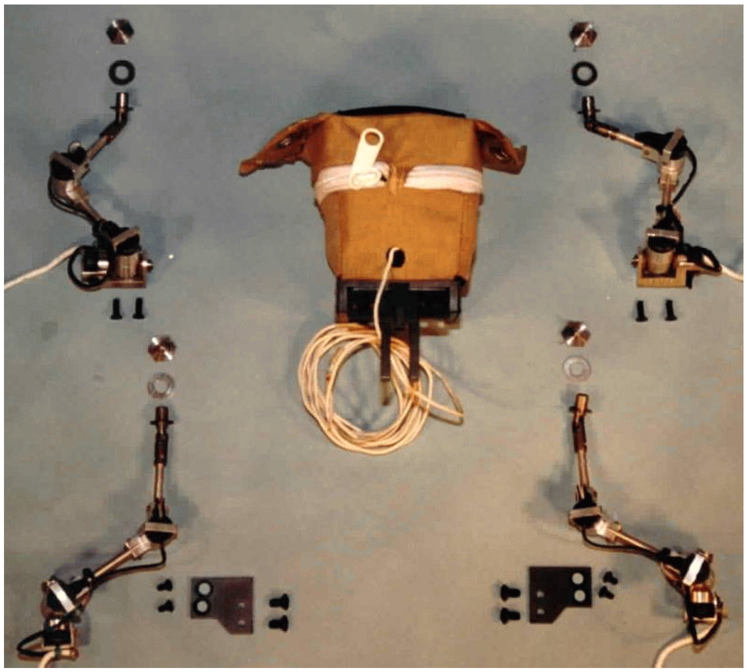

Figure 16.2- Exploded CRUX assembly

16.2.2 Attaching CRUX Units to the Upper Abdomen Assembly

The following procedure is a step-by-step description of how to mount the four CRUX units to the completed upper abdomen assembly. After the units have been attached to the thoracic instrumentation bracket, the bracket assembly will be ready for insertion into the THOR dummy. The numbers noted in ( ) refer to a specific drawing / part number for each part. The numbers noted in the { } indicate the hex wrench size required to perform that assembly. All bolts should be tightened to the torque specifications provided in Section 2.1.3.

1. Mount the Upper Right CRUX Unit (T1CXM001) onto the top right-side of the thoracic instrumentation bracket on the Upper Abdomen Assembly (T1UAM000) using two #10-24 x 5/8" FHSCS {1/8}, as shown in **Figure 16.3**. The base pot should be oriented to the right, away from the center of the bracket assembly as shown.

NOTE: The orientation of these units is essential, they must be positioned exactly as shown in the supplied photographs.

Figure 16.3- Upper Right CRUX installed

2. Mount the Upper Left CRUX unit (T1CXM002) onto the top left-side of the thoracic instrumentation bracket using two #10-24 x 5/8" FSHCS {1/8}, as shown in **Figure 16.4**. The base potentiometer should be oriented to the left, away from the center of the bracket assembly as shown.

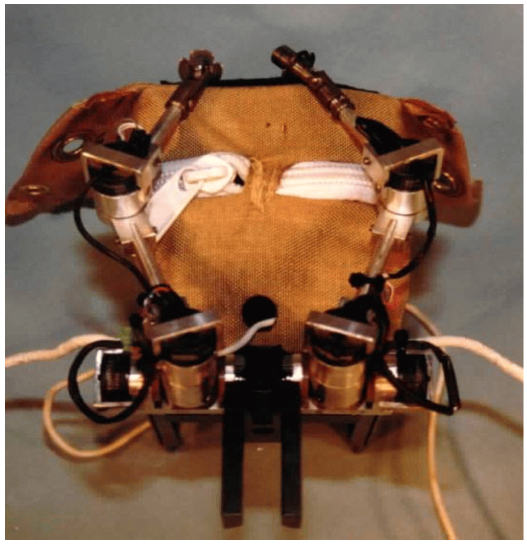

Figure 16.4- Upper Left CRUX installed

3. Mount the Lower Right CRUX Unit (T1CXM003) to the Lower Right CRUX Mounting Bracket (T1CXM400) using two #10-24 x 3/8" FSHCS {1/8}, as shown in **Figure 16.5**. The lower right CRUX mounting bracket is stamped with the letter R. When this piece is held so the stamp is readable, the piece is oriented correctly. The CRUX base should be mounted to the stamped side of the bracket. The flat heat bolts should fit into the countersunk holes in the mounting bracket. The base pot of the CRUX unit should be oriented so it points in the upward direction as shown.

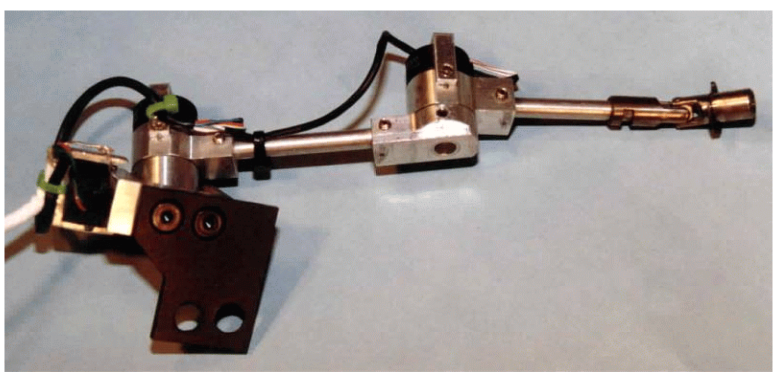

Figure 16.5- Lower Right Mounting Plate attached to Lower Right CRUX unit

4. Mount the Lower Left CRUX Unit (T1CXM004) to the Lower Left CRUX Mounting Bracket (T1CXM401) using two #10-24 x 3/8" FSHCS {1/8}, as shown in **Figure 16.6**. The lower left CRUX mounting bracket is stamped with the letter "L". When this piece is held so the stamp is readable, the piece is oriented correctly. The CRUX base should be

mounted to the stamped side of the bracket. The flat heat bolts should fit into the countersunk holes in the mounting bracket. The base pot of the CRUX unit should be oriented so it points in the upward direction.

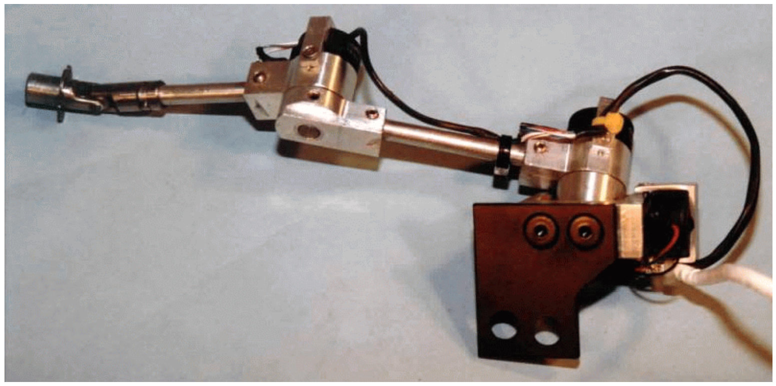

Figure 16.6- Lower Left Mounting Plate attached to Lower Left CRUX unit

5. Position the lower right CRUX / mounting bracket assembly on the right side of the upper abdomen assembly. Mount this bracket assembly using two 1/4-20 x 3/8" FHSCS {5/32}, as shown in **Figure 16.7**. The bolts should pass through the countersunk holes in the CRUX mounting bracket, through the upper abdomen internal mounting plate and into the upper abdomen spinal mounting bracket.

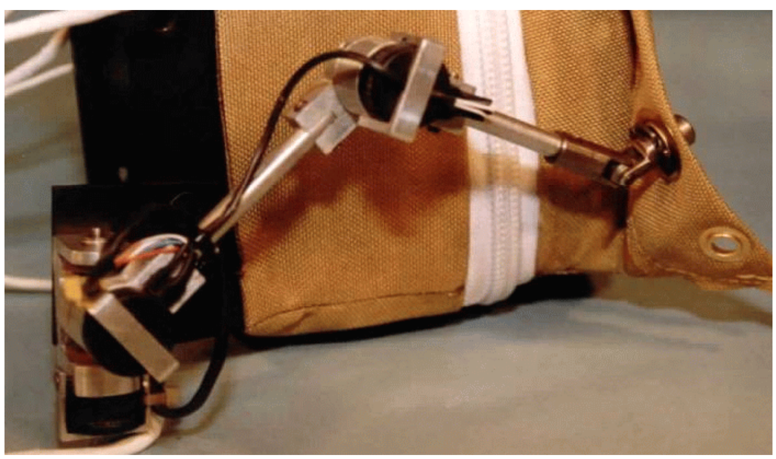

Figure 16.7- Lower Right CRUX installed

6. Position the lower left CRUX / mounting bracket assembly on the left side of the thoracic instrumentation bracket. Mount this bracket assembly using two 1/4-20 x 3/8" FHSCS {5/32}, as shown in **Figure 16.8**. The bolts should pass through the countersunk holes in the CRUX mounting bracket, through the upper abdomen internal mounting plate and into the upper abdomen spinal mounting bracket.

Figure 16.8- Lower Left CRUX installed

7. Secure the CRUX wires to the upper abdomen assembly with a 1/4-20 x ½" BHSCS {5/32} and a 1/4" nylon cable clamp on each side, as shown in **Figure 16.9**. These bolts are fastened through the top mounting hole of the upper abdomen assembly.

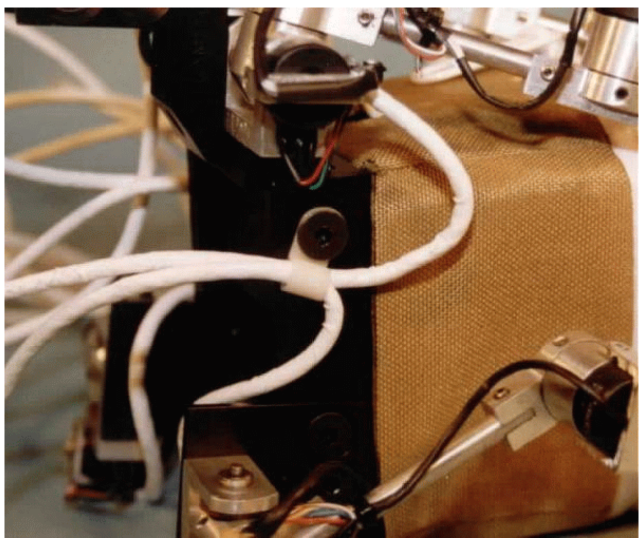

Figure 16.9- Wire strain relief location

16.2.3 Installing the Completed CRUX Bracket Assembly into the THOR Dummy

The following procedure is a step-by-step description of how to install the completed CRUX upper abdomen / CRUX assembly into the THOR dummy. The numbers noted in { } indicated the Hex wrench size required to perform that assembly step. All of the bolts in this assembly should be tightened securely.

1. Position the two tabs of the upper abdomen assembly over the lower thoracic spine weldment, and align the holes as indicated in **Figure 16.10**.

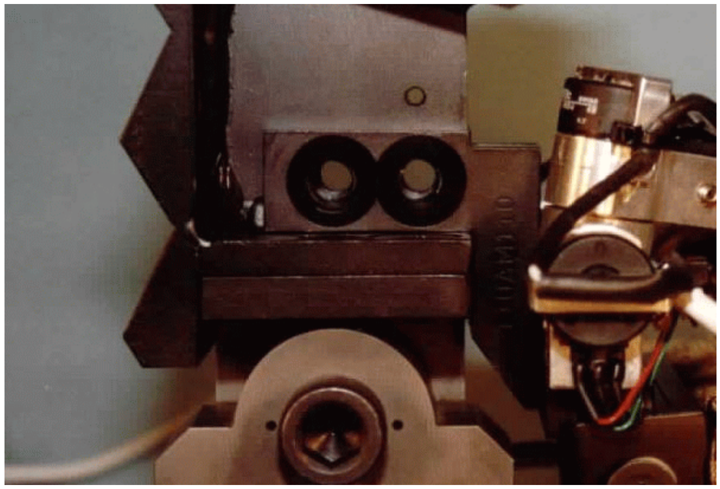

Figure 16.10- Proper hole alignment

WARNING: The bracket assembly must be inserted very carefully into the dummy to avoid damage to the instrumentation wiring. The lower thoracic tilt sensor wire is especially susceptible to damage during this procedure.

2. Secure the spinal mounting bracket of the upper abdomen assembly to the lower thoracic spine weldment placing two 5/16-18 x 1" FHSCS {3/16} into the two mounting holes in the spinal mounting bracket arms from the right side, as shown in **Figure 16.11**. The bolts should be inserted from the right hand side of the dummy and pass through one tab of the thoracic instrumentation bracket, through the holes in the lower thoracic spine weldment and thread into the other tab of the thoracic instrumentation bracket.

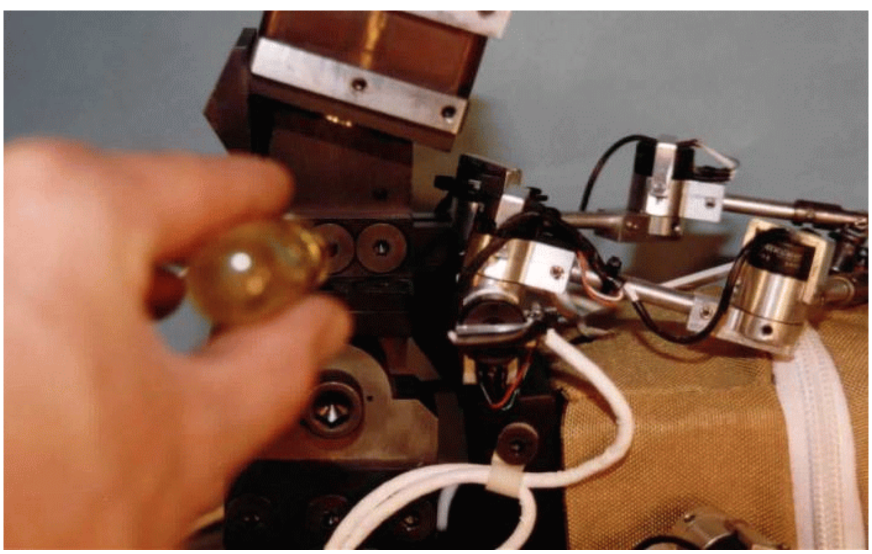

Figure 16.11- Upper Abdomen mounted to Spine

3. Continue by following the procedure outlined in Section 7.2.2 - Assembling the Thorax.

16.3 Adjusting the CRUX Units

The only adjustment required for the CRUX units is to ensure that the U-joint has been positioned in the middle of its rotational range of motion during the installation. The U-joint was designed for limited rotation on the end of the CRUX arm, and it should be set to the middle of this rotation range during installation, as shown in **Figure 16.12**. The position of the U-joint should be verified with a visual inspection.

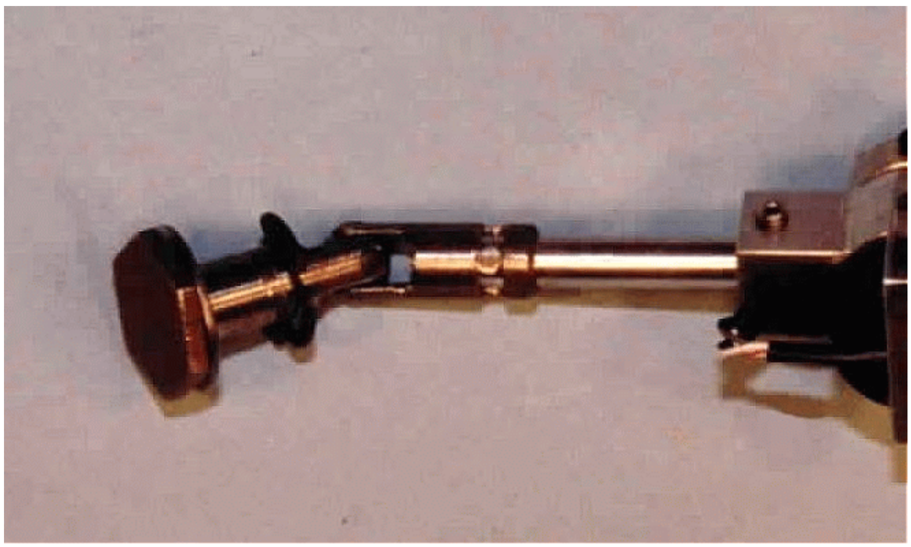

Figure 16.12- U-Joint centered in its range of motion

NOTE: A simple way of setting the U-joint in the middle of its range of motion is to tighten the CRUX rib connecting bolt using a 3/4" wrench until contact is felt. The U-joint will be at one end of its range of motion. Turn the rib bolt counterclockwise slightly, causing the U-joint to rotate on the CRUX arm until the U-joint is centered. The position of the U-joint must be verified visually.

16.4 Electrical Connections and Requirements

16.4.1 Wire Routing

The wire routing for the four CRUX units is very critical since the wires must be secured away from any moving parts within the thorax assembly. The proper routing for the instrumentation wires from each unit is described below. The wire routing is also depicted in **Figures 16.13** and **16.14.**

<u>Upper Right CRUX Uni</u>t: This wire is bundled with the lower right CRUX wire and is secured to the right side of the upper abdomen plate. The wire from this unit must run down along the rear of the spine assembly on the right-hand side. This wire must exit below rib #7 to join the wire bundle.

<u>Upper Left CRUX Unit</u>: This wire is bundled with the lower left CRUX, the mid-sternal uniaxial accelerometer, and the upper abdomen uniaxial accelerometer, and is secured to the left side of the upper abdomen plate. The wire from this unit must run down along the rear of the spine assembly on the left-hand side. This wire must exit below rib #7 to join the wire bundle.

<u>Lower Right CRUX Uni</u>t: This wire is bundled with the upper right CRUX wire and is secured to the right side of the upper abdomen plate. The wire from this unit should run parallel to the wire from the upper right unit and exit in the same location.

<u>Lower Left CRUX Unit</u>: This wire is bundled with the upper left CRUX, the mid-sternal uniaxial accelerometer, and the upper abdomen uniaxial accelerometer, and is secured to the left side of the upper abdomen plate. The wire from this unit should run parallel to the wire from the upper right unit and exit in the same location.

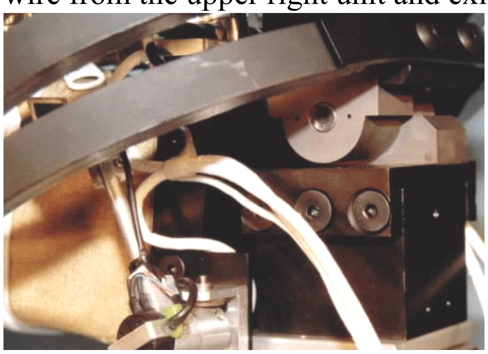

Figure 16.13- Left side wire routing

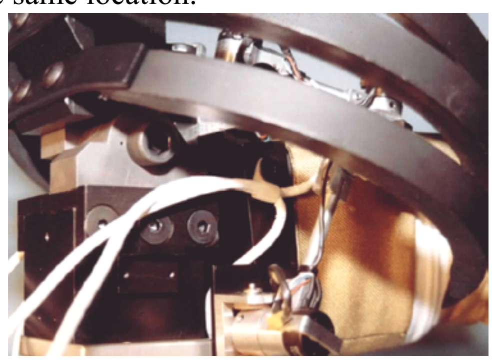

Figure 16.14- Right side wire routing

16.4.2 CRUX Unit Electrical Connection

Each CRUX unit is wired at GESAC with a 15' multi-conductor instrumentation wire. Depending on the dummy application, this wire may be terminated with a set of three high quality, four-pin LEMO connectors fully shielded, for the dummies that are on lease. The dummies that are commercially sold usually have a bare wire end.

On the leased dummies, the wires have been broken out into three bundles and the connector wires have wire color coding as described in Section 15 - Instrumentation and Wiring. **Table 16.1** shows the wiring code for the commercially sold products.

Table 16.1

Wire Color	Function
Red	Pot #1: +Excitation
Black	Pot #1: Ground
Green	Pot #1: Output
Orange	Pot #2: +Excitation
Black Stripe	Pot #2: Ground
Blue	Pot #2: Output
Red Stripe	Pot #3: +Excitation
Gray	Pot #3: Ground
White	Pot #3: Output

The potentiometers from the CRUX units are designed to be measured as a referenced single-ended channel configuration in which the + Signal lead is connected to a HI input channel of the data acquisition system. The data acquisition system is then configured as a referenced single-ended input to measure the voltage difference between the HI channel input and the ground reference. The CRUX multi-conductor wire is shielded to prevent cross-talk with other instrumentation. The recommended excitation voltage for the CRUX units is 10.00 V DC. Under normal operation conditions, the output signal from any of the three potentiometers should be between 0 and 10 volts DC. A simple voltage check may be used to determine if the potentiometers are outputting a voltage in the expected range of 0 to 10 V DC.

WARNING: The output voltage from the rotary potentiometers should never actually read 0.0 or 10.0 volts. Readings of exactly 0.0 or 10.0 indicate the potential existence of a short in the signal wire to either ground or + Excitation.

The CRUX units are designed to be removed and assembled as a complete unit. The disassembly of the individual components which make up a complete CRUX assembly is beyond the scope of this manual. The electrical connections and wiring for the CRUX units are performed during the assembly of the unit at GESAC. It is HIGHLY RECOMMENDED that the CRUX units experiencing electrical problems be returned to GESAC for repair. The following description of the CRUX unit wiring is provided as a reference and guide for test facilities wishing to attempt repair of these units themselves.

If a wire from a potentiometer should break or become disconnected, it is necessary to clean the contact and resolder the wire. (Note: A small piece of heat shrink tubing should be placed over the wire before reconnecting so the joint may be sealed after the repair is finished.) The correct orientation of the wires on the units can be obtained by holding the potentiometer so the top is facing upward and the side with the electrical contacts is visible. The contact on the right (as viewed) is ground, the contact on the left (as viewed) is positive excitation and the central contact is the output signal. This is shown in **Figure 16.15** below. Once the broken wire has been repaired, the heat shrink tubing should be positioned over the soldered joint, and heated with a hot-air gun to secure it in place.

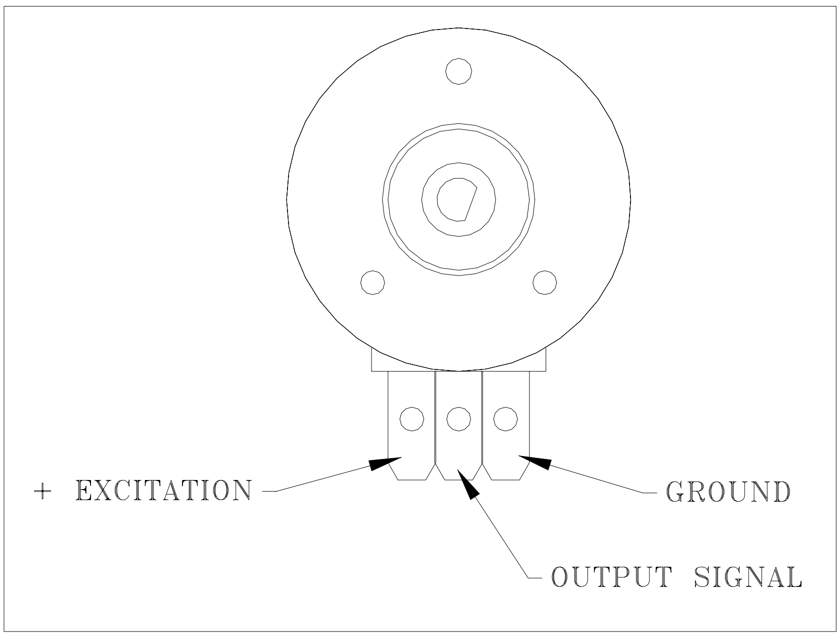

Figure 16.15- Potentiometer contact description

16.5 CRUX Measurement System Calibration

Prior to installing the CRUX units into the thorax assembly, each unit must be calibrated to determine the output voltage for various angular orientations. The calibration of these units is most easily performed on the CRUX Calibration Fixture (T1CME100) which is available for purchase from GESAC. This fixture was designed to accurately position the CRUX unit into several predefined orientations. The voltage output from each of the potentiometers is measured and recorded for each position to provide an accurate calibration. These voltage outputs are correlated with the known angles of the calibration plate and the calibration factor (mV/deg) and initial offset are calculated for use in the THORTEST. Each CRUX unit is calibrated by GESAC upon initial assembly, and may be returned to GESAC for recalibration at any time. It is recommended that the unit be recalibrated after 25 tests have been conducted.

The calibration procedures for the CRUX units are described in the THOR Calibration Manual, which is available from GESAC as a separate publication.

NOTE: If at any time during the testing the output of the CRUX units reaches the level of 0.00 (ground) or 10.0 (+excitation), or if the units have physical damage, the units should be removed, inspected,and recalibrated.

16.6 Inspection and Repairs

After a test series has been performed, there are several inspections which may be made to ensure the dummy's integrity has remained intact. Use good engineering judgement to determine the frequency of these inspections; however, GESAC recommends a thorough inspection after twenty tests have been performed. Inspection frequency should increase if tests are particularly severe or if unusual data signals are being recorded. Both electrical and mechanical inspections are most easily carried out during a disassembly of the dummy. Disassembly of the CRUX units from the dummy and upper abdomen assembly can be performed by simply reversing the assembly procedure. Some comments are provided below to assist in this process.

16.6.1 Electrical Inspections (Instrumentation Check)

Begin with the visual and tactile inspection of all instrument wires. Wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure they are properly strain relieved. A more detailed check of the individual instruments is covered in Section 15- Instrumentation and Wiring.

16.6.2 Mechanical Inspection

The CRUX units will require a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact GESAC regarding questions about items that fail the mechanical inspection.

<u>CRUX Units:</u> The following checklist should be used when inspecting the CRUX units for post-test damage:

- Check tightness of rib / bib connection bolts and CRUX rib connection bolts
- Check that U-joints for CRUX units are still positioned in the middle range of their allowable rotation.

In addition, a more detailed inspection can be conducted if the units are removed. (Removal is not recommended unless a problem is suspected.)

1. Inspect the universal joint end to ensure it moves freely and has free rotation about the end of the CRUX shaft. (Note: The rotation is limited by a pin, but the motion should be smooth and require little effort.)

WARNING: The potentiometers feature built in stops to prevent over rotation - do not force the unit past these stops. The potentiometers will have severe damage if the units are rotated past their designed range of motion.

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2. Inspect the three joints of the CRUX units to ensure that the motion of the joints is free and smooth. (**Note:** The potentiometers have built in stops that prevent the units from rotating 360 degrees.)

3. Inspect the potentiometers and joints for physical damage which may indicate contact between the CRUX units and another assembly within the thorax.

4. Inspect the two arms of the CRUX units for rotation where they attach to the joints. No rotation should be possible at these connection points. The only allowable rotation occurs at the universal joint.

5. Inspect the two arms of the CRUX units for physical damage. Bent or twisted arms may indicate a problem with the installation or orientation of the unit within the thorax.

6. Inspect the wiring for physical damage including broken connectors, pinched wires, missing insulation, etc.

If damage is found during the inspection of the CRUX units, the damaged unit should be returned to GESAC for repair or replacement. Due to the complicated nature of the CRUX units, the disassembly and repair of the individual components of each CRUX are beyond the scope of this manual. Contact GESAC's Engineering Department if further disassembly or inspection is required.

Section 17 - Double Gimbaled String Potentiometer (DGSP) Units

17.1 DGSP Unit Description and Features

The lower abdominal component uses two devices to measure the penetration of the abdomen. These deflection devices are referred to as double gimbaled string potentiometer (DGSP) sensors. The individual sensors on the DGSPs allow measurements of linear displacement along the axis of the telescopic columns, and rotations around two orthogonal axes. These three degrees of freedom are used for determining the three-dimensional coordinates of the telescope's end point. Connected to a high-speed data acquisition system, the instrumentation can be used to record the time history of an abdominal penetration during an impact test.
Figure 17.1 shows a detail drawing of the various parts of a DGSP unit for reference. The DGSP base is attached to the lower abdomen mounting bracket which bolts to the spine assembly. The DGSP U-joint assembly is mounted to the front of the lower abdomen assembly.

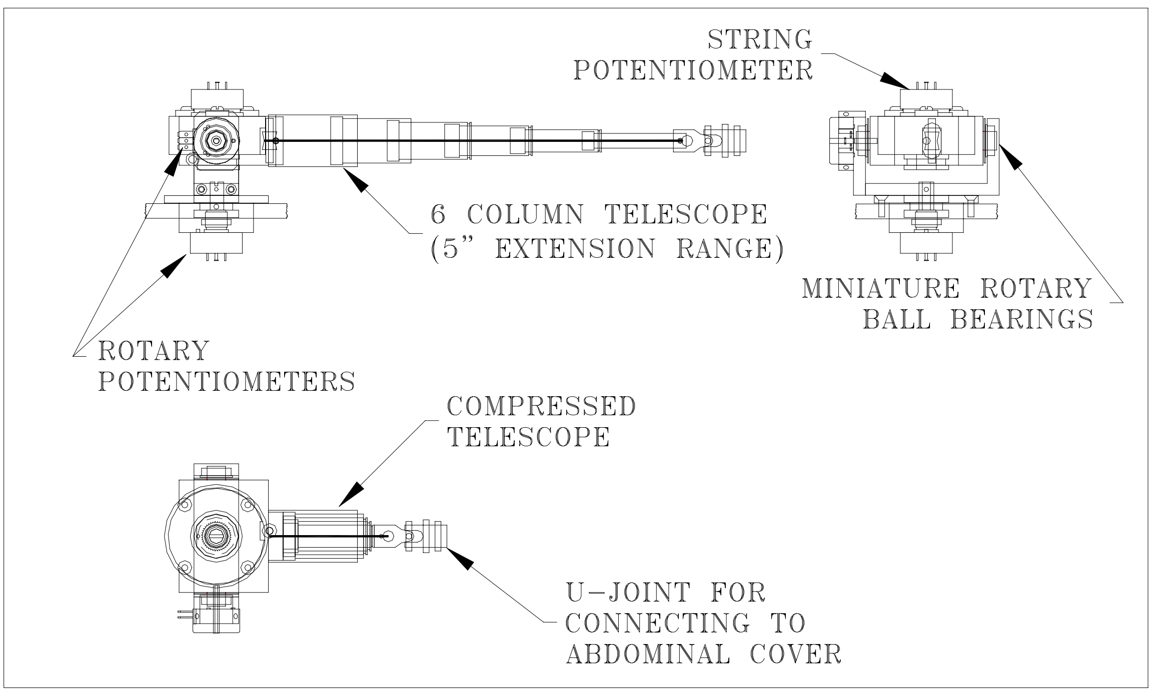

Figure 17.1- DGSP assembly

The DGSP sensor includes a string transducer and two rotary potentiometers. The string transducer measures the rotation of a drum as the cable coils and uncoils. The cable's inherent lack of rigidity required a series of telescoping columns. The columns reduce the cable's motion to a linear travel. The telescope and the potentiometer are assembled together and mounted on a double-gimbaled yoke. Two rotary potentiometers mounted in the gimbals measure the rotations of the orthogonal axes. The translational and rotational freedom of the yoke allows the end point of the telescope to sweep through a large volume of three-dimensional space.

The DGSP units are calibrated prior to insertion within the dummy's lower abdomen. Once the calibration has been performed, the unit may be inserted and tested up to 25 times before recalibrating. (Note: If damage or suspicious output is discovered at any time during testing, the units should be recalibrated.) During the calibration procedure, the output voltage from each of the three potentiometers is measured and recorded for various angular orientations of the unit. This calibration information is used to define the calibration and setup variables in the input parameter file to be used with the THORTEST software program. During impact testing, the output voltages from each of the three potentiometers are recorded with a data acquisition system. This data is processed post-test using the THORTEST program to convert the output voltages into actual three-dimensional coordinates (X, Y, Z displacement). Thus the initial, dynamic, and final positions of the unit can be determined directly from the potentiometer output voltage signals.

17.2 Assembling DGSP Units

17.2.1 Parts List

The parts list and all quantities for the DGSP assembly are listed in Appendix I - Bill of Materials under the DGSP subsection. Refer to drawing T1DPM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 17.2** is a photograph of the exploded DGSP units and mounting hardware.

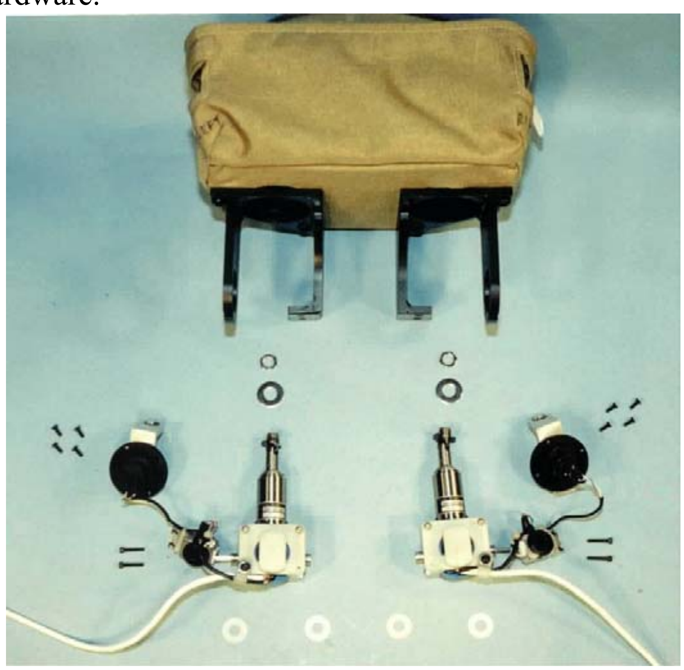

Figure 17.2- Exploded DGSP assembly

17.2.2 Attaching DGSP Units to the Lower Abdomen Assembly

The following assembly procedure is a step-by-step description of how to attach the two DGSP units to the completed lower abdomen assembly. After the units have been assembled onto the lower abdomen mounting bracket, the lower abdomen assembly will be ready for insertion into the THOR dummy. The numbers noted in ( ) refer to a specific drawing / part number for each part. The numbers noted in the { } indicate the hex wrench size required to perform that assembly step. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values.

1. Check the DGSP units for calibration date. If a calibration is due, the units must be calibrated prior to assembly. The calibration procedure is outlined in Section 17.5.

NOTE: The DGSP units must be calibrated prior to insertion in the lower abdomen assembly.

---

2. Identify the left and right DGSP units, noting that the left and right units are assembled differently. The difference relates to the position of the rotary potentiometer #2 in the final mounted position. On their perspective sides, the #2 rotary potentiometers are facing upward on the yoke and gimbal assembly. They are positioned this way to prevent interference with the side support brackets if facing downward. **Figure 17.3** shows the left and right DGSP units for reference.

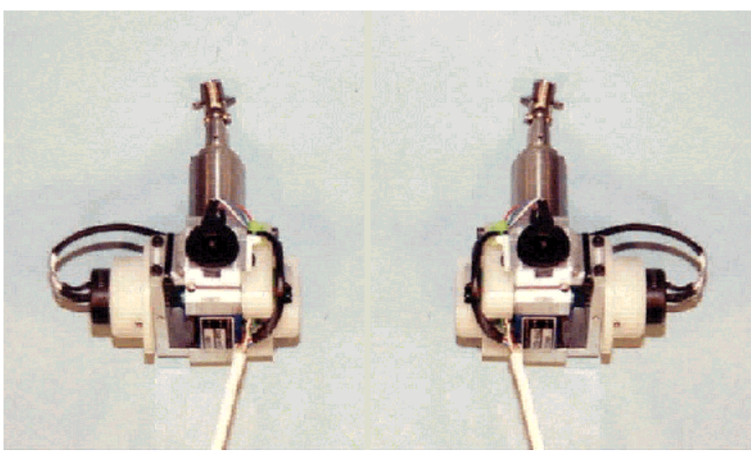

Figure 17.3- Comparison of the left and right DGSP units

3. Locate the Left DGSP Unit (T1DPM000). Remove the two #4-40 x 3/8" SHCS {3/32} that hold the Right Yoke Arm (T1DPM213) to the Left Yoke Arm (T1DPM212) and Gimbal Assembly (T1DPM200), as shown in **Figure 17.4**.

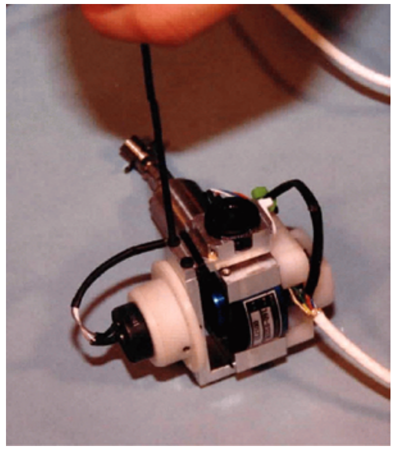

Figure 17.4- Bolt location for disassembly

WARNING: Due to the soldered connections, only a small distance separates the string potentiometer assembly from the yoke left arm. It is important to keep the two assemblies in close proximity to avoid applying tension to the wires.

4. Carefully separate the Rotary Potentiometer #1, DGSP Right Arm and String Potentiometer Assembly (T1DPM300) from the DGSP yoke left arm, as shown in **Figure 17.5**. Two Teflon washers will fall off the lower trunnions of the string potentiometer assembly.

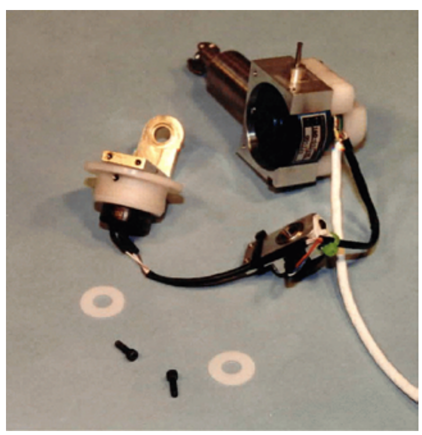

Figure 17.5- DGSP separation

5. Pass the wire which connects Rotary Potentiometer #1 (T1INM210) to the Yoke Axis Rotary Potentiometer (T1DPM210) through the slot in the rear of the Lower Abdomen Attachment Bracket - Left (T1LAW040). The DGSP assembly should be oriented to the inside of the attachment bracket as shown in **Figure 17.6**.

Figure 17.6- Route potentiometer wiring through slot in plate

6. Insert the Left DGSP telescope into the left access hole in the rear of the lower abdominal bag mounting plate, as shown in **Figure 17.7**.

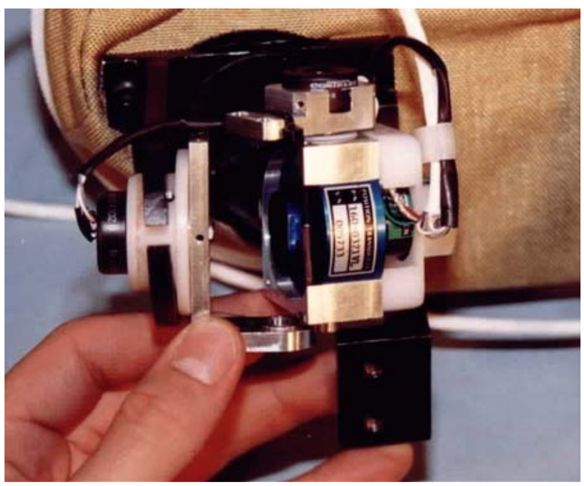

Figure 17.7- Insert telescope into access hole

7. Insert the Rotary Bushing (T1DPM211) and Yoke Axis Rotary Potentiometer (T1DPM210) through the 1.25" diameter hole of the left attachment bracket, as shown in **Figure 17.8**.

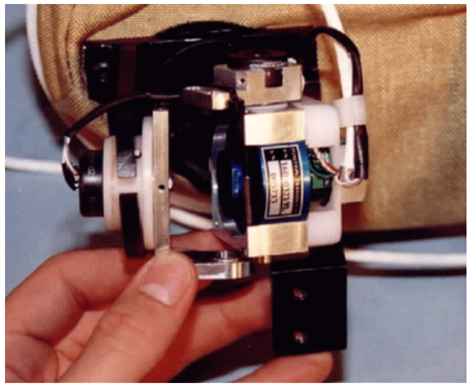

Figure 17.8- Insert bushing into hole in bracket

8. Rotate the flanged surface of the bushing until the engraved arrow is pointing upwards as shown in **Figure 17.9**. The orientation of the arrow will ensure proper operation of the yoke axis rotary potentiometer during the dynamic test event.

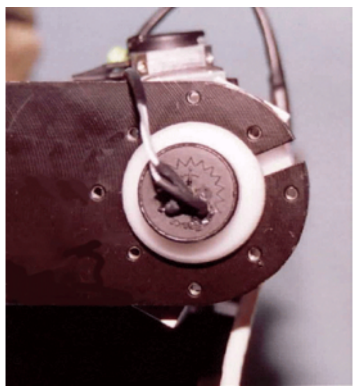

Figure 17.9- Proper orientation of the arrow

9. Secure the rotary bushing to the left attachment bracket using four #4-40 x 3/8" FHSCS {1/16}, as shown in **Figure 17.10**. Check to be sure that the engraved arrow is still oriented upwards.

NOTE: There are two patterns of #4-40 holes on the attachment bracket. The bushing will only fit on the bolt pattern with the smaller diameter.

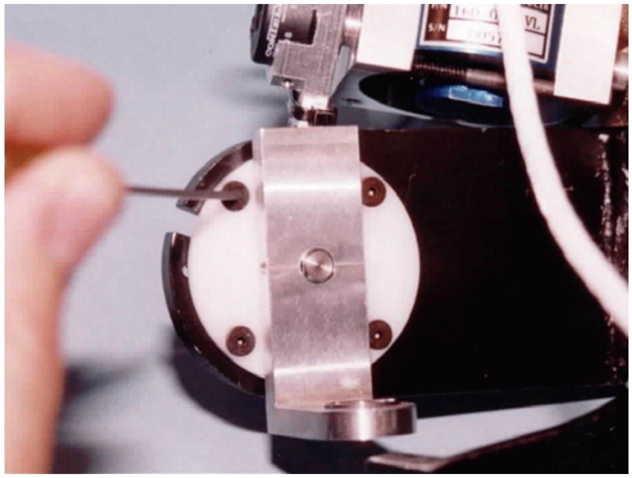

Figure 17.10- Secure the bushing to the bracket

10. Place the Teflon washers onto the lower trunnions of the String Potentiometer Assembly (T1DPM300) and reinsert the trunnion into the bearings of the DGSP yoke left arm. Replace the two #4-40 x 3/8" SHCS that hold the Right Yoke Arm (T1DPM213) to the Left Yoke Arm (T1DPM212) and Gimbal Assembly (T1DPM200), as shown in **Figure 17.11**.

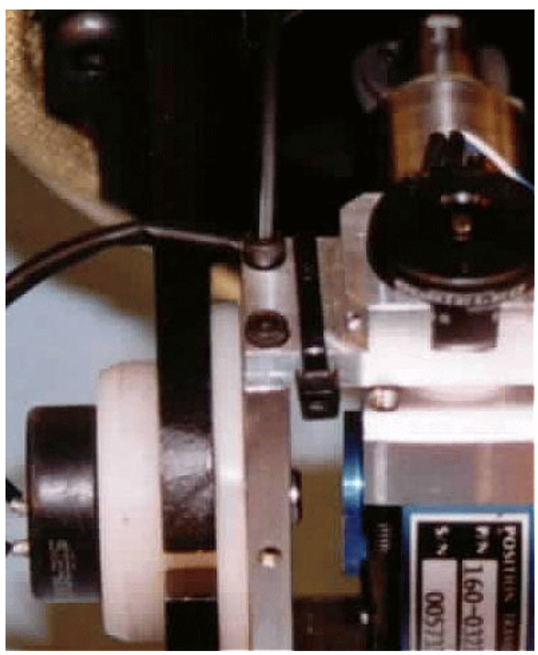

Figure 17.11- Reassembly of the yoke arms and gimbal assembly

11. Place the Potentiometer Cover (T1LAM011) over the exposed terminals of the yoke axis rotary potentiometer, so that the small groove in the cover provides strain relief to the

wire. Align the hole pattern of the cover with the pattern on the side support bracket, and secure the covers to the brackets using three #4-40 x ½" SHCS {3/32}, as shown in **Figure 17.12**.

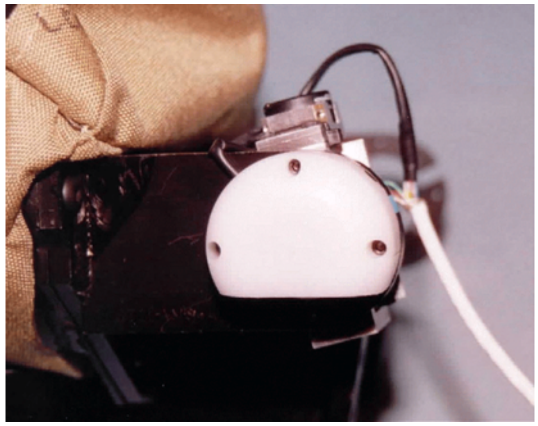

Figure 17.12- Proper positioning of the potentiometer cover

12. Repeat Steps 3 through 11 for the right hand DGSP unit.

13. Ensure the panel nut and stainless steel washer on the DGSP U-joints are removed. Attach the threaded end of a DGSP assembly cable to the tapped hole in the end of each DGSP unit.

14. Align the four ½" diameter bores in the Rear Abdominal Foam Layer (T1LAM013) with the posts protruding from the inside face of the internal mounting plate. Pass the DGSP assembly cables through the large bored holes in the rear foam layer. Press the rear layer of foam over the cones and against the internal mounting plate, as shown in **Figure 17.13**. The foam should be on the inside of the abdominal bag.

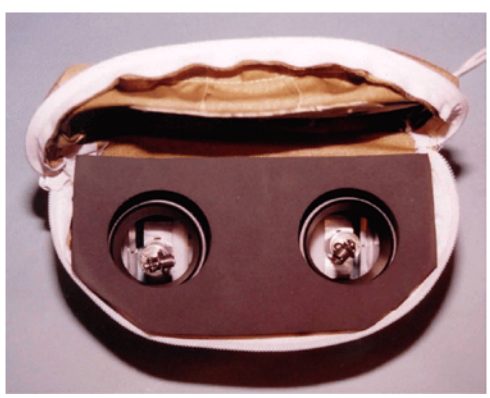

Figure 17.13- Rear foam layer inserted into lower abdominal bag

15. Examine the Front Abdominal Foam Layer (T1LAM012), position the flat face against the

exposed surface of the rear foam layer, as shown in **Figure 17.14**. Again, pass the DGSP assembly cables through the large bored holes in the front foam layer.

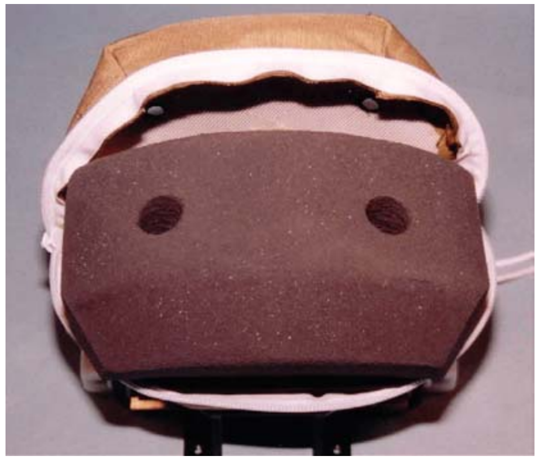

Figure 17.14- Front Abdominal Foam Layer properly positioned

16. Place a Load Distribution Plate (T1LAM014) onto each DGSP assembly cable, as shown in **Figure 17.15**. The small counterbore in one side of the distribution plate must be oriented toward the DGSP assembly. These load distribution plates will rest inside the lower abdomen bag and distribute the tension in the string potentiometer to a large area of the foam.

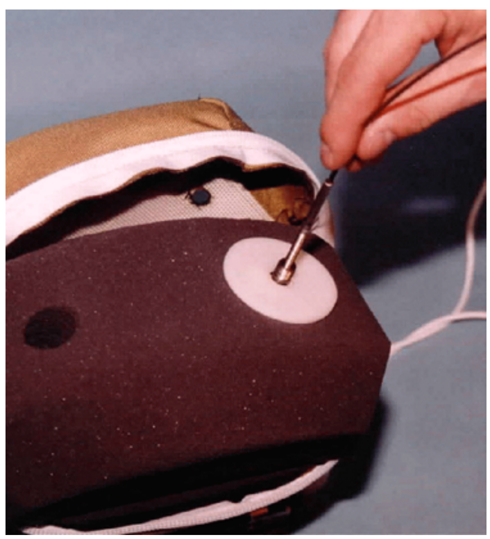

Figure 17.15- Load Distribution Plate assembled on the cable

17. Thread each DGSP assembly cable through their respective holes in the front of the abdominal bag.

NOTE: A good trick is to use a binder clip on the cables to prevent them from accidentally pulling back into the lower abdomen bag.

18. Close the lower abdominal bag and adjust the foam within the bag geometry. Zip the bag closed.

19. Thread a stainless steel washer and a panel nut onto each DGSP assembly cable, as shown in **Figure 17.16**.

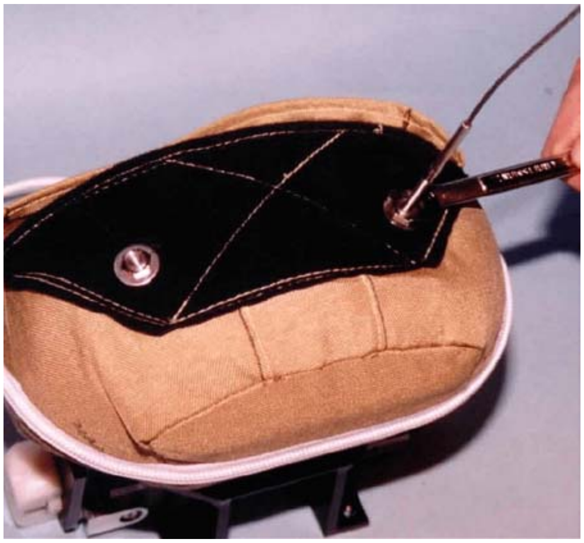

Figure 17.16- Install washer and thread on the panel nut

20. Grasp the left hand DGSP Assembly Cable and pull the DGSP telescope into an extended position. Change the angle of pull as necessary to "steer" the DGSP U-joint through the load distribution washer and lower abdomen bag. Continue holding tension on the cable.

21. Secure the DGSP unit to the front of the Lower Abdomen assembly using the washer and panel nut. Tighten the panel nut {½" crescent wrench} until it is flush with the threaded end of the U-joint.

WARNING: Do not over tighten the DGSP panel nuts. This will cause the U-joints to protrude further than necessary from the lower abdomen assembly.

22. Repeat Steps 20 and 21 for the right hand DGSP. The completed DGSP installation is shown in **Figure 17.17**.

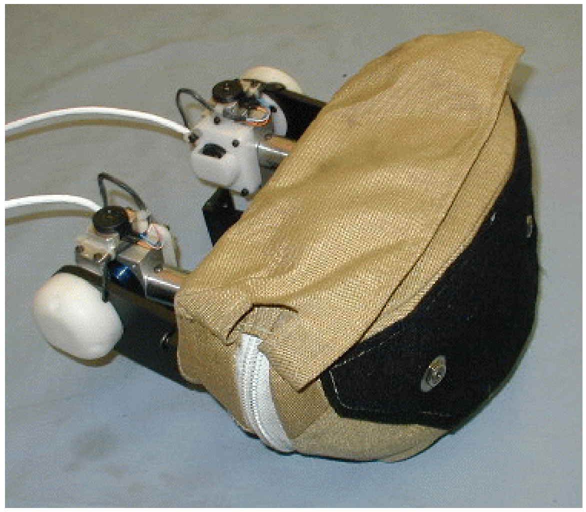

Figure 17.17- Complete DGSP assemblies installed in the Lower Abdomen

17.2.3 Removing the DGSP Units from the Lower Abdominal Assembly

Removal of the DGSP may be required for inspection or maintenance of the units. The simplest way to remove the DGSP is to remove the entire lower abdominal component from the dummy as described in Section 10- Lower Abdomen. Detaching the DGSP units can be accomplished by reversing the steps detailed in Section 17.2.2- Attaching DGSP units to the Lower Abdomen Assembly, with the following notes to aid the process.

WARNING: Do not allow the telescope to recoil too quickly. An unrestrained recoil could damage the transducer!

1. The DGSP assembly cables should be threaded into the ends of the U-joints to allow the DGSP units to be guided slowly into the collapsed position.

2. Using a ½" crescent wrench, unscrew the 3/8" thin electronics nut of the U-joint on the outside cover of the lower abdominal bag. Be careful to maintain tension on the DGSP so it does not snap into the unit.

3. When the nut and washer have been removed from the threads of the U-joint, slowly collapse the telescope.

4. Continue the disassembly as described in Section 17.2.2- Attaching DGSP Units to the Lower Abdomen Assembly, by reversing the assembly procedure.

17.3 Adjustments for the DGSP units

No adjustment of the DGSP units is required.

17.4 Electrical Connections and Requirements

17.4.1 Wire Routing

The wire routing for the two DGSP units is described in detail below and shown in **Figure 17.18**

Left DGSP Unit: The wires are routed to the left side of the spine and are joined to the wire bundle at the base of the spine.

Right DGSP Unit: The wires are routed to the right side of the spine and are joined to the wire bundle at the base of the spine.

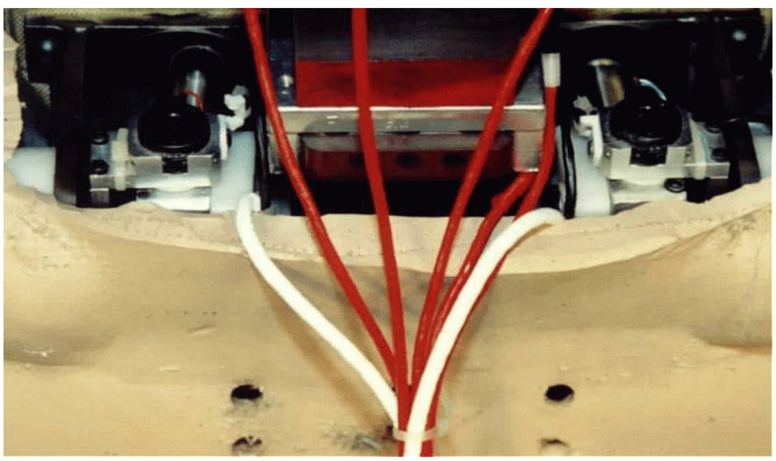

Figure 17.18- Proper wire routing for DGSP wires

17.4.2 CRUX Unit Electrical Connection

Each DGSP unit is wired at GESAC with a 15' multi-conductor instrumentation wire. Depending on the dummy application, this wire may be terminated with a set of three high quality, four-pin LEMO connectors for leased units, or a bare end for commercial units. The wire is fully shielded and the shield is passed through the connector.

On the leased dummies, the wires have been broken out into three bundles and the connector wires have the wire color coding as described in Section 15- Instrumentation and Wiring. **Table 17.1** lists the wiring code for commercially sold units.

Table 17.1

Wire Color	Function
Red	Pot #1 (String Pot): +Excitation
Black	Pot #1 (String Pot): Ground
Green	Pot #1 (String Pot): Output
Orange	Pot #2 (Yaw): +Excitation
Black Stripe	Pot #2 (Yaw): Ground
Blue	Pot #2 (Yaw): Output
Red Stripe	Pot #3 (Pitch): +Excitation
Gray	Pot #3 (Pitch): Ground
White	Pot #3 (Pitch): Output

The potentiometers from the DGSP units are designed to be measured as a referenced single-ended channel configuration in which the + Signal lead is connected to a HI input channel of the data acquisition system. The data acquisition system is then configured as a referenced single-ended input to measure the voltage difference between the HI channel input and the ground reference. The DGSP multi-conductor wire is shielded to prevent cross-talk with other instrumentation. The recommended excitation voltage for the DGSP units is 10.00 V DC. Under normal operation conditions, the output signal from any of the three potentiometers should be between 0 and 10 volts DC. A simple voltage check may be used to determine if the potentiometers are outputting a voltage in the expected range of 0 to 10 V DC.

WARNING: The output voltage from the rotary potentiometers should never actually read 0.0 or 10.0 volts. Readings of exactly 0.0 or 10.0 indicate the potential existence of a short in the signal wire to either ground or + excitation.

The DGSP units are designed to be removed and assembled as a complete unit. The disassembly of the individual components which make up a complete DGSP assembly is beyond the scope of this manual. The electrical connections and wiring for the DGSP units are performed during the assembly of the unit at GESAC. It is HIGHLY RECOMMENDED that DGSP units which are experiencing electrical problems be returned to GESAC for repair. Refer to the THOR drawing package for additional wiring details.

17.5 DGSP Measurement System Calibration

Prior to installing the DGSP units into the thorax assembly, each unit must be calibrated to determine the output voltage for various angular orientations. The calibration of these units is most easily performed on the DGSP Calibration Fixture (T1CEM200) which is available for purchase from GESAC. This fixture was designed to accurately position the DGSP units into several predefined orientations. The voltage output from each of the potentiometers is measured and recorded for each position to provide an accurate calibration. These voltage outputs are correlated with known angles of the calibration plate and the calibration factor (mV/deg), and initial offsets are calculated for use in the THORTEST. Each DGSP unit is calibrated by GESAC upon initial assembly, and may be returned to GESAC for recalibration at any time. It is recommended that recalibration be performed after 25 tests have been conducted.

The calibration procedures for the DGSP units are described in the THOR Calibration Manual, which is available from GESAC as a separate publication.

NOTE: If at any time during the testing the output of the DGSP units reaches the level of 0.00 (ground) or 10.0 (+ excitation), or if the units have been physically damaged, the units should be removed, inspected, and recalibrated.

17.6 Inspection and Repairs

After a test series has been performed, several inspections may be performed to ensure the dummy's integrity has remained intact. Use good engineering judgement to determine the frequency of these inspections; however, GESAC recommends a thorough inspection after twenty tests have been conducted. Inspection frequency should increase if the tests are particularly severe or if unusual data signals are being recorded. Both electrical and mechanical inspections are most easily carried out during a disassembly of the dummy. Disassembly of the DGSP units from the dummy and upper abdomen assembly can be performed by simply reversing the assembly procedure. Some comments are provided below to assist in this process.

17.6.1 Electrical Inspections (Instrumentation Check)

Begin with the visual and tactile inspection of all instrument wires. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections that would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure they are properly strain relieved. A more detailed check on the individual instruments is covered in Section 15 - Instrumentation and Wiring.

17.6.2 Mechanical Inspection

The DGSP units will require a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact GESAC regarding items which fail mechanical inspection.

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

- Check tightness of lower abdomen connection nuts
- Inspect the lower abdomen foam for permanent compression caused by DGSP cable tension. Procedures to relieve this tension are described in Section 2.4 and 2.8

In addition, a more detailed inspection can be conducted if the units are removed. (Removal is not recommended unless a problem is suspected.)

- Inspect the Universal joint end to ensure it moves freely.
- Inspect the extension and retraction of the telescopic column to ensure free sliding motion. The DGSP unit should retract forcefully under its own tension without binding or hesitation.
- Inspect the potentiometers and joints for physical damage which may indicate contact between the DGSP units and another assembly.
- Inspect the telescopic column of the DGSP units for physical damage.
- Inspect the wiring for physical damage including broken connectors, pinched wires, missing insulation, etc.

If any damage is found during the inspection of the DGSP units, the damaged unit(s) should be returned to GESAC for repair or replacement. Due to the complicated nature of the DGSP units, the disassembly and repair of individual components of each DGSP are beyond the scope of this manual. Contact GESAC's Engineering Department if further disassembly or inspection is required.

APPENDIX I. THOR-NT Bill of Material

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
FULL DUMMY					
T1FDM000	10	THOR DUMMY MECHANICAL ASSEMBLY		A	
T1FDM001	7	THOR DUMMY MECHANICAL ASSEMBLY PARTS LIST		A	
T1LXM000	8	THOR-LX MECHANICAL ASSEMBLY		A	2
T1FMM000	3	FEMUR MECHANICAL ASSEMBLY		A	2
T1JKF000	B1	TESTING JACKET FRONT / REAR PANEL ASSEMBLY		A	
T1PLM000	10	PELVIS ASSEMBLY		A	
T1SPM000	6	SPINE MECHANICAL ASSEMBLY		A	
T1LAM000	6	LOWER ABDOMEN MECHANICAL ASSEMBLY		A	
T1UAM000	4	UPPER ABDOMEN MECHANICAL ASSEMBLY		A	
T1CXM000	8	CRUX MECHANICAL ASSEMBLY TO THOR		A	
T1TXM000	7	THORAX ASSEMBLY		A	
T1SHM000	7	SHOULDER MECHANICAL ASSEMBLY		A	
T1NKM000	10	NECK MECHANICAL ASSEMBLY		A	
T1HDM000	10	HEAD MECHANICAL ASSEMBLY		A	
T1FCM000	1	FACE MECHANICAL ASSEMBLY		A	
T1AMP000	2	ARM ASSEMBLY PURCHASED PARTS		A	
T1FDM010	3	THOR SERIAL NUMBER LOCATION			1
T1FDM011	0	LOWER ABDOMEN ERECT POSTURE FOAM		M	1
T1FDM012	0	LOWER ABDOMEN NEUTRAL POSTURE FOAM		M	1
T1FDS000	7	THOR DUMMY SKIN ASSEMBLY		A	
T1FMS000	B0	FEMUR SKIN MOUNTING ASSEMBLY (RIGHT AND LEFT)		A	2
T1PLS000	2	PELVIS SKIN ASSEMBLY		A	1
T1NKS000	3	NECK SKIN ASSEMBLY		A	1
T1LLS000	3	TIBIA FLESH - MECHANICAL ASSEMBLY		A	2
T1FTS000	3	FOOT SKIN - MECHANICAL ASSEMBLY		A	2
T1HDS000	0	HEAD SKIN ASSEMBLY		A	1
T1FDE000	6	THOR ELECTRICAL ASSEMBLY		A	
T1INM010	1	STRAIN RELIEF MOUNTING PLATE		M	1
T1INF000	3	NYLON WIRE COVER		F	1
9604K22		BRASS WASHER GROMMET HOLE SIZE DIAMETER 1/4"	McMASTER-CARR	P	4
		8 FOOT ZIPPER AND CHAIN		F	1
W9350		BLACK CORDURA NYLON	PG	F	1
7515K45		STRAIN RELIEF MESH GRIP (1.25-1.50")	McMASTER-CARR	P	1
91253A583		5/16-18 x 1" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	1
T1FDT110	4	THOR H-POINT TOOL- MECHANICAL ASSEMBLY		A	1
T1FDT111	B1	H-POINT TOOL SHAFT		M	1
T1FDT112	C0	H-POINT TOOL INTERFACE DISK		M	1
T1FDT113	B1	H-POINT TOOL BEARING		M	1
59575K31		SHAFT DIA = 0.25"; FLANGED BEARING	McMASTER-CARR	P	1
T1FDT114	C0	H-POINT TOOL PLATE		M	1
95630A238		#8 TEFLON WASHSER	McMASTER-CARR	P	1
91255A189		#8-32 X 3/16" BHCS (ALLOY STEEL)	McMASTER-CARR	P	1
98380A508		3/16 X 3/4L DOWEL PIN	McMASTER-CARR	P	1
90145A553		1/4 X 3.0L DOWEL PIN	McMASTER-CARR	P	1
93740A215		1/8 X .75L SPRING PIN (420 SS)	McMASTER-CARR	P	1
T1FDT200	3	ABDOMEN FIXTURE MECHANICAL ASSEMBLY		A	
T1FDT211	B0	ABDOMEN FIXTURE BOLT		M	2
98847A029		THREADED ROD 1/4 - 20	McMASTER-CARR	P	2
T1FDT201	0	ABDOMEN FIXTURE PLATE BONDED ASSEMBLY		A	1
T1FDT212	3	ABDOMEN FIXTURE PLATE		M	1
T1FDT213	2	ABDOMEN FIXTURE FOAM BLOCK		M	1
66215A521		DEVCON 5 MINUTE EPOXY	McMASTER-CARR	P	1
6047K31		ALUMINUM FOUR-ARM CLAMPING KNOB	McMASTER-CARR	P	3

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
93995A370		1/4-20 ROUND THUMB NUT	McMASTER-CARR	P	3
91090A107		1/4" WASHER: ID=17/64, OD=7/8, THICK=3/64	McMASTER-CARR	P	1
6044K67		1/4-20 PULL KNOB	McMASTER-CARR	P	1
92949A535		1/4-20 X 3/8" B.H.S.C.S.	McMASTER-CARR	P	1
ARMS					
T1AMP000	2	ARM ASSEMBLY PURCHASED PARTS		A	
123-6000-1		ADVANCED DUMMY ARM ASSEMBLY, LEFT	DENTON ATD	P	1
123-6000-2		ADVANCED DUMMY ARM ASSEMBLY, RIGHT	DENTON ATD	P	1
CRUX					
T1CXM000	8	CRUX MECHANICAL ASSEMBLY TO THOR		A	
T1CXM004	4	CRUX LOWER LEFT UNIT MECHANICAL ASSEMBLY		A	
T1CXM100	3	CRUX BASE ASSEMBLY		A	
T1CXM110	3	CRUX BASE		M	1
91732A364		#10-24 X 0.19 HELI-COIL INSERT	McMASTER-CARR	P	2
T1CXM111	1	CRUX POT #2 JOINT-BOTTOM HALF		M	1
T1CXM112	4	CRUX POT #1 AXLE		M	1
T1CXM113	5	CRUX POT #2 AXLE		M	1
T1CXM114	0	CRUX BASE ROTATION WASHERS		M	2
T1CXM115	0	CRUX POT #1 AXLE-SET SCREW		M	2
92311A144		#6-32 x 1/4" S.S.S.	McMASTER-CARR	P	2
98410A111		1/8" EXTERNAL C-CLIP (STEEL)	McMASTER-CARR	P	2
98370A005		FINISHED WASHER (ID 1/8, OD 1/4" THK.1/16")	McMASTER-CARR	P	2
57155K144		1/8" BORE MINIATURE BALL BEARING	McMASTER-CARR	P	2
T1CXM200	3	CRUX-ROD #1 ASSEMBLY		A	
T1CXM211	B1	CRUX ROD #1-LOWER UNITS		M	1
T1CXM212	B1	CRUX POT #3 JOINT-BOTTOM HALF		M	1
T1CXM213	5	CRUX POT #3 AXLE		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	1
T1CXM214	2	CRUX-SET SCREW		M	2
91375A146		#6-32 x 3/8" S.S.S. (ALLOY)	McMASTER-CARR	P	2
92373A177		1/8" X ½" SS SPRING PIN	McMASTER-CARR	P	2
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	2
T1CXM300	7	CRUX-ROD #2 ASSEMBLY		A	
T1CXM311	B1	CRUX ROD #2-LOWER UNITS		M	1
T1CXM320	4	CRUX U-JOINT MECHANICAL ASSEMBLY		A	
UJ-HD375 KIT		SOLID, UNASSEMBLED 3/8" U-JOINT	BELDEN	P	1
T1CXM322	3	CRUX U-JOINT HALF - ROTATION END		M	1
T1CXM324	3	CRUX U-JOINT HALF - RIB CONNECTION (LOWER UNIT)		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	2
98381A216		1/8" X 5/16" DOWEL PIN (ALLOY STEEL)	McMASTER-CARR	P	1
92373A177		1/8' X 1/2' SS SPRING PIN	McMASTER-CARR	P	1
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	3
98410A134		HEAVY DUTY E-CLIP FOR 3/8" SHAFT	McMASTER-CARR	P	1
T1CXM013	2	CRUX-JOINT WASHER		M	2
T1CXM014	1	CRUX ROTARY POTENTIOMETER (MODIFIED)		M	3
T1INM210		ROTARY POTENTIOMETER (0.4 % LINEARITY)	CONTELEC	I	3
T1CXM015	1	CRUX POTENTIOMETER RETAINING BRACKET		M	3
98410A113		1/4" EXTERNAL C-CLIP	McMASTER-CARR	P	2
92210A077		#2-56 X 1/4" F.H.S.C.S. (S.S.)	McMASTER-CARR	P	6

APPENDIX I. THOR-NT Bill of Material

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1CXM001	4	CRUX UPPER RIGHT UNIT MECHANICAL ASSEMBLY		A	
T1CXM100	3	CRUX BASE ASSEMBLY		A	
T1CXM110	3	CRUX BASE		M	1
91732A364		#10-24 X 0.19 HELI-COIL INSERT	McMASTER-CARR	P	2
T1CXM111	1	CRUX POT #2 JOINT-BOTTOM HALF		M	1
T1CXM112	4	CRUX POT #1 AXLE		M	1
T1CXM113	5	CRUX POT #2 AXLE		M	1
T1CXM114	0	CRUX BASE ROTATION WASHERS		M	2
T1CXM115	0	CRUX POT #1 AXLE-SET SCREW		M	2
92311A144		#6-32 x 1/4" S.S.S.	McMASTER-CARR	P	2
98410A111		1/8" EXTERNAL C-CLIP (STEEL)	McMASTER-CARR	P	2
98370A005		FINISHED WASHER (ID 1/8, OD 1/4" THK.1/16")	McMASTER-CARR	P	2
57155K144		1/8" BORE MINIATURE BALL BEARING	McMASTER-CARR	P	2
T1CXM200	3	CRUX-ROD #1 ASSEMBLY		A	
T1CXM210	B1	CRUX ROD #1-UPPER UNITS		M	1
T1CXM212	B1	CRUX POT #3 JOINT-BOTTOM HALF		M	1
T1CXM213	5	CRUX POT #3 AXLE		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	1
T1CXM214	2	CRUX-SET SCREW		M	2
91375A146		#6-32 x 3/8" S.S.S. (ALLOY)	McMASTER-CARR	P	2
92373A177		1/8" X ½" SS SPRING PIN	McMASTER-CARR	P	2
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	2
T1CXM300	7	CRUX-ROD #2 ASSEMBLY		A	
T1CXM310	B1	CRUX ROD #2-UPPER UNITS		M	1
T1CXM320	4	CRUX U-JOINT MECHANICAL ASSEMBLY		A	
UJ-HD375 KIT		SOLID, UNASSEMBLED 3/8" U-JOINT	BELDEN	P	1
T1CXM322	3	CRUX U-JOINT HALF - ROTATION END		M	1
T1CXM323	5	CRUX U-JOINT HALF - RIB CONNECTION END (UPPER UNIT)		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	1
98381A216		1/8" X 5/16" DOWEL PIN (ALLOY STEEL)	McMASTER-CARR	P	1
92373A177		1/8' X 1/2' SS SPRING PIN	McMASTER-CARR	P	1
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	3
98410A134		HEAVY DUTY E-CLIP FOR 3/8" SHAFT	McMASTER-CARR	P	1
T1CXM013	2	CRUX-JOINT WASHER		M	2
T1CXM014	1	CRUX ROTARY POTENTIOMETER (MODIFIED)		M	3
T1INM210		ROTARY POTENTIOMETER (0.4 % LINEARITY)	CONTELEC	I	3
T1CXM015	1	CRUX POTENTIOMETER RETAINING BRACKET		M	3
98410A113		1/4" EXTERNAL C-CLIP	McMASTER-CARR	P	2
92210A077		#2-56 X 1/4" F.H.S.C.S. (S.S.)	McMASTER-CARR	P	6
T1CXM003	4	CRUX LOWER RIGHT UNIT MECHANICAL ASSEMBLY		A	
T1CXM100	3	CRUX BASE ASSEMBLY		A	
T1CXM110	3	CRUX BASE		M	1
91732A364		#10-24 X 0.19 HELI-COIL INSERT	McMASTER-CARR	P	2
T1CXM111	1	CRUX POT #2 JOINT-BOTTOM HALF		M	1
T1CXM112	4	CRUX POT #1 AXLE		M	1
T1CXM113	5	CRUX POT #2 AXLE		M	1
T1CXM114	0	CRUX BASE ROTATION WASHERS		M	2
T1CXM115	0	CRUX POT #1 AXLE-SET SCREW		M	2
92311A144		#6-32 x 1/4" S.S.S.	McMASTER-CARR	P	2
98410A111		1/8" EXTERNAL C-CLIP (STEEL)	McMASTER-CARR	P	2
98370A005		FINISHED WASHER (ID 1/8, OD 1/4" THK.1/16")	McMASTER-CARR	P	2
57155K144		1/8" BORE MINIATURE BALL BEARING	McMASTER-CARR	P	2
T1CXM200	3	CRUX-ROD #1 ASSEMBLY		A	

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1CXM211	B1	CRUX ROD #1-LOWER UNITS		M	1
T1CXM212	B1	CRUX POT #3 JOINT-BOTTOM HALF		M	1
T1CXM213	5	CRUX POT #3 AXLE		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	2
T1CXM214	2	CRUX-SET SCREW		M	2
91375A146		#6-32 x 3/8" S.S.S. (ALLOY)	McMASTER-CARR	P	2
92373A177		1/8" X ½" SS SPRING PIN	McMASTER-CARR	P	2
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	2
T1CXM300	7	CRUX-ROD #2 ASSEMBLY		A	
T1CXM311	B1	CRUX ROD #2-LOWER UNITS		M	1
T1CXM320	4	CRUX U-JOINT MECHANICAL ASSEMBLY		A	
UJ-HD375 KIT		SOLID, UNASSEMBLED 3/8" U-JOINT	BELDEN	P	1
T1CXM322	3	CRUX U-JOINT HALF - ROTATION END		M	1
T1CXM324	3	CRUX U-JOINT HALF - RIB CONNECTION (LOWER UNIT)		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	1
98381A216		1/8" X 5/16" DOWEL PIN (ALLOY STEEL)	McMASTER-CARR	P	1
92373A177		1/8' X 1/2' SS SPRING PIN	McMASTER-CARR	P	1
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	3
98410A134		HEAVY DUTY E-CLIP FOR 3/8" SHAFT	McMASTER-CARR	P	1
T1CXM013	2	CRUX-JOINT WASHER		M	2
T1CXM014	1	CRUX ROTARY POTENTIOMETER (MODIFIED)		M	3
T1INM210		ROTARY POTENTIOMETER (0.4 % LINEARITY)	CONTELEC	I	3
T1CXM015	1	CRUX POTENTIOMETER RETAINING BRACKET		M	3
98410A113		1/4" EXTERNAL C-CLIP	McMASTER-CARR	P	2
92210A077		#2-56 X 1/4" F.H.S.C.S. (S.S.)	McMASTER-CARR	P	6
T1CXM002	4	CRUX UPPER LEFT UNIT MECHANICAL ASSEMBLY		A	
T1CXM100	3	CRUX BASE ASSEMBLY		A	
T1CXM110	3	CRUX BASE		M	1
91732A364		#10-24 X 0.19 HELI-COIL INSERT	McMASTER-CARR	P	2
T1CXM111	1	CRUX POT #2 JOINT-BOTTOM HALF		M	1
T1CXM112	4	CRUX POT #1 AXLE		M	1
T1CXM113	5	CRUX POT #2 AXLE		M	1
T1CXM114	0	CRUX BASE ROTATION WASHERS		M	2
T1CXM115	0	CRUX POT #1 AXLE-SET SCREW		M	2
92311A144		#6-32 x 1/4" S.S.S.	McMASTER-CARR	P	2
98410A111		1/8" EXTERNAL C-CLIP (STEEL)	McMASTER-CARR	P	2
98370A005		FINISHED WASHER (ID 1/8, OD 1/4" THK.1/16")	McMASTER-CARR	P	2
57155K144		1/8" BORE MINIATURE BALL BEARING	McMASTER-CARR	P	2
T1CXM200	3	CRUX-ROD #1 ASSEMBLY		A	
T1CXM210	B1	CRUX ROD #1-UPPER UNITS		M	1
T1CXM212	B1	CRUX POT #3 JOINT-BOTTOM HALF		M	1
T1CXM213	5	CRUX POT #3 AXLE		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	2
T1CXM214	2	CRUX-SET SCREW		M	2
91375A146		#6-32 x 3/8" S.S.S. (ALLOY)	McMASTER-CARR	P	2
92373A177		1/8" X ½" SS SPRING PIN	McMASTER-CARR	P	2
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	2
T1CXM300	7	CRUX-ROD #2 ASSEMBLY		A	
T1CXM310	B1	CRUX ROD #2-UPPER UNITS		M	1
T1CXM320	4	CRUX U-JOINT MECHANICAL ASSEMBLY		A	
UJ-HD375 KIT		SOLID, UNASSEMBLED 3/8" U-JOINT	BELDEN	P	1
T1CXM322	3	CRUX U-JOINT HALF - ROTATION END		M	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1CXM323	5	CRUX U-JOINT HALF - RIB CONNECTION END (UPPER UNIT)		M	1
T1CXM011	B1	CRUX JOINT-TOP HALF		M	1
T1CXM012	2	CRUX JOINT BUSHING		M	2
98381A216		1/8" X 5/16" DOWEL PIN (ALLOY STEEL)	McMASTER-CARR	P	1
92373A177		1/8' X 1/2' SS SPRING PIN	McMASTER-CARR	P	1
98381A414		1/16" X 3/16" DOWEL PIN (ALLOY)	McMASTER-CARR	P	3
98410A134		HEAVY DUTY E-CLIP FOR 3/8" SHAFT	McMASTER-CARR	P	1
T1CXM013	2	CRUX-JOINT WASHER		M	2
T1CXM014	1	CRUX ROTARY POTENTIOMETER (MODIFIED)		M	3
T1INM210		ROTARY POTENTIOMETER (0.4 % LINEARITY)	CONTELEC	I	3
T1CXM015	1	CRUX POTENTIOMETER RETAINING BRACKET		M	3
98410A113		1/4" EXTERNAL C-CLIP	McMASTER-CARR	P	2
92210A077		#2-56 X 1/4" F.H.S.C.S. (S.S.)	McMASTER-CARR	P	6
T1CXM401	3	CRUX - LOWER UNIT MOUNTING PLATE (LEFT SIDE)		M	1
T1CXM400	3	CRUX - LOWER UNIT MOUNTING PLATE (RIGHT SIDE)		M	1
91253A244		#10-24 X 5/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	4
91255A537		1/4-20 X 1/2" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
91253A535		1/4-20 X 3/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	4
91253A240		#10-24 X 3/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	4
T1CXE000	4	CRUX ELECTRICAL ASSEMBLY TO THOR		A	
T1CXE001	4	CRUX UPPER RIGHT UNIT ELECTRICAL ASSEMBLY		A	
12CONWIRE		12 CONDUCTOR TENSOLITE WIRE (15 ')	DENTON	P	15'
7130K52		4" NYLON CABLE TIE (0.1" WIDE)	McMASTER-CARR	P	3
CP332R50ND		3/32" X 1/2" HEATSHRINK TUBING	DIGI-KEY	P	9
CP3321ND		3/32" X 5.25" HEATSHRINK TUBING	DIGI-KEY	P	1
CP1161ND		1/16" X 4.25" HEATSHRINK TUBING	DIGI-KEY	P	1
T1CXE002	4	CRUX UPPER LEFT UNIT ELECTRICAL ASSEMBLY		A	
12CONWIRE		12 CONDUCTOR TENSOLITE WIRE (15 ')	DENTON	P	1
7130K52		4" NYLON CABLE TIE (0.1" WIDE)	McMASTER-CARR	P	3
CP332R50ND		3/32" X 1/2" HEATSHRINK TUBING	DIGI-KEY	P	9
CP3321ND		3/32" X 5.25" HEATSHRINK TUBING	DIGI-KEY	P	1
CP1161ND		1/16" X 4.25" HEATSHRINK TUBING	DIGI-KEY	P	1
T1CXE003	4	CRUX LOWER RIGHT UNIT ELECTRICAL ASSEMBLY		A	
12CONWIRE		12 CONDUCTOR TENSOLITE WIRE (15 ')	DENTON	P	1
7130K52		4" NYLON CABLE TIE (0.1" WIDE)	McMASTER-CARR	P	3
CP332R50ND		3/32" X 1/2" HEATSHRINK TUBING	DIGI-KEY	P	9
CP3321ND		3/32" X 5.25" HEATSHRINK TUBING	DIGI-KEY	P	1
CP1161ND		1/16" X 4.25" HEATSHRINK TUBING	DIGI-KEY	P	1
T1CXE004	4	CRUX LOWER LEFT UNIT ELECTRICAL ASSEMBLY		A	
12CONWIRE		12 CONDUCTOR TENSOLITE WIRE (15 ')	DENTON	P	1
7130K52		4" NYLON CABLE TIE (0.1" WIDE)	McMASTER-CARR	P	3
CP332R50ND		3/32" X 1/2" HEATSHRINK TUBING	DIGI-KEY	P	9
CP3321ND		3/32" X 5.25" HEATSHRINK TUBING	DIGI-KEY	P	1
CP1161ND		1/16" X 4.25" HEATSHRINK TUBING	DIGI-KEY	P	1
RP325-ND		1/4" CABLE CLAMP (NYLON)	DIGI-KEY	P	1
91255A537		1/4-20 X 1/2" B.H.S.C.S (ALLOY)	McMASTER-CARR	P	2
RP327-ND		3/8" CABLE CLAMP (NYLON)	DIGI-KEY	P	1
T1CXT000	3	CRUX INSERTION TOOL MECHANICAL ASSEMBLY		A	
T1CXT010	2	INSERTION TOOL HANDLE		M	1
T1CXT011	2	INSERTION TOOL SHAFT		M	1

DGSP

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1DPM000	3	DGSP COMPLETE MECHANICAL ASSEMBLY		A	2
T1DPM100	3	DGSP TELESCOPE ASSEMBLY		A	2

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1DPM110	0	DGSP COLUMN #1		M	2
T1DPM111	2	DGSP COLUMN #2		M	2
T1DPM112	4	DGSP COLUMN #3		M	2
T1DPM113	2	DGSP COLUMN #4		M	2
T1DPM114	1	DGSP COLUMN #5		M	2
T1DPM115	1	DGSP COLUMN #6		M	2
T1DPM116	2	DGSP U-JOINT		M	2
UJ-HD-375		BELDEN 3/8" SOLID, UNASSEMBLED UNIVERSAL JOINT	BELDEN	P	2
91375A074		#2-56 X 1/8" S.S.S.	McMASTER-CARR	P	4
98410A117		EXTERNAL RETAINING CLIP 3/8"	McMASTER-CARR	P	2
98410A122		EXTERNAL RETAINING CLIP 1/2"	McMASTER-CARR	P	2
98410A126		EXTERNAL RETAINING CLIP 5/8"	McMASTER-CARR	P	2
98420A134		3/8" HEAVY-DUTY E-STYLE RETAINING CLIP	McMASTER-CARR	P	2
T1DPM200	2	DGSP GIMBALLED YOKE ASSEMBLY		A	2
T1DPM210	4	DGSP-YOKE AXIS ROTARY POTENTIOMETER		M	2
T1INM220	1	ROTARY POTENTIOMETER #2		M	2
ECS 78RBA102 W06508		PRECISION ROTARY POTENTIOMETER	VS	I	2
T1DPM211	3	DGSP-ROTARY BUSHING FOR YOKE		M	2
91732A701		#4-40 X .224" HELICAL THREAD INSERT	McMASTER-CARR	P	4
T1DPM212	1	DGSP-YOKE LEFT ARM		M	2
T1DPM213	3	DGSP-YOKE RIGHT ARM		M	2
T1DPM214	2	DGSP-D-SHAFT FOR CONTELEC ROTARY POT.		M	2
8890980		0.0980 DIAMETER GAGE PIN	MSC	P	2
64-3020		3/8-32 X 0.10" UNEF NUT	RADIO SHACK	P	2
98019A199		3/8" WASHER (SS)	McMASTER-CARR	P	2
91375A106		#4-40 X 1/4 S.S.S.	McMASTER-CARR	P	8
91732A267		#4-40 X 0.168" HELICAL INSERT	McMASTER-CARR	P	4
91251A108		#4-40 X 3/8" S.H.C.S.	McMASTER-CARR	P	4
91375A074		#2-56 X 1/8" S.S.S.	McMASTER-CARR	P	8
57155K156		PRECISION BEARING - BORE = 5/16" (SS)	McMASTER-CARR	P	4
95630A219		TEFLON WASHER (OD 3/4", ID 21/64")	McMASTER-CARR	P	4
T1INM210	1	ROTARY POTENTIOMETER #1		M	2
PD210-4B		CONTELEC ROTARY POTENTIOMETER	CONTELEC	I	2
T1DPM300	2	DGSP STRING POTENTIOMETER ASSEMBLY		A	2
T1INM230	2	STRING POTENTIOMETER		M	2
300647		MODEL 160-0321 THOR UPPER ABDOMEN		I	1
300159		MODEL 160-0321 THOR LOWER ABDOMEN		I	2
T1DPM311	4	DGSP STRING POTENTIOMETER MOUNT		M	2
T1DPM312	2	DGSP PULLEY WHEEL		M	2
T1DPM313	2	DGSP PULLEY WHEEL AXLE		M	2
8900460		0.0460" DIAMETER GAGE PIN	MSC	P	2
T1DPM314	0	DGSP FLAT LOW FRICTION WASHER		M	2
91251A158		#6-32 X 1 3/4" S.H.C.S.	McMASTER-CARR	P	2
91375A077		#2-56 X 1/4" S.S.S. (ALLOY)	McMASTER-CARR	P	4
57155K138		S.S. PRECISION BEARING (ID 0.047")	McMASTER-CARR	P	4
T1DPM010	6	STRING POTENTIOMETER COVER		M	2
91732A707		#6-32 X 0.276" HELICAL INSERT	McMASTER-CARR	P	4
91253A108		#4-40 X 3/8" F.H.S.C.S.	McMASTER-CARR	P	8
91255A106		#4-40 X 1/4" B.H.S.C.S.	McMASTER-CARR	P	4
91251A113		#4-40 X 3/4" S.H.C.S.	McMASTER-CARR	P	4
T1DPE000	6	DGSP COMPLETE ELECTRICAL ASSEMBLY		A	2
12CONWIRE		12 CONDUCTOR TENSOLITE WIRE (15 ')	DENTON	P	2
7130K52		4" NYLON CABLE TIE (0.1" WIDE)	McMASTER-CARR	P	2
CP332R50ND		3/32" X 1/2" HEATSHRINK TUBING	DIGI-KEY	P	18

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
CP3321ND		3/32" X 3.5" HEATSHRINK TUBE	DIGI-KEY	P	2
CP1161ND		1/16" X 3.0" HEATSHRINK TUBE	DIGI-KEY	P	2
91255A146		#6-32 X 3/8" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
RP324-ND		3/16" CABLE CLAMP	DIGI-KEY	P	2
91255A105		#4-40 X 3/16" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
RP322-ND		1/16" CABLE CLAMP	DIGI-KEY	P	2
FACE					
T1FCM000	1	FACE MECHANICAL ASSEMBLY		A	
T1FCM060	B1	FACE FOAM ASSEMBLY		A	1
T1FCM061	B1	FACE CONFOR FOAM		M	1
CF-45125		BLUE CONFOR FOAM	E-A-R FOAM CORP	P	1
T1FCM062	B0	FACE FRONT DISTRIBUTION PAD		M	1
8657K412		24" X 24" X 1/8" LDPE	McMASTER-CARR	P	1
T1FCM063	B1	FACE REAR DISTRIBUTION PAD		M	1
8657K412		24" X 24" X 1/8" LDPE	McMASTER-CARR	P	1
T1FCM100	3	FACE PLATE ASSEMBLY		A	1
T1FCM110	B0	FACE PLATE		M	1
T1FCM111	2	FACE CHINGUARD		M	1
91732A286		#6-32 UNC HELICAL INSERT	McMASTER-CARR	P	1
T1FCM112	4	FACE RIGHT EYE LOAD CELL PLATE		M	1
T1FCM113	3	LEFT EYE LOAD CELL PLATE		M	1
T1FCM114	4	RIGHT CHEEK LOAD CELL PLATE		M	1
T1FCM115	3	LEFT CHEEK LOAD CELL PLATE		M	1
T1FCM116	2	CHIN LOAD CELL PLATE		M	1
T1FCM117	1	MOCK FACE LOAD CELL		M	5
T1INM430	1	FACE LOAD CELL (ACTIVE)	DENTON	I	5
91253A151		#6-32 X 3/4" F.H.S.C.S.	McMASTER-CARR	P	6
91251A146		#6-32 X 3/8" S.H.C.S.	McMASTER-CARR	P	22
91253A146		#6-32 X 3/8" F.H.S.C.S.	McMASTER-CARR	P	20
91251A152		#6-32 X 7/8" S.H.C.S	McMASTER-CARR	P	2
98381A470		.125 DIAM X .375 DOWEL PIN	McMASTER-CARR	P	2
T1FCE000	2	FACE ELECTRICAL ASSEMBLY		A	1
FEMUR					
T1FMM000	3	FEMUR MECHANICAL ASSEMBLY		A	2
T1FMM100	B1	LEFT FEMUR BALL JOINT ASSEMBLY		A	1
T1FMM112	1	TROCHANTER LEFT		M	1
T1FMM114	2	HIP CYLINDER-LEFT		M	1
T1FMM115	B1	HIP ARM- LEFT		M	1
TIFMM119	B0	HIP SHAFT		M	1
T1FMM120	2	FEMUR BALL		M	1
T1FMM130	3	FEMUR RETAINING RING		M	1
92383A474		1-1/2" X 1/4" SPRING PIN	McMASTER-CARR	P	1
92383A458		1 1/4" X 1/4" SPRING PIN	McMASTER-CARR	P	2
91251A539		1/4-20 X 5/8" S.H.C.S	McMASTER-CARR	P	8
T1FMM101	B1	RIGHT FEMUR BALL JOINT ASSEMBLY		A	1
T1FMM113	1	TROCHANTER RIGHT		M	1
T1FMM116	2	HIP CYLINDER-RIGHT		M	1
T1FMM117	B1	HIP ARM- RIGHT		M	1
TIFMM119	B0	HIP SHAFT		M	1
T1FMM120	2	FEMUR BALL		M	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1FMM130	3	FEMUR RETAINING RING		M	1
92383A474		1-1/2" X 1/4" SPRING PIN	McMASTER-CARR	P	1
92383A458		1 1/4" X 1/4" SPRING PIN	McMASTER-CARR	P	2
91251A539		1/4-20 X 5/8" S.H.C.S	McMASTER-CARR	P	8
T1FMM010	9	FEMUR SHAFT BEARING HOUSING		M	2
00060244		#6-32 X .207 HELICOIL INSERT	MSC	P	2
82496068		3/8-16 X .5" HEAVY DUTY INSERT	MSC	P	2
T1FMM011	2	FEMUR END CAP		M	2
T1FMM012	6	FEMUR SHAFT HUB		A	2
00060244		#6-32 X .207 HELICOIL INSERT	MSC	P	2
91732A519		5/16-18 X 5/16" HELICOIL INSERT	McMASTER-CARR	P	10
91732A541		5/8-18 X 0.625" HELICAL INSERT	McMASTER-CARR	P	2
T1FMM013	5	NON-ACTIVE FEMUR LOAD CELL		M	2
FEMUR LOAD CELL (ALTERNATE TO THE NON-ACTIVE LOAD CELL T1FMM013)					
T1INM350		INSTRUMENT FEMUR LOAD CELL		I	2
T1FMM014	2	FEMUR COMPLIANCE BUSHING		M	2
FL10JKM		LINEAR BEARING (0.625" BORE)	PACIFIC BEARINGS	P	2
T1FMM015	1	FEMUR MODIFIED LINEAR BEARING		M	2
FL10JKM		LINEAR BEARING (0.625" BORE)	PACIFIC BEARINGS	P	1
T1FMM016	4	FEMUR SHAFT		M	2
T1FMM017	2	FEMUR BOLT BUSHING		M	10
9540K11		RUBBER BOLT BUSHING	McMASTER-CARR	P	10
T1FMM018	1	FEMUR LINEAR BOLT BUSHING		M	10
T1FMM019	3	FEMUR LOAD CELL BOLT		M	4
3816X1875		3/8-16 X 1.875" S.H.C.S. (ALLOY)	COLD HEADERS	P	4
T1FMM021	0	FEMUR STEEL WASHER		M	10
T1FMM022	6	FEMUR BALL JOINT RETAINING BOLT		M	2
91259A800		5/8" X 1.75" SHOULDER BOLT	McMASTER-CARR	P	2
T1INM015	2	FEMUR GROUND STRAP	AMERICAN GROUNDING SYSTEMS	P	2
91251A392		5/16-24 X 2 1/4" S.H.C.S.	McMASTER-CARR	P	10
95601A320		HARD FIBER WASHER (ID:5/16", OD:7/16")	McMASTER-CARR	P	10
91253A197		#8-32 X 3/4" F.H.C.S.	McMASTER-CARR	P	10
9452K63		O-RING (1 1/2" OD, 1 1/8" ID)	McMASTER-CARR	P	2
91251A446		1/4-28 X 1 1/2" S.H.C.S. (ALLOY)	McMASTER-CARR	P	2
90073A029		1/4" LOCK WASHER	McMASTER-CARR	P	2
90073A231		3/8" LOCK WASHER	McMASTER-CARR	P	4
98380A537		1/4" DIAM. X 1/2" DOWEL PIN	McMASTER-CARR	P	4
91255A144		# 6-32 X 1/4" B.H.C.S	McMASTER-CARR	P	4
91255A555		1/4-28 X .625 UNF-2B BHSCS	McMASTER-CARR	P	6
T1FMS000	B0	FEMUR SKIN MOUNTING ASSEMBLY		A	2
T1FMS010	B0	FEMUR SKIN RIGHT LEG		S	1
BRASS-6.5		6.5" BRASS ZIPPER	LENZIP CORP.	P	1
T1FMS011	B0	FEMUR SKIN LEFT LEG		S	1
BRASS-6.5		6.5" BRASS ZIPPER	LENZIP CORP.	P	1
HEAD					
T1HDM000	10	HEAD MECHANICAL ASSEMBLY		A	
T1HDM100	15	HEAD/SKULL ASSEMBLY		A	
T1HDM110	7	HEAD CAP		M	1
ATD6273		SKULL CAP ASSEMBLY	FTSS	S	1
00060020		#2-56 X .179 HELICAL INSERT	MSC	P	2

APPENDIX I. THOR-NT Bill of Material

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1HDM111	17	HEAD MACHINING		M	1
T1HDM130	1	HEAD CASTING		O	1
00060251		#6-32 x .276" HELICAL INSERT	MSC	P	6
00060590		1/4-20 x .375" HELICAL INSERT	MSC	P	4
T1HDM116	2	HEAD PLUG		M	1
T1HDM118	1	HEAD CG PART GROUP FOR BALLAST WEIGHTS DESIGN		M	1
T1HDM119	0	TOP BIAXIAL ACCELEROMETER MOUNT		M	1
T1HDM120	3	HEAD BALLAST		M	1
TIINM111	0	ENDEVCO UNIAXIAL ACCELEROMETER	ENDEVCO	P	2
92196A052		#0-80 x 1/8" S.H.S.C.S. (S.S.)	McMASTER-CARR	P	4
98370A001		18-8 SS WASHER (1/16" ID, 1/8" OD)	McMASTER-CARR	P	4
98380A471		1/8" x 1/ 2" DOWEL PIN (416 SS)	McMASTER-CARR	P	2
91251A831		#4-40 x 7/16" ALLOY S.H.C.S.	McMASTER-CARR	P	4
91251A539		1/4-20 X 5/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	4
90145A472		1/8" DIA x 5/8" LENGTH (SS)	McMASTER-CARR	P	2
91253A006		#10-32 X .625 FHSCS	McMASTER-CARR	P	2
T1HDM200	10	HEAD ACCELEROMETER MOUNT PLATE ASSEMBLY		A	
T1HDM210	8	HEAD ACCELEROMETER MOUNTING PLATE		M	1
91732A515		1/4-28 X 0.25 HELICAL INSERT	McMASTER-CARR	P	4
T1HDM212	11	7-ACCELEROMETER ARRAY FIXTURE		M	1
91253A305		#1/4-28 X 5/8" F.H.S.C.S.	McMASTER-CARR	P	4
91253A110		#4-40 X 1/ 2" F.H.S.C.S.	McMASTER-CARR	P	2
91251A052		#0-80 X 1/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	14
98370A001		18-8 SS WASHER (A/16" ID, 1/8" OD)	McMASTER-CARR	P	14
T1INM111	0	ENDEVCO UNIAXIAL ACCELEROMETER	ENDEVCO	I	7
T1INM501-1		TILT SENSOR ELECTRICAL ASSEMBLY HEAD	AOS	I	1
T1INM500	0	BI AXIAL TILT SENSOR ASSEMBLY		A	
T1INM511	4	UNIVERSAL TILT SENSOR MOUNT		M	1
SX-060-LIN		SX-060-LIN	AOS	P	2
91255A078		#2-56 X 5/16 B.H.S.C.S (ALLOY)	McMASTER-CARR	P	4
RP-323-ND		1/8" NYLON CABLE CLAMP	DIGI-KEY	P	1
91251A106		#4-40 X .25 S.H.C.S.	McMASTER-CARR	P	1
91241A005		#4 WASHER 1/8" X 5/16"	McMASTER-CARR	P	1
91253A309		1/4-28 X 1" F.H.S.C.S.	McMASTER-CARR	P	4
95868A106		#4-40 X 1/4" S.H.C.S.	McMASTER-CARR	P	2
T1HDS000	0	HEAD SKIN ASSEMBLY		A	
T1HDS010	B0	HEAD CAP SKIN		S	1
T1HDS020	8	HEAD SKIN SUB-ASSEMBLY		S	1
T1FCM060	B0	FACE FOAM ASSEMBLY		A	1
T1HDS021	B0	HEAD SKIN		S	1
T1HDS025	0	HEAD/NECK REINFORCEMENT MESH		S	1
T1HDS028	0	FACE REINFORCEMENT MESH		S	1
T1HDS026	0	LEFT CHEEK GUARD INSERT		F	1
T1HDS027	0	RIGHT CHEEK GUARD INSERT		F	1
T1HDE000	7	HEAD ELECTRICAL ASSEMBLY		A	
RP327-ND		DIA. 3/8" NYLON P-CLAMP	DIGI-KEY	P	1
91255A146		#6-32 X 3/8" BHSCS	McMASTER-CARR	P	1
3225T4		1/2" RUBBER CUSHIONED STEEL LOOP STRAP	McMASTER-CARR	P	1
91255A263		#10-32 X 3/8" BHSCS	McMASTER-CARR	P	1

TESTING JACKET

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1JKF000	B1	TESTING JACKET FRONT / REAR PANEL ASSEMBLY		A	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1JKF100	B1	TESTING JACKET FRONT PANEL ASSEMBLY		A	1
T1JKF110	B1	FRONT INSIDE PANEL PATTERN		F	1
T1JKF111	B1	FRONT OUTSIDE PANEL PATTERN		F	1
T1JKF112	B0	STIFFENER POCKETS		A	2
T1JKF113	B1	CHEST FOAM POCKET		A	1
T1JKF114	B1	UPPER RIGHT FOAM POCKET		A	1
T1JKF115	B1	UPPER LEFT FOAM POCKET		A	1
T1JKF116	B2	5" FRONT PANEL SHOULDER ZIPPER	LENZIP CORP.	P	1
T1JKF117	B2	12" LENZIP FRONT PANEL ZIPPERS	LENZIP CORP.	P	2
T1JKF118	B2	UPPER/ LEFT SIDE FOAM		F	2
T1JKF119	B2	WEIGHTED BIB		F	1
T1JKF120	B1	FRONT INTERIOR ABDOMEN PATCH		F	1
T1JKF121	B1	UPPER/ RIGHT SIDE FOAM		F	1
T1JKM010	2	STEEL STIFFENER		M	4
T1JKF134	0	SHOULDER POCKET (LEFT)		F	1
T1JKF135	0	SHOULDER POCKET (RIGHT)		F	1
9489K28		2" X 5" BLACK LOOP VELCRO	McMASTER-CARR	P	1
T1JKF130	B1	CROTCH STRAP ASSEMBLY		A	
T1JKF131	B1	INNER CROTCH STRAP PATTERN		F	1
T1JKF132	B1	OUTER CROTCH STRAP PATTERN		F	1
T1JKF133	B0	REAR CROTCH STRAP LOOP VELCRO		F	1
T1JKF200	B1	TESTING JACKET REAR PANEL ASSEMBLY (OUTSIDE VIEW)		A	
T1JKF201	B3	TESTING JACKET REAR PANEL ASSEMBLY (INSIDE VIEW)		A	
T1JKF210	B1	REAR INSIDE PANEL PATTERN		F	1
T1JKF211	B1	REAR OUTSIDE PANEL PATTERN		F	1
T1JKF212	B1	UPPER BACK FOAM POCKET		F	1
T1JKF213	B2	MID BACK FOAM POCKET		F	1
T1JKF214	B1	UPPER BACK FOAM		F	1
T1JKF215	B2	MID BACK FOAM		F	1
T1JKF216	B0	REAR PANEL HOOK VELCRO		F	1
T1JKF217	B0	REAR PANEL SHOULDER HOOK VELCRO		F	1

LOWER ABDOMEN

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1LAM000	6	LOWER ABDOMEN MECHANICAL ASSEMBLY		A	
T1LAF100	1	LOWER ABDOMEN BAG-SEWING ASSEMBLY		A	
T1LAF110	1	LOWER ABDOMEN TOP/SIDES/REAR BAG PATTERN		F	1
T1LAF111	1	LOWER ABDOMEN BOTTOM BAG PATTERN		F	1
T1LAF112	1	LOWER ABDOMEN TOP POCKET PATTERN		F	1
T1LAF113	1	LOWER ABDOMEN FRONT PATTERN		F	1
T1LAF114	2	LOWER ABDOMEN ZIPPER		F	1
9CF-DFL		YKK ZIPPER AND SLIDER	YKK	F	1
T1LAF115	1	LOWER ABDOMEN STIFFENING CLOTH		F	1
T1LAF116	2	LOWER ABDOMEN OUTSIDE VELCRO PATCH		F	1
T1LAF117	0	UPPER AND LOWER ABDOMEN VELCRO COVER		F	1
T1LAM010	1	LOWER ABDOMEN REAR ATTACHMENT PLATE		M	1
T1LAM011	4	LOWER ABDOMEN POTENTIOMETER COVER		M	2
T1LAM012	4	LOWER ABDOMEN FRONT FOAM LAYER		C	1
T1LAM013	4	LOWER ABDOMEN REAR FOAM LAYER		C	1
T1LAM014	0	LOWER ABDOMEN DISTRIBUTION PLATE		M	2
T1LAW040	7	LOWER ABDOMEN ATTACH BRACKET (LEFT) WELD ASSEMBLY		W	
T1LAM041	0	LOWER ABDOMEN SIDE BRACKET REAR FLANGE		M	1
T1LAM042	3	LOWER ABDOMEN SIDE BRACKET PLATES		M	1
T1LAM043	5	LOWER ABDOMEN SIDE ATTACH BRACKET FRONT PLATE (LEFT)		M	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1LAM044	1	LOWER ABDOMEN SIDE ATTACHMENT BRACKETS - DGSP MOUNT		M	1
T1LAW060	7	LOWER ABDOMEN ATTACH BRACKET (RIGHT) WELD ASSEMBLY		W	
T1LAM041	0	LOWER ABDOMEN SIDE BRACKET REAR FLANGE		M	1
T1LAM042	3	LOWER ABDOMEN SIDE BRACKET PLATES		M	1
T1LAM063	2	LOWER ABDOMEN SIDE ATTACH BRACKET FRONT PLATE (RIGHT)		M	1
T1LAM044	1	LOWER ABDOMEN SIDE ATTACHMENT BRACKETS - DGSP MOUNT		M	1
T1LAW080	2	LOWER ABDOMEN INTERNAL MOUNTING WELD ASSEMBLY		W	
T1LAM081	5	LOWER ABDOMEN INTERNAL PLATE		M	1
T1LAM082	4	LOWER ABDOMEN FLARED OVERLOAD CONES		M	2
T1LAM083	1	LOWER ABDOMEN THREADED PLUG		M	4
T1DPM000	3	DGSP COMPLETE MECHANICAL ASSEMBLY		A	2
92949A540		1/4-20 X 3/4" B.H.S.C.S.	McMASTER-CARR	P	4
91251A110		#4-40 X 3/4" S.H.C.S.	McMASTER-CARR	P	4
64-3020		3/8-32 X 0.10" UNEF NUT	RADIO SHACK	P	2
98019A399		3/8" WASHER	McMASTER-CARR	P	2
1420X625BP		1/4-20 X 5/8" B.H.S.C.S. W/ PELLET	COLD HEADERS	P	4
91253A624		3/8-16 X 1" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
91253A108		#4-40 X 3/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	8
T1INM014	1	INSTRUMENT LUMBAR SPINE GROUND STRAP	AMERICAN GROUNDING SYSTEMS	P	1
LOWER EXTREMITY					
T1LXM000	8	THOR-LX MECHANICAL ASSEMBLY		A	2
T1KNM011	7	KNEE OUTBOARD COVER - LEFT		M	1
T1KNM012	6	KNEE INBOARD COVER - LEFT		M	1
T1KNM013	7	KNEE OUTBOARD COVER - RIGHT		M	1
T1KNM014	6	KNEE INBOARD COVER - RIGHT		M	1
91251A440		1/4-28 x 3/4" UNF-2B S.H.C.S	McMASTER-CARR	P	8
91253A301		1/4-28 x 3/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	8
T1KNM000	3	KNEE ASSEMBLY MECHANICAL ASSEMBLY		A	
EX-593-1		ASSEMBLY, SLIDING KNEE, LEFT	DENTON-ATD	P	1
EX-593-2		ASSEMBLY, SLIDING KNEE, RIGHT	DENTON-ATD	P	1
T1KNS010	6	MODIFIED KNEE SKIN LEFT		S	1
78051-5		KNEE FLESH LEFT	FTSS	P	1
78051-27		KNEE INSERT	FTSS	P	1
T1KNS011	2	MODIFIED KNEE SKIN RIGHT		S	1
78051-6		KNEE FLESH RIGHT	FTSS	P	1
78051-27		KNEE INSERT	FTSS	P	1
T1LXM001	13	THOR-LX - LOWER MECHANICAL ASSEMBLY		A	2
T1FTM000	10	FOOT - MECHANICAL ASSEMBLY		A	2
T1FTM010	8	FOOT - COMPOSITE SOLE PLATE		M	2
93415A021		#4-40 X 0.25" EXPANSION INSERT	McMASTER-CARR	P	4
T1FTM011	4	FOOT COMPOSITE SOLE LAYUP		M	2
T1FTM210	11	HEEL / ACHILLES MOUNTING BRACKET		M	2
T1FTM214	5	HEEL PAD		M	2
T1FTM311	11	LOWER ACHILLES MOUNTING POST		M	2
91253A539		1/4-20 x 5/8" F.H.S.C.S.	McMASTER-CARR	P	8
91253A536		1/4-20 x 7/8" F.H.S.C.S.	McMASTER-CARR	P	6
91253A110		#4-40 x 1/2" F.H.S.C.S.	McMASTER-CARR	P	4
91251A110		#4-40 x 1/2" S.H.C.S.	McMASTER-CARR	P	2
T1FTM006	1	FOOT - TRI-PACK ACCELEROMETER ASSEMBLY		A	2
T1FTM012	5	FOOT 7264 TRI-PACK ACCELEROMETER MOUNTING PLATE		M	2
T1INM100	1	TRI-PACK ACCELEROMETER ASSEMBLY		A	2
T1INM130	6	TRI-PACK BLOCK		M	2
T1INM110	4	UNIAXIAL ACCELEROMETER	ENTRAN	I	6
91251A052		#0-80 X 1/8" S.H.C.S. (ALLOY)		P	12

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
90945A700		18-8 SS WASHER (0.063" ID, 0.099" OD, 0.014" MIN THK)		P	12
91251A102		#2-56 x 9/16" S.H.C.S. (Alloy)	McMASTER-CARR	P	4
T1AKM000	12	ANKLE MECHANICAL ASSEMBLY		A	2
T1AKM001	2	CENTER BLOCK ASSEMBLY		A	2
T1AKM012	8	ANKLE CENTER BLOCK		M	2
T1AKM030	7	ANKLE TORQUE SHAFT UPPER JOINT - MECHANICAL ASSEMBLY		A	2
T1AKM031	8	TORQUE SHAFT - UPPER JOINT		M	2
8890980		0.098" Diam Gage Pin	MSC	P	2
T1AKM040	7	ANKLE TORQUE SHAFT LOWER JOINT - MECHANICAL ASSEMBLY		A	2
T1AKM041	5	TORQUE SHAFT - LOWER JOINT		M	2
8890980		0.098" Diam Gage Pin	MSC	P	2
98381A541		1/4" DIA X 7/8" DOWEL PIN	McMASTER-CARR	P	4
T1AKM002	2	DORSI - PLANTAR SOFT STOP ASSEMBLY		A	2
T1AKM024	5	DORSI - PLANTAR SOFT STOP BASE		M	2
T1AKM025	4	DORSI - PLANTAR SOFT STOP		M	2
T1AKM003	2	INVERSION/EVERSION SOFT STOP ASSEMBLY		A	4
T1AKM016	B0	INVERSION - EVERSION SOFT STOP		M	4
T1AKM019	9	SOFT STOP BRACKET		M	4
T1AKM010	13	BOTTOM TORQUE BASE		M	2
00060632		1/4-20 x 0.25" HELICOIL INSERT	MSC	P	16
00062703		#6-32 x 0.138" SCREW LOCK HELICOIL INSERT	MSC	P	8
T1AKM011	16	TOP TORQUE BASE		M	2
00060590		1/4-20 x 0.375" HELICOIL INSERT	MSC	P	8
T1AKM020	0	Z ROTATION BEARING		M	2
PS1216-8		LINEAR BEARING (.75" ID, 1.0" OD, 1.0" LENGTH)	PACIFIC BEARINGS	P	2
T1AKM013	5	POTENTIOMETER COVER		M	4
T1AKM014	6	TORQUE BASE CAP		M	8
T1AKM018	1	RUBBER TORQUE CYLINDERS		M	32
DR-S 11x50		ROSTA DR-S VIBRATION BLOCK	BEARINGS & DRIVES	P	3
T1AKM022	2	DELRIN SPACER WASHER		M	8
T1AKM026	0	DORSI - FLEXION SOFT STOP COVER		M	2
T1AKM027	0	ANKLE Z-ROTATION STOP		M	4
T1AKM050	2	ACHILLES PULLEY BRACKET ASSEMBLY		A	2
95630A238		#8 TEFLON WASHER	McMASTER-CARR	P	4
S99NH2-BN0608		STERLING INSTRUMENTS NEEDLE ROLLER BEARING	STERLING INSTRUMENTS	P	4
92141A005		#4 WASHER	McMASTER-CARR	P	4
91831A005		#4-40 NYLOCK NUT	McMASTER-CARR	P	4
T1AKM051	5	ACHILLES PULLEY BRACKET		M	2
T1AKM052	1	ACHILLES CABLE PULLEY SHAFT		M	2
T1AKM053	2	ACHILLES CABLE PULLEY		M	2
T1AKM100	2	BUSHING PLATE ASSEMBLY		A	8
T1AKM110	7	BUSHING PLATE - POT END		M	4
T1AKM111	3	BUSHING		M	8
T1AKM112	8	BUSHING PLATE - END COVER		M	4
T1AKM004	2	ANKLE RETAINING BOLT ASSEMBLY		A	2
T1AKM028	3	ANKLE BOLT SLEEVE		M	2
T1AKM029	1	ANKLE RETAINING BOLT		M	2
91259A624		3/8" X 1" SHOULDER BOLT	McMASTER-CARR	P	2
PD210-4B		CONTELEC ROTARY POTENTIOMETER	CONTELEC	P	6
91253A108		#4-40 x 3/8" F.H.S.C.S. (Alloy)	McMASTER-CARR	P	8
91253A153		#6-32 x 1" F.H.S.C.S. (Alloy)	McMASTER-CARR	P	8
92311A142		#6-32 x 1/8" S.S.S. (18-8 SS)	McMASTER-CARR	P	8
92311A146		#6-32 x 3/8" S.S.S. (18-8 SS)	McMASTER-CARR	P	4
91255A145		#6-32 x 5/16" B.H.S.C.S. (Alloy)	McMASTER-CARR	P	8
91253A148		#6-32 x 1/2" F.H.S.C.S. (Alloy)	McMASTER-CARR	P	8
91253A112		#4-40 x 5/8" F.H.S.C.S. (Alloy)	McMASTER-CARR	P	8
91255A539		1/4" - 20 x 5/8" B.H.S.C.S. (Alloy)	McMASTER-CARR	P	16
91253A110		#4-40 x 1/2" F.H.S.C.S. (Alloy)	McMASTER-CARR	P	4

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1LLM000	13	LOWER LEG - MECHANICAL ASSEMBLY		A	2
T1LLM001	3	KNEE CLEVIS ASSEMBLY		A	2
T1LLM025	6	MOLDED KNEE BUMPER		M	2
T1LLM026	3	MOLDED KNEE BUMPER BACK PLATE		M	2
T1LLW020	7	KNEE CLEVIS WELDMENT		W	2
T1LLM021	8	KNEE CLEVIS - RIGHT		M	2
T1LLM022	7	KNEE CLEVIS - LEFT		M	2
T1LLM023	7	KNEE CLEVIS - BOTTOM PLATE		M	2
T1LLM024	7	KNEE BUMPER STIFFENER		M	2
91732A511		#10-32 x 0.19" HELICOIL INSERT	McMASTER-CARR	P	4
91255A263		#10-32 x 3/8" B.H.S.C.S. (Alloy)	McMASTER-CARR	P	4
T1LLM014	11	TIBIA GUARD		M	2
T1LLM002	4	LOWER TIBIA TUBE ASSEMBLY		A	2
T1LLM010	20	LOWER TIBIA TUBE		M	2
91732A515		1/4-28 x 0.25" HELICOIL INSERT	McMASTER-CARR	P	20
T1LLM414	0	MODIFIED LINEAR BEARING		M	2
PS1216-8		LINEAR BEARING 0.75" ID, 1.0" OD, 1" LENGTH	PACIFIC BEARINGS	P	2
PS1216-8		LINEAR BEARING 0.75" ID, 1.0" OD, 1.62" LENGTH	PACIFIC BEARINGS	P	2
T1LLM016	0	LOWER TIBIA TUBE PIN		M	2
98380A470		1/8" X 3/8" DOWEL PIN	McMASTER-CARR	P	2
T1LLM011	8	UPPER TIBIA TUBE		M	2
91732A515		1/4-28 x 0.25" HELICOIL INSERT	McMASTER-CARR	P	8
T1LLM012	10	UPPER TIBIA MOCK LOAD CELL		M	2
UPPER TIBIA LOAD CELL (ALTERNATE TO THE UPPER TIBIA MOCK LOAD CELL T1LLM012)					
4353 J		DENTON UPPER TIBIA LOAD CELL (4353 J)	DN	P	2
T1LLM013	14	LOWER TIBIA MOCK LOAD CELL		M	2
LOWER TIBIA LOAD CELL (ALTERNATE TO THE LOWER TIBIA MOCK LOAD CELL T1LLM013)					
4929 J		DENTON LOWER TIBIA LOAD CELL (4929 J)	DN	P	2
T1LLM015	1	TEFLON WASHER		M	2
T1LLM111	3	Z ROTATION WEDGE - #1		M	2
T1LLM112	2	Z ROTATION WEDGE - #2		M	2
T1INM110	4	THOR UNIAXIAL ACCELROMETER		P	4
T1LLM300	11	ACHILLES SPRING TUBE - MECHANICAL ASSEMBLY		A	2
T1LLM310	7	ACHILLES SPRING TUBE BASE		M	2
60269		#6-32 X 0.345 HELICOIL INSERT	MSC	P	8
T1LLM311	9	ACHILLES SPRING TUBE		M	2
T1LLM312	1	ACHILLES - PRIMARY LOAD WASHER		M	2
T1LLM313	2	ACHILLES - SPRING CAP		M	2
T1LLM314	2	ACHILLES - SPRING BASE CAP		M	2
T1LLM316	3	ELASTOMERIC SPRING ELEMENT		M	2
T1LLM317	2	ACHILLES - SOFT FOAM COMPRESSION ELEMENT		M	2
T1LLM318	4	ACHILLES CABLE RETAINING UNIT		M	2
93776A401		#10-32 HEX SERRATED FLANGE NUT (18-8 SS)	MSC	P	2
T1LLM319	7	ACHILLES CABLE ASSEMBLY		P	2
T1LLM320	2	MOCK ACHILLES LOAD CELL		M	2
ACHILLES LOAD CELL (ALTERNATE TO THE MOCK LOAD CELL T1LLM320)					
5145		DENTON ACHILLES LOAD CELL - 1000 LBF	DN	P	2
1S26090		COMPRESSION SPRING 3.5" - 137 lb/in.	MID-WEST EXPRESS	P	2
91375A103		#4-40 x 1/8" S.S.S. (Alloy)	McMASTER-CARR	P	2
T1LLM400	2	TIBIA COMPLIANT BUSHING ASSEMBLY		A	2
T1LLM410	7	COMPLIANT BUSHING PLUNGER		M	2
T1LLM411	9	COMPLIANT BUSHING - LOWER FLANGE		M	2

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1LLM412	6	COMPLIANT BUSHING		M	2
T1LLM413	5	PLUNGER RETAINING BOLTS		M	4
91251A440		1/4-28 x 3/4" S.H.C.S. (Alloy)	McMASTER-CARR	P	4
T1AKM021	1	TIBIA ROTARY POTENTIOMETER SHAFT		M	2
T1INM016	1	TIBIA GROUND STRAP	AMERICAN GROUNDING SYSTEMS	P	1
91255A553		1/4-28 x 1/2" B.H.S.C.S. (Alloy)	McMASTER-CARR	P	24
91253A303		1/4-28 x 1/2" F.H.S.C.S. (Alloy)	McMASTER-CARR	P	12
92695A152		#8-32 x 1/4" S.S.S (Cone Point)	McMASTER-CARR	P	2
91251A055		#0-80 x 1/4" S.H.C.S. (Alloy)	McMASTER-CARR	P	8
98381A504		3/16 x 7/16" Dowel Pin	McMASTER-CARR	P	4
98381A509		3/16 x 7/8" Dowel Pin	McMASTER-CARR	P	4
90945A700		18-8 SS WASHER (1/16" ID, 1/8" OD)	McMASTER-CARR	P	2
91255A555		1/4-28 x 5/8" B.H.S.C.S.	McMASTER-CARR	P	2
91255A559		1/4-28 x 7/8" B.H.S.C.S.	McMASTER-CARR	P	2
91251A439		1/4"-28 X 5/8" S.H.C.S.	McMASTER-CARR	P	8
T1LLS000	3	TIBIA FLESH - MECHANICAL ASSEMBLY		A	2
T1LLS010	1	LEFT TIBIA FLESH ASSEMBLY		A	1
T1LLS012	1	TIBIA FLESH LEFT		M	1
T1LLS014	1	ZIPPER		P	1
HDB9S-12"		YKK HEAVY DUTY 12" BRASS #9, SEPARATING 12"	YKK	P	1
T1LLS015	1	ZIPPER FLAPS		M	2
T1LLS011	2	RIGHT TIBIA FLESH ASSEMBLY		A	1
T1LLS013	1	TIBIA FLESH RIGHT		M	1
T1LLS014	1	ZIPPER		P	1
HDB9S-12"		YKK HEAVY DUTY 12" BRASS #9, SEPARATING 12"	YKK	P	1
T1LLS015	1	ZIPPER FLAPS		M	2
T1FTS000	3	FOOT SKIN - MECHANICAL ASSEMBLY		A	2
T1FTS010	2	FOOT FLESH - LEFT		S	1
FTM312	0	FOOT SKIN INSERT		M	1
T1FTS011	2	FOOT FLECH - RIGHT		S	1
FTM312	0	FOOT SKIN INSERT		M	1
T1AKE000	0	ANKLE ELECTRICAL ASSEMBLY		A	2
8876T11		1/8" WIRE CLAMP	McMASTER-CARR	P	8
91255A146		#6-32 X 3/8" B.H.S.C.S.	McMASTER-CARR	P	6
91255A144		#6-32 X 1/4" B.H.S.C.S.	McMASTER-CARR	P	2
T1LXC000	1	THOR-LX ANKLE ROTARY POTENTIOMETER CALIBRATION		A	
T1CEM420	0	ANKLE ROTARY POTENTIOMETER CALIBRATION FIXTURE		P	1
T1CEM421	0	CALIBRATION FIXTURE SHOULDER BOLT		M	2
91259A587	1	0.312" x 1 1/2 SHOULDER BOLT	McMASTER-CARR	P	2
T1CEM422	1	CALIBRATION FIXTURE SHOULDER BOLT # 2		M	4
93985A306		0.312" DIA X 3/4" SHOULDER BOLT (416 SS)	McMASTER-CARR	P	4
91251A440		1/4" - 28 x 3/4" S.H.C.S.	McMASTER-CARR	P	2
T1CEM410	1	ACHILLES CABLE CALIBRATION LOOP			1
3914T1		1/16" STOP SLEEVE	McMASTER-CARR	M	1
3458T145		1x7 STRAND CORE 0.027" DIAMETER WIRE ROPE	McMASTER-CARR	P	1
MID-STERNUM					
T1MSM005	B0	MID STERNUM BONDING ASSEMBLY		A	
T1MSM010	B0	MID-STERNUM PLATE		M	1
T1MSM014	0	MID-STERNUM MASS DAMPING FOAM # 1		C	1
T1MSM011	B0	MID-STERNUM MASS		M	2
T1MSM012	B0	MID-STERNUM MASS DAMPING FOAM # 2		C	1
T1MSM015	0	MID-STERNUM RUBBER PAD		M	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
8635K161		1/32" THICK SHORE 60 A (+/-5)	McMASTER-CARR	P	1
NECK					
T1NKM000	10	NECK MECHANICAL ASSEMBLY		A	
T1NKM100	9	NECK CABLES ASSEMBLY		A	
T1NKM104	0	NECK FRONT STOP ASSEMBLY			
T1NKM105	0	NECK MOLDED ASSEMBLY			
T1NKM110	B0	NECK BASE		M	1
T1NKM112	B0	NECK PLATE 1		M	1
T1NKM114	B0	NECK PLATE 2		M	1
T1NKM115	B0	NECK PLATE 3		M	2
T1NKM116	B0	NECK TOP PLATE		M	1
T1NKM123	0	NECK FRONT STOP		M	1
98381A502		3/16" DIAM. X 5/16" DOWEL PIN	McMASTER-CARR	P	1
9838A473		1/8 X 3/4" DOWEL PIN	McMASTER-CARR	P	2
T1NKM117	9	NECK REAR CABLE ASSEMBLY		P	1
T1NKM127	0	FRONT AND REAR CABLE THREADED SWAGE		M	1
T1NKM118	3	NECK REAR CABLE GUIDE HALF		M	16
T1NKM119	2	NECK CENTER CABLE ASSEMBLY		P	1
T1NKM128	0	NECK CENTER CABLE THREADED SWAGE		M	1
T1NKM120	4	NECK CENTER CABLE FIXTURE		M	1
T1NKM122	10	NECK FRONT CABLE ASSEMBLY		P	1
T1NKM127	0	FRONT AND REAR CABLE THREADED SWAGE		M	1
T1NKM124	1	NECK CABLE COVER		M	1
T1NKM125	0	NECK TOP PLATE CABLE GUIDE		M	1
T1NKM126	0	NECK TOP PLATE CABLE GUIDE HALF		M	2
91253A077		#2-56 X 1/4" FHCS	McMASTER-CARR	P	2
T1NKM200	B1	NECK/HEAD MOUNTING PLATFORM ASSEMBLY		A	
T1NKM028	B0	NECK NON-ACTIVE SPRING LOAD CELL		M	2
T1NKM045	0	OC STOP ASSEMBLY		A	
T1NKM046	0	NECK FLEXION-EXTENSION STOP PLATE		M	1
T1NKM047	1	NECK FRONT OC STOP (CONTINOUS)		M	1
T1NKM048	1	NECK REAR OC STOP (CONTINOUS)		M	1
T1NKM210	B2	NECK/HEAD MOUNTING PLATFORM		M	1
00060343		#8-32 X 0.25 HELICAL INSERT	MSC	P	6
00060129		#4-40 X 0.224 HELICOIL INSERT	MSC	P	2
00060629		#6-32 X 0.345 HELICOIL INSERT	MSC	P	2
T1NKM211	5	NECK FRONT/REAR SPRING TUBE		M	2
T1NKM214	5	NECK FRONT CABLE BUSHING		M	1
T1NKM216	2	NECK OCCIPITAL CONDYLE BUSHING		M	2
T1NKM400	B1	NECK/HEAD PULLEY BRACKET ASSEMBLY		A	
T1NKM410	B1	NECK/HEAD REAR PULLEY BRACKET		M	1
T1NKM311	3	NECK REAR CABLE PULLEY SHAFT		M	1
T1NKM312	2	NECK REAR CABLE PULLEY		M	1
95630A238		TEFLON WASHER	McMASTER-CARR	P	4
92141A005		#4 FLAT WASHER	McMASTER-CARR	P	2
91831A005		#4-40 HEX NYLOCK NUT	McMASTER-CARR	P	2
S99NH2-BN0608		STERLING INSTRUMENTS NEEDLE ROLLER BEARING	STERLING INSTRUMENTS	P	2
T1NKM030	B1	NECK FRONT SPRING ASSEMBLY		A	
9-1012-21		3"L x .630" x .315" ID (+/- 5% RATE TOLERANCE)	DANLY	P	1
T1NKM031	B2	NECK FRONT SPRING DAMPING TUBE		M	1
5553K13		3/8"OD X 1/4"ID SHORE 65A TYGON TUBE	McMASTER-CARR	P	1
T1NKM023	4	NECK SPRING BUSHING		M	2

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1NKM050	B1	NECK REAR SPRING ASSEMBLY		A	
9-1014-26		3.5" L x .625" OD (+/- 5% RATE TOLERANCE)	DANLY	P	1
T1NKM051	B2	NECK REAR SPRING DAMPING TUBE		M	1
5119K63		3/8"OD X 1/4"ID SHORE 90A VITON TUBE	McMASTER-CARR	P	1
T1NKM023	4	NECK SPRING BUSHING		M	2
91253A192		8-32 X 3/8" F.H.S.C.S.	McMASTER-CARR	P	6
T1NKM300	3	NECK PULLEY BRACKET ASSEMBLY		A	
T1NKM310	5	NECK REAR PULLEY BRACKET		M	1
T1NKM311	3	NECK REAR CABLE PULLEY SHAFT		M	1
T1NKM312	2	NECK REAR CABLE PULLEY		M	1
95630A238		NECK TEFLON WASHER	McMASTER-CARR	P	4
S99NH2-BN0608		STERLING INSTRUMENTS NEEDLE ROLLER BEARING	STERLING INSTRUMENTS	P	2
92141A005		#4 WASHER	McMASTER-CARR	P	2
91831A005		#4-40 NYLOCK NUT	McMASTER-CARR	P	2
T1NKM500	3	NECK STOP ASSEMBLY		A	
T1NKM510	5	NECK STOP 2		M	1
T1NKM511	1	NECK SOFT STOP 2		M	1
T1NKM512	4	NECK STOP 1		M	1
T1NKM513	1	NECK SOFT STOP 1		M	1
T1NKM600	1	NECK NON-ACTIVE LOWER LOAD CELL ASSEMBLY		A	
T1NKM610	3	NECK NON-ACTIVE LOWER LOAD CELL TOP PLATE		M	1
T1NKM611	2	NECK NON-ACTIVE LOWER LOAD CELL MID BLOCK		M	1
00060582		1/4-20 X 0.25 HELICOIL	MSC	P	4
00060608		1/4-20 X 0.5 HELICOIL	MSC	P	4
T1NKM612	2	NECK NON-ACTIVE UPPER LOAD CELL BOTTOM PLATE		M	1
91253A542		1/4-20 X 1" ALLOY FHSCS	McMASTER-CARR	P	4
91253A539		1/4-20 X 5/8" FHSCS	McMASTER-CARR	P	4
LOWER NECK LOAD CELL (ALTERNATE TO THE NON-ACTIVE LOAD CELL T1NKM600)					
T1INM320	3	INSTRUMENT LOWER NECK LOAD CELL		I	1
T1NKM700	0	NECK MECHANICAL ASSEMBLY NON-ACTIVE UPPER LOAD CELL		A	
91253A536		#1/4-20 X 7/8" F.H.S.C.S.	McMASTER-CARR	P	4
91458A17		PERMANENT LOCTITE 262	McMASTER-CARR	P	1
T1NKM710	0	NECK NON-ACTIVE UPPER LOAD CELL UPPER PLATE		M	1
T1NKM711	0	NECK NON-ACTIVE UPPER LOAD CELL LOWER PLATE		M	1
UPPER NECK LOAD CELL (ALTERNATE TO THE NON-ACTIVE LOAD CELL T1NKM700)					
T1INM310	3	INSTRUMENT UPPER NECK LOAD CELL		I	1
T1NKM043	2	NECK OCCIPITAL CONDYLE CAM		M	1
T1NKM010	B2	NECK OCCIPITAL CONDYLE BOLT		M	1
T1NKM011	4	NECK KEY WASHER		M	2
T1NKM012	2	NECK FRICTION WASHER		M	1
T1NKM014	3	NECK PULLEY PLATE		M	1
T1NKM017	B0	NECK ROTARY POTENTIOMETER HOUSING		M	1
T1NKM018	B0	NECK ROTARY POTENTIOMETER HOUSING COVER		M	1
T1NKM022	4	NECK CABLE SEAT COVER		M	2
T1NKM024	2	NECK LOWER NECK LOAD CELL BUMPER COVER		M	1
T1NKM025	3	NECK LOWER NECK LOAD CELL BUMPER		M	1
T1NKM027	3	NECK OCCIPITAL CONDYLE SET SCREW		M	1
T1NKM029	0	NECK CENTER CABLE WASHER		M	1
UI36-0170		CURVED DISK SPRING WASHER	SPEC -BARNES	P	4
91081A027		#10 FLAT WASHER 1/4" ID, 9/16" OD, 0.046" THK	McMASTER-CARR	P	1
91831A029		1/4-20 NUT W/ NYLON INSERT	McMASTER-CARR	P	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
91255A269		#10-32 X 3/4" B.H.S.C.S. (ALL0Y)	McMASTER-CARR	P	4
92314A239		#10-24 X 1/4" HEX HEAD	McMASTER-CARR	P	2
92831A411		#10-32 HEX NYLON INSERT LOCK NUT	McMASTER-CARR	P	2
91253A079		#2-56 X 3/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	4
91251A539		1/4-20 X 5/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	8
91831A120		1/4-28 NYLON INSERT LOCK NUT	McMASTER-CARR	P	1
90313A107		FLAT WASHER 9/32 ID X 1 OD X 3/64" THK	McMASTER-CARR	P	1
94639A144		NYLON SPACER .25 ID X .5 OD X .75"	McMASTER-CARR	P	1
98437A110		1/4" (.260 ID - .363 OD) LOCK WASHER	McMASTER-CARR	P	8
91255A117		#4-40 X 1 1/4" B.H.C.S	McMASTER-CARR	P	2
91255A105		#4-40 X 3/16" B.H.C.S	McMASTER-CARR	P	2
91251A190		#8-32 X 1/4" B.H.C.S. (ALLOY)	McMASTER-CARR	P	1
91255A145		#6-32 X 5/16" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
91255A146		#6-32 X 3/8" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
1420X050SP		1/4-20 X 5/8" S.H.C.S. - NP	COLD HEADERS	P	4
T1NKS000	3	NECK SKIN ASSEMBLY		A	
T1NKS100	B2	NECK FOAM ASSEMBLY		A	1
T1NKS110	B2	NECK FOAM		S	1
T1NKS112	B2	NECK FOAM REINFORCEMENT		F	1
9489K297		LOOP VELCRO (2" WIDE X 3.65" LONG)	McMASTER-CARR	F	1
9489K524		HOOK VELCRO (3/4" WIRE X 3.65" LONG)	McMASTER-CARR	F	1
T1NKS200	3	NECK SKIN		F	1
T1NKS210	0	NECK/HEAD SKIN ZIPPER	LENZIP CORP.	P	1
T1NKS211	0	NECK SKIN REAR ZIPPER	LENZIP CORP.	P	1
T1NKS212	0	NECK SKIN - OUTER CORDURA		F	1
W935ORD		9"X16" CORDURA FABRIC (RED)	PG	P	1
T1NKS213	0	NECK SKIN - INNER CORDURA		F	1
W935ORD		9"X16" CORDURA FABRIC (RED)	PG	P	1
T1NKS214	0	NECK SKIN - FOAM PATTERN		C	1
SCE 41		9"X16" 1/8" NEOPRENE W/NYLON COAT	GI	P	1
T1NKT010	0	NECK TOOL SPRING ADJUSTMENT SOCKET		M	1
5553A43		3/8" DEEP SOCKET	McMASTER-CARR	P	1
T1NKT011	1	NECK TOOL 3/8" RATCHET SPINNER		M	1
5522A27		3/8" RATCHET SPINNER	McMASTER-CARR	P	1
					1
PELVIS					
T1PLM000	10	PELVIS ASSEMBLY		A	
T1PLM001	9	PELVIS MAIN SUBASSEMBLY		A	1
T1PLM200	5	PELVIC BOX ASSEMBLY		A	1
T1PLM201	2	PELVIS LEFT ACETABULAR ASSEMBLY		A	1
T1PLM211	B1	PELVIS LOAD CELL MOUNTING PLATE (LEFT)		M	1
T1PLM217	9	PELVIS SOCKET ADAPTOR (LEFT)		M	1
00061283		3/4-10 X .75 HELI-COIL INSERT	MSC	P	1
00060657		1/4-28 X .5 HELI-COIL INSERT	MSC	P	3
1420X785FP		.25-20UNC X 7/8" F.H.S.C.S (N-P)	COLD HEADERS	P	4
94945A225		.5-20UNC NYLOCK HEX JAM NUT	McMASTER-CARR	P	1
98023A033		STEEL FLAT WASHER .50 I.D, 1.06 OD	McMASTER-CARR	P	1
98381A537		.25X .50 DOWEL PIN	McMASTER-CARR	P	4
T1PLM220	2	NON-ACTIVE ACETABULAR LOAD CELL		M	1
TIPLM222	2	ACETABULAR BOTTOM PLATE		M	1
00060624		1/4-20 X .750 HELICOIL	MSC	P	4
T1PLM221	2	ACETABULAR TOP PLATE		M	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
91253A542		1/4-20 X 1" F.H.S.C.S	McMASTER-CARR	P	4
T1PLM202	2	PELVIS RIGHT ACETABULAR ASSEMBLY		A	1
T1PLM212	B1	PELVIS LOAD CELL MOUNTING PLATE (RIGHT)		M	1
T1PLM218	8	PELVIS SOCKET ADAPTOR (RIGHT)		M	1
00061283		3/4-10 X .75 HELI-COIL INSERT	MSC	P	1
00060657		1/4-28 X .5 HELI-COIL INSERT	MSC	P	3
1420X785FP		.25-20UNC X 7/8" F.H.S.C.S (N-P)	COLD HEADERS	P	4
94945A225		.5-20UNC NYLOCK HEX JAM NUT	McMASTER-CARR	P	1
98023A033		STEEL FLAT WASHER .50 I.D, 1.06 OD	McMASTER-CARR	P	1
98381A537		.25X .50 DOWEL PIN	McMASTER-CARR	P	4
T1PLM220	2	NON-ACTIVE ACETABULAR LOAD CELL		M	1
TIPLM222	2	ACETABULAR BOTTOM PLATE		M	1
00060624		1/4-20 X .750 HELICOIL	MSC	P	4
T1PLM221	2	ACETABULAR TOP PLATE		M	1
91253A542		1/4-20 X 1" F.H.S.C.S	McMASTER-CARR	P	4
T1PLM300	1	PELVIS FRICTION ADJUSTMENT SOCKET SET SCREW ASSEMBLY		A	1
T1PLM310	1	PELVIS FRICTION ADJUSTMENT SET SCREW		M	2
3410X075SS		3/4-10 X 3/4" S.S.S.	COLD HEADERS	P	2
T1PLM311	0	PELVIS FRICTION ADJUSTMENT NYLON TIP		M	2
T1PLM214	B1	PELVIS REAR PLATE		M	1
T1PLM213	4	PELVIS TOP PLATE		M	1
T1PLM215	1	PELVIS FRONT PLATE		M	1
91732A211		#10-32 HELI-COIL X .125"	McMASTER-CARR	P	2
91263A531		#10-24 UNC X .375 F.H.S.C.S	McMASTER-CARR	P	13
91263A551		.25-20 UNC X .375 F.H.S.C.S	McMASTER-CARR	P	4
T1PLM101	7	PELVIS TRI-PACK ACCELEROMETER - MECHANICAL ASSEMBLY		A	1
T1PLM112	6	PELVIS TRI-PACK ACCELEROMETER BRACKET		M	1
91732A203		#2-56 X 0.086 HELICAL INSERT	McMASTER-CARR	P	2
T1INM100	1	TRI-PACK ACCELEROMETER ASSEMBLY		A	1
T1INM130	6	TRI-PACK MOUNTING BLOCK		M	1
T1INM110	4	UNIAXIAL ACCELEROMETER	ENTRAN	I	3
91251A052		#0-80 X 1/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	6
90945A700		18-8 SS WASHER (0.063" ID, 0.099" OD, 0.014" MIN THK)	McMASTER-CARR	P	6
256X0625		#2-56UNC X 0.563" S.H.C.S.	COLD HEADERS	P	2
T1PLM010	B2	PELVIS BASE MODULE		M	1
000600582		1/4-20 X .25 HELICOIL	MSC	P	4
00060590		1/4-20 X .375 HELICOIL	MSC	P	4
00060608		1/4-20 X .5 HELICOIL	MSC	P	6
T1PLM013	3	PELVIS COCCYX		M	1
T1PLM014	2	PELVIS LEFT D POINT		M	1
T1PLM015	2	PELVIS RIGHT D-POINT		M	1
98381A540		.25 DIAM X .75" DOWEL PIN	McMASTER-CARR	P	1
91253A542		.25 DIAM - 20 UNC X 1" F.H.S.C.S	McMASTER-CARR	P	6
91251A146		#6 - 32 UNC X .375" S.H.C.S	McMASTER-CARR	P	4
91255A537		.25 DIAM - 20 UNC X .5" B.H.C.S	McMASTER-CARR	P	4
91253A540		.25 DIAM - 20 UNC X .75" F.H.S.C.S	McMASTER-CARR	P	8
T1PLM012	4	PELVIS WING MACHINING (RIGHT)		M	1
00060590		1/4-20 X .375 HELICOIL INSERT	MSC	P	2
T1PLM026	0	RIGHT WING CASTING		M	1
T1PLM011	4	PELVIS WING MACHINING (LEFT)		M	1
00060590		1/4-20 X .375 HELICOIL INSERT	MSC	P	2
T1PLM025	0	LEFT WING CASTING		M	1
T1PLM019	0	H-POINT TOOL BEARING		M	2
T1PLM017	0	ILLIAC LOAD CELL WASHER		M	2

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1PLM018	3	ILIAC LOAD CELL PLUNGER		M	2
T1INM410	1	UNIAXIAL COMPRESSION LOAD WASHER		I	2
T1PLM219	4	PELVIS MACHINED FRONT PELVIC CASTING		M	1
T1PLM111	2	PELVIS ACCELEROMETER COVER		M	1
91253A542		.25 DIAM - 20 UNC X 1" F.H.S.C.S	McMASTER-CARR	P	2
91253A536		.25 DIAM - 20 UNC X .875" F.H.S.C.S	McMASTER-CARR	P	4
91253A001		#10-32 UNF X .375 F.H.S.C.S	McMASTER-CARR	P	2
91253A539		.25 DIAM-20 UNC X .625" F.H.S.C.S	McMASTER-CARR	P	4
98381A470		.125 DIAM X .375 DOWEL PIN	McMASTER-CARR	P	2
91253A108		#4-40 X 3/8" F.H.S.C.S	McMASTER-CARR	P	2
98381A541		1/4" DIA X 7/8" DOWEL PIN	McMASTER-CARR	P	6
RP323-ND		1/8" NYLON P-CLAMP	DIGI-KEY	P	2
91255A148		#6-32 X 1/2" BHSCS (ALLOY)	McMASTER-CARR	P	2
T1PLS000	2	MOLDED PELVIS SKIN ASSEMBLY		A	
T1PLS010	B0	MOLDED PELVIS SKIN		S	1

SHOULDER

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1SHM000	8	SHOULDER MECHANICAL ASSEMBLY		A	
T1SHM070	1	SHOULDER BLOCK ASSEMBLY (RIGHT)		A	
T1SHM079	B1	SHOULDER BLOCK BOND ASSEMBLY (RIGHT)		A	
T1SHW070	2	SHOULDER BLOCK WELD ASSEMBLY (RIGHT)		A	
T1SHM073	B1	SHOULDER BLOCK (RIGHT)		M	1
T1SHM075	B0	SHOULDER RIB SHELF (RIGHT)		M	1
T1SHM076	B0	SHOULDER RIB SHELF PAD		M	1
T1SHM077	0	SHOULDER INNER STOP ASSEMBLY		A	
T1SHM012	C0	SHOULDER INNER STOP END PLATE		M	1
T1SHM024	B0	SHOULDER INNER STOP BUMPER		M	1
92196A268		#10-32 X 7/16" SHCS	McMASTER-CARR	P	2
T1SHM071	1	SHOULDER BLOCK ASSEMBLY (LEFT)		A	
T1SHM078	B1	SHOULDER BLOCK BOND ASSEMBLY (LEFT)		A	
T1SHW071	2	SHOULDER BLOCK WELD ASSEMBLY (LEFT)		A	
T1SHM072	B1	SHOULDER BLOCK (LEFT)		M	1
T1SHM074	B0	SHOULDER RIB SHELF (LEFT)		M	1
T1SHM076	B0	SHOULDER RIB SHELF PAD		M	1
T1SHM077	0	SHOULDER INNER STOP ASSEMBLY		A	
T1SHM012	C0	SHOULDER INNER STOP END PLATE		M	1
T1SHM024	B0	SHOULDER INNER STOP BUMPER		M	1
92196A268		#10-32 X 7/16" SHCS	McMASTER-CARR	P	2
T1SHM002	3	SHOULDER CLAVICLE ASSEMBLY		A	
T1SHM019	X0	SHOULDER CLAVICLE		M	2
60745K23		BALL JOINT ROD END 5/16-24	McMASTER-CARR	P	4
90567A030		5/16-24 HEX JAM LOCKNUT	McMASTER-CARR	P	4
90692A145		3/32 X 5/8 SPRING PIN	McMASTER-CARR	P	4
T1SHM003	0	SHOULDER MOLDED RUBBER SLEEVE ASSEMBLY		A	
T1SHM031	1	SHOULDER MOLDED RUBBER SLEEVE		O	2
T1SHM032	1	SHOULDER BLOCK BUSHING		M	2
T1SHM004	1	SHOULDER PIVOT STOP ASSEMBLY		A	
T1SHM044	1	SHOULDER PIVOT STOP - RUBBER		M	2
T1SHM045	0	SHOULDER PIVOT STOP BUSHING		M	4
T1SHM005	3	SHOULDER YOKE ASSEMBLY		A	
T1SHM039	9	SHOULDER YOKE		M	2
T1SHM043	1	SHOULDER UPPER ARM SOFT STOP		M	2
98381A216		1/8" X 5/16" DOWEL PIN	McMASTER-CARR	P	6

APPENDIX I. THOR-NT Bill of Material

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
98381A503		3/16" X 3/8" DOWEL PIN	McMASTER-CARR	P	10
T1SHM006	3	SHOULDER YOKE MOUNT ASSEMBLY- (LEFT)		A	
T1SHM020	10	SHOULDER YOKE MOUNT (LEFT)		M	1
00060350		#8-32 X 0.328 HELICAL INSERT	MSC	P	2
00060699		5/16-18 X 0.469 HELICAL INSERT	MSC	P	1
D45-625		DOWEL PIN, 5/32" DIA., 5/8" LONG	PIC	P	2
PSFO81204		.50ID X .75OD X .50 FLANGE BEARING	PB	P	1
PSFO81206		.50ID X .75OD X .75 FLANGE BEARING	PB	P	1
T1SHM007	3	SHOULDER YOKE MOUNT ASSEMBLY- (RIGHT)		A	
T1SHM021	10	SHOULDER YOKE MOUNT (RIGHT)		M	1
00060350		#8-32 X 0.328 HELICAL INSERT	MSC	P	2
00060699		5/16-18 X 0.469 HELICAL INSERT	MSC	P	1
D45-625		DOWEL PIN, 5/32" DIA., 5/8" LONG	PIC	P	2
PSFO81204		.50ID X .75OD X .50 FLANGE BEARING	PB	P	1
PSFO81206		.50ID X .75OD X .75 FLANGE BEARING	PB	P	1
T1SHM008	B0	SHOULDER OUTER STOP ASSEMBLY		A	
T1SHM013	B0	SHOULDER OUTSIDE STOP END PLATE		M	2
T1SHM025	B0	SHOULDER OUTER STOP BUMPER		M	2
T1SHM010	0	SHOULDER STERNUM/CLAVICLE WASHER		M	4
T1SHM011	1	SHOULDER STERNUM/CLAVICLE BOLT		M	2
51624X890BS		5/16 X .89" BUTTON HEAD SHOULDER BOLT	COLD HEADERS	P	2
T1SHM018	2	SHOULDER UPPER STERNAL PLATE		M	1
T1SHM022	7	SHOULDER SUPPORT (LEFT)		M	1
T1SHM023	7	SHOULDER SUPPORT (RIGHT)		M	1
T1SHM026	3	SHOULDER YOKE STEEL WASHER		M	2
T1SHM027	3	SHOULDER YOKE DELRIN WASHER		M	2
T1SHM028	3	SHOULDER YOKE MOUNT WASHER		M	4
T1SHM030	2	SHOULDER RUBBER WASHER I		M	4
T1SHM035	1	SHOULDER SHAFT		M	2
T1SHM037	1	SHOULDER JOINT SPRING WASHER		M	2
T1SHM038	3	SHOULDER YOKE PIVOT BUSHING		M	2
T1SHM040	5	UPPER ARM PIVOT BUSHING		M	2
T1SHM041	2	UPPER ARM PIVOT WASHER		M	2
T1SHM042	3	UPPER ARM PIVOT NUT		M	2
T1SHM046	3	SHOULDER PIVOT STOP - STEEL		M	2
T1SHM047	0	UPPER ARM JOINT SPRING WASHER		M	2
T1SHM051	2	SHOULDER NECK SHROUD SUPPORT (RIGHT)		M	1
T1SHM052	2	SHOULDER NECK SHROUD SUPPORT (LEFT)		M	1
T1SHS110	B0	MOLDED SHOULDER PAD (RIGHT)		O	1
T1SHS112	1	SHOULDER CAST PAD RIGID SUPPORT INSERT		M	1
T1SHS113	1	SHOULDER CAST PAD FLEXIBLE SUPPORT INSERT		M	1
T1SHS114	2	SHOULDER CAST PAD STAND OFF INSERT		M	3
T1SHS111	B0	MOLDED SHOULDER PAD (LEFT)		O	1
T1SHS112	1	SHOULDER CAST PAD RIGID SUPPORT INSERT		M	1
T1SHS113	1	SHOULDER CAST PAD FLEXIBLE SUPPORT INSERT		M	1
T1SHS114	2	SHOULDER CAST PAD STAND OFF INSERT		M	3
T1SHM991	0	SHOULDER CLAVICLE SPACER		M	2
T1SHM992	X1	SHOULDER CLAVICLE END COVER		M	2
91251A578		5/16-18 X 1/2" F.H.S.C.S	McMASTER-CARR	P	8
92949A542		1/4-20 X 1" B.H.S.C.S.	McMASTER-CARR	P	6
98370A021		WASHER 1" OD, 13/32" ID, 1/8" THK (S.S.)	McMASTER-CARR	P	4
91255A265		#10-32 X 1/2" B.H.S.C.S.	McMASTER-CARR	P	4
91259A718		1/2 X 1-3/4 SHOULDER SCREW	McMASTER-CARR	P	2
95615A140		3/8-16 LOCKNUT	McMASTER-CARR	P	4

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
91081A030		WASHER 3/8" ID, 7/8" OD, 5/64" THK	McMASTER-CARR	P	2
92383A262		SPRING PIN, 1/8 DIA. 1-1/4" LONG	McMASTER-CARR	P	2
91251A192		#8-32 x 3/8" S.H.C.S.	McMASTER-CARR	P	4
98029A031		FLAT WASHER 7/8" OD, 13/32" ID	McMASTER-CARR	P	2
91259A624		3/8 X 1" SOCKET SHOULDER SCREW	McMASTER-CARR	P	2
91251A196		#8-32 x 5/8" S.H.C.S.	McMASTER-CARR	P	4
91251A146		#6-32 x 3/8" S.H.C.S.	McMASTER-CARR	P	4
91910A520		5/16-18 X 1 1/4" S.H.C.S	McMASTER-CARR	P	2
51618X0625SP		5/16-18 X .625 BHSCS W/NYLON PELLET	COLD HEADERS	P	2
SPINE					
T1SPM000	6	SPINE MECHANICAL ASSEMBLY		A	
T1SPM101	7	UPPER THORACIC SPINE MECHANICAL ASSEMBLY TRI-PACK ACCELEROMETER		A	
T1SPW120	3	UPPER THORACIC SPINE-WELDED BOX ASSEMBLY		W	
T1SPM121	5	UPPER THORACIC SPINE SIDE PLATE - RIGHT		M	1
T1SPM122	2	UPPER THORACIC SPINE SIDE PLATE - LEFT		M	1
T1SPM123	8	UPPER THORACIC SPINE BACK PLATE		M	1
T1INM100	1	TRI-PACK ACCELEROMETER ASSEMBLY			
T1INM130	6	TRI-PACK MOUNTING BLOCK			1
T1INM110	4	UNIAXIAL ACCELEROMETER	ENTRAN	I	3
91251A052		#0-80 X 1/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	6
90945A700		18-8 SS WASHER (0.063" ID, 0.099" OD, 0.014" MIN THK)	McMASTER-CARR	P	6
T1SPM114	4	SPINE T1 TRI-PACK ACCELEROMETER MOUNTING PLATE		M	1
00060012		#2-56 X 0.129" HELICAL INSERT	MSC	P	2
00060103		#4-40 x 0.112" HELICAL INSERT	MSC	P	2
91253A107		#4-40 X 5/16" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
2560625		#2-56 X 9/16" S.H.C.S. (ALLOY)	COLD HEADERS	P	2
RP324-ND		3/16" NYLON P-CLAMP	DIGI-KEY	P	1
91255A148		#6-32 X 1/2" BHSCS (ALLOY)	McMASTER-CARR	P	1
T1SPM310	B0	UPPER THORACIC SPINE FLEX JOINT MOLDED ASSEMBLY		O	
T1SPM311	B0	UPPER THORACIC SPINE FLEX JOINT TOP PLATE		M	1
T1SPM312	B0	UPPER THORACIC SPINE FLEX JOINT BOTTOM PLATE		M	1
T1SPM200	10	NECK PITCH CHANGE MECHANISM MECHANICAL ASSEMBLY		A	
T1INM501-2	0	TILT SENSOR ASSEMBLY - NECK		A	
T1INM500	0	BI AXIAL TILT SENSOR ASSEMBLY		A	
T1INM511	4	UNIVERSAL TILT SENSOR MOUNT		M	1
SX-060-LIN		SX-060-LIN	AOS	P	2
91255A078		#2-56 X 5/16 B.H.S.C.S (ALLOY)	McMASTER-CARR	P	4
RP-323-ND		1/8" NYLON CABLE CLAMP	DIGI-KEY	P	1
91251A080		#2-56 X .50 S.H.C.S.		P	1
92141A003		#2 WASHER 3/32" X 1/4"		P	1
T1SPM210	4	NECK PITCH CHANGE MECHANISM STAR PATTERN 1		M	1
T1SPM211	3	NECK PITCH CHANGE MECHANISM STAR PATTERN 2		M	1
T1SPM213	10	NECK PITCH CHANGE MECHANISM BASE PLATE		M	1
T1SPM216	13	NECK PITCH CHANGE MECHANISM TOP PLATE		M	1
T1SPM220	1	NECK PITCH CHANGE MECHANISM STAR PATTERN BOLTS		M	4
90298A535		1/4" DIA x 3/8" SHOULDER BOLT (SS)	McMASTER-CARR	P	4
97352A110		PULL-OUT DOWEL PIN, 1/4" X 3/4"	McMASTER-CARR	P	4
97395A435		1/8 DIA. X .375 L DOWEL PIN (SS)	McMASTER-CARR	P	2
91251A106		#4-40 X .25 SHCS (ALLOY)	McMASTER-CARR	P	1
91252A633		3/8-24 X 2 1/4 SHCS (ALLOY)	McMASTER-CARR	P	1
T1SPM400	3	LOWER THORACIC SPINE ASSEMBLY DRAWING		A	
T1SPW400	6	LOWER THORACIC SPINE WELDED ASSEMBLY		W	
T1SPM410	3	LOWER THORACIC SPINE RIB MOUNTING PLATE		M	1
T1SPM411	0	LOWER THORACIC SPINE TOP PLATE		M	1
T1SPM412	4	LOWER THORACIC SPINE CENTRAL PLATE		M	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1SPM413	0	LOWER THORACIC SPINE BOTTOM PLATE		M	1
T1INM500	0	TILT SENSOR ASSEMBLY			
T1INM511	4	UNIVERSAL TILT SENSOR MOUNT			1
SX-060-LIN		SX-060-LIN	AOS	P	2
91255A078		#2-56 X 5/16 B.H.S.C.S (ALLOY)	McMASTER-CARR	P	4
T1INM100	1	TRI-PACK ACCELEROMETER ASSEMBLY		A	
T1INM130	6	TRI-PACK BLOCK			1
T1INM110	4	UNIAXIAL ACCELEROMETER	ENTRAN	I	3
91251A052		#0-80 X 1/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	6
90945A700		18-8 SS WASHER (0.063" ID, 0.099" OD, 0.014" MIN THK)	McMASTER-CARR	P	6
91251A110		#4-40 X .5" SHCS (ALLOY)			1
256X0625		#2-56 X 9/16" SHCS (ALLOY)			2
98381A472		1/8" X 5/8" DOWEL PIN	McMASTER-CARR	P	2
98380A470		1/8" X 3/8" DOWEL PIN	McMASTER-CARR	P	6
T1SPM500	4	LUMBAR SPINE PITCH CHANGE ASSEMBLY		A	
T1SPM510	3	LUMBAR SPINE PITCH CHANGE UPPER-HALF ASSEMBLY		A	
T1SPM511	5	LUMBAR SPINE PITCH CHANGE TOP PLATE		M	1
T1SPM512	6	LUMBAR SPINE PITCH CHANGE STAR WHEEL - LEFT SIDE		M	1
91253A619		#3/8-16 X 5/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	3
T1SPM520	4	LUMBAR SPINE PITCH CHANGE LOWER-HALF ASSEMBLY		A	
T1SPM521	6	LUMBAR SPINE PITCH CHANGE BOTTOM PLATE		M	1
T1SPM522	8	LUMBAR SPINE PITCH CHANGE STAR WHEEL - RIGHT SIDE		M	1
91253A619		#3/8-16 X 5/8" F.H.S.C.S. (ALLOY)	McMASTER-CARR	P	3
91251A022		1/2-20 UNF X 2.5" S.H.C.S.	McMASTER-CARR	P	1
T1SPM501	3	LIUMBAR PITCH CHANGE MECHANISM SPINE POSTURE ADJUSTMENT		A	
T1SPM523	0	LUMBAR SPINE PITCH CHANGE - PITCH CHANGE INDICATOR		M	1
91255A108		#4-40 X 3/8" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	2
T1SPM620	0	THORACIC SPINE LOAD CELL (NON-ACTIVE)		A	
T1SPM621	0	THORACIC SPINE LOAD CELL (NON-ACTIVE) UPPER PLATE		M	1
T1SPM622	0	THORACIC SPINE LOAD CELL (NON-ACTIVE) LOWER PLATE		M	1
91253A587		5/16-18 X 1.5" F.H.S.C.S. (ALLOY)		P	4
THORACIC SPINE LOAD CELL (ALTERNATE TO THE NON-ACTIVE LOAD CELL T1SPM620)					
T1INM330	2	INSTRUMENT THORACIC SPINE LOAD CELL		I	1
T1SPM609	1	THORACIC SPINE LOAD CELL DAAPTOR PLATE INSTRUMENTATION ASSEMBLY		A	
T1SPM610	8	THORACIC SPINE LOAD CELL/FLEX JOINT ADAPTOR PLATE		M	1
T1INM100	1	TRI-PACK ACCELEROMETER ASSEMBLY		A	
T1INM130	6	TRI-PACK BLOCK		M	1
T1INM110	4	UNIAXIAL ACCELEROMETER	ENTRAN	I	3
91251A052		#0-80 X 1/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	6
90945A700		18-8 SS WASHER (0.063" ID, 0.099" OD, 0.014" MIN THK)	McMASTER-CARR	P	6
T1INM500	0	BI AXIAL TILT SENSOR ASSEMBLY		A	
T1INM511	4	UNIVERSAL TILT SENSOR MOUNT		M	1
SX-060-LIN		SX-060-LIN	AOS	P	2
91255A078		#2-56 X 5/16 B.H.S.C.S (ALLOY)	McMASTER-CARR	P	4
256X0563		#2-56 X 9/16" S.H.C.S.	COLD HEADERS	P	2
98380A469		1/8 DIAM X 1/4" DOWEL PIN	McMASTER-CARR	P	2
91255A107		#4-40 X 5/16" B.H.S.C.S (ALLOY)	McMASTER-CARR	P	1
RP324-ND		3/16" NYLON P-CLAMP	DIGI-KEY	P	1
91255A148		#6-32 X 1/2" BHSCS (ALLOY)	McMASTER-CARR	P	1
T1SPM710	B0	LUMBAR SPINE FLEX JOINT MOLDED ASSEMBLY		O	
T1SPM711	B0	LUMBAR FLEX JOINT - TOP PLATE		M	1
T1SPM712	B0	LUMBAR FLEX JOINT - BOTTOM PLATE		M	1
T1SPM800	7	PELVIS/LUMBAR MOUNTING BLOCK MECHANICAL ASSEMBLY		A	
T1SPM805	0	PELVIS/LUMBAR MOUNTING BLOCK HARDWARE ASSEMBLY		A	
T1SPM811	1	PELVIS/LUMBAR BLOCK BUSHING		M	2
T1SPM810	B3	PELVIS/LUMBAR MOUNTING BLOCK		M	1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
98380A472		1/8 DIA. X .625 L DOWEL PIN (ALLOY)		P	2
98380A537		1/4 DIA. X .5 L DOWEL PIN (ALLOY)		P	2
T1INM501-4	0	TILT SENSOR ASSEMBLY - PELVIS		A	
T1INM500	0	BI AXIAL TILT SENSOR ASSEMBLY		A	
T1INM511	4	UNIVERSAL TILT SENSOR MOUNT		M	1
SX-060-LIN		SX-060-LIN	AOS	P	2
91255A078		#2-56 X 5/16 B.H.S.C.S (ALLOY)	McMASTER-CARR	P	4
RP-322-ND		1/16" NYLON CABLE CLAMP	DIGI-KEY	P	1
91251A080		#2-56 X .50 S.H.C.S.		P	1
92141A003		#2 WASHER 3/32" X 1/4"		P	1
91251A110		#4-40 X .5 SHCS (ALLOY)		P	1
T1INM011	1	INSTRUMENT HEAD-NECK GROUND STRAP	AMERICAN GROUNDING SYSTEMS	P	1
1420X050FP		1/4-20 X 1/2" F.H.S.C.S. W/ NYLON PELLET	COLD HEADERS	P	4
1420X050SP		1/4-20 X 1/2" S.H.C.S. W/ NYLON PELLET	COLD HEADERS	P	8
51618X050FP		5/16-18 X 1/2" F.H.S.C.S. W/ NYLON PELLET	COLD HEADERS	P	2
51618X0625SP		5/16-18 X 5/8" F.H.S.C.S. W/ NYLON PELLET	COLD HEADERS	P	2
51618X075FP		5/16-18 X 3/4" F.H.S.C.S. W/ NYLON PELLET	COLD HEADERS	P	18
51618X1FP		5/16-18 X 1" F.H.S.C.S. W/ NYLON PELLET	COLD HEADERS	P	2
91251A542		1/4-20 x 1" S.H.C.S (ALLOY)	McMASTER-CARR	P	4
91255A261		#10-32 X 1/4 B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	1
91255A144		#6-32 X 1/4" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	1
THORAX					
T1TXM000	8	THORAX ASSEMBLY		A	
T1TXM310	2	THORAX ELLIPTICAL RIB #1 - ASSEMBLY		A	
T1TXM311	3	THORAX ELLIPTICAL RIB #1 - STEEL		M	1
T1TXM312	2	THORAX RIB #1 - DAMPING MATERIAL		M	2
T1TXM320	1	THORAX ELLIPTICAL RIB #2 - ASSEMBLY		A	
T1TXM321	3	THORAX ELLIPTICAL RIB #2 - STEEL		M	1
T1TXM322	1	THORAX RIB #2 - DAMPING MATERIAL		M	2
T1TXM330	B0	THORAX ELLIPTICAL RIB #3 - ASSEMBLY		A	
T1TXM331	4	THORAX ELLIPTICAL RIB #3 - STEEL		M	1
T1TXM332	B0	THORAX ELLIPTICAL RIB #3 DAMPING MATERIAL		M	2
T1TXM340	B0	THORAX ELLIPTICAL RIB #4 - ASSEMBLY		A	
T1TXM341	3	THORAX ELLIPTICAL RIB #4 - STEEL		M	1
T1TXM342	B0	THORAX RIB #4 DAMPING MATERIAL		M	2
T1TXM350	B0	THORAX ELLIPTICAL RIB #5 - ASSEMBLY		A	
T1TXM351	3	THORAX ELLIPTICAL RIB #5 - STEEL		M	1
T1TXM352	B0	THORAX RIB #5 DAMPING MATERIAL		M	2
T1TXM360	B0	THORAX ELLIPTICAL RIB #6 - ASSEMBLY		A	
T1TXM361	3	THORAX ELLIPTICAL RIB #6 - STEEL		M	1
T1TXM362	B0	THORAX ELLIPTICAL RIB #6 DAMPING MATERIAL		M	2
T1TXM370	B0	THORAX ELLIPTICAL RIB #7 ASSEMBLY		A	
T1TXM371	4	THORAX ELLIPTICAL RIB #7 - STEEL		M	1
T1TXM372	B0	THORAX ELLIPTICAL RIB #7 DAMPING MATERIAL		M	2
T1TXM010	5	THORAX ELLIPTICAL RIB STIFFENER #1		M	1
T1TXM011	6	THORAX ELLIPTICAL RIB STIFFENER #2		M	1
T1TXM012	6	THORAX ELLIPTICAL RIB STIFFENER #3		M	1
T1TXM013	6	THORAX ELLIPTICAL RIB STIFFENER #4		M	1
T1TXM014	6	THORAX ELLIPTICAL RIB STIFFENER #5		M	1
T1TXM015	5	THORAX ELLIPTICAL RIB STIFFENER #6		M	1
T1TXM016	5	THORAX ELLIPTICAL RIB STIFFENER #7		M	1
T1TXM017	0	RIB#1 LIFTING STRAP		M	1
3510T11		3/4" NYLON WEBBING		P	1
8800K42		.025" DIA. KEVLAR THREAD		P	1
T1TXM100	5	THORAX BIB ASSEMBLY		A	
T1TXM110	B0	THORAX OUTER BIB			1

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
9318T15		.0085" THREAD DIA, .0118" SQUARE	McMASTER-CARR	P	
T1MSM005	B0	MID STERNUM BONDING ASSEMBLY		A	
T1INM110	4	THOR UNIAXIAL ACCELROMETER			1
T1INM012	1	INSTRUMENT MID STERNUM GROUND STRAP	AMERICAN GROUNDING SYSTEMS	P	1
91255A263		#10-32 X 3/8" B.H.S.C.S. ALLOY	McMASTER-CARR	P	2
91251A052		#0-80 X 1/8" S.H.C.S. (ALLOY)	McMASTER-CARR	P	2
90945A700		18-8 SS WASHER (0.063" ID, 0.099" OD, 0.014" MIN THK)	McMASTER-CARR	P	2
91255A189		# 8-32 X 3/16" B.H.S.C.S (ALLOY)	McMASTER-CARR	P	1
T1INM013	1	INSTRUMENT THORACIC SPINE GROUND STRAP	AMERICAN GROUNDING SYSTEMS	P	1
51624X0375BP		5/16 - 24 X 3/8" B.H.S.C.S (ALLOY) W/NYLON PELLET	COLD HEADERS	P	4
51624X0005BP		5/16 - 24 X ½" B.H.S.C.S (ALLOY) W/NYLON PELLET	COLD HEADERS	P	10
91255A263		#10-32 X 3/8" B.H.S.C.S. ALLOY	McMASTER-CARR	P	2
91255A269		#10-32 X 3/4" .B.H.S.C.S. ALLOY	McMASTER-CARR	P	4
91255A267		#10-32 X 5/8" B.H.S.C.S. (ALLOY)	McMASTER-CARR	P	4
90333A009		#8 -5/8" OD. FLANGED WASHER	McMASTER-CARR	P	16
91255A265		#10-32 X 1/2" B.H.S.C.S	McMASTER-CARR	P	2
90131A101		#10 (9/16" OD) REINFORCED RUBBER WASHER	McMASTER-CARR	P	2
3225T2		RUBBER-CUSHIONED STEEL LOOP STRAP FOR 1/4" OD	McMASTER-CARR	P	2
91255A238		#10-24 X 1/4" B.H.S.C.S (ALLOY)	McMASTER-CARR	P	2
98065A140		#10-32 S-STYLE CAGE CLIP-ON NUT	McMASTER-CARR	P	10
T1CXM010	2	RIB CONNECTING BOLT		M	4
UPPER ABDOMEN					
T1UAM000	4	UPPER ABDOMEN MECHANICAL ASSEMBLY		A	
T1UAM010	2	UPPER ABDOMEN INTERNAL FOAM REAR LAYER		C	1
T1UAM011	2	UPPER ABDOMEN INTERNAL FOAM MIDDLE LAYER		C	1
T1UAM012	3	UPPER ABDOMEN INTERNAL FOAM FRONT LAYER		C	1
T1UAM013	3	UPPER ABDOMEN LOAD DISTRIBUTION PLATE		M	1
T1UAM014	2	UPPER ABDOMEN STRING/ACCELEROMETER MOUNT PLATE		M	1
T1UAM015	4	UPPER ABDOMEN ACCELEROMETER MOUNT		M	1
00060145		#4-40 X 0.336 HELICAL INSERT	MSC	P	2
00060483		#10-32 X 0.190 HELICAL INSERT	MSC	P	1
T1INM111	0	UNIAXIAL ACCELEROMETER 2000 g	ENTRAN	I	1
T1UAM100	4	UPPER ABDOMEN MOUNTING BRACKET MECHANICAL ASSEMBLY		A	
T1UAM110	5	UPPER ABDOMEN THORACIC INSTRUMENTATION BRACKET		M	1
T1UAM111	B0	UPPER ABDOMEN THORACIC INSTRUMENTATION BRACKET BASE PLATE		M	1
T1UAM113	7	UPPER ABDOMEN SPINAL MOUNT BRACKET		M	1
91253A544		1/4-20 X 1 1/4" F.H.S.C.S.	McMASTER-CARR	P	2
91253A539		1/4-20 X 5/8" F.H.S.C.S.	McMASTER-CARR	P	4
T1UAM200	5	UPPER ABDOMEN INSTRUMENTATION MOUNTING PLATE MECHANICAL ASSEMBLY		A	
T1UAM210	3	UPPER ABDOMEN PULLEY WHEEL MOUNTING BLOCK		M	1
T1UAM211	2	UPPER ABDOMEN PULLEY WHEEL AXLE BOLT		M	1
91251A347		#10-32 x 1" S.H.C.S (ALLOY)	McMASTER-CARR	P	1
T1UAM212	2	UPPER ABDOMEN PULLEY WHEEL		M	1
T1UAM213	1	UPPER ABDOMEN STRING POT. MOUNT BRACK.		M	1
T1UAM252	7	UPPER ABDOMEN INTERNAL MOUNT PLATE FRONT		M	1
T1INM230	2	STRING POTENTIOMETER		M	1
57155K144		DIA 1/8" MINIATURE RADIAL BEARINGS	McMASTER-CARR	P	2
95630A235		TEFLON FLAT WASHER	McMASTER-CARR	P	2
91375A108		#4-40 X 3/8" S.S.S. (ALLOY)	McMASTER-CARR	P	2
91253A146		#6-32 X 3/8" F.H.S.C.S.	McMASTER-CARR	P	7
91251A055		#0-80 X 1/4" S.H.C.S.	McMASTER-CARR	P	2
91253A110		#4-40 X 1/2" F.H.S.C.S.	McMASTER-CARR	P	2
90945A700		18-8 SS WASHER (0.063 ID, 0.099 OD)	McMASTER-CARR	P	2
91253A583		5/16-18 X 1" F.H.S.C.S.	McMASTER-CARR	P	2

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1UAF300	3	UPPER ABDOMEN BAG-SEWING ASSEMBLY		A	
T1UAF301	1	UPPER ABDOMEN SEWING ASSEMBLY		A	
9604K22		1/4" GROMMET	McMASTER-CARR	P	4
9604K24		3/8" GROMMET	McMASTER-CARR	P	2
T1UAF310	1	UPPER ABDOMEN FRONT VELCRO PATCH		F	1
T1UAF311	3	UPPER ABDOMEN TOP/SIDE/REAR FABRIC PATTERN		F	1
T1UAF312	1	UPPER ABDOMEN BOTTOM FABRIC PATTERN		F	1
T1UAF313	2	UPPER ABDOMEN FRONT STIFFENING CLOTH		F	1
T1UAF314	3	UPPER ABDOMEN FRONT OVERLAY FABRIC PATTERN		F	1
T1UAF315	4	UPPER ABDOMEN ZIPPER		F	1
MGMOL-106DAGS/4		YKK ZIPPER AND SLIDER	YKK	F	1

CALIBRATION EQUIPMENT

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1CEM100	1	CRUX CALIBRATION FIXTURE MECHANICAL ASSEMBLY		A	
T1CEM110	0	CRUX CALIBRATION - BASE PLATE - SHEET 1		M	1
T1CEM111	0	CRUX CALIBRATION - BASE PLATE - SHEET 2		M	1
T1CEM112	0	CRUX CALIBRATION - BASE PLATE - SHEET 3		M	1
T1CEM113	0	CRUX CALIBRATION - BASE PLATE - SHEET 4		M	1
T1CEM120	0	CRUX CALIBRATION - SPACER BLOCK		M	1
T1CEM130	0	CRUX CALIBRATION - BASE MOUNT		M	1
T1CEM140	1	CRUX CALIBRATION - U-JOINT MOUNT		M	1
91253A006		#10-32 X 5/8" F.H.S.C.S.	McMASTER-CARR	P	2
91251A342		#10-32 X ½" S.H.C.S.	McMASTER-CARR	P	3
T1CEM200	1	DGSP CALIBRATION FIXTURE MECHANICAL ASSEMBLY		A	
T1CEM210	1	DGSP CALIBRATION - BASE PLATE		M	1
T1CEM211	1	ROTARY POT. MOUNTING BRACKET		M	1
T1CEM212	1	TELESCOPIC MOUNTING BRACKET		M	1
T1CEM213	1	SHOULDER BOLT		M	1
91829A303		5/16 x 3/8" SHOULDER BOLT (SS)	McMASTER-CARR	P	1
57155K156		5/16 MINIATURE BEARINGS	McMASTER-CARR	P	1
98381A477		1/8 X 1.25" DOWEL PIN	McMASTER-CARR	P	1
98381A419		1/16 X 1/2" DOWEL PINS	McMASTER-CARR	P	2
91251A242		#10-24 X 1/2" S.H.C.S.	McMASTER-CARR	P	1
T1CEM300	0	POTENTIOMETER #1 CALIBRATION FIXTURE ASSEMBLY		A	
T1CEM310	2	POTENTIOMETER #1 CALIBRATION BASE PLATE		M	1
T1CEM311	2	POTENTIOMETER #1 HOLDER/ARMATURE		M	1
T1CEM312	0	POTENTIOMETER D-SHAFT		M	1
8890980		0.098 GAGE PIN	MSC	P	1
98380A546		1/4" DIAM. X 1-1/8" DOWEL PIN	McMASTER-CARR	P	1
91251A107		#4-40 X 5/16" S.H.C.S (ALLOY)	McMASTER-CARR	P	2

MOLDING EQUIPMENT

PART#	REV	DESCRIPTION	VENDOR	DWG TYPE	QTY PER DUMMY
T1LLS016	0	TIBIA MOLD INSERT		M	1