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User's Manual for the Hybrid III Large Male Test Dummy

RATIONALE

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

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INTRODUCTION

FOREWORD

The Hybrid III Large Male dummy was developed under a grant awarded by the Center for Disease Control (CDC) to the Ohio State University in 1997. A task force of experts from the SAE International Mechanical Human Simulation Subcommittee of the Human Biomechanics and Simulation Standards Committee supported the development activity. The design incorporated the same level of biofidelity and measurement capacity as the Hybrid III mid-size adult male. Therefore, the certification procedures are based on the test procedures that were developed for the Hybrid III mid-size adult male dummy. The basic test fixtures are the same.

The Hybrid III Large Male Dummy is based on the characteristic size and weight measurements taken from anthropometry studies of the large adult male. Its impact response requirements for the head, neck, chest, hip, knee and ankle were scaled from the biofidelity requirements of the Hybrid III mid-size male dummy. (See Mertz, H. J., Irwin, A. L., Melvin, J. W., Stalnaker, R. L., Beebe, M. S., “Size, Weight, and Biomechanical Impact Response Requirements for Adult Size Small Female and Large Male Dummies”, SAE #890756, SP-782, 1989.) The Hybrid III Large Male dummy is designed to represent the upper extreme of the United States adult population. Much of the anthropometry and design is a scaled version of the Hybrid III midsize adult male dummy.

MANUAL OVERVIEW

Appendices

Several guidelines and procedures apply to various parts throughout the dummy and are included in the appendices for easier reference.

- When handling an instrumented dummy, improper techniques can damage instrumentation, particularly accelerometers. Appendix A contains guidelines for safe handling of instrumented dummies.
- The vinyl flesh of dummies can be damaged, but is often repairable. Appendix B contains instructions for repairing dummy flesh.
- Procedures for adjusting the joints throughout the dummy are included in Appendix C.
- The axial integrity of the neck is listed in Appendix D.
- A bolt torque value chart is Appendix E.

SAE Documents

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

SAE Test Definitions

Certification Test

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

Inspection Test

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

Abbreviations

ASIS	Anterior Superior Iliac Spine
LCR	Load Cell Replacement

The following threaded fastener abbreviations are used in this manual.

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

CONSTRUCTION

- The skull and skull cap are both one-piece cast aluminum, with a removable one-piece vinyl head and skull cap skin. The skull cap is removable for access to the head instrumentation. The vinyl skin is tuned to give a human-like response to forehead impacts.
- The neck has a biofidelic “angle versus moment” response in both dynamic flexion (forward bending) and extension (rearward bending) articulations.
- A neck cable controls stretching responses, and increases the neck’s durability to high axial tension forces.
- The two-piece aluminum clavicle and clavicle-link assembly have cast integral scapulae (with a lip along the superior-medial edge) to prevent the neck from interfacing with shoulder belts.
- Six spring steel ribs with polymer-based damping material approximate the human chest force-deflection response characteristics. The sternum assembly connects to the front of the ribs and incorporates a slider for a chest deflection transducer to measure rib cage deflection relative to the thoracic spine.
- A curved lumbar spine gives a sitting posture to simulate a person of larger stature in the driving position.
- The pelvis has a human shape and comes equipped with load cell replacements that can be replaced by transducers that indicate submarining of the pelvis.
- A knee slider mechanism is used that consists of steel ball sliders with energy absorbing molded rubber mounted on aluminum knees. This allows for displacement of the tibia relative to the femur, simulating ligament response.
- The leg assemblies are steel structures covered with vinyl. The legs are interchangeable with instrumented versions.
- Constant friction movable joints are used that need few adjustments and provide consistent articulations.
- The standard model has a “seated” pelvis construction. A “sit/stand” pelvis version is optional, as are a neck covering for airbag testing, a deformable face for steering wheel rim testing, and a deformable abdomen for lap belt submarining and steering wheel rim evaluations.

CLOTHING

When used in testing, the dummy should wear snug-fitting cotton knit T-shirt and pants. The neckline should be small enough to prevent contact between a shoulder belt and the dummy's skin. The pants should end above the dummy's knee. The T-shirt and pants should each weigh no more than 0.27 kg (0.6 lb). Garments similar to thermal underwear (trimmed to be short-sleeved and above the knee) usually meet these requirements. To improve the quality of high-speed films taken of the dummy during testing (by avoiding excessive glare), the garments are usually dyed to a light pink. A size large shirt (L) and double extra large pants (XXL) are suggested sizes for proper fit and weight. The shoes used with the large male dummy are size 11XW shoe which meets the configuration size, sole, and heel thickness specifications of MIL-S-13192 change "P" and whose weight is 1.25 ± 0.2 pounds.

INSTRUMENTATION

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

The following is an instrumentation list currently available for the Hybrid III Large Male dummy.

Table 1 - Instrumentation

HYBRID III LARGE MALE DUMMY INSTRUMENTATION		
Location	Measurement	Number of Channels
Head C.G.	Acceleration	3
Head	Angular Acceleration	9 or 12
Head	Angular Rate	3
Head-Neck Interface	Forces & Moments	3
Head-Neck Interface	Forces & Moments	6
Neck-Thorax Interface	Forces & Moments	6
Thorax C.G.	Acceleration	3
Thoracic Spine	Forces & Moments	5
Sternum	Acceleration	3
Thoracic Spine (Front)	Acceleration	3
Sternum	Displacement	1
Lumbar Spine	Forces & Moments	3 or 6
Pelvis C.G.	Acceleration	3
Anterior Superior Iliac Spine	Load	2 each side
Femur	Forces & Moments	6 each femur
Femur	Force	1 each femur
Knee-Tibia	Displacement	1 each knee
Knee-Clevis	Force	2 each knee
Upper Tibia	Forces & Moments	5 each leg
Lower Tibia	Forces & Moments	5 each leg
Foot	Acceleration	3 each foot

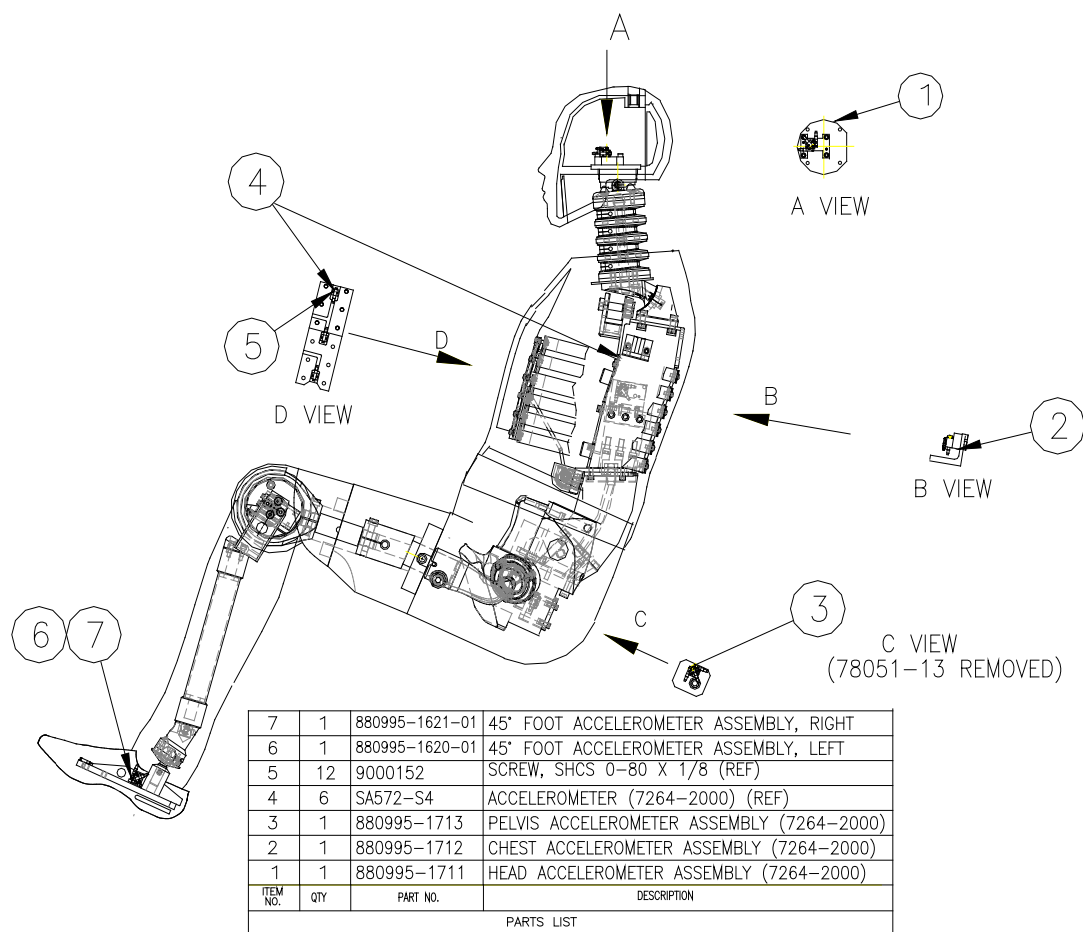


Figure 1 - ACCELEROMETER LOCATIONS

SPECIAL TOOLS

The following special tools will allow assembly, disassembly and certification of the Hybrid III large male dummy. For information concerning tool availability, contact the dummy manufacturers.

- Neck compression tool
- Ball hex wrench set
- Lumbar cable nut wrench
- Pelvis angle measurement tool
- Head skin thickness gauge
- Chest depth gauge
- Clavicle washer alignment tool
- Iliac bolt removal tool

1. SCOPE

This SAE Surface Vehicle Information Report identifies and defines the assembly/disassembly and certification procedures relating to the use of the Hybrid III Large Male Test Dummy.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

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

Mertz, H. J., Irwin, A. L., Melvin, J. W., Stalnaker, R. L., Beebe, M. S., "Size, Weight, and Biomechanical Impact Response Requirements for Adult Size Small Female and Large Male Dummies", SAE #890756, SP-782, 1989.

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

SAE J1733 Sign Convention for Vehicle Crash Testing

SAE J2517 Hybrid III Family Chest Potentiometer Calibration Procedure

SAE J2859 SAE Hybrid III Large Male Drawing Package

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

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

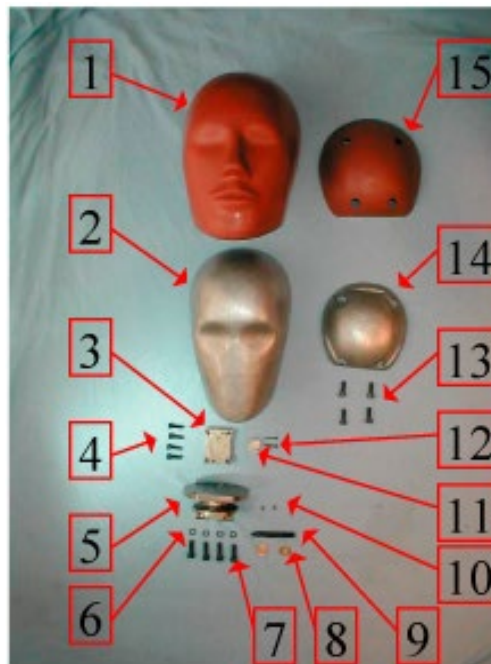
SAE J2570 Performance Specifications for Anthropomorphic Test Device Transducers

3. ASSEMBLY/DISASSEMBLY

3.1 Head/Neck

TABLE 2 - HEAD, EXPLODED VIEW PART LIST

Item Number	Quantity	Part Number	Description
1	1	880995-105	Head skin
2	1	880995-095X	Machined Skull
3	1	880995-1715	Accelerometer mount
4	4	9000224	SHCS 10-24 x 5/8
5	1	78051-383X	Upper neck load cell replacement (Upper neck load cell not shown)
6	4	9000677	Washer, Flat .2510 x .38 OD x .06 THR
7	4	9000453	SHCS 1/4-28 x 3/4
8	2	78051-253	Washer, Nodding Joint
9	1	78051-339	Pivot pin, Neck Transducer
10	2	9000452	SSCP 8-32 x 1/4
11	1	SA572-S80	Accelerometer cube
12	2	9000531	SHCS 2-56 x 5/8
13	4	78051-94	SHCS 1/4-20 x 5/8
14	1	78051-220	Machined skull cap
15	1	78051-229	Skull cap skin

**Figure 2 - Head, Exploded View**

3.1.1 Chest Jacket

Remove the chest jacket to permit easier access to the base of the neck bracket. For easy removal of the jacket, remove the arms first (Figure 17).

Remove the SHCS (Figure 3) that holds the upper neck bracket to the lower portion of the neck bracket and permits adjustment of the neck angle. Check the condition of the curved steel washer and note how it fits on the neck bracket.



Figure 3 - Neck Adjustment SHCS and Washer

Tilt the head and neck forward and remove the neck cable nut and four SHCS that hold the upper neck bracket to the base of the neck (Figure 4). Check for the presence of four steel washers between these four SHCS and upper neck bracket upon reassembly. If they are missing, replace them upon reassembly. The neck and head assembly is now disconnected from the plastic sternum-to-rib cage bib assembly.

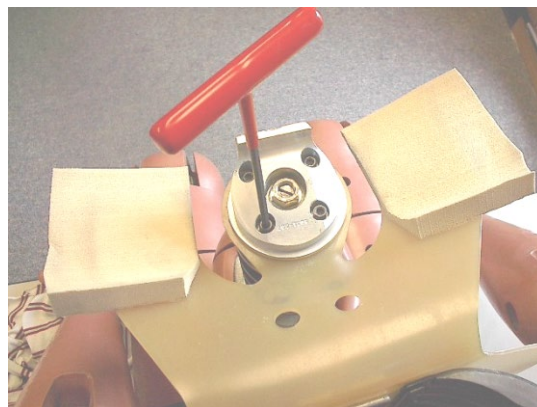


Figure 4 - Upper Neck Bracket and Bib

Remove four SHCS from the rear skull cap once the head and neck have been separated from the dummy (Figure 5).



Figure 5 - Skull Cap

For the six-channel neck transducer or its structural replacement, loosen two SSCP that secure the head-to-neck pivot pin (Figure 6).

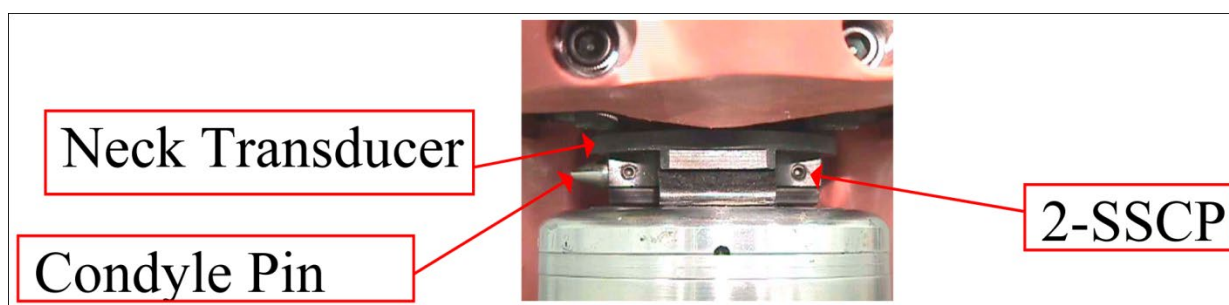


Figure 6 - Neck Transducer

There are several neck compression tools in existence. Figure 7 is a representative model of such a tool available to assist in the separation of the head and neck.

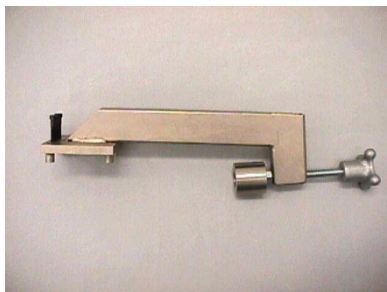


Figure 7 - Neck Compression Tool

For this design, the compression tool is mounted to the head by fastening the flat plate to the back of the skull. Then, slip the round end of the tool over the cable and turn the knob until the neck begins to compress (Figure 8).

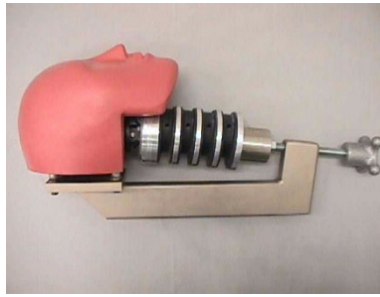


Figure 8 - Neck Removal

Slowly increase the compression on the neck until the pivot pin can be pushed or lightly tapped out with a minimal amount of effort. Reduce the compression on the head and neck, allowing the head and neck to separate at the nodding joint (Figure 9). Two brass washers and the two rubber nodding blocks may fall out in the disassembly process. To assemble the head and neck, be sure the nodding blocks, washers and nodding joint are in place before compressing the neck using the compression tool. Once compressed, slide the pivot pin into place while orienting the flats on the pin toward the set screw locations. Tighten the set screws to finish the assembly.

With the head and neck disassembled, inspect the neck cable for imperfections. No evidence of the cable pulling through the end fittings should exist. Examine the machined metal parts and compare the rubber sections of the neck against the drawing.

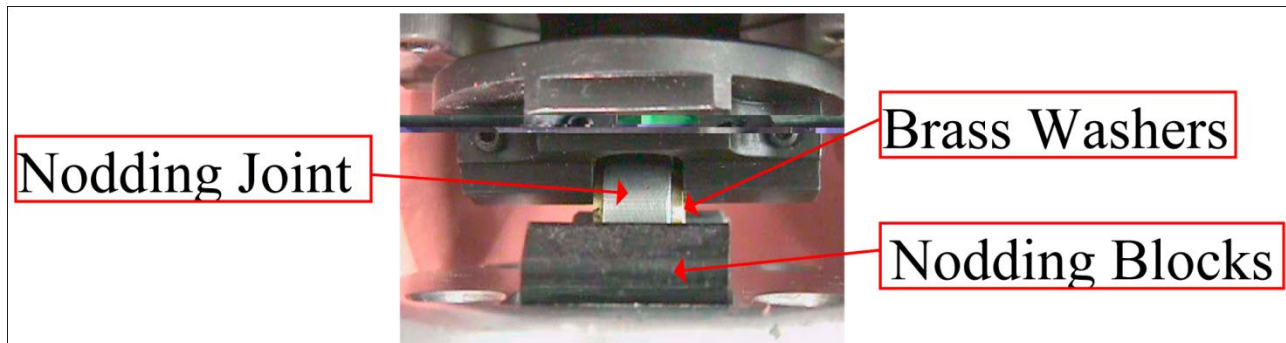


Figure 9 - Nodding Joint

Once separated, check the condition of the two rubber neck nodding blocks on the top of the nodding joint. The 90 degree surfaces of the nodding blocks fit opposite, rather than inside, the 90 degree grooves of the head-to-neck adaptor bracket (Figure 10).

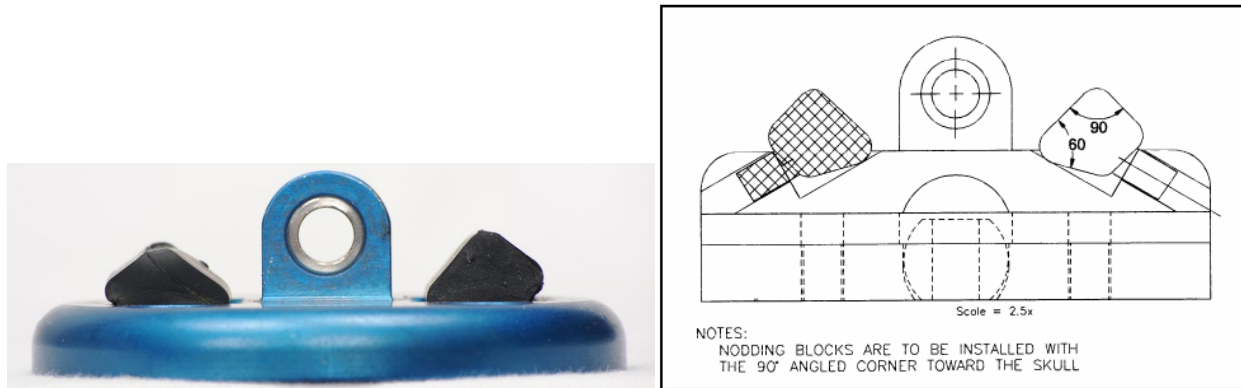


Figure 10 - Nodding Block Orientation

Upon re-assembly, assemble the two sections of the neck bracket with the adjustment set to 0 degree and measure the bracket angle. The lug on the nodding joint must fit very tightly in the slot in the bottom of the neck load cell. The tightness is controlled by a brass washer on each side of the yoke. These washers must be lapped to produce a 0.000 to 0.025 mm (0.000 to 0.001 in) interference fit at assembly. Because the inside diameter of these washers is also critical, validate this dimension against the drawing.

3.1.2 Head

Remove the four SHCS on the underside of the skull (Figure 11). A steel washer under each of the cap screws helps to protect the aluminum from being galled by the steel screws (Figure 2, Item 6). These are special washers and must be used under the load cell attachment bolts. Larger washers will interfere with load cell operation. After the screws have been removed, the transducer can then be removed by lifting it upward and out the back of the skull opening. The transducer may have to be turned slightly sideways to do this. The accelerometer mount and cube are shown as reference (Figure 2, Item 3 & 11). Accelerometer mounts and cubes can differ depending on the accelerometers being used and the manufacturer of the mount.



Figure 11 - Neck Transducer Removal

To remove the flesh from the skull, hold the skull by the back of the skull opening. Peel the skin forward starting at the top rear of the skull and skin assembly. This should allow the skin to pull away from the skull and then slide off the chin area. To remove the cap skin from the machined skullcap, follow a similar procedure. The skin should be inspected for nicks, tears or other damage that may be present after testing. If damaged, the skin should be repaired or replaced (see Special Care and Maintenance).

Inspect the skull for smoothness and freedom from flat spots and pits. Examine the bond of the skull ballast. If the ballast must be reinstalled or changed, see drawing for instructions.

3.1.3 Neck

Figure 12 is an exploded view of the neck assembly. Table 3 gives a general description of each item in Figure 12.

Table 3 - Neck Exploded View Part List

Item Number	Quantity	Part Number	Part Description
1	2	78051-253	Brass Washers
2	1	78051-339	Condyle Pin
3	1	180-2004	Upper Neck Bushing
4	1	880995-205	Cable
5	1	9000018	Nut, Hex Jam 1/2-20
6	1	9001260	Washer
7	1	180-2005	Lower Neck Bushing
8	4	9008001	Washer
9	4	9000498	Screw, SHCS 1/4-20 x 7/8
10	1	78051-305	Neck Adjustment Washer
11	1	9000021	Screw, SHCS 3/8-16 x 1
12	1	880995-1270	Upper Neck Adjustment Bracket
13	1	880995-201	Lower Neck Spacer
14	1	880995-1260	Neck Molded Assembly
15	1	880995-203	Upper Neck Spacer
16	1	78051-297	Nodding Joint Neck Assembly
17	2	78051-351	Nodding Block
18	4	9000124	Screw, FHCS 1/4-20 x 7/8

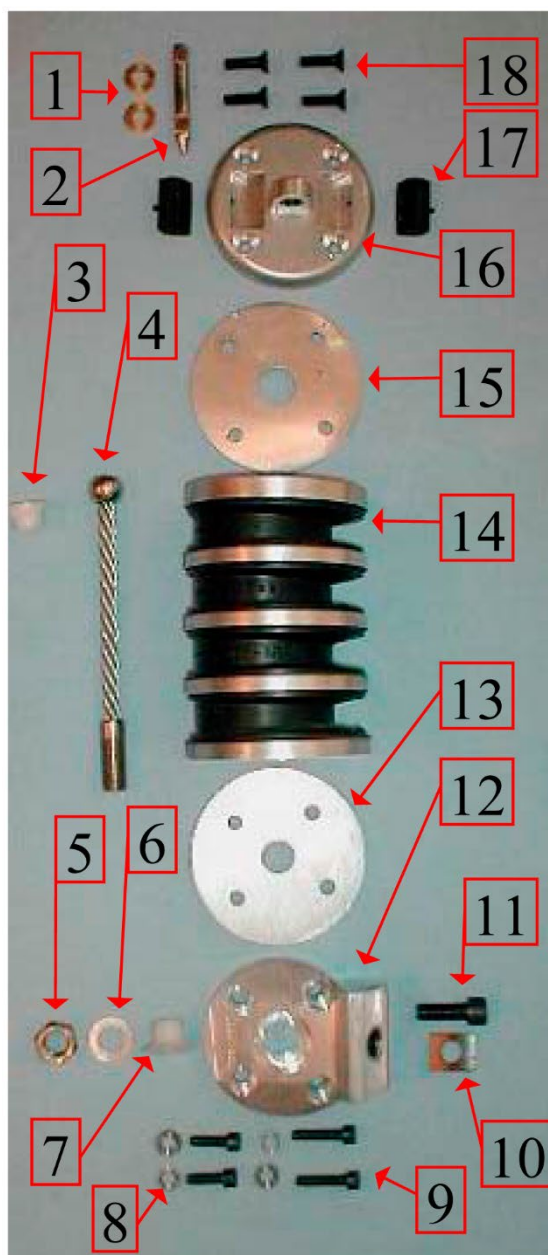


Figure 12 - Neck, Exploded View

Remove the nodding blocks and set aside. The pivot pin, nodding joint washers, SHCS and curved steel washer, as well as the neck bushings, washer and nut have been previously removed (see Head/Neck disassembly). Remove four FHCS from the top of the nodding joint bracket (Figure 13).



Figure 13 - Nodding Joint Bracket Removal

Upon removal of the four FHCS, the neck disassembly is complete (Figure 12). Note that the nodding joint bracket is separated from the upper neck by an upper neck spacer plate. The lower neck adjustment bracket is separated from the lower neck plate by a lower neck spacer plate. They are distinguishable by their hole patterns. The upper neck spacer plate has a symmetrical hole pattern that matches the nodding joint bracket while the lower neck spacer plate has an offset hole pattern that matches the lower neck adjustment bracket to ensure proper assembly.

3.1.4 Head/Neck Special Care and Maintenance

- Check for tears or breaks in the neck.
- Check the head skin for tears or cracks. Repair the head skin as outlined in Appendix B.
- Damage to the head skin in the forehead region should not be repaired, as this will affect test results. Replace.
- Check the skull casting for dents or cracks. Replace if damaged.
- Check the nodding blocks for wear and deformation. Noise and improper loading of the nodding joint will occur with damaged blocks.
- Check the axial integrity of the neck. (see Appendix D)
- The neck cable should be torqued to $1.36 \text{ N}\cdot\text{m} \pm 0.23 \text{ N}\cdot\text{m}$ ($12.0 \text{ in}\cdot\text{lbf} \pm 2.2 \text{ in}\cdot\text{lbf}$)

3.2 Upper Torso

3.2.1 Shoulder/Clavicles

Figures 14 and 15 show the clavicle and shoulder exploded views. The corresponding table is the general part description that correlates with the adjacent item number.

Table 4 - Clavicle Link Exploded View Parts List

Item Number	Quantity	Part Number	Part Description
1	1	9006001	SHSS
2	1	880995-358	Clavicle Link Pivot Bushing
3	2	78051-236	Clavicle Link Pivot Washer
4	1	880995-334 (left), 880995-335 (right)	Clavicle Link
5	1	78051-243	Washer
6	1	9000043	SHSS ½ x 1
7	1	880995-338	Clavicle Spring Stop
8	2	880995-339	Clavicle Spacer
9	1	880995-336 (left), 880995-337 (right)	Clavicle

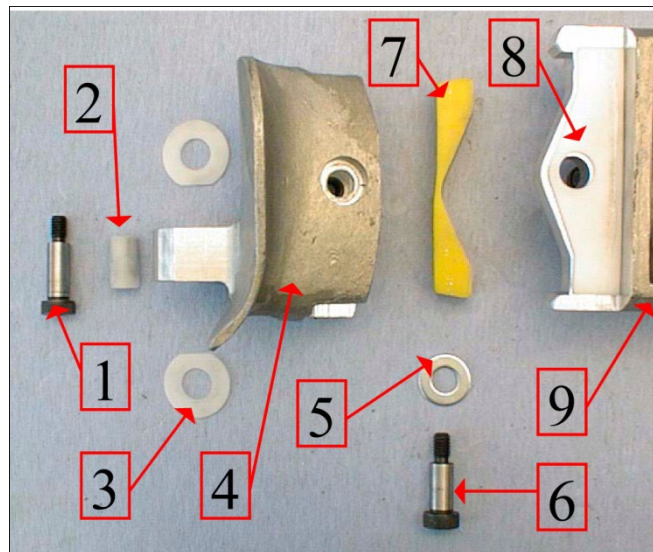
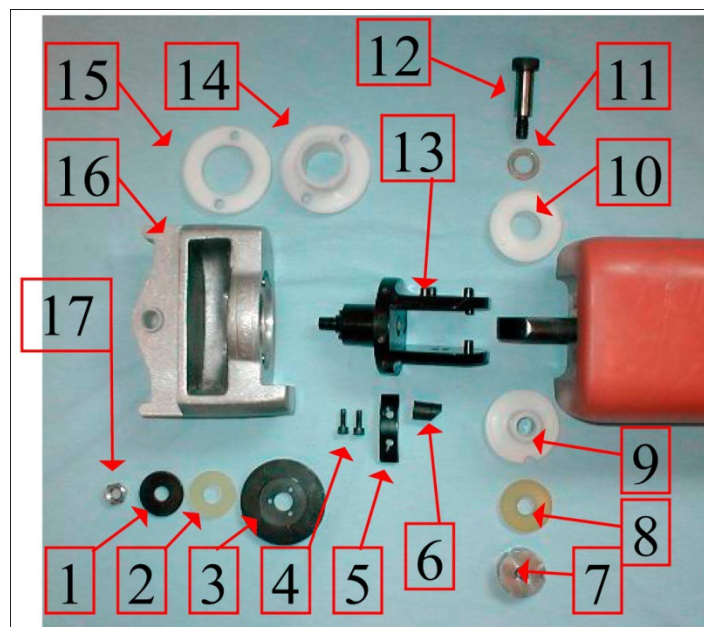
**Figure 14 - Clavicle Link, Exploded View**

Table 5 - Clavicle and Shoulder Yoke Exploded View Part List

Item Number	Quantity	Part Number	Part Description
1	1	78051-250	Washer, Shoulder Yoke Retaining
2	1	78051-249	Washer, Spring
3	1	78051-248	Washer, Steel Shoulder Yoke
4	2	9000047	SHCS
5	1	880995-346	Steel Stop
6	1	78051-245	Shoulder Stop Assembly
7	1	78051-202	Nut, Elbow Pivot
8	1	880995-351	Washer, Spring
9	1	880995-709	Bushing, Upper Arm and Elbow Pivot
10	1	880995-708	Washer, Upper arm and Elbow Pivot
11	1	880995-711	Washer
12	1	9000055	SHSS
13	1	880995-343	Shoulder Yoke Assembly
14	1	880995-348	Bushing, Shoulder Yoke Pivot
15	1	880995-349	Washer, Yoke Pivot
16	1	880995-336 (left), 880995-337 (right)	Clavicle
17	1	9000800	Locknut, Thin

**Figure 15 - Clavicle and Shoulder Yoke, Exploded View**

The right and left shoulder-clavicle and link assemblies consist of three main sections; the clavicle, clavicle link and shoulder yoke, which bolt to each other and then to the thoracic spine. These three sections permit arm rotation, up-down motion at the shoulder, forward-rear excursion (hunching), and up-down motion of the entire shoulder-clavicle unit. See Figure 16 for the assembled view of the shoulder clavicle link.

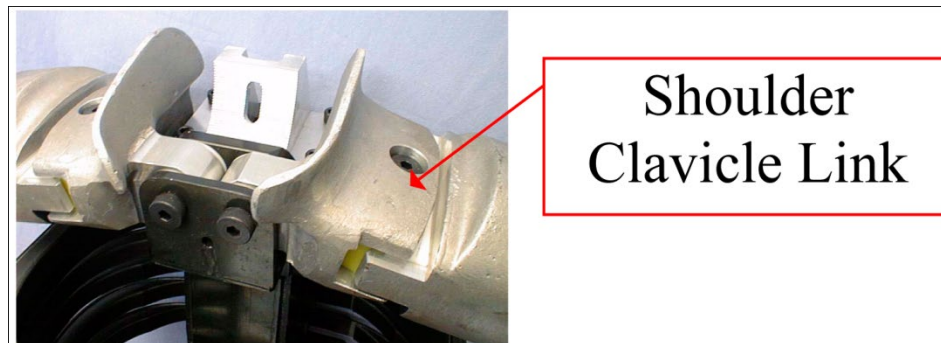


Figure 16 - Clavicle Link

To begin disassembling the clavicles, it is optional to first remove each arm at the shoulder yoke by unscrewing the SHSS (Figure 17). If necessary, clean the clavicle bushing and washers with isopropyl alcohol. Never lubricate any of the plastic bushings.

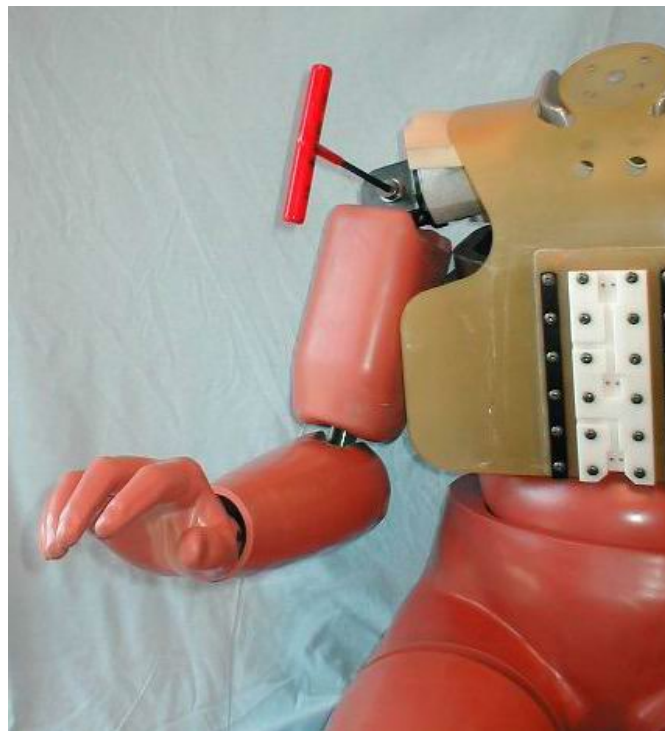


Figure 17 - Arm Removal

Detach the shoulder-clavicle unit from the thoracic spine assembly by reaching through a hole in the plastic chest "bib" and removing the SHSS at the extreme top of the thoracic spine (Figure 18). Pull the clavicle unit straight up. Check for the urethane washer at the rear of the cavity in the thoracic spine and for two clavicle washers isolating the clavicle from the spine. Make sure the pivot nut slides out freely. A clavicle bushing should also be present in the hole through the clavicle link.

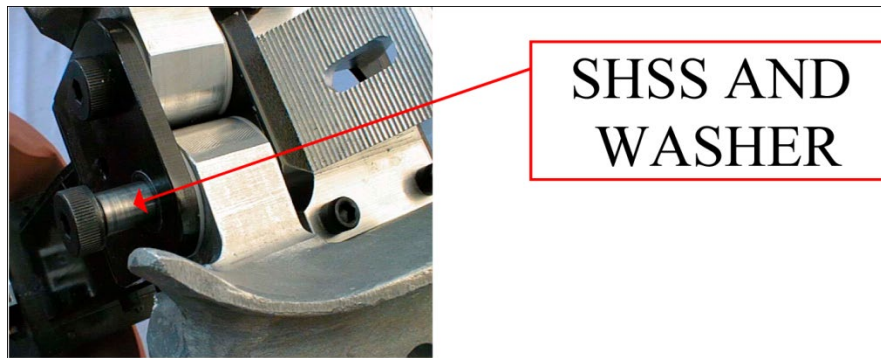


Figure 18 - Clavicle Link Bolt

At this time, use a pair of needle nose pliers to remove the rubber bumper stop from the Thoracic Spine (Figure 19). Inspect the shoulder yoke for damage. The stop should be free from tears or permanent deformation, and should be symmetrical in cross section.

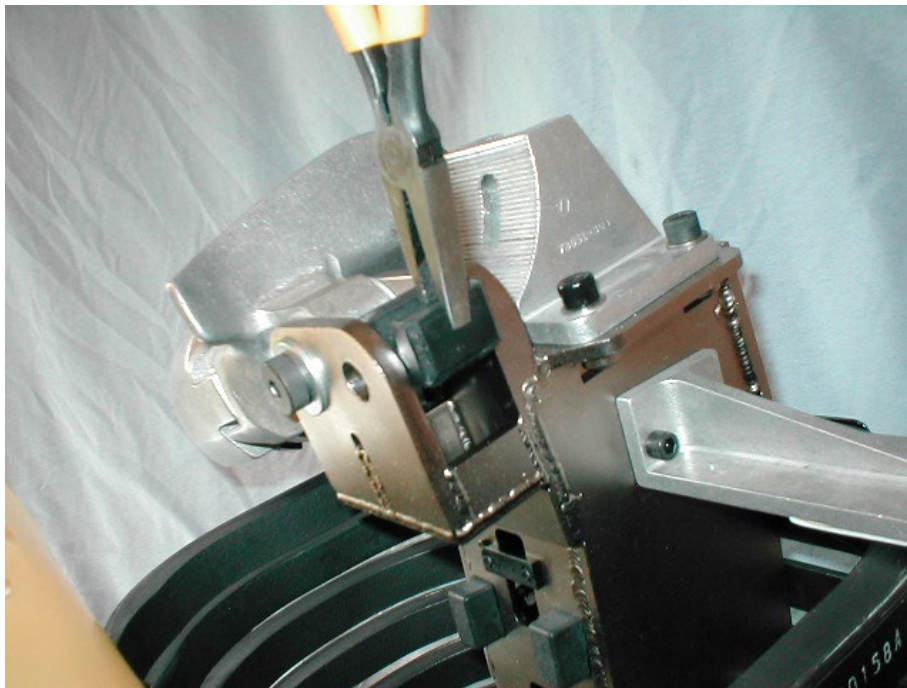


Figure 19 - Bumper Stop

The shoulder yoke assembly contains three stops. One is a steel stop that contacts a rubber rear stop when the arm is extended (Figure 20). There are four holes available for positioning the steel stop on the shoulder yoke. The steel stop should be positioned in the two mounting holes furthest from the rear stop, as shown in Figure 20. The third stop is the rubber shoulder pivot stop that prevents excessive arm abduction (Figure 21). Upon disassembly, all stops should be inspected for damage.



Figure 20 - Shoulder Yoke Rotation Stop

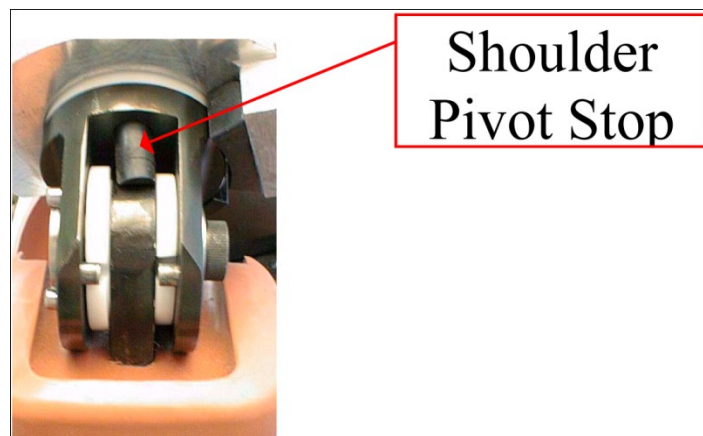


Figure 21 - Upper Arm Stop

Remove the SHSS (Figure 22) and its steel washer that holds the two aluminum sections of the clavicle and its link together.

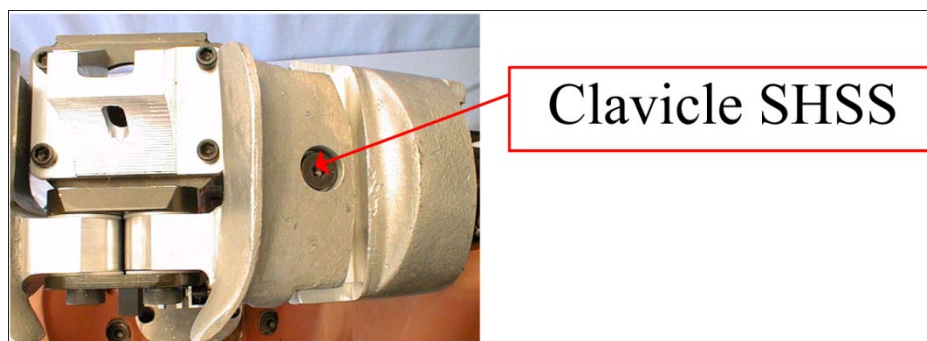


Figure 22 - Clavicle SHSS

A urethane spring "stop" should be located at the back of the cavity in the inner clavicle link (Figure 23).

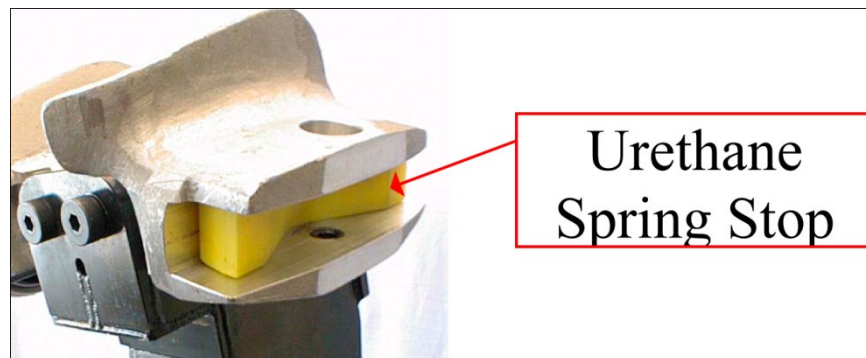


Figure 23 - Urethane Spring Stop

Top and bottom thin clavicle spacers (Figure 24) should isolate the two sections.

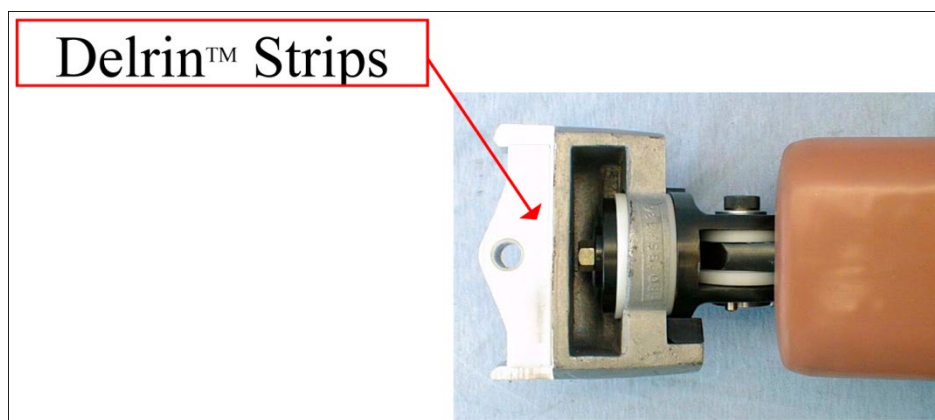


Figure 24 - CLAVICLE SPACERS

The shoulder yoke connects the arm to the clavicle. To remove the shoulder yoke, use an open wrench or equivalent tool to remove the lock nut (Figure 25). Once the nut is removed, the shoulder yoke will slide out and the disassembly is complete. Check for a steel stop on the rim of the shoulder yoke, held by two SHCS (Figure 20). The stop can be installed in two positions: one for the right side and the other for the left. Inspect clavicle aluminum parts for porosity and cracks. This will complete the disassembly of the clavicle from the clavicle link. Before assembly, ensure the spring stop is in position. Use a clamp or compression tool to squeeze the clavicle and clavicle link in order to compress the urethane spring stop until insertion of the clavicle SHSS is possible.