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Hybrid III Six-Year-Old Child Dummy User's Manual

RATIONALE

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INTRODUCTION

FOREWORD

In the late 1980's, the Centers for Disease Control (CDC) awarded Ohio State University a grant to develop a multisized family of test dummies based on the Hybrid III design. As part of that endeavor, the Mechanical Human Simulation Subcommittee of the Society of Automotive Engineers (SAE) formed a task group to define the size, weight, impact response characteristics and response measurements for a 6-year-old child dummy which would have, at least, the same level of biofidelity and measurement capacity as the mid-size adult male Hybrid III dummy.

The size and weight specifications of the Hybrid III 6 year old dummy are based on the average characteristic dimensions taken from anthropometry studies of 6 year old boys and girls. The biofidelic impact response requirements for head, neck, chest, and knees were extrapolated from the corresponding Hybrid III adult male responses taking into account the differences in size, weight, and tissue material properties that exist between children and adults (see Mertz, H.J. and Irwin, A.L., "Biomechanical Bases for the CRABI and Hybrid III Child Dummies", SAE 973317, 41st Stapp Car Crash Conference, Nov. 1997).

1. SCOPE

This user's manual covers the Hybrid III 6-year-old child test dummy, including changes specified in 49 CFR Part 572, Subpart N in the final rule dated December 9, 2010. It is intended for technicians who work with this device. It covers the construction and clothing, disassembly and reassembly, available instrumentation, external dimensions and segment masses, as well as certification and inspection test procedures. Appendix A contains guidelines for safe handling of instrumented dummies. Appendix B contains instructions for repairing dummy flesh. Appendix C includes procedures for adjusting the joints throughout the 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 version 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.

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 J2570 Performance Specifications for Anthropomorphic Test Device Transducers

2.2 Drawing Package

All part numbers in this manual refer to the drawing package in the docket of the National Highway Traffic Safety Administration. Copies of the drawing package for this dummy can be obtained from Leet-Melbrook, Division of MBC, 18810 Woodfield Road, Gaithersburg, MD 20879, (301) 670-0090.

3. DEFINITIONS AND ABBREVIATIONS

3.1 BHCS

Button Head Cap Screw

3.2 CERTIFICATION TESTS

Tests conducted to assure that the dummy is manufactured and maintained at the SAE specified performance levels for 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 the performance of new components or assemblies. Certification tests are performed periodically by dummy users to assure that the dummy is properly maintained.

3.3 FHCS

Flat Head Cap Screw

3.4 INSPECTION TESTS

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

3.5 SHCS

Socket Head Cap Screw

3.6 SHSS

Socket Head Shoulder Screw

3.7 SSCP

Socket Screw, Cup Point

3.8 1 G JOINT SETTING

The torque setting of a joint that supports the weight of its distal limb and will move when a minimal external force is applied (see APPENDIX C – JOINT ADJUSTMENT PROCEDURES)

4. CONSTRUCTION

The skull and skull cap are each one-piece cast aluminum, with removable one-piece vinyl head and cap skins. The vinyl skin has been tuned to give a human-like response for forehead impacts.

The rubber neck has been tuned to give human-like angle versus moment response in dynamic flexion (forward bending) and extension (rearward bending) articulations. A cable through the neck's longitudinal axis controls stretching responses and increases the neck's durability to high axial loads.

Six spring steel ribs with polymer-based damping materials approximate the chest force-deflection response characteristics. Top and bottom rib stops control the vertical movement of the rib cage. The sternum assembly connects to the front of the ribs and incorporates a "slider" for the chest deflection transducer to measure rib cage deflection relative to the spine.

The two-piece aluminum clavicle and clavicle link assemblies have cast integral scapulae to interface with shoulder belts.

The chest flesh has a zipper for easy removal.

The cylindrical rubber lumbar spine gives an automotive sitting posture.

The pelvis and abdominal assembly has a seated design, with vinyl skin and foam flesh molded over an aluminum pelvis casting. The pelvis has a humanlike shape.

The thighs contain ball jointed femurs and retaining rings for the hip pivot joint. The solid vinyl knee impact surface controls impact response.

5. CLOTHING

When used in tests, the dummy should wear shirt and pants which are children’s XS (size 4-5) thermal knit, waffle weave, 50%/50% polyester and cotton underwear or equivalent. 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 shirt and pants should each weigh no more than 0.09 kg (0.2 lb). The shoes should be children’s size 13M canvas oxford style sneakers. Each shoe weighs 0.38 kg ± 0.05 kg (0.83 lb ± 0.10 lb).

6. INSTRUMENTATION

The following instrumentation, shown in Figure 1, is recommended by the SAE Task Group to evaluate child restraints and air bag interactions with children of this size:

Three uniaxial accelerometers in the head	SA572-S4
Six-channel upper neck load cell	SA572-S11
Six-channel lower neck load cell	SA572-S26
Chest deflection potentiometer	SA572-S50
Two triaxial accelerometers on the sternum	SA572-S4
Two triaxial accelerometers at the front of the spine box	SA572-S4
Triaxial accelerometers in the upper torso and pelvis.....	SA572-S4
Six-channel lumbar spine load cell.....	SA572-S12
Two-channel anterior superior iliac spine load cell	SA572-S13
Six-channel femur load cell (single axis available)	SA572-S10

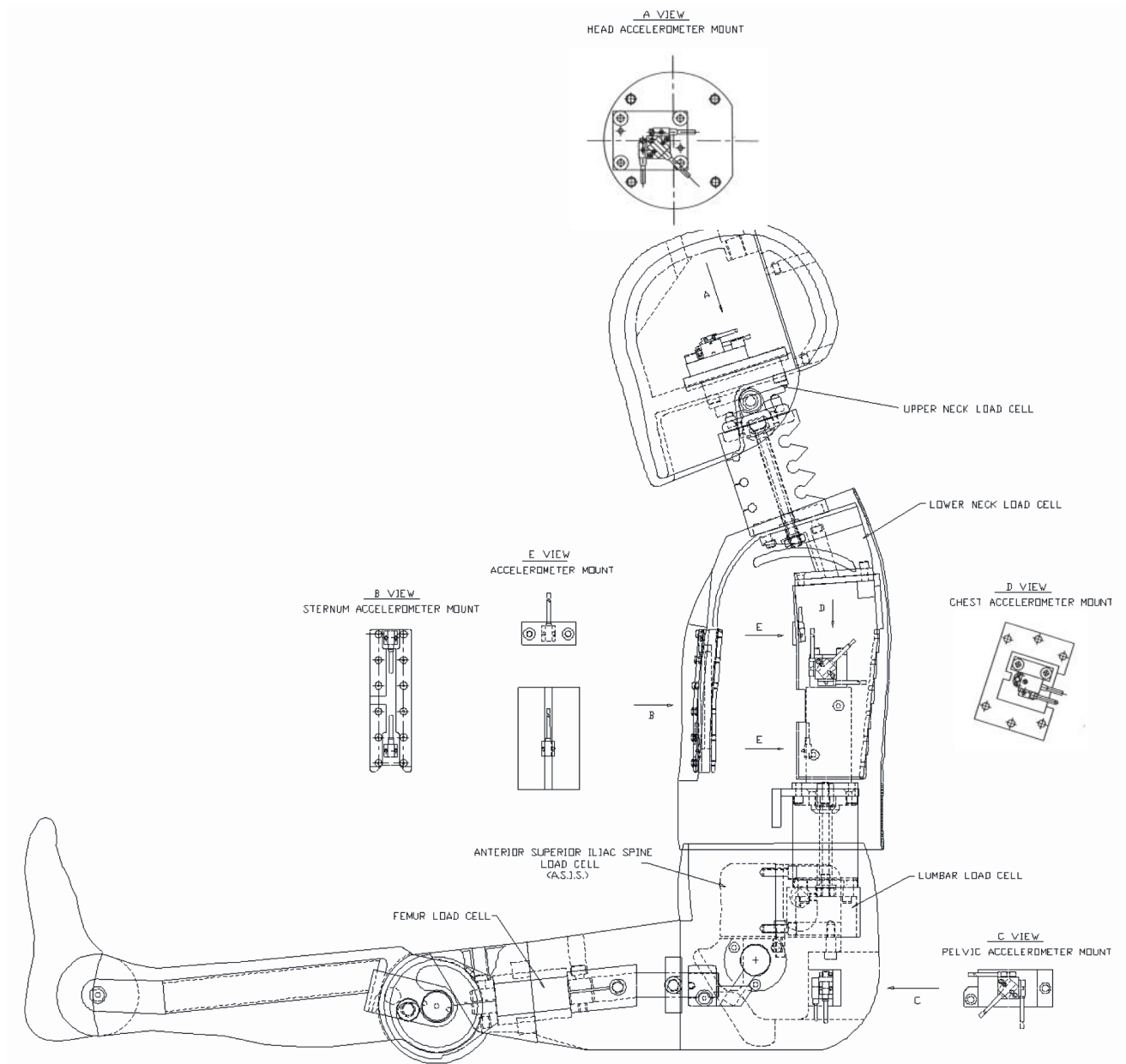


FIGURE 1 - INSTRUMENTATION LOCATIONS

7. DISASSEMBLY AND ASSEMBLY PROCEDURES

7.1 Head and Neck Assembly

The Head Assembly (127-1000) consists of:

Machined Skull	127-1001	Item-1, Figure 2
Load Cell Spacer	127-1003	Item-2, Figure 2
Machined Skull Cap	127-1004	Item-3, Figure 2
Head Skin	127-1008	Item-4, Figure 2
Skull Cap Skin	127-1009	Item-5, Figure 2
Pivot Pin, Neck Transducer	78051-339	Item-6, Figure 2
Neck Transducer, Structural Replacement	78051-383X	Item-7, Figure 2
Screw, SHCS 10-32 x 1/2	9000147	Item-8, Figure 2
Screw, SHCS 1/4-28 x 3/4	9000453	Item-9, Figure 2
Screw, SSCP 8-32 x 1/4	9000452	Item-10, Figure 2
Nodding Blocks	127-1020 (and 21)	Item-11, Figure 2
Screw, SHCS 10-32 x 1/2	9000147	Item-1, Figure 3
Modified SHCS (10-32 x 0.55)	127-2107	Item-3, Figure 3
Hex Nut 5/16-24	9000341	Item-4, Figure 3
Bib Assembly	127-8080	Item-5, Figure 3
Neck Bracket Assembly	127-8221	Item-6, Figure 3
Screw, SSCP 8-32 x 1/4	9000452	Item-1, Figure 4
Pivot Pin, Neck Transducer	78051-339	Item-2, Figure 4
Adaptor Plate	127-8221	Item-1, Figure 5
Pivot Pin, Neck Transducer	78051-339	Item-2, Figure 5
Nodding Blocks	127-1020 (and 21)	Item-3, Figure 5
Neck Transducer, Structural Replacement	78051-383X	Item-4, Figure 5
Load Cell Spacer	127-1003	Item-5, Figure 5

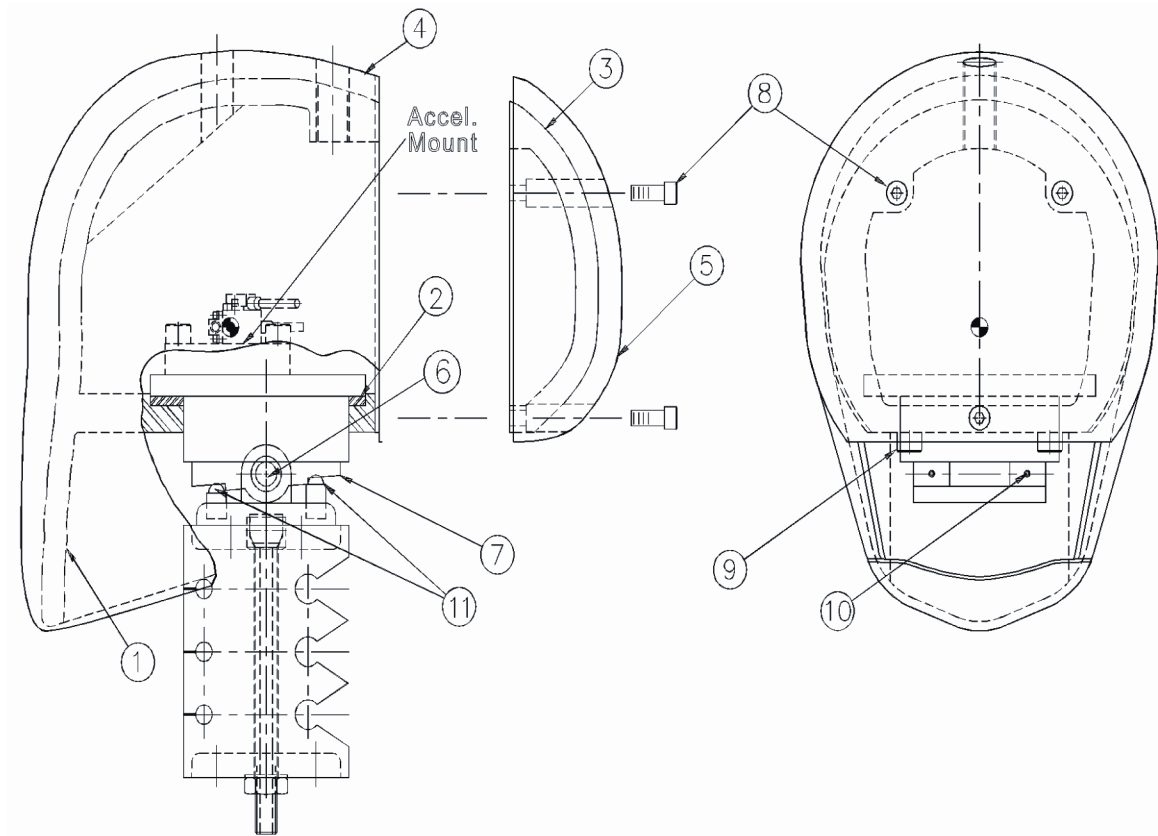


FIGURE 2 - HEAD ASSEMBLY

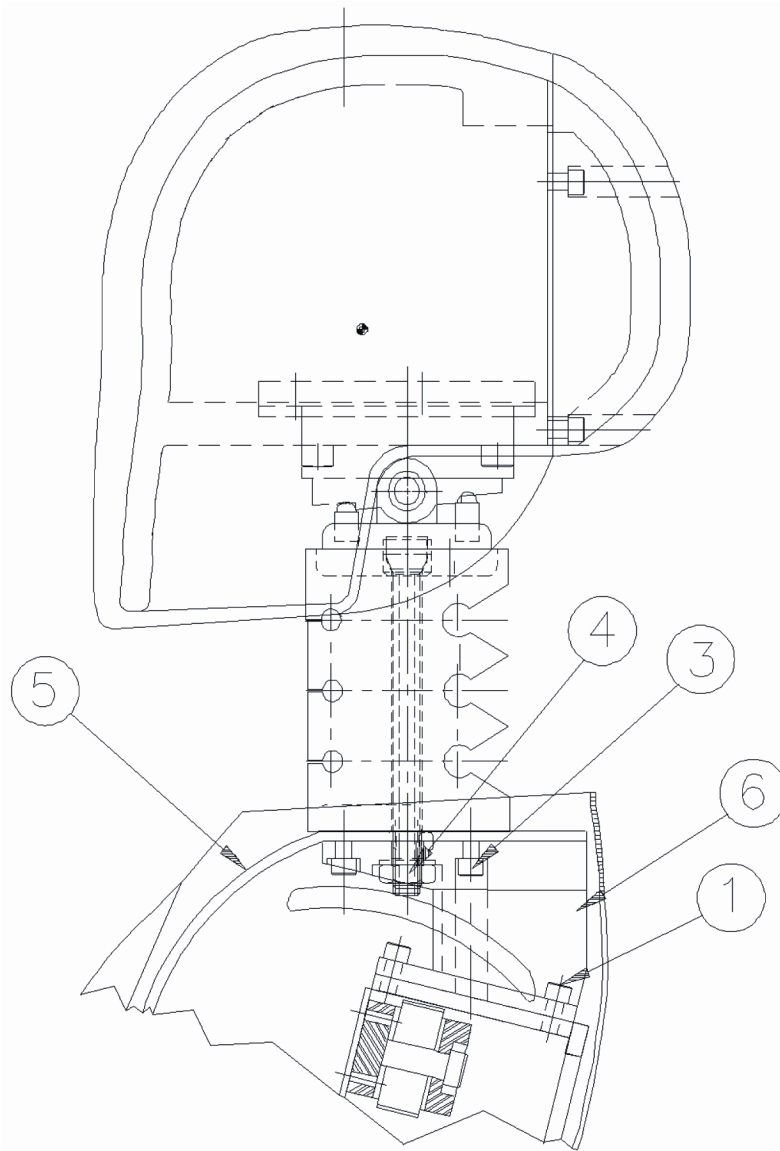


FIGURE 3 - HEAD AND NECK ASSEMBLY

7.2 Head and Neck Disassembly

Before beginning disassembly of the head and neck, remove the abdomen from the dummy. This is done to allow any screws that may fall during the disassembly process to drop into the abdominal cavity for easy retrieval. Remove the abdominal insert (127-8210) (Item-15, Figure 13) from the dummy by first removing the chest flesh (127-2010) (Item-5, Figure 7). To remove the chest flesh, first remove the arms (127-5000-1 Left, and -2 Right). This is done by taking out the 5/16 x 3/4 SHSS (Item-9, Figure 7) or (Item-5, Figure 8) at the arm-to-shoulder pivot. When removing the arm assemblies, notice the yoke spring washer (Item-1, Figure 8), bushings (Item-2, Figure 8) and pivot nut (Item-3, Figure 8) at the arm-to-shoulder pivot. This is important for reattaching the arms during reassembly.

With the arms out of the way, the chest flesh (127-2010) (Item-5, Figure 7) can be removed. Unzip the chest flesh at the rear of the dummy and pull it off the torso one side at a time. The flesh is resilient, but be careful not to tear it while pulling it off over the shoulder assemblies. With the chest flesh removed, push the upper torso rearward and pull the abdominal insert out through the opening in the front.

Begin disassembly of the head by removing the head-neck assemblies from the dummy. Remove the accelerometers and disconnect the load cell cables from the head first.

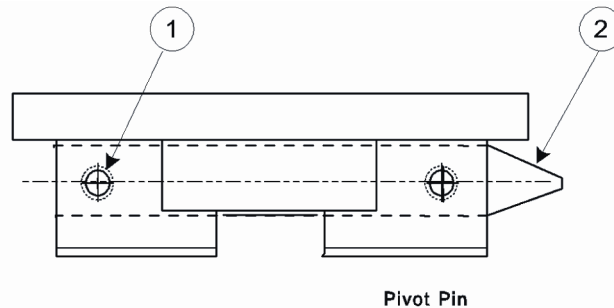


FIGURE 4 - ENLARGED VIEW OF THE UPPER NECK LOAD CELL

You can access these items by taking out the three 10-32 x 1/2 SHCS (Item-8, Figure 2) that hold the skull cap to the head.

To remove the neck bracket from the spine box, the shoulders must first be loosened to gain access to the front screws. To do this, loosen the 5/16 x 3/4 SHSS (Item-30, Figure 9) and push the shoulder assembly down. Then remove the four 10-32 x 1/2 SHCS (Item-1, Figure 3) that hold the neck bracket (Item-6, Figure 3) to the spine box, starting with the two rear screws. At this point, the head-neck assembly will still be connected to the upper torso by the bib assembly (Item-5, Figure 3). Remove the four 10-32 x 0.55 modified SHCS (Item-3, Figure 3) and the 5/16-24 Hex Nut (Item-4, Figure 3) from the underside of the neck bracket and pull the bracket away from the neck, allowing the assembly to be free from the bib assembly (Item-5, Figure 3) and upper torso.

With the head-neck assemblies free from the dummy, remove the head from the neck. Remove the two 8-32 x 1/4 SSCP (Item-10, Figure 2 or Item-1, Figure 4) that hold the load cell pivot pin (Item-6, Figure 2 or Item-2, Figure 4) in place. These two screws are located in the load cell/load cell replacement (Item-7, Figure 2) at the rear of the skull.

To take the head off the neck, it is recommended to use a neck compression tool (see Figure 5) and an adaptor plate (Item-1, Figure 5). First, attach the adaptor plate to the rear surface of the skull using three 10-32 x 1/2 SHCS. Next, attach the neck compression tool to the adaptor plate with at least two 1/4-20 x 1-3/8 SHCS. Compress the nodding blocks (Item-3, Figure 5) by turning the screw handle on the neck compression tool. Be sure the neck cable is inside the cylindrical cup (see Figure 5). With the nodding blocks compressed, the pivot pin (Item-2, Figure 5) should slide out of the nodding joint/load cell with little resistance. With the pivot pin out of the assembly, the neck can be easily pulled away from the head.

While separating the head and the neck, pay attention to the components that can fall out of the assembly. The nodding blocks (Item-3, Figure 5) sometimes fall out of the head-neck assembly. Also, there are two brass washers (Item-8, Figure 6) that will fall out. Do not confuse the brass washers with any others; they are trimmed for the proper fit of this joint.

NOTE: Newly purchased washers (78051-253) can be trimmed in several ways. The easiest is to rub the washer on coarse sandpaper or a file and check and recheck the fit of the joint. Repeat the trimming until the nodding joint and the load cell can be assembled snugly with the washers. The fit of the nodding joint and load cell should be snug but easily assembled.

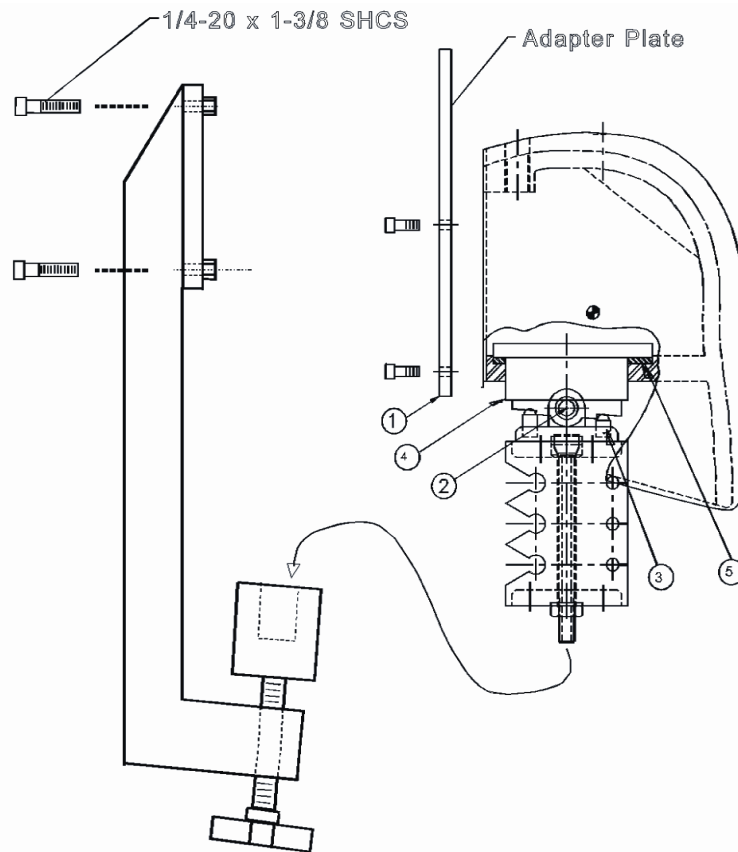


FIGURE 5 - NECK COMPRESSION TOOL

The head skin can be peeled away from the skull by firmly pulling the two components apart at the rear of the head. The cap skin is removed from the skull cap in the same manner as the head skin and skull.

Remove the Neck Transducer Structural Replacement (Item-4, Figure 5) by taking out the four 1/4-28 X 3/4 SHCS (Item-9, Figure 2) at the base of the skull. With the screws removed, the neck transducer structural replacement can be removed from inside of the skull. Remove the load cell spacer (Item-5, Figure 5) located between the neck transducer structural replacement and base of the skull.

7.3 Head and Neck Inspection

With all of the components separated, inspect each part for damage or flaws.

- Inspect the head skin for any cracks or tears. The skin should feel soft and pliable. If not, have the head skin re-certified or replaced.
- Check the skull, inside and out. Look for any dents, cracks, damaged threads, or loose ballast.
- When the neck is separated from the dummy, look to see if it is permanently deformed. If any tears or breaks are evident, the neck should be replaced.

7.4 Head and Neck Reassembly

- Install the Load Cell Spacer and the Neck Transducer Structural Replacement at the base of the skull.
- Put the skin back on the skull and skull cap. During reassembly, make sure that the skin is properly installed so no gap exists between the skin and the skull in the frontal, or forehead, area.
- Connect the neck to the head. Make sure that the shorter nodding block is in the front of the neck and the taller nodding block is in the back.
- Connect the head-neck assembly to the upper torso by connecting it to the bib assembly.
- Connect the neck bracket to the spine box.

7.5 Neck

The Neck assembly (127-1015) consists of:

Screw, FHCS 10-32 x 1/2	9000208	Item-1, Figure 6
Nodding Joint Assembly	127-1022	Item-2, Figure 6
Nodding Block, Back (taller)	127-1021	Item-3, Figure 6
Nodding Block, Front (shorter)	127-1020	Item-4, Figure 6
Molded Neck Assembly	127-1017	Item-5, Figure 6
Neck Cable	127-1016	Item-6, Figure 6
Hex Nut 5/16-24	9000341	Item-7, Figure 6
Nodding Joint Washer	78051-253	Item-8, Figure 6
Mounting Plate Insert	910420-048	Item-9, Figure 6
Washer Urethane	210-2050	Item-10, Figure 6

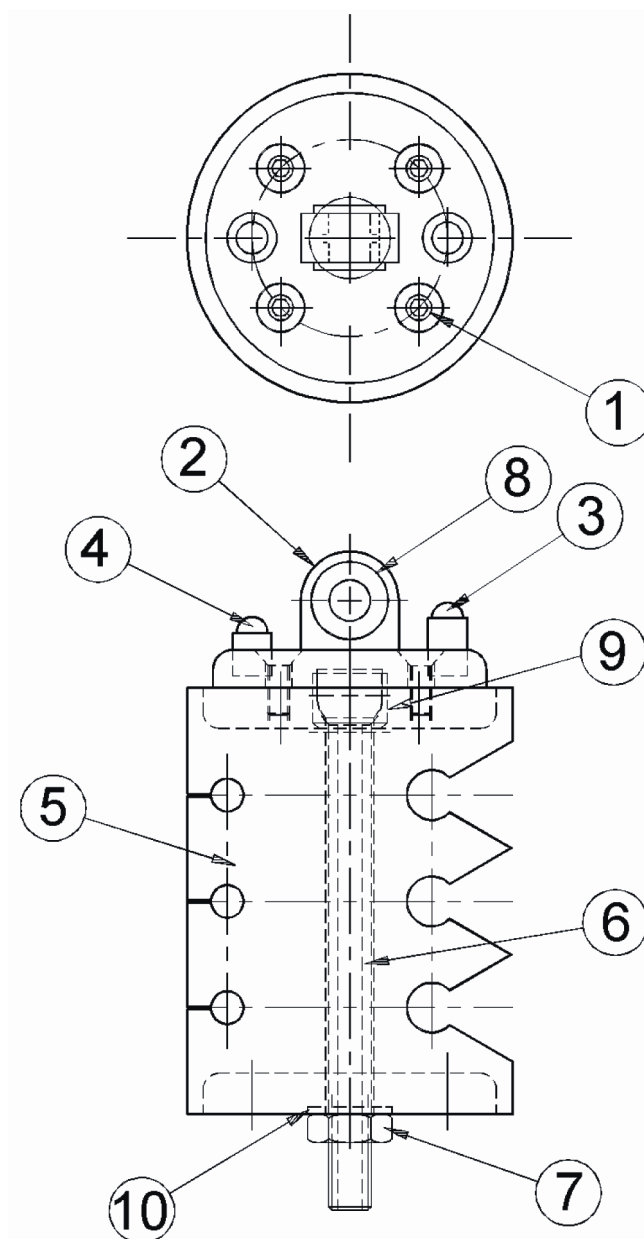


FIGURE 6 - NECK ASSEMBLY

7.6 Neck Disassembly

The first step of the neck disassembly is to remove the nodding blocks (Item-3 and 4, Figure 6). Notice that the front nodding block is shorter than the rear one; they are not interchangeable. If their positions are switched, the resistance to motion in the forward direction, or chin to chest motion, will be increased. The moment about the occipital condyle will go up and the total rotation will go down. The two nodding blocks are removed from the assembly by simply pulling them from their respective positions. Next, remove the four 10-32 x 1/2 FHCS (Item-1, Figure 6) from the top surface of the nodding joint and the nodding joint assembly will be free. Remove the 5/16-24 hex nut (Item 7, Figure 6) and urethane washer (Item 10, Figure 6) from the neck cable. The neck cable (Item-6, Figure 6) is removed by pulling it from the upper side of the molded neck, which is the nodding joint end.

Remove the plastic bushing at each end of the cable. These bushings are used to eliminate the possibility of metal-to-metal contact between the neck cable and the metal neck plates.

The molded rubber neck assembly (Item-5, Figure 6) is the final component of the neck assembly. If the assembly does not meet the certification requirements, this part is usually the problem. Be sure that the neck cable is torqued properly before conducting any tests with this device.

The neck cable torque should be: $0.22 \text{ N}\cdot\text{m} \pm 0.02 \text{ N}\cdot\text{m}$ (2.0 in-lbf $\pm$ 0.2 in-lbf).

7.7 Neck Inspection

- Inspect the nodding blocks. If are split or deformed, replace them because damaged nodding blocks will not provide the proper loading of the nodding joint allowing the head to rattle in the joint. Over time, this could damage the nodding joint.
- Check the neck cable. It should be tightly wound: the groups of strands should not be easily discernible. If the cable seems fatter in the middle, replace it.
- If the neck cannot be properly torqued, the cable has been stretched and should be replaced.

7.8 Neck Reassembly

- Place the cable with the two plastic bushings back in the molded rubber neck assembly
- Torque the neck cable to $0.22 \text{ N}\cdot\text{m} \pm 0.02 \text{ N}\cdot\text{m}$ (2.0 in-lbf $\pm$ 0.2 in-lbf)
- Install the nodding joint assembly
- Install the two nodding blocks. Make sure the shorter nodding block is in the front and the longer nodding block in the rear.

NOTE: Always make sure that the neck cable is properly torqued to $0.22 \text{ N}\cdot\text{m} \pm 0.02 \text{ N}\cdot\text{m}$ (2.0 in-lbf $\pm$ 0.2 in-lbf) before conducting any tests with this device. To properly torque it, the cable must be held with a screwdriver in the slot in the end of the cable. This prevents the cable from winding up as the nut is torqued. A special torque wrench is required.

7.9 Thorax

The Upper Torso assembly (127-2000) consists of:

Bib Assembly	127-8080	Item-3, Figure 7
Chest Flesh	127-2010	Item-5, Figure 7
Screw, BHCS 6-32 x 5/8	9000430	Item-7, Figure 7
Rib Set.....	127-RS	Item-8, Figure 7
Screw, SHSS 5/16 x 3/4	9000578	Item-9, Figure 7
Front Rib Stiffeners	127-2048	Item-13, Figure 7
Front Rib Strip, Threaded.....	127-8200	Item-14, Figure 7
Transducer Mount Assembly	127-8230	Item-16, Figure 7
Chest Deflection Transducer Assembly.....	127-8050	Item-18, Figure 7
Shoulder Assembly, Left	127-2079-1.....	Item-19, Figure 7
Shoulder Assembly, Right	127-2079-2.....	Item-20, Figure 7
Shoulder Elevation Bumpers	127-2082	Item-21, Figure 7
Screw, BHCS 6-32 x 1/2	9000247	Item-28, Figure 7
Ball Slider	127-8051	Item-32, Figure 7
Yoke Spring Washer	127-2102	Item-1, Figure 8
Bushing	127-2105-1.....	Item-2, Figure 8
Nut.....	127-5028	Item-3, Figure 8
Screw, SHSS 5/16 x 3/4.....	9000578	Item-5, Figure 8
Neck Bracket Assembly	127-8221	Item-1, Figure 9
Sternum.....	127-8240	Item-2, Figure 9
Sternum Stop	127-8090	Item-4, Figure 9
Spine Box, Welded	127-8000	Item-6, Figure 9
Screw, BHCS 6-32 x 3/8	9001213	Item-10, Figure 9
Screw, SHCS 10-32 x 1/2	9000147	Item-12, Figure 9
Rear Ribs Stiffener.....	127-8180	Item-15, Figure 9
Transducer Mount Assembly	127-8230	Item-16, Figure 9
Thorax C.G. Weight Assembly	127-8061	Item-17, Figure 9
Chest Deflection Assembly	127-8050	Item-18, Figure 9
Shoulder Elevation Bumpers	127-2082	Item-21, Figure 9
Shoulder Elevation Bushings	127-2085	Item-22, Figure 9
Nut.....	127-5028	Item-23, Figure 9
Screw, BHCS 10-32 x 5/16	9001369	Item-24, Figure 9
Pin, Dowel 1/8 x 3/8	9000046	Item-25, Figure 9
Transducer Arm Connector	127-2073	Item-26, Figure 9
Screw, SHCS 10-32 x 1/2	9000147	Item-27, Figure 9
Screw, SHCS 10-32 x 1/2	9000147	Item-29, Figure 9
Screw, SHSS 5/16 x 3/4	9000578	Item-30, Figure 9
Transducer Arm.....	127-8052	Item-33, Figure 9
Top Rib Stop Assembly	127-8015-1 (Left), -2 (Right)	Item-34, Figure 9
Lower Rib Stop.....	127-8030-1 (Left), -2 (Right)	Item-35, Figure 9
Screw, SHCS 10-32 x 1/2	9000147	Item-36, Figure 9
Screw, FHCS 10-32 x 3/4	9000262	Item-37, Figure 9

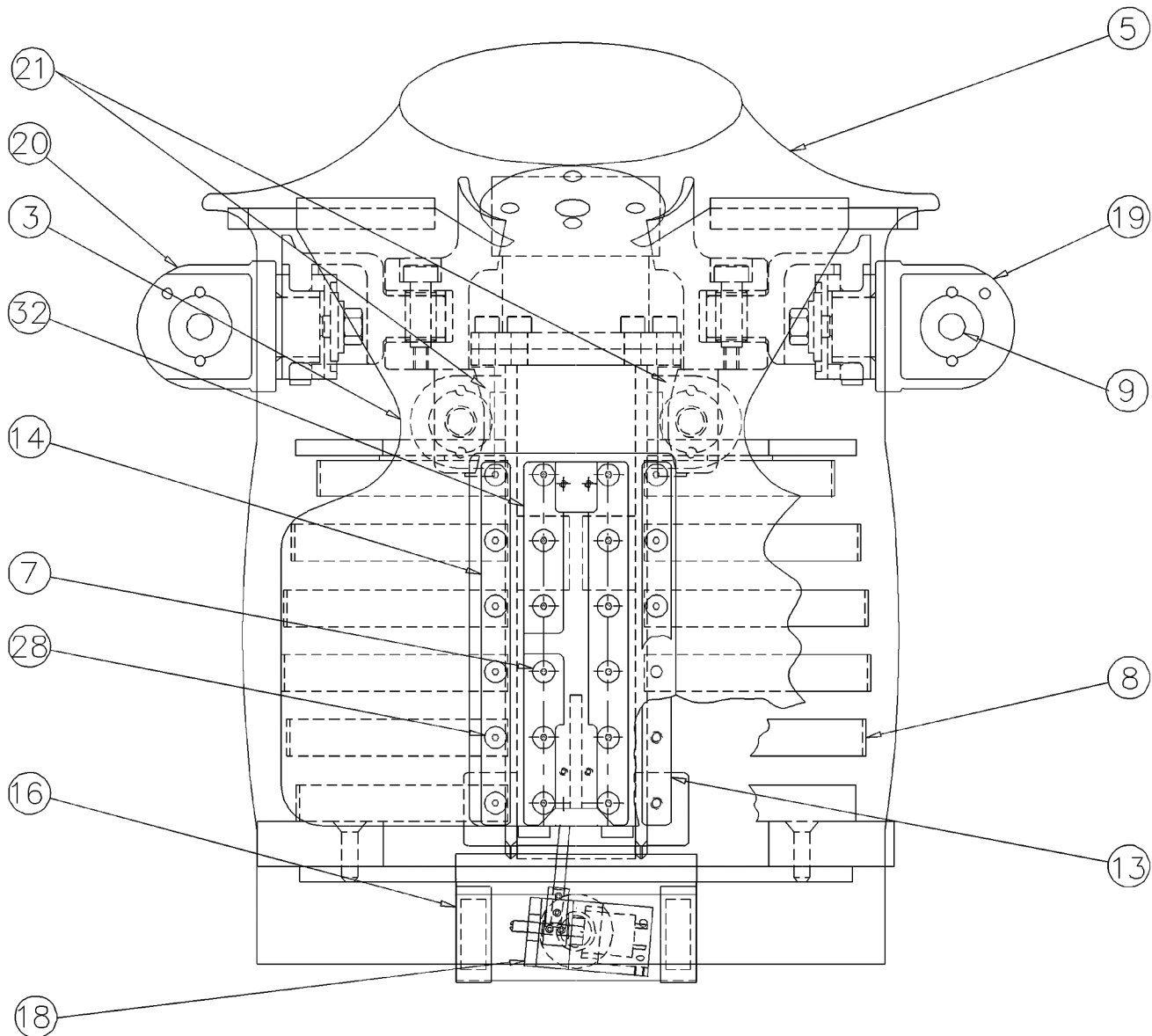


FIGURE 7 - FRONT VIEW OF CHEST ASSEMBLY

7.10 Upper Torso Disassembly

With the abdomen previously removed, remove the four 10-32 x 1/2 SHCS (Item-12, Figure 9) holding the upper torso to the lower torso. Lift the upper torso off the lower torso. Note that the transducer arm (127-8052) (Item-33, Figure 9) will slide out of the ball slider (Item-32, Figure 7). Remove the four 10-32 x 1/2 SHCS (Item-29, Figure 9) from the underside of the transducer mount assembly (127-8230) (Item-16, Figure 7). This removes the thorax C.G. weight assembly (127-8061) (Item-17, Figure 9) from the lower torso.

Note that once calibrated according to J2715, "Hybrid III Family Chest Potentiometer Calibration Procedure" the chest potentiometer assembly consisting of the transducer arm (Item 33, Figure 9), chest deflection assembly (Item 18, Figure 9) should not be mechanically adjusted or further disassembled.

Note that the thorax accelerometer mount attaches to the thorax C.G. weight assembly.

To take off the shoulder assemblies, remove the 5/16 x 3/4 SHSS (Item-30, Figure 9), one for each shoulder, attaching the shoulders to the spine box. Pull the shoulders away from the spine box and watch for the shoulder elevation bumpers (127-2082) (Item-21, Figure 9 and Figure 7) on each side of the spine, which can fall out.

In the shoulder joint, there are two shoulder elevation bushings (127-2085) (Item-22, Figure 9), one near the head of the shoulder screw and the other near the nut. There is a flat edge machined into the outside diameter of the part. Notice during disassembly that this flat edge is positioned toward the spine box.

To remove the bib assembly (127-8080) (Item-3, Figure 7) take out the twelve 6-32 x 1/2 BHCS (Item-28, Figure 7) holding the bib to the rib set. Be careful when removing the last screw because the front rib strip (through holes) (127-8200) (Item-14, Figure 7) and the front rib stiffeners (threaded holes) (127-2048) (Item-13, Figure 7) will fall off.

Take out the twelve 6-32 x 5/8 BHCS (Item-7, Figure 7) holding the ball slider (Item-32, Figure 7) to the bib. Again, watch the sternum assembly (127-8240) (Item-2, Figure 9) to keep it from falling off. The sternum assembly is a threaded aluminum bar used to hold the ball slider to the bib assembly. Once the button head screws are removed, the slider is removed from the bib. Next, remove both the left and right top rib stops (127-8015) (Item-34, Figure 9). This is done by removing the four 10-32 x 1/2 SHCS (Item-36, Figure 9) that hold the stops to the spine box.

With the bib and sternum assemblies removed, the only fasteners holding the ribs in place are twelve 6-32 x 1/2 BHCS (Item-10, Figure 9) along with the rear rib supports (127-8180) (Item-15, Figure 9) in the rear of the spine box. Take out these screws and their supports. Pull the ribs off from the bottom of the spine. Be careful not to pull the ribs open too much. Any change in the geometry of a rib will change its performance. Notice also that each of the ribs are different in size. The ribs are stamped in the rear with the numbers 1 through 6. These numbers correspond to their positions on the spine box; the number 1 rib is the highest on the spine and the number 6 rib is the lowest.

Next remove both the left and right lower rib stops (1278030) (Item-35, Figure 9). This is done by removing the four 10-32 x 3/8 FHCS (Item-37, Figure 9) that hold the lower stops to the spine box. You can now clearly see the front of the spine box where the sternum stop (Item-4, Figure 9) is glued.