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User's Manual for the 50th Percentile Male Hybrid III Dummy

RATIONALE

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FOREWORD

A group of Hybrid III users met at an SAE workshop held in June, 1984 to learn more about the design and use of the Hybrid III 50th percentile male dummy. They noted that a user's manual would be helpful. In response, the SAE Dummy Testing Equipment Subcommittee of the Human Biomechanics and Simulation Standards Committee prepared a User's Manual which became SAE Engineering Aid 23, published in June 1986. It has since become the basis for manuals on the entire Hybrid III family of dummies.

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1. SCOPE

The purpose of this document is to provide the user with the procedures needed to properly assemble and disassemble the 50th percentile male Hybrid III dummy, certify its components and verify its mass and dimensions. Also within this manual are guidelines for handling accelerometers, repairing flesh and setting joints.

2. REFERENCES

2.1 Applicable Publications

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.

Foster, Kortge and Wolanin, 1977, "Hybrid III—A Biomechanically Based Crash Test Dummy," Stapp Car Crash Conference

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

2.2 Related Publications

The following publications are provided for information purposes and are not a required part of this document.

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

SAE J2779 Low Speed Thorax Impact Test Procedure for the HIII 50th Male Dummy

SAE J2876 Low Speed Knee Slider Test Procedure for the Hybrid III 50th Male Dummy

3. ASSEMBLY AND DISASSEMBLY PROCEDURES FOR THE HYBRID III 50TH PERCENTILE MALE DUMMY

3.1 Introduction

The General Motors (GM) Hybrid III dummy (Figure 1) was an advancement of the ATD-502 dummy, developed in 1973 by GM under a NHTSA contract. The objective of the Hybrid III program was to produce a practical test dummy that would respond to an impact environment approximately as a human, based on the biomechanical data then available. The first version of this dummy became available in 1976 and was documented by Foster, Kortge and Wolanin in a 1977 Stapp Conference paper entitled "Hybrid III – A Biomechanically Based Crash Test Dummy." A number of improvements have followed. This Information Report should be used in conjunction with the engineering drawing package dated August 30, 1998, which details the parts and assemblies of the dummy.

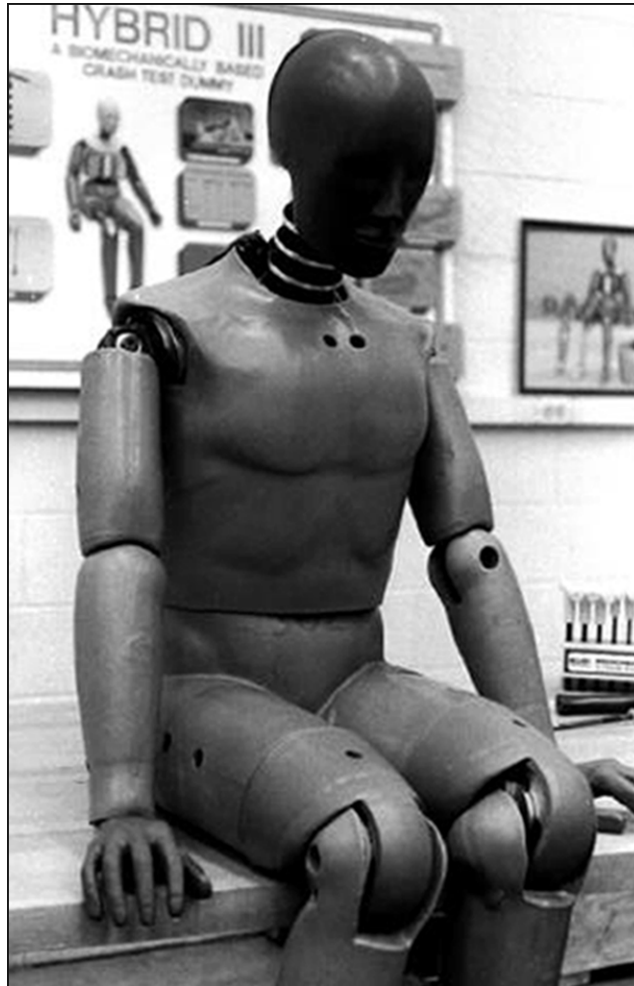


FIGURE 1 - ASSEMBLED HYBRID III DUMMY

The head of the Hybrid III dummy is anthropometrically shaped and responds in a similar manner to cadaver heads dropped on rigid surfaces. The head skin thickness is constant over the skull surface. The neck matches neck angle-torque response data in forward (flexion) and rearward (extension) directions for humans seated in automotive posture. Although not required, many users choose to use a neck shield during out-of-position testing to prevent possibly non-biofidelic interaction with air bags. Several styles of neck shield have been used, but none is yet universally accepted. If used, the neck shield should not change the neck bending response or provide a load path that bypasses the neck load cell. The shoulders show durability under shoulder belt loading. The shoulder joint torque remains essentially constant after adjustment. Most movable joints are of the constant friction type, and most have Delrin™-on-steel (or aluminum) surfaces. The adjustments should be checked before each test.

The chest matches the force-deflection characteristics (with rib fracture) of human cadavers from blunt chest impacts, with the force levels increased by 700 N to compensate for the cadavers' lack of muscle tone. The knee also matches cadaver response data. The lumbar spine is curved forward to add humanlike "slouch" to the seated dummy. The spine uses two laterally spaced cables which help stabilize the dummy in the lateral direction. An elastomeric insert over the machined knee and under the outer knee flesh simulation helps provide a soft, humanlike response. The abdomen is constructed of vinyl-encased foam. The feet now have a 45 degree range of motion, which matches human ankle range of motion in dorsiflexion. They also have a new construction which controls the response of the sole of the foot to loading. The Hybrid III hip joint range of motion also matches the range of a human hip joint. In addition, the hip joint incorporates a bumper that prevents metal-to-metal contact between the femur and hip bone. Test procedures for the foot and ankle compliance have been added as inspection procedures.

As a supplement to the calibration procedures included in this manual, European regulations include some additional calibration tests. They essentially involve dynamic impacts to the lower extremities. Users should be aware of these additional tests when using dummies to certify vehicles in Europe. Information about obtaining these procedures is found at the end of the calibration section.

The latest drawing package for the Hybrid III dummy was issued in 1998. It will be updated as modifications are accepted. The numbers in parentheses after a named part refer to the drawing number in the drawing package. The drawing package is available from Reprographic Technologies,

2000 'L' Street N.W., Washington, D.C. 20036,
Voice (202) 331-0576,
Fax (202) 331-0985.
Shop hours: Monday – Friday, 8:00 AM to 10:00 PM
<http://www.repro-tech.com/>

The Hybrid III dummy has many optional but recommended transducers listed in Table 1. On the lower extremities, they allow measurement of knee shear (tibia-femur displacement), knee clevis axial load (relative to the knee and ankle joints), and tibia-ankle shear and bending moments, plus three forces. For the neck (both top and bottom) spine, six-channel transducers that measure three moments and three forces are becoming the preferred transducers.

3.2 Special Tools

The following special tools will allow assembly, disassembly and calibration of the Hybrid III 50th percentile male dummy:

- a. Neck compression tool
- b. Ball hex wrench set
- c. Lumbar cable nut wrench
- d. Pelvis angle measurement tool (78051-532)
- e. Head skin thickness gauge
- f. Chest depth gauge (83-5006-007)
- g. Clavicle washer alignment tool
- h. Iliac bolt removal tool (for submarining pelvis only)

For information concerning tool availability, contact the dummy manufacturers.

TABLE 1 - HYBRID III 50TH PERCENTILE MALE DUMMY INSTRUMENTATION

HYBRID III 50th PERCENTILE MALE DUMMY INSTRUMENTATION				
Location	Measurement	Number of Channels	Required	Optional
Head c.g.	acceleration	3	X	
Head	angular acceleration	9 or 12		X
Head	angular rate	3		X
Head-neck interface	forces & moments	3		X
Head-neck interface	forces & moments	6	X	
Neck-thorax interface	forces & moments	6		X
Thorax c.g.	acceleration	3	X	
Thoracic spine	forces & moments	5		X
Sternum	displacement	1	X	
Sternum	displacement	8		X
Lumbar spine	forces & moments	5		X
Pelvis c.g.	acceleration	3		X
Pelvis	lap belt position	6		X
Upper femur	forces & moments	6 each femur		X
Lower femur	force	1 each femur	X	
Lower femur	forces & moments	6 each femur		X
Knee-tibia	displacement	1 each knee		X
Knee-clevis	force	2 each knee		X
Upper tibia	forces & moments	4 each leg		X
Lower tibia	forces & moments	4 each leg		X
Foot/ankle/toe	forces & moments	6 each foot		X
Shoulder	forces	2 each		X
Sternum	accelerations	2		X

3.3 Disassembly and Inspection

Every newly purchased Hybrid III dummy should be completely disassembled and compared against the latest engineering drawing package. Pay particular attention to parts critical to the performance of the dummy qualification tests. The following procedure will help verify that the newly purchased dummy conforms to the engineering drawing package. This procedure will also provide the basis to validate the dynamic component responses of the dummy.

3.4 Whole Dummy

Several guidelines and procedures apply to various parts throughout the dummy, and are included in the appendices for easier reference. First, when handling an instrumented dummy, improper techniques can damage instrumentation, particularly accelerometers. Appendix A contains guidelines for safe handling of accelerometers. Second, the vinyl flesh of dummies can be damaged, but is often repairable. Appendix B contains instructions for repairing dummy flesh. Third, procedures for adjusting the joints throughout the dummy are included in Appendix C.

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, along with descriptions of how to apply the positive right-hand rule sign convention.

3.5 Clothing

When used in testing, the dummy should wear a 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 lbm). 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. The shoes used with the 50th percentile male dummy are men's dress oxfords, size 11XW that meet military specification MIL-S-13192P. Each shoe weighs 0.613 kg $\pm$ 0.09 kg (1.35 lb $\pm$ 0.2 lb).

3.6 Arms

Remove each arm at the shoulder by unscrewing the 1/2x1-1/4 in long socket head shoulder screw (Figure 2). If necessary, clean the Delrin™ bushing and washers with a chlorinated solvent. Never lubricate any of the plastic bushings.

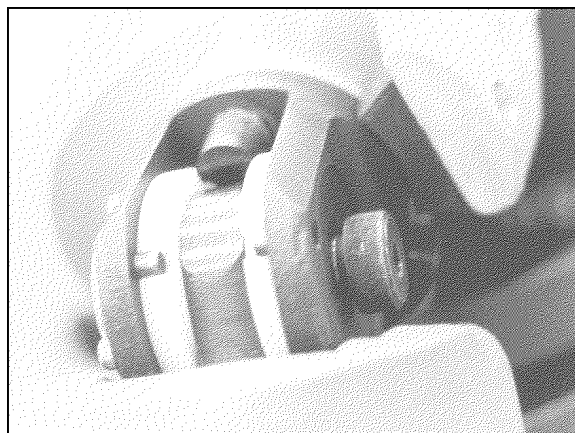


FIGURE 2 - SHOULDER YOKE ASSEMBLY

Push out the steel pivot nut in each shoulder yoke (Figures 3 and 4) (78051-255). If the nut does not slide out freely, use the just-removed shoulder screw to help pull it out. Make sure the nut slides freely in its hole. Inspect each yoke to make sure each one contains five alignment dowel pins and one rubber bumper (Figures 2 and 3).

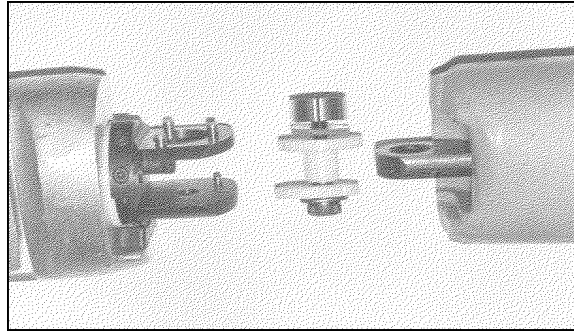


FIGURE 3 - EXPLODED VIEW OF THE SHOULDER YOKE ASSEMBLY

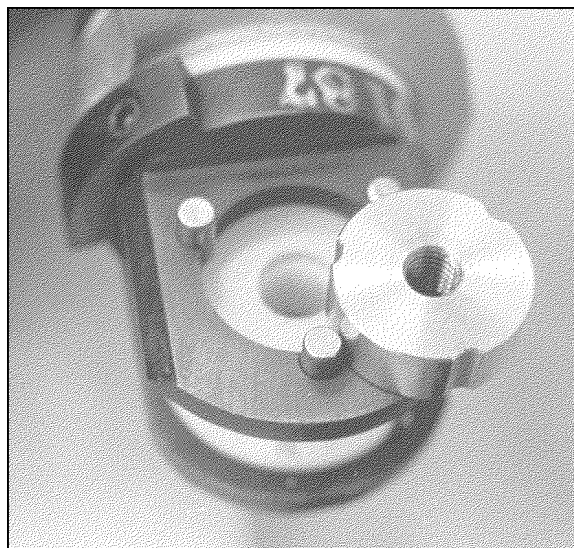


FIGURE 4 - SHOULDER YOKE PIVOT NUT

Separate the lower arms from the upper arms and examine the elbow joints, noting the condition and position of the various parts as for the shoulder joints. Look to see that the two elbow rubber stops (78051-198) are in place. Remove the elbow pivot nut (78051-202) and check that the nut slides freely in the hole. Detach the hands from the lower arms and disconnect the wrist rotation joint. The elbow and wrist rotation joints have no stops. Lubricate these two rotation joints with Moly Lub Anti-Seize™ lubricant made by Bel-Ray Co., P.O. Box 526, Farmingdale, N.Y. 07727, or an equivalent.

Examine all metal parts for burrs and sharp edges and remove them as necessary. Inspect vinyl-to-foam adhesion, cracked or cut vinyl skin, cracked or damaged bushings, and the condition of the threaded holes.

3.7 Head and Neck

Although not required nor universally recommended, some generic suggestions regarding neck shields are included here. Neck shields have usually been constructed of foam or another material that wraps around the dummy's neck and fills in or covers the gap in the chin. The seam of the neck shield is then secured with duct tape, rubber bands, or Velcro, but is generally not connected to the head or neck to avoid changing the neck's response. Begin the head and neck disassembly by removing the neck shield.

Remove the chest flesh to permit easier access to the base of the neck bracket. Remove the 3/8-16x1 in long cap screw (Figure 5) 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 (78051-305) and note how it fits on the neck bracket. Tilt the head and neck forward and remove the neck cable nut and four 1/4-20 x 5/8 in long socket head cap screws that hold the upper neck bracket to the base of the neck (Figure 6). If they are missing, install steel washers (78051-252) between these four socket head cap screws and upper neck bracket on reassembly. The neck and head assembly is now disconnected from the plastic sternum-to-rib cage bib assembly.

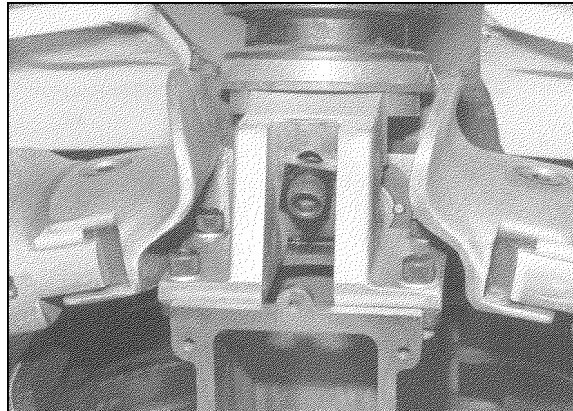


FIGURE 5 - NECK ANGLE ADJUSTMENT SCREW AND CURVED WASHER

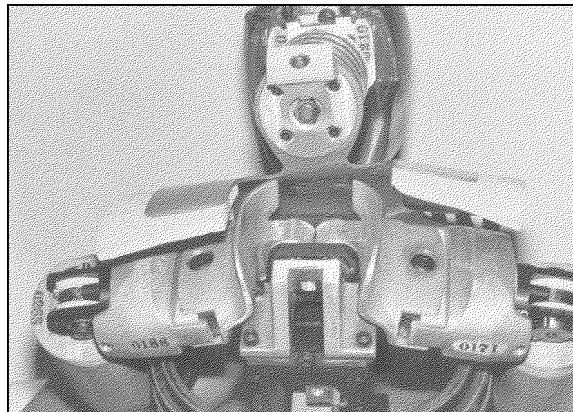


FIGURE 6 - NECK-TO-UPPER-NECK BRACKET ATTACHMENT HARDWARE

Remove four 1/4-20x5/8 in long cap screws from the rear skull cap. For the three-axis neck transducer or its structural replacement (78051-383), remove the three 1/4-20x3/4 in long socket head cap screws underneath the skull. Separate the head from the transducer or its structural replacement. Do not stress the neck transducer cable. Loosen the two 10-32x1/4 in long set screws. Reinstall the transducer to the head. Mount the nodding block compression tool (Figure 7) to the back of the skull. Slip the round end of the tool over the cable (Figure 8) and turn the knob until the neck is just being compressed. A different tool for this operation can be constructed, as shown in Figure 9.

For the six-channel neck transducer or its structural replacement, loosen two small 8-32x1/4 in long socket head set screws (Figure 10) which secure the head-to-neck pivot pin (Figure 11) (78051-339). Slowly increase the compression on the neck until the hinge pin can be pushed or lightly tapped out with a minimum of effort. Remove the nodding joint (78051-297) and disassemble the neck. The rubber sections of the neck are permanently bonded to the aluminum spacers and cannot be disassembled.

In particular, check the two rubber neck nodding blocks (78051-351) on the top of the nodding joint (Figure 12). The blocks must conform to the drawing which specifies a durometer between 80-90 Shore A. The 90 degree surfaces of the nodding blocks fit opposite, rather than inside, the 90 degree grooves of the head-to-neck adaptor bracket. A drawing of the nodding block orientation appears in Figure 13.

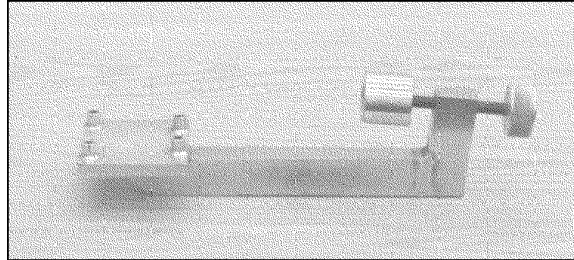


FIGURE 7 - NECK COMPRESSION TOOL

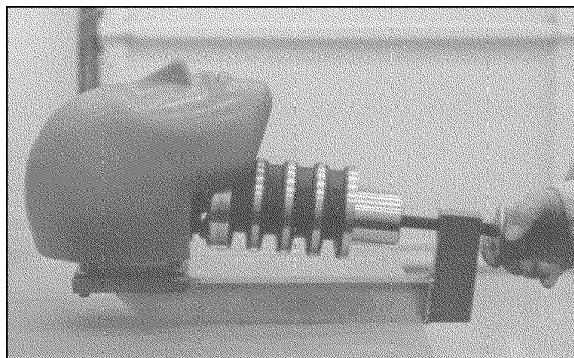


FIGURE 8 - NECK COMPRESSION TOOL ASSEMBLED TO THE HEAD AND NECK

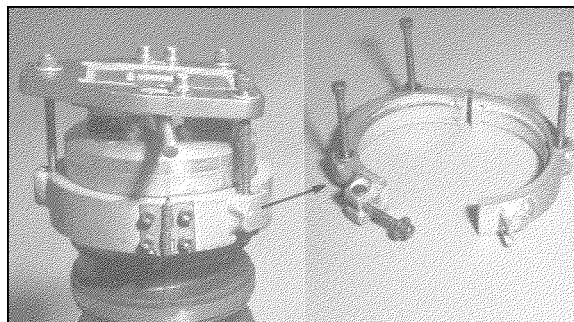


FIGURE 9 - THREE-CHANNEL NECK LOAD CELL OPTIONAL COMPRESSION TOOL

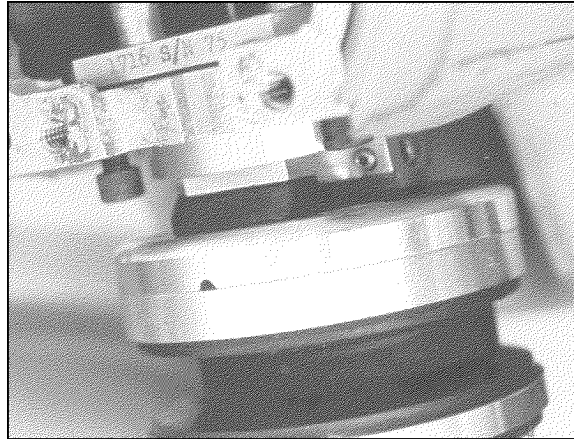


FIGURE 10 - NECK PIVOT PIN SET SCREWS

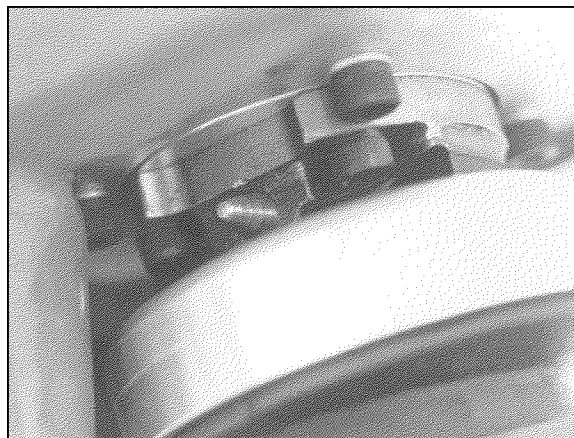


FIGURE 11 - NECK PIVOT PIN INSTALLED

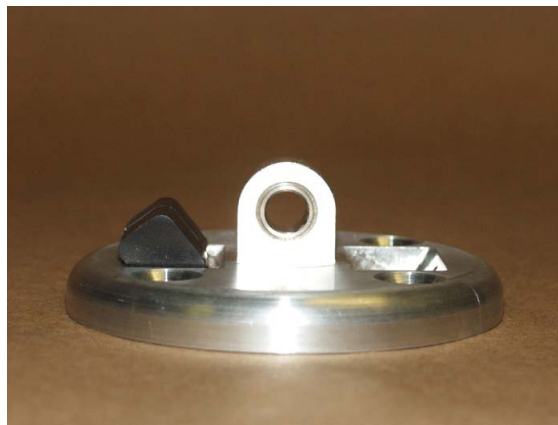


FIGURE 12 - NECK RUBBER NODDING BLOCKS ON NODDING JOINT

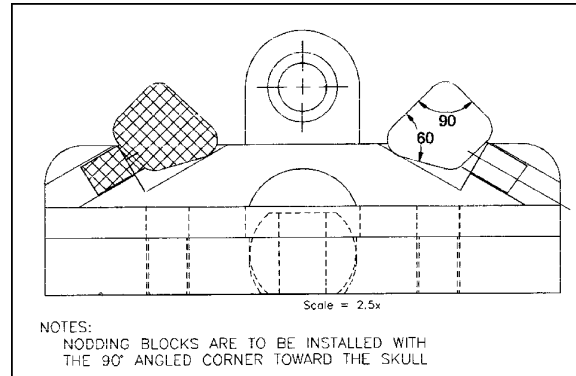


FIGURE 13 - DRAWING OF NODDING BLOCK ORIENTATION

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.

Remove the lower portion of the neck bracket. A steel washer under each of the cap screws helps to protect the aluminum from being galled by the steel screws. If the axial integrity of the neck is in question, the neck without its cable can be pull tested to 7 kN (1575 lbf). No separation should occur. Replace as required.

Assemble the two sections of the neck bracket (78051-303 and -307) with the adjustment set to 0 degree and measure the bracket angle. The angle should be $13^{\circ} 45' \pm 30'$ (Figure 14) relative to the bottom surface of the lower neck bracket.



FIGURE 14 - NECK BRACKET ANGLE MEASUREMENT

When using either optional neck transducer (3- or 6-channel), the lug on the nodding joint must fit very tightly in the slot in the bottom of the neck load cell (Figure 15). 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 drawing number 78051-253.

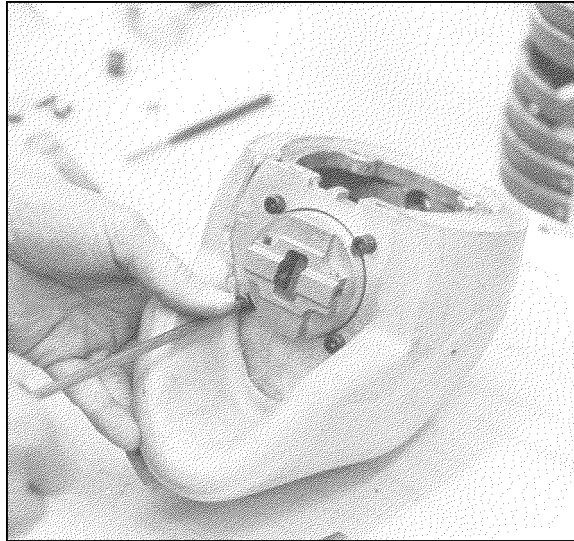


FIGURE 15 - NECK LOAD CELL PIVOT JOINT (SLOT) AND ATTACHING CAP SCREWS

In separating the 6-channel load cell from the head, remove the four 1/4x28-7/8 in long cap screws from the bottom (Figure 16). Special 1/4 ID x 3/8 OD x 1/16 thick washers are provided and must be used under the load cell attachment bolts. Larger washers will interfere with load cell operation. Use of ball hex wrenches (Figure 17) is recommended.

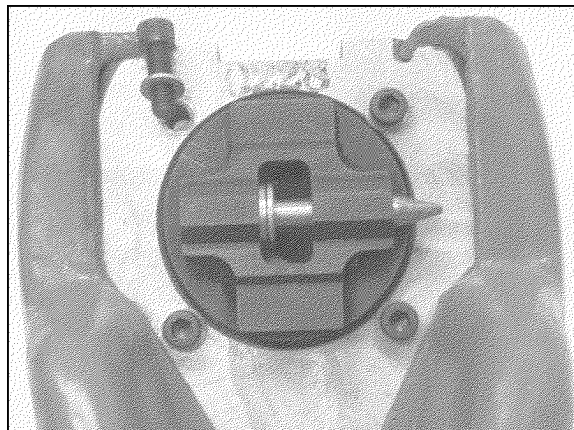


FIGURE 16 - SPECIAL WASHERS FOR THE SIX-CHANNEL NECK TRANSDUCER

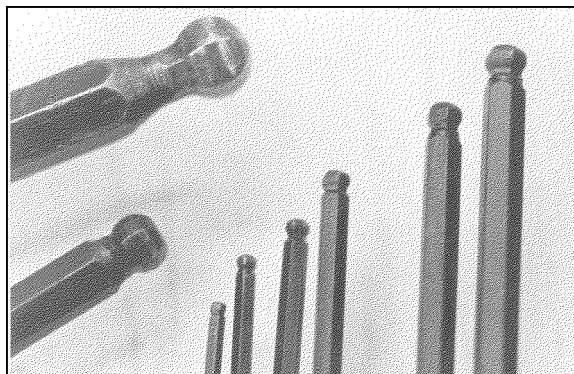


FIGURE 17 - BALL HEX WRENCHES

Remove the skin from the skull and skull cap and check for tears and general quality. 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 number 78051-61 for instructions.

Replace the skin on the skull and cap. Measure the thickness of the skin in the locations shown in drawing 78051-61. The thickness must be $11.2 \text{ mm} \pm 0.8 \text{ mm}$ ($0.441 \text{ in} \pm 0.031 \text{ in}$) as measured by the special thickness tool (Figure 18).

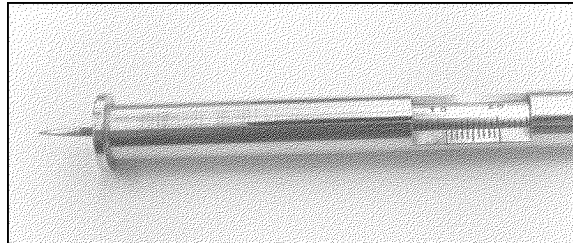


FIGURE 18 - SKIN THICKNESS MEASURING TOOL

Install the neck transducer and accelerometer block with simulated accelerometers as shown in drawing 78051-61. Install the skull cap. Weigh the assembly. The weight and center of gravity (c.g.) must conform to drawing 78051-338. If the head assembly does not comply with these weight and c.g. requirements, see number 78051-61 for instructions. In addition, Table 2 summarizes the c.g. specifications for the whole dummy.

3.8 Shoulder-Clavicles

The right and left shoulder-clavicle and link assemblies consist of three main sections that 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 drawing 78051-89 for details of this assembly.

We already have discussed the disassembly of the arm at the shoulder yoke. This same yoke provides shoulder rotation by rotating at the outer end of the clavicle.

Detach the shoulder-clavicle unit from the thoracic spine assembly by reaching through a hole in the plastic chest "bib" and removing the socket head shoulder screw (78051-239) at the extreme top of the thoracic spine (Figure 19). Pull the clavicle unit straight up. Check for the urethane washer at the rear of the cavity in the thoracic spine and for two Delrin™ washers isolating the clavicle from the spine. Make sure the pivot nut slides out freely. A Delrin™ bushing should also be present in the hole through the clavicle link. At this time, use a pair of needlenose pliers to remove the rubber bump stop (Figure 20) from the thoracic cavity. The stop should be free from tears or permanent deformation, and should be symmetrical in cross section. The durometer of this bump stop should fall between 75 - 85 Shore A.

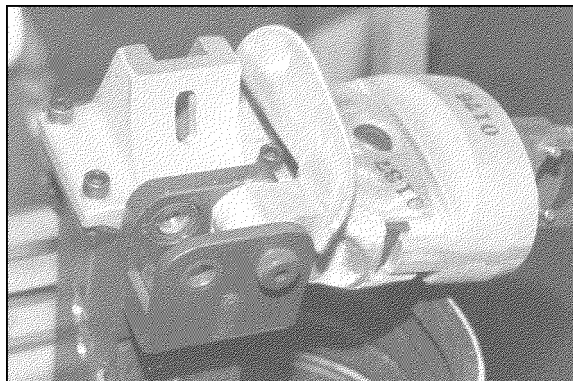


FIGURE 19 - CLAVICLE LINK-TO-SPINE ATTACHMENT
SHOULDER SCREWS

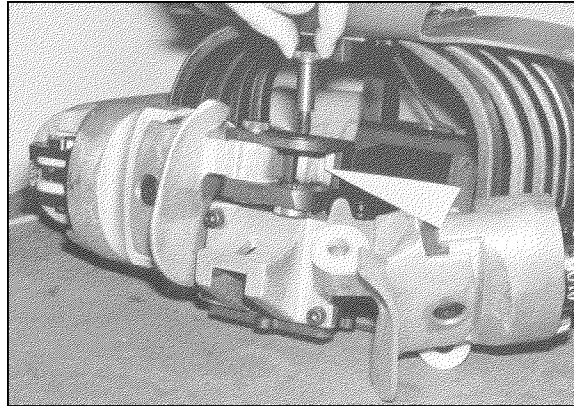


FIGURE 20 - THORACIC BUMP STOP

Remove the 1/2x1 in long shoulder screw (Figure 21) and its steel washer that holds the two aluminum sections of the clavicle and its link together. Top and bottom thin Delrin™ strips (Figure 22) should isolate the two sections. A urethane spring "stop" (Figure 23) should be located at the back of the cavity in the inner clavicle section.

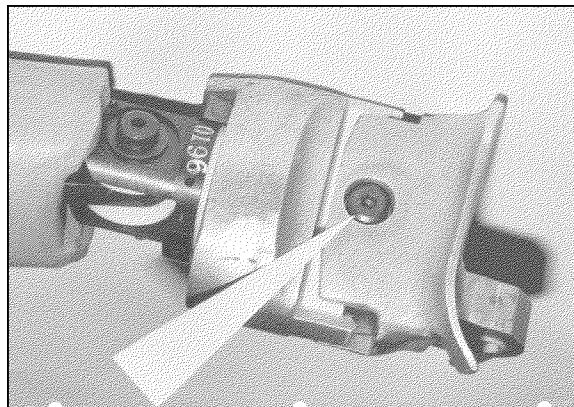


FIGURE 21 - CLAVICLE-TO-CLAVICLE LINK SHOULDER SCREW

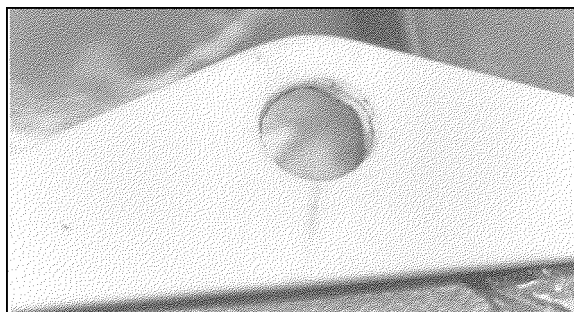


FIGURE 22 - CLAVICLE SPACER

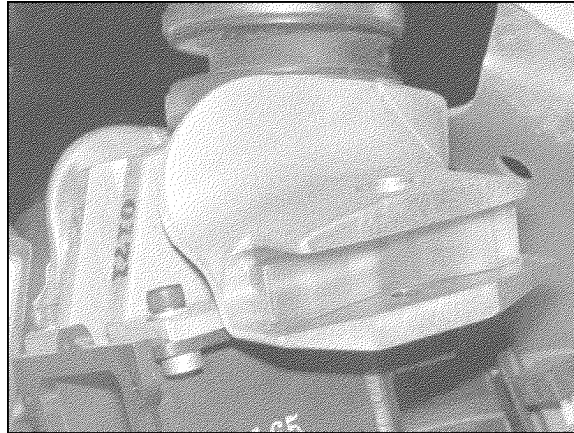


FIGURE 23 - URETHANE SPRING "STOP"

The durometer of this fore and aft bump stop is 40-45 Shore A. Be careful not to install this stop backwards. Examine the plastic parts for physical damage. Check the shoulder yoke for a rubber bumper (Figure 24) at the rear outer edge of the outer clavicle section for control of arm rotation.

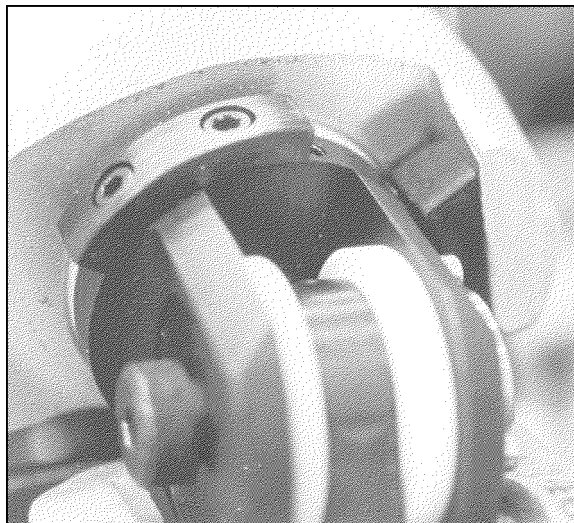


FIGURE 24 - SHOULDER ROTATION BUMP STOP

Remove the nut from the cavity on the bottom side of the outer clavicle section (Figure 25). Pull out the shoulder yoke and check for its two-piece Delrin™ bushing, elastomeric washer, and large and small steel washers upon which the nut tightens (Figure 26). Look to see if eight dowel pins are there. Check for a steel stop on the rim of the shoulder yoke, held by two 10-24x3/8 in long screws (Figure 24). 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.

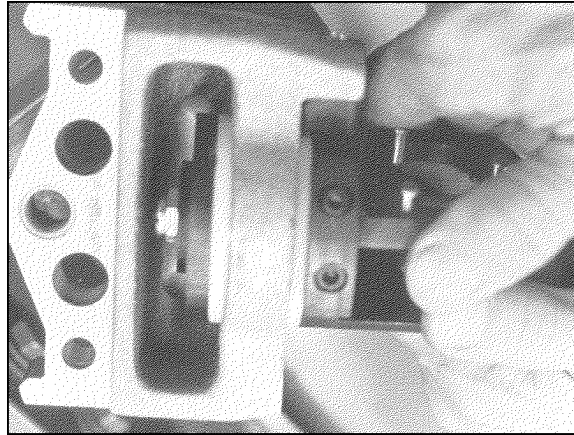


FIGURE 25 - SHOULDER YOKE-TO-CLAVICLE NUT

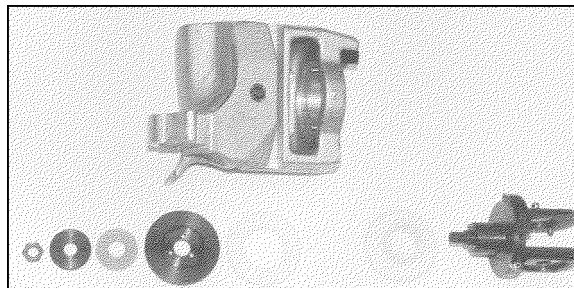


FIGURE 26 - EXPLODED VIEW OF THE CLAVICLE AND SHOULDER YOKE

3.9 Ribs and Sternum

Remove the twelve 10-32x5/8 in long button head cap screws holding the front of the ribs to the bib. Inspect the thin steel strips under the bolt heads for cracks. Check the thicker, slightly bent strips behind the rib ends for cracks. Note the way the strips fit the chest. The bend is not symmetrical; the upper portion is shorter than the lower. Detach the bib assembly. Do not loosen the set screw (Figure 27) because this will invalidate the chest pot calibration of SAE Recommended Practice J2517.

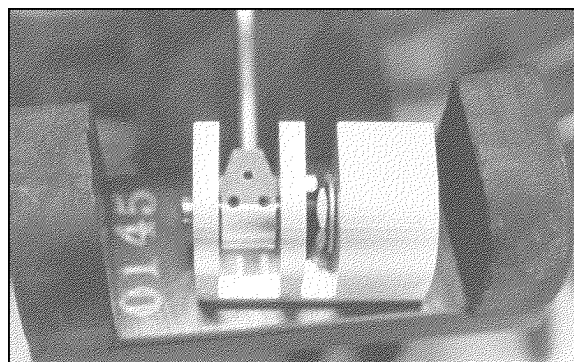


FIGURE 27 - DISPLACEMENT TRANSDUCER AND SET SCREW

Remove the twelve 10-32x5/8 in long screws holding the Delrin™ slider assembly to the bib (Figure 28). Examine the slider for damage and ensure that the slider ball moves freely in its track. Inspect the aluminum plate to which the slider assembly bolts. Check that the "V" shaped groove is at the bottom (Figure 29). Three rubber bumps stops prevent the sternum assembly from striking the spine box during testing. The two lower stops can be mounted to either the sternum assembly (Figures 29 and 30) or to the spine box (Figure 31). Mounting the stops to the spine box reduces the possibility of interaction with the sternal deflection rod.

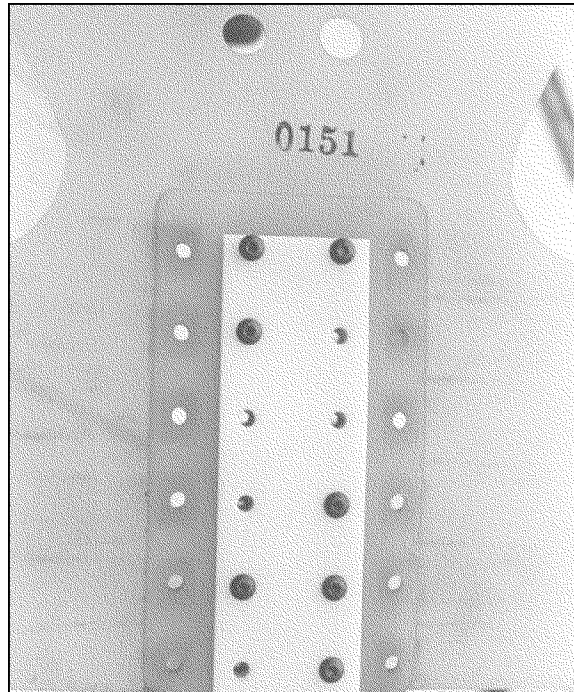


FIGURE 28 - SLIDER ASSEMBLY ATTACHED TO BIB

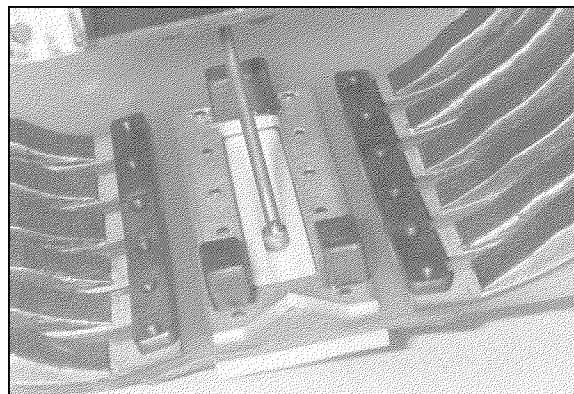


FIGURE 29 - STERNUM INSTALLED ON DUMMY

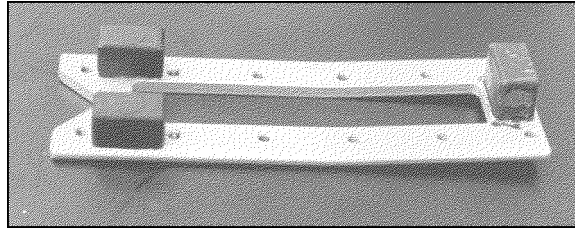


FIGURE 30 - STERNUM ASSEMBLY WITH RUBBER STERNUM STOPS

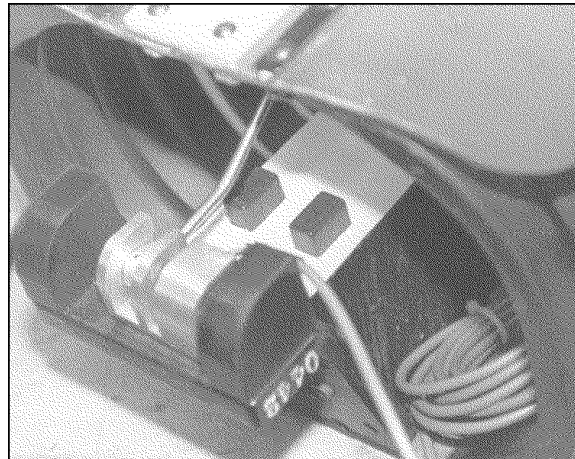


FIGURE 31 - STERNUM STOPS MOUNTED TO THE SPINE (SPINE BOX HIGHLIGHTED WHITE)

Inspect the bib for cracks, tears and imperfections. Compare the shape to the drawing. Clean all parts with isopropyl alcohol or an equivalent. Detach the six ribs (Figure 32) and their rear rib supports (Figure 33) by removing the twelve 10-32x1/2 in long screws at the rear of the thoracic spine assembly.

Carefully examine each rib and the rib damping material for cracks. Check for gaps or other failures of the epoxy bond between the rib damping material and the rib metal (Figure 34). Verify the contours of each rib against a template made from the information obtained from the rib drawings. When the rib ends are matched to the template, the rib contour should be within ± 1.50 mm (0.060 in) of the template. Minor reshaping of the ribs may be done by hand. Measure rib thickness. The Rockwell C hardness of each rib and rib support should fall between 44 and 46 at the center of the metal between the two screw holes. When reassembling, make sure the rib supports (78051-304) are not bent or damaged and are mounted the correct way.

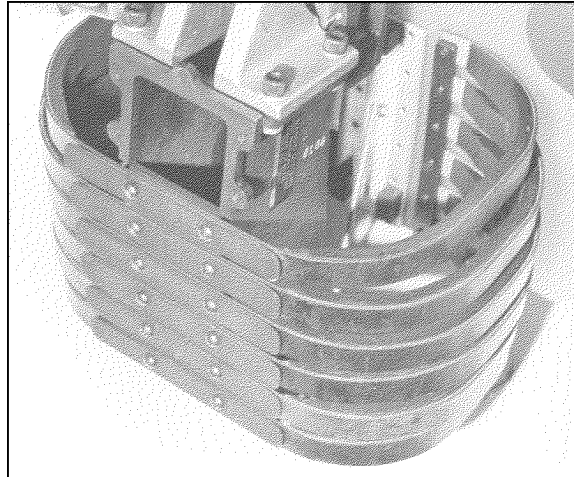


FIGURE 32 - RIB ASSEMBLY

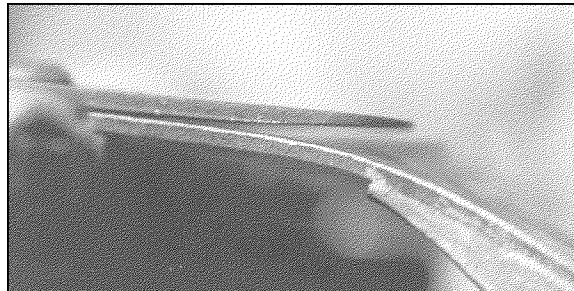


FIGURE 33 - REAR RIB SUPPORTS

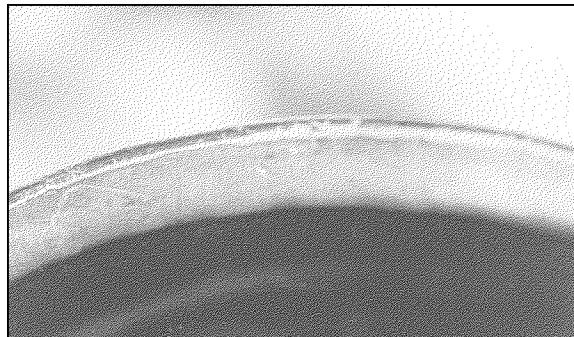


FIGURE 34 - STEEL RIB AND BONDED DAMPING MATERIAL

After assembling the ribs, or when checking rib condition, use the special tool (83-5006-007) to check for correct chest depth (Figure 35). The gauge is used to check the chest cavity depth at number one and number six ribs. The gauge should be pressed against the back edge of the spine box (not the rear rib supports). If the gauge probe contacts the front rib end threaded strip (78051-234), the condition is unacceptable and the ribs should be replaced. The gauge has two separate calibrated surfaces for the number one and number six ribs.