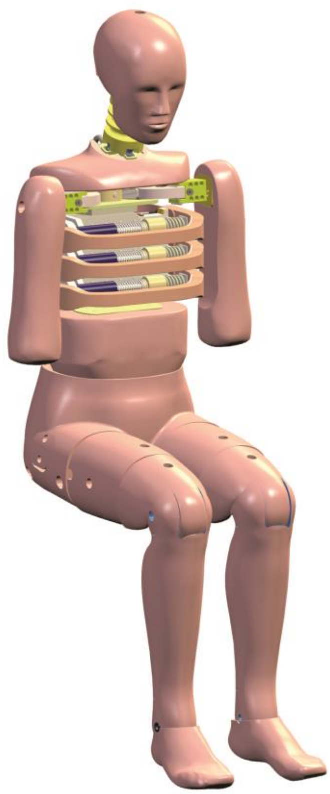
ES-2re
User Manual



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Notice: This product may contain lead

A list of components that may contain lead is being maintained on the Humanetics web site. The list, organized by dummy type, shows subcomponents that may currently or in the past have contained lead or a lead based alloy. Please refer to the Humanetics web site under ATD Lead Disclosure for information regarding lead in this product.
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List of Contents

1 General Introduction

1.1 History of ES-2re

Further a proposal to use the Eurosid-2 dummy in the US side impact regulation FMVSS 214, the National Highway Transport Safety Administration (NHTSA) has performed a test program to assess the capabilities of the dummy. This test program revealed serious issues with airbag and seat interaction which have led to a request for development of the "Rib-Extension Kit". Additional test programs by NHTSA have shown this modification to the ES-2 dummy to be an effective tool for side impact evaluations. With a number of modifications the ES-2-dummy equipped with these "rib-extensions" has been proposed for the use in the CFR 49, FMVSS 214 side impact regulation. The dummy has been re-named ES-2re part number designation 175-0000.

The ES-2 side impact dummy from Humanetics Innovative Solutions was developed with the Netherlands Organization for Applied Scientific Research (TNO) in Delft and partners in the SID-2000 project from the European Commission. The design of the dummy is based on the EUROSID-1, which is currently used as the regulatory dummy in European, Japanese and United Nations side impact legislation. Additional information on the history of the ES-2 and Eurosid-1 dummy can be found in the ES-2 user manual.

1.2 Modifications Incorporated in ES-2re

The modifications incorporated in ES-2re with respect to ES-2 are summarized below.

Shoulder

- Shoulder load cell structural replacements were introduced as a standard.

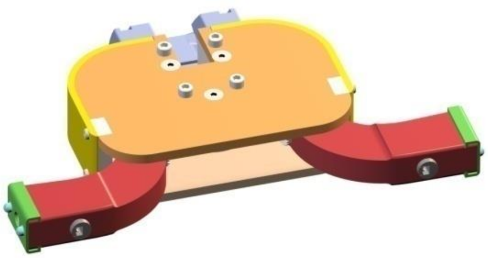

Figure 1: ES-2 Shoulder

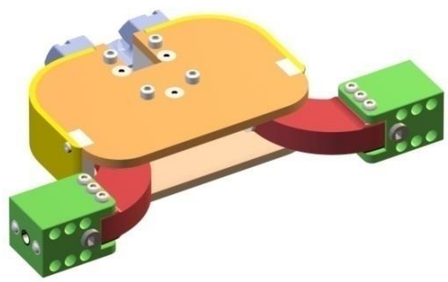

Figure 2: ES-2re Shoulder

Thorax

- Rear rib extensions were added on impact side to provide more realistic interactions with vehicle seatbacks.
- Roller bearing guidance of rib extension were added in the backplate.
- New backplate load cell was introduced.

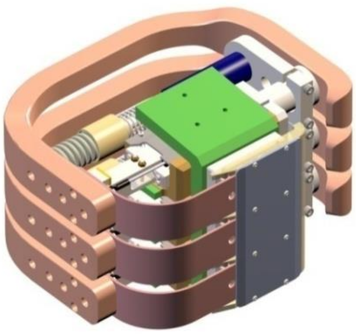

Figure 3: ES-2re Thorax

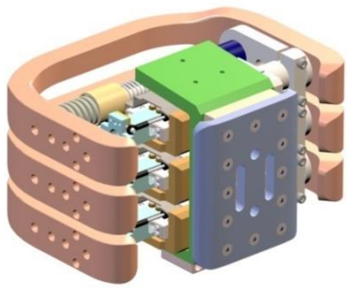

Figure 4: ES-2 Thorax

1.3 How to Use This Document

This document is divided into five major chapters in addition to this introduction. Each chapter provides information about a topic for the complete dummy.

2 ES-2re Description

2.1 Introduction

The ES-2re Side Impact Dummy represents a 50th percentile adult male, without lower arms. Masses and inertia of dummy parts are based on known anthropomorphic data. The total mass of the dummy (including rib displacement transducers, force transducers in the abdomen, pubic symphysis force transducer, and suit) is 72.0 ± 1.55 kg. In this chapter a description of the ES-2re per body part will be given. Although the figures and drawings show a dummy prepared for left side impacts, the ES-2re can easily be converted to right side impacts (see Section 4).

2.2 Head

The head is based on a 6-axis Hybrid III 50th percentile head comprised of an aluminum skull covered by a pliable vinyl skin (see Figure 5). The changes with respect to the Hybrid III head are in the head-upper neck load cell interface and the mass. The mass of the combined head and upper neck load cell is tuned. For more details regarding the Hybrid III head, see ref. [1] and [2]. At the head-neck interface, a 6-axis Upper neck load cell is mounted on the skull base. The interior of the skull is a cavity in which accelerometers can be located. Access is provided by removal of a skullcap at the back of the head.

Figure 5: ES-2re Head Showing Interface

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1 Hubbard, R.P. and D.G. McLeod: "Definition and Development of a Crash Dummy Head". SAE p 741193, Proceedings 18th Stapp Car Crash Conference, 1974.

2 USA Federal Regulations, Part 572 Anthropomorphic Test Dummies Subpart E 50th Percentile Male, issued August 1, 1973; Consolidated as CFR 49 dated October 1, 1991; Amended by Vol. 56. No. 220 November 14, 1991 and Vol. 57 No. 199 October 14, 1992.

2.3 Neck

The ES-2re neck consists of three main parts:

- Head/neck interface plate;
- Neck/torso interface plate;
- Central molded section made of special rubber linking the two interface plates.

The various neck parts are illustrated in Figure 6. In the central molded rubber section, intermediate plates are integrated at both ends. These plates are linked to the head-neck and neck-torso interface plates by means of a half spherical screw, providing a point of rotation at the top and bottom of the neck.

Figure 6: ES-2re Neck Parts: Interface Plates, Central Molding, Half-Spherical Screws

(4 x 5000285 Mounting Screws Not Shown)

To allow head-neck and neck-torso relative movements, respectively, two types of buffers are interposed between the plates:

- The triangular section buffers, which are integral with the central molding rubber.
- The circular section buffers, four each at the bottom and top of the neck. These buffers are used to tune the neck to comply with its required performance. The circular section buffers are delivered in three sets of eight buffers with a hardness of 60, 70 and 80 Shore A.

This design represents a system with two pivots and three modes of deformation. The centers of the half-spherical screws represent the two pivots. The three modes of deformation are:

- Simple lateral flexion (of the central part);
- Translation and rotation (relative movements of the interface plates);
- Elongation of the central part.

The play that exists around the buffers plus the flexibility of the buffers may give rise to torsion, i.e. a rotation around the neck's vertical axis.

The neck is mounted on the neck bracket (see Figure 7), which is attached to the shoulder box (see Section 2.4). The angle between the faces of the neck bracket is 25 degrees. Because the shoulder box is inclined 5 degrees backward. The resulting angle between neck and torso line is 20 degrees.

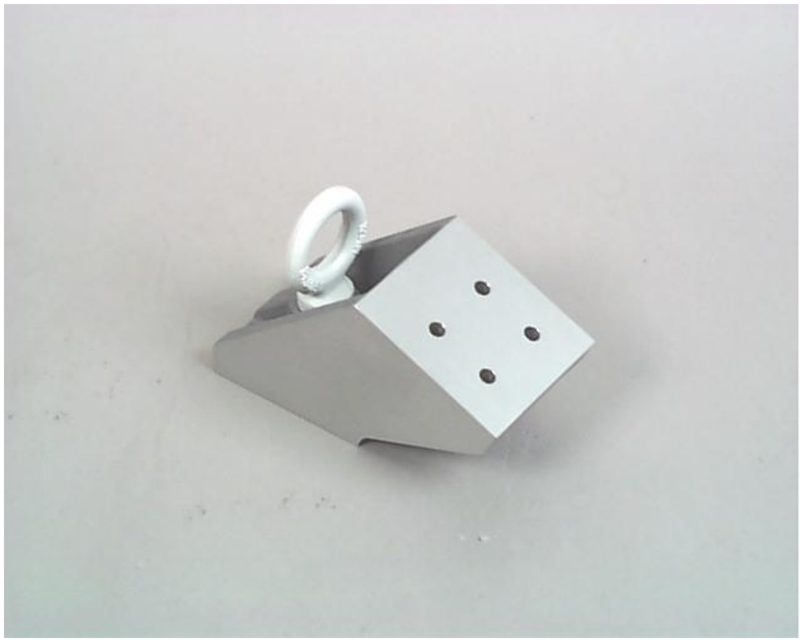


Figure 7: ES-2re Neck Bracket and Eyebolt

2.4 Shoulder

The ES-2re shoulder consists of four main parts:

- Assembly of top and bottom plate
- Two clavicles, with load cell structural replacements
- Shoulder foam cap

The shoulder box mainly consists of an aluminum spacer block and two PTFE coated aluminum plates on the top and bottom of the spacer block (see Figure 8). The shoulder box is attached to the top face of the spine box, which is inclined 5 degrees backwards. The clavicle contact with the spacer block is in the shape of a cam such that the initial point of contact, and the center of rotation of the clavicle, is at the posterior end of the box. The clavicles are attached to the box with a 'U' shaped spring and guided between the two PTFE coated shoulder plates, with a sliding contact that limits their movement to one plane. The clavicles are held in their neutral position by two elastic cords, which are clamped to the rear of the shoulder box (see Figure 9).

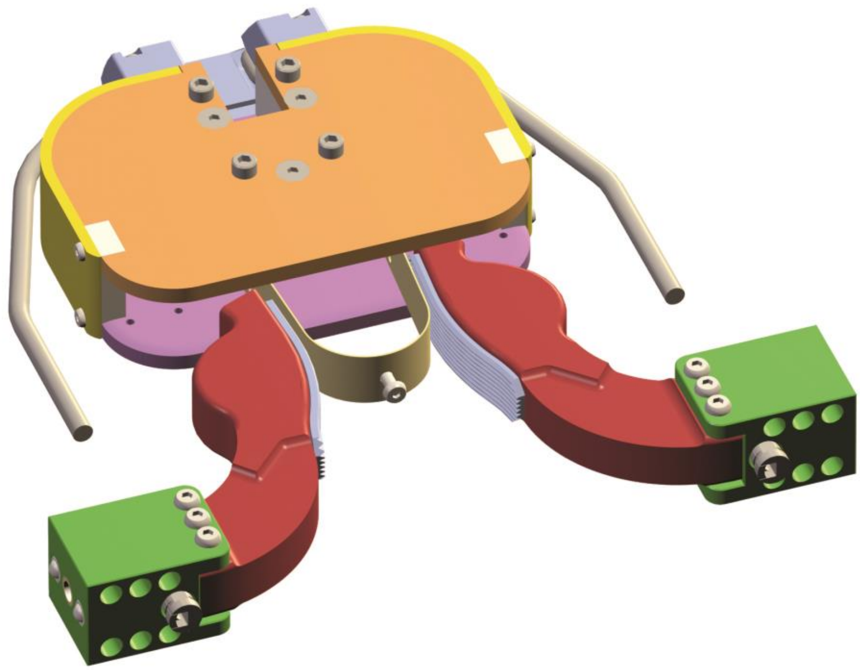


Figure 8: ES-2re Shoulder Assembly (Exploded View).

The outer ends of the clavicles contain a spring-loaded pin. In combination with the pivot stop plates in the arm, this design allows standard arm orientations (see Section 4.8). The clavicles have been reconfigured to allow the use of a 3-axis load cell on both sides.

The shoulder foam cap is made of low density polyurethane foam, and attaches to the shoulder box using Velcro strips.

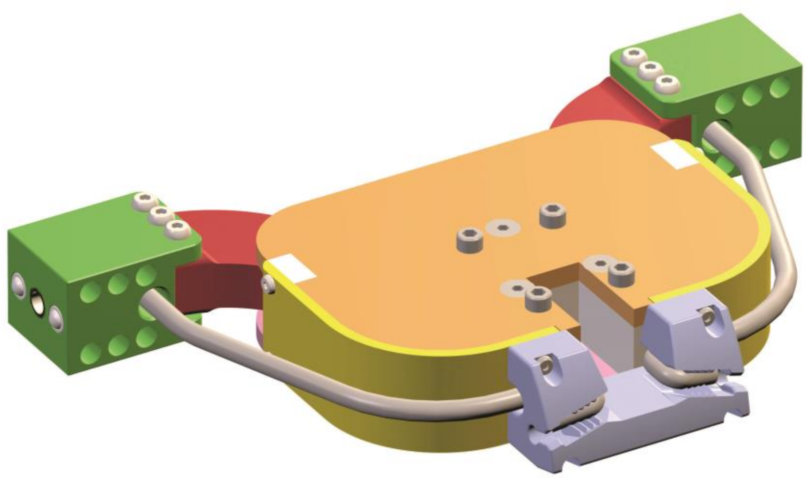


Figure 9: ES-2re Shoulder Assembly, Rear View

(Note Elastic Cord Holder and Routing of Cords)

2.5 Thorax

The ES-2re dummy incorporates a rear rib extension bracket on the impact side of each rib that together with a rear rib extension guide provides more realistic interaction with vehicle seatbacks.

The linear guidance system for the rib is based on a pair of needle bearing systems positioned back-to-back in the piston (see Figure 11 and exploded views in section 4). A linear potentiometer is positioned in the rib unit to measure the rib displacement. Three rib units are mounted on a new designed spine box to get the required interfaces with the shoulder, back plate and abdomen assemblies (see Figure 10).

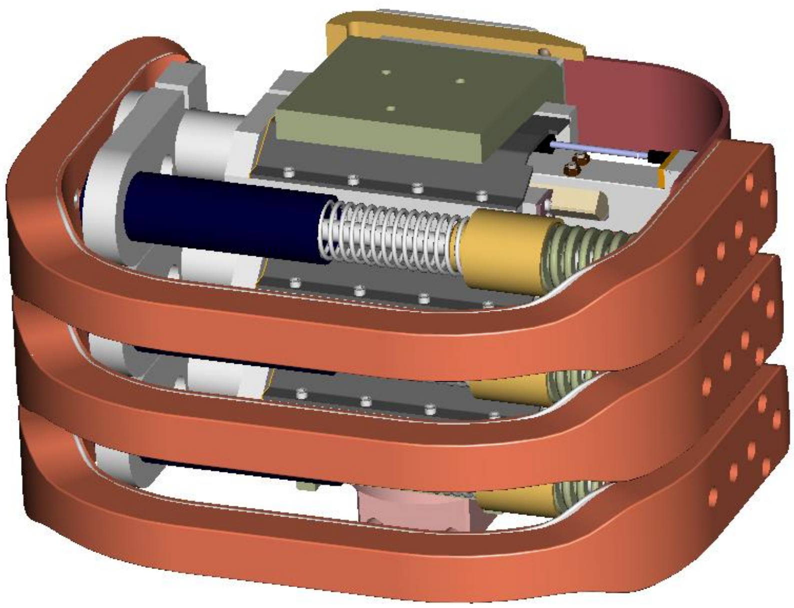


Figure 10: ES-2re Thorax Assembly

The ES-2re thorax consists of five main parts:

- Rigid thoracic spine box, including back plate assembly.
- T12 - load cell (or its structural replacement).
- Three rib modules individually attached to the spine box.
  A rib module consists of (see Figure 11):
  - A steel rib bow. The rib is covered with flesh simulating foam. The flesh system is held to the rib by a sleeve covered with a plastic coating;
  - A linear guidance assembly in the Y (impact) direction of the dummy. The linear guidance attaches to the impacted side and the non-impacted side of the rib to limit the deflection mode to purely lateral. The non-impacted side of the rib is rigidly attached to the spine box (see Figure 8).
  - A tuning spring located is in the cylinder. This spring is used to alter the performance of the rib module. Springs with different spring rates are available in the dummy toolbox.

- A hydraulic damper, working parallel to the linear guidance assembly. The damper is equipped with a low-stiffness return spring over the damper piston rod. A spring cup holds this spring in position.
- A stiff damper spring, connecting the damper piston to the impacted side of the rib.

- A displacement transducer on each rib to measure rib deformation between struck side and non-struck side.
- A rear rib extension bracket connected to the impact side of each rib between the rib and the rib rail assembly.

The rib modules are sensitive to impact from only one direction. The three rib modules are bolted to the spine box and can easily be reversed to change the impact direction of the dummy from the left side to the right side (see Section 4.7)

The rib extension is guided in the back plate with needle roller bearings to ensure a frictionless operation.

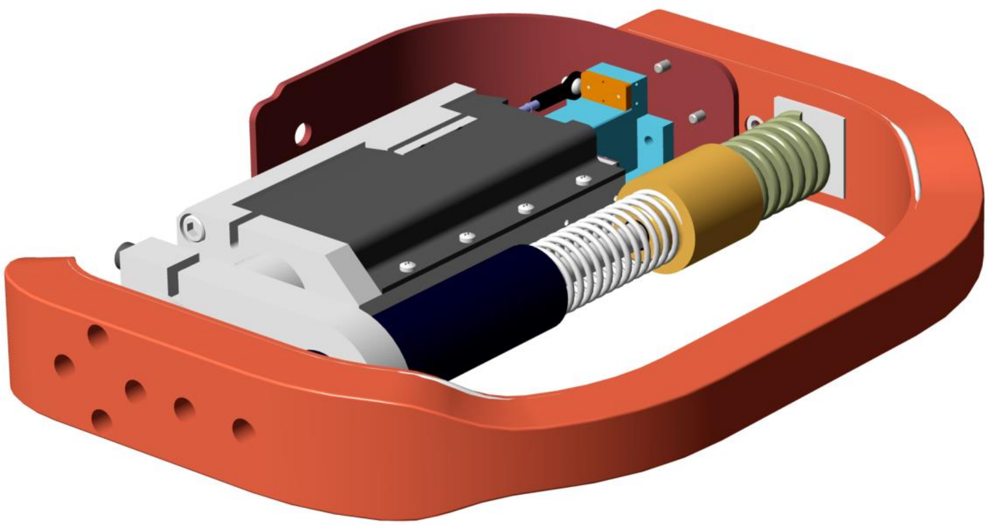


Figure 11: ES-2re Rib Module.

2.6 Arms

The ES-2re arm consists of a plastic skeleton covered by flesh-simulating foam and a plastic skin. The upper part of the arm is made of a high energy absorbing solid foam, while the lower part is constructed of soft foam. The arm is attached to the end of the shoulder clavicle. The arm/shoulder joint consists of a pivot stop plate, clamped to the arm skeleton and a small axial bearing between two washers. The assembly is held together by a self-locking bolt. The pivot stop plate allows for reproducible discrete arm orientations at 0°, 40° and 90° with respect to the torso line.

2.7 Abdomen

The ES-2re abdomen consists of four main components (see Figure 12):

- Cast aluminum abdominal drum.
- Foam covering.
- A set of three identical abdominal force transducers for the impact side.
- One set of three non-measuring blank units (Three for non-impact side, three abdominal loadcells are mounted on the impact side).

The central part of the abdomen section is a metal drum positioned around the lumbar spine and rigidly attached to the T12 - load cell (or its structural replacement) at the bottom side of the thorax. The drum is covered by foam. At both sides of the foam covering, a curved slab of lead-pellet-filled foam is integrated to obtain the required inertial mass and viscoelastic performance. The foam allows a penetration of 40 mm before 'bottoming out'.

Three abdominal force transducers can be positioned at each side of the abdomen between the foam covering and the rigid drum. The three transducers are positioned vertically and parallel to each other on the impacted side of the dummy, while on the opposite side, three non-measuring transducer replacements are mounted (see Section 4.9). Three additional non-measuring transducer replacements are included if no transducers are used on the abdomen. In this case, three transducer replacements per side are used to maintain proper balance. A cover plate provides fixation of the foam covering and prevents contact between the foam covering and the lower rib during use.

Figure 12: ES-2re Abdomen, Rear View (Separated at T12 Location)

2.8 Lumbar Spine

The ES-2re lumbar spine consists of a solid rubber cylinder with metal interface plates at each end. Pre-compression of the lumbar spine can be provided with the longitudinal steel cable running through the lumbar spine. Figure 13 shows the lumbar spine mounted in the pelvis.

Figure 13: ES-2re Lumbar Spine, Abdominal Assembly Removed

2.9 Pelvis

The ES-2re pelvis consists of eight main parts:

- Lumbar mounting plate;
- Sacrum block;
- Two iliac wings;
- Flesh simulated by foam covered with a plastic skin;
- Two proximal femur hip joints including attachment pins and H-point back plate;
- A pubic force transducer or structural replacement.

The iliac wings are made of plastic resin. The two iliac wings are linked together at the pubic symphysis by a force transducer or a transducer replacement. At the rear of the pelvis, the iliac wings are attached to each side of the sacrum block (see Figure 14). The lumbar mounting plate connects the sacrum block with the lumbar spine. This mounting plate can be replaced with a lower lumbar spine load cell. A foam plug has been placed against an H-point back plate, fixed on the iliac wing by an axle passing through the ball joint of the upper femur bracket (see Figure14).

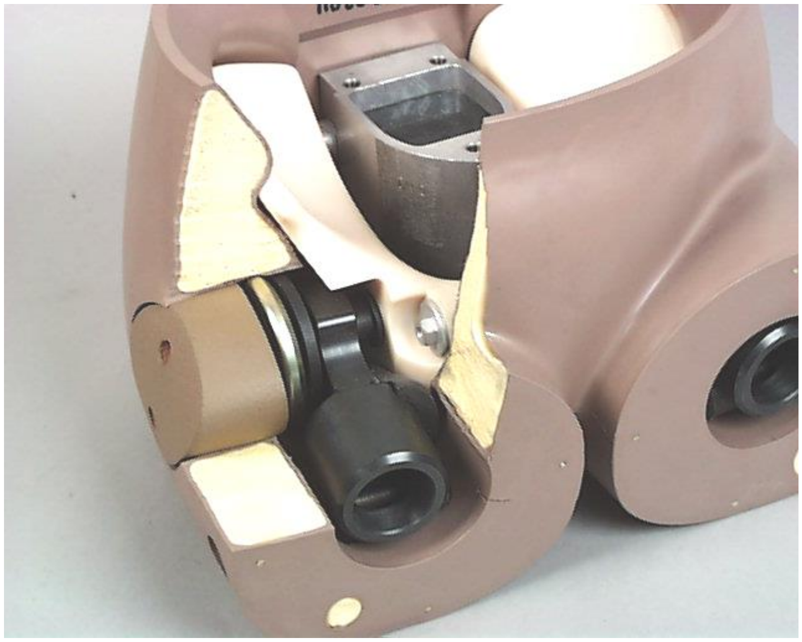


Figure 14: ES-2re Pelvis

Partial View Showing Femur Joint Assembly

The design of the hip joint allows abduction angles to approximately 19 degrees. Adduction angles are limited to approximately 13 degrees. The latter limitation is due to the interaction of the upper femur with the iliac wings in the pubic region. Two rubber buffers at each side prevent the occurrence of metal-to-metal contact at the ends of the adduction-abduction range of motion. The flesh system, which covers the sacrum-iliac assembly, is made of PVC skin filled with PU foam.

The sacrum block inside the pelvis is angled 5 degrees backward with respect to the horizontal. Therefore, a vertical position of the dummy torso line is achieved with forward bending of the upper part of the dummy to compensate for this angle. The external shape of the pelvis represents a 50^{th} percentile male in automotive seating posture. Important shape features are in the regions that are potentially hit in side impact tests, in the regions of interactions with the car seat, and at the iliac crests where the seat belt fits around the pelvis.

2.10 Legs

The legs consist of a metal skeleton covered by flesh-simulating polyurethane covering. The joints at hip, knee and ankle allow realistic motion of the leg parts. The legs are of the standard Hybrid II design ref. [3] except for the femur bone and the thigh flesh. These parts are modified to obtain a more humanlike mass distribution over the rigid bone structure and the soft flesh simulation. The flesh part is increased in mass and the femur bone is decreased in mass. The mass shift is approx. 2.75 kg. This modification is introduced to achieve a more humanlike knee-to-knee interaction performance. (For details, see ref. 2 on page 8.)

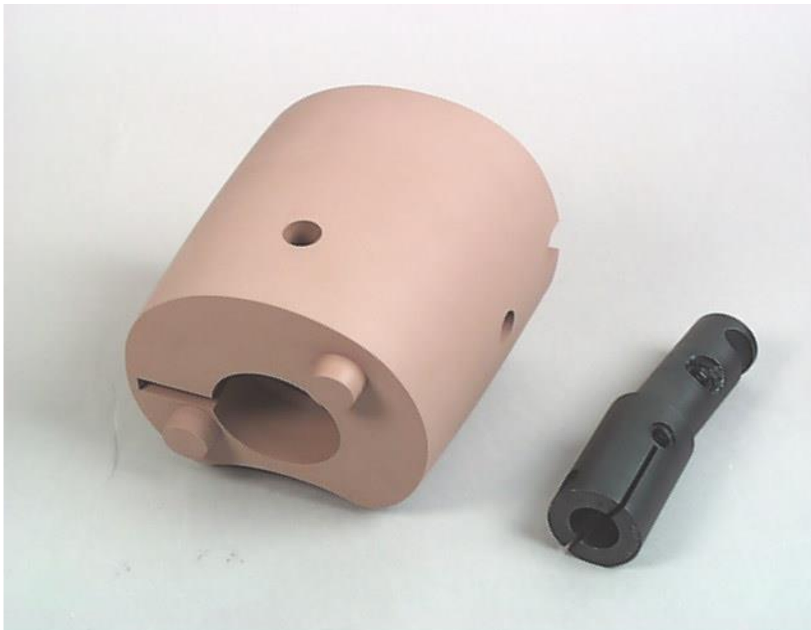


Figure 15: ES-2re Upper Leg Thigh Flesh and Femur Bone

[3] USA Federal Regulations, Part 572 Anthropomorphic Test Dummies Subpart B 50th Percentile Male, Drawings SA 150 MO80 and MO81, issued August 1, 1973; Consolidated as CFR 49 dated October 1, 1991; Amended by Vol. 56. No. 220 November 14, 1991 and Vol. 57 No. 199 October 14, 1992.

2.11 Suit

The ES-2re is provided with a neoprene suit that covers the arms, shoulder, thorax, abdomen and the upper part of the pelvis. Figure 16 shows the neoprene suit. Holes are provided in the sleeves to give access to the arm attachment screws.

Figure 16: ES-2re Suit

2.12 Toolbox

The ES-2re dummy is supplied with a toolbox (175-9510-H) containing all tools required to assemble and disassemble the dummy, as well as some consumables required for maintenance of the dummy. The content of the toolbox is listed in Table 1.

Table 1: Toolbox Table of Contents

Part Number	Qty.	Description
E.IBA-FT	1	TOOL BOX, EMPTY
175-9501-DN	1	PULLER TOOL
175-9500-DN	1	NECK COMPRESSION TOOL
175-3004-H	2	SHOULDER CAM CLAVICLE ASSEMBLY FOR LC
175-3015-FT	2	BUNGEE CORD
175-2020-DN	1	NECK BUFFER, SET OF 8, 80 DURO
175-2010-DN	1	NECK BUFFER, SET OF 8, 60 DURO
9002399	1	3/4" OPEN ENDED SPANNER
9002398	1	5/32" ALLEN KEY
9002397	1	3/16" ALLEN KEY
9002389	1	OIL BOTTLE
9002370	2	STRAIN RELIEF BUSHING, 5.6-6.22mm CABLE DIA.
9000591	4	SCREW, FHCS 1/4-20 X 1
8006248	1	ANTI-SEIZE COMPOUND TUBE
8006211	1	DAMPER OIL
8006209	1	ADHESIVE, LOCTITE
5000296	2	SCREW, LHCS M6 X 16
5000288	8	SCREW, MSSFP M4 X 8
5000283	3	SCREW, SHCS M2.5 X 0.45 X 16
5000281	4	SCREW, SHCS M6 X 1 X 12
5000129	1	SET ALLEN KEY
5000089	2	SCREW, SHSS M8 X 60
5000040	2	SCREW, BHCS M10 X 1.5 X 30 WITH NYLON LOCKING PATH

2.13 Mass and Dimension Characteristics

The following paragraphs describe some of the main ES-2re dummy characteristics, the mass of the dummy parts and the principal dimensions of the complete dummy.

2.13.1 Mass breakdown

Table 2 lists the mass of the main sub-assemblies and parts that make up each subassembly. The mass and mass-tolerance specifications allow the application of the required and optional instrumentation.

Table 2: Mass of Dummy Subassemblies

Assembly Weights		
Segment Weights	Specified Weights	
	Kg	Kg
Head	4.0	±0.05
Neck	1.0	±0.05
Thorax	22.4	±1.0
Arm Left	1.3	±0.1
Arm Right	1.3	±0.1
Abdomen	5.0	±0.25
Pelvis	12.0	±0.6
Leg Left	12.7	±0.6
Leg Right	12.7	±0.6
Total	72.4	±1.2

** Based on theoretical calculations assuming homogeneous materials. Final specification to be based on statistical sampling.*

2.13.2 External Dummy Dimensions

The principal dimensions of the ES-2re dummy as indicated in Figure 17 are given in Table 3. The measurements are valid for the following boundary conditions.

- Dummy is positioned on a flat table.
- Upper torso placed in vertical position using a level on torso back plate.
- Head lifted to obtain a straight neck, with parallel end plates.
- Suit is not included.
- Play of the clavicles is taken out to the bottom.

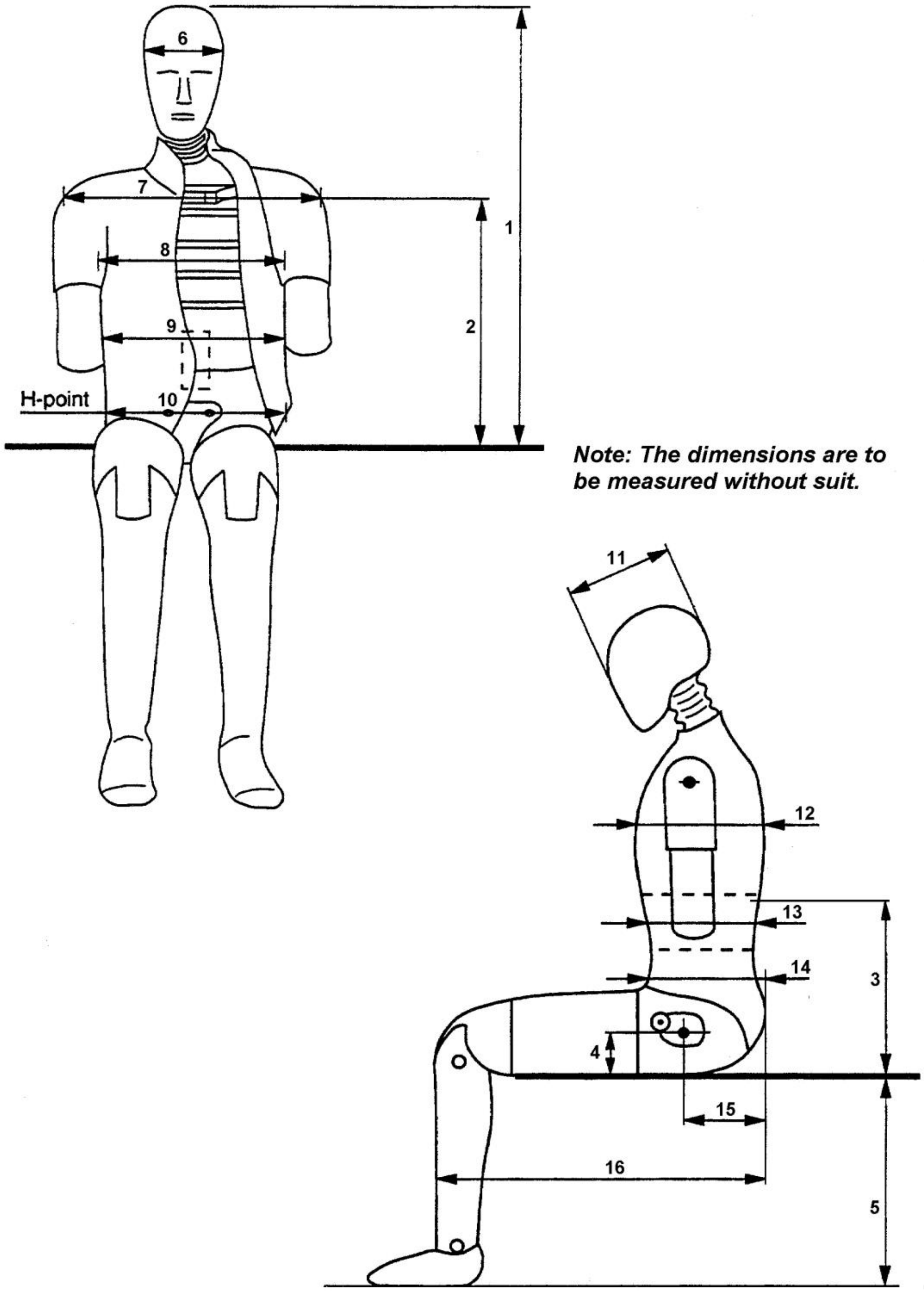


Figure 17: ES-2re External Dimensions, Excluding Suit

Table 3: ES-2re External Dimensions as Indicated in Figure 17

No.	Dimension	Value (mm)
1	Sitting Height	909 ± 9
2	Seat to Shoulder Joint	565 ± 7
3	Seat to Lower Face of Thoracic Spine Box	351 ± 5
4	Seat to Hip Joint (Center of Bolt)	100 ± 3
5	Sole to Seat, Sitting	442 ± 9
6	Head Width	155 ± 3
7	Shoulder / Arm Width	470 ± 9
8	Thorax Width	327 ± 5
9	Abdomen Width	280 ± 7
10	Pelvis Lap Width	366 ± 7
11	Head Depth	201 ± 5
12	Thorax Depth	267 ± 5
13	Abdomen Depth	199 ± 5
14	Pelvis Depth	240 ± 5
15	Back of Buttocks to Hip Joint (center of bolts)	155 ± 5
16	Back of Buttocks to Front Knee	606 ± 9

3 Instrumentation

3.1 Introduction

In this chapter, the instrumentation possibilities of ES-2re will be presented. Section 3.2 gives an overview of the instrumentation. The following sections describe the instrumentation per body part. Specific transducers are proposed for the optional instrumentation. Furthermore, channel filter classes according to ISO 6487 or SAE J211 are recommended.

3.2 Overview of the Instrumentation

The ES-2re dummy is designed to accept the following instrumentation (see also Figure 18):

- **Head**
  - Upper Neck Load Cell (IF-240) (6-axis: F_x, F_y, F_z and M_x, M_y, M_z)
  - Three Uni-axial Accelerometers in the head center of gravity
- **Neck**
  - Lower Neck Load Cell (IF-221) (6-axis: F_x, F_y, F_z and M_x, M_y, M_z)
- **Shoulder**
  - Clavicle Load Cell (IF-317) (3-axis: F_x, F_y, F_z)
- **Thorax**
  - Seating angle indicator (MSC 260 D/GP-M) (2-axis: static angle about x and y)
  - Torso Back Plate Load Cell (IF-441) (4-axis: F_x, F_y and M_y, M_z)
  - Tri-axial Accelerometer (or three uni-axial ones) at T1 in Shoulder Cavity
  - Three Uni-axial Accelerometers at T12 location
  - Uni-axial Accelerometers on each rib in x and y direction
  - Three Linear Potentiometers - one for each rib
- **Abdomen**
  - T12 – Load Cell (IF-420) (4-axis: F_x, F_y and M_x, M_y)
  - Three Force Transducers (IF-600) (uni-axial, F_y)
- **Pelvis**
  - Seating angle indicator (MSC 260 D/GP-M) (2-axis: static angle about x and y)
  - Lower Lumbar Spine Load Cell (IF-422) (3-axial: F_x, F_y, and M_x, M_y)
  - Pubic Symphysis Load Cell (IF-556) (uni-axial: 3 x F_y)
  - Tri-axial Accelerometer (or Three Uni-axial ones) in Sacrum Block
- **Legs**
  - Femur Load Cell (IF-631) (6-axis: F_x, F_y, F_z and M_x, M_y, M_z)

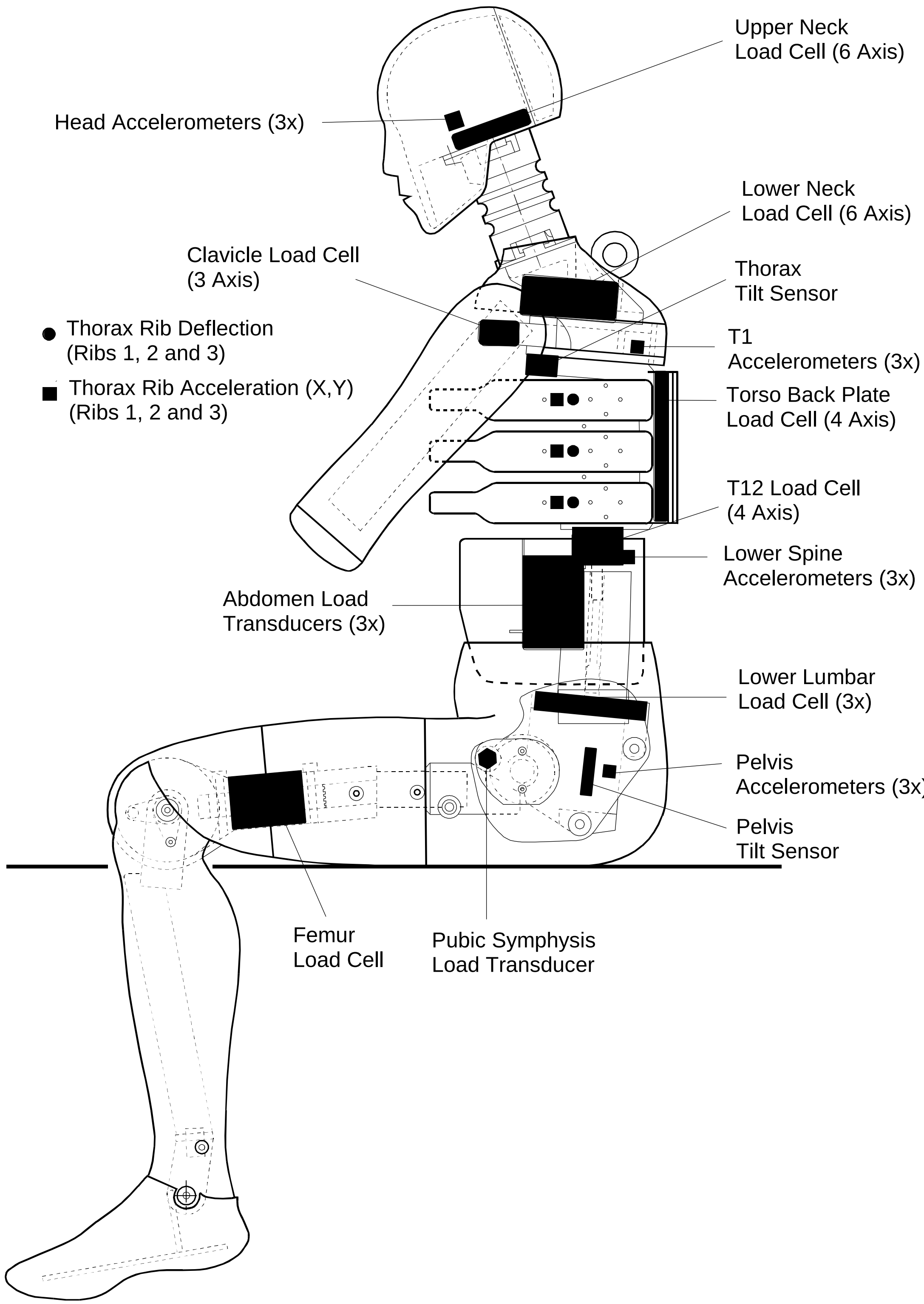


Figure 18: ES-2re Instrumentation Scheme (Standard and Optional)

3.3 Head

3.3.1 Load cell

The head-neck interface is equipped with a 6-axis upper neck load cell. The capacity specification of this load cell is

- ♦ Fx = 10 kN (2247 lb)
- ♦ Fy = 10 kN (2247 lb)
- ♦ Fz = 15 kN (3371 lb)
- ♦ Mx = 300 Nm (2654 in-lb)
- ♦ My = 300 Nm (2654 in-lb)
- ♦ Mz = 300 Nm (2654 in-lb)

Appropriate load cells for this application are the Humanetics IF-240 or equivalent. A structural replacement of the load cell is available (see Figure 19).

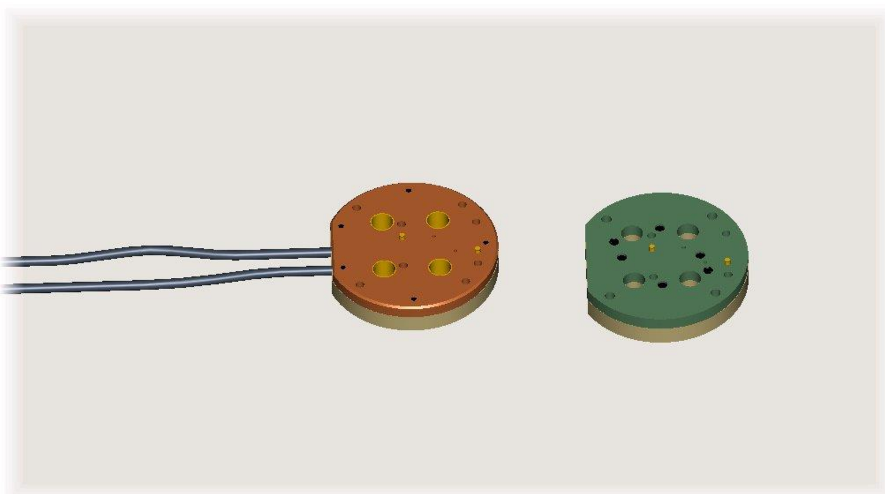


Figure 19: ES-2re Upper Neck Load Cell (Left) and Structural Replacement.

3.3.2 Accelerations

Three uni-axial accelerometers can be mounted at the center of gravity of the head on the upper face of the load cell or the load cell replacement (see Figure 20). Appropriate transducers are the Endevco model 7264A and Entran EGAS-500 or Endevco model 7264A-2000 and Kyowa ASM-200BA uni-axial accelerometers. A Channel Filter Class of 1000 according to ISO 6487 or SAE J211 is recommended for the head acceleration signals.

Figure 20: ES-2re Head Accelerometer Orientation on Structural Replacement

3.4 Neck

3.4.1 Load Cell

The neck-shoulder interface can be equipped with a 6-axis lower neck load cell. The capacity specification of this load cell is

- ♦ Fx = 12 kN (2697 lb)
- ♦ Fy = 12 kN (2697 lb)
- ♦ Fz = 14 kN (3146 lb)
- ♦ Mx = 450 Nm (3981 in-lb)
- ♦ My = 450 Nm (3981 in-lb)
- ♦ Mz = 300 Nm (2654 in-lb)

Appropriate load cells for this application are the Humanetics IF-221 or IF-226 or equivalent. The load cell replaces the standard neck bracket shown in Figure 7.

3.5 Shoulder

3.5.1 Load Cell

The shoulder-arm interface at the impact side can be equipped with a 3-axis Clavicle Load cell. The capacity specification of this load cell is:

- ♦ Fx = 4 kN (899 lb)
- ♦ Fy = 8 kN (1798 lb)
- ♦ Fz = 4 kN (899 lb)

Appropriate load cells for this application are the Humanetics IF-317 or IF-306 or equivalent.

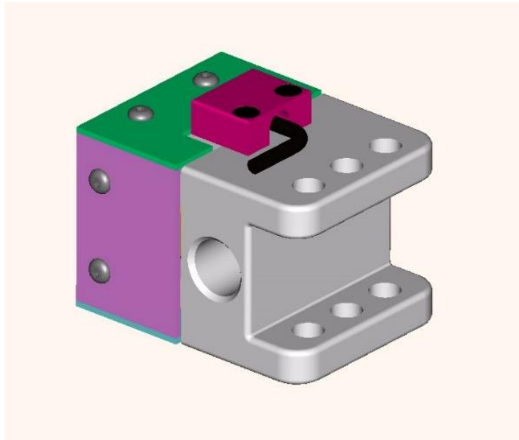


Figure 21: Shoulder Load Cell IF-317

3.5.2 Position indicator

Reference Appendix 1 for installation. A tilt sensor can be mounted on the shoulder top plate. This sensor indicates angles around Y- and X-axis and allows an accurate positioning of the dummy in a car-seat.

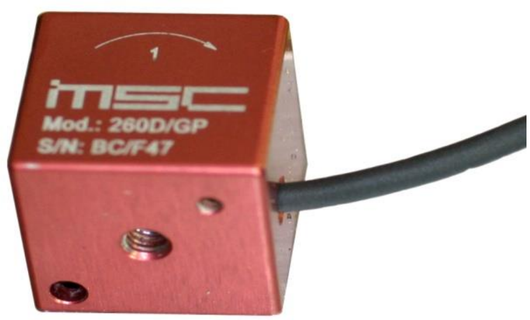


Figure 22: Shoulder Angle Indicator

3.6 Thorax

3.6.1 Load cell

The torso back plate can be equipped with a 4-axis load cell. The capacity specification of this load cell is:

- Fx = 3 kN (674 lb)
- Fy = 3 kN (674 lb)
- My = 160 Nm (1415 in-lb)
- Mz = 160 Nm (1415 in-lb)

An appropriate load cell for this application is the Humanetics IF-441 or equivalent. A structural replacement of the load cell is available (see Figure 23).

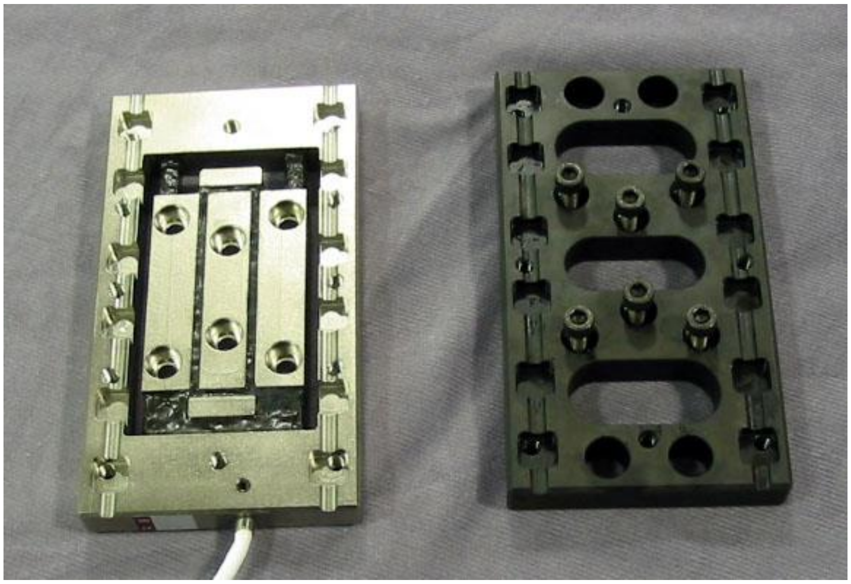


Figure 23: ES-2re Torso Back Plate Load cell (Humanetics IF-441) and Structural Replacement.

3.6.2 Accelerations

Provisions are made to mount a tri-axial accelerometer or three uni-axial accelerometers at the top of the thoracic spine to the shoulder bottom plate (see Figure 24). If rib acceleration measurements are required, uni-axial accelerometers measuring X and Y accelerations can be mounted on the faces near the spigot of the rib displacement transducer (see Figure 25). Furthermore, it is possible to attach three uni-axial accelerometers to a mounting block fixed on the T12 - load cell to obtain lower thoracic spine acceleration measurements (see Figure 26).

Appropriate transducers are the Endevco model 7264A and Entran EGAS-500 or Endevco model 7264A-2000 and Kyowa ASM-200BA uni-axial accelerometers, or at the shoulder, the Endevco 7267A-1500 or equivalent tri-axial accelerometer, which has sensitive axes through a single point. Mounting blocks to fit the different uni-axial transducer types on the shoulder and T12 location are available through Humanetics.

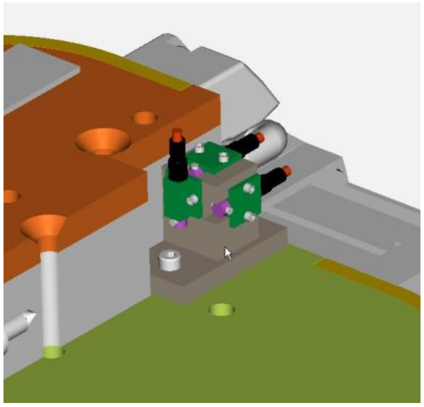


Figure 24: Upper Spine Accelerometers

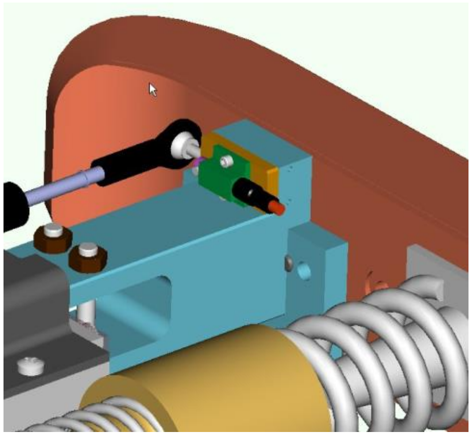


Figure 25: Rib Accelerometer, Y

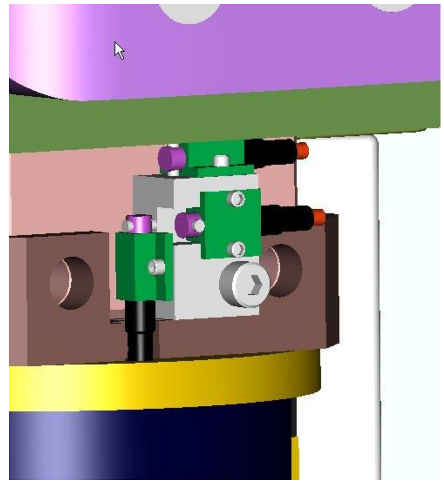


Figure 26: Accelerometers on T12 Location

A Channel Filter Class of 180 according to ISO 6487 or SAE J211 is recommended for both the thoracic spine and the rib accelerations. A special FIR 100 filter should be used for the TTI calculation.

3.6.3 Rib Displacement

Linear potentiometers are used to measure the rib displacement in the lateral direction relative to the spine box. The potentiometer with 76 mm (3") stroke is clamped on the housing to the guidance bracket and the rod is connected to the piston with a ball joint.

The main specifications of the potentiometer are:

- Resistance 4.5 kΩ
- Resistance tolerance ± 20%
- Linearity ± 0.1%
- Resolution infinite.

The wiring code is shown in Figure 27.

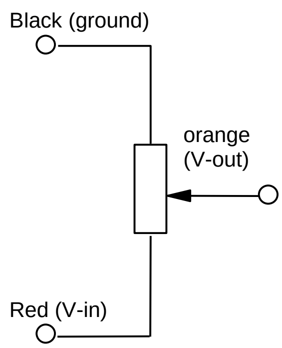


Figure 27 ES-2re Linear Potentiometer Wiring Code

A Channel Filter Class of 180 according to ISO 6487 or SAE J211 is recommended for the displacement signals.

3.7 Abdomen

3.7.1 Load Cell

The thorax-abdomen interface is equipped with a 4-axis T12 - load cell. The capacity specification of this load cell is

- ♦ Fx = 14 kN (3146 lb)
- ♦ Fy = 14 kN (3146 lb)
- ♦ Mx =1000 Nm (8848 in-lb)
- ♦ My =1000 Nm (8848 in-lb)

An appropriate load cell for this application is the Humanetics IF- 420 or equivalent. A structural replacement of the load cell is available (see Figure 28).

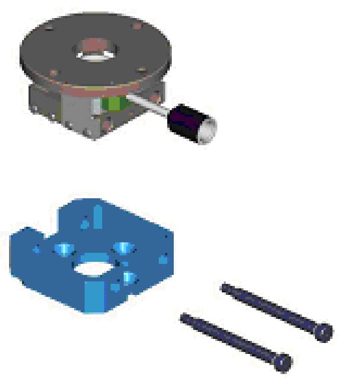


Figure 28: ES-2re T12 - Load Cell, Lumbar Spine Adapter and Shoulder Screws

> **NOTE:**
>
> The attachment of the load cell to the lumbar spine adapter with the shoulder bolts has tight tolerances. Application of high-pressure 'Never Seez®'- grease on the shaft of the shoulder bolts is recommended (supplied in the toolbox).

Three uni-axial force transducers are positioned on the abdomen drum at the impact side. The three transducers are identical and their specified capacity is:

- ♦ Maximum load : 5 kN (1124 lb)

Appropriate load cells for this application are the Humaentics IF-600 or equivalent. Structural replacements of the load cell are available and used at the non-impact side (see Figure 29).

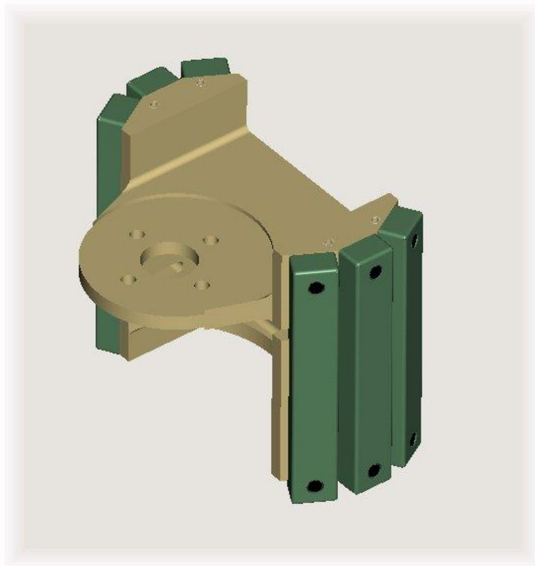


Figure 29: ES-2re Abdomen Drum With Load Transducer Structural Replacements

3.8 Lumbar Spine

3.8.1 Load Cell

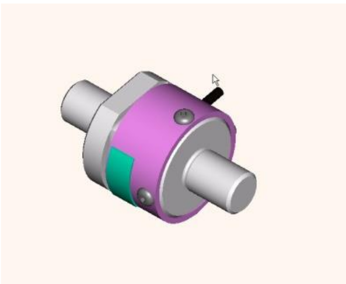
The lumbar spine-sacrum interface can be equipped with a 3-axis lower lumbar spine load cell. The capacity specification of this load cell is:

- ♦ Fy = 4.5 kN (1011 lb)
- ♦ Fz = 4.5 kN (1011 lb)
- ♦ Mx = 200 Nm (1769 in-lb)

Appropriate load cells for this application are the Humanetics IF-413 or equivalent. A structural replacement of the load cell is available.

3.9 Pelvis

3.9.1 Load Cells



The pelvis is equipped with a pubic symphysis load cell. The capacity specification of this load cell is:

- ♦ Maximum load : 20 kN (4494 lb)

Appropriate load cells for this application are the Humanetics IF-556 or equivalent. A structural replacement of the load cell is available.

Figure 30: Pubic Load Cell IF-556

NOTE:

> The use of a Sensotec Load Cell (Model T31) is discouraged. In the ES2 and ES2-re crash test dummies. This type of load cell can cause errors, as it is found to be sensitive to bending loads that may be introduced due to the ES2 and ES2-re hardware. This is not the case for the Eurosid-1.

3.9.2 Accelerations

The sacrum block of the ES-2re pelvis is designed to accept a tri-axial accelerometer or three uni-axial accelerometers to measure the pelvis accelerations. Appropriate transducers are the Endevco model 7264A and Entran EGAS-500 or Endevco model 7264A-2000 and Kyowa ASM-200BA uni-axial accelerometers or the Endevco 7267A-1500 or an equivalent tri-axial accelerometer, which has sensitive axes through a single point. Mounting blocks to fit the different uni-axial transducer types in the pelvis are available through Humanetics Europe.

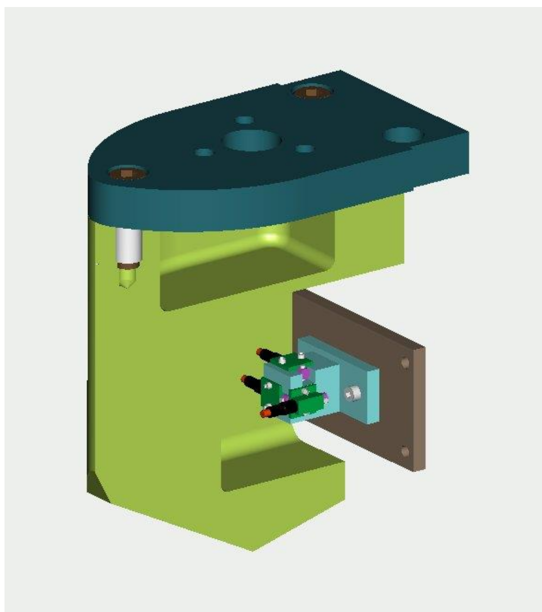


Figure 31: Pelvis Accelerometers

A Channel Filter Class of 180 according to ISO 6487 or SAE J211 is recommended for the pelvis acceleration signals.

3.9.3 Position Indicator

An angle indicator can be installed in the pelvis cavity. Reference Appendix 1 for installation. The sensor will measure angles around the Y- and X-axis.

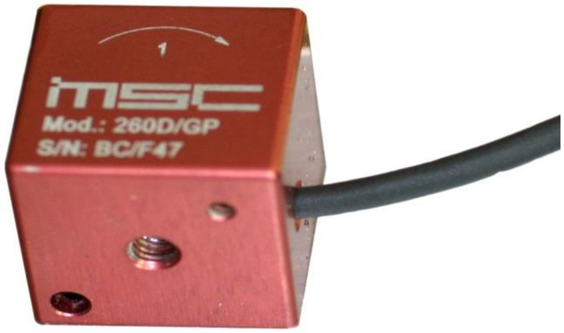


Figure 32: Pelvis Angle Indicator

3.10 Legs

3.10.1 Load Cells

The upper leg can be equipped with a 6-axis Femur Load cell. The capacity specification of this load cell is

- Fx = 13.4 kN (3000 lb)
- Fy = 13.4 kN (3000 lb)
- Fz = 22.3 kN (5000 lb)
- Mx = 339 Nm(3000 in-lb)
- My = 339 Nm(3000 in-lb)
- Mz = 339 Nm(3000 in-lb)

Appropriate load cells for this application are the IF-631 (6-axis femur with aluminum end caps 350 ohms) or IF-632 (6-axis femur with aluminum end caps 120 ohms) or equivalent.

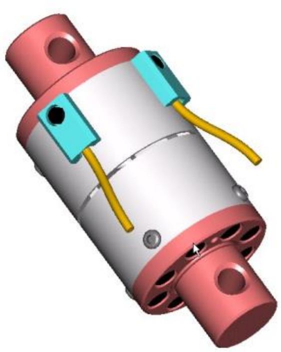


Figure 33: Femur Load Cell IF-631

NOTE:

The appropriate load cells each have a mass that is 0.370 kg higher than that of the leg parts they replace. To reduce this mass increase, aluminum end parts are available for the load cell at both suppliers. With these end parts installed, a mass increase of only 0.120 kg per leg remains. This increase is considered acceptable. The end parts are shown in Figure 34.

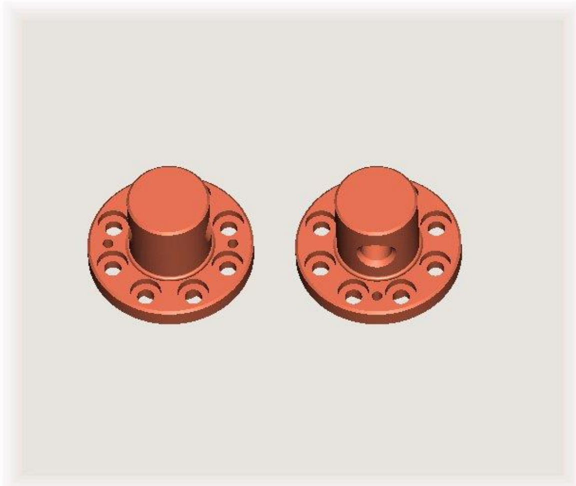


Figure 34: ES-2re High Strength Aluminum End Parts for Femur Load Cell

4 Assembly and Disassembly

4.1 Introduction

Disassembly and assembly of ES-2re is described in this chapter. Disassembly may be necessary to inspect, certify or repair the dummy or its parts. The body parts can usually be assembled by reversing the order described for the disassembly. Some instructions are given for important assembly actions. The description will be presented for each body part.

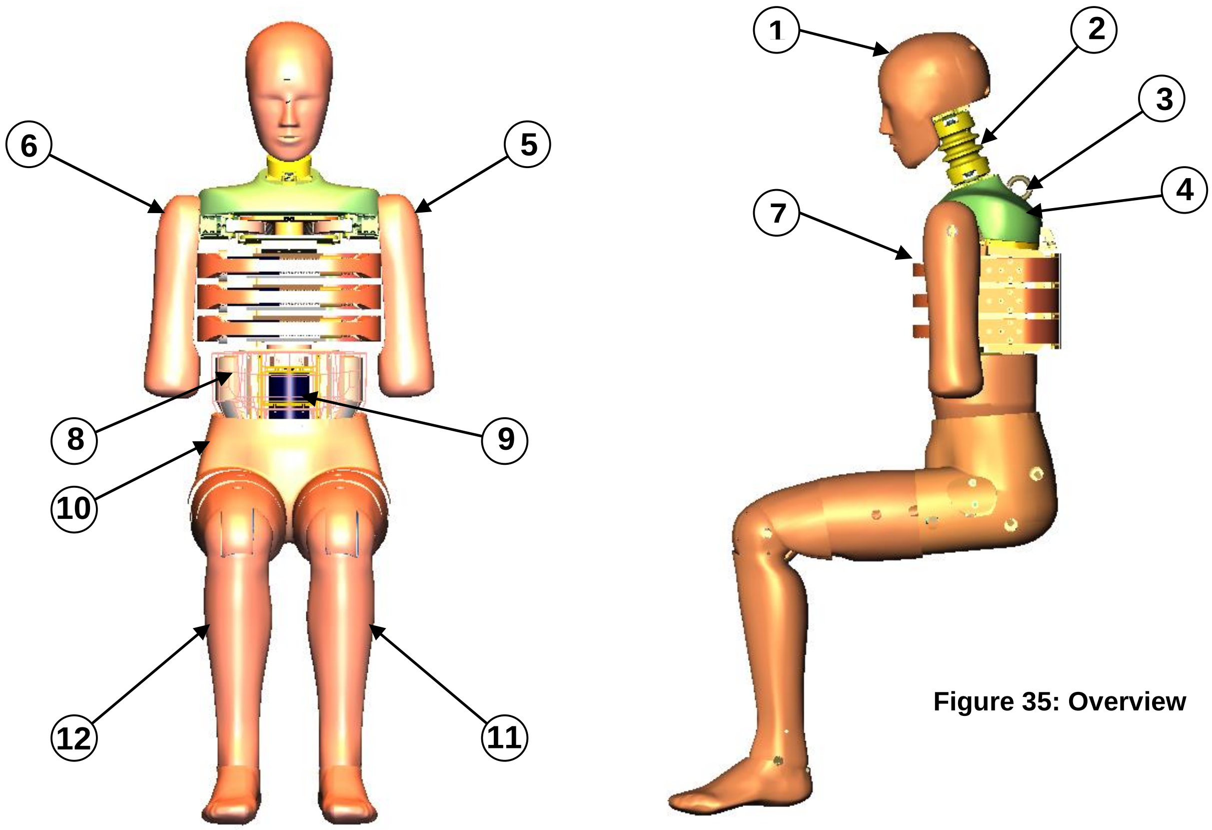


Figure 35: Overview

Major Subassemblies List

Item	Part Number	Qty	Description
1	175-1000	1	Head Assembly
2	175-2000	1	Neck Assembly, Tested/Certified
3	175-2500	1	Neck Bracket Including Lifting Eyebolt
4	175-3000	1	Shoulder Assembly
5	175-3500	1	Arm Assembly, Left
6	175-3800	1	Arm Assembly, Right
7	175-4000	1	Thorax Assembly with Rib Extensions
8	175-5000	1	Abdominal Assembly
9	175-5500	1	Lumbar Spine Assembly
10	175-6000	1	Pelvis Assembly
11	175-7000-1	1	Leg Assembly, Left
12	175-7000-2	1	Leg Assembly, Right
13	175-8000	1	Suit, Not Shown

4.2 Special Tools

A pelvis puller-tool and a neck compression tool (see Figure 36) are necessary for disassembly of the dummy. These tools are supplied with the dummy in the toolbox.

Figure 36: ES-2re Pelvis Puller Tool (left) and Neck Compression Tool

4.3 Fasteners

The fasteners used in the ES-2re dummy are metric. However, there are two exceptions:

- The top and bottom interfaces of the lumbar spine are threaded imperial UNC ¼"-20. The spine cable and the nut use UNF ½"-20.
- The fasteners and threads in the legs remain non-metric (because the Hybrid II legs are used).

Table 4 shows the size, type, quantity and, if applicable, torque specification of all fasteners used in the dummy.

Table 4: Fasteners used

WHERE	LOCATION	TYPE	SIZE	QTY	TORQUE
Head	Skull Cap - Skull	Cap head	M6x16	4	
	Load Cell - Skull	Cap head	M6x22	4	
	Accelerometer Mounting Block - Load Cell	Cap head	M2.5x14	2	
Neck	Load Cell - Neck	Cap head	M6x12	4	
	Neck - Interface Plates	Special half spherical	M12	2	10 Nm
	Neck - Neck Bracket	Cap head	M6X16	4	
Shoulder	Neck bracket - Shoulder	Cap head	M6x35	4	
	Eye bolt		M12	1	
	Cam Spring - Shoulder	Button head	M5x10	1	
	Cam Spring - Clavicle	Button head	M4x16	4	
	Cam Cover - Shoulder	Button head	M4x20	4	
	Accelerometer Plate – Shoulder	Cap head	M3x12	2	
	Elastic cord Holder	Button head	M4x25	4	

WHERE	LOCATION	TYPE	SIZE	QTY	TORQUE
	Shoulder - Spine Box	Countersunk	M6x50	3	
Arm	Arm - Shoulder	Button head lock screw	M10x30	2	
Thorax	Rib Unit - Spine Box	Cap head	M8x20	3x2	
	Torso Back Plate Load Cell - Spine Box	Cap head	M6x20	6	
	Torso Rib Extension guide to - Load Cell	Countersunk	M6x18	5	
	Rib Extension Cover to Rib Extension Guide	Button head	M3x6	8	
Rib unit	Protection Cover - Bracket	Cap head	M3x8	3x4	
	Transducer Mount - Bracket	Countersunk	M3x25	3x2	
	Transducer Head -Piston	Cap head	M2.5 x 16	3x1	
	Rib - Piston & Cylinder, nonstruck side	Button head	M4x10	3x4	
	Rib - Piston & Cylinder, struck side	Button head	M4x12	3x4	
	Damper - Cylinder	Cap head	M6x35	3x2	
	V-bearing to Piston	Countersunk	M4 x 20	3 x 6	
	V-bearing to Piston	Lock nut	M4	3 x 6	
	M-bearing to Bracket	Cap head	M4 x 20	3 x 6	
	Spring Locator to Piston	Cap head	M5 x 10	3 x 1	
	Cylinder to Bracket	Cap head	M6 x 18	3 x 3	
	Accel Mount to Piston	Cap head	M1.6 x 6	3 x 2	
	Spring Locator - Rib	Button head	M4x10	3x1	
T12 Load Cell	T12 Load Cell - Spine Box	Cap head Countersunk	M6x12 M6x12	2 2	
	T12 Load Cell - Lumbar Spine Adapter **(see warning below)**	Socket shoulder bolt	M8x60	2	
	Accelerometer Mounting Block - T12 Load Cell	Socket Head	M4x18	1	
Abdomen & Lumbar spine	T12 Load Cell - Abdomen Drum - Lumbar Spine	Counter sunk	UNC¼"-20x1"	4	
	Lumbar Spine – Lumbar Mounting Plate	Cap head	UNC¼"-20x¾"	4	
	Nut for Spine Cable	Hex	UNF ½"-20	1	

WHERE	LOCATION	TYPE	SIZE	QTY	TORQUE
	Cover Plate – Drum	Countersunk	M4x10	4	
	Transducers – Drum	Cap head	M4x16	12	
	Latching Plate – Drum	Cap head	M4x8	2	
	Accelerometer Block to T12	Cap head	M4x18	1	
Pelvis	Lumbar Mounting Plate - Sacrum Block	Cap head	M8x25	4	
	Iliac - Sacrum Block	Cap head	M10x40	4	
	Sacrum Cover Plate	Button head	M4x12	3	
	Accelerometer Plate - Sacrum Cover Plate	Cap head	M3x12	2	
	Hip Pivot Pin - Iliac Wing	Cap head	M8x25	2	
	H-Point Back Plate - Hip Pivot Pin	Low cap head	M6x16	2	
	Buffer Assembly - Upper Femur	Low cap head	M5x18	4	
	Upper Femur - Leg	Shoulder bolt	M12 x 40	2	
Legs	Femur Load Cell - Femur Bone and Knee Structure	Cap head	UNC⅜x16x1¾ ”	4	

CAUTION:

The attachment of the load cell to the lumbar spine adapter with the shoulder bolts has tight tolerances. The M8 x 60 shoulder bolts in T12 load cell must be mounted with high-pressure grease applied to prevent fretting. (High pressure ‘Never Seez®’-grease is available in the toolbox.)

4.4 Head

The head-neck interface of the ES-2re dummy differs from that of EUROSID-1 because of the integration of the upper neck load cell. Although it is not necessary, it is easier to remove the head/neck assembly from the thorax (see Section 4.7) before disassembling the head.

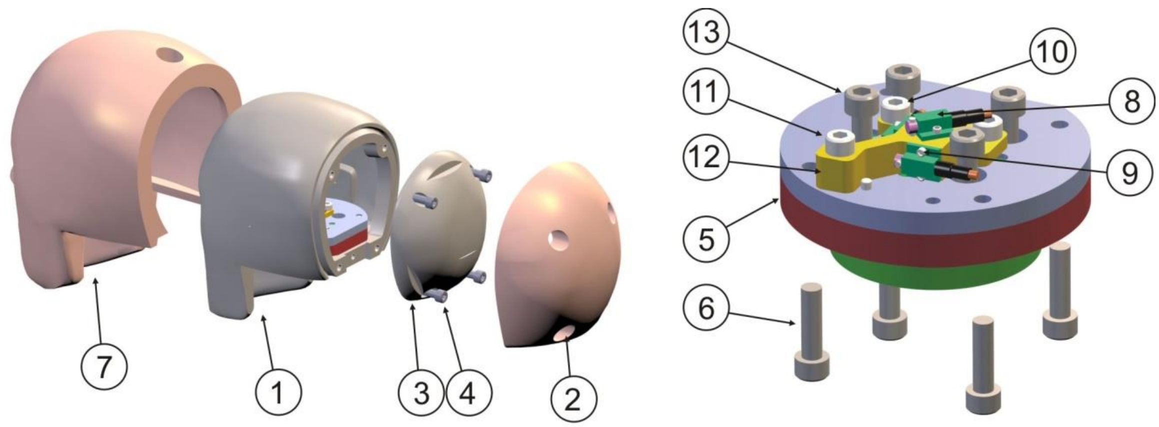


Figure 37: Head Assembly and Internal View

Parts List for Head Assembly

Item	Part Number	Qty	Description
1	175-1001	1	Skull Machined
2	175-1006	1	Skull Cap Skin
3	175-1003	1	Skull Cap
4	5000081	4	Screw, SHCS M6 x 16
5	175-1010	1	Upper Neck Load Cell Structural Replacement
6	5000282	4	Screw, SHCS M6 x 22
7	175-1005	1	Head Skin
8	*SA572-S4	3	Uni-axial Accelerometer (Ref. only)
9	*5000068	6	Screw, SHCS M1.4 x 3
10	*5000291	2	Screw, SHCS M5 x 10
11	*5000020	1	Screw, SHCS M5 x 16
12	*SA572-S81	1	Accelerometer Mount, Head CG
13	*5000281	4	Screw, SHCS M6 x 12

*** Items are part of the mount kit which can be purchased separately. They are not included if the mount kit is not purchased.**

To separate the head from the neck, first remove the skullcap by unscrewing four M6x16 screws (5000081) in the back of the head. Next, remove the four M6x12 screws (5000281) in the upper neck load cell (or structural replacement) inside the head and take the head-load cell combination from the neck. Finally, unscrew the four M6x22 screws (5000282) from the head bottom interface and remove the upper neck load cell (or structural replacement) from the head through the opening at the back of the head.

4.5 Neck

4.5.1 Disassembly

Unscrew the four M6x30 screws (5000008) connecting the neck bracket to the shoulder assembly and separate the head/neck-assembly from the shoulder. Turn the assembly upside down and unscrew the four M6x18 (5000285) screws at the base of the neck to separate neck and neck bracket. To remove the head, see Section 4.4.

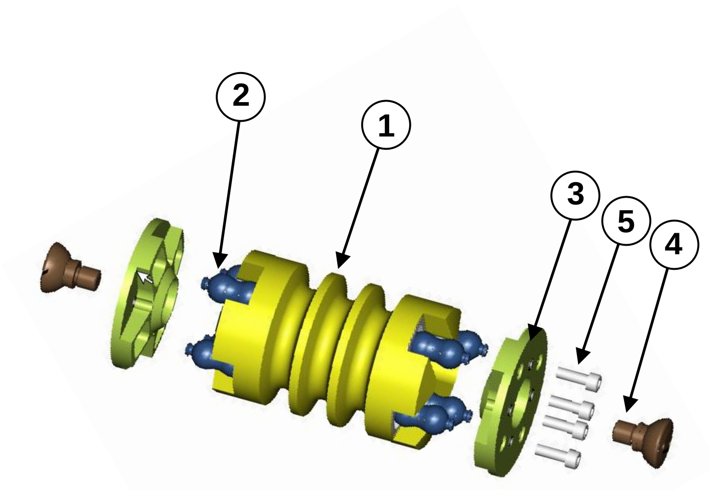


Figure 38: Neck Assembly
Reference Drawing 175-2000

Parts List for Neck Assembly

Item	Part number	Qty	Description
1	175-2001	1	Neck, Molded
2	175-2010/2015/2020	8	Neck Buffer Molded (60/70/80 Shore Durometer)
3	175-2003	2	Neck Head & Torso Interface Plate
4	175-2004	2	Half-Spherical Screw Eurosid-2
5	5000081	4	Screw, SHCS M6 x 16

Use the neck compression tool for disassembly of the neck. To remove the top and bottom interface plates and the eight circular section buffers from the central part, unscrew the half-spherical screw on the top and the bottom of the neck.

4.5.2 Assembly

The circular section buffer has one mushroom-shaped end and one cylindrical end (see Figure 39). The mushroom-shaped ends must be pressed firmly into the four holes of the interface plates. Check that the complete mushroom top protrudes in the counter bore at the flat face of the interface plate. Application of some non-oil based lubricant and a turning action during assembly may help to get the buffer into the correct position. The cylindrical end of circular section buffers should be positioned correctly into the intermediate plate (fixed to the central mounding part), when reassembling the top and bottom interface plates. Check that the bottom and top interfaces are aligned according to the marks 'top-rear' and 'bottom-rear'. The half-spherical screws can now be refitted. Before assembly, the half-spherical surfaces of the screws should be greased with high-pressure 'Never Seez®' grease, which is supplied in toolbox. Tighten the half-spherical screws with a torque of 10 Nm.

On further assembly of the neck in the dummy, make sure of the correct orientation with respect to head and thorax. This is indicated on the top and bottom interface plates.

Figure 39: ES-2re Neck Circular Section Buffers
Three Hardness Levels: 60 (Red), 70 (Yellow) and 80 (Blue) Shore A

4.6 Shoulder

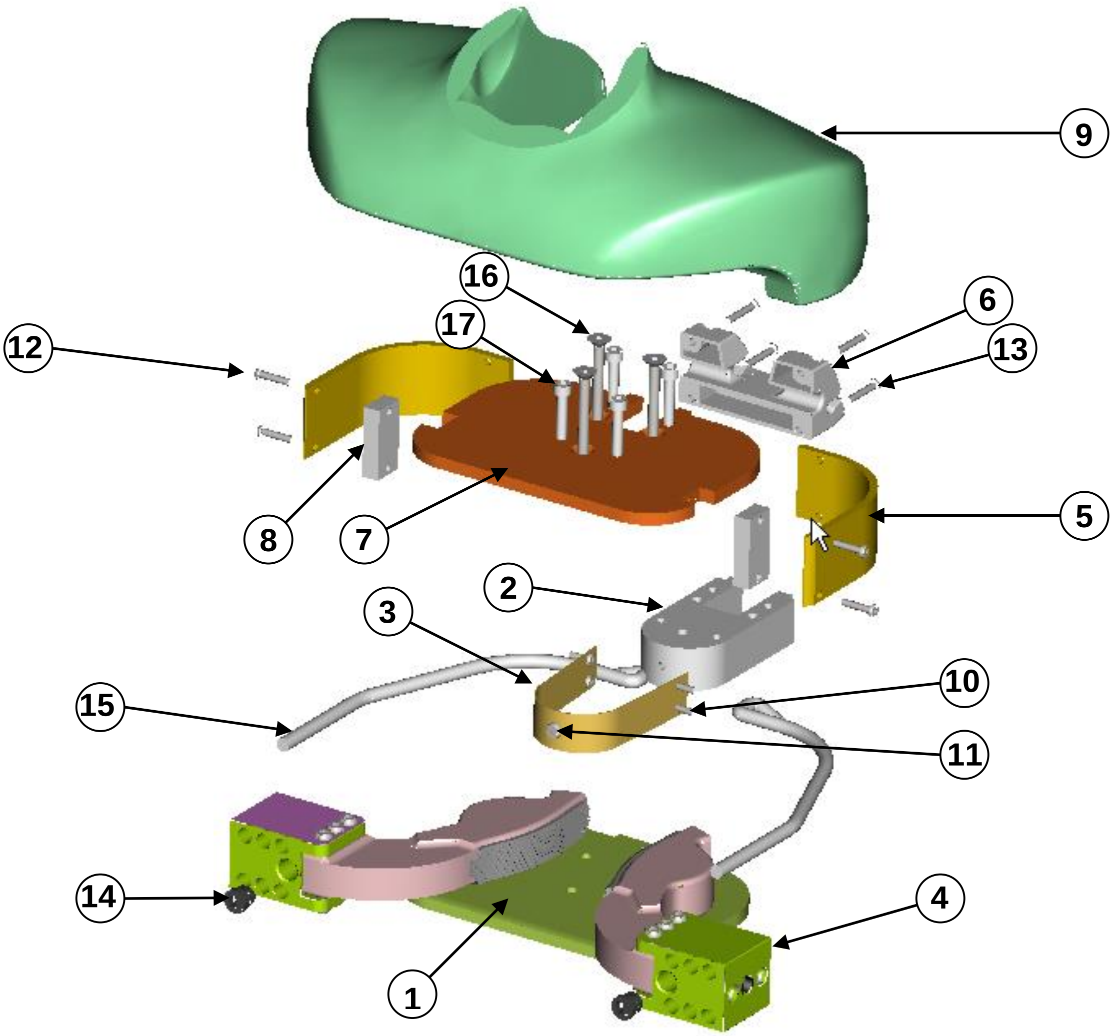
4.6.1 Disassembly

To start, the arms should be removed from the shoulder clavicles. Remove the head-neck assembly from the dummy (see Section 4.5). Unscrew three M6x50 (5000009) countersunk screws that attach the shoulder to the spine box and remove the shoulder.

To take off the clavicles, the elastic cords should first be released from the elastic cord holder by pulling the loose ends backward out of the toothed grooves. The clavicles can now be removed from the shoulder assembly by removing the central M5x10 screw (5000003) located at the front of the spacer. The clavicles/U-spring assembly can then be pulled out of the shoulder box. The clavicles can be separated from the U-spring by releasing the four M4x12 screws (5000005).

For a complete disassembly of the shoulder box, remove four M4x20 screws (5000007) from the shoulder cover plates and the four M4 x 25 screws (5000004) from back of the elastic cord holder. Now the coated top and bottom plates, the spacer block, the cover plates, the cam stops and the elastic cord holder come apart.

Figure 40: Shoulder Assembly Reference Drawing 175-3000



Parts List for Shoulder Assembly

Item	Part Number	Qty	Description
1	175-3001	1	Shoulder Bottom Plate
2	175-3002	1	Shoulder Spacer Block
3	175-3003	1	Shoulder U-Spring
4	175-3004	2	Shoulder Cam Clavicle
5	175-3006	1	Shoulder Cover Plate
6	175-3007	1	Elastic Cord Holder
7	175-3008	1	Shoulder Top Plate
8	175-3009	2	Cam Stop Block
9	175-3010	1	Shoulder Foam Pad
10	5000005	4	Screw, BHCS M4 x 12
11	5000003	1	Screw, BHCS M5 x 10

12	5000007	4	Screw, BHCS M4 x 20
13	5000004	4	Screw, BHCS M4 x 25
14	9002370	2	Bushing
15	175-3015	2	Bungee Cord
16	5000009	3	Screw, FHCS M6 x 50
17	5000008	4	Screw, SHCS M6 x 30

4.6.2 Assembly

When reassembling the shoulder, all surfaces of the clavicles and the inner surfaces of the top and bottom plates should be clean. The two clavicles should be fitted to the U-spring and be mounted in the shoulder assembly. The elastic cords should be reattached to the elastic cord holder and adjusted according to the certification procedure (see Section 5.8). The correct routing of the elastic cord is shown in Figure 41. First feed the cord through the hole, then pull the cords back out into the teethed groove and secure it in the open hole at the end of the groove. The left and right cords should not cross.

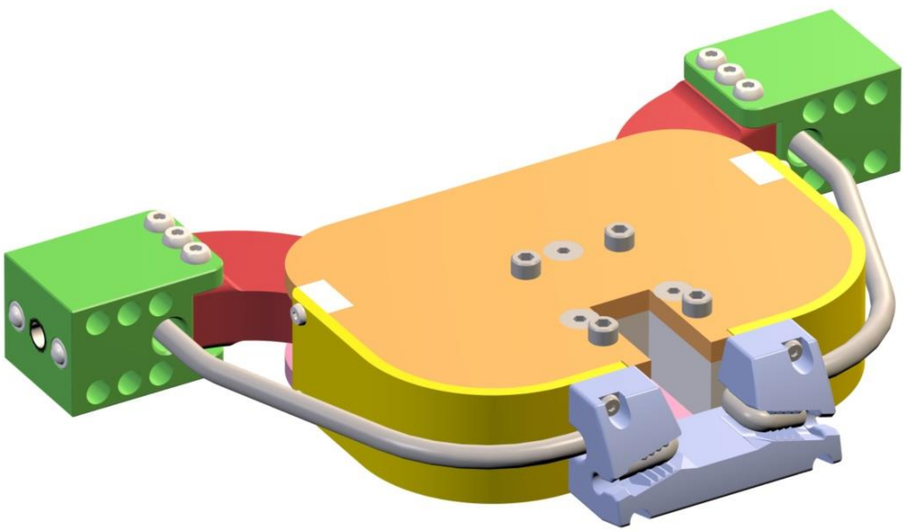
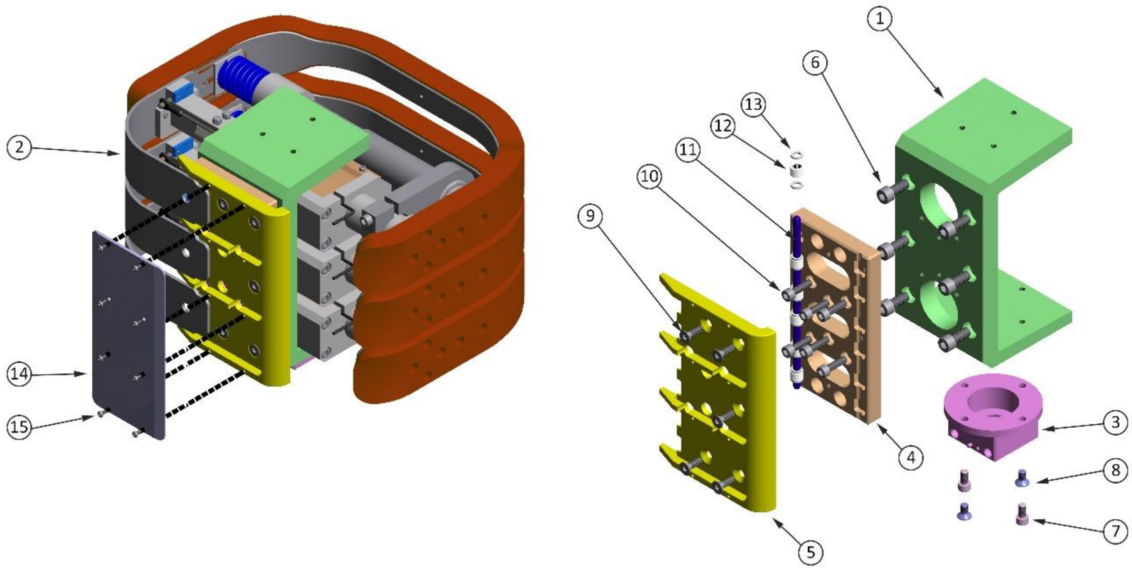


Figure 41: ES-2re Elastic Cord Routing Through Clavicle and Elastic Cord Holder

4.7 Thorax

In some cases, the work on the ES-2re thorax is easier if the dummy is split at the thorax-abdomen interface at the T12 location. To separate upper and lower body parts of the dummy remove the two M8x60 shoulder screws (5000089) located at the rear in the T12 load cell or structural replacement. When the screws are removed, the upper part of the dummy can easily be lifted off the lower part of the dummy using the eyebolt in the neck bracket (see Figure 7).

Figure 42: Thorax Assembly
Reference Drawing 175-4000



Parts List for Thorax Assembly

Item	Part Number	Qty.	Description
1	175-4001	1	Spine Box, Rib Extension
2	175-4002	3	Complete Rib Module with Rib Extensions
3	175-4070	1	T12 Structural Replacement
4	175-4080	1	Back plate, Load Cell Replacement, Rib Extensions
5	175-4081	1	Rib Extension Guide
6	5000075	6	Screw SHCS M8 x 20
7	5000281	2	Screw SHCS M6 x 12
8	5000139	2	Screw, FHCS M6 x 12
9	5000108	5	Screw, FHCS M6 x 18
10	5000282	6	Screw SHCS M6 x 22
11	175-4082	1	Rib Extension Shaft
12	9002664	6	Needle Roller Bearing, ¼”
13	175-4085	12	Rib Extension Spacer
14	175-4090	1	Rib Extension Cover
15	5000399	8	Screw BHCS M3 x 6

CAUTION:

Never lift the upper body by the ribs.
Use the eyebolt in the neck bracket in Figure 7.

4.7.1 Disassembly of the Thorax

To take a rib unit from the thorax, remove the rib extension cover by removing the eight M3x6 BHCS screws (5000399) that hold it in place. Remove the rib extension guide from the back plate by removing the five M6 x 18 FHCS (5000108). The rib extension shaft, which has six needle roller bearings and twelve spacers on it, can be removed from the back plate. Remove the back plate load cell replacement by removing the six M6 x 22 SHCS (5000282). Each rib unit can then be removed from the spine box by unscrewing the two M8x20 SHCS screws (5000075). The complete rib unit is shown in Figure 43.

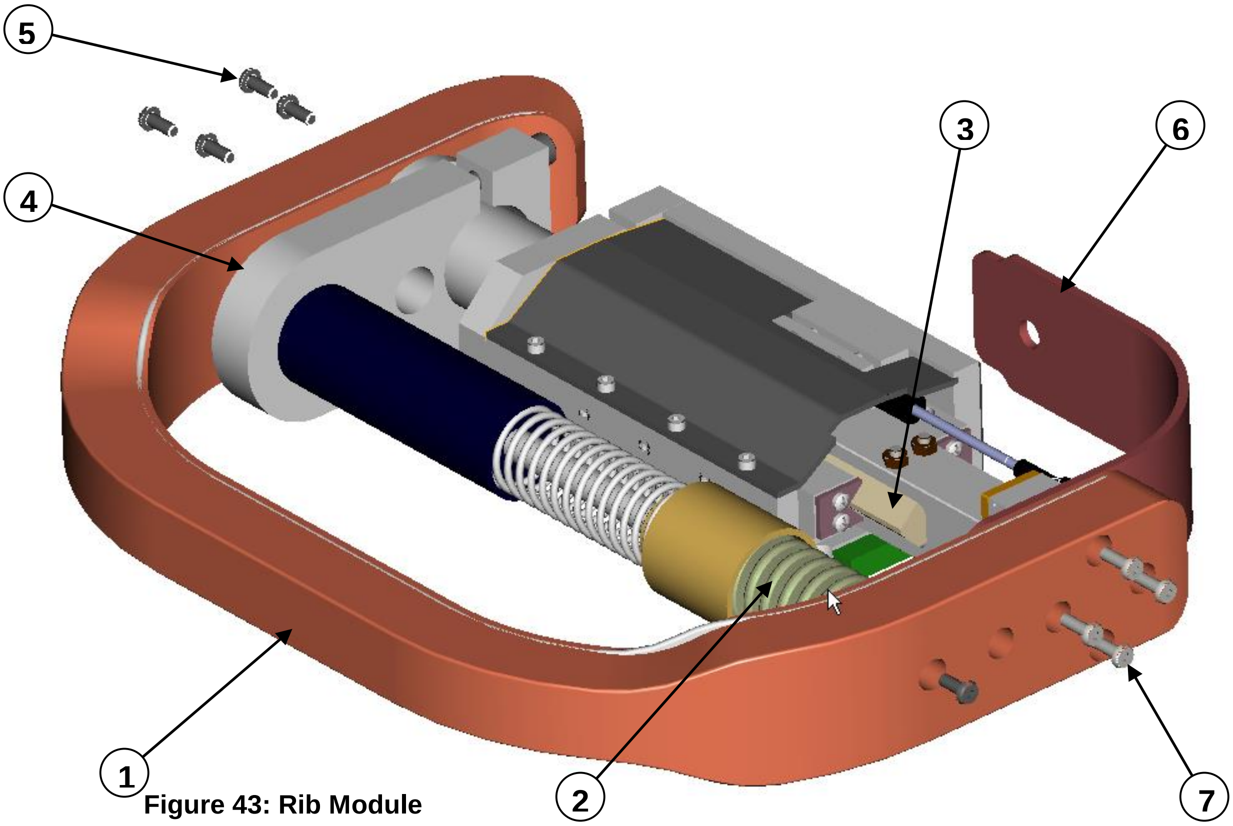


Figure 43: Rib Module
Reference Drawing 175-4003

Parts List for Rib Module

Item	Part Number	Qty.	Description
1	175-4003	1	Rib Assembly
2	175-4005	1	Damper Spring Locator
3	175-4006	1	Rib Rail Assembly
4	175-4050	1	Damper Spring Assembly
5	5000010	5	Screw BHCS M4 x 10
6	175-4060	1	Rib Extension Rear Bracket
7	5000005	4	Screw, BHCS M4 x 12

4.7.2 Disassembly of Rib Unit

The rib unit guide system linear bearings are protected with a transparent plastic cover. To remove the protection cover from the rib unit, unscrew the four M3x8 SHCS screws (5000388) at the forward side of the guidance bracket. Pull the cover forward to disengage it from the groove at the rear of the guidance bracket.

4.7.2.1 Disassembly of Transducer

Unscrewing the two M3x25 FHCS screws (5000355) from the mounting block and detaching the rod end from the piston side by unscrewing the M2.5 x 16 SHCS screw (5000283) will remove the linear displacement transducer.

4.7.2.2 Disassembly Damper System and Rib Bow

The damper can be removed from the rib unit by unscrewing the two M6x35 screws (5000014) in the mounting clamp. With the mounting clamp removed, the damper can be rotated and taken out of the rib unit. The right side of the piston is attached to the rib bow by four M4x10 BHCS screws (5000010). One additional M4 x 10 BHCS (5000010) holds the damper spring locator to the rib assembly. The left side of the rib bow is attached to the cylinder by four M4x12 BHCS (5000005). All screws can be reached through holes in the rib flesh. When the button head screws on the left end are removed, the rib extension rear bracket will be free to be removed. The damper system can now be checked following the steps given in Section 4.7.3.

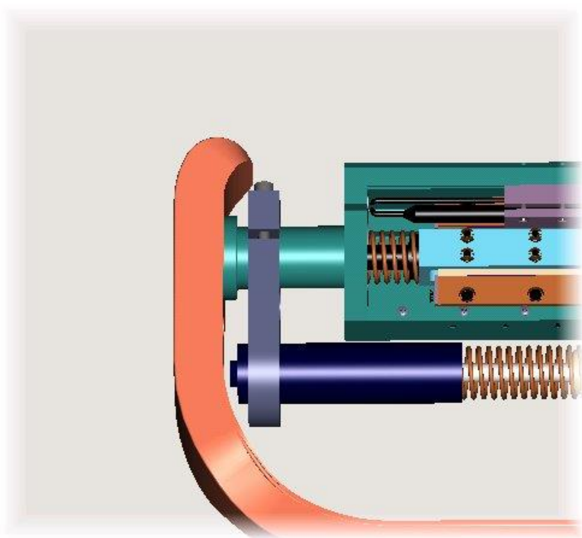


Figure 44: ES-2re Assembly of Damper in Rib Module

4.7.2.3 Disassembly of the Rib Linear Guide System

During normal servicing, the needle bearing guide system must be checked for proper performance of the following functions.

1. Check free movement of the piston, without any play or friction, over the full stroke.
2. Check that needle cages are aligned with the end stops in the two extreme positions.

For in-depth checks and troubleshooting, the needle bearing guide system can be checked following the steps given section 4.7.4. The needle bearing system can be disassembled by unscrewing the remaining screws and nuts in a sequence reversed to that describe in section 4.7.4 for assembly.

RECOMMENDATION
It is strongly recommended NOT to disassemble the rib guide system during normal servicing.

4.7.3 Checking and Bleeding of the Damper

The damper should be bled when the damper fails to pass its inspection test described in Section 5.9.5. Bleeding instructions in this paragraph should be followed.

1. Hold the damper vertical with the piston rod up. Move the piston and listen for any squishing noises of air in the oil. (This procedure causes air collection at the top end of the damper.)
2. Reverse the orientation of the damper by 180 degrees (piston rod down) and move the piston, again listening for any squishing noises. (This procedure will cause air collected in action 1 to pass through the damper piston, causing the squishing noise mentioned previously.)
3. If necessary, repeat actions specified in steps one and two. If air is heard in the oil, repeat step two slowly using strokes of decreasing amplitude and the piston rod near full extension. Support the damper vertically for a few moments. (This procedure causes all air to be collected on the annular side of the piston and the rest period allows the air that has been emulsified in the oil to be collected at the bleed hole.)
4. Carefully remove the bleed screw and either add some extra oil to the damper or carefully push in the piston, pushing the oil up to the top of the bleed hole.

NOTE:

Use only the special damper oil supplied in the toolbox. Other hydraulic oils are not suitable and will cause the damper to be out of specification.

5. Replace bleed-screw.
   CAUTION: DO NOT over-tighten the bleed screw.
6. Having bled the damper, recheck for air, operations 1 and 2.
7. In addition, check that the stroke of the damper is at least between 46 - 50 mm.

This procedure guarantees that the damper has not inadvertently been overfilled.

NOTE:

If a damper is overfilled, it might lock during a test.

4.7.4 Assembly of Rib Unit

When assembling the rib unit cleanliness of the working area is of utmost importance. Use a clean and dust-free assembly table and tools for this job.

4.7.4.1 Assembly of Linear Guide System

The parts of the linear bearing system can be recognised by their shape and are referred to as M-rail and V-rail.

1. Put the piston buffers (O-ring lace, D=8mm, L=14 mm) in the recesses. Make sure that these buffers do not protrude above the M-rail mounting faces of the guidance bracket.
2. Assemble the guidance bracket and the cylinder by the three M6 cap head screws.
3. Mount end stop plates to both ends of the M-rails using M3 button head screws. Push all the play out in direction to the non-guiding side of the M-rail.
4. Put bushings in the V-rails, with a little Loctite 222 on it to secure them, slide them back to back in the slot of the piston and assemble the M4 countersunk screws and the self-locking nuts at the top. Do not tighten the nuts at this stage.
5. Attach the tuning spring support on the left side of the piston with one M5x10 screw.
6. Make sure that the guidance bracket cylinder combination (including the piston buffers) is ready for assembly on the table with the cylindrical part to the left and the rail mounting recess up.
7. Wipe M-rail and V-rail -faces with clean cloth, making sure they are free of dust and extraneous particles.
8. Now stack in one hand in this sequence: M-rail, needle cage, piston with V-rails, needle cage and M-rail and drop the stack in the guidance bracket. Make sure that the M-rail's counterbore holes are facing up and the large piston end is facing to the right. Make sure that the plastic that connects the needle cages to each other is as far as possible from the point of the V of the V-rail. Otherwise rotate them 180° around its Z-axis.
9. Assemble all six screws (M4 cap heads) to hold the bearing assembly. Do not tighten the screws at this stage.
10. Screw in the four M4 set screws in the front face of the guidance bracket, not tightening them now.
11. Move the piston and needle cages to the leftmost retracted position. The piston must touch the end stop. Set the piston in a 'half way position' such that the nuts of the piston are on the same height with the bolds of the M-rail.
12. Put some pretension on the four M4 set screws in front face of the guidance bracket.
13. Tighten the six M4 screws of the M-rail. In combination with 11, all the play is pushed out into direction of the non-adjustable guidance bracket side.
14. Tighten the v-rails in the piston firmly after alignment. To tighten the V-rail screws and nuts, put the assembly on the rear face. A small amount of play allows the piston to be aligned with the V-rails before tightening the screws. This alignment is important for the installation of the transducer (see section 4.7.4.2 assembly step 5) (Note: The hexagon sockets of the screws can be reached through holes in the bottom face of the guidance bracket. Move the piston to mid position to align the screw heads with the holes.)
15. Set the 3 M4 M-rail screws on the non-adjustable side to 8 Nm.
16. Release the tension of the 4 M4 set screws and 3 M4 M-rail screws at the same side.

17. Check that the piston moves freely, without play, with even resistance over the complete length of the stroke. If not, the buffers installed in assembly step 1 may protrude and interfere with the V-rail.
18. Hand tighten the 3 screws in such way that movement of the M-rail still is possible, but with a minimum of play, so that no initial angle can be introduced between the guidance bracket and M-rail. Move the M-rail by turning gently the 4 M4 screws towards the M-rail. Do this in such a way that the rail is as parallel as possible relative to the V-rail. Feel the movement of the piston in the guidance bracket at every adjustment.
19. If there is not any play and is the piston moving smoothly, fasten the three screws on the adjustable side of the M-rail with a torque of 8 Nm.
20. Check the movement of the piston again. If movement of piston has changed, start over with point.
21. Insert the tuning spring as used during the certification test.
22. Attach the curved end of the rib to the piston using four M4x10 screws. Insert the rib extension bracket between the flat end of the rib and the cylinder using four M4x12 screws.
23. For transducer installation, refer to section 4.7.4.2.
24. For damper assembly installation, refer to section 4.7.4.3.
25. Install the bright plastic protection cover by inserting it in the guidance bracket groove at the aft side using four M3 screws at the forward side (see Figure 45).

Table 5: ES-2re Tuning Spring Color Codes

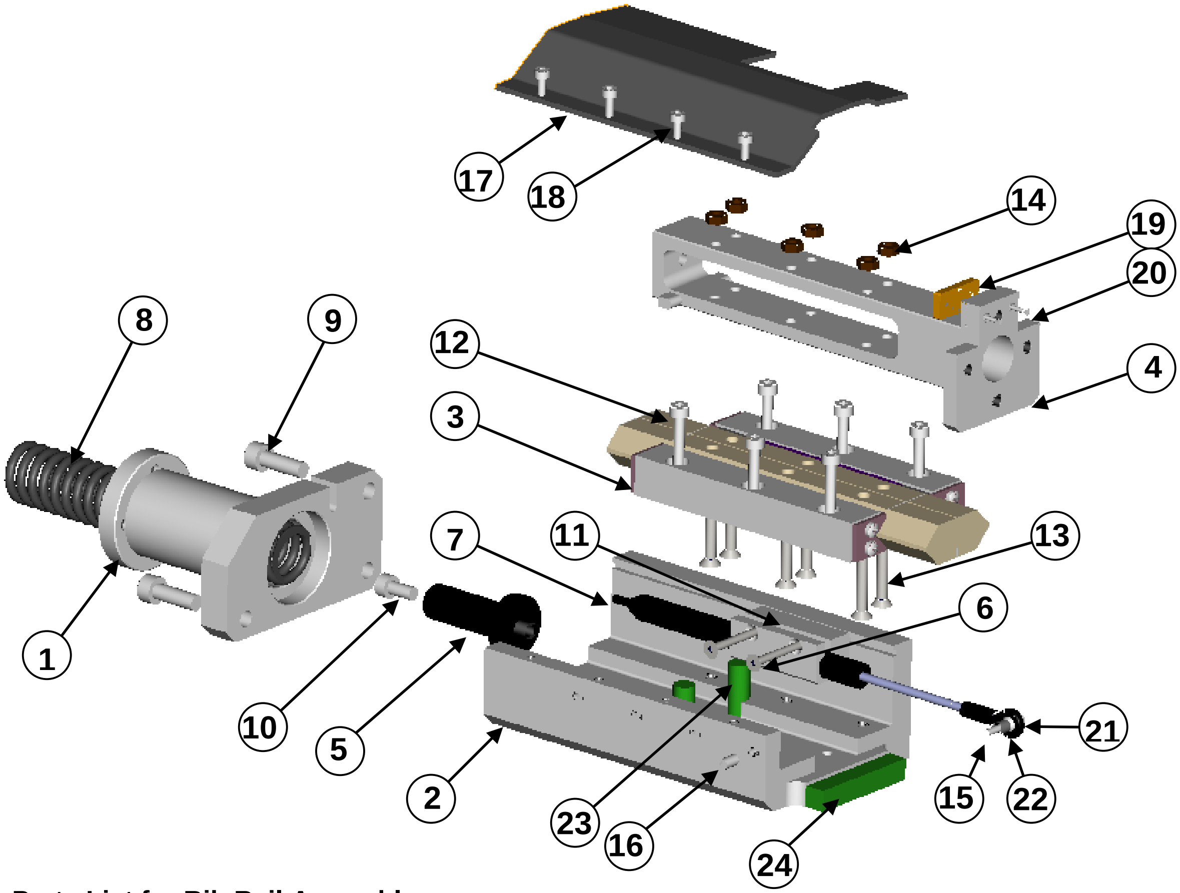
Part Number	Tuning Spring Color	Spring Rate (N/mm)	Wire Gauge (mm)
175-2010	White	13.8	3.25
175-2015	Black	16.4	3.50
175-2020	Blue	19.0	3.75

4.7.4.2 Assembly of Transducer

To mount the linear potentiometer, the following assembly steps must be performed:

1. Insert the transducer in the plastic-mounting block.
2. Attach the rod end of the transducer to the piston with the M2.5 x 16 SHCS screw (5000283) and the transducer bushing (175-4033).
3. Screw the mounting block to the guidance bracket with two M3x25 FHCS screws (5000355). Do not tighten the screws at this time.
4. Slide the transducer through the plastic-mounting bracket to obtain the required 60 mm free retraction length of the transducer rod. Figure 46 indicates the measurement to be taken.
5. Tighten the M3x25 FHCS screws (5000355) in the mounting block.
6. Check the alignment of the transducer housing and the rod. If the rod is bent, the piston must be re-aligned in the guide system.

Figure 45: Rib Rail Assembly
Reference Drawing 175-4006



Parts List for Rib Rail Assembly

Item	Part Number	Qty.	Description
1	175-4007	1	Cylinder Eurosid-2
2	175-4008	1	Guidance Bracket, Thorax
3	175-4010	1	Rail Guide Assembly
4	175-4020	1	Piston, Thorax
5	175-4021	1	Tuning Spring Support, Thorax
6	5000335	2	Screw FHCS M3 x 25
7	SA572-S54	1	Linear Position Transducer
8	175-4040/4041/4042	1	Tuning Spring: (Black 16.4±1.0 N/mm)/(White 13.8±1.0 N/mm)/ (Blue 19.0±1.0 N/mm)
9	5000285	3	Screw SHCS M6 x 18
10	5000291	1	Screw SHCS M5 x 10
11	175-4022	1	Transducer Mount, Thorax
12	5000287	6	Screw SHCS M4 x 20
13	5000289	6	Screw FHCS M4 x 30
14	5000290	6	Nut M4 Self Locking
15	5000283	1	Screw SHCS M2.5 x 16
16	5000288	4	FPSS M4 x 8
17	175-4031	1	Cover, Thorax
18	5000388	4	Screw, SHCS M3 x .5 x 8
19	175-4032	1	Rib Accelerometer Mount

20	5000343	2	Screw SHCS M1.6 x 6
21	6000081	1	Rod End 4-40
22	175-4033	1	Transducer Bushing, Thorax
23	175-4100	2	Piston Buffer
24	175-4110	1	Square Bumper

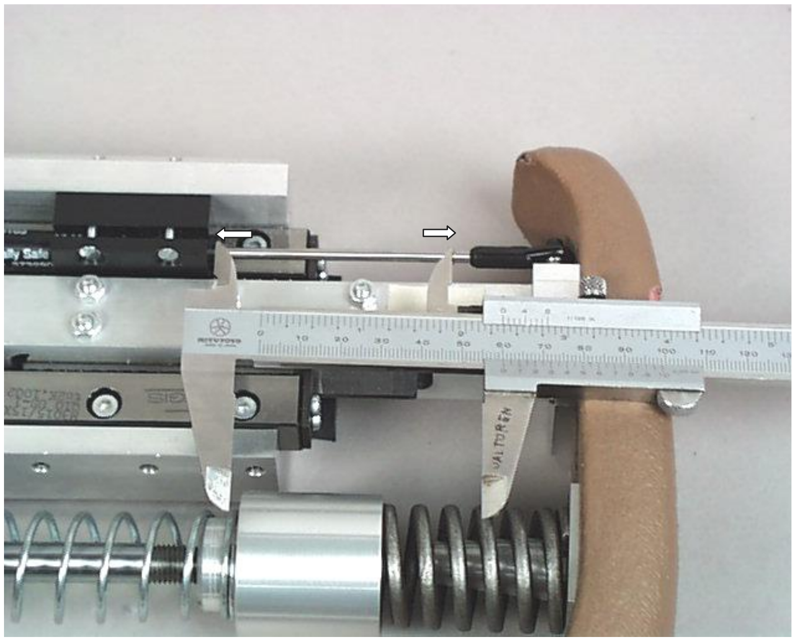


Figure 46: ES-2re Transducer Rod Minimum Free Retraction Length is 60 mm.

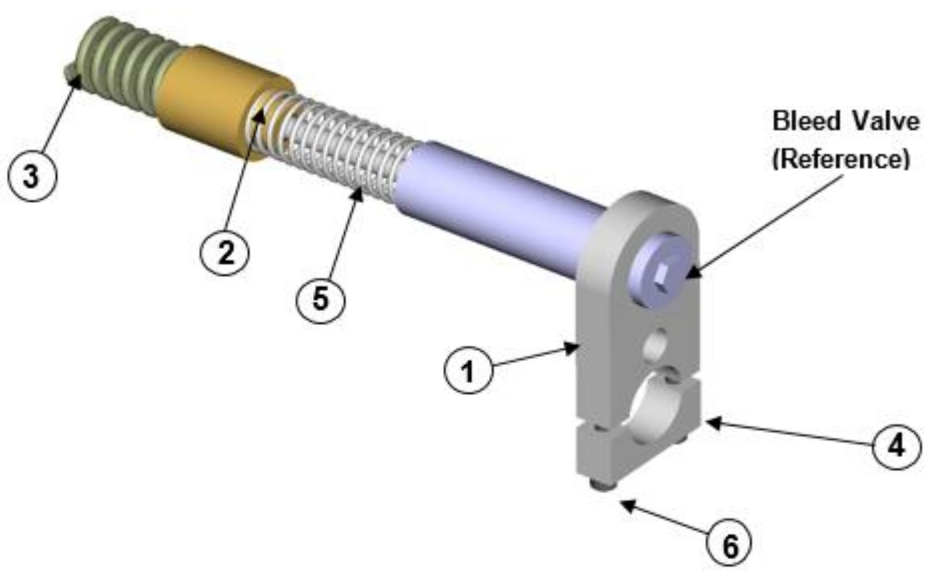


Figure 47: Damper Spring Assembly Reference Drawing 175-4050

Parts List for Damper Spring Assembly

Item	Part number	Qty.	Description
1	175-4051	1	Damper Assembly
2	175-4055	1	Damper Spring Cup
3	175-4056	1	Stiff Damper Spring
4	175-4057	1	Damper Bracket Clamp
5	175-4058	1	Damper Return Spring
6	5000014	2	Screw, SHCS M6 x 35

4.7.4.3 Assembly Damper System

The installation of the damper includes the following assembly steps:

1. Put the return spring over the damper rod.
2. Screw the damper cup on the damper rod, compressing the return spring. The thread on the damper rod should protrude through the damper cup.
3. Insert the stiff damper spring into the damper cup.
4. Position the damper-spring combination in the rib bow with the stiff damper spring engaged with the spring locator on the rib and the clamp-bracket on the cylinder. A small gap (2-5 mm) between the rib and bleed plug of the damper in required.
5. Install the clamp with two M6x35 SHCS screws (5000014). Make sure that the damper clamp bracket is parallel to the bottom face of the guidance bracket.
6. Remove the axial play of the stiff damper spring between the damper cup and the spring locator on the rib. This can be done by unscrewing the damper cup.

CAUTION:

DO NOT unscrew the cups so much that the damper stroke is reduced. If this does occur, the performance of the rib will be adversely affected. The rib may fail to meet the requirements during certification.

After certification (see Section 5.9), the rib modules can be assembled in the spine box for either left or right side impacts.

4.8 Arms

The arm is attached to the shoulder cam clavicle by a single M10x30 button head screw (5000040). This screw is self-locking by a prevailing torque plastic coating.

Between the arm skeleton and the head of the screw, a ball bearing cage is fitted between two washers. Between the arm skeleton and the shoulder cam clavicle, a Pivot Stop Plate (transparent plastic) is fitted allowing discrete arm orientations at 0°, 40° and 90° with respect to the torso line. Tighten the M10 screw to obtain a 1 - 2G holding force of the arm.

NOTE:

The Pivot Stop Plates for the left and right side are not interchangeable. The plates carry the indication LH and RH for respectively left hand and right hand application.

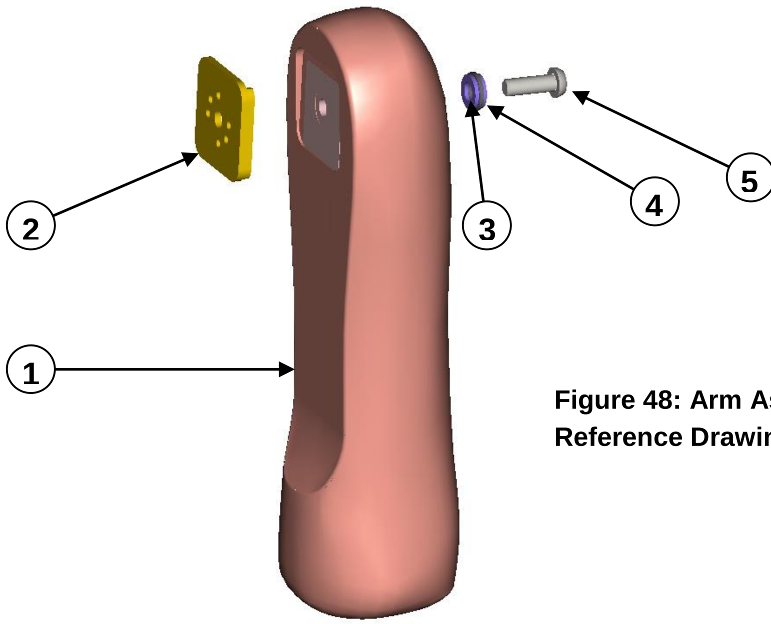


Figure 48: Arm Assembly, Left Reference Drawing 175-3500.

Parts list for Arm Assembly

Item	Part number	Qty./Arm	Description
1	175-3501	1	Upper Arm Left or Right
2	175-3502/3503	1	Pivot Stop Plate Left/Right
3	5000105	2	Washer Flat
4	5000104	1	Bearing Thrust
5	5000040	1	Self Locking Screw BHCS M10 x 30

4.9 Abdomen

To disassemble the abdomen, separate the dummy at the T12 location at the top of the lumbar spine (see Section 4.7). Remove four UNC 1/4"-20 countersunk screws connecting the T12 load cell base adapter and abdomen drum to the lumbar spine. Lift the complete abdomen assembly from the lumbar spine and turn it upside down (See Figure 49).

CAUTION:

Do not attempt to separate the abdomen foam covering from the drum while the abdomen is still assembled inside the dummy, as this will damage the covering.

Figure 49: Abdomen

To remove the abdomen foam covering, unscrew the two M4x8 SHCS screws (5000024) to remove the small latching plate (see Figure 51). The foam covering can be separated from the drum by slightly bending it open and lifting it off.

The force transducers and the non-measuring structural replacements can be removed by unscrewing the two outer M4x16 SHCS screws (5000025) on each unit (see Figure 51).

When changing the force transducers to the other side (to change the impact direction of the dummy) and/or reassembling the force transducers, ensure the correct the routing of the cables. The cables should be fed through the scallops in the drum and should not be squashed between the force transducers and the drum. First, position the front transducer, followed by the middle and finally the rear. When reassembling the molded abdomen, it should fit closely around the drum and the force transducers. **Do not pull the wings of the molded abdomen outward excessively to make it easier to install – this will damage the abdomen.** When installing or removing the abdomen from the abdominal drum, ensure it is done with as little distortion of the abdomen as possible. Unscrew the four FHCS (Item 6) then remove the cover plate (Item 1). See Figure 51.

Figure 50: ES-2re Abdomen Drum and Transducer Structural Replacements

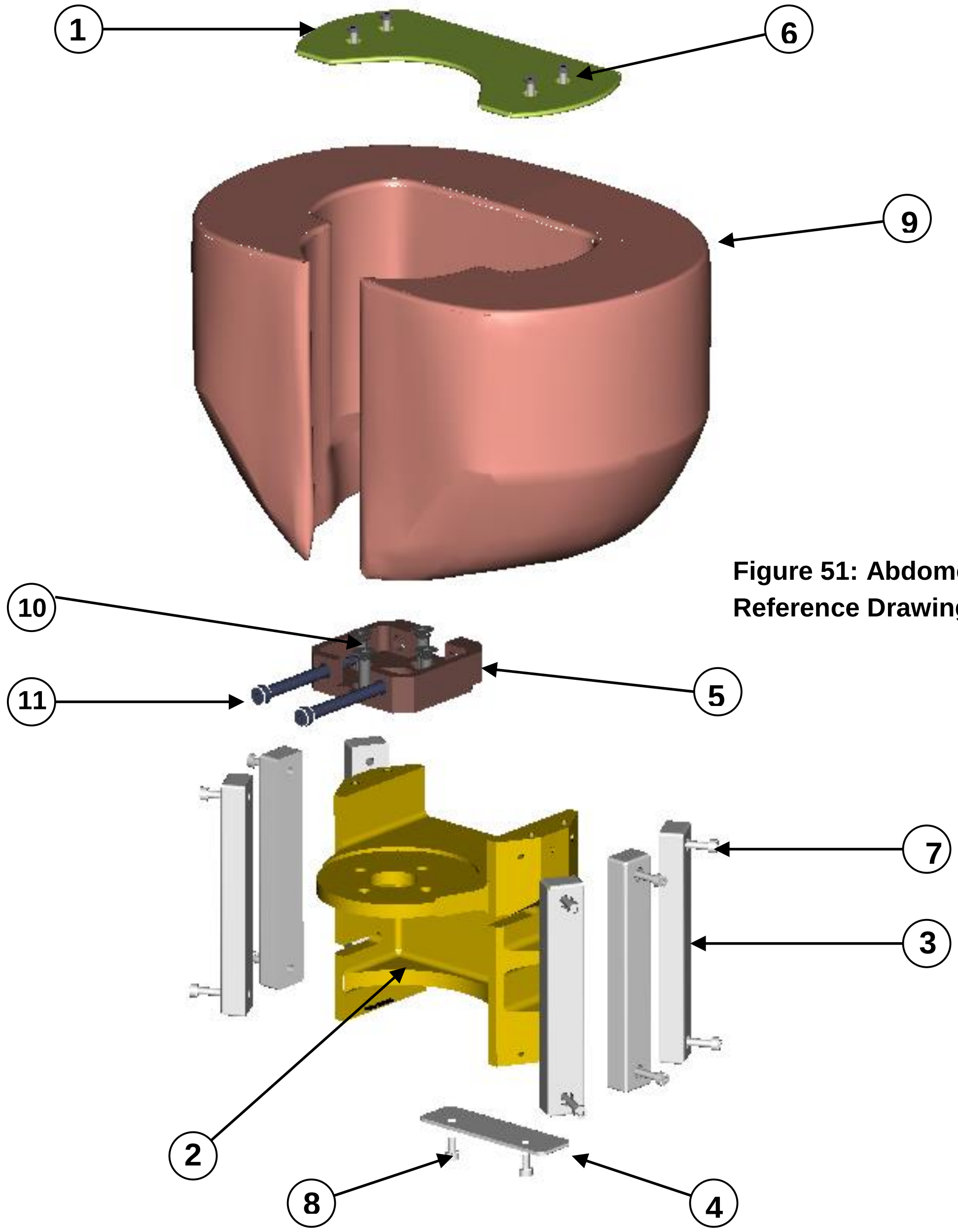


Figure 51: Abdomen Assembly Reference Drawing 175-5000

Parts List for Abdomen Assembly,

Item	Part Number	Qty.	Description
1	175-5001	1	Cover Plate
2	175-5002	1	Abdominal Drum
3	175-5003	3(6 total)	Transducer Structural Replacement
4	175-5004	1	Latching Plate
5	175-5005	1	T-12 Base Adaptor (B-4328)
6	5000023	4	Screw, FHCS M4 x 10
7	5000025	12	Screw, SHCS M4 x 16
8	5000024	2	Screw, SHCS M4 x 8
9	175-5010	1	Abdomen Molded Assembly, Certified
10	9000591	4	Screw, FHCS ¼-20 x 1
11	5000089	2	Screw, SHSS M8 x 60

4.10 Lumbar Spine

Before the lumbar spine can be reached, the abdomen has to be removed. Refer to Section 4.9 for abdomen disassembly. After the abdomen is removed, the lumbar spine is exposed, see Figure 53. To remove the lumbar spine, unscrew three M8x25 SHCS screws (5000030) at the sacrum cover plate or the lower spine load cell to remove it from the sacrum block in the pelvis. The sacrum cover plate can be removed from the lumbar spine by unscrewing three UNC ¼"-20 x ¾" screws (9000144) underneath the lumbar spine. In case of application of the lower lumbar spine load cell, there are four UNC ¼"-20 x ¾" screws (9000144) underneath the lumbar spine.

The steel cable can be removed from the rubber central part by unscrewing the UNF ½"-20 nut (9000005) on top of the lumbar spine. To prevent the spine cable from twisting during release and fastening of the nut, the cable must be held with a screwdriver. It is advised to lock the nut with "locktite 222" nut-lock agent. Reassembly of the lumbar spine is in reverse order.

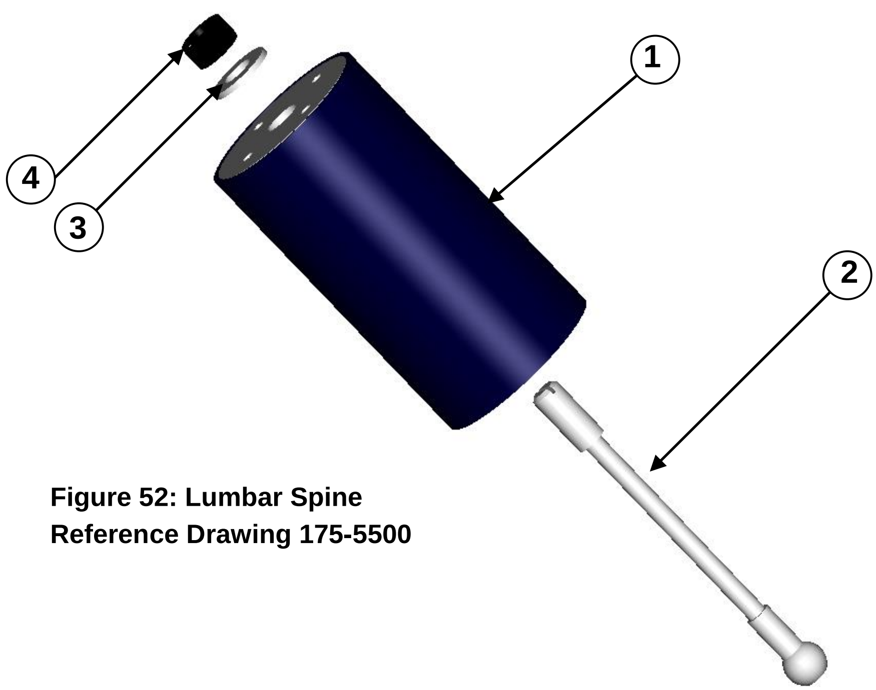


Figure 52: Lumbar Spine
Reference Drawing 175-5500

Parts list for Lumbar Spine Assembly

Item	Part Number	Qty.	Description
1	175-5501	1	Lumbar Spine Molded, Tested
	175-5505	1	Lumbar Cable Assembly (includes items 2 - 4)
2	175-5506	1	Cable, Lumbar
3	5000267	1	Washer 13mm ID x 24mm OD x 2.5mm THK.
4	9000057	1	Nut Hex ½-20

Figure 53: ES-2re Lumbar Spine and Bottom Plate Mounted on Pelvis Assembly

4.11 Pelvis

4.11.1 Disassembly

Once the upper part of the dummy has been detached (see Section 4.7) and the abdomen and the lumbar spine have been removed (see Sections 4.9 and 4.10), the pelvis can be disassembled.

The legs can be removed from the pelvis by unscrewing the M12x40 SHSS screws (5000033). These can be reached through the most forward holes on the side of the pelvis.

Pull out the H-point foam blocks from the pelvis flesh. Unscrew the M6x16 LHCS screws (5000296) in the center of the H-point back plate (see Figure 54). The H-point back plate and its buffer assembly will come out easily, see Figure 55.

To remove the pubic symphysis force transducer or the structural replacement, unscrew the transducer bushings (175-6001) at both sides using an extended socket wrench 13 mm across flats. The bushings can be reached through the openings where the H-point assemblies were fitted. After unscrewing them completely from the transducer thread, bushings will still be held against the iliac wings. Now screw the pelvis puller tool into the head of the transducer bushing and pull it out. Then the force transducer and spacers can be removed from the top side.

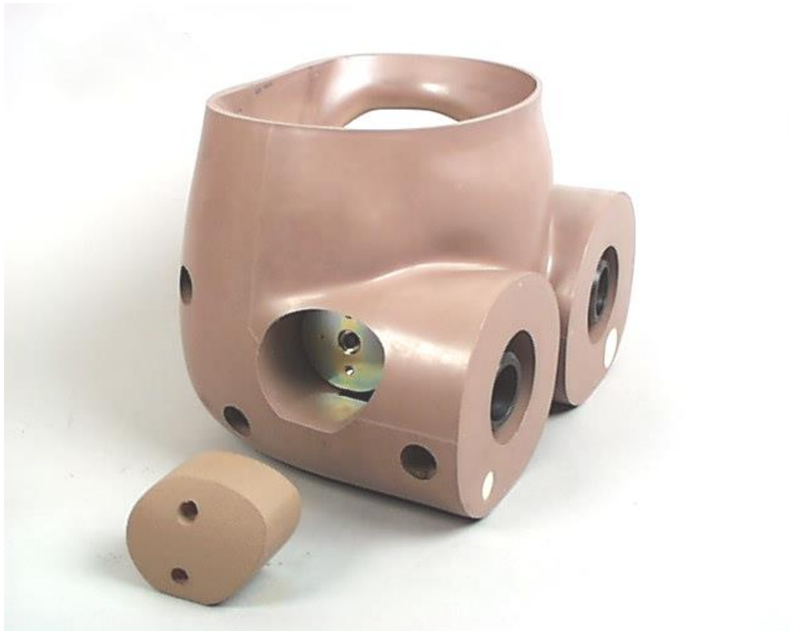


Figure 54: ES-2re Pelvis with H-point Foam Block Removed Showing H-point Back Plate

Figure 55: ES-2re H-point Back Plate and its Buffer Assembly Removed

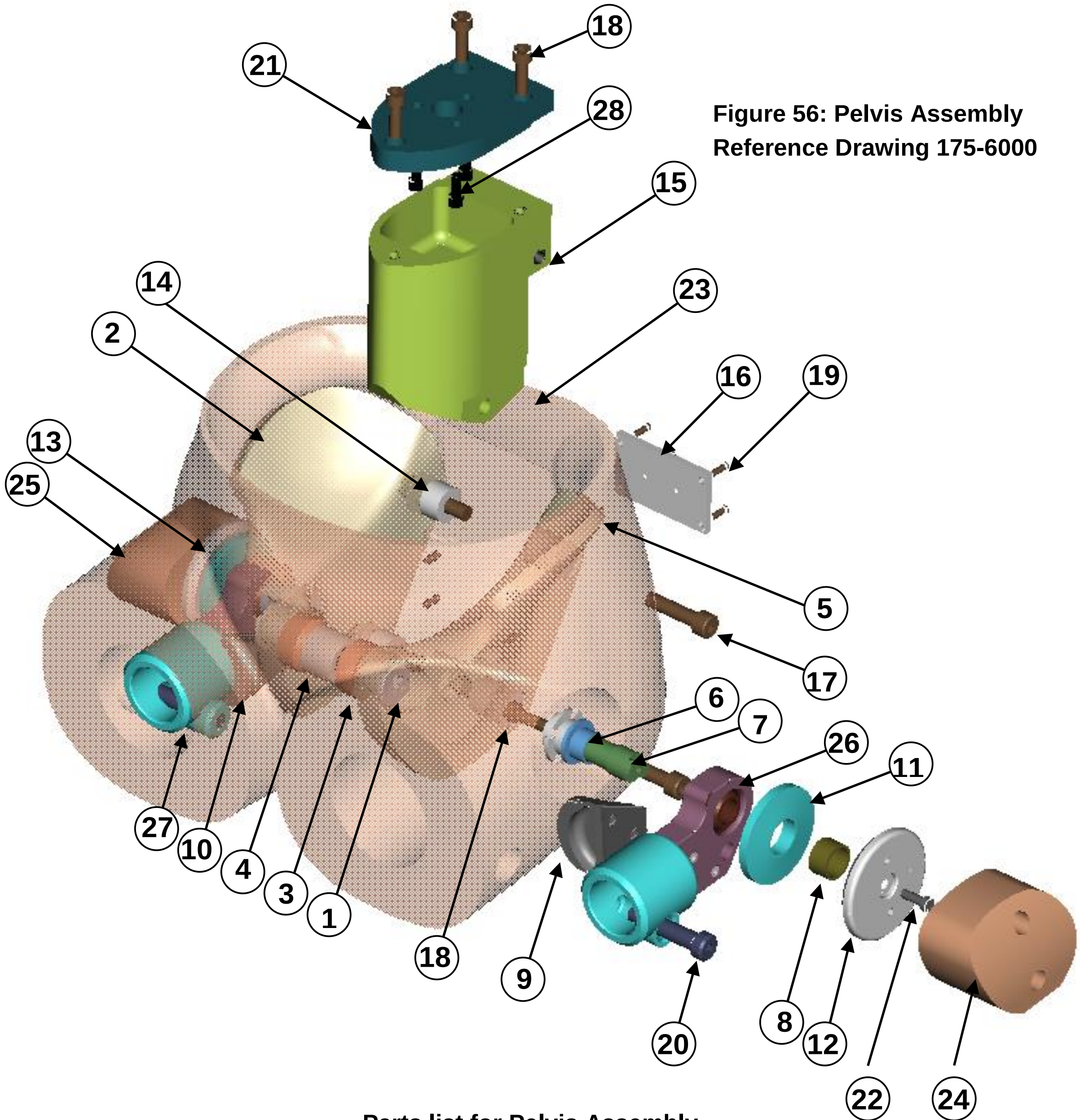


Figure 56: Pelvis Assembly Reference Drawing 175-6000

Parts list for Pelvis Assembly

Item	Part Number	Qty.	Description
1	175-6001	2	Transducer Bushing
2	175-6002	1	Iliac Wing Assembly Right
3	175-6005	2	Transducer Spacer
4	175-6006	1	Load Cell Structural Replacement
5	175-6010	1	Iliac Wing Assembly Left
6	175-6011	2	Spacer Ring
7	175-6012	2	Hip Pivot Pin
8	175-6013	2	Tube Stop
9	175-6015	1	Femur Buffer Assembly Left
10	175-6020	1	Femur Buffer Assembly Right
11	175-6025	2	Back Plate Buffer
12	175-6026	1	H-point Back Plate Left
13	175-6027	1	H-point Back Plate Right

14	175-6030	4	Sacrum Spacer
15	175-6040	1	Sacrum Block
16	175-6041	1	Sacrum Cover Plate
17	5000032	4	Screw SHCS M10 x 40
18	5000030	5	Screw SHCS M8 x 25
19	5000005	4	Screw BHCS M4 x 12
20	5000033	2	Screw MSHSS M12 x40
21	175-6045	1	Lumbar Mounting Plate
22	5000296	2	Screw LHCS M6 x 16
23	175-6050	1	Pelvis Molded
24	175-6055	1	H-Point Foam Block Left
25	175-6056	1	H-Point Foam Block Right
26	175-6060	1	Upper Femur w/ Bearing Left
27	175-6065	1	Upper Femur w/ Bearing Right
28	9000144	3	Screw, SHCS ¼-20 x 5/8

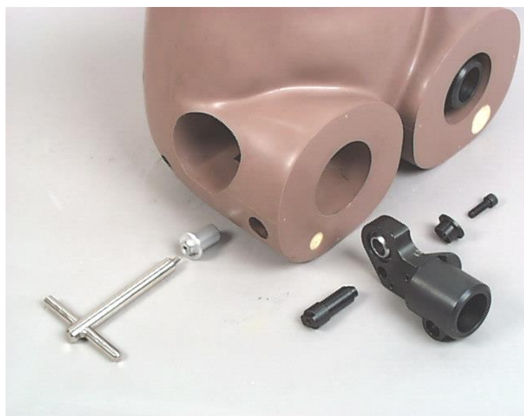


Figure 57: ES-2re Pelvis, Transducer Bushing and Upper Femur Removed

Disassembly of the upper femur is easier if the pubic force transducer is removed from the pelvis. The upper femur can be removed by unscrewing the M8 x 25 SHCS screw (5000030) located on the inside of the iliac wing. The hip pivot pins are held against rotation by a rectangular fit in the iliac wing. After pulling the hip pivot pins out, the upper femurs come out of the front (see Figure 57).

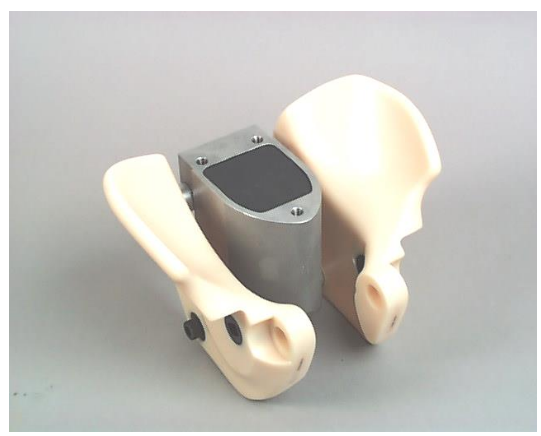


Figure 58: Pelvis Sacrum Block and Iliac Wings

Once the upper femurs and pubic force transducer have been removed, the iliac wings and sacrum block can be separated from the pelvis flesh molding. First, remove the sacrum block by unscrewing the two M10x40 SHCS screws (5000032) at each side that can be reached through the rearmost holes in the sides of the pelvis (see Figure 54).Pull the sacrum-block out of the pelvis and note the two spacer rings between sacrum block and iliac wing on both sides. When the sacrum block (Item 15) has been removed, loosen the transducer bushing (Item 1) with a 13mm hex socket then remove the transducer spacer (Item 3), next the illiac wings can be pulled out of the pelvis flesh molding.

4.11.2 Assembly

Assembly of the pelvis is in reverse order of disassembly. When reassembling the pelvis, attention should be paid to the tightening of the transducer bushings. The direction of the cable coming out of the transducer should point towards the lumbar mounting plate to prevent damaging the cable in tests. Tighten the transducer bushings with a torque of 10 Nm.

The H-point left and right back plates are not interchangeable. When assembling the H-point back plates, note that the flat side is facing downward.

4.12 Legs

The legs can be removed from the pelvis by unscrewing the M12x40 SHSS screws (5000033). These can be reached through the most forward holes on the side of pelvis flesh molding. To disassemble the femur load cells or structural replacements, unscrew the 3/8-16 x 2 SHCS screw (9000405) from the upper knee and the 3/8-16 x 1-3/4 SHCS screw (9000449) from the upper leg weldment. Check drawing 175-7000-1/2 for information on the internal components of the leg.

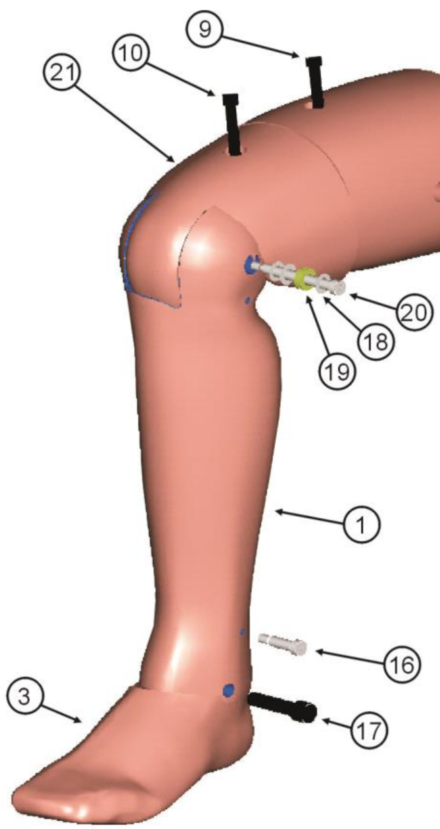


Figure 59: Leg Assembly, Left Reference Drawing 175-7000-1

Parts List for Legs (Left/Right)

Item	Part Number	Qty. / Leg	Description
1	175-7001-1/2	1	Lower Leg Assembly, Left/Right
2	175-7020-1/2	1	Ankle Rotation Assembly, Left/Right
3	175-7030-1/2	1	Foot Molded Assembly, Left/Right
4	175-7040	1	Washer
5	175-7050-1/2	1	Knee Joint Assembly, Left/Right
6	175-7060	1	Bushing
7	175-7065	1	Load Cell Simulator – Femur
8	175-7070	1	Upper Leg Bone Weldment
9	9000449	1	Screw, SHCS 3/8-16 x 1-3/4
10	9000405	1	Screw, SHCS 3/8-16 x 2
11	9000118	1	Washer, Spring Lock 5/16 (Bolt Size)
12	9000113	1	Screw, SHCS 5/16-24 x 7/8
13	9000117	1	Washer, Heavy Lock ¼ (Bolt Size)
14	9000115	1	Screw, SHCS ¼-28 x ½
15	9000119	1	Screw, SHCS #6-32 x ½
16	9000074	1	Screw, SHSS 3/8 x 1
17	9000111	1	Screw, SHCS ½-20 x 2
18	9000116	3	Washer Schnorr – Disc Spring
19	9000443	1	Thrust Bearing #B5-5
20	175-7080	1	Screw, SHSS 3/8 x 3
21	175-7085-1/2	1	Knee Flesh, Left/Right
22	175-7090-1/2	1	Thigh Molded, Left/Right

5 Certification

NOTE:
All corridors are specified in the Final Rule, 49 CFR Part 572, Subpart U comment period.

5.1 Introduction

The certification procedures for the various body parts are primarily based on the use of standard Part 572 [ref. 2] equipment. An exception is made for the thorax. The rib modules are separately tested in three series of drop tests.

Depending on the side to be impacted, dummy parts should be certified on the left or right side. The direction of the rib modules (including instrumentation) and the abdominal force transducers should be converted to the desired impact side (see Sections 4.7 and 4.9 for thorax and abdomen, respectively).

The certification tests on the dummy can be distinguished into two categories: component tests and full body tests.

Component tests:

- **Head** : a free-fall drop test with the side of the head impacting a flat rigid surface. Equipment needed is similar to equipment used in Part 572 subpart E;
- **Neck** : a test with a Part 572 subpart E pendulum using the EUROSID-1 head form and ES-2re interface, causing lateral flexion, as well as rotation and translation of the neck top interface;
- **Thorax** : impactor drop tests on each rib module;
- **Lumbar Spine** : a test with a Part 572 subpart E pendulum using the EUROSID-1 head form and ES-2re interface, causing lateral flexion, as well as rotation and translation of the lumbar spine top interface.

Full body tests:

- **Shoulder** : a lateral impact with the Part 572 subpart E, four wire suspended 23.4 kg impactor on the upper arm pivot;
- **Abdomen** : a lateral impact with the Part 572 subpart E, eight-wire suspended 23.4 kg impactor equipped with a 1.0 kg arm rest-face, on the center of the abdomen; Total weight 24.4 kg;
- **Pelvis** : a lateral impact with the Part 572 subpart E, eight wire suspended 23.4 kg impactor on the H-point of the dummy.
- **Thorax** : a lateral impact with the Part 572 subpart E, eight wire suspended 23.4 kg impactor on the middle rib of the dummy.

The certification procedure of each body part is described in Section 5.6 – 5.13. Special tuning and certification equipment necessary to perform the tests is described in Section 5.2. In Section 5.3, time interval requirements for the ES-2re certification tests are given and Section 5.4 deals with the trigger levels and time shifts to be used for processing ES-2re certification data.

NOTE:

The ES-2re certification tests are in generally equivalent to those applicable to its predecessor, ES-2. Some details of the certification procedures for the neck, thorax, abdomen and lumbar spine are revised.

5.2 Certification and Tuning Equipment

For the free-fall head drop test, a support and release mechanism as well as a rigid, flat impact surface is necessary. The release mechanism and impact surface can be similar to that of the Standard Part 572 subpart E head drop test [ref. 2]. The ES-2re head drop support can be used or any user-made item with a mass of 0.075 ± 0.005 kg that ensures the correct orientation of the head may be used.

Figure 60: ES-2re Head Drop Support

For the neck and lumbar spine tests, a pendulum is required similar to the Standard Part 572 subpart E, neck-bending pendulum [ref.2]. The pendulum is decelerated by aluminum honeycomb (crush strength 1.8 lbs. /cu. ft). The Lumbar spine and neck are tested using a head form (175-9000). The head form includes three rotational potentiometers so that no additional instrumentation is needed to measure the rotations of the head form. The head form is similar to the device used with Eurosid 1 and ES-2 dummies.

NOTE:

The slotted holes in the interface plate allow assembly to all known head form configurations.

Figure 61: ES-2re Neck and Lumbar Spine Interface Plate for Certification (175-9029)

For the impacts to the shoulder, abdomen and pelvis, a wire suspended Standard Part 572 subpart E pendulum is necessary [ref. 2]. In the abdomen test, this pendulum is equipped with an 'armrest' face. This impactor face is different from that of the Eurosid-1 and ES-2 dummies.

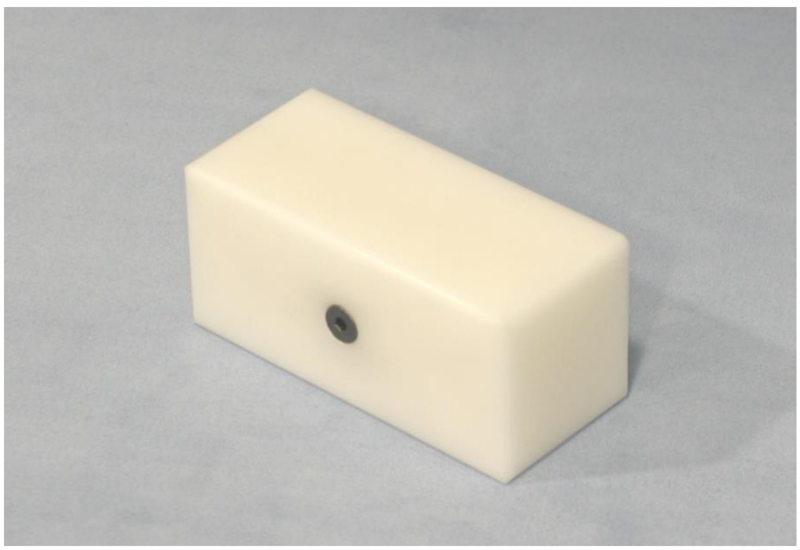


Figure 62: Armrest for Abdomen Calibration (TE-376)

For the certification of the rib modules and for the inspection tests on the dampers and rib only, a drop test rig is required. This drop rig consists of two different impactor faces, a release system, drop mass guiding cables, two different mounting brackets, a displacement measuring system and a support table. The drop rig is equivalent to the drop rig used for Eurosid-1 calibration, except for the ES-2re rib support shown below.

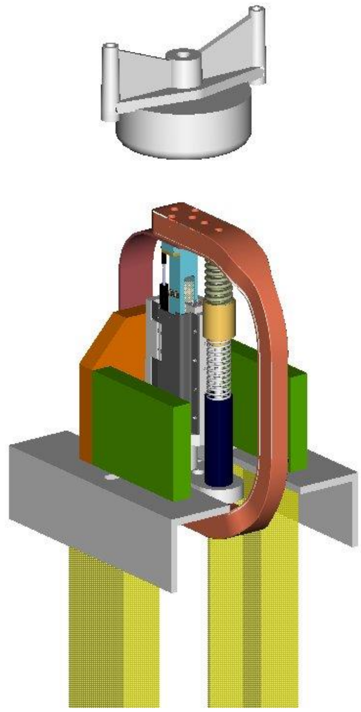


Figure 63: ES-2re Rib Support for Drop Rig, (H.AF)

Tuning springs are necessary for tuning of the ribs. A set of tuning springs is included in the ES-2re toolbox. Damper oil is required for servicing the dampers. Only use the damper oil provided in the toolbox.

5.3 Time Intervals In Between ES-2re Certification Tests

TEST ENVIRONMENT CONSIDERATIONS:
All testing done with ES-2re Crash Test Dummy should be performed in an enviroment at a temperature between 20.6 and 22.2 °C and a relative humidity of 10 to 70%.

When conducting certification tests or executing component testing, a minimal time interval between two tests should be observed. The following table shows the required time intervals per test.

Table 6: ES-2re Time Interval between Tests

Component	Time interval
Head	2 hrs
Neck	30 min
Shoulder	30 min
Ribs	5/30 min*
Lumbar spine	30 min
Abdomen	30 min
Pelvis	30 min

* *Between rib tests in a test cycle (all impact velocities) the time interval is 5 minutes. Between two separate test cycles, the time interval is 30 minutes.*

5.4 Trigger levels and time shifts for ES-2re Certifications

In some of the ES-2re certification procedures, a time requirement is specified. To apply the time requirement, it is necessary to define a 'time zero'. The following paragraphs indicate the required time shifts and 'time zero' definitions for the various ES-2re certification tests.

5.4.1 Neck and Lumbar Spine Pendulum Tests

For the neck and lumbar spine pendulum tests, the following sequence is required to obtain the correct time shift for all signals:

- Pendulum acceleration should be processed using an ISO 6487 or SAE J211 Channel Filter Class 60;
- Determine the instant in time at which the pendulum acceleration response crosses the -10.0 g level (T_{10}) for the first time;
- Calculate the time shift by T_{10}-T_m,
  (T_m = point in the middle of the pendulum acceleration corridor at the -10.0 g level);
- Shift all time responses by the above time shift.

Table 7: ES-2re Time Shift, T_m, For Neck and Lumbar Spine Certification Tests

Dummy Part	T_m (msec)
Neck	1.417
Spine	1.588

After filtering all individual data channels, the corrected time responses can be checked with respect to the required time corridors.

5.4.2 Full-body Certifications

For all full-body certification tests (shoulder, abdomen and pelvis) of the ES-2re, the following sequence should be used to achieve the correct time shift and 'time zero' for all channels:

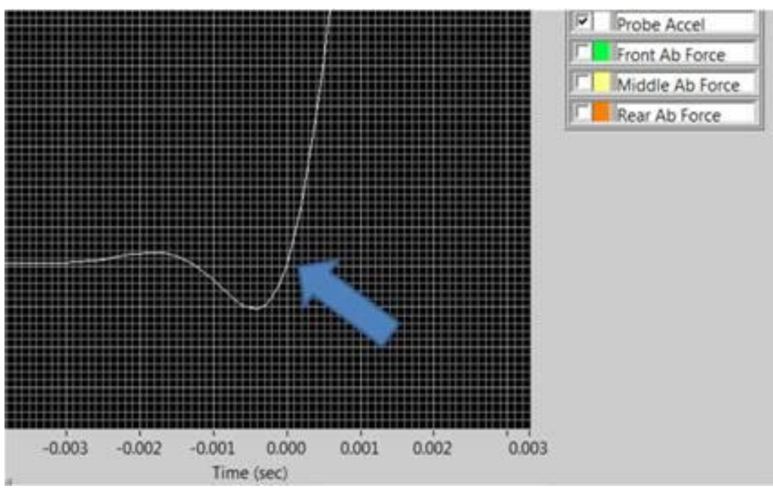
- Pendulum acceleration should be processed using an ISO 6487 or SAE J211 digital Channel Filter Class 180;

- Determine the instant in time at which the pendulum acceleration response crosses the 1.0 m/s^2 level for the first time (T_0), do this when the probe acceleration is positive. In case the probe acceleration is negative, the -1.0 m/s^2 must be used. Make sure that the T_0 that is searched for has the same polarity as the probe accelerometer (the arrow in the picture below is T_0).

- Calculate the time shift by T_0 - T_E,
  (T_E = time point of external trigger used in test);

- Shift all time responses by the above time shift.

The corrected data can be checked against the required time corridors.



5.5 Head

5.5.1 Introduction

The head should be visually inspected for damage to the skin and/or skull.

5.5.2 Test Set Up

This test uses the complete head assembly, which consists of the head assembly and the upper neck load cell structural replacement. The head has to be instrumented with a tri-axial accelerometer located at its center of gravity. Accelerations are to be filtered using ISO 6487 or SAE J211 Channel Filter Class 1000.

The head must be positioned with 200 ± 0.25 mm spacing above a flat, rigid impact surface, as described in Part 572 subpart E (surface finish between 8 and 80 micro-inches). The impact surface must be horizontal and the head has to be oriented such that its midsagittal plane has an angle of 35° ± 1° with the impact surface and its anterior-posterior axis is horizontal ± 1° (see Figure 64).

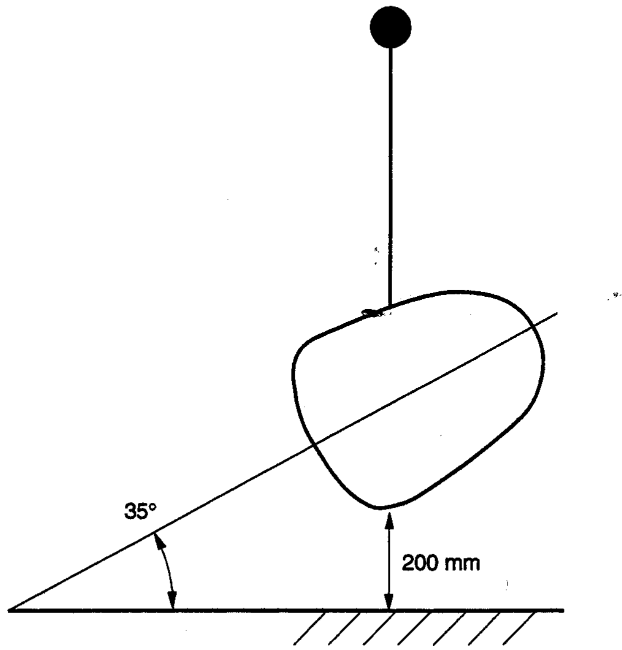


Figure 64: ES-2re Head Orientation Definition in Certification Test

A 'quick release' mechanism is required to drop the head on the impact surface. The head drop support should be attached to the base of the upper neck load cell structural replacement with the mark "F" to the front of the head, see Figure 65. For ease of assembly, it is advised to attach the head drop interface to the load cell replacement and then assemble both in the head and fasten the screws. Figure 66 shows the head drop for a left side impact. For a right side impact, reverse the head drop support by unscrewing the plastic rod from the aluminum base and assemble the parts turned 180°.

5.5.3 Requirements

The head passes the test if the peak resultant head acceleration is between 125 g and 155 g, unimodal 15% and frontal ±15 g. No use of lubricant (e.g. talcum powder) is allowed. In case of failure of the test, the skin should be replaced.

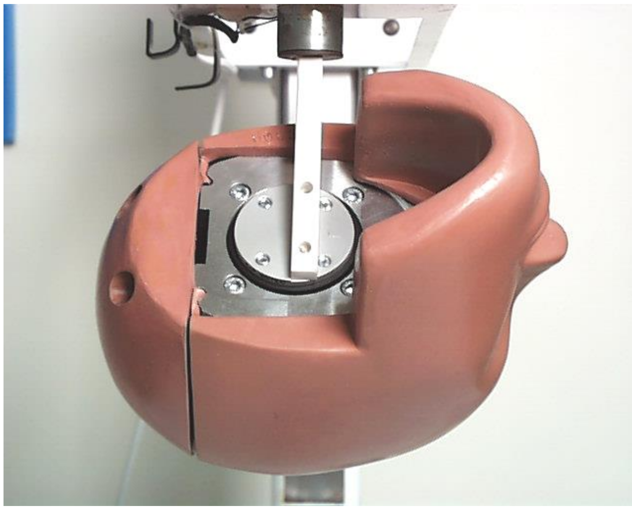


Figure 65: ES-2re Head Support Bracket Installed on the Head (Note the Orientation)

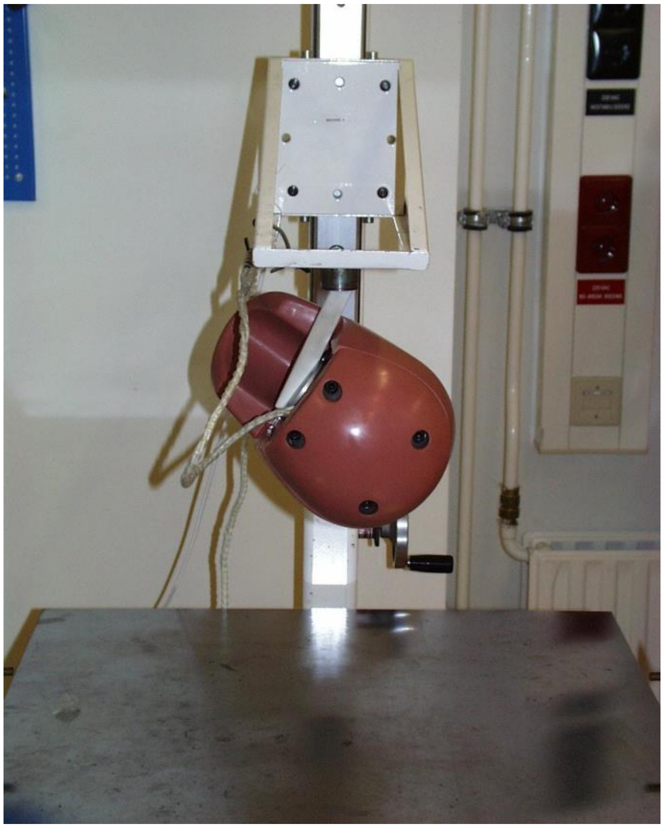


Figure 66: ES-2re Head Positioned Above a Drop Table

5.6 Neck

5.6.1 Introduction

The neck should be disassembled from the dummy (see Sections 4.4 and 4.5) and be visually inspected. If the neck is permanently bent or twisted, the circular section buffers and/or the central part must be replaced (see Section 4.4). If the central rubber section is damaged (e.g. tears) it must be replaced.

Grease the contact areas of the upper and lower half-spherical screws with appropriate grease (e.g. a high-pressure lubricant). The half-spherical screws are tightened using a torque of 88±5 in·lb, applied using the special ES-2re neck compression tool.

A dynamic calibration test using the Part 572 subpart E pendulum and the head form (175-9000) should be performed as described in the following sections.

5.6.2 Test Set Up

Attach the neck to the ES-2re head form interface plate with four M6x10 cap head screws. Mount the head form is with its rotational potentiometers on the LHS (looking in the direction of impact).

CAUTION:

The length of the screws is different from the screws used in the dummy. Therefore, make sure that screws do not protrude into the neck rubber and the screw ends are flush with the face of the neck interface plate.

The head form interface can now be attached to the head form with four M6 cap heads. The base of the neck is attached to the pendulum interface with M6 screws. Again, make sure these screws do not protrude into the neck rubber since this will influence performance; adjust the length of the screws accordingly. Attach the mounting base onto the pendulum, using four M6 screws.

Carefully slide the carbon fiber rods through the potentiometer housings on the pendulum. First, slide the pivot of the potentiometer closest to the pendulum over the central carbon fiber rod in the head form, followed by a small spacer ring and finally the second pivot, which has to be carefully tightened with the two M4 set screws. Be careful to not damage the carbon fiber rod when tightening these screws.

CAUTION:

Make sure that potentiometer C, which measures the angle of the head form, is connected to the rod of potentiometer A, which measures the fore angle. This is important to obtain correct results. See figure 67.

The pendulum must be vertical when the impact speed is decelerated until zero m/s. To obtain this vertical position of the pendulum, the aluminum honeycomb (this is: 1.8 lbs./cu. ft.) should have a nominal height of 76.2 mm (= 3 inches). The pendulum has to be equipped with a uni-axial accelerometer. The sensitive axis of the accelerometer should be 1657.4 mm from the pendulum pivot in accordance with Standard Part 572 subpart E.

The neck should be kept in the test room for a period of at least four hours prior to a test at a temperature of 20.6 – 22.2°C and humidity of 10 to 70%. The period in which the pendulum is in pre-impact position (i.e. not the vertical position) should not exceed 5 minutes.

The head form rotations are measured with the three rotational potentiometers. Data acquisition should be in accordance with ISO 6487 or SAE J211. The fore (A) and aft (B) pendulum base angles (see Figure 64) are directly measured during the certification test. The flexion angle of the head form must be determined using the following equation:

$$\beta = \Theta_A + \Theta_C - \pi/2$$

or

$$\beta = d\Theta_A + d\Theta_C$$

in which $d\Theta_A$ and $d\Theta_C$ are the deviations of the angles Θ_A and Θ_C (see Figure 67). After this calculation, all rotations are digitally filtered using ISO 6487 or SAE J211 CFC 180. The pendulum acceleration is also filtered digitally using ISO 6487 or SAE J211 CFC 60.

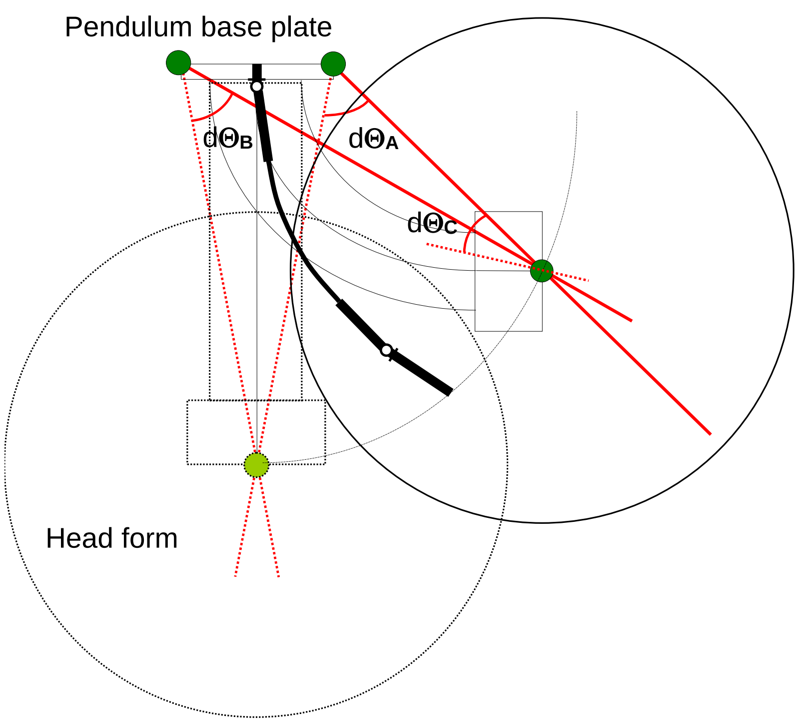


Figure 67: ES-2re Neck Certification: Angles Measured With Head Form Set-Up

The pendulum is released and allowed to fall freely from a height chosen to achieve an impact velocity of 3.4 ± 0.1 m/s, measured at the center of the accelerometer, 1657.4 mm from the pendulum axis. The velocity time-history of the pendulum should be inside the corridor specified in Figure 68.

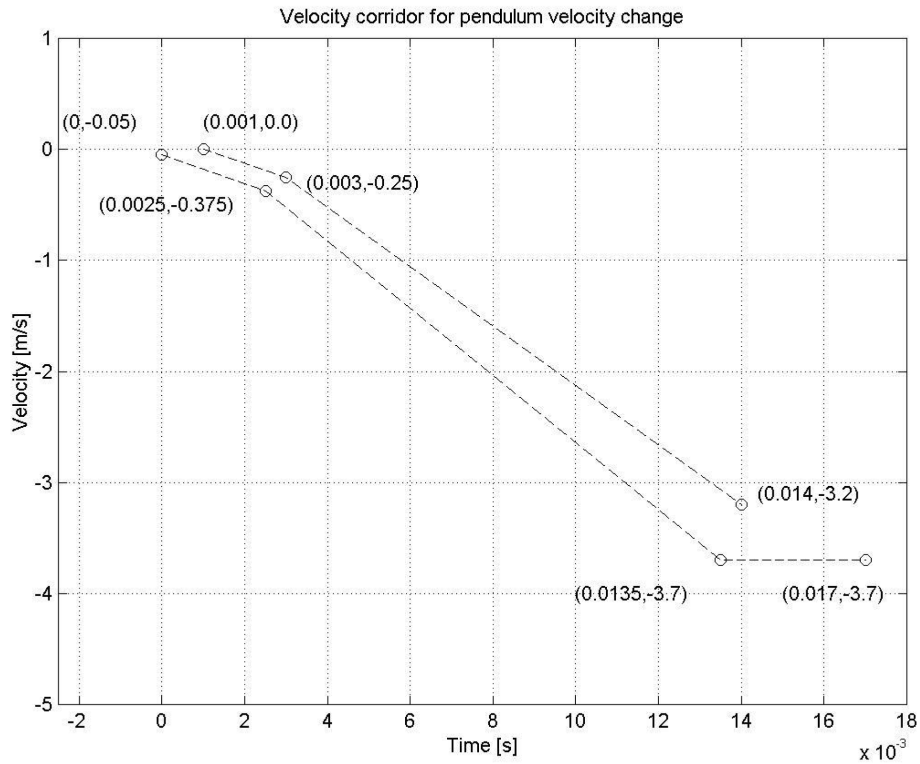


Figure 68: ES-2re Neck Certification Pendulum Velocity Corridor Graph

Table 8: ES-2re Neck Certification Pendulum Velocity Corridor

Upper Boundary		**Lower Boundary**	
Time [s]	**Velocity [m/s]**	**Time [s]**	**Velocity [m/s]**
0.001	0.0	0	-0.05
0.003	-0.25	0.0025	-0.375
0.014	-3.2	0.0135	-3.7
		0.017	-3.7

5.6.3 Requirements

The neck passes this test, if the following requirements are met:

- The maximum head flexion angle relative to the pendulum is 49 – 59 degrees and should occur between 54 and 66 ms., from time zero.
- The decaying headform translation-rotation vs. time curve shall cross the zero angle with respect to its initial position at time of impact relative to the pendulum centerline between 53 ms to 88 ms after the time the peak translation-rotation value is reached.

If the required values cannot be achieved, all eight circular section buffers can be replaced by buffers with a different hardness. Refer to Section 4.5 for assembly instructions of the buffers. A set of circular section buffers with a hardness of 60 (red), 70 (yellow) and 80 Shore A (blue) is supplied in the toolbox. If the given values cannot be achieved by using these buffers, the central part of the neck should be exchanged.

5.6.4 Calculation of Moments at the Occipital Condyles (OC)

The OC joint of the Eurosid dummy lies at the upper spherical joint. The location is 5 mm below the interface plane between the neck interface plate and the load cell, and along the neck central axis line. This means that the OC joint lies 20 mm below the neutral axes of the transducer. The measured moments must be corrected as follows:

$$M_{x,oc} = M_{x,measured} + 0.02 \cdot F_{y,measured}$$

and

$$M_{y,oc} = M_{y,measured} - 0.02 \cdot F_{x,measured}$$

5.7 Arm

No dynamic certification procedure is defined for the arms. Testing of the arm flesh is part of the shoulder certification (see Section 5.8). The mechanism of the joints and the construction of the arms should be visually inspected for damage.

5.8 Shoulder

5.8.1 Introduction

The construction of the shoulder (i.e. bearing, U-spring, elastic cords) and the condition of the arm flesh should be inspected for damage. The construction should be clean. The shoulder is checked statically as well as dynamically.

5.8.2 Static Test

The elastic cord tension must be set prior to certification. The arm should be removed (see Section 4.8) and the M10x30 button head screw inserted in the shoulder cam. The force required to move the shoulder cam forward, when applied at 4±1 mm of the outer edge of the clavicle and applied in the same plane as the clavicle movement, should be between 27.5 N and 32.5 N.

To set the elastic cord tension, the length of the elastic cord should be adjusted at elastic cord holder. Refer to Section 4.6 for instructions. After setting the elastic cord tension, check that the clavicles can travel the full range of motion and come to a stop on the cam stop blocks inside the shoulder box. If the shoulder range of motion is limited by the maximum extension of the elastic cord, the latter is worn and must be replaced. A dynamic test should then be performed as described in the following section.

5.8.3 Dynamic Test Set Up

The dummy (without suit and removed shoulder foam cap) is seated on a flat, horizontal, rigid surface without back support. Two sheets of 2 mm thick PTFE (Teflon) are placed between the dummy and the surface. The dummy legs should be horizontal and symmetrical about the midsaggital plane; the distance between the ankles should be 100 ± 5 mm, and the thorax vertical, i.e. when the torso back plate is vertical ± 2 degrees (measured at the rib extension cover). The dummy should not be supported to maintain this position. The dummy should be positioned such that the anterior-posterior axis of the dummy is perpendicular to the direction of impact. The position of the centerline of the impactor and the center pivot axis, i.e. the M10 x 25 pivot arm bolt of the upper arm, should be aligned within ± 5 mm and aligned so that at contact with the shoulder, its longitudinal axis is within ±0.5 degrees of a horizontal plane and perpendicular (±0.5 degrees) to the midsagittal plane of the dummy. The arms are oriented forward at the position of 50±2 degrees from horizontal, pointing downward. This is the middle pivot stop in the shoulder joint.

The impactor is the Standard Part 572 subpart E pendulum of 23.4 kg and 152.4 ± 0.25 mm diameter. The impactor must be suspended from rigid hinges by four wires, it is recommended that the centerline of the impactor at least 3.5 m below the rigid hinges, it is also recommended that the included angle of the wires must not be more than 20 degrees (viewed along the axis of the impactor). The impactor should freely swing towards the shoulder of the dummy. The impact velocity of the impactor has to be 4.3 m/s ± 0.1 m/s.

The impactor is equipped with an accelerometer sensitive in the direction of impact and located on the impactor axis. The acceleration signal should be filtered to ISO 6487 or SAE J211 Channel Filter Class 180.

5.8.4 Shoulder Requirements

The arm and shoulder pass the certification tests if the peak acceleration of the impactor is between 7.5 and 10.5 G during contact with the dummy. If the shoulder fails to meet the requirements, the elastic cord adjustment must be checked. If the shoulder, in repeated tests, fails to meet these specifications, the arm should be replaced.

5.9 Thorax

5.9.1 Introduction

Two components of the rib unit determine the performance: the damper and the rib. If the rib unit fails the test, component inspection tests should be carried out. The certification tests of the ES-2re thorax as well as the component inspection tests can be performed on a drop test rig. The procedure for thorax certification is shown in Figure 69.

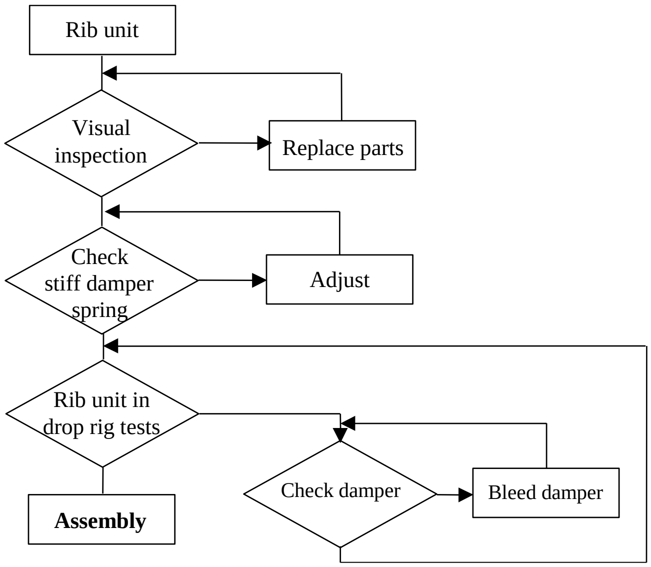


Figure 69: Thorax Certification Flow Chart

Each full rib module is certified separately. A maximum displacement corridor for two impact velocities is specified for the rib module. First, the rib module must be visually checked.

Following the visual inspection, the adjustment of the stiff damper spring should be checked and if necessary adjusted (see Section 4.7). If the cup is screwed on too far, so that the damper is pre-compressed, the rib can fail although the individual components are in correct working order.

If the module fails to meet the certification corridor then the damper must be removed and the presence of air in the damper must be audibly checked (see Section 4.7.3). If there is air in the damper oil, the damper should be bled, refitted in the rib and the full module should be tested again. If the rib module still fails to meet the requirements, the damper performance must be checked (see Section 5.9.5).

5.9.2 Visual Inspection of Rib Unit

The full rib module should first be visually inspected for signs of damage, e.g. flesh damage, damaged piston, play in the linear bearing, non-symmetry in the rib, loss of oil from the damper. In addition, check that the rib easily expands back out to the bump stop without assistance. If the module appears satisfactory and the damper spring is correctly adjusted, so that no axial play exists (see Section 4.7) between rib and damper, the full rib module should be evaluated in the certification procedure described below. If the rib flesh is damaged, the rib must be replaced. A repair service is available through your local Humanetics office.

5.9.3 Test Set Up

The drop test rig with a falling weight is used for the complete rib module certification see Figure 71. A free fall impactor with mass of 7.78 ± 0.01 kg free and with a flat face with 150.0 mm diameter is used for these tests. The rib unit is tested at two different impactor velocities. Displacement of the rib is measured with the rib unit's displacement transducer.

The rib module is mounted in the drop rig, impacted side up with the centerline of the mass, aligned with the centerline of the guide system piston. The ES-2re rib unit is mounted in the drop rig with a special bracket that makes use of the threads in the rib guidance bracket for rib to spine box attachment.

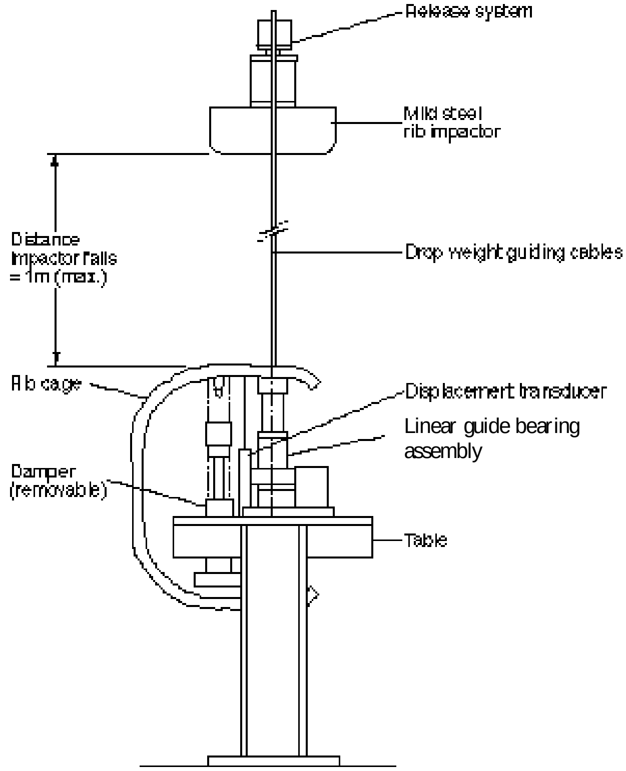


Figure 70: ES-2re Rib Unit Certification Test Set Up

5.9.4 Requirements for the Full Rib Unit

The 7.78 kg mass should fall freely onto the rib using impact velocities at 3 and 4 m/s. For each impact, the peak rib deflection should be recorded. The impact energies required are specified by impact speed of the impactor. The impact speed is to be measured and reported. The impact speeds and the performance requirements are given in Table 9.

Table 9: ES-2re rib unit certification requirements

Test sequence	Drop Height (mm)	Minimum Displacement (mm)	Maximum Displacement (mm)
1	815±8	46.0	51.0
2	459±5	36.0	40.0

Testing of the rib module should be carried out using the following procedure. See also Figure 69 for a flowchart of the rib module certification sequence:

- Attach the rib module to the drop test rig.
- Perform the drop test at the high impact velocity.
- Use if necessary a stiffer or weaker tuning spring (for available tuning spring stiffness and the corresponding colors, see Table 5.
- If the rib module fails to meet the requirements the following should be checked:
  1. The test can be repeated to ensure that the first drop test was executed correctly.
  2. If the rib still fails to meet the requirements the rib unit should be removed from the test rig and the damper should be removed from the rib unit. The damper should be checked for the presence of air in the oil. If air is present the damper should be bled (Section 4.7.3) and the damper should be tested according Section 5.9.5. If the damper fails to comply with the inspection test requirements after bleeding, the damper should be replaced.
  3. After reassembly of the damper, the rib unit should be tested again.
  4. If the module still fails, the rib bow itself should be checked carefully on its integrity. The rib bow must be replaced in case of permanent deformation. After replacement of any part, the module should be tested again.
- If the rib unit passes the high impact velocity test, then complete the drop tests in the sequence as indicated (high - low - medium impact velocity).

5.9.5 Damper Inspection Test

The damper inspection tests can be performed to check functionality of the damper. The tests are only performed if the complete rib unit fails to comply with its certification requirement (see section 5.9.4).

The drop test rig can also be used for the damper inspection test with the use of a different mounting plate. For the damper inspection test, a specially shaped impactor with a mass of 1.0 ± 0.01 kg is used. The impact face of the impactor is recessed to accept the stiff damper spring and the center of gravity of the impactor is below this face.

The damper is checked with the stiff damper spring incorporated. The pass/fail corridor is a damper piston displacement corridor (see
Table 10). The damper is tested at different impact velocities. The impact velocities are between 3 and 10 m/s. For each impact, the peak rib deflection should be recorded. The displacement of the damper is measured at the piston rod by means of the rib transducer. The mass of the spring cup including the moving parts of the displacement measuring system, mounted on the piston must be between 70 - 75 grams. The piston rod thread is not a standard M10 but a fine thread M10 x 1.25. Check that length of the damper return spring is set to 71 ± 1 mm for this test by screwing in or out the stiff damper spring cup.

The impact energies required are specified by the drop height of the impactor. Drop heights to be applied with an accuracy of ± 1% are measured between the impact point on the rib and the impactor face. The drop heights and the performance requirements are given in
Table 10.

The impactor should fall freely onto the end of the stiff damper spring. The axis of the mass should be aligned with the centerline of the spring. The mass should not fall sideways on impact. If it does, or if the recorded displacement is not within the corridor, the test at that velocity should be repeated.

Table 10: ES-2re Damper Functional Inspection Requirements

Test	Drop height (Accuracy 1%) (mm)	Minimum Displacement (mm)	Maximum Displacement (mm)
1	459	11.70	14.50
2	815	14.75	18.45
3	1274	17.75	22.25
4	2153	21.75	27.25
5	3261	25.60	32.00
6	5096	29.60	37.00

5.10 Full Body Thorax Test

5.10.1 Introduction

The thorax is part of the upper torso assembly shown in drawing 175–4000. For this full-body thorax impact test, the dummy is tested as a complete assembly (drawing 175–0000) with the struck-side arm (175–3500, left arm; 175–3800, right arm) removed. The dummy's thorax is equipped with deflection potentiometers as specified in drawing SA572–S69. When subjected to the test procedures specified in test procedure section, the thorax shall meet the performance requirements set forth in the performance criteria section.

5.10.2 Test Procedure

Soak the dummy assembly (175–0000), with struck-side arm (175–3500,left arm; 175–3800, right arm), shoulder foam pad (175–3010), and neoprene body suit (175–8000) removed, in a test environment as specified. The dummy is seated as shown in Figure 71, on a flat, horizontal, rigid surface covered by two overlaid 2 mm thick Teflon sheets and with no back support of the dummy's torso. The dummy's torso spine backplate is vertical within ±2 degrees and the midsagittal plane of thorax is positioned perpendicular to the direction of the plane of motion of the impactor at contact with the thorax. The non-struck side arm is oriented vertically, pointing downward. The dummy's legs are horizontal and symmetrical about the midsagittal plane with the distance between the innermost point on the opposite ankle at 100 ±5 mm.

The impactor is the Standard Part 572 subpart E pendulum of 23.4±0.02 kg and 152.4±0.25 mm diameter. The impactor is guided, if needed, so that at contact with the thorax its longitudinal axis is within ±0.5 degrees of horizontal and perpendicular ±0.5 degrees to the midsagittal plane of the dummy and the centerpoint of the impactor's face is within 5 mm of the impact point on the dummy's middle rib as shown in Figure 71. The impactor impacts the dummy's thorax at 5.5 m/s ±0.1 m/s.

To define Time zero, filter the pendulum acceleration data using a SAE J211 CFC 180 filter. Determine the time when the filtered pendulum accelerometer data first crosses the -1.0 m/s^2 (-.102 g) acceleration level (T0). Set the data time-zero to the sample number of the new T0.

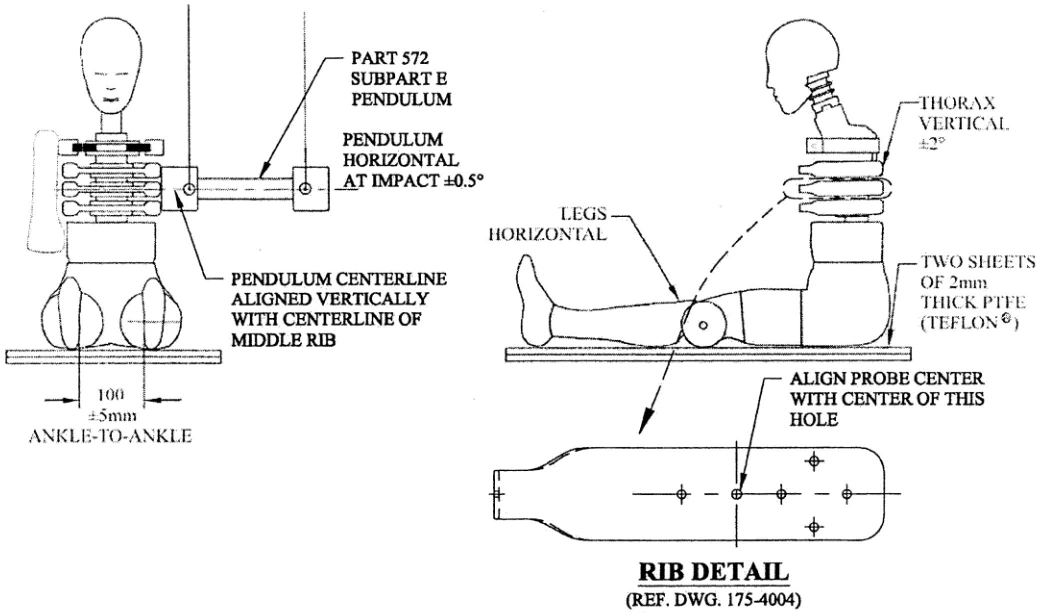


Figure 71: Thorax Test Set Up

5.10.3 Performance Criteria

Table 11: ES-2re Full Body Thorax Impact Test

Measurement	NHTSA response to petitions
Velocity (m/sec)	5.4 - 5.6
Peak Upper Rib Deflection (mm)	34 – 41
Peak Middle Rib Deflection (mm)	37 – 45
Peak Lower Rib Deflection (mm)	37 – 44
Peak Impactor Force after 6 ms (N)	5100 – 6200

5.11 Abdomen

5.11.1 Introduction

The abdomen section should be disassembled for inspection (see Section 4.9). The construction should be visually inspected for damage, in particular the foam covering, the force transducers and the cables from the force transducers. The foam covering should be changed if significant tears are visible. If the cables of the force transducer are damaged, they should be repaired.

5.11.2 Test Set Up

The tests are performed with the abdomen installed in the dummy (see Section 4.9). The dummy (without suit and without shoulder foam cap) should be placed in an upright seated position on a flat, rigid, horizontal surface without back support. Two sheets of 2 mm thick PTFE (Teflon) are placed between the dummy and the surface. The dummy legs and arms should be horizontal; the distance between the ankles should be 100 ± 5 mm, and the thorax vertical ± 2 degrees (measured at rib extension cover). The dummy should be positioned such that the anterior-posterior axis of the dummy is perpendicular to the direction of impact and the centerline of the impactor should be aligned with the center of the middle force transducer ± 5mm.

The impactor is the Standard Part 572 subpart E pendulum of 23.36 ± 0.02 kg and 152.4 ± 0.25 mm diameter. The pendulum is equipped with a horizontal 'armrest' impactor face of 1.0 ± 0.01kg. The 'rigid' armrest (70 mm high, 150 mm wide) should be allowed to penetrate at least 60 mm in the abdomen. The center of the armrest is positioned on the longitudinal axis of the pendulum. The pendulum is suspended by eight long wires to allow a guided impact with the abdomen at velocity of 4.0 ± 0.1m/s.

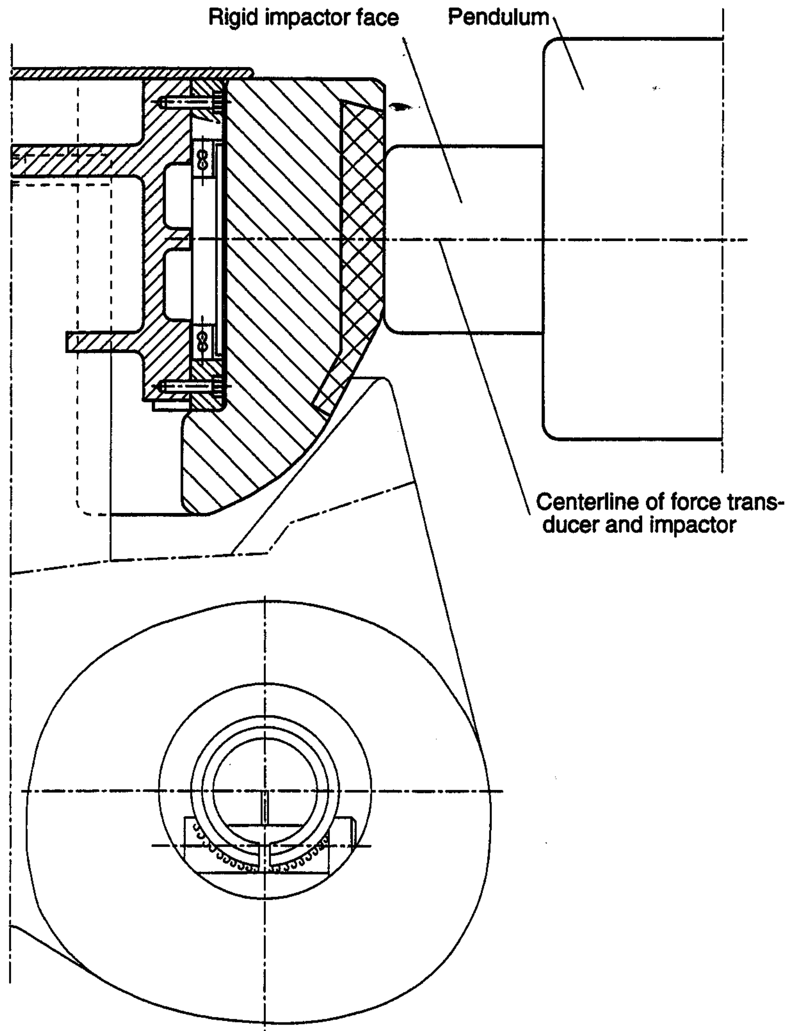


Figure 72: Abdomen Test Set Up

The pendulum should be equipped with an accelerometer located on the impactor axis and sensitive in the direction of impact. The accelerometer signals should be filtered to ISO 6487 or SAE J211 Channel Filter Class180 and the force transducer signals to ISO 6487 or SAE J211 Channel Filter Class 600.

5.11.3 Requirements

The force-time histories measured by the three abdominal force transducers must be summed and the peak force of this sum should be between 2.2 and 2.7 kN, and should occur between 10.0 and 12.3 msec. The maximum pendulum force (acceleration of the pendulum multiplied by the mass) should be between 4.0 and 4.8 kN, and occur between 10.6 and 13.0 msec. The signal should be concurrent at all times. If the abdomen, in repeated tests, fails to meet these specifications, the foam covering should be replaced.

5.12 Lumbar Spine

5.12.1 Introduction

The lumbar spine should be removed from the dummy (see Section 4.10) and visually inspected. Prior to the first certification test the nut should be tightened to 50 ± 5 in-lbs(use a wrench, hold end with screw driver). Most lumbar spines are likely to fulfill the requirements when adjusted to this pretension. In further certification tests, the length of the spine should be close to that of the previous passed certification test. A dynamic calibration test using the Part 572 subpart E pendulum and the head form (175-9000) should be performed as described in the following sections.

5.12.2 Test Set Up

Attach the lumbar spine lower side to the ES-2re head form neck and spine interface (see Figure 61) with four UNC ¼"-20 x ¾" cap head screws. Now attach the head form interface plate to the head form using four M6 screws. Ensure that the orientation of the lumbar spine is correct for the required impact direction. Attach the lumbar spine to the head form mounting base by four UNC ¼"-20 x 1" cap head screws. Attach the mounting base onto the pendulum, using four M6 screws.

Carefully slide the carbon fiber rods through the potentiometer housings on the pendulum. First, slide the pivot of the potentiometer closest to the pendulum over the central carbon fiber rod in the head form. Next add a small spacer ring and finally the second pivot, which has to be carefully tightened with the two M4 set screws. Be careful do not damage the carbon fiber rod when tightening these screws.

CAUTION:

> Make sure that potentiometer C, which measures the angle of the head form, is connected to the rod of potentiometer A, which measures the fore angle. This is important to obtain correct results.

The aluminum honeycomb (crush strength: 1.8 lbs./cu. ft.) should have a nominal length of 152.4 mm (= 6 inches). The pendulum is equipped with a uni-axial accelerometer. The sensitive axis of the accelerometer should be 1657.4 ± 0.25 mm from the pendulum axis in accordance with Standard Part 572 subpart E.

The lumbar spine should be kept in the test room for a period of at least four hours prior to a test at a temperature between 20.6 and 22.2°C and humidity of 10 to 70 %. The period in which the pendulum is in pre-impact position (i.e. not the vertical position) should not exceed 5 minutes.

The head form rotations are measured with the three rotational potentiometers. Data-acquisition should be in accordance with ISO 6487 or SAE J211. The fore (A) and aft (B) pendulum base is directly measured during the certification test. The flexion angle of the head form must be determined using the following equation:

$$\beta = \Theta_A + \Theta_C - \pi/2$$

or

$$\beta = d\Theta_A + d\Theta_C$$

in which $d\Theta_A$ and $d\Theta_C$ are the deviations of the angles Θ_A and Θ_C (see Figure 73) After this calculation, all rotations are digitally filtered using ISO 6487 or SAE J211 CFC 180. The pendulum acceleration is filtered digitally using ISO 6487 or SAE J211 CFC 60.

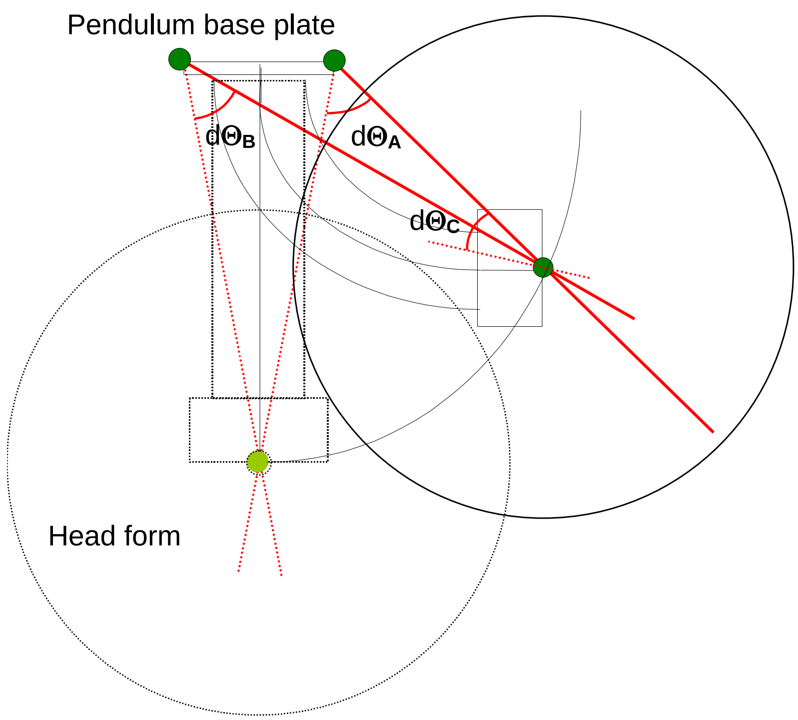


Figure 73: ES-2re Lumbar Spin Certification: Angles Measured With Head Form Set Up

The pendulum should be released and be allowed to fall freely from a height chosen to attain an impact velocity of 6.05 ± 0.1 m/s measured at the center of the accelerometer, 1657.4 mm from the pendulum axis. The velocity time-history of the pendulum should be inside the corridor specified in Figure 74.

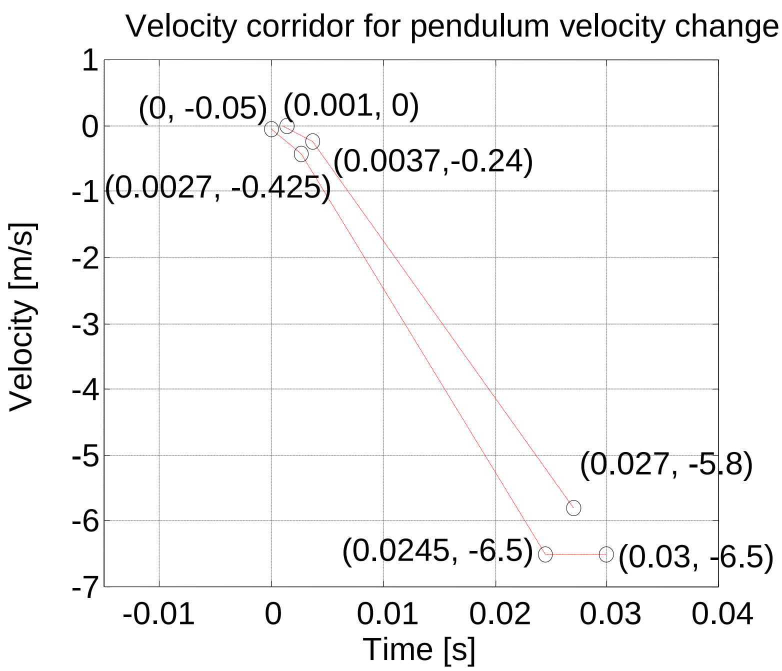


Figure 74: ES-2re Lumbar Spine Certification Pendulum Velocity Corridor

Table 12: ES-2re Lumbar Spine Certification Pendulum Velocity Corridor

Upper Boundary		**Lower Boundary**	
Time [s]	Velocity [m/s]	Time [s]	Velocity [m/s]
0.001	0.0	0	-0.05
0.0037	-0.24	0.0027	-0.425
0.027	-5.8	0.0245	-6.5
		0.03	-6.5

5.12.3 Requirements

For the lumbar spine certification the following requirements are defined:

- The maximum head flexion angle relative to the pendulum should be 50.0 ± 5.0 degrees and should occur between 39 and 53 ms.
- The decaying headform translation-rotation vs. time curve shall cross the zero angle with respect to its initial position at impact relative to the pendulum centerline between 37 ms to 57 ms after the time the peak translation-rotation value is reached.

If the required values cannot be attained, the length of the lumbar spine should be changed. If the flexion angle and/or base angles are less than required, increase the length of the lumbar spine by un-tightening the nut on top of the lumbar spine; if the values are more than required, decrease the length.

5.13 Pelvis

5.13.1 Introduction

The pelvis should be disassembled for inspection (see Section 4.11). Inspect the construction visually for damage. Damaged parts should be replaced. However, minor tears in the foam parts are acceptable, because these tears do not affect the pelvis performance.

5.13.2 Test Set Up

The dynamic certification is performed with the whole dummy. The pubic symphysis load cell is placed in position. The dummy (without suit and shoulder foam cap) should be placed in an upright seated position on a flat, rigid, horizontal surface without back support. Two sheets of 2 mm thick PTFE (Teflon) are placed between the dummy and the surface. The dummy should have a free side motion on the sheets of about 500 mm. The dummy legs and arms should be horizontal; the distance between the ankles should be 100 ± 5 mm, and the thorax vertical ± 2 degrees. The dummy should be positioned such that the anterior-posterior axis of the dummy is perpendicular to the direction of impact and the axis of the impactor should be aligned with the center of the H-point foam block ± 5 mm. This location is identical to the H-point back plate center.

The impactor is the Standard Part 572 subpart E pendulum of 23.4 ± 0.02kg and 152.4 ± 0.25 mm diameter. The pendulum is suspended by eight long wires to allow a guided impact with the pelvis at velocity of 4.3 ± 0.1 m/s. The pendulum should be equipped with an accelerometer sensitive in the direction of impact located on the impactor centerline. The acceleration signals of the pendulum should be filtered to ISO 6487 or SAE J211 Channel Filter Class 180. The pubic symphysis load-signal should be filtered to ISO 6487 or SAE J211 Channel Filter Class 600.

CAUTION:

As the dummy is hit at the pelvis in this test, it may fall towards the pendulum and its suspension cable during the impact. A proper catch of the dummy immediately after the impact may be necessary to prevent damage due to interference of the dummy with the pendulum suspension cables.

5.13.3 Requirements

The impactor force (acceleration of the pendulum multiplied by the mass of the pendulum) is required to be 4.7 – 5.4 kN and occur between 11.8 and 16.1 msec. The pubic symphysis load cell should indicate a load of 1.23 – 1.59 kN and occur between 12.2 and 17.0 msec.

The parts of the pelvis should be checked again if these requirements are not met. The H-point foam blocks, iliac wings or pelvic foam should be renewed if repeated tests do not attain the required results.

5.14 Legs

No dynamic certification procedure is defined for the legs. The mechanism of the joints and the construction of the legs and feet should be visually inspected for damage.

6 Handling procedures

6.1 Introduction

A few special handling procedures for the ES-2re will be presented in this chapter.

6.2 How to Lift the Dummy

The complete dummy should only be lifted by the eye bolt in the neck bracket (see Figure 7). The ES-2re dummy **cannot be lifted by the head**, because there is no cable incorporated in the neck. Further, to avoid tearing of the pelvis flesh of the leg skeleton, the legs should be well supported when the dummy is lifted.

6.3 Neoprene suit

The rubber suit protects the 'open' thorax design and instrumentation against penetration of small particles (e.g. broken glass from vehicle window during impact), dust, etc. If the dummy is used without rubber suit, e.g. in a certification test, contact of the rib flesh with sharp objects should be avoided.

6.4 Storage of ES-2re

When storing the ES-2re dummy between tests, or between a test and certification or vice versa, it is advisable to support the dummy's rigid parts. The eye bolt at the neck bracket (see Section 6.2) is suitable to support the dummy during storage. When doing so, ensure that the head is supported in such a way that the neck is not under tension.

CAUTION:

Avoid supporting the dummy on its soft parts, i.e. ribs and pelvis.

To avoid accelerated aging of dummy materials, the dummy should be kept out of direct sunlight when storing. Storage temperature should be between 10 and 30 degrees Celsius. Further, it is advisable to make sure that the humidity of the storage environment does not exceed 70%. To reduce the risk of corrosion, avoid direct contact between water and dummy parts.

APPENDIX 1

Tilt Sensor Installation

Two tilt sensors are installed in ES-2/ES-2re dummy. One is installed under the shoulder assembly to measure the thorax angles, and the second one is installed inside the sacrum block to measure the pelvis angles. MSC 260D/GP-M is a dual-axis tilt sensor, which has axis 1 and 2 corresponding to the dummy x-axis and y-axis, depending on how it is mounted inside the dummy. Some programming is needed to link the tilt sensor axis to the dummy axis (see tilt sensor user's instruction for details).

Thorax Tilt Sensor Installation

Tilt sensor in thorax is installed on the non-impact side of the dummy under the shoulder assembly as shown in Figure 1. The following parts are needed for the installation:

1) Mounting Bracket, 175-0013, Qty. 1
2) Screw, FHCS M4 x 10, 5000023, Qty.2
3) Screw, SHCS M4 x 8, 5000024, Qty.1
4) MSC 2-Axis Tilt Sensor, 6001805, Qty. 1

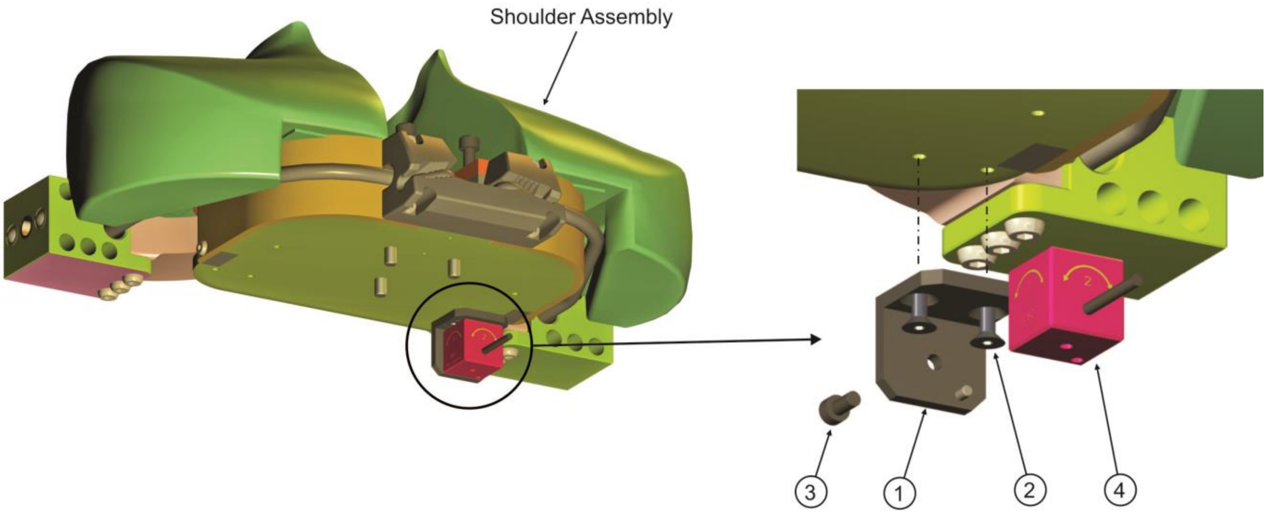


Figure 1: Thorax tilt sensor installation orientation

Tilt sensor axis 1 measures angle along dummy y-axis, axis 2 measure angle along dummy x-axis.

Pelvis Tilt Sensor Installation

The Tilt Sensor in the pelvis is installed inside the cavity of the sacrum. The following parts are needed for the installation:

1) Mounting Bracket, 175-0012, Qty. 1
2) Screw, SHCS, M3 x 8, 5000388, Qty. 2
3) Screw, FHCS M4 x 10, 5000023, Qty.1
4) MSC 2-Axis Tilt Sensor, 6001805, Qty. 1

First install the tilt sensor to the mount plate, PN 175-0012, as shown in Figure 2, using the FHCS (5000023).

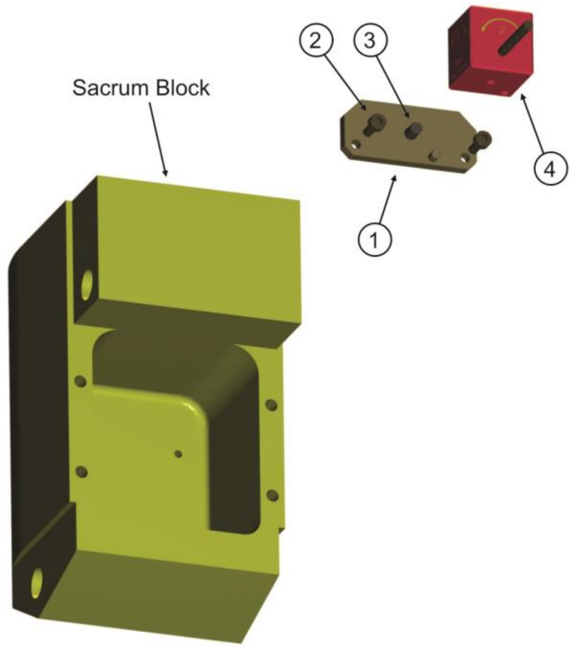


Figure 2: Pelvis tilt sensor and mounting bracket assembly

Secondly, use two SHCS, (5000388), to mount the assembly to the sacrum block as shown in Figure 3.

The pelvis tilt sensor axis 1 measures the angle along the dummy y axis, and tilt sensor axis 2 measures the angle along the dummy x axis.

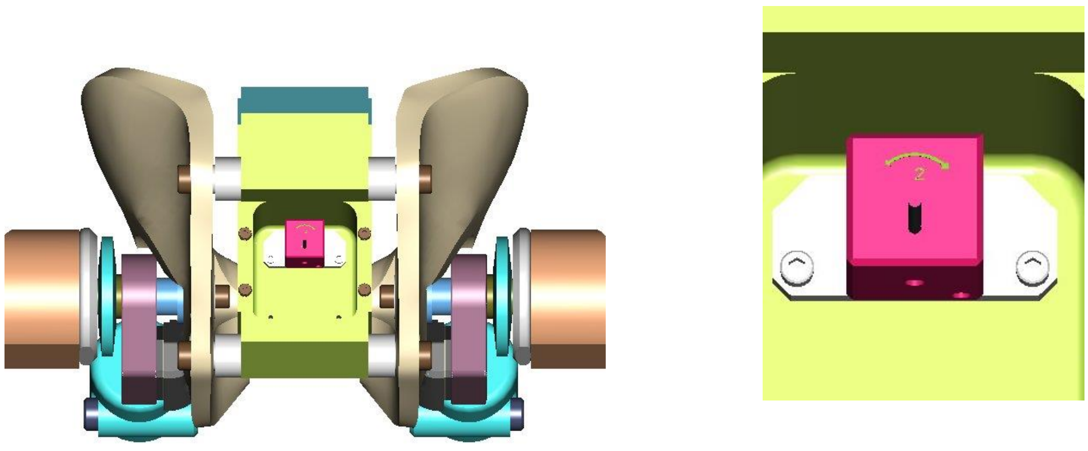


Figure 3: Pelvis tilt sensor installation

Manual Update Log

12/17/04 Corrected screw sizes on pgs. 89-90. P/N 5000023 was M4x8, corrected to M4x10; P/N 5000388 was M4x8, corrected to M3x8.

5/4/05 Added on pg. 75: Paragraph 5.6.4 Calculation of Moments at the Occipital Condyles (OC), per Jerry Wang.

3/20/06 Corrected screw sizes on pgs. 19 and 37 P/N 5000089 SHSS M8 x 60 was 5000125 SHCS M6 x 60. Removed on pg. 58 under section 4.11.1, The socket can be found in the toolbox.

Rev. E 3/08
Pg. 64, NOTE at the top of the page has changed from NPRM to Final Rule.
Pg. 64, Added in Full Body Test, the Thorax Test.
Pg. 74, 5.6.3-Requirement, 49-5 9° was 52-57°, 54 and 66 ms was 54 and 64 ms, 53 to 88 ms was 53 to 75 ms.
Pg. 76, 5.8.3-Dynamic Test Set up, 50±2° was 40°, 23.4 kg was 23.4±.02 kg.
Pg. 77, 5.9.3 The rib unit tested at Two different impactor velocities was Three.
Pg. 78, Added Drop Heights of 459±5 mm and 815±8 mm
Pg. 80-81, Added Full Body Thorax Test section, Update corridor dimensions in Table 10.
Pg. 83, correct Temp. read between 20.6 and 22.2°C
Pg. 85, 5.12.3-Requirement, 37-57 ms was 40-65 ms.
Pg. 85, Table 11, velocity value at 0.0027s, -0.425 m/s was -0.4251 m/s
Pg. 86, 5.13.3-Requirement, 4.7-5.4 kn was 4.8-5.5 kn, 11.8 and 16.1 ms was 10.3 and 15.5 ms, 1.23-1.59 kn was 1.31-1.49 kn, 12.2 and 17.0 ms was 9.9 and 15.9 ms.

Rev. F 6/08
Pg. 20, Updated Table 2
Pg. 36, Neck-Neck Bracket size M6 x 16 was M6 x 18
Pg. 40, Item 5, (5000081) M6 x 16 was (5000285) M6 x 18
Pg. 51, Added tolerance ±1.0 to tuning springs (175-4040, 175-4041 & 175-4042)
Pg. 81, Updated Full Body Thorax Impact Test Table
Pg. 63, Item # 7, 175-7065 was 175-6065

Rev. G 12/09
Pg. 19, Updated Table
Pg. 90, added Item 3, screw 5000024, in Thorax Installation. Item 2, screw 5000646 was 5000023 in Pelvis Installation.

Rev. H 2/11 **Pg. 90 & 91,** updated shoulder mount (175-0013) was 175-0011.

Rev. J 3/14 **Pg. 76**, Upated paragraph stating; Recommanded not Required in impactor set up.

Rev. K, 12/14 **Pg. 82,** 23.36 was 23.4 under 5.11.2 Test set-up

Rev. L, Jul. 2015	**Pg. 2**, Added lead material statement
Rev. M, May 2016	**Pg. 83,** Section 5.12.1: lumbar nut torque updated, "tightened to 50 ± 5 in-lbs" was "tightened hand tight and further tightened with two complete turns of the nut"
	Pg. 19, Updated Table 1**:** Toolbox Table of Contents; added two 175-3004-H Shoulder Cam Clavicle Assembly for LC. Removed ES-2re Toolbox picture.
	Pg. 25, Updated part number; HUMANETICS IF-240 was FTSS IF-240.
	Pg. 26, Updated part numbers; HUMANETICS IF-221, IF-226, IF-317, & IF-306 was FTSS IF-221, IF-226, IF-317, & IF-306.
	Pg. 45, Updated Figure 42