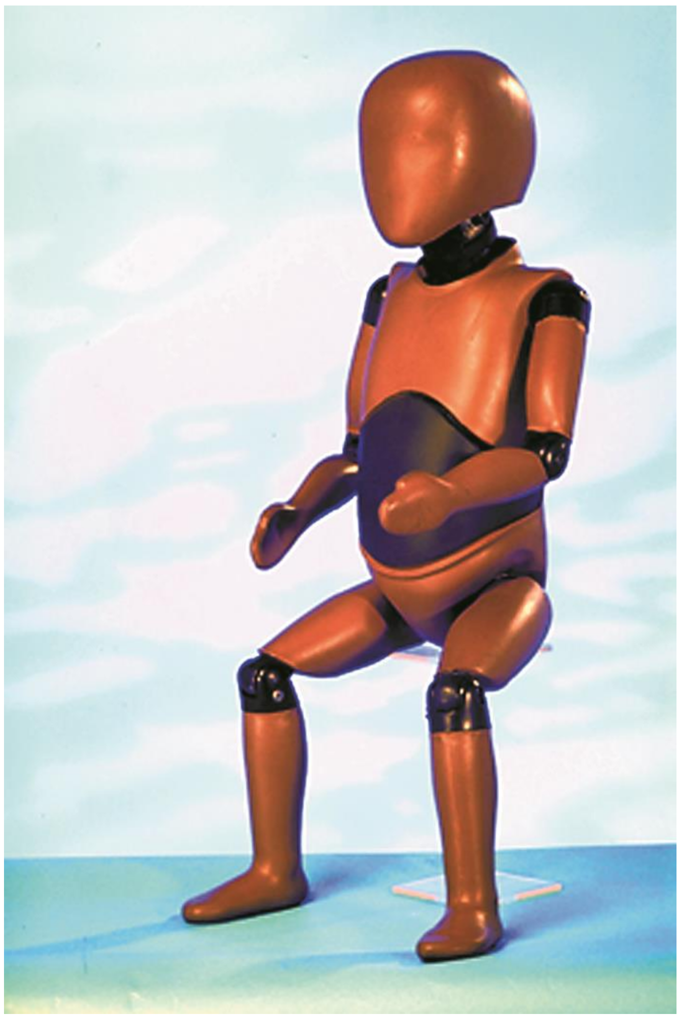
P1½ Child Dummy
User Manual



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Notice: This product may contain lead

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CONTENTS

1. INTRODUCTION

In September 1993, an ad-hoc working group of the United Nations' group of experts on passive safety (GRSP) decided to propose the addition of a "0+ Group" to ECE Regulation 44 (Child Restraint Systems). This group concerns rearward facing child restraint systems for children with a mass less than 13 kg that can be held by a conventional lap and shoulder belt system in front and rear passenger car seats. The working group decided that for the evaluation of this type of child restraint systems, an 18-month-old dummy was needed. On this basis, the TNO Crash-Safety Research Centre, together with Ogle Design Ltd., developed the P1½ child dummy.

The P1½ completes the series of child dummies for ECE Regulation 44. Table 1 shows the represented ages and masses of all P-dummies for ECE Regulation 44.

Table 1:Represented ages and masses of the P-series child dummies

child dummy	respresented age	nominal mass (kg)
P0	newborn	3.4
P¾	9 months	9
P1½	18 months	11
P3	3 years	15
P6	6 years	22
P10	10 years	32

This User Documentation describes the P1½ in its essential parts and shows how it is assembled and calibrated. Throughout this User Manual, the codes for the parts are indicated in square brackets: [ ]. Separate manuals are available for the P0 and the P¾, P3, P6 and P10 child dummies.

The P1½ is developed by the TNO Crash-Safety Research Centre (NL) and First Technology Safety Systems UK Ltd.

2. DESCRIPTION OF THE DUMMY

2.1 Main Characteristics

The P1½ consists of a head, neck, torso assembly (including the shoulder), abdomen, lumber spine, pelvis skeleton assembly, upper arms (left and right), lower arms (left and right), upper legs (left and right) and lower legs (left and right). Figure 1 shows the general configuration of the P1½.

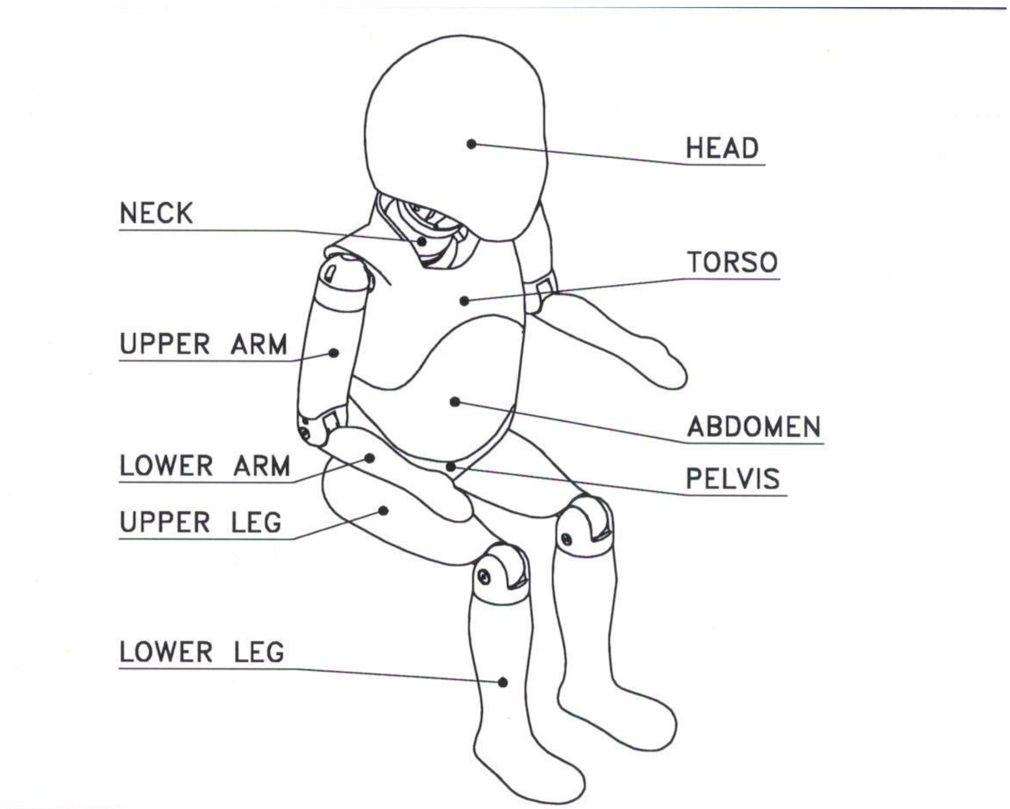

Figure 1: Configuration of the P1½

Head [Z.B]
The head of the P1½ incorporates a skull-skin moulding, an accelerometer mounting plate inside the skull, a structural replacement for the accelerometer(s), a structural replacement for the head-to-neck load transducer, a head to neck interface plate and several screws. The head can rotate with respect to the neck around a lateral axis (at the head-neck junction = OC-joint), allowing rotation of the head with respect to the neck in the midsagittal plane. Figure 2 shows the skull-skin moulding on one side and the other parts of the head in assembled state on the other.

Figure 2: ***Parts of the head of the P1½: skull-skin moulding and other parts of the head in assembled state***

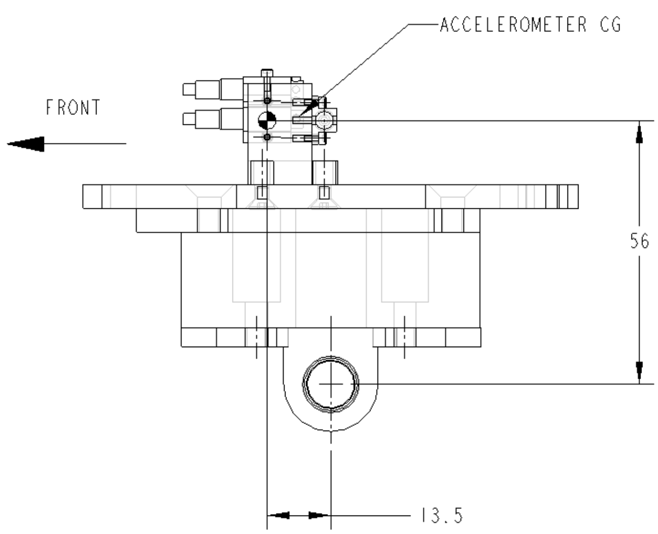

Figure 3: ***Head CG location***

Neck [Z.C]
The neck of the P1½ incorporates an OC-joint, a central rubber element, a lower neck buffer, a neck-to-thorax interface plate held by a spherical screw, and several screws and washers. The neck of the P1½ allows bending (flexion, extension and lateral bending) and a certain amount of twist. The protrusions at the upper end of the central rubber part of the neck provide a damped stop in case the head reaches its maximum flexion or extension. The OC-joint bolt is adjusted to the correct friction to control head-to-neck rotation (see calibration instructions, section 4.5). Figure 3 shows the dummy's neck in assembled state.

Figure 3: Neck of the P1½ (assembled)

Torso [Z.D]

The torso of the P1½ is a skin-flesh moulding around the thoracic skeleton (T-shaped) on which a structural replacement for the neck-to-thorax load transducer is mounted. The skin-flesh moulding covers the complete thorax area, pelvis area and back of the dummy. Also enclosed in the thorax are shoulder balls (screwed onto the thoracic skeleton), an accelerometer-mounting block, a structural replacement for the accelerometer(s) (mounted in the thorax cavity at the rear of the dummy) and several screws. The lumbar spine, abdomen and pelvis skeleton are placed inside the torso skin-flesh moulding (see assembly instructions, section 3.4). Figure 4 shows the torso skin-flesh system with assembled shoulder joints and the structural replacement for the neck-to-thorax load transducer.

Figure 4: Torso assembly of the P1½

Lumbar Spine [Z.E]

The lumbar spine of the P1½ incorporates a central rubber cylinder to which the thorax-to-spine and spine-to-pelvis interface plates are bonded. The lumbar spine also incorporates a steel cable for both durability reasons as well as for adjustment of the stiffness of the lumbar spine (see calibration instructions, section 4.3). The lumbar spine allows bending (flexion, extension and lateral bending) and twist. Figure 5 shows the elements of the lumbar spine in disassembled state.

Figure 5: Lumbar spine of the P1½ - disassembled

Abdomen [Z.G]

The abdomen of the P1½ is a one-piece moulding that snugly fits into the torso cavity once the lumbar spine and pelvis skeleton are put in place. The high density compressible foam used for the abdomen, represents the soft tissue of the child in this area. Figure 6 shows the abdomen of the P1½ in front and rear view.

Figure 6: Abdomen of the P1½

Pelvis Skeleton [Z.F]

The anatomically shaped pelvis skeleton of the P1½ includes a structural replacement for a load transducer at the spine-pelvis junction, a mounting plate for the accelerometer(s), a structural replacement for the accelerometer(s), a pelvic bone assembly, left and right hip pivots and several screws and washers. The pelvis skeleton assembly can be removed from the torso skin-flesh system, provided the lumbar spine and upper legs are disassembled from the pelvis skeleton (see assembly instructions, section 3.4). Figure 7 shows the pelvis skeleton in assembled state but removed from the torso skin-flesh system.

Figure 7: Pelvis skeleton assembly of the P1½

Arms [Z.K (left) and Z.L (right)]

The upper arms of the P1½ include a full upper arm moulding (skeleton, flesh and skin are moulded to become one element), a click-stop element (spring, peg and insert) and a shoulder cap held by 3 screws. The upper arms are mounted to the shoulder balls of the torso assembly (see assembly instructions). The click-stop in the shoulder provides defined initial positions of the upper arm. The lower arms of the P1½ include a full lower arm moulding (skeleton, flesh and skin are moulded to become one element) with an integral hand. The lower arm is attached to the upper arm at the elbow by means of a hinge joint. The elbow also incorporates a click-stop mechanism to control the initial position of the lower arm. Figure 8 shows a disassembled (right) arm of the dummy.

Figure 8: Disassembled (right) arm of the P1½

Legs [Z.M (left) and Z.O (right)]
The upper legs of the P1½ each consists of two element: a full upper leg moulding (skeleton, flesh and skin are moulded to become one element) and a hip pivot bolt. The lower legs of the P1½ include a lower leg moulding (skeleton, flesh and skin are moulded to become one element) and one screws and one washer at each knee joint. The foot is an integral part of the lower leg. Figure 9 shows the (right) leg of the dummy in disassembled state.

Figure 9: Disassembled (right) leg of the P1½

Clothing [Z.N]
The P1½ is provided with a cotton pyjama (sweater and trousers).

2.2 Principal Dimensions

The dimensions of the P1½ are based on anthropometry data. The dimensions are shown in Table 1 and Figure 10. Dimensions are ± 3 mm (± 6 mm for assembled parts).

Table II: Principal dimensions of the P1½

No.	Dimension	Value (mm)
1	back of buttocks to front knee	239
2	back of buttocks to popliteus, sitting	201
3	centre of gravity to seat	193
4	chest circumference	474
5	chest depth	113
7	head width	124
8	head length	160
9	hip circumference, sitting	510
10	hip circumference, standing (not shown)	471
11	hip depth, sitting	125
12	hip width, sitting	174
14	seat to elbow	125
15	shoulder width	224
17	height, sitting	495*
18	shoulder height, sitting	305
19	sole to popliteus, sitting	173
20	stature (not shown)	820*
21	thigh height, sitting	66

*: dummy sitting with buttocks, back and head resting against a vertical surface.

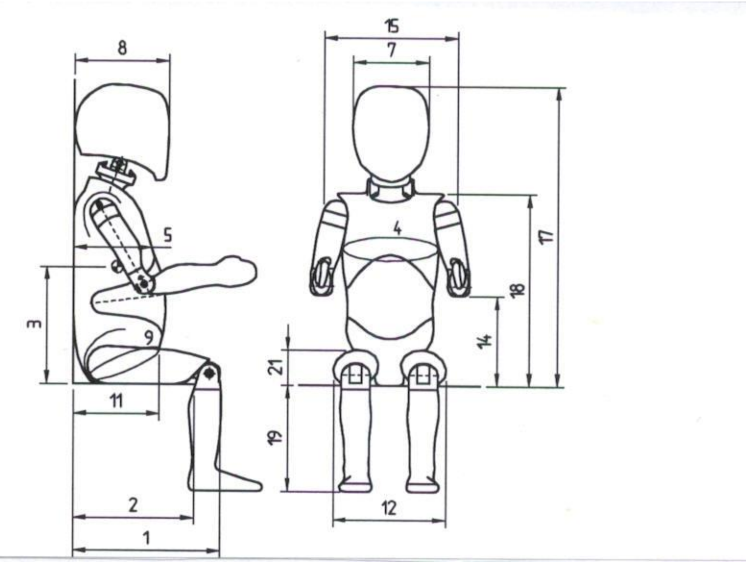

Figure 10: Principal dimensions of the P1½

2.3 Mass Distribution

Table III shows the masses of various components of the P1½. The masses include all necessary mounting and connecting parts as well as the structural replacements for instrumentation. The masses specified are ± 0.05 kg, except for the mass of the complete dummy, which is ± 0.20 kg.

Table III: Masses of various components of the TNO-P1½

No.	Component	Mass (kg)	Note
a	head + neck	2.73	
b	torso	5.06	includes abdomen, lumbar spine and pelvis skeleton
c	upper arm	0.27	× 2
d	lower arm	0.25	× 2
e	upper leg	0.61	× 2
f	lower leg	0.48	× 2
	total	**11.01**	= a+b + 2×(c+d+e+f)

2.4 Locations for Instrumentation

The P1½ is designed to accommodate three tri-axial accelerometers and three 6-channel load transducers, which can readily be mounted inside the dummy. It may not be necessary to use these instrumentation capabilities in all applications and some applications may even require additional instrumentation. Of course, the dummy may be fitted with markers to record its motion using high-speed film. ECE Regulation 44 (-03) requires instrumentation to record the thorax acceleration (in three directions), and assessment of head excursion and abdominal penetration using high-speed film.

Accelerometers

The P1½ is equipped with three structural replacements for triaxial accelerometers: one at the ***head***, one at the ***thorax*** and one at the ***pelvis***. The dummy is designed such that a commercially available tri-axial accelerometer can be mounted in the P1½ by just replacing a structural replacement by the actual transducer.

It is, however, also possible to equip the dummy with three uni-axial accelerometers at each location where a structural replacement for an accelerometer is present, using a special mounting block. For more information, please contact the Business Unit Dummies (address on first page of this manual).

The sensitive axes of the tri-axial accelerometer or cluster of three uni-axial accelerometers will closely coincide with the local body part coordinate system with its origin at or close to the centre of gravity of that body part. If other accelerometer types are used than those recommended by TNO, we advise that care is taken that the sensitive axes coincide with the local coordinate systems with an accuracy of ± 8 mm. Figure 11 shows the local coordinate system of a structural replacement for the accelerometers. Note that all three structural replacements for the tri-axial accelerometers are identical. ***Note that a structural replacement must be present if no accelerometer is mounted***; this is to assure correct mass (inertia) of that body part.

The structural replacement of the head accelerometer [Z.BE] is mounted onto the head-transducer mounting plate [Z.BB] (see assembly instructions, see section 3.6). The (tri-axial) accelerometer of the head is located at the head centre of gravity.

The structural replacement of the thorax accelerometer [Z.BE] is mounted onto the thorax accelerometer mounting block [Z.DB] and together, these are mounted inside the thorax skeleton in a cavity accessed from the back of the dummy (see assembly instructions, see section 3.4).

The structural replacement of the pelvis accelerometer [Z.BE] is mounted onto the pelvis accelerometer-transducer mounting plate [Z.FB] and together, these are mounted on the pelvis skeleton such that the structural replacement falls inside the cavity (see assembly instructions, see section 3.2).

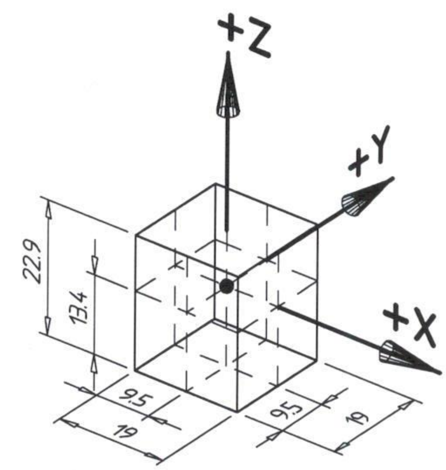

Figure 11: ***Coordinate system of the structural replacements for (tri-axial) accelerometers of the P1½***

Load Transducers

The P1½ is equipped with three structural replacements for 6-channel load transducers [Z.BC]: one at the ***head-neck junction*** (OC joint) which is a part of the head, one at the ***neck-thorax junction*** which is a part of the thorax and one at the ***lumbar spine-pelvis junction*** which is a part of the pelvis. These structural replacements are identical in mass and dimensions to a commercially available load transducer and are true parts of the dummy. The load transducer is capable of measuring three forces and three moments in an orthogonal axis system with its origin in the load transducer. ***Note that a structural replacement must be present if no load transducer is mounted.***

3. ASSEMBLY/DISASSEMBLY INSTRUCTIONS

Figure 12 shows an exploded view of the P1½. Table 2 contains a description of the parts of the dummy (not all screws and nuts are listed).

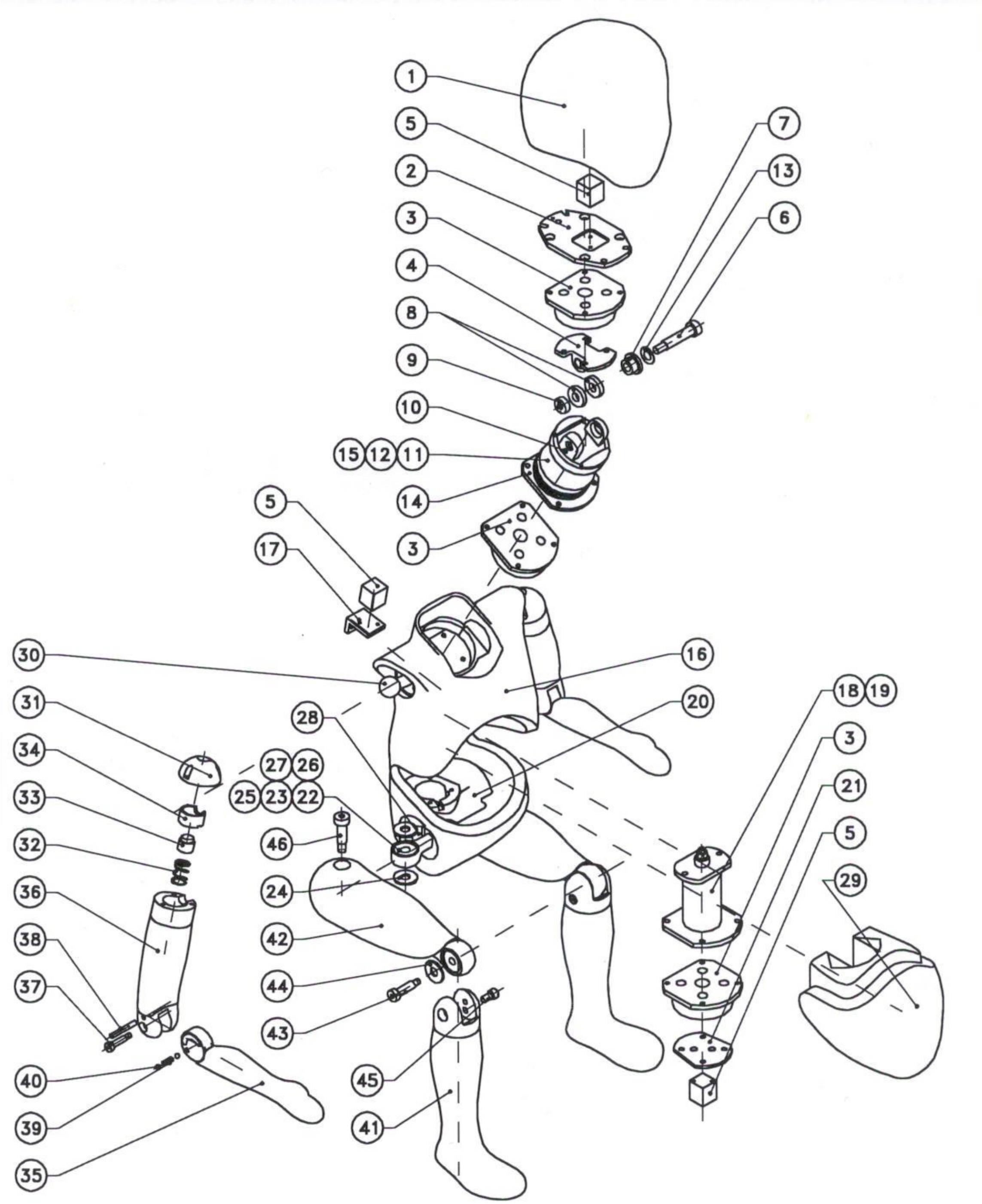

Figure 12: Exploded view of the P1½

Table III: Parts list of the P1½

No.	Name	Code	Qty.
1	head moulding	Z.BA	1
2	head transducer mounting plate	Z.BB	1
3	structural replacement for 6-channel load transducer	Z.BC	3
4	head-neck transducer interface plate	Z.BD	1
5	structural replacement for accelerometer	Z.BE	3
6	OC-joint bolt	Z.QD	1
7	support bush	Z.CA	1
8	neck spacer	Z.CB	2
9	sliding nut	Z.CC	1
10	location pin	Z.CD	1
11	neck central moulding	Z.CE	1
12	neck buffer	Z.CF	1
13	wave washer	Z.CG	1
14	neck-thorax transducer interface plate	Z.CH	1
15	spherical screw	Z.CI	1
16	torso moulding (includes thorax skeleton)	Z.DA	1
17	thorax accelerometer mounting block	Z.DB	1
17	thorax accelerometer mounting block for triax	Z.DBT	1
18	lumbar spine moulding	Z.EA	1
19	lumbar spine cable	Z.EB	1
20	pelvis moulding	Z.FA	1
21	pelvis transducer mounting plate	Z.FB	1
22	hip pivot pin	Z.QM	1
23	hip pivot moulding	Z.FE	2
24	hip friction washer	Z.FG	4
25	friction band	Z.FH	2
26	friction adjustment screw	Z.FI	2
27	hip pivot spring	Z.FJ	2
28	retaining plate (left and right)	Z.FL/Z.FM	1
29	abdomen	Z.G	1
30	shoulder ball moulding (left and right)	Z.HC/Z.HD	1
31	shoulder cap	Z.HE	2
32	shoulder compression spring	Z.HF	2
33	shoulder click-stop peg	Z.HG	2
34	shoulder lower insert moulding	Z.HH	2
35	lower arm (left and right)	Z.KA/Z.LA	1
36	upper arm (left and right)	Z.KB/Z.LB	1
37	elbow pivot bolt	Z.QP	2
38	elbow dowel pin	Z.QQ	2
39	elbow compression spring	Z.KC	2
40	elbow ball bearing	Z.KD	4
41	lower leg (left and right)	Z.MA/Z.OA	1
42	upper leg (left and right)	Z.MB/Z.OB	1
43	knee pivot bolt	Z.QR	2
44	knee friction washer	Z.FG	2
45	knee movement stop pin	Z.MD	2
46	hip pivot bolt	Z.QS	2
47	clothing (not shown)	Z.N	1

3.1 Starting Assembly of the P1½

The P1½ is delivered in assembled state. Nevertheless assembly/disassembly instructions are needed since the dummy should be calibrated regularly and different instrumentation may be required in different tests.

Since the P1½ incorporates structural replacements for transducers that have been developed in the USA, some bolts are used having UNC or UNF thread. Parts bolted onto the structural replacements for the load transducers (3) are all mounted using 10-32x3/8" screws. The structural replacements for the accelerometers (5) are all mounted using 4-40 UNC-2B screws. Also the head-neck interface plate is mounted using 10-32x3/8" screws. All other screws, nuts, etc. are metric.

Only one special tool is required to assemble the P1½. This is the neck compression tool [Z.CJ] to tighten the spherical screw at the bottom of the neck (further instructions are given below).

Tighten all screws, etc. by hand firmly, unless specified otherwise.

If you assemble the dummy for the first time, follow the assembly instructions in the order presented.

3.2 Pelvis Assembly

1. Mount the structural replacement for the accelerometer [Z.BE] (or an actual accelerometer) onto the pelvis transducer mounting plate [Z.FB] using two 4-40 UNC 2-B screws [Z.QF].
2. Place the pelvis transducer mounting plate onto the pelvis skeleton moulding [Z.FA] such that the structural replacement for the accelerometer falls inside the cavity and that the holes in the pelvis transducer mounting plate align with the threaded inserts in the pelvis skeleton. In the case an actual accelerometer is applied, make sure that the wiring exits through the slot at the front.
3. Mount the structural replacement for the load transducer [Z.BC] on top of the pelvis transducer mounting plate using four M4x16 cap head socket screws [Z.QL] that go through the mounting plate into the pelvis skeleton. Make sure that the round edge of the structural replacement for the load transducer is at the front. In case an actual load transducer is applied, make sure that the wiring runs along the lower edge of the iliac wings to the front (the pelvis moulding has small canals to accommodate the wiring).
4. Mount the dowel pin (d=8mm, l=70mm) [Z.QM] in the hole at the hip of the pelvis skeleton. This dowel pin serves as the rotation axis of the left and right hip joint and will self-centre during assembly.

Points 5 through 7 concern assembly of the left hip pivot. The same instructions apply to the right hip pivot except that the code of the retaining plate should read [Z.FM].

5. Place the friction band [Z.FH], the spring [Z.FJ] and the friction adjustment screw [Z.FI] in the hip cavity as shown in Figure 13. Slightly tighten the friction adjustment screws by only a few turns. Do not fully tighten the friction adjustment screws (for adjustment of the friction: see calibration instructions, section 4.6).

Figure 13: ***Hip assembly: friction band, friction adjustments screw, spring and hip pivot pin are shown.***

6. Place the hip pivot moulding [Z.FE] onto the dowel pin in the pelvis skeleton so that the friction band falls around it.
7. Mount the retaining plate [Z.FL] onto the pelvis skeleton using three M4x8 button head socket screws [Z.QN].

Repeat steps 5 through 7 for the right hand side (the retaining plate code changes to [Z.FM])

For disassembly, follow the instructions above in reverse order.

The hip friction washers [Z.FG] are part of the pelvis assembly but are only mounted when the upper legs are attached to the hip joints (see section 3.10).

Before placing the pelvis assembly into the torso skin-flesh moulding [Z.DA], it is often easier to mount the lumbar spine assembly onto the pelvis (at the upper side of the structural replacement for the load transducer). In case actual transducers are applied, make sure that the wiring exits at the upper-front level of the pelvis.

When you want to disassemble the pelvis from a full dummy, you first have to disassemble the legs from the hips, then disconnect the lumbar spine from the thoracic skeleton and finally disassemble the lumbar spine from the pelvis. Now you can take the pelvis assembly out of the torso skin-flesh system and disassemble the pelvis by following the instructions 1 through 7 in reverse order.

3.3 Lumbar Spine Assembly

1. Place the spine cable [Z.EB] through the lumbar spine moulding [Z.EA] so that the ball end of the spine cable is at the bottom of the lumbar spine (the largest interface plate).
2. Place the washer [Z.QI] over the threaded end of the spine cable exiting at the top of the lumbar spine and mount the lumbar spine nut [Z.QH]. The threaded end is provided with a slit to prevent the

cable from rotating during assembly/disassembly (a screwdriver with a 4 mm face fits; see also Figure 14). Slightly tighten the nut so that the spine cable is only just under tension.

Figure 14: Lumbar spine nut adjustment

The lumbar spine is now ready for calibration. Be sure to calibrate the lumbar spine before mounting it into the torso.

To disassemble the lumbar spine, follow the instructions above in reverse order.

Never replace the lumbar spine nut [Z.QH] by a standard nut since fine thread is used.

After calibration, the lumber spine can be mounted in the dummy. First the lumbar spine should be mounted onto the pelvis assembly using four 10-32x3/8" cap head socket screws [Z.QK] (make sure the round edge of the lower interface plate of the lumbar spine is at the front). The lumbar spine and pelvis can now be placed inside the torso skin and finally the lumbar spine can be attached to the thoracic skeleton using two M5x12 cap head socket screws [Z.QJ] (see also torso assembly instructions, section 3.4).

3.4 Torso Assembly

To assemble the torso, an assembled pelvis and an assembled and calibrated lumbar spine are needed (see sections 3.2 and 3.3).

1. Mount the shoulder ball moulding [Z.HC (left), Z.HD (right)] on either side of the thorax skeleton using three M4x16 button head socket screws [Z.QN] on each side.

Be sure to place the left shoulder ball moulding [Z.HC] at the left and the right shoulder ball moulding [Z.HD] on the right. The shoulder ball mouldings are marked for left and right hand side.

Be sure to place the shoulder ball mouldings so that the small indent points vertically downward (along the vertical axis of the torso) and the large indent is pointed 30 degrees forward of the vertical (to the front of the dummy).

2. Place the torso moulding [Z.DA] on its back on a flat surface.
3. Insert the assembled pelvis [Z.F] in the lower part of the torso moulding so that the hip pivots exit on either side through the holes in the lower part of the torso moulding. The pelvis should fit exactly.

In case actual transducers (load or accelerometer transducers) are mounted in the pelvis assembly, be sure that the wiring runs along the canals at the iliac wings to the front of the pelvis and finally exit the dummy at the side.

4. Bend the torso so that the top surface of the structural replacement of the lumbar spine-pelvis load transducer is fully exposed. This should be done with care in order not to tear the skin-flesh system of the torso.
5. Now mount the lumbar spine assembly [Z.E] on top of the structural replacement of the load transducer at the pelvis using four 10-32x3/8" cap head socket screws [Z.QK]. Make sure that the largest plate of the lumbar spine is at the pelvis side and the rounded part of this plate is at the front.
6. Bend the torso back so that the lumbar spine reaches the thorax skeleton. The nut at the top of the lumbar spine should fall inside the cavity at the lower end of the thorax skeleton.
7. Now mount the lumbar spine onto the thorax skeleton using two M5x12 cap head socket screws [Z.QJ].
8. Turn the torso so that the cavity at the back is exposed.
9. Mount the structural replacement for the thorax accelerometer [Z.BE] (or the accelerometers) onto the thorax accelerometer mounting block using two 4-40 UNC-2B screws [Z.QF].
10. Mount the thorax accelerometer block (with accelerometer or structural replacement) into the cavity at the back of the dummy using two M4x10 CSK socket screws. Be sure that the wiring runs below the skin to the neck (the skin is sufficiently flexible at this area) and exits the neck towards the side.
11. Mount the structural replacement for the neck-to-torso load transducer [Z.BC] (or the actual load transducer) into the neck opening at the top of the torso moulding [Z.DA] using four M4x12 cap head socket screws [Z.QT]. Be sure that no skin-flesh material or wiring is caught between the transducer and the thorax skeleton. If an actual transducer is used, let the wiring exit at the neck level at the sides towards the back of the dummy.

If an accelerometer is used in the thorax, it is easier to position this transducer before mounting the structural replacement at the neck-thorax junction. In some cases it is even easier to pull back the skin at the backside of the torso at the neck level and position the accelerometer from the neck side to the cavity in the thorax skeleton at the back of the torso (instead of pushing the connectors from the cavity to the neck opening). After locating the accelerometer and its wiring, start at step 10 of these instructions. Be sure not to forget to put back the structural replacement for the load transducer at the top (step 11 of these instructions).

To disassemble the torso, follow the instructions above in reverse order.

3.5 Neck Assembly and Mounting the Neck onto the Torso

1. Place the neck buffer [Z.CF] at the bottom of the central neck moulding [Z.CE] so that the protrusions of the buffer fall into the holes (chambers) in the central neck moulding.
2. Mount the neck-to-thorax transducer interface plate [Z.CH] onto the neck buffer at the bottom of the central neck moulding using the spherical screw [Z.CI]. Be sure that the round edge of the interface plate is at the front (and the head of the M10 shoulder bolt [Z.QD] is at the left hand side of the dummy) and the protrusions of the buffer fall into the holes of the interface plate. The spherical screw should be tightened using the neck compression tool [Z.CJ].

The neck is now ready for calibration (see calibration instructions). The neck should be calibrated before mounting it into the torso.

3. The neck can now be mounted onto the structural replacement of the neck-to-thorax load transducer (or the actual load transducer) [Z.BC] using four 10-32x3/8" cap head socket screws [Z.QE], provided the structural replacement of the neck-thorax load transducer has been mounted inside the torso (see section 3.4). Be sure that no skin-flesh material or wiring is caught between the neck and thorax.

Do not over tighten the four 10-32x3/8" cap head socket screws that attach the interface plate to the load cell, as this may deform the interface plate (the maximum torque to be applied is approx. 1 Nm).

4. After the neck has been placed onto the thorax, the head can be mounted onto the neck (see section 3.6).

To disassemble the neck, follow the instructions above in reverse order.

3.6 Head Assembly and Mounting the Head onto the Neck

1. Mount the structural replacement for the accelerometer [Z.BE] onto the head-transducer mounting plate [Z.BB] using two 4-40 UNC-2B screws [Z.QF] (Note: in case an accelerometer is mounted in the head, note the directions of sensitivity: the head-transducer mounting plate is provided with 3 holes for mounting into the skull; 2 at the front, 1 at the back).
2. Mount the structural replacement for the head-neck load transducer [Z.BC] (or 6-channel load transducer) onto the head-neck interface plate [Z.BD] using four 10-32x3/8" cap head socket screws [Z.QC].
3. Now mount the head-transducer mounting plate onto the structural replacement for the 6-channel load transducer using four 10-32x3/8" CSK socket screws [Z.QB] (Note: in case an actual 6-channel load transducer is applied, be sure that the wiring exits at the back).

You now have two elements of the head: the skull-skin moulding and the metal-head-part assembly (see also Figure 2).

The head should be mounted onto the neck after the neck has been mounted onto the torso.

Mounting the head onto the neck is done in two steps:

4. Mount the metal-head-part onto the neck using the M10 shoulder bolt [Z.QD]. Be sure that the sliding nut [Z.CC] and location pin [Z.CD] are in the correct place, the neck spacers [Z.CB] are on each side of the head-neck interface plate [Z.BD], the wave washer [Z.CG] is at the head of the shoulder bolt and the support bush [Z.CA] is between the wave washer and the metal part of the neck central moulding [Z.CE].
   Note: the M10 shoulder bolt [Z.QD] should easily go into the sliding nut [Z.CC] at first, but after several turns it picks up some resistance. Further tighten the shoulder bolt to adjust the correct friction in the OC-joint (see calibration instructions, section 4.5).
5. Finally, mount the skull-skin moulding [Z.BA] onto the head transducer mounting plate using three M5x12 cap head socket screws [Z.QA]. The assembly is easier if the head is rotated forward when tightening the rear bolt and rotated backward when tightening the two front bolts. (Note: in case an accelerometer is mounted in the head, be sure the wiring exits through a slot at the back of the head transducer mounting plate).

To disassemble the head, follow the instructions above in reverse order.

3.7 Arm Assembly

The instructions below apply to both left and right arm.

1. Place the compression spring [Z.KC] into the hole at the elbow side of the lower arm [Z.KA for left and Z.LA for right].
2. On each side of this spring a ball bearing [Z.KD] is placed.
3. While keeping the balls and spring in place, slide the lower arm into the upper arm [Z.KB for left and Z.LB for right] so that the holes for the dowel pin [Z.QQ] coincide.
4. Mount the dowel pin [Z.QQ]. This should be a tight fit.
5. Mount the elbow pivot bolt [Z.QP]. Tighten the elbow pivot bolt but not too tight: the lower arm should easily rotate at the elbow (some friction is allowed) and the click-stops provide the initial position of the lower arm.

To disassemble the arm, follow the instructions above in reverse order

Be careful when disassembling the elbow: the ball bearings are under tension! We advise to cover the elbow using a piece of cloth when the lower arm is taken out of the upper arm.

3.8 Mounting the Arms onto the Shoulders

The instructions below suppose the use of assembled arms and torso (see sections 3.7 and 3.4 respectively). The instructions below apply to both left and right arm.

1. Place the compression spring [Z.HF] into the cavity at the top of the upper arm.
2. Place the click-stop peg [Z.HG] on top of the compression spring.
3. Place the lower insert moulding [Z.HH] on top of the click-stop peg. Make sure that the opening in the lower insert moulding coincides with the recess in the upper arm skeleton.
4. Hold the top of the upper arm against the shoulder ball moulding [Z.HC for left hand side and Z.HD for right hand side].

5. Mount the shoulder cap [Z.HE] on top of the upper arm and shoulder ball, using three M4x10 cap head socket screws. Tighten the screws so that the shoulder cap fully joints the upper arm skeleton.

To disassemble the arms from the shoulders, follow the instructions above in reverse order.

3.9 Leg Assembly

The instructions below concern assembly of the left leg. The same instructions apply to assembly of the right leg, except that "left" should read "right" and the codes change.

1. Place the knee friction washer [Z.FG] on the left hand side of the left upper leg [Z.MB] at the knee joint (this washer exactly fits onto the skeleton).
2. While keeping this washer in place, slide the upper leg into the knee joint of the lower leg [Z.MA].
3. Mount the upper leg to the lower leg using the knee pivot bolt [Z.QR]. Only slightly tighten the knee pivot bolt (this bolt is used to adjust the friction at the knee; see calibration instructions, section 4.7).
4. Mount the movement stop pin [Z.MD] on the opposite of the knee. Make sure that the upper leg is in line with the lower leg when mounting the stop pin so that the stop pin falls into the slot of the upper leg (the stop pin should not stick outside the knee).

The hip pivot bolt [Z.QS] is also a part of the leg assembly but is mounted when mounting the leg assembly onto the hip (see instructions below).

3.10 Mounting the Legs onto the Pelvis

The instructions below apply to both left and right leg.

Before mounting the legs, the complete torso has to be assembled (including pelvis skeleton and lumbar spine).

1. Place the hip friction washers [Z.FG] onto the hip pivot moulding [Z.FE]: one on each side of the hip pivot.
2. Mount the leg assembly (see section 3.9) onto the hip pivot while keeping the washers in place. Use the hip pivot bolt [Z.QS] to attach the leg assembly to the hip pivot.

3.11 And Finally...

Finally, the P1½ is dressed with a cotton pyjama [Z.N]. The dummy should be dressed after calibration.

4. CALIBRATION PROCEDURES

4.1 General

It is recommended to follow the calibration procedures of this chapter in the order as presented. In case not all parts need calibration, be sure to calibrate all disassembled parts and adjust the friction in the joints (OC-joint, shoulders, elbows, hips and knees). Parts failing the calibration procedures should be replaced.

Calibration of the P1½ should be performed under standard laboratory conditions.

All parts of the P1½ delivered by Humanetics are calibrated before assembly and shipment. Adjustment of the joints should be done by the customer. If a part of the dummy fails calibration requirements after following the procedures specified in this User Documentation, please contact your local Humanetics representative.

4.2 Visual Inspection

Every calibration starts with a visual inspection for anomalies in the construction of the P1½. Damaged parts that are liable to affect the response of the dummy should be replaced.

4.3 Calibration of the Lumbar Spine

The lumbar spine assembly [Z.E] is calibrated before it is mounted in the dummy.

1. Attach the lower interface plate of the lumbar spine to a rigid vertical fixture so that the front side faces down; see Figure 15.

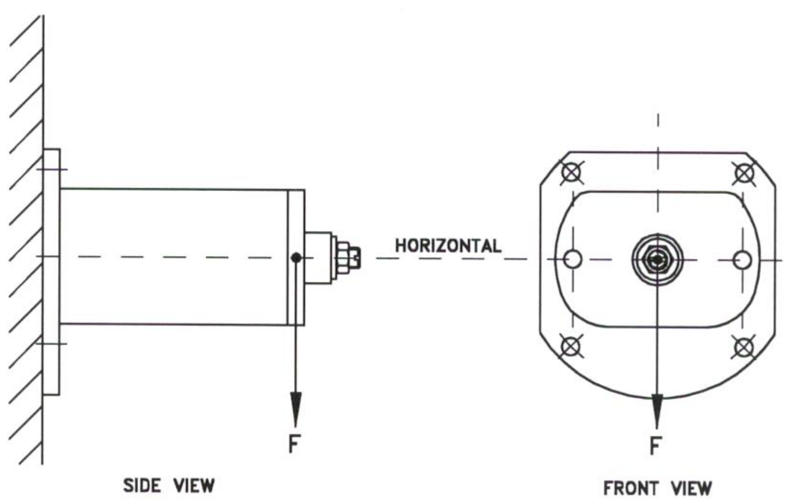

Figure 15: Lumbar spine calibration set-up

2. Apply a vertical downward load of 250 N to the upper interface plate of the lumbar spine, acting in the mid-sagittal plane of the lumber spine.
3. Record the vertical displacement δ_{ls} of the upper interface plate of the lumbar spine between 1 and 2 seconds after onset of force application (the force should remain vertically downward).

***Requirement:* $9\ mm \leq \delta_{ls} \leq 12\ mm$**

4. If the lumbar spine does not fulfil this requirement, release the force and adjust the nut [Z.QH] at the upper end of the spine (see also assembly instructions). Tighten the nut if the displacement is too large; loosen the nut if the displacement is too little. Repeat steps 2 through 4 until the lumbar spine fulfils the requirement.

The spine cable should always be under tension. Replace the lumbar spine if the nut cannot be adjusted to fulfil the requirement.

4.4 Calibration of the Abdomen.

The abdomen [Z.G] is calibrated before it is mounted in the dummy.

1. Place the abdomen on a rigid block with the same length and width (curvature) as the lumbar spine (see Figure 16). The height of this block shall be at least twice the diameter of the lumbar spine column. The procedure below has to be done three times. The average value of the three measurements is taken as the result of the abdomen.
2. Be sure there is no tolerance between the lumbar-spine structural replacement and the abdomen foam. This can be achieved by shortly pressing it firmly down on the replacement.
3. Place, when the foam is correctly fitted the centreline of the lumbar-spine structural replacement in line with the centreline of the abdomen compression rig. Be sure your structural replacement block has a smooth surface.
4. Apply an initial load on the abdomen of 20 N, using a flat rigid plate (see Figure 16) being sufficiently large so that its edges do not contact the abdomen during the calibration test. Place the initial weight **carefully** on the foam, read the display of the gage.

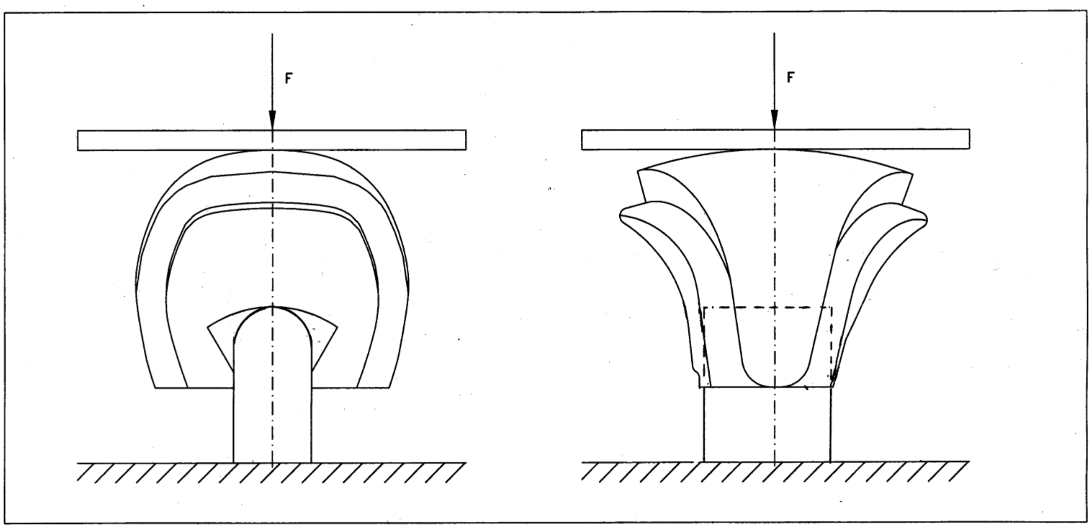

Figure 16: Abdomen calibration set-up

5. Place the additional weight, increasing the load on the abdomen to 50 N on the test rig within 10 seconds. From this point on wait 2 minutes.
6. Measure the abdomen deflection δ_a by recording the vertical displacement of the compressing plate after 2 minutes of applying the force of 50 N.

***Requirement:** 10 mm ≤ δ_a ≤ 14 mm*

4.5 Calibration of the Neck

The neck assembly [Z.C] is calibrated before it is mounted in the dummy.

Neck calibration is performed on the assembly of the neck central moulding [Z.CE], neck buffer [Z.CF], neck to thorax interface plate [Z.CH] and spherical screw [Z.CI] (see also assembly instructions, section 3.5).

1. Attach the neck to a rigid vertical fixture by the neck to thorax interface plate (see Figure 17) so that the central axis of the neck and the OC-axis are in the same horizontal plane and the front side of the neck is facing downward.

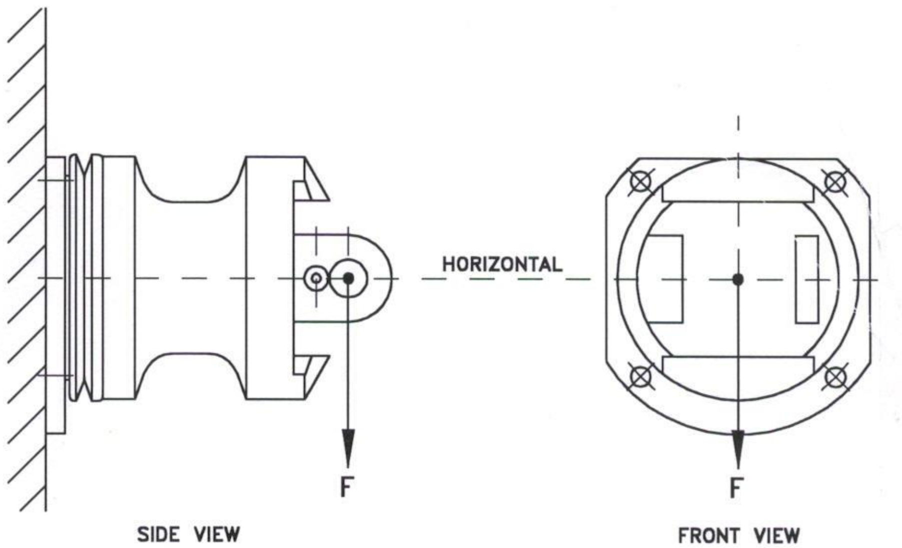

Figure 17: Neck calibration set-up

2. Apply a vertical downward force of 100 N acting at the point where the OC-axis crosses the mid-sagittal plane of the neck (the OC shoulder bolt [Z.QD] may be mounted for this purpose).
3. Record the vertical downward displacement δ_n of the OC-axis between 1 and 2 seconds after applying the load.

***Requirement:** 20 mm ≤ δ_n ≤ 24 mm*

If the neck does not fulfil the requirement, it can sometimes be tuned by replacing the buffer. Please contact the Business Unit Dummies if the neck falls outside the calibration requirement.

Sections 4.6 through 4.10 contain the joint adjustment specifications of the P1½, which are part of the calibration instructions. These joint adjustments should be performed using a fully assembled dummy (unless specified otherwise)!

4.6 Adjustment of the OC-joint

1. Place the dummy on its back onto a rigid flat table, so that the head and neck extend over the edge of the table (see Figure 18).

Figure 18: OC-joint adjustment set-up

2. Tighten the neck bolt [Z.QD] so that the head is just prevented from rotating (the so-called 1G setting).

4.7 Adjustment of the Hip

The instructions below apply to both left and right hip.

1. Remove the lower leg (see assembly/disassembly instructions, section 3.9).
2. Place the dummy on its buttocks onto a rigid flat table with its back vertical, so that the upper leg extends over the edge of the table (see Figure 19). The upper leg is placed horizontally.

Figure 19: Hip flexion adjustment set-up

3. Adjust the friction in the hip joint by adjusting the friction adjustment screw [Z.FI] so that the upper leg is just prevented from rotating (the so-called 1G setting).
4. Now place the dummy on its front onto a rigid flat table with its upper leg rotated 90 degrees outward and the upper leg extending over the edge of the table (see Figure 20).

Figure 20: Hip abduction/adduction adjustment set-up

5. Adjust the hip pivot bolt [Z.QS] so that the upper leg is just prevented from rotating (the so-called 1G setting).

4.8 Adjustment of the Knee

Adjustment of the knee joint should be performed after adjustment of the hip joint (see instructions above).

1. Mount the lower leg onto the upper leg (see assembly instructions, section 3.9)
2. Place the upper leg and lower leg in horizontal position, with the upper leg supported by a rigid flat table and the lower leg extending over the edge of the table (see Figure 21)

Figure 21: Knee adjustment set-up

3. Adjust the knee pivot bolt [Z.QR] so that the lower leg is just prevented from rotating (the so-called 1G setting).

4.9 Adjustment of the Shoulder

The P1½ is designed so that adjustment of the shoulder can be kept to a minimum. The instructions below apply to both left and right shoulder.

1. After having checked its parts and having assembled the shoulder (see assembly instructions, section 3.8), place the upper arm in the upper click-stop position with the lower arm extended.

Requirement: The upper arm should remain in the upper click-stop position under normal gravitation load.

If the shoulder fails this requirement, it needs servicing or replacement. Please contact the Business Unit Dummies if this occurs.

4.10 Adjustment of the Elbow

The P1½ is designed so that adjustment of the elbow can be kept to a minimum. The instructions below apply to both left and right elbow.

1. After having checked its parts and having assembled the elbow (see assembly instructions, section 3.7), place the lower arm in the upper click-stop position and make sure the lower arm is horizontal.

Requirement: The lower arm should remain in the upper click-stop position under normal gravitation load.

If the elbow fails this requirement, it needs servicing or replacement. Please contact FTSS if this occurs.

5. PHOTOGRAPH

Manual Update Log

Rev. B, Mar. 2011	Manual changed from FTSS to Humanetics
Rev. C, Jul. 2015	**Page 2**: Added lead material statement