

## Q0 User Manual





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# CHAPTER 1 - General

## 1.1 Summary

This document presents guideline for test engineers and dummy technicians to utilise the dummy in accident reconstruction crash test with in the CHILd-project. Within the CHILd-project the Q0 dummy is developed as a member of the Q-series child dummies. The Q0 dummy represents a 6 weeks old newborn child. The dummy is developed to be used in appropriate child restrained systems en car beds.

Information is provided about the design, instrumentation, assembly and disassembly, performance check and optioning, as well as performance criteria.

The early stage of development of the Q0 dummy results in the lack of sound and settled procedures for certification and handling, therefore it is stressed that this document can not be considered as a manual. The user is invited to submit comment and feedback about the content of this document as well as on the use of the dummy to the TNO. The feedback received can assist us to further improve the dummy design and its documentation.

## 1.2 Disclaimers

This document is made for the partners in the consortium of the European Commission funded CHILd-project. It must be read as user guidelines to support the use of the Q0 dummy in the accident reconstruction test within the project. The purpose of the document is to support the Q0 dummy utilisation by partners in the CHILd-project. The user of this manual is invited to provide TNO with his feedback and comment on the content of this manual and the use of the Q0 child dummy.

The decision to expose the dummy to a certain crash scenarios belongs to the responsibility of the partners that specify the test condition. TNO does not accept any responsibility of damage due to application of the Q0 dummy beyond its design conditions.

## 1.3 Introduction

The Q0 child dummy (see Figure 1) is designed as a tool to evaluate the protection offered to newborn children and babies by an appropriate child restraints used in cars as specified in the restraint manual in frontal, rear and side impact and rollover crash conditions. The dummy design is suitable for use in the standard EuroNCAP and ECE R44 child restraint evaluation test procedures. In the current evaluation test procedures the P0 dummy is specified. This dummy allows only a qualitative assessment of the protection in terms of remaining of the dummy in the child restraint as well as not exceeding certain specified space envelopes. The Q0 dummy enables besides the qualitative aspect also a quantitative assessment of the safety through the data obtained by the built in instrumentation. The measurement capabilities of the Q0 dummy make it suitable for application in accident scenario research.



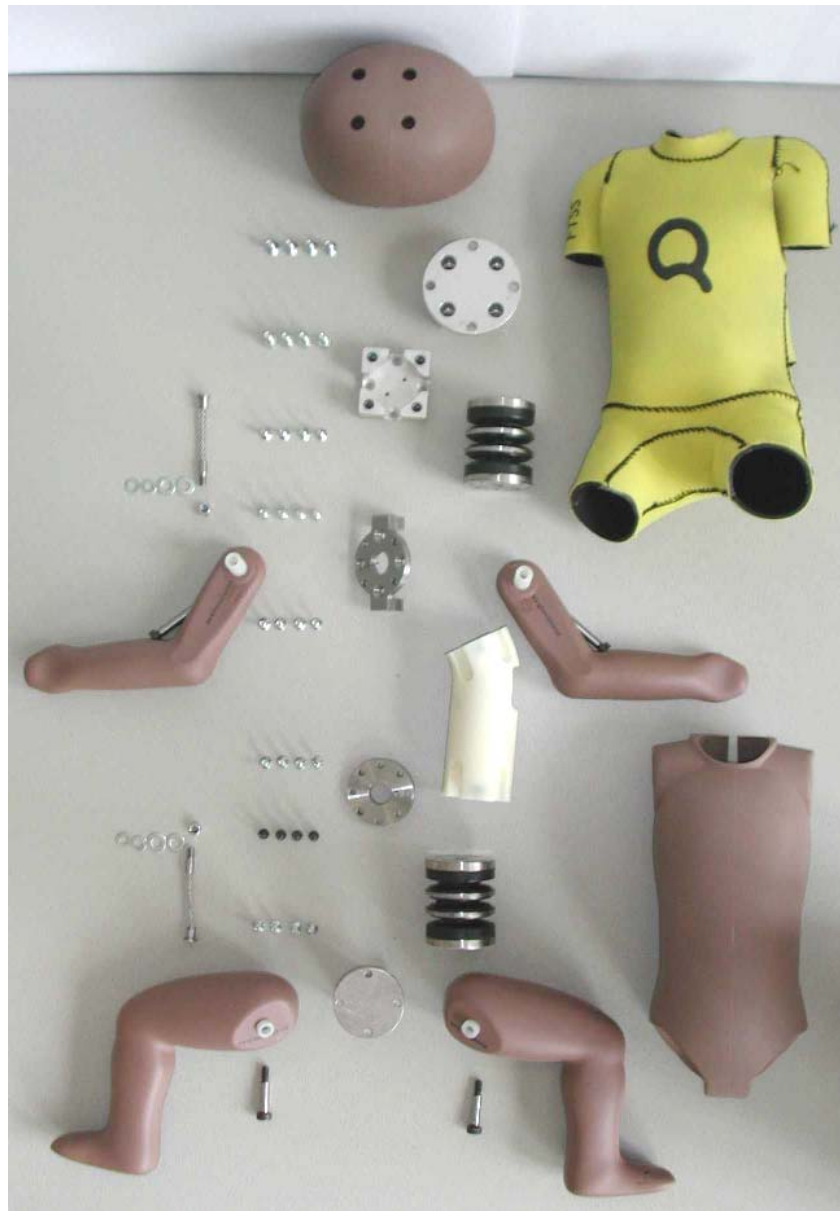
**Figure 1: Q0 newborn child dummy representing a six weeks old baby**

## CHAPTER 2 - Design Description

### 2.1 Introduction

The Q0 newborn child dummy represents a six weeks old baby. The mass and inertia are based on the anthropomorphic data collection called CANDAT [1]. The total mass of the dummy, including suit is  $3.4 \pm 0.05$  kg.

In this chapter a description of the Q0 child dummy design is given.



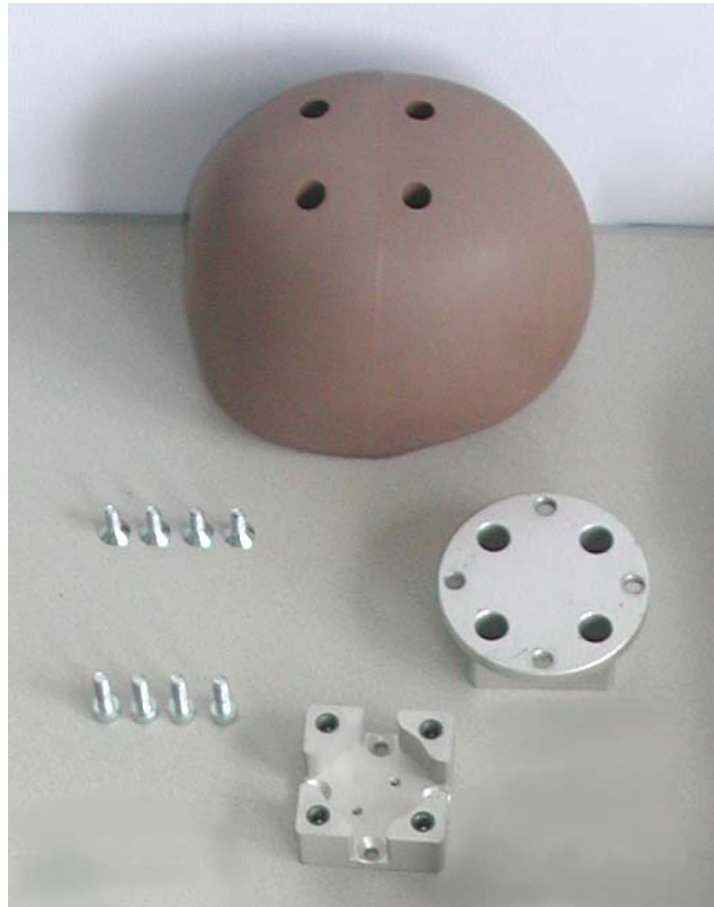
**Figure 2: Q0 child dummy in parts**

## 2.2 Head

The head of the Q0 child dummy comprises of three parts and two sets of bolts (Figure 3):

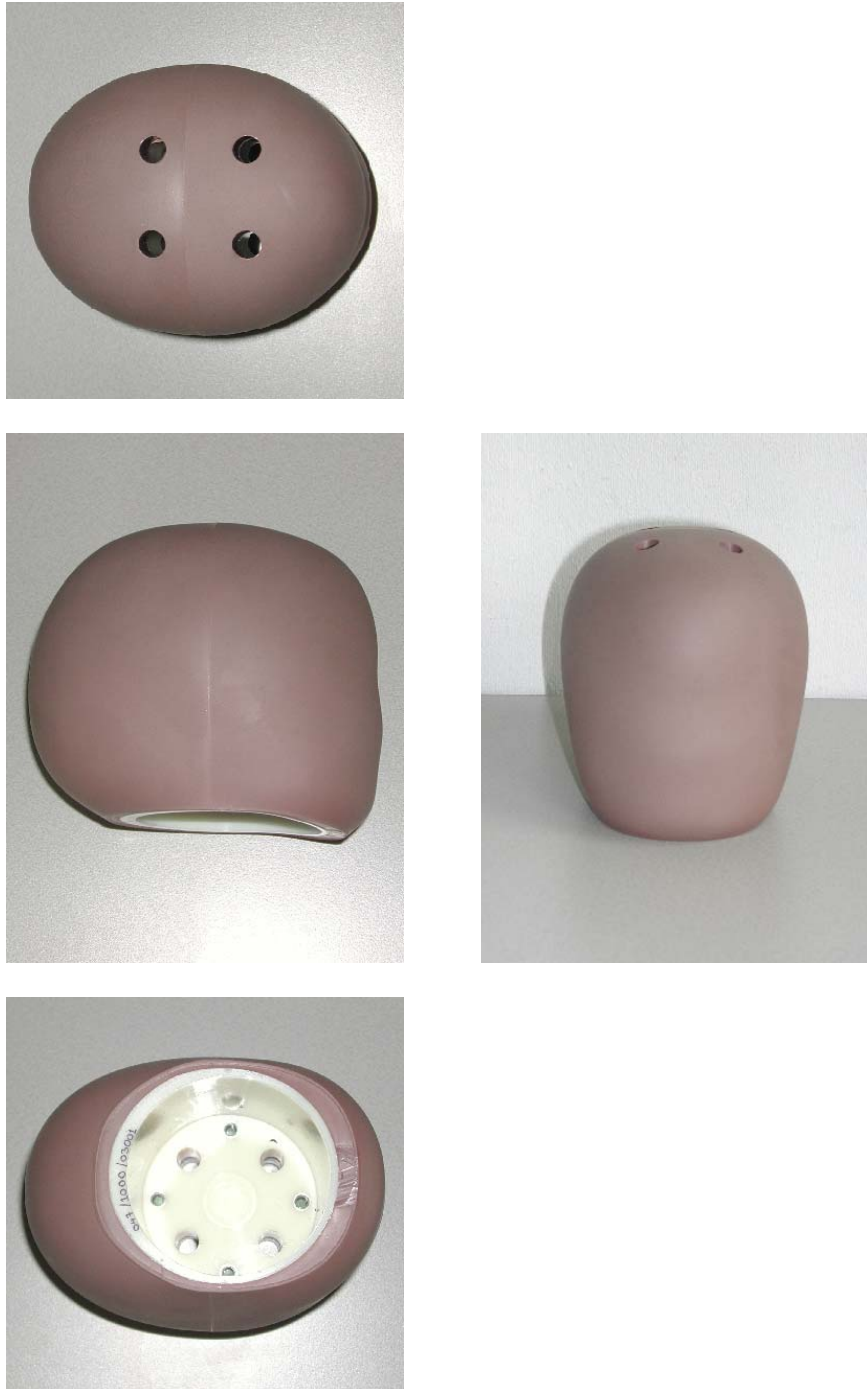
- a Polyurethane (PU) core covered with a bonded vinyl (PVC) skin.
- an upper neck load cell
- an accelerometer mounting bracket.
- four head to upper neck load cell attachment screws (countersunk screws)
- four upper neck load cell neck to accelerometer mounting bracket attachment screw (hexagon-socket screws)

The head outer shape is suitable to accept impacts from any direction and has featureless face. In the head core a large cavity provides accommodation for the upper neck load cell and the head accelerometer-mounting bracket (see Figure 4). The upper neck load cell, the accelerometer mounting bracket and two sets of interface attachment bolts (head to load cell and load cell to accelerometer mounting) belong to the head mass.



**Figure 3: Q0 child dummy head components - head mould, upper neck load cell replacement and accelerometer mounting bracket and two sets of interface attachment bolts**





**Figure 4: Q0 child dummy head in top, side, front and bottom view**

### **2.3 Neck**

The neck of the Q0 child dummy comprises of two parts and two sets of bolts (Figure 5):

- a neck mould that includes two end plates and two intermediate disks
- a neck cable with washers and nut
- four accelerometer mounting bracket to neck attachment screws (countersunk screws)
- four neck to shoulder plate attachment screws (hexagon-socket screws)

The neck mould has two steel end plates with threaded holes to attach the neck to the head and the thorax and two aluminium intermediate disks. The three rubber sections in the neck are equipped with transverse holes and slits at the front side. These incisions are applied to decrease the bending stiffness of the neck in the extension (rearward) bending mode. The neck cable protects the rather fragile neck for tension loads that may be too severe in combination with extensive bending.



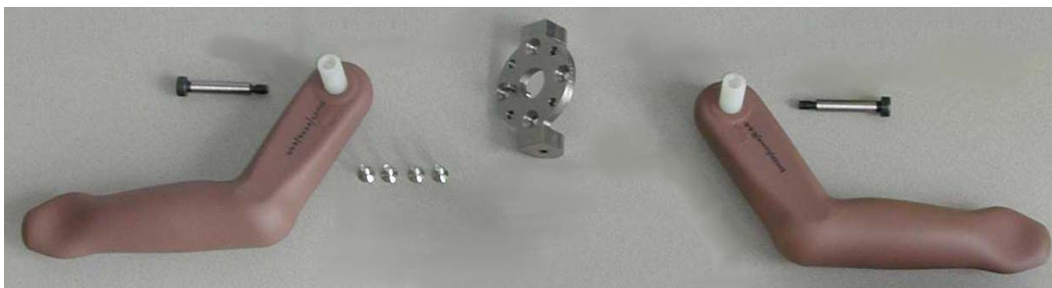
**Figure 5: Q0 child dummy neck - neck moulded rubber with two end plates and two intermediate disks, neck cable with washers and nut and two sets of interface attachment bolts.**

## **2.4 Shoulder and Arms**

The shoulder and arms of the Q0 child dummy comprise of three parts and some bolts (Figure 6):

- a shoulder bracket
- two arms (left hand and right hand one)
- two arm to shoulder attachment bolts (shoulder bolts)
- four shoulder to thoracic spine attachment screws (countersunk screws)

The shoulder bracket serves also as the top plate on the polyurethane thoracic spine.



**Figure 6: Q0 child dummy shoulder bracket, arms, arm attachment bolts and shoulder to spine attachment bolts**

## 2.5 Thorax

The Q0 child dummy thorax comprises of three parts and a set of interface attachment bolts

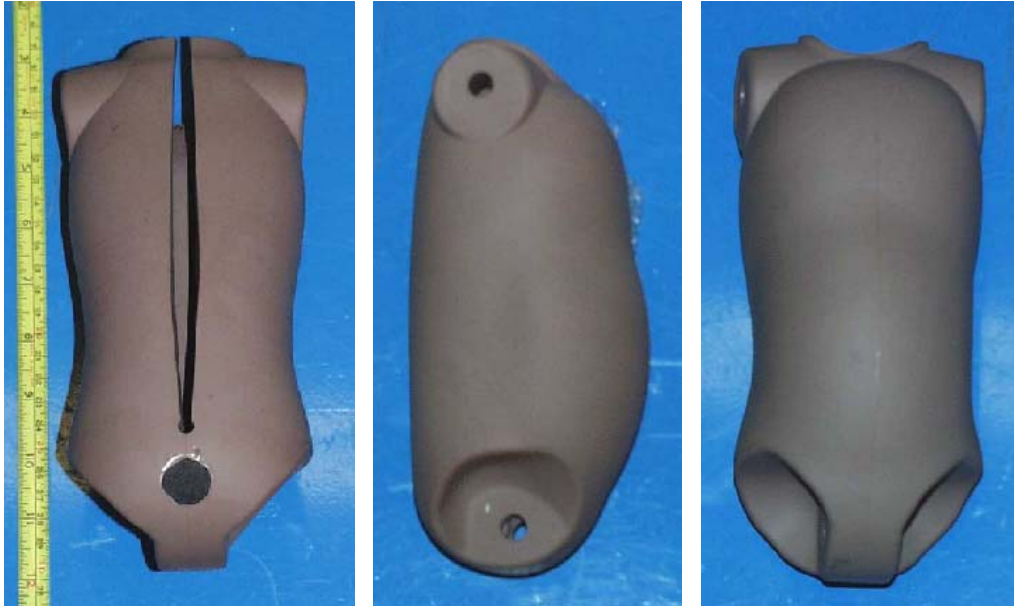
- a polyurethane thoracic spine
- a lower thoracic spine end plate
- four shoulder to thoracic spine attachment screws (countersunk screws)
- a torso flesh foam part covered with vinyl skin

The polyurethane thoracic spine is equipped with recesses at the top and bottom end that allow the insertion of screws to attach the neck and lumbar spine. A recess at the rear side allows the application of thoracic accelerometers.

The torso flesh is cut at the rear side to allow the insertion of the complete pelvis-lumbar spine-thoracic spine-shoulder-neck assembly.



**Figure 7: Q0 child dummy thoracic spine (spine colour may be black)**



**Figure 8: Q0 child dummy torso flesh foam**

## **2.6 Lumbar Spine**

The lumbar spine of the Q0 child dummy comprises of two parts and two sets of bolts (Figure 9):

- a lumbar spine mould that includes two end plates and two intermediate disks
- a lumbar spine cable with washers and nut
- four lower thoracic end plate to lumbar spine attachment screws (hexagon-socket screws)
- four lumbar spine to pelvis bracket attachment screws (countersunk screws)

The lumbar spine assembly is identical to the neck assembly.

The lumbar spine mould has two steel end plates with threaded holes to attach the lumbar spine to the thorax and the pelvis bracket and two aluminium intermediate disks. The three rubber sections in the lumbar spine are equipped with transverse holes and slits as required to decrease the bending stiffness of the neck in the extension (rearward) bending mode. The lumbar spine is mounted in the dummy with the slits at the rear side. The lumbar spine cable protects the rather fragile moulded part for tension loads.



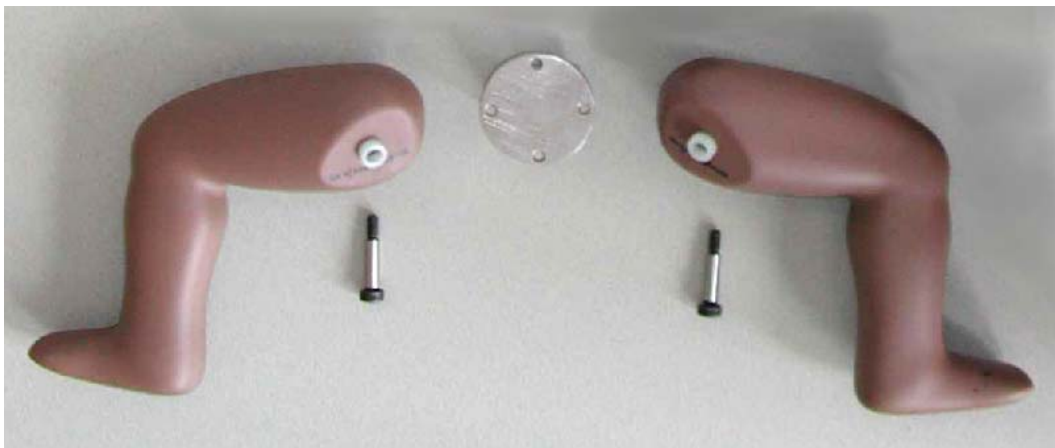
**Figure 9: Q0 child dummy lumbar spine**

### **2.7 Pelvis and Legs**

The pelvis and legs of the Q0 child dummy comprise of three parts and two bolts (Figure 10):

- a pelvis bracket
- two legs (left hand and right hand one)
- two pelvis to leg attachment bolts (shoulder bolts)

The pelvis bracket is equipped with a recess for pelvis accelerometers at the rear side.



**Figure 10: Q0 child dummy pelvis bracket and legs**

### **2.8 Rubber Suit**

The Q0 dummy is provided with a suit that covers the upper arms with short sleeves, the thorax, abdomen and pelvis and the upper legs with short sleeves (Figure 11). The suit can be opened at the back of the dummy with hook-and-loop-band.



**Figure 11: Q0 child dummy suit**

## **2.9 Tools**

The Q0 child dummy is supplied without special tools for disassembly and assembly. The dummy can be disassembled and assembled with standard tools like Allen-keys (2.5, 3 and 4 mm) flat end screwdriver (width 5 mm) and a box-wrench (8 mm). To reach the thoracic spine to neck and the thoracic spine to lumbar spine attachment screws an Allen-key with an reduced short end can be helpful.

## **2.10 Main Dummy Characteristics**

This section will describe some of the main Q0 child dummy characteristics with regards the mass and principle dimensions.

In Table 1 the masses of the main Q0 dummy components are given. A detailed description of the parts considered per component is presented.

**Table 1: Q0 child dummy component masses**

Component	Mass in kg	Principle Content
Head and neck	1.10 ± 0.10	Head, upper neck load cell accelerometer mounting bracket, neck assembly and 3 sets of screws
Arms (each)	0.14 ± 0.015	Arm and shoulder screw
Torso	1.50 ± 0.15	Shoulder bracket, thoracic spine, thoracic spine end plate, lumbar spine, pelvis bracket and 5 sets of bolts
Legs (each)	0.290 ± 0.03	Leg and shoulder screw
<b>Total</b>	<b>3.46 ± 0.34</b>	(tolerance including instrumentation allowance)

In Table 2 the principle dimensions Q0 dummy are given.

**Table 2: Q0 child dummy dimensions**

Dimension	Distance in mm
Sitting height	355 ± 7
Shoulder height	255 ± 5
Shoulder width	145 ± 5
Shoulder top to elbow	100 ± 2
Elbow to hand	127 ± 2
Buttock to knee	130 ± 5
Knee to foot	112 ± 2

## CHAPTER 3 - Instrumentation

### 3.1 Introduction

In this chapter the instrumentation options of the Q0 child dummy are presented.

Section 3.1 an overview of the instrumentation options is given. The subsequent sections describe the instrumentation options per body part.

The Q0 child dummy allows the application of 15 instrument channels.

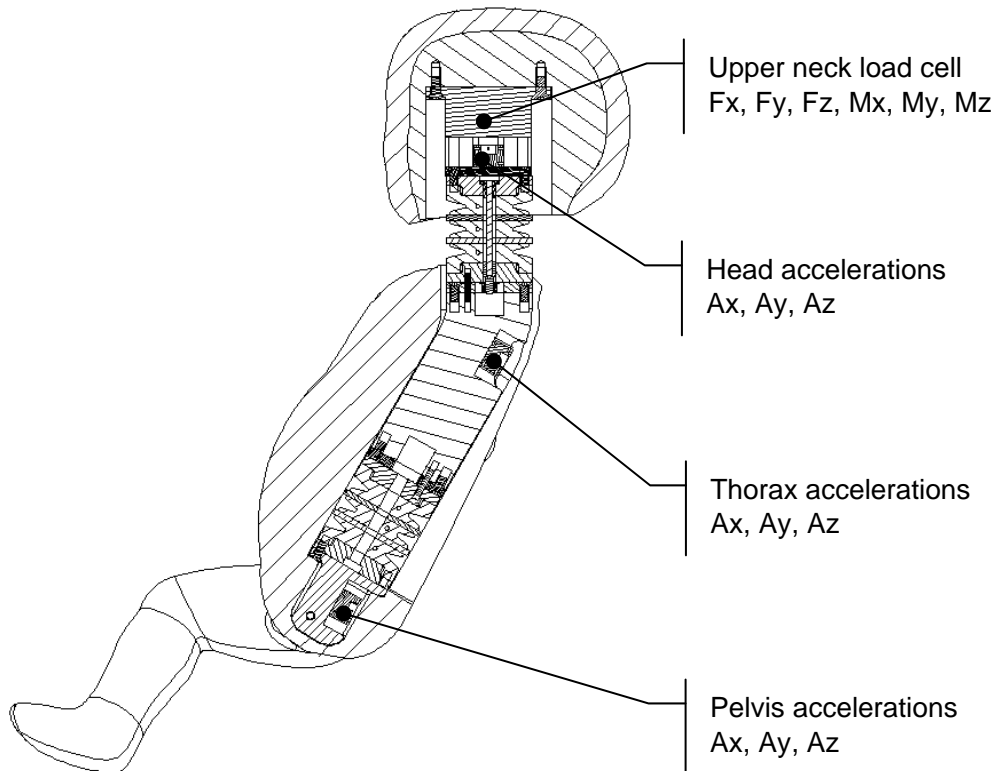
For all instrumentation channels a channel filter class according to ISO 6487: 2000 or SAE J211 (March 1995) is recommended.

### 3.2 Overview of Instrumentation

The Q0 dummy is designed to accept the following instrumentation options (see also Figure 12):

- **Head:** Three uni-axial accelerometers in the centre of gravity of the head  
Ax, Ay, Az (forward, lateral, downward)
- **Neck:** Upper neck load cell for three force and three moment channels  
Fx, Fy, Fz (forward, lateral, downward)  
Mx, My, Mz (RH ear down, nose up, nose right)
- **Thorax:** Three uni-axial accelerometers at about the T4 location  
Ax, Ay, Az (forward, lateral, downward)
- **Pelvis:** Three uni-axial accelerometers at about the sacrum location  
Ax, Ay, Az (forward, lateral, downward)





**Figure 12: Q0 child dummy instrumentation scheme**

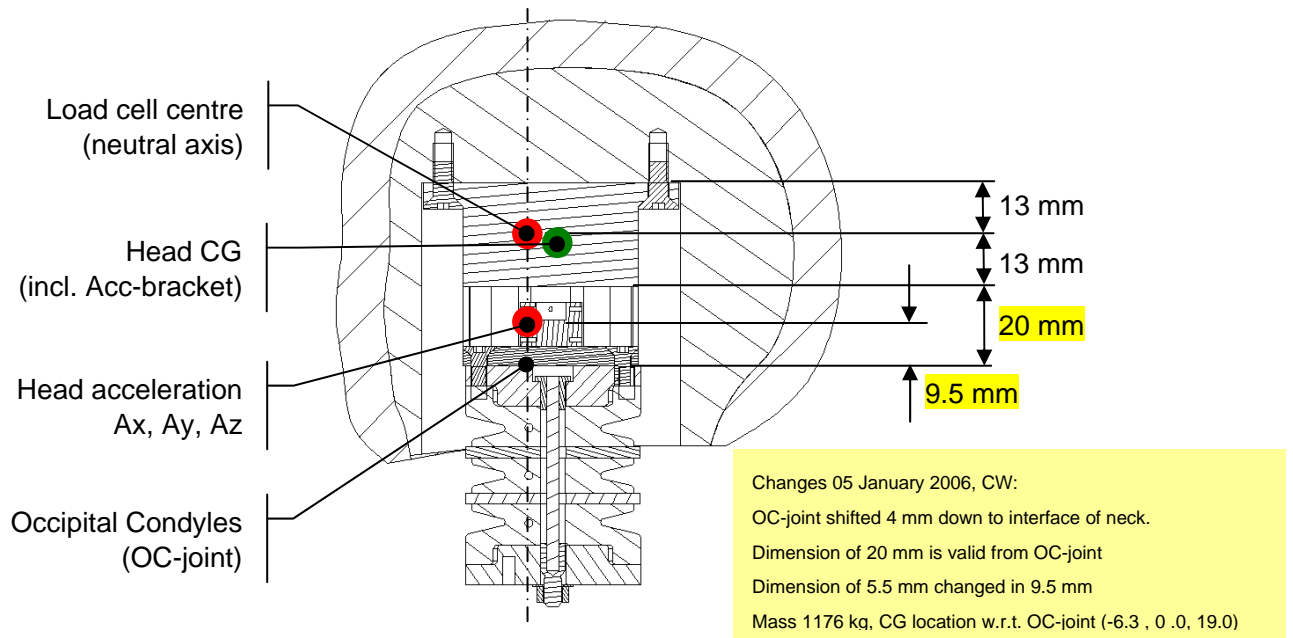
### **3.3 Head**

#### **3.3.1 Accelerations**

Three uni-axial accelerometers can be mounted in the accelerometer-mounting bracket located on top of the neck. The mounting bracket is equipped with a recess at the centre of gravity of the head that can accommodate a small block with three uni-axial accelerometers. One accelerometer ( $A_x$ ) is aligned with its sensitive axis parallel to the horizontal head-neck interface in the mid-sagittal plane. The second accelerometer ( $A_y$ ) is aligned with its sensitive axis parallel to the horizontal head-neck interface and perpendicular to the mid-sagittal plane. The third accelerometer ( $A_z$ ) is aligned with its sensitive axis perpendicular to the horizontal head-neck interface in the mid-sagittal plane.

Appropriate transducers are the Endevco model 7264A and Entran EGAS-500 or Endevco model 7264A-2000 and Kyowa ASM-200BA uni-axial accelerometers. The small accelerometer-mounting block should be adapted to the used type of transducer.

A Channel Filter Class of 1000 according to ISO 6487 or SAE J211 is recommended for the head acceleration signals.



**Figure 13: Q0 child dummy head and neck instrumentation location**

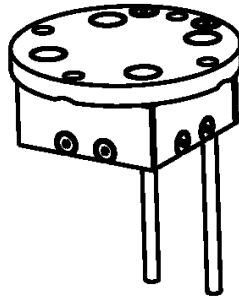
### 3.4 Neck

The head-neck interface is equipped with a 6-axis upper neck load cell. The load cell used in Q0 is identical to that of the Q3 Dummy.

The capacity specification of this load cell is

- ◆  $F_x = 5 \text{ kN}$  (1125 lbf)
- ◆  $F_y = 5 \text{ kN}$  (1125 lbf)
- ◆  $F_z = 6 \text{ kN}$  (1350 lbf)
- ◆  $M_x = 150 \text{ Nm}$  (1325 in-lbf)
- ◆  $M_y = 150 \text{ Nm}$  (1325 in-lbf)
- ◆  $M_z = 80 \text{ Nm}$  ( 700 in-lbf)

Appropriate load cells for this application are Denton model 3715 and FTSS IF-217 (see Figure 14). A structural replacement of the load cell is available.



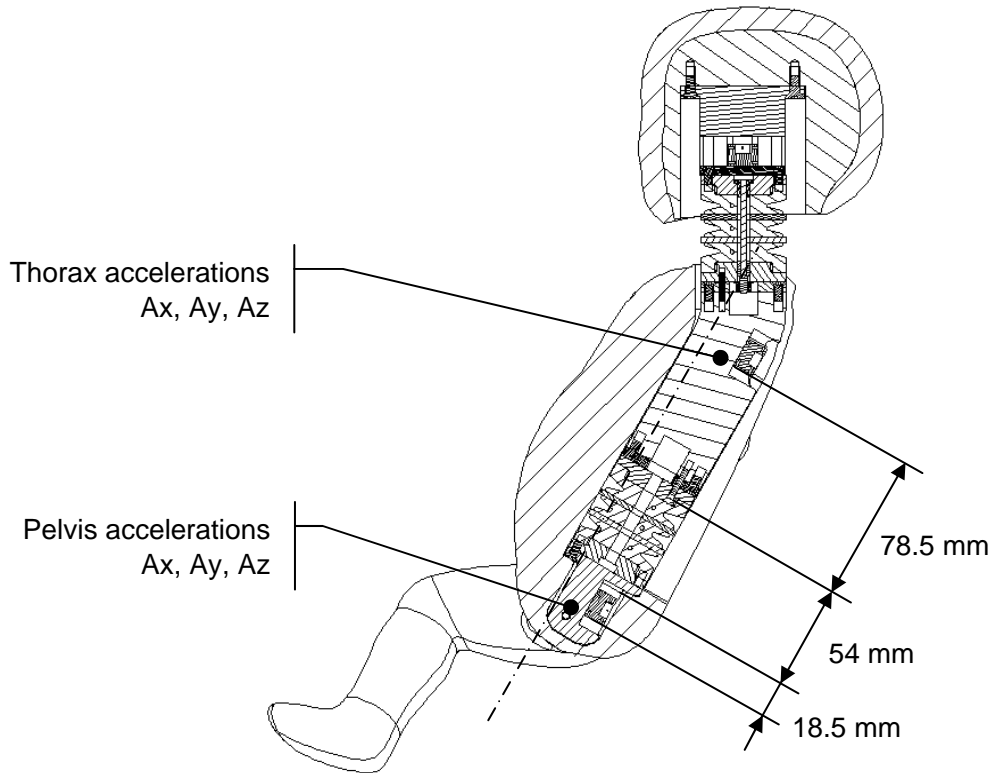
**Figure 14: Q0 child dummy upper neck load cell (FTSS IF-217)**

## **3.5 Thorax**

### *3.5.1 Accelerations*

Three uni-axial accelerometers can be mounted in the recess at the rear side of the thoracic spine at about the T4 location. The recess can accommodate a small block with three uni-axial accelerometers. One accelerometer ( $A_x$ ) is aligned with its sensitive axis parallel to the horizontal thoracic-lumbar spine interface in the mid-sagittal plane. The second accelerometer ( $A_y$ ) is aligned with its sensitive axis parallel to the horizontal thoracic-lumbar spine interface and perpendicular to the mid-sagittal plane. The third accelerometer ( $A_z$ ) is aligned with its sensitive axis perpendicular to the thoracic-lumbar spine interface in the mid-sagittal plane. Appropriate transducers are the Endevco model 7264A and Entran EGAS-500 or Endevco model 7264A-2000 and Kyowa ASM-200BA uni-axial accelerometers. The small accelerometer-mounting block should be adapted to the used type of transducer.

A Channel Filter Class of 1000 according to ISO 6487 or SAE J211 is recommended for the head acceleration signals.



**Figure 15: Q0 child dummy thorax and pelvis instrumentation location**

### **3.6 Pelvis**

#### *3.6.1 Accelerations*

Three uni-axial accelerometers can be mounted in the recess at the rear side of the pelvis bracket at sacrum location. The recess can accommodate a small block with three uni-axial accelerometers. One accelerometer ( $A_x$ ) is aligned with its sensitive axis parallel to the horizontal lumbar spine-pelvis interface in the mid-sagittal plane. The second accelerometer ( $A_y$ ) is aligned with its sensitive axis parallel to the horizontal lumbar spine-pelvis interface and perpendicular to the mid-sagittal plane. The third accelerometer ( $A_z$ ) is aligned with its sensitive axis perpendicular to the lumbar spine-pelvis interface in the mid-sagittal plane. Appropriate transducers are the Endevco model 7264A and Entran EGAS-500 or Endevco model 7264A-2000 and Kyowa ASM-200BA uni-axial accelerometers. The small accelerometer-mounting block should be adapted to the used type of transducer.

A Channel Filter Class of 1000 according to ISO 6487 or SAE J211 is recommended for the head acceleration signals.

## CHAPTER 4 - Disassembly and Assembly

### 4.1 Introduction

The disassembly and assembly of the Q0 child dummy is described in this chapter. Disassembly may be necessary in order to check, certify or repair the dummy or its parts. The parts are usually be assembled in reversed order described for disassembly. Some remarks and instructions important for assembly are given.

#### 4.1.1 Required Tools

The Q0 child dummy is a metric design. No special tools are required for disassembly and assembly. The standard tools to be used for disassembled and assembled are:

- Allen-keys (2.5, 3.0 and 4.0 mm)
- Flat end screwdriver (width 3.5 mm)
- Box-wrench (8 mm across flats).

To reach the thoracic spine to neck and the thoracic spine to lumbar spine attachment screws an Allen-key with an reduced short end or ball-head Allen-keys can be helpful.

#### 4.1.2 Fasteners List

In **Table 3** the fasteners are listed. Indicated are the body part, fastener location, size and quantity.

**Table 3: Fasteners List**

Body Part	Location	Size	Quantity
Head	Head to upper neck load cell	M5x12 c'sunk head	4
	Upper neck load cell to accelerometer mounting bracket	M5x16 socket head	4
	Accelerometer mounting bracket to upper neck	M4x10 c'sunk head	4
Neck	Lower neck to shoulder bracket	M4x14 socket head	4
	Neck cable	M5 nut self-locking	1
Shoulder and arms	Arms to shoulder bracket	M5x38 shoulder screw	2
	Shoulder bracket to thoracic spine	M4x10 c'sunk head	4
Thorax	Thoracic spine to lower thoracic spine end plate	M4x10 c'sunk head	4
	Lower thoracic spine end plate to upper lumbar spine	M4x14 socket head	4
Lumbar spine	Lumbar spine cable	M5 nut self-locking	1
	Lower lumbar spine to pelvis bracket	M4x10 c'sunk head	3
Pelvis and legs	Legs to pelvis bracket	M5x30 shoulder screw	2

## 4.2 Suit

All disassembly tasks with the Q0 child dummy, except the disassembly of the head, require stripping off the suit from the dummy

1. Open the hook-and-loop-band splice in the Q0 child dummy rubber suit.
2. Remove the rubber suit by stripping off.

### **Assembly remark or instruction:**

After assembly of the dummy up to and inclusive the neck of the shoulder bracket the suit can be put on. It is recommended to turn the suit inside out.

- Turn the suit inside out
- Put the trouser legs on the dummy legs with the edges up to just above the knees.
- Strip the suit trousers over the buttock of the dummy.
- Put the suit sleeves on the dummy arms with the edges up to just above the elbows.
- Strip the suit body over the shoulders.
- Rotate the arms and legs a few times 30 degrees up and down for a correct settlement of the suit on the arms and legs.

## 4.3 Head

To remove the head from the Q0 child dummy the four M5x16 socket head screws accessible from the top of the head should be unscrewed. With these fasteners the head and upper neck load cell combination is separated from the accelerometer-mounting bracket that remains attached to the neck. To separate the upper neck load cell from the head, unscrew the four M5x16 countersunk screws that attach the load cell inside the blind recess in the head. The accelerometer-mounting bracket can be disassembled from the neck by unscrewing the four M4x10 countersunk screws.

1. Remove head and upper neck load cell from the accelerometer-mounting bracket by unscrewing the four M5x16 socket head screws accessible from the top of the head.
2. Remove the upper neck load cell from the blind cavity in the head by unscrewing the four M5x16 countersunk screws.
3. Remove the accelerometer-mounting bracket from the neck by unscrewing the four M4x10 countersunk screws.

### **Assembly remark or instruction:**

The three interfaces described above can be mounted in four different directions each.

Caution:

- The direction of the head should be forward facing on the body.

- In case of accelerometer the accelerometer-mounting bracket should be positioned such the X- and Y-direction sensitive accelerometers are on the correct position.
- In case of load cell application the load cell direction should be such that the cable exits are at the rear side.

#### **4.4 Neck**

The neck can be separated from the dummy after the head and accelerometer-mounting bracket are removed. To reach the lower neck to thoracic spine interface fasteners, the complete spine should be separated from the torso flesh foam part by removal of the arms and legs. The neck cable can be removed from the neck moulded part.

1. Remove the head from the accelerometer-mounting bracket and the accelerometer-mounting bracket from the neck as described in section 4.3 step 1 and 3.
2. Remove the arms from the torso by unscrewing the two M5x38 shoulder bolts.
3. Remove the legs from the torso by unscrewing the two M5x30 shoulder bolts.
4. Open the torso flesh part at shoulder level to release the shoulder bracket from the torso flesh foam part.
5. Remove the neck, shoulder bracket, thoracic spine, lumbar spine and pelvis bracket assembly from the torso flesh foam part by carefully pulling it out of the opened torso flesh foam in upward direction.
6. Remove the neck assembly from the shoulder bracket by unscrewing the four M4x14 socket head screws.
7. Remove the neck cable from the neck moulded part by unscrewing the self-locking nut at the neck lower side. (Use an 8 mm box -wrench for the nut and hold the threaded end of the spine cable with a flat end screwdriver (width 3.5 mm)).

#### **Assembly remark or instruction:**

##### **Caution:**

- The neck cable should be assembled without any pretension. If the cable is too long the use of washers underneath the nut is allowed to fill the gap.
- The neck assembly should be mounted with the slits in its rubber sections on the forward side. A locator pin in the shoulder bracket prevents faulty assembly of the neck on top of the shoulder bracket.
- 

**Note:** The neck assembly is identical to the lumbar spine assembly the neck however is a part critical for the dummy performance, certification requirements are applicable for this part.

#### **4.5 Shoulder and Arms**

The arms can easily be removed by unscrewing the two M5x38 shoulder screws. The shoulder bracket can be separated from the dummy after the removal of the neck (see section 4.4).

1. Remove the neck (or the head neck assembly in case the head is not disassembled) from the dummy as described in section 4.4 steps 2 to 6.
2. Remove the shoulder bracket from the thoracic spine by unscrewing the four M4x10 countersunk screws.

##### **Assembly remark or instruction:**

###### **Caution:**

- The shoulder bracket should be mounted with its locator pin at the forward side. The locator pin protrudes at both sides of the shoulder bracket. A hole in the thoracic spine topside prevents faulty assembly of the shoulder bracket.

**Note:** The topside of the thoracic spine is the bend cylindrical side.

#### **4.6 Thorax**

The thoracic spine assembly can be separated from the dummy after removal of the shoulder bracket (see section 4.5) and removal of the lumbar spine. The lower thoracic spine end plate can be removed from the thoracic spine by unscrewing the four M4x10 countersunk screws.

1. Remove the shoulder bracket from the thoracic spine as described in section 4.5 steps 1 to 3.
2. Remove the thoracic spine assembly from the lumbar spine by unscrewing the four M4x14 socket head screws.
3. Remove the lower thoracic spine end plate from the thoracic spine by unscrewing the four M4x10 countersunk screws.

##### **Assembly remark or instruction:**

###### **Caution:**

- The thoracic spine end plate should be mounted with its locator pin at the rear side. The locator pin protrudes at both sides of the thoracic spine end plate. A hole in the thoracic spine bottom side prevents faulty assembly of the thoracic spine end plate.

**Note:** The bottom side of the thoracic spine is the straight cylindrical side.



## **4.7 Lumbar Spine**

The lumbar spine assembly can be separated from the dummy after the thoracic spine assembly is removed (see section 4.6). The lumbar spine cable can be removed from the lumbar spine moulded part.

1. Remove the thoracic spine assembly as described in section 4.6 step 1 and 2.
2. Remove the lumbar spine assembly from the pelvis bracket by unscrewing the four M4x14 socket head screws.
3. Remove the lumbar spine cable from the lumbar spine moulded part by unscrewing the self-locking nut at the neck lower side. (Use an 8 mm box -wrench for the nut and hold the threaded end of the spine cable with a flat end screwdriver (width 3.5 mm)).

**Assembly remark or instruction:**

Caution:

- The lumbar spine cable should be assembled without any pretension. If the cable is too long the use of washers underneath the nut is allowed to fill the gap.
- The lumbar spine should be mounted with the slits in its rubber sections on the rear side. A locator pin in the thoracic spine end plate prevents faulty assembly of the lumbar spine on the lower thoracic end plate.

Note: The lumbar spine assembly is identical to the neck assembly the lumbar spine however is not a part critical for the dummy performance, no certification requirements are applicable for this part.

#### **4.8 Pelvis and Legs**

The legs can easily be removed by unscrewing the two M5x30 shoulder screws. The pelvis bracket can be separated from the dummy after the removal the complete spine from the torso flesh foam part.

1. Remove the legs from the torso by unscrewing the two M5x30 shoulder bolts.
2. Remove the arms from the torso by unscrewing the two M5x38 shoulder bolts.
3. Open the torso flesh part at shoulder level to release the shoulder bracket from the torso flesh foam part.
4. Remove the neck, shoulder bracket, thoracic spine, lumbar spine and pelvis bracket assembly from the torso flesh foam part by carefully pulling it out of the opened torso flesh foam in upward direction.
5. Remove the pelvis bracket from the lumbar spine assembly by unscrewing the three M4x10 countersunk screws.

**Assembly remark or instruction:**

Caution:

- The pelvis bracket should be mounted with its accelerometer cavity to the rear side.
- If the pelvis bracket is not correctly mounted the legs will not fit properly

Note: The slits in its rubber sections of the lumbar spine are at the rear side.

## CHAPTER 5 - Certification

### 5.1 Introduction

The certification procedures to verify the performance of the Q0 child dummy are primarily based on the use of standard Part 572 equipment [2].

Depending on the side to be impacted, dummy parts should be certified for frontal, rear or left hand or right hand side impact. It is recommended to verify the Q0 child dummy performance for all direction each time a certification is desired or required.

The certification tests on the Q0 child dummy deal only with head and neck.

- **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:** tests with a Part 572 subpart E neck pendulum using the Q0 child head form and ES-2 interface, causing lateral flexion, as well as rotation and translation of the neck top interface;

Note: As the lumbar spine is identical to the neck the performance of the part can be verified in the same way as the neck. However there are no performance requirements applicable for the lumbar spine.

In the current stage of dummy development no certification requirements as commonly known from other dummy are set yet. In this chapter the performance verification tests of the design phase are documented to enable the check on consistent dummy performance. In a later stage of development proper pass / fail criteria will be established to verify the dummy performance.

### 5.2 Certification Equipment

The certification equipment required for the performance verification of the Q0 child dummy is given below. A detailed description of the application of the equipment is given in the section that deals with the procedure.

#### Head Drop Test

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 [2]. The Q0 head is suspended to the release mechanism with a simple rope harness. No special dummy-dedicated equipment is required for the Q0 head certification. In Figure 16 the head drop test set-up and the head suspension harness is shown.

## Neck Bending Tests

For the neck and lumbar spine tests, a pendulum is required similar to the Standard Part 572 subpart E, neck-bending pendulum [2]. The pendulum is decelerated by aluminium honeycomb (crush strength 1.8 lbs./cu. ft).

List of special equipment:

- Q3 pendulum mounting base
- Standard Q3 upper neck load cell replacement
- Modified accelerometer mounting bracket  
(centric hole 15 mm to accommodate the neck cable nut)
- Special bracket that replaces the accelerometer-mounting bracket on top of the neck  
(threaded holes to allow application of potentiometer shafts)
- Modified Q0 head  
(holes at both side to allow protrusion of the potentiometer shafts)
- Two potentiometer hardware as used for Hybrid III neck certification tests
- Shaft, potentiometer housing and bolt (on opposite side for mass compensation)
- Upper neck load cell mounted in the head

## 5.3 Head

### 5.3.1 Introduction

The head should be visually inspected for damage to the skin or core.

### 5.3.2 Test set-up

This test has to be conducted using the complete head assembly. The head consisting of the head, the upper neck load cell structural replacement and the accelerometer-mounting bracket (see Figure 3). The head has to be instrumented with three uni-axial accelerometers mounted on an accelerometer-mounting block located on the accelerometer-mounting bracket.

Accelerations are to be filtered using ISO 6487 or SAE J211 Channel Filter Class 1000.

The head must be positioned with a  $130 \pm 0.25$  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.

A 'quick release' mechanism is required to drop the head on the impact surface. The Q0 head is suspended to the release mechanism with a simple rope harness. No special dummy-dedicated equipment is required for the Q0 head certification. In Figure 16 the head drop test set-up and the head suspension harness is shown.



**Figure 16: Head drop table test set-up and Q0 child dummy head in harness (pictures do not show correct drop height and drop angle)**

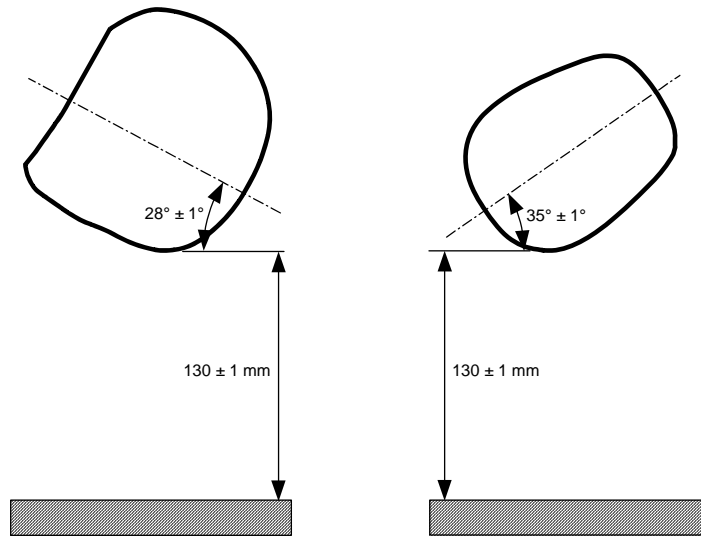
Three tests are to be performed: one frontal impact and two lateral impacts, one at each side.

**Frontal Impact**

The head has to be oriented such that the forehead is impacted. The angle between the head Z-axis and the impact surface shall be  $28^{\circ} \pm 1^{\circ}$ . The mid-sagittal plane of the head shall be vertical  $\pm 1^{\circ}$  (see Figure 17).

**Lateral Impact at both sides**

The head has to be oriented such that its mid-sagittal plane has an angle of  $35^{\circ} \pm 1^{\circ}$  with the impact surface and its anterior-posterior axis is horizontal  $\pm 1^{\circ}$  (see Figure 17).



**Figure 17: Q0 head drop tests**

Left: Frontal test:  $130 \pm 1$  mm,  $28^\circ \pm 1^\circ$ .  
 Right: Lateral test:  $130 \pm 1$  mm,  $35^\circ \pm 1^\circ$ .

Change 24 January 2006, CW:

**Check on impact direction**

Check in frontal test the lateral and in lateral test the frontal component. This component must be small to ensure that the impact direction is correct

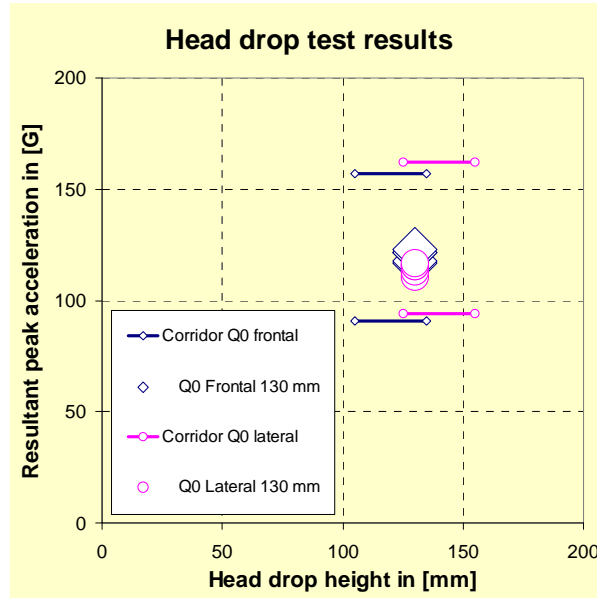
**5.3.3 Requirements**

The head passes the test if the peak resultant head acceleration is between: 91 g and 157 g for frontal impact and between 94 g and 162 g for lateral impact.

These requirement corridors are equivalent to the biomechanical requirements set for the Q0 child dummy design.

**5.3.4 Prototype compliance achieved**

To indicate the head drop test performance achieved with the prototype Q0 child dummy the results are shown in Figure 18



**Figure 18: Q0 child dummy head drop test result**

## 5.4 Neck

### 5.4.1 Introduction

The neck should be disassembled from the dummy (see section 4.4) and be visually inspected on cracks or tears in the moulded rubber part.

A dynamic calibration test using the Part 572 subpart E pendulum and some special parts as listed in section 5.2.

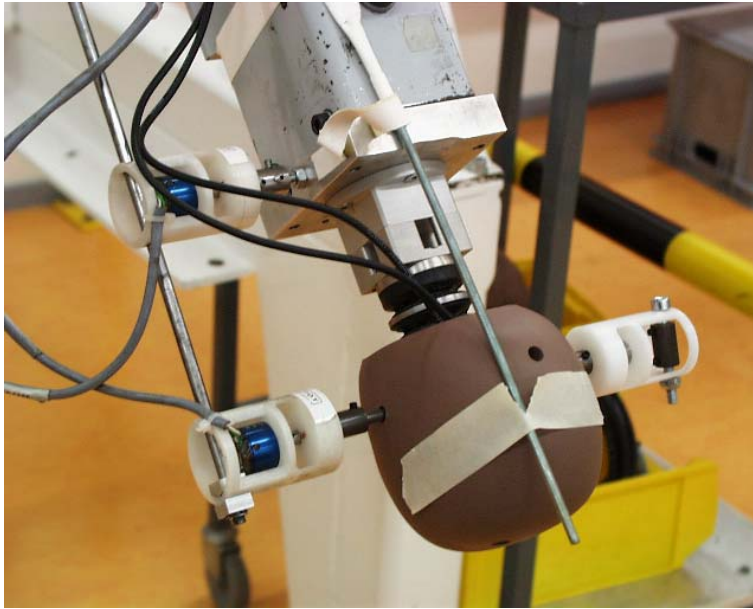
### 5.4.2 Test set-up

The neck should be kept in the test room for a period of at least four hours prior of a test at a temperature between 18°C and 22°C and humidity of 10 to 70 %.

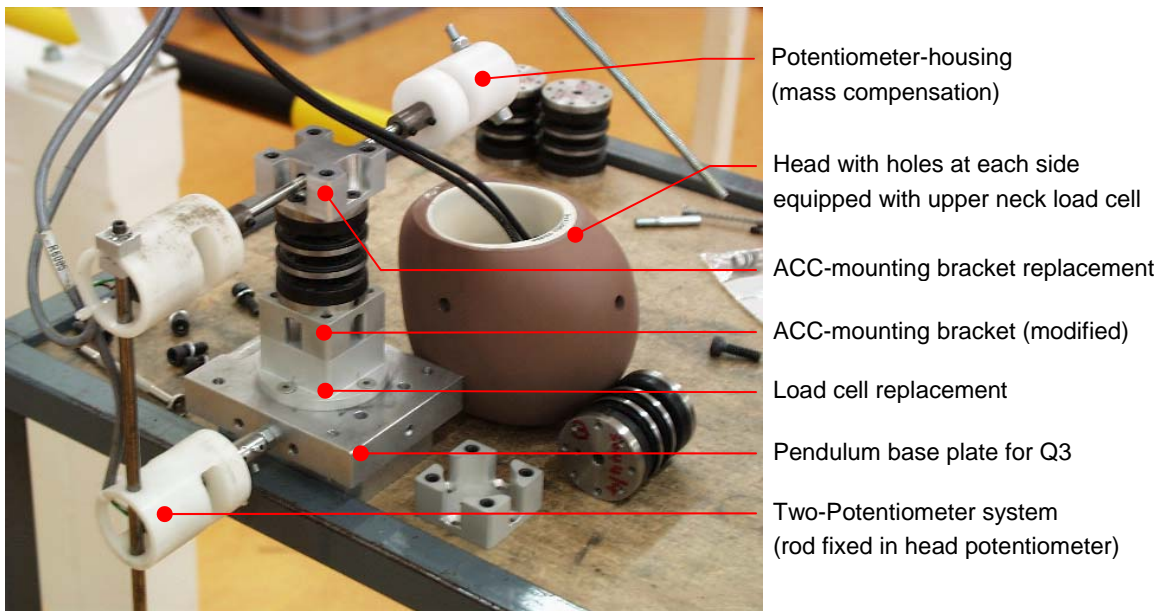
A test set-up overview with the complete assembled set configuration ready for a flexion test is shown in Figure 19. The special equipment used in the neck tests is shown in Figure 20.

#### List of special equipment:

- Q3 pendulum mounting base
- Standard Q3 upper neck load cell replacement
- Modified accelerometer mounting bracket  
(centric hole 15 mm to accommodate the neck cable nut)
- Special bracket that replaces the accelerometer-mounting bracket on top of the neck  
(threaded holes to allow application of potentiometer shafts)
- Modified Q0 head  
(holes at both side to allow protrusion of the potentiometer shafts)
- Two potentiometer hardware as used for Hybrid III neck certification tests
- Shaft, potentiometer housing and bolt (on opposite side for mass compensation)
- Upper neck load cell mounted in the head



**Figure 19: Q0 child dummy neck in pendulum test set-up (flexion)**



**Figure 20: Q0 neck pendulum test mounting equipment**



## Test set-up Assembly

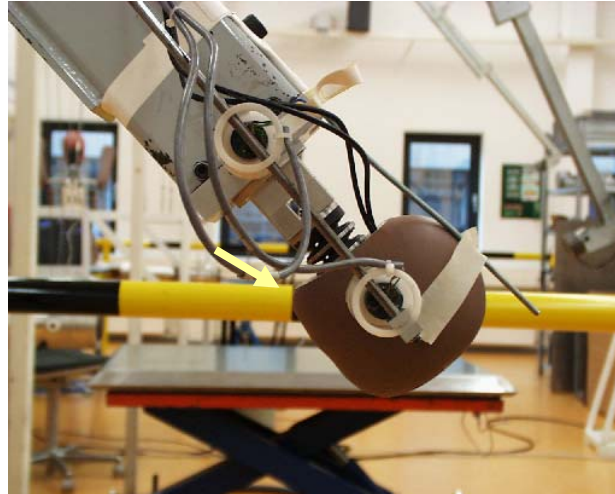
The actions to assemble the test set-up are:

- Attach the neck to the modified accelerometer-mounting brackets (see Figure 20).  
Make sure that orientation of the neck on the upper accelerometer-mounting bracket replacement is appropriate for the desired test-mode.  
(Threaded holes for the potentiometer shafts must be at the sides)
- Attach the modified accelerometer-mounting brackets the appropriate load cell (replacement) interfaces.  
Lower side of the neck (with neck cable nut) to the load cell replacement  
Upper side of the neck to the head load cell combination.  
Make sure that orientation of the neck on the upper neck load cell is correct. The cable exit shall be at the opposite side of the neck mould slits, see Figure 21 - flexion, Figure 22 - extension, Figure 23 - lateral flexion).
- Attach the head to the load cell in the appropriate direction.
  - Flexion and extension test with the load cell cable exit at the rear head.
  - Lateral flexion test with the head 90 degrees turned, cable exit at the head side
- Insert the potentiometer shafts at both sides of the head
- Attach the head, neck and interface parts assembly to the pendulum base plate.  
Make sure that orientation of the set-up on the pendulum base plate is appropriate for the desired test-mode.
- Mount the whole combination in the appropriate direction to the part 572 neck pendulum.
- Install the "two-potentiometer" system the one side of the set-up  
The rod between head and pendulum potentiometers should be fixed in head potentiometer to apply the main inertia loads to the pendulum base plate.
- Install a potentiometer housing are something with equivalent mass to the shaft at the opposite side of the head.

The Q0 child dummy neck is quite soft in the armed pendulum position the head neck system will slightly bend downwards. If the pendulum is release with this initially bend down position, oscillation of the head neck system is likely to occur at the moment of pendulum impact. To prevent this undesired oscillation the head is taped to a support rod in a "zero bending" position with a piece of pre-ripped paper tape (see Figure 19).

### Flexion Test

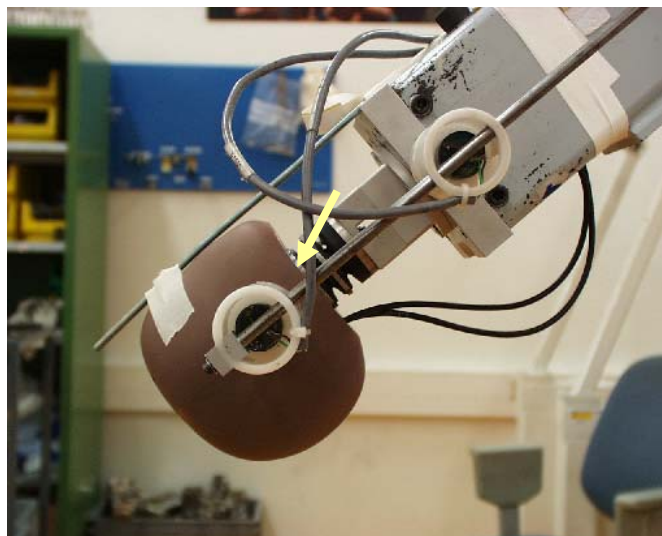
In the flexion test the slits in the moulded rubber segments of the neck shall be at the impact side of the pendulum. (See Figure 21)



**Figure 21: Q0 child dummy neck flexion test set-up**  
(arrow indicates position of neck slits, forward side of the neck)

### Extension Test

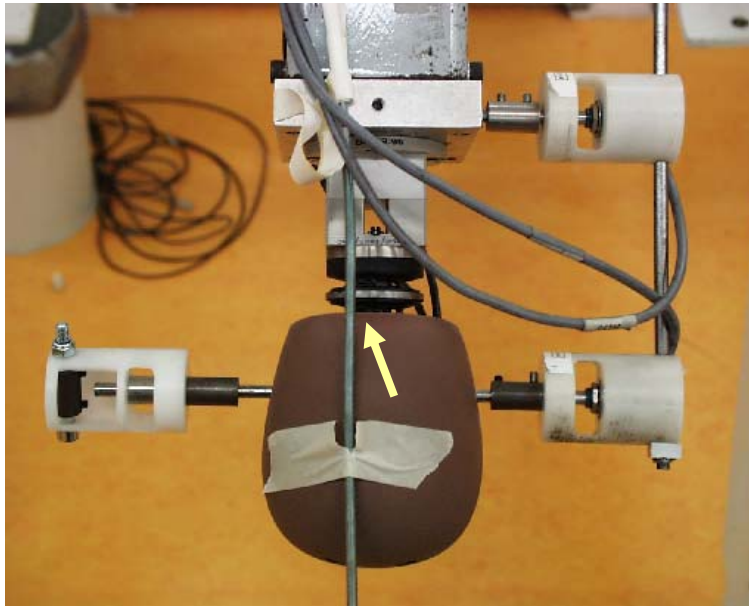
In the extension test the slits in the moulded rubber segments of the neck shall be the non-impact side of the pendulum. (See Figure 22)



**Figure 22: Q0 child dummy neck extension test set-up**  
(arrow indicates position of neck slits, forward side of the neck)

### Lateral Flexion Test

In the Lateral flexion test the slits in the moulded rubber segments of the neck shall be at the potentiometer or non-potentiometer side. To prevent rotation of the head in the lateral flexion test due to the centre of gravity offset from the neck centreline, the head is turned 90 degrees. In this way the neck is symmetrically loaded by the head mass inertia and the two-potentiometer system can be used in the same way as in the flexion and extension test. (See Figure 23)



**Figure 23: Q0 child dummy neck lateral flexion test set-up (head 90 degrees turned to obtain symmetric neck loading, arrow indicates position of neck slits, forward side of the neck)**

The period in which the pendulum is in pre-impact position (i.e. not the vertical position) should not exceed 5 minutes.

The pendulum is released and allowed to fall freely from a height chosen to achieve an impact velocity of  $3.2 \pm 0.1$  m/s, measured at the centre of the accelerometer, 1657.4 mm from the pendulum axis.

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#### **Deceleration pulse**

The number of honeycomb cells to be used to decelerate the pendulum in the tests shown in this manual is not known. Later test show that 16 cells is much too high. Decrease the number of cells such that a maximum initial neck moment of round about 2 Nm or -2 Nm at between 5 and 10 degrees is reached. (See Figure 24, Figure 25 and Figure 26)

The head rotation is measured with the two rotational potentiometers using an ISO 6487 or SAE J211 CFC 1000 hardware filter to acquire the data. The pendulum base and the head

potentiometer angle are directly measured during the certification test. The flexion angle of the head must be determined using the following equation:

$$\beta = d\Theta_{\text{pendulum}} + d\Theta_{\text{head}}$$

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.

#### *5.4.3 Requirements*

For the Q0 child dummy neck there are no simple certification requirements yet. The performance requirements used in the design phase are the moment-flexion angle corridors based on scaled down human neck behaviour. The Q0 child dummy neck complies quite well with these requirements (see Figure 24, Figure 25 and Figure 26). Based on the actual performance of the Q0 child dummy prototype neck the following provisional certification requirements are defined.

#### **Flexion Test**

The neck passes the flexion test, if the  $M_y$  moment at OC during the loading phase at a head flexion of 60 degrees is between 3.7 and 5.2 Nm.

#### **Extension Test**

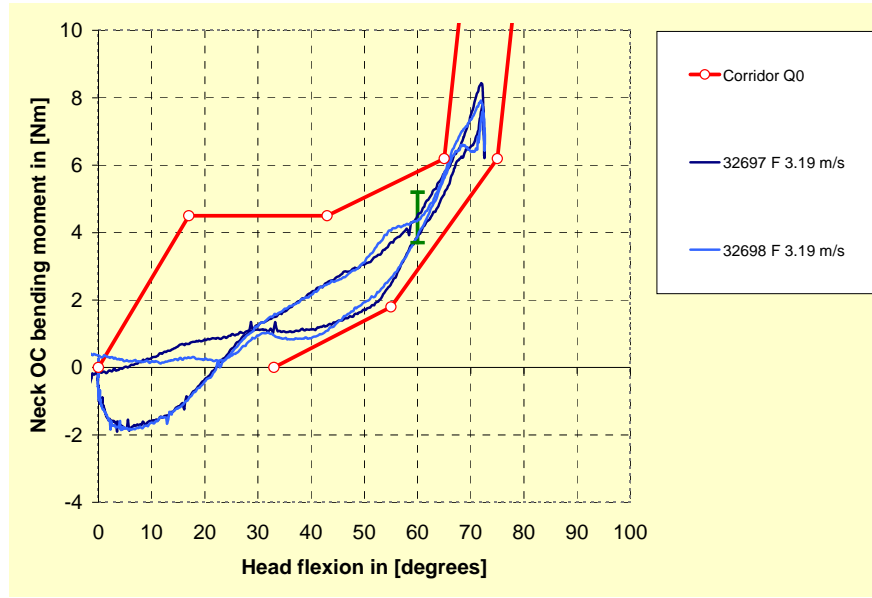
The neck passes the extension test, if the  $M_y$  moment at OC during the loading phase at a head extension of 50 degrees is between -0.5 and -2.0 Nm.

#### **Lateral Flexion Test**

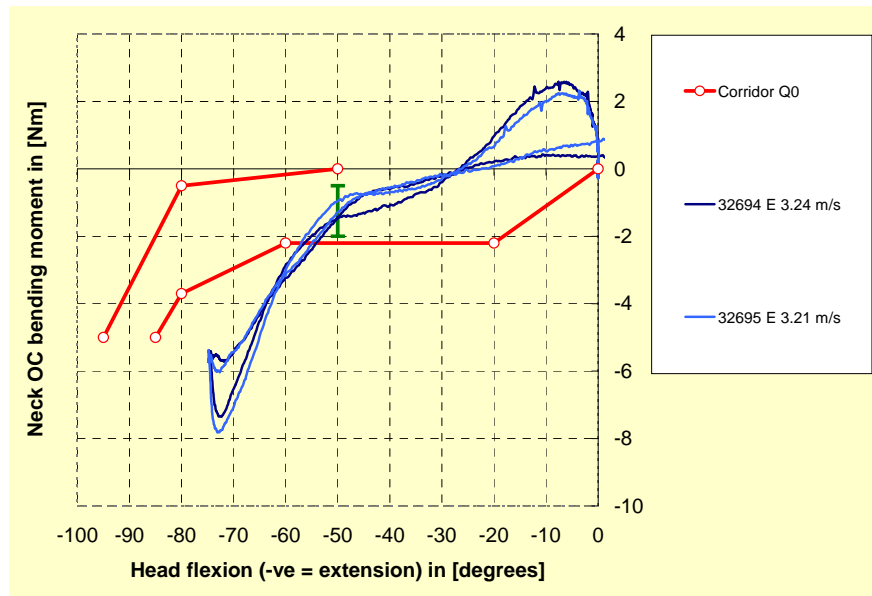
The neck passes the lateral flexion test, if the  $M_x$  moment at OC during the loading phase at a head lateral flexion of extension of  $\pm 40$  degrees is between  $\pm 0.5$  and  $\pm 2.0$  Nm.

#### *5.4.4 Prototype compliance achieved*

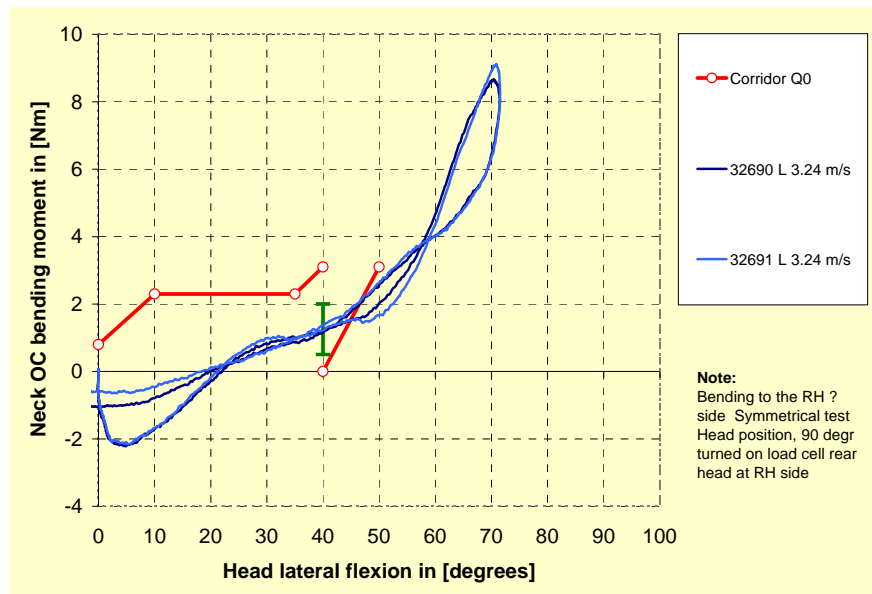
To indicate the compliance achieved with the prototype Q0 child dummy neck the results are shown in Figure 24 - flexion; Figure 25 - extension and Figure 26 - lateral flexion.



**Figure 24: Q0 child dummy neck flexion performance (provisional corridor indicate: 3.7 to 5.2 Nm at 60 degrees)**



**Figure 25: Q0 child dummy neck extension performance (provisional corridor indicate: -0.5 to -2.0 Nm at -50 degrees)**



**Figure 26: Q0 child dummy neck lateral flexion performance (provisional corridor indicate:  $\pm 0.5$  to  $\pm 2.0$  Nm at  $\pm 40$  degrees)**

### 5.5 Lumbar Spine

The Q0 child dummy lumbar spine is identical to the neck. The performance of the part can be verified in the same way as the neck (see section 5.4). However there are no performance requirements applicable for the lumbar spine.

It is recommended to certify the lumbar spine in according to the same procedure as used for the neck. In case the lumbar spine certification is skipped it is recommended to clearly label the lumbar spine "NOT CERTIFIED".

## **CHAPTER 6 - Handling Procedures and Application**

### **6.1 Introduction**

The handling procedure for the Q0 child dummy and its endorsed application are presented in this chapter.

### **6.2 Handling Procedures**

The Q0 child dummy design is robust and does not require special handling procedures. It is recommended to avoid impact contact with rigid sharp edges that may result in damage to the skin and the underlying structure.

Prior to a test the Q0 child dummy should be kept in the test room for a period of at least four hours prior to a test at a temperature between 18°C and 22°C and humidity of 10 to 70 %.

### **6.3 Storage of Q0 Child Dummy**

When storing the Q0 child dummy between tests, or between a test and certification or vice versa it is advisable to lay the dummy on its back.

To avoid accelerated ageing of dummy materials the dummy should be kept out of direct sunlight when storing. Storage temperature should be between 10° and 30° C. 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.

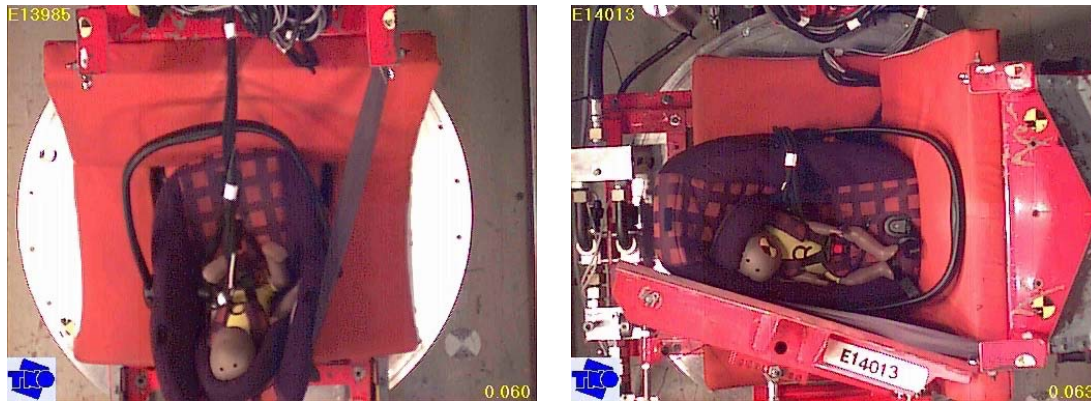
### **6.4 Application in Impact Tests**

The Q0 child dummy (see Figure 1) is designed as a tool to evaluate the protection offered to newborn children and babies by an appropriate child restraints used in cars as specified in the restraint manual in frontal, rear and side impact and rollover crash conditions. The dummy design is suitable for use in the standard EuroNCAP and ECE R44 child restraint evaluation test procedures. In the current evaluation test procedures the P0 dummy is specified. The P0 dummy allows only a qualitative assessment of the protection in terms of remaining of the dummy in the child restraint as well as not exceeding certain specified space envelopes. The Q0 dummy enables besides the qualitative aspect also a quantitative assessment of the safety through the data obtained by the built in instrumentation. The measurement capabilities of the Q0 dummy make it suitable for application in accident scenario research.

At TNO the dummy performance and response has be evaluate through in a program of 30 sled tests (see Figure 27):

- Frontal impact tests with CREST-deceleration pulse       $A_{max} = 34 \text{ G}$  ( 5 off)
- Frontal impact tests with EuroNCAP-deceleration pulse       $A_{max} = 42 \text{ G}$  (10 off)
- Rear impact tests ECE-44 pulse       $A_{max} = 19 \text{ G}$  ( 5 off)
- Side impact tests with moving door       $A_{max} = 21 \text{ G}$  (10 off)

In these tests the 15 possible measurement channels were recorded. In **Table 4** the maximum obtained values are given.



**Figure 27: Q0 child dummy in child restraint sled tests at TNO**

**Left: Frontal impact test**

**Right: Side impact test with moving door**

**Table 4: Channel reading maximum or minimum values in TNO sled tests**

Body part	Parameter	Unit	Value	Test case
Head	Ax	G	70.4	Rear impact
	Ay	G	88.7	Side - ECE44
	Az	G	72.8	Frontal - NCAP
	Ares	G	96.9	Side - ECE44
	HIC		809	Frontal - NCAP
Upper neck loads	Fx	N	616	Frontal - NCAP
	Fy	N	116	Side - ECE44
	Fz	N	415	Rear impact
	Mx	Nm	8.0	Side - ECE44
	My	Nm	28.6	Frontal - NCAP
	Mz	Nm	2.8	Side - ECE44
Thorax	Ax	G	68.8	Frontal - NCAP
	Ay	G	60.2	Side - ECE44
	Az	G	86.2	Frontal - NCAP
	Ares	G	96.2	Frontal - NCAP
Pelvis	Ax	G	83.7	Frontal - NCAP
	Ay	G	77.6	Side - ECE44
	Az	G	124	Frontal - NCAP
	Ares	G	146	Frontal - NCAP



The decision to expose the dummy to a certain crash scenarios belongs to the responsibility of the partners that specify the test condition. TNO does not accept any responsibility of damage due to application of the Q0 dummy beyond its design conditions.

## CHAPTER 7 - References

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- 1 CANDAT - Child Anthropomorphic DATabase - Since early 90's in house TNO developed database that combines data sets available from US, UK, Germany and The Netherlands. (see TNO-reports 1994: 75161275-B (Twisk, D.); 1994: 94.OR.BV.003/1/DT; 94.OR.BV.025.1/DT and 96.OR.BV.005.2/DT)
- 2 American Code of Federal Regulation 49 CFR Chapter V Part 572 (10-1-00 Edition)

### Manual Update Log

**Rev. B, June 2011**      Manual changed from FTSS to Humanetics