
**Road vehicles — Design and
performance specifications for the
WorldSID 50th percentile male side-
impact dummy —**

**Part 2:
Mechanical subsystems**

*Véhicules routiers — Conception et spécifications de performance
pour le mannequin mondial (WorldSID), 50e percentile homme, de
choc latéral —*

Partie 2: Sous-systèmes mécaniques



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 36, *Safety and impact testing*.

This third edition cancels and replaces the second edition (ISO 15830-2:2013), which has been technically revised.

The main changes are as follows:

- in [Figure 1](#) head CG location has been changed to head reference mark location;
- body segment assembly mass specifications have been changed;
- clothing mass specification has been changed;
- in [Table 1](#) specifications of head resultant acceleration have been changed for frontal and lateral drops;
- in [Table 3](#) new neck torsion specifications were added for new neck torsion validation test procedure;
- in [Table 4](#) new specification for decay time in shoulder validation test has been added;
- calculation procedure for neck validation has been changed;
- in [Table 5](#) thorax specifications have been changed and validation test procedure specifies a new pendulum face;
- thorax with arm specifications and validation test procedure have been removed;
- full arm description and specifications have been removed;
- in [Table 7](#) specifications for pelvis acceleration and pendulum force have been changed and a new specification for pubic force has been added;
- in [Table 9](#) specifications and CMM procedure for whole body dimensions have been added;

- drawing list has been removed;
- in [Annex B](#) new procedure for optional single rib test has been added.

A list of all parts in the ISO 15830 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

The purpose of the ISO 15830 series is to document the design and specifications of this side-impact dummy in a form suitable and intended for worldwide use.

In 1997, the WorldSID 50th percentile adult male dummy development was initiated, with the aims of defining a global-consensus side-impact dummy, with more humanlike anthropometry, improved biofidelity, and increased injury monitoring capabilities, suitable, for example, for regulatory use. Participating in the development were research institutes, dummy and instrumentation manufacturers, governments and vehicle manufacturers from around the world.

This document is intended to document information and design changes which have become available since the publication of the second edition of the ISO 15830 series (2013-05-15).

In order to apply the ISO 15830 series properly, it is important that all four parts be used together.

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Road vehicles — Design and performance specifications for the WorldSID 50th percentile male side-impact dummy —

Part 2: Mechanical subsystems

1 Scope

This document specifies requirements for mechanical components, specifications and validation tests for the WorldSID 50th percentile side-impact dummy, a standardized anthropomorphic dummy for near-side-impact tests of road vehicles.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

ISO 15830-1, *Road vehicles — Design and performance specifications for the WorldSID 50th percentile male side-impact dummy — Part 1: Vocabulary and rationale*

ISO 15830-3:2022 *Road vehicles — Design and performance specifications for the WorldSID 50th percentile male side-impact dummy — Part 3: Mechanical requirements for electronic subsystems*

ISO 15830-4:2022 *Road vehicles — Design and performance specifications for the WorldSID 50th percentile male side impact dummy — Part 4: User's manual*

ISO/TS 21002, *Road vehicles — Multidimensional measurement and coordinate systems definition*

SAE J211-1, *Instrumentation for impact test — Part 1: Electronic instrumentation*

SAE J1733, *Sign convention for vehicle crash testing*

SAE J2570, *Performance specifications for anthropomorphic test device transducers*

SAE J2856, *User's manual for 50th percentile male Hybrid III dummy*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15830-1 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Mechanical requirements for WorldSID

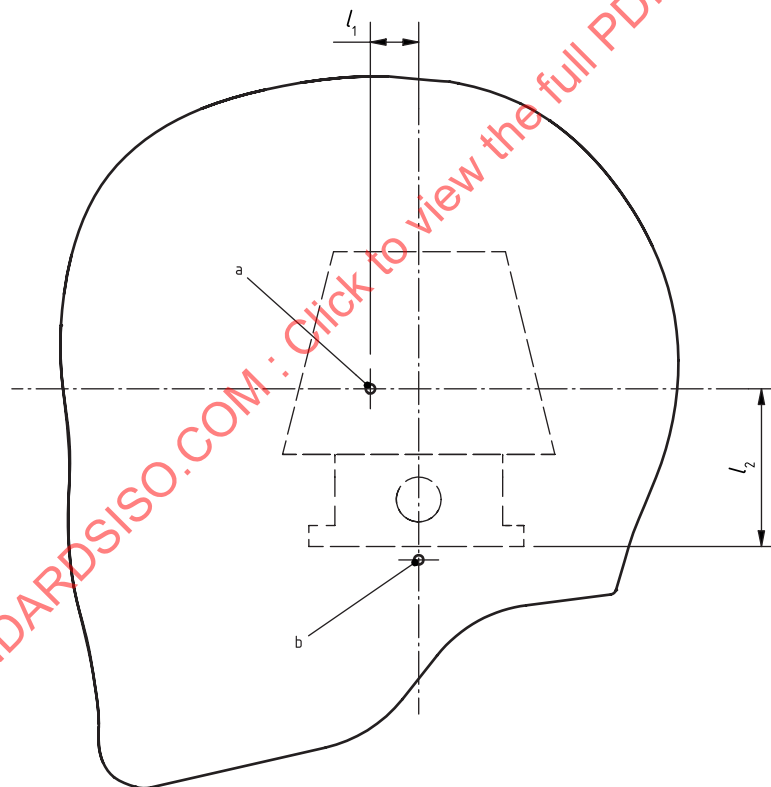
4.1 Head

4.1.1 General description

The head assembly shall consist of the components and assemblies shown in ISO 15830-4:2022, Clause A.1 excluding the neck shroud and five BHCS M4 × 0,7 × 10 LG.

4.1.2 Specifications

- The total assembly shall have a mass of 4,29 kg ± 0,05 kg.
- The head reference marks shall be located as indicated in [Figure 1](#).
- The materials used in the construction of the head assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.
- If present, cables exiting the head assembly shall exit at the rear and include a secure strain relief mechanism.



- l_1 (15,5 ± 2,5) mm
 l_2 (50,5 ± 2,5) mm
 a Head reference mark.
 b Occipital condyle.

Figure 1 — Head reference mark location

4.1.3 Validation

When assembled in accordance with ISO 15830-4 and tested using the procedure specified in 5.1, the head assembly shall meet the specifications given in Table 1.

Table 1 — WorldSID head validation specifications

Frontal drop	
Variable	Absolute value
Peak resultant acceleration (g)	205 to 255
Peak lateral acceleration, a_y (g)	< 15
Maximum percentage, subsequent-to-main peak (%)	< 10
Lateral drop	
Variable	Absolute value
Peak resultant acceleration at CG (g)	104 to 123
Peak longitudinal acceleration, a_x (g)	< 15
Maximum percentage, subsequent-to-main peak (%)	< 10

4.2 Neck

4.2.1 General description

The neck assembly shall consist of the components shown in ISO 15830-4:2022, Clause A.2.

4.2.2 Specifications

- The total assembly shall have a mass of $2,86 \text{ kg} \pm 0,02 \text{ kg}$.
- The materials used in the construction of the neck assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.
- If present, cables exiting the neck assembly shall include a secure strain relief mechanism.

4.2.3 Validation

4.2.3.1 Lateral flexion

When assembled in accordance with ISO 15830-4 and tested using the procedure specified in 5.2.1, the neck assembly shall meet the specifications given in Table 2.

Table 2 — WorldSID neck lateral flexion validation specifications

Variable	Absolute value
Maximum angular displacement of the head form relative to the pendulum, β (degrees)	50 to 61
Decay time of β to 0 degrees (ms) ^a	58 to 72
Peak moment at occipital condyle, M_{OCx} (N·m)	55 to 68
Peak moment decay time to 0 N·m (ms) ^a	71 to 87
Peak forward potentiometer angular displacement (degrees)	32 to 39
Time of peak forward potentiometer angular displacement, θ_F (ms) ^a	56 to 68
^a $T = 0 \text{ ms}$ is established following the procedure defined in 5.2.1.7.	

Table 2 (continued)

Variable	Absolute value
Peak rearward potentiometer angular displacement, θ_R (degrees)	30 to 37
Time of peak rearward potentiometer angular displacement, (ms) ^a	56 to 68
^a $T = 0$ ms is established following the procedure defined in 5.2.1.7.	

4.2.3.2 Torsion

When assembled in accordance with ISO 15830-4 and tested using the procedure specified in 5.2.2, the neck assembly shall meet the specifications given in Table 3.

Table 3 — WorldSID neck torsion validation specifications

Variable	Absolute value
Peak torsion fixture rotation, z-axis (degrees)	41,9 to 51,2
Torsion fixture rotation decay time to 0 degrees (ms) ^a	37,3 to 45,6
First peak torsion fixture angular rate, ω_z (degrees/s) ^b	1 440 to 1 760
Peak lower neck moment, M_z (N·m)	34,6 to 42,9
^a $T = 0$ ms is established following the procedure defined in 5.2.2.7.	
^b The angular rate is relative to the laboratory frame of reference, not the neck pendulum.	

4.3 Thorax/abdomen/shoulder

4.3.1 General description

The thorax/abdomen/shoulder assembly shall consist of the components and assemblies shown in ISO 15830-4:2022, Clause A.3.

4.3.2 Specifications

- The total assembly shall have a mass of 20,56 kg $\pm$ 0,35 kg.
- The materials used in the construction of the thorax/abdomen/shoulder assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.
- If present, cables exiting the thorax/abdomen/shoulder assembly shall include a secure strain relief mechanism.

4.3.3 Validation

4.3.3.1 Shoulders

When assembled in accordance with ISO 15830-4 and tested using the procedure specified in 5.3.2, the shoulder assembly shall meet the specifications given in Table 4.

Table 4 — WorldSID shoulder validation specifications

Variable	Absolute value
Peak pendulum force (kN)	2,6 to 3,3
Peak shoulder rib deflection (mm)	35 to 45

Table 4 (continued)

Variable	Absolute value
Delay time between peak pendulum force and peak shoulder rib deflection (ms)	> 15

4.3.3.2 Thorax

When assembled in accordance with ISO 15830-4 and tested using the procedure specified in 5.3.3, the thorax assembly shall meet the specifications given in Table 5.

Table 5 — WorldSID thorax validation specifications

Variable	Absolute value
Peak pendulum force (kN)	3,1 to 3,7
Peak T4 acceleration along y-axis (<i>g</i>)	14 to 20
Peak T12 acceleration along y-axis (<i>g</i>)	12 to 20
Peak thorax rib 1 deflection (mm)	35 to 45
Peak thorax rib 2 deflection (mm)	37 to 45
Peak thorax rib 3 deflection (mm)	33 to 41

4.3.3.3 Abdomen

When assembled in accordance with ISO 15830-4 and tested using the procedure specified in 5.3.4, the abdomen assembly shall meet the specifications given in Table 6.

Table 6 — WorldSID abdomen validation specifications

Variable	Absolute value
Peak pendulum force (kN)	2,7 to 3,1
Peak T12 acceleration along y-axis (<i>g</i>)	15 to 20
Peak abdomen rib 1 deflection (mm)	33 to 40
Peak abdomen rib 2 deflection (mm)	30 to 36

4.4 Arms

4.4.1 General description

The arm assembly shall consist of the components and assemblies shown in ISO 15830-4:2022, Clause A.4.

4.4.2 Specifications

- The total assembly shall have a mass of 1,76 kg ± 0,04 kg.
- The materials used in the construction of the arm assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.

4.5 Lumbar spine and pelvis

4.5.1 General description

The lumbar spine and pelvis assembly shall consist of the components and assemblies shown in ISO 15830-4: 2022, Clause A.5.

4.5.2 Specifications

- The total assembly shall have a mass of 19,30 kg $\pm$ 0,20 kg.
- The materials used in the construction of the pelvis assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.
- If present, cables exiting the pelvis assembly shall include a secure strain relief mechanism.

4.5.3 Validation

When assembled in accordance with ISO 15830-4 and tested using the procedure specified in 5.3.5, the pelvis assembly shall meet the specifications given in Table 7.

Table 7 — WorldSID pelvis validation specifications

Variable	Absolute value
Peak pendulum force (kN)	6,8 to 8,2
Peak T12 acceleration along y-axis (<i>g</i>)	10 to 14
Peak pelvis acceleration along y-axis (<i>g</i>)	37 to 47
Peak pubic force (kN)	1,25 to 1,55

4.6 Upper legs and knees

4.6.1 General description

The upper leg assembly shall consist of the components and assemblies shown in ISO 15830-4:2022, Clause A.6 and Clause A.7.

4.6.2 Specifications

- The total assembly shall have a mass of 5,86 kg $\pm$ 0,04 kg.
- The materials used in the construction of the upper leg assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.
- If present, cables exiting the upper leg assembly shall include a secure strain relief mechanism.

4.7 Lower legs, ankles, and feet

4.7.1 General description

The lower leg, ankle, and foot assembly shall consist of the components and assemblies shown in ISO 15830-4:2022, Clause A.8.

4.7.2 Specifications

- The total assembly shall have a mass of $5,06 \text{ kg} \pm 0,07 \text{ kg}$.
- The materials used in the construction of the lower leg assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.
- If present, cables exiting the lower leg assembly shall include a secure strain relief mechanism.

4.8 Clothing

4.8.1 General description

The clothing shall consist of a form fitting polychloroprene suit covering from neck to ankle and stopping at the shoulder (sleeveless) as specified in ISO 15830-4:2022, Clause A.9.

4.8.2 Specifications

- The total assembly shall have a mass of $1,62 \text{ kg} \pm 0,16 \text{ kg}$.
- The materials used in the construction of the clothing shall not contain lead or lead alloys.
- The external surface characteristics shall enable positive attachment of adhesive targets.

4.9 Whole dummy

4.9.1 General description

The whole dummy assembly shall consist of the components and assemblies shown in ISO 15830-4:2022, Annex A.

4.9.2 Specifications

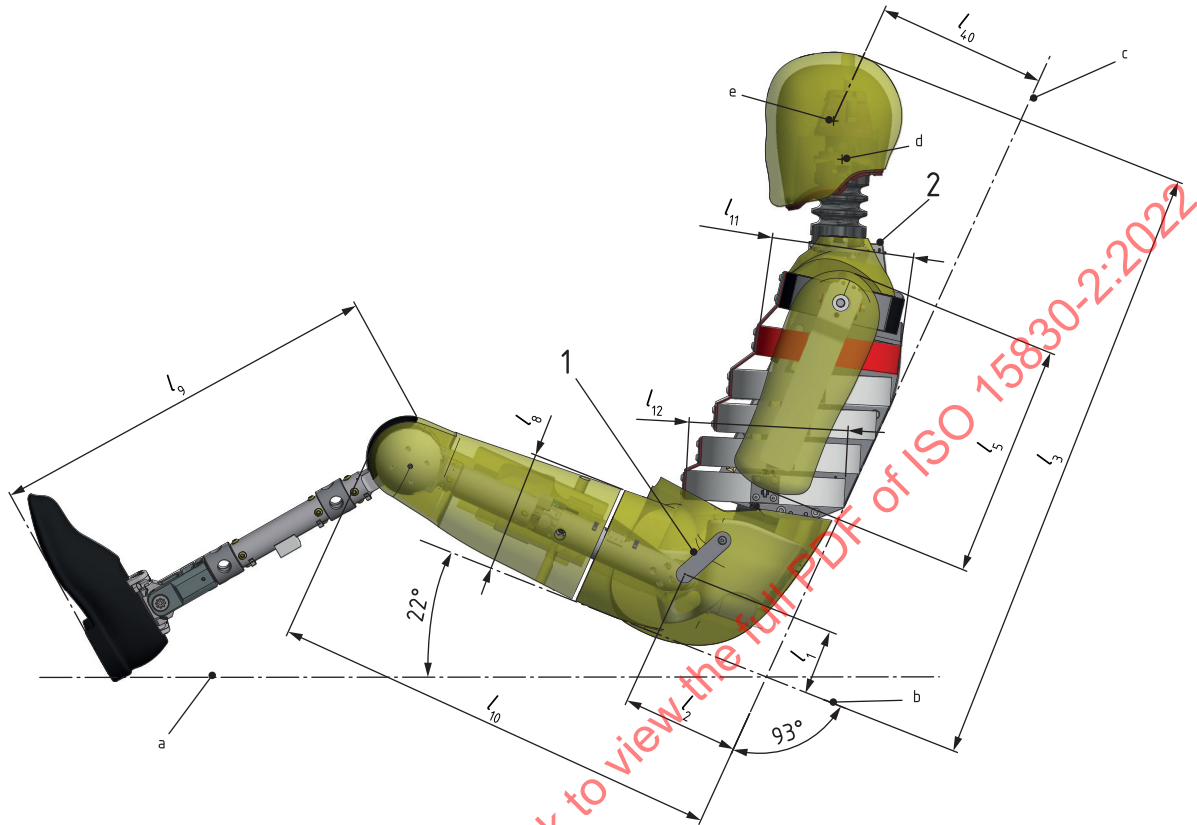
- The total dummy assembly with two half arms including clothing shall have a mass of $73,99 \text{ kg} \pm 1,08 \text{ kg}$.
- The body segment masses shall meet the specifications given in [Table 8](#).

Table 8 — WorldSID body segment mass specifications

Body segment	Mass [kg]
Head	$4,29 \pm 0,05$
Neck	$2,86 \pm 0,02$
Thorax/abdomen/shoulders	$20,56 \pm 0,35$
Two half arms	$3,52 \pm 0,08$
Lumbar spine and pelvis	$19,30 \pm 0,20$
Two upper legs/knees	$11,72 \pm 0,08$
Two lower legs/ankles/feet	$10,12 \pm 0,14$
Clothing	$1,62 \pm 0,16$
Total with clothing and half arms	$73,99 \pm 1,08$

4.9.3 Validation

When assembled in accordance with ISO 15830-4:2022, Annex A, excluding the suit and moulded lower leg flesh, and measured using the procedure given in [5.4](#), the dummy shall meet the whole-body measurements shown in [Figure 2](#) and [Figure 3](#), and specified in [Table 9](#).



Key

- 1 H-point tool
- 2 neck bracket
- a Horizontal.
- b Seat pan line.
- c Seat back line.
- d Occipital condyle.
- e Head reference mark.

Figure 2 — External dimensions, side view

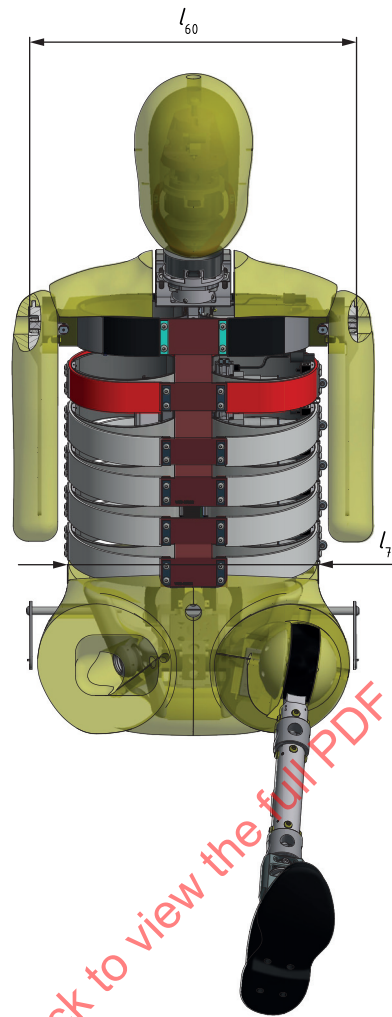


Figure 3 — External dimensions, front view

Table 9 — WorldSID linear dimension specifications

Dimensions in millimetres

Variable	Symbol	Value		
		Centre	Left	Right
Hip pivot height	l_1		85 ± 10	85 ± 10
Hip pivot to back line	l_2		175 ± 10	175 ± 10
Seated height	l_3	865 ± 20		
Head reference mark to seat back	l_{40}		250 ± 20	250 ± 20
Arm length	l_5		330 ± 10	330 ± 10
Width across shoulder attachment studs	l_{60}	435 ± 10		
Waist width	l_7	340 ± 10		
Thigh clearance	l_8		170 ± 10	170 ± 10
Knee to shoe height	l_9		580 ± 35	588 ± 35
Knee to back line	l_{10}		665 ± 15	665 ± 15
Thorax rib number 1 front to back	l_{11}		205 ± 10	205 ± 10

Table 9 (continued)

Variable	Symbol	Value		
		Centre	Left	Right
Abdomen rib number 2 front to back	l_{12}		225 ± 10	225 ± 10

5 Validation test procedures

5.1 Head

5.1.1 Principle

Certify the dynamic response of a head assembly by performing a 200 mm lateral drop on each side of the head and a 376 mm drop on the forehead.

5.1.2 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used.

- horizontal head impact surface:
 - horizontal chrome-plated steel plate rigidly supported;
 - 50,8 mm × 610 mm × 610 mm minimum;
 - surface finish rms value of 8 µm/mm to 80 µm/mm.
- head drop tool assembly;
 - 120 g maximum.
- instrumented head assembly as described in ISO 15830-4:2022, Clause A.1, including the instrumentation insert and upper neck load cell or structural replacement, but excluding the neck shroud and five BHCS M4 × 0,7 × 10 LG.

5.1.3 Sensors

Use a triaxial linear accelerometer or three single-axis linear accelerometers as specified in ISO 15830-3:2022, 4.1.3.2.

5.1.4 Preparation

- Expose the head assembly to an environment with a temperature of 20,6 °C to 22,2 °C and a relative humidity between 10 % and 70 % for a period of at least four hours prior to a test.
- Clean the head skin surface and the surface of the impact plate with isopropyl alcohol or equivalent.
- Install the triaxial accelerometer or three single-axis linear accelerometers in the head assembly.
- Install the upper neck load cell, angular accelerometers, and dual-axis tilt sensor, or their structural or mass replacements.
- Suspend the head above the head impact surface using a quick release mechanism.
- For lateral tests, attach the head drop tool to the bottom of the upper neck load cell or its structural replacement with two SHCS M6 × 12 as shown in [Figure 4](#). The tool orients the midsagittal plane at an angle of 35,0° ± 1,0° with the impact surface and its anterior-posterior axis is horizontal to

within 1° as shown in Figure 5. Position the head so its lowest point is $200 \text{ mm} \pm 0,25 \text{ mm}$ above the impact surface.

- For a frontal test, attach the head drop tool to the bottom of the upper neck load cell or its structural replacement with two SHCS M6 $\times$ 12 as shown in Figure 6. The tool orients the frontal plane at an angle of $35,0^\circ \pm 1,0^\circ$ with the impact surface and its anterior-posterior axis is horizontal to within 1° as shown in Figure 7. Position the head so the lowest point on the forehead is $376 \text{ mm} \pm 0,25 \text{ mm}$ above the impact surface.

Dimensions in millimetres

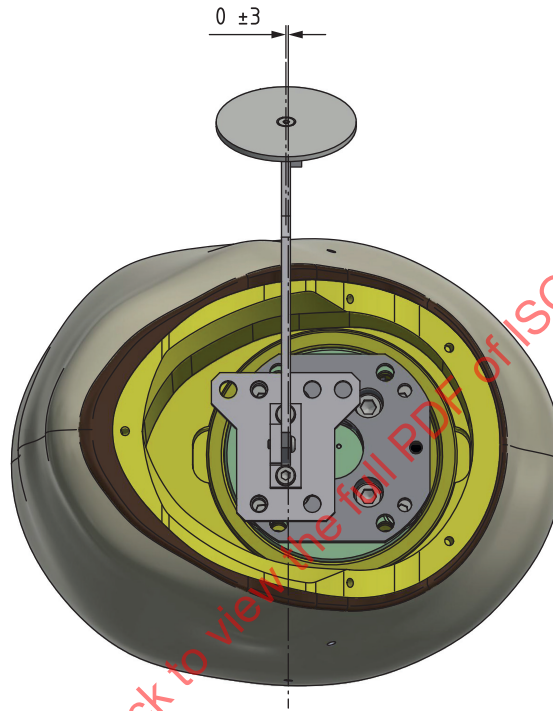


Figure 4 — Head drop tool installation for lateral drops

Dimensions in millimetres

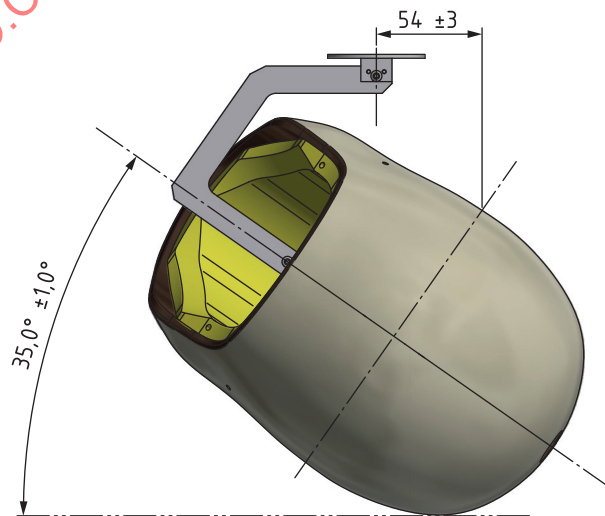


Figure 5 — Lateral head drop angle

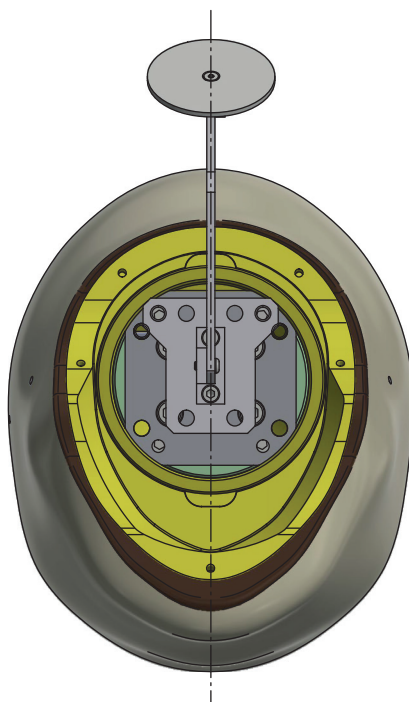


Figure 6 — Head drop tool installation for frontal drops

Dimensions in millimetres

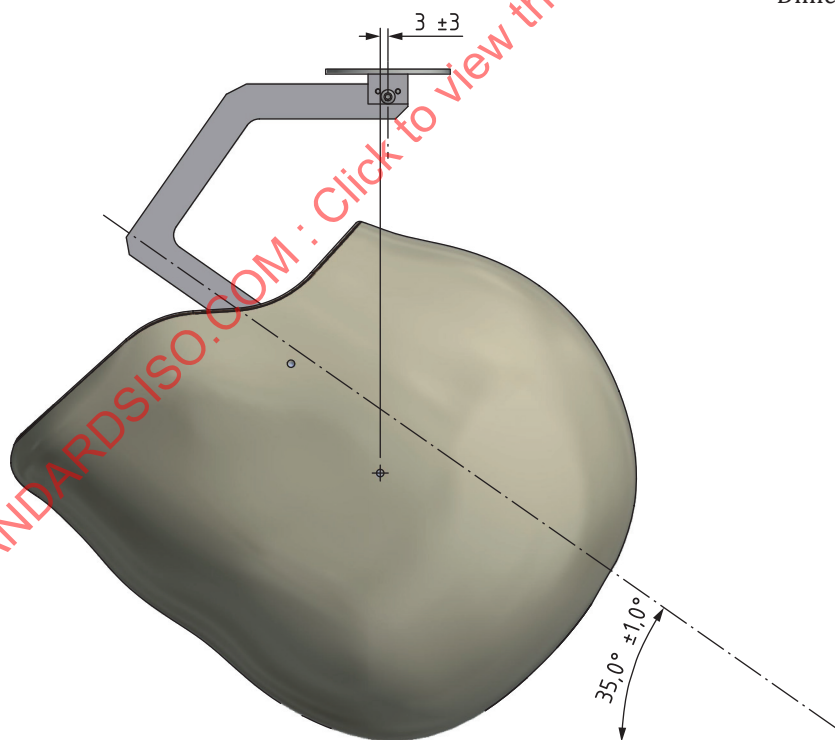


Figure 7 — Frontal head drop angle

5.1.5 Procedure

- Drop the head onto the rigid plate from the specified height by means that ensure quick release.

- Visually inspect the head for damage to the skin or skull and note any such damage in the test report.
- Allow at least 2 h between successive tests at the same location on the same head.

5.1.6 Calculation procedures and expression of results

- Define T_0 as time of contact of head to rigid plate.
- Zero all channels at T_0 .
- Filter all channels at CFC 1000 in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.
- Calculate resultant acceleration.

5.1.7 Test reports

Document the results of the lateral and the frontal drop tests.

5.2 Neck

5.2.1 Lateral flexion

5.2.1.1 Principle

Certify the dynamic response of the neck assembly by performing lateral pendulum tests.

5.2.1.2 Materials

For the pendulum stop, use aluminium honeycomb, of density $28,8 \text{ kg/m}^3 \pm 4,9 \text{ kg/m}^3$ and dimensions 102 mm minimum $\times$ 102 mm minimum with a thickness along the cells of $76 \text{ mm} \pm 4 \text{ mm}$ or alternative products which can be shown to lead to the same results.

5.2.1.3 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used:

- neck assembly as described in ISO 15830-4: 2022, Clause A.2;
- WorldSID head form as specified in [Figure 8](#):
 - $4,11 \text{ kg} \pm 0,02 \text{ kg}$ mass;
 - $16\,800 \text{ kg}\cdot\text{mm}^2 \pm 840 \text{ kg}\cdot\text{mm}^2$ mass moment of inertia about the x-axis;
 - NOTE CAD design tolerance for mass moment of inertia cannot be applied to the physical part;
- neck pendulum apparatus as specified in SAE J2856;
- pendulum mount rotary potentiometer assembly:
 - $1,41 \text{ kg} \pm 0,02 \text{ kg}$ mass.

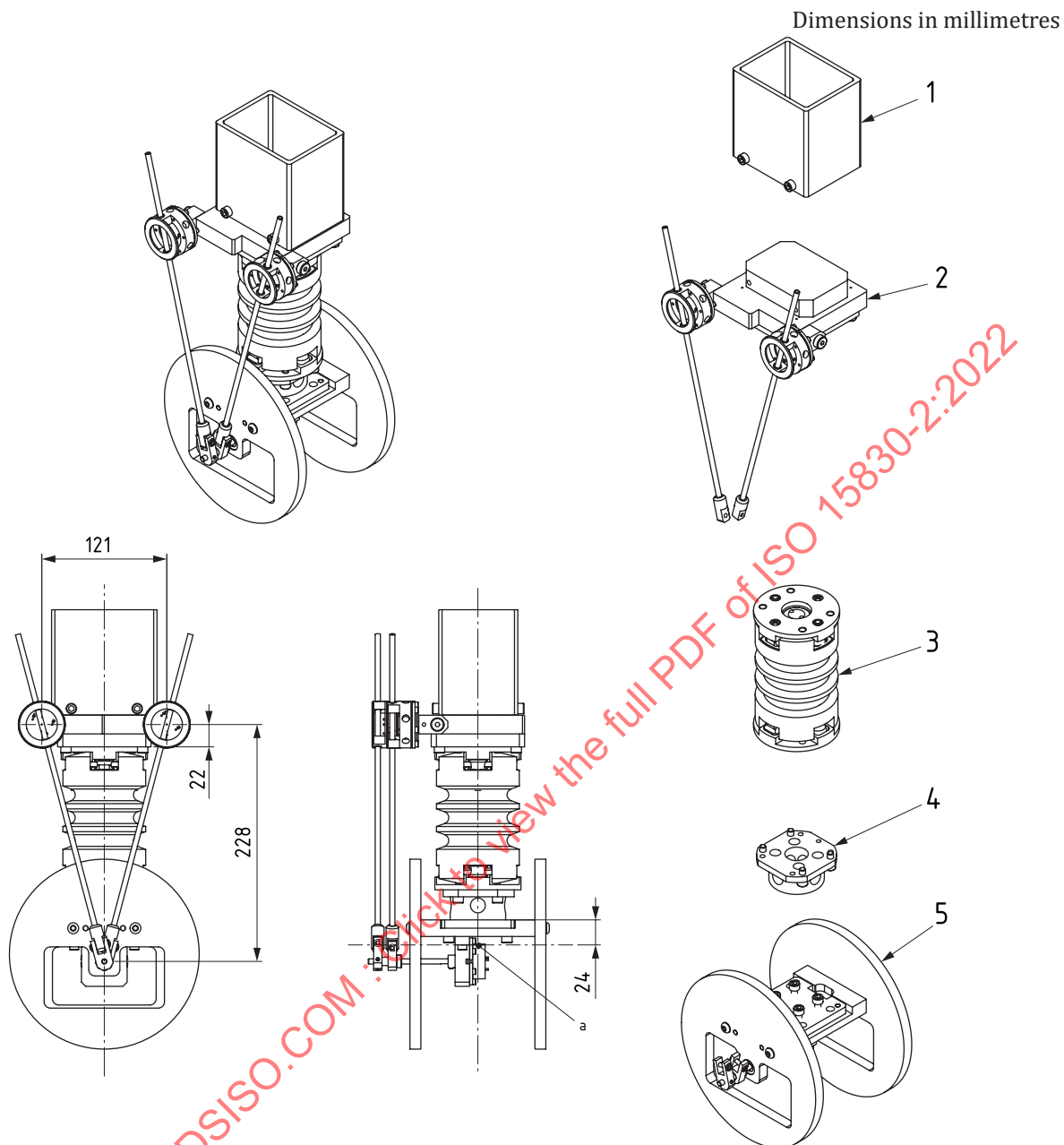


Figure 8 — Setup for neck lateral flexion validation test

5.2.1.4 Sensors

Perform the test using the sensors given in [Table 10](#).

Table 10 — Sensor specifications for neck lateral flexion test

Variable	Sensor	Performance
Pendulum acceleration	Single axis accelerometer	SAE J2570
Pendulum velocity	Not specified	Accuracy 0,02 m/s or better
Angular displacement of forward pendulum-to-head form sliding rod, positive when doing a right-side impact (θ_F)	Angular potentiometer	SAE J2570
Angular displacement of rearward pendulum-to-head form sliding rod, positive when doing a right-side impact (θ_R)	Angular potentiometer	SAE J2570
Angular displacement of head form about forward pendulum-to-head form sliding rod, positive when doing a right-side impact (θ_H)	Angular potentiometer	SAE J2570
Neck moment, M_x	Upper neck load cell ISO 15830-3:2022, 4.1.3.7	SAE J2570
Neck force, F_y	Upper neck load cell ISO 15830-3:2022, 4.1.3.7	SAE J2570

5.2.1.5 Preparation

- Expose the neck assembly to an environment with a temperature of 20,6 °C to 22,2 °C and a relative humidity between 10 % and 70 % for a period of at least four hours prior to a test.
- Attach the top of the neck to the head form.
- Attach the bottom of the neck to the pendulum interface. Ensure that the screws do not protrude into the neck rubber as this may influence the response. If the screws are too long, insert washers under the head of the screw to prevent rubber contact. Mount the pendulum interface to the pendulum such that the head form's midsagittal plane is vertical and is perpendicular to the plane of motion of the pendulum's longitudinal centreline.
- Slide the carbon fibre rods through the potentiometer housings on the pendulum. First, slide the pivot of the potentiometer closest to the pendulum over the central steel rod in the head form, then install the small spacer ring and the second pivot. Carefully tighten the second pivot.

5.2.1.6 Procedure

- After mounting the neck and head form to the pendulum, wait 15 min without manipulating the neck.
- Raise the pendulum arm to achieve a 3,4 m/s $\pm$ 0,1 m/s impact velocity measured at the centre of the pendulum-mounted accelerometer.
- Release the pendulum and allow it to fall freely.
- Decelerate the pendulum arm using the 28,8 kg/m³ aluminium honeycomb or alternative products which can be shown to lead to the same results, to achieve the pendulum pulse given in [Table 11](#).
- Allow the neck to flex without impact of the head form or neck with any object other than the pendulum arm.
- Conduct the test such that the time between raising the pendulum and releasing it does not exceed 5 min.
- Conduct the test such that the time between any tests on the same WorldSID neck is not less than 30 min.

Table 11 — Pendulum arm deceleration pulse

Variable	Value
Velocity change at 4 ms ^a	0,77 m/s to 1,04 m/s
Velocity change at 8 ms ^a	1,60 m/s to 1,90 m/s
Velocity change at 12 ms ^a	2,43 m/s to 3,29 m/s
^a $T = 0$ ms is established following the procedure defined in 5.2.1.7.	

5.2.1.7 Calculation procedures and expression of results

- Filter the pendulum acceleration data at CFC 1000 in accordance with ISO 6487 or SAE J211-1, whichever reference is most up to date.
- To calculate the bias, average the filtered pendulum acceleration data over the period between -50 ms and -10 ms prior to contacting the aluminium honeycomb or alternative product.
- Subtract the bias from the pendulum acceleration data.
- After removing the bias, set T_0 to the first data point where the pendulum acceleration is greater than $5g$.
- Integrate the filtered and adjusted pendulum acceleration time history from T_0 to the end of the sample period to obtain pendulum velocity.
- Calculate the flexion angle of the head form using the following formula:

$$\beta = \theta_F + \theta_H \quad (1)$$

where

- β is the angular displacement of head form relative to the pendulum;
- θ_F is the angular displacement of forward pendulum-to-head form sliding rod, positive when doing a right side impact;
- θ_H is the lateral angular displacement of head form about forward pendulum-to-head form sliding rod, positive when doing a right side impact.
- After performing this calculation, digitally filter all angular displacements and load cell data as specified in Table 12, in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.
- Calculate the moment about the occipital condyle as $M_{OCx} = M_x + (F_y) \times (0,019\ 5\ \text{m})$, where the M_x and F_y polarities shall be in accordance with the SAE J1733 sign convention.

Table 12 — Filter specifications for neck flexion test

Variable	Filter ^a
Pendulum acceleration	CFC 1000
Pendulum velocity	No digital filtering
Angular displacement of forward rod (θ_F)	CFC 180
Angular displacement rear rod (θ_R)	CFC 180
Angular displacement of head form (θ_H)	CFC 180
Neck moment, M_x	CFC 600
^a ISO 6487 or SAE J211, whichever reference is the most up to date.	
^b To calculate M_{OCx} correctly, M_x and F_y shall be filtered at CFC 600.	

Table 12 (continued)

Variable	Filter ^a
Neck force, F_y	CFC 1000 ^b
^a ISO 6487 or SAE J211, whichever reference is the most up to date.	
^b To calculate M_{OCx} correctly, M_x and F_y shall be filtered at CFC 600.	

5.2.1.8 Test reports

Document the results of the test.

5.2.2 Torsion**5.2.2.1 Principle**

Certify the dynamic response of the neck assembly by performing torsion tests.

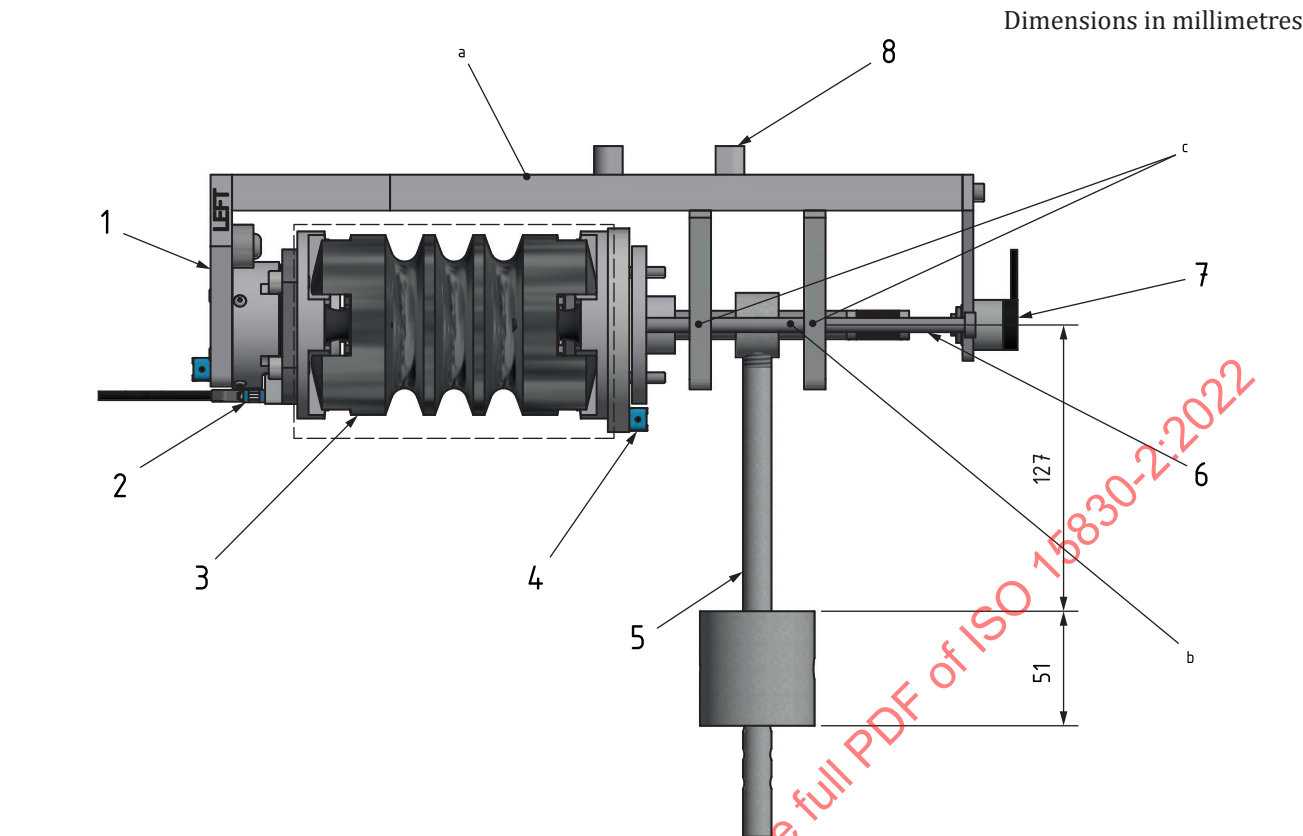
5.2.2.2 Materials

For the pendulum stop, use aluminium honeycomb, of density $28,8 \text{ kg/m}^3 \pm 4,9 \text{ kg/m}^3$ and dimensions 102 mm minimum $\times$ 102 mm minimum with a thickness along the cells of $152 \text{ mm} \pm 4 \text{ mm}$ or alternative products which can be shown to lead to the same results.

5.2.2.3 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used:

- neck assembly as described in ISO 15830-4:2022, Clause A.2 and validated according to [5.2.1](#);
- neck pendulum apparatus as specified in SAE J2856;
- neck torsion fixture as specified in [Figure 9](#):
 - 2,2 kg $\pm$ 0,02 kg mass:
 - mass specification includes all parts that rotate with the primary pendulum but not the secondary pendulum;
 - does not include load cell, neck assembly or zeroing pins;
- neck torsion secondary pendulum as specified in [Figure 9](#):
 - 1,7 kg $\pm$ 0,02 kg mass:
 - mass specification includes all parts that rotate with the secondary pendulum;
 - does not include load cell, neck assembly or zeroing pins;
 - 21 800 kg $\cdot$ mm² $\pm$ 1 090 kg $\cdot$ mm² mass moment of inertia about the rotational axis of the secondary pendulum;
 - NOTE CAD design tolerance for mass moment of inertia cannot be applied to the physical part.



- Key**
- 1 stationary fixture
 - 2 neck load cell
 - 3 WorldSID 50th neck assembly
 - 4 angular rate sensor
 - 5 secondary pendulum
 - 6 zeroing pins
 - 7 potentiometer
 - 8 neck pendulum adapter
 - a Origin point for CG of stationary components.
 - b Origin point for CG and moment of inertia and pivot for rotating components.
 - c Centre rod is supported on bearings.

NOTE The angular rate sensor rotates with the secondary pendulum.

Figure 9 — Setup for neck torsion validation test

5.2.2.4 Sensors

Perform the test using the sensors given in [Table 13](#).

Table 13 — Sensor specifications for neck torsion test

Variable	Sensor	Performance
Pendulum acceleration	Single axis accelerometer	SAE J2570
Pendulum velocity	Not specified	Accuracy 0,02 m/s or better
Torsion fixture angular rate, z-axis	Angular rate sensor	SAE J2570

Table 13 (continued)

Variable	Sensor	Performance
Torsion fixture rotation angle, z-axis	Angular potentiometer	SAE J2570
Lower neck moment, M_z	Lower neck load cell ISO 15830-3:2022, 4.1.3.7	SAE J2570

5.2.2.5 Preparation

- Label the neck assembly to identify top, bottom, front and rear so the neck orientation in the fully assembled WorldSID will be the same as in validation.
- Expose the neck assembly to an environment with a temperature of 20,6 °C to 22,2 °C and a relative humidity between 10 % and 70 % for a period of at least four hours prior to a test.
- Attach the lower neck load cell to the torsion fixture end plate.
- Use the access holes in the end plate to fasten the neck assembly to the lower neck load cell. The neck shall be properly oriented.
- Fasten the neck mounting adapter to the upper neck.
- Mount the neck torsion fixture to the neck pendulum.
- Attach the neck assembly to the torsion fixture by aligning the two locator pins on the end of the fixture with the holes in the end plate, while simultaneously aligning the four locator pins on the neck mounting adapter with the holes in the fixture's neck adapter plate. Rotate the torsion fixture pendulum rod back and forth to aid in aligning and seating the locator pins.
- Fasten the full neck assembly to the torsion fixture. When the neck assembly is completely installed in the neck torsion fixture, there should be a small gap between the neck mounting adapter and the fixture. Note that the gap allows for changes in the neck assembly length.
- Install the zeroing pins to hold the neck in the neutral position until right before the test.

5.2.2.6 Procedure

- Just before running the test, remove the zeroing pins to allow the neck to freely rotate. If the pins are not removed, the fixture may be damaged.
- Release the pendulum and allow it to fall freely from a height such that the velocity at impact is 5,20 m/s $\pm$ 0,10 m/s, measured at the centre of the pendulum-mounted accelerometer.
- Decelerate the pendulum arm using the 28,8 kg/m³ aluminium honeycomb or alternative products which can be shown to lead to the same results, to achieve the pendulum pulse given in [Table 14](#).
- Conduct the test such that the time between raising the pendulum and releasing it does not exceed 5 min.
- Conduct the test such that the time between any tests on the same WorldSID neck is not less than 30 min.

Table 14 — Pendulum arm deceleration pulse

Variable	Value
Velocity at 10 ms ^a	2,09 m/s to 2,38 m/s
Velocity at 15 ms ^a	3,19 m/s to 3,63 m/s
Velocity at 20 ms ^a	4,27 m/s to 4,87 m/s
^a $T = 0$ ms is established following the procedure defined in 5.2.2.7 .	

5.2.2.7 Calculation procedures and expression of results

- Filter the pendulum acceleration data at CFC 1000 in accordance with ISO 6487 or SAE J211-1, whichever reference is most up to date.
- To calculate the bias, average the filtered pendulum acceleration data over the period between –50 ms and –10 ms prior to contacting the aluminium honeycomb or alternative product.
- After removing the bias, set T_0 to the first data point where the pendulum acceleration is greater than $5g$.
- Integrate the filtered and adjusted pendulum acceleration time history from T_0 to the end of the sample period to obtain pendulum velocity.
- Filter the remaining data as specified in [Table 15](#) in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.

Table 15 — Filter specifications for neck torsion test

Variable	Filter ^a
Pendulum acceleration	CFC 1000
Pendulum velocity	No digital filtering
Torsion fixture rotation, z-axis	CFC 60
Torsion fixture angular rate, z-axis	CFC 60
Lower neck moment, M_z	CFC 600
^a ISO 6487 or SAE J211, whichever reference is the most up to date.	

5.2.2.8 Test reports

Document the results of the test.

5.3 Thorax/abdomen/shoulder/pelvis full body tests

5.3.1 Full body test setup

5.3.1.1 Materials

- Floating polytetrafluoroethylene (PTFE) sheets:
 - Seat 387 mm × 521 mm;
 - Back 514 mm × 514 mm.

5.3.1.2 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used:

- WorldSID assembly as described in ISO 15830-4:2022, Annex A with neck validated according to [5.2](#);
- H-point tool as specified in [Figure 10](#);
- tilt sensors;
- dummy validation test bench with fixed seat and back polytetrafluoroethylene (PTFE) sheets as specified in [Figure 11](#):
 - seat 394 mm × 752 mm;

- back 530 mm × 752 mm;
- Hybrid III 50th percentile adult male pendulum (23,4 kg, 152,4-mm face diameter) as specified in SAE J2856.

Dimensions in millimetres

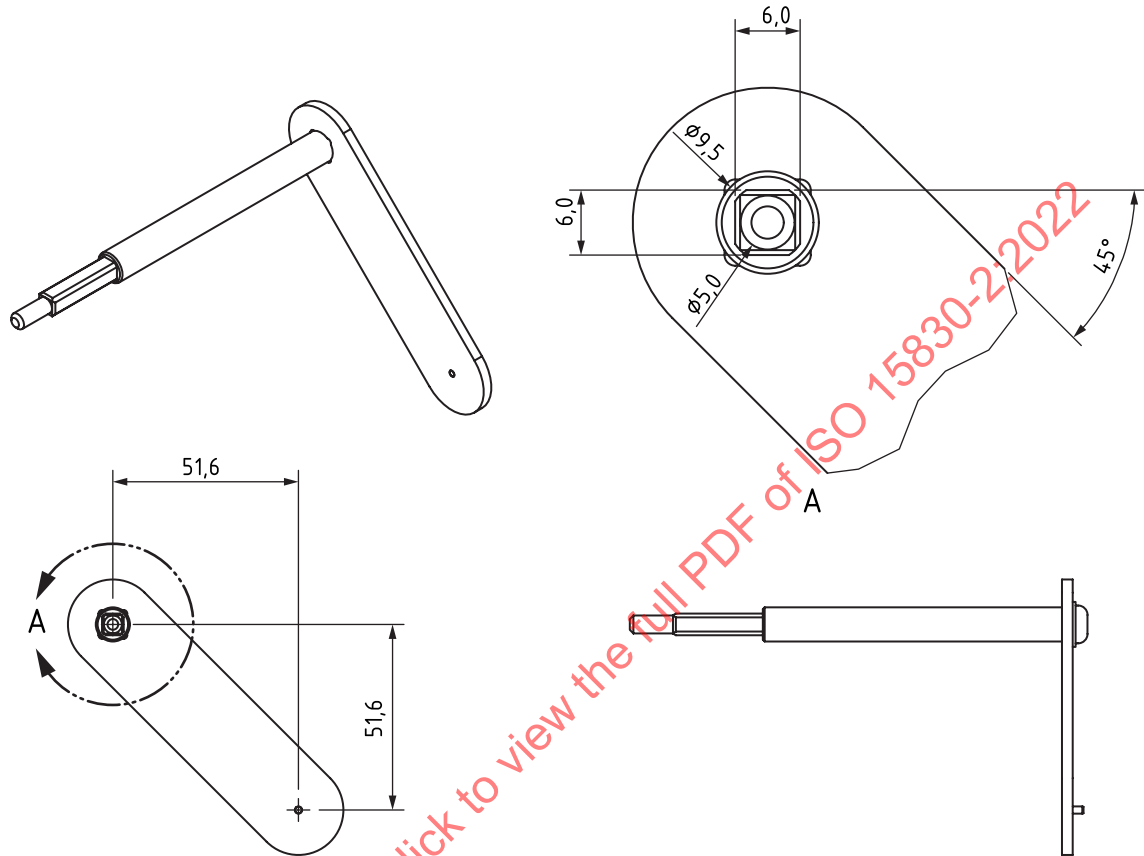
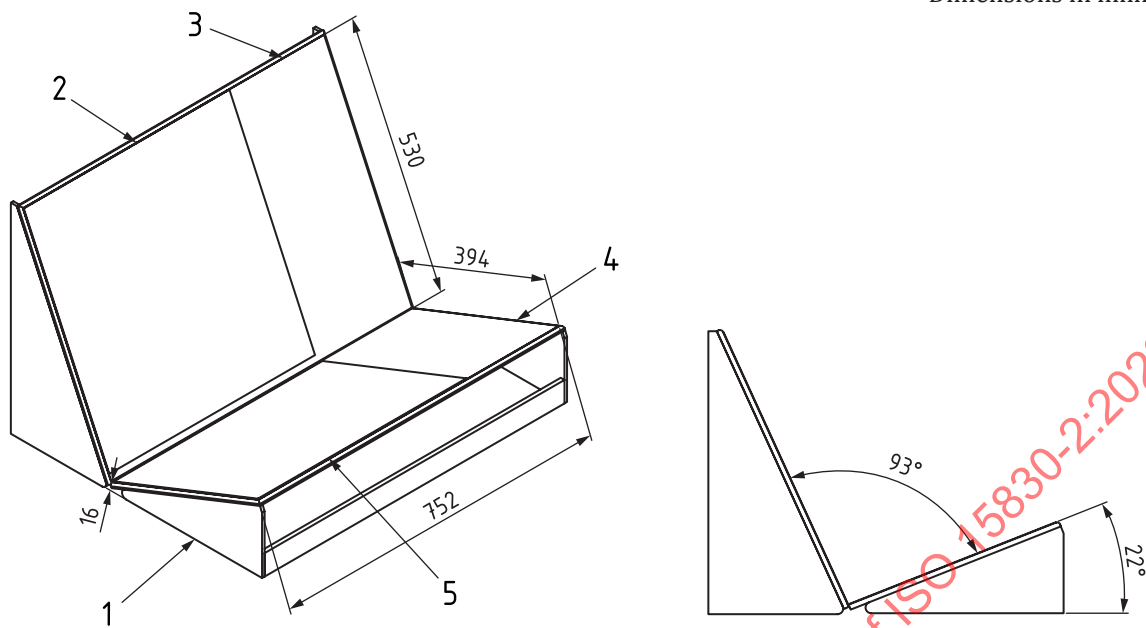


Figure 10 — H-point tool

Dimensions in millimetres



Key

- 1 rigid seat
- 2 floating PFTE sheet
- 3 fixed PFTE sheet
- 4 fixed PFTE sheet
- 5 floating PFTE sheet

Figure 11 — Validation bench

5.3.1.3 Preparation

Expose the dummy, clothed in its suit, to an environment with a temperature of 20,6 °C to 22,2 °C and a relative humidity between 10 % and 70 % for a period of at least four hours prior to a test.

5.3.1.4 Setup procedure

- Use dual axis tilt sensors in the head, thorax, and pelvis to check the angles about x and y direction.
- Cover the seat back and base with floating polytetrafluoroethylene (PTFE) sheets.
- Place the dummy on the rigid seat as shown in [Figure 12](#) and [Figure 13](#).
- Position the dummy on the seat using tilt sensors to verify the positions.
- Position the dummy according to the criteria given in [Table 16](#).
- Ensure abdomen rib 2 is inside the pelvis flesh, not on top of the pelvis flesh.
- Conduct the test such that the time between any full body tests on the same WorldSID is not less than 30 min.

Table 16 — Dummy set up criteria

Variable	Criteria
Thorax tilt sensor angles	$X = 0^\circ \pm 2^\circ, Y = 0^\circ \pm 2^\circ$ ^a
Pelvis tilt sensor angles	$X = 0^\circ \pm 2^\circ, Y = 5^\circ \pm 2^\circ$ ^b
Distance between knee centres	279 mm $\pm$ 50 mm
^a 0° thorax angle is equivalent to 0° (horizontal) angle of thorax ribs 2 and 3 and abdomen ribs 1 and 2.	
^b Which will orient the H-point tool at 40° below horizontal.	



Figure 12 — Front view of setup for full dummy validation tests

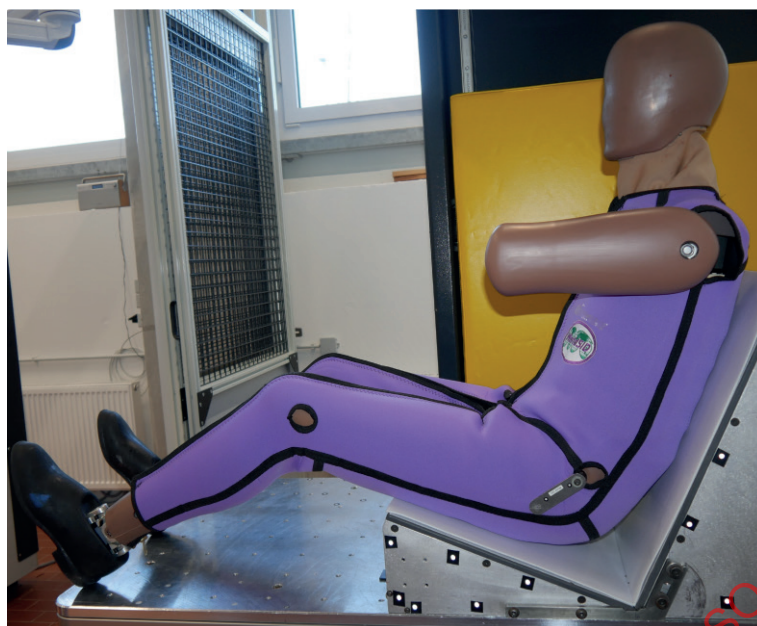


Figure 13 — Side view of setup for full dummy validation tests

5.3.2 Shoulder test

5.3.2.1 Principle

Perform a test involving a lateral impact to the shoulder to certify the dynamic response of the shoulders.

[Annex B](#) describes an optional single rib test that can be used to evaluate the shoulder rib inner band.

5.3.2.2 Sensors

Install instrumentation to obtain data for the items given in [Table 17](#).

Table 17 — Sensor specifications for shoulder test

Variable	Sensor	Performance
Peak pendulum acceleration (g)	Single axis accelerometer	SAE J2570
Peak shoulder rib deflection (mm)	Multidimensional measurement system ISO 15830-3: 2022, 4.1.3.8	SAE J2570
Impact velocity (m/s)	Not specified	Accuracy 0,02 m/s or better

5.3.2.3 Procedure

- Set up the dummy in standard test posture as described in [5.3.1](#) with the arm on the impact side positioned using the detent which holds the arm approximately horizontal as shown in [Figure 14](#).
- Align the pendulum centreline with the centreline of the shoulder y-axis rotation point.
- Raise the pendulum to achieve a $4,3 \text{ m/s} \pm 0,1 \text{ m/s}$ impact velocity.
- Release the pendulum to impact the dummy.



Figure 14 — Shoulder test, dummy and arm position

5.3.2.4 Calculation procedures and expression of results

- Define T_0 as time of contact of pendulum to shoulder.
- To calculate the bias, average the pendulum acceleration data over the period between -50 ms and -10 ms prior to T_0 .
- Subtract the bias from the pendulum acceleration.
- Filter the pendulum acceleration data as specified in [Table 18](#) in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.
- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the measured impactor mass.
- Follow ISO/TS 21002 calculation procedures for shoulder rib deflection instrumentation and any associated instrumentation, unless otherwise specified by its manufacturer.
- Filter the shoulder rib deflection data as specified in [Table 18](#) in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.
- Graph the time histories of impactor force and shoulder rib deflection.

Table 18 — Filter specifications for shoulder test

Variable	Filter
Pendulum acceleration (g)	CFC 180
Shoulder rib deflection (mm)	CFC 600

5.3.2.5 Test reports

Document the results of the test.

5.3.3 Thorax test

5.3.3.1 Principle

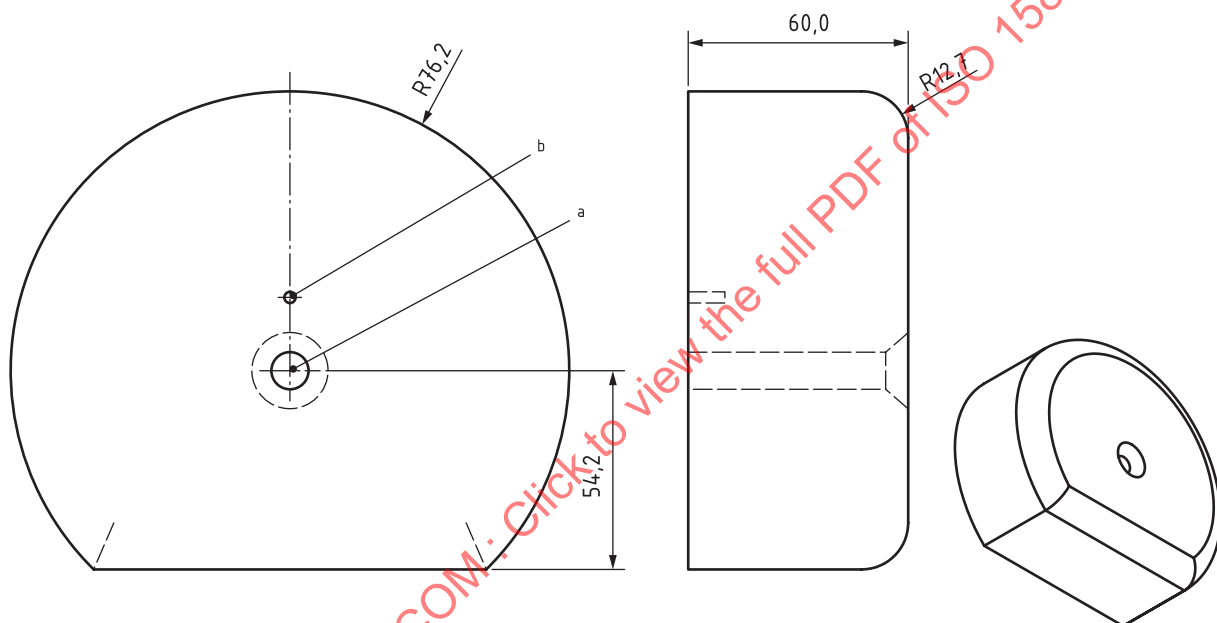
Perform a test involving a lateral impact to the thorax to certify the dynamic response of the thorax.

[Annex B](#) describes an optional single rib test that can be used to evaluate the thorax ribs.

5.3.3.2 Apparatus

The usual laboratory apparatus and, in particular, a probe face as specified in [Figure 15](#) is used:

- 0,500 kg $\pm$ 0,005 kg mass;
- attached to the impact face of the pendulum;
- the flat surface of the probe face oriented horizontal, $0^\circ \pm 0,5^\circ$.



- a Attachment to pendulum mass centre.
b Anti-rotation pin, optional.

Figure 15 — Probe face

5.3.3.3 Sensors

Install instrumentation to obtain data for the items given in [Table 19](#).

Table 19 — Sensor specifications for thorax test

Variable	Sensor	Performance
Peak pendulum acceleration (g)	Single axis accelerometer	SAE J2570
Peak upper spine (T4) y-axis acceleration (g)	Triaxial linear accelerometer ISO 15830-3:2022, 4.1.3.2	SAE J2570
Peak lower spine (T12) y-axis acceleration (g)	Triaxial linear accelerometer ISO 15830-3:2022, 4.1.3.2	SAE J2570

Table 19 (continued)

Variable	Sensor	Performance
First, second, and third thorax rib deflections (mm)	Multidimensional measurement system ISO 15830-3:2022, 4.1.3.8	SAE J2570
Impact velocity (m/s)	Not specified	Accuracy 0,02 m/s or better

5.3.3.4 Procedure

- Set up the dummy in standard test posture as described in [5.3.1](#).
- Raise the arm to a vertical orientation as shown in [Figure 16](#).
- Align the pendulum centreline with the centreline of the middle thorax rib.
- Raise the pendulum to achieve a $4,3 \text{ m/s} \pm 0,1 \text{ m/s}$ impact velocity.
- Release the pendulum to impact the dummy.

**Figure 16** — Thorax test, dummy and arm position**5.3.3.5 Calculation procedures and expression of results**

- Define T_0 as time of contact of pendulum to thorax.
- To calculate the bias of the pendulum acceleration, average the acceleration data over the period between -50 ms and -10 ms prior to T_0 .
- Subtract the bias from the pendulum acceleration.

- To calculate the bias of the T4 and T12 acceleration, average the data over the period between -50 ms and -10 ms prior to T_0 .
- Subtract the bias from the T4 and T12 acceleration.
- Filter the pendulum, T4 and T12 acceleration data as specified in [Table 20](#) in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.
- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the measured impactor mass.
- Follow ISO/TS 21002 calculation procedures for thorax rib deflection instrumentation and any associated instrumentation, unless otherwise specified by its manufacturer.
- Graph the time histories of impactor force, T4 and T12 y-axis accelerations, and deflections of thorax ribs 1, 2, and 3.

Table 20 — Filter specifications for thorax test

Variable	Filter
Peak pendulum acceleration (g)	CFC 180
Peak T4 y-axis acceleration (g)	CFC 180
Peak T12 y-axis acceleration (g)	CFC 180
Peak thorax rib 1 deflection (mm)	CFC 600
Peak thorax rib 2 deflection (mm)	CFC 600
Peak thorax rib 3 deflection (mm)	CFC 600

5.3.3.6 Test reports

Document the results of the test.

5.3.4 Abdomen test

5.3.4.1 Principle

Perform a test involving a lateral impact to the abdomen to certify the dynamic response of the abdomen ribs.

[Annex B](#) describes an optional single rib test that can be used to evaluate the abdomen ribs.

5.3.4.2 Apparatus

The usual laboratory apparatus and, in particular, a simulated armrest consisting of a rigid block as specified in [Table 21](#) shall be attached to the impact face of the pendulum. The armrest simulator shall be oriented with the 150 mm dimension horizontal. The centreline of the armrest simulator shall be aligned with the centreline of the pendulum.

Table 21 — Simulated armrest specifications

Variable	Value
Width (mm)	150 ± 1
Height (mm)	70 ± 1
Depth (mm)	70 ± 10
Corner radius (mm)	$4,5 \pm 0,5$
Mass (kg)	$1,00 \pm 0,01$
Impact surface hardness (Rockwell)	M85 minimum

5.3.4.3 Sensors

Install instrumentation to obtain data for the items given in [Table 22](#).

Table 22 — Sensor specifications for abdomen test

Variable	Sensor	Performance
Pendulum acceleration (<i>g</i>)	Single axis accelerometer	SAE J2570
Lower spine (T12) y-axis acceleration (<i>g</i>)	Triaxial linear accelerometer ISO 15830-3:2022, 4.1.3.2	SAE J2570
Abdomen rib 1 and 2 deflections (mm)	Multidimensional measurement system ISO 15830-3:2022, 4.1.3.8	SAE J2570
Impact velocity (m/s)	Not specified	Accuracy 0,02 m/s or better

5.3.4.4 Procedure

- Set up the dummy in standard test posture as described in [5.3.1](#) with the arm on the impact side positioned using the detent which holds the arm approximately horizontal as shown in [Figure 17](#).
- Centre the simulated armrest so it is aligned with the middle of the two abdomen ribs.
- Place the simulated armrest in contact with the side of the dummy.
- Raise the pendulum to achieve a $4,3 \text{ m/s} \pm 0,1 \text{ m/s}$ impact velocity.
- Release the pendulum to impact the dummy.



Figure 17 — Abdomen test, dummy and arm position

5.3.4.5 Calculation procedures and expression of results

- Define T_0 as time of contact of pendulum to abdomen.
- To calculate the bias of the pendulum acceleration, average the acceleration data over the period between -50 ms and -10 ms prior to T_0 .
- Subtract the bias from the pendulum acceleration.
- To calculate the bias of the T12 acceleration, average the data over the period between -50 ms and -10 ms prior to T_0 .
- Subtract the bias from the T12 acceleration.
- Filter the pendulum and T12 acceleration data as specified in [Table 23](#) in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.
- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the combined measured mass of the pendulum and armrest simulator.
- Follow ISO/TS 21002 calculation procedures for abdomen rib deflection instrumentation and any associated instrumentation, unless otherwise specified by its manufacturer.
- Graph the time histories of impactor force, T12 y-axis acceleration, and deflections of abdomen ribs 1 and 2.

Table 23 — Filter specifications for abdomen test

Variable	Filter
Pendulum acceleration (<i>g</i>)	CFC 180
T12 y-axis acceleration (<i>g</i>)	CFC 180
Abdomen rib 1 deflection (mm)	CFC 600
Abdomen rib 2 deflection (mm)	CFC 600

5.3.4.6 Test reports

Document the results of the abdomen test.

5.3.5 Pelvis test**5.3.5.1 Principle**

Perform a test involving a lateral impact to the pelvis to certify the dynamic response of the pelvis.

5.3.5.2 Sensors

Install instrumentation to obtain data for the items given in [Table 24](#).

Table 24 — Sensor specifications for pelvis test

Variable	Sensor	Performance
Pendulum acceleration (<i>g</i>)	Single axis accelerometer	SAE J2570
Lower spine (T12) y-axis acceleration (<i>g</i>)	Triaxial linear accelerometer ISO 15830-3:2022, 4.1.3.2	SAE J2570
Pelvis y-axis acceleration (<i>g</i>)	Pelvis triaxial linear accelerometer ISO 15830-3:2022, 4.1.3.2	SAE J2570
Pubic force (kN)	Pubic load cell ISO 15830-3:2022, 4.1.3.11	SAE J2570
Impact velocity (m/s)	Not specified	Accuracy 0,02 m/s or better

5.3.5.3 Procedure

- Set up the dummy with the arm on the impact side positioned using the detent which holds the arm approximately horizontal as shown in [Figure 18](#).
- Using an H-point tool, align the pendulum centreline with the H-point.
- Remove the H-point tool just before running the test to avoid equipment damage.
- Raise the pendulum to achieve a $6,7 \text{ m/s} \pm 0,1 \text{ m/s}$ impact velocity.
- Release the pendulum to impact the dummy.



Figure 18 — Pelvis test, dummy and arm position

5.3.5.4 Calculation procedures and expression of results

- Define T_0 as time of contact of pendulum to pelvis.
- To calculate the bias of the pendulum acceleration, average the acceleration data over the period between -50 ms and -10 ms prior to T_0 .
- Subtract the bias from the pendulum acceleration.
- To calculate the bias of the T12 and pelvis acceleration, average the data over the period between -50 ms and -10 ms prior to T_0 .
- Subtract the bias from the T12 and pelvis acceleration.
- Filter the data as given in [Table 25](#) in accordance with ISO 6487 or SAE J211-1, whichever reference is the most up to date.
- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the measured impactor mass.
- Graph the time histories of impactor force, pelvis y-axis acceleration, T12 y-axis acceleration, and pubic force.

Table 25 — Filter specifications for pelvis test

Variable	Filter
Pendulum acceleration (<i>g</i>)	CFC 180
T12 y-axis acceleration (<i>g</i>)	CFC 180
Pelvis y-axis acceleration (<i>g</i>)	CFC 180
Pubic force (kN)	CFC 600

5.3.5.5 Test reports

Document the results of the pelvis test.

5.4 Whole body dimensions

5.4.1 Principle

Certify the external dimensions of the dummy using a coordinate measuring machine (CMM).

[Annex A](#) describes an optional measurement procedure using mechanical measurement tools.

5.4.2 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used:

- dummy validation test bench, or equivalent fixture, resting on a platform to support the feet. The length of the platform along the longitudinal axis should be at least 600 mm measured from the front of the test bench. The junction between the seat pan and seat back should be 5 mm to 25 mm above the platform surface;
- lifting bracket;
- digital protractor;
- H-point tools; one each side;
- tilt sensors to measure roll about the x-axis and pitch about the y-axis; one each for head, torso, and pelvis;
- coordinate measuring machine.

5.4.2.1 Setup procedure

- Remove floating polytetrafluoroethylene (PTFE) sheets from the validation bench. The seat pan angle should be $22^\circ \pm 1^\circ$ from horizontal. The seat-pan-to-seat-back angle should be $93^\circ \pm 1^\circ$.
- Remove the suit (W50-80200), left and right shoulder pads (W50-35023-1 and W50-35023-2), and left and right moulded lower leg flesh (W50-53002). The lifting bracket (W50-84100) should only be installed for linear measurements L11 and L12.
- Ensure the neck bracket is set to zero. Refer to [Figure 19](#).
- Seat the dummy on the validation test bench. A cloth may be used to facilitate sliding the pelvis on the seat pan.
- Install one H-point tool on each side of the dummy with the blade pointed down and to the front. Refer to [Figure 20](#).
- Push the dummy back against the seat back so that both sides of the back of the spine box are in full contact with the seat back. Refer to [Figure 21](#).

- Position the pelvis so that the bottoms of the thigh portions of the pelvis flesh are in full contact with the seat pan.
- Ensure abdomen rib 2 is inside the pelvis flesh. Refer to [Figure 22](#).
- Position the H-point location and the pelvis, torso, and head tilt sensor angles close to the values specified in [Table 26](#).
- Position the legs so that the bottoms of the thigh flesh are in full contact with the seat pan. Set the knee heights, left and right to the value specified in [Table 26](#). Set the lateral distance between the knee centrelines to the value specified in [Table 26](#). The left and right knees shall be approximately the same distance from the mid-sagittal plane (estimated by eye).
- Positioning the legs in the previous step set the angle of the lower legs. Set the lateral distance between the ankle centrelines to the value specified in [Table 26](#). Align the foot centreline (heel to toe) with the lower leg tube (estimated by eye). The left and right ankles shall be approximately the same distance from the mid-sagittal plane (estimated by eye).
- Finally, adjust the pelvis, torso, and head without changing the position of the legs. Position the H-point location and the pelvis, torso, and head tilt sensor angles to the values specified in [Table 26](#). The final position of the dummy is shown in [Figure 23](#).

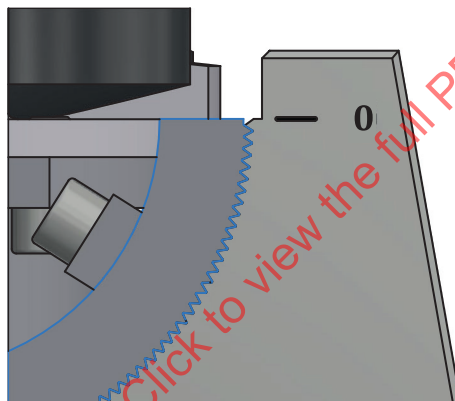


Figure 19 — Zero position of neck bracket



Figure 20 — H-point tool installed on the right side



Figure 21 — Spine in contact with seat back



Figure 22 — Abdomen rib 2 positioned inside pelvis flesh

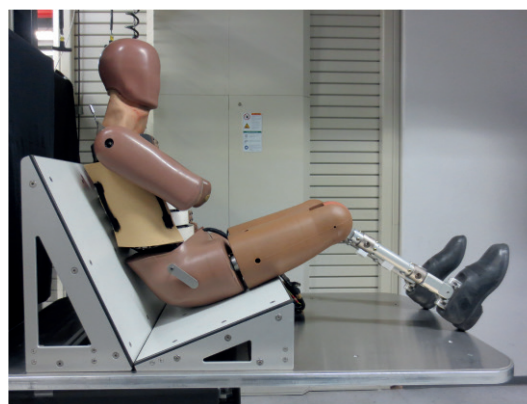


Figure 23 — Dummy positioned for external measurements excluding l_{11} and l_{12}

Table 26 — WorldSID setup specifications

Variable	Value
Head tilt sensor angle about x-axis	$0,0^{\circ} \pm 2,0^{\circ}$
Head tilt sensor angle about y-axis	$1,5^{\circ} \pm 2,0^{\circ}$
Torso tilt sensor angle about x-axis	$0,0^{\circ} \pm 2,0^{\circ}$
Torso tilt sensor angle about y-axis	$2,5^{\circ} \pm 2,0^{\circ}$
Pelvis tilt sensor angle about x-axis	$0,0^{\circ} \pm 2,0^{\circ}$
Pelvis tilt sensor angle about y-axis	$5,0^{\circ} \pm 2,0$
Hip pivot height, left and right ^a	85 mm $\pm$ 5 mm
Hip pivot to seat back line, left and right ^b	175 mm $\pm$ 5 mm
Knee height above platform, left and right	310 mm $\pm$ 25 mm
Distance between knee centres	279 mm $\pm$ 25 mm
Distance between ankle centres	219 mm $\pm$ 25 mm
^a Perpendicular to the seat pan.	
^b Perpendicular to the seat back.	

5.4.2.2 Measurement procedures

5.4.2.2.1 General

Confirm that the setup specifications in [Table 26](#) are met.

5.4.2.2.2 CMM setup of validation bench

It is recommended that the following measurements are taken to setup the CMM.

- Define a coordinate system as shown in [Figure 24](#). The origin is located at the intersection of the seat pan and seat back, on the right side of the validation bench. The x-axis is parallel to the platform and the z-axis is vertical.
- Measure points on the platform, seat pan, and seat back to calculate the equations that describe the three planes. These planes are required to calculate the external dimensions.

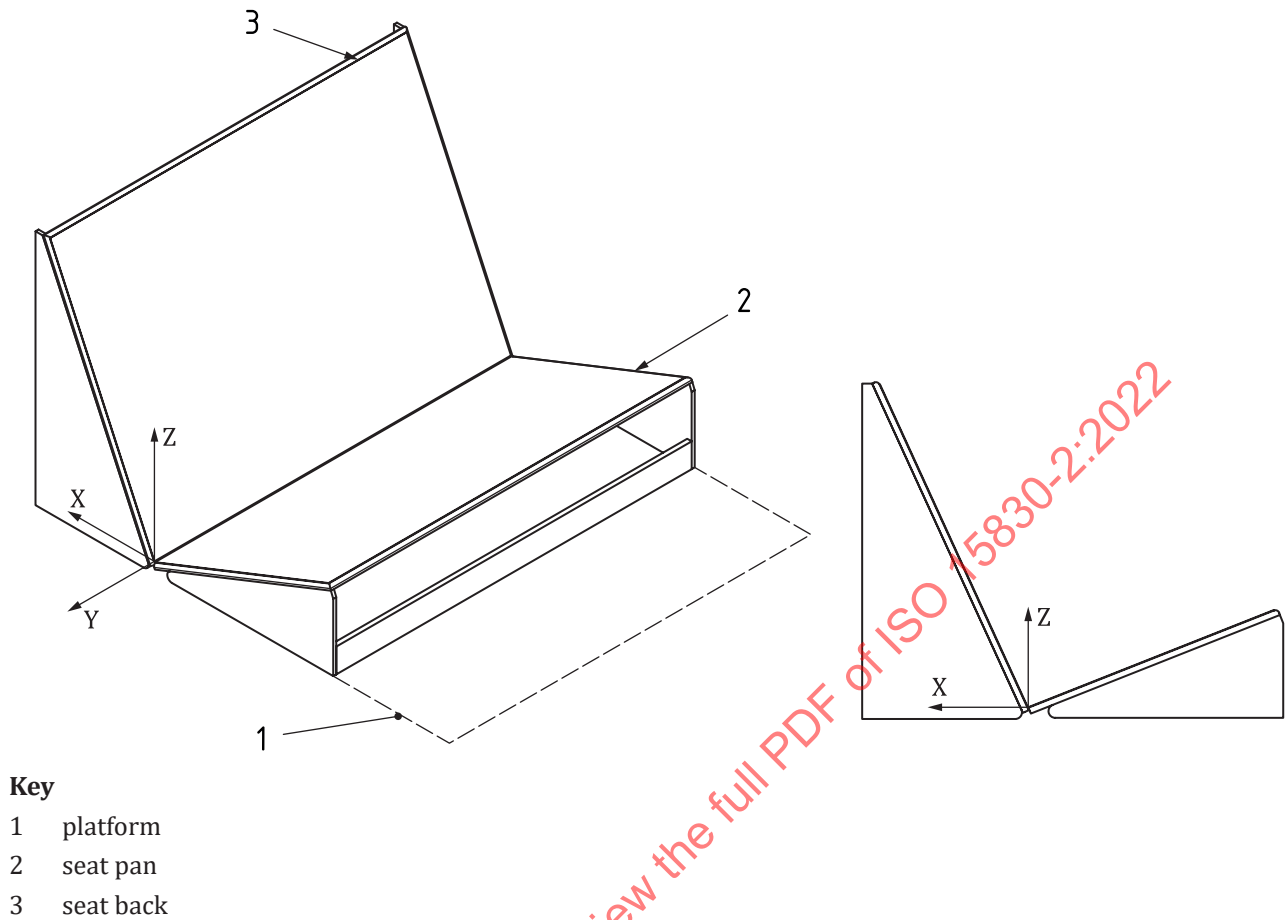


Figure 24 — Validation bench and CMM coordinate system

5.4.2.2.3 Linear measurements on validation bench

- Hip pivot height, l_1 - measure to the centre of the reference hole (1,995-mm diameter hole at the lower end of tool) on the left and right H-point tool. Refer to [Figure 25](#). Calculate the distance to the seat pan plane.
- Hip pivot to back line, l_2 - calculate the distance to the seat back plane from the left and right H-point measurements taken for the hip pivot height.
- Seated height, l_3 - measure the uppermost point on the head. Refer to [Figure 26](#). Calculate the distance to the seat pan plane.
- Head reference mark to seat back, l_{40} - measure the left and right head reference marks. Refer to [Figure 27](#). Calculate the distance to the seat back plane.
- Arm length, l_5 - measure the uppermost and lowermost points on each arm. Refer to [Figure 28](#) (a and b). Calculate the length of both arms.
- Width across the shoulder attachment studs, l_{60} - measure the centre of the left and right shoulder attachment studs. Refer to [Figure 29](#). Calculate the distance between points.
- Waist width, l_7 - measure the lateralmost points on the left and right sides at the top of the pelvis flesh. Refer to [Figure 30](#). Calculate the distance between points.
- Thigh clearance, l_8 - measure the uppermost point of the thigh portion of the pelvis flesh. Do not measure to the top of thigh flesh of the thighs. Refer to [Figure 31](#). Calculate the distance to the seat pan plane.

- Knee height, l_9 – measure points on the heel of the shoe and calculate a heel plane. Refer to [Figure 32 a](#)). Measure the uppermost point on the knee pad mould assembly. Refer to [Figure 32 b](#)). Calculate the distance between the point and the heel plane.
- Knee to back line, l_{10} – measure the forwardmost point on the knee pad mould assembly. Refer to [Figure 33](#). Calculate the distance to the seat back plane.



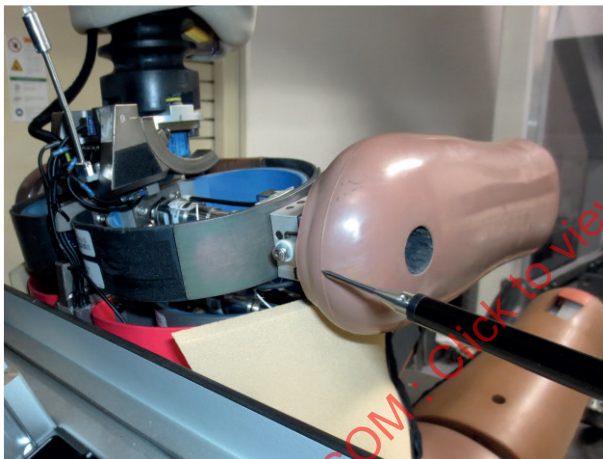
Figure 25 — Reference hole on H-point tool



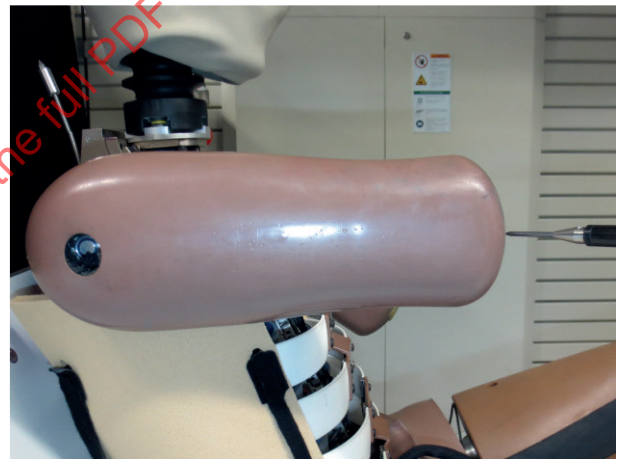
Figure 26 — Uppermost point on head



Figure 27 — Head reference mark



a) Uppermost

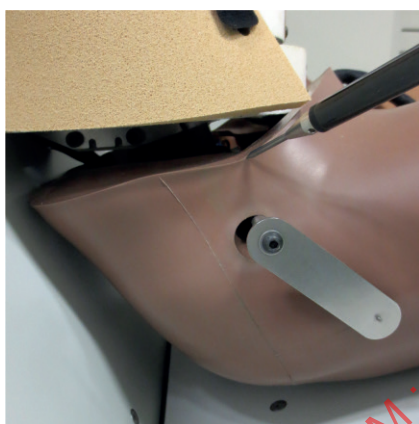


b) Lowermost

Figure 28 — Arm measurement points



Figure 29 — Shoulder attachment stud centre



a) Side view



b) Front view

Figure 30 — Lateralmost point at top of pelvis flesh

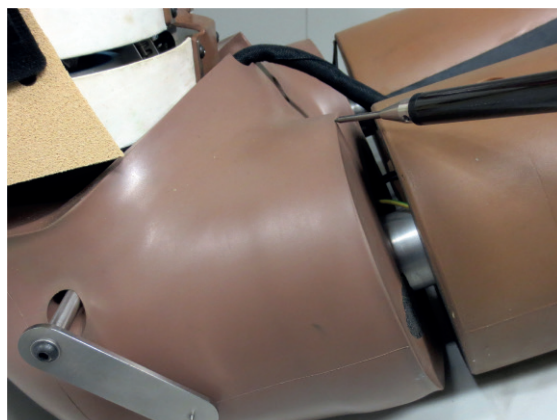
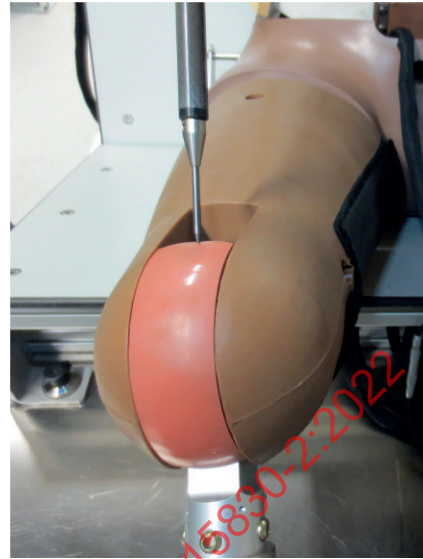


Figure 31 — Uppermost point of thigh on pelvis flesh



a) Heel plane



b) Uppermost point on knee pad

Figure 32 — Leg measurement points

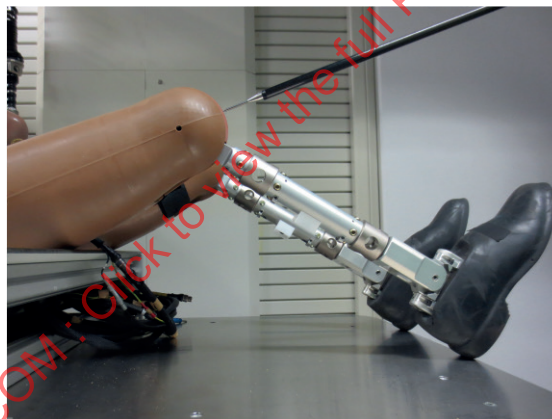


Figure 33 — Forwardmost point on knee pad mould assembly

5.4.2.2.4 CMM setup of spine box assembly

Define a coordinate system on the spine box assembly (W50-31000). The location of the origin is arbitrary. The orientation of the coordinate system shall align with SAE J1733 sign convention.

5.4.2.2.5 Linear measurements off the validation bench

Install the lifting bracket. Lift the dummy off the validation bench. Seat it on a rigid, flat, horizontal surface. Ensure that the dummy is not tipping. Refer to [Figure 34](#). Ensure abdomen rib 2 is inside the pelvis flesh.

- Thorax rib number 1 depth, l_{11} – measure the rearmost and forwardmost points on thorax rib 1. Refer to [Figure 35](#). Calculate the distance between points. This is easiest done with the dummy lifted off the validation bench.
- Abdomen rib number 2 depth, l_{12} – measure the rearmost and forwardmost points on abdomen rib 2. Refer to [Figure 36](#). Calculate the distance between points.

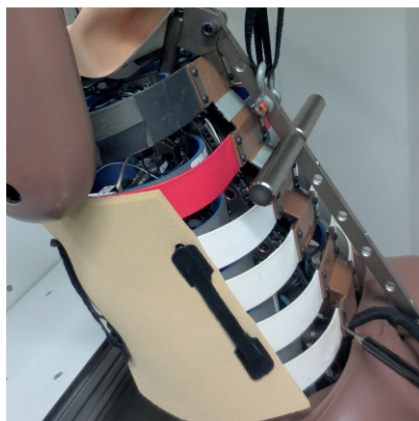
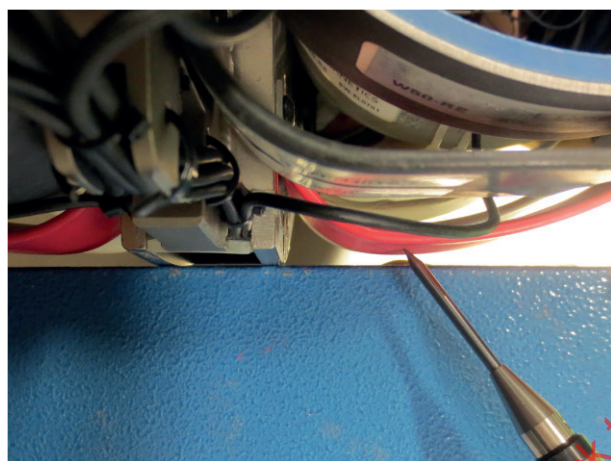
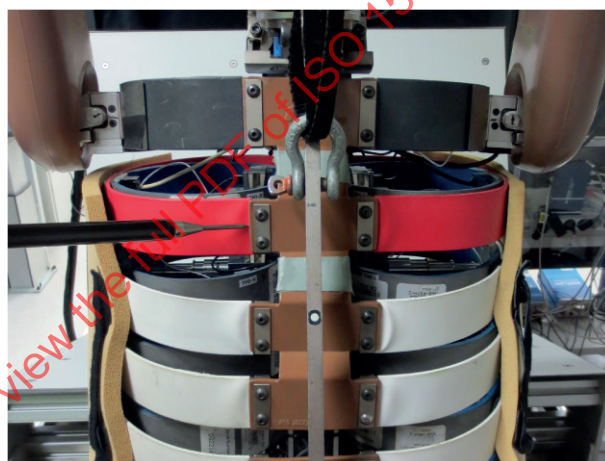


Figure 34 — WorldSID with lifting bracket for rib depth measurements



a) Rearmost

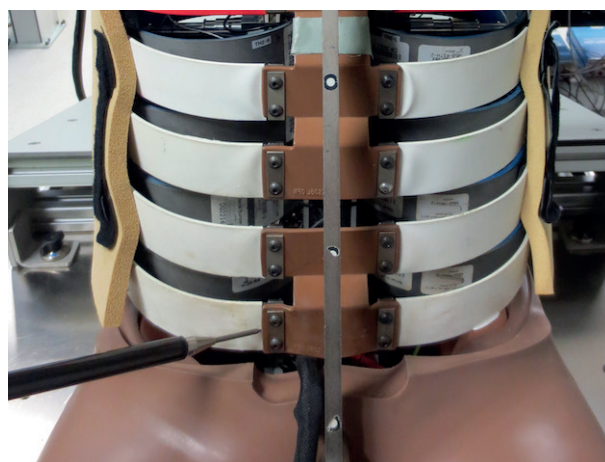


b) Forwardmost

Figure 35 — Thorax rib 1 measurement points



a) Rearmost



b) Forwardmost

Figure 36 — Abdomen rib 2 measurement points

5.4.2.3 Test reports

Document the setup specification measurements and the results of the external dimension measurements.

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