
**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), 50^e 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 15830-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 12, *Passive safety crash protection systems*.

ISO 15830 consists of the following parts, under the general title *Road vehicles — Design and performance specifications for the WorldSID 50th percentile male side impact dummy*:

- *Part 1: Terminology and rationale*
- *Part 2: Mechanical subsystems*
- *Part 3: Electronic subsystems*
- *Part 4: User's manual*

Introduction

This first edition of ISO 15830 (all parts) has been prepared on the basis of the existing design, specifications and performance of the WorldSID 50th percentile adult male (PAM) side impact dummy. The purpose of ISO 15830 is to document the design and specifications of this side impact dummy in a form suitable and intended for worldwide regulatory use.

In 1997, ISO/TC22/SC12 initiated the WorldSID 50th PAM dummy development, with the aims of defining a global-consensus side impact dummy, having a wider range of human-like anthropometry, biofidelity and injury monitoring capabilities, suitable for regulatory use. Participating in the development were research institutes, dummy and instrumentation manufacturers, governments, and vehicle manufacturers from around the world.

With regard to potential regulatory, consumer information or research, and development use of ISO 15830, users will need to identify which of the permissive (i.e. optional) sensors and other elements defined in Part 3 are to be used in a given application.

In order to apply ISO 15830 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 part of ISO 15830 specifies requirements for mechanical components, drawings and specifications, certification tests, and support equipment for the WorldSID 50th percentile side impact dummy, a standard anthropomorphic dummy for side impact testing of road vehicles. It is applicable to impact tests involving:

- passenger vehicles of category M1 and goods vehicles of category N1,
- impacts to the side of the vehicle structure, and
- impact tests involving use of an anthropomorphic dummy as a human surrogate for the purpose of evaluating compliance with vehicle safety standards.

2 Normative references

The following referenced documents are indispensable for the application 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, *Design and performance specifications for the WorldSID 50th percentile male side impact dummy — Part 1: Terminology and rationale*

ISO 15830-3:2005, *Design and performance specifications for the WorldSID 50th percentile male side impact dummy — Part 3: Electronic subsystems*

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

SAE J211-1:2003, *Instrumentation for impact test — Part 1: Electronic instrumentation*

SAE J2570:2001, *Reference specification for anthropomorphic test device transducers*

49 CFR Part 572, subpart E, *Anthropomorphic test dummies, United States of America Code of Federal Regulations issued by the National Highway Traffic Safety Administration (NHTSA), Washington, DC, US*

3 Terms and definitions

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

4 Mechanical requirements for WorldSID

4.1 Head

4.1.1 General description

The head assembly shall consist of the components and assemblies listed in head assembly drawing W50-10000.pdf (see Annex B).

4.1.2 Drawings and specifications

- The head assembly and components shall conform to head assembly drawing W50-10000.pdf (see Annex B) and the subassembly and component drawings listed therein.
- The total assembly shall have a mass of $4,22 \text{ kg} \pm 0,05 \text{ kg}$.
- The centre of gravity 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.

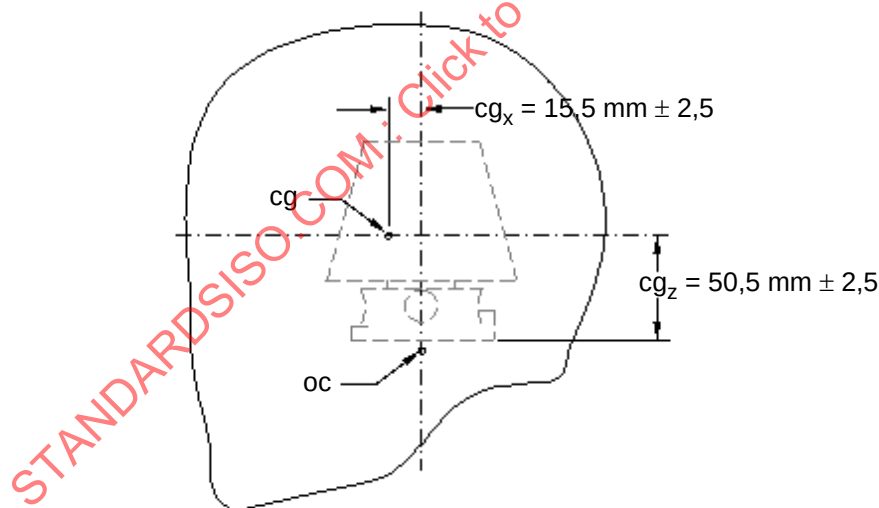


Figure 1 — Head centre of gravity location

4.1.3 Certification

When assembled according to 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 certification specifications

Frontal drop	
Variable	Absolute value
Peak resultant acceleration (G)	225 to 275
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)	99 to 121
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 and assemblies listed in neck assembly drawing W50-20000.pdf (see Annex B).

4.2.2 Drawings and specifications

- The neck assembly and components shall conform to neck assembly drawing W50-20000.pdf (see Annex B) and the subassembly and component drawings listed therein.
- The total assembly shall have a mass of 3,23 kg $\pm$ 0,15 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 Certification

When assembled according to ISO 15830-4, and tested using the procedure specified in 5.2, the neck assembly shall meet the specifications given in Table 2.

Table 2 — WorldSID neck certification 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)	58 to 72
Peak moment at occipital condyle (Nm)	55 to 68
Peak moment decay time to 0 Nm (ms) ^a	71 to 87
Peak forward potentiometer angular displacement (degrees)	32 to 39
Time of peak forward potentiometer angular displacement (ms) ^a	56 to 68
Peak rearward potentiometer angular displacement, θ_R (degrees)	30 to 37
Time of peak rearward potentiometer angular displacement, θ_R (ms) ^a	56 to 68
a T=0 s at initial pendulum contact with honeycomb or alternative products which can be shown to lead to the same results.	

4.3 Thorax/abdomen/shoulder

4.3.1 General description

The thorax/abdomen/shoulder assembly shall consist of the components and assemblies listed in thorax/abdomen/shoulder assembly drawing W50-30000.pdf (see Annex B).

4.3.2 Drawings and specifications

- The thorax/abdomen/shoulder assembly and components shall conform to thorax/abdomen/shoulder assembly drawing W50-30000.pdf (see Annex B) and the subassembly and component drawings listed therein.
- The total assembly shall have a mass of 20,55 kg $\pm$ 1,0 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 Certification

4.3.3.1 Shoulder

When assembled according to ISO 15830-4, and tested using the procedure specified in 5.3.1 and 5.3.2, the shoulder assembly shall meet the specifications given in Table 3.

Table 3 — WorldSID shoulder certification specifications

Variable	Absolute value
Peak pendulum force (kN)	2,6 to 3,3
Peak shoulder rib deflection (mm)	35 to 44

4.3.3.2 Thorax with half arm

When assembled according to ISO 15830-4, and tested using the procedure specified in 5.3.1 and 5.3.3, the thorax with half-arm assembly shall meet the specifications given in Table 4.

Table 4 — WorldSID thorax with half-arm certification specifications

Variable	Absolute value
Peak pendulum force (kN)	4,7 to 6,4
Peak T4 acceleration along y axis (G)	24 to 33
Peak T12 acceleration along y axis (G)	20 to 28
Peak thorax rib 1 deflection (mm)	35 to 47
Peak thorax rib 2 deflection (mm)	42 to 57
Peak thorax rib 3 deflection (mm)	40 to 54

4.3.3.3 Thorax without arm

When assembled according to ISO 15830-4, and tested using the procedure specified in 5.3.1 and 5.3.4, the thorax without arm assembly shall meet the specifications given in Table 5.

Table 5 — WorldSID thorax without arm certification specifications

Variable	Absolute value
Peak pendulum force (kN)	3,2 to 3,9
Peak T4 acceleration along y axis (G)	12 to 17
Peak T12 acceleration along y axis (G)	15 to 21
Peak thorax rib 1 deflection (mm)	34 to 43
Peak thorax rib 2 deflection (mm)	34 to 43
Peak thorax rib 3 deflection (mm)	34 to 43

4.3.3.4 Abdomen

When assembled according to ISO 15830-4, and tested using the procedure specified in 5.3.1 and 5.3.5, the abdomen without arm assembly shall meet the specifications given in Table 6.

Table 6 — WorldSID abdomen certification specifications

Variable	Absolute value
Peak abdomen rib 1 deflection (mm)	33 to 41
Peak abdomen rib 2 deflection (mm)	31 to 39
Peak pendulum force (kN)	2,6 to 3,3
Peak T12 acceleration along y axis (G)	15 to 20

4.4 Full arms

4.4.1 General description

The full arm assembly may be installed on either side of the dummy. If installed, it shall consist of the components and assemblies listed in full arm assembly drawings W50-61000.pdf (left) and W50-61001.pdf (right) (see Annex B).

4.4.2 Drawings and specifications

- The full arm assembly and components shall conform to full arm assembly drawings W50-61000.pdf (left) and W50-61001.pdf (right) (see Annex B) and the subassemblies and component drawings listed therein.
- The total assembly shall have a mass of $3,72 \text{ kg} \pm 0,15 \text{ kg}$.
- The materials used in the construction of the full arm 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 full arm assembly shall include a secure strain relief mechanism.

4.5 Half arms

4.5.1 General description

The half arm assembly shall consist of the components and assemblies listed in half arm assembly W50-62000.pdf (see Annex B).

4.5.2 Drawings and specifications

- The half arm assembly shall conform to half arm assembly drawing W50-62000.pdf (see Annex B) and the subassemblies and component drawings listed therein.
- The total assembly shall have a mass of $1,77 \text{ kg} \pm 0,09 \text{ kg}$.
- The materials used in the construction of the half arm assembly shall not contain lead or lead alloys.
- The flesh material and/or external surface characteristics shall enable positive attachment of adhesive targets.

4.6 Lumbar spine and pelvis

4.6.1 General description

The lumbar spine and pelvis assembly shall consist of the components and assemblies listed in lumbar spine and pelvis assembly drawing W50-40000.pdf (see Annex B).

4.6.2 Drawings and specifications

- The lumbar spine and pelvis assembly shall conform to lumbar spine and pelvis assembly drawing W50-40000.pdf (see Annex B) and the subassemblies and component drawings listed therein.
- The total assembly shall have a mass of 17,75 kg $\pm$ 0,90 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.

4.6.3 Certification

When assembled according to ISO 15830-4, and tested using the procedure specified in 5.3.1 and 5.3.6, the pelvis assembly shall meet the specifications given in Table 7.

Table 7 — WorldSID pelvis certification specifications

Variable	Absolute value
Peak acceleration along y axis (G)	41 to 51
Peak pelvis pendulum force (kN)	6,3 to 7,8
Peak T12 acceleration along y axis (G)	10 to 14

4.7 Upper legs

4.7.1 General description

The upper leg assembly shall consist of the components and assemblies listed in upper leg assembly drawings W50-51000.pdf (right) and W50-51050.pdf (left) (see Annex B).

4.7.2 Drawings and specifications

- The upper leg assembly and components shall conform to upper leg drawings W50-51000.pdf (right) and W50-51050.pdf (left) (see Annex B) and the subassemblies and component drawings listed therein.
- The total assembly shall have a mass of 6,71 kg $\pm$ 0,30 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.

4.8 Lower leg, ankle, and foot

4.8.1 General description

The lower leg, ankle, and foot assembly shall consist of the components and assemblies listed in lower leg, ankle, and foot assembly drawing W50-54054.pdf (right) and W50-54056.pdf (left) (see Annex B).

4.8.2 Drawings and specifications

- The lower leg assembly shall conform to lower leg, ankle and foot assembly drawing W50-54054.pdf (right) and W50-54055.pdf (left) (see Annex B) and the subassemblies and component drawings listed therein.
- The total assembly shall have a mass of $5,09 \text{ kg} \pm 0,13 \text{ kg}$.
- 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.

4.9 Clothing

4.9.1 General description

The clothing shall consist of the components and assemblies listed in clothing assembly drawing W50-80100.pdf (see Annex B).

4.9.2 Drawings and specifications

- The clothing shall conform to clothing assembly drawing W50-80100.pdf (see Annex B) and the subassemblies and component drawings listed therein.
- The total assembly shall have a mass of $1,85 \text{ kg} \pm 0,09 \text{ kg}$.
- 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.

4.10 Whole dummy

- The total dummy assembly including clothing shall have a mass of $74,88 \text{ kg} \pm 3,74 \text{ kg}$.

5 Certification 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

- 49 CFR Part 572, Subpart E, horizontal head impact surface
 - Chrome plated rigidly supported horizontal steel plate
 - 50,8 mm x 610 mm x 610mm
 - 8 – 80 rms micron/mm surface finish
- Head drop tool assembly (drawing W50-82100.pdf) (see Annex B)
- Instrumented head assembly (drawing W50-10000.pdf) (see Annex B) including the instrumentation insert and upper neck load cell or structural replacement
- Two SHCS M6 x 12

5.1.3 Sensors

Use triaxial linear accelerometers as described in ISO 15830-3:2005, 4.1.3.2.

5.1.4 Preparation

- Expose the head assembly to an environment with a temperature of $21,4 \text{ degrees C} \pm 0,8 \text{ degrees C}$ 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 1,1,1 trichlorethane or equivalent.
- Install the triaxial accelerometer in the head assembly.
- Install the upper neck load cell, angular accelerometers and dual-axis tilt sensor, or their structural or mass replacements.
- Attach the head drop tool to the bottom of the upper neck load cell or its structural replacement with the two SHCS M6x12. Mount the tool for left or right lateral, or frontal drops as shown in Figures 2, 3, 4 and 5. When mounted for lateral drops, position the head such that its midsagittal plane has an angle of $35^\circ \pm 1^\circ$ with the impact surface and its anterior-posterior axis is horizontal to within 1 degree.
- Suspend the head above the drop table using the head drop tool and a quick release mechanism.
- For lateral tests, position the head so its lowest point is $200 \text{ mm} \pm 0,25 \text{ mm}$ above the impact surface and drop the head.
- For a frontal test, position the head so the lowest point on the forehead is $376 \text{ mm} \pm 0,25 \text{ mm}$ above the impact surface.

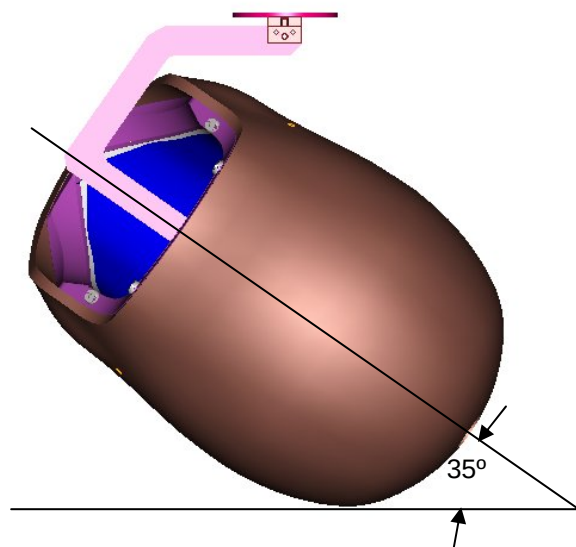


Figure 2 — Lateral head drop angle

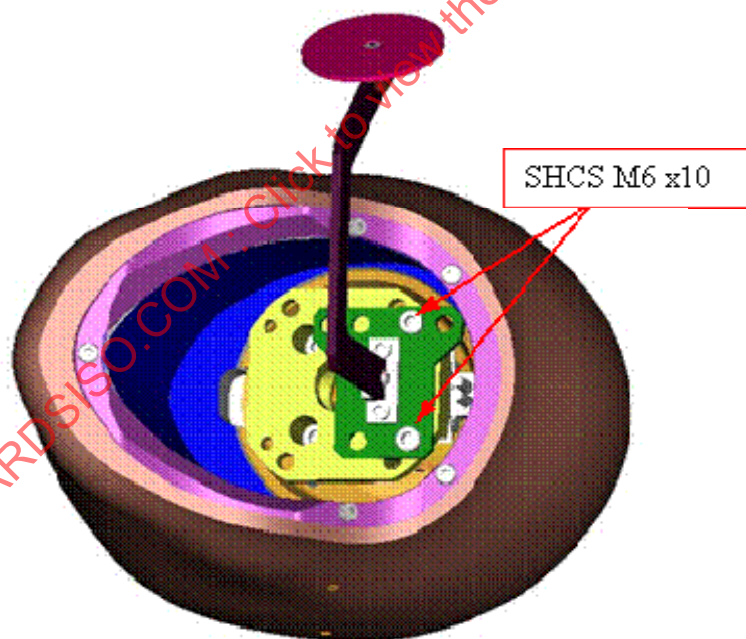


Figure 3 — Head bracket installation for lateral drops

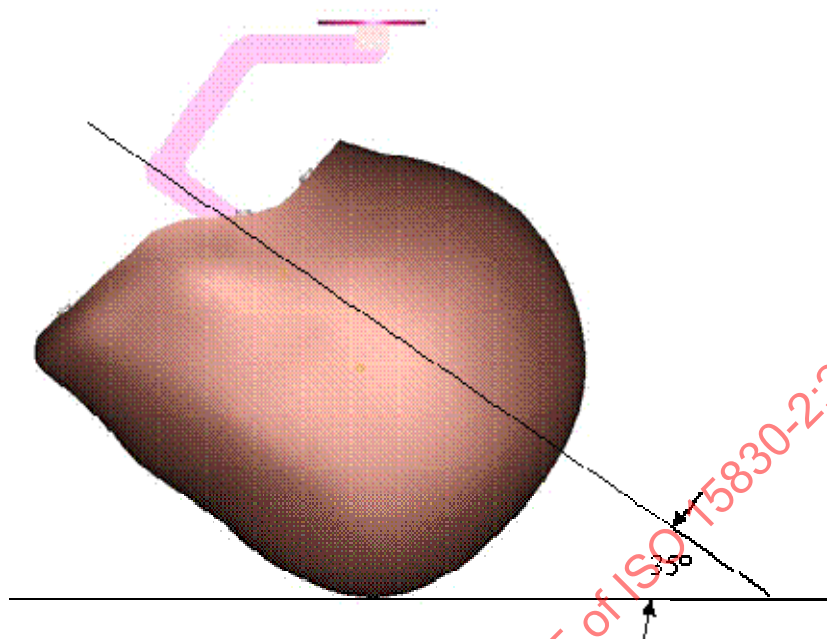


Figure 4 — Frontal head drop angle

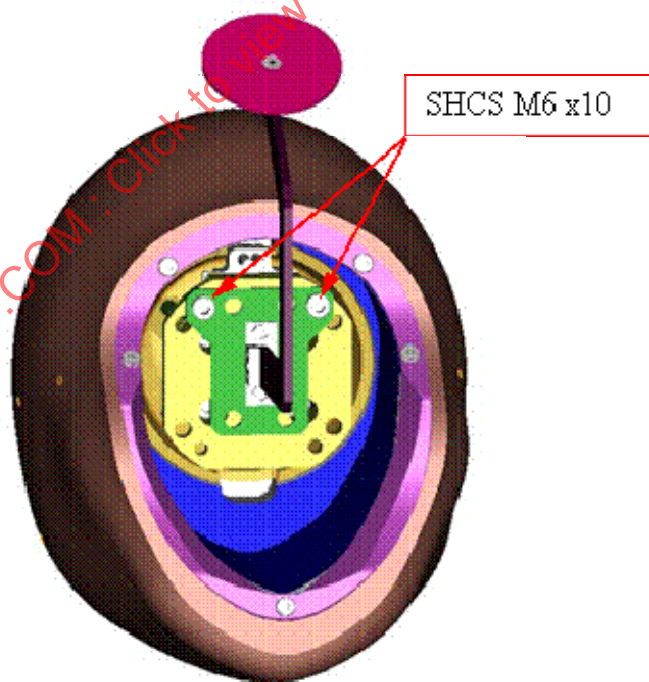


Figure 5 — Head bracket installation for frontal drops

5.1.5 Procedure

- Record and filter the head accelerations from the triaxial accelerometer according to SAE J211 and ISO 6487 Channel filter class 1000.
- 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 hours between successive tests on the same head.

5.1.6 Test report

Document the results of both the left and right lateral and the frontal drop tests.

5.2 Neck

5.2.1 Principle

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

5.2.2 Materials

For the pendulum stop, use aluminium honeycomb, of density $28,8 \text{ kg/m}^3 \pm 4,90 \text{ kg/m}^3$ and dimensions 102,0 mm minimum x 102,0 mm minimum with a thickness along the cells of $76,2 \text{ mm} \pm 4 \text{ mm}$ or alternative products which can be shown to lead to the same results.

5.2.3 Apparatus

- Neck assembly as specified in 4.2.1.
- WorldSID head form (drawing W50-83000.pdf) (see Annex B).
- Neck pendulum apparatus as specified in 49CFR Part 572, Subpart E.

5.2.4 Sensors

Perform the test using the sensors given in Table 8.

Table 8 — Sensors for neck assembly

Variable	Sensor	Performance
Pendulum acceleration	Single axis accelerometer Endevco 7231C-750 ^a	SAE J2570
Pendulum velocity	Not specified	Resolution 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

Variable	Sensor	Performance
Neck moment M_x	Upper neck load cell ISO 15830-3:2005, 4.1.3.5	SAE J2570
Neck force F_y	Upper neck load cell ISO 15830-3:2005, 4.1.3.5	SAE J2570
a Accelerometer model 7231C-750 is a product supplied by Endevco Corp. San Juan Capistrano, California, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Alternative products may be used if they can be shown to lead to the same results.		

5.2.5 Preparation

Expose the neck to the conditions specified in Table 9 for at least four hours prior to a test.

Table 9 — Neck test preconditions

Variable	Specification
Temperature (degrees C)	$21,4 \pm 0,8$
Relative humidity (%)	40 ± 30

- 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 in order 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 fiber 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.

5.2.6 Procedure

- Record and filter the data according to ISO 6487 or SAE J211 Channel filter class 1000.
- Release the pendulum and allow it to fall freely from a height such that the velocity at impact is $3,4 \text{ m/s} \pm 0,1 \text{ m/s}$, measured at the centre of the pendulum mounted accelerometer.
- Decelerate the pendulum arm using the $28,8 \text{ kg/m}^3$ aluminium honeycomb or alternative products which can be shown to lead to the same results, to achieve the pendulum pulse given in Table 10.
- Allow the neck to flex without impact of the head 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 minutes.
- Conduct the test such that the time between any tests on the same WorldSID neck is not less than 30 minutes.

Table 10 — 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 2,16 m/s
Velocity change at 12 ms ^a	2,43 m/s to 3,29 m/s
a T=0 s at initial contact with honeycomb or alternative products which can be shown to lead to the same results.	

5.2.7 Calculation procedures

- Filter the data according to ISO 6487 or SAE J211, as given in Table 11.
- Integrate the filtered and adjusted acceleration time histories.
- Calculate the flexion angle of the head form using the following equation:

$$\beta = \theta_F + \theta_H$$

where:

β = angular displacement of head form relative to the pendulum

θ_F = Angular displacement of forward pendulum-to-head form sliding rod, positive when doing a right side impact

θ_H = 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 using ISO 6487 or SAE J211 CFC 180
- Calculate the moment about the occipital condyle as $M_{OCx} = M_x + (F_y) \times (0,0195\text{m})$, where the M_x and F_y polarities are in accordance with the SAE J211 sign convention.

Table 11 — Filter specification for neck test

Variable	Filters ^a
Pendulum acceleration	CFC 60
Pendulum velocity	No digital filtering
Angular displacement of forward rod (θ_F)	CFC 1000
Angular displacement rear rod (θ_R)	CFC 1000
Angular displacement of head form (θ_H)	CFC 1000
Neck moment M_x	CFC 600
Neck force F_y	CFC 1000
a ISO 6487 or SAE J211	

5.2.8 Test reports

Document the results of the test.

5.3 Thorax/abdomen/shoulder full body tests

5.3.1 Full body test setup

5.3.1.1 Materials

Use Teflon^{®1)} sheets of sufficient size to cover seat.

5.3.1.2 Apparatus

- H-Point tool (drawing W50-82500.pdf) (see Annex B).
- Tilt sensor or inclinometer.
- Dummy certification test bench.
- Seat and back Teflon[®] sheets described in Annex A.1.

5.3.1.3 Preparation

Expose the dummy, clothed in its suit, to the conditions given in Table 12 for at least four hours prior to a test.

Table 12 — Dummy full body test preconditions

Variable	Value
Temperature (degrees C)	21,4 ± 0,8
Relative humidity (%)	40 ± 30

5.3.1.4 Setup procedure

- Install the H-point tool.
- Install 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 Teflon[®] sheets.
- Seat the dummy on the rigid seat as shown in Figure 6 and Figure 7.
- Place the dummy on the seat and position it using either mechanical measurements on a dummy component or tilt sensors to verify the positions. The relationship between mechanical angle measurements and the tilt sensors are given in Table 13.
- Position the dummy according to the criteria given in Table 14.

1) Teflon[®] is a commercial product. This information is given for the convenience of users of this Standard and does not constitute an endorsement of the product named. Alternative products may be used if they can be shown to lead to the same results.

Table 13 — Relationship between mechanical measurement indicators and the tilt sensors

Location	Mechanical reference	Tilt sensor (angular displacement about the noted axis)
Head zero	Landmark on head is horizontal	X : 0°, Y : 0°
Thorax zero	Top of the lower neck bracket is horizontal	X : 0°, Y : 0°
Pelvis zero	X angle zero degree H-point tool oriented at 45° below horizontal (Y)	X : 0°, Y : 14,5°

Table 14 — Dummy set up criteria

Variable	Criteria	Sensor readings
Thorax angle	0° ± 2°	
Pelvic orientation	5° ± 2° ^a	This pelvic orientation is coincident with H-point tool at 40° ± 2° below horizontal, and a pelvic tilt sensor at 19,5° ± 2°
Distance between knee centres	279 mm ± 50 mm	

^a Due to the low friction of the Teflon® pieces, the dummy is not able to sit at zero pelvis angle. Five degrees is an achievable angle on the test bench.

**Figure 6 — Front view of setup for full dummy certification tests**



Figure 7 — Side view of setup for full dummy certification tests



Figure 8 — Using an inclinometer with the H-point tool to check pelvis angle

5.3.2 Shoulder test

5.3.2.1 Principle

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

5.3.2.2 Apparatus

Use 49 CFR Part 572, subpart E Hybrid III 50th percentile adult male dummy pendulum (23,4 kg, 152,4 mm face diameter).

5.3.2.3 Sensors

Install instrumentation to obtain data for the items given in Table 15.

Table 15 — Sensors for shoulder test

Variable	Sensor	Performance
Peak pendulum acceleration (G)	See Table 8	Per SAE J2570
Peak shoulder rib deflection (mm)	IR-TRACC ISO 15830-3:2005, 4.1.3.6	See sensor specification details on electronic drawing number IF-363 (see Annex B)
Impact velocity (m/s)	Not specified	Resolution 0,02 m/s or better

5.3.2.4 Procedure

- Set up the dummy in standard test posture as described in 5.3.1 with the half arm aligned horizontal on the impact side as shown in Figure 9.
- 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 9 — Shoulder test, dummy and arm position

5.3.2.5 Calculation procedures and expression of results

- Filter the data according to ISO 6487 or SAE J211, as given in Table 16.
- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the measured impactor mass.
- Graph the time histories of impactor force and shoulder deflection.

Table 16 — Filter specifications for shoulder test

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

5.3.2.6 Test reports

Document the results of the test.

5.3.3 Thorax with half arm

5.3.3.1 Principle

Perform a test involving a lateral impact to the thorax with the half arm in order to certify the dynamic response of the thorax.

5.3.3.2 Apparatus

Use 49 CFR Part 572, subpart E Hybrid III 50th percentile adult male dummy pendulum (23,4 kg, 152,4 mm face diameter).

5.3.3.3 Sensors

Install instrumentation in order to obtain data for the items given in Table 17.

Table 17 — Sensor specifications for thorax with half arm test

Variable	Sensor	Performance
Peak pendulum acceleration (G)	See Table 8	SAE J2570
Peak upper spine (T4) y-axis acceleration (G)	Triaxial linear accelerometer ISO 15830-3:2005, 4.1.3.2	SAE J2570
Peak lower spine (T12) y-axis acceleration (G)	Triaxial linear accelerometer ISO 15830-3:2005, 4.1.3.2	SAE J2570
First, second and third thorax rib deflections (mm)	IR-TRACC ISO 15830-3:2005, 4.1.3.6	See sensor specification details on electronic drawing number IF-363 (see Annex B)
Impact velocity (m/s)	Not specified	Resolution 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 with the half arm parallel to the thorax.
- Align the pendulum centreline with the centreline of the middle thorax rib.
- 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.

5.3.3.5 Calculation procedures and expression of results

- Filter the data according to ISO 6487 or SAE J211, as given in Table 18.
- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the measured impactor mass.
- Plot the time histories of impactor force, T4 and T12 y-axis accelerations, and deflections of thorax ribs 1, 2, and 3.

Table 18 — Filter specifications for thorax with half arm 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 Thorax without arm

5.3.4.1 Principle

Perform a test involving a lateral impact to the thorax without the arm in order to certify the dynamic response of the thorax.

5.3.4.2 Apparatus

Use 49 CFR Part 572, subpart E Hybrid III 50th percentile adult male dummy pendulum (23,4 kg, 152,4 mm face diameter).

5.3.4.3 Sensors

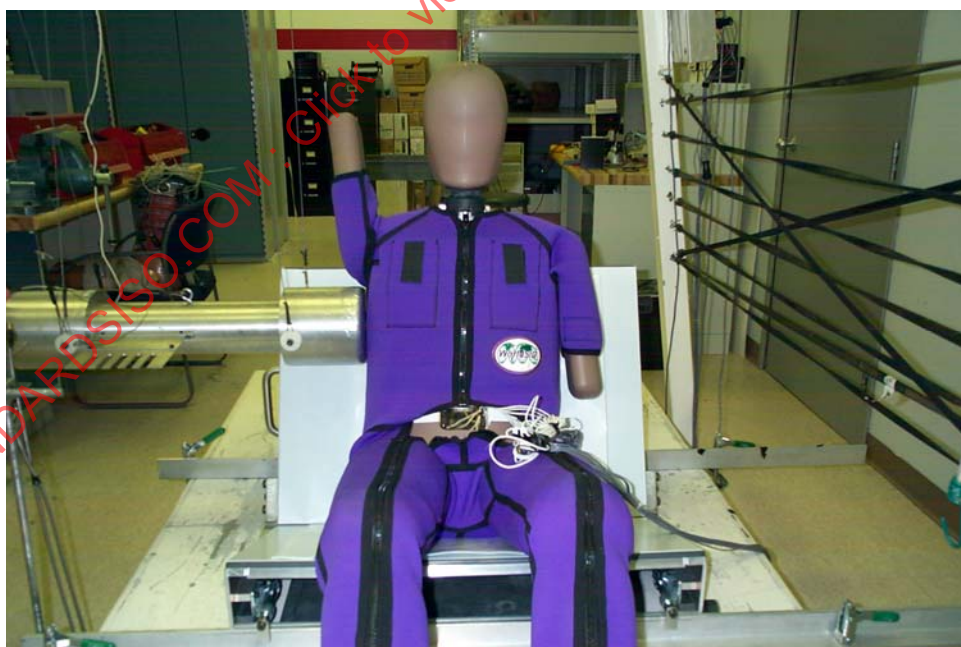
Install instrumentation to obtain data for the items given in Table 19.

Table 19 — Sensor specifications for thorax without arm test

Variable	Sensor	Performance
Peak pendulum acceleration (G)	See Table 8	SAE J2570
Peak upper spine (T4) y-axis acceleration (G)	Triaxial linear acceleration ISO 15830-3:2005, 4.1.3.2	SAE J2570
Peak lower spine (T12) y-axis acceleration (G)	Triaxial linear acceleration ISO 15830-3:2005, 4.1.3.2	SAE J2570
First, second and third thorax rib deflections (mm)	IR-TRACC ISO 15830-3:2005, 4.1.3.6	See sensor specification details on electronic drawing number IF-363 (see Annex B)
Impact velocity (m/s)	Not specified	Resolution 0,02 m/s or better

5.3.4.4 Procedure

- Set up the dummy without arm in standard test posture as described in 5.3.1.
- Raise the arm to a vertical orientation as shown in Figure 10.
- 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 10 — Thorax test without arm, dummy and arm position****5.3.4.5 Calculation procedures and expression of results**

- Filter the data according to ISO 6487 or SAE J211, as given in Table 20.

- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the measured impactor mass.
- 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 without half arm 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

5.3.4.6 Test reports

Document the results of the test.

5.3.5 Abdomen test

5.3.5.1 Principle

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

5.3.5.2 Apparatus

Use the following items:

- 49 CFR Part 572, subpart E Hybrid III 50th percentile adult male pendulum (23,4 kg, 152,4 mm face diameter).
- Simulated armrest consisting of a rigid hardwood block as given in Table 21 attached to the impact face of the pendulum. 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 ± 0,5
Height (mm)	70 ± 0,5
Depth (mm)	60 ± 0,5
Corner radius (mm)	10 ± 1
Mass (Kg)	1,00 ± 0,01

5.3.5.3 Sensors

Install instrumentation in order to obtain data for the items given in Table 22.

Table 22 — Sensor specifications for abdomen test

Variable	Sensor	Performance
Pendulum acceleration (G)	See Table 8	SAE J2570
Lower spine (T12) y-axis acceleration (G)	Triaxial linear accelerometer ISO 15830-3:2005, 4.1.3.2	SAE J2570
Abdomen rib 1 and 2 deflections (mm)	IR-TRACC ISO 15830-3:2005, 4.1.3.6	See sensor specification details on electronic drawing number IF-363 (see Annex B)
Impact velocity (m/s)	Not specified	Resolution 0,02 m/s or better

5.3.5.4 Procedure

- Set up the dummy in standard test posture as described in 5.3.1 with the half arm in the driving posture as shown in Figure 6.
- Align the wood block face so it is aligned with and parallel to the middle of the two abdomen ribs.
- Place the wood block 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.

5.3.5.5 Calculation procedures and expression of results

- Filter the data according to ISO 6487 or SAE J211-1, as given in Table 23.
- Calculate the pendulum impactor force by multiplying the pendulum acceleration time history by the combined measured mass of the pendulum and armrest simulator.
- 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 (G)	CFC 180
T12 y-axis acceleration (G)	CFC 180
Abdomen rib 1 deflection (mm)	CFC 600
Abdomen rib 2 deflection (mm)	CFC 600

5.3.5.6 Test reports

Document the results of the abdomen test.

5.3.6 Pelvis test

5.3.6.1 Principle

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

5.3.6.2 Apparatus

Use 49 CFR Part 572, subpart E Hybrid III 50th percentile adult male dummy pendulum (23,4 kg, 152,4 mm face diameter).

5.3.6.3 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 (G)	See Table 8	SAE J2570
Lower spine (T12) y-axis acceleration (G)	Triaxial linear accelerometer ISO 15830-3:2005, 4.1.3.2	SAE J2570
Pelvis acceleration (G)	Triaxial linear accelerometer ISO 15830-3:2005, 4.1.3.2	SAE J2570
Impact velocity (m/s)	Not specified	Resolution 0,02 m/s or better

5.3.6.4 Procedure

- Set up the dummy with half arm in standard test posture as described in 5.3.1.
- Align the pendulum centreline with the H-point.
- 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.

5.3.6.5 Calculation procedures and expression of results

- Filter the data according to ISO 6487 or SAE J211-1, as given in Table 25.
- 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 and T12 y-axis accelerations.

Table 25 — Filter specifications for pelvis test

Variable	Filter
Pendulum acceleration (G)	CFC 180
T12 y-axis acceleration (G)	CFC 180
Pelvis y-axis acceleration (G)	CFC 180

5.3.6.6 Test reports

Document the results of the pelvis test.

5.4 Data zero values

For all certification tests, set all data channels to a zero value at the time of initial contact of the moving component with the stationary component.

NOTE When using IR-TRACC sensors, due to the non-linear input-output relationship, the voltage should be converted to engineering units before setting the data channel to zero as required above.

STANDARDSISO.COM : Click to view the full PDF of ISO 15830-2:2005

Annex A (normative)

Support equipment

A.1 Specialized WorldSID support equipment

Specialized WorldSID support equipment needed for WorldSID assembly, handling, or certification testing shall consist of the items given in Table A.1.

Table A.1 — Specialized WorldSID support equipment

Reference	Description	Use	Part number ^b	Reference
5.1	Head drop tool	Certification	W50-82100	Annex B
5.2	Head form	Certification	W50-83000	Annex B
5.1	Head sensor extension cables for head drop test	Certification	Custom ^a	Annex B
5.2	Head form rotational potentiometers, quantity of three	Certification	F.1A	
5.2	Carbon rods for potentiometers	Certification	F.GL	
5.2	Circular section neck buffers with different hardness	Certification	W50-20006	Annex B
5.2	Neck and head form sensor extension cables for neck test	Certification	Custom ^a	
5.3	H-Point tool	Test set up	W50-82500	Annex B
5.3	Teflon® covered dummy certification test bench	Certification	W50-82200	Annex B
5.3	Small Teflon® sheets for the seat and back	Certification	W50-82244 W50-82245	Annex B
	Modified spanner wrench, 25 mm to 28 mm dia.	Assembly	W50-51001	Annex B
	Spanner wrench, 40 mm to 42 mm dia.	Assembly	W50-51002	Annex B
	Modified hex key wrench	Assembly	W50-51003	Annex B
	Modified 22 mm open-end wrench	Assembly	W50-51004	Annex B
	Shortened 6 mm hex key 15 mm long	Assembly	W50-20018	Annex B
	C-wrench for hip joint	Assembly	W50-42521	Annex B
	Lifting mechanism	Handling	W50-84100 ^a	Annex B
a This equipment may need to be customized for each lab. b Part numbers correspond to electronic drawing numbers (see Annex B).				

A.2 Other support equipment typically available in test laboratories

Other dummy support equipment needed for WorldSID certification and typically available in test laboratories shall be as given in Table A.2.

Table A.2 — Other standard support equipment

Reference	Description	Use
5.1	49 CFR Part 572, Subpart E horizontal head impact surface	Certification
5.1	Quick release mechanism	Certification
5.2	49 CFR Part 572, Subpart E neck pendulum apparatus	Certification
5.2	49 CFR Part 572, Subpart E pendulum decelerating aluminium honeycomb or alternative products which can be shown to lead to the same results	Certification
5.2	Neck bending pendulum accelerometer, Endevco 7231C-750 ^a	Certification
5.3	49 CFR Part 572, subpart E Hybrid III 50th percentile adult male dummy pendulum (23,4 kg with 6 in. dia.)	Certification
5.3	49 CFR Part 572, subpart E Hybrid III 50th percentile adult male dummy pendulum accelerometer, Endevco 7231C-750 ^a	Certification
E.BF	Neck compression wrench	Assembly

a Accelerometer model 7231C-750 is a product supplied by Endevco Corporation, San Juan Capistrano, California, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Alternative products may be used if they can be shown to lead to the same results.

Annex B
(normative)

Drawings and specifications, PDF and STP files

The WorldSID shall be fabricated according to the drawings and specifications contained in the electronic PDF and STP files which shall be accessed at <http://standards.iso.org/iso/15830-2/ed-1>.

STANDARDSISO.COM : Click to view the full PDF of ISO 15830-2:2005

Annex C (informative)

Drawing list

This annex lists the WorldSID drawings in Table C.1 and fasteners in Table C.2 for the convenience of users. The drawings are available electronically (see Annex B).

Table C.1 — WorldSID drawing list

Drawing number	Description	Electronic file format	
		PDF	STP
W50-00000	WorldSID ATD	X	
W50-10000	Head assembly, tested and certified	X	
W50-10007	Head core	X	
W50-10010	Rotational accelerometer replacement, Endevco 7302BM4	X	
W50-10011	Tilt sensor mass replacement	X	
W50-14014	Head, moulded tested and certified	X	X
W50-20000	Neck assembly	X	
W50-20002	Neck/head/torso interface plate	X	
W50-20006	Neck buffer assembly	X	
W50-20007	Screw, half spherical	X	
W50-20009	Lower neck bracket	X	
W50-20010	Upper neck bracket	X	
W50-20011	Nut, neck bracket	X	
W50-20016	Flexion extension buffer	X	
W50-20018	Shortened 6 mm hex key	X	
W50-21001	Neck assembly tested and certified	X	
W50-22003	Neck, moulded	X	X
W50-24013	Neck shroud assembly	X	
W50-24014	Neck shroud ring	X	
W50-24015	Neck shroud	X	
W50-30000	Torso-shoulder thorax abdomen, WorldSID	X	
W50-31000	Spine box assembly	X	
W50-31010	Upper bracket weldment, spine box, WorldSID	X	
W50-31011	Shoulder mounting plate	X	
W50-31012	Middle plate	X	
W50-31013	Neck bracket mounting plate	X	
W50-31020_1	Side plate, left Worldsid	X	
W50-31020_2	Side plate, left Worldsid	X	

Drawing number	Description	Electronic file format	
		PDF	STP
W50-31030_1	Side plate, right Worldsid	X	
W50-31030_2	Side plate, right Worldsid	X	
W50-31041	Spacer, WorldSID	X	
W50-31042	Mounting bracket #1	X	
W50-31043	Mounting bracket #2	X	
W50-31045	Cover plate spine box	X	
W50-31050	Ball joint assembly, ITRACC	X	
W50-31051	Ball-shaft assembly	X	
W50-31053	Ball-shaft, ITRACC	X	
W50-31054	Ball socket, ITRACC	X	
W50-31055	Ball retainer, ITRACC	X	
W50-31060	IR-TRACC mass replacement	X	
W50-32000	Rib, shoulder	X	
W50-32001	Rib assembly, shoulder	X	
W50-32010	Rib doubler, shoulder	X	
W50-32110	Thorax rib 1, WorldSID	X	
W50-32111	Thorax rib assembly 1 WorldSID	X	
W50-32130	Thorax rib 2 and 3 abdominal ribs WorldSID	X	
W50-32131	Thorax rib assembly, 2 and 3 WorldSID	X	
W50-32150	Thorax rib assembly, inner band, WorldSID	X	
W50-32151	Rib, damping	X	
W50-32152	Thorax rib bent, WorldSID	X	
W50-32155	Abdomen rib assembly, inner band, WorldSID	X	
W50-32156	Rib, damping	X	
W50-32160	Shoulder rib assembly, inner band, WorldSID	X	
W50-32161	Rib, damping	X	
W50-32162	Shoulder rib bent, WorldSID	X	
W50-32171	Shoulder rib mounting bracket, struck side, WorldSID	X	
W50-32172	Thorax and abdominal rib accelerometer mounting bracket, WorldSID	X	
W50-32173	Thorax and abdominal rib clamping bracket, WorldSID	X	
W50-32175	Shoulder rib sternum mounting strip, threaded	X	
W50-32176	Thorax and abdominal rib mounting strip, threaded	X	
W50-32177	Shoulder rib sternum mounting strip	X	
W50-32178	Thorax and abdominal rib sternum mounting strip	X	
W50-32179	Screw, rib ITRACC mount	X	
W50-32180	Clamp, damping	X	
W50-35021	Rib coupler abdominal, WorldSID	X	
W50-35021	Rib coupler abdominal, WorldSID	X	X

Drawing number	Description	Electronic file format	
		PDF	STP
W50-35022	Sternum, thorax rib	X	X
W50-35023-1	Shoulder pad, left, WorldSID	X	X
W50-35023-2	Shoulder pad, right, WorldSID	X	X
W50-35024	Pad, thorax	X	
W50-37011	Battery mounting bracket	X	
W50-37012	Battery structural replacement	X	
W50-37022	Backup plate mounting bracket	X	
W50-37023	Angular accelerometer, tilt sensor mount bracket	X	
W50-37024	T12 accelerometer mount, WorldSID	X	
W50-37029	Bracket, rotational accelerometer mount	X	
W50-38000	Battery assembly	X	
W50-38001	Back plate, battery enclosure	X	
W50-38002	Enclosure cover, battery	X	
W50-38004	Foam pad, 3 mm thick	X	
W50-40000	Pelvis assembly	X	
W50-41018	Lumbar spine rubber	X	X
W50-41019	Bushing lumbar	X	
W50-41020	Bushing, lumbar spine, top	X	
W50-41021	Lumbar lower clamping plate	X	
W50-41022	Lumbar upper clamping plate	X	
W50-41026	Lumbar mounting wedge	X	
W50-41030	Weldment lower lumbar mounting bracket	X	
W50-41031	Lower lumbar mounting bracket	X	
W50-41032	Dummy lifting socket	X	
W50-41041	DAS cover	X	
W50-41042	Docking station pelvis	X	
W50-42002	Sacro-iliac load cell backing plate	X	
W50-42005	Hip joint socket	X	
W50-42007	Inner ring hip joint	X	
W50-42008	Hip socket retainer	X	
W50-42010	Pelvis bone, left hand	X	X
W50-42011	Pelvis bone, right hand	X	X
W50-42012	Insert, iliac wing	X	
W50-42016	Sacro-iliac load cell interface left hand	X	
W50-42017	Sacro-iliac load cell interface right hand	X	
W50-42019	Pelvis flesh	X	X
W50-42030	Instrumentation bracket pelvis	X	
W50-42031	Instrumentation cover plate, pelvis	X	

Drawing number	Description	Electronic file format	
		PDF	STP
W50-42510	Pubic buffer moulded	X	
W50-42516	End plate medial	X	
W50-42517	End plate lateral	X	
W50-42521	C-wrench for hip joint	X	
W50-51000	Upper leg assembly, right	X	
W50-51001	Modification of small spanner wrench (25mm-28mm)	X	
W50-51002	Unmodified large spanner wrench (40mm-42mm)	X	
W50-51003	Modified 4mm hexagon key wrench	X	
W50-51004	Modified 22mm open end wrench	X	
W50-51017	Trochanter	X	
W50-51022	Trochanter tube assembly, right	X	
W50-51023	Trochanter assembly left	X	
W50-51034	Femoral neck assembly	X	
W50-51035	Femoral neck	X	
W50-51038	Femoral ball	X	
W50-51050	Upper leg assembly, left	X	
W50-51052	G5 DAS leg docking station	X	
W50-51053	G5 DAS structural replacement assembly	X	
W50-51058	Upper leg flesh - right - velcro application	X	X
W50-51059	Upper leg flesh - left - velcro application	X	X
W50-51060	Leg structural replacement assembly	X	
W50-51067	Leg extension tube assembly	X	
W50-51068	Leg extension tube	X	
W50-52001sheet1	Knee assembly right	X	
W50-52001sheet2	Knee assembly right part list	X	
W50-52002	Knee bone assembly	X	
W50-52004	Knee cover	X	
W50-52005sheet1	Knee clevis, right	X	
W50-52005sheet2	Knee clevis, right	X	
W50-52006	Knee clevis stop	X	
W50-52007	Knee pivot shaft	X	
W50-52008	Knee pivot shaft assembly	X	
W50-52009	Knee clevis assembly, right	X	
W50-52010	Knee pad moulded assembly	X	
W50-52011	Side plate	X	
W50-52015	Knee contact load cell structural replacement assembly	X	
W50-52019sheet1	Knee assembly, left	X	
W50-52019sheet2	Knee assembly, left parts list	X	

Drawing number	Description	Electronic file format	
		PDF	STP
W50-52020	Knee clevis, left	X	
W50-52021	Knee clevis assembly, left	X	
W50-52024	Knee bone	X	
W50-52063	Knee washer	X	
W50-52064	Friction washer assembly	X	
W50-52065	Braking washer	X	
W50-52066	Braking washer backing	X	
W50-53001	Lower leg tube	X	
W50-53002	Lower leg flesh	X	X
W50-53007	Zipper assembly	X	
W50-53008	Vinyl strips	X	
W50-54002	Ankle clevis right and left lower limb	X	
W50-54004	Left flexion centre rotational piece	X	
W50-54005	Ankle joint	X	
W50-54006	Base plate	X	
W50-54008	Thrust washer	X	
W50-54009	Z-pivot pin	X	
W50-54010	Z-axis rotational washer	X	
W50-54012	Potentiometer (optional)	X	
W50-54013	Potentiometer structural replacement	X	
W50-54014	Retainer bracket	X	
W50-54015	Ankle joint cover	X	
W50-54016	X-version bushing	X	
W50-54019	Front bearing cover	X	
W50-54020	Rear bearing cover	X	
W50-54021	X-version compression element	X	
W50-54022	Dorsiflexion and plantarflexion hard stop	X	
W50-54023	Z-axis nut	X	
W50-54024	Z-axis anti-rattle washer	X	
W50-54031	Z-axis rotation bearing	X	
W50-54033	Right flexion centre rotational piece	X	
W50-54034	Foot sole locator pins	X	
W50-54035	X-version resistive element	X	
W50-54036	Resistive element	X	
W50-54037	Bumper	X	
W50-54038	Orientation block	X	
W50-54041	Z-axis radial limit screw	X	
W50-54042	Front bearing assembly	X	