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

Part 1: Terminology and rationale

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

Partie 1: Terminologie et raisonnement

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Contents

Page

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(standards.iteh.ai)
ISO 15830-1:2013
https://standards.iteh.ai/catalog/standards/sist/8402328c-61ee-4765-816c-2075809f1c22/iso-15830-1-2013

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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. www.iso.org/directives

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

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 12, *Passive safety crash protection systems*.

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This second edition cancels and replaces the first edition (ISO 15830-1:2005), which has been technically revised. Technical amendments have been incorporated throughout all four parts, resulting from extensive experience with the standard and design changes.

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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*

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Introduction

This second edition of ISO 15830 has been prepared on the basis of the existing design, specifications, and performance of the WorldSID 50th percentile adult male side-impact dummy. 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 regulatory use.

In 1997, ISO/TC 22/SC 12 initiated the WorldSID 50th percentile adult male 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 ISO 15830-3 are to be used in a given application.

WorldSID drawings in electronic format are being made available. Details are given in ISO 15830-2, Annex B.[14]

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

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ISO 15830-1:2013
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Road vehicles — Design and performance specifications for the WorldSID 50th percentile male side-impact dummy —

Part 1: Terminology and rationale

1 Scope

This part of ISO 15830 provides the definitions, symbols, and rationale used in all parts of this International Standard for the WorldSID 50th percentile side-impact dummy, a standardized anthropomorphic dummy for side-impact testing of road vehicles. It is applicable to impact tests involving

— passenger vehicles of category M_1 and goods vehicles of category N_1,

— 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.

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2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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ISO 1207, *Slotted cheese head screws — Product grade A*

ISO 4026, *Hexagon socket set screws with flat point*

ISO 4027, *Hexagon socket set screws with cone point*

ISO 4029, *Hexagon socket set screws with cup point*

ISO 4762, *Hexagon socket head cap screws*

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

ISO 7379, *Hexagon socket head shoulder screws*

ISO 7380 (all parts), *Button head screws*

ISO/TR 9790:1999, *Road vehicles — Anthropomorphic side impact dummy — Lateral impact response requirements to assess the biofidelity of the dummy*

ISO 10642, *Hexagon socket countersunk head screws*

SAE J211-1:2007, *Instrumentation for impact test — Part 1: Electronic instrumentation*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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3.1
1-to-2-G-setting
joint friction setting which will support the weight of a horizontally extended limb segment but will not support twice the limb segment weight

3.2
abdomen rib
lowest two ribs of the six mechanical ribs in the WorldSID dummy

3.3
aluminium honeycomb
manufactured material comprising multi-layered bonded sheets of aluminium bent or corrugated in a rib pattern, in which there is an internal pattern of hexagonal cylindrical spaces, and which is used in this International Standard as an energy-absorbing element in validation tests

3.4
capacity
maximum force or moment which can be measured by a load cell without causing load cell damage

3.5
cheese screw
slotted button head screw, also referred to as a slotted cheese head screw as defined by ISO 1207

3.6
docking station
data recorder connection point inside the dummy which allows the recorder to be conveniently disconnected from the sensors

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3.7
full arm
assembly of the WorldSID dummy comprising the articulated upper arm and lower arm, including the hand

ISO 15830-1:2013
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3.8
frontal
forward-facing or anterior surfaces of the dummy, when it is in a standing posture

3.9
H-point
point on the outer surface of the dummy on an imaginary line which passes through the left and right hip ball centres

3.10
H-point tool
device which can be inserted into index holes in the dummy pelvis, which provides an external surface for indicating the orientation of the pelvis and an imaginary line connecting the left and right hip ball joint centres

3.11
half arm
assembly of the WorldSID dummy comprising dedicated upper arm components which are different from the components of the full arm

3.12
head form
mechanical device with the same mass and I_{xx} inertia as the WorldSID head, used for lateral neck validation tests

3.13
infrared telescoping rod for assessment of chest compression
IR-TRACC
sensor for deflection measurements

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3.14
lower leg
portion of the lower extremity between the knee and the ankle

3.15
mass replacement
non-electronic component which is substituted for a given dummy electronic component, which has the same mass as the given electronic component, and which does not act as a structural component of the dummy (e.g. an accelerometer)

3.16
rigid seat
specialized seat with defined seat bottom and seat back angles used to position the dummy for impact testing

3.17
shoulder rib
upper-most rib of the six mechanical ribs in the WorldSID dummy

3.18
structural replacement
non-electronic component which is substituted for a given dummy electronic component (e.g. a load cell), which has the same mass as the given component, and which also acts as a structural component of the dummy

3.19
thoracic rib
second, third, and fourth upper-most ribs of the six mechanical ribs in the WorldSID dummy

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3.20
T1
location corresponding to the first thoracic vertebra in a human

ISO 15830-1:2013
https://standards.iteh.ai/catalog/standards/sist/8402328c-61ee-4765-816c-2075809f1c22/iso-15830-1-2013

3.21
T4
location corresponding to the fourth thoracic vertebra in a human

3.22
T12
location corresponding to the twelfth thoracic vertebra in a human

3.23
tilt sensor
sensor internal to the dummy which transduces the two orientation angles of the respective body region relative to gravity

3.24
universal
capable of being mounted at several different locations on the dummy

3.25
upper leg
portion of the lower extremity between the knee and the hip ball

3.26
validation
process by which the relevant dummy component or whole dummy is verified and documented to meet the specifications

3.27
W50-
prefix denoting WorldSID 50th percentile adult male dummy part or drawing number

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3.28
WorldSID
anthropometric side-impact dummy intended to be used by vehicle manufacturers and all interested parties in the passive safety field to improve occupant protection and in regulatory and consumer information testing in various regions of the world

4 Symbols, subscripts, and abbreviated terms

4.1 Symbols

See Table 1.

Table 1 — Symbols and their meanings

Symbol	Meaning
a	Linear acceleration
F	Force
G	Acceleration due to gravity (9,81 m/s^2)
M	Moment
β	Angular displacement of the head form
δ	Deflection
θ	Angular displacement
φ	Rotation
x	Coordinate in accordance with ISO 6487 or SAE J211-1
y	Coordinate in accordance with ISO 6487 or SAE J211-1
z	Coordinate in accordance with ISO 6487 or SAE J211-1

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ISO 15830-1:2013
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4.2 Subscripts

See Table 2.

Table 2 — Subscripts and their meanings

Symbol	Meaning
F	Forward
H	Head
R	Rearward
x, y, z	Coordinate system : In the x, y, or z direction; about the x, y, or z axis where x, y, or z are in accordance with ISO 6487 or SAE J211-1

4.3 Abbreviated terms

See Table 3.

Table 3 — Abbreviated terms

Abbreviation	Meaning
AMVO	Anthropometry for Motor Vehicle Occupants dataset (established by UMTRI)
A-P	Anterior-posterior
ASIS	Anterior superior iliac spine
ASPECT	Automotive Seat and Package Evaluation and Comparison Tools (a Society of Automotive Engineers cooperative research program)
ATD	Anthropomorphic test device
BHCS	Button head cap screw, also referred to as a hexagon socket button head screw as defined by ISO 7380
CG	Centre of gravity
CPSS	Cone point set screw, also referred to as a hexagon socket set screw with cone point as defined by ISO 4027
CPSSS	Cone point socket set screw as defined by ISO 4027
CPNT	Cone point nylon tip
DAS	Data acquisition system
FHCS	Flat head cap screw, also referred to as a hexagon socket countersunk head screw as defined by ISO 10642
FTSS	First Technology Safety Systems
IHRA	International Harmonization Research Activities
ISO	International Organization for Standardization
LHSHCS	Low head socket head cap screw
MDB	Movable deformable barrier
NM	Not measured
OC	Occipital condyle
PC	Personal computer
R-L	Right-left

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ISO 15830-1:2013

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Table 3 *(continued)*

Abbreviation	Meaning
SHCS	Socket head cap screw, also referred to as a hexagon socket head cap screw as defined by ISO 4762
SHSS	Socket head shoulder screw, also referred to as a hexagon socket head shoulder screw as defined by ISO 7379
SI	Sacroiliac
SSCP	Set screw with cup point, also referred to as a hexagon socket set screw with cup point as defined by ISO 4029
SSFP	Set screw with flat point, also referred to as a hexagon socket set crew with flat point as defined by ISO 4026
SSHDP	Set screw with half dog point, as defined by ISO 4026
SSNT	Set screw with nylon tip
UMTRI	University of Michigan Transportation Research Institute

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ISO 15830-1:2013
https://standards.iteh.ai/catalog/standards/sist/8402328c-61ee-4765-816c-2075809f1c22/iso-15830-1-2013

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Annex A
(informative)

Rationale regarding background and goals for WorldSID

NOTE All references cited in Annex A are listed in the Bibliography.

A.1 Historical background

A.1.1 General

In November 1997, the WorldSID Task Group was formed under the auspices of the International Organization for Standardization (ISO) TC 22/SC 12/WG 5 — *Anthropomorphic test devices*. Document ISO/TC 22/SC 12/WG 5/N 512 (see Annex C) established the composition and responsibilities of the Task Group. The Task Group's purpose was to develop a unique, technologically advanced side-impact dummy which would have greater biofidelity and which would replace the variety of side-impact dummies used in regulation and in other testings. It was with this double objective of developing an advanced and globally harmonized dummy that the WorldSID Task Group was formed, including a Tri-Chair representing each of the Americas, Europe, and Asia-Pacific regions, and experts from more than 10 countries, including Australia, Canada, France, Germany, Japan, The Netherlands, Sweden, United Kingdom, and United States of America. The members comprised participants from vehicle manufacturers, governmental organizations, research institutes, test laboratories, and dummy and instrumentation manufacturers from around the world.

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Worldwide vehicle manufacturers and governmental bodies sponsored the WorldSID's development. A design team of worldwide dummy manufacturers, instrumentation manufacturers, and research organizations was formed to design, develop, and fabricate the prototype. Thirty-seven Task Group meetings were held in order to coordinate the definition, design, development, and evaluation of the dummy, as well as to develop an International Standard which was initially approved in 2005. During the development stage, more than 13 separate organizations from around the world conducted testing and evaluations of the dummy in order to assess its biofidelity, durability, repeatability, reproducibility, and other aspects of performance. Regulation-ready documentation was prepared in the form of ISO 15830, which is available to the relevant regulatory and consumer information bodies worldwide.

ISO 15830-1:2013
https://standards.iteh.ai/catalog/standards/sist/84023286-6bee-4765-816e-207589009f1c/iso-15830-1-2013

Following the release of ISO 15830:2005, testing, evaluation, and development continued. This revised International Standard documents improvements to the WorldSID, including improved rib damping material, improved durability, modified pelvis, new seating procedures, updated biofidelity scores, an updated user manual, and an updated electronic drawing package (available online).

The resulting WorldSID 50th percentile adult male is a new, advanced, global-consensus, side-impact dummy. It has an overall biofidelity classification of 8,0 ("good") using the ISO/TR 9790 biofidelity rating scale. It is planned to be the basis for the future development of a harmonized side-impact dummy family. The WorldSID 50th percentile adult male has a mass of 74,35 kg, a theoretical standing height of 1 753 mm, and a seated height of 911 mm. Almost every body region involves a new, innovative design, setting the WorldSID apart from all existing side-impact dummies. It can accommodate 207 permissible sensor channels (including six tilt sensors) and associated cabling, and up to 192 recording channels with an optional in-dummy data acquisition system (DAS).

A.1.2 Need for an International Standard side-impact dummy

As of December 2008, six other mid-sized male side-impact dummies were available for regulatory, consumer information and development use. These are: the USDOT-SID dummy, which is utilized in the United States side-impact protection regulation[31]; the EuroSID-1 dummy, which is regulated in a European standard[32]; the ES-2 dummy, the ES-2re; the SID/H3 dummy, which is utilized in the United

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States side-impact protection regulation FMVSS-201; and the BioSID dummy, which is available for developmental purposes. None of these dummies has "good" biofidelity (i.e. they all have a less than "6,5" rating using the ISO/TR 9790 biofidelity rating scale). The six dummies are structurally different and have different instrumentation capabilities and associated injury assessment criteria. Because of these differences, as well as the differences in the associated test procedures, these dummies typically provide a different design direction in the vehicle development process. This results in substantially different vehicle designs with regard to side-impact protection in the different world regions, despite the similarity in occupant protection needs among the regions.

The existing dummies are less human-like and cannot be instrumented for all the body regions of importance in side-impact protection. This means that they have limited effectiveness as tools for improving occupant protection.

In addition, the total costs to a vehicle manufacturer, and therefore to consumers, of developing different side protection systems for different regions are higher than a harmonized system.

Overall, with the existing diversity of dummies, the benefits in terms of occupant protection are lower, and the costs higher, than what would be the case if a more human-like side-impact dummy was adopted on a worldwide basis.

A.1.3 Benefits and economic impact of an International Standard side-impact dummy

A more human-like side-impact dummy, accepted via consensus among the participating regions by means of an International Standard, along with harmonized vehicle side-impact test procedures, will have significant benefits in terms of more realistic (and therefore more effective) occupant protection as well as reduced costs of side-impact protection system development.

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With regard to benefits, it is self-evident that a more advanced, human-like side-impact dummy would result in vehicle side-impact protection systems that would be more effective for human occupants and would be less likely to produce harmful designs, which, in principle, can result from dummies that are either less human-like or unable to monitor for injuries to some body regions.

ISO 15830-1:2013
https://standards.iteh.ai/catalog/standards/sist/84025282-01ec-4765-816c-2075809f1c22/iso-15830-1-2013

With regard to costs, it is also self-evident that vehicle manufacturers could eliminate the additional, wasteful efforts needed to develop vehicles to pass different regulatory tests, with different dummies, when they are to be sold in several markets. This process is costly for consumers and has no benefits for passive safety.

For these reasons, most of the major industrial nations, including members of the European Union, Canada, Japan, and the United States, signed the *"Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles,"* (1998), also referred to as the 1998 Global Agreement. This treaty implemented objectives and methods for proposing and developing within the forum of UN/ECE/TR ANS/WP29 global technical regulations (GTR), which contracting nations or groups of nations would have the option to adopt as part of their domestic rulemaking processes.

In summary, the WorldSID would be expected to have substantial benefits for occupant protection and would reduce total development costs.

A.1.4 Survey of and general differences from previous side-impact dummies

As mentioned in A.1.2, as of December 2008, there were six mid-sized male side-impact dummies, as well as some variations thereto, available for regulatory and development use. The six dummies have different levels of biofidelity. The USDOT-SID, EuroSID-1, ES-2, ES-2re, BioSID dummies have each been rated using the ISO biofidelity scale that provides classifications, as shown in Table A.1. These classifications quantify how closely the dummy dynamic response matches those of a sample of human subjects, for each body region and for all body regions. The USDOT-SID has an ISO biofidelity classification of "unacceptable", the EuroSID-1 and ES-2re have a classification of "marginal," and the BioSID and ES-2 have a classification of "fair."

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Table A.1 — ISO biofidelity rating scale

Excellent	**> 8,6 to 10**
Good	> 6,5 to 8,6
Fair	> 4,4 to 6,5
Marginal	> 2,6 to 4,4
Unacceptable	0 to 2,6

As reported by Byrnes, K. et al.[3], the USCAR OSRP (Occupant Safety Research Partnership) conducted a series of ISO/TR 9790 tests in order to compare the biofidelity ratings of the current 50th percentile male side-impact dummies USDOT-SID, EuroSID-1, ES-2, BioSID, and the WorldSID. Even if not all ISO/TR 9790 tests were carried out identically with each dummy (as described in, for example, Appendix G of ISO/TR 9790), the WorldSID was the only dummy to obtain a "good" rating on the ISO biofidelity scale.

As shown in Table A.2,[3] which includes updated WorldSID data and the ES-2re, the WorldSID achieved the best overall dummy rating and also the best single body region ratings for the head, thorax, abdomen, and pelvis.

Table A.2 — Biofidelity comparison of side-impact dummies

	Biofidelity rating						
	Head	**Neck**	**Shoulder**	**Thorax**	**Abdomen**	**Pelvis**	**Overall**
WorldSID production version	10,0	5,3	10,0	8,2	9,3	5,1	8,0
BioSID	6,7	6,7	7,3	6,3	3,8	4,0	5,7
ES-2	5,0	4,4	5,3	5,2	2,6	5,3	4,6
EuroSID-1	5,0	7,8	7,3	5,4	0,9	1,5	4,4
ES-2re	5,0	4,2	4,5	4,0	4,1	3,2	4,2
USDOT-SID	0,0	2,5	0,0	3,1	4,4	2,5	2,3

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ISO 15830-1:2013
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Independently, the US/NHTSA (National Highway Traffic Safety Administration) evaluated the WorldSID prototype (unrevised version) together with two other side-impact dummies, the ES-2 and the Hybrid III-SID, to a newly developed biofidelity ranking system called Bio Rank System, as reported by Rhule, H. et al.[20]

This Bio Rank System quantifies the ability of a dummy to load a sled wall as a cadaver does (External Biofidelity) and the ability of a dummy to replicate those cadaver responses that best predict injury potential (Internal Biofidelity). The ranking is based on the ratio of the cumulative variance of the dummy response relative to the mean cadaver response and the cumulative variance of the mean cadaver response relative to the mean plus one standard deviation. That ratio expresses how well a dummy duplicates a cadaver response. Contrary to the ISO rating system, the lower the rating value, the better the biofidelity.

Although still under development and not in use by the international community, the data presented by Rhule et al. indicate that this assessment system also showed the WorldSID prototype to have the best ranking out of the three tested dummies.

In summary, compared with other contemporary mid-sized adult male side-impact dummies, the WorldSID overall ratings are better than all others. It achieves by far the best overall rating and is, to date, the only side-impact dummy with an overall biofidelity rating of "good."

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