INTERNATIONAL STANDARD

ISO 7176-19

Third edition
2022-04

Wheelchairs —

Part 19: Wheelchairs for use as seats in motor vehicles

Fauteuils roulants —

Partie 19: Fauteuils roulants destinés à être utilisés comme sièges dans des véhicules à moteur

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Contents

Page

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 173, *Assistive products*, Subcommittee SC 1, *Wheelchairs*.

This third edition cancels and replaces the second edition (ISO 7176-19:2008), which has been technically revised. It also incorporates the Amendment ISO 7176-19:2008/Amd.1:2015.

The main changes are as follows:

— scope has been expanded to include wheelchairs for occupants with a mass less than 22 kg;

— clause has been added to address risk management in modification of wheelchairs;

— the conformance label has been revised;

— design and performance requirements have been expanded, for example related to wheelchair tiedown clear-paths, wheelchair-mounted occupant restraints, and wheelchair securement with strap-type tiedowns;

— specifications for the surrogate WTORS have been enhanced;

— a checklist of the requirements has been added in Annex L.

A list of all parts in the ISO 7176 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.

Introduction

Transportation safety research has shown that the vehicle seat is an important part of the occupant restraint system and therefore plays a key role in reducing the risk of serious injuries to vehicle occupants in many types of vehicle crashes. In particular, the seat needs to allow and facilitate the proper positioning of belt restraints on the skeletal regions of the occupant, not add to forces on the occupant during impact loading, and provide effective support for the occupant so that the belt restraint will remain in place over skeletal regions throughout a crash. People with physical disabilities often remain in their wheelchairs whilst travelling in motor vehicles as drivers or passengers. Since many wheelchairs were not designed for this purpose, wheelchair-seated occupants are often at higher risk of injury in crashes than are people seated in seats provided by the vehicle manufacturer.

ISO 10542-1 provides design, performance, labelling and manufacturer literature requirements, and specifies associated test methods, for Wheelchair Tiedown and Occupant Restraint Systems (WTORS). This document addresses the seating part of wheelchair-user occupant-protection systems by establishing design, performance, labelling and manufacturer literature requirements, as well as associated test methods, for wheelchairs that can be used as seats in motor vehicles.

Whilst wheelchairs can be secured by various types of tiedown and securement systems that were available throughout the world at the time this document was developed, effective wheelchair securement in the real world cannot be achieved without compatibility of the wheelchair tiedown system available in the vehicle and the method of securement provided on the wheelchair. At the time that this document was developed, the four-point strap-type tiedown was considered to be the most effective, common, and universally adaptable system for securing a wide range of wheelchair types and sizes. Therefore the provisions and test methods of this document are based on the use of four-point strap-type tiedowns to secure the wheelchair in the vehicle. However, wheelchairs can also be designed for securement in motor vehicles by other methods, such as docking-type devices, which are commonly used by wheelchair-seated drivers. Manufacturers who wish to evaluate wheelchairs with other methods of securement can make use of provisions and test methods of this document.

To evaluate the crashworthiness performance of wheelchairs, Annex A specifies procedures for dynamically testing a wheelchair loaded with an appropriate-size crash-test dummy using a 48 km/h crash pulse with the wheelchair secured facing forward on the impact sled. This test is based on well-documented motor vehicle crash and injury statistics, which show that more than 50 % of all serious injuries to occupants of motor vehicles occur in frontal crashes, and that more than 95 % of frontal crashes result in a longitudinal change in vehicle speed of less than 48 km/h. Dynamic performance for forward-facing wheelchairs in rear impacts is addressed in Annex G. Recent research has shown that some commercial wheelchairs offer significantly less protection in rear-impact than conventional motor vehicle seats. Manufacturers who wish to test wheelchairs to determine their performance in rear-impact conditions can use the test methods and performance measures in Annex G.

This document has also been developed with the recognition that the use of a pelvic-belt restraint alone does not provide the wheelchair occupant with the same level of crash protection in a frontal impact as does the use of both pelvic-belt and shoulder-belt restraints for adults or five-point harness restraints for children. Therefore, the provisions and test methods of this document are based on the use of both pelvic- and shoulder-belt-type restraints or five-point harness restraints.

The first edition of this document only addressed wheelchairs designed for use by people who weigh 22 kg or more because it is best practice to have those under 22 kg transfer to a child safety seat that meets applicable standards (e.g. FMVSS 213, UN Regulation No. 44). Whilst transfer to a child safety seat should continue to be the first choice, there is a portion of people who use wheelchairs and weigh less than 22 kg that cannot safely or practically transfer and these individuals would be safer in a crashworthy wheelchair. To fill this need, the scope of this document has been expanded (see scope) to include products designed for people who weigh between 12 kg and 22 kg and includes additional design features and performance criteria (including buckle release characteristics, restraint belt width, back-support height, restraint fit and adjustment) for these products that have been shown to provide a higher level of protection for smaller occupants.

The four-point strap-type tiedown system relies on the involvement of a second person and cannot be implemented by the wheelchair occupant. Accordingly, it is desirable to progress toward a securement method that can be implemented independently by the wheelchair-seated passenger who might travel in different public transportation and private vehicles. As a step toward this goal, Annex F establishes universal docking interface geometry (UDIG) for securement points on wheelchairs when it is intended for the wheelchair to be secured by docking-type securement devices in public transportation and/or multiple private vehicles.

It is recognized that single sample testing does not mean that every variation of a given wheelchair model will exhibit exactly the same performance behaviour. However, it is also recognized that it is not feasible for manufacturers to independently test every variation of a given wheelchair model. As such, the expectation is that wheelchair manufacturers will test a suitably representative sample (or samples) that adequately represents the range of model variation for which conformance is claimed, based on an engineering assessment. In addition, where requested, manufacturers should make details of the wheelchair configuration used for testing available to suppliers and/or purchasers, and specify which options are available on the wheelchair when used as a seat in a motor vehicle.

Finally, this document should be viewed in the totality of daily wheelchair use and the range of standards to which all wheelchairs are expected to conform. Wheelchairs primarily serve as mobility devices. Transportation is only one of many daily activities that introduce unique circumstances and requirements that wheelchairs and people who use wheelchairs can experience. Wheelchair products that conform with this document will have additional features that provide increased levels of occupant security and safety whilst their occupants are riding in motor vehicles. However, a wheelchair's failure to conform with this document cannot be used to limit access to, and availability of, motor vehicle transportation for people who use wheelchairs.

Wheelchairs —

Part 19:
Wheelchairs for use as seats in motor vehicles

1 Scope

This document specifies test methods, requirements and recommendations for wheelchairs intended for use as seats in motor vehicles related to design, performance, labelling, presale literature, user instructions and user warnings.

This document is applicable to all manual and powered wheelchairs, including scooters, which, in addition to their primary function as wheeled mobility devices, are also likely to be used as forward-facing seats in motor vehicles by children and adults with a body mass equal to or greater than 12 kg.

This document is applicable to complete wheelchairs, including a frame or powerbase and seating system. It is also applicable to wheelchairs equipped with additional components designed to facilitate conformity with one or more of the requirements of this document.

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 7176-5, *Wheelchairs — Part 5: Determination of dimensions, mass and manoeuvring space*

ISO 7176-15, *Wheelchairs — Part 15: Requirements for information disclosure, documentation and labelling*

ISO 7176-26, *Wheelchairs — Part 26: Vocabulary*

ISO 10542-1, *Technical systems and aids for disabled or handicapped persons — Wheelchair tiedown and occupant-restraint systems — Part 1: Requirements and test methods for all systems*

ISO 14971, *Medical devices — Application of risk management to medical devices*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 7176-26 and the following 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/

3.1
accessible transport vehicles for sitting and standing passengers
ATV-SS
large motor vehicle used in relatively slow-speed travel that allows for seated and standing passengers, and that provides for transporting people with disabilities who remain seated in their wheelchairs

3.2
anchor point
location on a vehicle interior component, floor or sidewall, on a wheelchair, or on a wheelchair tiedown assembly or securement system, that represents the centre of where tiedown and/or securement loads or belt-restraint loads are transferred to the vehicle, wheelchair, tiedown assembly or securement system when the wheelchair and occupant is in the traveling position

Note 1 to entry: This is a location based on a particular anchorage, and not necessarily any physical components or hardware that comprise the anchorage.

3.3
anchorage
component, or an assembly of components and fittings, which transfer loads directly from a WTORS assembly to the vehicle or wheelchair

EXAMPLE 1 The hardware at the end of a wheelchair tiedown strap that attaches to a vehicle floor (e.g. onto a track or other component on the vehicle floor).

EXAMPLE 2 An item of hardware such as a D-ring, and its associated fastener at the end of a wheelchair-mounted occupant restraint belt that attaches to the anchor point on the wheelchair.

3.4
anthropomorphic test device
ATD
crash-test dummy
articulated physical analogue of the human body used to represent a wheelchair occupant in a test

3.5
attachment hardware
mechanical means of attaching a seating system to the wheelchair frame

3.6
automatic-locking retractor
ALR
device to accommodate a belt or strap that allows extraction of the belt or strap to the desired length and then lock so that further extraction of the belt or strap is prevented without voluntary intervention

3.7
back restraint
device or system intended to limit rearward movement of an occupant during an impact by providing support force to the back of the torso

3.8
back support
postural support device that is part of a wheelchair seating system intended to support the posterior surface of the sacral, lumbar and/or thoracic segments of the trunk in an upright or partially reclined posture

3.9
belt
length of webbing material used as part of an occupant restraint or postural support device

3.10
clamp-type securement
clamp-type tiedown
method of wheelchair securement that uses only mechanical linkages and/or grips requiring manual positioning and tightening of the securement point end fittings to the wheelchair

3.11
docking-type securement
DEPRECATED: docking-type tiedown
method of securing a wheelchair to a vehicle interior in which one or more securement points attached to the wheelchair align and automatically engage with a docking securement device attached to the vehicle once the wheelchair is manoeuvred into position in the vehicle

Note 1 to entry: Engagement, securement and disengagement of the wheelchair can be automatic or manual.

3.12
docking securement device
DEPRECATED: docking tiedown device
assembly of fixtures and components designed for installation in a motor vehicle for the purpose of securing a wheelchair by engaging with a wheelchair securement adaptor mounted to the wheelchair

3.13
emergency-locking retractor
ELR
retractor mechanism used in belt restraints that locks the belt from further spool out when the vehicle acceleration or deceleration exceeds a threshold value and/or when the rate of belt spool out exceeds a threshold speed

Note 1 to entry: The vehicle acceleration or deceleration threshold value is usually 0,5 *g* or less.

Note 2 to entry: During normal driving conditions, the retractor does not restrict the freedom of movement of the wearer of the occupant restraint.

3.14
excursion
movement of an anthropomorphic test device or wheelchair during a test relative to its initial position on an impact sled

3.15
fastener
device used to physically secure hardware components and parts in place

Note 1 to entry: These include, but are not limited to, bolts, nuts, screws, pins and rivets

3.16
five-point harness restraint
occupant restraint for use primarily by child occupants comprised of two shoulder belts, a pelvic-belt, and a crotch strap that uses five anchor points and/or belt guides, with two located above and behind the shoulders, two located below and behind the pelvis, and one located below and slightly forward of the crotch

Note 1 to entry: Care should be taken not to confuse a torso postural support device with a five-point harness restraint.

3.17
foot/leg strap
length of webbing mounted forward and below the anthropomorphic test device knee to limit upward movement of the leg after peak forward motion of the anthropomorphic test device knee has occurred

Note 1 to entry: The foot/leg strap minimizes damage to the anthropomorphic test device and provides for more realistic movement of the lower extremities during frontal-impact loading by limiting extension of the knee joints and upward movement of the anthropomorphic test device's lower extremities. It does this in a manner that does not affect forward excursions of the anthropomorphic test device, but slightly reduces the severity of rearward rebound of the anthropomorphic test device while making this rebound more controlled and consistent between tests.

3.18
forward-facing
orientation in which the wheelchair-seated occupant faces the front of the vehicle with the wheelchair reference plane within 10° of the longitudinal axis of the vehicle

3.19
four-point tiedown
strap-type tiedown attaching to the wheelchair at four separate securement points

3.20
four-point strap-type tiedown
wheelchair tiedown system that uses four strap assemblies to secure the wheelchair in the vehicle, attaching to the wheelchair at four separate securement points and to the vehicle at four separate anchor points

3.21
H-point
point located on the left and right sides of the pelvic region of an anthropomorphic test device that represent the approximate locations of the human hip joint centre in the side views, as specified by the anthropomorphic test device manufacturer

3.22
head restraint
device intended to limit rearward movement of an occupant's head in a vehicle impact

3.23
head support
postural support device intended to support the head

Note 1 to entry: A head support is not designed or intended to provide head restraint in a vehicle impact

3.24
impact simulator
device for physically simulating a vehicle crash event by decelerating and/or accelerating an impact sled, including instrumentation for measuring pertinent data

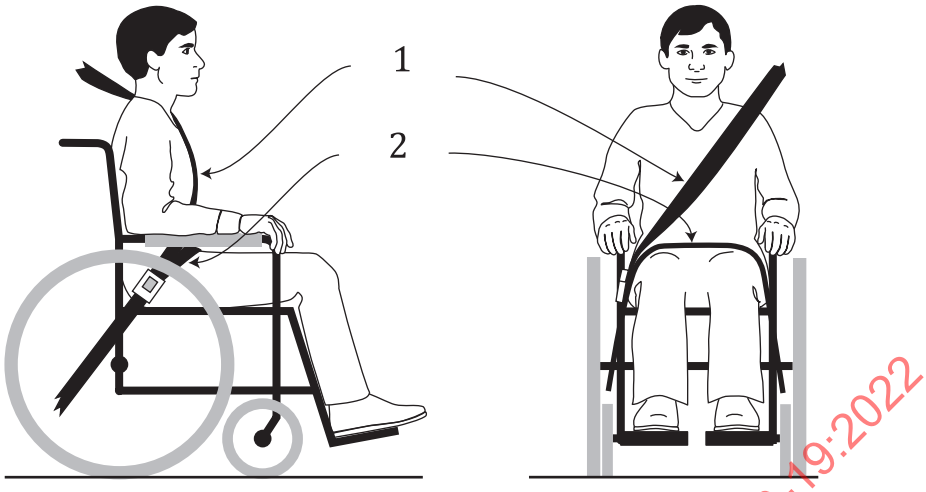
3.25
impact sled
part of an impact simulator on which components can be mounted for impact testing

3.26
multiple-point tiedown
strap-type tiedown attaching to the wheelchair at more than four separate securement points

3.27
occupant restraint
system or device designed to limit movement of a motor-vehicle occupant during crash events and thereby prevent ejection of an occupant from the vehicle, and prevent or minimize occupant contact with the vehicle interior components and other occupants

3.28
pelvic-belt restraint
lap-belt restraint
portion of a belt-type occupant restraint designed to limit movement of an occupant's lower torso in a vehicle impact by application of restraint forces to the pelvic area

Note 1 to entry: See Figure 1.



Key

1 shoulder-belt restraint

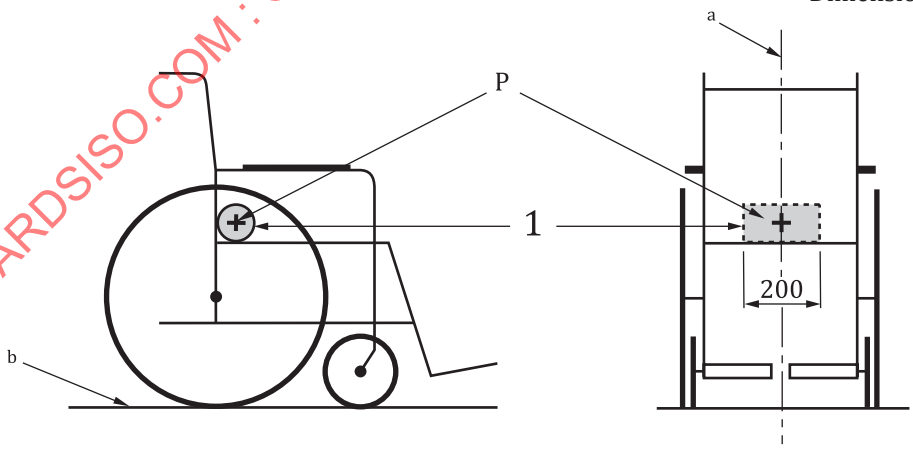
2 pelvic-belt restraint

Figure 1 — Three-point-belt restraint comprised of a pelvic-belt restraint and a shoulder-belt restraint that connect together near the hip of the occupant

3.29
point P
reference point of a wheelchair seating system that lies at the cross-sectional centre of a 100 mm diameter, 200 mm long, cylinder of mass not greater than 0,5 kg positioned with the longitudinal axis perpendicular to the wheelchair reference plane, such that the curved surface of the cylinder contacts the seat and back support surfaces

Note 1 to entry: See Figure 2.

Dimensions in millimetres



Key

1 cylinder, diameter 100 mm

P point P

a Wheelchair reference plane.

b Wheelchair ground plane.

Figure 2 — Wheelchair reference point P and wheelchair reference and ground planes

3.30
postural support device
postural support
postural belt
structure or belt, attached to a wheelchair, which has a surface that contacts the occupant's body and is used to either modify or accommodate the occupant's sitting posture

Note 1 to entry: Postural support devices are not designed or intended to provide occupant restraint in a vehicle impact.

3.31
retractor
device to accommodate a belt or strap, designed to retract the belt or strap, either manually or automatically

3.32
seat
postural support device intended to support the inferior surface of the buttocks and thighs

3.33
seating system
seat and back support and their attachment hardware, plus those accessories deemed necessary

Note 1 to entry: A seating system can also include postural support devices other than the seat and back support, for example lateral torso supports

3.34
securement point
structural point on the wheelchair frame, powerbase, seat frame or securement adaptor to which a tiedown securement point end fitting can be connected, or that can be effectively engaged with a securement device mounted to the vehicle

3.35
securement point end fitting
hardware at end of a wheelchair tiedown-strap assembly designed to attach to wheelchair securement points on a wheelchair frame, powerbase, seat frame or securement adaptor for the purpose of securing the wheelchair to a motor vehicle using a strap-type tiedown

3.36
seat frame
structural components that support the seat and back support

3.37
sharp edge
exposed, rigid edge with a radius of less than 2 mm

3.38
shoulder-belt restraint
DEPRECATED: upper torso restraint
portion of an occupant restraint intended to limit movement of the chest and head which passes diagonally across the front of the chest from the hip to the opposite shoulder

Note 1 to entry: See Figure 1.

3.39
strap
length of webbing or other material used in a wheelchair tiedown assembly

3.40
strap-type tiedown
wheelchair tiedown that uses strap assemblies to secure the wheelchair in the vehicle

3.41
surrogate tiedown
surrogate tiedown system
surrogate securement system
system for attaching a wheelchair to a test platform in a manner that simulates commercial tiedown or securement systems, and that includes reusable and/or replaceable components

Note 1 to entry: Specifications for design of a surrogate four-point strap-type tiedown system are provided in Annex E.

3.42
surrogate wheelchair
SWC
rigid, reusable device according to ISO 10542-1:2012, Annex E that is used to simulate a wheelchair for the purpose of testing wheelchair tiedown and occupant restraint systems

3.43
surrogate wheelchair tiedown and occupant restraint system
SWTORS
system for attaching a wheelchair with an anthropomorphic test device to a test platform in a manner that simulates commercial WTORS and that includes reusable and/or replaceable components

Note 1 to entry: Specifications for design of a surrogate four-point strap-type tiedown system and three-point belt restraint are provided in Annex E.

3.44
three-point belt restraint
DEPRECATED: three-point restraint
occupant restraint assembly with three anchorages comprised of both a pelvic-belt restraint and a diagonal shoulder-belt restraint that connect together near the hip of the occupant

Note 1 to entry: See Figure 1.

3.45
tilt seating
tilt-in-space
type of wheelchair seating system with integral seat frame that is mounted on the wheelchair frame or powerbase, and which allows the complete seating system to be rotated forward and backward about an axis perpendicular to the wheelchair reference plane

3.46
universal docking interface geometry
UDIG
specifications for the size, shape, and location of wheelchair securement points, including surrounding clear zones, that provides for effective engagement with docking securement devices installed in a wide range of vehicles

Note 1 to entry: ISO 10542-1:2012, Annex F and Annex F provide detailed UDIG specifications.

3.47
UDIG adaptor
wheelchair securement adaptor that conforms to the universal docking interface geometry

3.48
webbing
woven material used in belt and strap assemblies of occupant restraints and wheelchair tiedowns

3.49
webbing guide
hardware loop or ring mounted to a structural member in the vehicle, wheelchair or wheelchair back support, through which an occupant restraint belt passes, and changes direction, along the path to the wheelchair occupant

3.50
wheelchair
device to provide wheeled mobility with a seating support system for a person with impaired mobility

Note 1 to entry: A walking aid with wheels is not a mobility device

Note 2 to entry: The term encompasses for example standard manual wheelchairs, push wheelchairs, powered wheelchairs and three- and four-wheeled scooters, with different type of seating systems.

3.51
wheelchair frame
frame
assembly of structural members of a wheelchair to which wheels and postural support devices are attached.

3.52
wheelchair footprint
space outlined on the wheelchair ground plane by projecting vertically down from the outermost edges of the structural members that comprise the frame or powerbase and seating system of the wheelchair

Note 1 to entry: The footrests are included in the wheelchair footprint.

3.53
wheelchair ground plane
horizontal plane representing the surface on which the wheelchair rests

Note 1 to entry: See Figure 2.

3.54
wheelchair powerbase
powerbase
component of an electrically powered wheelchair which contains the drive system, batteries and wheels, and can be separated from the seating system.

3.55
wheelchair reference plane
vertical plane in the longitudinal centreline of the wheelchair

Note 1 to entry: See Figure 2.

3.56
wheelchair securement
wheelchair tiedown
device or system designed to attach a forward-facing wheelchair to a motor vehicle

3.57
wheelchair securement adaptor
wheelchair tiedown adaptor
hardware that is attached temporarily or permanently to the wheelchair frame, powerbase and/or seat frame to provide a securement point or points

3.58
wheelchair tiedown and occupant restraint system
WTORS
complete set of safety equipment for an occupant seated in a wheelchair when traveling in a motor vehicle comprised of equipment for wheelchair securement and occupant restraint

4 Design requirements and recommendations

4.1 General

Annex L provides a checklist of the requirements in Clause 4.

4.2 Wheelchair securement

4.2.1 Securement with strap-type tiedowns

a) The wheelchair shall be designed to provide for forward-facing securement in a motor vehicle using a four-point strap-type tiedown that conforms with ISO 10542-1, using two securement points at the front and two securement points at the rear, placed symmetrical about the wheelchair reference plane, that conform to the specifications given in Annex B and the applicable performance requirements in Clause 5, or

b) Where the wheelchair cannot meet the requirements in a) due to high mass features or facilities that accommodate the special needs of the intended occupant and requires additional securement points, the wheelchair shall meet the requirements of Annex K.

NOTE The four-point strap-type tiedown system is the most commonly available strap-type tiedown system in wheelchair transport worldwide. The use of a four-point strap-type tiedown system will improve ease of use and reduce misuse during the wheelchair securement process in the vehicle.

4.2.2 In addition, the wheelchair may be designed for forward-facing securement using other methods of wheelchair securement, including docking-type securement.

4.2.3 If a wheelchair is intended by the manufacturer to also be secured by a docking securement device in public transportation and/or different private vehicles (i.e. in a multiple-user setting), the securement points on the wheelchair and/or of the wheelchair securement adaptors should conform to the specifications given in Annex F and the applicable performance requirements in Clause 5.

4.3 Occupant restraints

4.3.1 Accommodation of vehicle-mounted three-point belt restraints

The wheelchair shall be constructed so that it does not interfere with the proper use and fit of vehicle-mounted belt restraints, and it shall allow the pelvic-belt restraint to make contact with the lower region of the occupant's pelvis and not prevent the shoulder-belt restraint from making good contact with the occupant's shoulder and chest. The wheelchair shall be constructed so that it achieves at least the performance requirements specified in 5.5.

NOTE Annex D contains test methods and 5.5 contains performance criteria for scoring and rating the wheelchair with regard to accommodating the proper use and placement of vehicle-mounted occupant belt restraints.

4.3.2 Wheelchair-mounted occupant restraints

a) Wheelchairs designed for use by people with a body mass under 23 kg shall provide a wheelchair-mounted five-point harness restraint in accordance with Annex H. The wheelchair shall be equipped with the belt restraint when purchased by, and delivered to, the consumer.

b) If a wheelchair designed for use by people with a body mass equal to or greater than 23 kg provides for the attachment of, or is equipped with, a wheelchair-mounted pelvic- and/or shoulder-belt restraint, the restraint and the anchorages shall be in accordance with Annex J.

NOTE The value of 23 kg is drawn from a child restraint classification using 50 lb (22,7 kg) as mass limit for needing it to be equipped with a five-point harness restraint.

4.4 Wheelchair head and back supports for small children

For a wheelchair designed to accommodate children with a body mass under 23 kg, the height of the back support at the centreline from the junction of the back support with the seat (i.e. the seat bight) to the top of the head support/restraint shall not be less than 555 mm.

NOTE Annex G provides additional design guidelines for wheelchair back and head supports for equipment that is also intended to serve as back and head restraints that provide occupant protection in a vehicle rear-impact crash event.

4.5 Risk management in modifying wheelchairs that conform to this document

If it is necessary to physically modify a wheelchair conforming with this document to accommodate medical needs of the occupant, the modifier shall conduct a risk management process in conformance with ISO 14971 to identify risks related to crashworthiness.

Changes to wheelchairs that are likely to affect conformance relative to this document include but are not limited to: moving the securement-point brackets, lowering the back-support height, shortening the seat length, adding rigid postural supports with mass greater than 150 g that are not firmly attached to the wheelchair, installing after-market postural seating, installing augmentative and alternative communication aids or other devices to suit the specific needs of the occupant, adding components that have sharp edges, or any change that compromises the structural integrity of the wheelchair frame.

5 Performance requirements and recommendations

5.1 General

Annex L provides a checklist of the requirements in Clause 5.

5.2 Frontal impact

5.2.1 Frontal impact with strap-type tiedowns

a) When tested in accordance with Annex A using a four-point tiedown that conforms with ISO 10542-1, the wheelchair shall meet the requirements of 5.2.3 and 5.2.4, or

b) Where the wheelchair cannot meet the requirements in a) due to high mass features or facilities that accommodate the special needs of the intended occupant and requires additional securement points, the wheelchair shall meet the requirements of Annex K.

5.2.2 In addition to 5.2.1, the wheelchair may also be tested using other methods of securement that conform with ISO 10542-1, such as a docking-type securement. To state conformance of the wheelchair with the frontal impact requirements for the additional securement method, the wheelchair shall meet the requirements of 5.2.3 and 5.2.4 when tested in accordance with Annex A using this other securement method.

5.2.3 During the test

a) The horizontal excursions of the ATD and the wheelchair with respect to the impact sled shall not exceed the limits in Table 1 until motion of the ATD and the wheelchair has ceased.

b) If the wheelchair is tested with a vehicle-mounted pelvic-belt, the peak forward ATD knee excursion shall exceed the peak forward wheelchair point P excursion by 10 % or more, as indicated by:

$$X_{knee} / X_{wc} \geq 1{,}1$$

NOTE Conformance with this requirement reduces the potential for the mass of the wheelchair to apply additional restraint forces to the wheelchair occupant in a crash, thereby reducing the risk of seatbelt-induced injury.

c) Batteries of powered wheelchairs or their surrogate replacement parts shall

1) not move completely outside the wheelchair footprint, and

2) not move into the wheelchair occupant's space (e.g. shall not contact the back of the ATD's legs).

d) No components of the securement system (i.e. securement hooks of the strap-type tiedown or docking device latch mechanism) shall completely detach or disengage from a wheelchair securement point or adaptor at any time during the test. A stabilizer bracket or other component of a docking securement device whose purpose is not primarily to secure the wheelchair, but to aide in alignment or preventing rotation, may detach or disengage during the test.

Table 1 — Horizontal excursion limits

Dimensions in millimetres

Measurement point	Excursion variable	3-year old child ATD	6-year old child ATD	10-year old child ATD	Small adult female ATD	Midsize and large adult ATD
wheelchair point P	X_{wc}	150	150	175	200	200
ATD knee centre	X_{knee}	300	300	325	375	375
ATD front of head	X_{headF}	500	500	500	550	650
ATD back of head	X_{headR}	-350	-350	-400	-400	-450

X_{wc}: Horizontal distance relative to the sled platform between the point P target on the wheelchair at time t_0, to the point P target at the time of peak wheelchair excursion.

X_{knee}: Horizontal distance relative to the sled platform between the ATD knee joint target at time t_0, to the knee-joint target at the time of peak knee excursion.

X_{headF}: Horizontal distance relative to the sled platform between the most forward point on the ATD's head above the nose at time t_0, to the most forward point on the ATD's head at the time of peak head excursion.

X_{headR}: Horizontal distance relative to the sled platform between the most rearward point on the ATD's head at time t_0, to the most rearward point on the ATD's head at the time of peak head excursion.

NOTE See the last paragraph of A.4.12 for a description of how to estimate the point P excursion when it is not possible to place a contrast marker at point P.

5.2.4 After the test

a) The wheelchair shall remain in an upright position on the test platform, and the ATD shall be retained in the wheelchair in a seated posture, as determined by the ATD torso being oriented at not more than 45° to the vertical when viewed from any direction.

b) The structural components of the wheelchair securement points shall not completely fail.

c) Rigid components, fragments or accessories of the wheelchair with a mass in excess of 150 g shall not be completely separated from the wheelchair.

d) Wheelchair components that can contact the occupant shall not fragment or separate in a manner that produces sharp edges.

e) Locking mechanisms of tilt seating adjusters shall not completely fail.

f) Removal of the ATD from the wheelchair shall not require the use of tools, other than a hoist to lift the ATD.

g) Release of the wheelchair from the securement system shall not require the use of tools.

h) The post-test height of the average of left and right ATD H-points relative to the wheelchair ground plane shall not have decreased by more than 20 % from the pre-test height.

i) The wheelchair and its components shall not cause complete failure of the webbing of any of the WTORS assemblies during the test.

j) No components of the wheelchair securement (i.e. securement point end-fittings of the strap-type tiedown or the latch mechanism of a docking securement device) shall completely detach or disengage from a wheelchair securement point or wheelchair securement adaptor. A stabilizer bracket or other component of a docking securement system whose purpose is not primarily to secure the wheelchair, but to aid in alignment or preventing rotation, may be detached or disengaged.

NOTE The impact response of wheelchairs and particularly the performance of wheelchair back supports and head supports/restraints in moderate-level rear impacts can be determined using the test methods and performance measures given in Annex G.

5.3 Accessibility of securement points intended for use with strap-type tiedowns

5.3.1 When tested in accordance with Annex C, each wheelchair securement point intended for use with a strap-type tiedown shall

a) allow one-handed attachment and engagement of the hook gauge specified in Figure C.2 within 10 s, and

b) allow one-handed disengagement and removal of the same hook gauge within 10 s.

5.3.2 Securement points on wheelchairs should also be provided with sufficient clear space to allow webbing and associated non-hook type securement point end fittings of tiedown assemblies to be easily inserted and attached or detached.

5.4 Clear paths for strap-type tiedowns

When tested in accordance with Annex C,

a) the path between each wheelchair securement point and the corresponding tiedown anchor point shall not deviate from a straight line by more than 40 mm,

b) it is recommended that the deviation of the path measured in 5.4 a) is as close as possible to zero,

c) all contactable edges of wheelchair components within a 50 mm radius of the centre of the tiedown path measured in 5.4 a) shall have a radius of 2 mm or greater.

d) a sharp edge that is within 50 mm of the centre of the tiedown path, but that would be unlikely to be contacted by a tiedown strap during normal travel or a frontal collision (e.g. because it is above the straight-line path or behind another structural component), is not considered to constitute failure of 5.4 c).

5.5 Accommodation of vehicle-mounted belt restraints

When tested in accordance with the procedures of Annex D using a vehicle-mounted three-point belt restraint that conforms with ISO 10542-1,

a) the rating for the wheelchair shall be at least “acceptable” with regard to the ease of proper placement of vehicle-mounted three-point belt restraints in accordance with the criteria of Table D.1 and as specified in D.6.1, and

b) the rating for the wheelchair shall be at least “acceptable” with regard to the extent to which proper positioning and geometry of the three-point belt restraint is achieved in accordance with the criteria in Tables D.2 to D.8 and as specified in D.6.2.

5.6 Wheelchair-mounted belt restraints

a) Wheelchair-mounted five-point harness restraint designed for use by people with a body mass under 23 kg shall meet the performance requirements in Annex H.

b) If a wheelchair designed for use by people with a body mass equal to or greater than 23 kg provides for attachment of, or is equipped with, a wheelchair-mounted pelvic- and/or shoulder-belt restraint it shall meet the performance requirements in Annex J.

6 Identification, labelling, user instructions, warning, and disclosure requirements and recommendations

6.1 General

a) ISO 7176-15 shall apply with the addition of the information given in 6.2 to 6.4. Annex L provides a checklist of the requirements in Clause 6.

b) Labels should be durable so as to remain legible and not work loose or curl.

NOTE IEC 60601-1 has reference procedures for label durability.

c) If the wheelchair is designed with more than four securement points, K.5.1 to K.5.3 apply in addition to the requirements in Clause 6.

6.2 Identification and labelling

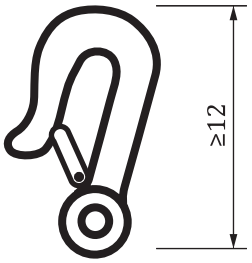
a) The wheelchair and/or its components shall be provided with permanent labels or markings that indicate the location of securement points for four-point strap-type tiedowns, using the symbol in Figure 3, where

1) each symbol has an overall height of at least 12 mm,

2) the symbol is of sufficient contrast to the background to be visible in normal room lighting from a distance of 1 m.

b) the symbol in Figure 3 shall not be used to mark securement points intended for purposes other than securement of the occupied wheelchair in a vehicle.

Dimensions in millimetres



ISO 7000 - 3743

Figure 3 — Symbol required at each wheelchair securement point for strap-type tiedowns

c) The wheelchair frame, powerbase and/or primary seating-system components, and if applicable wheelchair-mounted belt restraints, shall include permanent labels as required in ISO 7176-15 with

1) the manufacturer's name,

2) date of manufacture,

3) the product model number,

4) a unique product serial number, and

5) Figure 4 to indicate that the wheelchair conforms with the requirements of this document. The figure shall be

   — at least 12 mm in diameter, however larger symbols are strongly preferred whenever this is possible given the structure or surface on which the symbol is located,

   — rendered in any two contrasting colours such that the colour at the circumference contrasts with the colour of the component to which the symbol is attached

   — positioned so that the symbols can be easily seen by a vehicle operator or attendant when an occupied wheelchair enters a vehicle.

NOTE 1 A permanent label is one that will remain on the product with a high level of legibility during the expected life of the product, including after normal use and cleaning.

NOTE 2 Some information listed above under 6.2 c) can already be required by ISO 7176-15.

NOTE Application in which ISO 7000-0100 and ISO 7000-3710 are used in conjunction.

Figure 4 — Figure on labels on the wheelchair, primary seating-system components, and wheelchair-mounted belt restraints to indicate conformance with this document

d) For wheelchairs that provide securement points in addition to those required for strap-type tiedowns, (i.e. for docking type securement devices) affix appropriate markings or labels to indicate the locations of any additional securement points and the method of securement to be used.

6.3 Presale literature

In addition to the requirements in ISO 7176-15, the wheelchair manufacturer's presale literature shall include the following:

a) a statement that the wheelchair is designed to be secured facing forward when used as a seat in a motor vehicle and that it conforms with the requirements of this document;

b) a description of the types of wheelchair securement systems that are suitable for use with the wheelchair (i.e. four-point strap-type tiedown, clamp-type securement, specific type of docking securement devices, etc.);

c) a statement that ease of access to, and manoeuvrability in, motor vehicles can be significantly affected by wheelchair size and turning radius, and that smaller wheelchairs and/or wheelchairs with a shorter turning radius will generally provide greater ease of vehicle access and manoeuvrability to a forward-facing position;

d) a statement of whether the wheelchair is capable of use with a form of wheelchair-mounted belt restraints;

e) the ratings for wheelchair accommodation of vehicle-mounted three-point belt restraints, including

   1) the rating for ease of properly positioning a three-point belt restraint as required by 5.5 a), and

   2) the rating for the degree to which proper three-point belt-restraint positioning can be achieved as required by 5.5 b).

6.4 User and maintenance instructions

6.4.1 General

Instructions shall be provided with each wheelchair in at least one of the official languages of the country in which the wheelchair is marketed. These instructions shall include the following statements, descriptions, illustrations and warnings.

6.4.2 The user instructions shall include statements that

a) people using wheelchairs should transfer to the vehicle seat and use the vehicle-manufacturer-installed restraint systems whenever it is feasible, and the unoccupied wheelchair should be stored in a cargo area or secured in the vehicle during travel,

b) the wheelchair is designed to be forward-facing when used as a seat in a motor vehicle,

   NOTE Conformance with this document does not preclude using the wheelchair facing rearward in ATV-SS equipped with rear-facing wheelchair passenger stations.

c) the wheelchair conforms to the requirements of this document,

d) only the designated securement points should be used to secure the wheelchair to the vehicle, and

e) a statement of whether the wheelchair can be provided with and has been tested with any manufacturer-designated wheelchair-mounted belt restraints.

6.4.3 The user instructions shall include descriptions of

a) the types of tiedown systems that are suitable for use with the wheelchair (i.e. four-point strap-type tiedown, clamp-type securement, specific type of docking securement devices, etc.),

b) the locations of wheelchair securement points used in the frontal-impact tests of Annex A for each type of wheelchair securement for which the wheelchair was successfully tested, and the markings used to identify them,

c) belt-restraint anchor-point locations, if any, and the specifications for anchorage hardware and fasteners that are compatible with the wheelchair's anchor points,

d) the different ways that the wheelchair can be effectively secured in a vehicle, including if applicable the necessity for additional, or heavy duty tiedowns necessary to secure the wheelchair,

e) the types and sizes of securement point end fittings that are compatible with the wheelchair securement points,

f) the correct positioning of occupant belt restraints on the occupant, including statements that

1) the pelvic-belt restraint should be in contact with and worn low across the front of the pelvis, so that the angle of the pelvic-belt restraint is within the zone of 30° to 75° to the horizontal, similar to that shown in Figure J.1,

2) a steeper (greater) pelvic belt angle between 45° to 75° to the horizontal is preferred,

3) belt restraints should not be held away from the body by wheelchair components or parts, such as the wheelchair arm supports or wheels, together with an illustration similar to that of Figure 5,

4) shoulder-belt restraints should fit over the middle of the shoulders, as illustrated in Figure 6,

5) belt restraints should be adjusted as snugly as possible, consistent with occupant comfort, and

6) belt webbing should not be twisted when in use.

g) the recommended settings for any adjustable parts, including, where applicable, seat and back support positions and orientations, when the wheelchair is used in motor vehicles,

h) the wheelchair mass, as measured in ISO 7176-5,

i) the maximum recommended occupant mass.

6.4.4 The user instructions shall include illustrations of

a) the incorrect placement of belt restraints with the belts placed over the wheelchair arm supports, as shown in Figure 5 as an example,

b) the correct placement of belt restraints, using an illustration similar to Figure 6,

c) the locations of securement points for each type of tiedown method for which the wheelchair has been designed and successfully tested.

6.4.5 The user instructions shall include warnings, in 12-point or larger bold fond, that

a) the wheelchair conforms with the requirements of this document and, as such, has been designed and tested for use only as a forward-facing seat in a motor vehicle,

NOTE 1 Conformance with this document does not preclude using the wheelchair facing rearward in ATV-SS equipped with rear-facing wheelchair passenger stations.

b) the wheelchair has been dynamically tested in a forward-facing orientation with the ATD restrained by a three-point belt restraint,

c) both pelvic- and shoulder-belt restraints should be used to reduce the possibility of head and chest impacts with vehicle components,

d) pelvic- and shoulder-belt restraints should be used together as designed for (i.e. do not connect a latch plate to a pin-bushing anchorage unless the system is designed to interface this way),

e) in order to reduce the potential of injury to vehicle occupants, wheelchair-mounted trays not specifically designed for crash safety should

1) be removed and secured separately in the vehicle, or

2) be secured to the wheelchair but positioned away from the occupant with energy-absorbing padding placed between the tray and the occupant,

f) when possible, other auxiliary wheelchair equipment should be either secured to the wheelchair or removed from the wheelchair and secured in the vehicle during travel, so that it does not break free and cause injury to vehicle occupants in the event of a collision,

g) postural supports should not be relied on for occupant restraint in a moving vehicle, unless they conform with the requirements specified in this document,

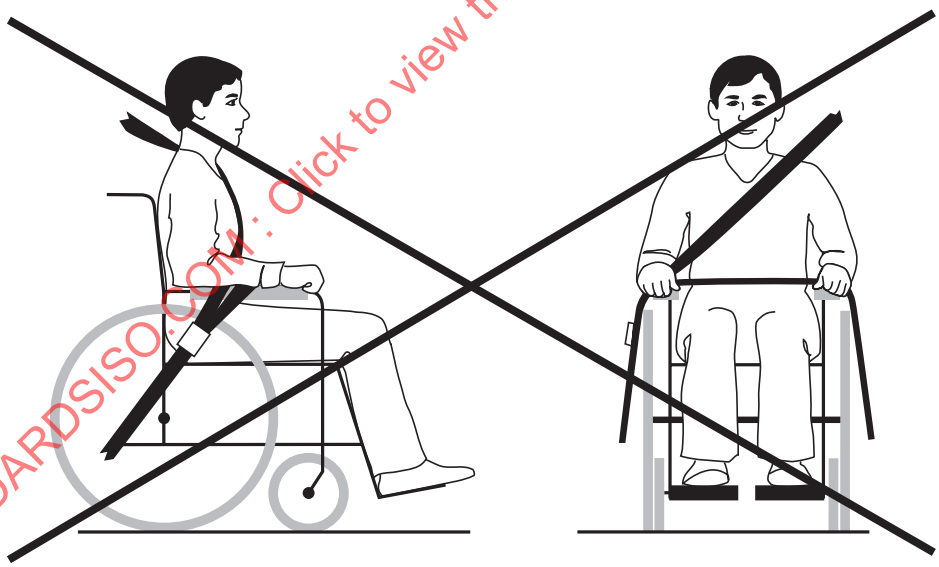
NOTE 2 Postural-support belts and harnesses that do not meet the requirements of a crashworthy occupant restraint can be helpful in retaining occupants in their wheelchairs during non-crash vehicle manoeuvres, such as sudden braking, and can help occupants maintain an upright seated posture that allows for good fit of the occupant restraints.

h) the wheelchair should be evaluated by a manufacturer's representative for determination whether the wheelchair is suitable for reuse after involvement in any type of vehicle collision,

i) alterations or substitutions should not be made to the wheelchair securement points or to structural and frame parts or components since this can affect the crashworthiness of the wheelchair, and it can also change the performance of the wheelchair in normal use. If it is considered necessary to make these kinds of alterations, the wheelchair manufacturer shall be consulted,

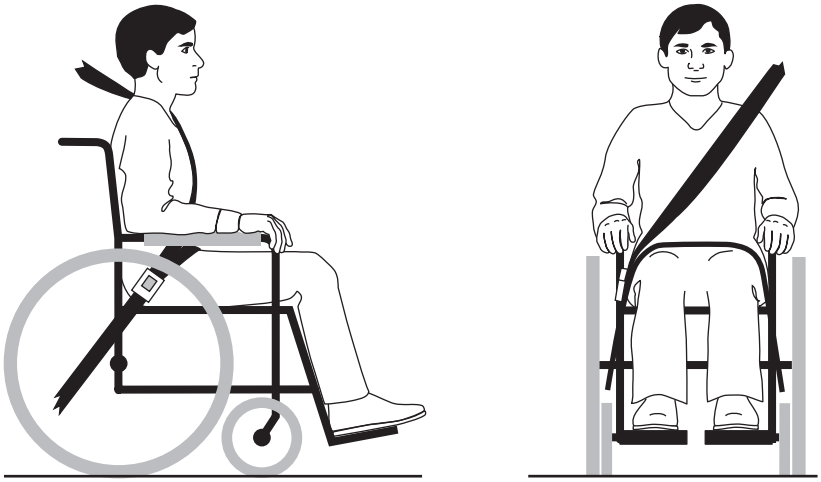
j) spill-proof sealed batteries, such as gelled electrolyte, should be installed on powered wheelchairs when used in a motor vehicle, and

k) care should be taken when applying the occupant restraint to position the seatbelt buckle so that the release button will not be contacted by wheelchair components during a crash.



Belt restraints shall not be held away from the body by wheelchair components such as arm supports or wheels.

Figure 5 — Illustration of improper belt-restraint fit



Belt restraints should make full contact with the shoulder, chest, and pelvis and pelvic belts should be positioned low on the pelvis near the thigh-abdominal junction.

Figure 6 — Illustration of proper belt-restraint fit

7 Documentation of conformance

7.1 General

7.1.1 The wheelchair manufacturer shall maintain documentation, including test reports, that provide evidence of conformance to the design and performance requirements of this document. This documentation shall include the information listed in 7.1.2, 7.2 and 7.3, and if applicable K.6.

7.1.2 The following shall be included in the report of each test conducted in accordance with this document:

a) a reference to this document, i.e. ISO 7176-19:2022;

b) the name and address of the testing institution;

c) the date that the test occurred, as well as the date of issue of the test report;

d) a unique test report number shown on each numbered page;

e) the name of the manufacturer, the product type and designation, and the serial number of the test wheelchair, the mass of the ATD, and the WTORS used and conformance of WTORS with ISO 10542–1;

f) a photograph of the complete test set-up.

7.2 Frontal impact test

The test report for the frontal impact shall also include

a) the measured or calculated value of the test velocity change,

b) descriptions and photographs of the WTORS and wheelchair as set up prior to the test,

c) if appropriate, indicate that the wheelchair was tested with a wheelchair-mounted pelvic-belt restraint and/or a wheelchair-mounted shoulder-belt restraint,

d) settings used for adjustable components, including seat and back support angles and locations,

e) a graph of the impact sled deceleration/acceleration plotted against time superimposed on the shaded area of Figure A.1,

f) the test results as specified in 5.2, including photographs of the wheelchair post-test and any separated and/or broken components, and

g) a statement as to whether or not the wheelchair met the criteria of 5.2 and any other relevant observations.

7.3 Design, labelling, and literature requirements

The wheelchair manufacturer shall maintain statements and evidence on file as to

a) whether securement points intended for use with four-point strap-type tiedowns are in conformance with the design requirements in 4.2.1 a) and Annex B,

b) whether securement points intended for attachment of four-point strap-type tiedowns are in conformance with the accessibility and clear path requirements of 5.3 and 5.4 when tested in accordance with Annex C,

c) if applicable, whether the wheelchair-mounted five-point harness restraint conforms with the requirements in 4.3.2 a), 5.6 a) and Annex H,

d) if applicable, whether the wheelchair-mounted belt restraints conform with the requirements in 4.3.2 b), 5.6 b) and Annex J,

e) whether the ratings for accommodation of vehicle-mounted occupant belts are in conformance with the requirements in 5.5 when tested in accordance with Annex D, and

f) whether the identification and labelling of the wheelchair and its components, and the manufacturer's literature conform with all the requirements in Clause 6.

Annex A
(normative)

Method for frontal impact test

A.1 General principle

The wheelchair is placed facing forward on an impact sled and loaded with an appropriate-size ATD. The wheelchair is secured in place and the ATD is restrained by a WTORS that conforms to the crashworthiness performance requirements of ISO 10542-1. The impact sled is subjected to a deceleration/acceleration pulse that falls within a specified *g*-level-versus-time envelope to achieve a longitudinal velocity change of 48 km/h. Observations and measurements are made during and after the test to assess the performance of the wheelchair and any wheelchair-mounted belt restraints under these dynamic loading conditions.

NOTE See Annex M to get an indication of the values of some key dimensions in this annex expressed in imperial units.

A.2 Test sample

An unused complete wheelchair is required for each test conducted, along with any wheelchair-mounted belt restraints, when applicable.

A.3 Test methods

A.3.1 Test equipment

The test equipment and facility shall include

a) an impact sled equipped with a flat, horizontal, structurally rigid platform on which the wheelchair can be mounted, and to which the WTORS can be fastened,

b) a horizontal track or guide path to provide unidirectional movement of the sled during the impact event,

c) a means to drive the impact sled through a change in velocity of 48 km/h (+2 -0) km/h using an acceleration/deceleration pulse that

   1) falls within the shaded area of Figure A.1,

   2) exceeds 20 *g* for a cumulative time period of at least 15 ms,

   3) exceeds 15 *g* for a cumulative continuous time period of at least 40 ms, and

   4) has a duration of at least 75 ms from t_0 to t_f, where t_o is the start time and t_f is the stop time, as seen in Figure A.1.

d) a rigid structure attached to the impact sled to which the shoulder-belt restraint can be mounted in the manner, and to the geometry, specified by the WTORS manufacturer,

e) an ATD selected from Table A.1 that is representative of the size range of occupants for which the wheelchair is designed. For testing a wheelchair with a five-point harness restraint, select an ATD with mass below 23 kg (i.e.3-year-old or 6-year-old ATD),

f) a means to position and tension a length of 25 mm wide webbing laterally in front of the ATD at specified distances forward and above the selected ATD's knee-joint centres as shown in Figure A.3 and Table A.2, to restrict upward movement of the ATD's legs and feet during frontal impact loading and rebound,

g) a length of 25 mm wide webbing with an anchoring mechanism at one end and a tensioning/anchoring mechanism at the other end for use in A.4.14,

h) a four- or multiple-point tiedown that conforms to ISO 10542-1. ISO 10542-1 uses an 85 kg surrogate wheelchair for testing. For testing a wheelchair above 85 kg, it is recommended to check the specifications of the WTORS to ensure it can be used as test equipment,

NOTE 1 Use of a strap type surrogate tiedown for testing wheelchairs will increase the repeatability as well as reproducibility of the results.

i) if an additional test is to be performed using a different type of wheelchair securement, the securement device (as appropriate for use with the test wheelchair mass) that conforms to the dynamic performance criteria specified in ISO 10542-1,

NOTE 2 In ISO 10542-1:2012 the dynamic performance criteria are given in 5.2.1 b).

j) a vehicle-mounted three-point-belt restraint, or a two-point shoulder-belt restraint as required to supplement the pelvic belt restraint provided with the wheelchair, that conforms to ISO 10542-1 and is appropriate for the mass of the ATD selected in accordance with Table A.1. ISO 10542-1 requires occupant restraints be tested with a midsize adult male ATD. For testing with a large adult male ATD, it is recommended to check the specifications of the occupant restraint to ensure it can be used as test equipment.

NOTE 3 The surrogate occupant restraint as specified in Annex E can be used for testing with a large adult male ATD.

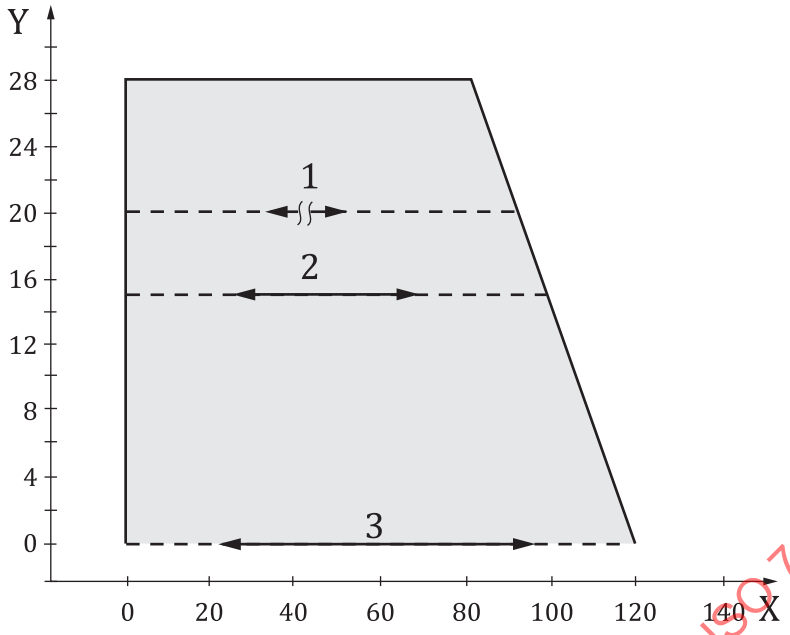
Table A.1 — Available ATDs for wheelchair testing

Occupant mass range kg	ATD size [a]	Approximate mass of ATD kg
12 to ≤18	3-year-old child	15
>18 to ≤27	6-year-old child	22
>27 to ≤43	10-year-old child	35
>43 to ≤57	small adult female	47
>57 to ≤75	small adult female, weighted [b]	59
>75 to ≤136	midsize adult male	77
>136	large adult male	102

[a] The midsize male ATD shall be a Hybrid II or Hybrid III type. The other sizes of ATDs may be Hybrid II, Hybrid III, VIP, P series, or Q series types.

[b] The ATD mass can be increased by attaching weighted material, such as lead sheeting, to the exterior of the ATD.

NOTE The ATD masses representing wheelchair occupants are based on precedents established in existing global automotive safety provisions.



Key

X	time (ms)	t_0	time 0, onset of impact acceleration/deceleration
Y	deceleration (g)	t_f	time final, end of impact acceleration/deceleration
1	a(t) > 20 g for 15 ms		
2	a(t) > 15 g for 40 ms		
3	(t_f – t_0) > 75 ms		

Figure A.1 — Acceleration/deceleration requirements for the 48+2/-0 km/h delta V impact test

A.3.2 Dynamic measurements

The test facility shall have a means to measure the following during the test:

a) the ATD and wheelchair horizontal excursions specified in 5.2.3 with a precision of ±5 mm;

NOTE A side-view high-speed camera or video system with a minimum frame rate of 500 frames per second can be used for these measurements.

b) the horizontal acceleration and/or deceleration of the impact sled in the direction of travel, at a sampling rate in accordance with ISO 6487, with a precision of ±0,5 g;

c) the horizontal velocity change (delta V) of the impact sled during the impact with a precision of ±0,5 km/h.

A.3.3 Data processing

The test facility shall have a means to filter transducer signals using a low-pass filter in accordance with ISO 6487, including

a) prefiltering of all transducer signals to Channel Class 1 000 (-4 dB at 1 650 Hz) prior to digitizing at 10 000 Hz, and

b) filtering of the digitized accelerometer and load-cell signals to Channel Class 60 (-4 dB at 100 Hz).

A.4 Test preparation and procedure

A.4.1 Perform the following prior to initiating the test.

a) Adjust the ATD to achieve a nominal static resistance of 1 *g* at each joint indicated by just noticeable movement from the weight of the distal body segment as specified by the ATD manufacturer.

b) Place snug-fitting cotton clothing on the pelvis, thighs and torso of the ATD.

c) Prepare the wheelchair for use in a motor vehicle, as specified by the manufacturer's user instructions in 6.4.3 g). If a range is specified for any adjustments, the midpoint of the range should be used.

d) Equip the wheelchair with any required wheelchair securement adaptor.

e) If a pelvic-belt or five-point harness restraint intended for use as an occupant restraint is provided as a component of the wheelchair, install it on the wheelchair according to the manufacturer's instructions.

f) If the wheelchair is equipped with liquid-electrolyte-type batteries, replace them with the nearest equivalent gel, sealed or a surrogate battery. Supplementary weights, if used, shall provide equivalent mass distribution to the original batteries.

g) Inflate any pneumatic tyres to the pressure recommended by the wheelchair manufacturer.

A.4.2 Install the anchorages for the wheelchair securement on the sled platform in accordance with the WTORS manufacturer's vehicle installation instructions, or as specified in ISO 10542-1 for other specific types of wheelchair securement. When a range of installation dimensions is specified, use the midpoint of the range. When using the surrogate tiedowns of a SWTORS of Annex E, install anchorages in accordance with specifications in Annex E.

A.4.3 Position the wheelchair facing forward on the sled platform, with the wheelchair reference plane parallel to the direction of sled travel ±3°.

A.4.4 Secure the wheelchair with the wheelchair securement according to the WTORS manufacturer's instructions, and where applicable as specified in ISO 10542-1. For testing with a four-point strap-type tiedown, the applicable procedures in ISO 10542-1 shall be applied. Apply brakes or wheel locks if provided, and turn off wheelchair power if applicable.

NOTE In ISO 10542-1:2012 the procedures for four-point strap-type tiedowns are given in A.5.9.

A.4.5 If applicable, adjust the seat and backrest as follows.

a) For wheelchairs with independently adjustable back supports, adjust the back-support angle according to the manufacturer's instructions. If no back support angles are specified, adjust the angle to between 5° and 10° relative to the vertical. Measure this angle on the structural members of the back-support with an inclinometer without the ATD in the wheelchair.

b) For wheelchairs with independently adjustable seat angles, adjust the seat frame according to the manufacturer's instructions. If no seat angles are specified, adjust the seat frame so that it is inclined up at the front between 5° and 10° relative to the horizontal. Measure this angle on the structural members of the seat with an inclinometer without the ATD in the wheelchair, making sure that the seat is tilted up at least 3° to 5° from the horizontal.

c) For wheelchairs with tilt seating, adjust the longitudinal seat frame members to a maximum angle of 30° to the horizontal or to an angle recommended by the wheelchair manufacturer, without the ATD in the wheelchair. It is recommended that the unloaded back-support angle be between 0° and 10° to the vertical and that the unloaded seat angle is between 0º and 10° to the horizontal.

d) If the seat position adjusts front to back, select the position recommended by the manufacturer. If no position is recommended, select the midpoint of the adjustment range.

e) If other seat components are adjustable, adjust them to fit the ATD intended for use by the manufacturer.

f) Lock any adjustment mechanisms that provide for tilt or recline of the seating system.

g) If a head restraint or head support is provided on the wheelchair, adjust the position according to the manufacturer's instructions. If no instructions are provided, adjust to be within 50 mm of the back of the ATD's head.

A.4.6 Position the ATD in the wheelchair sitting upright and symmetrically located about the wheelchair midline, with the pelvis and buttocks as far back on the wheelchair seat as possible and the elbows resting on the arm supports or on the ATD's thighs.

A.4.7 If the wheelchair is provided with postural belts, install and fasten the belts around the ATD as recommended by the manufacturer.

A.4.8 If the wheelchair is not equipped with a pelvic-belt restraint or five-point harness restraint, install the vehicle-mounted three-point belt of the specified commercial restraint system, or the surrogate restraint system of a SWTORS as specified in Annex E, as follows.

a) Locate and attach the floor anchorages of the pelvic-belt restraint as specified by the WTORS manufacturer to achieve side-view pelvic-belt-restraint angles between 30° and 75° to the horizontal, when the pelvic-belt restraint is positioned as low as possible on the ATD's pelvis.

b) Bolt the upper anchorage for the shoulder-belt restraint to the rigid support structure of A.3.1 d) in accordance with the WTORS manufacturer instructions. If no instruction is provided or a surrogate shoulder-belt restraint is being used, choose a location that provides a good fit of the shoulder-belt restraint to the ATD's chest and shoulder as illustrated in Figures J.2 and A.2 by

   1) achieving a side-view angle of 30° ± 5° with the anchor point or webbing guide located 300 mm ± 15 mm behind and 173 mm ± 15 mm above the top of the ATD's shoulder, and

   2) adjusting the lateral distance to the anchor point or webbing guide so that the shoulder-belt restraint crosses over the middle of the ATD's shoulder as shown in Figure A.2 for the midsize-male ATD.

c) Place the pelvic- and shoulder-belt restraints on the ATD with the pelvic-belt restraint located as low as possible on the ATD's pelvis and the shoulder-belt restraint over the shoulder and chest of the ATD.

d) Pull the pelvic-belt restraint snugly against the ATD pelvis and/or upper thighs.

e) If using a commercial shoulder-belt restraint with or without an emergency-locking or automatic-locking retractor, adjust the shoulder-belt restraint to achieve a snug fit.

f) If using a surrogate occupant restraint position and adjust the belts to achieve a snug fit with a 75 mm × 50 mm × 13 mm thick plate inserted between the ATD's chest and the belt webbing with the plate lying flat against the ATD's chest, and then remove the plate.

NOTE 1 Tape can be used to hold the shoulder belt in position on the ATD prior to conducting the test.

NOTE 2 When in place, the plate sits between the ATD's chest and the belt so that the 75 mm side extends outward from the chest, with the 50 mm x 13 mm surfaces touching the chest and the underside of the belt and the 75 mm x 50 mm surface is parallel to the wheelchair reference plane.

A.4.9 If the wheelchair provides anchor points for either the pelvic, shoulder, or five-point harness restraints on the wheelchair, install and position the belt restraints on the ATD as specified by the

wheelchair manufacturer. If ranges of belt-restraint anchor points are provided, select anchor points appropriate to achieve a good fit of the belt restraints to the ATD as indicated in H.2.1, J.3.2, J.3.6 and Figure J.2.

A.4.10 If the wheelchair is equipped with a wheelchair-mounted pelvic-belt restraint intended for use with a vehicle-mounted shoulder-belt restraint, proceed as follows.

a) Buckle the pelvic-belt restraint around the ATD's pelvis and adjust to achieve a snug fit. If a range of pelvic-belt restraint anchor points is provided, select anchor points appropriate to achieve a good fit of the belt to the ATD's pelvis as indicated in Figure H.1.

b) Bolt the upper anchorage of a shoulder-belt restraint to the rigid support structure of A.3.1 d) as described in A.4.8 b) and attach the connector at the lower end of the shoulder belt to the appropriate mating part (i.e. latch plate or pin/bushing) on the pelvic-belt restraint.

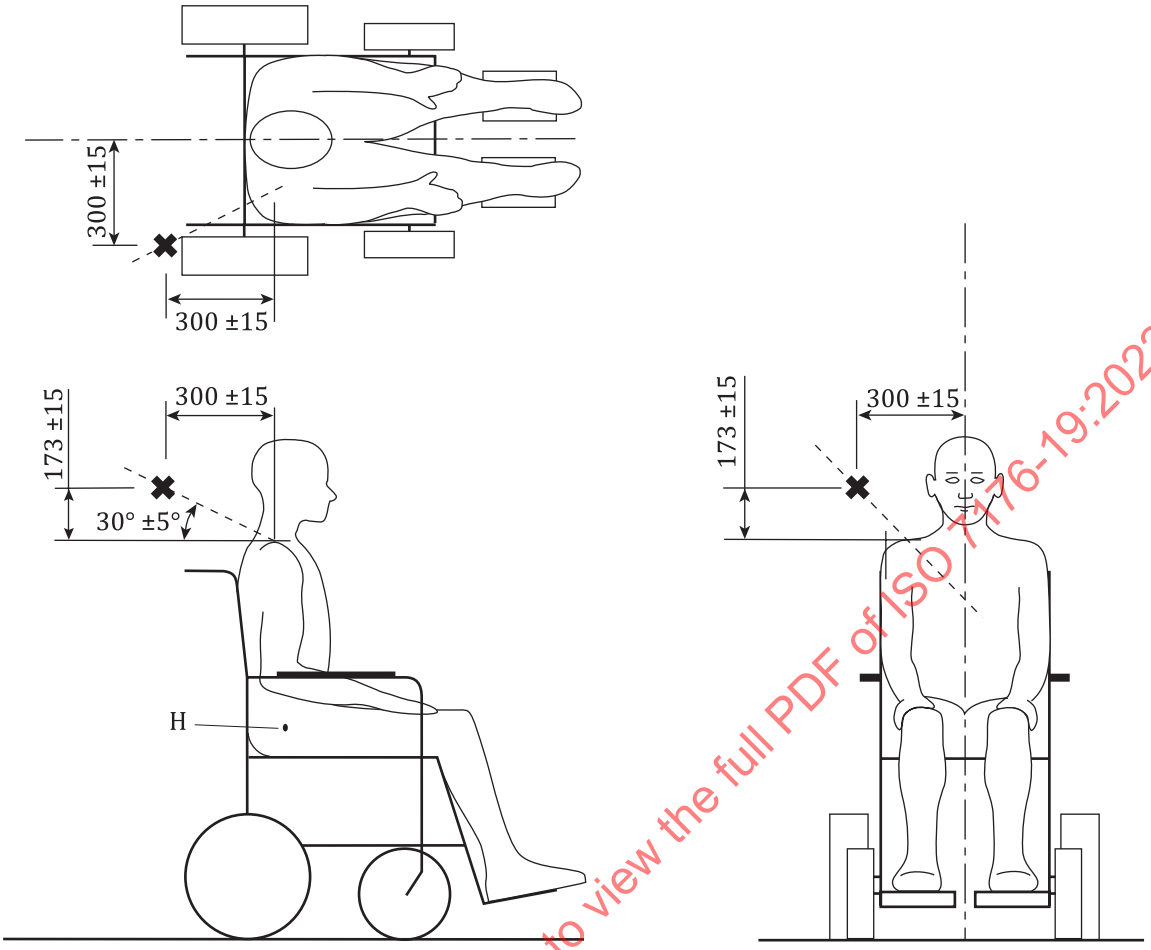
c) If using a commercial shoulder-belt restraint with or without an emergency-locking or automatic-locking retractor, adjust the shoulder-belt restraint to achieve a snug fit.

d) If using the surrogate shoulder-belt of a SWTORS as specified in Annex E, position and adjust the shoulder-belt restraint over the ATD's chest and shoulder to achieve a snug fit with a 75 mm × 50 mm × 13 mm thick plate inserted between the ATD's chest and the belt webbing with the plate lying flat against the ATD's chest, and then remove the plate.

NOTE 1 Tape can be used to hold the shoulder belt in position on the ATD prior to conducting the test.

NOTE 2 When in place, the plate sits between the ATD's chest and the belt so that the 75 mm side extends outward from the chest, with the 50 mm x 13 mm surfaces touching the chest and the underside of the belt and the 75 mm x 50 mm surface is parallel to the wheelchair reference plane.

Dimensions in millimetres



Key

H H-point

NOTE The anchor point can be located on either side of the wheelchair and ATD.

Figure A.2 — Test location for upper anchor point of shoulder-belt restraint and side-view angle of the shoulder-belt restraint

A.4.11 For wheelchairs designed with a five-point harness restraint as required by 4.3.2 a) for wheelchairs designed for use by children who weigh less than 23 kg, adjust the pelvic and harness belts to achieve a snug fit to the ATD and mark the belt webbing near any tension adjusters with a marker or paint pen to indicate the initial position.

A.4.12 If a high-speed camera or high-speed video is used for the measurements specified in A.3.2, apply contrast markers appropriate to the measurement system at

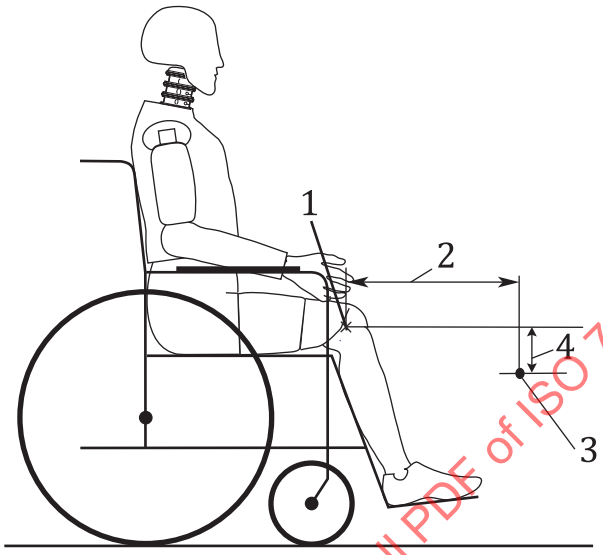
a) the lateral aspect and centre of the ATD's knee joint, and

b) at the point P of the wheelchair (see Figure 2), or points on the side of the wheelchair that are as close to the wheelchair point P as possible.

If it is not possible to place a target at point P, place targets on parts of the wheelchair frame that mark the horizontal and vertical position of point P close to its actual location (i.e. on the seatback canes and seat rails). These targets should be placed on frame members that will move in approximate unison with point P and thus can be used to track excursion.

A.4.13 Ensure that the wheelchair reference plane is aligned parallel to the centreline of impact within ±3°.

A.4.14 Install the 25 mm wide foot/leg strap of A.3.1 g) as described in A.3.1 f) so that the strap is 125 mm to 150 mm below the ATD's knee-joint centre and forward of the ATD's knee-joint centre by the length *2* listed in Table A.2. Tension the strap to 150 N to 200 N before the test.



Key

1 ATD's centre of knee joint
2 forward distance for knee strap, length 2 (see Table A.2)
3 centreline of foot/leg strap
4 distance of 125 mm to 150 mm below ATD centre of knee joint

Figure A.3 — Test location for foot/leg strap

Table A.2 — Length 2 for each ATD size

ATD size[a]	Length 2 mm
3-year-old child	212 to 229
6-year-old child	275 to 296
10-year-old child	325 to 349
small adult female	367 to 394
midsize adult male	400 to 430
large adult male	458 to 493

A.4.15 Record the locations of all WTORS anchor points relative to the wheelchair rear axles and the projected angles of any tiedown straps and all belt restraints relative to the horizontal longitudinal axis of the sled platform.

A.4.16 Record the average height (±5 mm) of the ATD's left and right H-point above the wheelchair ground plane.

A.4.17 Conduct the impact test by activating the sequence of events to record data and fire the impact sled.

A.5 Post-test measurements and calculations

A.5.1 Examine the wheelchair and ATD to determine and/or measure:

a) whether the ATD remained in the wheelchair,

b) whether the wheelchair remained on the test platform,

c) whether any securement points on the wheelchair completely failed,

d) whether any load-carrying parts of the wheelchair became separated, deformed or fractured in a way that would expose sharp edges with potential for occupant contact, and

e) whether rigid wheelchair components greater than 150 g completely detached from the wheelchair.

A.5.2 Determine peak excursions X_{wc}, X_{knee}, X_{headF} and X_{headR} as defined in 5.2.3, to an accuracy of ±5 mm.

A.5.3 Measure the heights of the left and right H-points of the ATD above the wheelchair ground plane and compute the percent change of the average H-point height from the pre-test position determined in A.4.16.

A.5.4 Use an inclinometer to estimate the maximum projected angle, relative to the vertical, of the ATD's torso in the post-test orientation, when viewed from any direction.

A.5.5 Release the belt restraint, remove the ATD, and record any wheelchair deformation that hinders removal of the ATD from the wheelchair.

A.5.6 Release the wheelchair from the tiedown and document any conditions that prevent removal of the wheelchair.

A.5.7 Measure and record the movement of adjustable wheelchair components from their pre-test settings.

Annex B
(normative)

Specifications for securement points on wheelchairs intended for attachment of four-point strap-type tiedowns

B.1 General principle

This annex establishes geometry and location specifications for wheelchair securement points intended to be engaged by the securement point end fittings of four-point strap-type tiedown assemblies that conform with ISO 10542-1.

B.2 Geometric specifications

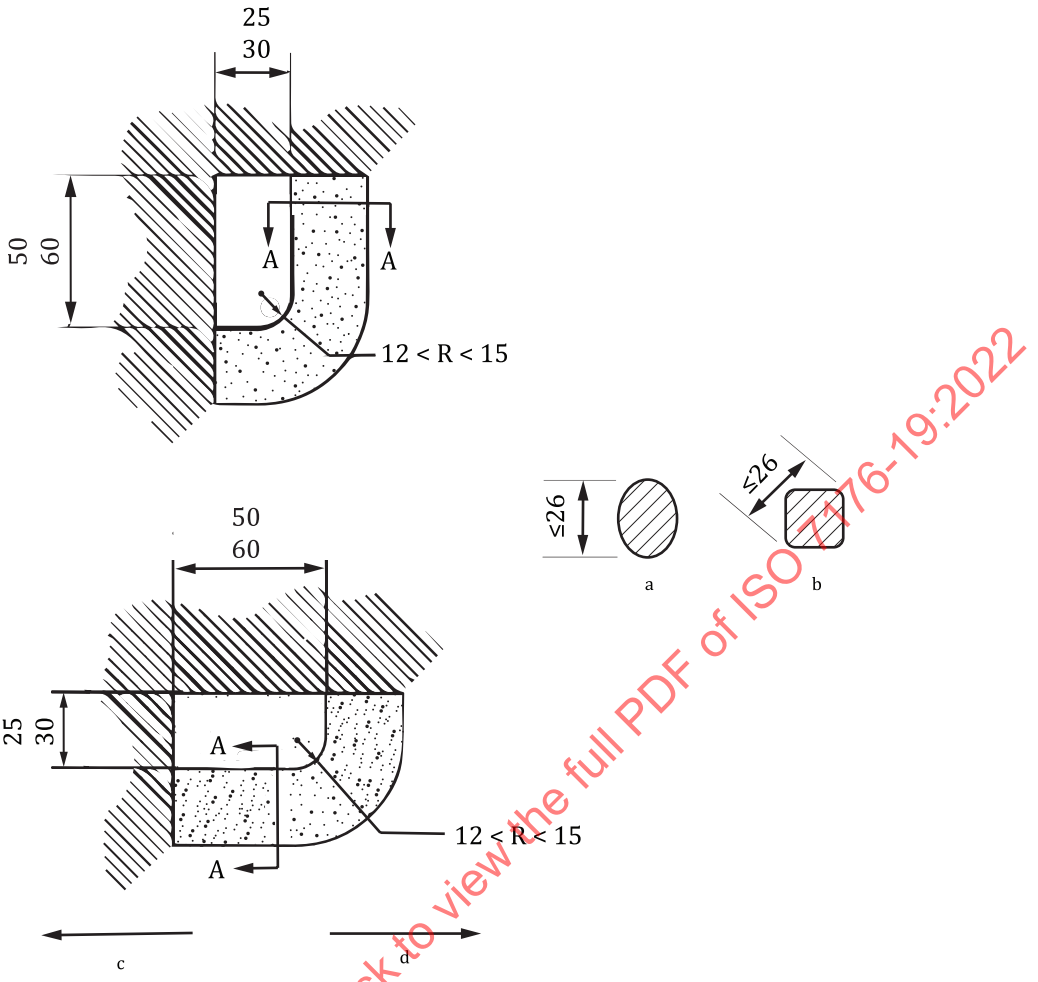
The securement points shall have dimensions in accordance with those given in Figure B.1 and such that

a) the shape of the securement-point opening shall be rectangular with dimensions before rounding of 25 mm to 30 mm on two opposite sides, and 50 mm to 60 mm on the opposing two opposite sides,

b) the structural members forming at least two adjacent sides of the opening specified in B.2 a) with which the securement point end fitting or strap will engage when the wheelchair is secured shall have a maximum cross-section dimension of 26 mm, and

c) the securement-point opening shall be oriented so that hooks and straps of tiedown assemblies engage with curved and rounded sections of the securement-point structural members and so that a tiedown strap threaded through the securement-point opening will lie flat on one side of the securement-point structure when a wheelchair is properly secured facing forward in a vehicle.

Dimensions in millimetres



Key

a Oval structural member cross section A-A example.

b Square structural member cross section A-A example.

c Towards wheelchair.

d Towards anchor point.

NOTE 1 Drawing is not to scale.

NOTE 2 Cross section A-A continues through elbow.

Figure B.1 — Required securement-point geometry, including minimum radii of the structural members

B.3 Location specifications

Wheelchair securement points intended for engagement with four-point strap-type tiedown assemblies shall be attached to the structural frame of the wheelchair or wheelchair seating system in accordance with B.4 such that

a) the locations of the front and rear securement points relative to the wheelchair ground plane, and with respect to each other, fall within the shaded zones of Figure B.2,

b) the horizontal distance between front and back securement points is not less than 100 mm,

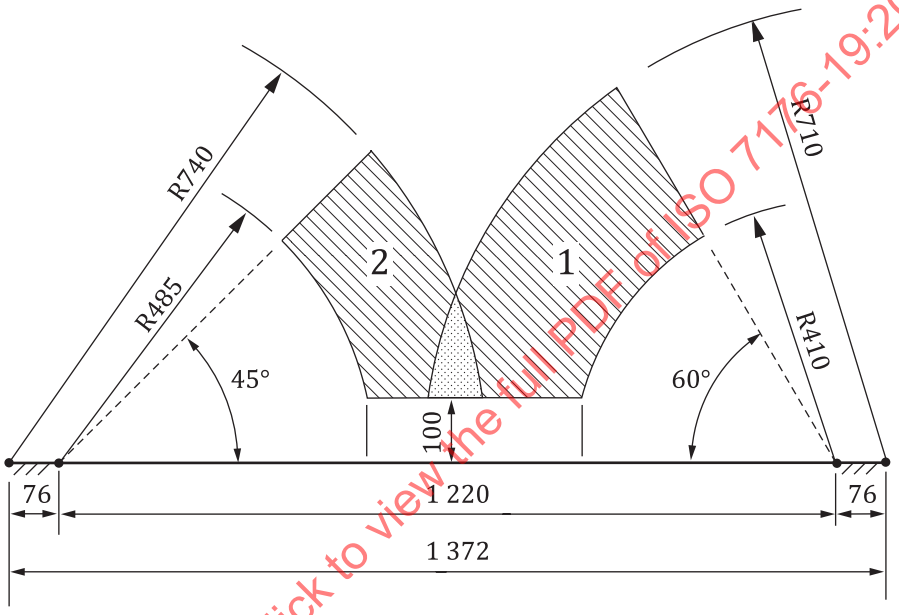
c) for wheelchairs with a seat width equal or greater than 400 mm, the horizontal distance between left and right rear-securement points is not less than 200 mm,

d) for wheelchairs with a seat width that is less than 400 mm, the horizontal distance between left and right rear-securement points may be less than 200 mm. When the distance is below 200 mm, it shall not be more than 50 mm less than the seat width, and

e) the horizontal distance between left and right front-securement points is not less than 100 mm.

NOTE The securement-point location is defined as the centre of contact between the hook gauge or securement-point end fitting and the securement-point structural member, when the wheelchair is secured using the procedures given in Annex A.

Dimensions in millimetres



Key

1 front-securement-point zone

2 rear-securement-point zone

NOTE 1 The securement-point zones are based on minimum and maximum strap lengths required by ISO 10542-1 and typical distances of 1 220 mm to 1 372 mm between front and rear vehicle anchor points. The actual distances between front and rear anchor points in different vehicles can be greater or less than these dimensions.

NOTE 2 The front- and rear-securement-point zones are specified relative to each other and the ground plane and do not have a specific relationship to wheelchair components.

Figure B.2 — Side view of required zones for front- and rear-securement points relative to each other and the ground plane

B.4 Attachment of securement points

B.4.1 All wheelchair securement points required by 4.2.1 shall

a) be attached to the wheelchair frame, powerbase or seat frame, either by designing the securement points to be an integral part of the frame structure or by attaching securement-point brackets to a frame member using permanent fasteners that cannot be removed without the use of tools,

b) not be attached or incorporated into moving or removable components (components that can be moved or removed without the use of tools), such as arm supports, wheels, and foot supports, and

c) always have the securement-point opening of Figure B.1 fully accessible and unobstructed for easy attachment and proper engagement of tiedown hooks and straps.

B.4.2 Securement-point brackets may be permanently attached in a manner that allows rotation or other movement to align the rounded portion of the securement point with the direction of tiedown forces as long as such rotation or movement is limited sufficiently to prevent any part of the securement-point opening from becoming inaccessible or blocked by wheelchair components and structures.

Annex C
(normative)

Method for testing accessibility and tiedown clear paths of wheelchair securement points intended for attachment of four-point strap-type tiedowns

C.1 General

All securement points intended for attachment of strap-type tiedowns should be easily accessible from the aisle side of the forward-facing wheelchair and should be located so that tiedown straps will travel in straight paths to the anchor points in the vehicle. This annex specifies equipment, conditions, and procedures to

a) evaluate the accessibility of securement points for one-handed attachment of a hook-type securement point end fitting,

b) determine whether clear paths are provided from these securement points to typical vehicle anchor points, and

c) determine the potential for contact of the tiedown straps by sharp edges on the wheelchair.

C.2 Equipment to be tested

A complete commercial or prototype wheelchair designed for securement by a four-point strap-type tiedown is required. The wheelchair manufacturer shall adjust the wheelchair to fit the ATD as selected in Annex A or shall provide adjustment instructions to the testing facility.

C.3 Test equipment

The test equipment and facility shall include the following:

a) **a rigid platform with wheelchair securement space**, as shown in Figure C.1,

b) **a hook gauge**, as specified by Figure C.2,

c) an **ATD** having the same anthropometric characteristics as the Hybrid II or III selected for frontal impact testing in Annex A,

d) a **timing device**, that is accurate to ±0,5 s,

e) Four or more-**tiedown-strap assemblies**, each consisting of

   1) a hook-type securement point end fitting as specified by Figure C.2,

   2) a 25 mm ± 2 mm wide strap connected to the back end of the hook-type securement point end fitting, and

   3) an anchorage with cam-lock adjusting/locking mechanism for the 25 mm wide strap, as illustrated in Figure C.3, that, when fastened to the test platform, allows the cam lock to rotate and align with the tensioned tiedown strap.

C.4 Test method for securement-point accessibility

The test method includes the following steps.

a) Inspect the wheelchair to ensure that it conforms with the manufacturer's instructions and adjust the wheelchair as specified in A 4.5, as appropriate to the type of wheelchair.

b) Position the ATD in the wheelchair, sitting symmetrically about the wheelchair reference plane, with the torso and pelvis as close to the seatback as possible.

c) Position the fore/aft midpoint of the wheelchair at the approximate centre of the test space shown in Figure C.1 by making the gap between the forward-most point on the wheelchair and the forward barrier approximately equal to the gap between the rearward-most point on the wheelchair and the rearward barrier. Align the wheelchair reference plane, to within ±3°, to the longitudinal centreline of the space and, if applicable, lock the brakes.

d) A test person using the hook gauge of Figure C.2 (i.e. the tester) shall be initially positioned standing on the side of the wheelchair opposite the long partition.

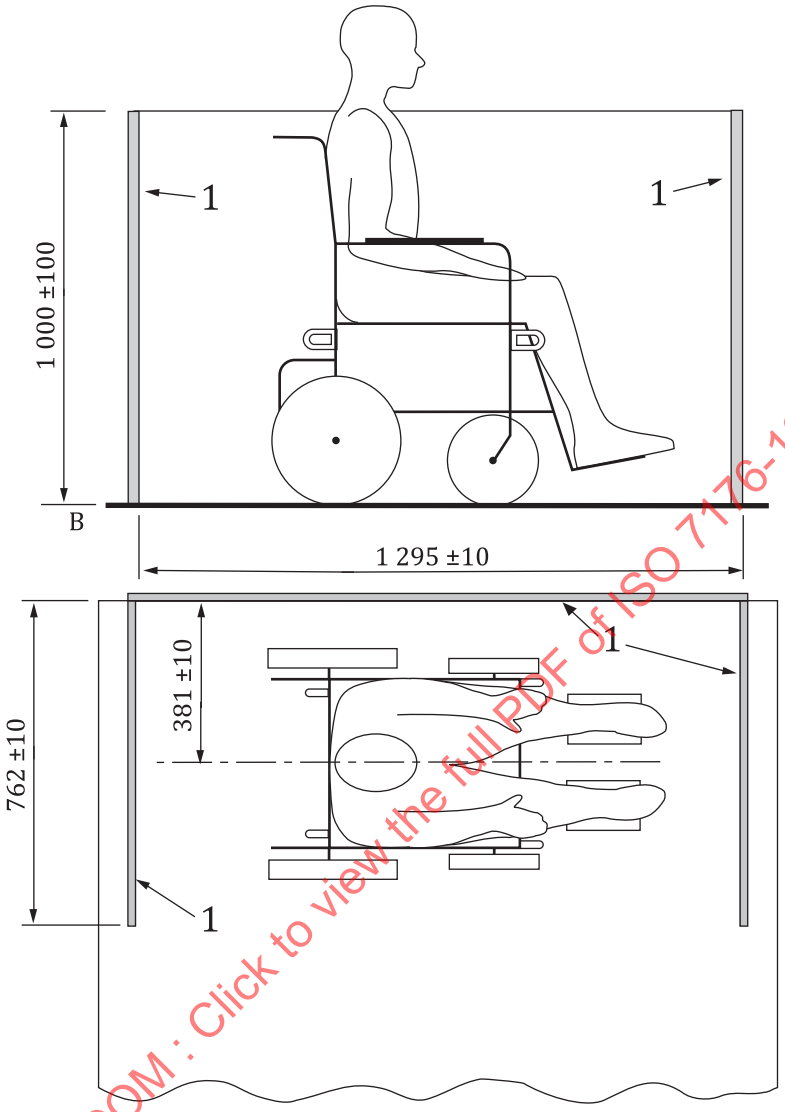
e) Upon command by a person with a timing device (i.e. the timer), the tester shall connect the hook to one of the selected securement points whilst gripping the hook gauge with one hand. The tester shall indicate when the hook is fully engaged and the time from the "start" command shall be noted and recorded.

f) After attachment of the hook gauge, the tester shall visually assess whether or not the hook is fully and effectively engaged with the securement point.

g) The timer shall then give the command to start to disconnect the hook gauge. The tester shall indicate when the hook gauge is completely disengaged and the time from the "start" command shall be measured.

h) Steps d) to g) shall be repeated three times for all wheelchair securement points.

Dimensions in millimetres

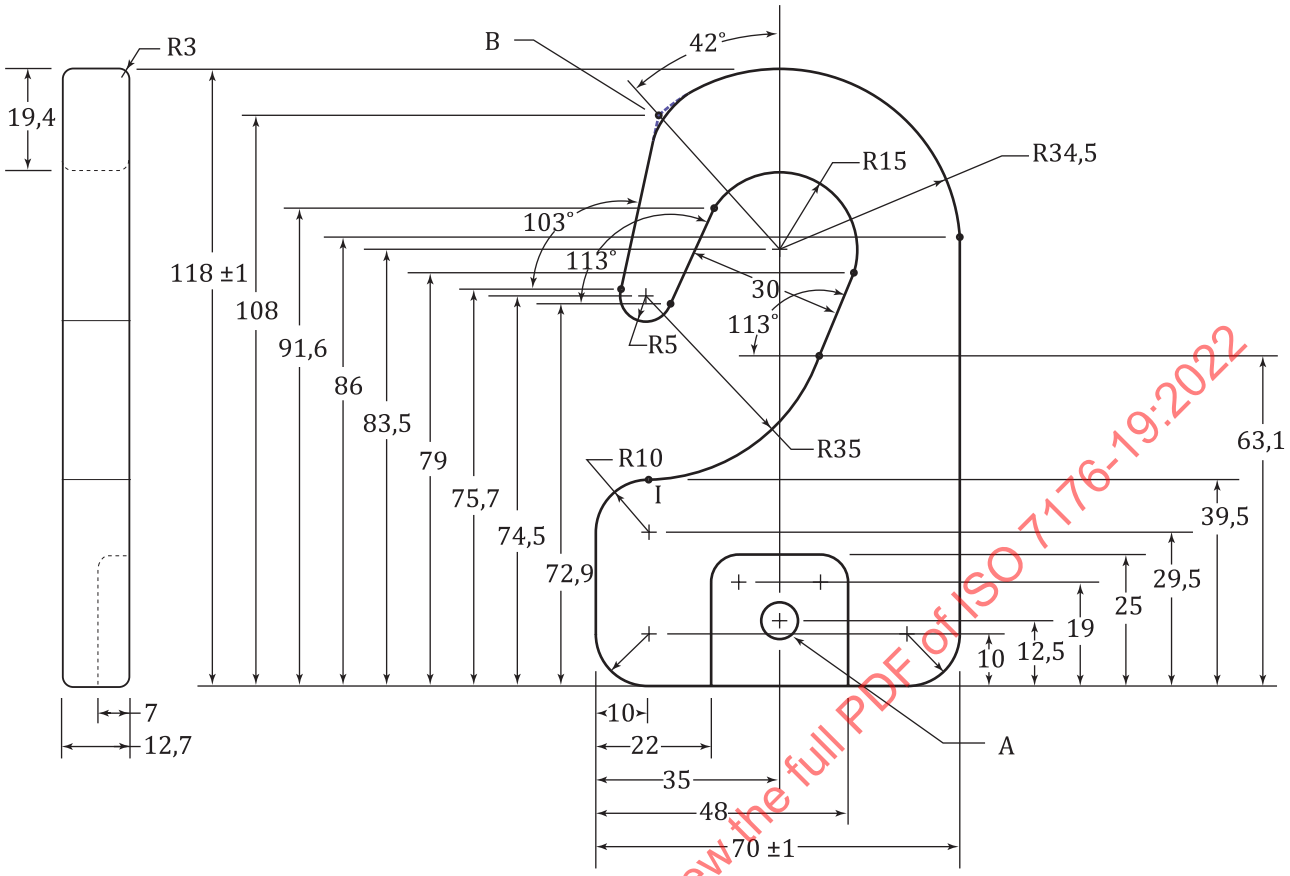


Key

1 removable partition(s)

Figure C.1 — Illustration of test set-up for determining securement-point accessibility

Dimensions in millimetres

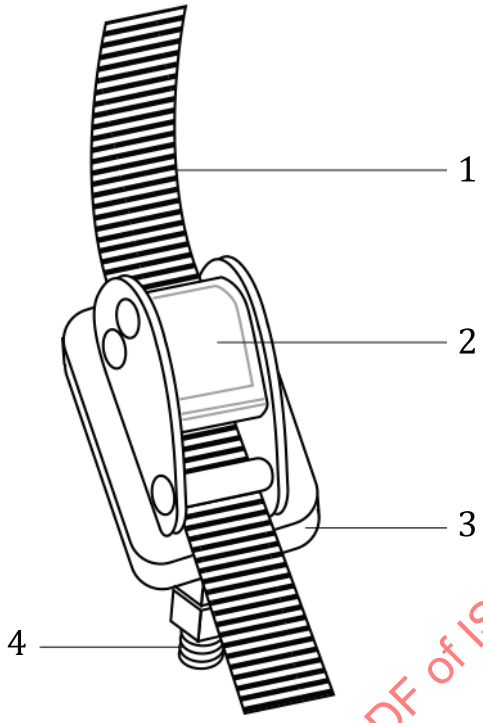


Key

A threaded hole (1/4 20 UNC or M8x1 tapped)

B bend-point tangent to hook-point radius

Figure C.2 — Hook gauge for use in one-hand securement-point accessibility test



Key

1 25-mm wide webbing
2 cam-lock mechanism
3 pivoting anchorage block
4 pivot bolt

Figure C.3 — Illustration of cam-lock tiedown anchorage with pivot bolt for anchoring tiedown straps during clear-path testing

C.5 Test method for tiedown clear paths

Perform the following:

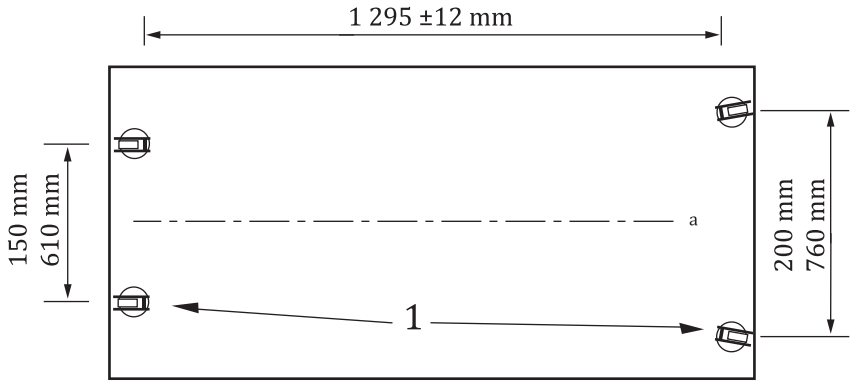
a) Remove the partitions used in the securement-point accessibility test and install the four cam-lock anchorages within the test space shown in Figure C.4, such that

   1) the distance between the front and rear anchor points is set to a preferred distance of 1 295 mm ± 12 mm,

   2) the rear anchor points are located laterally within 25 mm of the rear wheelchair securement points, but not less than 150 mm or more than 610 mm apart,

   3) the centres of the front anchor points are between 200 mm and 760 mm apart but between 0 mm to 100 mm outboard of the lateral positions of the front wheelchair securement points, and

   4) if the range of anchor-point geometries specified produces different results relative to sharp edge proximity (see C.6) or tiedown clear paths, the worst-case geometry should be selected for testing.



Key

1 cam-lock anchorages

a centre line

Figure C.4 — Top view of test space and anchor point locations for clear-path testing

b) Position the wheelchair between the front and rear anchor points, with the wheelchair reference plane located within ±25 mm of the longitudinal centreline of the test space.

c) Attach a length of 25 mm wide webbing to each of the test securement hooks specified in Figure C.2.

d) Connect one securement hook from each tiedown strap assembled in C.5 c) to each of the wheelchair securement points required by Annex B.

e) Thread the 25 mm wide tiedown straps through the cam-lock anchorage mechanisms illustrated in Figure C.3.

f) Position the wheelchair and pull the tiedown straps taut as illustrated in Figure C.5, so that the straight lines connecting the rear securement points and the rear anchor points form angles of 45° relative to the horizontal.

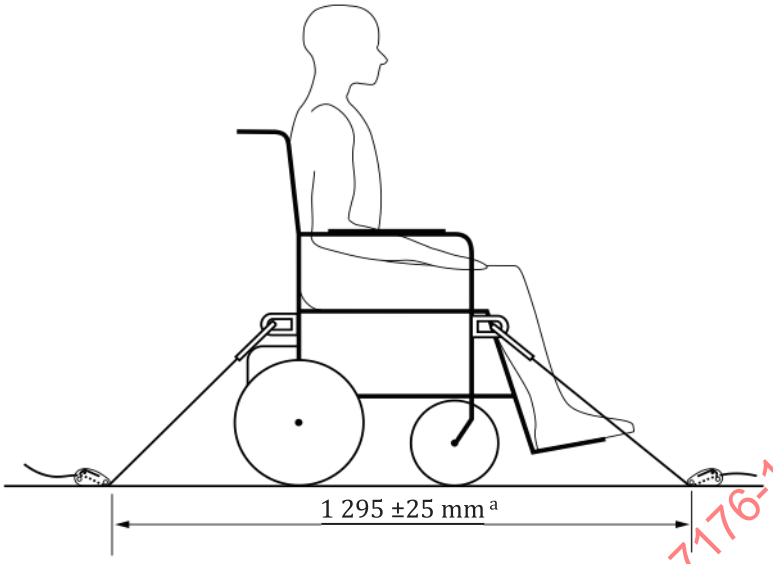
   1) If an angle of 45° cannot be achieved with a tiedown length of at least 495 mm, measured as the straight-line distance from the securement point to the anchor point, as shown in Figure C.6, increase the lengths of the rear tiedown strap assemblies to be from 495 mm to 521 mm.

   2) The angle of the straight-line path will depend on the location of the securement point and may, when using a tiedown length of at least 495 mm, be less than 45°.

g) Inspect the test hooks and record any contact of the hooks or straps with the wheelchair, other than contact that is within the designated engagement area of each hook.

h) For each tiedown strap, determine the maximum deviation from a straight-line path projected in the lateral plane as illustrated in Figure C.7. For situations involving multiple strap or hook contacts, only the maximum deviation is measured.

i) For each tiedown strap, determine the maximum deviation from a straight-line path in the rear-view plane for rear tiedowns and in the front-view plane for front tiedowns.



Key

a Side view.

Figure C.5 — Illustration of wheelchair secured for clear-path testing using 25 mm wide strap assemblies

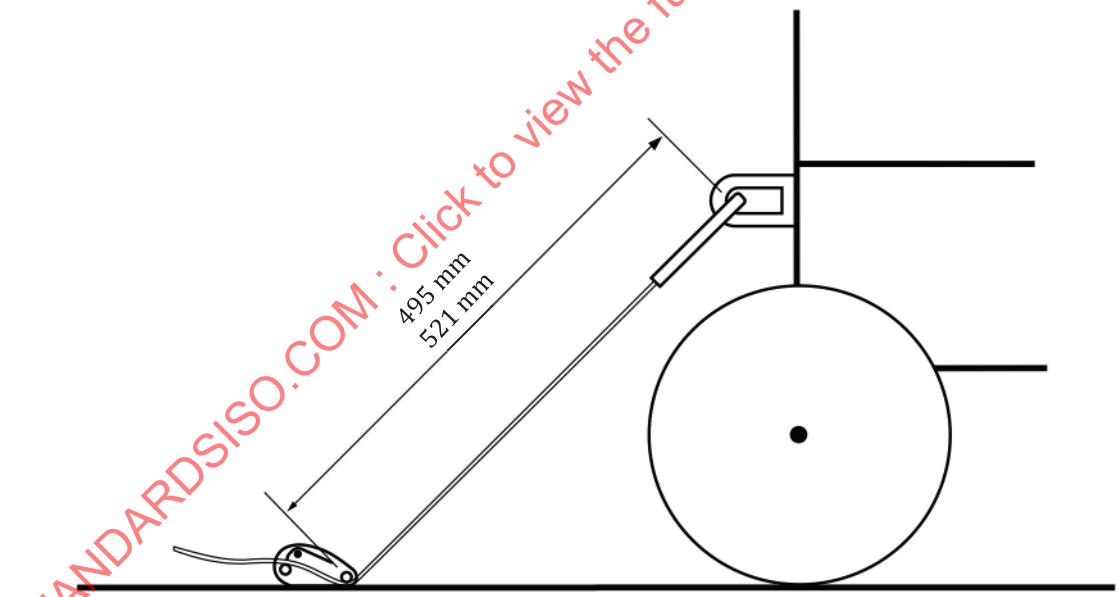
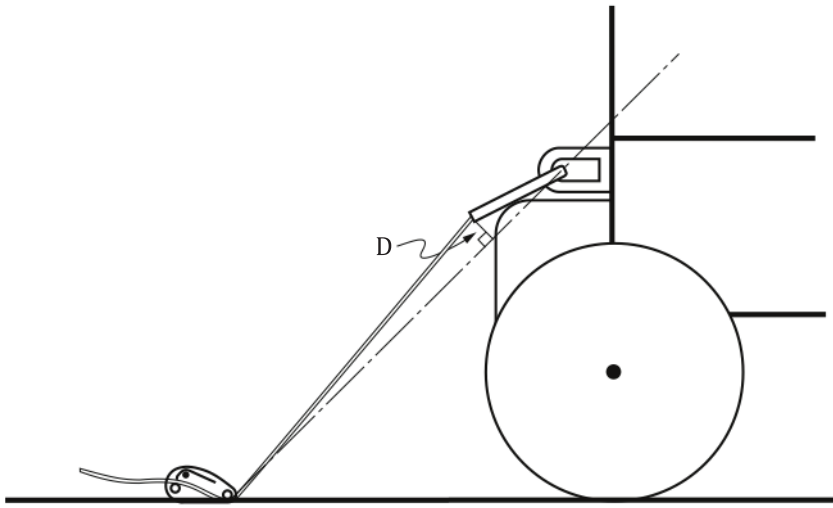


Figure C.6 — Illustration of rear tiedown length measurement



Key

D deviation

Figure C.7 — Illustration of the deviation, D, from a straight-line path projected onto the lateral-view plane

C.6 Test method for sharp edges near tiedown path

With the wheelchair positioned as specified in C.5 f), determine if any contactable sharp edges on the wheelchair are within a 50 mm radius of a straight line connecting the point of engagement of the hook with the securement point on the wheelchair to the anchor point. A sharp edge that is within 50 mm of the straight line defined above, but that would be unlikely to be contacted by a tiedown strap during normal travel or a frontal collision (e.g. because it is above the straight-line path or behind another structural component), is not considered to constitute failure of the test for sharp edges near the tiedown clear path. A 100 mm diameter disc with a slot to fit over the 25 mm strap, as illustrated in Figure C.8, may be used to assist with determining the proximity to sharp edges for cases where there is little or no deviation from a straight line tiedown path.

C.7 Test report

In addition to the requirements of Clause 7, the test report shall include

a) a full identification of the wheelchair tested,

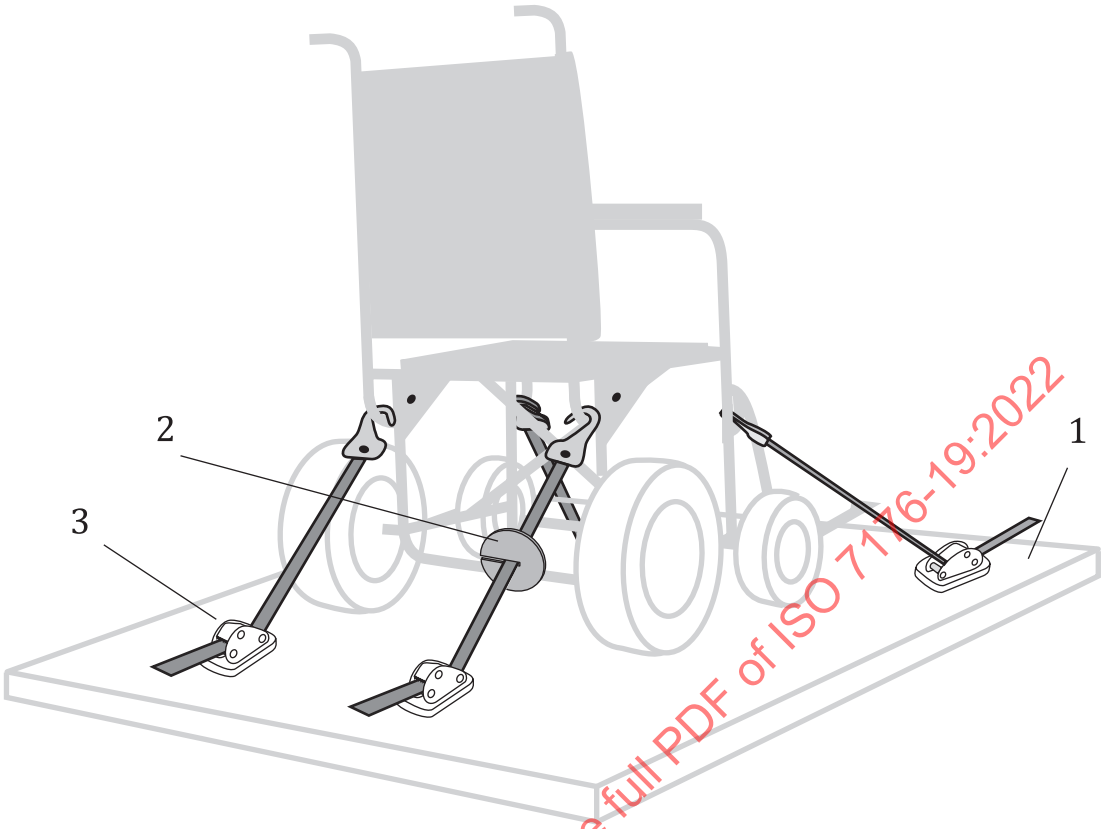
b) whether the test person was able to successfully engage and disengage the test hook to each of the securement points in accordance with the procedures of C.4 along with

   1) the times required to attach and to remove the test hook to/from each securement point, and

   2) the test person's comments relative to problems encountered attaching the hook if accessibility criteria are not met.

c) results of the clear-path tests from C.5, and whether any of the clear path deviations exceed 40 mm, and

d) results of the sharp-edge proximity test of C.6.



Key

1 test platform
2 100 mm diameter disc
3 cam-lock anchorage

Figure C.8 — Illustration of test for sharp edges performed by sliding a 100 mm diameter disc along each tiedown strap

Annex D
(normative)

Methods for rating wheelchair accommodation of vehicle-mounted occupant belt restraints

D.1 Rationale

Wheelchairs intended for users with a body mass equal to or greater than 23 kg shall be designed to accommodate the correct placement and positioning of vehicle-mounted 3-point occupant restraint systems.

This annex establishes test methods for rating wheelchairs with regard to

a) the ease by which a person other than the wheelchair occupant can properly position a vehicle-mounted belt restraint on a passenger seated in the wheelchair, and

b) the extent to which proper positioning of a vehicle-mounted belt restraint can be achieved.

D.2 Principle

The wheelchair is secured on a test platform using a four-point strap-type tiedown system that conforms to ISO 10542-1 or using the tiedown system specified in C.3 for clear-path testing. The ATD to be used in the frontal impact test of Annex A is seated in the wheelchair in accordance with the procedures of Annex A. A vehicle-mounted three-point belt that conforms to ISO 10542-1 is installed and positioned on the ATD. The ease of achieving proper belt placement is scored and rated based on the criteria in Table D.1. Scores indicating the extent to which proper belt fit is achieved, based on various factors including belt paths, belt angles, and location of the pelvic and shoulder belts on the ATD, are determined using the criteria in Tables D.2 to D.8. These scores are tallied to determine the overall rating of proper belt fit and belt paths in accordance with D.6. A wheelchair shall achieve ratings of at least “acceptable” for ease of achieving proper belt positioning and proper belt fit to conform with this document. In addition, both ratings shall be disclosed in the wheelchair manufacturer’s presale literature in accordance with 6.3.

D.3 Test sample

The complete production or prototype wheelchair to be used in the frontal impact test of Annex A (prior to the Annex A test), or a wheelchair configured with a seating system comparable in all respects to that used in Annex A shall be provided by the wheelchair manufacturer.

D.4 Test apparatus

The laboratory apparatus to conduct the test shall include the following:

a) a WTORS consisting of a four-point strap-type tiedown and vehicle-mounted three-point belt restraint that conforms with ISO 10542-1, and/or the tiedown system specified in C.3 for clear-path testing,

b) a test platform with adjustable anchor points for wheelchair tiedown straps and pelvic- and shoulder-belt-restraint anchor points, and

c) an ATD used in the frontal impact test of Annex A.

D.5 Test method

The test method includes the following steps.

a) Secure and adjust the wheelchair on the test platform using a four-point strap-type tiedown system and the set-up procedures of A.4.1 to A.4.5, as appropriate, or in accordance with C.5 if using the tiedown system specified in Annex C for clear-path testing.

b) Position arm supports of the wheelchair in their normal use position. Do not remove, move or pivot arm supports out of position during testing.

c) If provided, install all hardware and fasteners for attaching the commercial wheelchair-mounted pelvic-belt restraint used in the frontal-impact test of Annex A if not previously installed by the wheelchair manufacturer, but do not include the wheelchair-mounted pelvic-belt restraint.

d) Fasten the floor anchorages of the three-point-belt restraint to the test platform, selecting anchor points for the pelvic-belt restraint that are 0 mm to 100 mm forward of, and within ±100 mm lateral to, the rear-tiedown anchor points.

NOTE 1 The actual location of the pelvic-belt-restraint anchor points will depend on the space available between the rear-tiedown anchor points and the wheelchair base.

e) Place the ATD used in the frontal impact test of Annex A in the wheelchair seat with the pelvis firmly against the backrest.

f) Locate the upper shoulder-belt-restraint anchor point or webbing guide according to the procedures specified in A.4.8, as illustrated in Figure D.1. The anchor point may be located on either side of wheelchair and ATD, and is located relative to the top centre of the ATD's shoulder. The lateral position of the anchor point or webbing guide should be adjusted to achieve a good fit over the ATD's chest and shoulder.

g) Install and position the three-point-belt restraint on the ATD while attempting to achieve optimal placement of the pelvic-belt restraint across the lower pelvis at the thigh-abdominal junctions and the shoulder-belt restraint across the middle of the shoulder and diagonally across the chest.

h) Score the performance of the wheelchair during and after the belt-restraint installation process based on the criteria in Tables D.1 to D.8.

1) Use an inclinometer to estimate the projected side-view angles of the pelvic-belt restraint after installation on the ATD, and

2) Determine if there are any sharp edges on the wheelchair that are within the sharp edge clearance zone shown in Figure D.2 and that could be contacted by the belt restraint during normal travel or during expected belt movement in a frontal collision (e.g. because it is outboard of the belt path or behind another structural component). This can be done by positioning a transparent template of the sharp-edge clearance zone shown in Figure D.2 along the side of the wheelchair with the belt line on the template aligned with the belt angle.

i) Rate the overall performance of the wheelchair with regard to its ease of belt placement and the wheelchair's accommodation of the proper placement of vehicle-mounted belt restraints according to D.6.

NOTE 2 The scores in Table D.1 are based on attempts to achieve optimal belt-restraint placement for the wheelchair being tested. The scores in Tables D.2 to D.8 are assessed after achieving optimal placement.

Dimensions in millimetres

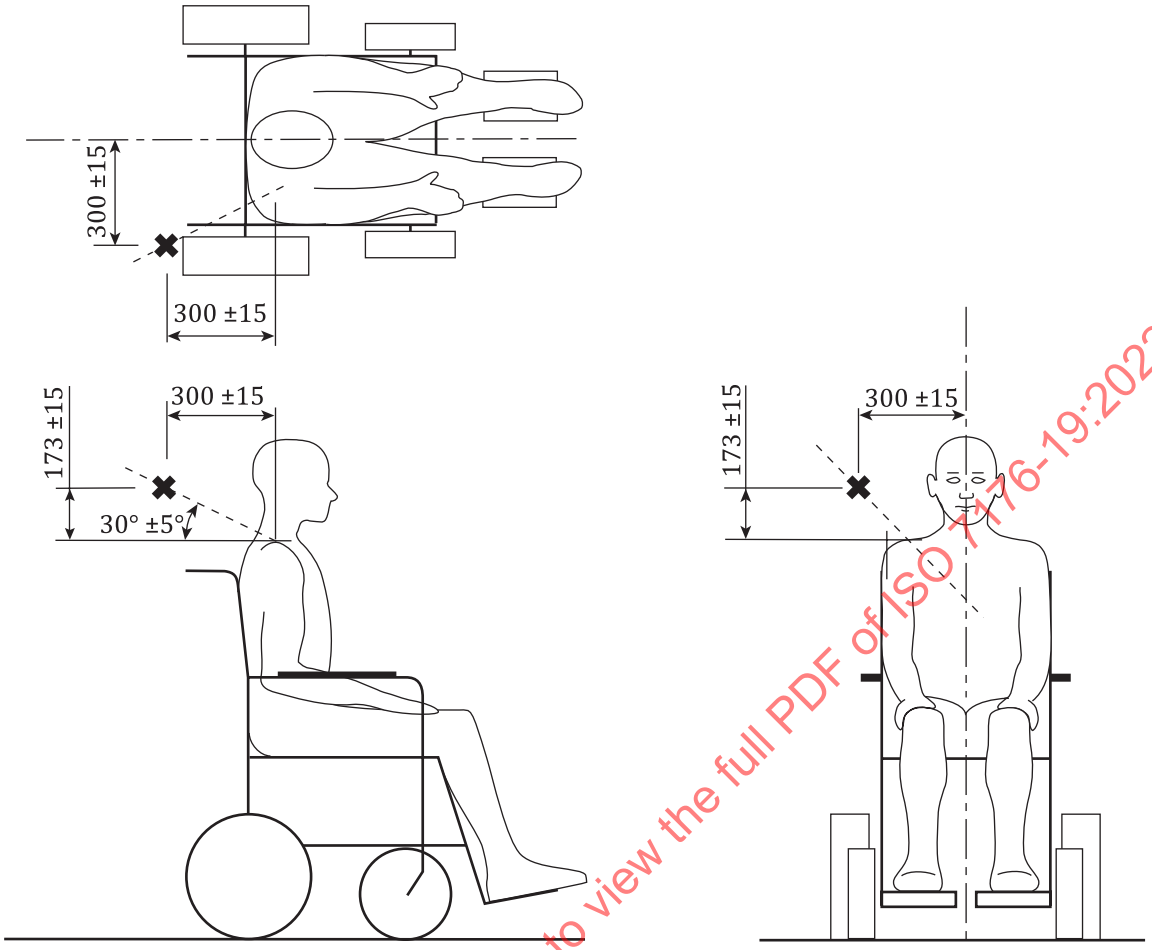


Figure D.1 — Test location of shoulder-belt-restraint upper anchor point or webbing guide, and angles of shoulder-belt restraint

Table D.1 — Ease of optimizing proper seatbelt placement on ATD

Rating	Description
Poor	Placement of pelvic and/or shoulder belts to optimize proper belt fit and positioning on the ATD can only be achieved by threading[a] the free-end of belt webbing through small openings of less than 75 mm in any direction, or by inserting[b] the belt webbing into tight spaces of less than 15 mm between wheelchair components.
Acceptable	Placement of pelvic and/or shoulder belts to optimize proper belt fit and positioning on the ATD requires threading the ends of the pelvic belt through relatively large openings that are equal to or greater than 75 mm in all directions.

[a] Threading means that the end of a belt is placed through an opening that is completely enclosed, such as through an opening at the bottom of a back support, without the removal of wheelchair components or hardware.

[b] Inserting means that the edge of the belt somewhere along its length can be placed into an opening between components because it is not completely enclosed, such as placing the edge of belt webbing down into the gap between a back-support post and the back of an arm support, without the removal of wheelchair components or hardware.

Table D.1 *(continued)*

Rating	Description
Good	Placement of pelvic and/or shoulder belts to optimize proper belt fit and positioning on the ATD can be achieved without threading the ends of the pelvic belt through openings in or between wheelchair components but requires inserting webbing into spaces that are between 15 mm and 25 mm wide.
Excellent	Placement of pelvic and/or shoulder belts to optimize proper belt fit and positioning on the ATD can be achieved without threading the ends of the pelvic belt through openings in or between wheelchair components and without having to insert webbing into openings less than 25 mm wide.

[a] Threading means that the end of a belt is placed through an opening that is completely enclosed, such as through an opening at the bottom of a back support, without the removal of wheelchair components or hardware.

[b] Inserting means that the edge of the belt somewhere along its length can be placed into an opening between components because it is not completely enclosed, such as placing the edge of belt webbing down into the gap between a back-support post and the back of an arm support, without the removal of wheelchair components or hardware.

Table D.2 — Pelvic-belt contact area

Description	Scorer
Belt is held completely away from the ATD's pelvis because of interference by wheelchair components.	0
Belt makes contact over the front of the ATD's pelvis but does not make contact with either or both of the ATD's hips due to interference by wheelchair components.	1
Belt makes contact over the front of the ATD pelvis and with both hips.	2

Table D.3 — Shoulder-belt contact area

Description	Scorer
Belt is held away from the ATD's chest and shoulder because of interference by wheelchair components.	0
Belt makes contact with the ATD's sternum but contact area is reduced due to interference by wheelchair components.	1
Belt makes full and unrestricted contact with the ATD's sternum and the anterior surface of the ATD's shoulder.	2

Table D.4 — Pelvic-belt location on ATD

Description	Scorer
Belt contacts the ATD above the pelvis (referenced by the anterior superior iliac spine or ASIS) and on the abdomen because of interference by wheelchair components.	0
Belt contacts the ATD on the upper part of the pelvis (over the ASIS) because of interference by wheelchair components.	2
Belt contacts the ATD low on the pelvis (below the ASIS) or at the thigh/abdominal junctions.	4

Table D.5 — Shoulder-belt contact area

Description	Scorer
Belt is off the shoulder of the ATD due to interference by wheelchair components.	0
Belt contacts the ATD's neck due to interference by wheelchair components.	1

Table D.5 *(continued)*

Description	Scorer
Belt travels over the middle of the ATD's shoulder.	2

Table D.6 — Pelvic-belt angle

Description	Scorer
The average of the projected side-view angles of the pelvic belt on both sides is less than 30° or greater than 75° to the horizontal.	0
The average of the projected side-view angles of the pelvic belt on both sides is between 30° and 45° to the horizontal.	1
The average of the projected side-view angles of the pelvic belt on both sides is between 45° and 75° to the horizontal.	2

Table D.7 — Pelvic-belt contact area

Description	Scorer
Belt makes contact with wheelchair components on either side of the wheelchair resulting in a change in belt angle greater than 15°.	0
Belt makes contact with wheelchair components on either side of the wheelchair resulting in a change in belt angle less than 15° but greater than 5°.	1
Belt path from the ATD to anchor points on both sides of the wheelchair does not deviate more than 5° from a straight line.	2

Table D.8 — Pelvic-belt proximity to sharp edges

Description	Scorer
Sharp edges on the wheelchair that could contact the belt during a frontal crash are within the sharp-edge clear zone of Figure D.2.	0
Sharp edges on the wheelchair that could contact the belt during a frontal crash are not within the sharp-edge clear zone, but are within 25 mm of the zone.	1
Sharp edges on the wheelchair that could contact the belt during a frontal crash are not within 25 mm of the sharp-edge clear zone.	2

D.6 Overall rating of belt-restraint accommodation

D.6.1 Ease of proper belt positioning

The rating for ease of proper belt positioning is as assigned in Table D.1.

D.6.2 Extent to which proper belt fit is achieved

The rating for belt fit plus belt paths is based on the sum of the scores from Tables D.2 to D.8 as follows:

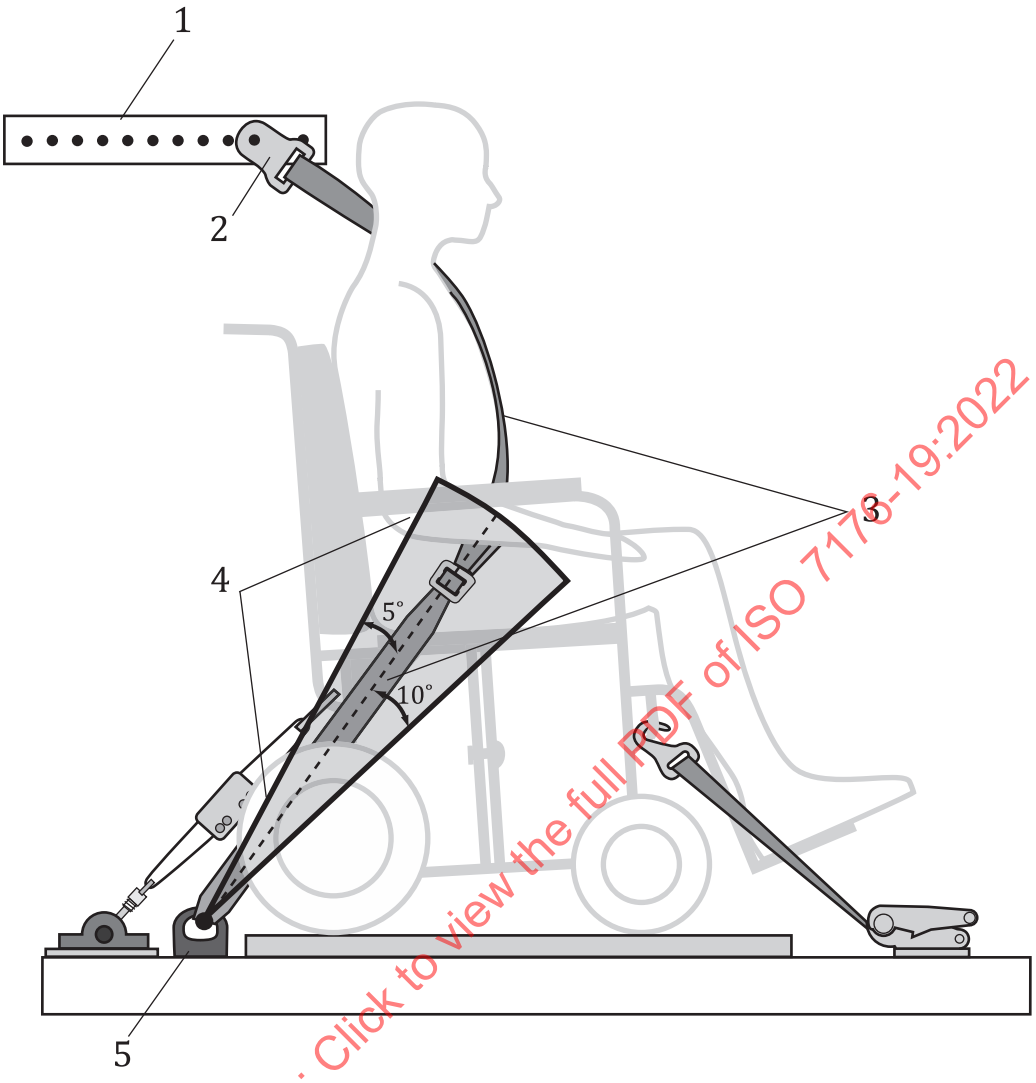
a) The rating is "Poor" and an overall score of zero shall be assigned if any of the criteria in Tables D.2 to D.8 receive a score of zero.

b) The rating is "Poor" if the total score is less than 8.

c) The rating is "Acceptable" if the total score is from 8 to 11.

d) The rating is "Good" if total score is 12 to 16 and the sum of the scores for Tables D.2, D.4, and D.6 is less than 8.

e) The rating is "Excellent" if the total score is 12 to 16 and the sum of the scores for Tables D.2, D.4, and D.6 is 8.



Key

1 rigid D-ring anchor points
2 D-ring
3 3-point vehicle-mounted belt restraint
4 sharp-edge clearance zone
5 pelvic-belt D-ring anchorage

Figure D.2 — Side-view drawing of the sharp-edge clearance zone

Annex E
(normative)

Specifications for Surrogate Wheelchair Tiedown and Occupant Restraint System (SWTORS) with four-point strap-type tiedown and three-point belt restraint

E.1 Principle

The purpose of SWTORS is to provide a laboratory device with sufficient durability and strength that can be used for repeated impact testing of all wheelchairs that can be tested in accordance with this document. The SWTORS also offers the additional advantage of providing accurate measures of impact-loading time histories, which can be useful in determining wheelchair failure loads and solutions for strengthening the wheelchair design. The following specifications are intended to serve as guidelines for laboratories wishing to use a surrogate tiedown system in the frontal impact test of Annex A.

E.2 General design features

The SWTORS uses a four-point strap-type tiedown capable of simulating the dynamic performance and wheelchair loading produced by common production four-point strap-type tiedowns that conform with applicable frontal-impact performance requirements of ISO 10542-1. In this configuration, the surrogate tiedown system is capable of securing a 136 kg wheelchair loaded with a large adult male ATD restrained by a three-point belt restraint with a wheelchair-mounted pelvic-belt restraint during the 48 km/h, 20 *g* frontal-impact test of Annex A. For wheelchairs with a mass greater than 136 kg, alternative hardware for the rear tiedown straps allows for the use of double-thickness tiedown webbing. In this configuration, the SWTORS is capable of securing a 200 kg wheelchair loaded with an adult ATD. Auxiliary rear tiedown assemblies can be used for heavy wheelchairs as well. The surrogate tiedown system provides for measurement of rear-tiedown force-time histories during a test. Whilst these force signals are not used to demonstrate conformance of the wheelchair with the performance criteria, they provide useful information for the wheelchair manufacturer, particularly in the event of securement point or wheelchair frame failures.

The SWTORS includes a shoulder-belt restraint, the lower connector of which can engage with the mating connector on a production wheelchair-mounted pelvic-belt restraint. The SWTORS also includes a surrogate three-point belt restraint with a vehicle-mounted pelvic-belt restraint. Both the wheelchair tiedowns and occupant restraints are comprised of durable, reusable components that, when interfaced with new seatbelt webbing, comprise the SWTORS. These components include four or more hooks for attaching tiedown-straps to wheelchair securement points, anchorages to attach tiedowns and restraints to the impact sled, mechanisms for attaching and adjusting webbing lengths and tensions without the need for sewing, a rigid structure that simulates vehicle side pillars or side walls for upper shoulder-belt anchor points, and a raised platform to position the wheelchair ground plane at the level of the rear wheelchair anchor points. These features are illustrated in Figure E.1

E.3 Summary of features and specifications

E.3.1 The SWTORS includes

a) four or more strap-type tiedown assemblies for securing forward-facing wheelchairs up to 200 kg with a wheelchair-mounted pelvic-belt restraint during a 48 km/h, 20 *g* frontal impact test, including two rear tiedown assemblies with split-drum mechanisms and two front tiedown assemblies with pivoting ratchet mechanisms,

b) an adjustable-length shoulder-belt restraint with fixed upper anchor point and an appropriate connector for attaching the lower end of the shoulder-belt restraint to the mating connector (e.g. pin-bushing, latch plate, buckle receptacle) on a production wheelchair-mounted pelvic-belt restraint that conform with J.3.6 (see Figures E.1a and E.1b),

c) a three-point belt restraint with vehicle-mounted pelvic-belt restraint (see Figures E.1 c), E.1 d) and E.1 e),

d) a three-point belt with surrogate wheelchair-mounted pelvic-belt restraint (see Figure E.1f, E.1g, and E.1 h), and

e) durable and reusable hardware components for all non-webbing parts of the surrogate wheelchair tiedown and occupant restraint system, including

   1) mechanisms that provide for manual adjustment of the lengths of wheelchair tiedown straps and belt restraints, and

   2) mechanisms that provide for implementing the tiedown straps and seat-belt assemblies using standard seat-belt webbing without the need for sewing.

E.3.2 The surrogate wheelchair tiedown shall be comprised of

a) unused energy absorbing webbing material such that

   1) the width of the webbing is not less than 45,7 mm or greater than 53 mm when measured according to applicable standards (see Table E.1 for examples),

   2) the elongation of the webbing does not extend more than 10 % when loaded at 11 145 N as specified in applicable standards (see Table E.1 for examples),

b) rear-tiedown anchorages consisting of heavy-duty, stainless-steel rod-end bearings attached to 12,5 mm diameter steel rods supported by steel side plates. The rod-end bearings should be instrumented with strain gages to measure the total force-time history in each rear-tiedown assembly during a test,

c) a means to secure and adjust the length of each rear-tiedown assembly by using either

   1) a split-drum webbing grip mechanism for use with single-thickness webbing resulting in a quasi-static stiffness of each rear-tiedown assembly of between 700 N/mm and 780 N/mm when tested at an initial length of 510 mm ± 10 mm, measured from hook securement point to rod-end anchor point, or

   2) a split-drum webbing grip mechanism for use with double-thickness webbing for testing wheelchairs with a mass greater than 136 kg, resulting in a quasi-static stiffness of each rear-tiedown assembly of between 1 000 N/mm and 1 200 N/mm when tested in the same configuration described above.

d) two pivoting front tiedown anchorages consisting of heavy-duty webbing reels and ratchets for tensioning the tiedown straps,

e) a raised, flat, rigid platform for the wheelchair resting surface, so that the centres of the rod-end anchor points are at the same height as the wheelchair ground plane, and

f) four to six securement hooks made of high-impact hardened steel that conform with the geometry in Drawing #11005 of the SWTORS engineering drawing package referenced in E.4.

E.3.3 The surrogate belt-restraint system shall be comprised of

a) unused webbing material specified in E.3.2 a),

b) a rigid structure to simulate the vehicle side wall or pillars for attaching the upper shoulder-belt anchorage at a range of anchor points to achieve good fit of the shoulder-belt restraint to the child- and adult-size ATDs listed in Table A.1 seated in a range of wheelchair models and sizes,

NOTE The structure is considered rigid if there is less than 25 mm of deflection at the point of load application when 10 000 N of static force is applied 1 220 mm above the wheelchair ground plane, at an angle of 30° forward and inward to the wheelchair reference plane.

c) a 75 mm × 50 mm × 13 mm rigid block for establishing the degree of slack in the surrogate shoulder-belt restraint as specified in A.4.8 f) or A.4.10 d) prior to running the frontal-impact test,

d) a surrogate shoulder-belt restraint for testing in Annex A of this document when a production wheelchair-mounted pelvic-belt restraint with lower shoulder-belt connector is supplied without a shoulder-belt restraint (see Figures E.1a and E.1b), including

1) a freely pivoting heavy duty D-ring to attach the upper end of the surrogate shoulder belt to the rigid structure,

2) a heavy duty three-bar clip to attach the upper end of the shoulder belt to the D-ring and that allows for adjusting the shoulder-belt length to fit the ATD,

3) a connector (i.e. triangular connector, buckle receptacle) to attach the lower end of the shoulder belt to the mating connector on a production wheelchair-mounted pelvic-belt restraint, and

4) a heavy duty three-bar clip to attach the lower end of the shoulder belt webbing to the lower shoulder belt mating connector on the pelvic belt.

NOTE Although the lower end of the shoulder belt illustrated in Figures E.1a and E.1b show a triangular connector for attachment to a pin-bushing anchorage, this connector can be replaced by other types of suitable hardware, such as buckle receptacles and latch plates.

e) a surrogate three-point-belt restraint with a vehicle-mounted pelvic-belt restraint for testing of wheelchairs and seating systems (see Figures E.1c, E.1d, and E.1e), including

1) a freely pivoting heavy duty D-ring to attach the upper end of the surrogate shoulder belt to the rigid structure,

2) a heavy duty three-bar clip to attach the upper end of the shoulder belt to the D-ring, and that allows adjustment of the shoulder-belt length to fit the ATD,

3) a fixed heavy duty eye bolt to attach the continuous loop of belt webbing that forms the lower end of the shoulder belt and the inboard end of the pelvic belt to the sled platform behind the test wheelchair on the side opposite to the upper shoulder-belt anchor point,

4) a heavy duty three-bar clip to connect the pelvic and shoulder belt together near the hip of the ATD on the side opposite the upper shoulder-belt anchor point, and

5) a heavy duty belt adjustment/locking mechanism to attach the outboard end of the pelvic belt to the sled platform on the same side of the test wheelchair as the upper shoulder-belt anchor point.

f) a surrogate three-point belt restraint with a wheelchair-mounted pelvic-belt restraint (see Figures E.1f, E.1g, and E.1h), including

1) a freely pivoting heavy-duty D-ring to attach the upper end of the surrogate shoulder belt to the rigid structure,

2) a heavy duty three-bar clip to attach the upper end of the shoulder belt to the D-ring and that provides for adjusting the shoulder-belt length to properly fit the ATD,

3) a freely pivoting heavy duty D-ring to attach to the test wheelchair below and behind the ATD's hip on the side opposite the upper shoulder-belt anchor point, thereby providing a wheelchair

anchor point for the continuous loop of belt webbing that forms the lower end of the shoulder belt and the inboard end of the pelvic belt,

4) a heavy duty three-bar clip to connect the pelvic and shoulder belt together near the hip of the ATD on the side opposite to the upper shoulder-belt anchor point,

5) a freely pivoting heavy duty D-ring to attach to the test wheelchair behind and below the ATD's hip on the same side as the upper shoulder-belt anchor point, thereby providing a wheelchair anchor point for the outboard portion of the pelvic belt, and

6) a heavy-duty three-bar clip to attach the outboard end of the pelvic belt to the freely pivoting heavy duty D-ring attached to the test wheelchair on the same side as the upper shoulder-belt anchor point.

Table E.1 — Examples of test methods for belt width and belt elongation

Subject	UN Regulation No. 16	FMVSS 209
belt width	6.3.1.2	S5.1 (a)
elongation		S5.1 (c)

E.4 Engineering drawings for a surrogate wheelchair tiedown and occupant restraint system with four-point strap-type tiedown

Copies of engineering drawings for the surrogate four-point strap-type wheelchair tiedown and pelvic/shoulder belt restraint system that can be used in the frontal-impact test of Annex A and described above can be obtained from:

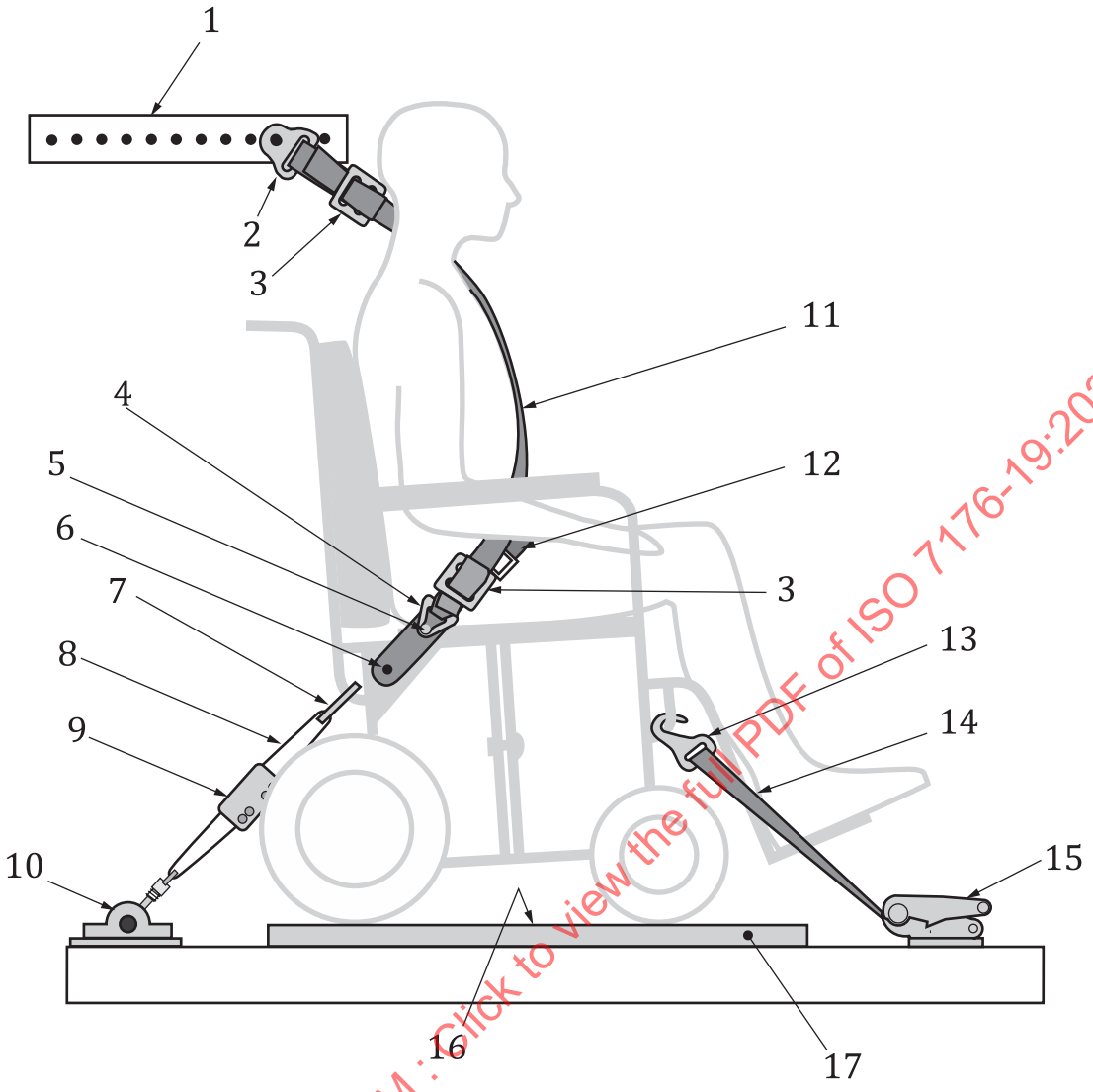
Biosciences Group

University of Michigan Transportation Research Institute (UMTRI)

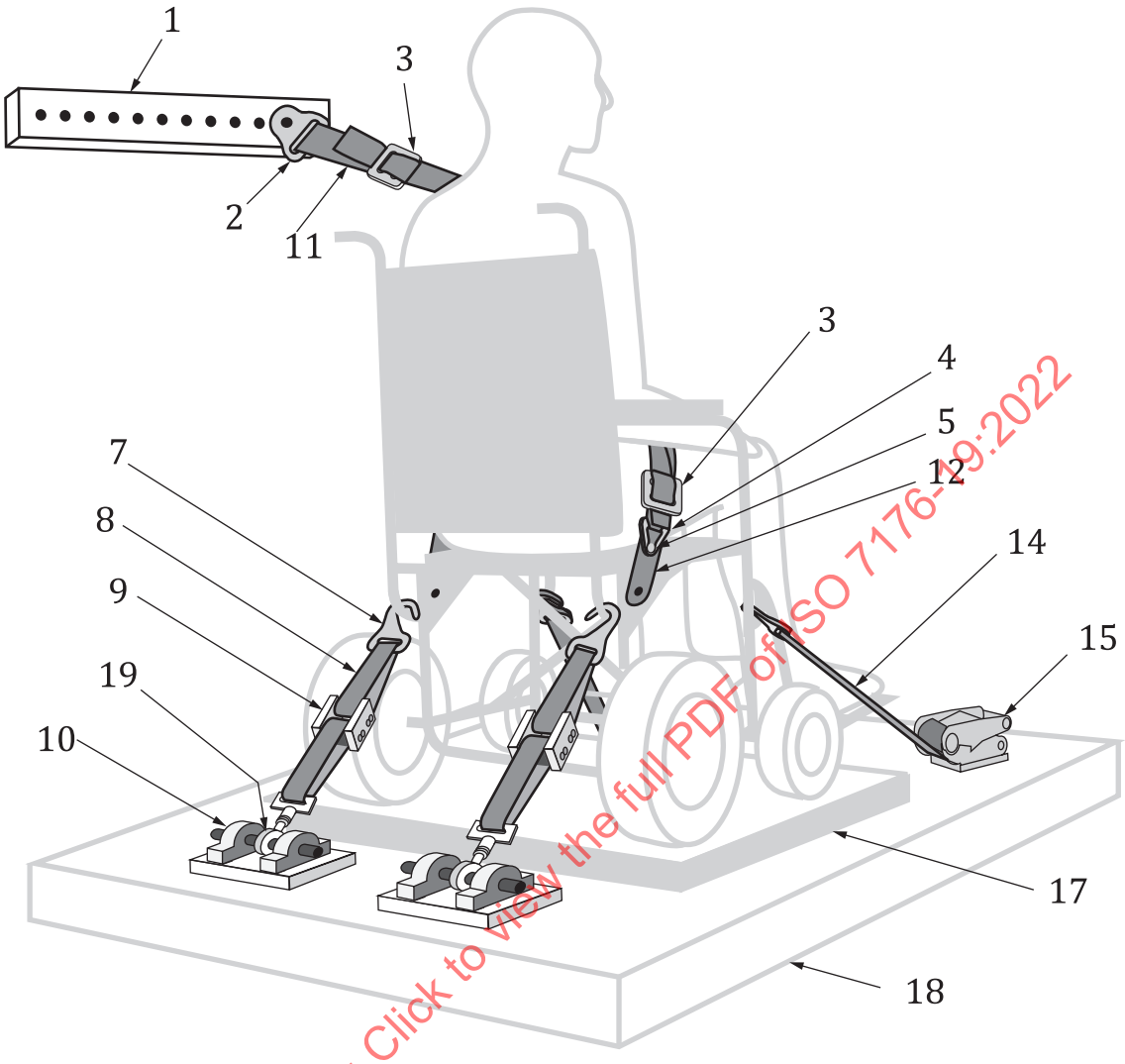
2901 Baxter Road, Ann Arbor, MI 48109-2150 USA

Phone: 734-763-3582, Fax: 734-647-3330

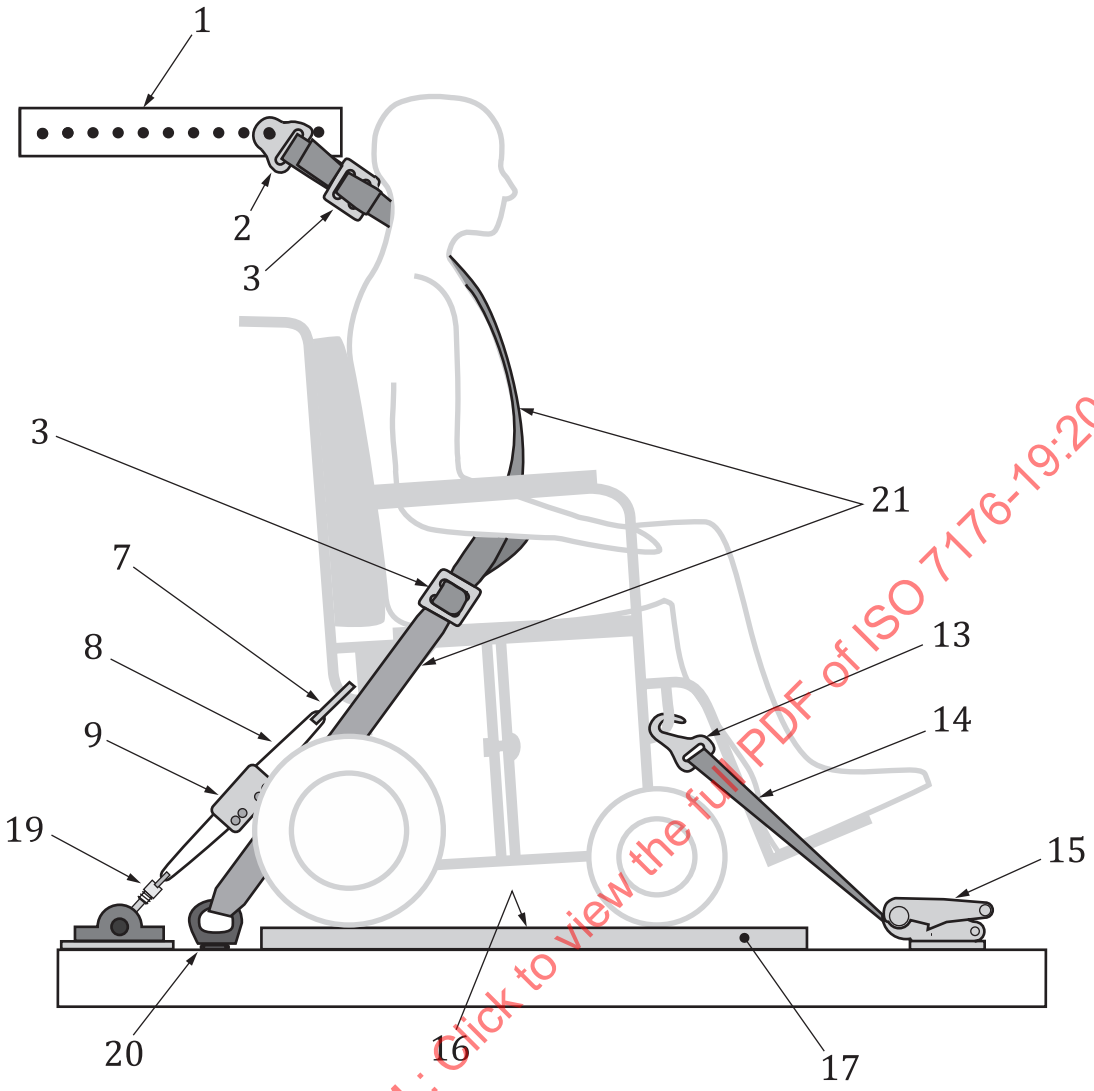
Copies can also be downloaded from the UMTRI Wheelchair Transportation Safety website:
http://wc-transportation-safety.umtri.umich.edu/wts-standards/WC4engineeringdrawings



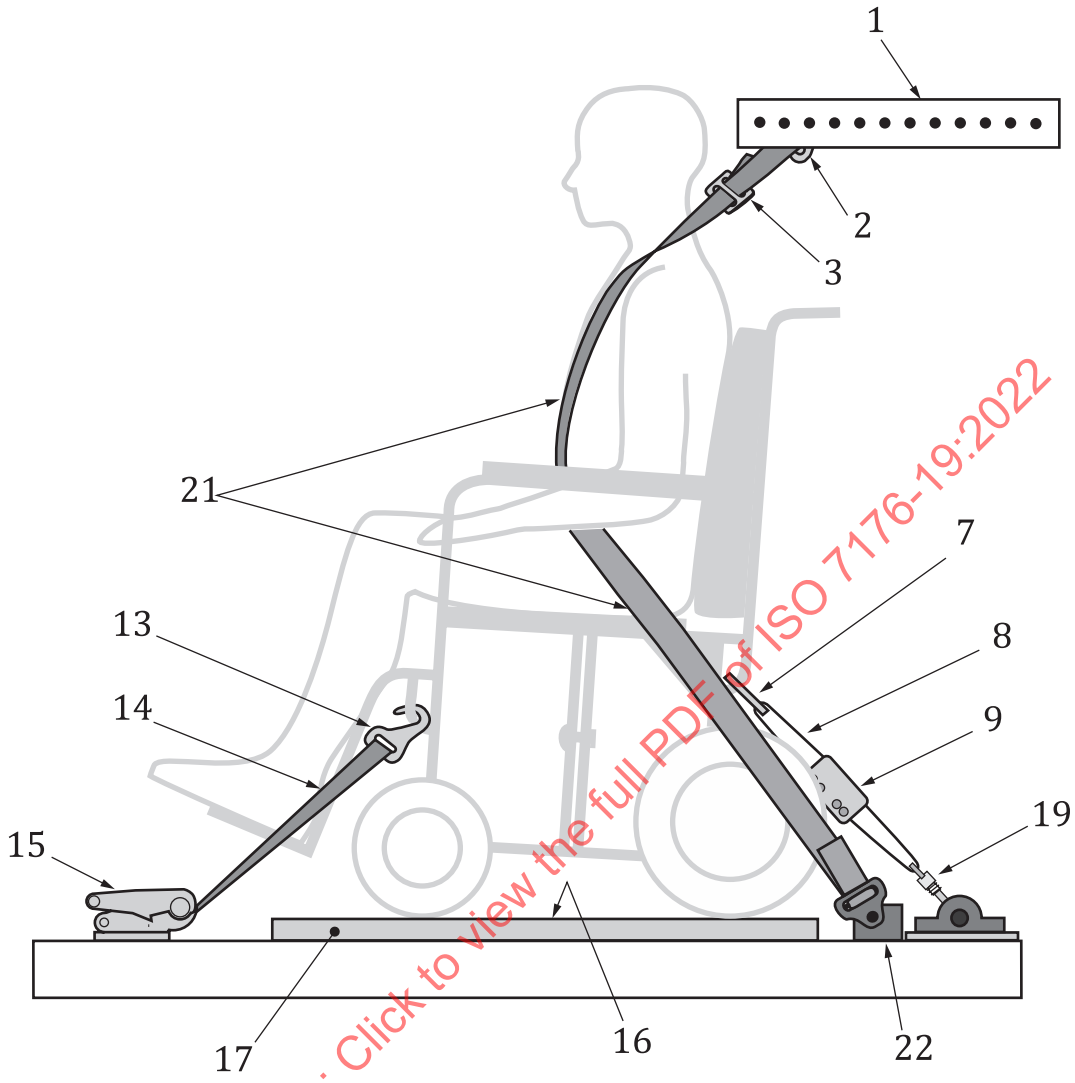
a) Side-view drawing of SWTORS with a surrogate shoulder belt and a wheelchair-mounted pelvic-belt restraint



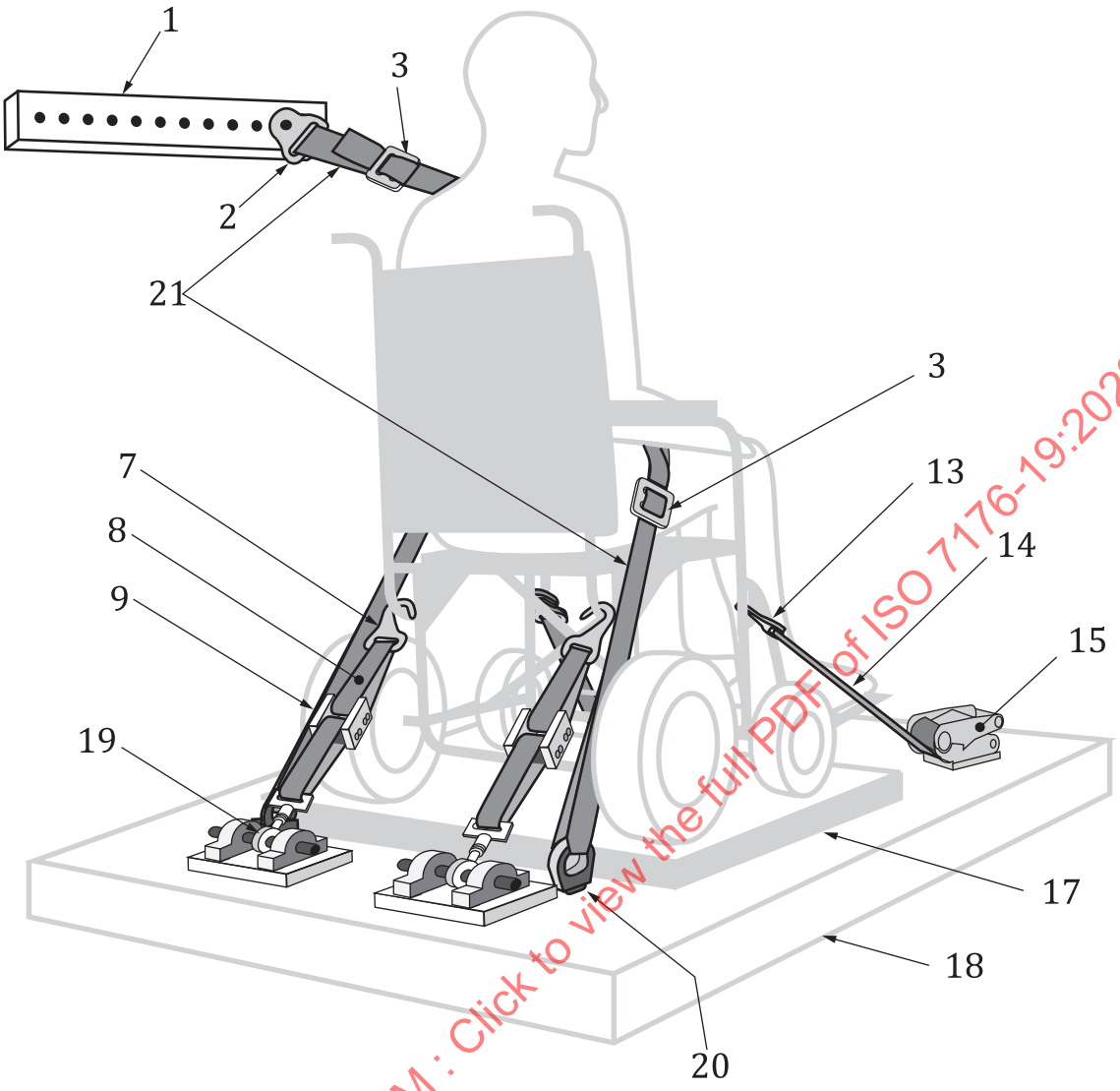
b) Rear-oblique view drawing of SWTORS with a surrogate shoulder belt and a wheelchair-mounted pelvic-belt restraint



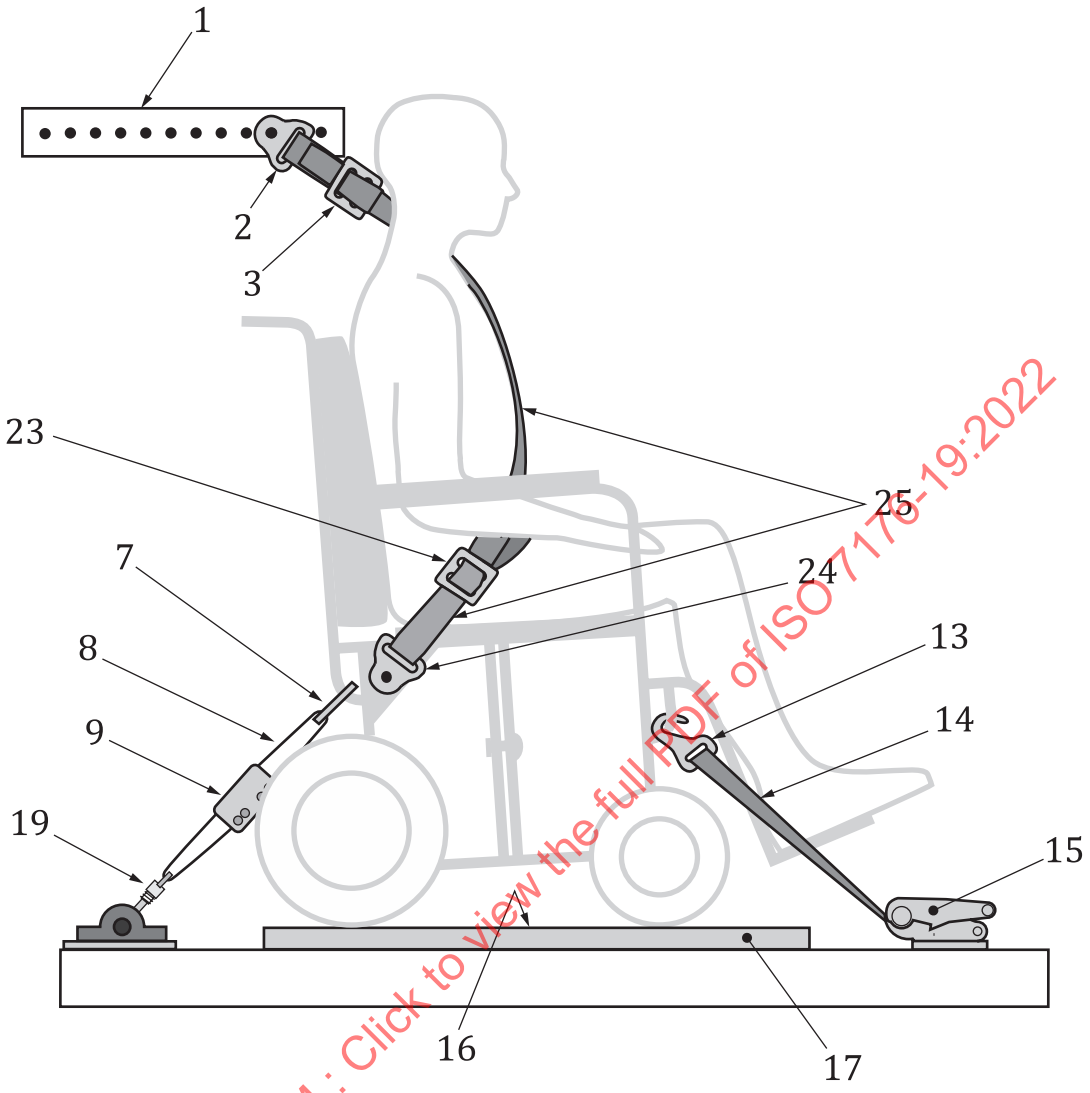
c) Inboard side-view drawing of SWTORS with a surrogate three-point vehicle-mounted belt restraint for optional testing of wheelchairs and seating systems



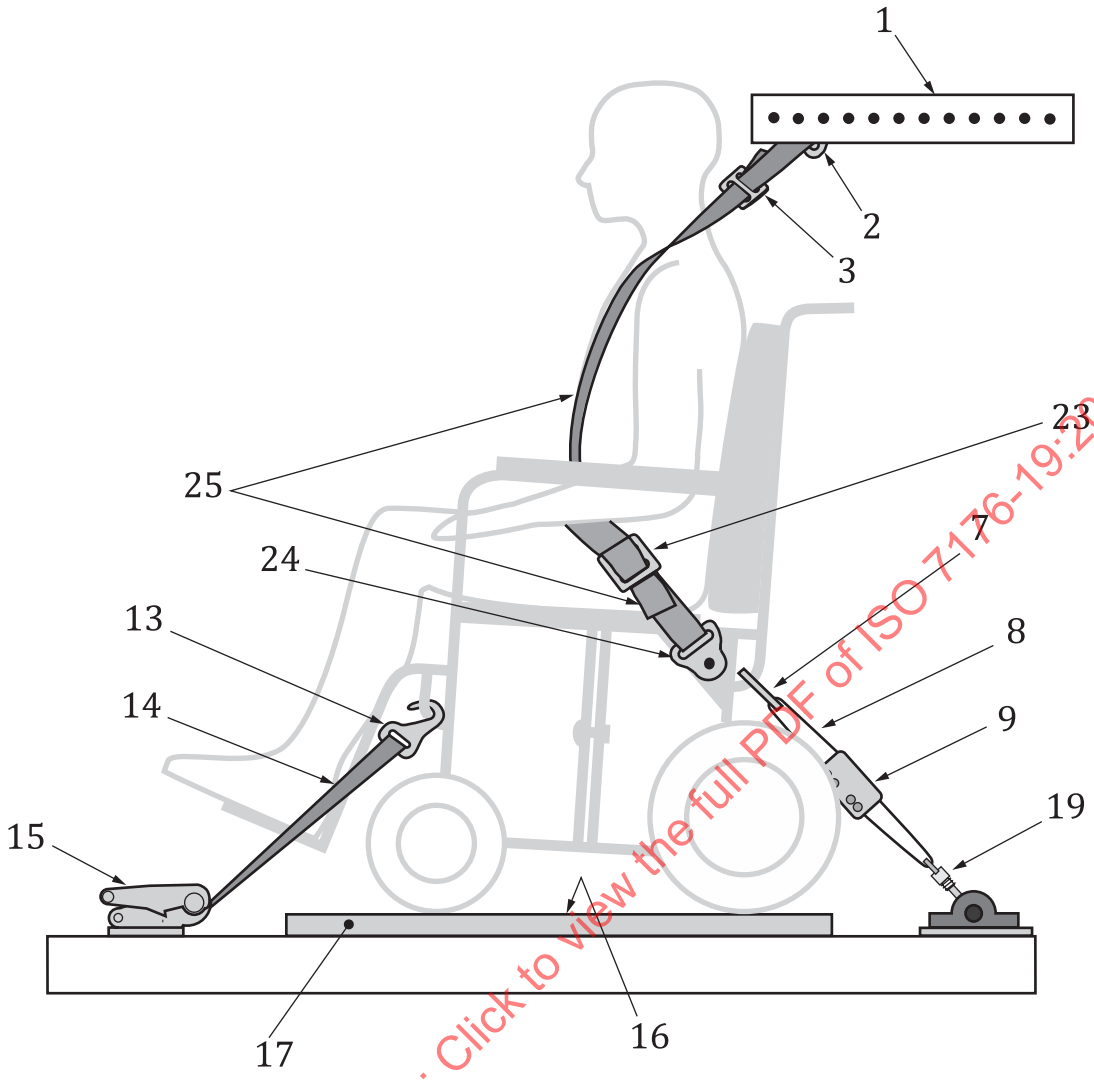
d) Outboard side-view drawing of SWTORS with a surrogate three-point vehicle-mounted belt restraint for testing of wheelchairs and seating systems



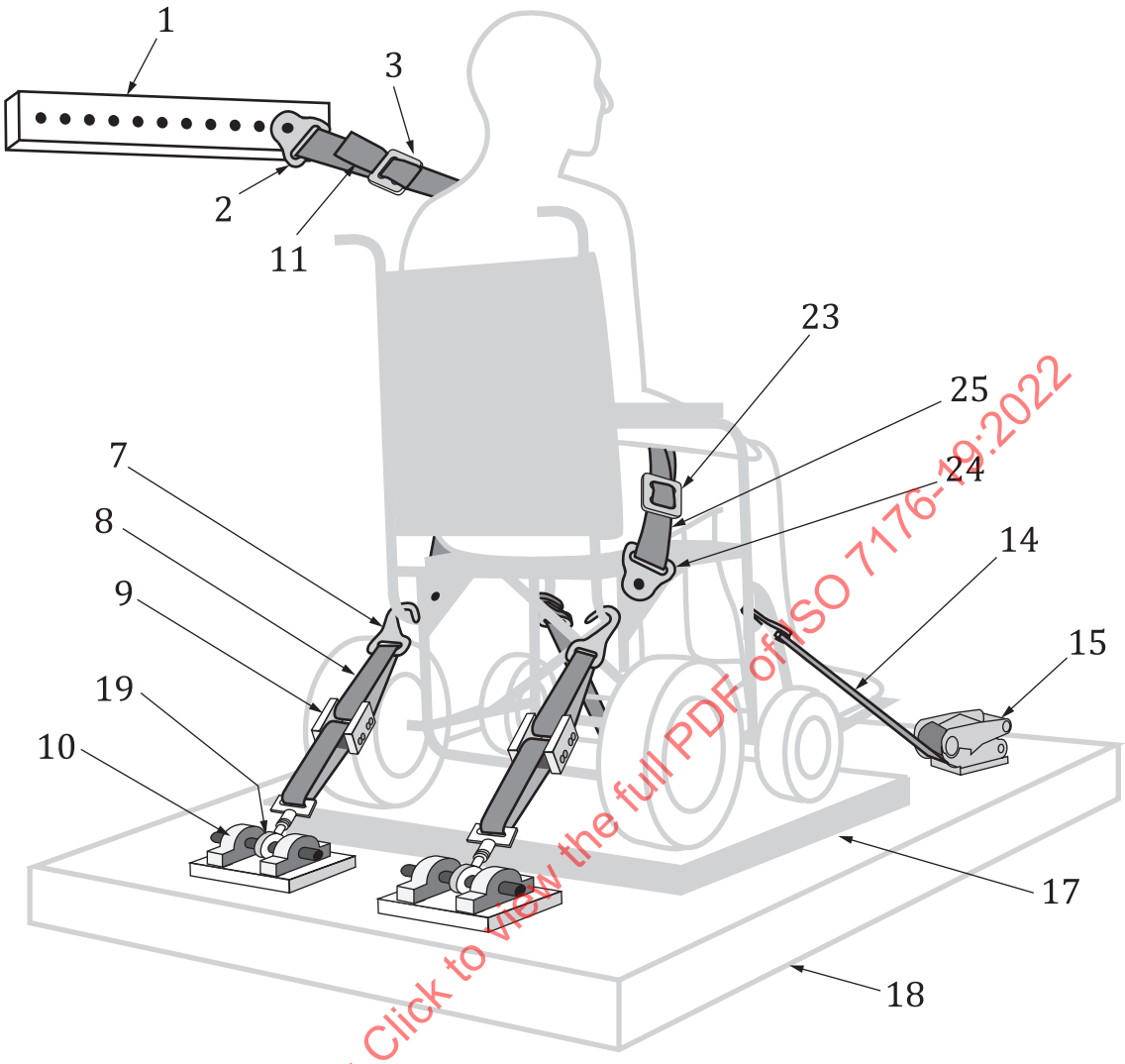
e) Rear-oblique view drawing of SWTORS with a surrogate three-point-belt restraint with a vehicle-mounted pelvic belt for testing of wheelchairs and seating systems



f) Inboard side-view drawing of SWTORS with a surrogate three-point belt restraint with a wheelchair-mounted pelvic belt for testing of seating systems or tiedown/securement systems



g) Outboard side-view drawing of SWTORS with a surrogate three-point belt restraint with a wheelchair-mounted pelvic belt for testing of seating systems or tiedown/securement systems



h) Rear-oblique view drawing of SWTORS with a surrogate three-point belt restraint with a wheelchair-mounted pelvic-belt for testing of seating systems or tiedown/securement systems

Key

1	rigid D-ring anchor points	14	front tiedown strap
2	pivoting D-ring	15	ratchet spool
3	3-bar belt fastener	16	wheelchair ground plane
4	pin-bushing standard connector	17	raised platform
5	pin-bushing mating connector	18	sled platform
6	wheelchair anchor point	19	instrumented rod-end bearing
7	rear tiedown hook	20	pelvic-belt floor anchorage eyenut
8	rear tiedown webbing loop	21	surrogate 3-point vehicle-mounted belt restraint
9	split drum grip assembly		
10	rear tiedown anchorage assembly	22	pelvic-belt latch plate floor anchorage

11	surrogate shoulder belt	23	heavy duty 3-bar belt fastener
12	production WC- mounted pelvic belt	24	pivoting pelvic-belt D-ring anchorage
13	front tiedown hook	25	surrogate 3-point vehicle-mounted

Figure E.1 — Side-view and rear-oblique view drawings of different SWTORS configurations

Annex F
(informative)

Specifications for wheelchair Universal Docking Interface Geometry (UDIG)

F.1 General

This annex provides the specifications for the UDIG for wheelchair structural components and/or wheelchair securement adaptors intended to permit engagement between vehicle-installed docking securement devices and wheelchairs that conform with these specifications. These specifications also include the three-dimensional clear zones surrounding the UDIG within which a UDIG compatible docking securement device can effectively function. The purpose of the UDIG is to allow wheelchair occupants to independently secure and release their wheelchairs in public transportation and/or multiple private vehicles by ensuring engagement compatibility between wheelchair securement points, including wheelchair securement adaptors, and docking securement devices installed in the vehicle. Adoption of this UDIG specification by wheelchair and WTORS manufacturers will facilitate the safe and independent travel of wheelchair occupants and the efficiency of transporting wheelchair occupants by transportation providers.

F.2 Principle

The criteria used to formulate the specifications for the UDIG are that it should

a) not impede the proper use and positioning of occupant restraints,

b) not preclude the use of other types of tiedown devices, such as four-point strap systems or clamp-type securement,

c) permit the retrofitting of UDIG adaptors to existing wheelchairs,

d) require minimal structural design modifications to most common wheelchairs,

e) enable effective wheelchair securement in public transportation and/or multiple private vehicles,

f) facilitate the design of UDIG adaptors, wheelchair securement points, and docking securement devices that will withstand the wheelchair securement loads consistent with the frontal-impact test specified in ISO 10542-1:2012, Annex A,

g) minimize any increase to the mass of the wheelchair,

h) minimize any loss of aesthetics or function of the wheelchair, and

i) not interfere with other wheelchair features and functions.

F.3 Specifications for the UDIG and clear zones

A wheelchair securement adaptor that conforms to this UDIG specification shall

a) have geometry as specified in Figure F.1,

b) be spatially located relative to the wheelchair and ground plane as specified in Figure F.2,

c) have operational clear zones, in which UDIG-compatible docking engagement mechanisms can function without obstruction, as specified by Key 6 in Figures F.3 and F.4,

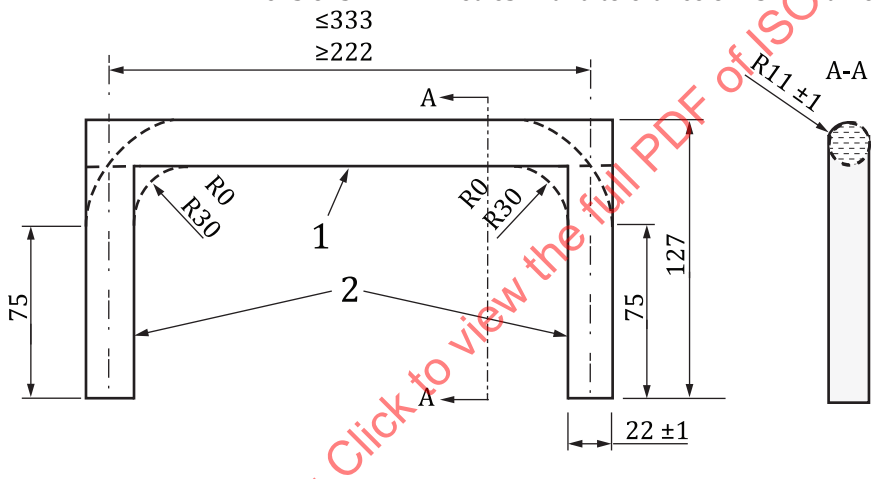
NOTE The intent of the specifications is to provide at least 25 mm clearance between any part of the UDIG and any part of the wheelchair, except in those locations specified by Key 5 in Figures F.3 and F.4, for attachment of the UDIG securement points to the wheelchair.

d) have a horizontal segment when mounted on wheelchairs with a mass greater than 30 kg, as illustrated by Key 1 in Figure F.1. The horizontal component is not required on wheelchairs with a mass less than 30 kg to permit lighter-weight manual wheelchairs with sideways-folding frames to be folded without having to remove the UDIG adaptor,

e) attach to the wheelchair structure using the attachment zones specified by Key 5 in Figures F.3 and F.4, and

f) Zones specified to be used for attachment of UDIG securement points by Key 5 in Figures F.3 and F.4 should not be designed for engagement with the docking securement device, as obstruction could occur.

Dimensions in millimetres with a tolerance of ±3 mm unless otherwise noted



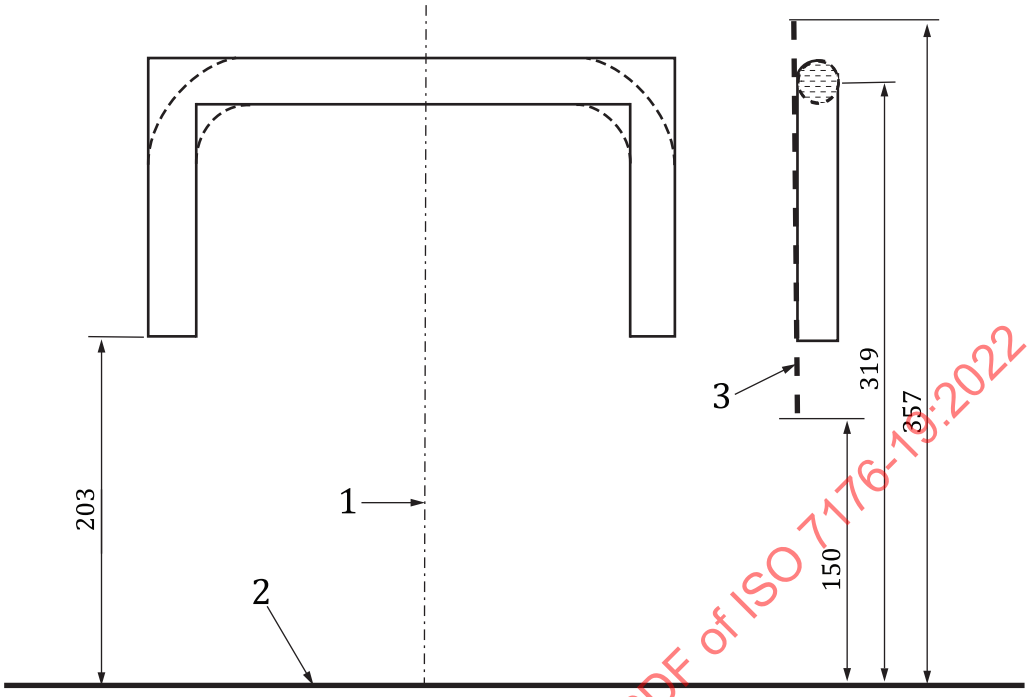
Key

1 horizontal segment

2 vertical segment

Figure F.1 — Specification of the UDIG (rear view and side view at section A-A)

Dimensions in millimetres with a tolerance of ±3 mm unless otherwise noted



Key

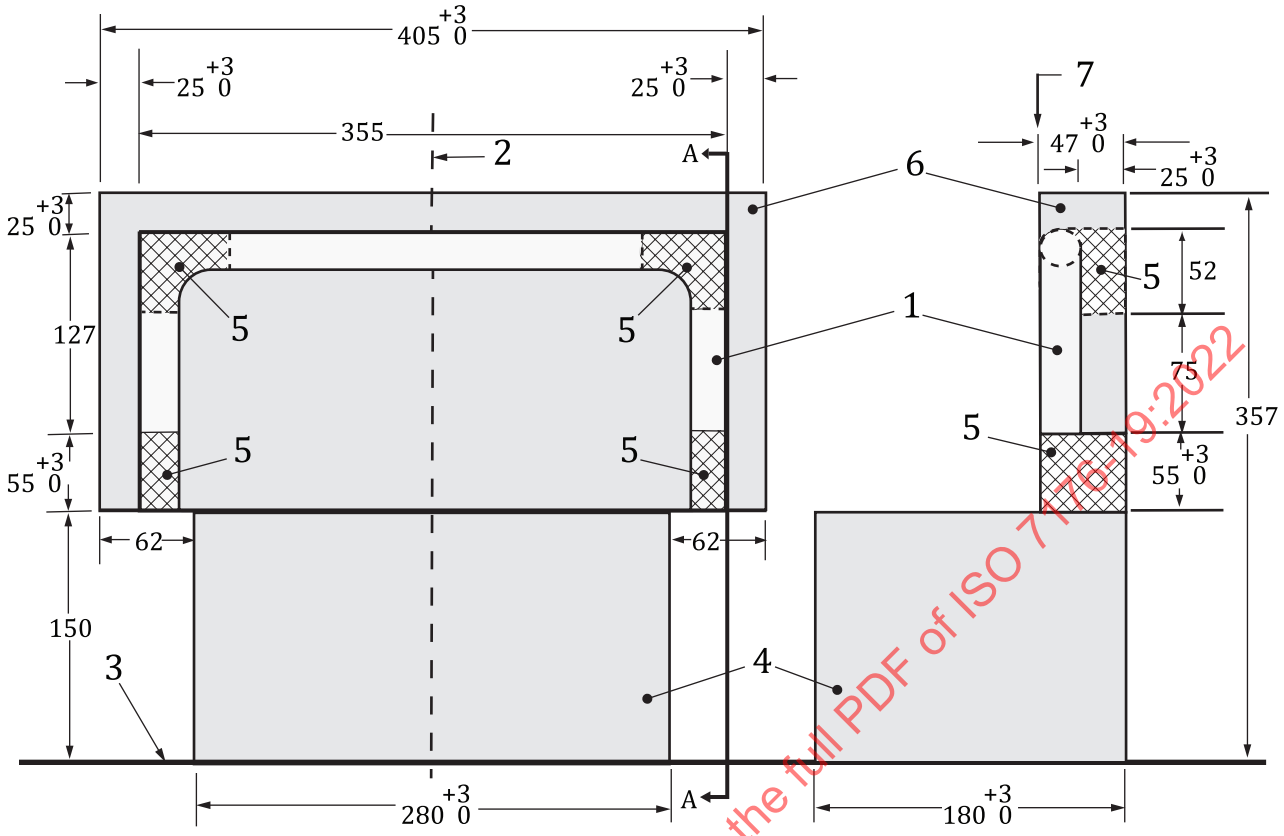
1 wheelchair reference plane (centreline) (the UDIG is located symmetrically about this plane)

2 wheelchair ground plane

3 rearmost reference plane, defined by a vertical line in the side view that passes through the most rearward point on the most rearward structural component of the wheelchair in a zone from 150 mm to 357 mm above the ground plane

Figure F.2 — Specification for the vertical and horizontal location of a UDIG adaptor, (rear and side view)

Dimensions in millimetres with a tolerance of ±3 mm unless otherwise noted

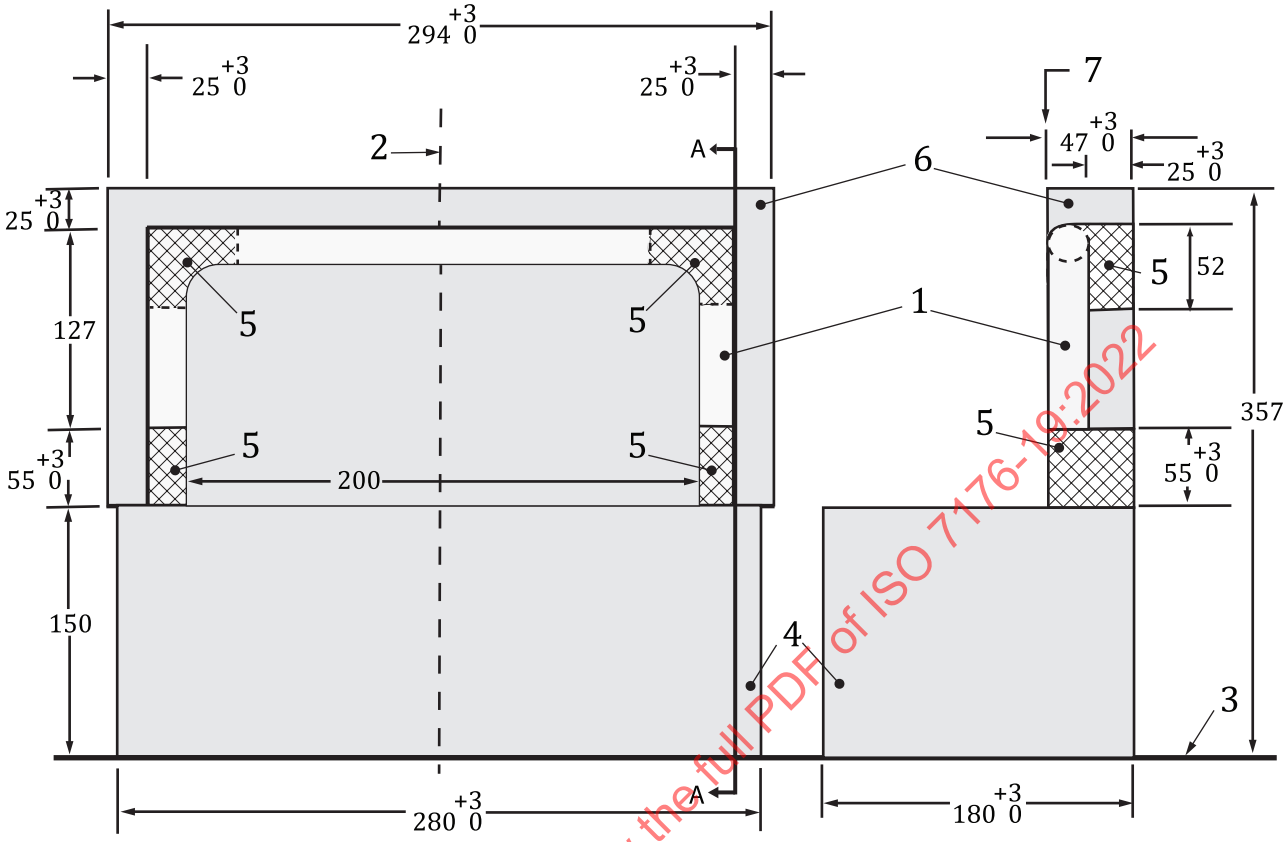


Key

1 UDIG in its maximum width configuration
2 wheelchair reference plane
3 wheelchair ground plane
4 docking-station clear zone that typically falls between the anti-tip devices of wheelchairs
5 attachment zones in which hardware for attaching the UDIG adaptor to the wheelchair may be located
6 clear space around the UDIG in which the docking engagement mechanism may function without obstruction
7 location of rear-most wheelchair structure at 150 mm to 357 mm above ground plane

Figure F.3 — Specification of the UDIG clear zones, shown in maximum width configuration (rear view and side view at section A-A)

Dimensions in millimetres with a tolerance of ±3 mm unless otherwise noted



Key

1 UDIG in its minimum width configuration
2 wheelchair reference plane
3 wheelchair ground plane
4 docking-station clear zone that typically falls between the anti-tip devices of wheelchairs
5 attachment zones in which hardware for attaching the UDIG adaptor to the wheelchair may be located
6 clear space around the UDIG in which the docking engagement mechanism may function without obstruction
7 location of rear-most wheelchair structure at 150 mm to 357 mm above ground plane

Figure F.4 — Specification of the UDIG clear zones, shown in minimum width configuration (rear view and side view at section A-A)

Annex G
(informative)

Wheelchair design, performance, and labelling recommendations for improved protection of occupants seated facing forward in wheelchairs during rear impacts

G.1 General

When people who remain seated in forward-facing wheelchairs riding in or driving motor vehicles are involved in rear-impact collisions, the wheelchair back support is the primary occupant restraint. As with vehicle seatbacks, wheelchair back supports shall limit rearward movement of the occupant's torso relative to the vehicle interior to prevent occupant ejection from the wheelchair and/or the vehicle, which will significantly increase the risk of serious injury due to contact with vehicle components, other occupants, or objects outside the vehicle.

At the current time, the only test of wheelchair back supports is loading of the ATD, or crash-test dummy in the frontal impact test of Annex A. Wheelchair back supports are not tested to the same static and dynamic load levels used in performance testing of vehicles seatbacks. in, for instance, FMVSS 207, UN Regulation No. 17, and other motor-vehicle safety standards, such as the rear-impact fuel-tank integrity test of FMVSS 301. Additionally, rear-impact sled tests of wheelchairs, including wheelchairs that conform with the performance criteria of 5.2 have shown that wheelchair back supports often do not provide effective occupant restraint in moderate-to-severe rear impacts, and can fail catastrophically in these tests.

Vehicle rear-head restraints are attached to, or integrated into, the vehicle seatback and are designed to limit the rearward movement of an occupant's head relative to the torso, and thus limit rearward rotation of the neck (i.e. neck extension) during rear impacts. When properly designed and positioned relative to the occupants head during normal vehicle travel, head restraints can further reduce the risk of serious head and neck injuries in rear-impact crashes. While all wheelchairs have back supports, some wheelchairs are also equipped with rear head supports that were designed to keep the head and neck upright during normal operation of the wheelchair, but were not designed to provide effective rear head restraint in rear-impact crashes. It is, however, possible to design wheelchair head supports, whether part of the original wheelchair equipment or added to the wheelchair as aftermarket components, so that they can serve a dual role of offering head support during normal wheelchair use and effective head restraint in vehicle rear impacts.

This annex sets forth design guidelines, a rear-impact test method and associated performance criteria, and manufacturer product labelling and literature recommendations for wheelchair manufacturers who wish to design their products with back supports and head supports that will provide effective restraint for the torso and head of their occupants when seated in wheelchairs while facing forward in a motor vehicle during rear-impact collisions. Wheelchairs that conform with these guidelines and performance rear-impact performance criteria will reduce the risk of serious head, neck, and torso injuries during rear-end crashes.

The severity of the rear-impact test in this Annex has been selected to be representative of the impact severity used to test vehicle seatbacks in the FMVSS 301 fuel-tank integrity test, and has been shown to also represent a moderate-to-severe real-world impact (about 80th percentile) based on analysis of representative crash-investigation databases, such as the National Automotive Sampling System (NASS) established and maintained by the National Highway Traffic Safety Administration (NHTSA).

G.2 Design recommendations for back supports and head support/restraints

G.2.1 Principle

A head restraint is a device intended to limit the rearward displacement of an occupant's head during crash events, and when properly designed and positioned, a head restraint can reduce the incidence of head and neck injuries in rear-impact crashes. Many wheelchairs are equipped with back supports or head supports that were not designed to provide crash protection and whose effect on injury outcomes is unknown. In some cases, head supports and head restraints are added to a wheelchair as aftermarket items and these would need to be tested in accordance with the dynamic test protocols in Annex A and Annex G with a commercial wheelchair to ensure that the attachment hardware is sufficient for the transportation environment. This clause provides specifications for head supports that can function as head restraints and are consistent with the goal of reducing injury.

G.2.2 General specifications

To provide head and back restraint, wheelchairs should

a) have head supports/restraints that are attached to the back support and not detach from the wheelchair when tested to the dynamic test criteria of Annex A or Annex G,

b) have a back support for the wheelchair occupant with sufficient height so that the top of the back support is at or above the height of the centre of rotation of the shoulder joint for the ATD selected for testing in G.3.3,

c) provide a padded head support/restraint contact surface that has energy absorbing properties similar to those required in automotive head restraints,

d) provide a padded head support/restraint surface of width ≥170 mm,

e) allow the head support/restraint to adjust so that the top-edge height equal to that of the most rearward point on the head of the ATD selected for testing in G.3.3, and

f) be able to adjust and fix the fore/aft position of the head support/restraint so that the smallest horizontal distance between the front surface and the most rearward point on the ATD's head is no more than 55 mm when the ATD is set up for testing in accordance with G.3.4

NOTE The 170 mm minimum width of the head support/restraint and the 55 mm backset are drawn from the requirements for automotive head restraints.

G.3 Rear-impact test

G.3.1 General

To simulate a typical moderate-to-severe rear-impact event to an occupied wheelchair, the wheelchair is placed on the test platform of an impact sled facing rearward to the direction of sled acceleration and/or deceleration. The wheelchair is loaded with an appropriate-size ATD and is secured by a four-point strap-type tiedown system, and the ATD is restrained by a three-point vehicle or wheelchair-mounted belt restraint. The sled is subjected to an acceleration/deceleration-time pulse that falls within a specified corridor to achieve the required horizontal change in velocity, or delta V. Observations and measurements are made during and after the test to determine if the wheelchair was effectively secured throughout the test, and if the back support and head support/restraint provided effective restraint for the ATD during rear-impact loading.

G.3.2 Test sample

An unused, complete production or prototype wheelchair shall be used for each test. The wheelchair may include a head support/restraint or an aftermarket head support/restraint may be added to the wheelchair.

NOTE Wheelchairs that have back supports and head supports/restraints that meet the design guidelines of G.2.2 are more likely to meet the performance criteria of this rear-impact test.

G.3.3 Test equipment

G.3.3.1 Impact simulator and surrogate tiedown/restraint equipment

An impact simulator shall be used that includes

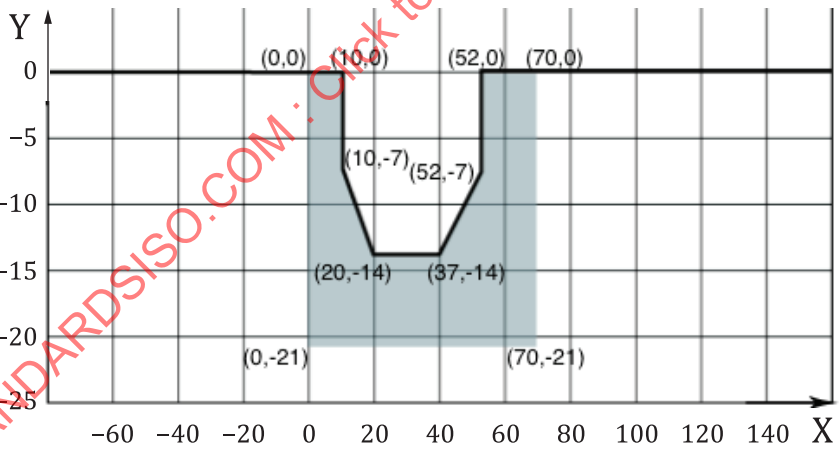
a) an impact sled equipped with a flat, horizontal, structurally rigid platform on which the wheelchair can be placed and to which anchorages of a WTORS with a four-point strap-type tiedown and three-point belt restraint can be fastened,

b) a rigid structure for attaching the upper shoulder-belt anchorage with adjustability in anchor-point location to achieve the desired shoulder-belt angles specified in Annex A,

c) a means to accelerate and/or decelerate the impact sled such that the processed acceleration and/or deceleration-time pulse falls within the shaded area of Figure G.1 and to achieve a change in sled velocity of 25 km/h -0+2 km/h,

d) a surrogate four-point strap-type tiedown and three-point belt restraint system, as defined in this document that conforms to ISO 10542-1, and

e) a Hybrid III ATD selected from Table G.1 based on wheelchair manufacturer's recommended occupant mass capacity.



Key

X time (ms)

Y acceleration (g)

Figure G.1 — 25 km/h acceleration corridor for rear impact test

Table G.1 — Available ATD for wheelchair rear-impact testing

Occupant mass range kg	ATD size	Approximate mass of ATD kg
18 to ≤27	6-year-old child	22
>27 to ≤43	10-year-old child	35
>43 to ≤57	Small adult female	47
>57 to ≤75	Small adult female, weighted [a]	59
>75 to ≤136	Midsize adult male	77
>136	Large adult male	102

[a] The ATD mass can be increased by attaching weighted material, such as lead sheeting, to the exterior of the ATD.

G.3.3.2 Test instrumentation and data collection

A means shall be provided to

a) measure the ATD and wheelchair horizontal excursions specified in G.3.6.2 with a precision and accuracy of ±5 mm using a side-view high-speed camera or video system with a minimum frame rate of 500 frames per second,

b) measure the horizontal acceleration and/or deceleration of the impact sled in the direction of travel, at a sampling rate in accordance with ISO 6487, and with a precision of ±0,5 g,

c) measure the horizontal velocity change (delta-V) of the impact sled during the impact with a precision of ±0,5 km/h, and

d) filter transducer signals using a low-pass filter in accordance with ISO 6487, including

   1) pre-filtering of all transducer signals to Channel Class 1 000 (–4 dB at 1 650 Hz) prior to digitizing at 10 000 Hz, and

   2) filtering of the digitized accelerometer and load-cell signals to Channel Class 60 (–4 dB at 100 Hz).

G.3.4 Test preparation and procedure

G.3.4.1 Perform the following prior to initiating the test.

a) Adjust the ATD to achieve a static resistance of 1 g at each joint indicated by just noticeable movement from the weight of the distal body segment as specified by the ATD manufacturer.

b) Place snug-fitting cotton clothing on the pelvis, thighs, and torso of the ATD.

c) Prepare the wheelchair for use in a motor vehicle as specified by the manufacturer's user instructions. If a range is specified for any adjustments, use the adjustment closest to the midpoint of the range for testing. If more than one adjustment position can be considered closest to the midpoint, use the adjustment position immediately rearward, down, outboard or more reclined from midpoint.

d) Equip the wheelchair with any required wheelchair securement adaptor as specified by the manufacturer.

e) If a pelvic belt intended for use as an occupant restraint is provided as a component of the wheelchair, attach it to the wheelchair according to the manufacturer's instructions.

f) If the wheelchair is equipped with non-impact worthy batteries they should be replaced by the nearest equivalent gel, sealed or a surrogate battery. Supplemental weights, if used, shall provide equivalent mass distribution to the original batteries.

g) Inflate any pneumatic tyres to the pressure recommended by the wheelchair manufacturer or to the maximum sidewall pressure with the chair unoccupied and on a level surface if no specification is given.

h) Turn the wheelchair power off, if applicable.

G.3.4.2 Install the wheelchair tiedown anchorages on the sled platform in accordance with the SWTORS instructions in the engineering package referenced in Annex E and the tiedown spacing and installation procedures of ISO 10542-1:2012, Annex A.

G.3.4.3 Position the wheelchair on the sled in the orientation appropriate for representing vehicle accelerations during rear-impact event and with the wheelchair reference plane parallel to the direction of sled travel ±3°.

G.3.4.4 Secure the wheelchair with the surrogate wheelchair tiedown according to the instructions in Annex E. Follow the tiedown spacing and installation procedures in of ISO 10542-1.

G.3.4.5 If applicable, apply wheelchair brakes.

G.3.4.6 If applicable, adjust the seat, back support, and head support/restraint in accordance with the instructions in A.4.5 and also adjust the rear head support/restraint so that its centre is vertically aligned with the most prominent point on the back of the ATD's head and so that the gap between head and head restraint is minimized.

G.3.4.7 Position the ATD in the wheelchair as described in A.4.6.

G.3.4.8 If the wheelchair is provided with postural belts, install and fasten the belts on the ATD as recommended by the manufacturer.

G.3.4.9 If the wheelchair provides for a wheelchair-mounted pelvic-belt restraint, fasten the belt on the ATD as recommended by the manufacturer and then complete the three-point occupant restraint with a vehicle-mounted shoulder-belt restraint. If the wheelchair does not provide a wheelchair-mounted pelvic-belt restraint, then apply the vehicle-mounted three-point belt restraint of the surrogate WTORS to the ATD.

G.3.4.10 Apply contrast markers at

a) the lateral aspect of the ATD's shoulder,

b) point P of the wheelchair (see Figure 2), or a point on the side of the back support of a wheelchair that is as close to the wheelchair point P as possible,

c) points corresponding to rigid structural parts of both sides of the top and the bottom of the back support to provide for measuring the back-support angle during and after the test,

d) two points on the lateral surface of the ATD head, one at the head centre of gravity and one approximately 50 mm directly above the centre of gravity, and

e) on the side of the head support/restraint.

G.3.4.11 Ensure that there is sufficient clear space around the wheelchair so that nothing will interfere with movements of the ATD and wheelchair during the test.

G.3.4.12 Measure and record the locations of all WTORS anchor points relative to the wheelchair rear axle.

G.3.4.13 Measure and record the projected angles of tiedown straps and restraint belts relative to the horizontal longitudinal axis of the sled platform.

G.3.4.14 Measure and record the horizontal and vertical distance between the top front edge of the back support relative to the centres of the tops of the ATD's shoulders.

G.3.4.15 Measure the vertical distances from the centre of the front surface of the rear head support/restraint to the ATD's head centre of gravity and the top-front edge of the back support.

G.3.4.16 Measure the smallest distance between the back of the ATD's head and the front surface of the head support/restraint.

G.3.4.17 Measure the back-support angle.

G.3.4.18 Measure the right and left H-point height of the ATD.

G.3.4.19 Conduct the impact test by activating the sequence of events to record data and initiate the impact acceleration/deceleration of the impact sled.

G.3.5 Test and post-test measurements and calculations

G.3.5.1 Examine the wheelchair and ATD to determine and/or measure

a) whether the ATD remained in the wheelchair,

b) whether the wheelchair remained on the test platform,

c) whether any securement points on the wheelchair showed signs of failure,

d) whether any load-bearing parts of the wheelchair became separated, deformed, or fractured,

e) whether rigid wheelchair components greater than 150 g became detached,

f) the average of the angles, relative to the vertical, of the left and right structural members of the back support, and

g) the final distance between the centre of the head support/restraint and the top edge of the back support.

G.3.5.2 Determine peak excursions X_{wc} and X_{headR} as defined in G.3.6.2, to a precision and accuracy of ±5 mm.

G.3.5.3 Determine the change in head-to-torso angle between the pre-impact posture and peak head-to-back rotation to a precision and accuracy of ±0,5° through analysis of the high-speed digital video and/or analysis of transducer information.

G.3.5.4 Determine peak dynamic back support angle to a precision and accuracy of ±0,5° by averaging the maximum angles observed on the left and right sides through analysis of the high-speed digital video.

G.3.5.5 Use an inclinometer to estimate the maximum projected angle, relative to the vertical, of the ATD's torso in the post-test orientation, when viewed from all directions.

G.3.5.6 Release the occupant restraint and remove the ATD, while noting any wheelchair deformation that interferes with removal of the ATD from the wheelchair.

G.3.5.7 Release the wheelchair from the tiedown hooks/straps and document any conditions that prevent manual removal of the tiedowns from the wheelchair securement points.

G.3.5.8 Measure and record the final location of adjustable wheelchair and seating components from their pre-test locations.

G.3.5.9 Measure the right and left H-point height of the ATD.

G.3.6 Performance requirements

G.3.6.1 General

When the wheelchair is tested in accordance with G.3.2 to G.3.5 the following criteria shall be met.

G.3.6.2 During the test

a) The horizontal excursions of the ATD and the wheelchair with respect to the impact sled shall not exceed the limits in Table G.2 until motion of the ATD and wheelchair has ceased.

b) The change in head-to-torso angle of the ATD shall not exceed 30°.

NOTE 1 Torso angle can be more easily measured with the addition of a rigid target bracket bolted between the torso and neck of the ATD or with the addition of appropriate transducers in the ATD head and chest.

c) The back support recline angle shall increase during the test by at least 10° to the vertical.

d) The peak dynamic back support angle of the wheelchair shall not exceed 65° to the vertical.

NOTE 2 Back support angle is the angle relative to vertical of the surface supporting the ATD torso. Automotive research has shown that deflections exceeding 65 degrees are associated with an increased threat of ejection.

Table G.2 — Horizontal excursion limits

Dimensions in millimetres

Measurement point	Excursion variable	6-year old child ATD	10-year old child ATD	Small adult female ATD	Midsize and large adult ATD
Wheelchair point P	X_{wc}	150	175	200	200
ATD back of head	X_{headR}	-350	-400	-400	-450

X_{wc} is the horizontal distance relative to the sled platform between the point P target on the wheelchair at time t_0, to the point P target at the time of peak rearward wheelchair excursion.

X_{headR} is the horizontal distance relative to the sled platform between the most rearward point on the ATD's head at time t_0, to the most rearward point on the ATD's head at the time of peak rearward head excursion (i.e. peak excursion toward the rear of the simulated vehicle).

NOTE See the last paragraph of A.4.11 for a description of how to estimate the point P excursion when it is not possible to place a contrast marker at point P.

G.3.6.3 After the test

a) The wheelchair shall remain in an upright position on the test platform and the ATD shall be retained in the wheelchair in a seated posture, as determined by the ATD torso being oriented at not more than 45° to the vertical when viewed from any direction.

b) The wheelchair securement points shall not show complete failure.

c) Components, fragments, or accessories of the wheelchair that are rigid and with a mass in excess of 150 g shall not have completely separated from the wheelchair.