INTERNATIONAL STANDARD

ISO 10542-1

Second edition
2012-10-01

Technical systems and aids for disabled or handicapped persons — Wheelchair tiedown and occupant-restraint systems —

Part 1: Requirements and test methods for all systems

Assistances et aides techniques pour les personnes invalides ou handicapées — Systèmes d'attache du fauteuil roulant et de retenue de l'occupant —

Partie 1: Exigences générales et méthodes d'essai pour tous les systèmes

Reference number
ISO 10542-1:2012(E)

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Published in Switzerland

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Foreword

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

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10542-1 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

This second edition of ISO 10542-1 cancels and replaces ISO 10542-1:2001, ISO 10542-2:2001, ISO 10542-3:2005, ISO 10542-4:2004 and ISO 10542-5:2004, which have been consolidated into one part.

ISO 10542 consists of the following parts, under the general title *Technical systems and aids for disabled or handicapped persons — Wheelchair tiedown and occupant-restraint systems*:

— *Part 1: Requirements and test methods for all systems*

Introduction

Many wheelchair users remain in their wheelchairs during motor-vehicle transport and hence their wheelchair serves as a vehicle seat. This usually means that the occupant restraint system installed by the vehicle manufacturer cannot be used to provide protection in a crash. In addition, the wheelchair needs to be secured to the vehicle so that it does not impose forces on its occupant and/or become a hazard to other vehicle occupants in collisions or sudden vehicle manoeuvres. Providing safe transportation for wheelchair-seated occupants therefore requires that equipment be used to provide effective wheelchair securement and occupant restraint.

This part of ISO 10542 applies to the design, testing, installation and use of wheelchair tiedown and occupant restraint systems (WTORS) used by forward-facing wheelchair-seated occupants. Transportation-related requirements for wheelchairs that are suitable for forward-facing occupant seating during motor vehicle transportation are specified in ISO 7176-19.

The primary purpose of this part of ISO 10542 is to reduce the risk of serious injuries to wheelchair-seated occupants involved in frontal collisions and it is anticipated that additional parts of ISO 10542 will be developed to address different impact conditions and directions. However, it can be expected that the proper use of equipment that complies with this part of ISO 10542 will also reduce the risk of injury in other types of crashes, as well as in vehicle rollovers, emergency vehicle manoeuvres, and normal operating conditions.

The provisions of this part of ISO 10542 are based on the premise that WTORS manufacturers are generally not able to control the end use of their products. This part of ISO 10542 therefore requires that WTORS intended for general use in all types and sizes of motor vehicles are dynamically tested for crashworthiness performance in a nominally worst-case 48 km/h, 20 g frontal sled impact test using an 85 kg surrogate wheelchair (SWC) and a midsize adult male anthropomorphic test device (ATD) to dynamically load the WTORS.

Although the forces on WTORS components in a small percentage of real-world crash events may exceed those produced in the nominally worst-case frontal-impact test in this part of ISO 10542 due to a number of factors, including higher crash severities, angled frontal impacts, a higher wheelchair mass, and a higher occupant mass, there is currently no evidence of any WTORS system or component failing in a real-world crash. Thus, while the performance of WTORS in real-world crash events needs to be carefully and continuously monitored, at this time there is no basis for increasing the mass of the surrogate wheelchair, the crash-test dummy, or the crash severity used in the frontal-impact test of WTORS intended for general use in this part of ISO 10542. However, in addition to testing to the conditions set forth in this part of ISO 10542, WTORS manufacturers can also test their equipment to higher test conditions than those required by this part of ISO 10542.

This part of ISO 10542 requires that every WTORS include a belt-type occupant restraint since this approach to occupant protection has been shown to be the most effective in frontal crashes, vehicle rollovers, and a large percentage of side impacts, and can be implemented relatively straightforwardly in forward-facing seating positions of passenger vehicles. Since the use of only a pelvic belt restraint will not provide the same level of crash protection and safety as the use of both a pelvic belt restraint and an upper-torso belt restraint, this part of ISO 10542 requires, and only specifies test methods for, WTORS that include both pelvic and upper-torso belt restraint systems.

In this regard, while ISO 7176-19 does not require wheelchairs to be crash-tested with a wheelchair-anchored pelvic-belt restraint, it does allow for this restraint condition, which can offer benefits to wheelchair passengers in terms of improved belt-restraint fit to their lower pelvic region and reduced interference with their personal space by drivers or attendants. In this situation, the tiedown portion of a WTORS will be subjected to higher loading conditions than with vehicle-anchored pelvic belts since a portion of the occupant restraint loads will be transferred through the wheelchair to the wheelchair tiedown/securement system. Thus, WTORS manufacturers may also wish to crash-test their tiedown/securement systems with a pelvic-belt restraint anchored to the surrogate wheelchair.

For accessible transport vehicles intended for use by both sitting and standing passengers (ATV-SS) for which crash events of any significance are rare events, it is generally sufficient to provide equipment and/or systems that provide for effective wheelchair containment and retention of the wheelchair-seated passenger in their wheelchair seating system. Such systems can be evaluated using simulated non-crash vehicle accelerations and decelerations that are less than 1g that are generated in emergency vehicle manoeuvres. For this reason, the use of rearward-facing wheelchair passenger spaces (RF-WPS) can provide a reasonably safe approach

to transporting wheelchair-seated passengers in a manner that is more acceptable to the operational needs of the transportation system. Performance of RF-WPSs is therefore addressed by ISO 10865-1.

At the time this part of ISO 10542 was developed, the four-point strap-type tiedown system was considered to be the most effective and universal method for securing a wide range of wheelchairs occupied by passengers travelling in public, school, and private vehicles. For this reason, ISO 7176-19 requires that wheelchairs intended for use as seats in motor vehicles provide for securement using a four-point strap-type tiedown system by providing at least four designated securement points, with two at the front and two at the back. However, wheelchairs can also be secured in motor vehicles using docking-type tiedown devices, such that the wheelchair is automatically secured when the wheelchair user moves his/her wheelchair into the designated wheelchair space. Currently, use of these types of securement systems is primarily limited to private vehicles where docking securement components added to the wheelchair are matched to the securement device in the vehicle. Annex F provides specifications for a universal docking interface geometry (UDIG), which, when implemented into the securement components of wheelchairs, either by wheelchair manufacturers or by after-market wheelchair adaptors, will allow wheelchair users increased independence and reduce the time required for loading and unloading wheelchair passengers in public vehicle environments.

This part of ISO 10542 establishes additional requirements for WTORS that are intended to be used with specific makes and models of wheelchairs. The belt-type occupant restraints may attach to the wheelchair such that occupant-restraint loads will be transferred through the wheelchair. As such, the performance of both the WTORS and wheelchair are evaluated as a total system.

Technical systems and aids for disabled or handicapped persons — Wheelchair tiedown and occupant-restraint systems —

Part 1: Requirements and test methods for all systems

1 Scope

This part of ISO 10542 specifies design and performance requirements and associated test methods for wheelchair tiedown and occupant-restraint systems (WTORS), as well as requirements for product marking and labelling and manufacturers' instructions and warnings to installers and consumers. It is applicable to all WTORS that use belt-type occupant restraints that are intended for occupied wheelchairs used as forward-facing seats by passengers and drivers of motor vehicles.

This part of ISO 10542 is applicable to WTORS intended for use with all types of manual and powered wheelchairs, including three- and four-wheeled scooters, used by children and adults with a body mass equal to or greater than 22 kg. It is applicable also to WTORS designed for limited use with a particular make or model of wheelchair.

This part of ISO 10542 is applicable primarily to complete WTORS, but portions can also be applied to components and subassemblies sold separately and for replacement parts.

2 Normative references

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

ISO 3795, *Road vehicles, and tractors and machinery for agriculture and forestry — Determination of burning behaviour of interior materials*

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

ISO 7176-19:2008, *Wheelchairs — Part 19: Wheeled mobility devices for use as seat in motor vehicles*

ECE R 16:2009, *Uniform provisions concerning the approval of safety belts, restraint systems, child restraint systems and isofix child restraint systems for occupants of power-driven vehicles,* Revision 6, 19 May 2009

FMVSS 209, *Seat belt assemblies,* Federal Motor Vehicle Safety Standards, 49 CFR part 571.209, 1 October 2004

3 Terms and definitions

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

3.1
adult
person having a mass equal to or greater than 43 kg

3.2
airbag
device installed to supplement occupant restraint systems in power-driven vehicles, i.e. system which, in the event of a severe impact affecting the vehicle, automatically deploys a flexible structure intended to limit, by compression of the gas contained within it, the gravity of the contacts of one or more parts of the body of an occupant of the vehicle with the interior of the passenger compartment

3.3
anchor point
location on a vehicle interior component, floor, wall, wheelchair or wheelchair tiedown, to which an anchorage is attached

3.4
anchorage
assembly of components and fittings by which loads are transferred directly from the wheelchair tiedown to the vehicle, or from the occupant restraint to the vehicle, or wheelchair, or wheelchair tiedown or vehicle interior component

3.5
anthropomorphic test device
ATD
articulated physical analogue used to represent a wheelchair occupant in a test

3.6
automatic-locking retractor
device to accommodate a belt or strap, allowing extraction of the belt or strap to the desired length and which, when the occupant restraint or wheelchair tiedown is fastened, automatically adjusts the belt to the wearer or strap to the wheelchair

NOTE 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 to the back of the torso

3.8
belt
length of webbing material used as part of an occupant restraint or postural support

3.9
child
person having a mass equal to or greater than 22 kg and less than 43 kg

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

3.11
docking tiedown device
docking securement device
assembly of fixtures and components designed for installation in motor vehicles for the purpose of securing a wheelchair by engaging with, and locking onto, securement points on the wheelchair frame or on wheelchair securement adaptors attached to the wheelchair frame

NOTE Securement of the wheelchair generally occurs automatically during wheelchair engagement with the device in the vehicle, but release of the wheelchair usually requires operation of a mechanical lever or electrical switch.

3.12
emergency-locking retractor
retractor with length-adjusting components, which automatically adjust the strap to the wearer, and a locking mechanism actuated in an emergency by deceleration of the vehicle (single sensitivity) or a combination of deceleration of the vehicle, movement of the webbing or any other automatic means (multiple sensitivity)

NOTE During normal driving conditions, the retractor does not restrict the freedom of movement of the wearer of the occupant restraint.

3.13
end fitting
hardware at the securement end of a wheelchair tiedown strap designed to attach to wheelchair securement points on a wheelchair or wheelchair adaptor for the purpose of anchoring the wheelchair in a moving motor vehicle

3.14
excursion
horizontal movement of an ATD or wheelchair relative to its initial position in an impact

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

NOTE These include, but are not limited to, bolts, nuts, screws, pins and rivets.

3.16
forward-facing
orientation in which the wheelchair-seated occupant faces the front of the vehicle, with the wheelchair reference plane within ten degrees of the longitudinal axis of the vehicle

3.17
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

3.18
harness
occupant-restraint assembly consisting of at least one belt designed to provide pelvic restraint and two belts that restrain the upper torso by applying forces to both shoulders

3.19
head restraint
device whose purpose is to limit the rearward displacement of an occupant's head in relation to his/her torso in order to reduce the danger of injury to the cervical vertebrae in the event of an accident

3.20
H point
point located on the left and right sides of the pelvic region of an anthropomorphic test device (ATD) that represent the approximate locations of the human hip joint centres in the side views, as specified by the ATD manufacturer

3.21
impact simulator
device capable of fulfilling the dynamic test requirements specified within Annex A

3.22
impact sled
part of an impact simulator to which components can be mounted for impact testing

3.23
manual adjustment device
mechanism that enables the length and/or tension of a tiedown strap to be adjusted without the use of tools when securing a wheelchair in a vehicle

3.24
occupant restraint
system or device designed to diminish the risk of injury to its wearer, in the event of collision or abrupt deceleration of a motor vehicle, by limiting the mobility of the wearer's body

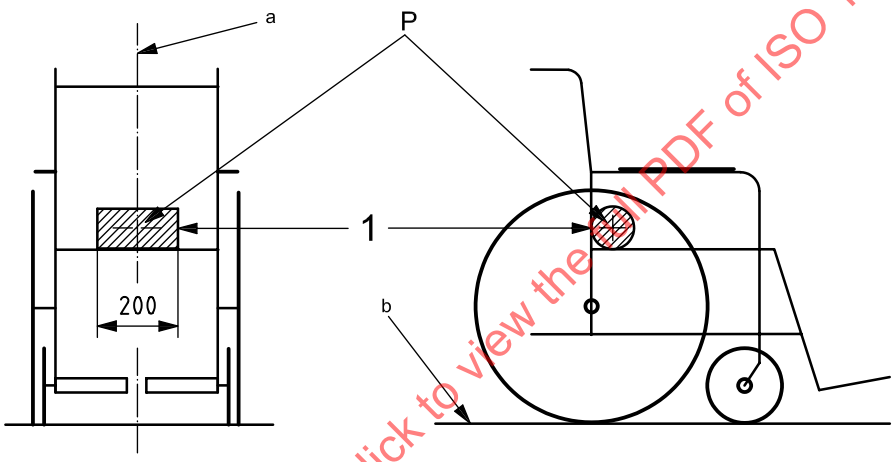
3.25
pelvic belt restraint
lap belt restraint
lower-torso restraint
pelvic belt
lap belt
portion of an occupant restraint which passes across the front of the wearer's pelvic region

See Figure 2.

3.26
point P
reference point that lies at the cross-sectional centre of a cylinder of diameter 100 mm and length 200 mm, positioned with the longitudinal axis perpendicular to the wheelchair reference plane such that the curved surface of the cylinder contacts the back support and the upper surface of the seat

See Figure 1.

Dimensions in millimetres



Key
1 cylinder, diameter 100 mm
P point P

a Wheelchair reference plane.
b Wheelchair ground plane.

Figure 1 — Wheelchair reference point P and wheelchair reference plane

3.27
postural support
postural belt
component or length of webbing material used to support a person in a desired seated position, but not intended to provide occupant restraint in a vehicle impact

3.28
powered docking tiedown device
powered docking securement device
docking tiedown device that uses external power to secure and/or release the wheelchair

3.29
securement points
points on the wheelchair to which wheelchair tiedowns are connected

NOTE Securement points may be located on hardware components that are permanently or temporarily fastened to the wheelchair.

3.30
specific wheelchair model
SWM
make or model of wheelchair for which the WTORS is specifically designed

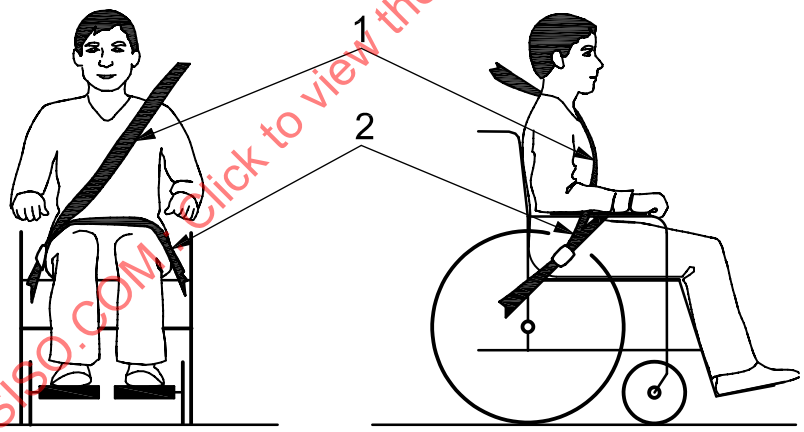
3.31
strap
length of webbing material used in a wheelchair tiedown

3.32
surrogate wheelchair
SWC
rigid, reusable device that conforms with Annex E and that is used to simulate a wheelchair for the purpose of testing wheelchair-tiedown and occupant-restraint systems

3.33
test wheelchair
TWC
SWC or SWM wheelchair that is used to test wheelchair-tiedown and occupant-restraint systems

3.34
three-point belt restraint
three-point belt
assembly of hardware and belt webbing comprised of both a pelvic belt restraint and a shoulder belt restraint with three anchor points that connect together near the hip of the user

See Figure 2.



Key
1 diagonal belt restraint
2 pelvic belt restraint

Figure 2 — Three-point belt restraint

3.35
universal docking interface geometry
UDIG
specifications for the size, shape and location of wheelchair securement points, including surrounding clear zones, intended for engagement with different docking tiedown devices in a wide range of vehicles

3.36
UDIG adaptor
wheelchair tiedown adaptor that conforms to the UDIG specification in Annex G

3.37
upper-torso restraint
shoulder belt restraint
diagonal belt restraint
shoulder belt
diagonal belt
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

3.38
webbing
woven material, used in belt and strap assemblies of occupant restraints and wheelchair tiedowns

3.39
webbing guide
hardware loop or ring anchored to a structural member in the vehicle or wheelchair back support, through which an occupant restraint belt passes, and changes direction, along the path to the vehicle anchor point

3.40
wheelchair footprint
space outlined on the horizontal wheelchair ground plane by projecting vertically down from the outermost edges of the structural members that comprise the mobile base and seat of the wheelchair

3.41
wheelchair ground plane
plane representing the surface on which the wheelchair rests

See Figure 1.

3.42
wheelchair reference plane
vertical plane in the longitudinal centre line of the wheelchair

See Figure 1.

3.43
wheelchair tiedown adaptor
wheelchair securement adaptor
hardware that is attached temporarily or permanently to the wheelchair frame to accommodate wheelchair securement by a wheelchair tiedown device

3.44
wheelchair-tiedown and occupant-restraint system
WTORS
complete restraint system for wheelchair-seated occupants comprised of equipment for wheelchair tiedown and a belt-type occupant restraint

3.45
wheelchair tiedown
wheelchair securement
device or system designed to secure a forward-facing wheelchair in place in a motor vehicle

4 Design requirements

4.1 WTORS

4.1.1 The WTORS shall:

a) consist of equipment to secure the wheelchair independently of the occupant;

b) be designed for use with only one wheelchair and one occupant at a time;

c) include a belt-type occupant restraint, either by specifying use of the occupant restraint and anchorages provided with the vehicle, or by providing a belt-type occupant restraint with the wheelchair tiedown that is designed to anchor to the vehicle or to parts of the wheelchair tiedown;

NOTE Specification of a vehicle-equipped belt-restraint system is primarily for situations in which the WTORS is intended for use by drivers but, even in this situation, it is recommended that the WTORS manufacturer provide a complete system, including both wheelchair tiedown and occupant restraint, for after-market installation in the vehicle.

d) not require components of wheelchair tiedowns and occupant restraints to pass through the wheels of a wheelchair;

e) not require removal of wheelchair frame material, drilling into the wheelchair frame, deformation of the wheelchair, welding, or use of an adhesive process during installation;

f) once installed, be operable without tools;

g) incorporate features to prevent unintentional loosening of all fasteners;

h) have all small manually detachable hardware and fittings tethered to WTORS subassemblies; and

i) include a manual override in case of power failure for any power-operated tiedown or restraint.

4.1.2 WTORS for specific wheelchair models shall include a belt-type occupant restraint either:

a) as stipulated in 4.1.1 c), or

b) by providing a belt-type occupant restraint that anchors to the specific wheelchair model.

4.2 Wheelchair tiedowns

4.2.1 General

In addition to the requirements of 4.1, wheelchair tiedowns and tiedown components shall:

a) not release if any wheelchair component deforms, or if one or more tyres deflate during a vehicle impact;

b) include a means to minimize vehicle-induced movement of the wheelchair that does not require the use of tools;

c) not depend on the wheelchair brakes;

d) not utilize the occupant restraint to secure any portion of the wheelchair.

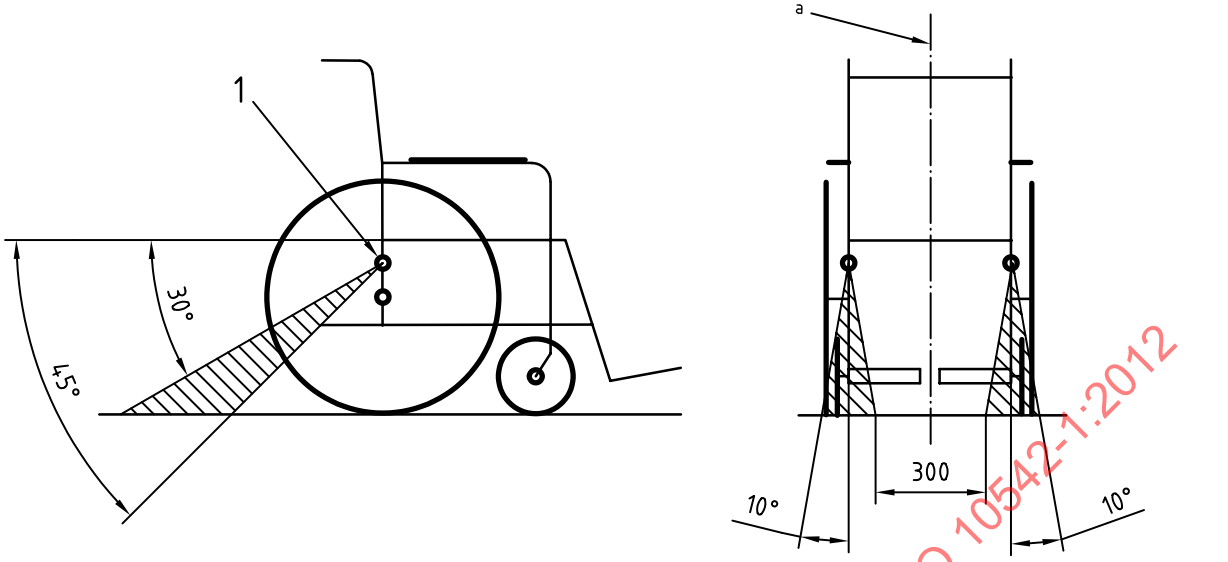
4.2.2 Four-point strap-type tiedowns

4.2.2.1 Four-point strap-type tiedowns shall be designed for effective attachment and tensioning on a wide range of wheelchair types and sizes while meeting the angles in Figures 3 and 4, by providing adjustment in strap assembly length, adjustment in the fore/aft location of vehicle anchor points, or both.

NOTE Figure I.1 shows recommended securement-point zones on wheelchairs for which a four-point strap-type tiedown system should be effective.

4.2.2.2 All securement-point end fittings of four-point tiedown assemblies shall effectively engage with the securement points specified in Figure E.4, and function accordingly when tested to the performance requirements in Clause 5.

Dimensions in millimetres



Key

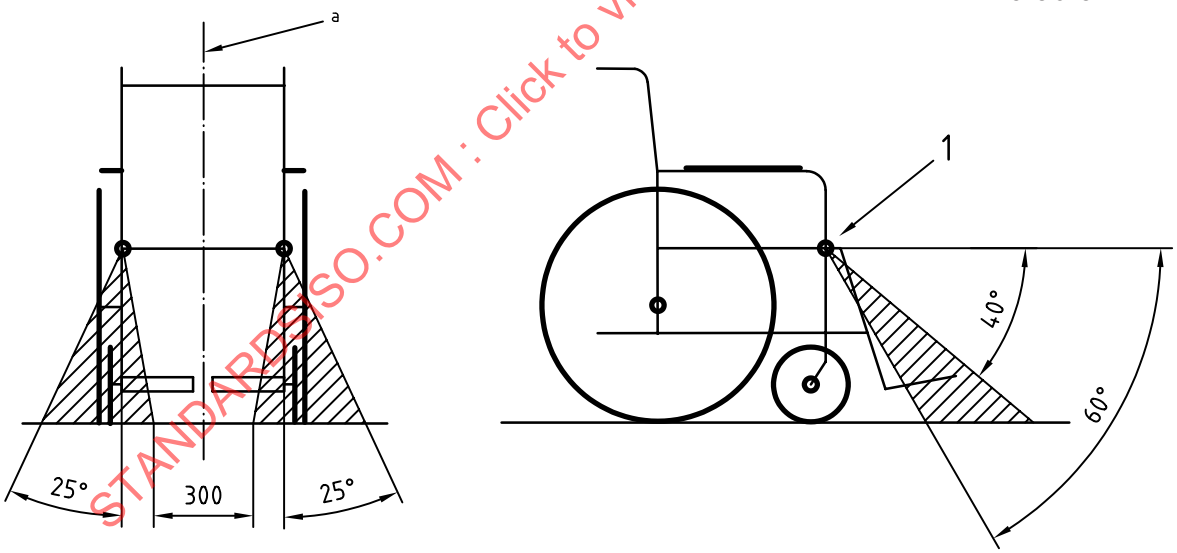
1 rear securement points

NOTE The angles shown are obtained by projecting the angle of each tiedown strap onto a vertical plane parallel to (side view) or perpendicular to (rear view) the wheelchair reference plane.

[a] Wheelchair reference plane.

Figure 3 — Preferred angles of rear wheelchair tiedown straps and locations of tiedown anchor points

Dimensions in millimetres



Key

1 front securement points

NOTE The angles shown are obtained by projecting the angle of each tiedown strap onto a vertical plane parallel to (side view) or perpendicular to (front view) the wheelchair reference plane.

[a] Wheelchair reference plane.

Figure 4 — Preferred angles of front tiedown straps and locations of tiedown anchor points

4.2.3 Docking tiedown devices

4.2.3.1 The docking tiedown device shall:

a) provide a head restraint if the docking tiedown device includes a back restraint;

b) provide auditory and visual means for indicating to the wheelchair user and vehicle driver when the wheelchair has been successfully secured and released;

c) include a manual override to release the wheelchair in the event of loss of power to any power-operated mechanisms that is accessible by an attendant;

d) remain in the locked position until manually released, in the event of loss of power to any power-operated mechanisms;

e) allow for accessible operation by the occupant of any electrical or mechanical devices that are necessary to engage or disengage the docking components;

f) prevent inadvertent release during normal or emergency vehicle operation.

4.2.3.2 For effective operation, the engagement mechanism of the docking tiedown device should allow for misalignment between a wheelchair and docking securement device when:

a) the wheelchair is laterally displaced from the midline of the docking station as much as 25 mm in either direction;

NOTE 1 For docking tiedown systems designed for engagement with a UDIG adaptor, it is recommended to allow for lateral misalignment of as much as 75 mm in either direction.

b) the wheelchair reference plane is rotated from the longitudinal centre line of the vehicle by as much as 10° in either direction;

c) the structural components on the wheelchair that comprise the wheelchair securement points are angled relative to the vertical by as much as 10° in any direction;

d) the height of any structural components comprising the wheelchair securement points vary vertically by as much as 20 mm due to low tyre inflation of the wheelchair.

NOTE 2 For docking tiedown systems designed for engagement with a UDIG adaptor it is recommended to accommodate for vertical variation as much as 50 mm

4.2.3.3 If the docking tiedown device is intended to secure a wide range of wheelchairs in a wide range of public vehicles, it should be designed to effectively engage with the UDIG specifications in Annex F, and function accordingly when tested to the performance requirements in Clause 5.

4.2.4 Clamp-type tiedowns

Clamp-type wheelchair tiedowns shall be designed such that securing and releasing the tiedown according to the manufacturer's instruction shall not require operating forces in excess of 60 N for hand-operated and 100 N for foot-operated devices or 2,25 N·m torque for screw-operated clamp-type tiedowns, and function accordingly when tested to the performance requirements of Clause 5.

4.3 Wheelchair securement adaptors

4.3.1 If a WTORS is designed to be used with a wheelchair securement adaptor, the adaptor shall:

a) not require removal of wheelchair frame material, drilling into the wheelchair frame, deformation of the wheelchair, welding, or use of an adhesive process during installation;

b) be designed to prevent inadvertent loosening from the wheelchair frame during normal use.

4.3.2 If the docking tiedown device is intended to secure a wide range of wheelchairs in a wide range of public vehicles, the wheelchair securement adaptor should conform to the UDIG specifications in Annex F.

4.4 Occupant restraints

4.4.1 In addition to the requirements in 4.1, occupant restraints shall:

a) have both pelvic and upper-torso belts designed to apply forces to the occupant's skeletal regions;

b) have belt restraints that can be adjusted in length without the use of tools.

4.4.2 When set up and measured in accordance with Annex B, occupant restraints shall:

a) produce rear-view projected angles of the pelvic belt within the zones shown in Figure 5;

b) produce side-view projected angles of the pelvic belt between 30° and 75° to the horizontal, and preferably between 45° and 75°, as shown in Figure 5;

c) provide for a range of adjustment of the pelvic belt restraint that allows for increasing and decreasing the total belt length by 200 mm from the nominal setup conditions, with at least 25 mm of webbing extending through any fitting where adjustment takes place;

d) provide for a range of adjustment in the upper-torso restraint that allows for increasing the length by 200 mm, and shortening the length by 300 mm, from the nominal setup conditions, with at least 25 mm of webbing extending through any fitting where adjustment takes place, when tested in accordance with Annex B;

e) have the junction of the shoulder and pelvic belts of three-point belt restraints located not less than 150 mm from the ATD centre line.

4.4.3 If occupant restraints include structural components for the attachment of upper anchorages or guides for upper-torso belts, locations for the upper anchor points shall be provided that are

a) adjustable in height so they can be positioned at or above the shoulder level of the intended user(s), or

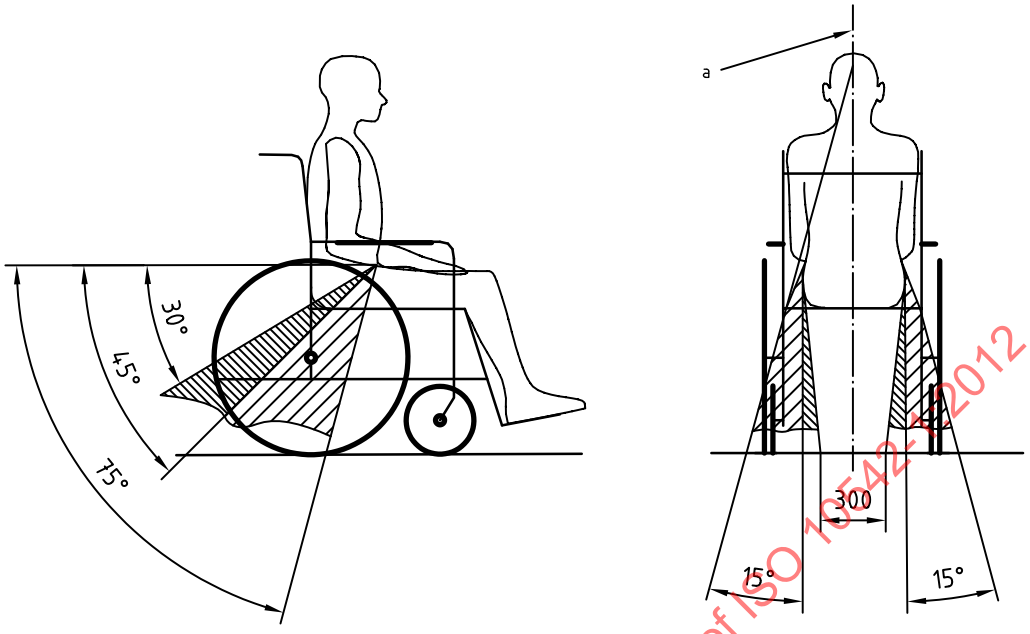
b) located at least 1 100 mm above the wheelchair ground plane.

4.4.4 Occupant restraints shall

a) only use an airbag for supplementary restraint in conjunction with a wheelchair tiedown and belt-type occupant restraint that conform with the requirements of this part of ISO 10542, and

b) not depend on an airbag in order to conform with the performance requirements of this part of ISO 10542.

Dimensions in millimetres



Key

preferred zone

optional zone

NOTE The angles indicated are obtained by projecting the angle of the pelvic belt onto a vertical plane that is parallel to (side view) or perpendicular (rear view) the wheelchair reference plane.

[a] Wheelchair reference plane.

Figure 5 — Ranges of angles for pelvic belts

5 Performance requirements

5.1 WTORS components

5.1.1 All webbing, metal parts, buckles, release mechanisms and adjustment mechanisms of wheelchair tiedown and occupant-restraint systems shall conform to the applicable subclauses indicated in the applicable column of Table 1 or Table 2 of either

a) ECE regulation No. 16, or

b) FMVSS 209 seatbelt assemblies.

5.1.2 All webbing and padding used in WTORS shall have a burning rate not exceeding 100 mm/min when tested as specified in ISO 3795.

Table 1 — Applicable subclauses of ECE regulation No.16

Subclause	Component	Subject	ECE R 16 tests referenced	Application[a]
6.2.1.1	rigid parts	sharp edges	—	OR + WTD
6.2.1.2	rigid parts	corrosion	7.2	OR + WTD
6.2.1.4	rigid parts	cold impact test	7.5.4	OR + WTD
6.2.2.1	buckles	correct use and size	—	OR
6.2.2.2	buckles	closing/releasing	7.8.2	OR
6.2.2.3	buckles	cold mating	7.5.3	OR
6.2.2.4	buckles	repeated testing	7.7	OR
6.2.3.2	adjustment devices	micro-slip	7.3	OR
6.2.3.4	belt-adjusting device	force	7.5.6	OR + WTD
6.2.5	various belt retractors	performance	7.2, 7.6.1 to 7.6.4	OR
6.2.6	preloading devices	performance	7.2, 7.9.2	OR
6.3.1	belts	general specs	7.4.3	OR
6.3.2	belts	strength	7.4.1.1, 7.4.2	OR + WTD
6.3.3	belts	strength	7.4.1, 7.4.2	OR + WTD
6.4.2	belts	strength	7.4.1.6, 7.4.2, 7.5	OR + WTD

[a] OR = occupant restraint, WTD = wheelchair tiedown.

Table 2 — Applicable subclauses of FMVSS 209

Subclause	Component	Subject	FMVSS 209 tests referenced	Application[a]
S4.1 (d)	hardware	burrs and sharp edges	—	OR + WTD
S4.1 (e)	release mechanism	design	—	OR
S4.1 (h)	webbing	unravelling	—	OR + WTD
S4.2 (a)	webbing	belt width	S5.1(a)	OR
S4.2 (b)	webbing	breaking strength	S5.1(b)	OR + WTD
S4.2 (c)	webbing	elongation	S5.1(c)	OR + WTD
S4.2 (d)	webbing	abrasion resistance	S5.1(d), S5.3(c)	OR
S4.2 (d)	webbing	abrasion resistance	S5.1(d)	WTD
S4.2 (e)	webbing	light resistance	S5.1(e)	OR + WTD
S4.3 (a)	hardware	corrosion resistance	S5.2(a)	OR + WTD
S4.3 (b)	hardware	temperature resistance	S5.2(b)	OR + WTD
S4.3 (d)	buckle release	release force	S5.2(d)	OR
S4.3 (e)	adjustment device	adjustment force	S5.2(e)	OR
S4.3 (f)	tilt-lock devices	locking angles	S5.2(f)	OR
S4.3 (g)	buckle latch	separation force	S5.2(g)	OR
S4.3 (i)	belt retractor	performance	S5.2(i)	OR
S4.3 (j)	belt retractor	performance	S5.2(j)	OR
S4.3 (k)	belt retractor	performance	S5.2(k), S4.4	OR
S4.4 (a)	pelvic restraints	performance	S5.3(a)	OR
S4.4 (b)	3-point restraints	performance	S5.3(b)	OR

[a] OR = occupant restraint, WTD = wheelchair tiedown.

5.2 Frontal impact requirements

5.2.1 General

a) When the WTORS is tested in accordance with Annex A using an SWC, the requirements of 5.2.2 and 5.2.3 shall be met during and after the test.

b) If a WTORS is tested in accordance with Annex A using an SWM, the requirements of 5.2.4 and 5.2.5 shall be met during and after the test.

5.2.2 Requirements during the test, when tested with SWC

When the WTORS is tested in accordance with Annex A using an SWC, the following requirements shall be met during the test:

a) the horizontal excursions of the ATD and SWC with respect to the impact sled shall not exceed the values given in Table 3;

b) the wheelchair tiedown shall prevent the TWC from imposing forward loads on the ATD, as indicated by the ATD knee excursion exceeding the TWC point-P excursion by 10 % or more ($x_{knee}/x_{wc} > 1{,}1$).

Table 3 — Horizontal excursion limits

Measurement point	Excursion variable	Excursion limit mm
Point P of TWC	x_{wc}	200
ATD knee centre	x_{knee}	375
ATD front of head	x_{head}	650

x_{wc} is the forward horizontal distance relative to the sled platform between the point-P target on the TWC at time t_0 and the point P target at the time of peak wheelchair excursion.

x_{knee} is the horizontal distance relative to the sled platform between the ATD knee joint target at time t_0 and the knee-joint target at the time of peak knee excursion.

x_{headF} is the horizontal distance relative to the sled platform between the most forward point on the ATD's head above the nose at time t_0 and the most forward point on the ATD's head at the time of peak head excursion.

5.2.3 Requirements after the test when tested with SWC

When the WTORS is tested in accordance with Annex A with an SWC, the following requirements shall be met at the conclusion of the test.

a) The ATD shall be retained in the seat of the TWC.

b) The TWC shall remain on all four wheels on the impact sled platform.

c) No WTORS anchorage components or securement end fittings shall be detached or separated.

d) Release of the TWC from the wheelchair tiedown shall not require the use of tools.

e) Release of the ATD from the occupant restraint shall not require the use of tools.

f) No part of the WTORS shall exhibit visible signs of tearing, fragmentation, fracture, or complete failure of any load-bearing part, unless such parts are intended to fail in a manner that limits the forces on the occupant.

g) The WTORS shall exhibit no dangerous roughness, sharp edges or protrusions likely to increase the risk of injury to the occupant.

5.2.4 Requirements during the test when tested with SWM

When the WTORS is tested in accordance with Annex A using an SWM, the following requirements shall be met during the test:

a) the horizontal excursions of the ATD and SWM with respect to the impact sled shall not exceed the limits specified in ISO 7176-19:2008, 5.2.1 a);

b) except for cases where the pelvic-belt restraint anchors to the SWM, the wheelchair tiedown shall prevent the SWM from imposing forward loads on the ATD as specified in 5.2.2 b);

c) if the SWM is a powered wheelchair, the movement of batteries or their surrogate replacement parts shall comply with ISO 7176-19:2008, 5.2.1 c).

5.2.5 Requirements after the test when tested with SWM

When the WTORS is tested in accordance with Annex A using an SWM, at the conclusion of the test:

a) the requirements of 5.2.3 c) to 5.2.3 g), and

b) the requirement in ISO 7176-19:2008, 5.2.2

shall be met.

5.3 Webbing slippage at tiedown adjustment devices

When tested in accordance with the procedure given in ECE R 16:2009, 7.3, or Annex C of this part of ISO 10542, strap-type adjustment mechanisms of wheelchair tiedowns shall not show slippage greater than 25 mm.

5.4 Partial engagement of anchorage and securement components

When WTORS anchorage and securement components are tested in accordance with Annex D, all improper and partial engagements shall separate with a force of less than 22 N.

5.5 Linear and rotational wheelchair movement

Docking devices should minimize wheelchair movement during normal vehicle operation. Manufacturers should evaluate the potential for linear and rotational wheelchair movement using the test method given in Annex G.

6 Identification, labelling, instruction and warning requirements

6.1 Identification and labelling

6.1.1 WTORS and replacement parts shall be permanently and legibly marked with

a) the manufacturer's name or trademark,

b) the month and year of manufacture, and any other identification necessary to clearly identify a WTORS in the event of a product recall, and

c) an indication that the WTORS conforms to ISO 10542-1:2012.

6.1.2 Primary WTORS components and subassemblies shall be accompanied by information that includes

a) the manufacturer's model and part number or an equivalent identification code, and

b) the name and intended use of each detachable WTORS component (e.g. right-rear tiedown, shoulder belt, pelvic belt).

6.1.3 A permanent notice shall be provided with the WTORS for posting in the vehicle at the wheelchair space, indicating the proper use and operation of the tiedown device and, if applicable, the manual override. The notice design (size of lettering, colour and luminance contrast of the background) should take account of people with visual impairment.

6.1.4 For WTORS that are intended for specific wheelchairs, the WTORS components and subassemblies shall be accompanied by information that includes the make and model of the wheelchairs and the maximum wheelchair and occupant mass which for which the WTORS can be used.

6.2 Instructions for installers

6.2.1 General

6.2.1.1 Manufacturers of WTORS shall provide written instructions for the installer in the principal language(s) of the country in which it is marketed.

6.2.1.2 The instructions shall include statements that:

a) the WTORS shall be installed for forward-facing wheelchairs;

b) identify the number of separate packages containing WTORS components;

c) the WTORS conforms to ISO 10542-1:2012;

d) indicate the minimum specifications for all wheelchair tiedown and occupant-restraint anchorage fasteners;

e) identify any components to be permanently fastened to the wheelchair;

f) indicate that the pelvic-restraint anchor points should be positioned to achieve belt angles between 30° and 75°, and preferably between 45° and 75° to the horizontal, as shown in Figure 5, in order to fit low across the pelvis and/or over the upper thighs and thereby reduce the possibility of the belt loading the abdomen;

g) indicate that rigid vehicle components inside the clear zones (as shown in Figure 6) should be covered with padding that conforms to the impact performance requirements of FMVSS 201 or ECE R 21;

h) indicate any limitations of use;

i) the permanent notice provided with the WTORS indicating the proper use and operation of the tiedown device and, if applicable, the manual override, should be posted in a visible location close to the installed device.

6.2.1.3 The instructions shall include descriptions of:

a) any wheelchair features that are required to allow correct fitting of tiedown adaptors;

b) procedures for attaching tiedown adaptors to the wheelchair;

c) how the WTORS is to be used, so that the installer is fully informed regarding the purpose and function of all components and how they should be installed;

d) the ranges of anchor-point or webbing guide locations of shoulder and harness restraints, and an explanation that these points should be selected so that the belt webbing fits near the midpoint of occupants' shoulder(s) and so that the height is at or above the shoulder heights of intended users, so as to minimize downward loads on the spine in a frontal crash;

e) minimum vehicle-strength recommendations at all WTORS anchor point locations.

6.2.1.4 The instructions shall include diagrams and drawings that illustrate:

a) acceptable methods for fastening WTORS anchorages to the vehicle, along with minimum strength requirements for all WTORS anchor points;

b) an exploded-view drawing and a parts list for all components required in the installation;

c) the locations for anchor points of vehicle-anchored belt restraints relative to wheelchair tiedown anchor points, along with the rear-view and side-view preferred angles for pelvic belt restraints as shown in Figure 5;

d) distances between WTORS anchor points and vehicle interior components, along with the rear clear zone (RCZ), the front clear zone (FCZ) and the seated head height (HHT) as shown in Figure 6.

6.2.1.5 The instructions shall include statements that:

a) the WTORS shall be installed by a suitably qualified technician;

b) both pelvic and upper-torso restraints shall be installed;

c) vehicle anchor points will require reinforcement, the suitability of which should be verified;

d) additional vehicle interior padding should have a burning rate that does not exceed 100 mm/min when tested in accordance with ISO 3795;

e) a vehicle-anchored back restraint shall be provided, if a head restraint is anchored to the vehicle, to minimize rearward deflection of the wheelchair back support and the potential for neck injury;

f) the WTORS shall not be installed in a manner that may interfere with the effective deployment of an airbag;

g) an airbag shall be used only as a supplementary occupant restraint in conjunction with a wheelchair tiedown and belt-type occupant restraint;

h) it is important to locate the anchor points in accordance with the WTORS manufacturer's instructions to ensure that the anchor points of the upper-torso and pelvic belts can achieve appropriate belt fit geometry;

NOTE The extent of head and chest excursions depends on the location of the upper-torso belt restraint anchor points and may increase as anchor-point distance above and behind the occupant's shoulder increases.

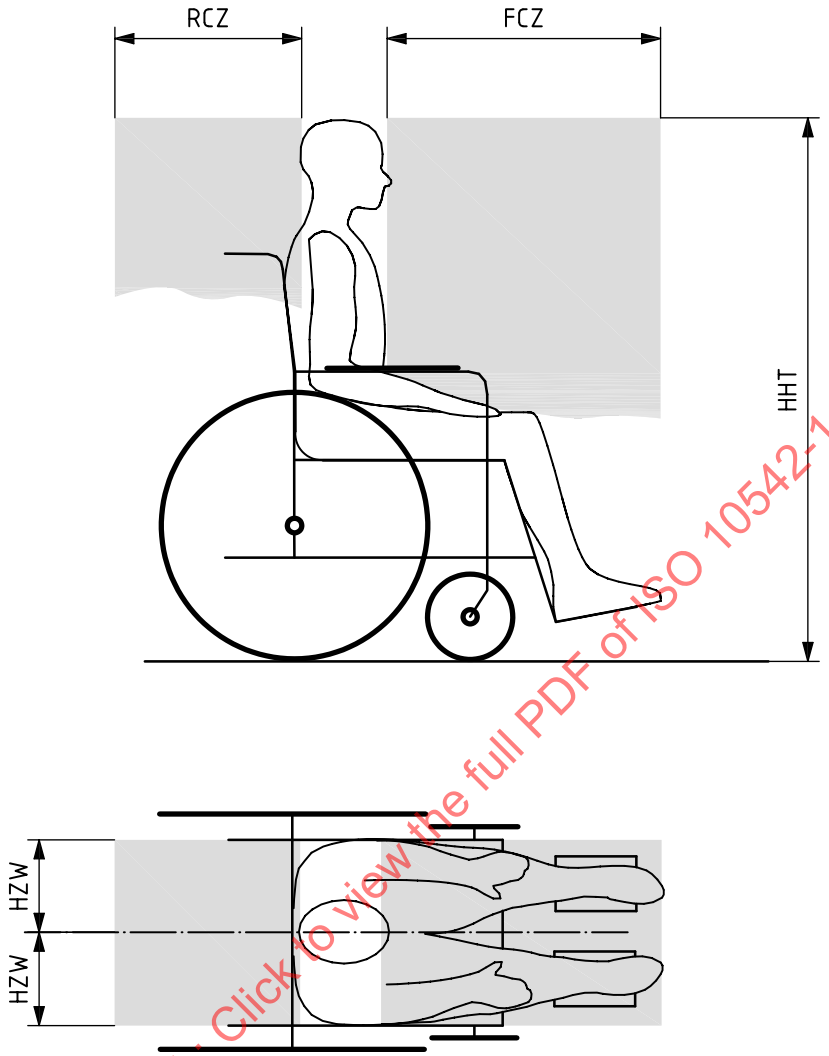
i) the WTORS manufacturer shall be consulted in case of questions as to the method of installation in the vehicle and/or of tiedown adaptors on the wheelchair;

j) alterations or substitutions to the WTORS components shall not be made without consulting the WTORS manufacturer;

k) components and subassemblies from different manufacturers shall not be mixed in order to make up a complete system;

l) webbing shall be protected from contacting sharp corners and edges, and potential corrosive liquids.

Dimensions in millimetres



Key

RCZ	rear clear zone
FCZ	front clear zone
HHT	seated head height
HZW	half clear zone width

NOTE 1 The RCZ is measured from the rearmost point on an occupant's head. The RCZ is 450 mm.

NOTE 2 The HZW is 220 mm.

NOTE 3 The FCZ is measured from the frontmost point on an occupant's head. The FCZ is 650 mm with upper-torso restraint. The FCZ may not be achievable with wheelchair-seated drivers.

NOTE 4 Although WTORS shall include an upper-torso restraint, it should be noted that the FCZ is 950 mm when the WTORS is used with only a pelvic belt restraint.

NOTE 5 Seated head height ranges from about 1 200 mm for a small adult female to about 1 550 mm for a tall adult male.

NOTE 6 Different values for the RCZ, FCZ, HTT and HZW might apply for WTORS designed for limited use with a particular make or model of wheelchair.

Figure 6 — Clear zones for wheelchair-seated occupants

6.2.2 Additional instructions for installers of four-point strap-type tiedowns

In addition to the instructions given in 6.2.1.1 to 6.2.1.5, manufacturers' instructions for installers of WTORS with four-point strap-type tiedowns shall include the recommendations for distances between anchor points of wheelchair tiedowns and the information illustrated in Figures 3 and 4, indicating that:

a) the preferred side-view projected angle for the rear tiedown straps is between 30° and 45° from the horizontal,

b) the preferred side-view projected angle for the front tiedown straps is between 40° and 60°,

c) the preferred rear-view projected angle of the rear tiedown straps is within 10° of the wheelchair reference plane, and

d) the preferred front-view projected angle of the front tiedown straps is within 25° of the wheelchair reference plane, but angled so as to provide some lateral stability to the wheelchair.

6.2.3 Additional instructions for installers of docking tiedown devices

In addition to the instructions given in 6.2.1.1 to 6.2.1.5, manufacturers' instructions for the installers of docking tiedown devices shall include statements indicating:

a) how the wheelchair should be manoeuvred relative to the wheelchair station for effective engagement and disengagement with the docking tiedown device;

b) recommended locations for electrical switches or other devices intended for use by the wheelchair occupant or vehicle driver;

c) where to position the docking tiedown device in the vehicle relative to occupant restraint anchor points for the most effective use of vehicle-anchored occupant restraint systems;

d) the requirements for electrical wiring and instructions for connecting to the power supply of the vehicle;

e) where the fuses or circuit-breakers should be mounted in order to provide easy access;

f) any required modifications to the vehicle;

g) a warning to consult the vehicle manufacturer before relocating original vehicle equipment;

h) a warning against damaging structural parts of the vehicle during installation of the docking tiedown device;

i) a description of the geometry and location of the wheelchair tiedown adaptor(s) or wheelchair securement point(s) required in order to achieve effective engagement with the docking tiedown device;

j) if applicable, the procedure for installation and removal of the wheelchair tiedown adaptor.

6.2.4 Additional instructions for installers of clamp-type tiedowns

In addition to the instructions given in 6.2.1.1 to 6.2.1.5, manufacturers' instructions for the installer of WTORS that use clamp-type tiedowns shall include statements that:

a) identify the circumstances in which a wheelchair tiedown adaptor is needed;

b) if applicable, specify the wheelchair tiedown adaptor to be used with the WTORS and the procedure for installation and removal.

6.2.5 Additional instructions for installers of tiedowns for specific wheelchair models

In addition to the instructions given in 6.2.1.1 to 6.2.1.5, manufacturers of WTORS components and subassemblies that are intended to be used with specific wheelchair models shall provide written information that includes

a) the make and model of wheelchairs and the maximum wheelchair and occupant mass that can be used with the components and/or subassemblies or WTORS, and

b) diagrams and/or drawings that describe the method of installation if the occupant restraint is to be anchored to the wheelchair.

6.3 User and maintenance instructions

6.3.1 General

6.3.1.1 Manufacturers shall provide written instructions for the use and maintenance of the WTORS in the principal language(s) of the country in which it is marketed.

6.3.1.2 The instructions shall include statements:

a) that the WTORS conforms to ISO 10542-1:2012;

b) that care should be taken to prevent contamination of the webbing with polishes, oils and chemicals, and particularly battery acid, along with procedures and materials to be used for cleaning parts of the WTORS;

c) that frayed, contaminated or damaged webbing, and broken or worn parts should be replaced;

d) that webbing should be protected from contacting sharp corners and edges;

e) of any limitations of use;

f) that occupant restraints should be adjusted to fit the user, and that:

   1) both pelvic and upper-torso restraints should be used to reduce the possibility of head and chest impacts with vehicle components,

   2) the extent of head and chest excursions also depends on the location of the upper-torso belt anchor points and may increase as anchor-point distance above and behind the occupants shoulder increases,

   3) the pelvic belt should be worn low across the front of the pelvis so as to bear upon the bony structure of the body, with any junctions between the pelvic and shoulder restraints located near the wearer's hip,

   4) the angle of the pelvic belt should be within a zone of 30° to 75° to the horizontal and preferably in the zone of 45° to 75° to the horizontal, as shown in Figure 5,

   5) belts should not be held away from the body by wheelchair components or parts such as the wheelchair arm supports or wheels, along with illustrations similar to that of Figures 7 and 8,

   6) occupant restraint belts should be adjusted as firmly as possible, consistent with user comfort,

   7) upper-torso restraints should fit over the shoulders,

   8) upper-torso anchor or webbing guide points that are adjustable in height should be set at or above the wheelchair occupant's shoulders so as not to impose downward loads on the spine in the event of a frontal collision, and

   9) restraint webbing should not be twisted;

g) that a notice should be posted in the vehicle at the wheelchair space, indicating the proper use and operation of the tiedown device and, if applicable the manual override procedures, and including information on how to obtain this notice if not available in the vehicle.

6.3.1.3 The instructions shall include descriptions of

a) how the WTORS is to be used,

b) the specifications of wheelchair tiedown adaptors, if applicable,

c) the specific features required of a wheelchair for effective attachment of tiedown end fittings, and

d) how to inspect, clean and maintain all WTORS webbing and components.

6.3.1.4 The instructions shall include warnings that:

a) the use of occupant restraints other than those specified by, or included in, the WTORS system may compromise the performance;

b) the WTORS shall be used only with forward-facing wheelchairs;

c) WTORS components, including anchorages, shall be replaced if they are suspected to have been in use during a severe impact, such as where the airbag is deployed or from which the vehicle must be towed;

d) the WTORS shall only be used with one wheelchair and one occupant at a time;

e) postural supports and belts shall not be relied upon for occupant restraint in motor vehicles;

f) auxiliary wheelchair equipment shall be effectively secured to the wheelchair or removed from the wheelchair and secured in the vehicle during transport, so as not to break free and cause injury to vehicle occupants in an impact;

g) items attached to the wheelchair in front of the wheelchair occupant, other than foot supports, shall be removed whenever possible and secured separately during transportation, in order to reduce the potential for injury to the wheelchair occupant and others in the vehicle.

6.3.1.5 The instructions for use should be supplied in a format suitable for display in a vehicle, and be accompanied by a recommendation that they should be displayed in the wheelchair space.

Figure 7 — Example of warning label illustrating improper positioning of occupant restraint belt

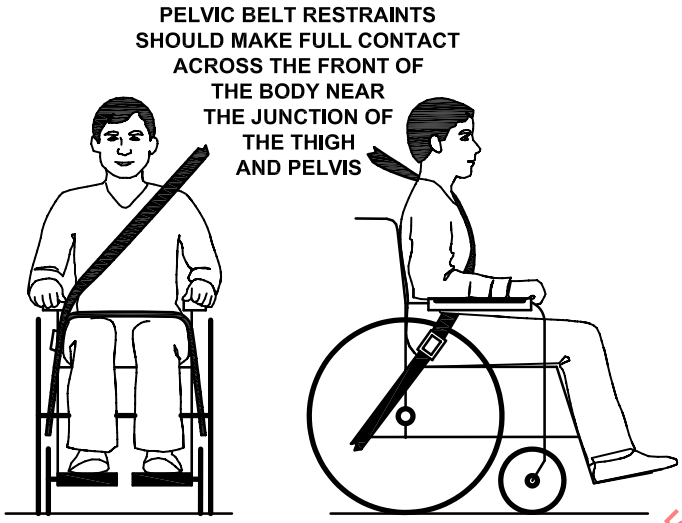


Figure 8 — Illustration of proper belt positioning

6.3.2 Additional user and maintenance instructions for four-point strap-type tiedowns

In addition to the instructions given in 6.3.1.1 to 6.3.1.5, manufacturers' instructions for users shall include recommendations for preferred angles of tiedown strap assemblies (see Figures 3 and 4), including statements that, whenever possible,

a) the preferred side-view projected angle for the rear tiedown straps is between 30° and 45° from the horizontal,

b) the preferred side-view projected angle for the front tiedown straps is between 40° and 60°,

c) the preferred rear-view projected angle of the rear tiedown straps is within 10° of the wheelchair reference plane, and

d) the preferred front-view-projected angle of the front tiedown straps is within 25° of the wheelchair reference plane, and angled laterally so as to provide some lateral stability to the wheelchair.

6.3.3 Additional user and maintenance instructions for docking tiedown devices

In addition to the instructions given in 6.3.1.1 to 6.3.1.5, user instructions for docking tiedown devices shall include:

a) the schedule for any maintenance requirements, including routine lubrication and adjustments;

b) how to release the wheelchair from the docking device in the event of a power failure;

c) the procedure for manoeuvring a wheelchair in order to achieve effective engagement with the docking securement device;

d) a description of the geometry and location of the wheelchair tiedown adaptor(s) or wheelchair securement point(s) required in order to achieve effective engagement with the docking tiedown device;

e) general information on any wheelchair securement adaptors that shall be provided for the wheelchair in order to achieve effective engagement with the docking tiedown device.

6.3.4 Additional user and maintenance instructions for clamp-type tiedowns

In addition to the instructions given in 6.3.1.1 to 6.3.1.5, user and maintenance instructions for WTORS that use clamp-type tiedowns shall include statements that:

a) specify the schedule for routine maintenance;

b) identify when wheelchair securement adaptors should be used;

c) specify the procedure for installation and removal of wheelchair securement adaptors, if used;

d) specify the procedures to attach and tension the clamp recommended by the manufacturer of the clamp(s);

e) the wheelchair can be adversely affected if the instructions of the wheelchair tiedown manufacturer are not followed.

6.3.5 Additional instructions for WTORS designed for specific wheelchair models

In addition to the instructions given in 6.3.1.1 to 6.3.1.5, user instructions for WTORS for specific wheelchair models shall include

a) descriptions of the features required of the wheelchair for effective attachment of occupant restraint anchorages, if applicable, and

b) warnings that the WTORS is only for use with a specific wheelchair.

6.4 Instructions for replacement parts and accessory WTORS components and subassemblies (when sold separately)

Replacement parts for WTORS, and accessory components of WTORS sold separately, that conform to appropriate requirements of this part of ISO 10542 shall

a) be described in accompanying pre-sale marketing literature as being part of a system or systems whose performance meets the requirements of this part of ISO 10542, and

b) be supplied with installation, user and maintenance instructions that include details of the WTORS devices and components with which they are compatible.

7 Test reports

7.1 The following information shall be included in each test report resulting from one or more tests conducted in accordance with this part of ISO 10542:

a) name and address of test institution;

b) date of test;

c) unique test report number shown on each numbered page;

d) manufacturer, product, and serial number, if applicable;

e) product type and designation;

f) name and address of manufacturer;

g) photograph of the WTORS test setup.

7.2 For the test of the design requirements, the test report shall also include a statement as to whether or not the requirements of the applicable subclauses of Clause 4 are met.

7.3 For the test of the performance of the WTORS components, the test report shall also include

a) the test results as specified in 5.1.1 and 5.1.2;

b) a statement as to whether or not the WTORS met the requirements of 5.1.1 and 5.1.2.

7.4 For the test of the identification, labelling, instruction and warning requirements, the test report shall also include a statement as to whether or not the requirements of the applicable subclauses of Clause 6 are met.

7.5 For the frontal impact test of Annex A, the test report shall also include:

a) a description and total mass of the ATD used in the test;

b) the measured or calculated value of the test velocity change;

c) descriptions and photographs of the WTORS and TWC as set up prior to the test;

d) a graph of the impact sled deceleration plotted against time and superimposed on Figure A.1;

e) the test results as specified in the applicable subclauses of 5.2;

f) a statement as to whether or not the WTORS met the requirements of 5.2;

g) for clamp-type tiedown systems, a statement of whether the device is hand- or foot-operated, and the operation force used to secure and release the clamp-type wheelchair tiedown as specified in Annex A;

h) any other relevant observations.

7.6 If the frontal impact test of Annex A is conducted with an SWC, the test report shall also include a description of the modifications to the SWC used in the test, if applicable.

If the frontal impact test of Annex A is conducted with an SWM, the test report shall also include:

a) the model, designation and serial number of the SWM used in the test;

b) the manufacturer of the SWM used in the test;

c) the mass of the SWM and a detailed description of its configuration;

d) descriptions and photographs of the SWM as set up prior to the test;

e) a statement that the SWM meets or does not meet each of the applicable requirements of 5.2.4 and 5.2.5.

7.7 For the tests of restraint belt geometry and length adjustment specified in Annex B, the report shall also include:

a) a photograph of the WTORS and wheelchair setup for the test;

b) the test results as specified in B.7;

c) a statement as to whether or not the occupant restraint tested met the requirements of 4.4.2;

d) any other relevant observations.

7.8 For the test for webbing slippage at adjustment devices of wheelchair tiedowns specified in Annex C, the test report shall also include:

a) a photograph of the test setup;

b) a photograph and description of each adjustment device tested;

c) the test results as specified in 5.3;

d) a statement as to whether or not the occupant restraint met the requirements of 5.3;

e) any other relevant observations.

7.9 For the test for partial engagement of Annex D, the test report shall also include:

a) a photograph and description of the components involved in each test;

b) the test results as specified in 5.4;

c) a statement indicating whether the equipment met the requirements of 5.4;

d) any other relevant observations.

Annex A
(normative)

Test method for frontal impact

A.1 Principle

A test wheelchair (TWC) is mounted in a forward-facing configuration on the impact sled of an impact simulator and is loaded with an anthropomorphic test device (ATD).

The WTORS is installed to secure the TWC and restrain the ATD. The sled platform is subjected to a defined acceleration/deceleration-time pulse in order to achieve a defined horizontal velocity change (Δv). Observations and measurements are made to determine whether the strength and performance of the WTORS are satisfactory under the test conditions.

A.2 Test sample

An unused WTORS, including upper-torso and pelvic restraints, all fittings, anchorages, fasteners and instructions for installation and use, shall be provided for testing. If a WTORS is designed to use the vehicle original equipment manufacturer (OEM) belt-type restraint system, the WTORS manufacturer shall provide a representative OEM restraint system, appropriately modified for use in testing. Documentation shall be included to indicate any components of the WTORS that are designed to provide controlled failure or deformation under dynamic loading.

A.3 Test wheelchair selection

Select a test wheelchair (TWC) for the frontal impact test as follows.

a) If the WTORS is intended for use with all types of manual and powered wheelchairs, then the TWC will consist of the surrogate wheelchair (SWC) constructed in accordance with Annex E.

b) If the WTORS is intended to be used only with specific makes and models of wheelchairs, then the TWC will consist of the specific wheelchair model (SWM) it is designed for.

A.4 Test equipment

A.4.1 An impact simulator shall be used that includes the following:

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

b) a rigid structure attached to the impact sled to which the upper-torso restraint can be anchored in the manner, and to the geometry, specified by the WTORS manufacturer;

c) a means to drive the impact sled through a change in velocity of 48 km/h $^{+2}_{0}$ km/h;

d) a means to accelerate and/or decelerate the impact sled and test setup such that the processed sled acceleration and/or deceleration time pulse

   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 time period of at least 40 ms, and

4) has a duration of at least 75 ms from t_o to t_f, where t_o is the time at the beginning of the deceleration and t_f indicates the time at the end of deceleration pulse.

A.4.2 If the WTORS is intended for use with all types of manual and powered wheelchairs, the following shall be used:

a) an SWC that conforms with the specifications of Annex E;

b) a Hybrid III 50th percentile ATD with an approximate total mass of 77,7 kg.

A.4.3 If the WTORS is intended to be used only with specific makes and models of wheelchairs, the following shall be used:

a) an SWM it is designed for;

b) an ATD that is

1) representative of the upper size range of users for which the SWM is designed,

2) selected from ISO 7176-19:2008, Table A.1, and

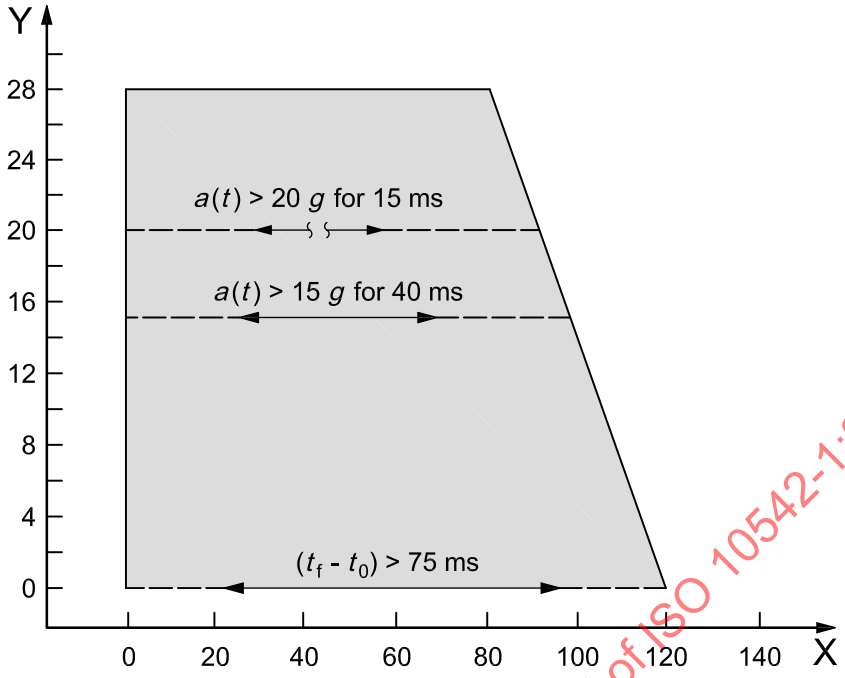
3) from the Hybrid III family of crash test dummies.

A.4.4 A means shall be provided to measure the ATD and TWC horizontal excursions specified in 5.2.2 a) and 5.2.4 a) with a precision of ±5 mm.

A side-view high-speed camera or video system with a minimum frame rate of 500 frames per second is recommended.

A.4.5 A means shall be provided to 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.

The acceleration/deceleration of the impact sled shall stay within the shaded area and exceed the indicated levels for the specified continuous (unbroken arrows) and cumulative (broken arrows) time periods.



Key

X time (ms)

Y deceleration (*g*)

Figure A.1 — Acceleration/deceleration requirements for the impact test 48 km/h $^{+2}_{0}$ km/h

A.4.6 A means shall be provided to measure the horizontal velocity change (delta-V) of the impact sled during the impact with a precision of ±0,5 km/h

A.4.7 Provision shall be made to filter analogue 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.5 Test preparation and procedure

A.5.1 The procedures for setting up the test may be undertaken in any order.

EXAMPLE It may be more convenient to position the ATD on the TWC prior to lifting the assembly onto the impact sled.

A.5.2 Adjust the ATD to achieve a static resistance of 1 g at each joint, as indicated by a just-noticeable movement from the mass of the distal body segment, as specified by the ATD manufacturer.

A.5.3 Place close-fitting cotton clothing on the pelvis, thighs and torso of the ATD.

A.5.4 Set up the test equipment (see A.4).

A.5.5 If the SWC is used as TWC, prepare it as follows.

a) Modify the frame structure as needed to accommodate the tiedown system to be tested while maintaining the SWC specifications within the tolerances specified in Annex E.

b) Inflate the SWC tyres as specified in Annex E, with the wheelchair unoccupied and resting on a horizontal surface.

c) Inspect the tyres for cracks or damage and replace if applicable.

d) Inspect the seat plate and plate-support structures and replace if deformed.

e) Inspect all frame joints and components and repair if there are signs of fatigue or deformation.

f) Install, if needed, wheelchair tiedown adaptors on the SWC.

A.5.6 If the SWM is used as TWC, prepare it as follows.

a) Set up the SWM as specified in ISO 7176-19:2008, A.4.1 c) to A.4.1 g).

b) If applicable, adjust the seat and back support as specified in ISO 7176-19:2008, A.4.5.

c) Equip the SWM with any required tiedown adaptors.

A.5.7 Position the TWC facing forward on the sled platform, with the wheelchair reference plane parallel to the direction of sled travel within ±3°.

A.5.8 Secure the TWC with the wheelchair tiedown according to the manufacturer's instructions.

A.5.9 In case of a four-point strap-type tiedown, prepare as follows.

a) Secure the TWC with the four-point tiedown, selecting anchor points that

1) are symmetrical about the wheelchair reference plane,

2) are located 1 300 mm $^{+20}_{0}$ mm from the front anchor point to the rear anchor point,

3) have a lateral distance between rear anchor points equal to the lateral distance between rear securement points of the TWC ±25 mm, and

4) have a lateral distance between front anchor points of 300 mm to 810 mm.

NOTE 1 For purposes of locating the anchor points, the front-to-back location of an anchor point is the location of the primary fastener that secures the anchorage to the test platform or, in the case of multiple fasteners, the centre of these fasteners. The lateral location of an anchor point is considered to be the centre of the location where the tiedown end fitting contacts the anchorage hardware attached to the test platform.

b) Secure the TWC in accordance with the WTORS manufacturer's instructions to achieve lengths of the rear tiedown strap assemblies of 495 mm to 533 mm, measured from the interface of the tiedown end fitting and the securement point on the wheelchair to the anchor point.

NOTE 2 For purposes of measuring the rear tiedown length, the anchor point is considered to be the point at which a straight line along the length of the strap assembly intersects with the wheelchair ground plane.

c) Tension the adjustable-length tiedown straps to the manufacturer's specifications, making sure that the TWC reference plane is parallel to the centre line of the impact simulator within 3°.

d) If the WTORS is tested with an SWM where the location of the securement points makes it impossible to comply with the anchor point locations and strap lengths as stipulated in a) and b), then the SWM should be secured within, or as close as possible to, the angles given in Figures 3 and 4.

A.5.10 For tiedown systems other than four-point strap-type tiedown, install the wheelchair tiedown anchorages in accordance with the manufacturer's instructions. If a range is given for any installation dimensions, use the

midpoint of the range. If fasteners supplied with the WTORS are not compatible with the impact sled, use replacement fasteners with the same thread and material specification.

A.5.11 In case of a clamp-type tiedown system,

a) measure the force for securing and releasing the wheelchair tiedown as specified in A.6, and

b) ensure that the forces to secure and release the clamp-type tiedown do not exceed the requirement in 4.2.4.

A.5.12 Position the ATD in the TWC, sitting upright and symmetrical about the wheelchair reference plane, with the pelvis and buttock as far back on the wheelchair seat as possible, and the elbows resting on the armrests or the hands resting on the ATD's thighs.

A.5.13 If the SWM is used as TWC,

a) apply the parking brakes, if fitted, and

b) install postural belts as specified in ISO 7176-19:2008, A.4.7, if provided.

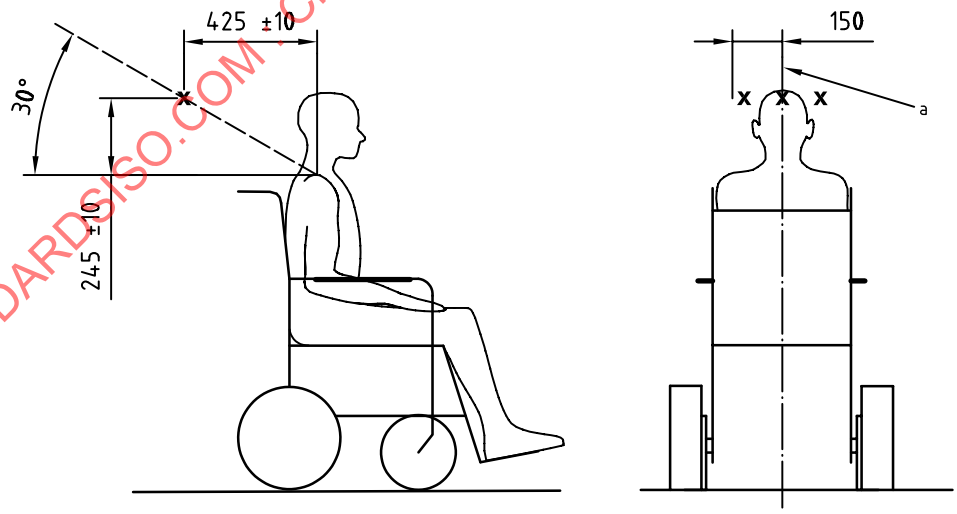
A.5.14 Install the pelvic restraint anchorages in accordance with the manufacturer's instructions, selecting anchor points at the midpoints of the recommended zones, if applicable.

A.5.15 For WTORS that do not include upper anchor or upper webbing-guide supports for shoulder or harness restraints, install the upper-torso restraint anchorages at the point or points marked by a bold cross (**X**) or crosses in Figure A.2 or A.3, as applicable, to achieve a fit across the ATD shoulders and chest as indicated in Figure H.1.

Use the upper-torso restraint anchorage and fastener hardware, if supplied as part of the complete WTORS by the manufacturer.

When an upper-torso restraint webbing guide is provided, the guide shall be located to achieve the desired shoulder belt geometry as indicated in Figure A.2 or Figure A.3, as appropriate.

Dimensions in millimetres

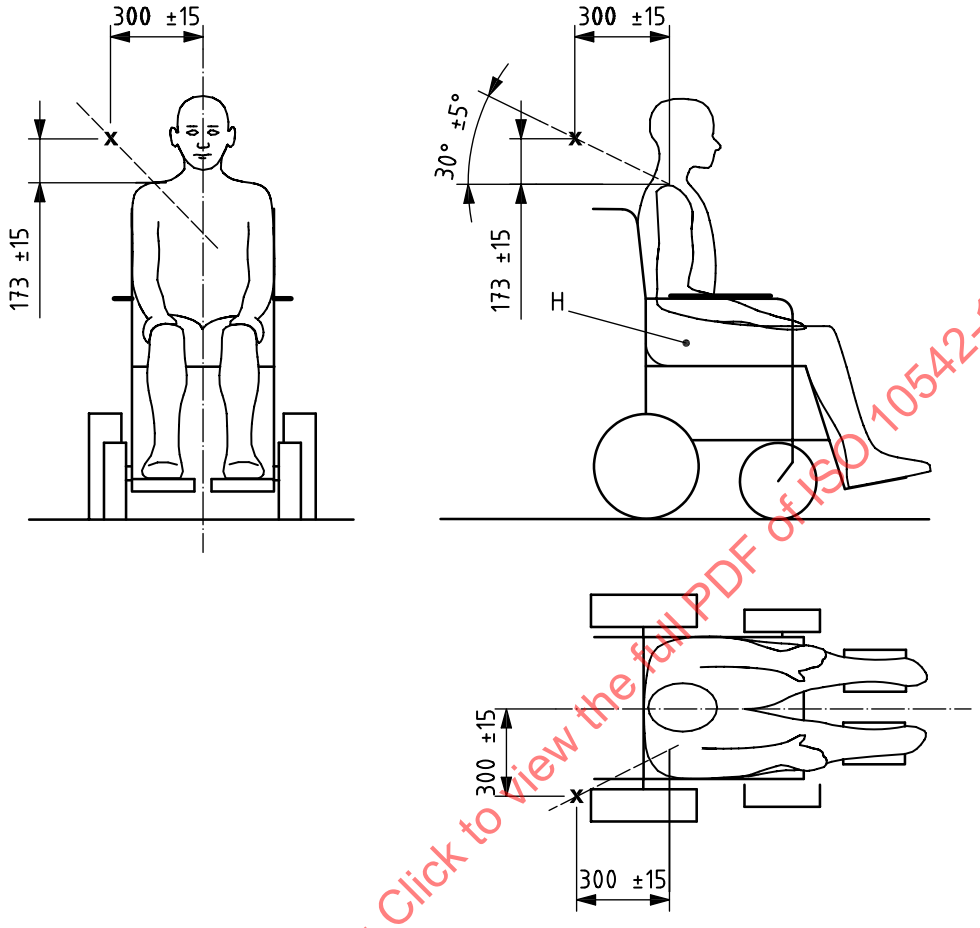


NOTE The anchor points are located relative to the top centre of the ATD's shoulders.

[a] Wheelchair reference plane.

Figure A.2 — Locations for upper anchor point(s) of centre-anchored and two-point-anchored harnesses in frontal impact test

Dimensions in millimetres



Adjust the anchor-point location to give a good fit to the ATD chest and shoulder.

The lateral position of the anchor point should be adjusted to achieve a good fit over the ATD's shoulder.

NOTE The anchor point may be located on either side of the wheelchair and ATD, and is located relative to the top centre of the ATD's shoulder.

Figure A.3 — Location for upper anchor point of shoulder belt in frontal impact test

A.5.16 For WTORS that include support components for upper anchor points or upper guide points for upper-torso belts, install the anchorages or guides as specified by the manufacturer to achieve a good fit to the ATD's shoulders and chest.

A.5.17 Place the pelvic belt on the ATD and adjust the tension in the pelvic belt to achieve a snug fit.

A.5.18 Place the shoulder belt or harness on the ATD and adjust the belts as follows.

a) If an emergency-locking or automatic-locking retractor is provided, adjust the belts to achieve a snug fit.

b) If no emergency-locking or automatic-locking retractor is provided, adjust the belts to achieve a snug fit with a 75 mm × 75 mm × 25 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.

A.5.19 If the SWM is used as TWC, and

a) if the SWM provides anchor points for wheelchair-anchored pelvic- and shoulder-belt restraints, install and position the occupant restraint as specified in ISO 7176-19:2008, A.4.9;

b) if the SWM is equipped with a wheelchair-anchored pelvic-belt restraint, install and position the pelvic-belt restraint as specified in ISO 7176-19:2008, A.4.10 a).

A.5.20 If a high-speed camera or high-speed video is used for the measurements in A.4.4, apply contrast markers appropriate to the measurement system at:

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

b) point P of the TWC, and

c) H points of the ATD.

NOTE Use appropriate targeting to give accurate displacement of P point.

A.5.21 Ensure that the TWC reference plane is parallel to the centre line of the impact simulator within 3°.

A.5.22 If the SWM is used as TWC,

a) install the foot/leg strap as specified in ISO 7176-19:2008, A.4.13, and

b) carry out the recordings and measurements as specified in ISO 7176-19:2008 A.4.14 and A.4.15.

NOTE To minimize damage to the ATD during testing, ISO 7176-19 specifies a foot/leg strap that restricts knee-joint and shoulder movements due to limb inertia in a manner that does not affect the WTORS loading and ATD excursions during testing. The leg strap changes ATD kinematics slightly during rebound, making the rebound more consistent and repeatable. It does not affect forward excursions and WTORS loading.

A.5.23 Make provisions to subject the impact sled and the test specimens to

a) a horizontal velocity change of 48 km/h $^{+2}_{0}$ km/h,

b) using a deceleration-time pulse that conforms to A.4.1.d.1) to A.4.1.d.4).

A.5.24 Conduct the test by executing the appropriate sequence of steps to activate the impact sled and start the recording equipment.

A.6 Measurement procedures for operation force

NOTE The measurement procedures for the operation force included in this annex are based on the measurement procedures defined in EN 12184.

A.6.1 Measurement procedure for lever-operated clamps

a) Select the part of the lever through which the force is to be applied.

1) If the lever is fitted with a generally spherical knob, apply the force through the centre of the knob.

2) If the lever is tapered, apply the force through the point where the largest cross-section intersects the centre line of the lever.

3) If the lever is parallel or any shape other than those above, apply the force through a point on the centre line of the lever 15 mm below the top.

4) If the shape of the lever is such that the lever is gripped by the whole hand- or is foot-operated, apply the force through the centre line of the lever 15 mm from the end.

5) If the lever is hand-operated by pushing or pulling a bar or pad, apply the force to the centroid of the bar or pad.

b) Operate the wheelchair tiedown by applying the means to measure the force until the wheelchair is secured in accordance with the manufacturer's instructions.

c) Record the maximum force applied for securing.

d) Operate the wheelchair tiedown by applying the means to measure the force until the wheelchair is released in accordance with the manufacturer's instructions.

e) Record the maximum force applied for releasing.

f) Repeat b) to e) three times in total and calculate the average values for securing and releasing.

g) Record the average values for securing and releasing.

A.6.2 Measurement procedures for screw-operated clamps

a) Apply force by using a torque meter positioned concentrically on the operating nut of the clamp-type tiedown system, increasing to the maximum operating force as slowly as possible.

NOTE The torque meter may require the addition of an appropriate device to fit the shape of the operating nut.

b) Record maximum operating torque for securing and releasing the wheelchair.

c) Perform a) and b) three times in total.

d) Calculate the average values for securing and releasing.

e) Record the average values for securing and releasing.

A.7 Evaluation of test results

After the test, examine the TWC, ATD and WTORS, and analyse the excursion measurements relative to the requirements of 5.2.3 or 5.2.5, to determine if the WTORS, and if applicable the SWM, meet the requirements of 5.2.

Annex B
(normative)

Measurement of WTORS belt lengths and geometry

B.1 Principle

If a belt-type occupant restraint system is provided with the WTORS, it is set up with an ATD seated in a wheelchair, with the upper anchor points or upper webbing guide points of the upper-torso restraint positioned at worst-case, real-world conditions. The fit of the belts to the ATD and adjustment lengths of the belts are then checked to ensure that the restraint system will accommodate a wide range of user and wheelchair sizes.

B.2 Test sample

The test sample comprises an unused WTORS, including upper-torso and pelvic restraints, all fittings, anchorages, fasteners and instructions for installation and use.

B.3 Test wheelchair selection

Select a test wheelchair (TWC) as follows.

a) If the WTORS is intended for use with all types of manual and powered wheelchairs, then the TWC will consist of the surrogate wheelchair (SWC) constructed in accordance with Annex E.

b) If the WTORS is intended to be used only with specific makes and models of wheelchairs, then the TWC will consist of the specific wheelchair model (SWM) it is designed for.

B.4 Apparatus

B.4.1 Flat, horizontal, rigid platform, on which the TWC chair can be mounted and to which the WTORS can be attached.

B.4.2 Rigid structure, fastened to the platform, that allows the anchorages for upper anchor points or upper webbing guides of the upper-torso restraint to be fastened at the locations specified in Figures B.1 and B.2.

B.5 Procedure

B.5.1 Secure the TWC to a flat, horizontal, rigid platform with the wheelchair tiedown in accordance with the WTORS manufacturer's instructions.

B.5.2 Position the ATD symmetrically in the TWC seat with the buttocks and pelvis against the back support and the arms positioned on the armrests or ATD thighs.

B.5.3 Install the pelvic belt in accordance with the manufacturer's instructions, selecting anchor points at the midpoint of the recommended zones, if applicable.

B.5.4 Install the upper-torso restraint as follows.

a) For WTORS that include support structures for upper anchorages of upper-torso restraint anchor points or webbing guides, locate the anchorages in accordance with manufacturer's instructions.

b) For WTORS that do not include support structures for upper anchor points or upper webbing guides, locate the anchorages

1) for three-point restraints at the point marked by the bold cross (**X**) in Figure B.1;

2) for centre-anchored harnesses at the point marked by the middle bold cross (**X**) in Figure B.2;

3) for two-point anchored harnesses at the points marked by the left and right outside bold crosses (**X**) in Figure B.2.

NOTE The setups in Figures B.1 and B.2 represent expected worst-case situations in actual vehicles with regard to the length requirements of upper-torso belts (see Figures H.2 to H.4 for preferred and optional zones). Subclause 4.4.2 d) requires additional length adjustment of the belt from anchor- or guide-point scenarios in order to accommodate larger users.

B.5.5 Adjust the tension in the pelvic and shoulder belts to achieve a snug fit.

B.6 Measurements

B.6.1 Measure and record the rear-view angle relative to the horizontal of the pelvic belt projected onto a plane that is perpendicular to the wheelchair reference plane, as shown in Figure 5.

B.6.2 Measure and record the side-view angle of the pelvic belt projected on to the wheelchair reference plane, as shown in Figure 5.

B.6.3 Measure and record the distance from the centre line of the ATD along the arc of the pelvic belt to the centre of the junction of the upper-torso belt and the pelvic belt.

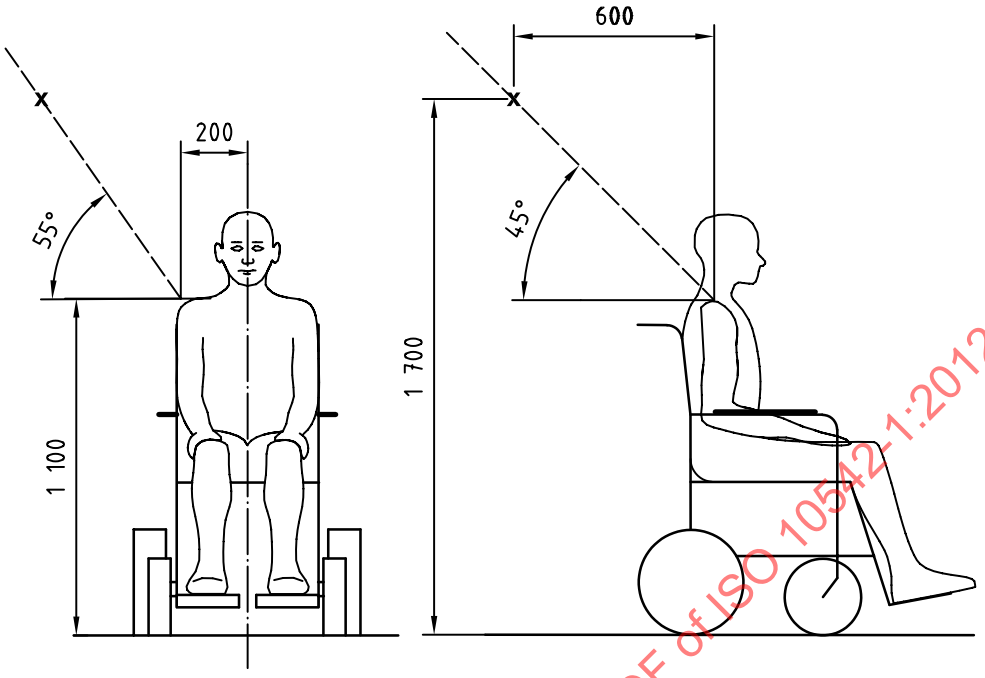
B.6.4 Mark the location of the webbing in the upper-torso restraint adjusters. Disconnect the upper-torso restraint at one anchor point and measure the total length of belt lengthening and shortening available, while checking to make sure that at least 25 mm of webbing extends through the restraint end fittings at all times.

B.6.5 Mark the location of the webbing at the pelvic restraint adjusters with the pelvic belt on the ATD as described in B.5.3. Unbuckle the pelvic belt and measure the total length of belt lengthening and shortening provided (including adjustment on both sides of the pelvic belt if applicable), while checking to make sure that at least 25 mm of webbing extends through the restraint end fittings at all times.

B.7 Results and compliance

Determine whether the test sample meets the requirements of 4.4.2.

Dimensions in millimetres



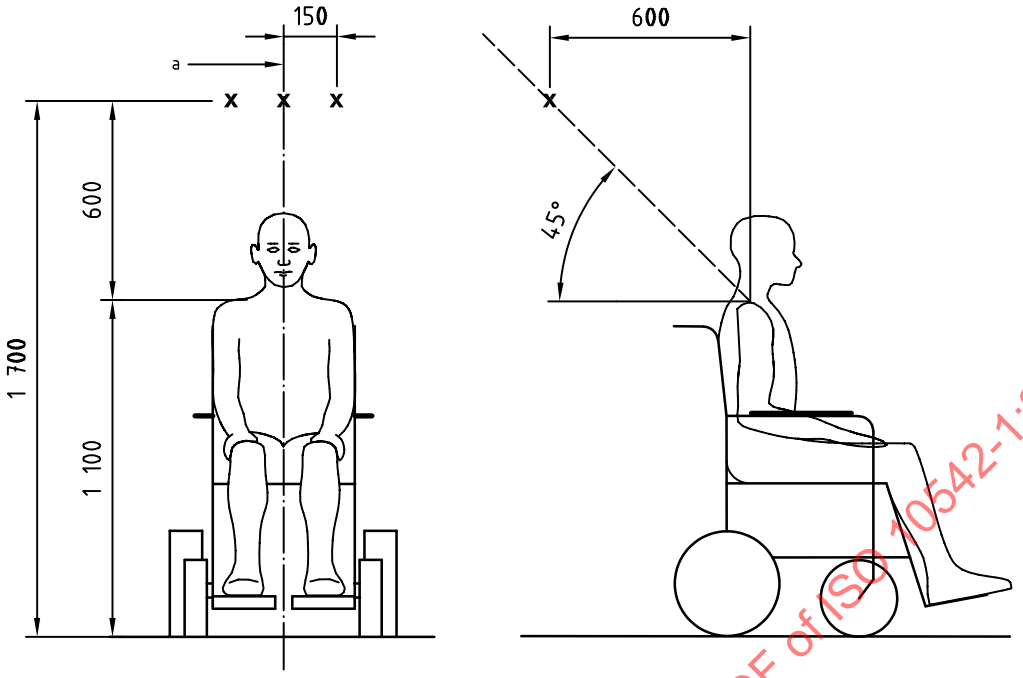
NOTE 1 Bold crosses (**X**) indicate the locations of the upper anchor points.

NOTE 2 Fore/aft location is relative to the top centre of the ATD's shoulder.

NOTE 3 The shoulder belt may be anchored to either side of wheelchair.

Figure B.1 — Anchor-point location for test setup with three-point restraint for WTORS that do not include support structures for upper anchor points or upper webbing guides

Dimensions in millimetres



NOTE 1 Bold crosses (**X**) indicate the locations of the upper anchor points.

NOTE 2 Fore/aft location is relative to the top centre of the ATD's shoulder.

Figure B.2 — Anchor-point locations for test setup with centre-anchored or two-point-anchored harness for WTORS that do not include support structures for upper anchor points or upper webbing guides

Annex C
(normative)

Test for webbing slippage at manual adjustment devices of wheelchair tiedown straps

C.1 Principle

The webbing and manual adjustment devices of a wheelchair tiedown assembly are subjected to cyclical loading for 1 000 cycles and the webbing slippage at the adjustment device is measured.

C.2 Test sample

Webbing and adjustment devices of wheelchair tiedown assemblies are used as test samples.

C.3 Apparatus

C.3.1 **Weight**, of mass 5 kg.

C.3.2 **Means of applying a reciprocating vertical motion** to the webbing and adjustment device under test, with a peak-to-peak amplitude of 300 mm $^{+20}_{0}$ mm, and a frequency between 0,5 Hz and 0,75 Hz.

C.4 Procedure

C.4.1 Store the adjustment device to be tested at a temperature of 20 °C $^{+5}_{0}$ °C and a relative humidity of 65 % (+10 %) for 24 h prior to testing.

C.4.2 Conduct the test at an ambient temperature between 15 °C and 30 °C within 2h of removing the components to be tested from storage in accordance with C.4.1 using the following procedures.

a) Arrange the webbing and adjustment device to be tested in the test apparatus, with the adjustment device not less than 200 mm from the end fitting as shown in Figure C.1.

b) Attach the weight (C.3.1) to the end fitting.

c) Adjust the webbing so that the bottom of the weight is 100 mm $^{+20}_{0}$ mm off the resting surface when the movement mechanism is at maximum upward travel.

d) Guide the weight to prevent the load from swaying and rotating during the test.

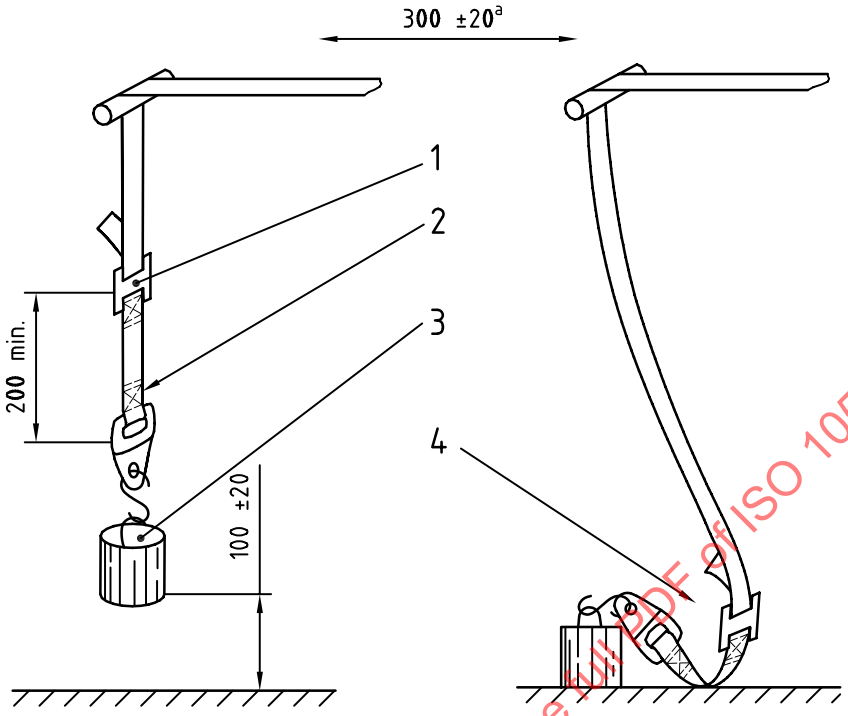
e) Apply a vertical oscillating motion with a peak-to-peak amplitude of 300 mm $^{+20}_{0}$ mm to the adjustment device by raising and lowering the webbing in the test fixture, and continue for 20 or more cycles to ensure that the test equipment is operating correctly. On the downward stroke, ensure that the webbing descends to form a downward loop when the mass is contacting the resting surface.

f) Mark the webbing position at the adjustment device.

g) Repeat the up/down oscillating motion in accordance with C.4.2 e) and continue for 1 000 cycles at a frequency between 0,5 Hz and 0,75 Hz.

h) Measure any movement of the webbing mark at the adjustment device after the test and record as the amount of webbing slippage.

Dimensions in millimetres



a) Taut position **b) Slack position**

Key

1 adjusting device
2 stitching
3 weight (5 kg)
4 downward loop

The initial distance between the adjusting device and the end fitting shall be 200 mm or greater.

[a] Total travel.

Figure C.1 — Setup for webbing slippage test at adjustment devices

C.5 Results and compliance

Determine whether the test sample meets the requirements of 5.3.

Annex D
(normative)

Test method for partial engagement

D.1 Principle

A separating force is applied between separable WTORS components that have been engaged in any manner other than complete and proper engagement. If the components do not disengage, a potential for partial engagement is demonstrated and the WTORS fails the test.

D.2 Test sample

Any WTORS components that are intended to be engaged during use and that have the potential for improper and incomplete engagement are used as test samples.

D.3 Test wheelchair selection

Select a test wheelchair as follows.

a) If the WTORS is intended for use with all types of manual and powered wheelchairs, use the surrogate wheelchair (SWC) with securement points as given in Figure E.4.

b) If the WTORS is intended to be used only with specific makes and models of wheelchairs, use the specific wheelchair model (SWM) it is designed for.

D.4 Apparatus

D.4.1 Means to apply a separating force of 22 N between the separate WTORS components, such as the separable parts of an anchorage mechanism, or a tiedown end fitting and the securement-point hardware on the wheelchair.

D.4.2 Means for measuring the applied force to an accuracy of 5 %.

D.4.3 Means for measuring the duration of the applied forces to an accuracy of 0,5 s.

D.5 Procedure

Identify all reasonably foreseeable ways in which the separate components of a securement or anchorage mechanism can be engaged, other than by complete engagement. For each of these ways,

a) engage the separate components of a securement or anchorage mechanism in any manner other than complete engagement;

b) apply a separating force of 22 N $^{+2}_{0}$ N between the components of the securement or anchorage mechanism, and maintain the force for a maximum of 3 s $^{+0,5}_{0}$ s.

D.6 Test results

For each test conducted,

a) record the manner of engagement, including photographs that are necessary to describe fully the condition, and

b) record the results of each test, i.e. whether the components separated or remained engaged at the applied force.

D.7 Results and compliance

Determine whether the test sample meets the requirements of 5.4.

Annex E
(normative)

Surrogate wheelchair specifications

E.1 General

Design, dimensional, material and performance specifications are provided for a surrogate wheelchair (SWC) that produces representative loading and seating conditions of a powered wheelchair for testing WTORS to the requirements of this part of ISO 10542.

E.2 Specifications

The surrogate wheelchair shall:

a) be of rigid durable construction, such that there is no permanent deformation of the frame, seat surface, or seatback in a 48 km/h, 20 g frontal impact test with a 77,7 kg ATD positioned and restrained in the SWC;

b) have a total mass of 85 kg ± 1 kg;

c) conform to the dimensions shown in Figures E.1 to E.4;

d) allow for adjustment to accommodate components and end fittings of different types of tiedown systems;

e) provide two front securement points and two rear securement points for four-point strap-type tiedowns at the locations indicated in Figure E.1 and with the geometry specified in Figure E.4;

f) provide pelvic restraint anchor points on both sides of the surrogate wheelchair located as shown in Figure E.1;

g) have a centre of gravity located 142 mm ± 25 mm forward of the rear axle and 287 mm ± 25 mm above the ground plane for the range of frame-to-floor clearance adjustments allowed;

h) have a rigid, flat seat surface, with dimensions as shown in Figures E.1 and E.3, that is oriented at an angle of 4° ± 1,5° to the horizontal (front end up), as shown in Figure E.1, when the SWC tyres are resting on a flat horizontal surface and inflated in accordance with l) and m) below;

i) have a rigid back support with height and width dimensions as indicated in Figures E.2 and E.3 that is oriented at 8° ± 1,5° to the vertical when the SWC tyres are resting on a flat horizontal surface and inflated in accordance with l) and m) below;

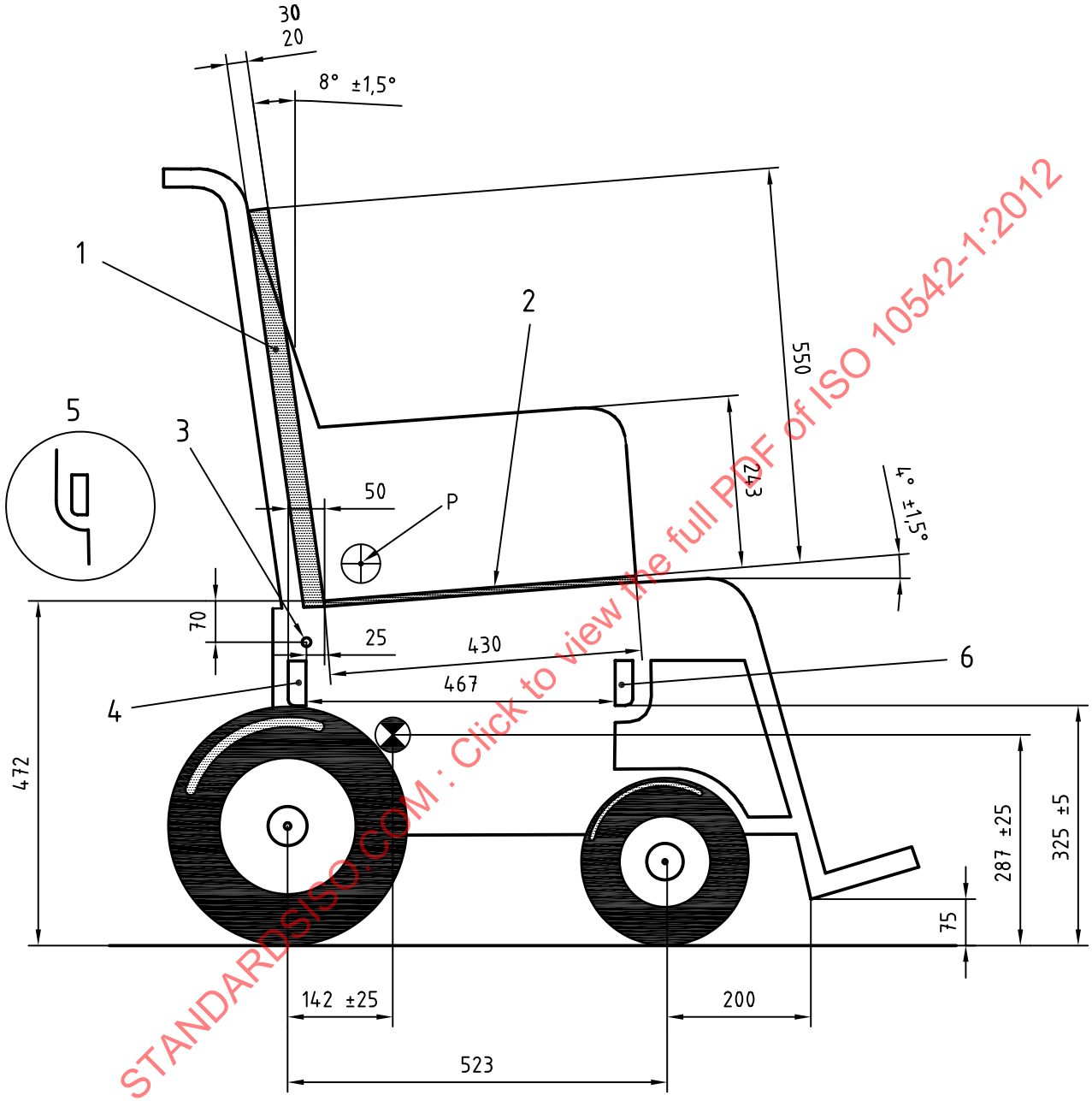
j) have a 20 mm to 30 mm thick, firm (i.e. Shore-A hardness of 60 to 80) rubber pad, with height and width dimensions as indicated in Figures E.1 and E.2, fixed to the front surface of the rigid back support;

k) have appropriate targeting to give accurate displacement of the point P on either side of the SWC;

l) have pneumatic front tyres that, when inflated to 320 kPa $^{+30}_{0}$ kPa) with the unoccupied surrogate wheelchair resting on a flat horizontal surface, have a diameter of 230 mm ± 10 mm, a width of 75 mm ± 10 mm, and a sidewall height of 54 mm ± 5 mm;

m) have pneumatic rear tyres that, when inflated to 320 kPa $^{+30}_{0}$ kPa with the unoccupied surrogate wheelchair resting on a flat horizontal surface, have a diameter of 325 mm ± 10 mm, a width of 100 mm ± 10 mm, and a sidewall height of 70 mm ± 5 mm.

Dimensions in millimetres
Tolerances ± 5 mm unless otherwise specified



Key

1 hard rubber back support
2 rigid seat surface
3 pelvic belt anchor point
4 rear securement point
5 rear securement point geometry
6 front securement point

NOTE Securement point locations do not imply recommended locations on production wheelchairs.

Figure E.1 — Side view of surrogate wheelchair

Dimensions in millimetres
Tolerances ± 5 mm unless otherwise specified

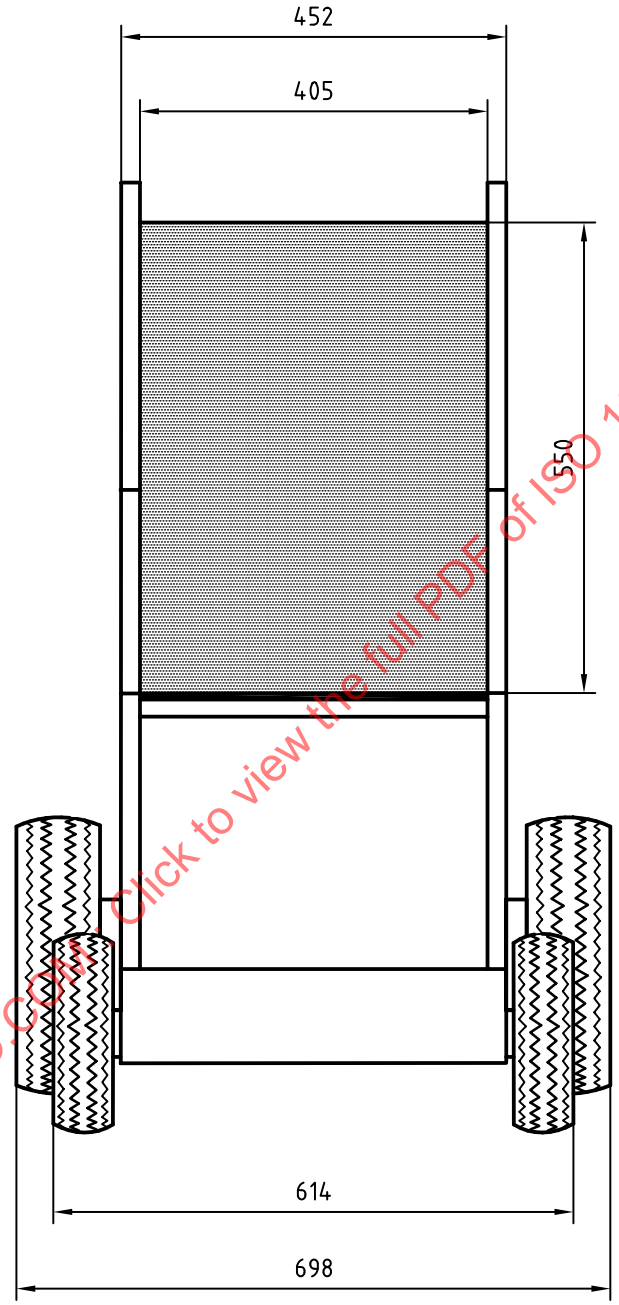
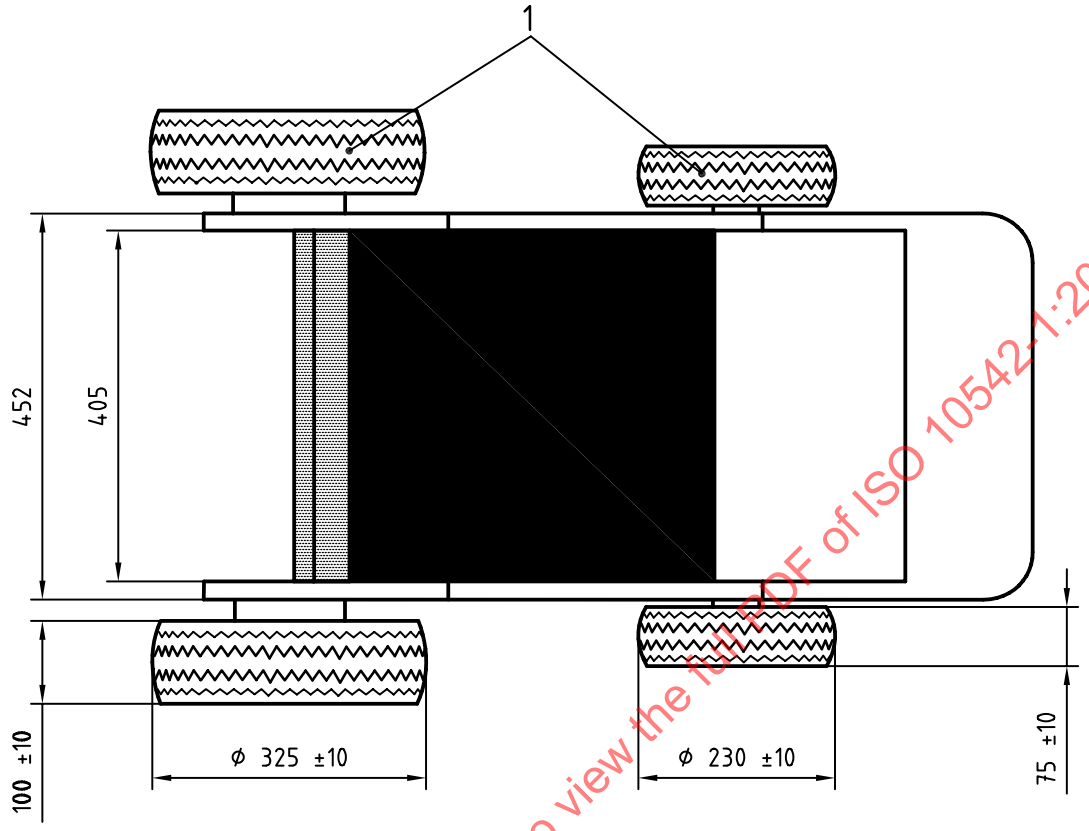


Figure E.2 — Front view of surrogate wheelchair

Dimensions in millimetres
Tolerances ± 5 mm unless otherwise specified

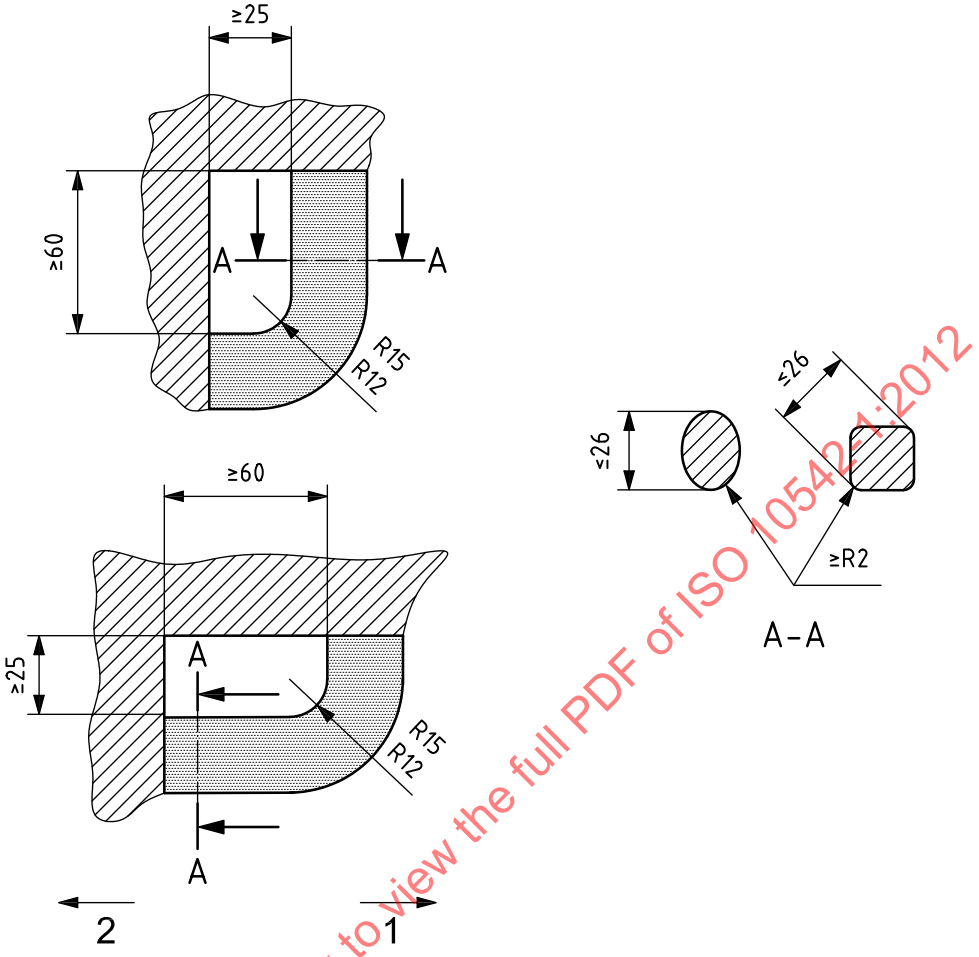


Key

1 pneumatic tyres

Figure E.3 — Top view of surrogate wheelchair

Dimensions in millimetres



Key

1 towards anchor point

2 towards wheelchair

Figure E.4 — Dimensions of wheelchair securement points intended to be engaged by the end fittings of four-point strap-type tiedown systems

NOTE 1 Securement point locations on SWC do not imply recommended locations on production wheelchairs.

NOTE 2 These dimensions are extracted from ISO 7176-19:2008, Annex B.

Annex F
(informative)

Specifications for the universal docking interface geometry (UDIG)

F.1 General

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

F.2 Principle

F.2.1 General

The criteria used to formulate the specifications for the universal docking interface geometry (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 clamping systems;

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 a wide range of private and public motor vehicles;

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

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

h) minimize any loss of aesthetics or function of the wheelchair;

i) not interfere with other wheelchair features and functions.

F.2.2 Specifications for the universal docking interface geometry (UDIG) and clear zones

A wheelchair securement adaptor that conforms to this UDIG specification should:

a) have a 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 may function without obstruction, as specified by key 6 in Figures F.3 and F.4;

NOTE 1 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;

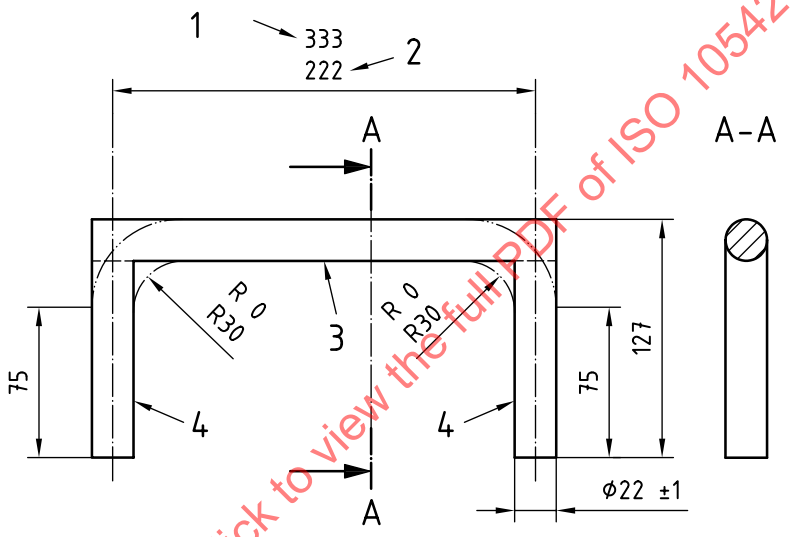
NOTE 2 The horizontal component is not required on wheelchairs with a mass of less than 30 kg to permit lighter weight manual wheelchairs with sideways folding frames to be folded without having to remove the UDIG adaptor.

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

NOTE 3 Zones specified for use for attachment of UDIG securement points in accordance with key 5 in Figures F.3 and F.4 should not be designed for engagement with the docking tiedown device, as obstruction may occur.

Dimensions in millimetres

Tolerance ± 3 mm unless otherwise indicated



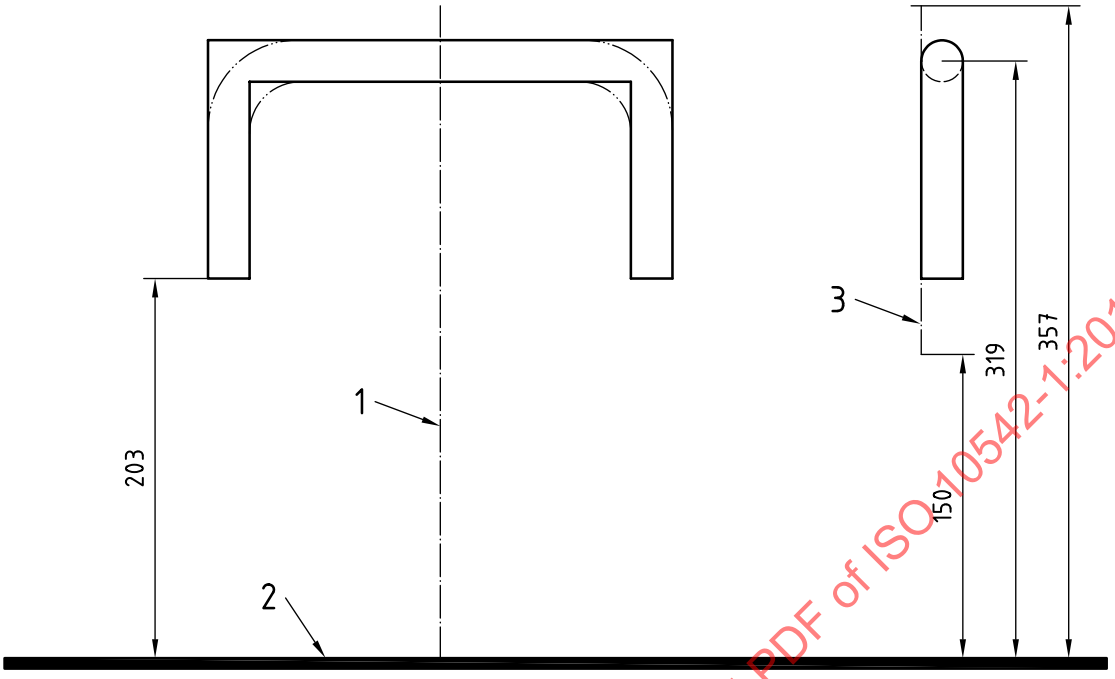
Key

1 maximum UDIG width
2 minimum UDIG width
3 horizontal segment
4 vertical segment

Figure F.1 — Specification of the Universal Docking Interfacing Geometry (UDIG)

Dimensions in millimetres

Tolerance ± 3 mm unless otherwise indicated



Key

1 wheelchair reference plane (centre line)

2 wheelchair ground plane

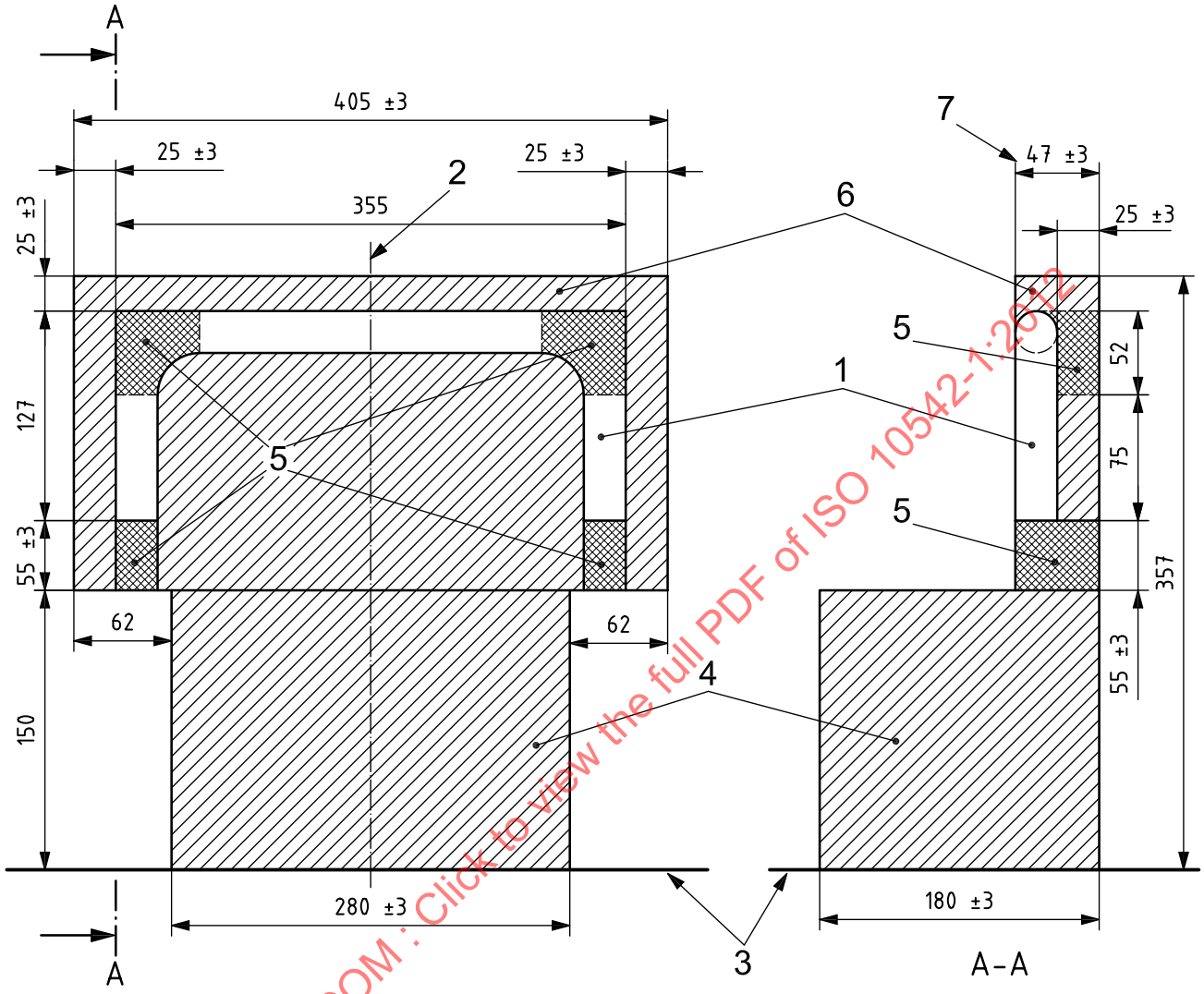
3 rearmost reference plane

[a] The UDIG is located symmetrically about the wheelchair reference plane.

[b] The rearmost reference plane is 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

Dimensions in millimetres
Tolerance ± 3 mm unless otherwise indicated

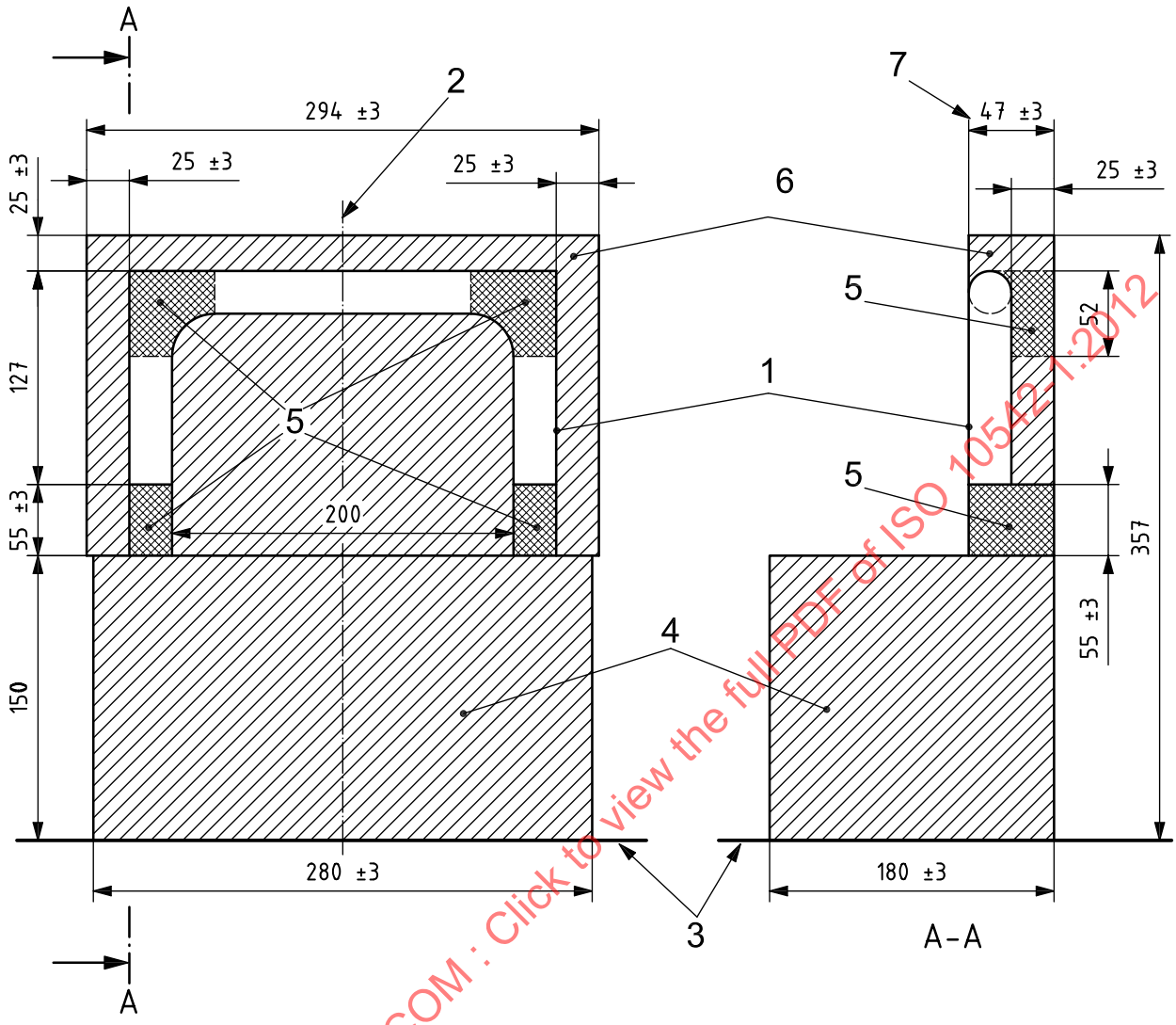


Key

1 UDIG
2 wheelchair reference plane
3 wheelchair ground plane
4 docking-station clear zone (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 rearmost wheelchair structure (150 mm to 357 mm above ground plane)

Figure F.3 — Specification of the UDIG clear zones (shown in maximum width configuration)

Dimensions in millimetres
Tolerance ± 3 mm unless otherwise indicated



Key

1 UDIG
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 rearmost wheelchair structure (150 mm to 357 mm above ground plane)

Figure F.4 — Specification of the UDIG clear zones (shown in minimum width configuration)

Annex G
(informative)

Tests for movement of wheelchairs secured by docking tiedown devices

G.1 Principle

To safeguard other passengers and provide the wheelchair-seated occupant with a comfortable ride, a docking tiedown device should limit the movement of the wheelchair relative to the vehicle interior during normal or emergency driving manoeuvres. This informative annex specifies equipment, test conditions and procedures for measuring the potential for lateral, forward and rotational movement of wheelchairs allowed by a docking tiedown device. This is done by simulating the magnitudes of forces that may act on an occupied wheelchair during emergency driving manoeuvres using a tilt table. To assess the performance of the docking securement device independent of variations in wheelchair structures and locations of wheelchair and occupant centres of gravity, the tests are conducted using the rigid surrogate wheelchair (SWC) specified in Annex E or with a specific wheelchair model (SWM), as appropriate.

G.2 Equipment to be tested

The equipment to be tested is a complete unused commercial or prototype docking tiedown device with wheelchair securement adaptor suitable for use with the TWC.

G.3 Test equipment

G.3.1 Flat platform that:

a) does not visibly deflect during testing (i.e. tilting) under the load of the secured TWC occupied by an ATD, as specified in Annex A;

b) has a surface area that is large enough to accommodate the docking tiedown device and the TWC when configured for the frontal impact test of Annex A, and as shown in Figures G.1 and G.3;

c) can be tilted to an angle of $25^{\circ}\ ^{+1^{\circ}}_{0^{\circ}}$ to the horizontal at a rate of at least 20° to 30° per minute;

d) has a surface with a coefficient of friction equivalent to that used in most transport vehicles, but not greater than 0,3 as determined by ISO 7176-13.

G.3.2 Test wheelchair (TWC), selected as follows.

a) If the WTORS is intended for use with all types of manual and powered wheelchairs, then the TWC will consist of the surrogate wheelchair (SWC) as specified in Annex E, adapted as follows:

   1) replace fixed front wheels with two 100 mm to 125 mm diameter castor wheels;

   2) locate castor stems within 25 mm of the vertical line passing through the fixed front wheel axle and the floor contact point.

b) If the WTORS is intended to be used only with specific makes and models of wheelchairs, then the TWC will consist of the specific wheelchair model (SWM) it is designed for.

G.3.3 ATD used in the frontal impact test of Annex A.

G.3.4 Means for restraining the ATD to the TWC back and seat, such as rope, webbing, or belt material.

G.3.5 Means for restraining the linear and rotational movements of the TWC, to an accuracy of ±3 mm and ±3°, respectively.

G.4 Test procedures

Perform the following steps in the order indicated.

a) Designate fore and aft reference points on the SWC for measuring the linear and rotational movement as follows:

   1) the rear reference point (RRP), located on the most rearward structure of the TWC that intersects with the TWC reference plane, at the height of the P point, as illustrated in Figures G.1, G.3 and G.4;

   2) the forward reference point (FRP), located on a forward structure of the TWC that intersects with the TWC reference plane, most likely between the foot supports, as illustrated in Figures G.1 and G.3.

b) Check all tyres on the TWC to ensure correct inflation.

c) Mount the docking tiedown device on the tilt platform in accordance with the manufacturer's instructions.

d) Locate the TWC on the tilt table and secure to the docking tiedown device so that the TWC reference plane is parallel to the tilt axis and the tilt platform centre line, as illustrated in Figure G.1.

e) Position the ATD in the TWC, sitting upright and symmetrical about the SWC reference plane, with the pelvis as close to the back support of the wheelchair as possible, and the forearms and hands resting on the thighs.

f) Restrain the ATD pelvis and torso snugly to the TWC seat using rope, webbing or belt material.

g) Tilt the test platform at a uniform rate to an angle of 25° ± 3°, as illustrated in Figures G.2 and G.4.

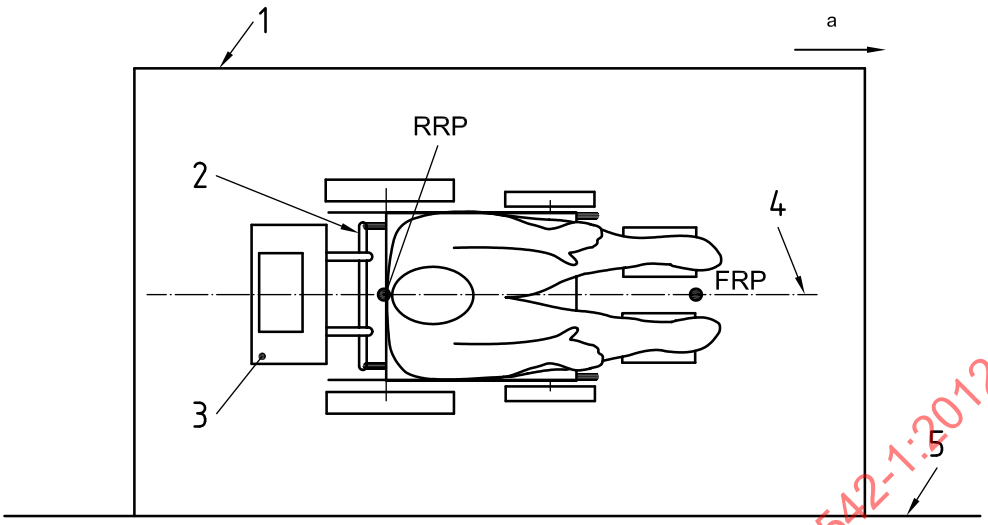
h) While the platform remains tilted to 25° ± 3°, measure the perpendicular displacement of RRP relative to the tilt platform to an accuracy of ±3 mm, as illustrated in Figure G.2. Measure the angular displacement of a line joining the FRP and the RRP relative to the centre line of the tilt platform, as illustrated in Figure G.2. Measure the distance that any wheels have raised off the surface of the tilt platform.

   NOTE The use of laser screen pointers mounted at RRP and FRP and projecting down to the tilt platform surface, parallel to the TWC reference plane, is one simple method of obtaining points on the tilt platform that can be used for measurement of both linear and angular displacements.

i) Perform the tilt test and measurement procedure a total of three times, repositioning the TWC and ATD to their initial position between trials, as necessary.

j) Calculate and record the average for the three trials.

k) Reinstall the docking securement device on the tilt platform so that the TWC reference plane is perpendicular to the tilt axis and centre line of the tilt platform, and the front of the TWC is facing downward during the test. Repeat steps h) and i) while measuring and recording only the forward displacement of the RRP relative to the tilt platform.

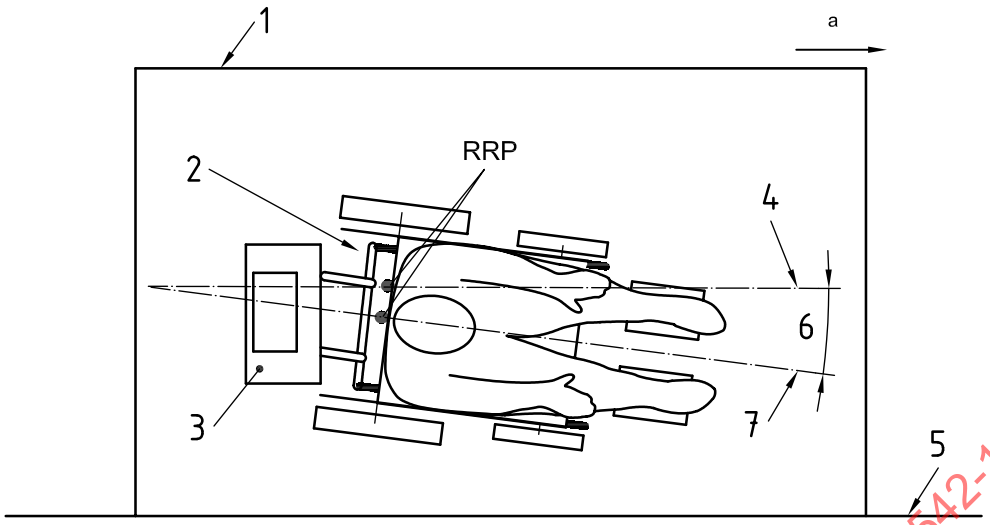


Key

1	tilt test platform
2	wheelchair securement adaptor
3	docking tiedown device
4	wheelchair reference plane and midline of test platform
5	test platform tilt axis
RRP	rear reference point
FRP	forward reference point

[a] Forward.

Figure G.1 — Top view illustration of TWC loaded with an ATD and secured by a docking securement device on the tilt platform prior to a lateral tilt test



Key

1	tilt test platform
2	wheelchair securement adaptor
3	docking tiedown device
4	pre-test wheelchair reference plane
5	test platform tilt axis
6	wheelchair rotation angle
7	wheelchair reference plane
RRP	rear reference point

[a] Forward.

Figure G.2 — Top view illustration of TWC loaded with an ATD and secured by a docking tiedown device on the tilt platform during a lateral tilt test