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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

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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

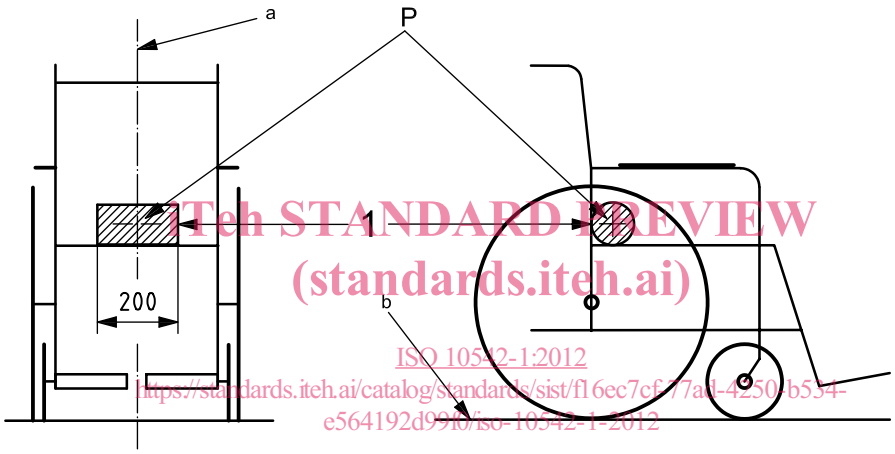
3.25
pelvic belt restraint
lap belt restraint
lower-torso restraint
pelvic belt
lap belt
portion of an occupant restraint which passes across the front of the wearer's pelvic region

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

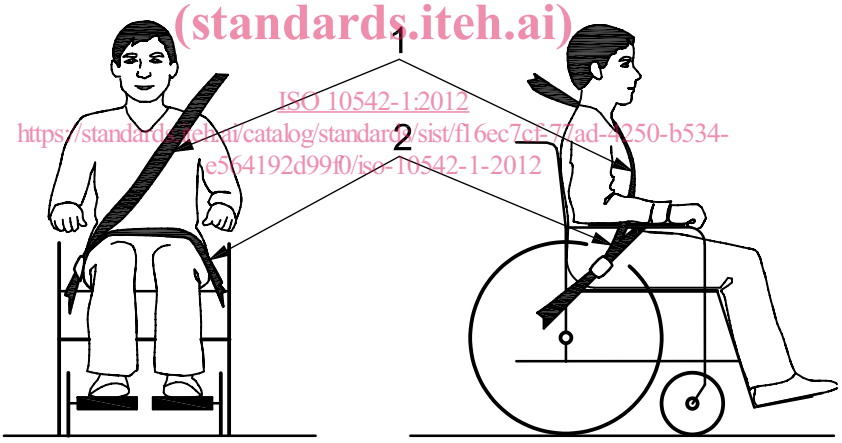
3.31
strap
length of webbing material used in a wheelchair tiedown

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.

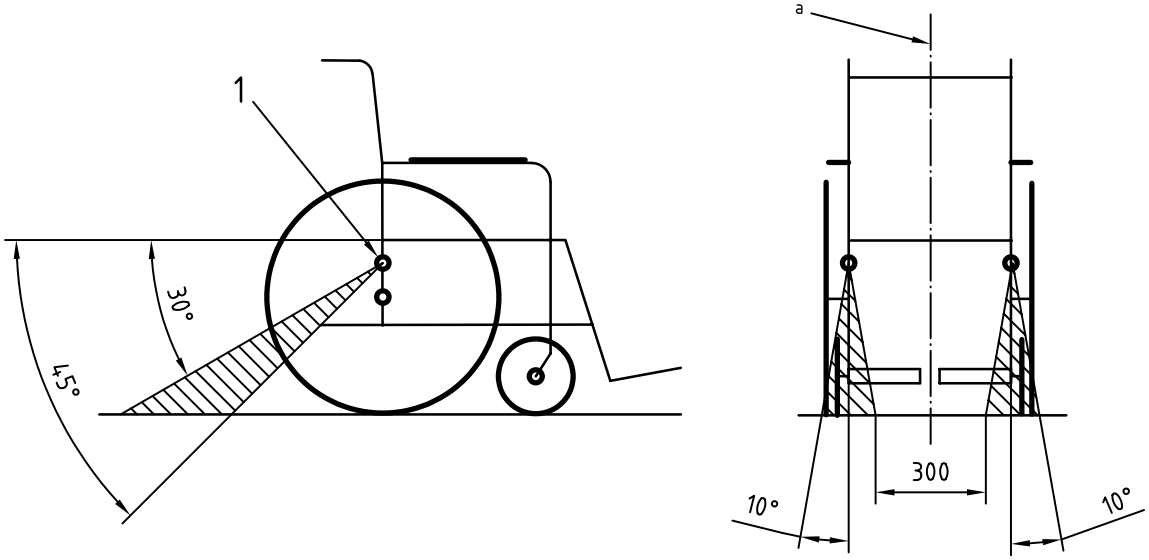
4.2.2 Four-point strap-type tiedowns

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

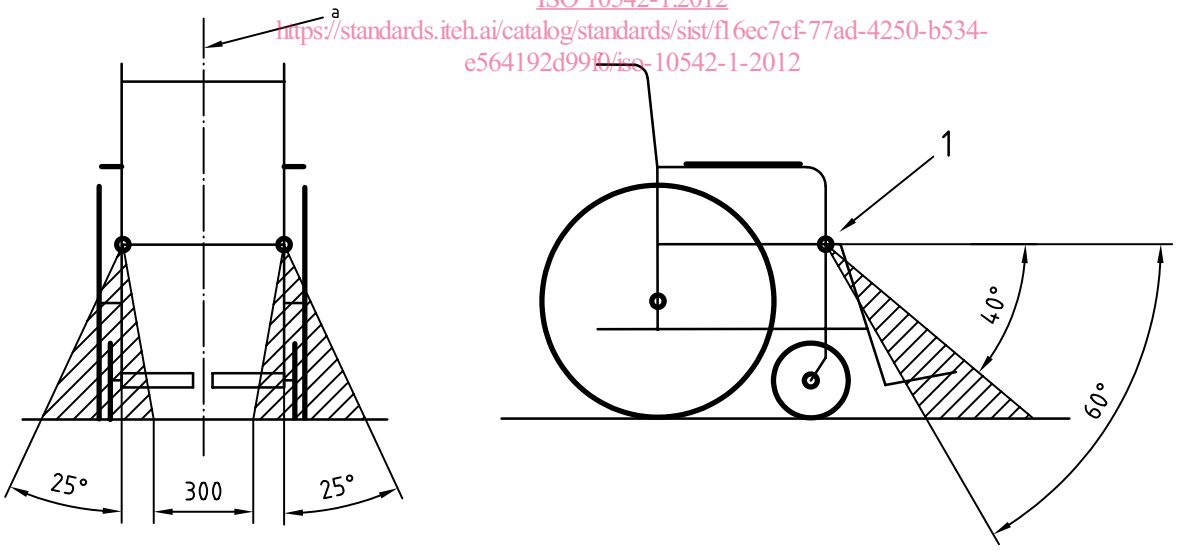
1 rear securement points

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.