

Australian/New Zealand Standard™

**Technical systems and aids for people
with disability—Wheelchair tiedown and
occupant-restraint systems**

**Part 1: Requirements and test methods
for all systems (ISO 10542-1:2012, MOD)**



AS/NZS 10542.1:2015

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee ME-067, Assistive Technology Products for Persons with Disability. It was approved on behalf of the Council of Standards Australia on 25 September 2015 and on behalf of the Council of Standards New Zealand on 10 September 2015.

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Australian/New Zealand Standard™

Technical systems and aids for people with disability—Wheelchair tiedown and occupant-restraint systems

Part 1: Requirements and test methods for all systems (ISO 10542-1:2012, MOD)

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-067, Assistive Technology Products for Persons with Disability, to supersede AS/NZS 10542.1:2009, *Technical systems and aids for disabled or handicapped persons—Wheelchair tiedown and occupant-restraint systems*, Part 1: *Requirements and test methods for all systems*, and AS/NZS 10542.2:2009, *Technical systems and aids for disabled or handicapped persons—Wheelchair tiedown and occupant-restraint systems*, Part 2: *Four-point strap-type tiedown systems*.

The objective of this Standard to specify 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 Standard is an adoption with national modifications and has been reproduced from ISO 10542-1:2012, *Technical systems and aids for disabled or handicapped persons—Wheelchair tiedown and occupant-restraint systems*, Part 1: *Requirements and test methods for all systems*, and its Corrigendum No.1 (2013), which is located at the end of the source text. The source document has been varied as indicated to take account of Australian/New Zealand conditions. The modifications are specified in Appendix ZZ and Appendix ZA. Response from consumers and industry has called for changes to AS/NZS 10542.1 to better describe the above-the-head clear space requirements (addressed in Appendix ZZ) and vehicle anchorage point requirements and occupant restraint upper anchorage points (addressed in Appendix ZA).

Clear space requirements shown in Figure 6 are modified to include a seated head height (HHT). The original Figure 6 could be interpreted as requiring the clear space to be equivalent to HHT, level with the top of the occupant's head. This figure has been modified to change this and now also includes a wheelchair with a headrest, which is consistent with best practice guidelines.

The 1550 mm minimum dimension is consistent with the 'Disability Standards for Accessible Public Transport 2002' requirements for access to accessible taxis (Clause 12.4).

The modifications contained in Appendix ZA set out minimum requirements for vehicle anchorage points consistent with Australian Design Rules, and the occupant restraint upper anchorage points. The specifications for occupant restraint upper anchorage points are provided as informative guidance in ISO 10524-1, Annex H, but are made normative in Appendix ZA.

As this Standard is reproduced from an International Standard, the following applies:

- (a) In the source text 'this part of ISO 10542' should read 'this Australian/New Zealand Standard'.
- (b) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard</i>	<i>Australian/New Zealand Standard</i>
ISO	AS/NZS
7176 Wheelchairs	3696 Wheelchairs
7176-19 Part 19: Wheeled mobility devices for use as seats in motor vehicles	3696.19 Part 19: Wheeled mobility devices for use as seats in motor vehicles (ISO 7176-19:2008, MOD)

Only normative references that have been adopted as Australian or Australian/New Zealand Standard have been listed.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the annex or appendix to which they apply. A 'normative' annex or appendix is an integral part of a Standard, whereas an 'informative' annex or appendix is only for information and guidance.

CONTENTS

1	Scope	1
2	Normative references	1
3	Terms and definitions	1
4	Design requirements	6
4.1	WTORS	6
4.2	Wheelchair tiedowns	7
4.3	Wheelchair securement adaptors	9
4.4	Occupant restraints	10
5	Performance requirements	11
5.1	WTORS components	11
5.2	Frontal impact requirements	13
5.3	Webbing slippage at tiedown adjustment devices	14
5.4	Partial engagement of anchorage and securement components	14
5.5	Linear and rotational wheelchair movement	14
6	Identification, labelling, instruction and warning requirements	14
6.1	Identification and labelling	14
6.2	Instructions for installers	15
6.3	User and maintenance instructions	19
6.4	Instructions for replacement parts and accessory WTORS components and subassemblies (when sold separately)	22
7	Test reports	22
Annex A	(normative) Test method for frontal impact	25
Annex B	(normative) Measurement of WTORS belt lengths and geometry	33
Annex C	(normative) Test for webbing slippage at manual adjustment devices of wheelchair tiedown straps	37
Annex D	(normative) Test method for partial engagement	39
Annex E	(normative) Surrogate wheelchair specifications	41
Annex F	(informative) Specifications for the universal docking interface geometry (UDIG)	46
Annex G	(informative) Tests for movement of wheelchairs secured by docking tiedown devices	51
Annex H	(informative) Recommendations for design, performance and documentation	57
Annex I	(informative) Recommendations for securement point locations on wheelchairs and adjustment lengths of strap assemblies	64
Annex J	(informative) Information sources	66
Bibliography		68

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 environment

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.

AUSTRALIAN/NEW ZEALAND STANDARD

Technical systems and aids for people with disability—Wheelchair tiedown and occupant-restraint systems**Part 1:****Requirements and test methods for all systems (ISO 10542-1:2012, MOD)****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

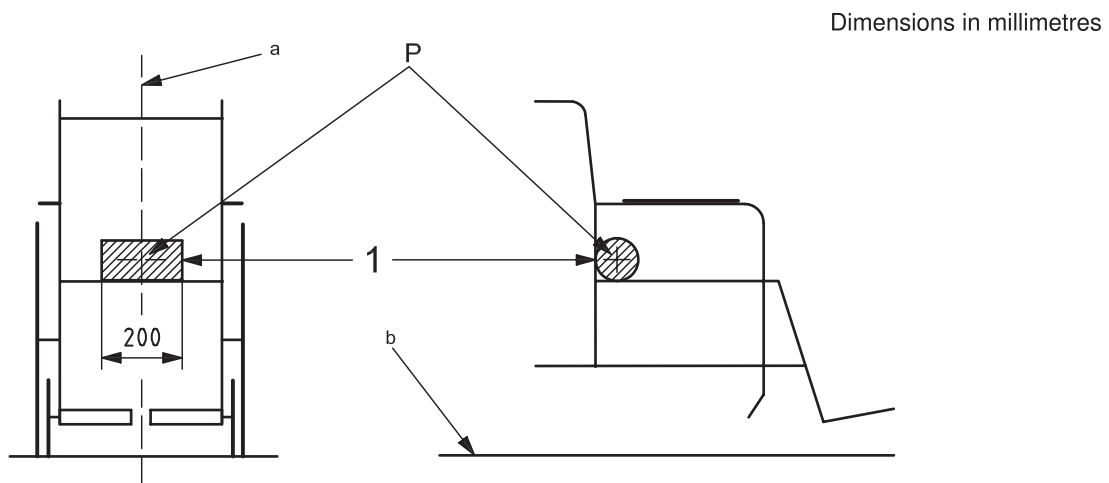
portion of an occupant restraint which passes across the front of the wearer's pelvic region

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.

**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**

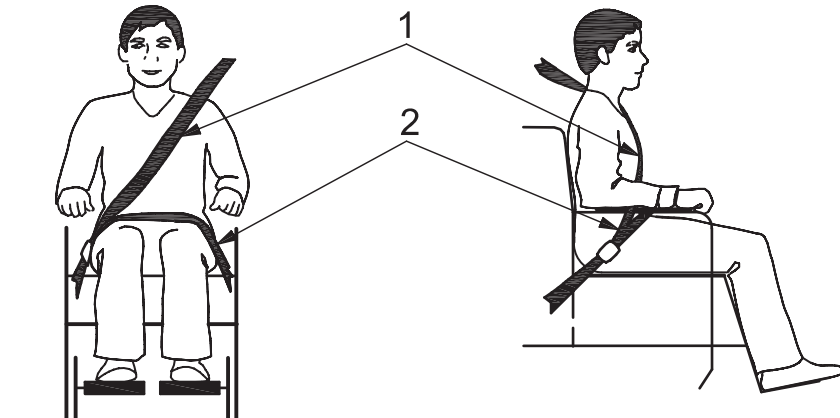
SWC or SWM wheelchair that is used to test wheelchair-tiedown and occupant-restraint systems

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:

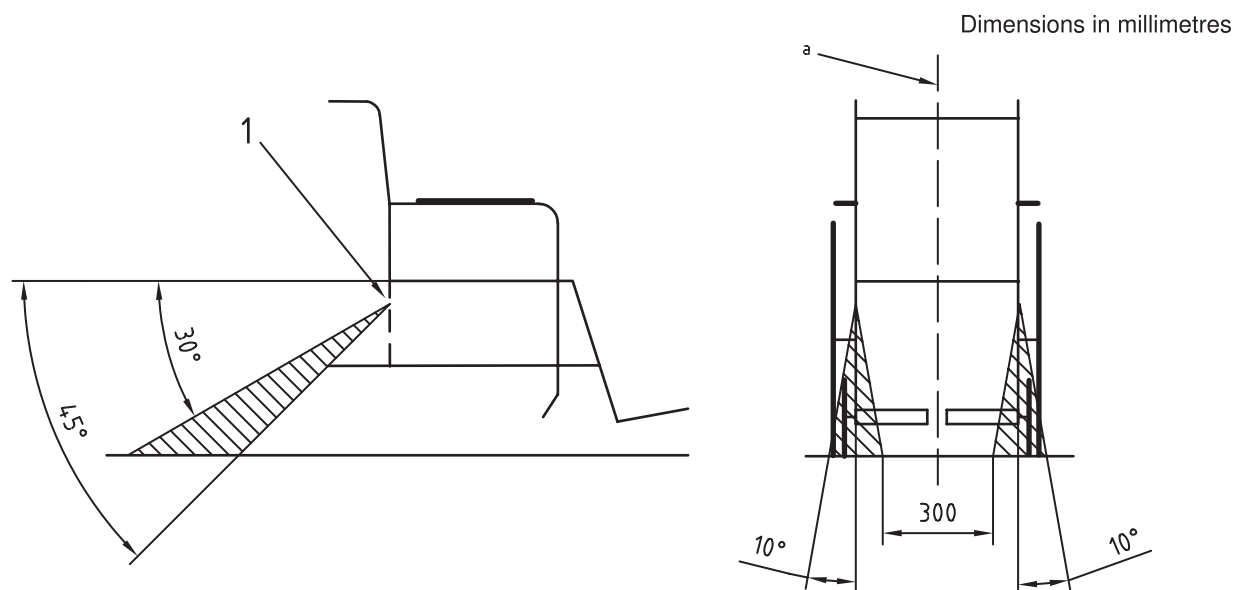
- a) not release if any wheelchair component deforms, or if one or more tyres deflate during a vehicle impact;
- b) include a means to minimize vehicle-induced movement of the wheelchair that does not require the use of tools;
- c) not depend on the wheelchair brakes;
- d) not utilize the occupant restraint 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.

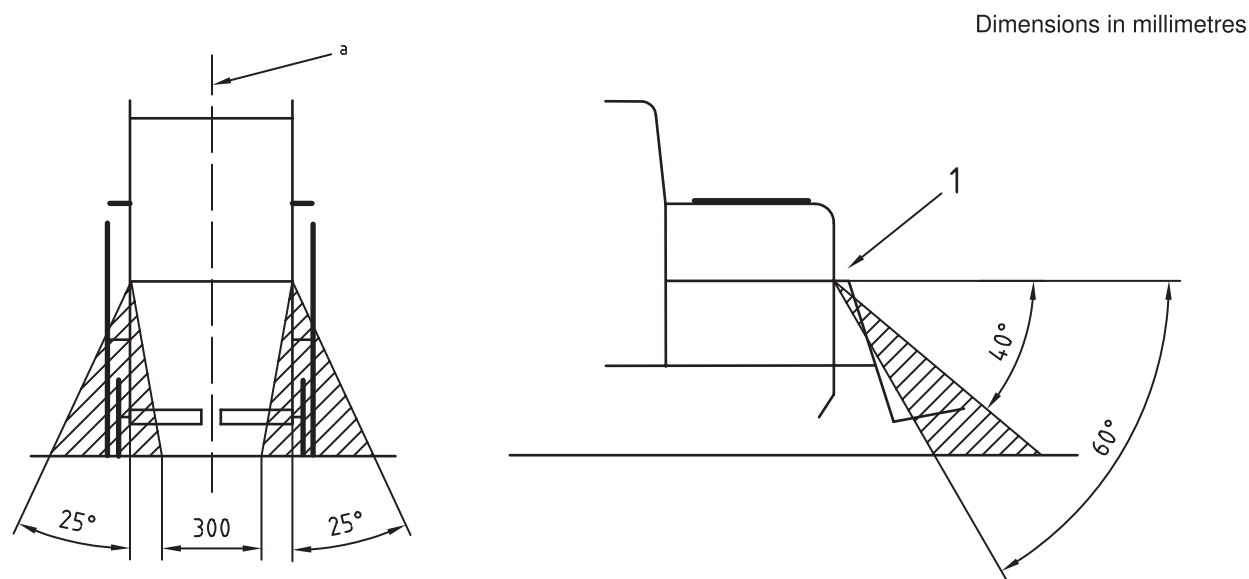
**Key**

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

**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.

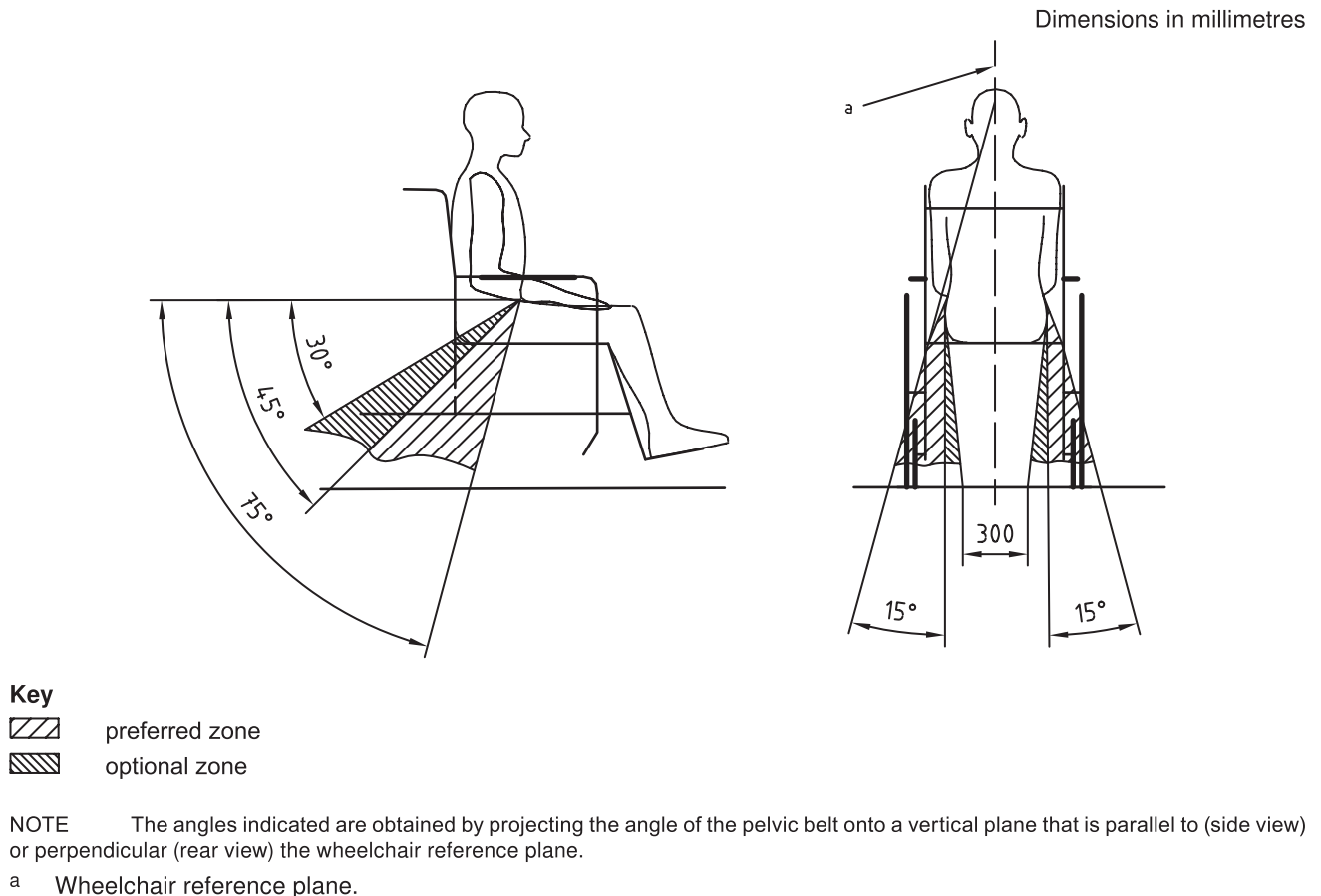


Figure 5 — Ranges of angles for pelvic belts

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 ($x_{\text{knee}}/x_{\text{wc}} > 1,1$).

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_{head} 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;

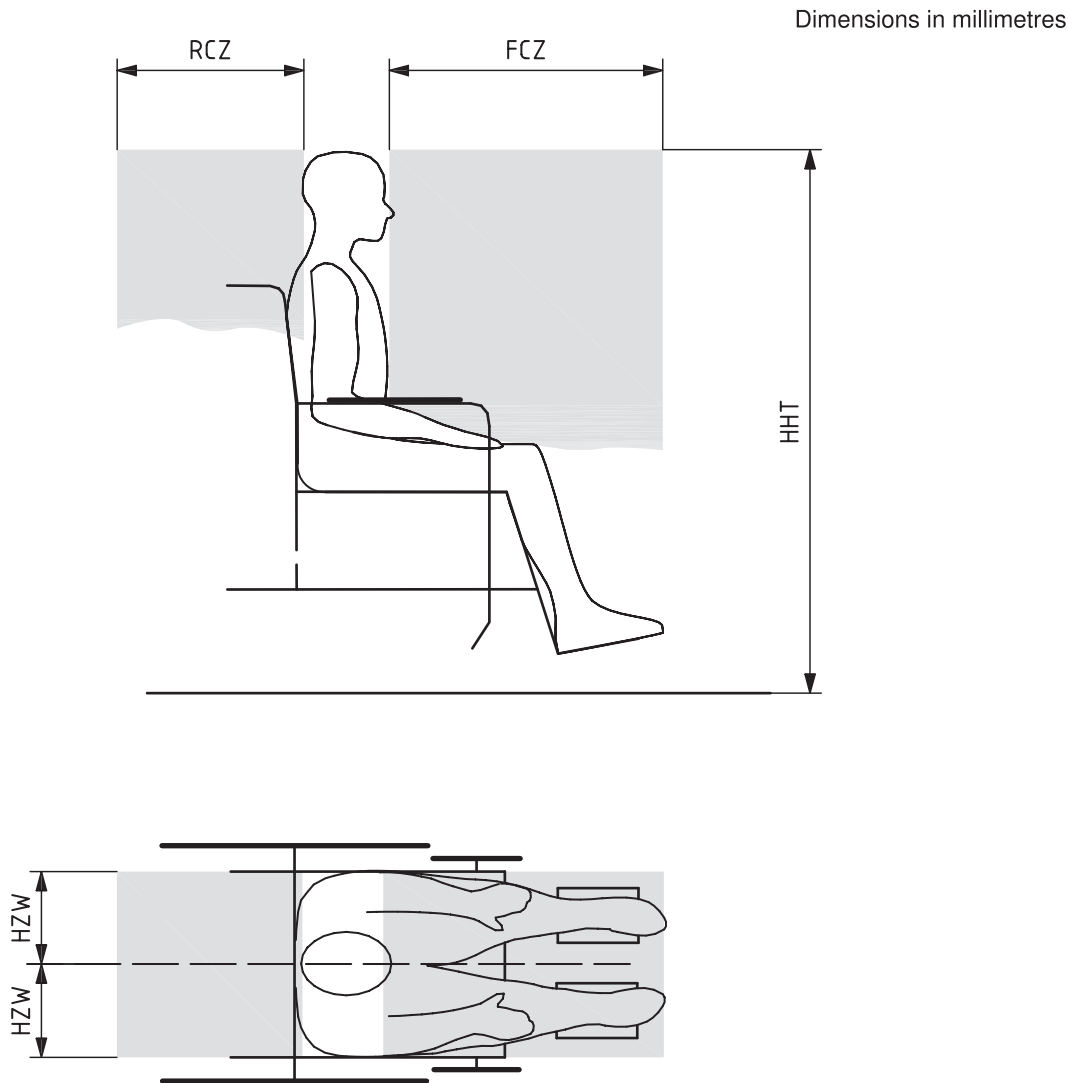
- b) an exploded-view drawing and a parts list for all components required in the installation;
- c) the locations for anchor points of vehicle-anchored belt restraints relative to wheelchair tiedown anchor points, along with the rear-view and side-view preferred angles for pelvic belt restraints as 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.



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, HHT 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