INTERNATIONAL STANDARD

ISO 7176-19

Second edition
2008-07-15

Wheelchairs —

Part 19: Wheeled mobility devices for use as seats in motor vehicles

Fauteuils roulants —

Partie 19: Dispositifs de mobilité montés sur roues et destinés à être utilisés comme sièges dans des véhicules à moteur

Reference number
ISO 7176-19:2008(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

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

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 7176-19 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

This second edition cancels and replaces the first edition (ISO 7176-19:2001), most clauses of which have been technically revised.

ISO 7176 consists of the following parts, under the general title *Wheelchairs*:

— *Part 1: Determination of static stability*

— *Part 2: Determination of dynamic stability of electric wheelchairs*

— *Part 3: Determination of effectiveness of brakes*

— *Part 4: Energy consumption of electric wheelchairs and scooters for determination of theoretical distance range*

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

— *Part 6: Determination of maximum speed, acceleration and deceleration of electric wheelchairs*

— *Part 7: Measurement of seating and wheel dimensions*

— *Part 8: Requirements and test methods for static, impact and fatigue strengths*

— *Part 9: Climatic tests for electric wheelchairs*

— *Part 10: Determination of obstacle-climbing ability of electrically powered wheelchairs*

— *Part 11: Test dummies*

— *Part 13: Determination of coefficient of friction of test surfaces*

— *Part 14: Power and control systems for electrically powered wheelchairs and scooters — Requirements and test methods*

— *Part 15: Requirements for information disclosure, documentation and labelling*

— *Part 16: Resistance to ignition of upholstered parts — Requirements and test methods*

— *Part 19: Wheeled mobility devices for use as seats in motor vehicles*

— *Part 21: Requirements and test methods for electromagnetic compatibility of electrically powered wheelchairs and scooters, and battery chargers*

— *Part 22: Set-up procedures*

— *Part 23: Requirements and test methods for attendant-operated stair-climbing devices*

— *Part 24: Requirements and test methods for user-operated stair-climbing devices*

— *Part 25: Requirements and test methods for batteries and their chargers for electrically powered wheelchairs and motorized scooters*

— *Part 26: Vocabulary*

A technical report, ISO/TR 13570-1, is also available, giving a simplified explanation of these parts of ISO 7176.

Introduction

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

ISO 10542-1 provides design, performance, labelling, and the manufacturer's literature requirements, and specifies associated test methods, for wheelchair tiedown and occupant-restraint systems (WTORS). This part of ISO 7176 addresses the seating part of wheelchair-user occupant-protection systems by establishing design, performance, labelling, and the manufacturer's literature requirements, as well as associated test methods, for wheelchairs that may be used as seats in motor vehicles.

Whilst wheelchairs may be secured by various types of tiedown and securement systems that were available throughout the world at the time this part of ISO 7176 was developed, effective wheelchair securement in the real world requires compatibility of the wheelchair tiedown system available in the vehicle and the method of securement provided on the wheelchair. At the time that this part of ISO 7176 was developed, the four-point strap-type tiedown was considered to be the most effective, common, and universally adaptable system for securing a wide range of wheelchair types and sizes. For these reasons, this part of ISO 7176 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 in front and two in the back. However, this part of ISO 7176 also provides for evaluating wheelchairs that are also designed for securement by other methods, such as docking-type securement systems.

To evaluate the crashworthiness performance of a wheelchair, Annex A specifies procedures for dynamically testing a wheelchair loaded with an appropriate-size crash-test dummy using a 48 km/h crash pulse with the wheelchair secured facing forward on the impact sled. This test is based on well-documented motor vehicle crash and injury statistics, which show that more than 50 % of all serious injuries to occupants of motor vehicles occur in frontal crashes, and that more than 95 % of frontal crashes result in a longitudinal change in vehicle speed of less than 48 km/h. Dynamic performance for forward-facing wheelchairs in rear and side impacts might be addressed in future International Standards.

This part of ISO 7176 has also been developed with the recognition that the use of a pelvic-belt restraint alone does not provide the wheelchair occupant with the same level of crash protection in a frontal impact as the use of both pelvic-belt and shoulder-belt restraints. Therefore, the provisions and test methods of this part of ISO 7176 are based on the use of both pelvic- and shoulder-belt-type restraints.

Although the four-point strap-type tiedown system was considered to be the most common and universal method for effectively securing a wide range of wheelchairs at the time this part of ISO 7176 was developed, it is a method of wheelchair securement that requires the involvement of a second person and cannot be implemented by the wheelchair occupant. Accordingly, it is desirable to progress toward a securement method that can be implemented independently by the wheelchair-seated passenger who may travel in different public transportation and private vehicles. As a step toward this goal, this part of ISO 7176 includes a normative annex (Annex F) that establishes universal docking interface geometry (UDIG) for securement points on wheelchairs when it is intended for the wheelchair to be secured by docking-type securement devices in public transportation and/or multiple private vehicles.

Finally, this part of ISO 7176 can be viewed in the totality of daily wheelchair use and the range of standards to which all wheelchairs are expected to comply. Wheelchairs are designed primarily to serve as effective mobility devices and, in that respect, they must first conform to the applicable requirements set forth in other

parts of the ISO 7176 series. Transportation is only one of many daily activities that introduce unique circumstances and requirements that wheelchairs and wheelchair occupants may experience. Wheelchair products that comply with this part of ISO 7176 will have additional features that provide increased levels of occupant security and safety whilst their occupants are riding in motor vehicles. However, a wheelchair's failure to comply with this part of ISO 7176 cannot be used to limit access to, and availability of, motor vehicle transportation for wheelchair users.

Wheelchairs —

Part 19: Wheeled mobility devices for use as seats in motor vehicles

1 Scope

This part of ISO 7176 applies to all manual and powered wheelchairs, including scooters, which, in addition to their primary function as wheeled mobility devices, are also likely to be used as forward-facing seats in motor vehicles by children and adults with a body mass equal to or greater than 22 kg. This part of ISO 7176 specifies wheelchair design requirements, performance requirements and associated test methods, and requirements for wheelchair labelling, presale literature, user instructions and user warnings. It applies to complete wheelchairs, including a base frame and seating system, as well as to wheelchairs equipped with add-on adaptive components designed to facilitate compliance with one or more of the requirements.

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

ISO 7176-15:1996, *Wheelchairs — Part 15: Requirements for information disclosure, documentation and labelling*

ISO 7176-22:2000, *Wheelchairs — Part 22: Set-up procedures*

ISO 7176-26:2007, *Wheelchairs — Part 26: Vocabulary*

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

ISO 10542-2, *Technical systems and aids for disabled or handicapped persons — Wheelchair tiedown and occupant-restraint systems — Part 2: Four-point strap-type tiedown systems*

FMVSS 209:2004, Standard No. 209, *Seat belt assemblies.* Federal Motor Vehicle Safety Standards, 49 CFR 571.209, 1 October, 2004

ECE Regulation 16, *Uniform provisions concerning the approval of safety belts and restraint systems for adult occupants of power-driven vehicles*, Revision 3, Amendment 2, 16 August 1993

3 Terms and definitions

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

3.1
add-on components
hardware that is attached to the wheelchair frame subsequent to sale by the wheelchair manufacturer, in a manner that requires the use of tools for removal, in order to enhance design and/or performance of the wheelchair

3.2
adult
person having a mass equal to or greater than 43 kg

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, wheelchair, wheelchair tiedown, or vehicle interior component

3.5
anthropomorphic test device
ATD
articulated physical analogue of the human body used to represent a wheelchair occupant in a test

3.6
belt
length of webbing material used as part of an occupant restraint or postural support device

3.7
child
person having a mass equal to or greater than 22 kg and less than 43 kg

3.8
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

3.9
docking-type tiedown
docking-type securement
method of wheelchair tiedown by which portions of the wheelchair structure, or add-on components fastened to the wheelchair, align, mate and engage with a docking tiedown device fastened to the vehicle, upon manoeuvring the wheelchair into position in the vehicle

NOTE Securement of the wheelchair may occur automatically during wheelchair engagement, or could require manual intervention through operation of a mechanical lever or electrical switch. Release of the wheelchair will usually require operation of a mechanical lever or electrical switch.

3.10
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

3.11
excursion
horizontal movement of an ATD or wheelchair during a test relative to its initial position on an impact sled

3.12
forward-facing
orientation in which the wheelchair-seated occupant faces the front of the vehicle with the wheelchair reference plane within 10° of the longitudinal axis of the vehicle

3.13
four-point tiedown
wheelchair tiedown that attaches to the wheelchair frame at four separate securement points and also attaches to the vehicle at four separate anchor points

3.14
four-point strap-type tiedown
four-point tiedown that uses four strap assemblies to secure the wheelchair in the vehicle

3.15
H-point
one of a pair of points 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 centre in the side views, as specified by the ATD manufacturer

3.16
head restraint
device intended to limit rearward excursion of the wheelchair occupant's head in a vehicle impact

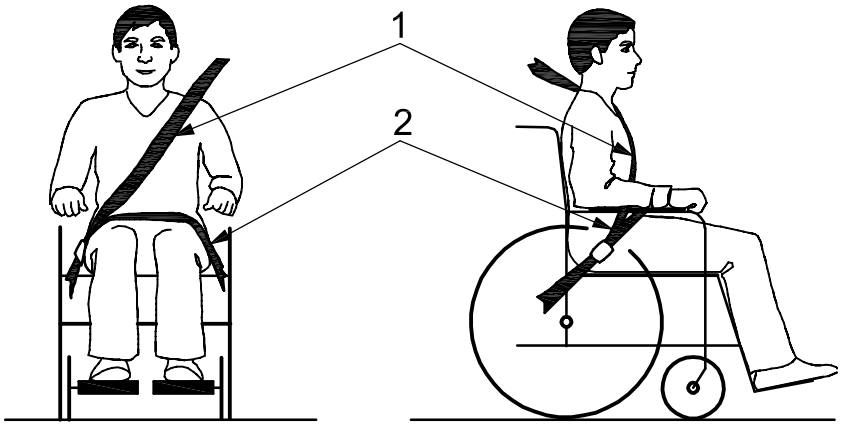
3.17
impact simulator
device for accelerating, decelerating, or a combination of decelerating and accelerating, a section of a vehicle or simulated vehicle structures, including instrumentation for measuring data required by this standard

3.18
impact sled
part of an impact simulator on which components can be mounted for impact testing

3.19
occupant restraint
system or device intended to restrain a motor-vehicle occupant during an impact in order to prevent ejection, and prevent or minimise contact with the vehicle interior components and other occupants

3.20
pelvic-belt restraint
lap-belt restraint
assembly of webbing and hardware intended to maintain an occupant in a seat during a crash

NOTE See Figure 1.



Key

1 shoulder-belt restraint

2 pelvic-belt restraint

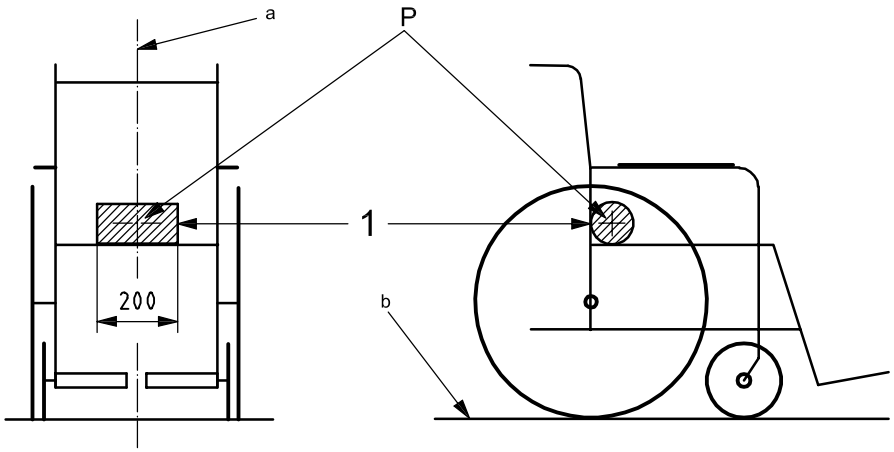
NOTE The use of a pelvic-belt restraint only is not recommended.

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

3.21
point P
side-view projection of a point that lies at the cross-sectional centre of a 100 mm diameter, 200 mm long, lightweight (max. 0,5 kg) cylinder 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

NOTE See Figure 2.

Dimensions in millimetres



Key

1 cylinder, diameter 100 mm

P point P

a Wheelchair reference plane.

b Wheelchair ground plane.

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

3.22
postural support device
component and/or belt used to support a person in a desired seated position during normal wheelchair use

NOTE Postural support devices are not designed or intended to provide occupant restraint in a vehicle impact

3.23
power(ed)
systems which are operated by means of an energy source other than manual effort

3.24
securement points
points on the wheelchair to which wheelchair tiedowns are connected

3.25
shoulder-belt restraint
upper torso restraint
portion of the occupant restraint intended to limit movement of the head and chest by application of restraint forces to either or both clavicles

NOTE See Figure 1.

3.26
strap
length of webbing material used in a wheelchair tiedown

3.27
surrogate tiedown
wheelchair securement system used during wheelchair testing to simulate commercial tiedown systems

NOTE Guidelines for designing surrogate tiedowns are provided in Annex E.

3.28
three-point belt restraint
three-point restraint (deprecated)
occupant-restraint assembly with three anchorages comprised of both a pelvic-belt restraint and a diagonal shoulder-belt restraint that connect together near the hip of the occupant

NOTE See Figure 1.

3.29
tilt seating
type of wheelchair seat design that allows the complete seat structure to rotate in the wheelchair reference plane relative to and about an axis located on the wheelchair base

3.30
universal docking interface geometry
UDIG
specifications for the size, shape, and location of wheelchair securement points, including surrounding clear zones, intended for use with a variety of docking tiedown devices installed in a wide range of vehicles

3.31
UDIG adaptor
wheelchair tiedown adaptor that conforms to the UDIG specification in Annex F

3.32
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

3.33
wheelchair ground plane
plane representing the surface on which the wheelchair rests

NOTE See Figure 2.

3.34
wheelchair reference plane
vertical plane in the longitudinal centreline of the wheelchair

NOTE See Figure 2.

3.35
wheelchair tiedown
wheelchair securement
device or system designed to secure a forward-facing wheelchair in place in a motor vehicle

NOTE The vehicle-anchored tiedown component may be installed using either permanent fasteners or by using a mechanical coupling that allows for position adjustment for different wheelchairs.

3.36
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

3.37
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

4 Design requirements

4.1 Wheelchair securement

4.1.1 The wheelchair shall be designed to provide for forward-facing securement in a motor vehicle using a four-point strap-type tiedown system that complies with ISO 10542-2 using a minimum of four securement points, two at the front and two at the rear, that conform to the geometric specifications set forth in Annex B and the performance requirements in Clause 5.

NOTE In addition to complying with this subclause, the wheelchair can be designed for forward-facing securement using other methods of wheelchair securement, including docking-type securement devices.

4.1.2 If a wheelchair is intended by the manufacturer to also be secured by a docking securement device in public transportation and/or different private vehicles, the securement points on the wheelchair and/or of the wheelchair tiedown adaptors shall conform to the specifications set forth in Annex F and the performance requirements in Clause 5.

4.2 Occupant restraints

4.2.1 Wheelchair-anchored pelvic-belt restraint

If a wheelchair-anchored pelvic-belt intended for use as an occupant restraint in a vehicle is provided as part of the wheelchair, when placed on the ATD in accordance with the set-up procedures for the frontal-impact test of Annex A, it shall

a) have its anchor points located so that the projected side-view angle of the belt is between 30° and 75° to the horizontal, as indicated in Figure 3, and

b) provide for adjustment of the pelvic-belt restraint that allows for increasing the length and decreasing the length as specified in Table 1.

NOTE 1 A steeper (larger) pelvic-belt restraint angle within the preferred zone shown in Figure 3 is desirable.

NOTE 2 At least 25 mm of webbing must extend through any fitting where adjustment takes place at all times during testing.

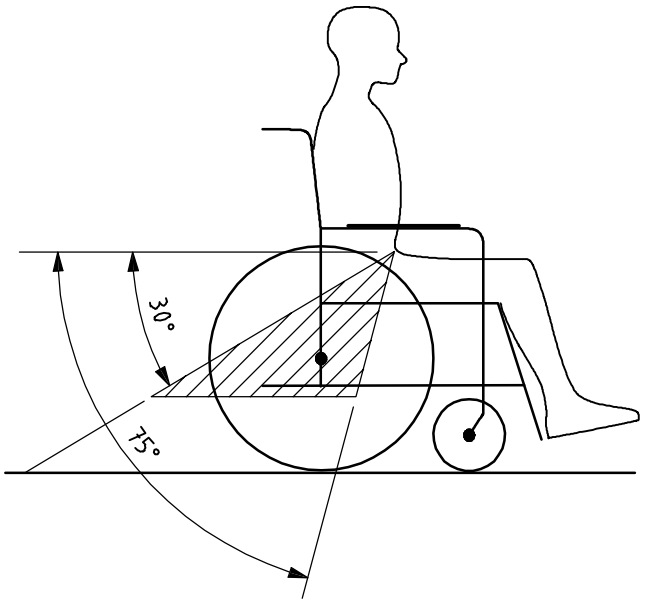
Table 1 — Requirements for pelvic-belt-restraint shortening and lengthening

Dimensions in millimetres

ATD size [a]	Required belt shortening [b]	Required belt lengthening [b]
6-year-old child	100	100
10-year-old child	100	100
small adult female	100	100
midsize adult male	200	200
large adult male	200	200

[a] See Table A.1.

[b] At least 25 mm of webbing must extend through any fitting where adjustment takes place at all times during testing.



NOTE The angles indicated are obtained by projecting the angle of the pelvic-belt restraint onto a vertical plane that is parallel to the wheelchair reference plane.

Figure 3 — Range of required angles of wheelchair-anchored pelvic-belt restraint when installed on the appropriate-size ATD used in the test of Annex A

4.2.2 Wheelchair-anchored shoulder-belt restraint

If a wheelchair-anchored shoulder-belt restraint intended for use as an occupant restraint is provided as part of the wheelchair, when installed on the ATD in accordance with the set-up procedures for the frontal-impact test in Annex A, it shall be designed to

a) fit over the shoulder and across the chest, passing through the 100-mm-wide shaded zone of the ATD used in the test of Annex A, as illustrated in Figure 4,

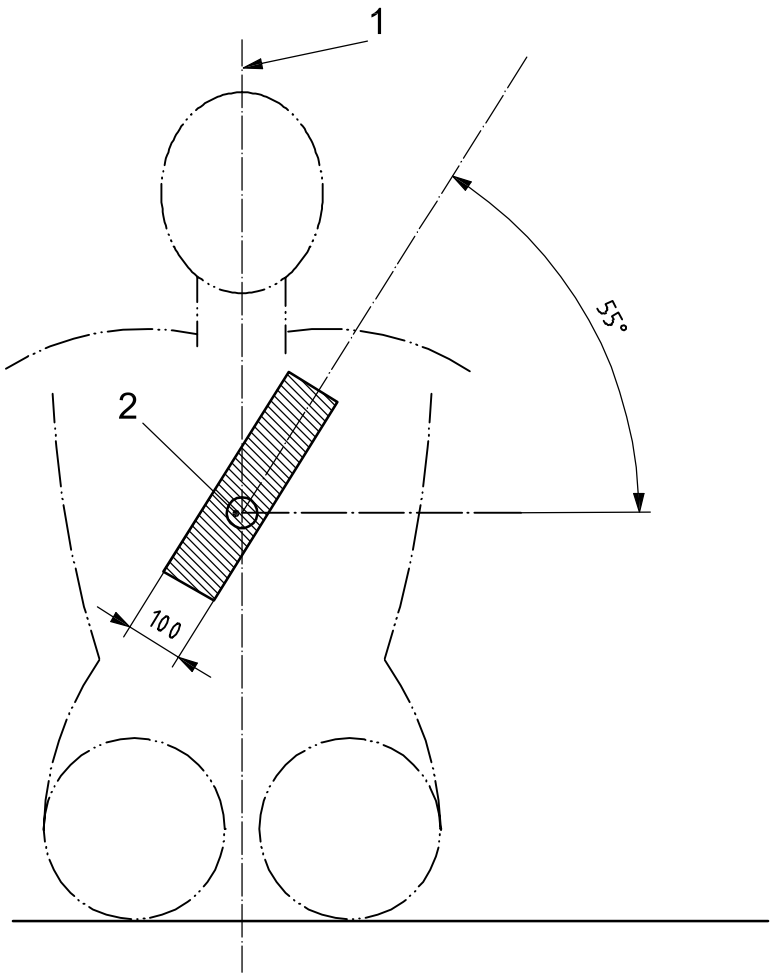
b) have an upper anchor point or upper guide point at, or above, the shoulder of the ATD used in the test of Annex A,

c) locate the shoulder-belt restraint/pelvic-belt restraint junction at least as far from the ATD centreline as shown in Table 3,

d) provide adjustment in the shoulder-belt restraint that allows for increasing and decreasing the length as specified in Table 4,

NOTE At least 25 mm of webbing must extend through any fitting where adjustment takes place at all times during testing.

Dimensions in millimetres



Key

1 ATD centreline

2 centre of sternum (measured from seating surface with ATD in upright seated posture)

NOTE The shoulder-belt restraint angle of 55° is relative to the horizontal and is measured in the frontal plane. Values for the centre of the sternum dimension for each ATD size are given in Table 2.

Figure 4 — Location of shoulder-belt restraint on occupant's torso

Table 2 — Height of centre of sternum from seat surface for each ATD size

Dimensions in millimetres

ATD size [a]	Centre of sternum
6-year-old child	275
10-year-old child	325
small adult female	353
midsize adult male	406
large adult male	432
[a] See Table A.1.	

Table 3 — Minimum distance of the shoulder-/pelvic- belt restraint junction from the ATD centreline

Dimensions in millimetres

ATD size [a]	ATD centreline to belt junction
6-year-old child	150
10-year-old child	150
small adult female	150
midsize adult male	200
large adult male	200
[a] See Table A.1.	

Table 4 — Requirements for shoulder-belt-restraint shortening and lengthening

Dimensions in millimetres

ATD size [a]	Required belt shortening [b]	Required belt lengthening [b]
6-year-old child	250	150
10-year-old child	250	150
small adult female	250	150
midsize adult male	300	200
large adult male	300	200
[a] See Table A.1. [b] At least 25 mm of webbing must extend through any fitting where adjustment takes place at all times during testing.		

4.2.3 Accommodation of vehicle-anchored occupant belt restraints

The test methods and performance criteria of Annex D shall be used to score and rate the wheelchair with regard to accommodating the proper use and placement of vehicle or tiedown-anchored belt restraints. The results shall be disclosed in the manufacturer's presale literature in accordance with 6.2.

Whether or not a wheelchair caters for the use of a vehicle-anchored lap-belt or lap-plus-shoulder-belt restraint, it is important to design the wheelchair frame and seating system to facilitate the proper use and placement of vehicle-anchored lap- and shoulder-belt restraints on the wheelchair user. Proper placement of the lap-belt restraint is low down near the thigh-abdominal junction, and proper placement of the shoulder-belt restraint is over the near middle of the shoulder and diagonally across the middle of one shoulder, with a connection to the lap-belt restraint near the hip of the user opposite the shoulder where the belt restraint crossed over. All belt restraints should make good contact with the occupant's body and not be held away by wheelchair components.

Use of a head restraint that is part of the wheelchair is recommended to reduce the risk of neck injuries in rear impacts. To be effective, the head restraint should be padded and be positioned within 50 mm of the back of the occupant's head, with the centre of the head restraint at least as high as the most rearward point on the back of the head (i.e. the occiput) during normal travel.

5 Performance requirements

5.1 Wheelchair-anchored belt restraints

All webbing, metal parts, buckles, release mechanisms and adjustment mechanisms of wheelchair–anchored belt restraints shall conform to applicable subsections of either ECE Regulation No. 16, and/or FMVSS 209, as indicated in Tables 5 and 6, respectively, or as specified in equivalent mutually recognised regulations.

All webbing of wheelchair-anchored belt restraints and postural belts shall have a burning rate not exceeding 100 mm/min when tested as specified in ISO 3795.

Table 5 — Applicable subclauses of ECE Regulation No.16

Subclause	Component	Subject	ECE No. 16 tests referenced
6.2.1.1	rigid parts	sharp edges	—
6.2.1.2	rigid parts	corrosion	7.2
6.2.1.4	rigid parts	cold impact test	7.5.4
6.2.2.1	buckles	correct use and size	—
6.2.2.2	buckles	closing/releasing	7.8.2
6.2.2.3	buckles	cold mating	7.5.3
6.2.2.4	buckles	repeated testing	7.7
6.2.3.2	adjustment devices	micro-slip	—
6.2.3.4	belt-restraint adjusting device	force	7.5.6
6.2.5	various belt-restraint retractors	performance	7.2, 7.6.1 thru 7.6.4
6.2.6	preloading devices	performance	7.2, 7.9.2
6.3.1	belt restraints	general specifications	—
6.3.2	belt restraints	strength	7.4.1.1, 7.4.2
6.3.3	belt restraints	strength	7.4.1, 7.4.2
6.4.2	belt restraints	strength	7.4.1.6, 7.4.2, 7.5

Table 6 — Applicable subclauses of FMVSS 209

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

5.2 Frontal impact

All wheelchairs shall comply with a); compliance with b) is optional.

a) When tested in accordance with Annex A using a four-point strap-type tiedown that complies with ISO 10542-2, the requirements of 5.2.1 and 5.2.2 shall be met during and after the test.

b) If a wheelchair is tested in accordance with Annex A using other methods of securement, such as a docking-type securement device, the requirements of 5.2.1 and 5.2.2 shall be met during and after the test.

5.2.1 During the test

a) The horizontal excursions of the ATD and the wheelchair with respect to the impact sled shall not exceed the limits in Table 7 at any time during the test.

b) If the wheelchair is tested with a vehicle-anchored pelvic-belt restraint intended for restraint in a motor vehicle, then the knee excursion shall exceed the wheelchair point P excursion as follows (see Table 7):

$$X_{\text{knee}} / X_{\text{wc}} \geqslant 1{,}1$$

NOTE Compliance with this requirement reduces the potential for the wheelchair to apply large horizontal loads to the wheelchair occupant.

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

1) not move completely outside the wheelchair footprint, and

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

Table 7 — Horizontal excursion limits

Dimensions in millimetres

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

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

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

X_{headF} 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, to the most forward point on the ATD's head at the time of peak head excursion.

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

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

5.2.2 After the test

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

b) The wheelchair securement points shall not show visible signs of material failure.

c) Rigid components, fragments or accessories of the wheelchair with a mass in excess of 100 g shall not be completely separated from the wheelchair.

d) Wheelchair components that may contact the occupant shall not fragment or separate in a manner that produces sharp edges, defined by as having a radius of less than 2 mm.

e) Primary load-carrying components of the wheelchair shall not show visible signs of failure, unless there is a backup system to provide support.

NOTE If half or more of the layers in a plywood seating system do not crack or fail, the seating system is considered to have adequate backup support.

f) Locking mechanisms of tilting seating adjusters shall not show signs of failure.

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

h) Release of the wheelchair from the tiedown system shall not require the use of tools.

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

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

5.3 Accessibility of securement points intended for use with four-point strap-type tiedowns with hook-type end-fittings

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

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

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

Securement points on wheelchairs should also be provided with sufficient clear space to allow webbing and associated end-fittings of tiedown assemblies without hook end-fittings to be easily inserted and attached or detached.

5.4 Accommodation of vehicle-anchored belt restraints

The wheelchair shall be tested for accommodation of vehicle-anchored occupant-restraint systems in accordance with Annex D and the resulting rating shall be reported in the product presale literature.

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

ISO 7176-15 applies with the addition of the information given in 6.1 to 6.3.

6.1 Identification and labelling

a) The wheelchair and/or its components shall be provided with permanent labels or markings that indicate the location of securement points for four-point strap-type tiedowns, using the symbol in Figure 5, where

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

   — the line width used to make the symbol is between 10 % and 20 % of the overall symbol height, and

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

b) For wheelchairs intended to provide attachment points for tiedowns in addition to the four-point strap-type, affix appropriate markings or labels to indicate the locations of any additional securement points and the method of securement to be used.

c) Indicate that the wheelchair complies with the requirements specified in ISO 7176-19:2008.

d) Affix a label to any belt restraints anchored to the wheelchair that are intended for use as an occupant restraint in a vehicle to indicate that they conform to ISO 7176-19:2008.

e) Affix a label to any postural support belt supplied by the wheelchair manufacturer that is not intended to be used as an occupant restraint in a moving vehicle to indicate that it should not be relied upon for occupant restraint in a moving vehicle.

Dimensions in millimetres

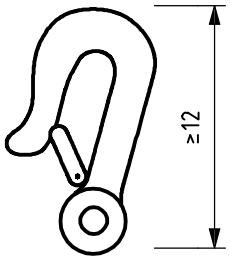


Figure 5 — Symbol required at each four-point strap-type securement point

6.2 Presale literature

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

a) a statement that the wheelchair is designed to be secured facing forward when used as a seat in a motor vehicle and that it complies with the requirements of ISO 7176-19:2008;

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

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

d) a statement of whether the wheelchair provides, has been tested with, and can be used with, any manufacturer-designated wheelchair-anchored belt restraints;

e) the rating of the wheelchair's accommodation of vehicle-anchored belt restraints based on the test methods of Annex D.

6.3 User and maintenance instructions

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

6.3.1 The user instructions shall include statements that

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

b) the wheelchair conforms to the requirements of ISO 7176-19:2008, and

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

6.3.2 The user instructions shall include descriptions of

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

b) the locations of all wheelchair securement points used in the frontal impact tests of Annex A and the markings used to identify them,

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

d) how the wheelchair is to be secured in a vehicle,

e) the types of tiedown end-fittings that are compatible with the wheelchair securement points,

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

   1) the pelvic-belt restraint should be worn low across the front of the pelvis, so that the angle of the pelvic-belt restraint is within the preferred zone of 30° to 75° to the horizontal, similar to that shown in Figure 3,

   2) a steeper (greater) angle within the preferred zone is desirable (see 4.2.1),

   3) belt restraints should not be held away from the body by wheelchair components or parts, such as the wheelchair armrests or wheels, together with an illustration similar to that of Figure 6,

   4) shoulder-belt restraints should fit over the shoulders, similar to the illustration provided in Figure 7,

   5) belt restraints should be adjusted as tightly as possible, consistent with user comfort, and

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

g) the recommended settings for any adjustable parts, including, where applicable, seat and back rest positions, when the wheelchair is in use in a motor vehicle,

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

i) the maximum recommended user mass.

6.3.3 The user instructions shall include illustrations of

a) the incorrect placement of belt restraints, as shown in Figure 6 as an example,

b) the correct placement of belt restraints, using an illustration similar to Figure 7 as an example,

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

6.3.4 The user instructions shall include warnings, in 12-point font or larger, that

a) the wheelchair complies with the requirements of ISO 7176-19:2008 and, as such, has been designed and tested for use only as a forward-facing seat in a motor vehicle,

NOTE 1 Compliance with this standard does not preclude using the wheelchair facing rearward in large accessible vehicles equipped with rear-facing wheelchair passenger stations.

b) the wheelchair has been dynamically tested in a forward-facing orientation with the ATD restrained by both pelvic and shoulder belts (e.g. a shoulder belt as part of a three-point belt restraint),

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

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

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

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

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

f) postural supports should not be relied on for occupant restraint in a moving vehicle, unless they are labelled as being in accordance with the requirements specified in ISO 7176-19:2008,

g) the wheelchair should be inspected by a manufacturer's representative before reuse following involvement in any type of vehicle collision,

h) alterations or substitutions should not be made to the wheelchair securement points or to structural and frame parts or components without consulting the wheelchair manufacturer,

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

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

Figure 6 — Illustration of improper belt-restraint fit

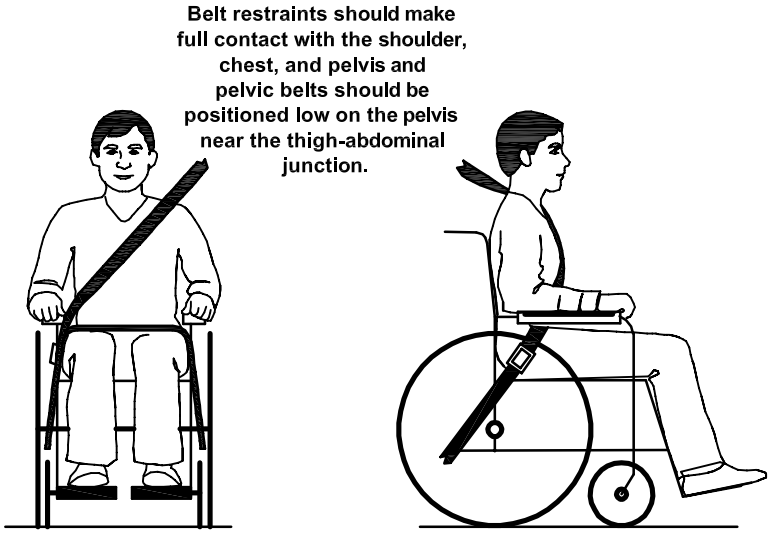


Figure 7 — Illustration of proper belt-restraint fit

7 Documentation of compliance

The wheelchair manufacturer shall maintain documentation, including test reports, that provide evidence of compliance to the design and performance requirements of this part of ISO 7176. This documentation shall include the information listed in 7.1 through 7.3.

7.1 General

The following shall be included in the report of each test conducted in accordance with this part of ISO 7176:

a) a reference to this part of ISO 7176;

b) the name and address of the testing institution;

c) the date of issue of the test report;

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

e) the name of the manufacturer, the product type and designation, and the serial number of the test wheelchair and the WTORS used;

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

7.2 Frontal impact test

The test report for the frontal impact shall also include

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

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

c) settings used for adjustable parts, including seat and backrest angles and locations,

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

e) the test results as specified in 5.2, and

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

7.3 Design, labelling, and literature requirements

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

a) whether securement points intended for use with four-point strap-type tiedowns are in accordance with the design requirements specified in 4.1,

b) whether securement points intended for attachment of four-point strap-type tiedowns are in accordance with the accessibility requirements specified in 5.3,

c) if applicable, whether wheelchair-anchored belt restraints are in accordance with the requirements of 4.2.1, 4.2.2, 5.1 and 5.2, and

d) whether the wheelchair, its components, and related literature are in accordance with the requirements of 6.1, 6.2, and 6.3.

Annex A
(normative)

Method for frontal impact test

A.1 General principle

The wheelchair is placed facing forward on an impact sled and loaded with an appropriate-size ATD. The wheelchair is secured in place and the ATD is restrained by a WTORS that conforms to the crashworthiness performance requirements of ISO 10542-1. The impact sled is subjected to a deceleration/acceleration pulse that falls within a specified g-level-versus-time envelope to achieve a longitudinal velocity change of 48 km/h. During-test and post-test observations and measurements are made using high-speed film or video and post-test inspection of equipment, respectively, to assess the performance of the wheelchair and any wheelchair-anchored belt restraints under these dynamic loading conditions.

A.2 Test sample

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

A.3 Apparatus

A.3.1 Impact simulator and tiedown/restraint equipment

An impact simulator and tiedown/restraint equipment shall be used that includes

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

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

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

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

e) an ATD selected from Table A.1 that is representative of the upper size range of users for which the wheelchair is designed,

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

g) a length of 25 mm wide webbing with an anchoring mechanism at one end and a tensioning/anchoring mechanism at the other end for use in A.4.13, and

h) a four-point strap-type tiedown and complete upper and lower belt-restraint system that conforms to ISO 10542-2.

For wheelchairs with a mass of 85 kg or more, and/or with wheelchair-anchored belt restraints, it is recommended that a surrogate tiedown, designed in accordance with Annex E, be used instead of a commercial wheelchair securement system.

i) if an additional test is to be performed using a different type of tiedown system, the tiedown device shall conform to the dynamic performance requirements specified in 6.2 of ISO 10542-1:2001,

j) a vehicle-anchored three-point-belt restraint or two-point shoulder-belt restraint that conforms to ISO 10542-1, as required to supplement the belt restraint provided with the wheelchair, and

k) a means to accelerate and/or decelerate the impact sled and test set-up, 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 continuous time period of at least 40 ms, and

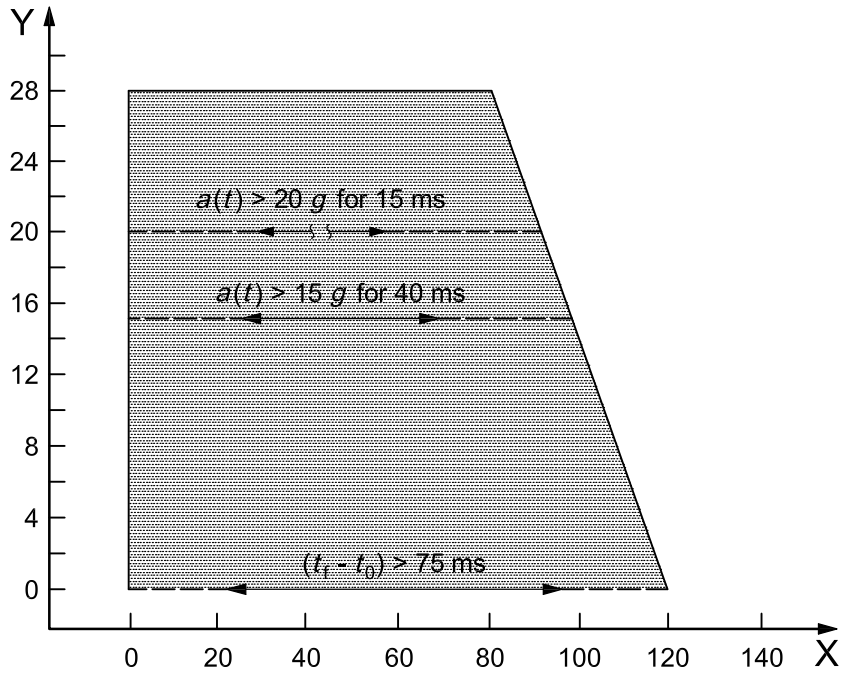
   4) has a duration of at least 75 ms from t_0 to t_f, where t_0 is the start time and t_f is the stop time, as seen in Figure A.1.

Table A.1 — Available ATDs for wheelchair testing

Occupant weight range kg (lb)	**ATD size** [a]	**Approximate mass of ATD** kg (lb)
> 18 to 27 (> 40-60)	6-year-old child	22,5 (50)
> 27 to 43 (> 60-95)	10-year-old child	35 (76)
> 43 to 57 (> 95-125)	Small adult female	47,0 (104)
> 57 to 75 (> 125-165)	Small adult female, weighted [b]	59,0 (130)
> 75 to 136 (> 165-300)	Midsize adult male	76,3 (170)
> 136 (> 300)	Large adult male	102,0 (225)

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

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



Key

X time (ms)

Y deceleration (g)

NOTE 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 period.

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

A.3.2 Dynamic measurements

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

a) the ATD and wheelchair horizontal excursions specified in 5.2.1 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.

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

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

A.3.3 Data processing

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

a) prefiltering of all transducer signals to Channel Class 1000 (– 4 dB at 1 650 Hz) prior to digitising at 10,000 Hz, and

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

A.4 Test preparation and procedure

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

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

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

c) Prepare the wheelchair for use in a motor vehicle, as specified by the manufacturer's user instructions in 6.3.2 h). If a range is specified for any adjustments, the midpoint of the range should be used.

d) Equip the wheelchair with any required add-on components.

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

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

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

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

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

A.4.4 Secure the wheelchair with the wheelchair tiedown according to the WTORS manufacturer's instructions, and as specified in ISO 10542-1. For testing with four-point strap-type tiedowns, follow the procedures in Annex A of ISO 10542-2:2001. If parking brakes are fitted, apply them.

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

a) Rotate the backrest rearward to obtain a backrest plane angle not exceeding 10° relative to the vertical.

b) For wheelchairs with independently adjustable seat angles, adjust the seat frame to a maximum incline angle of 10° relative to the horizontal.

Measure this angle with an inclinometer without the ATD in the wheelchair.

c) For wheelchairs with tilt seating, adjust the longitudinal seat frame members to a maximum angle of 30°, relative to the horizontal, without the ATD in the wheelchair or a position selected by the manufacturer.

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

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

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

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

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

A.4.8 If the wheelchair is not equipped with a pelvic-belt restraint, install the vehicle-anchored three-point belt of the specified WTORS as follows.

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

b) Bolt the upper anchorage for the shoulder-belt restraint to the rigid support structure of A.3.1 d), at a location that provides a good fit of the shoulder-belt restraint to the ATD's chest and shoulder as illustrated in Figure 7.

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

d) If an emergency-locking or automatic-locking retractor is provided, adjust the pelvic- and shoulder-belt restraints to achieve a snug fit.

e) If an emergency-locking or automatic-locking retractor is not provided:

   1) pull the pelvic-belt restraint snugly against the ATD pelvis and/or thighs;

   2) place the shoulder-belt restraint over the ATD's chest and shoulder with a 75 mm × 75 mm × 25 mm thick plate inserted between the ATD's chest and the belt webbing;

   3) adjust the shoulder-belt restraint to achieve a snug fit and then remove the plate.

A.4.9 If the wheelchair provides anchor points for both the pelvic- and shoulder-belt restraints on the wheelchair, install and position the belt restraints on the ATD as specified by the wheelchair manufacturer. If ranges of belt-restraint anchor points are provided, select anchor points appropriate to achieve a good fit of the belt restraints to the ATD as indicated in 4.2.1, 4.2.2, Figure 3 and Figure 4.

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

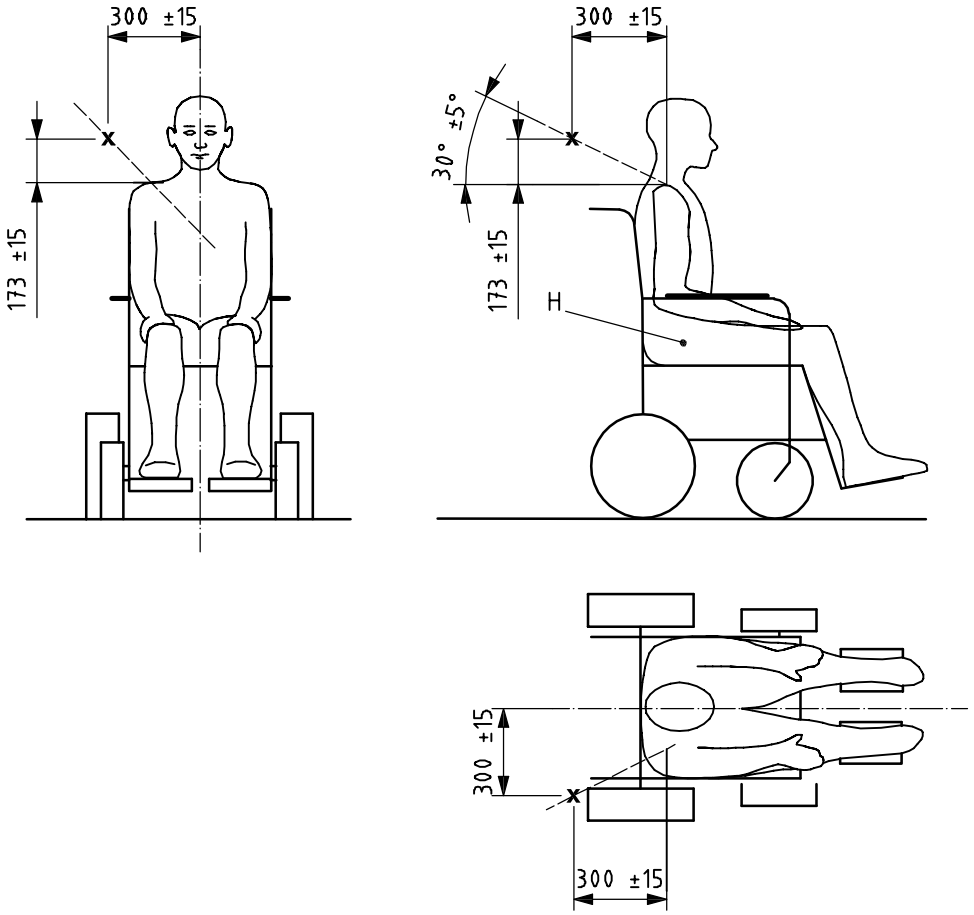
a) Buckle the pelvic-belt restraint around the ATD's pelvis and adjust to achieve a snug fit. If a range of pelvic-belt-restraint anchor points is provided, select anchor points appropriate to achieve a good fit of the belt to the ATD's pelvis as indicated in Figure 3.

b) Bolt the upper anchorage of a two-point shoulder-belt restraint to the rigid support structure of A.3.1 d), and the lower anchorage to the sled platform, at locations that provide a good fit of the shoulder-belt restraint to the ATD's chest and shoulder as illustrated in Figure 7.

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

d) If an emergency-locking or automatic-locking retractor is not provided, place a 75 mm × 75 mm × 25 mm thick plate between the ATD's chest and the belt-restraint webbing. Adjust the shoulder-belt restraint to achieve a snug fit with the plate in place, and then remove the plate.

Dimensions in millimetres



NOTE The anchor point can be located on either side of the wheelchair and ATD. Adjust the anchor-point location to achieve a good fit of the shoulder-belt restraint near the middle of the shoulder and the centre of the chest.

Figure A.2 — Test location for upper anchor point of shoulder-belt restraint when using the midsize-male ATD in the surrogate wheelchair base

A.4.11 If a high-speed camera or high-speed video is used for the measurements specified in A.3.2, apply contrast markers appropriate to the measurement system at

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

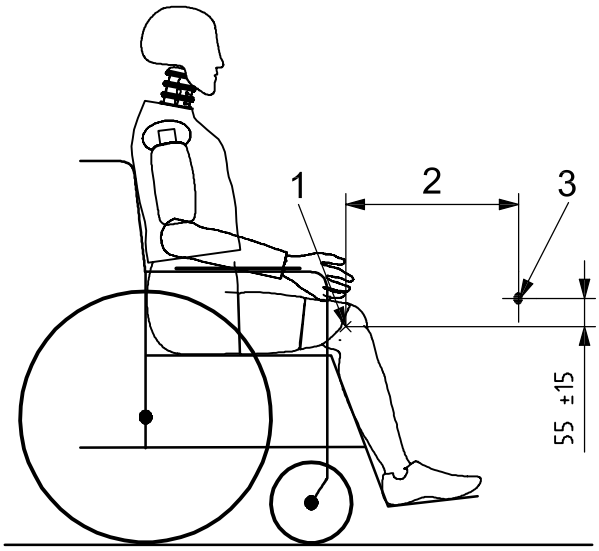
b) at the point P of the wheelchair (see Figure 2), or points on the side of the wheelchair that are as close to the wheelchair point P as possible.

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

A.4.12 Ensure that the wheelchair reference plane is aligned parallel to the centreline of impact within ± 3°.

A.4.13 Install the 25 mm wide foot/leg strap of A.3 g) as described in A.3 f) so that the strap is 55 mm ± 15 mm above the ATD's knee-joint centre and forward of the ATD's knee-joint centre by the length A listed in Table A.2. Tension the strap to 30 N to 50 N before the test.

Dimensions in millimetres



Key

1 ATD's centre of knee joint

2 forward distance for knee strap, length $A \pm 15$ mm (see Table A.2)

3 centreline of foot/leg strap

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

Table A.2 — Length A for each ATD size

ATD size [a]	Length A mm
6-year-old child	330
10-year-old child	390
small adult female	440
midsize adult male	510
large adult male	550
[a] See Table A.1.	

A.4.14 Record the locations of all WTORS anchor points relative to the wheelchair rear axles and the projected angles of any tiedown straps and all belt restraints relative to the horizontal longitudinal axis of the sled platform.

A.4.15 Measure and record the height ($\pm$ 5 mm) of the ATD's left and right H-point vertically from the sled platform.

A.4.16 Conduct the impact test by activating the sequence of events to record data and fire the impact sled.

A.5 Post-test measurements and calculations

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

a) whether the ATD remained in the wheelchair,

b) whether the wheelchair remained on the test platform,

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

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

e) whether rigid wheelchair components greater than 100 g became detached.

A.5.2 Determine peak excursions X_{wc}, X_{knee}, X_{headF} and X_{headR} as defined in 5.2.1, to an accuracy of $\pm$ 5 mm.

A.5.3 Measure the height of the left and right H-points of the ATD above the wheelchair ground plane (i.e. the raised platform), and compute the average change in height from the pretest position.

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

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

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

A.5.7 Measure and record the movement of adjustable components from their pretest settings.

Annex B
(normative)

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

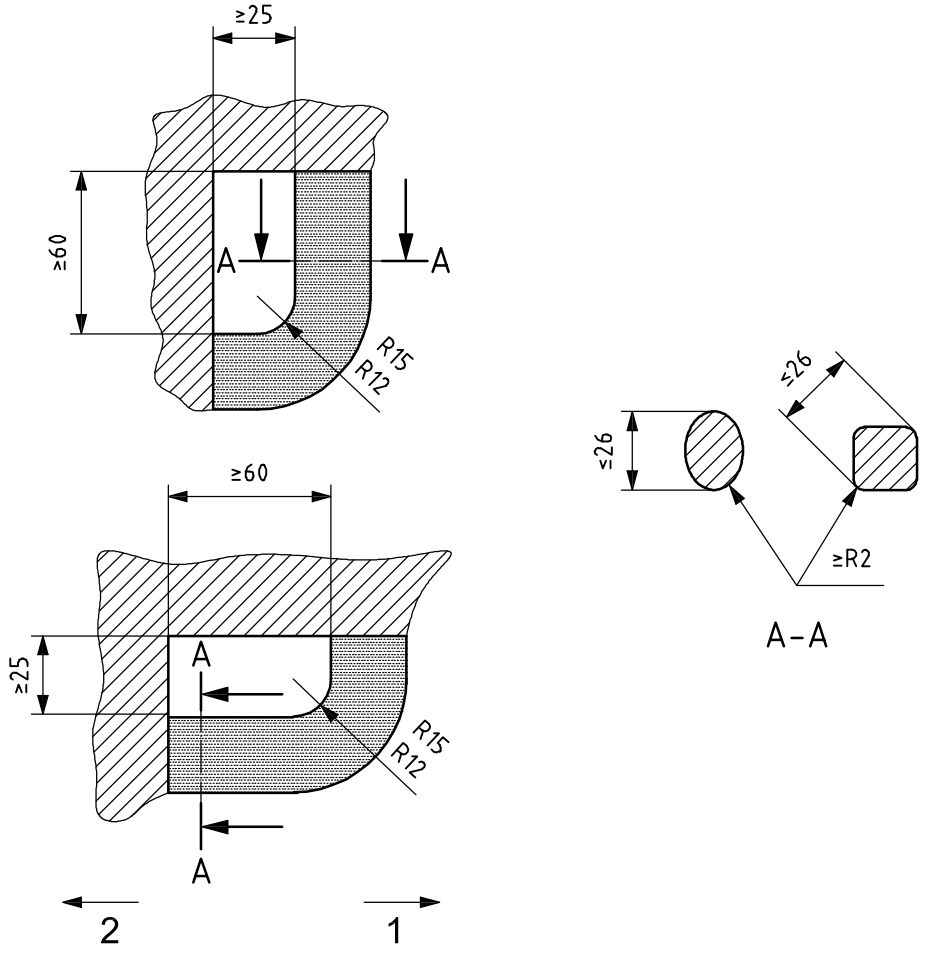
B.1 Principle

This annex establishes geometry and location specifications for wheelchair securement points intended to be engaged by the end-fittings of four-point strap-type tiedown assemblies that comply with ISO 10542-2.

B.2 Geometric specifications

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

Dimensions in millimetres



Key

1 towards anchor point
2 towards wheelchair

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

B.3 Location specifications

Wheelchair securement points intended for engagement with four-point strap-type tiedown assemblies shall be attached rigidly to the structural frame of the wheelchair such that

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

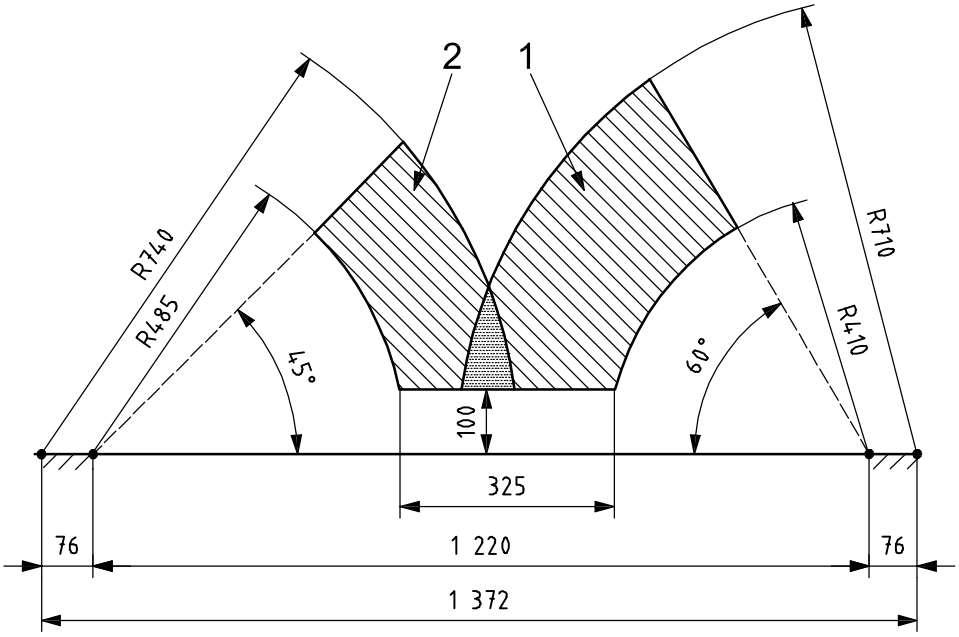
b) the horizontal longitudinal distance between front and back securement points is not less than 100 mm,

c) the lateral horizontal distance between left and right rear-securement points is not less than 200 mm, and

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

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

Dimensions in millimetres



Key

1 front-securement-point zone

2 rear-securement-point zone

NOTE 1 The securement-point zones are based on minimum and maximum strap lengths required by ISO 10542-2 and typical distances of 1 220 to 1 372 mm between front and rear vehicle anchor points. The actual distances between front and rear anchor points in different vehicles can be greater or less than these dimensions.

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

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

Annex C
(normative)

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

C.1 Principle

Securement points on the wheelchair should be easily accessible on both sides of the wheelchair. This annex specifies equipment, conditions and procedures to assess the one-handed accessibility of securement points that conform to the specifications of Annex B.

C.2 Equipment to be tested

A complete commercial or prototype wheelchair designed for securement by a four-point strap-type tiedown is required. The wheelchair manufacturer shall adjust the wheelchair to fit the anthropomorphic test dummy (ATD) or shall provide adjustment instructions to the testing facility.

C.3 Test equipment

C.3.1 Rigid platform with wheelchair securement space, as shown in Figure C.1.

C.3.2 Hook gauge, as specified by Figure C.2.

C.3.3 ATD, having the same anthropometric characteristics as the Hybrid II or III selected for frontal impact testing in Annex A.

C.3.4 Timing device, that is accurate to ± 0,5 s.

C.4 Test method

The test method includes the following steps.

a) Inspect the wheelchair to ensure that it complies with the manufacturer's instructions, and adjust the wheelchair as specified in A.4.5 through A.4.8, as appropriate to the type of wheelchair.

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

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

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

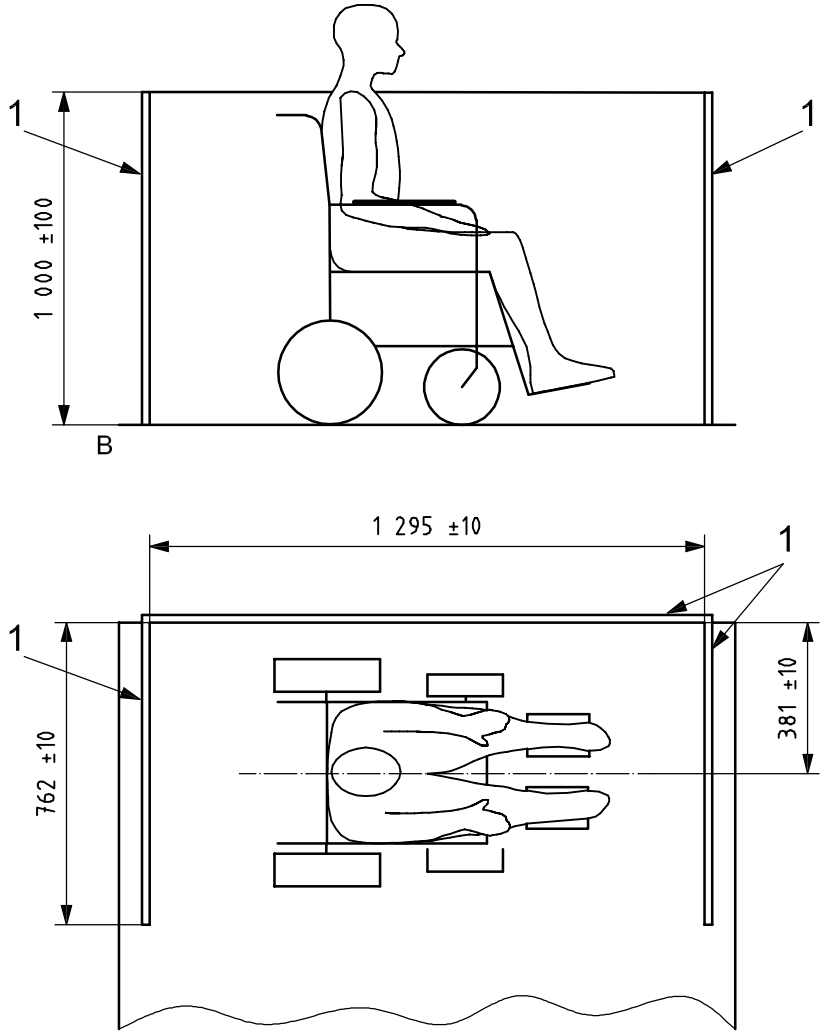
e) Upon command by a person with a timing device (i.e. the timer), the tester shall connect the hook to one of the selected securement points while gripping the hook gauge with one hand. The tester shall indicate when the hook is fully engaged and the time from the “start” command shall be noted and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

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

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

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

Dimensions in millimetres

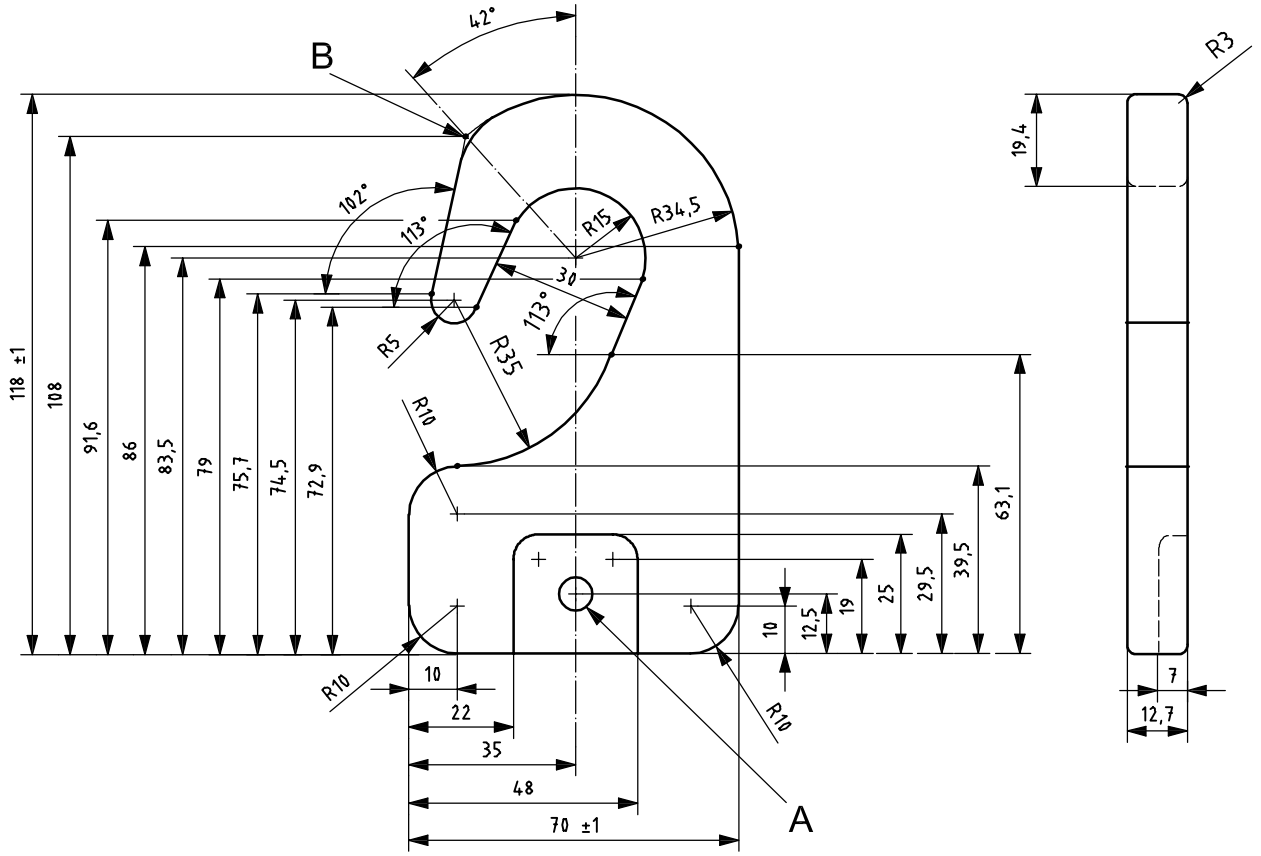


Key

1 removable partition(s)

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

Dimensions in millimetres



Key

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

B bend-point tangent to hook-point radius

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

Annex D
(normative)

Methods for rating wheelchair accommodation of vehicle-anchored belt restraints

D.1 Rationale

It is important that wheelchairs intended for occupancy in motor vehicles are designed to accommodate easy use and proper fit of vehicle-anchored three-point occupant-restraint systems. This annex establishes a test method for rating a wheelchair with regard to

a) the ease of positioning vehicle-anchored belt restraints on the wheelchair occupant,

b) the fit and contact of vehicle-anchored shoulder- and pelvic-belt restraints to the wheelchair occupant, and

c) the potential for contact of belt-restraint webbing with sharp edges on the wheelchair.

D.2 Principle

The wheelchair is secured on a test platform using a four-point strap-type tiedown system that conforms to ISO 10542-2. The ATD used in the frontal impact test of Annex A is seated in the wheelchair in accordance with the procedures of Annex A. A vehicle-anchored three-point belt that conforms to ISO 10542-1 is installed and positioned on the ATD, while the ease of belt placement, the locations and degree of belt webbing contact with the ATD, the angles and paths of the belt webbing to the anchor points, and the proximity of belt webbing to sharp edges are evaluated. Numerical scores of 0 (poor), 1 (acceptable), and 2 (good) are assigned for each of eight performance measures. If one or more of the scores is zero, the wheelchair is given a rating of C (poor) with regard to accommodation of vehicle-anchored belt restraints. If all of the performance scores are non-zero, the scores for all the measures are added together to determine whether the wheelchair is rated A (good) or B (acceptable).

D.3 Test sample

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

D.4 Test apparatus

The laboratory apparatus needed to conduct the test includes the following.

D.4.1 WTORS, consisting of a four-point strap-type tiedown and vehicle-anchored three-point belt restraint that complies with ISO 10542-2.

D.4.2 Test platform, with adjustable anchor points for wheelchair tiedown straps and pelvic- and shoulder-belt-restraint anchorages.

D.4.3 ATD, used in the frontal impact test of Annex A.

D.5 Test method

D.5.1 Secure and adjust the wheelchair on the test platform using a four-point strap-type wheelchair tiedown system and the set-up procedures of A.4.1 through A.4.5, as appropriate.

D.5.2 Fasten the floor anchorages of the three-point-belt restraint to the test platform, selecting anchor points for the pelvic-belt restraint that are 0 mm to 100 mm forward of, and within ± 100 mm lateral to, the rear-tiedown anchor points.

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

D.5.3 Place the ATD used in the frontal impact test of Annex A in the wheelchair seat with the pelvis firmly against the backrest.

D.5.4 Locate the upper shoulder-belt-restraint anchor point or guide point according to the procedures specified in A.4.8, as illustrated in Figure D.1.

D.5.5 Install and position the three-point-belt restraint on the ATD while attempting to achieve optimal placement of the pelvic-belt restraint across the lower pelvis at the thigh-abdominal junctions and the shoulder-belt restraint across the middle of the shoulder and diagonally across the chest.

NOTE Annex F of ISO 10542-1:2001 contains information on optimal belt-restraint fit.

D.5.6 Score the performance of the wheelchair during and after the belt-restraint installation process based on the criteria in Tables D.1 through D.8.

D.5.7 Rate the overall performance of the wheelchair with regard to its accommodation of the proper placement of vehicle-anchored belt restraints according to D.6.

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

Dimensions in millimetres

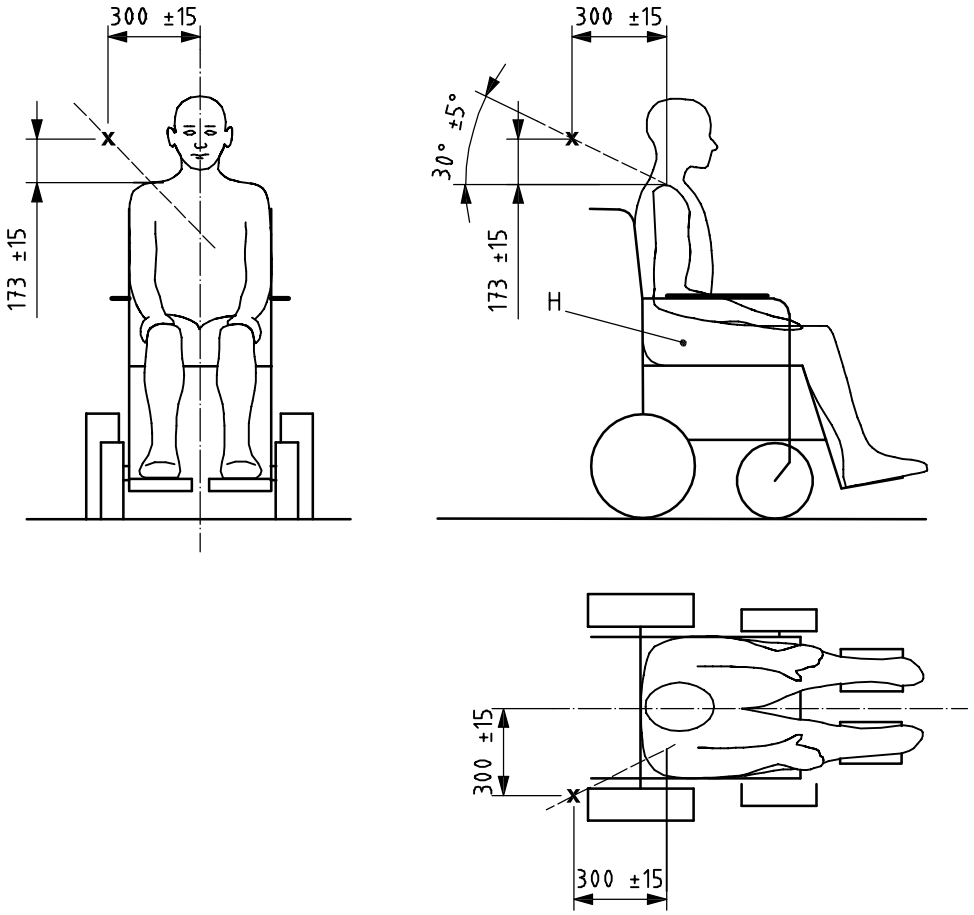


Figure D.1 — Test location of shoulder-belt-restraint upper anchor point or guide point, and angles of shoulder-belt restraint

Table D.1 — Overall ease of belt positioning

Rating	Description	Score
Poor	Requires threading belt restraint and/or hardware through any openings, such as openings between the lower part of the wheelchair backrest and the seat cushion, or requires forcing belt webbing into narrow gaps of less than 25 mm, such as between the backrest and armrests.	0
Acceptable	Requires inserting of belt restraint into gaps between wheelchair components but webbing fits easily into gap and threading of webbing and/or hardware through openings is not required. If there is a narrow gap (less than 25 mm) between armrests and wheelchair components, but armrests are removable for increased gap width, rating will be acceptable due to extra step required for application.	1
Good	Gaps for inserting belt restraint between wheelchair components are greater than 25 mm, or provision is made for positioning belt webbing on the occupant without placing it into gaps (e.g. armrests are open at the front or swing out of the way). Threading of webbing and/or hardware through openings is not required.	2

Table D.2 — Pelvic-belt-restraint contact area

Rating	Description	Score
Poor	Belt restraint is held completely away from ATD's pelvis because of wheelchair components	0
Acceptable	Belt restraint makes less than 50 % contact across the full breadth at the front of the ATD and does not contact the ATD H-points	1
Good	Belt restraint makes greater than 50 % contact across the full breadth at the front of the ATD and does contact the ATD H-points	2

Table D.3 — Shoulder-belt-restraint contact area

Rating	Description	Score
Poor	Belt restraint is held away from ATD's chest and shoulder because of wheelchair components	0
Acceptable	Belt restraint makes less than 50 % contact across the thoracic section of the ATD and touches the ATD's sternum	1
Good	Belt restraint makes greater than 50 % contact across the thoracic section of the ATD and contacts the sternum and anterior curve of the shoulder	2

Table D.4 — Pelvic-belt-restraint contact location

Rating	Description	Score
Poor	Belt restraint contacts the ATD above the pelvis and on the abdomen	0
Acceptable	Belt restraint contacts the ATD on the upper part of pelvis	1
Good	Belt restraint contacts the ATD low on the pelvis near or at the thigh-abdominal junction	2

Table D.5 — Shoulder-belt-restraint contact location

Rating	Description	Score
Poor	Belt restraint passes lateral to the ATD's shoulder	0
Acceptable	Belt restraint contacts the ATD's neck	1
Good	Belt restraint crosses near the middle of ATD's shoulder	2

Table D.6 — Pelvic-belt-restraint angle

Rating	Description	Score
Poor	Projected sideview angle is less than 30° or greater than 75° to the horizontal	0
Acceptable	Projected sideview angle is between 30° and 45° to the horizontal	1
Good	Projected sideview angle is between 45° and 75° to the horizontal	2
Use an inclinometer to estimate the projected side-view angle of the pelvic-belt restraint after installation on the ATD.		

Table D.7 — Pelvic-belt-restraint clear paths to anchor points

Rating	Description	Score
Poor	Belt restraint makes contact with wheelchair components resulting in a change in belt angle greater than 15°	0
Acceptable	Belt restraint makes contact with wheelchair components resulting in a change in belt angle of less than 15°, but greater than 5°	1
Good	Belt restraint makes no contact with wheelchair components, or resulting in a change in belt angle of less than 5°	2

Table D.8 — Belt-restraint proximity to sharp edges

Rating	Description	Score
Poor	Belt restraint makes contact with sharp edges on the wheelchair that could cause wear of belt material over time and/or failure of webbing during impact loading	0
Acceptable	Belt restraint does not contact but comes within 25 mm of sharp edges of the wheelchair	1
Good	Belt restraint does not come within 25 mm of any sharp edges on the wheelchair	2
NOTE A sharp edge is defined as an edge of less than 2 mm radius [(5.2.2 d)].		

D.6 Overall rating of belt-restraint accommodation

D.6.1 If the score for one or more of the tests obtained from Tables D.1 to D.8 is zero, an overall rating of "C" or "poor" should be recorded.

D.6.2 If none of the scores are zero, add the scores for the tests obtained from Tables D.1 to D.8 inclusive and assign a belt-restraint accommodation rating to the seating system as follows:

— Total score of 12 to 16 = A rating = good;

— Total score of 8 to 11 = B rating = acceptable;

— Total score of 7 or less = C rating = poor.

Annex E
(informative)

Guidelines for surrogate tiedown devices

E.1 Principle

The purpose of a surrogate tiedown is to provide a laboratory device with sufficient durability and strength that can be used for repeated impact testing of all wheelchairs that may be tested in accordance with this part of ISO 7176. The surrogate tiedown may also offer the additional advantage of providing accurate measures of impact-loading time histories, which can be useful in determining wheelchair failure loads and solutions for strengthening the wheelchair design. The following specifications are intended to serve as guidelines for laboratories wishing to use a surrogate tiedown device in the frontal impact test of Annex A.

E.2 General design guidelines

All surrogate tiedown designs should

a) meet the dynamic test requirements of ISO 10542-1:2001, Annex A,

NOTE When testing a wheelchair with a mass larger than the surrogate wheelchair used in ISO 10542-1, an increased tiedown strength can be required.

b) have demonstrated capability for consistent and repeatable results,

c) have demonstrated capability to produce response and energy-absorption characteristics similar to the type of wheelchair tiedown that it is intended to represent,

d) allow repeated use without requiring major repairs or replacement of primary hardware components,

e) provide for removal of slack or free space in wheelchair securement,

f) provide for measurement of peak tiedown loads,

g) have securement hardware, including end-fittings that simulate the type of securement intended by the manufacturer of the test wheelchair.

E.3 Additional guidelines for strap-type surrogate wheelchair tiedowns

Each surrogate tiedown assembly simulating a four-point strap-type tiedown system should

a) have end-fittings compatible with wheelchair securement points as specified in Figure B.1,

b) include a mechanism to adjust the pretest tension between front- and rear-tiedown assemblies,

c) allow for attaching replacement webbing to hardware components without sewing.

Guidelines for other types of surrogate tiedowns (e.g. docking) may be added to future versions of this part of ISO 7176.

Annex F
(normative)

Specifications for wheelchair 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 an 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 transportation and/or multiple private 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 transportation providers.

F.2 Principle

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 public transportation and/or multiple private 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 ISO 10542-1:2001, Annex A,

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

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

i) not interfere with other wheelchair features and functions.

F.2.1 Specifications for the universal docking interface geometry (UDIG) and clear zones

A wheelchair securement adaptor that conforms to this UDIG specification shall

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

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

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

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

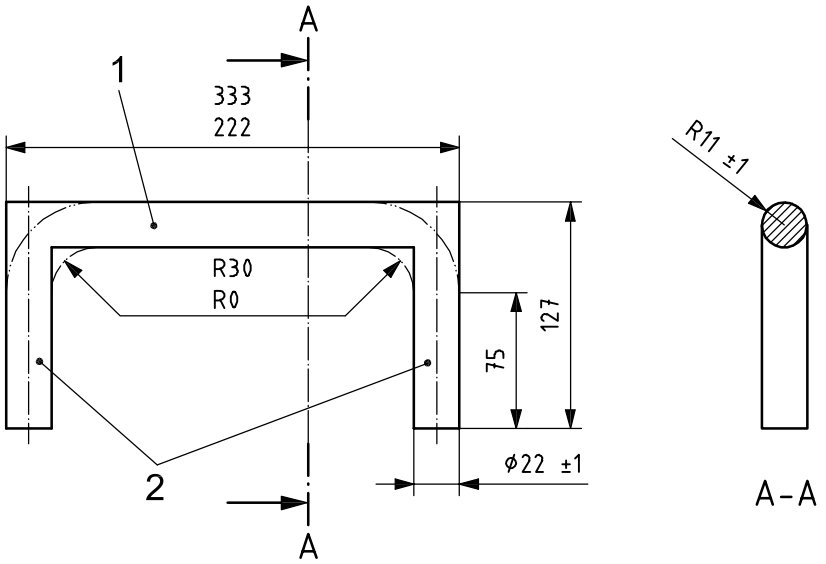
d) have a horizontal segment when mounted on wheelchairs with a mass greater than 30 kg, as illustrated by Key 1 in Figure F.1, and

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

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

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

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

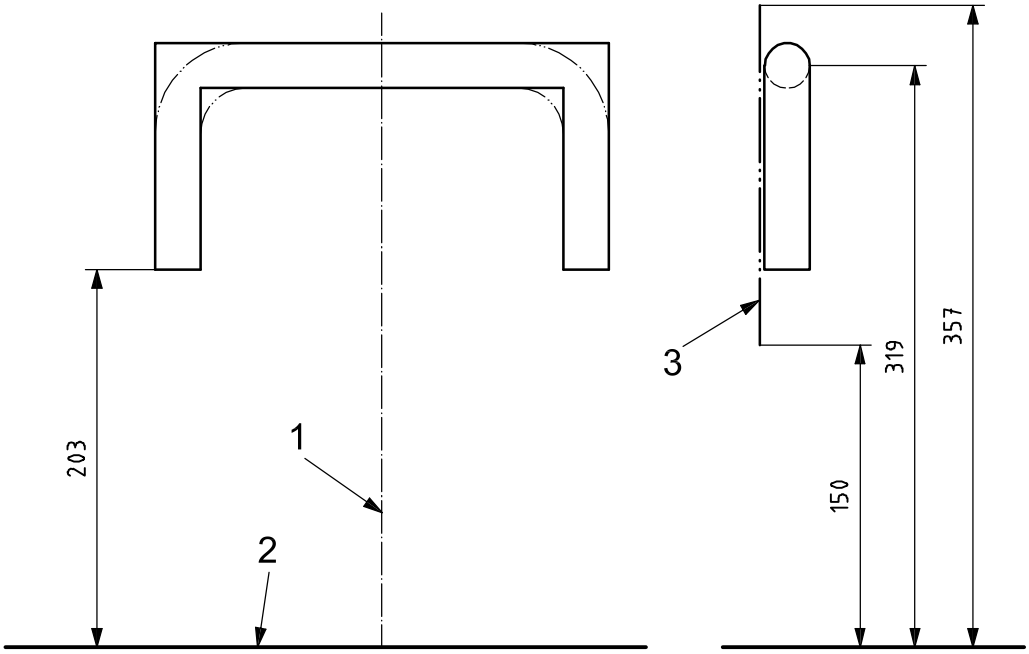


Key

1 horizontal segment
2 vertical segment

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

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



Key

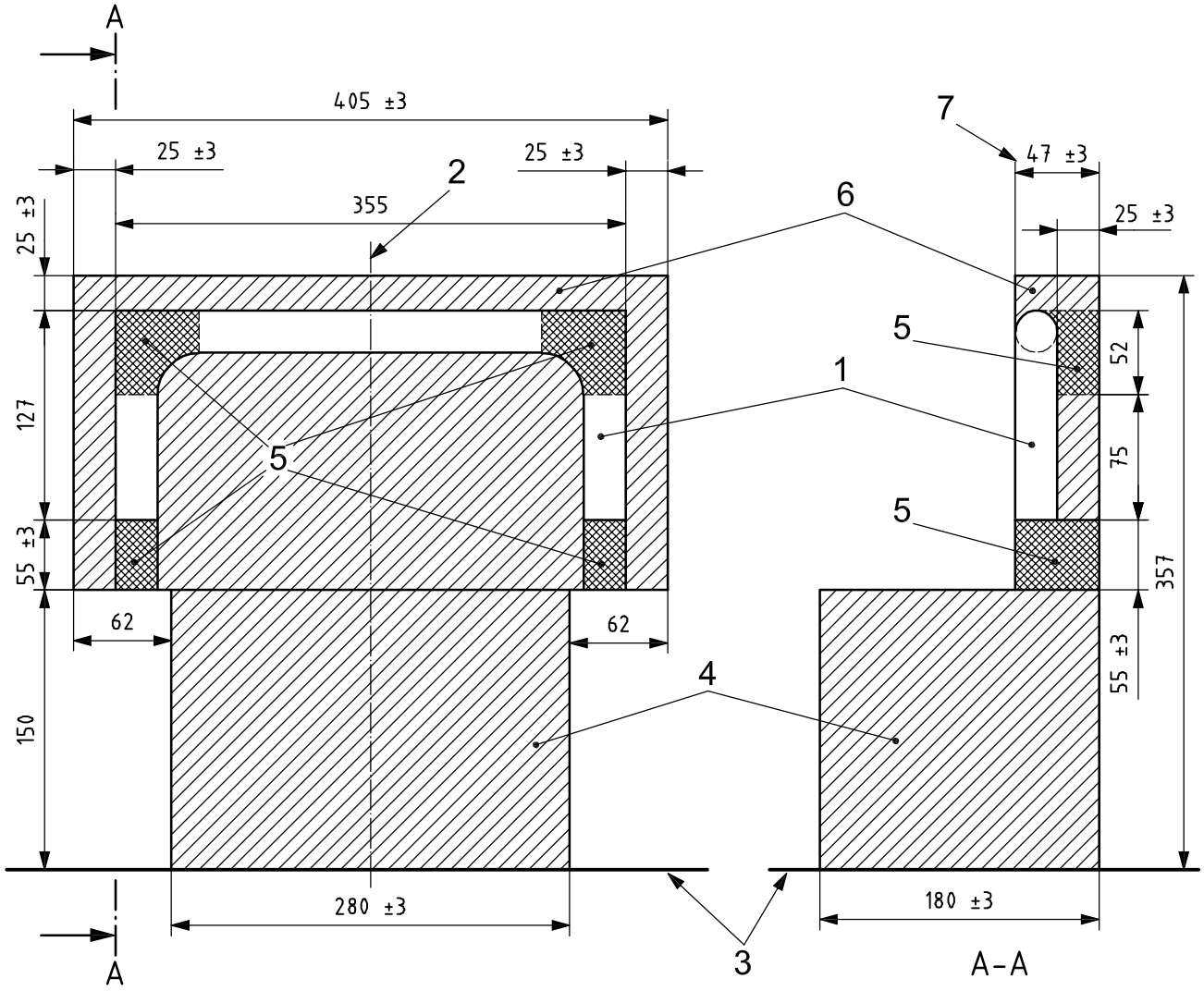
1 wheelchair reference plane (centreline) (the UDIG is located symmetrically about this plane)

2 wheelchair ground plane

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

Figure F.2 — Specification for the vertical and horizontal location of a UDIG adaptor

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

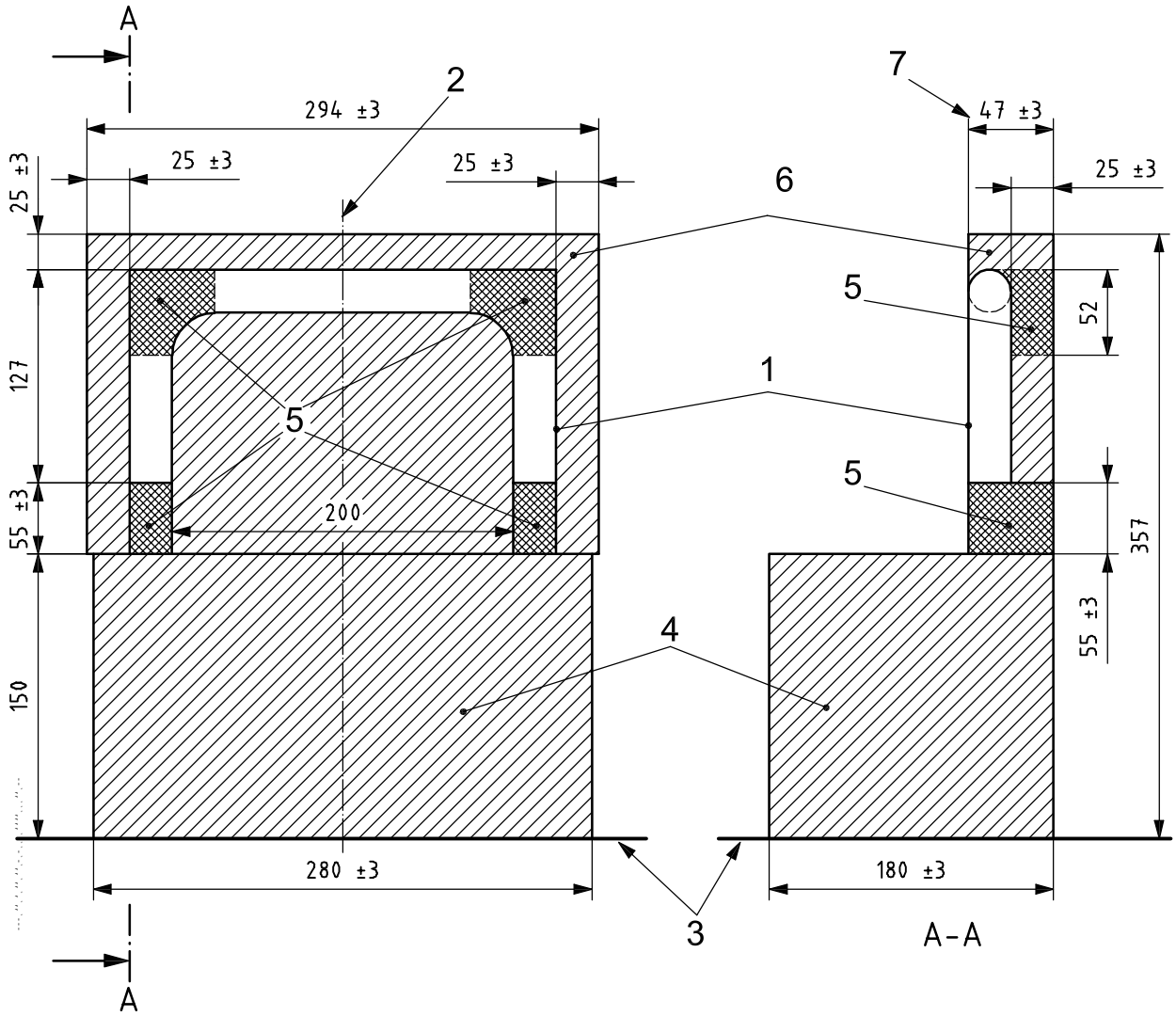


Key

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

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

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



Key

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

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

Bibliography

[1] ISO 6440, *Wheelchairs — Nomenclature, terms and definitions*

[2] ISO 7176-22, *Wheelchairs — Part 22: Set-up procedures*

[3] ISO 7193, *Wheelchairs — Maximum overall dimensions*

[4] ISO/TR 13570-1, *Wheelchairs — Part 1: Guidelines for the application of the ISO 7176 series on wheelchairs*

[5] ANSI/RESNA WC-19, *Wheelchairs for Use in Motor Vehicles*

[6] AS 2942-1994, *Wheelchair occupant restraint assemblies for motor vehicles*

[7] CSA Z604, *Transportable Mobility Aids*

[8] CSA Z605, *Mobility Aid Securement and Occupant Restraint (MASOR) Systems for Motor Vehicles*

[9] DIN 75 078 Teil 2, *Motor vehicles for transportation of handicapped persons Restraint systems — Concepts, requirements, testing*

[10] ECE R 14 rev. 2, *Uniform provisions concerning the approval of vehicles with regard to safety-belt anchorages*

[11] FMVSS 201, Standard No. 201; *Occupant Protection in Interior Impacts*, 49 CFR Part 571.201

[12] FMVSS 208, Standard No. 208; *Occupant Crash Protection*, 49 CFR Part 571.208

[13] FMVSS 222 Standard No. 222; *School Bus Passenger Seating and Crash Protection*, 49 CFR Part 571.222

[14] SAE J117, *Dynamic Test Procedure — Type 1 and Type 2 Seat Belt Assemblies*

[15] SAE J128, *Occupant Restraint System Evaluation Passenger Cars and Light-Duty Trucks*

[16] SAE J140, *Seat Belt Hardware Test Procedure*

[17] SAE J141, *Seat Belt Hardware Performance Requirements*

[18] SAE J2094, *Vehicle and Control Modifications for Drivers with Physical Disabilities Terminology*

[19] SAE J2249, *Wheelchair Tiedown and Occupant Restraint Systems for Use in Motor Vehicles*

[20] SAE J2252, *Surrogate Wheelchair Drawing Package and Maintenance Manual*

[21] SAE J383, *Motor Vehicle Seat Belt Anchorages Design Recommendations*

[22] NEN 2746, *Wheelchair tiedown and occupant restraint systems — Requirements and test methods*

ICS 11.180.10

Price based on 43 pages