INTERNATIONAL STANDARD

ISO 10542-1

First edition
2001-07-15

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

Part 1: Requirements and test methods for all systems

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

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

Reference number
ISO 10542-1:2001(E)

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Printed in Switzerland

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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 10542 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10542-1 was prepared by Technical Committee ISO/TC 173, *Technical systems and aids for disabled or handicapped persons*, Subcommittee SC 1, *Wheelchairs*.

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

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

— *Part 2: Four-point strap-type tiedown systems*

Annexes A, B, C, D and E form a normative part of this part of ISO 10542. Annexes F and G are for information only.

Introduction

Providing effective protection for the wheelchair-seated occupant of a motor vehicle usually requires that equipment be installed to secure the wheelchair and restrain the occupant of the wheelchair. ISO 10542 is applicable to this motor-vehicle adaptive equipment, which is referred to as wheelchair tiedown and occupant restraint systems (WTORS). The requirements and test methods of this part of ISO 10542 apply to all WTORS that use belt-type occupant-restraint systems. Additional parts of ISO 10542 will address specific types of WTORS, or deal with particular applications, and will supplement and/or modify the requirements of this part of ISO 10542. If an additional part of ISO 10542 exists for a particular type of WTORS, this part of ISO 10542 is not to be used alone for that WTORS.

This part of ISO 10542 places particular emphasis on design requirements, test procedures, and requirements with regard to the performance of WTORS in a frontal impact. Performance of WTORS used with rear-facing wheelchairs involved in frontal impacts, performance of WTORS in rear, side and rollover impacts, and performance of WTORS used with wheelchair-seated children, may be addressed in future versions of this part of ISO 10542 and its additional parts. Transportation-related requirements for wheelchairs that are suitable for occupant seating during motor-vehicle transportation are specified in ISO 7176-19.

The use of only a pelvic belt as an occupant restraint is unlikely to provide adequate safety to a wheelchair user in the event of a frontal impact. Therefore, this part of ISO 10542 only includes test set-ups and procedures for occupant restraints that incorporate both a pelvic and an upper torso restraint.

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

Part 1:
Requirements and test methods for all systems

1 Scope

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

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

This part of ISO 10542 applies to WTORS intended for use with all types of manual and powered wheelchairs intended for use by adults, including three- and four-wheeled scooters.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10542. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10542 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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*.

UN/ECE R 16, *Uniform provisions concerning the approval of safety belts and restraint systems for adult occupants of power-driven vehicles*, Revision 3, Amendment 3, 27 February 1996.

FMVSS 209, Standard No. 209; *Seat belt assemblies*. Federal Motor Vehicle Safety Standards, 49 CFR part 571.209, 1 October, 1992.

3 Terms and definitions

For the purposes of this part of ISO 10542, the following terms and definitions apply.

3.1
adult
person having a mass greater than 36 kg

3.2
airbag
inflatable restraint system
supplementary restraint system
supplemental occupant-restraint system, consisting primarily of a sensor or sensors, diagnostics, inflator(s) and module(s), which inflates a bag in certain vehicle crashes to assist in preventing the occupant(s) from impacting the interior portions of the vehicle

3.3
anchor point
point (area) on a vehicle interior component, floor, or 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 a midsize male used to represent a wheelchair occupant in a test

3.6
automatic-locking retractor
belt retractor incorporating adjustment by means of a positive, self-locking mechanism which is capable of withstanding occupant-restraint forces

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
emergency-locking retractor
belt retractor incorporating a locking mechanism that is activated by vehicle acceleration, deceleration, or rate of webbing movement relative to the vehicle, and that is capable, when locked, of withstanding occupant-restraint forces

3.10
end fitting
anchorage or securement hardware to which wheelchair-tiedown or occupant-restraint webbing is fastened, that attaches directly to an anchor point or to the securement point on the wheelchair

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

3.12
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.

3.13
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

3.14
four-point tiedown
wheelchair tiedown system that attaches to the wheelchair frame at four separate securement points and also attaches to the vehicle at four separate anchor points

3.15
four-point strap-type tiedown
a four-point tiedown that uses four strap assemblies to secure the wheelchair in the vehicle

3.16
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

3.17
head restraint
device intended to limit rearward displacement of the occupant's head

3.18
impact simulator
device for decelerating, accelerating, or a combination of decelerating and accelerating a section of a vehicle or assembly of simulated vehicle structures, including instrumentation for measuring data required by this part of ISO 10542

3.19
impact sled
part of an impact simulator to which components can be mounted for impact testing

3.20
occupant restraint
system or device intended to restrain a motor-vehicle occupant during an impact in order to prevent ejection, and prevent or minimize contact with the vehicle interior components and other occupants

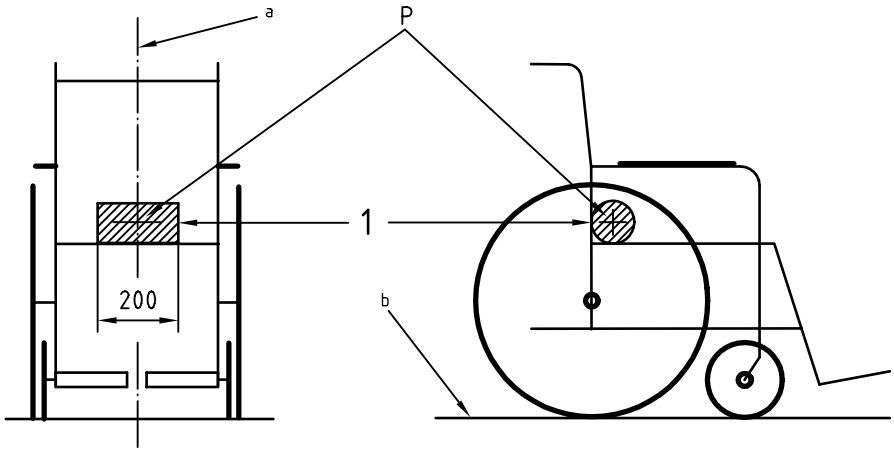
3.21
pelvic restraint
pelvic belt
lap belt
lap restraint
lower torso restraint
belt-restraint assembly intended to limit movement of the pelvis

3.22
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 backrest and the upper surface of the seat

See Figure 1.

3.23
postural support
postural belt
component or belt used to support a person in a desired seated position, but not intended to provide occupant restraint in a vehicle impact

Dimensions in millimetres



Key

1 Cylinder, diameter 100 mm

[a] Wheelchair reference plane

[b] Wheelchair ground plane

Figure 1 — Wheelchair reference point P and wheelchair reference plane

3.24

securement hardware

components of a wheelchair tiedown that attach to the wheelchair

3.25

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.

3.26

strap

length of webbing material used in a wheelchair tiedown

3.27

surrogate wheelchair

SWC

rigid, reusable device that conforms to the requirements of annex E and that is used to simulate a wheelchair for the purpose of testing wheelchair-tiedown and occupant-restraint systems

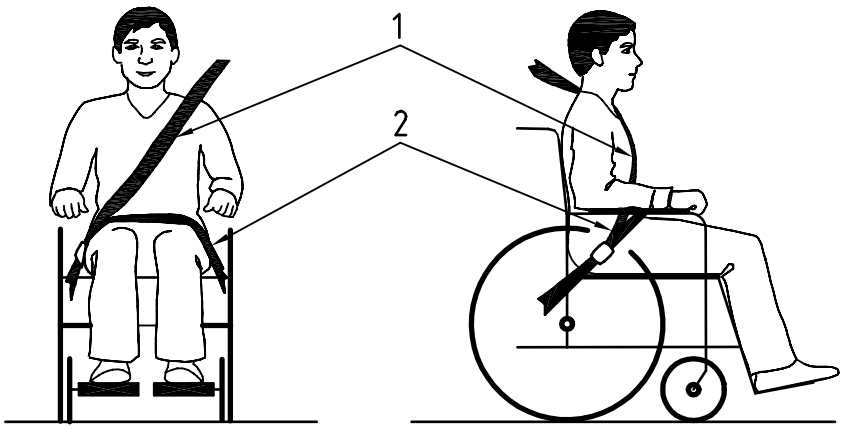
3.28

three-point restraint

three-point belt

occupant-restraint assembly comprised of both a pelvic belt and a diagonal shoulder belt that connect together near the hip of the user

See Figure 2.



Key

1 Diagonal shoulder restraint
2 Pelvic restraint

Figure 2 — Three-point belt

3.29

two-point restraint

two-point belt

belt-type occupant-restraint assembly comprised of a single length of webbing and related hardware that anchors at both ends

See Figure 3.

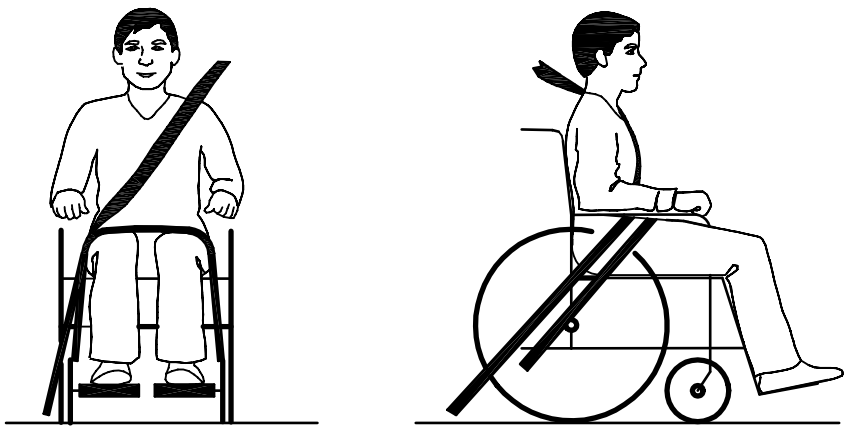


Figure 3 — Two versions of a two-point belt restraint: a two-point shoulder belt and a two-point pelvic belt

3.30

upper-torso restraint

shoulder belt

diagonal belt

diagonal restraint

chest harness

portion of an occupant restraint intended to limit movement of the chest and head by application of restraint forces to the shoulders and chest

3.31
webbing
woven material, usually made from nylon or polyester yarn, used in belt and strap assemblies of occupant restraints and wheelchair tiedowns

3.32
webbing guide
hardware loop or ring anchored to a structural member in the vehicle or wheelchair back, through which an occupant-restraint belt passes, and changes direction, along the path to the vehicle anchor point

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

See Figure 1.

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

See Figure 1.

3.35
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

3.36
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

WTORS shall

a) be for use with only one wheelchair and one occupant at a time, and

b) include a belt-type occupant restraint, either by specifying use of the belt restraint and anchorages provided with the vehicle, or by providing a belt-type occupant restraint with the wheelchair tiedown as part of a complete WTORS,

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

d) 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,

e) once installed, be operable without tools,

f) incorporate features to prevent unintentional loosening of all fasteners,

g) have all small manually detachable hardware and fittings tethered to WTORS subassemblies, and

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

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.

4.2 Wheelchair tiedowns

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, and

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

4.3 Belt-type occupant restraints provided by the WTORS manufacturer

4.3.1 Occupant restraints provided by the WTORS manufacturer shall

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

b) function independently of the wheelchair, such that the restraint belts anchor to either the vehicle or wheelchair tiedown components so that occupant-restraint loads are not transmitted through the wheelchair,

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

NOTE WTORS designed with occupant restraints that transfer occupant-restraint loads through the wheelchair require special labelling and will be dealt with in a future part of ISO 10542.

4.3.2 When set up and measured in accordance with annex B, occupant restraints provided by the WTORS manufacturer shall

a) produce rear-view projected angles of the pelvic belt within the zones shown in Figure 4,

b) produce side-view projected angles of the pelvic belt between 30° and 75° to the horizontal, as shown in Figure 4,

c) provide for a range of adjustment of the pelvic 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, and

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

4.3.3 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 that are

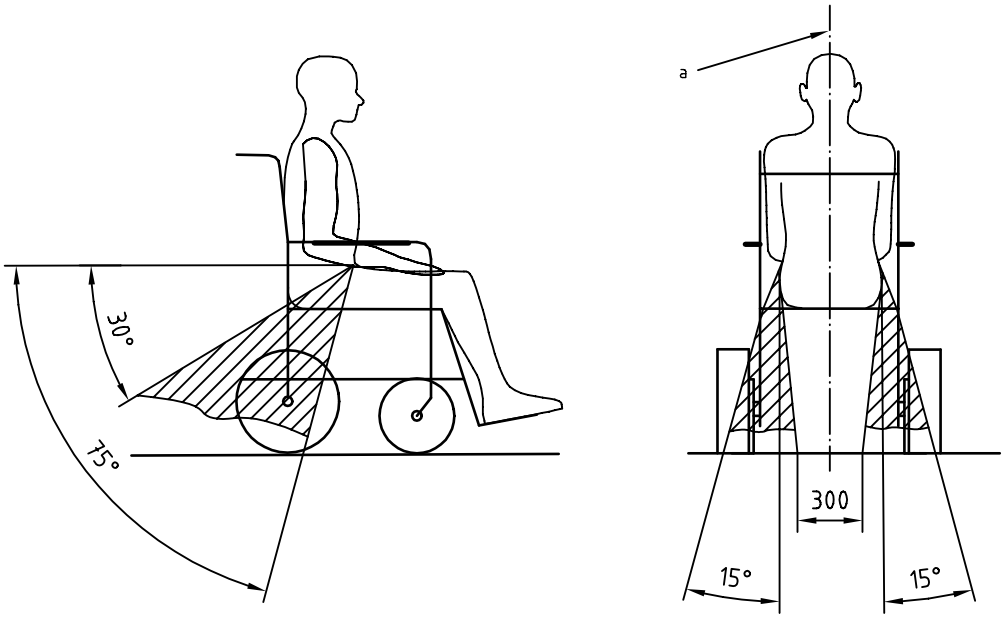
b) located at least 1 100 mm above the wheelchair ground plane.

4.3.4 Occupant restraints shall

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

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

Dimensions in millimetres



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

[a] Wheelchair reference plane

Figure 4 — Range of required angles for pelvic belts and locations of pelvic-belt anchor points

5 Identification, labelling, instruction and warning requirements

5.1 Identification and labelling

5.1.1 WTORS and replacement parts shall be permanently and legibly marked showing

a) manufacturer's name or trademark,

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

c) that it conforms with ISO 10542-1.

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

a) 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, etc.).

5.2 Instructions for installers

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

5.2.2 The instructions shall include statements that

a) the WTORS should be installed for forward-facing wheelchairs,

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

c) the WTORS conforms with ISO 10542-1,

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

e) identify any components to be permanently fastened to the wheelchair, and

f) indicate that the pelvic-restraint anchor points should be positioned to achieve belt angles of 30° or greater to the horizontal, and preferably between 45° and 75° to the horizontal, 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.

5.2.3 The instructions shall include descriptions of

a) any wheelchair features that are required to allow correct fitting of WTORS components that are to be permanently fastened to the wheelchair,

b) procedures for attaching any components to be permanently fastened to the wheelchair,

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

d) the location points of upper anchorages or webbing guides 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' shoulders and so that the height is at or above the shoulder heights of intended users, so as to minimise downward loads on the spine, and

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

5.2.4 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 independent belt restraints relative to wheelchair tiedown anchor points, along with the information in Figure 5,

d) distances between WTORS' anchor points and vehicle interior components, including the information in Figure 6.

5.2.5 The instructions shall include warnings that

a) the WTORS be installed by an experienced technician,

b) both pelvic and upper-torso restraints be installed to reduce the possibility of head and chest impacts with vehicle interior components, and that

c) vehicle anchor points may require reinforcement,

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 be provided if a head restraint is anchored to the vehicle, in order to minimize rearward deflection of the wheelchair seatback and the potential for neck injury,

f) the WTORS not be installed in a manner that may block deployment of an airbag,

g) an airbag 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 wheelchair anchor points properly with respect to the anchor points of the upper and lower torso belts to achieve good belt-fit geometry,

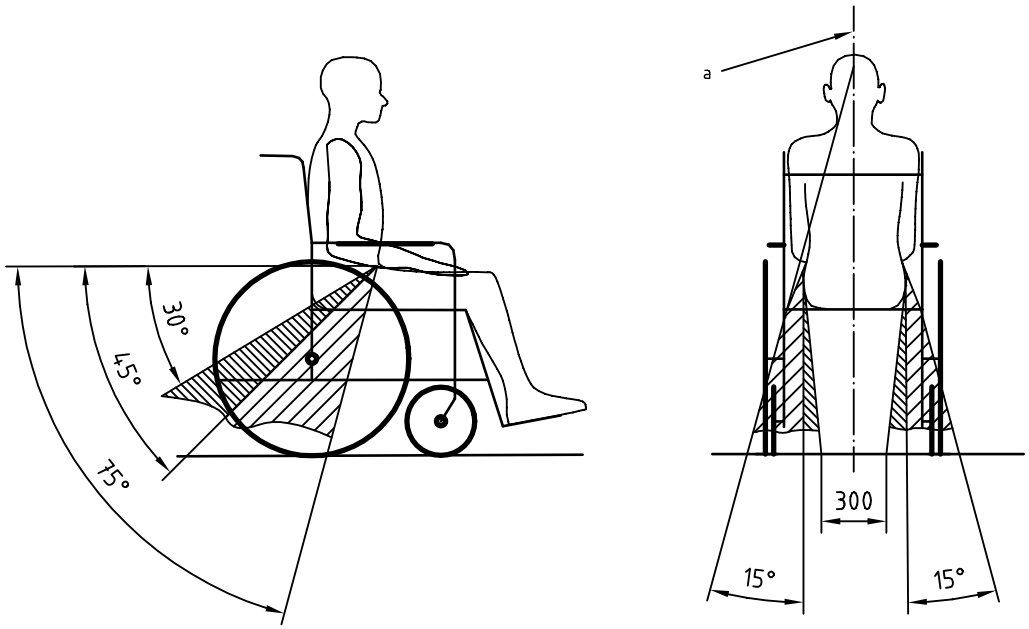
i) the WTORS manufacturer be consulted in case of questions as to the method of installation on the wheelchair and/or in the vehicle,

j) alterations or substitutions to the WTORS components should not be made without consulting the WTORS manufacturer,

k) webbing be protected from contacting sharp corners and edges, and potential corrosive liquids,

l) 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.

Dimensions in millimetres



Key

Preferred zone
Optional zone

[a] Wheelchair reference plane

Figure 5 — Preferred and optional angles for pelvic restraints

5.3 User and maintenance instructions

5.3.1 Manufacturers shall provide written instructions for the use and maintenance of the WTORS in the principal languages of the country in which it is marketed.

5.3.2 The instructions shall include statements that

a) the WTORS conforms with ISO 10542-1,

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

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

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

e) 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 the preferred zone of 45° to 75° to the horizontal, or the optional zone of 30° to 45° 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 armrests or wheels, along with an illustration similar to that of Figures 7 and 8,

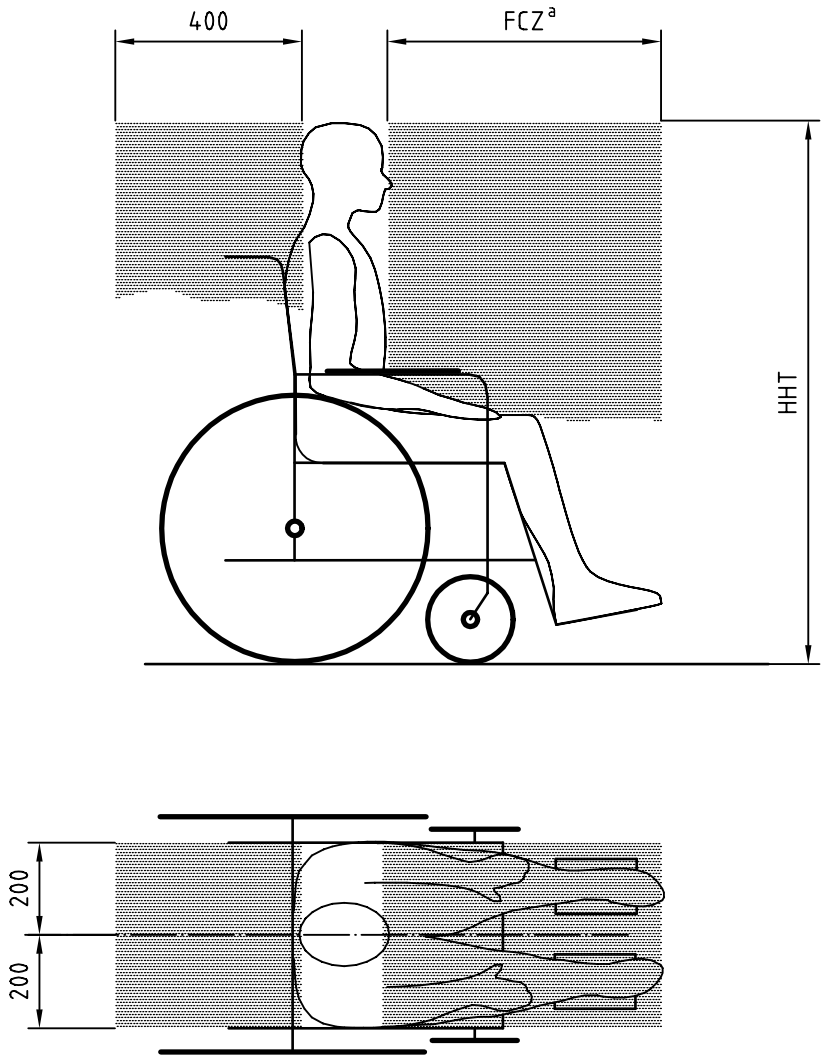
6) occupant restraints belts should be adjusted as firmly as possible consistent with user comfort,

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 shoulder so as not to impose downward loads on the spine in the event of an impact,

9) restraint webbing should not be worn twisted.

Dimensions in millimetres



Rigid vehicle components that are inside the clear zones should be covered with padding that conforms with the impact performance requirements of FMVSS 201, EC 74/60 or UN/ECE 21.

NOTE 1 The rear clear zone is measured from the rearmost point on an occupant's head. The front clear zone (FCZ) is measured from the frontmost point on an occupant's head.

NOTE 2 Seated head height (HHT) ranges from about 1 200 mm for a small adult female to about 1 550 mm for a tall adult male.

[a] 650 mm with upper torso restraint; 950 mm with only pelvic restraint. The FCZ may not be achievable with wheelchair -seated drivers.

Figure 6 — Clear zones for wheelchair-seated occupants

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

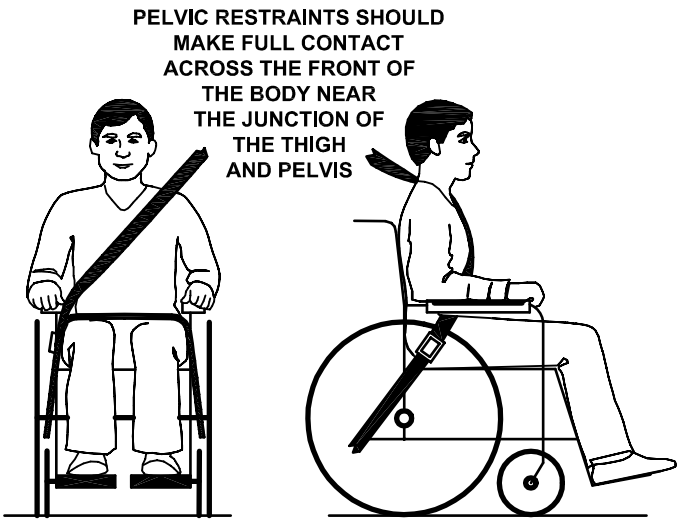


Figure 8 — Illustration of proper belt fit

5.3.3 The instructions shall include descriptions of

a) how the WTORS is to be used,

b) the types of anchorage hardware that may be used with the vehicle-installed anchorage components,

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

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

5.3.4 The instructions shall include warnings that

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

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

c) WTORS components, including anchorages, be replaced if they are suspected to have been in use during an impact from which the vehicle must be towed,

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

e) postural supports and belts not be used as occupant restraints,

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

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

5.4 Instructions for WTORS components and subassemblies sold separately

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

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

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

6 Performance requirements

6.1 WTORS components

6.1.1 All webbing, metal parts, buckles, release mechanisms and adjustment mechanisms of wheelchair tiedown and occupant-restraint systems shall conform with applicable subclauses of one or both of the following documents, as indicated in the applicable column of Table 1 and/or Table 2:

a) UN/ECE regulation No. 16;

b) FMVSS 209 seatbelt assemblies.

6.1.2 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 UN/ECE regulation No. 16

Subclause	Component	Subject	UN/ECE No. 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 thru 7.6.4	OR
6.2.6	preloading devices	performance	7.2, 7.9.2	OR
6.3.1	belts	general specs	—	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
S4.2 (h)	webbing	stain resistance	S5.1(h)	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-pt restraints	performance	S5.3(b)	OR

[a] OR = occupant restraint; WTD = wheelchair tiedown

6.2 Dynamic performance requirements

6.2.1 Post-test acceptance criteria

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

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

b) The SWC shall be in an upright position on the impact sled.

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

d) Release of the SWC 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.

h) The force required to open the buckle of any tiedown or occupant restraint components shall not exceed 60 N when tested as specified by 6.2.2.5 of ECE R 16:1996, in accordance with the procedures of 7.8.

6.2.2 Dynamic performance requirements during the test

When the WTORS is tested in accordance with annex A,

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

b) the WTORS shall prevent the wheelchair from imposing forward loads on the occupant, as indicated by the ATD knee excursion exceeding the wheelchair point P excursion by 10 % or more ($x_{\text{knee}}/x_{\text{wc}} \geqslant 1{,}1$).

Table 3 — Horizontal excursion limits

Measurement point	Excursion variable	Pelvic and shoulder restraint
		mm
Surrogate wheelchair	x_{wc}	200
ATD Knee	x_{knee}	375
ATD Head	x_{head}	650

x_{wc} is the horizontal distance relative to the sled platform between the point-P target on the SWC 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, and

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

6.3 Webbing slippage at tiedown adjustment devices

When tested in accordance with annex C, strap-type adjustment mechanisms of the wheelchair-tiedown system shall not show slippage greater than 25 mm.

6.4 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.

7 Test reports

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

a) name and address of test institution;

b) date of test;

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

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

e) product type and designation;

f) name and address of manufacturer;

g) a photograph of the WTORS test setup.

7.2 For the frontal impact test of annex A, the test report shall also include

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

b) a photograph of the WTORS and wheelchair as set up prior to the test,

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

d) the test results as specified in 6.2.1 and 6.2.2,

e) a statement as to whether or not the WTORS met the requirements of the clauses listed in d) above, and

f) any other relevant observations.

7.3 For the tests of restraint-belt geometry and length adjustment of annex B, the report shall also include

a) a photograph of the WTORS and wheelchair set up for the test,

b) the test results as specified in B.5,

c) a statement as to whether or not the occupant restraint tested met the requirements of 4.3.2, and

d) any other relevant observations.

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

a) a photograph of the test setup,

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

c) the test results as specified in 6.3,

d) a statement as to whether or not the occupant restraint met the requirements of 6.3, and

e) any other relevant observations.

7.5 For the test for test for partial engagement of annex D, the test report shall also include

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

b) the test results as specified in 6.4,

c) a statement indicating whether the equipment met the requirements of 6.4, and

d) any other relevant observations.

Annex A
(normative)

Test method for frontal impact

A.1 Principle

A surrogate wheelchair (SWC) constructed in accordance with annex E is mounted in a forward-facing configuration on the impact sled of an impact simulator and is loaded with an anthropomorphic test device (ATD).

The WTORS is installed to secure the SWC and restrain the ATD. The sled platform is subjected to a defined acceleration/deceleration-time pulse, in order to achieve a defined horizontal velocity change (Δv). Observations and measurements are made to determine if the WTORS conforms to the requirements of this part of ISO 10542.

A.2 Test sample

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

A.3 Apparatus

A.3.1 An **impact simulator** shall be used that includes the following:

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

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

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

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

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

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

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

   4) has a duration of at least 75 ms from t_0 to t_f;

e) a Hybrid II or Hybrid III ATD with a total mass of 76,3 kg $\pm$ 1 kg;

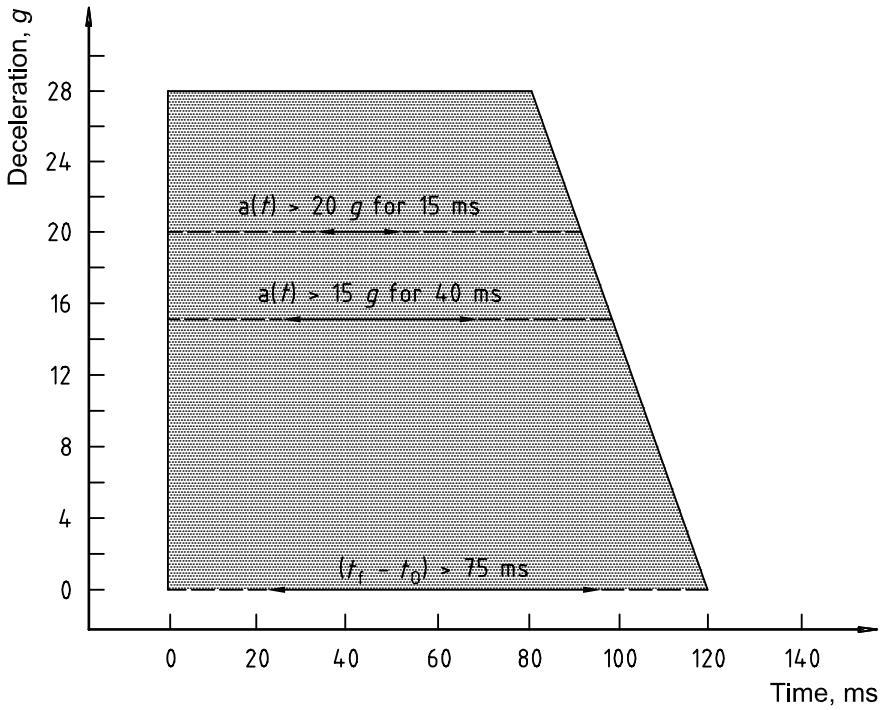
f) a surrogate wheelchair that conforms with the specifications of annex E.

A.3.2 A means shall be provided to measure the ATD and surrogate wheelchair **horizontal excursions** specified in 6.2.2 a) with an accuracy of $\pm$ 5 mm.

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

A.3.3 A means shall be used to measure the **horizontal acceleration and/or deceleration** of the impact sled in the direction of travel at a sampling rate in accordance with ISO 6487, and with a precision of $\pm$ 0,5 g.

A.3.4 A means shall be provided to measure the **horizontal velocity change** (Δv) of the impact sled during the impact with a precision of $\pm$ 0,5 km/h.



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

Figure A.1 — Acceleration/deceleration requirements for the $(48 \pm 2$ km/h$)$ **impact test**

A.3.5 Provision shall be made to filter analog transducer signals using a **low-pass filter** in accordance with ISO 6487, including

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

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

A.4 Test preparation and procedure

A.4.1 The procedures for setting up the test may be undertaken in any order.

A.4.2 Adjust the ATD to achieve a static resistance of 1 g at each joint, as indicated by just-noticeable movement from the mass of the distal body segment, as specified by the ATD manufacturer.

A.4.3 Place close-fitting cotton clothing on the pelvis, thighs and torso of the ATD.

A.4.4 Set up the test apparatus (see A.3).

A.4.5 Prepare the SWC as follows.

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

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

c) Inspect the tyres for cracks and replace if the weakness could cause the tyres to fail during a test.

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

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

A.4.6 Position the surrogate wheelchair facing forward on the sled platform, with the wheelchair reference plane parallel to the direction of sled travel $\pm 3°$.

A.4.7 Install the wheelchair tiedown anchorages in accordance with the manfacturer's instructions. If a range is given for any installation dimensions, use the midpoint of the range. If fasteners supplied with the WTORS are not compatible with the impact sled, use replacement fasteners with the same thread and material specification.

A.4.8 Secure the SWC with the wheelchair tiedown according to the manufacturer's instructions.

A.4.9 Position the ATD in the SWC sitting upright and symmetrical about the wheelchair reference plane, with the pelvis and buttock as far back on the wheelchair seat as possible, and the hands resting on the ATD's thighs.

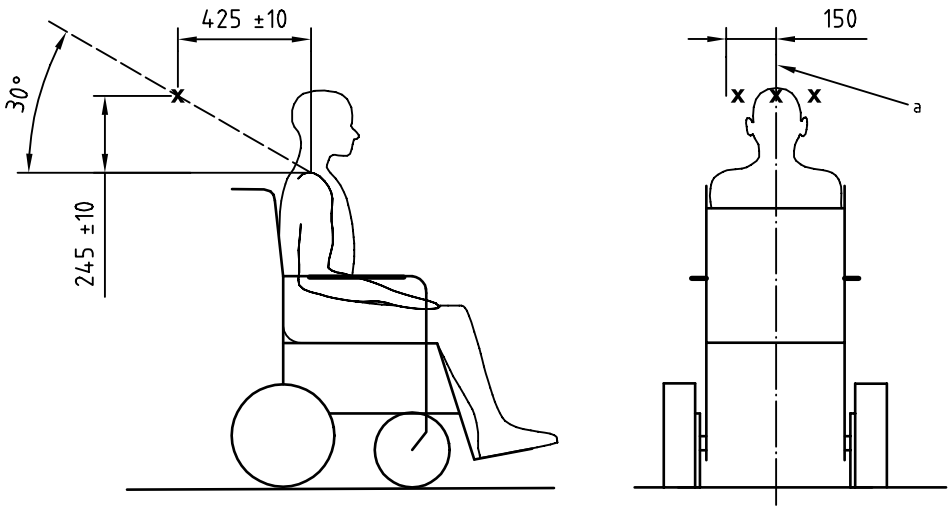
A.4.10 Install the pelvic restraint anchorages in accordance with the manufacturer's instructions, selecting anchor points at the midpoints of the recommended zones, if applicable.

A.4.11 For WTORS that do not include upper-anchor or upper webbing-guide supports for shoulder or harness restraints, install the upper-torso restraint anchorages at the point or points marked by a bold cross (X) or crosses in Figure A.2 or A.3, as applicable, to achieve a fit across the ATD shoulders and chest as indicated in Figure F.1 of annex F.

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

If an upper-torso restraint webbing guide is provided, locate it so that the contact interface between the restraint webbing and the webbing guide is at the intended anchor-point location.

Dimensions in millimetres

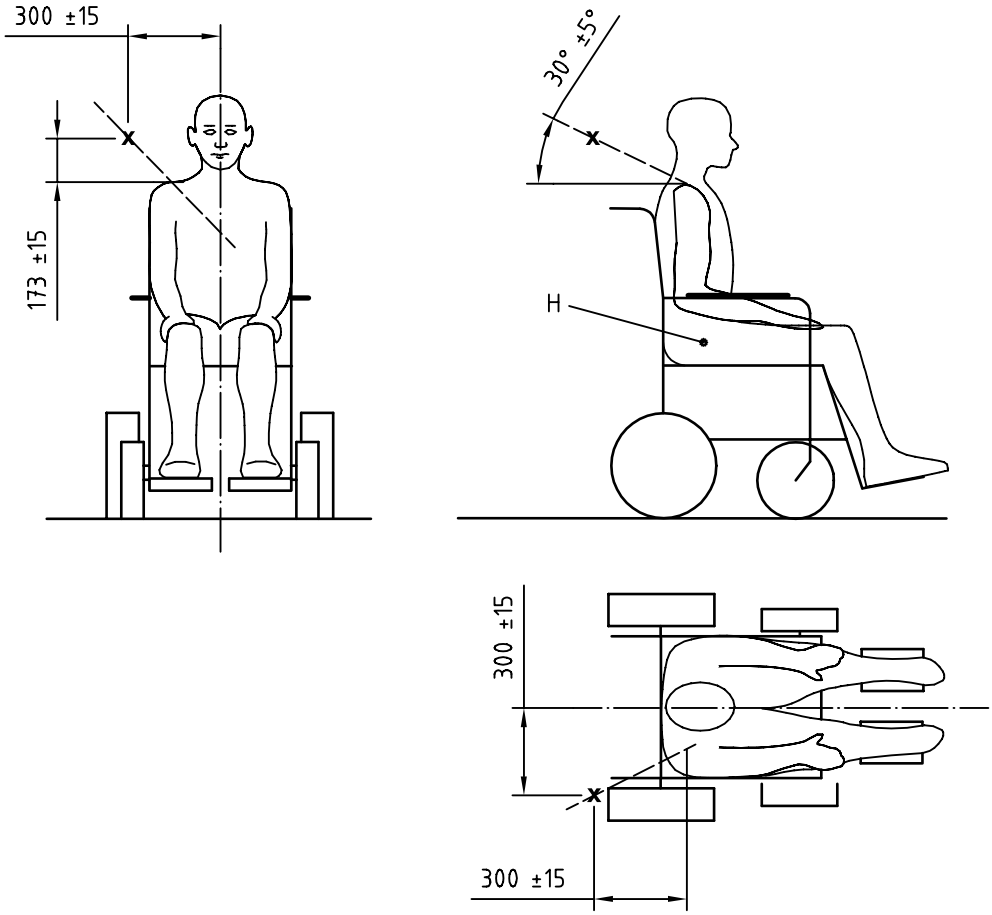


NOTE The anchor points are located relative to the top centre of the ATD's shoulders.

[a] Wheelchair reference plane

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

Dimensions in millimetres



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

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

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

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

A.4.12 For WTORS that include support components for upper anchor points or upper guide points for upper-torso belts, install the anchorages or guides as specified by the manufacturer, to achieve a good fit to the ATD's shoulders and chest.

A.4.13 Place the pelvic belt on the ATD and adjust the tension in the pelvic belt to achieve a snug fit.

A.4.14 Place the shoulder belt or harness on the ATD and adjust the belts as follows.

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

b) If no emergency-locking or automatic-locking retractor is provided, adjust the belts to achieve a snug fit with a 75 mm × 75 mm × 25 mm thick plate inserted between the ATD's chest and the belt webbing with the plate laying flat against the ATD's chest, and then remove the plate.

A.4.15 If a high-speed camera or high-speed video is used for the measurements 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) point P of the SWC.

A.4.16 Ensure that the SWC reference plane is parallel to the centreline of the impact simulator within $\pm 3^{\circ}$.

A.4.17 Make provisions to subject the impact sled and the test specimens to

a) a horizontal velocity change of 48 ± 2 km/h,

b) using a deceleration-time pulse that conforms with A.3.1 d).

A.4.18 Conduct the test by executing the appropriate sequence of steps to activate the impact sled and start the recording equipment.

NOTE To minimize damage to the ATD during testing, a future version of this part of ISO 10542 will consider allowing restrictions on knee-joint and shoulder movements due to limb inertia in a manner that does not affect WTORS loading and ATD excursions during testing. Test facilities are invited to explore methods to accomplish such restrictions in ways that simulate real-world situations (e.g. by placing a padded bolster to catch the ATD's feet prior to full knee-joint extension).

A.5 Evaluation of test results

After the test, examine the SWC, ATD, and WTORS, and analyse the excursion measurements to determine if the WTORS meets the requirements of 6.2.

Annex B
(normative)

Measurement of WTORS belt lengths and geometry

B.1 Principle

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

B.2 Test sample

An unused WTORS, including upper and lower torso restraints, all fittings, anchorages, fasteners, and instructions for installation and use.

B.3 Apparatus

B.3.1 **Flat, horizontal, rigid platform**, on which the SWC chair can be mounted, and to which the WTORS can be attached.

B.3.2 **Rigid structure**, fastened to the platform, that allows the anchorages for upper anchor points or upper webbing guides of the upper-torso restraint to be fastened at the locations specified in Figures B.1 and B.2.

B.4 Procedure

B.4.1 Secure the surrogate wheelchair to a flat, horizontal, rigid platform with the wheelchair-tiedown in accordance with the WTORS manufacturer instructions.

B.4.2 Position the ATD symmetrically in the SWC seat with the buttock and pelvis against the backrest and the arms positioned on the armrests or ATD thighs.

B.4.3 Install the pelvic belt in accordance with the manufacturer's instructions, selecting anchor points at the mid-point of the recommended zones, if applicable.

B.4.4 Install the upper-torso restraint as follows.

a) For WTORS that do not include support structures for upper-anchor points or upper webbing guides for shoulder or harness restraints, install the upper anchorage of the upper-torso restraint at the point or points marked by a bold cross (X) or crosses in Figure B.1 or B.2, as applicable, using hardware supplied by the manufacturer, if provided.

   NOTE The setups in Figures B.1 and B.2 represent expected worst-case situations in actual vehicles with regard to the length requirements of upper-torso belts (see Figures F.2 through F.4 of annex F for preferred and optional zones). Subclause 4.3.2 d) requires additional length adjustment of the belt from anchor- or guide-point scenarios, in order to accommodate larger users.

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

B.4.5 Adjust the tension in the pelvic and shoulder belts to achieve a snug fit.

B.5 Measurements

B.5.1 Measure and record the rear-view angle relative to the horizontal of the pelvic belt projected onto a plane that is perpendicular to the wheelchair reference plane, and the side-view angle of the pelvic belt projected on to the wheelchair reference plane.

B.5.2 Measure and record the distance from the centreline of the ATD along the arc of the pelvic belt to the centre of the junction of the upper torso belt and the pelvic belt.

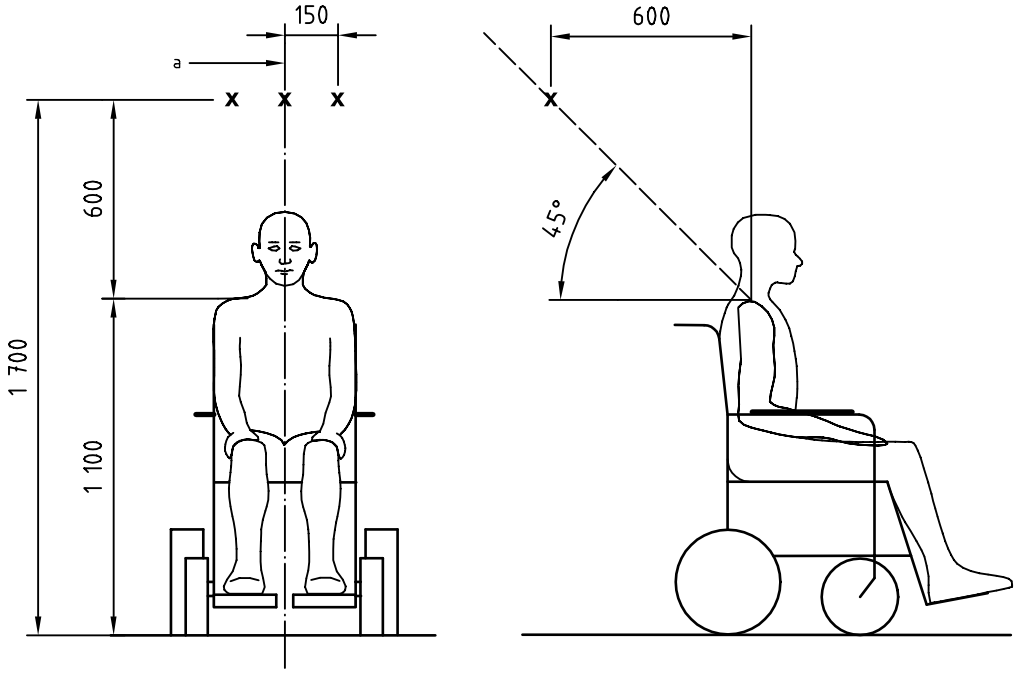
B.5.3 Mark the location of the webbing in the upper-torso restraint adjusters. Disconnect the upper-torso restraint at one anchor point and measure the total length of belt lengthening and shortening available, while checking to make sure that at least 25 mm of webbing extends through the restraint end fittings at all times.

B.5.4 Mark the location of the webbing at the pelvic restraint adjusters with the pelvic belt on the ATD as described in B.4.3. Unbuckle the pelvic belt and measure the total length of belt lengthening and shortening provided (including adjustment on both sides of the pelvic belt if applicable), while checking to make sure that at least 25 mm of webbing extends through the restraint end fittings at all times.

B.6 Results and compliance

Determine if the test sample meets the requirements of 4.3.2.

Dimensions in millimetres

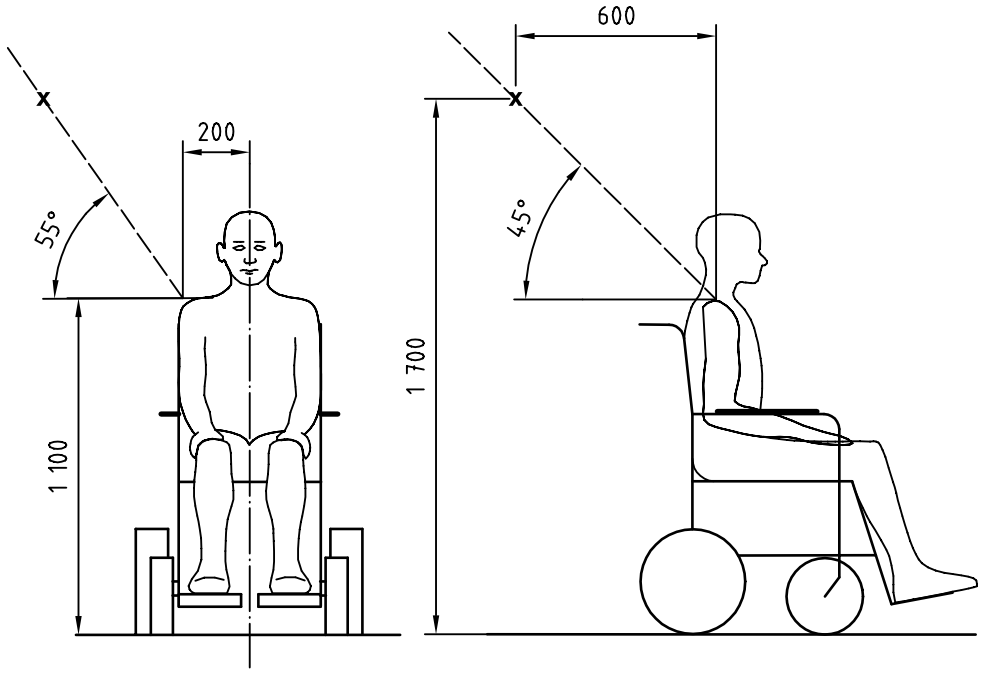


NOTE Bold crosses (**X**s) indicate the locations of the upper anchor points.

[a] Wheelchair reference plane

Figure B.1 — Anchor-point locations for test setup with centre-anchored or two-point anchored harness on the ATD seated in a wheelchair with dimensions specified in annex E

Dimensions in millimetres



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

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

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

Figure B.2 — Anchor-point location for test setup with three-point restraint on the ATD seated in a wheelchair with dimensions specified in annex E

Annex C
(normative)

Test for webbing slippage at adjustment devices of wheelchair tiedown straps

C.1 Principle

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

C.2 Test sample

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

C.3 Apparatus

C.3.1 **Weight**, of mass 5 kg ± 0,1 kg.

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

C.4 Procedure

C.4.1 Store the adjustment device to be tested at a temperature of 20 °C ± 5 °C and a relative humidity of 65 % ± 10 % for 24 h prior to testing.

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

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

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

c) Adjust the webbing so that the bottom of the weight is 100 mm ± 20 mm off the resting surface when the movement mechanism is at maximum upward travel.

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

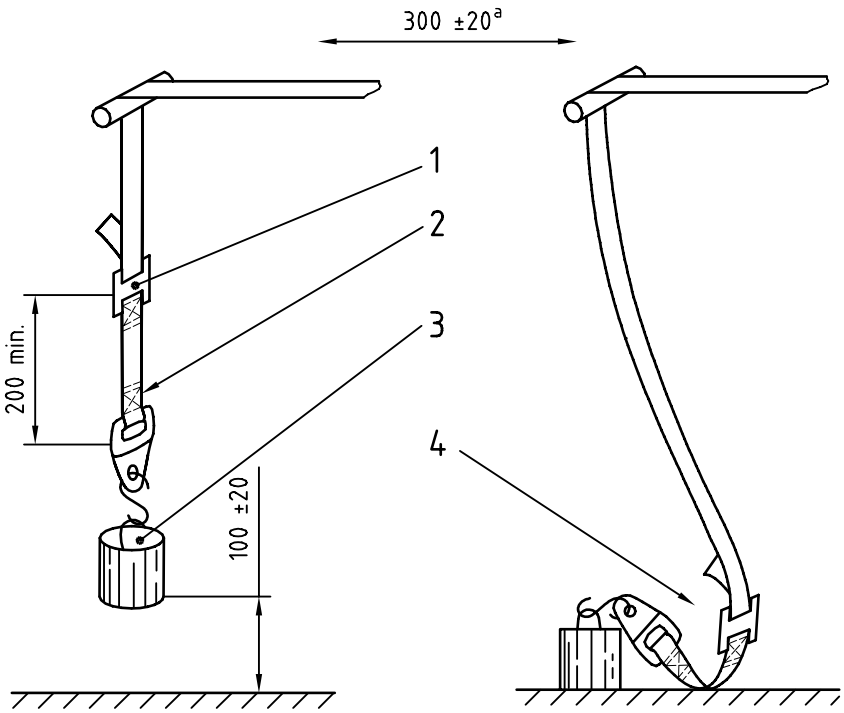
e) Apply a vertical oscillating motion with a peak-to-peak amplitude of 300 mm ± 20 mm to the adjustment device by raising and lowering the webbing in the test fixture, and continue for 20 or more cycles to ensure that the test equipment is operating correctly. On the downward stroke, ensure that the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

f) Mark the webbing position at the adjustment device.

g) Repeat the up/down oscillating motion in accordance with C.4 e) and continue for 1 000 cycles at a frequency between 0,5 Hz and 0,75 Hz.

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

Dimensions in millimetres



Key

1 Adjusting device
2 Stitching
3 5 kg weight
4 Downward loop

Initial distance between adjusting device and end fitting shall be 200 mm or greater.

[a] Total travel

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

C.5 Results and compliance

Determine if the test sample meets the requirements of 6.3.

Determine if the test sample meets the requirements of 6.4.

Annex D
(normative)

Test method for partial engagement

D.1 Principle

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

D.2 Test sample

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

D.3 Apparatus

D.3.1 Means to apply a separating force of 22 N between the separate WTORS components, such as the separable parts of an anchorage mechanism, or a tiedown end fitting and the securement-point hardware on the wheelchair.

D.3.2 Means for measuring the applied force to an accuracy of ± 5 %.

D.3.3 Means to measure the duration of the applied forces to an accuracy of ± 0,5 s.

D.4 Procedure

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

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

b) apply a separating force of 22 N ± 2 N between the components of the securement or anchorage mechanism, and maintain the force of a maximum of 3 s ± 0,5 s.

D.5 Test results

For each test conducted,

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

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

D.6 Results and compliance

Determine if the test sample meets the requirements of 6.4.

Annex E
(normative)

Surrogate wheelchair specifications

E.1 General

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

NOTE Details for the design, fabrication, and maintenance of a suitable surrogate wheelchair are available in SAE 2252, *Surrogate wheelchair drawing package and maintenance manual*.

E.2 Specifications

The surrogate wheelchair shall

a) be of rigid durable construction, such that there is no permanent deformation of the frame, seat surface, or seatback in a 48 km/h, 20 g frontal impact test with a 76,3 kg ATD positioned and restrained in the SWC,

b) have a total mass of 85 kg $\pm$ 1 kg,

c) conform with the dimensions shown in Figures E.1 through E.4,

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

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

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

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

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

i) have a rigid seatback with height and width dimensions as indicated in Figures E.2 and E.3 that is oriented at $8^\circ \pm 1{,}5^\circ$ to the vertical when the SWC tyres are resting on a flat horizontal surface and inflated in accordance with l) and m) below,

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

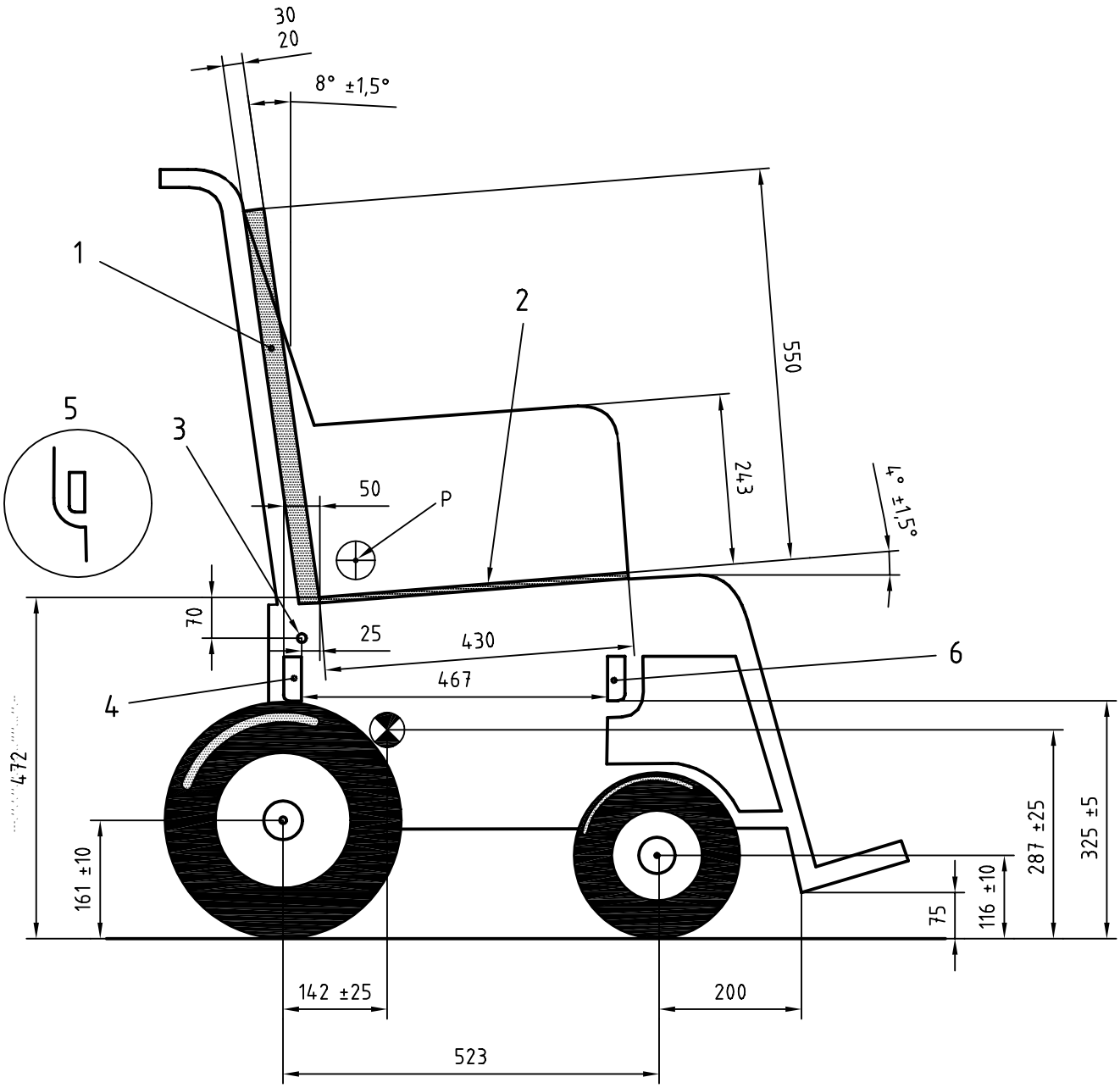
k) have a detachable, but rigid, mounting plate for placement of a side-view target at the location of reference point P outboard of tiedown and restraint system components on either side of the SWC,

l) have pneumatic front tyres that, when inflated to 320 kPa $\pm$ 30 kPa with the unoccupied surrogate wheelchair resting on a flat horizontal surface, have a diameter of 230 mm $\pm$ 10 mm, a width of 75 mm $\pm$ 10 mm, and a sidewall height of 54 mm $\pm$ 5 mm,

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

Dimensions in millimetres

Tolerances ±5 mm unless otherwise specified



Key

1 Hard rubber back rest
2 Rigid seat surface
3 Pelvic belt anchor point
4 Rear securement point
5 Rear securement point geometry
6 Front securement point

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

Figure E.1 — Side view of surrogate wheelchair

Dimensions in millimetres

Tolerances ±5 mm

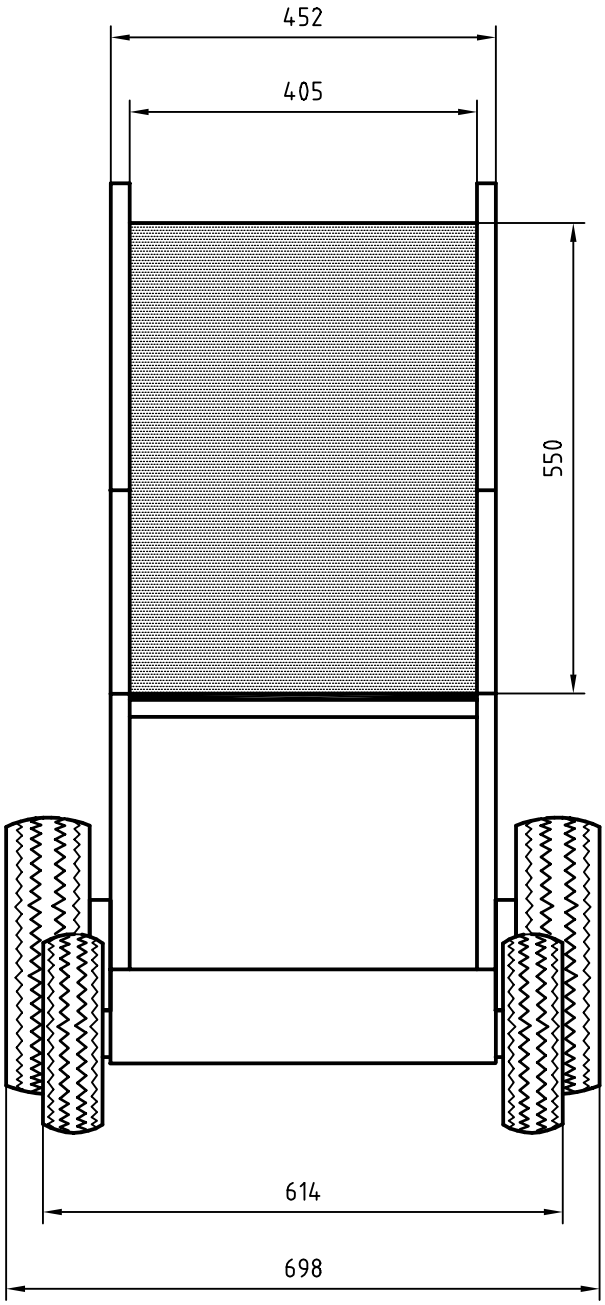
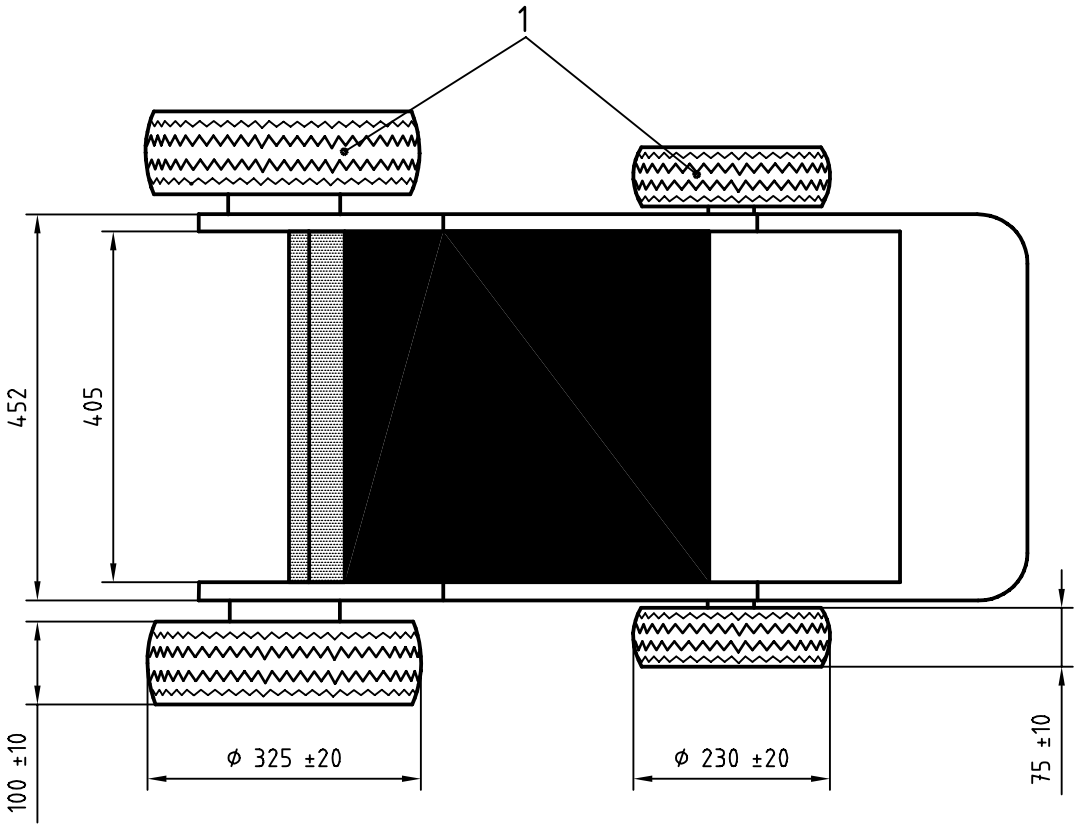


Figure E.2 — Front view of surrogate wheelchair

Dimensions in millimetres

Tolerances ±5 mm unless otherwise specified

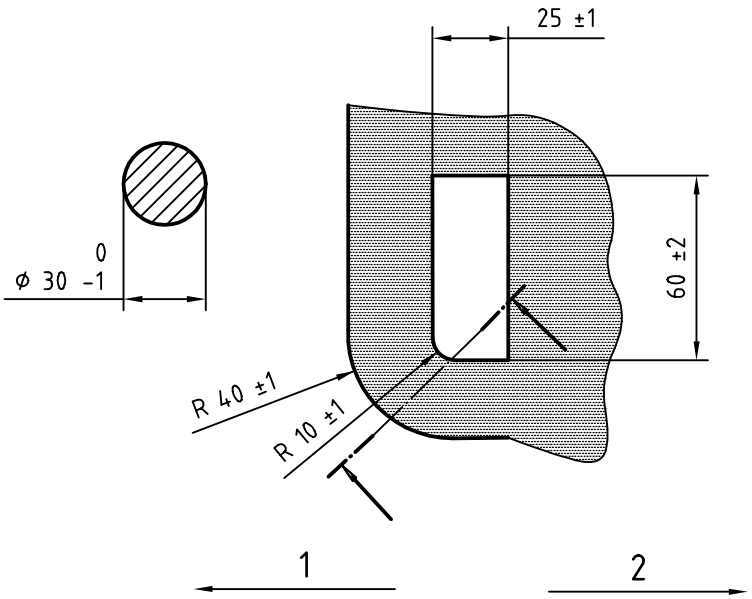


Key

1 Pneumatic tyres

Figure E.3 — Top view of surrogate wheelchair

Dimensions in millimetres



Key

1 Anchor point

2 Wheelchair

Figure E.4 — Dimensions of wheelchair securement points on surrogate wheelchair showing required engagement geometry for securement-point end fittings of four-point strap-type tiedowns

Annex F
(informative)

Recommendations for design, performance and documentation

F.1 This annex contains additional design, performance, and documentation recommendations for WTORS manufacturers, and guidelines for additional information that manufacturers may choose to provide to installers and users.

F.2 The WTORS manufacturer should maintain, and have available for inspection, an up-to-date product file containing, at a minimum, the following information for each type or model of WTORS:

a) statements of intended use and limitations,

b) results of the most recent tests specified in this part of ISO 10542,

c) certificates of conformity to ISO standards on flammability,

d) cross-reference to related tests of all or parts of other WTORS,

e) schedule of design changes, including dated supporting documentation,

f) installation instructions required by 5.2,

g) user instructions required by 5.3, and

h) any other relevant data.

F.3 Wheelchair tiedowns should minimize free-play in all directions during normal vehicle movement.

F.4 WTORS should provide for manual release of both the wheelchair and the occupant by a single attendant without the use of tools.

F.5 Reinforcing plates furnished for universal vehicle anchorage installations should

a) have a cumulative area of at least 10 000 mm^2 allocated equally among all wheelchair tiedown anchorage locations,

b) have a cumulative area of at least 7 500 mm^2 allocated equally among all occupant restraint anchorage locations,

c) have a minimum thickness of 3 mm,

d) have corners with a minimum radius of 5 mm to inhibit local tearing or penetration of the vehicle structure, and

e) be designed so that the load from each fastener is centrally located on the backing plate or washer to minimize edge loading on the vehicle sheet metal.

F.6 All rigid components of occupant restraints should minimize harm to the person riding in the wheelchair and damage to his/her clothing during use. To achieve this,

a) the overall width of any component attached to webbing likely to contact the wearer in normal use should not exceed the width of such webbing by more than 20 mm when measured at right angles to the length of each attached webbing, and

b) all parts should be smoothly finished, without sharp edges, burrs or irregularities.

F.7 Belts and other components used for postural support of wheelchair-seated persons should not be relied on for occupant restraint and protection in a crash unless they conform to all requirements in this part of ISO 10542.

F.8 Belts and other components used for postural support of wheelchair-seated persons that are placed over the abdomen and/or chest should break away at a force of 1 000 N or less in order to reduce the likelihood of injury.

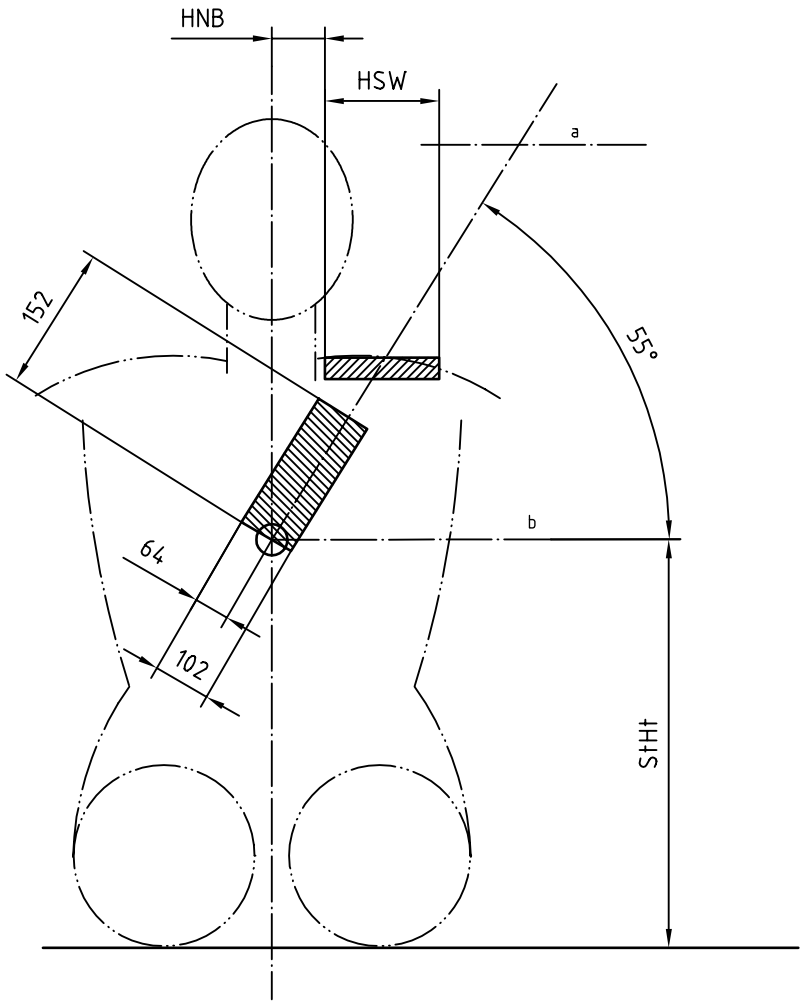
F.9 Components of wheelchair tiedowns that are permanently fastened to the wheelchair should not reduce the wheelchair-to-ground clearance distance, in order not to limit the primary use of the wheelchair.

F.10 Installation of an after-market airbag restraint system, or relocation of an original equipment airbag restraint system, should be done only after consultation with the vehicle manufacturer.

F.11 Upper torso restraints should fit over the shoulders and, in the case of shoulder belts of three-point restraints, across the chest of wheelchair-seated occupants. Figure F.1 and Table F.1 provide information on appropriate restraint fit dimensions and geometry for different-sized occupants.

F.12 Upper anchor points of shoulder and harness restraints should be selected to allow the restraint to fit over the shoulders of users in the intended population. Figures F.2 through F.4 and Table F.2 provide information on preferred and optional anchor point zones for different size occupants. Fixed upper anchor points for anchorages or webbing guides of shoulder and harness restraints should be placed at the level of, or above, the seated shoulder height of the tallest expected occupant in order to prevent downward loading on the spine under impact conditions. Installers should attempt to locate the upper anchor point in the applicable preferred zone, but should move the anchor point upward and rearward so that the belt passes through the preferred zone, if this is necessary to find a vehicle anchor point that conforms with the minimum strength recommendation of the WTORS manufacturer.

Dimensions in millimetres



See Table F.1 for typical values of HNB, HSW and StHt.

[a] Belt angle

[b] Sternum reference plane

Figure F.1 — Preferred zones for location of shoulder belt on occupant's torso

Table F.1 — Recommended belt-fit values for Figure F.1

Dimensions in millimetres

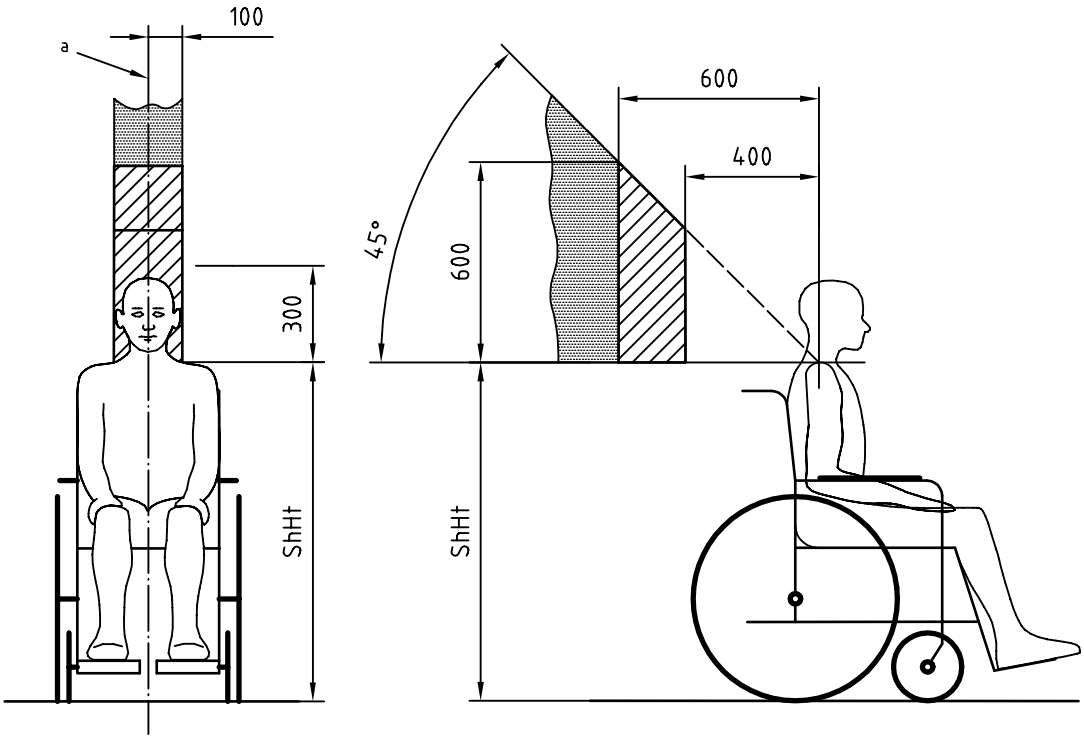
Occupant size	Half neck breadth HNB	Half shoulder width HSW	Sternum height StHt
Small female (1 500 mm, 47 kg)	66	109	353
Average male (1 753 mm, 77 kg)	76	127	406
Large male (1 880 mm, 102 kg)	81	135	432

Table F.2 — Typical values of ShHt, HSB, HNB, and seat height

Dimensions in millimetres

Occupant size	Shoulder height ShHt	Half shoulder breadth HSB	Half neck breadth HNB	Seat height
Small female (1 500 mm, 47 kg)	1 000	175	66	450
Average male (1 753 mm, 77 kg)	1 100	200	76	500
Large male (1 880 mm, 102 kg)	1 200	210	81	550

Dimension in millimetres



Key

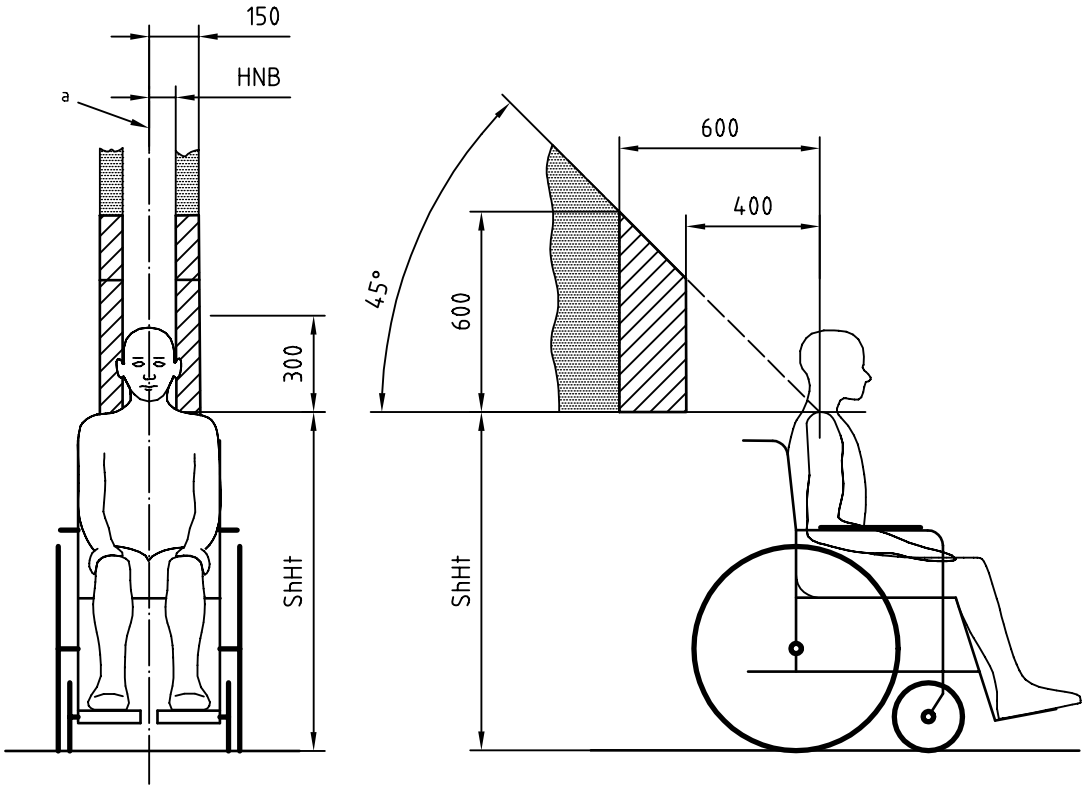
Preferred zone
Optional zone

NOTE See Table F.2 for typical values of ShHt.

[a] Wheelchair reference plane

Figure F.2 — Preferred and optional zones for centre vehicle anchor point of yoke-type restraint harness

Dimensions in millimetres



Key

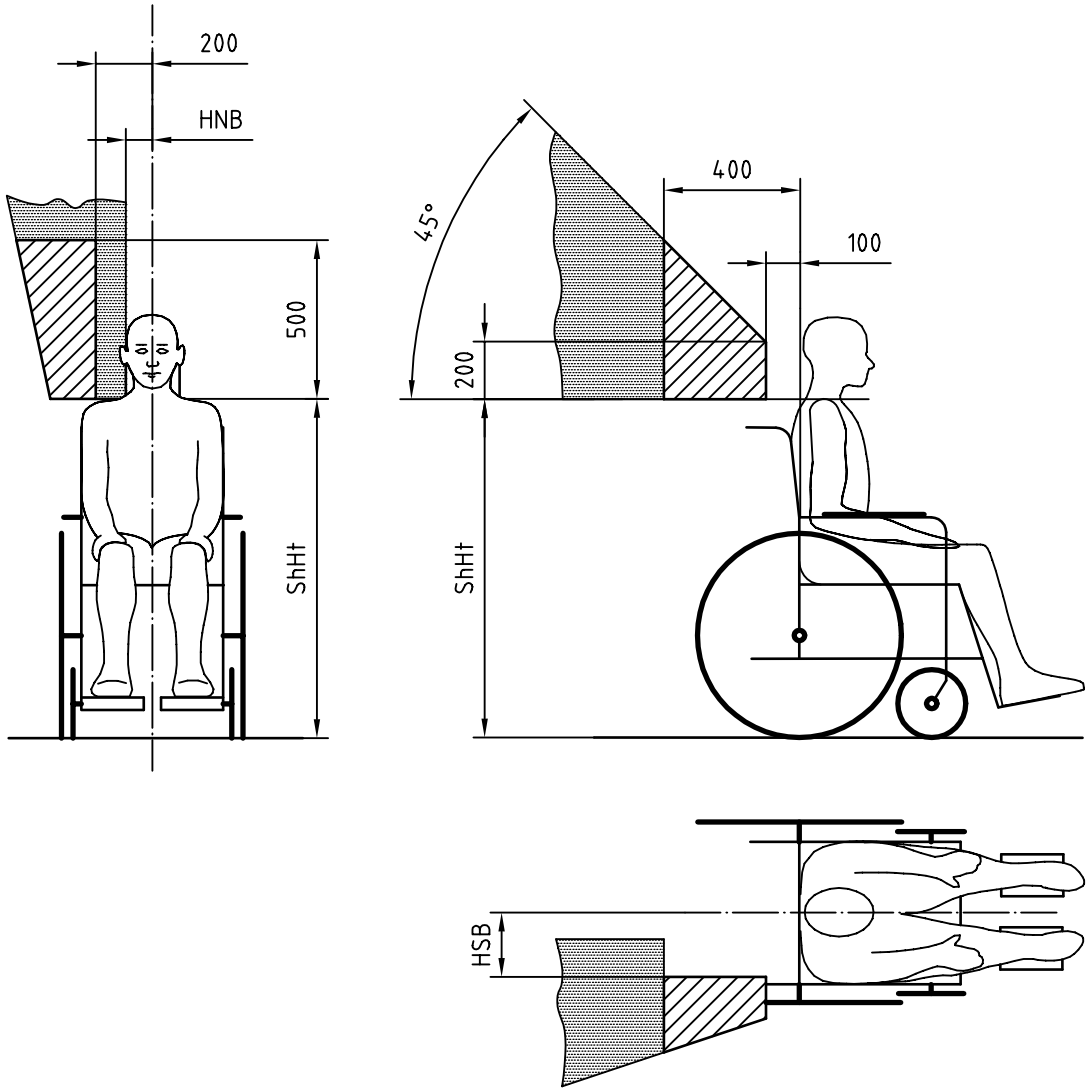
Preferred zone
Optional zone

NOTE 1 Seee Table F.2 for typical values of ShHt and HNB.

[a] Wheelchair reference plane.

Figure F.3 — Preferred and optional zones for upper vehicle anchor point of restraint harness

Dimensions in millimetres



Key

Preferred zone
Optional zone

NOTE 1 See Table F.2 for typical values of ShHt, HNB and HSB.

NOTE 2 The shoulder belt upper anchor point may be on either side of the wheelchair.

Figure F.4 — Preferred and optional zones for upper vehicle anchor point of shoulder belt

Annex G
(informative)

Information sources

G.1 Sources of anthropomorphic test devices

Hybrid II and Hybrid III ATDs can be purchased from[1)]:

— First Technology Safety Systems, Inc. Plymouth, Michigan, USA

— Vector Research, Inc. Milan, Ohio, USA

G.2 Sources of non-ISO standards

Copies of normative standards are available as follows:

— UN/ECE R 16 may be obtained from: United Nations office at Geneva, Conference Services Division, distribution and sales section, Office C-115-1 Palais des Nations, CH-1211 Geneva 10 Switzerland, Telefax: + 41 22 917 00 27

— U. S. Federal Motor Vehicles Safety standards (FMVSSs) are contained in 49 code of federal regulations parts 400 to 999 and are available from: U.S. Government Printing Office, Superintendent of documents, Mail stop: SSOP Washington, D.C. 20402-9320, USA

G.3 Sources of ISO standards

a) ISO Standards may be obtained from:

   — ISO Central Secretariat, 1, rue de Varembé Case postale 56 CH-1211 Genève 20 Switzerland; Telephone: + 41 22 749 01 11; Telefax: + 41 22 733 34 30; Telex: 41 22 05 iso ch

   — National standards organizations which are member bodies of ISO.

b) ISO standards may also be ordered:

   — by email from: “central@iso.ch”, and

   — on the worldwide web at: “http://www.iso.ch”

G.4 Sources of wheel/tyre assemblies for the surrogate wheelchair

Wheels for the surrogate wheelchair may be obtained from[1)]:

Martin Wheel Co., Inc.
42 West Avenue,
P.O. Box 157,
Tallmadge, Ohio 44278 USA
Tel.: 216 633-3278, 800 462-7846
Fax: 216 633-3303

1) This information is given for the convenience of users of this part of ISO 10542 and does not constitute an endorsement by ISO of these products.

Wheel assembly part numbers and specifications are as follows:

Part name	General description	Stock number	Bushing specification	Tyre characteristics
Front wheel assembly	226 mm (8,9 in) diameter 4-ply tyre on 50 mm (2 in) offset hub with 19 mm (3/4 in) grafoil bushing	284 DB4 SW25	not needed	280 4-ply sawtooth tread; 71 mm (2,8 in) wide; 345 kPa (50 psi) inflation
Rear wheel assembly	318 mm (12,5 in) diameter 4-ply tyre on 57 mm (2,25 in) offset hub with 19 mm (3/4 in) grafoil bushing	356 DB4 SW 241 I	34 IB	410 6 4-ply sawtooth tread; 104 mm (4,1 in) wide; 345 kPa (50 psi) inflation

Bibliography

[1] ISO 9999:1998, *Technical aids for disabled persons — Classification*.

[2] AS 2942-1994, (Australian) *Standard for wheelchair occupant restraint assemblies for motor vehicles*.

[3] CSA Z604, *Transportable mobility aids for occupancy in moving vehicles*.

[4] CSA Z605, *Mobility aid securement and occupant restraint systems for motor vehicles*.

[5] DIN 75078-2, *Motor vehicles for transportation of handicapped persons — Restraint systems — Concepts, requirements, testing*.

[6] UN/ECE R 14, *Uniform provisions concerning approval of vehicles with regard to safety-belt anchorages*, revision 2.

[7] UN/ECE Regulation No. 21, *Uniform provisions concerning the approval of vehicles with regard to their interior fittings*.

[8] FMVSS 201, Standard No. 201; *Occupant protection in interior impacts*, 49 CFR part 571.201.

[9] FMVSS 208, *Occupant crash protection*, 49 CFR part 571.208.

[10] FMVSS 222, *School bus passenger seating and crash protection*, 49 CFR part 571.222.

[11] ISO 7193, *Wheelchairs — Maximum overall dimensions*.

[12] SAE J117, *Dynamic test procedure — Type 1 and type 2 seat belt assemblies*.

[13] SAE J128, *Occupant restraint system evaluation*.

[14] SAE J140a, *Seat belt hardware test procedure*.

[15] SAE J141, *Seat belt hardware performance requirements*.

[16] SAE J383, *Motor vehicle seat belt anchorage design modifications*.

[17] SAE J2094, *Terminology report for vehicle and control modifications for drivers with physical disabilities*.

[18] SAE J2249, *Wheelchair tiedowns and occupant restraints for use in motor vehicles*.

[19] SAE J2252, *Surrogate wheelchair preparation, fabrication, and assembly manual*.

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

[21] VSE 87/1, *Code of practice, the safety of passengers in wheelchairs on buses*.

[22] EC 74/60, European Council Directive, 17 December 1973, *Approximation of laws of Member States relating to the interior fittings of motor vehicles.*

ICS 11.180

Price based on 40 pages