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ISO/TC 173 / SC 1

Title

Assistive products for persons with disability - Wheelchairs

Secretariat **SABS**

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English title

Assistive products for persons with disability — Wheelchair tiedown and occupant restraint systems for rearward facing wheelchair-seated passengers — Part 1: Systems for accessible transport vehicles designed for use by both seated and standing passengers

French title

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Introductory note

The current ISO 10542 series (parts 1 - 5) for "Wheelchair Tiedown and Occupant Restraint Systems" focuses on the Forward Facing wheelchair-seated passengers.As was described when the NWIP was balloted,there is a need for expanding to a wider field of transportation solutions.It is envisaged that this document will form part of a series of standards related to:"Wheelchair Tiedown and Occupant Restaint Systems for Rearward Facing Wheelchair -seated Passengers", with the following envisaged parts.

Part 1: ystems for large accessible vehicles for the transport of seated and standing passengers

Part 2: Systems for large accessible vehicles for the transport of seated passerngers

Part 3: Systems for accessible vehicles for the transport of no more than 8 seated passengers

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Assistive products for persons with disability — Wheelchair tiedown and occupant restraint systems for rearward facing wheelchair-seated passengers — Part 1: Systems for accessible transport vehicles designed for use by both seated and standing passengers

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Foreword

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

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

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

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

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

ISO nnn consists of the following parts, under the general title *Assistive products for persons with disability — Wheelchair tiedown and occupant restraint systems for rearward facing wheelchair-seated passengers*:

— *Part 1: Systems for assessible transport vehicles designed for use by seated and standing passengers*

Introduction

Providing effective protection for the wheelchair-seated occupant of a motor vehicle usually requires that after-market equipment be installed to secure the wheelchair and restrain the person in their wheelchair. The ISO 10542, parts 1-5 series of standards, provides design and performance requirements for wheelchair tiedown and occupant restraint systems (WTORS) intended for use in motor vehicles used to transport occupied wheelchairs. Since manufacturers could not be certain as to the size of vehicle in which their WTORS would be installed, it was necessary to conduct performance tests assuming the worst-case installation-in a small vehicle. Therefore, all device performance tests to date for the ISO10542 series have required 48kph/20g simulated frontal impact test, which make the WTORS suitable for use in all sizes of transport vehicles. However, use of these same devices in larger accessible transport vehicles (ATVs) means that the occupant restraint and securement devices are more robust than required.

In recent years, transport vehicles have become more accessible to wheelchair users. Wheelchair lifts, ramps, designated wheelchair securement spaces, various securement and restraint technologies, kneeling and low floor vehicle designs have served to increase the access to persons with various disabilities, including those who remain in their wheelchair whilst riding in the vehicle. This standard is concerned only with the larger accessible transport vehicle (ATV), defined as a vehicle that has areas suitable for both seated and standing passengers (ATV-SS), and is used most often in service areas limited to urban traffic speeds. A main goal of this standard is to provide passenger safety for wheelchair-seated passengers that is approximately equivalent to that of a standing passenger riding in a ATV-SS. It is generally accepted that a standing passenger, when holding fast to a vehicle hand-hold, can withstand a maximum deceleration load of approximately 1g.

Beginning in the early 1990’s, many European countries, Canada and Australia have been introducing the use of a rear-facing wheelchair passenger space (WPS) in ATV-SSs. The main advantage is to allow wheelchair users to enter and exit without the need for active wheelchair securement to be applied by an attendant or driver. Typical vehicle installations provide a vehicle-mounted head and back restraint (forward excursion barrier) that is located, ideally, in close proximity to the back and head of the rear-facing wheelchair occupant. Lateral displacement or rotation of the wheelchair is most often limited on one side by the wall of the vehicle and on the aisle-side by a vertical or horizontal lateral barrier. Movement towards the rear of the vehicle is limited by the brakes of the wheelchair, and/or the users’ ability to grasp the hand-holds located within the wheelchair passenger space. The rear-facing WPS is often provided as an alternative to a second forward-facing space in the vehicle that is equipped with WTORS devices that meet the ISO10542-1/2 standards.

In practice, from the injury-risk perspective, this rear-facing WPS concept has not realized the ideal in several important ways. Many wheelchair designs, combined with varying sizes of personal bags hung on the rear of the backrest, means that the head and back restraint often does not come in close proximity to the occupant’s head and back. Some wheelchairs do not have brakes or may have defective brakes. Wheelchair occupants have varying ability to use hand-holds, and aisle-side lateral barriers do not work effectively with some wheelchairs, i.e. scooters. These deficiencies have allowed, for example, tipping or swerving of wheelchairs into the centre aisle during vehicle cornering. Attempts to resolve these deficiencies have resulted in the addition of various types of secondary securement straps. This usually nullifies one of the main goals of the rear-facing WPS–independent vehicle access by the wheelchair user. Also, many countries have no national standards for the design, testing and installation of the rear-facing wheelchair passenger space, therefore misapplication of the concept may readily occur.

Accident data analysis from several countries on ATV-SSs clearly indicates that the frequency of fatalities or per million passenger kilometres is extremely small. These findings support the wheelchair occupant safety approach for these vehicles that deals primarily with the forces associated with normal (non-collision) and thereby accepts the very small risk that a vehicle collision will ever occur. Other research has shown that the forces associated with emergency manoeuvres during normal driving, (maximum braking, cornering, ascending hills whilst accelerating) all have values lower than 1g. For these reasons the scope of this standard is limited to providing the wheelchair-seated passenger a means of independently securing their wheelchair whilst reducing the potential for injurious head and back movements in a vehicle environment that is highly unlikely to transfer forces to the wheelchair and its occupant that exceed 1g.

Given the nature of advancing wheelchair and wheelchair seating technology, a wheelchair user entering the vehicle may have: a) no occupant restraints or postural supports; b) a safety-tested wheelchair-mounted lap belt, c) a postural pelvic belt; or d) a postural upper torso lateral support. This standard assumes that any one or more combinations of these body restraints/supports will withstand a 1g force, which can be experienced during normal operation of the wheelchair in non-transport outdoor community environments. The WPS and its contained components do not make any provisions for the control of body movements of the wheelchair occupant. Therefore the standard is limited to controlling only those movements of the wheelchair that may be hazardous to either the wheelchair user or other near-by passengers in the vehicle.

No attempt is made to specify the dimensions or location of any lateral movement structures within the WPS, as they may or may not be present in a specific installation. To do so would be unnecessarily design restrictive as there may be a variety of innovative methods to limit undesirable wheelchair movement in the lateral direction. However, the performance requirements do specify that the WPS installation must limit the wheelchair movement to no more than maximum specified values in the both lateral and longitudinal directions. How restriction of lateral or longitudinal movement is accomplished is left to the ingenuity of the WPS designer.

It can be argued that a WPS and its contained components are not a wheelchair securement or occupant restraint device, but rather a vehicle installation. As indicated above, the primary goal is to allow independent use of a WPS and transport vehicle by the wheelchair user through use of passive containment. However, in order to provide the desired level of safety for both the wheelchair user and near-by standing passengers a means of wheelchair containment will most likely be required. Some WPS designs may wish to assume that the wheelchair user has no wheelchair-mounted restraints and therefore provide an optional occupant restraint or auxiliary wheelchair securement straps as part of the WPS installation. To the extent that the above provisions are made by specific WPS installations in order to meet the performance requirements of this standard, wheelchair securement and occupant restraints may be provided that are consistent with the main WTORS sub-title of this standard.

In summary, it is the purpose of this ISO voluntary industry standard to specify dimensional, design, performance and installation requirements for rear-facing wheelchair passenger spaces and their contained components, intended for use by wheelchair-seated and ambulatory passengers. One required WPS component is a forward excursion barrier (FEB) located at the forward end of the WPS. The priority purpose of the FEB is to: a) provide a known stop for the rear-facing wheelchair, b) prevent forward movement of an occupied wheelchair during vehicle braking and c) limit the forward movement of the occupants back and head by providing a back and head restraint, ideally located in close proximity to the rear-facing wheelchair occupant. The FEB, combined with one or more optional lateral excursion barrier(s), are intended to limit the movement of the wheelchair in all directions within specified maximum values. Minimum strength requirements are specified for the critical WPS components to insure that they are sufficiently robust to withstand the maximum loads that can be anticipated during emergency driving manoeuvres or a low g frontal impact of transport vehicles designed for use by both standing and sitting passengers, including persons seated in wheelchairs.

Assistive products for persons with disability — Wheelchair tiedown and occupant restraint systems for rearward facing wheelchair-seated passengers — Part 1: Systems for accessible transport vehicles designed for use by both seated and standing passengers

1 Scope

This international standard applies to wheelchair passenger spaces (WPSs) intended for use by wheelchair-seated occupants, with a body mass greater than 22 kg, when travelling rear-facing in accessible transport vehicles (ATVs). It applies to ATVs designed to transport both standing and seated passengers (ATV-SS) used mainly on fixed route service, when operated under normal and emergency driving conditions. It assumes that the maximum acceleration load that may be imparted to the wheelchair and its occupant in any direction during emergency driving manoeuvres will not exceed 1g.

This standard specifies design and performance requirements and associated test methods, requirements for manufacturer instructions and warnings to installers and users, requirements for product labelling and disclosure of test information.

The WPS and its contained components do not make any specific provisions for the control of body movements of the wheelchair occupant. Therefore the standard is limited to controlling only those movements of the wheelchair that may be hazardous to either the wheelchair user or other passengers in the vehicle.

The provisions of this standard apply primarily to a complete WPS, but subsets of the provisions can be applied to components and subassemblies sold separately, as appropriate to the specific functions of the components and/or subassemblies they are intended to replace.

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 7176-13, *Determination of coefficient of friction of test surfaces*

ISO 7176-11, *Test dummies*

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

FMVSS 201, *Occupant protection in interior impact*

ECE reg. 21, *Uniform provisions concerning the approval of vehicles with regard to their interior fittings*

3 Terms and definitions

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

3.1
ambulatory passengers
passengers who do not require the use of a wheelchair.

3.2
forward excursion barrier (FEB)
a padded structure designed to limit forward movement relative to the vehicle of a rear-facing wheelchair and its occupant

3.3
gross vehicle weight rating (GVWR)
maximum total weight, as determined by vehicle manufacturer, at which the vehicle can be safely and reliably operated for its intended purpose

3.4
handhold (grab bar, handrail)
any device on board a transport vehicle that is designed to allow passengers to use their hand grip to manoeuvre through the vehicle or provide passengers with a more stable ride while on board the vehicle

3.5
accessible transport vehicle for seated and standing passengers (ATV-SS)
a motor vehicle, designed and manufactured to provide transport service for primary use by seated and standing ambulatory passengers but with provision for the needs of persons with physical disabilities. These vehicles may be equipped with a lift or ramp, one or more wheelchair passenger stations, have a low-floor design or be capable of kneeling.

3.6
lateral excursion barrier (LEB)
a structure to the right and or left of the occupied wheelchair designed to prevent the wheelchair from tipping, rotating or sliding into the centre aisle or vehicle wall during transport. It may be padded to reduce or cushion the impact of any accidental contact

3.7
active securement system
a system that requires the attachment of devices to the frame of a wheelchair in order to prevent undesirable movement

3.8
passive securement system
a system that does not require the attachment of devices to the frame of a wheelchair in order to prevent undesirable movement

3.9
wheelchair passenger space (WPS)
a location designed within a ATV-SS to limit the movement of a wheelchair through the use of a passive securement system

4 Design requirements

4.1 A wheelchair passenger space (WPS) shall:

a) allow the independent transport of a rear facing wheelchair seated passenger;

b) be fitted with:

i) a forward excursion barrier that provides a stop for a rear-facing forward moving wheelchair during severe vehicle braking or a low g fontal collision,

ii) a handrail or handhold to facilitate wheelchair occupant stability during transport,

iii) a means to limit lateral tipping, sliding and rotational movement of the wheelchair in either direction,

NOTE The vehicle wall could be the means to limit movement in one direction.

iv) a means to limit rearward (relative to the vehicle) sliding or tipping of the wheelchair,

v) a sign affixed in the area adjacent to the wheelchair passenger space that contains the text specified in 5.2.3d) and a pictogram as illustrated in figure 1, and

vi) a control affixed within the wheelchair passenger space that allows the wheelchair passenger to request a normal stop to egress from the vehicle;

c) be ready for use when entered by a wheelchair user;

d) be usable by any other passengers when no wheelchair user is present.

Figure 1 — Pictogram for wheelchair passenger space

5 Information, identification and instruction requirements

5.1 Identification and labelling

The WPS components and any subassemblies shall be labelled and identified as follows:

5.1.1 Permanent labelling

Permanently installed and replacement parts shall be permanently and legibly marked with:

a) manufacturer's name or trademark,

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

c) a mark showing that the device conforms with this ISO standard.

5.1.2 Identification

Primary 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 component.

5.2 Instructions for installers

Manufacturers of wheelchair passenger space (WPS) components shall provide written instructions for the installer in the principal language(s) of the country in which it is marketed.

5.2.1 General

The instructions shall include statements that:

a) indicate that the wheelchair passenger space should be installed for use only by rearward-facing wheelchairs,

b) indicate the number of separate components that comprise a complete WPS, and

c) indicate the minimum specifications for all structural parts, anchorage fasteners and related components used in an installation.

5.2.2 Installation Instructions

The instructions shall include descriptions of:

a) how the WPS 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, and

b) how the WPS is to be installed.

5.2.3 Diagrams, drawings and signs

The instructions shall include diagrams that illustrate:

a) if applicable, acceptable methods for fastening the WPS or WPS components to the vehicle,

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

c) a diagram showing the dimensional layout of the WPS, including the location of any structural components intended to come in contact with the wheelchair or its occupant, and

d) a sign affixed in the area adjacent to the wheelchair passenger space that contains the following text and pictogram as illustrated in figure 1. *Please give priority for a wheelchair. The wheelchair must face the rear of the vehicle and be positioned as close as possible to the forward barrier with the brakes applied.*

5.2.4 Warnings

The instructions shall include warnings that:

a) the WPS should be installed by an experienced technician,

b) vehicle anchor points may require reinforcement,

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

d) the WPS manufacturer should be consulted in case of questions as to the method of installation, and

e) alterations or substitutions to the WPS components should not be made without consulting the WPS manufacturer.

5.3 Instructions for vehicle operators

5.3.1 General

The instructions shall include information on how the WPS is to be used, so that the vehicle operator may be fully informed regarding the purpose and function of all components.

5.3.2 Warnings

The instructions for vehicle operators shall contain warnings that:

a) the wheelchair must be in the rear-facing orientation when in the WPS,

b) the wheelchair should be backed as closely as possible to the forward excursion barrier by removing items on the seat back, if possible, with the brakes applied,

c) alert the wheelchair user as to the preference to use a wheelchair mounted lap belt while seated in the vehicle,

d) alert the wheelchair user that may have limited upper body control to use their wheelchair-mounted postural lap belt and lateral trunk support(s) while seated in the vehicle, and

e) the WPS shall not be used for wheelchair passengers during such occasions when the operation of the vehicle does not allow standing passengers.

6 Performance requirements

6.1 Static strength of wheelchair passenger space components

6.1.1 Forward excursion barrier

When tested in accordance with Annex C.4.1, the FEB shall:

a) not fracture or expose sharp structures with a radius of less than 2 mm, and

b) not deform or lose adjustment greater than 15 mm from the pre-test position.

6.1.2 Lateral excursion barrier(s)

If provided, the LEB shall be tested in accordance with Annex C.4.2, and shall:

a) not fracture or expose sharp structures, and

b) not deform or lose adjustment greater than 15 mm from the pre-test position.

6.2 Wheelchair movement

When tested in accordance with Annex B, the wheelchair passenger space shall prevent:

a) sideways tipping of the wheelchair,

b) forward (relative to vehicle) tipping of the wheelchair,

c) sideways or rearward (relative to the vehicle) translation of the wheelchair in excess of 50mm, and

d) lateral rotation of the wheelchair greater than 15 degrees in either direction.

6.3 Coefficient of friction of floor material

When tested to ISO7176-13, the WPS floor surface floor material shall have a coefficient of friction in the range of 0.5-0.85.

6.4 Energy absorbing surfaces

Any components or structures that may contact the wheelchair occupant during emergency driving manoeuvres shall be designed to use energy absorbing materials that meet the performance specifications of FMVSS 201 or ECE reg. 21.

7 Test report

7.1 The following shall be included in each test report resulting from one or more tests conducted in accordance with this standard:

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) photograph of the test setup.

7.2 statement as to whether the WPS and its contained components have met the design requirements contained in clause 4

7.3 statement as to whether the information, identification and instruction requirements contained in clauses 5.1, 5.2 and 5.3 have been met.

7.4 statement as to whether the WPS and its contained components have met the performance requirements contained in clauses 6.1 to 6.4 inclusive.

Annex A
(normative)

Specifications for dimensions and clear spaces for wheelchair passenger spaces (WPS)

A.1 General

In order to facilitate independence and also provide occupant injury protection the wheelchair passenger space (WPS) must be fitted with a forward excursion barrier (FEB) that is securely mounted to the vehicle. The dimensions and location of the FEB, relative to other vehicle structures, are important considerations in the event that unexpected forces act on the wheelchair and its occupant as a result of an emergency driving condition, such as 'hard' braking. Therefore, design and location of structures within the WPS that are intended to prevent excessive lateral or longitudinal movement becomes important. Clear spaces need to be specified in and around the WPS, in which wheelchair passengers should not come into contact with injury-producing vehicle structures. Finally, injury protection of other passengers, sitting or standing, in close proximity to the WPS is also of importance. The purpose of this Annex is to specify the critical dimensions of a WPS and its required contained components, such as the forward excursion barrier and passenger handholds.

A.2 Principle

The WPS dimensions and clear spaces specified in this annex are based on the principle of passive wheelchair containment (no physical attachment of securement devices required). That is, to the extent possible, the wheelchair user should be afforded the same degree of independent use of the transport vehicle as all other passengers, and the physical intervention of the operator should be minimized. The standard also recognizes that the location and dimensions of the rear-facing forward excursion barrier is critical to providing the intended injury protection for the wheelchair occupant, and still allow the wheelchair easy access to the WPS.

A.3 Dimensional specifications

A wheelchair passenger space and its contained FEB for use in an ATV-SS shall have dimensions as specified in Figure A.1 and Table A.1.

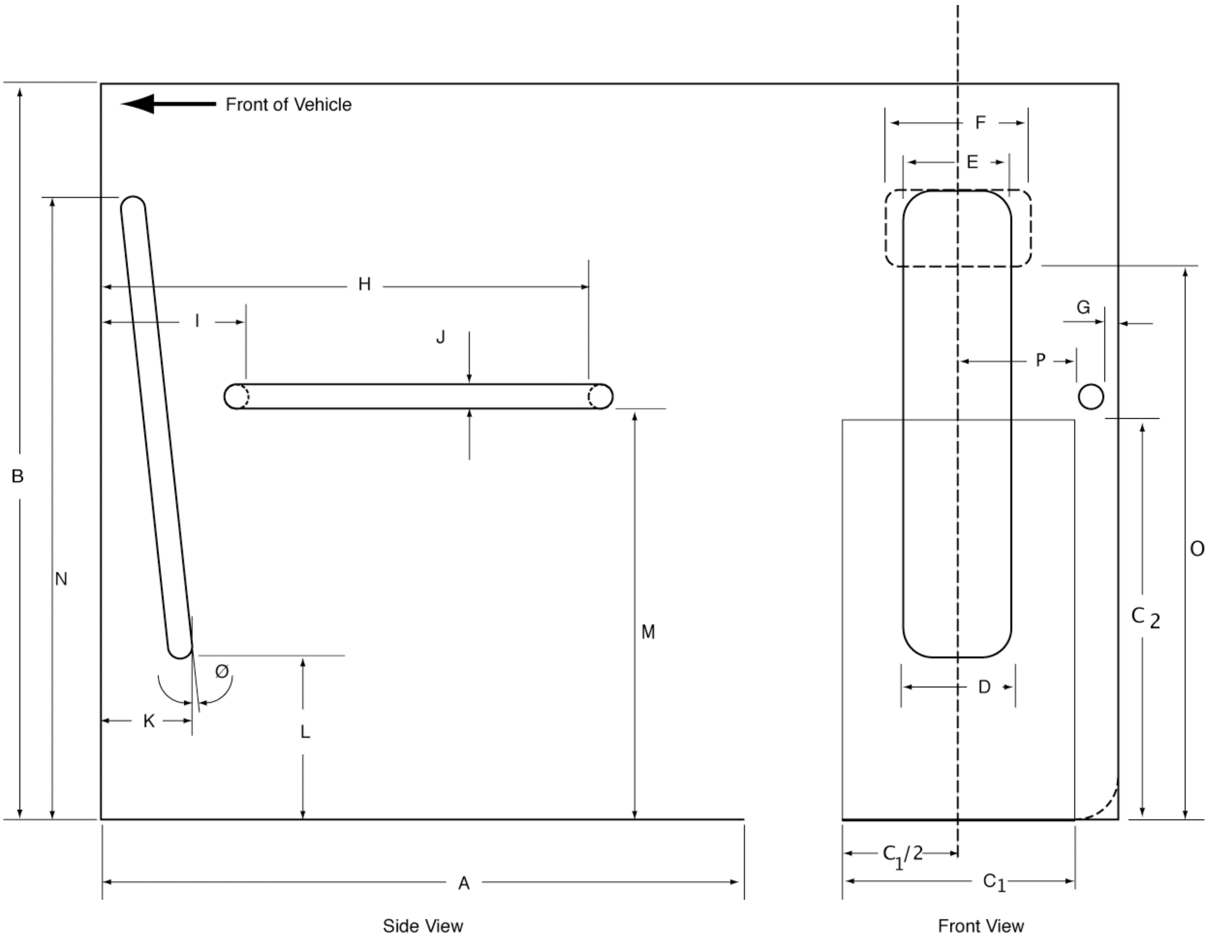

Figure A.1 Specifications for dimensions and clear spaces for a wheelchair passenger space

Table A.1 — Dimensions of wheelchair passenger space

Dimension	Description	mm
A	WPS length	≥ 1300
B	WPS height	≥ 1500
C_1	width of unobstructed wheelchair clear space at floor level extending vertically to a height 50mm below the handrail height. (dimension M)	≥ 700
C_2	height of unobstructed wheelchair clear space	750-850
E	width of upper FEB	270-300
F	width of headrest	≥ 300
G	handrail to nearest obstruction	≥ 45
H	horizontal distance to front handrail attachment	≥ 1000
I	horizontal distance to rear handrail attachment	≤ 300
*J	handrail cross section	30-35
K	horizontal distance to front of FEB	350-400
L	height to lower FEB	350-480

M	height to lower handrail	800-900
N	height to top of FEB	≥1300
O	height to bottom of headrest	≥1200
P	Inside handrail to centreline FEB	≥375
∅	angle of FEB	4-8°
NOTE 1 Handrail shall have a circular cross section with a diameter of not less than 30 mm and not more than 35 mm, or an oval cross section the maximum section of which is not more than 35 mm and not less than 30 mm, and the minimum section of which is not less than 20 mm.		

Annex B
(normative)

Test for wheelchair movement in a large accessible transport vehicle

B.1 General

Research has shown that emergency braking and evasive manoeuvring of an ATV-SS produces loads on the occupied wheelchair in the range of 0.3-0.8g. In general, the rear-facing WPS concept uses passive structures or barriers (no direct attachment to wheelchair) to limit the movement of the wheelchair. A forward-located, rearward facing structure (forward excursion barrier) limits both forward movement of the wheelchair and its occupant, as well as absorb loads on the occupant from rapid vehicle decelerations. Laterally mounted passive devices or structures (lateral excursion barriers) are typically used to limit movement or tipping of the wheelchair and occupant into the vehicle aisle due to lateral forces caused by rapid vehicle turning. Brakes on the wheelchair, when working effectively, in combination with high friction force between the wheelchair wheels and the vehicle floor, will help to prevent movement towards the rear of the vehicle during vehicle accelerations and/or ascending steep hills. The purpose of this annex is to evaluate the performance of the WPS and its installed components to limit the movement of the wheelchair to within specified maximum limits when subjected to the maximum loads that can be expected under emergency driving conditions, whilst seated in a wheelchair aboard a ATV-SS.

B.2 Principle

To safeguard other passengers and provide the wheelchair-seated occupant with a comfortable ride, a wheelchair passenger station (WPS) must limit movement of a wheelchair relative to the vehicle interior during normal and emergency driving manoeuvres. This normative Annex specifies equipment, test conditions, and procedures for measuring the potential for undesirable lateral, forward and rotational movement of an occupied wheelchair. This is done by simulating the maximum horizontal forces that may act on an occupied wheelchair during emergency driving manoeuvres. To assess the performance of the WPS independent of variations in wheelchair structures, locations of the wheelchair and variable centres of gravity, the tests are conducted using a surrogate manual wheelchair occupied by a 75kg test dummy. The tests may be conducted on a WPS installed in a vehicle or in a laboratory that has simulated the vehicle installation intended by the WPS manufacturer. The standard does not require the use of a lateral excursions barriers (LEB), therefore a LEB may or may not be present in a specific installation that is being tested.

B.3 Equipment to be tested

A complete unused commercial or prototype wheelchair passenger space and its contained components, complete with a floor surface with a coefficient of friction that meets the requirements of clause 6.3.

B.4 Test Equipment

B.4.1 A means to locate a longitudinal reference line (LRL) on the WPS floor surface that specifies the mid plane of the WPS.

B.4.2 A manual surrogate wheelchair (SWC) that meets the specifications of Annex D.

B.4.3 A 75 kg test dummy weighted to achieve the CoG specified in ISO 7176-11.

NOTE ISO 7176-11specifies the use of 30mm thick high density foam inserts both under the seat and behind the back sections of the dummy. If these foam inserts are not used, the mass distribution of the dummy plates will need to be altered to obtain the correct location of the CoG.

B.4.4 A means to apply a horizontal load, of at least 3.0 kN, through the combined centre of gravity of the SWC and ATD in the longitudinal and lateral directions.

B.4.5 A means to measure the lateral, longitudinal and rotational movements of the SWC to an accuracy of ± 5 mm and ± 1 degrees, respectively.

B.5 Test procedures

Perform the following steps in the order indicated.

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

   i) the rear reference point (RRP), located on a rearward structure of the SWC that intersects with the SWC reference plane, and

   ii) the forward reference point (FRP), located on a forward structure of the SWC that intersects with the SWC reference plane, most likely between the footrests;

b) Locate and mark the vertical and horizontal location of the combined centre of gravity (CoG) of the SWC and test dummy;

c) Check all tyres on the SWC, if pneumatic ensure inflation in accordance with the manufacturers instructions;

d) If conducted in a laboratory setting, mount the WPS on the test surface in accordance with the manufacturers instructions;

e) Locate the SWC in the WPS so that the SWC reference plane coincides with the mid plane of the test surface. Back the SWC against the FEB. Leave brakes unlocked and the caster wheels trailing in the direction of the rear of the vehicle;

f) Mark the initial position of the loaded SWC. Apply a longitudinal horizontal force of (equivalent to 1g)N through the combined CoG of the SWC and dummy in the direction of the front of the vehicle (towards FEB). Hold the test load for a minimum of 5 seconds. Measure the longitudinal movement of the SWC from the initial position. Return the SWC to the initial position, repeat the test three times, and record the average;

g) Apply the brakes on the SWC and repeat procedure f);

h) Reposition the SWC as described in e) and mark the initial position. Apply a longitudinal horizontal force of (equivalent of 0,3g)N through the combined CoG of the unbraked SWC and test dummy in the direction of the rear of the vehicle (away from FEB). Hold the test load for a minimum of 5 secs. Measure and record the movement of the SWC. Repeat the test three times and record the average;

i) Apply the brakes on the SWC and repeat procedure h);

j) Reposition the unbraked SWC as described in e) and mark the initial position. Apply a horizontal force of (equivalent of 0,75g)N, through the combined CoG, at 90 degrees to the mid plane of the SWC. Hold the test load for a minimum of 5 seconds. The force shall be applied separately toward each side of the SWC that is bounded by an aisle. Measure and record the movement of the SWC, including rotation, sliding or tipping. Tipping being defined as the lifting of any SWC wheel from the test surface. Repeat the test three times and record the average value(s);

k) Apply the brakes on the SWC and repeat procedure j).

Annex C
(normative)

Static strength tests for wheelchair passenger station structures and devices

C.1 General

Limitation of wheelchair movement in ATV-SSs assumes that the vehicle mounted structures or components within the WPS have sufficient strength to withstand the maximum lateral loads imposed during rapid swerving conditions, which have been found not to exceed 0,5g. In the rare event of a frontal collision, studies have shown that a stationary ATV-SS in 48kph delta V frontal collision with a large automobile can produce a floor level g load in the range of 2,75-3g. This Annex provides a means to test the strength performance of critical WPS components to ensure that these devices or structures meet a minimum static strength requirement, if subjected to the above loading events. Although the real-world loads applied to the structures are dynamic, for reasons of cost and simplicity if was agreed that static testing, including a 1,2 safety factor, would be used to provide strength validation.

C.2 Principle

The design requirement of clause 4 requires the installation of a forward excursion barrier (FEB). One purpose of the FEB if to limit excessive forward movement of the wheelchair and its occupant during extreme braking or minor frontal collision events. Therefore the specification of the total mass that will simulate a more worst-case occupied manual wheelchair becomes important. In general, electrically powered wheelchairs are much heavier than manual wheelchairs. All electrically powered wheelchairs, including scooters, have brakes that automatically lock the drive wheels when the wheelchair is stopped. These factors, combined with the requirement for a WPS floor surface with high coefficient of friction (CoF), means that there will be a high friction force that resists the sliding movement of the wheelchair. For example, a 200kg occupied wheelchair, having 75% of its weight supported by the rear wheels, located in a WPS with CoF of 0,75 between the rear wheels and the floor, generates a theoretical surface resistive force of 1kN. Therefore, the wheelchair type that is most likely to create the worst-case (highest) impact loads on the WPS structures is an unbraked manual wheelchair with a heavy occupant. Therefore, the mass of a manual wheelchair (20kg), occupied by 100kg person, increased by a safety factor of 1,2, has been used as the mass (144kg) to compute the static test loads specified in this Annex. Assuming a 3g worst-case horizontal loading, this results in a static test load for the FEB of 4,4kN.

Upon application and removal of that test load, as specified clause C4.1, the load application point of FEB in shall not have deformed more that 15mm or show evidence of structural failure.

The WPS must also restrict movement in the lateral direction. If a lateral excursion barrier is used to restrict lateral movement in the WPS installation, it shall be tested in accordance with C4.2. Using the same rationale as above and a 0,5g maximum lateral load condition under emergency turning manoeuvres, this results in a nominal lateral static test load of 0,7kN.

C.2 Equipment to be tested

The following devices or structures shall be tested:

a) The forward excursion barrier (FEB) intended to prevent forward (relative to the vehicle) movement or absorb energy of forward movement of an occupied wheelchair;

b) any device or structure intended to prevent lateral (angular or longitudinal) movement of an occupied wheelchair (lateral excursion barrier-LEB);

c) any device or structure intended to prevent rearward (relative to the vehicle) movement of an occupied wheelchair.

C.3 Test Equipment

C.3.1 A test machine that is capable of applying and monitoring the static loads of at least 5.0kN for a period of not less than 1.5 seconds.

C.3.2 A test bed capable of securing devices or structures as they would be mounted in a vehicle WPS installation.

C.3.3 A means of applying the test load through an area of 200 x 200 mm^2.

C.3.4 A means to measure deformation to an accuracy of ± 1 mm.

C.4 Test procedures

C.4.1 Forward Excursion Barrier (FEB)

Perform the following steps in the order indicated:

a) Fix the FEB to the test bed in accordance to the manufacturer's instructions using the fixing points supplied for the usual attachment to the vehicle structure;

b) Find the geometric centre of the FEB structure that will bear the loads imposed by a forward moving rear-facing wheelchair, with dimensions equivalent to those of the SWC specified in Annex D;

c) Set up the test machine so that the test force will pass through the geometric centre of the FEB on a horizontal plane in a direction towards the front of the vehicle;

d) Record the position of the geometric centre (GC) of the FEB in such a manner that a permanent change in the horizontal position of the GC in the longitudinal plane of the vehicle can be measured and recorded;

e) Apply a test load of 4.4kN ±10N for a period of not less than 1,5 seconds;

f) Measure and record the new horizontal position of the GC of the FEB. Record any difference between the two recordings to an accuracy of ± 1 mm;

g) Visually inspect the FEB to determine if any structural damage has occurred that would render the FEB non-functional, prevent removal of the wheelchair from the WPS, or has any exposed sharp surfaces that could injure a near-by person.

C.4.2 Lateral excursion barrier (LEB)

If provided, perform the following steps in the order indicated:

a) Fix the LEB to the test bed in accordance with the manufacturer's instructions using the fixing points supplied for the usual attachment to the vehicle structure;

NOTE this test can also be conducted in a vehicle

b) Determine the location on the LEB that will generate the largest destructive moments when a horizontal lateral force is applied and mark it as the force application point (FAP);

c) Record the position of the FAP in such a manner that a permanent change in the horizontal position of the FAP can be measured and recorded to an accuracy of 1mm;

c) Set up the test machine so the force applied will pass through the FAP in a horizontal plane in the lateral (aisle) direction, as when mounted in a vehicle;

e) Apply a laterally directed test load of 0.7kN ±10N for a period of not less than 1,5 seconds through the FAP;

f) Measure the new horizontal position of the FAP, compare it to the original position and record any difference to an accuracy of 2 mm. Visually inspect the LEB to determine if any structural damage has occurred that would render the LEB non-functional, prevent removal of the wheelchair from the WPS, or has any exposed sharp surfaces that could injure a near-by person.

Annex D
(normative)

Specifications for manual and surrogate wheelchair

D.1 General

The wheelchair movement tests in Annex B require testing using a surrogate wheelchair (SWC). The design of the SWC is based on the assumption that the testing will be done using a more worst-case occupied wheelchair and therefore all other types and sizes will have greater stability or resistance to movement, and therefore less potential for undesirable movement. The worst-case wheelchair type chosen is a lighter-weight manual adult wheelchair with a small wheelbase area, but wide enough to accommodate the 75kg ISO dummy. Both research and in-vehicle observation support this assumption since the lower mass of the manual wheelchair reduces the stabilizing floor friction and increases the vertical height of the combined CoG, when compared to a typical four-wheeled electrically powered wheelchair. That is, any object with a higher CoG, given that all other factors are equal, is more susceptible to tipping than one with a lower CoG. Also, all powered wheelchairs have brakes that are automatically applied when the wheelchair comes to a stop in order to prevent inadvertent rolling down hills. This provides a built in safety factor that is not present in manual wheelchairs that require manual application of brakes—that often have varying degrees of braking effectiveness. Since there is no destructive testing, the surrogate wheelchair does not need to be as robust as a SWC used in crash testing.

Therefore, the purpose of this Annex is to establish the design specifications for the surrogate wheelchair that is representative of a narrow range of production adult manual wheelchairs that would be the most unstable (tipping, rotating or sliding) when used as a seat in motor vehicle. Also, by specifying a surrogate wheelchair that meets specific design parameters means that the test results should be more consistent across test facilities.

D.2 Principle

Based on the principles of physics the physical wheelchair parameters that will affect the sliding, tipping or rotation of the SWC in the tests of Annex B can be identified. Integration of data bases of manual wheelchairs used in various markets allowed the determination of the range of values for the critical design parameters, extracted from a subset of wheelchairs thought to be the most unstable. This subset is based on those adult manual wheelchairs with a shorter wheelbase, narrower rear wheel track, and the higher seat heights. When 75kg test dummy is added to SWC seat, the high location of the combined CoG, plus the relatively small wheeled supporting base of the SWC, creates the situation for reduced stability typical of what could occur in the real world. Therefore, a successful Annex B test, using the SWC and 75kg dummy occupant that meets the specifications of this Annex, should provide reasonable assurance that all occupied wheelchairs on ATV-SSs, when subjected to maximum destabilizing forces, will not cause injury to either wheelchair occupants, or near-by standing passengers, due to uncontrolled wheelchair movement.

In order to reduce cost, but maintain consistency across test facilities, the 75kg test dummy specified in ISO 7176-11 was chosen as the surrogate occupant. A manufacturer may elect to use a production manual wheelchair or scooter in lieu of the specified surrogates. In this case the manufacturer must provide test results that confirm that the combined mass and CG location of the ISO test dummy and production base meet the values and tolerances specified in this Annex.

D.3 Specifications

D.3.1 Specifications for manual surrogate wheelchair (MSWC)

In order for wheelchair to qualify as a manual surrogate wheelchair (MSWC) for use in Annex B testing, it shall meet the specifications in Table D.1. In addition, it shall meet the following design requirements:

a) both the seat and back-rest shall be rigid to facilitate repeatability of dummy placement;

b) the front wheels must be castored;

c) the combined (MSWC + Dummy) CG must be located:

i) 600 mm, ±10mm above the ground plane, and

ii) 115 mm, ±10mm forward of the rear wheel contact point on the ground plane.

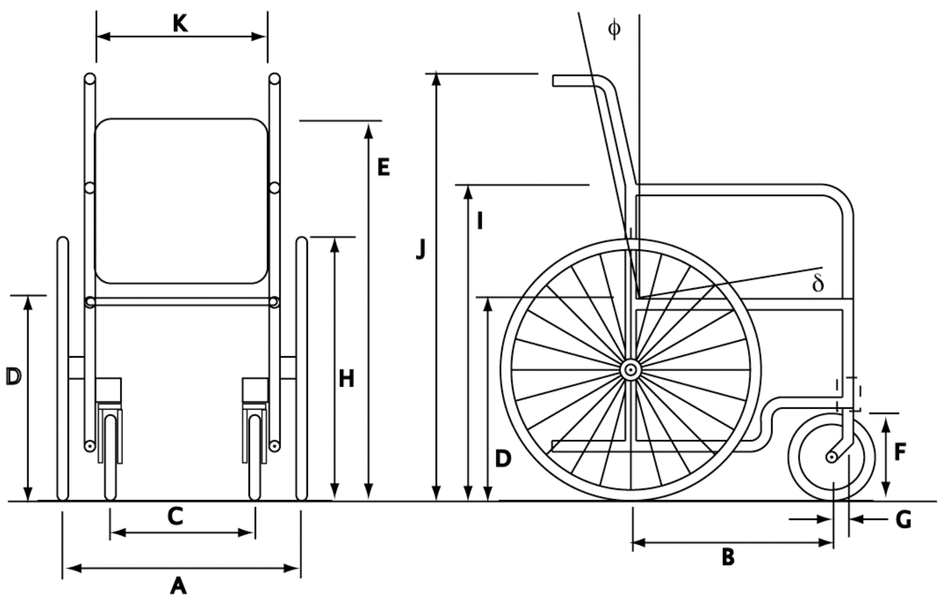

Figure D.1 Critical surrogate manual wheelchair dimensions

Table D.1 Specifications for surrogate manual wheelchair (MSWC)

	Feature	***Values**
	Total mass	(20kg), ±0.2kg
A	Rear wheel track	465mm
B	Wheelbase (measured with castors trailing rearward as shown)	360mm
C	Front wheel track	275mm
D	Seat bight height	530 mm
∂	Seat surface angle (from horizontal)	5-10 degrees
E	Top of backrest to floor	800mm

ø	Back rest angle (from vertical)	10 degrees
F	Castor wheel diameter	178mm
G	Castor trial offset	45mm
H	Rear wheel diameter	609mm
I	Arm Rest Height	720mm
J	Push handle height	950
K	Push handle inside width	325
	* Tolerances:	±5mm, ±1degree, unless otherwise noted

Bibliography

[1] Glaeser, K., “Rollstuhle in gebremsten Transportmittein—grenzen fur Kippen oder Rutschen,” Die Sicherung Von Rollstuhlfahrern In Linienbussen Und Behindertentransportwagen, Bundesminister Fuer Verkehr Von Der Bundesanstalt Fuer Strassenwesen Heft 88, 1992, pp. 23–30.

[2] Kasten, P., “Fahrgastfreundliche unde behindertengerechte Linienbusse—Beschleunigumgsmessungen an Rollstuhlen—in Linienbussen,” Die Sicherung Von Rollstuhlfahrern In Linienbussen Und Behindertentransportwagen, Bundesminister Fuer Verkehr Von Der Bundesanstalt Fuer Strassenwesen Heft 88, 1992, pp. 31–66.

[3] European Community CO-operation for Science and Techniques (COST), Low-Floor Buses, Final Report COST 322, Report No. EUR 16707 EN, Brussels, Belgium, 1995.

[4] Mercer, W., Demonstration of Dynamic Response of Passengers, Personal Mobility Devices, and Their Riders in a Low Floor Bus, Ministry of Transportation of Ontario, Toronto, Ontario, Canada, 1995.

[5] Canadian Standards Association, Accessible Transit Buses, Standard D435-02, 1st ed., Mississauga, Ontario, Canada, Aug. 2002.

[6] Cleveland-Clinic, Progress Report: Personal mobility aid securement and passenger restraint on transit vehicles. 1994, The Cleveland Clinic Foundation, Invacare Corporation: Cleveland.

[7] US-DOT, U.S. Department of Transportation, “Transportation for Individuals with Disabilities; Final Rule,” Federal Register, 49 CFR Parts 37 and 38, Sept. 6, 1991.

[8] Transportation Research Board, Transit Cooperative Research Program, TCRP Synthesis Report, Use of Rear-facing Position for Common Wheelchairs on Transit Buses, Washington, DC, 2003

[9] UK-Department of Transport, TRL Report: The safety of wheelchair occupants in road passenger vehicles, 2003

[10] Zaworski, K, Zaworski, J., Assessment of Rear Facing Wheelchair Accommodation on Bus Rapid Transit, Transit IDEA Project 38, Transportation Research Board, National Academies, Washington, D.C., January, 2005.

[11] Zaworski, K, Zaworski, J., Assessment of Rear Facing Wheelchair Accommodation on Bus Rapid Transit, Transit IDEA Project 38, Transportation Research Board, National Academies, Washington, D.C., January, 2005.

[12] Rutenburg ,U et al. Assessment of Low-floor Transit Bus G Forces on Rear-Facing Wheelchair Securement Systems, Transportation Development Centre, Transport Canada, March, 2005

[13] Cost Action 349, Asseccibility of Coaches and long Distance Buses for People with Reduced Mobility, Final Scientific Report, European Cooperation in the field of Scientific and Technical Research(COST), October, 2005

