BS ISO 10865-2:2015

BSI Standards Publication

Wheelchair containment and occupant retention systems for accessible transport vehicles designed for use by both sitting and standing passengers

Part 2: Systems for forward-facing wheelchair-seated passengers

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National foreword

This British Standard is the UK implementation of ISO 10865-2:2015.

The UK participation in its preparation was entrusted to Technical Committee CH/173/1, Wheelchairs.

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INTERNATIONAL STANDARD

ISO 10865-2

First edition
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Wheelchair containment and occupant retention systems for accessible transport vehicles designed for use by both sitting and standing passengers —

Part 2: Systems for forward-facing wheelchair-seated passengers

Dispositifs d'immobilisation des fauteuils roulants et systèmes de retenue des occupants pour véhicules accessibles destinés au transport de passagers assis et debout —

Partie 2: Systèmes pour les passagers assis dans des fauteuils roulants face à la route

Reference number
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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

ISO 10865 consists of the following parts, under the general title *Wheelchair containment and occupant retention systems for accessible transport vehicles designed for use by both sitting and standing passengers*:

— *Part 1: Systems for rearward-facing wheelchair-seated passengers*

— *Part 2: Systems for forward-facing wheelchair-seated passengers*

Introduction

Providing safe transportation for wheelchair-seated passengers of motor vehicles usually requires installation of aftermarket equipment to secure the wheelchair and provide passenger restraint during emergency vehicle manoeuvres and crash conditions that are appropriate to the size and travel conditions of the vehicle. ISO 10542-1 establishes design and performance requirements and associated test methods for wheelchair tiedown and occupant restraint systems (WTORS) intended for use by wheelchair-seated passengers in all types of motor vehicles that have been modified for use by people seated in wheelchairs. The provisions of ISO 10542-1 were based on the belief that WTORS manufacturers are not able to control the types of vehicles and travel modes in which most of their products are installed and used. ISO 10542-1 therefore requires frontal sled-impact testing of WTORS to nominally worst-case crash conditions of smaller vehicles, such as full-size vans and minivans, using a simulated crash acceleration/deceleration pulse that results in a change in sled speed (delta V) of 48 km/h.

While this one-size-fits-all approach to WTORS, crashworthiness testing is appropriate for equipment intended for general use in all types of motor vehicles, it generally leads to products that are over designed for larger and heavier vehicles used primarily in low-speed intra-city transportation. This is particularly the case for accessible transit vehicles in which passengers are allowed to travel standing as well as sitting, hereafter referred to as accessible transit vehicles for standing and sitting passengers (ATV-SS).

Recognizing these different and significantly lower transportation safety requirements for ATV-SSs in a new standard can be expected to result in alternative solutions for safely transporting wheelchair-seated passengers in these vehicle environments that are more compatible with the operational needs (e.g. fixed-route schedules) of these transportation services, and that offer wheelchair users a greater level of usability and independence than is achieved with WTORS designed to comply with 48 km/h crash conditions. More specifically, accident/injury data for ATV-SSs indicate that the frequencies of occupant fatalities and serious injuries per million passenger kilometres travelled are significantly lower than for smaller vehicles that travel at much higher speeds.[1] In fact, analysis of data from police reports of accidents involving fixed-route intra-city buses indicates that the likelihood of a collision event for these vehicles is sufficiently rare to justify basing performance requirements for safety equipment installed in these vehicles on accelerations and decelerations that occur during non-crash conditions, such as emergency vehicle manoeuvres, including sudden stopping, sudden acceleration, and turning. Three studies have clearly demonstrated that ATV-SS accelerations that may result from such emergency manoeuvres are all below 1 *g*.[2][3][4]

In-vehicle wheelchair user studies and user surveys have shown that commonly installed 4-point tiedown systems cannot be used independently by wheelchair-seated passengers, and vehicle operators are therefore responsible to secure wheelchairs using a 4-point, strap-type tiedown.[5][6][7] Due to the increasingly independent nature of public vehicles in combination with the length of time it takes to properly apply 4-point tiedown systems to wheelchairs, bus operators and wheelchair users often forfeit the use of strap-type tiedowns or bus operators fail to properly use all four tiedown straps. Unsecured wheelchairs in ATV-SSs have been demonstrated to slide or tip forward during vehicle stops, and wheelchairs rotated into the aisle and scooters tipped sideways during vehicle turns.[4] Additionally, there is anecdotal evidence of wheelchair passengers coming out of their wheelchairs and sustaining serious-to-fatal injuries during normal or sudden vehicle stops and turns due to non-use or improper use of belt restraint systems.

ISO 10542-1 provides design and performance criteria for docking-type tiedown systems which can be independently used by wheelchair users and reduce securement non-use. During in-vehicle observations, wheelchair users have expressed a preference for using a forward-facing automated docking securement system due to its independent and comfortable use, forward-facing travel direction and eliminated need for vehicle operator assistance.[8] However, wide-spread adoption of docking systems for use in ATV-SS cannot occur without the implementation of standardized universal docking interface geometry (described in ISO 10542-1 and ISO 7176-19 as a normative annex) for wheelchair securement on all wheelchairs, which is a long-term goal.

Over the past decade, rear-facing wheelchair passenger spaces (RF-WPS) have emerged in ATV-SSs because they allow independence and ease of use by wheelchair-seated passengers. ISO 10865-1

includes design requirements and performance criteria for RF-WPS. However, in-vehicle studies have shown that rear-facing travel is, for some people, less comfortable than forward-facing travel due to vertigo[8] and unexpected upper-body and head movements during vehicle stopping and starting.[3] Rear-facing travel also doesn't allow passengers to see stops down the road.

Thus, although RF-WPS may be a safer and more independent solution for wheelchair-seated travellers, forward facing can be the preferred orientation for passengers in ATV-SSs. Also, in the US, the Americans with Disabilities Act (ADA) currently allows rear-facing wheelchair transport but mandates at least one forward-facing WPS in ATV-SSs. Therefore, rear-facing systems only serve part of the wheelchair-seated passenger population who seek safer transportation when using ATV-SSs.

The purpose of this part of ISO 10865 is to establish minimum design requirements and performance criteria for forward-facing wheelchair passenger spaces (FF-WPSs) in ATV-SSs. This part of ISO 10865 also establishes test methods for the performance criteria, so that the passenger sitting in wheelchairs using a FF-WPS are provided a reasonable level of safety during transportation while maintaining a high level of usability and independence during travel in ATV-SSs. Since wheelchair and passenger act as independent systems under different types of vehicle accelerations (braking, accelerating and turning), a dynamic (non-static) test is required and described in Annex A. Furthermore, since manufacturers may design a close-fitting means of occupant retention to retain a wheelchair passenger, the dynamic test method of Annex A requires the use of a test dummy that represents the anthropometrics of an average passenger seated in a wheelchair. A fundamental principle behind the concept of a FF-WPS in ATV-SSs is that successful "containment" of an occupied wheelchair during normal travel and emergency vehicle manoeuvres is sufficient to provide a reasonable level of safety, that is, a level of safety comparable to that provided to other vehicle occupants, including standing passengers, who hold onto bars and straps to limit movement during non-crash vehicle accelerations and decelerations.

The primary feature of a FF-WPS required by this part of ISO 10865 is a means to prevent forward movement of wheelchairs and their occupants during vehicle decelerations that occur in normal or emergency braking. Lateral movement, rotation, and tipping of occupied wheelchairs in a FF-WPS are typically limited in one direction by the vehicle sidewall. Lateral movement, rotation, or tipping of the wheelchair into the centre aisle can be limited by a physical barrier, such as a vertical bar, horizontal bar or padded stanchion. During motor vehicle acceleration, wheelchair movement toward the rear of the motor vehicle can occur. This movement is limited, in part, by friction of the vehicle floor within the FF-WPS that will generate resistance forces on the tyres of wheels that have been locked by applying the wheelchair brakes or by the drive train of powered wheelchairs for which the power has been turned off during travel. Due to insufficient resistance to rearward movement from manual brakes, FF-WPS must also provide other means for limiting rearward wheelchair movement. For example, rearward wheelchair movement can be limited by vehicle-anchored wheelchair containment devices, such as a bar or raised padded area behind the wheelchair), a wheel "capturing" device, or a hook-type device that is within easy reach and that can be secured to the wheelchair by most wheelchair passengers.

Belt type occupant restraints have been provided in ATV-SSs to reduce the risk of injury among wheelchair passengers during travel. However, studies indicate that these belt-type occupant restraints are rarely used or are used improperly in ATV-SSs.[5][7][9] Belt-type restraints are also not commonly designed for independent use by most wheelchair-seated passengers seated in forward-facing wheelchairs.[5][10] When vehicle-anchored occupant belt restraints are not used, wheelchair passenger retention during vehicle decelerations during (braking) and during lateral vehicle decelerations during (turning) may be provided by wheelchair seating system supports such as the wheelchair armrests, and chest and pelvic support devices. However, lateral retention of the wheelchair passenger can be enhanced by FF-WPS components that limit lateral movement, and by occupant-retention devices (ORD). Retention of the occupant in their wheelchair is important to reduce the risk of serious injuries in low-*g* non-crash events. An ORD can reduce forward occupant movement in the vehicle and prevent wheelchair occupants from injurious impacts with the vehicle interior, such as the floor, sidewalls, or other interior components. The use of wheelchair-anchored postural pelvic belts will generally provide effective occupant retention during non-crash vehicle accelerations and decelerations and this practice is therefore encouraged in requirements for user warnings displayed in the FF-WPS. This part of ISO 10865 also requires a vehicle-anchored ORD that can be easily moved out of the way by most wheelchair passengers when its use it not desired. It also specifies design and location requirements for

handholds that can be used by many wheelchair passengers to augment containment of the wheelchair and enhance occupant retention and stability of the wheelchair passenger during travel.

Research has indicated that a frontal 48 km/h collision of a typical stationary ATV-SS and a full-size automobile generates peak accelerations of the ATV-SS in the range of 2,75 *g* to 3 *g*.[11] The risk of such a frontal collision is small but could occur and the static strength requirements of the excursion barriers and occupant retention device (ORD) are therefore, based on forces that may occur during a 3 *g* frontal impact of an ATV-SS. This part of ISO 10865 sets forth performance requirements and associated test methods to assess whether the components of an FF-WPS effectively limit forward, rearward, and lateral movement, rotation, and tipping of occupied wheelchairs in non-collision vehicle accelerations of less than 1 *g*. The test methods for wheelchair containment are set forth in Annex A are for non-collision vehicle accelerations and decelerations of less than 1 *g*, while Annex B specifies strength testing of the FF-WPS based on 3 *g* wheelchair-plus-occupant frontal-impact loading.

This part of ISO 10865 specifies a limited number of design requirements on FF-WPS to ensure that FF-WPS accommodate a wide range of wheelchair types and sizes and a wide range of wheelchair users. It primarily sets forth performance requirements and associated test methods to assess whether the combination of FF-WPS components will effectively contain wheelchairs and retain passengers seated in wheelchairs during vehicle accelerations and decelerations when vehicles are accelerated to increase speed, are braked to avoid a collision, or driven around a turn at a relatively high speed. FF-WPS may also be equipped with a wheelchair tiedown and occupant restraint system or may be designed to serve as a RF-WPS, but requirements and specifications for these systems are specified in ISO 10542-1 and ISO 10865-1, respectively.

INTERNATIONAL STANDARD ISO 10865-2:2015(E)

Wheelchair containment and occupant retention systems for accessible transport vehicles designed for use by both sitting and standing passengers —

Part 2:
Systems for forward-facing wheelchair-seated passengers

1 Scope

This part of ISO 10865 applies to wheelchair passenger spaces that are intended for use by passengers with a body mass greater than 22 kg who remain in their wheelchairs when travelling facing forward in accessible transport vehicles designed to transport both standing and sitting passengers on fixed-route service. It assumes that the maximum acceleration imparted to the vehicle during emergency driving manoeuvres will not exceed 1 *g* in any direction and rarely exceeds 3 *g* in frontal crashes. For the purposes of this part of ISO 10865, the term wheelchair includes manual and powered wheelchairs, and three and four wheeled scooters.

This part of ISO 10865 specifies performance requirements and associated test methods, design requirements, requirements for manufacturer instructions and warnings to installers, wheelchair users, and vehicle operators, and requirements for product labelling and disclosure of test information.

The provisions of this part of ISO 10865 apply primarily to a complete forward-facing wheelchair passenger space (FF-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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7176-26 and the following apply.

3.1
accelerometer reference point
ARP
location of the accelerometer relative to the wheelchair reference point

3.2
accessible transport vehicle for seated and standing passengers
ATV-SS
motor vehicle designed and manufactured to provide transport services for primarily seated and standing passengers with provision for the needs of persons with disabilities who remain seated in their wheelchairs during travel

3.3
ambulatory passengers
passengers who do not require the use of a wheelchair

3.4
anthropomorphic test device
ATD
physical analog of the human body comprised of articulated segments that is designed to simulate the response of an occupant of particular size and mass distribution in a simulated crash

3.5
forward-facing wheelchair passenger space
FF-WPS
location in a large transport vehicle that limits movement of an occupied forward-facing wheelchair and retains wheelchair occupants through the use of structures and devices that do not require the physical attachment of wheelchair-securement or occupant-restraint devices by the vehicle operator

3.6
frontal wheelchair reference plane
vertical plane going through point P and perpendicular to the centre line of the wheelchair

Note 1 to entry: See Figure 1.

3.7
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

3.8
ground reference point G
reference point on the ground plane that is positioned vertically below point P under pre-test conditions

Note 1 to entry: See Figure 1.

3.9
H-point
one of a pair of points located on the left and right sides of the pelvic region of an anthropomorphic test device (ATD) that represent the approximate locations of the human hip joint centre in the side view, as specified by the ATD manufacturer

3.10
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

3.11
lateral wheel base
sideways (left to right) distance between the centre of treads of wheels (or tyres) measured on the ground plane

3.12
occupant retention device
ORD
system or device used to retain the occupant of the wheelchair in a low-g environment

3.13
point P
side-view projection of a point that lies at the cross-sectional centre of a 100 mm diameter, 200 mm long, lightweight (max. 0,5 kg) cylinder positioned with the longitudinal axis perpendicular to the wheelchair reference plane, such that the curved surface of the cylinder contacts the back support and the upper surface of the seat

Note 1 to entry: See Figure 1.

3.14
rear facing wheelchair passenger space
RF-WPS
location in a large transport vehicle that limits movement of an occupied rearward-facing wheelchair through the use of structures and devices that do not require the physical attachment of wheelchair securement devices by the wheelchair user or vehicle operator

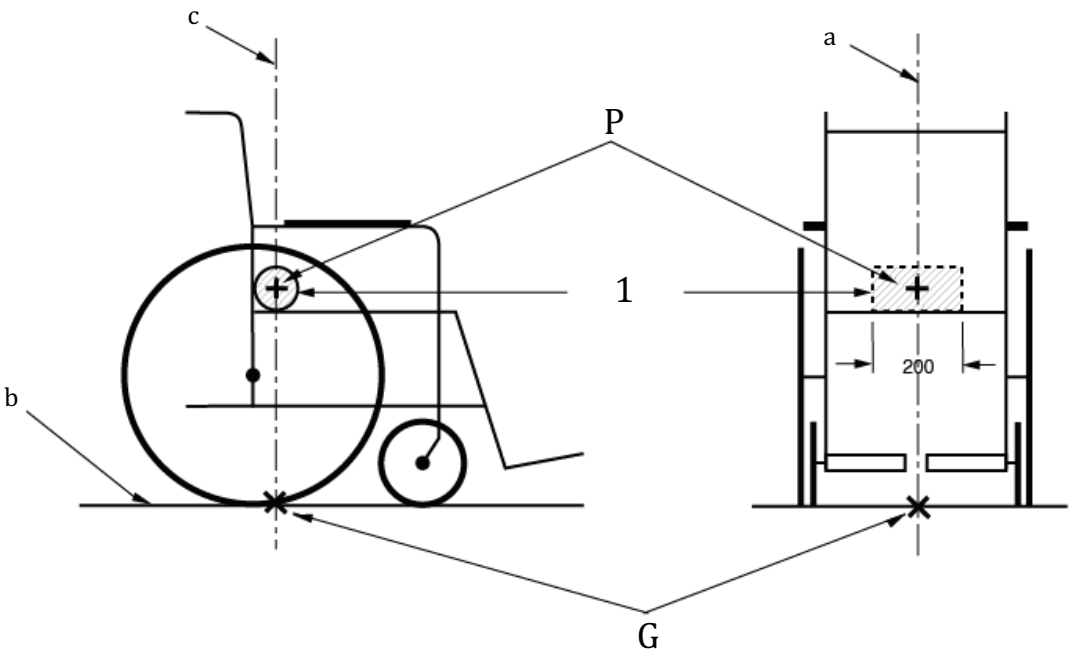
3.15
seat bight height
vertical distance from floor to the intersection of the seat and back planes of a wheelchair

3.16
manual surrogate wheelchair
MSWC
reusable manual wheelchair device that conforms with Annex C and that is used to simulate a production manual wheelchair for the purpose of Annex A wheelchair containment and occupant retention testing

3.17
scooter surrogate wheelchair
SSWC
reusable scooter-type device that conforms with Annex C and that is used to simulate a production scooter for the purpose of Annex A wheelchair containment and occupant retention testing

3.18
wheelchair reference plane
vertical plane in the longitudinal centreline of the wheelchair

Note 1 to entry: See Figure 1.



Key

1 cylinder, diameter 100 mm
G ground reference point G
P point P
a Wheelchair reference plane.
b Ground plane.
c Frontal wheelchair reference plane.

Figure 1 — Wheelchair reference point P, ground reference point G and wheelchair reference planes

4 Design requirements

4.1 Design requirements for a forward-facing wheelchair passenger space (FF-WPS)

A forward-facing wheelchair passenger space (FF-WPS) shall have the following:

a) designed to fit within a minimum area of 750 mm × 1 300 mm;

b) designed to

1) limit forward, lateral, and rearward wheelchair movement relative to the vehicle during normal travel and emergency vehicle manoeuvres,

NOTE The vehicle wall could be the means to limit lateral wheelchair movement in one direction. This means may also aid in the retention of the wheelchair-seated occupant under lateral accelerations associated with a vehicle turn.

2) include an occupant retention device that

   i) limits forward movement of passengers seated in wheelchairs with respect to the wheelchair, and

   ii) is deployed automatically when the system is in use, but can be manually moved out of the way by the wheelchair passenger or upon request by the passenger,

NOTE 1 The wheelchair back support functions as a means to limit excessive rearward movement of the wheelchair occupant during vehicle acceleration. Wheelchair arm supports, and pelvic and chest postural supports, help to limit lateral movement.

NOTE 2 If the ORD is not compatible with uncommon wheelchairs or scooters, an alternative restraining device (e.g. a passenger belt), that functions as a postural belt may be provided, or a wheelchair-mounted pelvic belt may be used in lieu of the ORD.

3) include a handrail or handhold to facilitate stability of passengers sitting in wheelchairs during travel, and

NOTE The ORD could be designed for use as a handhold.

4) include a device within the FF-WPS that allows passengers seated in wheelchairs to notify the driver that they want to exit the vehicle at the next stop;

c) ready for use by passengers sitting in wheelchairs (for example, the access-way is unobstructed and any flip-down seats are in the up position) when entered by a wheelchair user;

d) usable by other seated or standing passengers when not used by passengers seated in wheelchairs;

e) usable with other mobility devices when not being used by a passenger seated in a wheelchair;

EXAMPLE Other mobility devices could for example include Segways, empty strollers, walkers, etc.

f) allow for the quick release of the wheelchair and occupant without the use of tools in an emergency situation and/or loss of vehicle power;

g) have components or structures that may contact the wheelchair occupant or other passengers during emergency driving manoeuvres covered by energy absorbing materials that conform to the performance specifications of FMVSS 201 or ECE R 21;

h) have components in areas that can be contacted by the wheelchair and wheelchair occupant that are smoothly finished without sharp edges (<2 mm), burrs or irregularities;

i) have a floor surface that conforms with the coefficient of friction performance specifications of 5.3;

j) does not preclude the use of an ISO 10542-1 compliant wheelchair tiedown and occupant restraint system (WTORS) installed in the vehicle for travel modes that require all passengers to be seated.

5 Performance requirements

5.1 Strength of FF-WPS components

When tested in accordance with Annex B, all structural components of the FF-WPS, including the ORD, shall

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

b) not permanently deform greater than 50 mm from the pre-test configuration.

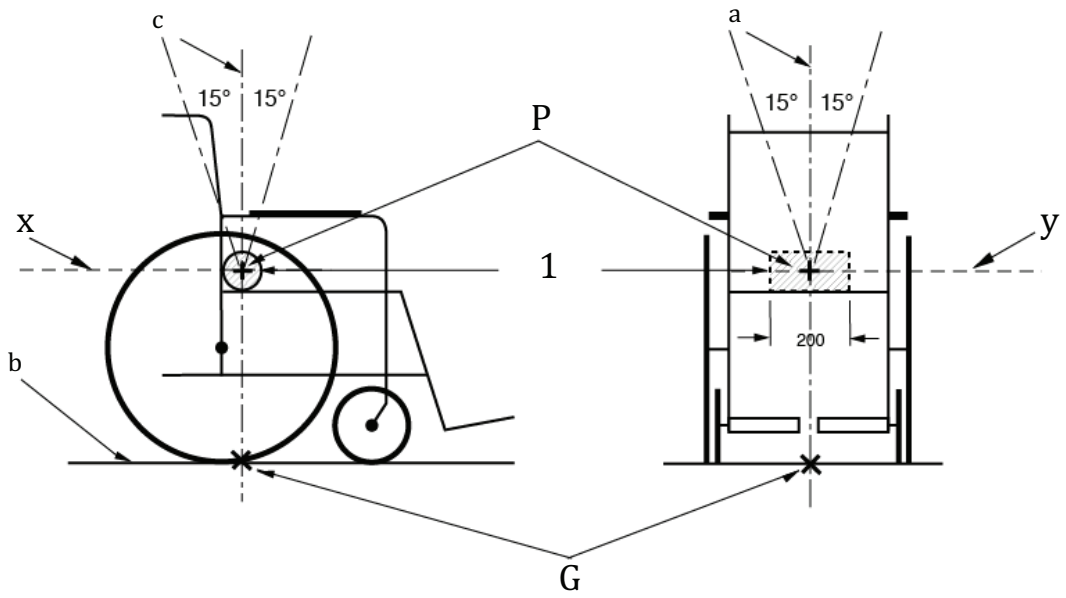
5.2 Wheelchair containment and occupant retention

5.2.1 Maximum excursions and rotation angles measured during testing in accordance with Annex A shall not exceed those in Table 1.

5.2.2 When tested according to Annex A, the ATD knee excursion shall exceed the MSWC or SSWC point P excursion as follows (see Table 1).

$$X_{\text{knee}} / X_{\text{wc}} \geq 1{,}1 \tag{1}$$

NOTE Compliance with this requirement reduces the potential for the wheelchair or scooter from imposing loads on the occupant.



Key

1 cylinder, diameter 100 mm
G ground reference point G
P point P
x x-axis
y y-axis
a Wheelchair reference plane.
b Ground plane.
c Frontal wheelchair reference plane.

Figure 2 — Illustration of forward/rearward and lateral rotation angles

Table 1 — Test limits of a MSWC or SSWC and ATD during testing

Measurement point	Excursion/angle variable	Allowed limit
Point P	X_{wc}	50 mm
ATD H-point	x_{ATD}	150 mm
Point P	$\alpha_{WC\text{-}X}$	15°
Point P	$\alpha_{WC\text{-}Y}$	15°
ATD knee centre and point P	x_{knee}/x_{ATD}	≥1,1

x_{wc} is the forward horizontal distance relative to the test platform between point P and at time t_0, to point P at the time of peak wheelchair movement.

x_{ATD} is the horizontal distance between the H-point target on the ATD relative to point P on the MSWC or SSWC at time t_0, to the most forward point of the H-point target relative to point P during the test.

X_{knee} is the forward horizontal distance relative to the test platform of the ATD knee-joint target at t_0, to the ATD knee-joint target at the time of peak knee movement.

$\alpha_{WC\text{-}X}$ is the angle of rotation about the x-axis through point P between the pre-test frontal MSWC or SSWC reference plane at time t_0, to the frontal wheelchair reference plane at the time of peak wheelchair forward/rearward rotation (tipping forward/rearward) during a test.

$\alpha_{WC\text{-}Y}$ is the angle of rotation about the y-axis through point P between the pre-test longitudinal wheelchair reference plane at time t_0, to the longitudinal wheelchair reference plane at the time of peak wheelchair lateral rotation (tipping sideways) during a test.

5.3 Coefficient of friction of vehicle floor

When tested to ISO 7176-13

a) FF-WPS horizontal floor surfaces shall have a coefficient of friction in the range of 0,65 to 0,80 in any direction, and

b) any floor with an angle exceeding 3° to the horizontal shall have a coefficient of friction range of 0,75 to 0,80.

6 Information, identification, and instruction requirements

6.1 Identification and labelling

The FF-WPS components and any subassemblies shall be labelled and identified as follows.

6.1.1 Permanent labelling of components

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 an assembly or subassembly in the event of a product recall, and

c) a label indicating that the device conforms with this part of ISO 10865.

6.1.2 Identification

Primary components and subassemblies shall be accompanied by information that includes

a) the manufacturer's model and part number or an equivalent identification code, and

b) the intended use of each component.

6.1.3 Information for FF-WPS users and vehicle passengers

Clear accessible information directed and accessible to passengers in wheelchairs will enhance safe transportation for passengers using the FF-WPS.

6.1.3.1 The FF-WPS shall contain a readable, high-contrast sign affixed in a readily visible location in or near the FF-WPS instructing wheelchair users and other vehicle passengers how the FF-WPS is to be used, including instructions to

a) apply wheelchair brakes and/or turn the power off when in the FF-WPS,

b) encourage the use of postural support devices (pelvic belts, chest straps) when in the FF-WPS,

c) use the occupant-retention device while in the FF-WPS and when the vehicle is in motion,

d) warn passengers that non-use of the occupant-retention device can result in injury to passengers in wheelchairs and other vehicle occupants,

e) if needed, ask the bus operator for assistance with the FF-WPS before the vehicle begins to move,

f) inform passengers that the FF-WPS is designed for forward facing transport, and

g) the sign must contain additional detail if there is a special approach needed to use the FF-WPS for a scooter, manual or power wheelchair. For example if there is a feature that interfaces with the scooter tiller this feature should be described.

6.2 Instructions for installers

Manufacturers of FF-WPS and/or their components shall provide written instructions for the installer in the principal language(s) of the country in which it is marketed.

6.2.1 General

The instructions shall include statements that

a) indicate that the components of the FF-WPS shall be installed for use by forward-facing wheelchair passengers,

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

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

6.2.2 Installation Instructions

The instructions shall include descriptions of

a) how the FF-WPS is to be used, so that the installer may be fully informed regarding the purpose and function of all components, and

b) how the FF-WPS is to be installed, including minimum specifications for anchorage fasteners and related components, and reflecting the strength conditions under which successful testing was conducted in Annex B.

6.2.3 Diagrams, drawings, and signs for installation

The instructions shall include a diagram that illustrates

a) acceptable methods for fastening a FF-WPS or its separate components to the vehicle,

b) an exploded-view drawing for all components required in the FF-WPS installation,

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

d) an occupied wheelchair properly positioned in the FF-WPS.

6.2.4 Warnings

The instructions shall include warnings that

a) FF-WPS should be installed by an experienced technician,

b) energy absorbing padding used to cover rigid surfaces and sharp edges near the wheelchair passenger should have a burn rate that does not exceed 100 mm/min when tested in accordance with ISO 3795,

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

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

6.3 Instructions for vehicle operators

The vehicle shall contain a sign affixed in a prominent and visible location instructing vehicle operators how the FF-WPS is to be used. The instructions shall include information indicating

a) how the FF-WPS is to be used so that the vehicle operator will be fully informed regarding the purpose and function of all components,

b) that occupied wheelchairs must face forward when using the FF-WPS,

NOTE The exception to 6.3 b) is when the FF-WPS is also equipped with a station for rearward-facing occupied wheelchairs that complies with ISO 10865-1.

c) the wheelchair should be positioned according to manufacturer instructions in the FF-WPS and the brakes should be applied or the power turned off, as applicable,

d) the wheelchair passenger should use the FF-WPS-mounted ORD at all times while in the FF-WPS unless it is not compatible with their wheelchair. In this case it is recommended to use a wheelchair-mounted postural device or an alternative restraining device (e.g. posy belt) provided in the vehicle, or a pelvic belt that is mounted to the passengers wheelchair, and

e) the FF-WPS should not be used by wheelchair passengers during situations when the operation of the vehicle does not allow standing passengers, in which case a WTORS system that complies with ISO 10542-1 should be used.

7 Test report and statement requirements

7.1 Test report

The following shall be included in each test report resulting from one or more tests conducted in accordance with this part of ISO 10865:

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) photographs of the test setup with the MSWC;

h) photographs of the test setup with the SSWC.

7.2 Statements

To show manufacturer compliance with this part of ISO 10865, each test report shall include statements to indicate

a) whether the FF-WPS and its components have met the design requirements of Clause 4,

b) whether the FF-WPS and its components have met the performance requirements of 5.1 through 5.3, and

c) whether the information, identification, and instruction requirements of 6.1, 6.2, and 6.3 have been met.

Annex A
(normative)

Test for wheelchair containment and occupant retention

A.1 Purpose and rationale

The purpose of this Annex is to evaluate the performance of FF-WPS and its components when subjected to the maximum vehicle accelerations that can be expected during emergency operating conditions of an ATV-SS. Without manual intervention by the wheelchair passenger, caregiver, or vehicle operator, the FF-WPS should limit movement of occupied forward-facing wheelchairs (i.e. containing wheelchairs in the wheelchair passenger space) and retain wheelchair passengers in the wheelchair.

Since the wheelchair and ATD may act as independent systems under different types of vehicle accelerations (braking, accelerating and turning), a dynamic test approach is deemed necessary to optimally evaluate the performance of a FF-WPS. Furthermore, since there may be a close-fitting interface of the FF-WPS with a wheelchair passenger, this dynamic test method requires the use of a test dummy that closely represents an average passenger seated in a wheelchair.

Research has shown that hard braking and evasive manoeuvring of an ATV-SS produces vehicle accelerations and decelerations between 0,25 *g* and 0,8 *g*.[4][12][13][14] In general, the FF-WPS concept uses components to limit forward and lateral movement of the wheelchair, thereby not requiring the physical attachment of securement devices to a wheelchair. To limit rearward rolling of the wheelchair, a semi-automatic or manual device may be used. The wheelchair back support can function as a means to limit rearward movement of the wheelchair occupant. An occupant retention device (ORD) is required and limits excessive forward movement of the wheelchair occupant.

A.2 Principle

To provide passengers seated in wheelchairs with a safe ride and also safeguard other passengers, a FF-WPS must limit movement and rotation of an occupied wheelchair and keep the wheelchair passenger in the wheelchair seat during normal and emergency driving manoeuvres, such as vehicle braking and turning. This normative Annex specifies equipment, test conditions, and procedures for measuring the potential for undesirable lateral, forward, rearward movements and lateral, forward and rearward rotations (tipping) of an occupied wheelchair and forward and lateral movement of the wheelchair passenger with respect to the wheelchair. Testing is performed by measuring movements and rotations of manual and scooter surrogate wheelchairs and movements of an anthropomorphic test device (ATD), or modified crash test dummy representing a typical relaxed wheelchair passenger in the FF-WPS during maximum acceleration forces generated in emergency vehicle manoeuvres.

To assess the performance of the FF-WPS for a representative range of wheelchair types and sizes, the tests are conducted using a MSWC and a SSWC loaded with an ATD that represents a midsize US male with a stature of about 175,2 cm (5’ 9”) and 76 kg (167 lb). Using surrogate wheelchairs increases test repeatability and objectivity across test facilities and therefore their use is required in this standard. To represent a passenger seated in a wheelchair and to maintain consistency across test facilities, a midsize-male Hybrid II or Hybrid III ATD modified to represent the lumbar-spine flexibility of a relaxed passenger is used as indicated in the force-angle stiffness corridor of Figure D.1. Modifications to these ATDs required to represent relaxed passengers under low-g conditions are further described in normative Annex D.

Table A.1 summarizes the peak acceleration levels by the direction of acceleration relative to the FF-WPS with loaded surrogate wheelchair. An example of a rotating test apparatus that simulates acceleration levels over certain time intervals is described in informative Annex E. Tests performed with a FF-WPS and occupied MSWC or SSWC using other types of test facilities are acceptable provided

that they produce acceleration-time characteristics specified in the corridors of Figures A.1 to A.3. These acceleration-time corridors have been derived from research data referenced in A.1 and range from 0,25 *g* to 0,8 *g*. For purposes of this part of ISO 10865 safety factor of 1,2 has been added to the measured peak acceleration levels to establish the test acceleration corridors. The peak forward acceleration applied longitudinally to a loaded surrogate wheelchair in the FF-WPS (i.e. towards the front of the vehicle) is based on 1 *g* maximum braking vehicle deceleration. The peak rearward acceleration is based on a peak vehicle acceleration of 0,3 *g.* The peak lateral acceleration is based on a peak lateral vehicle acceleration of 0,75 *g.*

Table A.1 — Peak acceleration as a function of acceleration direction to the FF-WPS

Acceleration Direction relative to the FF-WPS (vehicle action)	Peak test acceleration (*g*)
Forward longitudinal (braking)	1,0
Rearward longitudinal (accelerating)	0,3
Lateral (turning)	0,75

A.3 Equipment to be tested

A complete unused commercial or prototype FF-WPS and its components, complete with a floor surface with a coefficient of friction that meets the requirements of 5.3 shall be provided for testing.

A.4 Test equipment

A.4.1 MSWC that meets the specifications in Annex C.

A.4.2 SSWC that meets the specifications in Annex C.

NOTE A test device that is reconfigurable to meet the specifications of both the MSWC and SSWC specified in Annex C is acceptable.

A.4.3 Hybrid II or Hybrid III ATD that is modified to represent a midsize male with lumbar-spine bending criteria that represents a relaxed passenger in a wheelchair as in accordance with Figure D.1.

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

A.4.4 Means to measure the peak movement in lateral and longitudinal directions at point P of the surrogate wheelchair during testing to an accuracy of ±5 mm.

A.4.5 Means to measure the peak lateral, forward, and rearward rotations of the surrogate wheelchair to an accuracy of ±3°.

A.4.6 Means to measure longitudinal movement of the ATD H-point with respect to the MSWC and SSWC reference point P to an accuracy of ±5 mm.

A.4.7 Rigid test platform that will not deflect more than 3 mm when a normal load of 500 kg is applied onto the centre of the platform over an area of 1 000 mm × 1 000 mm.

A.4.8 Means to generate and maintain peak accelerations up to 1 *g* as specified in the corridors of Figures A.1 to A.3.

NOTE 1 All accelerations applied during testing need to fall within the shaded acceleration-time corridors of Figures A.1, A.2 and A.3.

NOTE 2 At the onset of the acceleration pulse, the FF-WPS, surrogate wheelchair, and ATD need to be in the pre-test positions specified in A.5.3.

A.5 Test procedures

Testing for wheelchair containment and occupant retention shall be performed for the 7 scenarios listed in Table A.2. Testing according to this Annex shall precede the strength testing specified in Annex B.

Table A.2 — Test matrix

Test setup	1,0 *g* (deceleration)	0,3 *g* (acceleration)	0,75 *g* (lateral deceleration)
MSWC No brakes No pelvic belt	Test 1	Test 4	Test 6
MSWC No Brakes With pelvic belt	Test 2	—	—
SSWC Brakes locked No pelvic belt	Test 3	Test 5	Test 7
NOTE 1 Test 2 (MSWC, without brakes and with a pelvic belt) represents a nominally worst-case scenario when a wheelchair is occupied by a person using a wheelchair-anchored pelvic belt that results in additional loads on the wheelchair containment system during sudden braking (i.e. vehicle deceleration). NOTE 2 Structures on the FF-WPS that are designed to deform during testing to absorb energy may exceed the deformation requirement of 5.1.b) and are therefore exempt from 5.1.b).			

A.5.1 General

For each test scenario, perform the steps in the order indicated.

A.5.2 Pre-test set up

Pre-test set up should include the following:

a) place contrast markers at

1) the reference point P of the MSWC or SSWC, it's vertical projection on the ground and the ground reference point G for measuring MSWC or SSWC rotations and horizontal movements from its pre-test orientation and position within the FF-WPS,

2) the ATD's H-point and knee for measuring ATD movement relative to point P,

3) FF-WPS reference points on structurally loaded components for measuring FF-WPS deflection, and

NOTE The FF-WPS reference point location depends on the FF-WPS design. Upon setup of the MSWC or SSWC in the FF-WPS, the FF-WPS reference point needs to be located in the transverse wheelchair reference plane at the height of the ATD's H-point and located on structural FF-WPS components that come in contact with the MSWC, the SSWC and/or the ATD.

4) accelerometer reference point (ARP) on the floor surface of the FF-WPS and in line with the frontal MSWC or SSWC reference plane C for measuring movements and rotations of point P relative to the projection of point P onto the ground;

NOTE See Figure 2.

b) check all pneumatic tyres on the MSWC and SSWC to ensure they are inflated to pressures specified in Annex D.

A.5.3 Tests for wheelchair containment and ATD retention during vehicle braking

Apply accelerations to the FF-WPS with a loaded MSWC or SSWC according to the deceleration versus time corridor of Figure A.1 using the following steps.

a) Rigidly mount a uniaxial accelerometer on the floor surface of the FF-WPS at the ARP.

b) Mount the FF-WPS on the test platform so the front of the FF-WPS is facing the direction of test accelerations.

NOTE When using the rotating test apparatus described in Annex E, the FF-WPS shall be oriented facing outward on the test platform.

c) Position the ATD in the MSWC or SSWC sitting upright and symmetrically about the longitudinal wheelchair reference plane, with the back of the pelvis against the back support of the MSWC or SSWC, and the forearms and hands resting on the ATD's thighs.

d) For Test 2 in Table A.2 apply a MSWC-anchored pelvic belt low and snug around the ATD's pelvis,

e) Position the MSWC or SSWC and ATD in the FF-WPS in accordance with the manufacturer's instructions and engage the wheelchair containment portion of the FF-WPS.

f) Do not lock the front wheels of the MSWC or SSWC so as to allow free rotation during testing.

NOTE Depending on the FF-WPS design, the caster wheels may be in a non-trailing or trailing direction.

g) Position the ORD per manufacturer instructions.

h) Measure the pre-test horizontal distance between the MSWC or SSWC reference point G and the ARP.

i) Measure the pre-test horizontal distance between the ATD H-point and the point P.

j) Record the initial positions of reference point P, point G, the ATD H-point, and FF-WPS reference point with respect to the ARP.

k) For Test 3 in Table A.2, lock the brakes of the MSWC and SSWC.

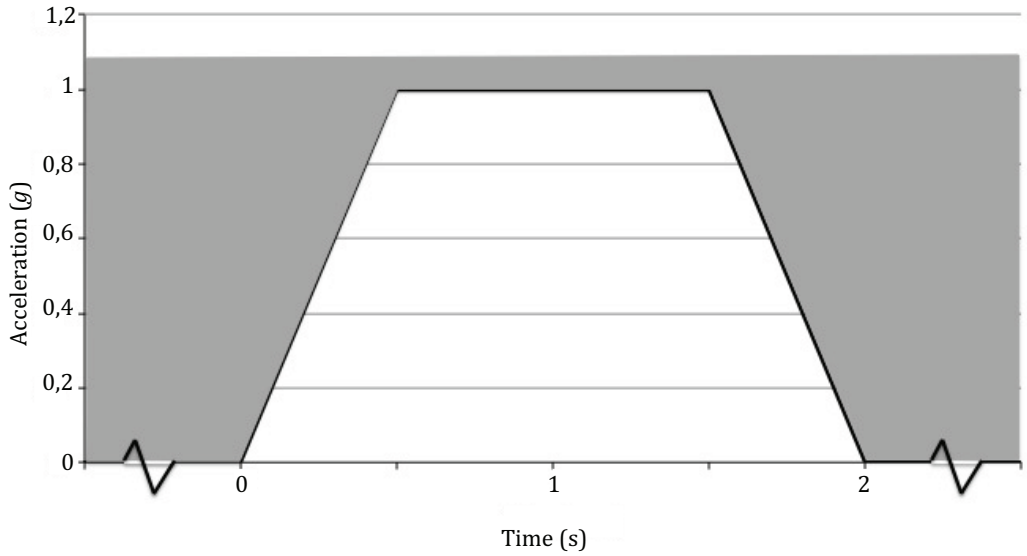
l) Apply an acceleration pulse with a peak of 1 g that falls within the acceleration-time corridor indicated by the shaded area in Figure A.1.

m) Record post-test measurements according to A.6.

n) Return the MSWC or SSWC, the ATD and FF-WPS to their pre-test positions and repeat the test two more times.

o) Calculate the average value for the measurements in A.6 from the three tests.

p) Perform A.5.3 c) to A.5.3 o) for the other deceleration tests of Table A.1.



NOTE Accelerations applied during testing need to stay within the shaded area of the acceleration-time corridor. It is allowed to take longer than 0,5 s. to reach 1 *g* and the maximum acceleration can be maintained longer than 1 s before returning to zero.[4]

Figure A.1 — Deceleration versus time corridor for the 1 *g* (braking) test

A.5.4 Tests for wheelchair containment and ATD retention during vehicle acceleration

Perform the following in the order indicated.

a) Position the MSWC or SSWC, ATD and FF-WPS in accordance with A.5.2.

NOTE When using the rotating test apparatus described in Annex E, the wheelchair shall be facing toward the centre of the test platform.

b) Mount the FF-WPS on the test platform so the rear of the FF-WPS is facing the direction of the test accelerations and position the ATD and the MSWC or SSWC in the FF-WPS per manufacturer instructions, then follow A.5.3c) to A.5.3k).

c) Document pre-test measurements according to A.5.3h) to A.5.3j).

d) For Test 5 in Table A.2 lock the brakes of the SSWC.

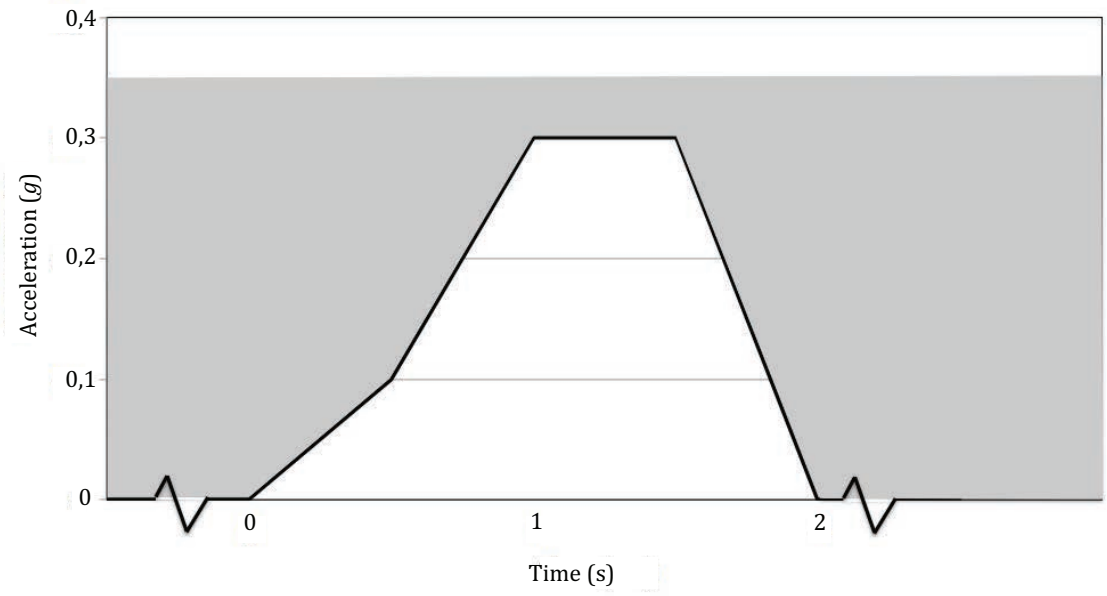
e) Apply an acceleration pulse of 0,3 *g* that follows the acceleration-time corridor indicated by the shaded area in Figure A.2.

f) Record post-test measurements according to A.6.

g) Return the MSWC or SSWC, the ATD and FF-WPS to their pre-test positions and repeat the acceleration test two more times.

h) Calculate the average value for the measurements in A.6 from the three tests.

i) Perform A.5.4 a) to A.5.4 h) for the other acceleration test of Table A.1.



NOTE Accelerations applied during testing need to stay within the shaded area of acceleration-time corridor. It is allowed to take longer than 1 s to reach 0,3 *g* and the maximum acceleration can be maintained longer than 0,5 s before returning to zero.[2]

Figure A.2 — Acceleration time corridor for the 0,3 *g* vehicle acceleration test

A.5.5 Tests for wheelchair containment and ATD retention during lateral accelerations that occur during vehicle turning

Perform the following in the order indicated.

If the FF-WPS installation is intended for use in vehicles that have aisle space on either side of the FF-WPS, this test shall be applied separately to each side of the FF-WPS unless the FF-WPS design is symmetrical in which case the test shall be applied to either the left or right side of the FF-WPS.

When using the rotating test apparatus described in Annex E, the MSWC or SSWC shall be facing sideways on the test platform (i.e. perpendicular to the radius of the apparatus).

a) Orient the FF-WPS on the platform so that either the left or right side of the FF-WPS is facing the direction of the test accelerations and position the ATD and the MSWC or SSWC in the FF-WPS per manufacturer instructions, then follow A.5.3 c) to A.5.3 k).

b) Position the MSWC or SSWC, the ATD, and FF-WPS according to A.5.2.

c) Document pre-test measurements according to A.5.3 h) to A.5.3 j).

d) For Test 7 in Table A.2 lock the brakes of the SSWC.

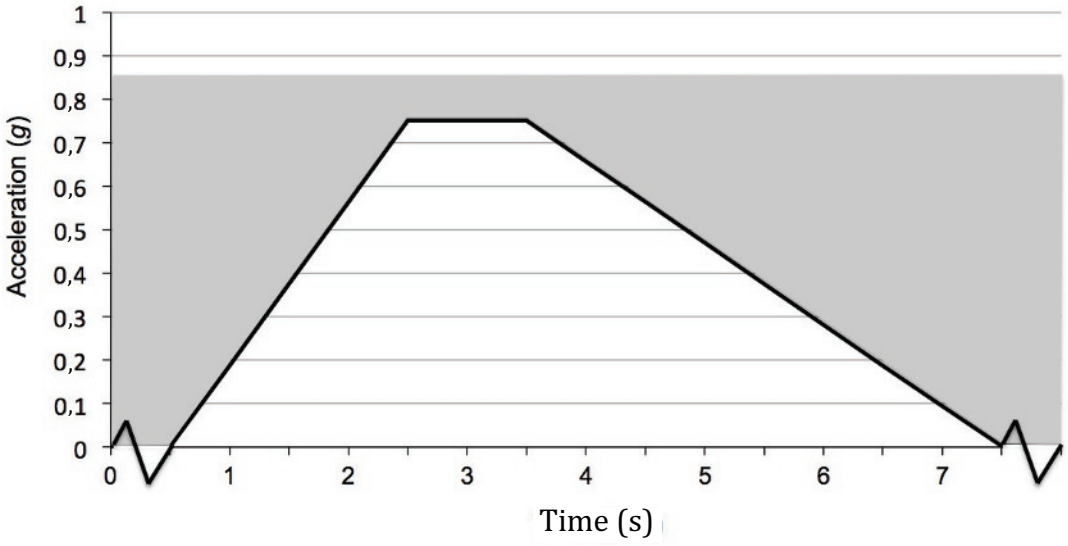
e) Apply an acceleration of 0,75 *g* that follows the acceleration time corridor indicated by the shaded area of Figure A.3.

f) Record post-test measurements according to A.6.

g) Return the MSWC or SSWC, the ATD and FF-WPS to their pre-test positions and repeat the test two more times.

h) Calculate the average values for the measurements in A.6 from the three tests.

i) Perform A.5.5.a through A.5.4.h for the other lateral acceleration test of Table A.1.



NOTE Accelerations applied during testing need to stay within the shaded area of acceleration-time corridor. It is allowed to take longer than 2 s to reach 0,75 *g* and the maximum acceleration can be maintained longer than 1,5 s before returning to zero.[4]

Figure A.3 — Acceleration time corridor for the 0,75 *g* vehicle turning acceleration test

A.6 Test measurements

The following measurements shall be taken during all tests in Table A.2:

a) peak horizontal excursion during testing of the point P relative to point G;

b) maximum forward or rearward rotation angle about an x-axis through point P and its original vertical projection point on the ground relative to the vertical axis;

c) peak lateral rotation angle about the y-axis through point P and its original vertical projection point on the ground relative to the vertical axis;

d) peak horizontal excursion at the ATD H-point relative to point P;

e) movement and/or rotation of any structural FF-WPS components relative to their pre-test positions.

Annex B
(normative)

Strength tests for FF-WPS structures

B.1 Purpose and rationale

Although the primary focus of this part of ISO 10865 is on wheelchair containment and wheelchair passenger retention in non-collision emergency vehicle manoeuvres, the low-g crash events to ATV-SS do occur. This Annex therefore describes procedures to test the strength of critical FF-WPS components to ensure that they will withstand the forces that may occur in a real-world frontal-impact event. Vehicle testing has indicated that a frontal impact to a stationary ATV-SS by a full-size automobile travelling at 48 km/h will generate a peak longitudinal acceleration of the ATV-SS in the range of 2,75 *g* to 3 *g*.[11] This Annex therefore specifies methods for evaluating the strength of a FF-WPS and its components for forces generated by an occupied wheelchair during a peak longitudinal rearward acceleration of 3 *g*. Either quasi-static or dynamic test methods may be used, and both are described.

B.2 Principle

In 5.1 a) and 5.1 b) require strength testing of FF-WPS components when tested in accordance with the procedure of this Annex to simulated loading based on a frontal collision with a peak acceleration of 3 *g*. Loading conditions are based on forces generated by the total static mass of an occupant sitting in a typical powered wheelchair during a 3 *g* rearward acceleration. While the drive wheels of electrically powered wheelchairs, including scooters, automatically lock when the wheelchair power is turned off, it is unknown if the locked drive mechanism will withstand a 3 *g* impact. Therefore, it is assumed that the full mass of an occupied powered wheelchair plus its occupant will load the FF-WPS components during a frontal 3 *g* impact. Wheelchair lift standards in several countries use a combined occupant and wheelchair mass of 272,7 kg for the test load. Using a 3 *g* peak longitudinal acceleration with a factor of safety of 1,2 results in a 9,6 kN peak test load for the FF-WPS. Alternatively, the FF-WPS and its components can be dynamically tested using a MSWC or SSWC plus ATD that have a combined mass of 272,7 kg and a peak acceleration of 3 *g* for a specified time period.

For both static and dynamic testing, a load is applied using an occupied SSWC that is properly positioned within the FF-WPS. Static testing involves application of a static test load at a point on the FF-WPS that would be loaded during forward facing travel, at the approximate vertical height of the SSWC plus ATD centre of gravity. A rigid load applicator may be used in lieu of a SSWC to apply the static load onto the FF-WPS.

For dynamic testing, the SSWC loaded with the ATD are placed in the FF-WPS and subjected to a 3 *g*-peak acceleration for a minimum of 1,5 s. Upon completion of either test, the FF-WPS and its components shall not show permanent deformations greater than established limits or evidence of structural failure.

Tests can be conducted either in a vehicle or in a laboratory. If conducted in a laboratory, the vehicle attachment components and in-vehicle configuration, as specified by the vehicle manufacturer, must be included to confirm that vehicle-to-FF-WPS attachment(s) will withstand the test forces.

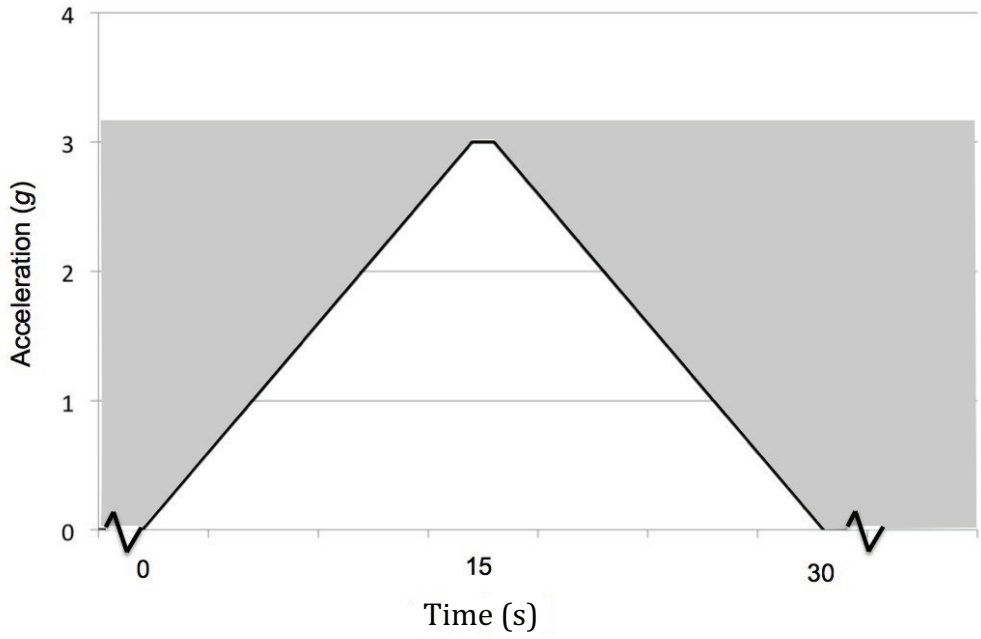
B.3 Equipment to be tested

A fully equipped FF-WPS, including a floor surface, shall be provided for testing.

B.4 Test equipment

The following test equipment is needed.

B.4.1 A test apparatus that is capable of applying and maintaining a static load of 9,6 kN or that is capable of generating an acceleration pulse with a peak value of at least 3 g that falls within the corridor indicated by the shaded area of Figure B.1.



NOTE Accelerations applied during testing need to fall within the shaded area of acceleration-time corridor. It is allowed to take longer than 15 s to reach 3 *g* and the maximum acceleration can be maintained more than 1,5 s before returning to zero.

Figure B.1 — Acceleration time corridor for the 3 *g* FF-WPS strength test

B.4.2 Test platform and associated vehicle components to allow installation of the FF-WPS and its components as they would be mounted in a vehicle.

B.4.3 SSWC specified in Annex C loaded with an ATD or a rigid load applicator.

B.4.4 Means to measure permanent structural deformation to an accuracy of ±5 mm and 5°.

B.5 Test procedures

All testing shall be performed with a rigid load applicator or the SSWC without brakes applied specified in Annex C loaded with a midsize-male ATD restrained with a SSWC-mounted pelvic belt.

B.5.1 Static strength evaluation of the FF-WPS

Perform the following steps in the order indicated.

a) If not testing the FF-WPS in a vehicle, fix the FF-WPS to the test platform in accordance with the manufacturer's instructions using the attachment points provided for the usual installation in the vehicle.

b) Position the SSWC loaded with the ATD according to A.5.2 and A.5.3 or setup the rigid load applicator

c) Measure and record the pre-test positions of the FF-WPS components being loaded.

d) Using the loaded SSWC or a rigid load applicator, apply a horizontal force of 9,6 kN ± 10 N to the FF-WPS for a period of 1,5 s.

NOTE If the SSWC component that interfaces with the FF-WPS is not strong enough to apply the desired load without deforming or breaking, a loader gauge having a similar interface as the SSWC can be used to apply the load.

e) After releasing the load, measure and record the post-test deformations of FF-WPS components that are directly loaded and record any difference to an accuracy of ±5 mm and 5°.

f) Repeat the test in case the FF-WPS can be used in different usage configurations, e.g. the structure of the FF-WPS is loaded differently by a SSWC versus a MSWC.

g) Inspect the FF-WPS or the loaded component to determine if any structural damage has occurred or if there are any exposed sharp edges that could injure the wheelchair passenger or other vehicle passenger.

B.5.2 Dynamic strength evaluation of the FF-WPS

Perform the following steps in the order indicated.

a) If not testing the FF-WPS in a vehicle, fix the FF-WPS to the test platform in accordance with the manufacturer's instructions using the attachment points supplied for the usual installation in the vehicle.

b) If testing the FF-WPS in a vehicle, fix the FF-WPS to the vehicle floor in accordance with the manufacturer's instructions.

c) Position the SSWC loaded with the ATD according to A.5.2 and A.5.3 or setup the rigid load applicator.

d) Measure and record the pre-test position of the FF-WPS components being loaded.

e) With the loaded SSWC installed in the FF-WPS, apply an acceleration pulse in the direction of frontal-impact loading that falls within the shaded corridor of Figure B.1.

NOTE If the SSWC component that interfaces with the FF-WPS is not strong enough to apply the desired load without deforming or breaking, a loader gauge having a similar interface as the SSWC can be used to apply the load.

f) Upon completion of the dynamic test, measure and record any post-test deformations of FF-WPS components that are directly loaded and record any difference to an accuracy of ±5 mm and 5°.

g) Inspect the FF-WPS or the loaded component to determine if any structural damage has occurred or if there are any exposed sharp edges that could injure the wheelchair passenger or other vehicle passenger.

Annex C
(normative)

Specifications for surrogate wheelchairs

C.1 Rationale

The containment, retention and static or dynamic strength tests in Annex A and B require the use of manual and/or scooter-type surrogate wheelchairs that conform with the specifications set forth in this Annex. This Annex describes the design specifications for the MSWC or SSWC used in Annex A, such that the surrogate wheelchairs are representative of a range of production adult manual wheelchairs and mid-sized three-wheeled scooters that would be the most unstable (tipping, rotating, or sliding) when used as a seat in an ATV-SS. By using MSWC or SSWC that comply with specific design criteria, the test results will be more consistent across test facilities.

The design of the surrogate wheelchairs is based on the principle that Annex A testing will be done using conditions that represent nominally worst-case occupied wheelchairs such that most other types and sizes of wheelchairs and scooters will have greater stability and resistance to movement, and therefore, less potential for injury to the wheelchair passenger. One worst-case wheelchair condition is a light-weight manual adult-size wheelchair with a small wheel track, and a seat that is just wide enough to accommodate a tall adult. The other potentially highly unstable situation in an ATV-SS is a mid-sized three-wheeled scooter occupied by an adult.

The low mass of the manual wheelchair reduces the stabilizing forces on the floor due to friction, and the narrow lateral wheel base increases the likelihood of the wheelchair tipping over during vehicle turns. The three-wheeled scooter has a lateral wheel base that makes it inherently less stable to tipping than a four-wheeled powered wheelchair or four-wheeled scooter. Since a scooter's mass is relative low compared to that of many powered wheelchairs, the stabilizing friction force on the floor is also relatively low. Therefore, undesirable rearward, and lateral rotation is more likely to occur with a three-wheeled scooter when compared to heavier powered wheelchairs. The use of the largest size of adult ATD that can be accommodated in the wheelchair seat increases the vertical height of the combined centre of gravity (CG), or centre of mass, compared to using a smaller size ATD. Testing with high CG increases the risk of tipping over, given that all other factors are equal. For similar reasons, the seat height of the scooter-type surrogate wheelchair was derived from production samples of scooters with adjustable seat heights set to their maximum seat height.

C.2 Principle

Based on principles of physics, the critical wheelchair and scooter parameters that affect sliding, tipping, and rotation during testing to the procedures of Annex A were identified. Analysis of databases of manual and scooter wheelchair dimensions and CG locations was used to determine the ranges of critical design parameters deemed to affect test results. In general, these critical values are based on adult manual wheelchairs and scooters with a short longitudinal wheelbase, a narrow lateral wheelbase, and high seats. When a midsize male ATD with a nominal mass of 76 kg is placed in the MSWC or SSWC, the relatively high location of the combined CG with the short wheel base creates conditions for low tipping and rotation stability. Therefore, a FF-WPS that is successfully tested to the procedures of Annex A using surrogate wheelchairs that comply with the specifications of this Annex and loaded with a midsize-male ATD should provide most passengers seated in wheelchairs and scooters with a safe ride during normal and emergency ATV-SS operating conditions.

C.3 Specifications

C.3.1 Specifications for a manual surrogate wheelchair (MSWC)

The MSWC shall have the following:

a) a rigid seat and a rigid back support to facilitate repeatability of ATD positioning;

b) two front wheels with pneumatic tyres that are 178 mm in diameter;

c) two rear wheels with pneumatic tyres that are 609 mm (24”) in diameter;

d) the tyres inflated to 345 kPa;

e) the two front wheels castored to they can rotate freely about a vertical axis;

f) footrests to support the ATD’s feet with the thighs horizontal;

g) the dimensions listed in Table C.1.

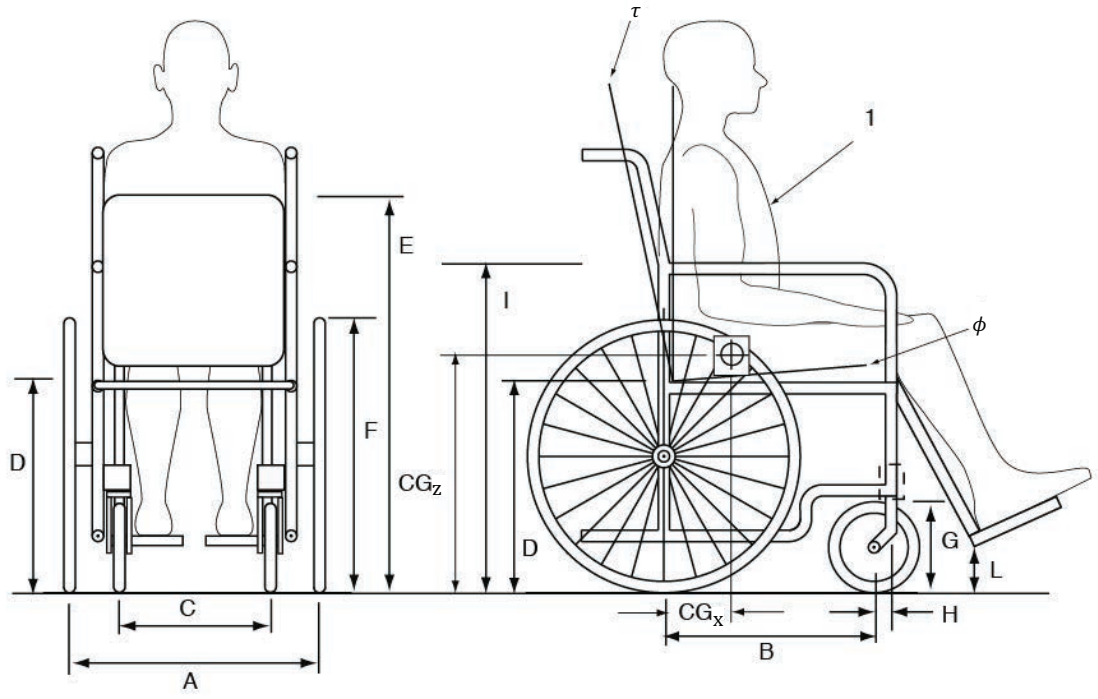


Figure C.1 — Critical dimensions of the MSWC

Table C.1 — Dimensions and specifications for the MSWC

	Feature	Values[a]
	Mass (without ATD)	20 kg ± 0,2 kg
A	Rear wheel track (lateral wheelbase)	465 mm
B	Wheelbase[b]	360 mm
C	Lateral distance between front castors	275 mm
D	Seat-bight height from ground	530 mm
E	Height of top of back support to ground	800 mm
F	Rear wheel diameter	609 mm
G	Castor wheel diameter	178 mm
H	Castor trail	45 mm
I	Arm support height	720 mm
L	Height at back of foot support	150 mm
ϕ	Seat angle (from horizontal)	5°
τ	Back-support angle (from vertical)	10°
CG_x	Forward location of the combined[c] CG from rear wheel axle	115 mm ± 10 mm
CG_z	Height of the combined[c] CG from ground	600 mm ± 10 mm

[a] Tolerances ±5 mm, ±1,5°, unless otherwise specified.

[b] Measured with castors trailing rearward as shown in Figure C.1.

[c] MSWC plus ATD.

C.3.2 Specifications for the scooter surrogate wheelchair (SSWC)

The SSWC shall have the following:

a) a rigid seat and a rigid back support to facilitate repeatability of ATD positioning;

b) two rear wheels with pneumatic 28/2,5-4 NHS nylon tyres that are 228 mm in diameter;

c) the rear tyres inflated to 345 kPa;

d) one front rigid wheel with a 203 mm diameter tyre that can rotate freely, and has a left and right range of rotation of minimally 45°;

e) a tiller-type structure positioned according to the specifications in Table C.2, and able to withstand a static load of 300 N when used for Annex A testing and 900 N when used for Annex B testing;

f) dimensions listed in Table C.2.

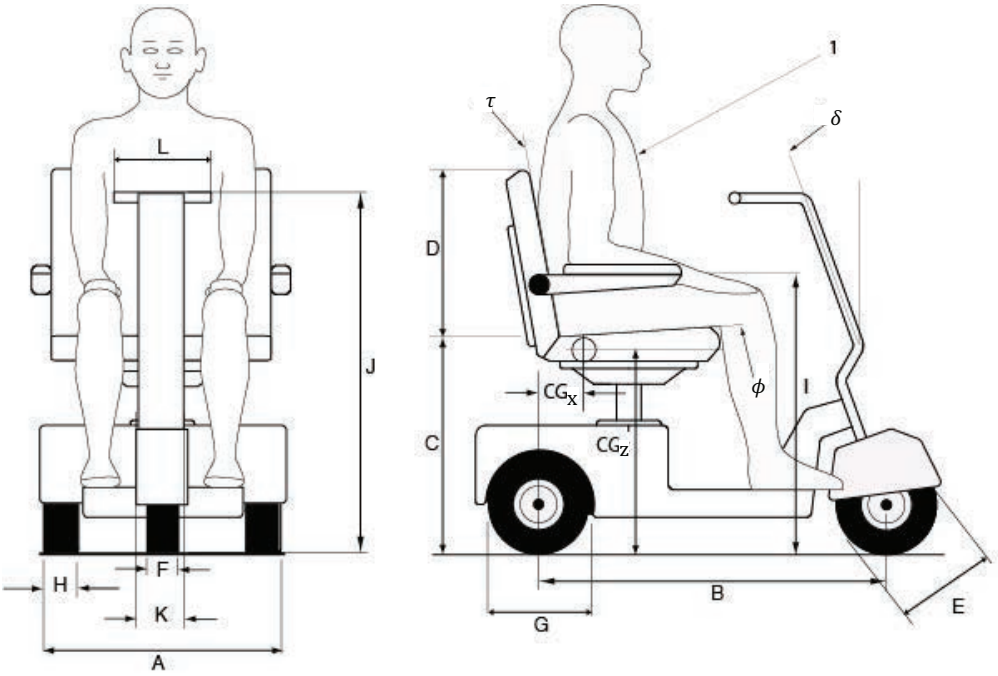


Figure C.2 — Critical dimensions of the SSWC

Table C.2 — Dimensions and specifications for the SSWC

	Feature	**Values**[a]
	Mass	68 kg ± 0,2 kg
A	Rear wheel outside width	565 mm
B	Wheelbase	800 mm
C	Seat bight height	625 mm
D	Back support height (above seat bight)	365 mm
E	Front wheel diameter	203 mm
F	Front wheel width	69 mm
G	Rear-wheels diameter	228 mm
H	Rear wheels width	76 mm
I	Arm support height	853 mm
J	Tiller height	910 mm
K	Tiller width at a height of 200 mm through 600 mm	200 mm
L	Tiller bar width	400 mm
δ	Tiller angle, rearward from vertical	20°
ϕ	Seat surface angle from horizontal (not shown)	3°
τ	Back support angle from vertical (not shown)	5°
CG_X	Forward location of the combined[b] CG from rear wheel axle	205 mm ± 10 mm
CG_Z	Vertical location of combined[b] CG from ground	536 mm ± 10 mm

[a] Tolerances ±5 mm, ±1,5°, unless otherwise specified.

[b] SSWC plus ATD.

Annex D
(normative)

Anthropomorphic test device

D.1 General

A Hybrid II or Hybrid III midsize-male anthropomorphic test device (ATD), or crash-test dummy, with a nominal mass of 76 kg and modified so that the forward-flexion lumbar/torso stiffness falls within the shaded corridor of Figure D.1 is used for Annex A and B testing. For the Hybrid II ATD, this flexion stiffness can be achieved by removing the abdominal insert. For the Hybrid III ATD, this flexion stiffness can be achieved by replacing the curved midsize-male lumbar spine with the shorter straight small-female Hybrid III lumbar spine and adding steel shims to maintain the midsize-male sitting height. Compared to a loader gage described in ISO 7176-11, these modified crash-test dummies better represent a relaxed passenger seated in a wheelchair with regard to retention in the wheelchair seat in Annex A testing.

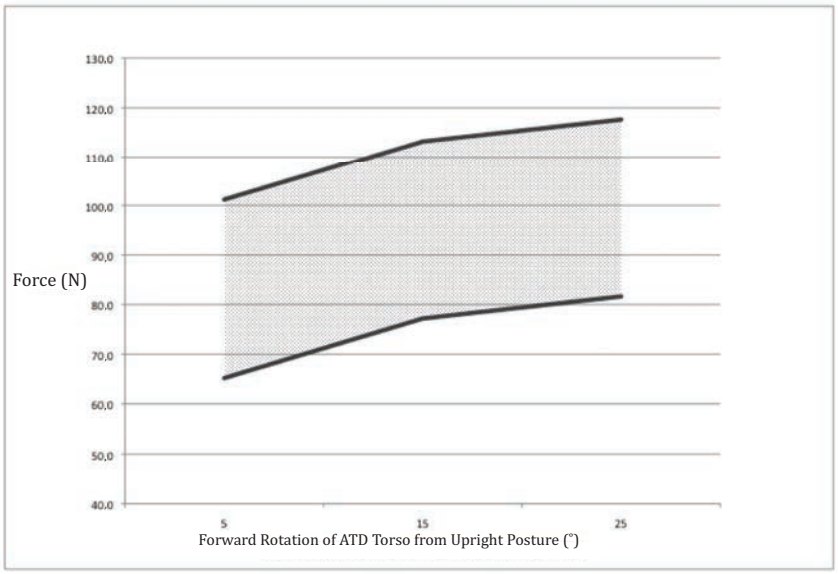


Figure D.1 — Torso force flexion angle corridor required of the ATD used in Annex A testing

D.2 Principle

A successful Annex A test using the SSWC or MSWC loaded with an ATD that meets the specifications of this Annex should provide reasonable assurance that all passengers seated in wheelchairs and scooters and using the FF-WPS on ATV-SSs will be provided with safe transportation during normal travel and emergency vehicle manoeuvres.

D.3 Specifications

A Hybrid II ATD shall be used for Annex A testing and shall comply with the design requirements set forth in 49 CFR Part 572 – Anthropomorphic Test Devices. Prior to Annex A testing, the abdominal insert of the Hybrid II ATD needs to be removed according to 49CFR Part 572.11 Test conditions and instrumentation. Removal of the abdominal insert results in a torso stability that is representative of typical passengers in wheelchairs under low-*g* braking and turning conditions.[15]

The use of a Hybrid III ATD is permitted if the lumbar spine stiffness is comparable to the force-angle characteristics in Figure D.1. An alternate lumbar-spine insert may be needed to achieve the necessary response.

Prior to testing, adjust the ATD to achieve a static resistance of 1 *g* at each joint indicated by just-noticeable movement from the weight of the distal body segment as specified by the ATD manufacturer.

Annex E
(informative)

Design of a low-g test apparatus

E.1 General

This Annex describes the design of one possible test apparatus to produce repeatable low acceleration forces that can be used in Annex A testing.[16][17]

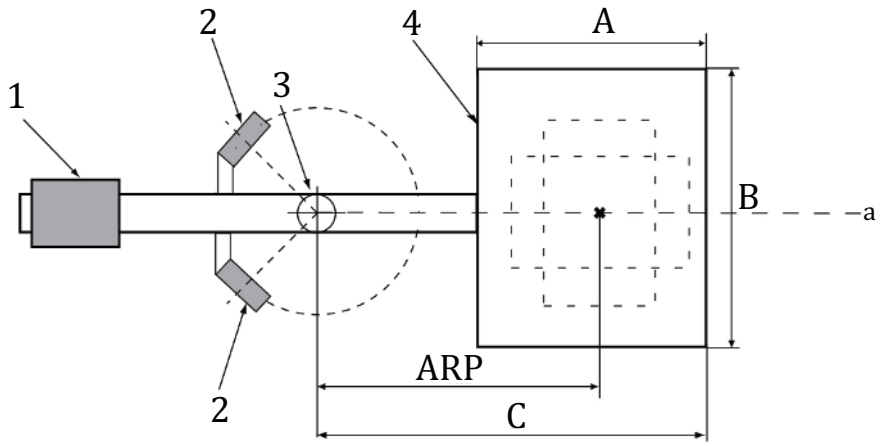
E.2 Principle

By placing a SSWC or MSWC, loaded with the ATD and the FF-WPS facing outward, inward, and radially on the rotating platform, the effects of ATV-SS braking, accelerating, and turning can be replicated and evaluated, respectively.

E.3 Specifications

The test device consists of a horizontally rotating platform that can support the load of a MSWC or SSWC, ATD and FF-WPS, including a floor surface under the test conditions specified in Annex A.

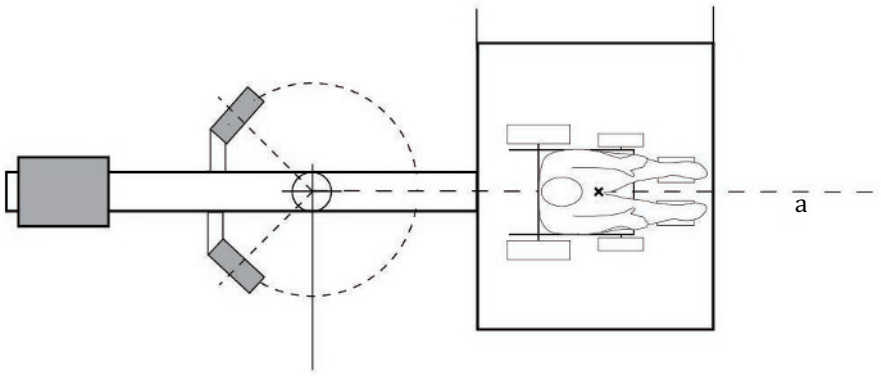
The test device complies with the device characteristics specified in Annex A, Clause 4.



Key

ARP Accelerometer Reference Point
1 counter balance
2 drive wheel
3 centre axle
4 test platform for MSWC or SSWC, ATD and FF-WPS
A 1 250 mm
B 1 500 mm
C 1 830 mm
a Centre line.

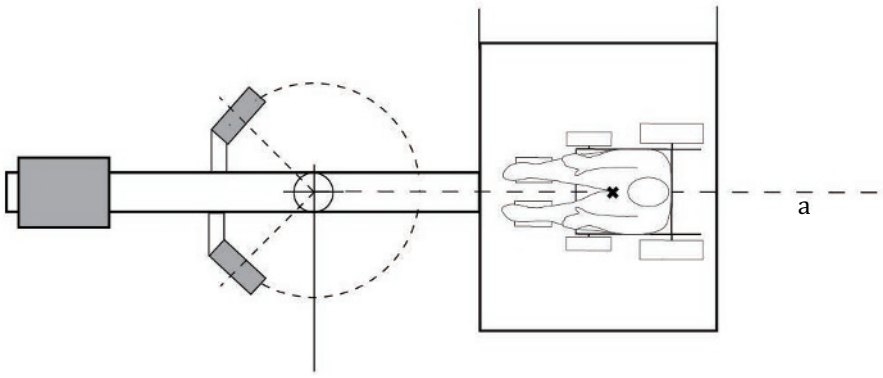
Figure E.1 — Top view illustration of the rotating platform



Key

a Centre line.

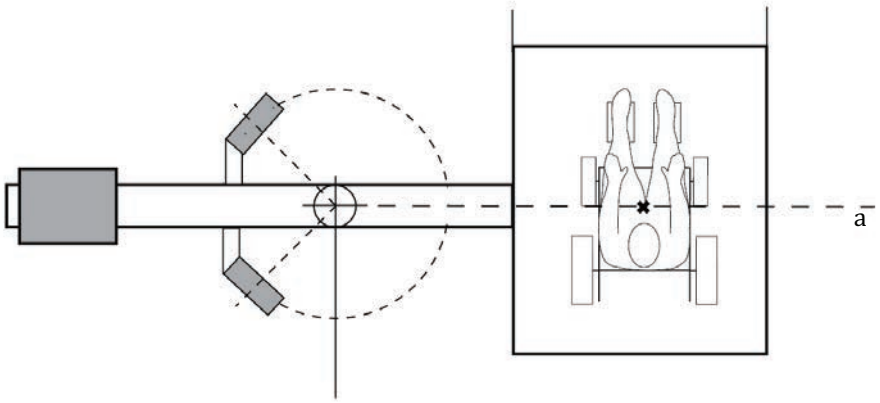
Figure E.2 — Top view illustration of the manual or scooter surrogate wheelchair and ATD on the test platform prior to vehicle braking (deceleration) test at 1 *g*



Key

[a] Centre line.

Figure E.3 — Top view illustration of the manual or scooter surrogate wheelchair and ATD on the test platform prior to vehicle acceleration test at 0,3 *g*



Key

[a] Centre line.

Figure E.4 — Top view illustration of the manual or scooter surrogate wheelchair and ATD on the test platform prior to left turn test at 0,75 *g*

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