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**Wheelchair seating —**

Part 4:

**Seating systems for use in motor  
vehicles**

*Sièges de fauteuils roulants —*

*Partie 4: Systèmes d'assise dans les véhicules à moteurs*

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Published in Switzerland

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## Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 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 16840-4 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

ISO 16840 consists of the following parts, under the general title *Wheelchair seating*:

- *Part 1: Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces*
- *Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity — Seat cushions*
- *Part 3: Determination of static, impact and repetitive load strengths for postural support devices*
- *Part 4: Seating systems for use in motor vehicles*

## Introduction

Transportation safety research has demonstrated that the design of the vehicle seat, the occupant restraints and seat compartment in motor vehicles play a vital role in protecting the occupant in the event of a crash. For some wheelchair users, it is not feasible to transfer to the seat provided by the vehicle manufacturer and they must remain seated in their wheelchair while travelling in a vehicle. ISO 7176-19 provides a means of evaluating the design and frontal crashworthiness performance of complete wheelchairs when used as forward-facing seats in motor vehicles. However, it is common practice that a seating system from one manufacturer and a wheelchair base from another manufacturer be used to form the complete wheelchair. Wheelchair seating systems may also be intended for use on multiple models of wheelchair bases. For this reason, there is a need to be able to evaluate the design and performance of wheelchair seating systems independent of the commercial wheelchair bases on which they may be installed. This part of ISO 16840 provides a means of assessing frontal impact crashworthiness of seating systems without the host wheelchair by using a surrogate wheelchair base.

Manufacturers may choose to not test customized variations of a given seating system. The manufacturer may test a representative variation of the seating system and it is for the manufacturer to document how the results of this test would apply to the limitations in use and instructions for use supplied with the product.

This part of ISO 16840 is intended to encourage safer motor vehicle transportation of wheelchair users by increasing the availability of wheelchair seating systems that comply with basic principles of occupant protection. This part of ISO 16840 should not be used to deny or limit wheelchair user access to motor vehicle transportation.

Currently this part of ISO 16840 addresses only complete wheelchair seating systems and the test requirements are representative of frontal impact conditions. However, future versions may address testing of the individual components of the seating system as well as other directions of impact such as side or rear.

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# Wheelchair seating —

## Part 4: Seating systems for use in motor vehicles

### 1 Scope

This part of ISO 16840 specifies test methods and requirements for design and performance, for instructions and warnings and for product marking and labelling of seating systems intended to be used as a forward-facing seat in a motor vehicle when fitted to a manual or powered wheelchair. It evaluates the frontal crashworthiness performance of complete seating systems for occupancy by adults or children of mass equal to or greater than 22 kg.

This part of ISO 16840 only applies to complete wheelchair seating systems including attachment hardware, designed to be used with a wheelchair base tested as part of a wheelchair system that conforms to ISO 7176-19 performance requirements and that has securement points for use with four-point, strap-type tiedowns.

This part of ISO 16840 applies to seating systems designed to be used with occupant restraints that anchor either to the vehicle, the tiedown system, the seating system or the wheelchair base.

Seating systems that are intended only for use with a specific wheelchair base should be tested to ISO 7176-19 using the specifically intended wheelchair base.

### 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 898-7, *Mechanical properties of fasteners — Part 7: Torsional test and minimum torques for bolts and screws with nominal diameters 1 mm to 10 mm*

ISO 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

ISO 7176-19:2008, *Wheelchairs — Part 19: Wheeled mobility devices for use as seats in motor vehicles*

ISO 10542-1:2001, *Technical systems and aids for disabled or handicapped persons — Wheelchair tiedown and occupant-restraint systems — Part 1: Requirements and test methods for all systems*

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

FMVSS 201, *Standard No. 201, Occupant protection in interior impact. (Federal Motor Vehicle Safety Standards), 49 CFR 571.201*

ECE Regulation 21, *Uniform provisions concerning the approval of vehicles with regard to their interior fittings, Revision 2, Amendment 2*

ASTM E527-83 (2003), *Standard Practice for Numbering Metals and Alloys (UNS)*

### 3 Terms and definitions

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

- 3.1 adult**  
person having a mass equal to or greater than 43 kg
- 3.2 anchor point**  
location on a vehicle interior component, floor, wall, wheelchair, or wheelchair tiedown, to which an **anchorage** (3.3) is attached
- 3.3 anchorage**  
assembly of components and fittings by which loads are transferred directly from the wheelchair tiedown to the vehicle, or from the occupant restraint to the vehicle, wheelchair, wheelchair tiedown or vehicle interior component
- 3.4 anthropomorphic test device ATD**  
articulated physical analogue used to represent a wheelchair occupant in a test
- 3.5 attachment hardware**  
mechanical means of attaching a seating system to the wheelchair frame
- EXAMPLE Metal or plastic hooks, nuts or bolts.
- 3.6 back support angle**  
angle of the back support reference plane with reference to a vertical plane
- NOTE Measurement method specified in ISO 7176-7.
- 3.7 back support surface**  
component of seating system intended to support the posterior surface of the sacral, lumbar and/or thoracic segments of the trunk
- 3.8 back support reference plane**  
plane associated with the back support of the wheelchair, which is referenced to make measurements
- NOTE Method for determining the location of this reference plane specified in ISO 7176-7.
- 3.9 belt**  
length of webbing material used as part of an occupant restraint or postural support
- 3.10 child**  
person having a mass equal to or greater than 22 kg and less than 43 kg
- 3.11 custom contoured**  
uniquely shaped to match the wheelchair occupant

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**3.12****excursion**

horizontal movement of an **ATD** (3.4) or wheelchair during a test relative to its initial position on an impact sled

**3.13****forward facing**

orientation in which the wheelchair-seated occupant faces the front of the vehicle, with the reference plane within ten degrees of the longitudinal axis of the vehicle

**3.14****four-point tiedown**

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

**3.15****four-point strap-type tiedown**

**four-point tiedown** (3.14) that uses four strap assemblies to secure the wheelchair in the vehicle

**3.16****H-point**

point located on the left and right side of the pelvic region of an **ATD** (3.4) that represents the approximate location of the human hip joint centre in the side view, as specified by the ATD manufacturer

**3.17****head support**

postural aid to support the head of a wheelchair occupant, not designed or intended to provide head restraint in a vehicle impact

**3.18****head restraint**

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

**3.19****impact simulator**

device for applying a programme of acceleration and deceleration modes to a section of a vehicle or simulated vehicle structures, including instrumentation for measuring data required by this part of ISO 16840

**3.20****impact sled**

part of an **impact simulator** (3.19) on which components can be mounted for impact testing

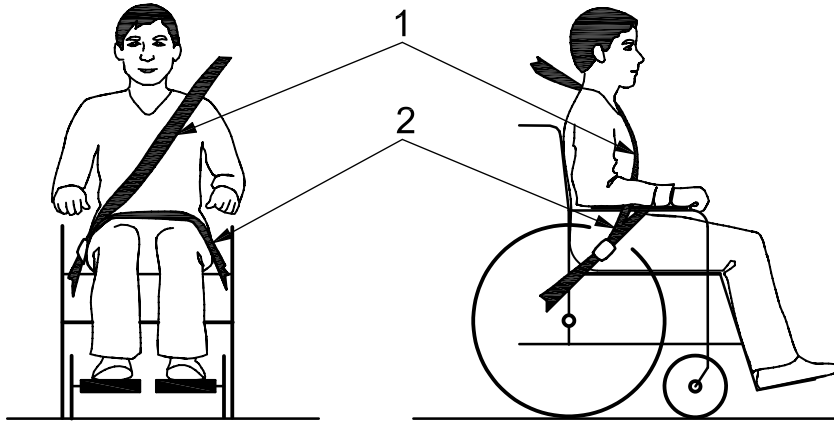
**3.21****occupant restraint**

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

**3.22****pelvic-belt restraint****lap-belt restraint**

portion of the occupant restraint intended to limit movement of the pelvis by application of restraint forces to the pelvis

See Figure 1.



**Key**

- 1 shoulder-belt restraint
- 2 pelvic-belt restraint

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

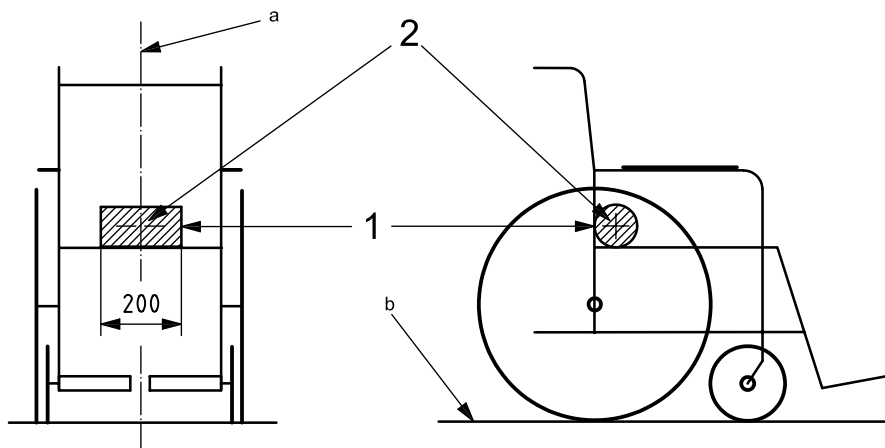
**3.23  
point P**

side-view projection of a point on the seating system which lies at the cross-sectional centre of a 100 mm diameter, 200 mm long, cylinder with a maximum weight of 0,5 kg positioned with the longitudinal axis perpendicular to the wheelchair reference plane, such that the curved surface of the cylinder is in contact with the seat and back support surfaces

See Figure 2.

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Dimensions in millimetres



**Key**

- 1 cylinder, diameter 100 mm
- 2 point P
- a Wheelchair reference plane.
- b Wheelchair ground plane.

**Figure 2 — Seating system reference point P and wheelchair reference and ground planes**

**3.24****postural support device**

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

NOTE Postural support devices are not designed or intended to provide occupant restraint on vehicle impact.

**3.25****seat plane angle**

angle of **seat reference plane** (3.27) with reference to a horizontal plane

NOTE Measurement method specified in ISO 7176-7.

**3.26****seat support surface**

component of seating system intended to support the inferior surface of the buttocks and thighs

**3.27****seat reference plane**

plane associated with the seat of the wheelchair, which is referenced to make measurements

NOTE Methods for determining the location of this reference plane are specified in ISO 7176-7.

**3.28****seating system**

seat and back support surfaces and their attachment hardware

**3.29****securement points**

points on the wheelchair to which wheelchair tiedowns are connected

**3.30****shoulder-belt restraint  
upper torso restraint**

portion of the occupant restraint intended to limit movement of the upper body by application of restraining forces to either or both clavicles

See Figure 1.

**3.31****strap**

length of webbing material used in a wheelchair tiedown

**3.32****support surface**

part of the seating system that is intended to contact the wheelchair occupant

**3.33****surrogate wheelchair base****SWCB**

re-usable device that conforms to the requirements of Annex B, used to simulate a wheelchair base for the purpose of testing seating systems

**3.34**

**three-point-belt restraint**

**three-point restraint**

occupant restraint assembly with three anchorages comprised of both a pelvic-belt restraint and a diagonal shoulder-belt restraint that connect together near the hip of the occupant.

See Figure 1.

**3.35**

**wheelchair base**

portion of the wheelchair consisting of the wheels and **wheelchair frame** (3.36)

**3.36**

**wheelchair frame**

portion of the wheelchair consisting of the members that make up the supporting structure

**3.37**

**wheelchair ground plane**

plane representing the surface on which the wheelchair rests

See Figure 2.

**3.38**

**wheelchair reference plane**

vertical plane in longitudinal centreline of the wheelchair

See Figure 2.

**3.39**

**wheelchair tiedown**

**wheelchair securement system**

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

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**3.40**

**wheelchair tiedown and occupant restraint system**

**WTORS**

complete restraint system for wheelchair-seated occupants comprised of equipment for wheelchair tiedown and a belt-type occupant restraint

## 4 Design requirements

NOTE It can be beneficial for some users to have a head restraint as a part of their seating system.

### 4.1 Reduction of sharp edges

Webbing shall be protected from contacting sharp corners and edges. If the edge of a rigid component of a seating system has a radius less than 2,0 mm, it shall be covered with padding capable of absorbing energy to reduce the likelihood of injuries to wheelchair users and other vehicle occupants during a vehicle impact. Energy-absorbing padding should conform to the requirements of FMVSS 201 and/or ECE Regulation No. 21.

### 4.2 Accommodation of vehicle-anchored occupant restraints

The seating system shall be constructed in such a way that any part of the system (e.g. frame, hip or thigh supports, etc) will not hold a lap-belt or shoulder-belt restraint away from a seated user's pelvis or upper torso.

## 5 Performance requirements

NOTE Informative Annex C provides manufacturers with a preliminary means to evaluate the performance of their seating system using low cost static tests. It is important to note that static testing results may not be equivalent to dynamic test performance.

### 5.1 Frontal impact test

#### 5.1.1 General

The wheelchair seating system shall be tested in accordance with Annex A using the surrogate wheelchair base, as specified in Annex B, secured by a four-point strap-type tiedown that complies with ISO 10542-1 and ISO 10542-2. The requirements of 5.1.2 and 5.1.3 shall be met during and after the conducted test.

#### 5.1.2 During the frontal impact test

When tested in accordance with Annex A, the following requirements shall be met during the test.

- a) The horizontal excursions of the ATD and the seating system shall not exceed the values given in Table 1.

NOTE Excursion limits are based upon prevention of occupant secondary impact with vehicle interior.

- b) Except when the test has been conducted using a wheelchair base or seat-anchored pelvic-belt restraint or a completely wheelchair base or seat-anchored occupant restraint system, the knee excursion,  $X_{\text{knee}}$ , shall exceed the point P excursion,  $X_{\text{ss}}$ , as follows:

$$X_{\text{knee}}/X_{\text{ss}} \geq 1,1$$

Refer to Table 1 for definitions of  $X_{\text{knee}}$  and  $X_{\text{ss}}$ .

NOTE Conformity with this requirement reduces the potential for the seating system to apply loads to the wheelchair occupant.

- c) The seating system shall not separate from the surrogate wheelchair base at any attachment point.

#### 5.1.3 After the frontal impact test

When tested in accordance with Annex A, the following requirements shall be met at the end of the test.

- a) The ATD shall be retained in the seating system in a seated posture, as determined by the ATD torso being oriented at not more than 45° to the vertical when viewed from any direction.

NOTE The angle of the ATD torso can be estimated by aligning the edge of an inclinometer with a line drawn connecting the centre of the ATD's shoulder and the ATD's hip.

- b) The load-carrying components of seating system and attachment hardware shall not show visible fractures or deformation that prevent it from supporting the mass of the ATD.
- c) Components, fragments or accessories of the seating system with a mass greater than 0,1 kg shall not have completely separated from the seating system.
- d) Rigid seating system components that may contact the occupant shall not fragment or separate in a manner that produces sharp edges with a radius of less than 2,0 mm.
- e) The post-test height of the average of left and right ATD H-points relative to the wheelchair ground plane shall not change by more than 20 % from the pre-test height.