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AMENDMENT 1
2021-04

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

Part 1: Requirements and test methods for all systems

AMENDMENT 1: Annexes K, L, M

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

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

AMENDEMENT 1: Annexes K, L, M

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This document was prepared by Technical Committee ISO/TC 173, *Assistive products*, Subcommittee SC 1, *Wheelchairs*.

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Introduction

Add the following text to the end of the third paragraph:

In addition, Annex K provides a test method and performance measures for WTORS manufacturers who wish to test the wheelchair securement system for rear-impact conditions, and Annex M provides a test method and performance measures for WTORS manufacturers who wish to evaluate the rear-impact performance of vehicle-mounted, head-and-back restraints.

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Add the following text to the end of the fourth paragraph:

Annex K provides a test method whereby they are exposed to a 14 *g*, 25 km/h rear impact sled test.

Add the following text to the end of the seventh paragraph:

Annex L provides a method for evaluating wheelchair securement systems for the situation of wheelchair occupants restrained by a three-point belt comprised of a vehicle-anchored shoulder belt and a wheelchair-anchored pelvic belt.

Clause 2

Add the following normative references:

ISO 16840-4:2009, *Wheelchair seating — Part 4: Seating systems for use in motor vehicles*

ISO 7176-19:2008/Amd 1:2015, *Wheelchairs — Part 19: Wheeled mobility devices for use as seats in motor vehicles — Amendment 1: Annex G*

Clause 3

Add the following terms and definitions:

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3.46
foot/leg strap
length of webbing mounted forward and below the ATD knee to limit upward movement of the leg after peak forward motion of the ATD knee has occurred

Note 1 to entry: The foot/leg strap minimizes damage to the ATD and provides for more realistic movement of the lower extremities during frontal-impact loading by limiting extension of the knee joints and upward movement of the ATD's lower extremities. It does this in a manner that does not affect forward excursions of the ATD, but slightly reduces the severity of rearward rebound of the ATD while making this rebound more controlled and consistent between tests.

3.47
sharp edge
exposed, rigid edge with a radius of less than 2 mm

3.48
vehicle-mounted, head-and-back restraint
vehicle-anchored, head-and-back restraint
optional portion of a WTORS that is positioned behind a forward-facing occupant seated in a wheelchair for the purpose of limiting rearward movement of the occupant's torso, head, and neck to reduce the risk of injury in rear-impact collisions

Note 1 to entry: A vehicle-mounted, head-and-back restraint system is an optional part of a WTORS.

5.2.1

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Add the following notes to the end of the subclause:

Note 1 The performance of WTORS in frontal impacts for systems with a wheelchair-anchored pelvic belt can be evaluated using the test method and performance criteria given in Annex L.

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Note 2 The performance of WTORS in rear impacts can be evaluated using the test method and performance criteria given in Annex K.

Note 3 The performance of a WTORS with an optional vehicle-mounted, head-and-back restraint in rear impacts can be evaluated using the design guidelines, test method and performance criteria given in Annex M.

J.4

Replace the text with the following:

J.4 Engineering drawings for test equipment

Engineering drawings for the surrogate wheelchair (SWC), surrogate WTORS (SWTORS) and the surrogate wheelchair base (SWCB) listed below can be obtained from:

> The Biosciences Group, University of Michigan Transportation Research Institute (UMTRI), 2901 Baxter Road, Ann Arbor, MI 48109-2150 USA, Phone: (734) 763-3582, Fax: (734) 647-3330 and downloaded from the website: http://wc-transportation-safety.umtri.umich.edu/wts-standards/WC4engineeringdrawings

The available drawings include

1) a surrogate wheelchair specified in Annex E and used in the frontal-impact tests of Annex A and Annex L and in the methods for measuring belt-restraint geometry of Annex B,

2) a surrogate wheelchair base (SWCB) used in ISO 16840-4 for frontal-impact testing of wheelchair seating systems and for rear-impact testing of vehicle-mounted, head-and-back restraints in Annex M,

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3) a surrogate WTORS with four-point strap type tiedown and three-point belt restraint with a means to anchor the pelvic belt to the SWC and the SWCB per Annex L and Annex M, respectively, and

4) a surrogate wheelchair docking securement system, including docking securement device, wheelchair adaptor, and front-stabilizing bracket for testing the crashworthiness of wheelchairs in ISO 7176-19 when secured by commercial docking devices, and for securing the SWCB during rear-impact tests of vehicle-mounted, head-and-back restraints in Annex M.

Annex K

Add the following annex after Annex J.

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Annex K
(informative)

Test method and performance criteria for rear impact of WTORS

K.1 Rationale

The primary focus of this document is to provide design and performance criteria for WTORS used with forward-facing occupants seated in a wheelchair during frontal-impact loading. This annex provides a test method and performance criteria for evaluating the effectiveness of wheelchair securement systems during rear-impact loading. The severity of the rear-impact test in this annex has been selected to align with the acceleration/deceleration pulse and delta V in ISO 7176-19:2008/Amd 1:2015, Annex G, which uses the rear-impact deceleration corridor of ECE R44 and a 25 km/h change in velocity. This change in velocity represents a moderate-to-severe real-world rear impact that corresponds to an 80th percentile real-world rear-impact event based on analysis of effective barrier speed rear-impact distributions from the US National Automotive Sampling System nationally representative crash/injury databases.

Throughout this annex, the term test wheelchair (TWC) is used. The TWC may be the surrogate wheelchair (SWC) specified in Annex E or it may be a specific wheelchair model (SWM) that the securement system is designed to secure. If a wheelchair securement system is to be tested with an SWM, the wheelchair's response should be evaluated using the performance criteria in ISO 7176-19:2008/Amd 1:2015, Annex G.

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K.2 Principle

To simulate a typical moderate-to-severe rear-impact event to an occupied wheelchair, the TWC is placed on the test platform of an impact sled facing rearward to the direction of sled acceleration and/or deceleration. The TWC is loaded with an appropriate size ATD as specified in K.4 below that is restrained by a three-point belt occupant restraint system, and the TWC is secured by the securement system to be evaluated in rear impact. The sled is subjected to an acceleration/deceleration-time pulse that falls within a specified corridor to achieve the required horizontal change in velocity, or delta V. Observations and measurements are made during and after the test to determine if the securement system effectively secured the TWC during rear-impact loading.

K.3 Test sample

Provide an unused WTORS, including all fittings, anchorages, fasteners, and instructions for installation and use, for testing. If a WTORS is designed to use a modified original equipment manufacturer (OEM) belt-type occupant restraint system, provide it for testing. Include documentation to indicate any components of the WTORS that are designed to provide controlled failure or deformation under dynamic loading.

K.4 Test equipment

K.4.1 Use an impact simulator that includes the following:

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

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

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c) a means to drive the impact sled through a change in velocity of 25 km/h $^{+2}_{0}$ km/h;

d) a means to accelerate and/or decelerate the impact sled and test setup such that the processed sled acceleration and/or deceleration-time pulse falls within the shaded area of Figure K.1,

K.4.2 If the WTORS is intended for use with all types of manual and powered wheelchairs, use the following:

a) a SWC that conforms with the specifications of Annex E;

b) a Hybrid III 50th percentile ATD (nominal mass 77 kg) or Hybrid II 50th percentile ATD (nominal mass 74 kg).

NOTE 1 A head restraint can be added to the SWC to help limit rearward rotation of the ATD's neck and rearward movement of the ATD's head. The addition of the head restraint can alter the centre of gravity of the SWC. This is acceptable as long as the SWC without the head restraint is compliant to Annex E.

NOTE 2 Utilizing the 50th percentile ATD harmonizes this testing with that specified in Annex A.

K.4.3 If the WTORS is intended to be used only with a specific wheelchair model (SWM), use the following:

a) the SWM it is designed for;

b) an ATD selected from ISO 7176-19:2008, Table A.1 that is representative of the upper size range of users for which the specific make or model of wheelchair is designed to carry or other similar sized ATD with equivalent mass, anthropomorphic shape, and mass distribution.

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K.4.4 Provide a means to measure the TWC horizontal excursion specified in K.7 with a precision of ±5 mm.

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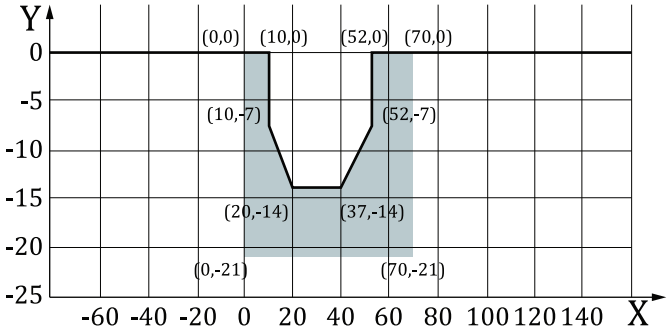
NOTE A side-view high-speed camera or video system with a minimum frame rate of 500 frames per second is suggested.

K.4.5 Provide a means to measure the horizontal acceleration and/or deceleration of the impact sled in the direction of travel at a sampling rate in accordance with ISO 6487, and with a precision of ±0,5 *g*.



Key

X time (ms)

Y deceleration (*g*)

Figure K.1 — Acceleration/deceleration corridor for 25 km/h rear impact

K.4.6 Provide a means to measure the horizontal velocity change (delta-V) of the impact sled during the impact with a precision of ±0,5 km/h.

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K.4.7 Make provisions to filter transducer signals using a low-pass filter in accordance with ISO 6487, including

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

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

K.5 Test preparation and procedure

K.5.1 Use the following procedures to set up and run the test. The procedures for setting up the test may be undertaken in any order.

NOTE For example, it can sometimes be more convenient to position the ATD on the TWC prior to lifting the assembly onto the impact sled.

K.5.2 Prepare the ATD by

a) adjusting each joint in the upper and lower extremities to achieve a static resistance of 1 *g* as indicated by just-noticeable movement with gravity acting on the mass of the distal body segment or segments, and

b) placing close-fitting cotton clothing on the pelvis, thighs, and torso.

K.5.3 Preparation of the TWC

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K.5.3.1 When the TWC is the SWC, prepare it as follows.

a) Inspect all frame junctions and components, and repair where there are signs of fatigue or deformation.

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b) Inspect tyres for cracks or damage and replace as needed.

c) Inflate the SWC tyres as specified in Annex E with the wheelchair unoccupied and resting on a horizontal surface.

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

e) Modify the frame as needed to accommodate a wheelchair securement adaptor provided by the WTORS manufacturer, while maintaining the SWC specifications within the tolerances specified in Annex E.

f) Install any wheelchair-securement adaptor provided by the WTORS manufacturer on the SWC per the manufacturer's instructions.

K.5.3.2 When the TWC is a SWM, prepare it as follows.

a) Prepare the wheelchair for use in a motor vehicle as specified by the manufacturer's user instructions.

b) If a range is specified for any adjustments, use the adjustment closest to the midpoint of the range for testing. If more than one adjustment position can be considered closest to the midpoint, use the adjustment position immediately rearward, down, outboard or more reclined from midpoint.

c) Equip the wheelchair with any required add-on components as specified by the manufacturer.

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

e) If the wheelchair is equipped with liquid electrolyte type batteries, replace them with the nearest equivalent gel type or a surrogate battery. Supplemental weights, if used, ought to provide equivalent mass distribution to the original batteries.

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f) Inflate any pneumatic tyres to the pressure recommended by the wheelchair manufacturer or to the maximum sidewall pressure with the chair unoccupied and on a level surface if no specification is given.

g) Turn the wheelchair power off, if applicable.

h) Equip the SWM with any required securement adaptors.

K.5.4 Position the TWC on the sled in the orientation appropriate for representing a rear-impact event and with the wheelchair reference plane parallel to the direction of sled travel ±3°.

K.5.5 When the method of wheelchair securement is a four-point tiedown tested with the SWC:

a) Select anchor points that

1) are symmetrical about the wheelchair reference plane,

2) are located 1 300 mm ± 20 mm from the front anchor point to the rear anchor point,

3) have a lateral distance between rear anchor points equal to 425 mm ± 25 mm, and

4) have a lateral distance between front anchor points of 600 mm ± 25 mm.

NOTE 1 For purposes of locating the anchor points, the front-to-back location of an anchor point is the location of the primary fastener that secures the anchorage to the test platform or, in the case of multiple fasteners, the centroid of the combined fastener locations. The lateral location of an anchor point is the centre of the location where the tiedown end fitting contacts the anchorage hardware attached to the test platform.

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b) Position the SWC to achieve lengths of the rear tiedown strap assemblies of 495 mm to 533 mm, measured from the interface of the tiedown end fitting and the securement point on the wheelchair to the anchor point.

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NOTE 2 For purposes of measuring the rear tiedown length, the anchor point is considered to be the point at which a straight line along the length of the strap assembly intersects with the wheelchair ground plane.

c) Tension all tiedown straps to the manufacturer's specifications.

K.5.6 For wheelchair securement systems other than four-point tiedowns or for WTORS meant to be used with an SWM:

a) Install the anchorage mechanism or mechanisms on the sled platform per the manufacturer's instructions.

b) If a range is given for any installation dimensions, use the midpoint of the given range, when possible.

c) If fasteners supplied with the securement system are not compatible with the impact-sled platform, replacement fasteners shall be supplied or specified by the manufacturer.

K.5.7 Position the ATD in the TWC sitting upright and symmetrical about the wheelchair reference plane, with the pelvis and buttock as far back on the wheelchair seat as possible, and the elbows resting on the TWC arm supports or with the hands resting on the ATD's thighs.

K.5.8 Install the occupant restraint system in accordance with A.5.14 to A.5.19.

K.5.9 Conduct the test using a deceleration/acceleration pulse that falls within the corridor of Figure K.1 and that produces a sled change in velocity of 25 km/h $^{+2}_{0}$ km/h by executing the appropriate sequence of steps to start data acquisition and activate the impact sled.

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K.6 Measurement procedures for operation force of clamp-type systems

K.6.1 The measurement procedures for operational forces as given in A.6 shall apply.

K.7 Performance criteria

K.7.1 General

a) When the securement system is tested with the SWC, the criteria of K.7.2 and K.7.3 should be met.

b) When the securement system is tested with a SWM, the performance criteria given in ISO 7176-19:2008/Amd 1:2015, G.3.5.1 and G.3.5.2, as well as K.7.3 c), d) and e) should be met.

K.7.2 During the test

When tested in accordance with the procedure given in K.5 using the SWC, the horizontal excursion of the SWC should not exceed the value given in Table K.1.

Table K.1 — Horizontal excursion limits

Measurement point	Excursion variable	Excursion limit mm
Point P of TWC	^{x}wc	200
x_{wc} is the horizontal distance relative to the sled platform between the point-P target on the TWC at time t_0 and the point P target at the time of peak rearward wheelchair excursion.		

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K.7.3 After the test

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When tested in accordance with the procedure given in K.5 using the SWC the following criteria should be met at the conclusion of the test.

a) The SWC should be in an upright position on the test platform with at least three of the four wheels in contact with the sled platform and the ATD should be in the wheelchair in a seated posture, as determined by the ATD torso being oriented at not more than 45° to the vertical when viewed from any direction.

b) Release of the SWC from the wheelchair securement system should not require the use of tools.

c) No tiedown strap end fitting or anchorage, and no mechanical securement system component, should have detached or separated from the TWC or test platform during the test.

d) Load carrying components of the securement system should not completely fail unless the part is designed to tear or fail in a controlled and predictable manner as described by the manufacturer before the test.

e) The WTORS should exhibit no sharp edges or protrusions that are contactable by the occupant and likely to increase the risk of injury to the occupant.

K.8 Post-test measurements and calculations

Determine peak rearward excursion x_{wc} to an accuracy of ±5 mm through analysis of the high-speed video.

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