American National Standard

for Wheelchairs –

Volume 4:
Wheelchairs and Transportation

RESNA

Rehabilitation Engineering and Assistive Technology Society of North America

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Foreword

This standard covers products and hardware that enhance safety for people who use wheelchairs as seats in motor vehicles. Specifically these products include: wheelchair tiedown and occupant restraint systems (WTORS), wheelchair spaces on large accessible transit vehicles (LATVs), manual and power wheelchairs (including scooters), and wheelchair seating systems that can be used with a range of wheelchair frames.

RESNA WC Volume 4 consists of the following sections under the general title Wheelchairs:

Volume 4: Wheelchairs and Transportation

Section 10 **Wheelchair containment and occupant retention systems for use in large accessible transit vehicles: systems for rearward-facing passengers**

Section 18: **Wheelchair tiedown and occupant restraint systems for use in motor vehicles**

Section 19: **Wheelchairs used as seats in motor vehicles**

Section 20: **Wheelchair seating systems for use in motor vehicles**

The following RESNA WC Volumes are also available:

Volume 1: Requirements and Test Methods for Wheelchairs (including Scooters)

Volume 2: Additional Requirements for Wheelchairs (including Scooters) with Electrical Systems

The following RESNA WC Volume is also under development:

Volume 3: Wheelchair Seating

This standard had its inception in the mid 1980s when the Restraint Systems Task Force (RSTF) of the Society of Automotive Engineers (SAE) Adaptive Devices Subcommittee (ADSC) began work on a WTORS Recommended Practice in response to concerns about the effectiveness of existing WTORS systems. This effort resulted in SAE Recommended Practice J2249, which was first published in 1996 and is the precursor for Section 18 of the current standard. Section 18 represents a comprehensive revision and improvement of SAE Recommended Practice J2249.

Once SAE J2249 was complete, the RSTF realized that, while WTORS were significantly improved, the wheelchair remained as the “weak link” in providing effective occupant crash protection for wheelchair-seated travelers. RESNA was the logical venue to develop requirements for wheelchairs used as seats in motor vehicles and development of Section 19 of ANSI/RESNA Volume 1 was therefore initiated by a Working Group of the wheelchair standards committee. The initial version of Section 19 was approved for publication in May of 2000. Section 19 that is provided in Volume 4 is a full scale revision of that original document based on the experiences with the standard to date and a more extensive knowledge of the needs of consumers, manufacturers, transportation providers and other key stakeholders.

Section 20 was subsequently developed in recognition that a given seating system may be used on many different wheelchair frames, that seating systems are often produced by a company that specializes in seating systems, and that seating systems may therefore be purchased separate

from the wheelchair frame. Section 20 provides for testing of wheelchair seating systems relative to their use as seats in motor vehicles independent of specific wheelchair frames.

Section 10 was added in recognition of the fact that not all vehicles and travel modes present the same level of injury risk to passengers. LATVs that travel fixed routes at relatively low speeds on urban roads represent a travel situation where the likelihood of a moderate-to-severe crash is extremely low. Therefore, providing a level of safety during travel for passengers seated in wheelchairs in LATVs that is equivalent to passengers in vehicle seats or who are standing using handholds does not require the same level of wheelchair securement and occupant restraint needed for people traveling in smaller vehicles and in vehicles traveling at highways speeds, for which the likelihood of being involved in a significant crash is much higher. Section 10 adapts an international standard (ISO) for rear-facing wheelchair passenger spaces on LATVs, ISO 10865-1, to the U.S. market.

The different sections of this RESNA Wheelchairs and Transportation standard have been developed in the United States in conjunction with similar and coordinated efforts by the International Standards Organization, Technical Committee 173, Subcommittee 1, Working Group 6 (ISO/TC173/SC1/WG6). These sections are now put forward by the RESNA Committee on Wheelchairs and Transportation (COWHAT), which is comprised of people representing a range of disciplines and organizations, including rehabilitation engineers, wheelchair manufacturers, transit providers, WTORS and seating-system manufacturers, clinicians, researchers, and consumers. Each section of the standard contains design and performance requirements, associated test methods to determine compliance with performance criteria, and requirements for product labeling and manufacturer literature relative to their use and effective performance in motor vehicles during normal vehicle operation, emergency vehicle maneuvers, and crash events.

The American National Standards Institute (ANSI) originally sanctioned the ANSI/RESNA Standards on Wheelchairs Section 19 in 2000. RESNA is now accredited as a standards organization and the Assistive Technology Standards Board oversees the work of the RESNA standards committees. RESNA is an interdisciplinary organization that promotes assistive technology for people with disabilities. The committee has also worked concurrently with other countries as an ANSI member body to the International Organization for Standardization (ISO), a worldwide federation of national standard bodies, to create comparable international standards pertaining to wheelchair transportation safety.

Suggestions for the improvement of this standard are welcome. They should be sent to the following address:

RESNA Assistive Technology Standards Board
1560 Wilson Boulevard, Suite 850
Arlington, VA 22209

This standard was approved by the RESNA Standards Committee on Wheelchairs and Transportation and the RESNA Assistive Technology Standards Board for submission to ANSI. Committee approval of the standard does not necessarily imply that all the committee members voted for its approval or the approval of every test method or requirement in the standard. At the time of the current revisions, the RESNA Standards Committee on Wheelchairs and Transportation consisted of the following members:

Organization Represented	*Name of Representative*
University of Michigan	Chair, Miriam Manary
US Federal Food and Drug Administration	Vice Chair, Shawn Shermer
University of Michigan	Secretary, Nichole Orton
All Wheels Up, Incorporated	Michele Erwin
American Seating Company	Chris Beals
AMF Bruns of America.	Peter Haarhuis, Steven Kost
Assistive Domotics	Massoud Saleh
B&D Independence	John Evans, Zach Lewis
Columbia Medical, LLC.	Matt Lawrence, Kimmie Sirimitr
Convaid, Inc.	Donald Griggs, Ed Packard
Douglas J. Cross Transportation Consulting	Douglas Cross
Exponent	Zdravko Salipur
EZ Lock, Inc.	Candace Constantin, Chris Hamilton
4ONE	Mike Moffa, Jeff Krueger
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IMMI	Aaron Acton, Charlie Vits
Invacare Corporation	Ramakant Rambhatla, Randy Norman
Linc Designs	Linda van Roosmalen
Marquette University	Gerald Harris
New Haven	Michale Porter
Ohio State University	Carmen DiGiovine, Theresa Berner
Orthosafe Systems International, Inc.	Winfried Kraft
Permobil, Inc.	David Algood
PMG Technologies, Inc.	Mark Cohen, Claude Sauvageau
Pride Mobility Products, Inc.	Michael Zablocky, Mark Maguire
Purdue University.	Brad Duerstock
Q'Straint, Inc and Sure-Lok.	Victoria Hodkinson-Gibbs, Joe Gabbay
Sunrise Medical	Mark Greig, Gary Hite
Shepherd Center	Dan Allison
University of Louisville	Gina Bertocci, Mary Ellen Buning
University of Michigan	Lawrence Schneider
University of Pittsburgh	Patricia Karg
US Federal Food and Drug Administration	Kathryn DeLaurentis
	Rick Aucoin

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Scope of Volume 4

Volume 4: Wheelchairs and Transportation of the RESNA wheelchair standards establishes requirements and test methods for WTORS, wheelchairs (including scooters), and wheelchair seating systems that are used to enhance safety for forward-facing wheelchair-seated passengers in a wide range of vehicles, including personal vans and minivans, school buses, paratransit vans, and buses. When possible and appropriate, sections of this standard may be applied to WTORS, wheelchairs, and wheelchair seating systems that fall outside the defined scope.

This standard specifies design and performance requirements, and associated test methods for determining compliance with performance criteria. These test results may be used to verify manufacturers' claims that a product complies with the requirements of this standard. This standard also specifies requirements for product labeling and for manufacturer literature, including pre-sale literature and instructions and warnings to installers and consumers.

WARNING: This RESNA Standard calls for the use of procedures that may be injurious to the testing technician if adequate precautions are not taken.

Section 10

Wheelchair containment and occupant retention systems for use in large accessible transit vehicles: systems for rearward-facing passengers

Contents

Foreword

This section of ANSI/RESNA WC-4 is based on ISO 10865-1, 2012. RESNA amended ISO 10865-1, 2012 to make the title more consistent with other sections of the RESNA Vol 4, wheelchair transportation standards, and to include harmonizing editorial and technical revisions that are more applicable to the US transport industry.

At the time of publication of this section, ISO 10865-1, 2012 was valid. More recent versions of the ISO document may contain revisions that do not appear in this document. In the event that this occurs, the RESNA amendments shall supersede the ISO revision.

In this section, strikethrough text indicates text that has been deleted from the ISO standard, and underlined blue text indicates text that has been added to the ISO standard.

Section 10 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 maneuvers and crash conditions that are appropriate to the size and travel conditions of the vehicle~~. ISO 10542-1~~ ANSI/RESNA WC-4:2017, Section 18 (WC18) establishes design and performance requirements and associated test methods for wheelchair tiedown and occupant restraint systems (WTORS) intended for use by forward-facing 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~~ WC18 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. ~~Therefore ISO 10542-1~~ WC18 therefore requires frontal sled-impact testing of WTORS to nominal 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 use in larger and heavier vehicles used primarily in low-speed intra-city transportation. This is particularly the case for larger accessible transit vehicles (LATV) in which passengers are allowed to travel sitting as well as standing~~, hereafter referred to as accessible transit vehicles-sitting and standard, or ATV-SS~~.

Recognizing these different and significantly lower transportation safety requirements for ~~ATV-SSs~~ LATVs in a new standard can be expected to result in alternative solutions for safely transporting wheelchair-seated passengers in these vehicle environments. These solutions are more compatible with the operational needs (e.g., fixed-route schedules) of these transportation services, and 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~~ LATVs indicate that the frequencies of occupant fatalities and serious injuries per million passenger kilometers 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 maneuvers, including sudden stopping, rapid acceleration, and turning corners at excessive speeds. Several studies have clearly demonstrated that ~~ATV-SS~~ LATV accelerations that may result from such emergency maneuvers are all below 1*g* [2,3].

Recognizing the different safety needs of ~~ATV-SS~~ LATV passenger environments in the early 1990's, many European countries [4,5,6], as well as Canada and Australia[7], began implementing rear-facing wheelchair passenger stations (RF-WPS) for use by wheelchair-seated passengers travelling in these vehicles. In practice, the RF-WPS concept has been well received by both wheelchair users and transit providers because of increased passenger independence, significantly reduced driver involvement, and reductions in schedule delays [7,8]. However, from an injury-risk perspective, the concept is not ideal in several important ways. For example, some wheelchairs do

not have brakes or may have defective brakes, allowing the wheelchair to have excessive movement. Also, some aisle-side barriers do not work effectively with some types of wheelchairs, such as scooters, and allow tipping or swerving of wheelchairs into the center aisle during vehicle turning. Attempts to resolve these deficiencies by some transporters have resulted in the addition of various types of auxiliary wheelchair securement straps that require driver intervention[7,9]. This nullifies a main advantage of the RF-WPS–independent vehicle access by the wheelchair user. Furthermore, many countries have no national standards for the design, testing, and installation of a RF-WPS, therefore misapplication of the rear-facing concept may readily occur in practice.

The purpose of this ~~part of ISO 10865~~ standard is to establish minimum design and performance requirements for RF-WPS, and to establish test methods for the performance requirements. This will provide wheelchair-seated passengers using RF-WPS with a reasonable level of transportation safety while maintaining a high level of usability and independence during travel in ~~ATV-SSs~~ LATVs.

A fundamental principle behind the concept of a RF-WPS in a ~~ATV-SS~~ LATV is that ~~correctly designed~~ successful passive containment (does not require the physical attachment of securement devices by the wheelchair user or vehicle operator) of an occupied wheelchair during normal travel and emergency vehicle maneuvers is sufficient to provide a reasonable level of transportation safety to wheelchair-seated passengers. This level of safety is comparable to that provided to other vehicle occupants, including standing passengers, who hold onto stanchions and straps to resist movement during vehicle accelerations and decelerations. In this regard, a primary feature of RF-WPS required by this ~~part of ISO 10865~~ standard is a forward excursion barrier, or FEB, against which the wheelchair passenger backs their wheelchair upon entering the RF-WPS. The primary function of the FEB is to prevent forward movement of the wheelchair during vehicle decelerations of normal or emergency braking. However, if the wheelchair ~~backrest~~ back support and the back of the head of the wheelchair user are in close proximity to, or in contact with, the FEB, this structure may also limit forward movement of the wheelchair passenger beyond that provided by the wheelchair ~~backrest~~ back support during emergency braking, or even in the rare event of a frontal collision. With regard to the latter, while the primary performance requirements for wheelchair containment set forth in Annex B of this standard are for non-collision vehicle accelerations and decelerations of less than 1*g*, Annex C of this standard specifies strength testing of the FEB structure based on a 3*g* wheelchair-plus-occupant loading.

Lateral displacement, rotation, or tipping of occupied wheelchairs in an RF-WPS are typically limited in one direction by the vehicle sidewall. Lateral displacement, rotation, or tipping of the wheelchair into the center aisle are typically limited by a physical barrier, such as a vertical stanchion or horizontal padded arm or bar, referred to as a lateral excursion barrier, or LEB. However, in an effort to avoid unnecessary design restrictions, this ~~part of ISO 10865~~ standard does not require or specify any particular structure to limit displacement, rotation, or tipping of the wheelchair toward the vehicle aisle. Rather, the ~~part of ISO 10865 establishes~~ standard sets performance requirements and associated test methods to assess whether the features of the RF-WPS sufficiently limit lateral wheelchair movement and tipping in this direction.

Wheelchair movement toward the rear of the vehicle is limited in the passive mode by requiring minimum friction properties for the vehicle floor within the RF-WPS that will generate friction forces on the tires 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. Active resistance to rearward wheelchair movement may also be provided by implementing vehicle-anchored occupant retention and/or wheelchair containment devices, such as a pivoting padded bar, referred to as a rearward excursion barrier or REB, and/or by the wheelchair user grabbing a handhold within the RF-WPS that complies with geometry and location specifications of this ~~part of ISO 10865~~ standard. Use of a handhold and/or an active occupant retention device will also help limit rearward movement of the wheelchair passenger relative to the wheelchair seat during vehicle accelerations. If a specific RF-WPS design requires active application of an occupant retention and/or wheelchair containment device to pass the rearward wheelchair containment test of Annex B, it is important that a warning to use this device be clearly displayed in the RF-WPS.

As indicated above, this ~~part of ISO 10865~~ standard assumes that retention of the occupant in their wheelchair, which is important to minimize the risk of serious injuries, even in low-*g* non-crash events, depends largely on retention features provided by, and on, the wheelchair. The wheelchair ~~backrest~~ back support will generally provide sufficient retention during vehicle braking but, as previously noted, the FEB can further reduce forward occupant movement in the vehicle when the back and head of the wheelchair passenger are in close proximity to, or in contact with, the FEB. Retention of the wheelchair passenger during lateral accelerations caused by vehicle turning is generally provided by wheelchair armrests and lateral torso postural supports that are customized components of the wheelchair seat, but may be augmented by LEBs. The use of wheelchair-mounted postural belts are important for passive occupant retention during vehicle accelerations and this practice is therefore encouraged by requirements for user warnings displayed in the RF-WPS. In addition, as noted above, this ~~part of ISO 10865~~ standard allows RF-WPS to provide active vehicle-anchored passenger retention and wheelchair containment devices that can be easily implemented by the wheelchair user or driver, and it specifies design and location requirements for handholds that can be used by capable wheelchair-seated passengers to augment containment of the wheelchair and enhance retention and stability of the wheelchair passenger. In addition, a vehicle–mounted lap belt or some other retention device is required that is intended to prevent an otherwise unrestrained occupant from falling out of their wheelchair during unexpected vehicle maneuvers.

Informative design guidelines are provided in Annex ~~F~~ E to aid manufacturers in designing RF-WPS that conform with the requirements of this ~~part of ISO 10865~~ standard. A RF-WPS may also be equipped with WTORS for use by forward-facing wheelchair users, but requirements and specifications for these systems are not within the scope of this ~~part of ISO 10865~~ standard.

Section 10:
Wheelchair Containment and Occupant Retention Systems for Use in Large Accessible Transit Vehicles: Systems for Rearward Facing Passengers

1 Scope

This ~~part of ISO 10865~~ standard ~~is applicable~~ applies to wheelchair passenger spaces (RF-WPSs) intended for use by rear-facing wheelchair-seated occupants with a body mass greater than 22 kg~~, when travelling in accessible transport vehicles~~. It ~~is applicable~~ applies to ~~systems~~ RF-WPSs for use in large accessible transit vehicles (LATVs) used mainly on fixed route services when operated under normal and emergency driving conditions~~, where passengers are allowed to travel both sitting and standing~~. For the purposes of this standard the term wheelchair includes scooters with three and more wheels. ~~It assumes that the maximum acceleration imparted to the vehicle in any direction during emergency driving maneuvers will not exceed 1 *g*.~~

This ~~part of ISO 10865~~ standard specifies design and performance requirements and associated test methods, requirements for manufacturer instructions and warnings to installers and users, as well as requirements for product labeling, and disclosure of test information.

The primary purpose of this ~~part of ISO 10865~~ standard is to ensure adequate clearance space for wheelchair access, provide head and back support for the wheelchair occupant, and limit those movements of a rear-facing wheelchair~~, including scooters with three or more wheels,~~ that ~~may~~ can result in hazardous occupant contact with the vehicle interior or injury to other passengers.

The provisions of this ~~part of ISO 10865~~ standard apply primarily to a complete RF-WPS, but subsets of the provisions can be applied to components and subassemblies sold separately, as appropriate to the specific functions of the components and/or subassemblies they are intended to replace.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

~~ISO 7176-11, *Wheelchairs — Part 11: Test dummies*~~

~~ISO 7176-13, *Wheelchairs — Part 13: Determination of coefficient of friction of test surfaces*~~

