



Using a Wheelchair as a Seat in a Motor Vehicle: An Overview of Wheelchair Transportation Safety and Related Standards

This is EP's first installment in a six part series on Wheelchair Transportation Safety (WTS), produced in partnership with the University of Michigan Transportation Research Institute. Look for more informative articles on WTS appearing throughout 2007.

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Perhaps you've heard

the precaution that "whenever feasible, people who use wheelchairs for personal mobility should transfer out of their wheelchair into the vehicle seat or a child restraint system (CRS) when traveling in a motor vehicle and store/secure the wheelchair separately." The reason, of course, is to provide the traveler with a higher level of safety in the event of a vehicle crash or emergency maneuver through use of a seat and occupant protection system that must comply with government federal safety standards. But why is it that remaining in a wheelchair when traveling in a vehicle is less safe, and what can be

done to make travel safer and easier for those individuals who are not able to transfer? These are questions that are being addressed by researchers, safety engineers, and students in the Rehabilitation Engineering Research Center on Wheelchair Transportation Safety (RERC WTS) that has recently been funded by a five-year grant from the National Institute on Disability and Rehabilitation Research (NIDRR). This is the first of a series of six articles on the topic of transportation safety for wheelchair-seated travelers and will highlight some of the basic issues and principles that have been considered in the develop-

ment of voluntary standards for wheelchair tiedown and occupant restraint systems (WTORS) as well as for wheelchairs that are used as seats in motor vehicles.

Although our understanding of injury causation in motor vehicle crashes has grown considerably in the past 30 to 40 years, a fundamental fact remains unchanged—the primary cause of disabling and life-threatening injuries is impact of the occupant's body with the vehicle interior or, in the case of ejection or partial ejection from the vehicle, with objects outside of the vehicle. For this rea-

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son, the best way to reduce the risk of serious injuries is to prevent, or at least minimize, injurious occupant contact through the proper use of seatbelts and CRS that comply with federal safety standards and, also, to provide a vehicle interior that reduces the likelihood of serious injuries if impact occurs. It is therefore not surprising that, in spite of significant advances in vehicle crashworthiness and occupant protection systems, a large proportion of the reduction in injury risk over the past twenty years has resulted from increased use of seatbelts and CRS due both to state seatbelt laws as well as educational campaigns that have increased public awareness of the importance of using restraint systems.

In large part the higher risk of injury for wheelchair-seated occupants is because these individuals are not able to use and benefit from federally regulated seatbelt-restraint systems provided by the vehicle manufacturer but rather must use aftermarket restraint systems that are not required to comply with federal safety standards. However, a significant part of the safety problem for wheelchair-seated travelers is that most wheelchairs have not been designed or tested for use as seats in motor vehicles.

To address these needs in the absence of adequate federal legislation to address safety concerns for wheelchair-seated travelers, national and international efforts were initiated in the 1980s and 1990s to develop voluntary safety standards for WTORS and wheelchairs. In the United States, these efforts resulted in completion in 1996 of SAE* Recommended Practice J2249 Wheelchair Tiedowns and Occupant Restraint Systems for Use in Motor Vehicles, which was followed in May 2000 by completion of Section 19 of ANSI/RESNA** Wheelchair Standards, Wheelchairs for Use as Seats in Motor Vehicles, which is also known simply as WC19. Proper use of products that com-

ply with these standards, which are referred to as transportation safety technologies or TSTs, will significantly increase transportation safety for wheelchair users as well as the ease of providing effective wheelchair securement and occupant restraint.

These voluntary standards are based on three general considerations:

- ◆ Equipment must be designed to comply with basic principles of occupant crash protection,
- ◆ Equipment must be comparable in crashworthiness performance to vehicle manufacturer seats and belt restraints that comply with federal

will not add to restraint forces on the occupant, and

- ◆ Occupants should use both upper torso and pelvic belts that are designed and positioned to apply impact forces to the bony pelvis and shoulders.

Providing equipment that is comparable in performance to federally regulated equipment means that WTORS and wheelchairs must be dynamically tested using a crash dummy to simulate typical occupant movements and loading (weight) that would occur in a frontal crash. Because full-scale vehicle crash testing is very expensive, dynamic testing of WTORS and wheelchairs is performed



safety standards, and

- ◆ Equipment must be acceptable for use in all types and sizes of motor vehicles.

There are three basic principles of occupant protection:

- ◆ Occupants should face toward the front of the vehicle so that seatbelts will provide effective restraint in frontal collisions, which account for more than half of disabling and fatal injuries,
- ◆ The vehicle seat (i.e., the wheelchair) must be secured independent of the occupant so that the weight of the seat

on an impact sled in a manner similar to federal testing of child restraint systems in federal motor vehicle safety standard 213 Child Restraint Systems (FMVSS 213). As with child restraint testing, the test is conducted without other vehicle interior components for the crash dummy to interact with and, therefore, constitutes primarily a dynamic strength test of the equipment.

Testing so that equipment can be used in all types and sizes of vehicles requires that WTORS and wheelchairs be tested at crash severities appropriate for van-sized

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*Society of Automobile Engineers

**American National Standards Institute/Rehabilitation Engineering and Assistive Technology Society of North America

Wheelchair Users Speak Out About Wheelchair Transportation Safety

Jill Hindman: 13-year Paratransit Consumer Board Member for the Chattanooga Area Regional Transportation Authority (CARTA), Chattanooga, TN

Type of wheelchair used: Quickie manual wheelchair

As a wheelchair user, my biggest concerns when using paratransit are:

- 1) The quality and condition of the restraint system used in paratransit vehicles.
- 2) The competency of the drivers of the paratransit system.

It's essential that paratransit systems use restraint systems that are strong and secure as well as durable. The restraints get a tremendous amount of use and must be durable. Transportation providers need to check restraints on a regular basis and replace them before they begin to show severe signs of wear and tear.

Proper and thorough training of drivers is an absolute pre-requisite for any transportation system but is especially important when transporting those with special needs. Annual refresher classes should be given to all drivers. Having people with disabilities involved in the training of drivers is extremely helpful in order to assist the drivers in understanding the needs of passengers with disabilities.

CARTA (Chattanooga Area Regional Transportation Authority) has been a leader in the area of paratransit services for the southeastern U.S. for a number of years. Many of their drivers are current as well as retired firefighters. Having a large number of firefighters as drivers means that they are well versed in potentially stressful situations. Additionally, for over 20 years, CARTA has had a paratransit consumer board, which has acted as advisors to CARTA on all paratransit and disability related issues.



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vehicles for which severe frontal crashes are more likely. Because federal regulatory testing has historically required frontal barrier crash tests of passenger vehicles to be conducted at 30mph, the standards require that WTORS and wheelchairs are crash tested using a 30mph, 20g frontal-impact pulse similar to that used in FMVSS 213. SAE J2249 requires dynamic sled testing of the WTORS at 30mph and 20g using an 85kg (187lb) SWC to load the tiedown system and a 170lb midsize adult male crash dummy to load the restraint system. Because a four-point, strap-type tiedown is the only universal method of wheelchair tiedown that can secure a wide range of wheelchair types and sizes in public transportation vehicles and school buses, all WC19-compliant wheelchairs must provide four easily accessible securement points (two in front and two

in back) with specified geometry. The wheelchair must be crash tested with an appropriate size crash dummy that represents a person whose body frame and weight is near the maximum capacity for which the wheelchair was designed.

In addition, WC19 addresses the effective use of belt restraints in two ways. First, it requires that wheelchair manufacturers provide the wheelchair user with the option of purchasing and using a wheelchair-anchored pelvic belt that has been designed for use as an occupant restraint and crash tested in the 30mph, 20g sled impact test. This pelvic belt must include a standard pin-bushing interface for connecting a vehicle-anchored shoulder belt to create a three-point restraint system. Second, the standard requires that wheelchairs are rated (A = good, B = acceptable, and C = poor) for the ease of properly using and positioning a vehi-

cle-anchored three-point belt on the wheelchair user and that these ratings are reported in the manufacturer's brochure that is available to a buyer before purchase.

In addition to establishing design and performance requirements for WTORS and wheelchairs, both standards require that the product be labeled and that the manufacturer provide instructions for proper installation and use in motor vehicles. In particular, permanent labels must be affixed to the frame of a wheelchair as well as on any crash-tested wheelchair-anchored belt restraints to indicate that the products are WC19 compliant. Also, any wheelchair-anchored belt intended only for basic postural support must be labeled with the tagline "do not rely on for restraint in a motor vehicle."

Because these standards for WTORS and WC19 wheelchairs are voluntary, their effectiveness depends, in large part, on wheelchair buyers demanding crash-tested products. This would include everyone from wheelchair users to family members and even transportation providers like physical therapists involved in transportation of wheelchair-seated students in school buses. WTORS manufacturers have a responsibility to ensure that their products comply with the requirements of SAE J2249, but the key to providing safer transportation for wheelchair users lies with the design and performance of wheelchairs. It is therefore critical that wheelchair manufacturers and third-party payers like Medicaid and Medicare recognize that people in wheelchairs do, indeed, ride in vehicles just like everyone else and so their wheelchair will, quite likely, be used as a seat in a motor vehicle. They also need to fully understand that transportation safety for wheelchair-seated occupants depends on the wheelchair's ability to be properly secured if it is to provide effective support, and thus greater protection from injury, for the user during a vehicle collision and if it is to accommodate the easy and correct use of belt restraints. •