

Wheelchair occupant restraints in motor vehicles

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Abstract

The issue of safety for wheelchair users in motor vehicles has been raised in Australia by parents of young people with disabilities. Investigations revealed that wheelchair users were not covered by any legislated safety requirements, and each case received special dispensation from compliance with regulations covering the able-bodied population. Dynamic testing of restraint systems at the University of Michigan had revealed that existing systems were unsafe. Dynamic tests confirmed those findings on systems used at that time in Australia.

Testing led to the design, development and marketing of a new wheelchair occupant and restraint system which remains a system of choice for use by organisations where the same people use the same buses in the same position each day. Australian Standard 2942-1987, Wheelchair Occupant Restraint Assemblies for Use in Motor Vehicles, has since been developed. It establishes design and performance requirements for these restraints and includes details of dynamic testing procedures.

This paper describes the development of the above restraint system and the subsequent Australian Standard.

Background

The issue of safety for wheelchair users in motor vehicles was brought to the author's attention in 1981 by parents of children and adolescents attending his centre. Initial investigations revealed that wheelchair users were not covered by any legislative safety requirements, and each case received special dispensation from compliance with regulations covering the able-bodied population.

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An extensive programme of dynamic testing of restraint systems at the University of Michigan had demonstrated that restraints in use at that time in the U.S. were not crashworthy (Schneider et al., 1979; Schneider, 1981^{1 and 2}).

Research at several centres identified specific crashworthiness design principles for transporting people with disabilities in buses:

1. Wheelchairs should not be placed in a side facing orientation because the wheelchair user is particularly vulnerable to injury during a common frontal collision (Schneider et al., 1979; Schneider, 1981^{1 and 2}).
2. Wheelchair securement hardware must be of adequate strength to withstand forces in the order of 25 times the combined weight of the wheelchair and occupant for a very brief time (approximately 100 ms) during a collision. Results of testing indicated that the primary weakness in most securement systems was not the wheelchair but the securement hardware (Schneider et al., 1979; Schneider, 1981^{1 and 2}).
3. The wheelchair and its occupant should be secured independently; a single lap belt anchored to the floor or wall should not be used to secure both the wheelchair and the occupant, because in the event of an accident, unduly high loads would be placed on the occupant (Schneider, 1981^{1 and 2}). Loads should be applied to the pelvis and other skeletal structures of the body (Schneider et al., 1979).
4. The restraint system must be anchored to the metal frame of the vehicle, not to unsound metal, or to wood or plastic structures. Wheelchair attachments should be at tubing joints such as the seat frame/rear upright junction and not at the centres of wheelchair tubing (Schneider, 1981²).
5. An upper torso restraint is an advantage in preventing the head from hitting vehicle

structures. A broad padded head restraint can prevent backward head excursion that can result in a whiplash neck injury (Schneider, 1981²; Kallieris et al., 1981).

6. The occupant support surface, often a vinyl seat, must be in good condition.
7. Strapping one side of a forward facing wheelchair to the side of the bus is unlikely to achieve complete restraint even in a direct frontal impact (Schneider, 1981¹).

A survey of restraint systems in use at the author's centre at that time (Seeger and Caudrey, 1983) concluded that:

1. Some restraints needed to be strengthened.
2. The incidence of side facing bus seats and wheelchairs should be reduced. (Side facing bus seats and wheelchairs have since been eliminated in Australia.)
3. Much greater use needed to be made of head restraints. In a few cases lap belts were absent and were subsequently fitted.

Dynamic testing

Dynamic tests of restraint systems in local use were necessary to demonstrate the problems to management, transport officers and users. The technique of tying wheelchairs to side bars in the bus, which was in widespread use in Australia, had not been tested in any of the US tests.

Fortunately access was available to a test sled owned by a seatbelt manufacturer. In tests, all the restraints in local use were shown to be ineffective, even in moderate collisions. Another common method of fastening wheelchairs in motor vehicles was also tested; a floor pod, stem, and clamp which fastened to the wheelchair frame. It was ineffective even in a moderate collision and, in any case, was only a wheelchair restraint, not a wheelchair occupant restraint. Dynamic tests confirmed that systems used at that time in Australia were not crashworthy (Seeger, 1983).

Development of a wheelchair and occupant restraint system

A new concept was developed using standard seatbelt metal fasteners and 50mm seatbelt webbing to restrain both the wheelchair and the occupant (Seeger and Luxton, 1984). It consisted of:

- webbing floor mountings at the front uprights
- webbing floor mountings at the rear uprights

- brackets which U-bolt to the rear uprights of the wheelchair immediately below seat level (Fig. 1). When the wheelchair is not restrained in the vehicle, the left side buckle mates with the right tongue. The brackets also secure the two halves of the occupant's lap belt.

Because of the structural weakness of wheelchairs, it was recognised as unlikely that wheelchair occupants would ever be quite as safe in motor vehicles as able-bodied people in car seats. Dynamic test conditions of full adult restraints in cars were considered too difficult to attain in wheelchair occupant restraints. The system was tested therefore to dynamic test conditions based on Australian Standard 1754, Child Restraints for Passenger Car Derivatives, except that a 74 kg (50th percentile) adult male dummy was used. The system successfully restrained chair and occupant in front, side and rear impacts. An accessory webbing chest strap around the dummy and the wheelchair uprights was used in the side and rear facing tests.

The advantages of this restraint system are:

1. It is simple, unobtrusive and suitable for buses and small vehicles.
2. It is applicable to the majority of existing wheelchairs without significant modifications.
3. It is manufactured from automotive quality materials which are subject to automotive quality control procedures.
4. It is easy to install and it is recommended that relevant State Traffic Authorities check to ensure a safe installation.
5. It is easy to use since all mating parts are seatbelt tongues and buckles.



Fig. 1. Safe-N-Sound wheelchair and occupant restraint systems attached to rear upright of wheelchair.

6. It is commercially available from Safe-N-Sound for only \$A77 (1989 price) plus installation.

The disadvantages of the new restraint system are that brackets must be attached to each wheelchair using the system and there is no upper torso restraint or head restraint, although both may be fitted separately.

This wheelchair occupant restraint system remains the system of choice for use by organisations where the same people use the same buses in the same position each day.

Australian Standard 2942-1987

The Australian Standard 2942, "Wheelchair Occupant Restraint Assemblies for Use in Motor Vehicles" (Australian Standard 2942-1987; Fisher et al., 1987), was subsequently developed. The need for a Standard became very apparent, so that providers of transport for people in wheelchairs could determine if their restraint systems were crashworthy, and manufacturers could have some clear design guidelines for future restraint systems. Australian Standard 2942 has served both of these functions admirably. It establishes design and performance requirements for restraints and includes details of dynamic test conditions, clear zones around wheelchairs and occupants, and anchorage locations.

Under the Standard, a lap belt is the basic occupant restraint required, with the wheelchair restrained independently of the occupant. The Standard, instead of specifying a "standard" design for wheelchair occupant restraint assemblies, is intended to ensure effective crash protection for wheelchair occupants with a minimum of restriction on the design of the restraints. It requires that instructions for installation and use of restraints be provided. Also included in the Standard is an advisory section providing general information for restraint users, such as the types of wheelchairs best suited for use in vehicles. Australian Standard 2942 appears to be the first national Standard for wheelchair occupant restraint assemblies for motor vehicles. It has provided manufacturers with clear performance requirements and they have used it to design new systems (see Suppliers).

Further information

An informative brochure and a video titled

"Wheels on Wheels" were also produced and are available from the author at Regency Park Centre.

International Standard

An International Standard is now being drafted, based on Australian Standard 2942. Several important issues are still to be agreed on. Among them are:

- Enlargement of the standard to cover public transport, vehicle drivers and wheelchair hardware.
- Agreement on appropriate dynamic test conditions.
- Concern over the strength of wheelchair frames.
- The degree of protection offered to a person in a wheelchair in comparison to passengers in car seats.
- How best to specify allowable excursion space so that each occupant is enveloped in a safety zone.
- Possible interaction with accessory systems such as impact absorbing bumpers.
- The use of a standard test seat or wheelchairs for dynamic testing of restraint systems.
- Specification of appropriate anchorages in the vehicle.

For further information contact the author.

Suppliers

- (a) Safe-N-Sound P/L
99 Derby Road
SUNSHINE VIC 3020
Australia
Tel: (03) 311 0611
Fax: (03) 311 5798
- (b) Easy Transs
Distributor: Alexander Packaging P/L
1 Brisbane Street
ELPHIN VIC 3095
Australia
Tel: (03) 465 7411
- (c) Mobil Tech Four Point
Distributor: Maverick Motor Industries
6 Williams Avenue
EAST KEILOR VIC 3033
Australia
Tel: (03) 336 4522
Fax: (03) 336 1930

- (d) Special Purpose Vehicles P/L
31-33 Parramatta Road
LIDCOMBE NSW 2141
Australia
Tel: (02) 648 3477
Fax: (02) 648 3467

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