VII. Guidelines for WTORS Designers

The information contained within this section is intended to provide WTORS designers with guidance related to the design and performance of their product. WTORS manufacturers are encouraged to obtain the actual SAE J2249 document for a complete representation of WTORS design requirements and performance criteria. The following guidelines focus primarily on the impact loading which WTORS may encounter in a 20 g/30 mph frontal sled impact test.

Expected Tiedown Loads

Loads from the wheelchair and occupant in a crash are transmitted to the vehicle floor through the front and rear tiedowns. Rear tiedown loads are typically greater than front tiedown loads in a frontal crash. Front tiedown loads may actually peak during the rebound phase of a crash. Tiedown loads can be influenced by a number factors including the following:

- Crash Severity
- Vehicle Mass
- WTORS Configuration - Integrated vs. Independent WTORS
- Occupant and Wheelchair Weight
- Wheelchair Securement Location
- Wheelchair Stiffness Characterisitics

The information below contains tiedown loading data derived through sled testing and computer simulations. These sled tests and computer simulations are representative of the SAE J2249 20g/30mph sled impact test crash pulse (SAE J2249 Appendix A). This frontal crash pulse is representative for a paratransit type van. Larger vehicles would experienced less sever crash pulses, while smaller vehicles could encounter a more severe frontal crash pulse. WTORS loading would proportionally increase or decrease consistent with the crash severity.

The SAE J2249 sled impact test utilizes a 187 lb surrogate wheelchair occupied by a 50th percentile male, 168 lb test dummy. The wheelchair and occupant weights used in this test are intended to serve as a benchmark, although in actually wheelchair and occupant weights will vary. Figure 1 shows the influence of combined wheelchair and occupant weight on rear tiedown load as calculated through computer simulations. WTORS in this study utilized a wheelchair-mounted (integrated) lap belt. The shoulder belt was mounted to the vehicle in an independent configuration. Therefore only a portion of the occupant load is placed on the rear tiedowns in this series of simulations. Rear tiedown peak loads vary from approximately 3500 lb to 7000 when combined wheelchair and occupant weight is varied from 210 to 460 lb (see figure 13).

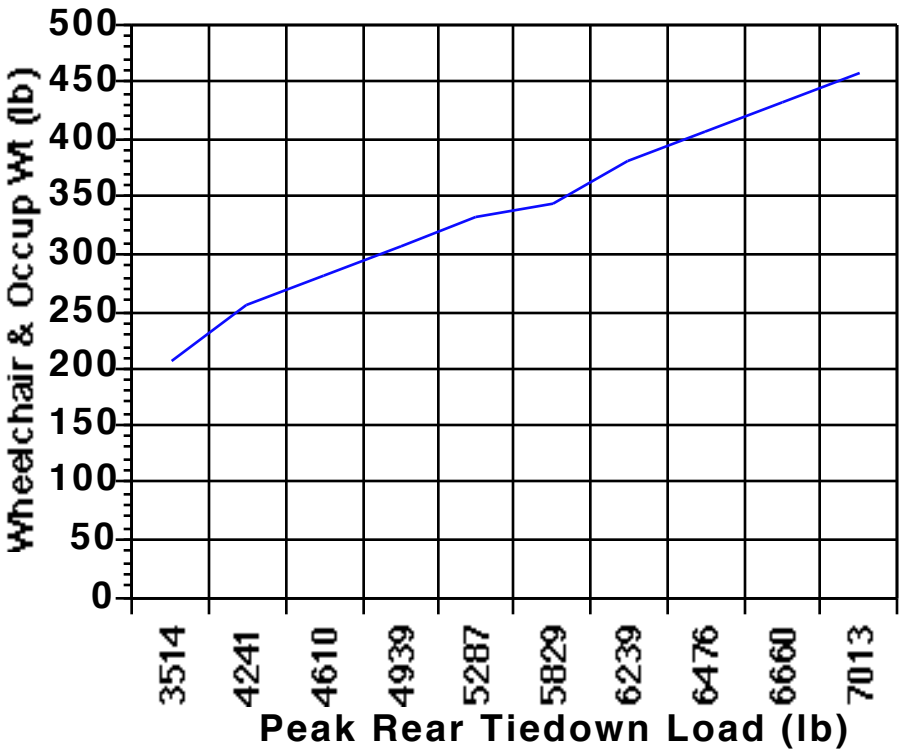

Figure 13 Rear Tiedown Loads for Varying Combined Wheelchair & Occupant Weight - 20g/30mph Frontal Crash
Note: Lap belt anchored to wheelchair, shoulder belt anchored to vehicle.

Table 7 provides loads measured through 20g/30 mph sled testing when using the 187 lb SAE J2249 surrogate wheelchair with a 168 lb 50th percentile male test dummy. Note that not all tests utilized the same WTORS configuration, i.e. integrated vs. independent restraints. As shown, rear tiedown loads vary significantly depending on whether the occupant load is transmitted through the rear tiedowns (integrated; SW 9608 & SW 9605) or directly to the floor (independent). Since the proposed ANSI/RESNA WC-19 WC Used as Motor Vehicle Seats Standard will require pelvic restraints to be anchored to the wheelchair, the combined loading of the occupant and the wheelchair will be applied to the rear tiedowns. Provisions will also be made through WC-19 to provide interface hardware on the pelvic belt which can act as the lower anchor point of the shoulder belt. Therefore, it is recommended that tiedowns be designed to withstand the combined wheelchair and occupant load.

Rear wheelchair securement point location can also influence front and rear tiedown loads. Table 7 provides tiedown forces measured through computer simulations as the rear securement point location was varied from above the wheelchair center of gravity to below the wheelchair center of gravity. As shown, tiedown loads can increase significantly when securement points are placed above the wheelchair center of gravity.

Table 7
Representative WTORS Loads for SAE J2249 20g/30mph Sled Tests

Test	WTORS Configuration	Peak Rear Tiedown Load (lb)
SW 9608	Integrated Restraint[1]	8463
SW 9605	Integrated Restraint[1]	8129
SW 9609	Independent Restraint	4810
SW 9606	Independent Restraint	4884

Note: All tests conducted using 187 lb SAE surrogate wheelchair and 168 lb ATD
Lap belt & lower shoulder belt anchored to wheelchair

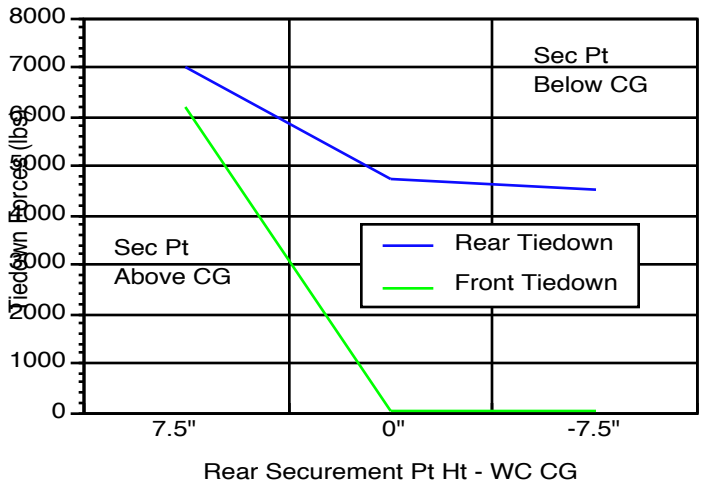

Figure 14 Rear Tiedown Load for Varying Securement Point Locations - 20g/30mph frontal crash

Predicted Occupant Restraint Loads

Occupant crash loads are transmitted to the vehicle floor either directly, or through the wheelchair or rear tiedown. Integrated restraints are anchored to the wheelchair or to the rear tiedown. Independent restraints are anchored directly to the vehicle floor. It is expected in the future that restraints will evolve to an integrated configuration since, as stated above, ANSI/RESNA WC-19 will phase-in (over two year) the requirement for wheelchair mounted lap belts which include shoulder belt interface hardware. This integrated approach will offer occupants with improved belt fit and hence, more effective occupant protection.

Some of the same factors which influence tiedown loads also affect occupant restraint loads. For example, increased crash severity will lead to increased occupant restraint loads. Therefore, for a given crash and occupant weight, occupant restraint loads are likely to be higher in a passenger car than in a large transit bus. Occupant weight largely

influences the loads placed on restraints. In a given crash, children will apply less load to restraints than an adult.

The SAE J2249 20g sled impact test utilizes the 50th percentile male, Hybrid III anthromorphic test device (ATD) which weighs 168 lb as the benchmark occupant. Table 8 provides lap and shoulder restraint load data as measured during ten 20g/30mph frontal crash sled tests which utilized the 168 lb Hybrid III ATD.

Table 8
Representative Occupant Restraint Loads - 20g/30mph Frontal Crash

	Shoulder Belt Load	Lap Belt Load
# of Measured Values	10	8
Mean Load	2110 lb	2160 lb
Standard Deviation	290	470
Minimum Load	1810 lb	1560 lb
Maximum Load	2800 lb	2920 lb

As described through the sled test and computer simulation generated measures, tiedown and occupant restraint loads can fluctuate significantly depending upon conditions. That is, crash severity, vehicle size, wheelchair and occupant weight, restraint configuration, wheelchair stiffness, and securement point location can all influence the resulting loads placed upon WTORS. Load data provided above is intended only as guidelines for WTORS designers, as actual loads may vary. The SAE J2249 sled impact test used to evaluate WTORS crash performance is a benchmark that is important to assure a predicted level of performance for consumers selecting WTORS. Designers are encouraged to anticipate the evolving and future demands, such as trends in increased power wheelchair weight and totally integrated occupant restraints when designing their products.