C5 Seat Belt Forces in Rear Impact Crashes With Seatback Collapse

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After attending this presentation, attendees will understand what happens to an occupant during a seatback collapse and will also understand the magnitude and timing of the belt forces relative to the occupant kinematics and injury causation.

This presentation will impact the forensic community by informing attendees about the forces that develop in seat belts during a rear impact with seatback collapse, the lack of restraining force offered by seat belts in this situation, and hopefully put to rest the misconception that seat belts are effective in seatback collapse accidents.

This presentation examines the seat belt loads for a properly restrained occupant involved in a rear-end collision when the occupant's seatback collapses.

Previous research examined the static effects of occupant girth measurements and slack introduced into the seat belt. The results showed that three-point restraints were not effective in providing restraint when seatback collapse occurs, and that the ease with which the occupant escaped the belt increased with larger abdomen and/or chest circumference. This study examines the dynamic response of the three- point restraint and the occupant during rear-end accidents with seatback collapse.

According to Newton's Laws of Motion, an occupant in a vehicle involved in a crash tends to continue along their pre-impact velocity vector. That is, in a rear-end impact the occupant must be accelerated by the seat. Relative to the vehicle, the occupant moves rearward into the seatback as the vehicle is accelerated forward beneath them. For a pillar-mounted seat belt, the occupant is moving away from the shoulder harness portion of the seat belt. Under normal conditions, their rearward motion would continue until accelerated to the vehicle velocity by friction with the seat bottom and contact with the seatback and head restraint. When the seatback deforms rearward, the occupant's motion is not arrested and he "ramps" up the seatback. Dangerous "ramping" occurs when the structural failure of the seat increases the angle of the seatback with respect to the occupant. Once the seatback angle changes significantly, the occupant can no longer be fully supported and contained by the seat. Head/shoulder impacts with the rear seat or rear interior vehicle structures, as well as ejection, can occur when an occupant has slid out from beneath their lap and shoulder harness system. Often in these cases, belt usage comes into question.

This study also examines data from a series of 9 sled tests run by Sacalzski and Pozzi. The sled tests were simulated rear impacts with ΔVs varying between 10 to 30 mph. The size of the test dummies ranged from a 5% female to a 50% male weighted to 240 pounds. In these tests the driver's seat was a "weak" seat with a pillar mounted belt while the passenger seat was a much stronger all-belts-to-seat (ABTS) seat. These tests dynamically demonstrate the ineffectiveness of three-point restraints when seatbacks collapse and the resulting injurious occupant kinematics. Belt loads measured during the tests were between 400 and 2100 Newtons. Data plots from these tests clearly demonstrate that the peak seat belt loads occurred 25 to 75 ms after the peak head and neck loads. Thus, the peak belt loads are occurring during the rebound phase of the occupant kinematics, and do not prevent serious head/neck injury resulting from body contact with interior vehicle structures behind the occupant. Data from a frontal NCAP crash test is also presented as a basis for comparison.

Two case studies are presented. In the first case, the driver was ejected when his seat back collapsed and his vehicle subsequently rolled. Seat belt usage was in question. Load marks on the seat belt and photographs from first responders demonstrated that the occupant was initially restrained and slipped out from under his seat belt. In the second case, the belted occupant also slipped under his belt when his seat back collapsed. An analysis with a surrogate occupant in an exemplar vehicle was used in conjunction with the MADYMO computer program to model the occupant kinematics and belt loads experienced during this rear impact where an occupant slipped out from under their restraint. The motion of the occupant in this simulation matched the forensic evidence and statements. The MADYMO results are also consistent with the dynamic test results showing that peak belt loads occur after the peak head and neck loads.

Seat Belt Loads, Rear-End Impact, Seatback Collapse

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