C7 Seat Failure Evidence in Rear Collisions

Mark C. Pozzi, MS, Sandia Safety Sciences, 2 Marietta Court, Suite A, Edgewood, NM 87015; and Kenneth J. Saczalski, PhD, Environmental Research and Safety Technologists, 1440 West Bay Avenue, Newport Beach, CA 92661*

After attending this presentation, attendees will have an understanding of forensic evidence that typically occurs when seats fail during rear impact. This will cover not only various failure modes of seats, but the evidence created by vehicle occupant contact with failed seats and various structures within vehicles.

This presentation will impact the forensic community by showing how to determine if a seat failure has occurred, as well as how a vehicle occupant moved out of their designated upright seating position as a result of that seat failure.

This study involves analysis of evidence created during rear impact laboratory testing of vehicles as well as forensic evidence found on seats and vehicles during field investigations. There have been static and dynamic tests conducted on vehicles, including seats and restraint systems for over 40 years. This includes testing per the minimum requirements of FMVSS 207 and 301-75, as well as research into vehicle crashworthiness and occupant protection effectiveness of various seat and belt combinations. Various types of seat failure, vehicle deformation, and occupant contact witness marks on vehicle structures are demonstrated. Despite the foregoing decades of testing and research proving the need for crashworthy seats and effective restraint systems in rear impact, there still are no government or industry occupant protection standards for rear impact.

The foregoing laboratory studies are compared with field investigations involving rear impacts. Seat failure modes, vehicle intrusion effects, and occupant contact witness marks are analyzed. In several instances there are direct comparisons between evidence found in field investigations and laboratory studies performed to demonstrate the circumstances of the collision. This includes side by side demonstrations of various seat and seat belt designs under identical collision circumstances. These side by side comparisons involve small adult females, average adult males, and heavy adult males. There are also depictions of the effects of these various seat failures on rear seat occupants, including children.

These laboratory and field studies have demonstrated numerous random modes of seat failure in foreseeable rear collisions. One common type of production seat has demonstrated at least seven failure modes. These include failures of seat tracks to floor pan attachments, separation of seat track longitudinal members, disengagement of seat track latches, separation of seat cushion frames from seat tracks, tearing of seat cushion frames, shearing of recliner-to-frame mounting bolts, fracturing of recliner frames, shearing and disengagement of recliner gears, bending of seat cushion frames and seatback frames, tearing of seatback frames, disengagement of adjustment pawls on electrically powered seats, failure of head restraints to remain attached, and pull-out of pin-and-socket hinges.

There is also depiction of fracture and dislocation of plastic rear seats, latch failures of rear seatbacks, and intrusion failures of rear seat structures by cargo. Evidence seen on alternative design seats, including belt integrated seats, is shown.

Seat belt witness marks found during laboratory crash tests and sled tests is demonstrated in conjunction with instrumentation data showing peak belt loads. Dummy contact marks and deformation from head and shoulder impacts into rear seats and other vehicle interior structures is depicted. This includes permanent deformation of rear seat structures correlated with dummy loads.

Comparison of head restraint interaction with occupants in collapsing and non-collapsing seats is shown. Typical collapsing seats show no interaction with occupant head or neck structures prior to seat collapse. This demonstrates that occupants in collapsing seats will typically only interact with head restraints from the mid-thoracic level downward, as they are ramping up the seatback and being ejected rearward.

Drag marks on seatbacks from occupant loading is shown, including correlation with vehicle Principal Direction of Force and evident occupant contact areas. Typical occupant head and shoulder impact marks, skin transfers, hair and fiber deposits, and other related evidence are shown.

Dynamic evaluation of conventional seat belts combined with collapsing seats shows lap belts typically slipping to lower thigh or knee level. Biomechanical studies have shown predictable levels of seat belt slack created by seat back collapse, even under static conditions. Under dynamic loading, these effects are exacerbated. As a result, it is common to find no load marks on seat belts in rear impacts due to the negligible loads imparted by an occupant that is falling away from the belt.

Rear Impact, Seat Failure, Occupant Witness Marks

 ** Presenting Author*