D4 Ejection of Belted Vehicle Occupants Due to Seat and Belt Failure in Rear Impacts

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The goal of this presentation is to inform attendees how and why restrained vehicle occupants can be partially or completely ejected from vehicles as a direct result of seat failure which can also cause failure of vehicle-anchored seat belts by causing excessive belt slack.

This presentation will impact the forensic science community by illustrating how seat belts can be defeated by weak seats in vehicles. Defeat of the seat belts can lead to the partial or complete ejection of initially restrained occupants.

Seat belts, seats, and head restraints are equally critical components of vehicle occupant protection systems. Based on human tolerance testing, Federal Motor Vehicle Safety Standard (FMVSS) 210 requires lap/torso belts to withstand 6,000 pounds of forward static load. Belt webbing and anchorages therefore are rarely overloaded in survivable front and side collisions. At 30mph ΔV, only 1" of belt slack increases vehicle occupant injury by 50%, and 4" of belt slack is equivalent to being unbelted. Pretensioners may minimize belt slack in frontal impacts where airbag deployments occur. Pretensioners rarely activate in rear impacts and have proven to be inadequate to provide belt effectiveness if significant seat deformation occurs.

Vehicle manufacturers warn against adjusting seats when vehicles are in motion because of increased injury risk and decreased effectiveness of seat belts. FMVSS 207 requires less than 300 pounds static load capacity for seats and does not consider human tolerance to impact or presence of an occupant in the seat. No occupant protection requirements exist for rear impact or rollover. Therefore, seats, head restraints, and seat belts predictably fail in moderate rear impacts and rollovers. When a seat fails rearward, head restraints cannot function and dangerous amounts of slack are created in any vehicle-anchored seat belt system, rendering the belt ineffective in exactly the manner warned about by manufacturers. Seven to 14 inches of static belt slack is created solely by recline of the front seat. Many vehicles allow ten or more inches of additional rearward belt buckle displacement. Any of these belt-slackening mechanisms created by seat failure will allow the lap belt to easily slip off the pelvis, negating any effective restraint. Mis-positioned lap belts cause serious or fatal injury from submarining as well as partial or complete ejection in subsequent collision or rollover. In 1967 FMVSS 209.4.1, it is required that lap belts remain on the pelvis at all times during collision or rollover. Despite objection from the National Transportation Safety Board (NTSB) and others, and decades of consistently poor crash test results proving this danger, in 1998 vehicle manufacturers successfully petitioned the United States Department of Transportation to rescind this critical dynamic seat belt performance requirement. No conceivable benefit to motorist safety occurred.

This study shows how and why predictable seat/head restraint failure and resultant dangerous seat belt slackening have allowed partial and complete ejection of belted occupants in crash testing and real-world collisions and rollovers. There have been numerous crashes and rollovers investigated for this study where belts were properly worn and seats were upright prior to the crash. The belts remain buckled but due to seat failure and belt slack the occupant was ejected either into the rear interior, other occupants, and/or completely out of the vehicle. In several instances, lighter-weight occupants, or similar-size occupants who loaded into stronger seat structures, were effectively restrained and protected by seats and head restraints that remained upright and belts that therefore remained effective. Published crash and sled test research since the 1960s has consistently demonstrated that when seats fail, no effective lap belt loads are generated prior to occupant contact with either the rear seat, other occupants, and/or ejection from the vehicle.

Effective countermeasures which prevent seat and belt failure are presented in this current study, utilizing recent dynamic side-by-side testing of crashworthy seats and head restraints, resulting in belts that function as intended. This is compared with O**riginal Equipment Manufacturer** (OEM) collapsing seats, head restraints, and resultant slackened seat belts that allow ejection. There is also comparison of biofidelic dummies having articulating pelvic and leg structures with non-biofidelic dummies that artificially snag lap belts.

The forensic community will benefit from this presentation by learning how to recognize forensic evidence associated with seat and belt failure, including deformation and witness marks on vehicle interiors, seats, and belts. Investigators will learn how and why ejection of belted occupants readily occurs in passenger cars, vans, and light trucks. Fatal injuries have occurred to such occupants while those in upright seats beside them were unhurt.

Vehicle Occupant Ejection, Seat Failure, Seat Belt Failure