C40 Determination of Seatback Movement Thresholds Resulting in Hazardous Amounts of Vehicle-Anchored Seat Belt Slack

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

After attending this presentation, attendees will understand the phenomenon of how and why vehicle-anchored seat belts are rendered ineffective due to slackening as a result of rearward seat deflection. Techniques for assessing this hazard and determination if belts were worn despite the occurrence of occupant ejection will be demonstrated. Lack of knowledge about this hazard has led to incorrect assessments of seat belt usage, pre-impact seat position, and driver identity.

This presentation will impact the forensic science community by providing critical information about a significant vehicle hazard which is not adequately addressed by existing motor vehicle safety standards or auto industry practices, and which affects the safety of both front and rear seat occupants.

Dynamic vehicle testing proved in the 1980s that 1" of seat belt slack increases injury by 50% and 4" of slack is essentially the same as being unrestrained in a frontal crash. Collapsing seats typically create 7-14" of vehicle anchored belt slack in rear impacts. Auto manufacturers warn against voluntary seat back or seat track movement when vehicles are in motion because seat movement can lead to a reduction in seat belt effectiveness and increased risk of injury, but most seats and belts cannot prevent these hazards. Crash safety research has proven that conventional belts are not effective at providing occupant restraint in rear impact or rollover crashes where significant seat back deformation and/or seat track movement has occurred. When seat backs reach 40-45 degrees aft of vertical, they can no longer provide effective restraint in a rear impact or rollover, and vehicle occupants begin ramping up the seat back and out of their belts. Seat and belt research by University of California, Los Angeles (UCLA) and the National Highway Traffic Safety Administration (NHTSA), as well as more recent research by Ward, Pozzi, Saczalski, et al., has repeatedly proven this in dynamic testing as well as field investigations. Testing to determine specific amounts of belt slack relative to seat back displacement involved determination of unloaded belt slack generated as a result of maximum available seat back recline, without buckle movement, with various-size adult human surrogates. This proved that larger occupant torso circumference (especially in females) tends to generate the greatest amount of belt slack when the upper torso falls away from the torso belt as a result of seat back movement. The resultant torso belt slack is then free to pass to the lap portion of the belt, especially if belts are equipped with pass-through latch plates. Rearward movement of buckles and hardware causes additional belt slack. Belt slack and rearward hardware movement as a result of seat deformation are contrary to the original intent of FMVSS 209, Section 4.1, which required that the lap belt remain on the pelvis at all times during collision or rollover. This is a well-recognized essential foundation for any effective belt restraint system. It is not good safety practice to knowingly design and install weak seats which will predictably create dangerous seat belt slack under foreseeable impact loading, contrary to warnings to vehicle occupants.

The purpose of this study was to scientifically determine whether lesser amounts of seat back movement can create significant slack in conventional belts which would significantly increase the likelihood of occupant injury and/or ejection. Front bucket seat backs in various vehicles were initially positioned at the full upright adjustment position, approximately 23 degrees aft of vertical and the seat track in a position to allow comfortable surrogate hand and foot contact with the vehicle controls. The surrogate entered the seat and applied the seat belt properly with available retractor tension and no slack. The seat belt was then clamped at the B pillar "D" ring to simulate retractor lock-up and prevent any further movement of the webbing. The seat back was reclined until the surrogate could consistently create sufficient slack to slide rearward up the seat back and out of the lap belt. The seat back deflection, belt slack, and occupant movement potential relative to the lap belt and vehicle interior were documented. Testing showed that static seat back deflection approximately mid-way between upright and full reclined would generally result in sufficient belt slack to allow complete ejection of the belted occupant out of the restraint system. A typical front seat back reclines from approximately 23-25 degrees to 45 degrees or more aft of vertical, with an approximate movement range of 20-22 degrees or more. The "threshold" of 10-12 degrees of static seat back deflection appears sufficient to disable many conventional vehicle-anchored belts.

Rear Impact, Seat Belt Slack, Seat back Movement

 ** Presenting Author*