D24 Driver Seat and Fuel System Failure in a Rear-End Collision

Kurt D. Weiss, MS, Case Study Collision Science, LLC, Santa Barbara, CA 93190; Mark C. Pozzi, MS*, Sandia Safety Sciences, Edgewood, NM 87015*

Learning Overview: The goal of this presentation is to share with the forensic science community the detailed methodology used to reconstruct a two-vehicle rear collision and to demonstrate the tear-down and examination of a Sport Utility Vehicle (SUV) seat assembly and fuel system that failed. Occupant kinematics analysis and alternative designs to prevent the failures and injuries will be presented.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating the failure mode of a common SUV seat structure that rendered the lap/shoulder belt ineffective, and multiple fuel tank failures that resulted in the predictable catastrophic injury of a driver in a moderate rear-end collision. Loss of survival space of rear seat occupants, especially children, is also demonstrated.

Collision Overview: A stationary 2004 Jeep® Wrangler® was struck from behind by a 2005 Ford® F150 and propelled forward approximately 100 feet into a pole. As a result, the Jeep® spewed gasoline from its ruptured, fully crushed fuel tank and the driver seat back collapsed and rotated rearward, allowing rearward driver ejection and forceful head contact into the rear compartment. The driver's head strike resulted in cervical spinal trauma and permanent paralysis.

Physical Evidence: Vehicle examination showed an offset distance of approximately 21 inches between the Jeep® and F150 centerlines at impact. The Jeep® sustained an average rear crush of approximately seven inches. The Jeep® frontal airbags did not deploy. The Jeep® driver's shoulder belt, found wrapped around his lower legs, caused police to misinterpret belt use and placement.

Reconstruction: The vehicle crush profile, weights, and stiffness coefficient analysis demonstrated a F150 impact speed of approximately 41mph and Jeep® velocity change of approximately 26mph with a Principle Direction Of Force (PDOF) of 6 o'clock during the rear impact and approximately 15mph impact of its right front corner into the pole.

Injury and Occupant Kinematic Analysis: In the rear impact, the properly lap-shoulder belted driver slid rearward relative to his vehicle interior, ramped up his collapsing seat back, struck his head in the rear compartment, and was partially ejected through the rear window. When this occurred, his safety belt was no longer in contact with the body it was designed to protect. The safety belt pass-through latch plate allowed webbing transfer from the shoulder belt to the lap belt, contributing to the ineffectiveness of the safety belt. The driver's catastrophic neck injury and paralysis was the direct result of the identified seat failures.

Vehicle Defects: Fuel system and seat defects were identified. The aft-of-axle fuel tank breach and filler neck separation with no check valve resulted in catastrophic fuel leakage. Spilled fuel failed to ignite into what most likely would have been a fatal fire. The fuel system in the rear crush zone was the same as the 1960's design. The driver's seat revealed predictable catastrophic buckling of seat recliner mechanisms at large lightening holes and adjacent weak structures. Static testing of the Original Equipment Manufacturer (OEM) and modified OEM seats replicated this failure mode and demonstrated inadequate seat strength to absorb predictable occupant loads in moderate rear collisions.

Alternative Designs: Alternative fuel tank and seat designs were identified and shown to be capable of preventing rearward occupant ejection and catastrophic injury. These designs were available and technologically and economically feasible at the time the vehicle was designed and produced; in fact, these alternate designs were installed by the same automaker in other model vehicles. Absent these defects, the driver seat back would not have rotated rearward, his safety belt would have effectively coupled him to his seat, he would not have ramped up his seatback, there would have been no head contact with the rear occupant compartment, and, therefore, there would not have been injurious neck loading and residual paralysis. Implementation of alternative designs would have prevented the observed failures and injuries.

Conclusion: In this crash, the Jeep® demonstrated foreseeable failures of the fuel system and weak driver seat structure resulting in catastrophic injury. Implementation of available, and technologically and economically feasible, alternative designs would have prevented these failures and resulting injury. Principles of crashworthy seats, fuel system design, and preservation of survival space were known to automakers and the Department Of Transportation (DOT) since mid-1960s.

Seat Failure, Fuel System Failure, Rear-End Collision

*Presenting Author