D27 A Forensic Performance Analysis of Load-Limiting Devices in Automotive Seat Belt Retractors

Louis Daulerio, BA, ARCCA, Inc, 2288 Second Street Pike, PO Box 78, Penns Park, PA 18943; Gary Whitman, BS, ARCCA, Inc, 2288 Second Street Pike, PO Box 78, Penns Park, PA 18943; Alan Cantor, BS, ARCCA, Inc, 2288 Second Street Pike, PO Box 78, Penns Park, PA 18943; Larry Sicher, BS, ARCCA, Inc, 2288 Second Street Pike, PO Box 78, Penns Park, PA 18943; and Mike Markushewski, BS, ARCCA, Inc, 2288 Second Street Pike, PO Box 78, Penns Park, PA 18943*

After attending this presentation, attendees will better understand the design and operation of automotive occupant safety restraints. Specifically, attendees will better understand the load-limiting device found in most modern automotive safety belt restraints.

This presentation will impact the forensic science community by providing a key aspect of forensic investigations and analysis of occupant safety belt restraints involved in automotive crashes.

The primary function of an automotive safety belt restraint system is to restrain the occupant within the vehicle's occupant compartment. The primary requirements of any occupant restraint system are: (1) to prevent ejection of the occupant, both partial or total, from the vehicle; (2) to prevent or minimize severe interior impacts of critical body areas with surfaces within the vehicle; and, (3) to control the occupant's kinematics in such a way as to load the body through the strong skeletal structures of the body that are most capable of withstanding the loading.

As such, the safety belt should be designed to apply loads to the body of the occupant through the clavicle, sternum, ribs, and pelvis. By using these robust structures within the body, and by optimizing belt elongation, properly designed lap and shoulder belts have been able to strike a balance between neck loading and the potential for severe interior strikes that body movement can cause in many crashes. The introduction of frontal airbags for front seat occupants, along with pretensioner devices to more effectively couple the occupant to the vehicle, provided an additional opportunity to the safety belt designers to address thoracic injuries that can be caused by the safety belt loading and thus provide added protection for the frailer segments of the population. This led to the introduction of safety belt load-limiting devices, which were intended to reduce belt loading while still maintaining proper restraint protection. Unfortunately, the implementation of these devices in some circumstances increased the potential of injury from head impact, ejection, and submarining.

This presentation focuses on the trade-offs involved in the effective design of such load-limiting devices (i.e., the reduction in maximum loading to the occupant versus the corresponding increase in safety belt webbing and subsequent occupant movement). Obviously, if the additional webbing introduced is not controlled properly, the risk of injury to the occupant is greatly increased and could result in more frequent and severe injuries rather than the reduction intended. This presentation assesses the amount of additional webbing introduced by the activation of the load-limiting device by forensic analysis of the affected safety belt and its components involved in real-world crashes.

Crash, Restraints, Load Limiters

*Presenting Author