C9 Identification of Airbag Design Features That Adversely Affect Injury Potential

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The goal of this presentation is to address how some airbag designs adversely affect occupant injury potential. Attendees will learn about pro- duction airbag system components, as well as airbag-associated injury pat- terns that have been attributed to those components.

This presentation will impact the forensic community and/or humanity by increasing knowledge of airbag design and by showing how visual inspection and experimental studies demonstrate the adverse inter- action between some production airbags and the occupants they are designed to protect.

Laboratory testing and field studies of real-world crashes clearly support the effectiveness of airbags to mitigate injury. However, airbags are also known to produce injury. Crash statistics and case studies doc- ument the following airbag-associated injuries:

- head and facial injuries (diffuse axonal and brainstem injuries, basilar skull fractures, ocular and TMJ injuries, and thermal burns),
- neck injuries (atlanto-occipital joint extension injury),
- chest injuries (rib fractures, lung contusion, aortic tears, and cardiac injuries), and
- upper extremity fractures.

Out-of-position occupants are particularly susceptible to airbag-asso- ciated injuries due to their proximity to the deploying airbag.

The airbag restraint system is designed to limit the forces exerted on the human body and control occupant deceleration during a motor vehicle crash. The basic components of the airbag restraint system include:

- the crash sensor,
- the diagnostic package for determining operability status, and
- the airbag assembly.

The airbag assembly consists of:

- the inflator,
- the module, and
- the bag.

The purpose of the sensor is to detect the impact. The diagnostic package determines operability status and provides the triggering signals to activate the inflator. The purpose of the inflator is to inflate the airbag. The module is simply the storage container for the airbag and inflator compo- nents.

Extensive research of airbag-associated injuries has led to the identi- fication of the following design parameters that affect injury risk: number and type of sensors, sensor location, and single versus multi- deployment thresholds,

- number and type of inflators,
- module cover size, tear pattern, and material properties,
- deployment location and direction, and
- airbag fabric, volume/size, shape, vents, tethers, aspirations, and folding pattern.

These design features dictate airbag performance (e.g., deployment timing, leading edge deployment speed, maximum excursion, steering column force).

The airbag sensors can lead to injuries when premature or late deployment occurs. Injuries have also been attributed to single-stage inflators, which trigger fast aggressive deployment in both low and high severity impacts. Head and arm injuries have been attributed to forceful module cover contact and related to its tear pattern and stiffness. The airbag deployment location and direction primarily influences passenger- side injury potential. Burn injuries are attributed to the airbag vents. Ocular injuries and arm fractures have been attributed to the absence of tethers (i.e., straps that connect the front and back airbag surfaces, limit the airbag excursion and deployment speed, and control the inflated bag shape and size). Specific folding patterns have been found to contribute to occupant eye injury potential.

Forensic analysis of airbag-associated injuries sustained in real-world crashes requires knowledge of these design features, as well as the perfor- mance characteristics of the subject vehicle airbag. However, the avail- ability of this information to the public is very limited. Since many manu- facturers offer "new and improved" airbags to replace deployed airbags, undeployed airbags acquired from salvaged vehicles have been found to be appropriate, if not optimum, specimens for inspection and testing. Many airbag design features can be identified by disassembly and visual inspection of undeployed salvaged airbags. Other design features, as well as performance characteristics, must be determined from static deployment testing. Multi-stage inflator designs are identified using the vehicle service manual or visually upon removal (e.g., dual-stage inflators have two wire connectors attached to the airbag module, and single-stage inflators have one connector attached to the airbag module). In static deployment tests, driver-side airbags are mounted to a steering wheel fixture and passenger- side airbags are mounted in the vehicle. Dynamic deployment character- istics are determined from full-scale frontal crash testing. High-speed films allow qualitative and quantitative comparisons of airbag designs.

Airbags, Injuries, Design

