C20 Forensic Testing of Shared Anchor Seat Belt Components

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After attending this presentation, attendees will understand how inadequately designed seat belt components, while saving production costs, can significantly reduce the ultimate strength of the assembly in real world traffic accidents.

This presentation will impact the forensic community and/or humanity by demonstrating how inadequately designed restraint systems can fail in real world traffic accidents.

THEORY OF THE ANALYSIS: Seat belts remain the primary safety device in reducing the risk of ejection in motor vehicle collisions. Ejection increases the risk of serious injury by a factor of 4.5. Pursuant to federal safety standards, hardware for the type 2 upper torso restraint shall be designed and located in the seat belt assembly such that the possibility of injury to the occupant is minimized. However, in real world accidents, it has been observed that some seat belt designs can be inadequate. Failure of seat belts can render vehicle occupants unrestrained, thereby increasing the risk of serious injury and ejection in rollover collisions.

A passenger van with seven occupants was traveling at highway speeds. Suddenly, an impact by a vehicle traveling in the same direction sent the van out of control. The van yawed clockwise, rolled over multiple times, and came to rest in the shoulder. Two rear seat occupants were ejected, one suffering severe head and chest injuries.

Inspection of the two adjacent seat belts revealed physical evidence confirming that the rear occupants were wearing their lap and shoulder seat belts at the time of collision. It was found that both seat belt buckles were designed to be secured to the seat frame by a single webbing strap passing through one bracket. However, it was determined that the stitching used to assemble the component failed, releasing the buckles from their anchorage.

Documentation of the history of this shared anchor component showed there was a design change during the vehicle production run. The former component design used two similar buckles, each attached to an anchor bracket with independent webbing straps. With this design, occupant loading was transferred through the webbing strap to the bracket attached to the seat frame. The redesigned buckle component uses one piece of webbing to attach two buckles to one anchor bracket. The webbing is routed through the two buckles and bracket, and the layers of webbing are stitched together. Documents show this redesigned component produced a 10¢ per end item savings, or a 24¢ per vehicle savings. However, the ultimate strength of the redesigned component is decreased by virtue of the stitching configuration used to assemble the component.

A series of twelve tension tests was conducted on new and used samples to evaluate the effect of loading angles on the failure strength of these two shared anchor component designs. The loading angle is defined as the included angle between the force vectors directed along the individual webbing straps of the adjacent seat belts. Three samples each were tested at loading angles of 60, 90, 120, and 180 degrees.

A rigid beam fixture was fabricated to establish the webbing strap angles of 60, 90, and 120 degrees. The buckle component was secured to the test bench using the factory original anchor bracket. To apply tension to the component, a latch plate was inserted into each buckle, and webbing routed through the latch plate was held by a split-drum grip as specified under FMVSS 209. The rigid beam was attached to the crosshead of an Instron tension-compression machine, and raised at a constant rate of 100 millimeters per minute.

The rigid beam was not used for the 180 degree loading angle. For this loading angle, a latch plate was inserted into each buckle, and webbing routed through the latch plate was held by split-drum grips. One split-drum grip was secured to the test bench. The other web grip was attached to the crosshead, and raised at a constant rate of 100 millimeters per minute.

At a 60 degree loading angle, the former component design did not fail during the test, while the redesigned component failed at an average force of 11,899 Newtons. At a 90 degree loading angle, the former component design did not fail, while the redesigned component failed at an average force of 6,592 Newtons. At 120 degrees, the former component design did not fail, while the redesigned component failed at an average force of 4,467 Newtons. Lastly, at a loading angle of 180 degrees, the former component design failed at a force of 22,153 Newtons, whereas the redesigned component failed at an average force of 2,169 Newtons.

Component designs can significantly effect the strength of seat belt attachments. The test series established that some designs reduce the strength of the seat belt so much they no longer satisfy the FMVSS 209 requirement for webbing breaking strength. Inadequate designs can result in restraint failure when the shared anchor component of adjacent seat belts are loaded with reasonably anticipated forces. Designers and manufacturers must consider failure mode effects analyses before implementing a component design change in order to reduce production costs.

Seat Belt, Anchorage, Testing

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