C5 End-Release Buckle Shock Testing

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Certain end-release safety belt buckles experience un-commanded unlock and unlatch during motor vehicle accidents. The goal of this presentation is to describe a simple method of finding the susceptibility of these end-release safety belt buckles to unlatch due to vertical acceleration. This hypothesis was tested to confirm that these buckles do exhibit un-commanded unlock and can and will unlatch in real-world rollover collisions.

This presentation will impact the forensic community and/or humanity by demonstrating When a seat belt restraint is found to be unlatched after a vehicle rollover event or a vehicle has sustained an upward vertical impact the authors recommend that accident investigators inspect the buckle design and its mounting method to find out if shock-related buckle unlatching occurred.

Certain end-release safety belt buckles experience un-commanded unlock and unlatch during motor vehicle accidents. This presentation describes a simple method of finding the susceptibility of these end-release safety belt buckles to unlatch due to vertical acceleration. This hypothesis was tested to confirm that these buckles do exhibit un- commanded unlock, and can and will unlatch in real-world rollover collisions.

The analyzed buckle is a common end-release buckle design described in U.S. Patent 4,575,907 issued on March 18, 1986. This buckle design has a sliding plate described as a “slideable control member,” which is “engaged between a portion of frame and the latch portion to positively lock the latch plate in the latched position.” In this design, a spring-actuated sliding plate sits atop a pivoting latch. In the unlatched position, two projections on the frame sidewalls limit upward movement of the sliding plate. When the latch plate is inserted, the latch pivots into a rectangular hole in the latch plate. This frees the spring- actuated sliding plate to move upward beneath the same two frame projections and, according to the patent, “positive locking of the [latch] in the latched position is very simply accomplished.” A tension spring attached to a bent arm on the latch accomplishes engagement of the sliding plate. When the latch plate is inserted, and the sliding latch plate is sandwiched between the latch and the frame projections, this tension spring is fully relaxed.

There are three methods of attaching safety belt buckles to a vehicle’s structure: cable, webbing, and rigid element. Of the three, the rigid element transmits the most shock upward from the vehicle during a rollover or when an object strikes the vehicle’s frame from underneath. The analyzed buckle design is from a vehicle using the rigid element attachment method.

An upward acceleration transmitted to the buckle frame allows the sliding plate to move downward with respect to the frame, unlocking the latch. This can allow the latch to pivot into the unlatched position, releasing the latch plate. To prove this, a drop fixture consisting of a sliding carriage spanning two vertical linear shafts was constructed. Elastometric pads beneath the carriage were used to shape the acceleration pulses, and a data acquisition system was used to record the shock pulses.

Each exemplar buckle, with latch plate inserted, was bolted in its normal position with respect to the test carriage. The buckle-mounting tang was vertical, allowing the buckle body to tilt inward (toward the occupant) by about 8 degrees. This represents the as-built configuration in a vehicle.

There were 446 tests with drop heights that produced approximately 8-millisecond total pulse lengths with maximum accelerations that ranged from 166 g peak at 2.9 m/s to 347 g at 4.25 m/s resulted in latch plate release for 120 tests. Different drop heights and elastometric pads with varying hardness also resulted in latch plate release.

A matrix of drop heights, buckle angles, and acceleration impulses using 20 buckles gives a range of conditions at which this buckle design will release. High speed video of tests with the buckle mechanism revealed show how the sliding plate moves downward, unlocking the latch.

When a seat belt restraint is found to be unlatched after a vehicle rollover event, or a vehicle has sustained an upward vertical impact, the authors recommend that accident investigators inspect the buckle design and its mounting method to find out if shock-related buckle unlatching occurred.

Buckle, Unlatch, Shock

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