## C12 Causation and Consequences of Spring Failure in RCF 67 Buckles

*Richard H. McSwain, PhD, PE**, Mark B. Hood, BSME, PE, William D. Carden, MSME, PE, and Eric .L Van Iderstine, BSME, PE, McSwain Engineering, Inc., 3320 McLemore Drive, Pensacola, FL 32514*

After attending this presentation, attendees will understand the consequences to occupant safety of a material failure within the RCF 67 spring-loaded buckle.

This presentation will impact the forensic community and/or humanity by demonstrating how when investigating an accident with an unlatched seat belt restraint present, accident investigators should explore the internal condition of the buckle locking mechanism, and should look further into the possibility of accident-related restraint system release.

After attending this presentation, attendees will understand the consequences to occupant safety of a material failure within the RCF 67 spring-loaded buckle. This research specifically addresses instances where a latched seat belt buckle has released during a crash or rollover event, with no outward indication of damage of the restraint system. This paper will discuss the mechanism by which the internal spring can fail and will also explain why this failure can go undetected. This undetected failure can result in a release of the buckle during a crash or rollover event.

A failure analysis was performed on an occupant restraint system RCF 67 buckle that contained a fractured latch spring. The investigation consisted of a thorough metallurgical evaluation of the broken internal latch spring, analysis of the manufacturing processes used in the manufacture of the broken spring, and the correlation of processing variability to in-service performance of the internal spring. Metallurgical evaluation of the internal spring included optical microscopy, scanning electron microscopy, and chemical analysis. Interpretation of these results indicated that the spring had failed due to metal fatigue. Fatigue is the formation and growth of a crack or cracks that progressively grow in size due to repeated fluctuations of stress within a component. These fatigue cracks can ultimately lead to fracture of the components after a sufficient number of stress applications. The resistance of a component to fatigue damage is dependent on the design, material selection, and manufacture of that component. Through metallurgical analysis, it was determined that the fatigue initiated on the steel spring in an area of excessive phosphate coating. Phosphate coatings are known to produce pitting on the surface of certain steels. This pitting results in a stress concentration in the metal; the stress concentration due to the phosphate coating process reduces the fatigue resistance of the spring.

Testing of RCF 67 buckles with normal, un-failed springs, and RCF 67 buckles with fractured springs, was performed to compare the acceleration impulse required to cause an inertial buckle release. The testing was performed on a guided-rod drop fixture with sliding carriage. RCF 67 buckles were clamped horizontally to the drop fixture carriage and a weight was suspended from the latch plate webbing to preload the belt buckle. The carriage of the drop fixture was instrumented with an accelerometer and the accelerometer was connected to a data acquisition system to record the time history acceleration of the buckles. The carriage was dropped from varying heights onto elastomeric pads, and the pads were used to shape the resulting acceleration pulses. The testing revealed that buckles with fractured springs required approximately 75% less acceleration to cause an inertial release when compared to buckles with normal, un-failed springs.

During the failure investigation, it was determined that buckles with fractured springs can not only give an audible latch, but can feel secure to vehicle occupants. Therefore, damage to the locking mechanism can be imperceptible to vehicle occupants.

When investigating an accident with an unlatched seat belt restraint present, accident investigators should explore the internal condition of the buckle locking mechanism, and should look further into the possibility of accident-related restraint system release.

**Buckle, Fatigue, Spring**

 