



## Engineering Sciences Section - 2014

### C36 Hazards of Seat Belt Load Limiters

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After attending this presentation, attendees will understand how seat belt load limiters can present a hazard to occupants in certain crashes.

This presentation will impact the forensic science community by explaining how seat belt load limiters work as well as their benefits and hazards.

**History of Seat Belt Load Limiters:** A seat belt load limiter controls tension in the seat belt in order to limit the force the seat belt applies to a restrained occupant during a crash. Load limiters can reduce head and upper torso injuries for dummies in frontal crash tests through increased energy management.<sup>1</sup> Load limiting belt systems were first allowed on passenger vehicles in the early 1980s but did not become prevalent until the mid 1990s.<sup>2</sup> The National Highway Traffic Safety Administration (NHTSA) currently has a Federal Motor Vehicle Safety Standard for seat belts (FMVSS 209). In this standard, there are limits on how much elongation is allowed in the seat belt webbing when a load is applied. In 1981, NHTSA amended FMVSS 209 to exempt seat belts from the belt elongation requirements of the standard if they were installed with an automatic restraint.<sup>3</sup> With this amendment, no upper limit on belt elongation was established because NHTSA believed that no manufacturer would design a load limiting seat belt that would elongate appreciably beyond the limits of FMVSS 209.<sup>4</sup> However, the current design belief is that the amount of elongation, should be larger than the available interior distance between the forward structures and the occupants chest in order to dissipate a larger amount of energy.<sup>5</sup> This design theory relies heavily on the front airbag to mitigate head injury.<sup>6</sup> While research conducted by NHTSA on fixed barrier crash tests showed a reduction of injury potential for both head and chest, recent narrow offset crash tests performed by the Insurance Institute for Highway Safety (IIHS) demonstrate an increased injury potential for both head and chest when load limiting seat belts are used.<sup>7,8</sup> A case study is shown to demonstrate that severe head injuries can result from a load limiter with no upper limit on webbing elongation designed into the system.

**Case Study:** The restrained driver of a passenger car sustained a debilitating head injury in a narrow offset frontal impact. The Delta V experienced by the vehicle was approximately 38mph. In the crash, the steering column moved inboard. Due to the dynamics of the accident, the driver moved toward the A-pillar, glancing off the deployed airbag, and impacting the structures in the area of the lower A-pillar. The seat belt load limiter allowed the driver's head to make contact with the driver's side A-pillar. This impact caused a severe skull fracture with resulting brain injury. In this event, a limit on the amount of webbing elongation would have prevented contact with the A-pillar structure and prevented the injurious head impact.

**Conclusions:** In conclusion, seat belt load limiters have been shown to reduce head and upper torso injuries for restrained dummies during frontal impact crash tests, but this same benefit is not realized for humans in high-speed offset frontal crashes. To prevent these serious injuries, a limit on webbing elongation should be utilized with load limiter designs.

#### References:

1. Walz MC, *NCAP Test Improvements with Pretensioners and Load Limiters*, Report #DOT HS 809 562, NHTSA Technical Report, National Highway Traffic Safety Administration, Washington, DC, March 2003.
2. *Federal Motor Vehicle Safety Standards: Seat Belt Assemblies*, 49 CFR Parts 571, Docket No. 80-12, Notice 2; NHTSA, Final Rule; Federal Register, Vol. 46, No.7, pp. 2618-2621, January 12, 1981.
3. *Standard No. 209: Seat Belt Assemblies*, Title 49 Code of Federal Regulations, Chapter V, Section 571.209, pp. 831-849, 10/1/08 Edition. Available at: <http://www.gpo.gov/fdsys/pkg/CFR-2008-title49-vol6/pdf/CFR-2008-title49-vol6-sec571-209.pdf>. Accessed: 7/24/13.
4. *Federal Motor Vehicle Safety Standards: Seat Belt Assemblies*, 49 CFR Parts 571, Docket No. 80-12, Notice 2; NHTSA, Final Rule; Federal Register, Vol. 46, No.7, pp. 2618-2621, January 12, 1981.
5. Mertz HJ and Dalmotas DJ, *Effects of Shoulder Belt Limit Forces on Adult Thoracic*



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6. Mertz, 2007, *ibid*
  7. Walz MC, 2003 *loc cit*.
  8. *New Crash Test Aims to Drive Improvements in Protecting People in Frontal Crashes*," Insurance Institute for Highway Safety, News Release, August 14, 2012, <http://www.iihs.org/news/rrs/pr081412.html>.
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### **Seat Belt, Load Limiter, Offset Frontal Impact**