C48 Strong vs. Weak Seats: Analysis of Matched Rear Impact Tests for Head and Neck Injury Risk Evaluation

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The goal of this presentation is to present quantitative and statistical evaluation methods, including static testing and side-by-side sled and crash testing, to determine relative risks of various vehicle seating systems. This has implications for vehicle crash investigators, safety researchers, and vehicle designers.

The presentation will impact the forensic science community by demonstrating how the experimental "side-by-side" & "matched pair" test protocol (properly matched in impact severity, etc.) provides a scientific means for evaluating vehicle rear-impact seat performance as related to high & low velocity neck injury risk & head injury risk for both front seated adults & rear seated children located behind.

A recent study, presented at the 2007 Society of Automotive Engineers International Meeting (SAE paper 2007-01-0708), has suggested that, during rear-impact, the weaker, single-recliner (SR) vehicle seat designs (i.e. about 3.2 kN strong), which tend to collapse rearward during moderate to severe rear impacts, provide similar occupant protection over the much stronger and available "belt-integrated" seat (BIS) designs (i.e., about 14.5 kN strong), for impact severities ranging from low velocity "whiplash" levels (i.e., 15 kph or less) on up to more severe rear impacts of 40 to 50 kph. Unfortunately, the above referenced study only examined data for front occupants and ignored dangers and risks to rear occupants like children. In addition, the article contained numerous serious errors, misrepresentations, and omissions that render the results scientifically invalid when properly corrected. The current study focuses on examining the complete seat performance issue as it relates to head & neck injury risks of both front & rear seated occupants subjected to rear impacts.

The current study uses an experimental matched pair, or side-by-side, scientific test method and protocol (presented by the authors at the 57th and 59th Annual Meeting of the AAFS) to evaluate head & neck injury risk of weaker SR seat designs compared to stronger BIS designs, for various sizes of Hybrid III surrogates (i.e., a 50 kg small 5th percentile female, a 80 kg average 50th percentile male, and a average male surrogate ballasted to 110 kg) seated in a sled-body buck system that in some cases includes rear seated child surrogates of various sizes and in different types of child restraints. Typical sedan & minivan vehicles, with full interiors, were used as baseline test vehicles. Strong and weak seat comparisons were made for the same size surrogates under identical impact conditions. Each surrogate was instrumented with head, neck, and chest instrumentation. In some cases the front adult surrogates were leaned forward "out-of-position" (OOP) from the headrests with a gap of 5 inches, to examine effects of front only occupants in non-optimum positions for both seat types (SR & BIS) during low & high velocity levels. Adult neck injury risk measures are based on the NHTSA "Combined Load NIJ Criteria" & probability curves. Head injury risk is based on "% population at risk of AIS 4+ head injury" using HIC criteria.

The data and results of the "matched pair" seat test comparisons for front-seated adults without rear children are summarized in several tables. Included in each table is a category for "% Risk of AIS 3+ Neck Injury Potential" & "% population at risk of AIS 4+ Head Injury". Rear seated child head & chest injury risk comparisons are made for both seat types with var- ious size front adults, subjected to a wide range of impact severity. The NIJ criterion is analyzed statistically by the "Student T-Test" to compare responses between the strong and weak seats for the front only adult cases. What the "statistical" results indicate is that for "low velocities" (i.e., 12 to 15 kph) there is no significant difference between the neck injury risks of either the SR or BIS seat designs for all sizes of front adult surrogates. Nei- ther seat type indicated a severe risk of neck or head injury. However, with the exception of the newer "self aligning headrests" (like those on many Volvo & Saab vehicles) the headrests of both seat types (SR & BIS) appear to be non-optimum and could be improved. On the other hand, at the mod- erate to higher impact severities (i.e. 18 to 50 kph) there is a clear high level of injury risk associated with the weaker SR seat for both the front adult average males and larger, as well as the rear seated child located behind. In contrast, the stronger BIS design appears to provide much improved occu- pant protection over the weaker SR seat for both the front seated adult and the child located behind for these higher impact severities. As a result of the "matched pair" study it is concluded that in the moderate to high impact severity range (i.e. 20 to 50 kph) the weaker SR designs pose a high risk of injury to both front adults and rear seated children, as compared to the improved protection of the stronger BIS designs (even without optimum headrest performance). Most importantly, however, ultimate evaluation of rear-impact seat system performance must consider protection of both the front seated adult and rear occupants like children located behind the front seat.

Seat Performance, Rear Impact, Occupant Protection

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