C11 Multi-Variable Measurement and Comparison of Rear-Impact Head/Neck Injury Risk for Motor Vehicle Seats

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The goal of this presentation is to present a test protocol, and results, for objective measurement and comparison of motor vehicle seat safety system performance, as it relates to rear-impact head/neck injury risk factors for various size occupants subjected to a high-low range of impact severities (i.e. whiplash range up to 50 kph rear-impact levels).

This presentation will impact the forensic community and/or humanity by demonstrating the multi-variable, high-low impact, "side-byside" test protocol, with full vehicle interiors, which provides a more accurate means for comparing vehicle safety system performance as it relates to occupant injury risk measures.

Prior studies dealing with evaluation of rear-impact head and neck injury performance of automotive seats have suggested that the more common, but weaker, single-recliner (SR) seat designs (i.e. about 3.2 kN strong), which tend to collapse rearward during rear impact, provide improved occupant protection over the much stronger and available "beltintegrated" seat (BIS) designs (i.e. about 14.5 kN strong), for impact severities ranging from low velocity "whiplash" levels (i.e. 17 kph or less) on up to more severe rear impacts of 40 to 50 kph. It has also been suggested in these studies that out-of-position (OOP) occupants in the stronger BIS designs are at greater risk of injury than if they were seated in the weaker SR seat designs. Unfortunately, these studies did not test the weaker seat performance within the full constraints of the vehicle interior and rear occupant space. These constraints include, among other things, non-yielding rear seatbacks, limited rear occupant space, hard rear surface structures like package shelves, and rear occupants themselves (such as children and infants). Also, other factors that are not likely to affect the BIS design, but can further degrade the performance of the collapsing SR seats (such as intrusion of rear seatbacks, vehicle pitch/yaw motions, and offset rear impact) have not been examined in these earlier studies.

This current study evaluates head and neck injury performance of each seat design by using a complete vehicle interior, with "side-by-side" testing of both the typical collapsing SR and strong BIS designs, for 3 sizes of restrained surrogates subjected to a "high-low" range of rear impact severity. Neck injury performance is based on the "percent risk of AIS (Abbreviated Injury Scale) 3+ injury" derived from the NHTSA (National Highway Traffic Safety Administration) combined load "Nij" values, calculated from the measured surrogate response. Head injury risk is based upon the HIC (Head Injury Criteria) curve for "percent population at risk of AIS 4+" head injury.

A typical 4-door family sedan vehicle, with full interior, was used as the baseline vehicle. Both "sled-body buck" tests and 2 complete "vehicleto-offset barrier" pole impact tests were used. A total of 3 sled-buck tests were run at a low "whiplash" severity level (17 kph) and 6 were run at the severe high impact velocity change (50 kph) (repeat tests were run at the high impact levels). The crash pulse applied to the body-buck system was matched to the crash pulse of the actual vehicle. Three occupant sizes (i.e. 5th Female (50 kg), a 50%tile Male (80 kg), & a large Male (50%tile Male ballasted to 110 kg)) were tested for each of the 2 velocity change levels. Each surrogate was instrumented with head, upper neck and chest instrumentation. Lap belt loads were also measured. In all cases the surrogates were leaned forward "out-of-position" (OOP) from the headrests with a gap of 5 to 6 inches, to examine effects of occupants in non-optimum seating positions for both seat types (SR and BIS). The effects of "rear seatback intrusion" and "vehicle pitch" that could adversely effect the weaker SR seat were excluded in the "sled-buck" tests, so that it would be possible to evaluate the collapsing SR seat performance under optimum conditions. Ultimately, the adverse effects of rear seatback intrusion, etc, were evaluated with the actual "vehicle-to-barrier" tests. These tests were run at the high severity level, with the heavy surrogate in the weaker SR driver seat in one test, and the other test run with the heavy surrogate in the BIS version of the driver seat. In some of the sled-buck tests a 6-year-old surrogate was placed in the rear bench seat to study other hazards of the collapsing SR seat design.

The data and results of the "side-by-side" seat tests are summarized in several tables. Included in each table is a category for "% Risk of AIS 3+ Neck Injury Potential," and "% Population at Risk of AIS 4+ Head Injury." What the results indicate is that for the strong BIS design there is no significant risk of head, neck or chest injury at either the "whiplash" 17-kph levels or the more severe 50-kph range. On the other hand, the weak SR seat demonstrates "serious and dangerous" risk of head and neck injury in the "severe" 50-kph ranges, for all size occupants, even with optimum headrest height and no adverse rear seatback

intrusion or vehicle pitch/yaw effects. Also, common vehicle mounted belts were ineffective in restraining all size occupants in the collapsing SR seat design at high severities. Finally, the effects of rear seatback intrusion, and vehicle pitch/yaw, as well as impact offset, clearly increases the injury risk factors for the SR seat, but have virtually no deleterious effect on the BIS designs.

Rear-Impact, Motor Vehicle Seats, Head/Neck Injury Risk

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