An Experimental Seat for Measuring External Biofidelity in Rear Impacts and a New Instrumentation Technique for the Cervical Spine of PMHS

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ABSTRACT

The goal of this study is to design, construct, and evaluate a seat for rear impact testing of both crash dummies and post-mortem human subjects (PMHS) on a HYGE sled. The seat should meet criteria necessary for biofidelity analysis: (1) matching the motion of a typical OEM seat for a given pulse, (2) durability, (3) repeatability and reproducibility, and (4) capability of measuring how the subject loads the seat during the event. The geometry and moment-rotation properties of a typical passenger vehicle seat were resolved from the literature. Dynamic analysis of a mass-spring-damper arrangement subjected to a moderate-velocity pulse (11 g, 24 km/h) was conducted to determine the spring constant K and damping factor C necessary to replicate the motion of a typical seat. Using the results of this analysis, two seats were constructed for attachment to a HYGE sled. The seat back, seat base, and head restraint were equipped with load cells to measure forces at 20 kHz, and seat back rotation was obtained using an angular rate sensor attached to the seat back. High speed video and accelerometers were used to verify rotation and for inertial compensation of the load cells. Baseline seat back rotation performance and repeatability was evaluated using steel plate ballast attached to the seat backs to eliminate potential variability in seat rotation due to dummy-seat back interaction. Performance and repeatability of the seats were also evaluated using ballast Hybrid III 50th percentile dummies to include the effect of dummy-seat back interaction as well as to assess the ability of the load cells to measure the forces applied by the dummy. Several sled tests were conducted with progressive versions of the seat until the performance criteria were satisfied. The final version of the seat was able to withstand multiple events without degradation in the repeatability of the seat back rotation response (CV < 5 %) and the two seats were reproducible when compared to one another (CV < 5%). Dynamic analysis of measured forces confirmed that the load cells were able to quantify the loading of the seat by the subject. A newly developed technique for instrumenting the anterior aspect of the bodies of the cervical vertebrae was proposed to measure detailed neck kinematics during the event. The next phase of this study is to test rear impact dummies and PMHS in this seat to generate internal and external biofidelity data in moderate-velocity conditions for use with the NHTSA Biofidelity Ranking System.