Interaction of child seats installed in aircraft seats in oblique sled impact tests

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The Federal Aviation Administration (FAA) has standards and regulations that are intended to protect aircraft occupants in the event of a crash. These standards focus primarily on providing protection during frontal and vertical impacts. Transport category passenger seats continue to evolve, with the latest development being a partially enclosed (pod) seat that is oriented obliquely with respect to the aircraft centerline, in what is commonly referred to as a “herringbone” arrangement. The oblique seats present a novel loading environment that may permit significant flailing and have an off-axis loading direction.

Performance standards for child restraint systems (CRS) sold in the United States are defined by Federal Motor Vehicle Safety Standard (FMVSS 213). There are important differences between airplane and automotive seats. The methods and fixtures used to certify child restraints may not produce results that effectively measure their performance in an oblique airplane seat. It is important to determine the performance of child restraints in a representative off axis test condition for these newer airplane configurations.

A series of static installation evaluation (N=6) and dynamic oblique (30 degree frontal offset) sled tests was performed using a sled system in which rear facing (RF, N=7) and forward facing (FF, N=10) child restraint seats were attached to the FAA rigid couch configured to reflect the typical oblique seat configurations based upon information from the SAE Seat Committee’s industry survey, mounted on an acceleration sled via a 2-point lap belt (with and without a deactivated inflatable airbag). A Q1 (representing a 1YO) and a Hybrid III 3YO Anthropomorphic Test Dummy (ATD) were secured to the CRS using the CRS 5-point harness system. Occupant kinetics (head, chest and pelvic accelerations) along with kinematics (via high-speed camera) were evaluated against standard Injury Assessment Reference Values (IARV) for injury thresholds. The addition of a sidewall or an armrest was also compared and contrasted for changes in overall responses. The entire setup was evaluated with the 16 G, 44 feet per second impact severity defined in the Code of Federal Regulations (CFR) 14 CFR Part 25.562.

In static tests evaluations, the RF seats had difficulty being installed with an inflatable seat belt (could not be looped through; especially with a base), while in the dynamic testing there was not visible head strike with the armrest or the side cabin wall. Inflatable seatbelt did not pose to be a problem in dynamic tests. Head, chest and neck accelerations along with HIC were all well within IARV values for injury mitigation, in both RF and FF seats with no significant differences between installation conditions. It was interesting to note increased HIC for CRSs installed with an inflatable seatbelt condition (153±32 as compared to131±42) (not significant; p=0.81) but this was attributed to the lack of tightness (seatbelt webbing tension) as compared to a regular seatbelt due to its inherent difference in thickness. Neck Injury Criterion (Nij) was greater than 1.0 for all test conditions (1.1±0.08) but was not significant across installation type, CRS orientation or ATD.