INJURY MECHANISMS IN OBLIQUELY ORIENTED SEATS

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Historically, the Federal Aviation Administration (FAA) has regulated aircraft emergency landings by requiring seat and restraint systems to protect occupants due to vertical and longitudinal crash forces. Occupant protection standards in the Title 14 Code of Federal Regulations, parts 25.562 and 25, have decreased fatality rates in lower commercial airline environments and increased survivability from airplane crashes. The number of fatalities per million flight hours between the years 1983 and 2000 was less than 0.1 per year with a crash survival rate of 96% for airline occupants. The aviation industry is changing the traditional side-by-side parallel row seating configuration, currently existing in most commercial airlines. Alternate seat positioning includes mounting the seat at an angle relative to the fore-aft centerline of the aircraft. Obliquity allows airlines to optimize space and more efficiently add passenger seating room and increase comfort. The FAA-regulated standards were originally designed to protect occupants in seats mounted in forward (aligned with the aircraft centerline, ± 18°) and aft (rotated 180° ± 18°, about the aircraft centerline) positions. The introduction of newer seats/seating configurations installed from 18 through 90 degrees from the centerline of the aircraft presents unique challenges because alterations in occupant kinematics, loading, and potential for injury in emergency landing scenarios as they differ from the traditional pure forward- or aft-facing seats.

In horizontal longitudinal accelerations like the FAA emergency landing condition pulse, an occupant in an obliquely mounted seat experience upper torso flexion (flail) in both the lateral and coronal planes about a lap belt restraint. This loading scenario causes oblique flexion bending in the spine. Sagittal plane flexion bending tolerance has been studied for a range of crash pulses; lateral flexion tolerance has been less well understood, but initial tolerance values are available. Oblique spine flexion tolerance remains relatively unknown. The spinal column is symmetric about the mid-sagittal plane with strong ligaments in the anterior and posterior aspects of the column. In oblique loading, it is hypothesized that the strongest stabilizing ligaments are not fully engaged, and the oblique tolerance may be less than in forward or lateral flexion.

Initial whole-body PMHS tests in the oblique loading scenario indicated severe spine dislocations under the standard FAA survivable crash pulse. To better define human injury tolerance in this mode, a series of isolated lumbar spine tests were conducted using a custom spinal position device (SPD) and an electro-hydraulic piston. The SPD was used to control the alignment of the sacrum relative to the lower thoracic spine (T12) to achieve pure flexion and oblique-flexion postures, and a tensile load was applied using the piston. Results from these preliminary experiments demonstrated consistent alignment across subjects and differences in loading patterns dependent on posture. Spinal kinematics, sacrum loads, and injury patterns will be and compared to whole-body PMHS tests.