C41 Failure Mode of an Aircraft Restraint

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After attending this presentation, attendees will review a failure mode in a general aviation shoulder harness retractor. Aircraft accident investigators will learn how to check for this failure mode and the cause of the failure.

This presentation will impact the forensic science community by demonstrating different injury patterns of similarly restrained occupants in an aircraft crash may be the result of many factors, e.g., position, body characteristics, age, intrusion, and, of course, restraint failure. This presentation focuses on a restraint failure mode and how to detect and document it.

The right front passenger was severely injured when the four-seat, high-wing aircraft crash landed due to a loss of power from a fatigue failure of the No. 4 cylinder. The plane broke apart as a result of the crash.

The single-engine plane was flying at about 3,500 feet when the occupants heard a loud bang and felt the plane shake. The pilot guided the plane toward a helicopter landing pad near a beach in southern California. The plane touched down on flat ground, then collided with the upslope side of a ditch and broke into pieces.

The restrained front passenger was about 196cm in stature and weighed approximately 117kg. His seat was pushed all the way back. This left no foot room for the restrained rear passenger who had to sit sideways in the rear seat with his feet on the left side and his back against the right side. The pilot was slightly smaller, 183cm, and weighed about 92kg.

Both front seats were equipped with three-point restraints in an unusual configuration. The lap belt buckles with end-push release were mounted on the outboard side of the seats with 36º upward travel from horizontal. The Automatic Locking Retractors (ALR) were on the inboard side. A double Emergency Locking Retractor, Web sensing (ELR-W) was mounted to a frame member in the roof. The right retractor was on the left side and the left retractor was on the right side with the shoulder webbing crossing each other near the roof. The other ends of the shoulder belt webbing were attached to fixed latch plates.

ELR-W retractor locks were activated by a rapid extraction of the webbing off of a storage reel in the range of 0.75g to 1.5g. To check the retractor locking activation operation, the webbing was quickly pulled out. The pilot's shoulder belt reel locked and the front passenger's did not.

Injuries to the passenger were consistent with a lack of upper body restraint. They included contact with the roof liner and windshield header. Witnesses noted that the front passenger was found partially outside the aircraft with the shoulder belt extended and around his neck.

To understand the nature of the failure, the retractor inertial locking mechanism was examined. This mechanism consisted of a centrally pivoted plastic arm attached to the rotating reel. The arm was held in place by a calibrated spring that had an engaging tooth that swung out against a plastic ring with internal fixed teeth. When rotational forces overcame the spring tension, the arm extended into a plastic ring that had two levers that rotated slightly when the arm locked and engaged a lock bar. This moved the lock bar into two sets of metal teeth attached to the webbing storage reel, stopping it.

When the sensor mechanism cover was removed, it was noted that the arm on the plastic ring had broken off so that it could not move the lock bar into locking position. The storage reel teeth cut a grove into one side of the lock bar and tooth tips were sheared off as the lock bar tried to engage the reel teeth. This phenomenon is also known as skip lock. This appeared to be a manufacturing error instead of a design error.

A detailed examination showed the retractor's failed components, and witness marks were found within the subject retractor.

Investigators must look at not only the equipment and its function but occupant kinematics, injury patterns, and witness statements to fully understand the event.

Seat Belt, Retractor, Aircraft

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