Crash investigation Report:
Crash of an Air Bag Equipped 1994
Oldsmobile Ninety-Eight into the
Rear End of a 1983 Ford Ranger Pickup

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Summary

A 1994 Oldsmobile Ninety-Eight equipped with driver and passenger side air bags impacted the rear end of a 1983 Ford Ranger pickup. The crash was of relatively low severity (delta V approximately 10 mph); however, the driver and passenger air bags in the Oldsmobile deployed. Both front seats were occupied and the occupants were wearing lap/shoulder safety belts. The male driver was uninjured, but the female passenger, who reported reaching forward to brace herself before impact, sustained multiple fractures of her right hand (AIS 2). From the investigation of the crash vehicles and medical reports, it was concluded that this injury was likely due to direct contact with the deploying passenger side air bag module door.

Crash Description

The crash occurred on Sunday, June 6, 1994 with the 1994 Oldsmobile Ninety-Eight four-door sedan (3,847 lbs) equipped with driver and passenger air bags striking the rear of a 1983 Ford Ranger pickup (2,843 lbs). The Ranger then struck the rear of a third vehicle. The driver of the Oldsmobile was believed to be braking heavily immediately prior to the crash, and the Oldsmobile front bumper underrode the rear bumper of the Ranger.

Vehicle Damage and Crash Severity

The Oldsmobile and the Ranger were examined following the crash; the third vehicle was unavailable. Direct damage to the front of the Oldsmobile was located between the hood and the top of the bumper, and spanned almost the entire width of the car (155 cm). The damaged areas included the grille, headlamps, and radiator support; the hood was only slightly damaged. The maximum displacement of the radiator support was approximately 25 cm. The windshield on the passenger side was also shattered. The Oldsmobile front bumper was equipped with hydraulic energy absorbers, which had not stroked, but the top center of the bumper cover had been slightly damaged by a trailer hitch protruding from the center of the rear bumper of the Ranger. Exterior damage to the Ranger was limited to slight bending (10-12 cm) at the unsupported ends of the rear bumper.

Although delta V is not usually calculated in cases of underride without bumper engagement, Calspan Corporation has developed a procedure that uses one-half the direct crush above the bumper to give an approximate delta V. Using the Calspan procedure, total delta V was estimated at 10 mph for the Oldsmobile and 13 mph for the Ranger. (Because the direction of force was 12 o'clock for the
Oldsmobile and 6 o’clock for the Ranger, the corresponding longitudinal delta V’s were 10 mph and 13 mph, respectively.) The Oldsmobile air bag is designed to deploy at 9-14 mph.

Seat Belt Use

Both occupants of the Oldsmobile reported that they were wearing lap/shoulder belts. The post-crash investigations showed evidence that both front seat belts had been loaded. On the shoulder portion of the driver’s belt, there was a faint diagonal D-ring scuff and evidence of abrasion to the soft plastic trim around the retractor opening. There were no scuff marks on the belt fabric of the passenger belt, but similar abrasions were found to the soft plastic trim. Data from the vehicle’s computer, which was accessed by General Motors engineers, confirmed the driver was belted; the computer does not track the status of the passenger belt.

Air Bag Performance

The Oldsmobile air bag crash sensing system has three crash zone sensors: one is attached to the top of the radiator support and one is attached to each of the bumper mounting rails. There is also an arming sensor in the occupant compartment. The bumper rails were undamaged in the crash, but the radiator support was damaged and the sensor mounted on the middle of the support sustained a direct impact. Data from the air bag control module indicated that the module received a valid signal to deploy. The crush zone sensor closed before the arming sensor by 3.4 msec (in a barrier crash the arming sensor will typically close first).

Both the driver and passenger air bags deployed. The driver air bag was un tethered and packaged in General Motor’s l-leaf seam module; the passenger air bag was tethered to a depth of 40 cm (16 inches). There was evidence that the passenger-side deployment door shattered the windshield. Small fragments of red plastic from the air bag module door were deposited on the windshield.

According to information from General Motors engineering staff, the air bag module door is not expected to shatter the windshield at an optimum temperature of 70°F. However, at higher temperatures the output of the inflator will increase, which could result in damage to the windshield. The ambient outside air temperature that day was around 70°F, and the vehicle was parked for some time in the open before being driven. It is likely that the module temperature was in excess of 70°F.
Occupant Contacts and Injury

Examination of the vehicle showed no definite occupant contact points for either the driver or the passenger. On the passenger side, there were small deposits of a white powdery residue on the A-pillar and on the roof near the B-pillar, which may have been byproducts of the air bag deployment. There was no flattening or deformation of the powder; thus, it seems unlikely that it could have been deposited by a hand contact. There was a small nick in the plastic covering of the glove compartment door, and a small nearby blood stain that may have indicated occupant contact. The glove compartment is located directly below the top-mounted passenger air bag deployment door. There were no signs of occupant contacts on the windshield or windshield header nor on any other interior component on the passenger side. There were several blood stains on the fabric of the passenger side air bag.

The driver was uninjured, but the passenger sustained multiple comminuted fractures of the right hand, which were displaced to the right (AIS 2). She sustained comminuted fractures (AIS 2) of the third, fourth, and fifth metacarpals (leading to the middle, ring, and little fingers). These fractures were distal (near the finger joint) but did not involve the joint. The passenger also suffered a comminuted intra-articular fracture of the middle phalanx of the little finger and the distal phalanx of the ring finger (AIS 1). There were open wounds on the volar aspect (palm side) of her ring and little fingers.

Injury Mechanism

The passenger reported that she was bracing herself against the dashboard at the time of impact. To explore this aspect of the crash, an investigator, the same height as the passenger (5' 9''), was seated in an undamaged exemplar vehicle with the seat in the full rearward position; in a natural bracing position, the middle of the hand was directly across the bottom edge of the deployment door. There are several possible injury mechanisms that could account for the hand injuries. The hand could have been accelerated by the deploying air bag module door and/or air bag into contact with an interior component of the vehicle; the injury could be the result of her hand becoming trapped between the deploying air bag and the dashboard and glove compartment; or the injury could be a direct result of impact from the deploying air bag module door and/or the air bag.

One possibility is that the passenger's hand was thrown into contact with the windshield, becoming sandwiched between the module door and the glass. The driver and passenger stated that the passenger's right hand could have been thrown against the windshield by the deploying air bag.
but they were not sure what had happened. However, there was no evidence of occupant contact points on the windshield, nor were there any abrasions or lacerations on the hand, which would be expected given that the windshield was broken. The hand may also have been propelled by the airbag into contact with the side door glass or the upper interior surfaces or the B-pillar. There was, however, no evidence of occupant contact with any of these surfaces.

It is also possible that her hand may have been bracing against the dashboard and glove compartment at the time the airbag deployed and may have become trapped between the bag and the dashboard by the accelerating airbag. There was a slight nick and a small blood stain on the top edge of the glove compartment, although there were no signs of deformation on the glove compartment door or surrounding structures. However, the glove compartment door latch was broken, and the door would not relatch.

Although the injury report obtained from the attending physician refers to the injury as a crush injury, this does not necessarily imply that the injury was the result of the hand being crushed between two surfaces. If the passenger’s hand was indeed braced against the module door at the time of deployment, it would have been subject to high magnitude loading from the palm side of the hand. The fractures were comminuted and displaced, but there was no evidence of crush injuries. The X-rays were examined by a radiologist. The metacarpal bone fragments were angled outward or away from the palm; this pattern suggests that the forces that caused the fracture were from the palm side. The radiologist concluded that the metacarpal fractures were the result of an impact to the palm side of the hand. It was also clear from the X-rays that the third, fourth, and fifth metacarpal fractures were aligned, indicating that the impacting edge may have been linear. This injury pattern suggests that the injuries were caused by the deploying airbag module door impacting the palm of the hand.

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