

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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**REDESIGNED AIR BAG SPECIAL STUDY (RABSS)
SCI TECHNICAL SUMMARY REPORT**

NASS CDS CASE 1998 - 11-135J

VEHICLE - 1998 DODGE DAKOTA PICKUP TRUCK

LOCATION - MICHIGAN

CRASH DATE - AUGUST, 1998

Contract No. DTNH22-94-07058

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness of the involved vehicle(s) or their safety systems.

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REDESIGNED AIR BAG SPECIAL STUDY 11-135J
SCI TECHNICAL SUMMARY REPORT
VEHICLE: 1998 DODGE DAKOTA PICKUP TRUCK
CRASH DATE: AUGUST, 1998

BACKGROUND

This investigation focused on the fatal injury mechanisms of the 16 year old male driver of a 1998 Dodge Dakota pickup truck, involved in a single vehicle/fixed object crash. The pickup departed the left side road, traveled 29 m (88 ft) off-road and sideswiped a 15 cm (6 in) tree with the left side of the pickup bed. The Dodge then continued on an additional 19 m (62 ft) and struck a 30 cm (12 in) tree with the front right area of the vehicle. The Dodge Dakota was equipped with a Supplemental Restraint System (SRS) that consisted of a redesigned driver and right front passenger air bag. The air bags deployed as a result of the 56+ km/h (35+ mph) crash. The driver sustained fatal multiple brain trauma (AIS 5) and other associated injuries as a result of the crash.

The crash was initially selected for investigation by the National Automotive Sampling System (NASS) as case 11-135J and was also included in the Redesigned Air Bag Special Study. The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) assigned the Special Crash Investigation (SCI) team at Veridian/Calspan the task of case review and final report preparation.

SUMMARY

Crash Scene

This single vehicle crash occurred during the early morning hours of August, 1998. At the time of the crash, it was daylight and the weather was not a factor; the roads were dry. The crash occurred off the north road edge of an east/west two lane asphalt roadway in a rural area of Michigan. The roadway was straight and level in the area of the crash. Immediately east of the crash scene, the road curved left for eastbound traffic. The speed limit at the crash scene was 72 km/h (45 mph) and had just changed from 89 km/h (55 mph) west of the roadside departure. The northern roadside was an open field with scattered trees and brush. There was an irregular negative grade to the north and east within the field. **Figure 1** is a eastbound trajectory view prior to roadside departure. The traffic cones in the center of the photograph denote the vehicle's path. **Figure 2** is a view along the pickup's trajectory prior to the sideswipe impact. **Figure 3** is a view of the point of frontal impact.



Figure 1: Trajectory view prior to roadside departure.



Figure 2: Trajectory view approaching the sideswipe impact.



Figure 3: View of the point of impact.

Crash

The 1998 Dodge Dakota pickup truck was driven-by a 16 year old male with a reported height and weight of 178 cm (70 in) and 66 kg (146 lb). The driver was operating the vehicle eastbound and was en-route to work. For unknown reasons, the driver steered counterclockwise, gradually crossed the center line, traversed the westbound lane and departed the north side of the road. There were no tire marks on the roadway nor brake marks within the vehicle's trajectory indicative of abrupt driver maneuvers. The vehicle was tracking throughout its pre-crash trajectory. It is possible the driver may have fallen asleep. Reconstruction of the crash indicated the vehicle was traveling approximately 72 to 80 km/h (45 to 50 mph) upon departing the road.

Over the course of the vehicle's east-northeast trajectory, it was traveling approximately perpendicular to the negative north slope of the roadside and was listing to the left. The Dodge traveled approximately 29 m (88 ft) off road and sideswiped a 15 cm (6 in) tree with the left side of the pickup bed. Direct contact with the bed began 61 cm (24 in) forward of the left rear axle and extended aft to the back of the bed. The maximum lateral deformation was approximately 6 cm (2 in) at the upper aspect of the bed's left rear corner. The Collision Deformation Classification (CDC) of this impact was 12-LBMS-01. This sideswiping contact did not significantly decelerate the vehicle or alter its trajectory.

Immediately beyond the sideswiping impact, the negative grade to the north began to level and the negative grade increased to the east. The vehicle listed right to a more level attitude. Approximately 19 m (62 ft) beyond the first impact, the Dodge struck a 30 cm (12 in) tree with the front right center aspect of the vehicle. The maximum deformation measured 110 cm (43 in) and was located 30 cm (12 in) right of the vehicle centerline. The force of the impact caused a forward weight shift and negative pitch of the vehicle. The rear wheels probably left the ground. The Dakota then rotated approximately 30 degrees clockwise and rebounded from the tree. The pickup came to rest facing southeastward approximately 5 m (15 ft) from the tree. The delta V of the impact was 56+ km/h (35+ mph). The vehicle's SRS deployed as a result of the impact.

Post-Crash

The driver of the Dodge Dakota sustained life-threatening injuries in the crash. He was found restrained and unconscious within the vehicle by police and rescue personnel. He was extricated from the vehicle by removal of the doors and roof. Life supportive measures were applied. The driver was immediately air lifted to a level 1 trauma center at a nearby University hospital. His Glasgow Coma Score on arrival was 3. Radiological diagnosis revealed a diffuse axonal cerebral injury (AIS 5) and swelling. A sub-arachnoid hemorrhage was also revealed. He was removed from life support approximately 31 hours post-crash and immediately expired. An autopsy was performed subsequent to organ donation. Multiple subtle facial abrasions were noted and as well as a C6-7 fracture of the cervical spine. The autopsy identified additional brain trauma not identified through standard diagnostic measures.

AIR BAG VEHICLE

The 1998 Dodge Dakota Sport pickup truck was identified by the Vehicle Identification Number (VIN): 1B7FL26X1WS (production sequence deleted). The vehicle was a standard cab, 2-wheel drive, compact pickup equipped with a 3.9 liter, V6 engine. The driver reportedly purchased the vehicle new in January 1998. The estimated vehicle mileage was 6,437 km (4000 miles) at the time of the crash.

Damage

Figures 4 and 5 are the front and right side views of the Dodge Dakota. The Dodge sustained 36 cm (14 in) of direct contact damage to the right center aspect of the frontal plane. The damage began 18 cm (7 in) right of center and extended to the right. The direct contact damage occurred in-board of the right frame rail and was directed longitudinally rearward. The measured crush profile was as follows: C1=23 cm (9 in), C2=118 cm (46 in), C3=119 cm (47 in), C4=116 cm (46 in), C5=112 cm (44 in), C6=69 cm (27 in), L=35 cm (14 in). The 12 o'clock direction of the impact force deformed the frontal structure of the pickup rearward into engine compartment. The magnitude of the force caused buckling of the truck frame rearward of the B pillar. The back of the cab contacted the forward edge of the pickup bed due the compressive forces of the crash. Both doors remained closed and were buckled. The right wheelbase was fore-shortened 49 cm (19 in).



Figure 4: Front view of the Dodge Dakota.



Figure 5: Right side view of the Dodge.

The Collision Deformation Classification (CDC) of this impact was 12-FREN-05. Forensic analysis of the vehicular damage and SCI experience indicated the delta V of this crash was above 56 km/h (35 mph). Reconstruction of this crash through the use of the WINSMASH model calculated a barrier equivalent delta V of 63 km/h (39 mph) using pole impact parameters.

Interior Damage

Interior damage to the vehicle identified through inspection was associated to both the exterior forces of crash and occupant contact. Intrusion of the left toe pan, instrument panel (left side) and steering column measured 27 cm (11 in), 11 cm (4 in) and 10 cm (4 in), respectively. The steering column was a fixed column and had been completely displaced from its shear capsule due to driver loading. There was approximately 2 cm (1 in) of deformation to the upper half of the steering wheel rim. Intrusion of the right toe pan and right side of the IP measured 50 cm (20 in) and 18 cm (11 in) respectively. The windshield fractured from the collision forces and had been removed during driver extrication. There was no evidence of driver contact to the laminate. Contact from the driver's lower extremities was noted on the driver's knee bolster and foot controls.

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

The vehicle was equipped with a Supplemental Restraint System that consisted of redesigned driver and right front passenger air bags. The air bags had deployed as a result of the crash. The driver air bag was housed in the typical manner in the center hub of the steering wheel. There was no contact evidence on the exterior surfaces of the module cover flaps. The driver air bag measured 48 cm (19 in) in its deflated state. The bag was tethered by 2 internal straps and vented internally back through the inflator. A blood smear was identified on the face of the air bag, **Figure 6**. Linear gray/black scuffs were noted in the 10 o'clock sector of the back side of the bag. These scuffs were indicative of an impeded deployment and developed from frictional contact with the interior surface of the upper cover flap.



Figure 6: View of the driver air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	16 year old male
Height:	178 cm (70 in)
Weight:	66 kg (146 lb)
Seat Track Position:	Mid-track
Restraint Use:	3-point lap and shoulder
Usage Source:	NASS inspection, police investigation
Vehicle Familiarity	Purchased new 8 months prior to crash
Route Familiarity:	Traveling to work

DRIVER INJURIES

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Cerebral sub-arachnoid hemorrhage, right	Serious (140684.3,1)	Inertial deceleration/ crash forces
Cerebral sub-arachnoid hemorrhage, left	Serious (140684.3,2)	Inertial deceleration/ crash forces
Right inferior fronto-temporal cortical contusions	Serious (140612.3,1)	Inertial deceleration/ crash forces
Cerebral swelling (not further specified)	Serious (140660.3,9)	Inertial deceleration/ crash forces
Cervical spinal fracture, C6/7	Moderate (650216.2,6)	Inertial deceleration/ crash forces
Bilateral abrasions - lower extremities	Minor (890202.1,3)	Knee bolster
Bilateral contusions - lower extremities	Minor (890402.1,3)	Knee bolster
Abrasion left foot	Minor (890202.1,2)	Foot Controls
Contusion left foot	Minor (890402.1,2)	Foot Controls
Right lung contusion (not further specified)	Serious (441402.3,1)	Inertial loading of 3-pt restraint
Never regained consciousness, (no response to pain) (GCS=3)	Critical (160824.5,0)	Inertial deceleration/ crash forces
Diffuse axonal cerebral injury	Critical (140628.5,9)	Inertial deceleration/ crash forces
Occipital scalp contusion	Minor (190402.1,6)	Rebound an unidentified source
Facial abrasions - left zygomatic arch	Minor (290202.1,2)	Inflating driver air bag
Facial abrasions - chin	Minor (290202.1,8)	Inflating driver air bag
Moderate herniation of the cerebellar tonsils	Critical (140202.5,8)	Inertial deceleration/ crash forces

DRIVER KINEMATICS

The 1998 Dodge Dakota was traveling eastbound at an approximate speed of 72 to 80 km/h (45 to 50 mph). The vehicle was operated by a 16 year old male driver, seated in a mid-track position and restrained by the vehicle's 3 point lap and shoulder belt system. The vehicle's pre-crash trajectory indicated a gradual north (left) roadside departure; the driver may have fallen asleep relinquishing vehicular control. The driver most likely moved out-of-position, possibly slumped forward over the steering wheel. The length of the Dakota's pre-crash trajectory was approximately 46 m (150 ft) from the roadside departure to frontal impact. At 72 km/h (45 mph), approximately 2.25 seconds elapsed during the pre-crash phase. The driver probably would have been awakened by the vehicle's dynamic off-road motions, however, it is unlikely he would have been oriented to time or position. The short duration of the pre-crash phase would have afforded the driver minimal time to perceive and react to the impending crash. There was no evidence of any pre-impact maneuvers by the driver. Inspection of the scene indicated the vehicle was tracking and traveled straight to the impact with the tree.

The Dodge impacted the tree inboard of the right frame rail in the (relatively) soft right center region of the front bumper. Deployment of the vehicle's SRS probably occurred late in the collision sequence at a time when the rapid build-up of the vehicle's deformation caused rapid build-up of the vehicle's stiffness. Narrow impacts by nature are more severe collisions than impacts with a wider damage distribution. The collision forces of a narrow impact are distributed over a correspondingly narrow region of the vehicle's structure necessitating the kinetic energy of the impact be absorbed in a proportionally smaller volume of the vehicle's structures. This results in accelerations (deceleration) of greater magnitude. These accelerations in-turn are transmitted to the occupant compartment.

At impact, the driver probably had an upright posture and possible forward position. His chest was positioned in close proximity to the steering wheel rim. The force of the impact caused a forward weight shift and negative pitch of the vehicle. The rear wheels probably came off the ground. The driver initiated a forward and upward trajectory in response to the 12 o'clock direction of the impact force and negative vehicular pitch. The driver contacted and loaded the 3-point restraint system evidenced by the contusion of the right lung. His lower extremities contacted and loaded the driver's knee bolster evidenced by the minor abrasions and contusions to those body regions. The left foot injuries were caused by the intruding foot controls.

The vehicle's SRS deployed due to the force of the impact, however deployment probably occurred late in the collision sequence as referenced above. The forward position of the driver caused the driver to contact the driver air bag prior to full inflation. His forward kinematic pattern loaded the steering column through the inflating air bag evidenced by the full displacement of the column from the shear capsules. The sudden deceleration of the driver's upper torso caused by the combined 3-pt restraint and air bag loading resulted in violent flexion of the head/neck complex. The linear and angular acceleration of the head/neck resulted in the cerebral sub-arachnoid hemorrhages, the right inferior fronto-temporal cortical contusions, the diffuse axonal cerebral injury and a C6/C7 cervical fracture. The expansion of the air bag abraded the driver's face and chin. The driver then rebounded, striking his occipital scalp on an unknown source.