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VERIDIAN ON-SITE AIR BAG RELATED BURN INVESTIGATION

VERIDIAN CASE NO. CA 97-018

1994 DODGE DAKOTA SPORT PICKUP TRUCK

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE - MARCH 1997

Contract No. DTNH22-94-D-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 are 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 performance of the involved vehicle(s) or their safety systems.

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<p>16. <i>Abstract</i></p> <p>This single vehicle crash involved a 1994 Dodge Dakota Sport pickup truck which was equipped with a front left driver air bag. The vehicle was struck on the right front door by a deer and subsequently departed the right side of the roadway and struck a tree stump with the right frontal plane. The impact with the tree stump deployed the air bag system.</p> <p>The driver was not using the three point manual lap and torso belt at the time of the crash. During the braking avoidance maneuver, he moved forward and was in close proximity to the air bag module cover at the time of the air bag deployment sequence. The deploying air bag contacted the driver's chest area resulting in circular burn marks in the driver's sweat shirt and undershirt which correlated with the location and design of the air bag vent ports. The driver continued to move forward and loaded the air bag and steering column resulting in the complete separation of the steering column shear plate from the shear capsules.</p> <p>The driver was sitting on the seat at the final rest position (FRP) with the steering wheel in his lap. He indicated that he was somewhat disoriented for a short time when he suddenly noticed that jacket he was wearing was smoldering. He exited the vehicle and was met by the right front occupant who helped him remove the jacket and throw it on the ground.</p> <p>The Dodge was towed back onto the roadway by a passing motorist. The driver of the Dodge then drove his vehicle back to his residence while steadying the detached steering column in his lap. He estimated the trip took approximately thirty minutes.</p> <p>Upon arrival home, the driver complained of pain to his right knee and was subsequently taken to a medical facility by his wife. He was treated and released. The driver described the injury to the front right occupant as aches and pains. He was not aware if he sought medical attention.</p>			
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VEHICLE - 1994 DODGE DAKOTA SPORT PICKUP TRUCK
LOCATION - STATE OF PENNSYLVANIA
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Background

A single vehicle crash involving a 1994 Dodge Dakota Sport pickup truck equipped with a frontal driver air bag occurred in the month of March 1997 in the State of Pennsylvania. NHTSA was notified of the crash by the driver via the Hotline who reported that his clothes were burned as the result of an air bag deployment. Veridian Engineering was requested by the Crash Investigation Division (CID) of the NHTSA to conduct an on-site investigation. A Veridian SCI investigator was on-site the following day and conducted an inspection of the vehicle and an interview with the driver.

Summary

This single vehicle crash involved a 1994 Dodge Dakota Sport pickup truck which was equipped with a front left driver air bag. The vehicle was struck on the right front door by a deer and subsequently departed the right side of the roadway and struck a tree stump with the right frontal plane. The impact with the tree stump deployed the air bag system. The crash occurred in the month of March, 1997 during daylight hours. The weather at the time of the crash was described as clear, no wind, with temperatures in the 4 degrees C (40 degrees F) range. Although the driver stated he did not remember the exact location of the crash, he indicated the area speed limit was either 40 km/h (25 mph) or 48 km/h (30 mph).

The driver, a 40 year old male who was 182.9 cm (72.0") tall and weighed 108.9 kg (240.0 lb), was traveling on a two lane rural roadway on a right curve when he encountered a herd of deer in the roadway. The driver attempted to avoid the deer by steering to the right and applying the brakes. One of the deer ran into the right front door resulting in damage to the door panel. According to the driver, this impact did not result in the deployment of the air bag system. The vehicle departed the right side of the roadway and struck a tree stump which was located in a "gully". Upon impact with the tree stump, the driver air bag system initiated the deployment sequence.

The driver was not using the three point manual lap and torso belt at the time of the crash. During the braking avoidance maneuver, he moved forward and was in close proximity to the air bag module cover at the time of the air bag deployment sequence. The deploying air bag contacted the driver's chest area resulting in circular burn marks in the driver's sweat shirt (**Figures 1 and 2**) and undershirt which correlated with the location and design of the driver air bag vent ports. The driver continued to move forward and loaded through the expanding air bag and compressed the energy absorbing steering column resulting in the complete separation of the steering column shear plate from the shear capsules.



Figure 1 -View of the burn marks on the front of the driver's sweatshirt



Figure 2 -View of the burn marks on the sweatshirt in correlation with the size and location of the air bag vent ports

The driver was sitting on the seat at the final rest position (FRP) with the steering wheel in his lap. He indicated that he was somewhat disoriented for a short time when he suddenly noticed the jacket he was wearing was smoldering. He exited the vehicle and was met by the front right occupant who helped him to remove the jacket and throw it on the ground.

The 35 year old male front right occupant was 182.9 cm (72.0") tall and weighed 108.9 kg (240.0 lb). He was also not wearing the three-point restraint system at the time of the crash and reportedly suffered some injury (not described by the driver). He exited the vehicle under his own power. The driver's dog was reportedly in the center seat position inside the cab, but was not injured.

The Dodge Dakota was towed back onto the roadway by a passing motorist. The driver of the Dodge then drove his vehicle back to his residence while steadying the separated steering column on his lap. He estimated the trip took approximately thirty minutes.

Upon arrival home, the driver complained of pain to his right knee and was subsequently taken to a medical facility by his wife. He was treated and released. The driver described the injury to the front right occupant as aches and pains. He was not aware if he sought medical attention.

Vehicle Data

Exterior

The 1994 Dodge Dakota which had 65,653 km (40,796 miles) on the odometer was undergoing repair at the time of this inspection. The direct damage from the impact with the tree stump was located 43.2 cm (17.0") right of the bumper centerline and measured 25.4 cm (10.0") in length (**Figures 3 and 4**). Damaged components included: the front bumper; grille; hood; right front fender; and right front door panel. The right front door panel was repaired at the time of this inspection.



Figure 3 - Right front corner view of the Dodge Dakota showing the direct impact damage to the right front bumper area



Figure 4 - Overhead view of the impact damage to the front bumper illustrating the extent of crush

The following table lists crush values obtained after setting the front bumper back in position following its removal by the repair shop. These values should be considered as minimum crush values.

1995 Dodge Dakota Front Bumper Crush	$C_1 = 0$	$C_2 = 1.6 \text{ cm (0.625")}$	$C_3 = 4.4 \text{ cm (1.75")}$
	$C_4 = 10.2 \text{ cm (4.0")}$	$C_5 = 10.5 \text{ cm (4.125")}$	$C_6 = 0$

CDC

The assigned Collision Deformation Classification (CDC) for the impact with the tree stump was 12-FREN-1. Due to the repaired door panel, a CDC for the impact with the deer was estimated at 03-RPEW-1.

Interior

The interior of the Dodge Dakota was under repair at the time of the inspection. The steering column assembly had been removed, but was available for inspection. The steering column was designed with a slotted jacket mandrel which was compressed 2.5 cm (1.0") by driver loading during the crash sequence (**Figure 5**). The shear plate was completely separated from the shear capsules during the crash.

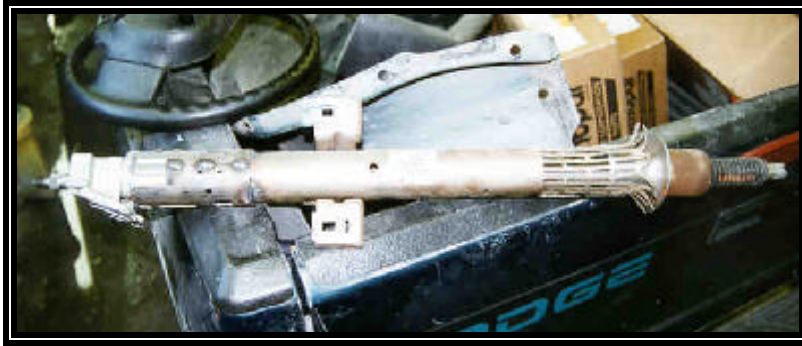


Figure 5 - View of the steering column showing the displacement of the slotted jacket at the mandrel located at the right side of the photograph

The steering wheel rim was not deformed as shown in **Figures 6 and 7**. The air bag module was removed by the repair facility.



Figure 6- Frontal view of the steering wheel rim

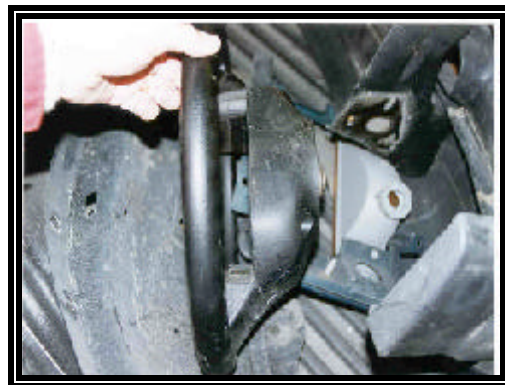


Figure 7 - View along the steering wheel rim

There was a heavy abrasion along the left edge of the ashtray located 10.2 cm (4.0") left of the vehicle centerline which measured 3.8 cm (1.5") in length. This artifact was attributed to contact with the driver's right knee (**Figure 8**). There was a minor scuff on the knee bolster which was located 44.4 cm (17.5") left of the vehicle centerline and left of the steering column. This scuff was attributed to contact by the driver's left knee during the crash sequence with the tree.



Figure 8 - Contact evidence along the left edge of the ashtray door (highlighted by a red box)



Figure 9 - View of cake like product embedded in vehicle control pedals

There was a food product (cake like substance) noted to the instrument panel and foot pedals. It appeared that this product had been on the seat and struck the instrument panel during the crash sequence. It apparently fell on the floor where the driver upon re-entering apparently stepped on the product and tracked it onto the accelerator, brake, and clutch pedals (**Figure 9**).

The bench seat was reportedly in the full rear adjusted position (**Figure 10**). The continuous loop three point manual lap and shoulder belts in the outboard set positions did not exhibit any latch plate witness marks (**Figure 11**) which was consistent with non-restraint usage in the crash. The D-rings were fixed.



Figure 10 - lateral view of the front seat area from the left side of the vehicle



Figure 11 - View of the front left restraint belt latch plate showing the lack of usage related witness marks

The vehicle was equipped with a five-speed manual transmission. There was no damage noted to the floor mounted shift lever.

WinSMASH Reconstruction

The damage routine of the WinSMASH reconstruction program was used to compute the delta V values. The total delta V for the Dodge was computed as 11.1 km/h (6.9 mph) which appeared to be slightly lower than a visually estimated value of 16-19 km/h (10-12 mph). The following table lists the WinSMASH results:

WinSMASH Reconstruction Damage Algorithm	1995 Dodge Dakota Pickup Truck
Total delta V	11.1 km/h (6.9 mph)
Longitudinal delta V	11.1 km/h (6.9 mph)
Lateral delta V	0 km/h
Energy dissipated	8,699 joules (6,424 ft-lb)
Barrier equivalent speed	11.1 km/h (6.9 mph)

Supplemental Restraint System (SRS)

The Supplemental Restraint System (SRS) in Dodge Dakota consisted of only a front left driver air bag which deployed during the impact with the tree stump. The total delta V computed by the WinSMASH speed reconstruction program was 11.1 km/h (6.9 mph). The SRS actuation sequence appeared to have performed as designed.

The air bag module cover opened in an "H" configuration with the vertical dimension of the upper flap measuring 6.4 cm (2.5") and the lower flap measuring 7.0 cm (2.75") vertically. The common lateral seam line width measured 16.5 cm (6.5"). The supple vinyl flap thickness measured 6.4 mm (0.25"). There was no driver related contact evidence noted on the surfaces of the flaps (**Figures 12 & 13**).



Figure 12 - View of the upper air bag module cover flap



Figure 13 - View of the lower air bag module cover flap

The air bag was a non-tethered design which measured 66.0 cm (26.0") in diameter. There were two 2.5 cm (1.0") diameter vent ports located on the back surface at the twelve o'clock position. The vents ports were separated by a measured distance of 5.0 cm (2.0") and 7.0 cm (2.75") below the perimeter of the air bag. There was brown discoloration around each vent port which was attributed to exhaust gases (**Figure 14**). The air bag identification number was: PUT 11446-02E.

The inflator unit was manufactured by Morton International with an identification label located on the back side of the inflator which read: CBE E8A 3Z CQF (**Figure 15**). There were no obvious defects in the inflator housing.



Figure 14 - View of the air bag vent ports illustrating the brown discoloration



Figure 15 - View of the rear surface of the inflator unit

The driver was wearing a wool blend wool designer jacket over a pullover green sweatshirt and a white undershirt. The jacket was worn in the open mode at the time of the crash. Following the crash, the driver noticed that his jacket was smoldering and exited his vehicle. With the assistance of the front right passenger, he removed the jacket, threw it on the ground, and stepped on it to extinguish it. The driver indicated that the jacket was ruined with burn holes, so he left it at the scene. The driver claimed he was a non-smoker.

The driver's sweatshirt (50/50 cotton polyester blend) exhibited well defined singe marks located along the left lower chest area which were attributed to contact with the air bag vent ports during the SRS actuation sequence. The prominent circular pattern noted in **Figure 16** (the pattern closest to the vertical calibrated tape) measured 3.2 cm (1.25") in diameter and was located 38.7 cm (15.25") below the shoulder and 7.0 cm (2.75") left of the shirt midline. There was a 9.5 mm (0.375") diameter burn hole in the upper right which was attributed to generant debris exiting the right vent port during the air bag actuation sequence. There were several surrounding circular brown singe marks



Figure 16 - View of the circular burn marks on sweatshirt which were attributed to exhaust gases from vent ports

above and below this pattern which were produced sequentially by the same vent port as the air bag was going through its expansion sequence.

The second set of singe marks (furthest away from the vertical calibrated tape) were located 4.8 cm (1.875") left of the of the first set and correlated with the location of the left vent port. There appeared to be four spherical impressions in this set which began vertically at the same height of as the first set and extended 10.2 cm (4.0") downward.

A 16.5 cm (6.5") white powder-type transfer mark was noted below the spherical singe marks on the left side (**Figure 17**). The transfer pattern appeared to be fashioned in an arc which was located 44.4 cm (17.5") below the left shoulder and 12.1 cm (4.75") left of the shirt centerline. This artifact was attributed to contact with the air bag during the expansion sequence.

The driver's white 100 percent cotton undershirt exhibited two distinct brown singe mark patterns which were located on the left side of the shirt and correlated with the singe marks noted on the sweatshirt (**Figure 18**). The first pattern which was closest to the centerline of the undershirt began 33.0 cm (13.0") below the left shoulder and extended 12.7 cm (5.0") downward. The second singe pattern was located 34.3 cm (13.5") below the left shoulder and 7.6 cm (3.0") left of the first pattern (center to center). Both singe marks measured 2.9 cm (1.125") in width.



Figure 17 - View of the white transfer mark on the left front lower surface of the sweatshirt



Figure 18 - View of the singe marks on the drive's undershirt which correlated with the location of the singe marks on the sweatshirt

Injury Data

The driver sustained a minor injury in the crash to his right knee, but was able to drive the vehicle back to his residence following the crash. Upon arriving home, he experienced discomfort with his right knee and was subsequently transported to a medical treatment facility where was treated and released. There were no medically diagnosed injuries. The driver indicated that his chest felt warm after the crash, but there were no related soft tissue lesions associated with the singed clothing. The right front occupant suffered non specified injuries.

Occupant Kinematics

The driver was traveling along a rural roadway when he encountered a herd of deer in the roadway. One of the deer ran into the right door of the Dodge Dakota. The driver attempted a right steering avoidance maneuver and applied the brakes. The vehicle departed the right side of the roadway and struck a tree stump which actuated the SRS sequence. The driver, who was not using the three-point manual lap and shoulder belt, moved forward during the braking avoidance maneuver and off roadway travel and was in close proximity to the air bag module cover at the time of actuation.

The air bag cover opened in the usual vertical pattern and more than likely contacted the driver's chest area even though there was no related physical evidence observed on the air bag module flaps or any related soft tissue injuries reported. The vent port area of the expanding air bag then contacted the driver's left chest area as noted by the side-by-side spherical shaped singe marks in his sweatshirt. The driver's chest which was moving forward in response to impact forces appeared to have trapped the expanding air bag where contact with the air bag restricted the normal flow of exhaust air bag gases and created back pressure in the air bag. At some point in the expansion sequence, the driver's force against the air bag lessened which allowed the air bag gases to escape and create the multiple singe patterns. Small dot-like burn holes noted within the singe pattern indicated that hot particulates also exhausted through the vent ports. It was hypothesized that the driver's outer jacket had also been subjected to these hot particulates which resulted in the burning that the driver described.

The combination of the driver loading the steering column and the air bag loading against the driver's chest resulted in a 2.5 cm (1.0") compression of the steering column with total separation of the shear plate from the shear capsules. The driver indicated that the steering wheel was laying in his lap at final rest.

The driver's right knee moved forward and contacted the left edge of the ashtray located in the lower center instrument panel. This was noted by an abrasion of the vinyl surface and correlated with the driver's description of pain to his right knee.

The driver came to rest in the driver's seat where he described himself as being dazed. He noticed smoke coming from his clothing and exited the vehicle under his own power. The front right occupant came to his assistance and helped him remove his jacket where it was thrown to the ground. He described the jacket as badly burned and left it at the scene.

The unrestrained front right occupant was not injured in the crash. He moved forward during the pre-impact braking and more than likely contacted the right instrument panel during the impact sequence. There were no visible contact marks noted to the instrument panel or windshield area.

The driver was also transporting his dog in the center front seat area. The driver indicated that the dog was not injured. There was no related contact evidence noted inside the vehicle.