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ON-SITE REDESIGNED AIR BAG CHILD FATALITY INVESTIGATION

CALSPAN CASE NO: CA98-038

VEHICLE: 1998 PLYMOUTH NEON

LOCATION: SOUTH CAROLINA

CRASH DATE: JULY, 1998

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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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This investigation focused on the deployment issues of a redesigned Supplemental Restraint System (SRS) in a 1998 Plymouth Neon and the fatal injury mechanisms of the Plymouth's 4 year old male occupant. The Plymouth Neon was involved in an intersection collision with a 1988 Chevrolet S-10 pick-up. The SRS of the Plymouth Neon consisted of redesigned driver and front right passenger air bags. At the time of the crash, the Plymouth was occupied by, a police reported, 10 occupants (4 front/6 rear). The 4 year old male occupant and a 5 year old child were seated on the lap of the front right passenger. The 4 year old male was the only injured occupant in the crash. He died 3 days post-crash. The coroner's report indicated he died as a result of an upper cervical spine fracture and subsequent complications secondary to the multi-vehicle collision.

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BACKGROUND

This investigation focused on the deployment issues of a redesigned Supplemental Restraint System (SRS) in a 1998 Plymouth Neon and the fatal injury mechanisms of the Plymouth's 4 year old male occupant. The Plymouth Neon was involved in an intersection collision with a 1988 Chevrolet S-10 pick-up. The SRS of the Plymouth Neon consisted of redesigned driver and front right passenger air bags. At the time of the crash, the Plymouth was occupied by, a police reported, 10 occupants (4 front/6 rear). The 4 year old male occupant and a 5 year old child were seated on the lap of the front right passenger. The 4 year old male was the only injured occupant in the crash. He died 3 days post-crash. The coroner's report indicated he died as a result of an upper cervical spine fracture and subsequent complications secondary to a multi-vehicle collision.

The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) was informed on the crash through the Atlanta Regional Office on July 7, 1998. NHTSA in-turn assigned an on-site investigation of the crash to the Special Crash Investigation (SCI) team at Veridian/Calspan the same day. Cooperation was established with the investigating county coroner and per the coroner's request the on-site investigation was initiated July 20, 1998. The coroner impounded the vehicles pending SCI investigation.

SUMMARY

This two vehicle crash occurred in the evening hours of July, 1998. At the time of the crash, it was dark without street lights. There were no adverse weather conditions; the road was dry. The crash occurred at the intersection of a 5 lane east/west undivided roadway and a 3 lane north/south private road. The private road intersected the primary roadway from the north and served as the entrance/exit to a shopping center adjacent to the roadway. The traffic lanes of the primary road were configured as two travel lanes in each direction with a center turn lane. There was an estimated +2 percent grade in the westbound direction. The traffic lanes of the private road were configured as a single entrance lane and two exit lanes (one eastbound/one westbound). A stop sign for traffic exiting from the private road controlled the

Figure 1: Westbound trajectory view of the crash scene.

intersection. **Figure 1** is a westbound trajectory view approximately 30 m (100 ft) east of the point of impact. The speed limit in the area of the crash was 72 km/h (45 mph).

The 1998 Plymouth Neon was a rental vehicle driven by a 22 year old female. The Plymouth was traveling west in the in-board lane of the roadway, passing in front of a shopping center/restaurant and was occupied by 10 unrestrained individuals (driver included). **Figure 2** is a view of the crash schematic. The 1988 Chevrolet S-10 pick-up, driven by a 16 year old male, exited south from the private road's center lane, directly into the path of the Plymouth. The driver of the Plymouth Neon braked prior to the crash evidenced by a 8.6 m (28.2 ft) skid mark. The skid mark was identified during the inspection of the crash scene and was attributed to the left front tire of the Neon. The skid mark was located in the inboard westbound lane and ended at the point of impact.

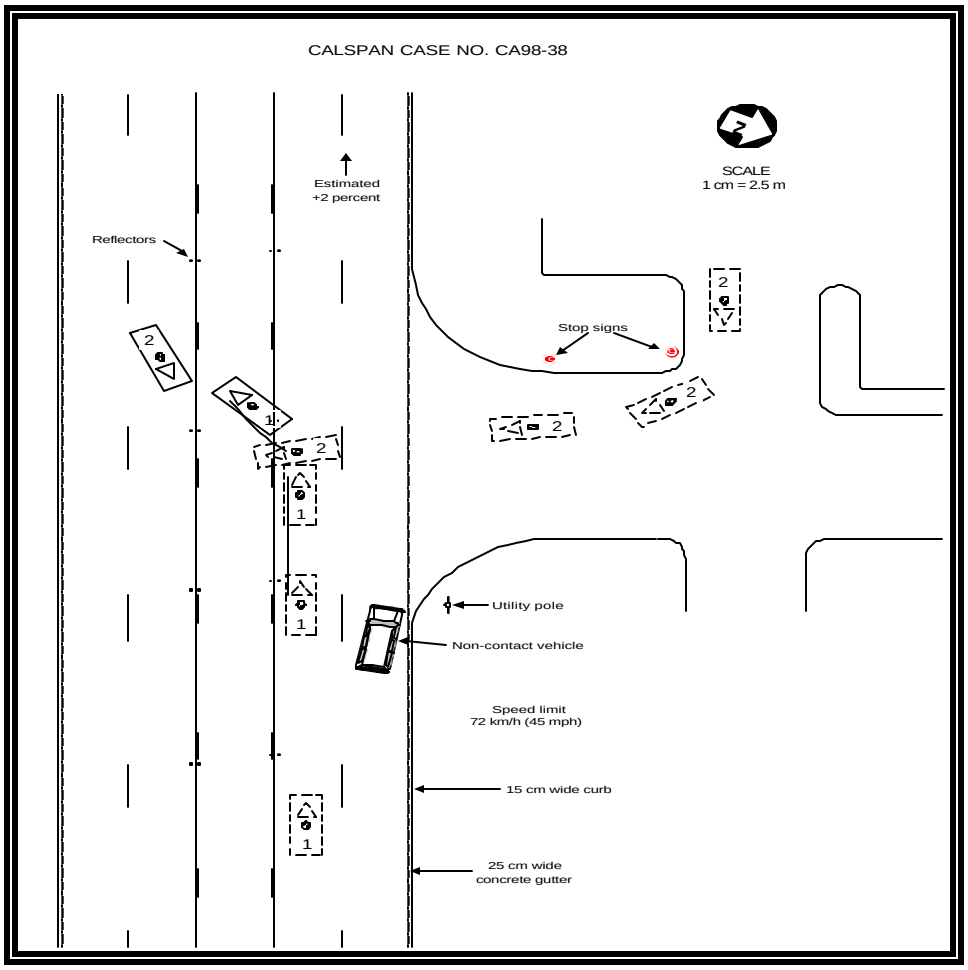

Figure 2: View of the crash schematic.

The impact occurred with the frontal plane of the Plymouth impacting the left side of the pick-up in a 1/10

o'clock impact configuration. The southward momentum of the pick-up caused the Neon to rotate approximately 30 degrees counterclockwise and the vehicle slid to rest in the center turn lane of the roadway facing southwestward. The 1 o'clock direction of the impact force deployed the redesigned SRS of the Plymouth Neon. The impact caused the Chevrolet pick-up to rotate counterclockwise and the vehicle reportedly came to rest in the eastbound lanes of the road facing northeastward. There was no scene evidence to support the final rest positions of the vehicles.

The Plymouth Neon sustained direct contact damage across the full 145 cm (57 in) frontal width of the vehicle. The damage was weighted more heavily to the vehicle's left side due to the lateral momentum of the pick-up. The measured crush profile was as follows: C1=21.1 cm (8.3 in), C2=21.6 cm (8.5 in), C3=14.5 cm (5.7 in), C4=9.4 cm (3.7 in), C5=6.9 cm (2.7 in), C6=3.8 cm (1.5 in). The Collision Deformation Classification (CDC) was 01-FDEW-1. The left front fender buckled rearward and slightly restricted the opening of the left front door. The forward aspect of the damaged left front inner fender was in contact with the left front tire. The left side wheelbase was foreshortened approximately 2.5 cm (1.0 in). The right side wheelbase dimension was unchanged. The hood buckled in the typical manner. All the doors were operational upon inspection and all window glazings were in-tact. A single fracture was located on the right side of the windshield. The fracture was linked to the altered deployment of the front right passenger air bag. The total Delta V calculated by the Damage Only Algorithm of the WINSMASH program was 28.3 km/h (17.6 mph). The longitudinal and lateral components were -27.3 km/h (-17.0 mph) and -7.3 km/h (-4.5 mph), respectively. The barrier equivalent speed was 20.7 km/h (12.9 mph). **Figures 3 and 4** are front and left lateral views of the Plymouth Neon.

Figure 3: Front view of the 1998 Plymouth Neon.

Figure 4: Left lateral view across the front plane of the Neon.

The Chevrolet S-10 pick-up sustained 186.7 cm (73.5 in) of direct contact damage to the vehicle's left plane, **Figure 5**. The damage began 35.8 cm (14.1 in) forward of the left rear axle and exteded forward to the leading edge of the left door. The measured crush profile of the vehicle was as follows: C1=24.1 cm (9.5 in), C2=27.3 cm (10.8 in), C3=33.0 cm (13.0 in), C4=43.2 cm (17.0 in), C5=32.4 cm (12.8 in), C6=10.4 cm (4.1 in). The maximum lateral deformation, located 11.4 cm (4.5 in) forward of C4 (166.9 cm (65.7 in) forward of the left rear axle), measured 48.3 cm (19.0 in). The impact bent the left frame rail of the pick-up, **Figure 6**. The left wheelbase was foreshortened 3.0 cm (1.2 in). Both doors were jammed shut. The left window glazing was shattered. The cab was shifted laterally to the right 8.4 cm (3.3

in) relative to the pick-up box. The CDC of the vehicle was 10-LPEW-3. The total Delta V calculated by the Damage Only Algorithm of the WINSMASH program was 30.9 km/h (19.2 mph). The longitudinal and lateral components were -15.5 km/h (-9.6 mph) and 26.8 km/h (-16.6 mph), respectively. The barrier equivalent speed was 37.3 km/h (23.2 mph).

Figure 5: Left side view of the 1988 Chevrolet S-10 pick-up.

Figure 6: Rear undercarriage view along the left frame rail.

The police report indicated the Plymouth Neon was occupied by 10 individuals (4 front/6 rear). None of the occupants were restrained. Reportedly, the occupants of the Neon were returning home from a birthday party. The vehicle was driven by a 22 year old female. The front right seated passenger was a 25 year female. Seated on the lap of the front right passenger was a 5 year old female and a 4 year old male. The 4 year old male was fatally injured in the crash. The 25 year old female was the boy's mother. Investigation revealed conflicting reports regarding the seated positions of the 5 year old female and 4 year old male, however, the 4 year old male most likely was seated on the outboard aspect of the mother's lap. The left and center rear seated positions were occupied by 4 male children, ages 13, 8, 9 and 6 respectively. The right rear position was occupied by a 26 year old male. A 23 month old female was seated on the lap of the right rear occupant. In a conversation, the coroner indicated there were 11 occupants (4 front/7rear) in the vehicle. That information could not be confirmed.

The driver of the Chevrolet S-10 pick-up was a 16 year old male. He had just finished work at one of the shopping center's stores and was in the process leaving the parking lot. It was the intention of the Chevrolet's driver to turn left and travel eastbound on the roadway. There reportedly was a westbound minivan (non-contact vehicle) in the outboard lane of the road ahead of the Plymouth turning right onto the private road. The minivan may have obstructed the vision of the respective drivers to each other.

Immediately prior to impact, the driver of the Plymouth applied the brakes in a pre-impact avoidance maneuver. The occupants responded to this braking force by initiating a forward trajectory. Upon impact, the occupants were displaced further forward in response to the 1 o'clock direction of the impact force. The forward pre-crash position and subsequent forward trajectory of the 4 year old caused the child to become positioned in the deployment path of the front right passenger air bag. The impact caused the redesigned air bag system in the Plymouth Neon to deploy. The deploying air bag contacted the 4 year old child in the upper chest, neck and head. The rear seated occupants loaded and deformed the front seat

backs forward. The loading and deformation of the front seat backs resulted in an increased longitudinal loading and displacement of the front seat occupants.

The 25 year old front right passenger stated to the coroner that she carried the 4 year old to the right shoulder and laid him in the grass. She did not realize he was injured until she sat him down. She then saw that he was bleeding about the mouth and neck. The 26 year old right rear passenger reported he saw the air bag deploy and contact the child in the head and neck. Police and ambulance personnel responded to the crash scene. The child was transported to the emergency room of a regional trauma center located within the city limits. The child was admitted into the facility's pediatric intensive care unit. The child died 3 days post-crash. It was the opinion of the in-charge pediatric physician the child's injuries were directly related to the air bag's deployment. An autopsy was performed . The pathologist performing the autopsy gave the opinion the cause of death was an upper cervical spine fracture (not further specified) and subsequent complications secondary to a multi-vehicle collision.

AIR BAG VEHICLE

The 1998 Plymouth Neon, 4 door sedan, was identified by a vehicle identification number (VIN): 3P3ES47Y3WT (production sequence deleted). The vehicle was manufactured in Mexico and had a manufacture date of 8/97. The Plymouth was owned by a rental car agency. The Neon was equipped with a 2.0 liter, I-4 engine linked to an automatic transmission. The braking system in the Neon was a standard hydraulic braking system; the vehicle was not ABS equipped. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of redesigned driver and front right passenger air bags. Chrysler Corporation's Safety Office confirmed the vehicle's SRS was redesigned.

INTERIOR CONFIGURATION AND INTERIOR DAMAGE

The interior of the Plymouth Neon was configured for 5 passengers, 2 front/3 rear. The interior was gray in color and the seat's fabric was cloth. The front seated positions were bucket seats with reclining back rests. The head restraints were adjustable. The rear seat was a split bench seat with folding backs.

At inspection, the left front seat track was positioned 7.6 cm (3.0 in) rearward of the most forward position. The total seat track travel was 22.9 cm (9.0 in). The left front seat back was deformed longitudinally forward as a result of the rear occupant loading. The seat back angle was reclined 5 degrees, from vertical, at inspection. Comparison exemplar measurements indicated the top of the seat back was deformed forward approximately 20.7 cm (8.2 in). The measurement of the anti-submarine angle of the left front seat cushion was 20 degrees.

The front right seat track was positioned 9.5 cm (3.8 in) rearward of the most forward position. The total seat track travel was 22.9 cm (9.0 in). The front right seat back was deformed longitudinally forward as a result of the rear occupant loading. A 2.5 cm x 7.6 cm (1.0 in x 3.0 in) scuff was identified on the seat back. The scuff was located 30 cm (12 in) above the floor and 43 cm (17 in) right of vehicle centerline The seat back was vertical (0 degrees) at inspection. Exemplar measurements indicated the top of the seat back was deformed approximately 21.3 cm (8.4 in). The horizontal distance between the aft edge of the

front right passenger air bag module and the deformed seat back was 53 cm (21 in). The measurement of the anti-submarine angle of the left front seat cushion was 20 degrees.

The right side of the windshield exhibited a fracture, **Figure 7**. The fracture site was located 30.5 cm (12.0 in) below the windshield header and 10.8 cm (4.3 in) left of the right A-pillar. An area of air bag fabric transfers surrounded the fracture site. The windshield fracture and surrounding transfers were resultant to the altered deployment path of the passenger air bag.

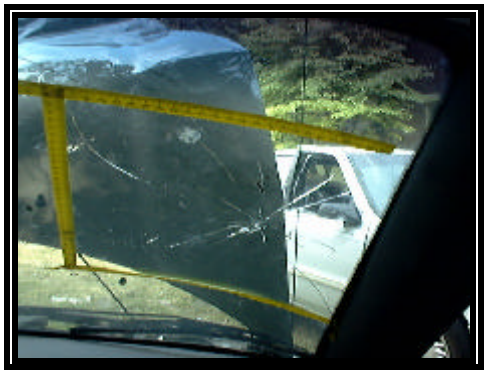

Figure 7: View of the windshield fracture.

The driver knee bolster exhibited two scuffed areas associated to contact from the driver's knees/lower extremities. A scuffed area 10 cm x 12 cm (4 in x 5 in), width by height, was located 18 cm (7 in) left of the steering wheel centerline and 36.8 cm (14.5 in) above the floor. A 3.8 cm x 8.9 cm (1.5 in x 3.5 in) scuffed area was located 3.8 cm (1.5 in) right of the steering column centerline and 34.3 cm (13.5 in) above the floor.

The right knee bolster was scuffed in two areas from contact with the knees/lower extremities of the front right passenger. A 2.5 cm x 7.6 cm (1.0 in x 3.0 in) area was located 24.1 cm (9.5 in) right of the vehicle centerline and 33.8 cm (13.3 in) above the floor. A 7.0 cm x 6.4 cm (2.8 in x 2.5 in) scuffed area was located 40.6 cm (16.0 in) right of centerline and 36.2 cm (14.3 in) above the floor.

MANUAL RESTRAINT SYSTEM

The Plymouth Neon was equipped with 3-point lap and shoulder belt systems in the 4 outboard seated positions. The center rear position was a lap belt. The front seat belt systems consisted of a continuous loop lap and shoulder belt webbing with a sliding latch plate. An inertia activated locking retractor was located in the base of each B-pillar. The restraint's upper anchorages (D-rings) were adjustable. The left and right D-rings were both positioned in the lowest adjustment. The police report indicated that all occupants of the Plymouth Neon were unrestrained. The driver and front right adult passenger (mother) admitted to the coroner, in separate interviews, that all the occupants were unrestrained as well. Additionally, the occupant kinematic pattern supports the fact the occupants were unrestrained.

SUPPLEMENTAL RESTRAINT SYSTEM

The 1998 Plymouth Neon was equipped with a Supplemental Restraint System (SRS) that consisted of redesigned driver and front right passenger air bags. The Safety Office of the Chrysler Corporation traced the Neon's Vehicle Identification Number (VIN) and confirmed the vehicle was equipped with a redesigned air bag system. There were no external identifiers (windows stickers) that identified the SRS as redesigned during the inspection.

The Plymouth Neon's steering column was fixed. There was no deformation of the steering wheel rim nor

displacement of the steering column's shear capsules. The driver air bag module was configured in the typical manner in the center hub of the steering wheel. The module cover flap design was a vinyl 2 piece flap, with an integral horn pad, that rotated up during the air bag deployment. The gross external measurements of the flap measured 23 cm x 15 cm (9 in x 6 in) width by height. There was no contact evidence on the cover flap. The interior flap measured 17.1 cm x 10.2 cm (6.8 in x 4.0 in). The horn pad was located between the inner and outer flaps. The date 5/97 was stamped on the inner flap.

The driver air bag, **Figure 8**, measured 63.5 cm (25.0 in) in its deflated state. The air bag was vented by two 2.5 cm (1.0 in) diameter vent ports located in the 11/1 o'clock sectors on the back side of the bag. The air bag was tethered by two 14.0 cm (5.5 in) wide straps. The face of the driver air bag was smudged in the lower left and lower right quadrants probably as a result of an altered deployment. The forward position of the driver probably impeded the normal deployment of the air bag and the smudges are resultant to a friction heating between the air bag fabric and the interior surfaces of the driver air bag module.

Figure 8: Driver air bag.

Figure 9: Front right passenger air bag module.

The front right passenger air bag module was configured as a top mount in the right aspect of the instrument panel, **Figure 9**. The passenger air bag module cover flap measured 33 cm x 15 cm (13 in x 6 in), width by height. The single vinyl flap design was hinged on the forward edge of the module and rotated forward during deployment. The left aspect of the cover flap was deformed relative to the right aspect. This deformation occurred as a result of the altered deployment sequence. There was not any direct evidence of occupant contact on the cover flap.

The passenger air bag measured 46 cm x 56 cm (18 in x 22 in) width by height at its extended face, **Figures 10 and 11**. The air bag extended rearward 33 cm (13 in) from aft edge of the module. The air bag was tethered by four 7.6 cm (3.0 in) wide straps sewn to the face of the air bag. The air bag was vented by a single 7.6 cm (3.0 in) port located in the 12 o'clock sector on the top surface of the bag. The following manufacturer's nomenclature was fixed to the module:

WC46175ZK11116
P/N 2000707M

Figure 10: Right lateral view of the front passenger air bag.

Figure 11: View of the face of the front passenger air bag.

The bottom surface and face of the air bag did not exhibit any contact evidence. On the right aspect of the air bag's top surface was a dark tissue transfer and a large area of melanin transfer, **Figures 12 and 13**.. The melanin transfer also extended onto the outboard surface of the bag. The tissue transfer measured 10 cm x 2 cm (4 in x 0.8 in), laterally by longitudinally, and was located 6.4 cm (2.5 in) rearward of the aft edge of the air bag module. The melanin transfer was dispersed over an area that measured 15 cm x 30 cm (6 in x 12 in), laterally by longitudinally, on the air bag's top surface. The melanin transfer on outboard aspect of the air bag was dispersed over an area that measured approximately 15.2 cm x 19.1 cm (6.0 in x 7.5 in), width by height.

Figure 12: Top surface of the air bag.

Figure 13: Close-up view of the tissue and melanin transfer.

CHILD OCCUPANT INJURIES

Injury	Severity	Injury Source
Upper cervical spinal fracture (not further specified)	Moderate (650216.2,6)	Deploying front right passenger air bag

The above injury information was disclosed in the Coroner's Investigative Report and was the only available source of medical information.

CHILD OCCUPANT KINEMATICS

The 1998 Plymouth Neon was occupied by 10 unrestrained individuals (4 front/6 rear). The 4 year old male was seated on the outboard aspect of the front right passenger's lap. A 5 year old female was seated on the inboard aspect of the passenger's lap. The front right seat was adjusted to a position approximately 2.0 cm (0.8 in) forward of mid-track. Seated in this position, the 4 year old child occupant was in close proximity to the right aspect of the instrument panel and the front right passenger air bag module. Immediately prior to impact, the driver of the Plymouth Neon braked in a panic avoidance maneuver. The 10 unrestrained occupants of the Neon all responded by initiating a forward trajectory. The front right passenger probably attempted to restrain the children by hugging them/pulling them back and bracing for the impact.

Upon impact, the occupants were displaced further forward in response to the 1 o'clock direction of the force. This forward kinematic pattern positioned the 4 year old in-close proximity to the front right passenger air bag module at the time of impact. The force of the impact deployed the redesigned Supplemental Restraint System of the Plymouth Neon. The cover flap opened and the expanding air bag contacted the child in the upper chest, neck and head. Contact with the air bag caused a hyper-extension of the neck and a resultant fracture of the child's upper cervical spine. The child's forward kinematic pattern altered the normal deployment path of the air bag, deflecting the bag upward into the windshield. The altered deployment path of the bag was evidenced by the fractured windshield laminate and melanin transfers to the bag's fabric.

The unrestrained rear seated occupants were displaced into the backs of the front bucket seats. This contact loaded and deformed the front seat backs approximately 21.6 cm (8.5 in) forward, resulting in an increased loading of the front seated occupants.