**CRASH DATA RESEARCH CENTER**

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

## NASS CDS CASE NO. 1999-43-176J

## RABSS VEHICLE - 1999 CHEVROLET CAVALIER Z24

## LOCATION - STATE OF NORTH CAROLINA

## CRASH DATE - OCTOBER, 1999

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

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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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| 16. *Abstract*<br>This investigation focused on a single vehicle crash involving a 1999 Chevrolet Cavalier Z24 4-door sedan equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of a frontal collision with a large diameter tree. The driver of the Chevrolet was operating the vehicle northbound and negotiating a left curve when she allowed the vehicle to depart the right (east) pavement edge in a forward tracking mode. As the Chevrolet exited the right pavement edge, the front right area impacted a large diameter tree resulting in severe damage. The restrained 41 year old female driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, knee bolster and deployed redesigned driver air bag. Loading of the manual restraint resulted in contusions to the right hip and left chest while loading of the knee bolster resulted in bilateral knee contusions. Contact to the deployed driver air bag resulted in a contusion to the left eyelid and a laceration to the upper lip. She also sustained a fractured right ankle from contact to the toepan. The driver was transported to a local trauma center for treatment and admitted for 5 days. The restrained 39 year old male front right passenger initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, glove compartment door and deployed redesigned passenger air bag. Loading of the manual restraint resulted in abrasions across the abdomen while loading of the glove compartment door resulted in a fractured right pelvis. Contact to the deployed passenger air bag resulted in a chin abrasion. He also sustained a right fibula fracture from contact to the intruded toepan. The front right passenger was transported by ambulance to a local trauma center for treatment and admitted for 4 days. | | | |
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## TABLE OF CONTENTS

**REDESIGNED AIR BAG SPECIAL STUDY (RABSS)**
**SCI TECHNICAL SUMMARY REPORT**
**NASS CDS CASE NO. 1999-43-176J**
**RABSS VEHICLE - 1999 CHEVROLET CAVALIER Z24**
**CRASH DATE - OCTOBER, 1999**

## *BACKGROUND*

This investigation focused on a single vehicle crash involving a 1999 Chevrolet Cavalier Z24 4-door sedan equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of a frontal collision with a large diameter tree. The driver of the Chevrolet was operating the vehicle northbound and negotiating a left curve when she allowed the vehicle to depart the right (east) pavement edge in a forward tracking mode. As the Chevrolet exited the right pavement edge, the front right area impacted a large diameter tree resulting in severe damage. The restrained 41 year old female driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, knee bolster and deployed redesigned driver air bag. Loading of the manual restraint resulted in contusions to the right hip and left chest while loading of the knee bolster resulted in bilateral knee contusions. Contact to the deployed driver air bag resulted in a contusion to the left eyelid and a laceration to the upper lip. She also sustained a fractured right ankle from contact to the toepan. The driver was transported to a local trauma center for treatment and admitted for 5 days. The restrained 39 year old male front right passenger initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, glove compartment door and deployed redesigned passenger air bag. Loading of the manual restraint resulted in abrasions across the abdomen while loading of the glove compartment door resulted in a fractured right pelvis. Contact to the deployed passenger air bag resulted in a chin abrasion. He also sustained a right fibula fracture from contact to the intruded toepan. The front right passenger was transported by ambulance to a local trauma center for treatment and admitted for 4 days.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 1999-43-176J and also included in the Redesigned Air Bag Special Study. The Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) assigned the Special Crash Investigation (SCI) team at Veridian the task of case review and final report preparation.

## *SUMMARY*

### Crash Site

This single vehicle crash occurred during the early morning hours of October, 1999. At the time of the crash, it was dark (street not lighted) with no adverse conditions as the road was dry. The crash occurred off the east pavement edge of a (level) 2-lane north/south rural roadway which curved left for northbound traffic **(see Figure 9 - page 7)**. The asphalt roadway was bordered by narrow paved shoulders with a wooded area located approximately 17.7 meters (58.1 feet) east of the road edge. No traffic control was present at the scene which had a posted speed limit of 72 km/h (45 mph).

**Pre-Crash**

The 41 year old female driver of the 1999 Chevrolet Cavalier Z24 was operating the vehicle northbound **(Figure 1)** and negotiating a left curve at a (driver reported) speed of 64 km/h (40 mph) when she became distracted by a conversation with the passenger and allowed the vehicle to depart the right (east) pavement edge in a forward tracking mode. The vehicle continued in a northeasterly direction approximately 28.0 meters (91.9 feet) and subsequently entered a wooded area. The driver reported no avoidance maneuvers in anticipation of the impending crash. The vehicle's pre-impact approach was evidenced by the soil furrows noted in the NASS scene images, however, this physical evidence *(and forward tracking approach)* was not plotted on the NASS scene diagram.

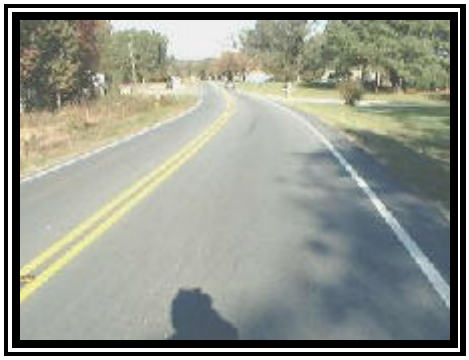

**Figure 1. Northbound approach for the 1999 Chevrolet Cavalier Z24.**

**Crash**

As the Chevrolet exited the right (east) pavement edge of the 2-lane rural roadway **(Figure 2)**, the front right area impacted a large diameter tree resulting in severe damage **(Figure 3)**. The WinSMASH reconstruction program computed a barrier equivalent velocity change of 56.1 km/h (34.9 mph) with a respective longitudinal component of -55.2 km/h (-34.3 mph), which seemed high. The impact induced deceleration was sufficient to deploy the Chevrolet's redesigned frontal air bag system. At this point, the vehicle rotated approximately 35 degrees clockwise and came to rest in close proximity to the point of impact facing northeast.

**Figure 2. Look back view from road departure showing road curvature.**

**Figure 3. Struck tree.**

**Post-Crash**

Contrary to the NASS case file, the Chevrolet occupants exited the vehicle with some assistance from rescue personnel and were found by emergency medical technicians (EMT's) to be ambulatory at the scene, and seated in the backseat of the vehicle awaiting treatment/transport. The driver and front right

passenger were subsequently transported by ambulance to a local trauma center for treatment and subsequently admitted for 5 days and 4 days, respectively. The vehicle was towed from the crash site due to disabling damage. The occupants were reportedly entrapped by jammed doors and a right instrument panel intrusion, however, the left side doors were still operational as the NASS researcher's intrusion measures and interior documentation were deficient to substantiate these mechanisms *(further evidenced by the EMS report).* In addition, the NASS researcher indicated the occupants were removed from the vehicle through the back light area. This was highly unlikely given the glazing was still intact and not removed post-crash by rescue personnel for occupant extrication.

### *RABSS VEHICLE*

The 1999 Chevrolet Cavalier Z24 was identified by the vehicle identification number (VIN): 1G1JF5246X7 (production number deleted). The vehicle was a 4-door sedan equipped with front-wheel drive and a 2.2 liter, 4-cylinder engine. The driver's employer was listed as the owner of the vehicle. The odometer reading at the time of the crash was unknown. The seating was configured with front bucket and rear bench seats (with folding backs). The driver reported no previous crashes or maintenance on the Chevrolet's frontal air bag system. No cell phone was present or in-use at the time of the collision.

### *VEHICLE DAMAGE*

#### Exterior

The 1999 Chevrolet Cavalier Z24 sustained severe frontal damage as a result of the impact with the large diameter tree **(Figure 4)**. The direct contact damage began at the front right bumper corner and extended 45.0 cm (17.7 in) inboard. The impact deformed the entire front end width resulting in a combined direct and induced damage length (Field L) of 95.0 cm (37.4 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia and partial honeycomb separation)*: C1= 14.0 cm (5.5 in), C2= 36.0 cm (14.2 in), C3= 49.0 cm (19.3 in), C4= 71.0 cm (28.0 in), C5= 88.0 cm (34.6 in), C6= 82.0 cm (32.3 in).

**Figure 4. Front right damage to the 1999 Chevrolet Cavalier Z24.**

The Collision Deformation Classification (CDC) for this impact to the Chevrolet was 12-FREW-4 with a principal direction of force of (+) 10 degrees. The NASS researcher reported no right side wheelbase reduction while (conversely) the crush seemed overstated, however, inadequate field documentation prohibited further SCI analysis for correctional purposes. The hood was deformed up and rearward from engagement against the tree. The right fender was displaced rearward which restricted the right front wheel/tire (not deflated), jammed the right side doors and produced outward buckling to the right front door window frame (with integrity loss). Induced contact damage also resulted in buckling to the right A-pillar, windshield header and roof area. The windshield was fractured from (exterior) impact forces (only).

**Interior**

Interior damage to the Chevrolet Cavalier identified through the vehicle inspection was moderate and was attributed to occupant contact and component intrusion. Loading marks were identified on the front left/right shoulder belt webbings. Scuff marks were documented on the left knee bolster, instrument panel and steering column **(Figure 5)** which was also displaced to the left. An indentation and fracture were documented on the glove compartment door. Longitudinal intrusions into the front passenger space involved 32.0 cm (12.6 in) of right instrument panel, 20.0 cm (7.9 in) of center instrument panel, and 20.0 cm (7.9 in) of right toepan intrusions.

**Figure 5. Scuff marks to the driver's knee bolster.**

***REDESIGNED AIR BAG SYSTEM***

The 1999 Chevrolet Cavalier Z24 was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags deployed as a result of the crash. The driver air bag was housed in the center of the steering wheel with a vertically oriented flap tear seam (I-configuration). The flaps were symmetrical in shape and measured 9.0 cm (3.5 in) in width and 11.0 cm (4.3 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, small areas of blood spattering were noted across the face of the air bag. The NASS researcher measured the diameter of the driver air bag at 54.0 cm (21.3 in) in its deflated state **(Figure 6)**. The bag was vented by two ports located at the 9 o'clock and 3 o'clock sectors on the rear aspect of the air bag. No internal tether straps were present.

The front right passenger air bag deployed from the right top instrument panel area with a single cover flap design hinged at the forward aspect. Although no contact evidence was identified on the exterior surface of the module cover flap, blood spattering was noted across the face and rear left aspect of the air bag. The cover flap was rectangular in shape and measured 36.0 cm (14.2 in) in width and 16.0 cm (6.3 in) in height. The NASS researcher measured the passenger air bag at 48.0 cm (18.9 in) in width and 65.0 cm (25.6 in) in height in its deflated state **(Figure 7)**. No internal tether straps or vent ports were reported for the front right passenger air bag.

**Figure 6. 1999 Chevrolet Cavalier Z24 deployed redesigned driver air bag.**

**Figure 7. 1999 Chevrolet Cavalier Z24 deployed redesigned passenger air bag.**

***DRIVER DEMOGRAPHICS***

| | |
|---|---|
| Age/Sex: | 41 year old female |
| Height: | 160 cm (63 in) |
| Weight: | 54 kg (120 lb) |
| Seat Track Position: | Mid-to-forward position |
| Manual Restraint Use: | 3-point lap and shoulder belt system |
| Usage Source: | NASS vehicle inspection, driver interview, police report |
| Eyeware: | None |
| Type of Medical Treatment: | Transported to a local trauma center and admitted (5 days) |

**Driver Injuries**

| ***Injury*** | ***Severity (AIS 90)*** | ***Injury Mechanism*** |
|---|---|---|
| *Fracture right ankle | Moderate (852200.2,1) | Left toepan |
| +Contusion left posterior wrist | Minor (790402.1,2) | Left instrument panel |
| +Contusion bilateral knees | Minor (890402.1,3) | Left knee bolster |
| +Contusion left eyelid | Minor (297402.1,2) | Driver air bag |
| +Contusion right hip | Minor (890402.1,1) | Lap belt webbing |
| +Contusion whole chest | Minor (490402.1,0) | Shoulder belt webbing |
| +Abrasion mid to lower chest | Minor (490202.1,0) | Shoulder belt webbing |
| +Laceration upper lip | Minor (290600.1,8) | Driver air bag |
| +Laceration right medial knee | Minor (890602.1,1) | Car keys |

*sources - discharge summary*/ER report+*

**Driver Kinematics**

The 41 year old female driver of the 1999 Chevrolet Cavalier Z24 was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to a mid-to-forward position. Belt usage was evidenced by the loading marks documented to the front left shoulder belt webbing **(Figure 8)** relative to the soft tissue injuries sustained across the occupant belt path. At impact, she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, knee bolster and deployed redesigned driver air bag. Loading of the manual restraint resulted in abrasions and contusions to the right hip and left chest. Contact to the knee bolster resulted in bilateral knee

**Figure 8. Loading marks to the driver's shoulder belt webbing.**

contusions and a laceration to the right medial knee from the car keys *(per the driver interview)* in the ignition. These mechanisms were evidenced by the scuff marks documented to the knee bolster and steering column. Contact to the deployed driver air bag resulted in a left eyelid contusion and laceration to the upper lip ("split lip"). Her left hand struck the mid-left instrument panel area which resulted in a contusion to the posterior aspect of the wrist, evidenced by the scuff marks and panel displacement identified to the left of the steering column. She also sustained a right ankle fracture from contact to the toepan as evidenced by the specific location of the injury in conjunction with the driver's placement of the foot on the accelerator pedal pre-crash. During clockwise vehicle rotation to final rest, she loaded the steering column as evidenced by the left shift noted to this component, however, no injury was reported as a result of this action. Following the crash, she exited the vehicle with some assistance from rescue personnel and was subsequently transported by ambulance to a local trauma center for treatment and admitted for 5 days. The redesigned driver air bag provided additional protection from further contact to the steering wheel hub/rim, and potential serious injury.

### *FRONT RIGHT PASSENGER DEMOGRAPHICS*

| | |
|---|---|
| Age/Sex: | 39 year old male |
| Height: | 173 cm (68 in) |
| Weight: | 60 kg (133 lb) |
| Seat Track Position: | Mid-to-rear position |
| Manual Restraint Use: | 3-point lap and shoulder belt system |
| Usage Source: | Vehicle inspection, driver interview, police report |
| Eyeware: | None |
| Type of Medical Treatment: | Transported to a local trauma center and admitted (4 days) |

**Front Right Passenger Injuries**

| ***Injury*** | ***Severity (AIS 90)*** | ***Injury Mechanism*** |
|---|---|---|
| *Fracture right 5th metatarsal | Moderate (852200.2,1) | Toepan |
| *Fracture right fibula (bimalleolar) | Moderate (851612.2,1) | Toepan |
| *Fracture right pelvis (acetabular) | Moderate (852602.2,1) | Glove compartment door (indirect contact injury) |
| *Fracture right mandible (condylar neck) | Moderate (250608.2,1) | Right A-pillar |
| +Abrasion chin (superficial) | Minor (290202.1,8) | Passenger air bag |
| +Abrasion abdomen | Minor (590202.1,0) | Lap belt webbing |
| +Abrasion anterior right shin | Minor (890202.1,1) | Glove compartment door |

*sources - discharge summary*/ER report+*

**Front Right Passenger Kinematics**

The 39 year old male front right passenger of the 1999 Chevrolet Cavalier Z24 was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the mid-to-rear position. Belt usage was evidenced by the loading marks documented to the front right shoulder belt webbing relative to the abrasions sustained across the abdomen. At impact, the front right passenger initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, glove compartment door and deployed redesigned passenger air bag. Loading of the glove compartment door resulted in abrasions to the anterior right shin and a fracture of the right pelvis, evidenced by the deformation documented to this component. Although the lack of associated injury to the right knee/femur would suggest the pelvic fracture was a result of contact to some other component, the type of fracture to the acetabular wall indicates this to be a typical indirect contact injury from glove compartment door loading. Contact to the deployed passenger air bag resulted in a chin abrasion. He also sustained a fractured right distal fibula and toe as a result of contact to the (intruded) toepan. This injury mechanism was evidenced by the deformation to the toepan and passenger's stated placement of the feet on the floor pre-crash. Contrary to the NASS case file, the fractured right mandible (condylar neck) was probably a result of contact to the right A-pillar as evidenced by the direction of force and associated kinematic response pattern, however, this could not be confirmed due to inadequate NASS interior vehicle images provided. Following the crash, he exited the vehicle with some assistance from rescue personnel and was subsequently transported by ambulance to a local trauma center for treatment and admitted for 4 days. The deployed redesigned passenger air bag provided additional protection against further contact to frontal components, and potential serious injury.

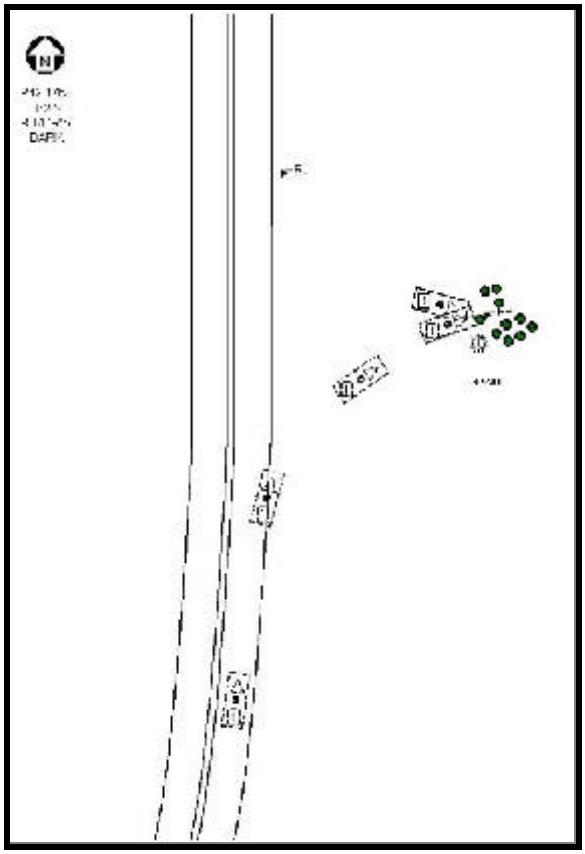

**Figure 9. NASS Scene Diagram (physical plant and vehicle plot not to scale).**