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ON-SITE OTHER INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN08044
LOCATION - TEXAS
VEHICLE - 2006 MAZDA 5
CRASH DATE - October 2008

Submitted:

September 28, 2009



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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 performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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15. <i>Supplementary Notes</i> On-site side air bag deployment investigation involving a 2006 Mazda 5, four-door station wagon, with manual safety belts and dual front, side, and curtain air bags, and a 1994 Chevrolet C1500 pickup truck					
16. <i>Abstract</i> This report covers an on-site investigation of a side air bag deployment crash that involved a 2006 Mazda 5 station wagon and a 1994 Chevrolet C1500 pickup truck. The focus of this case is the Mazda's side inflatable curtain air bags that deployed as a result of the crash. This right-angle type collision occurred within a 4-leg intersection. The right passenger area (doors and quarter panel) were impacted by the front of the Chevrolet. The Mazda's driver (31-year-old, female) was seated and restrained by her lap-and-shoulder, safety belt system. The driver sustained a police-reported "C" (possible) injury and received treatment at the scene from the responding emergency medical technicians. The second row left passenger (2-year-old, male) was seated in a forward-facing child safety seat, which was secured by the vehicle's lap-and-shoulder, safety belt system. This child passenger also received treatment at the scene. He sustained a police-reported "C" (possible) injury. The second row right passenger (1-year-old, female) was seated in a rear-facing child safety seat which was also secured by the vehicle's lap-and-shoulder, safety belt system. This child passenger was not transported by ambulance to the hospital and received treatment at the scene. She sustained a police-reported "B" (non-incapacitating-evident) injury.					
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This crash was brought to this contractor's attention on November 7, 2008 by the sampling activities of the National Automotive Sampling System–General Estimates System. This investigation was assigned on November 12, 2008. This crash involved a 2006 Mazda 5 station wagon and a 1994 Chevrolet C1500 pickup truck. The crash occurred in October 2008 at 0935 hours in Texas and was investigated by the applicable city police department. The focus of this investigation is the Mazda's side inflatable curtain air bag that deployed during the crash. This contractor inspected the scene and Mazda on November 20, 2008. Multiple attempts to interview the Mazda's driver were unsuccessful. This summary is based on the police crash report, scene and vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

CRASH CIRCUMSTANCES

Crash Environment: The traffic-way on which the Mazda was traveling was an 8-lane, divided, city street, traversing in an east-west direction, and the Mazda was approaching a 4-leg intersection (**Figure 1**). On the eastern leg of the intersection the east roadway had 2 through lanes, 1 combination through/left turn lane, and 1 left-hand turn lane. The west roadway had 3 through lanes and 1 left-hand turn lane. The trafficway on which the Chevrolet was traveling was a 6-lane, undivided, one-way, service road to a U.S. highway, traversing in a north-south direction, and the Chevrolet was approaching the same 4-leg intersection (**Figure 2**). On the northern leg of the intersection, the southbound service road had 2 through lanes, 1 combination through/left turn lane, 1 left turn lane, 1 channelized right turn lane, and 1 U-turn lane.

The specific road segment of the Mazda's city roadway was straight and level at the area of impact. The road segment was an underpass with the U.S. highway overhead. The pavement was concrete but traveled, and the width of the trafficway was 30.0 meters (98.4 feet) which included a 1.3 meter (4.3 foot) raised concrete median separating the east and westbound roadways. The width of the Mazda's eastern travel lane was 3.5 meters (11.5 feet). Both roadways were bordered by curbs. Pavement markings consisting of solid white lane lines separated each of the 4 designated lanes. The left-turn only lane had a Turn-Lane Use Arrow in conjunction with the elongated word ONLY, and the combination turn or through lane had a Turn and Through



Figure 1: Mazda's westbound path of travel toward intersection in inside through lane

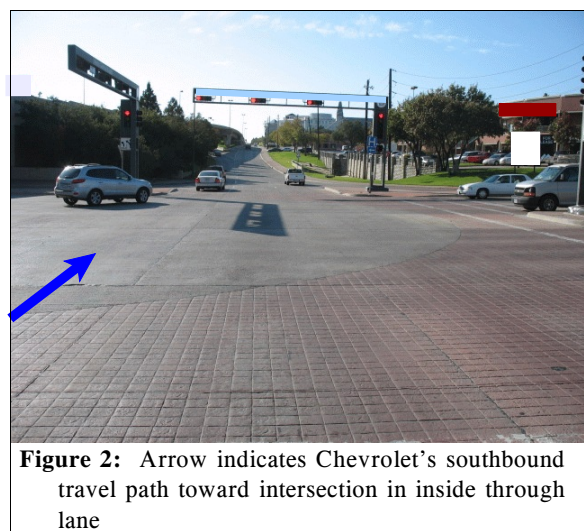


Figure 2: Arrow indicates Chevrolet's southbound travel path toward intersection in inside through lane

Lane-Use Arrow painted on the surface. Traffic controls consisted of 3-phase traffic control signals, mounted both horizontally and vertically, located in the median on the west leg of the intersection and on a traffic island on the northwest quadrant of the intersection (**Figure 1**). The speed limit was 56 km/h (35 mph). No regulatory speed limit sign was posted near the crash site.

The U.S. highway service roadway was straight and level (actual slope was 1.9%, negative to the south--a downgrade in the Chevrolet's direction of travel) at the area of impact. The pavement was concrete, but there was a bricked area at the mouth of the intersection. The width of the trafficway (from the left-hand turn lane to the channelized right-hand turn lane) was 17.5 meters (57.4 feet). The width of the Chevrolet's southern travel lane was 3.5 meters (11.5 feet). The roadway was bordered by curbs. Pavement markings consisted of a single solid white lane lines that separated the 6 designated lanes. Traffic controls consisted of 3-phase traffic control signals, mounted both horizontally and vertically, located on a traffic island on the southeast quadrant of the intersection and in a traffic island on the southwest quadrant of the intersection (**Figure 2**). The speed limit was 64 km/h (40 mph). No regulatory speed limit sign was posted near the crash site.

At the time of the crash the light condition was daylight, the atmospheric condition was either clear or cloudy, and the roadway pavement was dry. Traffic density was moderate, and the site of the crash was urban commercial; see Crash Diagram on page 13.

Pre-Crash: The Mazda was traveling west in the inside through lane, and the driver intended to continue straight through the intersection (**Figure 3**). The Chevrolet was traveling south in the inside through lane, and the driver intended to continue straight through the intersection. It is unknown if the Mazda's driver made any avoidance maneuvers prior to the crash. The crash occurred within the 4-leg intersection of the 2 trafficways.

Crash: The right side of the Mazda was impacted by the front of the Chevrolet, causing the Mazda's right side curtain air bag to deploy (**Figure 4**). The left front seat back-mounted side impact air bag and the left side curtain air bag also deployed during the collision sequence. The unoccupied right front seat's seat back-mounted side air bag did not deploy during the right side impact. The Mazda was redirected in a west-southwesterly direction and rotated approximately 190 degrees clockwise. The vehicle came to rest straddling the raised curbed median that separated the east and west roadways on the west leg of the intersection, heading in an east-southeasterly direction (**Figure 3**).

Post-Crash: According to the police crash report, the driver of the Mazda remained inside her vehicle at final rest; however, the condition of the driver is unknown. Based on the available evi-



Figure 3: Mazda's westbound travel path into intersection; foreground arrow indicates approximate impact location with Chevrolet; background arrow shows Mazda approximate final rest position

dence, the driver was able to exit the vehicle. The second row left and second row right passengers remained inside the vehicle within their respective child safety seats at final rest. The investigating police agency was notified of the crash within 3 minutes post-crash and arrived on-scene 7 minutes later. The driver and second row left and right passengers were not transported but did receive medical treatment at the scene. Following the police investigation, the Mazda and the Chevrolet were both towed from the scene due to damage.

CASE VEHICLE

The 2006 Mazda 5 was a front wheel drive, 6-passenger, 4-door station wagon (VIN: JM1CR29L060-----) equipped with a 2.3-liter, I-4 engine and a 4-speed automatic transmission. This vehicle was manufactured during January 2006. Braking was achieved by a power-assisted, front and rear disc, 4-wheel, anti-lock system with electronic brake force distribution. This vehicle's frontal air bags were manufacturer Certified Advanced 208-Compliant. The Mazda was equipped with multi stage driver and front right passenger air bag inflators, front height adjustable seat belts, and seat belt pretensioners with load limiters. There was an occupant weight sensor for the front right passenger seating position. The vehicle was also equipped with front seat back-mounted side impact air bags and right and left side curtain air bags protecting all outboard seating positions. Inspection of the vehicle's interior revealed adjustable front and second row bucket seats and a split third row bench seat with folding backs. There were height adjustable head restraints for all 6 seating positions and Lower Anchors and Tethers for Children (LATCH) system features. The Mazda's wheelbase was 275 centimeters (108.3 inches), and the odometer reading at inspection was 54,394 kilometers (33,799 miles).

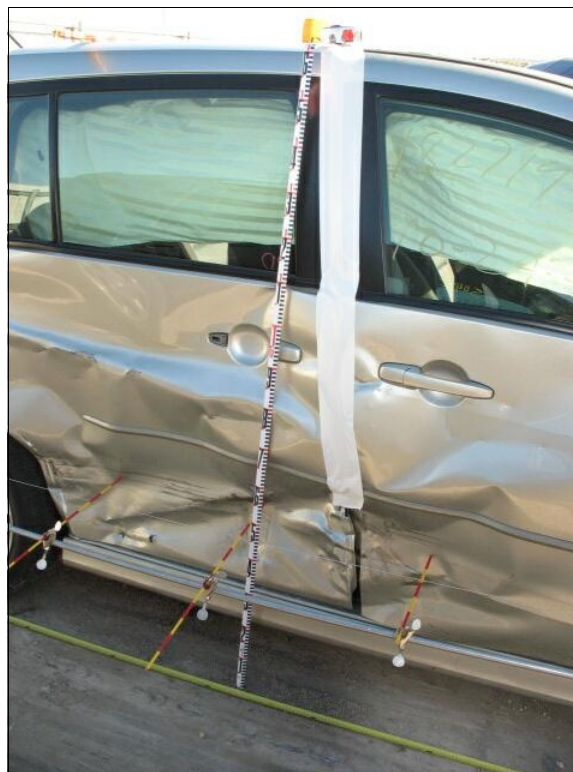


Figure 4: Mazda's right side damage from impact by Chevrolet showing crush positions C₃ through C₅ and deployed right side curtain air bag

CASE VEHICLE DAMAGE

Exterior Damage: The Mazda's contact with the Chevrolet involved the right side with the damage distributed along the back half (**Figure 5**). Direct damage began 197 centimeters (77.6 inches) rearward of the right front axle and extended 175 centimeters (68.9 inches) along the right side. The location of the Field L began 82 centimeters (32.3 inches) rearward of the right front axle and extended 222 centimeters (87.4 inches) along the right side (**Figure 6**). Residual maximum crush was measured as 14 centimeters (5.5 inches) at C₄ (**Figure 7**). The table below shows the case vehicle's crush profile.



Figure 5: Mazda's right side damage viewed from back; C₁ begins behind right rear wheel



Figure 6: Mazda's right side damage viewed from front; C₆ located mid-right front door

Units	Event	Direct Damage		Field L	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	175	14	222	0	10	14	14	8	1	-48	-61
in		68.9	5.5	87.4	0.0	3.9	5.5	5.5	3.2	0.4	-18.9	-24.0

The wheelbase on the Mazda's right side was extended 1 centimeters (0.4 inches) while the left side was unaltered from the crash. The Mazda's right front and right rear doors, right quarter panel, and right rear wheel assembly were directly damaged and crushed inward. There was induced damage to both the right side doors and both doors were jammed as a result of the collision. Remote buckling was also found on the right side roof rail and right roof. No obvious induced damage or remote buckling was noted to the remainder of the Mazda's exterior.

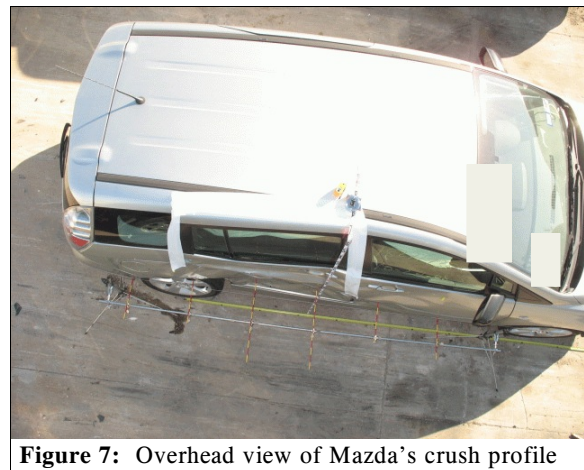


Figure 7: Overhead view of Mazda's crush profile

The Mazda manufacturer's recommended tire size was P205/50R17, and the vehicle was equipped with the proper sized tires. This vehicle's tire data are shown in the table below. The top of the Mazda's right rear tire was rotated 10 degrees inward from the crash.

Damage Classification: The Collision Deformation Classification for the Mazda was: **02-RZEW-2 (60 degrees)**. The WinSMASH reconstruction program, Missing Vehicle algorithm, was used on the Mazda's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs were, respectively: 19.0 km/h (11.8 mph), -9.5 km/h (-5.9 mph), and -16.5 km/h (-10.3 mph).

Tire	Measured Pressure		Vehicle Manufacturer's Recommended Cold Tire Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	179	26	234	34	5	6	None	No	No
LR	200	29	234	34	8	10	None	No	No
RR	159	23	234	34	6	7	None	No	No
RF	193	28	234	34	5	6	None	No	No



Figure 8: Mazda's instrument panel, steering wheel, and transmission selector lever with no apparent evidence of occupant contact, and non-deployed driver and front right passenger air bags

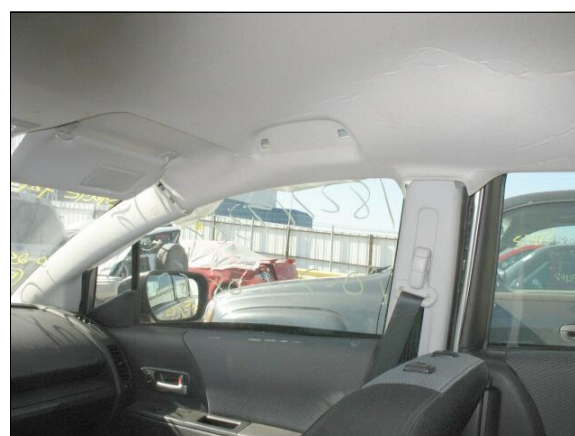


Figure 9: Mazda's right A- and B-pillars, instrument panel, front interior door surface, roof side rail and roof with no apparent evidence of occupant contact; roof headliner disrupted from induced damage (i.e., remote buckling)

Interior Damage: Inspection of the Mazda's interior revealed that there was no evidence of occupant contact on the interior surfaces (**Figures 8 through 10**). There were 14 centimeters (5.5 inches) of intrusion to the right rear door panel and 3 centimeters (1.2 inches) of intrusion to the side panel for the third row right seating position. There was no evidence of compression to the energy absorbing shear capsules in the steering column, and no deformation to the steering wheel rim.

MANUAL RESTRAINT SYSTEM

Restraints: The Mazda's manual restraint systems are shown in the table below.

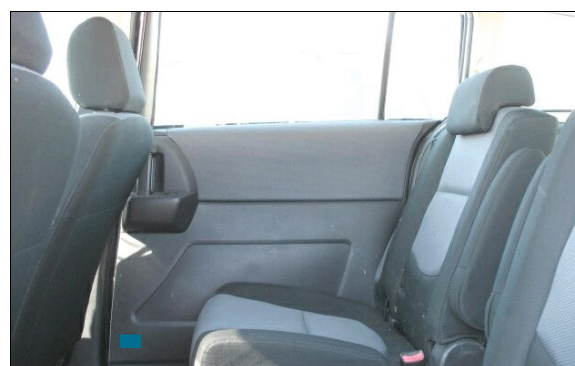


Figure 10: Interior surface of right rear door showing no apparent occupant contact evidence

	Left	Center	Right
First Row	Continuous loop, lap-and-shoulder, safety belt system with upper anchorage adjustor for the D-ring located in its down-most position; retractor-mounted pretensioner with force limiter; sliding type latch plate with ELR		Continuous loop, lap-and-shoulder, safety belt system with upper anchorage adjustor for the D-ring located in its down-most position; retractor-mounted pretensioner with force limiter; sliding type latch plate with ELR
Second Row	Continuous loop, lap-and-shoulder, safety belt system without upper anchorage adjustor for the D-ring; sliding type latch plate with switchable retractor type; lower anchor present; top tether anchor located behind the seat back		Continuous loop, lap-and-shoulder, safety belt system without upper anchorage adjustor for the D-ring; sliding type latch plate with switchable retractor type; lower anchor present; top tether anchor located behind the seat back
Third Row	Continuous loop, lap-and-shoulder, safety belt system with shoulder belt guide slot; sliding type latch plate with switchable retractor type		Continuous loop, lap-and-shoulder, safety belt system with shoulder belt guide slot; sliding type latch plate with switchable retractor type
ELR = Emergency Locking Retractor Switchable = either ALR = Automatic Locking Retractor			

Both front and second row seat belts exhibited indications of historical usage. The inspection of the driver’s safety belt webbing, D-ring, and latch plate revealed that the retractor-mounted pretensioner had not actuated and showed a loading scuff mark on the webbing, 102 centimeters (40.2 inches) from the stop button (**Figure 11**). The inspection of the second row left passenger's safety belt webbing, D-ring, and latch plate showed a faint scuff mark on the safety belt’s webbing, 82 centimeters (32.3 inches) from the base of the safety belt (no stop button was present–**Figure 12**). This scuff was probably from the child safety seat used by the second row left passenger. The inspection of the second row right passenger’s safety belt webbing, D-ring, and latch plate did not show any indications of usage during this crash.

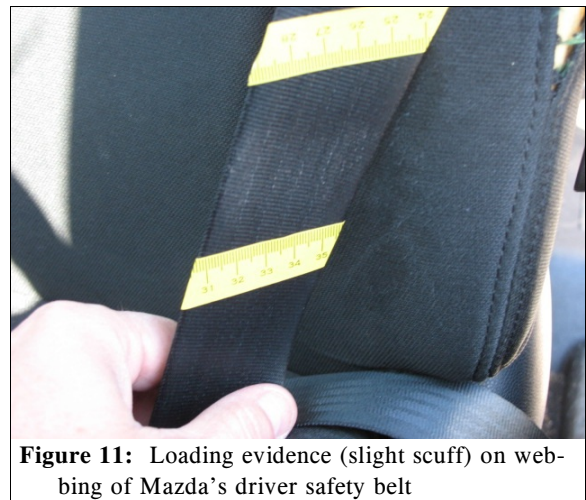


Figure 11: Loading evidence (slight scuff) on webbing of Mazda’s driver safety belt

The Mazda was equipped frontal air bags that were manufacturer Certified Advanced 208-Compliant and featured multi stage inflators at the driver and front right passenger positions. Based on the manufacturer’s website, the multi stage frontal air bag system senses the severity of a crash, then determines if the air bags should be deployed at stage 1 or 2 level. The front right passenger sensing system automatically switches the front right passenger air bag on or off based on the passenger’s weight and the type of pressure on the seat. The driver’s air bag was located in the steering wheel hub (Figure 8) and the front right passenger’s air bag was located in the middle of the instrument panel (Figure 8). Neither of these air bags deployed in this side impact crash.



Figure 12: Loading evidence (faint scuff) on webbing of Mazda’s second row left safety belt

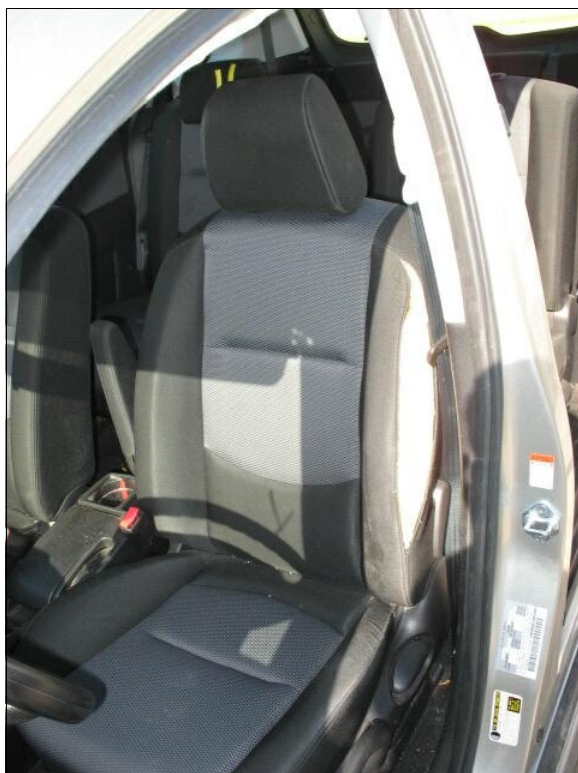


Figure 13: Mazda’s driver seat showing lateral location of seat back-mounted side impact air bag

The Mazda’s driver and right front side impact inflatable occupant protection systems (air bags) were located within the seat backs near the top and lateral portions of the front seats. The



Figure 14: Inboard surface of Mazda’s driver seat back-mounted side impact air bag; no evidence of occupant contact was readily apparent

bags were attached on the lateral surfaces (**Figure 13**). An inspection of the driver's seat and the air bag's fabric revealed that the air bag deployed through the designated tear points, and there was no evidence of unintended damage during the deployment to the air bag or to the side of the seat. The driver's side air bag was designed without any tethers or vent ports. The deployed air bag was designed in a reverse kidney shape with two circular areas connected by a common area (**Figure 14**). The top circular area had a diameter of 20 centimeters (7.9 inches) while the bottom circular area had a diameter of 16 centimeters (6.3 inches). The total height of the air bag was 58 centimeters (22.8 inches). An inspection of the driver's side air bag fabric revealed no contact evidence on either the outboard or inboard surfaces of the air bag's fabric.



Figure 15: Front portion of Mazda's left side curtain air bag; tether attached to lower left A-pillar



Figure 16: Middle portion of Mazda's left side curtain air bag



Figure 17: Back portion of Mazda's left side curtain air bag



Figure 18: Front portion of Mazda's right side curtain air bag; tether attached to lower portion of right A-pillar

The Mazda's right and left inflatable side curtain air bags were housed within the left and right roof side rails (**Figures 15 through 20**). Both air bags extended along the front, second row, and third row seats. They were designed to provide protection to an occupant's head during a side impact. Each side air bag was anchored to the lower portion of their respective A-pillars by a tethered cord 33 centimeters (13.0 inches) in length (**Figures 15 and 18**). Each curtain air bag was essentially rectangular with a length of 210 centimeters (86.7 inches) and a height of 37 centimeters (14.6 inches).

Each air bag was designed with one elongated inflation chamber located in the lower half of the air bags. The upper half of each bag contained inflatable and noninflatable areas designed to provide protection for the occupants. The most significant noninflatable areas were found at or behind the second row and third row seat backs where occupant loading was improbable. Inspection of the air bags revealed a probable deployment scuff on the interior surface of the right side curtain air bag's fabric (Figures 19 and 20) located 67 centimeters (26.4 inches) from the back edge of the air bag (Figure 21). There was no evidence of damage due to deployment on the outboard surfaces of either air bag or the inboard surface of left side curtain air bag. An inspection of both the left and right side curtain air bag's fabric revealed no contact evidence on the interior surfaces of the air bags.



Figure 19: Middle portion of Mazda's right side curtain air bag; probable deployment scuff (upper and lower portions bracketed by tape) near second row right seat back



Figure 20: Back portion of Mazda's right side curtain air bag with probable deployment scuff bracketed by tape

CHILD SAFETY SEAT

Both of Mazda's second row occupants were seated in child safety seats, but neither seat was available for inspection.

CASE VEHICLE KINEMATICS—OVERVIEW

It is unknown if the Mazda's driver attempted any pre-crash avoidance maneuvers. Because of the minor nature of this crash, coupled with the restraint use by the vehicle's occupants, their pre-impact body positions did not change just prior to impact. The Mazda's impact with the 2002 Chevrolet enabled the occupants to continue forward and rightward along a path opposite the Mazda's 60 degree direction of force as the vehicle decelerated. After the Mazda achieved maximum engagement with the Chevrolet, the occupants were redirected toward their left and rearwards towards their seat backs as the Mazda began to rotate rapidly clockwise. As the vehicle continued its rotation the occupants were probably displaced side-to-side. When the back of the

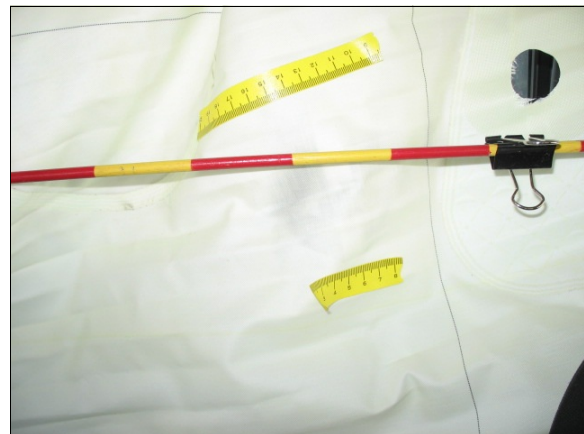


Figure 21: Close-up of probable deployment scuff on Mazda's right side curtain air bag

vehicle mounted the curbed median that separated the roadways on the western leg of the intersection, it is probable that the occupants moved rearward toward their seat backs as the vehicle came to final rest.

DRIVER KINEMATICS

The posture of Mazda’s driver (31-year-old, female) was unknown. Based on the vehicle inspection, the driver of the Mazda was probably seated in slightly reclined posture with her back against the seat back, her left foot on the floor, her right foot on the accelerator, and at least one of her hands on the steering wheel. The seat track was located in its rearmost position, the seat back was slightly reclined, and the location of steering column’s tilt adjustment was between its center- and full-down positions.

The driver was restrained by her lap-and-shoulder, safety belt system. As a result of the impact with the Chevrolet, the driver loaded her safety belts which mitigated her forward and rightward movement.

When the vehicles separated following maximum engagement, the driver probably moved leftward and rearward and contacted the deployed side impact and side curtain air bags as the vehicle rotated clockwise. As the vehicle moved along its post-crash trajectory, the driver continued to load her safety belts and probably moved slightly toward her seat back as the vehicle decelerated to final rest.

DRIVER INJURIES

According to the police crash report, the driver was not transported by ambulance to the hospital. She sustained a police-reported “C” (possible) injury and received treatment at the scene from the responding emergency medical technicians. The exact injuries sustained by the Mazda’s driver are unknown.

SECOND ROW LEFT PASSENGER KINEMATICS

Prior to the crash, the posture of the second row left passenger (2-year-old, male) was unknown. According to the police crash report, this occupant was seated in a forward-facing child safety seat of an unknown make or model. His seat track was located in its rearmost position, and the seat back was slightly reclined.

Based on the vehicle inspection, the second row left passenger’s child safety seat was secured by the vehicle’s lap-and-shoulder, safety belt system. As a result of the impact with the Chevrolet, the second row left passenger probably loaded the child seat’s safety harness which mitigated his forward and rightward movement.

When the vehicles separated following maximum engagement, the second row left passenger probably moved leftward and rearward and contacted the deployed side curtain air bag as the vehicle rotated clockwise. As the vehicle moved along its post-crash trajectory, the second row

left passenger continued to load the child seat's safety harness and probably moved slightly toward the back surface of his child seat as the vehicle decelerated to final rest.

SECOND ROW LEFT PASSENGER INJURIES

The second row left passenger was not transported by ambulance to the hospital and received treatment at the scene. He sustained a police-reported "C" (possible) injury, the exact nature of which is unknown.

SECOND ROW RIGHT PASSENGER KINEMATICS

The pre-crash posture of the second row right passenger (1-year-old, female) was unknown. According to the police crash report, this occupant was seated in a rear-facing child safety seat of unknown make or model. Her seat track was located in its rearmost position, and the seat back was slightly reclined.

The second row right passenger's child safety seat was probably secured by the vehicle's lap-and-shoulder, safety belt system. As a result of the impact with the Chevrolet, the second row right passenger probably loaded the outboard side and rear surface of her child safety seat while the seat's safety harness and the deploying right side curtain air bag mitigated her forward and rightward movement.

When the vehicles separated following maximum engagement, the second row right passenger probably moved leftward and forward in the child seat (i.e., toward the right and rear of the vehicle) and probably loaded the child seat's harness. As the vehicle moved along its post-crash trajectory, the second row right passenger continued to load his child seat's harness as the child was jolted about in her seat. As the vehicle decelerated to final rest, the child probably tried to move slightly toward the back of the vehicle's seat back, but her child seat's harness restrained her.

SECOND ROW RIGHT PASSENGER INJURIES

The Mazda's second row right passenger was not transported by ambulance to the hospital but received treatment at the scene. She sustained a police-reported "B" (non-incapacitating-evident) injury, but her specific injuries are unknown.

OTHER VEHICLE

Based on the VIN and manufacturer's specifications, the 1994 Chevrolet C1500 was a rear-wheel drive, 2-door, extended cab, long bed, pickup truck (VIN: 2GCEC19H0R1-----) equipped with a 5.0L, V-8 engine and was equipped with either the standard 5-speed manual or an optional 4-speed automatic transmission. Braking was achieved by a power-assisted, front disc and rear drum, rear-wheel, anti-lock system. The Chevrolet's wheelbase was 395 centimeters (155.5 inches). The Chevrolet was not equipped with any supplemental restraint systems (air bags). The Chevrolet was not inspected.

Damage Classification: With no available vehicle photographs, an assessment of the Chevrolet's damage was not possible. The WinSMASH reconstruction program, Missing Vehicle algorithm, was used as a representation of the Chevrolet's crash severity. The Total, Longitudinal, and Lateral Delta Vs were, respectively: 15.0 km/h (9.3 mph), -13.0 km/h (-8.1 mph), and 7.5 km/h (4.7 mph). The results were based only on the Mazda's crush profile and should be considered only as a borderline reconstruction for the Chevrolet's damage.

Chevrolet's Occupants: According to the police crash report, the Chevrolet's driver (36-year-old, male) was restrained by his lap-and-shoulder, safety belt. The driver was not transported by ambulance to the hospital, and he did not sustain any police-reported injuries as a result of this crash.

