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ON-SITE REDESIGNED AIR BAG INVESTIGATION

CASE NUMBER - IN-03-040
LOCATION - MISSOURI
VEHICLE - 2002 KIA SPECTRA
CRASH DATE - September 2003

Submitted:

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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 air bag deployment investigation involving a 2002 Kia Spectra, four-door sedan, with manual safety belts and dual front redesigned air bags, and a 1990 Chevrolet Camaro RS, two-door convertible					
16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 2002 Kia Spectra (case vehicle) and a 1990 Chevrolet Camaro RS (other vehicle). This crash is of special interest because the case vehicle was equipped with redesigned air bags and the case vehicle's unrestrained driver [58-year-old, White (non-Hispanic) female] was alleged to have sustained a severe cervical injury from her deploying driver air bag. The trafficway on which both vehicles were traveling was a four-lane, undivided, U.S. highway, traversing in a north-northwesterly and south-southeasterly direction, and the case vehicle was approaching a three-leg commercial driveway access junction. The north-south roadway had two through lanes in both the northern and southern directions. The case vehicle had been traveling north-northwestward in the inside northern lane and was making a left-hand turn. The Chevrolet was exiting a slight left-hand curve, traveling south-southeastward in the inside southern lane. The crash occurred in the inside southern lane of the roadway, within or near the driveway junction. The front of the case vehicle impacted the front left corner of the Chevrolet, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The Chevrolet's driver only air bag also deployed as a result of this crash. The case vehicle's driver was seated with her seat track located in its rearmost position, and the vehicle was not equipped with a tilt steering wheel. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to the interviewee and her medical records, severe injuries that included: a contused cervical spinal cord with incomplete cord syndrome, a small subdural hematoma, a minor nonanatomic brain injury, a fractured right femur, cuts on top of her left hand (i.e., knuckles), and contusions to her left hand, right distal thigh, and over her left tibia.					
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This investigation was brought to NHTSA's attention on September 24, 2003 by the attorney representing the case vehicle's driver. This crash involved a 2002 Kia Spectra (case vehicle) and a 1990 Chevrolet Camaro RS (other vehicle). The crash occurred in September 2003, at 3:35 p.m., in Missouri and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with redesigned air bags and the case vehicle's driver [58-year-old, White (non-Hispanic) female] was alleged to have sustained a severe cervical injury, *initially* believed to have resulted from her deploying driver air bag. A thorough *investigation* was *unable to pinpoint with any certainty the cause of her cervical injuries* and, thus, this case is of interest only because the vehicle was equipped with redesigned air bags. This contractor inspected the scene and vehicles on September 30, 2003. This contractor interviewed the husband of the case vehicle's driver on October 17, 2003. This report is based on the Police Crash Report, an interview with the husband of the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

Crash Environment: The trafficway on which both vehicles were traveling was a four-lane, undivided, U.S. highway, traversing in a north-northwesterly and south-southeasterly direction, and the case vehicle was approaching a three-leg commercial driveway access junction. The north-south roadway had two through lanes in both the northern and southern directions. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry. Traffic density was not determined, and the site of the crash was a combination of urban commercial and undeveloped. In addition, there was a driveway to a commercial establishment near the crash site; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle had been traveling north-northwestward in the inside northern lane and was making a left-hand turn, intending to proceed westward into an intersecting commercial driveway access. The Chevrolet was exiting a slight left-hand curve, traveling south-southeastward in the inside southern lane of the same roadway and intended to proceed straight ahead. Based on evidence left at the scene, the case vehicle left approximately 3 meters (9.8 feet) of skid marks in an attempt to avoid the crash. The driver of the Chevrolet steered to the right and braked, depositing approximately 12 meters (39.4 feet) of pre-impact skid marks, attempting to avoid the crash. The crash occurred in the inside southern lane of the roadway, within or near the driveway junction.

Crash: The front of the case vehicle impacted the front left corner of the Chevrolet, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The Chevrolet's driver only air bag also deployed as a result of this crash.

Post-Crash: As a result of this impact, the case vehicle was driven backwards (i.e., towards the south) and rotated approximately 125 degrees counterclockwise before coming to rest, obliquely oriented in the outside southern lane, heading in a south-southwesterly direction. Post-impact, the

Chevrolet continued in a southward path but was redirected approximately 30 degrees clockwise before it came to rest obliquely oriented, straddling the outside southern lane, heading in a south-southwesterly direction.

Case Vehicle: The 2002 Kia Spectra was a front wheel drive, four-door sedan (VIN: KNAFB121325-----) and was equipped with ADVANCED OCCUPANT PROTECTION SYSTEM features, including redesigned frontal air bags and LATCH system features.

Vehicle Exterior: The case vehicle’s contact with the Chevrolet primarily involved the front with the damage distributed on approximately the left two-thirds. Direct damage began at the front left bumper corner and extended 150 centimeters (59.1 inches) across the entire width of the front bumper. Field L was measured as 122 centimeters (48.0 inches) and also extended the entire width of the front bumper. Residual maximum crush was measured as 30 centimeters (11.8 inches) and was located 9 centimeters (3.5 inches) to the left of C₅. The case vehicle’s wheelbase was essentially unaltered from the crash. The case vehicle’s front bumper fascia, front bumper, grille, hood, radiator, left fender, and left headlight and turn signal assemblies were directly damaged and crushed rearward. The right headlight and turn signal assemblies sustained induced damage as well as the hood, both the right and left fenders, and the windshield’s glazing. Remote buckling was also found on the left front door. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle’s exterior.

The case vehicle manufacturer’s recommended tire size was: P185/65R14, but the case vehicle was equipped with tire size: P195/60R14. The case vehicle’s tire data are shown in the table below. In addition, none of the case vehicle’s tires were damaged, deflated, or physically restricted.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	152	22	200	29	6	8	None	No	No
RF	152	22	200	29	6	8	None	No	No
LR	159	23	200	29	6	8	None	No	No
RR	145	21	200	29	6	8	None	No	No

Exterior Damage: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **01-FDEW-2 (20 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 35.0 km.p.h. (21.7 m.p.h.), -32.9 km.p.h. (-20.4 m.p.h.), and -12.0 km.p.h. (-7.5 m.p.h.). Based on the vehicle inspection, this collision fits the reconstruction model, but the results appear to be high. The case vehicle was towed due to damage.

Vehicle Interior: Inspection of the case vehicle's interior revealed a significant lateral rightward movement to the steering column and steering wheel rim, most likely from loading by the case vehicle's driver. The steering column moved 3 centimeters (1.2 inches) and the steering wheel rim moved 5 centimeters (2.0 inches). There was no other evidence of intrusion to the case vehicle's interior and no deformation to the steering wheel rim. Furthermore, the steering column compression could not be determined. Although there was no evidence of occupant contact to the left or center instrument panels, the driver's knee bolster, the rearview mirror, or either sun visor, there was contact evidence on the windshield's glazing. Based on the interview with the husband of the case vehicle's driver, the driver's left hand most likely came off of the steering wheel rim, striking and cracking the windshield's left glazing. In addition, the available evidence (discussed below) indicates that the driver most likely contacted the windshield's right glazing.

Supplemental Restraints: The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each approximately 8 centimeters (3.1 inches) in width. The driver's air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located towards the center at the 9:30 and 2:30 clock positions. The deployed driver's air bag was round with a diameter of 64 centimeters (25.2 inches). An inspection of the driver's air bag fabric revealed no contact evidence readily apparent on the air bag's fabric.

The front right passenger's air bag was located in the middle of the instrument panel. An inspection of the front right air bag module's cover flaps and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed with one tether, approximately 10 centimeters (3.9 inches) in width and located vertically at the middle of the air bag. The front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 68 centimeters (26.8 inches) and a width of approximately 51 centimeters (20 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front right air bag's fabric.

Other Vehicle: The 1990 Chevrolet Camaro RS was a rear wheel drive, two-door convertible (VIN: 1G1FP33E8LL-----). The Chevrolet was equipped with a driver only air bag, which deployed during this crash.

Vehicle Exterior: The Chevrolet's contact with the case vehicle involved the entire front with the damage distributed all the way across. Direct damage began at the left front bumper corner and extended, a measured distance of 89 centimeters (35.0 inches), inward along the steel front bumper. The Field L along the actual bumper was 121 centimeters (47.6 inches). An undeformed end width of 160 centimeters (63.0 inches) was used for reconstruction purposes. Direct damage offset was determined to be -30 centimeters (-11.8 inches). Residual maximum crush was measured as 54 centimeters (21.3 inches) at C₁. The wheelbase on the case vehicle's left side was shortened 22 centimeters (8.7 inches) while the right side was extended approximately 1 centimeter (0.4 inches). The Chevrolet's front bumper fascia, front bumper grille, hood, radiator, left

fender, and left headlight and turn signal assemblies were directly damaged and crushed rearward. The right headlight and turn signal assemblies sustained induced damage as well as the hood and left fender.

The case vehicle manufacturer’s recommended tire size was: P215/65R15, but the Chevrolet was equipped with tire size: P265/65R15. The case vehicle’s tire data are shown in the table below. In addition, the Chevrolet’s left front tire was damaged and physically restricted from the crash.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	179	26	207	30	7	9	Slight avulsion of sidewall surface	Yes	No
RF	179	26	207	30	8	10	None	No	No
LR	179	26	207	30	8	10	None	No	No
RR	186	27	207	30	7	9	None	No	No

Exterior Damage: Based on the vehicle inspection, the CDC for the Camaro was determined to be: **12-FYEW-2 (350 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Chevrolet's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 30.0 km.p.h. (18.6 m.p.h.), -29.5 km.p.h. (-18.3 m.p.h.), and +5.2 km.p.h. (+3.2 m.p.h.). The Chevrolet was towed due to damage.

Case Vehicle’s Driver: The exact posture of the case vehicle's driver [58-year-old, White (non-Hispanic) female; 178 centimeters and 98 kilograms (70 inches, 215 pounds)] immediately prior to the crash is unknown. Most likely she was seated with her back near the seat back, her left foot on the floor, and her right foot on the brake. In addition, the exact position of her hands is unknown, but her left hand was most likely on the steering wheel rim. At the time of inspection, her seat track was located in its rearmost position, the seat back was slightly reclined, and the vehicle was not equipped with a tilt steering wheel. According to the driver’s husband, the driver normally drives with her seat positioned all the way back.

Based on this contractor’s vehicle inspection, the case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system; the belt system was equipped with a retractor-mounted pretensioner with force limiters housed within the “B”-pillar. Furthermore, there was no mention by the driver’s husband during his interview or on this occupant’s medical records of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver’s seat belt webbing, “D”-ring, and latch plate revealed that the pretensioner had actuated and showed that the webbing was taut between the "D"-ring and the floor mounted housing, indicating it was not in use at the time of the crash.

The case vehicle's driver was making a left-hand turn. She braked, depositing approximately 3 meters (9.8 feet) of skid marks, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, she most likely moved slightly forward just prior to impact. The case vehicle's impact with the Chevrolet enabled the case vehicle's driver to continue forward, slightly upward, and rightward along a path opposite the case vehicle's 20 degree Direction of Principal Force as the case vehicle decelerated. As a result of the impact, the driver most likely contacted the deploying driver air bag towards its right side and loaded the right side of the steering wheel rim causing the steering column and the right side of the rim to move laterally rightward and the rim forward toward the left instrument panel. As the case vehicle reached maximum engagement and began to move backwards while rotating approximately 125 degrees counterclockwise, the driver may have been redirected to her right by the deploying driver air bag. Regardless of the air bag's involvement, the driver moved upward and to her right because of the vehicle's rotation and the nonuse of her safety belts where she most likely contacted the front right passenger air bag as it began to deflate and most likely the right side of the windshield's glazing. After contacting the windshield's glazing and/or the deflating front right air bag, she most likely rebounded backwards toward the center console and/or the back of the front right seat back. The driver's position at final rest is unknown but, according to her husband's interview, she was removed from the vehicle by the emergency medical technicians.

The driver was transported by ambulance to the hospital. According to her attorney, the interview with the driver's husband, and her medical records, she sustained a severe cervical injury and was hospitalized for 13 days before being transferred to a rehabilitation facility. The injuries sustained by the case vehicle's driver included: a contused cervical spinal cord with incomplete cord syndrome, a small subdural hematoma, a minor nonanatomic brain injury, a fractured right femur, cuts on top of her left hand (i.e., knuckles), and contusions to her left hand, right distal thigh, and over her left tibia. Because of the driver's nonuse of her available restraints, the lack of contact evidence on either of the case vehicle's deployed air bags, and the apparent movement of the driver's body during the collision sequence, it could not be determined what caused this occupant's primary brain and cervical injuries. Her deploying driver air bag was considered, but the evidence is inconclusive. Her right femur fracture resulted from loading the driver's knee bolster. Furthermore, the lacerations to her left hand were most likely caused by her contact with the windshield's left glazing.

Chevrolet's Occupant: According to the Police Crash Report, the Chevrolet's driver [58-year-old, (unknown race and/or ethnic origin) male] was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by ambulance to the hospital, and he sustained a police-reported "A" (incapacitating) injury as a result of this crash. More specifically, the report indicates that the driver had no recollection of the crash.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a four-lane, undivided, U.S. highway (**Figure 1** below), traversing in a north-northwesterly and south-southeasterly direction, and the case vehicle was approaching a three-leg commercial driveway access junction. The north-south roadway had two through lanes in both the northern and southern

directions. The U.S. highway was straight and level (i.e., actual slope was 1.6%, negative to the north-northwest—a downgrade in the case vehicle's direction of travel), near the area of impact (**Figure 1**). The pavement was bituminous, but travel polished, and the width of the inside northern lane was 3.1 meters (10.2 feet) and the inside southern lane was 3.2 meters (10.5 feet). The shoulders were improved (i.e., bituminous), but the width of each shoulder was not determined. The roadway was not bordered by curbs. Pavement markings consisted of a double solid yellow centerline for both northern and southern traffic. The through lanes were divided by a dashed white line. In addition, solid white edge lines were present. The estimated coefficient of friction was 0.65. Traffic controls consisted of a **CURVE ARROW** warning sign (Manual on Uniform Traffic Control Devices, W1-2) with a **45 M.P.H.** (72 km.p.h.) advisory speed plate (MUTCD, W13-1), on the eastern roadside preceding the right-hand curve (**Figure 1**) that was ahead for northern traffic and a regulatory **SPEED LIMIT** sign (MUTCD, R2-1) was located on the western roadside, at the exit of the left-hand curve for southern traffic (**Figure 2**). The posted speed limit was 72 km.p.h. (45 m.p.h.). At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry. Traffic density was not determined, and the site of the crash was a combination of urban commercial and undeveloped. In addition, there was a driveway to a commercial establishment near the crash site; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle had been traveling north-northwestward in the inside northern lane and was making a left-hand turn, intending to proceed westward into an intersecting commercial driveway access (**Figure 1**). The Chevrolet was exiting a slight left-hand curve, traveling south-southeastward in the inside southern lane of the same roadway and intended to proceed straight ahead (**Figure 2**). Based on evidence left at the



Figure 1: Case vehicle's north-northwestward travel path in inside northern lane; Note: arrow shows approximate point of impact (case photo #02)



Figure 2: Chevrolet's south-southwestward travel path, exiting slight left-hand curve, in inside southern lane; Note: arrow indicates approximate location of impact near driveway junction (case photo #09)

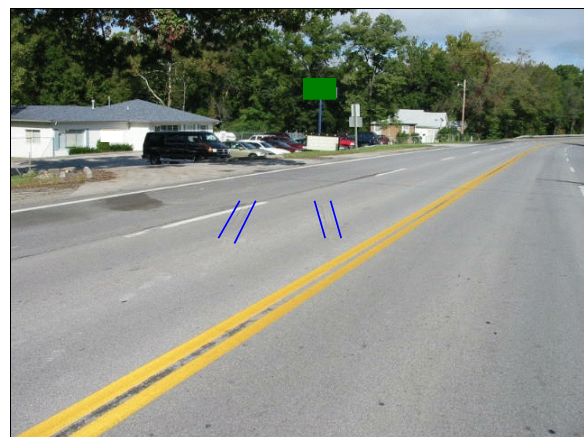


Figure 3: Case vehicle's pre-impact skid marks {highlighted} in inside southern lane deposited during case vehicle's left-hand turn toward commercial driveway on western roadside (case photo #04)

Crash Circumstances (Continued)

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scene, the case vehicle left approximately 3 meters (9.8 feet) of skid marks in an attempt to avoid the crash (**Figure 3** above). The driver of the Chevrolet steered to the right and braked, depositing approximately 12 meters (39.4 feet) of pre-impact skid marks, attempting to avoid the crash (**Figure 4**). The crash occurred in the inside southern lane of the roadway, within or near the driveway junction.



Figure 5: Case vehicle's frontal damage with contour gauge set at bumper level (case photo #17)

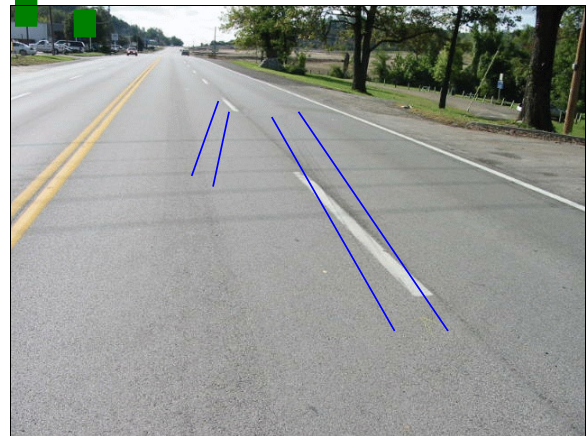


Figure 4: Chevrolet's rightward steering and pre-impact skid marks {highlighted} beginning in inside southern lane (case photo #12)



Figure 6: Chevrolet's frontal damage with contour gauge set at bumper level (case photo #58)

Crash: The front (**Figure 5**) of the case vehicle impacted the front left corner (**Figure 6**) of the Chevrolet, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The Chevrolet's driver only air bag also deployed as a result of this crash.

Post-Crash: As a result of this impact, the case vehicle was driven backwards (i.e., towards the south-**Figure 7**) and rotated approximately 125 degrees counterclockwise before coming to rest, obliquely oriented in the outside southern lane, heading in a south-southwesterly direction. Post-impact, the Chevrolet continued in a southward path but was redirected approximately 30 degrees clockwise (**Figure 8** below) before it came to rest obliquely oriented, straddling the outside southern lane, heading in a south-southwesterly direction (**Figure 9** below).

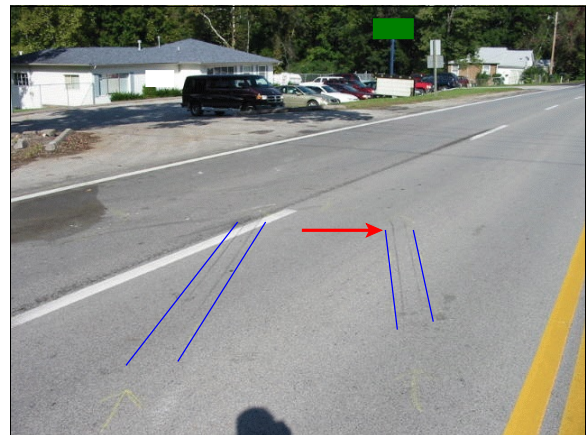


Figure 7: Close-up of case vehicle's pre-impact skid marks in inside southern lane, deposited during case vehicle's left-hand turn; Note: arrow shows deflection point of right front tire (case photo #05)

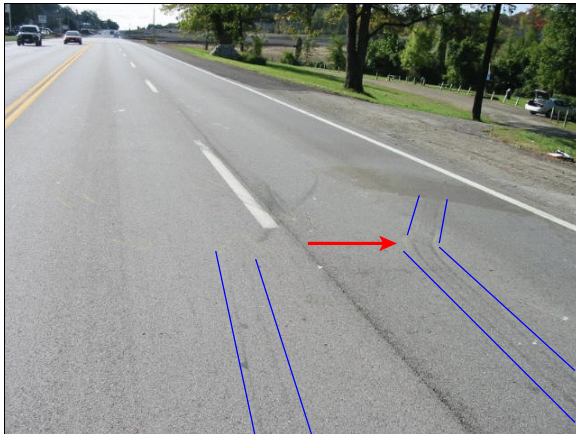


Figure 8: Chevrolet’s southwestward post-impact trajectory from impact (i.e., deflection points) position, straddling southern lanes, to final rest (i.e., fluid run off) position obliquely oriented in outside southern lane (case photo #06)

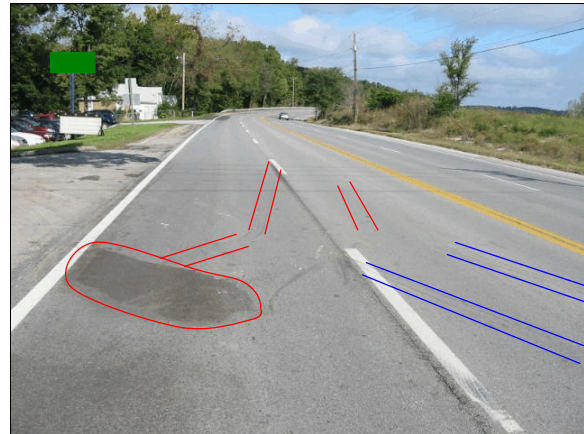


Figure 9: North-northwestward view in outside southern lane showing case vehicle’s pre-impact skid marks (blue lines) and Chevrolet’s pre-impact skid marks, deflection marks, and final rest position (i.e., fluid run off-red lines), obliquely oriented in outside lane (case photo #16)

CASE VEHICLE

The 2002 Kia Spectra was a front wheel drive, five-passenger, four-door sedan (VIN: KNAFB121325-----) equipped with a 1.8L, I-4 engine and a four-speed automatic transmission. Four-wheel, anti-lock brakes were not an option for this model. Braking was achieved by a power-assisted, front disc and rear drum system. The case vehicle’s wheelbase was 256 centimeters (100.8 inches), and the odometer reading at inspection is unknown because the case vehicle was equipped with an electronic odometer. The case vehicle was equipped with ADVANCED OCCUPANT PROTECTION SYSTEM features, including redesigned frontal air bags and LATCH system features.

Inspection of the vehicle’s interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back, split bench seat with integral head restraints for the back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the back center position. The front seat belt systems were equipped with manually operated, upper anchorage adjusters for the “D”-rings. Both the driver and front right passenger positions had their upper anchorage adjusters located in the upmost positions. The vehicle was equipped with knee bolsters for both the driver and front right seating positions, neither of which showed evidence of occupant contact or deformation. Automatic restraint was provided by



Figure 10: Reference line view from left showing case vehicle’s frontal damage with contour gauge set at bumper level (case photo #20)

a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the Chevrolet.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's contact with the Chevrolet primarily involved the front with the damage distributed on approximately the left two-thirds (Figures 5 and 10 above). Direct damage began at the front left bumper corner and extended 150 centimeters (59.1 inches) across the entire width of the front bumper. Field L was measured as 122 centimeters (48.0 inches) and also extended the entire width of the front bumper. Residual maximum crush was measured as 30 centimeters (11.8 inches) and was located 9 centimeters (3.5 inches) to the left of C₅ (Figure 11). The table below shows the case vehicle's crush profile.



Figure 11: Overhead view of case vehicle's frontal damage with contour gauge set at bumper level (case photo #30)

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	150	30	122	0	5	15	27	23	0	0	0
in		59.1	11.8	48.0	0.0	2.0	5.9	10.6	9.1	0.0	0.0	0.0

The case vehicle's wheelbase was essentially unaltered from the crash. The case vehicle's front bumper fascia, front bumper, grille, hood, radiator, left fender, and left headlight and turn signal assemblies were directly damaged and crushed rearward. The right headlight and turn signal assemblies sustained induced damage as well as the hood, both the right and left fenders, and the windshield's glazing. Remote buckling was also found on the left front door (Figure 12). No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.



Figure 12: Case vehicle's frontal damage viewed from left front showing induced damage to hood, left fender, and driver's door; arrow indicates bumper's fascia (case photo #21)

The case vehicle manufacturer's recommended tire size was: P185/65R14, but the case vehicle was equipped with tire size: P195/60R14. The case vehicle's tire data are shown in the table below. In addition, none of the case vehicle's tires were damaged, deflated, or physically restricted.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	152	22	200	29	6	8	None	No	No
RF	152	22	200	29	6	8	None	No	No
LR	159	23	200	29	6	8	None	No	No
RR	145	21	200	29	6	8	None	No	No



Figure 13: Elevated view of case vehicle’s steering wheel; Note: right side of steering wheel rotated forward toward left instrument panel and no obvious deformity of steering wheel’s rim and/or hub/spokes (case photo #34)

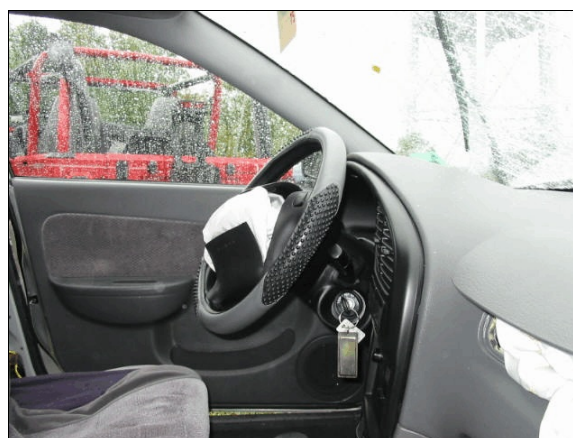


Figure 14: Case vehicle’s collapsed steering wheel viewed from right (case photo #34a)



Figure 15: Case vehicle’s driver seating area showing deployed driver air bag, collapsed steering wheel, and contact (i.e., yellow tape–arrow) to left side of windshield’s glazing (case photo #35)



Figure 16: Case vehicle’s front right seating area showing deployed front right air bag and cracks to right side of windshield’s glazing; Note: lower crack (red arrows) is most likely from contact by front right air bag module’s cover flap while upper crack (blue line) most likely resulted from contact by driver (case photo #37)

Interior Damage: Inspection of the case vehicle's interior revealed a significant lateral rightward movement to the steering column (**Figure 13** above) and steering wheel rim (**Figure 14** above), most likely from loading by the case vehicle's driver. The steering column moved 3 centimeters (1.2 inches) and the steering wheel rim moved 5 centimeters (2.0 inches). There was no other evidence of intrusion to the case vehicle's interior and no deformation to the steering wheel rim. Furthermore, the steering column compression could not be determined. Although there was no evidence of occupant contact to the left or center instrument panels (**Figures 15** and **16** above), the driver's knee bolster, the rearview mirror, or either sun visor, there was contact evidence on the windshield's glazing (**Figure 15** above and **Figure 17**). Based on the interview with the husband of the case vehicle's driver, the driver's left hand most likely came off of the steering wheel rim, striking and cracking the windshield's left glazing (**Figure 17**). In addition, the available evidence (discussed below) indicates that the driver most likely contacted the windshield's right glazing (**Figure 16** above).



Figure 17: Close-up of left side of case vehicle's windshield glazing, directly in front of steering wheel rim, showing occupant contact evidence (case photo #53)

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **01-FDEW-2 (20 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 35.0 km.p.h. (21.7 m.p.h.), -32.9 km.p.h. (-20.4 m.p.h.), and -12.0 km.p.h. (-7.5 m.p.h.). Based on the vehicle inspection, this collision fits the reconstruction model, but the results appear to be high. The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained redesigned frontal air bags at the driver and front right passenger positions. Both frontal air bags deployed as a result of the frontal impact with the Chevrolet. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical "H"-configuration cover flaps made of thin vinyl with overall dimensions of 15.5 centimeters (6.1 inches) at the horizontal seam and 9 centimeters (3.5 inches) vertically for the upper flap and 8 centimeters (3.1 inches) vertically for the lower flap. The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 36 centimeters (14.2 inches), 30 centimeters (11.8 inches) to the left "B"-pillar. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each approximately 8 centimeters (3.1 inches) in width. The driver's air bag

had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located towards the center at the 9:30 and 2:30 clock positions. The deployed driver's air bag was round with a diameter of 64 centimeters (25.2 inches). An inspection of the driver's air bag fabric revealed no contact evidence readily apparent on the air bag's fabric (**Figure 18**).

The front right passenger's air bag was located in the middle of the instrument panel. There was a single, essentially rectangular, modular cover flap. The cover flap was made of a medium weight stiff vinyl. The flap's dimensions were 33 centimeters (13.0 inches) at the lower horizontal seam and 20 centimeters (7.9 inches) along both vertical seams. The profile of the case vehicle's instrument panel resulted in a 1 centimeter (0.4 inch) setback of the leading edge of the cover flap relative to the protruding right instrument panel. The distance between the right "B"-pillar and the front surface of the air bag's fabric at full excursion was 28 centimeters (11.0 inches). An inspection of the front right air bag module's cover flaps and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed with one tether, approximately 10 centimeters (3.9 inches) in width and located horizontally at the middle of the air bag. The front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 68 centimeters (26.8 inches) and a width of approximately 51 centimeters (20 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front right air bag's fabric (**Figure 19**).



Figure 18: Case vehicle's deployed driver air bag showing no apparent occupant contact evidence on front surface of air bag's fabric (case photo #40)



Figure 19: Case vehicle's deployed front right passenger air bag showing no apparent evidence of occupant contact on front surface (case photo #48)

CASE VEHICLE DRIVER KINEMATICS

The exact posture of the case vehicle's driver [58-year-old, White (non-Hispanic) female; 178 centimeters and 98 kilograms (70 inches, 215 pounds)] immediately prior to the crash is unknown. Most likely she was seated with her back near the seat back, her left foot on the floor,

and her right foot on the brake. In addition, the exact position of her hands is unknown, but her left hand was most likely on the steering wheel rim. At the time of inspection, her seat track was located in its rearmost position, the seat back was slightly reclined, and the vehicle was not equipped with a tilt steering wheel. According to the driver's husband, the driver normally drives with her seat positioned all the way back.

Based on this contractor's vehicle inspection, the case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system; the belt system was equipped with a retractor-mounted pretensioner with force limiters housed within the "B"-pillar. Furthermore, there was no mention by the driver's husband during his interview or on this occupant's medical records of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate revealed that the pretensioner had actuated and showed that the webbing was taut between the "D"-ring and the floor mounted housing, indicating it was not in use at the time of the crash (**Figure 20**).

The case vehicle's driver was making a left-hand turn. She braked, depositing approximately 3 meters (9.8 feet) of skid marks, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, she most likely moved slightly forward just prior to impact. The case

vehicle's impact with the Chevrolet enabled the case vehicle's driver to continue forward, slightly upward, and rightward along a path opposite the case vehicle's 20 degree Direction of Principal Force as the case vehicle decelerated. As a result of the impact, the driver most likely contacted the deploying driver air bag towards its right side and loaded the right side of the steering wheel rim causing the steering column and the right side of the rim to move laterally rightward and the rim forward toward the left instrument panel. As the case vehicle reached maximum engagement and began to move backwards while rotating approximately 125 degrees counterclockwise, the driver may have been redirected to her right by the deploying driver air bag. Regardless of the air bag's involvement, the driver moved upward and to her right because of the vehicle's rotation and the nonuse of her safety belts where she most likely contacted the front right passenger air bag as it began to deflate and most likely the right side of the windshield's glazing. After contacting the windshield's glazing and/or the deflating front right air bag, she most likely rebounded backwards toward the center console and/or the back of the front right seat back. The driver's position at final rest is unknown but, according to her husband's interview, she was removed from the vehicle by the emergency medical technicians.



Figure 20: Rigid webbing along left "B"-pillar from case vehicle's driver safety belt indicating that pretensioner actuated while belt was not in use (case photo #54)

The driver was transported by ambulance to the hospital. According to her attorney, the interview with the driver’s husband, and her medical records, she sustained a severe cervical injury and was hospitalized for 13 days before being transferred to a rehabilitation facility. The injuries sustained by the case vehicle's driver included: a contused cervical spinal cord with incomplete cord syndrome, a small subdural hematoma, a minor nonanatomic brain injury, a fractured right femur, cuts on top of her left hand (i.e., knuckles), and contusions to her left hand, right distal thigh, and over her left tibia. Because of the driver's nonuse of her available restraints, the lack of contact evidence on either of the case vehicle's deployed air bags, and the apparent movement of the driver's body during the collision sequence, it could not be determined what caused this occupant's primary brain and cervical injuries. Her deploying driver air bag was considered, but the evidence is inconclusive. Her right femur fracture resulted from loading the driver's knee bolster. Furthermore, the lacerations to her left hand were most likely caused by her contact with the windshield's left glazing.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion {compression} cervical spinal cord with severe stenosis ¹ , acute and chronic, C ₃ -C ₆ resulting in incomplete cord syndrome (possibly central cord) requiring cord decompression ¹ , subtotal corpectomy ² C ₄ , discectomies ¹ C ₃ -C ₄ , C ₄ -C ₅ , and C ₅ -C ₆ and spinal fusion secondary to disk herniation and osteophytes	severe 640212.4,6	Unknown contact mechanism ³	Unknown	Hospitalization records
2	Hematoma, subdural, small, anteriorly but not further specified	severe 140652.4,9	Unknown contact mechanism ³	Unknown	Hospitalization records

¹ The following terms are defined in DORLAND’S ILLUSTRATED MEDICAL DICTIONARY as follows:
decompression (dekom-presh/n): 1. any removal of pressure. 4. a surgical operation for the relief of pressure in a body compartment.

decompression of spinal cord: relief of pressure on the spinal cord by means of surgery.

discectomy (kis-kek't-me): excision of an intervertebral disk; called also discectomy.

stenosis (st-no/sis): an abnormal narrowing of a duct or canal.

² The following came from **Spine-Health.com** via the Google.com search engine and was written by: Peter F. Ullrich, Jr., MD. **ANTERIOR CERVICAL CORPECTOMY SPINE SURGERY**: When the cervical disease encompasses more than just the disc space, the spine surgeon may recommend removal of the vertebral body as well as the disc spaces at either end, to completely decompress the cervical canal. This procedure, a *corpectomy*, is often done for multi-level cervical stenosis with spinal cord compression caused by bone spur (osteophytes) growth.

³ The source of the driver’s head and spine injuries could not be determined. The deployed driver’s air bag was considered, but there was a lack of evidence that the air bag was the source of these lesions (e.g., head/neck abrasions or contact evidence on the air bag’s fabric).

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Nonanatomic brain injury with no known loss of consciousness but with vomiting (emesis)	minor 160402.1,0	Unknown contact mechanism ³	Unknown	Emergency room records
4	Fracture, comminuted, transverse, mid-shaft (diaphysis) right femur with displacement	serious 851814.3,1	Knee bolster, driver's, right of steering column {indirect injury}	Certain	Hospitalization records
5	Contusion {ecchymosis} left hand with pain, not further specified	minor 790402.1,2	Air bag, driver's	Certain	Hospitalization records
6	Lacerations {cuts} on top of her left hand (i.e., knuckles)	minor 790600.1,2	Front left windshield's glazing	Probable	Interviewee (relative)
7	Contusion, small, right distal thigh, not further specified	minor 890402.1,1	Floor-mounted transmission selector lever	Possible	Hospitalization records
8	Contusion {ecchymosis} left proximal, medial, tibia	minor 890402.1,2	Steering column	Possible	Hospitalization records

OTHER VEHICLE

Based on the VIN and manufacturer's specifications, the 1990 Chevrolet Camaro RS was a rear wheel drive, four-passenger, two-door convertible (VIN: 1G1FP33E8LL-----) equipped with a 5.0L, V-8 engine and a five-speed manual transmission. Four-wheel, anti-lock brakes were not available for this model. Braking was achieved by a power-assisted, front disc and rear drum. The Chevrolet's wheelbase was 257 centimeters (101.0 inches), and the odometer reading is unknown because the Chevrolet's interior was not inspected. Furthermore, the vehicle was equipped with an air bag for the driver's seat position only and manual, three-point, lap-and-shoulder, safety belt systems for the front outboard seating positions. The back outboard seats had manual, two-point, lap belts. The interior was equipped with bucket seats for the driver and front right passenger, and the back bench seat was non-adjustable. The Chevrolet's driver air bag deployed during this crash.

Exterior Damage: The Chevrolet's contact with the case vehicle involved the entire front with the damage distributed all the way across (**Figure 21** and **Figure 22** below). Direct damage began at



Figure 21: Elevated view of Chevrolet's frontal damage viewed from left of front with contour gauge present at bumper level; Note: bumper fascia in lower right of photo (case photo #61)

the left front bumper corner and extended, a measured distance of 89 centimeters (35.0 inches), inward along the steel front bumper. The Field L along the actual bumper was 121 centimeters (47.6 inches). An undeformed end width of 160 centimeters (63.0 inches) was used for reconstruction purposes. Direct damage offset was determined to be -30 centimeters (-11.8 inches). Residual maximum crush was measured as 54 centimeters (21.3 inches) at C₁. The table below shows the case vehicle's crush profile.

The wheelbase on the case vehicle's left side was shortened 22 centimeters (8.7 inches) while the right side was extended approximately 1 centimeter (0.4 inches). The Chevrolet's front bumper fascia, front bumper grille, hood, radiator, left fender, and left headlight and turn signal assemblies were directly damaged and crushed rearward. The right headlight and turn signal assemblies sustained induced damage as well as the hood and left fender.



Figure 22: Elevated view from front right of Chevrolet's frontal damage with contour gauge present at bumper level (case photo #71)

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	89	54	160	54	43	49	32	8	0	-30	0
in		35.0	21.3	63.0	21.3	16.9	19.3	12.6	3.2	0.0	-11.8	0.0

The case vehicle manufacturer's recommended tire size was: P215/65R15, but the Chevrolet was equipped with tire size: P265/65R15. The case vehicle's tire data are shown in the table below. In addition, the Chevrolet's left front tire was damaged and physically restricted from the crash (Figure 23 below).

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	179	26	207	30	7	9	Slight avulsion of sidewall surface	Yes	No
RF	179	26	207	30	8	10	None	No	No
LR	179	26	207	30	8	10	None	No	No

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
RR	186	27	207	30	7	9	None	No	No

Damage Classification: Based on the vehicle inspection, the CDC for the Camaro was determined to be: **12-FYEW-2 (350 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Chevrolet's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 30.0 km.p.h. (18.6 m.p.h.), -29.5 km.p.h. (-18.3 m.p.h.), and +5.2 km.p.h. (+3.2 m.p.h.). The Chevrolet was towed due to damage.



Figure 23: Chevrolet's damaged (arrow) and restricted left front wheel (case photo #63a)

Chevrolet's Occupant: According to the Police Crash Report, the Chevrolet's driver [58-year-old, (unknown race and/or ethnic origin) male] was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by ambulance to the hospital, and he sustained a police-reported "A" (incapacitating) injury as a result of this crash. More specifically, the report indicates that the driver had no recollection of the crash.

