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## ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN09027

LOCATION - TEXAS

VEHICLE - 2007 KIA SPECTRA EX

CRASH DATE - May 2009

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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16. <i>Abstract</i> This on-site investigation focused on the side impact air bag system of a 2007 Kia Spectra EX, the crash dynamics, and the sources of the driver's injuries. The restrained 56-year-old female driver of the Kia was in the process of executing a left turn onto a divided city street when her vehicle was impacted on the left side plane by the front plane of a 1995 GMC C1500 Club Cab pickup truck. The direction of force on the Kia was within the 10 o'clock sector and the impact force was sufficient to trigger a deployment of the left side impact inflatable curtain (IC) air bag and the left front seat-mounted side impact air bag. The driver of the Kia sustained moderate injuries and was transported by ambulance to a hospital where she was treated in the emergency room and released. The driver and front passenger of the GMC were not injured. Both vehicles were towed due to damage.					
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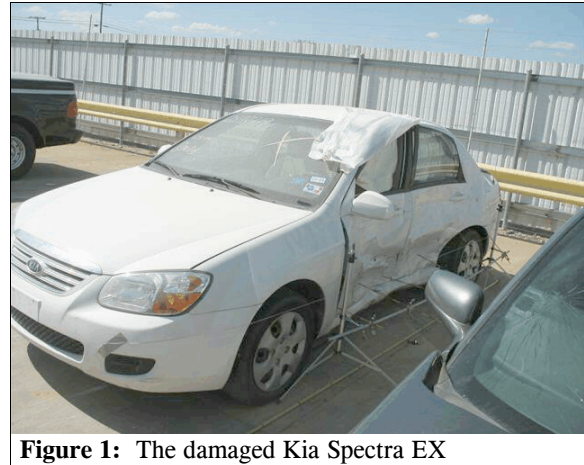
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This on-site investigation focused on the side impact air bag system of a 2007 Kia Spectra EX (**Figure 1**), the crash dynamics, and the sources of the driver's injuries. This crash was brought to our attention by the National Highway Traffic Safety Administration (NHTSA) on July 14, 2009 through the sampling activities of the National Automotive Sampling System–General Estimates System (NASS-GES). This investigation was assigned on August 13, 2009. The crash involved the Kia and a 1995 GMC C1500 Club Cab pickup truck. The crash occurred in May, 2009 at 1535 hours, in Texas and was investigated by the city police department. The vehicles and the crash scene were inspected on August 19 and 20, 2009. The driver of the Kia refused to be interviewed. This report is based on the police crash report, scene and vehicle inspections, occupant kinematic principles, driver's medical records, and evaluation of the evidence.

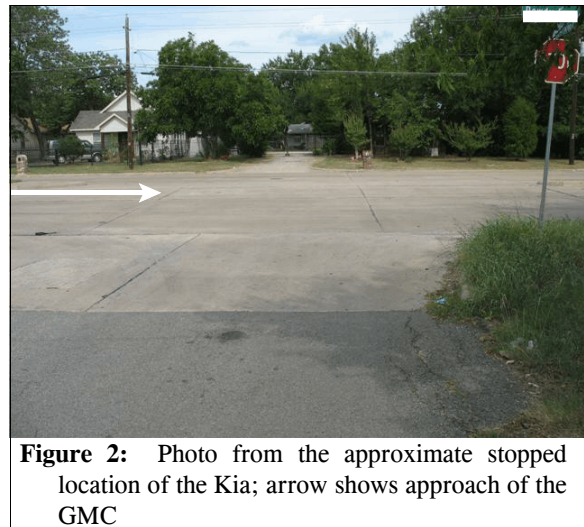


**Figure 1:** The damaged Kia Spectra EX

### CRASH CIRCUMSTANCES

**Crash Environment:** The trafficway that the Kia was traveling on was a 2-lane, undivided, city street, traversing in an east-west direction and approached a 3-leg intersection. The roadway was level bituminous with one through lane in each direction and was controlled by a stop sign. Each travel lane was 3.7 m (12 ft) in width. There were no roadway pavement markings. The trafficway that the GMC was traveling on was a curved, 6-lane, divided, city street, traversing in a north-south direction and approached the same intersection. The northern leg of the intersection had three through lanes in each direction and was divided by a curbed, grass median. Each travel lane was approximately 3.5 m (11.5 ft) in width and the median was 4.1 m (13.5 ft) in width. The roadway pavement markings consisted of broken white lane lines. There were no traffic controls for the GMC and the roadway surface was concrete with a negative 1.7% grade. The speed limit for the Kia was 48 km/h (30 mph) and 56 km/h (35 mph) for the GMC. At the time of the crash the light condition was daylight and the weather was clear. The roadway surface was dry. The Crash Diagram is on page 8 of this report.

**Pre-Crash:** The Kia's restrained 56-year-old female driver was stopped heading east (**Figure 2**) behind an uninvolved vehicle, which was stopped at the stop sign. The Kia's driver intended to turn left and proceed north. The GMC's restrained 34-year-old male driver was traveling south in the left lane (**Figure 3**) negotiating a right curve. The driver intended to continue south through the



**Figure 2:** Photo from the approximate stopped location of the Kia; arrow shows approach of the GMC

intersection. The uninvolved vehicle and the Kia proceeded into the intersection. It is not known if the Kia's driver took any actions to avoid the crash, which occurred within the intersection.

**Crash:** The front plane of the GMC (**Figure 4**) impacted the left side plane of the Kia (**Figure 5**). The direction of force on the Kia was within the 10 o'clock sector and the impact force was sufficient to trigger a deployment of the left side impact inflatable curtain (IC) air bag and the left front seat-mounted side impact air bag. The impact caused both vehicles to rotate counterclockwise. The Kia came to final rest within the intersection heading northeast. The GMC came to final rest within the intersection heading southeast.

**Post-Crash:** The police were notified of the crash at 1545 hours and arrived at the crash scene at 1605 hours. The Kia's driver was transported by ambulance to a hospital where she was treated and released. The GMC's driver and front right passenger were uninjured. Both vehicles were towed due to damage.

**CASE VEHICLE**

The 2007 Kia Spectra EX was a front wheel drive, 4-door sedan (VIN: KNAFE121275-----) equipped with a 2.0-liter, 4-cylinder engine, and automatic transmission. The front row was equipped with bucket seats, adjustable, active head restraints, lap-and-shoulder safety belts, dual stage driver and front right passenger frontal air bags, side impact IC air bags, and seat-mounted side impact air bags. The second row was equipped with a bench seat with folding backs, adjustable head restraints in the outboard seating positions, lap-and-shoulder safety belts, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The vehicle's specified wheelbase was 261 cm (102.7 in).



**Figure 3:** Approach of the GMC; number on pavement shows meters to impact area; arrow shows approach of Kia



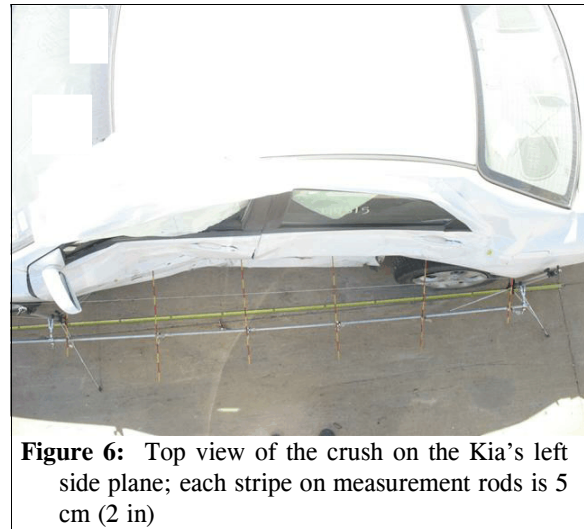
**Figure 4:** Front damage on the GMC from the impact with the left side plane of the Kia



**Figure 5:** Damage to the left side plane of the Kia from the impact with the GMC



**Exterior Damage:** The impact with the GMC involved the left side plane of the Kia. The left front door, B-pillar, left rear door, and quarter panel were directly damaged. The direct damage began 81 cm (31.9 in) rear of the left front axle and extended 181 cm (71.3 in) rearward along the left side. The crush measurements were taken at the lower door level and the residual maximum crush was 26 cm (10.2 in) occurring at C<sub>4</sub> (**Figure 6**). The vehicle’s sill height was 31 cm (12.2 in) and the height of the maximum crush was 35 cm (13.8 in). The door sill differential was 1 cm (0.4 in). The vehicle’s left side wheelbase was reduced 1 cm (0.4 in). The induced damage involved the left quarter panel and C-pillar. The table below shows the vehicle’s right side crush profile.



**Figure 6:** Top view of the crush on the Kia’s left side plane; each stripe on measurement rods is 5 cm (2 in)

Units	Event	Direct Damage		Field L	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	181	26	238	0	11	24	26	19	2	-41	-40
in		71.3	10.2	93.7	0.0	4.3	9.4	10.2	7.5	0.8	-16.1	-15.7

**Damage Classification:** The Collision Deformation Classification (CDC) was **10LZAW2 (300 degrees)** for the left side plane impact with the GMC. The Missing Vehicle algorithm of the WinSMASH program calculated the Kia’s total Delta V as 31 km/h (19.3 mph). The longitudinal and lateral velocity changes were -15.5 km/h (-9.6 mph) and 26.8 km/h (16.7 mph), respectively. Based on the damage on both vehicles, the results appeared reasonable.

The vehicle manufacturer’s recommended tire size was P195/60R15. The Kia was equipped with tires of the recommended size. The vehicle’s tire data are shown in the table below.

Tire	Measured Pressure		Vehicle Manufacturer’s Recommended Cold Tire Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	193	28	207	30	8	10	None	No	No
LR	200	29	207	30	8	10	None	No	No
RR	200	29	207	30	8	10	None	No	No

Tire	Measured Pressure		Vehicle Manufacturer's Recommended Cold Tire Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 <sup>nd</sup> of an inch			
RF	207	30	207	30	7	9	None	No	No

**Vehicle Interior:** The inspection of the Kia's interior revealed evidence of probable driver contact on the left front door (**Figure 7**). The arm rest was scuffed and displaced, probably from contact by the driver's left arm. The plastic on the rear lower quadrant of the door panel was cracked and broken, probably from contact by the driver's left hip. Some of the deformation on the rear lower door quadrant was also probably due to contact with the driver's seat as the door intruded during the crash. There was no deformation of the steering wheel or displacement of the energy absorbing steering column.



**Figure 7:** Damage and probable occupant contact on the left front door

The left front and left rear doors were jammed shut, while the right side doors remained closed and operational. The pre-crash status of all the window glazings was fixed or closed. The windshield was cracked and in place due to impact forces, while the left front window glazing was disintegrated due to impact forces.

The vehicle sustained 10 passenger compartment intrusions. The most severe intrusions in the driver's space involved the rear upper quadrant of the left front door (**Figure 7**), the driver's seat back, and the left instrument panel. These components intruded laterally 10 cm (3.9 in), 7 cm (2.8 in), and 3 cm (1.2 in), respectively.

#### **AUTOMATIC RESTRAINT SYSTEM**

The Kia was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front passenger frontal air bags, driver seat position sensor, safety belt usage sensors, retractor-mounted pretensioners and a front passenger pattern recognition sensor. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The frontal air bags did not deploy in this crash.

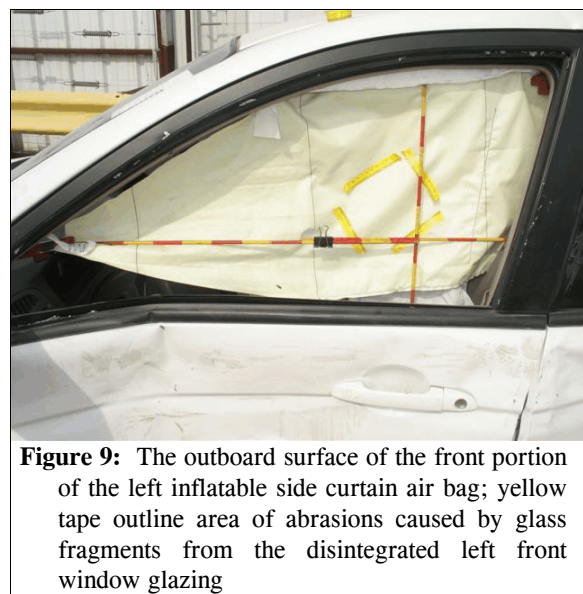
The Kia was also equipped with a side impact air bag system that consisted of front seat-mounted side impact air bags and roof side rail-mounted side impact IC air bags, which provided protection to the front and second row outboard seating positions. The driver's seat-mounted side impact air bag and the left IC air bag deployed in this crash.



The left IC air bag was located along the left roof side rail inside the headliner and extended from the A-pillar to the C-pillar (**Figure 8**). The IC air bag was designed with inflation chambers adjacent to the outboard seating positions. What appeared to be 4 cm (1.6 in) vent port was located on the outboard side of the air bag 40 cm (15.7 in) rear of the front of the air bag. The deployed IC air bag was 174 cm (68.5 in) in width and 35 cm (13.8 in) in height. It was attached to the A-pillar by a 5 cm (2 in) nylon rope. The gap between the front of the IC air bag and the A-pillar was 8 cm (3.1 in). Adjacent to the left front seating position, the IC air bag extended vertically 2 cm (0.8 in) below the beltline and curved upward to 8 cm above the beltline at the front of the IC air bag. Adjacent to the second row left seating position, the IC air bag extended 2 cm (0.8 in) above the beltline near the B-pillar and 10 cm (4 in) below the beltline at the back of the air bag. Inspection of the deployed IC air bag revealed no discernable evidence of occupant contact. There was no damage on the inboard side of the IC air bag. On the outboard side of the IC air bag, glass fragments from the disintegrated left front window glazing caused a 15 cm (6 in) x 13 cm (5.1 in) area of abrasions located 20 cm (7.9 in) forward of the B-pillar and 25 cm (9.8 in) below the top of the IC air bag (**Figure 9**). The location was adjacent to the probable location of the driver's head.



**Figure 8:** The left side impact IC air bag and left front seat-mounted side impact air bag



**Figure 9:** The outboard surface of the front portion of the left inflatable side curtain air bag; yellow tape outline area of abrasions caused by glass fragments from the disintegrated left front window glazing

The driver's seat-mounted side impact air bag was located within the outboard side of the seat back and deployed through a tear-seam. The deployed air bag was 64 cm (25.2 inches) in height and 22 cm (11.8 in) in width (**Figure 10**). The air bag was designed with one vent port located on the front edge of the air bag. There was a single circular tether where both sides of the air bag were sewn together. The sewn area was 3 cm (1.2 in) in diameter. It was located 15 cm (5.9 in) from the front of the air bag and 20 cm (7.9 in) from the top. Inspection of the deployed air bag revealed no damage and no discernable evidence of occupant contact.

The Kia was equipped with lap-and-shoulder safety belts for the front and second row seating positions. The driver’s safety belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), sliding latch plate, and an adjustable upper anchor that was in the full-up position. The front passenger safety belt was similarly equipped and the adjustable upper anchor was also in the full-up position. The second row seat belts were similarly equipped with the exception of fixed upper anchors.

The inspection of the driver’s safety belt assembly revealed historical usage scratches on the latch plate. The belt webbing was slightly stretched and there were load abrasions from the belt webbing across the width of the latch plate belt guide (Figure 11). The retractor was also jammed with a length of belt webbing extended out of the retractor consistent with usage. This evidence indicated that the driver was restrained at the time of the crash. The remaining seat positions were unoccupied.

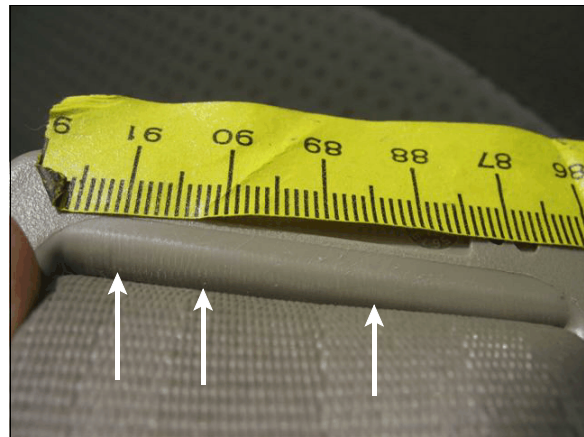
**CASE VEHICLE DRIVER KINEMATICS**

The Kia’s driver [56-year-old, female; unknown height and 98 kg (215 lbs)] was seated in an unknown posture. The seat track was adjusted to between the middle and rear positions and the seat back was slightly reclined. The adjustable head restraint was located in the full-down and full-forward tilt position (Figure 12). The distance from the top of the seat back to the top of the head restraint was 20 cm (7.9 in). The tilt steering column was located in the full-down position.

The left side impact with the GMC displaced the driver of the Kia to the left and forward opposite the 10 o’clock direction of force and she loaded the safety belt. The driver loaded through the deployed seat-mounted side impact air bag and contacted the intruding left front door, which caused fractures of the left 8<sup>th</sup> and 9<sup>th</sup> ribs. She also sustained a contusion on the left chest from loading the safety belt. While there was no discernable occupant contact evidence on the left IC air bag, the driver’s head probably loaded this air bag.



**Figure 10:** The left front seat-mounted side impact air bag



**Figure 11:** Load abrasions from the safety belt webbing on the driver’s latch plate belt guide

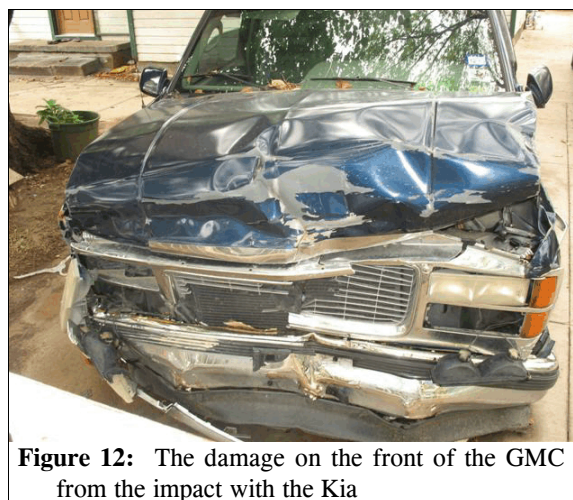
The driver of the Kia sustained moderate injuries and was transported by ambulance to a hospital where she was treated in the emergency room and released. The table below presents the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Fracture left 8 <sup>th</sup> and 9 <sup>th</sup> ribs, posteriorly, near costophrenic sulcus	moderate 450220.2,2	Left front door panel, rear upper quadrant	Probable	Emergency room records
2	Contusion left chest, not further specified	minor 490402.1,2	Torso portion of safety belt system	Probable	Emergency room records

### OTHER VEHICLE

The 1995 GMC C1500 was a rear wheel drive, extended cab (VIN: 2GTEC19K5S1-----) pickup truck equipped with a 5.7-liter, V8 engine.

**Exterior Damage:** While this contractor had the owner's permission to inspect the vehicle, the owner was not at home and it was not possible to enter the area where the vehicle was stored due to the presence of the owner's dog. The vehicle was photographed and the CDC was based on the photographs. The visual inspection indicated that the GMC sustained direct damage across the full width of the front plane. The damage involved the bumper, hood, grille, and both headlamp/turn signal assemblies (**Figure 12**). The induced damaged involved both fenders and the hood.



**Figure 12:** The damage on the front of the GMC from the impact with the Kia

**Damage Classification:** The CDC for the impact with the Kia was **01FDEW1 (20 degrees)**. The Missing Vehicle algorithm of the WinSMASH program calculated the GMC's total Delta-V as 20 km/h (12.4 mph). The longitudinal and lateral velocity changes were -18.8 km/h (-11.7 mph) and -6.8 km/h (-4.2 mph), respectively. The results should be considered borderline since they are based only on the crush sustained by the Kia.

**GMC's Occupants:** The police crash report indicated that the GMC's driver (34-year-old, male) and front passenger (12-year-old, female) were both restrained by the lap-and-shoulder safety belts. The driver and passenger were both uninjured.

