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ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN09039

LOCATION - TEXAS

VEHICLE - 2006 KIA SORENTO LX

CRASH DATE - September 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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16. <i>Abstract</i> This on-site investigation focused on the rollover of a 2006 Kia Sorento LX. The Kia was occupied by a restrained 41-year-old female driver, a restrained 10-year-old male front passenger, and a restrained 8-year-old male second row right passenger. The driver was executing a left turn at a 4-leg urban intersection to travel south when the vehicle was impacted on the right side plane (event 1) by the front plane of an eastbound 2000 Ford Focus SE. The direction of force on the Kia was within the 2 o'clock sector and the right side impact inflatable curtain (IC) air bag did not deploy. The Kia rotated clockwise and rolled over left side leading one quarter turn and came to final rest on the roadway heading east. None of the Kia's air bags deployed during the crash. The driver of the Kia was transported by ambulance to a hospital where she was treated in the emergency room for minor injuries and released. The two passenger's of the Kia where not injured. Both vehicles were towed from the crash scene due to damage.					
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CRASH DIAGRAM 9

This on-site investigation focused on the rollover of a 2006 Kia Sorento LX (**Figure 1**). This crash was brought to our attention on October 23, 2009 by the National Highway Traffic Safety Administration (NHTSA) through the sampling activities of the National Automotive Sampling System-General Estimates System (NASS-GES). This investigation was assigned on November 19, 2009. This crash involved the Kia and a 2000 Ford Focus SE. The crash occurred in September, 2009, at 1300 hours in Texas and was investigated by the city police department. The Kia was inspected on December 1, 2009. The crash scene inspection and interview with the driver of the Kia were both completed on December 2, 2009. The Ford was not inspected since it had been sold at auction. This report is based on the police crash report, crash scene and vehicle inspections, driver interview, exemplar vehicle inspection, occupant kinematic principles, and evaluation of the evidence.



Figure 1: The damaged 2006 Kia Sorento LX

CRASH CIRCUMSTANCES

Crash Environment: The trafficway that both vehicles were traveling on was a divided, 7-lane city street, that traversed in an east-west direction, and both vehicles were approaching a 4-leg intersection. Each vehicle's roadway had three travel lanes, a raised median, a left turn lane, and was bordered by concrete curbs. Each lane was approximately 3.3 m (10.8 ft) in width and the median was 1.3 m (4.3 ft) in width. Roadway pavement markings consisted of broken white lane lines, solid white left turn lane lines, left turn arrows, solid yellow median lines, solid white stop bars, and solid white edge lines for the pedestrian crossings. The intersection was controlled by 3-phase traffic signals. The speed limit for both vehicles was 56 km/h (35 mph). At the time of the crash the light condition was daylight and the weather was clear. The roadway surface was dry concrete and the traffic density at the time of the crash was light. The Crash Diagram is on page 9 of this report.

Pre-Crash: The Kia was occupied by a restrained 41-year-old female driver, a restrained 10-year-old male front passenger, and a restrained 8-year-old male second row right passenger. The driver stated during the SCI interview that she was in the process of executing a left turn at the intersection (**Figure 2**) to travel south. She estimated her travel speed was approximately 40 km/h (25 mph). The traffic signal was on the green phase. The 37-year-old female driver of the Ford was traveling east in the first lane from the right

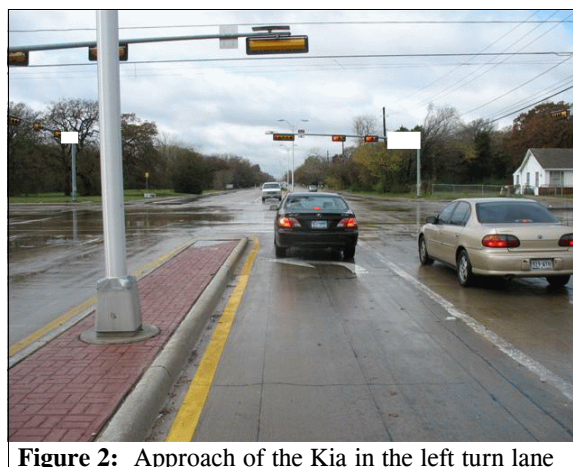


Figure 2: Approach of the Kia in the left turn lane

(Figure 3) and intended to continue straight through the intersection. The driver of the Kia did not take any avoidance actions prior to the crash, which occurred within the intersection.

Crash: The right side plane of the Kia (Figure 4) was impacted by the front plane of the Ford (event 1). The direction of force on the Kia was within the 2 o'clock sector and the right side impact inflatable curtain (IC) air bag did not deploy. Following the impact, the Kia rotated clockwise and rolled over (event 2) left side leading one quarter-turn (Figure 5). The vehicle continued to rotate clockwise while on its left side and came to final rest in the inside lane of the southbound roadway heading east (Figure 6). The Ford came to final rest in the mouth of the southbound roadway heading southeast. None of the Kia's air bags deployed during the crash.



Figure 3: Approach of the Ford; arrow shows approach of the Kia



Figure 4: Damage on the right side plane of the Kia from impact with the front plane of the Ford



Figure 5: Damage on the left side plane of the Kia from the rollover

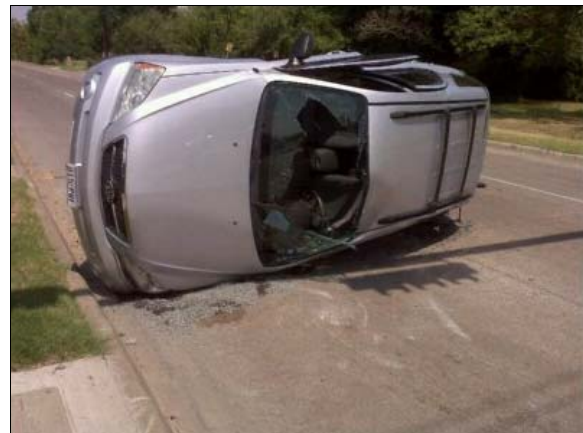


Figure 6: The final rest position of the Kia

Post-Crash: The police were notified of the crash at 1303 hours and arrived at the crash scene at 1310 hours. The driver of the Kia exited the vehicle through the backlight, which had disintegrated from the crash, with assistance of passers-by. The two passengers exited the vehicle through the right front door with the assistance of passers-by. The driver was transported by ambulance to a hospital where she was treated and released. The two passengers were uninjured and not transported. Both vehicles were towed from the crash scene due to damage.

The Kia was not equipped with any rollover mitigation features. The vehicle has been given a three star rollover rating on a five star scale by NHTSA and a Static Stability Factor of 1.16¹. A three star rating indicates that the vehicle has a 20%-30% chance of a rollover when involved in a single vehicle crash. The specific chance of rollover for this vehicle model was given as 21%. The Static Stability Factor (SSF) is a calculation based on the vehicle’s track width and height of its center of gravity. The result of the calculation is a measure of a vehicle’s resistance to a rollover. A higher SSF indicates a more stable vehicle. The majority of passenger vehicles have an SSF of 1.30 to 1.50². An exemplar vehicle did not tip-up during the dynamic steering maneuver test in which the test vehicle was put through a fish-hook shaped steering maneuver (i.e., hard left and hard right steer) at between 56 km/h-80km/h (35-50 mph).

The rollover of the Kia (event 2) was initiated by the impact with the Ford (event 1). The impact on the right side plane of the Kia caused the vehicle to rotate clockwise. The impact location on the Kia occurred at the lower door and sill level, which suggested that the front of the Ford also underrode the side of the Kia to some degree. The combination of these two factors caused the Kia to rollover left side leading one quarter turn onto its left side. The vehicle traversed approximately 8.6 m (28.2 ft) from the area of impact to the final rest position

CASE VEHICLE

The 2006 Kia Sorento LX was a rear wheel drive, 4-door sport utility vehicle (VIN: KNDJD733965-----) equipped with a 3.5-liter, V6 engine, an automatic transmission, and a tire pressure monitoring system. The front row was equipped with bucket seats, adjustable head restraints, lap-and-shoulder safety belts, driver and front passenger frontal air bags, and side impact IC air bags that provided protection for the front and second row. The second row was equipped with a split bench seat with folding backs, lap-and-shoulder safety belts, adjustable head restraints, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The vehicle’s mileage at the time of the inspection was approximately 33,626 miles (54,114 kilometers). The specified wheelbase was 271 cm (106.7 in).

CASE VEHICLE DAMAGE

Exterior Damage: The impact by the front of the Ford involved the right side plane of the Kia. The fender, front door, B-pillar, and rear door were directly damaged (**Figure 7**). The direct damage began 20 cm (7.9in) forward of the right front



Figure 7: Damage on the right side plane of the Kia from the impact with the front plane of the Ford

¹ www.safercar.gov, 11/29/09

² “Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans”, NHTSA Technical Report, DOT HS 809 868, June 2005

axle and extended 252 cm (99.2 in) rearward along the right side. The crush measurements were taken at the sill level and the residual maximum crush was 24 cm (9.4 in) occurring at C₄. The vehicle’s sill height was 46 cm (18.1 in). The Door Sill Differential was 0 cm, since there was greater crush on the sill than on the door (Figure 8). The induced damage involved the right fender and both right side doors. The table below presents the right side crush profile.



Figure 8: The maximum crush occurred on the sill

The rollover (event 2) involved the left side plane of the Kia. The direct damage on the left side plane extended the entire length of the vehicle. It began 59 cm (23.2 in) forward of the left front axle and extended 417 cm (164.2 in) rearward along the left side. The maximum residual lateral crush was 9 cm (3.5 in) and occurred at the top of the left A-pillar (Figure 9), 81 cm (31.9 in) rear of the left front axle. The maximum vertical crush was and 3 cm (1.2 in) and occurred at the left corner of the windshield header (Figure 9).

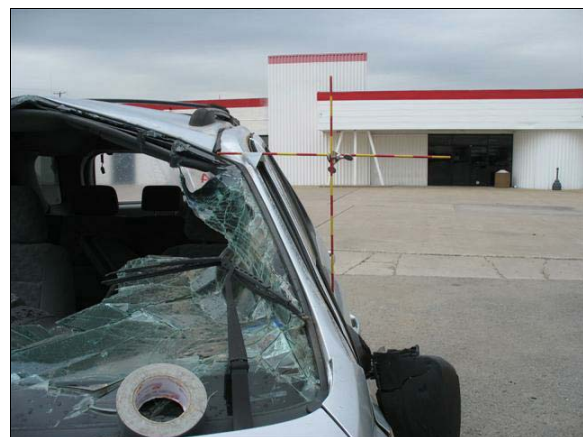


Figure 9 Max vertical crush

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	252	24	304	0	6	14	24	3	0	30	4
in		99.2	9.4	119.7	0.0	2.4	5.5	9.4	1.2	0.0	11.8	1.6

Damage Classification: The Collision Deformation Classifications were 02RYEW2 (60 degrees) for the left side plane impact and 00LDAO3 for the rollover. The Missing Vehicle algorithm of the WinSMASH program calculated the total Delta V for the Kia for the right side plane impact as 23 km/h (14.3 mph). The longitudinal and lateral velocity changes were -11.5 km/h (-7.1 mph) and -19.9 km/h (-12.4 mph), respectively. Based on the damage on the Kia, the results appeared reasonable. The severity of the damage from the rollover was moderate based on the extent of the passenger compartment intrusion.

The vehicle manufacturer’s recommended tire size was P245/70R16. The Kia was equipped with the recommended size tires. 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 nd of an inch			
LF	159	23	207	30	5	6	None	No	No
LR	159	23	207	30	8	10	None	No	No
RR	159	23	207	30	4	5	None	No	No
RF	159	23	207	30	5	6	None	No	No

Vehicle Interior: The interior inspection of the Kia revealed no discernable evidence of occupant contact. The tailgate was jammed shut as a result of the crash. The other doors remained closed and operational. All the window glazing was either fixed or closed prior to the crash. The backlight and third left window glazings were disintegrated by impact forces. The windshield was broken by passers-by during attempts to extricate the occupants. Based on the damage to the vehicle, the windshield was probably cracked and in place from impact forces during the rollover. The remaining glazings were undamaged.

The vehicle sustained 14 intrusions of the passenger compartment. The most severe intrusions into the driver's seating area involved the left A-and B-pillars and the left roof side rail. These components intruded laterally 9 cm (3.5 in), 7 cm (2.8 in), and 6 cm (2.4 in), respectively. The most severe intrusions from the impact with the Ford involved the forward lower quadrant of the right rear door and the sill below the right front door. These components intruded laterally 7 cm (2.8 in) and 8 cm (3.1 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, and front row seatbelt pretensioners with force limiters. The front passenger seat was equipped with a pattern recognition sensor. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the frontal air bag sensors were located on the center upper radiator support. 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. Neither of the frontal air bags deployed in this crash.

The Kia was also equipped with roof rail-mounted side impact IC air bags. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the side impact sensors were located within the lower B-pillars. Neither of the IC air bags deployed in this crash. Based on the SCI interview, the driver was the original owner of the vehicle. She stated it had never been in a crash and the air bag system had never been serviced. During the vehicle inspection, it was confirmed that there were IC air bag modules present in the vehicle.

The Kia was equipped with lap-and-shoulder safety belts for all of the vehicle's seating positions. The driver's safety belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), a sliding latch plate, and an adjustable upper anchor that was in the middle position. The front passenger safety belt was similar, but was equipped with a switchable ELR/Automatic Locking Retractor (ALR) and the adjustable upper anchor was located in the full-up position. The driver and front passenger safety belts were equipped with retractor-mounted pretensioners. The second row safety belts were similarly equipped as the front right passenger safety belt, but had fixed upper anchors and did not have pretensioners.

The inspection of the driver's safety belt assembly revealed historical usage scratches on the latch plate and the webbing appeared to be slightly stretched. Based on this evidence, the driver was restrained by the safety belt at the time of the crash. The pretensioner did not actuate.

The inspection of the front passenger's safety belt assembly revealed historical usage scratches and the webbing appeared to be slightly stretched. Based on this evidence, this passenger was restrained by the safety belt at the time of the crash. The pretensioner did not actuate.

The inspection of the second row right passenger's safety belt assembly revealed historical usage scratches, but there was no evidence of loading. Based on the driver interview, this occupant was probably restrained at the time of the crash.

CASE VEHICLE DRIVER KINEMATICS

Based on the SCI interview, the driver of the Kia [41-year-old, female; 168 cm (66 in) and 70 kg (155 lb)] was seated in an upright posture with her hands on the steering wheel at the 3 and 9 o'clock positions. The seat track was adjusted to the middle position and the seat back was slightly reclined. The tilt steering column was adjusted to the center position. The driver was not wearing glasses at the time of the crash.

The right side impact on the Kia displaced the driver to the right and forward opposite the 2 o'clock direction of force and she loaded the safety belt. As the vehicle rolled onto its left side, the driver was redirected to the left within the safety belt. She sustained a cervical strain from impact forces and a contusion on the iliac crest from the safety belt. The driver complained of headache, dizziness, and blurred vision but no head trauma was noted by the treating physician, and there was no discernable evidence of occupant contact found within the vehicle. The driver also sustained a contusion on the lower back, possibly from contact with the seat back. Passers-by helped the driver exit the vehicle through the backlight, which had disintegrated from the crash.

CASE VEHICLE DRIVER INJURIES

The driver of the Kia was transported by ambulance to a hospital where she was treated in the emergency room for minor injuries and released. She had one follow-up visit to a doctor and

did not miss any days of work due to the crash. 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	Injury head ³ with complaints of headache, dizziness, blurred vision without any known head trauma	unknown 115099.7,0	Unknown injury source	Unknown	Emergency room records
2	Strain, acute, cervical with posterior pain	minor 640278.1,6	Noncontact injury: impact forces	Probable	Emergency room records
3	Contusion over right iliac crest	minor 590402.1,1	Lap portion of safety belt system	Probable	Emergency room records
4	Contusion back, lower, with complaints of lower back pain, not further specified	minor 690402.1,8	Seat back, driver's	Possible	Emergency room records

CASE VEHICLE FRONT ROW PASSENGER KINEMATICS

The front passenger of the Kia [10-year-old, male; 152 cm (60 in) and 50 kg (110 lb)] was seated in an upright posture with his back against the seat back and his hands in his lap. The seat track was positioned between the middle and rear positions and the seat back was slightly reclined. The passenger was wearing glasses at the time of the crash.

The right side impact on the Kia displaced the passenger to the right and forward opposite the 2 o'clock direction of force and he loaded the safety belt. As the vehicle rolled onto its left side, the front passenger was redirected to the left. He remained in the safety belt at final rest. The front passenger exited the vehicle through the right front door with the assistance of passers-by.

CASE VEHICLE FRONT ROW PASSENGER INJURIES

The front passenger was not injured and was not transported. He did not miss any days of school due to the crash.

CASE VEHICLE SECOND ROW RIGHT PASSENGER KINEMATICS

The second row right passenger of the Kia [8-year-old, male 137 cm (54 in) and 39 kg (85 lb)] was seated in an upright posture with his back against the seat back and his hands in his lap. The passenger was not wearing glasses.

³ The emergency room physician diagnosed "head injury" as part of the final diagnoses.

The right side impact on the Kia displaced the passenger to the right and forward opposite the 2 o'clock direction of force. As the vehicle rolled onto its left side, the passenger was redirected to the left within the safety belt. He remained in his safety belt at final rest. The passenger exited the vehicle through the right front door with the assistance of passers-by.

CASE VEHICLE SECOND ROW RIGHT PASSENGER INJURIES

The second row right passenger was not injured and was not transported. He did not receive any medical treatment and did not miss any days of school due to the crash.

OTHER VEHICLE

The 2000 Ford Focus SE was a front wheel drive, 4-door, sedan (VIN: 1FAFP34P3YW-----) equipped with a 2.0-liter, 4-cylinder engine, and driver and front passenger frontal air bags. The Ford was not inspected since it had been sold at an auto auction prior to this investigation.

The Missing Vehicle algorithm of the WinSMASH program calculated the total Delta V for the Ford as 39 km/h (24.2 mph). The longitudinal and lateral velocity changes were -38.4 km/h (-23.9 mph) and 6.8 km/h (4.2 mph), respectively. The results should be considered borderline since they are based only on the damage on the Kia.

Other Vehicle's Occupants: The police crash report indicated that the driver of the Ford (37-year-old, female), and the second row right passenger (6-year-old, male) were restrained by their lap-and-shoulder safety belts. The police crash report also indicated the driver's frontal air bag deployment as unknown. The driver sustained a police reported B (non incapacitating) injury and was transported to a hospital. The second row right passenger sustained an C (possible) injury and was treated at the scene.

