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VERIDIAN ON-SITE ALLEGED INADVERTENT AIR BAG DEPLOYMENT/CLOTHING FIRE INVESTIGATION
CASE NO. CA97-010
VEHICLE: 1995 HYUNDAI ACCENT
LOCATION: VIRGINIA
CRASH DATE: MARCH, 1997

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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15. *Supplementary Notes* On-site investigation of an air bag deployment crash that resulted in a clothing fire to the driver's jacket and shirt. The subject vehicle was a 1995 Hyundai Accent that was equipped with frontal air bags for the driver and passenger positions.			
16. *Abstract* This on-site investigation focused on a clothing fire to the driver of a 1995 Hyundai Accent. The vehicle was equipped with frontal driver and passenger air bags which deployed as a result of a front-to-rear impact sequence with a stopped Volkswagen Golf. The exhaust gases and particulate from the expanding front right passenger air bag initiated a fire to the driver's corduroy jacket. As he exited the vehicle, the clothing flamed up and spread to his shirt. He was assisted by a driver of another vehicle in removing the jacket and shirt. As a result of the air bag deployment, the driver sustained a air bag related fling injury (sprain) of the left wrist from contact against the left sunvisor. He also sustained a superficial burn to the dorsal aspect of his left hand from the removal process of his clothing.			
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Background

This on-site investigation focused the deployment of the frontal driver and passenger air bags in a 1995 Hyundai Accent and the subsequent fire to the driver's clothing. The driver alleged that the air bags deployed inadvertently as he was decelerating on an approach to an intersection. The frontal area of the Hyundai **(Figure 1)** subsequently impacted the rear of a stopped Volkswagen Golf **(Figure 2)** which was displaced forward into the rear of a stopped 1995 Lexus. In addition to the driver's allegation of the inadvertent deployment, he alleged that the exhaust gases from the deploying air bags ignited his clothing, which consumed his jacket and pullover shirt. The driver's jeans and T-shirt were also scorched by the fire incident. The driver's injuries included a sprain of the left wrist from contact with the left sunvisor (fling injury) and minor burns to the dorsal aspect of his left hand that resulted post-crash as he removed his burning clothing. His eyebrows and facial hair (slight beard) were reportedly singed by the flames. There were no burns to his abdominal or thoracic areas.

Figure 1. Frontal damage to the 1995 Hyundai Accent

This crash occurred in March, 1997 during afternoon hours in Virginia. This special interest crash was reported to the NHTSA by the investigating police officer on March 11. An initial inspection of the Hyundai was performed by a representative of NHTSA's Crash Investigation Division and as a result of this inspection, the crash was assigned to Veridian's Special Crash Investigation Team on March 12. An extensive in-person interview was conducted with the driver of the Hyundai on Tuesday, March 18, with an inspection of the vehicle on March 19. NHTSA' s Office of Defects Investigation conducted a subsequent inspection of the vehicle, the air bag system, and consulted Hyundai to retrieve the data retained in the air bag system's diagnostic control module. The outcome of the ODI investigation is not included in this report.

Figure 2. Rear damage to the struck Volkswagen Golf

Vehicle Data

The involved 1995 Hyundai Accent was a two-door hatchback that was manufactured on 6/12/95 and was identified by vehicle identification number KMHVD14N9SU (production number deleted). The Accent

was equipped with a frontal driver and passenger air bag system that was manufactured by Allied Signal with a single point sensing/control module. This single point control module was mounted in the forward console area of the passenger compartment. There was no damage or interior intrusion in the area of this component. In addition to the air bag system, the Hyundai was equipped with 3-point lap and shoulder belts in the four outboard seated positions with adjustable upper anchorages for the front seat belt systems. A manual 5-speed transmission with a floor mounted transmission selector lever was coupled to the transverse mounted four cylinder, 1.5 liter engine. At the time of the SCI inspection, the odometer reading was 67,529 km (41,962 miles).

Vehicle History

The driver of the Hyundai was the owner of the vehicle, however, the vehicle was registered in his aunt's name who acted as the co-signer on the loan that was required for vehicle purchase. The driver stated that he purchased the vehicle new from a local Hyundai dealership in September, 1995. He was the primary driver and was responsible for all repair orders that were initiated for the vehicle. He stated the he returned the Hyundai to the dealership on two previous occasions for repair of the air bag system. Both of these problems resulted from his detection of the instrument panel mounted air bag indicator lamp which remained illuminated following a start cycle of the vehicle. The first air bag system repair was initiated on 1/25/96 with a vehicle odometer reading of 19,336 km (12,015 miles). This repair involved the replacement of the air bag control/sensing module. The second repair order occurred on 4/18/96 at 30,926 km (19,217 miles). Again, the air bag control/sensing module was replaced. Additional repairs performed at the dealer level included two oil changes, an adjustment of the washer nozzle, and a recent suspension repair. This suspension repair occurred on 2/14-2/21/97 for damage incurred from contact with a curb due to a control loss on an icy road surface. There was no air bag deployment associated with this incident. The driver stated that as a result of this repair process, the dealership issued a certificate to him for a complimentary oil change.

Driver Data

The driver of the Hyundai was a 21 year old male with a stated height of 180.3 cm (71.0") and weight of 81.6 kg (180.0 lbs.). On the day of the crash, he was wearing new pre-washed denim blue jeans, an oversized cotton tank-type T-shirt under a long sleeved, cotton pu1l-over shirt, and a corduroy hip length jacket. The jacket fabric was a wide-band corduroy and was black in color. He stated that the outer fabric was 100 percent cotton with a lining of a synthetic type fabric. The jacket was manufactured by "Brinks" and was a "retro 70's" style without side pockets. The driver stated that as exited his work place, the jacket was zipped to his mid chest area. The driver was employed as a sales representative for a large discount clothing retailer. He had completed his assigned work schedule for that day which began at 0800 hours. The driver further stated that he was not subjected to solvents or flammable liquids at his work place or home environment and did not use tobacco products.

Summary

Crash Sequence

Pre-Crash

The driver stated that he departed his work place at 1500 hours and planned to travel to the dealership immediately following work to redeem the oil change certificate since the Hyundai was overdue for an oil

change. He stated that he entered the Hyundai at his work place and started the vehicle. The driver stated that the SRS air bag indicator lamp initially illuminated during the check cycle then went off, however, the lamp immediately illuminated and remained on. The driver observed the SRS lamp and decided that since he was en route to the dealership for the oil change, he would proceed directly to the facility and report the alleged malfunction of the SRS system. He further stated that he turned the radio to the off-position and opened the driver's side window approximately 50 percent and proceeded en route to the dealership.

The driver was traveling in a westerly direction on the divided roadway and stated that he had traveled approximately 2 km (1.5 miles) which involved less than five minutes of travel time. As he approached a signalized intersection, the driver observed a line of standing traffic on the inboard westbound travel lane. He began to decelerate by down-shifting the manual transmission. He was seated in a normal posture with his right hand on the floor mounted transmission shift lever and his left hand on the steering wheel rim at the 11 o'clock position. The driver stated that his left foot was on the clutch pedal with his right foot over the brake pedal. During this deceleration mode, the driver stated that he heard a loud bang. He responded to the noise by flinching back from his driving position and raising both hands. He immediately detected a large cloud of white smoke within the vehicle and heard two distinct "tick" sounds which he said were similar to a clicking a pen clip against the pen barrel. He reached for the steering wheel and depressed the clutch and brake pedal in an attempt to control the vehicle as he remained aware of the stopped traffic. The driver stated that the brake pedal was hard to depress following his allegation of the inadvertent deployment. Although unconfirmed, this could have resulted from a stall of the engine and loss of vacuum to the power-assisted brakes. The deploying driver's side air bag expanded against the anterior aspect of the driver's left forearm which separated his hand grip from the 11 o'clock position on the steering wheel rim. His left arm flailed upward as his wrist impacted the left sunvisor. This contacted sequence scuffed the vinyl covering of the sunvisor and sprained his left wrist.

Crash

The frontal area of the Hyundai Accent impacted the rear of the stopped 1986 Volkswagen Golf resulting in a 12 o'clock/6 o'clock impact configuration. The direct contact damage on the Hyundai began on the bumper face 23.2 cm (9.1") right of center and extended 88.3 cm (34.75") to the left front corner. Maximum crush at bumper level was 4.1 cm (1.625") located at the left corner **(Figure 3)**. Following initial contact, the bumper of the Hyundai underrode the bumper face of the Volkswagen which allowed the grille and hood face to engage against the bumper of the Volkswagen. Maximum crush at the left comer of the hood face of Hyundai was 7.9 cm (3.1"). The struck Volkswagen sustained an estimated 7.6 cm (3.0") of rear bumper crush that was located approximately 10.2 cm (4.0") left of center. These values were estimated from the on-scene police photographs that were obtained from the investigating officer. The Collision Deformation Classifications (CDC) were 12-FDEW-1 for the Hyundai and 06-BZEW-1 for the Golf. Velocity changes of 13.4 km/h (8.3 mph) for the Hyundai and 13.3 km/h (8.3 mph) for the

Figure 3. Overhead view of the frontal deformation

struck Volkswagen were computed by the damage algorithm of the WinSMASH program. The longitudinal components were -13.4 km/h (-8.3) and 13.3 km/h (8.3 mph) for the Hyundai and Golf respectively. The Volkswagen was displaced forward by the impact where it subsequently impacted the rear of a stopped 1995 Lexus resulting in minor damage.

Post-Crash

Immediately following the crash, the driver noted the driver's air bag had deployed. This was his first detection of the deployed air bag. He stated that he remained in the vehicle for several seconds to collect his thoughts on the events that had just occurred. He then unbuckled his manual 3-point lap and shoulder belt system and exited the vehicle to check the status of the driver of the Volkswagen. The driver estimated that this entire sequence following impact involved 5-10 seconds. As he approached the struck Volkswagen, he noted that its driver had opened the left front door and that two occupants of the struck Lexus had exited their vehicle and were walking toward the Volkswagen. The Hyundai driver further noted that as he was approximately 1 m (4') from the left front door of the Volkswagen, the driver of the Lexus stated to him that his jacket was on fire. The driver of the Hyundai unzipped his jacket and threw it onto the earth median adjacent to the final rest position of the Volkswagen **(Figures 4 and 5)**. Both drivers attempted to stomp out the fire on the jacket, however, they were not successful. During this attempt, the driver of the Lexus stated to the Hyundai driver that his shirt was on fire. The Lexus driver reached with one hand and grabbed the pu1l-over shirt at the left shoulder area and pulled the shirt off the driver without extending it over his head. He threw the shirt onto the median adjacent to the jacket. The Hyundai driver sustained minor burns to the dorsal aspect of his left hand that resulted post-crash as he removed his burning clothing.

Figure 4. Remains of the burned jacket and shirt worn by the driver of the Hyundai

Figure 5. Close-up view of the remains of the burned jacket

A Virginia State Trooper was traveling past the crash scene and noted the burning clothing. He stopped his patrol vehicle and retrieved the fire extinguisher from the trunk of the vehicle and sprayed the clothing. The driver of the Hyundai noted that as the Trooper arrived on-scene, the jacket and shirt were completely burned with minimal flame extending from the smoldering clothing items. This Trooper notified the local police agency which dispatched an officer to the scene. In addition, an investigator from the Fire Marshal's Office responded to the scene of the crash since a fire was reported to have occurred. The driver of the Hyundai was subsequently transported to a local hospital by ambulance where he was treated for his

injuries and released. The hospital applied a splint wrapped with an ace bandage around the left hand and forearm to stabilize the sprain.

The driver of the Hyundai stated that the jacket was burning in the area of the lower right quadrant over the abdominal area. He further stated that as he removed the jacket, his shirt appeared to be more engulfed in fire, with flames extending across the right abdominal area diagonally upward onto the left chest area. He noted that his right eyebrow was singed by the flames, however, the investigating police officer who observed him at the hospital noted singeing to both eyebrows and to his beard. In addition to the loss of his jacket and shirt, the driver's blue denim jeans sustained superficial charring in the area of the right pocket. His tank-type, T shirt also had superficial charring over the right abdominal area **(Figure 6)**. The T-shirt probably protected the driver from sustaining burns to his abdominal and thoracic areas. As a result of the alleged inadvertent air bag deployment, the driver of the Hyundai stated that he experienced an irritation of the throat and a ringing sensation in his ears. Both of these symptoms dissipated within one hour of the crash. He also complained of cervical pain that was attributed to the impact force of the crash.

Figure 6. T-shirt worn by the driver of the Hyundai with faint charring of the right side

The Fire Marshal recovered the burned clothing items from the scene and retained them as evidence. The clothing was not placed in protective containers, therefore they were exposed to the air and possible contaminants. An informal meeting was scheduled on March 19 with representatives of NHTSA's Office of Defects Investigation (ODI), the Veridian SCI Team, the investigating police officer, and the Fire Marshal's Investigators. Prior to this meeting, the clothing remains were placed in sealed containers for transfer to ODI representatives.

SCI Vehicle Inspection

Air Bag System/Vehicle Interior

Figure 7. Deployed driver air bag

The Hyundai was inspected by the Veridian SCI Tearn on March 19 at the police impound lot. The vehicle had been previously inspected by a NHTSA representative, the Fire Marshal's Office, and the investigating police officers. At the time of our inspection, subtle evidence in the vehicle's interior had been eroded due to inclement weather conditions.

The driver and passenger air bag system deployed from the respective module assemblies in a normal mode **(Figures 7 and 8)**. The driver air bag deployed from symmetrical cover flaps within the four-spoke steering wheel assembly. The driver air bag was tethered by two internal tether straps and was vented with two 2.5 cm (1.0") ports located at the 10 and 2 o'clock positions. There was a trace amount of deployment

Figure 8. Deployed front right passenger air bag system

residue surrounding the right (2 o'clock) vent port. There were no deposits on the interior surfaces forward of the vent port locations.

The passenger air bag deployed from a top mount air bag module assembly located in the right upper instrument panel. The single top hinged cover flap was 35.3 cm (13.9") in width and 19.7 cm (7.75") in height. The passenger air bag was tether by two wide band internal tethers that were sewn to the face of the bag. The bag was vented directly into the passenger compartment by two 5.7 cm (2.25") located on the side panels of the bag at the 3 and 9 o'clock positions. The inboard vent port was centered 32.4 cm (12.75") rearward of the mid instrument panel. There was no damage to the air bag fabric or external burns. The interior of the passenger air bag was viewed through the inboard vent port **(Figure 9)**. Numerous small fragments of a blackened substance (similar to carbon) were visible within the bag. The majority of these fragments had settled on the bottom surface of the bag as it deflated. In addition to these fragments, the remants of a label were noted within the bag. Several large fragments which were approximately 13.0 mm (0.5") in diameter had settled to the bottom of the bag. Numerous smaller fragments of the label were also visible within the bag **(Figures 10 and 11)**. These fragments appeared to have been subjected to heat and were brittle and curled. Samples of the fragments were recovered and transferred to the ODI representatives. Further inspection of the air bag assembly focused on the inflator manifold. This alloy manifold was a cylindrical tube that contained four ports which provided transfer of the gas from the generator to the air bag. The ports were positioned near the bottom of the manifold which was surrounded by a fabric heat shield. A carbon-like substance surrounded the most inboard manifold port primarily on the thickness of the manifold and immediately outboard of the port. The two adjacent ports appeared free of deposits while the outboard ports had faint carbon-like transfers. The internal surface of the bag and heat shield in the area of the manifold was covered with a light carbon-like film that easily transferred onto the fingers of the field investigator during the inspection process.

Figure 9. Left (inboard) vent port of the front right passenger air bag

Figure 10. Close-up view of the left vent port of front right passenger air bag

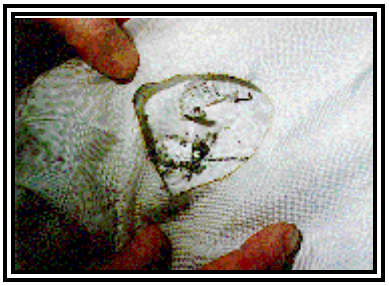

Figure 11. Label fragments and particulate on inside of air bag

A large whitish substance was noted on the right door panel, adjacent to the right vent port of the passenger air bag. This transfer had eroded significantly prior to our inspection of the vehicle. It was initially observed by the investigating police officer and the NHTSA representative who inspected the vehicle on March 12.

In addition to the vehicle inspection and interview with the Hyundai driver, a representative of Allied Signal was contacted via telephone to discuss the air bag system of the Hyundai. Allied Signal manufactured the

driver and passenger side air bag modules and the single point sensing/diagnostic module. The preliminary focus of this investigation has involved the passenger air bag which was suspected as a source of the clothing fire. The Allied Signal representative stated that the passenger inflator was a hybrid system that consisted of argon gas stored on a deep drawn high strength, low alloy steel container and an Arcite (extruded potassium perchlorate in a PVC binder with approximately 5 percent lithium carbonate added to bind the chlorine) inflator that was detonated by a squib. The combustion process produced nitrogen gas which heated and expanded the argon gas. These gases were then transferred and inflated the passenger side air bag. The by- product of this combustion process and particulate release into the bag was potassium chloride. The representative stated that the discharge residue on the right door panel was probably potassium chloride. He further noted that this type of inflator operates at a lower temperature than sodium azide inflators, therefore it was unlikely that the fire was attributed to the passenger air bag.

The Allied Signal representative did state that the possibility of an inadvertent deployment did exist. Two faults would had to have occurred which would involve a short to the power and a short to the ground. The on-board air bag system diagnostic module retains all active faults and would provide data to support an impact induced deployment versus an inadvertent deployment. Down loading of the data can be obtained by a trained technician using a multi-purpose universal tester (MUT). This task was scheduled to be accomplished on a secondary inspection of the vehicle by NHTSA, ODI, Hyundai, and Allied Signal representatives. The outcome of this inspection was not provided to the SCI team for inclusion into this report.

Other Possible Fire Related Sources

It should be noted that other sources of the fire have been investigated. These have included potential smoking by the driver, his exposure to flammable materials, and work place risks that could have harbored a spark, etc. The driver of the vehicle is a non-smoker and he has denied the use of tobacco products within the vehicle (and at all times). The ash tray of the Hyundai was clean of any ash residue and appeared to have been used exclusively to store business cards and personnel papers. The vehicle's cigarette lighter was positioned in the mid panel unit of the vehicle. The lighter was in a new condition and appeared to have never been used. There was no apparent exposure to heat on the elements of the lighter unit. The driver offered to take a drug test at the scene of the crash to disprove the possibility of drug usage. The vehicle was extremely clean and free of any tobacco-type material. As previously noted, the driver works in a clothing store and is not exposed to flammable materials or sparks. He was not in close contact with the drivers of the other vehicles at the scene of the crash, prior to the detection of the clothing fire. This eliminates the possibility of contact with a discarded smoking material from one of these drivers.

ODI has retained possession of the clothing remains for possible testing of foreign matter. In addition, the follow-up inspection of the vehicle and testing of the fragments recovered from the inside of the passenger side air bag, in combination with the down-loading of the system data, and possible disassembly of the passenger side air bag are probable tasks that will be directed under ODI supervision. It should be noted that the driver of the Hyundai was fully cooperative with the Veridian SCI investigation and that he appeared to be an extremely credible witness.

Driver Demographics

Age/Sex:	21 year old male
Height:	180.3 cm (71.0")
Weight:	81.6 kg (180.0 lbs)
Manual Restraint System Usage:	3-point lap and shoulder belt
Usage Source:	Interview
Eyeware:	None
Mode of Transport From Scene:	Ambulance to a local hospital
Type of Medical Treatment:	Treated and released

Driver Injuries

Injury	***Injury Severity (AIS90/Update 98)***	***Injury Source***
Sprain of the left wrist	Minor (751420.1,2)	Air Bag related fling injury against the left sunvisor
Blistered burn of the dorsal aspect of the left hand	Minor (792002.1,2)	Not crash related, occurred as the driver attempted to extinguish/remove burning clothing
Cervical pain	N/A	Impact force

** Source of injury - Driver interview (attorney refused to allow release of medical records)*