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VERIDIAN ON-SITE KNEE BOLSTER AIR BAG DEPLOYMENT INVESTIGATION
VERIDIAN CASE NO. CA 98-025
VEHICLE - 1997 KIA SPORTAGE
LOCATION - NEW JERSEY
CRASH DATE - APRIL 1998

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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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BACKGROUND

This on-site investigation focused of the crash severity and performance of the inflatable restraint system in a 1997 Kia Sportage, sport utility vehicle. The Kia was equipped with a frontal air bag system for the driver that consisted of a typical steering wheel mount air bag and a knee bolster air bag. The vehicle was not equipped with a front right passenger air bag. The system deployed as a result of a intersection-type crash with a 1984 Chevrolet Caprice. The 21 year old male driver of the Kia was restrained by the manual 3-point lap and shoulder belt system. He sustained a contusion of the left shoulder from loading the shoulder belt webbing and left ankle pain from loading the clutch pedal during the moderate severity crash. He was transported to a local hospital where he was treated for his injuries and released.

The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) was notified by rescue personnel on April 17, 1998, of the two vehicle crash. The crash occurred earlier in the month of April and involved a member of his rescue squad. The Veridian Special Crash Investigation team was directed by the CID to conduct an on-site investigation. The on-site investigation was initiated on April 20, three days following the Friday notification.

SUMMARY

Crash Site

The crash occurred on an east/west two lane roadway in an urban/commercial area during nighttime hours. The roadway was bordered by paved shoulders with a barrier curb located at the outboard aspect of the south shoulder. Commercial driveways that provided access to parking lots intersected the south curbline. The roadway was straight and level in the vicinity of the crash site and curved immediately following the impact location. The posted speed limit was 56 km/h (35 mph). At the time of the crash, the weather was clear and the environmental surfaces were dry.

Crash Sequence

Pre-Crash

Prior to the crash, the driver of the Kia Sportage attended a meeting that was held in a building adjacent to the parking lot on the south side of the two lane roadway. He entered his vehicle and traveled north in the parking lot to the south shoulder where he stopped at the mouth of the parking lot prior to entering the two lane roadway **(Figure 1)**. The driver stated that he looked to his left in a westbound direction and noticed the approach of the1984 Chevrolet Caprice **(Figure 2)** in the eastbound travel lane. He determined

the vehicle was far enough away that it did not pose a threat to his turning action. The driver of the Kia then checked the westbound travel lane and noted the absence of approaching vehicles. He proceeded to turn left, across the eastbound travel lane to proceed in a westbound direction. As he initiated the left turn, the driver of the Kia noted the presence of Chevrolet Impala, which he estimated at approximately 6 m (20') from the impending point of impact (POI). He subsequently attempted to avoid the crash by accelerating and shifting the manual transmission from first to second gear. The crash schematic is attached as **Figure 8**, page 9.

Figure 1
The Kia's travel path while departing the parking lot and attempting a left turn

Figure 2
The Caprice's eastbound trajectory 15 m(50') prior to the point of impact

Crash

The front right corner of the Chevrolet Caprice struck the front left corner of the Kia Sportage as the Kia entered the Chevrolet's path of travel. The L configuration crash resulted in an estimated 11o'clock direction of force to the Kia and a 1 o'clock impact force for the Chevrolet. It should be noted that the Kia was under repair at the time of the SCI inspection and the Caprice was not inspected. The damaged components of the Kia were inspected which provided a basis for the crash severity. Based on the inspection of these components, the Kia sustained an estimated velocity changed of 16-24 km/h (10-15 mph). This impact induced deceleration was sufficient to deploy the vehicle's driver frontal and knee bolster air bags.

The Kia Sportage rotated approximately 74 degrees in a clockwise direction and came to the rest 5.1 m (16.6') east of the point of impact, adjacent to the roadway centerline. This was based on physical evidence found at the crash scene. The Chevrolet Caprice rotated counterclockwise and traveled over the centerline where it came to the rest.

Post-Crash

The driver of the Kia Sportage attempted to exit his vehicle where he encountered a restriction of his right leg. This restriction was attributed to the rearward displacement of the knee bolster where the inboard edge of the bolster was pressing against the side of his lower leg/knee area. After a concentrated effort, the driver was able to free the leg by twisting his body position and exit the vehicle. He walked a short

distance to a grass area adjacent to the roadway when rescue arrived and directed him to lay on the ground. He was strapped to a backboard and transported via ambulance to a local treatment facility where he was treated for minor injuries and released.

The 54 year old male driver of the Chevrolet Caprice and his 58 year old female front right passenger sustained minor injuries and were transported to a local medical treatment facility where they were treated and released. The driver was listed by police as suffering pain of the back and the passenger was bleeding from the head.

Vehicle Data - 1997 Kia Sportage

The driver indicated that he purchased the Kia Sportage new in December, 1997. The vehicle was manufactured on 07/18/97 and was identified by vehicle identification number KNDJA7233V5 (production number omitted). At the time of the crash, the odometer reading was 8,853 km (5,501 miles). The 1997 KIA Sportage was a 4-door, 4x4 model that was equipped with a front driver air bag and driver knee bolster air bag which deployed as the result of the impact with the Chevrolet Caprice. In addition to the frontal air bag system, the Kia was equipped with front disc, rear drum brakes, alloy wheels, and a 2.0 liter, 4-cylinder gasoline engine linked to a 5-speed manual transmission. The interior was configured with front bucket seats with reclining backrests and a folding bench rear seat. The four outboard belt systems consisted of a continuous loop webbing with sliding latchplates, and dual mode locking retractors. The lower outboard aspects of the front lap belts were equipped with energy management loops. It should be noted that although the driver was restrained by the manual belt system, his loading force did not deploy the management loop.

Vehicle Damage

Exterior - 1997 Kia Sportage

The Kia Sportage was under repair at the time of the SCI inspection with the front bumper, grille, left front fender, and front wheels removed **(Figure 3)**. The collision shop had the vehicle positioned on jack stands in the frame straightening area of the shop. The structure of the vehicle was realigned prior to SCI arrival. The direct contact damage began 55.9 cm (22.0") left of center and extended 10.2 cm (4.0") to the front left bumper corner. Engagement continued onto the left front fender, terminating 35.6 cm (14.0") rearward of the corner area. Maximum crush was estimated at 5.1 cm (2.0") at the front left corner of the bumper with approximately 10.2 cm (4") of sheet metal crush occurring at the leading edge of the left front fender. The Collision Deformation Classification (CDC) for this impact was 11FYEW-1. The vehicle was towed from the scene.

Figure 3
Exterior view of the Kia Sportage that was under repair at time of the SCI inspection

Exterior - 1984 Chevrolet Caprice

The 1984 Chevrolet Caprice Classic station wagon reportedly sustained major crush to the right front/right side. The vehicle was towed from the scene due to damage. It was not inspected.

Interior - 1997 KIA Sportage:

Interior vehicle damage to the 1997 KIA Sportage was attributed to occupant contact and the deployment of the driver's frontal and knee bolster air bags. There was no intrusion or deformation associated with the exterior damage.

The lower instrument panel adjacent to the right side of the knee bolster was abraded and exhibited fabric transfers that were attributed to contact by the driver's right knee and lower leg. The contact pattern measured 12.7 cm (5.0") vertically and 8.9 cm (3.5") laterally and began 10.2 cm (4.0") left of the vehicle's centerline. Additionally, the vinyl surface of the instrument panel adjacent to the top of the contact point was fractured and was attributed to the same contact. The 14.0 cm x 6.7 cm (5.5" x 2.625") headlight switch panel located 58.4 cm (23.0") left of the vehicle centerline was dislodged from the lower instrument panel and the adjacent vinyl instrument panel cracked. This was attributed to contact by the driver's left knee during the crash sequence.

The driver knee bolster was constructed of a pliable vinyl cover which was backed by 12.7 mm (0.5") thick high density foam padding and reinforced by a 15.9 mm (1/16") thick sheet metal backing plate. The bolster panel was rectangular in shape with a U-shaped cutout for the steering column. The dimensions of the bolster are as follows: bottom edge 30.5 cm (12.0"); left and right edge 30.5 cm (12.0"); left top edge adjacent to the steering column 9.5 cm (3.75"); right top edge adjacent to the steering column 7.6 cm (3.0"); vertical distance from the bottom of the bolster to the base of the steering column 20.3 cm (8.0"). The adjacent lower instrument panel had a rake angle of 45 degrees. **Figure 4** is a view of the deployed knee bolster air bag.

Figure 4
View of the knee bolster and knee air bag

The knee bolster utilized six quick release points with three points along the left vertical edge and three on the right vertical edge **(Figure 5)**. The two lower 2.5 cm (1.0") diameter release points along the left edge were located 3.8 cm (1.5") inboard from the edge and 10.2 cm (4.0") and 19.7 cm (7.75") from the bottom of the bolster. The left top release attachment point measured 1.9 cm (0.75") in diameter and was recessed in a 2.5 cm (1.0") square. It was located 26.0 cm (10.25") from the bottom of the knee bolster and 3.8 cm (1.5") inboard from the edge. The two lower 2.5 cm (1.0") diameter releases along the right edge were located 3.8 cm (1.5") and 3.2 cm (1.25") inboard from the edge and 10.2 cm (4.0") and 19.7 cm (7.75") from the bottom of the bolster. The top release attachment point was located 26.0 cm (10.25") from the bottom of the knee bolster and 1.9 cm (0.75") inboard from the edge measured 1.9 cm (0.75") in diameter and recessed in a 2.5 cm (1.0") square.

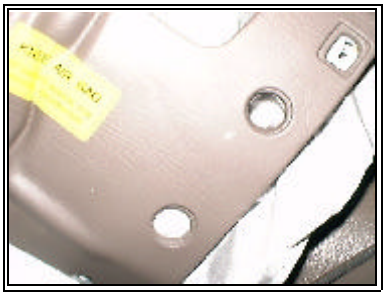


Figure 5
View of the knee bolster break away attachment points and warning label

A prominent yellow knee air bag warning label with black printing that measured 3.8 cm x 7.6 cm (1.5" x 3.0") was affixed to the vinyl surface of the knee bolster and was located 10.5 cm (4.125") from the bottom edge and centered across the lateral dimension. The label read as follows:

"KNEE AIR BAG"
SEE OWNER'S MANUAL FOR
ADDITIONAL INFORMATION

There was an identification label located on the back of the knee bolster metal plate read as follows: KKAH556AADV.

The knee bolster sustained deformation as the result of being displaced by the deploying knee air bag. The knee air bag was attached to the center of the knee bolster which restricted its rearward excursion to a measured distance of 8.3 cm (3.25"). As the center of the knee bolster reached the maximum extent of travel, the knee air bag continued to exert pressure along the rear outboard aspects of the bolster where the left and right sides continued to move rearward resulting in a "V" shaped deformation pattern. The extent of deformation measured from a reference line across the face of the knee bolster to the center of the bolster measured 5.1 cm (2.0").

The knee bolster air bag was a rectangular design that measured 50.8 cm (20.0") laterally and 30.5 cm (12.0") vertically. It was tethered and contained a 2.5 cm (1.0") diameter vent port. There was no driver contact evidence noted on the surface of the air bag.

The driver stated his seat track was adjusted two notches rearward of the full forward position to accommodate his height of 165.1 cm (65.0"). At the time of inspection, the seat was located 3.8 cm (1.5") from full rear over a seat adjustment range of 17.5 cm (6.875") with a seat back angle of 13 degrees. In the driver's stated position, the horizontal distance between the seat back support and the mid point of the driver air bag module was 47.3 cm (18.6"). This measurement was documented at a height of 39.4 cm (15.5") above the junction with the seat cushion. The center of the knee bolster was located 68.9 cm (27.125") forward of the seat back support.

The left front door surface located adjacent to the closure grab handle was deformed 6.4 mm (0.25") laterally. This was attributed to contact by the driver's left hip area during the crash sequence.

Frontal Air Bag System

The frontal air bag system in the 1997 KIA Sportage was designed with a typical driver air bag and a front left knee bolster air bag. Both air bags were exclusive to the driver, as the vehicle was not equipped with a front right air bag. The system deployed as a result of the impact with the 1984 Chevrolet Caprice.

The front left air bag module was housed in a conventional configuration within the four-spoke steering wheel rim. The bag deployed from H-configuration module cover flaps. The upper flap measured 6.7 cm

(2.625") vertically and the lower flap was 3.8 cm (1.5"). The lateral width of the common tear seam line measured 15.9 cm (6.25"). There were no apparent occupant contact points on the module cover surface.

The air bag membrane was a tethered by four internal straps located at the 12/6 and 3/9 o'clock positions. The tethers were sewn to the face of the bag with a 15.6 cm (6.125") diameter stitched reinforcement. The bag was vented by two 19.1 mm (0.75") diameter vent ports located at the 11 o'clock and 1 o'clock positions. The ports were located 17.8 cm (7.0") inboard of the peripheral seam on 17.8 cm (7.0") centers. The air bag measured 67.0 cm (26.4") in diameter in its deflated state. There was no evidence of driver contact to the surface of the air bag.

The front left driver knee bolster air bag was mounted behind the driver knee bolster panel. During the deployment sequence, the knee air bag displaced the knee bolster from the six attachment points and traveled a measured distance of 8.3 cm (3.25") toward the driver. The knee air bag had two tethers which limited the excursion of the bag and bolster panel. The tethers were located at the 10 o'clock and 2 o'clock position adjacent to the inflator unit and at 4 o'clock and 8 o'clock on the rear surface of the knee bolster. **Figure 6** is a schematic of the knee bolster air bag.

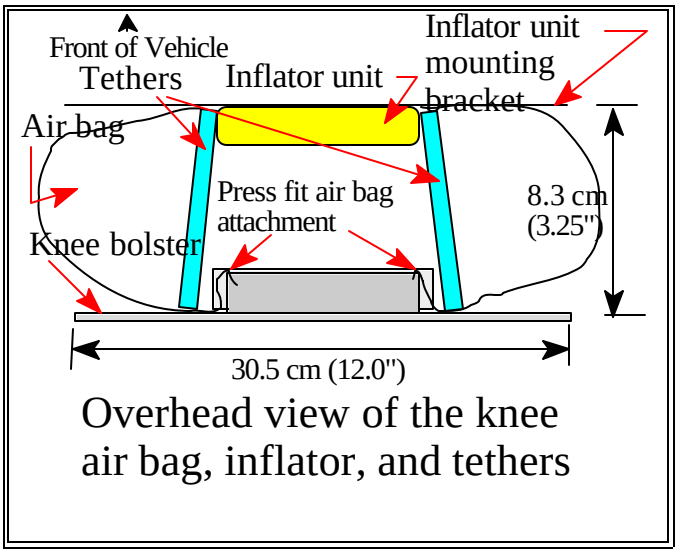


Figure 6. Schematic of the knee bolster air bag

The knee bolster air bag was mounted to the panel directly behind the knee bolster and was attached by a circular metallic press fit bracket on the knee bolster backing plate which measured 12.1 cm (4.75") in diameter. The internal tethers measured 11.4 cm (4.25") in length.

The knee bolster air bag was vented by a single 2.5 cm (1.0") diameter vent port that was located on the back side of the air bag, 5.1 cm (2.0") below the inflator unit. The air bag was covered by a fine white mesh nylon fabric that was used during the packing process to protect the air bag. The nylon mesh was designed in an octagon pattern with eight break-away tabs located along the perimeter. Seven of the eight tabs released during the deployment sequence. The tab which remained intact was located in the upper left quadrant.

The knee bolster air bag was a rectangular design which measured 50.8 cm (20.0") laterally and 30.5 cm (12.0") vertically. The air bag material was a coarse weave, gray color nylon fabric. There was no driver contact evidence noted on the surface of the knee air bag.

Driver Demographics

1997 Kia Sportage

Age/Sex:	21 year old male
Height:	165.1 cm (65.0")
Weight:	90.7 kg (200.0 lb)
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection, driver interview
Seat Track Adjustment:	Forward
Mode of Transport From Scene:	Ambulance to a local hospital
Type of Medical Treatment:	Treated and released

Driver Injuries

Injury	Injury Severity (AIS-90)	Injury Source
Contusion of the left shoulder and anterior chest	Minor (790402.1,2; 490402.1,0)	Shoulder belt webbing
Pain of the left ankle	Not codeable	Clutch pedal

Driver Kinematics

The driver of the Kia Sportage was seated in a normal driving posture with his seat adjusted two notches rear of the full forward position. He noted that his left hand was on the steering wheel rim at the 10 o'clock position and his right hand was grasping the floor mounted shift lever. The driver indicated that due to his short stature and the demands of shifting the manual transmission, he generally sat in an upright posture to accommodate the foot pedals. Just prior to the impact, the driver indicated that his left foot was on the clutch pedal and his right foot was on the accelerator pedal.

At impact, the driver's frontal air bag and knee bolster air bag deployed. The driver responded to the presumed 11 o'clock impact force by initiating a trajectory that was forward and to his left. Due to his forward position, his right knee contacted the instrument panel adjacent to the knee bolster as noted by the abrasion to the vinyl surface and a heavy fabric transfer pattern **(Figure 7)**. The location of the contact was consistent with the description by the driver of his right knee orientation prior to the crash. The driver's left knee contacted the headlight control panel that was subsequently dislodged. Although there was no conclusive evidence, the knee air bag may have contacted the

Figure 7
View of the contact area located adjacent to the knee bolster and knee air bag

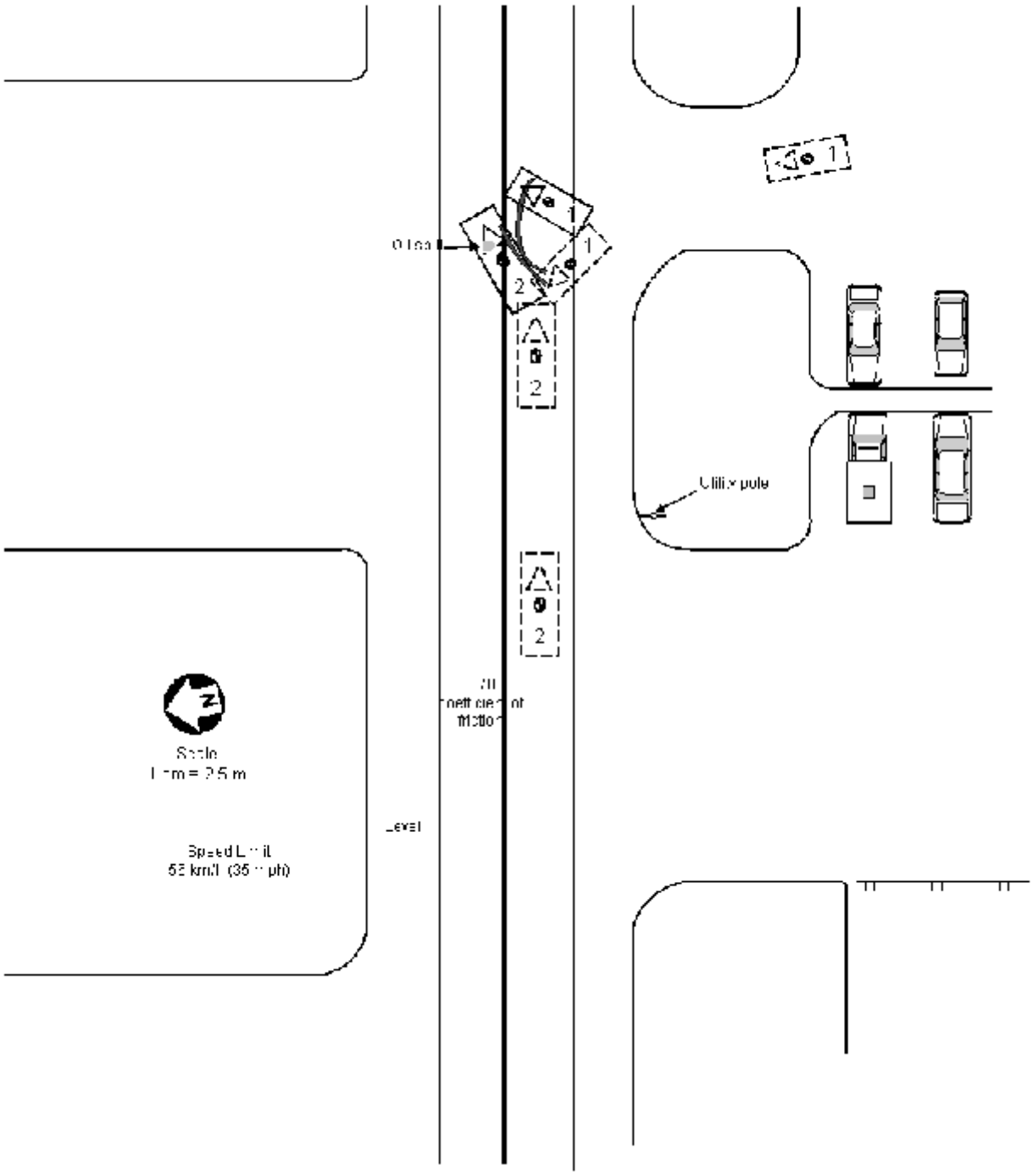
medial aspect of both knees resulting in an outward redirection of the driver's legs. The driver did not sustain knee injury.

The driver's left foot loaded the clutch pedal during the crash. The angular direction of force resulted in a complaint of pain to the left ankle. There was no damage or displacement of the clutch pedal.

The driver's upper torso moved forward and loaded the shoulder belt webbing. His loading force against the belt resulted in a contusion of the left shoulder and mid chest area. The energy management loop remained intact. As the Kia was displaced in a CW direction, the driver's left hip contacted the left front door panel as noted by the deformation of the armrest in the vicinity of the door closure grab handle. The driver rebounded back into the seat where he remained at final rest.

At final rest, the driver of the Kia attempted to exit the vehicle, but encountered a restriction of his right lower leg. Upon further inspection, he discovered that the knee bolster was displaced rearward from the lower instrument panel due to deployment of the knee air bag. This was in contact with his right lower leg. He then maneuvered his leg around the knee bolster/knee air bag and exited the vehicle through the left front door.

The driver walked a short distance to a south shoulder where he sat on a grassy area. The EMS immediately responded to his location and subsequently initiated rescue procedures. He was placed on a backboard with a cervical collar applied prior to being transported to a local hospital via ambulance. He was treated for his minor injuries and released.


Utility pole
Scale
1 cm = 2.5 m
Speed Limit
55 km/h (35 mph)