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ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

GENERAL DYNAMICS CASE NO: CA02-029

VEHICLE: 2002 VOLKSWAGEN PASSAT

LOCATION: VIRGINIA

CRASH DATE: JULY 2002

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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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16. Abstract This on-site investigation focused on the performance of the inflatable side impact occupant protection system in a 2002 Volkswagen Passat. The Passat was equipped with an advanced frontal air bag system that utilized retractor pretensioners in the four outboard seated positions; front seat back mounted side impact air bags for the driver and front right passenger positions, and inflatable side curtains that offered head protection for the front and rear seat outboard occupant positions. The left side air bag and side curtain deployed as a result of an intersection-type crash with a 1996 Ford Escort. The 41-year old female driver of the Volkswagen Passat was attempting to exit a service station parking lot and turn left onto a three-lane road 50 m (164') east of a signalized four-leg intersection. The driver of a non-contact sport utility vehicle stopped his vehicle in the westbound travel lane and waved the driver of the Passat across his lane of travel into the left turn lane. The 1996 Ford Escort was traveling in a westerly direction on the left turn lane as the Passat crossed her path of travel. The frontal area of the Escort impacted the left side of the Passat resulting in deployment of the left side impact air bag systems. The driver of the Passat was restrained by the manual 3-point lap and shoulder belt system. She contacted the deployed side impact air bags and was not injured. Her 7-year old son was seated in the rear left position and was restrained by the manual 3-point lap and shoulder belt system. A 4-year old male was seated in the rear right position, restrained in a Century Breverra belt positioning booster seat. The child was not injured in the crash. Both vehicles sustained moderate severity damage and were towed from the scene of the crash.			
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GENERAL DYMANNICS ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION SYSTEM INVESTIGATION
CASE NO. CA02-029
VEHICLE: 2002 VOLKSWAGEN PASSAT
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BACKGROUND

This on-site investigation focused on the performance of the inflatable side impact occupant protection system in a 2002 Volkswagen Passat **(Figure 1)**. The Passat was equipped with an advanced frontal air bag system that utilized retractor pretensioners in the four outboard seated positions; front seat back mounted side impact air bags for the driver and front right passenger positions, and inflatable side curtains that offered head protection for the front and rear seat outboard occupant positions. The left side air bag and side curtain deployed as a result of an intersection-type crash with a 1996 Ford Escort. The 41-year old female driver of the Volkswagen Passat was attempting to exit a service station parking lot and turn left onto a three-lane road 50 m (164') east of a signalized four-leg intersection. The driver of a non-contact sport utility vehicle stopped his vehicle in the westbound travel lane and waved the driver of the Passat across his lane of travel into the left turn lane. The 1996 Ford Escort was traveling in a westerly direction on the left turn lane as the Passat crossed her path of travel. The frontal area of the Escort impacted the left side of the Passat resulting in deployment of the left side impact air bag systems. The driver of the Passat was restrained by the manual 3-point lap and shoulder belt system. She contacted the deployed side impact air bags and was not injured. Her 7-year old son was seated in the rear left position and was restrained by the manual 3-point lap and shoulder belt system. A 4-year old male was seated in the rear right position, restrained in a Century Breverra belt positioning booster seat. The child was not injured in the crash. Both vehicles sustained moderate severity damage and were towed from the scene of the crash.

Figure 1. Left side of the 2002 Volkswagen Passat with the deployed side curtain.

A NHTSA staff member observed the crash and noted the deployment of the side curtain and the child passengers of the Passat. This person notified the NHTSA Special Crash Investigation team at Headquarters and the crash was assigned to the General Dynamics SCI team on July 8 as an on-site investigative effort. The on-site investigation was initiated on July 15.

SUMMARY

Crash Site

The crash occurred on a three-lane road in a suburban area during daylight hours. The east and westbound travel lanes were separated by a dual direction left turn lane that transitioned into a designated left turn lane for westbound traffic. A signalized four-leg intersection was located approximately 50 m (164') west of the crash site. The asphalt surfaced roadway was 10.8 m (35.4') in width, inclusive of a 3.1 m (10.2') wide westbound travel lane, a 4.2 m (13.9') center left turn lane, and a 3.5 m (11.5') eastbound travel lane. Both edges were bordered 0.6 m (2.0') wide concrete rain gutters that terminated at 15 cm (6") barrier curbs. Grass and sidewalks bordered the curb lines. Commercial driveways intersected the travel lanes. The Passat was attempting to exit a 14.3 m (47.0') wide driveway at the north curb line. In the vicinity of the crash site, the roadway was straight with a sag (bottom of two slopes). The posted speed limit was 40 km/h (25 mph). **Figure 2** is a view of the crash site from the Escort's path of travel.

Figure 2. Westbound view of the crash site from the left turn lane.

Vehicle Data

2002 Volkswagen Passat

The subject vehicle for this investigation was a 2002 Volkswagen Passat GLX, 4-door sedan. The Passat was manufactured in August 2001 and was identified by Vehicle Identification Number (VIN) WVWRH63B72P (production number deleted). The Passat was equipped with 2.6 liter, V-6 engine linked to a 5-speed manual transmission with front wheel drive. The braking system consisted of four-wheel powered-assisted disc brakes with anti-lock (ABS). The Passat was equipped with 7-spoke alloy wheels mounted with Michelin MXV4 Plus 205/55R16 tires. The manufacturer's recommended tire pressure was 193 kPa (28 PSI). There was no damage to the tires or OEM alloy wheels. The tread depth and tire pressures are summarized in the following table.

Position	Tread Depth	Pressure
Left Front	5.6 mm (7/32")	303.4 kPa (44.0 PSI)
Right Front	4.8 mm (6/32")	341.3 kPa (49.5 PSI)
Left Rear	6.4 mm (8/32")	286.1 kPa (41.5 PSI)
Right Rear	6.4 mm (8/32")	265.4 kPa (38.5 PSI)

The interior of the Volkswagen Passat was configured as a five passenger vehicle with front bucket seats and a rear bench seat with a split, forward folding 60/40 seat back. The front bucket seats were

power adjustable with reclining seat backs. All five seat positions were equipped with adjustable head restraints. The steering column was equipped with a tilt and telescope feature with a single locking lever that was located at the base of the column. The center console was fixed which housed the manual shifter, the emergency brake lever, and a center armrest/storage compartment. All five seat positions were equipped 3-point lap and shoulder belt systems. Both front belts had adjustable D-rings. The GLX package included leather seats and a sun roof. At the time of the crash, the Passat's odometer reading was 19,656 km (12,214 miles).

1996 Ford Escort

The striking vehicle in this crash was a 1996 Ford Escort LX, 4-door station wagon. The Escort was powered by a 2.0 liter I-4 engine linked to a 3-speed automatic transmission. The vehicle was equipped with frontal air bags for the driver and right passenger positions which deployed as a result of the crash. The Escort was identified by VIN: 1FASP15J1TW (production number deleted). At the time of the crash, the vehicle's odometer reading was 108,854 km (67,641 miles). The Escort was equipped with all-season radial tires mounted on OEM steel wheels with hubcaps.

Crash Sequence

Pre-Crash

The driver of the 2002 Volkswagen Passat was attempting to exit a driveway for a service station and initiate a left turn onto the three-lane road to travel in an easterly direction. As she stopped at the mouth of the driveway **(Figure 3)**, westbound traffic had backed-up for the signalized intersection that was located 50 m (164') west of the driveway. The driver of a large sport utility vehicle stopped his vehicle east of the driveway and waved the Passat driver out of the driveway, across the westbound travel lane. As she exited the driveway and traversed the westbound lane, the Passat driver initiated a left turning maneuver across the center left turn lane. The 22-year old female driver of the Ford Escort was traveling in a westerly direction on the center left turn lane, slowing to turn left at the signalized intersection. On her approach to the intersection, the Passat entered her lane from in front of the stopped non-contact vehicle. The driver of the Escort applied a rapid braking maneuver in an attempt to avoid the crash. The Passat driver did not initiate avoidance action.

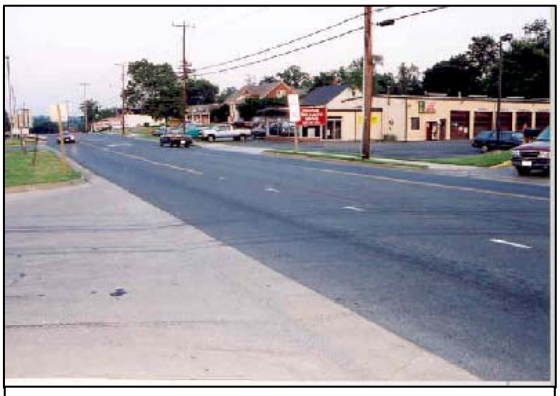

Figure 3. Passat driver's view of approaching westbound traffic.

Crash

The frontal area of the Ford Escort impacted the left side of the Volkswagen Passat. The resultant directions or force were within the 10 o'clock sector for the Passat and the 1 o'clock for the Ford Escort. The damage algorithm of the WinSMASH program computed total velocity changes of 13 km/h (8 mph) for the Passat and 21 km/h (13 mph) for the Escort. The specific longitudinal and lateral velocity changes for the Passat were -6.0 km/h (-3.7 mph) and 11 km/h (6.8 mph) respectively. As a result of the side impact crash, the Passat's side impact seat mounted air bag and

the left side curtain deployed. The frontal impact to the Ford Escort resulted in deployment of the frontal air bag system.

The Passat was rotated in a counterclockwise (CCW) direction and came to rest near the point of impact. The Escort was rotated CCW and came to rest in the center left turn lane near the point of impact. There was no physical evidence at the crash site to support the impact and final rest positions at the time of the SCI investigation.

Post-Crash

All occupants of the involved vehicles exited the vehicles unassisted and refused medical treatment. Both vehicles were towed from the scene of the crash to a local auto body shop where they were held for this SCI investigation.

Vehicle Damage

Exterior - 2002 Volkswagen Passat

The Volkswagen Passat sustained moderate severity left side damage. The direct contact damage began on the left front alloy wheel at the axle position and extended 310 cm (122") rearward onto the left doors and quarter panel, terminating 38 cm (15.1") rearward of the left rear axle on the wheel opening. This damage pattern, although continuous, involved the initial impact with the left door area **(Figure 4)** by the front left corner of the Escort then continued to a sideswipe engagement as the Passat rotated CCW. Maximum crush was 16 cm (6.4") in depth and was located on the left front door **(Figure 5)**, 8 cm (3.0") below the rub strip and 175 cm (67.9") forward of the left rear axle. The crush profile over the length of the damage was as follows: C1 = 0 cm, C2 = 0 cm, C3 = 2 cm (0.8"), C4 = 10 cm (3.4"), C5 = 5 cm (2.1"), C6 = 0 cm. The Collision Deformation Classification (CDC) for this event was 10-LYEW-1.

Figure 4. Damage to the left side of the Passat.

Figure 5. Continuation of damage on quarter panel.

All four doors remained closed during the crash and were fully operational post-crash. The left front door could not be unlatched from the exterior door handle; however, the interior latch mechanism remained operational. There was no glazing damage to the Passat. It should be noted that the hood, roof, and trunk deck had previous damage from a hail storm. This damage consisted of isolated

dents to the horizontal sheet metal surfaces.

Interior - 2002 Volkswagen Passat

The interior of the Passat sustained minor interior damage that was associated with the exterior deformation and side air bag deployment. The left front door panel was displaced from its fasteners by the exterior crush to the door. As result, the mid and rear aspect of the door panel intruded 3.8 cm (1.5") into the driver's space. The mid aspect of the plastic sill trim disengaged from its fasteners and intruded 3.8 cm (1.5") laterally into the drover's floor space. There was no intrusion of the sill structure.

The driver's side impact air bag deployed from the outboard aspect of the seat back. The leather seat cover stitching separated along the full length of the seat back [55.2 cm (21.75")] to allow for the deployment of the air bag. There was no tearing of the leather fabric.

The headliner separated from the left side rail to allow for deployment of the left side curtain air bag. Although there were no physical separation of components, the headliner was creased inboard of the side rail. This crease acted as a hinge point for the deployment of the curtain.

There were no occupant contact points within the Passat. A possible contact point was noted above the left C-pillar, however, this stain appeared to be previous and food related.

Exterior - 1996 Ford Escort

Figure 6. Frontal view of the Escort's damage.

The exterior of the Ford Escort sustained moderate severity damage that was limited to the frontal plane **(Figure 6)**. Maximum crush was 13 cm (5.25") located at the right corner of the front bumper. The direct contact damage began 30 cm (12.0") left of center and extended 102 cm (40.0") to the right bumper corner. The impact deformed the full width of the bumper system resulting in a combined direct and induced damage length of 144 cm (56.5"). The crush profile at bumper level **(Figure 7)** was at follows: C1 = 13 cm (4.0"), C2 = 11 cm (2.4"), C3 = 12 cm (3"), C4 = 15 cm (4"), C5 = 15 cm (4"), C6 = 17 cm (5.25"). The CDC for this event was 01-FDEW-1.

Figure 7. Right profile view of the frontal crush.

Air Bag Systems - 2002 Volkswagen Passat

The Volkswagen Passat was equipped with an advanced frontal air bag system that utilized redesigned air bags for the driver and right passenger positions linked with seat belt retractor

pretensioners for the four outboard seated positions. The electronic single point control module was located under the center instrument panel on top of the transmission tunnel. The driver air bag module was housed within the four-spoke steering wheel rim. The front right air bag was a top mount design in the upper right instrument panel. The frontal air bag system and the retractor pretensioners did not deploy in this crash.

The side impact air bag system utilized seat back mounted air bags that provided abdominal/thoracic protection for the driver and front right passenger positions and side curtain air bags that provided head impact protection to the four outboard seated positions **(Figure 8)**. The left side impact air bag and left side curtain air bag deployed as a result of the side impact sequence with the Ford Escort.

Figure 8. Deployed side impact air bag and side curtain.

The driver's seat mounted air bag deployed from the side bolster area of the seat back. Although there were no defined module cover flaps on the outboard aspect of the seat back, the vertical stitching on the forward aspect of the side panel of the seat back separated by the deployment of the air bag. This stitch seam was 55.2 cm (21.75") in length.

Figure 9. Exterior view of the deployed front left side air

Figure 10. Interior view of the front left air bags.

The seat mounted side impact air bag membrane was oval-shaped **(Figure 9)** with a vertical length of 52.1 cm (20.5") and a width of 29.2 cm (11.5") that extended from the inflator to the mid point of the bag. The bag, which extended to the full height of the seat back **(Figure 10)**, was vented by a single port at the forward aspect of the peripheral seam. The peripheral stitching was positioned 1.9 cm (0.75") inboard of the edge of the membrane. A break in the stitching formed a vent port that was located 14.0-17.8 cm (5.5-7.0") above the bottom aspect of the bag. The side impact air bag was not tethered internally. Although the driver probably contacted the side impact air bag during the crash, there was no damage or contact evidence to the bag membrane.

The left side curtain deployed from the head liner/side rail junction and provided head protection to the driver and the rear left passenger positions. A stored gas inflator was located in the upper left C-pillar which provided the inflation gas for the entire side curtain.

The left side curtain air bag extended the full length of the left side rail, extending from the left A-pillar to the left C-pillar. The bottom aspect of the curtain air bag was tethered at both the A- and C-pillars. The overall length of the curtain along the bottom edge was 163.2 cm (64.25"). The curtain, in its deflated state, extended 29.8 cm (11.75") vertically at a point forward of the left B-pillar. The vertical height between the beltline and the roof side rail at this point of the curtain was 36.8 cm (14.5").

Figure 11. Inflated chamber for the driver's head position.

The side curtain was stitched to form a series of chambers. The primary chamber that offered head protection to the driver **(Figure 11)** measured 52.1 cm (20.5") horizontally at the bottom edge and tapered rearward to approximately 15.2 cm (6.0"). The vertical height of the chamber was 29.2 cm (11.5").

Figure 12. Vertical profile of the rear left side curtain.

The side curtain air bag for the left rear occupant position extended vertically downward from the side rail 31.8 cm (12.5") at the rear aspect of the B-pillar to 22.9 cm (9.0") forward of the C-pillar **(Figure 12)**. The vertical height from the of the belt line to the side rail at these points were 36.8 cm (14.5") and 26.7 cm (10.5") respectively. The stitched chamber that provided head protection to a rear seated occupant **(Figure 13)** measured 33.0 cm (13.0") horizontally across the side rail, 21.6 cm (8.5") horizontally at the level of the belt line (bottom of curtain), and 24.1 cm (9.5") vertically.

Figure 13. Inflated rear left side curtain.

During the on-site SCI investigation, a small hole was cut into the membrane of the side curtain air bag and the bag was inflated with an available air supply. Although, the bag could not reach peak inflation pressure due to air loss through the bag fabric and the inflator, all chambers of the bag did inflate to various depths.

The side curtain air bag was identified by the following nomenclature that was printed onto the bottom edge of the membrane: 247201246209 >PA6.6+VMQ<ASCI

Occupant Demographics/Injuries - 2002 Volkswagen Passat

Driver

The driver of the Volkswagen Passat was a 41-year old female. She was seated in a full rear track position with the seat back reclined to a measured angle of 22 degrees aft of vertical. The seat cushion was adjusted to as slope of 15 degrees with the leading edge of the seat cushion positioned (11.75") above the floor of the Passat. In this position, the horizontal distance between the mid point of the driver air bag module and the seat back support was 59.7 cm (23.5"). The driver was restrained by the manual belt system. Due to the lateral crash force and the deployment of the side impact air bags, her loading of the belt system was minimal; therefore there was no loading evidence on the belt system. She initiated a lateral trajectory in response to the 10 o'clock impact force. She engaged the deployed side impact air bag and the curtain air bag which protected her from probable contact against the interior surfaces, thus preventing possible injury.

Rear Left Child Passenger

The rear left passenger of the Volkswagen Passat was a 7-year old male. He was reportedly restrained by the manual 3-point lap and shoulder belt system. At impact, he initiated a lateral trajectory and loaded the left rear door panel, and possibly the left side curtain air bag. There was no side impact air bag available to this occupant's position. The interior of the Passat did not yield contact evidence and the child passenger was not reported as injured in the crash.

Rear Right Child Passenger

The 4-year old male rear right child passenger was positioned in a Century Breverra child safety seat (CSS). At the time of the crash, the CSS was used as a belt positioning booster seat. The child was restrained by the manual 3-point lap and shoulder belt system. He would have initiated a lateral trajectory in response to the 10 o'clock impact force. He loaded the belt system which restrained the child to his seated position. This child was not injured as a result of the crash. The Century Breverra was not with the vehicle at the time of the SCI investigation; therefore the seat was not inspected.

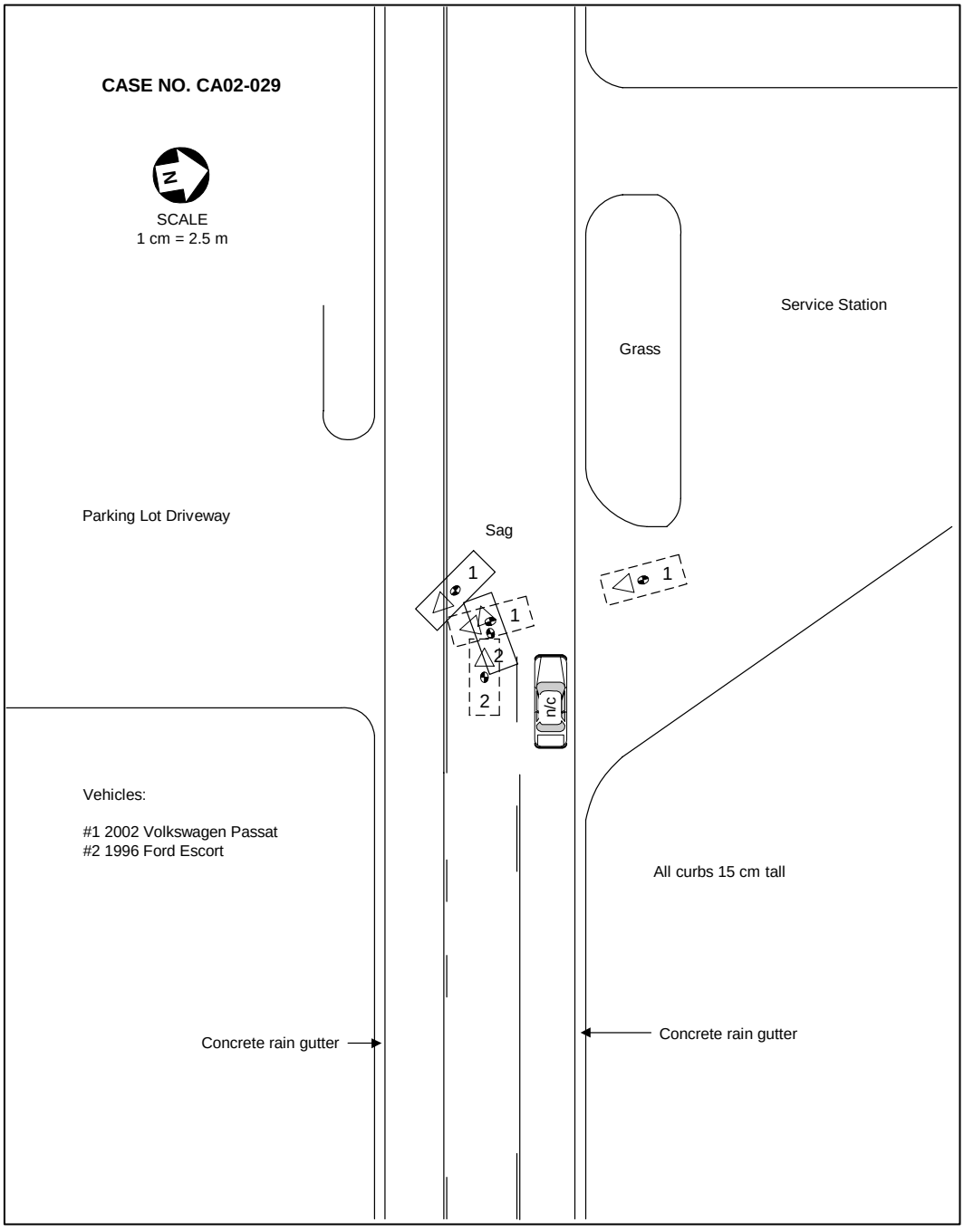

FIGURE 14. CRASH SCHEMATIC.