TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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CALSPAN ON-SITE DRIVER AIR BAG DEPLOYMENT/FATALITY INVESTIGATION

CALSPAN CASE NO. CA98-050

VEHICLE - 1995 FORD ESCORT

LOCATION - CONNECTICUT

CRASH DATE - JUNE, 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 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 of the involved vehicle(s) or their safety systems.

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17. *Abstract*

This investigation focused on the fatal injury mechanisms of a 62 year old female driver of a 1995 Ford Escort. The Ford was equipped with a frontal Supplemental Restraint System (SRS) that consisted of a driver and right front passenger air bags. The air bags deployed as a result of the vehicle's impact with a fence and 41 cm (16 in) tree. The fence was backed up by the tree at the point of impact. The driver sustained multiple blunt trauma of the chest that included multiple anterior rib fractures, fractured sternum and a probable defect of the left ventricle, as a result of her contact with the deploying driver air bag.

Immediately prior to crash, the 1995 Ford Escort entered an automatic car wash. The attendant, at the car wash entrance, reported that the driver acted appropriately and seemed "fine". The driver entered the wash bay and placed the Ford's transmission into neutral. At the car wash exit, the vehicle probably was pushed over an exit ramp by the automated roller system and the driver placed the transmission into gear. The Ford then accelerated straight ahead and struck a wooden stockade fence located approximately 10 m (35 ft) from the car wash exit. The barrier equivalent delta V of the crash was 21.9 km/h (13.6 mph).

The driver of the Ford had a reported height and weight of 155 cm (61 in) and 57 kg (125 lb). Due to the driver's small stature, she was seated in a mid to forward track position. The driver was not properly restrained at the time of the crash.

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BACKGROUND

This investigation focused on the fatal injury mechanisms of a 62 year old female driver of a 1995 Ford Escort. The Ford was equipped with a frontal Supplemental Restraint System (SRS) that consisted of a driver and right front passenger air bags. The air bags deployed as a result of the vehicle's impact with a fence and a 41 cm (16 in) tree. The fence was backed up by the tree at the point of impact. The driver sustained multiple blunt trauma of the chest that included multiple anterior rib fractures, fractured sternum and a probable defect of the left ventricle, as a direct result of her contact with the deploying driver air bag.

The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) was informed of the June, 1998 crash on September 10, 1998 by the investigating police agency. NHTSA in-turn assigned an on-site investigation of the crash to the Special Crash Investigation (SCI) team at Calspan on September 18. Cooperation with the local authorities was immediately established and the on-site investigation took place September 23, 1998. The Ford Escort had been in the police impound since the date of the crash.

SUMMARY

At the time of the crash, it was daylight and the weather was not a factor. The crash occurred on private property, at the exit from an automatic car wash located within the city limits. **Figure 1** is an on-scene police photograph of the car wash exit and crash scene.

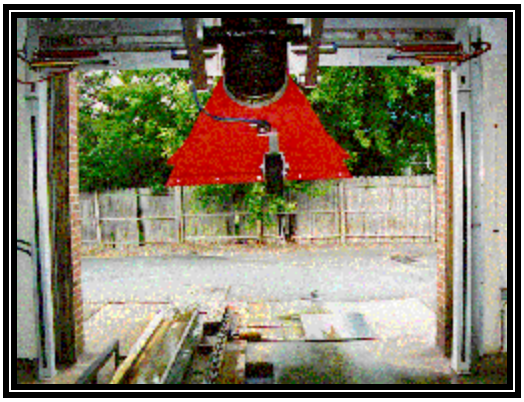

Figure 1: On-scene police photograph of the car wash exit and point of impact.

The typical operation of the car wash was as follows. The left side wheels of the vehicle were directed into a channel and the vehicle's transmission was placed in neutral. A roller, in the channel driven by a timing chain, impinged the vehicle's left rear tire and pushed the vehicle through the bay and timed wash cycle. At the car wash exit, the vehicle's right front tire encountered a 7.6 cm (3.0 in) high ramp (speed bump). The ramp served the purpose of alerting the driver of the exit from the wash bay. The driver must then engage the transmission and drive

away, turning either left or right to leave the premises.

Immediately prior to crash, the 1995 Ford Escort, driven by a 62 year old female, entered the automatic car wash. The attendant, at the car wash entrance, reported that the driver acted appropriately and seemed "fine". The driver entered the wash bay and placed the Ford's transmission into neutral. The automatic wash was started and the attendant lost sight of the Ford at that time. At the car wash exit, the vehicle probably was pushed over the ramp by the automated roller system and the driver placed the transmission into gear. The Ford then accelerated straight ahead and struck a wooden stockade fence located approximately 10 m (35 ft) from the car wash exit. No evidence of pre-impact braking was identified during the investigation.

Figure 2 is a close-up view of the fence at the point of impact. The fence consisted of 2.4 m (8.0 ft) sections of stockade type fencing attached to the back side of 10x10 cm (4x4 in) posts. The Ford's front bumper impacted the left center aspect of the fence section, directly opposite the car wash exit. The right front corner of the vehicle fractured and penetrated the center aspect of the fence section and Ford's bumper then impacted a 41 cm (16 in) diameter tree. The tree was located 25 cm (10 in) beyond the fence and backed up the fence at the impact site (**Figure 3**). The force of the impact with the tree caused the deployment of the Ford's Supplemental Restraint System.

Figure 2: Close-up view of the fence at the point of impact taken during the police investigation.

Figure 3: Close-up view of the base of the tree.

Figures 4 and 5 are the front and right lateral views of the Ford Escort. The vehicle was operational and driven from the impound during the SCI inspection. The Ford sustained 127 cm (50 in) of direct contact damage to the front bumper as a result of the contact with the fence. The damage began 2.5 cm (1.0 in) inboard of the left front bumper corner and extended to the right front bumper corner. The resultant fence damage consisted of scratches and scuffs to the vertical surface of the bumper and probably resulted in minimal residual crush. The Collision Deformation Classification (CDC) of this impact was 12-FDEW-1.

The width of the direct contact damage from the tree impact measured 33.3 cm (13.1 in). The contact damage began 6.6 cm (2.6 in) right of the center and ended 39.9 cm (15.7 in) right of center. The front

bumper's construction consisted of a molded plastic hollow section. The bumper fractured in bending from the tree impact. The bumper's fracture was located 10.9 cm (4.3 in) right of the vehicle's centerline. The maximum residual bumper crush measured 25.9 cm (10.2 in) and was located 14.7 cm (5.8 in) right of centerline. The rearward deformation of the bumper impacted the radiator core. However, the radiator remained intact. The residual crush profile measured across the bumper's 130 cm (51 in) deformed end width was: C1=0 , C2=7.9 cm (3.1 in), C3=15.0 cm (5.9 in), C4=25.4 cm (10.0 in), C5=13.7 cm (5.4 in), C6=3.8 cm (1.5 in). The CDC of the tree impact was 12-FZEN-2. There was no measurable change in the wheelbase dimensions. All the doors remained operational. The windshield was fractured by the right front passenger air bag module cover during the deployment sequence. The side windows and backlight were intact. The barrier equivalent delta V calculated by the Barrier Model of the WINSMASH program was 21.9 km/h (13.6 mph).

Figure 4: Front view of the Ford Escort.

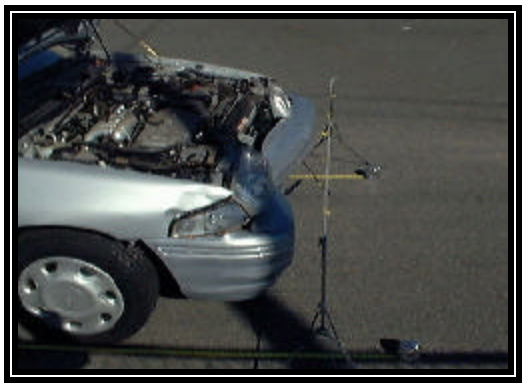

Figure 5: Right lateral view of the Ford.

The driver of the Ford had a reported height and weight of 155 cm (61 in) and 57 kg (125 lb). Due to the driver's small stature, she was probably seated in a mid to forward track position. The Ford Escort was equipped with an automatic shoulder/manual lap restraint system. The driver was not utilizing the automatic shoulder restraint, as evidenced by the vehicle inspection and the driver injury pattern. It was possible the driver was using the lap belt, however that condition would be indeterminate due to the lack of evidence. Therefore, the driver was either not restrained or not properly restrained in the crash. The first responders to the vehicle could not recall any information regarding restraint usage. The lap belt system was intact and fully retracted into the locking retractor during the SCI inspection.

At impact, the driver of the Ford responded to the 12 o'clock direction of the impact force and became positioned within the deployment path of the driver air bag. The driver air bag deployed and contacted the driver's chest. The driver sustained multiple anterior rib and sternum fractures and a (probable) ventricular defect as a direct result of contact with the deploying air bag.

Medical personnel and the ambulance responded to the crash and were on-scene within 5 minutes of the reported time of the crash. The medics indicated the driver was unresponsive with a Glasgow Coma

Score of 5. She was tachypneic and a blood pressure could not be obtained. It was noted that the driver was flexing inappropriately. Her on-scene blood glucose level measured approximately 30-40 mg/dl. The driver may have gone into diabetic shock, which would have been the probable cause of her loss of vehicular control. Normal blood glucose levels range from 65-130 mg/dl. The driver was not a known diabetic, according to the medical records obtained during the course of the police investigation.

The driver was removed from the vehicle, loaded into the ambulance and transported from the scene 19 minutes post-crash. She arrived at the Emergency Room of a local hospital 26 minutes post-crash. Medical intervention to stabilize and revive the driver was unsuccessful and she was pronounced dead in the ER 78 minutes post-crash.

AIR BAG VEHICLE

The 1995 Ford Escort was identified by the Vehicle Identification Number (VIN): 1FASP14J8SW (production sequence deleted). The date of manufacture was 7/95. The vehicle was equipped with a 1.9 liter, I-4 engine linked to an automatic transmission. The shifter was floor mounted and housed in the center console. The braking system in the vehicle was a conventional front disc/rear drum hydraulic system, not an anti-lock braking system. The odometer read 34,043 km (21,154 miles) at the time of the inspection.

INTERIOR CONFIGURATION AND DAMAGE

The only damage to the vehicle's interior were those directly associated to occupant contact and the deployment of the Supplemental Restraint System. There was no interior damage associated to the external forces of the crash.

The steering assembly was configured with a four spoke, fixed steering wheel. **Figures 6 and 7** are the right and left lateral views of the damaged steering assembly, respectively. Inspection of the assembly revealed evidence that the occupant loaded the steering column through the deploying air bag during the crash sequence. The upper aspect of the steering wheel rim between the 10 and 2 o'clock sector was deformed forward approximately 1.2 cm (0.5 in). There was an estimated 3-6 mm (1/8-1/4 in) of residual displacement at the steering column's shear plate. The trim panels surrounding the column, forward of the steering wheel, were deformed

Figure 6: Right lateral view of the deformed steering wheel and column.

Figure 7: Left lateral view of the deformed steering wheel and column.

and displaced due to the compression of the column. The turn signal and wiper control stalks were also fractured. Additionally, it was noted that the rotation of the steering wheel was partially restricted (binding) due to the residual displacement of the steering column's components.

The vehicle's interior was cloth and gray in color. The front bucket seats were covered by after-market red seat covers. The at-crash track position of the left front seat was not documented and the track position had been altered prior to SCI inspection. The seat was found in the full rear position. Given the driver's short stature, it was probably adjusted in a mid to forward track position at the time of the crash.

On the left aspect of the right seat cushion was a 10 cm by 8 cm (4 in by 3 in) vomit stain. The location of the stain was a probable indicator of the final rest position of the driver's head. There was no other contact evidence identified within the vehicle.

MANUAL/AUTOMATIC RESTRAINT SYSTEM

The 1995 Ford Escort was equipped with a front 4-point restraint system that consisted of automatic motorized shoulder belts and manual lap belts. The retractors for the shoulder restraints were attached to the center console. When in use, the shoulder belt webbing extended from the retractor and latched to the motorized mouse located in the track incorporated into the upper aspect of the side rails and pillars. When the door was opened, the mouse translated forward to allow the ingress/egress of the driver. By design, the shoulder belt did not need to be unlatched during normal use. The lap belt webbing extended from the retractor located in the base of the B-pillar and latched to the inboard buckle anchored to the floor at the center console.

All the belts of the left front and right front restraints were found in the stowed position at inspection. The first responders to the crash had no recollection of restraint usage. The motorized mice of the automatic shoulder restraints were operational. There was no evidence on the webbing or hardware surfaces of the left front restraint that indicated seat belt usage. The driver's injuries and kinematic pattern indicate her torso was unrestrained. The use of the lap belt was unknown.

SUPPLEMENTAL RESTRAINT SYSTEM

The 1995 Ford Escort was equipped with a frontal Supplemental Restraint System (SRS) that consisted of driver and right front passenger air bags that deployed as a result of the crash. The control module of the SRS was located within the occupant compartment. There were two forward crash sensors mounted to the upper radiator support. The sensors were symmetrically mounted 21.0 cm (8.3 in) left and right of the vehicle centerline, respectively. The right sensor was in the zone of direct contact with the tree.

The driver air bag module was designed in the typical manner in the center hub of the steering wheel. The H-configuration module cover flaps opened as designed during the deployment sequence. The width of the cover flap's center seam measured 17.8 cm (7.0 in). The height of the upper and lower flaps measured 10.9 cm (4.3 in) and 6.4 cm (2.5 in) respectively. There was no contact evidence on the

exterior surfaces of the flaps. The driver air bag diameter measured 64 cm (25 in) in its deflated state. It was tethered by four 2.5 cm (1.0 in) wide straps sewn to the internal face of the bag. The bag was vented by two 3.5 cm (1.4 in) diameter ports located in the 11/1 o'clock positions on the back side of the bag.

Figure 8 is a view of the driver air bag. Dispersed over the 9 to 12 o'clock sector on the face of the air bag was a dark/black transfer to the bag's fabric. The transfer probably developed as a result of contact with the driver's clothing during the deployment and expansion of the air bag. Upon inspection, all four quadrants of the back side of the air bag exhibited signs of an impeded deployment. Black transfers, resultant to frictional contact with the interior surfaces of the cover flaps, were dispersed over the back surface of the bag. The transfers were heavier in the 9/12 sector consistent with the contact evidence on the face of the air bag. In the 6 o'clock sector on the perimeter of the air bag was a 13 cm (5 in) smear of blood and body fluid.

Figure 8: View of the driver air bag.

The right front passenger air bag deployed from a mid-mount module designed in the right aspect of the instrument panel. The module cover measured 38 cm by 18 cm (15 in by 7 in), width by height. The module cover fractured the right side of the windshield during the deployment sequence. The face of the passenger air bag measured 38 cm by 30 cm (15 in by 12 in) width by height and extended 66 cm (26 in) from the aft edge of the module, in its deflated state. The bag was not tethered and was vented by two 5.7 cm (2.3 in) diameter ports located on the side panels of the bag. The inboard side panel of the passenger air bag was spattered with blood droplets. On the bottom surface of the air bag was a 8.9 cm (3.5 in) blood smear. The smear was located in the center aspect of the bag, 8.9 cm (3.5 in) forward of the face. These blood transfers probably were deposited as the driver was in rebound to final rest or as a result of medical intervention during driver extrication. The transfers were not a result of direct driver contact to the passenger air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	62 year old/female
Height:	155 cm (61 in)
Weight:	57 kg (125 lb)
Restraint Usage:	Unrestrained/not properly restrained (shoulder belt not used, lap belt use unknown)
Usage Source:	Vehicle inspection
Eyewear:	Unknown

DRIVER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Multiple anterior rib fractures w/ hemothoracies	Serious (450222.3,9)	Deploying driver air bag
1.5 cm (0.6 in) unspecified defect of the left ventricle	Serious (441099.3,4)	Deploying driver air bag (probable)
Sternum fracture	Moderate (450804.2,4)	Deploying driver air bag
9 x 3 cm (3.5 x 1.2 in) abrasion of the supra-clavicular region in the midline	Minor (790202.1,4)	Deploying driver air bag
Minor facial bleeding	Minor (290099.1,9)	Deploying driver air bag

NOTE: the above injuries were identified in the driver's Autopsy, Emergency Room and EMS records.

DRIVER KINEMATICS

The driver was seated in a probable forward to mid track position due to her short stature. She was not restrained by the automatic shoulder restraint. It was unknown if she was lap belted. The driver was possibly in diabetic shock. Her medical records indicated that she was not a known diabetic. However post-crash, the driver's blood glucose level reportedly measured 30-40 mg/dl. Normal blood glucose levels range from 65-130 mg/dl.

Upon impact with the fence, the driver initiated a forward trajectory in response to the 12 o'clock direction of the impact force. The driver's initial forward position coupled with her forward kinematic pattern positioned the driver in-close proximity to the driver air bag module at the time of deployment. The Ford's SRS deployed upon impact with the tree. The deploying driver air bag contacted the driver in the chest causing the multiple anterior rib and sternal fractures and a probable ventricular defect. The driver's forward position impeded the normal deployment path of the bag evidenced by the dark/black fabric transfers to the face of the bag and friction induced black transfers to the back side of the air bag. The driver's forward kinematic pattern loaded the steering column through the deploying air bag evidenced by the displaced column, deformed trim panels and bent steering wheel rim. The air bag expanded across the driver's chest causing the abrasion to the left upper arm and minor facial trauma. The driver then rebounded to her seat and slumped over to the right evidenced by the vomit stained right seat cushion.