TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 MERCURY SABLE INVESTIGATION

VERIDIAN CASE NO. 2000-11-075E

LOCATION - MICHIGAN

CRASH DATE - JUNE 2000

Contract No. DTNH22-94-07058

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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 on-site investigation focused on the performance of the redesigned occupant protection system in the 2000 Mercury Sable. The occupant protection system was a total redesign from earlier model years. The protection system consisted of an integrated use of 3-point lap and shoulder belts, pre-tensioners, seat position sensing and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependant on restraint use and seat position. The subject vehicle was also equipped with side air bags. The 2000 Mercury Sable was the striking vehicle in a front-to-rear crash that involved a stopped 1986 Lincoln Continental. The 34 year old male driver of the Mercury was restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt. The left restraint's buckle pretensioner fired as a result of the impact. The Mercury's air bags did not deploy. Reportedly, the driver had a complaint of pain, but was not visibly injured. He was transported to a medical facility for examination and was released. He was diagnosed with cervical strain and had a seat belt related contusion of the left shoulder.

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ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
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2000 MERCURY SABLE
LOCATION: MICHIGAN
CRASH DATE: JUNE, 2000

BACKGROUND

This on-site investigation focused on the performance of the redesigned occupant protection system in the 2000 Mercury Sable. The occupant protection system was a total redesign from earlier model years. The protection system consisted of an integrated use of 3-point lap and shoulder belts, pre-tensioners, seat position sensing and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependant on restraint use and seat position. The subject vehicle was also equipped with side air bags. The 2000 Mercury Sable was the striking vehicle in a front-to-rear crash that involved a stopped 1986 Lincoln Continental. The 34 year old male driver of the Mercury was restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt. The left restraint's buckle pretensioner fired as a result of the impact. The Mercury's air bags did not deploy. Reportedly, the Mercury driver had a complaint of pain, but was not visibly injured. He was transported to a medical facility for examination and was released. He was diagnosed with cervical strain and had a seat belt related contusion of the left shoulder.

This crash was identified by NASS PSU 11 and was subsequently selected for investigation within the NASS system. This crash report was forwarded to Zone Center 1 and the Special Crash Investigations team at Veridian Engineering. The Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash and subsequently assigned a joint investigation of the subject crash. The SCI team was assigned the specific task of inspecting the Mercury Sable and downloading the vehicle's Restraint Control Module, as part of the Advanced Occupant Protection System Study.

SUMMARY

Crash Site

This two-vehicle crash occurred in the early morning hours of June, 2000. It was dawn at the time of the crash and the weather was not a factor. The road surface was dry. At the scene, the primary roadway was a three lane divided highway, east/west in direction. The terrain of the center median consisted of grass and wooded. It was an estimated 23 m (60 ft) wide. The speed limit in the area of the crash was 89 km/h (55 mph). **Figure 1** is an eastbound view of

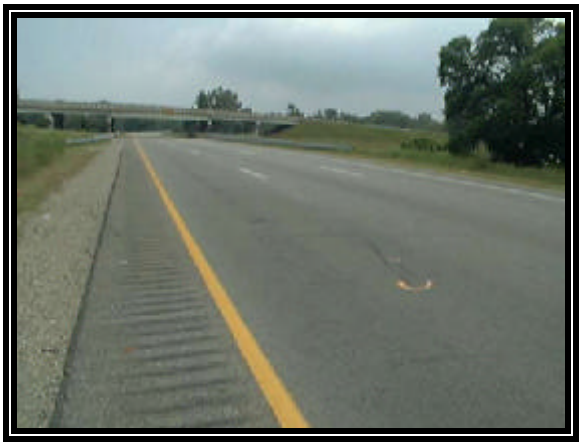

Figure 1: Eastbound trajectory at the point of impact.

the crash scene.

Pre-Crash

The 1986 Lincoln Continental was stopped in the inboard eastbound lane of the roadway. The vehicle had been abandoned for unknown reasons prior to the crash and was not occupied. The driver of the Lincoln was not identified. The 2000 Mercury Sable was eastbound driven by a 34 year old restrained male. The driver of the Mercury recognized the abandoned Lincoln late in the pre-crash sequence and swerved to the right. However, the steering maneuver came too late to avoid contact.

Crash

The front left corner of the Mercury struck the rear right corner of the Lincoln in an offset front-to-rear impact configuration. The point of impact was identified by two gouge marks attributed to the left front suspension of the Mercury (refer to Figure 1). The force of the impact displaced the Lincoln forward and to the left into the median. The steering maneuver altered the trajectory of the Mercury to the northeast. The impact force caused it to begin rotating counterclockwise. The vehicle slid across the eastbound traffic lanes and came to rest facing westward on the outboard road shoulder. **Figure 2** is a schematic of the crash scene. The force of the impact fired the pretensioner in the driver's buckle assembly. It did not deploy the front or side air bags of the Mercury.

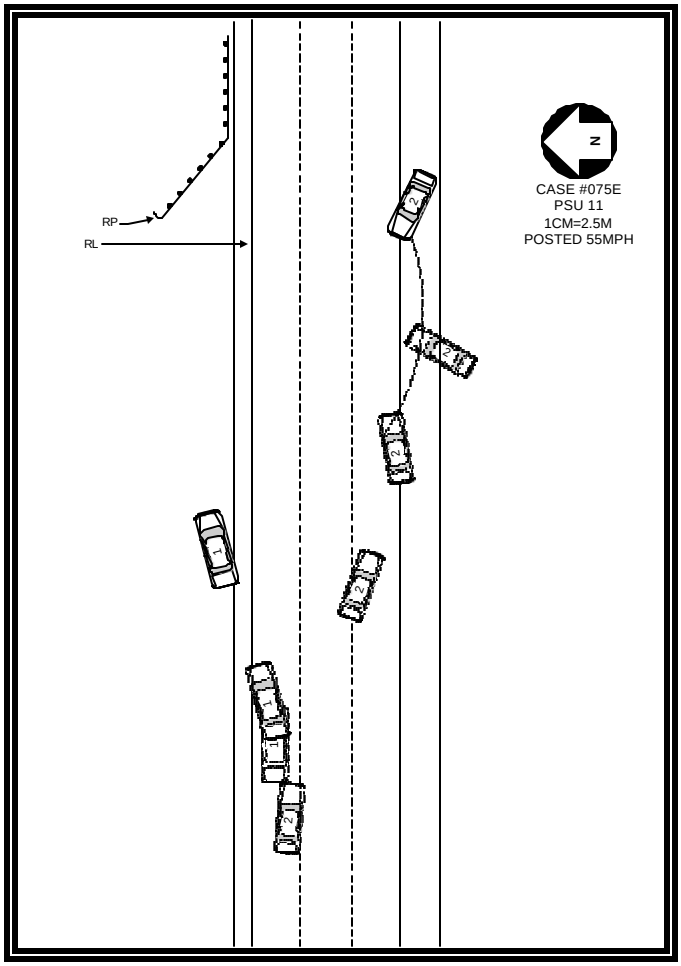

Figure 2: Crash scene schematic.

Post-Crash

The police and ambulance personnel responded to the scene of the crash. The driver of the Mercury had exited the vehicle under his own power and was found sitting on the road side. His chief complaint was a contusion to his left shoulder consistent with seat belt usage and upper back and neck pain. He was transported to a local hospital for examination and released. He was diagnosed with a cervical strain (AIS 1). Both vehicles were towed from the scene due to disabling damage.

2000 MERCURY SABLE

The 2000 Mercury Sable was identified by the Vehicle Identification Number (VIN): 1MEFM55S3YG

(production sequence deleted). The 4-door sedan's power train consisted of a 3.0 liter/V-6 engine linked to a 4-speed automatic transmission. The transmission gear selector was mounted in the center console. The leather trimmed interior was equipped with a power package that included power steering, brakes windows, door locks, and mirrors. The vehicle had adjustable foot controls and a 6-way power driver seat. Side impact air bags were located in the outboard aspect of the respective front seat backs. The vehicle was manufactured in December 1999. The odometer read 30,684 km (19,066 miles) upon inspection.

Exterior Damage

Figure 3 is a left front view of the Mercury. The vehicle's front plane sustained 28 cm (11 in) of direct contact damage that began 48 cm (19 in) left of center and extended to the left corner of the front bumper. The direct contact was confined to the left front aspect of the vehicle immediately outside the left uni-body frame rail and extended longitudinally into the left front suspension area. The left side damage extended rearward onto the left front door panel 264 cm (104 in) from the front of the vehicle. The crush profile measured at the bumper elevation was as follows: C1=38 cm (15 in), C2=2 cm (1 in), C3=0, C4=0, C5=0, C6=0. The left wheelbase was foreshortened 11.4 cm (4.5 in). The windshield was fractured and the left front glazing had disintegrated. The left front door was jammed shut by deformation. The remaining doors were operational. The Collision Deformation Classification (CDC) was 12-FLEE-6. The principle direction of the force was estimated to be 350 degrees. The total delta V calculated by the Damage Only algorithm of the WINSMASH model was 21.4 km/h (13.3 mph). The longitudinal and lateral components of the delta V were -21.1 km/h (-13.1 mph) and 3.7 km/h (2.3 mph) respectively. It should be noted the calculated delta V was slightly less than the values reported in the NASS file. The SCI revised calculation utilized a crash test based stiffness coefficient rather than the default stiffness values used by NASS.

Figure 3: Left front view of the Mercury's damage.

Occupant Protection System

The occupant protection system in the 2000 Mercury Sable, designated by the manufacturer as the Personal Protection System (PPS), was a total redesign from earlier model years. The protection system consisted of the integrated use of manual 3-point lap and shoulder belts, pre-tensioners, seat position sensing and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependant on restraint use and seat position. The Sable was also equipped with side impact air bags located in the outboard aspect of the front seat backs. The side impact air bags were designed to provide head and thorax protection. The Restraint Control Module (RCM) located on the vehicle's centerline, under the instrument panel, monitored and controlled the deployment of the vehicle's safety systems. The RCM was capable of recording data related to the crash

event.

The crash event data stored in the RCM was downloaded in the field during the SCI inspection. This data was then sent to the Safety Office of the Ford Motor Company for analysis. The results of the Ford's internal analysis of the data indicated the data file recorded by the RCM was not valid. The following statement regarding the crash data was received from the Safety Office:

> *"The crash events for the SCI investigation of case 2000-11-075 were not recorded by the Restraints Control Module. Therefore, no information about the crash pulse, or other conditions is available."*

Figure4 is a view of the driver's interior. The 6-way power driver's seat was adjusted to the full-rear track position. This was the at-crash position of the seat due to crash damage to the vehicle's electrical system. There was approximately 2 cm (1 in) of intrusion of the left kick panel into the driver's foot well due to the exterior crash force. The Mercury was equipped with adjustable foot controls. The pedals were in the full-forward position with respect to the vehicle, **Figure 5**.

Figure 4: View of the driver's position.

Figure 5: View of the adjustable pedals.

A scuff on the driver's knee bolster attributed to the left lower extremity was identified. The scuff measured 8 cm x1 cm (3 in x 0.5 in) laterally by vertically. It began 11.4 cm (4.5 in) left of the steering wheel centerline and extended to the left outboard edge of the bolster panel. It was located approximately 43 cm (17 in) above the floor. This contact did not produce an injury.

The tilt steering wheel was adjusted to a position between center and full-up. There was no steering wheel rim deformation. There was approximately 31 mm (0.12 in) movement of the left shear capsule. The right shear was not displaced. The steering column's lower support bracket was slightly bent on the outboard

side. The lower coupling was intact. Refer to **Figure 6**.

The vehicle was equipped with 3-point lap and shoulder belt systems in the front outboard seat positions. The front seat belt systems consisted of a continuous loop lap and shoulder belt webbing with a sliding latch plate. The vehicle sensitive/energy management retractors were located in the base of the B-pillars. The left latch plate exhibited marks consistent with belt use and the vehicle's age. There was no direct evidence of occupant loading to the left restraint webbing. The front restraints were also equipped with buckle mounted pretensioners. The driver's pretensioner fired as a result of the crash, **Figure 7**. The post-crash measurement of the pretensioner's barrel was 60.4 mm (2.38 in). The right buckle pretensioner did not fire.

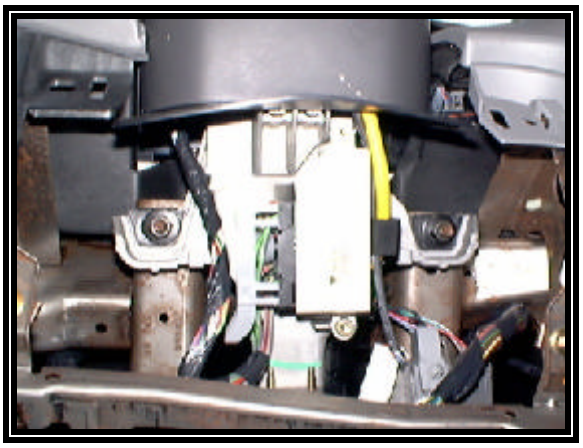

Figure 6: View of the steering column's shear capsules.

Figure 7: View of the left buckle from above.

The driver air bag was located in the typical configuration in the center hub of the steering wheel. The front right air bag was a top-mount design located in the right aspect of the instrument panel. The side impact head/thorax air bags were located in the outboard aspect of the front seat backs. The severity of the crash did not warrant the deployment of the air bag systems.

1986 LINCOLN CONTINENTAL

The 1986 Lincoln Continental was identified by a Vehicle Identification Number (VIN): 1LNBP96F6GY (production sequence deleted). The 4-door, rear-wheel drive sedan was equipped with a 5.0 liter/V-8 engine linked to a 3-speed automatic transmission. The odometer read 299,137 km (185,880 miles) at inspection. The vehicle had been abandoned on the roadway, for unknown reasons, at some point prior to the crash. It was not occupied in the crash.

Figure 8: Right rear view of the Lincoln.

The back plane of the Lincoln sustained 41 cm (16 in) of direct contact damage that began 44 cm (17 in) right of center and extended to the right corner of the rear bumper. Refer to **Figure 8**. The crush profile measured at the rear bumper elevation was as follows: C1=0, C2=0, C3=12 cm (4.7 in), C4=31 cm (12.2 in), C5=46 cm (18.1 in), C6=63 cm (24.8 in). The crash damage collapsed the trunk and buckled the right rear quarter-panel. The right wheelbase was foreshortened 8 cm (3 in). The Collision Deformation Classification was 06-BREE-03. The Lincoln's delta V calculated by the Damage Only algorithm of the WINSMASH model 17.7 km/h (11.7 mph). The SCI revised calculated delta V differed slightly from the values reported in the NASS file.

DRIVER DEMOGRAPHICS

Age/Sex:	34 year old/ Male
Height:	178 cm (70 in)
Weight:	79 kg (175 lb)
Restraint Use:	Restrained
Usage Source:	SCI inspection, Occupant Kinematics, RCM
Medical treatment:	Transported, examined and released

DRIVER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Cervical Strain	Minor (640278.1,6)	Hyper-flexion of the head/neck due to inertial contact w/ the seat belt
Left shoulder contusion	Minor (790402.1,2)	Inertial contact w/ seat belt

DRIVER KINEMATICS

The 34 year old male driver was the sole occupant of the Sable. He was restrained by the vehicle's 3-point lap and shoulder belt and seated with a normal posture. The driver's seat was adjusted to the full rear position. The driver recalled seeing the Lincoln, however he misjudged that it was not moving. He applied clockwise steering too late to avoid the impact.

At impact, the driver responded to the 12 o'clock direction of the impact force by initiating a forward trajectory. This forward translation combined with the right steering maneuver would displace the driver somewhat to the 11 o'clock direction. The force of the impact caused the left buckle pretensioner fire. The downward movement of the buckle removed the belt slack in the lap restraint and placed the shoulder

webbing in tension. The driver's chest contacted and loaded the shoulder belt causing the left shoulder contusion. With the chest restrained, the head/neck complex continued forward and flexed over the belt. The inertia of the head/neck was then restrained by the anatomic structures of the neck, causing the cervical strain.

The driver's left lower extremity contacted and scuffed the left aspect of the bolster. The driver probably loaded the steering wheel rim through his arms causing the small displacement of the left shear capsule and bent the lower mounting bracket. The driver then rebounded back into his seat coming to rest.