

**TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER**

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**ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 FORD TAURUS INVESTIGATION**

VERIDIAN CASE NO. CA00-041

LOCATION - MICHIGAN

CRASH DATE - SEPTEMBER 2000

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Prepared for:

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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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<p>16. <i>Supplementary Notes:</i> On-site investigation of a 2000 Ford Taurus equipped with an Advanced Occupant Protection System.</p>			
<p>17. <i>Abstract</i></p> <p>This on-site investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in the 2000 Ford Taurus. The AOPS consisted of the integrated use of 3-point lap and shoulder belts with load limiter retractors, seat belt buckle pre-tensioners, seat position sensing and dual-stage frontal air bags. The driver and front right passenger air bags were designed to deploy at different thresholds based on crash severity, restraint use, and seat position. The subject 2000 Ford Taurus was involved in a roadside departure and an offset frontal impact with a tree. The frontal air bags in the Ford Taurus deployed as a result of the crash. The 48 year old male driver of the Ford was unrestrained at the time of the crash by the vehicle's 3-point lap and shoulder belt. He suffered a police reported incapacitating injury and was transported to a local hospital. The driver refused to participate in the study therefore his injury data is unknown.</p> <p>This crash was identified during a concurrent SCI investigation conducted at a vehicle storage facility in Michigan on October 5, 2000. The Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash by the Veridian SCI team and was subsequently assigned the task of inspecting the subject vehicle as part of the Advanced Occupant Protection System Study. The crash data stored in the Restraint Control Module was downloaded and is a supplement to this crash investigation.</p>			
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**ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 FORD TAURUS INVESTIGATION**

**VERIDIAN CASE NO: CA00-041
LOCATION: MICHIGAN
CRASH DATE: SEPTEMBER, 2000**

BACKGROUND

This on-site investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in the 2000 Ford Taurus. The AOPS consisted of the integrated use of 3-point lap and shoulder belts with load limiter retractors, seat belt buckle pre-tensioners, seat position sensing and dual-stage frontal air bags. The driver and front right passenger air bags were designed to deploy at different thresholds based on crash severity, restraint use, and seat position. The subject 2000 Ford Taurus was involved in a roadside departure and an offset frontal impact with a tree. The frontal air bags in the Ford Taurus deployed as a result of the crash. The 48 year old male driver of the Ford was unrestrained at the time of the crash by the vehicle's 3-point lap and shoulder belt. He suffered a police reported incapacitating injury and was transported to a local hospital. The driver refused to participate in the study therefore his injury data is unknown.

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SUMMARY

Crash Site

This single-vehicle crash occurred during the nighttime hours of September, 2000 in a rural area of Michigan. It was dark at the time of the crash and the area was not illuminated by street lights. At the crash scene, the primary roadway was an east/west two-lane state route. A ditch and tree line bordered the south side of the road. It was raining and the newly paved asphalt road surface was wet. The speed limit in the area of the crash was 89 km/h (55 mph). An inspection of the crash scene was not conducted due to the delayed crash notification.

Pre-crash

The 2000 Ford Taurus was westbound driven by a 48 year old unrestrained male. The driver failed to maintain directional control and allowed the vehicle to drift to the right. The driver applied counterclockwise steering to correct his trajectory, however in doing so, he overcorrected. The rear tires

of the vehicle lost traction on the wet surface and it began to yaw counterclockwise. The vehicle crossed the centerline, traveled through the eastbound lane and off the left side of the road. The Taurus traversed a ditch bordering the roadside during its off-road trajectory. On-scene photographs taken by the investigating officer documented four tire marks leaving the roadway. The degree of yaw was an estimated 10 to 15 degrees.

Crash

The crash occurred with the right aspect of the front bumper impacting a 61 cm (24 in) diameter tree, **Figure 1**. The Principle Direction of Force was in the 1 o'clock sector. The tree was located approximately 6 m (20 ft) off the road. The total velocity change calculated by the WINSMASH model was approximately 39.1 km/h (24.2 mph). The longitudinal and lateral delta V components were -33.9 km/h (-21.1 mph) and -19.6 km/h(-12.2 mph), respectively. The force of the impact caused the deployment of the vehicle's frontal air bag system. The Taurus rotated counterclockwise upon disengagement from the tree and came to rest facing westward.



Figure 1: On-scene police photograph of the point of impact.

Post-crash

Police and EMS services responded to the crash scene. The Ford Taurus sustained disabling damage and had to be towed. The driver was found unrestrained, lying to the right with his head in the front passenger foot well. The police investigation determined he was alcohol impaired with a Blood Alcohol Content of 0.22. The police officer indicated the driver was mumbling and incoherent upon his arrival. He was transported to local hospital for examination. The officer indicated his incapacitation was related more to his physiological state than any crash related trauma.

2000 FORD TAURUS

The 2000 Ford Taurus, **Figure 2**, was identified by the Vehicle Identification Number (VIN): 1FAFP55U3YG (production sequence deleted). The vehicle's power train consisted of a 3.0 liter, V-6 engine linked to a 4-speed automatic overdrive transmission. The vehicle had 4-wheel disc brakes. It was not ABS equipped. The cloth trimmed interior was equipped with a power package that included power steering, brakes, windows, door locks, and mirrors. The 4-door sedan was manufactured in



Figure 2: Front view of the Taurus.

November 1999. The odometer read 29,326 km (18,223 miles) at the time of the inspection. The vehicle was owned by an automobile rental agency and was being rented by the driver at the time of the crash.

Exterior Damage

Figures 3 and 4 are the right front and right side views of the damaged Taurus. The vehicle sustained 14.0 cm (5.5 in) of direct contact damage to the frontal plane that began 67.3 cm (26.5 in) right of center and extended to the right front corner. The direct contact deflected the outboard end of the bumper reinforcement (bumper beam) rearward. The damage pattern extended rearward along the uni-body frame rail into the structural members of the right front suspension. The maximum penetration of the tree measured approximately 72 cm (28 in). The lateral dimension of the damage measured 25 cm (10 in) at the center of the right front wheel opening. The right aspect of the roof was buckled above the right front door opening. The right wheelbase was foreshortened 23 cm (9 in). The right front wheel was in direct engagement with the tree. The windshield was fractured by the exterior crash forces. All the doors remained operational. The side windows and backlight remained intact. The Collision Deformation Classification was 01-FREE-5.



Figure 3: Right front view of the Taurus.



Figure 4: Right side view of the Taurus.

Analysis of the crash utilized the Barrier Algorithm of the WINSMASH model. An adjusted crush profile was developed due to the narrow width of damage and is listed in the table below:

Location of Crush Profile	Crush Profile
Field L = 25 cm (10 in)	C1 = 72 cm (28 in)
Damage Offset = 66 cm (26 in)	C2 = 72 cm (28 in)
Field L Offset (D) = 66 cm (26 in)	C3 = 72 cm (28 in)
	C4 = 72 cm (28 in)

A total velocity change of 39.1 km/h (24.2 mph) was calculated for the impact. The longitudinal and lateral

delta V components were -33.9 km/h (-21.1 mph) and -19.6 km/h(-12.2 mph), respectively. While the nature of the corner impact and the resultant narrow damage pattern are not well supported due to the limitations of the model, the results of the analysis seemed reasonable based on SCI experience.

Advanced Occupant Protection System

The Advanced Occupant Protection System in the 2000 Ford Taurus, designated by the manufacturer as the Personal Protection System (PPS), was a total redesign from earlier model years. The AOPS consisted of the integrated use of manual 3-point lap and shoulder belts with load limiting retractors, buckle pre-tensioners, driver 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 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 data was downloaded in the field during the SCI inspection. This data was then electronically forwarded to the Safety Office of the Ford Motor Company for analysis. The results of the downloaded data are included as **Attachment A** at the end of this report.

The data indicated the front belt systems were not buckled at the time of the crash and the buckle pre-tensioners did not fire. The driver seat was not adjusted to a forward position and a stage 1 frontal air bag deployments were commanded to fire 25 milliseconds into the crash. (The second stage of the dual-stage system was disposed of approximately 100 milliseconds after the stage 1 deployment.) The RCM sensed and recorded the crash acceleration pulse for a duration of 78 milliseconds. The 78 millisecond longitudinal delta V recorded by the RCM was approximately -31.5 km/h (-19.7 mph). The 78 millisecond lateral delta V was approximately -21.6 km/h (-13.4 mph). Analysis of the acceleration pulse and velocity curves indicated the majority of the crash event was captured by the recording. The velocity curves had begun to plateau. There was reasonable agreement between the WINSMASH analysis and the crash event data.

Inspection of the vehicle's interior identified intrusion consistent with the exterior forces of the crash and damages consistent with the deployment of the frontal air bag system. The force of the crash displaced the right front suspension components rearward into the right aspect of the cowl. This deformation caused the right corner of the instrument panel to intrude rearward approximately 3.8 cm (1.5 in). The rearward displacement buckled the right aspect of the mid-panel immediately below the front passenger air bag module, **Figure 5**. The right side of the front passenger's toe pan was buckled approximately 5 cm (2 in) at its outboard edge. Inspection of the vehicle's interior did not identify any specific occupant contact points.



Figure 5: View of the deformed mid panel below the passenger air bag module.

The driver seat was adjusted to a rear track position and measured 7.1 cm (2.8 in) forward of full rear. The total seat track travel measured 24.9 cm (9.8 in). The 4-spoke adjustable steering wheel rim was adjusted to the center position. There was no rim deformation. Inspection of the steering column shear capsules, **Figure 6**, identified 13 mm (0.5 in) of separation on the inboard (right) side. There was no separation of the outboard (left) capsule. The inboard side of the bend bracket supporting the mid-aspect of the steering column was deformed. The shear coupling on the lower aspect of the column was intact.

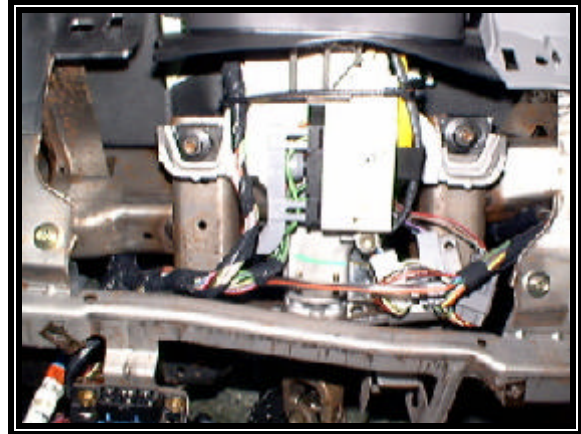


Figure 6: View of the shear capsules.

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/load limiting retractors were located in the base of the B-pillars. The front restraints were also equipped with buckle mounted pre-tensioners. The restraint's D-rings were adjustable. The rear seat was equipped with 3-point lap and shoulder restraints for all three seat positions.

Upon inspection, the driver's restraint webbing was stowed in the retractor and operational. The left front D-ring was adjusted to the full up position. Examination of the webbing and latch plate hardware revealed evidence of use historical. This was not an indicator of the driver's habitual restraint use, however, because the vehicle was a rental car. There was no evidence on the hardware or the webbing indicative of use during the crash. The driver's buckle pre-tensioner had not fired. The post-crash measurement of the pre-tensioner's piston barrel was 110 mm (4.3 in). Inspection of the driver's belt system determined the driver was not restrained at the time of the crash. This determination was consistent with the police investigation.

The driver air bag module was designed in the typical manner in the center of the steering wheel. The driver air bag had deployed from the H-configuration module cover flaps. The cover flaps opened along the designated tear seams. The height of the upper and lower flaps measured 6.4 cm (2.5 in) and 4.6 cm (1.8 in), respectively. The width of the flaps measured 17.2 cm (6.8 in). The deployed driver air bag measured 53 cm (21 in) in diameter. It was tethered by four straps sewn to the face of the bag. The bag was vented by two 2.9 cm (1.1 in) ports located in the 10/2 o'clock position of the back side of the bag. There was no evidence of occupant contact to the air bag.

The front right passenger air bag module was a top mount design located in the right aspect of the instrument panel. The air bag had deployed as designed from the module. The face of the deployed passenger bag measured 58.4 cm x 39.4 cm (23.0 in x 15.5 in), width by height, and extended 46 cm (18 in) from the aft edge of the module. Inspection of the passenger air bag was unremarkable.

DRIVER DEMOGRAPHICS

Age/Sex:	48 year old/Male
Height:	175 cm (69 in), police estimate
Weight:	111 kg (245 lb), police estimate
Restraint Use:	Unrestrained
Usage Source:	SCI inspection, Occupant Kinematics, RCM
Physiological Condition:	Impaired (BAC=0.22)
Medical treatment:	Treated and released

DRIVER INJURIES

The driver was uncooperative and refused participation in the study. The insurance company holding the automobile policy was contacted in order to gather further details regarding the driver and the crash. The representative handling the claim indicated the driver had no recollection of the crash. She had contacted him post-crash and the driver stated to her, he either, “did not know” or “did not remember”. He was not filing a medical claim, indicating his injuries, if any, were minor in nature. The police report did code an incapacitating injury for the driver. However, the investigating police officer felt his incapacitation was more related to his alcohol impaired state, rather than any crash related trauma.

DRIVER KINEMATICS

Immediately prior to the crash, the impaired driver relinquished directional of the Taurus and the vehicle drifted off the right side of the road. The driver overcorrected the vehicle’s errant trajectory by steering to the left. The vehicle traveled off the left side of the road while yawing counterclockwise. During this protracted trajectory, the driver moved out-of-position to his right.

Upon impact with the tree, the frontal air bag system in the vehicle deployed. The unrestrained out-of-position driver responded to the 1 o’clock direction of force by initiating a forward and right trajectory. The driver contacted the right aspect of the deployed driver air bag with his chest and loaded the steer column through the deployed air bag. This kinematic pattern was evidenced by the displacement of the inboard (right) shear capsule and the deformation of the bend bracket. The driver then slid off the right side of the bag and fell into the passenger foot well where he was found.

ATTACHMENT A

2000 Taurus/Sable EDR Report - Summary Page

Investigation Data

File Name:	CA00-341.hex	File Save Date:	13-Oct-2000
File Read-out Date:	N/A	Report Date:	20-Oct-2000
Report Version:	1.4		

EDR Control Module Data

Data Validity Check:	Valid	EDR Model Version:	141
Time From Side Sailing Decision to Left (Driver) Side Bag Deployment:			Not Deployed
Time From Side Sailing Decision to Right (Passenger) Side Bag Deployment:			Not Deployed
Passenger Airbag Switch Position During Event:			N/A
Diagnostic Codes Active When Event Occurred:			0

Algorithm Times

Actual initiation depends on restraint system status (below).

	ms
Time From Algorithm Wakeup to Pretensioner:	25
Time From Algorithm Wakeup to First Stage - Unbelted:	25
Time From Algorithm Wakeup to First Stage - Belted:	"
Time From Algorithm Wakeup to Second Stage:	"

Restraint System Status

Driver Seat Belt Buckle:	Not Engaged
Passenger Seat Belt Buckle:	Not Engaged
Driver Seat Track in Forward Position:	No
Passenger Seat Weight Switch Position:	N/A

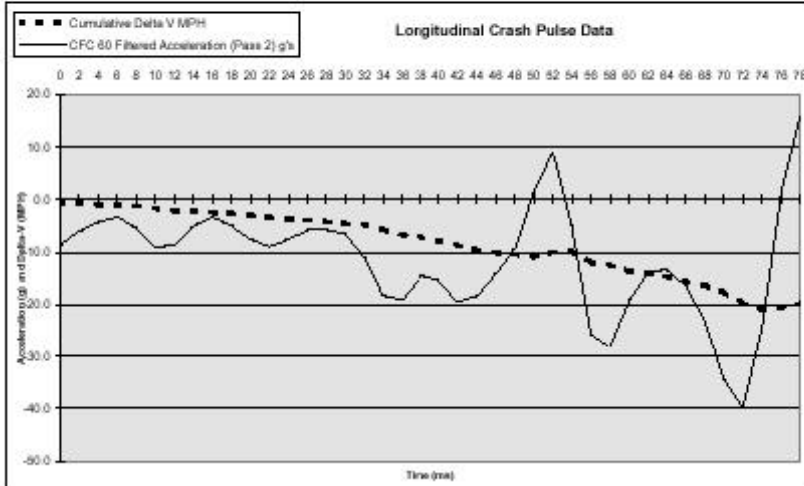
Deployment Initiation Attempt Times

	Driver	Passenger
Time From Algorithm Wakeup to Pretensioner Deployment Attempt:	Unbelted	Unbelted
Time From Algorithm Wakeup to First Stage Deployment Attempt:	25	25
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Disposal	Disposal

2000 Taurus/Sable EDR Report - Charts

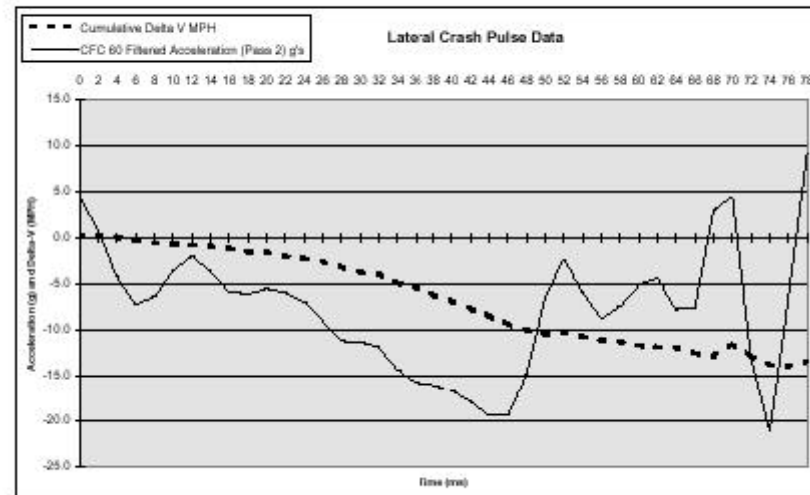
Longitudinal Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.6	-1.4	-2.2	-3.1	-4.0	-4.9	-5.8	-6.7	-7.6



Lateral Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.2	-0.7	-1.2	-1.7	-2.3	-2.9	-3.5	-4.1	-4.8



File Name: CA00-041.hex