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ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 FORD TAURUS INVESTIGATION

NASS/SCI CASE NO. 2000-11-145K

LOCATION - MICHIGAN

CRASH DATE - OCTOBER 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 Advanced Occupant Protection System (AOPS) in the 2000 Ford Taurus. The AOPS consisted of the integrated use of 3-point lap and shoulder belts, seat belt buckle pre-tensioners, seat position sensing and redesigned 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 an intersection crash with a 1990 Ford Ranger super cab pickup truck. Only the front seat belt pre-tensioners in the Ford Taurus fired as a result of the crash. The crash severity was below the threshold required to deploy the frontal air bags. The Taurus's 17 year old restrained male driver, 17 year old restrained male front right passenger, and 14 year old retrained right rear passenger were not injured in the crash. The 61 year old male driver of the Ranger suffered a police reported incapacitating injury.

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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, seat belt buckle pre-tensioners, seat position sensing and redesigned 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 an intersection crash with a 1990 Ford Ranger super cab pickup truck. Only the front seat belt pre-tensioners in the Ford Taurus fired as a result of the crash. The crash severity was below the threshold required to deploy the frontal air bags. The Taurus's 17 year old restrained male driver, 17 year old restrained male front right passenger, and 14 year old retrained right rear passenger were not injured in the crash. The 61 year old male driver of the Ranger suffered a police reported incapacitating injury.

This crash was identified through the weekly sampling of the local police jurisdictions conducted by PSU 11 of the National Automotive Sampling System (NASS). The crash was subsequently selected for investigation as CDS Case No. 11-145K. The Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) was informed of this crash by NASS Zone Center 1 and NHTSA assigned a combined NASS/SCI investigation of the crash to the Special Crash Investigations Team at Veridian Engineering. Specifically, the SCI team was instructed to download the crash data stored in the Restraint Control Module, as a supplement to the crash investigation. This investigation was conducted as part of the Advanced Occupant Protection System Study.

SUMMARY

Crash Site

This two-vehicle crash occurred during the nighttime hours of October, 2000. It was dark at the at the time of the crash and the area was lighted by overhead street lights. The weather was not a factor and the asphalt road surface was dry. The crash occurred at the intersection of a five-lane east/west roadway and a five-lane road north/south roadway. A standard (red/amber/green) traffic signal controlled the traffic flow through the intersection. The signal was functioning properly at the time of the crash. The speed limit in the area of the crash was 64 km/h (40 mph). **Figure 1** is a eastbound view looking into the intersection.

Figure 1: Eastbound trajectory view of the 2000 Ford Taurus.

Pre-Crash

The 2000 Ford Taurus was eastbound driven by a 17 year old male. The driver was restrained by the vehicle's 3-point lap and shoulder belt. The front right seat was occupied by a17 year old restrained male. A 14 year old restrained male was in the right rear seat. The traffic signal was in the green phase for eastbound traffic. Coincident to the Ford Taurus's approach to the intersection, a 1990 Ford Ranger was northbound driven by a 61 year old unrestrained male. The Ford Ranger entered the intersection against the red traffic signal and entered the path of the Taurus. An independent witness reported the Ranger entered the intersection against the red traffic signal at a high rate of speed. The driver of the Taurus steered the vehicle counterclockwise in an attempt to avoid the crash.

Crash

The crash occurred when the front right area of the Taurus struck the left frontal area of the Ranger in a 12/9 o'clock impact configuration. Refer to the crash schematic **Figure 2.** The lateral impact of the Taurus, forward of the Ranger's center of gravity, caused the Ranger to rotate clockwise. The pre-crash steering of the Taurus coupled with the lateral momentum of the Ranger caused the Taurus to rotate counterclockwise. As the respective vehicles rotated away from the initial impact, the left side of the Ranger contacted the right side of the Taurus in a secondary side slap.

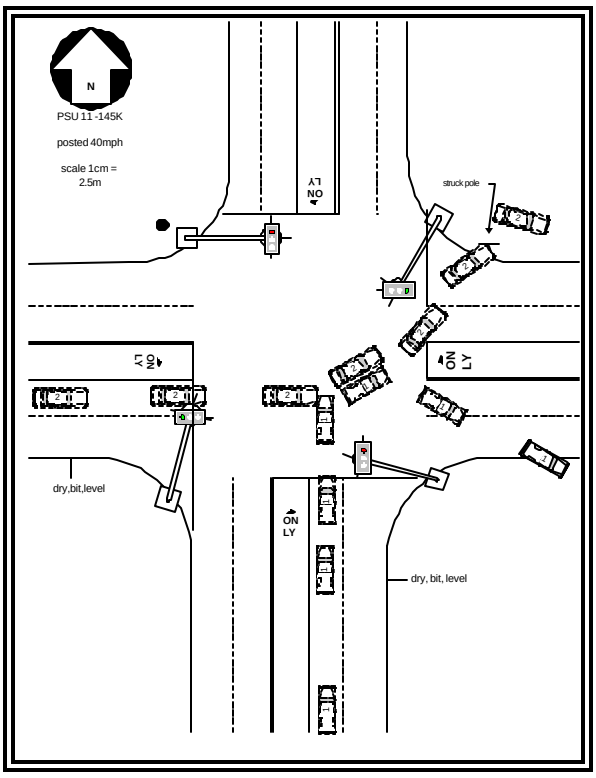


Figure 2: Crash schematic.

Upon separation, the Ranger continued rotating clockwise and it slid to rest beyond the southeast quadrant of the intersection. The vehicle came to rest facing southeast approximately 22 m (72 ft) from the point of impact. The Taurus came to rest in the northeast quadrant of the intersection approximately 28 m (93 ft) from the initial point of impact. The force of the crash caused the seat belt pre-tensioners in the Ford Taurus to fire. The crash severity was not great enough to warrant air bag deployment in the Taurus. The Ford Ranger was not equipped with an air bag system.

Post-Crash

The police and ambulance were dispatched to the scene. The restrained occupants of the Taurus exited the vehicle under their own power and were not injured. They did not require transport. The 61 year old unrestrained driver of the Ford Ranger suffered a police reported incapacitating injury and was transported to a local hospital. Both vehicles sustained disabling damage and were towed from the scene. The Ranger was subsequently sold for salvage by its insurance company and was not available for inspection.

2000 FORD TAURUS

The 2000 Ford Taurus was identified by the Vehicle Identification Number (VIN): 1FAFP56S8YG (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 discs brakes. It was not ABS equipped. The leather trimmed interior was equipped with a power package that included power steering, brakes windows, door locks, and mirrors. The vehicle also had adjustable foot controls and a 6-way power driver seat. The 4-door sedan was manufactured in June 2000. The odometer read 10,274 km (6,384 miles) at the time of the NASS inspection.

Exterior Damage

Figure 3 is a right front view of the damaged vehicle. The front plane of the Ford Taurus sustained 51 cm (20 in) of direct contact damage. The direct contact began 25 cm (10 in) right of center and extended to the right front bumper corner. This damage pattern wrapped around the right front corner and extended longitudinally 56 cm (22 in) on the right side of the vehicle. The crush profile measured at the bumper elevation was as follows: C1=0, C2=0, C3=0, C4=1.0 cm (0.4 in), C5=5.0 cm (2.0 in), C6=15.0 cm (6.0 in). There was no measurable change in the wheelbase dimensions. The Collision Deformation Classification (CDC) of the frontal impact was 01-FZEW-1. The Missing Vehicle algorithm of the WINSMASH model calculated total velocity change of 12.2 km/h (7.6 mph) for the frontal impact. The longitudinal and lateral components of the delta V were -11.5 km/h (-7.1 mph) and -4.2 km/h (-2.6 mph), respectively. It should be noted the SCI 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: Right front view of the damaged Taurus.

The right side damage resultant to the side slap extended along the full length of the vehicle. The damage consisted of CDC extent zone 1 buckling and abrasion of the body panels. The CDC of this impact was 03-RZEW-1.

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, 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 buckled and the buckle pre-tensioners fired. There was no command to deploy the frontal air bags. The driver seat was not adjusted to a forward position. The RCM sensed and recorded the crash acceleration pulse for a duration of 78 milliseconds. The typical duration of a vehicle-to-vehicle impact of this nature is greater than 78 milliseconds, therefore the entire crash event was not captured. The 78 millisecond longitudinal delta V recorded by the RCM was approximately -19.1 km/h (-11.9 mph). The 78 millisecond lateral delta V was approximately -20.0 km/h (-12.4 mph). It should be noted that the recorded delta V resulted from two concatenated events, namely the frontal impact and then the secondary side slap. Therefore, a direct comparison to the frontal delta V calculated by WINSMASH is not valid.

Figures 4 and 5 are views of the left and right interior, respectively. There was no interior damage or intrusion associated with the exterior forces of the crash. No interior occupant contacts were noted during the NASS inspection. The power-adjusted driver seat was in the full rear position at inspection. The right front seat was in a rear track position. The adjustable foot controls were in the full forward position (with respect to the vehicle).

Figure 4: Front left interior view.

Figure 5: Front right interior view.

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 identified 6 mm (0.25 in) of separation on the inboard (right) side. There was no separation of the outboard (left) capsule. 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.

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 upper anchorages (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 upper anchorage (D-ring) was adjusted to the full up position. Examination of the webbing and latch plate hardware revealed historical evidence of use consistent with the age of the vehicle. Inspection of the surface of the D-ring revealed a subtle transfer on the aft aspect of the friction surface. The driver's buckle pre-tensioner had fired. The post-crash measurement of the pretensioner's piston barrel was 86 mm (3.38 in). Inspection of the driver's belt system indicated the driver was restrained at the time of the crash.

The front right restraint webbing was stowed and operation at inspection. The webbing and latch plate exhibited historical evidence similar in nature to the driver's restraint. The adjustable right upper anchorage (D-ring) was positioned 2 cm (1 in) below full up. The friction surface of the right D-ring exhibited a transfer mark similar to that identified on the left side. The right buckle pretensioner had fired and the piston barrel measured 79 mm (3.12 in). All the evidence identified during the inspection indicated the front right passenger was restrained during the crash.

The right rear restraint was stowed and operational. The latch plate exhibited evidence of historical use. Inspection of the webbing was unremarkable. Given the minor severity of the impact, evidence of use as a result of the crash forces would not be expected. The driver indicated the passenger at this seat position was restrained. Proper use of this restraint was consistent with the occupant's medical outcome and kinematics.

The frontal air bag system consisted of redesigned dual stage air bags for the driver and front right passenger. The air bags did not deploy in the below threshold crash. The driver module was located in the typical manner in the center hub of the steering wheel rim. The front right passenger module was a top mount configuration located in the right aspect of the instrument panel.

OCCUPANT DEMOGRAPHICS

	Driver	Front right passenger
Age/Sex:	17 year old/Male	17 year old/Male
Height:	193 cm (76 in)	193 cm (76 in)
Weight:	79 kg (175 lb)	104 kg (230 lb)
Restraint Use:	3-point lap & shoulder	3-point lap & shoulder
Usage Source:	NASS/SCI inspection, RCM	NASS/SCI inspection, RCM
Medical Outcome:	No injury	Minor laceration from flying glass

	Left rear passenger	Right rear passenger
Age/Sex:	n/a	14 year old/Male
Height:	n/a	185 cm (73 in)
Weight:	n/a	104 kg (230 lb)
Restraint Use:	n/a	3-point lap & shoulder
Usage Source:	n/a	NASS/SCI inspection, interview
Medical Outcome:	n/a	No injury

OCCUPANT KINEMATICS

The three occupants of the Ford Taurus were restrained by their respective 3-point lap and shoulder belt systems immediately prior to the crash. Upon impact, the inertial locking retractors in the restraints locked the position of the webbing. The buckle pretensioners in the front restraints fired and removed some of the slack in the respective belt systems. The occupants responded to the 1 o'clock direction of the impact force by initiating a forward trajectory. The occupants loaded the 3-point restraints. As the vehicle's impacted in the side slap configuration, the occupants responded to the 3 o'clock direction of the impact by translating to the right. The occupants remained in contact with their respective belt system through the crash sequence. The proper use of the 3-point restraints effectively protected the occupants from contacting any of the interior components with significant force and effectively mitigated potential injury.

ATTACHMENT A

2000-11-145k.hex

2000 Taurus/Sable EDR Report - Summary Page

Investigation Data

File Name:	2000-11-145k.hex	File Save Date:	10-Nov-2000
File Read-out Date:	N/A	Report Date:	11-Dec-2000
Report Version:	1.6		

EDR Control Module Data

Data Validity Check:	Valid	EDR Model Version:	141
Time From Side Safing Decision to Left (Driver) Side Bag Deployment:			Not Deployed
Time From Side Safing 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:	112
Time From Algorithm Wakeup to First Stage - Unbelted:	112
Time From Algorithm Wakeup to First Stage - Belted:	0
Time From Algorithm Wakeup to Second Stage:	0

Restraint System Status

Driver Seat Belt Buckle:	Engaged
Passenger Seat Belt Buckle:	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:	112	112
Time From Algorithm Wakeup to First Stage Deployment Attempt:	Not Deployed	Not Deployed
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Not Deployed	Not Deployed

Notes

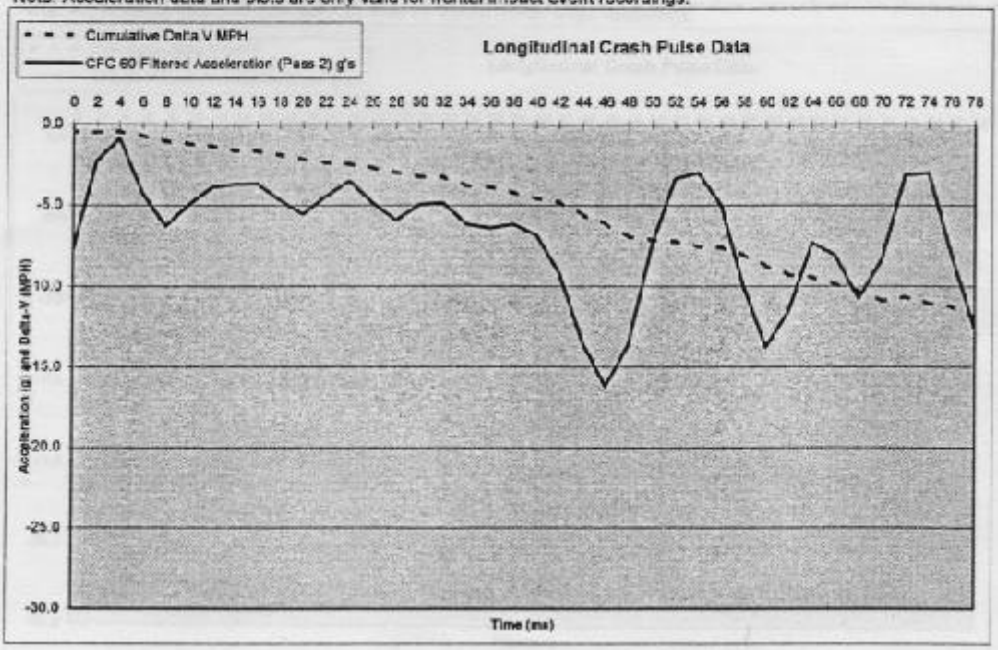
1. Read-out date is set by the PC interface tool.
2. Features and data parameters which are not available on the module are marked "N/A".
3. CFC 60 is a Butterworth 4-pole phaseless digital filter. (See SAE J211 Part 1 Appendix C dated March 1995.)
4. Total and maximum Delta-V results are not available from truncated/incomplete crash pulses.
5. Algorithm wakeup (0 ms) is not the first moment of vehicle contact or impact.
6. The Excel "Analysis ToolPak" Add-in must be enabled for this spreadsheet to operate properly.
7. Acceleration data and plots are only valid for frontal impact event recordings.

2000 Taurus/Sable EDR Report - Charts

Longitudinal Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.5	-1.2	-2.2	-3.2	-4.6	-7.1	-8.7	-10.9	-11.9

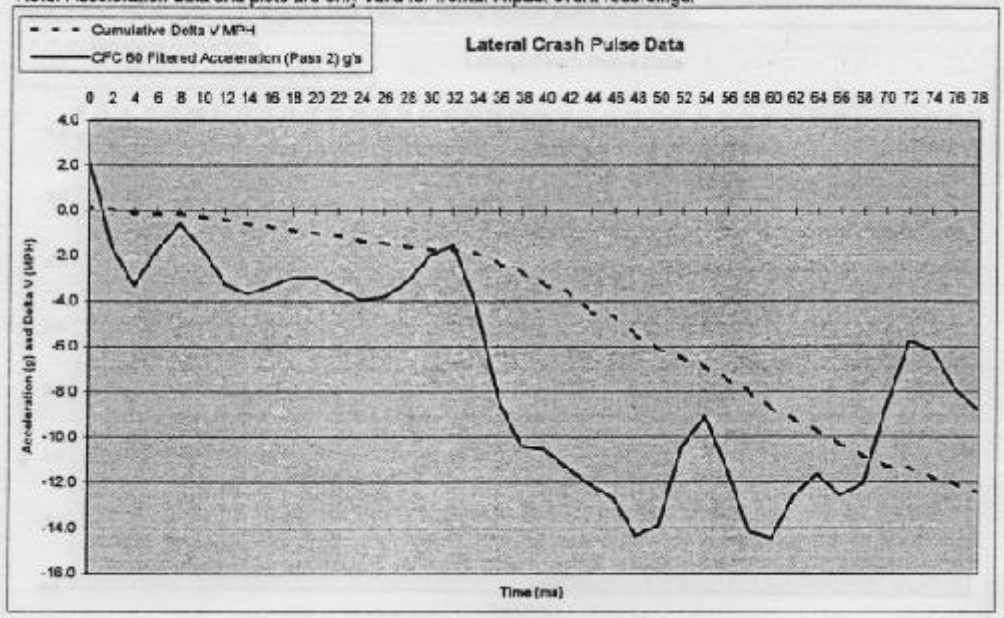
Note: Acceleration data and plots are only valid for frontal impact event recordings.



Lateral Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	0.2	0.3	-1.0	-1.7	-3.3	-6.1	-8.7	-11.3	-12.4

Note: Acceleration data and plots are only valid for frontal impact event recordings.



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