CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

SCI CASE NO.: CA09072

VEHICLE: 2007 FORD FOCUS SE

LOCATION: NORTH CAROLINA

CRASH DATE: SEPTEMBER 2009

Contract No. DTNH22-07-C-00043

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. CA09072	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Calspan On-Site Rollover Crash Investigation SCI Case No.: CA09072 Vehicle: 2007 Ford Focus SE Location: North Carolina Crash Date: September 2009		*5. Report Date*: April 2010 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* C00500.0000.0095 *11. Contract or Grant No.* DTNH22-07-C-00043	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		*13. Type of Report and Period Covered* Technical Report Incident Date: September 2009 *14. Sponsoring Agency Code*	
15. Supplementary Note This on-site investigation focused on an off-road rollover crash of a 2007 Ford Focus SE.			
16. Abstract This on-site investigation focused on an off-road rollover crash of a 2007 Ford Focus SE. The Ford was equipped with four-wheel anti-lock brakes and a Certified Advanced 208-Compliant (CAC) frontal air bag system. The manufacturer of the Ford has certified that the vehicle is compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, safety belt buckle switch sensors, retractor pretensioners, and a front right occupant presence sensor. The vehicle departed the roadway to the right, entered a ditch, and impacted a culvert with the right front wheel that induced a clockwise (CW) yaw. The Ford then initiated a left side leading rollover. The restrained 23-year-old female driver of the Ford sustained lower abdominal ecchymosis and cervical strain and was transported by ambulance to a local hospital where she was treated in the emergency department and released.			
17. Key Words Rollover CAC air bag system 2007 Ford Focus SE Minor Injuries		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 8	*22. Price*

TABLE OF CONTENTS

CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA09072
VEHICLE: 2007 FORD FOCUS SE
LOCATION: NORTH CAROLINA
CRASH DATE: SEPTEMBER 2009

BACKGROUND

This on-site investigation focused on an off-road rollover crash of a 2007 Ford Focus SE **(Figure 1)**. The Ford was equipped with four-wheel anti-lock brakes and a Certified Advanced 208-Compliant (CAC) frontal air bag system. The manufacturer of the Ford has certified that the vehicle is compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, safety belt buckle switch sensors, retractor pretensioners, and a front right occupant presence sensor. The vehicle departed the roadway to the right, entered a ditch, and impacted a culvert with the right front wheel that induced a clockwise (CW) yaw. The Ford then initiated a left side leading rollover. The restrained 23-year-old female driver of the Ford sustained lower abdominal ecchymosis and cervical strain and was transported by ambulance to a local hospital where she was treated in the emergency department and released.

Figure 1: 2007 Ford Focus case vehicle.

The Ford was identified through a visit to a regional vehicle salvage facility on October 19, 2009. Based on the rollover and roof crush to the Ford, this case was assigned for an on-site investigation on October 20, 2009. The on-site investigation was initiated on October 22, 2009, and involved the inspection and documentation of the Ford, an interview with the mother of the driver of the Ford, and the documentation of the crash site. The driver of the Ford refused to be interviewed

SUMMARY

Crash Site

This crash occurred during the evening hours of September 2009 on a two-lane north/south rural roadway. The environmental conditions at the time of the crash were dry, cloudy and dark. The roadway consisted of two asphalt surfaced travel lanes that were 3.5 m (11.5 ft) in width. The roadway was bordered by narrow asphalt shoulders that measured 40 cm (15.7 in) in width. The roadsides sloped away from the roadway and formed drainage ditches that extended outboard of the shoulders. On the west roadside, a 1.7 m (5.6 ft) grass area with a negative grade of -1.6 percent was adjacent to the west road edge. The ditch on the west roadside began 1.7 m (5.6 ft) west of the west road edge. The east ditch wall had a negative grade of -74 percent, with a grade of 88 percent on the west wall. The ditch was centered 2.9 m (9.5 ft) west of the west fog line

and was 2.4 m (7.9 ft) in width and 80 cm (31.5 in) in depth. There was a grass surfaced access driveway connecting the roadway to an agricultural field located west of the roadway. This driveway was 3.2 m (10.5 ft) in width and was located 24.2 m (79.4 ft) north of the reference point. In the pre-crash area of the Ford, the roadway was straight and had a negative grade of -1.6 percent. There was a curve unrelated to the crash that began 82.8 m (272 ft) north of the area in which the Ford departed the roadway to the right. The posted speed limit in the area of the crash was 89 km/h (55 mph). The crash schematic is included as **Figure 7** of this report.

Vehicle Data

2007 Ford Focus

The 2007 Ford Focus SE was manufactured in April 2007, and was identified by the Vehicle Identification Number (VIN): 1FAFP34N17W (production sequence deleted). The odometer reading at the time of the crash was 59,436 km (36,932 mi).

The front-wheel drive Ford was powered by an inline 2.0-liter, 4-cylinder transverse mounted engine linked to a 4-speed automatic transmission. The braking system consisted of power-assisted front disc and rear drum brakes with four-wheel antilock. All windows were closed prior to the crash, evidenced by tempered glass fragments in the upper weather stripping of all operable windows. The Ford was equipped with Hankook Optimo H725 tires mounted on OEM 15-inch steel wheels with plastic wheel covers. The tire size matched the vehicle manufacturer recommended tire size of P195/60R15. The vehicle manufacturer recommended cold tire pressure was 221 kPa (32 PSI) for the front and rear. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	193 kPa (28 PSI)	2 mm (3/32 in)	None
Left Rear	207 kPa (30 PSI)	3 mm (4/32 in)	None
Right Front	Tire flat	2 mm (3/32 in)	De-beaded
Right Rear	193 kPa (28 PSI)	3 mm (4/32 in)	None

The interior of the Ford was configured with cloth surfaced five-passenger seating. The front bucket seats were separated by a center console and were equipped with adjustable head restraints. The front left head restraint was 8 cm (3.1 in) above the full-down position. The front right head restraint was in the full-down position. The front left seat track was in a mid-track position at the time of the SCI inspection, located 5 cm (2 in) forward of the full-rear position. The front right seat track was in the full-rear position. The front left seat back was adjusted to an angle of 27 degrees aft of vertical, with an angle of 23 degrees aft of vertical for the front right seat. The second row consisted of a split-bench seat with forward folding backs. There were no head restraints for the rear seats.

The interior occupant safety systems consisted of 3-point lap and shoulder belt systems for the five designated seating positions, front seat safety belt retractor pretensioners, and dual stage CAC frontal air bags.

Crash Sequence

Pre-Crash

The restrained 23-year-old female driver of the Ford was operating the vehicle southbound on the rural roadway at a police estimated speed of 89 km/h (55 mph). She departed her work place and was en route to her residence and was approximately 8 km (5 mi) from her destination when the crash occurred. **Figure 2** depicts the pre-crash trajectory of the Ford. The mother of the driver reported that a deer ran into the roadway in front of the Ford. The driver initiated an avoidance maneuver by braking and steering to the right. The Ford departed the right side of the roadway at a degree angle of approximately 10 degrees and entered the ditch in a tracking mode. The right front tire rutted the soft soil of the ditch located between the west road edge and the east ditch wall and adjacent to the culvert and driveway.

Figure 2: Pre-crash trajectory of the Ford.

Crash

The front right corner area of the bumper fascia and the right front tire of the Ford impacted the driveway culvert. The impact reduced the right wheelbase by 21 cm (8.3 in). The impact actuated the driver's safety belt pretensioner and deployed the driver's frontal air bag. The Ford then rotated approximately 65 degrees clockwise (CW) as it traveled up the embankment onto the driveway. As the Ford traversed the grass driveway, the left tires engaged the ruts in the driveway that tripped the vehicle into a left side leading rollover along the west roadside. **Figure 3** depicts the location of the impact with the culvert and the initiation of the rollover. The Ford rolled six-quarter turns over a distance of 21 m (68.9 ft). Three gouges were noted to the grass roadside form the overturning vehicle. As it rolled, the Ford entered the ditch that interrupted the rollover. The Ford slid on its roof prior to coming to rest and came to rest in the ditch facing in a southerly direction. A 3.8 m (12.5 ft) section of disturbed soil on the west ditch wall and debris in the ditch evidenced the slide and final rest position of the Ford.

Figure 3: Initial impact location and tripping point of the Ford on the driveway.

Post-Crash

Police, emergency medical, and tow personnel responded to the crash site. It is unknown how the driver exited the vehicle. She was transported by ground ambulance to a local hospital where she was treated in the emergency department and released. The Ford was

towed from the scene due to disabling damage. The vehicle was transferred to a regional vehicle salvage facility where it was inspected for this investigation.

Vehicle Damage

Exterior

The initial impact to the culvert resulted in minor damage to the lower right corner of the front bumper fascia and the displacement of the right front axle. The front bumper beam was not damaged; therefore there was no residual crush. The right front axle was displaced 21 cm (8.3 in) rearward. The CDC for this event was 12-FRLE-3.

As a result of the rollover, the Ford sustained moderate severity damage to the left and right planes, and severe damage to the top plane. **Figures 4 and 5** depict the roof damage to the Ford. The scratches on the roof were oriented laterally and longitudinally, indicating the vehicle had rolled over the roof multiple times. The direct contact to the top plane extended 383 cm (150.8 in) longitudinally from the leading edge of the hood to aft of the C-pillars and 109 cm (42.9 in) laterally from the left roof side rail to the right roof side rail. The maximum vertical crush was located on the windshield header 40 cm (15.7 in) right of the left roof side rail and measured 32 cm (12.6 in) in depth. The maximum lateral crush measured 12 cm (4.7 in) and was located on the right roof side rail, located 6 cm (2.4 in) aft of the windshield header. The windshield was 100 percent fractured and the laminate was torn along the full-length of the windshield header and vertically along the upper half of the A-pillars. All glazing on the left and right sides and the backlight disintegrated as a result of the rollover. All four doors remained closed during the crash sequence. The right front door was jammed closed post-crash. The left front, left rear and right rear doors were operational post-crash. The CDC assigned for this rollover event was 00-TDDO-4.

Figure 4: Front bumper fascia damage and roof crush from the front of the Ford.

Figure 5: Rollover damage from above, left front.

Interior Damage

The interior of the Ford sustained moderate severity damage that was attributed to passenger compartment intrusion and occupant contact. The driver loaded the center console during the rollover resulting in a 10 cm (3.9 in) scuff mark located 4-14 cm (1.6-

5.5 in) aft of the left front edge of the console. The passenger compartment was reduced in size by intrusion of the roof structure. The intrusions are listed in the following table:

Position	Component	Direction	Magnitude
Row 1 Left	Windshield header	Vertical	27 cm (10.6 in)
Row 1 Left	Roof	Vertical	22 cm (8.7 in)
Row 1 Left	Roof side rail	Vertical	7 cm (2.8 in)
Row 1 Left	Roof side rail	Lateral	4 cm (1.6 in)
Row 1 Left	B-pillar	Lateral	4 cm (1.6 in)
Row 1 Left	A-pillar	Lateral	3 cm (1.2 in)
Row 1 Center	Windshield header	Vertical	20 cm (7.9 in)
Row 1 Center	Roof	Vertical	25 cm (9.8 in)
Row 1 Right	Windshield header	Vertical	22 cm (8.7 in)
Row 1 Right	Roof	Vertical	23 cm (9.1 in)
Row 1 Right	Roof side rail	Vertical	15 cm (5.9 in)
Row 1 Right	Roof side rail	Lateral	7 cm (2.8 in)
Row 1 Right	B-pillar	Lateral	6 cm (2.4 in)
Row 1 Right	A-pillar	Lateral	9 cm (3.5 in)
Row 2 Left	Roof	Vertical	5 cm (2 in)
Row 2 Left	Roof side rail	Vertical	10 cm (3.9 in)
Row 2 Left	Roof side rail	Lateral	4 cm (1.6 in)
Row 2 Left	C-pillar	Lateral	3 cm (1.2 in)
Row 2 Center	Roof	Vertical	13 cm (5.1 in)
Row 2 Right	Roof	Vertical	13 cm (5.1 in)
Row 2 Right	Roof side rail	Vertical	16 cm (6.3 in)
Row 2 Right	Roof side rail	Lateral	7 cm (2.8 in)
Row 2 Right	C-pillar	Lateral	7 cm (2.8 in)

Manual Restraint Systems

The Ford was equipped with 3-point lap and shoulder belts for the five designated seating positions. All belt systems consisted of continuous loop webbing and sliding latch plates. The front left belt system utilized a retractor-mounted pretensioner that actuated during the crash. The front left upper D-ring was height adjustable and was located in the full-up position. The driver's safety belt retracted onto an Emergency Locking Retractor (ELR). The driver used the safety belt at the time of the crash, which was supported by loading evidence on the belt webbing. This evidence consisted of a 4 cm (1.6 in) frictional abrasion on the belt webbing located 74-78 cm (29.1-30.7 in) above the floor anchor at the area of the latch plate. Additionally, the actuated retractor pretensioner locked the safety belt in the used position. The total length of webbing extending from the D-ring due to the locked retractor measured 192 cm (75.6 in).

The front right and second row safety belt systems utilized a switchable ELR/Automatic Locking Retractors (ALR). In addition, the front right belt system utilized a retractor pretensioner which did not actuate during the crash and a height adjustable D-ring that was in the full-up position.

Frontal Air Bag System

The Ford was equipped with a CAC frontal air bag system. The CAC system consisted of dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, safety belt buckle switch sensors, retractor pretensioners, and a front right occupant presence sensor.

Figure 6: Deployed driver's frontal air bag.

The driver's air bag was concealed within the center hub of the four-spoke steering wheel by two cover flaps. The upper cover flap measured 6 cm (2.4 in) in height and 18 cm (7.1 in) in width at the horizontal seam. The lower cover flap was trapezoidal in shape and measured 9 cm (3.5 in) in height, 6 cm (2.4 in) in width at the lower aspect and 18 cm (7.1 in) in width at the horizontal tear seam. There was an oval-shaped Ford logo in the center of the flaps, attached to the upper cover flap that measured 2.5 cm (1 in) in height and 6 cm (2.4 in) in width. The driver's air bag **(Figure 6)** measured 48 cm (18.9 in) in diameter in its deflated state. The air bag was vented by petal vents that were 3 cm (1.2 in) in width on the rear face of the air bag. There were three vents on the left aspect and two on the right. The air bag was tethered by one tether sewn to an oval-shaped seam at the center of the face of the air bag. This seam measured 3 cm (1.2 in) in height and 2 cm (0.8 in) in width. There were green and blue threads woven into the fabric of the air bag that tore as the air bag deployed to control the force and direction of the deployment. There was no damage or contact evidence to the driver's frontal air bag.

The front right air bag was mounted within the upper aspect of the right instrument panel. The front right seat was not occupied during the crash; therefore the CAC system suppressed the deployment.

Occupant Demographics/Data

Driver Age/Sex:	23-year-old/Female
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat Track Position:	Rear-track, adjusted 5 cm (2 in) forward of full-rear
Manual Safety Belt Use:	3-point lap and shoulder belt
Usage Source:	Vehicle Inspection
Egress from Vehicle:	Unknown
Mode of Transport from Scene:	Ground ambulance
Type of Medical Treatment:	Transported to a local hospital where she was treated in emergency department and released.

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Lower abdominal ecchymosis	Minor (590402.1,8)	Lap belt webbing
Cervical strain	Minor (640278.1,6)	Impact force

Source = Emergency Room Records

Driver Kinematics

The 23-year-old female driver of the Ford was seated in a rear-track position with the seat adjusted 5 cm (2 in) forward of full-rear. She was restrained by the manual 3-point lap and shoulder belt system. Prior to the initial impact, the driver was steering right and braking in an attempt to avoid a deer that allegedly ran into the roadway in front of the Ford. The Ford departed the roadway to the right at a shallow angle.

During the initial impact with the culvert, the driver's pretensioner actuated and the driver's frontal air bag deployed. The driver initiated a forward trajectory within the front left seating position and loaded the manual safety belt webbing. The impact with the culvert induced a CW yaw. The Ford subsequently tripped into a left-side leading rollover. During the rollover, the driver loaded the safety belt system and the center console. She sustained lower abdominal ecchymosis from loading the lap belt portion of the belt system. The medical records indicated the driver sustained cervical strain, probably associated with the impact force as no contact evidence was visible on the headliner of the Ford. As the vehicle came to rest on its roof, the driver was inverted in the vehicle, suspended from the safety belt. The driver was transported by ground ambulance to a local hospital where she was treated in the emergency department and released the same day.

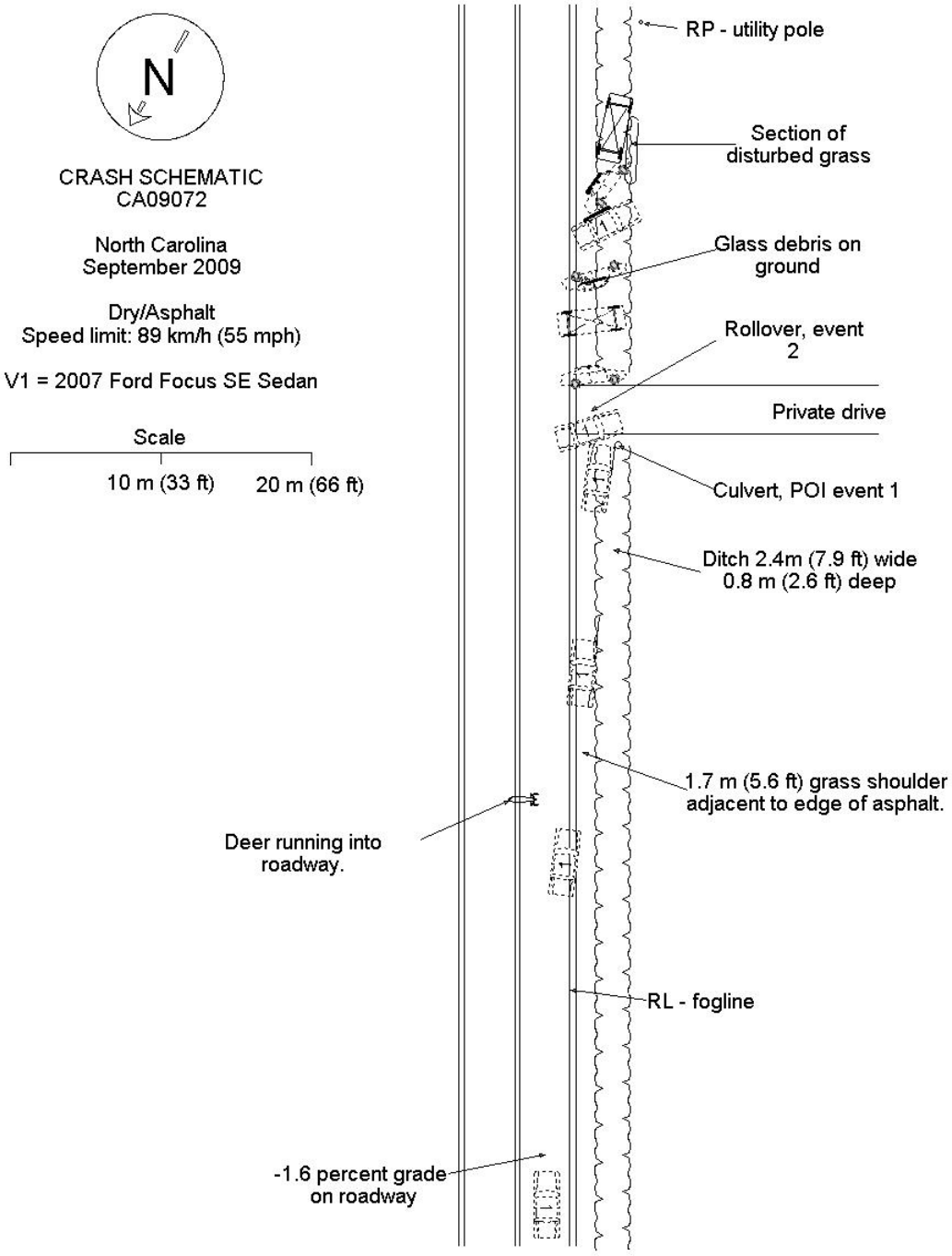

Figure 7: Crash Schematic