On Site ODI Tire Tread Separation / Rollover Investigation
Dynamic Science, Inc. (DSI), Case Number DS08003
1999 Ford Explorer XLT
Arizona
May 2007

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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 performance of the involved vehicle(s) or their safety systems.

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16. Abstract

This on-site investigation focused on a rollover crash that was caused by a tire tread separation. This single vehicle crash occurred at 1515 hours in May 2007 in Arizona. The crash occurred off the right shoulder of a three-lane interstate highway. The speed limit at this location was 105 km/h (65 mph). The subject vehicle was a 1999 Ford Explorer XLT sport utility vehicle that was being driven by a restrained 32-year-old female. The Ford was traveling northbound at a police estimated speed of 105 km/h (65 mph). The driver stated to police that the left rear tire sustained a blowout, which caused her to lose control of the vehicle. After the blowout, the vehicle initiated a clockwise rotation and traveled to the right across three travel lanes. The vehicle departed the roadway on the right side; the left side tires engaged and dug into the ground, and the vehicle initiated a trip rollover with its left side leading. It came to rest on its wheels in an unpaved area of ground to the right of the roadway. The driver sustained a left shoulder contusion, a left wrist sprain, a cervical strain, and complained of having a headache. She was transported by ground ambulance to a regional medical center where she was treated and released. The Ford was towed from the scene. It sustained impact damage to the left and right sides, front and back ends, and the top. It was later declared to be a total loss by the insurance company.

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS08003

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BACKGROUND

This on site investigation focused on a rollover crash that was caused by a tire tread separation. This single vehicle crash occurred at 1515 hours in May 2007 in Arizona. The crash occurred off the right shoulder of a three-lane interstate highway. The speed limit at this location was 105 km/h (65 mph). The case vehicle was a 1999 Ford Explorer sport utility vehicle that was being driven by a restrained 32-year-old female (**Figure 1**).

Figure 1. Subject vehicle, 1999 Ford Explorer XLT

The Ford was traveling northbound at a police estimated speed of 105 km/h (65 mph). The driver stated in the police report that the left rear tire sustained a blowout (**Figure 2**), which caused her to lose control of the vehicle. The Ford initiated a clockwise rotation and traveled across the three travel lanes. The vehicle departed the roadway on the right side; the left side tires engaged and dug into the ground, and the vehicle initiated a trip rollover with its left side leading. It came to rest on its wheels in an unpaved area of ground to the right of the roadway.

Figure 2. Left rear tire sustained tread separation

This On-Site Office of Defects Investigation (ODI) Tire Tread Separation/Rollover Investigation was initiated in response to a National Highway Traffic Safety Administration (NHTSA) review of online vehicle data sources. On January 18, 2008, DSI was instructed to locate the Ford Explorer. The vehicle had been sold by an insurance storage facility to an auto salvage company on January 22, 2008. On January 25, 2008, DSI obtained permission to inspect the Ford at the salvage lot. DSI obtained a copy of the police report and the case was assigned on January 28, 2008. The vehicle was inspected on January 30, 2008. At ODI's request, the left rear tire was obtained from the salvage facility and sent to NHTSA. On February 7, 2009, DSI received ODI's findings. A summary of the findings is included in this report.

SUMMARY

Crash Site

The crash occurred on a north/south configured interstate highway. The three northbound lanes were separated from the southbound lanes by a depressed median and a cable barrier. The roadway was composed of an asphalt surface, and was bordered on both sides by paved asphalt shoulders. The left shoulder was separated from the travel lanes by a single yellow stripe. The right shoulder was separated from the travel lanes by a single white stripe. The northbound lanes were delineated

by dashed white stripes. The roadway character was level and curved slightly to the right. Adjacent to the paved shoulders was uneven ground covered with dirt, sand and brush.

Pre Crash

The crash occurred during daylight hours. Conditions were mostly clear. The temperature was 96.8 degrees F (36.0 degrees C), winds were 7.4 km/h (4.6 mph), and visibility was 64.4 km (40.0 mi). The roadway was dry. The posted speed limit at this location was 105 km/h (65 mph). The Ford was being driven by a restrained 32-year-old female. There were no other occupants in the vehicle. The vehicle was traveling northbound in the inboard lane, three lanes from the right at a police estimated speed of 105 km/h (65 mph). The driver reported a blowout of the left rear tire. Following the blowout, the driver lost control of the Ford. The Ford traveled to the right across the three northbound lanes (**Figure 3**), and departed the east roadway edge (**Figure 4**).

Figure 4. Northbound approach

Figure 3. Area of rollover and final rest

Crash

When the vehicle traveled off the roadway and onto the dirt, the vehicles left side tires tripped on the ground. The vehicle then overturned and rolled left side leading. The vehicle rolled four quarter turns and came to final rest on the roadside.

Post Crash

The vehicle came to final rest on its wheels. The driver's mode of extrication and her post-crash mobility were not known. She sustained a left shoulder contusion, a left wrist sprain, a cervical strain, and complained of having a headache. She was transported by ground ambulance to a regional medical center where she was treated and released. The Ford was towed from the scene. It sustained impact damage to the left and right sides, front and back ends, and the top. It was declared to be a total loss by the insurance company.

VEHICLE DATA - 1999 Ford Explorer

The 1999 Ford Explorer was identified by the Vehicle Identification Number (VIN): 1FMZU34X3XZxxxxxx. The vehicle's date of manufacture was February 1999. The odometer reading was 127,539 km (79,251 miles). The Ford was equipped with a 4-liter, 6-cylinder engine, four wheel drive, an automatic transmission, and was configured with seating for five passengers. The first row seating in the Ford was equipped with fabric-covered bucket seats and integral head

restraints for the outboard seating positions. The second row seating was configured with a 60/40 split bench seat with folding backs and adjustable head restraints for the outboard seating positions. There was no head restraint for the middle seat position.

The vehicle manufacturer's recommended tire size was P235/75R15 and the recommended cold pressure was 179 kPa (26 psi). The Ford was equipped with Toyo H/T Open Country M+S tires, size P235/75R15, for the left front and right front positions. The tire manufacturer's maximum tire pressure was 241 kPa (35 psi). The right rear tire was a Radial LXT All Country, size P235/75R15. The manufacturer's maximum tire pressure was 283 kPa (41 psi).

The left rear tire was a Dominator All Season M+S, size P235/75R15. The tire sustained a tread separation (**Figures 5-6**). The tire was de-beaded and the sidewalls were abraded. The carcass and belts were exposed. There was a split parallel to the bead that measured approximately 6 cm (2.3 in) in length. The split began 2 cm (0.8 in) to the right of the valve stem and was 1 cm (0.4 in) from the rim. The tire manufacturer's maximum tire pressure could not be read due to damage. The Tire Identification Number (TIN) was UIHI TUL 0605. The build date was the 6th week of 2005, or February 2005. The tire tread separated prior to the rollover.

Figure 5. Left rear tire, from front

Figure 6. Left rear tire, from back

The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire flat	8 mm (10/32 in)	No	Tire de-beaded
LR	Tire flat	Unknown	No	Complete tread separation, tire de-beaded, sidewall scuffed
RR	165 kPa (24 psi)	6 mm (8/32 in)	No	None
RF	83 kPa (12 psi)	8 mm (10/32 in)	Yes	Tire scuffed

Summary of ODI Tire Examination

- The tire had de-beaded from the outer rim flange. Outer surfaces of the rim and sidewall displayed major scuffing. The outer rim flange displayed two major flat spots indicative of radial impacts.
- The valve stem was found mounted in-position, did not display any surface cracks, and was apparently intact. The valve stem cap was missing. The valve stem was not pressure-tested.
- The tire was missing its tread and outer steel belt and displayed major scuffing damage to its outer sidewall. This damage extended to the rubber that coated the bead region and, in one location, some of the bead wires were exposed.
- The inner liner and upper sidewall exhibited damage (separation, abrasion, and wrinkling) that was indicative of being operated for a short period at high speed with no appreciable air pressure.
- Examination of the inner liner identified two repair patches spaced about 7.6 cm (3 in) apart. Due to post tire failure damage, a failure origin could not be identified and no causal link could be drawn between the road hazard repairs and the tread separation.

Vehicle Damage

Exterior Damage

The Ford sustained moderate damage as a result of the rollover (**Figure 7**). The left front and left rear tires were flattened. The front grille was cracked and holed. There was direct damage to the left and right side A-, B- and D-pillars, and the left C-pillar. Direct damage to the left and right sides extended along the entire length of the vehicle. Direct damage to the top began at the leading edge of the hood, extended rearward 413 cm (161.6 in), and ended at the left D-pillar. The lateral aspect of the direct damage was distributed from roof rail to roof rail. The CDC for the rollover was 00TDDO3.

Figure 7. View showing crush to roof

The maximum lateral crush measurement was taken at the right roof rail near the A-pillar and measured 5 cm (2.0 in). The maximum vertical crush measurement was taken at the right windshield header and measured 17 cm (6.7 in).

There were several rubber transfers inside the left rear wheel well (**Figure 8**). The left rear wheel well was holed and there was a split in the left rear quarter panel located above the tire. The interior left panel was fractured and displaced into the rear cargo area (**Figure 9**). This damage was probably caused by contact from the loose tire tread as it rotated with the tire.

Figure 8. Rubber transfer to inner wheel well

Figure 9. Fracture and displacement of interior left side panel

Interior Damage

The Ford sustained minor interior damage as a result of passenger compartment intrusion. There was integrity loss to the windshield, backlight and side window glazing. The windshield was cracked and out of place. The backlight and left rear window were disintegrated. All doors remained closed and operational. The specific passenger compartment intrusions were documented as follows:

Row	Position	Intruded Component	Magnitude of Intrusion	Direction
1	Right	Roof	18 cm (11.4 in)	Vertical
1	Right	Windshield header	15 cm (5.9 in)	Vertical
1	Right	Roof rail	13 cm (5.1 in)	Vertical
1	Right	A-pillar	13 cm (16.9 in)	Vertical
1	Middle	Windshield header	11 cm (4.3 in)	Vertical
1	Left	Windshield header	3 cm (3.1 in)	Vertical

Manual Restraints

The Ford was equipped with 3-point manual lap and shoulder belts for the first row outboard seat positions. The front row safety belts were configured with adjustable D-rings. The left D-ring was adjusted to the full down position and the right D-ring was set in the middle position. The front row left safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). The latch plate exhibited evidence of historical usage and the belt webbing exhibited wear marks. The right passenger safety belt was configured with a sliding latch plate. The retractor was set to ELR mode. The vehicle was not equipped with safety belt pretensioners.

The Ford was equipped with 3-point manual lap and shoulder belts for the second row outboard seat

positions. They were configured with sliding latch plates, switchable Automatic/Emergency Locking Retractors (ALR/ELR), and were equipped with non-adjustable anchorage assemblies. The middle seat was equipped with a lap belt and sewn-on latch plate.

Supplemental Restraint Systems

The Ford was equipped with first row frontal air bags. The driver's air bag was located in the steering wheel hub. The passenger air bag was located in the middle instrument panel. The cover flap for the passenger air bag measured 37 cm (14.6 in) in length by 17 cm (6.7 in) in height. No air bag switch was present. No air bags deployed in the crash.

Rollover Dynamics

The 1999 Ford Explorer was equipped with rear-wheel drive and 4-wheel standard anti-lock brakes. The rollover resistance and static stability factor was not known. The vehicle was equipped with a wishbone front suspension with stabilizer bar independent with torsion springs, and a beam rear suspension with stabilizer bar rigid with leaf springs.

After the tread separated from the left rear tire, the Ford began a clockwise rotation. The vehicle crossed the adjacent travel lanes and departed the roadway on the right side. The driver's ability to steer the vehicle was compromised due to the rapid deflation and tread loss of the left rear tire. As the left side tires and rims engaged and dug into the sand, dirt and loose gravel along the roadside, the vehicle tripped and rolled with its left side leading. The vehicle rolled four quarter turns and came to final rest on its wheels on the roadside.

The handling characteristics of the vehicle were compromised due to the tire failure and the stability control features were not a determining factor in the rollover.

OCCUPANT DEMOGRAPHICS - 1999 Ford Explorer

	Driver
Age/Sex:	32/Female
Seated Position:	Front left
Seat Type:	Bucket; the seat track was adjusted to the full back position.
Height:	Unknown
Weight:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used.

OCCUPANT KINEMATICS

Driver Kinematics

The 32-year-old female driver was seated in an unknown posture and was restrained by the 3-point manual lap and shoulder belt. She probably had her hands on the steering wheel and her right foot on the accelerator. She was traveling at a police reported speed of 105 km/h (65 mph). The driver reported a blowout of the left rear tire. The Ford initiated a clockwise rotation and traveled across to the right and across three lanes. The driver remained in place in her seat due to the belt restraint.

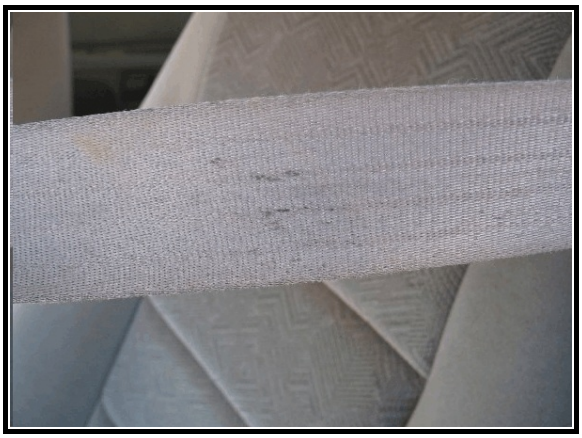

Figure 10. Occupant contact, loading of safety belt webbing

The vehicle traveled off the right side of the road and tripped with its left side leading. The driver was displaced to the left and loaded the safety belt webbing (**Figure 10**). There were load marks that covered an 18 cm (7.1 in) section of belt that were located between the buckle and the stop button. During the rollover, the driver contacted the left side interior hardware with her left shoulder, causing a left shoulder contusion. She contacted an unknown component with her left hand or wrist that resulted in a wrist sprain. There was no contact evidence observed on the steering wheel or column, and those components did not exhibit any deformation. The driver complained of a headache and sustained a cervical strain. There was no evidence that indicated the occupant contacted the roof. It is probable that her cervical injury was a non-contact injury. After the crash, the driver was transported by ambulance to a regional medical center, treated, and released.

OCCUPANT INJURIES - 1999 Ford Explorer

Driver: Injuries obtained from emergency room and radiological records.

Injury	OIC Code	Injury Mechanism	Confidence Level
Left shoulder contusion	751010.1,2	Left side hardware or armrest	Probable
Cervical strain	640278.1,6	Impact forces	Probable
Left wrist sprain/strain	751420.1,2	Unknown	Unknown

Attachment 1. Scene Diagram