ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN08042
LOCATION - TEXAS
VEHICLE - 2008 LEXUS RX 350
CRASH DATE - September 2008

Submitted:

March 30, 2009

Contract Number:  DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003
DISCLAIMERS

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 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.
On-site rollover investigation involving a 2008 Lexus RX 350 and a 2007 Mack CTP series dump truck that was pulling a flat bed trailer.

This report covers an on-site rollover investigation that involved a 2008 Lexus RX 350, which rolled over on the roadway after it impacted a flat bed trailer that was being pulled by a 2007 Mack CTP series dump truck. The focus of this on-site investigation was the Lexus’ rollover. The Lexus was traveling south on a 2-lane city street approaching a 4-leg intersection as the Mack was backing its trailer east into the intersection. The front right corner of the Lexus impacted the right rear corner of the trailer. The Lexus rotated clockwise following the impact and rolled over, left side leading, one quarter turn onto its left side. The Lexus was equipped with a rollover sensor and the vehicle’s rollover side curtain air bags deployed during the rollover. The restrained 73-year-old female driver of the Lexus refused transport to a hospital. She sustained minor injuries and was subsequently treated by her private physician. While there was no discernable occupant contact evidence on the left rollover side curtain air bag, occupant kinematic principles indicated that the driver probably loaded her head on the deployed left rollover side curtain air bag during the rollover. The driver reported no head injury.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACKGROUND</td>
<td>1</td>
</tr>
<tr>
<td>CRASH CIRCUMSTANCES</td>
<td>1</td>
</tr>
<tr>
<td>CASE VEHICLE: 2008 LEXUS RX 350</td>
<td>2</td>
</tr>
<tr>
<td>Case Vehicle Damage</td>
<td>3</td>
</tr>
<tr>
<td>Automatic Restraint System</td>
<td>4</td>
</tr>
<tr>
<td>Manual Restraint System</td>
<td>5</td>
</tr>
<tr>
<td>Case Vehicle Driver Kinematics</td>
<td>6</td>
</tr>
<tr>
<td>Case Vehicle Driver Injuries</td>
<td>6</td>
</tr>
<tr>
<td>OTHER VEHICLE: 2007 MACK CTP DUMP TUCK</td>
<td>7</td>
</tr>
<tr>
<td>Crash Diagram</td>
<td>8</td>
</tr>
</tbody>
</table>
BACKGROUND

This crash was brought to the National Highway Traffic Safety Administration’s (NHTSA) attention on September 28, 2008 by the sampling activities of the National Automotive Sampling System-General Estimates System. This on-site investigation was assigned on November 12, 2008. The crash involved a 2008 Lexus RX350 (Figure 1) and a 2007 Mack CTP Series dump truck that was pulling an Interstate flat-bed trailer. The crash occurred in September, 2008 at 0922 hours, in Texas and was investigated by the applicable city police department. The focus of this on-site investigation was the Lexus’ rollover. This contractor inspected the Lexus on November 19, 2008 and inspected the crash scene on November 21, 2008. The Mack could not be located and was not inspected. The interview with the Lexus’ driver was completed on November 25, 2008. This report is based on the police crash report, scene and vehicle inspections, driver interview, occupant kinematic principles, and this contractor’s evaluation of the evidence.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the Lexus was traveling was a 2-lane, undivided, city street, traversing in a north-south direction. It formed a 4-leg intersection with the trafficway on which the Mack was traveling. The Lexus’ roadway was 12.2 m (40 ft) in width and had no pavement markings. Parking was allowed on each side of the roadway. The roadway was not controlled by stop signs at the intersection. The trafficway on which the Mack was traveling was a 2-lane, undivided, city street, traversing in an east-west direction. The Mack’s roadway was 8 m (26.2 ft) in width and controlled by a stop sign. The roadway had no pavement markings. The posted speed limit was 48 km/h (30 mph) for both roadways. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and both the roadways were dry, level concrete. The traffic density was light crash and the site of the crash was suburban residential. See the Crash Diagram on page 8 of this report.

Pre-Crash: The restrained 73-year-old female driver of the Lexus was traveling south (Figure 2) and she intended to continue through the intersection. The Mack’s restrained 38-year-old male driver was backing the Mack and trailer east into the 4-leg intersection (Figure 3). The Lexus’ driver stated during the interview that she did not see the Mack and did not take any actions to avoid the crash.

Crash: The front right corner of the Lexus impacted and underrode the back right corner of
the Mack’s trailer (Figure 4). The Lexus’ direction of principal force was within the 12 o’clock sector. The impact engaged only the Lexus’ right fender and the impact force was not sufficient to deploy the driver’s frontal air bag. The impact caused the vehicle to rotate clockwise and it was redirected to the southeast. As the vehicle rotated, it traversed approximately 11 m (36.1 ft). The opposing force between the left side wheels and the pavement produced a roll moment and the vehicle tripped and rolled over, left side leading, one quarter turn. The vehicle traversed an additional 3 m (9.8 ft) on its left side and came to final rest on the north lane heading southwest. The vehicle was equipped with Electronic Stability Control (ESC); however, the impact induced rotation was severe and the driver was unable to regain control prior to the rollover. The vehicle was also equipped with a rollover sensor, which triggered the deployment of the vehicle’s left and right side rollover curtain air bags. The scene inspection revealed a small gouge in the pavement, indicating the general vicinity of the rollover and final rest position of the Lexus (Figure 5).

**Post-Crash:** The police and emergency personnel were notified of the crash at 0927 hours and arrived on the scene in thirteen minutes. A passer-by helped the Lexus’ driver open the vehicle’s sunroof and she crawled out of the vehicle. The driver refused transport to a hospital but subsequently sought medical treatment from a private physician. The driver of the Mack was not injured nor transported to a hospital. The Lexus was towed from the scene due to damage while the Mack was driven from the scene.

**CASE VEHICLE**

The 2008 Lexus RX350 was a front wheel drive, 5-door utility wagon (VIN: 2T2GK31U98C------), equipped with a 3.5L, V-6 engine, automatic transmission, 4-wheel anti-lock disc brakes, traction control, ESC, electronic brake force distribution, and a rollover sensor. The front row was equipped with bucket seats, adjustable head restraints, lap-and-shoulder belts, a tilt and telescoping steering column, driver and
Case Vehicle (Continued)

front right passenger frontal air bags, knee air bags, seat back-mounted side air bags, and rollover side curtain air bags that protected all outboard seating positions. The second row was equipped with a split bench seat with folding backs (40/20/40), adjustable head restraints, lap-and-shoulder belts, and Lower Anchors and Tethers for Children (LATCH) at the outboard seating positions. The vehicle’s mileage at the time of the inspection was 10,005 kilometers (6,217 miles) and the specified wheelbase was 272 cm (107.1 in). The NHTSA has given this vehicle a four star rollover rating on a five star scale and a Static Stability Factor of 1.18. The NHTSA has also assigned this vehicle’s chance of rollover as 19%.

Case Vehicle Damage

Exterior Damage: The Lexus’s initial impact with the trailer involved its extreme front right corner. The bumper bar was not contacted or damaged, but the front right portion of the bumper cover, right fender, right headlamp/turn light assembly, right front wheel, right rocker panel, and both right front and rear doors were directly contacted, and the bumper fascia was torn off the vehicle (Figure 6). Some of the sheet metal on the right front and rear doors had been cut away prior to inspection, but the appearance of the damage to the remaining sheet metal indicated that direct extended onto the right rear door. The direct damage to the frontal plane began at the front right corner and extended 14 cm (5.5 in) across the front of the right fender. Crush measurements were taken both on the bumper bar and at the upper radiator support level. There was no crush on the front bumper bar. The maximum residual crush at the upper radiator support level was 13 cm (5.1 in) and occurred at C6. The table below shows the average of the two levels of crush.

<table>
<thead>
<tr>
<th>Units</th>
<th>Event</th>
<th>Direct Damage Width CDC</th>
<th>Field L</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>Direct</th>
<th>Field L</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm</td>
<td>1</td>
<td>14 13 125 0 0 0 0 7 73 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>5.5 5.1 49.2 0.0 0.0 0.0 0.0 2.8 28.7 0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Lexus’s rollover involved the left side plane (Figures 1 and 7). The direct damage began 24 cm (9.4 in) forward of the left front axle and extended rearward 307 cm (121 in). The
roof structure sustained no lateral crush. The Lexus’ left wheelbase was unchanged and the right wheelbase was shortened 3 cm (1.2 in).

**Damage Classification:** The Collision Deformation Classifications for the Lexus were **12-FREE-8** (0 degrees) for the front impact with the trailer, and **00-LDAO-2** for the rollover. The Barrier algorithm of the WinSMASH program was used to determine a Barrier Equivalent Speed (BES) for the Lexus’s front impact and the BES was 12 km/h (7.5 mph). The severity of the rollover damage was minor based on the extent of damage to the vehicle’s left side.

The vehicle manufacturer’s recommended tire size was P235/55R18. The Lexus was equipped with tires of the recommended size. The vehicle’s tire data are shown in the table below.

<table>
<thead>
<tr>
<th>Tire</th>
<th>Measured Pressure</th>
<th>Manufacturer’s Recommended Cold Pressure</th>
<th>Tread Depth</th>
<th>Damage</th>
<th>Restricted</th>
<th>Deflated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kPa</td>
<td>psi</td>
<td>kPa</td>
<td>psi</td>
<td>millimeters</td>
<td>32nd of an inch</td>
</tr>
<tr>
<td>LF</td>
<td>234</td>
<td>34</td>
<td>207</td>
<td>30</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>LR</td>
<td>234</td>
<td>34</td>
<td>207</td>
<td>30</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>RR</td>
<td>241</td>
<td>35</td>
<td>207</td>
<td>30</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>RF</td>
<td>Flat</td>
<td>Flat</td>
<td>207</td>
<td>30</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

**Vehicle Interior:** The inspection of the Lexus’s interior revealed no discernable occupant contact evidence. All of the window glazing was either closed or fixed and there was no damage to any of the glazing. There was no evidence of steering rim deformation or compression of the energy absorbing steering column, and all of the doors remained closed and operational. The vehicle sustained no passenger compartment intrusion.

**Automatic Restraint System**

The Lexus was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, seat position sensors, seat belt usage sensors, retractor mounted pretensioners and a front right passenger weight recognition sensor. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

The driver’s frontal air bag was located in the steering wheel hub and the front right passenger frontal air bag was located within the middle of the instrument panel. The front impact sensors were located at the driver and passenger side inner fenders. Neither of these air bags deployed during the crash.
The rollover side air bag system of the Lexus consisted of front seat back-mounted air bags and roof side rail-mounted side curtain air bags. The Lexus’ side impact sensors were located within the lower B and C-pillars and the side curtain air bag inflation cylinders were located within the roof rail between the B and C-pillars. The seat back-mounted side air bags were located in the outboard sides of the front seat backs and did not deploy during the crash.

The left rollover side curtain air bag was located along the left roof side rail inside the headliner and extended from the A-pillar to the C-pillar (Figures 8 and 9). The deployed side curtain air bag was 170 cm (67 in) in length and 40 cm (15.7 in) in height. It was attached at the A-pillar by a 30 cm (11.8 in) cloth tether. There was no tether at the C-pillar. The fold creases on the air bag indicated that it had been folded accordion fashion within the headliner. Inspection of the left side curtain showed no discernable occupants contacts, and there was no damage to either the inboard and outboard sides of the air bag. The right side curtain was of the same dimensions and no contacts or damage were found.

**Figure 8:** The Lexus’ left side curtain (rear portion)

**Figure 9:** Left side curtain air bag, front portion

**MANUAL RESTRAINT SYSTEM**

The Lexus was equipped with lap-and-shoulder belts for both front row seating positions and all three second row seating positions. The driver’s seat belt consisted of continuous loop belt webbing, a sliding latch plate, an Emergency Locking Retractor (ELR), and adjustable upper anchor that was located in the full down position. The front right seat belt was equipped with a switchable ELR/Automatic Locking Retractor (ALR), a sliding latch plate, and adjustable upper anchor that was located in the full up position. The front row seat belts were equipped with retractor-mounted pretensioners. The second row seat belts consisted of continuous loop belt webbing, switchable ELR/ALRs, sliding latch plates and fixed upper anchors.

Inspection of the driver’s seat belt system revealed that the pretensioner had actuated. The retractor was jammed and would not retract the seat belt. A length of belt webbing that was 119 cm (46.9 in) in length as measured from the D-ring to the stop button was extended out of the retractor. A friction burn was also present on the D-ring housing (Figure 10). The evidence indicated that the driver was restrained by the lap-and-shoulder belt. The remaining seat positions were unoccupied.
The driver of the Lexus [73-year-old, female; 157 cm and 61 kilograms (62 in and 135 pounds)] was seated in an upright posture with both hands on the steering wheel at the 10 and 2 o’clock positions. The seat track was adjusted to between the full forward and middle positions and the seat back was slightly reclined. The adjustable head restraint was located in the full down position, and the distance from the top of the seat back to the top of the head restraint was 21 cm (8.3 in). The tilt and telescoping steering column was adjusted to the full down and full rear position, respectively. The driver was wearing sunglasses at the time of the crash.

The Lexus’s front impact with the trailer displaced the driver forward opposite the 12 o’clock direction of force and she loaded the lap-and-shoulder belt, which caused a contusion over her sternum and right breast. As the Lexus rotated clockwise, the driver was probably redirected to the left. As the vehicle rolled over onto its left side, the driver was displaced to her left. While there was no discernable evidence of occupant contact, the driver probable loaded her upper left arm on the upper left rear quadrant of the left front door, which caused a contusion on the upper left arm. While there was no discernable occupant contact evidence on the left rollover side curtain air bag, occupant kinematics principles indicated the driver’s head also probably loaded the deployed left rollover side curtain air bag. The driver reported no head injury. She remained restrained in her seat position and came to final rest against the left front door.

**CASE VEHICLE DRIVER INJURIES**

The driver sustained a police reported C (possible) injury but refused transport to a hospital. She was subsequently treated by her private physician and released. The table below shows the injuries that she reported during the interview.

<table>
<thead>
<tr>
<th>Injury Number</th>
<th>Injury Description (including Aspect)</th>
<th>NASS Injury Code &amp; AIS 90</th>
<th>Injury Source</th>
<th>Source Confidence</th>
<th>Source of Injury Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contusion over sternum and right breast</td>
<td>minor 490402.1,1</td>
<td>Torso portion of safety belt system</td>
<td>Certain</td>
<td>Interviewee (same person)</td>
</tr>
<tr>
<td>2</td>
<td>Contusion, 5.1 cm (2 in), left lateral proximal (outer, upper) arm</td>
<td>minor 790402.1,2</td>
<td>Left front door, rear upper quadrant</td>
<td>Probable</td>
<td>Interviewee (same person)</td>
</tr>
<tr>
<td>3</td>
<td>Contusion, 7.6 x 2.5 cm (3 x 1 in) right medial proximal (inside, upper) arm</td>
<td>790402.1,1</td>
<td>Unknown injury source</td>
<td>Unknown</td>
<td>Interviewee (same person)</td>
</tr>
</tbody>
</table>
The 2007 Mack CTP series was a 6 x 4 conventional cab dump truck (VIN: 1M2A504C07M------) that was pulling an Interstate flat bed trailer loaded with a piece of construction equipment.

**Exterior Damage:** The Mack and its trailer could not be located and were not inspected. There were no photographs of the vehicle available and a Truck Deformation Classification (TDC) could not be estimated.

**Other Vehicle’s Driver:** The police crash report indicated that the Mack’s driver [34-year-old, male] was restrained by the lap-and-shoulder belt. He was not injured and not transported to a medical facility.
IN08042
Clear, Daylight
Dry, Level Concrete
Speed Limit Both Roadways = 48 km/h (30 mph)
V1: 2008 Lexus RX350
V2: 2007 Mack CTP Series Dump Truck
pulling an Interstate flat bed trailer loaded
with a piece of construction equipment

Front right corner of V1 impacts
right rear corner of V2's trailer
(Event 1)

V2 backing into intersection

V1 Rolls over onto left side
(Event 2)