

INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER

School of Public and Environmental Affairs
501 South Morton Street Suite 105
Bloomington, Indiana 47403-2452
(812) 855-3908 Fax: (812) 855-3537

ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN09007
LOCATION - MISSOURI
VEHICLE - 2008 HONDA CR-V EX
CRASH DATE - February 2009

Submitted:

September 3, 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.

Technical Report Documentation Page

1. <i>Report No.</i> IN09007		2. <i>Government Accession No.</i>		3. <i>Recipient's Catalog No.</i>	
4. <i>Title and Subtitle</i> On-Site Rollover Investigation Vehicle - 2008 Honda CR-V EX Location - Missouri			5. <i>Report Date:</i> September 3, 2009		
			6. <i>Performing Organization Code</i>		
7. <i>Author(s)</i> Special Crash Investigations Team #2			8. <i>Performing Organization Report No.</i>		
9. <i>Performing Organization Name and Address</i> Transportation Research Center Indiana University 501 South Madison Street, Suite 105 Bloomington, Indiana 47403-2452			10. <i>Work Unit No. (TRAIS)</i>		
			11. <i>Contract or Grant No.</i> DTNH22-07-C-00044		
12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation (NVS-411) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003			13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: February 2009		
			14. <i>Sponsoring Agency Code</i>		
15. <i>Supplementary Notes</i> On-Site Rollover Investigation involving a 2008 Honda CR-V EX.					
16. <i>Abstract</i> This report covers an on-site rollover investigation that involved a 2008 Honda CR-V EX, which departed the roadway and rolled over. This investigation focused on the Honda's rollover and the sources of the driver's injuries. The Honda's restrained 58-year-old female driver was traveling north on a 4-lane divided state highway. The driver fell asleep just prior to entering a right curve and the Honda departed the left (west) side of the roadway. The driver awoke and initiated a right steering maneuver. The vehicle began to rotate clockwise as it traveled along the negative grade of an embankment adjacent to the west shoulder and tripped and rolled over left side leading. The vehicle rolled over 7 quarter turns and came to final rest on its left side on the roadway heading southwest. The vehicle was equipped with inflatable side curtain air bags with rollover sensing and they deployed during the rollover. The driver's seat back-mounted side impact air bag and frontal air bag also deployed. The driver remained restrained in her seat throughout the rollover. She was transported by ambulance to a hospital and treated in the emergency room for minor injuries and released.					
17. <i>Key Words</i> Rollover Side Curtain Air Bag			Motor Vehicle Traffic Crash Injury Severity		18. <i>Distribution Statement</i> General Public
19. <i>Security Classif. (of this report)</i> Unclassified	20. <i>Security Classif. (of this page)</i> Unclassified		21. <i>No. of Pages</i> 10	22. <i>Price</i>	

TABLE OF CONTENTS

IN09007

Page No.

BACKGROUND 1

CRASH CIRCUMSTANCES 1

ROLLOVER DISCUSSION 2

CASE VEHICLE: 2008 HONDA CR-V EX 3

 CASE VEHICLE DAMAGE 3

 EVENT DATA RECORDER 6

 AUTOMATIC RESTRAINT SYSTEM 6

 MANUAL RESTRAINT SYSTEM 7

 CASE VEHICLE DRIVER KINEMATICS 8

 CASE VEHICLE DRIVER INJURIES 9

CRASH DIAGRAM 10

This on-site investigation focused on the rollover of a 2008 Honda CR-V EX (**Figure 1**), and the sources of the driver's injuries. This crash was brought to the National Highway Traffic Safety Administration's (NHTSA) attention on February 27, 2009 by this contractor. This investigation was assigned on February 27, 2009. The crash occurred in February, 2009 at 2108 hours, in Missouri and was investigated by the Missouri State Highway Patrol. The Honda was inspected on March 3, 2009 and the crash scene on March 5, 2009. The driver's husband, who was following the driver at the time of the crash, was interviewed on March 21, 2009. The driver was present at the time of the interview but spoke little English. This report is based on the police crash report, vehicle and crash scene inspections, an exemplar vehicle inspection, interview information, occupant kinematic principles, driver medical records, and evaluation of the evidence.



Figure 1: The damaged 2008 Honda CR-V EX

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the Honda was traveling was a 4-lane, divided state highway that traversed in a nominal north-south direction. The trafficway had two travel lanes in each direction separated by a grass median and was bordered by bituminous shoulders. Each travel lane was approximately 3.6 m (11.8 ft) in width and the median was 28.3 m (92.8 ft) in width. The outside and inside shoulders were 3.7 m (12.1 ft) and 3.1 m (10.2 ft) in width, respectively. The roadway pavement markings consisted of solid white outside edge lines, broken white lane lines, and solid yellow median lines. The Honda's roadway was initially straight and curved right prior to the area of roadway departure. The roadway's radius of curvature in this area was 1143 m (3750 ft). The roadway was superelevated positive 5.2% to the west and had a positive 1% grade. The posted speed limit was 105 km/h (65 mph). At the time of the crash the light condition was dark with no artificial lighting. The atmospheric condition was cloudy and the roadway pavement was wet bituminous. The traffic density was light and the site of the crash was rural. The Crash Diagram can be seen on page 10 of this report.

Pre-Crash: The Honda's restrained 58-year-old female driver was traveling north in the straight section of the roadway approaching the right curve. Based on the SCI interview, the driver fell asleep and the vehicle continued straight as it entered the curve and departed the left side of the roadway (**Figure 2**). The driver awoke and initiated a right steering maneuver. The vehicle entered the median and began to rotate clockwise



Figure 2: Approach of the Honda to roadway departure (arrow); number shows feet to departure point from the shoulder into the median

at it traveled along the negative grade of an embankment adjacent to the west shoulder (Figure 3).

Crash: As the vehicle approached the top of the embankment (Figure 4), it tripped and rolled over, driver side leading, across the west shoulder and onto the roadway. During the rollover, the vehicle's rollover sensor triggered deployment of the inflatable side curtain air bags, and the left front seat back-mounted side impact air bag deployed. The corners of the front bumper engaged the ground during the rollover and the driver's frontal air bag also deployed. The vehicle came to final rest in the center of the roadway heading southwest.

Post-Crash: The police were notified of the crash at 2113 hours and arrived on scene at 2124 hours. Emergency medical personnel also responded to the crash scene. Emergency medical personnel removed the driver from the vehicle through the back hatch and transported her by ambulance to a hospital. The vehicle was towed due to damage.

ROLLOVER DISCUSSION

The Honda's rollover mitigation features consisted of rollover sensing and Electronic Stability Control (ESC). The NHTSA has given the vehicle a four star rollover rating on a five star scale and a Static Stability Factor of 1.26¹. A four star rating indicates that the vehicle has a 10%-20% chance of a rollover when involved in a single vehicle crash. The specific chance of a rollover for this vehicle model was given as 15%. The Static Stability Factor (SSF) is a calculation based on the vehicle's track width and height of its center of gravity. The result of the calculation is a measure of a vehicle's resistance to rollover. A higher SSF indicates a more stable vehicle. The majority of passenger vehicles have an SSF of 1.30 to 1.50². The test vehicle also did not tip-up during the dynamic steering maneuver test in which the test vehicle is put through a fish-hook shaped steering maneuver (i.e., hard left and hard right steer) at between 56 km/h-80km/h (35-50 mph).



Figure 3: Orange paint marks and arrows show Honda's path of travel along the embankment



Figure 4: Arrow shows area where vehicle tripped and began to rollover driver side leading

¹ www.safercar.gov, 8/18/09

² "Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans", NHTSA Technical Report, DOT HS 809 868, June 2005

The Honda departed the west side of the roadway and traveled along the embankment for 61 m (200 ft) as the driver continued to steer to the right. As the vehicle approached the top of the embankment, the left side tires furrowed into the ground, which tripped the vehicle and it rolled over, driver side leading, across the shoulder and onto the roadway. The damage from the rollover was located primarily on the hood, tops of the fenders, A-pillars and front portion of the roof (**Figure 5**). The vehicle rolled over 7 quarter turns across a distance of 33.3 m (109.2 ft) and came to final rest in the center of the northbound lanes on its left side heading southwest (**Figure 6**).

CASE VEHICLE

The 2008 Honda CR-V EX was an all wheel drive, 4-door, sport utility vehicle (VIN: JHLRE48538C-----) that was manufactured in April 2008. It was equipped with a 2.4L engine, 5-speed automatic transmission, 4-wheel anti-lock disc brakes with electronic break force distribution, traction control and electronic stability control. The front row was equipped with bucket seats, adjustable, active head restraints, lap-and-shoulder belts, dual stage driver and front right passenger frontal air bags, seat back-mounted side impact air bags, and inflatable side curtain air bags with rollover sensing that provided protection for the front and second row. The second row was equipped with a split bench (40/60) with split folding backs, adjustable head restraints, lap-and-shoulder belts, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions.. The vehicle was equipped with an electronic odometer and the mileage at the time of the inspection could not be determined since the vehicle was without power. The driver’s husband estimated the vehicle’s mileage as approximately 22,530 kilometers (14,000 miles). The vehicle’s specified wheelbase was 262 cm (103.1 in).

CASE VEHICLE DAMAGE

Exterior Damage: The damage from the rollover involved the top and both sides of the Honda. The direct damage on the top plane (**Figures 5 and 7**) began at the front of the hood and extended to 72 cm (28.3 in) rear of the right B-pillar and 4 cm (1.6 in) rear of the left B-pillar. It involved the full width of the roof, 103 cm (40.6 in). The direct damage on the left side (**Figure 1**) began

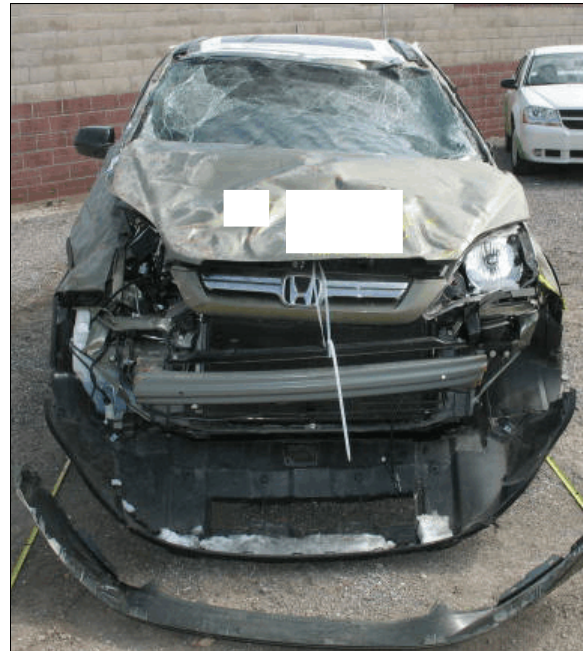


Figure 5: Front view of the damage from the rollover



Figure 6: View back through the area of final rest (arrow) to the path of the rollover

43 cm (16.9) rear of the left rear axle and extended 375 cm (147.6 in) forward to the corner of the front bumper bar. The direct damage on the right side (**Figure 8**) was located along the roof side rail, A-pillar, and the top portion of the fender. It began 46 cm (18.1 in) forward of the right rear axle and extended 289 cm (113.8 in) forward to the corner of the front bumper bar. The maximum residual vertical crush (**Figures 9 and 10**) was 10 cm (3.9 in) and occurred on the windshield header 31 cm (12.2 in) right of the top of the left A-pillar. There was no lateral crush of the roof structure.



Figure 7: Damage to the top plane



Figure 8: Damage to right side from the rollover



Figure 9: Maximum vertical crush occurred to the windshield header

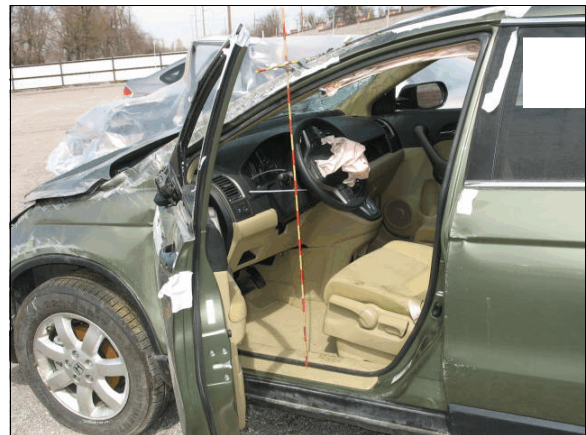


Figure 10: Left side view of measurement scale for maximum vertical crush

Damage Classification: The Honda's Collision Deformation Classification was **00-TYDO-3**. The WinSMASH program could not be used on this crash because rollovers are out of scope for the program. Based on the extent of the roof crush, the severity of the rollover damage was moderate.

The vehicle manufacturer's recommended tire size was P225/65R17. The Honda was equipped with tires of the recommended size. The vehicle's tire data are shown in the table below.

Tire	Measured Pressure		Vehicle Manufacturer's Recommended Cold Tire Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	193	28	207	30	5	6	None	No	No
LR	Flat	Flat	207	30	6	8	Bead separated	Yes	Yes
RR	207	30	207	30	6	8	None	No	No
RF	193	28	207	30	5	6	None	No	No

Vehicle Interior: The inspection of the Honda's interior revealed two possible occupant contact scuffs on the frontal air bag, possibly from contact by the driver's forearms. A scuff and slight impression 29 cm (11.4 in) in length was located on the edge of the left front door armrest and the plastic below it was broken (**Figure 11**). It was probably due to the driver's left hip contacting the armrest. Two small scuffs, one on the roof and one on the sunroof panel (**Figure 12**) were located directly above and to the right of the driver's seat. They were possibly related to contact by the driver's right hand. Several small blood stains were also located at the top of the left A-pillar. These appeared to be blood spatter and not direct occupant contact.



Figure 11: Occupant contact on left front door arm rest

All the vehicle's doors remained closed and operational during the crash. The pre-crash condition of all the window glazing was either fixed or closed. The windshield was in place and cracked from impact forces, while the left front and right front window glazings were disintegrated due to impact forces.

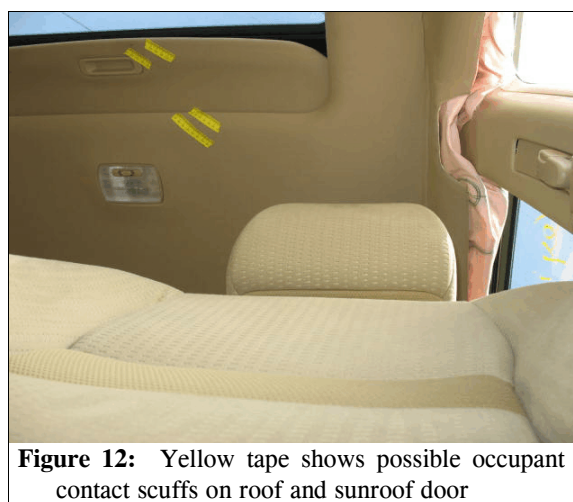


Figure 12: Yellow tape shows possible occupant contact scuffs on roof and sunroof door

The vehicle's passenger compartment sustained 11 intrusions due to the rollover. The most severe intrusions into the driver's occupant space involved the left A-pillar, roof, windshield header and the windshield. These components intruded vertically 7 cm (2.8 in), 9 cm (3.5 in), 9 cm (3.5 in), and 16 cm (6.3 in), respectively.

The Honda's Air Bag Control Module (ACM) was removed from the vehicle and sent to NHTSA headquarters in Washington D.C. for shipment to the manufacturer for imaging of the data. The manufacturer's report indicated that the vehicle's impact and rollover sensing systems detected a front impact, rollover, and left side impact. The ACM commanded deployment of the driver's frontal air bag, both inflatable side curtain air bags, and the driver's seat back-mounted side impact air bag. The driver's seat belt was recorded as buckled and the driver's seat belt pretensioners were commanded to actuate. The driver's seat position sensor recorded the seat in the far position (not defined in report). The vehicle's rollover sensor detected a left side leading rollover. No other information regarding rollover sensing was reported. The side impact sensor located in the left B-pillar detected a side impact during the rollover. The "safing on time" and "delta-t on time" for the driver's seat back-mounted side impact air bag were both reported as 41.5 msec. The "front crash sensor on time" was reported as -14 msec. The ACM Electronic Control Unit "on time" for the frontal air bag was reported as 46 msec. It was not clear in the report how the terms in quotations specifically relate to the activation of the vehicle's crash sensing system and the deployment of the respective air bags.

AUTOMATIC RESTRAINT SYSTEM

The Honda was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger frontal air bags, driver seat position sensor, seat belt usage sensors, retractor and seat belt buckle mounted pretensioners and a front right passenger weight sensor. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the frontal air bag impact sensors were located on the left and right inner fenders. 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 Honda was also equipped with inflatable side curtain air bags with rollover sensing and front seat back-mounted side impact air bags. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the vehicle's side impact sensors were located within the lower B and C-pillars. The inflatable side curtain air bag inflators were located under the roof panel forward of the hatchback opening. Both inflatable side curtain air bags and the left front seat back-mounted side impact air bag deployed in this crash.

The driver's frontal air bag deployed during the crash while the front right passenger air bag did not deploy, since no front right passenger was seated in the vehicle. The driver's frontal air bag was located in the steering wheel hub and the module cover was a three flap configuration constructed of pliable vinyl. The top flap was 13 cm (5.1 in) in width and 11 cm (4.3 in) in height at the Honda emblem. Each bottom flap was



Figure 13: The driver's frontal air bag; each increment on measurement rods is 5 cm (2 in); steering wheel is rotated clockwise approximately 90 degrees

triangular-shaped and was 7.5 cm (3 in) in width and height as measured along the tear seams. An inspection of the air bag module cover flaps revealed that they opened at the designated tear points. The deployed air bag (**Figure 13**) was round with a diameter of 50 cm (19.7 in) and was designed with two 4 cm (1.6 in) vent ports located on the back of the air bag at the 11 and 1 o'clock positions. Inspection of the air bag revealed no damage and two possible occupant contact scuffs. One scuff was located within the left upper quadrant and the other within the right upper quadrant.



Figure 14: The driver's seat, left inflatable side curtain air bag, seat back-mounted side impact air bag, and frontal air bag

The left inflatable side curtain air bag was located along the left roof side rail (**Figures 14**) inside the headliner and extended from the A-pillar to the D-pillar. It was designed with inflation chambers adjacent to the driver and second row left seat positions. The deployed inflatable side curtain air bag was 166 cm (65.4 in) in width and 44 cm (17.3 inches) in height. It extended 12 cm (4.7 in) below the beltline. The gap between the front center of the air bag and the A-pillar was 28 cm (11 in). The inflatable side curtain air bag was attached at the A-pillar by a 27 cm (10.6 in) rope tether, which had been cut in two, probably by rescue personnel. There was no visible tether at the D-pillar. There was no discernible occupant contact evidence on the air bag and it sustained no damage. The right inflatable side curtain air bag was of the same dimensions and features.



Figure 15: Location of the left front seat back-mounted side impact air bag module

The driver's seat back-mounted side impact air bag was located in the outboard side of the seat back (**Figures 14** and **15**) and deployed from behind a triangular-shaped plastic trim panel on the side of the seat. The deployed air bag was 35 cm (13.8 inches) in height and 28 cm (11 in) in width at the top. Inspection of the deployed air bag revealed no damage and no discernible evidence of occupant contact.

MANUAL RESTRAINT SYSTEM

The Honda was equipped with lap-and-shoulder belts for the driver and front right seating positions. The driver's seat belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), sliding latch plate, and an adjustable upper anchor that was in the full-down position. The front right seat belt was equipped with a switchable ELR/Automatic Locking

Retractor (ALR), sliding latch plate, and adjustable upper anchor that was also located in the full-down position. The driver and front right passenger seat belts were equipped with retractor-mounted and buckle-mounted pretensioners. The second row lap-and-shoulder belts consisted of continuous loop belt webbing, sliding latch plates, ALRs, and fixed upper anchors.

Inspection of the driver's seat belt assembly revealed that both the retractor-mounted and buckle-mounted pretensioners actuated in the crash. The retractor was jammed with a length of belt webbing extended out of the retractor consistent with usage by the driver. The length of the buckle stalk was reduced 2 cm (0.8 in) due to actuation of the pretensioner. The latch plate showed historical usage scratches and slight load abrasions were present on the latch plate belt guide. The evidence indicated that the driver was restrained by the lap-and-shoulder belt. The remaining seat positions were unoccupied.

CASE VEHICLE DRIVER KINEMATICS

Based on the SCI interview, the Honda's driver (58-year-old, female; 142 cm and 49 kg (56 in, 108 lbs) was seated in an upright position with her back against the seat back, feet on the floor, and both hands on the steering wheel. The seat track position was adjusted one notch rear of the full-forward position and the seat back was slightly reclined. The tilt steering column was located in the center position and the telescoping adjustment was located in the full-back position.

Prior to the rollover, the Honda was in a clockwise yaw and the driver was steering to the right as it traveled along the embankment. As a result, the driver was probably leaned to the left to some extent. As the vehicle rolled over with the left side leading, the driver was displaced to the left and toward the roof within the seat belt. During the rollover, the left rear wheel impacted the west shoulder. The impact was of sufficient force to gouge the pavement (**Figure 16**) and damage the wheel (**Figure 17**) altering its camber angle to approximately positive 15 degrees. The driver probably loaded through the deployed inflatable side curtain air bag and her left shoulder probably contacted the left front window sill, which caused a sprained left shoulder. During the rollover, she also sustained an abrasion on the left side of the neck due to contacting the seat belt webbing and multiple abrasions on the right fingers from flying glass fragments from the disintegrated left front window glazing. The driver sustained no other injuries and remained restrained in her seat throughout the rollover. She was removed from the vehicle by emergency



Figure 16: Gouge on the shoulder due to impact by the Honda's left rear wheel



Figure 17: Damage to the Honda's left rear wheel

medical personnel through the back hatch and was transported by ambulance to a hospital. The driver’s medical records indicated that the extrication took approximately 20 minutes.

CASE VEHICLE DRIVER INJURIES

The driver was treated in the hospital emergency room and released. She received no follow-up treatment and lost three work days as a result of the crash. The table below shows the driver’s injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Sprain {strain} left shoulder with pain left arm, not further specified	minor 751020.1,2	Left front window sill	Probable	Emergency room records
2	Abrasion on left side of neck, not further specified	minor 390202.1,2	Torso portion of safety belt system	Certain	Interviewee (relative)
3	Abrasions, multiple, right fingers and/or hand with embedded glass in fingers	minor 790202.1,1	Noncontact injury: flying glass, left front glazing	Certain	Emergency room records

