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# ON-SITE VEHICLE ROLLOVER INVESTIGATION

CASE NUMBER - IN-07-005
LOCATION - OKLAHOMA
VEHICLE - 2006 CHEVROLET C3500 CREW CAB PICKUP TRUCK
CRASH DATE - December 2006

Submitted:

April 5, 2007
Revised: May 14, 2008


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

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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.

**Technical Report Documentation Page**

| | | | |
|---|---|---|---|
| 1. *Report No.*<br>IN-07-005 | 2. *Government Accession No.* | 3. *Recipient's Catalog No.* | |
| 4. *Title and Subtitle*<br>On-Site Rollover Investigation<br>Vehicle - 2006 Chevrolet C3500 Crew Cab Pickup Truck<br>Location - Oklahoma | | 5. *Report Date:*<br>April 5, 2007<br>6. *Performing Organization Code* | |
| 7. *Author(s)*<br>Special Crash Investigations Team #2 | | 8. *Performing Organization Report No.* | |
| 9. *Performing Organization Name and Address*<br>Transportation Research Center<br>Indiana University<br>222 West Second Street<br>Bloomington, Indiana 47403-1501 | | 10. *Work Unit No. (TRAIS)*<br>11. *Contract or Grant No.*<br>DTNH22-07-C-00044 | |
| 12. *Sponsoring Agency Name and Address*<br>U.S. Department of Transportation (NPO-122)<br>National Highway Traffic Safety Administration<br>National Center for Statistics and Analysis<br>Washington, D.C. 20590-0003 | | 13. *Type of Report and Period Covered*<br>Technical Report<br>Crash Date: December 2006<br>14. *Sponsoring Agency Code* | |
| 15. *Supplementary Notes*<br>On-site rollover investigation involving a 2006 Chevrolet C3500 crew cab pickup truck with manual safety belts and dual front redesigned air bag system. | | | |
| 16. *Abstract*<br>This report covers an on-site investigation of a rollover crash that involved a 2006 Chevrolet C3500 crew cab pickup truck pulling a 7.3 meter (24 foot) twin axle, goose neck, cattle trailer. This crash is of special interest because the Chevrolet rolled over and the Chevrolet's driver (19-year-old, male) and front right passenger (20-year-old, male) were not injured. The Chevrolet was traveling west-southwest in the outside through lane of an Interstate highway. The driver stated he fell asleep. The Chevrolet drifted to the right and departed the north side of the roadway and rolled over two quarter turns. The Chevrolet came to rest on the north shoulder on its top facing west-southwest. The Chevrolet's trailer remained coupled to its hitch and came to rest on the roadside on its top facing southwest. Both the driver and front right passenger were restrained by their integral lap-and-shoulder safety belt systems. | | | |
| 17. *Key Words*<br>Rollover<br>Event Data Recorder<br>Motor Vehicle Traffic Crash<br>Injury Severity | | 18. *Distribution Statement*<br>General Public | |
| 19 *Security Classif. (of this report)*<br>Unclassified | 20. *Security Classif. (of this page)*<br>Unclassified | 21. *No. of Pages*<br>11 | 22. *Price* |

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This single vehicle crash was brought to NHTSA's attention on or before February 1, 2007 by NASS GES sampling activities. It involved a 2006 Chevrolet C3500 crew cab pickup truck, which was pulling a 7.3 meter (24 foot) twin axle, goose neck, cattle trailer that departed the roadway and rolled over. The crash occurred in December 2006 at 3:53 a.m., in Oklahoma and was investigated by the Oklahoma Department of Public Safety. This crash is of special interest because the Chevrolet rolled over and the Chevrolet's driver (19-year-old, male) and front right passenger (20-year-old, male) were not injured. The Chevrolet was equipped with multiple Advanced Occupant Protection System (AOPS) features and an Event Data Recorder (EDR). This contractor conducted and on-site investigation on February 13, 2007 and inspected the scene, Chevrolet, trailer and downloaded the EDR. A telephone interview was conducted on March 2, 2007 with the Chevrolet's driver. This report is based on the police crash report, scene inspection, vehicle and trailer inspections, Chevrolet driver interview, EDR data, occupant kinematic principles, and this contractor's evaluation of the evidence.

## SUMMARY

The Chevrolet was traveling west-southwest in the outside through lane of a four-lane divided interstate highway. The driver stated during the interview that he fell asleep. The Chevrolet drifted to the right and departed the north roadside and rolled over two quarter turns. The Chevrolet came to rest on the north shoulder on its top facing west-southwest. The Chevrolet's trailer remained coupled to its hitch and came to rest on the roadside on its top facing southwest. At the time of the crash the light condition was dark, the weather was cloudy, and the roadway pavement was dry.

The Collision Deformation Classification (CDC) for the Chevrolet's rollover event was determined to be: **00-TYDO-3**. The maximum vertical crush occurred at the windshield header approximately 6 centimeters (2.4 inches) right of the right A-pillar. There was no measurable lateral crush to the roof structure. Rollovers are out-of-scope for the WinSMASH reconstruction program. However, based on the extent of the roof crush, the severity was determined to be moderate. The Chevrolet was towed due to damage.

Both the driver and front right passenger were restrained by their integral lap-and-shoulder safety belt system. They remained restrained in their respective seat positions during the rollover and were not injured. The safety belt usage mitigated the interaction between the occupants and the Chevrolet's interior components.

## CRASH CIRCUMSTANCES

***Crash Environment:*** The trafficway on which the Chevrolet was traveling was a straight, four-lane, divided, interstate highway, traversing in an east-northeasterly and west-southwesterly direction. Each roadway had two through lanes and was bordered by bituminous shoulders with a rumble strip. Each travel lane was approximately 3.7 meters (12 feet) in width. The outside shoulders were approximately 3 meters (10 feet) in width. The Chevrolet's approach roadway had a positive 2.9% grade. The trafficway was divided by a concrete jersey barrier and the speed

limit was 121 km.p.h. (75 m.p.h.). There was no regulatory speed limit sign posted near the crash site. The roadway pavement markings consisted of solid white edge lines, broken white center lines and solid yellow median edge lines. At the time of the crash the light condition was dark, the weather was cloudy, and the roadway pavement was dry, traffic polished bituminous. The traffic density at the time of the crash was light, and the site of the crash was rural. See the Crash Diagram at the end of this report.

***Pre-Crash:*** The Chevrolet was traveling west-southwest in the outside through lane (**Figure 1**) at a driver reported speed of 113 km.p.h. (70 m.p.h.). The driver intended to continue straight ahead. The driver stated during the interview that he fell asleep. The Chevrolet drifted to the right, departed the north roadside, crossed the shoulder and traveled onto the grassy roadside and down and across an embankment (**Figures 2** and **3**). The Chevrolet's driver steered left in an attempt to reenter the roadway. As a result, the Chevrolet began to rotate counterclockwise and the trailer began to jackknife. The Chevrolet's EDR data indicated that the driver was applying the brakes prior to the rollover. The rollover occurred on the grass embankment on the north side of the road as the Chevrolet was ascending the embankment while attempting to reenter the roadway (**Figure 4**).

**Figure 1:** View opposite approach of Chevrolet from the area of final rest

**Figure 2:** View of area where the Chevrolet departed the north shoulder

**Figure 3:** Chevrolet's tire marks (left and center arrows) and trailer tire marks (right arrow) in grass approaching rollover location

**Figure 4:** Chevrolet's approach to rollover, divots in ground (arrows) show contact of trailer during rollover

***Crash:*** As the Chevrolet traversed the embankment, it rotated counterclockwise approximately 40 degrees at which point the trailer began to rollover right side leading followed by the vehicle rolling over passenger side leading. The vehicle rolled over two quarter turns and slid on its top along the shoulder. The Chevrolet's air bags did not deploy in this crash because the vehicle's longitudinal deceleration during the rollover was not sufficient to require their deployment.

***Post-Crash:*** The Chevrolet came to rest on the north shoulder on its top facing west-southwest. The vehicle's trailer remained coupled to its hitch and came to rest on the roadside on its top facing southwest.

## CASE VEHICLE

The 2006 Chevrolet C3500 was a rear wheel drive, 4x2, four-door, crew cab, long bed pickup truck (VIN: 1GCJC33D26F------) equipped with a 6.6L, V8 diesel engine, automatic transmission and four wheel, anti-lock disc brakes. The front seating row was equipped with bucket seats with adjustable head restraints, redesigned driver and front right passenger air bags, and driver and front right passenger integral lap-and-shoulder safety belt systems. The back seating row was equipped with a bench seat with folding backs, three point, lap-and-shoulder safety belts, adjustable head restraints in the outboard seating positions and an integral head restraint in the center seating position. The vehicle was also equipped with an EDR and a LATCH system for securing child safety seats. The Chevrolet was towing a 7.3 meter (24 foot), twin axle, gooseneck cattle trailer. The trailer hitch mechanism was located within the truck bed.

## CASE VEHICLE DAMAGE

The direct contact damage involved the top and right side of the Chevrolet. Pavement grinding marks were observed on the hood, roof, right A-pillar and right fender. Dirt and damage folds were present on the left fender, and the left side view mirror was broken off the vehicle. This damage was most likely due to vehicle removal as the vehicle was rolled back over onto its wheels. The maximum vertical crush was located at the windshield header, approximately 6 centimeters (2.4 inches) right of the right A-pillar (**Figure 5** and **Figure 6** below), and measured 8 centimeters (3 inches) in depth. There was no lateral crush to the roof structure. Induced damaged involved the truck bed, which interacted with the trailer during the rollover (**Figures 7** and **8** below), and the roof. The Chevrolet's wheelbase was unchanged due to the crash.

**Figure 5:** Front right view of Chevrolet's rollover damage, arrow shows location of maximum vertical crush to windshield header

**Figure 6:** Front left view of Chevrolet's rollover damage

**Figure 7:** Left side view of Chevrolet's rollover damage, damage to truck bed due to interaction with trailer during rollover

**Figure 8:** Damage to right side of truck bed due to interaction with the trailer during the rollover

**Figure 9:** Front right view of trailer, arrows show grass jammed in running board and front frame

Damage to the trailer involved the right side and top. Grass was embedded in the right front running board and front frame rail **(Figure 9)**, and the front left corner of the top was dented (**Figure 10**). In addition, there were dirt deposits across the top of the trailer.

The manufacturer's recommended tire size was P215/85R16. The Chevrolet was equipped with LT215/85R16 size tires. The Chevrolet's tire data are shown in the table below. The pressure of the rear tires is indicated as unknown in the table because their pressure exceeded the 60 PSI limit of the tire pressure gauge.

**Figure 10:** Rollover damage to top of trailer

| *Tire* | *Measured Pressure* | | *Recommend Pressure* | | *Tread Depth* | | *Damage* | *Restricted* | *Deflated* |
|---|---|---|---|---|---|---|---|---|---|
| | kPa | psi | kPa | psi | milli-meters | 32nd of an inch | | | |
| LF | 414 | 60 | 448 | 65 | 4 | 5 | None | No | No |
| RF | 379 | 55 | 448 | 65 | 4 | 5 | None | No | No |
| LR Outside | Unk | Unk | 448 | 65 | 5 | 6 | None | No | No |
| LR Inside | Unk | Unk | 448 | 65 | 4 | 5 | None | No | No |
| RR Inside | Unk | Unk | 448 | 65 | 4 | 5 | None | No | No |
| RR Outside | Unk | Unk | 448 | 65 | 4 | 5 | None | No | No |

***Vehicle Interior:*** The inspection of the Chevrolet's interior (**Figures 11** and **12**) revealed a possible occupant contact on the right roof side rail just behind the right A-pillar. No other evidence of occupant contact was observed on any of the interior surfaces or components. The Chevrolet's passenger compartment sustained several intrusions during the rollover. The three most severe intrusions involved the interior roof structure, which intruded vertically into the front left, middle and right seating positions. The intrusions from left to right were respectively: 16 centimeters (6.3 inches), 17 centimeters (7 inches) and 12 centimeters (4.7 inches). There was no evidence of compression of the energy absorbing steering column or deformation of the steering wheel rim.

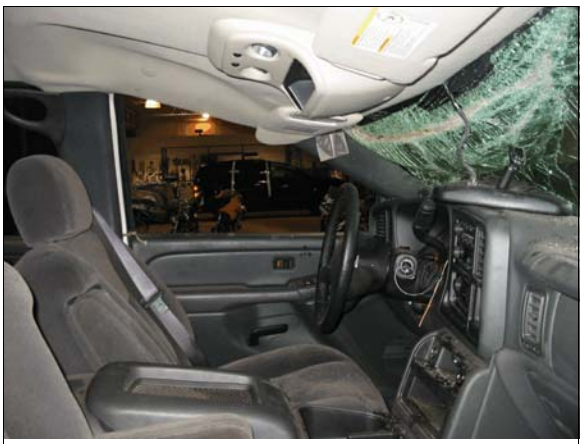


**Figure 11:** View of Chevrolet driver's seat position, roof intrusion and windshield header intrusion

**Figure 12:** View of Chevrolet's front right passenger seating area

***Damage Classification:*** The CDC for the Chevrolet's rollover event was determined to be: **00-TYDO-3**. Rollovers are out-of-scope for the WinSMASH reconstruction program. However,

based on the extent of the roof crush, the rollover severity was determined to be moderate. The Chevrolet was towed due to damage.

**AUTOMATIC RESTRAINT SYSTEM**

The Chevrolet was equipped with redesigned driver and front right passenger air bags. The driver's air bag was located within the steering wheel hub and the front right passenger air bag was located in the middle of the instrument panel. Neither air bag deployed in this crash. The Chevrolet sustained insufficient longitudinal deceleration during the rollover to command air bag deployment in this crash.

**EVENT DATA RECORDER**

The Chevrolet's EDR was downloaded via the diagnostic link connector during the vehicle inspection. The data indicated that a non-deployment event was recorded and that multiple events were associated with the EDR record. The EDR data indicated that the driver's safety belt switch circuit was recorded as buckled and the SIR warning lamp was recorded as off. The EDR report is attached at the end of this report.

**CASE VEHICLE DRIVER KINEMATICS**

Immediately prior to the crash, the driver [19-year-old, white (non-Hispanic) male, 170 centimeters and 100 kilograms (67 inches, 220 pounds)] was seated upright but leaning to the right and had fallen asleep. The driver last recalled having his hands on the steering wheel at the 5 and 8 o'clock positions. His left foot was on the floor and his right foot was on the accelerator pedal. The driver's seat track was located in the middle position and his seat back was slightly reclined. The tilt steering column was located in the center position. The driver was wearing contact lenses at the time of the crash.

Based on the driver interview and supported by the EDR data, the Chevrolet's driver was restrained by the integral lap-and-shoulder safety belt system. Inspection of the safety belt assembly showed no evidence of loading, which is not unusual for a restrained driver in a rollover crash.

It is probable that the driver was awakened as the Chevrolet crossed the rumble strip on the outside shoulder. As the vehicle traveled down the embankment, the driver steered left and applied the brakes. It is probable that his safety belt retractor locked. As the Chevrolet began to rotate counterclockwise, the driver likely leaned to the right within his safety belt. As the Chevrolet began to roll over, right side leading, the driver was redirected to the right and then toward the roof while he loaded his safety belt. He remained restrained in the seat and continued to load his safety belt as the vehicle rolled over two quarter turns and slid to final rest on its roof. The driver stated he broke the left front window and exited the vehicle through the window opening.

The driver of the Chevrolet was not injured during the crash.

## CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

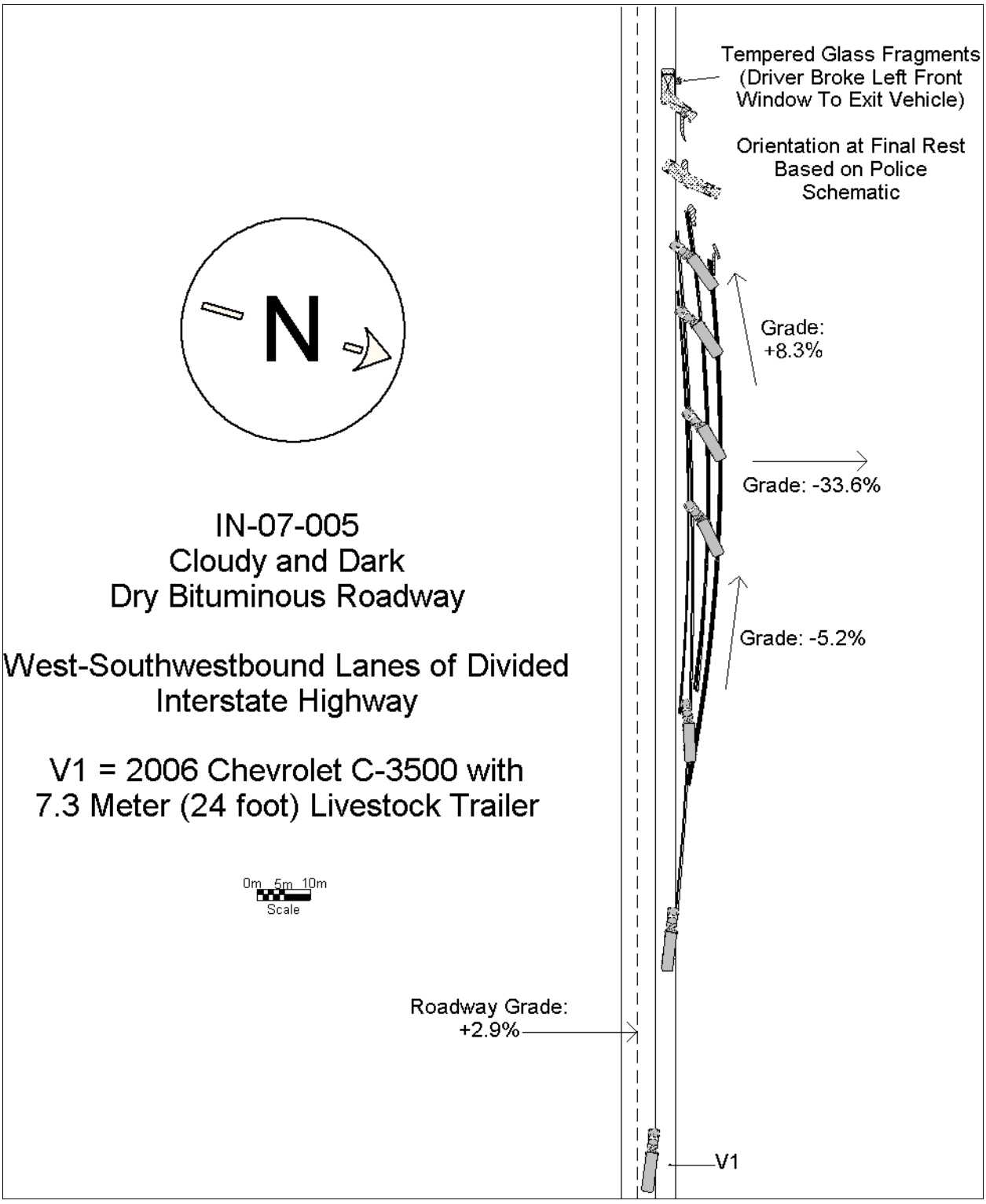
Immediately prior to the crash, the Chevrolet's front right passenger [20-year-old, white (non-Hispanic) male, 200 centimeters and 123 kilograms (77 inches, 270 pounds)] was seated in an upright position and asleep. He had both feet on the floor, but the position of his hands and feet was not determined. Based on the vehicle inspection, the front right passenger's seat track was located in the full rear position and his seat back was slightly reclined. The front right passenger was wearing contact lenses at the time of the crash.

Based on the driver interview, the front right passenger was restrained by the integral safety belt system. Inspection of the safety belt assembly showed no evidence of loading, which is not unusual for a restrained passenger in a rollover crash.

It is probable that the front right passenger was awakened as the Chevrolet crossed the rumble strip on the outside shoulder. However, his position likely did not change significantly. As the vehicle began to rotate counterclockwise, the front right passenger most likely leaned to the right within his safety belt and up against the right front door. As the vehicle began to roll over, right side leading, the front right passenger moved to the right against the right front door and then toward the roof, and he loaded his safety belt. He remained restrained throughout the crash sequence. Given the passenger's height, he likely loaded on the roof side rail and/or roof with his head as the vehicle rolled over. The front right passenger exited the vehicle under his own power.

## CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right passenger was not injured during the crash.


N
IN-07-005
Cloudy and Dark
Dry Bituminous Roadway
West-Southwestbound Lanes of Divided Interstate Highway
V1 = 2006 Chevrolet C-3500 with 7.3 Meter (24 foot) Livestock Trailer
0m 5m 10m
Scale
Tempered Glass Fragments (Driver Broke Left Front Window To Exit Vehicle)
Orientation at Final Rest Based on Police Schematic
Grade: +8.3%
Grade: -33.6%
Grade: -5.2%
Roadway Grade: +2.9%
V1

## CDR File Information

| | |
|---|---|
| Vehicle Identification Number | 1GCJC33D26F****** |
| Investigator | |
| Case Number | |
| Investigation Date | |
| Crash Date | |
| Filename | IN07005.CDR |
| Saved on | Tuesday, February 13 2007 at 02:09:21 PM |
| Collected with CDR version | Crash Data Retrieval Tool 2.800 |
| Collecting program verification number | 9238B95E |
| Reported with CDR version | Crash Data Retrieval Tool 2.800 |
| Reporting program verification number | 9238B95E |
| Interface used to collected data | Block number: 00<br>Interface version: 4A<br>Date: 11-08-05<br>Checksum: 7500 |
| Event(s) recovered | Non-Deployment |

## SDM Data Limitations

SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.
The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within 25.4 seconds of one another. Deployment Events cannot be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the Non-Deployment Event file will be locked after a Deployment Event, if the Non-Deployment Event occurred within 5 seconds before the Deployment Event. If multiple Non-Deployment Events occur within 5 seconds prior to a Deployment Event, then the most severe Non-Deployment Event will be recorded and locked. If multiple Non-Deployment Events precede a Deployment Event, and multiple Non-Deployment Events occur within 5 seconds of each other (but not necessarily all within 5 seconds of the Deployment Event), and subsequent Non-Deployment Events are less severe than prior Non-Deployment Events, and the last of the multiple Non-Deployment Events occurs within 5 seconds of a Deployment Event, then the most severe of the Non-Deployment Events (which may have occurred more than 5 seconds prior to the Deployment Event) will be recorded and locked.

SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For Deployment Events and Deployment Level Events, the SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. For Non-Deployment Events, the SDM will record the first 150 milliseconds of data after algorithm enable.
-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.
-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.
-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM receive an invalid message from the module sending the pre-crash data.
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Belt Switch Circuit may be reported other than the actual state.
-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than 25.4 seconds, "N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-Multiple Events Associated with this Record: This parameter will indicate whether one or more associated events preceded the recorded event.

Chevrolet's CDR File Information and SDM Data Limitations

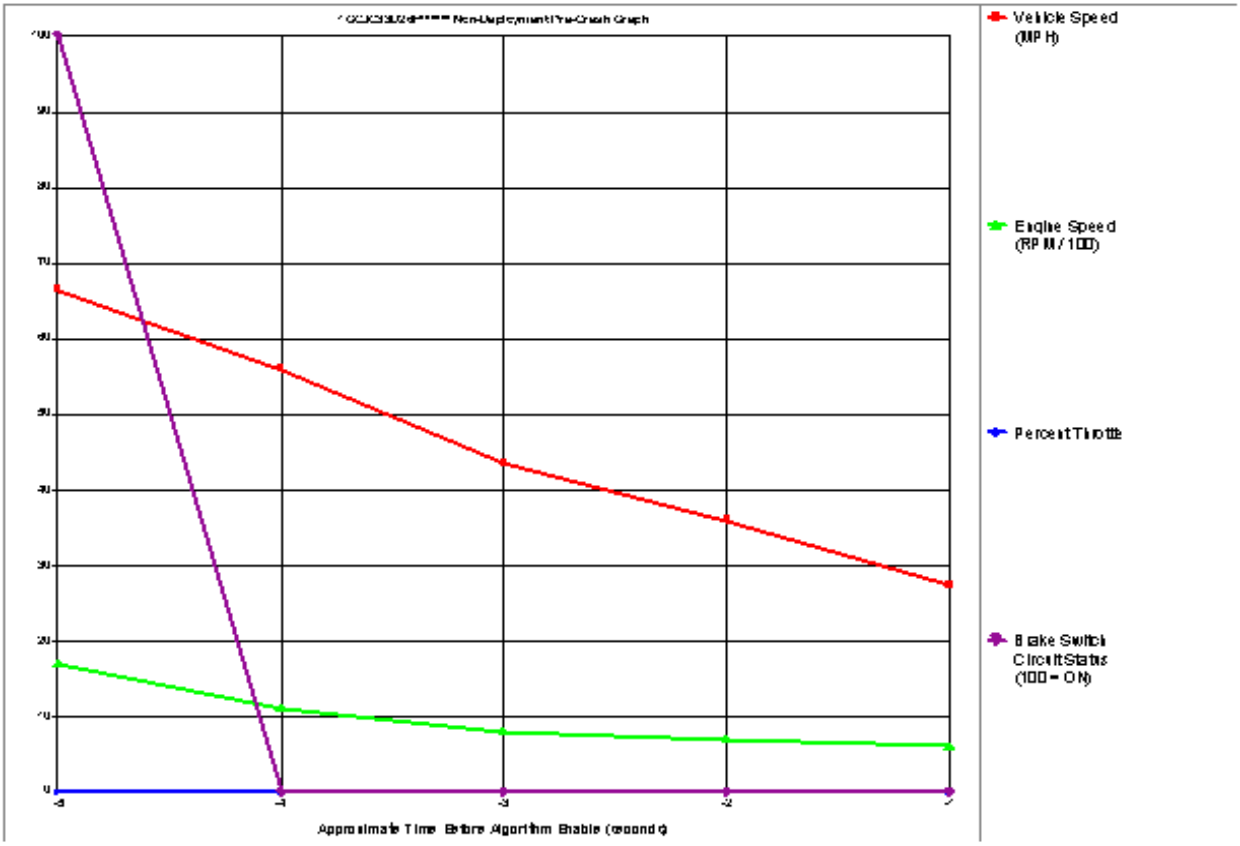
-One or More Associated Events Not Recorded: If a single event is recorded, this parameter will indicate whether one or more associated events, prior to the recorded event, was not recorded.
If two associated events are recorded, this parameter for the first event will indicate whether one or more associated events, prior to the first event, was not recorded.
If two associated events are recorded, this parameter, for the second event, will indicate whether one or more associated events, between the first and second events, was not recorded.

SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the vehicle's communication network, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the vehicle's communication network, to the SDM.
-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.

Chevrolet's SDM data limits continued

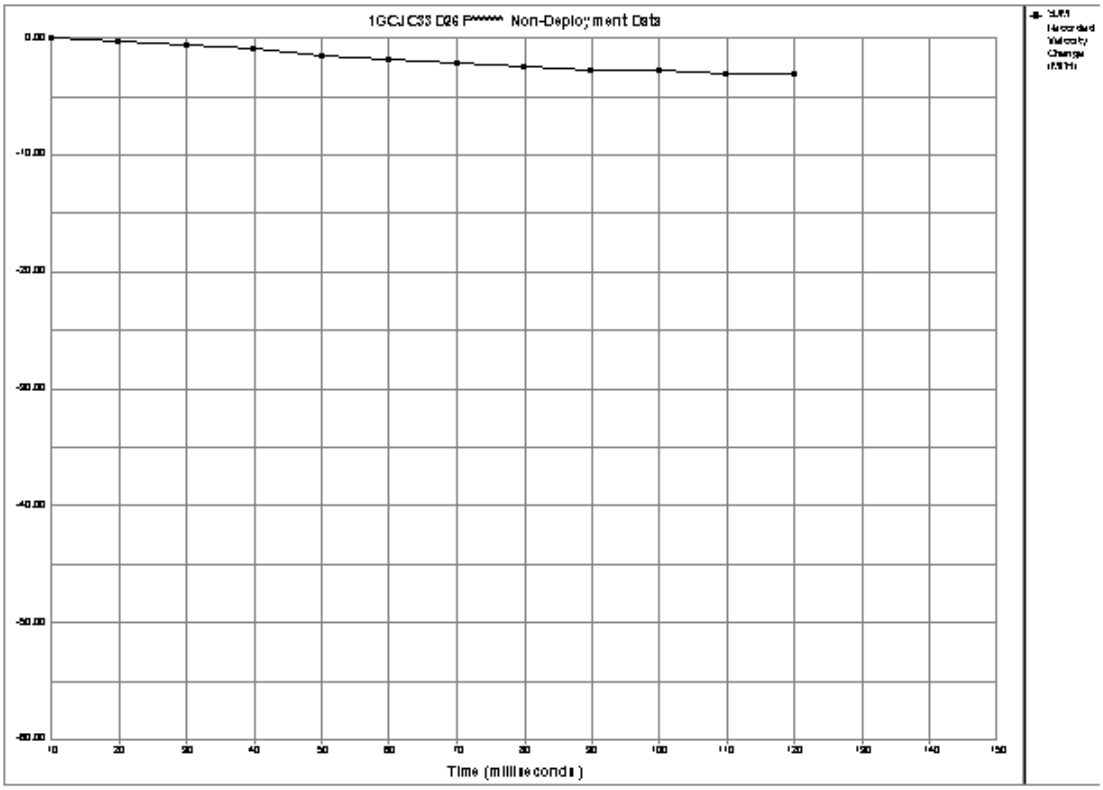
## System Status At Non-Deployment

| | |
|---|---|
| SIR Warning Lamp Status | OFF |
| Driver's Belt Switch Circuit Status | BUCKLED |
| Ignition Cycles At Non-Deployment | 1645 |
| Ignition Cycles At Investigation | 1650 |
| Maximum SDM Recorded Velocity Change (MPH) | -3.51 |
| Algorithm Enable to Maximum SDM Recorded Velocity Change (msec) | 127.5 |
| Crash Record Locked | No |
| Event Recording Complete | Yes |
| Multiple Events Associated With This Record | Yes |
| One Or More Associated Events Not Recorded | Yes |




| Seconds Before AE | Vehicle Speed (MPH) | Engine Speed (RPM) | Percent Throttle | Brake Switch Circuit Status |
|---|---|---|---|---|
| -5 | 67 | 1664 | 0 | ON |
| -4 | 56 | 1088 | 0 | OFF |
| -3 | 44 | 768 | 0 | OFF |
| -2 | 36 | 704 | 0 | OFF |
| -1 | 27 | 576 | 0 | OFF |

Chevrolet's System Status at Non-Deployment report and pre-crash data




| Time (milliseconds) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recorded Velocity Change (MPH) | 0.00 | -0.31 | -0.62 | -0.93 | -1.55 | -1.86 | -2.17 | -2.48 | -2.79 | -2.79 | -3.10 | -3.10 | N/A | N/A | N/A |

Chevrolet's Non-Deployment velocity change graph