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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-04-030
LOCATION - MISSOURI
VEHICLE - 2004 CHEVROLET SILVERADO Z-71
CRASH DATE - September 2004

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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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On-site air bag investigation involving a 2004 Chevrolet Silverado Z71, four-door pickup truck with manual safety belts and dual front advanced air bag system.

16. *Abstract*
This report covers an on-site investigation of an air bag deployment crash that involved a 2004 Chevrolet Silverado Z71, four-door pickup truck (case vehicle), which ran-off-road in a curve and sustained multiple impacts and a rollover. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including certified advanced 208-compliant air bags as well as an Event Data Recorder (EDR), and the case vehicle's unrestrained driver (19-year-old, male) sustained fatal injuries as a result of the crash. The trafficway on which the case vehicle was traveling was a curved, two-lane, undivided residential street traversing in a northwest and southeast direction. The case vehicle was in the curve traveling northwest in the middle of the roadway and was accelerating up to a speed of 146 to 159 km.p.h (91 to 99 m.p.h.) just prior to the crash. The driver was unable to negotiate the curve, and the case vehicle departed the north side of the roadway, sideswiped a metal luminaire pole, traveled up an embankment, impacted concrete steps, vaulted and rolled over driver side leading in a "cork screw" motion while airborne, and then impacted the ground and a house. The impact to the concrete steps resulted in a first stage deployment of the driver's air bag. The driver sustained fatal injuries due to contact with the steering wheel assembly subsequent to his air bag deployment when the case vehicle impacted the house. The driver was pronounced dead at the crash scene and had to be extricated from the case vehicle. He sustained numerous internal injuries due to contact with the steering wheel (which was unprotected by the air bag due to its prior deployment) including a complete transection of the aorta, lacerations of the left ventricle, pericardium, left lung, left kidney, liver and the mesentery as well as multiple rib fractures. Drug test results revealed that the driver tested positive for Falbamate, an anticonvulsant used in the treatment of seizures.

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TABLE OF CONTENTS

Page No.

BACKGROUND 1

SUMMARY 1

CRASH CIRCUMSTANCES 4

CASE VEHICLE: 2004 CHEVROLET SILVERADO Z-71 PICKUP TRUCK 6
- CASE VEHICLE DAMAGE 7
- AUTOMATIC RESTRAINT SYSTEM 9
- CRASH DATA RECORDING 10
- CASE VEHICLE DRIVER KINEMATICS 11
- CASE VEHICLE DRIVER INJURIES 13

EVENT DATA RECORDER DATA 16

CRASH DIAGRAM 20

SELECTED PHOTOGRAPHS
- Figure 1: Case vehicle's approach in outside northwestbound in curve left . . . 4
- Figure 2: Approach of the case vehicle to area or roadway departure and impact with metal luminaire pole 5
- Figure 3: Case vehicle's tire marks in grass and impacted luminaire pole 5
- Figure 4: Impacted concrete steps 5
- Figure 5: Overview of area of case vehicle's airborne travel 5
- Figure 6: Dirt and grass jammed in case vehicle's left fender, left front door seam and left front door 6
- Figure 7: Divot in ground from case vehicle's left side impact as case vehicle touched down in yard of impacted house 6
- Figure 8: Case vehicle at final rest inside house 6
- Figure 9: Overview of case vehicle's damage from front right corner 7
- Figure 10: Overview of case vehicle's damage from back left corner 7
- Figure 11: Right side view of crush to case vehicle's front end 7
- Figure 12: Damage to case vehicle's steering wheel due to intrusion of roof . . . 9
- Figure 13: Case vehicle's driver air bag 9
- Figure 14: Case vehicle's driver air bag vent ports 10
- Figure 15: Two small cuts in driver's air bag 10
- Figure 16: Occupant contact marks on right roof side rail 10

Page No.

Figure 17: Driver contact mark, hair in driver's right sunvisor hinge 11
Figure 18: Driver contact mark, hair on windshield header 12
Figure 19: Driver contact mark, hair and blood on right roof side rail 12
Figure 20: Blood on roof above back seat, path of driver extraction 13
Figure 21: Rescue personnel in process of removing driver from case vehicle . . 13
Figure 22: Case vehicle's EDR System Status at Deployment report 16
Figure 23: Case vehicle's EDR Deployment Pre-Crash Graph 17
Figure 24: Case vehicle's EDR deployment SDM Recorded Velocity Change graph 17
Figure 25: Case vehicle's EDR System Status at Non-Deployment Report 18
Figure 26: Case vehicle's EDR Non-Deployment Pre-Crash Graph 19
Figure 27: Case vehicle's EDR non-deployment SDM Recorded Velocity Change graph 19

BACKGROUND

This investigation was brought to NHTSA's attention on or before September 30, 2004 by the father of the driver of the case vehicle. This crash involved a 2004 Chevrolet Silverado Z-71 pickup truck (case vehicle) which ran-off-road, vaulted, rolled over and impacted a house. The crash occurred in September 2004, at 12:14 p.m., in Missouri and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including certified advanced 208-compliant air bags, as well as an Event Data Recorder (EDR), and the case vehicle's driver [19-year-old, White (non-Hispanic) male] sustained a fatal injury as a result of the crash. This contractor inspected the vehicle and downloaded the EDR on October 14, 2004 and inspected the scene and interviewed the driver's father on October 15, 2004. This report is based on the police crash report, scene and vehicle inspections, an interview with the case vehicle driver's father, occupant kinematic principles, driver autopsy records, EDR data and this contractor's evaluation of the evidence.

SUMMARY

Crash Environment: The trafficway on which the case vehicle was traveling was a curved, two-lane, undivided, residential city street, traversing in a northwest and southeast direction. At the time of the crash the light condition was daylight, the atmospheric condition was cloudy, and the roadway pavement was dry. Traffic was very light, and the site of the crash was residential.

Pre-Crash: The case vehicle was traveling northwest in the middle of the roadway in a left curve and was accelerating to a speed of approximately 146 to 159 km.p.h. (91 to 99 m.p.h.) just prior to the crash. The driver apparently intended to negotiate the curve and continue northwestbound. The EDR data indicates the driver braked just prior to the crash. The driver did not negotiate the curve and departed the right side of the roadway. The crash occurred in a residential yard.

Crash: The case vehicle departed the right side of the roadway, and the left fender and left front tire sideswiped a metal luminaire pole. The case vehicle then traveled through a yard, across a driveway and the front undercarriage impacted a set of concrete steps that traversed up a hill on the west side of the driveway. This impact caused the first stage of the dual-stage air bag to deploy. The vehicle ramped up the hill, became airborne, rolled left in a "cork screw" motion, crossed the yard and an adjacent side street while airborne, impacted the ground and then impacted and penetrated into a house. During the course of the airborne and house impact sequence, the case vehicle rolled counterclockwise a total of three quarter turns.

Post-Crash: The case vehicle came to rest in the living room of the house partially on its roof and right side facing northwest. The driver sustained fatal injuries in the crash and had to be extricated from the case vehicle.

Case Vehicle: The 2004 Chevrolet Silverado Z-71 was a four wheel drive, four-door pickup truck (VIN: 1GCEK19T24E------). The case vehicle was equipped with four wheel, anti-lock disc brakes; dual stage driver and front right passenger air bags, integrated driver and front right passenger three point, lap and shoulder safety belt systems; driver and front right passenger seat belt buckle switch sensors, an air bag suppression switch for the front right passenger air bag, an EDR housed within the Sensing and Diagnostic Module (SDM), and a front right passenger occupant detection and automatic air bag suppression system.

Vehicle Exterior: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-L9ES 1** (**360** degrees) for sideswiping the luminaire pole, **12-FDLW 9** (**0** degrees) for the undercarriage impact with the concrete steps and **00-LDAO-2** for the rollover. Multiple CDCs were assigned to address the damage to the front, top, both sides and the undercarriage due to the case vehicle's penetration of the house as follows: **00-FDAW-6**, **00-LDAW-3**, **00-RDAW-4**, **80-TDDW-5**, and **00-UDDS-1**. The WinSMASH reconstruction program could not be used on this crash due to the catastrophic nature of the damage, non-horizontal impacts, and overlapping damage associated with this crash. The visually estimated crash severity for the case vehicle was high [i.e., greater than 40 km.p.h. (25 m.p.h.)]. The case vehicle was towed due to damage.

Exterior Damage: The case vehicle's initial contact with the luminaire pole involved at least the left fender and left front tire. The length of contact down the left side from this impact is unknown due to overlapping damage from subsequent impacts in the crash. The entire vehicle sustained direct and induced damage due to the subsequent impacts with the concrete steps, ground and the house.

The case vehicle's standard tire size was determined from published data to be P245/75R16. The case vehicle was equipped with tires size LT285/75R16. The tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	0	0	241	35	5	6	Cut in sidewall, wheel torn off vehicle	No	Yes
RF	0	0	241	35	4	5	Cut in sidewall	Yes	Yes
LR	0	0	241	35	4	5	Scuffs in sidewall, bead separated	No	Yes
RR	0	0	241	35	6	7	Wood from house jammed in wheel and bead	No	Yes

Vehicle Interior: Inspection of the case vehicle's interior revealed occupant contacts to the steering wheel, left instrument panel, ceiling, air bag, left sun visor, windshield header and right roof side rail. There was extensive intrusion of the passenger compartment. The steering wheel was broken due to impact by the intruding windshield header and the energy absorbing steering column was compressed due to occupant contact.

Supplemental Restraints: The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. An inspection of the driver's air bag fabric revealed two small blood stains and two small cuts through the air bag fabric on the front of the air bag. In addition, there was an area of scuffing at the bottom of the air bag that appeared to be possible occupant contact.

The front right passenger's air bag was located in the middle of the instrument panel. This air bag properly did not deploy because there was no passenger seated in the front right seat. The air bag suppression switch was set on "Auto".

Crash Data Recording: The download of the case vehicle's EDR was done during the vehicle inspection via direct connection to the case vehicle's (SDM). The downloaded data indicated that a non-deployment event and deployment event were recorded. It is this contractor's opinion that the non-deployment event occurred when the case vehicle sideswiped the metal luminaire pole as the case vehicle departed the right side of the roadway. The deployment event then occurred as the case vehicle's front undercarriage impacted the concrete steps prior to the case vehicle becoming airborne. The EDR data show that the SIR warning lamp was recorded as off, and the driver's seat belt switch circuit was recorded as unbuckled. The pre-crash data for the non-deployment event recorded the vehicle accelerating at 100 % throttle with the brake switch circuit recorded as off for the five seconds prior to algorithm enable (AE). The pre-crash data for the deployment event also shows the case vehicle accelerating at 100% throttle, and at one second prior to AE the case vehicle was recorded traveling 146 km.p.h. (91 mph), and the brake switch circuit was recorded as on indicating the driver applied the brakes just prior to the crash.

Case Vehicle's Driver: Immediately prior to the crash, the case vehicle's driver [White (non-Hispanic) male, 191 centimeters and 68 kilograms (75 inches, 150 pounds)] was most likely seated in an upright driving posture with both hands on the steering wheel. The driver most likely had his left foot on the floor and his right foot on the accelerator and was steering the case vehicle left. Due to the damage to the case vehicle, the exact position of his seat track is unknown. However, based on the driver's height, it is estimated that the driver's seat would likely have been adjusted to the rear-most, or between its middle and rear-most positions. At the time of inspection, the driver's seat back was slightly reclined.

Based on the vehicle inspection and supported by the EDR data, the case vehicle's driver was not using his three-point, integral, lap-and-shoulder safety belt system. The inspection of the driver's seat belt webbing, shoulder belt guide and latch plate showed no evidence of loading.

During the course of the crash, the case vehicle's driver moved forward in response to the concrete step impact and his face and chest contacted his deployed air bag. He then moved left as the case vehicle vaulted and rolled over. When the case vehicle impacted the ground and house, the driver moved left then forward, and his chest impacted the steering wheel (which was now unprotected due to prior deployment of the air bag) resulting in lacerations to numerous internal organs including the aorta, left ventricle, both lungs, pericardium, left kidney, liver and mesentery, and multiple bilateral rib fractures. In addition, as the case vehicle's roof shifted left during the house impact, the driver's head impacted the right roof side rail probably resulting in a cerebral edema. Based on the on-scene photographs, damage to the case vehicle and evidence found in the case vehicle, it appears likely that the driver was removed from the case vehicle through the backlite by rescue personnel.

The driver expired at the scene. An investigator for the county medical examiner removed the body from the scene for subsequent autopsy.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a two-lane, undivided, residential city street, traversing in a northwest and southeast direction. The roadway curved left, was superelevated and ascended up a 5% grade prior to the location where the case vehicle left the roadway. The roadway was composed of traveled bituminous with a friction coefficient of 0.72 based on police skid tests. The case vehicle's approach was uncontrolled and there were no roadway pavement markings. The width of the roadway was 8.4 meters (27.6 feet), and it was bordered by mountable curb and gutter. The police reported speed limit was 40 km.p.h. (25 m.p.h.). There was no posted speed limit sign in the area where the crash occurred. At the time of the crash, the light condition was daylight, the atmospheric condition was cloudy, and the roadway pavement was dry. Traffic was very light, and the site of the crash was residential.

Pre-Crash: The case vehicle was traveling northwest in the middle of the roadway (**Figure 1**) in a left curve and was accelerating to a speed of 146 km.p.h. to 159 km.p.h. (91 to 99 m.p.h.), and the driver apparently intended to negotiate the curve and continue northwestbound. The police crash report indicated that the speed of the case vehicle prior to leaving the roadway was 159 km.p.h. (99 m.p.h.). The police reconstructionist used a critical speed analysis based on a yaw mark (i.e., a mark left by a tire that is rotating and slipping sideways) left by the case vehicle as the driver attempted to negotiate the curve. The police calculated the radius of the yaw mark by using a chord 21.3 meters (70 feet) long and measured a middle ordinate of 20.3 centimeters (8 inches). They conducted a series of three skid tests on the roadway using a Vericom VC 200 brake test computer and determined a roadway coefficient of friction of 0.72. These data were used in the critical speed equation to calculate the speed of the case vehicle at the onset of the yaw

Figure 1: Case vehicle's approach northwestbound in curve left to roadway departure and initial impact with metal luminaire pole, indicated by arrow (case photo #02)

mark. The police reconstruction is supported by the case vehicle's EDR pre-crash data, which indicated that the vehicle's speed was 146 km.p.h. (91 m.p.h.) one second prior to AE for the deployment event (i.e., impact with the concrete steps). The EDR data also indicated that the driver applied the brakes just prior to the crash. The driver did not negotiate the left curve and the case vehicle departed the right side of the roadway. The crash occurred in a residential yard.

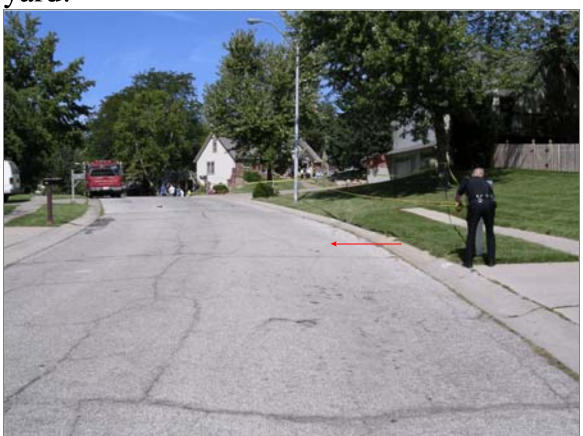


Figure 2: On-scene photo showing area of roadway departure and case vehicle's yaw mark, indicated by arrow (case photo # 111)

Figure 4: On-scene photo showing damage to concrete steps due to impact from case vehicle's front undercarriage, case vehicle at final rest inside house (case photo #112)

Figure 3: Case vehicle's tire marks in grass, damage to luminaire pole due to impact by case vehicle's left fender and left front tire (case photo #06)

Figure 5: Case vehicle traveled airborne over the side yard and street and landed in yard on opposite side of street in area indicated by arrow, then impacted the house (case photo #14)

Crash: The case vehicle departed the right side of the roadway (**Figure 2**) and the left fender and left front tire sideswiped a metal luminaire pole (**Figure 3**). The case vehicle then traveled through a yard, across a driveway and the front undercarriage impacted a set of concrete steps that traversed up a hill on the west side of the driveway (**Figure 4**). The vehicle then ramped up the hill, became airborne and rolled left in a "cork screw" motion. The vehicle was airborne across the yard and an adjacent side street that extended perpendicular to the original roadway (**Figure 5**). Total airborne distance was measured at approximately 30 meters (98 feet). The left side of the case vehicle (**Figure 6** below) then impacted the ground as the vehicle touched down in the front yard of a house on the west side of the street (**Figure 7** below). The case vehicle ramped off the ground, continued to rotate counterclockwise about its longitudinal axis, and the front of the vehicle impacted the house resulting in nearly the entire case vehicle penetrating into the house (**Figure 7**). During the course of the airborne and house impact sequence, the case vehicle rolled over counterclockwise a total of three quarter turns.

It is this contractor's opinion that the undercarriage impact with the concrete steps just prior to the vehicle becoming airborne caused the case vehicle's driver air bag to deploy. The downloaded EDR data indicated that only the first stage of the dual-stage air bag activated. The case vehicle was equipped with an automatic air bag suppression system and an air bag suppression switch for the front right passenger air bag. The suppression switch was set to the "auto" position. This air bag properly did not deploy during the crash sequence because there was no front right passenger in the vehicle.

Post-Crash: The case vehicle came to rest in the living room of the house partially on its roof and right side facing northwest (**Figure 8**). The driver sustained fatal injuries in the crash and was extricated from the case vehicle by rescue personnel.

Figure 6: Dirt and grass jammed in left fender, left front door seam (arrow) and left front door (case photo #38)

Figure 7: On-scene photo showing divot in ground from impact by case vehicle's left side and final rest of case vehicle in house (case photo #113)

Figure 8: Close view of case vehicle at final rest inside of house (case photo #114)

CASE VEHICLE

The 2004 Chevrolet Silverado Z-71 was a four wheel drive, four-door pickup truck (VIN: 1GCEK19T24E------). The case vehicle was equipped with a 5.3L V8 gas engine, automatic transmission; power assisted, four wheel, anti-lock disc brakes; tilt steering column, and split bench seat with separate back cushions and adjustable head restraints. The case vehicle's wheelbase was 364.5 centimeters (143.5 inches). The odometer reading is unknown because the case vehicle was equipped with an electronic odometer.

The case vehicle was equipped with multiple AOPS features including dual stage driver and front right passenger air bags, driver and front right passenger seat belt buckle switch sensors, integrated driver and front right passenger three point, lap and shoulder safety belt systems; an air bag suppression switch for the front right passenger air bag, an EDR housed within the Sensing and Diagnostic Module (SDM), and a front right passenger occupant detection and automatic air bag suppression system.

Figure 9: Overview of damage to case vehicle from front right corner (case photo #32)

The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity and driver and front right passenger seat belt usage to determine the front air bag inflation level appropriate for the severity of the crash. For the front right seat position, an occupant weight pressure sensor and a seat belt tension sensor provide data to the electronic control module. The electronic control module compares the seat pressure and seat belt tension data to threshold values, determines if the front right air bag should be suppressed or enabled and communicates the decision to the air bag control module. The air bag will be suppressed when the seat pressure is at or below what a 6-year-old child in a booster seat produces or when the belt tension is above 6.8 kilograms (15 pounds). The air bag will be enabled if the seat pressure is at or above what a 46.7 kilograms (103 pound) occupant produces and the seat belt tension is below 6.8 kilograms (15 pounds).

Figure 10: Overview of damage to case vehicle from back left corner (case photo #47)

Figure 11: Right side view of crush [each stripe on rods is 5 cm (2 in)]to front of case vehicle (case photo #29)

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's initial contact with the luminaire pole involved at least the left fender and left front tire. The length of contact down the left side is unknown due to overlapping damage from subsequent impacts in the crash. The left fender, left side doors and truck bed were directly damaged and dirt and grass were jammed in the fender, fender seam and front portion of the left side of the truck bed when the left front side of the vehicle impacted the ground. The subsequent impact with the house directly damaged the entirety of the vehicle (**Figures 9** and **10** above) with the exception of the back end. Crush measurements were taken at the bumper and above bumper levels (**Figure 11** above) on the front of the case vehicle. The direct damage began at the front right bumper corner and extended 155 centimeters (61 inches) across the front bumper. Residual maximum crush was measured as 27 centimeters (10.6 inches) at C_6. Above the bumper the residual maximum crush was measured as 37 centimeters (14.6 inches) at C_6. The average residual maximum crush at C_6 was 32 centimeters (12.6 inches). The case vehicle's entire front plane including both A-pillars, windshield and windshield header were directly damaged and crushed rearward. There was also direct damage to the full length of both sides of the vehicle with considerable leftward displacement of the right side of the truck bed. Lastly, the entire roof was directly damaged and crushed downward and to the left. The table below shows the case vehicle's front crush profile after averaging the bumper and above bumper crush values.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								$\pm$D	$\pm$D
cm	1	155	37	155	27	19	6	8	18	32	0	0
in		61.0	14.6	61.0	10.6	7.5	2.4	3.2	7.1	12.6	0.0	0.0

The case vehicle's wheelbase was reduced 15 centimeters (5.9 inches) on the left side while the right side wheelbase was shortened 6 centimeters (2.4 inches). Induced damage involved the back bumper.

The recommended tire size was P245/75R16. The case vehicle was equipped with tires size LT285/75R16. The tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	0	0	241	35	5	6	Cut in sidewall, wheel torn off vehicle	No	Yes
RF	0	0	241	35	4	5	Cut in sidewall	Yes	Yes
LR	0	0	241	35	4	5	Scuffs in sidewall, bead separated	No	Yes
RR	0	0	241	35	6	7	Wood from house jammed in wheel and bead	No	Yes

Vehicle Interior: Inspection of the case vehicle's interior revealed occupant contacts to the steering wheel, left instrument panel, ceiling, air bag, left sunvisor, windshield header and right roof side rail. There was extensive intrusion of the roof and its components into the passenger compartment. The primary intrusions into the front seat area included 54 centimeters (21.3 inches) of vertical roof intrusion, 52 centimeters (20.5 inches) of longitudinal left A-pillar intrusion and 38 centimeters (15 inches) of vertical right B-pillar intrusion. In addition, there was 33 centimeters (13 inches) of longitudinal intrusion of the left instrument panel and 15 centimeters (5.9 inches) of longitudinal intrusion of the steering assembly. The steering wheel was also broken due to impact by the intruding windshield header (**Figure 12**) and the steering column was compressed due to contact by the driver.

Figure 12: Damage to steering wheel due to intrusion of windshield header (case photo #78)

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-L9ES 1** (**0** degrees) for sideswiping the luminaire pole, **12-FDLW 9** (**0** degrees) for the undercarriage impact with the concrete steps and **00-LDAO-2** for the rollover. Multiple CDCs were assigned to address the damage to the front, top, both sides and the undercarriage due to the case vehicle's impact and penetration of the house as follows: **00-FDAW-6**, **00-LDAW-3**, **00-RDAW-4**, **80-TDDW-5**, and **00-UDDS-1**.

The WinSMASH reconstruction program could not be used on this crash due to the catastrophic nature of the damage, non-horizontal impacts, and overlapping damage associated with this crash. The visually estimated crash severity for the case vehicle was high [i.e., greater than 40 km.p.h. (25 m.p.h.)]. The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with certified advanced 208-compliant air bags at the driver and front right passenger positions. The driver's air bag deployed as a result of the case vehicle's impact with the concrete stairs. The front right air bag properly did not deploy because there was no passenger seated in the front right seat.

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or

Figure 13: Case vehicle's driver air bag, yellow tape shows location of two small cuts in air bag (case photo #83)

the cover flaps. The deployed driver's air bag (**Figure 13** above) was round with a diameter of approximately 63 centimeters (24.8 inches). The driver's air bag was designed with two tethers, each approximately 12 centimeters (4.7 inches) in width, and had two vent ports (**Figure 14**), approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions. The air bag module cover flaps consisted of two symmetrical flaps constructed of pliable vinyl. The tear seams were located across the top and bottom and vertically down the center of the flaps. Each flap was approximately 7.5 centimeters (3 inches) wide at the top, 5.5 centimeters (2.2 inches) wide at the bottom and 11.5 centimeters (4.5 inches) high along the center tear seam. An inspection of the driver's air bag fabric revealed two small blood stains and two small cuts through the air bag fabric on the front of the air bag (**Figures 13** above and **15**). The cuts in the air bag fabric were probably due to glass fragments. In addition, there was an area of scuffing at the bottom of the air bag that appeared to be possible occupant contact.

Figure 14: Back of top portion of driver's air bag, arrows show vent ports (case photo #88)

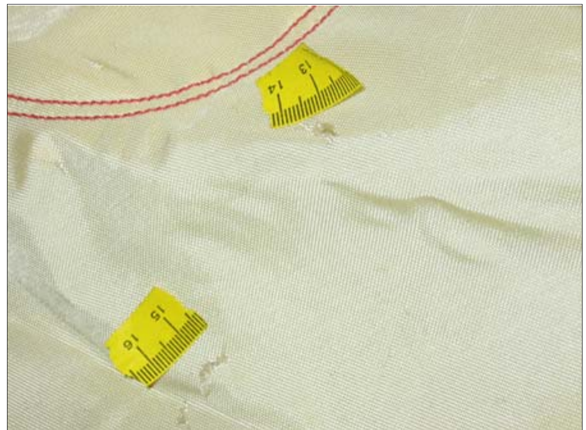


Figure 15: Close view of two small cuts in driver's air bag (case photo #84)

The front right passenger's air bag was located in the middle of the instrument panel (**Figure 16**). This air bag properly did not deploy because there was no passenger seated in the front right seat. The air bag suppression switch was set on "Auto".

Figure 16: Passenger air bag located in middle of right instrument panel (double head arrow), arrow shows driver's head contact on right roof side rail (case photo #91)

Crash Data Recording

The download of the case vehicle's EDR was done during the vehicle inspection via direct connection to the case vehicle's Sensing and Diagnostic Module (SDM). The EDR reports are presented in **Figures 22-27** at the end of this report. The downloaded data indicated that a non-deployment event and deployment event were recorded. In addition, the data indicated there were two frontal deployment level events. It is this contractor's opinion that the non-deployment event occurred when the case vehicle sideswiped the metal luminaire pole as the case vehicle departed the right side of the roadway. The deployment event then occurred as the case vehicle's front undercarriage impacted the concrete steps prior to the case vehicle becoming airborne. The additional deployment level event most likely occurred when the case vehicle impacted the house. The system status reports show that the SIR warning lamp was recorded as off, and the driver's seat belt switch circuit was recorded as unbuckled. In addition, the maximum SDM recorded velocity change (Delta V) was recorded as -7.87 km.p.h. (-4.89 m.p.h.) for the deployment event occurring 130 milliseconds after AE, and -0.72 km.p.h. (-0.45 m.p.h.) for the non-deployment event occurring 5 milliseconds after AE. The deployment event system status report shows that the driver's air bag, first stage deployment criteria was met 7.5 milliseconds after AE, and the second stage deployment criteria was not met.

The non-deployment event pre-crash data indicates the case vehicle was traveling 126 km.p.h. (78 mph) five seconds prior to AE (i.e., the sideswipe impact with the metal luminaire pole), and the vehicle's speed was increasing at 100% throttle to 138 km.p.h. (86 m.p.h.) one second prior to AE. In addition, the brake switch circuit was recorded as off for each of the one second sample periods. The deployment event pre-crash data indicates that the case vehicle's speed continued to increase to 146 km.p.h. (91 mp.h.) one second prior to AE (i.e., the impact with the concrete steps), at which time the brake switch circuit is recorded as on indicating the driver applied the brakes just prior to the crash. The System Status at Deployment report indicates that the time between non-deployment and deployment events was 0.5 seconds. The time is consistent with the case vehicle's approximate average speed and distance traveled between the metal luminaire pole and concrete step impacts.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash, the case vehicle's driver [White (non-Hispanic) male, 191 centimeters and 68 kilograms (75 inches, 150 pounds)] was most likely seated in an upright driving posture with both hands on the steering wheel. The driver most likely had his left foot on the floor and his right foot on the accelerator and was steering the case vehicle left. Due to the damage to the case vehicle, the exact position of his seat track is unknown. However, based on the driver's height, it is estimated that the driver's seat would likely have been adjusted to its rear-most position, or between the middle and rear-most positions. At the time of inspection, the driver's seat back was slightly reclined.

Based on the vehicle inspection and supported by the EDR data, the case vehicle's driver was not using his three-point, integral, lap-and-shoulder safety belt system. The inspection of the driver's seat belt webbing, shoulder belt guide and latch plate showed no evidence of loading.

Figure 17: Close view of Figure 12 above showing hair in hinge of driver's sunvisor (case photo #80)

Figure 18: Close view of Figure 12 above showing hair deposit on center portion of windshield header, indicated by arrow (case photo #81)

Figure 19: Close view of Figure 16 above showing blood and hair from driver's head contact to right roof side rail (case photo #92)

The case vehicle's sideswipe impact with the metal luminaire pole likely resulted in little change to the driver's pre-crash position, but may have caused him to continue slightly forward. The EDR data indicates that the driver most likely had one of his feet on the brake as the case vehicle's front undercarriage impacted the concrete steps. This impact caused the driver to move down into his seat and forward, and contact his deployed air bag with his face and chest. As the case vehicle became airborne and rolled left, the driver moved left and was most likely against the left front door when the case vehicle's left side impacted the ground. The left side ground impact caused the driver to load into his door. The contact with the door probably resulted in his fractured left upper arm, bruised left forearm and abraded left shoulder, forearm, flank and thigh. The compressed steering column and occupant contact marks found on the right portion of the left sunvisor (**Figure 17** above), center portion of the windshield header (**Figure 18**) and right roof side rail (**Figure 19**) indicate the driver then moved generally forward and right as the case vehicle impacted the house and continued to rotate counterclockwise about its longitudinal axis, penetrating into the house and crushing the roof and shifting it leftward. During this phase of the crash the driver impacted his chest on the steering wheel, which was now unprotected due to prior deployment of the air bag during the concrete step impact. The driver's contact with the steering wheel resulted in lacerations to numerous internal organs including the aorta, left ventricle, both lungs, pericardium, left kidney, liver and mesentery, and fractures to posterior left ribs 1st through 12th and right ribs 1st through 7th. As the case vehicle's roof was shifted left, the driver's head probably impacted the right roof side rail resulting in a cerebral edema. Lastly, there were smears of blood and hair on the center portion of the roof over the back seat (**Figure 20** below). This contact evidence was most likely related to the extraction of the driver from the vehicle. Based on the on-scene photographs including **Figure 21** below, and the damage to the case vehicle, it appears likely that the driver was removed from the case vehicle through the backlite by rescue personnel.

Figure 20: Blood on roof over back seat, photo taken from right side of case vehicle (case photo #95)

Figure 21: Rescue personnel in process of removing driver from the case vehicle (case photo #115)

CASE VEHICLE DRIVER INJURIES

The case vehicle driver expired at the scene. The body was removed by an investigator for the county medical examiner for subsequent autopsy. The driver's injuries and injury mechanisms are presented in the table below. A drug test revealed a positive result (130mg/ml) for Falbamate[1].

CASE VEHICLE DRIVER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Edema, cerebral, not further specified	serious 140660.3,9	Roof, right front side rail	Probable	Autopsy
2	Laceration {complete transection}, major, descending aorta distal to left subsclavian artery with hemorrhage not confined to mediastinum	maximum 420218.6,4	Steering wheel hub and/or spokes and rim	Certain	Autopsy
3	Laceration {tear}, 1 cm (0.4 in), posterior wall left ventricle with perforation	critical 441012.5,4	Steering wheel hub and/or spokes and rim	Certain	Autopsy

[1] ***felbamate (fel′ba-mat")***: an anticonvulsant used in the treatment of partial seizures in adults with severe epilepsy and as an adjunct in the treatment of seizures associated with Lennox-Gastaut syndrome in children; administered orally.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
4	Lacerations, fracture-type, extensive, bilateral lungs including one to left lobe of left lung at hilum and with bilateral hemothorax–1200 cc and hemomediastinum and blood loss greater than 20% by volume	critical 441456.5,3	Steering wheel hub and/or spokes and rim	Certain	Autopsy
5	Laceration {tear} pericardium, traumatically	moderate 441602.2,4	Steering wheel hub and/or spokes and rim	Certain	Autopsy
6	Laceration {near total transection} with perforation main stem bronchus left lung	severe 442608.4,4	Steering wheel hub and/or spokes and rim	Certain	Autopsy
7	Laceration, 2.5 cm (1.0 in), left kidney with severe hemorrhage of peri-renal tissue	moderate 541620.2,2	Steering wheel hub and/or spokes and rim	Certain	Autopsy
8	Laceration right lobe of liver with maceration, not further specified	moderate 541820.2,1	Steering wheel hub and/or spokes and rim	Certain	Autopsy
9	Laceration {shearing injury} of mesentery–portions of large intestine separated from their points of fixation to abdominal wall, not further specified	moderate 542022.2,8	Steering wheel hub and/or spokes and rim	Certain	Autopsy
10	Fracture bilateral ribs: left 1st through 12th posteriorly and right 1st through 6th posteriorly and right 7th rib laterally	critical 450240.4,3	Steering wheel hub and/or spokes and rim	Certain	Autopsy
11	Fracture mid-shaft left humerus, not further specified	moderate 752602.2,2	Left side interior surface, excluding hardware and/or armrest	Probable	Autopsy
12	Laceration, 1.2 cm (0.5 in), left temporal scalp with underlying hemorrhage present	minor 190602.1,2	Roof, left front side rail	Possible	Autopsy
13	Abrasions and small incised wounds, numerous, left face-obliquely oriented	minor 290202.1,2	Noncontact injury: flying glass, left front glazing	Probable	Autopsy
14	Abrasions x 2, 1.8 cm (0.7 in) and 2.3 cm (0.9 in) left chest, **and** scattered abrasions, 10 cm (3.9 in) area, left lower chest	minor 490202.1,2	Steering wheel hub and/or spokes and rim	Probable	Autopsy

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
15	Laceration, large, left chest wall in 7th intercostal space	minor 490602.1,2	Steering wheel hub and/or spokes and rim	Probable	Autopsy
16	Abrasions x 2, parallel, left flank, extending entire width of flank	minor 590202.1,2	Left side interior hardware and/or armrest	Probable	Autopsy
17	Abrasions over 9 cm (3.5 in) area lower back	minor 690202.1,8	Right side interior surface, excluding hardware and/or armrest	Probable	Autopsy
18	Contusions over 9 cm (3.5 in) area lower back	minor 690402.1,8	Right side interior surface, excluding hardware and/or armrest	Probable	Autopsy
19	Abrasions, 2 cm (0.8 in) and 4 cm (1.6 in) left shoulder, **and** scattered abrasions over 6 cm (2.4 in) area left posterior forearm, not further specified	minor 790202.1,2	Left side interior surface, excluding hardware and/or armrest	Probable	Autopsy
20	Contusions scattered over 6 cm (2.4 in) area left posterior forearm, not further specified	minor 790402.1,2	Left side interior surface, excluding hardware and/or armrest	Probable	Autopsy
21	Abrasion scattered over 5 cm (2.0 in) area anterolateral left thigh	minor 890202.1,2	Left side interior hardware and/or armrest	Probable	Autopsy
22	Abrasion scattered over 7 cm (2.8 in) area left knee	minor 890202.1,2	Knee bolster, driver's, left of steering column	Probable	Autopsy
23	Abrasions scattered over 8 cm (3.1 in) area right shin	minor 890202.1,1	Knee bolster, driver's, right of steering column	Probable	Autopsy
24	Contusions scattered over 8 cm (3.1 in) area right shin	minor 890402.1,1	Knee bolster, driver's, right of steering column	Probable	Autopsy

1GCEK19T24Exxxxxx System Status At Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Deployment	1925
Ignition Cycles At Investigation	1926
Maximum SDM Recorded Velocity Change (MPH)	-4.89
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	130
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	7.5
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	Suppressed
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Time Between Non-Deployment And Deployment Events (sec)	.5
Frontal Deployment Level Event Counter	2
Event Recording Complete	Yes
Multiple Events Associated With This Record	Yes
One Or More Associated Events Not Recorded	No

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.24	-2.79	-2.48	-2.48	-2.79	-3.41	-3.72	-4.65	-4.34	-4.03	N/A	N/A	N/A	N/A	N/A

PRE-CRASH DATA

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	80	3392	100	OFF
-4	81	Invalid	100	OFF
-3	84	Invalid	100	OFF
-2	86	3456	100	OFF
-1	91	0	100	ON

Figure 22: Case vehicle's System Status at Deployment report

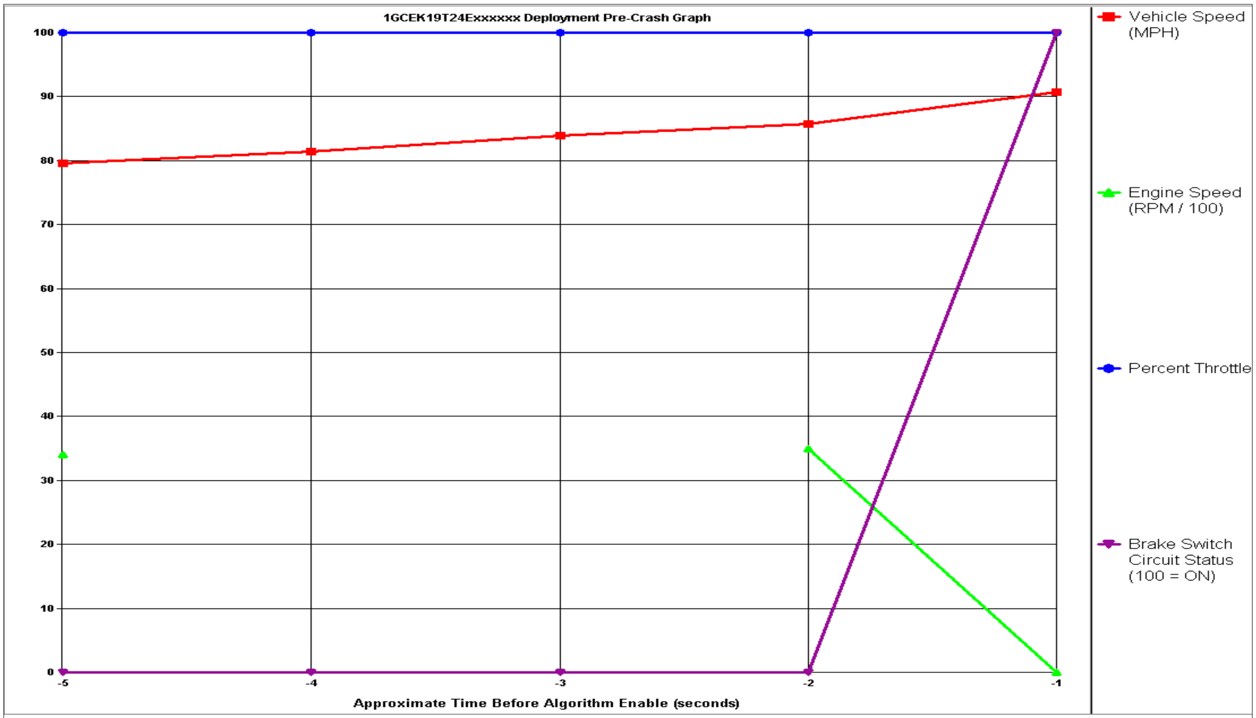


Figure 23: Case vehicle's Deployment Pre-Crash Graph

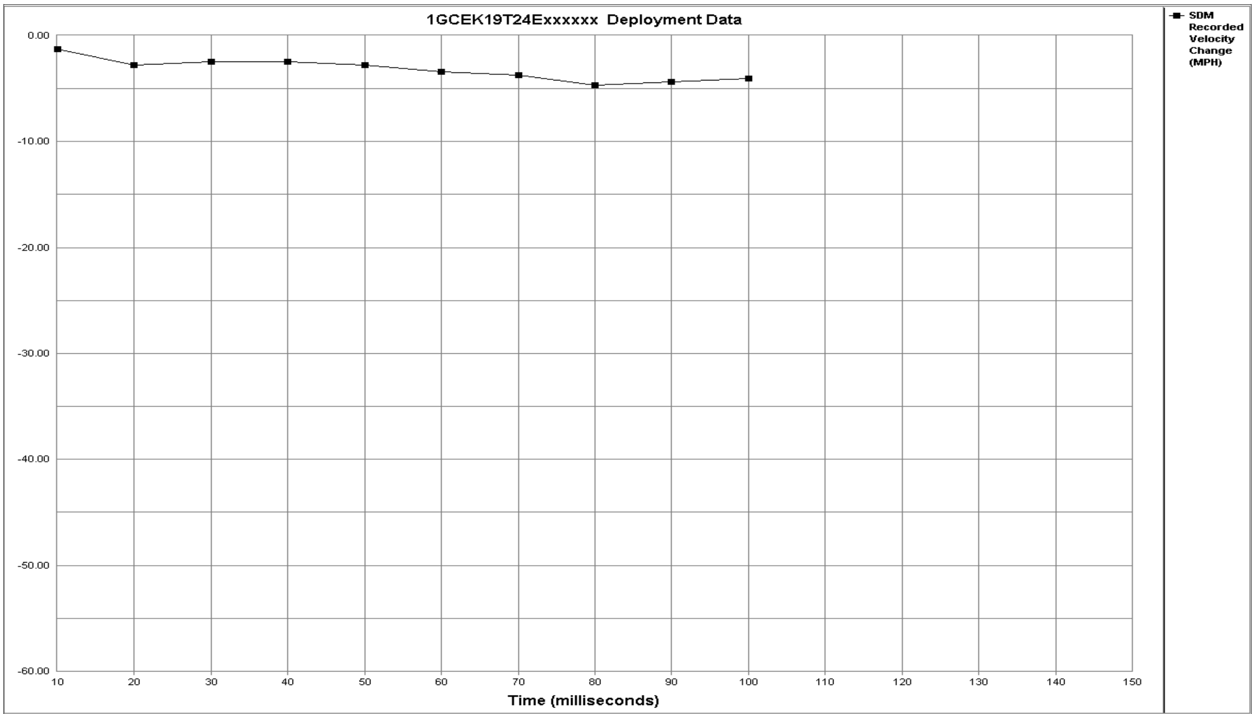


Figure 24: Case vehicle's deployment SDM Recorded Velocity Change graph

1GCEK19T24Exxxxxx System Status At Non-Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Non-Deployment	1925
Ignition Cycles At Investigation	1926
Maximum SDM Recorded Velocity Change (MPH)	-0.45
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	5
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	0.00	0.00	0.00	0.00	0.00	0.00	-0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PRE-CRASH DATA

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	78	3264	100	OFF
-4	80	3328	100	OFF
-3	81	3392	100	OFF
-2	84	3520	100	OFF
-1	86	3584	100	OFF

Figure 25: Case vehicle's System Status at Non-Deployment Report

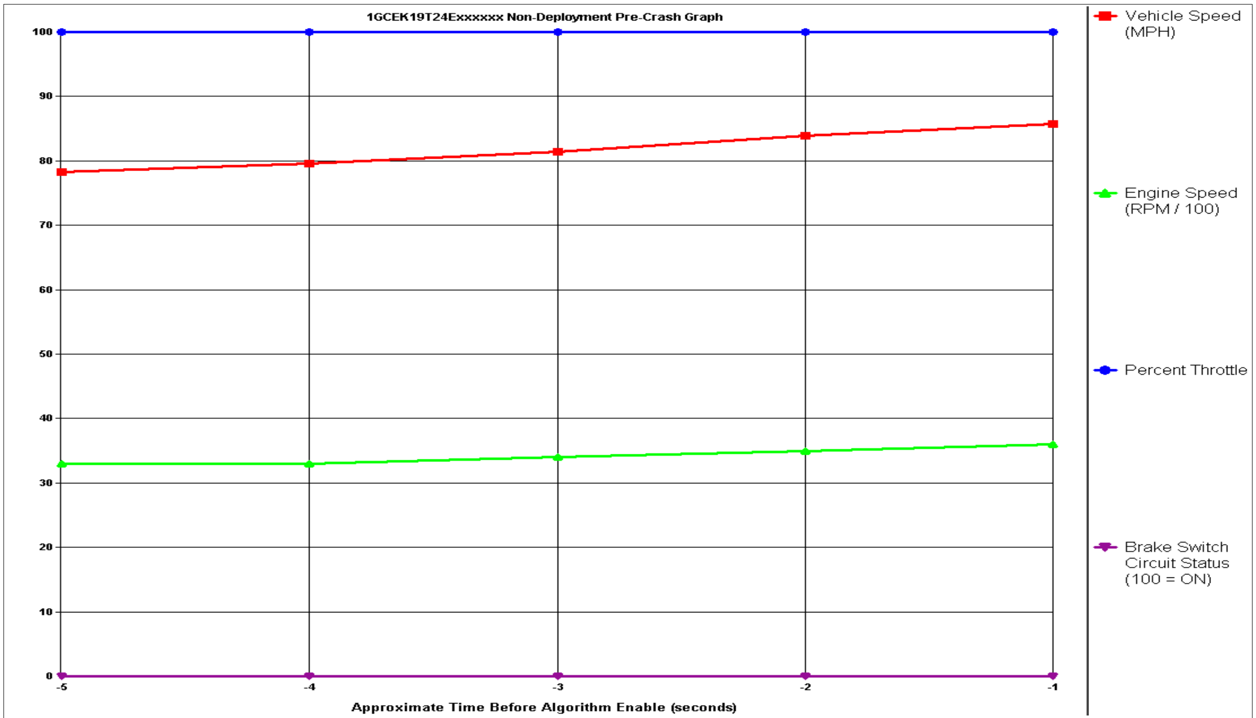


Figure 26: Case vehicle's Non-Deployment Pre-Crash Graph

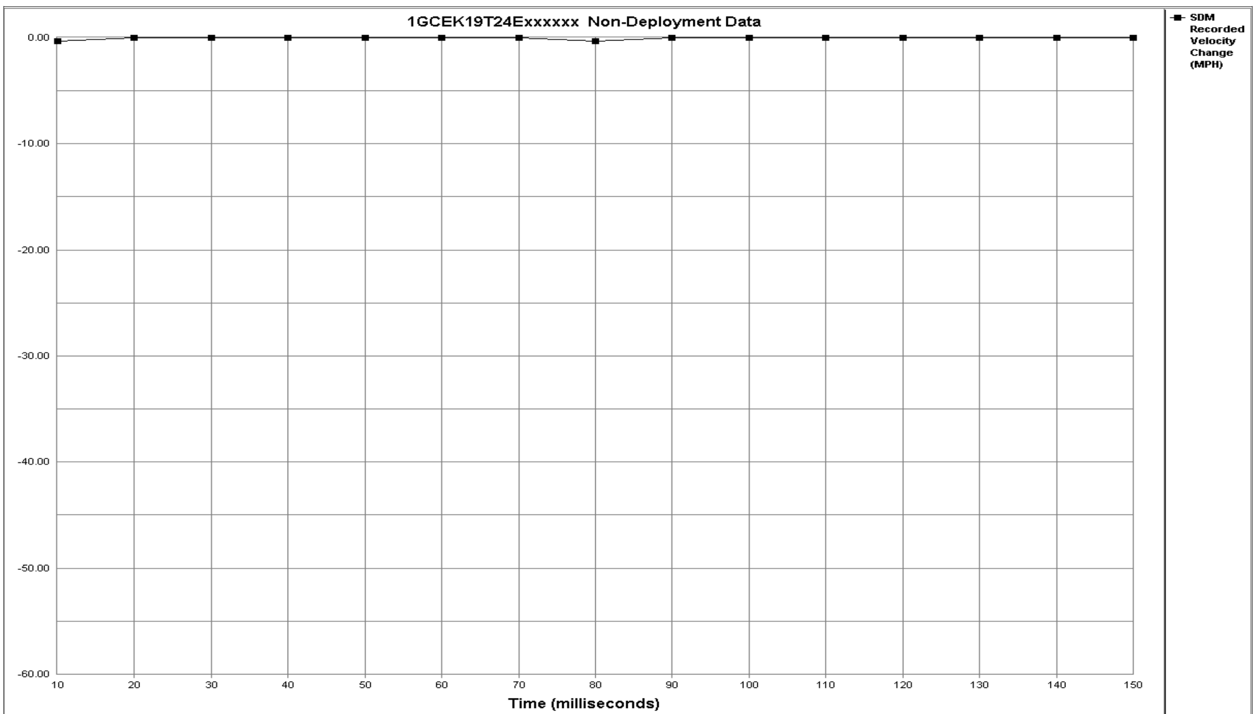
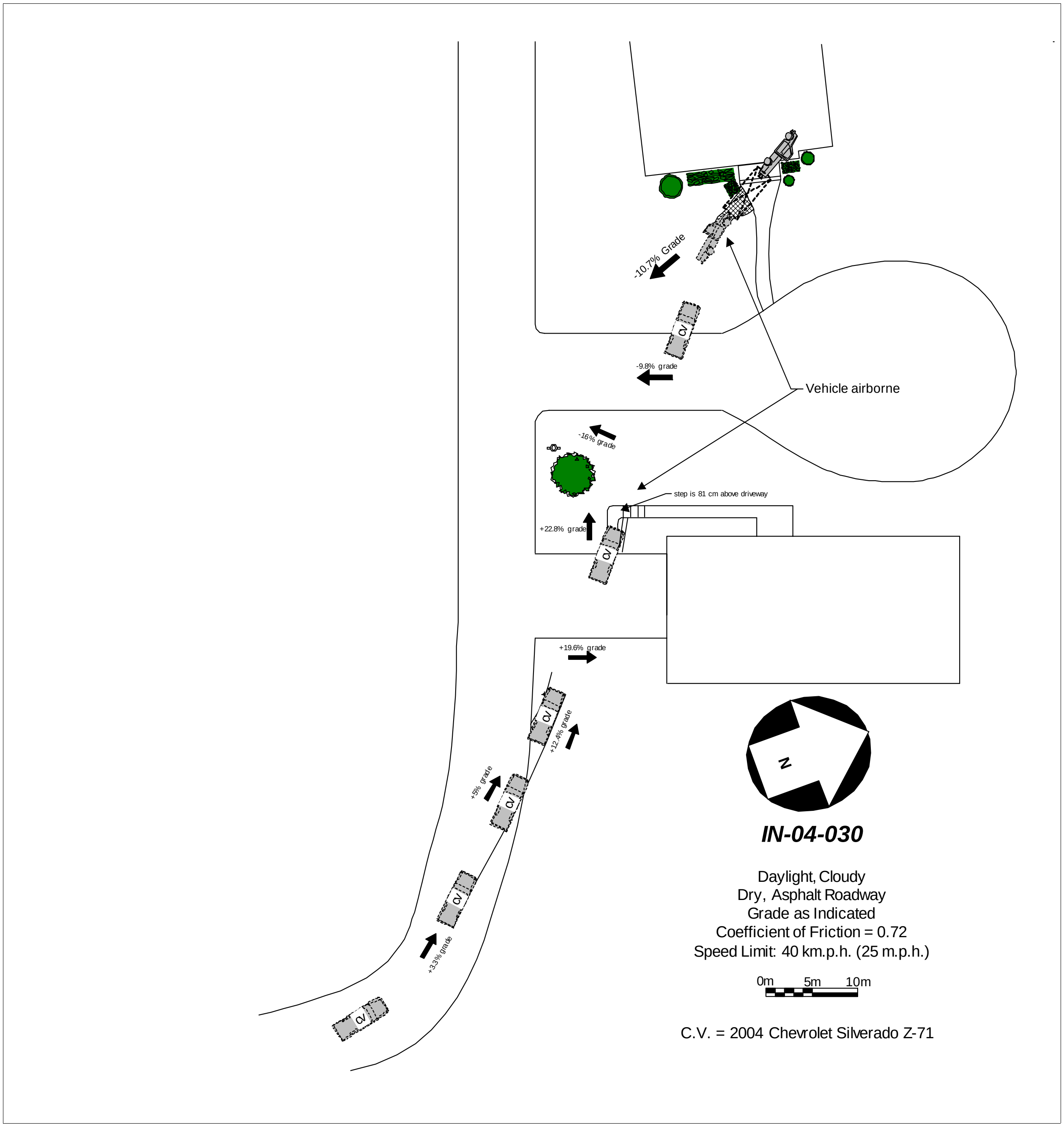


Figure 27: Case vehicle's non-deployment SDM Recorded Velocity Change graph


-10.7% Grade
CV
-9.8% grade
Vehicle airborne
-16% grade
step is 81 cm above driveway
+22.8% grade
CV
+19.6% grade
CV
+12.4% grade
+5% grade
CV
CV
+3.3% grade
CV
N
IN-04-030
Daylight, Cloudy
Dry, Asphalt Roadway
Grade as Indicated
Coefficient of Friction = 0.72
Speed Limit: 40 km.p.h. (25 m.p.h.)
0m 5m 10m
C.V. = 2004 Chevrolet Silverado Z-71