Certified Advanced 208-Compliant Vehicle Investigation / Vehicle to Object
Dynamic Science, Inc. / Case Number: 2004-78-124C
2004 Cadillac Escalade
Arizona
August, 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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16. Abstract

This single vehicle crash occurred in August, 2004 at 0918 hours. The crash occurred on a two-lane divided interstate highway. The case vehicle is a 2004 Cadillac Escalade 4x4 sport utility vehicle that was being driven by a lap and shoulder belt restrained 20-year-old male The Cadillac is equipped with dual stage front air bags, side impact air bags, power adjustable foot controls, and a front right passenger sensing system. The Cadillac was traveling eastbound at a constant EDR reported speed of 121 km/h (75 mph) with the cruise control ON. The driver of the Cadillac fell asleep and the vehicle began to drift to the left. The Cadillac traveled for 32 m (104 ft) on the dirt median before striking the end treatment of the median guardrail with its front end. At impact with the guardrail, the driver's air bag deployed. The Cadillac vaulted into the air and rolled on top of the guardrail for 62 m (205 ft). The Cadillac came to rest upside down on the guardrail facing south. The driver was transported from the scene with moderate injuries and hospitalized for one day.

17. Key Words	18. Distribution Statement
Air bag, deployment, Advanced 208 Compliant, rollover, injury, door failure.	

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Dynamic Science, Inc.
Accident Investigation
Case Number: 2004-78-124C

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BACKGROUND:

Description:	This Certified Advanced 208-Compliant (CAC) Vehicle Investigation was identified by the local National Automobile Sampling System (NASS) Primary Sampling Unit (PSU). A CAC vehicle is certified by the manufacturer to be compliant to Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case was reported to DSI on October 7, 2004 with instructions to determine what information had been obtained by the PSU. The case vehicle was inspected and the data from the electronic data recorder downloaded on October 12, 2004 by the NASS investigator. DSI provided NHTSA with this information on October 14, 2004 and was assigned the case on that same day. This was an SCI/NASS combination case.
Investigation Type:	Combination
Crash Location:	Arizona
Crash Date:	August, 2004
Notification Date:	October 14, 2004
Field Work Completed:	NA

SUMMARY:

Crash Site

This single vehicle crash occurred in August, 2004 at 0918 hours. The crash occurred on a two-lane divided interstate highway. Prior to the crash site, there is a depressed dirt median separating westbound and eastbound traffic. At the crash site, the westbound traffic is separated from the eastbound traffic by a metal guardrail followed by a dirt median. On the southern side of the roadway there is a second metal guardrail followed by dirt shoulder. The roadway was straight and level. The speed limit is 121 km/h (75 mph).

Figure 1. Approach to impact with guardrail end treatment–east

Pre Crash

The case vehicle is a 2004 Cadillac Escalade 4x4 sport utility vehicle (VIN: 1GYEK63N54Rxxxxxx) that was being driven by a lap and shoulder belt restrained 20-year-old male (185 cm/73 in, 100 kg/220 lbs). The shoulder harness exhibited a blood drip pattern consistent with usage at the time of the crash. The electronic data recorder (EDR) report indicates that the driver was buckled. The seat belt was integral to the bucket seat. The bucket seat was adjusted to the

middle track position. The seat back was upright. The Cadillac is equipped with dual stage front air bags, side impact air bags, power adjustable foot controls, and a front right passenger sensing system.

Figure 2. Impact with end treatment (replaced)

The Cadillac was traveling eastbound at a constant EDR reported speed of 121 km/h (75 mph) for 5 seconds prior to algorithm enable (AE). The combination of a constant engine speed of 2,112 RPM with 0 percent throttle indicates that the driver had set the cruise control. The driver of the Cadillac fell asleep and the vehicle began to drift to the left.

Crash

Figure 3. Front, Cadillac Escalade

The Cadillac traveled for 32 m (104 ft) on the dirt median before striking the end treatment of the median guardrail with its front end (CDC=12FCEW2). At impact with the guardrail, the driver's air bag deployed. This was a second stage deployment. The EDR generated a deployment event. The Cadillac vaulted into the air and rolled on top of the guardrail for 62 m (205 ft). The investigator indicated that the vehicle had rolled 10 quarter turns, but this could not be verified. The Cadillac came to rest upside down straddling the guardrail and facing south (CDC=00TDD04). At some point during this sequence a non-deployment event was generated. Both events were recorded by the EDR.

Post Crash

The driver sustained a concussive head injury, facial lacerations, and lacerations to the left side of his neck and upper arm. He was transported to an area hospital where he was admitted for treatment. He was hospitalized for one day.

The Cadillac sustained major damage and was towed from the scene.

VEHICLE DATA - 2004 Cadillac Escalade 4x4 sport utility vehicle

The 2004 Cadillac Escalade was equipped with an automatic transmission[1], 4-wheel drive, 4-wheel anti-lock brakes, air conditioning, power steering, power adjustable foot controls, cruise control, and leather upholstery.

VIN:	1GYEK63N54Rxxxxxx
Odometer:	Unknown
Engine:	6.0L V8
Reported Defects:	Both the front right and left rear doors came open during the crash due to latch/striker failure.
Cargo:	None

The 2004 Cadillac Escalade was equipped with Sumitomo P285/50R20 tires. The specific tire data is as follows:

Tire	Tread	Measured pressure	Manufacturer recommended pressure
LF	10 mm (0.4 in)	221 kPa (32 psi)	Unknown
RF	10 mm (0.4 in)	234 kPa (34 psi)	Unknown
LR	10 mm (0.4 in)	234 kPa (34 psi)	Unknown
RR	10 mm (0.4 in)	234 kPa (34 psi)	Unknown

The front seating positions in the Cadillac Escalade were comprised of leather covered bucket seats with adjustable head restraints that were not damaged. Both front seats were adjusted to the middle track position and the seat backs were upright. The second row seating positions were comprised of leather covered bucket seats with adjustable head restraints that were not damaged. Both second row seats were adjusted to the middle track position and the seat backs were upright.

[1]SCI change, per photographs

VEHICLE DAMAGE

Exterior Damage - 2004 Cadillac Escalade

Damage Description:	Major front end damage to bumper, hood, grille, and radiator. There was rollover damage to the roof and both sides of the vehicle. Both the front right and left rear doors came open during the crash due to latch/striker failure. There was also integrity loss through the side windows, windshield and roof glass. There was intrusion through both top and side planes with the greatest intrusion coming through the roof and measuring 29.0 cm (11.4 in) vertically.	
CDC:	Impact 1: 12FCEW2 (guardrail) Impact 2: 00TDDO4 (rollover)	
Delta V (impact 1):	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown
Delta V (impact 2):	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Direct damage from Impact 1 (guardrail) began 55.0 cm (21.7 in) to the right of the front left bumper corner and extended laterally 50.0 cm (19.7 in). The direct and induced damage included the entire front bumper and measured 135.0 cm (53.1 in). A crush profile was taken at the bumper level which measured: C1= 0 cm (0 in), C2= 7.0 cm (2.8 in), C3=34.0 cm (13.4 in), C4=36.0 cm (14.2 in), C5=17.0 cm (6.7 in), C6=23.0 cm (9.0 in). The right side wheelbase was shortened by 9.0 cm (3.5 in).

Figure 4. Front right, Cadillac Escalade

Interior Damage - 2004 Cadillac Escalade

Interior damage to the Cadillac Escalade was significant and was attributed to occupant contact and passenger compartment intrusion. The left front and right rear doors were jammed shut. The right front and left rear doors came open due to latch/striker failure. The windshield sustained fracture damage from impact forces. The glazing for left front, right front, left rear, right rear, and the back light positions were all disintegrated from impact forces. There was extensive intrusion through the top and both side planes. The maximum intrusion was to the roof and extended into both the front and second seat rows. It measured 29.0 cm (11.4in) vertically. The maximum intrusion on the right side was to the A pillar into the right front seat area and measured 14.0 cm (5.5 in). There were occupant contact related scuffs to the steering wheel and left interior surface. There was blood found on the deployed air bag, roof, and along the left interior–as well as on the shoulder belt.

Figure 5. Front left, Cadillac Escalade

Figure 6. Roof intrusion

Figure 7. Overview of roof and right side intrusion

MANUAL RESTRAINT SYSTEMS - 2004 Cadillac Escalade

The Cadillac Escalade was configured with manual 3-point lap and shoulder belts with sliding latch plates for all four seating locations. The driver's manual restraint was configured with an emergency locking retractor (ELR). The remaining restraints were configured with switchable retractors that were in the ELR mode. Both front seat belts were integral to the seats.

Figure 8. View of driver's seat showing blood drip pattern to shoulder belt

FRONTAL AIR BAG SYSTEM - 2004 Cadillac Escalade

The case vehicle was equipped with advanced, dual stage driver and front right passenger air bags. The driver's air bag was mounted in the steering wheel hub. The deployed driver's air bag was round. The dual module cover flaps opened in an "I" type tear configuration. There were no indications of any damage to driver's air bag or the module cover flaps. The front right passenger air bag was a mid instrument panel mount. The passenger sensing system did not detect a front right passenger and the front right air bag was suppressed and did not deploy. The vehicle was also equipped with a front seat back mounted side air bags that also did not deploy.

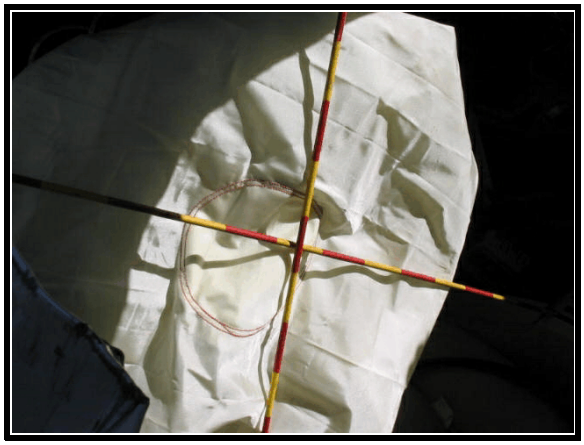


Figure 9. Driver's air bag

Figure 10. Blood drops found on driver's air bag

The case vehicle was equipped with advanced occupant protection systems. The systems consists of the Sensing and Diagnostic Module (SDM), dual stage driver and front right passenger air bags with a passenger air bag suppression switch, a front right Passenger Sensing System, and a driver's seat belt latch usage detector. The system is controlled by the SDM. The primary function of the SDM is to control the deployment of the occupant protection systems. The system records the vehicle's forward velocity change. The SDM will record 100 milliseconds of data after the deployment criteria is met and up to 50 milliseconds of data before deployment criteria is met. For non-deployments the SDM will record the first 150 milliseconds after algorithm enable. The SDM data was downloaded using the Vetronix Crash Data Retrieval System. The Vetronix report indicates that there were two events. The first event was the initial impact with the guardrail end treatment. This event was then locked into the recorder. The second event occurred at some point during subsequent rollover on top of the guardrail.

Deployment Event

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Ignition cycles at deployment were 177.
4. Ignition cycles at investigation were 180.
5. Maximum SDM recorded velocity change was -15.57 km/h (-9.68 mph).
6. The time from algorithm enable (AE) to maximum recorded velocity change was 192.5 milliseconds
7. Driver first stage time algorithm enabled to deployment command criteria met was 5 milliseconds.
8. Driver's second stage time algorithm enable to deployment command criteria met was 7.5 milliseconds.
9. Passenger first stage time algorithm enabled to deployment command was SUPPRESSED.
10. Passenger second stage time algorithm enabled to deployment command was SUPPRESSED.
11. The brake switch circuit status was OFF five seconds before AE.
12. The vehicle speed was a constant 121 km/h (75 mph)103 km/h from five seconds before AE to one second before AE.

Non Deployment Event

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Ignition cycles at deployment were 177.
4. Ignition cycles at investigation were 180.
5. Maximum SDM recorded velocity change was -11.73 km/h (-7.29 mph).
6. The time from algorithm enable (AE) to maximum recorded velocity change was 162.5 milliseconds.
7. The brake switch circuit status was OFF five seconds before AE and continued ON until one second before AE.
8. The vehicle speed was 121 km/h (75 mph) five seconds before AE. The vehicle speed decelerated to 3 km/h (2 mph) one second before AE. The vehicle's wheels had likely left the ground at this point and these value do not represent an actual speed.

OCCUPANT DEMOGRAPHICS - 2004 Cadillac Escalade

	Occupant 1
Age/Sex:	20/Male
Seated Position:	Front left
Seat Type:	Leather covered bucket seat. Seat adjusted to middle track position. Seat back was upright.
Height:	185 cm (73 in)
Weight:	100 kg (220 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	Positive for benzodiazepines[2] and cannabinoids[3] per medical report
Driving Experience:	Unknown
Body Posture:	Asleep, held generally upright by shoulder harness
Hand Position:	Unknown
Foot Position:	Both feet presumed to be on floor. Cruise control on.
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Driver's air bag available, deployed. Passenger side frontal air bag, did not deploy. Dual seat back mounted side air bags, did not deploy.

[2]Benzodiazepines are a class of drug commonly known as tranquillizers and sleeping pills.

[3]The psychoactive chemical substances found in marijuana (Cannabis sativa).

OCCUPANT INJURIES - 2004 Cadillac Escalade

Driver: Injuries obtained from emergency room records.

Injury	OIC Code	Injury Mechanism	Confidence Level
Concussion	161000.2,0	Roof	Certain
Facial laceration, forehead	290602.1,7	Flying glass	Certain
Facial laceration, left cheek	290602.1,2	Flying glass	Certain
Facial laceration, nose	290602.1,4	Flying glass	Certain
Upper arm, shoulder, and elbow lacerations (left)	790602.1,2	Flying glass	Certain
Laceration, left side of neck	390600.1,2	Flying glass	Certain

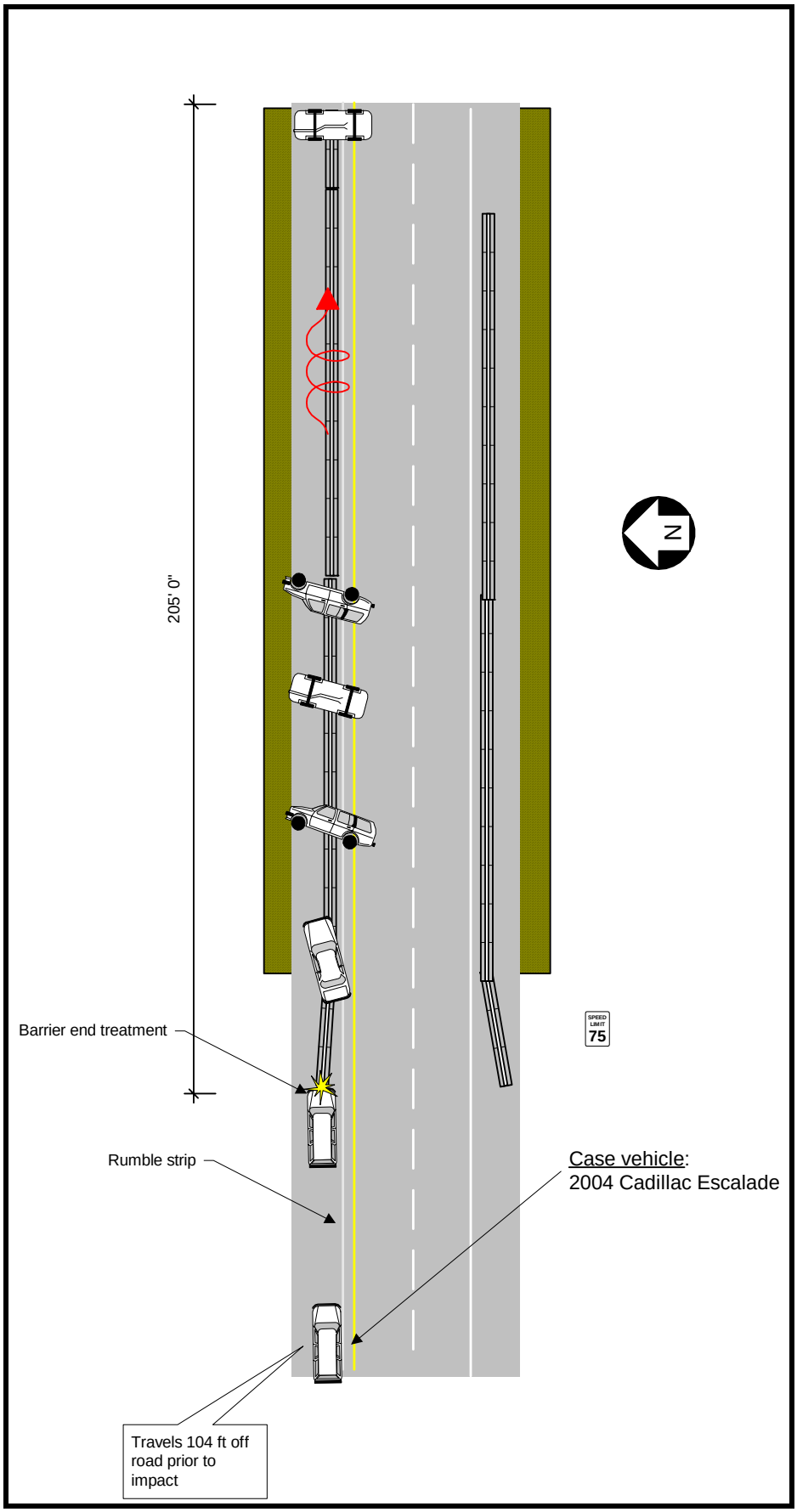
OCCUPANT KINEMATICS - 2004 Cadillac Escalade

The 20-year-old male driver was seated generally upright but had fallen asleep. He later tested positive for benzodiazepines and cannabinoids. He was wearing the available lap and shoulder belt. He was likely being held in place by the shoulder harness. The seat belt was integral to the bucket seat. The bucket seat was adjusted to the middle track position. The seat back was upright. The tilt steering column was in the center position. Both feet were on the floor. The vehicle cruise control was ON. At impact with the guardrail end treatment, the driver exhibited a forward trajectory in response to the 12 o'clock direction of force and loaded the manual restraint. The driver's air bag deployed upon impact. There were no resultant injuries from the seat belt or the driver's air bag. As the vehicle over-rode the guardrail it rolled over with the right side leading. At some point during the rollover the driver contacted the roof area and sustained a concussion (see Figures 11 and 12). Also during the rollover, he contacted the left side interior surface. The glazing had disintegrated during the rollover and the driver sustained a number of small lacerations from the glass–primarily on the left side of his face.

Figure 11. Possible head contact to roof

Figure 12. Blood/tissue contact to roof/A pillar area

Attachment 1. Scene Diagram



Attachment 2. Vetronix Report

CDR File Information

Vehicle Identification Number	1GYEK63N54Rxxxxxx
Investigator	[illegible]
Case Number	124C
Investigation Date	Monday, October 11 2004
Crash Date	
Filename	2004-78-124 WITHOUTSEQUENCE NUMBER.CDR
Saved on	Monday, October 11 2004 at 11:12:03 AM
Data check information	1069A8DC
Collected with CDR version	Crash Data Retrieval Tool 2.24
Collecting program verification number	70CD83DD
Reported with CDR version	Crash Data Retrieval Tool 2.50
Reporting program verification number	30CAB595
Interface used to collected data	Block number: 00 Interface version: 39 Date: 10-09-03 Checksum: 0300
Event(s) recovered	Deployment Non-Deployment

SDM Data Limitations

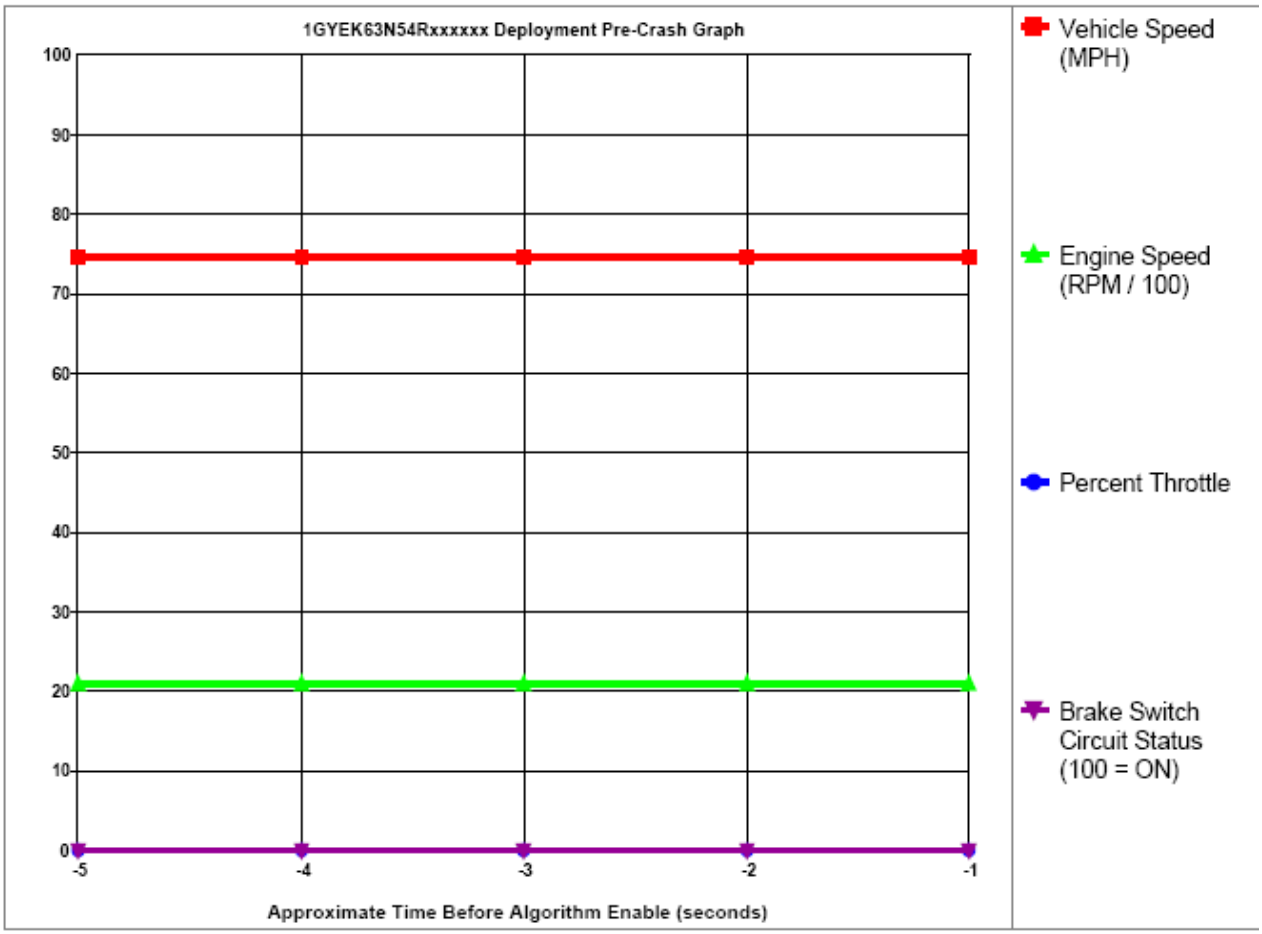
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store 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 five 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 file will be locked after a deployment, if the non-deployment occurred within 5 seconds before the deployment or a deployment level event occurs within 5 seconds after the deployment.

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 deployments 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-deployments, 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 does not receive a valid message.
-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit
-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.

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 Class 2 data link, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the Class 2 data link, to the SDM.
-In most vehicles, the Driver's Belt Switch Circuit is wired directly to the SDM. In some vehicles, the Driver's Belt Switch Circuit Status data is transmitted from the Body Control Module (BCM), via the Class 2 data link, to the SDM.

System Status At Deployment

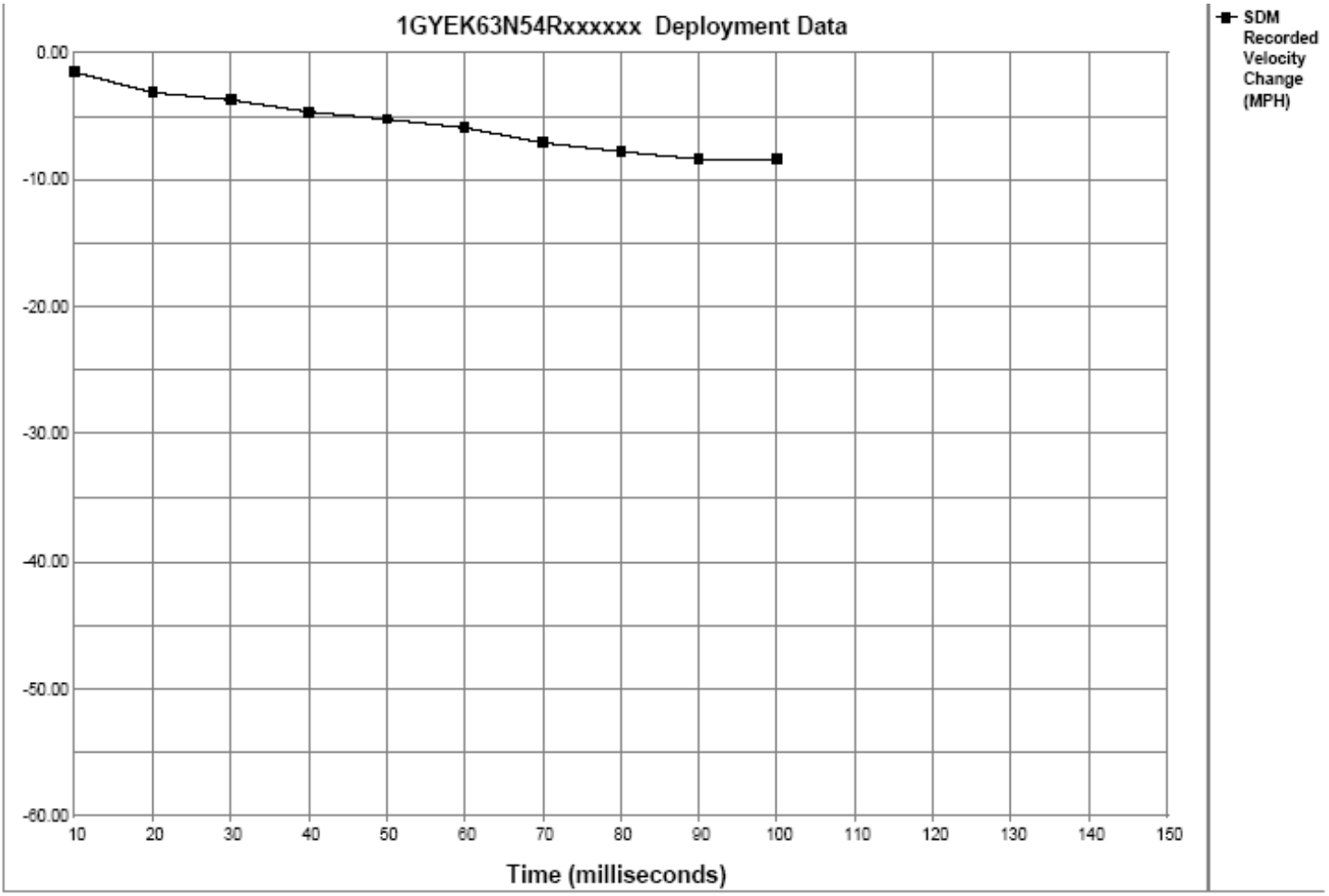
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	177
Ignition Cycles At Investigation	180
Maximum SDM Recorded Velocity Change (MPH)	-9.68
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	192.5
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	5
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	7.5
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)	Suppressed
Time Between Non-Deployment And Deployment Events (sec)	N/A
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No



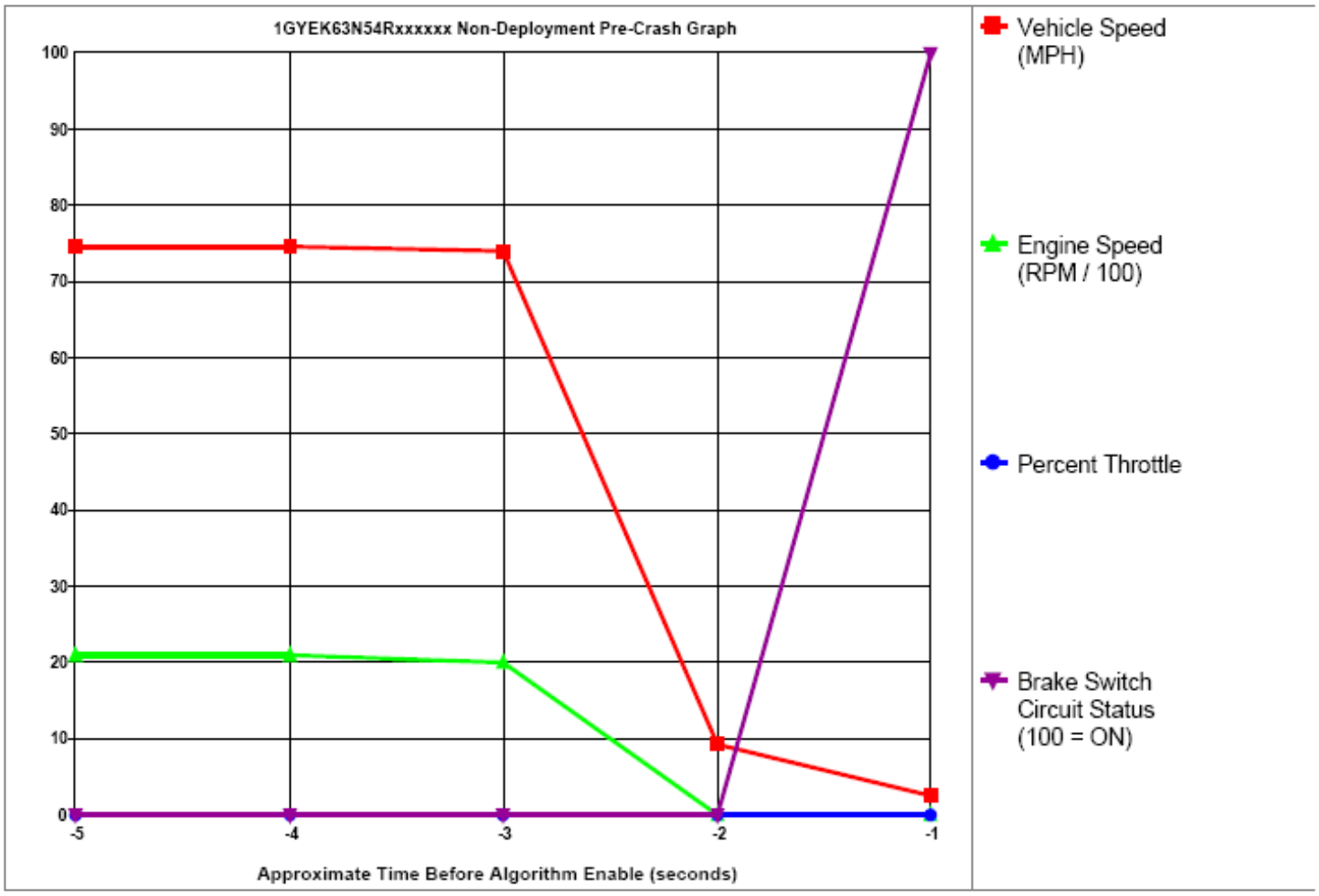
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	75	2112	0	OFF
-4	75	2112	0	OFF
-3	75	2112	0	OFF
-2	75	2112	0	OFF
-1	75	2112	0	OFF

System Status At Non-Deployment

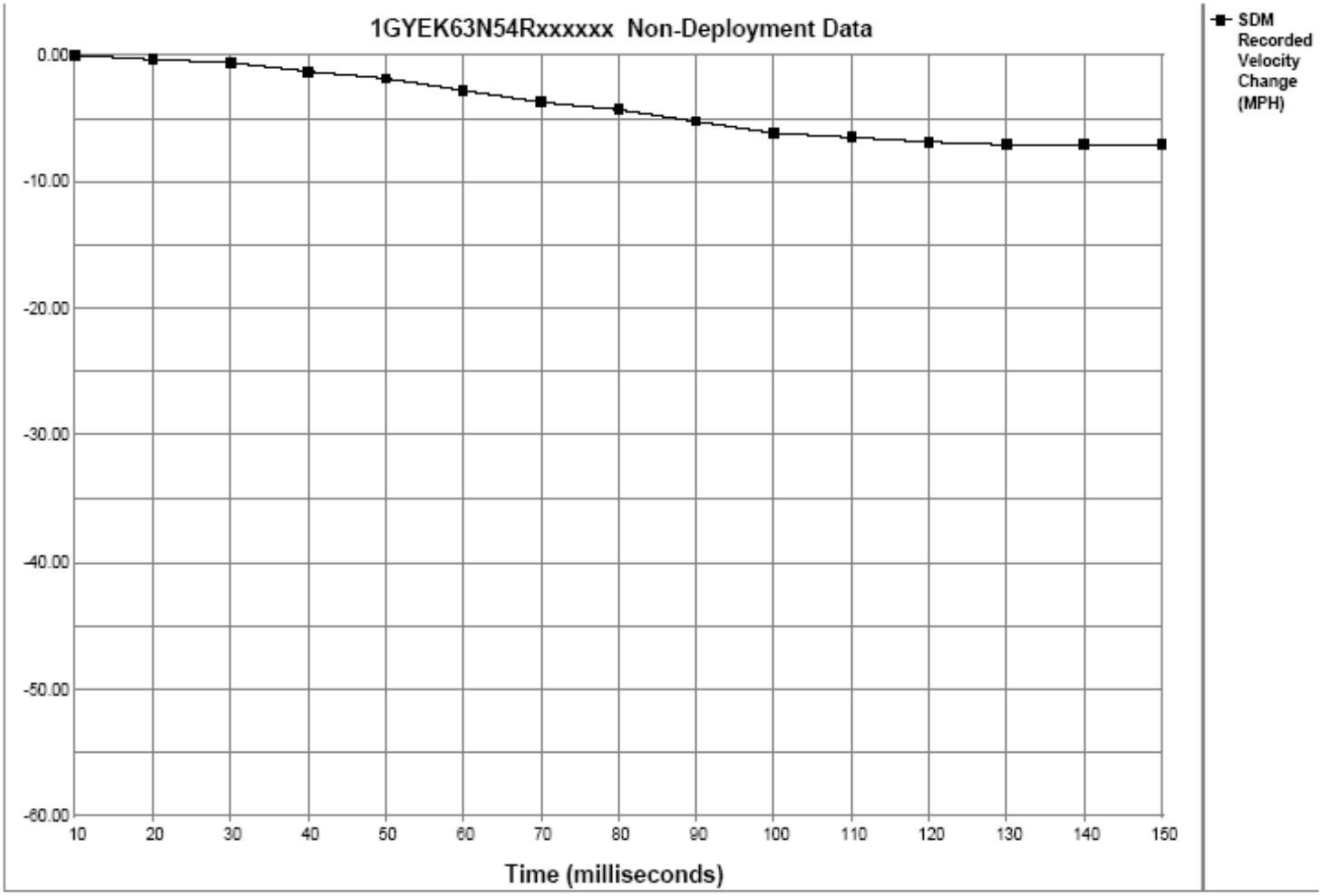
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	177
Ignition Cycles At Investigation	180
Maximum SDM Recorded Velocity Change (MPH)	-7.29
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	162.5
Event Recording Complete	Yes
Multiple Events Associated With This Record	Yes
One Or More Associated Events Not Recorded	Yes



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.55	-3.10	-3.72	-4.65	-5.27	-5.89	-7.13	-7.75	-8.37	-8.37	N/A	N/A	N/A	N/A	N/A



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	75	2112	0	OFF
-4	75	2112	0	OFF
-3	74	2048	0	OFF
-2	9	0	0	OFF
-1	2	0	0	ON



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	-1.24	-1.86	-2.79	-3.72	-4.34	-5.27	-6.20	-6.51	-6.82	-7.13	-7.13	-7.13