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Special Crash Investigations On-Site Guardrail End Terminal Investigation; Vehicle: 2011 Chevrolet Impala; Location: Missouri; Crash Date: January 2018

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Technical Report Documentation Page

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15. Supplementary Notes Each crash represents a unique sequence of events and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was written.			
16. Abstract This report covers an on-site investigation of a 2011 Chevrolet Impala impact to a Soft Stop guardrail end terminal that is of interest to the Federal Highway Administration (FHWA). This crash occurred on the south roadside of a 6-lane, divided interstate highway. The Chevrolet was a 4-door sedan equipped with multi-stage frontal air bags, front-seat-mounted side-impact air bags, inflatable curtain air bags, and an event data recorder. An unbelted 28-year-old-female driver occupied the vehicle. The Chevrolet was traveling northeast and departed the right side of the roadway, where the front plane struck the end terminal of a blocked-out W-beam guardrail. The vehicle continued northeast and damaged 11.1 m (36.4 ft) of guardrail and six posts and was subsequently struck by two other vehicles. The Chevrolet's driver sustained police reported "C" (possible) injuries from the guardrail impact. She sustained police reported "A" (incapacitating) injuries from the subsequent two crashes and was transported by ambulance to a hospital where she died from her injuries. The Chevrolet was towed from the crash site due to damage.			
17. Key Words Soft Stop guardrail end terminal, motor vehicle traffic crash, police-reported "C" (possible), injury		*18. Distribution Statement* Document is available to the public from the National Technical Information Service, www.ntis.gov.	
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ON-SITE GUARDRAIL END TREATMENT INVESTIGATION
CASE NUMBER - IN18001
VEHICLE - 2011 CHEVROLET IMPALA
LOCATION - MISSOURI
CRASH DATE - JANUARY 2018

BACKGROUND

This report covers an on-site investigation of a passenger vehicle impact to a Soft Stop guardrail end terminal (**Figure 1**) that is of interest to the Federal Highway Administration (FHWA). This crash was identified by an engineer with the Missouri Department of Transportation (MoDOT), who submitted photographs of the vehicle and the damaged guardrail end terminal to the FHWA. The FHWA determined that the guardrail end terminal and crash type were of interest. This crash investigation was then initiated by the National Highway Traffic Safety Administration in January 2018 and assigned to the Special Crash Investigation (SCI) team at the Indiana University Transportation Research Center. This crash involved a 2011 Chevrolet Impala (**Figure 2**). The crash occurred in Missouri in January 2018 during dark early morning hours and was investigated by a local police agency. The guardrail and crash scene were inspected in January 2018.

Figure 1: The damaged guardrail and end terminal, view northeast

Figure 2: The damaged 2011 Chevrolet Impala

This crash occurred on the south roadside of a six-lane, divided interstate highway. The Chevrolet was a 4-door sedan equipped with multi-stage frontal air bags, front-seat-mounted side-impact air bags, inflatable curtain (IC) air bags, and an event data recorder (EDR). An unbelted 28-year-old female driver occupied the vehicle. The Chevrolet was traveling northeast in an unknown lane and departed the right (south) side of the roadway, where the front plane struck the end terminal of a blocked-out W-beam guardrail. The vehicle continued northeast and damaged 11.1 m (36.4 ft) of guardrail and six posts. The vehicle came to final rest heading east. The back plane of the Chevrolet was subsequently struck by two other vehicles. The Chevrolet's driver sustained police reported "C" (possible) injuries from the guardrail impact. She sustained police reported "A" (incapacitating) injuries from the subsequent two crashes and was transported by ambulance to a hospital where she died from her injuries. The Chevrolet was towed from the crash site due to damage.

CRASH SUMMARY

Crash Site

This crash occurred during dark early morning hours on the south roadside of a six-lane, divided interstate highway. The weather conditions were clear visibility with west winds at 23 km/h (14 mph), a temperature of 3.3 °C (38 °F), and a dew point of 3.3 °C (38 °F) according to the local weather reports. The roadway was straight and had three bituminous northeast-bound through lanes and a right exit lane. The roadway grade in the area of the Chevrolet's approach to the crash scene was 2 percent. The through lanes were 3.7 m (12 ft) wide and were bordered by a 2.3 m (7.9 ft) wide bituminous shoulder on the south side and a 3.6 m (11.8 ft) wide bituminous shoulder on the north side. A blocked out W-beam guardrail equipped with a Soft Stop end terminal was located on the south side of the roadway. The speed limit was 105 km/h (65 mph). The crash diagram is included at the end of this report.

Pre-Crash

The Chevrolet was traveling northeast in an unknown lane at an EDR-reported speed range of 114 km/h (71 mph) to 105 km/h (65 mph)[1] from -2.5 to -0.5 sec prior to algorithm enable (AE). The Chevrolet's EDR-reported accelerator pedal position, vehicle speed, engine speed, percent throttle, and brake switch circuit state are presented in the table below.

Parameter	-2.5 sec	-2.0 sec	-1.5 sec	-1.0 sec	-0.5 sec
Accelerator Pedal Position (percentage)	0	0	0	0	0
Vehicle Speed km/h (mph)	114 (71)	113 (70)	113 (70)	108 (67)	105 (65)
Engine Speed (rpm)	1,792	1,664	1,600	1,472	1,344
Percent Throttle	22	19	17	17	16
Brake Switch Circuit State	Off	Off	Off	Off	Off

Crash

For unknown reasons, the Chevrolet traveled off the south road side (**Figure 3**) and the front plane (**Figure 4**) struck the end terminal. The force direction on the vehicle was in the 12 o'clock sector and the impact resulted in a stage one and two deployment of the driver's frontal air bag. The WinSMASH program could not be used to calculate delta V since a yielding object impact is out of scope for the program. However, WinSMASH was used to calculate a barrier equivalent speed (BES) of 38 km/h (24 mph) based on the damage to the front bumper. The vehicle's EDR reported the maximum longitudinal and lateral delta Vs as -34.40 km/h (-21.38 mph) and -1.14

[1] The manufacturer's recommended tire size was P225/60R16 and the left wheels of the Chevrolet were equipped with tires sized P255/60R16. The difference in diameter was 4.6 cm (1.8 in). It is unknown if this size difference affected the EDR-reported speed of the vehicle.

km/h (-0.71 mph), respectively. The vehicle remained in contact with the end terminal as it continued northeast damaging 11.1 m (34.6 ft) of guardrail and six posts. The vehicle rotated clockwise an estimated 45 degrees prior to coming to final rest heading east with the front plane against the guardrail and the back plane extending into the right lane.

Figure 3: Northeast approach to end terminal

Post-Crash

The Chevrolet's driver exited the vehicle. She then reentered the vehicle and unsuccessfully attempted to start it, according to a witness who stopped to assist her. The vehicle was then struck by a 2006 Lexus RX400 and a 2006 International 4000 straight truck. These were separate crashes and not included in this investigation since the Chevrolet had come to final rest prior to them occurring and therefore met the definition of stabilization.

Figure 4: Damage to front plane of the Chevrolet from end terminal impact

The police were notified of the crash at 0303 hours and arrived on scene at 0315 hours. The driver sustained police reported "C" (possible) injuries during the impact with the end terminal and "A" (incapacitating) injuries from the subsequent crashes. She was transported by ambulance to a hospital where she died from injuries sustained in the subsequent crashes. The vehicle was towed from the crash scene due to damage.

END TERMINAL AND GUARDRAIL DAMAGE

Figure 5: Anchor bolt secured to end of guardrail tab

The front plane of the Chevrolet struck the guardrail head, which was mounted on top of an angular guide chute. The end of one section of guardrail 3.8 m (12. 5 ft) long was routed through the guide chute and attached by a bolt to the ground anchor (Post 0, **Figure 5**). During an end terminal impact, these guardrail sections are designed to enter the upstream end of the terminal and pass through the chute, which is angled downward and rearward. The rail is extruded underneath the vehicle toward the ground and dissipated crash energy through compaction. During this crash, 8.0 m (26.4 ft) of

guardrail was extruded through the chute onto the ground extending from the ground anchor to the end terminal. A total of 11.1 m (36.4 ft) of guardrail and six posts were damaged.

Figure 6: Soft Stop guardrail head

The face of the end terminal was 18 cm (7 in) wide and 51 cm (20 in) high. It sustained minor damage (**Figure 6**). Posts 1 and 2 collapsed downstream to the ground and detached from the damaged guardrail. Posts 3, 4, 5, and 6 were all bent downstream and were detached from the damaged guardrail. Posts 7-12 were not damaged and remained attached to the guardrail. Composite offset blocks were installed on all posts except Post 1. The offset blocks on posts 3-6 became detached during the crash. The offset block for post 2 was damaged and remained loosely attached. The offset blocks for posts 8-12 remained attached and were undamaged.

There was a minor kink in the third guardrail panel between posts 6 and 7. The FHWA guardrail form is attached to the end of this report as **Appendix B**.

2011 CHEVROLET IMPALA

Description

The Chevrolet was a front-wheel drive, 5-occupant, 4-door sedan with the Vehicle Identification Number 2G1WG5EK3B1xxxxxx, manufactured in January 2011, and was equipped with a 3.5-liter, V-6 engine, a 4-speed automatic transmission, 4-wheel anti-lock brakes with electronic brake force distribution, traction control, and electronic stability control. The vehicle was also equipped with multi-stage frontal air bags, front seat belt pretensioners, front-seat-mounted side impact and side impact IC air bags, an EDR, and a tilt steering column that was adjusted to the full down position. The specified wheelbase was 281 cm (111 in).

The vehicle manufacturer's recommended tire size was P225/60R16. The vehicle was equipped with Cordovan Tour Plus tires on the left side wheels, size 255/60R16 and a Goodyear Assurance tire of the recommended size on the right front wheel. The right front tire sustained a sidewall puncture. The right rear tire was missing and could not be located. The left side tires were not damaged. The left front tire was in poor condition and the remaining tires were all in good condition prior to the crash.

The front row was equipped with cloth-covered bucket seats with adjustable head restraints. The second row was equipped with a cloth-covered bench seat with folding backs and integral head restraints. The driver's seat track was adjusted between the middle and rear most positions and the seat back was reclined 26 degrees aft of vertical. The remaining seats were unoccupied at the time of the crash. All seats were damaged from the impacts with the Lexus and International.

Exterior Damage
The Chevrolet sustained damage to the front plane during the impact with the end terminal. The bumper fasica, bumper bar, hood, grille, and right head lamp/turn signal assembly were directly damaged. The direct damage began 59 cm (23.2 in) right of the left front bumper corner and extended 18 cm (7.1 in) to the right. The field L was 107 cm (42.1 in). The maximum residual crush was 40 cm (15.7 in) occurring 67 cm (26.3 in) right of the front left bumper corner. The crush values were: C1 = 9 cm, (3.5 in), C2 = 19 cm (7.4 in), C3 = 32 cm (12.6 in), C4 = 40 cm (15.7 in), C5 = 26 cm (10.2 in), C6 = 11 cm (4.3 in).

Damage Classification
The collision deformation classifications (CDC) was 12FCEN2
(0 degrees). The severity of the damage was moderate.

Event Data Recorder
The Chevrolet's EDR was imaged with version 17.6 of the Bosch Crash Data Retrieval software and reported with version 19.3. Electrical power was supplied by an external battery and the data were imaged via connection to the diagnostic link connector. The EDR reported a deployment and a non-deployment event and the event recording was complete for both records. The driver's seat belt switch circuit status was reported as "Unbuckled" for both events. The EDR report is attached to the end of this report as **Appendix B**.

The EDR was capable of recording deployment and non-deployment events. Up to one non-deployment event could be stored but could be overwritten by a deployment event if the non-deployment event is not locked. If a non-deployment event occurs within 5 seconds of a deployment event, the non-deployment event will be locked to the deployment and cannot be overwritten. Deployment events cannot be overwritten or cleared by the sensing diagnostic module.

System Status At Deployment: The SIR warning lamp status was "OFF" for this event and there were no diagnostic trouble codes (DTCs) reported. The record reported that the first and second stage deployment loops of the driver's frontal air bag and both seat belt pretensioners were commanded. The first and second stages of the driver's frontal air bag met the deployment command criteria at 20 msec and 22 msec, respectively. The maximum longitudinal and lateral velocity changes were reported as -34.40 km/h (-21.38 mph) and –1.14 km/h (-0.71 mph) and occurred 210 msec after AE and at AE, respectively.

The non-deployment event was related to the subsequent crash.

Interior Damage
The interior of the Chevrolet did not sustain any intrusion from the end terminal impact. Inspection of the vehicle's interior revealed no discernable evidence of occupant contacts.

Manual Restraint Systems
The front row was equipped with three-point lap and shoulder seat belts with sliding latch plates, adjustable upper anchors, and retractor-mounted pretensioners at the outboard seating positions. The second row was too badly damaged to determine the type of seat belt equipment present.

The driver was not restrained by the lap and shoulder seat belt as evidenced by the seat belt webbing retracted tightly by the pretensioner. The EDR also reported the driver's belt switch circuit status as "Unbuckled."

Supplemental Restraint Systems

The Chevrolet was equipped with multi-stage frontal air bags, front-seat-mounted side impact air bags, and side impact IC air bags. The driver's frontal air bag deployed during the crash.

The driver's frontal air bag was located in the steering wheel hub and the deflated air bag was 55 cm (34.2 in) in diameter. No discernable evidence of occupant contact was present on the air bag and there was no damage. The module cover was a two-flap configuration constructed of pliable vinyl with a vertical tear seam between the flaps. Each flap was 8 cm (3.1 in) wide and 13 cm (5.1 in) high. The cover flaps opened at the designated tear seams and were undamaged.

2011 CHEVROLET IMPALA OCCUPANT

Driver Demographics

Age/sex:	28-year-old/female
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat type:	Bucket
Seat track position:	Between middle and rearmost positions
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags:	Driver frontal, deployed; Side impact and side IC, not deployed
Alcohol/drug involvement:	None
Egress from vehicle:	Exited under own power
Transport from scene:	Ambulance
Medical treatment:	Pronounced deceased at the hospital, probably from injuries related to crashes occurring after this crash.

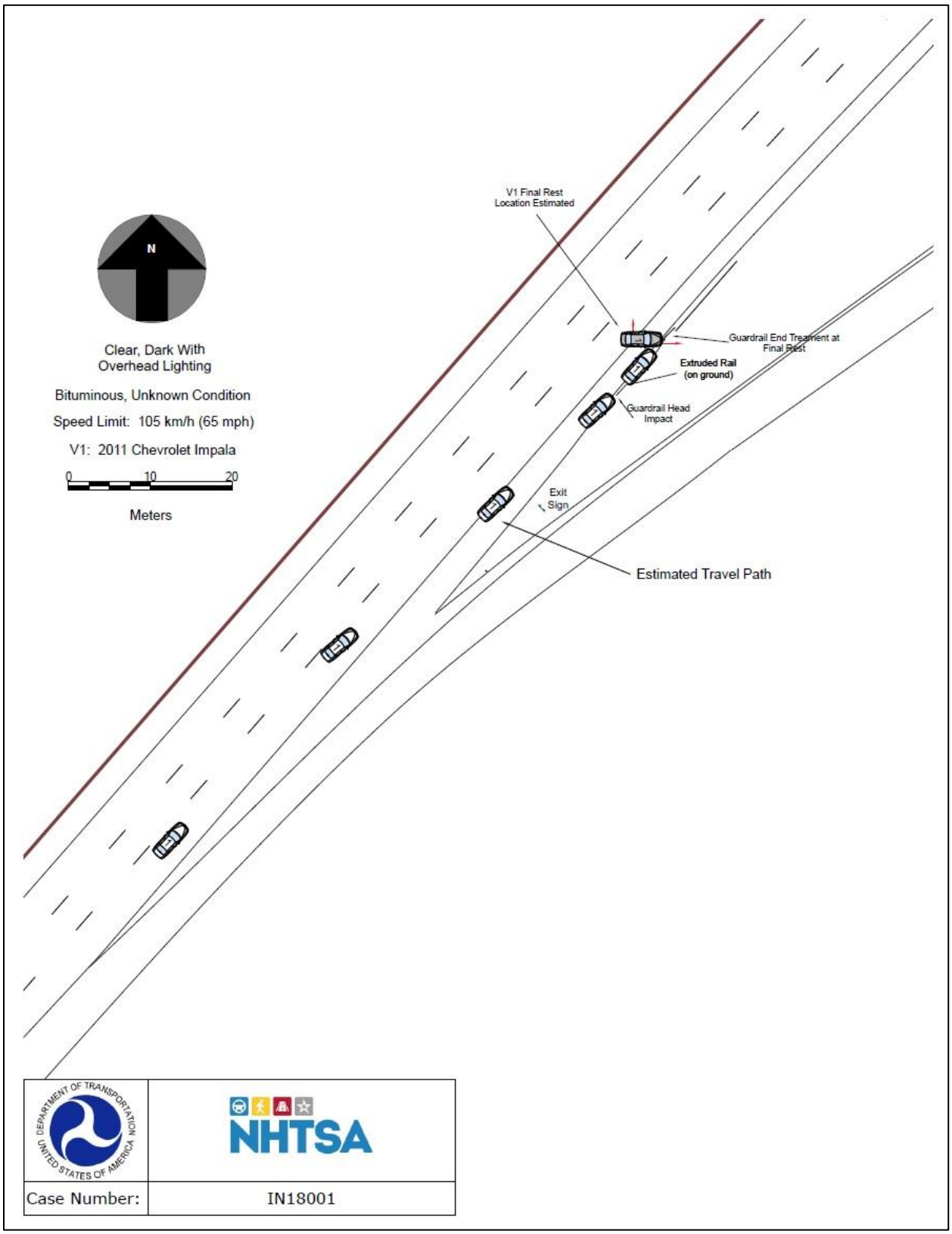
Driver Injuries

No injury information was available for the driver.

Driver Kinematics

The driver was not restrained by the lap and shoulder seat belt and the seat track was adjusted between the middle and rearmost positions. The front plane impact with the end terminal displaced the driver forward. She loaded the frontal air bag and was redirected to the left as the vehicle rotated clockwise. Her injuries from the guardrail crash are unknown.

CRASH DIAGRAM



APPENDIX A:
FHWA GUARDRAIL FORM

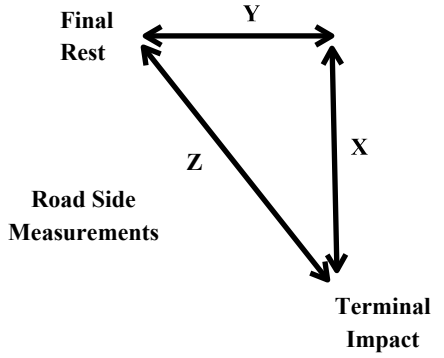
Case No.: IN180001

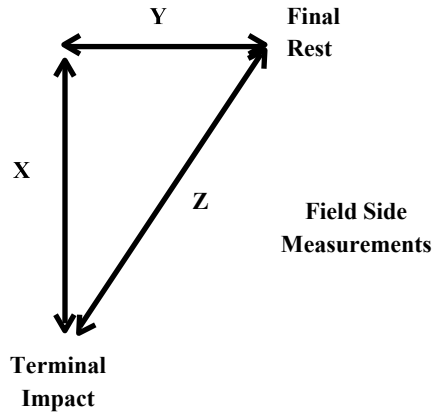
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	January 2018	**TIME OF CRASH (MILITARY)**	Early Morning
Case Number	IN18001	**State**	MO
Traffic Route	Interstate	**Direction (Southbound = SB)**	EB
Ambient Conditions (at time of crash)			
Temperature (°F)	3	**Lighting**	Dark, overhead lighting
Atmospheric	Clear		

SCENE INFORMATION	
Type of area where crash occurred	❒Urban ❒Rural ☑Suburban
Terminal on a horizontal curve?	☑No ❒Curve/LT ❒Curve/RT
Estimated or Reconstructed Speed at Impact (MPH)	65 mph
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 24 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 22.8 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 7.4 ft
Super elevation	❒+2% ☑-2% ❒ NONE or FLAT
Curve Radius (ft.)	N/A

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: IN18001

ON-SCENE INFORMATION		
End Treatment Type	☑Extruder	❒ET2000 ❒ET-PLUS 4in ❒ET-PLUS 5in ❒SKT ❒FLEAT ☑SOFT STOP
	❒Telescope	❒X-LITE ❒X-TENSION
Curb?	☑No ❒Yes	❒AASHTO Type A ❒AASHTO Type B ❒AASHTO Type C ❒AASHTO Type D ❒AASHTO Type E ❒AASHTO Type F ❒AASHTO Type G ❒AASHTO Type H
Curb Height:		

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
0	N/A	N/A	N/A	N/A	N/A		8.6’		0
1	Steel	6x4	N/A	N/A	Unknown		8.8		5’ 9”
2	Steel	6x4	Composite	Damaged	Unknown		9.7		7’ 8”

Case No.: IN18001

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type Steel Wood Other	Dim. D x W (in.) or Dia. (in.)	Type Steel Wood Composite	Dim. D x W (in.)	Yes No Unknown	Describe	Travel way	Curb	
3	Steel	6x4	Composite	N/A	Unknown		9.7		6’ 4”
4	Steel	6x4	Composite	N/A	Unknown		9.5		6’ 4”
5	Steel	6x4	Composite	N/A	Unknown		9.8		6’ 0”
6	Steel	6x4	Composite	N/A	Unknown		9.8		5’ 10.5”
7	Steel	6x4	Composite	7.5x4	None		9.75		6’ 2.5”
8	Steel	6x4	Composite	7.25x4	None		9.5		6’ 3.5”

Case No.: IN18001

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
9	Steel	6x4	Composite	11.5x4	None		9.6		6’ 3”
10	Steel	6x4	Composite	11.5x4	None		9.5		6’ 3”
11	Steel	6x4	Composite	11.5x4	None		9.4		6’3”
12	Steel	6x4	Composite	11.5x4	None		9.3		6’3”

Additional Comments

Case No.: IN18001

EXTRUDER			
Feeder Channel Width at impact head	❒4inches ❒5 inches ☑Other 6”		
Guide Chute Exit Height (in.)	5”		
Connection of feeder channels to head damaged?	☑No ❒Yes	Are Welds Broken?	☑No ❒Yes
Anchor Cable Present?	❒No ☑Yes	Connected?	❒No ☑Yes
Rail Extrusion?	❒No ☑Yes	Length (ft. in.)	26’ 5”
Rail Extrusion Direction	❒Traffic Side ❒Field Side (Straight down on ground)		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	36’ 5”		

TELESCOPE				
Rail Displacement	❒No	❒Yes; Length:	No of Panels Displaced	❒1 ❒2 ❒3 ❒4 ❒5 ❒6

ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	❒No	☑Yes;	No. of Kinks in Rail: 1
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	☑No ❒Yes		
Did vehicle impact other objects after impact with terminal?	❒No ☑Yes		
Object Contacted			

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	-14%	-9%	-32%
Adjacent Lane Width (ft)	12’		
Lane Type (NAS EDS Variable: Sur. Type)	Bituminous		
Shoulder Type	Bituminous		
Shoulder Width (ft)	8’ 4”		
Guardrail Height (in)	29” 5”		

Case No.: IN18001

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	4-Door Sedan, Hardtop	
Vehicle Identification Number (VIN)	2G1WG5EK3B1xxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3555 Lbs.	
Vehicle orientation upon impact	☑Case Type 1 ❒ Case Type 2 ❒Case Type 3 ❒ Case Type 4 ❒ Case Type 5 ❒ Case Type 6 ❒ Case Type 7 ❒ Case Type 8 ❒ Other	
If 'Other', describe		
Collision Deformation Classification	12FCEN2	
Delta-V	24 mph (Barrier Equivalent Speed)	
Occupant Compartment Penetration of rail	☑No	❒Yes; Describe:
Quarter Turns (NASS EDS variable: Rollover)	❒1 ❒2 ❒3 ❒4 ❒5 ❒6 ❒7 ❒8 ❒9 ❒10 ❒11 ❒12 ❒13 ❒14 ❒15 ❒16 ❒17+	
Object Precipitating Rollover, (NASS EDS variable: Rollobj)	N/A	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	N/A	

APPENDIX B:
2011 CHEVROLET IMPALA
EVENT DATA RECORDER (EDR) REPORT[2]

[2] The EDR report contained in this technical report was imaged using the current version of the Bosch CDR software at the time of the vehicle inspection. The CDR report contained in the associated Crash Viewer application may differ relative to this report.

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	2G1WG5EK3B1******
User	
Case Number	
EDR Data Imaging Date	01/18/2018
Crash Date	
Filename	IN18001_V1_ACM.CDRX
Saved on	Thursday, January 18 2018 at 15:37:29
Imaged with CDR version	Crash Data Retrieval Tool 17.6
Imaged with Software Licensed to (Company Name)	NHTSA
Reported with CDR version	Crash Data Retrieval Tool 19.3
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	Deployment Non-Deployment

Comments

No comments entered.

Data Limitations

Recorded Crash Events:

There are two types of recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event records data but does not deploy the air bag(s). The minimum SDM Recorded Vehicle Velocity Change, that is needed to record a Non-Deployment Event, is five MPH. A Non-Deployment Event may contain Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event will be cleared by the SDM, after approximately 250 ignition cycles. This event can be overwritten by a second Deployment Event, referred to as Deployment Event #2, if the Non-Deployment Event is not locked. If a Non-Deployment occurs within 5 seconds of a deployment event, the ND will be locked to the deployment and cannot be overwritten. A locked Non Deployment Event cannot be overwritten by the SDM. A Non-Deployment can also be locked if two or more Non-Deployment Events occur within five seconds of one another. The recorded pre-crash data will be from the first Non-Deployment Events. A locked Non Deployment Event cannot be overwritten or cleared by the SDM.

The second type of SDM recorded crash event is the Deployment Event. It also may contain Pre-Crash and Crash data. The SDM can store up to two different Deployment Events. If a second Deployment Event occurs any time after the Deployment Event, the Deployment Event #2 will overwrite any non-locked Non-Deployment Event. Deployment Events cannot be overwritten or cleared by the SDM. Once the SDM has deployed an air bag, the SDM must be replaced.

Data:

-SDM Recorded Vehicle Velocity Change reflects the change in velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle 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. For Deployment Events, the SDM can record 220 milliseconds of data after Deployment criteria is met and up to 70 milliseconds before Deployment criteria is met. For Non-Deployment Events, the SDM can record up to the first 300 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.

-The CDR tool displays time from Algorithm Enable (AE) to time of Deployment command in a Deployment event and AE to time of maximum SDM recorded vehicle velocity change in a Non-Deployment event. Time from AE begins when the first air bag system enable threshold is met and ends when Deployment command criteria is met or at maximum SDM recorded vehicle velocity change. Air bag systems such as frontal, side, or rollover, may be a source of an enable. The time represented in a CDR report can be that of the enable of one air bag system to the Deployment time of another air bag system.

-Maximum Recorded Vehicle Velocity Change is the maximum square root value of the sum of the squares for the vehicle's combined "X" and "Y" axis change in velocity.

-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 by various factors, including but not limited to the following:

-Significant changes in the tire's rolling radius
-Final drive axle ratio changes
-Wheel lockup and wheel slip

-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Pre-Crash data is recorded asynchronously. The 0.5 second Pre-crash data value (most recent recorded data point) is the data point last sampled before AE. That is to say, the last data point may have been captured just before AE but no more than 0.5 second before AE. All subsequent Pre-crash data values are referenced from this data point.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if:
-The SDM receives a message with an "invalid" flag from the module sending the pre-crash data
-No data is received from the module sending the pre-crash data
-No module present to send the pre-crash data
-Pre-crash data associated with this event will always be for the first event even if it is not recorded.
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit.
-The Time Between Non-Deployment to Deployment Events is displayed in seconds. If the time between the two events is greater than five seconds, "N/A" is displayed in place of the time. If the value is negative, then the Deployment Event occurred first. If the value is positive, then the Non-Deployment Event occurred first.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-The ignition cycle counter relies upon the transitions through OFF->RUN->CRANK power-moding messages, on the GMLAN communication bus, to increment the counter. Applying and removing of battery power to the module will not increment the ignition cycle counter.
-Once a firing loop has been commanded to be deployed, it will not be commanded to be deployed again during the same ignition cycle. Firing loop times for subsequent deployment type events, during the same ignition cycle, will record the deployment times as N/A.
-If more than one event is recorded, use the following to determine which event the Multiple Event Data is associated with:
-If a Deployment event and not locked Non-Deployment event are recorded, the Multiple Event Data is associated with the Deployment event.
-If a Deployment event and a locked Non-Deployment event are recorded, then the Multiple Event Data is associated with both events.
-If a Deployment event and Deployment event #2 are recorded, then the Multiple Event Data is associated with both events.
-All data should be examined in conjunction with other available physical evidence from the vehicle and scene.

Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle's communication network.
-The Belt Switch Circuit is wired directly to the SDM.

Hexadecimal Data:
Data that the vehicle manufacturer has specified for data retrieval is shown in the hexadecimal data section of the CDR report. The hexadecimal data section of the CDR report may contain data that is not translated by the CDR program. The control module contains additional data that is not retrievable by the CDR tool.

01004_SDMC-autoliv_r008

Multiple Event Data

Associated Events Not Recorded	0
Event(s) was an Extended Concatenated Event	No
An Event(s) was in Between the Recorded Event(s)	No
An Event(s) Followed the Recorded Event(s)	No
The Event(s) Not Recorded was a Deployment Event(s)	No
The Event(s) Not Recorded was a Non-Deployment Event(s)	No

System Status At AE

Low Tire Pressure Warning Lamp (If Equipped)	Invalid
Vehicle Power Mode Status	Run
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Active

Pre-crash data

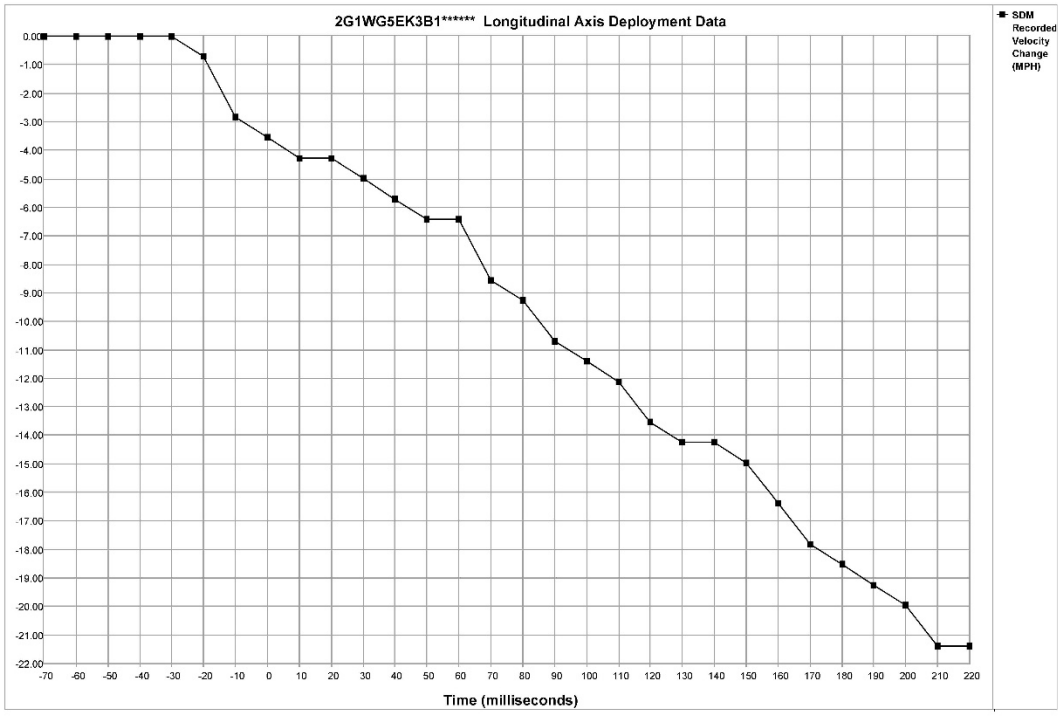
Parameter	-1.0 sec	-0.5 sec
Reduced Engine Power Mode	OFF	OFF
Cruise Control Active (If Equipped)	No	No
Cruise Control Resume Switch Active (If Equipped)	No	No
Cruise Control Set Switch Active (If Equipped)	No	No
Engine Torque (foot pounds)	Invalid	Invalid

Pre-Crash Data

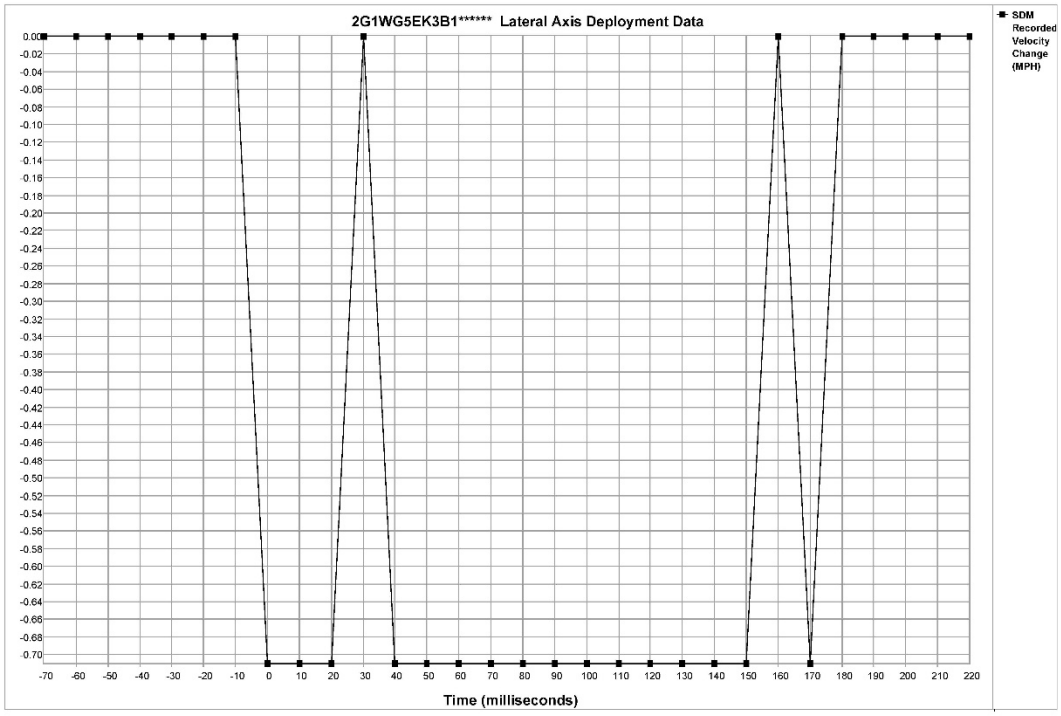
Parameter	-2.5 sec	-2.0 sec	-1.5 sec	-1.0 sec	-0.5 sec
Accelerator Pedal Position (percent)	0	0	0	0	0
Vehicle Speed (MPH)	71	70	70	67	65
Engine Speed (RPM)	1792	1664	1600	1472	1344
Percent Throttle	22	19	17	17	16
Brake Switch Circuit State	OFF	OFF	OFF	OFF	OFF

System Status At Deployment

Ignition Cycles At Investigation	13702
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON Time Continuously (seconds)	0
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	441
Ignition Cycles At Event	13686
Ignition Cycles Since DTCs Were Last Cleared	255
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Passenger Classification Status at Event Enable	Passenger Seat Empty
Passenger Air Bag Indicator Status at Event Enable	OFF
Diagnostic Trouble Codes at Event, fault number: 1	N/A
Diagnostic Trouble Codes at Event, fault number: 2	N/A
Diagnostic Trouble Codes at Event, fault number: 3	N/A
Diagnostic Trouble Codes at Event, fault number: 4	N/A
Diagnostic Trouble Codes at Event, fault number: 5	N/A
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Diagnostic Trouble Codes at Event, fault number: 7	N/A
Diagnostic Trouble Codes at Event, fault number: 8	N/A
Diagnostic Trouble Codes at Event, fault number: 9	N/A
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	20
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	22
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
Driver Side or Roof Rail/Head Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger Side or Roof Rail/Head Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Time Between Events (sec)	0.0
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
SDM Synchronization Counter	13685
Event Recording Complete	Yes
Driver First Stage Deployment Loop Commanded	Yes
Passenger First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	Yes
Driver 2nd Stage Deployment Loop Commanded for Disposal	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Driver Pretensioner Deployment Loop Commanded	Yes
Passenger Pretensioner Deployment Loop Commanded	Yes
Driver Side Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Right Side Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No



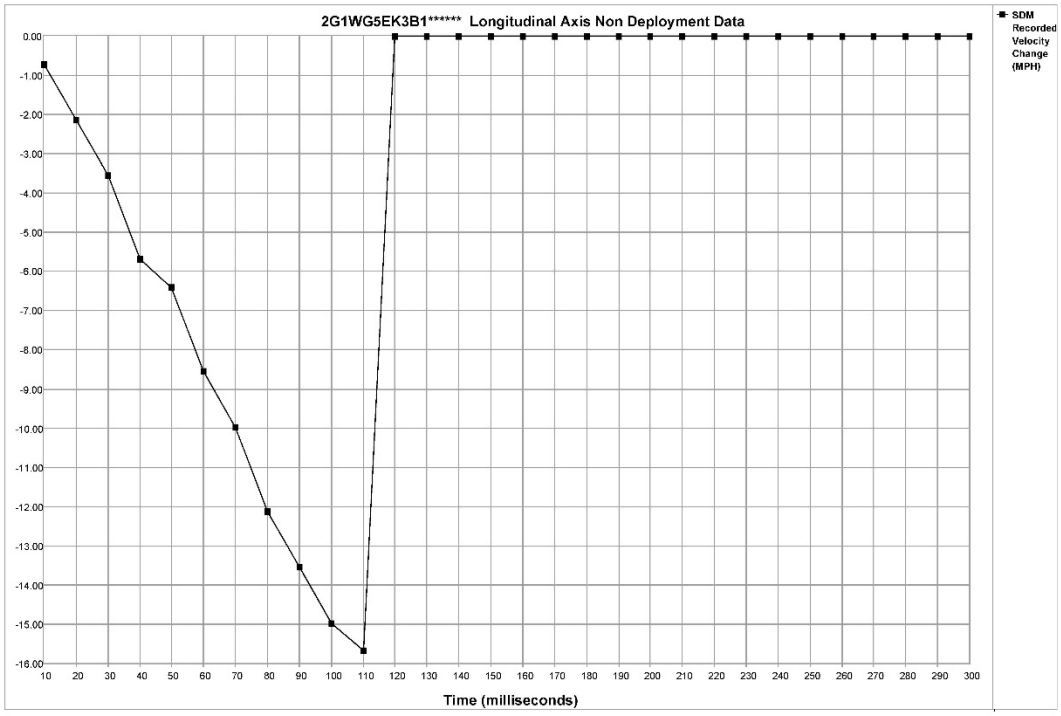
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	-0.71	-2.85	-3.56	-4.28	-4.28	-4.99	-5.70	-6.41	-6.41	-8.55
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-9.27	-10.69	-11.40	-12.12	-13.54	-14.25	-14.25	-14.97	-16.39	-17.82	-18.53	-19.24	-19.96	-21.38	-21.38



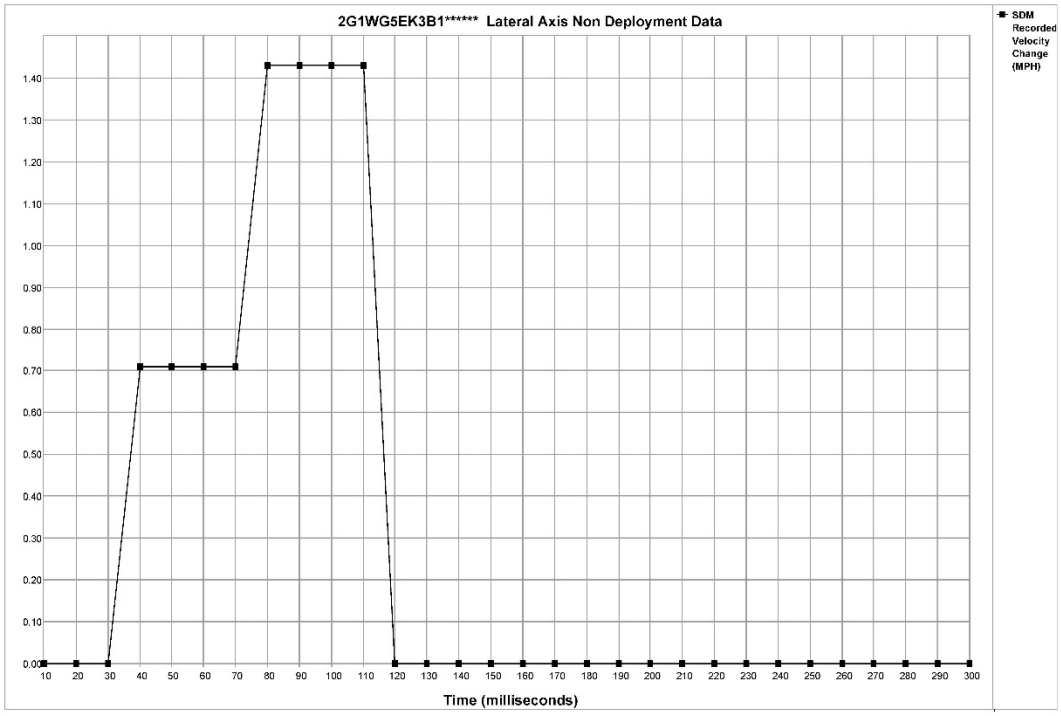
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.71	-0.71	-0.71	0.00	-0.71	-0.71	-0.71	-0.71
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Lateral Axis Recorded Velocity Change (MPH)	-0.71	-0.71	-0.71	-0.71	-0.71	-0.71	-0.71	-0.71	0.00	-0.71	0.00	0.00	0.00	0.00	0.00

System Status At Non-Deployment

Ignition Cycles At Investigation	13702
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON Time Continuously (seconds)	0
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	441
Ignition Cycles At Event	13686
Ignition Cycles Since DTCs Were Last Cleared	255
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Diagnostic Trouble Codes at Event, fault number: 1	B0052-00
Diagnostic Trouble Codes at Event, fault number: 2	B0056-00
Diagnostic Trouble Codes at Event, fault number: 3	N/A
Diagnostic Trouble Codes at Event, fault number: 4	N/A
Diagnostic Trouble Codes at Event, fault number: 5	N/A
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Diagnostic Trouble Codes at Event, fault number: 7	N/A
Diagnostic Trouble Codes at Event, fault number: 8	N/A
Diagnostic Trouble Codes at Event, fault number: 9	N/A
Maximum Resultant SDM Recorded Vehicle Velocity Change (MPH)	18.32
Time From Algorithm Enable to Maximum Resultant SDM Recorded Vehicle Velocity Change (msec)	110
Crash Record Locked	Yes
Deployment Event Recorded in the Non-Deployment Record	No
Vehicle Event Data (Pre-Crash) Associated With This Event	No
SDM Synchronization Counter	13685
Event Recording Complete	Yes
Driver First Stage Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded for Disposal	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Driver Pretensioner Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Right Side Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-0.71	-2.14	-3.56	-5.70	-6.41	-8.55	-9.98	-12.12	-13.54	-14.97	-15.68	0.00	0.00	0.00	0.00
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.71	0.71	0.71	0.71	1.43	1.43	1.43	1.43	0.00	0.00	0.00	0.00
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Hexadecimal Data

$01	01	09	00	00	00	00	00
$02	47	31	57	47	35	45	4B
$03	33	42	31	32	32	31	37
$04	32	31	00	00	00	00	00
$05	80	26	00	00	00	00	00
$06	40	00	00	00	00	00	00
$0A	08	00	00	20	00	00	00
$0B	01	01	00	00	00	00	00
$0C	00	00	00	00	00	51	00
$0D	00	06	55	00	00	00	00
$0E	00	00	00	00	00	00	00
$0F	00	00	00	00	00	00	00
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$11	01	15	15	00	00	00	00
$12	FF	F0	F0	F0	C0	00	00
$13	FF	F0	F0	30	40	00	00
$14	FF	F0	F0	30	40	00	00
$15	01	02	03	04	0B	0C	05
$16	06	16	17	07	08	00	00
$17	00	00	00	00	00	00	00
$18	01	03	04	05	00	00	00
$19	07	02	07	03	00	02	07
$1A	07	07	07	02	02	00	00
$1B	00	00	00	00	00	00	00
$1C	00	00	00	00	00	00	00
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$2C	00	00	00	00	00	00	00
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$2E	00	00	00	00	00	80	00
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$40	00	00	00	00	00	00	00
$41	00	00	00	00	00	80	90

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$A5   0A 0B 00 00 00 00 00

$01   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
$02   00 00 00 00
$03   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
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$43  00 00 FC 9F
$44  C6 00 00 FC 80 C0
$45  00 00 1E 1E 64 64 64 64 08 64
$46  00 00 00 00 00 00 00 00 00 00 04 64
$47  18 08 08
$B4  41 53 37 32 37 34 45 39 39 30 57 31 52 44 34 30
$C1  01 8B 94 48
$C2  01 5B 90 AA
$CB  01 8B 9E 6A
$CC  01 8B 9E 6A
$DB  41 41
$DC  41 41
```

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May 2020

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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