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Special Crash Investigations On-Site End Terminal Guardrail Investigation Vehicle: 2003 GMC Yukon Location: Missouri Crash Date: January 2017

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Technical Report Documentation Page

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15. Supplementary Notes On-site end terminal guardrail investigation involving a 2003 GMC Yukon. 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.			
16. Abstract This report documents the on-site investigation of a sport utility vehicle (SUV) impact to an ET-Plus 10 cm (4 in) model end terminal guardrail that is of interest to the Federal Highway Administration (FHWA). This crash occurred at night in an interchange area on the west roadside of an entrance ramp acceleration lane to an eight-lane, divided, interstate highway. The GMC was a 4-door sport utility vehicle (SUV) equipped with frontal and front seat-mounted side impact air bags and an event data recorder (EDR). A belted 51-year-old male driver occupied the vehicle. The GMC was traveling southeast in the entrance ramp acceleration lane when the driver lost control on the wet and ice-covered roadway. The GMC then departed the west side of the road and the front plane struck the ET- Plus (Event 1). The left front door of the vehicle was then struck by a kink in the guardrail (Event 2) as the guardrail was deformed and displaced. The impact damaged and displaced 9.5 m (31.2 ft) of the guardrail. The vehicle came to final rest against the guardrail heading southwest. The driver sustained police-reported “A” (incapacitating) injuries and was transported by ambulance to a hospital, where he was hospitalized for two days for treatment of moderate severity injuries. The GMC was towed from the crash scene due to damage.			
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Indiana University
Transportation Research Center
On-Site End Terminal Guardrail Investigation
Case Number: IN17009
Vehicle: 2003 GMC Yukon
Location: Missouri
Crash Date: January 2017

BACKGROUND

This report documents the on-site investigation of an SUV impact to an ET-Plus 10 cm (4 in) model end terminal guardrail (**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 end terminal and crash type were of interest. This crash investigation was then initiated by the National Highway Traffic Safety Administration in January 2017 and assigned to the Special Crash Investigation team at the Indiana University Transportation Research Center. This single-vehicle crash involved a 2003 GMC Yukon (**Figure 2**). The crash occurred in Missouri in January 2017 at night and was investigated by a local police agency. The vehicle, guardrail, and crash scene were inspected in January 2017. A telephone interview was conducted with the driver in June 2017.

Figure 1: The damaged ET-Plus and guardrail.

Figure 2: The damaged 2003 GMC Yukon.

This crash occurred at night in an interchange area on the west roadside of an entrance ramp acceleration lane to an eight-lane, divided, interstate highway. The GMC was a 4-door Sport Utility Vehicle (SUV) equipped with frontal and front-seat-mounted side impact air bags and an event data recorder (EDR). A belted 51-year-old male driver occupied the vehicle. The GMC was traveling southeast in the entrance ramp acceleration lane when the driver lost control on the wet and ice-covered roadway. The GMC then departed the west side of the road and the front plane struck the ET-Plus (Event 1). The left front door of the vehicle was then struck by a kink in the guardrail (Event 2) as the guardrail was deformed and displaced. The impact damaged and displaced 9.5 m (31.2 ft) of the guardrail. The vehicle came to final rest against the guardrail heading southwest. The driver sustained police-reported “A” (incapacitating) injuries and was transported by ambulance to a hospital, where he was hospitalized for two days for treatment of moderate severity injuries. The GMC was towed from the crash scene due to damage.

CRASH SUMMARY

Crash Site

This crash occurred at night hours in an interchange area on the west roadside of the entrance ramp acceleration lane to an eight-lane, divided, interstate highway. The weather conditions were light freezing rain with 3.1 kilometers (5 miles) visibility, westerly winds at 10 km/h (6 mph), a temperature of -2.8 °C (27 °F), and a dew point of -7.2 °C (19 °F), according to local weather reports. The roadway surface was wet and icy according to the police crash report. The entrance ramp had one bituminous southeast-bound lane that merged with three bituminous southeast-bound through lanes. The southeast-bound through lanes were separated from the three northwest-bound through lanes and one exit ramp lane by a concrete median barrier. The entrance ramp lane was 4.0 m (13.1 ft) wide. The right, center, and left southeast-bound through lanes were 3.6 m (11.8 ft), 3.9 m (12.8 ft), and 3.4 m (11.2 ft) wide, respectively. The southeast-bound roadway was bordered by a 3.2 m (10.5 ft) wide bituminous median shoulder and a 2.2 m (7.2 ft) wide bituminous outside shoulder. A blocked-out W-beam guardrail equipped with an ET-Plus 10 cm (4 in) end terminal was adjacent to the outside shoulder. The grade for southeast-bound traffic was level. The speed limit was 89 km/h (55 mph). The crash diagram is included at the end of this report.

Pre-Crash

The GMC was traveling southeast in the entrance ramp acceleration lane and the driver was intending to merge with southeast-bound traffic. The vehicle's EDR reported the travel speed as 72 km/h (45 mph) at -5.0 sec prior to algorithm enable (AE) increasing to 111 km/h (69 mph) at -3.0 sec. The brake switch was then reported as "ON" at -2.0 sec and remained on to -1.0 sec (end of the pre-crash recording) at which point the speed was reported as 56 km/h (35 mph[1]). The EDR-reported braking was consistent with the driver's subsequent statement to police that a vehicle suddenly entered his lane and he applied the brakes to avoid a crash. The road surface was wet and icy according to the police crash report, suggesting that the driver of the unidentified vehicle lost control on the slick roadway surface. The brake application by the driver of the GMC and possible right steering input to avoid the non-contact vehicle resulted in a loss of vehicle control, and the GMC began to rotate clockwise, traveling toward the west roadside and the guardrail (**Figure 3**).

Figure 3: View southeast to GMC's approach from approximately 30 m (100 ft) from impact with ET- Plus.

[1] The EDR-reported speed at -2.0 and -1.0 sec probably does not accurately reflect the vehicle's speed at those time increments since the calculated deceleration value based on the speed loss from -3.0 to -1.0 sec is 0.77 g. This level of deceleration is not consistent with typical deceleration values on a wet and icy roadway, which, according to the Northwestern University Traffic Institute's Traffic Accident Reconstruction Manual, can range from 0.05 to 0.40 g depending on the extent of ice on the roadway. The EDR-reported speed was probably the result of antilock brake activation on the vehicle's speed sensor readings.

Crash

The left corner of the GMC's front plane (**Figure 4**) struck the end terminal (**Figure 5**, event 1). The impact speed is not known. The impact extruded 1.0 m (3.3 ft) of guardrail from the end terminal as the guardrail was deformed and displaced toward the field side of the guardrail. The vehicle's EDR reported the maximum longitudinal velocity change as -14.4 km/h (-9.35 mph) occurring at 485 msec following AE. The WinSMASH program could not be used to calculate delta-V since an impact with a yielding object is out of scope for the program. However, the barrier algorithm of WinSMASH was used to calculate a barrier equivalent speed (BES) based on the crush to the front plane. The calculated BES was 17 km/h (11 mph).

Figure 4: Damage to the front left corner of the GMC from impact with the ET-Plus.

The impact damaged and displaced the guardrail, resulting in five kinks in the guardrail. One of these kinks (probably the kink at the entrance to the guide chute on the end terminal) struck the vehicle's left front door (**Figure 6**, Event 2) creating an approximate 42 cm (17 in) long tear in the sheet metal and damaged the door's latch mechanism, which caused a separation of the latch and striker. The door remained partially attached to the vehicle by the lower hinge. The vehicle then came to final rest heading southeast after traveling 13.2 m (43.3 ft) from the initial impact with the end terminal.

Figure 5: The damaged ET-Plus.

Post-Crash

The police were notified of the crash at 2244 hours and arrived on scene at 2347 hours. The driver sustained police-reported "A" (incapacitating) injuries and was transported by ambulance to a hospital where he was hospitalized for two days for treatment of moderate severity injuries. The vehicle was towed from the crash scene due to damage.

Figure 6: Damage to GMC's left front door from impact with kink in guardrail.

END TERMINAL GUARDRAIL DAMAGE

The GMC's front plane impact to the end terminal extruded 1.0 m (3.3 ft) of guardrail (**Figure 7**) to the field side and damaged five posts and 9.5 m (31.3 ft) of guardrail (**Figure 8**) resulting in five kinks in the guardrail. The direct damage to the face of the end terminal involved its full width (38 cm [15.0 in]) and height (71 cm [28.0 in]). The guardrail was displaced from posts 1to 6; however, post 6 was not damaged or displaced. Post 1 pivoted downstream and separated from its base. It was found 8.5 m (27.9 ft) downstream of its base. Post 2 was bent downstream approximately 75 degrees off vertical. Post 3 was bent downstream approximately 70 degrees off vertical. The bolt pulled through the guardrail and remained attached to the post, while the composite offset block separated and was found near post 13. Post 4 was bent downstream approximately 40 degrees off vertical. The bolt pulled through the guardrail and the offset block was damaged but remained attached to the post. Post 5 was bent downstream approximately 60 degrees from vertical. The bolt was separated from the post and the offset block was damaged. Post 6 was not damaged or displaced but the bolt was pulled through the guardrail. Posts 7 and 8 were undamaged. The offset block for post 9 was cracked and the offset block for post 10 was cracked and displaced slightly downstream. This damage appeared to be unrelated to this crash and may have occurred during installation. There was no damage on the face of the guardrail near or at either of these posts. The FHWA guardrail form is attached to the end of this report as **Appendix A**.

Figure 7: Extruded guardrail from the end terminal.

Figure 8: Damaged and displaced posts and guardrail, view southeast.

2003 GMC YUKON

Description

The GMC was a 4-wheel drive, 9-occupant, 4-door SUV with the VIN 3GKFK16Z53Gxxxxxx. The vehicle was equipped with a 5.3-liter, V-8 engine, 4-speed automatic transmission, and 4-wheel antilock brakes with electronic brake force distribution. The vehicle was also equipped with frontal air bags, front-seat-mounted side impact air bags, and a tilt steering column that was adjusted to the full-up position. The specified wheelbase was 330 cm (129.9 in).

The vehicle manufacturer's recommended tire size was P265/70R16. The vehicle was equipped with Perelli Scorpion tires size P275/55R20 on the front wheels and Dunlop Sport 5000 tires size

P275/55R20 on the rear wheels. The vehicle manufacturer's recommended cold tire pressure for the front and rear tires was 241 kPa (35 psi). All the tires were in good condition prior to the crash.

The front row was equipped with driver and passenger leather-covered bucket seats with adjustable head restraints. The second row was equipped with leather-covered bucket seats with adjustable head restraints. The third row was equipped with a bench seat with folding backs and adjustable head restraints in the outboard positions. The driver's seat track was adjusted between the middle and forward-most positions and the seat back was slightly reclined. The remaining seats were unoccupied at the time of the crash.

Exterior Damage

Exterior Damage Event 1: The GMC sustained direct and induced damage to the front plane during the impact with the end terminal. The direct damage began and the left corner of the front bumper and extended 33 cm (13.0 in) to the right involving the bumper, left headlamp/turn signal assembly, and left fender. The Field L was 182 cm (71.7 in). Crush measurements were taken on the bumper and the maximum residual crush was 20 cm (7.9 in) occurring at C_1. The crush values were: C_1 = 20 cm (7.9 in), C_2 = 11 cm (4.3 in), C_3 = 0 cm, C_4 = 0 cm, C_5 = 0 cm, C_6 = 0 cm.

Damage Classification Event 1: The Collision Deformation Classification (CDC) was 12FLEE2 (350 degrees). The severity of the damage was moderate.

Exterior Damage Event 2: The left plane sustained direct and induced damage when the vehicle struck a kink in the guardrail as the guardrail deformed during the first impact. The direct damage involved the fender, both doors, running board, sill, and quarter panel. The sheet metal of the left front door was torn during this impact and door latch assembly damaged resulting in the latch releasing from the striker. The direct damage to the left plane began 42 cm (16.5 in) forward of the left rear axle and extended 229 cm (90.2 in) rearward. No crush measurements were taken since the left front door was partially displaced from the vehicle.

Damage Classification Event 2: The CDC was 10LDEW2. The severity of the damage was moderate.

Event Data Recorder

The vehicle's EDR was imaged with version 17.1 of the Bosch Crash Data Retrieval software via the data link connector (DLC) and reported with version 17.9.1. The EDR reported one non-deployment event and also reported that multiple events occurred and were not recorded. The driver's seat belt switch circuit was reported as "Buckled" and the air bag warning lamp was reported as "Off." The maximum velocity change was reported on the "System Status at Non-Deployment" record as 15 km/h (-9.35 mph) occurring at 485 msec following AE. The EDR report is attached at the end of this report as **Appendix B**.

Interior Damage
The interior of the GMC sustained minor damage from an estimated 5 cm (2 in) of lateral intrusion of the rear lower quadrant of the left front door. The intrusion was estimated since the door was partially displaced from the vehicle and the interior door panel was off the door. Evidence of occupant contact consisted of an area of scuffing on the rear upper quadrant of the left front door from probable contact by the driver's left forearm. There was also a crack in the door panel in the rear lower quadrant, possibly from contact by the driver's left hip. No other discernable occupant contact evidence was observed. The left front door latch and striker were separated due to damage when a kink in the guardrail contacted the door. The left rear door was jammed shut. The right-side doors and the tailgate remained closed and operational. The left front glazing was disintegrated from impact forces. The remaining glazing was undamaged.

Manual Restraint Systems
The front row seating positions were equipped with three-point lap and shoulder seat belts with sliding latch plates and adjustable upper anchors. The front row seating positions were not equipped with seat belt pretensioners.

The driver was likely belted in this crash since the vehicle's EDR reported the status of his seat belt switch as "Buckled." Inspection of the driver's seat belt assembly revealed no discernable evidence of loading, which is not unusual given the low delta-V (15 km/h [-9.35 mph]) and long duration crash pulse reported by the vehicle's EDR.

Supplemental Restraint Systems
The GMC was equipped with frontal and front row seat-mounted side impact air bags. No air bags deployed during this crash.

2003 GMC YUKON OCCUPANT

Driver Demographics

Age/Sex:	51 years/male
Height:	185 cm (73 in)
Weight:	95 kg (209 lbs)
Eyewear:	Contact lenses
Seat Type:	Bucket
Seat Track Position:	Between forward-most and middle Manual Restraint
Usage:	Lap and shoulder belt
Usage Source:	EDR
Air Bags:	Frontal and seat-mounted side impact, not deployed
Alcohol/Drug Involvement:	None
Egress From Vehicle:	Removed by emergency responders
Transport From Scene:	Ambulance
Medical Treatment:	Hospitalized two days

Driver Injuries

Injury No.	Injury	AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Concussion with brief loss of consciousness, including nausea, emesis (vomiting), and headache, not further specified	161002.2	Roof side rail, left	Probable
2 3	Contusion/hematoma, lateral left hip and thigh, knee to hip, with intractable pain[2], not further specified	510402.1 810402.1	Left front door panel, rear lower quadrant	Probable

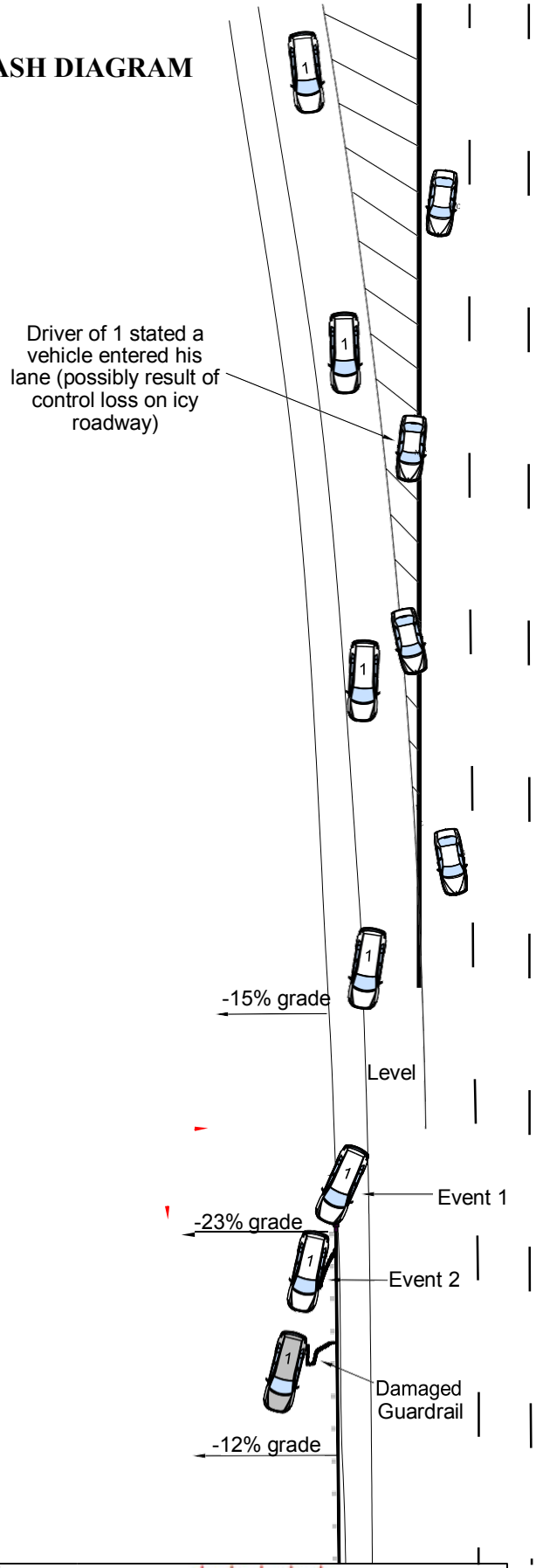
Sources: Emergency room records, hospitalization records, EMS treatment record, physical therapy records, and interviewee data–Same person. Injury numbers 1 through 3 came from a combination of all records except EMS treatment.

Driver Kinematics

The driver was restrained by the lap and shoulder seat belt. The seat track was adjusted between the forward-most and middle positions and the seat back was slightly reclined. The front plane impact to the end terminal displaced the driver forward in his seat belt. The secondary impact to the left plane by the deformed guardrail redirected the driver to the left and forward and his left hip probably contacted the left front door resulting an a contusion to the hip and thigh. His head also probably contacted the left roof side rail resulting in a concussion with brief loss of consciousness. The driver was removed from the vehicle through the left front door by emergency responders. He sustained police-reported "A" (incapacitating) injuries and was transported by ambulance to a hospital, where he was treated in the emergency room and then hospitalized for two days for treatment of moderate severity injuries.

[2] This driver/patient was admitted for pain control, but he also had some noncrash-related health issues.

CRASH DIAGRAM



Dark with Artificial Lighting

Light Freezing Rain

Wet and Ice Covered Bituminous Roadway

Speed Limit = 89 km/h (55 mph)

1 = 2003 GMC Yukon

0 10 20

Meters

www.nhtsa.gov

Case Number:	IN17009

APPENDIX A: FHWA Guardrail Forms

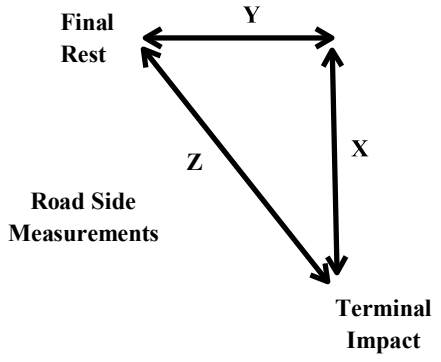
Case No.: IN17009

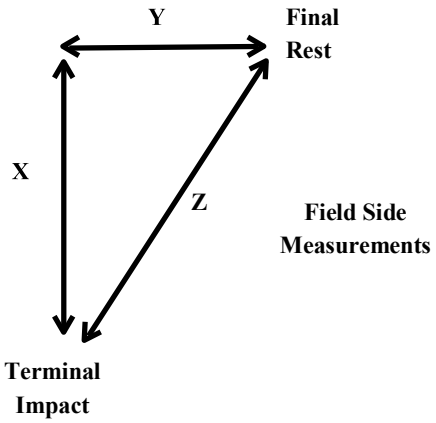
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	January 2017	**TIME OF CRASH (MILITARY)**	Night time
Case Number	IN17009	**State**	Missouri
Traffic Route	Interstate	**Direction (Southbound = SB)**	SEB
Ambient Conditions (at time of crash)			
Temperature (°F)	27	**Lighting**	Dark
Atmospheric	Light freezing rain		

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)	
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 36 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 33 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 20 ft (edge line)
Super elevation	❒+2% ❒-2% ☒ NONE or FLAT
Curve Radius (ft.)	N/A

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: IN17009

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		N/A	N/A	N/A
1	Steel	6x4	None	N/A	Unk		7.3	N/A	6'3"
2	Steel	6x4	None	N/A	Unk		7.0	N/A	6'4"

Case No.: IN17009

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.)					
3	Steel	6x4	Composite	4x7.5	Unk		7.3	N/A	6'1"
4	Steel	6x4	Composite	4x7.5	Unk		7.2	N/A	6'3"
5	Steel	6x4	Composite	4x7.5	Unk		7.0	N/A	6'3"
6	Steel	6x4	Composite	4x7.5	No		6.8	N/A	6'2"
7	Steel	6x4	Composite	4x7.5	No		6.7	N/A	6'4"
8	Steel	6x4	Composite	4x7.5	No		6.6	N/A	6'3"

Case No.: IN17009

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	4x7.5	No		6.5	N/A	6'3"
10	Steel	6x4	Composite	4x7.4	No		6.3	N/A	6'3"
11	Steel	6x4	Composite	4x7.5	No		6.3	N/A	6'3"
12	Steel	6x4	Composite	4x7.5	No		6.3	N/A	6'3"

Additional Comments

Case No.: IN17009

EXTRUDER			
Feeder Channel Width at impact head	☒4inches ☐5 inches ☐Other _____		
Guide Chute Exit Height (in.)	15 in		
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.)	3 ft 3 in
Rail Extrusion Direction	☐Traffic Side ☒Field Side		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	31.3 ft		

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: 5
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 - %	18%	23%	12%
Adjacent Lane Width (ft)	12.8 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Concrete		
Shoulder Type	Concrete		

Shoulder Width (ft)	7.2 ft
Guardrail Height (in)	27 in

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	Sport Utility Vehicle	
Vehicle Identification Number (VIN)	3GKFK16Z53Gxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	5414 (including est weight of driver)	
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	12FLEE2	
Delta-V	-9.35 mph (longitudinal value from EDR)	
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: 2003 GMC Yukon Event Data Recorder Report[3]

[3] 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	3GKFK16Z53G******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	IN17009_V1_ACM.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 17.1
Imaged with Software Licensed to (Company Name)	NHTSA
Reported with CDR version	Crash Data Retrieval Tool 17.9.1
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	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). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event may be overwritten by another 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 a Deployment Level Event, if the Non-Deployment Event is not locked. The data in the Non-Deployment Event file will be locked, if the Non-Deployment Event occurred within five seconds before a Deployment Event. 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 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. If multiple Non-Deployment Events occur within five seconds prior to a Deployment Event, then the most severe Non-Deployment Event will be recorded and locked. If multiple Non-Deployment Events precede a Deployment Event, and occur within five seconds of each other (but not necessarily all within five seconds of the Deployment Event), then the most severe of the Non-Deployment Events (which may have occurred more than five seconds prior to the Deployment Event) will be recorded and locked. If a Deployment Level Event occurs within five seconds after the Deployment Event, the Deployment Level Event will overwrite any non-locked Non-Deployment Event. If multiple Non-Deployment Events occur within five seconds prior to a Deployment Event, and one or more of those events was a Pretensioner Deployment Event, then the most recent Pretensioner Deployment Event will be recorded and locked. 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 Longitudinal Velocity Change reflects the change in longitudinal velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Longitudinal 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 will record 100 milliseconds of data after Deployment criteria is met and up to 50 milliseconds before Deployment criteria is met. For Non-Deployment Events, the SDM can record up to the first 150 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.
-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 open/closed state of the brake switch circuit.
-Pre-Crash data is recorded asynchronously. The 1.0 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 1.0 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

-Engine Speed is reported at two times the actual value in the following vehicles, if the vehicle is equipped with a 6.6L Duramax diesel engine (RPO LB7, LBZ, LLY, or LMM):

-2001-2006 Chevrolet Silverado
-2007 Chevrolet Silverado Classic
-2001-2006 GMC Sierra
-2007 GMC Sierra Classic
-2006-2007 Chevrolet Express
-2006-2007 GMC Savana
-2003-2009 Chevrolet Kodiak
-2003-2009 GMC Topkick

-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Driver's Belt Switch Circuit may be reported other than the actual state.
-The Time between Non-Deployment to Deployment Events is displayed in seconds. If the time between the two events is greater than 25.4 seconds, "N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-Multiple Events will indicate whether one or more associated events preceded the recorded event.
-Multiple Events Not Recorded can be used in the following scenarios:

-If a single event is recorded, this parameter will indicate whether one or more associated events prior to the recorded event was not recorded due to insufficient record space (because there were more events than there were available event records).
-If two associated events are recorded, this parameter for the first event will indicate whether one or more associated events prior to the first event was not recorded due to insufficient record space.
-If two associated events are recorded, this parameter for the second event will indicate whether one or more associated events between the first and second events was not recorded due to insufficient record space.

-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 Speed, Engine Speed, and Percent Throttle data are transmitted by the Powertrain Control Module (PCM), via the vehicle's communication network, to the SDM.
-Brake Switch Circuit Status data is transmitted by either the ABS module or the PCM, via the vehicle's communication network, to the SDM.
-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.

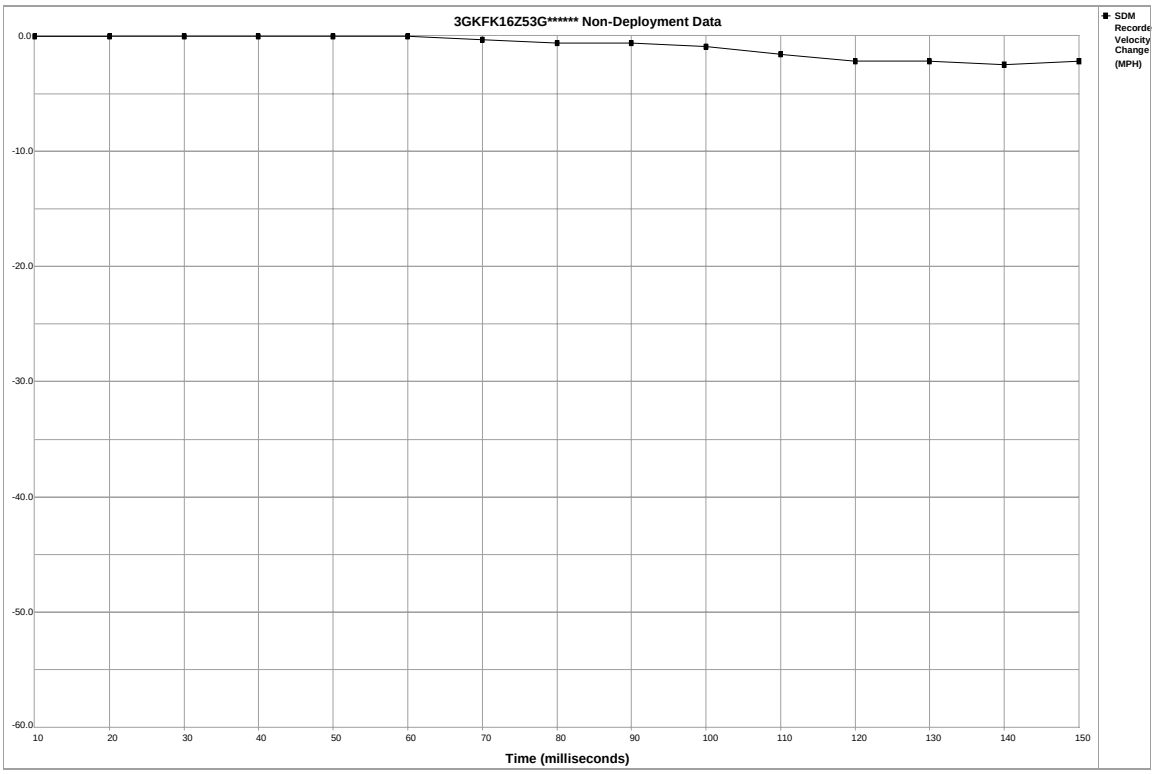
01027_SDMGF_r007

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Seat Position Switch Circuit Status	Rearward
Ignition Cycles At Non-Deployment	32336
Ignition Cycles At Investigation	32339
Maximum SDM Recorded Velocity Change (MPH)	-9.35
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	485
Crash Record Locked	No
Event Recording Complete	Yes
Multiple Events	Yes
Multiple Events Not Recorded	Yes

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	45	1984	40
-4	56	2112	45
-3	69	2176	36
-2	37	1088	0
-1	35	960	0

Seconds Before AE	Brake Switch Circuit State
-8	OFF
-7	OFF
-6	OFF
-5	OFF
-4	OFF
-3	OFF
-2	ON
-1	ON



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

Hexadecimal Data

$01	F0	21	F7	3C	B0	F8
$02	F1	F1	3C	3C	A8	00
$03	41	53	32	32	34	39
$04	56	30	54	32	34	31
$05	30	32	5A	33	36	34
$06	15	05	78	14	00	00
$07	32	02	31	56	00	00
$08	41	44	75	06	56	22
$09	48	48	36	44	32	32
$0A	41	44	75	06	56	22
$0B	48	48	36	44	34	46
$0C	00	00	00	00	00	00
$0D	00	00	00	00	00	00
$0E	41	55	75	08	58	22
$0F	39	4A	34	44	35	4E
$10	F0	35	F8	00	00	00
$11	81	80	81	7D	7C	7D
$12	9A	00	00	3C	3E	00
$13	FF	03	00	00	00	00
$14	1D	1D	10	45	44	40
$15	FA	FA	FA	FA	FA	FA
$16	FA	FA	FA	FA	FA	FA
$17	FA	FA	00	00	00	00
$18	00	3F	55	AC	F1	00
$19	09	00	0A	00	00	64
$1A	00	00	00	00	00	00
$1B	00	00	00	00	00	00
$1C	00	0C	00	00	00	00
$1D	00	00	00	00	00	00
$1F	FF	00	00	00	00	00
$20	1E	FD	00	00	FF	FF
$21	FF	FF	FF	FF	FF	FF
$22	FF	FF	FF	FF	FF	FF
$23	FF	FF	FF	FF	FF	FF
$24	00	01	E2	00	C2	1A
$25	33	00	00	03	FF	FF
$26	00	00	00	00	00	00
$27	01	02	02	03	05	07
$28	07	08	07	00	F0	35
$29	FF	A5	FF	FF	FF	FF
$2A	FF	FF	FF	FF	FF	FF
$2B	FF	FF	FF	FF	FF	FF
$2C	FF	FF	FF	FF	FF	FF
$2D	FF	FF	00	00	00	00
$30	FF	FF	FF	FF	FF	FF
$31	FF	FF	FF	FF	FF	FF
$32	FF	FF	FF	FF	FF	FF
$33	FF	FF	FF	FF	FF	FF
$34	FF	FF	FF	FF	FF	FF
$35	FF	FF	FF	FF	FF	FF
$36	FF	FF	FF	FF	FF	FF
$37	FF	FF	FF	FF	FF	FF
$38	FF	FF	FF	FF	FF	FF
$39	FF	FF	FF	FF	FF	FF
$3A	FF	FF	FF	FF	FF	FF
$3B	FF	FF	FF	FF	FF	FF
$3C	FF	FF	FF	FF	FF	FF
$3D	FF	FF	00	00	00	00
$40	05	38	3C	6F	5A	00
$41	60	00	1B	00	00	5C
$42	73	00	08	0F	11	22
$43	21	00	80	FE	00	00
$44	38	3C	6F	5A	49	00
$45	C0	00	00	00	5C	73

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$46   65 00 0F 11 22 21
$47   1F 00 7D 80 00 00
$48   00 00 00 00 00 00
$49   00 00 00 00 00 00
$4A   00 00 08 08 08 08
$4B   08 00 7D 80 00 00
$4C   FF FF FF FF FF FF
$4D   FF FF FF FF FF FF
$4E   FF FF FF FF FF FF
$4F   FF FF FF FF 00 00
$50   FF FF FF FF FF FF
$51   FF FF FF FF FF FF
$52   FF FF FF FF FF FF
$53   FF FF FF FF FF FF
$54   FF FF FF FF FF FF
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Disclaimer of Liability

The users of the CDR product and reviewers of the CDR reports and exported data shall ensure that data and information supplied is applicable to the vehicle, vehicle's system(s) and the vehicle ECU. Robert Bosch LLC and all its directors, officers, employees and members shall not be liable for damages arising out of or related to incorrect, incomplete or misinterpreted software and/or data. Robert Bosch LLC expressly excludes all liability for incidental, consequential, special or punitive damages arising from or related to the CDR data, CDR software or use thereof.

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**National Highway
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