U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

NHTSA

DOT HS 813 222

December 2021

Special Crash Investigations: On-Site Guardrail End Terminal Crash Investigation; Vehicle: 2007 Pontiac G5; Location: Missouri; Crash Date: January 2017

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Indiana University Transportation Research Center. (2021, December). *Special crash investigations: On-site guardrail end terminal crash investigation; Vehicle: 2007 Pontiac G5; Location: Missouri; Crash date: January 2017* (Report No. DOT HS 813 222). National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No. DOT HS 813 222	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Special Crash Investigations: On-Site Guardrail End Terminal Crash Investigation; Vehicle: 2007 Pontiac G5; Location: Missouri; Crash Date: January 2017		5. Report Date: December 2021 6. Performing Organization Code	
7. Author Indiana University Transportation Research Center		8. Performing Organization Report No. IN17010	
9. Performing Organization Name and Address Transportation Research Center Indiana University 501 South Madison Street, Suite 105 Bloomington, Indiana 47403-2452		10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTNH22-12-C-00270	
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration National Center for Statistics and Analysis (NSA-110) 1200 New Jersey Avenue SE Washington, DC. 20590-0003		13. Type of Report and Period Covered Technical Report Crash Date: January 2017 14. Sponsoring Agency Code	
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 submitted.			
16. Abstract This report documents a passenger vehicle impact to an ET-Plus guardrail end treatment that is of interest to the Federal Highway Administration. The Pontiac was a 2-door coupe with frontal air bags and an event data recorder. An unbelted 23-year-old female drove the vehicle. The crash occurred as the Pontiac was traveling west in the right westbound lane when the driver lost control on the rain-covered roadway. The vehicle rotated clockwise and departed the north side of the road where the front plane struck the guardrail head (Event 1). The impact damaged and displaced the guardrail and resulted in the deployment of the Pontiac's driver's frontal air bag. The left plane of the vehicle struck a kink in the guardrail (Event 2) as the guardrail was deformed and displaced, resulting in significant passenger compartment intrusion by the left B-pillar, left front door, and side panel rear of the left front door. The vehicle then came to final rest on the field side of the guardrail heading northwest. The driver sustained police-reported "B" (non-incapacitating) injuries and was transported by ambulance to a hospital. Her treatment status is not known. The Pontiac was towed from the crash scene due to damage.			
17. Key Words ET Plus guardrail end treatment, motor vehicle traffic crash, moderate injury		18. Distribution Statement This document is available to the public from the DOT, BTS, National Transportation Library, Repository & Open Science Access Portal, rosap.ntl.bts.gov.	
19 Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 36	22. Price

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On-Site Guardrail End Terminal Crash Investigation
Case Number: IN17010
Vehicle: 2007 Pontiac G5
Location: Missouri
Crash Date: January 2017

Background

This report documents a passenger vehicle impact to an ET-Plus (10 cm [4 in] model) guardrail end treatment (Figures 1 and 2) that is of interest to the Federal Highway Administration (FHWA). This crash was identified by an engineer with the Missouri Department of Transportation, who submitted photographs of the vehicle and the damaged guardrail end treatment to the FHWA. The FHWA determined that the guardrail end treatment 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 2007 Pontiac G5 (Figure 3). The crash occurred in the morning in Missouri and was investigated by a local police agency. The vehicle, guardrail, and crash scene were inspected in January 2017.

Figure 1. The damaged guardrail and guardrail head, view west

Figure 2. The damaged guardrail and guardrail head, view east

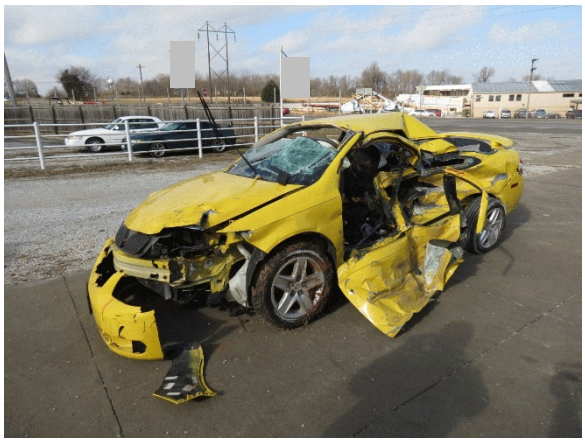


Figure 3. The damaged 2007 Pontiac G5

This crash occurred on the north roadside of a four-lane, divided U.S. highway. The Pontiac was a 2-door coupe equipped with frontal air bags and an event data recorder (EDR). An unbelted 23-year-old female drove the vehicle. The crash occurred as the Pontiac was traveling west in the right westbound lane when the driver lost control on the wet roadway. The vehicle rotated clockwise and departed the north side of the road where the front struck the guardrail head (Event 1). The impact damaged and displaced the guardrail and resulted in deployment of the Pontiac's driver's frontal air bag. The left plane of the vehicle struck a kink in the guardrail (Event 2) as the guardrail was deformed and displaced, resulting in significant passenger compartment intrusion by the left B-pillar, left front door, and side panel rear of the left front door. The vehicle then came to final rest on the field side of the guardrail heading northwest. The driver sustained police-reported "B" (non-incapacitating) injuries and was transported by ambulance to a hospital. Her treatment status is not known. The Pontiac was towed from the crash scene due to damage.

Crash Summary

Crash Site

This crash occurred during daytime on the north roadside of a four-lane, divided U.S. highway. The weather conditions were rain with 3.2 kilometers (2 miles) visibility, northerly winds at 13 km/h (8 mph), a temperature of 1.1 ℃ (34 ℉), and a dew point of -1.1 ℃ (30 ℉), according to local weather reports. The highway ran east/west and had two 3.7 m (12.1 ft) wide concrete lanes in each direction separated by a grass median. The roadways were bordered by 1.6 m (5.3 ft) wide concrete median shoulders and 2.8 m (9.2 ft) wide concrete outside shoulders. A blocked-out W-beam steel guardrail equipped with an ET-Plus end treatment was located on each side of the westbound lanes adjacent to the shoulders. The guardrails were in place to protect errant vehicles from the concrete bases and steel poles of an overhead highway sign structure. The roadway grade was level. The speed limit was 113 km/h (70 mph). A crash diagram is included at the end of this report.

Pre-Crash

The Pontiac was traveling west in the right westbound lane (Figure 4) at an EDR-reported speed of 126 km/h (78 mph) at -5.0 sec prior to algorithm enable (AE). The antilock brake system was reported as active beginning at -3.0 sec prior to AE and remaining active to -1.0 sec (the end of the pre-crash recording), at which point the reported speed of the vehicle was 84 km/h (52 mph). The driver told police following the crash that she lost control on the rain-slick roadway and the EDR-reported antilock brake activity is consistent with the driver attempting to regain control of the vehicle. Yaw tire marks were found on the north shoulder (Figure 5) during the SCI crash scene inspection, indicating that the vehicle was yawing clockwise as it departed the roadway onto the shoulder and approached impact with the guardrail head.

Figure 4. Westbound approach of the Pontiac

Figure 5. Approach of the Pontiac to impact with the guardrail head, arrows show yaw tire marks on shoulder, view northwest

Crash

The front plane of the Pontiac (Figure 6) struck the guardrail head (Figure 7, Event 1) at a calculated[1] speed of 64 km/h (40 mph). The vehicle's EDR reported the maximum longitudinal and lateral velocity changes -7.62 km/h (-4.74 mph) and 31.62 km/h (19.65 mph). The force direction on the vehicle was within the 10 o-clock sector and the impact resulted in a stage two deployment of the driver's frontal air bag. The impact displaced and deformed the guardrail and the left plane of the vehicle struck a kink in the deformed guardrail (Event 2). The impact with the guardrail kink resulted in 45 cm (17.7 in) of lateral intrusion of the left front door and 31 cm (12.2 in) of lateral intrusion of the left B-pillar into the driver seating area. The intruding components contacted the driver's seat deforming and displacing the seat 28 cm (11.0 in) to the right (Figure 8). The guardrail kink also penetrated through the intruded side panel rear of the left B-pillar an estimated 15 cm (5.9 in) into the second row. The crash damaged a total of 11.4 m (37.4 ft) of guardrail and fractured and displaced wooden posts 1 to 6 and slightly displaced wooden post 7.

Figure 6. Damage to the front left corner of the Pontiac from the impact with the guardrail head

Figure 7. The face of the guardrail head struck by the Pontiac

Figure 8. Intrusion into the Pontiac driver's seating area and displacement of the driver's seat

[1] The speed was calculated by using the equation of motion for calculating end speed based on an initial speed, a deceleration value, and time. The initial speed and time were based on the EDR-reported speed of 84 km/h (52 mph) at -1.0 sec prior to AE. A deceleration value of -0.55g was used based on the table of drag factors from the Northwestern University Traffic Institute, Traffic Accident Reconstruction Manual. The calculated radius of the Pontiac's wheels were 1.0 cm (0.4 in) larger than the vehicle manufacture's recommended wheels which resulted in about a 7% difference in speed. Also, it was assumed that the yaw resulted in minimal effect on the EDR-reported speed at -1.0 sec

Post-Crash

The police arrived on-scene within 10 minutes of being notified of the crash. Emergency responders used a hydraulic rescue tool to remove the roof and both doors of the vehicle to extricate the driver. The driver sustained police-reported "B" (non-incapacitating) injuries and was transported by ambulance to a hospital. Her treatment is not known. The Pontiac was towed from the crash scene due to damage.

Guardrail Damage

The front plane impact of the Pontiac to the SKT extruded 2.0 m (6.6 ft) of guardrail to the field side (Figure 9) and damaged and displaced seven wooden posts. The full height and width [71 cm (27.9 in) and 38 cm (14.9 in)] of the face of the SKT was directly damaged. The guardrail was displaced from posts 1 to 6, which were fractured and separated from the ground. Post 7 was slightly displaced in the ground but remained secured to the guardrail. The bolts at posts 7 to 9 remained secured to the guardrail. The bolts at posts 10 and 11 were pulled through the guardrail. It's not known if the displacement of the bolts at posts 10 and 11 was related to the assembly or movement of the guardrail during the crash. The guardrail was kinked in seven locations. Five of the kinks were in the first section of guardrail with the remaining two kinks occurring in the second section of guardrail. The width of the feeder channel at the impact head was 10 cm (4.0 in) and the guide chute exit height was 38 cm (15.0 in). The connection of the feeder channel to the head was not damaged and the anchor cable was present but disconnected from its anchor. The "In-Service End Treatment Evaluation Data Collection Form" is attached to the end of this report as Appendix A.

Figure 9. Extruded guardrail from guardrail head

2007 Pontiac G5 Description

The Pontiac was a front-wheel-drive, 5-occupant, 2-door coupe with the VIN 1G2AL15F277xxxxxx. The vehicle had a 2.2-liter, l-4 engine, 4-speed automatic transmission, 4-wheel antilock brakes with electronic brake force distribution, frontal air bags, EDR, and a tilt steering column that was adjusted to the full-up position. The specified wheelbase was 262 cm (103.1 in).

The vehicle manufacturer's recommended tire size was P195/60R15. The vehicle had Uniroyal Tigerpaw tires size P205/55R16 on the front wheels and Bridgestone Ecopia tires size P205/55R16 on the rear wheels. The vehicle manufacturer's recommended cold tire pressure for the front and rear tires was 207 kPa (30 psi). All the tires were in fair condition.

The front row had driver and passenger cloth-covered bucket seats with folding backs and adjustable head restraints. The second row had a cloth-covered bench seat with adjustable head restraints in the outboard seating positions. The seat track adjustment for the driver's seat could not be determined since the seat was damaged and displaced in the crash.

Exterior Damage

Exterior Damage Event 1: The Pontiac sustained direct and induced damage to the front plane during the impact with the guardrail head. The left portion of the front bumper, left headlamp/turn signal assembly, and left fender were directly damaged. The direct damage began at the left corner of the front bumper and extended 26 cm (10.2 in) to the right across the bumper. The Field L was 112 cm (44.1 in). Crush measurements were taken on the bumper bar and the maximum residual crush was 15 cm (5.9 in), occurring at the left-front bumper-corner. The crush values were: C_1 = 15 cm (5.9 in), C_2 = 7 cm (2.8 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 10FLEE2 (310 degrees). The WinSMASH program could be used to calculate minimal aspects of the delta V since an impact with a yielding object is out of scope for the program. However, WinSMASH was used to calculate a barrier equivalent speed (BES) of 11 km/h (7 mph) based on the crush to the front plane.

Exterior Damage Event 2: The left plane sustained direct and induced damage from the impact with a kink in the deformed guardrail. The direct damage involved the left fender, door, and quarter panel. The direct damage began 205 cm (80.7 in) forward of the left rear axle and extended 272 cm (107.1 in) rearward. The Field L was also 272 cm (107.1 in). Crush measurements were taken at the mid-door level and the maximum residual crush was 37 cm (14.5 in), occurring 107 cm (42.1 in) forward of the left-rear axle. The crush values were: C_1 = 0 cm, C_2 = 32 cm (12.5 in), C_3 = 34 cm (13.3 in), C_4 = 37 cm (14.5 in), C_5 = 21 cm (8.2 in), C_6 = 10 cm (3.9 in).

Damage Classification Event 2: The CDC was 09LZEW4. WinSMASH calculated the BES as 43 km/h (26 mph).

Event Data Recorder

The Pontiac's EDR was imaged with version 17.1 of the Bosch Crash Data Retrieval software and reported with version 17.7. The vehicle was without power and the EDR was imaged via direct connection to the air bag control module. The EDR reported a deployment event and a non-deployment event. The non-deployment event was not related to this crash since the reported ignition cycles at the non-deployment event (19,025) did not match those reported for the deployment event (19,128). The deployment event was the result of the front plane impact with the ET Plus. The EDR report is attached to the end of this report as Appendix B.

The "System Status at Deployment" record reported the driver's safety belt switch circuit status as "Unbuckled." The supplemental inflatable restraint warning lamp status was reported as "Off." A first and second stage deployment of the driver's frontal air bag was reported. The times from AE to the "Deployment Command Criteria Met" for stage one and two were 20 and 36 msec, respectively. The maximum reported longitudinal and lateral velocity changes were reported as-7.62 km/h (-4.74 mph) and 31.62 km/h (19.65 mph), respectively occurring at 50 and 220 msec, respectively following AE.

Interior Damage

The interior of the Pontiac sustained severe damage from intrusion when a kink in the guardrail struck the left plane. The most severe intrusion into the driver's seating area involved the rear upper quadrant of the left front door and B-pillar, which intruded 45 cm (17.7 in) and 31 cm (12.2 in), respectively. The door intrusion was approximate since the door was jammed shut during the crash and removed by emergency responders. The right front door remained closed during the crash and was also removed by emergency responders. The left front and left rear glazing were probably disintegrated during the crash since this area of the vehicle was directly struck by the guardrail. The right front and right rear glazing were probably not damaged since the right plane of the vehicle was not struck. The windshield and backlight could have been damaged during the crash; however, their status could not be determined since the roof had been cut and removed by emergency responders.

Manual Restraint Systems

The front and second row seating positions were equipped with three-point lap and shoulder safety belts with sliding latch plates and fixed upper anchors. The driver was not restrained by the lap and shoulder safety belt as evidenced by the absence of load marks on the D-ring and latch plate belt guide. The vehicle's EDR also reported the "Driver's Belt Switch Circuit Status" as "Unbuckled" and the "Driver Pretensioner Deployment Loop Command" as "Yes."

Supplemental Restraint Systems

The Pontiac was equipped with dual-stage frontal air bags. Both stages of the driver's frontal air bag deployed during the impact with the guardrail head. There was no crash-related damage to the air bag and no discernable evidence of occupant contact. The passenger's frontal air bag did not deploy. The air bag was suppressed due to no occupant in that seating position.

2007 Pontiac G5 Occupant

Driver Demographics

Age/sex:	23 years/female
Height:	Unknown
Weight:	Unknown
Eyewear:	None
Seat type:	Bucket with folding back
Seat track position:	Unknown
Manual restraint usage:	None
Usage source:	Vehicle inspection and EDR
Air bags:	Frontal air bag deployed
Alcohol/drug involvement:	None
Egress from vehicle:	Exited with assistance
Transport from scene:	Ambulance
Medical treatment:	Unknown

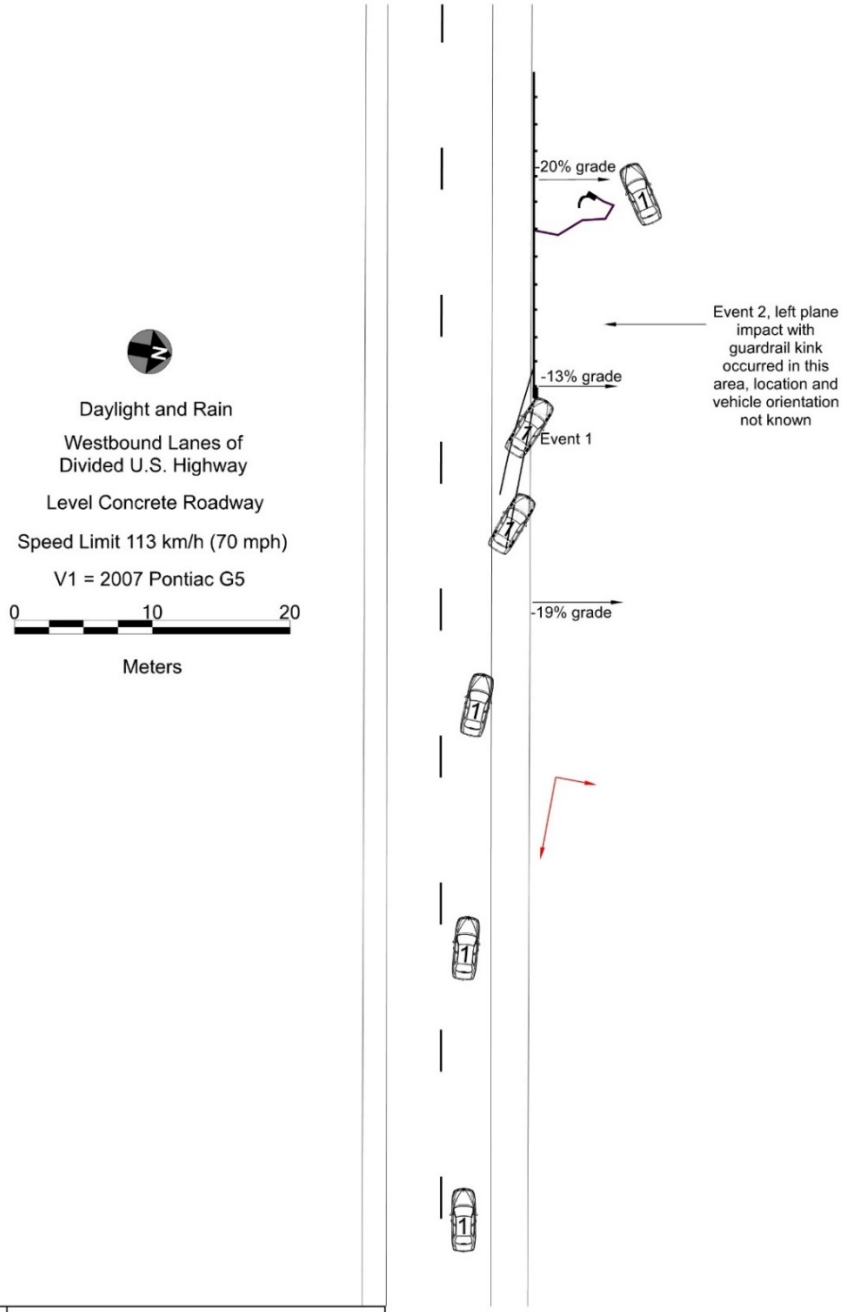
Driver Injuries

No injury data was available for the driver.

Driver Kinematics

The driver was not restrained by the lap and shoulder safety belt. The seat track adjustment could not be determined since the seat was damaged and displaced during the crash. The crash scene evidence documented during the SCI inspection showed that the vehicle was in a clockwise rotation as it approached impact with the guardrail head. The driver was probably displaced to the left to some degree during this rotation. The front plane impact to the guardrail head resulted in deployment of the driver's frontal air bag. The driver was displaced forward and to the left and her face and chest probably loaded the frontal air bag. It is also likely that the left side of her body contacted the driver's door and her knees contacted the lower left instrument panel. The driver probably rebounded rearward and to the right and was then redirected to the left as the left plane of the vehicle struck a kink in guardrail. The left side of the driver's body probably contacted the left front door again. She was then redirected to the right by the intruded left front door, which contacted and damaged the driver's seat. The driver then probably contacted the right front door. The crash jammed the left front door shut and emergency responders used a hydraulic rescue tool to cut and remove the roof and both doors to extricate the driver from the vehicle. She sustained police reported "B" (non-incapacitating) injuries and was transported by ambulance to a hospital where her treatment status is unknown.

Crash Diagram



Case Number:	IN17010

Appendix A: In-Service End Treatment Evaluation Data Collection Form

In-Service End Treatment Evaluation Data Collection Form

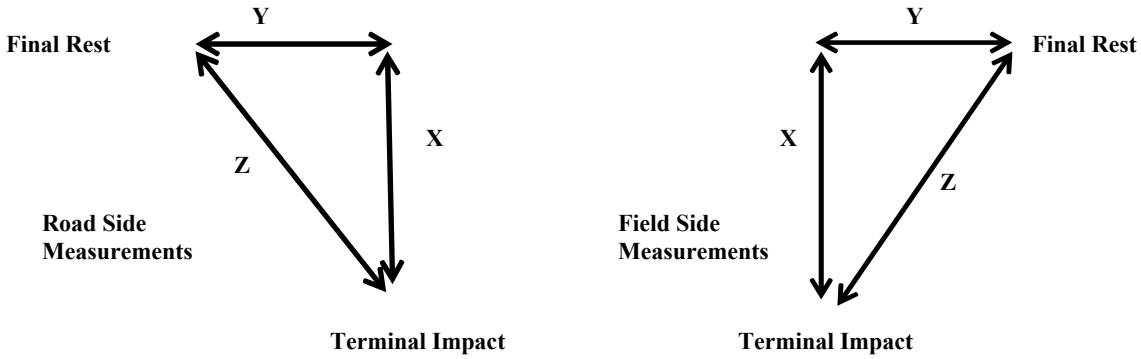
Case No.: IN17010

PREPOPULATED DATA (BY OTHERS)			
Date of Crash	January 2017	**TIME OF CRASH (MILITARY)**	Morning
Case Number	IN17010	**State**	Missouri
Traffic Route	Divided U.S. Highway	**Direction (Southbound = SB)**	WB
Ambient Conditions (at time of crash)			
Temperature (°F)	34	**Lighting**	Daylight
Atmospheric	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)	40 mph (Reconstructed)		
. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 54 ft		
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 49 ft		
Est. distance (normal) from either the white paint line; or roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 26 ft		
Super elevation	☐+2%	☐-2%	☒ NONE or FLAT
Curve Radius (ft.)	N/A		

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements



In-Service End Treatment Evaluation Data Collection Form

Case No.: IN17010

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.					
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)	Yes No Unknown	Describe	Travel way	Curb	
0	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
1	Wood	7.5x5.25	No	N/A	Unk		9.6	N/A	0
2	Wood	7.25x5.25	No	N/A	Unk		9.6	N/A	6’3”

In-Service End Treatment Evaluation Data Collection Form

Case No.: IN17010

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	x W (in.)					
3	Wood	7.25x5.25	Wood	8x5.75	Unk		10.3	N/A	6’3”
4	Wood	7.75x5.25	Wood	Unk	Unk		Unk	N/A	6’3”
5	Wood	7.75x5.5	Wood	8x5.75	No		10.4	N/A	6’4”
6	Wood	7.5x5.75	Wood	8x5.75	No		10.3	N/A	7’4”
7	Wood	8x6	Wood	7.5x6	No		10.3	N/A	6’4”
8	Steel	6x4	Wood	7.5x6	No		10.3	N/A	6’1”

In-Service End Treatment Evaluation Data Collection Form

Case No.: IN17010

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	) x W (in.)					
9	Steel	6x4	Wood	7.5x6	No		10.3	N/A	6’4”
10	Steel	6x4	Wood	7.5x6	No		10.5	N/A	6’1”
11	Steel	6x4	Wood	7.5x6	No		10.3	N/A	6’4”
12	Steel	6x4	Wood	7.5x6	No		10.3	N/A	6’2”

Additional Comments

Case No.: IN17010

EXTRUDER			
Feeder Channel Width at impact head	☒ 4inches ☐ 5 inches ☐ Other _____		
Guide Chute Exit Height (in.)	15		
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.)	6'6"
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.]	37.4		

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: 7
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	☐ No ☒ Yes	Guardrail kink	
Did vehicle impact other objects after impact with terminal?	☐ No ☒ Yes		
Object Contacted	Guardrail kink		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**In advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	-19%	-13%	20%
Adjacent Lane Width (ft)	12		
Lane Type (NAS EDS Variable: Sur. Type)	Concrete		
Shoulder Type	Concrete		

Shoulder Width (ft)	9.2
Guardrail Height (in)	28”

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	Passenger vehicle, 2 door coupe	
Vehicle Identification Number (VIN)	1G2AL15F277xxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3005 lbs (Includes approximate 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	Impact with ET-Plus =10FLEE2, Impact with guardrail kink = 09LZEW4	
Delta-V	Unknown	
Occupant Compartment Penetration of rail	☐No	Describe: Guardrail kink penetrated an esti-mated 6 in into ; second row left seating position
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)		
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)		

Appendix B: 2007 Pontiac G5 Event Data Recorder Report

The EDR report contained in this technical report was imaged using the current version of 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	1G2AL15F277******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	IN17010_V1_ACM.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 17.1
Imaged with Software Licensed to (Company Name)	Company Name information was removed when this file was saved without VIN sequence number
Reported with CDR version	Crash Data Retrieval Tool 17.7
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 can be overwritten by an event that has a greater SDM recorded vehicle velocity change. 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. The data in the Non-Deployment Event file will be locked, if the Non-Deployment Event occurred within five seconds of 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 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 up to 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. If a CDR Printout user were to calculate resultant velocity change using X and Y axis time history data, the calculated value may be different than the Maximum SDM Recorded Velocity Change parameter value displayed in the CDR report. This is due to the rounding that occurs within the SDM while calculating the Maximum SDM Recorded Velocity Change value.

-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 is present to send the pre-crash data
-Vehicle speed, Transmission Gear Select, and Transmission Actual Gear will be marked as invalid for manual transmission vehicles
-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, except: The Passenger Belt Switch Circuit Status for 2005 vehicles is available only on the Cadillac STS. The Passenger Belt Switch Circuit Status for 2006 Chevrolet Cobalt Sport Coupe (AP) model vehicles, with the option package that includes Recaro brand seats (RPO ALV), always reports a default value of “Buckled,” because there is no passenger belt switch with the Recaro seat option. The Passenger Belt Switch Circuit Status for 2010 Chevrolet Cobalt and 2010 Pontiac G5 vehicles, with RPO Z49, will report a default value of "Buckled". The Passenger Belt Switch Circuit Status for 2010 and 2011 Chevrolet HHR, with the LS or LT trim package and RPO Z49, will report a default value of "Buckled".
-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. Time Between events is measured from end of one event to the beginning of a next event. An event may occur within 5 seconds of another event, known as an extended event. This occurs when three or more sequential events are separated by more than 5 seconds but each event in the sequence is no more than 5 seconds apart from a subsequent event. Pre-crash data is locked to the first event in an extended event.
-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 counter.
-Steering Wheel Angle data is displayed as a positive value when the steering wheel is turned to the right and a negative value when the steering wheel is turned to the left, except for Cadillac STS model vehicles with StabiliTrak 3.0 systems (RPO JL7). For Cadillac STS model vehicles with StabiliTrak 3.0 systems (RPO JL7), when the steering wheel is turned to the right, a negative value will be displayed and when the steering wheel is turned to the left, a positive value will be displayed. The Steering Wheel Angle data is reported in 16 degree increments.
-If more than one event is recorded, use the follow 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.

01016_SDMEps_r009

Multiple Event Data

Associated Events Not Recorded	0
An Event(s) Preceded the Recorded Event(s)	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

Vehicle Identification Number	**2AL15F*7*******
Low Tire Pressure Warning Lamp (If Equipped)	OFF
Vehicle Power Mode Status	Run
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Active
Brake System Warning Lamp (If Equipped)	OFF

System Status At 1 second

Transmission Range (If Equipped)	Fourth Gear
Transmission Selector Position (If Equipped)	Fourth Gear
Traction Control System Active (If Equipped)	No
Service Engine Soon (Non-Emission Related) Lamp	OFF
Service Vehicle Soon Lamp	OFF
Outside Air Temperature (degrees F) (If Equipped)	36
Left Front Door Status (If Equipped)	Closed
Right Front Door Status (If Equipped)	Closed
Left Rear Door Status (If Equipped)	Unused
Right Rear Door Status (If Equipped)	Unused
Rear Door(s) Status (If Equipped)	Closed

Pre-crash data

Parameter	-2 sec	-1 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

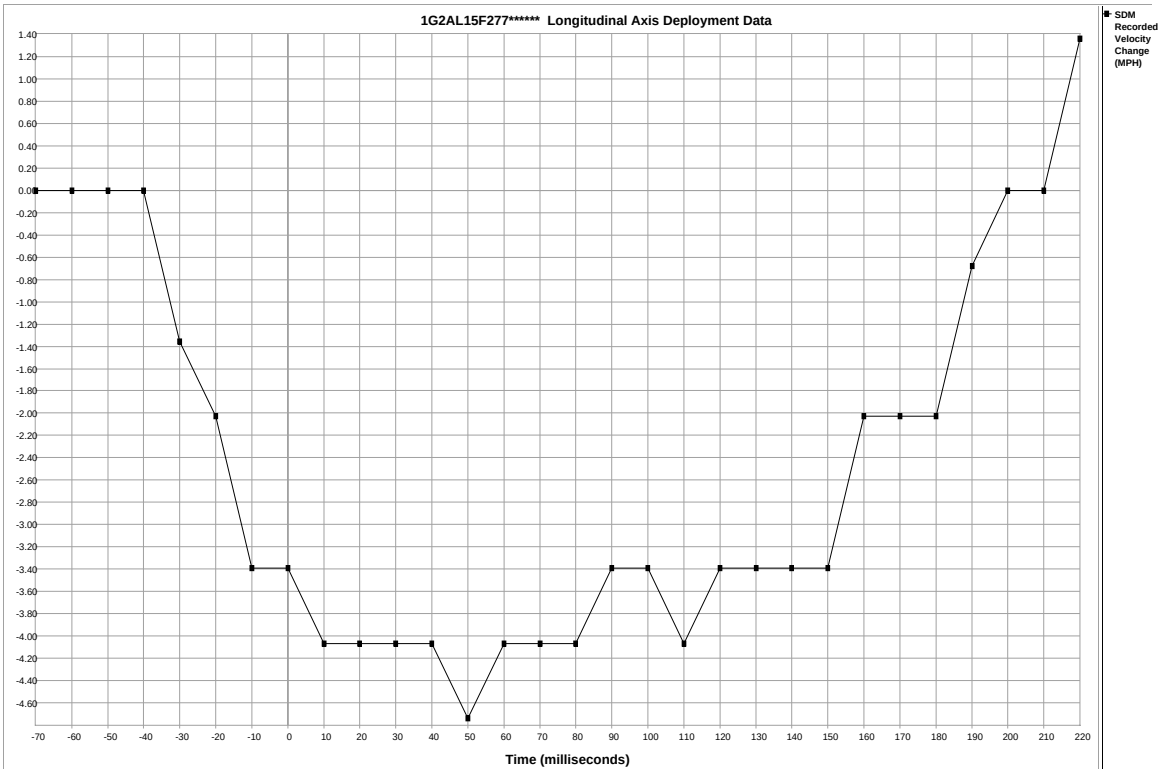
Pre-Crash Data

Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Speed (MPH)	78	79	78	75	52
Engine Speed (RPM)	2688	2688	2752	2496	1728
Percent Throttle	46	45	22	21	20
Accelerator Pedal Position (percent)	31	29	0	0	0
Antilock Brake System Active (If Equipped)	No	No	Yes	Yes	Yes
Lateral Acceleration (feet/s²)(If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid
Yaw Rate (degrees per second) (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid

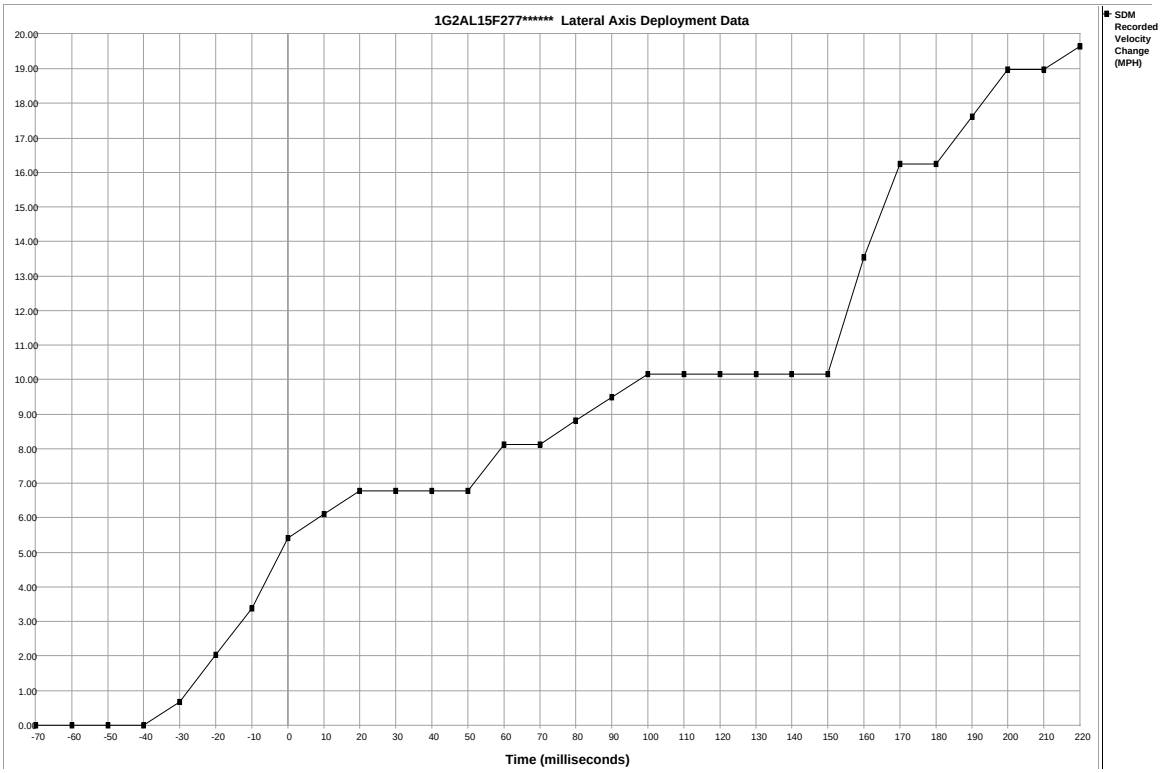
Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Steering Wheel Angle (degrees) (If Equipped)	0	0	0	0	0
Vehicle Dynamics Control Active (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid

System Status At Deployment

Ignition Cycles At Investigation	19128
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	542140
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	520
Ignition Cycles At Event	19128
Ignition Cycles Since DTCs Were Last Cleared	254
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	UNBUCKLED
Diagnostic Trouble Code at Event Enable, fault number: 1	N/A
Diagnostic Trouble Code at Event Enable, fault number: 2	N/A
Diagnostic Trouble Code at Event Enable, fault number: 3	N/A
Diagnostic Trouble Code at Event Enable, fault number: 4	N/A
Diagnostic Trouble Code at Event Enable, fault number: 5	N/A
Diagnostic Trouble Code at Event Enable, fault number: 6	N/A
Automatic Passenger SIR Suppression System Validity Status at AE	Valid
Automatic Passenger SIR Suppression System Status at AE	Air Bag Suppressed
Automatic Passenger SIR Suppression System Validity Status at First Deployment Command	Valid
Automatic Passenger SIR Suppression System Status at First Deployment Command	Air Bag Suppressed
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)	36
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Time Between Events (sec)	0
Driver First Stage Deployment Loop Commanded	Yes
Driver Second Stage Deployment Loop Commanded	Yes
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	Yes
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	Yes
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Third Row Left Roof Rail/Head Curtain Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Third Row Right Roof Rail/Head Curtain Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded for Disposal	No
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
Event Recording Complete	Yes



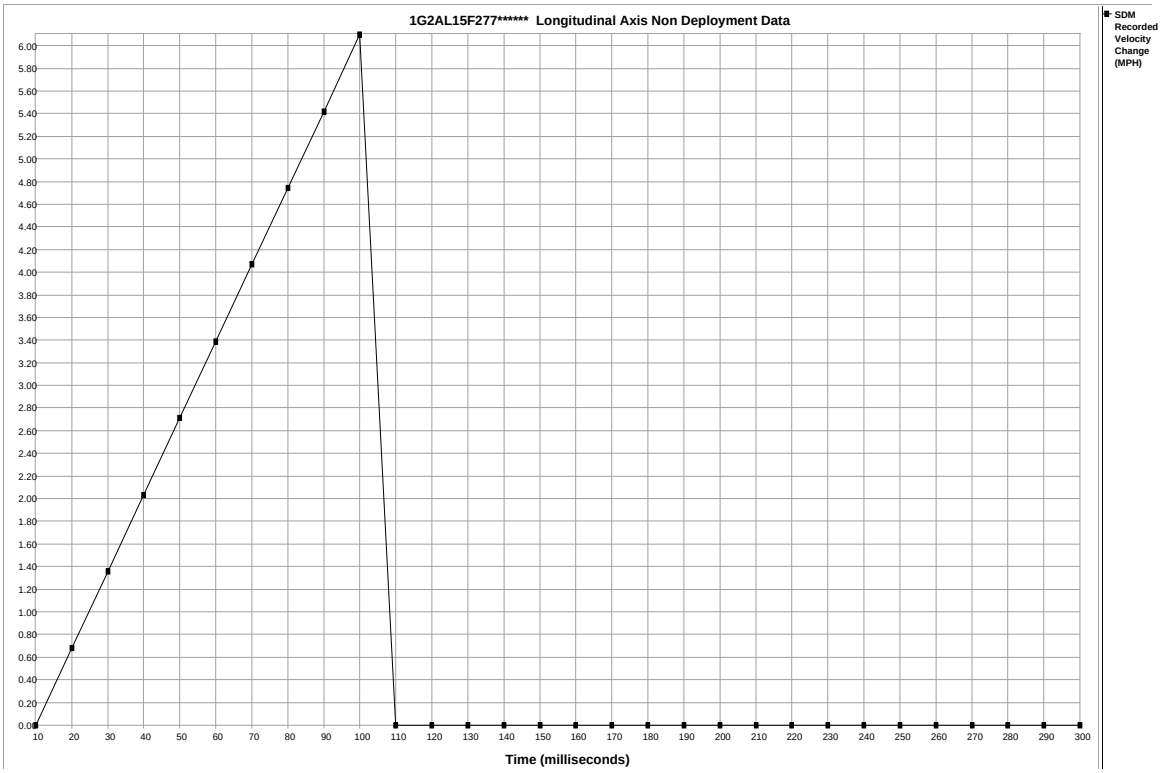
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	-1.36	-2.03	-3.39	-3.39	-4.07	-4.07	-4.07	-4.07	-4.74	-4.07	-4.07
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-4.07	-3.39	-3.39	-4.07	-3.39	-3.39	-3.39	-3.39	-2.03	-2.03	-2.03	-0.68	0.00	0.00	1.36



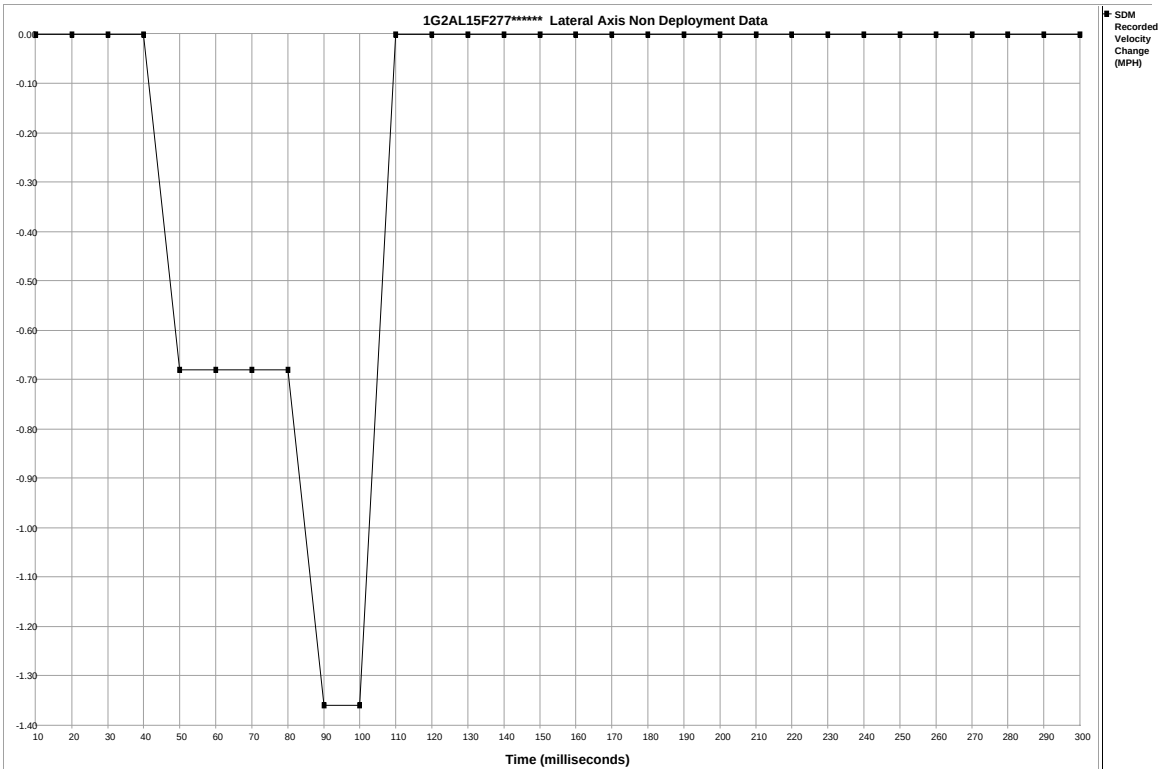
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.68	2.03	3.39	5.42	6.10	6.78	6.78	6.78	6.78	8.13	8.13
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Lateral Axis Recorded Velocity Change (MPH)	8.81	9.49	10.17	10.17	10.17	10.17	10.17	10.17	13.55	16.26	16.26	17.62	18.98	18.98	19.65

System Status At Non-Deployment

Ignition Cycles At Investigation	19128
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	411690
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	417
Ignition Cycles At Event	19025
Ignition Cycles Since DTCs Were Last Cleared	167
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	UNBUCKLED
Automatic Passenger SIR Suppression System Validity Status at AE	Valid
Automatic Passenger SIR Suppression System Status at AE	Air Bag Suppressed
Diagnostic Trouble Code at Event Enable, fault number: 1	N/A
Diagnostic Trouble Code at Event Enable, fault number: 2	N/A
Diagnostic Trouble Code at Event Enable, fault number: 3	N/A
Diagnostic Trouble Code at Event Enable, fault number: 4	N/A
Diagnostic Trouble Code at Event Enable, fault number: 5	N/A
Diagnostic Trouble Code at Event Enable, fault number: 6	N/A
Maximum SDM Recorded Vehicle Velocity Change (MPH)	6.25
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	100
Driver First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Third Row Left Roof Rail/Head Curtain Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Third Row Right Roof Rail/Head Curtain Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Crash Record Locked	No
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
Deployment Event Recorded in the Non-Deployment Record	No
Event Recording Complete	Yes



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.68	1.36	2.03	2.71	3.39	4.07	4.74	5.42	6.10	0.00	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	0.00	-0.68	-0.68	-0.68	-0.68	-1.36	-1.36	0.00	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

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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.

DOT HS 813 222
December 2021

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

15448-112321-v3