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

NHTSA

DOT HS 812 553

July 2018

# Special Crash Investigations On-Site Guardrail End Treatment Impact Investigation
# Vehicle: 2002 Chevrolet Blazer
# Location: Missouri
# Crash Date: March 2016

## Disclaimer

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was published.

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| *15. Supplementary Note*<br>An investigation of an impact to an X-Lite guardrail end treatment involving a 2002 Chevrolet Blazer. | | | |
| *16. Abstract*<br>The interest in this on-site investigation was the impact of a 2002 Chevrolet Blazer to an X-Lite guardrail end treatment. The Chevrolet's belted 23-year-old female driver sustained police-reported C-level (possible) injuries and was transported by ambulance to a local hospital. The crash occurred on an on-ramp to a limited-access roadway during daylight hours in March 2016. The front plane/right aspect of the Chevrolet struck the X-Lite guardrail end treatment, and displaced the first panel of the W-beam downstream to the east (Event 1). The lateral trajectory of the Chevrolet back toward the roadway cantilevered the first panel away from the second panel at Post 3. As the vehicle continued east, the (now) exposed forward edge of the W-beam at Panel-2 cut the sidewall of the right front tire and then engaged the lower A-pillar and right front door (Event 2). The lower A-pillar deformed 27 cm (10.6 in) longitudinally as the right front door compressed and buckled. The impact force overloaded the door's hinges and the B-pillar-attachment of the striker and the door completely separated from the Chevrolet as it continued along an eastward trajectory. The Chevrolet disengaged from the guardrail, rotated approximately 100 degrees clockwise and came to rest facing south 10.4 m (34.1 ft) from the initial impact. The driver was transported to a hospital by ambulance, where she was evaluated, treated, and then released. | | | |
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## BACKGROUND

The primary interest in this on-site investigation was the X-Lite guardrail end treatment impact of a 2002 Chevrolet Blazer (**Figure 1**). The Chevrolet's belted 23-year-old female driver sustained police-reported C-level (possible) injuries and was transported by ambulance to a local hospital. This crash was identified by an engineer with the Missouri Department of Transportation (MoDOT), who submitted photographs of the damaged guardrail end treatment and the vehicle to the Federal Highway Administration (FHWA). The FHWA determined that the crash type and guardrail end treatment were of interest for further investigation and subsequently provided notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration on March 2016. The CID assigned an on-site investigation of the crash to the Special Crash Investigations (SCI) team at Crash Research & Analysis, Inc., on the same day.

**Figure 1:** Front right oblique view of the Chevrolet Blazer depicting the vehicle deformation.

The SCI team contacted the MoDOT, and the on-site investigation occurred March 2016. The on-site investigation involved the inspection, documentation, and measurement of the physical plant and the guardrail system at the crash site. The condition of the guardrail end treatment was assessed. Following inspection of the crash site, the Chevrolet was inspected at a local tow facility to quantify the exterior condition, deformation, and occupant compartment intrusion, identify points of occupant contact within the interior and assess the use and status of the vehicle's safety systems. The Chevrolet was equipped with an event data recorder (EDR) supported by the Bosch Crash Data Retrieval (CDR) software and tool. During the SCI vehicle inspection, data was imaged from the Chevrolet's EDR. Medical record documentation concerning the driver's injuries and course of treatment were obtained from the treating medical facility. The SCI team contacted the driver to conduct an interview, but she refused to cooperate.

## CRASH SUMMARY

### *Crash Site*

The crash occurred on the on-ramp to a limited-access roadway during midday hours in March of 2016. According to the National Weather Service, conditions in the locale at the time of the crash included clear skies with a temperature of 8.3 °C (47 °F), 68% relative humidity, and 20.4 km/h (12.7 mph) south winds. The police-reported environmental conditions were daylight, clear and dry.

The physical environment of the roadway was documented during the SCI crash site inspection using a Nikon Nivo 5.M+ total station mapping system. In the area of the crash, the on-ramp entered the eastbound portion of an east/west limited-access roadway. The total length of the on-ramp from its origin at an intersection to the area of the merge lane into the eastbound portion of the limited-access roadway was approximately 400 m (1,310 ft). The on-ramp consisted of a single 4.9 m (16.1 ft) wide travel lane that was bordered by a single solid-white right lane line and a single solid-yellow left lane line. It progressed up an approximate 3 percent grade as it approached the limited-access roadway.

The limited-access roadway's eastbound section consisted of two lanes, both of which were 3.7 m (12.1 ft) wide. They were separated by a dashed white line, with single solid white and yellow edge lines to the respective right and left. The eastbound portion was divided from the westbound portion by a 2.5 m (8.2 ft) wide inboard shoulder and raised concrete Jersey-style barrier. The right shoulder measured 1.4 m (4.6 ft) wide.

**Figure 2:** East-facing view of the Chevrolet's pre-crash travel trajectory on the on-ramp entering the limited-access roadway.

**Figure 3:** East-facing view of the crash site and the X-Lite guardrail.

**Figures 2 and 3** depict the Chevrolet's east trajectory up the on-ramp toward the limited-access roadway and crash site. In the area of the on-ramp's approach to the merge lane, a guardrail was located adjacent to the south roadway edge. This guardrail was equipped with an X-Lite Tangent end treatment (described in further detailed in Guardrail section of this report). Although there was no posted speed limit for the on-ramp, the posted speed limit for the limited-access roadway was 97 km/h (60 mph). In the area of the merge section and guardrail, the entire roadway was essentially

level. The roadway transitioned to a negative grade to the east. All surfaces were asphalt. A crash diagram is included on **Page 11** of this technical report.

***Pre-Crash***

The 23-year-old female driver of the Chevrolet was restrained at the time of the crash by the manual 3-point lap and shoulder seat belt. She was operating the vehicle on the entrance ramp with the intent of merging onto the limited-access roadway to travel east. The EDR reported speed of the Chevrolet at 63 km/h (39 mph) 5 seconds prior to algorithm enable (AE). Reconstruction of the crash indicated that the vehicle departed the travel lane, traveled through the right shoulder and the right tires departed the road edge. The driver recognized her errant trajectory evidenced by an EDR-reported brake application one second prior to AE. The EDR reported that the speed of the Chevrolet was 60 km/h (37 mph) at this time interval. The SCI reconstruction determined that it was probable that the driver also steered the vehicle to the left back toward the roadway.

***Crash***

The front plane/right aspect of the Chevrolet struck the X-Lite guardrail end treatment (**Figure 4**). The impact force sheared the bolted connection of the slider assembly and displaced the first panel of the W-beam to the east (Event 1). The lateral trajectory of the Chevrolet back toward the roadway cantilevered the first panel away from the second panel at Post 3. As the vehicle continued east, the (now) exposed forward edge of the W-beam at Panel-2 cut the sidewall of the right front tire and then engaged the lower A-pillar and right front door (Event 2). The lower A-pillar deformed 27 cm (10.6 in) longitudinally as the right front door compressed and buckled. The impact force overloaded the door's hinges and the B-pillar-attachment of the striker and the door completely separated from the Chevrolet as it continued along an eastward trajectory. The combined forces of the offset impacts imparted a clockwise rotation to the vehicle evidenced by the arcing 5.6 m (18.4 ft) long tire mark identified on the merge lane. The mark was attributed to the left rear tire of the Chevrolet. The Chevrolet disengaged from the guardrail, rotated approximately 100 degrees and came to rest facing south 10.4 m (34.1 ft) from the initial impact.

**Figure 4:** East-looking image depicting the crash site and the X-Lite guardrail end terminal damage.

***Post-Crash***

The police and emergency medical services (EMS) personnel responded to the crash scene. The driver exited the Chevrolet without assistance. She reported to the police investigator that the Chevrolet's steering had the tendency to pull to the right and that she was not paying attention leading up to the crash. The driver was evaluated at the scene and transported to the hospital by

EMS with police-reported C-level (possible) injuries. The Chevrolet was removed from the crash scene by a local service to a tow yard where it was located at the time of the SCI inspection.

## X-LITE END TREATMENT AND GUARDRAIL

The X-Lite End Treatment was a re-directive, gating end terminal designed for terminating the ends of W-beam guardrail systems. The manufacturer's literature and installation manuals can be found at www.barriersystemsinc.com/xlite-end-terminal. The system was manufactured by Barrier Systems Inc., and could be configured in either a seven-post or a nine-post installation with a tangent or flared designs. It had energy-absorbing capabilities during head-on impacts, was re-directive starting at Post 3 and has been tested in accordance with the Test Level 3 (TL3) conditions of the National Cooperative Highway Research Project (NCHRP) Report 350. The X-Lite was comprised of an impact head, specially designed crimped posts, tension rods, a cable assembly, a slider assembly, and other standard guardrail components. The end terminal did not absorb energy by extrusion of the W-beam through the impact head; rather, energy absorption occurred through the slider assembly and the telescoping movement of the impact head and up to three W-beam panels.

The struck guardrail was a tangent system, comprised of seven posts on nominal 196 cm (76 in) spacing. The posts were 15 x 10 cm (6 x 4 in) I-beams. The W-beam height measured 77 cm (30.5 in) at an undamaged section adjacent to Post 11. The Chevrolet struck the impact face of the end terminal and displaced Panel-1 of the W-beam 7.5 m (25 ft). **Figure 5** is a schematic of the seven-post installation depicting the pre-crash and post-crash arrangement of the end terminal.

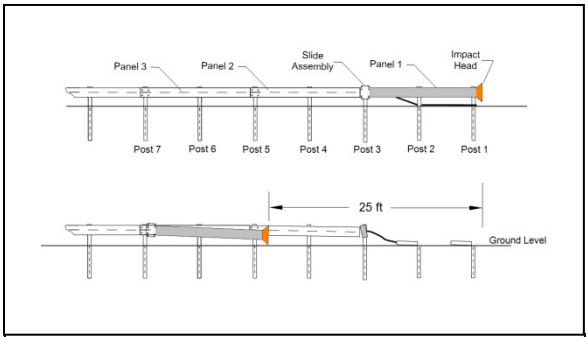



**Figure 5:** Schematic depicting the pre-crash and post-crash arrangement of the X-Lite end terminal**.**

The impact-face measured 33 x 61 cm (13 x 24 in), width x height, and was attached to the leading edge of the W-beam. W-beam Panel-1 spanned Posts 1 through 3 and was bolted to slots in Post- 1 and -2. No block-outs were required at Post-1 and -2. A slider assembly that was attached to the end of Panel-1 was bolted to Post-3 through a block-out and a slotted connection in the slider. The slots allowed the panel to separate from the posts during an impact and the panel telescoped down the guardrail via the slider assembly. Tensioned ground struts connected Post-1 and -2 with a tensioned cable between Post-2 and -3. Post-1 was weakened by slots cut into the flanges of the I-beam. The impact force fractured the beam 5 cm (2 in) below ground level through the weakened section. Post-2 also fractured at ground level during the impact.

Panel-2 of the W-beam spanned Post 3 through 5. This panel was bolted through the slot in the W-beam and a block-out to Post-4. Panel-3 of the W-beam spanned Posts 5 through 7 and was bolted through block-outs at Post-6 and -7. Four shear bolts (painted yellow by the manufacturer for identification) connected the adjacent sections of the W-beam (**Figure 6**). These bolts were designed to shear during a crash and allow the panels to telescope.

In this particular crash due to the offset of the impact and the lateral component of the vehicle's momentum back toward the roadway, the impact head did not engage Panel-2. Rather, Panel-1 was cantilevered back toward the roadway and the impact-head passed to the left of the end of Panel-2. As the vehicle continued eastward, the exposed forward edge of Panel-2 engaged and cut the vehicle's right front tire, and then engaged and deformed the lower A-pillar and right front door. The slider assembly of Panel-1 engaged the carriage bolts at Post 4 and Post 6 and the bolt heads were pulled through the deformed W-beam slot. The displaced slider assembly then struck Post-7 and the carriage bolt, block-out and I-beam deformed. The bolt head was pulled through the W-beam. The slider assembly then stopped at Post-7 (**Figure 7**), as the Chevrolet rotated and separated from the guardrail.

Minor deformation to the block-out and W-beam at Post-8 and -9 was also observed. Pre-existing damage was observed at the block-outs on Post-13 and -14. A diagram depicting the deformed guardrail is included on **Page 12**. The FHWA Guardrail Form is included at the end of this report as **Appendix A**.

**Figure 6:** South-looking image of the displaced Panel-1 at Post-5 and the shear bolt connection between Panel 2 and 3.

**Figure 7:** Overhead view depicting the Slider Assembly and the deformation at Post-7.

## 2002 CHEVROLET BLAZER

### *Description*

The 2002 Chevrolet Blazer (**Figure 8**) was manufactured in March 2002 and was identified by Vehicle Identification Number 1GNDT13WX2Kxxxxxx. The digital odometer reading was unknown due to impact damage to the 12-volt battery. The four-wheel drive sports utility vehicle (SUV) was built on a 272 cm (107.1 in) wheelbase and was powered by a 4.3 liter V-6 gasoline engine linked to a 4-speed automatic transmission with a column-mounted shifter. The gross vehicle weight rating was 2,427 kg (5,350 lb) with gross axle weight ratings of 1,270 kg (2,800) front and 1,315 kg (2,900 lb) rear.

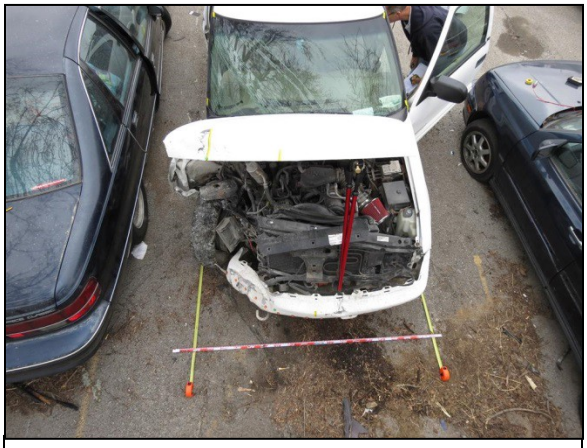


**Figure 8:** Overhead view of the Chevrolet depicting the frontal damage.

The curb weight was 1,903 kg (4,196 lb). The service brakes were power-assisted four-wheel discs with ABS and electronic brakeforce distribution. Exterior features included an OEM roof rack with lateral load bars and a frame-mounted Class III receiver hitch. At the time of the crash, the Chevrolet was equipped with Goodyear Wrangler all-season radial tires of the manufacturer-recommended size P235/75R15 mounted on OEM alloy wheels. The tires had matching Tire Identification Numbers of M6HL FNWR 2815. The vehicle manufacturer recommended cold tire pressures were 221 kPa (32 PSI) at both axle positions. The specific tire data at the time of the SCI inspection was as follows.

| Position | Measured Pressure | Measured Tread Depth | Restricted | Damage |
|---|---|---|---|---|
| LF | 241 kPa (35 PSI) | 9 mm (11/32 in) | No | Sidewall scuffing |
| LR | 221 kPa (32 PSI) | 8 mm (10/32 in) | No | None |
| RR | 221 kPa (32 PSI) | 8 mm (10/32 in) | No | None |
| RF | Tire Flat | 9 mm (11/32 in) | Yes | Sidewall cut |

The Chevrolet was configured for seating of five occupants with front bucket seats and a split, forward-folding, three-passenger second row seat. All seating surfaces were cloth. The front seats had integral head restraints. The driver seat was adjusted to a position that measured 5 cm (1.8 in) aft of full forward (between middle and full forward). The total seat track travel measured 19 cm (7.5 in). The driver seat back was reclined 25 degrees aft of vertical. The manual safety systems consisted of 3-point lap and shoulder seat belts for the five seats. The Chevrolet was also equipped with second-generation frontal air bags for the driver and front row right occupant.

***Exterior Damage***

The Chevrolet (**Figure 9**) sustained impact damage to its front and right planes. The direct contact damage on the front plane (Event 1) began 30 cm (11.8 in) right of center and extended 46 cm (18.2 in) to the corner. The right aspect of the rigid, formed-steel bumper deformed and the frontal impact also involved the forward right structures of the engine compartment. Crush extended vertically from the bumper onto the hood face 15 cm (6.0 in). A residual crush profile was documented by the SCI investigator using a Nikon Nivo 5.M+ total station mapping system. Measured along the bumper beam this profile produced the following measurements: C1 = 0 cm, C2 = 0 cm, C3 = 2 cm (0.8 in), C4 = 3 cm (1.2 in), C5 = 9 cm (3.5 in), C6 =33 cm (13.0 in). The right wheelbase was reduced 7 cm (2.8 in). The Collision Deformation Classification (CDC) assigned to this damage pattern was 12FREW2. This crash-type was out of the scope for analysis by the WinSMASH program due to the yielding object impact. A borderline analysis of the crash severity (delta-V) was calculated using the WinSMASH barrier algorithm for comparison purposes only. The calculated barrier equivalent speed (BES) was 17 km/h (11 mph).

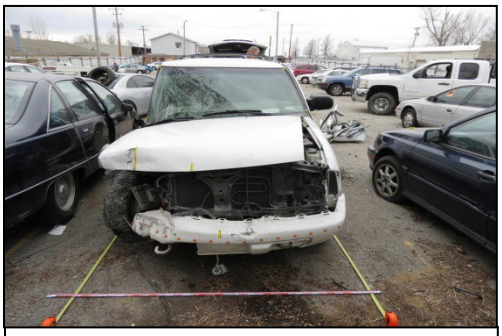


**Figure 9:** Front image of the Chevrolet depicting the deformation.

The exposed end of the W-beam at Panel-2 engaged the Chevrolet right plane in sideswiping/snagging contact. The right front tire was cut and deflated. Deformation was noted at the wheel opening and to the lower hinge pillar **(Figure 10**). The longitudinal pillar deformation measured 27 cm (10.7 in). The right front door crushed and buckled. The hinges of the right door were overloaded and the striker was torn from the B-pillar as the door separated. **Figure 11** is an image depicting the residual deformation of the separated right front door. The CDC assigned to this damage pattern was 12FRES7.

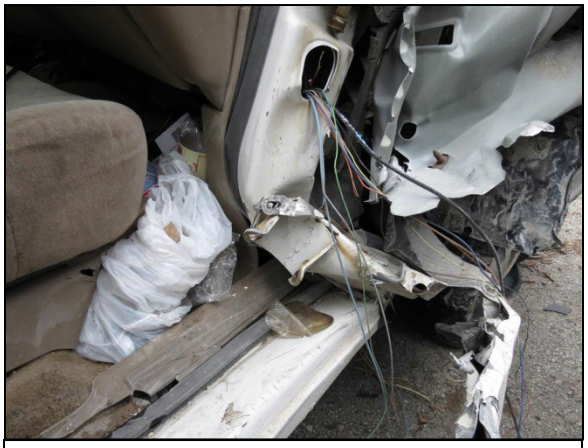


**Figure 10:** Right view depicting the deformation at the Chevrolet's right hinge pillar

**Figure 11:** Image depicting the crushed and separated front right door.

***Event Data Recorder***

The Chevrolet Blazer was equipped with an air bag control module (ACM) that performed the diagnostic, sensing, and deployment command functions for the vehicle's supplemental restraint systems. This module had EDR capabilities and was located on the center tunnel of the vehicle. It monitored and recorded acceleration in the longitudinal direction in terms of the velocity change (delta-V). The EDR component was imaged with the Bosch Crash Data Retrieval tool and software version 16.4 via a hardware link to the diagnostic link connector (DLC) located under the left aspect of the instrument panel. Twelve-volt electrical power was applied through the vehicle's fuse block to image the data. The imaged data is reported with version 17.6.1 and is included at the end of this report as **Appendix B**.

The data limitations reported that this EDR was capable of recording two event types, namely Non-Deployment events and Deployment events. The EDR could store one Non-Deployment event record. This record could be overwritten by a subsequent Non-Deployment event of greater severity or would be cleared after approximately 250 ignition cycles. This type of Non-Deployment event was considered to be unlocked. A Non-Deployment event that occurred within 5 seconds of a Deployment event became locked and could not be overwritten. Deployment events by definition deployed air bags. The recorded data from a Deployment event became locked and could not be overwritten. This EDR could store two Deployment events.

The imaged data indicated that the Chevrolet's EDR contained one Non-Deployment event. A data field with the record indicated that this Non-Deployment event occurred 0.1 seconds after a previous event. Based on the data limitations, that previous event had to have been another Non-Deployment of lesser severity. Any EDR data recorded in relation to first Non-Deployment event was overwritten.

The system status at the time of the recording indicated that the event occurred on ignition cycle 24,448. The ignition count at the time of the investigation SCI investigation was 24,449. At the time of the event, the air bag warning lamp in the instrument cluster was Off. The driver seat belt status was "Buckled." The maximum recorded longitudinal delta-V was -0.31 km/h (-0.19 mph) at 30 milliseconds. This value was not indicative of the total delta-V experienced by the vehicle during the crash.

The EDR also recorded 5 seconds of pre-crash vehicle performance parameters and 8 seconds of brake switch circuit status that described the operation of the vehicle. The pre-crash data was measured asynchronously relative to Algorithm Enable (AE). The recorded pre-crash data is listed in the following table. Note, only 5 seconds of brake data are shown here for simplicity. The brakes were reported as Off for the -8, -7 and 6-second intervals:

| | -5 seconds | -4 seconds | -3 seconds | -2 seconds | -1 second |
|---|---|---|---|---|---|
| **Vehicle Speed** | 63 km/h (39 mph) | 63 km/h (39 mph) | 63 km/h (39 mph) | 63 km/h (39 mph) | 60 km/h (37 mph) |
| **Percent Throttle** | 21% | 21% | 0% | 0% | 73% |
| **Engine RPM** | 1792 | 1728 | 1216 | 1088 | 1024 |
| **Brake Switch Status** | Off | Off | Off | Off | On |

Examination of the data trends indicated the vehicle maintained a constant speed as it progressed up the grade of the on-ramp. The throttle percentage and brake switch circuit status then changed between the -2 and -1-second intervals. It was probable that during this time the driver reacted to the errant position of the vehicle off of the road and applied the brakes and steered to the left in an attempted avoidance maneuver.

***Interior Damage***

The interior damage of the Chevrolet was biased to the front row right (**Figure 12**). The right instrument panel intrusion measured 19 cm (7.5 in). The intrusion of the right lower A-pillar measured 34 cm (13.2 in). The right toe pan intruded 19 cm (7.5 in).

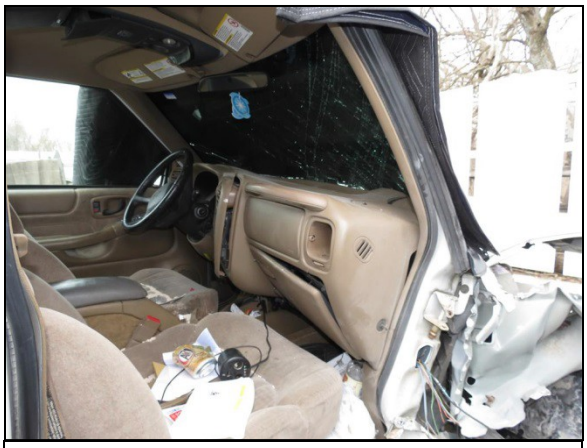


**Figure 12:** Right interior view of the Chevrolet.

The driver seat was adjusted to a mid-to-forward track position that measured 5 cm (1.8 in) aft of full-forward. The total seat track travel was 19 cm (7.5). There was no deformation of the steering wheel rim or displacement of the shear capsules.

Scuffing abrasions to the knee bolster consistent with the driver's lower extremities were identified. A 6 cm (2.5 in) scuff was centered 17 cm (6.8 in) left of the steering wheel centerline and 36 cm (14.0 in) above the floor. A 10 cm (4.0 in) long scuff was located 7 cm (3.0 in) to the right steering column, also 36 cm (14.0 in) above the floor.

***Manual Restraint Systems***

The Chevrolet was equipped with 3-point lap and shoulder safety belts for all seat positions. Each front safety belt system consisted of continuous-loop webbing, a sliding latch plate, and a fixed D-ring. The driver's safety belt webbing retracted onto an Emergency Locking Retractor (ELR), while the front right system used a switchable Automatic Locking Retractor (ALR)/ELR. An Energy Management Loop (EML) was sewn into the webbing of each front row safety belt near the floor anchor.

The driver's safety belt was stowed at initial inspection. It had been regularly used, as the webbing was soiled and its edges were frayed. Examination of the latch plate also revealed indicators of historical use. However, the stitching of the EML appeared to be stretched, which was indicative of driver loading. It was apparent that the driver of the Chevrolet was belted at the time of the crash. This determination was consistent with the imaged EDR data.

***Supplemental Restraint Systems***

The Chevrolet was equipped with second generation air bags for the driver and front row right occupant. The air bags did not deploy as a result of the crash.

**2002 CHEVROLET BLAZER OCCUPANT DATA**

***Driver Demographics***

| | |
|---|---|
| Age/Sex: | 23 years / female |
| Height: | 168 cm (66 in) |
| Weight: | 103 kg (228 lb) |
| Eyewear: | Unknown |
| Seat Type: | Forward-facing bucket seat with integral head restraint |
| Seat Track Position: | Mid-to-forward track adjustment |
| Manual Restraint Usage: | 3-point lap and shoulder seat belt |
| Usage Source: | SCI vehicle inspection, EDR, and PAR |
| Air Bags: | Dual stage frontal air bag available; Not deployed |
| Alcohol/Drug Involvement: | None |
| Egress from Vehicle: | Exited vehicle under own power |
| Transport from Scene: | Ambulance to a local hospital |
| Type of Medical Treatment: | Treated and released |

***Driver Injuries***

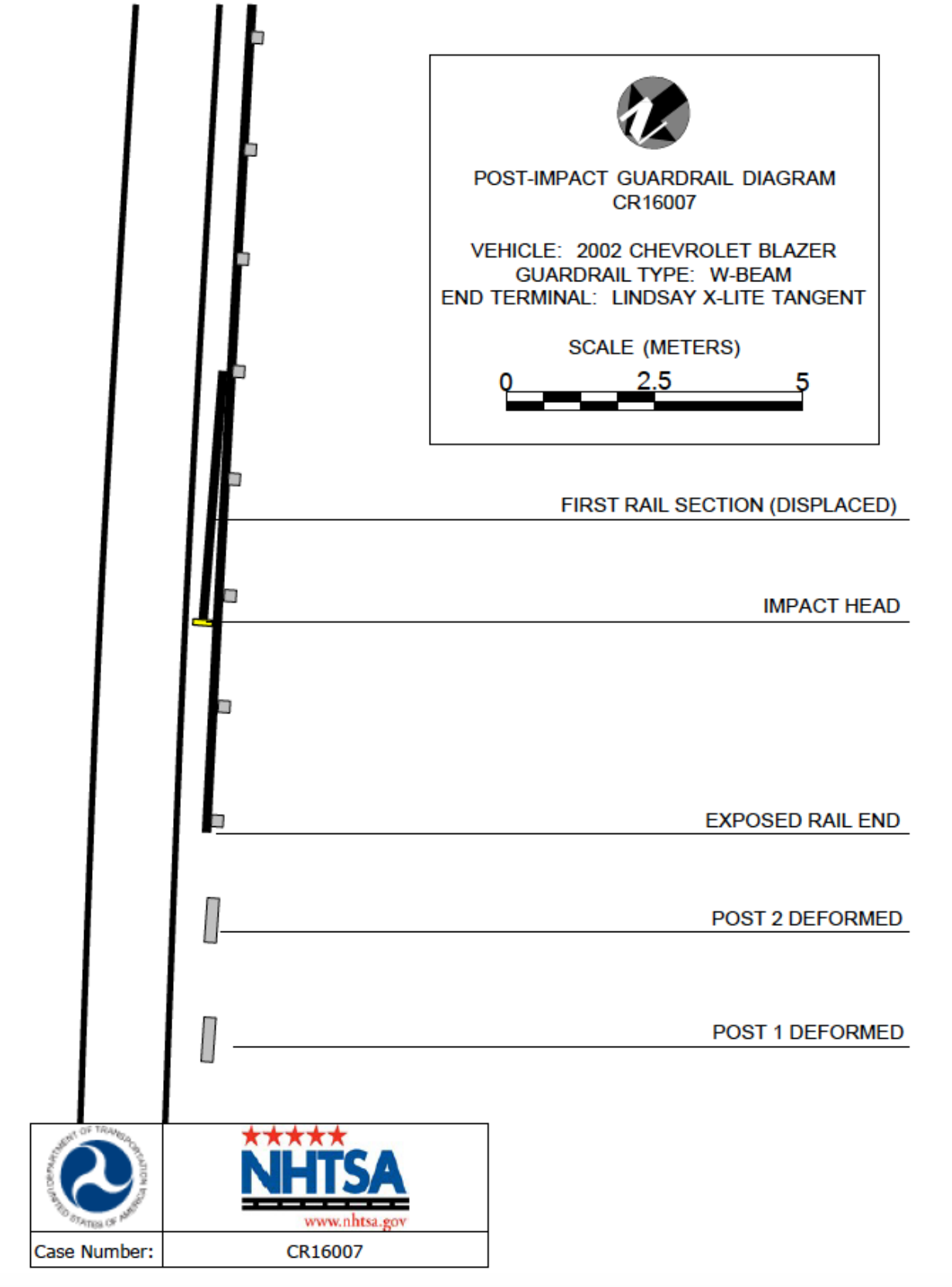
| Injury No. | Injury | AIS 2015 | Injury Source | Confidence |
|---|---|---|---|---|
| 1 | Right knee abrasion | 810202.1,1 | Knee bolster | Certain |

*Source – Emergency Room records*

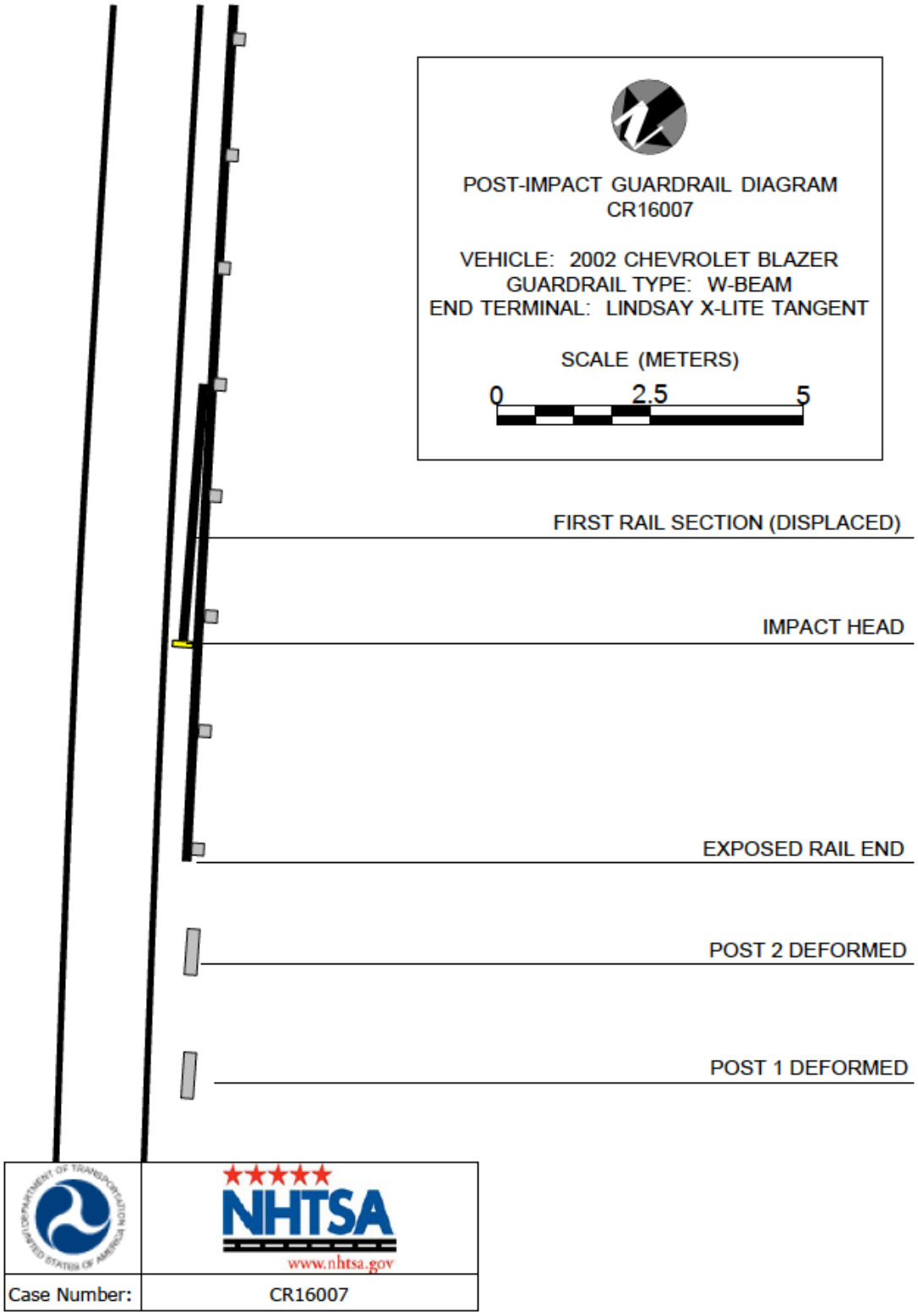
***Driver Kinematics***

The 23-year-old female driver was restrained by the manual 3-point lap and shoulder belt with her seat adjusted in a mid-to-forward track position. She reported to the investigating officer that she was distracted and the vehicle drifted to the right precipitating the crash. At impact, the emergency mode of the retractor locked the seat belt. The driver responded to the 12 o'clock direction of the impact with a forward trajectory. She contacted and loaded the seat belt with her left shoulder, torso, and pelvis. Her lower extremities contacted and scuffed the knee bolster. The driver remained in contact with the seat belt and rode down the force of the crash. She rebounded back into her rest as the Chevrolet rotated to final rest. The driver was able to exit the vehicle under her own power and was transported to a local hospital with complaints of pain, but no apparent injury.

**CRASH DIAGRAM**



**POST-IMPACT GUARDRAIL CRASH DIAGRAM**



# APPENDIX A:
# Federal Highway Administration Guardrail Forms

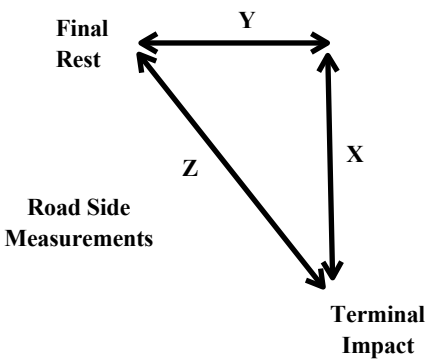
***Case No.: CR16007***

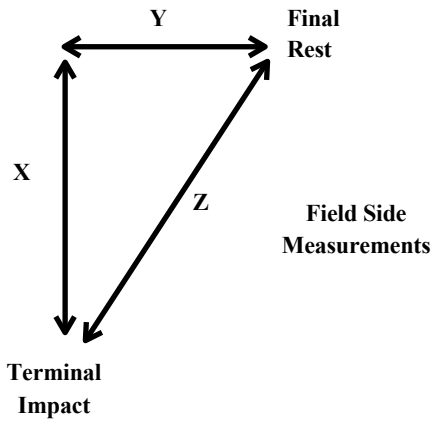
| PREPOPULATED DATA (BY OTHERS) | | | |
|---|---|---|---|
| **Date of Crash** | March 2016 | **Time of Crash (Military)** | Morning |
| **Case Number** | CR16007 | **State** | MO |
| **Traffic Route** | Limited Access | **Direction (Southbound = SB)** | EB |
| **Ambient Conditions (at time of crash)** | | | |
| **Temperature (°F)** | 47° | **Lighting** | Daylight |
| **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) | 37 mph (*EDR data*) |
| Est. distance (straight line) from terminal impact to COM final rest position (ft.) | Z = 34.1 ft<br>■Road side ❒Field side |
| Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.) | X = 33.1 ft |
| Est. distance (normal) from either<br>1. the white paint line; or<br>2. roadway/shoulder/pavement edge<br>to COM rest position (ft.) | Y = 7.9 ft |
| Super elevation | ❒+2% ❒-2% ■ NONE or FLAT |
| Curve Radius (ft.) | N/A |

**KEY**:

- COM - Center of Mass of Vehicle
- Distance Measurements



**Case No.: CR16007**

| ON-SCENE INFORMATION | | |
|---|---|---|
| End Treatment | ❒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: N/A | | |

| 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 | - | - | - | - | - | - | - | - | - |
| 1 | Steel | 6 x 4 | None | N/A | No | N/A | 5 ft 10 in | N/A | 6 ft 2 in |
| 2 | Steel | 6 x 4 | None | N/A | No | N/A | 5 ft 9 in | N/A | 6 ft 3 in |

**Case No.: CR16007**

| 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 | 6 x 4 | Composite | 7.5x4 | No | N/A | 6 ft 7 in | N/A | 6 ft 4 in |
| 4 | Steel | 6 x 4 | Fractured / Missing | | No | N/A | 6 ft 5 in | N/A | 6 ft 3 in |
| 5 | Steel | 6 x 4 | Composite | 7.5x4 | No | N/A | 6 ft 7 in | N/A | 6 ft 2 in |
| 6 | Steel | 6 x 4 | Composite | 7.5x4 | No | N/A | 6 ft 4 in | N/A | 6 ft 2 in |
| 7 | Steel | 6 x 4 | Composite | 7.5x4 | No | N/A | 6 ft 4 in | N/A | 6 ft 1 in |
| 8 | Steel | 6 x 4 | Composite | 7.5x4 | No | N/A | 6 ft 3 in | N/A | 6 ft 1 in |

**Case No.: CR16007**

| 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 | 6 x 4 | Composite | 7.5x4 | No | N/A | 6 ft 3 in | N/A | 6 ft 3 in |
| 10 | - | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - |

Additional Comments:

Panel 1 of W-beam driven downstream by vehicle. Slider at the end of panel captured at Post 7 with deformation of bolt & bolt pulled through W-beam. Block-out at Post 8 deformed. Damage extends to Post 9 – Slight movement of W-beam visible at bolt head.

Pre-existing damage to block-outs at Post 13 and 14

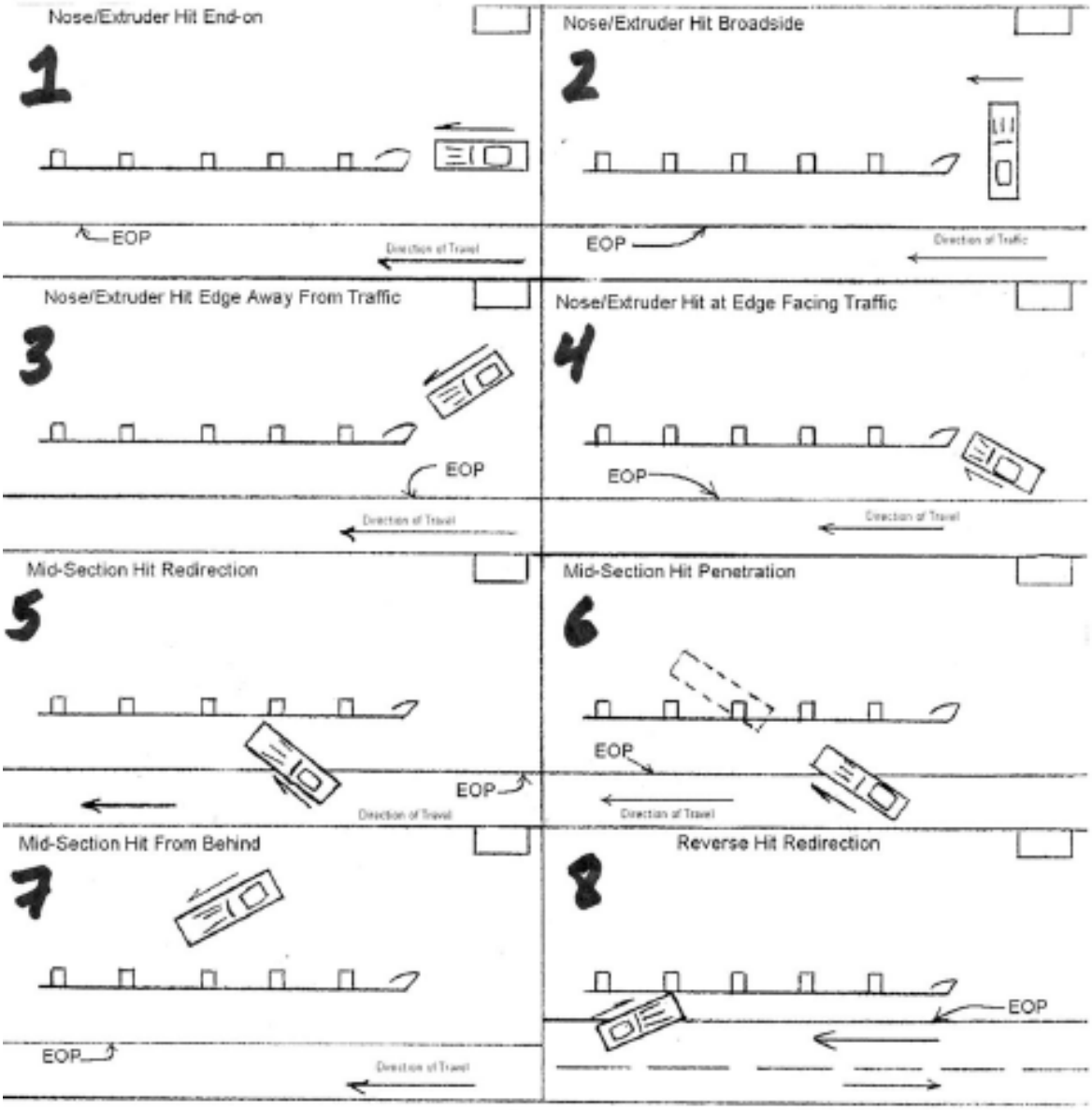
| EXTRUDER | | | |
|---|---|---|---|
| Feeder Channel Width at impact head | ❒4inches ❒5 inches ❒Other _____ | | |
| Guide Chute Exit Height (in.) | N/A | | |
| Connection of feeder channels to head damaged? | ❒No ❒Yes | Are Welds Broken? | ❒No ❒Yes |
| Anchor Cable Present? | ❒No ❒Yes | Connected? | ❒No ❒Yes |
| Rail Extrusion? | ❒No ❒Yes | Length (ft. in.) | N/A |
| 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.] | | | |

| TELESCOPE | | | | |
|---|---|---|---|---|
| Rail Displacement | ❒No | ■Yes; Length: 25.0 ft | No of Panels Displaced | ■1 ❒2 ❒3 ❒4 ❒5 ❒6 |

| ALL-SYSTEM PERFORMANCE | | |
|---|---|---|
| Railkinks Downstream of Head? | ■No | ❒Yes; No. of Kinks in Rail: N/A |
| 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 | N/A | |

| ALL-SYSTEM PERFORMANCE ENVIRONMENT | | | |
|---|---|---|---|
| **SIDESLOPE** | **50 ft in advance of Post 1** | **At Post 1** | **50 ft Past Post 1** |
| Percent - % | 11.5% | 16.3% | 22.1% |
| Adjacent Lane Width (ft) | 12.8 ft | | |
| Lane Type (NAS EDS Variable: Sur. Type) | Asphalt | | |
| Shoulder Type | Asphalt | | |
| Shoulder Width (ft) | 4.6 ft | | |
| Guardrail Height (in) | 30.5 in (*measured at Post 11*) | | |

| VEHICLE INFORMATION | | |
|---|---|---|
| Vehicle Type (NHTSA Input) | 2002 Chevrolet Blazer | |
| Vehicle Identification Number (VIN) | 1GNDT13WX2KXXXXXX | |
| Vehicle Mass (NASS var.: veh.wgt) | 4,196 lb | |
| Vehicle orientation upon impact | ■Case Type 1 ❒ Case Type 2 ❒ Case Type 3 ❒ Case Type 4 ❒ Case Type 5 ❒ Case Type 6 | |
| If 'Other', describe | N/A | |
| Collision Deformation Classification | Event 1 - 12FREW2<br>Event 2 – 12FRES7 | |
| Delta-V | Less than 15 mph | |
| Occupant Compartment Penetration of rail | ■No | ❒Yes; Describe: |
| Did the Vehicle Rollover? | ❒ Yes ■ No | |
| 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 | |


Nose/Extruder Hit End-on
1
EOP
Direction of Travel
Nose/Extruder Hit Broadside
2
EOP
Direction of Traffic
Nose/Extruder Hit Edge Away From Traffic
3
EOP
Direction of Travel
Nose/Extruder Hit at Edge Facing Traffic
4
EOP
Direction of Travel
Mid-Section Hit Redirection
5
EOP
Direction of Travel
Mid-Section Hit Penetration
6
EOP
Direction of Travel
Mid-Section Hit From Behind
7
EOP
Direction of Travel
Reverse Hit Redirection
8
EOP

**APPENDIX B:**
**2002 Chevrolet Blazer Event Data Recorder 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 | 1GNDT13WX2K****** |
| User | |
| Case Number | |
| EDR Data Imaging Date | |
| Crash Date | |
| Filename | 201650S1CR16007_V1_ACM.CDRX |
| Saved on | |
| Imaged with CDR version | Crash Data Retrieval Tool 16.4 |
| Reported with CDR version | Crash Data Retrieval Tool 17.6.1 |
| 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 a Deployment Level Event occurs within five seconds after the Deployment Event, the Deployment Level Event 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 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 will record up to the first 150 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.

-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 ³Data Invalid´ if:

- -The SDM receives a message with an ³invalid´ 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 Belt Switch Circuit Status indicates the status of the driver¶s 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.
-Passenger Front Air Bag Suppression Switch Circuit Status indicates the status of the suppression switch circuit.
-The Time Between This Event and the Previous Events is displayed in seconds. If the time between the two events is greater than five seconds, ³N/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.
-If the vehicle is a 2000 - 2002 Chevrolet Cavalier Z24 or a Pontiac Sunfire GT, with a manual transmission (RPO MM5) and a 2.4L engine (RPO LD9), the Brake Switch Circuit Status data will be reported in the opposite state than what actually occurred, e.g. an actual brake switch status of ³ON´ will be reported as ³OFF´.
-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 SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle¶s communication network.
-The Passenger Front Air Bag Suppression 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.

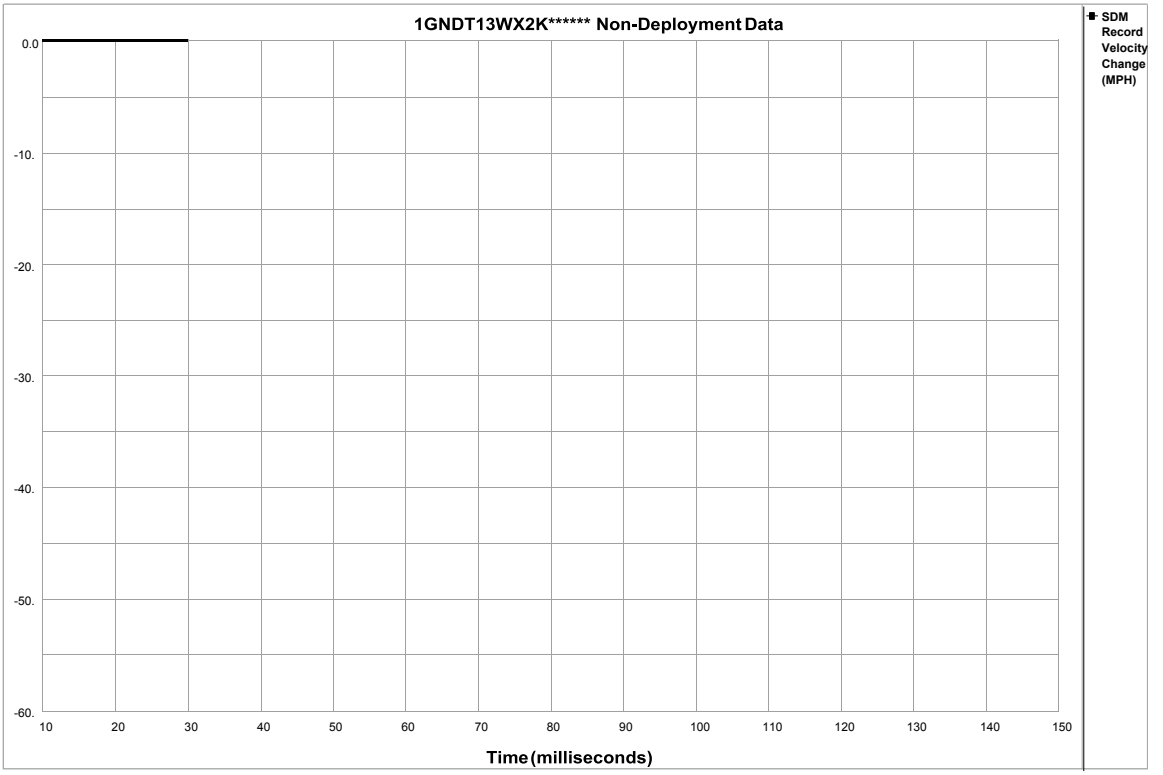
01025_SDMG-99JXZ09-10_r004

## *System Status At Non-Deployment*

| | |
|---|---|
| SIR Warning Lamp Status | OFF |
| Driver's Belt Switch Circuit Status | BUCKLED |
| Passenger SIR Suppression Switch Circuit Status (if equipped) | Air Bag Not Suppressed |
| Ignition Cycles At Non-Deployment | 24448 |
| Ignition Cycles At Investigation | 24449 |
| Maximum SDM Recorded Velocity Change (MPH) | -0.19 |
| Algorithm Enable to Maximum SDM Recorded Velocity Change (msec) | 30 |
| Time Between this Event and the Previous Event (sec) | 0.1 |

| Seconds Before AE | Vehicle Speed (MPH) | Engine Speed (RPM) | Percent Throttle |
|---|---|---|---|
| -5 | 39 | 1792 | 21 |
| -4 | 39 | 1728 | 21 |
| -3 | 39 | 1216 | 0 |
| -2 | 39 | 1088 | 0 |
| -1 | 37 | 1024 | 73 |

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




| Time (milliseconds) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SDM Recorded Velocity Change | 0.00 | 0.00 | 0.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

## Hexadecimal Data

```
$01  08 23 00 00
$02  DA D1
$03  41 53 32 30 35 33
$04  4B 33 56 36 55 31
$05  00
$06  15 07 32 52
$10  F4 0F FE
$11  93 95 95 7E 9C 00
$14  03 84 34 80
$18  82 81 82 BA FF 00
$1C  FA FA FA FA FA FA
$1D  FA FA FA FA FA FA
$1E  FA FA
$1F  FF 02 00 00 00
$20  A0 00 00 FF 00 C0
$21  FF FF FF FF FF FF
$22  FF FF FF FF FF FF
$23  FF 00 00 0E 01 00
$24  00 00 FF FF FF FF
$25  FF FF FF FF FF FF
$26  FF FF 03 3B 3E 3E
$27  3E 3E 00 80 00 B9
$28  00 00 36 36 00 10
$29  11 13 1B 1C 00 F4
$2A  0F FF FE 5F 79 5F
$2B  75 5F 79 00 00 00
$2C  00 31 00 00
$2D  0C 03 01 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
$3C  FF FF FF FF
$40  FF FF FF FF FF FF
$41  FF FF FF FF FF FF
$42  FF FF FF FF FF FF
$43  FF
```

## *Disclaimer of Liability*

DOT HS 812 553
July 2018

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**


13684-070318-v3b