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of Transportation

**National Highway  
Traffic Safety  
Administration**



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March 2020

**Special Crash Investigations  
On-Site Guardrail End Terminal  
Crash Investigation  
Vehicle: 2003 Mitsubishi Galant  
Location: Missouri  
Crash Date: October 2017**

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## Technical Report Documentation Page

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	<b>15. Supplementary Notes</b> Each crash represents a unique sequence of events, and 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.		
<b>16. Abstract</b> This report documents the on-site investigation of a passenger vehicle impact to a Soft Stop guardrail end treatment that is of interest to the Federal Highway Administration. This crash occurred on the west side of the southbound lanes of a four-lane, divided, interstate highway. The Mitsubishi was a 4-door sedan equipped with redesigned frontal air bags. The vehicle was not equipped with an event data decoder that was supported by a commercially available tool available to the SCI team. An unbelted 30-year-old male drove the vehicle. The Mitsubishi was traveling in the right southbound through lane. The vehicle sustained two left plane sideswipe impacts with an unknown vehicle (Events 1 and 2). The Mitsubishi then departed the right side of the roadway and the front plane struck the end terminal (Event 3), likely resulting in deployment of both frontal air bags. The vehicle remained in contact with the end terminal coming to final rest heading south. The driver sustained police-reported "B" (non-incapacitating) injuries and was transported by ambulance to a hospital where he was treated and released. The vehicle was towed from the crash scene due to damage.			
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**Special Crash Investigations**  
**On-Site Guardrail End Terminal Crash Investigation**  
**Case Number: IN17031**  
**Vehicle: 2003 Mitsubishi Galant**  
**Location: Missouri**  
**Crash Date: October 2017**

**BACKGROUND**

This report documents the on-site investigation of a passenger vehicle impact to a Soft Stop guardrail end treatment (**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, who submitted photographs of the damaged end terminal and vehicle 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 November 2017 and assigned to the Special Crash Investigations team at the Indiana University Transportation Research Center. This crash involved a 2003 Mitsubishi Galant (**Figure 2**) and an unknown hit-and-run vehicle. The crash occurred in Missouri in October 2017 during nighttime hours and was investigated by a local police agency. The guardrail, crash scene, and vehicle were inspected in November 2017.



**Figure 1.** The damaged end terminal and guardrail, view south.

This crash occurred on the west side of the southbound lanes of a four-lane, divided interstate highway. The Mitsubishi was a 4-door sedan equipped with redesigned frontal air bags. The vehicle was not equipped with an event data recorder (EDR) supported by a commercially available tool available to the SCI team. An unbelted 30-year-old male drove the vehicle. The Mitsubishi was traveling in the right southbound through lane. The vehicle sustained two left plane sideswipe impacts with an unknown vehicle (Event 1 and 2). The Mitsubishi then departed the right side of the roadway and the front plane struck the end terminal (Event 3), likely resulting in deployment of both frontal air bags. The vehicle remained in contact with the end terminal, coming to final rest heading south. The driver sustained police-reported “B” (non-incapacitating) injuries and was transported by ambulance to a hospital where he was treated and



**Figure 2.** The damaged 2003 Mitsubishi Galant.

released. The vehicle was towed from the crash scene due to damage.

## SUMMARY

### *Crash Site*

This crash occurred at night on the west side of the southbound lanes of a four-lane, divided, State highway. The weather conditions were cloudy with clear visibility, north-northwest winds at 21 km/h (13 mph), a temperature of 4.4 °C (40 °F), and a dew point of -4.4 °C (24 °F), according to local weather reports. The interstate traversed in a north/south direction and had two bituminous through lanes in each direction that were divided by a grass median. The southbound roadway was bordered by rumble strips, a 3.1 m (10.1 ft) wide bituminous west shoulder and a 1.3 m (4.3 ft) wide bituminous median shoulder. The right southbound through lane was 3.6 m (11.8 ft) wide and the left southbound through lane was 3.8 m (12.5 ft) wide. The roadway pavement markings consisted of a solid white edge line, broken white center line, and a solid yellow median line. A blocked-out, W-beam guardrail equipped with a Soft Stop end terminal was located on the west side of the road adjacent to the shoulder. The speed limit was 113 km/h (70 mph). The crash diagram is included at the end of this report.

### *Pre-Crash*

The Mitsubishi was traveling in the right southbound lane when it departed the right side of the roadway (**Figure 3**). The police crash report stated that the driver did not know what happened. Damage to the left plane of the vehicle indicated that it was probably sideswiped by a hit-and-run vehicle resulting in the roadway departure. A tire mark was found in the grass during the SCI crash scene inspection. The path of the tire mark was projected back to the roadway on the scaled crash diagram and indicated that the Mitsubishi departed the right side of the right through lane onto the shoulder at an approximate distance of 68 m (223 ft) prior to the end terminal.

### *Crash*

The left plane, beginning on the Mitsubishi's left fender, was struck by the right plane of an unknown vehicle (Event 1). A separate area of sideswipe damage to the Mitsubishi's left quarter panel indicated it was struck again (Event 2) by the right plane of the unknown vehicle. The force direction on the Mitsubishi was in the 12 o'clock sector and no air bags deployed. The



**Figure 3.** Approach of Mitsubishi to end terminal, view south.



**Figure 4.** View east to damaged guardrail and final rest position of Mitsubishi.

vehicle then departed the right side of the roadway and traveled an estimated 45 m (148 ft) across the shoulder and the right-side tires entered the grass. The tire mark in the grass curved back toward the roadway indicating the driver attempted to steer the vehicle back onto the roadway as it traveled an additional 23 m (75 ft) and the front plane struck the end terminal (Event 3). The impact speed is not known. The force direction on the vehicle was in the 12 o'clock sector and the impact resulted in deployment of both frontal air bags. WinSMASH could not be used to calculate 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 39 km/h (24mph) based on the crush to the front bumper.

The Mitsubishi remained in contact with the end terminal extruding 2.4 m (7.8 ft) of guardrail and displacing two posts. The vehicle came to final rest heading south with the front plane against the end terminal (**Figure 4**).

### ***Post-Crash***

The driver sustained police-reported “B” (non-incapacitating) injuries and was transported by ambulance to a hospital where he was treated and released. The Mitsubishi was towed from the crash scene due to damage.

### **END TERMINAL AND GUARDRAIL DAMAGE**

The front plane impact of the Mitsubishi to the Soft Stop extruded 239 cm (94.0 in) of guardrail and damaged 7.6 m (25 ft) of guardrail and three posts. The direct damage involved the full height and width [51 cm (20.1 in) and 18 cm (7.1 in)] of the face of the Soft Stop (**Figure 5**). All the guardrail posts were constructed of steel. Post 1 had no offset block. The remaining posts had composite offset blocks. Post 1 was bent downstream to the ground. Post 2 was bent downstream approximately 20 degrees off vertical and the offset block was fractured and displaced. Post 3 was slightly twisted and the offset block was fractured and displaced from the post. The bolt was bent from contact by the guide chute vertical support and displaced downstream approximately 15 cm (5.9 in) slicing the guardrail (**Figure 6**), but remained attached to the post and guardrail. The remaining posts were undamaged. There were no kinks in the guardrail. The width of the feeder channel 15 cm (6.0 in). The guide chute exit height was also 15 cm (6.0 in). The connection of the feeder channel to the head was not damaged and no welds were broken. The anchor remained attached to the



**Figure 5.** Face of end terminal.



**Figure 6.** Slice in guardrail from post bolt.

guardrail and bracket at post 0. The height of the undamaged guardrail was 48 cm (19.0 in). The FHWA guardrail form is attached to the end of this report as **Appendix A**.

## **2003 MITSUBISHI GALANT**

### ***Description***

The Mitsubishi was a front-wheel-drive, 5-occupant, 4-door sedan with the Vehicle Identification Number (VIN) 4A3AA46G73Exxxxxx manufactured in December 2002. The vehicle was equipped with a 2.4-liter, I-4 engine, 4-speed automatic transmission, and redesigned frontal air bags. The specified wheelbase was 264 cm (103.9 in). The vehicle manufacturer's recommended tire size was P195/65R15. The vehicle was equipped with BF Goodrich Advanture T/A tires of the recommended size on the front tires. The left rear tire was a Continental Conti ProContact and the right rear tire was a Cooper (unknown model), both of the recommended size. The manufacturer's recommended cold tire pressure for the front and rear tires was 200 kPa (29 psi).

The front row was equipped with cloth-covered bucket seats with adjustable head restraints. The second row was equipped with a cloth-covered bench seat with folding backs and fixed head restraints. The driver's seat track was adjusted between the middle and rear-most positions and the seat back was reclined 19 degrees aft of vertical. The remaining seating positions were not occupied at the time of the crash.

### ***Exterior Damage***

#### ***Exterior Damage Events 1 and 2***

The Mitsubishi sustained minor damage during two sideswipe impacts to the left plane by an unknown vehicle. The direct damage for the first impact began 31 cm (12.2 in) forward of the left front axle and extended 276 cm (108.7 in) rearward on the fender and both doors. The Field L was also 276 cm (108.7 in). Crush measurements were taken at the mid-door level and the maximum residual crush was 5 cm (2.0 in) occurring over the front axle. The direct damage for the second impact began 34 cm (13.4 in) rear of the left rear axle and extended rearward 63 cm (24.8 in) rearward. There were only scratches from this impact.

#### ***Damage Classification Events 1 and 2***

The Collision Deformation Classifications (CDC) were 12LYES1 (0 degrees) and 12LBES1 (0 degrees). The severity of the damage was minor for each impact.

#### ***Exterior Damage Event 3***

The front plane sustained direct and induced damage during the impact with the end terminal. The direct damage involved the bumper, grille, and hood. The direct began 20 cm (7.9 in) left of the right corner of the front bumper and extended 18 cm (7.1) to the left. The Field L was 85 cm (33.5 in). Crush measurements were taken at the bumper level and the maximum residual crush was 38 cm (15.0 in) occurring 20 cm (7.9 in) right of the vehicle's centerline. The crush values were:  $C_1 = 0$  cm,  $C_2 = 12$  cm (4.7 in),  $C_3 = 25$  cm (9.8 in),  $C_4 = 38$  cm (15.0 in),  $C_5 = 34$  cm (13.4 in), and  $C_6 = 15$  cm (5.9 in).

### ***Damage Classification Event 3***

The CDC was 12FREN2 (0 degrees). The severity of the damage was moderate.

### ***Event Data Recorder***

The Mitsubishi was not equipped with an event data recorder that was supported by a commercially available tool available to the SCI team.

### ***Interior Damage***

The interior of the Mitsubishi sustained no occupant compartment intrusion during the crash. Evidence of occupant contact consisted of a slightly displaced lower left instrument panel with a possible scuff mark from contact by the driver's left knee. All the doors were jammed shut. There was a discoloration to the right portion of the driver sun visor and slight displacement of the rear view mirror from possible contact by the driver's head. There was also a light scuff on the roof near the left B-pillar from possible contact by the driver's head.

### ***Manual Restraint Systems***

The front and second row seating positions were equipped with lap and shoulder seat belts with sliding latch plates and fixed upper anchors. Inspection of the driver's seat belt assembly revealed no evidence of usage. The police crash report also reported the driver as unbelted.

### ***Supplemental Restraint Systems***

The Mitsubishi was equipped with redesigned frontal air bags. Both air bags deployed during the impact with the end terminal. Blood spatter was found on the top and left sides of the front of the air bag.

## **2003 MITSUBISHI GALANT OCCUPANT**

### ***Driver Demographics***

Age/sex:	30 years/male
Height:	180 cm (71 in)
Weight:	66 kg (145 lb)
Eyewear:	Unknown
Seat type:	Bucket
Seat track position:	Between middle and rear-most
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags	Frontal, deployed
Alcohol/drug data:	Alcohol, yes, per police; drugs, no
Egress from vehicle:	Unknown
Transport from scene:	Ambulance
Medical treatment:	Treated and released

### ***Driver Injuries***

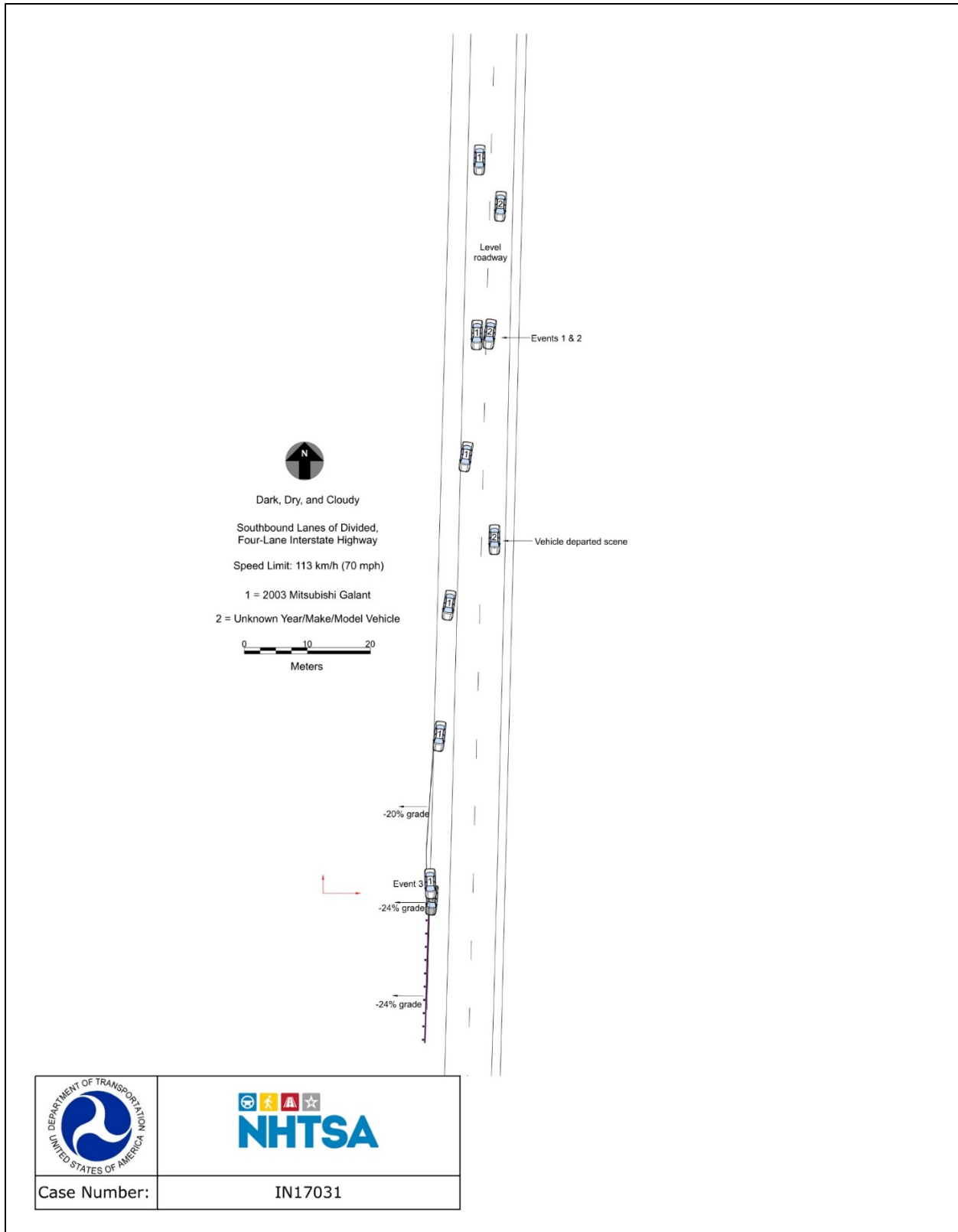
<b>Injury No.</b>	<b>Injury</b>	<b>Injury Severity AIS 2015</b>	<b>Involved Physical Components (IPC)</b>	<b>IPC Confidence Level</b>
1	Cervical spinal muscle strain, acute (whiplash injury), no further specificity	640278.1	Isolated Left air bag - steering wheel hub	Probable
2	Skin/subcutaneous/muscle contusion; hematoma, lip	210402.1	Isolated Left air bag - steering wheel hub	Certain

*Source: emergency room records.*

### ***Driver Kinematics***

The driver was unbelted and his seat track was adjusted between the middle and rear-most positions. The seatback was reclined 19 degrees aft of vertical. The driver was probably displaced forward during the side swipe impact with the unknown vehicle. He was also displaced forward during the impact with the end terminal and his left knee probably contacted the lower left instrument panel. His face and chest loaded the deployed frontal air bag, which likely caused the lip contusion as well as the cervical strain as he flexed over the air bag. The driver sustained police-reported B (non-incapacitating) injuries and was transported by ambulance to a hospital where he was treated and released.

# CRASH DIAGRAM



**APPENDIX A: FHWA Guardrail Form**

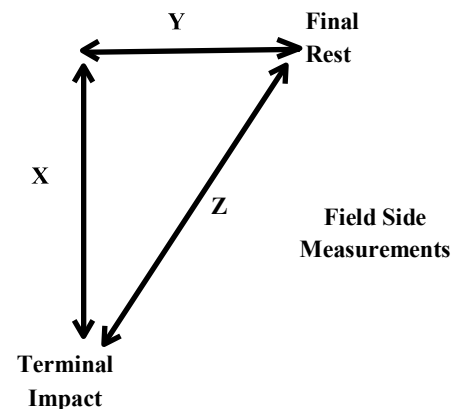
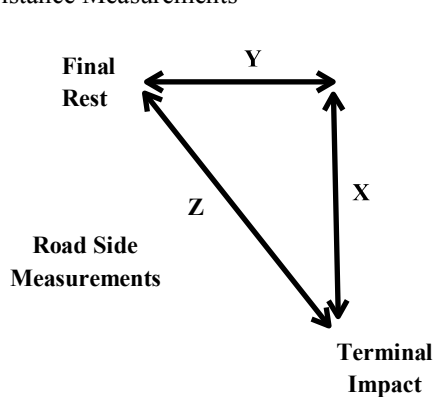
Case No.: IN17031

PREPOPULATED DATA (BY OTHERS)			
Date of Crash	October 2017	TIME OF CRASH (MILITARY)	Nighttime
Case Number	IN17031	State	Missouri
Traffic Route	Interstate	Direction (Southbound = SB)	SB
Ambient Conditions (at time of crash)			
Temperature (°F)	40	Lighting	Dark
Atmospheric	Clear		

SCENE INFORMATION	
Type of area where crash occurred	<input type="checkbox"/> Urban <input checked="" type="checkbox"/> Rural <input type="checkbox"/> Suburban
Terminal on a horizontal curve?	<input checked="" type="checkbox"/> No <input type="checkbox"/> Curve/LT <input type="checkbox"/> Curve/RT
Estimated or Reconstructed Speed at Impact (MPH)	Unknown
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 3.0 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 3.0 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 9.8 ft
Super elevation	<input type="checkbox"/> +2% <input type="checkbox"/> -2% <input checked="" type="checkbox"/> NONE or FLAT
Curve Radius (ft.)	

**KEY:**

- COM - Center of Mass of Vehicle
- Distance Measurements



Case No.: IN17031

ON-SCENE INFORMATION							
End Treatment Type	<input checked="" type="checkbox"/> Extruder	<input type="checkbox"/> T2000	<input type="checkbox"/> ET-PLUS 4in	<input type="checkbox"/> ET-PLUS 5in	<input type="checkbox"/> SKT	<input type="checkbox"/> FLEAT	<input checked="" type="checkbox"/> SOFT STOP
	<input type="checkbox"/> Telescope	<input type="checkbox"/> X-LITE	<input type="checkbox"/> X-TENSION				
Curb?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> AASHTO Type A					<input type="checkbox"/> AASHTO Type E
	<input type="checkbox"/> Yes	<input type="checkbox"/> AASHTO Type B	<input type="checkbox"/> AASHTO Type C	<input type="checkbox"/> AASHTO Type D	<input type="checkbox"/> AASHTO Type F		<input type="checkbox"/> AASHTO Type G
Curb Height:		<input type="checkbox"/> AASHTO Type H					

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	Steel	5.5 x 7.25	N/A	N/A	Unk		10.8	N/A	4' 8"	
1	Steel	7.75 x 4.0	N/A	N/A	Unk		10.8	N/A	5' 9"	
2	Steel	6.0 x 4.0	Composite	7.5 x 3.75	Unk		11.8	N/A	6' 10"	

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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	6.0 x 4.0	Composite	7.5 x 4.0	No		11.6	N/A	6' 4"
4	Steel	6.0 x 4.0	Composite	7.5 x 4.0	No		11.7	N/A	6' 1"
5	Steel	6.0 x 4.0	Composite	7.5 x 3.75	No		11.5	N/A	6' 4"
6	Steel	6.0 x 4.0	Composite	7.5 x 4.0	No		11.5	N/A	6' 5"
7	Steel	6.4 x 4.0	Composite	7.5 x 3.75	No		11.5	N/A	6' 1"
8	Steel	6.0 x 4.0	Composite	7.5 x 3.75	No		11.4	N/A	2' 11"

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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	6.0 x 4.0	Composite	7.75 x 4.0	No		11.5	N/A	3' 3"
10	Steel	6.0 x 4.0	Composite	7.5 x 4.0	No		11.3	N/A	3' 2"
11	Steel	6.0 x 4.0	Composite	7.5 x 4.0	No		11.3	N/A	3' 1"
12	Steel	6 x 4	Steel	7.5 x 3.75	No		11.3	N/A	3' 2"

Additional Comments:

Case No.: IN17031

<b>EXTRUDER</b>			
Feeder Channel Width at impact head	<input type="checkbox"/> 4 inches <input type="checkbox"/> 5 inches <input checked="" type="checkbox"/> Other (6")		
Guide Chute Exit Height (in.)	6"		
Connection of feeder channels to head damaged?	<input checked="" type="checkbox"/> No <input type="checkbox"/> Yes	Are Welds Broken?	<input checked="" type="checkbox"/> No <input type="checkbox"/> Yes
Anchor Cable Present?	<input type="checkbox"/> No <input type="checkbox"/> Yes	Not Applicable	<input type="checkbox"/> No <input type="checkbox"/> Yes
Rail Extrusion?	<input type="checkbox"/> No <input checked="" type="checkbox"/> Yes	Length (ft. in.)	7' 10"
Rail Extrusion Direction	<input type="checkbox"/> Traffic Side <input type="checkbox"/> Field Side <input checked="" type="checkbox"/> Not applicable		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	25		

<b>TELESCOPE</b>			
Rail Displacement	<input type="checkbox"/> No	<input type="checkbox"/> Yes; Length:	No of Panels Displaced <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6

<b>ALL-SYSTEM PERFORMANCE</b>			
Railkinks Downstream of Head?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes;	No. of Kinks in Rail:
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	<input checked="" type="checkbox"/> No <input type="checkbox"/> Yes		
Did vehicle impact other objects after impact with terminal?	<input checked="" type="checkbox"/> No <input type="checkbox"/> Yes		
Object Contacted			

<b>ALL-SYSTEM PERFORMANCE ENVIRONMENT</b>			
SIDESLOPE	50 ft in Advance of Post 1	At Post 1	50 ft Past Post 1
Percent - %	-20%	-24%	-24%
Adjacent Lane Width (ft)	11.8		
Lane Type (NAS EDS Variable: Sur. Type)	Bituminous		

**Case No.: IN17031**

Shoulder Type	Bituminous
Shoulder Width (ft)	10.1
Guardrail Height (in)	19

VEHICLE INFORMATION	
Vehicle Type (NHTSA Input)	Four-door sedan
Vehicle Identification Number (VIN)	4A3AA46G73Exxxxxx
Vehicle Mass (NASS var.: veh.wgt)	3,031
Vehicle orientation upon impact	<input checked="" type="checkbox"/> Case Type 1 <input type="checkbox"/> Case Type 2 <input type="checkbox"/> Case Type 3 <input type="checkbox"/> Case Type 4 <input type="checkbox"/> Case Type 5 <input type="checkbox"/> Case Type 6 <input type="checkbox"/> Case Type 7 <input type="checkbox"/> Case Type 8 <input type="checkbox"/> Other
If 'Other', describe	
Collision Deformation Classification	12FREN2
Delta-V	Unknown (Barrier Equivalent Speed = 24 mph)
Occupant Compartment Penetration of rail	<input checked="" type="checkbox"/> No <input type="checkbox"/> Yes
Quarter Turns (NASS EDS variable: Rollover)	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/> 8 <input type="checkbox"/> 9 <input type="checkbox"/> 10 <input type="checkbox"/> 11 <input type="checkbox"/> 12 <input type="checkbox"/> 13 <input type="checkbox"/> 14 <input type="checkbox"/> 15 <input type="checkbox"/> 16 <input type="checkbox"/> 17+
Object Precipitating Rollover, (NASS EDS variable: Rollobj)	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	

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U.S. Department  
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**National Highway  
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