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Special Crash Investigations: On-Site Guardrail End Terminal Crash Investigation; Vehicle: 2002 Kia Optima; Location: Missouri; Crash Date: March 2017

DISCLAIMER

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15. Supplementary Notes Each crash represents a unique sequence of events, and generalized conclusions cannot be made concerning the crashworthiness performance of the involved 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.			

16. Abstract

This report documents the on-site investigation of a passenger vehicle impact to an ET-Plus (10 cm [3.9 in] model) guardrail end terminal that is of interest to the Federal Highway Administration. The investigation was conducted on behalf of FHWA. This crash occurred on the west roadside in an interchange of a four-lane, divided U.S. highway. The 2002 Kia Optima was a 4-door sedan equipped with frontal air bags and front seat-mounted side impact air bags. An unbelted 46-year-old male driver, a 29-year-old female passenger, and a 29-year-old male passenger occupied the vehicle. The Kia was southbound when it departed the right side of the road. The left corner of the vehicle struck the end terminal (Event 1). The guardrail separated from the end terminal resulting in the guardrail penetrating through the cowl behind the left front wheel and into the driver's seating position. The vehicle rolled over (Event 2), left side leading, a total of two quarter turns and its top plane struck the damaged guardrail (Event 3), coming to final rest on top of the end terminal heading west. The driver sustained serious injuries and was transported by ambulance to a hospital where he was admitted. The two passengers were injured and sought treatment later at an unknown type medical facility. The Kia 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: IN17013
Vehicle: 2002 Kia Optima
Location: Missouri
Crash Date: March 2017

BACKGROUND

This report documents the on-site investigation of a passenger vehicle impact to an ET-Plus (10 cm [3.9 in] model) guardrail end terminal (**Figure 1**) that is of interest to the Federal Highway Administration (FHWA). The investigation was conducted on behalf of FHWA. This crash was identified by an engineer with the Missouri Department of Transportation (MoDOT), who submitted photographs of the vehicle and the damaged guardrail end terminal to the FHWA. The FHWA determined that the guardrail end terminal and crash type were of interest. This crash investigation was then initiated by the National Highway Traffic Safety Administration in March 2017 and assigned to the Special Crash Investigation team at the Indiana University Transportation Research Center. This single-vehicle crash involved a 2002 Kia Optima (**Figure 2**). The crash occurred in Missouri in March 2017 in the morning and was investigated by the local police agency. The guardrail, crash scene and vehicle were inspected in March 2017.

Figure 1. View north to the damaged end terminal and guardrail.

Figure 2. The damaged 2002 Kia Optima.

This crash occurred on the west roadside in an interchange of a four-lane, divided U.S. highway. The Kia was a 4-door sedan equipped with frontal air bags and front-seat- mounted side impact air bags. The vehicle was not supported by the Bosch Crash Data Retrieval tool. An unbelted 46-year-old male driver, a 29-year-old female passenger, and a 29-year-old male passenger (seating positions and seat belt use unknown) occupied the vehicle. The Kia was southbound in an unknown lane when it departed the right (west) side of the road. The left corner of the vehicle's front plane struck the guardrail end terminal (Event 1). The guardrail separated from the end terminal resulting in the guardrail penetrating through the cowl behind the left front wheel and into the driver's seating position. The vehicle rolled over (Event 2), left side leading, two quarter turns and its top plane struck the damaged guardrail (Event 3) as the vehicle came to

final rest on top of the guardrail, heading west. The driver sustained serious injuries to his right leg and hip from contact with the intruded guardrail. He was transported by ambulance to a hospital where he was admitted and his right leg was amputated. The two passengers were injured and sought treatment later at an unknown type medical facility. The Kia was towed from the crash scene due to damage.

Figure 3. Southbound approach of the Kia in an unknown lane.

SUMMARY

Crash Site

This crash occurred in the dark early morning on the west roadside in an interchange of a four-lane, divided U.S. highway. The weather conditions were clear with a temperature of 2.2 °C (36 °F) and a dew point of 2.8 °C (27 °F), according to local weather reports. The southbound roadway was level and had three through lanes and an acceleration lane from an entrance ramp that were bordered by bituminous shoulders. Each lane was approximately 3.7 m (12.1 ft) wide. The southbound lanes were separated from the four northbound lanes by a concrete median barrier. A steel, blocked-out, W-beam guardrail equipped with an ET-Plus (10 cm [3.9 in] model) end terminal was located on the right (west) side of the southbound lanes. The shoulder adjacent to the guardrail was 2.6 m (8.5 ft) wide. The median shoulder was 2.0 m (6.6 ft) wide. The roadway pavement markings consisted of a solid white edge line, broken white lane lines, and a solid yellow median line. The speed limit was 105 km/h (65 mph). A crash diagram is included at the end of this report.

Figure 4. The damaged end terminal.

Figure 5. Torn guardrail in feeder channel.

Pre-Crash

The Kia was traveling south (**Figure 3**) at an unknown speed and in an unknown travel lane when the vehicle departed the right (west) side of the roadway. The police crash report stated that the female passenger thought the driver fell asleep.

Crash

The front plane of the Kia struck the end terminal (**Figure 4**, Event 1) at an unknown speed. The impact occurred to the left corner of the vehicle's front plane resulting in snagging of the end

terminal on the left front wheel. The end terminal was displaced toward the field side as 3.0 m (9.8 ft) of guardrail were extruded toward the field side. The guardrail kinked at the entrance to the feeder channel and tore and separated from the end terminal (**Figure 5**). The guardrail then penetrated through the cowl behind the left front wheel (**Figure 6**) and into the driver's seating position space (**Figure 7**). The direction of penetration was from the 10 o'clock direction. The guardrail contacted the driver's right leg and hip as evidenced by blood and tissue transfer on the guardrail and continued into the front row right seating position where it contacted and displaced the front right seatback rearward. The vehicle also began to roll over (Event 2), left side leading, as the guardrail was deformed. The vehicle rolled over a total of two quarter turns and the top plane struck the damaged guardrail (Event 3) as the vehicle came to final rest heading west on top of the guardrail (**Figure 8**). The total rollover distance was estimated to be 8 m (26.2 ft). The total distance traveled from impact with the end terminal to the final rest position was 13.6 m (44.6 ft). The crash damaged a total of 12.4 m (40.7 ft) of guardrail and damaged seven posts.

Figure 6. Guardrail penetrated through Kia's left cowl and into the driver's seating position.

Post-Crash

The police were notified of the crash and arrived on scene in minutes. Emergency responders used a hydraulic rescue tool to remove the Kia's right rear door. They also cut and removed a 97 cm (38.2 in) long section of the intruded guardrail, then removed the driver from the vehicle. The two passengers exited the vehicle without assistance. The driver sustained serious injuries to his right leg from contact with the intruded guardrail. The vehicle was towed from the crash scene due to damage.

Figure 7. Pole shows path of guardrail penetration through the driver's seating position.

GUARDRAIL DAMAGE

The front plane impact of the Kia to the end terminal extruded 3.0 m (9.8 ft) of guardrail to the field side and damaged seven posts. The height and width of the face of the end terminal was 71 cm (28.0 in) and 38 cm (15.0 in),

respectively, and the direct damage involved the total area of the face of the end terminal. The width of the feeder channel was 10 cm (3.9 in) and the guide chute exit height was 51 cm (20.1 in). The anchor cable disconnected from the guardrail during the crash and was found on the field side of the guardrail between posts 3 and 4 during the SCI crash scene inspection. The guardrail kinked at the entrance to the feeder channel and then tore and separated from the end terminal. The guardrail was also displaced from posts 1 to 7. Post 1 was separated from its base at the bolt hinge and the post was deformed. Post 2 was bent to the ground in the downstream direction. The ground strut remained in place. Posts 3 to 5 were bent in the downstream direction nearly to the ground and the composite offset blocks were displaced from the posts. Post 6 was slightly displaced in the ground. The offset block remained attached to the post but was displaced. The bolt pulled through the guardrail, which was kinked at the post. Post 7 and the offset block were not displaced but the bolt pulled through the guardrail. The guardrail was kinked in five locations (**Figure 9**). There were four kinks in the first section of the guardrail. One occurred at the entrance to the feeder channel where the guardrail tore and separated. Two more occurred in the mid-section of the rail and the forth occurred at the splice between rails one and two. The fifth kink occurred in rail two at post 6. The "In-Service End Terminal Evaluation Data Collection Form" is attached to the end of this report as **Appendix A**.

Figure 8. The Kia at final rest on top of the damaged guardrail, view north. Photo provided by local law enforcement agency.

Figure 9. The kinked sections of guardrail, view south.

2002 KIA OPTIMA

Description

The Kia was a front-wheel drive, 5-occupant, 4-door sedan with the VIN KNAGD126525xxxxxx. The vehicle was equipped with a 2.4-liter, I-4 engine, 4-speed automatic transmission, frontal air bags, front-seat-mounted side impact air bags, and a tilt steering column that was adjusted to the full-down position. The specified wheelbase was 270 cm (106.3 in).

The vehicle manufacturer's recommended tire size was P205/60R15. The vehicle was equipped with Cooper CS5 Grand Touring tires of the recommended size on the left front and right rear. A

Hankook Optimo H418 size P195/60R15 was on the left rear and a B F Goodrich Touring T/A of the recommended size was on the right front. The vehicle manufacturer's recommended cold tire pressure for the front and rear tires was 207 kPa (30 psi). The tread on the left and right front tires was in poor condition as evidenced by the exposed wear bars. The rear tires were in fair condition.

The front row was equipped with driver and passenger leather-covered bucket seats with adjustable head restraints. The second row was equipped with a leather-covered bench seat with folding back and adjustable head restraints. The driver's and front passenger's seat tracks were each adjusted between the middle and rear-most positions. The driver's seat back was slightly reclined. The front passenger's back had been displaced by contact with the intruded guardrail. The top of the driver's head restraint was located 21 cm (8.3 in) above the top of the seatback.

Exterior Damage

Exterior Damage Event 1
The Kia sustained direct and induced damage to the front plane from the impact with the end terminal. However, there was also overlapping direct damage across the whole front plane above the bumper level from contact with an embankment that occurred during the rollover. The direct damage from the impact with the end terminal was located at the left corner of the front plane and involved the bumper, left headlamp/turn signal assembly, and left fender. The back of the left front wheel well, lower left A-pillar, sill, and lower front portion of the left front door were also directly damaged when the end terminal separated from the guardrail and the guardrail penetrated through this area into driver's and front row right seating positions. The direct damage to the front plane from the end terminal began at the left corner of the front bumper and extended 38 cm (15.0 in) to the right. A crush profile for this impact could not be determined since the bumper bar was constructed of fiberglass and the left portion of it was fractured and displaced off the vehicle. The bumper bar itself was also partially detached from the vehicle.

Damage Classification Event 1
The Collision Deformation Classification (CDC) was 12FLEE9 (0 degrees). The extent zone was based on the extent of guardrail penetration into the occupant compartment. The severity of the damage was considered severe, also due to the penetration of the guardrail.

Exterior Damage Events 2 and 3
The left and top planes sustained direct and induced damage when the vehicle rolled over, left side leading. The direct damage on the left plane involved the A-pillar, roof side rail, both doors, and the quarter panel. The top plane sustained direct damage to the hood from contact with ground and an embankment. A separate damage pattern occurred to the top plane from contact with the top of the deformed guardrail.

Damage Classification Events 2 and 3
The CDC for the rollover was 00TYDO2. The CDC for the contact between the guardrail and the vehicle's top plane was 00TPDN2. The severity of the damage for each impact was minor based on the extent of damage to the top plane.

Event Data Recorder
The Kia was not supported by the Bosch Crash Data Retrieval tool.

Interior Damage
The interior of the Kia sustained severe damage as a result of the penetration of the guardrail. The left cowl, lower left instrument panel, driver's seat cushion, floor-mounted gear shift lever, and center console were deformed and displaced. The front passenger's seatback was also directly contacted and displaced by the guardrail. Evidence of occupant contact consisted of a spider web-shaped fracture to the windshield from possible contact by the driver's head. The windshield was also fractured in the same pattern possibly from a head contact of one of the two passengers, whose seating positions are not known. The left front and left rear doors were jammed shut. The right front and right rear doors remained closed and operational. Emergency responders used a hydraulic rescue tool to remove right rear door. The left front, left rear, and sunroof glazing were disintegrated from impact forces. The right front and right rear glazing was disintegrated but this likely occurred during rescue activities. The windshield was cracked due to vehicle damage and occupant contact but remained in place.

Manual Restraint Systems
The front and second row seating positions were equipped with three-point lap and shoulder seat belts with sliding latch plates and fixed upper anchors. The front row seat belts were also equipped with retractor-mounted pretensioners. There was no evidence that the pretensioners actuated since the retractors functioned normally.

Inspection of the driver's seat belt assembly revealed no evidence of loading on the belt webbing, D-ring, or the belt guide of the sliding latch. There were also no traces of blood on the belt webbing. Given the extensive amount of blood in the driver's seating position, the absence of blood on the seat belt webbing suggested that the seat belt was in the retracted position at the time of the crash and not in use. The seating positions and restraint status of the two passenger's is not known.

Supplemental Restraint Systems
The Kia was equipped with frontal air bags and front seat-mounted side impact air bags. Both frontal air bags and the driver's seat-mounted side impact air bag deployed during the crash. The bottom portion of the side impact air bag appeared to have been cut, possibly by emergency responders. There was no discernable evidence of occupant contact scuff marks on either of the driver's air bags; however, the driver's frontal air bag had extensive blood deposits on the front and back from the driver's right leg injury.

2002 KIA OPTIMA OCCUPANTS

Driver Demographics

Age/sex:	46 years/male
Height:	183 cm (72 in)
Weight:	89 kg (196 lb)
Eyewear:	Unknown
Seat type:	Bucket

Seat track position:	Between middle and rear-most positions
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags:	Frontal and seat-mounted side impact, deployed
Alcohol/drug data:	BAC=0; positive for amphetamines
Egress from vehicle:	Removed by emergency responders
Transport from scene:	Ambulance
Medical treatment:	Hospitalized for 65 days

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Open pelvic ring fracture – diastases of pubic symphysis, comminuted right superior and right inferior pubic rami, right sacral fracture, widening of sacroiliac joint	856174.5	Intruding guardrail	Certain
2	Almost complete traumatic amputation of right leg at lower thigh above knee	811002.4	Intruding guardrail	Certain
3	Right anterior acetabulum fracture	856251.2	Intruding guardrail	Certain
4	Dislocation of left hip	873030.2	Intruding guardrail	Certain
5	Scrotum hematoma	544010.1	Intruding guardrail	Certain
6	Penis hematoma	543010.1	Intruding guardrail	Certain
7	Lower abdomen contusion	510402.1	Intruding guardrail	Certain

Source: hospital records.

Driver Kinematics

The driver was not restrained by the lap and shoulder seat belt. The seat track was adjusted between the middle and rear-most positions and the seatback was slightly reclined. The front plane impact to the end terminal resulted in deployment of the driver's frontal air bag. The driver was displaced forward and his face and chest probably loaded the frontal air bag. The end terminal separated from the guardrail resulting in penetration of the guardrail through the left cowl and into the driver's seating position where it contacted his right leg and hip. The driver was redirected to the left and toward the roof as the vehicle rolled over, left side leading. Emergency responders used a hydraulic rescue tool to remove the Kia's right rear door. They also cut and removed a 97 cm (38.1 in) long section at the end of the intruded guardrail, then removed the driver from the vehicle. The driver sustained serious injuries and was transported by ambulance to a hospital where he was admitted, and his right leg was amputated resulting in a hospitalization stay of 65 days.

Female Occupant (Unknown Seating Position) Demographics

Age/sex:	29 years/female
Height:	165 cm (65 in)
Weight:	57 kg (126 lb)
Eyewear:	Unknown
Seat type:	Unknown
Seat track position:	Unknown
Manual restraint usage:	Unknown
Usage source:	Vehicle inspection
Air bags:	Unknown
Alcohol/drug data:	Not reported
Egress from vehicle:	Exited without assistance
Transport from scene:	No
Medical treatment:	Sought treatment later at an unknown medical facility

Female Occupant (Unknown Seating Position) Injuries

No injury information was available for this occupant.

Female Occupant (Unknown Seating Position) Kinematics

The female occupant was seated in an unknown position and her restraint status is unknown. This occupant told police that she was talking on her cellular telephone at the time of the crash. The front plane impact to the end terminal displaced the occupant forward and she was then redirected to the left and toward the roof as the vehicle rolled over, left side leading. The occupant exited the vehicle without assistance following the crash. The police crash report indicated that this occupant was out of the vehicle prior to the arrival of emergency responders. The occupant sought treatment later at an unknown medical facility.

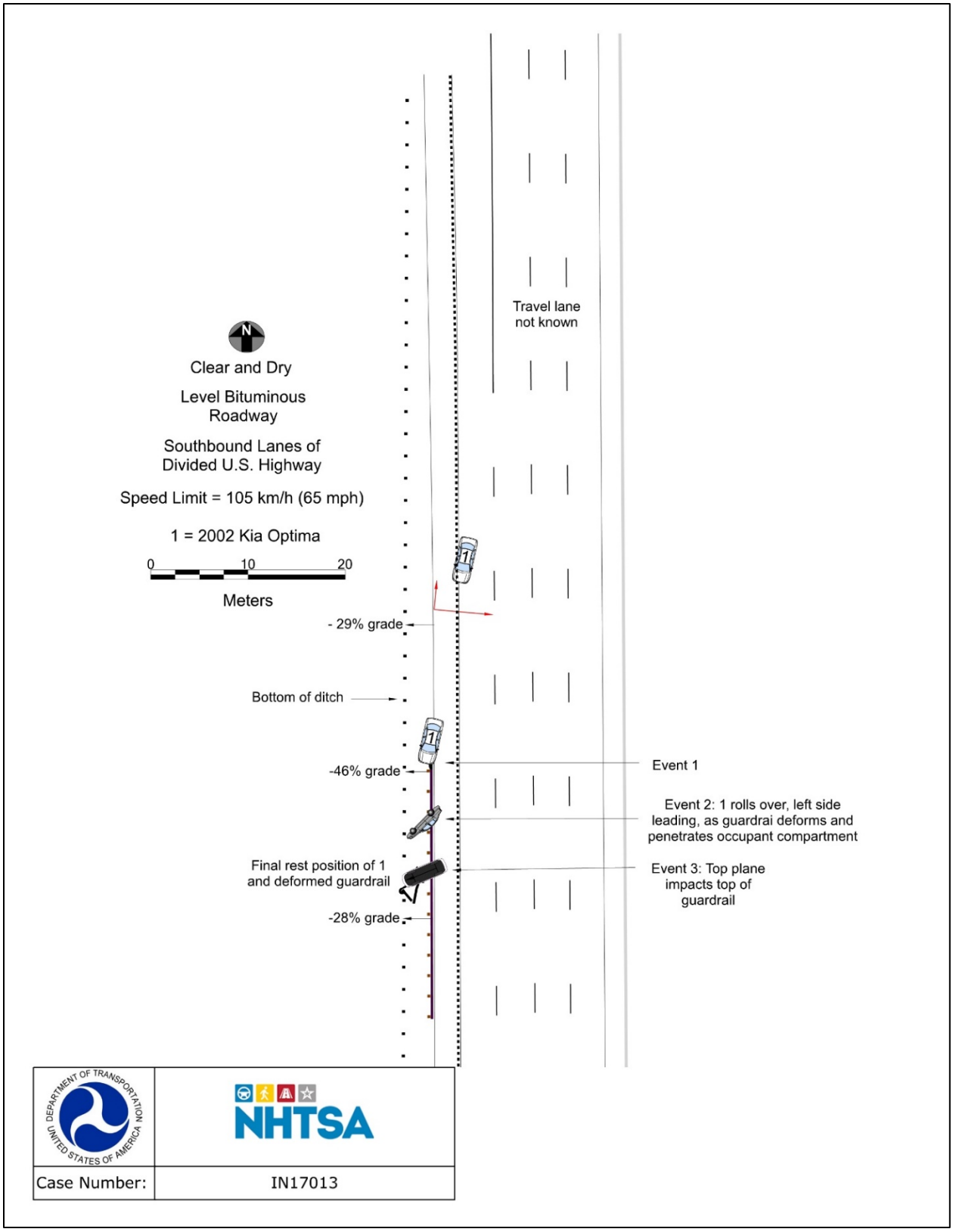
Male Occupant (Unknown Seating Position) Demographics

Age/sex:	29 years/male
Height:	185 cm (73 in)
Weight:	82 kg (181 lb)
Eyewear:	Unknown
Seat type:	Unknown
Seat track position:	Unknown
Manual restraint usage:	Unknown
Usage source:	Vehicle inspection
Air bags:	Unknown
Alcohol/drug data:	Not reported
Egress from vehicle:	Exited without assistance
Transport from scene:	No
Medical treatment:	Sought treatment later at an unknown medical facility

Male Occupant (Unknown Seating Position) Injuries
No injury information was available for this occupant.

Male Occupant (Unknown Seating Position) Kinematics
The male occupant was seated in an unknown position and his restraint status is unknown. It was reported to the police by the female passenger that this occupant was asleep at the time of the crash. The front plane impact to the end terminal displaced the occupant forward and he was then redirected to the left and toward the roof as the vehicle rolled over, left side leading. The occupant exited the vehicle without assistance following the crash. The police crash report indicated that this occupant was out of the vehicle prior to the arrival of emergency responders. The occupant sought treatment later at an unknown medical facility.

CRASH DIAGRAM



APPENDIX A: FHWA In-Service End Terminal Evaluation Data Collection Form

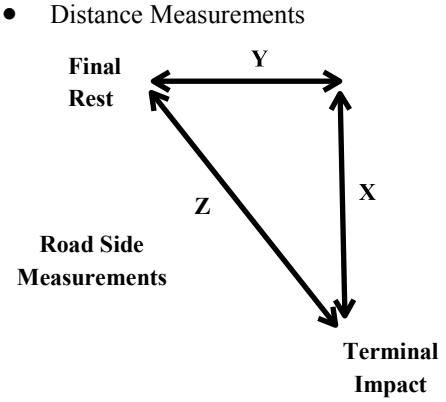
Case No.: IN17013

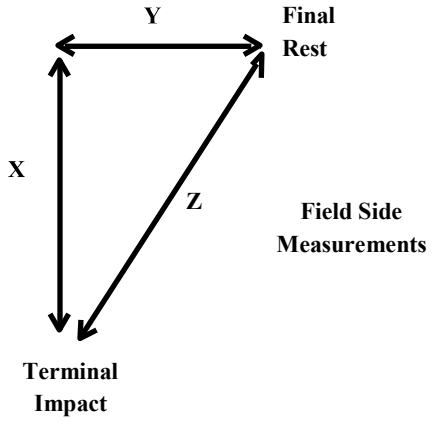
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	March 2017	**TIME OF CRASH (MILITARY)**	Morning
Case Number	IN17013	**State**	Missouri
Traffic Route	Divided U.S. Highway	**Direction (Southbound = SB)**	SB
Ambient Conditions (at time of crash)			
Temperature (°F)	36 degrees	**Lighting**	Dark
Atmospheric	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)	Unknown
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 44.6 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 44.6 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 11.8 ft
Super elevation	❒+2% ❒-2% ☒ NONE or FLAT
Curve Radius (ft.)	N/A

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: IN17013

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

GUARDRAIL INSTALLATION

Post No.	Post		Offset Block		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel Way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
0	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
1	Steel	6 x 4	None	N/A	Unk		10		0
2	Steel	6 x 4	None	N/A	Unk		10.3		6’ 0”

Case No.: IN17013

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	
3	Steel	6 x 4	Composite	Unk	Unk		10.4		6’ 3”
4	Steel	6 x 4	Composite	Unk	Unk		10.5		6’ 6 ‘
5	Steel	6 x 4	Composite	Unk	Unk		10.5		6’ 3”
6	Steel	6 x 4	Composite	7.5 x 3.75	Unk		10.3		6’ 0”
7	Steel	6 x 4	Composite	7.5 x 3.75	Unk		10.2		6’ 0”
8	Steel	6 x 4	Composite	7.5 x 3.75	No		10.2		6’ 3”

Case No.: IN17013

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	8 x 6.25	No		10.1		6’ 3”
10	Steel	6 x 4	Composite	8 x 6.25	No		10.1		6’ 3”
11	Steel	6 x 4	Composite	8 x 6.25	No		10.0		6’ 4”
12	Steel	6 x 4	Composite	8 x 6.25	Yes	Rail okay, but offset block has two pieces missing. Could be related to installation.	10.0		6’ 6”

Additional Comments:

Case No.: IN17013

EXTRUDER			
Feeder Channel Width at impact head	☒4inches ☐5 inches ☐Other _____		
Guide Chute Exit Height (in.)	20 in		
Connection of feeder channels to head damaged?	☐No ☒Yes	Are Welds Broken?	☒No ☐Yes
Anchor Cable Present?	☐No ☒Yes	Connected?	☒No ☐Yes
Rail Extrusion?	☐No ☒Yes	Length (ft. in.)	9ft 9in
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.]	40.6 ft		

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

ALL-SYSTEM PERFORMANCE		
Railkinks Downstream of Head?	☐No	☒Yes ; No. of Kinks in 5 Rail:
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?		☐No ☒Yes Guardrail
Did vehicle impact other objects after impact with terminal?		☐No ☒Yes
Object Contacted	Ground during rollover	

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in Advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	-30%	-46%	-28%
Adjacent Lane Width (ft)	12 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Bituminous		
Shoulder Type	Bituminous		

Shoulder Width (ft)	8.6 ft
Guardrail Height (in)	25.5 in

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	4-door sedan	
Vehicle Identification Number (VIN)	KNAGD126525xxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3190 lbs	
Vehicle orientation upon impact	❒Case Type 1 ❒ Case Type 2 ❒ Case Type 3 ☒ Case Type 4 ❒ Case Type 5 ❒ Case Type 6 ❒ Case Type 7 ❒ Case Type 8 ❒ Other	
If 'Other', describe		
Collision Deformation Classification	12FLEE9	
Delta-V	Unknown	
Occupant Compartment Penetration of rail	❒No	☒Yes Describe: Rail 1 kinked at the entrance to the feeder channel and tore and separated from the ET-Plus. The rail then penetrated through the cowl behind the left front wheel and into the driver's seating position contacting and severely injuring the driver's right leg, which subsequently required amputation.
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)	Guardrail	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	"Other rollover initiation type:" Penetration of guardrail into vehicle and deformation of guardrail resulted in a left side leading rollover.	

DOT HS 812 950
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**National Highway
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