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Guardrail Terminal Crashes Reconstructed by both Missouri and FHWA

Report No.: 03091100254
Date: 3/9/2011
Inclement Weather: No
Vehicle: 2005 Chevy Impala

Posted Speed Limit: 65 mph
Estimated Speed at Impact: 65 mph
Estimated Angle at Impact: Low angle
Terminal: 4" ET-Plus
Extrusion Length: 15 to 20 ft

Description: A 4" ET-Plus was struck at nearly head-on conditions. Gating did not occur since the vehicle came to rest nearly adjacent to the guardrail system. The vertical teeth of the ET-Plus engaged the vehicle on the front bumper near the passenger side, circled in red in picture 1. This caused the vehicle to yaw with the rear of the vehicle rotating back to the road. Approximately 15 to 20 feet of rail was extruded. An abrupt buckling in the rail occurred once the yawing reached a critical limit. There is also evidence that the guardrail locked up since it is slightly protruding out of the traffic-side widow (green circle). Once the buckling occurred, the terminal head folded over, leaving an exposed elbow in the rail. Since the impact angle was low, the vehicle stayed relatively aligned with the guardrail, allowing the elbow to strike, and ultimately impale the occupant compartment. This crash was an "A" injury, where the victim sustained lacerations to the right leg.



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Report No.: 130173363

Date: 3/23/2013

Inclement Weather: Yes

Vehicle: 2001 Toyota Camry

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Sliding sideways

Terminal: 4" ET-Plus

Extrusion Length: None

Description: A 4" ET-Plus was struck nearly head-on. The terminal did not gate, as evidenced by the vehicle being adjacent to the guardrail system (picture 1). The impact occurred on the driver's side of the bumper (picture 2) where the 15" footprint of the ET-Plus can be seen. Picture 3 shows no extrusion, and the anchor cable is in view. This indicates a very early buckle in the rail. In fact, numerous full buckles occurred almost immediately (see picture 4) indicating high levels of energy at the time of buckling (mode 2 and 3 buckling). Witness accounts indicated that the vehicle was sliding. This impact condition was supported by the relative angle made by the footprint in picture 2. However, the impact was still low angle. Upon buckling (almost immediately), the newly-formed elbow in the rail penetrated the occupant compartment through the driver's door. The driver was struck by the elbow and killed immediately.



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Report No.: 130783059

Date: 12/13/2013

Inclement Weather: Yes

Vehicle: 1992 Ford Taurus

Posted Speed Limit: 65 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Sideways

Terminal: 4" ET-Plus

Extrusion Length: 4 to 5 ft

Description: A 4" ET-Plus terminal was struck wherein approximately 4 to 5 feet of rail was extruded. The guardrail buckled early in the event, and some part of the guardrail system struck the rear door on the driver's side, partially penetrating the compartment. The subsequent impact between the door and the occupant in that seat lead to a fatality. It's unclear exactly where initial contact was made (either rear driver's side door or front left corner). The vehicle rolled over, killing one and injuring two others.



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Report No.: 140032043

Date: 1/17/2014

Inclement Weather: No

Vehicle: 1987 Ford Bronco

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Sideways

Terminal: 4" ET-Plus

Extrusion Length: 4 to 5 ft

Description: This crash was reconstructed by the Missouri State Highway Patrol. A mid-sized sedan struck the Bronco, causing it to veer to the right and strike the end of a guardrail (4" ET-Plus). According to a passenger in the Bronco, they were sideways at the time of the impact, indicating that the terminal head struck the driver's door, partially penetrating the compartment and ejecting the driver out the back of the vehicle. The driver was killed and the passenger was injured.



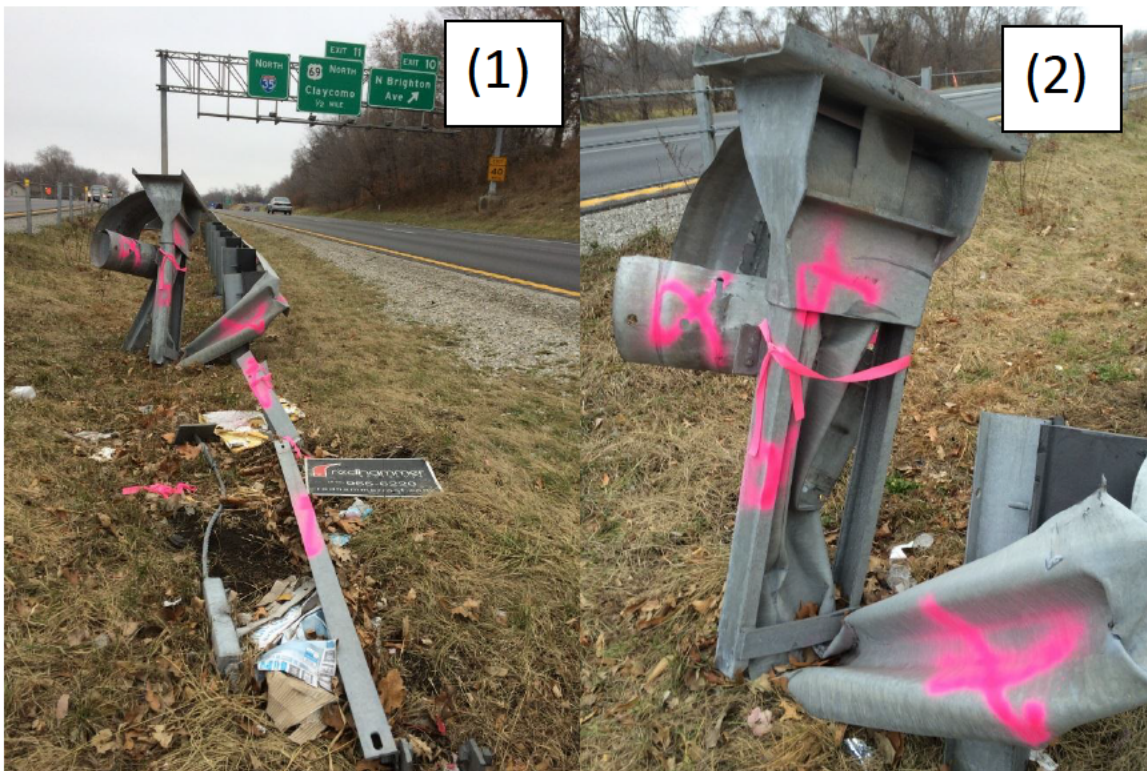
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Additional Guardrail Terminal Crashes Identified by Motorists in Missouri

Report No.: Unknown
Date: Unknown
Inclement Weather: Unknown
Vehicle: Unknown
Posted Speed Limit: 65 mph

Estimated Speed at Impact: Unknown
Estimated Angle at Impact: Low angle
Terminal: 4" ET-Plus
Extrusion Length: 5 to 7 ft

Description: This crash involved a 4" ET-Plus. It extruded approximately 5 to 7 feet. The guardrail inside the terminal but upstream of the squeezer plates appears to be substantially deformed (picture 2), indicating that the guardrail locked up inside the head.



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Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

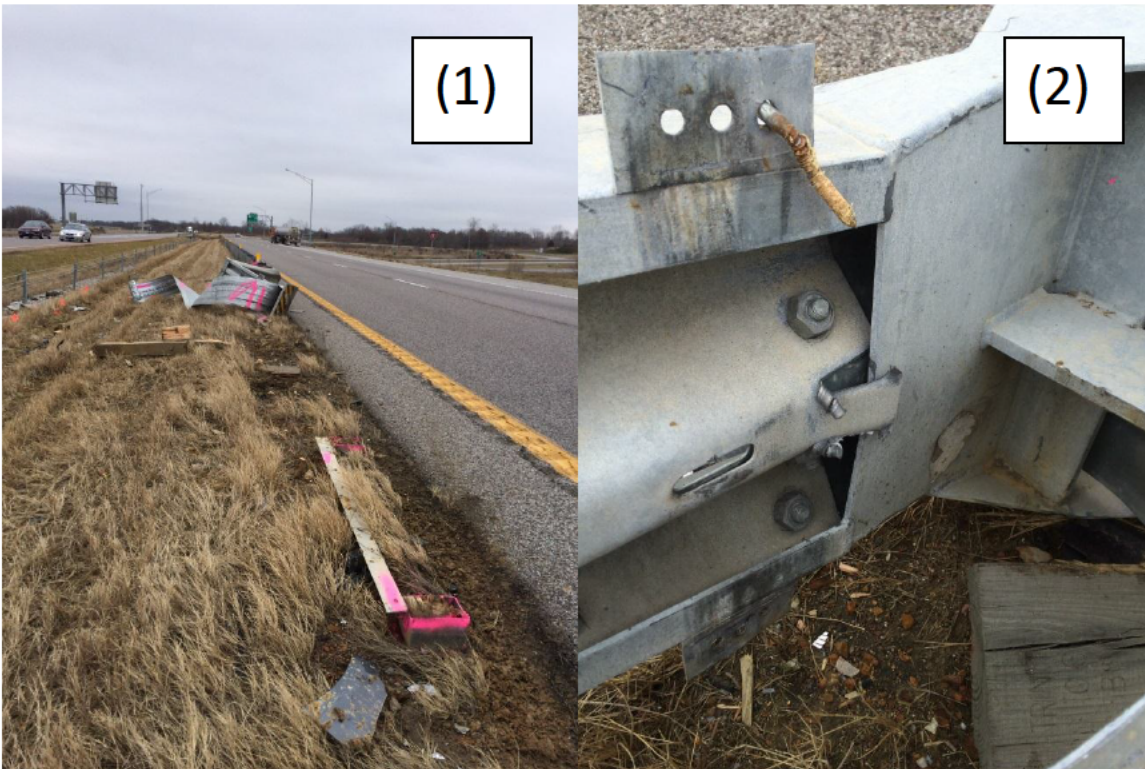
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 5" ET-Plus

Extrusion Length: 25 ft

Description: This crash involved a 5" ET-Plus. It extruded approximately 25 feet. The leading edge of the second rail section was struck by the leading edge of the inlet to the terminal head (picture 2). This caused extrusion to stop and the rail to buckle.



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Additional Guardrail Terminal Crashes Identified by Missouri DOT Officials

File: 1

Location: Cape, Highway 55

Report No.: 14006415

Date: 9/27/2014

Inclement Weather: No

Vehicle: 1993 Toyota Camry

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 5 ft

Description: This crash involved a 4" ET-Plus. It extruded approximately 5 feet. Contact was most likely toward to the driver's side of the front bumper, considering the secondary impact with the sign support breakaway pole. The terminal head did not appear to extrude properly, and upon impact and subsequent seizing up, the rail buckled in numerous locations. The result of the impact was vehicular rollover, for which the driver sustained severe, "A" level injuries.



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File: 2

Location: Cass County, Peculiar, MO

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: 45 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 1 ½ ft

Description: This crash involved a 4" ET-Plus. It extruded approximately 1 ½ feet. The HBA post and cable bracket are still near their original locations. This road has a posted speed limit of 45 mph, and this crash appears to be a low-speed event. However, there was enough resistance in the head of the terminal such that the energetically favorable mode was buckling in the rail. Therefore, this head locked up and did not perform properly. Note that the two buckles are opposing in direction, indicating that gating did not occur.



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File: 3

Location: Clay, Highway 435

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

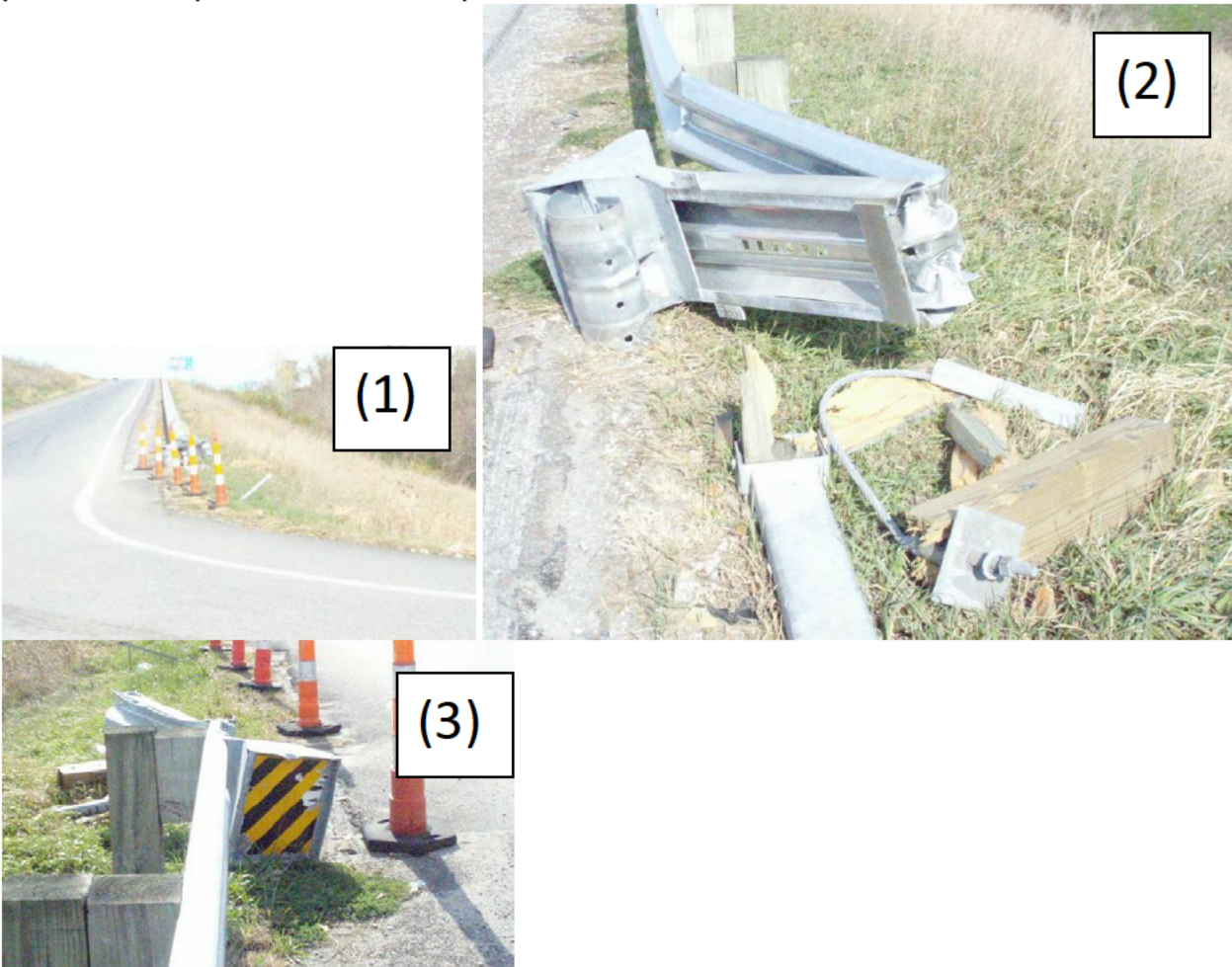
Estimated Speed at Impact: Low speed from a turn

Estimated Angle at Impact: > 15 deg from behind

Terminal: ET-2000

Extrusion Length: 2 ft

Description: This crash involved an ET-2000. The rail extruded only about 2 feet, and the cable and bracket assembly are near their original locations. The extreme buckle in the rail immediately upstream of the leading edge of the terminal head indicates that this terminal was struck by a vehicle making a shallow right-hand turn onto the ramp. As such, the terminal gated in the opposite direction (relative to NCHRP Report 350 Test No. 3-30, for example). This terminal performed as expected under those impact conditions.



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File: 4

Location: Clay, Highway 35

Report No.: 140013404

Date: 1/8/2014

Inclement Weather: Wet/icy road

Vehicle: 2001 Chevy 1500

Posted Speed Limit: 65 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 3 ft

Description: This crash involved a 4" ET-Plus. The driver lost control of his vehicle on ice and struck the end of the terminal. The rail extruded approximately 3 feet before the upstream guardrail buckled. The HBA post is on the traffic side of the remaining line posts and not far from its original location. This is a possible indication that the trajectory of the vehicle was angled back to the road rather than away from it. Upon impact, and after extrusion, the upstream rail first pushed post 3 backwards before the rail at post 2 buckled as the terminal gated. This appeared to perform properly. The occupant was unharmed, and the crash was listed as PDO.



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File: 5

Location: Dallas, Highway 32

Report No.: 130032000

Date: 1/16/2013

Inclement Weather: No

Vehicle: 1998 Chevy 3500

Posted Speed Limit: 55 mph

Estimated Speed at Impact: > 55 mph

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 19 ft

Description: This crash involved a 4" ET-Plus. The guardrail extruded approximately 19 feet before the guardrail buckled ahead of the terminal. The vehicle rolled down the embankment shown in the photos. Knowing this, and seeing the deformation to the terminal, it is likely that the heavy vehicle had enough kinetic energy to continue on, up and over the terminal, leading to the instability that caused the rollover. There is some evidence of contact with the truck at the buckle immediately upstream of the terminal head (and with the terminal head itself). This indicates that the vehicle was partially speared and vaulted, but likely not penetrated. The driver fled the scene, and as such, the injuries were unknown.



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File: 6

Location: Greene, Highway 44

Report No.: 120520372

Date: 8/14/2012

Inclement Weather: No

Vehicle: 2012 Subaru Forester

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 30 ft

Description: This crash involved a 4" ET-Plus. The guardrail extruded approximately 30 feet before the upstream guardrail buckled. The impacting vehicle came to rest in the road. This indicated that the impact was on the driver's side of the front bumper. The force of the impact cause the vehicle to spin out, as commonly seen in ¼ point offset, head-on crash tests. This terminal performed as intended. The crash severity was listed as PDO.



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File: 7

Location: Jackson, Highway 470

Report No.: 140552485

Date: 8/29/2014

Inclement Weather: Wet road

Vehicle: 2002 Ford Ranger

Posted Speed Limit: 60 mph

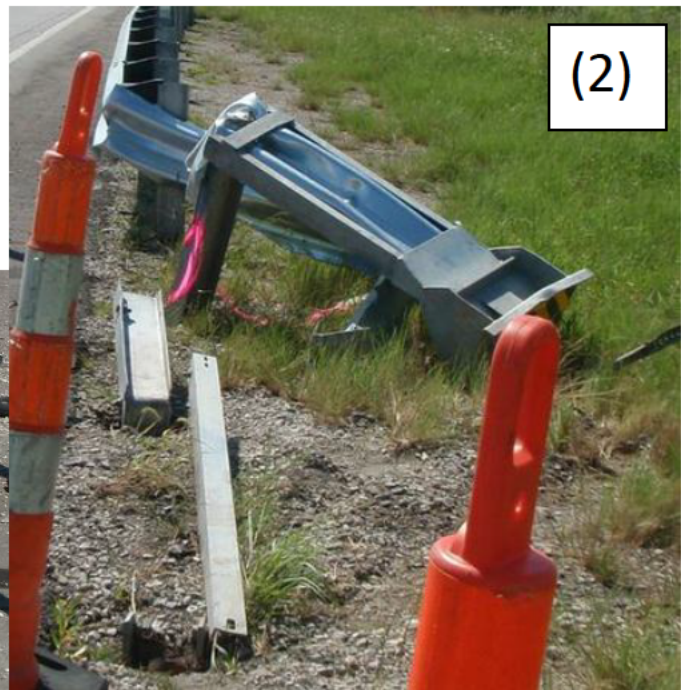
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: None

Description: This crash involved a 4" ET-Plus. There was almost no evidence of any rail extrusion. The driver stated that he lost control, and the rear of his vehicle slid out from behind him. This indicates that the crash may have included a side impact although it is not explicitly stated in the crash report. However, the terminal did not extrude rail or gate (as evidenced by the fact that the rail has two opposing kinks). Also, the rail inside the window of the terminal head shows evidence of large compressive forces following rail lockup. Therefore, this terminal did not perform as intended. In fact, the vehicle overturned, leading to "B" level injuries.



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File: 8

Location: Jackson, Highway 24

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 12 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 12 feet. The crash appears to have been close to head-on or a low angle impact. Initial impact was made on the passenger side front bumper. The offset of the impact location caused the vehicle to yaw counterclockwise, pushing the terminal head back to the road. Before the vehicle came to rest or passed in front the barrier, the rail ahead of the terminal buckled in two locations. However, without knowing more specifics of the crash, it would appear that the terminal performed properly.



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File: 9

Location: Jackson, Highway 50

Report No.: 1-13-000936

Date: 1/15/2013

Inclement Weather: No

Vehicle: 2005 Mazda 3

Posted Speed Limit: 60 mph

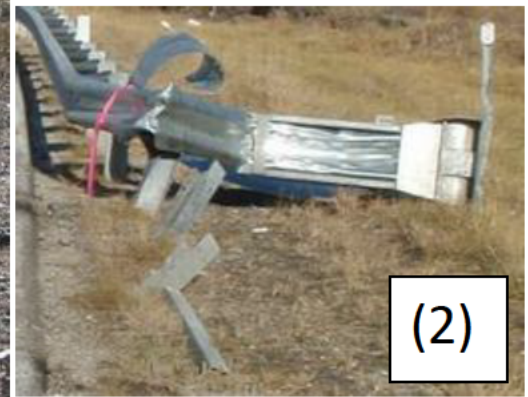
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: > 15 Deg

Terminal: 4" ET-Plus

Extrusion Length: 8 to 10 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 8 to 10 feet. The rail visible in the window of the terminal head is substantially damaged and includes a long tear. Therefore, this rail was likely locked in the squeeze plates, causing numerous modes of buckling in the flanges of the W-beam rail. Additionally, upon buckling and twisting relative to the vehicle, the guardrail in the window of the head could have been exposed to a hard point that may have cut the guardrail in the fashion depicted. This terminal did not function properly. The driver initially declined medical treatment, but revised that decision, prompting the officer to report "C" level injuries.



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File: 10

Location: Jackson, Highway 71

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 8 to 10 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 8 to 10 feet. The direction of the bent posts and the fact that the head has rotated back to the road indicates a low angle impact with contact on the passenger's side of the front bumper. This caused the vehicle to yaw clockwise, thus rotating the terminal relative to the upstream guardrail. Inside the window to the head, the guardrail has some non-contact deformation. This indicates that the rail seized up in the squeeze plates, leading to a premature buckling. This terminal appears to have not performed as intended.



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File: 11

Location: Jackson, Highway 291

Report No.: 2012-81498

Date: 11/5/2012

Inclement Weather: Rain

Vehicle: 1997 Ford Ranger

Posted Speed Limit: 55 mph

Estimated Speed at Impact: 35 mph

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 2 to 3 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 2 to 3 feet. The impact speed was approximately 35 mph, according to the driver. Tire skid marks next to the terminal indicate that the vehicle hit the terminal head on and probably close to the center line of the vehicle. The driver stated that his tires began to slide causing him to leave the roadway to the right. The scene diagram shows that the vehicle came to rest in front of the terminal. The rail buckled in two locations (disqualifying gating), which also indicates that the resistive force in the terminal was greater than the compressive capacity of the rail. Therefore, the terminal locked up and did not perform properly. The occupant was uninjured.



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File: 12

Location: Jackson, Highway 435

Report No.: 13-8768

Date: 2/5/2013

Inclement Weather: None

Vehicle: 2002 Toyota Rav4

Posted Speed Limit: 65 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: >> 15 Deg, sideways

Terminal: 4" ET-Plus

Extrusion Length: 2 to 3 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 2 to 3 feet. The impact with the guardrail was the second event, preceded by a lane-change collision with another vehicle. From witness and driver accounts, after the two-car contact was made, the driver of the subject vehicle then struck a guardrail, leading one to believe that this was an over-correction maneuver, which is also evidenced in picture 3 via distinct tire skid marks. Not only was this a high-angle hit, but the width of those skid marks would indicate that the vehicle was partially sideways. The terminal extruded a small amount of rail before gating open, as designed. The occupant sustained level "C" injuries.



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File: 13

Location: Jackson, Highway 435(2)

Report No.: 14-21100

Date: 3/30/2014

Inclement Weather: No

Vehicle: 1997 Isuzu Rodeo

Posted Speed Limit: Unknown

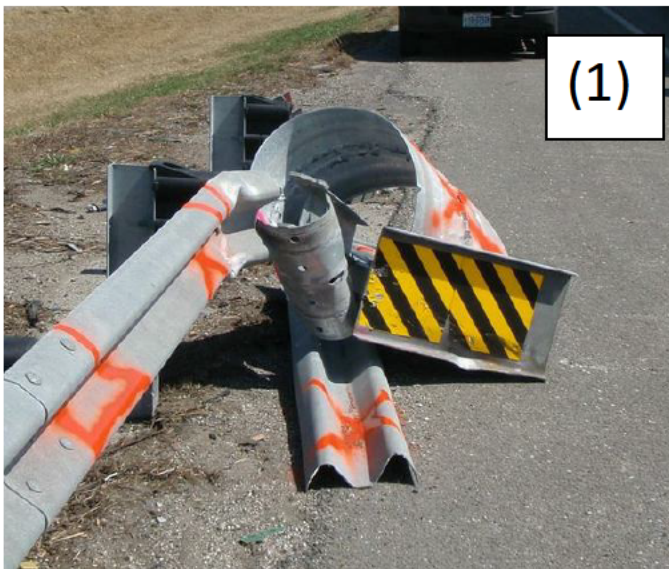
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 10 to 12 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 10 to 12 feet. The second post is not bent to the ground substantially, and the third post isn't bent at all. This indicates that contact with the terminal head was made by the outside edge of the passenger side front bumper. It appears that the vehicle began to yaw clockwise in an extreme manner, as evidenced by the tire marks in picture 2. Upon doing so, the vehicle overturned. The terminal head folded over on the guardrail as in a gating crash. The fact that the vehicle rolled is a possible indicator that the vehicle was already yawing prior to impact. Therefore, this terminal likely performed as intended. The occupant's injuries were labeled as level "B".



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File: 14

Location: Jackson, Highway 470(2)

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: 10 to 15 Deg

Terminal: 4" ET-Plus

Extrusion Length: 10 to 12 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 10 to 12 feet. There was no crash report. However, the guardrail visible in the window of the terminal head (picture 1) demonstrates buckling modes indicative of very high forces. Therefore, it is likely that this terminal locked up, causing the rail to buckle and form a potential spear. This terminal did not perform as intended.



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File: 15

Location: Jackson, Highway 470(3)

Report No.: 1-13-017249

Date: 10/18/2013

Inclement Weather: Rain

Vehicle: 2005 Ford F-Series

Posted Speed Limit: 65 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 1 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 2 feet. The scene and vehicle damage diagrams in the crash report indicate that this was a side impact crash. The tire marks in picture 1 could be from the impacting vehicle, but it could also be a first responder or a tow truck. In picture 1, the rail is buckled about a foot ahead of the upstream end of the terminal head. In the one-foot space, the guardrail exhibits a wavy deformation pattern, indicative of high forces. With 3 major buckling points, it appears that the terminal did not gate properly.



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File: 16

Location: Jackson, Highway 470(4)

Report No.: 120717821

Date: 11/12/2012

Inclement Weather: Icy

Vehicle: 2004 Jeep Liberty

Posted Speed Limit: 65 mph

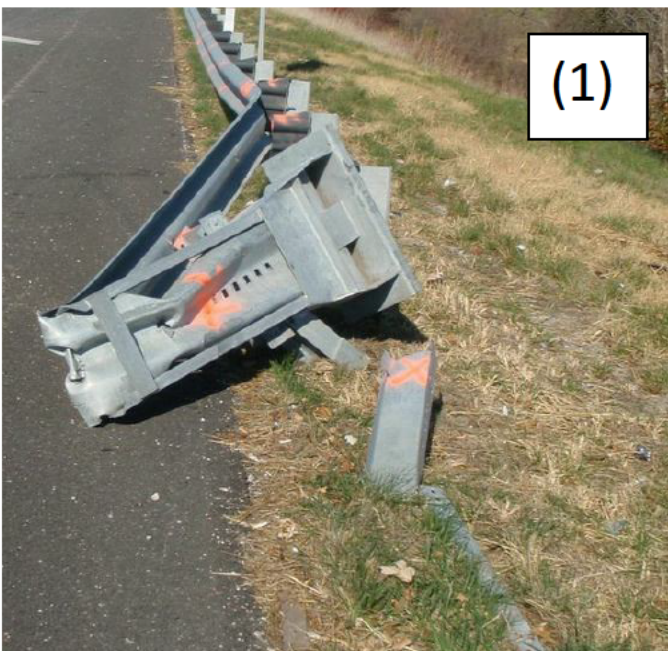
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 4 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 4 feet, based on the location of the cable mounting bracket holes. Icy conditions led to the vehicle spinning out and, according to the scene diagram in the crash report, striking the guardrail end with the rear of the vehicle. There is a substantial amount of local buckling in the rail seen in the window of the terminal head. This would indicate high forces, indicating that the rail locked up. Therefore, this terminal did not perform as intended. The occupant was unharmed in the crash.



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File: 17

Location: Jackson, Highway 35

Report No.: 12-40189

Date: 6/10/2012

Inclement Weather:

Vehicle: 2004 Chevy S10

Posted Speed Limit: 25 mph

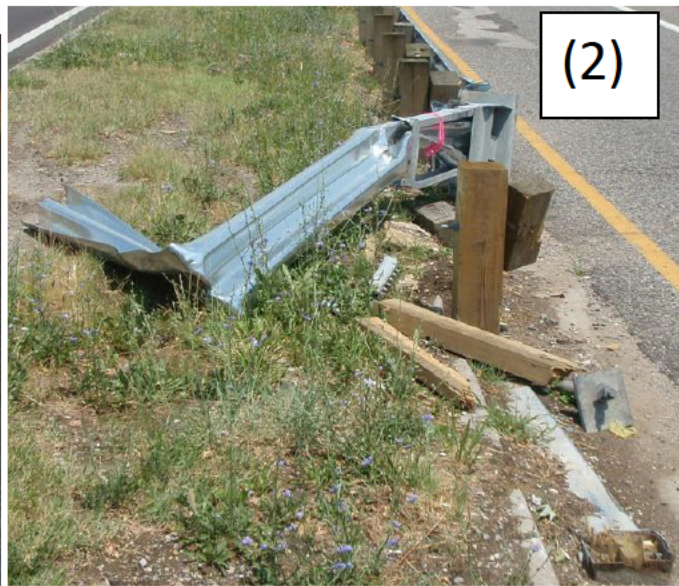
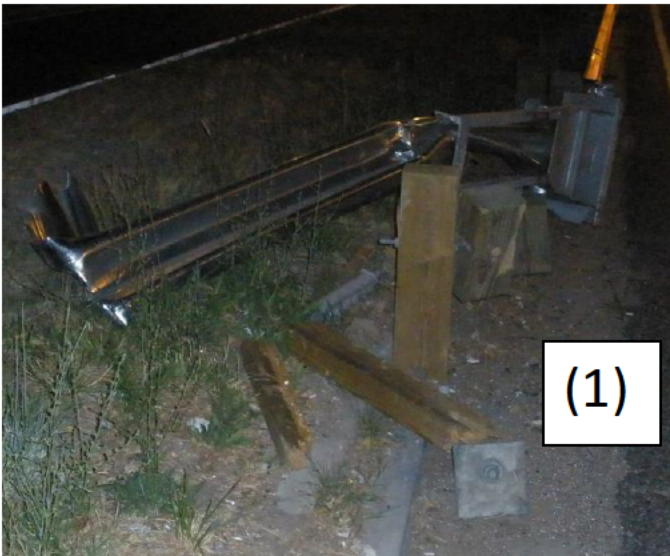
Estimated Speed at Impact: > 25 mph

Estimated Angle at Impact: Low angle

Terminal: 5" ET-Plus

Extrusion Length: 1 to 2 ft

Description: This crash involved a 5" ET-Plus. The guardrail appears to be cut several feet upstream of the terminal head (picture 1 shows a clean severance). This is not likely to occur in the event of the crash. However, the rail inside the window of the terminal head is deformed in a manner that would suggest a moment that acted about a horizontal axis was applied to the head, causing the bottom corrugations to fold (picture 2). Therefore, this terminal did not perform as intended. However, the crash report highlights a second collision with a utility pole. Therefore, it is uncertain what lead to the injuries (level "B") sustained by the driver.



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File: 18

Location: Jackson, Highway 70

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

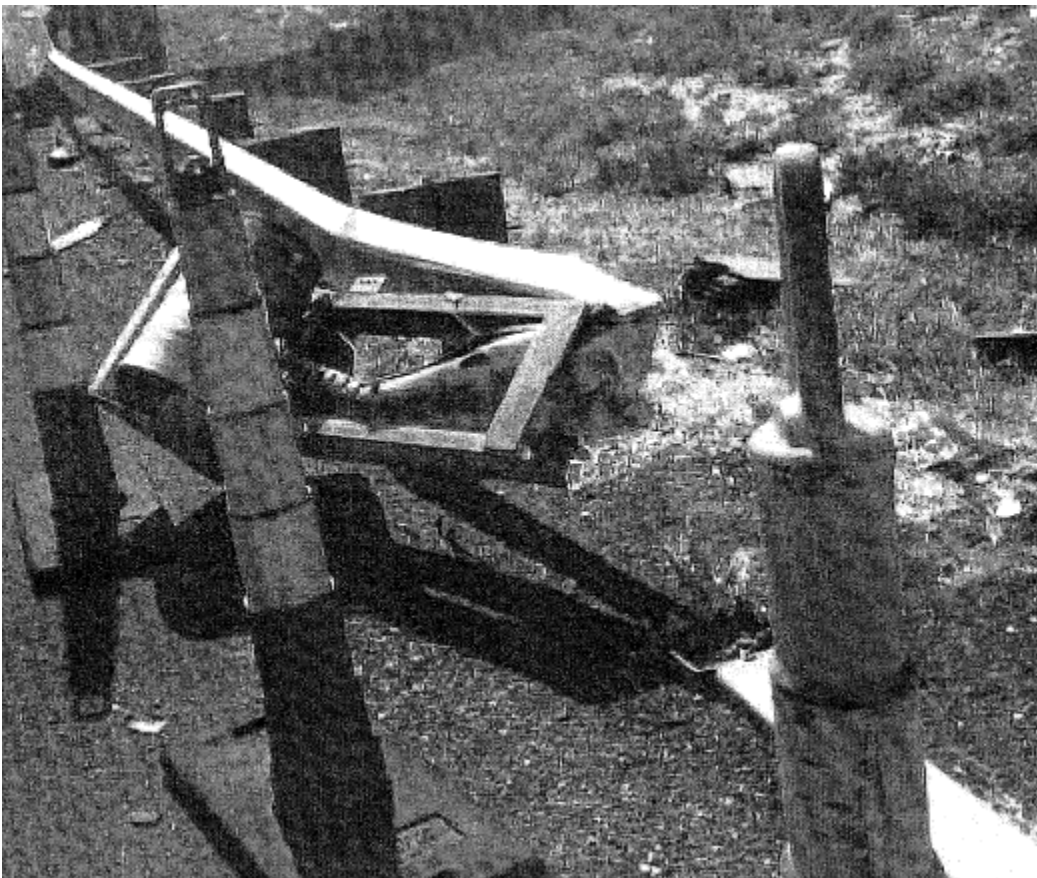
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: ET-2000

Extrusion Length: 2 to 3 ft

Description: With this picture, it is difficult to identify the system. It is of the ET-family and most likely an ET-2000. There is very little extrusion, and the rail inside the guide channels is deformed abnormally, suggesting that this terminal did not perform as intended. Consequently, the rail buckled, forming a potential spear.



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File: 19

Location: Jackson, Highway 70(2)

Report No.: 2013-38569

Date: 6/6/2013

Inclement Weather: No

Vehicle: 2008 Kia Optima

Posted Speed Limit: 45 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 10 to 12 ft

Description: This crash involved a 4" ET-Plus (the variable height difference at the inlet is barely visible in picture 2). The rail extruded approximately 10 to 12 feet. The posts are lying down roughly parallel with the untouched upstream guardrail. The terminal head itself is adjacent to the barrier. Therefore, this was a head-on or low angle impact and probably an offset impact on the front bumper. This would facilitate a spin-out away from the upstream guardrail. The terminal appears to have performed as intended. The driver of this vehicle was not harmed.



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File: 20

Location: Johnson, Highway 13

Report No.: 130486838

Date: 8/3/2013

Inclement Weather: No

Vehicle: 1997 Mercury Mountaineer

Posted Speed Limit: 60 mph

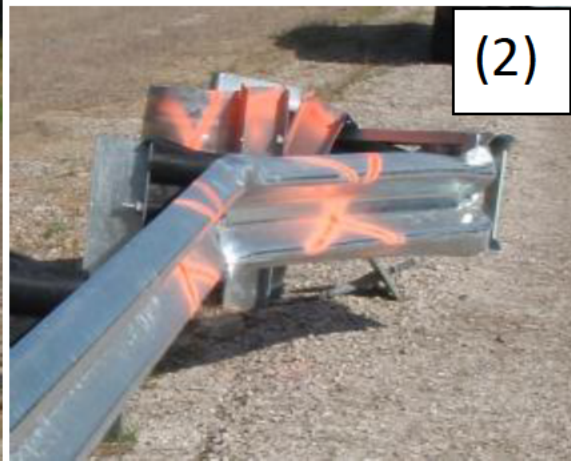
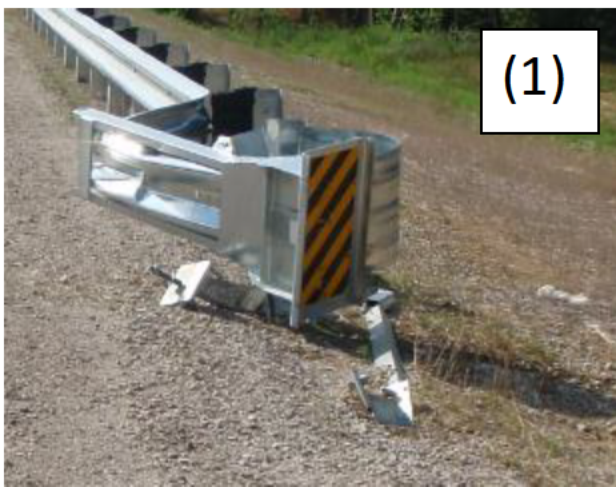
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 4 ft

Description: This crash involved a 4" ET-Plus. The rail extruded approximately 4 feet. A tire on the impacting vehicle blew out, and according to witness accounts, this caused the vehicle to go off to the side of the road. Then, the vehicle traveled parallel to the roadway before striking the guardrail. Guardrail in the guide channels shows damage consistent with a large compressive force, indicating that the rail locked up in the terminal head. Altogether, the terminal did not perform as intended. The driver sustained "A" level injuries in the form of seizures.



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File: 21

Location: Lafayette, Highway 70

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Unknown

Terminal: 4" ET-Plus

Extrusion Length: 1 ft

Description: This crash involved a 4" ET-Plus. Rail extrusion was minimal. It appears that the cable did not release at all. This is evidenced by the large deformation in the guide channels. When the cable doesn't release, the cable mounting bracket becomes a rigid object. When the guide channels strike the mounting bracket, the force causes the guide channels to bow. In addition, the angle of the cable pulls the upstream end of the terminal head and the guardrail itself to the ground, often resulting in vehicle instability. In this incident, it appears that the vehicle did, in fact, go up and over the top of the face plate of the ET-Plus. It did not perform as intended.



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File: 22

Location: Lafayette, Highway 70(2)

Report No.: 120147136

Date: 3/10/2012

Inclement Weather: No

Vehicle: a trailer pulled by a truck

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 6 to 7 ft

Description: This crash involved a 4" ET-Plus. Rail extruded approximately 6 to 7 feet. A pickup truck towing a trailer jack knifed, and the sliding trailer struck the terminal. The cable appeared to release properly. Rail was extruded without evidence of locking up. This terminal performed as intended. No one was injured.



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File: 23

Location: New Madrid, Highway 55

Report No.: 140536986

Date: 8/22/2014

Inclement Weather: No

Vehicle: 2002 Toyota Tacoma

Posted Speed Limit: 70 mph

Estimated Speed at Impact:

Estimated Angle at Impact:

Terminal: SKT

Extrusion Length: 10 to 12 ft

Description: This crash involved a SKT. The crash report indicates that the vehicle was traveling 70 mph and no braking occurred immediately prior to the crash. The vehicle overturned and ended up on the backside of the barrier. In addition, the face plate of the terminal does not show uniform contact. This indicates that the vehicle clipped the head. The buckling in the rail and the offset nature of the impact indicate that the vehicle was likely yawing or sliding as it struck the terminal, which caused the rail to fold as shown in picture 1. Contact with the terminal would have exacerbated the yawing, leading to rollover. Picture 2 was taken about one month prior to the crash, and it shows a deficient rail mounting height. This lowered center of mass would have contributed to the tripping mechanism that caused the rollover. This terminal was not installed properly at the time of the crash, but in spite of that, the terminal gated for the yawing vehicle as intended. The driver sustained "B" level injuries upon being ejected after the rollover.



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File: 24

Location: Oregon, Highway 63

Report No.: 140099432

Date: 2/17/2014

Inclement Weather: No

Vehicle: 1995 Peterbilt Glider

Posted Speed Limit: 65 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 1 to 2 ft

Description: This crash involved a 4" ET-Plus. Very little rail extruded. However, this terminal was struck by a semi tractor-trailer. The cable should release almost immediately regardless of the energy imparted on the terminal during a crash. In this case, the cable and bearing plate are next to the first anchor post, which also shows signs of large soil displacement. This indicates that the cable did not release right away. Therefore, even though the vehicle was well outside the design constraints, the terminal did not perform correctly. There were no injuries.



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File: 25

Location: Perry, Highway 55

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 10 ft

Description: This crash involved a 4" ET-Plus. Rail extruded approximately 10 feet. The snow makes it impossible to discern if the cable anchor was at fault. However, the guardrail that is lodged in the window of the terminal head shows that the head stopped moving down the guardrail and began to pitch downward, crushing the guardrail. This indicates that the terminal did not perform properly.



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File: 26

Location: Perry, Highway 55(2)

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 10 ft

Description: This crash involved a 4" ET-Plus. Rail extruded approximately 10 feet. Normally, deformation in the guide channels indicates a cable release malfunction. However, this case looks more like a semi tractor-trailer struck the terminal and pinned it underneath the truck, causing the guide channels to fold over, as shown in the picture. This is very similar to the Peterbilt crash in Report No. 140099432 (File 24). Unlike in that case, there is no available information at the point of the first anchor post. Therefore, a tentative conclusion was made that the terminal performed as intended.



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File: 27

Location: Scott, Highway 55

Report No.: 140189955

Date: 3/29/2014

Inclement Weather: Rain

Vehicle: 2013 Chevy 1500

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: 10 deg

Terminal: 4" ET-Plus

Extrusion Length: 3 ft

Description: This crash involved a 4" ET-Plus. Rail extruded approximately 3 feet. The rail was cut, most likely by emergency responders. Tire tracks in the picture are consistent with the scene diagram provided in the crash report, where the vehicle passed hundreds of feet behind the terminal. The picture indicates that the rail in the window of the terminal head was slightly crushed which in this case was likely caused by the terminal being bent backwards and slightly upwards as the vehicle gated through. The impact angle appears to be approximately 10 degrees, based on the tracks shown in the picture. The driver sustained "A" level injuries.



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File: 28

Location: Scott, Highway 55(2)

Report No.: 140732722

Date: 11/25/2014

Inclement Weather: No

Vehicle: 2015 International Harvester Conventional

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 3 ft

Description: This crash involved a 4" ET-Plus. Rail extruded approximately 3 feet. The terminal was struck by a semi tractor-trailer, which proceeded behind and beyond the terminal, colliding with the trees shown in the background of the picture. The terminal buckled in 3 places, indicating a large compressive force in the rail. The higher energy level should have simply extruded more rail than the standard 50-ft length. However, that did not happen, leading one to believe that this terminal did not function properly. No one was injured.



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File: 29

Location: Stone, Highway 13

Report No.: L13-00361

Date: 3/4/2013

Inclement Weather: No

Vehicle: 2012 Chevy Cruze

Posted Speed Limit: 45 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: ET-Plus

Extrusion Length: 2 to 3 ft

Description: This crash involved an ET-Plus, but the camera angles prevent the positive distinction between 4" and 5". The crash report indicates that a rock barrier was struck first, causing the vehicle to become partially airborne just before hitting the guardrail terminal. This vertical undulation at impact would have increased the propensity for the rail to buckle by adding vertical displacements and possibly torsional loading (via the suspension of the vehicle), depending on how the vehicle interacted with the rail. After the two buckles formed, the vehicle continued down the rail, coming to rest on the guardrail. This indicates a head-on collision where gating was not expected. Last, the rail that is visible in the window of the terminal head indicates that the bottom guide channel was forced up, crushing the bottom corrugation, then down, crushing the top corrugation. This is consistent with the airborne statement from the witness. Altogether, under these loading conditions, the terminal performed as well as it could have. There were no injuries.



(1)



(2)

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File: 30

Location: Andrew, Highway 29

Report No.: 130690358

Date: 10/30/2013

Inclement Weather: Wet

Vehicle: 2003 Ford Ranger

Posted Speed Limit: 70 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Unknown

Terminal: 5" ET-Plus

Extrusion Length: 3 to 4 ft

Description: The provided photos do not appear to align with the location description or scene diagram in the crash report, even though the reported latitude and longitude are close. Picture 1 is the provided photo of a damaged ET-Plus (5"), and picture 2 is a Google street view of the same location taken in October 2013, the same month as the crash. Picture 3 is a Google street view taken in September 2013 and matches the scene diagram and location description. Therefore, the crash report could not be used to supplement picture 1. The terminal in picture 1 shows substantial rail damage in the window of the terminal, indicative of excessive forces caused by a locking up of the rail. Therefore, that terminal did not function properly.



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File: 31

Location: Holt, Highway 159

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

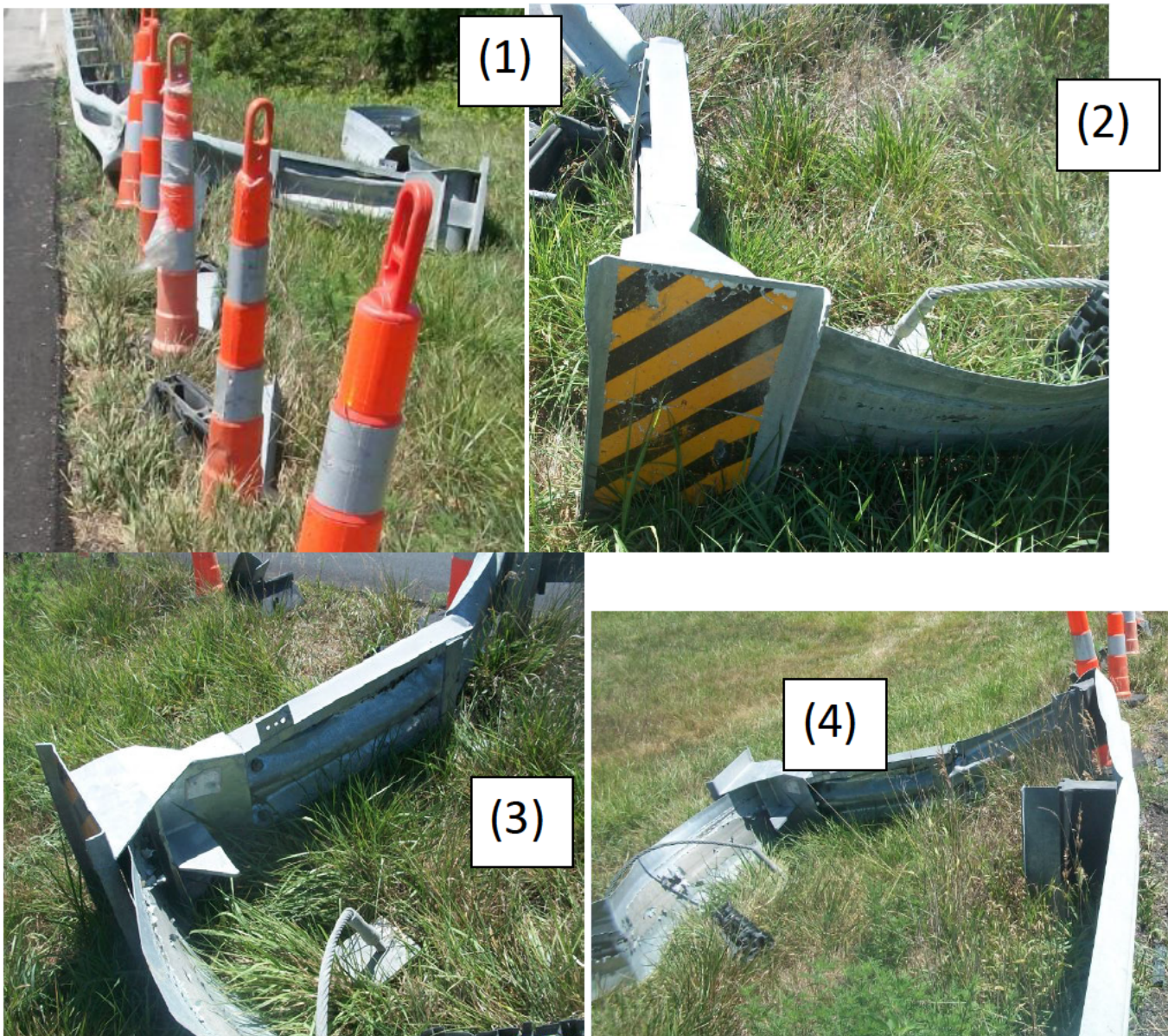
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: 5 to 10 deg

Terminal: 4" ET-Plus

Extrusion Length: 25 ft

Description: This crash involved a 4" ET-Plus. Approximately 25 feet of rail was extruded (see splice bolts in picture 3). In that same picture, there appears to be some compressive buckling in the rail caused by the passing of the splice bolts through the exit gap. Prior to this point, the terminal performed properly. However, due to this locking mechanism, the rail buckled ahead of the terminal, leaving an exposed end. Therefore, the terminal did not perform properly throughout the entire duration of the crash.



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File: 32

Location: Holt, Highway 29

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

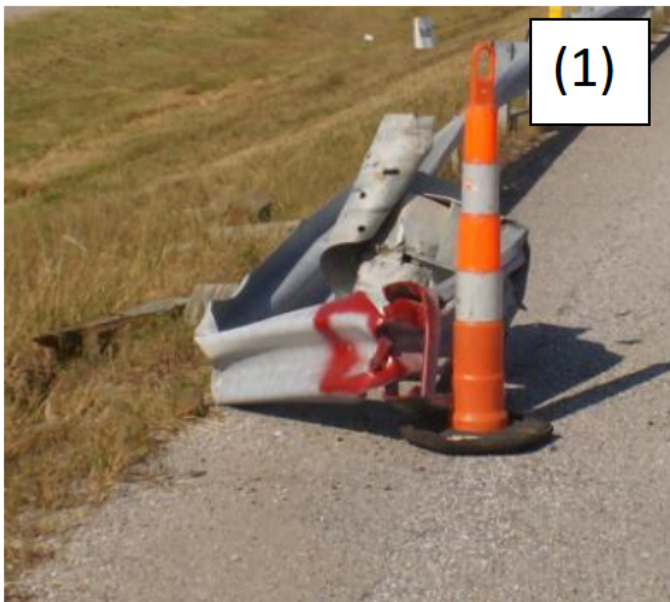
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Unknown

Terminal: 4" ET-Plus

Extrusion Length: 3 ft

Description: This crash appeared to have involved a 4" ET-Plus. Picture 1 shows a face plate that appears more like the ET-Plus than the ET-2000 (shown in the repaired terminal in picture 2). Also, the mangled guide channels feeding into the terminal inlet appear to be inserted rather than butt welded, indicating the 4" version. Only about 3 feet of rail extruded. Regardless of the impact conditions, this terminal did not perform as intended. However, the exact nature of its malfunction may be any number of possibilities. One possibility is that the cable did not release, causing the guide channels to strike the rigid cable mounting bracket and deform as shown in the picture. Also, earlier evaluations in this paper showed some similarities of deformation when struck by a semi tractor-trailer. Unlike those large-vehicle collisions, this one shows almost no damage to the upstream guardrail (in contrast, see File 24).



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File: 33

Location: Holt, Highway 29(2)

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

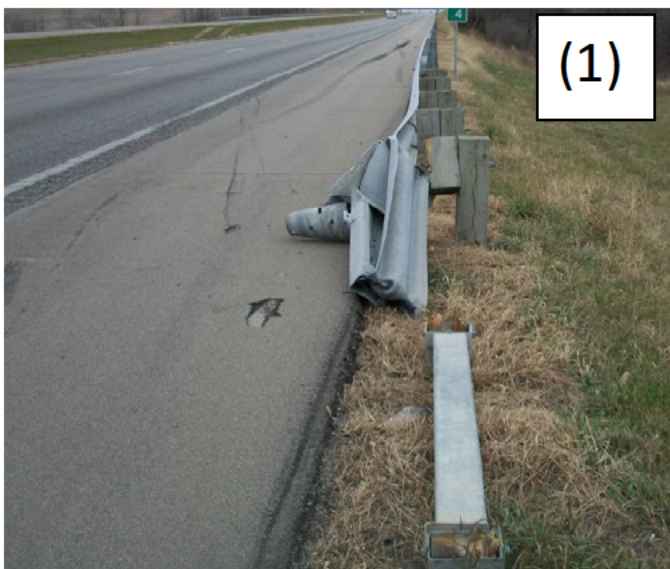
Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: ET-2000

Extrusion Length: 3 ft

Description: This crash involved an ET-2000. Tire and gouge marks on the pavement indicate a trajectory that would have merely clipped the terminal head. Only about 3 feet of rail extruded, however, the clipping nature of contact and the impact angle (which appears to be headed back into the traveled way) would cause the terminal to gate. It appears that the terminal performed properly.



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File: 34

Location: Linn, Highway 36

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: ET-Plus

Extrusion Length: 17 ft

Description: This crash appeared to have involved an ET-Plus (the photos could not be used to distinguish between the 4" and 5" versions). The rail extruded approximately 17 feet before the terminal appeared to gate towards the road. This may have occurred if the vehicle was in a maneuver to return to the road prior to the impact with the terminal. Therefore, this terminal appeared to function properly.



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File: 35

Location: Nodaway, Highway 136

Report No.: Unknown

Date: Unknown

Inclement Weather: Unknown

Vehicle: Unknown

Posted Speed Limit: Unknown

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: ET-2000

Extrusion Length: 50 ft

Description: This crash involved an ET-2000. The terminal extruded nearly 50 feet of rail prior to buckling. This indicates a high-energy impact where the vehicle struck the terminal at an angle very close to 0 degrees and centered on the front bumper. Also, the rail buckled only when the rail began to transition to three-beam. This terminal not only performed as intended, but appeared to exemplify the desired outcome of a high-energy crash.



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File: 36

Location: Cole, Highway 50

Report No.: 2014-7135

Date: 2/19/2014

Inclement Weather: No

Vehicle: 2002 Ford Explorer

Posted Speed Limit: 60 mph

Estimated Speed at Impact: Unknown

Estimated Angle at Impact: Low angle

Terminal: 4" ET-Plus

Extrusion Length: 2 to 3 ft

Description: This crash involved a 4" ET-Plus. Rail extruded approximately 2 to 3 feet. Three buckles formed in the rail upstream of the leading end of the terminal. This indicates that the terminal did not gate. The vehicle was entering the highway from a ramp. The driver stated that she over-corrected after swerving. This caused the vehicle to impact the terminal on the head at a low angle. The crash report also indicates that the vehicle rolled onto its side after passing behind the terminal. Typically, when a car can pass behind a terminal, it does so safely only if the terminal gates. This terminal did not gate and presented a tripping mechanism. The rail inside the window of the terminal shows evidence of large compressive forces typical of a rail that has locked up inside the head. This terminal did not function properly. The driver did not sustain any injuries.

