



U.S. Department
of Transportation
**Federal Highway
Administration**

1200 New Jersey Ave., SE
Washington, D.C. 20590

May 6, 2011

In Reply Refer To:
HSST/CC-116

Mr. Scott Whittemore
Highway Safety Engineer
Federal Highway Administration
Eastern Federal Lands Highway Division
21400 Ridgetop Circle
Sterling, VA 20166

Dear Mr. Whittemore:

This letter is in response to your request for the Federal Highway Administration's (FHWA) acceptance of a roadside safety device for use on the National Highway System (NHS).

Name of device:	Steel Backed Timber Guardrail Tangent End Terminal
Type of device:	Timber Guardrail Gating End Terminal
Test Level:	NCHRP 350 TL-2
Testing conducted by:	National Crash Analysis Center
Date of request:	November 22, 2010
Task Force 13 Designator:	SED01

You requested that we find this device acceptable for use on the NHS under the provisions of the National Cooperative Highway Research Program (NCHRP) Report 350 testing guidelines.

Requirements

Roadside safety devices should meet the guidelines contained in the NCHRP Report 350. The FHWA memorandum "**ACTION**: Identifying Acceptable Highway Safety Features" of July 24, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Description

The Steel Backed Timber (SBT) Guardrail Tangent End Terminal overall length is 12.42 meters (40 feet 9 inches). It consists of nine (9) wood rail segments and nine (9) wood posts. The rail segments' cross-sectional area is 150 millimeters x 250 millimeters (6 inches x 10 inches), similar to the cross-section of the steel-backed timber SBT barrier rail segments. The length of the first rail segment is 1.6 meters (5 feet 3 inches). The last rail segment (number 9) is 1.75 meters (5 feet 9 inches) in length. The remaining rails (numbers 2-8) are 1.676 meters (5 feet 6 inches) in length. These rail segment lengths are about half the rail segment lengths of the SBT barrier and were selected such that the spacing between the posts is 1.22 meters (4 feet).



Both ends of the rail segments are cut at a 1:2 (26 degree) angle, with the exception of first rail segment, which has one end at 90 degree, and the last rail segment, which has one end cut at a 1:1 (45 degree) angle. The first rail of the SBT guardrail is also cut at a 1:1 (45 degree) angle to fit the end of the terminal.

The posts are 150 millimeters x 250 millimeters (6 inches x 10 inches) in cross-section and 2.1 meters (6 feet 11 inches) in length. The post embedment in the ground is 1.43 meters (4 feet 8 inches), similar to the SBT barrier post embedment. Holes are drilled in the posts at ground level. The hole diameter for the first three posts is 115 millimeters (4.5 inches) and the hole diameter for the remaining six posts is 75 millimeters (3 inches). Steel tubes encase the embedded portion of the wood posts to ensure consistent failure of the posts at ground level. The tubes are 150 millimeters x 250 millimeters x 4.75 millimeters (6 inches x 10 inches x 3/16 inch) in cross-section and 1.422 millimeters (4 feet 8 inches) length.

The rail segments of the end-terminal are connected to the posts through steel splices and wood blockouts. This setup is based on the original SBT barrier connection but was modified to allow for release of the rail segments from the posts in head on impacts and to absorb some the vehicle kinetic energy. Details A, B, and C in Figure 8 show the end-terminal rail-to-post connections. At each post, the ends of two adjacent rail segments are connected to the steel splice (splice plate?) through lag screws. The lag screws are 16 millimeters (5/8 inch) in diameter and 100 millimeters (4 inches) in length. Three lag screws are used to connect the splice to the rail segment that is closer to the start of the terminal while four lag screws are used for the adjacent rail segment. With this configuration, the rail segment closer to the start of end-terminal will separate from post before the adjacent rail segment and allow for a more controlled deceleration of the vehicle during the head on impact. The three lag screws are placed in 22 millimeter x 178 millimeter (7/8 inch x 7 inches) slotted holes and placed such that the screws pull out from the rail segments one at a time. This design reduces the impact forces while maximizing the energy absorbed during the head on impact. This setup was also configured such that the rail segments will not separate from the post during the redirection impacts.

The steel splices and wood blockouts are connected to the posts using 16 millimeter (5/8 inch) diameter bolts. The bolts are 380 millimeters (15 inches) in length. The steel splices are 150 millimeters x 750 millimeters x 10 millimeters (6 inches x 30 inches x 3/8 inch). The wood blockouts are 300 millimeters x 225 millimeters x 100 millimeters (12 inches x 9 inches x 4 inches). Both are of similar size to the original SBT barrier.

Drawings of the SBT Guardrail Tangent End Terminal are included as enclosures to this correspondence.

Crash Testing

The following methods used for analysis of the Backed Timber Guardrail Tangent End Terminal.

A. Simulation

Computer simulations were performed to evaluate the end-terminal under the seven tests recommended for Test Level 2 (TL-2) impact condition. Results from these simulations are as follows.

The simulation results showed that the final design meets all NCHRP Report 350 recommendations for gating end terminals under TL-2 impact conditions. Based on these simulation results five tests were selected for testing. These include tests 2-30, 2-31, 2-32, 2-34, and 2-35. The other two tests, 2-33 & 2-39, were omitted based on the simulation results that showed that they meet requirements and are less critical than the remaining five. The test house therefore requests to waive the remaining two tests, 2-33 & 2-39.

B. Physical Crash Testing:

The NCHRP Report 350 outlines the criteria used to determine the crashworthiness of roadside features, including traffic barriers and their terminals. The end terminal for the SBT guardrail was tested according to these requirements, but requested a waiver for two of the seven crash tests required for TL-2 based upon simulation and previous experience with gating terminals. The test house has therefore conducted the following five out of seven crash tests:

- Test 2-30: An 820C small car impacting the end-terminal at an angle of 0 degrees and a speed of 70 km/hr (43.5 mi/hr). The vehicle strikes the end-terminal head on with an offset of 1/4 the width of the vehicle.
- Test 2-31: A 2000P pickup truck impacting the end-terminal at an angle of 0 degrees and a speed of 70 km/hr (43.5 mi/hr). The vehicle strikes the end-terminal head on at the vehicle centerline.
- Test 2-32: An 820C small car impacting the end-terminal at an angle of 15 degrees and a speed of 70 km/hr (43.5 mi/hr). The vehicle strikes the end-terminal head on at the vehicle centerline.
- Test 2-34: An 820C small car impacting the end-terminal at an angle of 15 degrees and a speed of 70 km/hr (43.5 mi/hr). The vehicle strikes the end-terminal at the critical impact point (selected between posts 2 and 3 of the end-terminal).
- Test 2-35: A 2000P pickup truck impacting the end-terminal at an angle of 20 degrees and a speed of 70 km/hr (43.5 mi/hr). The vehicle strikes the end-terminal at the start of length of need point (selected at post 4 of the end-terminal).

Crash test summaries of the above mentioned tests are provided as enclosures to this correspondence.

Findings

Based on the successful completion of the aforementioned simulation and NCHRP Report 350 tests, we agree that the SBT Guardrail Tangent End Terminal meets the evaluation criteria for NCHRP 350 on gating end terminals at TL-2 impact conditions. In addition we also agree to the waiver of tests 2-33 & 2-39. Test 2-33 was a critical test specifically for turn-down terminals which are no longer recommended as an acceptable roadside safety installation. In addition, test 2-39 is only specified if the terminal is positioned where being struck in the reverse direction at high speed is deemed to be likely. This should be conveyed to the agency within the system specifications.

Therefore, the system described in the request above and detailed in the enclosed drawings is acceptable for use on roadways in Federal Lands jurisdiction only under the range of conditions tested, when such use is deemed acceptable by the engineer.

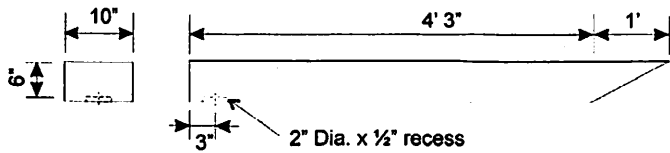
Please note the following standard provisions that apply to the FHWA letters of acceptance:

- This acceptance provides a AASHTO/ARTBA/AGC Task Force 13 designator that should be used for the purpose of the creation of a new and/or the update of an existing Task Force 13 drawing.
- This acceptance is limited to the crashworthiness characteristics of the devices and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the device will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our acceptance.
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has essentially the same chemistry, mechanical properties, and geometry as that submitted for acceptance, and that it will meet the crashworthiness requirements of the FHWA and the Manual for Assessing Safety Hardware.
- To prevent misunderstanding by others, this letter of acceptance is designated as number CC-116, and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented device for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate device, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

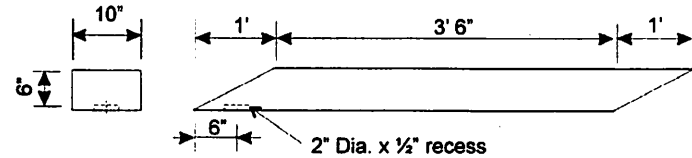
Sincerely yours,



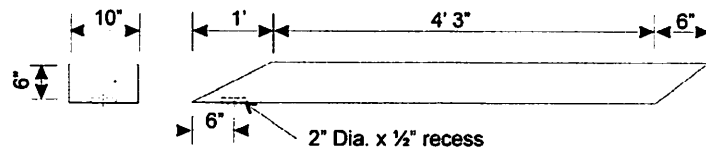
Michael S. Griffith
Director, Office of Safety Technologies
Office of Safety



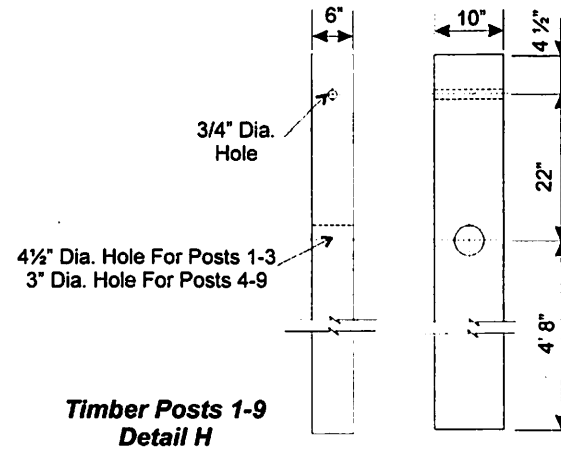
**Timber Rail 1
Detail D**



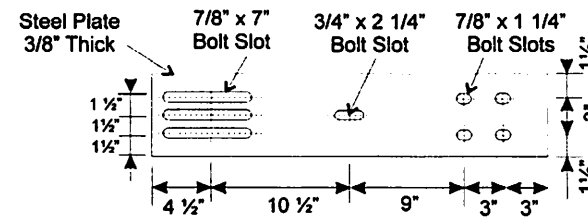
**Timber Rails 2 - 8
Detail E**



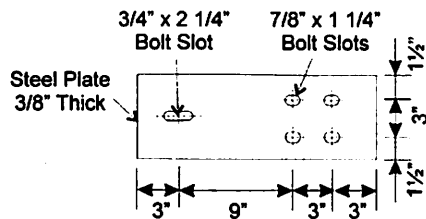
**Timber Rails 9
Detail F**



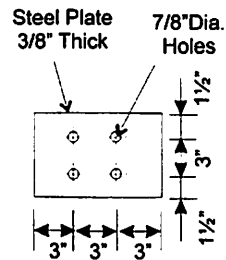
**Timber Posts 1-9
Detail H**



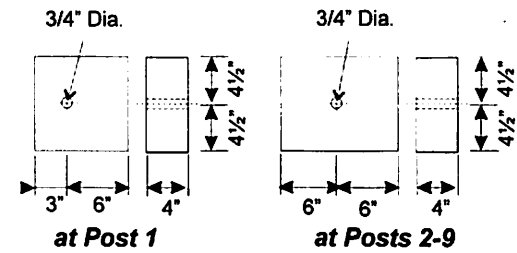
**Splice Plate at Posts 2 - 9
Detail I**



**Splice Plate at Post 1
Detail G**



**Filler Plate at Post 10
Detail J**



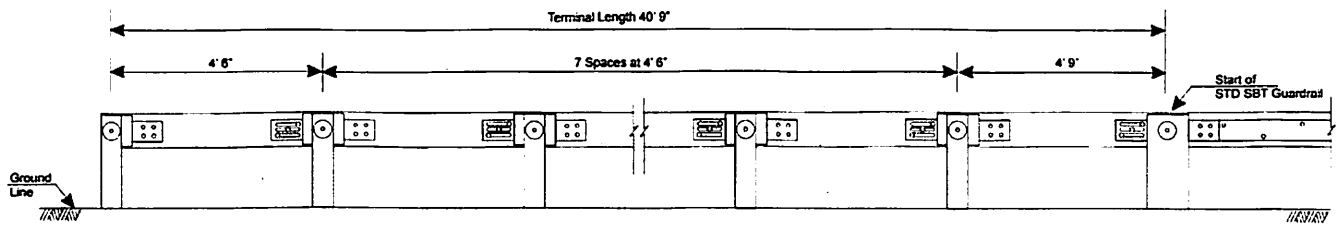
**Timber Block
Detail K**

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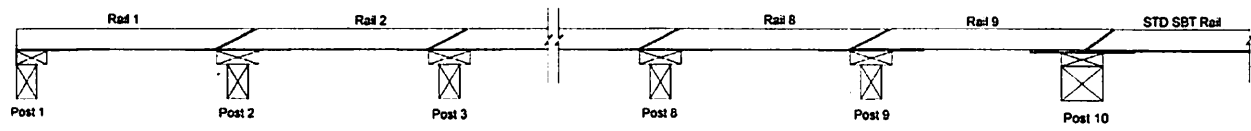
Sheet 2 of 2

**TL2 End-Terminal for
Steel-Backed Timber Guardrail**

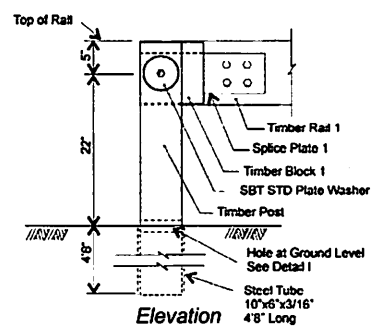
The National Crash Analysis Center
The George Washington University



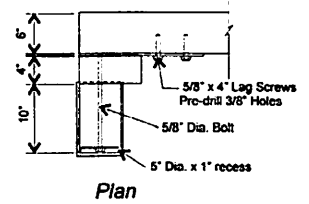
Elevation



Plan

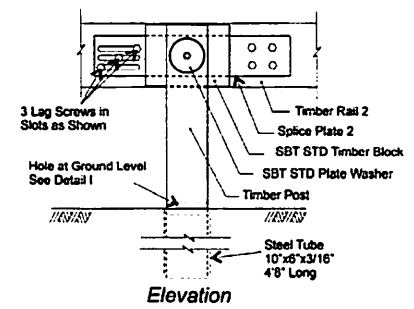


Elevation

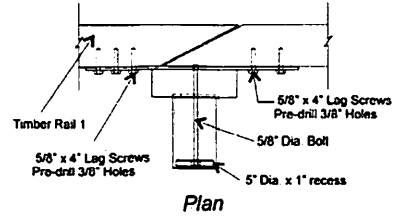


Plan

Post/Rail Connection at Post 1
Detail A

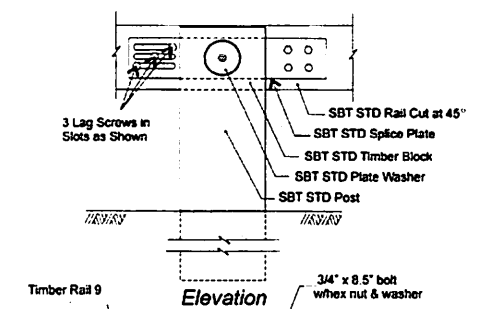


Elevation

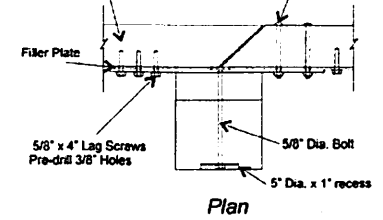


Plan

Post/Rail Connection at Posts 2-9
Detail B



Elevation



Plan

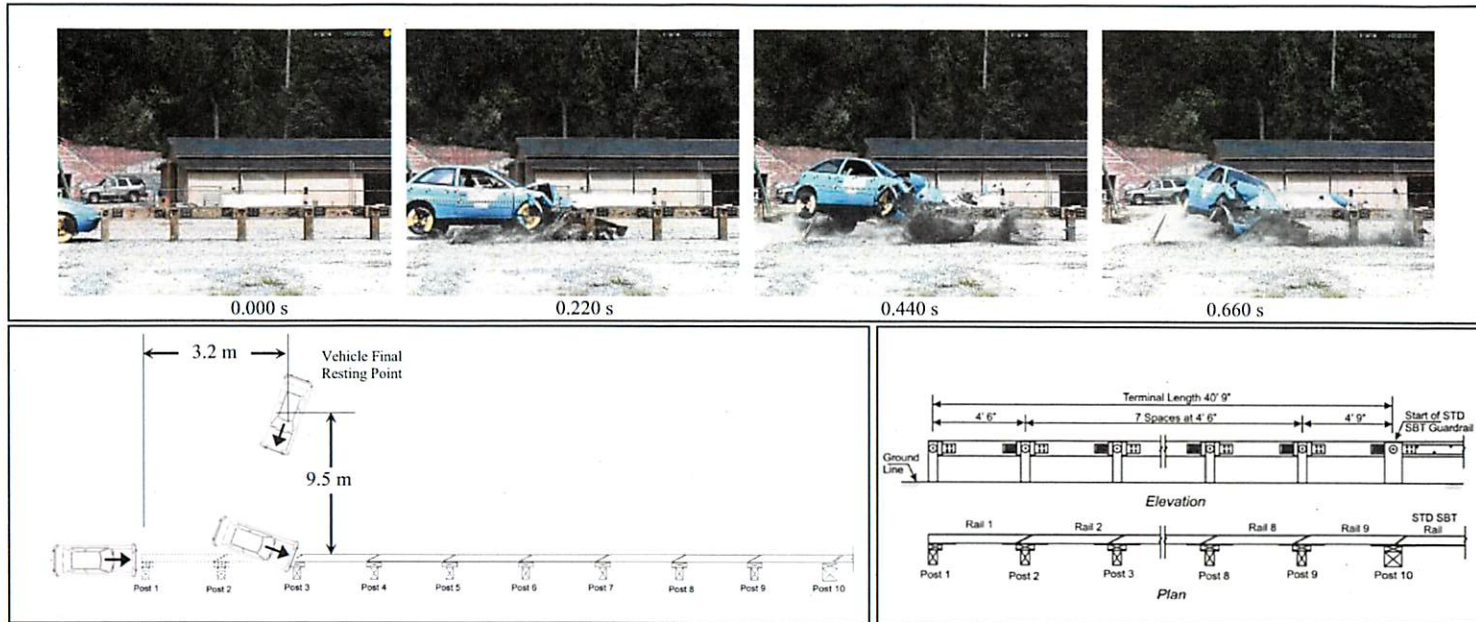
Post/Rail Connection at Post 10
Detail C

Revised: 09/10/2009

**TL2 End-Terminal for
Steel-Backed Timber Guardrail**

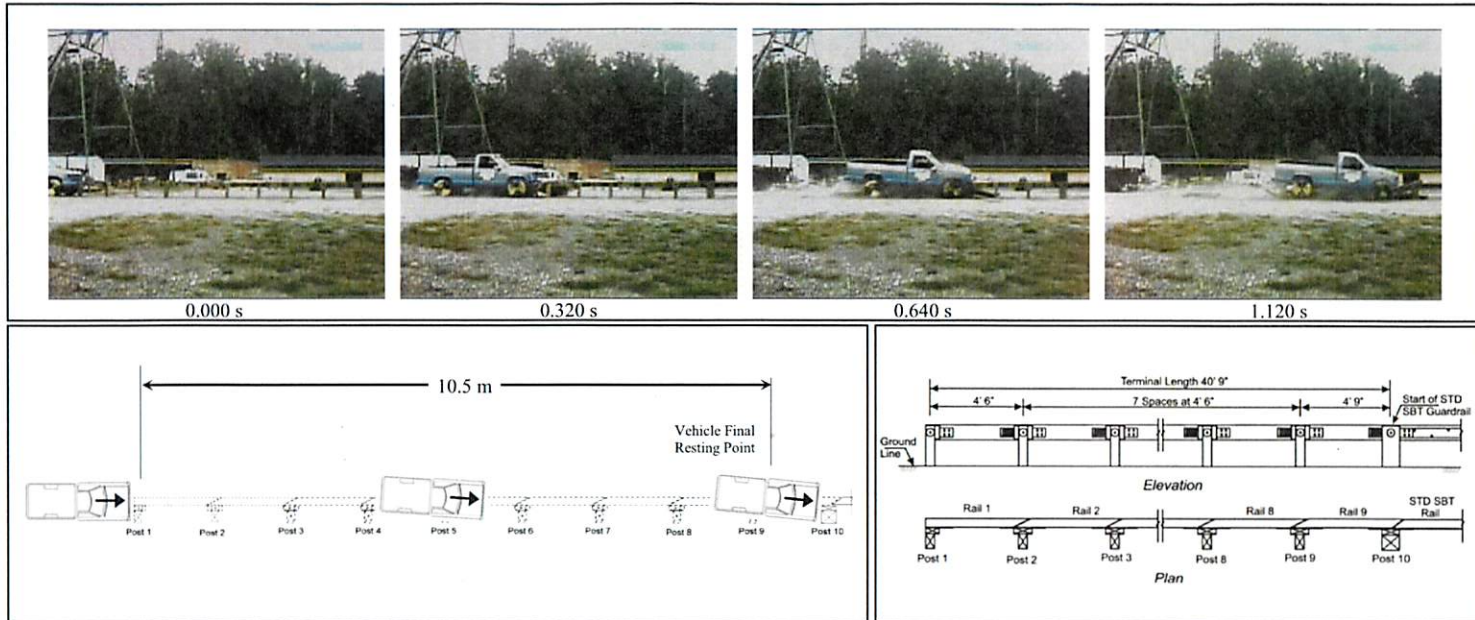
The National Crash Analysis Center
The George Washington University

Sheet 1 of 2



<p>General Information</p> <p>Test Agency Federal Outdoor Impact Lab. Test No. 09005 Date 08/20/2009</p> <p>Test Article</p> <p>Type End-Terminal for SBT Guardrail Name or Mfg Generic Installation length (m). 21.5 m Size and/or dimension and material of key 12.35 m end-terminal length and 1.37 m post spacings elements 9 breakaway posts</p> <p>Soil Type and Condition Standard, dry</p> <p>Test Vehicle</p> <p>Type Production Designation 820C Model 1997 Geo Metro Mass (kg) Curb 796.5 Test Inertial 892.0 Dummy 69.5 Gross Static 892.0</p>	<p>Impact Conditions</p> <p>Speed (km/h) 69.94 Angle (deg) 0</p> <p>Exit Conditions</p> <p>Speed (km/h) 0 Angle (deg) 45</p> <p>Occupant Risk Values</p> <p>Impact Velocity (m/s)</p> <p>x-direction 8.0 y-direction 0.0 THIV (optional) N/A Ridedown Accelerations (g's)</p> <p>x-direction 16.6 y-direction 5.8 PHD (optional) N/A ASI (optional) N/A Max. 0.050-s Average (g's)</p> <p>x-direction -11.86 y-direction -3.02 z-direction 4.34</p>	<p>Test Article Defelction (m)</p> <p>Dynamic N/A Permanent N/A</p> <p>Vehicle Damage</p> <p>Exterior</p> <p>VDS N/A CDC N/A</p> <p>Interior</p> <p>OCDI N/A Maximum Exterior</p> <p>Vehicle Cruch (mm) N/A Max. Occ. Compart. Deformation (mm) 0</p> <p>Post-Impact Behavior</p> <p>Max. Roll Angle (deg) N/A Max. Pitch Angle (deg) N/A Max. Yaw Angle (deg) N/A</p>
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Figure 13: 09005 Crash Test Summary



General Information

Test Agency Federal Outdoor Impact Lab.
 Test No. 09006
 Date 09/16/2009

Test Article

Type End-Terminal for SBT Guardrail
 Name or Mfg Generic
 Installation length (m). 21.5 m
 Size and/or dimension and material of key elements 12.35 m end-terminal length
 1.37 m post spacings
 9 breakaway posts

Soil Type and Condition Standard, dry

Test Vehicle

Type Production
 Designation 2000P
 Model 1999 Chevrolet C2500
 Mass (kg) Curb 2105.0
 Test Inertial 2029.0
 Dummy 0.0
 Gross Static 2029.0

Impact Conditions

Speed (km/h) 71.26
 Angle (deg) 0

Exit Conditions

Speed (km/h) 0
 Angle (deg) 2

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 4.9
 y-direction 0.2
 THIV (optional) N/A
 Ridedown Accelerations (g's)
 x-direction 8.2
 y-direction 3.7
 PHD (optional) N/A
 ASI (optional) N/A
 Max. 0.050-s Average (g's)
 x-direction -4.34
 y-direction -1.11
 z-direction -2.48

Test Article Deflection (m)

Dynamic N/A
 Permanent N/A

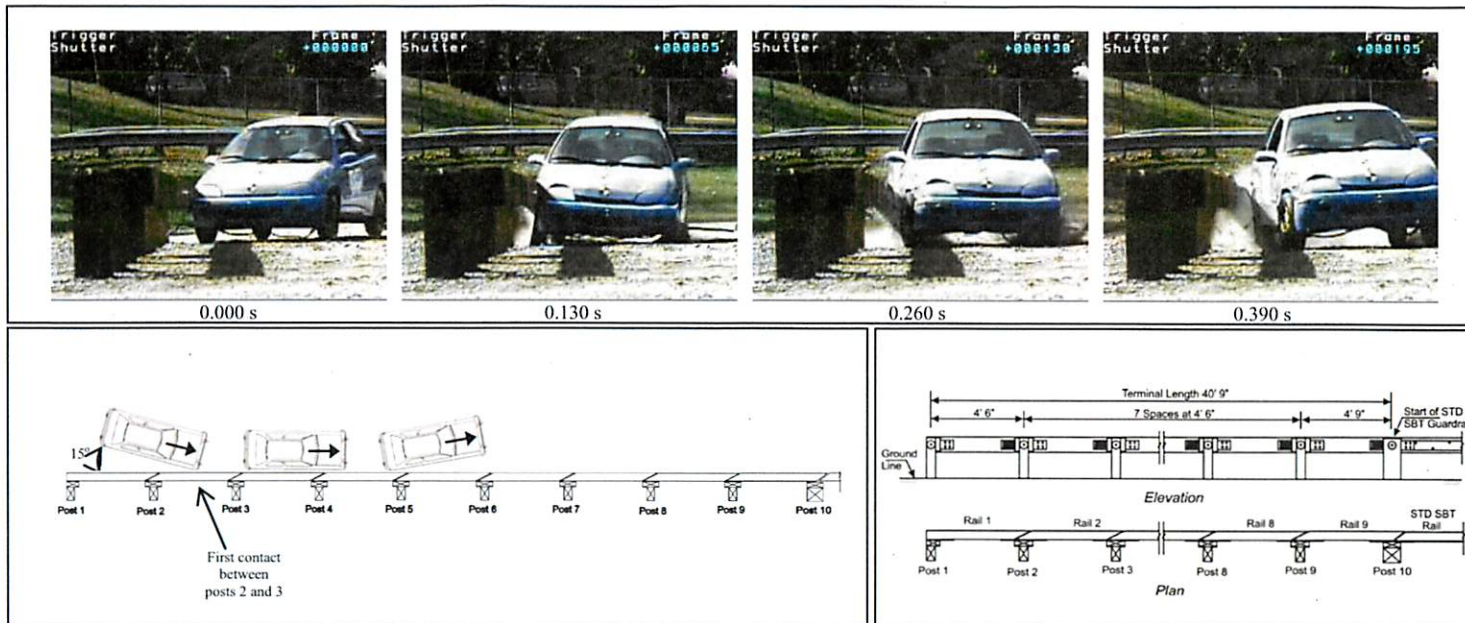
Vehicle Damage

Exterior
 VDS N/A
 CDC N/A
 Interior
 OCDI N/A
 Maximum Exterior
 Vehicle Cruch (mm) N/A
 Max. Occ. Compart.
 Deformation (mm) 0

Post-Impact Behavior

Max. Roll Angle (deg) N/A
 Max. Pitch Angle (deg) N/A
 Max. Yaw Angle (deg) N/A

Figure 18: 09006 Crash Test Summary



General Information

Test Agency Federal Outdoor Impact Lab.
 Test No. 09008
 Date 10/13/2009

Test Article

Type End-Terminal for SBT Guardrail
 Name or Mfg Generic
 Installation length (m) 21.5 m
 Size and/or dimension 12.35 m end-terminal length
 and material of key 1.37 m post spacings
 elements 9 breakaway posts

Soil Type and Condition Standard, dry

Test Vehicle

Type Production
 Designation 820C
 Model 1997 Geo Metro
 Mass (kg)
 Curb 791.0
 Test Inertial 885.5
 Dummy 69.5
 Gross Static 885.5

Impact Conditions

Speed (km/h) 69.83
 Angle (deg) 15

Exit Conditions

Speed (km/h) 61
 Angle (deg) 4

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 3.6
 y-direction 6.5
 THIV (optional) N/A
 Ridedown Accelerations (g's)
 x-direction 3.0
 y-direction 8.9
 PHD (optional) N/A
 ASI (optional) N/A
 Max. 0.050-s Average (g's)
 x-direction -2.62
 y-direction -6.15
 z-direction 1.21

Test Article Deflection (m)

Dynamic 0
 Permanent 0

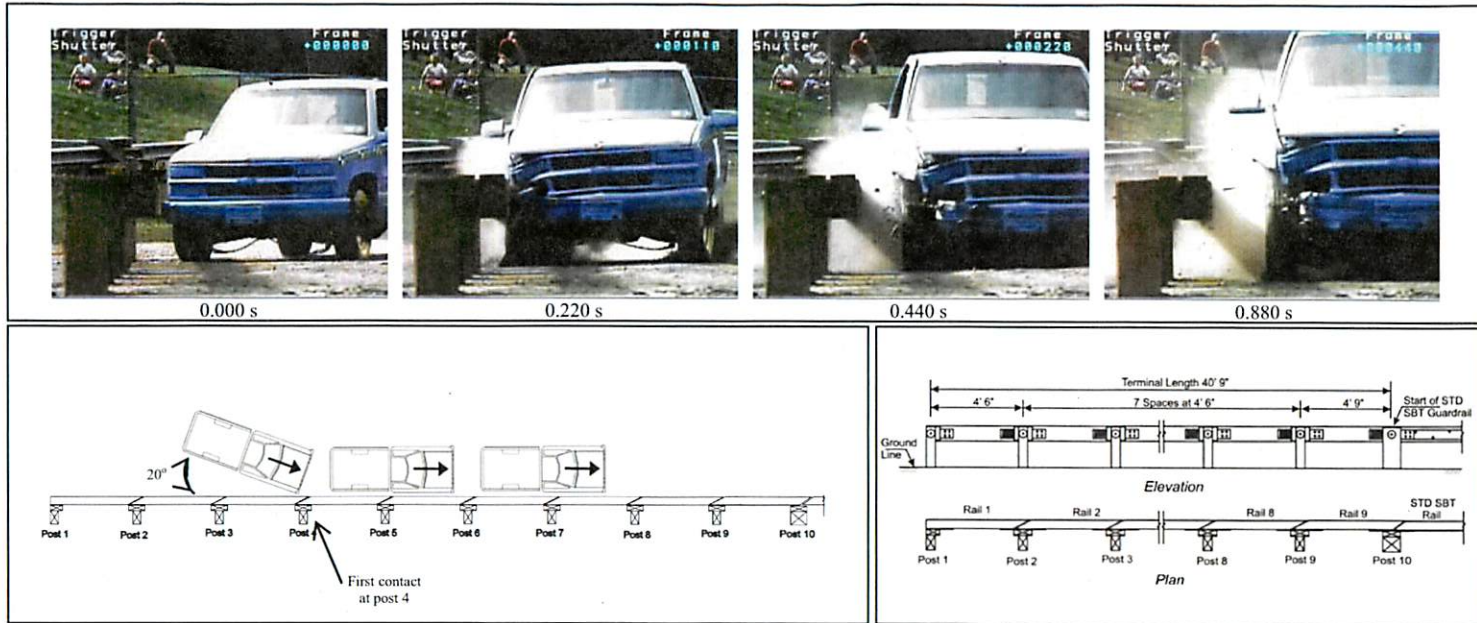
Vehicle Damage

Exterior
 VDS N/A
 CDC N/A
 Interior
 OCDI N/A
 Maximum Exterior
 Vehicle Cruch (mm) N/A
 Max. Occ. Compart.
 Deformation (mm) 0

Post-Impact Behavior

Max. Roll Angle (deg) N/A
 Max. Pitch Angle (deg) N/A
 Max. Yaw Angle (deg) N/A

Figure 28: 09008 Crash Test Summary



General Information

Test Agency Federal Outdoor Impact Lab.
 Test No. 09009
 Date 10/22/2009

Test Article

Type End-Terminal for SBT Guardrail
 Name or Mfg Generic
 Installation length (m) 21.5 m
 Size and/or dimension 12.35 m end-terminal length
 and material of key 1.37 m post spacings
 elements 9 breakaway posts

Soil Type and Condition Standard, dry

Test Vehicle

Type Production
 Designation 2000P
 Model 1999 Chevrolet C2500
 Mass (kg) Curb 2061.5
 Test Inertial 2025.0
 Dummy 0.0
 Gross Static 2025.0

Impact Conditions

Speed (km/h) 69.96
 Angle (deg) 20

Exit Conditions

Speed (km/h) 52
 Angle (deg) 6

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 3.2
 y-direction 4.9
 THIV (optional) N/A
 Ridedown Accelerations (g's)
 x-direction 1.5
 y-direction 3.9
 PHD (optional) N/A
 ASI (optional) N/A
 Max. 0.050-s Average (g's)
 x-direction -3.50
 y-direction -5.03
 z-direction -1.62

Test Article Defelction (m)

Dynamic 0
 Permanent 0

Vehicle Damage

Exterior
 VDS N/A
 CDC N/A
 Interior
 OCDI N/A
 Maximum Exterior
 Vehicle Cruch (mm) N/A
 Max. Occ. Compart.
 Deformation (mm) 0

Post-Impact Behavior

Max. Roll Angle (deg) N/A
 Max. Pitch Angle (deg) N/A
 Max. Yaw Angle (deg) N/A

Figure 33: 09009 Crash Test Summary