



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

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

March 11, 2014

In Reply Refer To:  
HSST/B-246

Mr. Barry Stephens  
Trinity Highway Products, LLC  
3617 Cincinnati Avenue  
Rocklin, CA. 95765

Dear Mr. Stephens:

This letter is in response to your request for the Federal Highway Administration (FHWA) to review a roadside safety system for eligibility for reimbursement under the Federal-aid highway program.

Name of system: Retro-Rail™, MASH  
Type of system: Longitudinal Barrier  
Test Level: AASHTO MASH TL3  
Testing conducted by: E-Tech Testing Services, Inc.  
Task Force 13 Designator SGR48  
Date of request: October 30, 2013  
Date of completed package: November 30, 2013

**Decision:**

The following device is eligible, with details provided in the form which is attached as an integral part of this letter:

- Retro-Rail™, MASH

Based on a review of crash test results you submitted certifying the device described herein meets the crash test and evaluation criteria of the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH), the device is eligible for reimbursement under the Federal-aid highway program. Eligibility for reimbursement under the Federal-aid highway program does not establish approval or endorsement by the FHWA for any particular purpose or use.

The FHWA, the Department of Transportation, and the United States Government do not endorse products or services and the issuance of a reimbursement eligibility letter is not an endorsement of any product or service.

**Requirements**

To be found eligible for Federal-aid funding, roadside safety devices should meet the crash test and evaluation criteria contained in the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH).

**Description**

The device and supporting documentation are described in the attached form.

**Summary and Standard Provisions**

Therefore, the system described and detailed in the attached form is eligible for reimbursement and may be installed under the range of conditions tested. Please note the following standard provisions that apply to FHWA eligibility letters:

- This letter 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 existing Task Force 13 drawing for posting on the on-line 'Guide to Standardized Highway Barrier Hardware' currently referenced in AASHTO Roadside Design Guide.
- This finding of eligibility does not cover other structural features of the systems, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may influence system conformance with MASH will require a new reimbursement eligibility letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals safety problems, or that the system is significantly different from the version that was crash tested, we reserve the right to modify or revoke this letter.
- You are expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You are expected to certify to potential users that the hardware furnished has the same chemistry, mechanical properties, and geometry as that submitted for review, and that it will meet the test and evaluation criteria of the MASH.
- To prevent misunderstanding by others, this letter of eligibility is designated as number B-246 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 letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder. The FHWA does not become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

- Because it is a steel product, the Retro-Rail™, MASH is subject to Section 635.410 (Buy America) of Title 23, U.S. Code of Federal Regulations, and cannot be permanently incorporated into any federally funded project unless it is made in the U.S. from U.S. steel.

Sincerely yours,



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

Enclosures

## Request for Federal Aid Reimbursement Eligibility Of Highway Safety Hardware

<b>Submitter</b>	Date of Request:	October 30, 2013	<input checked="" type="radio"/> New <input type="radio"/> Resubmission
	Name:	Barry Stephens	Signature: <i>Barry S. Stephens</i> 10/30/2013
	Company:	Trinity Highway Products, LLC	
	Address:	3617 Cincinnati Ave, Rocklin, CA 95765	
	Country:	USA	
	To:	Michael S. Griffith, Director FHWA, Office of Safety Technologies	

I request the following devices be considered eligible for reimbursement under the Federal-aid highway program.

[Help](#)

System Type	Submission Type	Device Name / Variant	Testing Criterion	Test Level
'B': Barriers (Roadside, Median, Bridge Railings)	<input checked="" type="radio"/> Physical Crash Testing <input type="radio"/> FEA & V&V Analysis	Retro-Rail™	AASHTO MASH	TL3

By submitting this request for review and evaluation by the Federal Highway Administration, I certify that the product(s) was (were) tested in conformity with the AASHTO Manual for Assessing Safety Hardware and that the evaluation results meet the appropriate evaluation criteria in the MASH.

Identification of the individual or organization responsible for the product:

Contact Name:	Barry Stephens	Same as Submitter <input checked="" type="checkbox"/>
Company Name:	Trinity Highway Products, LLC	Same as Submitter <input checked="" type="checkbox"/>
Address:	3617 Cincinnati Ave, Rocklin, CA 95765	Same as Submitter <input checked="" type="checkbox"/>
Country:	USA	Same as Submitter <input checked="" type="checkbox"/>

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Contact Name:	Barry Stephens	Same as Submitter <input checked="" type="checkbox"/>
Company Name:	Trinity Highway Products, LLC	Same as Submitter <input checked="" type="checkbox"/>
Address:	3617 Cincinnati Ave, Rocklin, CA 95765	Same as Submitter <input checked="" type="checkbox"/>
Country:	USA	Same as Submitter <input checked="" type="checkbox"/>

### PRODUCT DESCRIPTION

New Hardware
--------------

The Retro-Rail™ System has been crash tested and found to successfully meet MASH Test Level 3 impact criteria when properly attached to structurally-sound, "Strong-Post" Guardrail, with a rail height of 25" to 29", [Reference- 2009 American Association of State Highway and Transportation Officials (AASHTO) Publication; Manual for Assessing Safety Hardware (MASH)]. Height is measured to the top of the rail from a horizontal tangent projected out from the top of an adjacent roadway. The following types of Strong-Post Guardrail have been evaluated and are deemed suitable for retrofitting with the Retro-Rail™ System:

- SGR04c - Steel Post/ Wood Blockout.
- SGR04b - Wood Post/ Wood Blockout.
- SGR04c - Steel Post/ Plastic or Composite Blockout (Similar to King Block®, width 105mm[4.0"] height 355mm [14.0"], depth 185mm [7.3"]).

The Retro-Rail™ System consists of two Cable End Brackets, a single 3/4" (19 mm) galvanized wire rope running the length of the installation, and numerous Cable Mid Brackets supporting the wire rope ~ 6" (152 mm) above the top of the rail. Cable Mid Brackets are installed every 12'-6" (1,905 mm), using standard guardrail splice locations. The Cable End Brackets and Mid Brackets maximize use of existing holes in the rail for attachment, minimizing the need to drill additional holes.

The Cable End Bracket consists of inner and outer galvanized components that "sandwich" a guardrail splice at the termination points of the Retro-Rail™. The Cable End Brackets are designed to work with the rail to resist normal and impact Retro-Rail™ Cable tension. The top of the Cable End Brackets are fitted with a steel tube that accommodates the threaded end of the Cable. The Cable End Bracket design is universal, allowing a single component to be installed at either end of the system.

The Cable Mid Brackets incorporate an "engineered cable retention slot" intended to allow the Cable to float freely within the bracket. During Guardrail impacts, the Bracket is designed to bend rearward, which facilitates release of the Cable. This "release" transfers a significant portion of the impact vehicle's lateral impact energy into the tensioned Retro-Rail™ Cable. The Cable Mid Bracket is designed to maintain standard wire rope tension when installed on guardrail with concave radii of 100' or greater. If the Bracket experiences significant longitudinal loading during impacts, it is designed to bend and lay flat on top of the rail, reducing vehicle snagging.

The Cable is 3/4" 3 x 7 galvanized wire rope with threaded cable ends. It is pre-stretched at the factory. During the Retro-Rail™ installation, the Cable is tensioned to ~3500 pounds (dependent on the ambient temperature at the time of the installation).

A combined MASH Test Level 3 Guardrail & End Terminal system can be created by attaching one of the above NCHRP 350 Retro-Rail™-fitted Strong-Post Guardrails immediately downstream from a MASH, TL-3-accepted End Terminal.

## CRASH TESTING

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
3-10 (1100C)	Two MASH 3-10 tests were successfully completed on the Retro-Rail™ System, Test 01-0289-002 and 01-0289-004. Both installations used Steel Posts/ Routed Wood Blockouts on 6'-3" centers, 13'-6 1/2" long 12 Ga W-Beam Guardrail with the top edge 25" above grade and the Retro-Rail™ System attached above and tensioned. Test 01-0289-002 impact occurred 48" downstream of Post #19, L/2. This location was selected because it is believed to be "worst case". Impact would create the greatest snag potential between the post and vehicle and create the greatest likelihood of W-Beam rupture. Test 01-0289-004 impact occurred 12" downstream of post #3 to establish system Beginning Length of Need (BLON).	PASS



Required Test Number	Narrative Description	Evaluation Results
3-11 (2270P)	Four MASH 3-11 tests were successfully completed on the Retro-Rail™ System, Test 01-0289-001 and 01-0289-003 installations used Steel Posts/ Routed Wood Blockouts on 6'-3" centers, 13'-6 1/2" long 12 Ga W-Beam Guardrail with the top edge 25" above grade and the Retro-Rail™ System attached above and tensioned. Test 01-0289-001 impact occurred 48" downstream of Post #19, L/2. This location was selected because it is believed to be "worst case". Impact would create the greatest snag potential between the post and vehicle and create the greatest likelihood of W-Beam rupture. Test 01-0289-003 impact occurred 12" downstream of post #3 to establish system Beginning Length of Need (BLON). Tests 01-0289-005 and 01-0289-006 were conducted to further evaluate Post/ Blockout combinations: Wood Post/ Blockout and Steel Post/ Composite Blockout respectively. To create the worst case scenario for these Post and Blockout combinations, the impact occurred 48" downstream of Post #19, L/2. This impact would create the greatest snag potential between the post and vehicle and create the greatest likelihood of W-Beam rupture.	PASS
3-20 (1100C)	At this time the intended use of the Retro-Rail™ System is not to improve impact performance in transitioning from semi-rigid to rigid barrier. Instead, replacement of this transition area may be required to reach acceptable performance levels. The Retro-Rail™ System has been designed to attach to various Transition types and heights.	WAIVER REQUESTED
3-21 (2270P)	See comments above (Required Test Number 3-20 (1100C))	WAIVER REQUESTED

Full Scale Crash Testing was done in compliance with MASH by the following accredited crash test laboratory (cite the laboratory's accreditation status as noted in the crash test reports.):

Laboratory Name:	E-Tech Testing Services, Inc.	
Laboratory Contact:	John F. LaTurner	Same as Submitter <input type="checkbox"/>
Address:	3617B Cincinnati Ave, Rocklin, CA 95765	Same as Submitter <input type="checkbox"/>
Country:	USA	Same as Submitter <input checked="" type="checkbox"/>
Accreditation Certificate Number and Date:	A2LA, Mechanical #0989.01, November 30, 2013	

## ATTACHMENTS

Attach to this form:

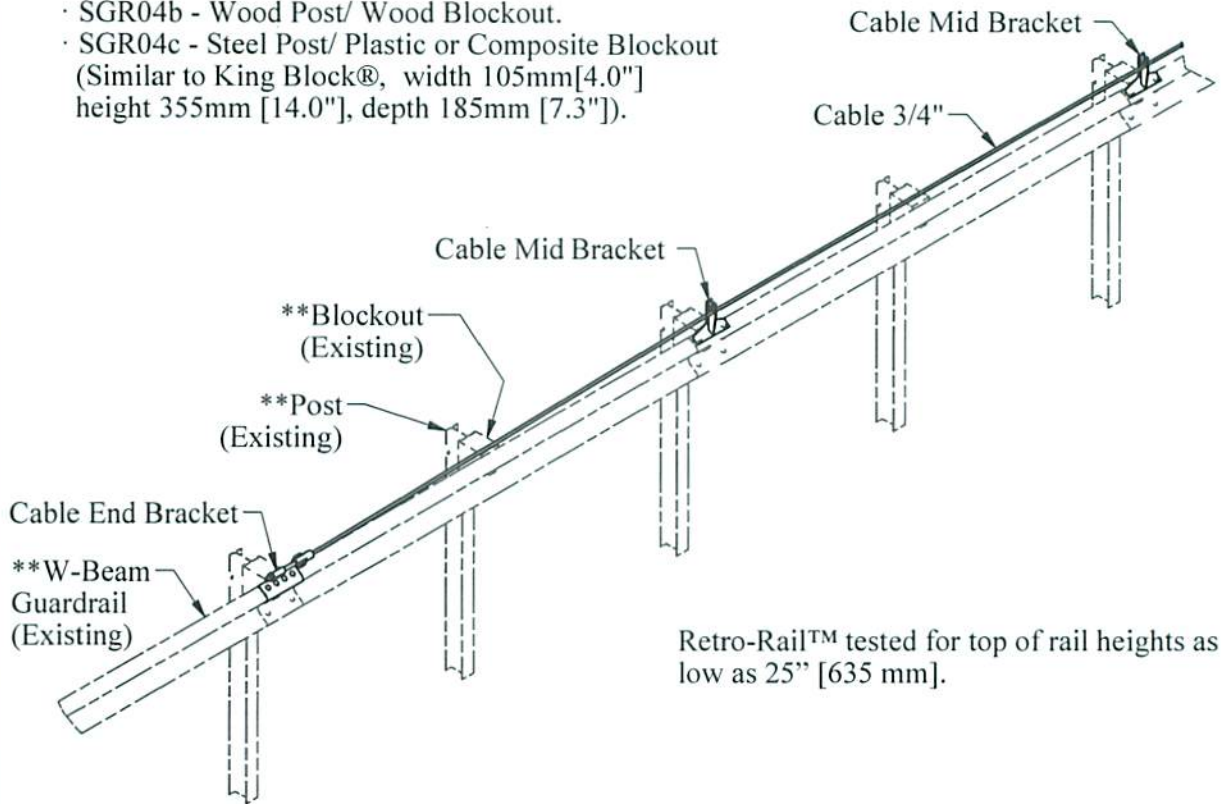
- 1) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
- 2) A drawing or drawings of the device(s) that conform to the Task Force-13 Drawing Specifications [[Hardware Guide Drawing Standards](#)]. For proprietary products, a single isometric line drawing is usually acceptable to illustrate the product, with detailed specifications, intended use, and contact information provided on the reverse. Additional drawings (not in TF-13 format) showing details that are key to understanding the performance of the device should also be submitted to facilitate our review.

**FHWA Official Business Only:**

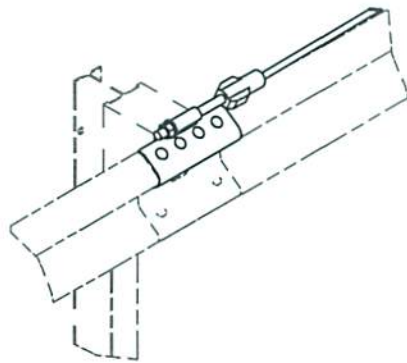
Eligibility Letter		AASHTO TF13	
Number	Date	Designator	Key Words
B246	February 18, 2014	SGR48	MASH TL3, Retrofit Strong-Post Guardrail, Cable End Brackets, Mid Brackets.



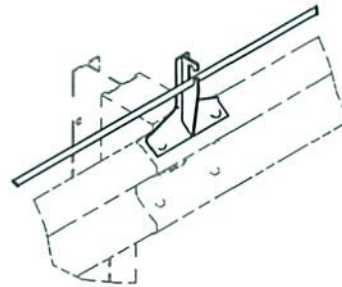
- \*\*Strong-Post W-Beam Guardrail types:**
- SGR04c - Steel Post/ Wood Blockout.
  - SGR04b - Wood Post/ Wood Blockout.
  - SGR04c - Steel Post/ Plastic or Composite Blockout (Similar to King Block®, width 105mm[4.0"] height 355mm [14.0"], depth 185mm [7.3"]).



Retro-Rail™ tested for top of rail heights as low as 25" [635 mm].



Cable End Bracket



Cable Mid Bracket

2013

**Retro-Rail™ System**



**TRINITY**  
**HIGHWAY PRODUCTS**  
 ENERGY ABSORPTION SYSTEMS

**XX**

SHEET NO.

DATE

1 of 2

10/30/2013

### INTENDED USE

The Retro-Rail™ System has been crash tested and found to successfully meet MASH Test Level 3 impact criteria when properly attached to structurally-sound, “Strong-Post” Guardrail, with a rail height of 25” to 29”, [Reference- 2009 American Association of State Highway and Transportation Officials (AASHTO) Publication; Manual for Assessing Safety Hardware (MASH)]. Height is measured to the top of the rail from a horizontal tangent projected out from the top of an adjacent roadway. The following types of Strong-Post Guardrail have been evaluated and are deemed suitable for retrofitting with the Retro-Rail™ System:

- SGR04c - Steel Post/ Wood Blockout.
- SGR04b - Wood Post/ Wood Blockout.
- SGR04c - Steel Post/ Plastic or Composite Blockout (Similar to King Block®).

The Retro-Rail™ System consists of two Cable End Brackets, a single 3/4” (19 mm) galvanized wire rope running the length of the installation, and numerous Cable Mid Brackets supporting the wire rope ~ 6” (152 mm) above the top of the rail. Cable Mid Brackets are installed every 12’-6” (3,810 mm), using standard guardrail splice locations. The Cable End Brackets and Mid Brackets maximize use of existing holes in the rail for attachment, minimizing the need to drill additional holes.

A combined MASH Test Level 3 Guardrail & End Terminal system can be created by attaching one of the above NCHRP 350 Retro-Rail™-fitted Strong-Post Guardrails immediately downstream from a MASH, TL-3-accepted End Terminal.

### APPROVALS

The Retro-Rail™ System is compliant to MASH criteria for TL3 applications.  
FHWA Eligibility Letter XXXX/B-XX, XX/XX/2013.

### REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), Executive Committee 2008-2009; The AASTHO Manual for Assessing Safety Hardware (MASH), 2009

### CONTACT INFORMATION

2525 North Stemmons Freeway  
Dallas, TX 75207  
Telephone: (888) 323-6374  
Fax: (800) 770-6755  
<http://www.highwayguardrail.com/>

### Retro-Rail™ System

<b>XX</b>	
SHEET NO.	DATE
2 of 2	10/30/2013

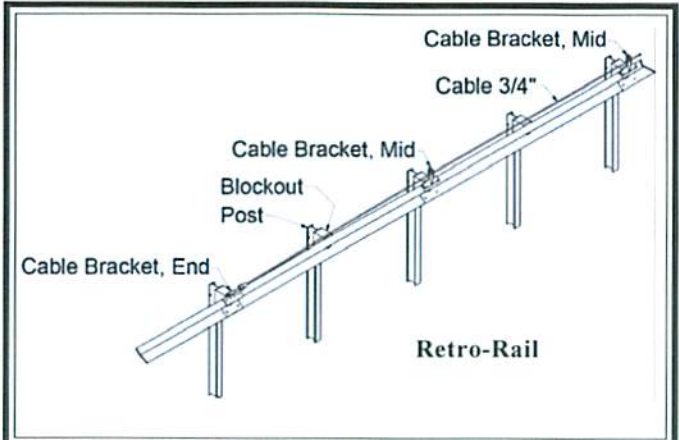
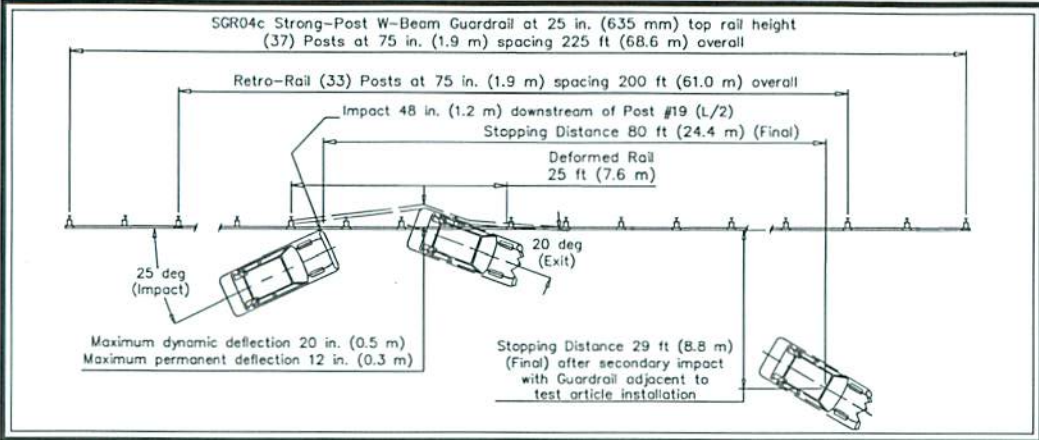


**TRINITY**  
HIGHWAY PRODUCTS  
ENERGY ABSORPTION SYSTEMS





E-TECH Testing Services, Inc.

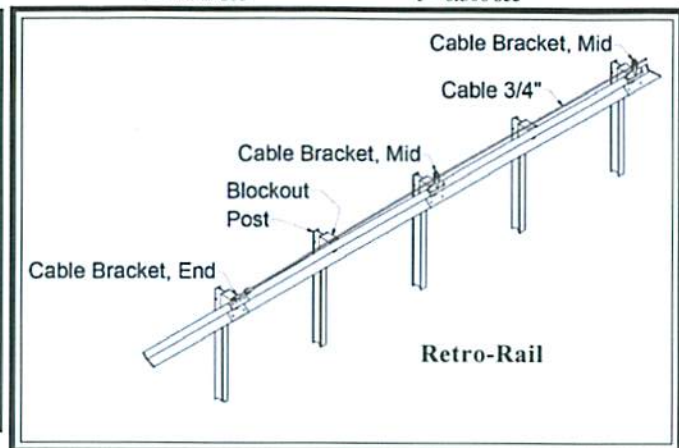
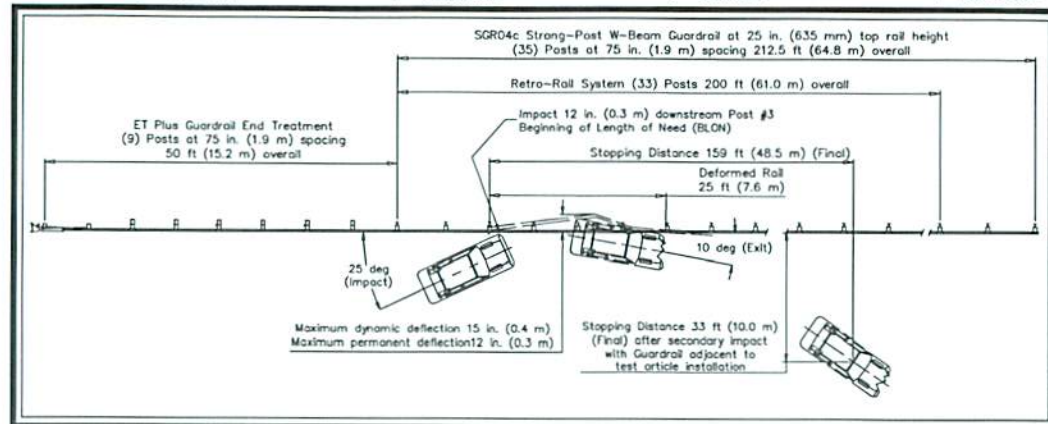
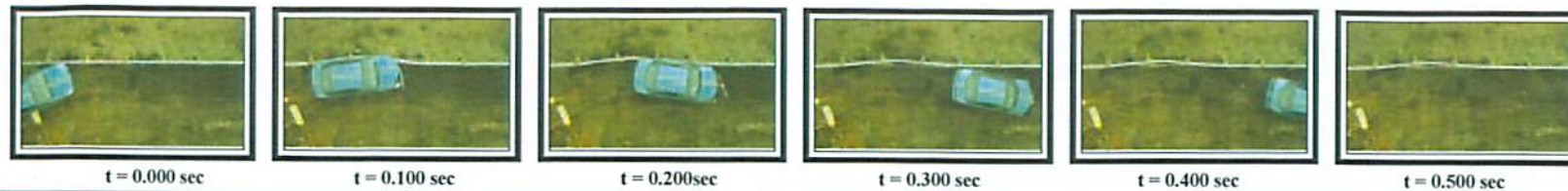


Retro-Rail™ Crash Test Results - 17 of 100

<b>General Information</b>		<b>Exit conditions</b>	
Test Agency .....	E-TECH Testing Services	Speed .....	33.6 mi/h (54 km/h)
Test Designation .....	MASH Test 3-10 at L/2	Angle (deg - veh. c.g.) .....	20
Test No. ....	01-0289-002	<b>Occupant Risk Values (absolute values)</b>	
Date .....	10/4/12	<b>Impact Velocity</b>	
<b>Test Article</b>		x-direction .....	19.2 ft/s (5.8 m/s)
Type .....	Trinity Highway Products, LLC	y-direction .....	23.0 ft/s (7.0 m/s)
Installation Length .....	Retro-Rail System	<b>Ridedown Acceleration (g's)</b>	
.....	SGR04c Guardrail 225 ft (68.6 m)	x-direction .....	12.0
.....	overall at 25 in. (635 mm) top height	y-direction .....	9.6
.....	with 200 ft (61 m) Retro-Rail	<b>European Committee for Normalization (EN) Values</b>	
<b>Material and key elements</b> .....	Retro-Rail Cable 3/4" (19 mm) 3 x 7	THIV .....	19.6 mi/h (31.5 km/h)
.....	galvanized, End and Mid Brackets	PHD (g's) .....	14.0
.....	galvanized steel	ASI .....	1.2
<b>Foundation Type and Condition</b> .....	AASHTO Strong Soil, compacted and	<b>Post-Impact Vehicular Behavior (deg - rate gyro)</b>	
.....	well drained	Maximum Roll Angle .....	8.1
<b>Test Vehicle</b>		Maximum Pitch Angle .....	-4.1
Type .....	Production Model	Maximum Yaw Angle .....	80.5
Designation .....	1100C	<b>Test Article Deflections</b>	
Model .....	2004 Kia Rio	Dynamic .....	20 in. (0.5 m)
<b>Mass</b>		Permanent .....	12 in. (0.3 m)
Curb .....	2354 lb (1068 kg)	<b>Vehicle Damage (Primary Impact)</b>	
Test inertial .....	2414 lb (1095 kg)	Exterior	
Dummy .....	N/A	VDS .....	LFQ-3
Gross Static .....	2414 lb (1095 kg)	CDC .....	11LFEW3
<b>Impact Conditions</b>		Interior	
Speed .....	63.9 mi/h (102.9 km/h)	VCDI .....	NS0000000
Angle (deg) .....	25	Maximum Deformation .....	Negligible
Impact Severity .....	58.9 ft-kip (79.8 kJ)		

Figure 1. Summary of Results - Retro-Rail Test 01-0289-002





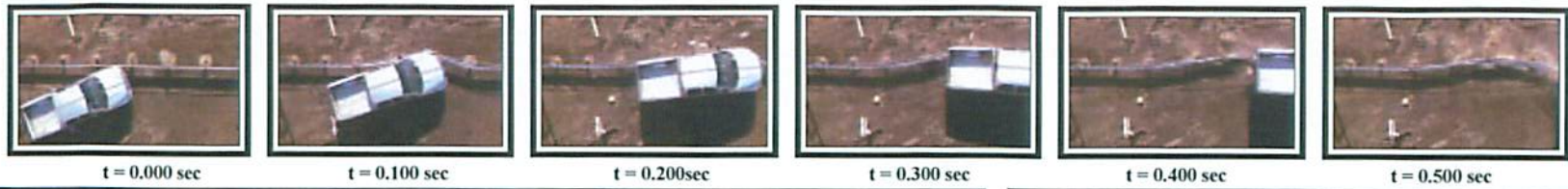
E-TECH Testing Services, Inc.

Retro-Rail™ Crash Test Results - 23 of 100

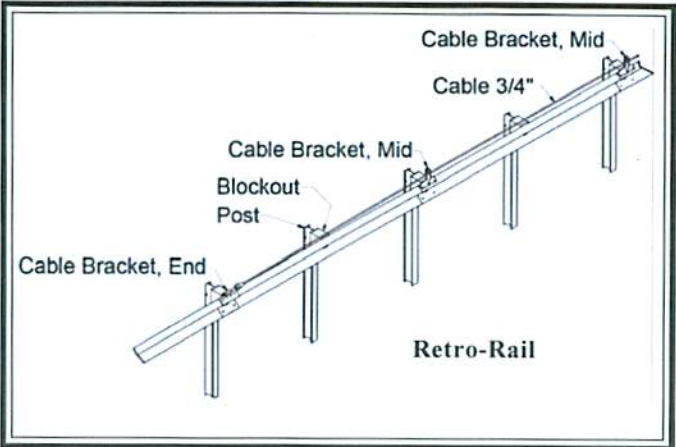
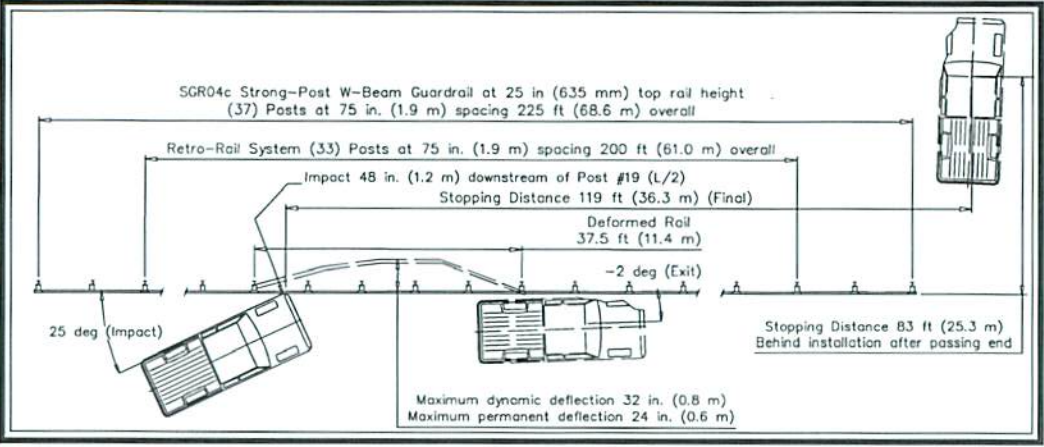
<b>General Information</b>			
Test Agency .....	E-TECH Testing Services	Exit conditions	
Test Designation .....	MASH Test 3-10 at BLON	Speed .....	44.7 mi/h (72 km/h)
Test No. ....	01-0289-004	Angle (deg - veh. c.g.) .....	10
Date .....	1/9/13	Occupant Risk Values (absolute values)	
Test Article		Impact Velocity	
Type .....	Trinity Highway Products, LLC	x-direction .....	13.3 ft/s (4.0 m/s)
Installation Length .....	Retro-Rail System	y-direction .....	22.2 ft/s (6.8 m/s)
.....	SGR04c Guardrail 212.5 ft (64.8 m)	Ridedown Acceleration (g's)	
.....	overall at 25 in. (635 mm) top height	x-direction .....	6.2
.....	with 200 ft (661.0 m) Retro-Rail and	y-direction .....	9.3
.....	50 ft (15.2 m) upstream ET Plus End	European Committee for Normalization (EN) Values	
.....	Terminal anchorage	THIV .....	17.6 mi/h (28.4 km/h)
Material and key elements .....	Retro-Rail Cable 3/4 in. (19 mm)	PHD (g's) .....	10.6
.....	3 x 7 galvanized, End and Mid	ASI .....	1.2
.....	Brackets galvanized steel	Post-Impact Vehicular Behavior (deg - rate gyro)	
Foundation Type and Condition .....	AASHTO Strong Soil, compacted and	Maximum Roll Angle .....	-3.3
.....	well drained	Maximum Pitch Angle .....	3.1
Test Vehicle		Maximum Yaw Angle .....	36.9
Type .....	Production Model	Test Article Deflections	
Designation .....	1100C	Dynamic .....	15 in. (0.4 m)
Model .....	2005 Kia Rio	Permanent .....	12 in. (0.3 m)
Mass		Vehicle Damage (Primary Impact)	
Curb .....	2351 lb (1066.5 kg)	Exterior	
Test inertial .....	2399 lb (1088 kg)	VDS .....	LFQ-3
Dummy .....	7165 lb (5 kg)	CDC .....	11LFEW3
Gross Static .....	2564 lb (1163 kg)	Interior	
Impact Conditions		VCDI .....	NS0000000
Speed .....	60.0 mi/h (96.5 km/h)	Maximum Deformation .....	Negligible
Angle (deg) .....	25		
Impact Severity .....	51.5 ft-kip (69.8 kJ)		

Figure 6. Summary of Results - Retro-Rail Test 01-0289-004





E-TECH Testing Services, Inc.



Retro-Rail™ Crash Test Results - 29 of 100

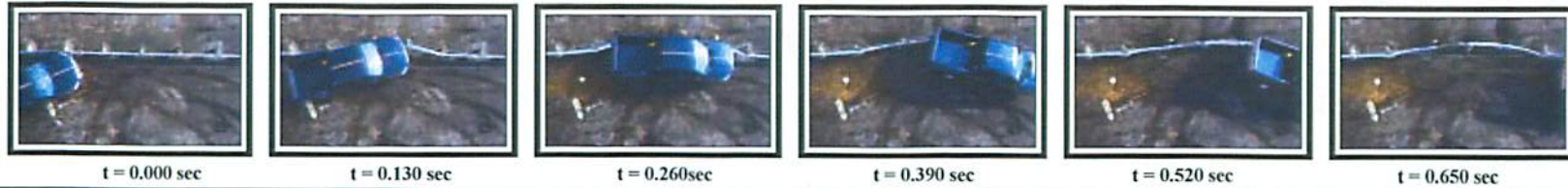
**General Information**

Test Agency .....	E-TECH Testing Services
Test Designation .....	MASH Test 3-11 at L/2
Test No. ....	01-0289-001
Date .....	9/21/12
<b>Test Article</b>	
Type .....	Trinity Highway Products, LLC
Installation Length .....	Retro-Rail System
Material and key elements .....	SGR04c Guardrail 225 ft (68.6 m) overall at 25 in. (635 mm) top height with 200 ft (61.0 m) Retro-Rail, Retrofit-Rail Cable 3/4 in. (19 mm) 3 x 7 galvanized, End and Mid Brackets galvanized steel
Foundation Type and Condition .....	AASHTO Strong Soil, compacted and well drained
<b>Test Vehicle</b>	
Type .....	Production Model
Designation .....	2270P
Model .....	2006 Dodge Ram Pickup
<b>Mass</b>	
Curb .....	4976 lb (2257 kg)
Test inertial .....	4974 lb (2256 lb)
Dummy .....	N/A
Gross Static .....	4974 lb (2256 kg)
<b>Impact Conditions</b>	
Speed .....	62.0 mi/h (99.7 km/h)
Angle (deg) .....	25
Impact Severity .....	114.0 ft-kip (154.6 kJ)

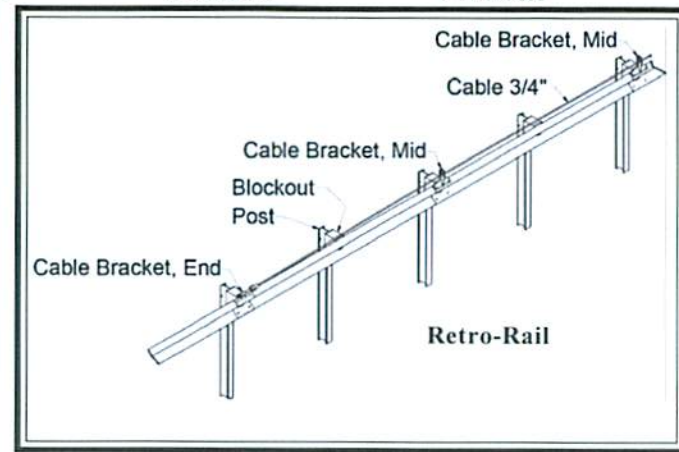
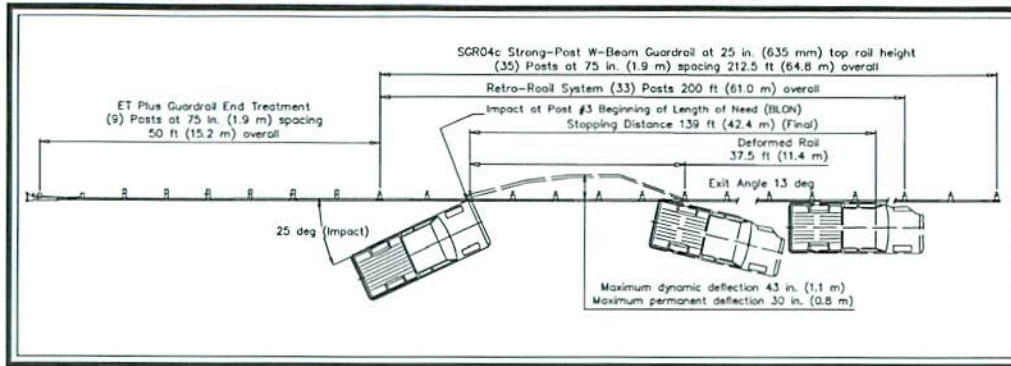
Exit conditions	
Speed .....	42.3 mi/h (68 km/h)
Angle (deg - veh. c.g.) .....	-2
<b>Occupant Risk Values (absolute values)</b>	
Impact Velocity	
x-direction .....	15.6 ft/s (4.7 m/s)
y-direction .....	15.7 ft/s (4.8 m/s)
Ridedown Acceleration (g's)	
x-direction .....	8.1
y-direction .....	6.5
<b>European Committee for Normalization (EN) Values</b>	
THIV .....	14.2 mi/h (22.9 km/h)
PHD (g's) .....	10.2
ASI .....	0.6
<b>Post-Impact Vehicular Behavior (deg - rate gyro)</b>	
Maximum Roll Angle .....	31.3
Maximum Pitch Angle .....	-6.7
Maximum Yaw Angle .....	-29.9
<b>Test Article Deflections</b>	
Dynamic .....	43 in. (1.1 m)
Permanent .....	30 in. (0.8 m)
<b>Vehicle Damage (Primary Impact)</b>	
<b>Exterior</b>	
VDS .....	LFQ-2
CDC .....	11LFEW2
<b>Interior</b>	
VCDI .....	NS0000000
Maximum Deformation .....	Negligible

Figure 11. Summary of Results - Retro-Rail Test 01-0289-001





E-TECH Testing Services, Inc.



**General Information**

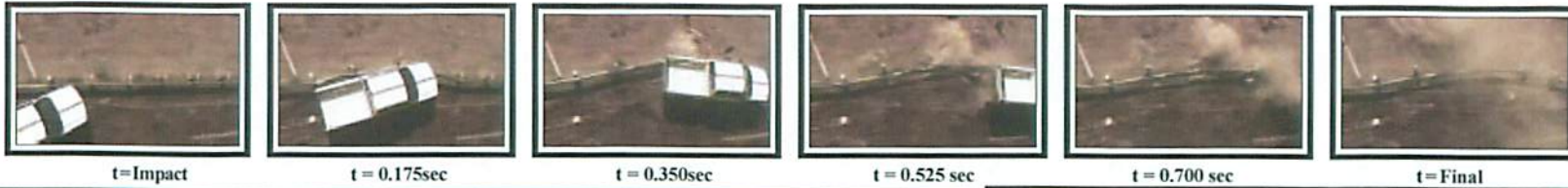
Test Agency .....	E-TECH Testing Services
Test Designation .....	MASH Test 3-11 at BLON
Test No. ....	01-0289-003
Date .....	12/11/12
<b>Test Article</b>	
Type .....	Trinity Highway Products, LLC
.....	Retro-Rail System
Installation Length .....	SGR04c Guardrail 212.5 ft (64.8 m)
.....	overall at 25 in. (635 mm) top height
.....	with 200 ft (61.0 m) Retro-Rail and
.....	50 ft (15.2 m) upstream ET Plus End
.....	Terminal anchorage
Material and key elements .....	Retro-Rail Cable 3/4 in. (19 mm)
.....	3 x 7 galvanized, End and Mid
.....	Brackets galvanized steel
Foundation Type and Condition .....	AASHTO Strong Soil, compacted and
.....	well drained
<b>Test Vehicle</b>	
Type .....	Production Model
Designation .....	2270P
Model .....	2006 Dodge Ram Pickup
<b>Mass</b>	
Curb .....	5046 lb (2289 kg)
Test inertial .....	4996 lb (2266 kg)
Dummy .....	N/A
Gross Static .....	4496 lb (2266 kg)
<b>Impact Conditions</b>	
Speed .....	61.3 mi/h (98.6 km/h)
Angle (deg) .....	25
Impact Severity .....	112.0 ft-kip (151.9 kJ)

<b>Exit conditions</b>	
Speed .....	37.9 mi/h (61.0 km/h)
Angle (deg - veh. c.g.) .....	13
<b>Occupant Risk Values (absolute values)</b>	
Impact Velocity	
x-direction .....	13.3 ft/s (4.1 m/s)
y-direction .....	16.0 ft/s (4.9 m/s)
Ridedown Acceleration (g's)	
x-direction .....	8.0
y-direction .....	9.0
<b>European Committee for Normalization (EN) Values</b>	
THIV .....	13.8 mi/h (22.2 km/h)
PHD (g's) .....	9.5
ASI .....	0.8
<b>Post-Impact Vehicular Behavior (deg - rate gyro)</b>	
Maximum Roll Angle .....	13.0
Maximum Pitch Angle .....	-13.3
Maximum Yaw Angle .....	37.6
<b>Test Article Deflections</b>	
Dynamic .....	43 in. (1.1 m)
Permanent .....	30 in. (0.8 m)
<b>Vehicle Damage (Primary Impact)</b>	
Exterior	
VDS .....	LFQ-2
CDC .....	11LFEW2
Interior	
VCDI .....	NS0000000
Maximum Deformation .....	Negligible

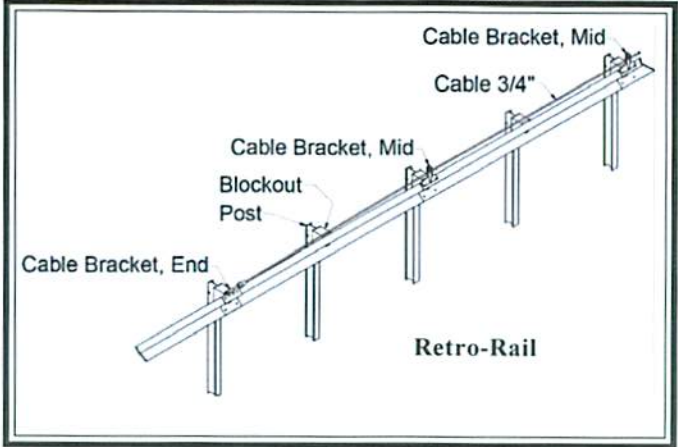
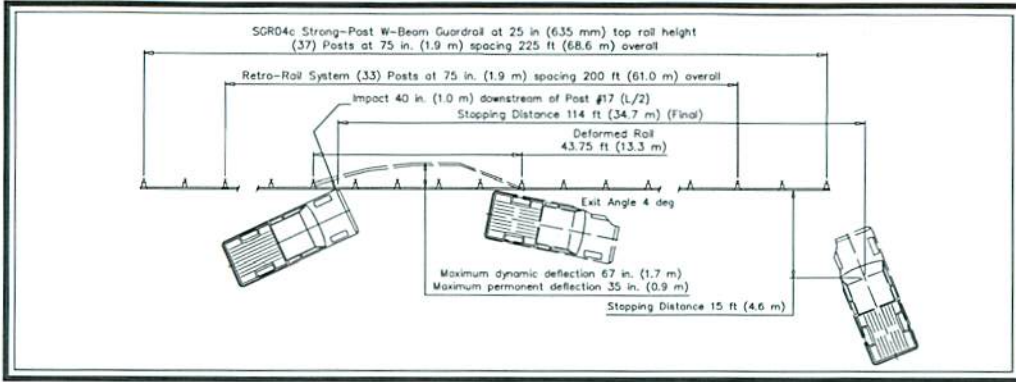
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**Figure 16. Summary of Results - Retro-Rail Test 01-0289-003**





E-TECH Testing Services, Inc.



**General Information**

Test Agency .....	E-TECH Testing Services
Test Designation .....	MASH Test 3-11
Test No. ....	01-0289-005
Date .....	7/24/13
Test Article	
Type .....	Trinity Highway Products, LLC
Installation Length .....	Retro-Rail System
Material and key elements .....	SGR04b Guardrail 225 ft (68.6 m)
Foundation Type and Condition .....	overall at 25 in. (635 mm) top height
	with 200 ft (61.0 m) Retro-Rail
	Retro-Rail Cable 3/4 in. (19 mm)
	3 x 7 galvanized, End and Mid
	Brackets galvanized steel
	AASHTO Strong Soil, compacted and
	well drained

**Test Vehicle**

Type .....	Production Model
Designation .....	2270P
Model .....	2007 Chevrolet Pickup

**Mass**

Curb .....	5337 lb (2421 kg)
Test inertial .....	5062 lb (2296 kg)
Dummy .....	N/A
Gross Static .....	5062 lb (2296 kg)

**Impact Conditions**

Speed .....	61.2 mi/h (98.5 km/h)
Angle (deg) .....	25
Impact Severity .....	113.1 ft-kip (153.4 kJ)

Exit conditions	
Speed .....	49.1 mi/h (79.0 km/h)
Angle (deg - veh. c.g.) .....	4
Occupant Risk Values (absolute values)	
Impact Velocity	
x-direction .....	8.5 ft/s (2.6 m/s)
y-direction .....	11.3 ft/s (3.4 m/s)
Ridedown Acceleration (g's)	
x-direction .....	5.1
y-direction .....	3.6
European Committee for Normalization (EN) Values	
THIV .....	9.4 mi/h (15.2 km/h)
PHD (g's) .....	5.1
ASI .....	0.4
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle .....	28.1
Maximum Pitch Angle .....	-8.2
Maximum Yaw Angle .....	111.9
Test Article Deflections	
Dynamic .....	67 in. (1.7m)
Permanent .....	35 in. (0.9 m)
Vehicle Damage (Primary Impact)	
Exterior	
VDS .....	LFQ-3
CDC .....	11LFEW3
Interior	
VCDI .....	NS0000000
Maximum Deformation .....	Negligible

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Figure 21. Summary of Results - Retro-Rail Test 01-0289-005



Note: Cameras triggered late, no images at impact.



t = Impact

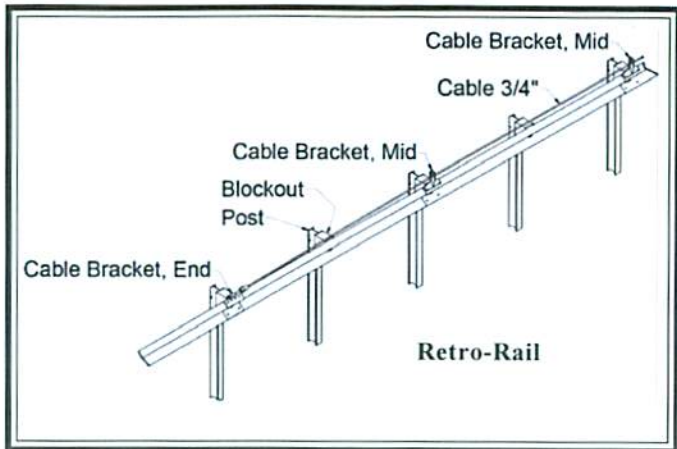
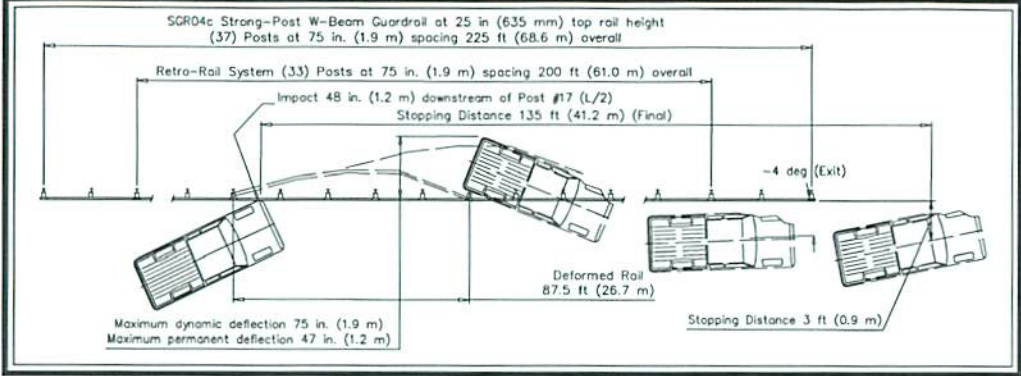
t = 0.175sec

t = 0.350sec

t = 0.525sec

t = 0.700sec

t = Final



E-TECH Testing Services, Inc.

**General Information**

Test Agency .....	E-TECH Testing Services
Test Designation .....	MASH Test 3-11
Test No. ....	01-0289-006
Date .....	8/16/13
Test Article	
Type .....	Trinity Highway Products, LLC Retro-Rail System
Installation Length .....	SGR04b Guardrail 225 ft (68.6 m) overall at 25 in. (635 mm) top height with 200 ft (61.0 m) Retro-Rail
Material and key elements .....	Retro-Rail Cable 3/4 in. (19 mm) 3 x 7 galvanized, End and Mid Brackets galvanized steel
Foundation Type and Condition .....	AASHTO Strong Soil, compacted and well drained
Test Vehicle	
Type .....	Production Model
Designation .....	2270P
Model .....	2007 GMC Pickup
Mass	
Curb .....	5245 lb (2379 kg)
Test inertial .....	5066 lb (2298 kg)
Dummy .....	N/A
Gross Static .....	5066 lb (2298 kg)
Impact Conditions	
Speed .....	61.6 mi/h (99.2 km/h)
Angle (deg) .....	25
Impact Severity .....	114.9 ft-kip (155.7 kJ)

**Exit conditions**

Speed .....	1.9 mi/h (3.0 km/h)
Angle (deg - veh. c.g.) .....	-4
Occupant Risk Values (absolute values)	
Impact Velocity	
x-direction .....	17.2 ft/s (5.3 m/s)
y-direction .....	12.8 ft/s (3.9 m/s)
Ridedown Acceleration (g's)	
x-direction .....	9.6
y-direction .....	8.4
European Committee for Normalization (EN) Values	
THIV .....	14.1 mi/h (22.7 km/h)
PHD (g's) .....	12.6
ASI .....	0.7
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle .....	36.4
Maximum Pitch Angle .....	9.0
Maximum Yaw Angle .....	28.3
Test Article Deflections	
Dynamic .....	75 in. (1.9 m)
Permanent .....	47 in. (1.2 m)
Vehicle Damage (Primary Impact)	
Exterior	
VDS .....	LFQ-3
CDC .....	11LFEW3
Interior	
VCDI .....	NS0000000
Maximum Deformation .....	Negligible

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Figure 26. Summary of Results - Retro-Rail Test 01-0289-006