U.S. Department
of Transportation
Federal Highway Administration

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

June 15, 2017

In Reply Refer To:
HSST-1/CC-133

Mr. Gerrit A. Dyke
Lindsay Transportation Solutions, Inc.
180 River Road
Rio Vista, CA 94571

Dear Mr. Dyke:

This letter is in response to your February 7, 2017 request for the Federal Highway Administration (FHWA) to review a roadside safety device, hardware, or system for eligibility for reimbursement under the Federal-aid highway program. This FHWA letter of eligibility is assigned FHWA control number CC-133 and is valid until a subsequent letter is issued by FHWA that expressly references this device.

Decision

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

- MAX-Tension™ Guardrail Terminal System (MAX™)

Scope of this Letter

To be found eligible for Federal-aid funding, new roadside safety devices should meet the crash test and evaluation criteria contained in the American Association of State Highway and Transportation Officials'(AASHTO) Manual for Assessing Safety Hardware (MASH). However, the FHWA, the Department of Transportation, and the United States Government do not regulate the manufacture of roadside safety devices. Eligibility for reimbursement under the Federal-aid highway program does not establish approval, certification or endorsement of the device for any particular purpose or use.

This letter is not a determination by the FHWA, the Department of Transportation, or the United States Government that a vehicle crash involving the device will result in any particular outcome, nor is it a guarantee of the in-service performance of this device. Proper manufacturing, installation, and maintenance are required in order for this device to function as tested.

This finding of eligibility is limited to the crashworthiness of the system and does not cover other structural features, nor conformity with the Manual on Uniform Traffic Control Devices.

Eligibility for Reimbursement

Based solely on a review of crash test results and certifications submitted by the manufacturer, and the crash test laboratory, FHWA agrees that 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). Therefore, the device is eligible for reimbursement under the Federal-aid highway program if installed under the range of tested conditions.

Name of system: MAX-Tension™ Guardrail Terminal System (MAX™)
Type of system: Crash Cushion
Test Level: AASHTO MASH Test Level 3
Testing conducted by: Safe Technologies, Inc.
Date of request: February 7, 2017
Date initially acknowledged: February 10, 2017
Date of completed package: February 10, 2017

FHWA concurs with the recommendation of the accredited crash testing laboratory as stated within the attached form.

Full Description of the Eligible Device

The device and supporting documentation, including reports of the crash tests or other testing done, videos of any crash testing, and/or drawings of the device, are described in the attached form.

Notice

This eligibility letter is issued for the subject device as tested. Modifications made to the device are not covered by this letter and will need to be tested in accordance with all recommended tests in AASHTO's MASH as part of a new and separate submittal.

You are expected to supply potential users with sufficient information on design, installation and maintenance 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 AASHTO's MASH.

Issuance of this letter does not convey property rights of any sort or any exclusive privilege. This letter is based on the premise that information and reports submitted by you are accurate and correct. We reserve the right to modify or revoke this letter if: (1) there are any inaccuracies in the information submitted in support of your request for this letter, (2) the qualification testing was flawed, (3) in-service performance or other information reveals safety problems, (4) the system is significantly different from the version that was crash tested, or (5) any other information indicates that the letter was issued in error or otherwise does not reflect full and complete information about the crashworthiness of the system.

Standard Provisions

- To prevent misunderstanding by others, this letter of eligibility designated as FHWA control number CC-133 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 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.

- If the subject device is a patented product it may be considered to be proprietary. If proprietary systems are specified by a highway agency for use on Federal-aid projects: (a) they must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that they are essential for synchronization with the existing highway facilities or that no equally suitable alternative exists; or (c) they must be used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes. Our regulations concerning proprietary products are contained in Title 23, Code of Federal Regulations, Section 635.411.

Sincerely,

Robert Ritter
Acting Director, Office of Safety
Technologies
Office of Safety

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter	Date of Request:	February 07, 2017	◉ New ○ Resubmission
	Name:	Gerrit A. Dyke, P.E.	
	Company:	Lindsay Transportation Solutions, Inc.	
	Address:	180 River Road, Rio Vista, CA 94571	
	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.

Device & Testing Criterion - Enter from right to left starting with Test Level

!-!-!

System Type	Submission Type	Device Name / Variant	Testing Criterion	Test Level
'CC': Crash Cushions, Attenuators, & Terminals	◉ Physical Crash Testing ○ Engineering Analysis	MAX-Tension	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.

Individual or Organization responsible for the product:

Contact Name:	Gerrit A. Dyke, P.E.	Same as Submitter ☒
Company Name:	Lindsay Transportation Solutions, Inc.	Same as Submitter ☒
Address:	180 River Road, Rio Vista, CA 94571	Same as Submitter ☒
Country:	USA	Same as Submitter ☒

Enter below all disclosures of financial interests as required by the FHWA `Federal-Aid Reimbursement Eligibility Process for Safety Hardware Devices' document.

Safe Technologies, Inc. (STI) performs testing and analysis services for Lindsay Transportation Solutions, Inc. (LTS). STI is a wholly owned subsidiary of LTS. STI is a fully accredited crash test facility per A2LA 17025 and recognized by the US Federal Highway Administration (FHWA) to perform full scale crash tests per NCHRP Report 350 and MASH criteria.

The STI laboratory manager, technicians, and laborers are compensated by LTS for salaries and wages. The STI staff does not receive any incentive, compensation, commissions, or professional fees corresponding to the outcome of any testing or analysis.

STI or staff does not receive any research funding or other research support from LTS. STI and staff also do not have any financial interest in patents, copyrights, or other intellectual property associated with the products they perform testing or analysis on.

KARCO Engineering, LLC. was contracted by LTS to collaborate with STI for this testing program. KARCO provided guidance, recommendations, and suggestions for testing and reporting practices. KARCO reviewed test data and reports to ensure accuracy and correct representation of test parameters and results. KARCO nor any testing facility employee has any financial interest in LTS, STI, or the product being tested.

PRODUCT DESCRIPTION

(•) New Hardware or Significant Modification ( ) Modification to Existing Hardware

The MAX-Tension™ Guardrail Terminal System (MAX™) is a re-directive gating end terminal for corrugated W-beam barrier systems in tangent configurations. The MAX system utilizes tensioned cables, telescoping panels, and a cutting tooth to absorb the kinetic energy and safely contain or redirect impacting vehicles. The system is comprised of a friction based energy absorbing impact head, two tension cables, a releasable post 1, a ground anchor assembly, and an energy absorbing coupler with integrated cutting tooth used in conjunction with standard AASHTO 12 Gauge guardrail panels, posts, blockouts, and hardware. The system length is approximately 27ft [8.2m] and has an effective length of approximately 50 ft [15.25m], with the anchor assembly extending forward approximately 4 ft [1.2m]. The Length of Need is at Post 3, 9ft 4in [2.86m] downstream of the first post.

The MAX can be applied directly to W-Beam guardrail systems at, or transitioned to, 31" rail height with panels and post spacing configured at mid-span splice. Transitions to strong post W-beam guardrail systems or other barriers where the splice is not mid-span can be accomplished using 3ft 1 1/2in [0.95m], 9ft 4 1/2in [2.85m], or 15ft 7 1/2in [4.75m] panels after the MAX system (minimum 50ft [15.25m] downstream of the first post) in accordance with Federal, State, and local standards. Transitions to other barrier systems such as thrie beam or rigid bridge or roadside barriers shall be in accordance with Federal, State, and local requirements and attached after the MAX system (minimum 50ft [15.25m] downstream of the first post).

The MAX can be applied with a 0 to 2 ft [610mm] offset in accordance with FHWA recommendations and memorandum titled "Guidelines for the Selection of W-Beam Barrier Terminals" dated October 26, 2004.

The MAX may be configured using wood or composite blockouts with 8in [200mm] or 12in [305mm] depths. Reference Enclosure A, "MAX-Tension System Configurations Justification".

The MAX may utilize standard AASHTO 8.5lb/ft or 9lb/ft line posts after post number one. Reference Enclosure A.

The MAX may utilize standard AASHTO M-180 12 Gauge panels in 12ft -6in [3.8m] or 25ft [7.6m] lengths within the system. Reference Enclosure A.

The MAX may be painted, stained, or powder coated on surfaces that do not effect the function of the system in place of or in addition to galvanizing. Reference Enclosure A for details regarding surfaces that may be coated and the components or surfaces that should not.

Any delineation pattern, tape, or decal may be placed on the Delineation Bracket attached to the MAX impact head. In addition, several variations of brackets may be utilized with the MAX. Reference Enclosure A.

The MAX may display identification decals, tags, or stamps for product identification, component tracking and quality control. The identification method and location shall not effect the capacity, function, or performance of the MAX. Reference Enclosure A.

Two minor modifications to the system components are proposed in Enclosure A. The section titled "Stamped vs. Welded Traffic Side Slider Brackets" details an alternative manufacturing method for the coupler where it is stamped from a single sheet of steel instead of welding two components together. The section titled "Soil Anchor Modification" details a reduction in length of stiffeners intended to support the post during installation. These components may be fabricated in either configurations with no effect on the capacity, function, or performance of the MAX.

CRASH TESTING

By signature below, the Engineer affiliated with the testing laboratory, agrees in support of this submission that all of the critical and relevant crash tests for this device listed above were conducted to meet the MASH test criteria. The Engineer has determined that no other crash tests are necessary to determine the device meets the MASH criteria.

Engineer Name:	Joseph Nagy	
Engineer Signature:	Joseph Nagy — Digitally signed by Joseph Nagy Date: 2017.02.07 16:58:26 -08'00'	
Address:	170 River Road, Rio Vista, CA 94571	Same as Submitter ☐
Country:	USA	Same as Submitter ☐

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	The MAX-Tension End Terminal satisfied the MASH structural adequacy criteria for its intended function as an end terminal. The test article first captured and later redirected the 1100C vehicle in a controlled manner. The vehicle did not penetrate, underride, or override the installation. The test article exhibited controlled permanent and dynamic deflection in the test. All of the occupant risk criteria were satisfied in testing the MAX-Tension End Terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were well below the preferred limit of 30.0 ft/s (9.6 m/s). Ridedown accelerations in the longitudinal and lateral directions were well below the preferred limit of 15.0 G. There was no test article debris detached during the test. There was no deformation to the occupant compartment of the 1100C test vehicle. There were no intrusions into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll, pitch and yaw. The MAX-Tension End Terminal was judged as satisfying the applicable MASH vehicle trajectory criteria. The Terminal was judged to have successfully met all of the evaluation criteria for MASH Test 3-30.	PASS

Required Test Number	Narrative Description	Evaluation Results
3-31 (2270P)	Test MET015 and Test MET170105: The MAX-Tension End Terminal satisfied the MASH structural adequacy criteria for its intended function as an End Terminal in both tests. The test article captured the 2270P vehicles in a controlled manner. The vehicles did not penetrate, underride, or override the installation. The test articles exhibited controlled permanent and dynamic deflection in each test. All of the occupant risk criteria were satisfied in both tests. Theoretical occupant impact velocities in the longitudinal and lateral directions were all well below the preferred limit of 30.0 ft/s (9.1 m/s). Ridedown accelerations in the longitudinal and lateral directions were well below the preferred limit of 15 G. There was no test article debris detached during the tests. There was no deformation to the occupant compartments of the 2270P test vehicles. There were no intrusions into the occupant compartments. The test vehicles remained upright during and after the collision with minor roll, pitch and yaw. The vehicle did not intrude into adjacent lanes. The MAX-Tension End Terminal was judged as satisfying the applicable MASH vehicle trajectory criteria in both tests. The Terminal was judged to have successfully met all of the evaluation criteria for MASH Test 3-31in each test.	PASS

3-32 (1100C)	The MAX-Tension End Terminal satisfied the MASH structural adequacy criteria for its intended function as an End Terminal. The test article captured the 1100C vehicle in a controlled manner. The vehicle did not penetrate, underride, or override the installation. The test article exhibited controlled permanent and dynamic deflection in the test. All of the occupant risk criteria were satisfied in testing the MAX-Tension End Terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were well below the maximum limit of 40.0 ft/s (12 m/s). Ridedown accelerations in the longitudinal and lateral directions were well below the preferred limit of 15.0 G. There was no test article debris detached during the test. There was no deformation to the occupant compartment of the 1100C test vehicle. There were no intrusions into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll, pitch and yaw. The MAX-Tension End Terminal was judged as satisfying the applicable MASH vehicle trajectory criteria. The Terminal was judged to have successfully met all of the evaluation criteria for MASH Test 3-32.	PASS

3-33 (2270P)	The MAX-Tension End Terminal satisfied the MASH structural adequacy criteria for its intended function as an End Terminal. The test article captured the 2270P vehicle in a controlled manner and brought the vehicle to a safe and stop. The vehicle did not gate to the backside of the system. The vehicle did not penetrate, underride, or override the installation. The test article exhibited controlled permanent and dynamic deflection in the test. All of the occupant risk criteria were satisfied . Theoretical occupant impact velocities in the longitudinal and lateral directions were well below the preferred limit of 30.0 ft/s (9.1 m/s). Ridedown accelerations in the longitudinal and lateral directions were well below the preferred limit of 15 G. There was no test article debris detached during the test. There was no deformation to the occupant compartment of the 2270P test vehicle. There were no intrusions into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll, pitch and yaw. The vehicle did not intrude into adjacent lanes. The MAX-Tension End Terminal was judged as satisfying the applicable MASH vehicle trajectory criteria. The Terminal was judged to have successfully met all of the evaluation criteria for MASH Test 3-33.	PASS

3-34 (1100C)	The MAX-Tension End Terminal satisfied the MASH structural adequacy criteria for its intended function as an End Terminal. The test article redirected the 1100C vehicle in a controlled manner. The vehicle did not penetrate, underride, or override the installation. The test article exhibited some permanent and dynamic deflection in the test. All of the occupant risk criteria were satisfied. Theoretical occupant impact velocities in the longitudinal and lateral directions were well below the preferred limit of 30.0 ft/s (9.1 m/s). Ridedown accelerations in the longitudinal and lateral directions were well below the preferred limit of 15.0 G. There was no test article debris detached during the test. There was no deformation to the occupant compartment of the 1100C test vehicle. There were no intrusions into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll, pitch and yaw. The MAX-Tension End Terminal was judged as satisfying the applicable vehicle trajectory criteria in MASH. There was no vehicle intrusion into adjacent lanes. The Terminal was judged to have successfully met all of the evaluation criteria for MASH Test 3-34.	PASS

3-35 (2270P)	The MAX-Tension End Terminal satisfied the MASH structural adequacy criteria for its intended function as an End Terminal. The test article contained the 2270P vehicle in a controlled manner and brought the vehicle to a safe and controlled stop. The vehicle did not penetrate, underride, override or gate the installation. The test article exhibited some permanent and dynamic deflection in the test. All of the occupant risk criteria were satisfied in testing the MAX-Tension End Terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were well below the preferred limit of 30.0 ft/s (9.1 m/s). Ridedown accelerations in the longitudinal and lateral directions were well below the preferred limit of 15.0 G. There was no test article debris detached during the test. There was no deformation to the occupant compartment of the 2270P test vehicle. There were no intrusions into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll, pitch and yaw. The MAX-Tension End Terminal was judged as satisfying the applicable vehicle trajectory criteria in MASH. There was no vehicle intrusion into adjacent lanes. The Terminal was judged to have successfully met all of the evaluation criteria for MASH Test 3-35.	PASS
3-36 (2270P)	The MAX-Tension is applied only to corrugated W-profile guardrail barrier systems of equal lateral stiffness. Therefore this test is not relevant and was not conducted.	Non-Relevant Test, not conducted

3-37 (2270P)	The MAX-Tension End Terminal satisfied the MASH structural adequacy criteria for its intended function as an end Terminal. The test article redirected the 2270P vehicle in a controlled manner. The vehicle did not gate to the backside of the system. It did not penetrate, underride, or override the installation. The test article exhibited controlled permanent and dynamic deflection in the test. All of the occupant risk criteria were satisfied in testing the MAX-Tension End Terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were well below the preferred limit of 30.0 ft/s (9.1 m/s) . Ridedown accelerations in the longitudinal and lateral directions were well below the preferred limit of 15.0 G. There was no test article debris detached during the test except for pieces of a blockout that shattered upon impact. There was no deformation to the occupant compartment of the 2270P test vehicle. There were no intrusions into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll, pitch and yaw. The MAX-Tension End Terminal was judged as satisfying the applicable vehicle trajectory criteria in MASH. The Terminal was judged to have successfully met all of the evaluation criteria for MASH Test 3-37.	PASS
3-38 (1500A)	Calculations performed to demonstrate acceptable occupant risk values per MASH evaluation criteria. Reference Enclosure A, "MAX-Tension System Configurations Justification" section titled "1500A Vehicle Mathematical Simulation".	PASS
3-40 (1100C)		Non-Relevant Test, not conducted
3-41 (2270P)		Non-Relevant Test, not conducted
3-42 (1100C)		Non-Relevant Test, not conducted
3-43 (2270P)		Non-Relevant Test, not conducted
3-44 (2270P)		Non-Relevant Test, not conducted
3-45 (1500A)		Non-Relevant Test, not conducted

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:	Safe Technologies, Inc.	
Laboratory Signature:	Joseph Nagy Digitally signed by Joseph Nagy Date: 2017.02.07 17:04:57 -08'00'	
Address:	170 River Road, Rio Vista, CA 94571	Same as Submitter ☐
Country:	USA	Same as Submitter ☐
Accreditation Certificate Number and Dates of current Accreditation period :	1851.01, Valid through March 31, 2017	

Submitter Signature*: Gerrit Dyke Digitally signed by Gerrit Dyke Date: 2017.02.07 17:06:30 -08'00'

Submit Form

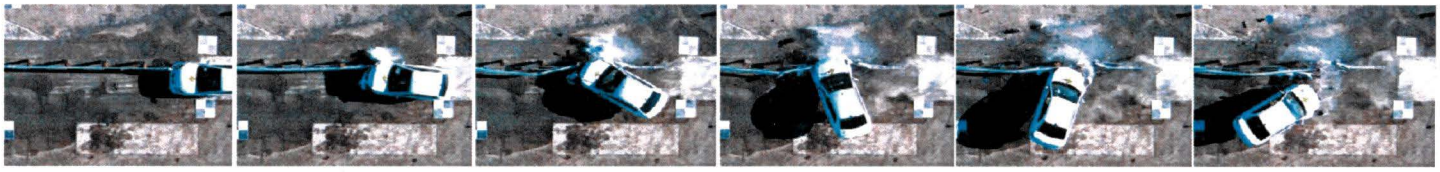
ATTACHMENTS

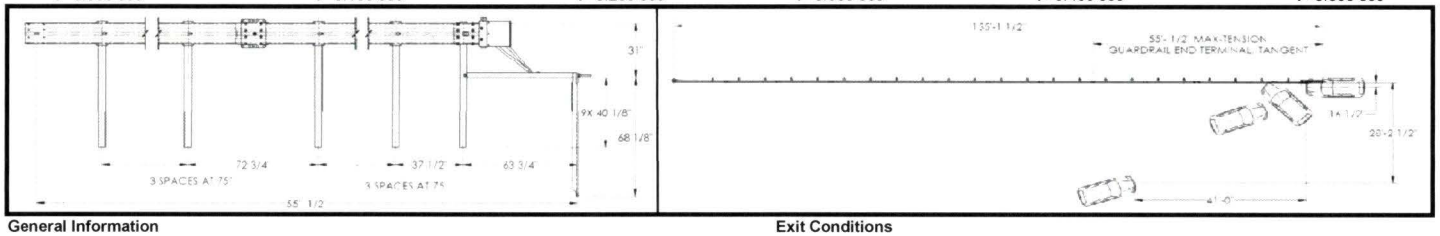
Attach to this form:

1) Additional disclosures of related financial interest as indicated above.
2) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
3) 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 relevant to understanding the dimensions and performance of the device should also be submitted to facilitate our review.

FHWA Official Business Only:

Eligibility Letter		
Number	Date	Key Words





General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET161228
Test Designation	MASH 3-30
Date	12/28/2016

Test Article

Name	Lindsay Transportation - MaX-Tension
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3m)
Width	17.4 in (441.3mm)
Height	31 in (787mm)

Soil Conditions

Type of Soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	12,933 lbs

Test Vehicle

Type / Designation	1100C
Make and Model	2011 Kia Rio, 4-Door
Curb Weight	2463.7 lbs (1117.5 kg)
Test Inertial Weight	2280.7 lbs (1034.5 kg)
Gross Static Weight	2446.0 lbs (1109.5 kg)

Impact Conditions

Speed	61.7 mph (99.3 km/h)
Angle	0 deg
Location / Orientation	1/4 Offset

Exit Conditions

Speed (mph)	21.4 (34.5 km/h)
Angle (deg)	31

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance, ft (m)	41 (12.5) dwnstrm and 28.2 (8.6) to the left

Occupant risk Values

Longitudinal OIV	31.5 ft/s (9.6 m/s)
Lateral OIV	3.9 ft/s (1.2 m/s)
Longitudinal ORA	11.2 g's
Lateral ORA	5.8 g's
THIV	31.8 ft/s (9.7 m/s)
PHD	12.5 g's
ASI	1.22

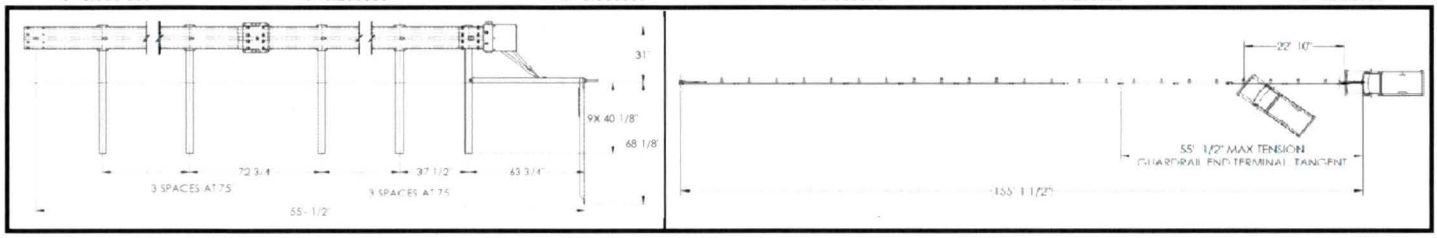
Test Article Damage Substantial

Test Article Deflections

Permanent	10.6 in (0.27 m) front 7.5 in (0.19 m) rear
Dynamic	19.1 in (0.49 m) front

Vehicle Damage

VDS	12-FR-5
CDC	12FREN3
Interior Deformation	No interior damage



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET170105
Test Designation	MASH 3-31
Date	1/5/2017

Test Article

Name	Lindsay Transportation - MAX-Tension
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3m)
Width	17.4 in (441.3mm)
Height	31 in (787mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	13,767 lbs

Test Vehicle

Type / Designation	2270P
Make and Model	2012 Dodge Ram 1500 Quad Cab Pickup
Curb Weight	4790.6 lbs (2173.0 kg)
Test Inertial Weight	5022.1 lbs (2278.0 kg)
Gross Static Weight	5022.1 lbs (2278.0 kg)

Impact Conditions

Speed	62.6 mph (100.7 km/h)
Angle	0.0 deg
Location / Orientation	Front/Center

Exit Conditions

Speed (mph)	N/A
Angle (deg)	N/A

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	22.8 ft (7.0 m)
Vehicle Snagging/Pocketing	Captured

Occupant risk Values

Longitudinal OIV	24.3 ft/s (7.4 m/s)
Lateral OIV	1.6 ft/s (0.5 m/s)
Longitudinal ORA	9.4 g's
Lateral ORA	2.4 g's
THIV	24.3 ft/s (7.4 m/s)
PHD	9.6 g's
ASI	0.82

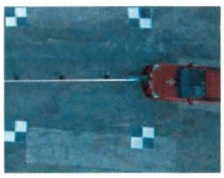
Test Article Damage Substantial

Test Article Deflections

Permanent lateral deflection	2.38 ft (0.73 m)
Longitudinal system stroke	20.8 ft (6.3 m)

Vehicle Damage

VDS	12-FC-5
CDC	12FCEN2
Maximum Deformation	No interior damage



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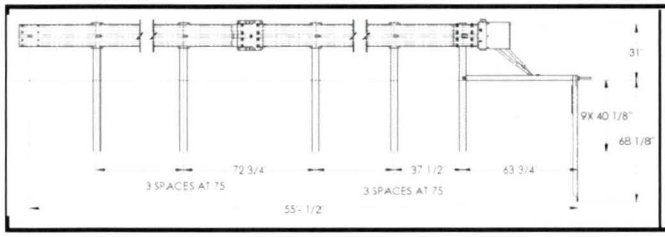
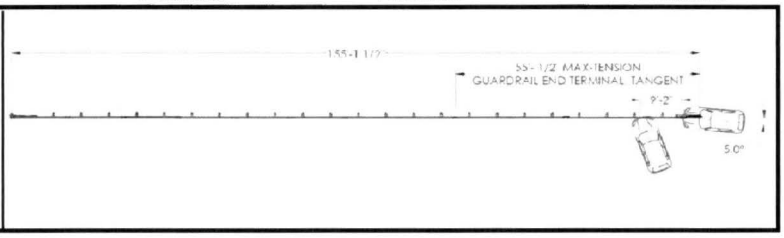




General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET161203
Test Designation	MASH 3-32
Date	12/3/2016

Test Article

Name	Lindsay Transportation - MaX-Tension
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3m)
Width	17.4 in (441.3mm)
Height	31 in (787mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	17,198 lbs

Test Vehicle

Type / Designation	1100C
Make and Model	2011 Kia Rio
Curb Weight	2428.4 lbs (1101.5 kg)
Test Inertial Weight	2436.1 lbs (1105.0 kg)
Gross Static Weight	2601.5 lbs (1180.0 kg)

Impact Conditions

Speed	61.6 mph (99.2 km/h)
Angle	5.0 deg
Location / Orientation	Front/Center

Exit Conditions

Speed (mph)	N/A
Angle (deg)	N/A

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	9.5 ft (2.9m)
Vehicle Snagging/Pocketing	None

Occupant risk Values

Longitudinal OIV	35.4 ft/s (10.8 m/s)
Lateral OIV	0.7 ft/s (0.2 m/s)
Longitudinal ORA	10.9 g's
Lateral ORA	3.3 g's
THIV	35.4 ft/s (10.8 m/s)
PHD	11 g's
ASI	1.49

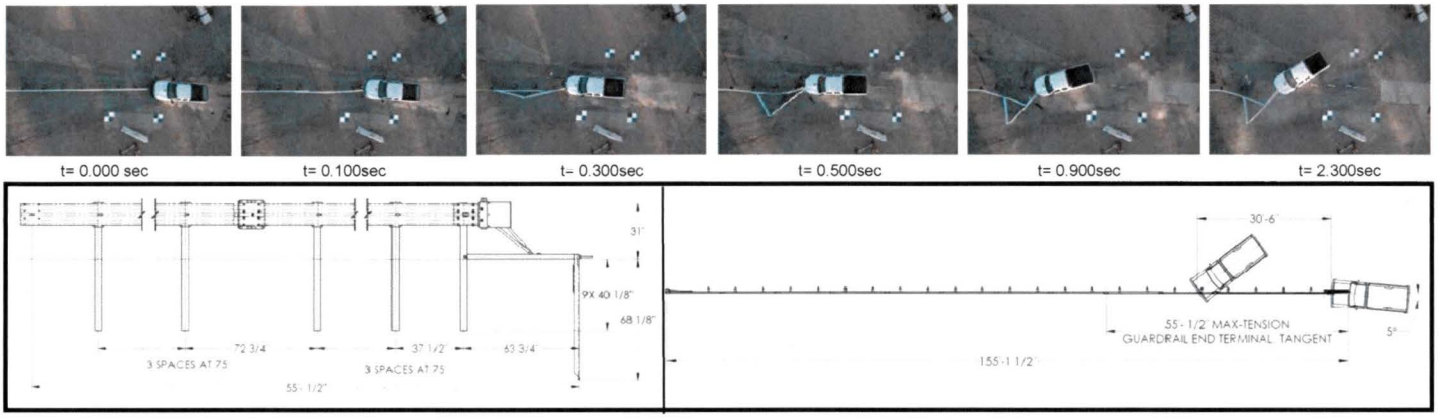
Test Article Deformation Moderate

Test Article Deflections

Permanent	9.0 in (0.23 m) front
Dynamic	19.1 in (0.49 m) front

Vehicle Damage

VDS	12-FC-6
CDC	12FDEN3
Maximum Deformation	No interior damage



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET161206
Test Designation	MASH 3-33
Date	12/6/2016

Test Article

Name	Lindsay Transportation - MaX-Tension
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3m)
Width	17.4 in (441.3mm)
Height	31 in (787mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	16,041 lbs

Test Vehicle

Type / Designation	2270P
Make and Model	2010 Dodge Ram 1500 Quad Cab Pickup
Curb Weight	4968.1 lbs (2253.5 kg)
Test Inertial Weight	4973.6 lbs (2256.0 kg)
Gross Static Weight	4973.6 lbs (2256.0 kg)

Impact Conditions

Speed	62.3 mph (100.5 km/h)
Angle	5.5 deg
Location / Orientation	Front/Center

Exit Conditions

Speed (mph)	N/A
Angle (deg)	N/A

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	30.5 ft (9.3m)
Vehicle Snagging/Pocketing	None

Occupant risk Values

Longitudinal OIV	24.9 ft/s (7.6 m/s)
Lateral OIV	0.0 ft/s (0.0 m/s)
Longitudinal ORA	10.4 g's
Lateral ORA	3.1 g's
THIV	24.9 ft/s (7.6 m/s)
PHD	10.4 g's
ASI	0.75

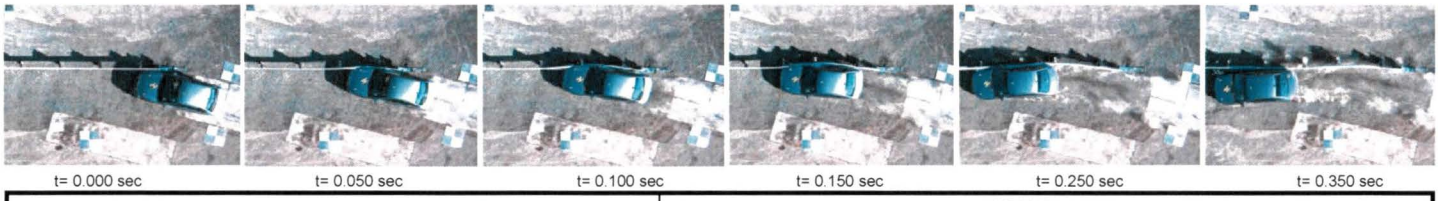
Test Article Damage Substantial

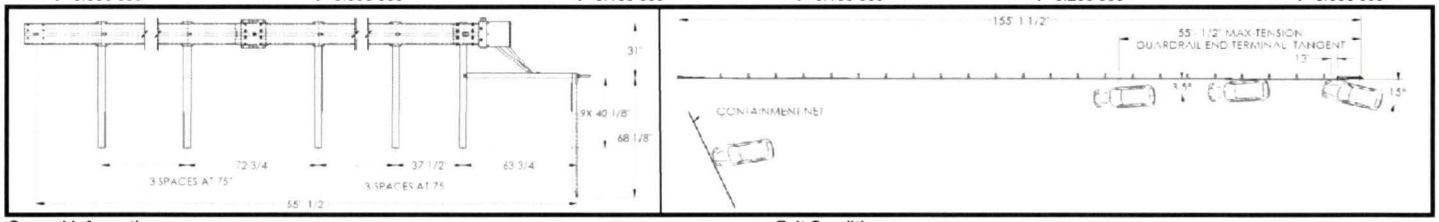
Test Article Deflections

Permanent	11.55 ft (3.52m)
Dynamic	11.64 ft (3.55m)

Vehicle Damage

VDS	12-FC-5
CDC	12FCEN2
Maximum Deformation	No interior damage





General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET161229
Test Designation	MASH 3-34
Date	12/29/2016

Test Article

Name	Lindsay Transportation - MaX-Tension
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3m)
Width	17.4 in (441.3mm)
Height	31 in (787mm)

Soil Conditions

Type of Soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	12,934 lbs

Test Vehicle

Type / Designation	1100C
Make and Model	2011 Kia Rio, 4-Door
Curb Weight	2444.9 lbs (1109.0 kg)
Test Inertial Weight	2282.9 lbs (1035.5 kg)
Gross Static Weight	2448.2 lbs (1110.5 kg)

Impact Conditions

Speed	62.2 mph (100.1 km/h)
Angle	15.0 deg
Location / Orientation	13" downstream from middle of post 1

Exit Conditions

Speed (mph)	46.2 (74.3 km/h)
Angle (deg)	3.5

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	NA - captured
Vehicle Snagging/Pocketing	None

Occupant risk Values

Longitudinal OIV	10.8 ft/s (3.3 m/s)
Lateral OIV	17.7 ft/s (5.4 m/s)
Longitudinal ORA	8.6 g's
Lateral ORA	9.6 g's
THIV	19.0 ft/s (5.8 m/s)
PHD	9.7 g's
ASI	0.65

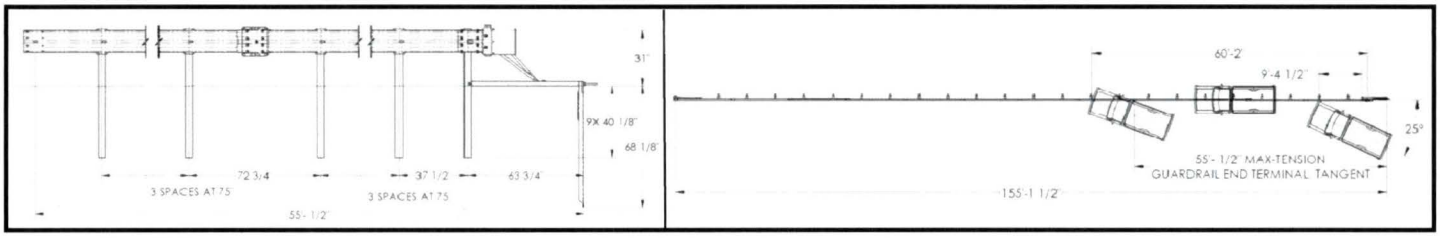
Test Article Damage: Moderate

Test Article Deflections

Permanent	7.1 in (0.18m)
Dynamic	11.4 in (0.29m)

Vehicle Damage

VDS	1-RFQ-4
CDC	01FREA3
Interior Deformation	No interior damage



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET161212
Test Designation	MASH 3-35
Date	12/12/2016

Test Article

Name	Lindsay Transportation - MaX-Tension
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3m)
Width	17.4 in (441.3mm)
Height	31 in (787mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	13,489 lbs

Test Vehicle

Type / Designation	2270P
Make and Model	2010 Dodge Ram 1500 Quad Cab Pickup
Curb Weight	4692.5 lbs (2128.5 kg)
Test Inertial Weight	4984.7 lbs (2261.0 kg)
Gross Static Weight	4984.7 lbs (2261.0 kg)

Impact Conditions

Speed	62.3 mph (100.3 km/h)
Angle	25.0 deg
Location / Orientation	2.86m downstream from middle of post 1

Exit Conditions

Speed (mph)	N/A
Angle (deg)	N/A

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	60.2 ft (18.33m)
Vehicle Snagging/Pocketing	Some (see Figure 8)

Occupant risk Values

Longitudinal OIV	17.4 ft/s (5.3 m/s)
Lateral OIV	13.8 ft/s (4.2 m/s)
Longitudinal ORA	10.7 g's
Lateral ORA	7.5 g's
THIV	21.3 ft/s (6.5 m/s)
PHD	12.7 g's
ASI	0.64

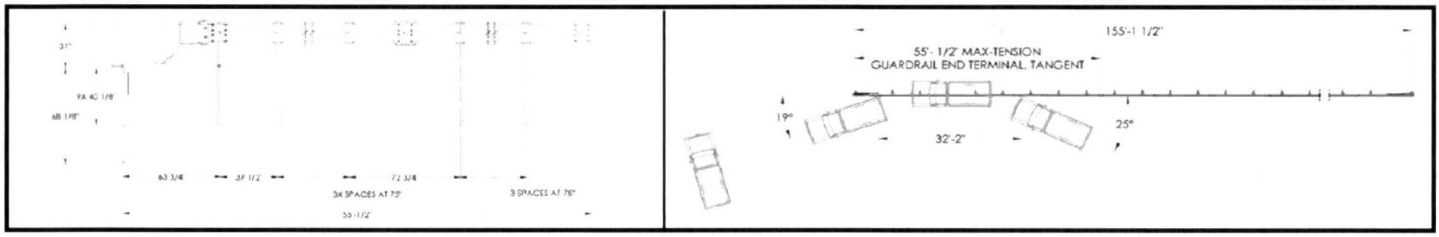
Test Article Damage Substantial

Test Article Deflections

Permanent	4.27 ft (1.30m)
Dynamic	5.25 ft (1.60m)

Vehicle Damage

VDS	1-RFQ-4
CDC	01FREA4
Maximum Deformation	No interior damage



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET161220
Test Designation	MASH 3-37
Date	12/20/2016

Test Article

Name	Lindsay Transportation - MaX-Tension
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3m)
Width	17.4 in (441.3mm)
Height	31 in (787mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	14,705 lbs

Test Vehicle

Type / Designation	2270P
Make and Model	2011 Dodge Ram 1500 Quad Cab Pickup
Curb Weight	5069.5 lbs (2299.5 kg)
Test Inertial Weight	5006.7 lbs (2271.0 kg)
Gross Static Weight	5006.7 lbs (2271.0 kg)

Impact Conditions

Speed	62.4 mph (100.4 km/h)
Angle	25.0 deg
Location / Orientation	32.2 ft (9.8 m) from post 1

Exit Conditions

Speed (mph)	23.1 (37.1 km/h)
Angle (deg)	19

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	28.48 ft (8.7m)
Vehicle Snagging/Pocketing	Some snagging and pocketing

Occupant risk Values

Longitudinal OIV	16.7 ft/s (5.1 m/s)
Lateral OIV	15.1 ft/s (4.6 m/s)
Longitudinal ORA	6.5 g's
Lateral ORA	7.2 g's
THIV	22.3 ft/s (6.8 m/s)
PHD	9.1 g's
ASI	0.66

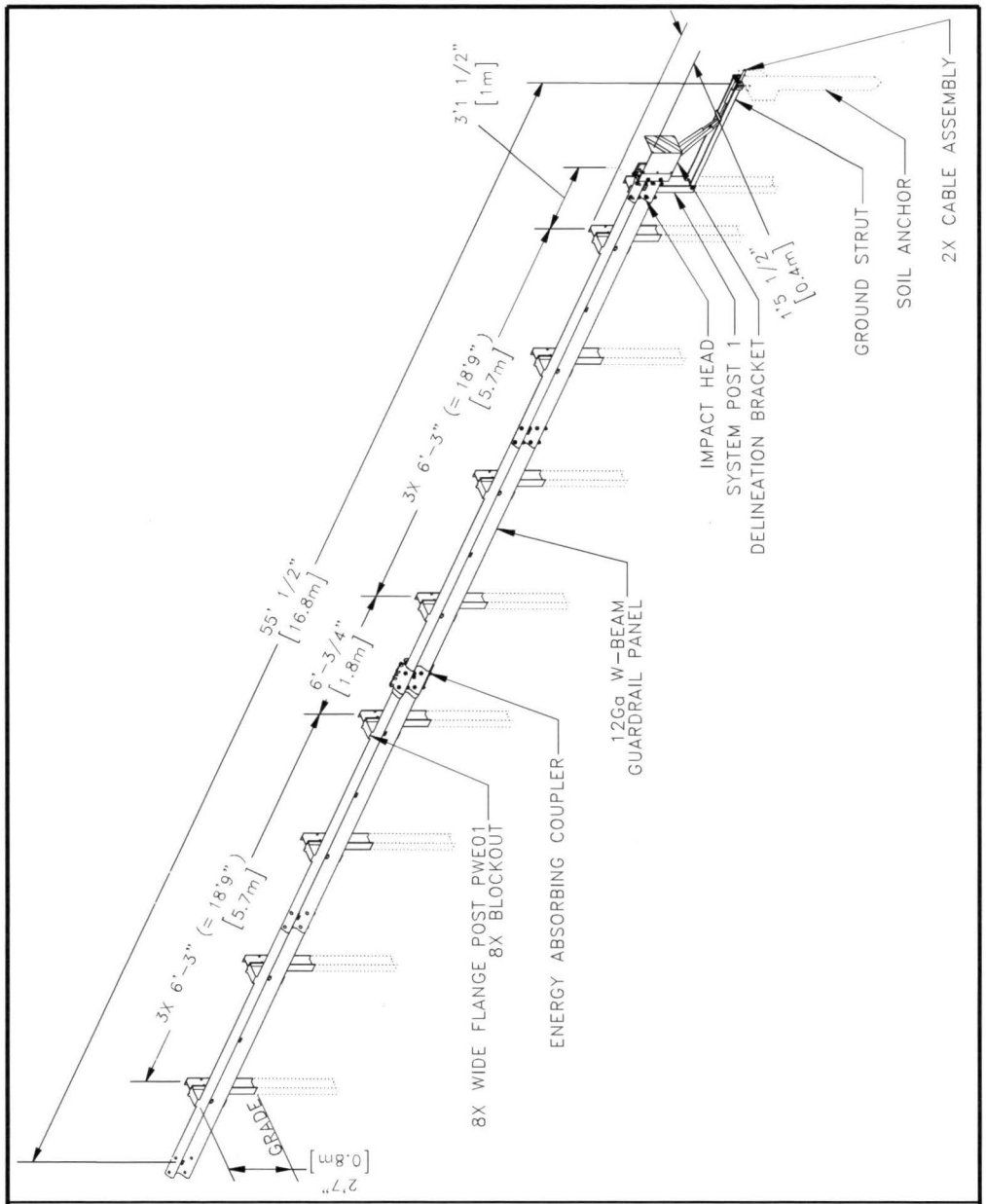
Test Article Damage Substantial

Test Article Deflections

Permanent	1.87 ft (0.57m)
Dynamic	3.64 ft (1.11m)

Vehicle Damage

VDS	1-RFQ-4
CDC	01FYEA3
Maximum Deformation	No interior damage



MAX-TENSION GUARDRAIL END TERMINAL, TANGENT

LINDSAY™ TRANSPORTATION SOLUTIONS | ROAD ZIPPER® BY LINDSAY

Lindsay Transportation Solutions, 180 River Rd., Rio Vista CA. 94571, 888-800-3691
www.theroadzipper.com

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SHEET NO.	DATE:
1 OF 2	.

INTENDED USE

The MAX-Tension™ Guardrail End Terminal (MAX) is a re-directive, gating tension-based end terminal for corrugated W-Beam barrier systems in tangent configurations. It can be used to protect motorists from unforgiving terminations of longitudinal barriers. The MAX system absorbs the energy and gradually decelerates an impacting vehicle when impacted head-on and contains and redirects a vehicle during side impacts. The BLON is at post 3. The MAX system integrates directly into a corrugated W-Beam guardrail system.

The system consists of an impact head, energy absorbing coupler, two tension cables, soil anchor and ground strut, in addition to standard guardrail components such as posts, blockouts, and rails. The system can be installed on any guardrail system transitioned to a rail height of 31" [787] with mid-span splices. Contact the manufacturer for further information and installation instructions.

The MAX-Tension can be applied in the following configurations:

- 8" or 12" blockouts, wood or composite
- Standard AASHTO line post can be 8.5 or 9 lb/ft
- Four standard AASHTO 12 Ga. 12-'6" 4-Space W-beam or two 25'-0" 4-Space W-beam rails
- Transition to 27 1/2" downstream guardrail with or without mid-span splice
- Transition directly to thrie-beam or other bridge rail transition
- Up to 2 ft. offset

APPROVALS

The MAX-Tension Tangent system has been fully tested in conformance with MASH Test Level 3 and is eligible for Federal reimbursement.

FHWA Eligibility Letters: XXXXXXX

CONTACT INFORMATION

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MAX-TENSION GUARDRAIL END TERMINAL, TANGENT