U.S. Department
of Transportation
Federal Highway
Administration

December 17, 2018

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

In Reply Refer To:
HSST-1/CC-134A

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 November 9, 2018 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-134A 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™) MASH16

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™) MASH16
Type of system: Terminal
Test Level: AASHTO MASH Test Level 2
Testing conducted by: Safe Technologies, Inc.
Date of request: October 30, 2018
Date initially acknowledged: November 1, 2018
Date of completed package: November 9, 2018

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-134A 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.

- This FHWA eligibility letter is not an expression of any Agency view, position, or determination of validity, scope, or ownership of any intellectual property rights to a specific device or design. Further, this letter does not impute any distribution or licensing rights to the requester. This FHWA eligibility letter determination is made based solely on the crash-testing information submitted by the requester. The FHWA reserves the right to review and revoke an earlier eligibility determination after receipt of subsequent information related to crash testing.

- 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,

Michael S. Griffith

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

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter	Date of Request:	November 09, 2018	○ 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, TL-2	AASHTO MASH	TL2

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 to ISO 17025 by A2LA and is 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. STI and staff does not receive any incentives, 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 test or analyze.

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 KARCO 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™ Test Level 2 Guardrail Terminal System (MAX-TL2) is a non gating re-directive end terminal for corrugated W-beam barrier systems in tangent configurations. The MAX-TL2 system utilizes tensioned cables, a telescoping panel, 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 Ga guardrail panels, posts, blockouts, and hardware. The system length is approximately 14ft 6in [4.4m] and has an effective length of approximately 25.8 ft [7.9m], with the anchor assembly extending forward approximately 4.2 ft [1.3m]. The Length of Need is at Post 1.

The MAX-TL2 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-TL2 system (minimum 25.8ft [7.9m] 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-TL2 system (minimum 25.8ft [7.9m] downstream of the first post).

The MAX-TL2 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-TL2 may be configured using wood or composite blockouts with 8in [200mm] or 12in [305mm] depths. Reference Enclosure A, "MAX-Tension TL-2 System Configurations Justification".

The MAX-TL2 may utilize standard AASHTO 8.5lb/ft or 9lb/ft line posts after post number one. Reference Enclosure A.

The MAX-TL2 may utilize standard 25ft [7.6m] AASHTO M-180 12 Gauge panels after the slider assembly (panel 2 and beyond). Reference Enclosure A.

The MAX-TL2 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-TL2 impact head. In addition, several variations of brackets may be utilized with the MAX-TL2. See Enclosure A.

The MAX-TL2 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-TL2. 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. This component may be fabricated in either configuration with no effect on the capacity, function, or performance of the MAX-TL2.

Manufacturing drawings may be adjusted to ensure manufacturing capability and consistency with MASH tested and certified product.

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: 2018.11.09 16:26:15 -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
2-30 (1100C)	This testing as per eligibility letter CC-134 dated Jan 10, 2018. The MAX-Tension TL-2 was judged to have successfully met all of the evaluation criteria for MASH Test 2-30 for non-gating end terminals. The MAX-Tension TL-2 end terminal satisfied the MASH structural adequacy criteria for its intended function as a non-gating 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 TL-2 end terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were 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 minimal deformation to the occupant compartment of the 1100C test vehicle shown in Table 4. There was no intrusion into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll and pitch. The MAX-Tension TL-2 end terminal was judged as satisfying the applicable MASH vehicle trajectory criteria.	PASS

Required Test Number	Narrative Description	Evaluation Results
2-31 (2270P)	This testing as per eligibility letter CC-134 dated Jan 10, 2018. The MAX-Tension TL-2 was judged to have successfully met all of the evaluation criteria for MASH Test 2-31 for non-gating end terminals. The MAX-Tension TL-2 end terminal satisfied the MASH structural adequacy criteria for its intended function as a non-gating end terminal. The test article captured the 2270P 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 TL-2 end terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were below the preferred limit of 30.0 ft/s (9.1 m/s). Ridedown accelerations in the longitudinal and lateral directions were 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 shown in Table 4. There was no intrusion into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll and pitch. The MAX-Tension TL-2 end terminal was judged as satisfying the applicable MASH vehicle trajectory criteria.	PASS

2-32 (1100C)	This testing as per eligibility letter CC-134 dated Jan 10, 2018. The MAX-Tension TL-2 was judged to have successfully met all of the evaluation criteria for MASH Test 2-32 for non-gating end terminals. The MAX-Tension TL-2 end terminal satisfied the MASH structural adequacy criteria for its intended function as a non-gating 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 TL-2 end terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were below the maximum limit of 40.0 ft/s (12 m/s). Ridedown accelerations in the longitudinal and lateral directions were below the preferred limit of 15.0 G. There was no test article debris detached during the test. There was minimal deformation to the occupant compartment of the 1100C test vehicle shown in Table 4. There was no intrusion into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll and pitch. The vehicle did not intrude into adjacent lanes. The MAX-Tension TL-2 end terminal was judged as satisfying the applicable MASH vehicle trajectory criteria.	PASS

2-33 (2270P)	This testing as per eligibility letter CC-134 dated Jan 10, 2018. The MAX-Tension TL-2 was judged to have successfully met all of the evaluation criteria for MASH Test 2-33 for non-gating end terminals. The MAX-Tension TL-2 end terminal satisfied the MASH structural adequacy criteria for its intended function as a non-gating end terminal. The test article captured the 2270P 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 TL-2 end terminal. Theoretical occupant impact velocities in the longitudinal and lateral directions were 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 minimal deformation to the occupant compartment of the 2270P test vehicle shown in Table 4. There was no intrusion into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll and pitch. The MAX-Tension TL-2 end terminal was judged as satisfying the applicable MASH vehicle trajectory criteria.	PASS

2-34 (1100C)	This testing as per eligibility letter CC-134 dated Jan 10, 2018. The MAX-Tension TL-2 was judged to have successfully met all of the evaluation criteria for MASH Test 2-34 for non-gating end terminals. The MAX-Tension TL-2 end terminal satisfied the MASH structural adequacy criteria for its intended function as a non-gating 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 in testing the MAX-Tension TL-2 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 minimal deformation to the occupant compartment of the 1100C test vehicle shown in Table 4. There was no intrusion into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll and pitch. The vehicle did not intrude into adjacent lanes. The MAX-Tension TL-2 end terminal was judged as satisfying the applicable MASH vehicle trajectory criteria.	PASS

2-35 (2270P)	This testing as per eligibility letter CC-134 dated Jan 10, 2018. The MAX-Tension TL-2 was judged to have successfully met all of the evaluation criteria for MASH Test 2-35 for non-gating end terminals. The MAX-Tension TL-2 end terminal satisfied the MASH structural adequacy criteria for its intended function as a non-gating end terminal. The test article captured and redirected the 2270P 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 TL-2 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 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 was no intrusion into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll and pitch. The vehicle did not intrude into adjacent lanes. The MAX-Tension TL-2 end terminal was judged as satisfying the applicable MASH vehicle trajectory criteria.	PASS
2-36 (2270P)	The MAX-Tension TL-2 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

	The MAX-Tension TL-2 end terminal satisfied the TL-2 MASH structural adequacy criteria for its intended function as a non-gating end terminal. The test article partially redirected the 1100C vehicle in a controlled manner. 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 TL-2 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.	
2-37b (1100C)	There was some deformation to the passenger side toe pan area of the 1100C test vehicle but the deformation was within acceptable limits. There were no intrusions into the occupant compartment. The test vehicle remained upright during and after the collision with minor roll and pitch. The MAX-Tension TL-2 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 2-37b. Additional testing, MASH Test 2-37a was also performed as per eligibility letter CC-134 dated Jan 10, 2018. The terminal was judged to have successfully met all of the evaluation criteria for MASH Test 2-37a.	PASS
2-38 (1500A)	These calculations as per eligibility letter CC-134 dated Jan 10, 2018. Calculations performed to demonstrate acceptable occupant risk values per MASH evaluation criteria. Reference Enclosure A, "MAX-Tension TL-2 Configurations Justifications" section titled "1500A Vehicle (MASH Test 2-38)".	PASS
2-40 (1100C)	Not applicable.	Non-Relevant Test, not conducted
2-41 (2270P)	Not applicable.	Non-Relevant Test, not conducted
2-42 (1100C)	Not applicable.	Non-Relevant Test, not conducted
2-43 (2270P)	Not applicable.	Non-Relevant Test, not conducted
2-44 (2270P)	Not applicable.	Non-Relevant Test, not conducted
2-45 (1500A)	Not applicable.	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: 2018.11.09 16:35:05 -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, 2020	

Submitter Signature*: Gerrit Dyke Digitally signed by Gerrit Dyke Date: 2018.11.09 16:35:35 -08'00'

Submit Form

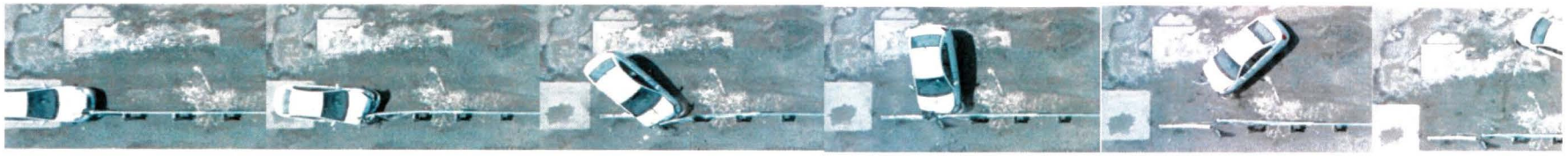
ATTACHMENTS

Attach to this form:

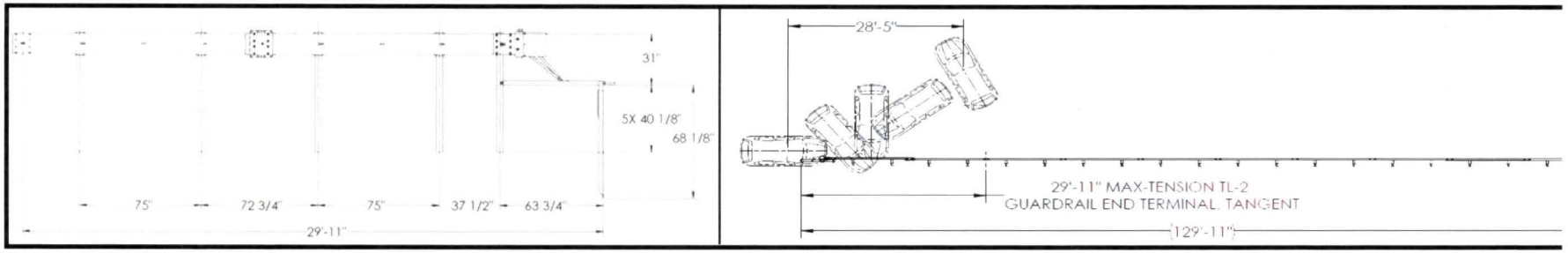
1) Additional disclosures of related financial interest as indicated above.
2) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
3) A drawing or drawings of the device(s) that conform to the Task Force-13 Drawing Specifications [Hardware 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



t= 0.000 sec | t= 0.100sec | t= 0.300sec | t= 0.500sec | t= 0.800sec | t= 1.500sec



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET230-C1
Test Designation	MASH 2-30
Date	8/22/2017

Test Article

Name	Lindsay Transportation - MaX-Tension TL-2
Type	Guardrail End Terminal
Installation Length	129.9 ft (39.6 m)
Width	17.5 in (444.5 mm)
Height	31 in (787 mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	11,742 lb (52.2 kN)

Test Vehicle

Type / Designation	1100C
Make and Model	2011 Hyundai Accent
Curb Weight	2,462 lb (1,116.5 kg)
Test Inertial Weight	2,448 lb (1,110.5 kg)
Gross Static Weight	2,614 lb (1,185.5 kg)

Impact Conditions

Speed	44.3 mph (71.3 kph)
Angle	0 deg
Location / Orientation	1/4 offset

Exit Conditions

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

Post Impact Trajectory

Vehicle Stability	Satisfactory
Longitudinal Stopping Distance (CG)	28.4 ft (8.67 m)
Vehicle Snagging/Pocketing	N/A

Occupant Risk Values

Longitudinal OIV	28.9 ft/s (8.8 m/s)
Lateral OIV	1.31 ft/s (0.4 m/s)
Longitudinal ORA	10 g's
Lateral ORA	3.3 g's
THIV	29.2 ft/s (8.9 m/s)
PHD	10.2 g's
ASI	0.96

Test Article Damage: Moderate

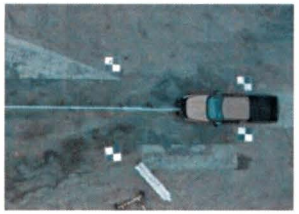
Test Article Deflection

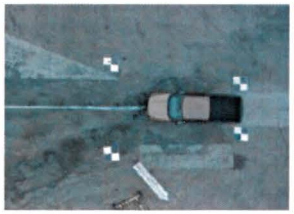
Longitudinal system stroke	5.58 ft (1.70 m)
Permanent lateral deflection	0.23 ft (0.07 m)
Dynamic lateral deflection	1.38 ft (0.42 m)

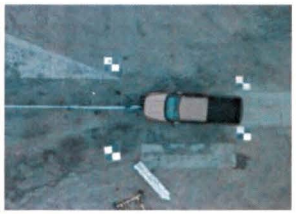
Vehicle Damage

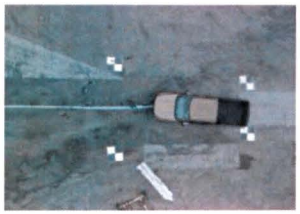
VDS	12-FR-4
CDC	12FREN3
Maximum Interior Deformation	0.25 in (6.35 mm) - dashboa


t= 0.000 sec

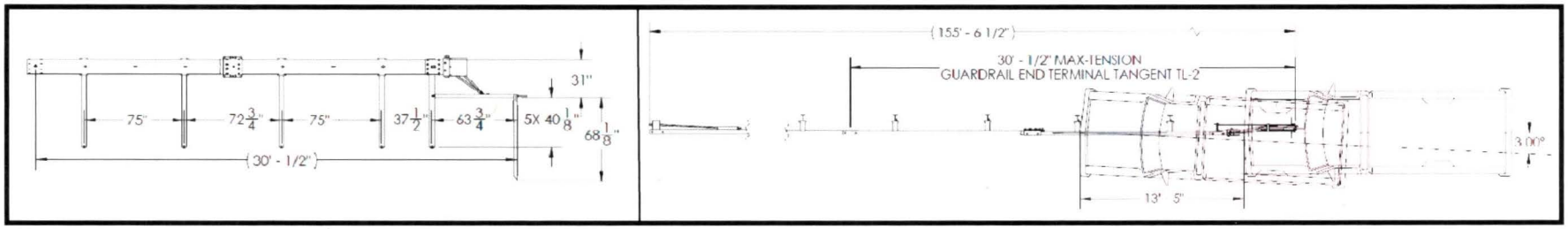

t= 0.100sec


t= 0.300sec


t= 0.500sec


t= 0.800sec


t= 1.200sec



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET170201
Test Designation	MASH 2-31
Date	2/1/2017

Test Article

Name	Lindsay Transportation - MAX-Tension, TL-2
Type	Guardrail End Terminal
Installation Length	155.5 ft (39.8 m)
Width	17.5 in (444.5mm)
Height	31.0 in (787mm)

Soil Conditions

Type of Soil	AASHTO Grade A/B Soil-Aggregate
Soil Strength	14,764.6 lb (65.7 kN)

Test Vehicle

Type / Designation	2270P
Make and Model	2012 Dodge Ram 1500 Quad Cab Pickup
Curb Weight	5029.0 lb (2281.0 kg)
Test Inertial Weight	5002.0 lb (2269.0 kg)
Gross Static Weight	5002.0 lb (2269.0 kg)

Impact Conditions

Speed	41.8 mph (67.3 km/h)
Angle	0 deg
Location / Orientation	Front/Center

Exit Conditions

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

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	13.4 ft (4.1 m)
Vehicle Snagging/Pocketing	N/A (see Figure 6)

Occupant risk Values

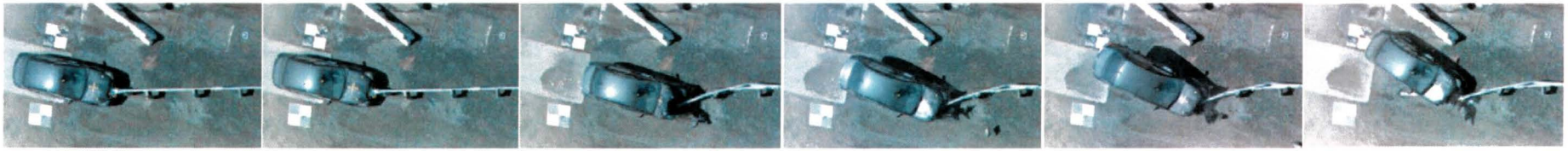
Longitudinal OIV	23.3 ft/s (7.1 m/s)
Lateral OIV	0.7 ft/s (0.2 m/s)
Longitudinal ORA	7.4 g's
Lateral ORA	1.5 g's
THIV	23.3 ft/s (7.1 m/s)
PHD	7.4 g's
ASI	0.55
Test Article Damage:	Moderate

Test Article Deflections

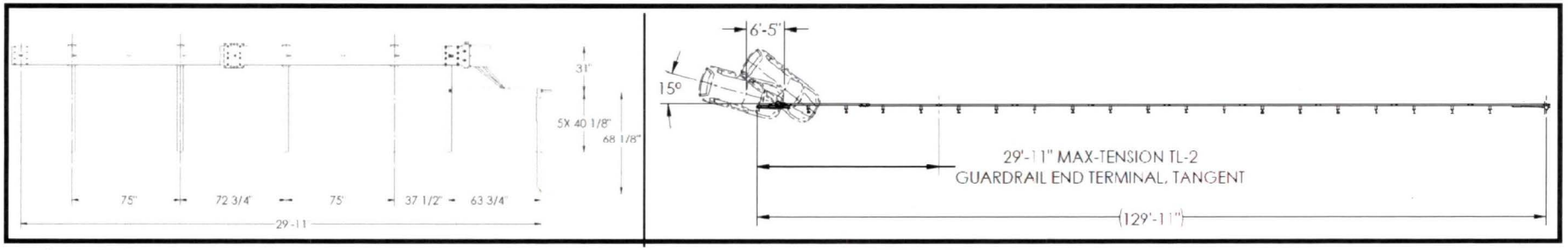
Longitudinal system stroke	10.5 ft (3.2 m)
Permanent lateral deflection	0.43 ft (0.13 m)
Dynamic lateral deflection	0.49 ft (0.15 m)

Vehicle Damage

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



t= 0.000 sec | t= 0.100 sec | t= 0.200 sec | t= 0.300 sec | t= 0.500 sec | t= 1.600 sec



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET232-C1
Test Designation	MASH 2-32
Date	8/15/2017

Test Article

Name	Lindsay Transportation - MaX-Tension TL-2
Type	Guardrail End Terminal
Installation Length	129.9 ft (39.6 m)
Width	17.5 in (444 mm)
Height	31.0 in (787 mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	13,465 lb (59.9 kN)

Test Vehicle

Type / Designation	1100C
Make and Model	2011 Kia Rio
Curb Weight	2,434 lb (1,104 kg)
Test Inertial Weight	2,449 lb (1,111 kg)
Gross Static Weight	2,615 lb (1,186 kg)

Impact Conditions

Speed	43.9 mph (70.6 kph)
Angle	15.0 deg
Location / Orientation	Front/Center

Exit Conditions

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

Post Impact Trajectory

Vehicle Stability	Satisfactory
Longitudinal Stopping Distance (CG)	6.40 ft (1.95 m)
Vehicle Snagging/Pocketing	N/A

Occupant Risk Values

Longitudinal OIV	31.5 ft/s (9.6 m/s)
Lateral OIV	0.98 ft/s (0.3 m/s)
Longitudinal ORA	11.2 g's
Lateral ORA	2.5 g's
THIV	31.5 ft/s (9.6 m/s)
PHD	11.2 g's
ASI	1.01

Test Article Damage: Moderate

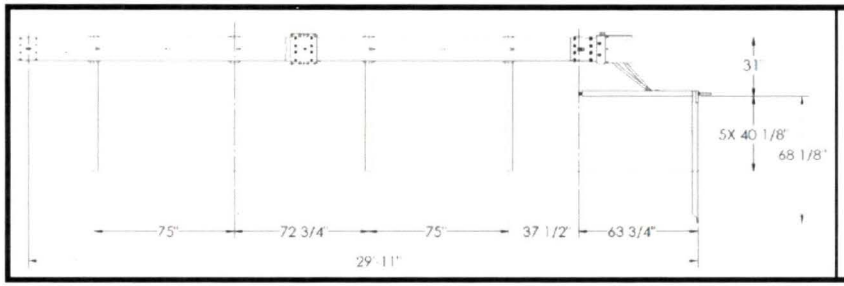
Test Article Deflection

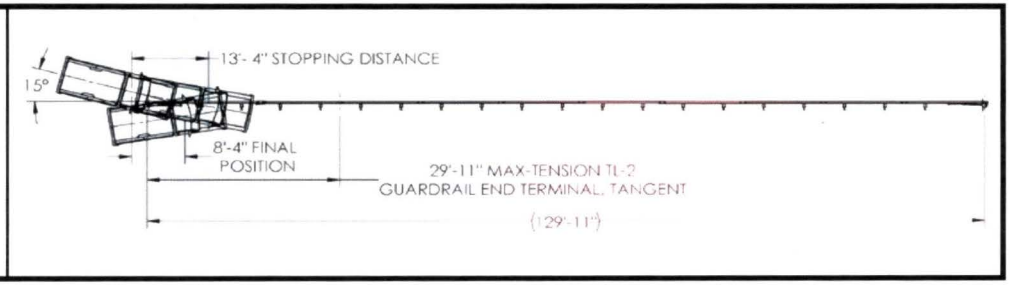
Longitudinal system stroke	4.93 ft (1.50 m)
Permanent lateral deflection	1.51 ft (0.46 m)
Dynamic lateral deflection	2.59 ft (0.79 m)

Vehicle Damage

VDS	12-FC-4
CDC	12FDEW2
Maximum Interior Deformation	1.13 in (28.6 mm) - ceiling

t= 0.000 sec | t= 0.100sec | t= 0.300sec | t= 0.600sec | t= 1.000sec | t= 1.500sec





General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET233-C1
Test Designation	MASH 2-33
Date	8/14/2017

Test Article

Name	Lindsay Transportation - MaX-Tension TL-2
Type	Guardrail End Terminal
Installation Length	129.9 ft (39.6 m)
Width	17.5 in (444.5 mm)
Height	31 in (787 mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	13,234 lb (58.9 kN)

Test Vehicle

Type / Designation	2270P
Make and Model	2012 Dodge Ram 1500
Curb Weight	4,900 lb (2,222.5 kg)
Test Inertial Weight	5,005 lb (2,270 kg)
Gross Static Weight	5,005 lb (2,270 kg)

Impact Conditions

Speed	42.6 mph (68.6 kph)
Angle	15 deg
Location / Orientation	Front/Center

Exit Conditions

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

Post Impact Trajectory

Vehicle Stability	Satisfactory
Longitudinal Stopping Distance (CG)	13.3 ft (4.05 m)
Vehicle Snagging/Pocketing	N/A

Occupant risk Values

Longitudinal OIV	24.9 ft/s (7.6 m/s)
Lateral OIV	1.31 ft/s (0.4 m/s)
Longitudinal ORA	8.9 g's
Lateral ORA	1.9 g's
THIV	24.9 ft/s (7.6 m/s)
PHD	9.0 g's
ASI	0.70

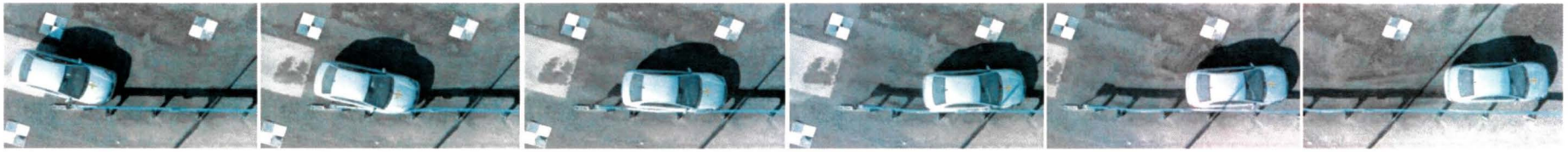
Test Article Damage: Substantial

Test Article Deflection

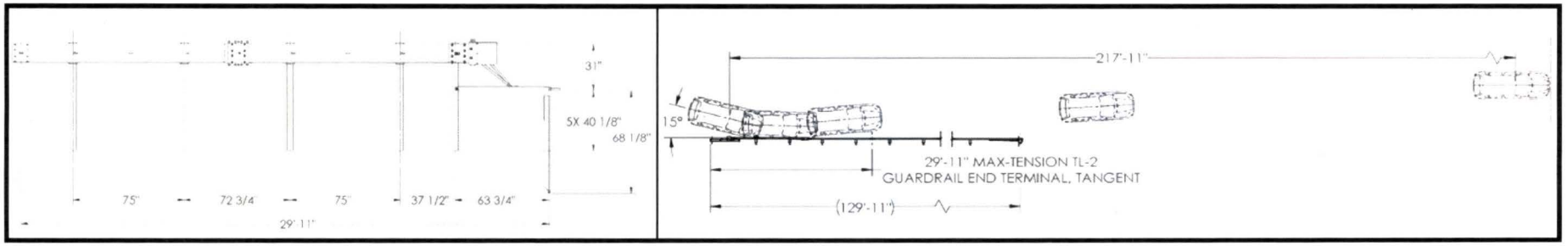
Longitudinal system stroke	6.23 ft (1.90 m)
Permanent lateral deflection	0.76 ft (0.23 m)
Dynamic lateral deflection	1.77 ft (0.54 m)

Vehicle Damage

VDS	12-FC-3
CDC	12FCEW2
Maximum Interior Deformation	0.44 in (11.1 mm) - floor pan



t= 0.000 sec | t= 0.100 sec | t= 0.200 sec | t= 0.300 sec | t= 0.400 sec | t= 0.600 sec



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET234-C1
Test Designation	MASH 2-34
Date	8/24/2017

Test Article

Name	Lindsay Transportation - MaX-Tension TL-2
Type	Guardrail End Terminal
Installation Length	129.9 ft (39.6 m)
Width	17.5 in (445 mm)
Height	31.0 in (787 mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	9,636 lb (42.9 kN)

Test Vehicle

Type / Designation	1100C
Make and Model	2011 Kia Rio
Curb Weight	2,438.3 lb (1,106.0 kg)
Test Inertial Weight	2,449.3 lb (1,111.0 kg)
Gross Static Weight	2,614.7 lb (1,186.0 kg)

Impact Conditions

Speed	43.8 mph (70.5 kph)
Angle	15.0 deg
Location / Orientation	1.77 ft (0.54 m) downstream from post 1

Exit Conditions

Speed	35.9 mph (57.8 kph)
Angle	4.8 degrees

Post Impact Trajectory

Vehicle Stability	Satisfactory
Longitudinal Stopping Distance (CG)	Approximately 218 ft (66.4 m), stopped by containment barrier
Vehicle Snagging/Pocketing	N/A

Occupant risk Values

Longitudinal OIV	8.2 ft/s (2.5 m/s)
Lateral OIV	15.1 ft/s (4.6 m/s)
Longitudinal ORA	2.7 g's
Lateral ORA	3.7 g's
THIV	17.1 ft/s (5.2 m/s)
PHD	4.6 g's
ASI	0.54
Test Article Damage:	Minimal

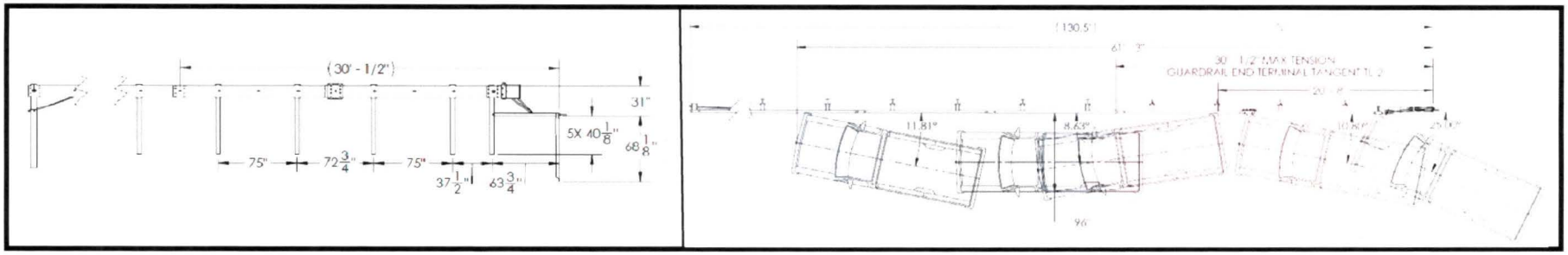
Test Article Deflection

Longitudinal system stroke	N/A
Permanent lateral deflection	0.35 ft (0.11 m)
Dynamic lateral deflection	0.52 ft (0.16 m)

Vehicle Damage

VDS	1-RFQ-1
CDC	01RFEN1
Maximum Interior Deformation	0.88 in (22.2 mm) - dashboard

t= 0.000 sec | t= 0.200sec | t= 0.400sec | t= 0.800sec | t= 1.300sec | t= 1.500sec



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET170224
Test Designation	MASH 2-35
Date	2/24/2017

Test Article

Name	Lindsay Transportation - MaX-Tension TL-2
Type	Guardrail End Terminal
Installation Length	129.9 ft (39.6 m)
Width	17.5 in (444.5 mm)
Height	31 in (787 mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	15,708 lb (69.9 kN)

Test Vehicle

Type / Designation	2270P
Make and Model	2011 Dodge Ram 1500 Quad Cab Pickup
Curb Weight	4,986.0 lb (2,261.5 kg)
Test Inertial Weight	5,019.0 lb (2,276.5 kg)
Gross Static Weight	5,019.0 lb (2,276.5 kg)

Impact Conditions

Speed	42.5 mph (68.4 kph)
Angle	25.0 deg
Location / Orientation	BLON, Post 1

Exit Conditions

Speed	15.6 mph (25.1 kph)
Angle	8.6 degrees

Post Impact Trajectory

Vehicle Stability	Satisfactory
Stopping Distance	58.25 ft (17.75 m)
Vehicle Snagging/Pocketing	Minimal

Occupant risk Values

Longitudinal OIV	11.5 ft/s (3.5 m/s)
Lateral OIV	13.8 ft/s (4.2 m/s)
Longitudinal ORA	8.0 g's
Lateral ORA	6.4 g's
THIV	17.4 ft/s (5.3 m/s)
PHD	9.0 g's
ASI	0.57

Test Article Damage Substantial

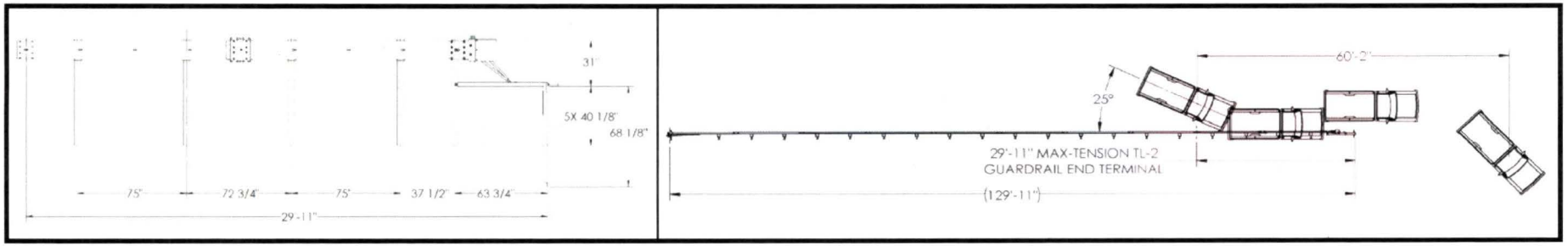
Test Article Deflections

Longitudinal system stroke	N/A
Permanent	1.08 ft (0.33 m)
Dynamic	1.44 ft (0.44 m)

Vehicle Damage

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

t= 0.000 sec | t= 0.100 sec | t= 0.200 sec | t= 0.300 sec | t= 0.500 sec | t= 2.700 sec



General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET237a-C1
Test Designation	MASH 2-37a
Date	8/18/2017

Test Article

Name	Lindsay Transportation - MaX-Tension TL-2
Type	Guardrail End Terminal
Installation Length	129.9 ft (39.6 m)
Width	17.5 in (444.5 mm)
Height	31.0 in (787.4 mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	16,037 lb (71.3 kN)

Test Vehicle

Type / Designation	2270P
Make and Model	2011 Dodge Ram 1500
Curb Weight	4,768 lb (2,162.5 kg)
Test Inertial Weight	5,006 lb (2,270.5 kg)
Gross Static Weight	5,006 lb (2,270.5 kg)

Impact Conditions

Speed	42.7 mph (68.7 kph)
Angle	25.0 deg
Location / Orientation	19.7 ft (6.00 m) from post 1

Exit Conditions

Speed (mph)	19.0 mph (30.6 kph)
Angle (deg)	9.5 degrees

Post Impact Trajectory

Vehicle Stability	Satisfactory
Longitudinal Stopping Distance (CG)	60.2 ft (18.3 m)
Vehicle Snagging/Pocketing	Minimal

Occupant risk Values

Longitudinal OIV	16.4 ft/s (5.0 m/s)
Lateral OIV	12.1 ft/s (3.7 m/s)
Longitudinal ORA	9.4 g's
Lateral ORA	7.5 g's
THIV	19.4 ft/s (5.9 m/s)
PHD	11.9 g's
ASI	0.52

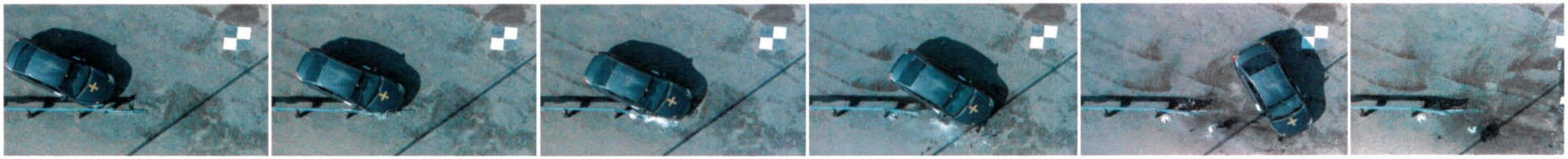
Test Article Damage: Substantial

Test Article Deflection

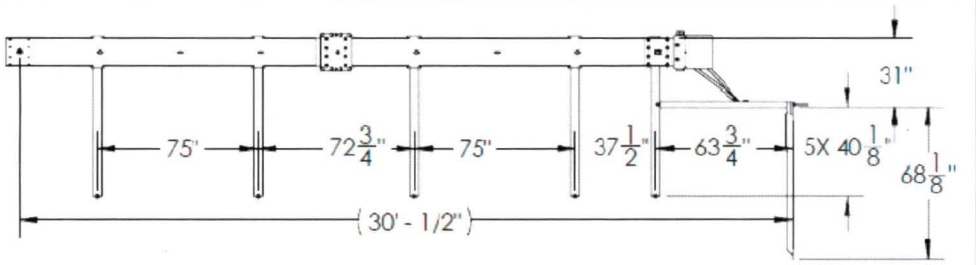
Longitudinal system stroke	N/A
Permanent lateral deflection	1.18 ft (0.36 m)
Dynamic lateral deflection	2.16 ft (0.66 m)

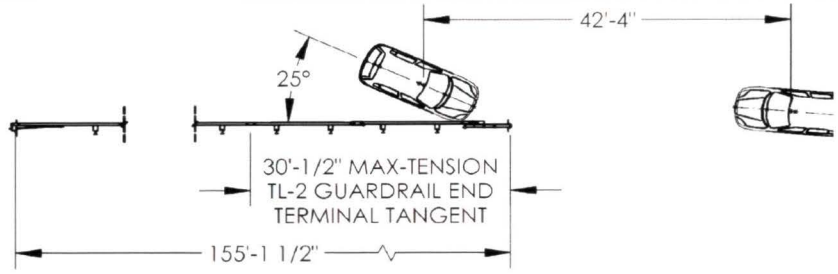
Vehicle Damage

VDS	1-RFQ-3
CDC	01RFEW1
Maximum Interior Deformation	0.88 in (22.2 mm) - floor pan



t = 0.000 sec | t = 0.050 sec | t = 0.100 sec | t = 0.200 sec | t = 0.400 sec | t = 0.600 sec





General Information

Test Agency	**SAFE TECHNOLOGIES, INC.**
Test Number	MET237b-C1
Test Designation	MASH 2-37b
Date	8/31/2018

Test Article

Name	MAX-Tension Tangent, TL-2
Type	Guardrail End Terminal
Installation Length	155.1 ft (47.3 m)
Width	17 3/8 in (441 mm)
Height	31 in (787 mm)

Soil Conditions

Type of soil	AASHTO Grade A/B Soil-Aggregate
Soil strength	12,781 lb (56.9 kN)

Test Vehicle

Type / Designation	1100C
Make and Model	2011 Hyundai Accent
Curb Weight	2,404 lb (1,090.5 kg)
Test Inertial Weight	2,432 lb (1,103 kg)
Gross Static Weight	2,597 lb (1,178 kg)

Impact Conditions

Speed	44.0 mph (70.8 km/h)
Angle	25 deg
Location / Orientation	29.8 in (75.8 cm) from post 2 towards the Impact Head

Exit Conditions

Speed	28.3 mph (45.5 km/h)
Angle	10 degrees

Post Impact Trajectory

Vehicle Stability	Satisfactory
Longitudinal Stopping Distance (CG)	42.3 ft (12.9 m)
Vehicle Snagging/Pocketing	Minimal

Occupant Risk Values

Longitudinal OIV	25.3 ft/s (7.7 m/s)
Lateral OIV	12.5 ft/s (3.8 m/s)
Longitudinal ORA	7.5 G
Lateral ORA	3.3 G
THIV	28.2 ft/s (8.6 m/s)
PHD	7.5 G
ASI	0.96

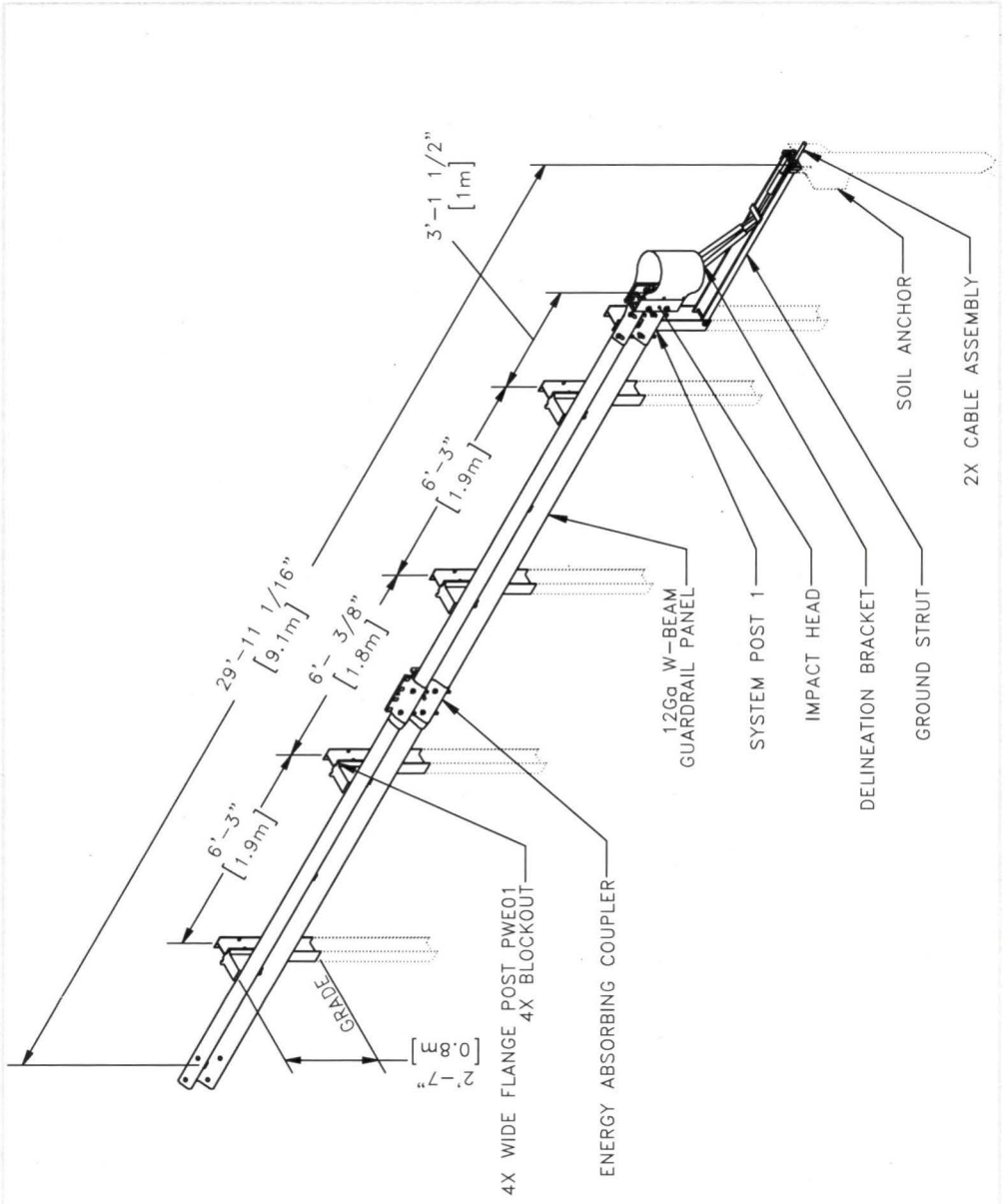
Test Article Damage: Minimal

Test Article Deflection

Longitudinal System Stroke	N/A
Permanent Lateral Deflection	6.3 in (16.1 cm)
Dynamic Lateral Deflection	10.1 in (25.6 cm)

Vehicle Damage

VDS	1-RFQ-4
CDC	01RFEW2
Maximum Interior Deformation	6.25 in (159 mm) - toe pan



MAX-TENSION TL-2 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

SHEET NO.	DATE:
1 OF 2	.

INTENDED USE

The MAX-Tension™ TL-2 Guardrail End Terminal (MAX-Tension TL-2) is a re-directive, non-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-Tension TL-2 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 1. The MAX-Tension TL-2 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 TL-2 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
- Two standard AASHTO 12 Ga. 12-'6" 4-Space W-beam or one AASHTO 12 Ga. 12-'6" 4-Space W-beam and one 25'-0" 4-Space W-beam
- 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 TL-2 Tangent system has been fully tested in conformance with MASH Test Level 2 and is eligible for Federal reimbursement.

FHWA Eligibility Letters: XXXXXXX

CONTACT INFORMATION

Lindsay Transportation Solutions
180 River Rd.
Rio Vista, CA 94571
www.barriersystemsinc.com
Phone: 888-800-3691 or 707-374-6800
Fax: 707-374-6801
Email: info@barriersystemsinc.com

MAX-TENSION TL-2 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