U.S. Department of Transportation
Federal Highway Administration

April 10, 2019

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

In Reply Refer To:
HSST-1 / CC-143

Mr. Kaddo Kothman
Road Systems, Inc.
3616 Howard County Airport
Big Spring, TX 79720

Dear Mr. Kothman:

This letter is in response to your June 16, 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. We appreciate the additional information you sent dated January 9, 2019 and March 15th, 2019 to facilitate our review.This FHWA letter of eligibility is assigned FHWA control number CC-143 and is valid until a subsequent letter is issued by FHWA that expressly references this device.

Decision

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

- MFLEAT Terminal

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 AASHTO's 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: MFLEAT Terminal
Type of system: Terminal
Test Level: MASH Test Level 3 (TL3)
Testing conducted by: KARCO
Date of request: June 16, 2018
Date initially acknowledged: July 17, 2018

FHWA concurs with the recommendation of the accredited crash testing laboratory on 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. Any modifications to this device should be submitted to the user (i.e., state DOT) as per their requirements.

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-143 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
Director, Office of Safety Technologies
Office of Safety

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter	Date of Request:	July 02, 2018	◉ New ○ Resubmission
	Name:	Robert Ramirez	
	Company:	KARCO Engineering, LLC.	
	Address:	9270 Holly Road, Adelanto, CA 92301	
	Country:	United States	
	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	MFLEAT Terminal	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:	Kaddo Kothman	Same as Submitter ☐
Company Name:	Road Systems, Inc.	Same as Submitter ☐
Address:	3616 Howard County Airport, Big Spring, TX 79720	Same as Submitter ☐
Country:	United States	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.

Road Systems, Inc. is the manufacturer and marketer of device.

KARCO Engineering, LLC Is an independent research and testing laboratory having no affiliation with any other entity. The company Is solely-owned and operated by Mr. Frank D. Richardson and Ms. Jennifer W. Peng (husband and wife) and was established on September 2, 1994. KARCO is actively Involved In data acquisition and compliance/certification testing for a variety of government agencies and equipment manufacturers. The principals and staff of KARCO Engineering have no past or present financial, contractual or organizational interest in any company or entity directly or indirectly related to the products that KARCO tests. If any financial Interest should arise, other than receiving fees for testing, reporting, etc., with respect to any project, the company will provide, In writing, a full and immediate disclosure to the FHWA.

PRODUCT DESCRIPTION

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

The MASH FLEAT terminal is a flared W-beam guardrail terminal consisting of: an impact head assembly, a breakaway cable anchorage system with a ground strut, three (3) rail sections, and eight (8) posts. The terminal is installed with a straight flare of 3 ft (0.9 m) offset over a length of 39.6 ft (12.1 m).
The MASH FLEAT impact head assembly is 6.9 ft (2.1 m) long, consisting of an impact head and an attached guide chute that partially encloses the rail. Inside the impact head is a deflector plate which, together with the kinker beam, sequentially kinks the guardrail as it is fed through the impact head, thus dissipating the kinetic energy of the impacting vehicle.

The anchorage system consists of: an end post (Post 1) and a hinged Post 2 connected with a ground strut, a cable anchorage assembly to transmit the force from the rail to the end post and its foundation, and a cable release bracket that disengages the cable anchor from the rail upon impact by the end of the guide chute. Post 1 has a 2.4 ft (0.7 m) long top portion constructed of 6 in. x 6 in. x 0.125 in. (152 mm x 152 mm x 3 mm) steel tube and a 6 ft (1.8 m) long bottom section constructed of W6 x 15 steel I-beam. The top and bottom sections are pinned together by a 0.625 in. (16 mm) diameter bolt and nut. Post 2 (the same for Post 3) consists of one 2.8 ft (0.9 m) long top portion and a 6 ft (1.8 m) long bottom portion, both constructed of W6x9 steel I-beam and pinned together by a 0.75 in. (19 mm) diameter bolt and nut. The upstream end of the cable anchor is attached to Post 1 through a 0.625 in. (16 mm) thick, 8.0 in. (203 mm) square steel bearing plate. The downstream end of the cable anchor is attached to a cable release bracket designed to disengage from the rail section upon impact by the end of the guide chute. The ground strut is mounted to a second 0.625 in. (16 mm) bolt through Post 1 and by the 0.75 in. (19 mm) hinge bolt in Post 2.

All guardrail sections consist of 12-ga W-beam rail sections. The end section is 12.5 ft (3.8 m) long with hole patterns for rail splices and attachment of the cable release bracket, as well as slots to initiate kinking. The second rail section is 10.4 ft (3.2 m) long so that the next splice is mid-span between Posts 5 and 6. The third rail section is 13.5 ft (4.1 m) long, followed by standard 12.5 ft (3.8 m) rail sections. With the exception of the first splice, all splices are mid-span between posts.

There are eight (8) posts in the terminal section. In addition to the breakaway end post, posts 2 and 3 are hinged posts. Posts 4 through 8 are standard 6.0 ft (1.8 m) W6 x 9 steel posts and can utilize 8.0 in (203 mm) or 12 in. (305 mm) deep wood or recycled plastic blockouts. Post spacing between Posts 1 and 2 and Posts 2 and 3 is 6.25 ft (1.9 m), which is then reduced to 50 in. (1.3 m) through the rest of the terminal from Posts 3 through 8. The post spacing then reverts back to the standard 6.25 ft (1.9 m) beyond the terminal.

The MASH FLEAT Terminal may utilize powder coated or painted rail sections, impact head and other components. Reference attachment Powder Coated Report 08/27/2009.

Test Chronology:
Test 3-34 and 3-35 were conducted between 01/31/17 to 03/27/17
Test 3-32, 3-31, and 3-33 were conducted between 02/01/18 to 02/05/18 with design Modification I
Test 3-30 and 3-37 were conducted between 03/20/18 to 03/30/18 with design Modification I and II
Reference Appendix C for complete details on the modifications.

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:	Robert Ramirez	
Engineer Signature:	Robert Ramirez Digitally signed by Robert Ramirez DN: cn=Robert Ramirez, o=KARCO Engineering, ou=Project Engineer, email=rramirez@karco.com, c=US Date: 2018.06.15 17:00:44 -07'00'	
Address:	9270 Holly Rd., Adelanto, CA 92301	Same as Submitter ☐
Country:	United States	Same as Submitter ☐

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	KARCO Test No. P38079-01. An 1100C (2,425 lb) passenger car impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 0 degree, respectively, with the quarter point of the vehicle aligned with the centerline of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2013 Hyundai Accent 4-door sedan weighing 2,431.7 lb (1,103.0 kg), impacted the MASH FLEAT terminal head-on at impact speed and angle of 59.91 mph (96.42 km/h) and 0.7 degrees, respectively. The vehicle pushed the impact head down the length of the guardrail past the Post 4, at which point the rail began to buckle and the vehicle began to yaw clockwise. The vehicle then impacted the rail at the bend at the passenger door on the driver side before coming to a stop next to the rail on the field side, 48.1 ft (14.7 m) from the point of initial impact. The test vehicle sustained moderate damage to the front end and to the driver side with a maximum occupant compartment deformation of 3 in. (76 mm). The vehicle remained upright and did not leave its lane. The test article received extensive damage from post 1 through post 6. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. In summary, the MASH FLEAT terminal passed all evaluation criteria for Test 3-30. The test was conducted on 3/20/18 with Modification I and Modification II detailed in Appendix C.	PASS

Required Test Number	Narrative Description	Evaluation Results
3-31 (2270P)	KARCO Test No. P38022-01. A 2270P (5,000 lb) pickup truck impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 0 degree, respectively, with the centerline of the vehicle aligned with the centerline of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2013 Dodge Ram 1500 four-door pickup truck, with a test inertial mass of 5,009.9 lb (2,272.5 kg) impacted the MASH FLEAT terminal head-on at impact speed and angle of 60.40 mph (97.21 km/h) and 0.3 degree, respectively. The vehicle pushed the impact head down the length of the guardrail past Post 9 and came to rest 53.7 ft (16.4 m) downstream from the point of initial impact. The test vehicle sustained moderate damage to the front end with negligible occupant compartment deformation. The vehicle remained upright and did not leave its lane. The test article received extensive damage from Post 1 through Post 9. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. In summary, the MASH FLEAT terminal passed all evaluation criteria for Test 3-31 The test was conducted on 2/2/18 with Modification I detailed in Appendix C.	PASS

3-32 (1100C)	KARCO Test No. P38050-01. An 1100C (2,425 lb) passenger car impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 5 degrees, respectively, with the centerline of the vehicle aligned with the centerline of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2012 Kia Rio 4-door sedan weighing 2,428.4 lb (1,101.5 kg), impacted the MASH FLEAT terminal head-on at impact speed and angle of 62.06 mph (99.88 km/h) and 5.3 degrees, respectively. The vehicle pushed the impact head down the length of the guardrail past the fifth post, at which point the vehicle gated through the guardrail at a speed and angle of 29.8 mph (48.0 km/h) and 4.7 degrees, respectively. The vehicle then proceeded forward behind the guardrail and came to rest 189.5 ft (57.8 m) downstream from the point of initial impact. The test vehicle sustained moderate damage to the front and left side with negligible occupant compartment deformation. The vehicle remained upright and did not leave its lane. The test article received extensive damage from post 1 through post 5. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. In summary, the MASH FLEAT terminal passed all evaluation criteria for Test 3-32. The test was conducted on 2/1/18 with Modification I detailed in Appendix C.	PASS

3-33 (2270P)	KARCO Test No. P38051-01. A 2270P (5,000 lb) pickup truck impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 5 degrees, respectively, with the centerline of the vehicle aligned with the centerline of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2013 Dodge Ram 1500 4-door pickup truck weighing 5,006.6 lb (2,271.0 kg), impacted the MASH FLEAT terminal head-on at an impact speed and angle of 62.60 mph (100.75 km/h) and 4.9 degrees, respectively. The vehicle pushed the impact head down the guardrail past the fifth post at which point the vehicle gated through the guardrail in a controlled manner at a speed and angle of 44.1 mph (71.0 km/h) and 7.7 degrees, respectively. The vehicle then proceeded forward behind the guardrail and impacted the test article again between posts 16 and 17 before coming to rest against the rail 132.9 ft (40.5 m) downstream from the point of initial impact. The vehicle sustained moderate damage at the front and left side with negligible deformation to the occupant compartment. The vehicle remained upright and did not leave its lane. The test article received extensive damage from posts 1 through Post 5. Posts 6 through 12 were not impacted, but separated from the guardrail as a result of the rail buckling. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. In summary, the MASH FLEAT terminal passed all evaluation criteria for Test 3-33. The test was conducted on 2/5/18 with Modification I detailed in Appendix C.	PASS

3-34 (1100C)	KARCO Test No. P37028-01. An 1100C (2,425 lb) passenger car impacting the terminal at a nominal impact speed and angle of 100 km/h (62.2 mph) and 15 degrees, respectively, with the corner of the vehicle bumper aligned with the critical impact point (CIP) of the length of need (LON) of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2011 Kia Rio 4-door sedan weighing 2,415.1 lb (1,095.5 kg), impacted the downstream end of the impact head 26.9 in. (682 mm) downstream of Post 1 at impact speed and angle of 61.93 mph (99.66 km/h) and 15.3 degrees, respectively. The impact angle relative to the terminal was 19.3°. The vehicle was contained and redirected by the guardrail before separating from the test article near Post 7 and coming to rest near Post 9, 41.2 ft (12.6 m) downstream of the point of initial impact. The vehicle remained upright and stable throughout the impact sequence and did not leave its lane. The test vehicle sustained moderate damage to the front right side with negligible occupant compartment deformation. The test article received extensive damage from Post 1 through Post 7. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. In summary, the MASH FLEAT terminal passed all evaluation criteria for Test 3-34. There were no design modifications used on this test. The test was conducted on 3/27/17.	PASS

3-35 (2270P)	KARCO Test No. P36061-01. A 2270P (5,000 lb) pickup truck impacting the terminal at a nominal impact speed and angle of 100 km/h (62.2 mph) and 25 degrees, respectively, with the corner of the vehicle bumper aligned with the beginning of the LON of the terminal. This test is primarily intended to evaluate structural adequacy and vehicle trajectory criteria. The test vehicle, a 2011 Dodge Ram 1500 4-door pickup truck weighing 4,993.4 lb (2,265.0 kg), impacted the guardrail at Post 4, the beginning of length-of-need, at impact speed and angle of 62.08 mph (99.91 km/h) and 25.4 degrees, respectively. The impact angle relative to the terminal was 29.7°. The vehicle was contained and redirected by the guardrail before separating from the test article near Post 10 at a velocity of 36.76 mph (59.16 km/h) and an exit angle of 28.2 degrees and proceeded downstream adjacent to the guardrail on the traffic side. The vehicle then turned back toward the guardrail before coming to rest 99.9 ft (30.5 m) downstream from the point of initial impact. The vehicle remained upright and stable throughout the impact sequence and did not leave its lane. The test vehicle sustained moderate damage to the front right side with negligible occupant compartment deformation. The test article received extensive damage from Post 4 through Post 9. The maximum static lateral deformation was 3.7 ft (1.1 m) around Post 8. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. In summary, the MASH FLEAT terminal passed all evaluation criteria for Test 3-35. There were no design modifications used on this test. The test was conducted on 1/31/17.	PASS

3-36 (2270P)	MASH Test Designation 3-36. A2270P (5,000 lb) pickup truck impacting the terminal at a nominal Impact speed and angle of 100 km/h (62 mph) and 25 degrees, respectively, with the corner of the vehicle bumper aligned with the critical Impact point (CIP) with respect to the transition to the stiff barrier or backup structure. This test is primarily intended to evaluate the performance of the terminal when connected to a stiff barrier or a backup structure. As a W-beam guardrail terminal, the MFLEAT terminal is designed to attach to W-beam barrier, transitions to alternative barriers downstream of the terminal will require case-by-case evaluation.	Non-Relevant Test, not conducted
3-37 (1100C)	KARCO Test No. P38080-01. A 1100C (2,425 lb) passenger car impacting the terminal at a nominal impact speed and angle of 100 km/h (62.2 mph) and 25 degrees, respectively, at Post 3 in the reverse direction. This test is intended to evaluate the performance of a terminal for a "reverse" hit. The test vehicle, a 2012 Hyundai Accent 4-door sedan weighing 2,427.2 lb (1,101.0 kg), impacted the guardrail at Post 3 in the reverse direction at an impact speed and angle of 60.84 mph (97.92 km/h) and 25.5 degrees, respectively. The vehicle impacted Post 2, the back side of the impact head, the anchor cable, and then Post 1 before separating from the test article at an exit velocity of 32.4 mph (52.1 km/h) and an angle of 30.1 degrees. The vehicle sustained moderate damage at the front with negligible deformation to the occupant compartment of 0.3 in. (8 mm). The test article received extensive damage between Posts 1 and 2. The impact head and cable anchor assembly stayed with the guardrail. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. In summary, the MASH FLEAT terminal passed all evaluation criteria for Test 3-37. The test was conducted on 3/30/18 with Modification I and Modification II detailed in Appendix C.	PASS

3-38 (1500A)	MASH Test Designation 3-38. A1500A (3,307 lb) passenger car impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 0 degree, respectively, with the center line of the vehicle aligned with the center line of the nose of the terminal. This test Is primarily intended to evaluate the performance of the staged attenuator/ terminal when Impacted by a mid-size vehicle. The MFLEAT terminal is not a staged device, because the force required to move the Impact head down the rail does not change.	Non-Relevant Test, not conducted
3-40 (1100C)	Test for non-redlrective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-41 (2270P)	Test for non-redlrective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-42 (1100C)	Test for non-redlrective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-43 (2270P)	Test for non-redlrective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-44 (2270P)	Test for non-redlrective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-45 (1500A)	Test for non-redlrective crash cushion, not applicable for terminals	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:	KARCO Engineering, LLC.	
Laboratory Signature:	AB Digitally signed by Alex Beltran DN: cn=Alex Beltran, o=KARCO Engineering, ou=Testing Laboratory, email=abeltran@karco.com, c=US Date: 2018.06.13 11:16:40 -07'00'	
Address:	9270 Holly Road, Adelanto, CA 92301	Same as Submitter ☐
Country:	United States	Same as Submitter ☐
Accreditation Certificate Number and Dates of current Accreditation period :	TL-371; October 12, 2017 - July 1, 2019	

Submitter Signature*: Robert Ramirez Digitally signed by Robert Ramirez DN: cn=Robert Ramirez, o=KARCO Engineering, ou=Project Engineer, email=rramirez@karco.com, c=US Date: 2018.06.13 11:16:54 -07'00'

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

MASH 2016 Test 3-30 Summary

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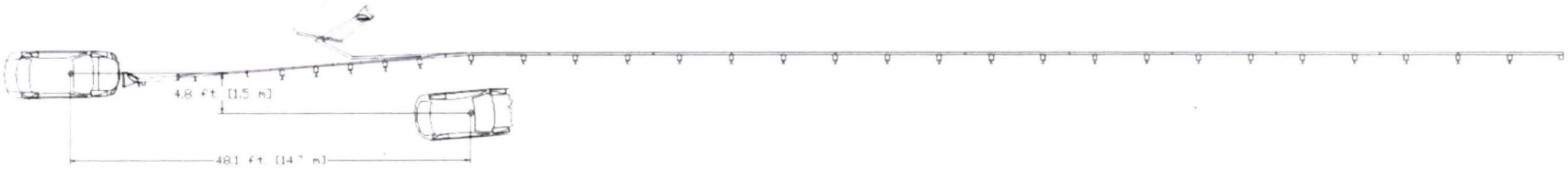


General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P38079-01
Test Designation	3-30
Test Date	3/20/18

Test Article	
Name / Model	MFLEAT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	170.8 ft. (52.1 m)
Terminal Length	39.6 ft. (1.2 m)
Road Surface	Medium to fine silty sand

Test Vehicle	
Type / Designation	1100C
Year, Make, and Model	2013 Hyundai Accent
Curb Mass	2,525.4 lbs (1,145.5 kg)
Test Inertial Mass	2,431.7 lbs (1,103.0 kg)
Gross Static Mass	2,622.4 lbs (1,189.5 kg)

Impact Conditions	
Impact Velocity	59.91 mph (96.42 km/h)
Impact Angle	0.7°
Location / Orientation	Frontal Offset 15.8 in. (401 mm)
Kinetic Energy	291.8 kip-ft (395.6 kJ)

Exit Conditions	
Exit Velocity	9.6 mph (15.4 km/h)
Exit Angle	41.9°
Final Vehicle Position	48.1 ft (14.7 m) downstream 4.8 ft (1.5 m) Field Side
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	16.4°
Maximum Pitch Angle	-11.1°
Maximum Yaw Angle	-52.4

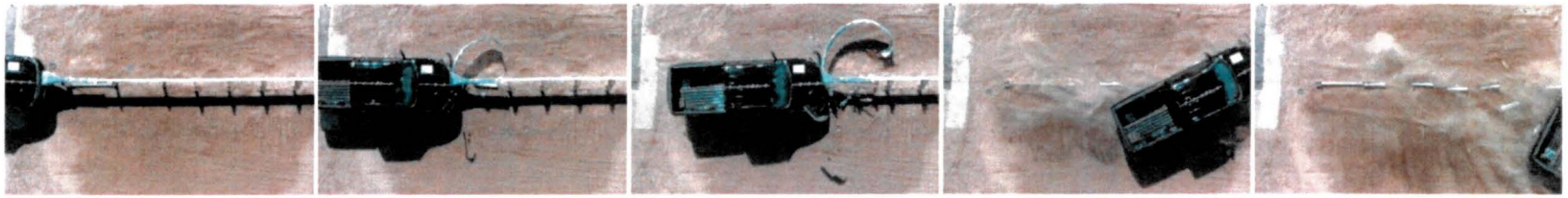
Occupant Risk	
Longitudinal OIV	23.0 ft/s (7.0 m/s)
Lateral OIV	3.3 ft/s (1.0 m/s)
Longitudinal RA	-11.7 g
Lateral RA	8.9
THIV	23.0 ft/s (7.0 m/s)
PHD	14.1 g
ASI	0.70

Test Article Deflections	
Static	6.0 ft. (1.8 m)
Dynamic	6.6 ft. (2.0 m)
Working Width	8.1 ft. (2.5 m)
Debris Field	73.0 ft. (22.2 m) Downstream 26.2 ft. (8.0 m) Field Side

Vehicle Damage	
Vehicle Damage Scale	12-FC-4
CDC	12FDEW2
Maximum Intrusion	3.0 in (76 mm)

Figure 2 Summary of Test 3-30

MASH 2016 Test 3-31 Summary



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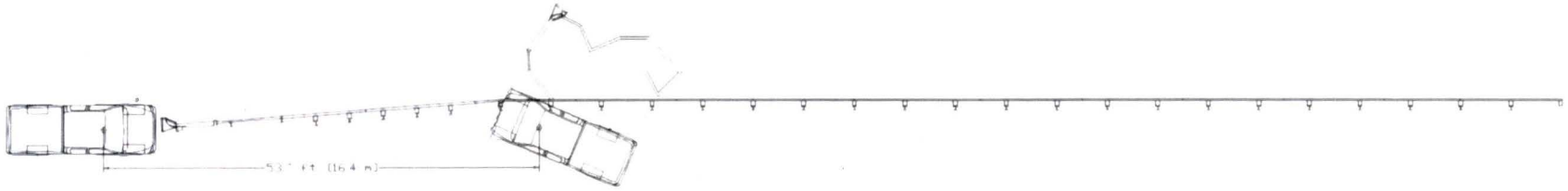


General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P38022-01
Test Designation	3-31
Test Date	2/2/18
Test Article	
Name / Model	MFLEAT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	170.8 ft. (52.1 m)
Terminal Length	39.6 ft. (12.1 m)
Road Surface	Medium to fine silty sand
Test Vehicle	
Type / Designation	2270P
Year, Make, and Model	2013 RAM 1500
Curb Mass	5,034.2 lbs (2,283.5 kg)
Test Inertial Mass	5,009.9 lbs (2,272.5 kg)
Gross Static Mass	5,009.9 lbs (2,272.5 kg)

Impact Conditions	
Impact Velocity	60.40 mph (97.21 km/h)
Impact Angle	0.3°
Location / Orientation	0.7 in. (18 mm) Left of vehicle CL
Kinetic Energy	611.0 kip-ft (828.4 kJ)
Exit Conditions	
Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	53.7 ft. (16.4 m) Downstream 1.75 in. (44 mm) Field side
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	7.8°
Maximum Pitch Angle	2.2°
Maximum Yaw Angle	81.3°

Occupant Risk	
Longitudinal OIV	17.1 ft/s (5.2 m/s)
Lateral OIV	0 ft/s (0 m/s)
Longitudinal RA	-4.5 g
Lateral RA	-4.1 g
THIV	31.2 ft/s (9.5 m/s)
PHD	4.6 g
ASI	0.48
Test Article Deflections	
Static	11.8 ft. (3.6m)
Dynamic	11.8 ft. (3.6 m)
Working Width	13.2 ft. (4.0 m)
Debris Field	40.3 ft. (12.3 m) Downstream 2.9 ft. (0.9 m) Left
Vehicle Damage	
Vehicle Damage Scale	12-FC-4
CDC	12FCLN2
Maximum Intrusion	0.3 in. (8 mm)

Figure 2 Summary of Test 3-31

MASH 2016 Test 3-32 Summary

0.000 s 0.100 s 0.300 s 0.500 s 0.700 s

General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P38050-01
Test Designation	3-32
Test Date	2/1/18
Test Article	
Name / Model	MFLEAT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	170.8 ft. (52.1 m)
Terminal Length	39.6 ft. (12.1 m)
Road Surface	Medium to fine silty sand
Test Vehicle	
Type / Designation	1100C
Year, Make, and Model	2012 Kia Rio
Curb Mass	2,462.5 lbs (1,117.0 kg)
Test Inertial Mass	2,428.4 lbs (1,101.5 kg)
Gross Static Mass	2,600.3 lbs (1,179.5 kg)

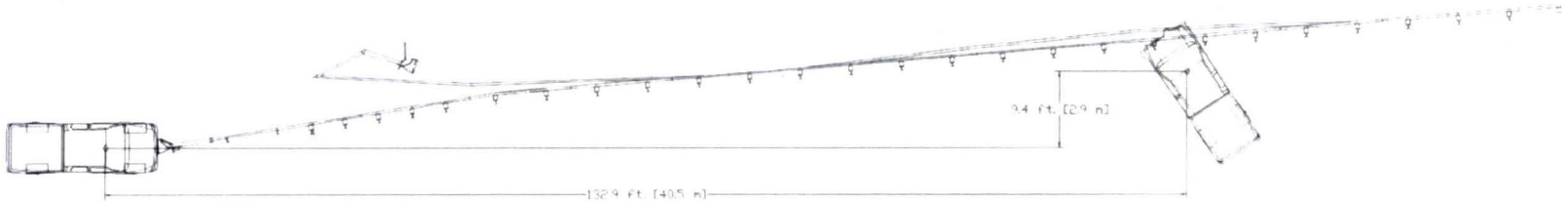
Impact Conditions	
Impact Velocity	62.06 mph (99.88 km/h)
Impact Angle	5.3°
Location / Orientation	0.6 in. (15 mm) Left of vehicle CL
Kinetic Energy	312.7 kip-ft (423.9 kJ)
Exit Conditions	
Exit Velocity	29.8 mph (48.0 km/h)
Exit Angle	4.7°
Final Vehicle Position	189.5 ft (57.8 m) Downstream 15.0 ft (4.6 m) Field side
Vehicle Snagging	Minor
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	5.5°
Maximum Pitch Angle	3.0°
Maximum Yaw Angle	9.7°

Occupant Risk	
Longitudinal OIV	24.3 ft/s (7.4 m/s)
Lateral OIV	2.3 ft/s (0.7 m/s)
Longitudinal RA	-7.3 g
Lateral RA	4.6 g
THIV	24.6 ft/s (7.5 m/s)
PHD	8.5 g
ASI	0.68
Test Article Deflections	
Static	3.0 ft. (0.9 m)
Dynamic	3.2 ft. (1.0 m)
Working Width	4.6 ft. (1.4 m)
Debris Field	78.3 ft. (23.9 m) Downstream 6.6 ft. (2.0 m) Right
Vehicle Damage	
Vehicle Damage Scale	12-FD-4
CDC	12FDEW3
Maximum Intrusion	0.2 in. (5 mm)

Figure 2 Summary of Test 3-32

MASH 2016 Test 3-33 Summary

0.000 s 0.100 s 0.200 s 0.400 s 0.600 s



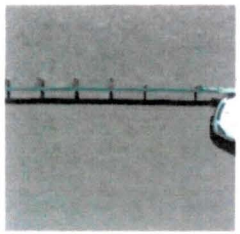
General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P38051-01
Test Designation	3-33
Test Date	2/5/18
Test Article	
Name / Model	MFLEAT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	170.8 ft. (52.1 m)
Terminal Length	39.6 ft. (12.1 m)
Road Surface	Medium to fine silty sand
Test Vehicle	
Type / Designation	2270P
Year, Make, and Model	2013 RAM 1500
Curb Mass	4,920.6 lbs (2,232.0 kg)
Test Inertial Mass	5,006.6 lbs (2,271.0 kg)
Gross Static Mass	5,006.6 lbs (2,271.0 kg)

Impact Conditions	
Impact Velocity	62.60 mph (100.75 km/h)
Impact Angle	4.9°
Location / Orientation	1.2 in. (30 mm) Left of vehicle CL
Kinetic Energy	655.9 kip-ft (889.3 kJ)
Exit Conditions	
Exit Velocity	44.1 mph (71.0 km/h)
Exit Angle	7.7°
Final Vehicle Position	132.9 ft. (40.5 m) Downstream 9.4 ft. (2.9 m) left
Vehicle Snagging	Minor
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-3.8°
Maximum Pitch Angle	2.5°
Maximum Yaw Angle	21.8°

Occupant Risk	
Longitudinal OIV	16.1 ft/s (4.9 m/s)
Lateral OIV	3.3 ft/s (1.0 m/s)
Longitudinal RA	-7.0 g
Lateral RA	11.9 g
THIV	16.4 ft/s (5.0 m/s)
PHD	13.6 g
ASI	0.73
Test Article Deflections	
Static	8.0 ft. (2.4 m)
Dynamic	8.3 ft. (2.5 m)
Working Width	9.7 ft. (3.0 m)
Debris Field	45.2 ft. (13.8 m Downstream 6.8 ft. (2.1 m) Right
Vehicle Damage	
Vehicle Damage Scale	12-FC-4
CDC	12FYEW3
Maximum Intrusion	1.3 in. (33 mm)

Figure 2 Summary of Test 3-33

MASH 2016 Test 3-34 Summary



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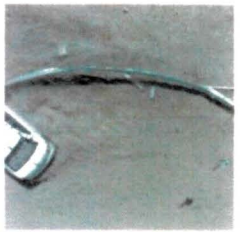
0.175 s

0.350 s

0.575 s



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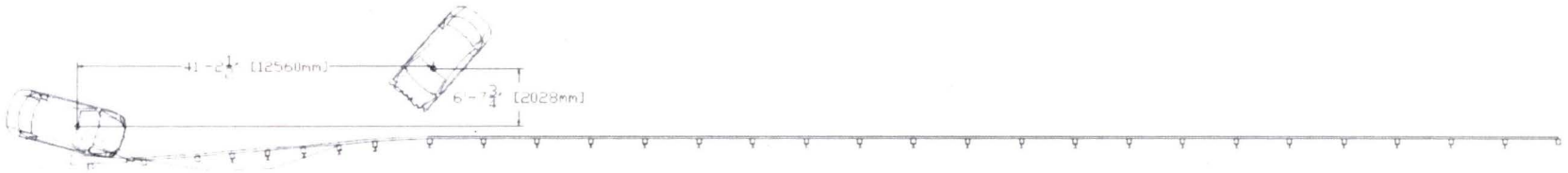


General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P37028-01
Test Designation	3-34
Test Date	3/27/17
Test Article	
Name / Model	MFLEAT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	170.9 ft. (52.1 m)
Terminal Length	39.6 ft. (12.1 m)
Road Surface	Medium to fine silty sand
Test Vehicle	
Type / Designation	1100C
Year, Make, and Model	2011 Kia Rio
Curb Mass	2,495.6 lbs (1,132.0 kg)
Test Inertial Mass	2,415.1 lbs (1,095.5 kg)
Gross Static Mass	2,576.1 lbs (1,168.5 kg)

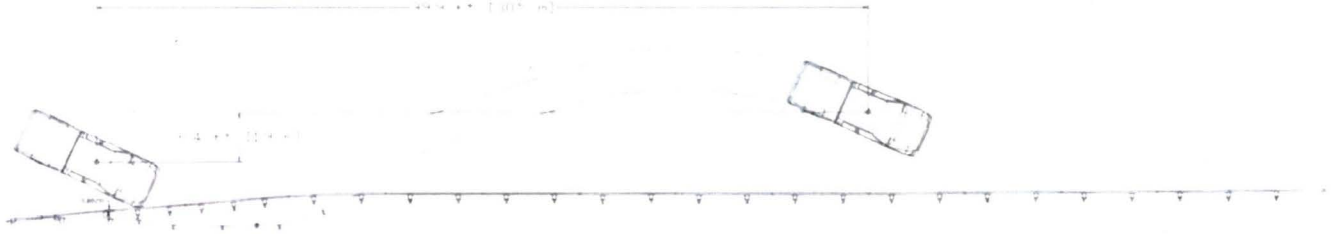
Impact Conditions	
Impact Velocity	61.93 mph (99.66 km/h)
Impact Angle (LON)	15.3°
Impact Angle (Terminal)	19.6°
Location / Orientation	26.9 in. (682 mm) downstream of post 1
Impact Severity	21.6 kip-ft (29.2 kJ)
Exit Conditions	
Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	41.2 ft (12.6 m) downstream 6.7 ft (2.0 m) traffic side
Vehicle Snagging	Minor
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-7.4°
Maximum Pitch Angle	-5.5°
Maximum Yaw Angle	46.8°

Occupant Risk	
Longitudinal OIV	15.7 ft/s (4.8 m/s)
Lateral OIV	12.5 ft/s (3.8 m/s)
Longitudinal RA	-8.7 g
Lateral RA	-6.0
THIV	18.4 ft/s (5.6 m/s)
PHD	10.2 g
ASI	0.69
Test Article Deflections	
Static	2.3 ft. (0.7 m)
Dynamic	2.7 ft. (0.8 m)
Working Width	3.1 ft. (1.0 m)
Vehicle Damage	
Vehicle Damage Scale	01-RFQ-2
CDC	01RFEW1
Maximum Intrusion	Negligible

Figure 2 Summary of Test 3-34

MASH 2016 Test 3-35 Summary

0.000 s 0.200 s 0.400 s 0.600 s 0.800 s



General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P36061-01
Test Designation	3-35
Test Date	1/31/17
Test Article	
Name / Model	MFLEAT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	170.9 ft. (52.1 m)
Terminal Length	39.6 ft. (12.1 m)
Road Surface	Medium to fine silty sand
Test Vehicle	
Type / Designation	2270P
Year, Make, and Model	2011 RAM 1500
Curb Mass	4,914.0 lbs (2,229.0 kg)
Test Inertial Mass	4,993.4 lbs (2,265.0kg)
Gross Static Mass	4,993.4 lbs (2,265.0 kg)

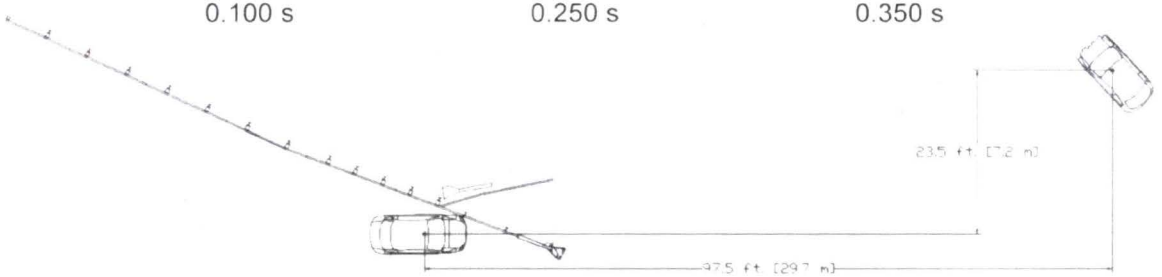
Impact Conditions	
Impact Velocity	62.08 mph (99.91 km/h)
Impact Angle (LON)	25.4°
Impact Angle (Terminal)	29.7°
Location / Orientation	Post 4
Impact Severity	118.4 kip-ft (160.5 kJ)
Exit Conditions	
Exit Velocity	36.76 mph (59.16 km/h)
Exit Angle	28.2°
Final Vehicle Position	99.9 ft (30.5 m) downstream 6.4 ft (1.9 m) Left
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	43.1°
Maximum Pitch Angle	-18.9°
Maximum Yaw Angle	-50.3

Occupant Risk	
Longitudinal OIV	20.7 ft/s (6.3 m/s)
Lateral OIV	13.8 ft/s (4.2 m/s)
Longitudinal RA	-15.1 g
Lateral RA	-7.1
THIV	24.9 ft/s (7.6 m/s)
PHD	16.2 g
ASI	0.71
Test Article Deflections	
Static	3.7 ft. (1.1 m)
Dynamic	4.3 ft. (1.3 m)
Working Width	4.6 ft. (1.4 m)
Debris Field	81.9 ft. (25.0 m) downstream 33.9 ft. (10.3 m) right
Vehicle Damage	
Vehicle Damage Scale	01-RFQ-2
CDC	01RFEW1
Maximum Intrusion	Negligible

Figure 2 Summary of Test 3-35

MASH 2016 Test 3-37 Summary

0.000 s 0.100 s 0.250 s 0.350 s 0.650 s

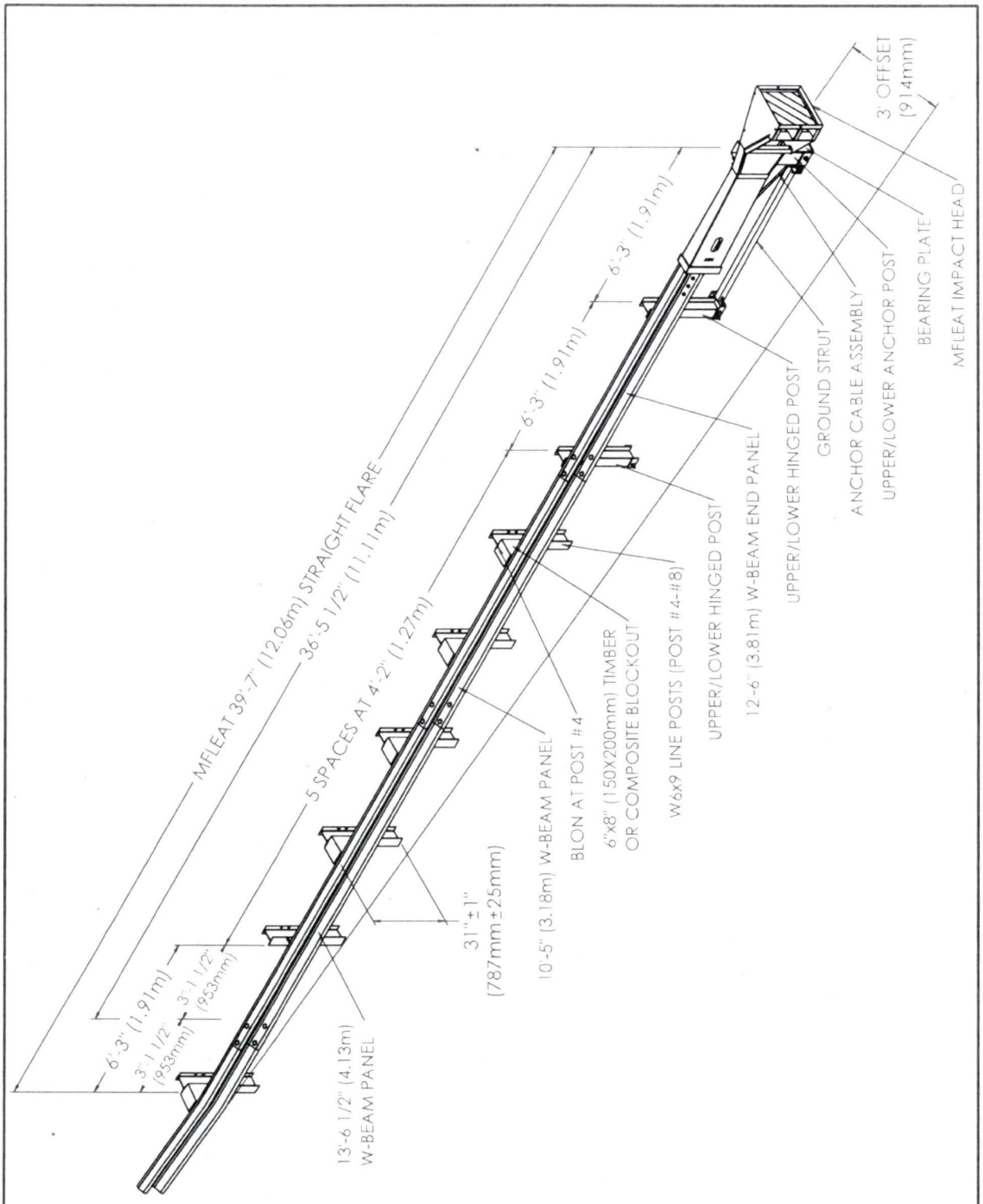


General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P38080-01
Test Designation	3-37
Test Date	3/30/18
Test Article	
Name / Model	MFLEAT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	83.3 ft. (25.4 m)
Terminal Length	39.6 ft. (12.1 m)
Road Surface	Medium to fine silty sand
Test Vehicle	
Type / Designation	1100C
Year, Make, and Model	2012 Hyundai Accent
Curb Mass	2,505.5 lbs (1,136.5 kg)
Test Inertial Mass	2,427.2 lbs (1,101.0 kg)
Gross Static Mass	2,601.4 lbs (1,180.0 kg)

Impact Conditions	
Impact Velocity	60.84 mph (97.92 km/h)
Impact Angle	25.5°
Location / Orientation	3.1 in. (79 mm) upstream from post 3
Impact Severity	55.7 kip-ft (75.5 kJ)
Exit Conditions	
Exit Velocity	32.4 mph (52.1 km/h)
Exit Angle	30.1°
Final Vehicle Position	97.5 ft (29.7 m) Downstream 23.5 ft (7.2 m) Field side
Vehicle Snagging	Minor
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-6.3°
Maximum Pitch Angle	5.8°
Maximum Yaw Angle	25.0°

Occupant Risk	
Longitudinal OIV	31.8 ft/s (9.7 m/s)
Lateral OIV	8.2 ft/s (2.5 m/s)
Longitudinal RA	-9.6 g
Lateral RA	4.2 g
THIV	32.8 ft/s (10.0 m/s)
PHD	10.4 g
ASI	0.98
Test Article Deflections	
Static	9.0 ft. (2.7 m)
Dynamic	14.3 ft. (4.4 m)
Working Width	14.9 ft. (4.5 m)
Debris Field	18.1 ft. (5.5 m) Downstream 61.1 ft. (18.6 m) Field Side
Vehicle Damage	
Vehicle Damage Scale	01-FL3
CDC	01FYEW2
Maximum Intrusion	0.3 in. (8 mm)

Figure 2 Summary of Test 3-37



MFLEAT - MASH FLEAT - MGS System

Road Systems Inc.

SEW14c

SHEET NO	DATE
1 of 2	06-21-18

INTENDED USE

The **MFLEAT** (MASH FLEAT) is a flared roadside energy-absorbing terminal that has been designed and tested under MASH criteria. The MFLEAT system has a 3-ft straight flare offset over the length of the system and has a top-of-rail height of 31" with a plus-or-minus 1" height tolerance.

The first two posts in the terminal are bolted posts connected by a strut. Downstream of post #2 the terminal requires the use of a 10'-5" W-Beam panel to set splices at mid-span between posts, one additional bolted post with no blockout, and five W6x9 (or W6x8.5) steel line posts having 8" or 12" wood or composite blocks. The third 12 gage W-Beam panel is 13'-6 1/2" long and extends 3'-1 1/2" beyond post #8 for a TL-3 system.

The MFLEAT is used to protect the ends of MGS W-Beam barriers. During end-on impacts, the vehicle pushes the MFLEAT impact head down the rail section while sequentially kinking the rail element. The kinked rail exits the impact head on the traffic side of the rail.

The MFLEAT is a cable-anchored system. When impacted on the traffic side within the length of need and within design limits, the MFLEAT contains and redirects the errant vehicle back toward its original travel path. A cable anchor bracket is attached to the backside of the first 12'-6" rail section with special high strength shoulder bolts. The cable anchor bracket locks into place for traffic face redirection impacts but releases for end-on impacts.

ACCEPTANCE

FHWA Letter CC-xx, x x, 2018 - MFLEAT Test Level 3

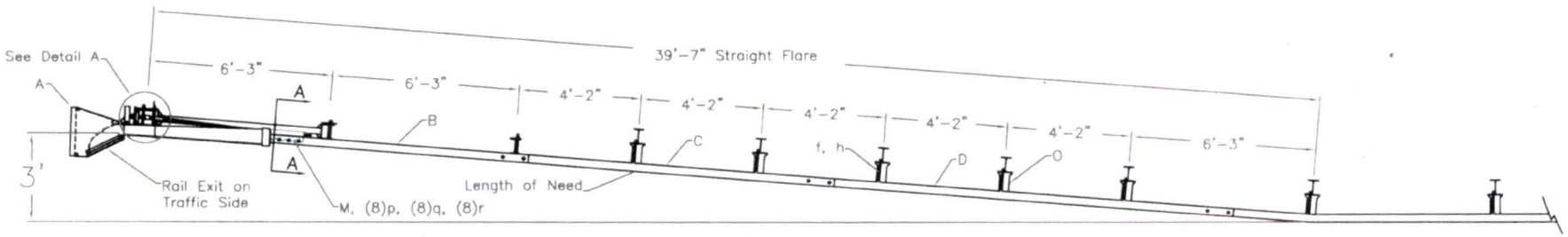
CONTACT INFORMATION

Road Systems, Inc.
3616 Old Howard County Airport
Big Spring, Texas 79720
Phone 432-263-2435Fax 432-267-4039
www.roadsystems.com

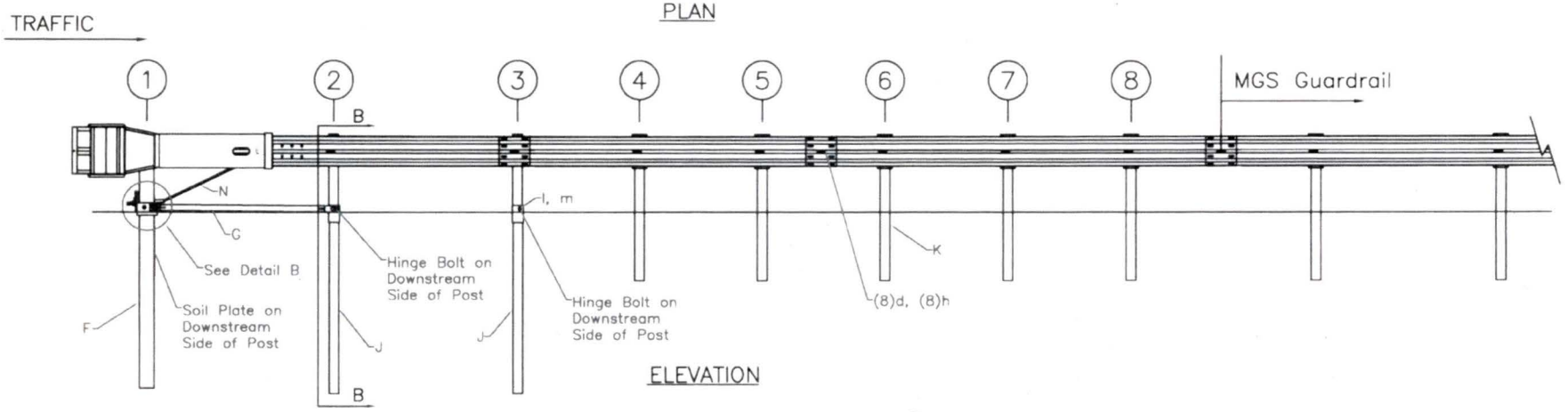
MFLEAT - MASH FLEAT - MGS System

SEW14c	
SHEET NO.	DATE
2 of 2	06-21-18

RSI Road Systems Inc.

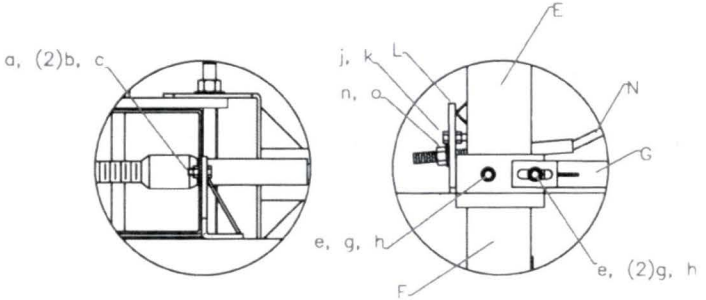


PLAN



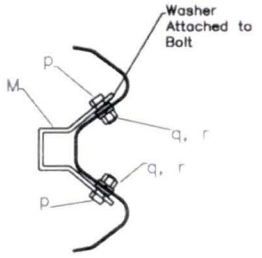
ELEVATION

ITEM	QTY	BILL OF MATERIALS	ITEM NO.
A	1	FLEAT IMPACT HEAD	MF3000
B	1	FLEAT ANCHOR RAIL 12'-6"	SF1303
C	1	FLEAT SECOND RAIL 10'-5"	F1324
D	1	FLEAT THIRD RAIL 13'-6 1/2"	F1334
E	1	FIRST POST TOP (6X6X$\frac{3}{16}$" Tube)	MP1A
F	1	FIRST POST BOTTOM (6' W6X15)	MP1B
G	1	GROUND STRUT	MS785
H	2	HINGE POST UPPER	MHP2A
J	2	HINGED POST LOWER	HP2B
K	5	STEEL LINE POST 6'	P621
L	1	MASH BEARING PLATE	ME750
M	1	CABLE ANCHOR BOX	S760
N	1	BCT CABLE ANCHOR ASSEMBLY	E770
O	5	RECYCLED PLASTIC BLOCK OR EQUIV.	CBSP-14
		HARDWARE (ALL DIMENSIONS IN INCHES)	
a	2	5/16 x 1 HEX BOLT GRD 5	B5160104A
b	4	5/16 WASHER	W0516
c	2	5/16 HEX NUT	N0516
d	18	5/8 x 1 1/4 SPLICE BOLT	B580122
e	2	5/8 x 9 HEX BOLT GRD 5	B580904A
f	5	5/8 x 10 H.G.R. BOLT	B581002
g	3	5/8 WASHER	W050
h	25	5/8 H.G.R NUT	N050
j	1	5/8 x 5" BOLT GRD A449	B580504A
k	1	5/8 HEX NUT	N055
l	2	3/4 x 8 1/2 HEX BOLT GRD A449	B340854A
m	2	3/4 HEX NUT	N030
n	2	1 ANCHOR CABLE HEX NUT	N100
o	2	1 ANCHOR CABLE WASHER	W100
p	8	1/2 RSI SHOULDER BOLT W/WASHER	SB12A
q	8	1/2 STRUCTURAL NUT	N012A
r	8	1/2 STRUCTURAL WASHER	W012A

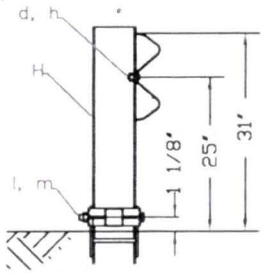


Detail A
Impact Head Connection

Detail B
Post #1 Connection



SECTION A–A
Anchor Bracket



SECTION B–B
Post #2

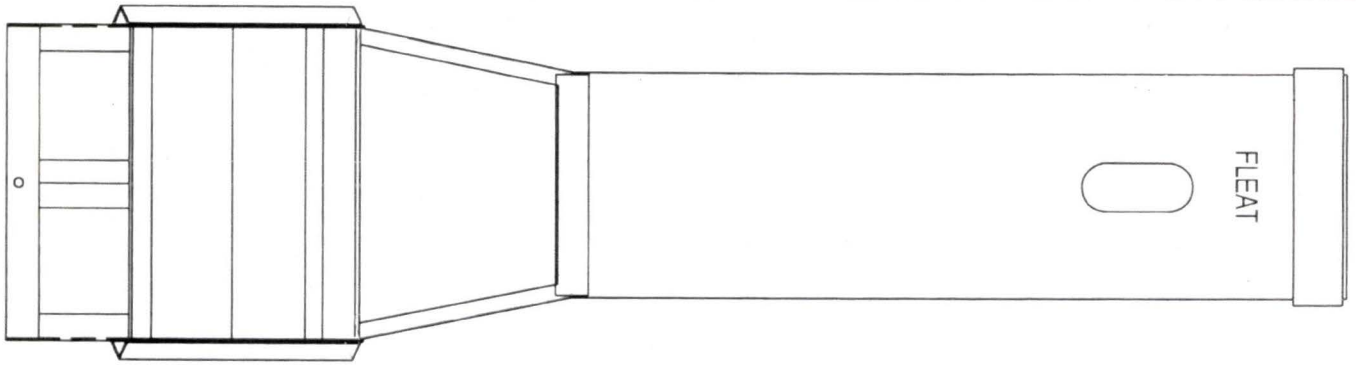
GENERAL NOTES:

1. All bolts, nuts, cable assemblies, cable anchors and bearing plates shall be galvanized.
2. The lower sections of the Posts 1, 2 & 3 shall not protrude more than 4 in above the ground (measured along a 5' cord). Site grading may be necessary to meet this requirement.
3. The lower sections of the hinged posts should not be driven with the upper post attached. If the post is placed in a drilled hole, the backfill material must be satisfactorily compacted to prevent settlement.
4. When competent rock is encountered, a 12" Ø post hole, 20 in. deep cored into the rock surface may be used if approved by the engineer for Posts 1 and/or 2. Granular material will be placed in the bottom of the hole, approximately 2.5" deep to provide drainage. The first post can be field cut to length, placed in the hole and backfilled with suitable backfill. The soil plate may be trimmed if required.
5. The breakaway cable assembly must be taut. A locking device (vice grips or channel lock pliers) should be used to prevent the cable from twisting when tightening nuts.

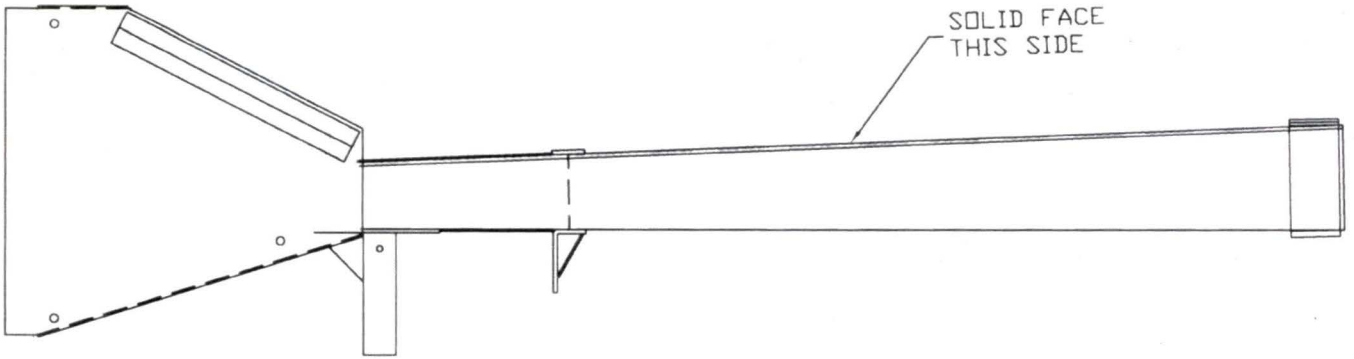
RSI
Road Systems, Inc.
Big Spring, TX
Phone: 432-263-2435
or Phone: 330-348-0721

MASH FLEAT Terminal
TL-3 Standard Post System

		1
		04.14.18
		JRR
MFLT	None	0

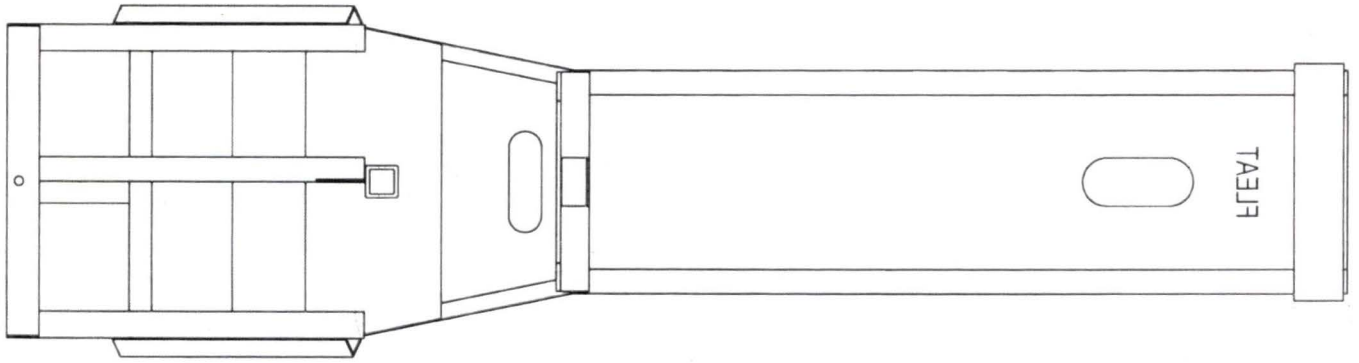


TRAFFIC SIDE



TRAFFIC SIDE

POST SIDE



POST SIDE

RSI
Road Systems, Inc.
Big Spring, TX
Phone: 432-263-2435
or Phone: 330-346-0721

MASH FLEAT
IMPACT HEAD

Sheet: 1

Date: 01/10/18

Drawing Name: MF3000

Scale: NONE

By: JRR

Rev: 0