U.S. Department of Transportation
Federal Highway Administration

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

June 1, 2018

In Reply Refer To:
HSST-1 / CC-126G

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

Dear Mr. Kothman:

This letter is in response to your April 6, 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-126G 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:

- MSKT-SP-MGS Terminal (MASH 2016)

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: MSKT-SP-MGS Terminal (MASH 2016)
Type of system: Terminal
Test Level: MASH Test Level 3 (TL3)
Testing conducted by: KARCO
Date of request: May 17, 2018
Date initially acknowledged: May 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-126G 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,

(for)

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:	April 06, 2018	◉ New ○ Resubmission
	Name:	Alex Beltran	
	Company:	KARCO Engineering	
	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	MSKT-SP-MGS Terminal (MASH 2016)	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 ofdevice.

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 ofgovernment agencies and equipment manufacturers. The principals and staffofKARCO 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. Ifany 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 MSKT-SP-MGS (MASH Sequential Kinking Terminal Standard Post-Midwest Guardrail System) terminal Is a W-beam guardrail terminal consisting of: an Impact head assembly, a breakaway cable anchorage system and a 12.5 ft (3.8 m) end section. The system requires use of a 37.5 ft (11.4 m) standard guardrail section downstream of the terminal incorporating MGS guardrail mounted on 8 in. deep wood or composite blocks and W6x9 (or W6x8.5) steel posts. A 9.4 ft (2.9 m) W-beam rail section is required downstream of Post 3 to transition the rail splices to mid-span.

The MASH SKT Impact head assembly Is 6.8 ft (2.1 m) long, consisting of an impact head and an attached guide chute that partially endoses 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. x0.125 in. 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 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. (18 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 plate 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. (18 mm) hinge bolt in Post 2.

All guardrail sections consist of 12-ga W-beam rail sections. The end section is 125 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 rall section is 9.4 ft (2.9 m) long so that the next splice is be midspan between Posts 4 and 5. The remaining rails are standard 12.5 ft (3.8 m) long rail sections with the splices mid-point between posts.

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:	Alex Beltran	
Engineer Signature:	Alex Beltran — Digitally signed by Alex Beltran DN: cn=Alex Beltran, o=KARCO Engineering, ou=Testing Laboratory, email=abeltran@karco.com, c=US Date: 2018.04.06 07:56:12 -07'00'	
Address:	9270 Holly Road, 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)	KARCOTest No. P35125-01. An 1lOOC (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 degrees, respectively, with the quarter point of the vehicle aligned with the center line of the nose of the terminal. This test is primarily Intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2009 Kia Rio 4-door sedan weighing 2,390.9 lb (1,084.5 kg), Impacted the MASH SKT terminal head on at Impact speed and angle of61.54 mph (99.05 km/h) and 0.9 degree, respectively. The vehicle pushed the Impact head down the length of the guardrail past the fifth post, at which point the rail began to buckle and the vehicle began to yaw counter-clockwise until it impacted the rail at the bend before coming to a stop next to the rail on the traffic side. The test vehicle sustained moderate damage to the front end with no occupant compartment deformation. The vehicle remained upright without excessive roll or pitch. The test article was extensively damage from Post 1 through Post 5 and the rail wrapped around Post 6. The Occupant Impact Velocities (OIV) and rIdedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal	PASS

Required Test Number	Narrative Description	Evaluation Results
3-31 (2270P)	KARCO Test No. P34149-01. 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 degrees, respectively, with the center line ofthe vehicle aligned with the center line of the nose ofthe terminal. This test Is primarily Intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2008 Dodge Ram 4-door pickup truck. with a test inertial mass weighing 4,896.4 lb (2,221 kg). impacted the MASH SKTterminal head-on at impact speed and angle of62.33 mph (100.31 km/ h) and 0.4 degrees, respectively. The vehicle pushed the impact head down the length of the guardrail past Post 8 and came to rest 50.5 ft (15.4 m) from the point of Initial Impact The test vehicle sustained moderate damage to the front end with no occupant compartment deformation. The vehicle remained upright and stable. The test article was extensively damaged from Post 1 through Post 8. The Occupant Impact Velocities (OIV) and rldedown accelerations are within the recommended limits. The MSKT-SP terminal passed all evaluation criteria for Test 3-31.	PASS

3-32 (1100C)	KARCO Test No. P35025-01. An 11 OOC (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 center line of the vehicle aligned with the center line of the nose ofthe terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 201 oKia Rio 4-door sedan weighing 2,457.o lb (1,114.5 kg), Impacted the MASH SKT terminal head-on at Impact speed and angle of61.47 mph (98.93 km/h) and 4.4 degrees, respectively. The vehicle pushed the impact head down the length of 3-32 (11 OOC) PASS the guardrail past the fifth post, at which point the vehicle mounted the guardrail. Upon dismounting the rail, the vehicle proceeded forward and to the left and remained upright throughout the impact sequence. The test vehicle sustained moderate damage to the front and left side with no occupant compartment deformation. The vehicle remained upright and stable. The test article was extensively damaged from Post 1 through Post 5. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test3-32.	PASS

3-33 (2270P)	KARCO Test No. P34149-04 . 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 center line of the vehicle aligned with the center line of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2008 Dodge Ram 4-door pickup truck weighing 4,895.3 lb (2,220.5 kg), impacted the MASH SKT terminal head-on at an Impact speed and angle of 62.74 mph (100.97 km/h) and 5.7 degrees, respectively. The vehicle pushed the impact head down the guardrail past the fifth post at which point the vehicle mounted the guardrail in a controlled manner without excessive deceleration and proceeded forward. The vehicle then impacted Post 6 before separating from the guardrail. The vehicle impacted the test article again between Posts 23 and 24. The vehicle sustained moderate damage at the front and left side and deformations to the occupant compartment were negligible. The vehicle remained upright and stable. The test article was extensively damaged from Posts 1 through Post 6. Post 7 was 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. The MSKT-SP terminal passed all evaluation criteria for Test 3-33.	PASS

3-34 (1100C)	KARCO Test No. P35126-01. An 11 OOC (2,425 lb) passenger car Impacting the terminal at a nominal Impact speed and angle of 62.2 mph (100 km/h) 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 2010 Kia Rio 4-door sedan weighing 2,436.1 lb (1,105.0 kg), Impacted the downstream end of the Impact head between Posts 1 and 2 at Impact speed and angle of 61.37 mph (98.77 km/h) and 15.3 3-34 (11 OOC) degrees, respectlvely. The vehicle was PASS contained and redirected by the guardrail before separating from the test article near Post 6 at a velocity of 27.7 mph and an exit angle of 17.o degrees and proceeded downstream adjacent to the guardrail. The vehicle remained upright and stable throughout the impact sequence. The test vehicle sustained moderate damage to the front right side with no occupant compartment deformation. The test article was extensively damaged from Post 1 through Post 5. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-34.	PASS

3-35 (2270P)	KARCO Test No. P35103-01. A2270P (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 length-ofneed (LON) of the terminal. This test is primarily intended to evaluate structural adequacy and vehicle trajectory criteria. The test vehicle, a 2011 Dodge Ram 4-door pickup truck weighing 4,942.6 lb (2,242.0 kg), Impacted the guardrail at Post 3, the beginning of length-of-need, at impact speed and angle of 62.36 mph (100.36 km/h) and 26 degrees, respectively. The vehicle was contained and redirected by the guardrail before separating from the test article near Post 9 at a velocity of 32.75 mph (52.71 km/h) and an exit angle of34.93 degrees and proceeded downstream adjacent to the guardrail on the traffic side. The vehicle then veered back toward the guardrail and impacted Post 20 before coming to rest at Post 26. The vehicle remained upright and stable throughout the Impact sequence. The test vehicle sustained moderate damage to the front right side with no occupant compartment deformation. The test article was extensively damaged from Post 1 through Post 9. The maximum static lateral deformation was 30.2 in (768 mm) between Posts 5 and 6. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-35.	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 MSKTSP-MGS 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 (2270P)	Test No. P38021-01. A 1100C (2,425 lb) small car involves the vehicle impacting the terminal at a nominal speed of 100 km/h (62 mph) at an angle of 25 deg. between the nose and the end of the terminal in the reverse direction. This test is intended to evaluate the performance of a terminal for a "reverse" hit. The small car was deemed as the more critical vehicle for this test according the MASH 2016. The test vehicle was a 2013 Hyundai Elantra weighing 2,420.6 lb (1098 kg). The vehicle impacted the guardrail at post 3 with a speed of 61.00 mph (98.17 km/h) and an angle of 25.6 deg. The vehicle impacted post 3 and then continued to impact post 2 and the back side of the impact head. The vehicle was continued forward at an angle of 24.4 deg. The vehicle sustained moderate damaged to the front end. The occupant compartment was not penetrated and none of the intrusion limits were exceeded. The first rail was deformed due to the impact and the impact head was forced off the first rail element. The occupant impact velocities (OIV) and ridedown accelerations were within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-37.	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 MSKf-SP-MGS terminal is not a staged device, because the force required to move the Impact head down the rail does not change. The 3-30 test with the 11 OOC vehicle makes this test unnecessary.	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:	Alex Beltran — Digitally signed by Alex Beltran DN: cn=Alex Beltran, o=KARCO Engineering, ou=Testing Laboratory, email=abeltran@karco.com, c=US Date: 2018.04.05 16:55:13 -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 :	October 12, 2017 - July 1, 2018	

Submitter Signature*: Alex Beltran — Digitally signed by Alex Beltran DN: cn=Alex Beltran, o=KARCO Engineering, ou=Testing Laboratory, email=abeltran@karco.com, c=US Date: 2018.04.05 16:55:46 -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 3-37 Summary

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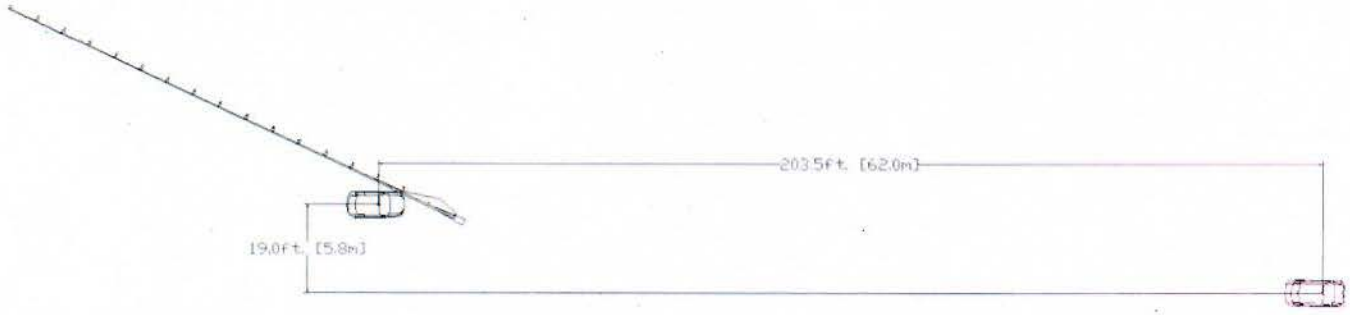


General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P38021-01
Test Designation	3-37
Test Date	2/1/18

Test Article	
Name / Model	MSKT -SP-MGS Terminal
Type	Guardrail Terminal
Installation Length	106.3 ft. (32.4 m)
Terminal Length	12.5 ft. (3.8 m)
Road Surface	Medium to fine silty sand

Test Vehicle	
Type / Designation	1100C
Year, Make, and Model	2013 Hyundai Accent
Curb Mass	2,518.7 lbs (1,142.5 kg)
Test Inertial Mass	2,420.6 lbs (1,098.0kg)
Gross Static Mass	2,588.2 lbs (1,174.0 kg)

Impact Conditions	
Impact Velocity	61.00 mph (98.17 km/h)
Impact Angle	25.6°
Location / Orientation	Post 3
Impact Severity	56.2 kip-ft (76.2 kJ)

Exit Conditions	
Exit Velocity	36.6 mph (58.9 km/h)
Exit Angle	24.4°
Final Vehicle Position	203.5 ft (62.0 m) downstream 18.8 ft (5.7 m) Right
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	4.7°
Maximum Pitch Angle	8.0°
Maximum Yaw Angle	-3.2

Occupant Risk	
Longitudinal OIV	31.8 ft/s (9.7 m/s)
Lateral OIV	13.8 ft/s (4.2 m/s)
Longitudinal RA	-6.6 g
Lateral RA	3.5
THIV	33.1 ft/s (10.1 m/s)
PHD	6.9 g
ASI	1.02

Test Article Deflections	
Static	2.5 ft. (754 mm)
Dynamic	4.1 ft. (1.2 m)
Working Width	4.4 ft. (1.3 m)

Vehicle Damage	
Vehicle Damage Scale	11-FL-4
CDC	11FLEW1
Maximum Intrusion	Negligible

Figure 2 Summary of Test 3-37

SECTION 4

MASH TEST 3-30 SUMMARY

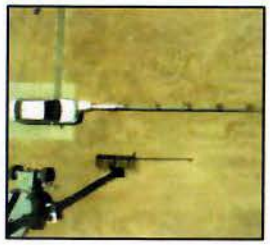
Test Article: Road Systems MSKT-SP-MGS Terminal

Test Program: MASH 3-30

Project No. P35125-01

Test Date: 07/02/15

SEQUENTIAL PHOTOGRAPHS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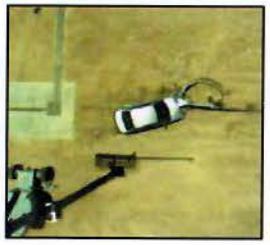
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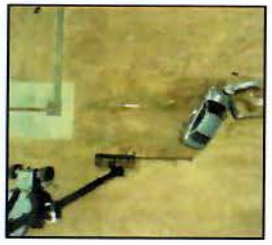
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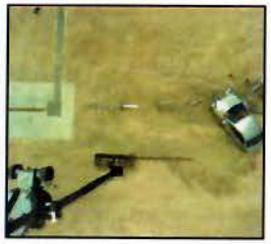
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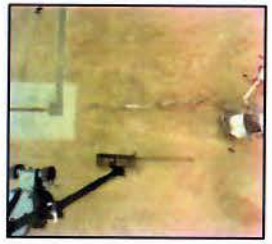
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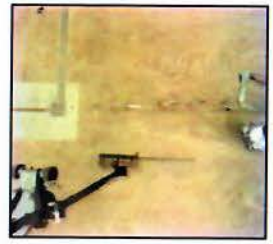
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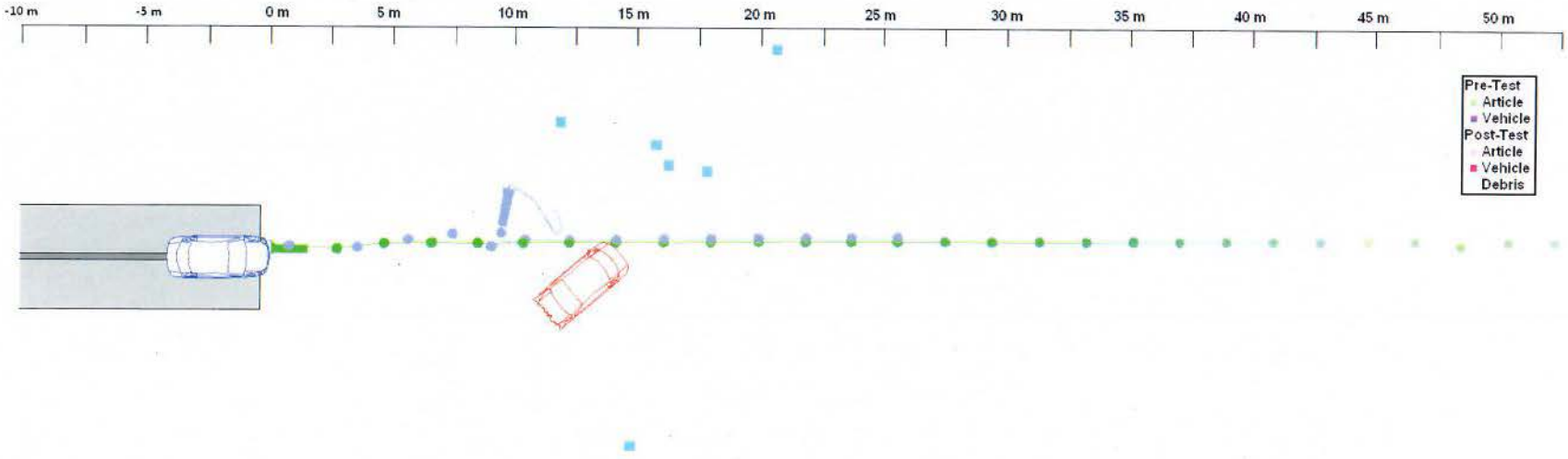
PLAN VIEW



SECTION 4

MASH TEST 3-30 SUMMARY ... (CONTINUED)

Test Article: Road Systems MSKT-SP-MGS Terminal — Project No. P35125-01

Test Program: MASH 3-30 — Test Date: 07/02/15

SUMMARY TABLE

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC.
TEST NUMBER	P35125-01
TEST DESIGNATION	3-30
TEST DATE	7/2/15
TEST ARTICLE	
NAME / MODEL	MSKT-SP-MSG Terminal
TYPE	Guardrail Terminal / End Treatment
KEY ELEMENTS	12 Ga. W-Beam, W6x15 / 6"x6"x0.125" Breakaway Post, W6 x 9 Breakaway Post
TERMINAL LENGTH	12.5 ft. (3.8 m)
ADJOINING BARRIER LENGTH	156.24 ft. (47.6 m)
RAIL MOUNTING HEIGHT	32.0 in. (813 mm)
ROAD SURFACE	Compacted Soil
SOIL TYPE / CONDITION	Medium to fine silty sand
TEST VEHICLE	
TYPE / DESIGNATION	1100C
YEAR, MAKE AND MODEL	2009 Kia Rio
CURB MASS	2,319.2 lbs (1,052.0 kg)
TEST INERTIAL MASS	2,390.9 lbs (1,084.5 kg)
GROSS STATIC MASS	2,551.8 lbs (1,157.5 kg)

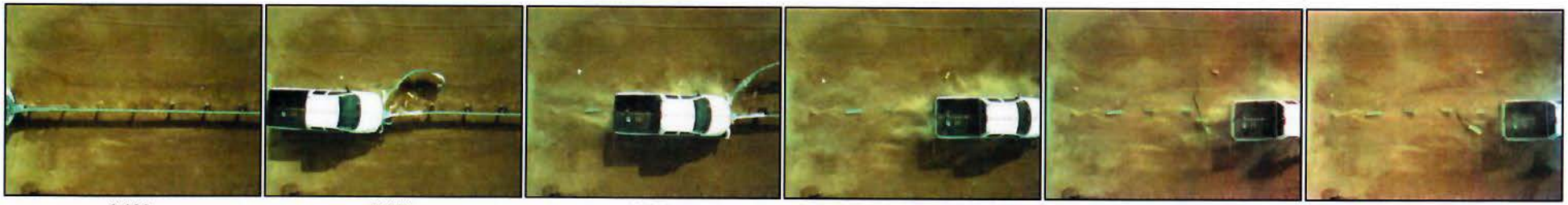
IMPACT AND EXIT CONDITIONS		
IMPACT VELOCITY		61.34 mph (98.72 km/h)
IMPACT ANGLE (°)		0.9
MAXIMUM ROLL ANGLE (°)		17.6
MAXIMUM PITCH ANGLE (°)		-14.0
MAXIMUM YAW ANGLE (°)		149.7
STOPPING DISTANCE		36.1 ft (11.0 m)
IMPACT SEVERITY		321.0 kip-ft (435.2 kJ)
OCCUPANT RISK VALUES		
OCCUPANT IMPACT VELOCITY	Longitudinal	22.0 ft/s (6.7 m/s)
	Lateral	0.3 ft/s (0.1 m/s)
RIDEDOWN ACCELERATION	Longitudinal	-6.5 g
	Lateral	-4.1 g
THIV		22.0 ft/s (6.7 m/s)
PHD		6.8 g
ASI		0.65
VEHICLE DAMAGE		
VEHICLE DAMAGE SCALE		12-FL-4
COLLISION DAMAGE CLASSIFICATION		12FDEW1
MAXIMUM DEFORMATION		8.0 in. at C3 to the left of the vehicle centerline

SECTION 4

MASH TEST 3-31 SUMMARY

Test Article:	Road Systems MSKT-SP Terminal	Project No.	P34149-01
Test Program:	MASH 3-31	Test Date:	11/20/14

SEQUENTIAL PHOTOGRAPHS



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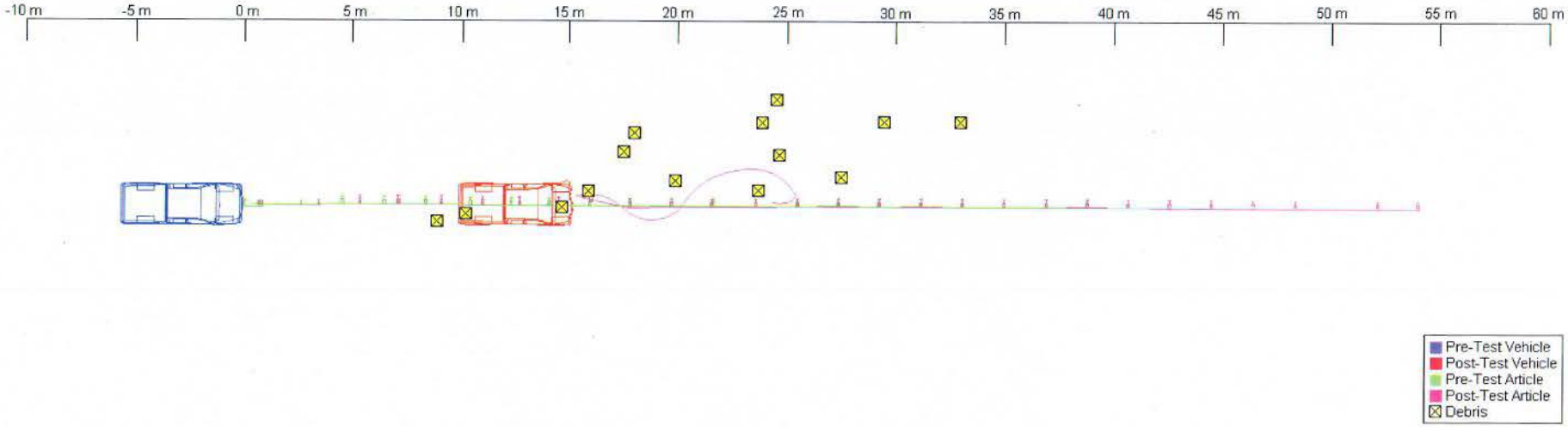
PLAN VIEW



SECTION 4

MASH TEST 3-31 SUMMARY...(CONTINUED)

Test Article: Road Systems MSKT-SP Terminal — Project No. P34149-01

Test Program: MASH 3-31 — Test Date: 11/20/14

SUMMARY TABLE

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC.
TEST NUMBER	P34149-01
TEST DESIGNATION	3-31
TEST DATE	11/20/14
TEST ARTICLE	
NAME / MODEL	SKT-SP Terminal
TYPE	Guardrail Terminal / End Treatment
KEY ELEMENTS	12 Ga. W-Beam, W6x15 / 6"x6"x0.125" Breakaway Post, W6 x 9 Breakaway Post
INSTALLATION LENGTH	174.9 ft. (53.3 m)
RAIL MOUNTING HEIGHT	28.0 in. (711 mm)
ROAD SURFACE	Compacted Soil
SOIL TYPE / CONDITION	Medium to fine silty sand
TEST VEHICLE	
TYPE / DESIGNATION	2270P
YEAR, MAKE AND MODEL	2008 Dodge Ram
CURB MASS	4,953.7 lbs (2,247.0 kg)
TEST INERTIAL MASS	4,896.4 lbs (2,221.0 kg)
GROSS STATIC MASS	4,896.4 lbs (2,221.0 kg)

IMPACT AND EXIT CONDITIONS		
IMPACT VELOCITY		62.33 mph (100.31 km/h)
IMPACT ANGLE (°)		0.4
MAXIMUM ROLL ANGLE (°)		4.1
MAXIMUM PITCH ANGLE (°)		1.7
MAXIMUM YAW ANGLE (°)		1.6
STOPPING DISTANCE		50.5 ft (15.4 m)
IMPACT SEVERITY		635.9 kip-ft (861.9 kJ)
OCCUPANT RISK VALUES		
OCCUPANT IMPACT VELOCITY	Longitudinal	19.4 ft/s (5.9 m/s)
	Lateral	1.0 ft/s (0.3 m/s)
RIDEDOWN ACCELERATION	Longitudinal	-6.9 g
	Lateral	-2.7 g
THIV		19.4 ft/s (5.9 m/s)
PHD		6.9 g
ASI		0.35
VEHICLE DAMAGE		
VEHICLE DAMAGE SCALE		12-FC-2
COLLISION DAMAGE CLASSIFICATION		12FCEW1
MAXIMUM DEFORMATION		7.2 in. (184 mm) at C3 to the left of the vehicle centerline on the front bumper

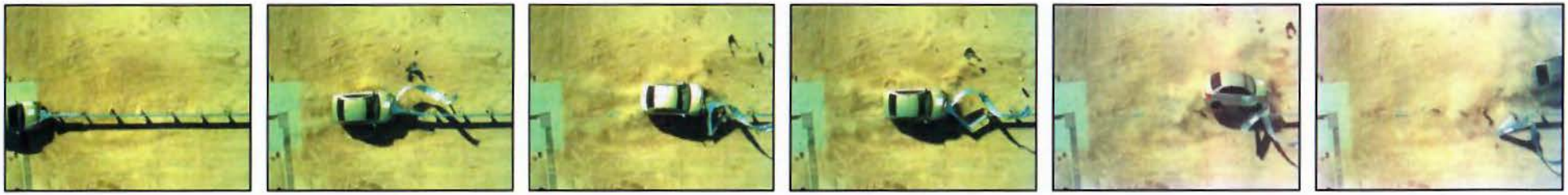
SECTION 4

MASH TEST 3-32 SUMMARY

Test Article: Road Systems MSKT-SP-MGS Terminal Project No. P35025-01

Test Program: MASH 3-32 Test Date: 02/12/15

SEQUENTIAL PHOTOGRAPHS



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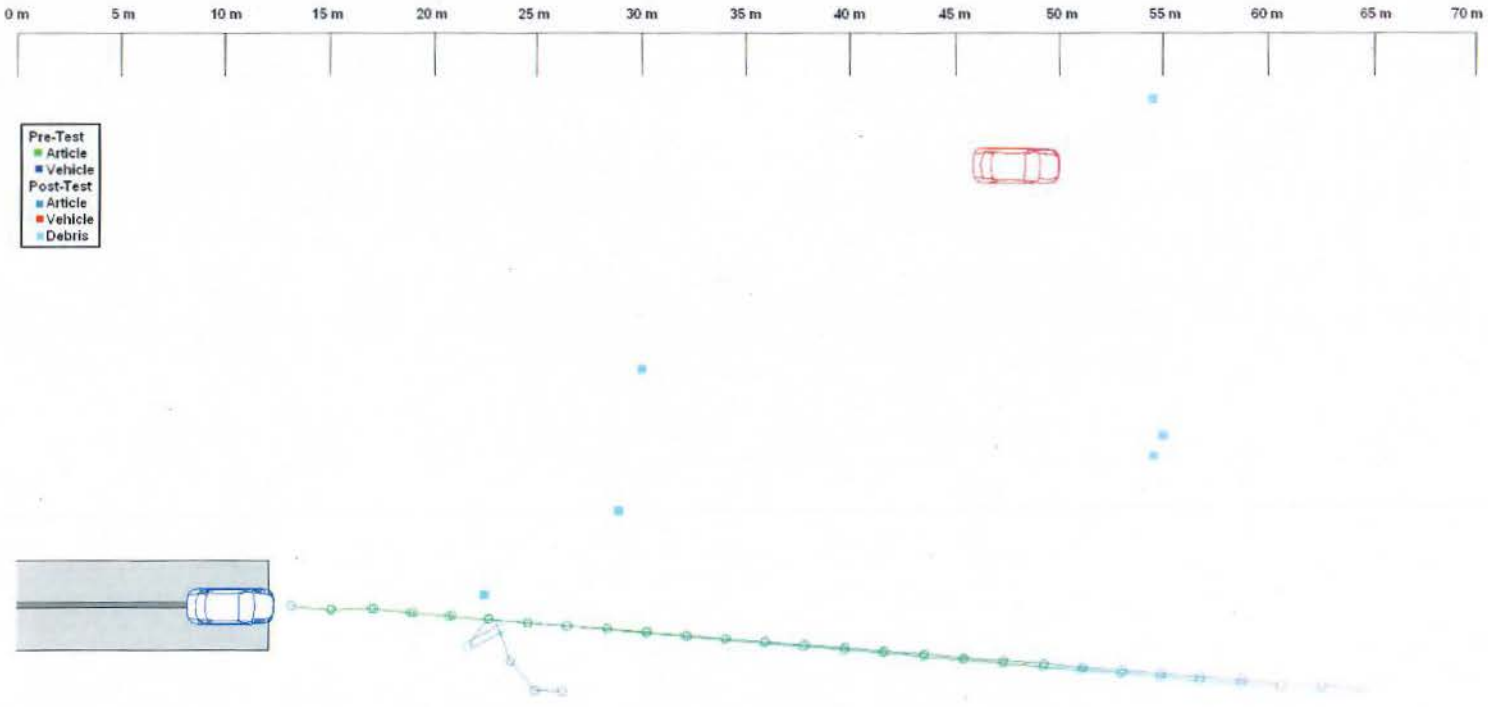


SECTION 4

MASH TEST 3-32 SUMMARY ... (CONTINUED)

Test Article: Road Systems MSKT-SP-MGS Terminal — Project No. P35025-01

Test Program: MASH 3-32 — Test Date: 02/12/15

SUMMARY TABLE

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC.
TEST NUMBER	P35025-01
TEST DESIGNATION	3-32
TEST DATE	2/12/15
TEST ARTICLE	
NAME / MODEL	MSKT-SP-MGS Terminal
TYPE	Guardrail Terminal / End Treatment
KEY ELEMENTS	12 Ga. W-Beam, W6x15 / 6"x6"x0.125" Breakaway Post, W6 x 9 Breakaway Post
INSTALLATION LENGTH	168.75 ft. (51.44 m)
RAIL MOUNTING HEIGHT	32.0 in. (813 mm)
ROAD SURFACE	Compacted Soil
SOIL TYPE / CONDITION	Medium to fine silty sand
TEST VEHICLE	
TYPE / DESIGNATION	1100C
YEAR, MAKE AND MODEL	2010 Kia Rio
CURB MASS	2,485.7 lbs (1,127.5 kg)
TEST INERTIAL MASS	2,457.0 lbs (1,114.5 kg)
GROSS STATIC MASS	2,630.1 lbs (1,193.0 kg)

IMPACT AND EXIT CONDITIONS		
IMPACT VELOCITY		61.47 mph (98.93 km/h)
IMPACT ANGLE (°)		4.4
MAXIMUM ROLL ANGLE (°)		-45.9
MAXIMUM PITCH ANGLE (°)		-10.2
MAXIMUM YAW ANGLE (°)		40.8
STOPPING DISTANCE		
IMPACT SEVERITY		310.2 kip-ft (420.7 kJ)
OCCUPANT RISK VALUES		
OCCUPANT IMPACT VELOCITY	Longitudinal	22.6 ft/s (6.9 m/s)
	Lateral	0.3 ft/s (0.1 m/s)
RIDEDOWN ACCELERATION	Longitudinal	-8.1
	Lateral	5.0
THIV		22.6 ft/s (6.9 m/s)
PHD		8.1
ASI		0.56
VEHICLE DAMAGE		
VEHICLE DAMAGE SCALE		12-FL-4
COLLISION DAMAGE CLASSIFICATION		12FDEW2
MAXIMUM DEFORMATION		13.7 in. at C5 to the right of the vehicle centerline

SECTION 4

MASH TEST 3-33 SUMMARY

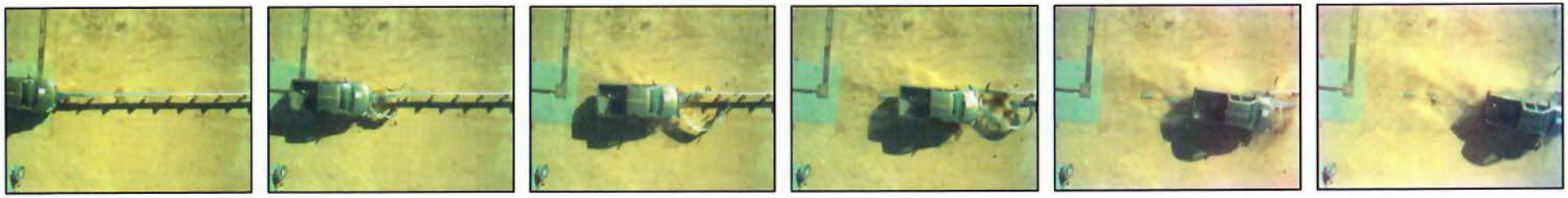
Test Article: Road Systems MSKT-SP Terminal

Project No. P34149-04

Test Program: MASH 3-33

Test Date: 02/12/15

SEQUENTIAL PHOTOGRAPHS



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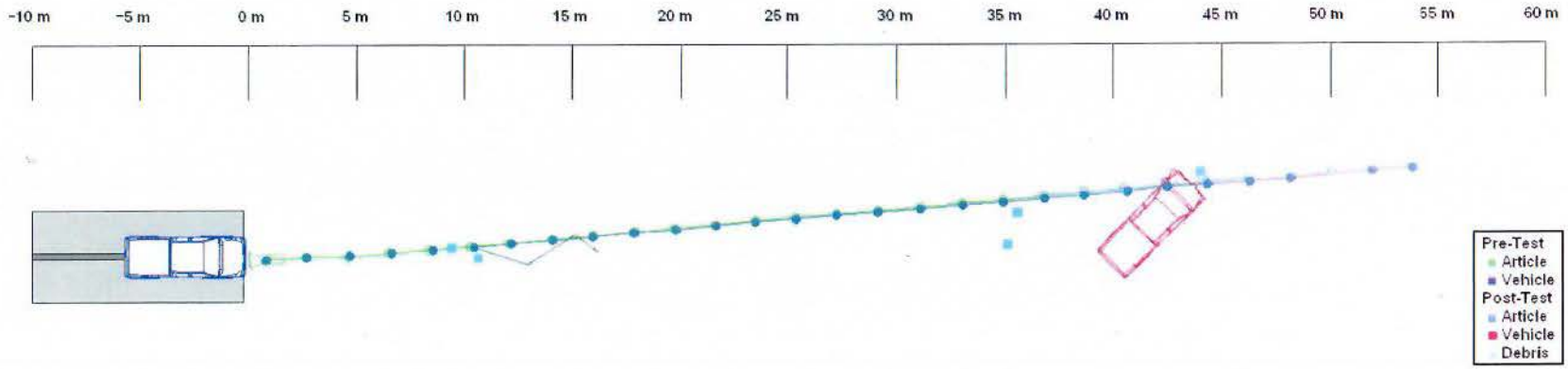
PLAN VIEW



SECTION 4

MASH TEST 3-33 SUMMARY ... (CONTINUED)

Test Article: Road Systems MSKT-SP Terminal — Project No. P34149-04

Test Program: MASH 3-33 — Test Date: 02/12/15

SUMMARY TABLE

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC.
TEST NUMBER	P34149-04
TEST DESIGNATION	3-33
TEST DATE	2/12/15
TEST ARTICLE	
NAME / MODEL	MSKT-SP Terminal
TYPE	Guardrail Terminal / End Treatment
KEY ELEMENTS	12 Ga. W-Beam, W6x15 / 6"x6"x0.125" Breakaway Post, W6 x 9 Breakaway Post
INSTALLATION LENGTH	174.3 ft. (53.1 m)
RAIL MOUNTING HEIGHT	28.0 in. (799 mm)
ROAD SURFACE	Compacted Soil
SOIL TYPE / CONDITION	Medium to fine silty sand
TEST VEHICLE	
TYPE / DESIGNATION	2270P
YEAR, MAKE AND MODEL	2008 Dodge Ram
CURB MASS	4,764.1 lbs (2,161.0 kg)
TEST INERTIAL MASS	4,895.3 lbs (2,220.5 kg)
GROSS STATIC MASS	4,895.3 lbs (2,220.5 kg)

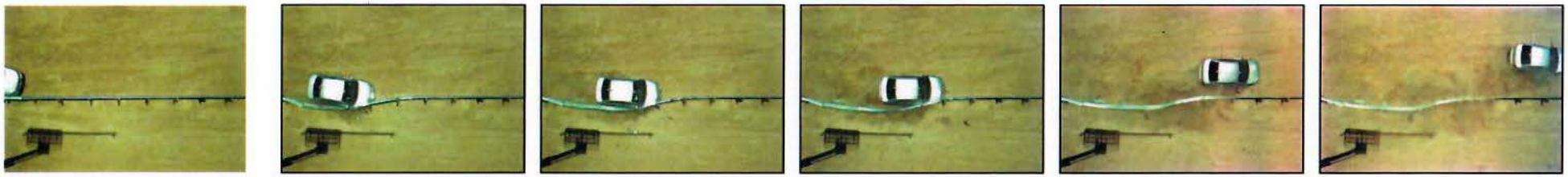
IMPACT AND EXIT CONDITIONS		
IMPACT VELOCITY		62.74 mph (100.97 km/h)
IMPACT ANGLE (°)		5.7
MAXIMUM ROLL ANGLE (°)		24.3
MAXIMUM PITCH ANGLE (°)		10.4
MAXIMUM YAW ANGLE (°)		-6.9
STOPPING DISTANCE		148.3 ft (45.2 m)
IMPACT SEVERITY		637.9 kip-ft (864.9 kJ)
OCCUPANT RISK VALUES		
OCCUPANT IMPACT VELOCITY	Longitudinal	18.0 ft/s (5.5 m/s)
	Lateral	0.3 ft/s (0.1 m/s)
RIDEDOWN ACCELERATION	Longitudinal	-6.1
	Lateral	-3.0
THIV		18.0 ft/s (5.5 m/s)
PHD		6.2
ASI		0.40
VEHICLE DAMAGE		
VEHICLE DAMAGE SCALE		12-FL-4
COLLISION DAMAGE CLASSIFICATION		12FDEW2
MAXIMUM DEFORMATION		25.4 in. at C1 to the left of the vehicle centerline

SECTION 4

MASH TEST 3-34 SUMMARY

Test Article:	Road Systems MSKT-SP-MGS Terminal	Project No.	P35126-01
Test Program:	MASH 3-34	Test Date:	07/16/15

SEQUENTIAL PHOTOGRAPHS



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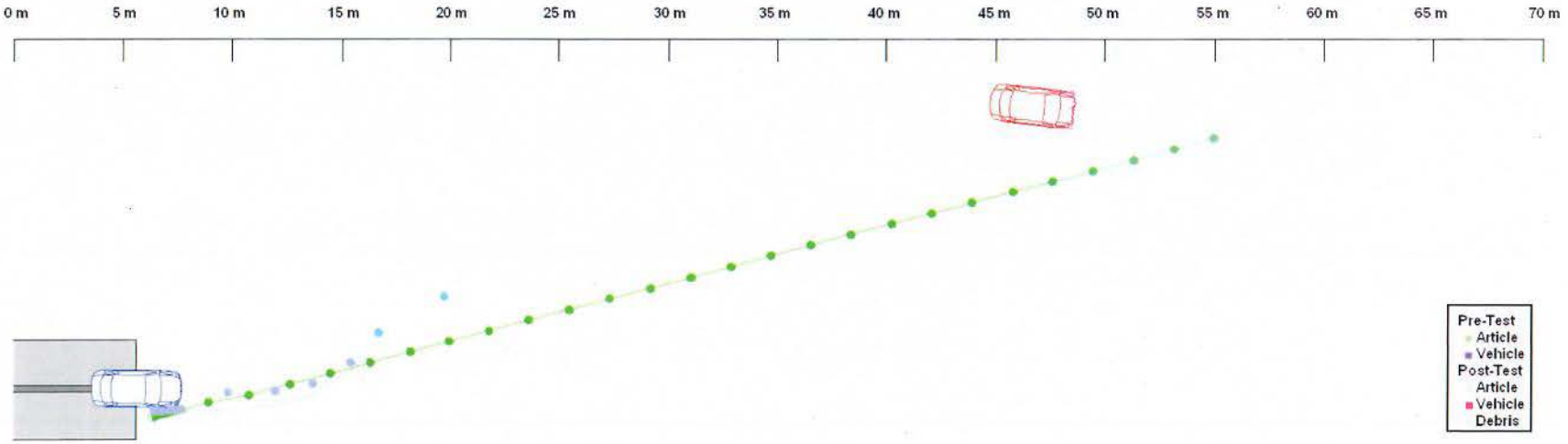
PLAN VIEW



SECTION 4

MASH TEST 3-34 SUMMARY ... (CONTINUED)

Test Article: Road Systems MSKT-SP-MGS Terminal — Project No. P35126-01

Test Program: MASH 3-34 — Test Date: 07/16/15

SUMMARY TABLE

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC.
TEST NUMBER	P35126-01
TEST DESIGNATION	3-34
TEST DATE	7/16/15
TEST ARTICLE	
NAME / MODEL	MSKT-SP-MGS Terminal
TYPE	Guardrail Terminal / End Treatment
KEY ELEMENTS	12 Ga. W-Beam, W6 x15 / 6"x6"x0.125" Breakaway Post, W6 x 9 Breakaway Post
TERMINAL LENGTH	12.4 ft. (3.8 m)
ADJOINING BARRIER LENGTH	156.2 ft. (47.6 m)
RAIL MOUNTING HEIGHT	32.0 in. (813 mm)
ROAD SURFACE	Compacted Soil
SOIL TYPE / CONDITION	Medium to fine silty sand
TEST VEHICLE	
TYPE / DESIGNATION	1100C
YEAR, MAKE AND MODEL	2010 Kia Rio
CURB MASS	2,473.5 lbs (1,122.0 kg)
TEST INERTIAL MASS	2,436.1 lbs (1,105.0 kg)
GROSS STATIC MASS	2,601.4 lbs (1,180.0 kg)

IMPACT AND EXIT CONDITIONS		
IMPACT VELOCITY		61.37 mph (98.77 km/h)
IMPACT ANGLE (°)		15.3
MAXIMUM ROLL ANGLE (°)		-7.1
MAXIMUM PITCH ANGLE (°)		-5.0
MAXIMUM YAW ANGLE (°)		17.9
STOPPING DISTANCE		134.8 ft. (41.1 m)
IMPACT SEVERITY		22.8 kip-ft (30.9 kJ)
OCCUPANT RISK VALUES		
OCCUPANT IMPACT VELOCITY	Longitudinal	18.7 ft/s (5.7 m/s)
	Lateral	11.48 ft/s (3.5 m/s)
RIDEDOWN ACCELERATION	Longitudinal	-13.6
	Lateral	-6.5
THIV		23.6 ft/s (7.2 m/s)
PHD		14.1 g
ASI		0.61
VEHICLE DAMAGE		
VEHICLE DAMAGE SCALE		2-RFQ-7
COLLISION DAMAGE CLASSIFICATION		12RFMW1
MAXIMUM DEFORMATION		N/A

SECTION 4

MASH TEST 3-35 SUMMARY

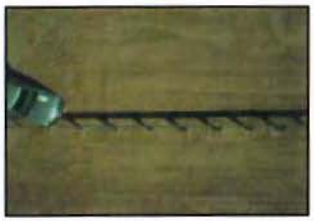
Test Article: Road Systems MSKT-SP-MGS Terminal

Project No. P35103-01

Test Program: MASH 3-35

Test Date: 06/25/15

SEQUENTIAL PHOTOGRAPHS



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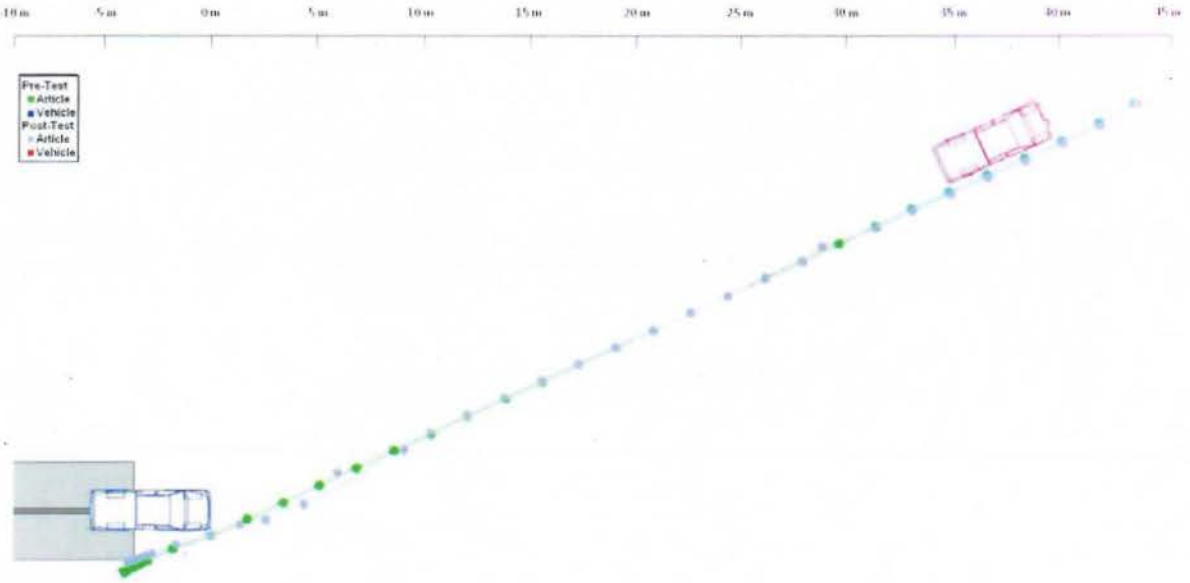
PLAN VIEW



SECTION 4

MASH TEST 3-35 SUMMARY... (CONTINUED)

Test Article: Road Systems MSKT-SP-MGS Terminal — Project No. P35103-01

Test Program: MASH 3-35 — Test Date: 06/25/15

SUMMARY TABLE

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC.
TEST NUMBER	P35103-01
TEST DESIGNATION	3-35
TEST DATE	6/25/15
TEST ARTICLE	
NAME / MODEL	MSKT-SP-MGS Terminal
TYPE	Guardrail Terminal / End Treatment
KEY ELEMENTS	12 Ga. W-Beam, W6 x15 / 6"x6"x0.125" Breakaway Post, W6 x 9 Breakaway Post
TERMINAL LENGTH	12.5 ft. (3.8 m)
ADJOINING BARRIER LENGTH	156.2 ft. (47.6 m)
RAIL MOUNTING HEIGHT	30.0 in. (762 mm)
ROAD SURFACE	Compacted Soil
SOIL TYPE / CONDITION	Medium to fine silty sand
TEST VEHICLE	
TYPE / DESIGNATION	2270P
YEAR, MAKE AND MODEL	2011 Dodge Ram 1500
CURB MASS	5,061.7 lbs (2,296.0 kg)
TEST INERTIAL MASS	4,942.6 lbs (2,242.0 kg)
GROSS STATIC MASS	4,942.6 lbs (2,242.0 kg)

IMPACT AND EXIT CONDITIONS		
IMPACT VELOCITY		62.36 mph (100.36 km/h)
IMPACT ANGLE (°)		26.0
MAXIMUM ROLL ANGLE (°)		14.8
MAXIMUM PITCH ANGLE (°)		-6.5
MAXIMUM YAW ANGLE (°)		36.6
STOPPING DISTANCE		143.6 ft. (43.8 m)
IMPACT SEVERITY		123.2 kip-ft (167 kJ)
OCCUPANT RISK VALUES		
OCCUPANT IMPACT VELOCITY	Longitudinal	20.0 ft/s (6.1 m/s)
	Lateral	23.0 ft/s (7.0 m/s)
RIDEDOWN ACCELERATION	Longitudinal	-8.8 g
	Lateral	-9.1 g
THIV		21.7 ft/s (6.6 m/s)
PHD		9.6
ASI		0.7
VEHICLE DAMAGE		
VEHICLE DAMAGE SCALE		1-RFQ-5
COLLISION DAMAGE CLASSIFICATION		01RFEW2
MAXIMUM DEFORMATION		

SECTION 4

MASH TEST 3-37 SUMMARY

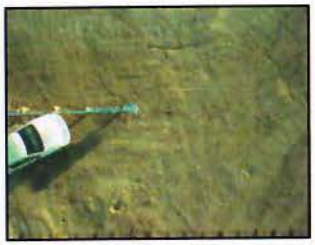
Test Article: Road Systems MSKT-SP Terminal

Project No. P35025-02

Test Program: MASH 3-37

Test Date: 03/07/15

SEQUENTIAL PHOTOGRAPHS



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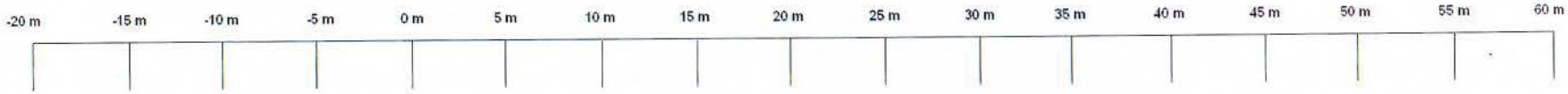
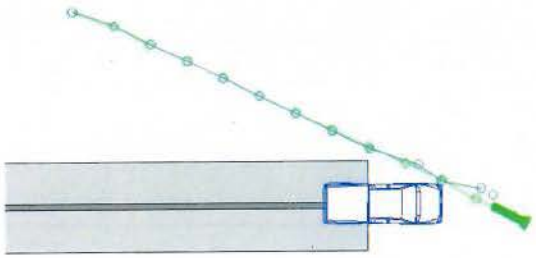
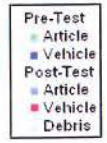
PLAN VIEW







SECTION 4

MASH TEST 3-37 SUMMARY ... (CONTINUED)

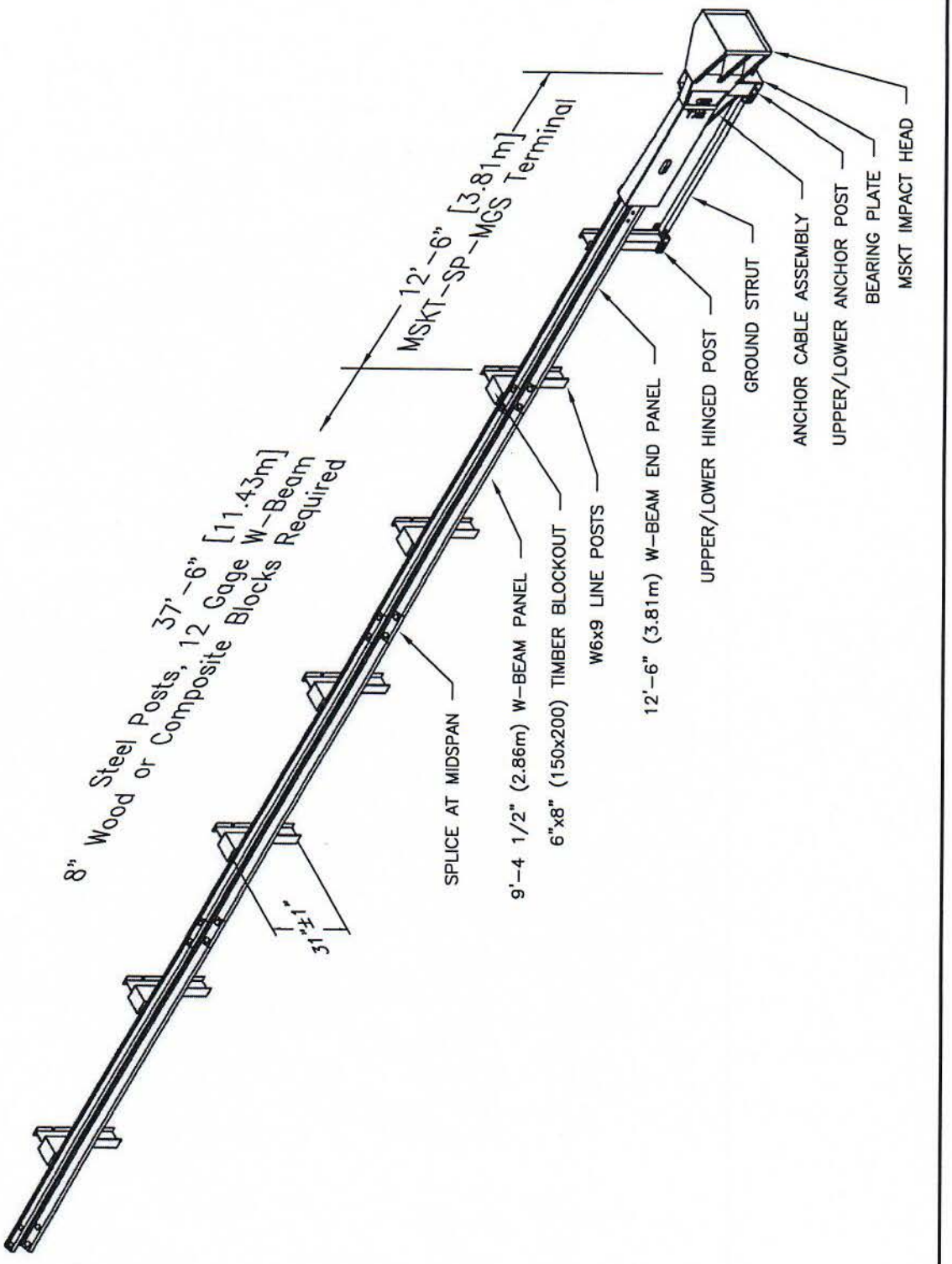
Test Article: Road Systems MSKT-SP Terminal — Project No. P35025-02

Test Program: MASH 3-37 — Test Date: 03/07/15

SUMMARY TABLE

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC.
TEST NUMBER	P35025-02
TEST DESIGNATION	3-37
TEST DATE	3/7/15
TEST ARTICLE	
NAME / MODEL	MSKT-SP Terminal
TYPE	Guardrail Terminal / End Treatment
KEY ELEMENTS	12 Ga. W-Beam, W6x15 / 6"x6"x0.125" Breakaway Post, W6 x 9 Breakaway Post
INSTALLATION LENGTH	75.0 ft. (35.43 m)
RAIL MOUNTING HEIGHT	28.0 in. (711 mm)
ROAD SURFACE	Compacted Soil
SOIL TYPE / CONDITION	Medium to fine silty sand
TEST VEHICLE	
TYPE / DESIGNATION	2270P
YEAR, MAKE AND MODEL	2009 Dodge Ram
CURB MASS	4,800.5 lbs (2,177.5 kg)
TEST INERTIAL MASS	4,964.7 lbs (2,252.0 kg)
GROSS STATIC MASS	4,964.7 lbs (2,252.0 kg)

IMPACT AND EXIT CONDITIONS		
IMPACT VELOCITY		63.13 mph (101.60 km/h)
IMPACT ANGLE (°)		24.9
MAXIMUM ROLL ANGLE (°)		25.7
MAXIMUM PITCH ANGLE (°)		-33.3
MAXIMUM YAW ANGLE (°)		-13.6
STOPPING DISTANCE		
IMPACT SEVERITY		543.6 kip-ft (738 kJ)
OCCUPANT RISK VALUES		
OCCUPANT IMPACT VELOCITY	Longitudinal	17.1 ft/s (5.2 m/s)
	Lateral	-6.6 ft/s (-2.0 m/s)
RIDEDOWN ACCELERATION	Longitudinal	-6.8 g
	Lateral	-2.6 g
THIV		18.7 ft/s (5.7 m/s)
PHD		7.2
ASI		0.67



MSKT - MASH SKT - MGS System

Road Systems Inc.

SEWXX

SHEET NO.	DATE
1 of 2	01-16-16

INTENDED USE

The **MSKT** (MASH SKT) **SP** (Standard Post) **MGS** (Midwest Guardrail System) is a tangent roadside energy-absorbing terminal that have been designed and tested under MASH criteria. The MSKT-SP-MGS system 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 9' - 4 1/2" W-Beam panel to set splices at mid-span between posts, six W6x9 (or W6x8.5) steel line posts, 8" wood or composite blocks and 12 gage W-Beam extending a minimum of 3' - 1 1/2" beyond post #8 for a TL-3 system.

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

The MSKT-SP-MGS is a cable-anchored system. When impacted on the traffic side within the length of need and within design limits, the MSKT contains and redirects the errant vehicle back toward its original travel path. A cable anchor bracket is attached to the backside of the first 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.

APPROVALS

FHWA letter (CC-XX) XX XX, 2016 - MSKT-SP-MGS MASH Test Level 3

CONTACT INFORMATION

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

MSKT – MASH SKT – MGS System

SEWXX	
SHEET NO.	DATE:
2 of 2	01–16–16

RSI Road Systems Inc.