U.S. Department of Transportation
Federal Highway Administration

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

July 14, 2025

In Reply Refer To:
HSST-1/CC-181

Bret Eckert
Valtir, LLC
15601 Dallas Parkway, Suite 525
Addison, TX 75001
USA

Dear Mr. Eckert:

We received your initial correspondence on May 13, 2024 requesting issuance of a Federal-aid reimbursement eligibility letter under the Federal-aid highway program for the roadside safety system, device, design, product, or hardware (collectively "device") described below. On December 12, 2024, we received a complete set of files needed to complete our review. We write to inform you that the device 4-Foot Flared Trend Terminal (4F-T^{TM}) is eligible for Federal-aid reimbursement. This letter is assigned Federal Highway Administration (FHWA) control number CC-181.

ELIGIBILITY LETTERS

The FHWA issues Federal-aid reimbursement eligibility letters for new roadside safety devices that are crash tested in accordance with the industry standard of the American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware (MASH).

FHWA, the Department of Transportation, and the United States (government) do not regulate roadside safety devices, crash test facilities, or the manufacturing industry. Issuance of eligibility letters is discretionary and provided only as a service to the states. FHWA may, at its discretion, decline to issue, revise, or rescind an eligibility letter. Eligibility letters are only issued by the FHWA headquarters Office of Safety.

Eligibility letters are issued only as notice to the states that a device is eligible for reimbursement under the Federal-aid highway program. They do not establish approval or certification for any other purpose. Issuance of an eligibility letter is not a prerequisite or requirement for state transportation agencies seeking to use Federal-aid funds for roadside safety devices. State agencies may use a device for which an eligibility letter has not been issued and seek Federal-aid reimbursement.

FEDERAL-AID REIMBURSEMENT

The request for issuance of this letter certified the device was crash tested in accordance with the industry standard of AASHTO's MASH. This eligibility letter is based on that certification and

the material offered in support of its issuance. The device described below is eligible for reimbursement under the Federal-aid highway program.

Name of system: 4-Foot Flared Trend Terminal (4F-T^{TM})
Type of system: Terminal
Test Level: Test Level 3
Testing conducted by: Applus IDIADA KARCO Engineering, LLC
Date of request: May 13, 2024

Information about the device, including material such as the eligibility request, crash test reports, drawings, or images are included in one or more attachment(s) to this letter.

Eligibility letter CC-181 is inapplicable to devices, optional equipment, alternate materials, or other features that were not crash tested in accordance with AASHTO's MASH.

This letter is issued only for the subject device as crash tested under AASHTO's MASH. Later modification(s) of the device are not eligible for Federal-aid reimbursement under this letter. Notice of later modification(s) should be given to transportation agencies, facility owners, and operators (collectively "agencies").

Agencies should be provided appropriate information about the device's design, installation, maintenance, materials, and mechanical properties.

Issuance of this letter is discretionary, and it may be revised or rescinded at FHWA's discretion. This letter is not a determination of compliance with the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) or ownership of any intellectual property rights.

This eligibility letter is not a determination by the government that a crash involving the subject device will result in any particular outcome. It is limited to only the device's eligibility for Federal-aid reimbursement.

INTELLECTUAL PROPERTY

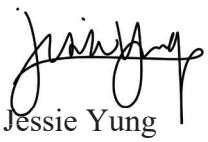
Issuance of this eligibility letter does not convey property rights of any sort nor any exclusive privilege. This letter is not authorization or consent by the government for the use, manufacture, or sale of any patented or proprietary system, device, design, product, or hardware for which the requester is not the patent owner. Eligibility letters are not an expression of any view, position, or determination by the government as to the validity, scope, or ownership of any intellectual property rights to a specific device. These letters do not grant, impute, suggest, or otherwise establish any ownership, distribution, or licensing rights to the requester. The government expresses no opinion about the intellectual property rights relating to any device for which this or any other eligibility letter is issued.

PUBLIC DISCLOSURE

To prevent any misunderstanding, and as discussed above, this Federal-aid eligibility letter is assigned FHWA control number CC-181. It should only be reproduced in full with its attachment(s). This Federal-aid eligibility letter and the material offered by the requester supporting its issuance is public information. All eligibility letters and supporting material are subject to public disclosure under the Freedom of Information Act (FOIA). Eligibility letters are available to the public at https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/.

If you have any questions please contact Paul LaFleur at Paul.LaFleur@dot.gov.

Sincerely,



Jessie Yung
Director, Office of Safety Technologies
Office of Safety

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter			
	Date of Request:	May 13, 2024	◉ New ○ Resubmission
	Name:	Bret Eckert, P.E.	
	Company:	Valtir, LLC	
	Address:	15601 Dallas Parkway, Suite 525, Addison, TX 75001	
	Country:	USA	
	To:	Michael S. Griffith, Director FHWA, Office of Safety Technologies	

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

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

! - ! - !

System Type	Submission Type	Device Name / Variant	Testing Criterion	Test Level
'CC': Crash Cushions, Attenuators, & Terminals	◉ Physical Crash Testing ○ Engineering Analysis	4-Foot Flared TREND® Terminal (4F-T™)	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:	Gregory A. Neece	Same as Submitter ☐
Company Name:	Valtir, LLC	Same as Submitter ☐
Address:	15601 Dallas Parkway, Suite 525, Addison, TX 75001	Same as Submitter ☐
Country:	USA	Same as Submitter ☐

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

The 4-Foot Flared TREND® Terminal ("4F-T™") system technology is the commercial embodiment of intellectual property that was assigned to Valtir, LLC ("Valtir"). Valtir does not pay royalties for sales of the 4F-T™. The 4F-T™ system was designed and developed by engineers and employees at Valtir.

Applus IDIADA KARCO Engineering, LLC ("KARCO") conducted the certification tests of the 4F-T™ system. KARCO is an internationally accredited third-party crash testing laboratory. Full-scale crash testing on the 4F-T™ system was performed in accordance with testing criteria, as set forth by the American Association of State Highway and Transportation Officials (AASHTO) in the Manual for Assessing Safety Hardware ("MASH") (2016), with 2020 Errata. Other than fees paid to KARCO to conduct the tests and then analyze and report the test results, KARCO and Valtir do not share financial interests. The fees paid to KARCO were not dependent or contingent on the results of the tests.

PRODUCT DESCRIPTION

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

The 4-Foot Flared TREND® Terminal ("4F-T™") is a single-sided, flared, redirective/gating, energy-absorbing terminal/system for use with various longitudinal highway barriers, in either unidirectional or bidirectional applications, to include roadside, and shoulder applications. It is also suitable for use as either an approach or departure terminal.

The 4F-T™ can be connected directly to Midwest Guardrail System ("MGS"). No radiused or curved W-Beam guardrail is allowed within the 4F-T™. However, there is a slight radius created between post nine of the 4F-T™ and the first (1st) downstream line post, due to the four-foot flare of the 4F-T™, when installed/assembled. The 4F-T™ has a system length of 34' 4-1/2" [10.48 m], measured from the center of post one to the first (1st) splice location behind post nine. The 4F-T™ is to be installed at a height of 31" [787 mm] with a tolerance of +1" [25 mm], -0", measured from finished grade to top of rail. The Impact Head extends forward of the center of Post 1 by 10-¾" [273 mm] and the system is flared, away from traffic, 4' [1.22 m] over its system length - relative to the downstream guardrail.

Main components which the 4F-T™ utilizes are: an Impact Head, a Formed Ground Strut, a Tension Cable, one (1) Hinged Breakaway Post ("HBA®") at Post 1 location, eight (8) Steel Yielding Terminal Posts ("SYTP®") at post locations two through nine, special steel Spacer Blocks, Backing Plates and various other fastener and hardware components. A 4F-T™ Formed Ground Strut is connected between HBA® Post 1 and Post 2 (the first SYTP®). Posts in positions one through three utilize below-grade soil plates on the downstream side of the posts, for increased soil bearing resistance. All post spacing within the 4F-T™ is 4'-2" [1270mm], on center. Additionally, the 4F-T™ includes ten (10) proprietary 10ga W-Beam guardrail panels, of which eight (8) are slotted, one (1) is a Transition panel (used at the downstream end of the 4F-T™ to attach to MGS) and one (1) is a welded Head Attachment Rail Panel. All nine (9) posts utilize a special steel Spacer Block, one (1) of the special steel Spacer Blocks (at post 2) provides a method to anchor the tensioned anchor cable to the 4F-T™. Backing Plates are utilized at post locations two through nine. All components of the 4F-T™ are galvanized and are specifically designed to be "universal", allowing the same set of components to be assembled on either side of the roadway, as well as utilized in trailing/departure end applications.

System installation height, as tested, was 31" [787 mm] with a tolerance of +1" [25 mm], -0". Adhesive-backed delineation was attached to the Impact Head and various identification decals were applied to various components, during testing.

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:	 Digitally signed by Alex Beltran DN: cn=Alex Beltran, o=IDIADA KARCO, ou=Lab, email=Alex.Beltran@idiada.com, c=US Date: 2024.09.23 17:39:05 -07'00'	
Address:	9270 Holly Road, Adelanto, CA 92301	Same as Submitter ☐
Country:	USA	Same as Submitter ☐

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	Applus IDIADA KARCO Test No. P43089-01. Test Date September 15, 2023. Crash Test Report No. TR-P43089-01-NC. MASH Test 3-30 of the Valtir 4 Foot Flared TREND® Terminal (4F-T™). The terminal was impacted by a 2017 Kia Rio at a velocity of 62.55 mph (100.67 km/h) and a CIA of 0.7° relative to the downstream rail, with the vehicle offset a 1/4 of its width so that the 1/4 width point aligns with the center of resistance of the terminal at the Impact Head. Upon impact the vehicle forced the rail downstream until coming to a controlled stop 35.1 ft (10.7 m) from initial point of contact next to the system. MASH deformation limits were not exceeded and there was no penetration into the vehicle's occupant compartment. The vehicle experienced a maximum occupant impact velocity (OIV) of 32.5 ft/s (9.9 m/s) and a maximum ridedown acceleration (RA) of -14.7 g. The 4F-T™ flared terminal met all the requirements for MASH 2016 Test 3-30.	PASS
3-31 (2270P)	Applus IDIADA KARCO Test No. P43090-01. Test Date August 30, 2023. Crash Test Report No. TR-P43090-01-NC. MASH Test 3-31 of the Valtir 4 Foot Flared TREND® Terminal (4F-T™). The terminal was impacted by a 2017 Ram 1500 pickup truck at a velocity of 61.42 mph (98.84 km/h) and a CIA of 0.4° relative to the downstream rail, with the centerline of the vehicle impacting the centerline of resistance at the Impact Head. Upon impact the truck forced the rail downstream until coming to a controlled stop 56.7 ft. (17.3 m) from initial point of contact next to the system. MASH deformation limits were not exceeded and there was no penetration into the vehicle's occupant compartment. The vehicle experienced a maximum occupant impact velocity (OIV) of 23.6 ft/s (7.2 m/s) and a maximum ridedown acceleration (RA) of -9.5 g. The 4F-T™ flared terminal met all the requirements for MASH 2016 Test 3-31.	PASS

Required Test Number	Narrative Description	Evaluation Results
3-32 (1100C)	Applus IDIADA KARCO Test No. P43091-01. Test Date December 12, 2023. Crash Test Report No. TR-P43091-01-NC. MASH Test 3-32 of the Valtir 4 Foot Flared TREND® Terminal (4F-T™). The terminal was impacted by a 2019 Kia Rio at a velocity of 62.47 mph (100.53 km/h) and a CIA of 4.0° relative to the downstream rail, with the centerline of the vehicle directed at the center of the nose of the system. Upon impact the vehicle forced the rail downstream until coming to a controlled stop 30.6 ft. (9.3 m) from initial point of contact with the system. MASH deformation limits were not exceeded and there was no penetration into the vehicle's occupant compartment. The vehicle experienced a maximum occupant impact velocity (OIV) of 28.9 ft/s (8.8 m/s) and a maximum ridedown acceleration (RA) of -20.4 g. 4F-T™ flared terminal met all the requirements for MASH 2016 Test 3-32.	PASS
3-33 (2270P)	Applus IDIADA KARCO Test No. P43092-01. Test Date December 19, 2023. Crash Test Report No. TR-P43092-01-NC. MASH Test 3-33 of the Valtir 4 Foot Flared TREND® Terminal (4F-T™). The terminal was impacted by a 2017 Ram 1500 pickup truck at a velocity of 61.48 mph (98.94 km/h) and a CIA of 4.2° relative to the downstream rail, with the centerline of the vehicle directed at the center of the nose of the system. Upon impact the truck forced the rail downstream until coming to a controlled stop 104.0 ft. (31.7 m) from initial point of contact next to the system. MASH deformation limits were not exceeded and there was no penetration into the vehicle's occupant compartment. The vehicle experienced a maximum occupant impact velocity (OIV) of 23.0 ft/s (7.0 m/s) and a maximum ridedown acceleration (RA) of -7.4 g. The 4F-T™ flared terminal met all the requirements for MASH 2016 Test 3-33.	PASS

3-34 (1100C)	Applus IDIADA KARCO Test No. P43093-01. Test Date December 28, 2023. Crash Test Report No. TR-P43093-01-NC. MASH Test 3-34 of the Valtir 4 Foot Flared TREND® Terminal (4F-T™). The terminal was impacted by a 2019 Kia Rio at a velocity of 60.60 mph (97.53 km/h) and a CIA of 15.1° relative to the downstream rail, with the vehicle impacting the CIP located at 18 inches from the centerline of post 1. Upon impact the vehicle deflected the rail towards the field side before coming to a stop 34.2 ft. (10.4 m) from initial point of contact with the system. MASH deformation limits were not exceeded and there was no penetration into the vehicle's occupant compartment. The vehicle experienced a maximum occupant impact velocity (OIV) of 26.2 ft/s (8.0 m/s) and a maximum ridedown acceleration (RA) of -11.1 g. The 4F-T™ flared terminal met all the requirements for MASH 2016 Test 3-34.	PASS
3-35 (2270P)	Applus IDIADA KARCO Test No. P43094-03. Test Date August 03, 2023. Crash Test Report No. TR-P43094-03-NC. MASH Test 3-35 of the Valtir 4 Foot Flared TREND® Terminal (4F-T™). The terminal was impacted by a 2017 Ram 1500 pickup truck at a velocity of 62.62 mph (100.77 km/h) and a CIA of 24.8° relative to the downstream rail. Upon impact the truck redirected and continued downstream until coming to a controlled stop. MASH deformation limits were not exceeded and there was no penetration into the vehicle's occupant compartment. The vehicle experienced a maximum occupant impact velocity (OIV) of 20.7 ft/s (6.3 m/s) and a maximum ridedown acceleration (RA) of -7.1 g. The 4F-T™ flared terminal met all the requirements for MASH 2016 Test 3-35.	PASS
3-36 (2270P)	Test 36 is only recommended for terminals or crash cushions directly attached to very stiff barriers or backup structures. The 4F-T™ is not designed to be attached directly to a stiff barrier or backup structure.	Non-Relevant Test, not conducted

3-37b (1100C)	Applus IDIADA KARCO Test No. P43096-02. Test Date November 27, 2023. Crash Test Report No. TR-P43096-02-NC. MASH Test 3-37b of the Valtir 4 Foot Flared TREND® Terminal (4F-T™). The terminal was impacted by a 2018 Kia Rio at a velocity of 62.65 mph (100.82 km/h) and a CIA of 26.2° relative to the downstream rail, with the front bumper of the vehicle impacting the CIP located at the centerline of Post 3. Upon impact the vehicle deflected the rail towards the field side before coming to a stop 109.3 ft. (33.3 m) downstream from initial point of contact with the system. MASH deformation limits were not exceeded and there was no penetration into the vehicle's occupant compartment. The vehicle experienced a maximum occupant impact velocity (OIV) of 34.1 ft/s (10.4 m/s) and a maximum ridedown acceleration (RA) of 6.4 g. The 4F-T flared terminal met all the requirements for MASH 2016 Test 3-37b.	PASS
3-38 (1500A)	The results of the Occupant Risk Estimation for a 1500A Vehicle found in MASH 2016 Appendix G was conducted utilizing the accelerometer data from Test 3-31 on the 4F-T™. The estimated OIV and RA values of 9.76 m/s and -17.85 g were found to comply with the evaluation criteria set forth in Chapter 5 of the Manual for Assessing Safety Hardware (MASH 2016). Reference Appendix F in all Test Reports.	Non-Relevant Test, not conducted
3-40 (1100C)		Non-Relevant Test, not conducted
3-41 (2270P)		Non-Relevant Test, not conducted
3-42 (1100C)		Non-Relevant Test, not conducted
3-43 (2270P)		Non-Relevant Test, not conducted
3-44 (2270P)		Non-Relevant Test, not conducted
3-45 (1500A)		Non-Relevant Test, not conducted

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

Laboratory Name:	KARCO Engineering, INC	
Laboratory Signature:	Digitally signed by Alex Beltran DN: cn=Alex Beltran, o=IDIADA KARCO, ou=Lab, email=Alex.Beltran@idiada.com, c=US Date: 2024.09.23 17:39:22 -07'00'	
Address:	9270 Holly Road, Adelanto, CA 92301	Same as Submitter ☐
Country:	USA	Same as Submitter ☐
Accreditation Certificate Number and Dates of current Accreditation period :	International Accreditation Services (IAS) ISO 17025 Accreditation Certificate #TL-371 Issued December 5, 2022. Expires July 1, 2024	

Submitter Signature*: Bret Eckert Digitally signed by Bret Eckert Date: 2024.09.24 07:21:00 -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

0.000 seconds 0.400 seconds 0.800 seconds 1.200 seconds 1.600 seconds

GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test Number	P43089-01
Test Designation	3-30
Test Date	9/15/23

TEST ARTICLE

Name / Model	4F-T flared terminal
Type	Terminal
Installation Length	141.4 ft. (43.1 m)
Terminal Length	34.4 ft. (10.5 m)
Road Surface	Smooth concrete to fine silty soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2017 Kia Rio
Curb Mass	2,555.1 lbs (1,159.0 kg)
Test Inertial Mass	2,464.7 lbs (1,118.0 kg)
Gross Static Mass	2,611.3 lbs (1,184.5 kg)

Impact Conditions

Impact Velocity (Target)	62.14 mph (100.00 km/h)
Impact Velocity (Actual)	62.55 mph (100.67 km/h)
Impact Angle (Target)	0.0° relative to downstream rail
Impact Angle (Actual)	0.7° relative to downstream rail
Location/Orientation (Target)	1/4 vehicle width (16.9 in. [430 mm]) from the center of resistance
Location/Orientation (Actual)	15.29 in. (388 mm) from the center of resistance
Kinetic Energy	322.1 kip-ft (436.7 kJ)
Minimum KE Required	288.0 kip-ft (390.0 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	35.1 ft. (10.7 m) Downstream 7.8 ft. (2.4 m) Left
Vehicle Snagging	Satisfactory
Vehicle Pocketing	Satisfactory
Vehicle Stability	Satisfactory
Maximum Roll Angle	-32.1 °
Maximum Pitch Angle	-6.3 °
Maximum Yaw Angle	223.6 °

Occupant Risk

Longitudinal OIV	32.5 ft/s (9.9 m/s)
Lateral OIV	-2.6 ft/s (-0.8 m/s)
Longitudinal RA	-14.7 g
Lateral RA	7.6 g
THIV	33.1 ft/s (10.1 m/s)
PHD	14.7 g
ASI	0.80

Test Article Deflections

Static	7.4 ft. (2.2 m)
Dynamic	9.8 ft. (3.0 m)
Working Width	8.1 ft. (2.5 m)
Debris Field	N/A

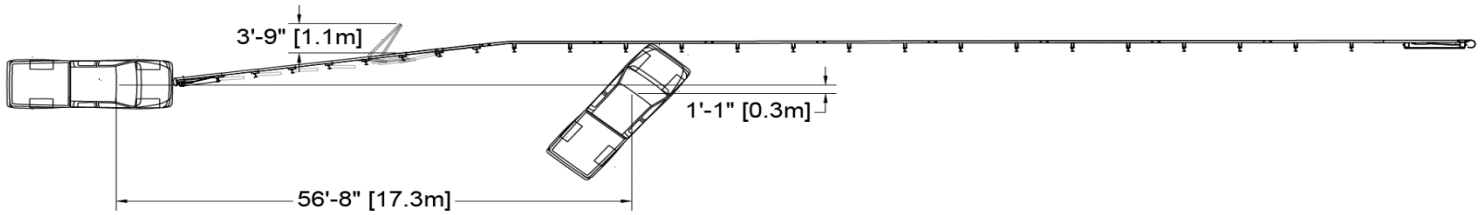
Vehicle Damage

Vehicle Damage Scale	12-FD-7
CDC	12FDEW8
Maximum Deformation	(0.0 in.) 0.0 mm

Figure 2 Summary of Test 3-30

MASH 2016 Test 3-31 Summary

0.000 seconds | 0.300 seconds | 0.600 seconds | 0.900 seconds | 1.200 seconds



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test Number	P43090-01
Test Designation	3-31
Test Date	8/30/23

TEST ARTICLE

Name / Model	4F-T flared terminal
Type	Terminal
Installation Length	141.4 ft. (43.1 m)
Terminal Length	34.4 ft. (10.5 m)
Road Surface	Smooth concrete to fine silty soil

TEST VEHICLE

Type / Designation	2270P
Year, Make, and Model	2017 RAM 1500
Curb Mass	5,251.3 lbs (2,382.0 kg)
Test Inertial Mass	5,011.0 lbs (2,273.0 kg)
Gross Static Mass	5,011.0 lbs (2,273.0 kg)

Impact Conditions

Impact Velocity (Target)	62.14 mph (100.00 km/h)
Impact Velocity (Actual)	61.42 mph (98.84 km/h)
Impact Angle (Target)	0.0° relative to downstream rail
Impact Angle (Actual)	0.4° relative to downstream rail
Location / Orientation (Target)	Center of head mounting bolts
Location / Orientation (Actual)	0.8 in. (20 mm) toward the passenger side
Kinetic Energy	631.9 kip-ft (856.7 kJ)
Minimum KE Required	594.0 kip-ft (806.0 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	56.7 ft. (17.3 m) Downstream 1.1 ft. (0.3 m) Right
Vehicle Snagging	Satisfactory
Vehicle Pocketing	Satisfactory
Vehicle Stability	Satisfactory
Maximum Roll Angle	7.2 °
Maximum Pitch Angle	13.0 °
Maximum Yaw Angle	-42.7 °

Occupant Risk

Longitudinal OIV	23.6 ft/s (7.2 m/s)
Lateral OIV	-2.0 ft/s (-0.6 m/s)
Longitudinal RA	-9.5 g
Lateral RA	3.8 g
THIV	24.0 ft/s (7.3 m/s)
PHD	9.7 g
ASI	0.56

Test Article Deflections

Static	2.6 ft. (0.8 m)
Dynamic	3.4 ft. (1.0 m)
Working Width	3.8 ft. (1.1 m)
Debris Field	N/A

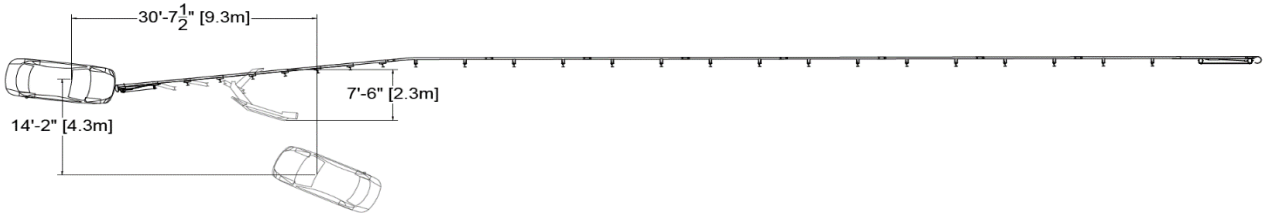
Vehicle Damage

Vehicle Damage Scale	12-FD-7
CDC	12FDEW2
Maximum Deformation	0.0 in. (0 mm) 0.0 in. (0 mm)

Figure 2 Summary of Test 3-31

MASH 2016 Test 3-32 Summary

0.000 seconds 0.450 seconds 0.900 seconds 1.350 seconds 1.800 seconds



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test Number	P43091-01
Test Designation	3-32
Test Date	12/12/23

TEST ARTICLE

Name / Model	4F-T flared terminal
Type	Terminal
Installation Length	141.4 ft. (43.1 m)
Terminal Length	34.4 ft. (10.5 m)
Road Surface	Smooth, concrete to fine silty soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2019 Kia Rio
Curb Mass	2,469.1 lbs (1,120.0 kg)
Test Inertial Mass	2,436.1 lbs (1,105.0 kg)
Gross Static Mass	2,601.4 lbs (1,180.0 kg)

Impact Conditions

Impact Velocity (Target)	62.14 mph (100.00 km/h)
Impact Velocity (Actual)	62.47 mph (100.53 km/h)
Impact Angle (Target)	5.0° relative to downstream rail
Impact Angle (Actual)	4.0° relative to downstream rail
Location / Orientation (Target)	Vehicle centered to center of Impact Head
Location / Orientation (Actual)	3.5 in. (88 mm) from center of Impact Head
Kinetic Energy	317.8 kip-ft (430.8 kJ)
Minimum KE Required	288.0 kip-ft (390.0 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	30.6 ft. (9.3 m) Downstream 14.2 ft. (4.3 m) Right
Vehicle Snagging	Satisfactory
Vehicle Pocketing	Satisfactory
Vehicle Stability	Satisfactory
Maximum Roll Angle	-33.7 °
Maximum Pitch Angle	56.1 °
Maximum Yaw Angle	153.2 °

Occupant Risk

Longitudinal OIV	28.9 ft/s (8.8 m/s)
Lateral OIV	-3.6 ft/s (-1.1 m/s)
Longitudinal RA	-20.4 g
Lateral RA	-7.3 g
THIV	29.2 ft/s (8.9 m/s)
PHD	21.4 g
ASI	0.99

Test Article Deflections

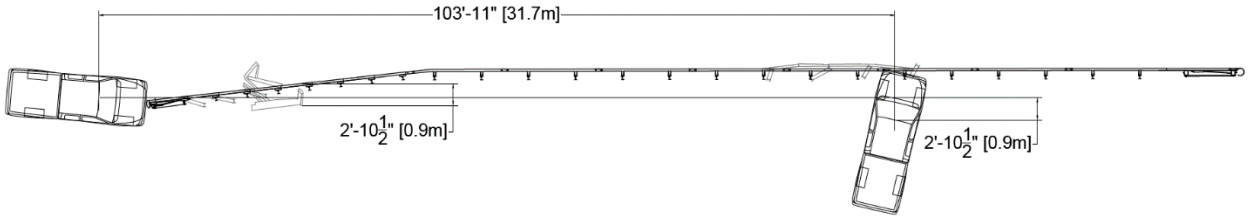
Static	6.0 ft. (1.8 m)
Dynamic	7.9 ft. (2.4 m)
Working Width	7.5 ft. (2.3 m)
Debris Field	N/A

Vehicle Damage

Vehicle Damage Scale	12-FD-7
CDC	12FDEW2
Maximum Deformation	(0.0 in.) 0.0 mm

Figure 2 Summary of Test 3-32

MASH 2016 Test 3-33 Summary



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test Number	P43092-01
Test Designation	3-33
Test Date	12/19/23

TEST ARTICLE

Name / Model	4F-T flared terminal
Type	Terminal
Installation Length	141.4 ft. (43.1 m)
Terminal Length	34.4 ft. (10.5 m)
Road Surface	Smooth concrete to fine silty soil

TEST VEHICLE

Type / Designation	2270P
Year, Make, and Model	2017 Ram 1500
Curb Mass	5,057.3 lbs (2,294.0 kg)
Test Inertial Mass	5,033.1 lbs (2,283.0 kg)
Gross Static Mass	5,033.1 lbs (2,283.0 kg)

Impact Conditions

Impact Velocity (Target)	62.14 mph (100.00 km/h)
Impact Velocity (Actual)	61.48 mph (98.94 km/h)
Impact Angle (Target)	5.0° relative to downstream rail
Impact Angle (Actual)	4.2° relative to downstream rail
Location / Orientation (Target)	Vehicle centered to center of Impact Head
Location / Orientation (Actual)	1.5 in. (38 mm) from center of Impact Head
Kinetic Energy	635.9 kip-ft (862.2 kJ)
Minimum KE Required	594.0 kip-ft (806.0 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	103.9 ft. (31.7 m) Downstream 2.9 ft. (0.9 m) Right
Vehicle Snagging	Satisfactory
Vehicle Pocketing	Satisfactory
Vehicle Stability	Satisfactory
Maximum Roll Angle	-8.4 °
Maximum Pitch Angle	-6.7 °
Maximum Yaw Angle	-82.7 °

Occupant Risk

Longitudinal OIV	23.0 ft/s (7.0 m/s)
Lateral OIV	-4.9 ft/s (-1.5 m/s)
Longitudinal RA	-7.4 g
Lateral RA	-3.8 g
THIV	23.3 ft/s (7.1 m/s)
PHD	7.6 g
ASI	0.54

Test Article Deflections

Static	2.6 ft. (0.8 m)
Dynamic	2.7 ft. (0.8 m)
Working Width	2.9 ft. (0.9 m)
Debris Field	N/A

Vehicle Damage

Vehicle Damage Scale	12-FD-7
CDC	12FDEW2
Maximum Deformation	(0.0 in.) 0.0 mm

Figure 2 Summary of Test 3-33

MASH 2016 Test 3-34 Summary

0.000 seconds 0.250 seconds 0.500 seconds 0.750 seconds 1.000 seconds

GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test Number	P43093-01
Test Designation	3-34
Test Date	12/28/23

TEST ARTICLE

Name / Model	4F-T flared terminal
Type	Terminal
Installation Length	141.4 ft. (43.1 m)
Terminal Length	34.4 ft. (10.5 m)
Road Surface	Smooth concrete to fine silty soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2019 Kia Rio
Curb Mass	2,515.4 lbs (1,141.0 kg)
Test Inertial Mass	2,433.8 lbs (1,104.0 kg)
Gross Static Mass	2,598.2 lbs (1,178.5 kg)

Impact Conditions

Impact Velocity (Target)	62.14 mph (100.00 km/h)
Impact Velocity (Actual)	60.60 mph (97.53 km/h)
Impact Angle (Target)	15.0° relative to downstream rail
Impact Angle (Actual)	15.1° relative to downstream rail
Location / Orientation (Target)	18 in. (457 mm) downstream of Post 1 centerline
Location / Orientation (Actual)	21.8 in. (554 mm) downstream of Post 1 centerline
Impact Severity	20.3 kip-ft (27.5 kJ)
Minimum IS Required	19.0 kip-ft (26.0 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	34.2 ft. (10.4 m) Downstream 8.9 ft. (2.7 m) Right
Vehicle Snagging	Satisfactory
Vehicle Pocketing	Satisfactory
Vehicle Stability	Satisfactory
Maximum Roll Angle	7.8 °
Maximum Pitch Angle	8.0 °
Maximum Yaw Angle	-77.1 °

Occupant Risk

Longitudinal OIV	26.2 ft/s (8.0 m/s)
Lateral OIV	-13.8 ft/s (-4.2 m/s)
Longitudinal RA	-11.1 g
Lateral RA	8.5 g
THIV	27.2 ft/s (8.3 m/s)
PHD	11.4 g
ASI	1.07

Test Article Deflections

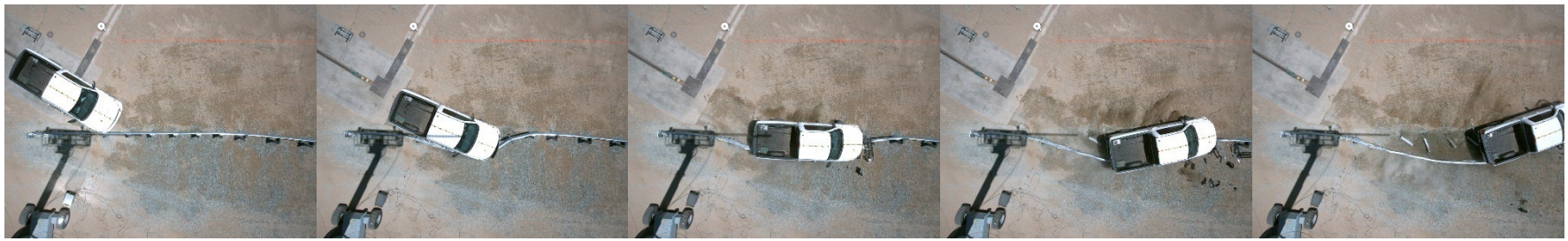
Static	2.2 ft. (0.7 m)
Dynamic	2.5 ft. (0.8 m)
Working Width	2.8 ft. (0.9 m)
Debris Field	N/A

Vehicle Damage

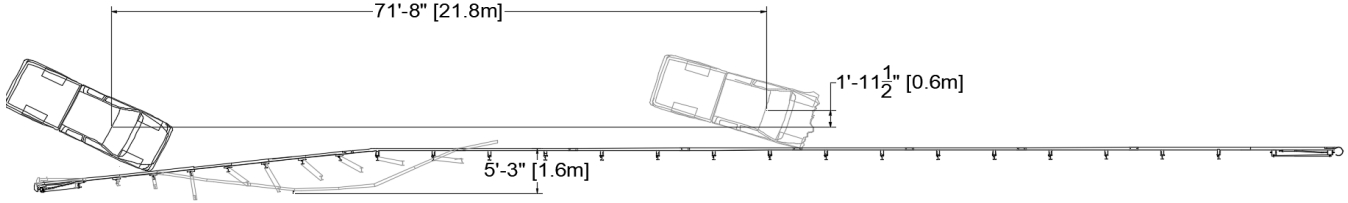
Vehicle Damage Scale	11-FL-6
CDC	11FLEN2
Maximum Deformation	(0.0 in.) 0.0 mm

Figure 2 Summary of Test 3-34

MASH 2016 Test 3-35 Summary



0.000 seconds | 0.150 seconds | 0.300 seconds | 0.450 seconds | 0.750 seconds



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test Number	P43094-03
Test Designation	3-35
Test Date	8/3/23

TEST ARTICLE

Name / Model	4F-T flared terminal
Type	Terminal
Installation Length	141.4 ft. (43.1 m)
Terminal Length	34.4 ft. (10.5 m)
Road Surface	smooth concrete to fine silty soil

TEST VEHICLE

Type / Designation	2270P
Year, Make, and Model	2017 RAM 1500
Curb Mass	5,158.7 lbs (2,340.0 kg)
Test Inertial Mass	5,004.4 lbs (2,270.0 kg)
Gross Static Mass	5,004.4 lbs (2,270.0 kg)

Impact Conditions

Impact Velocity (Target)	62.14 mph (100.00 km/h)
Impact Velocity (Actual)	62.62 mph (100.77 km/h)
Impact Angle (Target)	25.0° relative to downstream rail
Impact Angle (Actual)	24.8° relative to downstream rail
Location / Orientation (Target)	Vehicle bumper to Post 4 centerline
Location / Orientation (Actual)	3.46 in. (88 mm) upstream of Post 4 centerline
Impact Severity	115.4 kip-ft (156.5 kJ)
Minimum IS Required	106.0 kip-ft (144.0 kJ)

Exit Conditions

Exit Velocity	14.80 mph (23.82 km/h)
Exit Angle	25.8°
Final Vehicle Position	71.7 ft. (21.8 m) Downstream 2.0 ft. (0.6 m) Left
Vehicle Snagging	Satisfactory
Vehicle Pocketing	Satisfactory
Vehicle Stability	Satisfactory
Maximum Roll Angle	25.7 °
Maximum Pitch Angle	23.3 °
Maximum Yaw Angle	-47.0 °

Occupant Risk

Longitudinal OIV	20.7 ft/s (6.3 m/s)
Lateral OIV	15.4 ft/s (4.7 m/s)
Longitudinal RA	-7.1 g
Lateral RA	-5.8 g
THIV	24.9 ft/s (7.6 m/s)
PHD	8.9 g
ASI	0.72

Test Article Deflections

Static	5.0 ft. (1.5 m)
Dynamic	5.0 ft. (1.5 m)
Working Width	5.3 ft. (1.6 m)
Debris Field	N/A

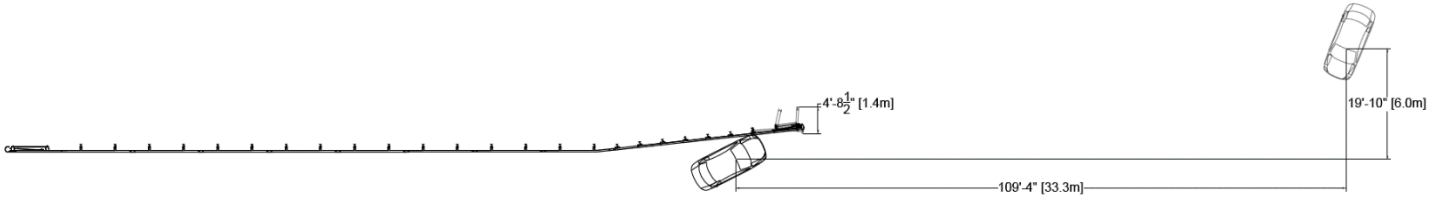
Vehicle Damage

Vehicle Damage Scale	11-FL-4
CDC	11FREN4
Maximum Deformation	MASH Deformation Limits Not Exceeded (0.0 in.) 0.0 mm

Figure 2 Summary of Test 3-35

MASH 2016 Test 3-37b Summary

0.000 seconds 0.150 seconds 0.300 seconds 0.450 seconds 0.600 seconds



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test Number	P43096-02
Test Designation	3-37b
Test Date	11/27/23

TEST ARTICLE

Name / Model	4F-T flared terminal
Type	Terminal
Installation Length	141.4 ft. (43.1 m)
Terminal Length	34.4 ft. (10.5 m)
Road Surface	Smooth concrete to fine silty soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2018 Kia Rio
Curb Mass	2,530.9 lbs (1,148.0 kg)
Test Inertial Mass	2,429.5 lbs (1,102.0 kg)
Gross Static Mass	2,594.8 lbs (1,177.0 kg)

Impact Conditions

Impact Velocity (Target)	62.14 mph (100.00 km/h)
Impact Velocity (Actual)	62.65 mph (100.82 km/h)
Impact Angle (Target)	25.0° relative to downstream rail
Impact Angle (Actual)	26.2° relative to downstream rail
Location/ Orientation(Target)	Vehicle bumper to post 3 centerline
Location/ Orientation(Actual)	1.6 in. (41 mm) downstream from post 3 centerline
Impact Severity	62.1 kip-ft (84.2 kJ)
Minimum IS Required	51.0 kip-ft (69.7 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	109.3 ft. (33.3 m) downstream 19.8 ft. (6.0 m) Left
Vehicle Snagging	Satisfactory
Vehicle Pocketing	Satisfactory
Vehicle Stability	Satisfactory
Maximum Roll Angle	24.5 °
Maximum Pitch Angle	26.5 °
Maximum Yaw Angle	198.4 °

Occupant Risk

Longitudinal OIV	34.1 ft/s (10.4 m/s)
Lateral OIV	-9.2 ft/s (-2.8 m/s)
Longitudinal RA	3.4 g
Lateral RA	6.4 g
THIV	33.1 ft/s (10.1 m/s)
PHD	10.2 g
ASI	1.12

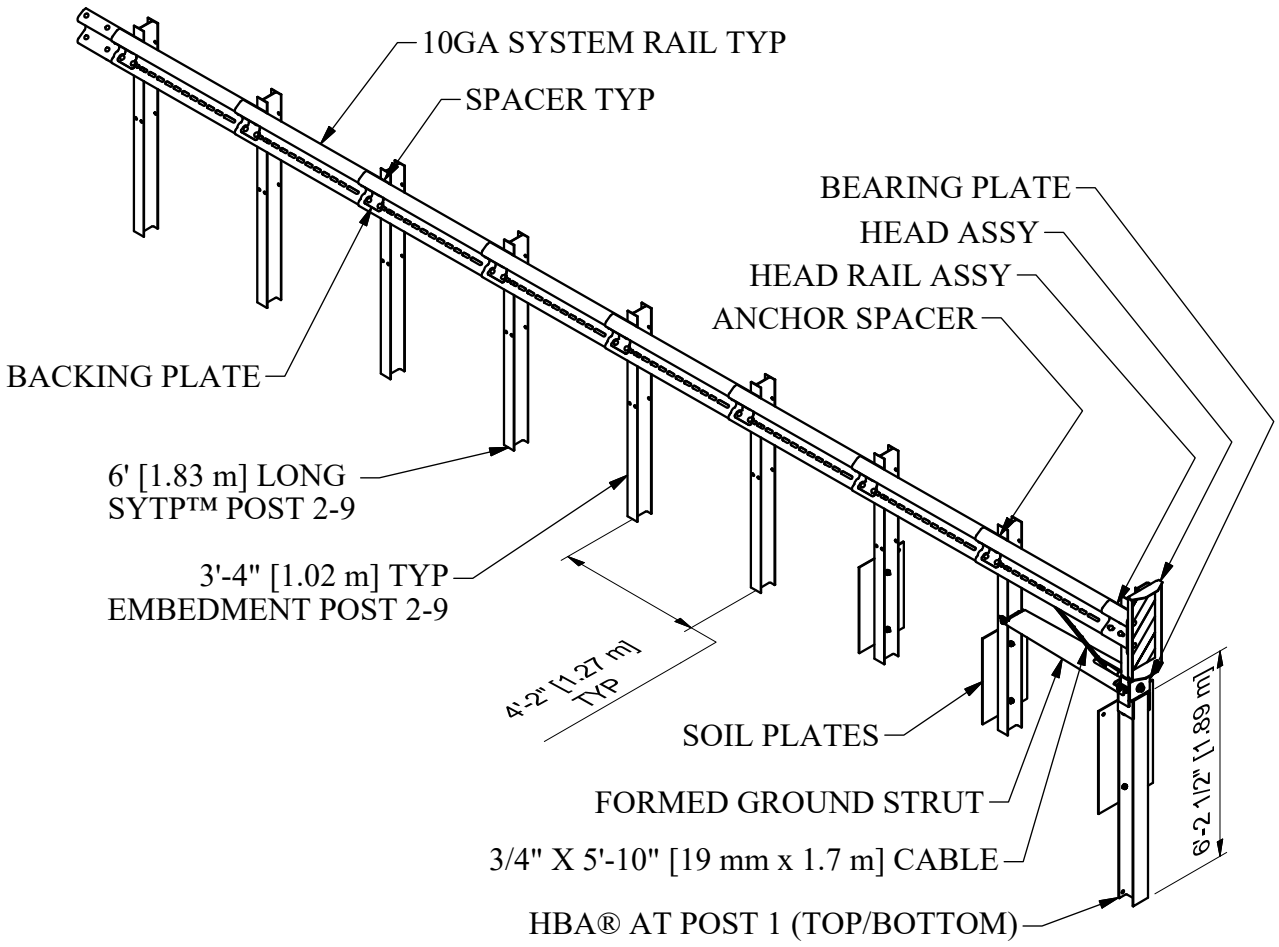
Test Article Deflections

Static	3.5 ft. (1.1 m)
Dynamic	4.8 ft. (1.5 m)
Working Width	4.7 ft. (1.4 m)
Debris Field	N/A

Vehicle Damage

Vehicle Damage Scale	11-FL-7
CDC	11FDEW2
Maximum Deformation	(0.0 in.) 0.0 mm

Figure 2 Summary of Test 3-37b



NOTES:
1. VARIOUS DELINEATION OPTIONS ARE AVAILABLE.
2. 4F-T™ TO BE INSTALLED WITH A 4 FOOT FLARE, WITH NO RADII OR CURVING OF SYSTEM GUARDRAIL WITHIN SYSTEM.
3. SYSTEM REQUIRES SPECIFIC ASTM A325 BOLT/NUT COMBINATIONS TO BE TORQUED TO 100 lb-ft [135 Nm], ALL OTHER FASTENERS TO BE TIGHTENED SNUG.
4. REFER TO 4F-T™ ASSEMBLY MANUAL (119662) AND DWG SS-XXXX FOR FULL DETAILS OF ASSEMBLY AND INSTALLATION.
5. PROPER SITE GRADING IS REQUIRED.

2024

4F-T™ (4 Foot Flared End Terminal)

VALTIR

SEWxx	
SHEET NO.	DATE
1 of 2	1/12/2024

INTENDED USE

The 4-Foot Flared TREND® Terminal ("4F-T™") is a single-sided, flared, redirective/gating, energy-absorbing terminal/system for use with various longitudinal highway barriers, in either unidirectional or bidirectional applications, to include roadside, and shoulder applications. It is suitable for use as either an approach or departure terminal.

FEATURES

The 4F-T™ has a System length of 34' 4-1/2" [10.48 m], measured from the center of post one to the first (1st) splice location behind post nine. The 4F-T™ is to be installed at a height of 31" [787 mm] with a tolerance of +1" [25 mm], -0", measured from finished grade to top of rail. The impact head extends forward of the center of Post 1 by 10-3/4" [27.31 mm] and the system is flared, away from traffic, 4' [1.22 m] over its system length - relative to the downstream guardrail.

The 4F-T™ consist of an impact head, a formed ground strut, a tension cable, one (1) Hinged Breakaway Post ("HBA®") at Post 1 location, eight (8) Steel Yielding Terminal Posts ("SYTP®") at post locations two through nine, special steel spacer blocks, backing plates and various other fastener and hardware components. Posts in position one through three utilize below-grade soil plates on the downstream side of the posts, for increased soil bearing resistance. Additionally, the System includes ten (10) proprietary 10ga W-Beam guardrail panels, of which eight (8) are slotted, one (1) is a Transition panel (used at the downstream end of the System to attach to MGS) and one (1) is a welded Head Attachment Rail Panel. All nine (9) posts utilize a special steel spacer block, one (1) of those special steel spacer blocks (at post 2) provides a method to anchor the tensioned anchor cable to the System. Backing plates are utilized at post locations two through nine.

All components of the 4F-T™ are galvanized and are specifically designed to be "universal", allowing the same set of components to be assembled on either side of the roadway, as well as utilized in trailing/departure end applications.

System installation height, as tested, was 31" [787 mm] with a tolerance of +1" [25 mm], -0".

SPECIFICATIONS

System Length:	34'-4 1/2" [10.48 m]
System Width (at Impact Head):	12" [305 mm]
System Height:	31", +1"/-0" [787 mm, +25 mm/-0 mm]
System Weight:	~1,220 lbs [~553 kg]

ELIGIBILITY

The 4F-T™ has been tested in conformance to MASH 2nd Edition (2016) with 2020 Errata Test Level 3 specifications and is eligible for Federal reimbursement by FHWA.
FHWA Eligibility Letter(s): [Report #] dated [Month Day, Year] for MASH 2nd Edition (2016) Test Level 3.

REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), Manual for Assessing Safety Hardware (MASH) 2nd Edition (2016) with 2020 Errata.

CONTACT INFORMATION

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Telephone: (888) 323-6374
www.valtir.com

4F-T™ (4 Foot Flared End Terminal)

SEWxx	
SHEET NO.	DATE
2 of 2	1/12/2024

VALTIR