U.S. Department of Transportation
Federal Highway Administration

May 15, 2020

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

In Reply Refer To:
HSST-1/CC-162

Mr. Ron Faulkenberry
Gibraltar Global, LLC.
1208 Houston Clinton Dr
Burnet TX 78611
USA

Dear Mr. Faulkenberry:

This letter is in response to your January 30, 2020 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-162 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:

- TL-3 4 Cable End 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: TL-3 4 Cable End Terminal
Type of system: End Terminal
Test Level: MASH Test Level 3 (TL3)
Testing conducted by: Applus IDIADA KARCO Engineering, LLC.
Date of request: January 30, 2020

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-162 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.

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:	January 30, 2020	◉ New ○ Resubmission
	Name:	Steven Matsusaka	
	Company:	Applus IDIADA KARCO Engineering, LLC.	
	Address:	9270 Holly Rd, Adelanto, CA 92301	
	Country:	United States of America	
	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, Attenua	◉ Physical Crash Testing ○ Engineering Analysis	TL-3 4 Cable End 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:	Ron Faulkenberry	Same as Submitter ☐
Company Name:	Gibraltar Global, LLC.	Same as Submitter ☐
Address:	1208 Houston Clinton Dr, Burnet TX 78611	Same as Submitter ☐
Country:	United States of America	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.

Gibraltar Global, LLC. and Applus IDIADA Karco Engineering, LLC. share no ($0.00) financial interests between the two organizations. This includes no ($0.00) financial interest but not limited to:

i. Compensation, including wages, salaries, commissions, professional fees, or fees for business referrals (dollar values are not needed);
ii. Consulting relationships;
iii. Research funding or other forms of research support;
iv. Patents, copyrights, and other intellectual property interests;
v. Licenses or contractual relationships; or
vi. Business ownership and investment interest.

PRODUCT DESCRIPTION

Help

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

The Gibraltar Global TL-3 4 Cable End Terminal consists of one (1) anchor post assembly, one (1) cable release assembly, two (2) J-bolt posts, and two (2) sockets. The terminal is classified as a gating redirective end terminal designed to be used with the Gibraltar Global 4 cable MASH system. The Gibraltar Global Cable Barrier system can be installed with post spacing ranging from 7.0 ft (2.1 m) to 21.0 ft. (6.4 m), the post spacing used for this test was 7.0 ft (2.1 m) to evaluate vehicle stability and occupant compartment damage. The as-tested terminal had a total length of 27.5 ft. (8.4 m) and the complete installation length was 214.8 ft. (65.5 m). As recommended in MASH the cables were tensioned to the manufacturer's specified tension at 100°F, which was 4200 lbs.

There was one modification made during the testing of the Gibraltar Global TL-3 4 Cable End Terminal during the MASH test program. For Tests 30 and 31, the system included a LON line post installed at the end of the terminal section, 7.5 ft. (2.3 m) downstream of the second J-bolt post and 27.5 ft. (8.4 m) from the anchor post. The final system design, as used for Tests 32, 33, 34, 35, and 37b, the LON line post at the downstream end of the terminal was moved to 14.5 ft. downstream from the second J-bolt post. The overall terminal length for both versions of the system was 27.5 ft. (8.4 m). Complete details on the design modification is included in Attachment A to this submission and in the complete test reports.

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:	Steven Matsusaka	
Engineer Signature:	Steven Matsusaka DN: cn=Steven Matsusaka, email=steven.matsusaka@idiada.com, c=US Digitally signed by Steven Matsusaka Date: 2020.01.14 19:07:40 -08'00'	
Address:	9270 Holly Rd, Adelanto, CA 92301	Same as Submitter ☒
Country:	United States of America	Same as Submitter ☒

A brief description of each crash test and its result: Help

Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	Applus IDIADA KARCO Test No. P37410-01. An 1100C test vehicle impacting the terminal end at a nominal speed and angle of 62 mph and 0°, respectively, with the quarter point of the vehicle aligned with the centerline of the terminal. This test is primarily intended to evaluate structural adequacy, occupant risk, and vehicle trajectory. A 2013 Kia Rio 4-door sedan with a test inertial mass of 2425.0 lbs (1100.0 kg) impacted the terminal at a velocity of 61.48 mph (98.95 km/h) and and angle of 0.4°. The impact activated the cable release post and the vehicle was allowed to penetrate the system in a controlled manner. The occupant compartment was not penetrated and deformation limits were not exceeded. The Occupant Impact Velocities (OIV) were 8.9 ft/s (2.7 m/s) and 1.0 ft/s (0.3 m/s) in the x- and y-directions, respectively. The Ridedown Accelerations were -5.6 g and -3.9 g, respectively. The Gibraltar Global TL-3 4 Cable Terminal met all of the requirements for MASH Test 3-30.	PASS
3-31 (2270P)	Applus IDIADA KARCO Test No. P37411-01. A 2270P test vehicle impacting the terminal end at a nominal speed and angle of 62 mph and 0°, respectively, with the centerline of the vehicle aligned with the centerline of the terminal. This test is primarily intended to evaluate structural adequacy, occupant risk, and vehicle trajectory. A 2012 Chevrolet Silverado 1500 4-door pickup truck with a test inertial mass of 4992.3 lbs (2264.5 kg) impacted the terminal at a velocity of 60.11 mph (96.74 km/h) and and angle of 1.1°. The impact activated the cable release post and the vehicle was allowed to penetrate the system in a controlled manner. The occupant compartment was not penetrated and deformation limits were not exceeded. The Occupant Impact Velocities (OIV) were 2.6 ft/s (0.8 m/s) and 3.9 ft/s (1.2 m/s) in the x- and y-directions, respectively. The Ridedown Accelerations were -2.0 g and 1.7 g, respectively. The Gibraltar Global TL-3 4 Cable Terminal met all of the requirements for MASH Test 3-31.	PASS

Required Test Number	Narrative Description	Evaluation Results
3-32 (1100C)	Applus IDIADA KARCO Test No. P37403-01. An 1100C test vehicle impacting the terminal end at a nominal speed and angle of 62 mph and 5°, respectively, with the centerline of the vehicle aligned with the centerline of the terminal. This test is primarily intended to evaluate structural adequacy, occupant risk, and vehicle trajectory. A 2013 Hyundai Accent 4-door sedan with a test inertial mass of 2425.0 lbs (1100.0 kg) impacted the terminal at a velocity of 62.53 mph (100.64 km/h) and and angle of 5.3°. The impact activated the cable release post and the vehicle was allowed to penetrate the system in a controlled manner. The occupant compartment was not penetrated and deformation limits were not exceeded. The Occupant Impact Velocities (OIV) were 8.9 ft/s (2.7 m/s) and 1.3 ft/s (0.4 m/s) in the x- and y-directions, respectively. The Ridedown Accelerations were -4.0 g and -5.0 g, respectively. The Gibraltar Global TL-3 4 Cable Terminal met all of the requirements for MASH Test 3-32.	PASS
3-33 (2270P)	Applus IDIADA KARCO Test No. P38257-01. A 2270P test vehicle impacting the terminal end at a nominal speed and angle of 62 mph and 5°, respectively, with the centerline of the vehicle aligned with the centerline of the terminal. This test is primarily intended to evaluate structural adequacy, occupant risk, and vehicle trajectory. A 2012 Chevrolet Silverado 1500 4-door pickup truck with a test inertial mass of 4946.0 lbs (2243.5 kg) impacted the terminal at a velocity of 61.60 mph (99.14 km/h) and and angle of 5.2°. The impact activated the cable release post and the vehicle was allowed to penetrate the system in a controlled manner. The occupant compartment was not penetrated and deformation limits were not exceeded. The Occupant Impact Velocities (OIV) were 0.3 ft/s (0.1 m/s) and 3.0 ft/s (0.9 m/s) in the x- and y-directions, respectively. The Ridedown Accelerations were -1.4 g and 0.8 g, respectively. The Gibraltar Global TL-3 4 Cable Terminal met all of the requirements for MASH Test 3-33.	PASS

3-34 (1100C)	Applus IDIADA KARCO Test No. P38333-01. An 1100C test vehicle impacting the terminal at a nominal speed and angle of 62 mph and 15°, 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 structural adequacy, occupant risk, and vehicle trajectory. A 2013 Kia Rio 4-door sedan with a test inertial mass of 2432.8 lbs (1103.5 kg) impacted the terminal at a velocity of 62.33 mph (100.31 km/h) and and angle of 15.6°. The system contained and redirected the vehicle within the exit box and with a Working Width of 3.7 ft. (1.1 m). The occupant compartment was not penetrated and deformation limits were not exceeded. The Occupant Impact Velocities (OIV) were 10.8 ft/s (3.3 m/s) and 12.1 ft/s (3.7 m/s) in the x- and y-directions, respectively. The Ridedown Accelerations were -6.1 g and -8.0 g, respectively. The Gibraltar Global TL-3 4 Cable Terminal met all of the requirements for MASH Test 3-34.	PASS
3-35 (2270P)	Applus IDIADA KARCO Test No. P38194-01. A 2270P test vehicle impacting the terminal at a nominal speed and angle of 62 mph and 25°, respectively, with the corner of the vehicle bumper aligned with the beginning of the Length of Need (LON) of the terminal. This test is primarily intended to evaluate structural adequacy, occupant risk, and vehicle trajectory. A 2012 Chevrolet Silverado 1500 4-door pickup truck with a test inertial mass of 5008.8 lbs (2272.0 kg) impacted the terminal at a velocity of 63.23 mph (101.76 km/h) and and angle of 25.2°. The system contained and redirected the vehicle within the exit box and with a Working Width of 9.7 ft. (3.0 m). The occupant compartment was not penetrated and deformation limits were not exceeded. The Occupant Impact Velocities (OIV) were 3.9 ft/s (1.2 m/s) and 10.5 ft/s (3.2 m/s) in the x- and y-directions, respectively. The Ridedown Accelerations were -3.7 g and 4.4 g, respectively. The Gibraltar Global TL-3 4 Cable Terminal met all of the requirements for MASH Test 3-35.	PASS

3-36 (2270P)	MASH Test Designation 3-36. A 2270P test vehicle impacting the terminal at a nominal impact speed and angle of 62 mph and 25°, respectively, with the corner of the vehicle bumper aligned with the Critical Impact Point (CIP) with respect to the transition to a 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 cable barrier terminal, the Gibraltar Global TL-3 4 Cable Terminal is not designed to be transition into a stiff barrier or backup structure and therefore Test 36 is not relevant and was not conducted.	Non-Relevant Test, not conducted
3-37 (2270P)	Applus IDIADA KARCO Test No. P38236-01. An 1100C test vehicle impacting the terminal at a nominal speed and angle of 62 mph and 25°, respectively, with the corner of the vehicle bumper aligned with the Critical Impact Point (CIP) of the terminal for reverse direction impacts. This test is primarily intended to evaluate structural adequacy, occupant risk, and vehicle trajectory in a reverse direction impact. A 2012 Kia Rio 4-door sedan with a test inertial mass of 2448.2 lbs (1110.5 kg) impacted the terminal at a velocity of 62.53 mph (100.63 km/h) and and angle of 24.9°. Upon impact, cables released and allowed the vehicle to gate through the system in a controlled manner. The occupant compartment was not penetrated and deformation limits were not exceeded. The Occupant Impact Velocities (OIV) were 23.3 ft/s (7.1 m/s) and 19.7 ft/s (6.0 m/s) in the x- and y-directions, respectively. The Ridedown Accelerations were -16.0 g and 12.9 g, respectively. The Gibraltar Global TL-3 4 Cable Terminal met all of the requirements for MASH Test 3-37b.	PASS
3-38 (1500A)	MASH Test Designation 3-38. A 1500A test vehicle impacting the terminal end-on at a nominal impact speed and angle of 62 mph and 0°, respectively, with the centerline of the vehicle aligned with the centerline of the terminal. This test Is primarily intended to evaluate the performance of a staged attenuator/ terminal when Impacted by a mid-size vehicle. The Gibraltar Global TL-3 4 Cable Terminal is not a staged device, because the force required to move the Impact head down the rail does not change. Therefore, Test 38 is not relevant and was not conducted.	Non-Relevant Test, not conducted

3-40 (1100C)	Test for non-redirective crash cushions, not applicable for terminals.	Non-Relevant Test, not conducted
3-41 (2270P)	Test for non-redirective crash cushions, not applicable for terminals.	Non-Relevant Test, not conducted
3-42 (1100C)	Test for non-redirective crash cushions, not applicable for terminals.	Non-Relevant Test, not conducted
3-43 (2270P)	Test for non-redirective crash cushions, not applicable for terminals.	Non-Relevant Test, not conducted
3-44 (2270P)	Test for non-redirective crash cushions, not applicable for terminals.	Non-Relevant Test, not conducted
3-45 (1500A)	Test for non-redirective crash cushions, 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:	Applus IDIADA KARCO Engineering, LLC.	
Laboratory Signature:	Steven Matsusaka DN: cn=Steven Matsusaka, email=steven.matsusaka@idiada.com,c=US Digitally signed by Steven Matsusaka Date: 2020.01.14 19:07:54 -08'00'	
Address:	9270 Holly Rd, Adelanto, CA 92301	Same as Submitter ☒
Country:	United States of America	Same as Submitter ☒
Accreditation Certificate Number and Dates of current Accreditation period :	TL-371: July 2019 - July 2022	

Submitter Signature*: Steven Matsusaka Digitally signed by Steven Matsusaka DN: cn=Steven Matsusaka, email=steven.matsusaka@idiada.com, c=US Date: 2020.01.14 19:07:59 -08'00'

Submit Form

ATTACHMENTS

Attach to this form:

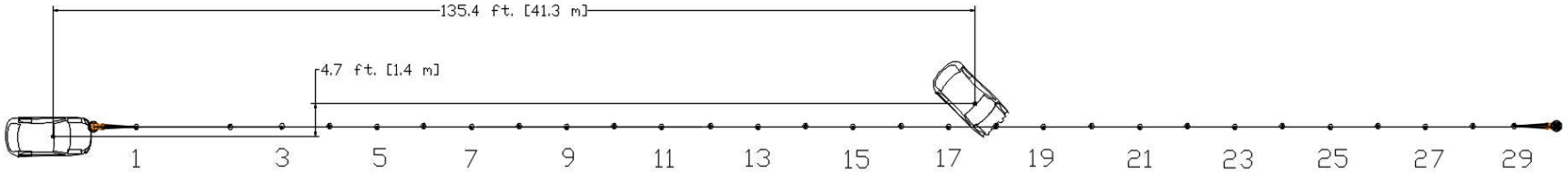
1) Additional disclosures of related financial interest as indicated above.
2) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
3) A drawing or drawings of the device(s) that conform to the Task Force-13 Drawing Specifications [Hardware Guide Drawing Standards]. For proprietary products, a single isometric line drawing is usually acceptable to illustrate the product, with detailed specifications, intended use, and contact information provided on the reverse. Additional drawings (not in TF-13 format) showing details that are relevant to understanding the dimensions and performance of the device should also be submitted to facilitate our review.

FHWA Official Business Only:

Eligibility Letter		
Number	Date	Key Words

MASH 2016 Test 3-30 Summary

0.000 s 0.100 s 0.200 s 0.300 s 0.500 s



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test No	P37410-01
Test Designation	3-30
Test Date	1/29/18

TEST ARTICLE

Name / Model	TL-3 4 Cable Terminal
Type	End Terminal
Installation Length	214.8 ft. (65.5 m)
Terminal Length	27.5 ft. (8.4 m)
Road Surface	Compacted Soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2013 Kia Rio
Curb Mass	2,508.8 lbs (1,138.0 kg)
Test Inertial Mass	2,425.0 lbs (1,100.0 kg)
Gross Static Mass	2,600.3 lbs (1,179.5 kg)

Impact Conditions

Impact Velocity	61.48 mph (98.95 km/h)
Impact Angle	0.4°
Location / Orientation	Offset 16.3 in. (414 mm)
Kinetic Energy	306.4 kip-ft (415.5 kJ)

Exit Conditions

Exit Velocity	Vehicle did not exit
Exit Angle	N/A
Final Vehicle Position	135.4 ft. (41.3 m) Downstream 4.7 ft. (1.4 m) Left
Exit Box Criteria Met	N/A
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	4.0 °
Maximum Pitch Angle	1.7 °
Maximum Yaw Angle	17.8 °

Occupant Risk

Longitudinal OIV	8.9 ft/s (2.7 m/s)
Lateral OIV	1.0 ft/s (0.3 m/s)
Longitudinal RA	-5.6 g
Lateral RA	-3.9 g
THIV	8.9 ft/s (2.7 m/s)
PHD	5.8 g
ASI	0.21

Test Article Deflections

Static	N/A
Dynamic	5.6 ft. (1.7 m)
Working Width	5.6 ft. (1.7 m)
Debris Field	129.4 ft. (39.4 m) Downstream 5.3 ft. (1.6 m) Left

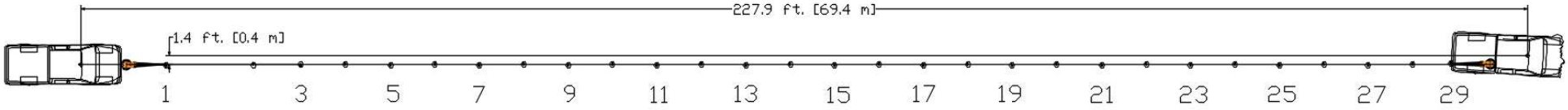
Vehicle Damage

Vehicle Damage Scale	12-FD-3
CDC	12FDEW2
Maximum Intrusion	0.2 in. (5 mm)

Figure 4 Summary of Test 3-30

MASH 2016 Test 3-31 Summary

0.000 s 0.100 s 0.200 s 0.300 s 0.500 s



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test No	P37411-01
Test Designation	3-31
Test Date	1/29/18

TEST ARTICLE

Name / Model	TL-3 4 Cable Terminal
Type	Emd Terminal
Installation Length	214.8 ft. (65.5 m)
Terminal Length	27.5 ft. (8.4 m)
Road Surface	Compacted Soil

TEST VEHICLE

Type / Designation	2270P
Year, Make, and Model	2012 Chevrolet Silverado 1500
Curb Mass	4,898.6 lbs (2,222.0 kg)
Test Inertial Mass	4,992.3 lbs (2,264.5 kg)
Gross Static Mass	4,992.3 lbs (2,264.5 kg)

Impact Conditions

Impact Velocity	60.11 mph (96.74 km/h)
Impact Angle	1.1°
Location / Orientation	1.4 in (36 mm) Left
Kinetic Energy	603.0 kip-ft (817.6 kJ)

Exit Conditions

Exit Velocity	Vehicle did not exit
Exit Angle	N/A
Final Vehicle Position	227.9 ft. (69.5 m) Left 1.4 ft. (0.4 m) Downstream
Exit Box Criteria Met	N/A
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	2.3 °
Maximum Pitch Angle	-2.5 °
Maximum Yaw Angle	4.4 °

Occupant Risk

Longitudinal OIV	2.6 ft/s (0.8 m/s)
Lateral OIV	3.9 ft/s (1.2 m/s)
Longitudinal RA	-2.0 g
Lateral RA	1.7 g
THIV	4.9 ft/s (1.5 m/s)
PHD	2.2 g
ASI	0.1

Test Article Deflections

Static	N/A
Dynamic	3.3 ft. (1.0 m)
Working Width	3.3 ft. (1.0 m)
Debris Field Lateral	6.7 ft. (2.0 m)

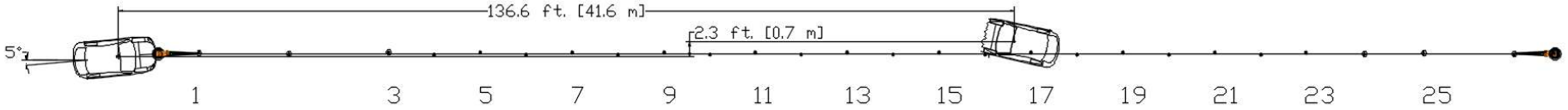
Vehicle Damage

Vehicle Damage Scale	12-FD-2
CDC	12FDEW2
Maximum Intrusion	0.3 in. (8 mm)

Figure 4 Summary of Test 3-31

MASH 2016 Test 3-32 Summary

0.000 s 0.120 s 0.240 s 0.360 s 0.540 s



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test No	P37403-01
Test Designation	3-32
Test Date	2/12/18

TEST ARTICLE

Name / Model	TL-3 4 Cable Terminal
Type	End Terminal
Installation Length	213.0 ft. (64.9 m)
Terminal Length	27.5 ft. (8.4 m)
Road Surface	Compacted Soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2013 Hyundai Accent
Curb Mass	2,489.0 lbs (1,129.0 kg)
Test Inertial Mass	2,425.0 lbs (1,100.0 kg)
Gross Static Mass	2,592.6 lbs (1,176.0 kg)

Impact Conditions

Impact Velocity	62.53 mph (100.64 km/h)
Impact Angle	5.3°
Location / Orientation	1.5 in. (38 mm) Right of CL
Kinetic Energy	317.0 kip-ft (429.8 kJ)

Exit Conditions

Exit Velocity	Vehicle did not exit
Exit Angle	N/A
Final Vehicle Position	136.6 ft. (41.6 m) Downstream 2.3 ft. (0.7 m) Left
Exit Box Criteria Met	N/A
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-3.6 °
Maximum Pitch Angle	6.3 °
Maximum Yaw Angle	-12.9 °

Occupant Risk

Longitudinal OIV	8.9 ft/s (2.7 m/s)
Lateral OIV	1.3 ft/s (0.4 m/s)
Longitudinal RA	-4.0 g
Lateral RA	-5.0 g
THIV	8.9 ft/s (2.7 m/s)
PHD	6.3 g
ASI	0.23

Test Article Deflections

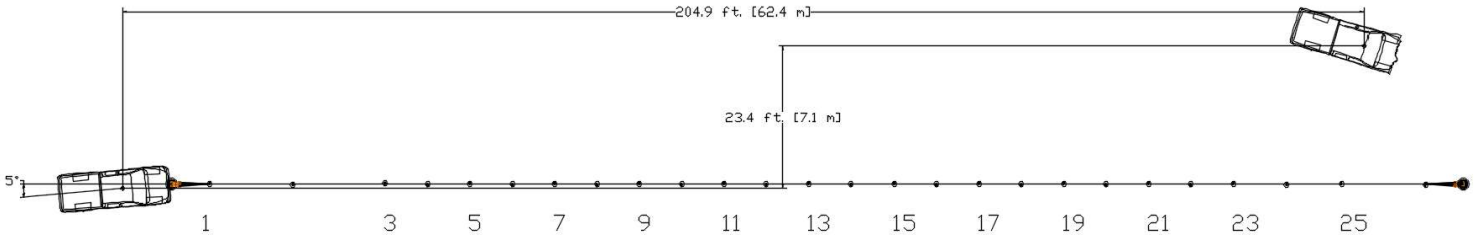
Static	N/A
Dynamic	5.6 ft. (1.7 m)
Working Width	11.1 ft. (3.4 m)
Debris Field	119.1 ft. (36.3 m) Downstream 14.0 ft. (4.3 m) Left

Vehicle Damage

Vehicle Damage Scale	12-FR-4
CDC	12FZEW2
Maximum Intrusion	Negligible

Figure 3 Summary of Test 3-32

MASH 2016 Test 3-33 Summary



GENERAL INFORMATION

Test Agency	IDIADA KARCO Engineering
Test No	P38257-01
Test Designation	3-33
Test Date	8/31/18

TEST ARTICLE

Name / Model	TL-3 4 Cable Terminal
Type	End Terminal
Installation Length	213.0 ft. (64.9 m)
Terminal Length	27.5 ft. (8.4 m)
Road Surface	Compacted Soil

TEST VEHICLE

Type / Designation	2270P
Year, Make, and Model	2012 Chevrolet Silverado 1500
Curb Mass	5,060.6 lbs (2,295.5 kg)
Test Inertial Mass	4,946.0 lbs (2,243.5 kg)
Gross Static Mass	4,946.0 lbs (2,243.5 kg)

Impact Conditions

Impact Velocity	61.60 mph (99.14 km/h)
Impact Angle	5.2°
Location / Orientation	0.75 in. (19 mm) left of CL
Kinetic Energy	615.8 kip-ft (835.0 kJ)

Exit Conditions

Exit Velocity	59.36 mph (95.53 km/h)
Exit Angle	3.4°
Final Vehicle Position	204.9 ft. (62.5 m) Downstream 23.4 ft. (7.1 m) Left
Exit Box Criteria Met	N/A
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-0.7 °
Maximum Pitch Angle	1.9 °
Maximum Yaw Angle	-3.3 °

Occupant Risk

Longitudinal OIV	0.3 ft/s (0.1 m/s)
Lateral OIV	3.0 ft/s (0.9 m/s)
Longitudinal RA	-1.4 g
Lateral RA	0.8 g
THIV	3.6 ft/s (1.1 m/s)
PHD	1.6 g
ASI	0.09

Test Article Deflections

Static	N/A
Dynamic	3.3 ft. (1.0 m)
Working Width	3.3 ft. (1.0 m)
Debris Field	64.3 ft. (19.6 m) Downstream 7.9 ft. (2.4 m) Left

Vehicle Damage

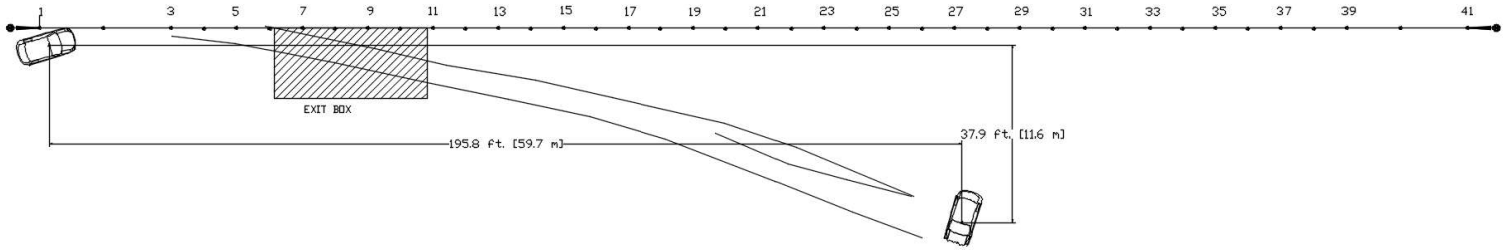
Vehicle Damage Scale	12-FD-2*
CDC	12FDLW1*
Maximum Intrusion	Negligible*

* Before secondary impact

Figure 4 Summary of Test 3-33

MASH 2016 Test 3-34 Summary

0.000 s 0.100 s 0.200 s 0.300 s 0.500 s



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test No	P38333-01
Test Designation	3-34
Test Date	11/20/18

TEST ARTICLE

Name / Model	TL-3 4 Cable Terminal
Type	End Terminal
Installation Length	318.3 ft. (97.0 m)
Terminal Length	27.5 ft. (8.4 m)
Road Surface	Compacted soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2013 Kia Rio
Curb Mass	2,554.0 lbs (1,158.5 kg)
Test Inertial Mass	2,432.8 lbs (1,103.5 kg)
Gross Static Mass	2,637.8 lbs (1,196.5 kg)

Impact Conditions

Impact Velocity	62.33 mph (100.31 km/h)
Impact Angle	15.6°
Location / Orientation	3.4 in. (86 mm) from midspan
Impact Severity	22.8 kip-ft (31.0 kJ)

Exit Conditions

Exit Velocity	48.09 mph (77.39 km/h)
Exit Angle	4.5°
Final Vehicle Position	195.8 ft. (59.7 m) Downstream 37.9 ft. (11.6 m) Right
Exit Box Criteria Met	Yes
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	2.9 °
Maximum Pitch Angle	8.9 °
Maximum Yaw Angle	-19.5 °

Occupant Risk

Longitudinal OIV	10.8 ft/s (3.3 m/s)
Lateral OIV	12.1 ft/s (3.7 m/s)
Longitudinal RA	-6.1 g
Lateral RA	-8.0 g
THIV	18.0 ft/s (5.5 m/s)
PHD	9.8 g
ASI	0.41

Test Article Deflections

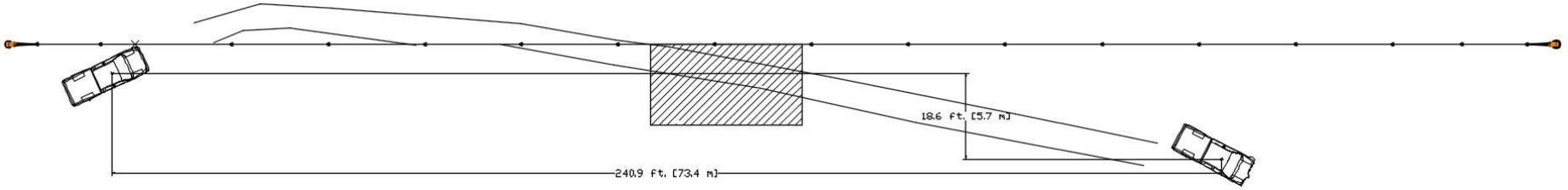
Static	N/A
Dynamic	3.2 ft. (1.0 m)
Working Width	3.7 ft. (1.1 m)
Debris Field	100.1 ft. (30.5 m) Downstream 24.7 ft. (7.5 m) Lateral

Vehicle Damage

Vehicle Damage Scale	11-LFQ-4
CDC	11LYEW3
Maximum Intrusion	0.6 in. (15 mm)

Figure 3 Summary of Test 3-34

MASH 2016 Test 3-35 Summary



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test No	P38194-01
Test Designation	3-35
Test Date	6/29/18

TEST ARTICLE

Name / Model	TL-3 4 Cable Terminal
Type	End Terminal
Installation Length	335.7 ft. (102.3 m)
Terminal Length	27.5 ft. (8.4 m)
Road Surface	Concrete and compacted soil

TEST VEHICLE

Type / Designation	2270P
Year, Make, and Model	2012 Chevrolet Silverado 1500
Curb Mass	5,049.6 lbs (2,290.5 kg)
Test Inertial Mass	5,008.8 lbs (2,272.0 kg)
Gross Static Mass	5,008.8 lbs (2,272.0 kg)

Impact Conditions

Impact Velocity	63.23 mph (101.76 km/h)
Impact Angle	25.2°
Location / Orientation	LON Point
Impact Severity	121.4 kip-ft (164.5 kJ)

Exit Conditions

Exit Velocity	Out of Camera View
Exit Angle	N/A
Final Vehicle Position	240.9 ft. (73.4 m) Downstream 18.6 ft. (5.7 m) Right
Exit Box Criteria Met	Yes
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	11.3 °
Maximum Pitch Angle	3.9 °
Maximum Yaw Angle	24.9 °

Occupant Risk

Longitudinal OIV	3.9 ft/s (1.2 m/s)
Lateral OIV	10.5 ft/s (3.2 m/s)
Longitudinal RA	-3.7 g
Lateral RA	4.4 g
THIV	10.8 ft/s (3.3 m/s)
PHD	4.4 g
ASI	0.42

Test Article Deflections

Static	3.4 ft. (1.0 m)
Dynamic	9.7 ft. (3.0 m)
Working Width	9.7 ft. (3.0 m)
Debris Field	172.8 ft. (52.7 m) Downstream 37.0 ft. (11.3 m) Field Side

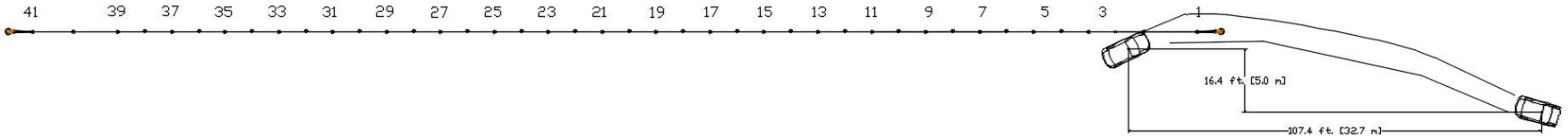
Vehicle Damage

Vehicle Damage Scale	11-LFQ-3
CDC	11FRMN2
Maximum Intrusion	Negligible

Figure 4 Summary of Test 3-35

MASH 2016 Test 3-37b Summary

0.000 s 0.100 s 0.300 s 0.500 s 0.700 s



GENERAL INFORMATION

Test Agency	Applus IDIADA KARCO
Test No	P38236-01
Test Designation	3-37b
Test Date	9/17/18

TEST ARTICLE

Name / Model	TL-3 4 Cable Terminal
Type	End Terminal
Installation Length	314.8 ft. (96 m)
Terminal Length	27.5 ft. (8.4 m)
Road Surface	Compacted soil

TEST VEHICLE

Type / Designation	1100C
Year, Make, and Model	2012 Kia Rio
Curb Mass	2,417.3 lbs (1,096.5 kg)
Test Inertial Mass	2,448.2 lbs (1,110.5 kg)
Gross Static Mass	2,613.5 lbs (1,185.5 kg)

Impact Conditions

Impact Velocity	62.53 mph (100.63 km/h)
Impact Angle	24.9°
Location / Orientation	Terminal Post 2
Impact Severity	56.7 kip-ft (76.9 kJ)

Exit Conditions

Exit Velocity	32.06 mph (51.60 km/h)
Exit Angle	3.2°
Final Vehicle Position	107.4 ft. (32.7 m) Downstream 16.4 ft. (5.0 m) Right
Exit Box Criteria Met	N/A
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-7.1 °
Maximum Pitch Angle	3.7 °
Maximum Yaw Angle	-62.6 °

Occupant Risk

Longitudinal OIV	23.3 ft/s (7.1 m/s)
Lateral OIV	19.7 ft/s (6.0 m/s)
Longitudinal RA	-16.0 g
Lateral RA	12.9 g
THIV	39.7 ft/s (12.1 m/s)
PHD	20.1 g
ASI	1.39

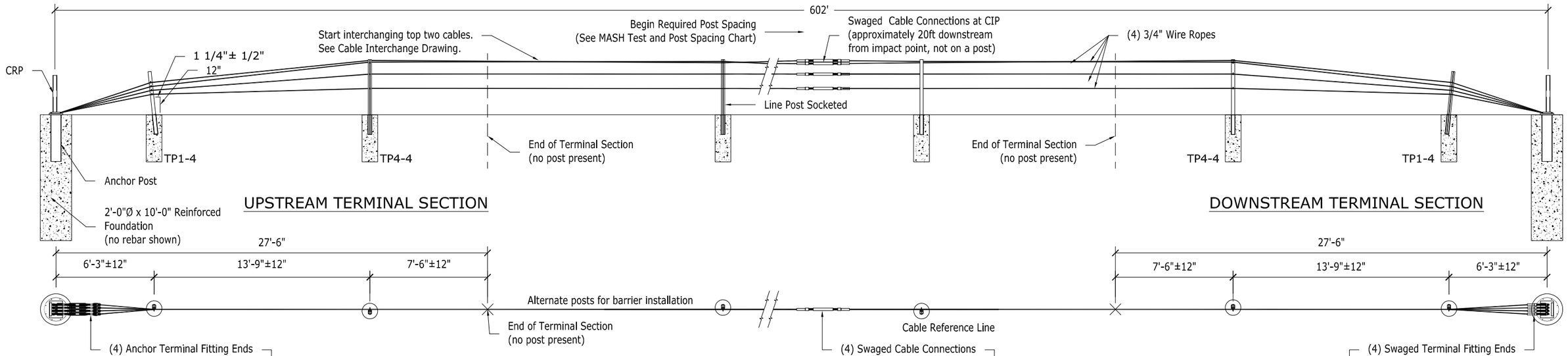
Test Article Deflections

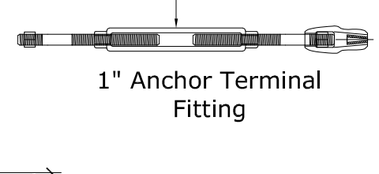
Static	N/A
Dynamic	4.3 ft. (1.3 m)
Working Width	16.0 ft. (4.9 m)
Debris Field	146.1 ft. (44.5 m) Downstream 32.8 ft. (10 m) Lateral

Vehicle Damage

Vehicle Damage Scale	01-LFQ-4
CDC	01FDEW3
Maximum Intrusion	0.7 in. (18 mm)

Figure 4 Summary of Test 3-37b

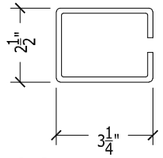




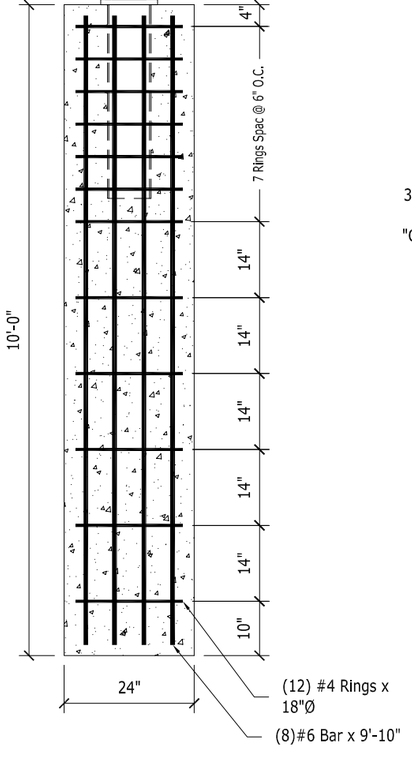
1" Anchor Terminal Fitting

1" Swaged Cable Connection

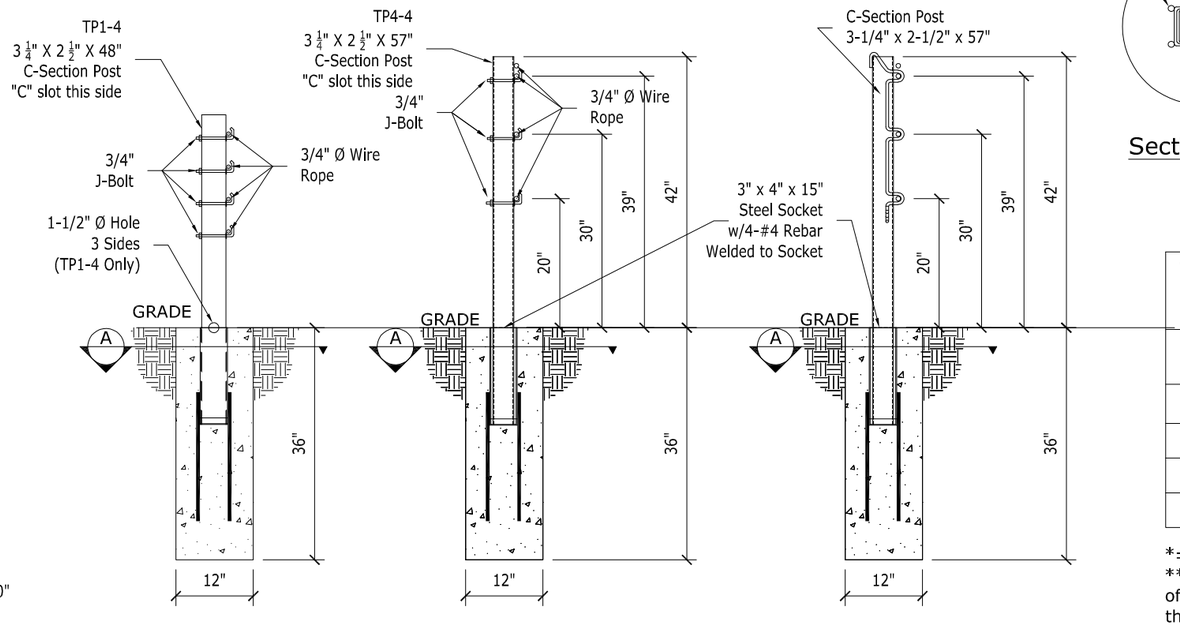
1" RH Swaged Terminal Fitting



C Section Post



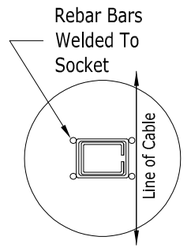
Cable Release & Anchor Post



Terminal Post
(Welded Rebar Socket)

Terminal Post
(Welded Rebar Socket)

Line Post
(Welded Rebar Socket)



Section A

TL-4 4 Cable MASH Test and Post Spacing Chart	
MASH TEST	Line Post Spacing*
3-10	7'-0"
3-11	7'-0"
3-11	21'-0"
4-12**	21'-0"

*±6" post spacing tolerance
**All tests are impacted near the midpoint of the installation at a 25° angle, except the 4-12 test, which is impacted at 15°.

Cable Tension Chart*	
-10 °F	8600
0 °F	8200
10 °F	7800
20 °F	7400
30 °F	7000
40 °F	6600
50 °F	6200
60 °F	5800
70 °F	5400
80 °F	5000
90 °F	4600
100 °F	4200
110 °F	3800

*Allowable Deviation from Chart +/- 10%

MASH 4 Cable Tests
PROPRIETARY TO GIBRALTAR

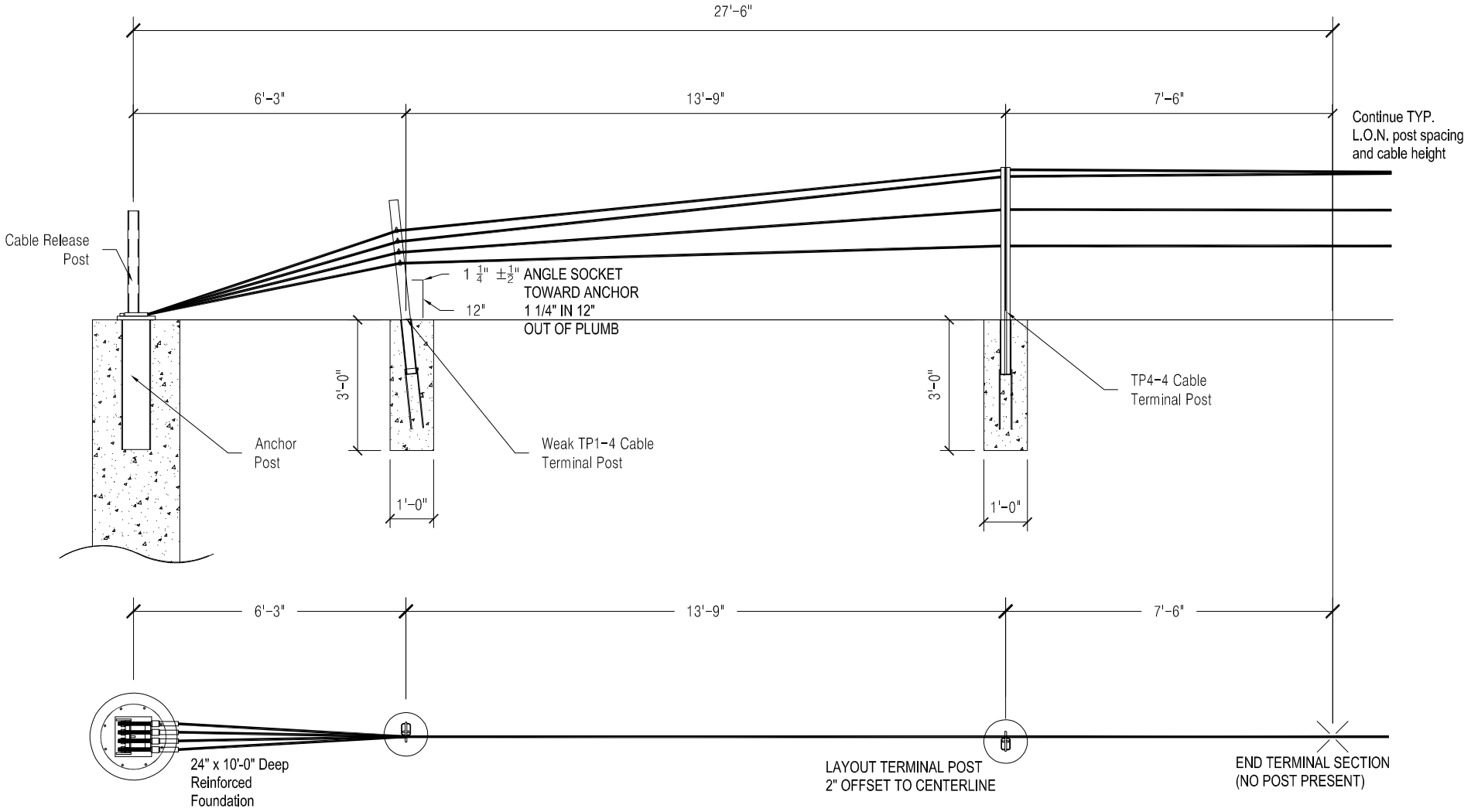
GIBRALTAR CABLE BARRIER

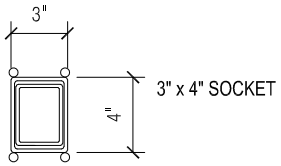
TL-4 4 Cable System Layout

Gibraltar Cable Barrier Systems

Scale:	Date:
NTS	12-19-18
Layout:	Drafter:
ANSI B	JP

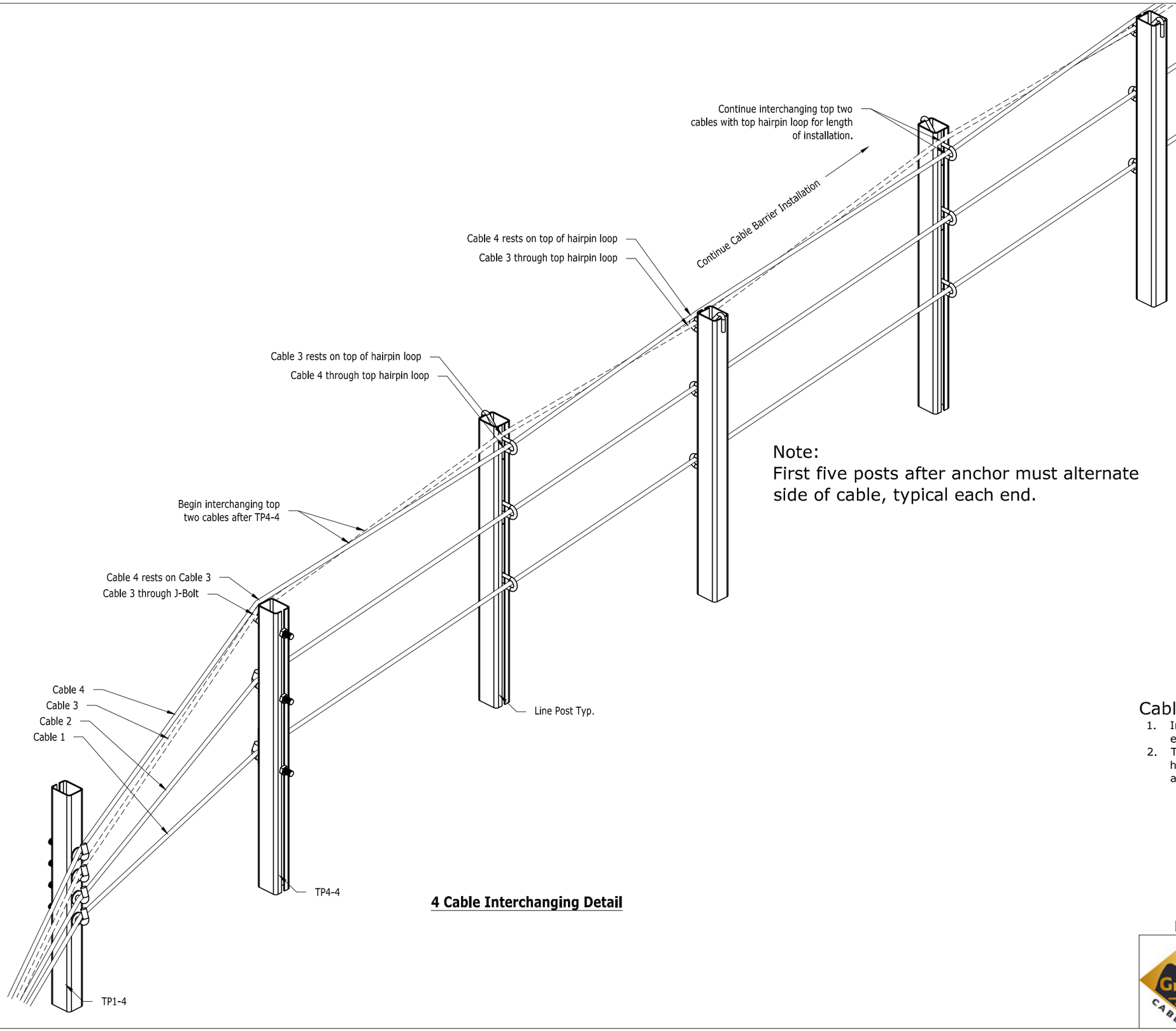
Rev Date:	Approver:
1-23-19	BH





PROPRIETARY TO GIBRALTAR

	TL-3 4-Cable MASH Terminal Layout
	Gibraltar Cable Barrier Systems
Scale: NTS	Date: 1-23-19
Layout: ANSI B	Drafter: BH



Note:
First five posts after anchor must alternate side of cable, typical each end.

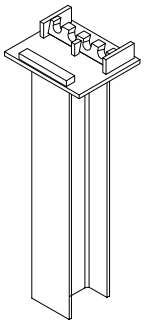
4 Cable Interchanging Detail

Cable Installation Note:

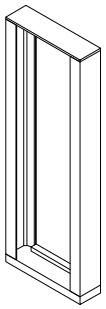
1. Interchanging top two cables run semi-parallel to each other, never twisting.
2. The top cables alternate passing through the top hairpin loop and resting on the top hairpin loop at each post starting after TP4-4.

MASH 4 Cable Tests
PROPRIETARY TO GIBRALTAR

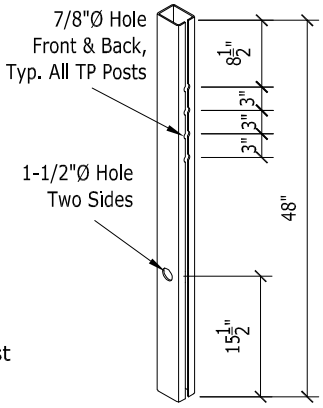
	TL-4 4 Cable Interchanging
	Gibraltar Cable Barrier Systems
Scale: **NTS**	Date: **1-2-19**
Layout: **ANSI B**	Drafter: **JP**



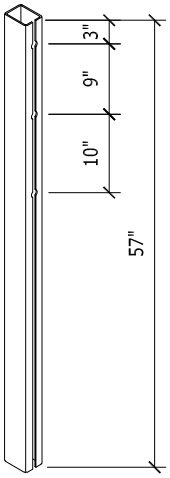
Anchor Post



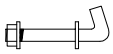
Cable Release Post



TP1-4
Terminal Post
No. 1/Weak



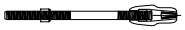
TP4-4
Terminal Post



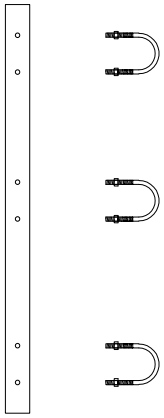
J-BLT
J-Bolt

RH STUD ATF ASSY
Anchor Terminal Fitting RH Stud

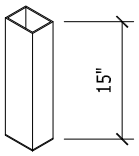
ATF
Anchor Terminal Fitting



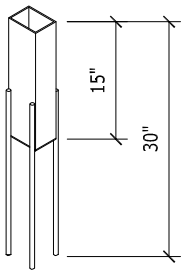
ATF-END
Anchor Terminal Fitting End



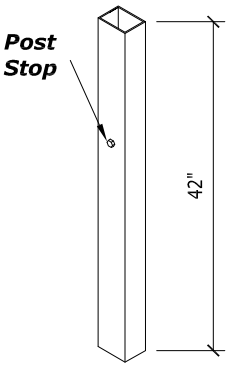
U-Bolt Lock-Plate Assembly



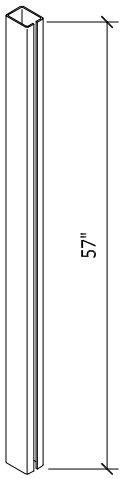
Tube Socket
(Steel or Plastic)



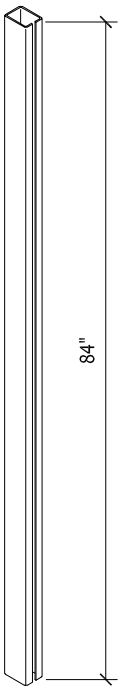
SOCK-S
Short Rebar Socket



TUBE-D
Driven Socket



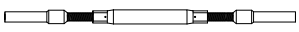
4-LNP-S
Line Post/Socketed



4-LNP-D
Line Post/Driven

4-HPIN ALUM

4-LOCK
TL4 Lockplate



RH/LH SWAGE ASSY

CSTB
Cable Splice Turnbuckle

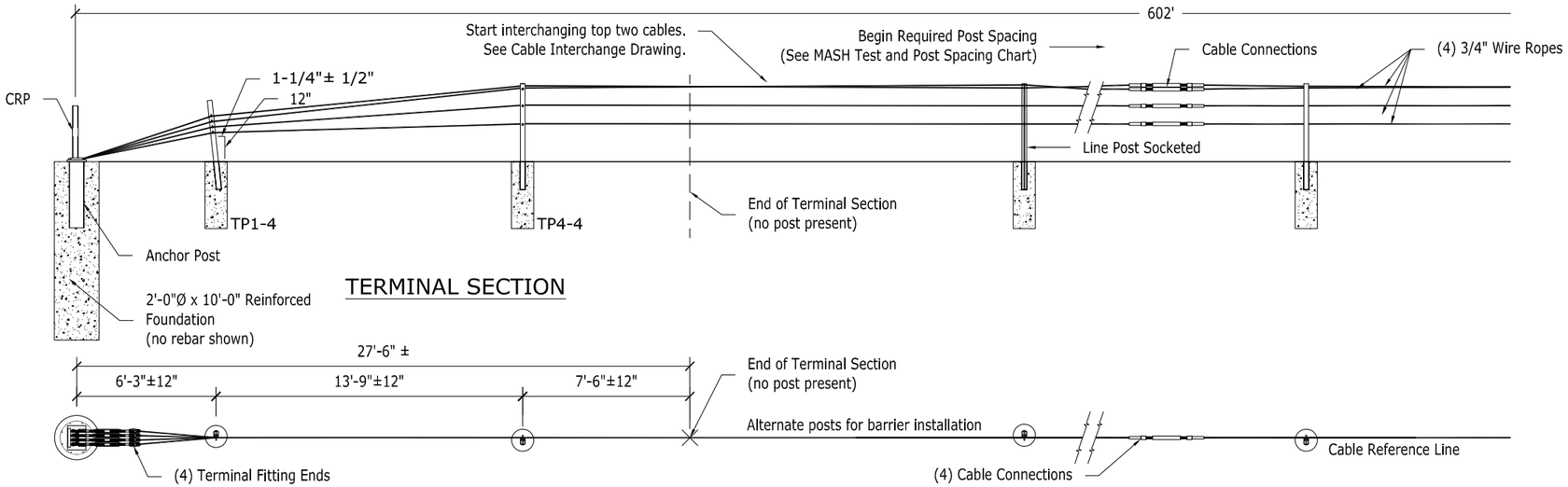
WEDGE
W-1 Wedge

ACORN
Acorn w/ Wedge

TORP
Longitudinal Section ONLY
Torpedo Cable Splice

PROPRIETARY TO GIBRALTAR

GIBRALTAR CABLE BARRIER	**TL4 MASH System Parts**	
	Gibraltar Cable Barrier Systems	
	Scale: **NTS**	Date: **12/19/18**
	Layout: **ANSI B**	Drafter: **BH**

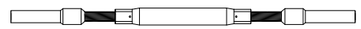


TERMINAL SECTION

RH STUD ATF ASSY
Anchor Terminal Fitting RH Stud

ATF
Anchor Terminal Fitting

ATF-END
Anchor Terminal Fitting End

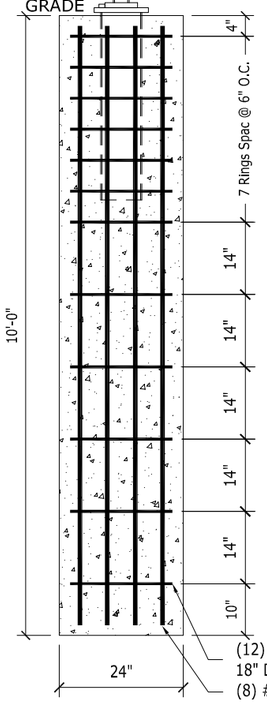


RH/LH SWAGE ASSY

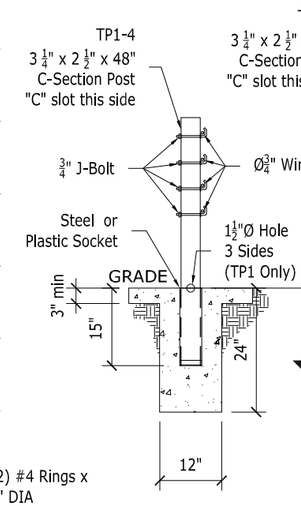
LON Fittings
Cable Splice Turnbuckle

GENERAL NOTES:

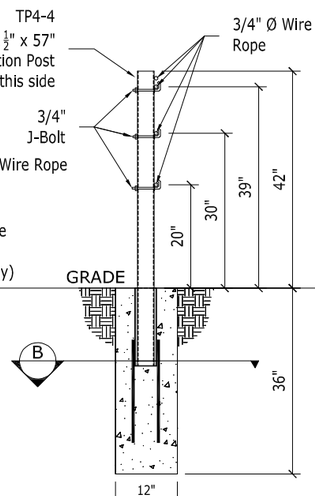
1. For additional information contact Gibraltar, Inc. at 1-833-715-0810 or see the manufacturer's product manual.
2. All concrete shall be per specification; minimum 2500 PSI.
3. The Cable Barrier System shall be installed on shoulders or on medians with slopes of 6:1 or flatter. If installed on slopes steeper than 6:1 up to 4:1 the TL-4 system performs as a TL-3 and Gibraltar must be contacted for various guidelines related to placement. (Max. Post Spacing 18' on 4:1)
4. The Cable Barrier System is accepted by the FHWA Test Level - 4.
5. See the specification for delineation.
6. Rock Clause: Where solid rock is encountered:
   - 6.A. For socketed post, continue digging 12" diameter, 15" deep into rock or the required plan depth, whichever comes first.
   - 6.B. For driven post, core drill a 4" diameter hole 18" deep into rock or the required plan depth, whichever comes first.
   - 6.C. For Anchor post, continue digging 24" diameter, 30" deep into rock or the required plan depth, whichever comes first.
7. The Gibraltar cable barrier system shall be installed in standard compacted soil. Soil must be well drained.
8. All non-welded rebar by others.
9. Minimum recommended line post foundation.
   - 9.A. Without mowstrip, 36" Deep x 12" diameter foundations with #3 rebar ring x 8" diameter with two #4 rebar vertical bars 30" long or 30" welded rebar socket.
   - 9.B. With 4" minimum depth hot mix asphalt, 30" deep x 12" diameter foundations with #3 rebar ring x 8" diameter with two #4 rebar vertical bars 30" long or 30" welded rebar socket.
   - 9.C. With 3" minimum depth concrete mowstrip, 24" deep x 12" diameter foundations. (No rebar required).
   - 9.D. Direct drive driven post and driven socket 42" deep.



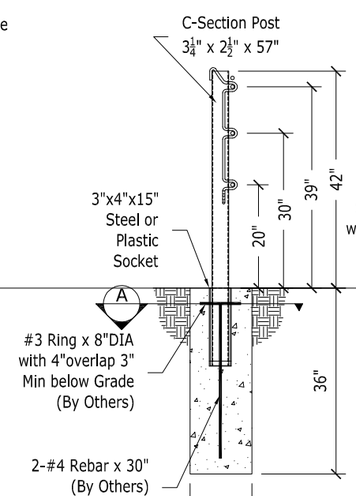
Cable Release &
Anchor Post



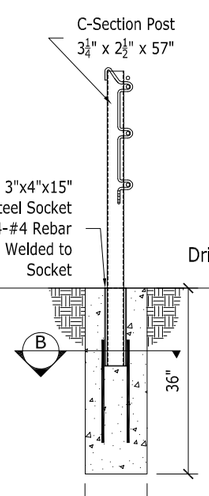
Terminal Post
(Shown with Concrete
Mowstrip)



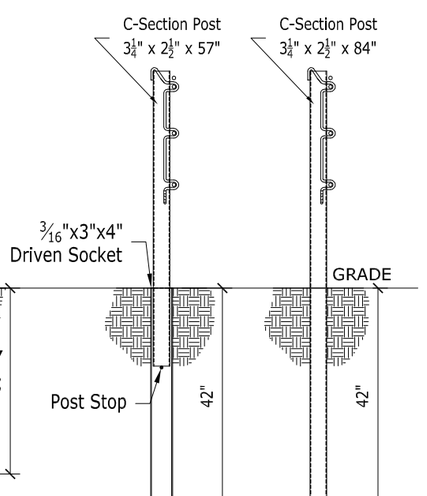
Terminal Post
(Welded Rebar Socket)



Line Post
(Rebar Ring/Bars Socket Option)

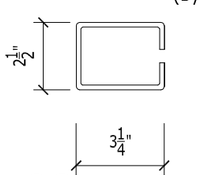


Line Post
(Welded Rebar Socket Option)

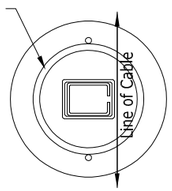


Line Post
(Driven Socket Option)

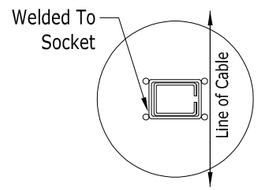
Line Post
(Driven Post Option)



C-Section Post



Section A



Section B

Cable Tension Chart*	
-10 °F	8600
0 °F	8200
10 °F	7800
20 °F	7400
30 °F	7000
40 °F	6600
50 °F	6200
60 °F	5800
70 °F	5400
80 °F	5000
90 °F	4600
100 °F	4200
110 °F	3800

*Allowable Deviation from Chart +/- 10%

TL-4 4 Cable MASH Test and Post Spacing Chart

MASH TEST	Line Post Spacing
3-10	7'-0"
3-11	7'-0"
3-11	21'-0"
4-12	21'-0"

*±6" post spacing tolerance

MASH 4 Cable Tests PROPRIETARY TO GIBRALTAR

TL-4 4M Cable System Layout

Gibraltar Cable Barrier Systems

Scale:	Date:
NTS	1-7-2019
Layout: ANSI B	Drafter: BH