VALTIR

CASS® S3 4:1

CABLE SAFETY SYSTEM

PRODUCT MANUAL

PN 620005
SEPTEMBER 2022

CASS® S3 4:1
Cable Safety System

The CASS® S3 4:1 Cable Safety System ("CASS® S3") has been tested to National Cooperative Highway Research Program ("NCHRP") Report 350 criteria and to American Association of State and Highway Transportation Officials ("AASHTO") Manual for Assessing Safety Hardware, 1st Edition-2009 ("MASH") criteria, has been deemed eligible for Federal-aid reimbursement on the National Highway System ("NHS") by the Federal Highway Administration ("FHWA"). The NCHRP Report 350 and MASH CASS® S3 Test Level 3 system can be placed on slopes 1V:4H or flatter. The NCHRP Report 350 CASS® S3 Test Level 4 system can be placed on slopes 1V:6H or flatter. The MASH CASS® S3 Test Level 4 can be placed on slopes 10:1 or flatter.

Production Description
Assembly Manual

VALTIR

15601 Dallas Parkway
Suite 525
Addison, Texas 75001

Warning: The state/specifying agency, distributors, owners, and contractors are RESPONSIBLE for the assembly, maintenance, and repair of the CASS® S3. Failure to fulfill these RESPONSIBILITIES with respect to the assembly, maintenance, and repair of the CASS® S3 could result in serious injury or death.

Important: These instructions are for standard assembly specified by the state/specifying agency**. In the event the specified system assembly, maintenance, or repair would require a deviation from standard assembly parameters, contact a Valtir, LLC ("Valtir") representative**. This system has been deemed eligible by the FHWA for use on the NHS under strict criteria utilized by that agency.

This manual must be available to the worker overseeing and/or assembling the product at all times. For additional copies, contact Valtir at (888) 356-2363 or visit Valtir.com.

The information contained in this manual supersede all previous versions. The instructions, illustrations, and specifications are based on the latest CASS® S3 information available to Valtir at publication. We reserve the right to make changes at any time. Please visit Valtir.com to confirm the latest revision.

Revision G September 2022

Table of Contents

CASS® S3 ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
CASS® S3	The CASS® S3 4:1 Cable Safety System
CBOD	Cable Barrier Overlap Distance
CCA	CASS® Cable Anchor
CCT	CASS® Cable Terminal
CFR	Code of Federal Regulation
CRP	Cable Release Post
FHWA	Federal Highway Administration
MASH	Manual for Assessing Safety Hardware
Median	Ditch width (distance between break points)
MSC	Minimum Strength Concrete
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
OSHA	Occupational Safety & Health Administration
PN	Valtir Product Number
PPE	Personal Protective Equipment
TL-3	Test Level 3
TL-4	Test Level 4
Valtir	Valtir, LLC
1V:"x"H	Slope Measurement-1 Foot Vertical Distance to "x" Foot Horizontal Distance

Customer Service Contacts

Valtir is committed to the highest level of customer service. Feedback regarding CASS® S3, its assembly procedures, supporting documentation, and performance is always welcome. Additional information can be obtained from the contact information below:

Valtir

Telephone	(888) 356-2363 (USA) +1 214 589 8140 (International)
Contact Link	Valtir.com
Website:	www.Valtir.com

Valtir, LLC

15601 Dallas Parkway

Suite 525
Addison, TX 75001

Important Introductory Notes

Proper assembly of CASS® S3 is essential to achieve the performance that has been evaluated and deemed eligible for federal-aid reimbursement by the FHWA per NCHRP Report 350 and to AASHTO MASH. These instructions are to be read in their entirety and understood before assembling CASS® S3. These instructions are to be used only in conjunction with standard CASS® S3 assemblies specified by the state/specifying agency. **If you need additional information, or have questions about CASS® S3, please contact the state/specifying agency that has planned and specified this assembly and, if needed, contact Valtir Customer Service.** This product must be assembled in the location specified by the state/specifying agency. If there are deviations, alterations, or departures from the assembly instructions specified in this manual, the device may not perform as tested.

Note: The Metric conversion from Imperial in this manual uses a soft conversion.

A state/specifying agency's careful evaluation of the site layout, vehicle population type and speed, traffic direction, and visibility are some of the elements that require evaluation in the selection of a highway product. For example, curbs could cause an untested effect on an impacting vehicle.

A set of product and project shop drawings will be supplied by Valtir. The shop drawings will be for each section of the assembly. These drawings are to be reviewed and studied thoroughly by a qualified individual who is skilled in interpreting them.

Limitations and Warnings

Valtir, in compliance with NCHRP Report 350 and MASH, contracts with ISO 17025 A2LA accredited testing laboratories to perform crash tests, evaluate tests, and submit the test results to the FHWA for review.

CASS® S3 has been deemed eligible by FHWA as meeting the requirements and guidelines of NCHRP Report 350 and MASH, Test Level 3 ("TL-3") and Test Level 4 ("TL-4"). These tests typically evaluate product performance defined by NCHRP Report 350 and MASH involving a range of vehicles on roadways, NCHRP Report 350 and approximately 1,100kg [2,420 lb.] for MASH) and full size pickup trucks (approximately 2,000 kg [4,400 lb.] for NCHRP Report 350 and approximately 2,270 kg [5,000 lb] for MASH) at 100 kph [62 mph]. For TL-4, the vehicle is single-unit van truck, approximately 8,000 kg [18,000 lb.] for NCHRP Report 350 and approximately 10,000 kg [22,000 lb] for MASH. The speed and angle for NCHRP Report 350 is at approximately 80 kph [45 mph]/15 degrees and 90 kph [56 mph]/15 degrees for MASH.

CASS® S3 is tested pursuant to the test matrix criteria of MASH as designated by AASHTO and FHWA and NCHRP Report 350 as designated by FHWA. The FHWA AASHTO tests are not intended to represent the performance of systems when impacted by every vehicle type or in every impact condition existing on the roadway. Every departure from the roadway is a unique event.

Valtir expressly disclaims any warranty or liability for injury or damage to persons or property resulting from any impact, collision or harmful contact with its products, other vehicles, or nearby hazards or objects by any vehicle, object or person, whether or not the products were assembled in consultation with Valtir or by third parties.

CASS® S3 is intended to be assembled, delineated, and maintained within specific state and federal guidelines. It is important for the state/specifying agency the use of a highway product to select the most appropriate product configuration for site specifications.

The state/specifying agency's careful evaluation of the site layout, vehicle population type and speed, traffic direction, and visibility are some of the elements that require evaluation in the selection of a highway product. For example, curbs could cause an untested effect on an impacting vehicle.

After an impact with the system, all debris must be removed from the area immediately in compliance with the most applicable agency policy. The specified CASS® S3 must be evaluated and restored to its original specified condition or replaced as the state/specifying agency determines/requires, as soon as possible. Product selection, approval, proper installation, and maintenance of any highway product is the sole responsibility of the state/specifying agency.

Safety Alert Symbols appear throughout this manual and indicate Danger, Warning, Caution or Important statements. Failure to read and follow these warnings could result in serious injury or death in the event of a vehicle impact with the system.

WARNING: Do not assemble, maintain, or repair CASS® S3 until you have read this manual thoroughly and completely understand it. Ensure that all Danger, Warning, Caution, and Important statements within the manual are completely followed. Please call Valtir at (888) 356-2363 if you have any questions about instructions in this manual.

WARNING: Safety measures incorporating appropriate traffic control devices and personal protective equipment ("PPE") specified by the state/specifying agency must be used to protect all personnel while at the assembly, maintenance, or repair site.

WARNING: Ensure the assembly site meets all appropriate Manual on Uniform Traffic Control Devices ("MUTCD") and local standards.

WARNING: Only Valtir parts that are specified herein can be used for assembly, maintenance, or repair on CASS® S3. Do not utilize or otherwise commingle parts from other systems, even if those systems are other Valtir systems. Such configurations have not been tested, nor have they been approved for use. Assembly, maintenance or repairs using unspecified parts or accessories is strictly prohibited. Failure to follow this warning could result in serious injury or death in the event of a vehicle impact with such an UNACCEPTED system.

WARNING: Do NOT modify the CASS® S3 in any way.

IMPORTANT: Valtir makes no recommendation whether use or reuse of any part of CASS® S3 is appropriate or acceptable after system impact. It is the responsibility of the state/specifying agency and its engineers to make that determination.

IMPORTANT: It is the responsibility of the owner, state/specifying agency to inspect CASS® S3 after assembly is complete to ensure the instructions provided in this manual have been strictly followed.

Danger: It is critical that the CASS® S3 posts are placed in suitable soil that will allow the system to fully perform in accordance with design specifications. Should you have any questions

about this, please contact the state/specifying agency that specified CASS® S3 at this particular location for guidance. Valtir is available for consultation with that agency.

Warning: Do not allow pedestrians or workers to stand near this system, when under tension, in circumstances where the cable may be impacted or cut. Failure to follow this warning can result in serious injury or death to the workers, bystanders and/or pedestrians in the event of a vehicle impact with the system.

Warning: It is imperative, before assembly, that you contact a Valtir representative and state/specifying agency engineer for special criteria for soils which do not meet or exceed NCHRP Report 350 soil conditions. It is also recommended that you consult your own soils or structural engineer.

Warning: Be aware of hazards of using compressed air (small objects may become projectiles). Failure to follow this warning can result in serious injury or death to the workers and/or bystanders.

Warning: When drilling rock, it is the responsibility of the installer to consult Occupational Safety & Health Administration ("OSHA") silica respiratory standard 29 Code of Federal Regulation ("CFR") 1910.134 for debris removal and ensure compliance.

Warning: Ensure that CASS® S3 delineation used meets all federal, state/specifying agency specifications.

Warning: CASS® S3 shall be placed on a median or roadside without obstructions, depressions, etc. that may significantly affect the stability of an errant vehicle. Grading of the site and/or appropriate fill materials may be required. The assembler shall "flatten" or "round" various topographical inconsistencies that could interfere with the ability to consistently maintain the design height (in relation to the terrain) of the cables. To address assembly in rock, see Appendix C: Encountering Rock.

Note: Based on soil conditions at the site, ANY or ALL foundations may need larger/deeper concrete footings or larger soil plates (for driven applications) as determined by soil analysis.

General CASS® S3 Information

CASS® S3 is a 4-Cable Barrier consisting of steel S3 x 5.7# [S75 x 8] posts and four (4) pre-stretched 3/4" [19 mm] wire rope cables. The posts can be driven, placed in a driven sleeve, placed in a sleeve and concrete footing, placed in a sleeve in a mow strip, or base plated. One inch [25 mm] or 3/4" [19 mm] fitting hardware can be used. The NCHRP Report 350 and MASH CASS® S3 Test Level 3 system can be placed on slopes 1V:4H or flatter. The NCHRP Report 350 CASS® S3 Test Level 4 system can be placed on slopes 1V:6H or flatter. The MASH CASS® S3 Test Level 4 can be placed on slopes 10:1 or flatter

The bottom two (2) cables are retained by a hook bolt. The top two cables are placed in a slot at the top of the post and separated with a plastic spacer. Cable heights are approximately 17.4" [440 mm], 29.5" [750 mm], 38.1" [970 mm], and 41.7" [1060 mm]. A stainless steel strap is placed around the post over the top cable.

The post spacing will be in accordance to the contract plans. The barrier is terminated either with a CCT, or a CCA. **Only use the CCA when not on the NHS or when it cannot be impacted in either direction.**

For 1V:6H or flatter slopes, a 12" [300 mm] diameter x 30" [762 mm] minimum depth concrete footing is used. For slopes steeper than 1V:6H, the footing depth is increased by 6" [150 mm]. The footing depths can be increased if the soils do not meet or exceed the NCHRP Report 350 soil conditions. Contact Valtir for these designs.

The Minimum Strength Concrete ("MSC") for all concrete components of the CASS® S3 is 3,000 psi [21 MPa] or greater to meet the agency's specifications.

NCHRP Report 350 CASS® S3

The CASS® S3 Test Level 3 can be installed anywhere on slopes 1V:10H or flatter.

For slopes steeper than 1V:10H and 1V:6H, see the Ground Preparation Section for additional placement criteria. For slopes 1V:4H or flatter; but, steeper than 1V:6H, it must be installed 0 to 4' [0-1.2 m] from the break point. For back slope applications, the installation must be a minimum of 11' [3.4 m] from the V-ditch center. The maximum post spacing is 21' [6.4 m]. The minimum post spacing is 10'-6" (3.2 m).

The CASS® S3 Test Level 4 can be placed on slopes 1V:6H or flatter. See the Ground Preparation Section for additional placement criteria. The maximum post spacing is 21' [6.4 m]. The minimum post spacing is 10'-6" [3.2 m].

MASH CASS® S3

The CASS® S3 Test Level 3 can be installed anywhere on slopes 1V:10H or flatter.

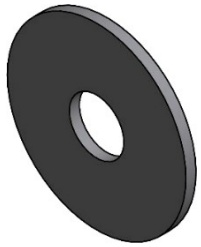
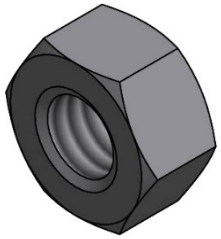
For slopes 1V:4H or flatter; but, steeper than 1V:10H, it must be installed 0 to 4' [0-1.2 m] from the break point. For back slope applications, the installation must be a minimum of 11' [3.4 m] from the V-ditch center. The maximum post spacing is 10'-6" [3.2 m].

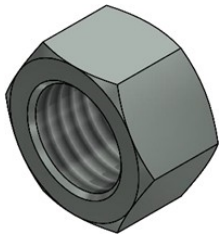
The CASS® S3 Test Level 4 can be placed on slopes 1V:10H or flatter. The maximum post spacing is 10'-6" [3.2 m].

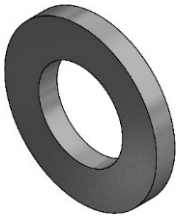
CASS® Components

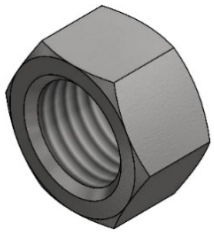
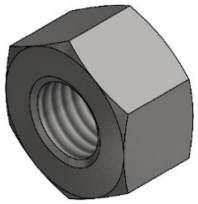
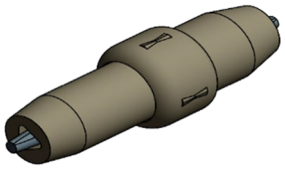
Below is a pictorial of components for **CASS® S3** Hardware. Please see **Valtir drawings** for specific lists of quantities. All Valtir Part Numbers ("PN") are provided for standard parts only.

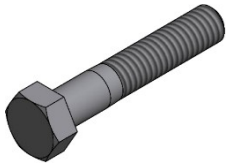
Note: The following components are not shown to scale.

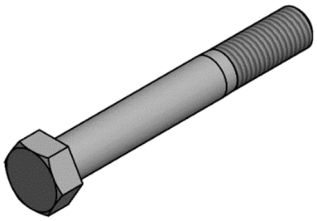
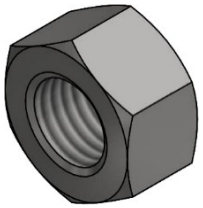
PN: 3240G	PN:3245G	PN: 3300G
		
5/16" Flat Washer (F844)	5/16" Hex Nut (A563)	5/8" Flat Washer (F844)

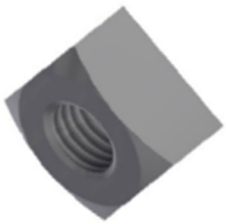
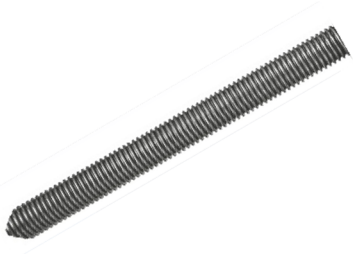
PN: 3310G	PN: 3361G	PN: 3536G
		
5/8" Lock Washer	5/8" Hex Nut	1" Stud Flattened-RHT

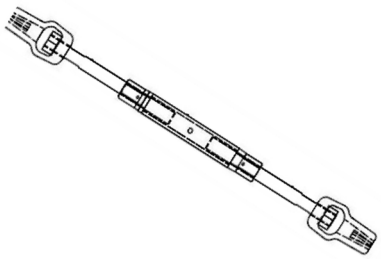
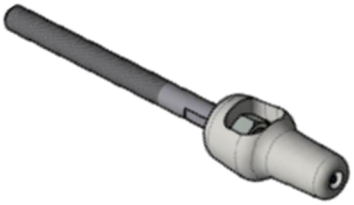
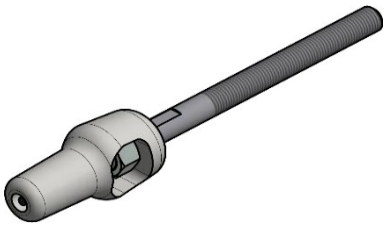
PN: 3537G	PN: 3700G	PN: 3701G
		
1" Stud Flattened-LHT	3/4" Flat Washer (F844)	3/4" Flat Washer (F436)

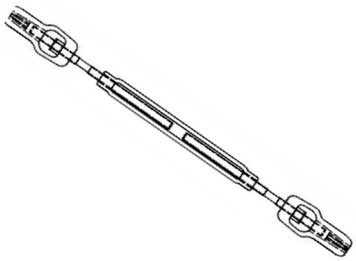
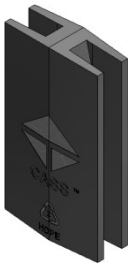
PN: 3710G	PN: 3711G	PN: 4099G
		
3/4” Hex Nut (A563)	3/4” Hex Nut (A194 2H)	Torpedo Cable Splice

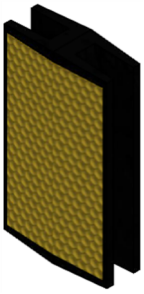
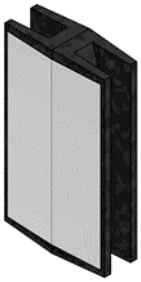
PN: 4199B	PN: 4211G	PN: 4225G
		
3/4” Cable Wedge (3 x 7)	5/16” x 1 3/4” Hex Bolt (A307)	Cable Hook Bolt (A307)

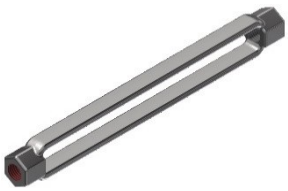
PN: 4779G	PN: 4902G	PN: 4903G
		
3/4” x 4 1/2” Hex Bolt (A325)	1” Flat Washer (F436)	1” Hex Nut (A194 2H)

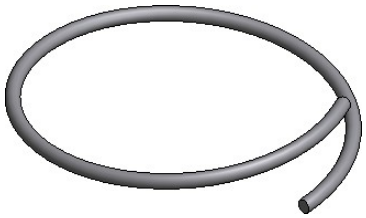
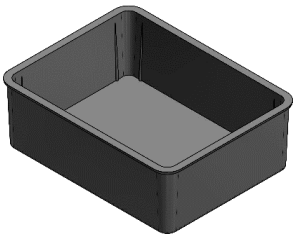
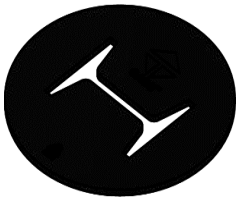
PN: 4959G	PN: 5225G
	
3/4” Heavy Square Nut	5/8” x 7 1/2” Rod (A193 B7)

PN: 5633G	PN: 5634G	PN:5635G
		
Assembled 1” Cable Splice	3/4” Cable Field Splice Left	3/4” Cable Field Splice Right

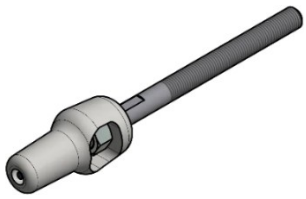
PN: 5698G	PN: 5700B
	
Assembled 3/4” Cable Splice	4” Cable Spacer w/o Reflector

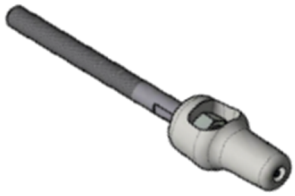
PN:5701B	PN: 5702B	PN: 5709B
		
4” Cable Reflector Spacer Yellow	4” Cable Reflector Spacer White	CASS® Thermometer (Infrared)

PN: 5711G	PN: 5825G	PN: 5826G
		
3/4” Turnbuckle Open Body	Cable Lock Bolt (A307)	1” Turnbuckle Closed Body

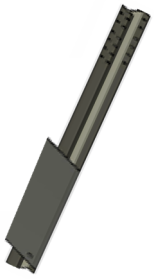
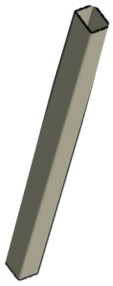
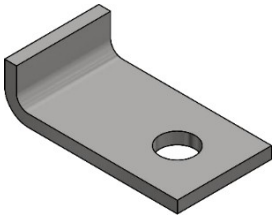
PN: 5836G	PN: 5837B	PN: 5839B
		
8” Concrete Reinforcing Ring	S3 Sleeve Cap Bottom	S3 Sleeve Post Cover

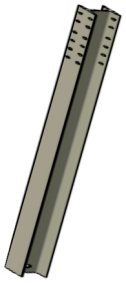
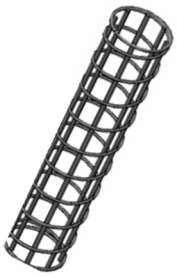
PN: 5840G	PN: 5850B	PN: 5851B
		
5’-0” Cable Field Repair Section	CASS® Cable Pulling Tool	Reflector Median (LEFT)

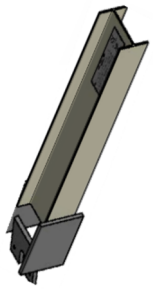
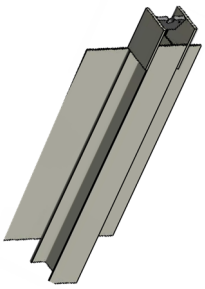
PN: 5852B	PN: 5878B	PN: 5909G
		
Reflector Roadside (RIGHT)	CASS® Tension Meter	1” Field Wedge Open Left

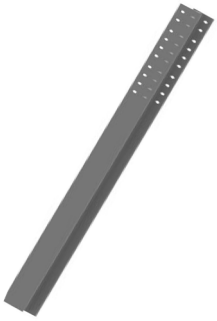
PN: 5910G	PN: 5919B
	
1” Field Wedge Open Right	#4 x 2’-8” Rebar Rod

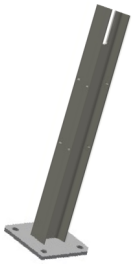
PN: 6722G	PN: 9021G
	
5/8" X 8" ATR CHSL PT A449	Bearing Angle

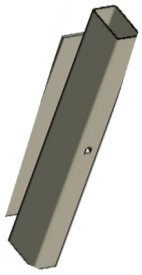
PN: 33903A	PN: 33908G	PN: 33909G
		
Driven Terminal Posts w/soil Plates-S3 Posts 4-7	Terminal Post Sleeve-S3 Post	CRP-Cable Bracket

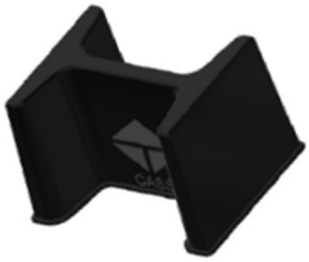
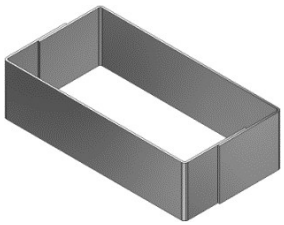
PN: 33910G	PN: 33916B	PN: 33934A
		
S3 Terminal Post-in Sleeve Posts 4-7	CRP Reinforcing Cage	Bottom CRP (in Concrete)

PN: 33935A	PN: 33936A	PN: 33952A
		
Top CRP	Bottom CRP (w/Soil Plate)	Driven Terminal Sleeve w/soil Plates-S3 Posts 4-9

PN: 33955G	PN: 33989A	PN:34036G
		
S3 Terminal Post-in Sleeve Posts 8 and 9	Driven S3 Terminal Post w/Soil Plates-Posts 8 & 9	S3 Post-Driven

PN: 34037A	PN: 34038G	PN: 34039G
		
S3 Base Plated Post	Post Sleeve-Concrete Footing	27” Driven Sleeve

PN: 34045G	PN: 34047A	PN: 34049G
		
S3 Post-Concrete Footing	Driven Sleeve w/soil Plate Post-30 3/4”	Standard Splice Post in Sleeve

PN: 105201B	PN: 105202T	PN: 105204G
		
Post Cap	S3 Post Strap	3/4” Stud Flattened-LHT

PN: 105205G

3/4” Stud Flattened-RHT

Important: Valtir makes no recommendation whether use or reuse of any part of the system is appropriate or acceptable following an impact. It is the sole responsibility of the local highway authority and its engineers to make that determination. It is critical that you inspect this product after assembly is complete to make certain that the instructions provided in this manual have been strictly followed.

Recommended Tools

Documentation

- Manufacturer's CASS® S3 4:1 **CA**ble **S**afety **S**ystem Assembly Manual (Current Version)
- CASS® S3 4:1 System Drawing(s). Current Versions of SS742 CASS® S3 (4:1 SLOPES) or SS743 CASS® S3 (6:1 SLOPES)

Personal Protective Equipment (PPE)

- Eye Protection
- Work Gloves
- Back Protection
- Safety-Toe Shoes
- Reflective Vest
- Apron

Wrenches

- Pipe Wrenches
- Adjustable Spanner
- Adjustable Jaw Wrenches
- Imperial and Metric Wrenches

Concrete equipment

- Concrete Vibrator
- Concrete Tools

Cable/Miscellaneous equipment

- Traffic Control Equipment and Plan per local standards and the MUTCD
- Cable Tension Meter (PN-5878B)
- CASS™ Thermometer (Infrared) (PN-5709B)
- Abrasive Cutoff Blade/Saw
- C-Clamps
- CASS® Cable Pulling Tool (PN-5850B)
- Locking Pliers
- Duct tape
- Pry Bars
- Line/String
- Plumb Line
- Straight Edge
- Level
- Drift Pin
- Tape Measure
- Come-along/Lever chain hoist (3 ton minimum capacity)
- Backhoe (optional tensioning device)
- Chain (5 ton minimum capacity) of appropriate length for tensioning equipment
- Marking Paint
- Post Pounder
- Auger

Note: The provided list of tools is a general recommendation and should not be considered an extensive list. Depending on specific site conditions and the complexity of the assembly specified by the appropriate agency, the required tools may vary. Decisions as to what tools are needed to perform the job are entirely the responsibility of the specifying agency and the agency's selected contractor performing the assembly of the system at the agency's specified assembly site.

Ground Preparation and Barrier Alignment

CASS® S3 shall be placed on a median or roadside without obstructions, depressions, etc. that may significantly affect the stability of an errant vehicle. Grading of the site and/or appropriate fill materials may be required. The assembler shall "flatten" or "round" various topographical inconsistencies that could interfere with the ability to consistently maintain the design height (in relation to the terrain) of the cables. To address assembly in rock, see Appendix C: Encountering Rock.

Warning: It is imperative, before assembly, that you contact a Valtir representative and state/specifying agency engineer for special criteria involving soil conditions not meeting or exceeding NCHRP Report 350 soil conditions. It is also recommended that you consult your own soils or structural engineer.

Note: Based on soil conditions at the site, ANY or ALL foundations may need larger/deeper concrete footings or larger soil plates (for driven applications) as determined by soil analysis.

Ground Preparation

When CASS® S3 is placed in a median, use the following criteria for locating the system:

Ensure that the finished grade (side slope) is 1V:4H or flatter.

When the NCHRP Report 350 CASS® S3 is placed on a ditch section and the side slope is 1V:4H or flatter; but, steeper than 1V:6H, the maximum offset from the hinge point is 4' [1.3 m] and minimum offset from the bottom of the ditch is 11' [3.3 m]. According to FHWA and AASHTO, on side slopes steeper than 1V:10H, the cable median barrier (including CASS® S3) cannot be placed within 1' to 8' [0.3m to 2.4 m] from the ditch line.

When the MASH CASS® S3 is placed on a ditch section and the side slope is 1V:4H or flatter; but steeper than 1V:10H, the maximum offset from the hinge point is 4' [1.3 m] and minimum offset from the bottom of the ditch is 11' [3.3 m]. When the side slope is 1V:10H or flatter, CASS® S3 can be placed anywhere in the median.

Barrier Alignment

Follow all procedures in the placement of the footing and/or post to ensure proper alignment. It is suggested that a string line or other means be used to provide a consistent horizontal and vertical alignment that meets specifications. If assembled on a horizontal curve, a minimum 650 foot [198 m] radius is required. If assembled on a **sag vertical curve**, the K value is ≥ 100' [30 m]. See "Assembly on a Curve" Section.

CASS® S3 can be placed on the roadside in front of slopes 1V:2H or flatter. Use a minimum distance of 2' [0.6 m] in front of the hinge point to the center of the post.

Use the state/specifying agency or agency's guardrail terminal standards for grading and widening for the CCT.

There may be instances where a break will be required in the cable run. In these circumstances proper overlap of the terminals is required in order to prevent a vehicle from passing through the protected area. Depending on the location of the cable with respect to the direction of traffic, there are two situations which can occur. See Appendix B for recommended overlaps.

Important: A flare rate of 30:1 or flatter is required if the barrier must be flared, transverse across the median, or if CASS® S3 must change in direction (See Appendix A).

Assembly on a Curve

Horizontal Curve

Complete the following steps to place the posts or post foundations along a curve.

1. When the cable is placed on a curve, post spacing may need to be reduced based on the radius.
2. Weak soil conditions may necessitate a larger/deeper footing for the line posts, based on the radius of the curve.
3. When placing posts on a curve, use the table below to adjust the spacing as required:

Curve Radius	Post Spacing (NCHRP Report 350)	Post Spacing (MASH)
0 to 650' [0 to 198 m]	CASS® S3 is not recommended	CASS® S3 is not recommended
651' to 1,300' [198 m to 396 m]	10'-6" [3.2 m] post spacing or less (as specified by state/specifying agency)	10'-6" [3.2 m] post spacing or less (as specified by state/specifying agency)
Greater than 1,301' [396 m]	21' [6.4 m] post spacing or less (as specified by state/specifying agency)	10'-6" [3.2 m] post spacing or less (as specified by state/specifying agency)

Note: If any of the post spacing for a particular radii grouping is larger than the contract specifications, use the contract specification post spacing.

Vertical Curve

For a sag vertical curve, the recommended minimum K value is 100' [30 m]. There is no K value limit for crest vertical curves.

$K = L / (g_1 - g_2)$

L = length of vertical curve in feet [meters) between the two tangents

g_1 = grade of tangent in

g_2 = grade of tangent out

When the minimum sag vertical curve value is not met, the use of intermediate terminals at the low point of the sag curve is recommended to minimize the cables from rising beyond the allowable height tolerance relative to grade.

Line Post Foundation Placement

Warning: If the post cannot be placed, pursuant to these assembly instructions, because of soil conditions, or any other environmental factor, please contact the appropriate state/specifying agency immediately! NEVER attempt to place posts if these assembly instructions cannot be complied with.

Post Alignment

Lay out the post alignment and post spacing according to the contract specifications. Maximum post spacing for the NCHRP Report 350 CASS® S3 is 21'-0" [6.4 m]; Maximum post spacing for MASH CASS® S3 is 10'-6" (3.2 m].

Driven Foundation Sleeve With and Without Soil Plate

Complete the following steps for a driven foundation sleeve assembly.

1. Drive the foundation sleeve (PN-34039G) or foundation sleeve with soil plate (PN- 33952A) with an appropriate driving head. During the driving process ensure that the sleeve is aligned, properly oriented (with interior tabs 15" [375 mm] from the top of the tube sleeve and the 3" [75 mm] side parallel to the roadway), soil is prevented from coming up into the sleeve, and the sleeve is not damaged.

Sleeve in Poured Concrete Footing

Complete the following steps for placing a sleeve in a poured concrete footing.

1. Place a plastic cap (PN-5837B) on the bottom of the foundation sleeve (PN-34038G) or tape the bottom end of the foundation sleeve to prevent the concrete from coming into the tube.
2. Punch or auger a minimum 12" [300 mm] diameter x 30" [762 mm] deep hole for the concrete footing.
3. Pour the MSC in the hole, ensuring the concrete is flush with the finish grade.
4. Place the foundation sleeve in the poured concrete footing. Ensure that the sleeve is positioned plumb, flush with the top of the footing, a minimum of 3" [75 mm] from the edge of the footing, properly oriented (with interior tabs 15" [375 mm] from the top of the tube sleeve and the 3" [75 mm] side parallel to the roadway) and in alignment. Consolidate the concrete to remove air pockets in compliance with applicable state specifications for similar applications.
5. Place a rebar ring (PN-5836B) around the top of the sleeve 2" to 3" [50 mm to 75 mm] from the top of the footing.
6. Smooth off the top of the concrete footing with a slight crown from the sleeve.
7. Allow the footing to attain the required concrete strength before disturbing the foundations, including the placement of posts.

Sleeve in a Mow Strip

Valtir may allow the use of an alternate line post footing if the system is installed with an acceptable mow strip application. Please contact Valtir for additional details. If the mow strip is not acceptable, follow the steps in "Sleeve in Poured Concrete Footing" section.

Precast Concrete Footings

The precast concrete footings will be made in forms and fabricated the same as if placed in an augured or punched hole.

Post Placement

Posts

The CASS® S3 posts can be driven, placed in a driven sleeve, placed in a sleeve in a concrete footing (poured or precast), or mounted to a concrete surface.

Driven Posts

Complete the following steps for a driven post assembly.

1. Lay out the post alignment and post spacing according to contract specifications and drive the post (PN-34036G) with an appropriate driving head equipment.
2. The height from the finished grade to the top of the post is approximately 3’-10” [1.17 m]

Posts in Sleeve

Complete the following steps for a post in the sleeve assembly

1. Place the post sleeve cover (PN-5823B) on the bottom end of the CASS® S3 post (34045G).
2. Place the post in the sleeve so it rests on the first tab in the sleeve or bottom of the sleeve and the sleeve cover is located at the top of the sleeve.
3. The height from the finished grade to the top of the post is approximately 3’-10” [1.17 m].

Base Plated Post

For Base Plated Post Assembly, see Appendix D.

CASS® S3 Cable End Treatments

CASS® S3 is terminated with either a CCT or a CCA.

CCT

The CCT consists of four (4) CRP (Bottom CRP and Top CRP) and six (6) S3 x 5.7# [S75 x 8] terminal line posts. The cables are terminated at the CRP, one at each post. The terminal line posts are placed with sleeve in a concrete footing, a sleeve with a soil plate, or a driven post with a soil plate.

See Figure 1 for the footing locations and spacing.

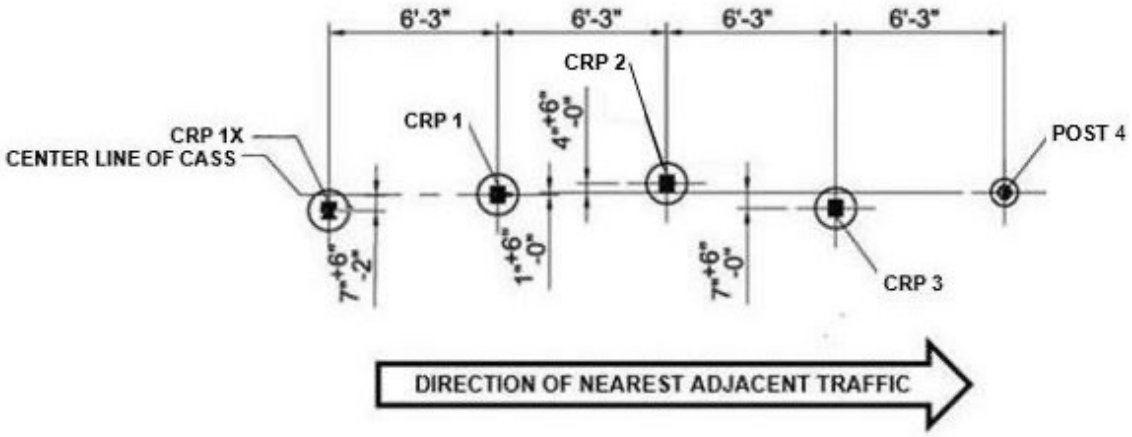


Figure 1
CRP Offset

Based on soil conditions at the site, the CCT may need larger/deeper concrete anchors or larger soil plates (for driven applications) as determined through soil analysis.

Bottom CRP with Concrete Footings

Place the Bottom CRP (PN 33936A) in a minimum 18” [450] diameter x 5’-0” [1.50 m] deep reinforced MSC footing. The footing is reinforced with a spiral rebar cage.

Complete the following steps for the placement of the Bottom CRP in the concrete footing:

1. Lay out the four (4) CRP footings.
2. Punch or auger the appropriate hole for the concrete footing.
3. Fabricate a rebar cage in accordance with project/shop drawing requirements. A standard spiral rebar cage that may be applicable is PN-33916B (See Figure 2).
4. Place the rebar cage in the footing hole, ensuring a minimum of 3” [75 mm] of concrete surrounds the cage on all sides and the cage is approximately 3” [75 mm] from the top of the footing (finished grade). Place the Bottom CRP in the center of the spiral rebar cage, ensuring the top of the post is no more than 4” [100 mm] above the finished grade. See Figure 3 for the orientation of the post.
5. Place the MSC in the hole. Consolidate the concrete to remove air pockets in compliance with applicable state specifications for similar applications.
6. Smooth off the top of the concrete footing with a slight crown from the sleeve.
7. Allow the footing to attain the required concrete strength before disturbing the foundations, including the placement of posts.

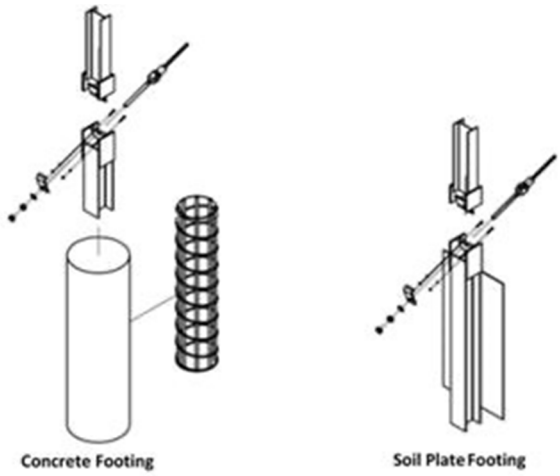


Figure 2
CRP Footing Details

Bottom CRP with Soil Plate

The Bottom CRP with Soil Plate assembly, size based on soil conditions, can be driven or placed in an augured hole. The soil plate can be either welded or bolted to the bottom CRP (See Figure 2).

Complete the following steps for assembling the CCT Bottom CRP with Soil Plate:

1. Lay out the four (4) footings.
2. Punch or auger a pilot hole approximately 4'-0" [1.92 m] or deeper for the Bottom CRP with soil plate if the post is not completely driven. Place the Bottom CRP with soil plate in the hole. The post is to be aligned with the soil plate on the downstream side of the post. Drive the post so that the top of the Bottom CRP does not protrude more than 4" [100 mm] above the finished grade.
3. Backfill the hole with material in 6" [150 mm] lifts and compact to optimum compaction.

CCT Line Footings

Post Alignment

Lay out the post alignment and post spacing. Starting at post 4 (See Figure 1), post spacing for posts 4 through 9 is 6'-6" [1.98 m]. The posts will be on the center line of the cable assembly.

Terminal Line Sleeve in a Poured Concrete Footing – Posts 4 through 9

Complete the following steps for placing a line terminal sleeve in a poured concrete footing:

1. Place the end cap (PN-5837B) on the bottom of the foundation sleeve (PN-33908G) to prevent the concrete from coming into the tube.

Note: These sleeves are different than the standard line post sleeves.

2. Punch or auger a minimum 12" [300 mm] diameter x 36" [0.91 m] deep hole for the concrete footing.
3. Pour the MSC in the hole with the top of the footing flush with the finished grade.
4. Place the foundation sleeve in the poured concrete footing. The sleeve is to be positioned plumb, flush with the top of the footing, a minimum of 3" [75 mm] from the edge of the footing, and in alignment. Consolidate the concrete to remove air pockets in compliance with applicable state specifications for similar applications.
5. Place a re-bar ring (PN-5836B) around the top of the sleeve 2" to 3" [50 mm to 75 mm] from the top of the footing. Place two re-bars (PN-5919B) vertically as shown in Figure 3. If the specifying agency requires a deeper footing, the length of the vertical re-bars will be the footing depth minus 4" [100 mm]. The two vertical re-bars do not have to be attached to the ring.
6. Smooth off the top of the footing.
7. Allow the footing to attain the required concrete strength before disturbing the foundations, including the placement of posts.

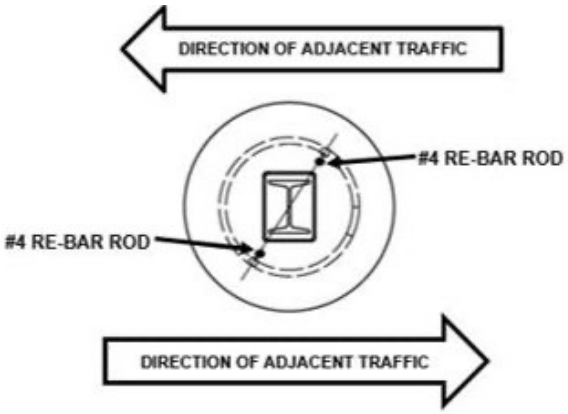


Figure 3
CCT Re-bar placement

Terminal Line Precast Concrete Footings-Posts 4 to 9

The precast concrete footings will be made in forms and fabricated the same as if placed in an augured hole. The precast footing will be placed in a punched or augured hole**.**

Terminal Line Driven Foundation Sleeve with a Soil Plate-Posts 4 to 9

Complete the following steps for placement of a driven foundation sleeve with a soil plate**.**

1. Drive the foundation sleeve with soil plate (PN-33952A) with an appropriate driving head. Ensure that the driving head keeps the sleeve orientated in the proper alignment and prevents soil from coming up into the sleeve while the post is being placed.

CCT Posts Assembly

Terminal Posts

The CCT consists of four (4) CRPs and six (6) S3 x 5.7# [S75 x 8] terminal line posts (positioned in a sleeve or a driven post).

Cable Release Post (CRP) – Post 1X to Post 3

Complete the following steps for the placement of the CRP.

1. Place the top CRP (PN-33935A) on the assembled bottom CRP.
2. Place PN-4211G bolt in the two holes of the sloping plates of the top and bottom CRP.
3. Place a PN-3240G and PN-3245G on each of the bolts.
4. Tighten the nuts to a snug position with a minimum of two (2) bolt threads protruding beyond the nut.

Terminal Line Posts in Sleeve (Concrete Footing) – Posts 4 to 9

Complete the following steps for the placement of the terminal line posts in the sleeve:

1. Place the post sleeve cover (PN-5839B) on the bottom end of the terminal line post (PN-33910G).
2. Place posts in sleeves 4 to 9. The cover will be located at the top of the sleeve.

Terminal Line Posts in Driven Sleeve – Posts 4 to 9

1. Complete the following steps for the placement of the terminal line posts in the driven sleeve: Place the post sleeve cover (PN-5839B) on the bottom end of the terminal line post (PN-33910G or PN-33955G).
2. Place post PN-33910G in sleeves 4 to 7; post PN-33955G in sleeves 8 and 9. The cover will be located at the top of the sleeve
3. Place a bearing angle (PN-9021G) on each side of the post 4 at the ground line (See Figure 4).
4. Place two (2) hex bolts (PN-4779G) and flat washers (PN-3701G) through the two (2) bearing angles. Place a hex nut (PN-3711G) and flat washer (PN-3701G) on the bolt. Tighten the nuts to a sung position with a minimum of two (2) bolt threads protruding beyond the nut.

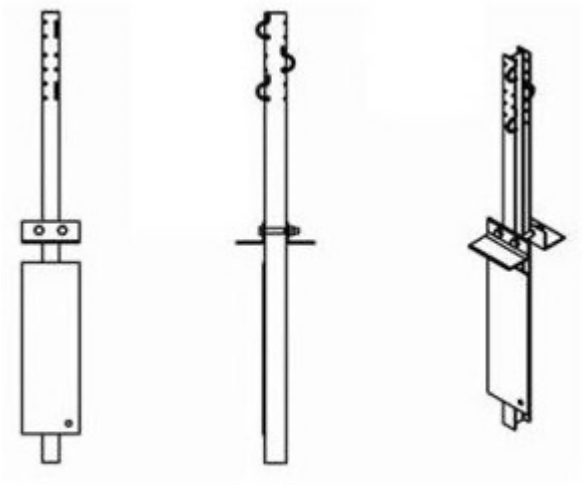


Figure 4
Bearing Angles

Terminal Line Driven Post with Soil Plate – Posts 4 to 9

Complete the following steps for the placement of a driven post with a soil plate:

1. Drive post (PN-33903A) at post locations 4 through 7 and post (PN-33989A) at post locations 8 and 9 with an appropriate driving head/equipment.
2. Follow Steps 3 and 4 in the “Terminal Line Posts in Driven Sleeve-Posts 4 through 9” section above.

Terminal Cables

The cables used in the CCT are pre-stretched, consisting of four (4) precut cables with factory applied fittings (Option A) on each end; or cables can be field cut (Option B) taken from cable reels. The precut cable lengths are 41’-9” [12.73 m] (CRP 3), 48’-0” [14.63 m] (CRP 2), 54’-3” [16.54 m] (CRP 1) and 60’-6” [18.44 m] (CRP 1X). The field cut lengths can be the same as for precut, or can be of greater lengths, depending on specification and shop drawing provided for the cable run.

Complete the following steps for placing the CCT cables:

Installing the Cables to the CRP:

Option A (Precut Cables)

A. Lay out the four (4) precut cables. The right threaded end of the cables will be attached to the CRP. The CRP 1X (PN-5692G) starts at CRP 1X (post location 1X) and is placed on the front side (traffic side) of the line terminal posts; CRP 1 cable (PN-5817G) starts at CRP 1 (post location 1) and is placed on the back side (non- traffic side) of the line terminal posts; the CRP 2 cable (PN-5818G) starts at CRP 2 (post location 2) and is placed on the back side (away from traffic) of the line terminal posts; and the CRP 3 cable (PN-5819G) starts at CRP 3 (post location 3) and is placed on the front side (traffic side) of the line terminal posts.

B. Place the right threaded end of the fitting through the hole formed by the top and bottom CRP.

C. Place the CRP Cable Bracket (PN-33909G) on the threaded end. The angle end of the bracket is placed up (See Figure 3).

D. Place a flat washer (PN-4902G) and hex nut (PN-4903G) on the threaded fitting on the cable. Thread the nut approximately halfway on to it. Place on the fitting a second hex nut up against the first nut

E. Perform Steps B-D for the other three (3) cables.

Option B (Field Cut Cables)

A. Cut four (4) lengths of cable from the cable reel.

B. Place a right-hand and left-hand field fitting (use the same size fittings used for line cables) on the end of the cables. See the Field Splice section for assembling the fittings.

C. Perform Steps A-D in Option A **except** for Step D if using 3/4" fittings, then replace PN-4902G with PN-3701G and PN-4903G with square nut (PN-4959G).

Installing the Cables on the line terminal posts:

1. The CRP 1X cable attached to CRP 1X will use holes 3 and 4 on line terminal post 9; holes 5 and 6 on line terminal post 8; and middle two (2) holes for posts 4-7.
2. The CRP 1 cable attached to CRP 1 will use the top two (2) holes of line terminal post 9; holes 3 and 4 on line terminal post 8; and the top two (2) holes for post 4-7.
3. The CRP 2 cable attached to CRP 2 will use the bottom two holes on line terminal posts 4-9.
4. The CRP 3 cable attached to CRP 3 will use the middle two holes (holes 5 and 6) for line terminal post 9; holes 7 and 8 on line terminal post 8; and bottom two holes on line terminal posts 4-7.
5. The cables are attached to the posts using cable lock bolts (PN-5925G) (See Figure 5).
6. Insert the non-threaded end of the cable lock bolt in one of the two required holes and place the cable lock bolt around the cable and insert the threaded end in the other required hole (**either orientation of the cable lock bolt is acceptable**). Place a hex nut (PN-3245G) on the cable lock bolt, and tighten until snug with a minimum of two threads beyond the nut.

Figure 5
Placement of the Cable Lock Bolt

Line Cables

The cables used in the CASS® S3 System are pre-stretched. They are supplied on reels, either precut with factory applied fittings (in 1,000' [305 m] increments) or continuous length to be cut in the field and field applied fittings attached. The reels can be supplied with 2,000' to 3,000' [610 m to 914 m] of cable on each reel. The precut cable has a right-hand fitting on one end and left-hand fitting on the other end. The cables are placed on the reel with the left-hand fitting placed on the reel first. The right-hand fitting end for the cable must come off first and the end is painted red for identification. When there is more than one cable on the reel, the last cable placed on the reel will have the right-hand fitting painted red and also a yellow mark. This will be the first cable removed from the reel.

Lengths less than 1,000’ [305 m] can be supplied with a factory applied fitting (right–hand fitting) on one end, or the lengths can be cut from a continuous reel and a field applied fitting placed on both ends

Cable Splices

There are three types of cable splices that can be utilized.

- Factory applied fittings with a turnbuckle (1” hardware only).
- Field applied fittings with a turnbuckle (3/4” and 1” hardware).
- Torpedo fitting.

Factory Applied Fittings with Turnbuckle

1. To assemble a factory applied splice, one of the two cable ends must have a fitting with right-handed threads and the other cable must have a fitting with left-handed threads. Place a mark 1 1/2” [38 mm] from the end of each fitting. On one of the threaded end place a turnbuckle (PN-5826). Attached the turnbuckle where it is held on the threaded end by only a couple of threads.
2. Place the other threaded end in the turnbuckle.
3. While rotating the turnbuckle, prevent the two threaded ends from rotating. Rotate the turnbuckle until both threaded ends are into the turnbuckle beyond the 1 1/2” [38 mm] mark. See Figure 6 for the complete assembly.

Figure 6
1” Cable Splice with Turnbuckle

Field Applied Fittings with Turnbuckle

There are two situations where a field applied fitting will be used: either when a fitting is required to complete an assembly; or when no factory applied fittings are used and field applied fittings are needed to make all of the cable connections. See Figure 6a for a 1” Cable Splice (PN-5633G) and Figure 6b for 3/4” Cable Splice (PN-5698G).

Figure 6a
1” Cable Splice with Turnbuckle

Figure 6b
¾” Cable Splice with Turnbuckle

Perform the following steps to complete a splice using a field applied fitting and a turnbuckle:

1. Ensure that the cable has a clean square cut by using a saw with an abrasive blade tool or an electric band saw.
2. Insert the cut end of the cable into the field casting (PN-4190G) through the triangular end.
3. With the cable inside the casting, separate the cable with two flathead screwdrivers for insertion of the tapered triangular wedge (PN-4199B) between the three strands of cable.
4. Insert the wedge into the cable with the smaller diameter end towards the triangular hole. Ensure that the wedge is pushed 1/2" [13 mm] beyond the end of the cable (plus or minus 1/8" [3 mm].

Note: All three bundles of the cable are to be located in the appropriate grooves of the wedge

5. Once the wedge is inserted, use a hammer and drift pin (or other appropriate tool) to seat the wedge by hitting on the triangular end of the casting. Several hits should be made to seat the wedge.
6. A heavy hex nut (PN-3908G for 1" fitting) or heavy square nut (PN-4959G for 3/4" fitting) has to fit inside the housing. Once the wedge has been seated, check to make sure the nut will fit. If it will not, reseat the wedge.
7. After the wedge is properly seated, one (1) wire of the cable must be bent over the end of the wedge.
8. Insert the appropriate hex nut in the housing.
9. Place the left-hand threaded stud (PN-3537G for 1" fitting or PN-105204G for 3/4" fitting) or right-hand threaded stud (PN-3536G for 1" fitting or PN-105205G for 3/4" fitting) in the housing and into the nut. Screw the stud into the nut until it will not go any further. A minimum of two (2) threads of the stud must show beyond the nut.
10. With the field applied fitting attached, follow the steps for a "Factory Applied Fitting" section to connect the two cables with a turnbuckle.

Torpedo Cable Splice

When two cable ends are spliced together other than where ~~a~~ spliced with a turnbuckle, a Torpedo Cable Splice can be used. The Torpedo Cable Splice (PN-4099G) is made up of two (2) housings, one of which has threads on it, a threaded ring, and two (2) triangular wedges. See Figure 7.

Warning: **The distance from the torpedo splice to any other fitting must be 100' [30 m] or greater.**

Perform the following steps to complete a splice:

1. Ensure that the cables has a clean square cut by using a saw with an abrasive blade or an electric band saw.
2. Insert the cut end of the cable through the triangular end of the threaded Torpedo fitting.
3. Separate one of the wires from the others by bending it out of the way.
4. Cut the remaining twenty (20) of the twenty-one (21) wires off about 1/2" to 3/4" (13 mm to 19 mm) from the end of the cable. Care should be taken to not nick the separated wire.
5. With the wires cut off, separate the cable with two flathead screwdrivers so the tapered triangular wedge (PN-4199B) can be inserted.

6. With the wedge inserted into the cable, drive the wedge into the casting until the twenty (20) wire strands are flush with the end of the casting.
7. Bend the one (1) extended wire of the cable over the end of the wedge.
8. On the other cable, place the threaded ring on it so the threads inside the ring are towards the end of the cable.
9. On this same cable, follow Steps 1-7 to assemble the cable in the fitting.
10. Place the two Torpedo Cable pieces together and connect them with the threaded ring. Tighten the connection with a pipe wrench(s), ensuring no more than two threads are shown after the connection.

Note: No more than two threads should be shown after the connection.

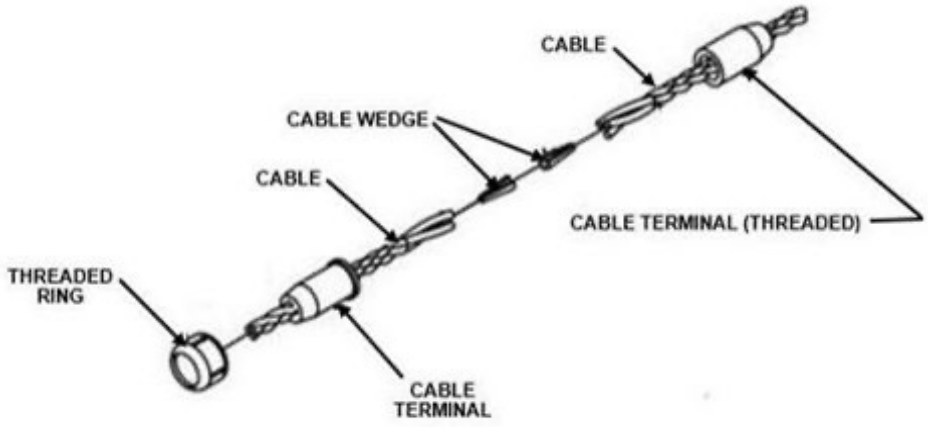


Figure 7
Torpedo Cable Splice

Laying Out the Cable / Attaching the Cables to the Posts

The cable can be either precut lengths or length from a cable reel. The method of laying out the cable will be determined by the contractor. The cables can be laid out one (1) cable at a time or multiple at the same time. The Valtir Shop Drawings supplied for the project is used to determine what cables need to be used where. The cables are identified as top (CRP-1), low top CRP-1X), high bottom (CRP-3), and bottom (CRP-2).

Complete the following steps for laying out the cable and attaching the cables to the posts:

1. Using the Valtir Shop Drawings for the cable run to select the cable needed to complete the assembly.
2. Attach the right threaded end of the cable to the terminal or Anchor cables. Use the factory applied fitting with a turnbuckle method or field-applied fittings with a turnbuckle to make the connection. Ensure that the top, low top, high bottom and bottom cables are identified.
3. Place the bottom cable on the embankment side and the high bottom cable on the opposite side of the post. The cables are attached to the post with a cable hook bolt (PN-4225G). The bottom cable is attached to the post using the bottom hole and the high bottom cable is attached using the top hole. The cable hook bolt is placed around the cable with the opening of the bolt down (See Figure 8). Secure the bolt to the post with a hex nut (PN-3245G) and tighten until snug with a minimum of two threads beyond the nut.

4. Place the low top cable in the notch at top of the post (See Figure 9). Place a spacer (PN-5700B (black), PN-5701B (yellow) or PN-5702B (white)) on top of the cable.
5. Place the top cable on top of the spacer. Place a post strap (PN-105202T) on top of the cable (See Figure 10).

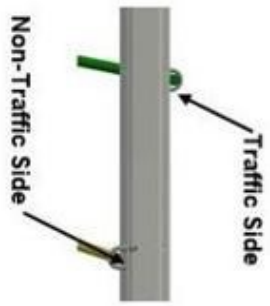


Figure 8
Bottom/High Bottom Cable Installed

Figure 9
Lower Top Cable Installed

Figure 10
Top Cable Installed

It is recommended before tensioning that for runs of cable greater than 5,000' [1,525 m], to pull the cable at intervals of 3,000' [915 m] to remove excess slack Ensure no turnbuckles or torpedo splices will interfere with the posts during the tensioning. If there are any, remove the post(s) or the cables from the post.

Important: For long runs of cable, check the turnbuckles at every location to ensure the cable has not unthreaded during the laying out or slack pulling process. Ensure the threaded rod can be seen through the holes on each end of the turnbuckle and the 1 1/2" [38 mm] mark cannot be seen.

Tensioning and Tension Meter

After all of the cables have been placed in the posts, tensioning can take place. The tension placed on the cables is to be determined by the cable temperature at the time of tensioning. The tension meter shall be set for pre-stretched cable. An infrared thermometer is to be on-site at the point of tensioning to obtain the correct cable temperature. If an infrared thermometer is not available, obtain the air temperature from a reliable source in the immediate area and not influenced by other factors. See the CASS® S3 Temperature and Tension Chart for the tension requirements at the back of this manual.

Note: Due to frictional forces, it is recommended to start tensioning from the bottom cable, working upwards to the top cable.

The means of placing tension on the cable will be determined by the contractor. Whatever means is chosen, it must ensure that the tension from the tension chart can be obtained.

Important: Completely review the manufacturer's manual included with the CASS® S3 tensioning meter prior to tensioning of the cable.

Important: Ensure that the tension meter is set for pre-stretched cable.

Important: Completely review the infrared thermometer manufacturer's manual prior to tensioning of the cable.

Warning: Infrared light is harmful if shined into the eyes.

Warning: Read and understand the directions provided for the CASS® cable pulling tool.

Warning: Extreme care should be taken to ensure that the CASS® cable pulling tool is attached to the cable in such a location that if it slips, the chain or CASS® cable pulling tool will not hit anyone. It is suggested that the pulling equipment be placed between the workers and the CASS® cable pulling tool. Read the directions and ensure the tool is clean, dry and not worn.

Complete the following steps to tension the cables:

1. Check the cable run to see if any of the turnbuckles or torpedo cable splice will pass from one side of the post to the other during the tensioning process. If they will, pull the post for the tensioning process. Also check the fitting marks at each turnbuckle to make sure no marks are showing.
2. The tensioning of the cable will be taken at a location no closer than 500' [167 m] from the end that has not been connected to the CCT or Anchor Cables. It is recommended that cable tension readings be taken in tangential sections.
3. For cable runs greater than 5,000' [1,525 m], the cable should be pulled every 3,000' [915 m] to remove the slack from the cable.
4. With the required tension on the cable, place a mark on the cable where it meets the threaded end of the CCT.
5. Release the tension on the cable. Go back approximately 28" [0.71 m] from the mark and cut the cable.
6. Place a right-hand field applied fitting using the procedures in the Field Applied Fittings with a Turnbuckle section.
7. On the CCT end, place a turnbuckle (PN-5826G for 1" fitting; PN-5711G for 3/4" fitting) on the fitting by only a couple of threads. Pull the cable until the cables are connected to the turnbuckle. With both fittings inserted in the turnbuckle, the turnbuckle will be turned until the 1 1/2" [38 mm] marks on the cables ends of both threaded rods are in the turnbuckle.

8. With the cables connected, release the cable pulling tool from the cable. Check the tension on the cable. If a higher tension is needed, rotate the turnbuckle while the cables are restrained to prevent twisting.
9. Replace any posts removed during the tensioning process. If a turnbuckle or torpedo cable splice falls where there is a post, or if the turnbuckle or torpedo cable splice is 1' [300 mm] from the post, replace the post with a splice interference post (PN-34049G/post in sleeve or PN-34061G/driven post).
10. Two (2) or three (3) days after tensioning, check and record the tension values, at the same locations as taken in step 2. If adjustment is needed to meet the tension on the tension chart, the turnbuckles can be adjusted. After adjustment, ensure the threaded rod is no more than 4" [100 mm] into the turnbuckle. It is suggested that the tension recorded be set approximately 800 lbf. [3.6 kN] above the value on the tension chart.
11. **It is recommended that approximately two (2) to three (3) weeks after the checking the cable tensioning in Step 10, the cable tension is checked again against the tension chart. Make any adjustments necessary to meet the appropriate tension**.

Delineation

The specifying agency will establish the criteria for delineation of the line posts. The delineation is typically provided on the spacer used to separate the cables; but, can be placed in other locations.

It is suggested for the terminal CRP that reflective sheeting (PN- 5851 or PN-5851) be affixed to delineate them, which could help to reduce some impacts. Valtir makes no guarantees they meet the minimum specifications, comply with MUTCD requirements or comply with state/specifying agency requirements. It is recommended that all of the CRPs be delineated.

Repairs

After an impact, the system will require repair. Full scale crash testing conducted in conformance with NCHRP Report 350 or MASH indicates that the cable will typically remain close to its original height depending on the number of posts damaged. It is recommended that the system be repaired as soon as possible by the appropriate state or specifying agency.

After most impacts, the system can be repaired in a relatively short period of time. Any part or parts which visually appears broken, frayed, torn, and/or damaged must be replaced. Additional specific parts of the CASS® S3 system, which must be replaced in order to bring the system back into full service, is a decision that must be made by the appropriate state or specifying agency.

An impact that encounters a CCT may require re-tensioning of the entire run of cable. After repairing the cable, the tension throughout the system should be checked.

It is recommended that for impacts outside of the testing parameters that the cable be checked to determine if re-tensioning is required.

Important: Valtir makes no recommendation whether use or reuse of any part of the system is appropriate or acceptable following an impact. It is the sole responsibility of the state/specifying agency and its engineers or its agent to make that determination. It is critical that you inspect this product after assembly is complete to make certain that the instructions provided in this manual have been strictly followed.

Repair for CASS® S3 Impact (CRP Not Impacted)

If an impact occurs and a CCT CRP is not involved, usually only the line or terminal posts will have to be replaced and the cables re-inserted in the posts or attached to the post. Follow the steps below in making this repair:

1. Inspect the damaged system and determine what components will be required to correct and repair CASS® S3 to originally specified working condition.
2. Remove the damaged posts. During very cold weather and in Northern climates, the post may become frozen into the socket. Successful means of extraction have utilized propane torches or a hammer drill to break-up the ice. With approval from the State specifying agency, calcium chloride (a common deicing chemical) can also be mounded over the top of the ice for 24 hours prior to removal of the post. As always, wear appropriate safety equipment such as work gloves and eye protection during post removal. If the posts are driven, they will have to be pulled out of the ground.
3. Replace any damaged posts.
4. Replace the cables. For the line cables, see the "**Laying Out the Cable/Attaching the Cables to the Post"** section. For the CCT cables, see the **"Terminal Cables"** section.

Depending on the severity of the impact, after the repair, the cable may need to be re-tensioned, Valtir recommends the tension of the cable be checked with the CASS® tension meter. If the tension is not in accordance with the CASS® S3 System Temperature/Tension chart, adjust turnbuckles to bring the cable to the correct tension. See the **"Tensioning and Tension Meter"** section to make any tension adjustments.

Note: The reflective sheeting may be placed on the spacer for CASS® S3 based on the agency's specification.

Repair for System Impact (CRP Involved)

When the system has been impacted and CRP is involved, follow the steps below:

1. Inspect the damaged system and determine what material will be required to make the repairs.
2. For the CRPs that have been impacted, inspect the top and bottom post for damage. Repair and replace any damaged posts. See the **"CASS® S3 Terminal Post Assembly"** section. For any other posts that have been damaged, follow the criteria in the **"Repair for CASS® S3 Impact (CRP Not Impacted)"** section.
3. Attach any detached cables and re-tension the cable.

Emergency Repairs

There is a possibility that an accident could cause significant traffic congestion, or the cable can be entangled with the vehicle. When a vehicle is entangled in the cable, the first step that must be undertaken is to move or drive the vehicle as close to the centerline of the cable system as a feasible, in order to reduce tension. The following suggestions may help to get traffic moving and the cable untangled:

Road Blocked Due to an Accident

To resume traffic flow after an accident or to get emergency vehicles access to the accident site, crossover access through the cable may be necessary. To provide this access, remove cables from several posts upstream and downstream of the desired opening. The opening width can be adjusted by removing posts from the ground sleeves. The cable can be held down and the traffic or emergency vehicles can pass over it.

PPE equipment such as protective gloves, safety goggles, and mask must always be used. **Keep personnel out of the area upstream and/or downstream from the point of the cut.**

In life threatening or emergency situations the cable can be cut.

If the cable was put under additional tension due to the accident, the tension can be reduced at the turnbuckles closest to the impact. The turnbuckle can be backed off; however, **it is critical that the fittings remain engaged within the turnbuckle a minimum of 3/4" [19mm] when the cable is under tension.**

To reduce the amount of the cable damage during cutting and limit fraying, tape must be wrapped around the cable and the cut made through the tape. **Some agencies have also cut through the turnbuckle itself.** This may help to reduce the maintenance/repair effort. When cutting through a turnbuckle, ensure that all posts, both upstream and downstream for a distance of 50'-0" [15 m], are removed in order to prevent turnbuckle or fitting interference.

If time permits, the tension can be released by pushing over one or more of the CRP(s) with a piece of equipment.

Removing Entangled Cable from a Vehicle

When the cable is entangled with a vehicle that must be towed away, remove the entangled cable by lifting one or more of the cables up over the vehicle. During this operation, if any of the line posts entangled with the cable start to lift up out of the sleeves, the lifting must be stopped and the posts removed from the cable. Once the posts are removed, the cable can be lifted up over the vehicle.

In addition, if the entangled vehicle is located near the CCT end, it is possible to reduce tension by loosening the two large nuts on the terminal cable end. The nuts can be backed off to the end of the fitting. **DO NOT COMPLETELY REMOVE EITHER OF THE NUTS!**

Repairing a Cut or Damaged Cable

Following are various methods to repair cables that have been cut or damaged:

Method 1 – Splicing the Cable

Splicing the cable may be necessary if a cable is cut or damaged during an impact. The length of the cable must be 50'-0" [15 m] or longer to make the splice.

1. Re-cut the ends of the cable to ensure the ends are clean and smooth.
2. Refer to the **"Cable Splices**" Section when making a cable splice connection.
3. If an accurate length of cable is used for the splice section, two cable splice connectors will be required to connect the cables together.
4. Connect one end of the splice cable to one end of the cut cable with a connector.
5. Apply another connector to the other end of the splice cable and the end of the cut cable.
6. Assemble the cable splice connector using a backhoe or other mechanical means.
7. Check the tension on the cable with the tension meter and adjust the turnbuckles to bring the cable to the correct tension based on the infrared thermometer cable temperature reading and the values on the CASS® S3 Temperature/Tension Chart.

Note: If the cable splice has been cut accurately, the tension may be obtained by turning the turnbuckles at each side of the cut.

If the tension cannot be obtained at the turnbuckles at each side of the splice, it may be necessary to follow the procedures in the **"Tension and Tension Meter**" Section. Some assemblies may have field splices at all locations. If this is the case, the measuring, cutting, and re-connecting can be done at any location.

Method 2 – 5'-0" [1.5 m] Section

A second method to reconnect the cables is to use a 5'-0" [1.5 m] Cable Field Repair Section (PN-5840G) of cable with a factory applied fitting on each end. This method will also require two turnbuckles and a left-hand and right-hand threaded fitting to complete the connection.

1. Remove approximately 9'-8" [2.9 m] of cable from the cut cable.

2. Connect the threaded fittings and the cable ends connections per the **"Factory Applied Fittings with Turnbuckle"** Section.

Method 3 – Other Than 5'-0" [1.5 m] Cable

When using a cable length other than 5'-0" [1.5 m], the amount of cable removed from the cut cable is to be adjusted based on the cable length removed.

1. To help to determine the amount of cable to be removed, after the threaded fittings are placed on the piece of splice cable, take a measurement from end-of-fitting to end-of fitting. Take this measurement and add 4'-6" [1.3 m] and this will be the amount of cable to be removed from the cut cable.

2. If the length of cable used is less than 5'-0" [1.5 m], remove less than 9'-8" [2.9 m] of cable from the cut cable.

3. If more than 5'-0" [1.5 m] of cable is used, remove more than 9'-8" [2.9 m] of cable from the cut cable.

Method 4 – Use of Fitting Connections Only

If the damaged cable, after cutting, is less than a total of 4'-6" [1.3 m], the connection can be made with a left and right threaded fitting and a turnbuckle.

1. Remove 4'-6" [1.3 m] of cable from the cable run.
2. Place a left-hand threaded fitting on one end of the cut cable and right-hand threaded fitting on the other end of the cut cable.
3. Follow the procedures in the **"Field Applied Fittings with Turnbuckle"** Section. Check the tension on the cable with the tension meter and adjust the turnbuckles to bring the cable to the correct tension based on the cable temperature and the values on the CASS® S3 Temperature/Tension Chart

After completing one (1) of the four (4) methods above, check the tension on the cable with the tension meter and adjust the turnbuckles to bring the cable to the correct tension based on the cable temperature and the values on CASS® S3 Temperature/Tension Chart and complete the CASS® S3 Assembly/Repair Checklist.

Cable Tension Inspection Program

Valtir recommends the cable tension be checked at least once a year. The tension value is established based on the cable temperature, which can be taken using an infrared thermometer for the cable temperature. If an infrared thermometer is not available, obtain the air temperature from a reliable source in the immediate area and not influenced by other factors. See CASS® S3 Temperature/Tension Chart for the tension values.

CASS® S3 Assembly/Repair Checklist

(File With Project/Maintenance Records)

Performed by: _____

Date: _____

Location: _____

- ☐ 1. Ensure only Valtir CASS® S3 parts are used for the assembly/repair of CASS® S3 and that all parts are free of damage. (p 4)
- ☐ 2. Ensure required traffic control is in place to conduct CASS® S3 assembly/repair. (p 4)
- ☐ 3. Ensure proper site grading for the CCT complies with state/specifying agency guidelines for guardrail terminals or AASHTO Roadside Design Guide, whichever is more stringent. (pp 5 &14)
- ☐ 4. Ensure proper site grading for the CASS® S3 complies with state/specifying agency guidelines or AASHTO Roadside Design Guide. (pp 5 & 14)
- ☐ 5. Ensure the Sleeve Cover is paced on the post and is flush with the top of the Post Sleeve. (p 17).
- ☐ 6. Ensure the Bottom CRP and Top CRP are oriented correctly. (p 18)
- ☐ 7. Ensure the top of the Bottom CRP's does not protrude more than 4" [100 mm] above the finished grade. (p 18)
- ☐ 8. Ensure the bent part of the Cable Anchor Bracket at CRP's is up and hooked over the Top CRP's. (pp 21 & 22)
- ☐ 9. Ensure two (2) 1" Hex Nuts have been placed on the ends of the cable fittings at the CRP's. (p 22)
- ☐ 10. Ensure the cables are located and assembled at the proper holes of the Terminal Line Posts with the Cable Lock Bolts. (pp 21 & 22)
- ☐ 11. Ensure that the Field Applied Fittings have a single cable strand bent over the wedge. (p 24)
- ☐ 12. Ensure the bottom cable is located on the non-traffic side of the post and the high bottom cable is located on the traffic side of the post. (p 26)
- ☐ 13. Ensure Cable Spacer is placed between the top two (2) cables. (p 26)
- ☐ 14. Ensure the CASS® S3 delineators are placed per the contract plans. (p 26)
- ☐ 15. Ensure the Stainless Steel Post Strap is placed above the top cable. (p 26)
- ☐ 16. Ensure the Fittings are a minimum of 1 1/2" [38 mm], maximum of 4" [100 mm] into the turnbuckle. (p 28)
- ☐ 17. Ensure the Tension on the cable has been checked and is as specified in the "CASS® S3 Temperature/Tension Chart". (p 28)
- ☐ 18. Ensure there are no damaged/frayed/bent cables. (p 28)
- ☐ 19. Ensure delineation is placed on CASS® S3 CRP's and line post per MUTCD and/or state/specifying agency. (p 28)

CASS® S3 Routine Inspection Checklist
(File with Maintenance Records)

Performed by: _____

Date: _____

Location: _____

Valtir recommends the state/specifying agency develop and administer their own end terminal inspection program, based on location of unit, volume of traffic and impact history.

Important: CASS® S3 and all of its components shall be inspected for damage after every impact. Repair using only Valtir parts that are specified for use within the CASS® S3 **CA**ble **S**afety **S**ystem Product Description Assembly Manual, latest edition.

If no CASS® S3 or Cable Barrier inspection program exists, Valtir recommends visual drive-by inspections at least once every month and walk-up inspections every one (1) year. These inspections shall, at a minimum, consist of:

Visual Drive-By Inspections (Recommended Frequency: Monthly)

- ☐ Check for damage caused by vehicle impacts.
- ☐ Check for damage caused by impacts from snowplow, mowing or roadway operations.
- ☐ Check for misalignment.
- ☐ Check for missing system components.
- ☐ Check for vandalism.
- ☐ Check for damage caused by adverse weather conditions (i.e. erosion, weight of snow, UV).

Walk-Up Inspections (Recommended Frequency: Yearly)

Walk-Up Inspections include ALL Visual Drive-By Inspection items (listed above) as well as the items listed below.

- ☐ Ensure required traffic control is in place to conduct walk-up inspection.
- ☐ Check and record the tension per the manufacturer's recommendation.
- ☐ Clear and dispose of any debris or trash found on the CASS® S3 or interfere with the performance of CASS® S3.
- ☐ Check for erosion to the site grading around the system or any CRP movement.
- ☐ Check all fasteners to ensure they are tight.

If any of the above items are identified during the inspection process as being deficient, swift action shall be taken to correct and repair the CASS® S3 to working condition as outlined in the **CASS® S3 4:1 CAble Safety System** Product Description Assembly Manual, latest edition.

CASS® S3 Temperature / Tension Chart

Pre-Stretched Cable			
°F	Tension (lbf)*	°C	kN
-15	7500	-26	33.3
-10	7300	-23	32.5
-5	7100	-21	31.6
0	7000	-18	31.1
5	6800	-15	30.3
10	6600	-12	29.4
15	6500	-9	28.9
20	6300	-7	28.0
25	6100	-4	27.1
30	6000	-1	26.7
35	5800	2	25.8
40	5600	4	24.9
45	5500	7	24.4
50	5300	10	23.6
55	5100	13	22.7
60	5000	16	22.2
65	4800	18	21.4
70	4600	21	20.5
75	4500	24	20.0
80	4300	27	19.1
85	4100	29	18.2
90	4000	32	17.8
95	3800	35	16.9
100	3600	38	16.0
105	3500	41	15.6
110	3300	43	14.7
115	3100	46	13.8
120	3000	49	13.3
125	2800	52	12.5
130	2700	54	12
135	2600	57	11.6
140	2500	60	11.1
145	2400	63	10.7
150	2300	65	10.2
160	2100	71	9.3
170	1900	77	8.5
180	1700	82	7.6
190	1500	88	6.7
200	1300	93	5.8

* **Tolerance: –200 to + 800 pounds force [-0.9 to + 3.6 kN]**

Tension Log
CAble Safety System™

Project Owner:____
Project Number: ____________________ **Project Description:** ___________________
***CASS*™ Version:** ____________________ **Valtir Drawing #:** ______________________
Date Checked: ____________________ **By: _Company/Agency:** _______________
IR Temperature of Steel: _______________ **Corresponding Chart Lbf. Tension:**___

ALWAYS check tension in a tangential (NON-radii) section of the cable installation, a minimum of 500 LF from a terminal.

Run # ________ STA: _________ to STA: ___________ LF of Run: ___________

Loc: ___	Actual Lbf.	Loc: ______	Actual Lbf.	Loc: ______	Actual Lbf.
Top	___________	Top	___________	Top	______________
Low Top	___________	Low Top	___________	Low Top	______________
High Bottom	___________	High Bottom	___________	High Bottom	______________
Bottom	___________	Bottom	___________	Bottom	______________

Loc: ___	Actual Lbf.	Loc: ______	Actual Lbf.	Loc: ______	Actual Lbf.
Top	___________	Top	___________	Top	______________
Low Top	___________	Low Top	___________	Low Top	______________
High Bottom	___________	High Bottom	___________	High Bottom	______________
Bottom	___________	Bottom	___________	Bottom	______________

Loc: ___	Actual Lbf.	Loc: ______	Actual Lbf.	Loc: ______	Actual Lbf.
Top	___________	Top	___________	Top	______________
Low Top	___________	Low Top	___________	Low Top	______________
High Bottom	___________	High Bottom	___________	High Bottom	______________
Bottom	___________	Bottom	___________	Bottom	______________

Loc: ___	Actual Lbf.	Loc: ______	Actual Lbf.	Loc: ______	Actual Lbf.
Top	___________	Top	___________	Top	______________
Low Top	___________	Low Top	___________	Low Top	______________
High Bottom	___________	High Bottom	___________	High Bottom	______________
Bottom	___________	Bottom	___________	Bottom	______________

Loc: ___	Actual Lbf.	Loc: ______	Actual Lbf.	Loc: ______	Actual Lbf.
Top	___________	Top	___________	Top	______________
Low Top	___________	Low Top	___________	Low Top	______________
High Bottom	___________	High Bottom	___________	High Bottom	______________
Bottom	___________	Bottom	___________	Bottom	______________

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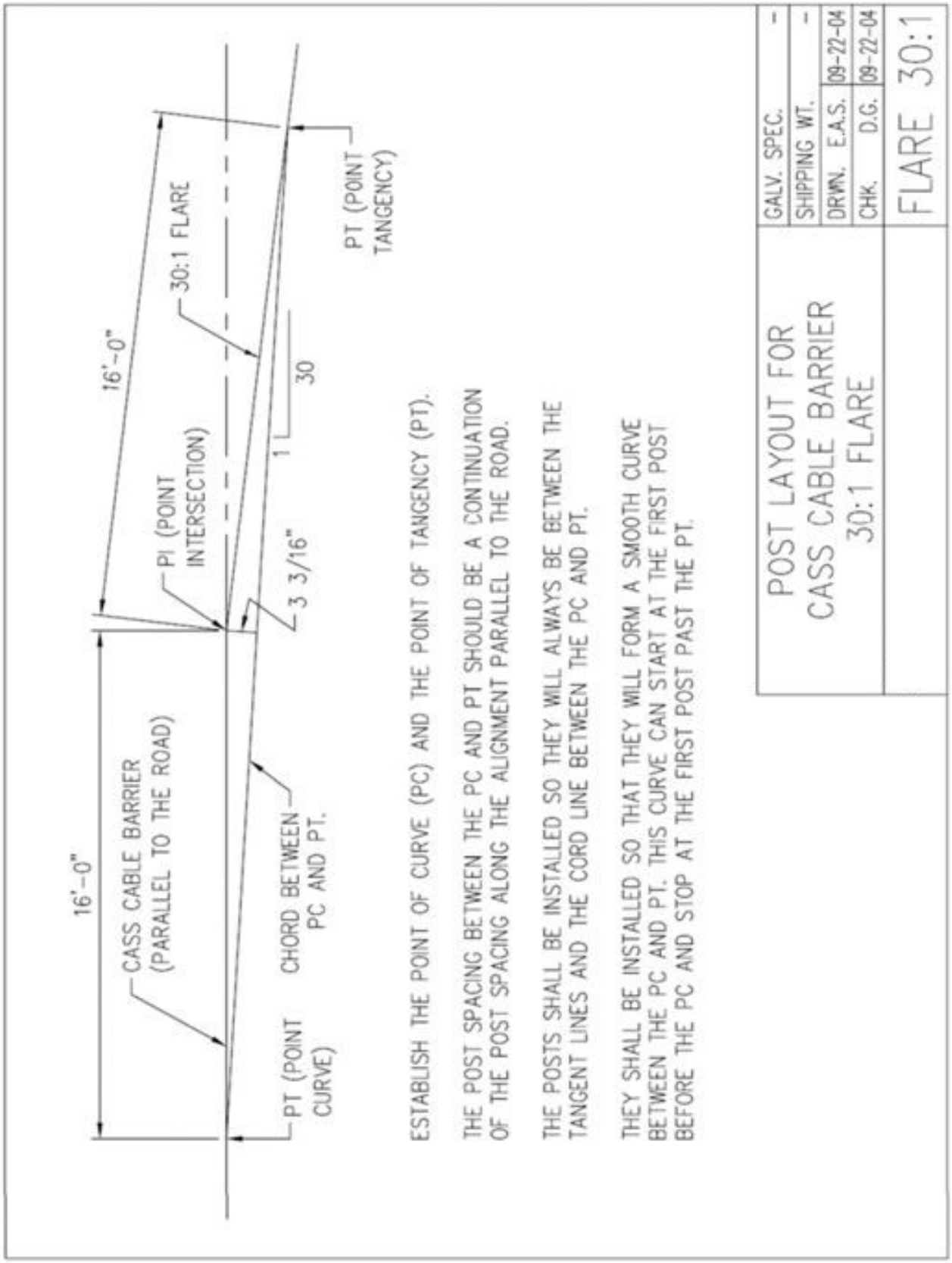
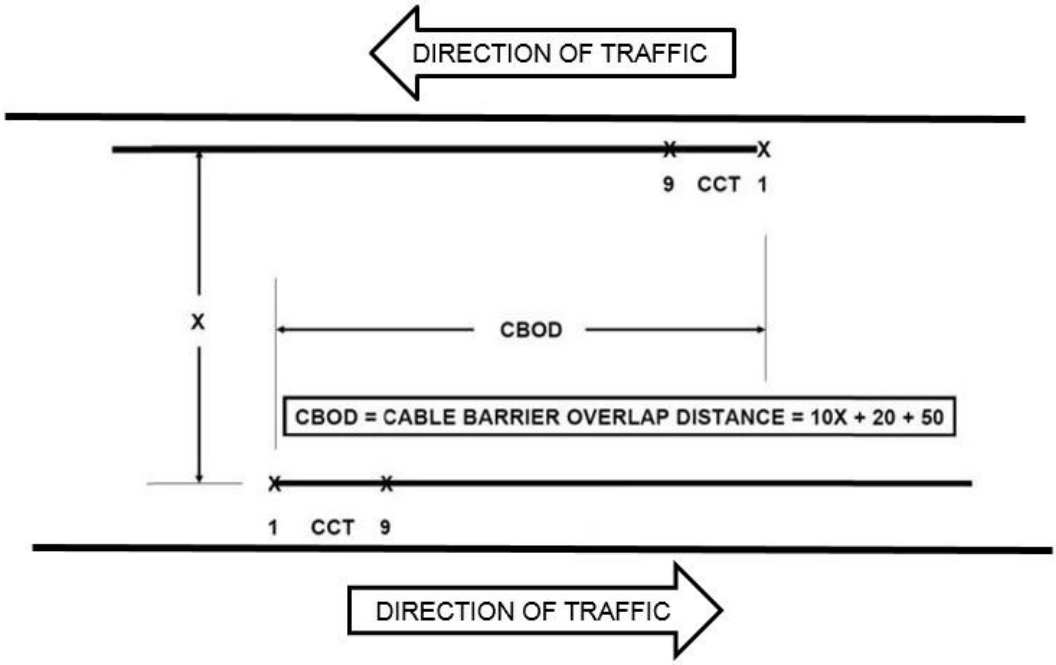
Appendix A: Flare Assemblies 30:1 Flare

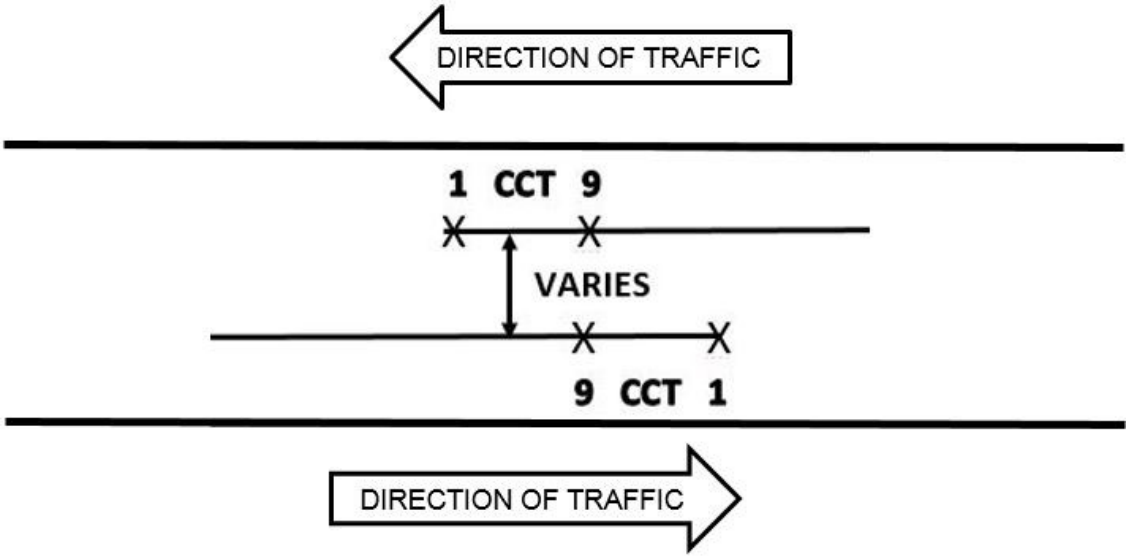


Appendix B: Cable Barrier Overlap



Use the cable barrier overlap distance calculated by the use of the CBOD formula. If the CBOD is greater than 370' {113 m}, use 370' {113 m}.

Cable Barrier Overlap Detail A



Cable Barrier Overlap Detail B

Appendix C: Encountering Rock

Assembling Foundation Tubes or Posts when Encountering Rock

Foundation Tubes

Complete the following steps to assemble foundation tubes when encountering rock:

1. Select Option A or Option B below when encountering rock, unless there is a more restrictive state or specifying agency specification.

Option A - If rock is encountered and 9” [225 mm] or less of the full length foundation tube remains to be embedded.

A. Drill a 12” to 16” [300 to 400 mm] diameter hole into the rock.
B. Drill the hole 3” [75 mm] deeper than the required embedment depth.
C. Fill the hole with MSC.
D. Place the foundation tube and rebar ring per the “Sleeve in a Concrete Footing (Poured Footing)” section.

Option B - If rock is encountered and more than 9” [225 mm] of the full length foundation tube remains to be embedded.

A. Drill a 12” to 16” [300 mm to 400 mm] diameter hole into the rock. The minimum depth to the bottom of the hole from the ground line shall be 21” [525 mm]. The 21” [525 mm] includes 3” [75 mm] below the tube.
B. Cut off the bottom end of the foundation tube so the top of the tube will be flush with finished ground.
C. Follow the steps in C and D in “Option A” above.

Foundation Tubes with Soil Plates

For Foundation with Tubes with Soil Plates, remove the soil plate from the sleeve and follow the “Foundation Tube” steps above.

Driven Posts

For Driven Posts, it is recommended that the post be installed with a Foundation Tube. Follow the Foundation Tube steps above.

Bottom CRP-Posts 1 to 3

Complete the following steps to place Bottom CRP when encountering rock:

Select Option A or Option B below when encountering rock, unless there is a more restrictive state or specifying agency specification.

Option A - If rock is encountered and 30” [750 mm] or less depth is required to complete the assembly of the full post:

1. Drill an 18” [450 mm] diameter hole into the rock.
2. Place the rebar cage and Bottom CRP in the hole. Complete the steps in the “Bottom CRP with Concrete Footings” section for the assembly of the rebar cage and the Bottom CRP.

Option B - If rock is encountered and more than 30” [750 mm] is required to complete the placement of the full rebar cage:

1. Drill an 18” [450 mm] diameter hole 33” [825 mm] into the rock.
2. Cut off the rebar cage so there will be 3” [75 mm] of concrete below the cage.
3. Follow the steps in C and D in “Option A” above.

Appendix D: Base Plated Post Assembly

The base plated post (PN-34037A) must be placed on a concrete surface 6” [150 mm] or more in depth (See Figure 11). The post length varies per concrete elevation.

Figure 11
Base Plated Post

Complete the following steps for the base plated post assembly.

1. Drill four (4) 3/4” [19 mm] holes, 6” [150 mm] deep for the rod (PN-5225G or PN6722G).
2. Clean the holes according to the adhesive manufacturer’s recommendations.
3. Place the rods and adhesive in the holes according to the manufacturer’s recommendations.

Note: A 5/8” [16 mm] mechanical anchor with a pull out strength of 10,000 lbs. [4536 kg] can also be used.

4. Allow the adhesive to cure according to the manufacturer’s recommendations.
5. Place the base plated post on the rods.
6. Place flat washer (PN-3300G) and lock washer (PN-3310G) between the hex nut (PN-3361G) and the plate (See Figure 12).
7. Tighten the nuts to a snug position with an appropriately sized wrench or socket and the lock washer is flat with a minimum of two (2) threads showing.

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