

Summary of ET-Plus Guardrail End Treatment Inspections

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Maine Department of Transportation

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In the summer of 2015, a statewide effort to identify and locate MaineDOT-owned ET-Plus terminal ends was undertaken by Project Development and Maintenance & Operations personnel. This effort consisted of identifying projects where the ET-2000 and ET-Plus crash ends may have been used, and personnel were sent to those locations to confirm and document the crash ends. Ultimately, the effort identified a total of 634 units. However additional units may still exist in areas where our records may not have properly documented the installation of this type of crash end or the crash end may have been installed through a separate maintenance or safety improvement action.

This summary describes the process and findings of detailed inspections of a randomly selected portion of the 634 units.

Because the units were already geocoded, the Results and Information Office was able to generate a random sample of 100 units, provide temporary inventory numbers and location maps.

A detailed inspection checklist of 28 specific items was developed using the manufacturer’s documentation and with input from FHWA. The Team conducted a brief field inspection to gain knowledge of this terminal end and to evaluate and finalize the checklist. For each of the 28 inspection items a rating was given as follows: 1 = fully functional, 2 = some deficiency, 3 = non-functioning. Thus an overall rating of 28 means that all items are fully functional or the unit is installed completely per manufacturers recommendations. Overall rating greater than 28 indicates that there are some deficiencies noted in the unit. In some cases the unit is deemed non-functional because of critical deficiencies. These are described below.

Table 1 below shows the sample size required to have a 95% confidence level with a margin of error of 10%.

Sample Size Calculator	
Population Size:	634
Confidence Level (%):	95
Margin of Error (%):	10
Sample Size:	84

Table 1- Sample size calculated with SurveyMonkey

Table 2 summarized the total number randomly chosen points and the number of assets inspected per region.

	Assets Inspected	Number of random Points available
Region1:	44	46
Region2:	20	20
Region3:	15	18
Region4:	7	14
Region5:	0	2
Total:	86	100

Table 2 – Number of Assets inspected per region

Table 3 gives the number and the percentage of functional, somewhat deficient and non-functional units.

Functionality

<i>Characteristics</i>	<i>Number</i>	<i>Percentage</i>
<i>Functional or Fully Functional</i>	53	62%
<i>Some Deficiencies</i>	21	24%
<i>Non Functional</i>	12	14%

Table 3 – Functionality of Assets inspected

Summary of Findings & Discussion

Twelve (12) of the 86 units inspected (14%) were deemed nonfunctional. Of these 12 units, six (6) had the w-beam disengaged from the extruder head [Photo 1]. One (1) was damaged such that the extruder head was completely off the assembly [Photo 2]. Most of these were damaged on the trailing end of a guardrail run. The damage appeared to be caused by impact in the opposite direction from the impacts these systems were designed to handle. Three (3) units were hit from the head on direction, sustaining damage and requiring replacement [Photo 3]. Two (2) nonfunctional units were not part of the random sample but were noted in the same area as the unit being inspected [Photo 4].



Photo 1
Location 892718



Photo 2
Location 45974



Photo 3
Location 76077



Photo 4
Location 282554

NOTE: The Regions and applicable urban compact municipalities have been notified of these nonfunctional units and actions to repair or replace are underway.

In addition, twenty-one (21) units or 24% had some deficiencies: Installation and maintenance issues including inadequate height, hinge posts installed backwards [Photo 5], cable/bearing plate not installed correctly [Photo 6 & 7], and missing/incorrect/ bolts or hardware incorrectly bolted together [Photo 8].



Photo 5
Location 282554



Photo 6
Location 35976



Photo 7
Location 890162



Photo 8
Location 42948

Fifty-three (53) units or 62% had no deficiencies noted or some minor deficiencies such as a few small bolts reversed or missing and signs of minor hits.

The ET-Plus terminals are used in applications where a tangent, or slightly flared (up to two feet), system is required to reduce impacts. The MaineDOT Guardrail Policy states that four foot flared terminals are preferred. The Policy allows tangent terminals, but cautions that tangent terminals are more likely to experience head-on and nuisance hits, and suggests that safety and maintenance concerns should be weighed against potential cost savings and impact minimization when considering tangent terminals.¹ . As already

mentioned, a significant effort to document the locations of these units was completed earlier this year. Thus we now have a fairly accurate inventory that is in the process of being incorporated into our overall guardrail asset inventory. However other tangent, energy absorbing systems such as the SKT by Road Systems Inc. and the X Lite by Lindsay Transportation Services have been used less frequently and their locations have not been thoroughly documented to the level of the ET-Plus at this time.

It is important to note that MaineDOT has had a guardrail inventory for over a decade. At present, this inventory is in excess of 14,000 assets. Unfortunately, due to the early collection methods using route log mileage, lack of detailed crash-end training at the crew level, and an overall lack of resources focused on the quality and completeness of this data, this inventory could not be relied upon for the information required for this ET-Plus effort. However, recent focus in this area through the assignment of Asset Technicians in the regions, in addition to better tools and greater emphasis on the accuracy of work reporting, has been steadily improving our guardrail asset data along with numerous other assets. Furthermore, it is important to recognize that these efforts are not building one-time snapshot inventories that quickly become outdated and unreliable, but they are instead building critical elements of our work and asset management systems that not only capture what exists today, but what exists on an ongoing basis as a result of maintenance, repairs and upgrades. This is an important effort that needs continued support in order to help us be better prepared for the future questions that may arise regarding our guardrail systems.

A comparison of other tangent, energy absorbing terminals would be helpful at this time. These systems include the SKT (Sequential Kinking Terminal) and the X-Lite. Current MATS data shows there are roughly 100 SKT units installed. The X-Lite is a very new system with only a handful of installations to date.

The use of the flared, energy absorbing and non-energy absorbing terminal ends offers another comparison since the SRT and the FLEAT systems have been installed throughout the state. Locations have not been completely documented, but there are enough locations identified to select 80-100 units of each type to inspect. MATS data shows 1100 SRT's and 900 Fleat 350's installed. The SRT is "Slotted Rail Terminal", a non-energy absorbing flared terminal. The Fleat is "Flared Energy Absorbing Terminal". Comparison of results of flared versus tangent systems would have to be done with the understanding that there are differences between the systems. While flared systems may have similar installation and maintenance issues, flared systems may experience fewer nuisance hits, especially on the trailing ends of guardrail runs caused by opposite direction vehicles.

Recommendations

1. Based on the results of the ET Plus assessment, the Team felt that many of the issues that were noted were not likely unique to the ET Plus system and may be representative of more widespread issues with guardrail terminals in general. Other end types might prove to be more or less resilient to the rigors of the real world, but all are expected to have issues of similar nature. Therefore, the team recommends that a more detailed condition inspection be expanded to include between 80-100 crash ends of each of the following types: Fleet 350, SKT, and the SRT.
2. More widespread training is recommended for any MaineDOT personnel that oversee guardrail crash end installations. Improper installation has occurred on 24% of those units inspected.

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ⁱ Maine DOT's "Guardrail and Guardrail Terminal Policy", August, 2014, p.1

Maine Department of Transportation
Qualified Products List of
Terminals for W-Beam Guardrail Systems

Terminals	Test Level	FHWA Eligibility Letters	Manufacturer/Supplier
Buried-in-Backslope Terminal			
Buried-in-Backslope Terminal	3	CC-53, CC-53A	Generic
Flared Terminals (Non-Energy Absorbing)			
Modified Eccentric Loader Terminal (MELT)	2	CC-84	Generic
Slotted Rail Terminal (SRT-350)	3	CC-31, CC-31A, CC-72	Trinity Highway Products, LLC
Flared Terminals (Energy Absorbing)			
X-Tension Guardrail End Terminal [†]	3	CC102	Lindsay Transportation Services
Trend 350 Flared End Terminal	3	CC-123F	Trinity Highway Products, LLC
Flared Energy Absorbing Terminal (FLEAT)	2,3	CC-46A, B, and C	Road Systems, Inc.
	2	CC-61B, C and CC-88	
Tangent Terminals (Energy Absorbing)			
X-Lite Tangent Terminal	3	CC-120	Lindsay Transportation Services
X-Tension Guardrail End Terminal [†]	3	CC-102	Lindsay Transportation Services
Sequential Kinking Terminal (SKT-SP)	2, 3	CC-40A, C-40 B, CC-61A, CC-61B, C-61- C, CC-88, C-88A, C-88B	Road Systems, Inc.
31 inch Height Terminals			
Slotted Rail Terminal (SRT-31) [*]	3	CC-100	Trinity Highway Products, LLC
Flared Energy Absorbing Terminal (FLEAT)	3	CC-88, CC-96	Road Systems, Inc.
Trend 350 Flared End Terminal	3	CC-123F	Trinity Highway Products, LLC
Sequential Kinking Terminal (SKT-SP)	3	CC-88, CC-96	Road Systems, Inc.
X-Tension Guardrail End Terminal [†]	3	CC-102A	Lindsay Transportation Services
X-Lite Tangent Terminal	3	CC-120	Lindsay Transportation Services

^{*} Non Energy Absorbing

[†] Use of this product is governed by Special Provision only.

Test Level 2 – For design speeds < 45 mph

Test Level 3 – For use at all design speeds

End treatments not listed above may not be incorporated into any MaineDOT work without prior approval. Please contact the Product Evaluation Coordinator at 207-624-3288 with any questions.

Sales Representatives seeking approval of a new product should submit their product's Materials Technical Data Sheets, Installation Instructions, Safety Data Sheets, and a completed [MaineDOT New Product Evaluation Form](#) for each product submitted.

Last update: 11/20/2015

Maine Department of Transportation
Field Inspection of Trinity Highway's
ET-PLUS Terminal Ends on Maine Highways

Ensure that proper installation procedures were used during initial installation and/or maintenance:

1. Pavement or well graded gravel should extend at least 2 feet from the face of rail and 10 feet ahead of the end post. Grading should be a continuation of the shoulder cross slope.
2. The inslope adjacent to the terminal should be 3:1 or flatter.
3. Is the system 4-inch or 5-inch?
4. The height as measured from the ground surface at face of rail to the top of rail should be 27 ¾ "
5. Post 1 - Hinged Break-Away (HBA) post on steel post systems plumb and w/o damage.
6. Post 1 – steel tubes or post plates to the HBA bottom post do not protrude more than 4" from the finished grade, as measured by the AASHTO 5' chord method.
7. Post 1 – HBA Post has two bolts on either side of the post with the larger bolt downstream of the smaller (away from the impact head)
8. Post 2-6 or 8 depending on the system steel yielding posts (SYP) should be plumb w/o damage and have the weakened post section (holes in flange) at or near ground level on steel post systems. On wood post systems the topmost hole is at grade.
9. Ensyre post 3-8 have 8" offset blocks (wood or composite) blocks should be plumb and have not rotated and are fully intact w/o damage and securely fastened to the post. Ensure wood offset blocks are toe-nailed to wood posts, and are in good condition.
10. W-beam is fully seated into Extruder Head making sure the rail is in the Channel Chute on wood or steel post systems.
11. Existing damage to w-beam from impact head through post 10 should be noted.
12. If there is previous impact damage was it repaired correctly?
13. Has a ground strut at ground level between Post 1&2 on wood or steel post systems
14. Guardrail not attached to Post 1 on wood or steel post systems
15. Post 1&2 do NOT have an offset block on wood or steel post systems
16. Angle Strut attached to the flange of the HBA Post 1 with ¾" Hex Head Bolt placed through the top and bottom Post Plates and connect with a ¾" Washer and Lock washer under the ¾" nut.
17. Check that the overlap is correct on 12'6" rails.
18. Post 3-8 have 5/8" x 10" HGR Bolt thru Rail Panel, 8" Offset Block, and SYP on steel post systems.
19. On tangent or flared systems Extruder Head post breaker points away from traffic on wood or steel post systems
20. Top and Bottom Flanges on the side of the Extruder Head each has 3 holes ensure the hole that best aligns with the holes in top and bottom of the HBA post (or lag bolted to wood post) & Extruder Head is parallel to the rail panels
21. The Cable Anchor Bracket is locked into place.
22. Shank portion of Cable Anchor positioned against bottom web of top portion of HBA post Post 1 on steel post systems.
23. Ensure cable is taut and deflects less than 1" on all systems.

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24. Ensure the Cable Bearing Plate is Oriented such that 5” dimension from bolt hole is up and plate has not rotated; on all systems.
 25. Ensure the end fitting on the anchor cable is positioned vertically, up flush against the bottom web of the top section of the post. The end fitting of the cable **MUST** be centered horizontally so the bearing plate bears uniformly on both flanges of Post 1 on steel post systems.
 26. Backfill material at post holes must be low enough to not obstruct/constrain the bearing plate and other hardware at the HBA posts.
 27. Ensure guardrail delineation is in place including reflective sheeting on the extruder face.
 28. Face of Extruder Head may **NOT** be set back more than 2 feet from the face of the standard guardrail.