

Memorandum

To: e-Distribution
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Highways Engineer

Date: September 14, 2022

Subject: MASH Box Beam Terminal-MBEAT, and MASH Box Beam Updates

General

This memo is intended to provide guidance in support of MDT policy 5.03.002 (Roadside Safety Hardware Upgrades Policy), as approved and revised to the date of this distribution. Specifically, this guidance is applicable to section 2.3 of the policy procedures memo, as it pertains to new box beam guardrail permanently installed on all Federal Aid projects let after May 12, 2022. This memo also updates MASH testing status of all box beam hardware in use by MDT and guidance provided in other sources.

Background

At the time the interim guidance for box beam was established and placed on the MDT website, the BEAT terminal section was incorrectly identified as a MASH approved terminal. The "BEAT" terminal that Road Systems, Inc had successfully tested to MASH includes many identical components but is modified somewhat from the original and is called the MBEAT. The manufacturer of MDT's other Optional Box Beam Terminal Section, the WY-BET, discontinued the production of these terminals several years ago, with no plans for development of a MASH tested replacement. In moving forward with MASH approved hardware, we are adopting the use of the MBEAT box beam terminal and eliminating the optional bid since there really is only one option that fits our needs. Eliminating the options allows us to meet the requirements of the MBEAT terminal without the need to have an extended section that approximates the length of the obsoleted WY-BET. This provides a shorter terminal for most applications and more flexibility in fitting box beam guardrail in areas with site constraints.

Guidance

The 2022 MDT detailed drawings, effective with contracts in the April 25, 2022-bid letting and later, no longer have details specific to proprietary terminal sections, and the end section widening detail for box beam rail has been modified to match the reduced length and application of the MBEAT. The following discusses changes in bid items, pay limits, and other design, construction, and maintenance guidance for all box beam related items.

Bid Items:

MASH BOX BEAM TERMINAL – MBEAT (606010037) replaces both: GUARDRAIL - MBEAT TERM SEC TL-3 (606010039), and GD RL BOX BEAM OPT TERM SEC (606010641). Note: The 039-bid item was an interim item used in conjunction with a project specific detail and is essentially the same as the new 037-bid item but included one 18-foot stick of regular box beam rail in the pay limits. The 037-item includes only the short section (11.9 feet including the impact head) of thinner

walled tubing, cable anchor/ground strut, and impact head (Detailed Drawing 606-55) and will be specified for all applications. To meet MASH test level 3 (TL-3), the 11.9-foot MBEAT terminal must be connected to at least one 18-foot section of standard box beam rail which is measured and paid separately (included in the length of standard box beam rail). The MBEAT terminal section is a gating section and should be located entirely outside of the Length of Need (LON) of the guardrail run. The first post of the rail that the MBEAT is attached to is the beginning/ending of the LON.

Design Considerations

The most obvious change for design (and the most immediate need) is matching the new pay limits established by the detailed drawings. For projects already designed with the old optional terminal section bid item and let to contract prior to January 1, 2023, you can simply replace the old optional bid item with the new MBEAT and add 36 feet of standard box beam rail at each terminal location. No change in stationing is required.

For all projects let after January 1, 2023, the following considerations apply:

- The pay limit changes mentioned above must be considered.
- The length of need (LON) point (where full-strength lateral rail is assumed) has shifted slightly, from a location near the terminal/rail joint to the first post location of standard rail downstream of the terminal.
- The length of the terminal head itself is shorter (11 feet -11 5/16 inches from connection joint to the end of the impact head for MBEAT vs. the BEAT at approx. 14 feet)
- The minimum length of rail for some installations has changed.
- New considerations for upgrading in-place WY-BETs on pavement preservation projects.
- Other miscellaneous considerations.

To Calculate the length of a new run of box beam rail using warrants, the following method should be used to account for the change in LON point:

Example 13-7: Box Beam Guardrail (revised version from RDM, appx. K)

Given: Length of need for barrier is determined to be between Stations 17+50.00 and 32+75.00. Box Beam guardrail will be used to shield the hazard(s). The facility is a two-lane, two-way roadway requiring an MBEAT terminal at each end, and there is a private approach at station 33+40 on the same side of the roadway as the guardrail.

Problem: Determine the beginning and ending stations and the length of rail for payment.

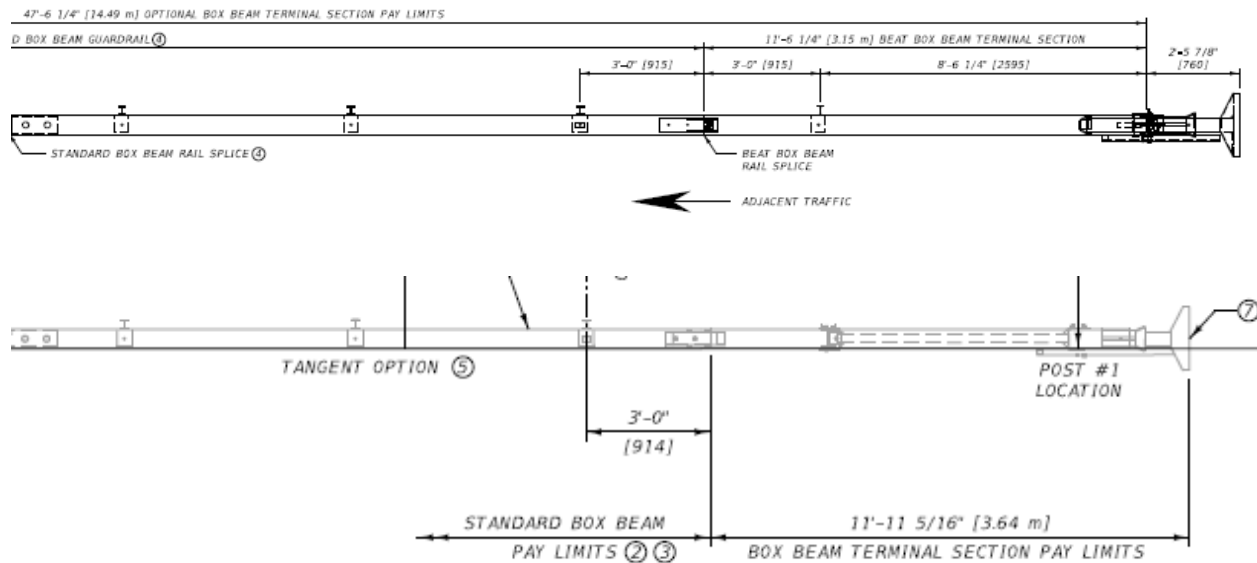
Solution:

1. $[(32+75.00) - (17+50.00)] + (2) \times (3.0' \text{ reduction in LON at each MBEAT connection}) \div 18' \text{ increment} = 85.06 \text{ sections, Round } 86 \text{ sections of Box Beam guardrail} \Rightarrow$
2. $86 \times 18' = 1,548.0' \text{ Payment Length of Box Beam Guardrail}$
3. Because of the approach located at station 33+40, locate the rail as far back on stationing as possible to reduce impacts to sight distance and turning maneuvers associated with the approach.

 $[32+75.00] + 14.9' \text{ for MBEAT/Box Beam outside of length of need} = 32+89.90 \text{ Ending Station}$
 $[32+89.90] - 1,548.0' \text{ of standard run rail} - (2 \times 11.9' \text{ MBEAT length}) = 17+18.10 \text{ Beginning Station}$
4. Includes 2 each MASH BOX BEAM TERMINAL - MBEAT

Note that the difference between the results here and the original design with OTS terminals is very slight (original was station 17+17.80 to 32+90.20) and the overall length of the run is reduced. The original stations also are measured to the first post of each OTS, rather than the end of the impact head, which we've included with the MBEAT length/stationing here. The original calcs also used the slightly longer WY-BET length of 48.2' and shorter length of full-strength rail, although this option has been unavailable for some time. The detailed drawings will be modified to indicate the end of the impact head as the end station shown in the plans, rather than the location of the first post.

Comparison of BEAT (top) and MBEAT terminals:



Length considerations:

The minimum length of Box Beam runs can be reduced for applications where the length of need required does not determine the terminal location for rail connected to bridges. For example: a bridge end on the departure side of adjacent traffic and outside the clear zone of opposing traffic on a two-way roadway. Under the old system, this bridge end would require the box beam bridge approach section applicable for the bridge rail and a 48.2-foot optional terminal section. With the MBEAT, meeting MASH TL-3 would only require one 18-foot box beam section and the 11.9-foot MBEAT length be added to the bridge approach section.

For free standing runs of rail (not fully supported at one end), the Road Design Manual indicates a minimum length of run excluding terminal sections should be 100 feet. However, this was considering w-beam rail with the addition of 50-foot OTS more so than other types of rail. New York State's detail for box beam requires that for runs shorter than 130 feet the post spacing is reduced to 3 feet on centers and connected to the rail at all non-joint locations. Additionally, the MBEAT was MASH tested with a total run length of 168.3 feet (156.4' beyond the tested terminal), although this length may have been selected to test the terminal as an upstream anchor only, as the needed stroke length for end impacts falls within 30 feet. Lastly, the MASH 3-10 test for the Wyoming Box Beam Rail indicated a length was tested meeting the "186 feet [LON] required between [terminal] posts 2 and 33" (180 feet of standard rail).

Based on this data and the elimination of standard rail from inclusion in the MBEAT terminal pay limits, the minimum length of free-standing box beam rail run in a TL-3 environment should include 180 feet of standard box beam rail between the terminals. If site conditions dictate a shorter run is needed and engineering analysis and judgment indicate that a shorter run of free-standing box beam is the preferred treatment of all options, documentation at the project scope of work level is required.

Due to the higher operating and regulatory speeds on our interstate system, all MBEAT terminals installed on this system should connect to at least 36 feet of standard box beam rail to account for the potential impact at much higher speed/energy than was tested. This likely won't be an issue based on development length requirements for new installations where warrants are evaluated. It is likely more of a concern where W-beam bridge approach rail is being replaced with box beam rail with longer bridge approach sections.

For locations with limiting site conditions outside of a project's scope of work, or where a lower test level design is appropriate, some deviation from the normal minimum lengths described above may be considered. For example, a low-speed, gravel, off-system bridge replacement project with private or public approaches in proximity, may require consideration of a lesser design advancement length. We don't have any box beam bridge approach transitions or terminal sections tested for the lower TL-2 (45 mph), however the kinetic energy of a vehicle at this TL speed is slightly more than half that of the same vehicle under TL-3 conditions (62 mph). Reduction of the 18-foot section of standard rail and/or inclusion of the "normal rail" portion of the bridge approach section may be the preferred treatment option. Any deviation such as this requires engineering analysis and judgment and reasons for selecting this as the preferred option and must be documented at the scope of work level.

WY-BET replacements, pavement preservation, and interstate considerations:

For the design of pavement preservation work, our Guidelines for Nomination and Development of Pavement Projects (3R agreement) has varying requirements for replacing roadside hardware based on level of treatment and age/condition/testing level of in-place devices. Although the WY-BET was tested and met the requirements of NCHRP 350 TL-3, the nature of its design does not allow for additional capacity much beyond the testing criteria. Once the energy absorption limit of the internal crushing mechanism is reached, the system may not behave as expected, as it essentially functions as a blunt end at that point. Conversely, the BEAT energy absorbing mechanism can continue to function and absorb energy beyond its tested level and stroke length requirements. With the increase in vehicle mass from NCHRP-350 to MASH of about 13.5% for the heavier vehicle, the increase in energy at the tested speed is also increased by 13.5%. If impacted at a higher than test level speed, the energy is exponentially greater. For example, the kinetic energy of the same vehicle hitting the impact head at 75 mph is about 46% higher than at the TL-3 test speed of 62 mph. **It is recommended that we consider replacing WY-BET terminals on projects of all scopes with new MBEAT terminals, on high-speed facilities (>50 mph). For projects with design speeds of 70 mph or greater, any existing WY-BET should be replaced with an MBEAT terminal (as described below), or the reason to leave the WY-BET in place must be documented in the project scope of work.**

For replacements without new warrant review, do the following:

- If replacing a BEAT with an MBEAT, all that needs to be removed is the 14-foot BEAT end section and replaced with a new MBEAT terminal, so long as the existing box beam is in functional condition. Ensure that the first 18 feet (36 feet for interstates) is in like new condition or replace it with new rail.

- If replacing a WY-BET terminal, the entire 48.2 feet of terminal included in our old box beam OTS for this terminal needs to be removed and replaced with 36 feet of standard box beam and the new MBEAT terminal.
- For replacement of w-beam or other rail types with box beam, compare LON (full strength rail) of the existing rail and replace it with box beam to match or exceed. Ensure minimum length criteria described above is met or documented in these cases as well.

Other considerations and updates:

- Do not specify weathering steel for guard rail elements.
- The MBEAT and first 18-foot section of box beam rail cannot be bent.
 - For installations on the inside of curves, verify the taper shown on detailed drawing 606-55 keeps the terminal head from encroaching on the shoulder. If needed, include another 18-foot section of the standard rail in the tapered length and/or modify the taper angle to fit (where curve begins near terminal end), or extend the rail through the curve to a point of tangency. The detailed drawing currently prohibits tapering the end section on the interstate system, however an exception to this is allowed for fitting an MBEAT and tangent 36-foot box beam rail section on the inside of a curve. Note all deviations from the detailed drawings in the plans.
 - On the outside of curves, it is ok if the terminal section moves out from the roadway due to the curve. The taper angle shown on the detailed drawing may be reduced or eliminated where it otherwise would be required if it results in maintaining a similar offset in the curved area as it does where it is installed along a tangent. In all cases, the terminal section widening requirements shown for post one should be provided based on the actual post location.
- MDT is in a pooled fund study for a MASH bridge approach section for our MASH box beam bridge rail. Testing is complete and this transition is expected for use soon. Once approved for use, it may not apply for all bridge rail conditions. This will not alter any guidance provided above.

Maintenance and Construction

The MBEAT terminal end and the new end section widening detail (606-55) can be used for all future or current work. Please consider the following:

- If replacing a damaged WY-BET terminal, see the previous discussion for removal and replacement requirements with MBEAT terminal.
- Install MBEAT terminal sections per manufacturers drawings. Ensure the T-bar is mounted on the traffic side of the terminal regardless of the installation (upstream or down)
- The 11.9-foot MBEAT terminal can be substituted for the 14-foot BEAT in all cases. For existing projects bid with OTS, accomplish any requested substitutions without change order. (MBEAT plus 36 feet of box beam rail is approved as OTS)
- For maintenance inventories, be sure to specify MBEAT (has a ground strut and other modifications) or BEAT for each location installed.
- For repairs to MBEAT terminals, refer to manufacturer for any parts that are interchangeable (BEAT and MBEAT) and which pieces may be reused.
- The new end section widening detail may be substituted for existing contracts where a BEAT or MBEAT is installed.

- For tight constraints where the preferred end section widening is not feasible, consult the Highways Bureau or regional Guardrail Mentor for the best management practice and minimum widening requirements.
- Contact a MDT Guardrail Mentor or the Highways Bureau for any questions or concerns with guardrail installation issues.

This guidance is effective immediately, and the Road Design Manual, Guidelines for Nomination and Development of Pavement Projects, Detailed Drawings, and the MASH interim guidance table on our Roadside Safety Hardware Resources webpage will be updated to reflect this guidance.

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