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Montana Department of Transportation

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Memorandum

To: e-distribution
see below

From: Lesly Tribelhorn, P.E., Highways Engineer

Date: February 8, 2018

Subject: MASH Guardrail Implementation Guidance

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 w-beam guardrail permanently installed on all Federal Aid projects let after Dec. 31, 2017.

Included Items

MDT will specify the Midwest Guardrail System (MGS) w-beam barrier with 8-inch block-outs for all new, permanent w-beam installations on projects let after the 2017 calendar year. In most instances, this system is materially the same as the w-beam system currently used in the state. However, the MGS is mounted at a height of 31 inches to the top of the rail, and the posts are positioned such that the guardrail splices are located midspan of post connections. The following is a list and brief description of the items MDT utilizes for MASH w-beam guardrail:

MGS GUARDRAIL (606010330) replaces GUARDRAIL-STEEL (606010030), and is measured to the nearest 0.1 feet from center of splice to center of splice at each end (may not be located at a post). We will continue to specify individual w-beam segments that are at least 12.5 feet or longer, however we may specify run lengths that include one or more segments of w-beam that are 15.6 feet (actual dimension is 15'-7 ½" between centers of splices) in some instances (see example 2, of this guidance). MGS rail meets MASH criteria for top of rail heights of 28-32 inches. [DWG. 606-05 A&B]

MGS GUARDRAIL/LONG POSTS (606010337) replaces GUARDRAIL-STEEL/LONG POSTS (606010038), and other items that have been used when 2 feet of widening behind the rail was not provided. It is measured to the nearest 0.1' from center of splice to center of splice at each end. There is not currently an option for six-foot posts at a reduced post spacing that has been tested to MASH

criteria. Current options are for 7.5' wood posts or 8' steel posts on normal 6'-3" centers, with 2:1 or flatter slopes starting at the center of post (wood) or face of rail (steel). We will use this bid item regardless if both options are allowed, or if we have a need to specify a specific post type in the plans. [DWG. 606-11 A&B]

MGS LONG SPAN GUARDRAIL (606010338) replaces GUARDRAIL-NESTED (606010042), for use with shallow obstructions up to 22.5 feet in length (i.e. Culverts). It is measured to the nearest 0.1 feet from center of splice to center of splice. This new item will be either 50.0 feet or 62.5 feet in length, depending on the length of the obstruction that is spanned (compared to 87.5 and 100.0 feet for former item). [DWG. 606-09]

MGS GRDL STIFF 1/4 POST SPACING (606010339) and MGS GRDL STIFF 1/2 POST SPACING (606010341) replace GUARDRAIL-STIFFENED (606010012), and are guardrail sections with reduced dynamic deflection for use in shielding above ground obstacles that are 2'-11" to 3'-8", and 3'-8" to 5'-4" behind the face of guardrail, respectively. Each type is measured to the nearest 0.1 feet from center of splice to center of splice. Lengths are in increments of 12.5 feet that provide the necessary length of reduced deflection and stiffness transition in the direction(s) of oncoming traffic. [DWG. 606-07]

MGS ONE-WAY DEPARTURE TERMINAL SECTION (606010345) replaces ONE-WAY DEPART TERM SECTION (606010023). This item is measured per each, is still 12.5 feet long, and is provided in addition to the length of need on the downstream end of w-beam guardrail on divided/one-way roadways. It has been modified for 31" mounting height and midspan splices. [DWG. 606-18]

MASH W-BEAM TERMINAL SECTION (606010335) replaces GUARDRAIL-OPTIONAL TERM SECT (606010642), and is measured per each. As of the date of this memo, MDT will allow either the SoftStop (Trinity Highway) or MASH Sequentially Kinking Terminal (MSKT) (Road Systems, Inc.) terminal sections for w-beam installations. Refer to the Qualified Product List (QPL) for changes to the allowed terminal sections. The SoftStop and MSKT terminals have slightly different overall lengths but identical lengths of full-strength rail (34'-4 1/2"). This allows for their use as options, however stations identifying the Length of Need (LON) posts (rather than end posts) will be used to ensure proper placement regardless of the option selected. Both terminals have 3'-1 1/2" less full-strength rail than the old Optional Terminal Sections (OTS). Both terminals have a 31-inch top of rail mounting height, with a +/- 1 inch construction tolerance. [DWG. 606-13 for layout only]

MGS INTERSECTING ROADWAY TERMINAL SECTION (606010346) replaces GD RAIL-STL INT RDWY TERM SECT (606010047). This item is measured to the nearest 0.1 feet, and comes in 12.5-foot increments from 37.5 feet to 75.0 feet, depending on the number and radius of bent rail segments included. It is materially identical to the old item, except that the height has been raised to 31 inches and the detail modified to show an additional post required for mounting to MGS rail. **This item does not meet the requirements of either MASH or NCHRP 350 criteria. Its continued use is only allowed when a MASH**

approved system that provides the necessary hazard mitigation will not fit the site conditions. [DWG. 606-46]

The implementation date for bridge rails and transitions is December 31, 2019. The MDT Bridge Bureau is in the process of evaluating bridge railings that meet the MASH criteria in preparation for this future implementation. MDT has adopted a non-proprietary MASH w-beam/bridge rail transition (bridge approach section) that will transition from w-beam guardrail to vertical, single slope, and modified Jersey shape concrete bridge rail/parapet. The use of this item will be determined by the design team case-by-case, depending upon applicability of bridge railing, project scope, and site constraints. **This item may not be suitable for bridges with approach slabs. The use of this bridge approach section requires modification at the ends of the standard Jersey shape bridge barrier and most concrete bridge rail mounted on curbs. For mounting on existing or modified bridge railings/parapets, project specific details for any bridge rail end modifications and mounting hardware/connections will need to be created and included in the plans until standard details are developed.:**

MASH THRIE BEAM BR/APPRCH SEC (606010342) can be used in place of either GUARDRAIL-STL/BR APPR-TY 1 (606010150) or GUARDRAIL-STL/BR APPR-TY 3 (606010230) (when the curb has concrete rail added on top), and is measured per each. This Bridge Approach Section transitions from w-beam to nested thrie-beam (semi-rigid to rigid) over a 37.5 foot length, and is 31 inches tall throughout. Note that this item does not fully replace any of our current bridge approach sections, but is in addition to them. [DWG. 606-23 A&B]

All temporary guardrail items are excluded from this immediate implementation date, and we have not created new MASH bid items for these at this time. **One recent change to temporary barrier is worth noting here:**

The items TEMPORARY BARRIER RAIL (618190100) and RESET TEMP BARRIER RAIL (618190110) replace TEMP CONCRETE BARRIER RAIL (605000010 and 606011081) and RESET TEMP CONCR BARRIER RAIL (605000100 and 606011287), respectively. The new items are measured for payment to the nearest foot, though calculated warrant lengths should continue to be rounded up to the next 10-foot increment for estimating quantities. The name and unit of measure have been changed to allow for varying materials and segment lengths of temporary barriers approved for use by MDT (current and future). Although the item numbers represent these as traffic control devices (618) rather than roadside safety hardware (605 or 606), they will continue to be used for all temporary installations where positive protection is needed for roadside hazards and work zones, and where other temporary guardrail is not feasible. They are typically measured separately for payment and included in the guardrail quantities frame when required by the contract, unless included in a lump sum item such as a Detour (206).

Height transition sections will now be included in the length of MGS guardrail rather than being paid for separately. Bid items (606010340) MGS TO METAL GUARDRAIL TRANSITION and (606010343) MGS TO METAL GRDL TRANS/LONG POST have been discontinued. [DWG. 606-20]

There are some guardrail items that will remain unchanged (i.e. Raise, Revise, Reset items) throughout this and subsequent MASH guardrail implementations.

Details

The new MGS guardrail items are intended to replace metal guardrail items currently in use. In most cases, the 2014 MDT Detailed Drawings for w-beam items have been replaced completely with the January 2018 Supplemental Drawings. For all projects let with these items, the Supplemental Detailed Drawings are in place, and additional plan set details are not required. The use of older items on a project will require a reference to use the 2014 MDT Detailed Drawings including supplemental drawings through October 2017 for installation.

Specific details of the MASH W-Beam Terminal Sections will not be included as part of MDTs Detailed Drawings. For these items, we will maintain a list of qualified products and require installation based on current manufacturer drawings. General location and stationing information is provided on the revised Terminal End Section Widening detailed drawing [DWG. 606-13].

The Thrie-Beam bridge approach section does not replace our current approach section types 1-3, so an additional detailed drawing has been created for this item. **The use of this item will require project specific details for bridge rail modifications and mounting requirements.**

The 2014 MDT Detailed Drawings including supplemental drawings through January 2018 can be found here:

http://www.mdt.mt.gov/business/contracting/detailed_drawings.shtml

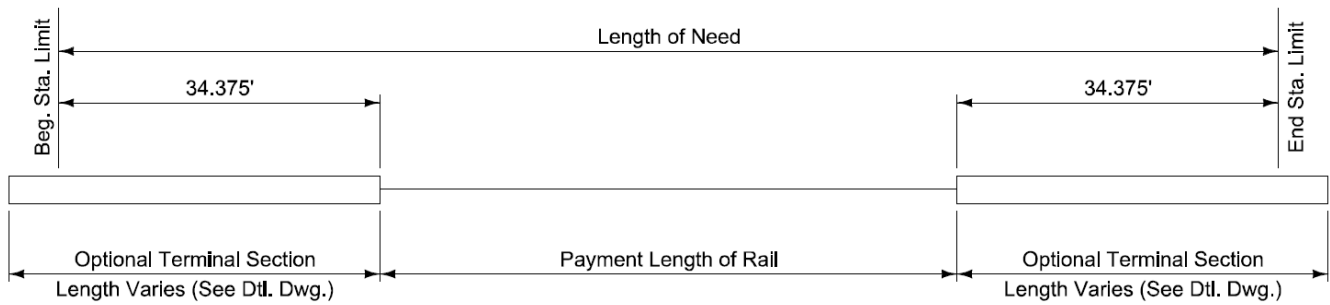
Design Guidance

This implementation only affects the design in terms of the physical characteristics of the new MASH w-beam hardware, and generally not a change in when/where we install w-beam guardrail. In other words, the decision to install a section of w-beam rail and the length of need determination remain the same. The difference in design is limited to determining the quantities and locations of the new MASH hardware relative to site and application conditions and requirements of the hardware elements themselves.

For a new installation of MGS not attached to a bridge/barrier, the quantity of rail is calculated similarly to how it has been done in the past; only the change in length of the terminals and the length of full strength rail must be considered. See the example calculation below for reference:

Example 1

Given: W-beam guardrail is warranted between Stations 9+90 and 15+00 on the left side of a two-way roadway. There are no roadway approaches or other features that influence the guardrail location.



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

Solution:

1. $[15+00.00] - [9+90.00] = 510.00'$ actual length of need
2. Per the Detailed Drawings, 34.375' of each MASH terminal provides full strength for length of need.
3. $(510.00' - 2(34.375')) \div 12.5'/\text{section} = 35.3\dots$ sections, Round \rightarrow 36 sections
4. $36 \times 12.5' = 450.00'$ Payment Length of Rail

NOTE: Because of the reduced lengths of full strength rail provided by the MASH terminal, the amount of rail between the terminals required is increased from 437.5' needed for the same condition with our current OTS. The actual installation of guardrail is approximately 6.3' longer measured from the ends of the impact/extruder heads.

5. In this case, no features have been identified to restrict guardrail placement. Locate the guardrail to provide the additional length on the advancement side of the adjacent traffic. Since the rail is on the left side of the roadway, adjacent traffic is moving opposite the direction of increasing stationing, therefore start the calculation from the lower station value:

$$\text{Beginning Station} = \text{L.O.N. Station} = 9+90.00$$

$$\begin{aligned} \text{Ending Station} &= [9+90.00] + 450.00' \text{ Payment Length} + 2(34.375' \\ &\text{full strength MASH terminal}) \\ &= 15+08.75 \end{aligned}$$

NOTE: The two MASH terminal sections that MDT has identified for use differ in dimension and post location outside of the length of need (LON) post. For this reason, **we will identify the run location of rail in the plans based on the LON post station when MASH Terminal Sections are specified.** The widening required for either option is the same, with the full width widening extending from the LON post 12.5 feet in the

direction of the impact head. We will continue to identify the rail run station limits at the end post for One-Way Departure Terminals, even though the entire 12.5' length is added to the end of the LON rail.

The changes in lengths for MGS Stiffened and Long-Span rail and the proposed Bridge Approach Section will affect quantities and locations as well. The MASH Bridge Approach Section and Long Span rail lengths are different than our current items. For all these items, connection to specific locations or shielding objects at specific locations affects their placement. For this reason, these elements act as control points for locating the run, and will dictate the stationing of the run as well.

For MGS rail attached to existing 29" high w-beam (or bridge rail that will not accommodate the thrie-beam transition), the physical differences between our old w-beam elements and the new MGS elements add complexity. If these installations include a 31" terminal, a length of MGS rail at least 28.1' long (including one 15'-7 1/2" rail segment) is needed to allow for the height transition from the 29" w-beam to the 31" terminal. The odd length section mentioned above was added to simplify the installation for the contractor/maintenance, as it allows the use of existing post hole locations for replacement work, rather than backfilling these and driving/drilling new post locations. It also has the effect of simplifying some conversions for projects that have been designed, with respect to guardrail end section widening.

Example 2

Given: A section of w-beam advancement rail to a bridge end is damaged/low and has been identified for replacement with a pavement preservation project. The intent is to replace the rail/OTS with MGS rail and a MASH terminal section in the existing location. The existing rail runs from station 213+64.33 to 215+14.33, where it connects to the bridge rail. The bridge rail is T-101 rail, for which we do not have a MASH transition.

Problem: Determine the quantities for all pay items included in the run, and the stationing identified in the plans.

Solution:

1. $[215+14.33] - [213+64.33] = 150.00'$ of guardrail replaced (assumes Bridge Approach Section Type 2 replacement as well)
2. Since this section of rail will have a MASH terminal and require a transition in height, the run length will be an increment of 12.5'.
3. $(150.0') \div 12.5'/\text{increment} = 12 \text{ incr.}$
4. Check for adequate rail length for rail replacement condition including height transition:
 - 29" Br. App. and MASH terminal requires 8 incr. min. → Condition met (2 for Br. App., 2.25 for rail, and 3.75 for entire length of MASH terminal)

- MASH terminal only requires 6 incr. minimum (2.25 for rail and 3.75 for MASH terminal)

5. The payment length of rail = $(12 - 2 - 3.75) \text{ incr.} \times 12.5' / \text{incr.}$
 = 78.125' Round → 78.1' MGS Guardrail

Additional pay items include:

- 150 feet of Remove Guardrail
- 1 each Bridge Approach Section Type 2
- 1 each MASH W-Beam Terminal Section

6. The station range shown on the plans would be 213+76.83 (LON of MASH terminal) to 215+14.33 (connection to bridge rail). If the remove guardrail is indicated on a separate line of the summary frame, the stations for that would be those indicated in the above Given statement.

Example 3A

Given: The design for an overlay of a two-lane roadway has been completed for a project that will be let in May of 2018. There is an existing bridge within the project limits that currently has blunt ends (vertical concrete parapets) and no bridge approach slabs. There is a private approach located at 14+50 RT (edge of approach @ 14+62) that limits the length of advancement rail on one corner, no other limitations exist for rail on the other corners. The following is the current summary frame with identified guardrail treatments:

GUARDRAIL										
STATION		linear feet				each				REMARKS
		METAL GUARDRAIL		INTERSECTING ROADWAY TERMINAL SECTION		OPTIONAL TERMINAL SECTION		BRIDGE APPROACH SECTION TYPE 1		
FROM	TO	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	
NEW RAIL										
14+33.50	15+08.50 BE					1		1		
14+63.00	15+08.50 BE		12.5		37.5				1	8.0' RT RADIUS
16+33.50 BE	17+08.50						1		1	
16+33.50 BE	18+08.50	100.0				1		1		
SUBTOTAL		100.0	12.5	0.0	37.5	2	1	2	2	
TOTAL		112.5		37.5		3		4		

Problem: Determine the changes to the plans to best meet the MASH implementation policy.

Solutions:
(Preferred)

The preferred solution would be to install all rail at the 31" height, as the information provided indicates that to be feasible. The changes include accounting for the additional length of the three-beam bridge approach section, the reduced length and stationing of the MASH terminals, and changes to the bid items identified in the frame (see example 1 methodology):

GUARDRAIL										
STATION		linear feet				each				REMARKS
		MGS GUARDRAIL		MGS INTERSECTING ROADWAY TERMINAL SECTION		MASH W-BEAM TERMINAL SECTION		MASH THRIE-BEAM BRIDGE APPROACH SECTION		
FROM	TO	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	
NEW RAIL										
14+36.60	15+08.50 BE					1		1		
14+63.00	15+08.50 BE				37.5				1	8.0' MGS IRT RADIUS
16+33.50 BE	17+05.40						1		1	
16+33.50 BE	18+05.40	100.0				1		1		
SUBTOTAL		100.0	0.0	0.0	37.5	2	1	2	2	
TOTAL		100.0		37.5		3		4		

Note that the minimum length section (bridge approach and terminal) has an increased length of full strength rail and no check is necessary to verify LON is met. Since the rail to the BR at 15+08.50 RT already had an IRT (no NCHRP 350 solution), a solution meeting MASH testing is not currently available for this corner either. The 12.5' of rail that was included on the corner with the IRT has been replaced by the equivalent length increase in the bridge approach section. No similar reduction to the advancement rail on the opposite end of the bridge indicates that the reduction of full strength rail of the MASH terminal required an additional segment of rail (ie. actual LON station 17+94). Any change in stationing due to differences in mounting the transitions to the bridge parapets is ignored in this example. This solution requires a thrie-beam/parapet connection detail added to the plans.

(Alternate)

The following summary frame represents another solution that meets the criteria of the MASH implementation policy but does not include MASH bridge approach sections (see example 2 methodology):

GUARDRAIL										
STATION		linear feet				each				REMARKS
		MGS GUARDRAIL #		MGS INTERSECTING ROADWAY TERMINAL SECTION #		MASH W-BEAM TERMINAL SECTION		BRIDGE APPROACH SECTION TYPE 1		
FROM	TO	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	
NEW RAIL										
14+21.00	15+08.50 BE	28.1				1		1		
14+63.00	15+08.50 BE		12.5		37.5				1	8.0' MGS IRT RADIUS, RAIL HEIGHT 29"
16+33.50 BE	17+21.00		28.1				1		1	
16+33.50 BE	17+96.00	103.1				1		1		
SUBTOTAL		131.2	40.6	0.0	37.5	2	1	2	2	
TOTAL		171.8		37.5		3		4		

INSTALL MGS RAIL AND IRT TO 29" TOP OF RAIL HEIGHT 14+63 TO 15+08.50 RT

Some of our earliest MASH conversions were done in this manner, as the thrie-beam bridge approach section has only recently been adopted by MDT. Also, if the existing condition had bridge approach slabs or rail that prevented the proper installation of the thrie-beam approach section, this solution would be the preferred treatment, and it is included here to illustrate notes required for installing the one corner to the 29-inch height. As it meets policy where possible, this design does not require further documentation.

Example 3B

Given: The same condition and summary frame as stated in Example 3A, except it has been determined that the thrie-beam bridge approach section will not work for this

location, and an additional approach exists at station 17+35 RT (edge of approach @ 17+23).

Problem: Determine the changes to the plans to best meet the MASH implementation policy with the given constraints.

Solution:

The preferred solution indicated for Example 3A is not feasible since the MASH transitions cannot be used. Working through the steps of the alternate solution of 3A, both corners on the left have a MASH solution for w-beam and terminal sections, but now neither corner on the right will work. The corner at BE 16+33.50 RT would result in a conflict between the MASH terminal and the approach at 17+35 when the rail is added to transition the height to properly install the MASH terminal. Since a MASH solution does not currently exist for this corner, we need to provide a solution that meets NCHRP 350 criteria if we can. Unlike the corner at BE 15+08.50 RT, the current design meets NCHRP 350 criteria:

GUARDRAIL												REMARKS
STATION		linear feet				each						
		MGS GUARDRAIL #		MGS INTERSECTING ROADWAY TERMINAL SECTION #		MASH W-BEAM TERMINAL SECTION		OPTIONAL TERMINAL SECTION %		BRIDGE APPROACH SECTION TYPE 1		
FROM	TO	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	
NEW RAIL												
14+21.00	15+08.50 BE	28.1				1				1		
14+63.00	15+08.50 BE		12.5		37.5						1	
16+33.50 BE	17+08.50								1			1
16+33.50 BE	17+96.00	103.1				1				1		
SUBTOTAL		131.2	12.5	0.0	37.5	2	0	0	1	2	2	
TOTAL		143.7		37.5		2		1		4		

INSTALL MGS RAIL AND IRT TO 29" TOP OF RAIL HEIGHT 14+63 TO 15+08.50 RT
 % INSTALL PER OCTOBER 2017 SUPPLEMENTAL DETAILED DRAWINGS

Note that the OTS in this solution requires a reference to the October 2017 Supplemental Drawings, as the OTS drawings have been replaced with the new end section widening drawing. Also note that, unlike the LON stationing for MASH terminals, the stationing for the OTS is shown to the center of the end post. Since the MASH policy is met for the extent that it can, given the existing condition and project scope, no further documentation is required.

Exceptions to Policy

The previous examples illustrate some instances where the MASH implementation policy cannot be fully implemented given site conditions and project scope. Policy procedures are general in nature and supplemented by guidance such as this. Circumstances may arise where it may be impractical and/or infeasible to provide MASH compliant features in accordance with policy. Deviations may be appropriate to provide necessary design flexibility. When it is determined that policy procedure deviation is justified and appropriate, the decision and justification need to be included in the Scope of Work report (SOW), or added to an approved SOW by addendum. This is true whether the elected exception is for one element or it is a systematic (project-wide) deviation. Considerations for when a deviation may be warranted include:

- project scope,
- site constraints and application for alternatives considered,

- roadway system/type/functional classification,
- traffic volumes,
- percent of the work that can be made compliant (uniformity of applicable devices),
- crash history,
- availability of new MASH compliant hardware, and
- documented performance of existing or available roadside hardware

Exceptions to policy indicated above does not reduce or eliminate the need for a design exception when required by MDT Guidelines for Nomination and Development of Pavement Projects.

Please contact Damian Krings (406.444.6225) with any questions on this guidance.

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