Frequently Asked Questions about Guardrails, Crash Cushions, and End Treatments

Q: What is MASH?

A: MASH stands for "Manual for Assessing Safety Hardware". Developed through the National Cooperative Highway Research Program (NCHRP) Project. It is the latest uniform set of guidelines for crash-testing permanent and temporary safety highway devices such as guardrail, crash cushions, and end anchorages, etc. MASH is an update to and supersedes the NCHRP Report 350 - Recommended Procedures for the Safety Performance Evaluation of Highway Features, for evaluating new and upgraded safety hardware devices. MASH testing includes changes in test matrices, test vehicles, test situations, evaluation criteria, test documentation, and performance evaluations. Highway safety devices shall comply with the performance criteria contained in NCHRP Report 350 (only for devices developed prior to 2011) or within MASH criteria (acceptable for all devices).

Q: Why switch to MASH and not stay with NCHRP-350?

A: Today's passenger vehicles in general have become higher, larger, and heavier than the vehicles crash tested in the 1990's under NCHRP Report 350. Crash testing has shown that some highway safety products tested under NCHRP Report 350 failed to meet current vehicle conditions. A more appropriate way of crash testing was required. Therefore, AASHTO (American Association of State Highway and Transportation Officials) and the FHWA came up with MASH, which is a more accurate way of crash testing highway products for today's vehicles. The FHWA believes that the corresponding improvements to these highway devices because of MASH will greatly improve the safety of our highways.

Q: Who is responsible for MASH?

A: AASHTO, the FHWA, the NCHRP, every state DOTs, other transportation organizations (public and private), and some manufacturing companies of highway safety products. AASHTO is the group that produces and maintains the MASH manual.

Q: How are manufacturer's highway safety devices going to become MASH compliant?

A: The FHWA discontinued issuing eligibility letters (an approval of manufacturer's safety products for use on highways) on December 31, 2015 under NCHRP 350 testing. After January 1, 2016, all safety devices will require testing under MASH to receive a Federal-aid eligibility letters from the FHWA.

Q: When will highway safety devices have to meet MASH-tested only requirements?

- December 31, 2017: W-beam barriers and cast-in-place concrete barriers.
- June 30, 2018 - W-beam end terminals.
- December 31, 2018: Crash cushions
- December 31, 2019: Cable barrier, Cable barrier terminals, Bridge rails, transitions, all other longitudinal barriers (including portable barriers installed permanently), all other terminals types, sign supports, all other breakaway hardware, and temporary work zone devices including portable barriers.

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The purpose of highway guardrail is to help prevent an errant vehicle from crashing into roadside obstacles or on to oncoming traffic (commonly prevented by median barriers). Guardrails must be crash tested and pass strict Federal Highway requirements. They have to be installed according to the manufacturer's instructions. Median structures, bridge piers, culvert headwalls, non-traversable ditches, trees, and other hazards along highways should be removed, redesigned, or shielded with guardrails. When guardrails are placed to shield these features, the potential for damage to people and structures are greatly reduced.

1. **Q: Why did the height of guardrails increase from 28 inches to (MGS) 31 inches?**

   A: The Midwest Guardrail System (MGS) has been tested and accepted through the AASHTO Manual for Assessing Safety Hardware (MASH). Results of the MASH tests showed improved crash-test performance at 31-inches regarding the capacity of the guardrail to contain and redirect vehicles with higher center-of-gravity such as pickup trucks and SUVs. Please refer to the new M-Standard: M-606-1 MGS 31 Inches Guardrail for the design of the 31-inch high MGS guardrail.

2. **Q: When is CDOT going too completely switch over to installing only the MGS guardrail?**

   A: Please see the Project Support Memo 2015-4: "Mash Tested 31-Inch Guardrail Implementation and Mash Implementation Dates" for more guidance. The deadline for using the 31-inch high MASH tested guardrail on all highway projects is December 31, 2017 (FHWA is recommending implementation as soon as possible). CDOT began this implementation for using the MGS guardrail on all highway projects advertised after March 31, 2016.

3. **Q: What are the major differences between the 28-inch guardrail and the 31-inch MGS guardrail?**

   A: Here are a few, but please see the MGS Issuance letter for more detailed information:

   - The height of the guardrail is now 31 inches instead of 28 inches.
   - The depth of the attaching offset blockouts have increased from 8 inches to 12 inches.
   - The joining of the guardrail panels (splices) are now between two guardrail posts instead of being on the guardrail post.
   - Type 3G and 3H transitions from the W-Beam guardrail to the concrete sections of Bridge rail have been reshaped so they have a level top.

4. **Q: How is the height of guardrail measured?**

   A: There are a number of different scenarios for guardrail height measurement:
   1. If the guardrail is directly located above pavement, measure the height from the top of the pavement to the top of the W-Beam rail.
   2. If the guardrail is located 2 feet off the edge of the pavement, use a 10-foot straightedge to extend the pavement/shoulder slope to the back of the rail. Measure from the bottom of the straightedge to the top of the rail.
   3. If guardrail is located 2 feet off a recent pavement overlay, follow the guidance in #2 above. You may have to re-set the barrier to achieve proper height. The gap between the pavement edge and the guardrail posts should be backed up with fill material to accommodate low-speed or shallow angle incursions.
   4. If guardrail is located down a 1(V):10(H) slope, measure from the nominal terrain. Contractors can get fairly even grading, but it will rarely be perfect enough to be spot on the design height. Use a string line or straight edge to even out terrain variations.

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5. **Q: How is the height transition between a 28" guardrail to 31" MGS (and its terminals) done?**

   A: The transition from a 28-inch tall guardrail to a 31-inch tall guardrail is done over the span of 25 feet, composed of W-Beam guardrail panels. When replacing or repairing long portions of a damaged guardrail, the new guardrail should be installed at the designed height, then transitioning down to the existing guardrail height. The transition from W-Beam to Thrie-Beam bridge rail may need to use the new, 31-inch, non-symmetric transitions that keeps the top height of the entire rail at 31 inches (see sheet 11 of 19 of the M-606-1). In addition, there is no need to transition in height to 28-inch end terminals anymore. The SRT, FLEAT, and SOFTSTOP end terminals have all been tested and accepted at the 31-inch rail height for use. Using them with the MGS provide the benefits of 31-inch guardrail without transitioning in height down to a lower end terminal system. A new detail drawing of the 31 inch to 28-inch transition guardrail will be included in the next revision of the "M-606-1, 31 Inch MGS Guardrail" M-Standard.

6. **Q: How high does a guardrail need to be raised that is lower than 26 ½ inches? What are the best ways to do that?**

   A: The guardrail should be raised to 31 inches, which represents the target height for new installations of the MGS W-Beam systems. If the pavement work requires the barrier to be moved, then the posts should be carefully extracted and if in good condition, re-driven at the new location so that the guardrail height will be at 31 inches. If the barrier is not going to be moved, then the guardrail and blocks should be moved up three inches along the post to the top, pre-drilled bolt hole. Please see the Project Support Memo 2015-4: "Mash Tested 31-Inch Guardrail Implementation and Mash Implementation Dates" for more information.

7. **Q: How high does a guardrail need to be raised when an overlay has reduced the height?**

   A: The guardrail's minimum height shall be 26-1/2 inches after an overlay. Please see AASHTO Roadside Design Guide, 4th Edition, (RDG p. 5-17) for further information.

8. **Q: Would drilling a new hole in the Midwest Guardrail System (MGS) guardrail weaken the system?**

   A: FHWA does not recommend altering a conventional W-Beam rail by drilling new holes to accommodate the MGS. If the guardrail does not come with slots pre-punched at the 3'-1-1/2" lateral mark, attempting to drill a new hole may compromise the performance of the rail or constrain its lateral movement. Providing additional factory-punched holes or slots at the 3'-1-1/2" lateral mark does not reduce the effective cross-section.

9. **Q: Why do guardrails have blockouts?**

   A: The purpose of guardrail blockouts are to reduce the possibility of "wheel snag" on a guardrail post when a vehicle interacts with the guardrail. These blocks are typically made of wood or recyclable plastic.

10. **Q: Can I use the MGS without blockouts?**

    A: Yes, where there is no space for the blockouts and posts together, like on steep slopes in the mountains. Please see the Project Special detail standard: D-606-2 – MGS 31 Inches without Blocks for designing the MGS without blockouts.

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11. **Q: Have terminal sections for 31-inch W-Beam guardrails been found eligible without blockouts or do all systems have either 8 inch or 12 inch blockouts? Can they be used with systems without blockouts?**

    A: Current CDOT end terminals for 31 inches and 28 inches are both options. When repairing, best practice is to match the existing situation. For example, if you are replacing an end terminal on a system between 26.5 inches and 28 inches, use a matching terminal that will not require a transition. Alternatively, a 27 or 27 ¾-inch terminal may be installed and transitioned to 31 inches when you reach beyond 25 feet downstream end of the terminal. Consult the terminal manufacturer the latest design details.

12. **Q: What is an impact attenuator?**

    A: An impact attenuator or "crash cushion," is a common device used on our highway system to shield hazardous objects. Attenuators may be installed on the ends of guardrail, at gore areas, toll booths, concrete barrier ends, bridge piers, or other potentially hazardous areas.

13. **Q: What type of crash cushions can be used?**

    A: Please see CDOT's Safety Selection Guide on Crash Cushions, End Treatments, and Barrier for assistance in the proper selection and use of hardware.

14. **Q: Which end treatments can be used with guardrails?**

    A: Site-specific conditions such as the speed limit, slope, or roadside hazards should be taken into consideration when selecting an end treatment at the end of the guardrails. Please see M-Standard M-606-1, Midwest Guardrail System (MGS) Type 3 W-Beam 31 Inches for end treatments choices and their detail drawings, and the CDOT Safety Selection Guide for further information.

15. **Q: When highways are signed for 75 mph, shouldn't crash cushions be used that have been crash tested at speeds higher than 62.5 mph?**

    A: No, the FHWA Office of Safety considers that a 62.5 mph test is representative of worst case run-off-road crashes. That regardless of posted speeds, most impacts with fixed objects occurred at somewhat reduced speeds, probably because most drivers are braking hard as they are about to run off the road or into some fixed object. Historically, crash cushions have been directly responsible for very few fatalities and even fewer of these can be attributed directly to inadequate cushion capacity. A longer cushion will perform better in some head-on full-speed crashes, but the cost-effectiveness of a 75 mph cushion over a 62.5 mph design has not proven. The FHWA position is that highway features tested to Report 350 TL-3 (i.e., 62 MPH) are sufficient. TL-4 and 5 are intended for trucks over 17,000 lbs. MASH and NCHRP 350 Test Levels are as follows:

Test Level	NCHRP 350 (MPH)	MASH (MPH)
1	31	31
2	43	44
3	62 and up	62 and up
4	50	56
5	50	50

Manufacturers sometimes certify above 62 MPH, but those certifications are not related to FHWA, MASH, or NCHRP 350.

16. **Q: If guardrail crosses a culvert and a post cannot be driven into it, can the post be omitted?**

A: The 31-inch Midwest Guardrail System (MGS) has been successfully tested with up to three posts omitted over a gap for a maximum span of 25 feet. **One post may be omitted without any modification to the guardrail run.** When omitting two or three posts, three special breakaway timber posts are installed at each end of the gap but the guardrail does not have to be doubled up, or "nested". Standard 28-inch W-Beam guardrail may also be installed over a gap with up to three omitted posts for a span of 25 feet, and with three breakaway timber posts at each end. However, the guardrail must be nested across the gap and the 6 breakaway posts. The MGS system is allowed to be placed closer to the headwall than the nested 28-inch W-beam long span system. Please see M-Standard M-606-1, Midwest Guardrail System(MGS) Type 3 W-Beam 31 Inches, Sheet 18 of 19 for details and information.

17. **Q: Is it appropriate to use re-straightened guardrail w-beam panel?**

A: No, all W-Beam guardrail types are placed under significant tensile loading when they are impacted. They are at their performance limits when tested to the AASHTO Manual for Assessing Safety Hardware (MASH) Test 3-31 crash standards. Any potential alteration of the strength of the rail by deformation during an impact or by re-straightening could compromise its performance.

Useful FHWA links:

- W-Beam Guardrail Repair Guide: https://safety.fhwa.dot.gov/local_rural/training/fhwasa08002/
- Criteria for Restoration of Longitudinal Barriers http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_656.pdf
- Task Force 13 Guide to Standardized Highway Barrier Rail Hardware: http://www.aashtotf13.org/Barrier-Hardware.php.

18. **Q: Can a mow strip be paved under Cable Barrier guardrails to prevent vegetation growth?**

A: Yes. Leave-outs are not required around cable barrier posts as they are with guardrail posts. Do not use any kind of asphalt spray, seal coat, or chip seal treatment for mow strips. The designer must also consider the concerns of maintenance personnel when determining the optimum vegetation control to be used.

19. **Q: What kind of highway guardrail hardware must be replaced or upgraded?**

A: On September 29, 1994, the FHWA Executive Director signed a memorandum "Action: Traffic Barrier Safety Policy and Guidance" that identified various items that were to be inventoried and scheduled for replacement or upgrade if found within the clear zone. The FHWA Headquarters did not conduct a formal follow up to that memo. But now, more than 15 years later, it is time all remaining examples of these devices/situations be scheduled for correction as soon as practical. Terminals meeting NCHRP Report 350 or MASH are to be used.

The following terminals/transitions will be upgraded on the NHS:

- Blunt End Terminals***** for W-beam guardrail or median barrier.
- Turned-down terminals*****

- Bridge approach guardrail that is not connected to the bridge railing.

The following device will be upgraded when encountered within the limits of a project on the NHS:

- Breakaway Cable Terminal**

*****Versions of these terminals may be used on the downstream end to anchor the rail if they are outside the reverse direction clear zone and/or cannot be struck by vehicles crossing the centerline or median, impacting from the opposite direction.

******The BCT may also remain as a downstream anchor if outside the clear zone. It is also acceptable for use within some cable-to-guardrail transition designs. A crash test of the BCT as a Test Level 2 device failed.

If you would have further questions or would like to comment on this Guardrail FAQ, please email M-Standards Engineer Dave Kosmiski, (david.kosmiski@state.co.us), thank you.