U.S. Department of Transportation
Federal Highway Administration

Memorandum

SENT VIA ELECTRONIC MAIL

Subject: ACTION: Application and Installation of Roadside Hardware (**REVISED November 3, 2010**)

Date: November 3, 2010

From: Michael S. Griffith
Director, Office of Safety Technologies

In Reply Refer To: HSSI

To: Division Administrators

Summary of Action Required

This memorandum addresses the proper application and installation of roadside safety hardware, and supersedes the memorandum of the same subject dated October 1, 2010. Each Division Office should ensure that its State highway agency includes safety hardware design, selection, construction, and maintenance in their oversight reviews of projects on the National Highway System (NHS).

Background

While many devices have been developed to improve roadside safety, it is imperative that their effectiveness be maintained through proper application and installation. In other words, we must assure that the correct device is used for a particular situation, and that it is installed correctly.

It is the responsibility of the owner agency to verify proper hardware selection and installation for the intended use. Misapplication of safety hardware can result from misinterpretation of details of the crash tested hardware in the design, construction, and maintenance phases. As a service to the roadside safety community, the FHWA has been writing formal Acceptance Letters for roadside hardware since 1976. Letters are issued for devices that have been successfully crash tested, or have been evaluated by FHWA and judged to be equivalent to crash tested devices because of their similarity to the original device. These letters acknowledge that the devices meet the requirements of NCHRP Report 350 or the AASHTO Manual for Assessing Safety Hardware (MASH) and often include detailed information on proper installation or cautions on improper usage.

For example, our acceptance letter for a crash cushion included the following:

> "Non-redirective, gating systems are designed to allow penetration into the area behind the system when struck at an angle on the side by an errant motorist. Furthermore, as seen in [the crash testing] some high-angle, high-speed impacts into the side of the… attenuator can result in vehicular vaulting and subsequent intrusion over 100 feet into the area behind the barrier, thus requiring a significant clear runout area. This fact must continue to be stressed in your product literature and to your customers to ensure proper barrier design and layouts in the field."

Each Division Office should ensure that its State highway agency includes safety hardware design, selection, construction, and maintenance in their oversight reviews of projects on the NHS. State personnel should be made aware of the resources available on the FHWA Safety Web site where details of each federally-accepted roadside safety device are linked: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware.

Attachment A consists of frequently asked questions regarding the proper installation of accepted roadside safety hardware and its intended use. Attachment B consists of errata to the AASHTO MASH courtesy of the Midwest Roadside Safety Facility.

2 Attachments

cc: Mr. John R. Baxter, Associate Administrator for Federal Lands
Mr. King W. Gee, Associate Administrator for Infrastructure
Mr. Jeffrey A. Lindley, Associate Administrator for Operations
Federal Land Engineers
Mr. Pat Hasson, RC Safety and Design Technical Service Team
Mr. Rob Elliott, RC Construction and Project Management Technical Service
Mr. Grant Zammit, RC Operations Technical Service Team
Mr. Shay Burrows, RC Structures Technical Service Team
Safetyfield

Attachment A

More Frequently Asked Questions

(The first series of frequently asked questions (FAQs) are on line at: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/qa_bttabr.cfm)

The FHWA barrier guidance is contained in the AASHTO Roadside Design Guide. However, FHWA field offices raise numerous issues that involve interpretations, extrapolations, device selection, hardware deployment, or simply trying to fit safety devices into real world conditions. These questions and answers offer clarification on the use of roadside hardware for issues not covered by FHWA policy or topics that simply need additional explanation. These answers represent the professional opinions of engineers in the FHWA Office of Safety. Please refer to these FAQs before contacting FHWA Headquarters or Resource Center experts.

The Division Office is in the best position to know if any of these concerns apply in its State. Please discuss them with your State and express our mutual interest in seeing that roadside safety hardware is selected, designed, installed, and maintained in a manner that will achieve the greatest probability of saving lives.

CRASH CUSHIONS

Q: WHEN CAN I USE A NON-REDIRECTIVE CRASH CUSHION?

A: Care must be used in applying a non-redirecting, gating crash cushion. They are designed to decelerate a vehicle impacting head-on on the nose. Vehicle penetration is likely to occur for angle hits from the nose to near the mid-point of the array. Vehicle penetration / override of the system is possible for high speed, high angle impacts near the rear of the device.

All gating, non-redirective crash cushions should be applied to hazards that are not likely to be impacted at an angle on the side at any significant velocity. They are appropriate on low speed facilities, and in work zones with higher speeds where lane widths are constrained and the potential for high angle hits is limited. Potential problems with these non-redirecting attenuators include vaulting over the nose of the attenuator into the work area, and inadequate clear run out areas behind the devices. Side redirect impacts into these devices are known to push acceptable safety limits and as such, their use in the field requires scrutiny to ensure adequate safety for both vehicle occupants as well as workers in downstream construction areas. Typical examples of non-redirecting/gating attenuators installed in a manner that increases the likelihood of compromised impact performance include: 1) not providing adequate clear run-out areas behind these units and 2) positioning them at sites where the probability of high-speed, severe-angle (i.e. - high energy) impacts is high.

All users of these devices should be made aware of the factors that contribute to proper performance as outlined in the crash test report. Examples of non-redirecting, gating crash cushions include all sand barrel arrays, the Triton CET (Concrete End Treatment), ACZ350, NEAT, and the ABSORB 350.

Please note that adequate clear run out areas are required for both non-redirective and redirective devices. The run out areas are longer for non-redirective devices. The additional length is typically the length of the non-redirective device.

It should also be noted that non-redirective crash cushions such as sand barrel arrays can pose a hazard if impacted in the reverse direction on the heavy barrels adjacent to the rigid hazard. Impact in the reverse direction at this point in the array is untested and the large mass of the final barrels could cause rapid and violent deceleration of the impacting vehicle that would exceed our occupant risk limits.

Q: WHAT TYPE OF CRASH CUSHION SHOULD I USE?

A: When more than one crash cushion / impact attenuator system is approved for use in your State, carefully evaluate the structural and safety characteristics of each candidate system for the site in question. These include such factors as impact decelerations (as indicated by the Test Level to which the device was tested), redirection capabilities, anchorage and back-up structure requirements, and debris produced by impact. All of the systems described in the Roadside Design Guide as meeting MASH or NCHRP Report 350, TL-3 evaluation criteria have the capability to stop compact cars and pickup trucks impacting head-on at 100 km/h [62 mph] within tolerable deceleration levels, and to redirect or contain those vehicles impacting on the sides of the units within the system's length-of-need. However, the costs of initial installation and maintenance, the ease of repair, and the system's durability (to environmental conditions and impacts) vary greatly. In addition, the contract plans need to include enough details showing the type of system desired, the hazard needing protection, and/or how the specifying agency intends to have the device attached to the hazard.

Attenuators that are categorized as *self-restoring* or *low maintenance* are premium systems that are designed for high traffic areas where impacts can be expected to be frequent. The high initial cost can be offset by the long-term savings in maintenance and repair costs.

Traffic speeds, geometric constraints, weaving maneuvers, congestion, worker exposure, space available to repair, potential for secondary impacts, and sight distance are just a few of the factors that should be considered at potential locations for redirective crash cushions. They have demonstrated the ability to redirect vehicles away from the corner of the hazard, as well as safely decelerate vehicles hitting the nose of the attenuator head-on.

Sand barrel arrays are most appropriate for hazards that are located well off of the traveled way where impacts are expected to be infrequent, yet very serious when they do occur. The relatively low initial cost of these sacrificial crash cushions is a good investment to prevent serious injury when a crash does occur.

W-BEAM GUARDRAIL

Q: WHERE DO I MEASURE THE HEIGHT OF THE GUARDRAIL FROM?

A: There are a number of different scenarios for guardrail height measurement. Only the first one is easy:

1) Guardrail is located above pavement: Measure the height from the pavement to the top of the w-beam rail.

2) Guardrail is located 2 feet off of 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) 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) Guardrail is located down a 1V:10H slope: Measure from the *nominal terrain*. Good contractors can get fairly even grading, but it will rarely be perfect enough to always be spot on the design height. Use a string line or straight edge to even out terrain variations.

5) Guardrail is located down a 1V:4H slope: If located more than 2 feet beyond the slope break point, remove the guardrail. Guardrail may not be placed on a steep slope. The Roadside Design Guide specifies where you may place guardrail on slopes as steep as 1V:6H, but guardrail must remain about two feet off the edge of the shoulder when there is a 1:4 slope behind it. (If steeper than 1:3 you may need longer posts, or additional posts, but that is yet another forthcoming FAQ pending the completion of ongoing research.)

Q: WHY IS THE W-BEAM CONSTRUCTION TOLERANCE NOW ONLY ONE INCH?

A: Crash testing has shown that the standard strong post w-beam guardrail without rub rail is acceptable in the range from 27-3/4 inches to 30 inches above the ground. When the rail was tested at a lower height the pickup truck vaulted over the rail. A taller rail without rub rail can cause significant wheel snagging on small cars. This leaves a very narrow range of installation heights, and FHWA recommended 29 inches +/- one inch.

The Midwest Guardrail System (MGS) tolerance is greater at plus one to minus three inches. The MGS was initially tested at its design height of 31 inches with 12-inch blockout with no rub rail. It was known that the performance would be acceptable down to 27-3/4 inch just like the G4(1S) but we wanted to encourage the taller initial height so we recommended a construction tolerance of just one inch from the design height of 31 inches. A subsequent crash test (in July 2010) of the MGS at a height of 34 inches using the small passenger car was successful (which is generally considered the worst case scenario for tall guardrail), and now testing with the MASH pickup truck at 34 inches (or above) is pending to confirm an installation tolerance of +/- 3 inches.

Q: HOW DO WE HANDLE THE HEIGHT TRANSITION BETWEEN G4(1S) AND MGS AND THEIR TERMINALS?

A: You should transition from a 27-3/4 inch tall barrier or terminal to a 31-inch tall barrier over the span of two 12-foot, 6-inch pieces of w-beam rail. When replacing or repairing long portions of a damaged rail the new rail should be installed at the proper design height, transitioning down to the existing rail over the length of two 12 foot, six inch, pieces of rail at either end. W-Beam to Thrie-Beam bridge transitions may need to use the non-symmetric W-to-Thrie connector that keeps the top height of the entire rail at approximately 31 inches. In addition, there is no need to transition in height to many 27 ¾-inch high terminals. The SKT, FLEAT, and ET end terminals have all been tested and accepted at the 31-inch rail height and provide the benefits of 31" guardrail without transitioning in height down to a lower system

Q: OUR GUARDRAIL CROSSES A CULVERT AND WE CAN'T DRIVE A POST. CAN WE OMIT THE POST?

A: The Midwest Guardrail System (31-inch rail height) has been successfully tested with three posts omitted, leaving a span of 25 feet. Special posts (CRT, or Controlled Releasing Terminal posts) are used at either end of the gap but the rail does not have to be doubled up, or "nested" over the gap. Standard strong-post w-beam rail (minimum 27-3/4 inch rail height) can also be installed with three CRT posts at either side of a three- post gap, but the rail needs to be nested across the gap as well as up- and down-stream from the gap, for a total length of 100 feet. In addition, the MGS system is allowed to be placed closer to the headwall than the nested W-beam long span system.

Q: CAN WE PAVE A MOW STRIP UNDER OUR GUARDRAIL?
Q: CAN WE PLACE GUARDRAIL POSTS IN A CONCRETE SIDEWALK OR MEDIAN?

A: Concrete or asphalt pavement under the guardrail would have to be constructed with a gap behind the post and backfilled with a loose material to allow the post to move when the rail is struck. An asphalt spray surface treatment would be acceptable as it would not prevent post movement through the soil. There are also various commercial products that can be placed under the W-beam to block weeds. Check with the manufacturer to see that they have designed the product with post deflection in mind. The FHWA also provided guidance on this issue in 2004 in our memorandum "W-Beam Guardrail Installations in Rock and in Mowing strips," http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/pdf/b64b.pdf

Q: HOW CAN WE DESIGN OUR BARRIERS TO BE "MOTORCYCLE-FRIENDLY?"

A: Any time a motorcyclist leaves the roadway unintentionally there are likely to be severe consequences. Even the "safest" barriers can cause serious injury whether the motorcyclist is still on his/her bike or they are sliding/rolling on the pavement. Although there are many barrier modifications being used in Europe intended to moderate the severity of impact with guardrail posts, FHWA does not yet advocate the use of any such modifications on the NHS. As of Fall, 2010, there are two research projects underway that will analyze motorcycle crashes in depth.

One is a general study of motorcycle crash causes, while the other is specifically targeting motorcycle impacts with roadside barriers. When these studies are completed, we hope to have information that will help us to determine the nature of motorcycle impacts with barriers, and whether or not the barriers can be redesigned without adversely affecting the good performance we have experienced with four-wheel passenger vehicle impacts to date.

Q: MANY OF OUR GUARDRAIL TERMINALS HAVE A STEEL BEARING PLATE ON THE FIRST POST THAT SOMETIMES ROTATES UNTIL IT IS UPSIDE-DOWN. IS THIS OK?

A: No. This bearing plate (8 x 8-inch square with an off-center hole) must be installed with the longer dimension upright (5" dimension up and the 3" dimension down). If the cable slackens over time traffic vibrations may allow this plate to rotate downward due to gravity. If this happens the ability of post #1 to fracture in a head-on impact (thus preventing a snag point) is severely compromised. On wood posts, a nail can be driven to prevent this rotation. A solution that works on both wood and steel breakaway posts is to specify that this steel plate be fabricated with tabs on either side that will wrap around the side of the post an inch or so to prevent rotation. This is an acceptable modification to all crashworthy terminals that use this 8 x 8-inch bearing plate. Of course, it is still critical to install the bearing plate with the 5" dimension up and the 3" dimension down. (The function of the bearing plate is to transfer load from the cable to the end anchorage.)

Q: HOW DO WE KNOW THAT DAMAGED BARRIER NEEDS REPAIR?

A: Small dents and dings do not seriously affect the performance of guardrail. Vertical tears and bent posts are a different matter. A recent NCHRP study was completed and published as “Criteria for Restoration of Longitudinal Barriers” and it is available for download at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_656.pdf.
Also, the 2008 FHWA guide “W-Beam Guardrail Repair” is available for download at: http://safety.fhwa.dot.gov/local_rural/training/fhwasa08002.

Q: WHAT GUARDRAIL HARDWARE MUST BE REPLACED OR UPGRADED ON THE NHS?

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 should be upgraded on the NHS:
1. Blunt End Terminals* for W-beam guardrail or median barrier.
2. Turned-down terminals*
3. Bridge approach guardrail that is not connected to the bridge railing.

The following device is to be upgraded whenever encountered within the limits of a project on the NHS:

4. Breakaway Cable Terminal**

We are currently preparing a memorandum dealing with upgrading of length-of-need guardrail and will address height of the barrier that may remain in place, offset blocks, rectangular washers, post length relative to the hinge point, and other details.

*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.

Q: WHAT KIND OF FOUNDATION DO WE NEED FOR OUR CONCRETE MEDIAN BARRIER?

A: Many variations exist between highway agencies regarding reinforcing and footing details for concrete median barriers; however, there have been few reported problems with any particular design and a need for a standard detail is not apparent. Concrete median barriers develop loads as a function of the barrier capacity and the foundation capacity. While it is true that some median barrier designs have been show to work with minimal foundation design, this does not suggest that any median barrier design can be installed in this manner. Thus, it falls on the designer to consider the combination of barrier and foundation that meets the design impact loading safely.

BREAKAWAY DEVICES

Q: SHOULD WE USE BREAKAWAY BASES FOR SIGN AND LIGHT POLES MOUNTED ON CONCRETE MEDIAN BARRIERS?

A: No, breakaway bases should not be used. Mounting any pole on top of a median barrier should be avoided because trucks will lean over the barrier upon impact and hit whatever is on top. A rigid pole may or may not break off, but there is no safety advantage in making it easier for the pole to break away and fly into the opposing travel lanes.

The potential for a pole being struck by the box of the truck can be minimized by making the barrier wider. If you transition to a vertical face and/or taper the width of the barrier you can provide additional offset to the pole. The point is to minimize the potential for broken poles to fly into the opposite roadway. Larger passenger vehicles as well as their occupants may contact objects on top of barriers under severe impact conditions.

Work zone signs may be mounted on barriers if you use roll up signs on fiberglass supports as they have less potential for causing serious damage.

Q: CAN WE STILL USE PENDULUM TESTS TO ASSESS BREAKAWAY PERFORMANCE OF SIGN AND LIGHTING POLES?

A: The status of pendulum testing under MASH is undetermined – if the bases can be considered modifications of bases tested under Report 350 then we will agree to review pendulum testing done under 350 criteria (until 1/1/11). If they are totally new designs, then they need to be tested under MASH. Whatever test method you use must evaluate the roof crush and windshield damage as required in MASH. Based on experience in reviewing both full scale testing and pendulum tests of breakaway supports, we do not see how pendulum testing can answer those questions. The old "rule of thumb" limiting luminaire supports to 1000 pounds cannot be relied upon because vehicle structures have changed and MASH now requires the pickup truck be used. Crash tests of luminaire supports with pickups is very limited (we are not aware of any such tests) so we have no way to assess the potential for roof crush except through full-scale testing.

Q: SHOULD WE USE OMNI-DIRECTIONAL BREAKAWAY BASES EVERYWHERE?

A: Crashworthy omni-directional bases are designed to meet NCHRP Report 350 criteria regardless of which direction they are struck. They are required when installing signs and other breakaway hardware near intersections (including expressway ramps ending on local roads and in roundabouts) and preferred on other undivided facilities. Uni-directional bases (i.e., 4-bolt slip bases) should only be used along divided highways where impacts are limited to the direction of travel of the roadway they are next to.

Q: SHOULD TREES, POLES, OR OTHER FIXED OBJECTS BE ALLOWED IN A ROUNDABOUT?

A: Typically it is desirable to have some type of streetscape/landscaping installed within the central island of the roundabout to increase conspicuity, break the headlight glare of oncoming vehicles, and promote lower speeds through the roundabout. However, care is needed when considering landscaping that introduces fixed objects that may pose a safety concern for errant vehicles. In most cases, fixed objects should be minimized in the perimeter area of the central island where there is a higher risk of the objects being struck.

Small trees, structures and statues placed within the inner portion of the central island may offer the benefit of helping obscure the line of sight straight through the roundabout. The perimeter portion of the central island may be landscaped with low-level vegetation so that stopping sight distances are maintained for vehicles within the circulatory roadway and at the entrance lines of the roundabout.

As for "clear zone", consideration of the roundabout context and expected operating speeds should be considered consistent with the principles outlined in the updated AASHTO Roadside Design Guide for urban conditions.

Q: WHAT IS THE JANUARY 1, 2013 DEADLINE FOR BREAKAWAY SUPPORTS?

A: All sign supports within the clear zone of highways signed at speeds of 50 mph or greater must be mounted on breakaway supports or be shielded with a barrier by January 1, 2013, per the MUTCD.

Breakaway supports meeting the current crash test criteria* have been required on all Federal-Aid Projects since 1990. (Since the ISTEA of 1991 that requirement has applied to all projects on the NHS regardless of funding source.) The 2000 edition of the MUTCD made breakaway supports mandatory for signs within the clear zone <u>of all roads open to public travel in the United States.</u> This requires that all new sign installations be on breakaway supports. While shielding with guardrail is an option, use of breakaway supports is preferred. The 2003 edition of the MUTCD set a 10-year implementation period to retrofit sign supports on highways signed at 50 mph or greater.

* The 'current crash test criteria' were established in 1985 with the publication of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. The 1993 NCHRP Report 350 incorporated *the same test and evaluation criteria* in metric form. Because the metric conversion in Report 350 resulted in tests that were slightly more liberal than the 1985 Specifications, all breakaway testing done between 1985 and 1993 is considered acceptable under NCHRP Report 350. The 2009 MASH adds the pass/fail criteria for windshield damage and roof crush, and requires testing with the 5000# pickup truck, but maintains test and velocity change evaluation criteria for the small car equivalent to that adopted in 1985.

Q: WE WANT TO ADD LIGHTS, A BATTERY, AND A SOLAR PANEL TO OUR SCHOOL ZONE SIGN. DOES THE COMBINATION HAVE TO BE CRASH TESTED?

A: There are four factors that determine the acceptability of breakaway supports:

1. Stub height (Must be 4 inches or less. As this will not change with the addition of auxiliary hardware it will not be discussed further.)
2. Vehicle velocity change / occupant impact forces. The addition of flashing lights and solar panels or other auxiliary equipment will not likely affect the change in velocity experienced by the vehicle or its occupants unless it becomes substantial compared to the mass of the pole. Additional hardware attached at or above the sign will raise the center of gravity of the system slightly but since it is away from the base the breakaway features will still perform as intended. The overall mass of the pole, sign, and auxiliary equipment should not exceed 600 pounds.
3. Windshield penetration. Windshield damage was not a formal pass/fail criterion under the 1985 AASHTO Sign and Luminaire spec and we did not change this when we adopted Report 350 in 1994. However, windshield damage will be pass/fail evaluation criteria under the AASHTO MASH. If the auxiliary hardware is at or above the sign, the effect should be minimal.
4. Roof crush. Roof crush up to 5 inches was permitted under NCHRP Report 350, but very few sign installations even approached that amount. (Luminaire poles weighing 1000#

or more could easily fail this test.) The addition of more hardware could increase the risk under low speed impacts, but roof crush can be controlled by following the 600 pound weight limit mentioned above. Under MASH, roof crush will be limited to 3 inches maximum.

Safe placement of these types of devices on the sign also depends on the structure of the sign, the sign height, the type of vehicle impacting the sign, and the breakaway nature of the sign support when it is impacted. The conditions outlined above assume the sign pole is rigid and that the pole itself will not deform upon impact. Also the breakaway feature must be a slip base, frangible coupling system, or a cast aluminum transformer base – "base bending or yielding" systems such as u-channel posts, perforated square steel tube posts, or composite posts require full scale crash testing.

Attachment B

MASH ERRATA

(Courtesy of the Midwest Roadside Safety Facility)

This document contains all of the known corrections to the MASH 2009. The corrections are noted below. This document will be further updated over time as more corrections are identified.

Corrections

I. Appendix B - In the publishing of the final document, Appendix B was published using one of the early drafts of the section rather than the final version. As such, there are several discrepancies between the final version of Appendix B and the version in the published MASH document. These discrepancies include:

   a. The soil test post size was changed from W6x15 to W6x16. A W6x16 was used in the test program to produce similar flange width to the standard W6x9 post . The W6x16 post was also used in order to prevent yielding of the post during deflection through the soil, thus allowing the testing to isolate the soil response.

   b. Changed the size of the soil fill hole on the drawings from 24" diameter to 36" diameter. We used a 36" hole in the 22-14 program and would recommend that labs use a similar size hole for their testing, however, it is not required to do so. There is some concern that a 24" hole may be too small to develop consistent post loading through 15" of post deflection.

   c. Some English to metric unit conversions were incorrect and were fixed.

   d. Some of the graph legends and formatting were modified for clarity.

   e. The unconfined compressive strength test noted in section B5 was changed from AASHTO T 208 to ASTM D2166.

   f. The final version of Appendix B is located on the AFB20 server with this document.

      i. \\129.93.15.147\public\AFB20\MASH Errata and Clarifications\

II. Table 5-1 of MASH:

   a. Criteria H should include Test Designation No. 82

   b. Criteria I should include Test Designation Nos. 45, 54, 60, 61, 62, 70, 71, 72, and 82.

   c. Test Designation No. 44 should be removed from Criteria I

d. Criteria N should include Test Designation Nos. 37 and 38 for gating terminals as well as Test Designation Nos. 40, 41, 45, 62, 72, 82, 90, 91

III. Table 2-1 of MASH:

a. Table 2-1 of MASH is currently labeled as gross static mass for the MASH test vehicles. However, gross static mass includes the mass of a surrogate occupant by definition, and this has caused some confusion. Table 2-1 should be labeled "Vehicle Test Inertial Mass Upper and Lower Limits" in order to alleviate any confusion.

IV. Table 4-1 of MASH

a. Table 4-1 of MASH currently lists the recommended masses and tolerances for the 1500A vehicle. The test inertial mass for the 1500A vehicle is listed a 3300 ± 220 lb (1500 ± 100 kg) while the gross static mass is listed as 3300 ± 75 lb (1500 ± 35 kg). The tolerances listed are incorrect on the 1500A vehicle for the test inertial mass. The test inertial mass should read 3300 ± 75 lb (1500 ± 35 kg).

If further corrections are identified, we will continue to notify all of you. We would also request that the users of MASH contact us with other issues or discrepancies that they identify, so we can correct them and notify the group