Session 3: Testing Requirements and Performance Characteristics of Common Barrier Systems
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Session 3 Learning Outcomes

At the end of this session, you will be able to:

- Understand how barriers are tested for crashworthiness
- Identify common barrier systems
- Explain how these barrier systems function
- Define the key components of a transition design

Crash Testing Guidelines

- In 1993, crash testing and evaluation criteria were published as NCHRP Report 350
- In 2009, the Manual for Assessing Safety Hardware (MASH) was published by AASHTO. It was used by FHWA as the testing standard for all new products
- In 2016, an update to MASH was adopted and a timetable for implementation of new installations complying with this edition was signed between FHWA and AASHTO
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MASH Implementation Timeline
(January 1, 2009 – January 1, 2020)

2008
MASH Published

2016
MASH 2016

December 31, 2017
• W-Beam Barriers
• Cast-in-Place Concrete Barriers

December 31, 2018
• Crash Cushions

December 31, 2019
• W-Beam Tangent Terminals

2016 December 31, 2019
• W-Beam Barriers
• Cast-in-Place Concrete Barriers

MASH 2016 Published
• Bridge Rails
• Transitions
• All Other
• Barriers/Portable
• All Other Terminals
• Cable Barrier and Terminals
• Sign Supports
• Other Breakaway Hardware

2009 MASH Published
June 30, 2018
• Crash Cushions

December 31, 2018
11 years
10 years
9 ½ years
7 years
2 years

Ref: AASHTO/FHWA Agreement, Jan. 2016
Modified: 08/03/2018

• W-beam Tangent Terminals

MDT MASH Implementation
Included terminals by 12/31/17

Montana Department of Transportation

Memorandum
To: e-distribution
From: Lardy Tribalhorn, P.E., Highway Engineer
Date: February 6, 2018
Subject: MASH Guardrail Implementation Guidance

General
This memo is intended to provide guidance in support of MASH policy 0-03-302 (Ridgeline Safety Hardware Upgrade Policy), as approved and revised to the date of this publication. Specifically, the guidance is applicable to section 3.3 of the policy procedures manual, as it pertains to new w-beam guardrail permanently installed on all Federal Aid projects after Dec. 31, 2017.

Included Items
MDT will specify the following Guardrail System (MGS) w-beam barrier with 6-inch blocks for all new permanent w-beam installations on projects after the 2017 calendar year. In most instances, this system is identical to the w-beam system currently used on the state highway system. However, the MGS is mounted at a height of 5 feet above the midplane of post connections. The following is a list and brief description of the terms MDT utilizes for MASH w-beam guardrail:

• W-Beam Barriers
• Cast-in-Place Concrete Barriers
• Crash Cushions
• W-Beam Tangent Terminals

Participant Notebook  Page 3-2
Selection of a performance level is based on speed and traffic mix.

- **TL-1, TL-2, and TL-3**: crash tests with small car and pickup truck with a 25° impact angle at 31, 44, and 62 mph, respectively.

**MASH Test Conditions**

- 2,420 lbs. 1100C
- 5,000 lbs. 2270P

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**NCHRP 350 comparison with MASH Crew Cab Truck**

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MASH Test Conditions (cont’d)

- **TL-4**: TL-3 + 15° impact angle, 56 mph Single-Unit Truck
- **TL-5**: TL-3 + 15° impact angle, 50 mph Tractor-Van Trailer
- **TL-6**: TL-3 + 15° impact angle, 50 mph Tractor-Tank Trailer

<table>
<thead>
<tr>
<th>Weight</th>
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<tbody>
<tr>
<td>22,000 lbs.</td>
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<tr>
<td>80,000 lbs.</td>
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Functional Requirement of Barrier

1. Contain Vehicle
   - No Penetration
   - No Vaulting/Under-riding
2. Redirect Vehicle Smoothly (low exit angle) with no snagging/overturning, and no excessive rotation (75 degree max)
3. Tolerable Occupant Impact Forces
4. Minimum Occupant Compartment Deformation and no Debris Intrusion
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Standard Barrier Systems

- Rigid Systems
- Semi-Rigid Systems
- Flexible Systems
- Median Barrier Systems

Barrier Systems: Rigid Barriers

Rigid Barrier Systems have little (between 0 to 1 ft.) deflection under the TL-3 pickup impact. They are generally anchored by some acceptable means.

Examples include:

- New Jersey Safety Shape Concrete Barrier
- F-shape Concrete Barrier
- Single or Slope Concrete Barrier
- Vertical Wall
Rigid Barrier

F-Shape

Vertical Wall

MASH Testing of 32" New Jersey Shaped Concrete Barrier

Video Clip
MDT Rigid Barrier – NJ Shape
MDT Rigid Barrier – NJ Shape

[Diagram of MDT Rigid Barrier – NJ Shape with dimensions and specifications]
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MUST MAINTAIN TENSION IN BARRIER SYSTEM

PRE-ASSESSMENT PHOTO
MUST MAINTAIN TENSION IN BARRIER SYSTEM
### Barrier Systems: Semi-Rigid

Semi-Rigid Barrier Systems have deflections of a few feet (between 2 to 5 ft.) under the TL-3 pickup impact. Typically consist of beam and post elements.

<table>
<thead>
<tr>
<th>Semi-Rigid Barrier Systems have</th>
<th>deflections of a few feet (between 2 to 5 ft.) under the TL-3 pickup impact. Typically consist of beam and post elements.</th>
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#### W-Beam Steel Guardrail – “Old”, 350 Guardrail
- 12” wide W-beam rail section (12-gauge thickness).
- Posts are spaced at 6’-3” centers, and the nominal rail height is 27” – 29”
- Rail splice at the post.
- Two post options:
  - Steel posts, W6 x 8.5/9.0 x 6’-0” long.
  - Wood posts, 6” x 8” x 6’-0” long.
  - Blocks: 6” x 8” wood or plastic.
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SPWB with Wood Post & Wood Block-Out 27 5/8” Height

Failed Test!!!

SPWB with Steel Post & Wood Block-Out 27 5/8” Height

Video Clip

Video Clip
Steel Guardrail - Height Measurement
ONLY “Old”, 350 Guardrail

For slopes 10:1 or flatter, the height is measured from the ground directly beneath the rail.

For slopes steeper than 10:1 but no steeper than 6:1, and within 2 feet of the breakpoint, the height is measured from the shoulder slope extended as shown.

Barrier Systems: Semi-Rigid

- Midwest Guardrail System (MGS)
  - 31” Height – Tolerance ±1"
  - Rail Splice mid-span.
  - Post spacing 6’-3”
  - Two post options:
    - Steel posts, W6 x 8.5/9.0 x 6’
    - Wood posts, 6” x 8” x 6’
    - Block: 8” (or 12”) wood or composite
**Midwest Guardrail System (MGS)**

- Rail Splice Mid-Span
- 31”
- 8” or 12”
- 6’-3”

**MGS MASH Test 3-11**

Video Clip
MDT MGS Detail – Steel Post

STEEL POST AND MOUNTING DETAIL

@ STANDARD UNLESS SPECIFIED OTHERWISE IN PLANS.

REFERENCE:

DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

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Existing Guardrail Height

Must be $\geq 27 \frac{3}{4}''$ to remain in place
Box Beam Barrier

Roadside

Median

Box Beam Barrier MASH Test 3-31
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MDT Box Beam Detail

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MDT Box Beam Guidance

9.4.1.3 Box Beam Guardrail

Box beam guardrail (weak post) is a semi-rigid system with a dynamic deflection of 3 feet, 9 inches. Resistance in this system is achieved through the combined flexure and tensile stiffness of the rail. Posts near the impact are designed to break or tear away, thereby distributing the impact force to adjacent posts.

Box beam guardrail is generally used in snow drift areas and areas that require substantial snow plowing where cable guardrail is not acceptable (such as on the inside of curves, where the 12-foot deflection distance required for cable guardrail is not available). Box beam guardrail used on curves with radii less than 715 feet should be shop-bent (Note: NOT WITHIN THE TERMINAL).

Barrier Systems: Flexible Barriers

Flexible Barrier Systems typically have relatively large deflections

Examples of Flexible Barriers include:

- Weak post W-beam
- Low tension cable
- High tension cable

Not presented
Barrier Systems: Flexible Barriers

Advantages of cable systems include:

- Low initial cost
- Lower deceleration forces
- Effective vehicle containment and redirection
- Installation conditions (cable)
- SNOW
Barrier Systems: Flexible Barriers

- High Tensioned Cable Barrier
  - Five different proprietary designs available
  - Each requires a unique proprietary terminal
  - Somewhat reduced deflections
  - Generally easier maintenance
  - Can retain effectiveness after most impacts
High-Tension Cable Systems

- Brifen
- Safence
- CASS (Trinity Steel)
- Nucor
- Gibraltar

MDT HTC Guidance

MDT has used pre-stretched, tensioned cable within the median to address crossover crashes and to close median crossovers left in place. For such installations, MDT requires the posts be socketed for ease of maintenance, and require the rail meets TL-3 criteria. Use information provided in the AASHTO Roadside Design Guide for additional guidance on best practices for placement in the median (2).
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Four Cable System

Video Clip
Which Barrier System to Use?

Barriers in the Median

- Used to separate opposing traffic on a divided highway or to separate through traffic from local traffic.
- Many barriers approved for roadside applications can be modified for use in the median.
- Width of the median is an important consideration.
- Also must consider the dynamic deflection of the barrier to avoid intrusion into opposing traffic.
- There are terminals designed specifically to shield the ends of median barriers.
MASH 27" W-Beam Median Barrier Test

Failed Test!!!

MASH MGS Median Barrier Test

Flexible Median Barriers

Advantage of high tension cable is it may remain effective after impact.
Transition Sections

- When a softer (more flexible) barrier precedes a stiffer barrier, a gradual stiffening must occur between the two systems.
- An effective transitions must provide the following:
  - Adequate connection (TENSION continuity)
  - Adequate length to gradually increase stiffness.
Inadequate Transition

Video Clip

Transition Sections

Successfully crash-tested transitions include the following essential elements (in addition to a structural connection):

- Additional and/or Larger Posts
- Nested rail (w-beam or Thrie-beam)
- Curbs (only as crash-tested transition unit), Rub Rails, and/or Flared Parapet Wall to Prevent Snagging
MGS Transition Design

- Compatible with most existing Thrie-beam to bridge railing transition designs
- Uses a non-symmetrical w-beam to thrie-beam transition piece.
- Posts can either be steel or wood.

MDT Transition – MGS

![Diagram of MDT Transition – MGS](image-url)
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MGS Transition

Video Clip

MDT Transition – MGS
Connections to Low Parapets or Combination Rails

If the concrete parapet or portion of a combination rail is less than the transition height (29”, or 32” for thrie beam), a steel plate may be applicable to adjust the height.
Transition: Box Beam to MGS (w-beam)
Transition: Box Beam to MGS (w-beam)

No stiffening required as relatively same stiffness; must have tension continuity

Transition: HTC to Guardrail (Spatial)
Manufacturers may not be providing this under MASH 16

Review Learning Outcomes

- Understand how barriers are tested for crashworthiness
- Identify common barrier systems
- Explain how these barrier systems function
- Define the key components of a transition design