Crash Testing “Growth”

Common Roadside Hardware Systems

Draft FHWA and AASHTO Requirements for Implementing MASH 2015
Nothing New Under the Sun
The Vehicle Fleet Changes over Time

- https://www.youtube.com/watch?feature=player_detailpage&v=C_r5UJrxccck
Chronology of Length of Need Crash Test Conditions

- **HRB 482 (1962)**
  - 4400# car

- **NCHRP 115 (1971)**
  - 4000 to 5000 lb. cars

- **NCHRP 118 (1972)**
  - 2000 and 4500 lb. cars

- **NCHRP 153 (1974)**
  - 2250 and 4500 lb. cars. ("TL-3")

- **NCHRP 230 (1981)**
  - Added testing for a range of buses and for 80,000 lb. tractor/trailer including van or tanker trailer. ("TL-5" and "TL-6")

- **NCHRP 350 (1993)**
  - Substituted pickup truck for large car in test matrix. Increased impact angle for small car from 15° to 20°. (TL-3)
  - Deleted buses, added 18,000 lb. single unit truck. (TL-4)

- **MASH 2009**
  - Increased mass of pickup truck from 4,400 lb. to 5,000 lb. Increased impact angle of small car from 20° to 25°.
  - Increased mass of single unit truck from 18,000 lb to 22,000 lb. Increased impact speed of single unit truck from 50 mph to 56 mph

- **MASH 2015**
  - Adding more testing conditions for cable barrier to reflect new critical conditions from ongoing crash testing.
Progression of Test Level 3 Impact Severity For Barrier Length of Need Testing

Impact Severity (kJ)

Year


Small Car
Large Car/Pickup

Report 153
Report 230
Report 350
MASH
Progression of Test Level 4 Impact Severity for Barrier Length of Need Testing

- **2009**: MASH 2009 SINGLE UNIT TRUCK - 209.34 kJ
- **1993**: NCHRP 350 SINGLE UNIT TRUCK - 132.06 kJ

Impact Severity (kJ)
The Test Vehicle is a Moving Target
The Test Vehicle is a Moving Target
### Guardrail End Tests for Gating Terminals

<table>
<thead>
<tr>
<th>Crash Testing Criteria</th>
<th>Number of End Terminal Tests</th>
<th>General Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCHRP 153</td>
<td>4</td>
<td>Head-on (2) at End</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Angle at Length of Need (LON) Point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Angle Halfway from End to LON</td>
</tr>
<tr>
<td>NCHRP 230</td>
<td>6</td>
<td>Head-on at End (Large Cars)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Offset Head-on (2) at End (Small Cars)</td>
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<tr>
<td></td>
<td></td>
<td>Angle at Mid-Terminal (2)(Small Cars)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Angle at LON (Large Cars)</td>
</tr>
<tr>
<td>NCHRP 350</td>
<td>7</td>
<td>Offset Head-on at End (Cars)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Head-on at End (Pickup)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Angled at End (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Angled at CIP (Car)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Angled at LON (Pickup)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Opposite Direction at Mid-Terminal (Pickup)</td>
</tr>
<tr>
<td>Crash Testing Criteria</td>
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</tr>
<tr>
<td>------------------------</td>
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</tr>
<tr>
<td>MASH</td>
<td>7</td>
<td>Tests 3-32 and 3-33, angled impact on the nose of the terminal. The impact angle is changed from 15 degrees to 5 degrees. Test 3-35, the length of need point test. Increased the angle of impact from 20 degrees to 25 degrees for the pickup. Test 3-37 (was formerly covered by deleted Test 3-39), the reverse direction impact. Increased impact angle for the pickup from 20 degrees to 25 degrees, and changed the impact point from L/2 to the critical impact point. Test 3-38 is newly defined for MASH. It is a head-on (zero degrees) impact on the nose of the terminal with an intermediate car (1500A)</td>
</tr>
</tbody>
</table>
Gating Guardrail Terminal Test 3-32 and Test 3-33
NCHRP 350 vs. MASH

First, the NCHRP 350 condition.

- NCHRP 350 Small car (820C) Test 32; or Pickup (2000P) Test 33
- 100 kph impact speed
- 15 degree impact angle
Gating Guardrail Terminal Test 3-32 and Test 3-33
NCHRP 350 vs. MASH

Compare to the MASH condition.

- MASH Small car (1100C) Test 32; or Pickup (2270P) Test 33
- 100 kph impact speed
- 5 degree* impact angle

*Flatter angle is considered more critical for gating devices in most cases.

Summary

- Flatter impact angle
- Heavier vehicle.
Gating Guardrail Terminal Test 3-35
NCHRP 350 vs. MASH

First, the NCHRP 350 condition.

NCHRP 350 Pickup (2000C)
100 kph impact speed
20 degree impact angle
Compare the MASH condition.

MASH Pickup (2270P)
100 kph impact speed
25 degree impact angle

Summary
- Steeper impact angle
- Heavier pickup.
- IS increases from 90 kJ to 156 kJ.
First, the NCHRP 350 condition.

- NCHRP Pickup (2000P) Test 39
- 100 kph impact speed
- 20 degree impact angle
Gating Guardrail Terminal Test
NCHRP Test 3-39 vs. MASH Test 3-37

Compare the MASH condition.

- MASH Pickup (2270P) Test 37
- 100 kph impact speed
- 25 degree impact angle

**Summary**
- Steeper impact angle
- Heavier pickup.
- IS increases from 90 kJ to 156 kJ.
Gating Guardrail Terminal Test 3-38
New Test Under MASH

- MASH intermediate car (1500A) Test 38
- 100 kph impact speed
- 0 degree impact angle
Criteria are More Detailed and Complex

MASH
Report 350
Report 230
Report 153

In-Service Evaluation
Reporting Evaluation Criteria
Documentation
Test Conditions
Test Installation
Test Vehicles
Type of Device
Lab Certification
Roadside Hardware Overview

- Guardrail Terminals
- Midwest Guardrail System
- High Tension Cable Median Barrier
- Impact Attenuators
- Culvert Gratings
Some Problems with Early Guardrail Terminals
Some Problems with Early Guardrail Terminals
Energy Absorbing Terminal
This page includes approved devices for “Traffic Barrier Terminals” as well as for Impact Attenuators and High Tension Cable Median Barrier.
# Midwest Guardrail System

<table>
<thead>
<tr>
<th></th>
<th>29 inch Guardrail System*</th>
<th>Midwest Guardrail System (MASH Compliant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>29 inches (formerly 27.5 in)</td>
<td>31 inches</td>
</tr>
<tr>
<td>Post Length</td>
<td>6 ft (formerly 6 ft 9 in)</td>
<td>6 ft</td>
</tr>
<tr>
<td>Post Embedment</td>
<td>43 in (formerly 53.5 in)</td>
<td>40 in</td>
</tr>
<tr>
<td>Blockout Depth</td>
<td>12 in</td>
<td>6 in</td>
</tr>
<tr>
<td>Splice Location</td>
<td>On post</td>
<td>Mid Span</td>
</tr>
</tbody>
</table>

* FHWA recommends 29 inches as the minimum nominal top of rail height measured from ground level at the rail to comply with NCHRP 350 crash testing criteria.
Test No. MIW-2
2,034 kg/99.8 km/h/27.7 deg
706 mm (27.8 in.) Height
Vehicle Override & Redirection (Failure)
Dynamic Deflection = 42.7 in.
Test No. NPG-4
1,986 kg/98.1 km/h/25.6 deg
787 mm (31 in.) Height
Vehicle Redirected (Pass)
Dynamic Deflection = 43.1 in.
Midwest Guardrail System

- Changed from 6 in blockout to 12 in blockout.
ELEVATION

FOOTING FOR POST WHEN IMPERVIOUS MATERIAL IS ENCOUNTERED
Hole backfilled with earth or aggregate and capped with HMA mixture or grout.
Why is HTC used?
- To greatly reduce cross median crashes.
- In some cases, to serve as a roadside barrier.

Performance Level?
- Test Level 3

Deflection of HTC?
- Allow 12 feet
- See BDE Manual for reduced deflection
  - (Fig 38-7.F)
• Four cables

• TL-4 (NCHRP 350) on slopes not steeper than 1:6

• TL-3 at locations where the slopes are steeper than 1:6 and not steeper than 1:4
Cable Deflection vs Post Spacing and End Anchor Spacing

Figure 38-7.F
MWP-4 (MASH 3-11)
List of Approved Devices for High Tension Cable Median Barrier

- http://www.idot.illinois.gov/doing-business/material-approvals/metals/index

- This page includes approved devices for “Traffic Barrier Terminals” as well as for Impact Attenuators and High Tension Cable Median Barrier.
Impact Attenuators

Purpose
- Provide crashworthy end treatment for barriers
- Provide crashworthy shielding for point hazards

How they work
- Energy Dissipation
  - Shredding or deforming steel, plastic, or other parts
  - Ported hydraulic cylinder
- Momentum Transfer
  - Water or sand
Impact Attenuators - Redirection

Classifications

- Fully-Redirective
  - Vehicle stays on impact side if it impacts anywhere along the device’s side
- Partially-Redirective
  - Vehicle “gates” through a defined part of the length of the device before reaching the redirective part
- Non-Redirective
  - Vehicle either passes through the device or is captured if impact is on the side of the device.
Partially Redirective Device
Classifications

- Resettable
  - Major parts of the device can be reused by restoring or re-assembling, and possibly replacing low cost parts.
- Severe Use
  - Major parts of the device can be reused by restoring or re-assembling, and possibly replacing low cost parts.
  - Crash cushion should retain some residual capacity to absorb additional frontal impacts while awaiting repairs.
Fully-Redirective Resettable Device
Fully-Redirective
Severe Use Device
List of Approved Devices for Impact Attenuators

- http://www.idot.illinois.gov/doing-business/material-approvals/metals/index

- This page includes approved devices for “Traffic Barrier Terminals” as well as for Impact Attenuators and High Tension Cable Median Barrier.
Culvert Grates for Parallel Slopes

- Emulates a roadside slope
  - 1:3 or flatter
- Needs a clear runout area
- Tested to TL-3
- Grating should extend to the flowline
AASHTO and FHWA Responsibilities

**AASHTO**
- Technical Committee on Roadside Safety will continue to be responsible for developing and maintaining the evaluation criteria as adopted by AASHTO.

**FHWA**
- FHWA will continue its role in issuing letters of eligibility of highway safety hardware for federal-aid reimbursement.
“Encouraged” Actions for Agencies

- Establish a process to replace existing highway safety hardware that has not been successfully tested to NCHRP Report 350 or later criteria.
Upgrade existing highway safety hardware to comply with the 2015 edition of MASH either when it becomes damaged beyond repair, or when an individual agency’s policies require and upgrade to the safety hardware.
Letting Date Deadlines for New Permanent Installations and Full Replacements on National Highway System (NHS)

- **December 31, 2017:**
  - W-beam barriers
  - Cast-in-place concrete barriers
- **June 30, 2018**
  - W-beam terminals
- **December 31, 2018**
  - Cable barriers, cable barrier terminals, and crash cushions
December 31, 2019

- Bridge rails and transitions
- All other longitudinal barriers (including portable barriers installed permanently)
- All other terminals
- Sign supports
- All other breakaway hardware.
Temporary work zone devices, including portable barriers, manufactured after December 31, 2019 must have been successfully crash tested to MASH 2015.

Temporary work zone devices manufactured on or before December 31, 2019, and successfully tested to NCHRP Report 350 or the 2009 edition of MASH, may continue to be used throughout their normal service lives.
After December 31, 2016

- FHWA will no longer issue eligibility letters for highway safety hardware that has not been successfully crash tested to the 2015 edition of MASH.
After December 31, 2016

- Modifications of eligible highway safety hardware must utilize criteria in the 2015 edition of MASH for re-evaluation and/or retesting.
After December 31, 2016

- Non-significant modifications of eligible hardware that have a positive or inconsequential effect on safety performance may continue to be evaluated using finite element analysis.
Questions???

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