Motorcycle Crash Testing

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Roadside Safety Hardware
Roadside Safety Hardware Testing Standards

1962: Highway Research Circular 482
1974: NCHRP Report 153
1980: NCHRP Report 230
1993: NCHRP Report 350
2009: MASH
2016: MASH 2106 Update

Manual for Assessing Safety Hardware (MASH) – Version 2016

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How about Motorcycles?

- Limited research to address riders safety when impacting roadside safety hardware
- No US testing standards for motorcycle riders safety when impacting roadside safety devices
- No world testing standards when impacting in upright position
  - Real world crash data showing approximately 50% of motorcycle crashes into barriers occur with the rider in the **upright position**.
In US, per 100,000 registered motorcycles, 59 bikers are involved in **fatal** road accidents (compared to 10 vehicle fatal accidents)
- In EU: 11 fatal road accidents for motorcyclists and 5 fatal vehicle occupant accidents

Over years passenger vehicle deaths have been reduced while motorcyclists deaths have remained constant.
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- Further developed same French test configuration resulting in Spanish national standard UNE-135900 in 2005.

2008: AENOR (Spain)
- Further revision of UNE-135900 standard included additional test speed of 70 km/h (43 mi/h).
Standards and Technical Specifications

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- **2011**: Technical Specification (EU)
  - **EN 1317-8**: “Motorcycle road restraint systems which reduce the impact severity of motorcyclist collisions with safety barriers” (motorcyclist protection systems added to barriers)
Standards and Technical Specifications

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<table>
<thead>
<tr>
<th>Impact Configuration</th>
<th>Impact Speed</th>
<th>Impact Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1. Launch Configuration 1: Post-Centered Impact</td>
<td>60 km/h, 37.3 m/s</td>
<td>30°</td>
</tr>
<tr>
<td></td>
<td>70 km/h, 43.5 m/s</td>
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<tr>
<td>Test 2. Launch Configuration 2: Post-Offset Impact</td>
<td>60 km/h, 37.3 m/s</td>
<td>30°</td>
</tr>
<tr>
<td></td>
<td>70 km/h, 43.5 m/s</td>
<td></td>
</tr>
<tr>
<td>Test 3. Launch Configuration 3: Mid-Span Impact</td>
<td>60 km/h, 37.3 m/s</td>
<td>30°</td>
</tr>
<tr>
<td></td>
<td>70 km/h, 43.5 m/s</td>
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</tbody>
</table>

(a) Example: barrier + MPS
No protrusions rearward of complete system
- » ACCEPTABLE PERFORMANCE

(b) Example: barrier + MPS
Arm protrudes rearward of complete system
- » SYSTEM FAILS TEST

**Severity Level**

**Maximum Admissible Values**

<table>
<thead>
<tr>
<th>Severity Level</th>
<th>HIC&lt;sub&gt;50&lt;/sub&gt;</th>
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<tbody>
<tr>
<td>I</td>
<td>650</td>
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<tr>
<td>II</td>
<td>1,000</td>
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</table>

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<thead>
<tr>
<th>Head</th>
<th>F&lt;sub&gt;x&lt;/sub&gt; (N)</th>
<th>F&lt;sub&gt;x&lt;/sub&gt; tension (N)</th>
<th>F&lt;sub&gt;x&lt;/sub&gt; compression (N)</th>
<th>M&lt;sub&gt;Neck&lt;/sub&gt; (N·m)</th>
<th>M&lt;sub&gt;Neck&lt;/sub&gt; extension (N·m)</th>
<th>M&lt;sub&gt;Neck&lt;/sub&gt; flex (N·m)</th>
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<tr>
<td>I</td>
<td>650</td>
<td>See Table</td>
<td>See Table</td>
<td>134</td>
<td>42</td>
<td>190</td>
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<td>134</td>
<td>57</td>
<td>190</td>
</tr>
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</table>
**Standards and Technical Specifications**

- **TRL Ltd. (Transport Research Laboratory) (UK)**
  - “TRL have not, and will not be testing to this standard (EN 1317-8) due to the costs involved (...)” (Gavin Williams, Technical Specialist)

- **2005 International Standard**
  - **ISO 13232** “Motorcycles - Test and Analysis Procedures for Research Evaluation of Rider Crash Protective Devices Fitted to Motorcycles” (8 parts) ([Motorcycle vs. car](#))

- **DEKRA Crash Test Center (Germany)**
  - Motorcycle crash tests (ISO 13232)

- **BASl (Federal Highway Research Institute) (Germany)**
  - Has defined an homologation procedure for impact protector
Quincy, 1988 (INRETS, France)  
“Motorcycle Impacts with Guardrail”

- 2 designs to reduce aggressiveness of beam guardrail: (a) added lower beam & upper beam, (b) removed upper beam & reduced lower beam stiffness
51% of cases: impacted barrier in upright position; 45% of cases: motorcycle slid on its side before striking barrier

Kawasaki ER 5 Twister (180kg + 272kg ATD)

ATD: Hybrid III dummy: loads measured for head (HIC, \(a_{3ms}\)), chest (\(a_{3ms}\)), pelvis (\(a_{3ms}\)) and femur (\(F_{left}, F_{right}\)) corresponding to moment of first “primary” impact into guard rail and “secondary” impact onto road surface

Steel Barrier was modified \(\rightarrow\) injury risk lower w/ modified system. Underrun protection board eliminated risk of snagging for ATD and absorbed kinetic energy due to deformation after impact

Further improvements needed since motorcycle was not redirected away from protection system

Questioned biofidelity of Hybrid III to sufficiently predict injury risks

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<tr>
<td>Test 1. Upward Driving Condition - Steel Guard Rail</td>
<td>60 km/h</td>
<td>12°</td>
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<tr>
<td></td>
<td>37.3 m/s</td>
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<tr>
<td>Test 2. Upward Driving Condition - Concrete Barrier</td>
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<tr>
<td>Test 3. Motorcycle Skidding on its Side - Steel Guard Rail</td>
<td>60 km/h</td>
<td>25°</td>
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<tr>
<td></td>
<td>37.3 m/s</td>
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<tr>
<td>Test 4. Motorcycle Skidding on its Side - Concrete Barrier</td>
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17 staged motorcycle crash tests were conducted at World Reconstruction Exposition 2000 (WREX2000) held at College Station.

**Objective:** evaluate characteristics of heavy motorcycle involved in collisions w/ two stationary targets: rigid heavy concrete block (7), and an automobile (10).
Hybrid II 50\textsuperscript{th} (Humanetics)

Hybrid III 50\textsuperscript{th} (Humanetics)
Anthropomorphic Test Devices (ATDs)

Hybrid III 50th (Humanetics) MODIFIED

- Meets SAE J211 and ISO 13232-4
- Sit/stand pelvis; gripping hands;
- 28 ISO standardized biofidelity enhancements
- Arm: NO frangible
- Limb amputation: NO (leg cables)
Why Computer Simulation?

- Computer simulations are quick and inexpensive compared to full-scale crash tests
- Several different motorcycle crash scenarios can be simulated to observe motorcycle rider behavior and injury risk
Finite Element Motorcycle
FE Motorcycle Summary
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Motorcycle and Rider ATD
Motorcycle Simulation Impact with Rigid Wall

- Impact speed: 30 mph
  - Based on ISO 13232-7 standards
- Simulation run time of 0.04 seconds
  - Time when motorcycle began to rebound from wall
Motorcycle Simulation Impact with Barrier
Full-Scale Testing - Motorcycle Guide System
Combination Barrier and Pedestrian Rail
Future Work

- Validate motorcycle model components
- Validate motorcycle against full-scale crash test
- Include ATD to determine motorcycle crash scenarios with severe injury probability
Acknowledgements

- Robert Wunderlich (Director, Center for Transportation Safety, TTI)
- Dr. Dean Alberson (Roadside Safety & Physical Security Division, TTI)
- Dr. Mike Manser (Human Factors Program Manager, TTI)
Questions?

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