NHTSA Research on Restraint Performance in Dynamic Rollovers

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NHTSA/VRTC
Rollover Restraint Tester (RRT)
Introduction/Objectives

- Previous NHTSA research found reduced occupant excursion with improved restraint systems.
  - Without reaction surface & air curtain
  - Vertical and lateral
- Evaluate current and prototype restraint systems in a rollover condition with a reaction surface.
  - Using a cab and rollover style curtain
  - Occupant excursion from seat
RRT Test Fixture

Adjustable Shock Tower

Test Platform

Framework

Drop Tower
Modified Reaction Surface
Fixture Dynamics

• Roll Rate (~308 deg/s at impact)
  • 1990’s NHTSA RRT (260 deg/sec)
  • Crash Data (180-360 deg/sec)
  • Dolly (~360 deg/sec)
• Impact Force (~100000 N)
• Shock Deflection (up to 25 cm)
• Acceleration Under Seat (~50 g)
• Lap/Shoulder Belt Forces
• Reaction Surface-
  • 2007 Chevy Silverado 1500 air curtain
  • Repeatable air curtain deployment
Belt Configurations

**Non-Integrated 3-point:**

- **Baseline (No Pretension)**
  - Lower D-Ring C
  - Upper D-Ring D

**Pretensioners**

- Retractor Pretensioner E
- Buckle Pretensioner F
- Retractor & Buckle Pretensioner G
- Motorized Pretensioner H
- Motorized & Buckle Pretensioner I

**Integrated 3-Point:**

- No Pretensioner A
- SWAP No Pretensioner B

**4-Point Belts:**

- 4-Point w/ Pretensioners J
- 4-Point redesign w/ Pretensioners M

**Inflatable Belts:**

- Inflatable Belt w/ Pretensioner K
- Inflatable Belt (No Pretension) L
50th, 5th, 95th Comparison
Lateral Excursions: non-reaction

KEY
RED- 50th Male
BLUE-5th Female
GREEN-95th Male

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50th, 5th, 95th Comparison
Vertical Excursions: non-reaction

KEY
RED- 50th Male
BLUE-5th Female
GREEN- 95th Male

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Summary of Non-Reaction Surface Testing on RRT

- Pretensioners and integrated seats reduced lateral and vertical excursions, both pre- and post-impact.
- Motorized retractor pretensioners reduced pre-impact lateral excursions.
- Inflatable belts with pretensioners produced the largest reductions in vertical and outboard lateral excursions.
- 4-point belts reduced vertical and inboard lateral excursions.
- Results did vary with dummy size, but general trends held.
Belt Configurations

Non-Integrated 3-point:
- Baseline (No Pretension)
  - Lower D-Ring C
  - Upper D-Ring D
- Pretensioners
  - Retractor Pretensioner E
  - Buckle Pretensioner F
  - Retractor & Buckle Pretensioner G
  - Motorized Pretensioner H
  - Motorized & Buckle Pretensioner I

Integrated 3-Point:
- No Pretensioner A
- SWAP No Pretensioner B

4-Point Belts:
- 4-Point w/Pretensioners J
- 4-Point redesign w/Pretension K

Inflatable Belts:
- Inflatable Belt w/Pretensioner K
- Inflatable Belt (No Pretension) L
Reaction vs Non-Reaction Lateral Excursions

KEY
RED - 50th Male
BLUE - 5th Female

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Reaction vs Non-Reaction Vertical Excursions

KEY
RED- 50th Male
BLUE-5th Female
5th Female Config “C” vs “I” Reaction Surface
Summary of Reaction Surface Testing on RRT

- The air curtain reduces lateral outboard excursions for both sized occupants
  - Differences from belt configurations are relatively small
- The air curtain reduces vertical excursion for both sized occupants and in all belt configurations
- When used with an air curtain and compared to belt configuration “C”:
  - Configurations “G” and “I” reduced excursions for both sized occupants
  - Configuration “M” reduced excursion for the 5th female
Full-Scale Dynamic Rollover Tests

- Goals
  - Identify the dynamics and belted occupant kinematics in various rollover scenarios
  - Assess what dynamics and belted occupant kinematics should be considered when evaluating restraint performance in rollovers
  - Compare performance of restraints to that from RRT tests
## Test Matrix

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Config C 3-PT Belt</th>
<th>Config I Motorized Retractor &amp; Buckle Pretens.</th>
<th>Config G Retractor &amp; Buckle Pretens.</th>
<th>Config A Integrated Belt</th>
<th>Air Curtain?</th>
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<tr>
<td>FMVSS 208 Dolly #1</td>
<td>1, 2</td>
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<tr>
<td>FMVSS 208 Dolly #4</td>
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<td>Corkscrew Ramp</td>
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<td></td>
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<tr>
<td>Corkscrew Ramp</td>
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<tr>
<td>Soil Trip</td>
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<tr>
<td>Curb Trip</td>
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<tr>
<td>Curb Trip</td>
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<td>YES</td>
</tr>
</tbody>
</table>

1 – Front Occupant, Trailing Side  
2 – Rear Occupant, Trailing Side  
3 – Front Occupant, Leading Side
Test Set-Up

- Vehicle: 2007 Ford Expedition
  - Replaced rear seat with a front seat
    - Allow front-to-rear comparison
  - Hybrid-III 50th male dummies
- Restraints chosen based on performance on RRT and availability
  - Config. C - 3PT
  - Config. G - Buckle & Retract. Pretensioner
  - Config. A - 3PT Integrated Belt
  - Config. I - Motor. Retract. & Buckle Pretensioner
For additional inquiries, contact

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Thank You!