Evaluation of Advance Compatibility Frontal Structures Using the Progressive Deformable Barrier

45th GRSP – May 2009

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Overview

- Introduction
- Vehicle selection
- Test Configuration
- Method of Test Evaluation
- Test results / Comparison
- Conclusion
Introduction

- Bilateral agreement between French DSCR and US NHTSA to enhance cooperation and increase the efficient use of resources to promote the development of improved vehicle safety programs and related regulations.

- Investigate whether barrier deformation using PDB, intrusion, and dummy injury measures can differentiate compatibility performances between vehicles.
  - Evaluates criteria of self protection and partner protection in the offset frontal crash test configuration with vehicles that have structures designed for good partner protection.
  - Compares current tests with prior research conducted under the cooperative agreement.
  - Compares the results to prior car-to-car crash tests and real world crash analysis.
Prior Research

- Prior effort between DSCR and NHTSA (ESV Paper No. 07-0303)
  - PDB Offset tests with a body-on-frame Chevrolet Silverado pick-up truck and a unibody Chrysler Town & Country minivan

- U.S. NCAP Testing
  - Full width rigid barrier at 56 km/h
  - Frontal stiffness and force matching height data available for both Honda Odysseys

- U.S. Vehicle-to-Vehicle Tests
  - Honda Odysseys (with and w/o ACE) were crashed into a Ford Focus in a full frontal crash configuration
Test Configuration

PDB-XT = PDB + 90mm in the back

- Offset PDB+
- 50 % overlap
- 60 km/h

2 Belted 50th percentile males – Driver had Thor-Lx legs
Vehicle Selection

- 2 Honda Odyssey minivans
  - MY 2004 – w/o ACE
  - MY 2005 – with ACE
  - Body-in-white showing Honda ACE structure
Method of Test evaluation

- Test Severity Evaluation
  - Equivalent Energy Speed

- Self Protection (Vehicle based metrics)
  - Compartment intrusion
  - Dummy injury criteria

- Partner Protection (Barrier based metrics)
  - AHOD  Average Height Of Deformation
  - ADOD  Average Depth Of Deformation
  - Dmax  Maximum Deformation
## Test Severity

<table>
<thead>
<tr>
<th>Odyssey with ACE</th>
<th>Odyssey without ACE</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image of Odyssey with ACE" /></td>
<td><img src="image2.jpg" alt="Image of Odyssey without ACE" /></td>
</tr>
<tr>
<td>• PDB Energy Absorbed by the barrier: 104 kJ</td>
<td>• Energy Absorbed by the barrier: 97 kJ</td>
</tr>
<tr>
<td>• EES: 49.6 km/h</td>
<td>• EES: 50.6 km/h</td>
</tr>
</tbody>
</table>
## Self Protection

### Odyssey with ACE vs. Odyssey without ACE

#### Intrusion Measures

<table>
<thead>
<tr>
<th>Intrusion</th>
<th>Odyssey with ACE</th>
<th>Odyssey without ACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASHBOARD</td>
<td>±20.0</td>
<td>±30.0</td>
</tr>
<tr>
<td>A PILLAR WAIST</td>
<td>±20.0</td>
<td>±20.0</td>
</tr>
<tr>
<td>PEDAL AXLE</td>
<td>±40.0</td>
<td>±60.0</td>
</tr>
<tr>
<td>FOOTWELL</td>
<td>±50.0</td>
<td>±70.0</td>
</tr>
<tr>
<td>A PILLAR SILL</td>
<td>±60.0</td>
<td>±80.0</td>
</tr>
</tbody>
</table>

#### Injury Measures

<table>
<thead>
<tr>
<th>Injury Measures</th>
<th>Driver</th>
<th>Pass.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIC36</td>
<td>290</td>
<td>284</td>
</tr>
<tr>
<td>Chest Def</td>
<td>26.6</td>
<td>26.5</td>
</tr>
<tr>
<td>Chest Gs</td>
<td>39.2</td>
<td>27.4</td>
</tr>
<tr>
<td>Left Femur</td>
<td>4.76</td>
<td>2.03</td>
</tr>
<tr>
<td>Right Femur</td>
<td>1.21</td>
<td>0.97</td>
</tr>
</tbody>
</table>

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<th>Pass.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIC36</td>
<td>283</td>
<td>273</td>
</tr>
<tr>
<td>Chest Def</td>
<td>28.7</td>
<td>33.4</td>
</tr>
<tr>
<td>Chest Gs</td>
<td>37.1</td>
<td>28.7</td>
</tr>
<tr>
<td>Left Femur</td>
<td>1.61</td>
<td>2.78</td>
</tr>
<tr>
<td>Right Femur</td>
<td>0.75</td>
<td>1.36</td>
</tr>
</tbody>
</table>
## Partner Protection: Front End Behavior

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image of Odyssey with ACE" /></td>
<td><img src="image2.png" alt="Image of Odyssey without ACE" /></td>
</tr>
<tr>
<td><img src="graph1.png" alt="Graph of Odyssey with ACE" /></td>
<td><img src="graph2.png" alt="Graph of Odyssey without ACE" /></td>
</tr>
</tbody>
</table>

- **Vertical Connections**
- **Frame Rail**
- **Crossbeam**
Partner Protection: Parameters

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<tbody>
<tr>
<td>Town &amp; Country Minivan</td>
<td>Chevrolet Silverado Pick-up Truck</td>
</tr>
</tbody>
</table>

- Vertical Connections
- Frame Rail
- Crossbeam
Partner Protection: Parameters

**Odyssey with ACE**

- DM: 619
- ADOD: 321
- AHOD: 397

**Odyssey without ACE**

- DM: 676
- ADOD: 287
- AHOD: 401

**Town & Country Minivan**

- DM: 570
- ADOD: 275
- AHOD: 404

**Chevrolet Silverado Pick-up Truck**

- DM: 654
- ADOD: 289
- AHOD: 414
### Vehicle-to-Vehicle Crashes: Stiffness

<table>
<thead>
<tr>
<th>Model</th>
<th>KW400* N/mm</th>
<th>Accel. At CG in Focus (m²/s)</th>
<th>Accel. At CG in Striking Vehicle (m²/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002 Ford Focus</td>
<td>934</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bullet Vehicles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 Chrysler Town &amp; Country</td>
<td>1,137</td>
<td>90.5</td>
<td>47.6</td>
</tr>
<tr>
<td>2003 Honda Odyssey w/o ACE</td>
<td>1,448</td>
<td>108</td>
<td>32.1</td>
</tr>
<tr>
<td>2005 Honda Odyssey w/ACE</td>
<td>1,456</td>
<td>113.5</td>
<td>40.3</td>
</tr>
<tr>
<td>2003 Chevrolet Silverado</td>
<td>1,619</td>
<td>86.2</td>
<td>32.9</td>
</tr>
</tbody>
</table>

*KW400 is the stiffness-related crush energy absorbed by a vehicle in the first 400 mm of crush (also called work stiffness).*
Vehicle-to-Vehicle Crashes: Performance

**Bullet: Odyssey with ACE**

**Bullet: Odyssey without ACE**

**Bullet: Town & Country Minivan**

**Bullet: Chevrolet Silverado P/U Truck**

Target Vehicle is a 2002 Ford Focus
Real World Performance of ACE

- NASS CDS Case No. 2007-04-0137
- Minor severity crash
- CDC code of 01FYEW02
- Principle direction of force: 20°
- Honda Odyssey
  - $\Delta V = 15$ km/h
  - Airbags deployed
  - Driver sustained minor injuries
- Ford Escape
  - Airbags did not deploy
  - Driver sustained minor injuries
- Intrusion in both vehicles likely insignificant (based on photos)

2005 Honda Odyssey (2,102 kg)

2006 Ford Escape (1,545 kg)
Summary

- Homogeneous deformation of the PDB suggests good horizontal and vertical engagement with a partner vehicle, as shown by the vehicle-to-vehicle tests.

- Analysis of compatibility metrics indicates stiffness alone may not indicate aggressivity.

- Further evaluation is needed to address both the stiffness of the vehicle as well as the homogeneity of that stiffness.
Full Analysis can be found in
ESV Paper 09-0329

The End