NHTSA Frontal Offset Research

Update on
40% Offset Deformable Barrier
And
Vehicle-to-Vehicle Tests

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Objectives

- Reduce death and injury
- Reduce long term impairment, pain and suffering (especially lower extremities)
- Reduce costs of recovery and rehabilitation
- Ensure the test procedure does not induce disbenefits to the collision partner
• Maximum AIS$_{90}$ level injury to each body region
• For a specified crash mode, the risk of AIS 2+ injury to a specific body region is

\[
\frac{\text{No. of occupants in specified crash mode with at least one AIS 2+ injury to specified body region}}{\text{Total no. of occupants in specified crash mode}}
\]
Risk of AIS 2+ Injuries

Body Region

- head
- neck
- chest
- abdomen
- spine
- arms
- legs

Risk of AIS 2+ Injury

- full frontal
- left offset
- right offset
- all frontal
• NHTSA estimates approximately 110,000 occupants sustain AIS 2 or 3 lower extremity injuries every year.
• Annual Cost estimated at $9.2 billion.
• Lower Extremity Injuries
  – Knee-thigh-hip complex
    ■ 55% of AIS 2+ injuries
    ■ 42% Associated functional Life-years Lost to Injury
  – Remaining Lower extremities
    ■ 45% of AIS 2+ injuries (74% foot and ankle)
    ■ 58% Associated functional Life-years Lost to Injury
• FMVSS 208 designed to reduce fatalities and serious head, neck and torso injuries in frontal crashes
Thor-Lx/HIIIr

Axial Compliant Element

Accelerometers x,y

Triaxial Accelerometer

Upper Tibia Load Cell
Fx,Fz,Mx,My

Lower Tibia Load Cell
Fx,Fy,Fz,Mx,My

Ankle Rotation
(x,y,z)
# Injury Criteria for Thor Lower Leg

<table>
<thead>
<tr>
<th>Region</th>
<th>Thor-Lx/HIII Criteria and Limits</th>
<th>Thor-FLx/HIII Criteria and Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>knee-thigh-hip</td>
<td>Femur Fz = 9040 N</td>
<td>Femur Fz = 6510 N</td>
</tr>
<tr>
<td>Knee ligament</td>
<td>Knee shear = 15 mm</td>
<td>Knee shear = 13 mm</td>
</tr>
<tr>
<td>Tibia Plateau</td>
<td>Upper tibia Fz = 5.6 kN</td>
<td>Upper tibia Fz = 4.0 kN</td>
</tr>
<tr>
<td>Leg Shaft</td>
<td>RTI=F/12+M/240=0.91</td>
<td>RTI=F/8.6+M/146=0.91</td>
</tr>
<tr>
<td>Calcaneus, pilon, midfoot</td>
<td>Lower tibia Fz = 5.2 kN</td>
<td>Lower tibia Fz = 3.8 kN</td>
</tr>
<tr>
<td>Ankle /malleolus</td>
<td>Dorsiflexion angle = 35 deg</td>
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</tr>
<tr>
<td></td>
<td>Xversion angle = 35 deg</td>
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</tbody>
</table>
40% Offset Deformable Barrier (ODB) Test Setup
2002 Dodge Neon with 5th HIII
### 50th HIII with Thor-Lx/HIII Test Matrix

<table>
<thead>
<tr>
<th>Make</th>
<th>Model</th>
<th>Year</th>
<th>Closing Speed (kph)</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Nissan</td>
<td>Quest</td>
<td>2002</td>
<td>56</td>
<td>02 Quest</td>
</tr>
<tr>
<td>Lincoln</td>
<td>Navigator</td>
<td>2003</td>
<td>56</td>
<td>03 Nav</td>
</tr>
<tr>
<td>Dodge</td>
<td>Neon</td>
<td>2002</td>
<td>56</td>
<td>02 Neon</td>
</tr>
<tr>
<td>Dodge*</td>
<td>Neon</td>
<td>2002</td>
<td>56</td>
<td>02 Neon RS</td>
</tr>
<tr>
<td>Nissan</td>
<td>Altima</td>
<td>2002</td>
<td>60</td>
<td>02 Altima (60kph)</td>
</tr>
</tbody>
</table>

* Vehicle impacted on the right side
50th HIII Lower Leg Responses with Thor-Lx/HIIIr

Normalized Femur Load

Normalized Knee Displacement
50th HIII Lower Leg Responses with Thor-Lx/HIIIr (continued)

Max Upper Tibia Index

Max Lower Tibia Index
50th HIII Lower Leg Responses with Thor-Lx/HIIIr (continued)

Normalized Max Upper Tibia Axial Force

Normalized Max Lower Tibia Axial Force
50th HIII Lower Leg Responses with Thor-Lx/HIIIr (continued)

Normalized Max Dorsiflexion

Normalized Max Inversion / Eversion

 QUEST  | 03 NAV  | 02 NEON  | 02 NEON RS  | ALTIMA (60 kph)
---|---|---|---|---
02 | 0.25 | 0.5 | 0.75 | 1.0 | 1.25 | 1.5

(60 kph)
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5th HIII Lower Leg Responses with Thor-Lx/HIIIr (continued)

Normalized Max Dorsiflexion

Normalized Max Inversion / Eversion

02 NEON 02 ALTIMA 02 ALTIMA

(60kph)
- Injury assessment with 50th HIII Thor-Lx/HIIIr is in accordance with injury distribution seen in real world crashes
- Previous results can be found at http://www-nrd.nhtsa.dot.gov/departments/nrd-01/presentations/SAE.html
Vehicle-to-Accord tests

Objective

• To determine the disbenefits, if any, from requiring the 40% Offset Deformable Barrier crash tests to evaluate high speed frontal offset crashes
Vehicle-to-Accord Test Configuration

Light Vehicle Aggressivity
Front, Offset, Oblique

35 Mph.

Honda Accord

LTV

35 Mph.

30E
## Test Matrix

<table>
<thead>
<tr>
<th>Category</th>
<th>“Before”</th>
<th>“After”</th>
</tr>
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<tbody>
<tr>
<td>Large Car</td>
<td>Cadillac Seville (3,885 lbs.) IIHS Rating: Poor</td>
<td>Cadillac Seville (4,008 lbs.) IIHS Rating: Good</td>
</tr>
<tr>
<td>Large Car</td>
<td>Toyota Avalon (3,225 lbs.) IIHS Rating: Marginal</td>
<td>Toyota Avalon (3,468 lbs.) IIHS Rating: Good</td>
</tr>
<tr>
<td>Pickup</td>
<td>Dodge Ram 1500 (4,930 lbs.) IIHS Rating: Poor</td>
<td>Dodge Ram 1500 (4,969 lbs.) IIHS Rating: Good</td>
</tr>
<tr>
<td>SUV</td>
<td>Chevrolet Blazer IIHS Rating: Poor</td>
<td>Chevrolet TrailBlazer IIHS Rating: Marginal</td>
</tr>
<tr>
<td>SUV</td>
<td>Mitsubishi Montero Sport IIHS Rating: Poor</td>
<td>Mitsubishi Montero Sport IIHS Rating: Good</td>
</tr>
<tr>
<td>Minivan</td>
<td>Toyota Previa (3,810 lbs.) IIHS Rating: Poor</td>
<td>Toyota Sienna (3,937 lbs.) IIHS Rating: Good</td>
</tr>
</tbody>
</table>
Blazer Pre-Test Pictures

1997 Blazer (IIHS rated “poor”)  
(4686 lbs, Width=1700 mm)

2002 TrailBlazer (IIHS rated “marginal”)  
(5181 lbs, Width=1847 mm)
Post-test Pictures (Accord)

1997 Blazer Test

2002 TrailBlazer Test
Montero Pre-Test Pictures

1999 Montero Sport (IIHS rated “poor”) 1997 Accord
(4646 lbs, Width=1705 mm)

2001 Montero Sport (IIHS rated “good”) 1997 Accord
(4715 lbs, Width=1750mm)
Post-test Pictures (Accord)

1999 Montero Sports Test

2001 Montero Sport Test
Normalized HIC 15 for Accord Driver

Normalized HIC 15

(4.7)

1.5

1.0

0.5

0.0

Blazer

Montero

Sport

Striking Vehicle

Old

Redesigned

Old

Redesigned
Normalized chest Gs for Accord Driver

Striking Vehicle
Normalized Chest Displacement for Accord Driver

Striking Vehicle

Normalized Chest Defl.

- Old
- Redesigned

Blazer

Montero Sport
Vehicle-to-Accord Findings to Date

• Both vehicles showed increased risk in both the head and chest injuries
• Not able to assess the contribution of stiffness, mass and geometry has toward the increase in injury measures
• Need to complete fleet study to determine if the same trend applies for all types of vehicles