Effect of Test Setup and Seating Position Variance in Oblique Frontal Offset Tests

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Background – Oblique Impacts

- Oblique impacts account for a significant amount of accidents
- Vehicle crash mechanisms and occupant kinematics differ from co-linear impacts
Background – Test Procedure

• NHTSA has developed an oblique test procedure

• Test setup and seating position tolerances are immanent to full-scale testing

OMDB
90 km/h
2500 kg
35% overlap
15° oblique

+/- 5mm
+/- 20mm
Objective

Evaluate effect of:

• OMDB test setup parameters  
  (Test setup study)

• Seating position parameters  
  (THOR position study)
Definitions I

**Repeatability Study:** Within test tolerances

**Sensitivity Study:** Beyond test tolerances
Definitions II

Seating position further away from impact location

“Far-side”

Seating position closer to impact location

“Near-side”
Methods – FE Simulation

• A validated baseline model of a 2014 mid-size sedan was used

• The model with ~ 5.000.000 elements included the vehicle with interior and restraints, the OMDB, and two 50% THOR occupants

• Approximately 200 simulations were conducted
Methods – Baseline Model Correlation

- Baseline model correlated reasonably well with full-scale test results (Test #8789 2014 Honda Accord 4 door sedan)
Methods – DOE

Design of Experiments (DOE) →
FEM Simulation →
Response Surface Construction →
Data Analysis and Comparison

Parameter Importance Index

Delta-V

Higher GMRB mass & higher speed
Lower GMRB mass & lower speed
Methods – Data Analysis

Evaluation Criteria

- Vehicle kinematics and intrusions
- Occupant kinematics and injury criteria
- Comparison of time history data using CORA/ISO 18571, e.g. GOOD > 0.8
Effect and importance of OMDB test setup parameters within and beyond defined tolerances were evaluated.

### Repeatability Study

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact angle [degree]</td>
<td>14-16</td>
</tr>
<tr>
<td>Vertical Misalignment (MA) [mm]</td>
<td>-50-50</td>
</tr>
<tr>
<td>Horizontal MA [mm] / Overlap</td>
<td>-50 (33%) - 50 (38%)</td>
</tr>
<tr>
<td>OMDB Mass [kg]</td>
<td>2486-50</td>
</tr>
<tr>
<td>Impact speed [km/h]</td>
<td>89-91</td>
</tr>
</tbody>
</table>

### Sensitivity Study

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact angle [degree]</td>
<td>10-20</td>
</tr>
<tr>
<td>Overlap [%]</td>
<td>30-40</td>
</tr>
<tr>
<td>OMDB Mass [kg]</td>
<td>2000-2500</td>
</tr>
<tr>
<td>Impact speed [km/h]</td>
<td>80-90</td>
</tr>
</tbody>
</table>
Results – Test Setup Repeatability Study Driver

Near-side occupant kinematics well controlled

Similar overall injury risk and CORA ratings greater than 0.86 indicate good test repeatability
Far-side occupant kinematics less controlled

CORA ratings between 0.81 and 0.94 indicate good test repeatability
Impact speed most important for chest (72%) and overall risk (49%)

Higher impact speed correlated with higher chest deflection and overall injury risk

More oblique angle and smaller overlap correlated with higher BRIC and lower HIC

CORA scores between 0.71 and 0.87
Results – Test Setup Sensitivity Passenger

Significant differences in occupant kinematics

Impact speed most important parameter for overall injury risk (49%) and BRIC (69%)

More oblique angle and higher speed corelated with higher BRIC

Cora scores between 0.73 and 0.9
Varying impact angle from co-linear to +20° showed significant differences:

- Vehicle yaw
- Vehicle y-pulse
Results – Impact Angle Study Driver

Similar overall injury risk for different impact angles were observed because:

- More oblique conditions correlated with higher BRIC values
- More oblique conditions correlated with lower chest deflection
Results – Impact Angle Study Passenger

For the passenger, more oblique conditions correlated with:

- Larger lateral head trajectories
- Higher BRIC and tibia values
- Higher overall injury risk
Seating Position Parameters

Effect and importance of THOR positioning parameters were determined

<table>
<thead>
<tr>
<th>Repeatability Study</th>
<th>Range (Driver)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-Point (x)</td>
<td>-5 BL +5</td>
</tr>
<tr>
<td>H-Point (Y)</td>
<td>-5 BL +5</td>
</tr>
<tr>
<td>H-Point (Z)</td>
<td>-5 BL +5</td>
</tr>
<tr>
<td>Head Angle</td>
<td>-1 BL +1</td>
</tr>
<tr>
<td>Knee/Heel Position</td>
<td>-10 BL +10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensitivity Study</th>
<th>Range (Passenger)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-Point (x)</td>
<td>-20 BL +20</td>
</tr>
<tr>
<td>H-Point (y)</td>
<td>-5 BL +5</td>
</tr>
<tr>
<td>H-Point (Z)</td>
<td>BL +10 +20</td>
</tr>
<tr>
<td>Head Angle</td>
<td>-5 BL +5</td>
</tr>
<tr>
<td>Knee/Heel Position</td>
<td>BL +30 +60</td>
</tr>
</tbody>
</table>

HP-x
+20/0/-20mm

HP-z
0/+10/+20mm

Head/torso
+5/0/-5°

Knee-to-knee
BL/+30/+60mm
Changing seating position of near-side occupant within defined test tolerances showed good repeatability:

• Small variance in occupant kinematics

• “GOOD” correlation of time history data (CORA ratings between 0.81 and 0.94)

• Tibia loads most sensitive due to interaction with gas pedal
Changing seating position of the far-side occupant beyond defined test tolerances resulted in more significant differences:

- Differences in occupant kinematics
- HP-x most important (76%) for Femur
- Time history data with larger variance (CORA ratings between 0.7 and 0.9)
NHTSA’s oblique test showed good overall repeatability when relevant parameters were changed within defined tolerances.

Far-side occupant results were more sensitive to parameter variations than the near-side occupant.

More oblique impact scenarios tended to produce higher overall injury risk for the far-side occupant.
Limitations

• Study has been conducted using a specific mid-size sedan vehicle model which was validated using NHTSA test #8789 (2014 Honda Accord 4-door sedan)

• Effect of individual and combination of parameters was determined using DOE surrogate models
Acknowledgment

- Baseline FE vehicle model with restraints developed by EDAG and Key Safety Systems
- THOR occupant FE model developed by UVA
- Project has been sponsored and directed by NHTSA
Thank You

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