Head Restraint GTR
Informal Working Group

OICA
Data Submission
September 7-9, 2005
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- Gap Measurement Procedure
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- Summary of Recommendations
## Design Data: Backset vs Torso Angle

### DaimlerChrysler Head Restraint Backset Design Data

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Torso Angle</th>
<th>Backset by Design (CATIA)</th>
<th>Δ Backset</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 Chrysler 300 (Leather Seats)</td>
<td>21.7</td>
<td>32.7</td>
<td>51.0@24</td>
</tr>
<tr>
<td>2005 Jeep Grand Cherokee (Leather Seats)</td>
<td>7.1</td>
<td>19.4</td>
<td>39.4@24</td>
</tr>
<tr>
<td>2005 Dodge Durango (Leather Seats)</td>
<td>7.2</td>
<td>21.5</td>
<td>34.8@22</td>
</tr>
</tbody>
</table>
# Backset Variation due to Changes in Torso Angle

**Question:**
What is the change of backset resulting from torso rotation by 1 degree?

<table>
<thead>
<tr>
<th>Vehicle: 2004MY Ford Focus</th>
<th>Test data</th>
</tr>
</thead>
<tbody>
<tr>
<td>First torso angle =</td>
<td>25.5 deg</td>
</tr>
<tr>
<td>Second torso angle =</td>
<td>15.4 deg</td>
</tr>
<tr>
<td>Backset at 1st torso angle =</td>
<td>45.0 mm</td>
</tr>
<tr>
<td>Backset at 2nd torso angle =</td>
<td>2.0 mm</td>
</tr>
<tr>
<td>Difference in torso angles =</td>
<td>10.1 deg</td>
</tr>
<tr>
<td>Difference in measured backsets =</td>
<td>43.0 mm</td>
</tr>
</tbody>
</table>

**Answer:**
The average backset change per 1 deg of torso rotation = 4.3 mm
Seat Setup and R-Point and H-Point

SRP vs H-Point

MAX. 12.1
MAX. 9.0
MAX. 21.5
MAX. 16.8

AM 50\% LEG
AM 95\% LEG

UP
Down

Fr
Rr

(mm)
Recommendation

- Use seating reference point (R-/SgRP-point) instead of “H” point.
- Repeatability of measurements
- Reproducibility of measurements
- R-point is basic reference point for vehicle design and other regulations (e.g. seat belt anchorages)
Vehicle Backset Measurement
Repeatability Data
# Vehicle Backset Measurement Repeatability Data

## DaimlerChrysler H Point & Head Restraint Repeatability Data

<table>
<thead>
<tr>
<th></th>
<th>H Point Variability</th>
<th>Backset Average (Up)</th>
<th>Backset Variability (Up)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2005 Jeep Grand Cherokee</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver @16°</td>
<td>0.82 mm</td>
<td>2.30 mm</td>
<td>N/A</td>
</tr>
<tr>
<td>Driver @25°</td>
<td>0.55 mm</td>
<td>1.46 mm</td>
<td>25.75 mm</td>
</tr>
<tr>
<td>Passenger @16°</td>
<td>0.83 mm</td>
<td>2.39 mm</td>
<td>9.25 mm</td>
</tr>
<tr>
<td>Passenger @25°</td>
<td>0.55 mm</td>
<td>2.50 mm</td>
<td>40.50 mm</td>
</tr>
<tr>
<td><strong>2005 Chrysler 300</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver @16°</td>
<td>0.42 mm</td>
<td>0.49 mm</td>
<td>N/A</td>
</tr>
<tr>
<td>Driver @25°</td>
<td>0.07 mm</td>
<td>0.85 mm</td>
<td>12.25 mm</td>
</tr>
<tr>
<td>Passenger @16°</td>
<td>3.05 mm</td>
<td>1.21 mm</td>
<td>N/A</td>
</tr>
<tr>
<td>Passenger @25°</td>
<td>2.94 mm</td>
<td>2.00 mm</td>
<td>14.75 mm</td>
</tr>
<tr>
<td><strong>2005 Dodge Durango</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver @16°</td>
<td>2.44 mm</td>
<td>1.27 mm</td>
<td>2.50 mm</td>
</tr>
<tr>
<td>Driver @25°</td>
<td>2.44 mm</td>
<td>1.39 mm</td>
<td>39.00 mm</td>
</tr>
<tr>
<td>Passenger @16°</td>
<td>5.80 mm</td>
<td>2.58 mm</td>
<td>N/A</td>
</tr>
<tr>
<td>Passenger @25°</td>
<td>5.20 mm</td>
<td>1.69 mm</td>
<td>31.75 mm</td>
</tr>
</tbody>
</table>

ICBC Test Procedure
N/A = Interference; data is not applicable
Backset Measurement Error
Ford Data: 3 Vehicles & 3 US Gages

<table>
<thead>
<tr>
<th>Backset (mm)</th>
<th>Vehicle 1</th>
<th>Vehicle 2</th>
<th>Vehicle 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td></td>
<td>12mm</td>
<td></td>
</tr>
<tr>
<td>Variability</td>
<td>18.6mm</td>
<td></td>
<td>15mm</td>
</tr>
</tbody>
</table>

12mm difference between 3 gages in 1 seat
18.6mm variability of 3 gages in 1 seat
15mm variability of 1 gage in 1 seat
Backset Variation due to Build Variability

- 45 Lincoln TownCars MY 2005 measured with a single operator and gauge.

<table>
<thead>
<tr>
<th>Backset (mm)</th>
<th>Full up</th>
<th>Full down</th>
<th>Rated Point</th>
<th>Torso Angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigma</td>
<td>6.993359</td>
<td>7.226704</td>
<td>7.044501</td>
<td></td>
</tr>
<tr>
<td>3 sigma</td>
<td>20.98008</td>
<td>21.68011</td>
<td>21.1335</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>90.04444</td>
<td>80.9556</td>
<td>85.5</td>
<td>24.95556</td>
</tr>
<tr>
<td>Max</td>
<td>105</td>
<td>95</td>
<td>100</td>
<td>25.9</td>
</tr>
<tr>
<td>Min</td>
<td>69</td>
<td>58</td>
<td>63.5</td>
<td>24</td>
</tr>
<tr>
<td>Range</td>
<td>36</td>
<td>37</td>
<td>36.5</td>
<td>1.9</td>
</tr>
<tr>
<td>3+1.5sigma</td>
<td>31.47012</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Backset Variation due to Build Variability (cont)

- 45 Lincoln TownCars MY 2005 measured with a single operator and gauge.

Descriptive Statistics

Variable: Full up

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>90.0444</td>
</tr>
<tr>
<td>StDev</td>
<td>6.9934</td>
</tr>
<tr>
<td>Variance</td>
<td>48.9071</td>
</tr>
<tr>
<td>Skewness</td>
<td>-1.1E-01</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.909831</td>
</tr>
<tr>
<td>N</td>
<td>45</td>
</tr>
<tr>
<td>Minimum</td>
<td>69.000</td>
</tr>
<tr>
<td>1st Quartile</td>
<td>85.500</td>
</tr>
<tr>
<td>Median</td>
<td>89.000</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>95.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>105.000</td>
</tr>
<tr>
<td>95% Confidence Interval for Mu</td>
<td></td>
</tr>
<tr>
<td>87.943</td>
<td>92.145</td>
</tr>
<tr>
<td>95% Confidence Interval for Sigma</td>
<td></td>
</tr>
<tr>
<td>5.789</td>
<td>8.834</td>
</tr>
<tr>
<td>95% Confidence Interval for Median</td>
<td></td>
</tr>
<tr>
<td>88.000</td>
<td>90.928</td>
</tr>
</tbody>
</table>
Backset Variation due to Build Variability (cont)

45 Lincoln TownCars MY 2005 measured with a single operator and gauge.

### Descriptive Statistics

#### Variable: Full down

- **Anderson-Darling Normality Test**
  - A-Squared: 0.687
  - P-Value: 0.068

- **Mean**: 80.9556
- **StDev**: 7.2267
- **Variance**: 52.2253
- **Skewness**: -2.9E-01
- **Kurtosis**: 1.08115
- **N**: 45

- **Minimum**: 58.0000
- **1st Quartile**: 76.0000
- **Median**: 80.0000
- **3rd Quartile**: 85.5000
- **Maximum**: 95.0000

- **95% Confidence Interval for Mu**
  - Lower: 78.7844
  - Upper: 83.1267

- **95% Confidence Interval for Median**
  - Lower: 77.5358
  - Upper: 83.0000
Field Complaint Data on Inadequate Backset

- 2005 DaimlerChrysler SUV
- Designed to meet FMVSS 202 NPRM 50mm requirement (44 mm backset at 25° to provide compliance margin)
- Field survey intended to duplicate and predict JD Power survey (268 questions)
- Aug ’04 through May ’05 build data
- 2945 respondents (8/1/05)
  - #1 Miscellaneous Interior (6.9%)
  - #8 Headrests (3.6%, 1.8% backset, 0.9% rearward visibility)
  - #21 Seat Belt Retractors (2.8%)
  - #37 Seat Belt Buckle (1.8%)
Field Complaint Data on Inadequate Backset

- Sample Narratives:
  - "HEAD RESTRAINTS ARE VERY UNCOMFORTABLE FOR A PERSON UNDER 5 FOOT 4. TILTS HEAD FORWARD IN AWKWARD POSITION.
  - HEADRESTS SET TOO FAR FORWARD. AGGREVATED/PINCHED NERVE IN NECK REQUIRING PHYSICAL THERAPY TO MINIMIZE PAIN/DISCOMFORT. NEED TO REMOVE HEADRESTS.
  - HEADREST IS TOO FAR FORWARD. WE HAVE TO BEND OUR NECK FORWARD, AS WE CAN'T SIT STRAIGHT UP IN THE SEAT. I'M 5'8" & MY HUSBAND IS 6'. VERY BOTHERSOME AND I WISH I'D HAVE NOTICED ON OUR TEST DRIVE, I REALLY WOULD HAVE THOUGHT TWICE ABOUT PURCHASE.
  - HEADREST TOO FORWARD, UNCOMFORTABLE DURING LONG TRIPS.
  - HEADRESTS BOTHERS HAIR
  - VERY POOR-DOESN'T ALLOW ME TO SIT TALL W/GOOD SPINAL POSTURE-HITS BACK OF HEAD WHEN I TRY TO SIT TALL. IT'S NOT ADJUSTABLE, I REMOVED AND REINSERTED IT FACING 180 DEGS FROM ITS INTENDED POSITION."
Design and Actual Torso Angle

There are many vehicles which are not 25 degree design angle.
Backset Recommendation:

- 80 mm (Alliance petition for reconsideration) at design torso angle allows for design, manufacturing and audit tolerance
  - Short stature people expected to benefit most from increased backset
  - Wide variety of design torso angles depending on the vehicle type
Non-use Position:
Objective Criteria

☐ Retain +/- 60° rotation criteria

☐ Expand objective alternatives and add:
  ■ Discomfort metric
  ■ 5° torso angle change between in use and non use positions
  ■ Pop up telltale
  ■ Warning label
Non-use Position: “Discomfort Metric”

Definition of lower edge of head restraint in non-use position:

\[ 460 \, \text{mm} \geq H_{\text{LE}} \geq 250 \, \text{mm} \]

and

\[ S \geq 25 \, \text{mm} \]

Maximum height (460 mm) needed to get discomfort even for small people.

Minimum height (250 mm) needed to prevent misinterpretation of non-use position as upright seating position.
Non-use Position: "Discomfort Metric"

Validation of proposed maximum height for lower edge of head restraint:

- 460 mm height is below the shoulder height of 5%-women
Non-use Position: “Discomfort Metric”

Validation of proposed minimum height for lower edge of head restraint:
- 250 mm height is above the pelvic bone of 95%-man, so that the back of even tall passengers can always touch the seat back. Misinterpretation of the “non-use position” as a “proper head restraint” position is very unlikely.

Data from „handbook of ergonomics“ from Prof. Dr. H.W. Jürgens, Kiel, Germany:
Iliocristale height (see picture) of a 95%-male is 270 mm. With consideration of overlapping with smooth upholstery and location of hip point this corresponds with a dimension of 160 mm above the SRP.
Non-use Position: “Discomfort Metric”
Chrysler Stow ‘n’ Minivan Parameters

- $H_{LE} = 375.8 - 391.5$ mm
- $S = 28 --29$ mm
- $\Delta$Torso Angle = $5.5^\circ -7^\circ$
Non-use Position: “Discomfort Metric”
Chrysler Stow ‘n’ Go Minivan Complaint Narratives

- “VERY UNCOMFORTABLE TO SIT IN THE SEATS W/ THE HEADREST ALL THE WAY DOWN.
- MIDDLE AND REAR MUST BE RAISED FOR OCCUPANT COMFORT, BUT THEN LOWERED TO BE STOWED.
- THE SEATS BACKS ARE SO LOW THAT ANY ADULT SITTING THERE MUST ADJUST THE HEADREST SO IT'S NOT IN THEIR BACK.
- THEY HIT MY BACK AWKWARDLY UNLESS I MOVE THEM TO AN EXTENDED POSITION.
- WITH HEADRESTS IN DOWN POSITION, IT IS VERY UNCOMFORTABLE, AS THEY HIT YOU IN THE LOWER NECK AND IN THE RAISED POSITION THEY ARE IN DRIVER'S VIEW (WHEN NO PASSENGERS ARE PRESENT).”
Non-Use Position: Indicator Proposal

Rear Seat Head Restraint Concept

The height adjustment button sits proud of the surface in the lowest position, showing a red warning flag. To raise the head restraint the button is depressed and the restraint is adjusted. The red is not visible when in adjusted to a higher position.
Non-Use Position: Indicator Proposal

Rear Seat Head Restraint Concept

The warning tag could appear, perhaps inflated as the head restraint is pressed down into the lowest position. As the head restraint is raised the tag would deflate and flatten against the bottom of the head restraint.
Volvo XC90 Second Row with Non-use Position Warning Label
Volvo XC90 2nd Row Center with Non-use Position Warning Label
Volvo XC90 2nd Row Center In-use Position (Close up view)
Volvo XC90 2nd Row Center Non-use Position Warning Label (Close up view)
Non-Use Position: Warning Label

Warning label coupled with owner’s manual verbiage to educate occupant as to correct head restraint positioning.
Non-Use Position: Warning Label
Lock Retention Test: Proposal

- Measure head restraint vertical deflection on the bottom of the head restraint relative to adjustment rods.
- This is not a cushion force deflection test, but a lock retention test.
Backset Test Procedure – Possible Concept

**Procedure:**

1. Mount the seat to the test fixture.

2. Mount the clevis to the fixture and adjust its location until the pivot line of the clevis is aligned with theoretical SgRP location with respect to the recliner pivot line.

3. Apply force $F$ to the torso form to produce a rearward moment (with respect to SgRP) equal to the moment (TBD) generated by the SAE-J826 manikin at the design torso angle.

4. Recline the seat back to achieve the design torso angle.

5. Measure the head restraint height in all positions of adjustment at which downward retention is provided.

6. Level the backset measuring arm and measure the head restraint backset at all HR positions at which the height is within 700-800mm range.

**Goal:** Reduce backset measurement variability by eliminating the contribution of H-point variability
FMVSS 202a Gap Measurement Procedure
Preferred Gap Measurement Procedure (ECE R17)
Surrogate Testing for Automatic “Return to In-use” Position

- Objective test device (Hybrid III 5%F or 50%M) alternative is mandatory for self certification countries.
- Human volunteers may be permitted under a type approval authority.
Recommendations Summary

- Backset is torso angle, “H” point, and measurement method sensitive.
- Backset Proposed 80 mm at design torso angle
- Effective “non-use position” alternatives exist besides +/- 60° rotation
- Lock retention test should measure relative motion between the lock and adjustment rod, not cushion deflection
- Backset/height measurement proposal eliminates “H” point variability
- Use ECE R17 gap measurement procedure for seat back to head restraint gap measurement.
- Objective test needed as alternative to surrogate testing for self certification markets