Performance of head restraints as a function of seat back strength in rear impact sled tests

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NHTSA recently proposed an upgrade to the dynamic test option in FMVSS 202. The head rotation with respect to torso should not exceed 12 degrees for a 50th percentile male HIII dummy and 20 degrees for a 95th percentile male HIII dummy in a 17.5 km/h rear impact sled test.
**FMVSS 202 Sled Tests**

- To examine the performance of current seats with respect to the upgraded dynamic test:
- \( \Delta \text{deltaV}=17.5 \text{ km/h} \) sled tests with OEM seats

<table>
<thead>
<tr>
<th>Dummy</th>
<th>Head Restraint Height (mm)</th>
<th>OEM Seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% HIII</td>
<td>750</td>
<td>Taurus</td>
</tr>
<tr>
<td>50% HIII</td>
<td>800</td>
<td>Taurus, Volvo, Camry, Easi</td>
</tr>
<tr>
<td>95% HIII</td>
<td>800</td>
<td>Saab, Deville</td>
</tr>
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</table>

Backset=50 mm in all tests
Typical Sled Pulse
Test with 50\textsuperscript{th} % HIII male dummy in Taurus seat with 750 mm head restraint height

Seat rotation = 18 deg

Head rotation = 42 deg.

Nij (upper) = 0.2

HIC\textsubscript{15} = 23
Test with 50th % HIII male dummy in Volvo seat with 800 mm head restraint height

Seat rotation = 8.4 deg

Head rotation = 22 deg.

Nij (upper) = 0.1

HIC15 = 35
Summary of 202 Tests

202 Tests

- 50%,750 (Taurus)
- 50%,800 (Volvo, Camry, Taurus)
- 95%,800 (Saab, Deville)

Graph showing data for different vehicle model combinations and test conditions.
Relationship between Seat Rotation and Head Rotation in Optional 202 Dynamic Tests

![Graph showing the relationship between seat rotation and head rotation with a correlation coefficient $R^2 = 0.96$. The graph includes data points for seat rotation at 750 mm and 800 mm, with line fits for each distance.](image)
Seat and head rotation in 202 sled tests with 50th percentile male

Taurus 99

Volvo 2000

Head rotation with respect to torso --- Seat Rotation

Peak Nij occurs approximately at time of peak head rotation
Summary of Results

• Relative head rotation with respect to torso depends on the seat rotation as well as the head restraint height.
• Nij and other neck measures increase with the increase in relative head rotation.
• Seat cushion, head restraint flexibility, upholstery and other characteristics of the seat may also influence dummy head and torso kinematics.
Seat Back Stiffness and Head Rotation

- Additional sled tests conducted with the FMVSS 202 pulse (17.5 km/h) using the 95th percentile male HIII dummy
  - Head restraint height=800 mm
  - Backset=50 mm
  - Seat strength = varied
    - Baseline: 35 Nm/deg
    - 200% : 70 Nm/deg
    - 500%: 175 Nm/deg
    - rigid
Tests Conducted at JHU-APL

- Head Contact Switch
- String Potentiometer
- Load Bolts
- Adjustable Shock Absorbers
Initial Position (95M vs. 50M)
(800 mm head restraint height, backset=50 mm)
Head CG Level at Max Torso Height (95M vs. 50M)
Initial Head Contact (95M vs 50M)
Max Head Rotation (95M vs 50M)

HIII95@Max Seatback Rotation (150ms)

HIII50@Max Seatback Rotation (150ms)
Effect of Seatback Stiffness on Dummy Kinematics

Baseline stiffness 500% stiffness
Effect of Seatback Stiffness on Rearward Seat Rotation

![Bar chart showing the peak rotation (deg.) for different seatback rotational stiffness levels: 100%, 200%, 500%, and rigid. The peak rotations are 28 degrees for 100%, 20 degrees for 200%, 11 degrees for 500%, and 0 degrees for rigid.]
Effect of Seatback Stiffness on Head and Chest Rotation

- Head Rotation
- Chest Rotation
- Head Rotation wrt Chest
- Head wrt Chest Rot. at Contact Time
Effect of Seatback Stiffness on Head Rotation and Contact Time

Rotation (Degrees)

Time (Seconds)

Seat Stiffness (%)

Rel. Rotation

Time of Head Contact
Effect of Seatback Stiffness on Upper Neck Response

![Graph showing the effect of seatback stiffness on upper neck response. The x-axis represents seat stiffness at 100%, 200%, 500%, and rigid. The y-axis represents force (N) and moment (Nm). The graph includes bars for Fx, Fz, and My.]
Effect of Seatback Stiffness on Nij Neck Injury Criteria

![Bar chart showing the effect of seatback stiffness on Nij neck injury criteria for upper and lower necks. The x-axis represents seatback stiffness levels (100%, 200%, 500%, rigid), and the y-axis represents Nij values ranging from 0 to 0.7. The chart compares the Nij values for upper and lower necks across different stiffness levels.](chart_image)
Conclusions

• Tests conducted at APL did not show conclusive trends between seatback stiffness and relative head to torso rotation for the 95th male HIII dummy.

• The flexibility of head restraint influenced head kinematics after head contact.

• Future testing: Similar sled tests at 17.5 km/h DeltaV with 50th % male HIII dummy.