FMVSS No. 202 Final Rule
Backset and Height Retention Testing

Justification for Load Values

2nd Head Restraint Informal Working Group Meeting
April 11-13, 2005
Initial Seat Back Position for Retention Tests

Initial torso reference line angle = 25° from vertical

800 mm for Backset Retention.
800 and highest for Height Retention.
Backset Retention Force Application

373 Nm moment applied through 165 mm diameter head form.

373 Nm moment applied through SAE J826 back pan.

Schematic Representation of Seat Back Frame Rigid Fixation
Backset Retention Procedure in Final Rule

- Displaced torso reference achieved by 373 Nm moment through back pan.
- Seat back rigidly fixed.
- 37 Nm moment applied with head form, 65 mm below top of head restraint, to achieve reference position.
- 373 Nm moment applied.
  - For 800 mm head restraint, $F \times 0.735 \text{ m} = 373 \text{ Nm}$
  - $F = 507 \text{ N}$
  - 102 mm limit on displacement beyond torso reference line.
- Return to 37 Nm moment.
  - 13 mm limit on change from reference position to assure locks held.
Height Retention Force Application

500 N force applied through 165 mm diameter cylinder.

Cylinder Axis of Revolution

Schematic Representation of Seat Back Frame Rigid Fixation
Height Retention Procedure in Final Rule

- **50 N force applied to top of head restraint to achieve reference position.**
  - 25 mm limit on displacement for 50 N force.
    - Required because some designs with frictional positioning will displace under this small force.

- **500 N force applied.**
  - Load consistent with that applied during backset retention.

- **Return to 50 N force.**
  - 13 mm limit on change from reference position to assure locks held.
Final Rule vs. Original Proposal

- NPRM (Notice of Proposed Rulemaking)
  Commenters concerned about stringency of test.
  - NPRM tested unfixed seat back.
- Performed limited testing on 5 seats. 1 seat had no locks. No paired data.
  - Fixed and unfixed seat backs
  - 50 N and 100 N initial reference load.
- Results.
  - 2 of 4 seats passed height retention @ 13 mm.
  - 3 of 4 passed backset retention @13 mm.
  - Only unfixed seats exceeded limit.
- Procedure altered to provide relief.
  - Displacement limit increased from 10 to 13 mm.
  - Seat back rigidly fixed.
Appropriateness of Force Level

- For both backset and height retention test the maximum applied load is \( \approx 500 \) N.
- The rearward force applied in Backset retention test has been the same since 1968.
- Justification for height retention force in Final Rule.
  - It was reasonable to apply a similar level of force to height retention as was applied to backset retention.
  - Average upper neck shear forces in 50%ile male dummy in FMVSS No. 301 rear impacts was \( \approx 350 \) N.
More Through Examination of Head Restraint Loading

- Looked at all previous rear impact testing where seat back rotation was known.
- Crash tests
  - FMVSS No. 301 Rear Impacts, Avg. $\Delta V = 26$ km/h
- Sled tests
  - Simulating FMVSS No. 301, $\Delta V \approx 30$ km/h.
  - FMVSS No. 202 Sled Tests, $\Delta V \approx 17.3$ km/h.
- Hybrid III Dummies
  - 5th %ile Female, 50th %ile Male, 95th %ile Male
- 1998 – 2004 Seats
Detailed Analysis of Head Restraint Loading

Head Accelerometer Coordinate System

Load Cell Coordinate System

Head Restraint Loading

Ax

Fx

Fz

Az

FHRx

FHRz

Head Coordinate System

+x

+z
Detailed Analysis of Head Restraint Loading

- Equations in head coordinate system
  - $F_{HRx} + F_x = mAx$
  - $F_{HRz} + F_z = mAz$
    - $m \rightarrow$ head mass
    - $A \rightarrow$ CG acceleration
    - $FHR \rightarrow$ Force on the head applied by the head restraint.
  - $F_x \rightarrow$ Shear force at the top of the neck
  - $F_z \rightarrow$ Tensile force at the top of the neck.
- $F_{HRx} = mAx - F_x$
- $F_{HRz} = mAz - F_z$
Detailed Analysis of Head Restraint Loading

- $\phi \rightarrow$ the angle of the head and seat back in the global coordinate system.
- $\theta = \phi_s - \phi_h$
- The transformation in the head coordinate system to the seat back coordinate systems.
- $F_{HRxs} = F_{HRx} \cos \theta - F_{HRz} \sin \theta$
- $F_{HRzs} = F_{HRx} \sin \theta + F_{HRz} \cos \theta$
Head Restraint Loading in Seat Coordinate System

- FHRzs
  - FHRxs
  - ZS
  - XS
Maximum Rearward Force on Head Restraint

- **5th %ile**: Newtons
- **50th %ile**: Newtons
- **95th %ile**: Newtons

**FMVSS No. 301**

$\Delta V \approx 22 - 30 \text{ km/h}$

**FMVSS No. 202**

$\Delta V \approx 17 \text{ km/h}$
Maximum Downward Force on Head Restraint

<table>
<thead>
<tr>
<th>Dummy Size</th>
<th>5th %ile</th>
<th>50th %ile</th>
<th>95th %ile</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMVSS 202</td>
<td>200 N</td>
<td>1000 N</td>
<td>1200 N</td>
</tr>
<tr>
<td>FMVSS 301</td>
<td>300 N</td>
<td>1500 N</td>
<td>1800 N</td>
</tr>
</tbody>
</table>

FMVSS No. 301 $\Delta V \approx 22 - 30$ km/h
FMVSS No. 202 $\Delta V \approx 17$ km/h
Average Maximum Rearward Force on Head Restraint

![Bar chart showing average maximum rearward force on head restraint for different dummy sizes and FMVSS standards.]

FMVSS No. 301 $\Delta V \approx 22 - 30$ km/h
FMVSS No. 202 $\Delta V \approx 17$ km/h
Average Maximum Downward Force on Head Restraint

- FMVSS No. 301 $\Delta V \approx 22 – 30$ km/h
- FMVSS No. 202 $\Delta V \approx 17$ km/h
Test Video

- 1999 Cadillac Deville
- 50th %ile Male Dummy
- 800 mm height
- 50 mm backset
- FMVSS No. 301 sled test ($\approx 30$ Km/h $\Delta V$)
- Peak FHRxs = 672 N
- Peak FHRzs = -842 N
- Resultant load = 1054 N @ -51°
1999 Cadillac Deville – 50th Male, 301 Speed
Test Video

- 1999 Sebring
- 95th %ile Male Dummy
- 800 mm height
- 50 mm backset
- FMVSS No. 301 sled test (≈ 30 Km/h ΔV)
- Peak FHRxs = 2676 N
- Peak FHRzs = -1816 N
- Resultant load = 2986 N @ -34°
1999 Sebring – 95th Male, 301 Speed

Head Restraint Force Fx

Head Restraint Force Fz
Test Video

- 1999 Toyota Camry
- 50th %ile Male Dummy
- 800 mm height
- 50 mm backset
- FMVSS No. 202 sled test (≈ 17 Km/h $\Delta V$)
- Peak FHRxs = 575 N
- Peak FHRzs = -1006 N
- Resultant load = 1153 N @ -60°
1999 Camry – 50th Male, 202 Speed
Test Video

- 2000 Saab 9-3
- 95th %ile Male Dummy
- 800 mm height
- 50 mm backset
- FMVSS No. 202 sled test (≈ 17 Km/h ΔV)
- Peak FHRxs = 976 N
- Peak FHRzs = -704 N
- Resultant load = 1184 N @ -35°
2000 Saab 9-3, 95th Male, 202 speed