Federal Motor Vehicle Safety Standard No. 213
Child Restraint Systems

Presented by:

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Safety Standards Engineer
NHTSA

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What Did Congress Say?

Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act, says in part:

- Section 14 (a). Not later than 12 months after the date of the enactment of this Act, initiate rulemaking to improve the safety of child restraints.
Elements for Consideration

Use of dynamic tests to:
- Replicate side- and rear-impact crashes
- Reflect the design of the current fleet of passenger motor vehicles

Use of anthropomorphic test devices:
- New Hybrid III dummies
- Represent a greater range of children, including a 10-year-old

Apply scaled injury criteria performance levels of adults including neck injury

Raise the upper weight limit of the standard from 50 to 80 pounds

Improve protection from head injuries in side- and rear-impact crashes
What Did NHTSA Do?

- Crash data analysis (FARS, NASS, and University of Pennsylvania CHOP)
- Sled testing program
- Measurements of vehicle compartment seat & belt geometry and stiffness
- Analysis of measurements of seats and vehicle crash dynamics (pulses)
Crash Data Analysis
Crash Data Analysis
Child Passenger Safety — 1999 FARS

Child Fatalities by Age — Ages 0 through 10

- Unrestr.
- Restr. CSS
- Belted
- Type Unk
- Unk.
Crash Data Analysis
1991 – 1999 FARS

Children Ages 0-8 years
Fatalities by Impact Zone

- Frontal: 51%
- Side: 40%
- Rear: 9%

FMVSS No. 213 Child Restraint Systems
Dynamic Test Procedure
Dynamic Test Procedure

In response to TREAD, NHTSA initiated a test program to assess seat parameters of production seats, working with

- Veridian Engineering (Veridian)
- U.S. Naval Air Warfare Center Aircraft Division at Patuxent River, Maryland (PAX)

Analysis of FMVSS No. 208 crash pulses

Survey of 41 interior measurements from vehicles that are representative of the current US vehicle fleet
Dynamic Test Procedure
Seat Assembly – Side View

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>8°</td>
<td>15°</td>
</tr>
<tr>
<td>$\beta$</td>
<td>15°</td>
<td>22°</td>
</tr>
<tr>
<td>Seat back assembly</td>
<td>Flexible</td>
<td>Fixed</td>
</tr>
</tbody>
</table>
Dynamic Test Procedure
Seat Assembly – Frontal View

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spacing of center seat belt anchorages</td>
<td>222 mm</td>
<td>392 mm</td>
</tr>
<tr>
<td>Spacing of outboard seat belt anchorages</td>
<td>356 mm</td>
<td>472 mm</td>
</tr>
</tbody>
</table>

Center spacing
Outboard spacing
Dynamic Test Procedure
Combined Crash Pulse

FMVSS 213 vs 208 — Combined Crash Pulse
Dynamic Test Procedure
Passenger Car Crash Pulse

FMVSS 213 vs 208 — Passenger Car Crash Pulse

![Graph showing acceleration vs time for Dynamic Test Procedure for Passenger Car Crash Pulse comparing FMVSS 213 and 208 standards.](image-url)
Dynamic Test Procedure
SUV Crash Pulse

FMVSS 213 vs 208 — SUV Crash Pulse

![Graph showing acceleration vs time for FMVSS 213 vs 208 — SUV Crash Pulse](image)
Dynamic Test Procedure
Light Truck Crash Pulse

FMVSS 213 vs 208 — Light Truck Crash Pulse

![Graph showing acceleration over time for FMVSS 213 vs 208 light truck crash pulse.](image)
Upgrade of Dynamic Test Procedure
Proposed Crash Pulse Corridor

Current vs Proposed FMVSS No. 213 Pulse

\[ \Delta V = 29.5 - 30 \text{ mph} \]
New Anthropomorphic Test Devices and Injury Criteria

- Represent a greater range of children, including a 10-year-old
- New Hybrid III dummies
## Hybrid III Height and Weight Comparison

<table>
<thead>
<tr>
<th></th>
<th>Standing Height (ft in)</th>
<th>Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Female</td>
<td>4'11&quot;</td>
<td>108.0</td>
</tr>
<tr>
<td>10-year-old</td>
<td>4'5&quot;</td>
<td>76.0</td>
</tr>
<tr>
<td>6-year-old</td>
<td>3'9&quot;</td>
<td>51.6</td>
</tr>
</tbody>
</table>
New Anthropomorphic Test Devices and Injury Criteria

Development of 10-Year-Old Dummy

The 10-Year-Old Hybrid III Dummy First Prototype
# New Anthropomorphic Test Devices and Injury Criteria

## Development of 10-Year-Old Dummy

### Schedule

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specifications and Prototype Development</td>
<td>January - Sept 2001</td>
</tr>
<tr>
<td>Perform component and sled tests</td>
<td>October 2001 – Feb 2002</td>
</tr>
<tr>
<td>Publish NPRM</td>
<td>Fall 2002</td>
</tr>
<tr>
<td>Publish final rule</td>
<td>Fall 2003</td>
</tr>
</tbody>
</table>

FMVSS No. 213 Child Restraint Systems
New Anthropomorphic Test Devices and Injury Criteria

**Weighted 6-Year-Old Dummy**

- Developed a weighted 6-year-old dummy
- Increased weight from 51.6 to 62.0 pounds
- For possible use to test child restraints for children weighing from 50 to 65 pounds
New Anthropomorphic Test Devices and Injury Criteria

Weighted 6-Year-Old Dummy

Fig. 1. Oblique frontal view of spine weights

Fig. 2. Location and shape of pelvis weight

Pelvis Weight
New Anthropomorphic Test Devices and Injury Criteria

The Hybrid III Family

- CRABI 12-month
- 3-year-old
- 6-year-old

Added features vs. Hybrid II
  - Neck loads
  - Chest compression
  - Additional load measurement
## New Anthropomorphic Test Devices and Injury Criteria
### Dummy Equivalency Evaluation

### Injury Assessment Reference Values (IARV)

<table>
<thead>
<tr>
<th>Dummy</th>
<th>HIC</th>
<th>Nij</th>
<th>Chest Acceleration (G's)</th>
<th>Chest Deflection (mm)</th>
<th>Head Excursion (mm)</th>
<th>Head Excursion no tether (mm)</th>
<th>Knee Excursion (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-month-old CRABI</td>
<td>390&lt;sub&gt;15&lt;/sub&gt;</td>
<td>1</td>
<td>50</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid III 3-year-old</td>
<td>570&lt;sub&gt;15&lt;/sub&gt;</td>
<td>1</td>
<td>55</td>
<td>34</td>
<td>720</td>
<td>813</td>
<td>915</td>
</tr>
<tr>
<td>Hybrid III 6-year-old</td>
<td>700&lt;sub&gt;15&lt;/sub&gt;</td>
<td>1</td>
<td>60</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid II 9-month-old</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>720</td>
<td>813</td>
<td>915</td>
</tr>
<tr>
<td>Hybrid II 3-year-old</td>
<td>1000&lt;sub&gt;∞&lt;/sub&gt;</td>
<td>N/A</td>
<td>60</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid II 6-year-old</td>
<td>1000&lt;sub&gt;∞&lt;/sub&gt;</td>
<td>N/A</td>
<td>60</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New Anthropomorphic Test Devices and Injury Criteria

Head Injury Criterion ~ HIC

HIC = max \[
\frac{1}{t_2-t_1} \int_{t_1}^{t_2} a(t) \, dt \quad (t_2-t_1)^{2.5}
\]

Data on this slide adapted from Clifford C. Chou, Ford Motor Company, 1998

<table>
<thead>
<tr>
<th>HIC Value</th>
<th>HIC&lt;sub&gt;0&lt;/sub&gt;</th>
<th>HIC&lt;sub&gt;36&lt;/sub&gt;</th>
<th>HIC&lt;sub&gt;15&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>229.0</td>
<td>200.0</td>
<td>184.2</td>
</tr>
<tr>
<td>(t&lt;sub&gt;1&lt;/sub&gt;,t&lt;sub&gt;2&lt;/sub&gt;)</td>
<td>(66.30,121.4)</td>
<td>(83.54,119.5)</td>
<td>(103.7,118.7)</td>
</tr>
<tr>
<td>(t&lt;sub&gt;2&lt;/sub&gt;-t&lt;sub&gt;1&lt;/sub&gt;)</td>
<td>(55.10)</td>
<td>(36.00)</td>
<td>(15.00)</td>
</tr>
</tbody>
</table>

HIC<sub>15</sub> ≤ HIC<sub>36</sub> ≤ HIC<sub>0</sub>
New Anthropomorphic Test Devices and Injury Criteria

Nij In-position Critical Values

FMVSS No. 213 Proposed Nij Values vs FMVSS No. 208

3-Year-Old

FMVSS No. 213 Child Restraint Systems

Proposed Nij Limits for 213

FMVSS No. 208 Axial Load Limits
New Anthropomorphic Test Devices and Injury Criteria

Nij In-position Critical Values

CRABI 12-month and Hybrid III 3- & 6-year-old

![Graph showing force and moment values for different age groups.](image)
New Anthropomorphic Test Devices and Injury Criteria

NHTSA Testing Purposes

- Establish the equivalency of child dummies
  - CRABI-12 vs. Hybrid II 9-month-old infant
  - Hybrid III vs. Hybrid II 3-year-old
  - Hybrid III vs. Hybrid II 6-year-old

- Determine Hybrid III dummy performance levels with child restraint systems

- Repeatability and reproducibility validation
### New Anthropomorphic Test Devices and Injury Criteria

**FMVSS No. 213 Sled Frontal Tests**

<table>
<thead>
<tr>
<th>Dummy Type</th>
<th>Rear-facing 5pt belt</th>
<th>Tether 5pt belt</th>
<th>No tether 5pt belt</th>
<th>LATCH 5pt belt</th>
<th>Booster w/ lap/shoulder belt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid III CRABI-12</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid II 9-Month-Old</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid III 3-Year-Old</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Hybrid II 3-Year-Old</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Hybrid III 6-Year-Old</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Hybrid II 6-Year-Old</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Side Impact Protection
Side Impact Protection
1991 – 1999 FARS

Child in Child Restraint System Fatalities by Vehicle Seating Position

- Near Side: 385 (65%)
- Far Side: 125 (21%)
- Middle: 83 (14%)

Total Fatalities: 593
Side Impact Protection
Previous Regulatory Activities

Requirements proposed to specify a minimum level of performance for child restraints in dynamic side impact would be first in the world

On March 1, 1974, agency proposed
- 20 mph lateral impact (90°) dynamic test
- Limits head motion to 19 inches in each lateral direction
- No loss of structural integrity

Agency withdrew 1974 proposal
- Only tethered restraints satisfy requirements
- Tethers not widely used at the time
- High cost implications
Side Impact Protection
Testing of European Child Restraints

- Dynamic sled test of European and U.S. manufactured child restraints
  - Passenger compartment Grand Am test buck
  - 90° lateral impact
  - 15 and 21 mph
  - 3-year-old Hybrid III dummies in outboard seating positions

- No difference in head containment between European and U.S. child restraints
Side Impact Protection
U.S. vs European CRS

U.S. Child Restraint System
Century (meets FMVSS 213)

European Child Restraint System
Britax (meets ECE Regulation 44)
Side Impact Protection
Grand Am Test Buck — Side View
Side Impact Protection
U.S. Child Restraint System
Side Impact Protection
European Child Restraint System
Side Impact Protection
Additional Side Impact Testing

- Dynamic sled testing (summer 2001)
  - 20 mph (same as New South Wales Consumer Ratings Program and NHTSA 1974 proposal)
  - 45° and 90° impact orientations

- LATCH seats

- Hybrid III 3-year-old dummy
Side Impact Protection
Side Impact Test with Wall
Proposed Revisions to FMVSS No. 213—Child Restraint Systems

Summary

❖ Use of dynamic tests
  • Revision of FMVSS No. 213 standard seat assembly and crash pulse to more accurately reflect the design of current passenger motor vehicles

❖ Use of anthropomorphic test devices
  • Incorporation of most technologically advanced anthropomorphic test devices available, to include 12-month-old CRABI and Hybrid III 3- and 6-year-old dummies

❖ Apply scaled injury criteria performance levels of adults including neck injury
  • Adoption of scaled injury criteria performance levels similar to FMVSS No. 208, to include neck and chest deflection parameters
Proposed Revisions to FMVSS No. 213—Child Restraint Systems

Summary

- Raise the upper weight limit of the standard from 50 to 80 pounds
  - Upper weight limit of FMVSS No. 213’s applicability raised from 50 to 65 pounds
  - Adoption of weighted 6-year-old dummy as a short-term, interim approach for testing child restraints certified for use by children weighing more than 50 pounds

- Improve side and rear head protection
  - ANPRM issued to seek input on possible development of a dynamic side impact test for FMVSS No. 213
  - Near-side crash scenario requires long-term effort