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National Highway Traffic Safety Administration

Memorandum

Docket NHTSA-03-15351-3

Subject: **ACTION**: Final Regulatory Evaluation for Amendment to FMVSS No. 213, Frontal Test Procedure

Date: JUN 13 2003

From: Rose A. McMurray
Associate Administrator
for Planning, Evaluation and Budget

Reply to Attn. of:

To: The Docket

THRU: Jacqueline Glassman
Chief Counsel

Attached is a copy of the Final Regulatory Evaluation for Amendment to FMVSS No. 213, Frontal Test Procedure. Please submit this report to Docket number NHTSA-03-15351.

Attachment

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FINAL REGULATORY EVALUATION

AMENDMENT TO
FMVSS No. 213
FRONTAL TEST PROCEDURE

Office of Regulatory Analysis and Evaluation
Planning, Evaluation, and Budget
May 2003

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EXECUTIVE SUMMARY

This Final Regulatory Evaluation analyzes the potential impact of new performance requirements for child restraint systems in frontal crashes. This rulemaking is in response to the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act, Public Law 106-414 to improve child restraint systems.

Final Rule

The final rule incorporates (1) new dummies, including a 12-month-old CRABI[1] and a Hybrid III 3-year-old, a Hybrid III 6-year old, and a Hybrid III weighted 6-year-old in compliance tests; (2) expanded child weight limits up to 65 lbs, (3) current FMVSS No. 213 injury criterion requirements and the injury criterion performance limits, except for the head injury criterion; (4) a real-world representative test seat assembly; and (5) a lengthening crash pulse corridor in the compliance test.

The final rule does not incorporate the injury criteria as proposed in the NPRM. The NPRM proposed to incorporate the FMVSS No. 208 injury criterion requirements and the scaled injury criterion performance limits. However, after thoroughly reviewing all the comments, the agency has decided that this final rule will not adopt these injury criteria and performance limits. These changes to FMVSS No. 213 represent a significant review

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[1] Child Restraint Air Bag Interaction Dummy.

and updating of the requirements to incorporate advanced technologies and parameters more representative of the vehicle fleet.

Test Results

The agency conducted a series of tests to evaluate the impact of the final rule. Based on the test result analysis, the upgrades of new dummies and test seat assembly had minimal effects. All the current child restraint systems tested are already compliant with the final rule.

Benefits

Since all the current child restraint systems that were tested pass the requirements of this final rule, there are no measurable safety benefits associated with these systems. However, the revised standards will assure the child restraint systems are tested using the most advanced technologies and parameters that are more representative of the vehicle fleet.

Cost of the Amendment

There are compliance costs associated with the amendment: one-time costs and the long-term incremental costs. The estimated one-time costs include $1.68 million for manufacturers to purchase the new test dummies and $1.39 to $3.44 million to certify existing child restraints to the new dummies and test requirements. The annual long-term incremental costs are the costs for certifying new models of booster seats with a weighted-6-year-old dummy. The annual long-term costs are estimated to be $31,200.

Leadtime

The final rule specifies two years of leadtime, as proposed in the NPRM. The agency believes that the two years of leadtime is adequate for manufacturers to changeover to the new dummies and seat test assembly.

CHAPTER I. INTRODUCTION

This final regulatory evaluation accompanies the agency's final rule to amend Federal Motor Vehicle Safety Standard No. 213, Child Restraint Systems. The final rule is in response to the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act to improve child restraint systems in the frontal crash environment. The TREAD Act, Public Law 106-414, asks the agency to conduct a detailed review of FMVSS No. 213 and determine whether the standard should be revised as outlined in the Act.

May 2002, Notice of Proposed Rulemaking

In response to the TREAD Act, the agency has conducted a number of research projects to explore areas of improvements for FMVSS No. 213. Based on the research project results and following the TREAD Act provisions, on May 1, 2002, the agency published in the Federal Register (67 FR 21806) a notice of proposed rulemaking (NPRM) to upgrade FMVSS No. 213, Child Restraint Systems.

The NPRM proposed that FMVSS No. 213 incorporate the following provisions:

(1) Use of the 12-month-old CRABI[1], a Hybrid III 3-year-old, and a Hybrid III 6-year old in the standard's compliance tests;

(2) Extension of the upper weight limit to 65 pounds from 50 pounds by using a Hybrid III weighted 6-year old dummy in the standard's compliance test;

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[1] Originally this dummy was named the Child Restraint Air Bag Interaction Dummy.

(3) Incorporation of FMVSS No. 208 child injury criteria and scaled injury criterion performance limits (ICPLs), with a modification in the neck injury criteria;

(4) Modifications to the standard seat assembly geometry to better represent the current vehicle fleet; and

(5) Extending the corridor for the sled test pulse.

The agency received a total of 34 comments in response to the NPRM. These comments were placed in the Docket (Docket # NHTSA-2002-11707). All comments are centered on the three main issues of this rule: dummy, injury criteria, and seat assembly. For the dummy issue, most of the commenters supported using the 12-month-old CRABI and the Hybrid III child dummies. These comments also supported the proposed increase in the upper weight limit to 65 pounds. However, some questioned the neck performance of the Hybrid III 6-year old dummy and the validity and suitability of the weighted 6-year-old dummy for use in testing to represent heavier children.

For the injury criterion issue, commenters presented different positions. Some supported adopting the head injury criteria and the injury criteria performance limits proposed in the FMVSS No 208, advanced air bag final rule. However, the majority opposed incorporation of the chest deflection and neck injury criteria and the use of scaled injury criteria performance limits. Given that child restraint systems have been proven to perform very well in a variety of crash environments, these commenters were concerned that unintended safety consequences of proposed changes might occur if manufacturers redesign their child restraint systems to meet the reduced injury criterion performance limits.

<u>For the test assembly issue</u>, the majority of the commenters supported using the revised seat assembly geometry that better reflects the current vehicle fleet in compliance tests. Most of the commenters also favored lengthening the corridor for the sled pulse. However, the majority of the commenters opposed a more severe crash pulse.

After thoroughly evaluating all the comments, in this final rule, the agency has decided to:

(1) Use the 12-month-old CRABI, a Hybrid III 3-year-old, and a Hybrid III 6-year-old in the standard's compliance tests;

(2) Extend the upper weight limit to 65 pounds from 50 pounds by using a Hybrid III weighted 6-year-old dummy to ensure that the structural integrity of a child restraint is maintained in the standard's compliance test;

(3) Maintain the existing injury criteria and the injury criterion performance limits (ICPLs) in the existing FMVSS No. 213, but incorporate a 36 milliseconds (msec) measurement window for HIC calculation.

(4) Revise the test seat assembly to better represent the existing vehicle fleet and more closely harmonize with the test seat assembly used in the European standard ECE R44.

(5) Lengthen the corridor for the sled pulse in testing.

The final rule is different from the NPRM proposal. Table I-1 summaries the final rule and lists the major differences between the final rule and the NPRM proposals.

Table I-1 Comparison Between the Final Rule and NPRM Proposal

	Final Rule	NPRM Proposal
Dummy Required in the Compliance Test	12-month-old CRABI 3-year-old 6-year-old Weighted 6-year-old (only used to ensure structural integrity)	12-month-old CRABI 3-year-old 6-year-old Weighted 6-year-old
Weight Limits	65 pounds (using weighted 6-year-old for structural integrity)	65 pounds (using weighted 6-year-old dummy)
Injury Criteria and Injury Criterion Performance Limits*	Existing FMVSS 213 Injury Criteria and ICPLs, except using HIC_{36}.	Incorporating the FMVSS 208 injury criteria and scaled ICPLs
Seat Assembly		
Seat Back Angle	20 $\pm$ 1 degree	22 degrees
Seat Cushion Angle	15 degrees	15 degrees
Anchorage Spacing Center Seating Outboard Seating	 400 mm 472 mm	 392 mm 472 mm
Seat Back Type	Fixed	Fixed
Sled Crash Pulse	Extending the corridor for the sled pulse in testing	Extending the corridor for the sled pulse in testing

* Please see Tables III-1 and III-2 for the detailed requirements.

This final regulatory evaluation analyzes the potential impact of the agency's final rule requirements to use new dummies (CRABI, the Hybrid III 3-, 6-, and weighted 6-year-old dummies), to incorporate 36 msec for calculating HIC (HIC_{36}), and to use the new seat assembly and sled crash pulse. In Chapter II, the evaluation first establishes the child safety problem based on the real-world crash data. Then, in Chapter III, the evaluation discusses the injury criteria and corresponding injury probability risk curves. Next, in Chapter IV, the evaluation analyzes the laboratory crash test data to establish the performance of the current child restraint systems. Appendix A lists all the detailed information on crash tests. The injury probability curves and the laboratory crash tests are used to derive the fatality/injury reduction rates. Subsequently, in Chapter V, the size of the safety problem and the fatality/injury reduction rates are used to estimate the potential benefits of the final rule. Following the benefit estimate, in Chapter VI the evaluation examines the costs and the leadtime of the final rule. Finally, in Chapter VII the evaluation examines the impacts of the final rule on small business entities.

In response to changes made between the NPRM and the final rule, and comments specific to the preliminary regulatory evaluation, this final regulatory evaluation made the following revisions:

(1) Updated the child fatalities and injuries by using the most current available crash data: 2001 Fatality Analysis Reporting System, 2001 General Estimate System, and 1993-2001 Crashworthiness Data Systems.

(2) Used HIC_{36} injury risk curves to assess the head injury risk.

(3) Used the highest injury outcome among the repeated crash tests to calculate the compliance rates of child restraint systems instead of using the average injury outcome as used in the preliminary regulatory evaluation.

(4) Updated the child restraint manufacturer list.

(5) Incorporated new crash test data.

All comments on the PRE and the agency's responses are listed in Appendix B.

CHAPTER II. SAFETY PROBLEM

This chapter estimates the number of child passenger vehicle fatalities and injuries in frontal crashes that could benefit from this amendment. A child is defined as being between ages 0 through 12 years old. All the statistics presented here are for children 0 to 12 years old to demonstrate the child injury safety problem[1]. However, only children sitting in child restraints are assumed to be impacted by FMVSS 213 and are used in the benefit estimation.

The following real-world crash data are used to derive the fatalities and non-fatal injuries in frontal crashes: the 2001 Fatality Analysis Reporting System (FARS), the 2001 General Estimates System (GES)[2], and the 1993-2001 Crashworthiness Data System (CDS). FARS is a census of fatalities and was used to derive the fatalities. Both GES and CDS are sampling systems. GES is a nationally representative sample of police-reported crashes not limited to the passenger vehicle towaway crashes as sampled by CDS. Thus, GES was used to derive the overall size of the non-fatal injury safety problem. CDS has a much smaller sample than does GES, but with a more in-depth investigation of injury profiles. Thus, the multiple years of CDS were used in the detailed descriptive statistics analysis to reduce variability.

This rule is designed to improve the performance of child restraints in frontal crashes. The fatal frontal crashes in FARS were defined as the initial (IMPACT1) or principal

[1] In some cases, the broader range of ages is needed to get a reasonable estimate of injuries by body region.
[2] General Estimates System Coding Manual 2001.

(IMPACT2) impact points in the 11, 12, and 1 o'clock directions. Because data elements describing crash characteristics varied between FARS and CDS, frontal crashes were defined differently in CDS. The frontal crashes in CDS were defined by their principal direction of force (DOF1), the general area of damage (GAD1), and the primary specific horizontal location (SHL1). They included crashes with (1) DOF1 between 11 and 1 o'clock direction, or (2) DOF1 was 10 or 2 o'clock direction and GAD1 was front or side with damage forward of the A-pillar. GES does not include clock impact direction as does FARS and CDS, all the crash modes in GES were used later in this chapter for injury adjustment.

CDS has been found to underestimate the overall injury population due to its small sample size. To compensate for this problem, the non-fatal injuries in frontal crashes derived from 1993-2001 CDS were adjusted to 2001 GES CDS-equivalent level. GES CDS-equivalent injuries were those injuries in GES that have the same attributes of CDS, i.e., passenger vehicle occupant injuries in crashes that had at least one passenger vehicle towed. As mentioned earlier, GES does not include clock impact direction as does FARS and CDS. The analysis did not use frontal crashes in GES for injury adjustment. Instead, all the injuries in the GES CDS-equivalent crashes, regardless of crash types, were used in the injury adjustment process. The injury adjustment is the ratio of total GES CDS-equivalent child occupants of the age group to that of 1993 – 2001 CDS average. The injury adjustment factor, for each specific age group, from CDS to the GES CDS-equivalent level is the ratio between the passenger vehicle occupants in GES CDS-equivalent crashes and in CDS crashes, i.e.,

$$f = \frac{\text{all passenger vehicle occupants in 2001 GES for a specific age group}}{\text{Annualized occupants in 1993} - \text{2001 CDS for the same age group}}$$

Detailed descriptive analysis such as crash severity, injured body region, child restraint orientation, etc., were based on 1993-2001 CDS. Their corresponding fatalities and injuries were adjusted to the 2001 FARS and 2001 GES CDS-equivalent level, respectively.

A. Problem Size

Annually, about 539 child passenger vehicle[3] occupants age 0 to 12 years old are fatally injured in the front or rear seats in frontal crashes. In 2001, 84 (16 percent) of these fatally injured children were in a child restraint system (CRS). Sixty-six (12 percent of total fatalities) of these fatalities were in a properly used CRS when this crash occurred: 9 were in the front seats and 57 were in the rear seats. Eighteen were in an improperly used CRS. Table II-1 summarizes the child occupant fatalities in frontal crashes by age groups, restraint use, and seating position. Note that the restraint use among these child fatalities was based on the 2001 FARS. The rear seats include the second, third, and fourth row seats.

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[3] Defined as passenger cars, light trucks, vans, and sport utility vehicles with a GVWR of 4,536 kilograms (10,000 pounds) or less.

In addition to fatalities, frontal crashes are also associated with 6,485 MAIS[4] 2-5 and 88,741 MAIS 1 non-fatal injuries, annually. Tables II-2 and II-3 report these child MAIS 2-5 and MAIS 1injuries, respectively, by age groups, restraint use, and seating position. As shown in these two tables, about 1,415 (22 percent) MAIS 2-5 and 24,522 (28 percent) MAIS 1 injuries were in a properly used CRS when the frontal crash occurred. The injuries were derived from 1993-2001 CDS and then adjusted to the 2001 GES CDS-equivalent level. The adjustment is achieved by multiplying the adjustment factor (f) as described previously to the annualized injuries from 1993-2001 CDS. Note that the improperly used CRS in both FARS and CDS was defined as being cases where the child safety seat orientation was not positioned according to the manufacturer's designed orientation use, or the seat was not properly secured, or a child was not properly secured in the seat or was in the wrong type of CRS.

[4] Maximum Abbreviated Injury Scale, 1-Minor Injury, 2-Moderate Injury, 3-Serious Injury, 4-Severe Injury, 5-Critical Injury. Only one injury with the most severity is counted per occupant.

Table II-1 Child Occupant Fatalities in Frontal Crashes By Seating Position, Age, and Restraint Use

Age (Years Old)	Child Restraint System*	Improperly Used CRS	Belted	Not Belted	Total
Front Seats					
0-1	8	4	3	24	39
2-3	1	0	3	18	22
4-6	0	0	25	26	51
7-10	0	0	38	29	67
11-12	0	0	11	23	34
Total	9	4	80	120	213
Rear Seats					
0-1	19	10	1	26	56
2-3	30	2	9	22	63
4-6	8	2	34	39	83
7-10	0	0	39	43	82
11-12	0	0	16	26	42
Total	57	14	99	156	326
Front + Rear Seats					
0-1	27	14	4	50	95
2-3	31	2	12	40	85
4-6	8	2	59	65	134
7-10	0	0	77	72	149
11-12	0	0	27	49	76
Total	66	18	179	276	539

Source: 2001 Fatality Analysis Reporting System

* Properly used CRS

Table II-2 Child Occupant Non-Fatal MAIS 2-5 Injuries in Frontal Crashes By Seating Position, Age, and Restraint Use

Age (Years Old)	Child Restraint System*	Improperly Used CRS	Belted	Not Belted	Total
Front Seats					
0-1	263	5	91	97	456
2-3	43	1	245	76	365
4-6	37	1	145	670	853
7-10	0	0	527	185	712
11-12	0	0	150	175	325
Total	343	7	1158	1203	2711
Rear Seats					
0-1	348	11	54	81	494
2-3	690	21	36	146	893
4-6	34	0	418	244	696
7-10	0	0	581	580	1161
11-12	0	0	451	79	530
Total	1072	32	1540	1130	3774
Front + Rear Seats					
0-1	611	16	145	178	950
2-3	733	22	281	222	1258
4-6	71	1	563	914	1549
7-10	0	0	1108	765	1873
11-12	0	0	601	254	855
Total	1415	39	2698	2333	6485

Source: 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)
Note: MAIS 2-5 Injuries were derived from 1993-2001 CDS and adjusted to 2001 GES CDS-equivalent level.
*Properly used CRS

Table II-3 Child Occupant Non-Fatal MAIS 1 Injuries in Frontal Crashes By Seating Position, Age, and Restraint Use

Age (Years Old)	Child Restraint Systems*	Improperly Used CRS	Belted	Not Belted	Total
Front Seats					
0-1	1450	30	1038	472	2990
2-3	2772	57	1492	669	4990
4-6	92	2	6555	1201	7850
7-10	0	0	8498	3033	11531
11-12	0	0	3868	2331	6199
Total	4314	89	21451	7706	33560
Rear Seats					
0-1	8368	259	200	1181	10008
2-3	8781	272	1869	1295	12217
4-6	3059	95	7885	2326	13365
7-10	0	0	11274	2819	14093
11-12	0	0	3684	1814	5498
Total	20208	626	24912	9435	55181
Front + Rear Seats					
0-1	9818	289	1238	1653	12998
2-3	11553	329	3361	1964	17207
4-6	3151	97	14440	3527	21215
7-10	0	0	19772	5852	25624
11-12	0	0	7552	4145	11697
Total	24522	715	46363	17141	88741

Source: 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)
Note: MAIS 1 Injuries were derived from 1993-2001 CDS and adjusted to 2001 GES CDS-equivalent level.
* Properly used CRS

B. Children in CRS

Of particular interest for the analysis are the children in a CRS when the crash occurred. Table II-4 shows the children in a CRS by seating position and orientation of the CRS. Of the 9 child occupant fatalities in the front seat, 2 were in a forward-facing CRS and 7 were in a rear-facing CRS. Of the 57 rear-outboard child occupant fatalities, 40 were in a forward-facing CRS and 17 were in a rear-facing CRS. As expected, all the fatalities and injuries for children age 2 and older sitting in a CRS in the rear seat were in a forward-facing CRS.

As for MAIS 2-5 injuries in the front seats, about 242 children were in a forward-facing CRS and 101 were in a rear-facing CRS. Of the 1,072 MAIS 2-5 child injuries in the rear seats, 947 were in a forward-facing CRS and 125 were in a rear-facing CRS.

Table II-4 Children in Properly Used Child Restraint System (CRS) by Age, Seating Position, and Orientation of the CRS

Age (Years Old)	Front Seats			Rear Seats		
	Forward Facing	Rear Facing	Total	Forward Facing	Rear Facing	Total
Fatalities						
0-1	1	7	8	2	17	19
2-3	1	0	1	30	0	30
4-6	0	0	0	8	0	8
7-10	0	0	0	0	0	0
11-12	0	0	0	0	0	0
Total	2	7	9	40	17	57
MAIS 2-5 Injuries						
0-1	162	101	263	223	125	348
2-3	43	0	43	690	0	690
4-6	37	0	37	34	0	34
7-10	0	0	0	0	0	0
11-12	0	0	0	0	0	0
Total	242	101	343	947	125	1072
MAIS 1 Injuries						
0-1	1337	113	1450	5598	2770	8368
2-3	2772	0	2772	8781	0	8781
4-6	92	0	92	3059	0	3059
7-10	0	0	0	0	0	0
11-12	0	0	0	0	0	0
Total	4201	113	4314	17438	2770	20208

Source: 2001 Fatality Analysis Reporting System; 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)
Note: MAIS 1-6 Injuries were derived from 1993-2001 CDS and adjusted to 2001 GES-CDS equivalent level.

C. Relevant Statistics

The section presents statistics by crash severity (measured by Delta-V) and injured body region. The majority of the MAIS 1 injuries were skin bruises. We believe the effectiveness of the new requirements for these injuries would be minimal. Thus, the analysis focuses on fatalities and MAIS 2-5 non-fatal injuries. Due to small sample sizes, the statistics are based on all children regardless of age, seating position, and restraint use.

Statistics by Crash Severity

As shown in Table II-5, about 72 percent of child fatalities and 87 percent of MAIS 2-5 injuries in frontal crashes occurred at Delta-V less than or equal to 30 mph. Note that the percentage distribution in Table II-5 was based on the 1993-2001 CDS. CDS is the only crash database that contains the Delta-V information.

Table II-5 All Child MAIS 2+ Occupant Injuries by Crash Severity Regardless of Restraint Use

Injury Severity Frequency Percent	Crash Severity (Delta-V in MPH)				
	0-20	21-30	31-40	41+	Total
Fatality	214 40%	175 32%	98 18%	52 10%	539 100%
MAIS 2-5 Injuries	3632 56%	2011 31%	584 9%	258 4%	6485 100%

Source: 2001 Fatality Analysis Reporting System; 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)
Note: MAIS 2-5 Injuries were derived from 1993-2001 CDS and adjusted to 2001 GES-CDS equivalent level.

Statistics by Injured Body Region

Table II-6 shows the child MAIS 2+ passenger vehicle occupant injuries by MAIS injured body region. Head is the predominate injury body region. Neck injuries were rare occurrences. Due to small sample sizes and unknown injured body regions for fatalities, the percentages derived from MAIS 4-5 and fatalities combined were applied to fatalities. The statistics were based on 1993-2001 CDS. CDS is the only data system used in the analysis that records the injured body region.

Table II-6 All Child MAIS 2+ Injuries by MAIS and Body Region Regardless of Restraint Use

Injury Severity Frequency Percent	MAIS Injured Body Region				
	Head	Neck	Chest	Other*	Total
Fatality	377 70%	6 1**%	32 6%	124 23%	539 100%
MAIS 2-5 Injuries	2789 43%	12 0**%	389 6%	3295 51%	6485 100%

* Including abdomen, spine, upper extremity, and lower extremity
** Very small sample
Source: 2001 Fatality Analysis Reporting System; 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)
Note: MAIS 2-5 Injuries were derived from 1993-2001 CDS and adjusted to 2001 GES-CDS equivalent level.

Based on Table II-6, head, neck, and chest comprised about 77 percent of fatalities and 49 percent of all MAIS 2+ injuries. Table II-7 shows the properly used child safety seat occupants with a fatal/MAIS 2-5 head, neck, or chest injuries regardless of seating position. These numbers were derived by multiplying 77 and 49 percent by the fatalities and MAIS 2-5 injuries in Table II-4, respectively.

As shown in Table II-7, 51 properly restrained children died from a head, neck, or chest injury. Of these, 32 (63 percent) were in a forward-facing CRS, and 19 (37 percent) were in a rear-facing CRS. In addition to the 51 deaths, about 696 children suffered a MAIS 2-5 head, neck, or chest injury. About 585 (84 percent) of these child MAIS 2-5 injuries were in a forward-facing CRS, and 111 (16 percent) were in a rear-facing CRS.

Table II-7 Children in Properly Used Child Restraint Systems (CRS) With a Fatal or MAIS 2-5 Head, Neck, or Chest Injury

Age (years Old)	Forward-Facing CRS	Rear-Facing CRS	Total
Fatalities			
0-1	2	19	21
2-3	24	0	24
4-6	6	0	6
7-10	0	0	0
11-12	0	0	0
Total	32	19	51
MAIS 2-5 Injuries			
0-1	189	111	300
2-3	361	0	361
4-6	35	0	35
7-10	0	0	0
11-12	0	0	0
Total	585	111	696

Source: 2001 Fatality Analysis Reporting System; 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)
Note: MAIS 2-5 Injuries were derived from 1993-2001 CDS and adjusted to 2001 GES-CDS equivalent level.

CHAPTER III. DUMMIES AND INJURY CRITERIA

This chapter discusses the changes for FMVSS 213. These changes include: 12-month-old CRABI and Hybrid III test dummies, injury criteria and its corresponding injury criterion performance limits (ICPLs), seat assembly, and sled crash pulse. In addition, the chapter provides injury probability risk curves that will be used in the benefit estimates.

A. Dummies

The agency will use a 12-month-old CRABI dummy and the more advanced Hybrid III 3-year-old and 6-year-old dummies for compliance tests. These dummies will replace the existing required 9-month-old and Hybrid II dummies. To further protect older children weighing between 50 and 80 pounds, the agency will use a 65-pound Hybrid III weighted 6-year-old dummy to test the structural integrity of the child safety systems. This section discusses the 12-month-old CRABI, the Hybrid III 3- and 6-year-old dummies and the weighted 6-year-old dummy. Readers can consult the following references for more information on dummy research and analysis:

1. Development and Evaluation of the Hybrid III Three-Year-Old Child Crash Test Dummy (H-III3C), December, 1998
2. Development and Evaluation of the Hybrid III Type Six-Year-Old Child Dummy, June 1998

3. Evaluation of the Weighted Hybrid III Six-Year-Old Dummy, June, 2001
4. A Comparative Evaluation of the Hybrid II and Hybrid III Child Dummy Families, June, 2001.

Hybrid III vs Hybrid II

Currently, FMVSS No. 213 specifies a newborn, 9-month, and Hybrid II 3-year and 6-year-old dummies be used in compliance tests. The newborn is used to ensure the structural integrity of child restraint systems (CRSs), and also ensure that the seat back angle does not exceed the 70 degrees limit specified in S5.14 of FMVSS 213. The 9-month old dummy is used to measure head and knee excursions. The Hybrid II 3- and 6-year-old dummies are used to measure HIC, head excursion, chest acceleration, and knee excursion.

The 12-month-old infant (CRABI) and the Hybrid III 3- and 6-year-old child dummies are more technologically advanced and equipped with greater instrumentation. These dummies contain a more advanced and biofidelic neck design. Readers can consult the NHTSA technical report titled "A Comparative Evaluation of Hybrid II and Hybrid III Child Dummy Families" for a detailed assessment of dummy equivalency research.

Weighted 6-Year-Old Dummy

The weighted 6-year-old dummy is the Hybrid III 6-year-old dummy with supplemental weights added to a total of 65 pounds. A 1994 NHTSA study[1] showed that children do not properly fit into standard vehicle safety belt systems without booster seats until they reach 4 foot 9 inch height which correlates with an average weight of 80 pounds. To improve the protection of the children weighing between 50 and 80 pounds, the agency is developing a 10-year-old dummy. The Hybrid III 10-year-old dummy weighs approximately 78 pounds. The weighted 6-year-old dummy is the agency's near-term solution to cover the weight gap until the completion of the 10-year-old dummy. To ensure the CRSs adequately protect older children, the agency will use the weighted 6-year-old dummy to test the structural integrity of the restraint systems in compliance tests. Readers can consult NHTSA's report "Evaluation of the Weighted Hybrid III Six-Year-Old Dummy, June 2001" for detailed information.

B. Injury Criteria

The current FMVSS No. 213 uses head injury criterion (HIC), 3 ms chest acceleration (chest g), head excursion, and knee excursion to assess the performance of child restraint systems. HIC unlimited ($HIC_{Unlimited}$), an unrestricted time interval measurement, is used to predict head injury. The injury criteria performance limits (ICPL) are: 1000 for $HIC_{Unlimited}$, 60 g for 3 ms chest acceleration, 720 millimeter (28 inches) for child

[1] Klinich KD, Pritz HB, Beebe MS, Welty K, Burton RW, Study of older child restraint/booster seat fit and NASS injury analysis, DOT/HS 808 248, National Highway Traffic Safety Administration, Vehicle Research and Test Center, East Liberty, OH, 1994.

restraints tested with tether or 813 millimeter (32 inches) when tested without tether for head excursion, and 915 millimeter (36 inches) for knee excursion. The ICPLs are the same for all dummy sizes.

In the NPRM, the agency proposed to amend FMVSS No. 213 to incorporate FMVSS No. 208 injury criteria, except for the neck limits, and its ICPLs. FMVSS No. 208 requires HIC_{15}, chest g, chest deflection, and neck criteria (Nij) with peak neck tension and compression limits to minimize the risk from a deploying air bag. The NPRM also proposed to adopt the scaled ICPLs required in FMVSS No. 208. The required ICPLs in FMVSS No. 208 are different depending on the dummy size to ensure a consistent performance requirement and adequate safety protection to all occupants.

The agency received many comments on the NPRM. After carefully considering all the comments, in the final rule, the agency decided to preserve current FMVSS No. 213 injury criteria and ICPLs with minor revision to the head injury criterion. Instead of HIC_{15} as proposed in the NPRM, the final rule requires HIC_{36} with 1000 as the ICPL for head injury criterion. The basis for this decision is described in Chapter IV.

In summary, the final rule requires HIC_{36} for head injury, chest g for chest injury, head excursion, and knee excursion to assess the performance of CRSs. The required ICPL is 1000 HIC_{36}, 60 chest g's, 720 millimeters (28 inches) - child restraint tested with tether or 813 millimeters (32 inches) - tested without tether for head excursion, and 915 millimeters (36 inches) for knee excursion. The ICPLs are the same for all dummy sizes, except the weighted 6-year-old. The weighted 6-year-old dummy is used to ensure the structural integrity of a child restraint. Table III-1 shows the final rule requirements on injury criteria and the ICPLs. For comparison purposes, the injury criteria and ICPLs proposed in the NPRM are listed in Table III-2.

Table III-1
Final Rule Requirements on Injury Criteria and Injury Criteria Performance Limits

		Hybrid III Child Dummy Size		
Injury Criteria	**12-Month-Old CRABI**	**3-Year-Old**	**6-Year-Old**	**Weighted 6-Year-Old*** **
Head Criterion (HIC_{36ms})	1000	1000	1000	NR
Thoracic Criteria				
Chest Acceleration (g)**	60	60	60	NR
Head Excursion				
With Tether (mm)**	720 28”	720 28”	720 28”	NR NR
Without Tether (mm)**	813 32”	813 32”	813 32”	NR NR
Knee Excursion (mm)**	915 36”	915 36”	915 36”	NR NR

NR: not required
** Current FMVSS No. 213 standard
*** for structural integrity only

Table III-2
NPRM Proposal on Injury Criteria and Injury Criteria Performance Limits

Injury Criteria	Hybrid III Child Dummy Size 12-Month-Old CRABI	3-Year-Old	6-Year-Old	Weighted 6-Year-Old***
Head Criterion (HIC_{15ms})	390	570	700	700
Neck Criterion (Nij)	1	1	1	1
Critical Neck Value*				
$F_{z\ CRIT}$:Tension (N)	1460	2340	3096	3096
$F_{Z\ CRIT}$: Compression (N)	1460	2120	2800	2800
$M_{y\ CRIT}$: Flexion (N-m)	43	68	93	93
$M_{Y\ CRIT}$: Extension (N-m)	17	30	42	42
Thoracic Criteria				
Chest Acceleration (g)	50	55	60	60
Chest Deflection (mm)	30 1.2"	34 1.4"	40 1.6"	42 1.7"
Head Excursion **				
With Tether (mm)	720 28"	720 28"	720 28"	720 28"
Without Tether (mm)	813 32"	813 32"	813 32"	813 32"
Knee Excursion (mm)**	915 36"	915 36"	915 36"	915 36"

* Critical values to calculate Nij
** Current FMVSS No. 213 standard
*** Scaled from 6-years-old ICPLs

C. Injury Risk Curves

The injury curves are used to estimate the probability of risk of a fatality or injury at a given injury value. The difference between the probabilities of a given set of crash test injury values and of the proposed ICPLs would be used to assess the benefits of the final rule. The majority of MAIS 1 injuries were skin bruises. The final rule has minimal impact on these types of injuries because the final rule does not change the interaction between child dummies and restraint systems. Thus, this analysis assumes that the final rule would impact only on MAIS 2+ injuries. For this reason, this section provides only MAIS 2+ through 5+ and fatality injury probability risk curves.

The head and chest injury risk curves are the variations of those presented in the Final Economic Assessment, FMVSS No. 208, Advanced Air Bags. The development of original injury probability curves was documented in NHTSA's report "Supplement: Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, March 2000[2]." Also, see NHTSA report "Final Economic Assessment, FMVSS No. 208, Advanced Air Bags, May 2000" for a summary of the injury probability curves.

Head Injury Criterion (HIC_{36})

The HIC_{36} probability curves are used to measure the chances that a vehicle occupant would receive certain MAIS head injury at a given HIC value. The analysis uses both variations of Prasad/Mertz and Hertz (lognormal)[3] curves to estimate head injury probabilities. The Prasad/Mertz curves were developed by assuming that the injury threshold levels were normally distributed. The mean of the normal distribution is the average of the lowest risk factor of injured specimens and the highest risk factor of uninjured specimens. The lognormal curves were developed using logistic regression and assumed that the injury threshold levels were a lognormal distribution. The Prasad/Mertz curves generally underestimate the probability of injury at lower HIC level relative to the lognormal curves. Please see the NHTSA's biomechanics technical reports, March 1999

[2] Docket Number NHTSA-2000-7013-3.
[3] See the Final Economic Assessment, FMVSS No. 208, Advanced Air Bags, Office of Regulatory Analysis & Evaluation, Plans and Policy, May 2000.

(Docket Number NHTSA 1999-6407-5) for the detailed comparison of statistical methodologies that were used to develop these curves.

The HIC curves for children in the NPRM were originally developed in support of the FMVSS No. 208, air bag final rule. In FMVSS No. 208, the risks of head injury for 12-month-old CRABI, 3-year-old, and 6-year-old dummy were established by the scaled HIC_{15} values. A12-month-old infant with a HIC_{15} of 390 would have the same head injury risk as a 3-year-old with a HIC_{15} of 570 and as a 6-year-old with a HIC_{15} of 700 (see HIC ICPLs in Table III-2). These HIC_{15} injury risk curves were used as the basis to derive the HIC_{36} head injury curves. First, these HIC_{15} values (390, 570, 700) were mapped to their HIC_{36} equivalent level by using the linear equation $HIC_{15} = 0.7 * HIC_{36}$[4]. Their corresponding HIC_{36} values would be 557, 814, and 1000. If measured by HIC_{36}, a 12-month-old infant with a HIC_{36} of 557 would have the same head injury risk as a 3-year-old with a HIC_{36} of 814 and as a 6-year-old with a HIC_{36} of 1000. In this final rule, the base HIC_{15} injury curves will be shifted accordingly to derive the HIC_{36} curves.

Prasad/Mertz Probability Curves

The Prasad/Mertz HIC_{36} curves for the 12-month-old CRABI are:

AIS 2+ Percent Injury Probability = $[1 / (1 + \exp^{(2.49 + 111.4/HIC - 0.00867*HIC)})] \times 100\%$.

AIS 3+ Percent Injury Probability = $[1 / (1 + \exp^{(3.39 + 111.4/HIC - 0.00668*HIC)})] \times 100\%$.

AIS 4+ Percent Injury Probability = $[1 / (1 + \exp^{(4.90 + 111.4/HIC - 0.00630*HIC)})] \times 100\%$.

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[4] NHTSA's report "Supplement: Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, March 2000."

AIS 5+ Percent Injury Probability = $[1 / (1 + \exp^{(7.82 + 111.4/HIC - 0.00770*HIC)})] \times 100\%$.

Fatality Percent Injury Probability = $[1 / (1 + \exp^{(12.14 + 111.4/HIC - 0.01014*HIC)})] \times 100\%$.

Figure III-1 depicts these curves. Table III-3 shows the probability risk values that are derived from these curves. Based on Table III-3, the variation of Prasad/Mertz curves, at the HIC_{36} ICPL level of 1000, a 12-month-old infant in a CRS in the frontal crash would have a 89.9 percent chance of receiving a MAIS 2-5 non-fatal head injury (at 1000 HIC_{36}, add together 3.8% for MAIS 2, 17.6% for MAIS 3, 34.2% for MAIS 4, and 34.4% for MAIS 5) and have about a 9.9 percent chance of receiving a fatal head injury.

The Prasad/Mertz HIC_{36} curves for the 3-year-old dummy are:

AIS 2+ Percent Injury Probability = $[1 / (1 + \exp^{(2.49 + 168.2/HIC - 0.00593*HIC)})] \times 100\%$.

AIS 3+ Percent Injury Probability = $[1 / (1 + \exp^{(3.39 + 168.2/HIC - 0.00457*HIC)})] \times 100\%$.

AIS 4+ Percent Injury Probability = $[1 / (1 + \exp^{(4.90 + 168.2/HIC - 0.00431*HIC)})] \times 100\%$.

AIS 5+ Percent Injury Probability = $[1 / (1 + \exp^{(7.82 + 168.2/HIC - 0.00527*HIC)})] \times 100\%$.

Fatality Percent Injury Probability = $[1 / (1 + \exp^{(12.14 + 168.2/HIC - 0.00694*HIC)})] \times 100\%$.

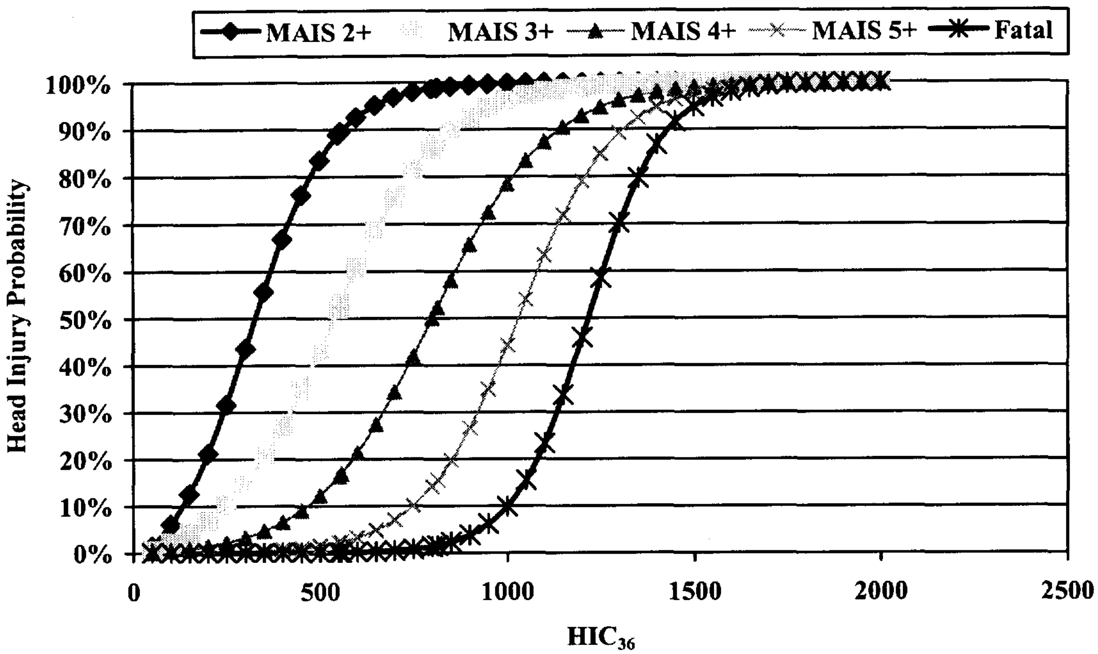

Figure III-1
Head Injury Probability vs HIC_{36} for 12-Month-Old CRABI
(Derived From Prasad/Mertz Curves)

Figure III-2 depicts these curves for the 3-year-old dummy. Table III-4 shows the probability risk values that are derived from these curves. Based on Table III-4, the variation of Prasad/Mertz curves, at the HIC_{36} ICPL level of 1000, a child represented by the 3-year-old dummy in a CRS in the frontal crash would have a 95.9 percent chance of receiving a MAIS 2-5 non-fatal head injury (at 1000 HIC_{36}, add together 22.9% for MAIS 2, 41.4% for MAIS 3, 25.8% for MAIS 4, and 5.8% for MAIS 5) and have about a 0.4 percent chance of receiving a fatal head injury.

Table III-3
Prasad/Mertz HIC_{36} Probability Risk Values for 12-Month-Old CRABI

HIC_{36}	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
50	0.9%	0.4%	0.1%	0.0%	0.0%
100	4.0%	1.7%	0.4%	0.0%	0.0%
150	8.5%	3.3%	0.8%	0.1%	0.0%
200	14.4%	5.4%	1.4%	0.1%	0.0%
250	21.4%	8.0%	2.1%	0.2%	0.0%
300	28.8%	11.4%	3.0%	0.3%	0.0%
350	35.4%	15.6%	4.3%	0.4%	0.0%
400	39.9%	20.4%	5.9%	0.6%	0.0%
450	41.5%	25.7%	8.0%	1.0%	0.0%
500	40.3%	31.0%	10.7%	1.4%	0.1%
550	36.8%	35.8%	14.1%	2.1%	0.1%
600	32.0%	39.3%	18.1%	3.1%	0.2%
650	26.6%	41.2%	22.6%	4.5%	0.3%
700	21.3%	41.2%	27.3%	6.5%	0.5%
750	16.6%	39.4%	32.0%	9.2%	0.8%
800	12.7%	36.0%	35.8%	12.8%	1.4%
850	9.5%	31.6%	38.3%	17.4%	2.3%
900	7.1%	26.8%	39.0%	22.8%	3.8%
950	5.2%	22.0%	37.5%	28.8%	6.2%
1000	3.8%	17.6%	34.2%	34.4%	9.9%
1050	2.7%	13.8%	29.4%	38.5%	15.5%
1100	2.0%	10.6%	23.9%	40.0%	23.4%
1150	1.4%	8.1%	18.6%	38.2%	33.7%
1200	1.0%	6.1%	13.8%	33.2%	45.9%
1250	0.7%	4.5%	10.0%	26.2%	58.6%
1300	0.5%	3.4%	7.0%	18.9%	70.2%
1350	0.4%	2.5%	4.8%	12.7%	79.7%
1400	0.3%	1.8%	3.2%	8.0%	86.7%
1450	0.2%	1.3%	2.1%	4.8%	91.6%
1500	0.1%	1.0%	1.4%	2.7%	94.8%
1550	0.1%	0.7%	0.9%	1.5%	96.8%
1600	0.1%	0.5%	0.6%	0.8%	98.0%
1650	0.0%	0.4%	0.4%	0.4%	98.8%
1700	0.0%	0.3%	0.2%	0.2%	99.3%
1750	0.0%	0.2%	0.1%	0.1%	99.6%
1800	0.0%	0.2%	0.1%	0.0%	99.7%
1850	0.0%	0.1%	0.1%	0.0%	99.8%
1900	0.0%	0.1%	0.0%	0.0%	99.9%
1950	0.0%	0.1%	0.0%	0.0%	99.9%
2000	0.0%	0.0%	0.0%	0.0%	100.0%

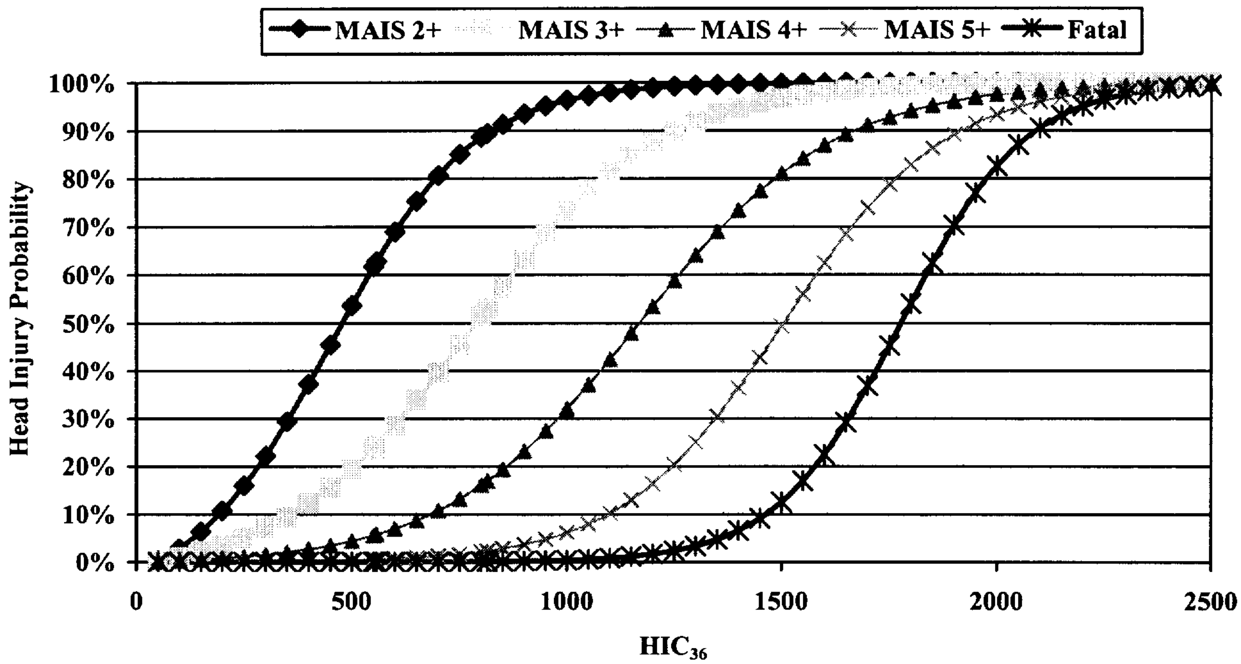

Figure III-2
Head Injury Probability vs HIC_{36} for 3-Year-Old Dummy
(Derived From Prasad/Mertz Curves)

The Prasad/Mertz HIC_{36} curves for the 6-year-old dummy are:

AIS 2+ Percent Injury Probability = $[1 / (1 + \exp^{(2.49 + 200/HIC - 0.00483*HIC)})] \times 100\%$.

AIS 3+ Percent Injury Probability = $[1 / (1 + \exp^{(3.39 + 200/HIC - 0.00372*HIC)})] \times 100\%$.

AIS 4+ Percent Injury Probability = $[1 / (1 + \exp^{(4.90 + 200/HIC - 0.00351*HIC)})] \times 100\%$.

AIS 5+ Percent Injury Probability = $[1 / (1 + \exp^{(7.82 + 200/HIC - 0.00429*HIC)})] \times 100\%$.

Fatality Percent Injury Probability = $[1 / (1 + \exp^{(12.14 + 200/HIC - 0.00565*HIC)})] \times 100\%$.

Figure III-3 depicts these curves. Table III-5 shows the probability risk values that are derived from these curves. Based on Table III-5, the variation of Prasad/Mertz curves, at the HIC_{36} ICPL level of 1000, a child represented by the 6-year-old dummy in a CRS in the frontal crash would have a 89.3 percent chance of receiving a MAIS 2-5 non-fatal

Table III-5
Prasad/Mertz HIC_{36} Probability Risk Values for 6-Year-Old Dummy

HIC_{36}	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
50	0.1%	0.1%	0.0%	0.0%	0.0%
100	1.1%	0.5%	0.1%	0.0%	0.0%
150	2.8%	1.2%	0.3%	0.0%	0.0%
200	4.9%	2.0%	0.5%	0.0%	0.0%
250	7.4%	2.9%	0.8%	0.1%	0.0%
300	10.3%	3.9%	1.0%	0.1%	0.0%
350	13.7%	5.1%	1.3%	0.1%	0.0%
400	17.5%	6.5%	1.7%	0.1%	0.0%
450	21.5%	8.1%	2.1%	0.2%	0.0%
500	25.7%	9.9%	2.6%	0.2%	0.0%
550	29.7%	11.9%	3.2%	0.3%	0.0%
600	33.5%	14.2%	3.8%	0.4%	0.0%
650	36.7%	16.7%	4.6%	0.5%	0.0%
700	39.2%	19.4%	5.5%	0.6%	0.0%
750	40.8%	22.2%	6.6%	0.7%	0.0%
800	41.5%	25.2%	7.8%	0.9%	0.0%
850	41.3%	28.2%	9.2%	1.2%	0.1%
900	40.3%	31.1%	10.8%	1.4%	0.1%
950	38.5%	33.9%	12.6%	1.8%	0.1%
1000	36.2%	36.3%	14.6%	2.2%	0.1%
1050	33.5%	38.4%	16.8%	2.8%	0.2%
1100	30.6%	39.9%	19.2%	3.4%	0.2%
1150	27.6%	41.0%	21.7%	4.2%	0.3%
1200	24.6%	41.4%	24.3%	5.2%	0.4%
1250	21.7%	41.2%	27.0%	6.3%	0.5%
1300	19.0%	40.5%	29.6%	7.7%	0.6%
1350	16.5%	39.2%	32.1%	9.3%	0.9%
1400	14.2%	37.5%	34.4%	11.3%	1.1%
1450	12.2%	35.3%	36.3%	13.5%	1.5%
1500	10.4%	32.9%	37.8%	16.0%	2.0%
1550	8.8%	30.3%	38.7%	18.8%	2.6%
1600	7.4%	27.6%	39.0%	21.9%	3.5%
1650	6.3%	24.9%	38.7%	25.1%	4.6%
1700	5.3%	22.3%	37.7%	28.4%	6.0%
1750	4.4%	19.7%	36.1%	31.7%	7.8%
1800	3.7%	17.4%	33.9%	34.6%	10.2%
1850	3.1%	15.2%	31.3%	37.2%	13.1%
1900	2.6%	13.2%	28.5%	39.0%	16.7%
1950	2.2%	11.4%	25.4%	39.9%	21.0%
2000	1.8%	9.8%	22.4%	39.8%	26.1%

Lognormal Probability Curves

Figure III-4 and Table III-6 show the probability risk values derived from the lognormal curves for children represented by the 12-month-old CRABI. Figure III-5 and Table III-7 show the probability risk values for children represented by the 3-year-old. Figure III-6 and Table III-8 show the probability risk values for children represented by the 6-year-old dummy.

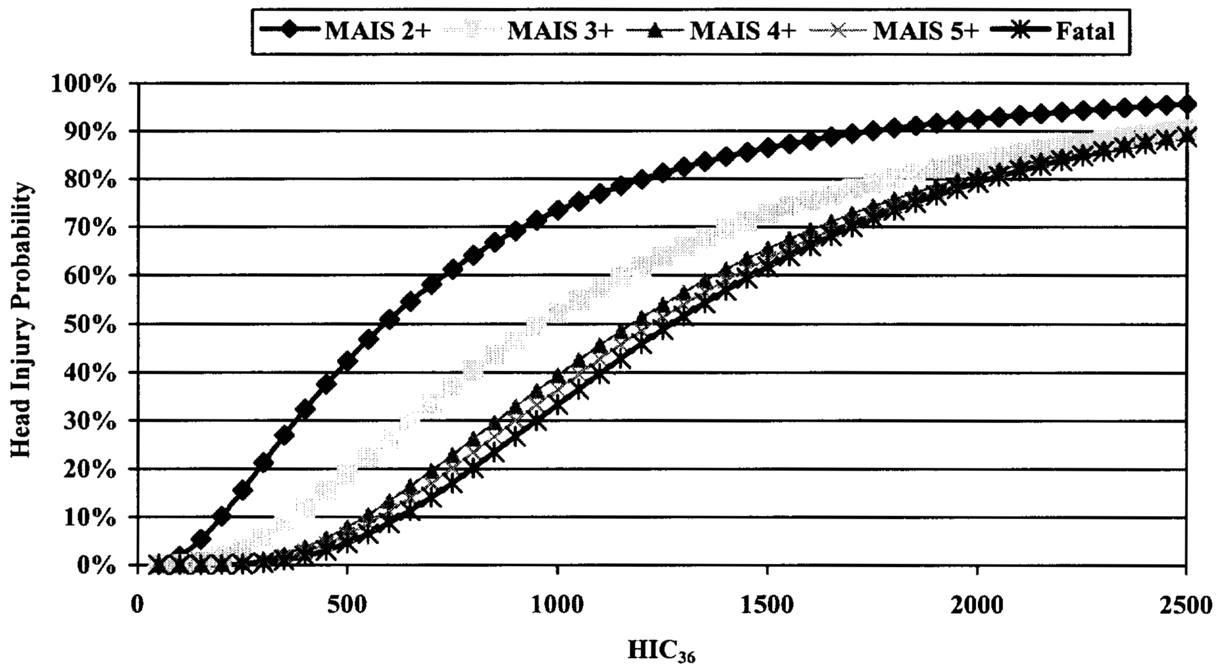

Figure III-4
Head Injury Probability vs HIC_{15} for 12-Month-Old CRABI
(Derived From Lognormal Curves)

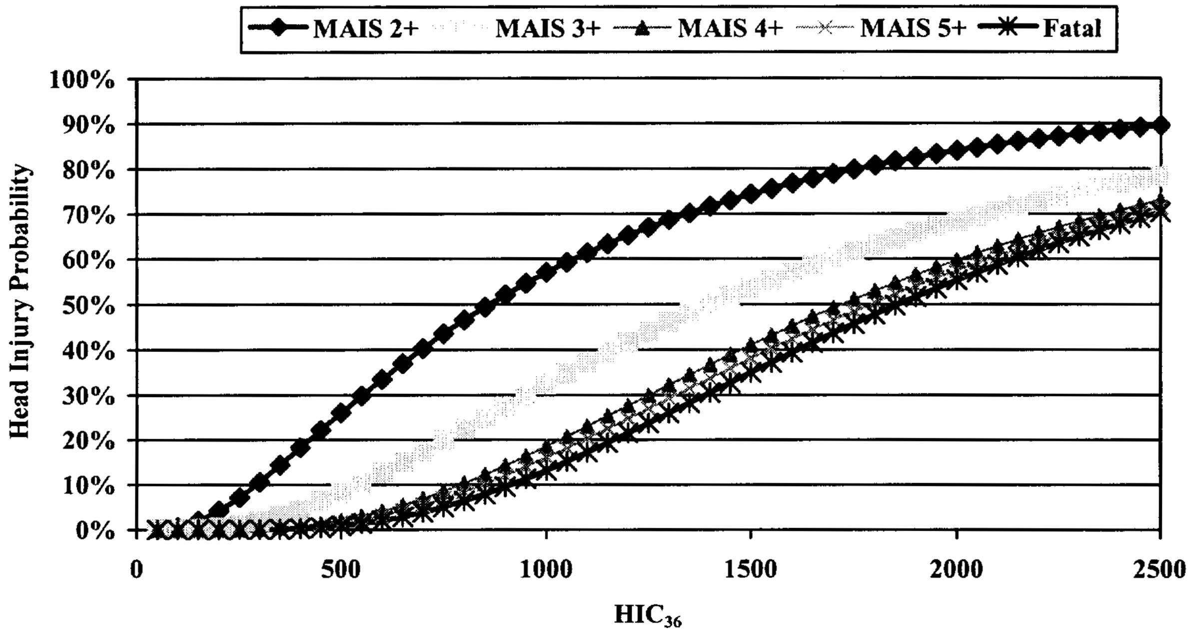

Figure III-5
Head Injury Probability vs HIC_{15} for 3-Year-Old Dummy
(Derived From Lognormal Curves)

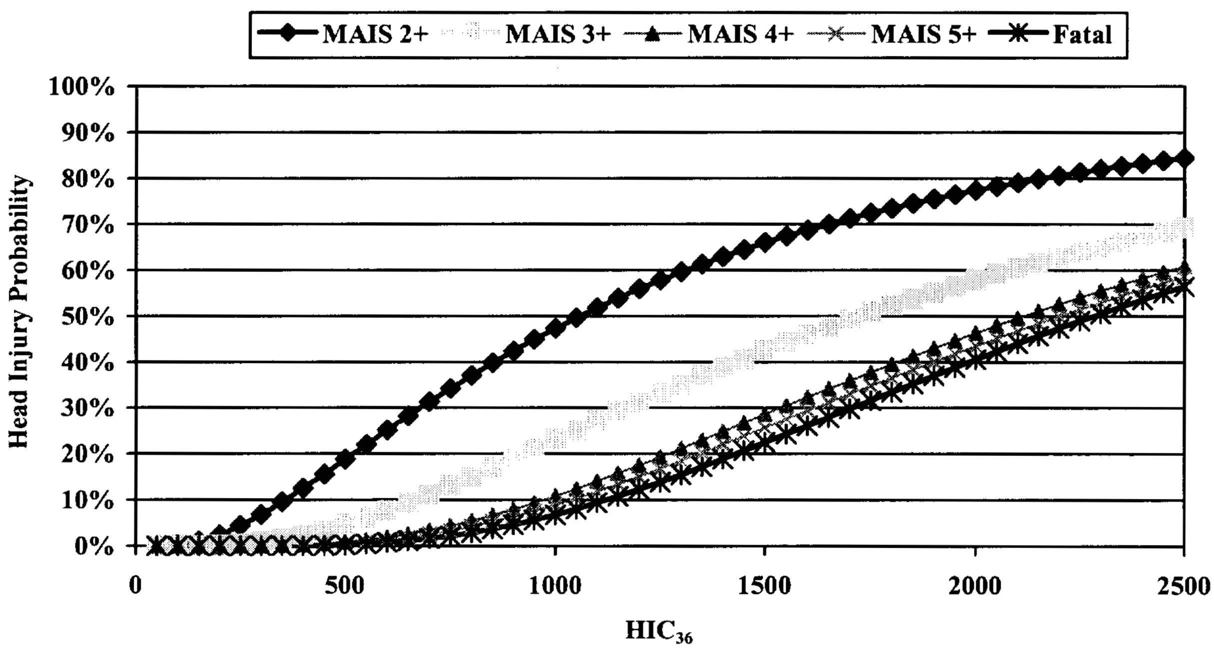

Figure III-6
Head Injury Probability vs HIC_{15} for 6-Year-Old Dummy
(Derived From Lognormal Curves)

Table III-6
Lognormal HIC_{36} Probability Risk Values for 12-Month-Old CRABI

HIC_{36}	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
50	0.2%	0.0%	0.0%	0.0%	0.0%
100	1.7%	0.1%	0.0%	0.0%	0.0%
150	4.7%	0.6%	0.0%	0.0%	0.0%
200	8.4%	1.5%	0.1%	0.1%	0.0%
250	12.1%	2.9%	0.2%	0.2%	0.2%
300	15.5%	4.6%	0.4%	0.4%	0.5%
350	18.3%	6.4%	0.6%	0.7%	1.0%
400	20.6%	8.1%	0.9%	1.0%	1.9%
450	22.2%	9.6%	1.2%	1.4%	3.1%
500	23.4%	11.0%	1.6%	1.7%	4.6%
550	24.2%	12.1%	1.9%	2.1%	6.5%
600	24.6%	12.9%	2.1%	2.4%	8.8%
650	24.7%	13.5%	2.4%	2.7%	11.3%
700	24.6%	13.9%	2.6%	2.9%	14.1%
750	24.3%	14.0%	2.7%	3.1%	17.1%
800	23.9%	14.0%	2.8%	3.2%	20.2%
850	23.3%	13.9%	2.9%	3.3%	23.4%
900	22.7%	13.6%	3.0%	3.3%	26.7%
950	22.0%	13.2%	3.0%	3.2%	30.0%
1000	21.2%	12.8%	2.9%	3.2%	33.3%
1050	20.5%	12.3%	2.9%	3.1%	36.5%
1100	19.7%	11.7%	2.9%	3.0%	39.7%
1150	18.9%	11.2%	2.8%	2.8%	42.9%
1200	18.1%	10.6%	2.7%	2.7%	45.9%
1250	17.4%	10.0%	2.6%	2.5%	48.8%
1300	16.6%	9.4%	2.5%	2.4%	51.7%
1350	15.9%	8.8%	2.4%	2.2%	54.4%
1400	15.2%	8.2%	2.3%	2.0%	56.9%
1450	14.5%	7.7%	2.2%	1.8%	59.4%
1500	13.9%	7.2%	2.1%	1.7%	61.8%
1550	13.2%	6.6%	2.0%	1.5%	64.0%
1600	12.6%	6.1%	1.9%	1.4%	66.1%
1650	12.0%	5.7%	1.8%	1.2%	68.1%
1700	11.5%	5.2%	1.6%	1.1%	70.0%
1750	10.9%	4.8%	1.6%	1.0%	71.8%
1800	10.4%	4.4%	1.5%	0.8%	73.5%
1850	9.9%	4.0%	1.4%	0.7%	75.1%
1900	9.5%	3.7%	1.3%	0.6%	76.6%
1950	9.1%	3.4%	1.2%	0.5%	78.0%
2000	8.6%	3.1%	1.1%	0.4%	79.3%

Table III-7
Lognormal HIC_{36} Probability Risk Values for 3-Year-Old Dummy

HIC_{36}	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
50	0.0%	0.0%	0.0%	0.0%	0.0%
100	0.5%	0.0%	0.0%	0.0%	0.0%
150	1.8%	0.1%	0.0%	0.0%	0.0%
200	3.8%	0.4%	0.0%	0.0%	0.0%
250	6.2%	0.9%	0.0%	0.0%	0.0%
300	8.8%	1.7%	0.1%	0.1%	0.1%
350	11.4%	2.6%	0.2%	0.1%	0.1%
400	13.8%	3.7%	0.3%	0.3%	0.3%
450	16.0%	4.9%	0.4%	0.4%	0.5%
500	17.9%	6.1%	0.6%	0.6%	0.9%
550	19.6%	7.3%	0.8%	0.8%	1.4%
600	21.0%	8.4%	1.0%	1.1%	2.1%
650	22.1%	9.5%	1.2%	1.3%	2.9%
700	23.0%	10.5%	1.4%	1.6%	3.9%
750	23.7%	11.3%	1.6%	1.8%	5.1%
800	24.2%	12.0%	1.8%	2.1%	6.4%
850	24.5%	12.7%	2.0%	2.3%	7.9%
900	24.7%	13.1%	2.2%	2.5%	9.6%
950	24.7%	13.5%	2.4%	2.7%	11.3%
1000	24.7%	13.8%	2.5%	2.9%	13.2%
1050	24.5%	14.0%	2.6%	3.0%	15.2%
1100	24.3%	14.1%	2.7%	3.1%	17.2%
1150	24.0%	14.1%	2.8%	3.2%	19.4%
1200	23.6%	14.0%	2.9%	3.2%	21.6%
1250	23.2%	13.9%	2.9%	3.3%	23.8%
1300	22.8%	13.7%	3.0%	3.3%	26.0%
1350	22.3%	13.4%	3.0%	3.3%	28.3%
1400	21.8%	13.2%	3.0%	3.2%	30.5%
1450	21.3%	12.9%	3.0%	3.2%	32.8%
1500	20.8%	12.5%	2.9%	3.1%	35.0%
1550	20.3%	12.2%	2.9%	3.1%	37.2%
1600	19.8%	11.8%	2.9%	3.0%	39.4%
1650	19.2%	11.4%	2.8%	2.9%	41.6%
1700	18.7%	11.0%	2.8%	2.8%	43.7%
1750	18.2%	10.6%	2.7%	2.7%	45.7%
1800	17.6%	10.2%	2.6%	2.6%	47.8%
1850	17.1%	9.8%	2.6%	2.5%	49.7%
1900	16.6%	9.4%	2.5%	2.4%	51.7%
1950	16.1%	9.0%	2.4%	2.2%	53.5%
2000	15.6%	8.6%	2.4%	2.1%	55.3%

Table III-8
Lognormal HIC_{36} Probability Risk Values for 6-Year-Old Dummy

HIC_{36}	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
50	0.0%	0.0%	0.0%	0.0%	0.0%
100	0.3%	0.0%	0.0%	0.0%	0.0%
150	1.0%	0.1%	0.0%	0.0%	0.0%
200	2.3%	0.2%	0.0%	0.0%	0.0%
250	4.0%	0.4%	0.0%	0.0%	0.0%
300	5.9%	0.9%	0.0%	0.0%	0.0%
350	8.0%	1.4%	0.1%	0.1%	0.0%
400	10.1%	2.1%	0.1%	0.1%	0.1%
450	12.2%	2.9%	0.2%	0.2%	0.2%
500	14.1%	3.8%	0.3%	0.3%	0.3%
550	15.9%	4.8%	0.4%	0.4%	0.5%
600	17.5%	5.8%	0.6%	0.6%	0.8%
650	18.9%	6.8%	0.7%	0.7%	1.2%
700	20.2%	7.7%	0.9%	0.9%	1.7%
750	21.2%	8.7%	1.0%	1.1%	2.2%
800	22.1%	9.5%	1.2%	1.3%	2.9%
850	22.9%	10.3%	1.4%	1.5%	3.8%
900	23.5%	11.0%	1.6%	1.7%	4.7%
950	23.9%	11.7%	1.7%	1.9%	5.7%
1000	24.3%	12.2%	1.9%	2.1%	6.8%
1050	24.5%	12.7%	2.1%	2.3%	8.1%
1100	24.7%	13.1%	2.2%	2.5%	9.4%
1150	24.7%	13.4%	2.3%	2.6%	10.8%
1200	24.7%	13.7%	2.5%	2.8%	12.3%
1250	24.6%	13.9%	2.6%	2.9%	13.9%
1300	24.5%	14.0%	2.6%	3.0%	15.5%
1350	24.3%	14.1%	2.7%	3.1%	17.2%
1400	24.1%	14.1%	2.8%	3.2%	18.9%
1450	23.8%	14.0%	2.8%	3.2%	20.7%
1500	23.5%	14.0%	2.9%	3.2%	22.5%
1550	23.1%	13.8%	2.9%	3.3%	24.3%
1600	22.8%	13.7%	3.0%	3.3%	26.1%
1650	22.4%	13.5%	3.0%	3.3%	28.0%
1700	22.0%	13.3%	3.0%	3.2%	29.8%
1750	21.6%	13.0%	3.0%	3.2%	31.6%
1800	21.2%	12.8%	3.0%	3.2%	33.5%
1850	20.8%	12.5%	2.9%	3.1%	35.3%
1900	20.3%	12.2%	2.9%	3.1%	37.1%
1950	19.9%	11.9%	2.9%	3.0%	38.9%
2000	19.5%	11.6%	2.8%	2.9%	40.6%

Based on Table III-6, the variation of lognormal curves, at the HIC_{36} ICPL level of 1000, a 12-month-old infant occupant in the frontal crash would have a 40.1 percent chance of receiving a MAIS 2-5 non-fatal head injury (at 1000 HIC_{36}, add together 21.2% for MAIS 2, 12.8% for MAIS 3, 2.9% for MAIS 4, and 3.2% for MAIS 5) and have about a 33.3 percent chance of receiving a fatal head injury.

Based on Table III-7, the variation of lognormal curves, at the HIC_{36} ICPL level of 1000, a 3-year-old child occupant in the frontal crash would have a 43.9 percent chance of receiving a MAIS 2-5 non-fatal head injury (at 1000 HIC_{36}, add together 24.7% for MAIS 2, 13.8% for MAIS 3, 2.5% for MAIS 4, and 2.9% for MAIS 5) and have about a 13.2 percent chance of receiving a fatal head injury

Based on Table III-8, the variation of the lognormal curves, at the ICPL level of 1000, a 6-year-old child occupant would have a 40.5 percent chance of receiving a MAIS 2-5 non-fatal head injury (at 1000 HIC_{36}, add together 24.3% for MAIS 2, 12.2% for MAIS 3, 1.9% for MAIS 4, and 2.1% for MAIS 5), and have about a 6.8 percent chance of receiving a fatal head injury.

Chest Acceleration

The thoracic injury probability is a function of chest acceleration (chest g's). Chest g's were based on a 3 ms clip of the spinal acceleration. The chest acceleration injury probability curves for children represented by the 12-month-old CRABI[5] are:

[5] The original chest acceleration probability formula were listed in the "Final; Economic Assessment, FMVSS NO 208, Advanced Air Bags, May 2000".

AIS 2+ Percent Injury Probability $= [1 / (1 + \exp^{(1.2324 - 0.06912*g)})] \times 100\%$

AIS 3+ Percent Injury Probability $= [1 / (1 + \exp^{(3.1493 - 0.07560*g)})] \times 100\%$

AIS 4+ Percent Injury Probability $= [1 / (1 + \exp^{(4.3425 - 0.07560*g)})] \times 100\%$

AIS 5+ Percent Injury Probability $= [1 / (1 + \exp^{(8.7652 - 0.07908*g)})] \times 100\%$

Fatality Percent Injury Probability $= [1 / (1+ \exp^{(8.7652 - 0.07908*g)})] \times 100\%$

Where, g = chest g's.

Figure III-7 depicts these curves and Table III-9 lists the corresponding MAIS risk probabilities for children represented by the 12-month-old CRABI. Note that there were insufficient data to measure fatality risk. The AIS 5+ curve was therefore used as a proxy for fatalities.

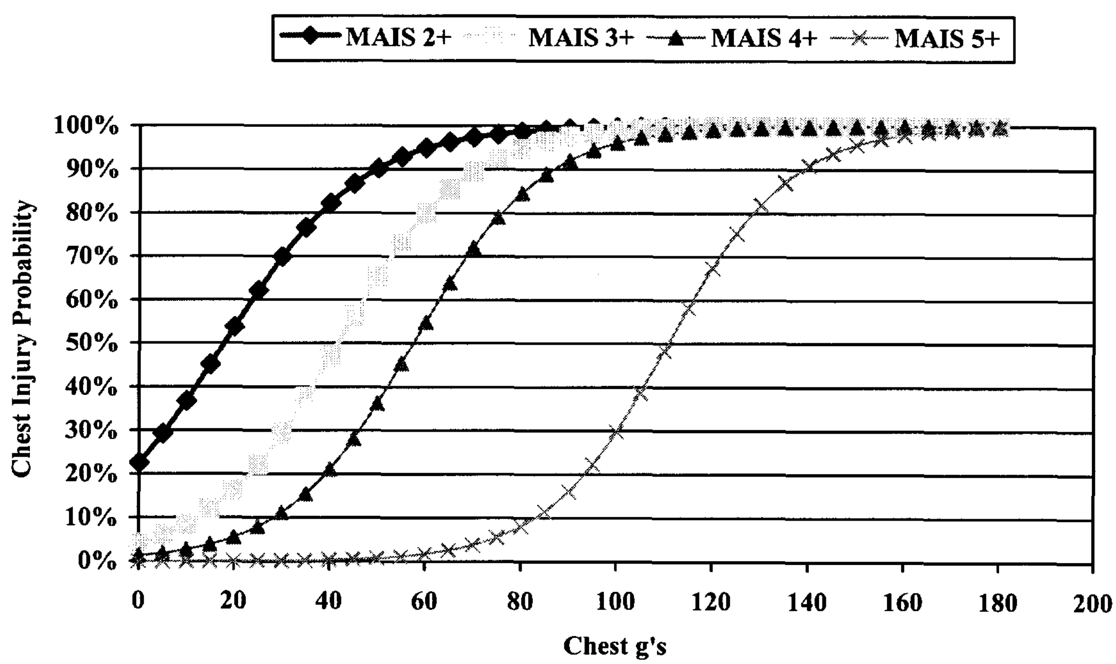

Figure III-7
Chest Injury Probability vs Chest Acceleration (g's) for 12-Month-Old CRABI

Table III-9
Chest g Probability Risk Values for 12-Month-Old CRABI

Chest g	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
0	18.5%	2.8%	1.3%	0.0%	0.0%
5	23.3%	4.0%	1.8%	0.0%	0.0%
10	28.4%	5.7%	2.7%	0.0%	0.0%
15	33.4%	7.9%	3.8%	0.1%	0.1%
20	37.5%	10.7%	5.5%	0.1%	0.1%
25	40.0%	14.2%	7.8%	0.1%	0.1%
30	40.6%	18.1%	11.0%	0.2%	0.2%
35	38.9%	22.2%	15.2%	0.3%	0.3%
40	35.4%	25.8%	20.7%	0.4%	0.4%
45	30.5%	28.2%	27.5%	0.6%	0.6%
50	25.0%	29.0%	35.5%	0.8%	0.8%
55	19.6%	27.9%	44.2%	1.2%	1.2%
60	14.9%	25.2%	53.1%	1.8%	1.8%
65	10.9%	21.5%	61.3%	2.6%	2.6%
70	7.9%	17.4%	68.3%	3.8%	3.8%
75	5.6%	13.5%	73.5%	5.6%	5.6%
80	3.9%	10.2%	76.6%	8.0%	8.0%
85	2.7%	7.4%	77.5%	11.5%	11.5%
90	1.8%	5.3%	76.0%	16.1%	16.1%
95	1.3%	3.8%	72.3%	22.2%	22.2%
100	0.9%	2.7%	66.4%	29.8%	29.8%
105	0.6%	1.8%	58.7%	38.7%	38.7%
110	0.4%	1.3%	49.8%	48.3%	48.3%
115	0.3%	0.9%	40.6%	58.2%	58.2%
120	0.2%	0.6%	31.8%	67.4%	67.4%
125	0.1%	0.4%	24.0%	75.4%	75.4%
130	0.1%	0.3%	17.6%	82.0%	82.0%
135	0.1%	0.2%	12.6%	87.1%	87.1%
140	0.0%	0.1%	8.9%	90.9%	90.9%
145	0.0%	0.1%	6.2%	93.7%	93.7%
150	0.0%	0.1%	4.2%	95.7%	95.7%

Based on Table III-9, at the ICPL level of 60 g's, a 12-month-old infant occupant in the frontal crash would have a 95.9 percent chance of receiving a MAIS 2-5 non-fatal chest injury (at 60 g's add together 14.9% for MAIS 2, 25.2% for MAIS 3, 53.1% for MAIS 4, and 1.8% for MAIS 5) and have about a 1.8 percent chance of receiving a fatal chest injury.

The chest acceleration injury probability curves for children represented by the 3-year-old child dummy are:

AIS 2+ Percent Injury Probability $= [1 / (1 + \exp^{(1.2324 - 0.06284*g)})] \times 100\%$

AIS 3+ Percent Injury Probability $= [1 / (1 + \exp^{(3.1493 - 0.06873*g)})] \times 100\%$

AIS 4+ Percent Injury Probability $= [1 / (1 + \exp^{(4.3425 - 0.06873*g)})] \times 100\%$

AIS 5+ Percent Injury Probability $= [1 / (1 + \exp^{(8.7652 - 0.07189*g)})] \times 100\%$

Fatality Percent Injury Probability $= [1 / (1 + \exp^{(8.7652 - 0.07189*g)})] \times 100\%$

Where, g = chest g's.

Figure III-8 depicts these curves and Table III-10 lists the corresponding MAIS risk probabilities for children represented by the 3-year-old dummy. Note that there were insufficient data to measure fatality risk. The AIS 5+ curve was therefore used as a proxy for fatalities.

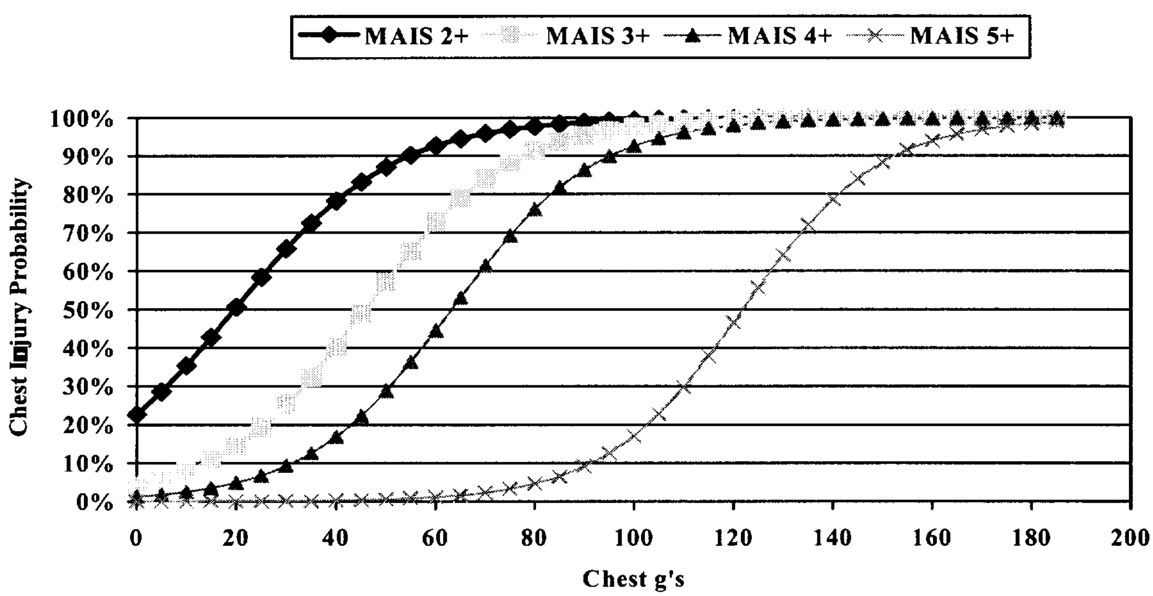

Figure III-8
Chest Injury Probability vs Chest Acceleration (g's) for 3-Year-Old Dummy

Table III-10
Chest g Probability Risk Values for 3-Year-Old Dummy

Chest g	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
0	18.5%	2.8%	1.3%	0.0%	0.0%
5	22.8%	3.9%	1.8%	0.0%	0.0%
10	27.5%	5.3%	2.5%	0.0%	0.0%
15	32.1%	7.2%	3.5%	0.1%	0.1%
20	36.1%	9.6%	4.8%	0.1%	0.1%
25	39.1%	12.5%	6.7%	0.1%	0.1%
30	40.6%	15.9%	9.1%	0.1%	0.1%
35	40.2%	19.6%	12.4%	0.2%	0.2%
40	38.1%	23.2%	16.6%	0.3%	0.3%
45	34.5%	26.3%	21.9%	0.4%	0.4%
50	30.0%	28.4%	28.2%	0.6%	0.6%
55	25.0%	29.0%	35.5%	0.8%	0.8%
60	20.1%	28.1%	43.4%	1.2%	1.2%
65	15.7%	25.8%	51.5%	1.6%	1.6%
70	11.9%	22.6%	59.2%	2.3%	2.3%
75	8.9%	18.9%	65.9%	3.3%	3.3%
80	6.5%	15.2%	71.4%	4.7%	4.7%
85	4.7%	11.9%	75.2%	6.6%	6.6%
90	3.4%	9.1%	77.2%	9.2%	9.2%
95	2.4%	6.8%	77.3%	12.6%	12.6%
100	1.7%	5.0%	75.5%	17.1%	17.1%
105	1.2%	3.7%	71.8%	22.9%	22.9%
110	0.9%	2.7%	66.4%	29.8%	29.8%
115	0.6%	1.9%	59.4%	37.8%	37.8%
120	0.4%	1.4%	51.5%	46.6%	46.6%
125	0.3%	1.0%	43.1%	55.5%	55.5%
130	0.2%	0.7%	34.9%	64.1%	64.1%
135	0.1%	0.5%	27.4%	71.9%	71.9%
140	0.1%	0.4%	20.9%	78.6%	78.6%
145	0.1%	0.3%	15.6%	84.0%	84.0%
150	0.1%	0.2%	11.5%	88.3%	88.3%

Based on Table III-10, at the ICPL level of 60 g's, a 3-year-old child occupant in the frontal crash would have a 92.9 percent chance of receiving a MAIS 2-5 non-fatal chest injury (at 60 g's add together 20.1% for MAIS 2, 28.1% for MAIS 3, 43.4% for MAIS 4, and 1.2% for MAIS 5) and have about a 1.2 percent chance of receiving a fatal chest injury.

The chest acceleration injury probability curves for children represented by the 6-year-old dummy are:

AIS 2+ Percent Injury Probability = $[1 / (1 + \exp^{(1.2324 - 0.05760*g)})] \times 100\%$.

AIS 3+ Percent Injury Probability = $[1 / (1 + \exp^{(3.1493 - 0.06300*g)})] \times 100\%$.

AIS 4+ Percent Injury Probability = $[1 / (1 + \exp^{(4.3425 - 0.06300*g)})] \times 100\%$.

AIS 5+ Percent Injury Probability = $[1 / (1 + \exp^{(8.7652 - 0.06590*g)})] \times 100\%$

Fatality Percent Injury Probability = $[1 / (1 + \exp^{(8.7652 - 0.06590*g)})] \times 100\%$

Where, g = chest g's.

Figure III-9 depicts the chest injury probability vs chest g's. Table III-11 lists the risk values by chest g's. Note that there were insufficient data to measure fatality risk. The AIS 5+ curve was therefore used as a proxy for fatalities.

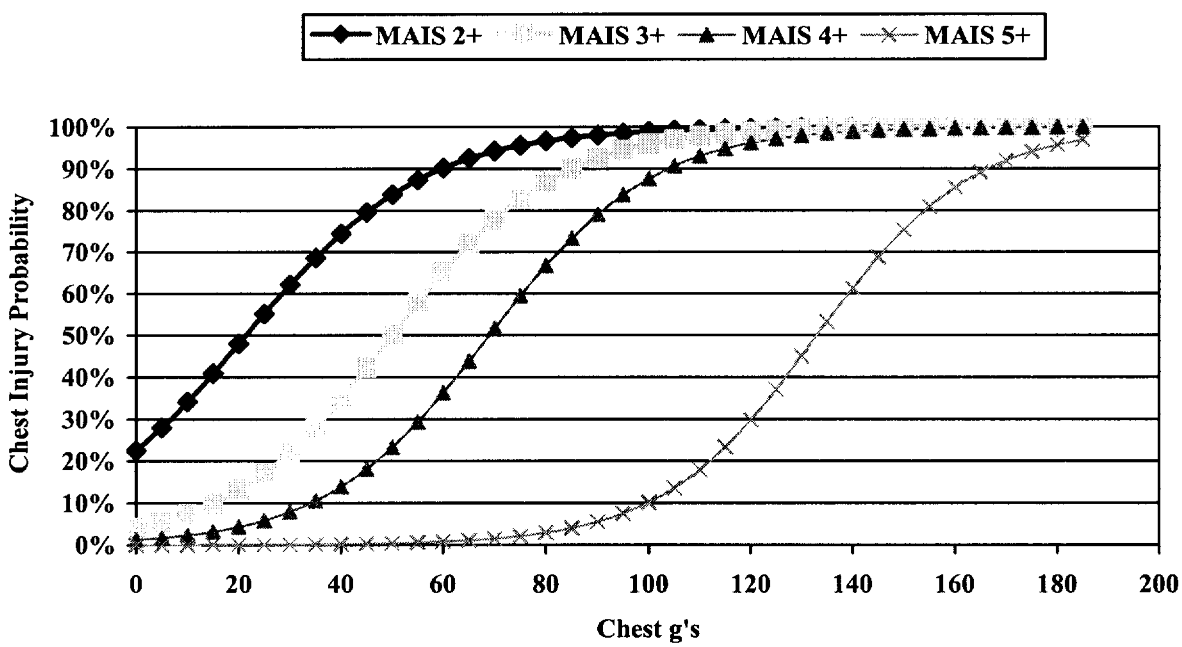

Figure III-9
Chest Injury Probability vs Chest Acceleration (g's) for 6-Year-Old Dummy

Table III-11
Chest g Probability Risk Values for 6-Year-Old Dummy

Chest g	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
0	18.5%	2.8%	1.3%	0.0%	0.0%
5	22.5%	3.8%	1.7%	0.0%	0.0%
10	26.7%	5.1%	2.4%	0.0%	0.0%
15	31.0%	6.7%	3.2%	0.0%	0.0%
20	34.9%	8.8%	4.3%	0.1%	0.1%
25	38.0%	11.3%	5.8%	0.1%	0.1%
30	40.0%	14.2%	7.8%	0.1%	0.1%
35	40.7%	17.5%	10.4%	0.2%	0.2%
40	39.7%	20.9%	13.7%	0.2%	0.2%
45	37.4%	24.1%	17.8%	0.3%	0.3%
50	33.8%	26.7%	22.9%	0.4%	0.4%
55	29.6%	28.5%	28.8%	0.6%	0.6%
60	25.0%	29.0%	35.5%	0.8%	0.8%
65	20.5%	28.2%	42.7%	1.1%	1.1%
70	16.4%	26.2%	50.1%	1.6%	1.6%
75	12.8%	23.4%	57.3%	2.1%	2.1%
80	9.8%	20.1%	63.8%	3.0%	3.0%
85	7.4%	16.7%	69.3%	4.1%	4.1%
90	5.6%	13.5%	73.5%	5.6%	5.6%
95	4.1%	10.7%	76.2%	7.6%	7.6%
100	3.0%	8.3%	77.4%	10.2%	10.2%
105	2.2%	6.3%	77.0%	13.6%	13.6%
110	1.6%	4.8%	75.0%	18.0%	18.0%
115	1.2%	3.6%	71.4%	23.4%	23.4%
120	0.9%	2.7%	66.4%	29.8%	29.8%
125	0.6%	2.0%	60.1%	37.1%	37.1%
130	0.4%	1.5%	52.9%	45.1%	45.1%
135	0.3%	1.1%	45.2%	53.3%	53.3%
140	0.2%	0.8%	37.6%	61.3%	61.3%
145	0.2%	0.6%	30.4%	68.8%	68.8%
150	0.1%	0.4%	24.0%	75.4%	75.4%

Based on Table III-11, at the ICPL level of 60 g's, a 6-year-old child occupant in the frontal crash would have a 92.9 percent chance of receiving a MAIS 2-5 non-fatal chest injury (at 60 g's add together 25.0% for MAIS 2, 29.0% for MAIS 3, 35.5% for MAIS 4, and 0.8% for MAIS 5) and have about a 0.8 percent chance of receiving a fatal chest injury.

D. Seat Assembly

The final rule requires the following revisions to the seat assembly from current FMVSS 213 requirements:

a. Revise the seat back angle from 15 degrees to 20 degrees,

b. Revise the seat cushion angle from 8 degrees to 15 degrees,

c. Revise the lap belt anchorage spacing from 222 mm to 400 mm in the center seat position and from 500 mm to 472 mm in the outboard seating position, and

d. Revise the seat assembly to represent the fixed seat back as opposed to the current flexible seat back.

These revisions make the test seat assembly more representative of the existing vehicle fleet and more closely harmonize with the test seat assembly used in the European standard, ECE R44.

The test seat assembly is slightly different than the seat assembly proposed in the NPRM. Table III-12 summarizes the seat assembly differences among the final rule, those proposed in the NPRM, and those required in current FMVSS No. 213.

Table III-12 Test Seat Assembly

Test Seat Assembly	Final Rule	NPRM Proposal	Current FMVSS No. 213
Seat Back Angle	20 $\pm$ 1 degrees	22 degrees	15 degrees
Seat Cushion Angle	15 degrees	15 degrees	8 degrees
Anchorage Spacing Center Seating Outboard Seating	 400 mm 472 mm	 392 mm 472 mm	 222 mm 500 mm
Seat Back Type	fixed	fixed	flexible

E. Crash Pulse Corridor

The agency proposed to establish a crash pulse corridor. The corridor will not reduce the stringency of the test because a sled pulse within the proposed corridor will have similar characteristics to the pulse currently specified in the standard. The change will make it easier to conduct the compliance tests closer to 48 km/h (30 mph). With a wider test corridor, more test facilities will be easily able to conduct compliance tests. The final rule crash pulse corridor is the same as proposed in the NPRM.

CHAPTER IV. ANALYSIS OF CRASH TEST DATA

This chapter analyzes available FMVSS No. 213 sled crash test data. After publication of the NPRM, NHTSA contracted with the U.S. Naval Air Warfare Center Aircraft Division at Patuxent River, Maryland (PAX) to conduct tests with the NPRM proposed seat assembly. These tests were limited to 5-point harness rear-facing infant seats, convertible safety seats, and belt positioning seats. These CRSs were installed using a lap belt, a lap/shoulder belt, and the LATCH system. Later, the agency realized that some PAX tests had testing problems with neck injury and chest deflection data. To resolve the problems, the agency's Vehicle Research and Test Center (VRTC) replicated PAX tests with the 3- and 6 year-old dummies using the same type of CRSs and test characteristics.

Because the seat assembly used in tests conducted after the publication of the NPRM was much closer to the final rule, these crash test data were used to compare the dummy performance and effect of the revised seat assembly. This chapter is organized into four sections. The first section compares the Hybrid III to the Hybrid II dummies. The second section examines the difference of HIC_{36} and $HIC_{Unlimited}$. The third section analyzes the impact of the revised seating assembly, and the last section calculates the pass/fail rates. All detailed test information including test configuration, CRS types, and injury outcomes are listed in Tables A-1 to A-9 of the Appendix under the title "Tests Conducted after the NPRM". Tests used in the PRE are listed under the title "Tests Using Current FMVSS No. 213 Seat Assembly" in Appendix A. Note that the "revised seat assembly" and the "NPRM proposed seat assembly" were used interchangeably in the analysis.

A. Hybrid III vs Hybrid II

PAX tested the CRSs using the NPRM proposed seat assembly. One set of the tests was with a Hybrid III child dummy (3- or 6-year-old). The other set of the tests was conducted with a current Hybrid II child dummy (3- or 6-year-old). The following four tables used these data to compare the injury outcomes of Hybrid III and Hybrid II dummies. Tables IV-1-A and IV-1-B list the injury criteria that were measured by both types of 3-year-old dummies under the FMVSS No. 213 test condition but with the NPRM proposed seat assembly. These tests were originally designed in response to the NPRM proposal, thus HIC_{36} was not measured. Instead, $HIC_{Unlimited}$ was used to compare the head injury outcomes of these two dummies. As shown in the tables, there was no particular trend to indicate whether the injury outcomes of the Hybrid III dummy were constantly higher or lower than that of the Hybrid II dummy. Nevertheless, these CRSs passed the proposal with either dummy. The HIC_{36} generally is lower than $HIC_{Unlimited}$, thus, all these CRSs passed the final rule requirement of HIC_{36} 1000. The same conclusion was drawn for the 6-year-old dummies. Tables IV-2-A and IV-2-B lists the comparison data for the 6-year-old dummy. Note the comparison data for the 6-year-old dummies were based on only two CRSs tested.

In addition to these test results, readers can consult the agency report titled 'A Comparative Evaluation of Hybrid II and Hybrid III Child Dummy Families' for in-depth information on the dummy design and instrumentation. The report presents the comparison methodology and results in greater detail. The comparison report concludes that the Hybrid III and Hybrid II child dummies show similar performance in the sled test environment, that the overall performance is repeatable, but that the Hybrid III dummies are more technologically advanced and have more measurement capabilities.

Table IV-1-A Comparison Injury Criterion Outcomes Between Hybrid III and Hybrid II Dummies
3-Year-Old Child Dummy
Head and Chest Injury Criteria

Child Safety Restraint Configuration	HIC Unlimited		% Change*	Chest g's		% Change*
	Hybrid III	Hybrid II		Hybrid III	Hybrid II	
Cosco Touriva Convertible Lap Belt No Tether	447	703	-36%	36.5	40.4	-10%
Century Accel Convertible Lap Belt No Tether	355	627	-43%	36.1	26.8	35%
Century Breverra Hybrid Lap Belt No Tether	537	670	-20%	45.9	9.2	57%
Cosco HB Booster Hybrid Lap Belt No Tether	705	446	58%	46.1	41.6	11%

Source: Crash tests conducted by PAX.
* "% Change" is the percent change from Hybrid II performance

Table IV-1-B Comparison Injury Criterion Outcomes Between Hybrid III and Hybrid II Dummies
3-Year-Old Child Dummy
Head and Knee Excursion

Child Safety Restraint Configuration	Head Excursion (mm)		% Change*	Knee Excursion (mm)		% Change*
	Hybrid III	Hybrid II		Hybrid III	Hybrid II	
Cosco Touriva Convertible Lap Belt No Tether	394	498	-21%	671	671	0%
Century Accel Convertible Lap Belt No Tether	505	495	2%	640	681	-6%
Century Breverra Hybrid Lap Belt No Tether	541	572	-5%	739	696	6%
Cosco HB Booster Hybrid Lap Belt No Tether	743	572	30%	775	660	17%

Source: Crash tests conducted by PAX.
* "% Change" is the percent change from Hybrid II performance

Table IV-2-A Comparison Injury Criterion Outcomes Between Hybrid III and Hybrid II Dummies
6-Year-Old Child Dummy
Head and Chest Injury Criteria

Child Safety Restraint Configuration	HIC Unlimited		% Change*	Chest g's		% Change*
	Hybrid III	Hybrid II		Hybrid III*	Hybrid II	
Century Breverra High-Back BPB Lap/Shoulder Belt No Tether	416	209	99%	41.4	35.1	18%
Cosco HB Booster High-Back BPB Lap/Shoulder Belt No Tether	756	381	98%	38.3	42.2	-9%

Source: Crash tests conducted by PAX.
* "% Change" is the percent change from Hybrid II performance

Table IV-2-B Comparison Injury Criterion Outcomes Between Hybrid III and Hybrid II Dummies
6-Year-Old Child Dummy
Head and Knee Excursion

Child Safety Restraint Configuration	Head Excursion (mm)		% Change*	Knee Excursion (mm)		% Change*
	Hybrid III*	Hybrid II		Hybrid III*	Hybrid II	% Change
Century Breverra High-Back BPB Lap/Shoulder Belt No Tether	508	500	2%	297	500	-41%
Cosco HB Booster High-Back BPB Lap/Shoulder Belt No Tether	467	447	4%	610	701	-13%

Source: Crash tests conducted by PAX.
* "% Change" is the percent change from Hybrid II performance

B. HIC_{36} vs $HIC_{Unlimited}$

This analysis used the test data with the current FMVSS No. 213 required seat assembly. These data can be found in Tables A-10 to A-14 of Appendix A. Figures IV-1 to IV-3 indicate that HIC_{36} and $HIC_{unlimted}$ are highly linearly correlated. The Microsoft Excel, Regression analysis tool was used to generate the linear model. Figure IV-1 was plotted based on the 19 CRABI test data, rear- and forward-facing combined. The figure shows that $HIC_{36} = 0.9163 * HIC_{Unlimited}$, with the adjusted $R^2 = 0.91$ percent. For CRABI, this equation means that HIC_{36} 916 = $HIC_{Unlimited}$ 1000 or HIC_{36} 1000 = $HIC_{Unlimited}$ 1091. The R^2 represents the correlation of predicted HIC_{36} and the predicted HIC_{36}.

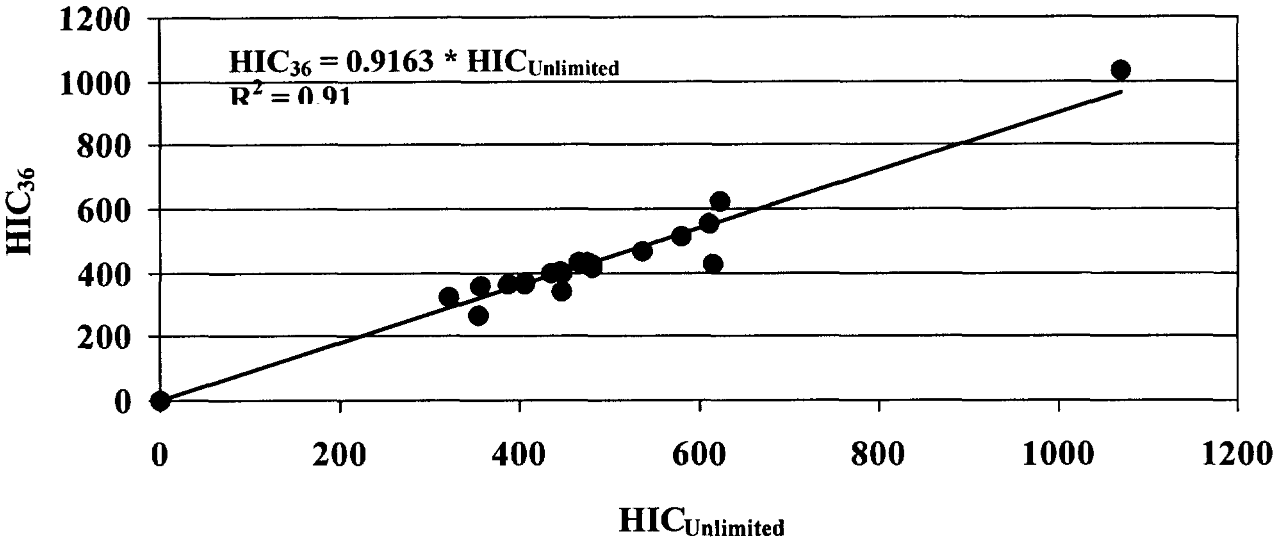

Figure IV-1 HIC_{36} v.s. $HIC_{Unlimited}$
12-Month-Old CRABI

Figure IV-2 depicts the linear relationship between HIC_{36} and $HIC_{Unlimited}$ for the Hybrid III 3-year-old dummy. As shown, $HIC_{36} = 0.9707 * HIC_{Unlimited}$, with adjusted $R^2 = 0.82$. The equation means that HIC_{36} 971 = $HIC_{Unlimited}$ 1000 or HIC_{36} 1000 = $HIC_{Unlimited}$ 1030. Figure IV-3 depicts the HIC relationship for the Hybrid III 6-year-old dummies. For 6-year-old, the HIC relationship would be $HIC_{36} = 0.8518 * HIC_{Unlimited}$, with adjusted $R^2 = 0.89$. The equation means that HIC_{36} 852 = $HIC_{Unlimited}$ 1000 or HIC_{36} 1000 = $HIC_{Unlimited}$ 1174. These figures show that the overall difference between HIC_{36} and $HIC_{Unlimited}$ is small.

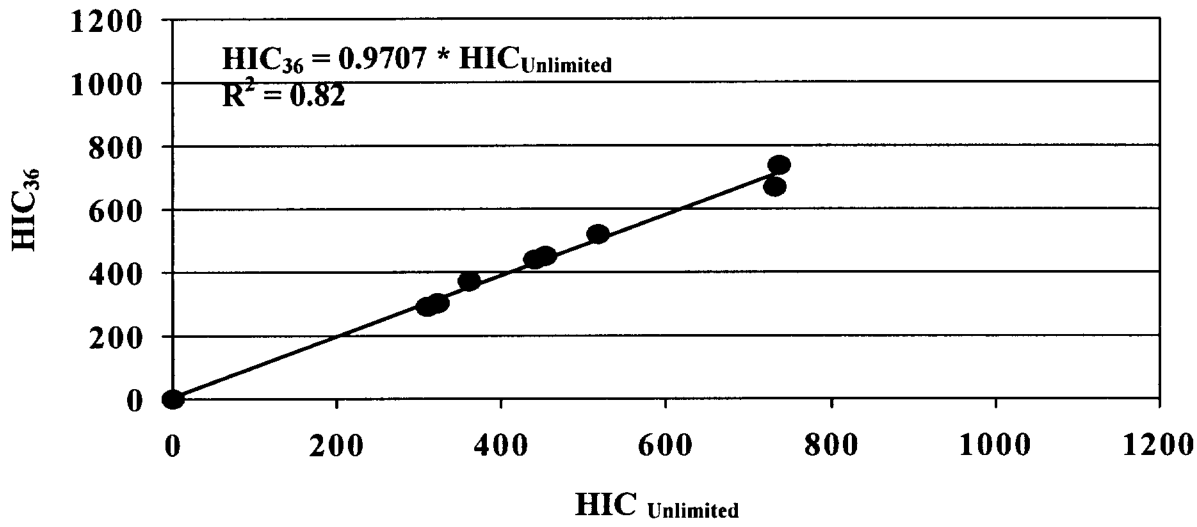

Figure IV-2 HIC_{36} v.s. $HIC_{Unlimited}$
Hybrid III 3-Year-Old Dummy

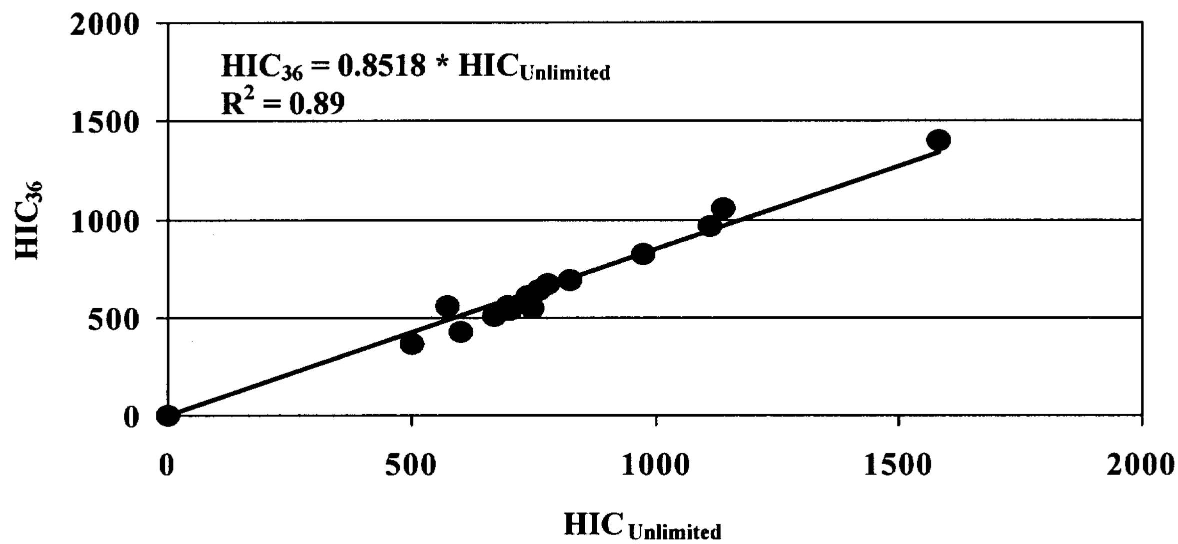

Figure IV-3 HIC_{36} v.s. $HIC_{Unlimited}$
Hybrid III 6-Year-Old Dummy

C. Hybrid III HIC_{36} vs Hybrid II $HIC_{Unlimited}$

The final rule upgrades the child test dummies from the Hybrid II to Hybrid III dummies and requires new head injury measurement HIC_{36}. This section assesses the combined impact of new dummies and HIC_{36}. The HIC_{36} measurements from Hybrid III dummies were compared to the $HIC_{Unlimited}$ measurement from Hybrid II dummies. Tables IV-3-A to IV-3-D show the comparison tests performed on identical child restraints. Tables IV-3-A and IV-3-B list the available tests that were conducted using the NPRM proposed seat assembly, one for the 3-year-old dummy and the other one for the 6-year-old. Tables IV-3-C and IV-3-D list tests that were conducted using the existing FMVSS No. 213 seat assembly. In this set of data, if a CRS was tested more than once, the averaged outcome was used for comparison. The "Trend" shows how the Hybrid III HIC_{36} measurements compare to the Hybrid II $HIC_{Unlimited}$.

For the 3-year-old dummy, 3 of 4 tests as shown in Table IV-3-A had the Hybrid III HIC_{36} less than the Hybrid II $HIC_{unlimited}$. On the other hand, data from Table IV-3-C show a different pattern. For 6-year-old dummy, data in both Tables IV-3-B and IV-3-D show that the Hybrid III HIC_{36} generally is greater than Hybrid II $HIC_{unlimited}$. Given that all the current CRSs have already met both conditions and passed with a significant margin, the improvements on child restraint performance relating to the change will be insignificant.

Table IV-3-A
Hybrid III HIC_{36} vs Hybrid II $HIC_{Unlimited}$
3-Year-Old Child Dummy
(Tested Using with The NPRM Proposed Seat Assembly)

	Hybrid III* HIC_{36}	Hybrid II $HIC_{Unlimited}$	Trend
Cosco Touriva Convertible Lap Belt No Tether	~ 434	703	Hybird III HIC_{36} *Less than* Hybrid II $HIC_{Unlimited}$
Century Accel Convertible Lap Belt No Tether	~ 344	627	Hybird III HIC_{36} *Less than* Hybrid II $HIC_{Unlimited}$
Century Breverra Hybrid Lap Belt No Tether	~ 521	670	Hybird III HIC_{36} *Less than* Hybrid II $HIC_{Unlimited}$
Cosco HB Booster Hybrid Lap Belt No Tether	~ 684	446	Hybird III HIC_{36} *Greater than* Hybrid II $HIC_{Unlimited}$

Source: adopted from Table IV-1-A
* HIC_{36} were not calculated, the relationship HIC_{36} = 0.97 * $HIC_{Unlimited}$ was used to approximate HIC_{36}.

Table IV-3-B
Hybrid III HIC_{36} vs Hybrid II $HIC_{Unlimited}$
6-Year-Old Child Dummy
(Tested Using the NPRM Proposed Seat Assembly)

	Hybrid III* HIC_{36}	Hybrid II $HIC_{Unlimited}$	Trend
Century Breverra High-Back BPB Lap/Shoulder Belt No Tether	~ 354	209	Hybird III HIC_{36} *Greater than* Hybrid II $HIC_{Unlimited}$
Cosco HB Booster High-Back BPB Lap/Shoulder Belt No Tether	~ 643	381	Hybird III HIC_{36} *Greater than* Hybrid II $HIC_{Unlimited}$

Source: adopted from Table IV-2-A
* HIC_{36} were not calculated, the relationship HIC_{36} = 0.85 * $HIC_{Unlimited}$ was used to approximate HIC_{36}.

Table IV-3-C
Hybrid III HIC_{36} vs Hybrid II $HIC_{Unlimited}$
3-Year-Old Child Dummy
(Tested Using Existing FMVSS No. 213 Seat Assembly)

	Hybrid III HIC_{36}	Hybrid II $HIC_{Unlimited}$	Trend
FF Convertible, Lap Belt	671	385	
FF Convertible, Lap Belt		479	
FF Convertible, Lap Belt		424	
Average	671	429	Hybird III HIC_{36} *Greater than* Hybrid II $HIC_{Unlimited}$
FF Convertible, Lap and Tether	303	387	
FF Convertible, Lap and Tether	362	396	
Average	333	392	Hybird III HIC_{36} *Less than* Hybrid II $HIC_{Unlimited}$
FF Convertible, LATCH	292	281	
FF Convertible, LATCH	518	336	
Average	408	309	Hybird III HIC_{36} *Greater than* Hybrid II $HIC_{Unlimited}$
FF Hybrid, Lap and Tether	452	392	
FF Hybrid, Lap and Tether	439	501	
Average	446	447	=

Table IV-3-D
Hybrid III HIC_{36} vs Hybrid II $HIC_{Unlimited}$
6-Year-Old Child Dummy
(Tested Using Existing FMVSS No. 213 Seat Assembly)

	Hybrid III HIC_{36}	Hybrid II $HIC_{Unlimited}$	Trend
High Back Booster, Lap/Shoulder Belt	826	326	
High Back Booster, Lap/Shoulder Belt	688	530	
Average	757	428	Hybird III HIC_{36} *Greater than* Hybrid II $HIC_{Unlimited}$

D. Revised Test Seat Assembly vs Current Seat Assembly

The final rule test seat assembly is slightly different than that proposed in the NPRM (see Table I-1 or Table III-3). The agency did not test CRSs using the final rule seat assembly. However, the agency believes that the small revision would not change the injury outcomes of the tests using the NPRM proposal if they had used the final rule requirements. To compare the final rule seat assembly to the current FMVSS No. 213

seat assembly, the analysis uses those tests with the NPRM proposed seat assembly as the surrogate tests for the final rule seat assembly. This analysis provides two types of comparisons. One is to assess the overall performance difference between these two seating assemblies. The other one is to assess the effect of the rigid seat back.

For overall impact assessment of the seat assembly, each of those CRSs tested with the NPRM proposed seat assembly was paired with its compliance tests. The analysis examines the seat back rotation and injury performance outcomes of the paired data. For seat back impact assessment, those CRSs tested with the NPRM proposed seat assembly with the rigid seat back were paired with the tests with same seat assembly but with a flexible seat back.

Impact on Child Safety Seat Back Rotation

Table IV-4-A lists the child safety seat back rotation measurement for CRSs tested with a newborn or a 9-month-old rear-facing dummy. There is no clear trend of impact of the revised seat assembly. Compared to the current FMVSS No. 213 seat assembly, the CRSs tested with a newborn dummy under the revised seat assembly, the change was from –8 percent to 20 percent. For CRSs tested with a 9-month-old infant dummy, the change in rotation measurement was from –5 percent to 25 percent. All tests with the revised seat assembly were well under the FMVSS No. 213 standard of 70 degrees.

Table IV-4-A Comparison Between NPRM Proposed and The Existing FMVSS No. 213 Test Seat Assemblies
Child Safety Seat Back Rotation (degrees)

Restraint Configuration	Revised	Existing *	% Change
New Born Infant (Rear-Facing)			
Evenflo On-My-Way Lap/Shoulder Belt No Tether	51.5	43.0	20%
Century 560 Lap/Shoulder Belt No Tether	42.5	46.0	-8%
Century Accel Convertible Lap/Shoulder Belt No Tether	50.7	Not Tested	n.a.
Century STE 2000 Convertible Lap/Shoulder Belt No Tether	40.0	Not Tested	n.a.
Cosco Triad Convertible Lap/Shoulder Belt LATCH	43.1	Not Tested	n.a.
9-Month-Old Infant (Rear-Facing)			
Evenflo On-My-Way Lap/Shoulder Belt No Tether	53.9	57.0	-5%
Century 560 Lap/Shoulder Belt No Tether	52.9	52.0	2%
Century STE 2000 Convertible Lap/Shoulder Belt No Tether	50.6	42.0	21%
Cosco Touriva Convertible Lap/Shoulder Belt No Tether	63.0	51.0	24%

* Current FMVSS No. 213 compliance tests; n.a.: not available.

Impact on HIC

All the tests using the current FMVSS No. 213 seat assembly were compliance tests. These compliance tests only reported the required $HIC_{Unlimited}$ measurement. Thus, $HIC_{Unlimited}$ was used for comparison. Table IV-4-B lists $HIC_{Unlimited}$ measurement for 3- and 6-year-old Hybrid II dummies. Three out of 4 tests with a 3-year-old dummy showed an increased $HIC_{Unlimited}$ when tested on the revised test seat assembly. One had a decreased $HIC_{Unlimited}$. Overall, the change was from –17 percent to 41 percent. As for the 6-year-old, all tests conducted on the revised seat assembly had a lower $HIC_{Unlimited}$.

The change was from –39 percent to –5 percent. Overall, all $HIC_{Unlimited}$ values were at least 30 percent below the 1000 HIC threshold.

Impact on Chest g's

Table IV-4-B lists chest g's for 3- and 6-year-old Hybrid II dummies. For 3-year-old, all 4 tests showed a lower chest g's with the revised test seat assembly. The change was from –42 percent to –4 percent. As for the 6-year-old dummy, 3 out of 4 tests showed an increased chest g's. The change was from –12 percent to 5 percent. As shown in the table, the chest g's from the tests with the revised seat assembly were well below the established threshold of 60 g's.

Impact on Head Excursion

Table IV-4-C lists the head excursion measurements for 9-month-old infant dummy and 3- and 6-year-old Hybrid II dummies. There was no clear trend of impact for the revised seat assembly. However, for the 6-year-old dummy, 3 out of 4 tests with the revised seat assembly had a longer head excursion that those with the current FMVSS No. 213 requirements. As shown in Table IV-4-C, head excursions of all these tests were well below the 813 mm (without tether) required in the current FMVSS No. 213.

Table IV-4-B Comparison Between NPRM Proposed and The Existing FMVSS No. 213 Test Seat Assemblies $HIC_{Unlimited}$ and Chest g's

	$HIC_{Unlimited}$			Chest g's		
Restraint Configuration	Revised	Existing*	% Change	Revised	Existing*	% Change
3-Year-Old Hybrid II Dummy (Forward Facing)						
Cosco Touriva Convertible Lap/Shoulder Belt No Tether	703	500	41%	40.4	42.0	-4%
Century Accel Convertible Lap/Shoulder Belt No Tether	627	480	31%	26.8	46.0	-42%
Century Breverra Hybrid Lap/Shoulder Belt No Tether	670	659	2%	29.2	40.0	-27%
Cosco High Back Hybrid Booster Lap/Shoulder Belt No Tether	446	535	-17%	41.6	44.0	-6%
6-Year-Old Hybrid II (Forward Facing)						
Cosco Gr. Explorer Backless BPB Lap/Shoulder Belt No Tether	267	438	-39%	49.2	44.0	12%
Cosco Gr. Explorer Backless BPB Lap/Shoulder Belt No Tether	328	438	-25%	38.6	44.0	-12%
Century Breverra High-Back BPB Lap/Shoulder Belt No Tether	209	308	-32%	35.1	33.0	6%
Cosco High Back Booster BPB Lap/Shoulder Belt No Tether	63.0	51.0	-5%	42.2	40.0	6%

* Current FMVSS No. 213 compliance tests

Table IV-4-C Comparison Between NPRM Proposed and The Existing FMVSS No. 213 Test Seat Assemblies
Head and Knee Excursion

	Head Excursion (mm)			**Knee Excursion (mm)**		
Restraint Configuration	Revised	Existing*	% Change	Revised	Existing*	% Change
9-Month-Old Infant Dummy (Forward Facing)						
Cosco Touriva Convertible Lap/Shoulder Belt No Tether No Tether	434	432	1%	546	483	13%
Century Accel Convertible Lap/Shoulder Belt No Tether	396	483	-18%	485	559	-13%
3-Year-Old Hybrid II Dummy (Forward Facing)						
Cosco Touriva Convertible Lap/Shoulder Belt No Tether	498	660	-25%	671	813	-18%
Century Accel Convertible Lap/Shoulder Belt No Tether	495	635	-22%	681	762	-11%
Century Breverra Hybrid Lap/Shoulder Belt No Tether	572	483	18%	696	584	19%
Cosco High Back Hybrid Booster Lap/Shoulder Belt No Tether	572	432	32%	660	635	4%
6-Year-Old Hybrid II Dummy (Forward Facing)						
Cosco Gr. Explorer Backless BPB Lap/Shoulder Belt No Tether	363	381	-5%	610	686	-11%
Cosco Gr. Explorer Backless BPB Lap/Shoulder Belt No Tether	457	381	20%	653	686	-5%
Century Breverra High-Back BPB Lap/Shoulder Belt No Tether	500	457	9%	500	610	-18%
Cosco High Back Booster BPB Lap/Shoulder Belt No Tether	447	432	4%	701	686	2%

* Current FMVSS No. 213 compliance tests

Impact on Knee Excursion

Table IV-4-C lists the knee excursion measurements for 9-month-old infant dummy and 3- and 6-year-old Hybrid II dummies. There was no clear trend of impact for the revised seat assembly. However, for the 6-year-old dummy, 3 out of 4 tests with the revised seat assembly had a shorter knee excursion that those with the current FMVSS No. 213 requirements. The impact direction was not in sync with that of head excursion. As shown in Table IV-4-C, knee excursions of these tests were well below the 813 mm required in the current FMVSS No. 213.

Overall Seat Assembly Impact

Based on the crash tests listed in Tables IV-4-A to IV-4-C, there was no clear indication whether the revised seat assembly had a positive or negative effect on the overall injury outcome. However, the injury measurements of all the tests with the revised seat assembly were well below the final rule ICPLs and the ICPLs required in the current FMVSS No. 213.

Rigid vs Flexible Seat Back

VRTC conducted several CRS tests with the NPRM proposed seat assembly but using the flexible seat back. These CRS tests include: 1 with a forward-facing 12-month-old CRABI, 3 with a forward-facing Hybrid III 3-year-old dummy, and 2 with a forward-facing Hybrid III 6-year-old dummy. Each CRS test was paired to its comparison test, i.e., same CRS tested in the identical testing configuration except for the seat back type. These tests were listed in Tables A-10 to A-12 of Appendix A.

For the 3-year-old tests, there are only two tests in the comparison group. Based on the performance outcomes (i.e., HIC_{36}, chest g's, head excursion, and knee excursion) of these tests, the agency believes that the effect of replacing the existing required flexible seat back by a rigid seat back would be minimal.

D. Pass/Fail Rate

This section summarizes the pass/file rates from all the test data on Hybrid III dummies using the NPRM proposed seat assembly. Each CRS test has an equal weight in calculating the pass/fail rates. All these tests are listed in Appendix A under the title "Tests Conducted After NPRM". There were repetitive tests for some types of CRS/belt/tether configurations. In this case, these repetitive tests are only counted as one test and the highest injury values of these tests were used in the pass/fail rate calculation.

<u>12-month-old CRABI</u>

Table IV-5-A summarizes the passing rate information for tests with the 12-month-old CRABI. A total of 11 tests on 7 different CRSs were performed with a rear-facing CRABI. Four of these 7 CRSs were tested twice: once with a lap belt and the second time with a lap/shoulder belt. The remaining 3 CRSs were tested with a lap belt. Thus, a total of 7 tests each with a different CRS were used for the pass/fail rate calculation. All these CRSs tested passed the final requirement of HIC_{36} 1000 and chest g of 60'g.

A total of 11 tests on 8 different CRSs were performed with a forward-facing CRABI. Two of these 4 CRSs were tested in two conditions: one with a lap belt and one with a lap/shoulder belt. Two CRSs were tested with a LATCH system and one had a repeated test. The remaining 4 CRSs were tested with a lap belt. A total of 8 tests (8 CRSs) were used for the pass rate analysis. All these forward-facing CSRs passed the final rule requirements.

Table IV-5-A Pass Rates for 12-Month-Old CRABI

CRS Orientation	Attachment to Seat	# of Tests	Injury Criteria			
			HIC_{36}	Head Excursion with/withoutTether (mm)	Chest Acceleration (g)	Knee Excursion (mm)
Standard			1000	720/813	60	915
Rear-Facing	Lap	7	100%	na	100%	na
	Lap/Shoulder	4*	100%		100%	
	Overall	7**	100%	na	100%	na
Forward-Facing	Lap	6	100%	100%	100%	100%
	Lap/Shoulder	2*	100%	100%	100%	100%
	LATCH	2	100%	100%	100%	100%
	Overall	8**	100%	100%	100%	100%

* same CRSs as those tested with a lap belt.
** Distinctly different CRSs

3-Year-Old Dummy

Table IV-5-B lists the pass rates for the Hybrid-III 3-year-old dummy in a forward-facing CRS. There were a total of 27 tests on 13 different CRSs. Many of these were repetitive tests. Eleven of these 13 CRSs were tested with a lap belt and 2 were tested with a LATCH. Four of those tested with a lap belt were also tested with a lap/shoulder belt. As shown in the table, all these CRS tests with a 3-year-old dummy passed the final rule ICPLs.

Table IV-5-B Pass Rates for Hybrid III 3-Year-Old Dummy

CRS Orientation	Attachment to Seat	# of Tests	Injury Criteria			
			HIC_{36}	Head Excursion with/wo Tether (mm)	Chest Acceleration (g)	Knee Excursion (mm)
Standard			1000	720/813	55	915
Forward-Facing	Lap	11	100%	100%	100%	100%
	Lap/Shoulder	4*	100%	100%	100%	100%
	LATCH	2	100%	100%	100%	100%
	Total	13**	100%	100%	100%	100%

* same CRSs as those tested with a lap belt.
** Distinctly different CRSs

6-Year-Old Dummy

Table IV-5-C lists the pass rates for the Hybrid-III 6-year-old dummy in a forward-facing CRS. A total of 11 tests were in this group. But, many of these were repetitive tests. These tests accounted for only 6 different CRSs. All passed the final rule requirements. Note that the highest injury values were used for tests with the same configuration.

Table IV-5-C Pass Rates for Hybrid III 6-Year-Old Dummy

CRS Orientation	Attachment to Seat	# of Tests	Injury Criteria			
			HIC_{36}	Head Excursion with/wo Tether (mm)	Chest Acceleration (g)	Knee Excursion (mm)
Standard			1000	720/813	60	915
Forward-Facing	Lap/Shoulder Belt	6*	100%	100%	100%	100%

* different CRSs

Weighted 6-Year-Old Dummy

The weighted 6-year-old dummy was used to test the structure integrity of the CRSs. No CRSs were tested using the final rule or the NPRM proposed seat assembly with a weighted 6-year-old dummy. However, based on the inspection of the CRSs after the test using current FMVSS No. 213 test seat assembly, no compromise of the structural integrity ever occurred.

In summary, the current CRSs performed well. They all passed the final rule requirements and no structural integrity was comprised.

CHAPTER V. POTENTIAL BENEFITS

This chapter estimates the potential benefits of the final rule. The analysis utilizes the information introduced from previous chapters to derive the estimated benefits. The information includes the real world safety problem, laboratory crash test data, and injury probability curves. The real world safety problem was used to identify the safety population that would be impacted by the final rule. The laboratory test data and injury curves were used to estimate the magnitude of the fatality/injury reduction probabilities.

The chapter is organized into four sections. The first section describes the benefit estimation methodology. The second section estimates the target population represented by each dummy size. The third section presents the fatality and MAIS 2-5 non-fatal injury reduction rates. Finally, the fourth section estimates the potential benefits.

A. Overview of Methodology

The benefit estimation process consists of five steps: (1) identify the target population; (2) estimate the fatality/injury probabilities; (3) calculate the fatality/injury reduction rates; (4) calculate the total weighted fatality/injury reduction rates; and (5) derive benefits. The following is a detailed description of each step.

Step 1: Identify target population. The FMVSS No. 213 test is designed to assess child restraint performance in frontal impacts. Therefore, the target population would be all the child passenger vehicle occupant fatalities and injuries in a CRS in frontal crashes. However, the agency believes that the new requirements would have a minimal impact on non-fatal MAIS 1 injuries because the majority of these were skin bruise injuries. Thus, the target population for non-fatal injuries was limited to MAIS 2-5 injuries. For a conservative estimate, the analysis also assumes that a child would not be protected in an improperly used CRS. Finally, the final rule requires a head and chest injury performance. Thus, the analysis assumes that the final rule would impact children with a fatal or MAIS 2-5 head, neck, or chest injury. As a result, the target population used for the benefit calculation includes the child occupants in a properly used CRS who had a fatal or a MAIS 2-5 head, neck or chest injury.

The target population represented by the 12-month-old CRABI is children 1 year old and younger; represented by the 3-year-old dummy is children aged 2 to 3 years old; represented by the 6-year-old dummy is children aged 4 to 6 years old, and represented by the weighted 6-year-old dummy were children aged 7 to 10 years old who weigh less than 66 pounds. The target population is summarized in Table V-1.

Step 2: Estimate the fatality/injury probabilities. For each injury criterion, the corresponding injury probability curves were used to estimate the injury probabilities for each test failing the final rule ICPL. For example, if a 3-year-old dummy had a chest g measurement of 70 g's, the child, would have an 2.3 percent chance of dying from the chest injury and a 96.0 percent chance of receiving a MAIS 2-5 chest injury. The baseline fatal probability for chest g's at the level of the standard (i.e., 60 g's), is 1.2 percent and baseline MAIS 2-5 injury probability is 92.8 percent.

Step 3: Calculate the fatality/injury reduction rates. After estimating the injury probability, the reduction rate (r) was calculated for each test failing the ICPL by injury criteria. The reduction has the form: $r = \frac{p_t - p_{ICPL}}{p_t}$,

Where p_t = fatality/injury probability at the crash test level,

p_{ICPL} = fatality/injury probability at the final rule ICPL level.

For example, a CRS test failed at chest g = 70 g's the fatality and MAIS 2-5 injury reduction rates for this CRS would be 34.7 [=(2.3-1.5)/2.3] and 3.3 [=(96.0-92.8)/96.0] percent, respectively, after implementing the final rule.

Step 4: Calculate the total weighted reduction rates. For each dummy size, the total weighted fatality and MAIS 2-5 injury reduction rates were calculated separately for each injury criterion, i.e., HIC, neck, chest g, and chest deflection. The total reduction rate was derived using the formula:

$$r = \sum w_i * r_i, \quad i \in \{1,2,3,\ldots k\}$$

Where r = the total fatality/injury reduction rate

w_i = the proportion of the specific CRS market share

r_i = the fatality/injury reduction rate from Step 3

k = the number of CRSs failing to meet the specific injury ICPL

The analysis, however, is unable to obtain the market share of each CRS on the market today. The agency believes that the CRSs tested are representative of popular brands on the market, thus, the analysis gives each CRS tested an equal weight, i.e., $w_i = 1/n$ for every i. The number n is the total number of CRS tested within the same dummy group.

Step 5: Estimate Benefits. The last step is to apply the reduction rate derived from Step 4 to the corresponding population to estimate benefits:

$$B = \sum TP_i * r_i, \quad i \in \{1, 2, 3\}$$

Where, B = benefits (lives that would be saved or MAIS 2-5 injuries that would be reduced

TP_i = head, neck, or chest target injuries

r_i = the corresponding reduction rate from Step 4.

B. Target Population

The target population as defined in the methodology section is all the child occupant fatalities and MAIS 2-5 injuries seated in a properly used CRS when a frontal impact occurred. These occupants had a MAIS 2+ head, or neck, or chest injury. Table V-1 (adapted from Table II-7) shows the target child population that would be impacted by the new dummy and injury criteria by age and orientation of CRS. Because the target population is small, the analysis does not segregate the target population further by injured body region.

Annually, there are about 51 fatalities and 696 MAIS 2-5 non-fatal injuries as shown in Table V-1 that could be impacted by the final rule. The target population represented by the 12-month-old CRABI was children 1 year old and younger. These included 21 infant fatalities and 300 MAIS 2-5 injuries. Represented by the 3-year-old dummy were children aged 2 to 3 including 24 fatalities and 361 MAIS 2-5 injuries. Represented by the 6-year-old dummy were children aged 4 to 6 years old including 6 fatalities and 35 MAIS injuries. Represented by the weighted 6-year-old dummy were children aged 7 to 10 years old with weight less than 66 pounds. This group included only 1 fatality.

The target population is derived based on the NHTSA collected real-world crash data: the 2001 FARS, 1993-2001 CDS, and 2001 GES. The child fatalities were derived from 2001 FARS and MAIS 2-5 non-fatal injuries were derived from 1993-2001 CDS. The injuries were adjusted to the 2001 GES CDS-equivalent levels. The 2001 FARS and GES are the most currently available fatality and injury data.

Table V-1 Children in Properly Used Child Restraint System (CRS) With a MAIS 2+ Head, Neck, or Chest Injury

Age	Forward Facing CRS	Rear Facing CRS	Total
Fatalities			
0-1 Years Old	2	19	21
2-3 Years Old	24	0	24
4-6 Years Old	6	0	6
7-10 Years Old	0	0	0
Total	32	19	51
MAIS 2-5 Injuries			
0-1 Years Old	189	111	300
2-3 Years Old	361	0	361
4-6 Years Old	35	0	35
7-10 Years Old	0	0	0
Total	585	111	696

Source: 2001 Fatality Analysis Reporting System; 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)
Note: MAIS 2-5 Injuries were derived from 1993-2001 CDS and adjusted to 2001 GES-CDS equivalent level.

C. Fatality and Injury Reduction Rates

Table V-2 represents the total fatality and MAIS 2-5 non-fatal injury reduction rates by dummy size and injury criteria. Because all the CRSs passed the final rule requirements, all the reduction rates were 0s.

Table V-2
Fatality and MAIS Injury Reduction Rates
by Dummy Size and Injury Criteria

	Fatality		MAIS 2-5 Injury	
Dummy Size	HIC_{36} Prasad/Mertz (Lognormal)	Chest g's	HIC_{36} Prasad/Mertz (Lognormal)	Chest g's
CRABI				
Rear-Facing	0.0% (0.0%)	0.0%	0.0% (0.0%)	0.0%
Forward-Facing	0.0% (0.0%)	0.0%	0.0% (0.0%)	0.0%
3-Year-Old	0.0% (0.0%)	0.0%	0.0%	0.0%
6-Year-Old	0.0% (0.0%)	0.0%	0.0%	0.0%
Weighted 6-Year-Old	n.a.	n.a.	n.a.	n.a.

Note: unless specified, 0.0% means that all the tests have met the ICPLs
n.a – not applicable

D. Benefits

Since all the current child restraint systems that were tested passed the requirements of this final rule, there are no measurable safety benefits associated with the final rule. However, the revised standards will assure the child restraint systems are tested using the most advanced technologies, and parameters that are more representative of the vehicle fleet.

CHAPTER VI. COST AND LEAD TIME

This chapter discusses the costs of the final rule and the leadtime that will be allowed for compliance. The potential costs of the final rule include the compliance cost and technology costs. The compliance cost is the cost to conduct the required tests. The technology cost is the cost of technology countermeasures. Costs are in 2002 dollars. The 2002 dollar values were inflated from the 2001 dollars listed in the Preliminary Regulatory Evaluation[1] by the GDP implicit price deflator[2]. The implicit price deflator was 109.42 for 2001 and 110.66 for 2002. The adjustment factor is 1.01.

A. Compliance Test Costs

The section discusses the estimated costs for a vehicle or manufacturer to perform compliance tests. Costs are in 2002 dollars and rounded to the nearest 100 dollars.

<u>Sled Test</u>

Based on experience with sled tests currently carried out by NHTSA's enforcement program, the cost of a sled test is estimated to be about $1,300. One additional test - with

[1] Preliminary Regulatory Evaluation, Proposed Amendment to FMVSS 213, Frontal Test Procedure, February, 2002, Office of Planning and Evaluation, Planning, Evaluation, and Budget, NHTSA.
[2] Quality and Price Indexes for Gross Domestic Product, Bureau of Economic Analysis, U.S Department of Commerce.

a weighted six year-old dummy - is required for those child restraints labeled for use by children over 50 pounds, thus, there will be added sled test costs.

Dummy Costs

Table VI-1 lists the cost estimates for final rule child dummies (Hybrid III) and those used in the current FMVSS 213 (Hybrid II). The dummy cost estimates for the final rule would be those with the minimum instrumentation. These estimates were based on the commercial prices of various available child dummies.

Table VI-1
Costs of Child Dummies
(2002 Dollars*)

Dummy Type	With No Instrumentation	With Minimum Instrumentation	With Maximum Instrumentation
Proposed Dummies			
12-month-CRABI	$17,200	$30,300	$61,000
Hybrid III 3-year-old	$36,800	$62,300	$97,200
Hybrid III 6-year-old	$32,800	$58,400	$82,300
Hybrid III Weighted 6-year-old	$32,800	$58,400	$82,300
Used in the Current FMVSS 213			
9-month-old	$7,800	$11,400	$26,000
Hybrid II 3-year-old**	$11,400	$16,000	$25,600
Hybrid II 6-year-old**	$16,200	$19,700	$23,900

* Adjusted from the 2001 dollar values reported in the Preliminary Economic Evaluation by 1 percent and rounded to nearest 100 dollars.
** Currently specified dummies for CRS certification

Testing Costs by Dummy Size

Table VI-2 lists the costs of compliance tests by dummy size. The incremental test costs to update the current FMVSS 213 to the final rule are listed in Table VI-3. The final rule does not require extra tests for CRSs that were designed to hold a child up to 50 pounds. Thus, costs for testing these types of CRS are estimated to be the incremental costs of new dummies. For booster seats, however, there is an extra test using the weighted 6-year-old dummy. The incremental dummy cost is the total cost of the new dummies since new dummies must be purchased for testing.

Table VI-2
Costs of Compliance Tests
(2002 Dollars)

Dummy Type	Sled Test	Dummy Costs*
12-month-CRABI	$1,300	$30,300
Hybrid III 3-year-old	$1,300	$62,300
Hybrid III 6-year-old	$1,300	$58,400
Hybrid III Weighted 6-year-old	$1,300	$58,400

* Using the dollar values for dummy with minimal instrumentation from Table VI-1

Table VI-3
Incremental Costs of Upgrading FMVSS 213
(2002 Dollars)

Dummy Type	Sled Test	Dummy Costs*
12-month-CRABI	$0	$30,300
Hybrid III 3-year-old	$0	$62,300
Hybrid III 6-year-old	$0	$58,400
Hybrid III Weighted 6-year-old	$1,300	$58,400

* Using the dollar values for dummy with minimal instrumentation from Table VI-1

B. Technology Cost

The technology costs would be the cost of technology countermeasures that will be implemented to comply with the final rule. As discussed in Chapter IV, all the CRSs tested already complied with the final rule. No technology costs would be associated with the final rule.

C. Total Cost of the Amendment

The total cost of the amendment would be the sum of (1) the technology costs that manufacturers have to spend to improve the CRS and (2) the compliance costs that CRS manufacturers incur to conduct to meet the final rule. Since all the CRSs passed the final rule, there would be no technology costs. The total costs would only be from the compliance costs. As discussed before, the compliance costs include two parts: dummy costs and the sled test costs.

Total Dummy Costs

NHTSA estimates there are a total of 17 child safety seat manufacturers. Thirteen are manufacturers of portable child restraints and 4 are manufacturers of built-in child safety seats[3] (see Table VII-1 in Chapter VII). Three of the portable child seat manufacturers have a total of 10 or fewer employees and three have 11 to 35 employees. All of the 4 built-in integrated child safety seat manufacturers are large automobile companies. The

[3] DaimlerChrysler, Volvo in Ford Motor Company, General Motors, and Nissan

final rule requires a new set of dummies be used in the compliance tests. The analysis assumes that the 7 portable child safety manufacturers with more than 50 employees would purchase all of the proposed four dummies – a 12-month-CRABI, a 3-year-old, a 6-year-old, and a weighted 6-year-old. The remaining six companies with 50 or less employees are assumed to employ other fully equipped facilities to conduct the tests. The analysis assumes they would share a set of 4 dummies. The analysis also assumes that the 4 built-in child safety seat manufacturers will not purchase the new dummies for this final rule because they already have these dummies for the FMVSS No. 208 compliance tests. Thus, the CRS manufacturers (portable and built-in) would purchase a total of eight sets of dummies. A set of 4 dummies cost about $209,400 (= $30,300 + $62,300 + $58,400 + $58,400). The total dummy costs for these eight sets are estimated to be $1.68 million.

Total Sled Test Costs

Note that while the manufacturers are required to self-certify that their products meet FMVSS No. 213, they are not required to do sled tests. Typically, they do perform sled tests in developing and self-certifying their new child restraints. This analysis attempts to estimate a minimum and maximum number of sled tests the manufacturers might run to certify all of their current models of child restraints comply with the test requirements with the new dummies. However, after running a few exploratory tests they might discover the dummy and other changes will not affect their product certifications. In this case, the number of tests run could be much lower than the "minimum" assumed in this analysis.

The number of tests required would depend on the type of CRS models. This analysis uses the agency's 1998-2000 certification tests to estimate the annual number of production portable CRS models in the current market. Excluding the discontinued models, 31 infant seat models, 57 convertible seat models, 33 booster seat models, and 2 infant/convertible/booster combined seat models were tested. Assume each infant seat requires 8 tests[4]. Assume each of the convertible seats with recline requires 14 tests[5], and each convertible seat without recline requires 10 tests for certification[6]. All the current booster seat models have a weight specification over 50 lbs, thus, assume each of the booster seats with an internal restraint system requires 6 sled tests[7] to be certified, and booster seats without an internal restraint system[8] require 3 tests for certification. The vast majority of the convertible seats come with reclines. The analysis uses the maximum 14 tests for the convertible seat group to estimate the potential maximum sled costs for this group. Similarly, the analysis uses the maximum 6 tests for the booster seats because most of them have the internal restraint system. Thus, the portable CRS manufacturers of the infant/convertible/booster seat models could conduct 28 sled tests to

[4] Newborn: 4 tests - with or without CRS base, with or without LATCH; 12-month-old, rear-facing: 4 tests – CRS base and LATCH.
[5] 12-month-old CRABI, rear-facing 2 tests: with or without LATCH; 12-month-old CRABI, forward-facing: 4 tests – Lap belt (with or without tether) and LATCH (with or without tether); Hybrid III 3-year-old: 8 tests – seating angle (upright or reclined), Tether (with or without), and LATCH (with or without).
[6] Same as 5, except for the 3-year-old dummy tests. Only upright angle is required.
[7] Hybrid III 3-year-old, lap belt with internal restraint system: 4 tests – Lap belt (with and without tether) and see LATCH (with and without tether); Hybrid III 6-year-old dummy with lap/shoulder belt: 1 test; Hybrid III weighted 6-year-old with lab/shoulder belt: 1 test.
[8] Same as 7, except for the 3-year-old dummy: 1 test with lap/shoulder belt.

certify each of the models. For a full certification, the portable CRS manufacturers could conduct a maximum total of 1,300 sled tests. Each test costs $1,300.

As for the built-in CRSs, this analysis assumes that all seats built by the same manufacturer and designed for a similar vehicle body type are one single model. Thus, the 4 built-in integrated child restraint manufacturers produce 4 built-in integrated CRS models[9]. Two of the 4 built-in models[10] have a maximum child weight specification of 50 lbs or less and each requires 5 certification tests with 2 different dummies (3-year-old, 6-year-old). The remaining 2 models[11] can fit a child weighing over 50 lbs and each requires 6 certification tests with 3 dummies (3-year-old, 6-year-old, and weighted-6-year-old). For a full certification, the built-in CRS manufacturers would be required to certify to a total of 22 (see Table VI-4) sled tests. The agency believes that once the vehicle buck is built, the built-in test costs are probably not much different than $1,300 per test. The estimated test costs for the built-in CRS manufacturers would be $28,600.

Overall, for a full compliance, the CRSs manufacturers (portable and built-in) would need to conduct a total of 1,322 sled tests. Each test costs $1,300. The estimated total cost of these sled tests would be $1,718,600 (= $1,300 * 1,322).

[9] (1) DaimlerChrysler: Chrysler - 2003 Voyager and 2003 Town & Country, Dodge – 2003 Caravan and Grand Caravan; (2) Ford Motor Company: Volvo – 2003 S40, V40, S60, V70, XC70. S80, XC90; (3) General Motors: Chevrolet 2003 Venture, Pontiac 2003 Montana; and (4) Nissan 2003 Quest

[10] DaimlerChrysler and General Motors.

[11] Volvo in Ford Motor Company (33-85 lbs); Nissan (at least 1 year old and up to 66 lbs)

The above estimated cost is only the total cost for the initial number of the sled tests that the CRS manufacturers have to conduct to certify. The manufacturers might conduct repetitive tests to ensure the consistency of the CRS performance. The analysis assumes that each model will be tested 4 times on average and that 2 CRSs can be put on each sled. The estimated total cost is \$3,437,200 ($= \frac{\$1,718,600 \text{ x } 4}{2}$). Table IV-4 lists the number of sled tests and its estimated costs by CRS model types.

Table VI-4
Estimated Maximum Costs of Certification Sled Tests

Portable Child Restraint Systems	**Number of Models**	**Sled Tests for Each Model**	**Total Number of Sled Tests**	**Total Costs of the Sled Tests**
Infant Seat	31	8	248	$322,400
Convertible Seat	57	14	798	$1,037,400
Booster Seat	33	6	198	$257,400
Infant/Convertible/Booster	2	28	56	$72,800
Total for Initial Tests	123		1,300	$1,690,000
Built-in Child Restraint Systems*				
Weight limit ≤ 50 lbs	2	5[1]	10	$13,000
Weight limit > 50	2	6	12	$15,600
Total for Initial Tests	4		22	$28,600
Portable + Built-in Total Initial Tests	127		1,322	$1,718,600
Portable + Built-in Total**			2,644	$3,437,200

* Treated as booster seats
** Twice the number of the initial tests.
1. Require certification only with 2 dummies (3-year-old and 6-year-old)

However, in year 2003, the agency's FMVSS No. 213 compliance test contract only specifies 2 tests for the infant seats, 6 for the convertible seats, and 2[12] for booster seats, and thus 10 tests for the infant/convertible/booster combined seats. The agency's 2003 test configuration for certification does not specify the requirements for the built-in

[12] 3-year-old and 6-year-old child dummies.

integrated child safety seats. Each model of the built-in integrated child safety seats also requires 2 tests to be certified. The CRS manufacturer industry could conduct these specified tests plus one new test with a Hybrid III weighted 6-year-old dummy to be fully certified. This new test is required for the (1) booster seats, (2) infant/convertible/booster combined seats, and (3) built-in integrated child safety seats with a weight specification of 50 lbs and greater. With this new test, each model of the booster seats requires a minimum of 3 tests. Each model of the infant/convertible/booster seats requires a minimum of 11 tests. Each model of the built-in integrated child safety seats with a maximum weight limit greater than 50 lbs requires 3 tests. The analysis considers the estimated cost of these specified tests is the minimal cost. Under this minimum test scenario, the CRS manufacturers would conduct a total of 1,070 sled tests. The estimated minimal costs would be $1,391,000. Table IV-5 lists the minimum number of sled tests and the associated costs by CRS model types. Overall, the estimated total sled test costs would be $1.39 to $3.44 million.

Table VI-5
Estimated Minimal Costs of Certification Sled Tests

Portable Child Restraint Systems	**Number of Models**	**Sled Tests for Each Model**	**Total Number of Sled Tests**	**Total Costs of the Sled Tests**
Infant Seat	31	2	62	$80,600
Convertible Seat	57	6	342	$444,600
Booster Seat	33	3	99	$128,700
Infant/Convertible Booster	2	11	22	$28,600
Total for Initial Tests	123		525	$682,500
Built-in Child Restraint Systems*				
Weight limit ≤ 50 lbs	2	2	4	$5,200
Weight limit > 50	2	3	6	$7,800
Total for Initial Tests	4		10	$13,000
Portable + Built-in Total Initial Tests	127		535	$695,500
Portable + Built-in Total**			1,070	$1,391,000

* Treated as booster seats

** Total initial tests times 2

D. The Net Cost of the Amendment

The net cost of the amendment is the incremental cost of the compliance tests from current FMVSS 213 requirements to the final rule. The costs include the costs of the dummies and the additional sled test costs. The total cost on dummies is estimated to be $1.68 million.

The final rule requires only one additional compliance test – weighted 6-year-old for structural integrity. The analysis assumes that each model will be tested 4 times on average and that 2 child restraint systems can be put on each sled. The total cost of this additional test is $2,600 ($=\frac{\$1,300 \times 4}{2}$). There are 37 child restraint seat models - 35 portable booster seats (booster and infant/convertible booster seats) and 2 built-ins labeled for over 50 lbs. The analysis assumes that these CRS manufacturers redesign their CRSs every three years. Thus, on an annual basis, there are 12 new models (=37/12) that must be tested. The total additional cost is estimated to be $31,200 annually. Table IV-6 lists the estimated annual long-term net costs.

Table VI-6
The Estimated Annual Long-Term Net Costs of the Amendment

Dummy Type	Sled Test Costs	Total Additional Tests	Total Sled Test Costs
12-month-Old CRABI	$1,300	0	$0
Hybrid III 3-year-old	$1,300	0	$0
Hybrid III 6-year-old	$1,300	0	$0
Hybrid III Weighted 6-year-old	$1,300	24*	$31,200
Total			$31,200

* For 12 models, each tested twice.

E. Leadtime

The agency proposed two years of leadtime after publication of a final rule before requiring the new dummies, injury criteria, and injury criterion performance limits. The new dummies include a 12-month-old CRABI, a Hybrid III 3-year-old, a Hybrid III 6-year-old, and a Hybrid III weighted 6-year-old. Based on the CRS crash test results (Chapter IV), all the current CRSs passed the final rule. Thus, the agency believes that two years of leadtime is appropriate for this rule.

CHAPTER VII REGULATORY FLEXIBILITY ACT AND UNFUNDED MANDATES REFORM ACT ANALYSIS

A. Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980 (5 U.S.C. § 601 et seg.) requires agencies to evaluate the potential effects of their proposal and final rules on small businesses, small organizations, and small governmental jurisdictions.

5 U.S.C. § Section 603 requires agencies to prepare and make available for public comment an initial and final regulatory flexibility analysis (RFA) describing the impact of proposed and final rules on small entities. Each RFA must contain:

(1) A description of the reasons why action by the agency is being considered;

(2) A succinct statement of the objectives of, and legal basis for, the final rule;

(3) A description of and, where feasible, an estimate of the number of small entities to which the final rule will apply;

(4) A description of the projected reporting, record keeping and other compliance requirements of a final rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;

(5) An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the final rule;

(6) Each final regulatory flexibility analysis shall also contain a description of any significant alternatives to the final rule which accomplish the stated objectives of applicable status and which minimize any significant economic impact of the final rule on small entities.

1. <u>Description of the reasons why action by the agency is being considered</u>

NHTSA is considering this action to improve the safety of child restraint systems in frontal impact.

The more biofidelic 12-month-old CRABI and Hybrid III family dummies equipped with greater instrumentation are available for crash tests. Child restraints will be tested to conditions representing current model vehicles. The final rule also extends protection to children up to 65 lbs. The final rule fulfills the mandate in the TREAD Act to improve the safety of the child restraints and lays a foundation for future technology advancements.

2. <u>Objectives of, and legal basis for, the final rule</u>

NHTSA is requiring these changes under the Authority of 49 U.S.C. 322, 30111, 30115, 30117, and 30666; delegation of Authority at 49 CFR 1.50.

3. Description and estimate of the number of small entities to which the final rule will apply

The final rule would affect the portable and built-in CRS manufacturers and dummy manufacturers.

Suppliers of Child Restraint Systems

NHTSA estimates there are about 13 manufacturers of portable child restraints, six of which could be small businesses. In addition, there are about 4 built-in CRS manufacturers. All of these built-in CRS manufacturers are large companies. Table VII-1 shows these 13 portable and 4 built-in CRS manufacturers.

Business entities were generally defined as small businesses by Standard Industrial Classification (SIC) code, for the purposes of receiving Small Business Administration assistance. The SIC codes have changed. In the small business section of our analyses we have used 500 employees as the cut-off for small businesses for many years. Business entities are now defined as small businesses using the North American Industry Classification System (NAICS) code, for the purposes of receiving Small Business Administration assistance. One of the criteria for determining size, as stated in 13 CRF 121.201, is the number of employees in the firm. There is no separate NAICS code for child restraints. Possible categories include: a) To qualify as a small business in the Motor Vehicle Seating and Interior Trim Category (NAICS 336360), the firm must have fewer than 500 employees, b) In the "All Other Motor Vehicle Parts Manufacturing" category (NAICS 336399), the firm must have 750 employees, c) In the "All Other

Transportation Equipment Manufacturing" category (NAICS 336999), the firm must have 500 employees. We believe child restraints fit better into category a) or c). Thus, we will continue to use 500 employees as the limit.

The agency does not believe that the rule will have any significant impact on these businesses because all the current CRSs passed the final rule.

Table VII-1
Employment of Child Restraint Manufacturers*
(Less than 500 employees qualifies as a small business)

Portable Child Restraint Manufacturer	**Number of Employees**
Babyhood Manufacturing Co.	10
Basic Comfort, Inc	20
Britax Child Safety, Inc. (Part of Britax International)	Large company
Cosco (Dorel Juvenile Group)	1,000
Early Development Co. has less than 10 employees, However, it is partly owned and a joint venture with Takata of Japan	Large company
Evenflo itself has 250 employees, but Evenflo is a division of Spalding & Evenflo Co. Inc.	2,600
Ferno-Washington, Inc.	515
Graco/Century	1,000
Little Cargo, Inc.	< 10
Peg Perego	1,500 (worldwide)
Recaro North America, Inc.	35
Safeline Children's Products Co.	< 10
Snug Seat	35
Built-In Child Restraint Manufacturer	
DaimlerChrysler	Large company
Ford Motor Company (Volvo brand)	Large company
General Motors	Large company
Nissan	Large company

*Source: Standard and Poor's Register of Corporation Directors, 2003; Ward's Business Directory of U.S. Private and Public Company, 45th Edition; D&B Principal International Business, 2002/03, The World Marketing Directory; D&B Million Dollar Directory, America's Leading Public and Private Companies, 2002 Edition.

Test Dummy Manufacturers

The final rule should have a small positive effect on the manufacturers of test dummies and the manufacturers of instrumentation for test dummies. In order to do the required tests, an increased number of dummies would be needed. Currently, there are four manufacturers of dummies or parts of dummies: First Technology Safety Systems, Advanced Safety Technology Corp., UTAMA, and GESAC. They are all qualified as small business with less than 500 employees. There are six manufacturers of instrumentation of test dummies. Four manufacture load cells (P.A. Denton, First Technology Safety Systems, Sensor Developments, Inc., and Sensotec) and two manufacture accelerometers (Endevco and Entran). All of these, except Endevco, are small businesses. The economic impact on these entities would be small because the current FMVSS No. 213 test procedure uses instrumented Hybrid II dummies.

4. Description of the projected reporting, record keeping and other compliance requirements for small entities

The final rule requires improved test dummies and an updated test procedure that would improve measures of performance of child restraint systems. Manufacturers would have to certify their products comply with the final rule.

5. Duplication with other Federal rules

There are no relevant Federal rules that may duplicate, overlap or conflict with the final rule.

6. Description of any significant alternatives to the final rule

NHTSA considered different injury criteria as alternatives to this final rule.

B. Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditures by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for the year 2002 results in $113 million (110.66/98.1 = 1.13). The assessment may be included in conjunction with other assessments, as it is here.

This final rule is not estimated to result in expenditures by State, local or tribal governments of more than $113 million annually. It is not going to result in the expenditure by child restraint system manufacturers of more than $113 million annually. The estimated cost for this amendment is a one-time cost of $1.68 million for manufacturers to purchase the new test dummies and $1.39 to $3.44 million to certify existing child restraints to the new dummies and test requirements. The annual long-term costs are estimating to be $31,200 to test new models of booster seats (including the built-in CRSs) with a weighted 6-year-old dummy.

These effects have been discussed in this Final Regulatory Evaluation. Please see the chapter on Costs.

APPENDIX A: CRASH TEST DATA

The Appendix provides all the FMVSS No. 213 pulse sled test data. After publication of the NPRM, the agency conducted a series of tests using the NPRM proposed test seat assembly. One series of these tests used the proposed CRABI and Hybrid III child dummies. The other set used the existing FMVSS 213 dummies. These tests conducted after the NPRM were reported under the title "Tests Conducted After NPRM". Those tests published in the Preliminary Regulatory Evaluation for the NPRM were listed under the title "Tests Using Current FMVSS No. 213 Seat Assembly".

A. Tests Conducted After NPRM

Tables A-1 to A-4 list the CRSs tests with a proposed dummy but using the NPRM proposed seat assembly. The purpose of the tests is to evaluate the impact of seat assembly changes. These tests were used to calculate the pass/fail rates. In addition, these tests were paired with other tests to assess the impact of proposed new dummies and seat assembly.

Table A-1
12-Month-Old CRABI, Rear-Facing

ID	Restraint Configuration	Text #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Evenflo On-My-Way Lap Belt No Tether	PAX	165	n.c.	424	n.a.	35.8	n.a.
2	Century 560 Lap Belt No Tether	PAX	138	n.c.	234	n.a.	39.6	n.a.
3	Century STE 2000 Convertible Lap Belt No Tether	PAX	100	n.c.	264	n.a.	33.6	n.a.
4	Cosco Touriva Convertible Lap Belt No Tether	PAX	175	n.c.	366	n.a.	36.6	na
5	Evenflo On-My-Way Lap/Shoulder Belt No Tether	PAX	226	n.c.	256	n.a.	44.7	n.a.
6	Century 560 Lap/Shoulder Belt No Tether	PAX	95	n.c.	265	n.a.	37.7	n.a.
7	Century STE 2000 Convertible Lap/Shoulder Belt No Tether	PAX	97	n.c.	265	n.a.	37.7	n.a.
8	Cosco Touriva Convertible Lap/Shoulder Belt No Tether	PAX	237	n.c.	495	n.a.	45.6	n.a.
9	Century Snug Ride Lap Belt No Tether	F66	224	389	579	na	45.72	na
10	Evenflo Cozy Carry Lap Belt No Tether	F67	208	301	301	na	46.8	na
11	Britax Roundabout 5-pt. Lap Belt No Tether	F68	308	546	602	na	36.89	na

Note: These CRSs were tested using NPRM proposed seat assembly
PAX: tests conducted by PAX River; F-series: tests conducted by VRTC
n.c. – Not calculated (values were lower than $HIC_{Unlimited}$)
n.a. – Not Applicable

Table A-2
12-Month-Old CRABI, Forward-Facing

Id	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Century Accel Convertible Lap Belt No Tether	PAX	208	n.c.	290	470 (18.5)	36.5	508 (20.0)
2	Cosco Touriva Convertible Lap Belt No Tether	PAX	186	n.c.	351	424 (16.7)	35.6	541 (21.3)
3	Century Accel Convertible Lap/Shoulder Belt No Tether	PAX	232	n.c.	314	419 (16.5)	38.3	643 (25.3)
4	Cosco Touriva Convertible Lap/Shoulder Belt No Tether	PAX	113	n.c.	317	424 (16.7)	30.5	493 (19.4)
5	Cosco Triad Convertible LATCH	PAX	163	n.c.	334	251 (9.9)	44.9	333 (13.1)
6	Cosco Triad Convertible LATCH	PAX	328	n.c.	370	500 (19.7)	42.8	549 (21.6)
7	Britax Expressway Convertible LATCH	PAX	184	n.c.	428	371 (14.6)	46.6	368 (14.5)
8	Evenflo Triumph 5-pt. Lap Belt No Tether	F69	331	516	523	640	38.87	813
9	Evenflo Titan V 5-pt. Lap Belt No Tether	F70	270	387	388	602	39.16	736
10	Cosco Touriva OHS Lap Belt No Tether	F71	283	561	594	657	38.52	780
11	Evenflo Titan V OHS, Lap Belt No Tether	F72	235	415	443	641	44.06	779

Note: These CRSs were tested using NPRM proposed seat assembly
PAX: tests conducted by PAX River; F-series: tests conducted by VRTC
n.c. – Not calculated (values were lower than $HIC_{Unlimited}$)

Table A-3
Hybrid III 3-Year-Old Dummy, Forward-Facing

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Cosco Touriva Convertible Lap Belt No Tether	PAX	216	n.c.	447	394 (15.5)	37.6	671 (26.4)
2	Cosco Touriva Convertible Lap Belt No Tether	F59	517	687	687	751 (29.6)	36.5	839 (33.0)
3	Century Accel Convertible Lap Belt No Tether	PAX	183	n.c.	355	505 (19.9)	36.1	640 (25.2)
4	Century Accel Convertible Lap Belt No Tether	F58	204	431	444	691 (27.2)	46.6	853 (33.6)
5	Century Breverra Hybrid Lap Belt No Tether	PAX	299	n.c.	537	541 (21.3)	50.1	739 (29.1)
6	Century Breverra Hybrid Lap Belt No Tether	F52	308	588	613	784 (30.9)	45.9	920 (36.2)
7	Cosco HB Booster Hybrid Lap Belt No Tether	PAX	213	n.c.	705	340 (13.4)	41.6	569 (22.4)
8	Cosco HB Booster Hybrid Lap Belt No Tether	F53	403	659	681	743 (29.3)	39.0	775 (30.5)
9	Cosco Touriva Convertible Lap/Shoulder Belt No Tether	PAX	223	n.c.	393	475 (18.7)	36.5	523 (20.6)
10	Cosco Touriva Convertible Lap/Shoulder Belt No Tether	F56	233	422	425	631 (24.8)	40.1	740 (29.1)
11	Century Accel Convertible Lap/Shoulder Belt No Tether	PAX	149	n.c.	286	391 (15.4)	31.4	500 (19.7)
12	Century Accel Convertible Lap/Shoulder Belt No Tether	F57	229	412	415	592 (23.3)	40.1	725 (28.5)

Note: These CRSs were tested using NPRM proposed seat assembly.
PAX: tests conducted by PAX River; F-series: tests conducted by VRTC
n.c. – Not calculated (values were lower than $HIC_{Unlimited}$)

Table A-3
Hybrid III 3-Year-Old Dummy, Forward-Facing - Continued

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
13	Century Breverra Hybrid Lap/Shoulder Belt No Tether	PAX	296	n.c.	479	259 (10.2)	30.7	488 (19.2)
14	Century Breverra Hybrid Lap/Shoulder Belt No Tether	F55	252	456	482	652 (25.7)	37.0	771 (30.4)
15	Cosco HB Booster Hybrid Lap/Shoulder Belt No Tether	PAX	474	n.c.	691	373 (14.7)	40.4	498 (19.6)
16	Cosco HB Booster Hybrid Lap/Shoulder Belt No Tether	F54	338	470	470	585 (23.0)	38.5	669 (26.3)
17	Cosco Triad Convertible LATCH	PAX	176	n.c.	294	445 (17.5)	46.5	478 (18.8)
18	Cosco Triad Convertible LATCH	F51	395	547	548	438 (17.2)	48.8	627 (24.7)
19	Britax Expressway Convertible LATCH	PAX	246	n.c.	383	396 (15.6)	40.0	467 (18.4)
20	Britax Expressway Convertible LATCH	F50	192	297	298	481 (18.9)	40.3	661 (26.0)
21	Cosco Touriva OHS Lap Belt No Tether	F66	375	707	763	639	33.81	711
22	Cosco Grand Explorer w/ shield Lap Belt No Tether	F67	300	593	678	605	41.90	551

Note: These CRSs were tested using NPRM proposed seat assembly
PAX: tests conducted by PAX River; F-series: tests conducted by VRTC
n.c. – Not calculated (values were lower than $HIC_{Unlimited}$)

Table A-3
Hybrid III 3-Year-Old Dummy, Forward-Facing - Continued

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
23	Evenflo Vanguard 5-pt Lap Belt No Tether	F69	390	614	637	633	37.32	902
24	Evenflo Titan V 5-pt. Lap Belt No Tether	F70	333	491	495	714	37.06	780
25	Cosco Alpha Omega OHS Lap Belt No Tether	F71	583	750	750	669	40.79	787
26	Cosco Voyager BPB Lap/Shoulder Belt No Tether	F74	600	809	809	389	41.44	679
27	Century Next Step SE BPB Lap/Shoulder Belt No Tether	F75	341	569	597	381	39.17	633

Note: These CRSs were tested using NPRM proposed seat assembly
PAX: tests conducted by PAX River; F-series: tests conducted by VRTC

Extra Hybrid III 3-Year-Old Dummy, Rear-Facing

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Britax Roundabout, Rear-facing Lap Belt No Tether	F68	537	873	936	na	51.28	na
2	Evenflo Titan V OHS, Rear-facing Lap Belt No Tether	F72	660	787	787	na	42.00	na
3	Cosco Alpha Omega OHS, Rear-facing Lap Belt No Tether	F73	447	774	806	na	40.08	na

Note: These CRSs were tested using NPRM proposed seat assembly
PAX: tests conducted by conducted by VRTC

Table A-4
Hybrid III 6-Year-Old Dummy, Forward-Facing

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Evenflo Right Fit Backless BPB Lap/Shoulder Belt No Tether	PAX	140		358	297 (11.7)	37.8	498 (19.6)
2	Evenflo Right Fit Backless BPB Lap/Shoulder Belt No Tether	F50	261	547	649	469 (18.5)	43.0	614 (24.2)
3	Evenflo Right Fit Backless BPB Lap/Shoulder Belt No Tether	PAX	108		276	485 (19.1)	36.0	533 (21.0)
4	Evenflo Right Fit Backless BPB Lap/Shoulder Belt No Tether	F51	232	479	626	385 (15.2)	41.6	635 (25.0)
5	Century Breverra High-back BPB Lap/Shoulder Belt No Tether	PAX	158		416	508 (20.0)	41.4	297 (11.7)
6	Century Breverra High-back BPB Lap/Shoulder Belt No Tether	F52	231	394	536	400 (15.7)	39.2	688 (27.1)
7	Cosco HB Booster High-back BPB Lap/Shoulder Belt No Tether	PAX	344		756	467 (18.4)	38.3	610 (24.0)
8	Cosco HB Booster High-back BPB Lap/Shoulder Belt No Tether	F53	315	486	535	359 (14.1)	37.7	770 (30.3)
9	Cosco Grand Explorer w/o shield Lap/Shoulder Belt No Tether	F73	226	358	462	405	42.61	664
10	Cosco Voyager BPB Lap/Shoulder Belt No Tether	F74	362	680	792	457	31.56	707
11	Century Next Step SE BPB Lap/Shoulder Belt No Tether	F75	224	437	590	461	41.58	650

Note: These CRSs were tested using NPRM proposed seat assembly
PAX: tests conducted by PAX River; F-series: tests conducted by VRTC

Tables A-5 to A-9 list the CRSs tests with a current required FMVSS 213 dummy but using the NPRM proposed seat assembly. The purpose of the tests is to evaluate the impact of seat assembly changes. Thus, each CRS test was paired with its compliance test.

Table A-5
Current FMVSS 213 Newborn Dummy, Rear-Facing

			NPRM Proposed Seat Assembly					Current FMVSS 213 Seat Assembly				
ID	Restraint Configuration	Test #	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Evenflo On-My-Way Lap/Shoulder Belt No Tether		51.5	n.a.	n.a.	n.a.	n.a.	43.0	n.a.	n.a.	n.a.	n.a.
2	Century 560 Lap/Shoulder Belt No Tether		42.5	n.a.	n.a.	n.a.	n.a.	46.0	n.a.	n.a.	n.a.	n.a.
3	Century Accel Convertible Lap/Shoulder Belt No Tether		50.7	n.a.	n.a.	n.a.	n.a.	Not Tested	n.a.	n.a.	n.a.	n.a.
4	Century STE 2000 Convertible Lap/Shoulder Belt No Tether		40.0	n.a.	n.a.	n.a.	n.a.	Not Tested	n.a.	n.a.	n.a.	n.a.
5	Cosco Triad Convertible Lap/Shoulder Belt LATCH		43.1	n.a.	n.a.	n.a.	n.a.	Not Tested	n.a.	n.a.	n.a.	n.a.

n.a. Not Applicable

Table A-6
Hybrid II 9-Month-Old Dummy, Rear-Facing

			NPRM Proposed Seat Assembly					Current FMVSS 213 Seat Assembly				
ID	Restraint Configuration	Test #	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Evenflo On-My-Way Lap/Shoulder Belt No Tether		53.9	n.a.	n.a.	n.a.	n.a.	57.0	n.a.	n.a.	n.a.	n.a.
2	Century 560 Lap/Shoulder Belt No Tether		52.9	n.a.	n.a.	n.a.	n.a.	52.0	n.a.	n.a.	n.a.	n.a.
3	Century STE 2000 Convertible Lap/Shoulder Belt No Tether		50.6	n.a.	n.a.	n.a.	n.a.	42.0	n.a.	n.a.	n.a.	n.a.
4	Cosco Touriva Convertible Lap/Shoulder Belt No Tether		63.0	n.a.	n.a.	n.a.	n.a.	51.0	n.a.	n.a.	n.a.	n.a.

n.a. – Not Applicable

Table A-7
Hybrid II 9-Month-Old Dummy, Forward-Facing

			NPRM Proposed Seat Assembly					Current FMVSS 213 Seat Assembly				
ID	Restraint Configuration	Test #	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion (mm)	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Cosco Touriva Convertible Lap/Shoulder Belt No Tether No Tether		n.a.	n.a.	434 (17.1)	n.a.	546 (21.5)	n.a.	n.a.	432 (17.0)	n.a.	483 (19.0)
2	Century Accel Convertible Lap/Shoulder Belt No Tether		n.a.	n.a.	396 (15.6)	n.a.	485 (19.1)	n.a.	n.a.	483 (19.0)	n.a.	559 (22.0)

Note: These CRSs were tested using NPRM proposed seat assembly

Table A-8
Hybrid II 3-Year-Old Dummy, Forward-Facing

			NPRM Proposed Seat Assembly					Current FMVSS 213 Seat Assembly				
ID	Restraint Configuration	Test #	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Cosco Touriva Convertible Lap/Shoulder Belt No Tether		n.a.	703	498 (19.6)	40.4	671 (26.4)	n.a.	500	660 (26.0)	42.0	813 (32.0)
2	Century Accel Convertible Lap/Shoulder Belt No Tether		n.a.	627	495 (19.5)	26.8	681 (26.8)	n.a.	480	635 (25.0)	46.0	762 (30.0)
3	Century Breverra Hybrid Lap/Shoulder Belt No Tether		n.a.	670	572 (22.5)	29.2	696 (27.4)	n.a.	659	483 (19.0)	40.0	584 (23.0)
4	Cosco High Back Hybrid Booster Lap/Shoulder Belt No Tether		n.a.	446	572 (22.5)	41.6	660 (26.0)	n.a.	535	432 (17.0)	44.0	635 (25.0)

Table A-9
Hybrid II 6-Year-Old Dummy, Forward-Facing

			NPRM Proposed Seat Assembly					Current FMVSS 213 Seat Assembly				
ID	Restraint Configuration	Test #	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)	Seat Back Rotation	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Cosco Gr. Explorer Backless BPB Lap/Shoulder Belt No Tether		n.a.	267	363 (14.3)	49.2	610 (24.0)	n.a.	438	381 (15.0)	44.0	686 (27.0)
2	Cosco Gr. Explorer Backless BPB Lap/Shoulder Belt No Tether		n.a.	328	457 (18.0)	38.6	653 (25.7)	n.a.	438	381 (15.0)	44.0	686 (27.0)
3	Century Breverra High-Back BPB Lap/Shoulder Belt No Tether		n.a.	209	500 (19.7)	35.1	500 (19.7)	n.a.	308	457 (18.0)	33.0	610 (24.0)
4	Cosco High Back Booster BPB Lap/Shoulder Belt No Tether		n.a.	381	447 (17.6)	42.2	701 (27.6)	n.a.	399	432 (17.0)	40.0	686 (27.0)

Note: These CRSs were tested using NPRM proposed seat assembly

Tables A-10 to A-12 list the tests conducted at VRTC using the hybrid seat assembly condition – NPRM proposed seat assembly with flexible seat back. These tests were used to compare the injury outcomes between a rigid and flexible seat back. The end of each table lists the comparison tests. The comparison tests are those CRSs with identical tests condition but using the rigid seat back. These comparison tests were already listed in Tables A-1 to A-3. These tests were repeated just for easy reference.

Table A-10, VRTC Frontal Sled Tests Using Flexible Seat Back
12-Month-Old CRABI, Rear-Facing

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Century Snug Ride Lap Belt No Tether	F65	210	399	651	na	40.98	na

Comparison Tests (Rigid Seat Back)

1	Century Snug Ride Lap Belt No Tether	F66	224	389	579	na	45.72	na

Table A-10, VRTC Frontal Sled Tests Using Flexible Seat Back
Hybrid III 3-Year-Old Dummy, Forward-Facing

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Cosco Grand Explorer w/ shield Lap Belt No Tether	F62	239	494	577	598 (23.5)	37.27	634 (25.0)
2*	Cosco Touriva 5-pt Lap Belt No Tether	F63	333	562	696	717 (28.2)	40.40	821 (32.3)
3	Cosco Touriva OHS Lap Belt No Tether	F64	396	778	830	674 (26.5)	37.80	793 (31.2)

Comparison Tests (Rigid Seat Back)

1	Cosco Grand Explorer w/ shield Lap Belt No Tether	F67	300	593	678	605 (23.8)	41.90	551 (21.7)
2	Cosco Touriva OHS Lap Belt No Tether	F66	375	707	763	639 (25.2)	33.81	711 (28.0)

* no comparison test

Table A-12, VRTC Frontal Sled Tests Using Flexible Seat Back
Hybrid III 6-Year-Old Dummy, Forward-Facing

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Evenflo Right Fit Lap/Shoulder Belt No Tether	F60	224	382	511	413 (16.3)	45.90	614 (24.2)
2	Century Breverra Lap/Shoulder Belt No Tether	F61	240	501	653	456 (18.0)	43.36	738 (29.1)

Comparison Tests (Rigid Seat Back)

ID	Restraint Configuration	Test #	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Chest Acceleration (g)	Knee Excursion mm (in)
1	Evenflo Right Fit Backless BPB Lap/Shoulder Belt No Tether	F50	261	547	649	469 (18.5)	43.0	614 (24.2)
2	Evenflo Right Fit Backless BPB Lap/Shoulder Belt No Tether	F51	232	479	626	385 (15.2)	41.6	635 (25.0)
3	Century Breverra High-back BPB Lap/Shoulder Belt No Tether	F52	231	394	536	400 (15.7)	39.2	688 (27.1)

B. Tests Using Current FMVSS 213

These tests were published in the Preliminary Regulatory Evaluation. Two new pieces of information were added to the tables: test number and HIC_{36}. All the tests with a Hybrid III dummy were used to calculate the pass/fail rate of current CRSs.

B.1 Hybrid III Dummy Family

Table A-10
12-Month-Old CRABI, Rear-Facing

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Century SmartFit Lap Belt	B5893	270	429	614	na	0.95	927	1.39	9.45	8.81	39.6	na	na
Evenflo On-My-Way Lap Belt	B5891	226	340	448	na	1.14	1319	127.82	12.93	5.81	43.5	na	na
Cosco Touriva with Tray	B4951	239	515	579	na	1.34	1206	280.08	2.37	11.97	41.2	na	na
Evenflo Scout T-Shield	B4955	241	434	476	na	1.49	1153	83.85	4.15	12.52	55.1	na	na
Kolcraft Automat 5 Point Harness	B4960	130	264	354	na	1.12	628	32.30	4.77	11.84	38.9	na	na

*B denotes Biomechanics database

Table A-11
12-Month-Old CRABI, Forward-Facing

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Cosco Touriva Lap Belt Top Tether	B5985	208	322	322	472 (18.6)	1.10	1203	186.18	12.27	11.06	55.4	na	531 (20.9)
Cosco Touriva Lap Belt Top Tether	B5897	235	355	356	472 (18.6)	1.10	1283	326.97	10.18	12.21	57.4	na	526 (20.7)
Cosco Touriva with Tray	B4952	563	1033	1071	658 (25.9)	1.51	1541	145.08	11.69	10.12	44.7	na	na
Evenflo Scout T-Shield	B6173	411	622	622	607 (23.9)	1.30	1707	145.86	13.25	7.72	51.1	na	na
Kolcraft Automat 5 Point Harness	B4858	213	418	480	658 (25.9)	1.06	1218	38.93	17.09	5.30	42.3	na	na
Kolcraft Automat 5 Point Harness	B4959	302	552	611	655 (25.8)	1.12	1357	38.60	16.27	6.45	44.5	na	na
Kolcraft Automat 5 Point Harness	B4961	231	469	537	643 (25.3)	1.14	1305	8.06	12.11	5.78	42.0	na	na
Fisher Price Safe Embrace 5 Point harness Top Tether	B4992	225	368	406	574 (22.6)	1.03	1397	3.63	15.10	8.16	53.5	na	na
Fisher Price Safe Embrace 5 Point Harness Top Tether	B4993	194	362	388	551 (21.7)	1.18	1372	6.04	18.26	7.45	55.6	na	na
Fisher Price Safe Embrace 5 Point Harness Top Tether	B4994	247	432	466	574 (22.6)	1.02	1353	3.63	11.85	8.81	50.1	na	na

*B denotes Biomechanics database

Table A-11
12-Month-Old CRABI, Forward-Facing - Continued

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Fisher Price Safe Embrace 5 Point Harness Top Tether	B4995	193	364	407	551 (21.7)	1.17	1382	7.62	18.90	7.62	50.7	na	na
Fisher Price Safe Embrace 5 Point Harness Top Tether	B4998	245	426	481	584 (23.0)	1.01	1352	3.76	11.89	8.46	52.2	na	na
Fisher Price Safe Embrace 5 Point Harness Top Tether	B4999	227	399	436	577 (22.7)	1.19	1552	8.99	16.28	11.74	56.2	na	na
Fisher Price Safe Embrace 5 Point Harness Top Tether	B5000	248	402	446	577 (22.7)	1.04	1443	2.36	14.89	9.10	52.0	na	na
Fisher Price Safe Embrace 5 Point Harness Top Tether	B5001	205	399	448	577 (22.7)	1.13	1424	8.16	15.32	10.26	57.9	na	na

*B denotes Biomechanics database

Table A-12
Hybrid III 3-Year-Old Child, Forward Facing

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Century Breverra Classic (5pt) Lap Belt Top Tether	B5887	316	452	452	601 (24.0)	1.34	2052	188	21.3	14.2	48.3	18 (0.7)	719 (28.3)
Century Breverra Classic (5pt) Lap Belt Top Tether	B5889	287	439	439	566 (22.3)	1.17	1964	222	16.4	11.5	44.7	15 (0.6)	678 (26.7)
Cosco Touriva Lap Belt No Top Tether	V3632	375	671	733	686 (27.0)	0.85	1341	102	4.2	15.3	43.4	20 (0.8)	805 (31.7)
Cosco Touriva Lap/Shoulder Belt No Top Tether	V3694	489	738	738	620 (24.4)	0.76	1369	85	15.0	16.2	53.8	18 (0.7)	795 (31.3)
Cosco Touriva Lap Belt Top Tether	B5884	167	303	323	551 (21.7)	0.71	1232	210	13.2	9.1	37.5	10 (0.4)	681 (26.8)
Cosco Touriva Lap Belt Top Tether	B5886	194	362	369	511 (20.1)	0.76	1384	127	12.3	11.3	42.6	10 (0.4)	645 (25.4)
Cosco Triad LATCH	V3632	173	292	310	523 (20.6)	0.72	1492	114	6.8	10.6	47.6	13 (0.5)	681 (26.8)
Cosco Triad LATCH	V3694	345	518	518	485 (19.1)	0.67	1472	251	9.7	12.1	48.1	13 (0.5)	605 (23.8)

*B denotes Biomechanics database; V denotes Vehicle database

Table A-13
Hybrid III 6-Year-Old Child, Forward-Facing

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Century Breverra Metro Lap/Shoulder Belt No Retractor	B5458	228	426	602	523 (20.6)	0.90	1844	45	22.0	21.3	48.2	28 (1.1)	612 (24.1)
Century Breverra Metro Lap/Shoulder Belt No Retractor	B5460	241	537	700	478 (18.8)	1.12	2910	125	22.4	17.8	49.4	30 (1.2)	637 (25.1)
Century Breverra Metro Lap/Shoulder Belt No Retractor	B5462	252	508	668	480 (18.9)	1.00	2612	162	20.2	20.2	40.2	30 (1.2)	640 (25.2)
Century Breverra Classic Lap/Shoulder Belt Retractor	B5888	469	826	974	533 (21.0)	1.17	2889	16	21.1	47.0	54.3	30 (1.2)	620 (24.4)
Century Breverra Classic Lap/Shoulder Belt Retractor	B5890	441	688	825	546 (21.5)	1.07	2329	22	18.0	43.3	54.4	33 (1.3)	551 (21.7)
Century Breverra Metro Lap/Shoulder Belt Retractor	B4963	401	552	748	na	0.91	2181	26	20.3	23.4	42.9	36 (1.4)	na
Century Breverra Metro Lap/Shoulder Belt Retractor	B4964	247	563	575	na	1.22	2433	90	34.7	39.3	42.2	25 (1.0)	na
Century Breverra Metro Lap/Shoulder Belt Retractor	B4966	209	368	500	na	1.73	1664	142	20.7	53.9	54.2	16.6 (0.7)	na

*B denotes Biomechanics database

Table A-13
Hybrid III 6-Year-Old Child, Forward-Facing – Continued

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Century Breverra Metro Lap/Shoulder Belt Retractor	B5177	548	961	1111	577 (22.7)	1.20	2645	103	28.6	37.6	52.0	29 (1.1)	630 (24.8)
Century Breverra Metro Lap/Shoulder Belt Retractor	B5452	311	670	781	523 (20.6)	1.13	1875	105	25.6	30.8	24.6	25 (1.0)	646 (24.5)
Century Breverra Metro Lap/Shoulder Belt Retractor	B5205	314	642	762	519 (20.4)	1.00	2479	153	20.5	28.4	50.0	33 (1.3)	646 (25.4)
Century Breverra Metro Lap/Shoulder Belt Retractor	B5207	309	605	739	526 (20.7)	0.94	2234	39	18.9	25.7	50.7	25 (1.0)	642 (25.3)
Century Breverra Metro Lap/Shoulder Belt Retractor	B5209	286	563	698	523 (20.6)	0.87	2130	13	18.2	24.7	49.7	29 (1.1)	634 (25.0)
Graco Cherished Cargo Lap/Shoulder Belt Retractor	B5446	923	1399	1582	620 (24.4)	1.34	3090	186	28.8	43.2	30.0	31 (1.2)	714 (28.1)
Cosco Grand Explorer Lap/Shoulder Belt Retractor	B5448	716	1053	1141	505 (19.9)	1.23	2588	30	22.9	49.5	54.0	31 (1.2)	584 (23.0)

*B denotes Biomechanics database

Table A-14
Hybrid III 6-Year-Old Child Without Child Safety Seat

3 Point Belt	B4965	304	569	610	na	1.33	1781	107	28.39	41.92	46.3	26.8 (1.1)	na
3 Point Belt	B4968	237	418	562	na	1.51	2214	116	28.00	49.01	47.2	24.5 (1.0)	na
3 Point Belt	B5450	818	1360	1483	574 (22.6)	1.42	3733	33	24.5	41.5	33.0	33 (1.3)	638 (25.1)

Table A-15
Hybrid III Weighted 6-Year-Old Child, Forward-Facing

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Graco Cherished Cargo Lap/Shoulder Belt No Retractor	B5433	422	773	942	533 (21.0)	1.09	2811	159	36.4	16.7	56.8	36 (1.4)	660 (26.0)
Graco Cherished Cargo Lap/Shoulder Belt No Retractor	B5455	272	546	746	523 (20.6)	1.06	2532	197	31.5	18.4	58.5	36 (1.4)	678 (26.7)
Century Breverra Lap/Shoulder Belt No Retractor	B5435	340	649	780	505 (19.9)	1.17	2958	181	38.6	21.9	54.0	38 (1.5)	678 (26.7)
Century Breverra Lap/Shoulder Belt No Retractor	B5441	190	431	568	533 (21.0)	0.83	1536	14	25.8	19.7	58.3	48 (1.9)	653 (25.7)
CenturyBreverra Lap/Shoulder Belt No Retractor	B5459	194	403	574	483 (19.0)	0.89	1906	22	28.8	20.0	49.9	38 (1.5)	656 (25.8)
Century Breverra Lap/Shoulder Belt No Retractor	B5461	161	360	526	468 (18.4)	0.75	1596	32	28.5	16.7	51.1	41 (1.6)	646 (25.4)
Century Breverra Lap/Shoulder Belt No Retractor	B5463	172	394	563	498 (19.6)	0.84	2071	104	26.5	22.6	44.8	36 (1.4)	655 (33.8)
Century Breverra Lap/Shoulder Belt Retractor	B5465	264	569	751	484 (19.1)	0.99	2654	127	26.7	25.7	49.1	36 (1.4)	690 (27.2)
Century Breverra Lap/Shoulder Belt Retractor	B5467	246	516	683	488 (19.2)	0.93	2240	117	26.7	25.5	45.5	36 (1.4)	650 (25.6)
Century Breverra Lap/Shoulder Belt Retractor	B5469	269	509	651	505 (19.9)	0.88	1934	59	26.4	23.7	53.1	38 (1.5)	671 (26.4)

*B denotes Biomechanics database

B.2 Hybrid II Family

Table A-16
9-Month-Old Infant, Forward-Facing (TNO P3/4)

Restraint Configuration	HIC 15ms	HIC 15ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Cosco Touriva w/ Top Tether	na	na	na	533 (21.0)	na	na	na	na	na	na	na	584 (23.0)
Cosco Touriva w/ Top Tether	na	na	na	533 (21.0)	na	na	na	na	na	na	na	na

Table A-17
Hybrid II 3-Year-Old Child, Forward-Facing

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Cosco Touriva Lap Belt No Top Tether	B5892	226	372	385	620 (24.4)	na	na	na	na	na	41.9	na	645 (25.4)
Cosco Touriva Lap Belt No Top Tether		na		479	711 (28.0)	na	na	na	na	na	37.2	na	813 (32.0)
Cosco Touriva Lap Belt No Top Tether		na		424	711 (28.0)	na	na	na	na	na	35.6	na	813 (32.0)
Cosco Touriva Lap Belt Top Tether		na		387	584 (23.0)	na	na	na	na	na	46.4	na	711 (28.0)
Cosco Touriva Lap Belt Top Tether		na		396	584 (23.0)	na	na	na	na	na	46.3	na	813 (32.0)
Century Breverra Classic (5pt) Lap Belt Top Tether	B5894	388	501	501	584 (23.0)	na	na	na	na	na	48.8	na	744 (29.3)
Century Breverra Classic (5pt) Lap Belt Top Tether		na		392	610 (24.0)	na	na	na	na	na	41.4	na	737 (29.0)
Cosco Triad LATCH Top Tether	B5883	118	218	281	498 (19.6)	na	na	na	na	na	38.9	na	602 (23.7)
Cosco Triad LATCH Top Tether	B5885	142	257	336	566 (22.3)	na	na	na	na	na	44.8	na	632 (24.9)

*B denotes Biomechanics database

Table A-18
Hybrid II 6-Year-Old Child, Forward-Facing

Restraint Configuration	Test # *	HIC 15ms	HIC 36ms	HIC Unlimited	Head Excursion mm (in)	Nij	Peak Tension	Peak Compression	Peak Flexion	Peak Extension	Chest Acceleration (g)	Chest Deflection mm (in)	Knee Excursion mm (in)
Century Breverra Classic (5pt) Lap/Should Belt	B5892	na		326	432 (17.0)	na	na	na	na	na	32.0	na	635 (25.0)
Century Breverra Classic (5pt) Lap/Should Belt	B5896	192	417	530	480 (18.9)	na	na	na	na	na	44.6	na	645 (25.4)
Cosco Grand Explorer Lap/Shoulder Belt		na		347	406 (16.0)	na	na	na	na	na	38.6	na	584 (23.0)
Cosco Grand Explorer Lap/Shoulder Belt	B5898	179	379	454	460 (18.1)	na	na	na	na	na	65.8	na	612 (24.1)

*B denotes Biomechanics database

Appendix B. Response to Comments

The agency received only one comment, which was from the Ford Motor Company (Ford) on the Preliminary Regulatory Evaluation (PRE). Ford commented on three areas: pass/fail rates, compliance test costs, and suppliers of child restraint systems.

Pass/Fail Rate

Ford commented that the pass/fail rates in Chapter IV of PRE are unrealistic because they were based on the average of the readings from the repeated tests.

Response: The Final Regulatory Evaluation (FRE) changed the pass/fail rate calculation. The pass/fail rates in the FRE were based on the highest reading from the repeated tests. In other words, any failure in the repeat tests would be counted as a failure.

Compliance Test Costs

Ford stated that sled tests of built-in-child seats are much more expensive than the $1,300 estimated in the PRE. Manufacturers may have to construct a unique vehicle buck using hand-built prototype seats, child restraints, seat belts, etc. The prototype may cost from $500,000 to nearly $1 million.

Response: The built-in child restraint systems have not gained consumer acceptance and its market share is dwindling. In MY 2002, there were 4 built-in child safety restraint systems which have an extremely limited market share. The agency does not believe the vehicle manufacturers would spend that huge amount of money to re-test a current built-in child restraint. In addition, if a built-in child restraint is being developed, then the seat would use the heavier weighted 6-year-old dummy in testing. Once the vehicle buck is built, the test costs are probably not much different than $1,300 per test. Thus, the FRE does not change the cost of a sled test.

Suppliers of Child Restraint Systems

Ford suggested the agency update the supplier list to reflect recent new entries, exit, and consolidations.

Response: The FRE updated the supplier list to reflect the changes in the current child restraint market.