

**CHILD RESTRAINT SYSTEMS**  
**Transportation Recall Enhancement,**  
**Accountability, and Documentation Act**

U.S. Department  
Of Transportation

**National Highway**  
**Traffic Safety**  
**Administration**

**Report to Congress**

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**Office of Rulemaking**

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## Executive Summary

Child restraints are highly effective in reducing the likelihood of death and/or serious injury in motor vehicle crashes. The National Highway Traffic Safety Administration (NHTSA) estimates ("Revised Estimates of Child Restraint Effectiveness," Hertz, 1996) that for children less than 1-year-old, a child restraint can reduce the risk of fatality by 71 percent when used in a passenger car and by 58 percent when used in a pickup truck, van, or sport utility vehicle (SUV). Child restraint effectiveness for children between the ages 1 to 4 years old is 54 percent in passenger cars and 59 percent in light trucks.

On November 1, 2000, Congress enacted the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act (Pub. L. 106-414, 114 Stat. 1800) which, in part, requires the Secretary of Transportation to “initiate a rulemaking for the purpose of improving the safety of child restraints, including minimizing head injuries from side impact collisions.” Section 14(b) of the Act identifies specific elements that the Secretary must consider. The Act gives substantial discretion over the decision whether to issue a final rule on the specific elements. Section 14(c) of the Act specifies that if any element described in Section 14(b) is not incorporated in a final rule, the Secretary shall explain in a report to Congress the reasons for not incorporating the element in a final rule.

In response, NHTSA of the Department published a Notice of Proposed Rulemaking (NPRM) on May 1, 2002, proposing a number of revisions to the Federal Motor Vehicle Safety Standard (FMVSS) No. 213, “Child restraint systems,” including proposals for incorporating improved test dummies and updated procedures used to test child restraints, new or revised injury criteria to assess the dynamic performance of child restraints, and extension of the standard to apply it to child restraints recommended for use by children weighing up to 65 pounds. After (1) reviewing the public comments received in response to the NPRM, and (2) evaluating subsequent tests performed by the agency and others in response to the specific proposals outlined in the NPRM, NHTSA published a final rule that incorporates most – but not all – of the NPRM proposals [68 FR 37620, June 24, 2003]. The agency (1) adopted a number of revisions to the standard seat assembly used to test child restraints to make it more representative of the existing vehicle fleet and similar to that used in the European child restraint standard, (2) adopted a sled pulse corridor to be used in dynamic tests, (3) incorporated the newest child dummies into FMVSS No. 213 compliance tests, (4) extended the upper weight limit of the standard’s applicability from 50 to 65 pounds, and (5) slightly modified the measurement time period for the calculation of Head Injury Criterion (HIC) in FMVSS No. 213 testing.

Based on the available testing and information, however, the agency decided that it was not prudent to amend the standard in each of the areas identified in Section 14(b) of the Act. There were a number of areas of uncertainty regarding the performance of child restraints in side impact crashes, and these questions made it impracticable for the

agency to adopt a technically-justified, meaningful dynamic side impact test procedure and corresponding performance requirements into FMVSS No. 213 at this time. The agency developed a research program to evaluate side impact protection of children restrained in child safety seats. Following initial testing, scheduled to be completed by Spring 2004, NHTSA will reassess whether there is sufficient data to proceed with a NPRM or whether further research will be needed. The agency is in the process of evaluating a 10-year-old dummy, but this effort is not complete at this time, and as such, the agency is unable to extend the upper weight limit of the standard to 80 pounds as recommended in the Act. Lastly, the agency concluded that it is not appropriate to adopt the scaled injury criteria limits that have been adopted for use in FMVSS No. 208 compliance tests into FMVSS No. 213 tests at this time. In accordance with Section 14(c) of the Act, this report outlines the agency's reasons for not fully adopting the recommendations specified in the Act.

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## **BACKGROUND**

The lack of occupant restraint use by motorists is a significant factor in most fatalities resulting from motor vehicle crashes. Of the 31,910 passenger vehicle occupants killed in 2001, 1,003 were children ages 0 through 10 years old. Four hundred ninety-seven of these were less than 5 years old. The failure to use occupant restraints is a significant factor in most fatalities resulting from motor vehicle crashes for both adults and children. Of the 31,910 passenger vehicle occupants killed in 2001, over half (55 percent) were unrestrained. Forty-six percent of the 1,003 child occupant fatalities, ages 0 through 10 years old, were unrestrained. For child occupants less than 5 years old, 45 percent of the 497 fatalities were unrestrained<sup>1</sup>. In 2001, 202 child occupants under 5 years of age were killed while restrained in child restraints, and another 32,000 were injured.

Child restraints are highly effective in reducing the likelihood of death and/or serious injury in motor vehicle crashes. NHTSA estimates ("Revised Estimates of Child Restraint Effectiveness," Hertz, 1996) that for children less than 1-year-old, a child restraint can reduce the risk of fatality by 71 percent when used in a passenger car and by 58 percent when used in a pickup truck, van, or sport utility vehicle (light truck). Child

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<sup>1</sup> Of the 2,787,000 passenger vehicle occupants injured in crashes in 2001, only 12 percent (324,000) were reported as unrestrained. The rates are about the same for child occupants. For children ages 0 - 10 years old, an estimated 147,000 were injured in motor vehicle traffic crashes in 2001, and 12 percent (18,000) of these children were unrestrained. Of the 59,000 child occupants less than 5 years of age who were injured, 11 percent (6,000) were unrestrained.

restraint effectiveness for children between the ages 1 to 4 years old is 54 percent in passenger cars and 59 percent in light trucks.

Notwithstanding the effectiveness of child restraints certified to FMVSS No. 213, the agency is continuing to examine whether the safety of children in child restraints can be enhanced even further. In 2001, 202 child occupants under 5 years of age were killed while restrained in child restraints, and another 32,000 were injured. On November 27, 2000, NHTSA published a planning document that defined the agency's vision for enhancing child passenger safety over the next 5 years (65 FR 70687). The plan contained the agency's views on implementing three strategies for enhancing the safety of child occupants from birth through age 10: increasing restraint use; improving the performance and testing of child restraints; and improving mechanisms for providing safety information to the public. The agency requested comments on the plan and received suggestions on the various initiatives (Docket NHTSA 7938).

Many commenters responded to the second of the three strategies, making suggestions as to how they believed FMVSS No. 213 should be improved to further enhance child restraint performance. There was general concurrence with the agency's plan to undertake rulemaking with regard to the dynamic test and test seat assembly, child dummies used in this testing, and the criteria used to evaluate these tests. There was no objection to the agency's then-announced intention to improve side impact protection as a measure that would be pursued internationally in concert with other government and industry bodies. However, it was apparent from the few comments

received on the subject that those commenters considered child side impact protection to be a long-term project requiring several years of research and development.

After NHTSA completed its draft plan, but before it published the plan in the Federal Register, the TREAD Act was enacted on November 1, 2000. Section 14 of the TREAD Act directed the Secretary of Transportation to initiate a rulemaking for the purpose of improving the safety of child restraints by November 1, 2001, and to complete it by issuing a final rule or taking other action by November 1, 2002. The relevant provisions in Sections 14 are as follows:

(a) In General. Not later than 12 months after the date of enactment of this Act, the Secretary of Transportation shall initiate a rulemaking for the purpose of improving the safety of child restraints, including minimizing head injuries from side impact collisions.

(b) Elements for Consideration. In the rulemaking required by subsection (a), the Secretary shall consider--

(1) whether to require more comprehensive tests for child restraints than the current Federal motor vehicle safety standards requires, including the use of dynamic tests that--

(A) replicate an array of crash conditions, such as side-impact crashes and rear-impact crashes; and

(B) reflect the designs of passenger motor vehicles as of the date of enactment of this Act;

(2) whether to require the use of anthropomorphic test devices that--

- (A) represent a greater range of sizes of children including the need to require the use of an anthropomorphic test device that is representative of a ten-year-old child; and
  - (B) are Hybrid III anthropomorphic test devices;
- (3) whether to require improved protection from head injuries in side-impact and rear-impact crashes;
  - (4) how to provide consumer information on the physical compatibility of child restraints and vehicle seats on a model-by-model basis;
  - (5) whether to prescribe clearer and simpler labels and instructions required to be placed on child restraints;
  - (6) whether to amend Federal Motor Vehicle Safety Standard No. 213 (49 C.F.R. 571.213) to cover restraints for children weighing up to 80 pounds;
  - (7) whether to establish booster seat performance and structural integrity requirements to be dynamically tested in 3-point lap and shoulder belts<sup>2</sup>;
  - (8) whether to apply scaled injury criteria performance levels, including neck injury, developed for Federal Motor Vehicle Safety Standard No. 208 to child restraints and booster seats covered by in [sic] Federal Motor Vehicle Safety Standard No. 213; and
  - (9) whether to include [a] child restraint in each vehicle crash tested under the New Car Assessment Program (NCAP).

(c) Report to Congress. If the Secretary does not incorporate any element described in subsection (b) in the final rule, the Secretary shall explain, in a report

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<sup>2</sup> Standard No. 213 currently requires booster seats to be dynamically tested in 3-point (lap and shoulder) belts. As such, the agency is taking no action with respect to this provision of the TREAD Act. [Footnote added.]

to the Senate Committee on Commerce, Science, and Transportation and the House of Representatives Committee on Energy and Commerce submitted within 30 days after issuing the final rule, specifically why the Secretary did not incorporate any such element in the final rule.

(d) Completion. Notwithstanding any other provision of law, the Secretary shall complete the rulemaking required by subsection (a) not later than 24 months after the date of the enactment of this Act.

Each of the initiatives contemplated by the TREAD Act as possible upgrades to FMVSS No. 213 was included in NHTSA's plan as a possible candidate for rulemaking to enhance the performance of child restraint systems<sup>3</sup>. Notwithstanding the effectiveness of child restraints certified to FMVSS No. 213, the thrust of the 5-year plan was to consider possible rulemaking that could enhance the performance of child restraints even further. Enhancements were considered in terms of improved crash protection and increased usability of the restraints so that misuse is reduced. At the same time, NHTSA believed then, and continues to do so now, that in making regulatory decisions on possible safety enhancements, the agency must bear in mind the consumer acceptance of cost increases. Weighing all these factors, the agency tentatively decided that safety enhancements were warranted in certain aspects of the child restraint standard,

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<sup>3</sup> In addition, Section 14(g) of the TREAD Act required an NPRM to establish a child restraint safety rating consumer information program to provide consumers information for use in the purchase of child restraints. An NPRM was published November 6, 2001 (66 FR 56146, 66 FR 56048). The final rule was published on November 5, 2002 (67 FR 67491). The Act also required a study on the use and effectiveness of booster seats and a 5-year strategic plan to reduce, by 25 percent, deaths and injuries caused by failure to use the appropriate booster seat in the 4- to 8-year-old age group. The study was published on November 27, 2002 and the strategic plan was published on August 7, 2002.

and published an NPRM outlining proposed changes in a number of different areas on May 1, 2002<sup>4</sup>.

### **TREAD NPRM and ANPRM**

In response to Section 14(b) of the TREAD Act, NHTSA comprehensively examined possible ways of revising and updating the child restraint standard, FMVSS No. 213. The May 1, 2002 NPRM was substantially based on a combination of pre- and post-TREAD Act agency activities, including extensive testing of child restraints and dummies by NHTSA's Vehicle Research & Test Center (VRTC) and by the agency in New Car Assessment Program (NCAP) tests, and on evaluations of vehicle seat assemblies and pulses. The proposal was also based on data analysis, as well as agency review of existing global research papers and international standards. NHTSA also took into consideration submissions by the public in response to the agency's Safety Plan and sought an exchange of ideas with child restraint manufacturers as to the research being conducted in response to the TREAD Act, meeting with them in February 2001 (Docket NHTSA 11707-8).

The proposed revisions outlined in the NPRM would incorporate five elements into the standard: (1) an updated bench seat used to dynamically test add-on child restraint systems (subsection (b)(1)(B)); (2) a sled pulse that provides a wider test corridor (subsection (b)(1)(B)); (3) improved child test dummies (subsections (b)(2)(A)

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<sup>4</sup> Separately, the agency issued an NPRM on Standard No. 213's labeling and owner's manual requirements that responds to Section 14(b)(5) of the Act (66 FR 55623, November 2, 2001). A final rule was published on October 1, 2002 (67 FR 61523).

and (B)); (4) expanded applicability to child restraint systems recommended for use by children weighing up to 65 pounds (subsection (b)(6)) ; and (5) new or revised injury criteria to assess the dynamic performance of child restraints (subsection (b)(8)).

Concurrent with the publishing of the May 1, 2002 NPRM, the agency published an Advance Notice of Proposed Rulemaking (ANPRM) on a possible side impact protection standard for child restraint systems. NHTSA addressed side impact protection in an ANPRM, instead of a NPRM at the time, because there were uncertainties in too many areas to issue a NPRM. These areas included: (a) crash characteristics associated with serious and fatal injuries to children in child restraints and the child injury mechanisms in side impacts; (b) development of test procedures, a suitable test dummy and appropriate injury criteria; and (c) identification of cost beneficial countermeasures. The schedule specified in the TREAD Act for initiating and completing this rulemaking limited the amount and variety of information that the agency could obtain, and testing that the agency could conduct. This also limited the development of test procedures and corresponding injury criteria, and the identification of possible countermeasures and evaluation of their efficacy on child restraint performance. The agency was also hampered by a lack of specific accident data on children in motor vehicle crashes available in the agency's National Automotive Sampling System (NASS) and Fatality Analysis Reporting System (FARS) databases. There are few available data on how children are being injured and killed in side impacts (e.g., to what degree injuries are caused by intrusion of an impacting vehicle or other object). Together, these limitations made it difficult to assess and compare the benefits and costs of provisions that could be

included in a rulemaking proposal on side impact. NHTSA's National Center for Statistics and Analysis (NCSA) has initiated a comprehensive study of available data for children ages 12 and under in rear seating positions involved in motor vehicle crashes over the past 10 years, to include frontal, side, and rear impact crashes, regardless of restraint type (i.e., child restraint, vehicle belt system, or unrestrained). NHTSA hopes that this data will yield information that will help the agency better understand the specific injury mechanisms for children, especially those involved in side impact crashes.

The Partners for Child Passenger Safety (PCPS) is a research partnership of The Children's Hospital of Philadelphia, State Farm Insurance Companies and the University of Pennsylvania. PCPS is part of TraumaLink, a comprehensive child injury research center based at The Children's Hospital of Philadelphia and the University of Pennsylvania. Since PCPS began in 1997, the researchers have studied more than 200,000 vehicle crashes, gathering information about how and why children are injured.

PCPS acknowledges that side impact collisions pose a great risk to children in crashes, but also notes that information about the injury mechanisms in these crashes is limited. In a study published in September 2001<sup>5</sup>, PCPS examined in-depth crash investigations to identify injury mechanisms to children in side impact collisions. Ninety-three children in 55 side impact crashes were studied. Twenty-three percent (22) of the children received an Abbreviated Injury Scale (AIS) score  $\geq 2$  (clinically significant) injuries. In these 22 children, head (40%), extremity (23%), and abdominal

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<sup>5</sup> Arbogast K.B., "Factors influencing pediatric injury in side impact collisions," J Trauma 2001 Sep., 51(3):469-77

injuries (21%) were the most common significant injuries. The cases revealed that serious injuries, particularly head injuries, occur even in minor crashes, and efforts should be made to make the interiors of vehicles more child occupant friendly. PCPS noted that lower extremity and abdominal injuries occurred because of contact with the intruding door, and concluded that design of vehicles to minimize crush should mitigate the occurrence and severity of these injuries.

Notwithstanding these limitations, NHTSA felt that progress had been made toward the development of a potential regulatory proposal to improve the side impact performance of child restraint systems. NHTSA analyzed crash data and developed a dynamic side impact test. The agency identified possible countermeasures. However, NHTSA did not evaluate the countermeasures to determine their feasibility and benefit, although the agency committed to study potential countermeasures for rear-facing restraints in 2002. Information from that study was envisioned to help NHTSA further evaluate the course of action that the agency should pursue in this rulemaking. From the information and analysis available at the time the ANPRM was published, it appeared that if the agency were to issue an NPRM on side impact, it might involve significantly higher costs per equivalent life saved than those in most NHTSA vehicle safety rulemakings.

Because of all these factors, NHTSA felt that the most appropriate course of action at the time was to issue an ANPRM to obtain additional information that would help decide whether it was possible and appropriate to issue a proposal in the near future

and/or identify additional work that needs to be done. Through issuing the ANPRM, the agency hoped to obtain more information about matters such as the harm to restrained children in side impacts, such as the child injury mechanisms and the crash characteristics associated with serious and fatal injuries. NHTSA sought comment on the suitability of the test procedures that the agency was considering, of the dummy that might be used in a test procedure, and on possible injury criteria. NHTSA asked for cost, benefit and other information on possible countermeasures that would be effective in improving side impact protection, particularly the possible countermeasures that had been identified. As a result of issuing the ANPRM, the agency anticipated receiving information that would improve its ability to assess the merits of this rulemaking and thus aid the agency in making decisions about the future course of this rulemaking. Comments received on the ANPRM are discussed in subsequent sections of this report.

## **TREAD FINAL RULE**

NHTSA received a number of comments in response to the NPRM, many of which were generally supportive of the proposed changes to FMVSS No. 213. Commenters were largely in favor of the proposals to revise the standard seat assembly and to use the newer dummies in FMVSS No. 213 compliance tests. Each commenter expressed beliefs that the upper weight limit of FMVSS No. 213 should be increased, but some questioned the suitability of the proposed weighted 6-year-old dummy for use in testing restraints certified for heavier children. Finally, commenters presented widely-varying positions on the appropriateness of the proposed injury criteria limits. While

some commenters generally supported the inclusion of scaled injury criteria limits similar to those adopted in FMVSS No. 208 advanced air bag testing, many others expressed serious concerns regarding the basis for use of these injury thresholds in FMVSS No. 213 testing given the distinct differences in the two test scenarios and testing results that show an inability of existing child restraints to meet the proposed injury criteria limits, specifically in the area of neck injury.

A final rule that incorporates most of the revisions to FMVSS No. 213 that were proposed in the May 1, 2002 NPRM was published in the Federal Register on June 24, 2003 (68 FR 37620). This final rule was developed after having evaluated the comments received in response to the NPRM, and results of additional testing – conducted by the agency and by the Juvenile Products Manufacturers Association (JPMA) – that had been done in support of these issues. Based on all available information and data, the agency has decided to proceed with a number of revisions to “modernize” the test requirements of FMVSS No. 213, and to extend the upper weight limit of the standard from 50 to 65 pounds. Specifically, NHTSA has revised FMVSS No. 213 as follows:

(a) The standard test seat assembly has been revised to make it more representative of the existing vehicle fleet, and more closely harmonize with the test seat assembly used in the European standard, ECE R44. The following changes have been made:

- (1) Revise the seat back angle from 15° to 20°;
- (2) Revise the seat cushion angle from 8° to 15°;

(3) Revise the lap belt anchorage spacing from 222 mm to 400 mm in the center seating position and from 356 mm to 472 mm in the outboard seating position; and

(4) Revise the seat back assembly to represent a fixed seatback as opposed to the current flexible seat back.

(b) A sled pulse corridor has been included for use in compliance testing.

(c) The CRABI 12-month-old dummy and the Hybrid III 3- and 6-year-old dummies have been adopted for use in FMVSS No. 213 compliance tests.

(d) The upper weight limit of FMVSS No. 213 has been extended from 50 to 65 pounds, and a weighted Hybrid III 6-year-old dummy will be used to ensure that the structural integrity of a child restraint is maintained in compliance tests for all restraints certified for children weighing more than 50 pounds.

(e) The existing injury criteria limits as prescribed in FMVSS No. 213 have been retained, but a 36 ms measurement window for the calculation of Head Injury Criterion (HIC) will be used as opposed to the current unlimited measurement window. These criteria apply to the CRABI 12-month-old dummy, as well as the Hybrid III 3- and 6-year-old dummies.

The agency has declined to incorporate a number of elements, or portions thereof, identified in Section 14(b) of the TREAD Act. While subsections (b)(1)(A) and (b)(3) of Section 14 asked NHTSA to consider the development of side- and rear-impact dynamic crash tests designed to reduce head injuries in these crashes for inclusion into FMVSS No. 213, the uncertainties regarding side impact crashes and associated issues that were

identified in the ANPRM (and discussed earlier) still exist and make it impracticable to issue a final rule addressing these issues at this time. Subsection (b)(2)(A) directed the agency to consider the use of anthropomorphic test devices that represent a greater range of sizes of children, including the need to require the use of an anthropomorphic test device that is representative of a 10-year-old child. While the agency will be using a weighted 6-year-old Hybrid III dummy for evaluating child restraints recommended for children weighing up to 65 pounds, the development of the 10-year-old dummy has not been completed. Accordingly, the agency has raised the upper weight limit of the standard's applicability to 65 pounds instead of the recommended 80 pounds identified in Section 14(b)(6) of the Act. Finally, the agency has concluded that it is not appropriate to incorporate the scaled injury criteria performance levels, including neck injury, developed for FMVSS No. 208 into FMVSS No. 213 at this time. The remainder of this report is dedicated to outlining the specific reasons why these elements have not been incorporated into FMVSS No. 213 at this time.

## **HEAD PROTECTION IN SIDE- AND REAR-IMPACT CRASHES**

Sections 14(b)(1)(A) and (b)(3) asked NHTSA to consider the replication of an array of crash conditions, such as side- and rear-impact crashes to provide improved head protection. It is important to note that no country or region currently has a regulation specifying a minimum level of performance requirement for child restraints in a dynamic side impact simulation. Efforts around the world to improve child restraint safety have concentrated on performance in frontal impacts because they accounted for more injuries and fatalities than any other crash mode.

The ANPRM published on May 1, 2002 identified numerous areas of technical uncertainty that hindered agency efforts to formulate a definitive proposal for side impact testing of child restraints. In issuing an ANPRM, as opposed to an NPRM, the agency sought to obtain insight from commenters that would aid the development of performance requirements leading to reductions in serious and fatal head injuries for children involved in side impact crashes. While the majority of commenters supported agency efforts to develop a dynamic side impact test procedure and corresponding performance requirements in response to the TREAD Act mandate, those commenters also generally confirmed the presence and scope of the uncertainties raised by NHTSA in the ANPRM. Commenters also agreed that until these uncertainties are resolved, any such efforts to develop FMVSS No. 213 dynamic side impact test requirements will be a long-term project as opposed to something that can be accomplished within the time frame originally contemplated by the TREAD Act.

While commenters provided some information regarding the questions raised by NHTSA in the ANPRM, there was general agreement that more work is necessary to adequately answer the questions regarding injury causation/mechanism and the suitability of a test dummy to assess such injury mechanisms before potential countermeasures can be defined and evaluated. Further, there was widespread support for NHTSA to monitor the progress of the extensive effort underway by the International Organization for Standardization (ISO) to develop a harmonized side impact test procedure. A draft ISO standard has been developed for a side impact test using a sled with a hinged door. A pivoted door structure is rotated in relation to the test seat, at a relative velocity within a band of velocities measured in full-scale tests to represent an intruding door structure

relative to the rear seat. Many commenters noted that the replication of an intruding door member, as done in the draft ISO test procedure, should be a vital element in any potential side impact test procedure.

The ISO working group's draft side impact test method has not been finalized. The working group has recognized that, although a potential test method has been developed, there are no dummies available at the present time whose construction is designed for side impact validation. Given the lack of an approved test dummy, and corresponding injury criteria, a final version of an ISO test procedure is not expected in the near future.

NHTSA will make work to develop enhanced side impact protection for children in child restraints a priority effort for the next several years. NHTSA will continue efforts to obtain detailed crash data, from both within and outside of the agency, to identify specific injury mechanisms that arise in side impact crashes involving children. NHTSA is currently conducting dynamic testing to evaluate the effects of incorporating a number of potential countermeasures that are thought to provide improved protection to children in child restraints in side impact crashes. While these tests are being conducted using the test dummies proposed for use in FMVSS No. 213 testing, the agency will also conduct similar tests with the European Q3 dummy to compare the results. The Q3 3-year-old child dummy was designed for use in both frontal and lateral impacts.

Section 14(b)(9) of the TREAD Act also directed the agency to consider whether to include a child restraint in each vehicle crash tested under the NCAP. This, in conjunction with the provisions of Sections 14(b)(1)(A) and 14(b)(3), prompted the

agency to conduct a limited number of side impact NCAP crash tests with child restraints installed. A total of eight model year 2002 vehicles were tested with a child restraint system installed in the rear seat of the vehicle. The side impact NCAP test replicates a vehicle traveling at 17 mph being struck in the side by another vehicle traveling at 34 mph. NHTSA hoped that these tests would help address a number of the questions posed in the ANPRM for dynamic side impact testing of child restraints. The following test objectives were posed: (1) investigate injury mechanisms that might arise when children in child restraint systems are subjected to side impact vehicle crashes, (2) find and compare the general performance variation of child restraints across vehicle types, and (3) provide performance data for child restraints in full-scale vehicle tests to compare with side impact sled tests. Since suitable child side impact dummies do not exist, frontal impact dummies representing a 12-month-old and a 3-year-old were used.

Based on the very limited number of crash tests conducted, the following observations were made:

- 1.) HIC measurements for the dummy positioned on the struck side of the vehicle were within the FMVSS No. 213 limit of 1000 (for frontal crash tests) in each of the eight side impact NCAP tests. However, chest acceleration measurements exceeded the FMVSS No. 213 limit of 60 g's in three of the eight NCAP tests.<sup>6</sup>

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<sup>6</sup> As noted above, since suitable child side impact dummies do not exist, frontal impact dummies representing a 12-month old and a 3-year-old were used. Also, there are no established injury thresholds set for HIC and chest acceleration for children involved in side impact crashes. Further, the average change in velocity for the side impact NCAP tests was 17.38 mph, whereas the FMVSS No. 213 frontal compliance tests are conducted at a velocity change of 30 mph.

- 2.) Upon a side impact crash, the child dummy's head most often impacted the side wing of the child restraint. For dummies seated on the struck side, in severe impact situations with significant door intrusion, the head of the child dummy tended to move beyond the side wing and contact the door trim of the vehicle or the windowsill. When this happened, high HIC values usually resulted.
- 3.) The injury metrics recorded by the dummies located on the struck side of the vehicle were generally greater than those recorded by dummies on the non-struck side of the vehicle.
- 4.) The intrusion of the door around the child restraint system area ranged from 3.5 to 10 inches.
- 5.) Vehicles that performed well in providing side crash protection to adult dummies in side impact NCAP tests also provided better side crash protection to the rear seat children. For example, SUVs and pickup trucks tend to offer better side protection than smaller passenger cars for children.

Although the testing performed was very limited in scope, the vehicles were chosen so that the test matrix included vehicles from across six vehicle classes: 2-door passenger cars, 4-door passenger cars (light), 4-door passenger cars (compact), SUVs, pickup trucks, and minivans. The results from this limited, initial set of side impact NCAP crash tests will be used by the agency to serve as a linkage between existing and future crash data analysis and the development of a dynamic side impact test procedure. Side impact NCAP tests gives the agency an opportunity to carefully examine each of the

above areas of concern through detailed film and data analysis under controlled, laboratory conditions. This information will help the agency validate any dynamic side impact test procedure that is ultimately adopted.

Although the agency has decided not to pursue the development of a side impact test procedure for inclusion into FMVSS No. 213 at this time, NHTSA is currently conducting a program of child restraint side impact testing in an effort to learn more about the particular injury mechanisms. The agency plans to complete this testing by Spring 2004. Following this initial testing, the agency will reassess whether sufficient data is available to proceed with an NPRM, or whether further research will be needed. The following is the side impact testing that the agency is conducting this year:

- (1) Initial evaluation of mitigation concepts, such as adding padding material to the child restraint, modifying the size of the side wings of the child restraint, use of rigid lower anchorages and additional tethering of the child restraint for both rear- and forward-facing child restraints in side impacts;
- (2) If the results from (1) above are successful in reducing injury levels, tests will be conducted to determine if the Hybrid III 3-year-old dummy or the Netherlands Organization for Applied Scientific Research (TNO) Q3 dummy is better able to assess the risk.
- (3) The agency will also evaluate alternative tether locations and additional types of foam material in an effort to maximize protection for the child dummies in side impact crashes.

To more fully address head trauma and improve chest protection for a wide segment of the U.S. population, the agency is planning to upgrade the side impact standard, FMVSS No. 214, by setting additional requirements through added tests and newer test devices. These are likely to promote advanced countermeasures for head and chest protection in higher severity side crashes for different size occupants and enhance side impact protection for children.

The ANPRM also requested information regarding the possible incorporation of a rear impact dynamic crash test for rear-facing child restraints. Data from FARS for 1991-2000 show that 9580 passenger vehicle occupants between the ages of 0 and 8 years old were fatally injured. Of these, 662 (6.9 percent) were killed in rear impact crashes, while 3536 (36.9 percent) were killed in frontal crashes and 2759 (28.8 percent) were killed in side impact crashes. Of the 662 children killed in rear impact crashes between 1991-2000, 214 were restrained in a child restraint; 128 were restrained with a lap or lap/shoulder belt; 266 were unrestrained and 54 were of other or unknown restraint use. Further, of the 104 children under the age of 1 that were killed during this time period, 60 were in child restraints, 2 were in lap or lap/shoulder belts, 38 were unrestrained, and 4 were of other or unknown restraint use.

The breakdown of restraint use for children under the age of 1 was provided to identify the possible benefits associated with establishing a rear impact test for rear-facing restraints in FMVSS No. 213 which would be similar to that which is conducted under the European Regulation R44. In the European test, rear-facing restraints are subjected to a rear impact test conducted at 30 km/hr (18.6 mph), with peak deceleration

between 14 g and 21 g over a 70 msec time period. Limits on the amount of allowable head excursion during the dynamic test are specified.

During dynamic sled testing performed by NHTSA in support of FMVSS No. 202 and FMVSS No. 207, a rear-facing child restraint with the CRABI 12-month-old dummy was added to three different tests. The tests were conducted using a 1999 Dodge Intrepid vehicle buck. An Evenflo On My Way child restraint, with the attached base, was positioned in the rear seat of the vehicle for each test. One test, simulating a dynamic FMVSS No. 202 condition, was conducted at approximately 17.5 km/h (11 mph). The other two tests were conducted at approximately 30.5 km/h (19 mph). Regardless of simulated impact speed, the CRABI 12-month-old in the rear-facing child restraint was able to easily meet the injury criteria that are proposed under FMVSS No. 208; however, compliance with the Economic Commission of Europe (ECE) Regulation R44 requirements were not verified. Given the results of the above testing, in conjunction with the data showing that fatalities for children as a result of rear impact crashes constitute a much smaller percentage of the total than other crash modes, the agency decided to concentrate efforts at this time on side impact protection rather than rear impact requirements.

Commenters generally concurred with the agency's assessment of rear impact crash protection for rear-facing child restraints. No data was provided to support the establishment of a test that would parallel the existing European requirement that tests rear-facing child restraints in a 18.6 mph rear-impact dynamic crash. Given the above,

NHTSA believes that it is unnecessary to incorporate a rear-impact dynamic crash test at this time for rear-facing child restraints.

### **10-YEAR-OLD DUMMY**

In early 2000, NHTSA asked the Society of Automotive Engineers (SAE) Dummy Family Task Group (DFTG) to develop a test dummy representative of a 10-year-old child<sup>7</sup>. The development and adoption of a dummy this size is seen as a long-term solution to ensuring the proper restraint of the approximately 10 percent of the population between the sizes of 6-year-olds and 5th percentile adult females, and could potentially be used in evaluating the performance of booster seats and vehicle belt systems. The group met initially in May 2000 to define the concept. The weight and height of the proposed dummy were provided from the Center for Disease Control Data Bank, and was targeted to be approximately 4'6" and 72 lb. The basic construction was envisioned to be similar to that of the Hybrid III small female dummy. The dummy was to be able to be positioned in erect seated, slouched seated, standing, and kneeling postures to fully evaluate possible restraint configurations.

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<sup>7</sup> The legislative history to TREAD indicates that Congress was interested in the potential for using the 10-year-old dummy specified in ECE 44. That dummy is manufactured by the Netherlands Organisation for Applied Scientific Research (TNO), which manufactures the other test dummies referenced in ECE 44. These dummies are TNO's "P" series of child dummies, which includes a newborn, a 9-month, 18-month, and 3-, 6-, and 10-year-old. All P series dummies are of similar construction. The agency evaluated the 9-month and 3-year-old child dummies and found them to have insurmountable seating stability problems when placed in a child restraint, and un-human-like impact kinematics because of their cervical and thoracic spine construction. We also found problems with the instrumentation. As a result, because of design similarities of all P series dummies, our engineering judgment was that the 10-year-old TNO dummy would not be suitable for use in crash testing. Subsequently, TNO began developing the Q series dummies, which appear likely to be more biofidelic, stable and reliable than their predecessor.

The task group held its first review meeting in June 2000, and reviewed impact responses scaled from the small female and 6-year-old dummies. At that time, provisional performance requirements were defined, and the anthropometry and mass goals were finalized. The dummy instrumentation was specified to measure injury parameters for the following body regions: head, neck, shoulder, thorax, pelvis, femur, and tibia.

The first 10-year-old prototype was assembled in February 2001. It weighed about 76 pounds. The task group reviewed this prototype, and directed design corrections. Subsequently, the first drawings were completed in April 2001. General Motors (GM) and NHTSA separately performed preliminary dummy performance verifications in Spring 2001 and Summer 2001, respectively. Subsequently, NHTSA has been working with SAE and dummy manufacturers to resolve dummy design and production issues. The evaluation testing was completed in May 2003. NHTSA will initiate rulemaking to propose the incorporation of the 10-year-old dummy into 49 CFR Part 572, "Anthropomorphic Test Devices." NHTSA anticipates publication of an NPRM in late 2004 or early 2005.

### **FMVSS No. 213 UPPER WEIGHT LIMIT**

Section 14(b)(6) directed NHTSA to consider whether to amend FMVSS No. 213 to cover restraints for children weighing up to 80 pounds. There has been considerable interest over the years in raising the limit to require that child restraint systems that are

recommended for older children (i.e., booster seats) to perform adequately in a crash. The aim of raising the limit was to bring booster seats that are recommended for children over 50 pounds within FMVSS No. 213 and subject them to that standard's dynamic test, just as other restraints are tested under the standard. The intent to evaluate booster seat performance more thoroughly by dynamically testing them could not be realized, however, without a test dummy representing an older child. It would make little sense to raise the standard's limit above 50 pounds if a test device were not available to test the performance of the restraint. Further, booster seats were not being marketed so as to be beyond the standard's purview; their recommended usage included children weighing less than 50 pounds so they were, at least, subject to the 30 mph dynamic test with the 6-year-old (48 lb) dummy. For these reasons, NHTSA decided against increasing the 50-pound limit in the definition of "child restraint system." (See 58 FR 46928, 46932 for a discussion of the agency's decision not to undertake rulemaking on this issue.)

In the May 1, 2002 NPRM, NHTSA proposed to incorporate a weighted 6-year-old dummy (62 lb total weight) into 49 CFR Part 572. NHTSA tentatively concluded that the dummy can provide useful information on the performance of booster seats that are recommended for children above 50 lb. Accordingly, the agency proposed to increase the 50 lb weight limit in the definition of child restraint system to 65 lb. The final rule published on June 24, 2003 maintained this amendment. As noted in the previous section, the development of the 10-year-old dummy has not been completed at this time. As such, it is impracticable to increase the upper weight limit of the standard beyond 65 pounds without the corresponding test device to confirm the performance of a child

restraint certified for higher weights. NHTSA will revisit the proposal to extend the applicability of the standard beyond 65 pounds, and possibly to 80 pounds as recommended in Section 14(b)(6) of the TREAD Act, concurrent with incorporation of the 10-year-old dummy into Part 572.

On December 4, 2002, Congress enacted “Anton’s Law,” (Pub. L. 107-318, 116 Stat. 2772) which, in part, requires the agency to “develop and evaluate an anthropomorphic test device that simulates a 10-year old child for use in testing child restraints used in passenger motor vehicles.” Anton’s Law requires NHTSA to perform this development and evaluation not later than 24 months after the date of the Act, and to subsequently initiate a rulemaking proceeding for the adoption of the new dummy within 1 year following the initial development and evaluation. As described above, the current development status of the Hybrid III 10-year-old dummy is consistent with the timelines put forth in Anton’s Law.

### **SCALED INJURY CRITERIA**

Section 14(b)(8) directed the agency to consider whether to apply scaled injury criteria performance levels, including neck injury, developed for FMVSS No. 208, to child restraints and booster seats covered in FMVSS No. 213. While the agency proposed in the May 1, 2002 NPRM to use the new and scaled injury criteria of FMVSS No. 208 in FMVSS No. 213 compliance testing, the agency has decided to maintain the existing injury limits of FMVSS No. 213 with only minor changes.

In determining the appropriate injury criteria limits to impose in FMVSS No. 213 compliance testing – either the scaled injury limits adopted by FMVSS No. 208 and proposed in the TREAD NPRM, the existing FMVSS No. 213 limits that have been in place for many years, or any other alternative set of injury criteria – NHTSA believes that it is imperative to first distinguish a number of critical differences between the FMVSS No. 208 air bag and the FMVSS No. 213 child restraint dynamic test loading conditions. Whereas FMVSS No. 208 testing involves impact loading (with the air bag) to evaluate the blunt trauma on out-of-position occupants, FMVSS No. 213 is a non-impact (there is no structure forward of the standard test seat assembly), inertial loading evaluation of in-position occupants. As such, the FMVSS No. 213 and 208 dynamic tests, and their associated injury criteria limits used to confirm compliance and ensure occupant safety, protect against very different injury types and injury mechanisms. The fundamental differences in how the respective dynamic tests in FMVSS Nos. 208 and 213 are conducted are important to understand the agency’s decision to retain the existing FMVSS No. 213 injury criteria limits, with minor amendments, and not adopt the scaled injury criteria limits that were proposed in the NPRM and that have been adopted for FMVSS No. 208.

In developing the final rule, NHTSA considered results from agency testing performed at two different laboratories, along with testing performed by JPMA in support of their comments to the TREAD NPRM. In the final rule, NHTSA decided against incorporating the scaled injury limits used in FMVSS No. 208 because the data obtained

from the JPMA and NHTSA test programs indicated that current child restraints generally do not meet the proposed limits.

There are several reasons why this was a concern for the agency. First and foremost, child restraints are currently highly effective in reducing the likelihood of death and/or serious injury in motor vehicle crashes. The agency was unable to identify a safety problem that the scaled injury limits of FMVSS No. 208 would remedy.

Second, it is unknown what modifications to child restraints would be necessary for the restraints to meet the proposed injury limits. NHTSA does not have information on how child restraints that failed to meet the proposed Neck Injury Criterion (Nij) and other limits could be modified to meet the criteria. Assuming that the restraints could be redesigned to meet the proposed injury limits, there would likely be costs associated with the redesign which would result in increases in the price of the restraints. The agency considers the consumer acceptance of cost increases to child restraints (an already highly-effective item of safety equipment) in determining the net safety effects of changes to the child restraint standard. In balancing the effects of meeting the scaled injury criteria against the possible impacts on the price of restraints, the agency determined that the net effect on safety could be negative in this instance because of the minimal benefits of such a change, weighed against the delayed replacement of old restraints by current owners or non-purchase by non-owners. For these reasons, in accordance with the TREAD Act, the agency has considered whether to apply scaled injury criteria performance levels

developed for FMVSS No. 208 to child restraints and have determined it would not be prudent to do so.

Discussions of each of the specific injury criteria are provided as follows:

Head Injury Criterion (HIC). The final rule retained the existing FMVSS No. 213 HIC threshold of 1000 for the CRABI 12-month-old and Hybrid III 3- and 6-year-old dummies, but limited the time measurement for the calculation of HIC to 36 ms rather than the 15 ms window that was proposed in the NPRM. As discussed in a following section, the agency did not feel that it was appropriate to incorporate a neck injury criterion in FMVSS No. 213 compliance testing at this time. For the 15 years before NHTSA had a neck injury criterion in FMVSS No. 208, NHTSA used a 36 msec time interval to measure HIC, primarily because this method indirectly provided neck injury protection.<sup>8</sup> This indirect neck injury protection is provided because HIC<sub>36</sub> includes acceleration due to neck elongation forces, which are also a potential neck injury mechanism for children. Further, data showed that in FMVSS No. 213 dynamic sled tests, HIC measurements using a 36 ms window and an unlimited measurement window as currently specified in the standard were very similar. Given that the agency declined to adopt a neck injury criterion at this time, the longer measurement window associated with HIC<sub>36</sub> as opposed to the proposed HIC<sub>15</sub> will provide assurances that a child's neck will not be subjected to excessive forces in a crash.

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<sup>8</sup> Reference NHTSA's advanced air bag Supplemental Notice of Proposed Rulemaking (64 FR 60556; November 5, 1999)

Chest Acceleration/Chest Deflection. The final rule does not adopt the proposed chest injury criteria relating to acceleration and deflection. A safety need for adopting the proposal has not been established. NHTSA was persuaded that there are not sufficient data that demonstrate that children have been seriously injured due to excessive chest acceleration or deflection in current restraint designs. Historically, the majority of child injuries are to the head as opposed to the chest. The agency is concerned about possible negative effects of adopting the proposed chest injury criteria on increased head excursion. Further, not enough is known about the countermeasures that could be employed to meet the proposed criteria. If child restraint manufacturers were to redesign their restraints to meet such requirements, the agency is concerned about the possibility of those revised designs compromising other aspects of the occupant's injury protection.

The data presented by JPMA, and to a lesser degree, the follow-on tests conducted at VRTC, show difficulty for current restraints to meet the scaled chest criteria. Redesigning the restraints to meet the requirements, assuming such redesign is practicable, would involve a cost increase to manufacturers, which would be passed on to consumers. The agency does not believe that the cost increase is justified in this instance, and is concerned about the possible effect the cost increase could have on the purchase and use of child restraints. For the aforementioned reasons, NHTSA concluded that it is not in the interest of safety

to adopt the chest injury criteria developed for FMVSS No. 208 into FMVSS No. 213.

Neck Injury Criterion (Nij). NHTSA likewise decided that it was not appropriate to incorporate Nij into FMVSS No. 213 compliance tests at this time. Both NHTSA and JPMA testing demonstrated that existing restraints could not meet the proposed neck injury criteria limits in the majority of tests. Neither NHTSA nor child restraint manufacturers identified any countermeasures that could be readily incorporated into existing designs that would promote compliance with the proposed requirements. As discussed in the section regarding head injury criterion, the adoption of a 36 ms measurement window for HIC, as opposed to the 15 ms window that was presented in the NPRM, will also serve as a surrogate for a neck injury criterion to ensure that children continue to be well protected.

## **CONCLUSIONS**

NHTSA is confident that the changes to FMVSS No. 213 adopted in response to the TREAD Act will result in a performance standard that is more representative of the existing vehicle fleet, thereby allowing child restraint manufacturers to optimize their designs to better protect properly restrained children. NHTSA is continuing to investigate potential countermeasures and requirements that will enhance side impact protection for children.