U.S. Department of Transportation
**National Highway Traffic Safety Administration**

# Memorandum

Subject: Advanced Air Bag Final Rule and Final Economic Analysis -- As Submitted to OMB for Review

Date: MAY 10 2000

From: Stephen P. Wood
Assistant Chief Counsel for Rulemaking

Reply to Attn. of:

To: Docket No. NHTSA 00-7013; Notice 1

Pursuant to section 6(a)(3)(E) of Executive Order 12866, Regulatory Planning and Review, I am submitting to Docket No. NHTSA 00-7013; Notice 1, two documents: the final rule on advanced air bags and accompanying final economic analysis as submitted in draft on March 1, 2000, to the Office of Management and Budget (OMB) for review under the Executive Order. The final rule and final economic analysis as issued May 4, 2000, have already been placed in the docket.

We made three substantive changes in the regulatory text in the final rule:

1. Maximum speed for unbelted rigid barrier test

   Draft final rule as submitted for review March 1: That test would have been phased-in for increasing percentages of motor vehicles during the first stage phase-in, from September 1, 2003, to August 31, 2006, with a maximum speed of 25 mph. During the second stage phase-in, from September 1, 2007 to August 31, 2010, the maximum test speed for the unbelted rigid barrier test would have increased to 30 mph.

   Final rule as issued May 4: That test will be phased-in for increasing percentages of motor vehicles during the first stage phase-in, from September 1, 2003, to August 31, 2006, with a maximum speed of 25 mph. This part of the final rule was issued as an interim final rule.

2. Maximum speed for belted rigid barrier test using mid-size male dummy

   Draft final rule as submitted for review March 1: The final rule would not have changed the current maximum test speed (30 mph) for the belted rigid barrier test.

   Final rule as issued May 4: The maximum speed for belted rigid barrier test using mid-size male dummy will increase to 35 mph during the second stage phase-in, from September 1, 2007, to August 31, 2010.

Get it together!
SAFETY BELTS SAVE LIVES

DOT TRANSPORTATION
00 MAY 10 AM 1:33

3. Due care

Draft final rule as submitted for review March 1: The existing due care provision in Standard No. 208, Occupant Crash Protection, for rigid barrier testing would have been extended to the new crash tests added by the final rule and to the out-of-position tests that involve the deployment of an air bag. The due care provision would have sunsetted at the end of the second phase-in period (i.e., September 1, 2010).

Final rule as issued May 4: The existing due care provision in Standard No. 208 for rigid barrier testing is not extended to any new test. The existing provision will sunset during the first stage phase-in, i.e., September 1, 2003, to August 31, 2006.

We made changes to the preamble of the final rule that are too numerous and extensive to identify individually. Instead, we have set forth below the table of contents for the May 4 final rule and underlined the titles of the parts of the preamble that differ significantly from their counterparts in the March 1 draft final rule. In addition, we note that Appendices B, C and D of the May 4 final rule appeared near the beginning of the preamble of the March 1 draft final rule as sections III, V, and VI, respectively.

**TABLE OF CONTENTS**

**I. Safety Problems**
- **A. Frontal Crashes and the "Second Collision" -- The Leading Cause of Occupant Deaths**
- **B. Preventing or Mitigating the Effects of the Second Collision Using Seat Belts and Air Bags**
- **C. Air Bag Risks and Fatalities**
- **D. Causes of Air Bag Fatalities**

**II. The Rule, Its Rationale, and Its Implementation**
- **A. Key Provisions of the Rule**
- **B. Other Provisions of the Rule**
- **C. Future Rulemaking Plans**
- **D. Monitoring of Implementation and Field Experience; Research and Technology Assessment**

**III. Our Proposals for Advanced Air Bags**
- **A. Our Initial Proposal (September 1998)**
- **B. Our Supplemental Proposal (November 1999)**

**IV. Public Comments on the Supplemental Proposal**

**V. Diagrams of the Rule Requirements**

**VI. Improving the Protection of Unbelted Occupants in Serious Crashes**
- **A. Summary of Proposed Requirements**

B. Type of Test

C. Agency Decision to Establish Maximum Test Speed at 40 km/h (25 mph)

1. The Supplemental Proposal

2. Summary of Comments

3. Decision on Maximum Test Speed

D. Other Issues

1. Location of 5th Percentile Adult Female Dummy

2. Minimum Test Speed

VII. Improving the Protection of Belted Occupants in Serious Crashes

A. Belted Rigid Barrier Crash Test

B. Belted Offset Deformable Barrier Crash Test

VIII. Minimizing the Risk of Injuries and Deaths Caused by Air Bags

A. Safety of Infants

1. Option 1: Feature (e.g., Weight or Size Sensor) That Suppresses the Air Bag When an Infant Is Present

2. Option 2: Low-Risk Deployment for Infants in Rear-Facing Child Safety Seats

B. Safety of Young Children

1. Option 1: Feature (e.g., Weight or Size Sensor) That Suppresses the Air Bag When a Child Is Present

2. Option 2: Low-Risk Deployment for Young Children

3. Option 3: Feature That Suppresses the Air Bag When a Child Is Out-of-Position

C. Safety of Teenage and Adult Drivers

1. Option 1: Low-Risk Deployment for Drivers

2. Option 2: Feature That Suppresses the Air Bag When a Driver Is Out-of-Position

IX. Injury Criteria

A. Head Injury Criteria

B. Neck Injury Criteria

C. Thoracic Criteria

D. Other Criteria

X. Lead Time and Effective Date

A. Large Manufacturers

B. Limited Line, Small, Multi-Stage Manufacturers and Alterers

1. Limited Line Manufacturers

2. Small Manufacturers

3. Multi-Stage Manufacturers and Alterers

XI. Availability of Original Equipment and Retrofit Manual On-Off Switches

XII. Warning Labels, Consumer Information, and Telltale Devices

A. Warning Labels and Consumer Information

B. Telltale Devices

MAR 1 2000

MAR 1 2000

# DRAFT

**DEPARTMENT OF TRANSPORTATION**

**National Highway Traffic Safety Administration**

**49 CFR Parts 552, 571, 585 and 595**

**[Docket No. NHTSA 00- ; Notice ]**

**RIN 2127-AG70**

## Federal Motor Vehicle Safety Standards; Occupant Crash Protection

**AGENCY**: National Highway Traffic Safety Administration (NHTSA), DOT.

**ACTION**: Final rule.

**SUMMARY**: This final rule amends our occupant crash protection standard to require that future air bags (1) create less risks of serious air bag-induced injuries than current air bags, particularly for small women and young children; (2) provide at least as much protection as current air bags for all occupants; and (3) provide improved frontal crash protection, particularly for small women. Most aspects of this final rule are supported by vehicle manufacturers, air bag suppliers, safety advocates and others. This final rule is required by the Transportation Equity Act for the 21st Century (TEA 21). That Act mandates that we conduct a rulemaking to improve protection for occupants of all sizes, belted and unbelted; and minimize the risks posed by air bags to infants, children, and other occupants, by means that include advanced air bag technology.

**DATES**:

Effective Date: The amendments made in this rule are effective [insert date 30 days after publication in the **Federal Register**].

The incorporation by reference of the publications listed in the rule is approved by the Director of the Federal Register as of **[insert date that is 30 days after date of publication in the Federal Register]**.

*Petitions:* Petitions for reconsideration must be received by **[insert date that is 45 days after date of publication in the Federal Register]**.

**ADDRESSES**: Petitions should refer to the docket and notice number of this notice and be submitted to: Administrator, National Highway Traffic Safety Administration, 400 Seventh Street, SW, Washington, DC 20590.

**FOR FURTHER INFORMATION CONTACT**:

**For information about air bags and related rulemakings:** Visit the NHTSA web site at http://www.nhtsa.dot.gov and select "Air Bags" under "Popular Information."

You may also view the materials in the docket for this rulemaking on the Internet. To do this, do the following:

(1) Go to the Docket Management System (DMS) Web page of the Department of Transportation (http://dms.dot.gov/).

(2) On that page, click on "search."

(3) On the next page (http://dms.dot.gov/search/), type in the four-digit docket number shown at the beginning of this document. Example: The docket number for the Supplemental Proposal in this rulemaking is "NHTSA 99-6407." If you want to view the materials filed for that notice, you would type "6407." After typing the docket number, click on "search."

(4) On the next page, which contains docket summary information for the docket you

selected, click on the desired comments. You may download the comments and other materials.

For non-legal issues, you may contact Clarke Harper, Chief, Light Duty Vehicle Division, NPS-11. Telephone: (202) 366-2264. Fax: (202) 366-4329. E-mail: Charper@NHTSA.dot.gov.

For legal issues, you may contact Edward Glancy or Rebecca MacPherson, Office of Chief Counsel, NCC-20. Telephone: (202) 366-2992. Fax: (202) 366-3820.

You may send mail to both of these officials at the National Highway Traffic Safety Administration, 400 Seventh St., S.W., Washington, D.C., 20590.

**SUPPLEMENTARY INFORMATION:**

Note to readers: As an aid to readers who are outside the engineering community, we have provided a glossary that briefly explains the key technical terms used in this preamble. In the case of the term, "fixed barrier crash test," we have supplemented the explanation with illustrations. That glossary appears at the end of the preamble, immediately before the regulatory text. Interested persons may find it helpful to review that glossary before reading the rest of this document.

**Table of Contents**

**I. Overview of the Final Rule, Its Rationale, and Its Implementation**
- **A. Key Provisions of the Final Rule**
- **B. Other Provisions of the Final Rule**
- **C. Future Rulemaking Plans**
- **D. Monitoring of Implementation and Field Experience; Research and Technology Assessment**

**II. Statutory Requirements for Improving Air Bags**
**III. Evolution of the Air Bag Requirements in Standard No. 208**
**IV. Safety Problems**

A. Frontal Crashes and the "Second Collision" -- The Leading Cause of Occupant Deaths
B. Preventing or Mitigating the Effects of the Second Collision Using Seat Belts and Air Bags
C. Air Bag Risks and Fatalities
D. Causes of Air Bag Fatalities

V. DOT and NHTSA Responses to Air Bag Risks and Fatalities
A. Introduction
B. Chronology

VI. Advanced Technologies for Improving Air Bags
A. Introduction
B. Key Parts of Air Bag Systems
C. Specific Advanced Technologies
D. Installation of Advanced Technologies in Current Production Motor Vehicles

VII. Our Proposals for Advanced Air Bags
A. Our Initial Proposal (September 1998)
B. Our Supplemental Proposal (November 1999)

VIII. Public Comments on the Supplemental Proposal

IX Diagrams of the Final Rule Requirements

X. Improving the Protection of Unbelted Occupants in Serious Crashes
A. Introduction
B. Summary of Proposed Requirements
C. Type of Test
D. Agency Decision to Phase in Maximum Speed in Two Stages: a 40 km/h (25 mph) Maximum Speed During Stage 1 and a 48 km/h (30 mph) Maximum Speed During Stage 2
1. The Supplemental Proposal
2. Summary of Comments
3. Maximum Test Speed Adopted in the Final Rule
4. Overall Rationale
5. A Maximum Test Speed of 48 km/h (30 mph) Will Provide Greater Assurance of High Safety Benefits than a Maximum Test Speed of 40 km/h (25 mph)
6. Motor Vehicles Can Be Designed to Meet the Unbelted 48 km/h (30 mph) Rigid Barrier Test for Both 50th Percentile Adult Male Dummies and 5th Percentile Adult Female Dummies, and the Requirements to Minimize Risks
7. A Maximum Test Speed of 48 km/h (30 mph) Will Not Necessitate a Return to More Powerful Air Bags and Thus Will Not Result in Higher Risks for Out-of-Position Occupants

a. **Our Testing of Vehicles with Redesigned Air Bags Demonstrates That Those Air Bags Have Sufficient Power to Enable Vehicles to Meet the Unbelted 48 km/h (30 mph) Barrier Test for the Adult Dummies**

b. **The Relatively Few Vehicles with Redesigned Air Bags that do not Current Meet the 48 km/h (30 mph) Unbelted Test can be Designed to Meet it without Increasing Air Bag Aggressivity**

c. **The Overall Requirements of Today's Final Rule Are Likely to Require Vehicle Manufacturers to Decrease Aggressivity of Current Redesigned Air Bags**

8. **Manufacturers Can Meet a 48 km/h (30 mph) Rigid Barrier Test and the Rest of Today's Final Rule Using Technologies that are or will soon be in Production Vehicles; No Major Technological Breakthroughs are Needed**

E. **Other Issues**

1. **Location of 5th Percentile Adult Female Dummy**
2. **Minimum Test Speed**

XI. **Improving the Protection of Belted Occupants in Serious Crashes**

A. **Belted Rigid Barrier Crash Test**

B. **Belted Offset Deformable Barrier Crash Test**

XII. **Minimizing the Risk of Injuries and Deaths Caused by Air Bags**

A. **Safety of Infants**

1. **Option 1: Feature (e.g., Weight or Size Sensor) That Suppresses the Air Bag When an Infant Is Present**
2. **Option 2: Low-Risk Deployment for Infants in RFCSS**

B. **Safety of Young Children**

1. **Option 1: Feature (e.g., Weight or Size Sensor) That Suppresses the Air Bag When a Child Is Present**
2. **Option 2: Low-Risk Deployment for Young Children**
3. **Option 3: Feature That Suppresses the Air Bag When a Child Is Out-of-Position**

C. **Safety of Teenage and Adult Drivers**

1. **Option 1: Low-Risk Deployment for Drivers**
2. **Option 2: Feature That Suppresses the Air Bag When a Driver Is Out-of-Position**

XIII. **Injury Criteria**

A. **Head Injury Criteria**

B. Neck Injury Criteria
C. Thoracic Criteria
D. Other Criteria
XIV. Lead Time and Effective Date
A. Large Manufacturers
B. Limited Line, Small, Multi-Stage Manufacturers and Alterers
1. Limited Line Manufacturers
2. Small Manufacturers
3. Multi-Stage Manufacturers and Alterers
XV. Availability of Original Equipment and Retrofit Manual On-Off Switches
XVI. Warning Labels, Consumer Information, and Telltale Devices
A. Warning Labels and Consumer Information
B. Telltale Devices
XVII. Miscellaneous Issues
A. Child Restraints Used for Testing Suppression and Low-Risk Deployment Features
B. Dummy Positioning for Static Suppression and Low-Risk Deployment Tests
C. Due Care Provision
D. Selection of Compliance Options
E. Credits for Early Compliance
F. Choice Between Complying with Existing And/or New Injury Criteria and Test Requirements
G. Time Periods for Measuring Injury Criteria During Tests
H. Cruise Controls
I. Rescue Operations
J. Hybrid III Dummy Neck
K. Seating Procedure for 5th Percentile Adult Female Dummy
L. Deletion of Tests Between the Initial and the Supplemental Proposals
M. Consideration of Unintended Consequences
N. Reporting Requirements
O. Use of Children and Adults for Testing Static Suppression Systems
P. Small Business Concerns
Q. Other Issues
1. Ability to Comment Effectively on SNPRM
2. Resubmittal of Petition for Rulemaking by Donald Friedman and Carl Nash
XVIII. Benefits and Costs
XIX. Rulemaking Analyses and Notices
XX. Glossary
Regulatory Text

# I. Overview of the Final Rule, Its Rationale, and Its Implementation

## A. Key Provisions of the Final Rule

Early Agency Efforts to Reduce Air Bag Risks

Air bags provide substantial life-saving benefits. However, we have found that when people, especially unrestrained children and small adults, are out-of-position, air bags can also sometimes cause deaths and serious injuries.

Since the early 1990s, NHTSA has been taking steps to change behavior and induce design changes to reduce the risk of such deaths and injuries. We focused our initial efforts to reduce air bag risks on a public education campaign to alert the public about the dangers of air bags to children in general and to infants in particular. We urged parents to place their children in the back seat whenever possible and to ensure that they were always properly restrained. We required informative, text-only, warning labels in new motor vehicles and on child restraints.

1996 Comprehensive Plan for Addressing Air Bag Risks

To address the problems that arose with many of the air bags installed in motor vehicles, the agency announced a comprehensive plan in November 1996. The plan set forth an array of immediate, interim and long term measures. The immediate and interim measures focused on behavioral changes and relatively modest technological changes. The long term measures focused on more significant technological changes, i.e., advanced air bag technologies. The immediate steps included expanding efforts to persuade parents to place their children in the rear seat and giving motorists at risk the chance to turn off their air bags, requiring new labels with eye-catching graphics and colors and strong, clear warning messages, permitting the installation of original equipment on-off switches in new vehicles in which young children could not be

placed in a child restraint system in a rear seating position, and permitting the installation of retrofit on-off switches to protect people in at-risk groups. Because of the lead time needed to develop and install advanced air bag technologies, NHTSA announced plans to propose an interim measure to accelerate manufacturer efforts to depower their air bags and make other short term design changes. In the long term, the agency said that it would conduct rulemaking to require the installation of advanced air bags.

Contribution of Behavioral Changes and the Current, Redesigned Air Bags to Reducing Air Bag Risks

To implement the interim phase of the comprehensive plan and speed the redesigning and recertifying of air bags to reduce the risks to out-of-position occupants, we amended Standard No. 208, Occupant Crash Protection, 49 CFR 571.208, to establish a temporary option under which vehicle manufacturers could certify their vehicles based on an unbelted sled test. 62 F.R. 12960; March 19, 1997. The sled test aided the manufacturers' efforts to redesign their air bags because it is simpler, less expensive, and easier to meet than the pre-existing 48 km/h (30 mph) unbelted test involving a crash into a rigid barrier. Available data appear to indicate that the redesigned air bags, together with behavioral changes, have reduced the risks from air bags for the at-risk populations.

Although there has been only about two years of field experience with redesigned air bags, these data indicate that the redesigned air bags in model year (MY) 1998 and 1999 vehicles provide essentially the same level of frontal crash protection as that provided by earlier air bags. One reason that the redesigned air bags work as well as they have is that the vehicle manufacturers did not depower all models. As to those models that they did depower, they did

not depower their air bags as they said they would or as much as we anticipated they would in the economic analysis accompanying our 1997 final rule adopting the sled test option. Instead, NHTSA tests have shown that the manufacturers typically chose levels of depowering that still enabled them to pass the pre-existing 48 km/h (30 mph) unbelted crash test with a 50th percentile adult male dummy. Further, these tests have revealed that vehicles with redesigned air bags pass that test with that dummy by roughly the same margin of compliance as earlier vehicles did. In other words, the vast majority of redesigned air bags are, by and large, still 48 km/h (30 mph) air bags.

As to the extent of the depowering actually performed and the performance of the current redesigned air bags, we note the following points. First, as discussed below, depowering is not the only way of reducing the aggressiveness of air bags. Second, when the vehicle manufacturers began to accelerate their depowering efforts after the March 1997 final rule, they knew that the sled test option was scheduled to terminate in MY 2002. Third, since mid-1998, the vehicle manufacturers have faced the prospect of a rulemaking under TEA 21 that would require future air bags to be more protective than current ones.

While the redesigned air bags in current motor vehicles have helped to reduce the risk of air bag-induced injuries, they can still cause death or serious injury to unrestrained occupants. We have selected the provisions in this final rule to ensure that future air bags meet the goals of TEA 21: creating even less risk than current air bags, and providing more frontal crash protection.

<u>The Gathering of Information and Soliciting of Comments for this Rulemaking to Reduce Air Bag Risks Further</u>

Since 1996, the agency has been carefully laying the groundwork for completing the implementation of its comprehensive plan by issuing this final rule. We have made extensive efforts to gather information and solicit public comments that would help us identify and select a sensible, effective array of requirements for increasing protection and minimizing risk. In February 1997, we held a public technical workshop on advanced air bag technologies. In December 1997, we sent an Information Request (IR) to the vehicle manufacturers to obtain detailed information concerning their changes in air bag design during the 1990s. In April 1998, Jet Propulsion Laboratories completed, at NHTSA's request, a report titled "Advanced Air Bag Technology Assessment." In mid-1998, Congress made the judgment that advanced air bags should be required. It enacted TEA 21 mandating that we amend our occupant protection standard again, this time to require vehicle manufacturers to improve the protection provided by air bags and to reduce the risks associated with them by means that include advanced air bag technologies. Although TEA 21 required only that we seek public comment once on our proposals before taking final action, we asked for public comment twice. We issued a notice of proposed rulemaking (NPRM) in September 1998, and a supplemental notice of proposed rulemaking (SNPRM) in November 1999. To help us thoroughly explore the issues, we proposed or discussed a variety of alternatives and posed a wide-ranging array of questions. Based on the information we received in response to the 1997 IR, we completed a report titled "Air Bag Technology in Light Passenger Vehicles" in December 1999.

Changes to Our Initial Proposals in Response to Information and Comments

We carefully considered the information we gathered and the comments we received on the 1998 NPRM and appropriately adjusted our proposals in the 1999 SNPRM to respond to

those materials. For example, based on the public comments on the NPRM regarding the type and number of tests needed to meet the risk minimization goals of TEA 21, we significantly reduced the number of those tests when we issued the SNPRM.

Further, while the primary issue regarding unbelted testing in the NPRM was whether we should retain a sled test for testing the ability of vehicles to protect unbelted occupants or return to an improved rigid barrier crash test with new injury criteria, a new dummy and new complementary tests, the primary issue regarding unbelted testing in the SNPRM was whether the top speed for the improved unbelted rigid barrier crash test should be established at 48 km/h (30 mph) or at 40 km/h (25 mph). We noted in the SNPRM that agency testing showed that the vast majority of current vehicles, whether judged on the basis of the existing or the new, enhanced injury criteria, could meet the 48 km/h (30 mph) unbelted crash test using mid-size adult male dummies with adequate compliance margins. We sought comment on our tentative conclusions about that testing. We also sought comment on whether and when future vehicles could be designed so that they would provide the same protection using small adult female dummies.

To improve occupant protection, we proposed in the SNPRM to adopt one of several alternative crash tests to evaluate the protection of unbelted occupants in moderate to high speed crashes, i.e., those that are potentially fatal. One alternative was an unbelted rigid barrier test with a maximum speed to be established within the range of 40 to 48 km/h (25 to 30 mph). We said that if we reduce the maximum speed to 40 km/h (25 mph) permanently, we might also increase the maximum speed of the belted rigid barrier test from the current 48 km/h to 56 km/h (30 to 35 mph). Another alternative was an unbelted offset deformable barrier test with a

maximum speed to be established in the final rule within the range of 48 to 56 km/h (30 to 35 mph).

We also sought comment on other alternatives. One was to issue a final rule temporarily reducing the maximum speed for the unbelted rigid barrier test to 40 km/h (25 mph) (or some other speed, e.g., 44 km/h (27.5 mph)) and then increasing it to 48 km/h (30 mph) after an appropriate period of time, e.g., after the TEA 21 phase-in.

Public Comments on the SNPRM

The commenters on the SNPRM, including vehicle manufacturers, air bag manufacturers, insurance companies, public interest groups, academia, and the National Transportation Safety Board, generally agreed with most aspects of that document. For example, the commenters agreed with the agency's proposals to reduce air bag-induced risks by specifying that driver air bags deploy in a low-risk manner in low speed crashes and the passenger air bags either deploy in that manner or turn off in the presence of young children.

With respect to our proposals for improving occupant protection, the commenters, including the motor vehicle manufacturers, agreed that the unbelted sled test should be replaced by an unbelted rigid barrier crash test. Most of them also agreed with the low end of the range of test speeds for that test.

However, there was significant difference of opinion among the commenters on the SNPRM regarding the maximum speed for the unbelted rigid barrier crash test. Several safety advocacy and consumer groups urged that the maximum speed be returned to 48 km/h (30 mph) immediately; i.e., during the TEA 21 phase-in period. The vehicle manufacturers, an insurance industry safety organization, several other organizations and a government safety agency urged

that the maximum speed be reduced to 40 km/h (25 mph) during the TEA 21 phase-in period and left there pending analysis of field experience with the air bags installed in motor vehicles during that period. There were also significant differences of opinion regarding our proposals about the provision providing a due care defense against findings of noncompliance with the air bag requirements of Standard No. 208 and about the wording of the statements regarding air bag-induced risks on the proposed vehicle labels.

The Development of a Sensible, Data-Based Final Rule For Improving Air Bags

Before we decided on what needed to be included in this final rule to improve air bag performance as required by TEA 21, we carefully considered the available information and the public comments, the underlying safety problems, the performance of current motor vehicles, the ability (including lead time needs) of vehicle manufacturers to achieve better performance in future motor vehicles, the air bag technology (including advanced air bag technology) currently available or being developed, the cost of compliance, and other factors. We also carefully considered the comments concerning the alternatives for improving the protection provided by air bags, and the costs, benefits and risks associated with each alternative.

The requirements in today's final rule for improving protection and minimizing risk are challenging and will push the vehicle manufacturers to make needed safety improvements in air bag performance. The selection of those requirements was a data-driven decision, based on available test data and analysis.

The Principal Provisions of the Final Rule

The final rule will be phased in during two stages.

First stage phase-in. During the first stage phase-in, from September 1, 2003 to August

31, 2006, increasing percentages of motor vehicles will be required to meet requirements for reducing air bag risks, either through automatically turning off the air bag in the presence of young children or deploying the air bag in a manner much less likely to cause serious or fatal injury to out-of-position occupants. If they so wish, manufacturers may choose to use a combination of those two approaches. Manufacturers that decide to turn off the air bag will use weight sensors and/or other means of detecting the presence of young children. To test the ability of those means to detect the presence of children, the final rule specifies that child dummies be placed in child seats and put in the passenger seat. It also specifies that tests by conducted with unrestrained child dummies that are sitting, kneeling, standing, or lying on the passenger seat. For manufacturers that decide to design their passenger air bags to deploy in a low risk manner, the final rule specifies that unbelted child dummies and the 5th percentile adult female dummy be placed against the instrument panel. This is the location was selected because pre-crash braking causes unrestrained children and small adults to move forward into that position before the air bag deploys. The air bag is then deployed. The ability of driver air bags to deploy in a low risk manner will be tested by placing the 5th percentile adult female dummy against the steering wheel and then deploying the air bag.

In addition, they will be required to meet a rigid barrier crash test with both unbelted 5th percentile adult female dummies and unbelted 50th percentile adult male dummies. The unbelted rigid barrier test replicates what happens to motor vehicles in real world crashes better than the current sled test does. During the first stage phase-in, the maximum test speed for unbelted dummy testing will be 40 km/h (25 mph).

The unbelted rigid barrier crash test specified by this final rule for the future is effectively

different in a very fundamental way from the unbelted rigid barrier test that Standard No. 208 has specified in the past. In the past, the Standard specified only that test and the belted rigid barrier test. The Standard placed no other check on methods used to achieve compliance with the unbelted rigid barrier test. In the future, however, that test must be met using new injury criteria with the new 5th percentile adult female dummy as well as the existing 50th percentile adult male dummy. Further, the test will be tightly linked with the risk reduction requirements. Together, these and other additions made by this rule to the Standard will substantially affect how manufacturers comply with unbelted rigid barrier test.

One of those other additions is a offset deformable barrier test. To ensure that vehicle manufacturers upgrade their crash sensing and software systems as necessary to prevent late air bag deployments in crashes with soft pulses, vehicles will also be required to meet an up-to-40 km/h (25 mph) offset deformable barrier test using belted 5th percentile adult female dummies. A late air bag deployment would allow enough time for an unrestrained occupant to move forward into the steering wheel or instrument panel during a crash before the air bag deploys.

As part of the first stage phase-in, vehicles will have to meet new injury criteria and tests using new test dummies. For both belted and unbelted tests, we are adopting improved injury criteria to assure greater protection by air bags in high speed crashes. More specifically, we are changing the way in which the risk of head injuries is measured, adding a new neck injury measure that accounts for the combination of flexion, extension, tension, and compression, and reducing the amount of allowable chest deflection. The rule also specifies the use of an entire family of test dummies: the existing dummy representing 50th percentile adult males, and new dummies representing 5th percentile adult females, six-year old children, three-year old children,

and one-year old infants.

Second stage phase-in. During the second stage phase-in, from September 1, 2007 to August 31, 2010, the maximum test speed for the unbelted rigid barrier test will return to 48 km/h (30 mph). The return to that speed will require future vehicles to provide 5th percentile adult females with the same level of protection that current vehicles provide 50th percentile adult males.[1] As in the case of the first-stage requirements, the second-stage requirements will be phased in for increasing percentages of motor vehicles.

Schedule for Implementation

The schedule for implementing the requirements is a prudent one. As indicated above, we have decided to implement this final rule in two stages. We took this approach because we want to ensure that the designing and producing of the next generation of air bags is done carefully and correctly. The schedule puts the initial priority where it ought to be–on minimizing the risk for young children and small adults. While the priority during the first stage is placed on reducing air bag risks, important measures for improving the protection of air bags are included in that stage.

The schedule provides plenty of lead time–as much as TEA 21 allows for the first stage, and even more for the second stage. This will give the vehicle manufacturers time to complete their development and design activities and to incorporate the results of that work in their vehicles. It also provides for earning credits for early compliance.

We have also decided to change the date on which the implementation of this final rule

---

[1] NHTSA's testing indicates the vast majority of current vehicles can meet the injury criteria at 48 km/h (30 mph) using the 50th percentile adult male dummy and that a majority can meet the injury criteria at 40 km/h (25 mph) using the 5th percentile adult female dummy.

begins from September 1, 2002, as proposed in the SNPRM, to September 1, 2003. This gives vehicle manufacturers as much lead time as TEA 21 permits for the first stage phase-in. TEA 21 does not permit a later starting date. This shift will give the manufacturers a lead time of 3 ½ years for vehicles produced during the first year (MY 2004) of that phase-in and 6 ½ years for vehicles produced during MY 2007, the first MY in which vehicle manufacturers will be required to manufacture all of their vehicles in compliance with the first stage requirements without the aid of credits.

We changed the starting date in part because the vehicle manufacturers will be required to do a great deal during the first stage. They will need to certify their vehicles to an unbelted barrier test instead of a sled test. Moreover, they will need to meet this test for the new 5th percentile adult female dummy as well as for the existing 50th percentile adult male dummy. They will also need to meet a new belted offset deformable barrier test using the 5th percentile adult female dummy. For all of these tests, they will need to meet new injury criteria performance limits. Finally, the vehicle manufacturers will need to certify their vehicles to an array of test requirements to minimize the risk to infants, children, and other occupants from injuries and deaths caused by air bags using the 5th percentile adult female dummy and the child dummies. The starting date of September 1, 2003 will give the manufacturers additional time to gain experience with the new dummies, final specifications for which have only recently been established in the case of some of the dummies, and are yet to be established in the case of other dummies.

Further, the longer lead time before the first stage phase-in will also promote technological innovation. Returning to the 48 km/h (30 mph) maximum test speed in the latter

part of a two-stage process will also provide vehicle manufacturers a longer period of time to complete development of any advanced technologies they plan to use, before they have to certify a vehicle to the higher test speed. While we believe that the requirements in today's final rule can be met by careful use of technologies already on the road or about to be introduced on the road, we are aware that suppliers are continuing work on many additional technologies. With greater flexibility regarding timing, manufacturers will be better able to explore using some of these technologies still under development as opposed to relying on the technologies that are already on the road. In addition, a longer period will make it easier for vehicle manufacturers to improve crash pulses and make other structural changes, should vehicle manufacturers wish to avail themselves of this opportunity.

The lead time for the second stage requirements is even longer. Manufacturers will have a lead time of 7 ½ years for vehicles produced during the first year of that phase-in and 10 ½ years for vehicles produced during MY 2011, the first MY in which vehicle manufacturers will be required to manufacture all of their vehicles in compliance with the second stage requirements without the aid of credits.

Highlights of Rationales for Risk Minimization Requirements

The agency drafted the risk minimization requirements to give vehicle manufacturers a broad choice among those advanced air bag technologies that can be used either to turn air bags off in appropriate circumstances or cause air bags to deploy in a low risk manner.[2] Thus, the

---

[2] The final rule also establishes very general performance requirements for dynamic automatic suppression systems (DASS) and a special expedited petitioning and rulemaking process for considering procedures for testing advanced air bag systems incorporating a DASS. In response to comments, modifications have been made to address concerns about confidentiality and timing.

vehicle manufacturers will have the freedom to choose from a variety of available technological solutions or to innovate by developing new ones if they so desire.

We conclude that advanced air bag technologies can be used to eliminate almost all risk of air bag-induced serious and fatal injuries. Our analysis estimates that advanced air bag technologies (suppression and low risk deployment) could have eliminated 95 percent of the known air bag fatalities that have occurred to date in low speed crashes. For example, the installation of weight sensors in the passenger seat to simply turn off the passenger air bag when children, from infants up to the typical 6-year-old, are present should essentially eliminate the risk of air bag-induced fatal injuries for children in that age range.

The availability of advanced air bag technologies is not just a theoretical possibility. Vehicle manufacturers are very actively working on completing their efforts to get weight sensor systems ready for installation for the passenger air bags in their motor vehicles as early as the next model year. Means of reducing risk for drivers, including dual-stage air bags coupled with sensors for driver seat belt use and driver seat position, are already being installed in some vehicles. As noted above, this final rule gives the vehicle manufacturers substantial lead time to complete any remaining development and design work.

Highlights of Rationales for Protection Improvement Requirements

The agency decided to return to a unbelted rigid barrier crash test for the reasons explained in the NPRM and SNPRM. Among those reasons is that such a test replicates how vehicle structures and air bag systems work together in real world crashes. A sled test cannot do that because while the vehicle is quickly decelerated in such a test, it never crashes into anything.

Temporary Maximum Test Speed of 40 km/h (25 mph)

We decided to set the maximum test speed for the unbelted rigid barrier crash tests at 40 km/h (25 mph) during the first stage for several reasons.

First, since most current vehicles can already satisfy the new improved unbelted barrier crash test at 40 km/h (25 mph), setting the maximum speed at that level will permit vehicle manufacturers to focus their resources and compliance efforts during the first stage on meeting the risk reduction requirements. We want to continue the progress already made in using technological means for reducing air bag-induced risks. While the manufacturers' resources for dealing with air bags, as well as all the other engineering issues associated with future motor vehicles, are extensive, there are limits to how much can be done thoroughly and carefully at any one time. As noted above in the discussion of the implementation schedule, the array of new requirements that the manufacturers will have to meet in the first stage is challenging. Initially setting the maximum speed at 40 km/h (25 mph) will also give them a chance to gain experience with advanced air bag technologies and the new dummies before the return to 48 km/h (30 mph) as the top test speed. We want the installation of advanced air bag technologies by the vehicle manufacturers across the full spectrum of their fleets to be done correctly--the first time.

Second, delaying the return to a maximum test speed of 48 km/h (30 mph) will also give the manufacturers more time to redesign any potential outlying problem vehicles, e.g., those light trucks with particularly stiff crash pulses, so that they will be able to comply with that higher test speed.

Return to Maximum Test Speed of 48 km/h (30 mph); Ensuring that Future Air Bags Are at Least as Protective as the Current Ones

The existence of a clear, definite requirement for returning ultimately to the maximum

test speed in the long term to 48 km/h (30 mph) will help ensure that the focus during the first stage on risk reduction will not result in a reduction of protection in high speed crashes. The agency believes that it is important to ensure that future air bags are as protective as current ones. As noted above, NHTSA's testing shows that most current vehicles can already meet a 48 km/h (30 mph) unbelted barrier test with the 50th percentile adult male dummy. The requirement to return to that speed in the long term will induce the vehicle manufacturers to maintain or enhance that level of performance, thus preventing any loss of benefits.

The possibility that vehicle manufacturers might design their future air bags to provide only the minimum level of protection actually required to meet a 40 km/h (25 mph) unbelted crash test (even with appropriate compliance margins) has been a significant concern to the agency. Our concern that the vehicle manufacturers might reduce the protectiveness of their future air bags is based on the incentive for them to choose to comply with the risk minimization requirements by relying primarily on further reductions in power and making other design changes (e.g., reduce air bag size or depth) that could result in less protective air bags, instead of relying primarily on advanced air bag technologies. This could lead to an overall loss of benefits notwithstanding the addition of the 5th percentile adult female dummy and the adoption of new injury criteria.

As noted above, future air bags designed to provide that minimum level of protection would be less protective than current redesigned ones. The difference between a 40 km/h (25 mph) and a 48 km/h (30 mph) crash is significant. The significance does not lie in the 20 percent increase in speed, but in the 40 percent increase in crash energy. It is because of that increase in crash energy that the risk of serious or fatal injury is significantly higher at 48 km/h (30 mph)

than at 40 km/h (25 mph). Further, 50 percent of vehicle occupant fatalities occur in crashes over 48 km/h (30 mph). As a result, if air bags were designed only to minimally meet a 40 km/h (25 mph) crash test, many occupants, particularly larger occupants, would not be adequately protected in higher speed crashes. We estimate that 248 to 413 lives could be lost annually if that were to occur.

Sales of LTVs might increase the potential losses. We note that occupants of smaller vehicles will likely experience an increase in high delta V crashes in the future, as a result of greater sales of LTVs. Fifty percent of new sales of light vehicles are LTVs, and LTVs now comprise 33 percent of the fleet. The average weight of the fleet is around 3,900 pounds now and is likely to increase in the future as evidenced by the introduction of heavier vehicles, especially LTVs, in the fleet.

NHTSA expects that the vehicle manufacturers will conduct whatever research and development and other activities may be necessary to enable them to make steady progress toward improving their vehicles so that they meet the 48 km/h (30 mph) test using 5th percentile adult female dummies as well as 50th percentile adult male dummies. Meeting the enhanced injury criteria in 48 km/h (30 mph) tests with the small adult female dummies will close the current safety gap between the level of protection provided small adult females and the level of protection provided mid-size adult males by existing redesigned air bags.

Taking the step now of adopting a requirement for returning to the 48 km/h (30 mph) crash test speed will ensure that steady progress is made. Further, the certainty of this return will increase the incentive for vehicle manufacturers to introduce and continue to improve advanced air bag technologies.

Consideration of Commenters' Concerns about Returning to a 48 km/h (30 mph) Maximum Test Speed

Before deciding to return ultimately to a 48 km/h (30 mph) maximum test speed, the agency carefully considered several arguments advanced by the vehicle manufacturers, and, in turn, adopted or endorsed by several organizations and another Federal agency.

Repowering

First, the vehicle manufacturers have raised the prospect of increased air bag-induced deaths, based on an assertion that a return to a 48 km/h (30 mph) crash test could necessitate a return to more powerful air bags. NHTSA does not believe that repowering will be necessary. The manufacturers provided very limited information to substantiate that assertion. The relatively few confidential examples they cited were almost exclusively vehicles with particularly stiff crash pulses. Based on NHTSA crash tests (including tests of some vehicles with stiff crash pulses) of a representative subset of the current new vehicle fleet, we conclude that the air bags in the vast majority of current vehicles would pass a 48 km/h (30 mph) crash test using a 50th percentile adult male dummy with much the same compliance margins as before. Thus, more power is not needed for those vehicles to pass that test with that dummy. Further, the fact that some current vehicles with stiff pulses meet the injury criteria suggests that vehicle manufacturers may not have to repower air bag systems in other stiff pulse vehicles in order to meet the criteria.

More fundamentally, air bags that currently have enough power to meet the injury criteria using the 78 kg (172 lb.) 50th percentile adult male dummy will not need more power in the future to meet the criteria using the much lighter 50 kg (110 lb.) 5th percentile adult female

dummy. Our tests show the primary problem for the small female dummy in those current vehicles that do not satisfy the injury criteria in a 48 km/h (30 mph) test with the 5th percentile adult female dummy is that the dummy experiences too much force in the neck or chest area. The solution for the smaller, lighter female dummy would not be to put additional power into the bag. Not only would that step be unnecessary to protect the 50th percentile adult male dummy, but also it would be likely to exacerbate the problem with the small female dummy. Instead, the solution is to redesign the air bag system- - using recessed air bags and new sensors, inflation levels, fold patterns, bias flaps, etc.- - to reduce the potential for injury for the 5th percentile adult female dummy.

Thus, we conclude that a 48 km/h (30 mph) crash test need not lead to repowering for most motor vehicles and need not lead to significant repowering for any vehicles. We conclude further that if any power had to be added to protect large occupants in outlying, problem vehicles, the result need not be an increase the risk of harm to lighter, smaller, out-of-position occupants.

Protecting Both Small Adults and Mid-Size Males/Large Females in 48 km/h (30 mph) Test

Second, the vehicle manufacturers suggested that the 48 km/h (30 mph) crash test creates a difficult-to-resolve conflict between protecting the 5th percentile adult female dummy and protecting the 50th percentile adult male dummy. It is true that this final rule introduces the 5th percentile adult female dummy and for the first time requires manufacturers to ensure that their vehicles meet the injury criteria with 5th percentile adult female and 50th percentile adult male dummies representing a wide range of occupants. However, the challenge cited by the vehicle manufacturers of protecting people of different sizes is not the result of any decision made in this

rulemaking. The reality is that the driver and passenger population has always included a wide variety of sizes of people. The reality also is that smaller drivers tend to sit closer to the steering wheel and foot controls than larger drivers do. While many smaller drivers reportedly do not move their seat all the way forward, some do. The need to protect those people exists regardless of what dummies or requirements are specified in this rulemaking. As noted above, since most current vehicles already meet the 48 km/h (30 mph) unbelted rigid barrier test using the larger, heavier 50th percentile adult male dummy, the decision to return to 48 km/h (30 mph) is not going to necessitate repowering. Thus, that decision is not going to exacerbate the existing challenge of protecting both small and large people.

NHTSA recognizes that an air bag needs to move into place particularly quickly to protect people who sit very close to the steering wheel. However, this need too exists quite apart from this rulemaking. Manufacturer concerns that designing air bags to protect these people may cause air bags to be aggressive toward those people can be addressed by a variety of measures. Among them are recessing the air bag in the steering wheel, limiting the distance that the seat can be moved forward, and providing adjustable foot controls that allow smaller drivers to move back from the steering wheel. Further, the agency notes that the air bag is part of a full vehicle protection system that includes the energy absorbing characteristics of the vehicle structure as well as the air bag itself. Although it would be more expensive and need more lead time than other measures, vehicle manufacturers can reduce the speed needed to deploy air bags by modifying the vehicle structure so as to produce a softer crash pulse. To the extent that vehicle manufacturers can soften the crash pulse, the drivers will move forward less quickly in frontal crashes, thus providing more time for the air bag to deploy.

The vehicle manufacturers also suggested that they need a small bag for the 5th percentile adult female dummy and a large one for the 50th percentile adult male dummy. In support of this suggestion, the manufacturers pointed to tests of current production vehicles and noted that in some cases, the smaller dummy failed to meet some of the injury criteria (the new neck injury criteria in particular) in a 48 km/h (30 mph) crash test. The manufacturers' characterization of these test results misses their real significance. The failure of existing vehicles to meet an injury criterion they were not designed to meet is not evidence either of the impossibility or even the difficulty of meeting that criterion. Indeed, the ability of half the tested vehicles to meet a criterion that they were not required to meet indicates that compliance will be feasible once the manufacturers add the new criterion to their design goals for future air bags.

We note that we examined some of the driver air bag hardware from these test vehicles and found that there were a significant number of countermeasures used in some of the better performing vehicles that were not used in other vehicles. These include low-force breakout cover, I-tear seam pattern, 4 tether straps, advanced folding pattern, recessed module, energy absorbing steering column, etc. Incorporating some of these design features, as well as dual-level inflators, could reduce the aggressivity to the occupant and improve the trajectory of deployment.

Finally, manufacturer suggestions that they need entirely new technologies in order to comply using the small female dummy are misplaced and unsupported. The rulemaking record indicates that manufacturers can design air bags that protect both the 5th percentile adult female and 50th percentile adult male dummies at 48 km/h (30 mph), in passenger cars and trucks, using technology already being installed in some current production vehicles.

For example, NHTSA tested a MY1999 Saturn SL1 and found that it met the new injury

criteria in 48 km/h (30 mph) crash tests on both the driver and passenger sides with both the 5th percentile adult female and 50th percentile adult male dummies. It does this using air bags that are relatively shallow (as opposed to the deeper air bags that the vehicle manufacturers asserted are necessary for the larger dummy). More significant, the MY 1999 Econoline van, which has a much stiffer pulse than the Saturn, met the new injury criteria in 48 km/h (30 mph) crash tests on both the driver and passenger sides with both sizes of dummies. In addition, the MY 1998 Taurus met the new injury criteria in 48 km/h (30 mph) crash tests on both the driver and passenger sides with both sizes of dummies. The MY 1999 Tacoma met the criteria in 48 km/h (30 mph) crash tests on the driver side with both sizes of dummies, while the MY 1999 Acura RL met the criteria in 48 km/h (30 mph) crash tests on the passenger side with both sizes of dummies.

This demonstrates that the designs and technologies that can be used to enable vehicles to comply on both the driver and passenger sides with both dummies are already being used in some current production vehicles. These technologies include improved air bag folding, bias flaps, and internal baffles/tethers. Manufacturers could add other measures such as dual-stage inflators, seat position sensors, recessed air bag modules, and better energy absorbing steering columns. If any vehicle manufacturer wishes to do so, it could also develop and provide chambered, dual-stage air bags that are designed to fill fully only an inner chamber of the air bag, instead of the entire air bag, when the driver seat is near the full forward adjustment position on the seat track.

NHTSA recognizes that, for the 5th percentile adult female dummy, 2 of the 7 production vehicles we tested did not meet all of the injury criteria in a 48 km/h (30 mph) unbelted crash test at the driver position and 3 of 7 vehicles did not meet all of those criteria at the passenger

position. However, these vehicles were not required to meet those criteria when tested at that speed using a 5th percentile adult female dummy. Given the lead time provided by this final rule, and the test data cited above, NHTSA concludes that the vehicle manufacturers can make the modifications necessary to provide air bags that would protect both the mid-sized male and the small female in a 48 km/h (30 mph) unbelted crash test at both positions.

**B. Other Provisions of the Final Rule**

Facilitation of low risk deployment technologies. In the Supplemental Notice of Proposed Rulemaking (SNPRM), we proposed that the low risk deployment requirements would have to be met for inflation levels at which air bags would deploy in rigid barrier crash tests at speeds up to 29 km/h (18 mph). 64 F.R. 60556; November 5, 1999. We also proposed that the injury criteria for the unbelted rigid barrier crash test would have to be met within the range between a minimum speed of 29 km/h (18 mph) and the maximum speed, inclusive. Some vehicle manufacturers responded that being required to test under the low risk deployment option for the inflation level (or levels) at which their air bags would deploy in crashes below 29 km/h (18 mph), combined with being required to protect unbelted dummies in crashes at 29 km/h (18 mph) and above, would limit design flexibility and discourage development of low risk deployment air bag systems. The manufacturers claimed that it is difficult to design dual-stage air bags that could both meet the low risk deployment requirements and the barrier crash test injury criteria, particularly given the gray zone in which either a low level or high level deployment may occur.

In order to avoid inadvertently discouraging the development of low risk deployment technologies, we have decided that air bags with multiple inflation levels must meet the injury

criteria for the low risk deployment tests for the inflation levels at which the air bags would be deployed in crashes of 26 km/h (16 mph) or below (with unbelted 5th percentile adult female dummies at both seating positions), instead of crashes of 29 km/h (18 mph) or below. However, if these air bags do not deploy at all in crashes of 26 km/h (16 mph) or below, the injury criteria must be met using the lowest level of inflation. We have also decided to raise the lower end of the range of speeds at which the unbelted rigid barrier crash test is conducted from 29 km/h (18 mph) to 32 km/h (20 mph). Together, these two changes are intended to facilitate use of the low risk deployment option by providing flexibility for the transition of dual-stage air bag systems from low level deployments designed to protect occupants in low speed crashes and not to injure out-of-position occupants to high level deployments designed to protect occupants from injuries in severe crashes.

Elimination of unneeded tests. In developing this final rule, as in developing the SNPRM, we looked for opportunities to reduce the number and types of test configurations necessary to assure that future air bags minimize the risk of air bag-induced injuries.[3] We have made several further reductions. We proposed testing unrestrained rear-facing child seating systems (RFCSS) at any angle plus or minus 45 degrees from the vehicle seat's longitudinal

---

[3] As noted above, when we issued the SNPRM, we reduced the number of proposed dynamic and static tests, especially those relating to the proposed requirements for reducing the risks of air bags. We reduced, from 14 to nine, the number of proposed dynamic crash tests that would be applicable to all vehicles. We originally proposed that vehicles equipped with static air bag suppression systems (e.g.,weight sensors and pattern sensors) be subject to being tested with any child restraint manufactured over a ten-year period. This would have created the possibility of testing with any one of several hundred different models of child restraints. Recognizing that, we solicited comments to aid us in identifying a much more limited number of specific models that would be representative of the array of available child restraints. Based on the public comments, we proposed to require that vehicles be able to meet the applicable requirements when tested with any one of a far more limited number of child restraints representing a cross-section of the restraints currently on the market. We also significantly reduced the number of positions in which test dummies or child restraints could be placed for testing a static suppression system. This was accomplished largely by eliminating positions that were substantially similar to other positions.

plane. Because of difficulties in setting up the test and the unlikelihood that parents would place a RFCSS in an angled position, we have revised this test procedure to specify placement only at zero degrees of the longitudinal plane. We also proposed testing unrestrained RFCSS tipped forward onto the dashboard. The intent behind the test was to mimic a situation in which, through pre-crash braking, a child restraint slides forward and flips onto the dashboard. However, this test configuration too was difficult to set up in some circumstances. Further, this position does not test for a problem that static suppression systems are designed to address. Accordingly, we have dropped this test condition. Likewise, we have dropped the two static suppression positions for the 3 year old dummy and the one static suppression position for the 6 year old dummy where the applicable dummies were placed in the low risk deployment positions. These positions do not test for a problem that static suppression systems are designed to address.

As proposed in the SNPRM, we have dropped the requirement for conducting oblique angle tests on vehicles using belted 5th percentile adult female dummies. We proposed to limit use of this dummy to the perpendicular mode to avoid unnecessary test requirements and because we believed that if a vehicle can pass the perpendicular test with 5th percentile adult female dummies and the oblique tests with unbelted 50th percentile adult male dummies, it would also pass the oblique test using 5th percentile adult female dummies. Additionally, we have dropped the belted oblique angled tests for the belted 50th percentile adult male dummy. Given the unbelted oblique tests, we believe that the belted oblique angled tests are unnecessary.

New, more stringent injury criteria. In the final rule, we have added a neck injury criterion and adopted a more stringent limit on chest deflection. The injury criteria are very similar to the ones we proposed in the SNPRM. The Nij approach to the risk of neck injury was

generally accepted by the vehicle manufacturers, although they requested some modifications. We have made those modifications.

Extended due care provision with sunset date. In the SNPRM, we proposed to maintain the "due care" provision for the existing crash test requirements and apply it to the new ones as well. However, we did not propose to apply the provision to test requirements that do not involve crashes, based on our belief that these tests are not affected by the variability associated with dynamically-induced dummy movement and/or vehicle deformation. In the final rule, we have decided that, in addition to extending the due care provision to new crash tests, we are also extending it to out-of-position tests that involve deployment of an air bag, but not to the suppression tests. The deployment of the air bag creates an event that is highly dynamic in nature, similar to that of a crash test. However, we have also decided to sunset the due care provision for all requirements at the end of the second phase-in period (i.e., September 1, 2010). As we explained in the earlier notices, the inclusion of such a provision in a safety standard does not fit very well with the overall statutory scheme. Further, based on our experience with Standard No. 208 compliance activities, we do not believe there is an intrinsic need for a "due care provision."

Extended availability of air bag on-off switches. As proposed, we have decided to sunset the provisions which allow original equipment (OE) and retrofit on-off switches under specified circumstances. However, instead of sunsetting those provisions at the end of the TEA 21 phase-in period, as we proposed in the SNPRM, we are sunsetting them on September 1, 2012, two years after the end of the second phase-in. In response to a wide consensus among commenters, we have concluded that extending their availability to that date is desirable to ensure that

consumers have had a chance to gain substantial experience with advanced air bag systems. This should ensure that confidence in those systems is strong enough by the sunset date to remove any desire for a manual on-off switch in vehicles produced with an advanced air bag.

Labels with strong warning messages. We have decided to adopt a new permanent sun visor label for vehicles certified as meeting the requirements of this rule. We proposed to alter the wording of the label to reflect the lower risk that will be associated with advanced air bags. However, as the commenters on the SNPRM noted, advanced air bags will significantly reduce the risk of death or serious injury, but they will not eliminate all risk. Accordingly, we decided that the new label should have warnings similar to those on the current label. The label will also have new graphics. In addition, we have adopted a new temporary label that states that the vehicle meets the new requirements for advanced air bags. Like the new permanent label, the new temporary label will have warnings similar to those on the current temporary one.

### C. Future Rulemaking Plans

NHTSA plans to issue several proposals for further improvements in frontal occupant crash protection. One proposal would be to increase the maximum speed for the belted rigid barrier test using the 5th percentile adult female and 50th percentile adult male dummies from the current 48 km/h to 56 km/h (30 to 35 mph). Although the SNPRM requested comments on such an increase, it did so only in conjunction with our also adopting a permanent reduction of the maximum speed of the unbelted rigid barrier test to 40 km/h (25 mph). In view of the fact that we did not adopt a permanent reduction, we want to obtain further public comments on an increase in the maximum speed for the belted rigid barrier test. Because 56 km/h (35 mph) is the same speed at which we currently conduct our New Car Assessment Program (NCAP) frontal

crash tests using belted 50th percentile adult male dummies, we will ask also for public comments on what adjustments, if any, we should make to the frontal NCAP test program.

The other proposal would be to adopt a high speed belted offset deformable barrier test. The SNPRM sought comments on such a test, but as a substitute for the unbelted rigid barrier test, not as a supplement to it. The addition of this test to Standard No. 208 would lead to improved vehicle structure and thus to reduced injuries due to intrusion, benefitting both belted and unbelted occupants. We submitted a first status report on this initiative to Congress in April 1997, and will submit a second one this spring. We will issue the proposal later this year.

We anticipate that if either or both of these two rulemaking proposals were adopted as a final rule, implementation would begin sometime during the second first phase-in established by today's final rule.

### D. Monitoring of Implementation and Field Experience; Research and Technology Assessment

NHTSA will work with the motor vehicle industry and other interested organizations and governmental agencies to monitor and assess the implementation of this final rule, as well as the ultimate measure of performance, i.e., the record of air bags in the real world. More particularly, the agency will meet with industry and use other available means as necessary to keep informed about the industry's research, development and production plans and activities and assess whether steady and timely progress is being made toward providing the more protective and safer air bags required by this final rule. The agency will also use its various data sources[4] to identify

---

[4] These data sources include, e.g., NHTSA's Special Crash Investigation (SCI) program, Fatality Analysis Reporting System, (FARS), National Automotive Sampling System (NASS), and Crash Injury Research & Engineering Network (CIREN).

and analyze trends in field data concerning the performance of air bags. Changes in belt use rates will also be tracked. As appropriate, the agency will continue to test production vehicles and conduct other research concerning advanced air bag technologies.

NHTSA will share the results of its monitoring and other activities with other interested parties and the public to the fullest extent possible, consistent with providing appropriate protection of confidential information concerning future product plans.

## II. Statutory Requirements for Improving Air Bags

The Transportation Equity Act for the 21st Century (TEA 21), enacted by Congress in June 1998, requires us to issue a final rule amending Federal Motor Vehicle Safety Standard No. 208, Occupant Crash Protection, in ways that are consistent with two important goals:

(1) improve occupant protection for occupants of different sizes, belted and unbelted, and

(2) minimize the risk to infants, children, and other occupants from injuries and deaths caused by air bags.[5]

TEA 21 specifies that its twin goals are to be accomplished by means that include

---

[5] The full text of the mandate enacted by Congress reads as follows:

> to improve occupant protection for occupants of different sizes, belted and unbelted, under Federal Motor Vehicle Safety Standard No. 208, while minimizing the risk to infants, children, and other occupants from injuries and deaths caused by air bags, by means that include advanced air bags.

(Emphasis added.)

This mandate differs significantly from legislative language initially offered during the early stages of Congress' deliberations. That initial language would have established a hierarchy of priorities, placing minimizing the risks of air bags above improving the protection they provide, and placing the protection of belted occupants above the protection of unbelted occupants. In the enacted version of the mandate in TEA 21, Congress did not mandate any preferences.

advanced air bag technologies. Although these technologies are beginning to be incorporated in some new vehicles, many aspects of those technologies are still undergoing development and refinement today.

In seeking to promote the development and use of new and improved vehicle safety technologies through rulemaking, TEA 21 is similar to the National Traffic and Motor Vehicle Safety Act of 1966, the statute under which Standard No. 208 was originally issued. 49 U.S.C. 30101 et seq. The Vehicle Safety Act authorizes NHTSA to issue safety standards that make it necessary for vehicle manufacturers to improve existing technology and to develop new technology.[6]

TEA 21 also requires that the final rule be consistent with section 30111 of Title 49. Section 30111 requires that, among other things, Federal motor vehicle safety standards be

---

[6] As described by the Sixth Circuit Court of Appeals in a case involving NHTSA's first requirements relating to air bags, Chrysler Corp. v. Department of Transportation, 472 F.2d 659, at 671 (6th Cir. 1972):

> [t]he explicit purpose of the [Vehicle Safety] Act, as amplified in its legislative history, is to enable the Federal government to impel automobile manufacturers to develop and apply new technology to the task of improving the safety design of automobiles as readily as possible. The Senate Report, in a section entitled "Purpose and Need," states:
>
> > This legislation reflects the faith that the restrained and responsible exercise of Federal authority can channel the creative energies and vast technology of the automobile industry into a vigorous and competitive effort to improve the safety of vehicles.
>
> S.Rep. 1301, 89th Cong., 2d Sess., 2 U.S.Code, Cong. and Admin.News, 2709 (1966).
>
> The same report continues:
>
> > While the bill reported by the committee authorizes the Secretary to make grants or award contracts for research in certain cases, a principal aim is to encourage the auto industry itself to engage in greater auto safety and safety-related research.
>
> Id. at 2718.

practicable, meet the need for motor vehicle safety, and be stated in objective terms.

TEA 21 provides that we issue the final rule by September 1, 1999, unless we determined that the final rule could not be issued by that date. The many issues in this rulemaking led us to make such a determination. We notified Congress of this determination in a letter dated August 3, 1999. Therefore, under TEA 21, we were required to issue the final rule by March 1, 2000.

TEA 21 addresses various other issues, including the effective date and phase-in for the requirements adopted in this final rule, as well as the opportunity to earn phase-in credits through early compliance. A complete discussion of TEA 21's provisions is included in the 1998 notice of proposed rulemaking (NPRM). See 63 F.R. 49958 at 49961; September 18, 1998.

## III. Evolution of the Air Bag Requirements in Standard No. 208

The occupant protection requirements in Standard No. 208 have been evolving for more than 30 years. It is only relatively recently, however, that vehicle manufacturers have actually been required to install any air bags. Although vehicle manufacturers first installed air bags in a small number of vehicles in the mid-1970s and began installing air bags in a significant number of vehicles in the mid-1980s, it was not until the mid to late 1990s (MY 1997) that manufacturers were first required to install any air bags in any motor vehicle.

We issued our first notice concerning air bags in 1969. 34 F.R. 11148; July 2, 1969. In response to the low rate of seat belt use, we amended Standard No. 208 in 1971 to require automatic restraints (i.e., devices like air bags and automatic belts that protect without requiring any action by the occupant) in all passenger cars in 48 km/h (30 mph) crash tests beginning with

MY 1976. 37 F.R. 3911; February 24, 1972.[7] In Chrysler Corp. v. DOT, the Sixth Circuit Court of Appeals upheld the basic validity of that requirement, finding it reasonable and practicable, but directed NHTSA to issue more precise test dummy specifications in order to achieve greater objectivity. After complying with that directive, NHTSA proposed automatic restraint requirements in 1974. We did not take final action on that proposal.

Instead, after issuing a new notice in 1976 (41 F.R. 24070; June 14, 1976) seeking comment on a variety of alternative actions including promoting seat belt use laws, requiring automatic restraints, and initiating a field test of automatic restraints, the Department decided in early 1977 to initiate a field test of automatic restraints. Pursuant to that decision, contracts were negotiated with vehicle manufacturers for the voluntary offering for sale of 500,000 automatic restraint passenger cars. It was anticipated that those passenger cars would be equipped with air bags.

However, this field test was never completed. Instead, in mid-1977, the Department decided to go ahead and once again mandate automatic restraints in passenger cars. 42 F.R. 34289; July 5, 1977. The requirements were to be phased in, beginning in MY1983. However, in 1981, NHTSA rescinded the requirements because it said that it was unable to find that more than minimal safety benefits would result from the vehicle manufacturers' plan to comply with the requirements by installing detachable automatic belts instead of air bags. 46 F.R. 53419;

---

[7] Passenger cars manufactured between August 1973 and August 1975, could meet the requirements of FMVSS No. 208 through any of three options, two of which were for automatic restraints. One of the automatic restraint options required automatic protection in frontal crashes and required manual seat belts at each designated seating position. The other automatic restraint option required automatic protection in frontal, side and rollover crashes and did not require any seat belts in the vehicle. The other option was for manual seat belts. Cf. 49 CFR 571.208 S4.1.2. These options were later extended in several rulemakings to August 31, 1986.

October 29, 1981.

In June 1983, the Supreme Court held that NHTSA's rescission of the automatic restraint requirements was arbitrary and capricious. Motor Vehicle Manufacturers' Association v. State Farm Mutual Automobile Insurance Co., 463 U.S. 29 (1983). In particular, the Court found the agency had failed to present an adequate basis and explanation for rescinding the requirement.

The Court unanimously found that, even if the agency was correct that detachable automatic belts would yield few benefits, that fact alone would not justify rescission. Instead, it would justify only a modification of the requirement to prohibit compliance by means of that type of automatic restraint. The Court also unanimously held that having concluded that detachable automatic belts would not result in significantly increased usage, NHTSA should have considered requiring that automatic belts be continuous (i.e., nondetachable) instead of detachable, or that Standard No. 208 be modified to require the installation of air bags.

In response to the Supreme Court's decision, the Department issued a proposal in late 1983 seeking public comment on an array of alternatives similar to those in the Department's 1976 notice. 48 F.R. 48622; October 19, 1983. Among those alternatives was mandating air bags.

However, when the Department issued a final rule in 1984, it did not establish such a mandate. Instead, it required that some type of automatic restraint be installed in passenger cars. Thus, the manufacturers had a choice of a variety of methods of providing automatic protection, including automatic seat belts and air bags, as long as certain specified performance requirements were met in a 48 km/h (30 mph) crash test into a rigid barrier using 50th percentile adult male dummies. Further, the requirements gave vehicle manufacturers broad flexibility in selecting the

design and performance characteristics of their automatic restraints as long as they met the performance requirements.

The Department expressly recognized in its 1984 final rule that the vehicle manufacturers had raised concerns about potential adverse effects of air bags to out-of-position occupants. In response to those concerns, the Department identified a variety of technological concepts for addressing those risks. See the July 11, 1984 Final Regulatory Impact Analysis, pp. III-8 to 10.[8] The flexibility provided by the 1984 final rule included the opportunity for vehicle manufacturers to develop and incorporate those technologies, now known as advanced air bag technologies. However, that final rule (unlike the one being adopted today) did not adopt any regulatory provisions requiring or encouraging the use of those technologies.

The automatic protection requirements were phased in, beginning with MY 1987. Later, the requirements were extended to light trucks, beginning with MY 1995.

A number of vehicle manufacturers initially chose to comply with those requirements by installing automatic belts in many of their vehicles. However, ultimately, the early decisions of some manufacturers to install air bags as standard equipment and the positive response of the market to those decisions led to a general move within the industry toward installing air bags in many passenger cars and light trucks by the early 1990's.

---

[8] The July 11, 1984 Final Regulatory Impact Analysis (FRIA) listed a variety of potential technological means for addressing the problem of injuries associated with air bag deployments including dual level inflation systems and other technological measures such as bag shape and size, instrument panel contour, aspiration, and inflation technique. It also noted that a variety of different sensors could be used to trigger dual level inflation systems, e.g., a sensor that measures impact speed, a sensor that measures occupant size or weight and senses whether an occupant is out of position; and an electronic proximity sensor.

For the most part, the introduction of these technologies in new motor vehicles did not begin until the late 1990's. A number of the vehicle manufacturers are known to be now working very actively on an array of advanced air bag technologies.

In 1991, Congress included a provision in the Intermodal Surface Transportation Efficiency Act (ISTEA) directing us to amend Standard No. 208 to require that all passenger cars and light trucks provide automatic protection by means of air bags.[9] ISTEA required air bags in all passenger cars beginning with MY 1998, and in all light trucks beginning with MY 1999. We published the final rule implementing this mandate on September 2, 1993 (58 F.R. 46551).

Like the automatic restraint requirements issued in 1984, the air bag requirements issued in 1993 were performance requirements that did not specify the design of an air bag system. Instead, they gave vehicle manufacturers substantial design flexibility. They permitted, but did not require, vehicle manufacturers to develop and use advanced air bag technologies in designing their air bags to minimize the risks from air bags, in particular, the risk of serious injury to unbelted, out-of-position occupants, including children and small drivers.

Thus, the manufacturers had significant freedom under Standard No. 208 to develop and install means of protecting the wide variety of occupants under a broad range of crash conditions, such as the types of crashes, the crash speeds at which the air bags deploy, the initial direction in which they deploy, the force with which they deploy, the time of deployment during the crash, air bag tethering and venting to control inflation force when a deploying air bag encounters an occupant close to the steering wheel or dashboard, the use of sensors to suppress air bag inflation in the presence of rear-facing child restraints or the presence of small children, the use of sensors

---

[9] TEA 21 is thus the second Congressional act narrowing the discretion provided by the Department's 1984 final rule regarding automatic protection. That final rule mandated automatic protection, but explicitly provided discretion with respect to the type of automatic protection (e.g., automatic seat belts and air bags), and implicitly allowed the use of advanced air bag technologies.

ISTEA mandated the installation of air bags. TEA 21 mandates the use of advanced air bag technologies or other means to reduce air bag-induced risks.

to detect occupant position to prevent air bag inflation if appropriate, and the use of multi-stage inflators to adjust air bag force to the crash situation. Multi-stage inflators allow tailoring of air bag performance to match the circumstances of a crash. For example, air bag deployment can be tailored in response to crash severity so that force levels are lower in less severe crashes than they are in more severe crashes. The less severe crashes are the type of crashes in which full force is not needed and in which air bag-induced fatalities to out-of-position occupants have occurred.

Until March 1997, the injury criteria limits in Standard No. 208 had to be met for air bag-equipped vehicles in barrier crashes at speeds up to 48 km/h (30 mph), with the 50th percentile adult male dummies wearing seat belts, and in separate barrier crashes at those speeds with dummies unbelted. Then, however, concerns about the rising number of air bag-induced fatalities involving children and some adults led us to publish a final rule (62 F.R. 12960; March 19, 1997) providing manufacturers with the option of certifying the air bag performance of their vehicles with an unbelted dummy in a sled test incorporating a 125 millisecond standardized crash pulse instead of in a vehicle-to-barrier crash test. We adopted this amendment for two principal reasons. First, the lead time for reducing a significant portion of the risk of air bag-induced fatalities through reducing the force of air bags as they deploy (i.e., depowering) was shorter than the lead time for addressing those risks through developing and installing advanced air bag technologies. Second, allowing manufacturers to use the less stringent, less expensive and easier to conduct sled test made it easier to maintain compliance with Standard No. 208 while depowering their air bags and making other design changes. This shortened the lead time for depowering, compared to the time it would have taken to recertify vehicles with depowered air bags using a barrier crash test.

In the March 1997 final rule, we specified that the sled test option would terminate on September 1, 2001. We concluded that there was no need to reduce Standard No. 208's performance requirements permanently, based on our belief in 1997 that advanced air bag technologies could be incorporated into new vehicles by 2001 and thus enable manufacturers to reduce air bag risks while continuing to meet the 48 km/h (30 mph) unbelted barrier crash test.

The September 1, 2001 sunset date for the sled test option was superseded by a provision in TEA 21. In a paragraph titled "Coordination of Effective Dates," TEA 21 provides that the unbelted sled test option "shall remain in effect unless and until changed by [the final rule for advanced air bags]."

## IV. Safety Problems

### A. Frontal Crashes and the "Second Collision"-- The Leading Cause of Occupant Deaths

The twin goals of TEA 21 both relate to safety problems associated with frontal crashes, the most significant cause of motor vehicle fatalities. Each year, approximately 18,000 drivers and right front passengers are killed in frontal crashes, accounting for 63 percent of all occupants killed in vehicle crashes. More than two-thirds of those approximately 18,000 people are unbelted when they die. Young people, i.e., those in their teens and twenties, account for about 40 percent of the unbelted deaths.

The frontal crash of a vehicle involves two collisions. The first collision occurs when the vehicle strikes another vehicle or an object such as a tree. The second collision is the human collision with the vehicle interior.

When a vehicle collides with an object, a front seat occupant who is not wearing a seat

belt becomes a projectile and keeps moving forward at speeds up to the vehicle's pre-crash speed. If that unbelted occupant is not protected by an air bag, the head or chest of the occupant usually slams into the steering wheel, dashboard, roof pillars or windshield. If the vehicle were going at 48 km/h (30 mph) when it hit a rigid object, an unrestrained occupant in that vehicle would keep moving forward at that speed and slam into the vehicle interior at 40 to 48 km/h (25 to 30 mph); i.e., roughly the speed at which a person dropped from a 9.1-m (30-foot) height would hit the ground. In the absence of an air bag, even belted occupants, particularly belted drivers, are likely to strike the vehicle interior with their head, neck or chest in a serious crash.

### B. Preventing or Mitigating the Effects of the Second Collision Using Seat Belts and Air Bags

To prevent or mitigate the effects of the second collision, Standard No. 208 requires that vehicles be equipped with seat belts and frontal air bags. Seats belts are estimated to save 9,500 lives in America each year. Research has found that lap/shoulder belts, when used properly, reduce the risk of fatal injury to front seat passenger car occupants by 45 percent and the risk of moderate-to-critical injury by 50 percent. For light truck occupants, seat belts reduce the risk of fatal injury by 60 percent and moderate-to-critical injury by 65 percent.

Air bags are also highly effective in reducing fatalities from frontal crashes. Between 1986 and March 1, 2000, air bags have saved an estimated 5,303 front seat occupants (4,496 drivers (85 percent) and 807 right front passengers (15 percent)).[10] Of the 5,303 people, 72 percent were unbelted and 28 percent belted. If observed seat belt use rates were to increase to

---

[10] These estimates are based on comparisons of the frequency of front seat occupant deaths in vehicles without air bags and in vehicles with air bags. These life savings occurred predominantly in moderate and high speed crashes; i.e., those with a velocity change (delta V) above 20 mph.

85 percent, the goal for 2000 set by DOT in 1997, the distribution of lives saved would change from 72 percent unbelted/28 percent belted to 60 percent unbelted and 40 percent belted.

The number of lives saved annually by air bags is continuing to increase as the percentage of air bag-equipped vehicles on the road increases. We estimate that air bags will save more than 3,200 lives annually in passenger cars and light trucks when all light vehicles on the road are equipped with driver and passenger air bags. This estimate is based on an anticipated fleet of vehicles meeting all of the requirements in this final rule and on 1997 seat belt use rates (66.9 percent, according to State-reported surveys). However, if observed seat belt use rates were to reach 85 percent, the annual savings of lives due to air bags would be reduced to approximately 2,400.

### C. Air Bag Risks and Fatalities

As the numbers above indicate, the attempt through seat belts and air bags to substitute a survivable event for an unsurvivable one or to substitute a less injurious event for a more injurious one is not always successful. However, no safety device is perfect.

While air bags are saving an increasing number of people in moderate and high speed crashes, they occasionally cause fatalities, especially to unrestrained, out-of-position children, in relatively low speed crashes. As of February 1, 2000, NHTSA's Special Crash Investigation (SCI) program had confirmed a total of 152 fatalities induced by the deployment of an air bag. Eighty-eight of those fatally-injured were children. Six adult passengers have also been fatally injured. Fifty-eight drivers were fatally injured. An additional 40 fatalities are under investigation by SCI, but they have not been confirmed as having been induced by air bags.

Changes have already occurred that are reducing the number of persons killed by air bags.

Some changes are behavioral. As a result of public education programs, improved labeling and media coverage, the public is much more aware of the dangers air bags pose to children in the front seat and to drivers sitting too close to the air bag and is taking steps to reduce those dangers. For example, more children are being put in the back seat. More short-statured drivers are moving back from the steering wheel.

Other changes are technological. Even before MY 1998, there were numerous improvements in the design of driver and passenger air bags, as reflected in the responses to the IR that we sent in December 1997 to nine motor vehicle manufacturers.[11] As NHTSA noted in its report regarding those responses, "Air Bag Technology in Light Passenger Vehicles" (December 1999), the data provided by the manufacturers show that air bag outputs (i.e., pressure rise rate and the peak pressure) have been reduced significantly in many MY 1998 motor vehicles in comparison to the earlier vehicles. While there are many means by which air bag aggressiveness can be reduced, reducing air bag outputs is a quick means of accomplishing this goal. The agency's analyses also show that, between MY 1997 and MY 1998, 50 to 60 percent of the vehicles in the fleet covered by the 1997 IR lowered the output of the driver-side air bag, while about 40 to 50 percent of the vehicles in that fleet lowered the output for the passenger side. Comparison of the data for MY 1997 and MY 1998 vehicles shows that, on average, the pressure rise rate in MY 1998 vehicles decreased about 22 percent for the driver air bag and 14 percent for the passenger air bags.

The data provided by the manufacturers also show that they have made significant

---

[11] For example, some vehicle manufacturers had already depowered some air bags prior to March 1997. Some had adjusted other air bag characteristics, such as fold patterns, volume, venting, tethers, etc.

changes in the design of their air bag systems other than the air bag pressure rise rate and peak pressure in their air bag designs, some over a period of many years. One change is the recessing of driver air bags so that the module is located farther away from the plane of the steering wheel, and thus farther from the driver. Although this feature was not common in the early 1990s, it is found in almost half of the MY 1997 and MY 1998 vehicles in the responses to the 1997 IR. Similarly, the air bag mounting location on the passenger side has also shown significant changes. Other features, such as cover tear patterns, tear pressure, fold patterns and the number and type of tethers, have changed in recent years, all of which may have collectively contributed to the reduced aggressiveness of air bags.

To assess the impact of the redesigned air bags on the numbers of air bag-induced fatalities, we used the available SCI data. We compared the rate per million registered vehicles of air bag-induced fatalities for the first 27 months that MY1998 redesigned vehicles were on the road with the rate of air bag-induced fatalities for the first 27 months that MY 1996-97 vehicles were on the road. We took this approach in an effort to ensure that the amount of exposure was comparable for both groups of vehicles. We found that the air bag-induced fatality rate for all MY 1998 vehicles is 66 percent less than the fatality rate for MY 1996-97 vehicles (0.48 for MY 1998 versus an average of 1.43 for MY 1996-97).

Part of this reduction is the result of changes in behavior; i.e., using seat belts more frequently, moving children into the back seat, and moving the driver's seat further back. We found evidence of behavioral changes by examining the front seat vs. rear seat distributions of all child passengers (age 0 to 12) in passenger cars, survivors plus fatalities, in the Fatal Analysis Reporting System (FARS) from 1995 through mid-1999. In cars with passenger air bags, the

percentage of toddlers and infants riding in the back seat increased from about 70 percent in 1995 to about 90 percent in 1999. There were also moderate increases for children that are 6 to 10 years old.

### D. Causes of Air Bag Fatalities

Several factors are common to air bag-induced fatalities. First, they involve air bags that do not meet the suppression or low risk deployment requirements of this final rule. Thus, for example, the passenger air bags do not turn themselves off in the presence of young children. The driver air bags are not dual-stage air bags that deploy in a crash with reduced power under certain circumstances, such as when the driver seat is in or near the full forward position or when the crash occurs at a relatively low speed.

Second, the occupants are generally very close to an air bag module when the air bag begins to deploy during a crash.[12] The one fact that is common to all persons who died is <u>not</u> their height, weight, gender, or age. Instead, it is the fact that they were very close to an air bag when it started to deploy. For some people, e.g., infants in rear-facing infant seats, this occurred because they were initially sitting very close to the air bag. For the other occupants, this typically occurred because they were not restrained by seat belts or child safety seats and moved forward during pre-crash braking.

Closeness is a problem because, in order for an air bag to cushion an occupant's head, neck, chest and abdomen and keep the occupant from hitting the steering wheel, windshield or instrument panel, the air bag must move into place quickly. The force of a deploying air bag is

---

[12] Vehicle speed is not a causative factor. Most of the crashes involving fatalities that have been confirmed as air bag-induced occurred at relatively low speeds. If the passenger air bag had not deployed in those low speed crashes, the people would probably not have been killed or seriously injured.

greatest as the air bag begins to inflate. If occupants are very close to or in contact with the cover of an air bag that does not meet the low risk deployment requirements of this final rule, they can be hit with enough force to cause serious injury or death when the air bag begins to inflate. This can be caused either by the cover as the air bag breaks out of the module (known as the "punch-out" effect) or by the unfolding and inflating air bag as it first conforms to the contours of the occupant and then moves rapidly into its fully-inflated shape (known as the "membrane" effect).[13]

In all of the 86 SCI confirmed fatalities involving children, the children were very close to the instrument panel when the air bag deployed. Because of their proximity, the children sustained fatal head or neck injuries from the deploying passenger air bag.

Eighteen fatally-injured infants were close to the air bag because they were in rear-facing infant seats installed directly in front of a passenger air bag. A rear-facing infant seat which is installed in the front seat of a vehicle with a passenger air bag will almost always position the infant's head very close to the passenger air bag. Several other infants were being held in the lap of a passenger.

All but a few of the 68 fatally-injured older children were not using any type of restraint.[14] Of those who were restrained, most were not correctly restrained. The non-use or improper use

---

[13] In general, a driver can avoid any serious air bag risks by sitting at least 10 inches away from the air bag (measured from the breastbone to the center of the air bag cover) and by wearing a lap/shoulder seat belt. Teenage and adult passengers can avoid this risk by moving their seat as rearward as possible and wearing their seat belts. Even in a vehicle that does not have any air bags, children should ride in the rear seat whenever possible, since that is a significantly safer location.

[14] NHTSA notes that almost all of the 68 fatally-injured children were 1 - 7 years old.

of occupant restraints allowed the children to move forward during pre-impact braking[15] before the actual crash. As a result, they were very close to the air bag when it deployed.

As in the case of the children fatally injured by air bags, the key factor regarding the confirmed deaths of adults has been their closeness to the air bag when it deployed. The most common factor that allowed them to become very close to the air bag was the failure to use seat belts. Only 16 of the 57 drivers are known to have been properly restrained by lap and shoulder belts at the time of the crash.

## V. DOT/NHTSA Responses to Air Bag Risks and Fatalities

### A. Introduction

As the following chronology demonstrates, DOT/NHTSA have repeatedly and publicly addressed the issue of risk to out-of-position occupants from air bags in regulatory decisions about automatic restraints and air bags for more than 20 years. More important, concerns about that issue helped to shape the DOT/NHTSA regulatory decisions during 1980s and 1990s.

### B. Chronology

In its 1977 final rule requiring automatic restraints, the Department discussed the possibility of "side effects of air bag installation" at length. That discussion included the issue of risks for out-of-position occupants. 42 F.R. 34289; July 5, 1977.

In 1981, Minicars, Inc., a NHTSA research contractor, issued reports on the successful efforts to build and test devices, including dual-stage inflators, for controlling passenger air bag

---

[15] Pre-impact braking was a factor in a very high percentage of crashes resulting in the deaths of the older children.

inflation so as to avoid harming out-of-position children.[16]

In deciding in 1984 to issue final rule requiring automatic restraints, the Department considered vehicle manufacturer comments that air bags would pose risks to out-of-position occupants, particularly in small cars. The lack of experience with the technical means for addressing those risks was one of the reasons expressly cited by the Department for rejecting the alternative of mandating air bags. 49 F.R. 28962, at 29001; July 17, 1984.

While the Department noted in the 1984 final rule that use of technical solutions such as sensors to adjust deployment could lessen the problem, it said that it could not "state for certain that air bags will never cause injury or death to a child." As discussed above, other technical solutions were identified in the Final Regulatory Impact Analysis for that rule, including dual-stage inflation systems and other technological measures such as bag shape and size, instrument panel contour, aspiration, and inflation technique. It also noted that a variety of different sensors could be used to trigger dual-stage inflation systems.

In 1985, NHTSA denied petitions for reconsideration of the 1984 final rule. NHTSA noted that the 1984 "final rule acknowledged concerns about the effects of air bag systems on out-of-position occupants; however, it also explained that technical solutions are available to address the out-of-position occupant problem." NHTSA said that concerns about air bag risks and a variety of other factors led to the Department's decision not to mandate air bags for all cars. 50 F.R. 35233, at 35234; August 30, 1985.

Two years later, in 1987, NHTSA amended Standard No. 208 to delay the requirement

---

[16] "Small Car Front Seat Passenger Inflatable Restraint System (Vol. I - Chevette and Omni)," "Small Car Front Seat Passenger Inflatable Restraint System (Vol. II - Citation)," "Upgrade Volvo Production Restraint System."

for any type of automatic restraint for the passenger seating position in a passenger car if the car had a driver air bag. This action was taken in response to a petition by Ford. The agency said that the length of the delay was based on the time that the vehicle manufacturers said was necessary to complete the development and installation of passenger air bags. Ford said in its petition that there were a number of uncertainties, including technical problems, concerning the development of those air bags. Ford said that it was concerned that passenger air bags could pose risks for standing children and other occupants who are out of position due, for example, to pre-crash braking. It said, however, that it expected to solve these problems if its petition were granted so that it could proceed in an orderly, controlled manner to gain experience with passenger-side applications. 52 F.R. 10096; March 30, 1987.

In 1991, NHTSA issued a final rule amending Standard No. 201, Occupant Protection in Interior Impact, 49 CFR 571.201, to facilitate installation of top-mounted, vertically deploying passenger air bags. This rulemaking was conducted in response to a petition by Chrysler, which said that this type of air bag would reduce the risks for standing children and out-of-position occupants. Ford and GM supported the petition and concurred that these air bags had the potential for reducing risks to out-of-position children and adults. 56 F.R. 26036; June 6, 1991.

Also in 1991, NHTSA issued a Consumer Advisory warning owners of rear-facing child seats not to use such a restraint in the front seat of a vehicle equipped with a passenger air bag. This warning was based on preliminary results of testing regarding this problem. At that time, no casualties to infants had occurred.

In the 1993 final rule implementing the air bag mandate in ISTEA, NHTSA required vehicles equipped with air bags to bear labels on the sun visors providing four specific cautions,

including a statement not to install rearward-facing child seats in front passenger positions, and advising the occupant to see the owner's manual for further information and explanations. 58 F.R. 46551; September 2, 1993.

In 1994, NHTSA issued a final rule amending Standard No. 213, Child Restraint Systems, to require rear-facing child seats to bear a warning against using the restraint in any vehicle seating position equipped with an air bag. 59 F.R. 7643; February 16, 1994.

In 1995, NHTSA issued a final rule allowing manufacturers to install a manual device that motorists could use to deactivate the front passenger-side air bag in vehicles in which rear-facing child seats can only fit in the front seat. 60 F.R. 27233; May 23, 1995. On October 27, 1995, in response to several fatalities to improperly-restrained children in air bag-equipped positions, NHTSA issued a strong warning in a press release. This release broadened the previous agency warnings about young children to apply to older children and even adults who may ride unrestrained.

In 1996, the agency issued a final rule requiring improved labeling on new vehicles and child restraints to better ensure that drivers and other occupants are aware of the dangers posed by passenger air bags to children, particularly to children in rear-facing infant restraints in vehicles with operational passenger air bags. 61 F.R. 60206; November 27, 1996.

In 1997, the agency took three important steps to address air bag risks through vehicle safety rulemaking. First, we issued a final rule extending until September 1, 2000, the existing provision permitting vehicle manufacturers to offer manual on-off switches for the passenger air bag for new vehicles without rear seats or with rear seats that are too small to accommodate rear-facing infant restraints. 62 F.R. 798; January 6, 1997. Second, we issued a final rule temporarily

amending Standard No. 208 to facilitate efforts of vehicle manufacturers to redesign their air bags quickly so that they inflate less aggressively. This change, coupled with the broad flexibility already provided by the standard's existing performance requirements, provided the vehicle manufacturers maximum flexibility to quickly reduce the adverse effects of current air bags. 62 F.R. 12960; March 19, 1997. Third, we issued a final rule exempting, under certain conditions, motor vehicle dealers and repair businesses from the "make inoperative" prohibition of 49 U.S.C. 30122 by allowing them to install retrofit manual on-off switches for air bags in vehicles owned by people whose request for a switch had been authorized by NHTSA. 62 F.R. 62406; November 21, 1997.

## VI. Advanced Technologies for Improving Air Bags

### A. Introduction

The level of risk of air bag-induced fatalities depends to a significant extent on air bag system design. There are various advanced air bag technologies that have been or are being developed and that, if incorporated in air bag systems, can improve protection of occupants of different sizes, belted and unbelted, and minimize the risks from air bags.[17] For example, an air bag need not be designed so that it inflates with full force under all circumstances. Dual-stage inflators can be used in combination with various types of sensors (e.g., crash severity, seat position, and belt use) and improved algorithms to adjust the deployment threshold or air bag inflation pressure and pressure rise rate and thereby reduce risk. Different folding patterns and

---

[17] Air bag systems are only one of many automotive applications of increasingly sophisticated technology. Equally sophisticated technology is being used in many other existing vehicle systems as well as in entirely new ones. Examples include backup obstacle detection warning systems, adaptive cruise controls, rollover sensors, rain-activated windshield wiper systems, global positioning systems, head-up displays of information on the windshield, night vision systems, antilock braking systems, and tire pressure monitoring systems.

aspiration designs, as well as systems that suppress air bag deployment altogether in appropriate circumstances, also could reduce risk. For example, higher speed deployment thresholds could prevent deployment in low speed crashes, and weight sensors could be used to prevent deployment when children are present. In addition, recessed air bag modules, compartmentalized and internally-tethered air bags, bias flaps, and low break-out force covers could make deploying air bags more benign for out-of-position occupants.

### B. Key Parts of Air Bag Systems

In analyzing potential improvements in air bag system performance, it is useful to divide the system into 3 discrete parts:

1. Information: acquiring information about crashes and occupants,
2. Analysis/Decision: analyzing that information to determine the nature of the crash and the circumstances of the front seat occupants, and deciding how to adjust the response of the air bag system accordingly, and
3. Response: adjusting the performance of the air bag in response to the decisions regarding the acquired information.

Air bag systems acquire information through the use of sensors. All air bag systems have some kind of crash sensor indicating the occurrence of a crash and its severity. The systems process information from the sensors and use an algorithm to make decisions on the desired air bag deployment and performance based on predictions about the crash event. The systems may also have sensors which provide information about such things as belt use, child seat use, occupant weight and size, seat adjustment position, and occupant location. The information from the sensors is used by the electronic control unit in making decisions as to whether and when the

air bag is to be deployed. Air bags using advanced technologies could use the information to tailor the inflation levels of multi-stage air bags.

The information, analysis/decision, and response aspects of air bag systems each offer opportunities for improving occupant protection. With more and better information, improved decision-making algorithms, and greater adjustment capability to tailor the inflation, an air bag system can be designed to provide an improved response.

For example, with improved information about crash severity, the deploy/don't deploy decision can be made earlier in a crash. By deploying earlier during a crash, before the occupant has moved very far forward, the air bag can better protect the occupant and is less likely to pose risks to the occupant. If an air bag system includes sensors which provide information about occupant weight and/or size or location, it can be designed to suppress deployment in the presence of a young child or to deploy differently for small adults and large adults (e.g., a lower level of inflation for a smaller adult than that for a larger one).

While some aspects of improved performance are dependent on more or better sensor information, others are not. For example, while a suppression device requires information about occupant category or location, other approaches that could reduce air bag aggressiveness, such as improved fold patterns, lighter weight air bag fabrics, air bag cover design, low break-out force openings, tethering and bias flaps are not information-dependent.

### C. Specific Advanced Technologies

Sensors - General. Advanced air bag systems can use various types of sensors to obtain information about crashes, vehicles and their occupants. This information can be used to adapt the performance of the air bag to the particular circumstances of the crash. As noted above, it

can be used in determining whether an air bag should deploy, when it should deploy, and (if it has multiple inflation levels) at what level of inflation (pressure rise) and inflation rate (pressure rise rate).

Sensors - Impending crash. Anticipatory sensors, which can identify the direction and velocity of a striking object, may be used in conjunction with the vehicle crash severity sensors to provide additional information to the air bag sensing and diagnostics module to make an earlier assessment of how to deploy the air bag (e.g., at what inflation level). (Note: As we noted at the beginning of this section on advanced technologies, some of these technologies are still under development. This is one of them.)

Sensors - Crash severity. Crash severity sensors measure the severity of a crash; i.e., the rate of reduction in velocity when a vehicle strikes another object. If a relatively low severity crash is sensed, only the lowest stage of a dual-stage inflator will fill the air bag; if a moderate severity crash is sensed, both stages will fill the air bag with a specific time delay between the two stages; and if a more severe crash is sensed, both stages will fill the air bag either simultaneously or with a 5 - 10 msec interval in between the stages.

Improvements are being made in crash sensing hardware to provide earlier crash detection and more accurate estimates of crash severity and proper decision for timely deployment. Current trends in crash sensor hardware involve the use of either a single-point electronic sensor or a combination of electromechanical and electronic sensors.[18] Electronic sensors use microprocessor technology to compute the deceleration time history of the vehicle

---

[18] Based on information from the responses to the December 1997 IR, 44 percent of the MY 1998 vehicles in the IR fleet had only one crash sensor and 73 percent had either a single electronic or a combination electronic and electromechanical.

along with the integration of various other input factors to determine whether air bag deployment is appropriate.

Sensors - Passenger weight and seat pattern. Passenger air bag systems may incorporate advanced technologies to suppress the air bag in the presence of children to prevent undesirable deployments. To accomplish this, manufacturers are refining seat weight or seat pattern recognition systems for detecting passenger occupant size and/or position.

For example, some occupant detection systems will use an array of sensors in the seat cushion to measure either the pressure distribution or deflection pattern resulting from the occupant in the seat to make a determination on whether to deploy or suppress the air bag system. Child safety seats, for example, are more readily identifiable by these systems, since they have a distinct "footprint" when compared to the human buttocks.

Weight sensing systems estimate the weight of the occupant through various load cell technologies located in the seat cushion or at the base of the seat. The latter approach has the potential for avoiding the possible difficulties that can be created for seat-cushion weight sensors when the seat back is tilted back enough to transfer a significant portion of the occupant's weight from the seat cushion to the seat back. The algorithms associated with these devices can be designed to take into consideration and minimize the effects of belt cinch forces (for example, from child safety seats) by using belt tension-measuring hardware to make an adjusted assessment of weight.

Sensors - Occupant size and/or location. Other advanced occupant detection systems under development use technologies, such as capacitive, ultrasonic, and infrared, for sensing occupant size and/or location with respect to the air bag module. These are used in the

development of dynamic and static suppression strategies.

Strategies for static occupant detection systems[19] include the ability to make a determination of whether air bag deployment is warranted (or what level of inflation is appropriate) for the size and/or position of the occupant (e.g., whether the occupant is a small child or a full-sized adult, or whether the occupant is against the seat back or is sitting on the edge of the seat, closer to the air bag). These technologies may be used in conjunction with seat weight sensing/pattern recognition systems (or seat belt use and crash severity sensing) to improve the reliability of the occupant classification and location estimates.

Dynamic suppression strategies using advanced technologies, such as capacitive, ultrasonic, and infrared, will be able to make dynamic assessments of when an occupant is out of position by determining the location of the occupant during the course of a crash. These technologies must have rapid sensing capabilities and algorithms to make the air bag deployment or suppression decision, for example, in the event of pre-impact braking. These systems would have the added benefit of protecting not only children, but also out-of-position adults. (Note: This is another advanced technology still under development.)

Sensors - Belt use or forward/aft seat adjustment position. Air bag systems may be linked to sensors that determine whether the occupant is using his or her seat belt and whether the occupant has positioned the vehicle seat along the seat track (i.e., all or nearly all the way forward or farther back). An advanced air bag system in vehicles with crash severity sensors and dual-stage inflators could use seat belt use information to adjust deployment thresholds or

---

[19] Static detection systems monitor steady state conditions such as occupant weight. In contrast, dynamic detection systems continuously monitor an occupant's position in relation to the air bag module.

inflation levels depending on whether the occupant is belted or unbelted. Since an unbelted occupant is more susceptible than a belted occupant to injury in less severe crashes, the unbelted occupant needs the protection of an air bag at lower crash severities than a belted occupant does. Accordingly, the air bag would deploy at a lower threshold for an unbelted occupant.

Seat position sensors determine how far forward or back a seat is adjusted on its seat track. An advanced air bag system could be designed so a dual-stage air bag deploys at a lower level when the seat is all the way forward than it does when the seat is farther back. This would benefit those short-statured drivers who move their seats all the way forward, or mid-to-tall-statured drivers who move their seats farther back.

In the MY 2000 Ford Taurus/Mercury Sable, the air bag system will fire the low energy strategy for the driver air bag when the seat is positioned in or near the full forward position. This provides a more benign deployment for small-statured occupants who sit closer to the air bag. Ford also provides the option of installing adjustable pedals on some of its vehicle platforms to assist driver occupants in positioning themselves further away from the air bag. Both seat position sensors and adjustable pedals can be used in conjunction with the previously mentioned seat belt use and crash severity information to affect air bag performance.

Multiple crash severity thresholds. Some current production motor vehicles are using information from crash severity sensors in conjunction with seat belt use sensors to select the appropriate crash severity threshold levels for belted and unbelted occupants. For instance, dual speed thresholds for deploying air bags have been used in Mercedes-Benz vehicles produced for the U.S. market for several years. In these vehicles, the lower threshold for air bag deployment is approximately 19 km/h (12 mph) when an occupant is unbelted and a higher threshold of

approximately 29 km/h (18 mph) is utilized when the an occupant is belted. A belt buckle switch provides the information to allow the selection between these two thresholds. Other vehicle manufacturers also have implemented similar strategies.

Multiple levels of inflation. In addition to using crash severity and seat belt use information for dual threshold strategies, this information also can be utilized to employ different inflation levels for belted and unbelted occupants through the use of a multi-stage air bag inflator. For instance, a belted occupant may only need a low powered inflation level, since the seat belts also provide restraint, while an unbelted occupant may require a full-powered air bag to provide a timely inflation and full protection by the air bag. Similarly, the crash severity information may be used with a multi-stage inflator to employ a low level of air bag inflation in a low severity crash or a full power inflation in a high severity crash, in which additional restraint is needed for occupant protection.

Improved seat belt systems. Many advances have also been made in seat belt systems to improve their performance when used in conjunction with air bag systems. These systems can reduce the risk of air bag-induced injury to a belted occupant. Many production vehicles (approximately 180 vehicle models)[20] are providing seat belt energy management features and/or pretensioners in MY 2000 vehicles. Pretensioners are devices that retract the seat belt to remove excess slack during a crash event. Energy management features, such as load limiting retractors or webbing tear stitching, allow yielding of the seat belt system in order to prevent too much force from being imposed on the occupant's upper chest or lap during a severe crash. Additional seat belt enhancements include adjustable anchorages, which allow the positioning of the

---

[20] NHTSA brochure DOT HS 808 988: "Buying a Safer Car 2000", September 1999.

shoulder strap to accommodate a person's size, and integrated seat belt systems, which mount the entire seat belt system directly into the seat to allow better belt fit and restraint performance. Development work also is being done on seat belt webbing spool-out sensors, which could provide additional information about an occupant's size and movement in relation to the air bag module.

Improved air bag hardware. Manufacturers also have made advances in integrating countermeasures into the air bag hardware to mitigate injuries without compromising high speed occupant protection. For example, the driver air bag system of the MY 1999 Saturn SL1 has been designed with a number of injury-mitigating countermeasures. These include a patented I-tear seam cover, a unique air bag fold, recessed air bag module, 4 internal tether straps, and an air bag whose depth and volume are relatively small. The MY 1999 Saturn SL1 passenger air bag also includes an internal bias flap, which redirects the flow of gas laterally instead of toward the occupant.

Other available air bag hardware countermeasures which minimize the risks to out-of-position occupants include:

Low break-out force covers - By reducing the amount of force needed for an air bag to break out of the module housing in the steering wheel or instrument panel, these covers help make it possible to reduce the "punch out" effect of deploying air bags.

Radial deployment paths - For an air bag with a radial deployment path, the initial primary thrust of the deploying air bag is radial instead of toward the person sitting in front of the air bag.

Compartmented air bags - These air bags can function as an air bag within an air bag. If coupled with a dual-stage inflator, the first stage can inflate the smaller, inner air bag for small adults seated near the steering wheel and both stages can inflate the full air bag.

Pyrotechnic venting - One means of reducing the aggressiveness of a deploying air bag is to provide an alternative inflation path for venting air bag gases. If an out-of-position occupant is putting pressure on the air bag, the pressure can be vented in a different direction. This can be achieved through vent holes in the inflator canisters or pyrotechnically actuating vents which close holes in the reaction surface of the inflator canister.

Air bag aspiration - Another means of reducing the aggressiveness of a deploying air bag is to use an aspirated inflation system to draw in outside air into the gas stream as the air bag is being filled. If an out-of-position occupant interferes with the deployment of the air bag, the pressure within the bag will increase, and the aspirating system would cease operating as soon as that increased pressure within the air bag reaches a predetermined design level.

### D. Installation of Advanced Technologies in Current Production Motor

**Vehicles**

One type of advanced air bag technology was installed in production motor vehicles 25 years ago by GM. GM equipped 10,000 MY1974-1976 Buicks, Pontiacs and Oldsmobiles with dual-stage passenger air bags. Although advanced air bag technologies did not substantially reappear in motor vehicles until the late 1990s, a steadily increasing number of passenger car models are now being equipped with them. Many of these models are foreign luxury vehicles. However, both the 1999 second best selling (Honda Accord) and third best selling (Ford Taurus) non-luxury passenger car models are equipped with dual-stage air bags and various advanced technology sensors.

A list of MY 2000 models equipped with advanced air bag technologies appears below:

Acura 3.5 RL and 3.2 TL are equipped with

Dual-stage passenger air bag[21]

Advanced crash severity sensor

Passenger belt use sensor

BMW 3- and 5- models are equipped with

Advanced crash severity sensor

Dual-threshold deployment for driver and passenger air bag

Sensor to help prevent unnecessary deployment of passenger air bag

---

21 According to the Acura website, the air bag system:

> automatically adjusts the deployment of the front passenger's air bag SRS based on the severity of the crash and whether or not the passenger is wearing the seat belt. During a slow speed collision, the dual-stage inflator system for the dash-mounted air bag is triggered in sequence, resulting in slower overall air bag deployment with less initial force. During a higher speed-collision, both inflators operate simultaneously for full immediate inflation in order to correspond with the greater impact force.

BMW 7-series models are equipped with

Advanced crash severity sensor

Dual-threshold deployment for driver and passenger air bags

Dual-stage passenger air bag

Sensor to help prevent unnecessary deployment of passenger air bag

BMW X5 is equipped with

Dual-stage driver and passenger air bags

Advanced crash severity sensor

Driver and passenger belt use sensor

Dual-threshold deployment for driver and passenger air bags

BMW Z3 and BMW M coupe/roadster are equipped with

Dual-threshold deployment for driver and passenger air bags

Sensor to help prevent unnecessary passenger air bag deployment

Ford Taurus and Mercury Sable are equipped with

Dual-stage driver and passenger air bags

Advanced crash severity sensor

Driver seat position sensor

Driver belt use sensor

Power adjustable accelerator and brake pedals

Honda Accord is equipped with

Dual-stage passenger air bag

Advanced crash severity sensor

Passenger belt use sensor

Mercedes S-class and CL coupe are equipped with

Passenger air bag features dual inflation rates based on impact severity.

Advanced crash severity sensor

Volvo S80 is equipped with

Passenger belt use sensor

Dual deployment threshold for driver and passenger air bags

## VII. Our Proposals for Advanced Air Bags

### A. Our Initial Proposal (September 1998)

Pursuant to TEA 21, on September 18, 1998, we published in the Federal Register (63 FR 49958) a notice of proposed rulemaking (NPRM) to upgrade Standard No. 208 to require vehicles to be equipped with advanced air bags that meet new, more rigorous performance requirements. The NPRM proposed to require advanced air bags in some new passenger cars and light trucks beginning September 1, 2002, and in all new cars and light trucks beginning September 1, 2005.

We proposed several new performance requirements to ensure that the advanced air bags do not pose unreasonable risks to out-of-position occupants. The NPRM gave options for complying with those requirements so that vehicle manufacturers would be free to choose from a variety of effective technological solutions and to develop new ones if they so desire. With this flexibility, they could use either technologies that modulate or otherwise control air bag deployment so deploying air bags do not cause serious injuries or technologies that prevent air bag deployment if children or out-of-position occupants are present, or both.

To ensure that the new air bags are designed to avoid causing injury to a broad array of occupants, we proposed test requirements using a family of dummies, including ones representing 12-month-old, 3-year-old and 6-year-old children, and 5th percentile adult females, as well as tests representing 50th percentile adult males. We noted that many of the proposed test procedures were new, and specifically requested comments about their suitability for measuring the performance of the various advanced systems under development.

We also proposed requirements to ensure that the new air bags are designed to protect an

array of belted and unbelted occupants, including teenagers and small adults. The standard's current crash test requirements specify the use of 50th percentile adult male dummies only. We proposed also to specify the use of 5th percentile adult female dummies in crash tests. The weight and size of these dummies are representative of not only small women, but also many teenagers. By testing with both the 50th percentile adult male dummy and the 5th percentile adult female dummy, we can address the risks faced by most of the entire adult female population and much of the adult male population.[22]

In addition to the existing rigid barrier test, representing a relatively "stiff" or "hard" pulse crash when conducted perpendicularly, and a more moderate pulse crash when conducted obliquely, we proposed to add a deformable barrier crash test, representing a relatively "soft" pulse crash. This proposed new soft pulse crash test requirement was intended to ensure that air bag systems are designed so that they do not deploy too late. Some current air bags deploy relatively late in certain types of crashes, such as pole impacts. If an air bag deploys too late, normally seated occupants may move too close to the air bag before it starts to inflate. In such a situation, the air bag is less likely to protect the occupant and more likely to pose a risk to the occupant. We proposed to use belted 5th percentile adult female dummies in this test because small adults sit farther forward than larger adults and thus represent a "worst case."

We also proposed to phase out the unbelted sled test option as we phased in requirements for advanced air bags. We acknowledged that the sled test option has been an expedient and useful temporary measure that enabled the manufacturers to speed up the redesigning all of their

---

[22] A 95th percentile adult female, on average, weighs 199 lb and stands 5'7" tall. The 50th percentile adult male dummy weighs 171 lb and stands 5'9" tall.

air bags to reduce risks. The sled test also helped to ensure that protection would continue to be provided by air bags in high-speed crashes. Nevertheless, we stated that sled testing was not a fully satisfactory means of assessing the extent of occupant protection that a vehicle and its air bag together will afford occupants in the real world and thus was not suitable in the long run.

Finally, we proposed new and/or upgraded injury criteria for each of the proposed new test requirements, and also proposed to upgrade some of the injury criteria for the standard's existing test requirements.

### B. Our Supplemental Proposal (November 1999)

We received comments on the September 1998 NPRM from a wide range of interested persons including vehicle manufacturers, air bag manufacturers, insurance companies, public interest groups, academia, and government agencies. Commenters generally supported the goals mandated by TEA 21-- improving the benefits of air bags, while minimizing risks from air bags-- but expressed widely differing views as to how to accomplish those goals.

On November 5, 1999, in response to the public comments on our 1998 NPRM and to other new information we obtained after issuing that proposal, we published the SNPRM (64 FR 60556), which updated and refined the amendments under consideration in this rulemaking.

In the SNPRM, we reiterated the goals set for us by Congress in TEA 21, i.e., to improve occupant protection for occupants of different sizes, belted and unbelted, while minimizing the risk to infants, children, and other occupants from injuries and deaths caused by air bags. Further, we emphasized the need to ensure that the needed improvements in occupant protection were made in accordance with the statutory implementation schedule.

In developing the SNPRM, we sought to reduce the number of proposed tests to the

extent possible without significantly affecting the benefits of the NPRM. We were persuaded by the commenters that reducing the amount of testing was important, given the costs to manufacturers (and ultimately consumers) associated with certifying vehicles to such a large number of new test requirements. At the same time, we wanted to be sure that the final rule would include sufficient tests to ensure that air bags would meet the goals of TEA 21. Given the continued debate over what requirements should be relied upon to ensure protection to unbelted occupants, we also wanted to be sure that we received and considered public comments on the various alternative approaches reflecting the more recent views and information available to us.

The most significant differences between the NPRM and the SNPRM can be summarized as follows:

- Two alternative unbelted test procedures. While we proposed one unbelted test procedure in the NPRM, an up-to-48 km/h (30 mph) rigid barrier test using the 50th percentile adult male dummy and the 5th percentile adult female dummy, we proposed and sought comments on two alternative unbelted test procedures in the SNPRM.

  The first alternative was an unbelted rigid barrier test whose injury criteria would have to be met within the range of a minimum speed of 29 km/h (18 mph) and a maximum speed to be established between 40 to 48 km/h (25 to 30 mph), inclusive. Within this alternative was the potential for a phase-in sequence in which the maximum speed would initially be set at 40 km/h (25 mph) to provide vehicle manufacturers additional flexibility when they are introducing advanced air bags during the phase-in. Under this phase-in sequence, the final rule could

provide that the maximum speed would return to 48 km/h (30 mph) after some period of time.

The second alternative was an unbelted offset deformable barrier test within the range of a minimum speed of 35 km/h (22 mph) and a maximum speed to be established within the range of 48 to 56 km/h (30 to 35 mph). The latter alternative was developed in response to a recommendation made by IIHS in its comment on the NPRM.[23]

We proposed the 29 and 35 km/h (18 and 22 mph) lower ends of the ranges of test speeds for the two alternatives because we wanted to be sure that the standard would not inadvertently create incentives to push deployment thresholds downward; i.e., cause air bags to be deployed at lower speeds.

- Possible higher speed belted rigid barrier test. We stated that if we reduced the maximum speed of the unbelted rigid barrier test to 40 km/h (25 mph) permanently, we might also increase the maximum speed of the belted rigid barrier test from the current 48 km/h to 56 km/h (30 to 35 mph) and use both 5th percentile adult female and 50th percentile adult male dummies.
- Reduced number of tests. In the SNPRM, we significantly reduced the total number of proposed tests as compared to the NPRM. In a number of situations, we tentatively concluded that a proposed test could be deleted because the performance we sought to secure by means of that test would largely be assured

[23] We noted that IIHS's views had changed since making that recommendation. Its changed views were discussed in the SNPRM.

by one or more of the other tests.

- Reduced offset testing. The proposed up-to-40 km/h (25 mph) offset crash test using belted 5th percentile adult female dummies would be conducted only with the driver side of the vehicle engaged, instead of both testing with the driver side engaged and separately testing with the passenger side engaged.
- Ensuring that certain static suppression systems can detect real children and adults. For our proposed static test requirements for systems which suppress air bags in the presence of infants and children (e.g., weight sensors), we proposed a new option which would permit manufacturers to certify to requirements referencing actual children, instead of 3-year-old and 6-year-old child dummies, in a stationary vehicle to test the suppression systems. (This option would not apply to systems designed to suppress the air bags only when an infant is present.) Adult human beings could also be used in the place of 5th percentile adult female dummies for the portions of those static test requirements which make sure that the air bag is activated for adults. Steps would be taken to ensure the safety of all subjects used for these tests, e.g., by turning off the air bags.
- Reduced number of child restraints used for testing suppression systems. Instead of requiring manufacturers to assure compliance of a vehicle in tests using any child restraint which was manufactured for sale in the United States any time during a specified period prior to the manufacture of the vehicle, we proposed to require them only to assure compliance using each child restraint on a relatively short list of specified child restraint models. Those models would be chosen to be

representative of the array of available child restraints. The list would be updated from time to time to reflect changes in the types of available child restraints.

- Modified requirements for systems that suppress the air bag for out-of-position occupants. We significantly modified the proposed requirements for systems that suppress the air bag when an occupant is out of position during a crash. In the NPRM, we proposed a single test procedure for all types of such suppression systems. However, we were persuaded by the commenters that the proposed test procedure was not appropriate for many of the systems that are currently under development. Because we did not have sufficient information or prototype hardware to develop a new test procedure, and because no single test procedure may be appropriate for a number of comparably effective suppression technologies, we proposed a provision that would permit manufacturers or others to petition the agency to establish technology-specific test procedures under an expedited rulemaking process.
- No full scale dynamic out-of-position test requirements. We eliminated from this rulemaking the proposed option for full scale dynamic out-of-position test requirements (the option which included pre-impact braking as part of the test procedure). We were persuaded by the commenters that the proposed test procedure was not workable at this time. Moreover, we concluded that this option was unnecessary at this time, since other options were available for the range of effective technologies we understand to be currently under development.

In developing the SNPRM, we carefully considered all of the comments we received in

response to the NPRM. Moreover, because the SNPRM differed significantly in many aspects from the NPRM, we explained that we did not contemplate any further consideration of the comments on the NPRM in developing the final rule. We stated that if any persons believe that we did not adequately consider particular issues raised in comments on the NPRM, they should raise those issues again in commenting on the SNPRM.

Accordingly, in developing today's final rule, we have focused our consideration on the comments submitted in response to the SNPRM.

**VIII. Public Comments on the Supplemental Proposal**

As in the case of the NPRM, we received comments on the November 1999 SNPRM from a wide range of interested persons including vehicle manufacturers, air bag manufacturers, insurance companies, public interest groups, and government agencies. In this section, we provide a general summary of those comments. A more detailed description of the comments is provided below in the sections which address the issues raised by commenters, and in the Final Regulatory Evaluation and three separate technical papers which are being placed in the public docket.

Improving the Protection of Unbelted Occupants in Serious Crashes.

Nearly all commenters supported the unbelted rigid barrier test over the unbelted offset deformable barrier test.

Vehicle manufacturers stated that the rigid barrier test is practicable and repeatable and does not entail the variability associated with deformable barriers and the kinematics of an offset test. They also stated that the European barrier used in the offset test is not appropriate for testing larger SUVs and light trucks.

The Center for Auto Safety (CAS) stated that the unbelted offset test holds promise as a supplemental test, but is not yet suitable for inclusion in Standard No. 208. That organization stated that there are currently insufficient data to allow for a comprehensive analysis of the consequences that would accompany the adoption of the offset test.

Some other commenters also argued that an unbelted offset test offers promise for the future, either as a replacement for the rigid barrier test or as a supplemental test.

While a near-consensus of commenters supported adoption of an unbelted rigid barrier test, there was sharp disagreement over the maximum speed for that test. Auto companies, air bag suppliers, the Insurance Institute for Highway Safety (IIHS), and the National Transportation Safety Board (NTSB) supported a maximum speed of 40 km/h (25 mph). Safety groups including Public Citizen, CAS, and Parents for Safer Air Bags (Parents) supported returning to 48 km/h (30 mph).

The primary arguments made by those commenters supporting a maximum speed of 40 km/h (25 mph) can be summarized as follows:

- Current redesigned air bags work well.
- There has been no loss in benefits.
- There is no reason to believe that manufacturers would reduce air bag effectiveness in the future under a 40 km/h (25 mph) maximum test speed.
- A 40 km/h (25 mph) test speed allows flexibility to design air bags for all occupants.
- A return to a 48 km/h (30 mph) test speed would require a return to overly aggressive air bags.

- A 48 km/h (30 mph) test speed could result in disbenefits in low speed crashes.
- There are significant technological challenges in meeting a 48 km/h (30 mph) requirement for both the 50th percentile adult male dummy and the 5th percentile adult female dummy.
- Advanced technologies are not currently available that address aggressivity and practicability problems.

The primary arguments made by those commenters supporting a maximum test speed of 48 km/h (30 mph) can be summarized as follows:

- A maximum test speed of 48 km/h (30 mph) will result in higher benefits than a test speed of 40 km/h (25 mph).
- Half of all fatalities in frontal crashes occur at a delta V above 48 km/h (30 mph).
- In NHTSA tests, almost all vehicles with redesigned air bags passed the 48 km/h (30 mph) rigid barrier test with the 50th percentile adult male dummy, implying that a return to a 48 km/h (30 mph) test speed would not require a return to overly aggressive air bags.
- Advanced technologies can be used to enable all vehicles to meet requirements for high speed protection and risk reduction.
- There is no justification to reduce the test speed to 40 km/h (25 mph).
- A 40 km/h (25 mph) test speed would not encourage use of advanced technologies.
- A 40 km/h (25 mph) test speed would be inconsistent with the TEA 21 requirement to improve protection for unbelted occupants.

- The increase of the belted test speed to 56 km/h (35 mph) would not recover lives lost as a result of reducing the unbelted test speed to 40 km/h (25 mph).

While maximum speed was the most controversial issue concerning the unbelted test, commenters raised other issues as well. Some vehicle manufacturers objected to the proposal to test over a range of speeds from 29 km/h (18 mph) to the highest speed. They argued that being required to meet test requirements to ensure protection beginning at 29 km/h (18 mph), combined with the proposal to test under the low risk deployment option for inflation level (or levels) that would be deployed in crashes below 29 km/h (18 mph), would limit design flexibility and discourage development of low risk deployment air bag systems.

Another significant issue addressed by commenters concerned the seating procedure for the 5th percentile adult female dummy. Vehicle manufacturers objected to the proposal to test with the seat in the full forward position. They argued that occupants, including small females, rarely if ever sit in that position. They also argued that adoption of this position could result in consequences such as smaller, less protective air bags, and reduced ingress/egress space for rear passengers.

Several safety advocacy groups argued in favor of testing with the seat in the full forward position. They argued that some occupants sit in that position and that it is necessary to test in the "worst case" condition.

Improving the Protection of Belted Occupants in Serious Crashes.

Commenters supported our proposal to add the 5th percentile adult female dummy to the existing 48 km/h (30 mph) belted rigid barrier test.

Most supporters of a 40 km/h (25 mph) unbelted rigid barrier test, including most vehicle

manufacturers, also supported increasing the maximum speed of the belted rigid barrier test to 56 km/h (35 mph). However, these commenters urged that the 56 km/h (35 mph) belted rigid barrier test be phased in after the TEA 21 phase-in period. They also urged that the higher speed test initially be conducted only with the 50th percentile adult male dummy, and that a separate rulemaking be initiated to consider whether the 5th percentile adult female dummy should be tested at that speed.

Most commenters also supported our proposal to add the up-to-40 km/h (25 mph) offset deformable barrier test using belted 5th percentile adult female dummies. Some of these commenters, however, urged that an out-of-position test for the passenger side be developed as an alternative to the test. DaimlerChrysler opposed adoption of this test, arguing that the European barrier used in the test is not appropriate for testing heavier vehicles such as SUVs and light trucks.

Some commenters expressed concerns that our proposal would result in there being too many crash tests in Standard No. 208, and requested that we reconsider whether all of the proposed tests are needed.

Minimizing the Risk of Injuries and Deaths Caused by Air Bags.

Commenters supported the basic approach of our proposed requirements to minimizing the risk of injuries and deaths caused by air bags, including providing a variety of testing options that account for the kinds of effective technological solutions that are under development.

Vehicle manufacturers argued that some of the test conditions specified for the proposed static suppression tests, including the range of seat back angles and seat track positions, would make the tests impracticable.

Some commenters emphasized that we need to allow manufacturers to use both suppression and low risk technologies. As noted earlier, some commenters argued that adjustments need to be made in both the unbelted rigid barrier test requirements and in the requirements for the low risk deployment option to avoid limiting use of the low risk deployment option.

Commenters were generally supportive of our proposal to permit manufacturers to certify to requirements referencing human beings in a stationary vehicle to test suppression systems, so long as steps are taken to ensure the safety of all subjects used for testing.

Other Issues.

Commenters generally supported the proposed injury criteria and associated performance limits, although vehicle manufacturers recommended some changes.

We received numerous comments raising specific technical issues concerning how dummies are to be positioned for the various tests.

Commenters generally argued that current provisions allowing manual on-off switches for air bags under certain circumstances should remain in effect for a longer period of time, and a number of commenters argued that existing warning labels should not be weakened or eliminated at this time.

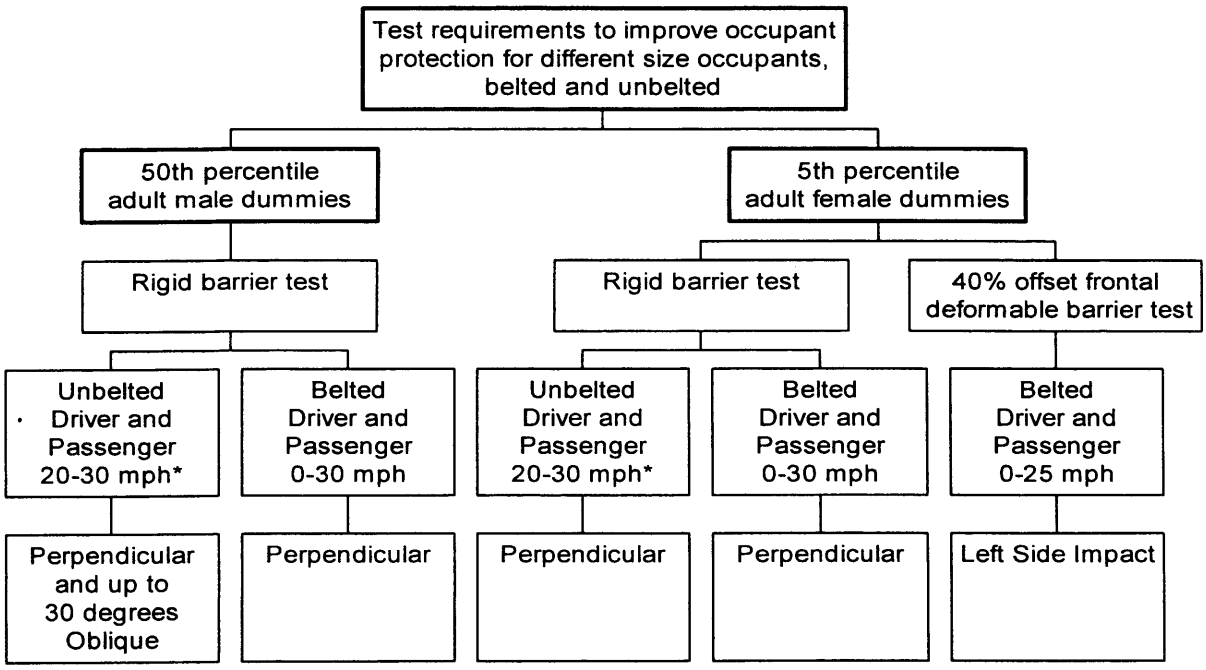
There was also significant differences of opinion regarding our proposals about the provision providing a due care defense against findings of noncompliance with the air bag requirements of Standard No. 208.

Several commenters raised concerns about possible unforeseen consequences resulting from the use of advanced air bag technologies.

We received several comments expressing concern about the potential impacts of this rulemaking on small businesses.

## IX. Diagram of the Final Rule Requirements

After carefully considering the comments, we have decided to issue a final rule along the lines of the SNPRM. The key differences between the SNPRM and the final rule are discussed in the Executive Summary and will not be repeated here. The test requirements to improve occupant protection for different size occupants, belted and unbelted, and to minimize risks to infants, children, and other occupants from injuries and deaths caused by air bags, are shown in Figures 1 and 2 below.




* Range is 20-25 mph during first stage of the phase-in of the final rule

Figure 1

Test Requirements to Improve Occupant Protection for Different Size Occupants,

Belted and Unbelted

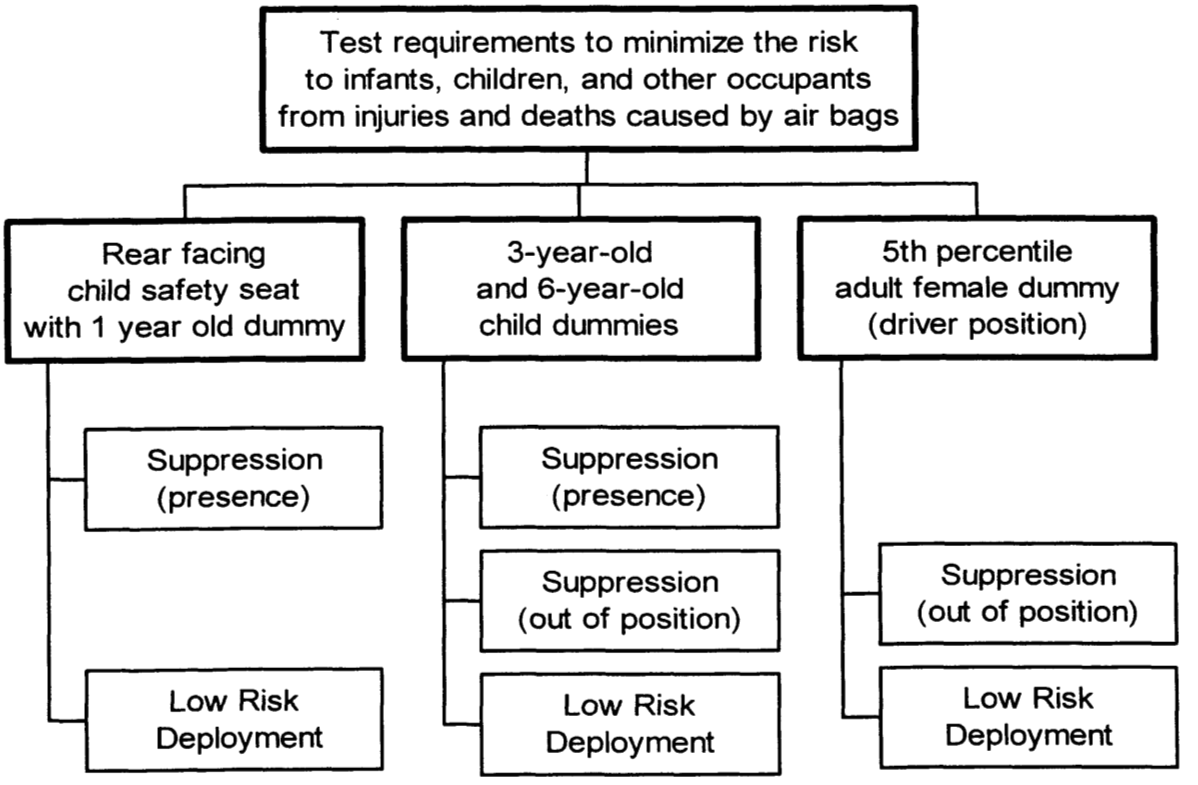



Figure 2

Test Requirements to Minimize the Risk to Infants
Children and Other Occupants from Injuries
And Deaths Caused by Air Bags

## X. Improving the Protection of Unbelted Occupants in Serious Crashes

### A. Introduction

One of the most significant issues of this rulemaking is what test requirements should be adopted to ensure improvement in the protection of unbelted occupants in serious crashes. There are two reasons why this issue is of particular significance.

The first reason is that this issue has the largest potential effect on the number of lives that will be saved by air bags. We project that more than 3,200 lives will be saved annually by air bags once all vehicles are equipped with them and note that almost three quarters would be unbelted occupants. This projection is based on several assumptions, the most important of which is that the current level of air bag effectiveness is maintained. The validity of that assumption hinges on the decision in this final rule about the test for protecting unbelted occupants.[24] However, if future air bags are designed in ways that do not take full advantage of opportunities to enhance the safety of unbelted occupants in serious crashes, some of those savings will be lost.

The second reason for the importance of the issue is the technical challenge that the unbelted test requirements may pose for vehicle manufacturers when coupled with the broad array of other requirements that are the subject of this rulemaking. Some commenters contended that the unbelted test requirements could act as a constraint that would make it difficult for manufacturers to meet the other requirements.

### B. Summary of Proposed Requirements

---

[24] This projection also assumes the continuation of current levels of seat belt usage. As noted earlier, if observed seat belt use rates were to increase to 85 percent, the goal for 2000 set by DOT in 1997, the annual savings of lives due to air bags would be reduced to approximately 2,400, about 60 percent of whom would be unbelted.

In the SNPRM, we proposed to phase out the unbelted sled test option as the requirements for advanced air bags are phased in. There were two reasons for this proposal. First, because the test is relatively benign, it is not representative of many potentially fatal crashes. Second, as explained below, sled tests have inherent limitations as compared to crash tests in measuring occupant protection.

We explained that, unlike a full scale vehicle crash test, a sled test cannot measure the actual protection an occupant will receive in a crash. We noted that while the current sled test measures some performance attributes of the air bag, it cannot measure the performance provided by the vehicle structure in combination with the air bags or even the full air bag system by itself. We also noted that the sled test does not evaluate the actual timing of air bag deployment (e.g., crash sensors), does not replicate the actual crash pulse of a particular vehicle model, does not measure the potential for harm from vehicle components that are pushed back into the occupant compartment during a crash, and does not measure how a vehicle performs in angle crashes.

The purpose of the sled test option was to make it easier for vehicle manufacturers to make quick changes to their air bags to reduce risks to out-of-position occupants. Vehicle manufacturers could not immediately incorporate advanced technologies in their vehicles, and the sled test facilitated the process of quickly certifying large numbers of vehicles with redesigned air bags to Standard No. 208. We believe the sled test has been useful as a short-term measure. Over the longer time frame, however, we believe that a better test is needed to ensure the protection of unbelted occupants.

To replace the sled test, we proposed two alternative unbelted crash test procedures: an unbelted rigid barrier test and an unbelted offset deformable barrier test. We proposed that the

unbelted rigid barrier test be conducted perpendicular and up to ± 30 degrees oblique to perpendicular with 50th percentile adult male dummies, but perpendicular only in tests with 5th percentile adult female dummies. The injury criteria would have to be met within the range of a minimum speed of 29 km/h (18 mph) and a maximum speed to be established within the range of 40 to 48 km/h (25 to 30 mph). This alternative was based on the unbelted crash test that has been part of Standard No. 208 for many years but which has, as a practical matter, been temporarily superseded by the sled test option since March 1997. The barrier test represents a vehicle striking a vehicle of the same size, weight and structure head on at the same speed.

We indicated that within this first alternative, the potential existed for a phase-in sequence in which the maximum speed would temporarily be set at 40 km/h (25 mph) to provide vehicle manufacturers additional flexibility when they are introducing advanced air bags during the TEA 21 phase-in. Under this approach, the final rule could provide that a maximum speed of 48 km/h (30 mph) would apply after that period. We also indicated that if we were to reduce the maximum speed to 40 km/h (25 mph) permanently, we might also increase the maximum speed of the belted rigid barrier test from the current 48 km/h to 56 km/h (30 to 35 mph).

We proposed that the second alternative procedure, the unbelted offset deformable barrier test, would be conducted using both 50th percentile adult male dummies and 5th percentile adult female dummies, with a minimum speed of 35 km/h (22 mph) and a maximum speed to be established within the range of 48 to 56 km/h (30 to 35 mph). This alternative was based on a type of crash test used by IIHS and by Europe, except that unbelted dummies would be used.

For both alternatives, we proposed to conduct the crash tests with 50th percentile adult male dummies with the seat in the middle seat track position. However, we proposed in the

SNPRM to conduct tests using 5th percentile adult female dummies with both the driver and passenger seats in the full forward position. We tentatively selected this position because some small adults sit there and because we believe that air bags should protect those people.

We noted, however, that placement of the 5th percentile adult female dummy in the full forward position tests the occupant restraint system under a condition that may not generally occur in the real world. The University of Michigan Transportation Research Institute (UMTRI) conducted a study in which it concluded that even drivers who are approximately the same size as the 5th percentile adult female dummy generally do not sit in the full forward seat track position (Docket No. NHTSA-1998-4405-69). Also, while some short-statured drivers might need to move the driver's seat all the way forward to reach the controls, a passenger in the front passenger seat would be less likely to have a similar need. Another concern was whether, in order to meet tests for conditions that rarely occur in the real world, manufacturers might select air bag designs that offer reduced protection for conditions that are more common in the real world. Accordingly, we requested comments on whether testing the 5th percentile adult female dummy with the seat in something other than the full forward seat track position would adequately protect properly-seated individuals of all sizes while potentially allowing more design freedom.

### C. Type of Test

Commenters that previously advocated retention of the sled test indicated a willingness to accept the unbelted rigid barrier test. No commenters disputed the inherent limitations of sled tests as compared to crash tests. Nearly all commenters supported the unbelted rigid barrier test over the unbelted offset deformable barrier test. However, as discussed in the next section, the

commenters that had previously supported the sled test wanted the maximum speed of the unbelted barrier test reduced to 40 km/h (25 mph).

Vehicle manufacturers stated that the rigid barrier test is practicable and repeatable and does not entail the variability associated with deformable barriers and the kinematics of an offset test. They also stated that the European barrier used in the offset test is not appropriate for testing larger SUVs and light trucks. Several vehicle manufacturers, including GM, Honda and DaimlerChrysler, stated that a high speed unbelted offset test would pose problems for vehicle sensor systems.

CAS stated that the unbelted offset test holds promise as a supplemental test, but is not yet suitable for inclusion in Standard No. 208. That organization stated that there are currently insufficient data to allow for a comprehensive analysis of the consequences that would accompany the adoption of the offset test.

Several other commenters also argued that an unbelted offset test offers promise for the future, either as a replacement for the rigid barrier test or as a supplemental test. Ford stated that although not practicable during the TEA 21 phase-in period, it believes that a 48 km/h (30 mph) offset test potentially represents a better long-term approach for enhancing unbelted protection.

Parents stated that the final rule should include both the unbelted rigid barrier test and the unbelted offset test. That organization argued that the two tests provide distinct means of ensuring protection in very different circumstances, and that inclusion of both tests is necessary in order to ensure adequate protection for unbelted occupants.

After considering the comments, we have decided to adopt the unbelted rigid barrier test to ensure protection for unbelted occupants in serious crashes. This is the unbelted crash test

included in Standard No. 208 for the past 30 years. We also use a belted rigid barrier test for Standard No. 208 and our New Car Assessment Program (NCAP). Detailed information about this type of test is presented in a paper prepared by our Office of Research and Development titled "Updated Review of Potential Test Procedures for FMVSS No. 208." That paper was prepared to accompany our SNPRM.[25]

We note that we sought comment in the SNPRM on the unbelted offset test principally to ensure that we received the benefit of public comments on all of the various alternative approaches that are available at this time. In the NPRM, we indicated that while we believed the unbelted rigid barrier test was a good approach, we were also willing to consider alternative unbelted crash tests. The only alternative unbelted crash test advocated by a commenter that could realistically be implemented within the time frame of this rulemaking was the offset deformable barrier test.

However, the commenter that originally suggested consideration of the unbelted offset test, IIHS, withdrew its support before the SNPRM was published. No commenter on the SNPRM supported adopting the unbelted offset test instead of the unbelted rigid barrier test.

As to Parents' recommendation that we adopt both unbelted tests, we believe that adoption of the proposed unbelted high speed offset test would be inappropriate at this time. As noted above and also discussed in the SNPRM, several manufacturers have raised concerns that the proposed high speed unbelted offset test would pose problems for vehicle sensor systems. See 64 FR 60579. Manufacturers have also argued that the proposed high speed unbelted offset

---

[25] One commenter, DaimlerChrysler, submitted a critique of that paper as part of its comments. We are placing in the docket an addendum to the paper which responds to that critique.

test is not appropriate for testing larger SUVs and light trucks. We would want to further analyze these issues before including this test in a Federal motor vehicle safety standard.

We also note that while we agree with Parents that the two high speed tests provide distinct means of ensuring protection in different circumstances, this does not mean that adoption of those particular two tests would be needed to ensure protection in those different circumstances. We believe that the combination of an unbelted rigid barrier test and belted offset tests can accomplish the same purpose.

As discussed in the SNPRM, the high speed unbelted rigid barrier test and the high speed unbelted offset test are significantly different, and each has potential advantages as compared to the other. The two principal advantages of an offset test are that it provides a more challenging test of vehicle crash sensors and of vehicle structure. However, these areas of performance are addressed by belted offset tests as well as unbelted offset tests.

As discussed later in this document, we are adopting an up to 40 km/h (25 mph) belted offset deformable barrier test as part of today's final rule. This test will help ensure improved sensing systems, which will benefit both belted and unbelted occupants. We are also separately pursuing our previously-announced plans to consider adding a high speed belted offset test to Standard No. 208. This test would help ensure improved vehicle structure and reduced intrusion injuries, again benefitting both belted and unbelted occupants. Because the combination of an unbelted rigid barrier test and belted offset tests (either being adopted today or currently being considered by the agency for rulemaking) can accomplish the same purpose as an unbelted offset test, we do not currently plan to consider further adopting an unbelted offset test.

**D. Agency Decision to Phase in the Maximum Test Speed in Two Stages:**

**a 40 km/h (25 mph) Maximum Speed During Stage 1 and a 48 km/h (30 mph) Maximum Speed During Stage 2**

**1. The Supplemental Proposal**

In the SNPRM, we proposed that the maximum speed for the unbelted rigid barrier test be established within the range of 40 to 48 km/h (25 to 30 mph).

We stated that it was our intent to maximize, to the extent consistent with TEA 21, the protection that air bags offer in crashes potentially resulting in fatal injuries. Thus, we stated that it was our preference to establish such a test requirement at as high a severity as practicable. We stated that the 40 km/h (25 mph) lower end of the maximum test speed range was set forth for comment to ensure that commenters addressed a crash test recommended by AAM in late August 1999.

We also stated that the potential existed for a phase-in sequence in which the maximum speed would initially be set at 40 km/h (25 mph) to provide vehicle manufacturers additional flexibility when they are introducing advanced air bags during the phase-in. We explained that under this phase-in sequence, the final rule could provide that a maximum speed of 48 km/h (30 mph) would apply after a reasonable period of time.

We noted that, in commenting on the NPRM, the commenters opposing the 48 km/h (30 mph) unbelted barrier test had raised two primary issues. First, they argued that the test is not representative of typical crashes. Second, they argued that returning to this test would prevent continued use of "depowered" air bags and would require a return to "overly aggressive" air bags.

We addressed each of these issues in the SNPRM. As to whether the test is representative of typical crashes, we stated that because the purpose of Standard No. 208 is

primarily to reduce serious and fatal injuries, we believed that the relevant question is how representative the test is of the crashes that produce those injuries. We presented data from the National Automotive Sampling System (NASS) for years 1993-1997 showing, among other things, that about 50 percent of fatalities in frontal crashes occur at delta Vs below 48 km/h (30 mph), and about 50 percent occur at delta Vs above 48 km/h (30 mph). Looking separately at unbelted and belted occupants, we noted that 51 percent of the fatalities involving unbelted occupants and 47 percent of the fatalities involving belted occupants occur in frontal crashes at delta Vs below 48 km/h (30 mph). We noted that the delta V in NASS represents the speed at which the vehicle would strike a rigid barrier to duplicate the amount of energy absorbed in the crash. Thus, about half of fatalities in frontal crashes occur in crashes that are more severe than a 48 km/h (30 mph) rigid barrier crash, and half of all frontal crash fatalities occur in crashes that are less severe than a 48 km/h (30 mph) rigid barrier crash.

Given that Standard No. 208's unbelted crash test requirements are intended to save lives, we stated that we disagree that 48 km/h (30 mph) rigid barrier crashes are unrepresentative of the kinds of crashes in which we are seeking to ensure protection. We also noted that since we were proposing to require vehicles to meet the unbelted test requirements for a range of speeds up to and including 48 km/h (30 mph), we were addressing protection for lower severity crashes as well as higher severity crashes.

As to the argument that returning to the unbelted 48 km/h (30 mph) rigid barrier test would prevent continued use of "depowered" air bags and require use of "overly aggressive" air bags, we stated that a key way of assessing the validity of the argument that a return to the 48 km/h (30 mph) barrier test would -- at least in the absence of additional technological

improvements -- prevent continued use of redesigned air bags was to test vehicles with those air bags in 48 km/h (30 mph) barrier tests and see how they perform. We noted that we had tested a total of 13 MY 1998-99 vehicles with redesigned air bags in a perpendicular rigid barrier crash test at 48 km/h (30 mph) with unbelted 50th percentile adult male driver and passenger dummies. The vehicles represented a wide range of vehicle types, sizes, and crash pulses.[26]

We stated that, for the driver position, 12 of the 13 vehicles passed all the relevant injury criteria performance limits we proposed in the SNPRM. In the one vehicle with a failure, the MY 1999 Acura RL, the driver dummy exceeded the femur load criteria. For the passenger position, 12 of the 13 vehicles also passed all of the relevant injury criteria performance limits. The MY 1998 Dodge Neon slightly exceeded the 60 g chest acceleration limit (with a value of 61.4 g). The other proposed injury criteria performance limits (i.e., for HIC, chest deflection, and Nij) were easily met in all the tests; for most vehicles, there was a greater than 20 percent margin of compliance for both the driver and passenger seating positions.

We stated that the tested vehicles with redesigned air bags, ranging widely in vehicle type and size, therefore appeared to continue to meet Standard No. 208's 48 km/h (30 mph) unbelted rigid barrier test requirements for 50th percentile adult male dummies, many of them by wide margins.

We also noted that the relevant issue for this rulemaking is not whether some MY 1998-99 vehicles with redesigned, single-inflation level air bags would not meet a 48 km/h (30 mph)

---

[26] In particular, the 13 vehicles included one sub-compact car, one compact car, four mid-size cars (representing high sales volume vehicles), one full-size car, two mid-size sport utility vehicles, one full-size sport utility vehicle, one pickup truck, one minivan, and one full-size van. The specific vehicles and their classes included a Saturn (sub-compact car), a Neon (compact car), an Intrepid, Camry, Taurus, and Accord (mid-size cars), an Acura RL (full-size car), an Explorer and Cherokee (mid-size SUVs), an Expedition (large SUV), a Tacoma (pickup truck), a Voyager (minivan), and an Econoline (full-size van).

unbelted barrier test requirement. The more relevant issue is whether vehicles to be manufactured in MY 2003 and later would be able to comply with such a requirement, perhaps by means of currently available technologies not in many air bag systems as well as technologies still being or yet to be developed. We explained that TEA 21 mandates the issuance of a final rule based on means that include advanced air bag technologies. We stated that we believe the selection of future compliance tests under TEA 21 must be made in the context of those technologies, and not in the context of today's less sophisticated one-size-fits-all air bag designs.

We explained that today's air bag systems are not advanced air bags and thus do not respond to factors such as crash severity, occupant weight and occupant location. By contrast, the incorporation of advanced technologies would make air bag systems responsive to those factors.

We also noted:

> If a manufacturer decided to use a somewhat more powerful air bag to meet a 48 km/h (30 mph) unbelted rigid barrier test, or to provide protection in more severe crashes, the manufacturer could use advanced air bag technologies to provide less powerful levels of inflation in lower severity crashes, for smaller occupants, for belted occupants, and for occupants sitting with the seat in the full-forward position. Manufacturers could also reduce aggressivity of air bags by various means such as optimizing fold patterns, different cover designs, lighter fabrics, etc. Advanced technologies would also enable the manufacturer to suppress air bag deployment in appropriate circumstances, such as when children are present.

In our Preliminary Economic Assessment (PEA) accompanying the SNPRM, we estimated the benefits of an unbelted rigid barrier test with a maximum speed of 40 km/h (25 mph) vs. 48 km/h (30 mph). The PEA concluded that if the full fleet of vehicles' air bags were designed in the context of unbelted 40 km/h (25 mph) rigid barrier and oblique tests, an estimated 214 to 397 lives saved annually by pre-MY 1998 air bags might not be saved.

### 2. Summary of Comments

Commenters on the SNPRM nearly unanimously supported adoption of an unbelted rigid barrier test, but sharply disagreed over the maximum speed for that test. Safety advocacy groups, supported returning to 48 km/h (30 mph). Auto companies, air bag suppliers, IIHS, and NTSB supported a maximum speed of 40 km/h (25 mph).

Commenters supporting 48 km/h (30 mph).

Safety advocacy groups supporting a maximum test speed of 48 km/h (30 mph) argued that it would result in higher life-saving benefits than a 40 km/h (25 mph) speed.

These commenters emphasized that half of all fatalities in frontal crashes occur at delta Vs above 48 km/h (30 mph). Parents argued that a 48 km/h (30 mph) test speed is very typical of potentially fatal crashes since it is in the middle of the crash speeds that cause fatalities. That commenter also argued that air bag systems certified as meeting the injury criteria at the higher speeds proposed in the rule will have greater efficacy in severe frontal collisions than would air bags certified as complying at some lesser speed.

CAS stated that the 5 mph difference between 40 km/h (25 mph) and 48 km/h (30 mph) is substantial. It stated that a 48 km/h (30 mph) barrier crash is 40 percent more severe than a 40 km/h (25 mph) crash. It also stated that NHTSA data show that almost 20 percent of occupant fatalities in frontal crashes occur between 40 km/h (25 mph) and 48 km/h (30 mph) delta V.

Public Citizen stated that real world driving conditions require the return to a 48 km/h (30 mph) test. That organization stated that these conditions include higher speed limits, as well as the prevalence of vastly increased numbers of SUVs and LTVs designed with stiff front ends. Public Citizen stated that the stiffness of these vehicles, as well as other factors including higher

mass, transmit increased forces to passenger cars in crashes.

Public Citizen also argued that over the past 30 years, Americans have used the 48 km/h (30 mph) rigid barrier test as the litmus test for a vehicle's crashworthiness. It noted that other motor vehicle safety standards are based on a 48 km/h (30 mph) test. Public Citizen stated that if the 48 km/h (30 mph) test were dropped, the public would view the decision as a step backward.

Public Citizen stated that one indicator of the inadequacy of a 40 km/h (25 mph) test is a statement by GM in the 1980's that it could pass an unbelted 40 km/h (25 mph) test with "friendly interiors" and no air bag at all.

CAS also stated that a 40 km/h (25 mph) unbelted test, even if coupled with a 56 km/h (35 mph) belted test, is but a slight variation of GM's proposal to Secretary Dole in 1984 for a 40 km/h (25 mph) unbelted and 48 km/h (30 mph) belted standard. CAS argued that if a car with friendly interiors could meet a 40 km/h (25 mph) barrier test in 1984 without an air bag, as GM suggested then that it could, then the addition of a cosmetic air bag would enable a vehicle to meet Standard No. 208 today, even with its revised injury criteria.

These commenters also cited the agency's estimates in the PEA that a 40 km/h (25 mph) test speed could result in 214 to 397 fewer lives saved each year.

These safety advocacy groups also argued that there is no justification to reduce the longstanding 48 km/h (30 mph) test speed and that such a reduction would be inconsistent with the TEA 21 requirement to improve protection of occupants of different sizes, belted and unbelted.

CAS argued that reducing the unbelted test speed to 40 km/h (25 mph) would decrease the level of protection for unbelted occupants who are involved in moderate to high speed

collisions. According to that commenter, Congress cannot possibly have envisioned a backward step as an improvement to safety when it mandated that the advanced air bag rulemaking take place.

Public Citizen stated that the whole point of upgrading Standard No. 208 is to ensure that automakers make better air bag restraint systems and that the standard should reflect as much as possible the protection needed in real world crashes.

According to Public Citizen, a 48 km/h (30 mph) unbelted barrier test would force manufacturers to incorporate more advanced technology. Public Citizen argued that without the additional challenge of the 48 km/h (30 mph) unbelted test, the automakers would have little motivation to move forward technologically in the future.

These commenters strongly disagreed with the arguments of the industry and some others that a 48 km/h (30 mph) standard would require overly aggressive air bags or not be possible to meet for both 50th percentile adult male dummies and 5th percentile adult female dummies.

Parents stated that the industry's rationale for a 40 km/h (25 mph) maximum speed is that the traditional 48 km/h (30 mph) speed compels production of air bag systems that are necessarily and unavoidably dangerous for small occupants in lower speed collisions. That organization stated that it strongly disagrees with this position. According to Parents, this position ignores the outstanding safety record of many well designed air bag systems that have complied with the 48 km/h (30 mph) requirement over the years. Parents also stated that this argument does not take into account advanced air bag technologies, the technologies that the advanced air bag rule is supposed to foster.

Parents also argued that the SNPRM rebutted the industry's argument that adoption of a

48 km/h (30 mph) test speed would necessarily require vehicle manufacturers to revert to excessive deployment forces found in many systems prior to sled testing. Parents stated that the agency pointed out that virtually all of the depowered air bag systems it tested still passed the 48 km/h (30 mph) test. That organization also stated that compliance margins were fairly wide and typically as wide as margins used by industry in complying with the 48 km/h (30 mph) test. Parents stated that for systems that don't meet the 48 km/h (30 mph) test, development of advanced technologies would allow these vehicles to also meet the test.

Consumers Union argued that the agency's testing of 13 vehicles with redesigned air bags leads it to conclude that even before the comprehensive redesign in air bag systems contemplated in this rulemaking, a wide variety of vehicles with depowered air bags already can pass the 48 km/h (30 mph) unbelted test. That organization stated that, contrary to the industry argument, air bags in many varieties of vehicles apparently do not need to be repowered or made "overly aggressive" in order to pass the 48 km/h (30 mph) test.

Consumers Union also stated that in NHTSA tests, two of four vehicles tested, the MY 1999 Saturn and MY 1998 Taurus, passed all the injury criteria for the driver and passenger using unbelted 5th percentile adult female and 50th percentile adult male dummies in 48 km/h (30 mph) rigid barrier tests. That organization argued that if these vehicles can pass these tests even before they have been redesigned to meet a revised Standard No. 208, other vehicles can be engineered to do so as well. These tests were also cited by other commenters supporting a 48 km/h (30 mph) standard.

Public Citizen argued that any trade-offs between meeting requirements for the 5th percentile adult female and 50th percentile adult male dummies can be overcome with the right

combination of new technologies. Public Citizen cited dual or multi-level inflators, innovative folding patterns and bag shapes, lighter weight fabrics, tethers, pedal extenders, moving modules, deep dish steering wheels, collapsible steering columns, knee bolsters, stitching that keeps bags narrow to protect in low-level inflation and separates to protect occupants in higher impact crashes, top mounted vertically deploying air bags, chambered air bags (in effect, a smaller bag inside a larger one), and occupant position sensors that adjust deployment level or suppress deployment altogether.

Public Citizen also stated that the new test requirements, including static and dynamic tests using infant, child and small adult size dummies, already address the manufacturers' concerns regarding the "excessive" power of air bags in low severity crashes.

Syson-Hille and Associates presented an analysis of the history of air bags which it argued shows that the fatalities that have been caused by air bags are the result of poor air bag designs and not the 48 km/h (30 mph) barrier test.

Commenters supporting 40 km/h (25 mph).

Commenters supporting a maximum test speed of 40 km/h (25 mph) argued that there would not be a loss of benefits associated with a test at this speed, as compared to a 48 km/h (30 mph) standard.

AAM stated that the benefits of redesigned air bags will be maintained with a 40 km/h (25 mph) test. It argued that there is no reason to believe air bags designed to the sled test requirements have compromised protection, and that a 40 km/h (25 mph) barrier test has a more severe pulse than the sled test.

AAM also stated that a new 40 km/h (25 mph) test cannot simply be compared to the old

48 km/h (30 mph) test because the new test would include additional injury criteria and an additional dummy. It stated that the benefits of the other tests included in the final rule should also be considered.

AAM argued that the analyses of benefits presented in the PEA are based on dummy readings from one dummy at one position in a single type of crash test in a single direction at a single speed. It stated that this approach is not comprehensive enough. AAM also argued that the strongest evidence that there are analytical limitations inherent in the agency's benefit analyses (past and present) is that past analyses predicting similar dire consequences for the adoption of the sled test that simply have not come true.

AAM stated that it had considered the level-of-benefit question from two different perspectives. The first involved the generation of benefit estimates using a MADYMO math model to develop a theoretical "optimum" design for both the 40 km/h (25 mph) and 48 km/h (30 mph) suite of tests. The performance of those designs was then modeled over a broad spectrum of real world crash configurations. Based upon an injury/fatality risk analysis of the model's output injury measures, relative benefits were calculated. The second perspective utilized an "opportunities matrix" approach to examine relative benefits by generating effectiveness estimates and applying these estimates to the spectrum of real world crash conditions.

According to AAM, both of these approaches yield the same conclusion--when considering air bag designs constrained by testing unbelted occupants at 40 km/h (25 mph) or 48 km/h (30 mph), the desired goal of reducing serious-to-fatal injuries in real world crashes is best served by requiring testing at 40 km/h (25 mph).

Vehicle manufacturers stressed the argument that the agency should focus on the experience of redesigned air bags in MY 1998 and MY 1999 models. They argued that these redesigned air bags have provided real world benefits and that there is no evidence that more power is needed.

Toyota stated that NHTSA's belief that manufacturers will substantially decrease power in future air bags compared to current systems is unfounded. It presented data comparing velocity vs. time traces for the sled test and the 40 km/h (25 mph) test for both an SUV and a sedan, and noted that the 40 km/h (25 mph) test pulses were more severe. Toyota argued that, in order to manage this level of energy, the air bags for these vehicles cannot be depowered further than the current levels, and that there is no reason to believe that air bags designed to the 40 km/h (25 mph) rigid barrier test will perform worse in high speed collisions than those designed to the sled pulse.

IIHS stated that it does not agree that a high-speed barrier test using unbelted dummies will necessarily lead to improved protection for any occupants, belted or unbelted. That organization stated that it disagreed with what it characterized as the agency's claim that, unless it returns to the 48 km/h (30 mph) barrier test, air bags will offer inadequate protection to many unbelted occupants, especially large people in more severe frontal crashes. That organization stated that in a number of studies of air bag performance in moderate to severe frontal crashes, it has shown that drivers are not dying because air bags offer too little protection; rather, drivers are dying because of overwhelming intrusion that no air bag design can overcome, ejection of occupants, or because of injury from the air bag itself.

IIHS argued that these observations call attention to what it believes are two errors in the

agency's logic for returning to a 48 km/h (30 mph) test. First, that commenter argued that if air bags are not powerful enough, there should be some real world cases in which the energy of the deploying bags was inadequate to protect individuals in otherwise survivable frontal crashes. IIHS stated that it is not aware of any such case. It also stated that the agency's concern that air bags certified to the unbelted generic sled pulse would be less effective in frontal crashes has no foundation in real world crash data.

Second, IIHS argued that the agency has failed to appreciate that serious and fatal injuries from deploying air bags are happening not only in low speed crashes, but also in the high speed crashes in which air bags are supposed to be most effective. That commenter stated that a recent update (including 1996 data) of its analyses of driver fatalities in air bag-equipped cars indicates air bags were the most likely source of the fatal injuries in about 15 percent of frontal crash deaths. IIHS argued that the agency must account for these deaths, as well as those more easily documented in low speed crashes, before it can justify a return to the 48 km/h (30 mph) unbelted barrier test.

IIHS also addressed the agency's concern that, without what that organization termed a "severe crash test" for unbelted occupants, manufacturers may reduce air bag inflation energy, or the size of air bags, thereby compromising their effectiveness. IIHS argued that such changes are constrained by other non-regulatory crash tests to which the manufacturers are subject. That organization stated that NCAP requires that air bags be reasonably deep in order to prevent dummies' heads from striking through the bags, and that offset crash testing by it and others worldwide means manufacturers will continue to install air bags with sufficient radial size to keep occupants squarely behind their air bags, even under conditions of sharp vehicle rotation.

NADA argued that the agency's proposed advanced air bag performance criteria fail to account for reasonably projected increases in safety belt and child restraint usage or for the real-life incremental benefits attributable to "depowered" air bags. NADA stated that it is reasonable to assume that by MY 2003, proper driver and passenger (including children) seat belt usage and child restraint usage rates will exceed 80 percent, and that by MY 2006, these rates should exceed 90 percent.

Vehicle manufacturers also argued that it is difficult or impossible to comply with the 48 km/h (30 mph) rigid barrier test for both the 50th percentile adult male dummies and the 5th percentile adult female dummies. They also argued that it may not be possible to satisfy both the 48 km/h (30 mph) unbelted rigid barrier test and the low risk deployment tests.

AAM stated that while the agency has claimed that most vehicles with redesigned air bags continue to meet the unbelted 48 km/h (30 mph) barrier test, very little testing has been done with these same vehicles at 48 km/h (30 mph) with 5th percentile adult female dummies. AAM stated that the little testing that has been done produced a 50 percent failure rate. That organization stated that this testing illustrates the design tensions that the industry has been emphasizing. According to that organization, these tensions result from technology constraints which presently discern limited information about occupant size and location, crash sensors with limited predictive capability and air bags with only two power levels.

According to AAM, it is especially challenging to balance occupant protection for both the 5th percentile adult female and the 50th percentile adult male dummies and assure compliance with the barrier test. As an example, AAM cited the agency's test of the Toyota Tacoma, which resulted in an Nij of 2.65 for the 5th female passenger dummy, nearly three times

the allowable injury reference value. According to AAM, the air bag size and fill needed to assure compliance with the chest injury limits with 50th percentile adult male dummies at 48 km/h (30 mph) results in noncompliant neck and thorax injury reference values for 5th percentile adult female dummies seated closer to the air bag. Conversely, according to AAM, if the air bag is sized for the unbelted 5th percentile female dummy at 48 km/h (30 mph), there is insufficient restraint of the unbelted 50th male dummy. AAM argued that testing at 40 km/h (25 mph) allows the restraint engineer to design the air bag to provide reasonable occupant protection for a broader range of occupant sizes.

GM made arguments similar to those of AAM. It argued that the unbelted 48 km/h (30 mph) barrier test using the 50th percentile adult male dummy determines the restraint energy, drives the depth of the air bag, and requires a deeper air bag that has more potential to injure a 5th percentile adult female. It argued that the unbelted 48 km/h (30 mph) barrier test using the 5th percentile adult female would require a shallower air bag that would not assure compliance for an unbelted 50th percentile adult male. According to GM, a 40 km/h (25 mph) test would permit air bag depth to be optimized for both the 5th percentile adult female and 50th percentile adult male dummies.

Ford stated that testing of the MY 2000 Taurus using 5th percentile adult female and 50th percentile adult male dummies demonstrates the difficulties of balancing requirements with a 48 km/h (30 mph) test even for vehicles equipped with advanced technologies. That company noted that the MY 2000 Taurus has dual-level inflators and other advanced technologies.

GM argued that there is no technology or combination of technologies existing today that could satisfy both the 48 km/h (30 mph) unbelted rigid barrier test and the low risk deployment

tests. Honda stated that it had concerns about being able to meet the rigid barrier test for the 50th percentile adult male dummy and also meet the low risk deployment test for out-of-position occupants.

Commenters supporting a maximum speed of 40 km/h (25 mph) also argued that a 48 km/h (30 mph) maximum speed would require a return to overly aggressive air bags.

AAM stated that field evidence suggests that the current depowered air bags offer a high level of occupant protection in the real world while enhancing protection for at-risk groups. That organization stated that a return to 48 km/h (30 mph) unbelted testing would require increasing air bag inflator outputs in some vehicles, serving to increase the risk of harm to certain groups.

GM stated that it strongly recommends that "depowered" air bags continue to be the highest force level inflation boundary necessary to comply with Standard No. 208. It argued that given the positive indications from the field on the effects of depowering, and the continued positive indications in engineering laboratory testing, it would be a serious setback to motor vehicle safety should the agency send Standard No. 208 backwards by mandating a 48 km/h (30 mph) unbelted rigid barrier test.

Toyota stated that it believes a return to 48 km/h (30 mph) unbelted barrier testing would require an increase in air bag power in many models. That company stated that, given the lack of evidence that higher powered air bags are necessary, it strongly believes that reinstating this requirement would serve only to increase risk to at-risk groups, including out-of-position children and small statured adults.

DaimlerChrysler argued that a return to the unbelted 48 km/h (30 mph) barrier test would necessitate an increase in air bag inflator power, all things being equal. That commenter stated

that staged inflators can reduce, but not eliminate, the risk to smaller and out-of-position occupants in lower speed deployments. DaimlerChrysler asserted that to assure compliance, it would expect the power level of the staged deployment necessary to meet the requirements of an unbelted 48 km/h (30 mph) impact to be comparable to the pre-depowering level.

IIHS stated that while NHTSA crash tests indicate that some vehicles may meet the unbelted 48 km/h (30 mph) test without adding more energy, it believes the agency must recognize that this may not be possible in all, or even most, cases. That organization stated that when compliance becomes difficult, it will be far too easy for manufacturers to meet the 48 km/h (30 mph) test by increasing air bag inflation energy (or the second stage of the air bag).

NTSB stated that it is concerned that the 48 km/h (30 mph) unbelted barrier test could result in a return to higher energy air bags.

### 3. Maximum Test Speed Adopted in the Final Rule

After carefully considering the comments, we have decided to return the maximum speed of the unbelted test to 48 km/h (30 mph), but not immediately. The final rule will be phased in during two stages. During the first stage, from September 1, 2003 to August 31, 2006, increasing percentages of motor vehicles will be required to meet requirements for reducing air bag risks, either through automatically turning off the air bag in appropriate circumstances or deploying in a manner that will not cause serious injury to out-of-position occupants, or through a combination of those two approaches. A maximum test speed of 40 km/h (25 mph) will be phased in for the unbelted test during this first stage.

During the second stage, from September 1, 2007 to August 31, 2010, the maximum test speed for the unbelted crash testing will increase to 48 km/h (30 mph). As in the case of the

first-stage requirements, the second-stage requirements will be phased in for increasing percentages of motor vehicles.

### 4. Overall Rationale

We begin by taking note of where we have been and where we are now with respect to improving protection for occupants of all sizes, belted and unbelted, and minimizing the risks posed by air bags.

To speed the redesigning and recertifying of air bags to reduce the risks to out-of-position occupants, we amended Standard No. 208 to establish a temporary option under which vehicle manufacturers could certify their vehicles based on an unbelted sled test. We took this interim step because some design changes, such as depowering, could be implemented more quickly than the development and introduction of advanced air bag technologies. The sled test aided the manufacturers' efforts to redesign their air bags because it is simpler, less expensive, and easier to meet than the pre-existing 48 km/h (30 mph) unbelted test involving a crash into a rigid barrier. Available data indicate that the redesigned air bags have reduced the risks from air bags for the at-risk populations.

Although there has been only about two years of field experience with redesigned air bags, these data indicate that the redesigned air bags provide essentially the same level of frontal crash protection as that provided by earlier air bags. One reason we conclude that the redesigned air bags work as well as they have is that the vehicle manufacturers did not depower their air bags as much as we anticipated they would in the regulatory evaluation accompanying our 1997 final rule adopting the sled test option. Instead, NHTSA tests have shown that the manufacturers typically chose levels of depowering that still enabled them to pass the pre-existing 48 km/h (30

mph) unbelted crash test with a 50th percentile adult male dummy. Further, these tests have revealed that vehicles with redesigned air bags pass that test with that dummy by roughly the same margin of compliance as earlier vehicles did.

While the redesigned air bags in current motor vehicles have reduced the risk of air bag-induced injuries, they can still cause death or serious injury to unrestrained occupants. We are issuing today's final rule to meet two different, but equally important goals set forth in TEA 21:

> improve occupant protection for occupants of different sizes, belted and unbelted, under Federal Motor Vehicle Safety Standard No. 208, while minimizing the risk to infants, children, and other occupants from injuries and deaths caused by air bags, by means that include advanced air bags.

To minimize air bag-induced risks, we are specifying test requirements to ensure that driver air bags deploy in a low-risk manner in low speed crashes and that passenger air bags either deploy in that manner or automatically turn off in the presence of young children.[27] These new requirements will require vehicle manufacturers to further reduce the risks of current air bags.

As vehicle manufacturers redesign their air bags to meet the new requirements to minimize risks, we are concerned that, in the absence of an unbelted 48 km/h (30 mph) test requirement, they might reduce the protectiveness of current air bags. The cheapest and easiest way to meet the requirements to minimize risks is to make further reductions in the power and size of air bags. However, this would reduce the protection current air bags provide to unbelted occupants in moderate to serious crashes.

---

[27] The final rule also establishes very general performance requirements for dynamic automatic suppression systems (DASS) and a special expedited petitioning and rulemaking process for considering procedures for testing advanced air bag systems incorporating a DASS.

Air bags designed to minimally meet an unbelted 40 km/h (25 mph) crash test would be less protective than current redesigned ones. The difference between a 40 km/h (25 mph) and a 48 km/h (30 mph) crash is significant. The significance does not lie in the 20 percent increase in speed, but in the 40 percent increase in crash energy. It is because of that increase in crash energy that the risk of serious or fatal injury is significantly higher at 48 km/h (30 mph) than at 40 km/h (25 mph). Further, 50 percent of vehicle occupant fatalities occur in crashes over 48 km/h (30 mph). As a result, if air bags were designed only to minimally meet a 40 km/h (25 mph) crash test, some occupants would not be adequately protected in higher speed crashes. We estimate that 248 to 413 lives could be lost annually if that were to occur.

We also believe that a 40 km/h (25 mph) test is sufficiently benign so as not to constitute a good long-term test of the protection provided by a vehicle's restraint system. As we discussed in the SNPRM, GM advocated a 40 km/h (25 mph) unbelted rigid barrier test in the mid-1980s to facilitate passive interiors, i.e., building in safety by improving steering columns and padding. At that time, GM believed passive interiors would be better than automatic restraints, i.e., air bags or automatic seat belts. Based on available test data, including tests of then-current production vehicles, we concluded that it was generally evident that it was within the state-of-the-art to pass Standard No. 208's head and chest injury criteria at 40 km/h (25 mph) with unbelted 50th percentile adult male dummies without air bags. 49 FR 28995, July 17, 1984.

Given the addition of the Nij injury criteria performance limit, the more stringent limit on chest displacement and the addition of the 5th percentile adult female dummy, we believe that it

is unlikely that vehicles could pass an unbelted 40 km/h (25 mph) test without an air bag.[28] Nevertheless, the fact that passenger cars might pass the historic chest injury criteria and head injury criteria performance limits for 50th percentile adult male dummies without an air bag indicates that the test is too benign to constitute a good long-term test of the protection provided by an air bag-equipped vehicle.

We have considered the arguments of some commenters that a 40 km/h (25 mph) test would not result in a loss of benefits. The primary argument was that we should rely on the experience of redesigned air bags. However, the protection provided by current vehicles with redesigned air bags does not represent the minimum level of protection required by the sled test or a 40 km/h (25 mph) barrier test. The available data instead indicate that the vast majority of vehicles with redesigned air bags meet the 48 km/h (30 mph) barrier test. Thus, if we wanted to ensure that future air bags perform as well, it would follow that we should return to the 48 km/h (30 mph) barrier test. A lower standard would allow a degradation of performance.

We have also carefully considered two other key arguments advanced by the vehicle manufacturers, and in turn adopted or endorsed by several organizations and another Federal agency.

First, the vehicle manufacturers have raised the prospect of increased air bag-induced deaths, based on an assertion that a return to a 48 km/h (30 mph) crash test might necessitate a general return to more powerful air bags. NHTSA does not believe that there will be any general

---

[28] We note that we addressed a similar issue in the rulemaking establishing the temporary sled test option. Agency testing indicated that the unbelted sled test was sufficiently benign that vehicles could pass Standard No. 208's historic injury criteria for 50th percentile adult male dummies even if the air bag did not deploy. We added neck injury criteria performance limits to ensure that deployment of the air bag would be required to meet the test. However, we never intended the sled test to be the long-term test of the protection provided by an air bag-equipped vehicle.

need to repower. The manufacturers provided very limited information to substantiate that position. The relatively few confidential examples they cited were almost exclusively vehicles with particularly stiff crash pulses. Based on NHTSA crash tests of a representative subset of the current new vehicle fleet, including tests of some vehicles with stiff crash pulses, we conclude that the vast majority of current vehicles would pass a 48 km/h (30 mph) crash test using a 50th percentile adult male dummy with much the same compliance margins as before. Thus, more power is not needed for those vehicles to pass that test with that dummy. Further, the fact that some current vehicles with stiff pulses meet the injury criteria suggests that vehicle manufacturers may not have to repower air bag systems in other stiff pulse vehicles in order to meet the criteria.

Further, air bags that currently have enough power to meet the injury criteria using the 78 kg (172 lb.) 50th percentile adult male dummy will not need more power in the future to meet the criteria using the much lighter 50 kg (110 lb.) 5th percentile adult female dummy. Our tests show the primary problem for the small female dummy in those current vehicles that do not satisfy the injury criteria in a 48 km/h (30 mph) test with the 5th percentile adult female dummy is that the dummy experiences too much force in the neck or chest area. The solution for the smaller, lighter female dummy would not be to put additional power into the bag. Not only would that step be unnecessary to protect the 50th percentile adult male dummy, but also it would be likely to exacerbate the problem with the small female dummy. Instead, the solution is to redesign the air bag system- - using recessed air bags and new sensors, inflation levels, fold patterns, bias flaps, etc.- - to reduce the potential for injury for the 5th percentile adult female dummy.

Thus, we conclude that a 48 km/h (30 mph) crash test need not lead to repowering for most motor vehicles and need not lead to significant repowering for any vehicles. We conclude further that whatever power might be added to protect large occupants in outlying, problem vehicles need not increase the risk of harm to lighter, smaller, out-of-position occupants, particularly in view of the requirement that vehicles be able to satisfy low risk deployment requirements with 5th percentile adult female dummies in the driver's seat. The same steps described at the end of the preceding paragraph could be taken to ensure that there is not any increased risk.

Second, the vehicle manufacturers suggested that the 48 km/h (30 mph) crash test creates a difficult-to-resolve conflict between protecting the 5th percentile adult female dummy and protecting the 50th percentile adult male dummy. It is true that this final rule introduces the 5th percentile adult female dummy and for the first time requires manufacturers to ensure that their vehicles meet the injury criteria with dummies representing small females as well as mid size males and large females. However, the challenge cited by the vehicle manufacturers of protecting people of different sizes is not the result of any decision made in this rulemaking. The reality is that the driver and passenger population has always included a wide variety of sizes of people. The reality also is that smaller drivers tend to sit closer to the steering wheel and foot controls than larger drivers do. While many smaller drivers reportedly do not move their seat all the forward, some do. The need to protect those people exists regardless of what dummies or requirements are specified in this rulemaking. As noted above, since most current vehicles already meet 48 km/h (30 mph) using the larger, heavier dummy, the decision to return to 48 km/h (30 mph) is not going to necessitate repowering. Thus, that decision is not going to

exacerbate the existing challenge of protecting both small and large people.

NHTSA recognizes that an air bag needs to move into place particularly quickly to protect people who sit very close to the steering wheel. However, this need too exists quite apart from this rulemaking. Manufacturer concerns that designing air bags to protect these people this may cause air bags to be aggressive toward those people can be addressed by a variety of measures. Among them are recessing the air bag in the steering wheel and providing adjustable foot controls that allow smaller drivers to move back from the steering wheel. Further, the agency notes that the air bag is part of a full vehicle protection system that includes the energy absorbing characteristics of the vehicle structure as well as the air bag itself. While it would be more expensive and require more lead time, vehicle manufacturers could reduce the speed needed to deploy air bags by modifying the vehicle structure so as to produce a softer crash pulse. To the extent that a vehicle manufacturer softens the crash pulse, the drivers will move forward less quickly in frontal crashes, thus providing more time for the air bag to deploy.

The vehicle manufacturers also suggested that they need a small bag for the 5th percentile adult female dummy and a large one for the 50th percentile adult male dummy. In support of this suggestion, the manufacturers pointed to tests of current production vehicles and noted that in some cases, the smaller dummy failed to meet some of the injury criteria (the new neck injury criteria in particular) in a 48 km/h (30 mph) crash test. The manufacturers' characterization of these test results misses their real significance. The failure of existing vehicles to meet an injury criterion they were not designed to meet is not evidence either of the impossibility or even the difficulty of meeting that criterion. Indeed, the ability of half the tested vehicles to meet a criterion that they were not designed to meet indicates that compliance will not be difficult once

the manufacturers add the new criterion to their design goals for future air bags.

Finally, manufacturer suggestions that they need entirely new technologies in order to comply using the small female dummy are misplaced and unsupported. The rulemaking record indicates that manufacturers can design air bags that protect both the 5th percentile adult female and 50th percentile adult male dummies in crashes at 48 km/h (30 mph), in passenger cars and trucks, using technology already being installed in some current production vehicles.

For example, NHTSA tested a MY1999 Saturn SL1 and found that it met the new injury criteria in 48 km/h (30 mph) crash tests on both the driver and passenger sides with both the 5th percentile adult female and 50th percentile adult male dummies. It does this using relatively air bags that are relatively shallow (as opposed to the deeper air bags that the vehicle manufacturers asserted are necessary for the larger dummy). Further, and more significant, the MY 1999 Econoline van, which has a much stiffer pulse than the Saturn, met the new injury criteria in 48 km/h (30 mph) crash tests on both the driver and passenger sides with both sizes of dummies. Further, 4 of the 7 production vehicles crash tested by NHTSA passed on the driver side with both sizes of dummies, while 4 of those 7 vehicles passed on passenger side with both sizes of dummies.

This demonstrates that the designs and technologies that can be used to enable vehicles to comply on both the driver and passenger sides with both dummies are already being used in some current production vehicles. These technologies include dual-stage inflators, seat position sensors, improved air bag folding, bias flaps, and internal baffles/tethers. If any vehicle manufacturer wishes to do so, it could also develop and provide chambered, dual-stage air bags that are designed to fill fully only an inner chamber of the air bag, instead of the entire air bag,

when the driver seat is near the full forward adjustment position on the seat track.

NHTSA recognizes that, for the 5th percentile adult female dummy, 2 of the 7 production vehicles we tested did not meet all of the injury criteria in a 48 km/h (30 mph) unbelted crash test at the driver position and 3 of 7 vehicles did not pass all of those criteria at the passenger position. However, these vehicles were not designed to meet those criteria when tested at that speed using a 5th percentile adult female dummy. Given the leadtime provided by this final rule, and the test data cited above, NHTSA concludes that the vehicle manufacturers can make the modifications necessary to provide air bags that would protect both the mid-sized male and the small female in a 48 km/h (30 mph) unbelted crash test at both positions.

While we believe that vehicle manufacturers can generally design vehicles to meet the 48 km/h (30 mph) unbelted test requirements and the other requirements of today's rule during the TEA 21 timeframe, we believe, for reasons discussed below, that safety is best served by returning to the 48 km/h (30 mph) unbelted test speed over a longer period.

As to ensuring protection to unbelted occupants in serious crashes, we believe that, so long as a 48 km/h (30 mph) unbelted test requirement is in place for the future, there will be a strong disincentive for vehicle manufacturers to design their air bags to minimally comply with the 40 km/h (25 mph) test. If manufacturers were to significantly reduce the protectiveness of current redesigned air bags which pass the 48 km/h (30 mph) test, they would create a much more difficult task for themselves for the second stage of the phase-in. We believe this would be very unlikely to happen.

Moreover, we believe that providing a 40 km/h (25 mph) maximum speed for an initial, fixed period would promote safety. Because a 40 km/h (25 mph) maximum test speed provides

greater flexibility, it will let vehicle manufacturers focus their attention on meeting the new requirements to reduce risks to out-of-position occupants. It will also enable them to gain experience with using the new dummies in both the tests to ensure protection to belted and unbelted occupants in serious crashes and in the new tests to reduce risks.

We note that the vehicle manufacturers will be required to do a great deal during the first stage. They will need to certify their vehicles to an unbelted barrier test instead of a sled test. Moreover, they will need to meet this test for the new 5th percentile adult female dummy as well as for the existing 50th percentile adult male dummy. They will also need to meet a new belted offset deformable barrier test using the 5th percentile adult female dummy. For all of these tests, they will need to meet new injury criteria performance limits. Finally, the vehicle manufacturers will need to certify their vehicles to an array of test requirements to minimize the risk to infants, children, and other occupants from injuries and deaths caused by air bags.

Returning to the 48 km/h (30 mph) maximum test speed in the latter part of a two-stage process will also provide vehicle manufacturers a longer period of time to complete development of any advanced technologies they plan to use, before they have to certify a vehicle to the higher test speed. This longer period will avoid a situation where a vehicle manufacturer might find compliance unexpectedly difficult when using an advanced technology and then have a problem with meeting the standard's test requirements.

This longer period may also promote technological innovation. While we believe that the requirements in today's final rule can be met by careful use of technologies already on the road or soon to be introduced on the road, we are aware that suppliers are continuing work on many additional technologies. With greater flexibility, manufacturers may be better able to explore

using some of these technologies still under development as opposed to relying on the technologies that are already on the road.

In addition, a longer period would make it easier for vehicle manufacturers to improve crash pulses and make other structural changes, should vehicle manufacturers wish to avail themselves of this opportunity. While IIHS did not support a 48 km/h (30 mph) unbelted test, it did argue that efforts by the vehicle manufacturers to improve the crash pulses of their light trucks would make it easier for them to design non-aggressive air bags. These types of design improvements are much easier and much less costly when done as part of a complete vehicle redesign. Under the two-stage phase-in, vehicle manufacturers will have more than 10 years before they have to certify a particular vehicle to the unbelted 48 km/h (30 mph) rigid barrier test.

We also considered the possibility of establishing a 40 km/h (25 mph) requirement now, and deciding later, based on data concerning the effectiveness of air bags designed to meet that requirement, whether there was a need to return to 48 km/h (30 mph). However, we believe this would set too low a minimum long-term safety requirement. In essence, this approach would make protection of unbelted occupants in serious crashes largely voluntary.

We are concerned that this type of approach could result in a significant reduction in the number of lives saved by air bags. In this rulemaking, we have identified technologies that enable vehicle manufacturers to minimize risks to out-of-position occupants and provide protection to unbelted occupants in serious crashes, as evidenced by complying with the 48 km/h (30 mph) barrier test. If we established a 40 km/h (25 mph) requirement now, and waited until extensive data were collected to determine whether vehicle manufacturers were voluntarily providing adequate protection to occupants in serious crashes, there is a potential that hundreds

of fewer lives would be saved if vehicle manufacturers designed their air bags minimally to meet a 40 km/h (25 mph) standard.

In the sections which follow, we will present a more detailed discussion of several of the key issues raised by commenters.

**5. A Maximum Test Speed of 48 km/h (30 mph) Will Provide Greater Assurance of High Safety Benefits than a Maximum Test Speed of 40 km/h (25 mph).**

After reviewing the comments in the light of the information and data available to us, we have concluded that a maximum test speed of 48 km/h (30 mph) will produce greater safety benefits than a maximum test speed of 40 km/h (25 mph). We believe that this test will better ensure that the level of safety performance evident in MY 1998 and later vehicles will be preserved and improved. Together with low speed tests to reduce the risk that air bags present to some occupants, the 48 km/h (30 mph) test will accomplish the TEA 21 goals of improving protection and reducing risk.

We base our view, first, on our assessment of NASS data[29], which show that about 50 percent of unbelted fatalities in frontal crashes occur in crashes that are more severe than a 48 km/h (30 mph) rigid barrier crash, and half of unbelted frontal crash fatalities occur in crashes that are less severe than a 48 km/h (30 mph) rigid barrier crash. Of the fatalities occurring below 48 km/h (30 mph), the NASS data indicate that about 20 percent occur in crashes with delta Vs between 40 km/h (25 mph) and 48 km/h (30 mph). Thus, approximately 70 percent of fatalities occur at speeds higher than 40 km/h (25 mph). A barrier test speed of 48 km/h (30 mph) will

---

[29] AAM raised several issues about the reliability of NASS data. These issues are addressed in the FEA.

address a significantly larger percentage of potentially fatal crashes.

More detailed information concerning the numbers of potentially fatal crashes represented by unbelted 40 km/h (25 mph) and 48 km/h (30 mph) barrier tests is presented in chapter V of the FEA and in the paper prepared by our Office of Research and Development titled "Updated Review of Potential Test Procedures for FMVSS No. 208."

It is also important to note that occupants of smaller vehicles will likely experience an increase in high delta V crashes in the future, as a result of greater sales of LTVs. Fifty percent of new sales of light vehicles are LTVs, and LTVs now comprise 33 percent of the fleet. The average weight of the fleet is around 3900 pounds now and is likely to increase in the future as evidenced by the introduction of heavier vehicles, especially LTVs, in the fleet. To illustrate the effects on delta V for smaller vehicles, in a full frontal collision between two 3,000-pound passenger cars traveling at 48 km/h (30 mph), the delta V would be 48 km/h (30 mph) for each vehicle. However, if one of these cars instead had the same collision with a 4,000-pound SUV, the passenger car would experience a delta V of 34.3 mph.

Real-world effectiveness data indicate that air bag-equipped vehicles certified to the 48 km/h (30 mph) barrier test have been highly effective in saving lives of unbelted occupants across a range of delta Vs. Using these data, the FEA estimates that, if all passenger vehicles had air bags with the effectiveness of pre-MY 1998 air bags, there would be the following distribution of unbelted lives saved each year: 0 to 40 km/h (0 to 25 mph) delta V--1,044 lives; 41 km/h to 48 km/h (26 mph to 30 mph) delta V--569 lives; 49 km/h to 56 km/h (31 mph to 35 mph) delta V--384 lives; 57+ km/h (36+ mph) delta V--415 lives. Therefore, the 32 km/h (20 mph) to 48 km/h (30 mph) range also represents a significantly larger percentage of survivable

crashes than the 32 km/h (20 mph) to 40 km/h (25 mph) range.

A second basis for the agency's conclusion that the 48 km/h (30 mph) test will provide greater benefits is that the range of speeds over which a vehicle will be tested includes the range of speeds for the 40 km/h (25 mph) test. Under the 48 km/h (30 mph) test, a vehicle is required to meet the injury criteria at any speed between 32 km/h (20 mph) and 48 km/h (30 mph), thus providing protection throughout the 32 km/h (20 mph) to 40 km/h (25 mph) speed range for the 40 km/h (25 mph) test in addition to providing protection up to 48 km/h (30 mph). Adding protection in the 40 km/h (25 mph) to 48 km/h (30 mph) speed range does not diminish the protection provided in the lower range. The result is that there are benefits at higher speeds in addition to those at lower speeds.

A third consideration weighing against the 40 km/h (25 mph) test speed is the concern that air bags designed to this test could be unable to prevent unbelted occupants from "bottoming out" on the steering column, windshield, or roof pillars in high speed, but survivable, crashes. If an air bag was designed to pass minimally an unbelted 40 km/h (25 mph) barrier test, there would be a risk that occupants could bottom out the air bag in more severe crashes. This is a particular concern for heavier occupants. Half of all men and a significant number of women are heavier than the 50th percentile adult male dummy. These heavier occupants would be more likely to bottom out the air bag than the dummy.

Moreover, given the numbers of lives being saved in crashes above a 48 km/h (30 mph) delta V, a significant loss in the number of lives saved could occur even if the problem of bottoming out occurred at a severity level well above 40 km/h (25 mph).

We also note that the inability of a vehicle to pass Standard No. 208's injury criteria in

unbelted barrier tests at speeds above 40 km/h (25 mph) would indicate poorer occupant protection in crashes of that severity level and higher. For example, higher chest g's would indicate a greater risk of fatality due to chest injury.

The PEA, and FEA, used available data to estimate the number of lives saved by a 48 km/h (30 mph) standard vs. a 40 km/h (25 mph) standard. We have ample real world data concerning the lives saved by vehicles designed to meet a 48 km/h (30 mph) standard, but no reliable evidence about the performance of vehicles designed to meet a 40 km/h (25 mph) standard. This is because air bag-equipped vehicles have never been designed to meet either a long-term sled test or a long-term 40 km/h (25 mph) standard. We used two approaches to derive the estimated number of lives saved.

Approach 1 of the PEA/FEA examined real world data concerning the effectiveness of vehicles certified to the 48 km/h (30 mph) unbelted barrier test by delta V. Target populations (unrestrained front-outboard occupant potential fatalities) and lives saved were computed for four different delta V categories. These data produced estimates of different effectiveness rates for each speed category, with lower effectiveness levels for speeds under 20 mph and over 31 mph and highest in the range of 21 mph to 48 km/h (30 mph). To estimate the effectiveness of vehicles certified to a 40 km/h (25 mph) unbelted barrier test, it was assumed that the distribution of the effectiveness of air bags would be shifted down by 8 km/h (5 mph).

Approach 2 of the PEA compared the results of 40 km/h (25 mph) unrestrained and 48 km/h (30 mph) unrestrained tests for matching makes/models. The ratio of the vehicles' performance in these tests was then used as a proxy measure for the differences that might occur with the different test speeds. This was a mathematical approach that assumed that if air bags

were designed to a 40 km/h (25 mph) standard instead of a 48 km/h (30 mph) standard, vehicles would attain the same compliance margin at 40 km/h (25 mph) that they actually achieved at 48 km/h (30 mph), and the 48 km/h (30 mph) result would be the ratio between 48 km/h (30 mph) and 40 km/h (25 mph).

The FEA concludes that permanent adoption of a 40 km/h (25 mph) unbelted test speed could result in 248 to 413 fewer lives saved each year.

We have carefully considered the arguments advanced by commenters claiming that a 40 km/h (25 mph) maximum speed would not result in fewer benefits, as compared to a 48 km/h (30 mph) standard. We believe that each of these arguments has serious errors.

The primary argument advanced by the vehicle manufacturers and IIHS was that the real world experience of MY 1998 and MY 1999 vehicles with redesigned air bags indicates there would be no loss of benefits associated with a maximum test speed of 40 km/h (25 mph). These commenters argued that since the available data do not indicate any loss of high speed benefits associated with the sled test, and since a 40 km/h (25 mph) barrier test is slightly more stringent than the sled test, we should assume that there would be no loss of benefits associated with a 40 km/h (25 mph) barrier test.

We agree that the available field data show that the redesigned air bags are performing creditably. We believe that the data show that the manufacturers have taken effective steps to reduce the aggressivity of air bags without sacrificing protection. Our test data persuades us, however, that they have not accomplished this result by reducing the power of their air bags to the minimum level permitted by the sled test but by employing a variety of measures, including reductions in air bag power, that do not significantly compromise their vehicles' capacity to meet

the 48 km/h (30 mph) barrier test. Their depowered air bags are performing as well as the air bags they formerly certified to the 48 km/h (30 mph) barrier test because these air bags are, by and large, still 48 km/h (30 mph) air bags. Therefore, the real-world experience of vehicles with redesigned air bags in providing high-speed protection is not indicative of the benefits that would be ensured by a sled test or 40 km/h (25 mph) barrier test.

The argument that the experience with redesigned air bags demonstrates that there would be no loss of benefits with a 40 km/h (25 mph) barrier test implicitly assumes that vehicle manufacturers would continue to voluntarily produce vehicles that would comply with the 48 km/h (30 mph) test even if not required to do so. We believe this is an unreasonable assumption.

First, current vehicles were originally designed to comply with the 48 km/h (30 mph) barrier test, not the sled test. A barrier test affects many aspects of vehicle design, including that part of the vehicle structure which affects the crash pulse. Moreover, when air bags were redesigned and certified to the sled test, they were not depowered to the full extent they could have been.

Second, vehicle manufacturers have never designed vehicles in the expectation of either a permanent sled test or a permanent 40 km/h (25 mph) rigid barrier test. When we amended Standard No. 208 to add the sled test option, we included a sunset provision. While this sunset provision has been superseded by TEA 21, we have repeatedly indicated that we expected to terminate that option when the advanced air bag requirements take effect. Therefore, there is no reliable evidence on how vehicle manufacturers would respond, in the long run, to a permanent sled test or a permanent 40 km/h (25 mph) barrier test.

Third, in the absence of an effective long-term unbelted test requirement, the new

requirements in today's rule to minimize risks to out-of-position occupants would create an incentive to produce smaller, less protective air bags. This incentive would exist because the easiest and cheapest way to reduce risks is to make the air bag smaller and less powerful.

We have also analyzed the other arguments made by commenters in claiming that a 40 km/h (25 mph) maximum test speed would not result in a loss of benefits.

IIHS claimed that if current redesigned air bags are not powerful enough, there should be some real world cases in which the energy of the deploying bags was inadequate to protect individuals in otherwise survivable frontal crashes. There are several problems with this argument.

First, IIHS's argument focuses on the experience of current air bags, the vast majority of which meet the unbelted 48 km/h (30 mph) barrier test, and ignores the kinds of air bags that would be permitted by an unbelted 40 km/h (25 mph) barrier test. Also, as discussed elsewhere in this document, it incorrectly assumes that a 48 km/h (30 mph) test would require a return to more aggressive air bags.

We also note that, in response to IIHS's comment and as discussed in the FEA, we have examined NASS cases and identified several fatalities in which the air bag was inadequate to protect individuals in otherwise survivable frontal crashes. Some of these cases involved vehicles certified to the unbelted 48 km/h (30 mph) unbelted test. Given the large number of lives currently being saved by air bags in crashes more severe than a 40 km/h (25 mph) barrier test, we believe that this could become a much greater problem if the maximum speed for that test were set at 40 km/h (25 mph).

We have also considered IIHS's argument that we should not return to an unbelted 48

km/h (30 mph) barrier test because it would lead to additional serious and fatal injuries from air bags in high speed crashes. We disagree with IIHS for several reasons.

First, we believe the number of fatalities to out-of-position occupants in high speed crashes is much lower than IIHS suggests. In response to that organization's comment and as discussed in the FEA, we have examined every case of a driver or passenger fatality in NASS with air bags and known delta V over 40 km/h (25 mph). Between 1991 through the first half of 1999, we found ten drivers and two passengers where the air bag probably caused a fatality in a high speed crash. These cases do not represent 15 percent of frontal crash fatalities. However, the data are not sufficient to allow us to make a reasonable estimate of the number of fatalities they represent nationwide. Given the sparseness of the data, however, we can be confident that the number is nothing like 15 percent of frontal crash deaths. Moreover, we believe that if air bag performance were reduced so that vehicles minimally passed a 40 km/h (25 mph) barrier test, we would find many more cases in high speed crashes where the air bag did not provide sufficient protection.

Second, IIHS's argument is linked to its belief that a 48 km/h (30 mph) unbelted test would require more aggressive air bags. In fact, as discussed later in this document, advanced air bags that satisfy such a test need not be more aggressive than redesigned air bags. Moreover, many of the design changes that have been, and are currently being, made to reduce aggressivity will make advanced air bags significantly less aggressive than pre-redesigned air bags, even in crashes where the high level of a dual level inflation system deploys. These changes include such things as lower inflator power than pre-redesigned air bags, tethers, internal baffles, recessed modules, improved covers, lighter fabrics, etc.

We also note that, as discussed earlier, some vehicles with single inflation level air bags pass, on the driver side, the unbelted 48 km/h (30 mph) barrier test with a 50th percentile adult male dummy and the low risk deployment requirements with the 5th percentile adult female dummy in two positions directly against the steering wheel. This indicates that driver air bags with dual level inflators can be designed so that even the higher level of inflation used for high speed crashes is not aggressive to out-of-position occupants. As for the passenger side, adult passengers are much less likely than drivers to become out of position, since they typically sit much farther away from the air bag. Manufacturers can use weight sensors or similar devices to suppress air bag deployment for children.

We have considered two mathematical models advocated by AAM which it claims show that a maximum speed of 40 km/h (25 mph) is superior to and would result in greater savings of lives than a maximum speed of 48 km/h (30 mph). The FEA analyzes both approaches, which involve complicated models with numerous assumptions. There are a number of problems with the two models, and some of the key assumptions are contradicted by real world evidence.

The opportunities matrix is a conceptual model of the impact of air bag design changes in single-stage air bags on benefits. It assumes that an air bag designed to a 48 km/h (30 mph) standard will achieve its highest benefits (be most effective) at 48 km/h (30 mph) and that an air bag designed to a 40 km/h (25 mph) standard will achieve its highest benefits at 40 km/h (25 mph). It also assumes that at delta V levels higher or lower than the design speed, effectiveness decreases at regular intervals resulting in effectiveness being represented by a roughly bell-shaped pattern around the design point. Based on the model, AAM concluded that an air bag designed to 40 km/h (25 mph) standard would result in 21 percent more benefit than an air bag

designed to a 48 km/h (30 mph) standard.

However, real-world data developed using NASS-CDS shows that air bags designed to the 48 km/h (30 mph) standard were most effective at 34 km/h to 40 km/h (21 mph to 25 mph), not at 48 km/h (30 mph), and that effectiveness around that speed did not drop off smoothly. The real world data used in the PEA and FEA vary enough from the opportunity matrix model to produce the opposite conclusion: that an air bag designed to a 48 km/h (30 mph) standard would have more overall benefits than an air bag designed to a 40 km/h (25 mph) standard.

In essence, the opportunities matrix makes vehicles with air bags designed to a maximum test speed of 40 km/h (25 mph) look better than ones designed to a maximum test speed of 48 km/h (30 mph) by assuming higher fatality reduction effectiveness for the 40 km/h (25 mph) air bags for crashes near 40 km/h (25 mph). There is no basis for this assumption, even for single inflation level air bags. Moreover, dual level inflators permit different inflation levels for different crash severities.

The MADYMO model presents a mathematical, theoretical relative benefits analysis for one experimental passenger car. AAM first assumed a theoretical mid-size passenger car with a dual-stage driver air bag. It then considered variations in vents, bag size, and inflators, resulting in 336 different air bag designs. Computer simulations were run with both 50th percentile adult male dummies and 5th percentile adult female dummies in unbelted rigid barrier tests at assumed delta Vs of 40 km/h (25 mph) and 48 km/h (30 mph); with both dummies in static out-of-position tests; with the 50th percentile adult male dummy in a belted 56 km/h (35 mph) test; and with the 5th percentile adult female dummy in a 40 km/h (25 mph) belted offset test. Designs were determined to be either acceptable or not acceptable based on whether all injury criteria values

were below the accepted injury reference values with a compliance margin of 20 percent for regulatory tests and 10 percent for non-regulatory tests.

Of the 336 designs, 21 met acceptance criteria when subjected to the suite of tests including an unbelted 40 km/h (25 mph) rigid barrier test. None of the designs met the acceptance criteria for the suite of tests including an unbelted 48 km/h (30 mph) test. AAM then selected the theoretical "best" design from each test suite, and calculated the potential benefits for each design.

We believe there are numerous problems with this approach when used to compare the benefits of a maximum test speed of 40 km/h (25 mph) and 48 km/h (30 mph).

First, AAM has not shown that these air bag designs are representative of what vehicle manufacturers would produce under a 40 km/h (25 mph) standard and a 48 km/h (30 mph) standard. As discussed elsewhere in this document, we are concerned that, in the absence of a 48 km/h (30 mph) test, vehicle manufacturers might choose the meet the low risk requirements for out-of-position occupants by making air bags smaller and less protective. So far as we can tell, AAM's model does not estimate benefits for air bag designs that might minimally meet the 40 km/h (25 mph) test.

Also, the AAM model does not take account of the many technologies that can be used to improve air bag performance. The AAM model only varies vents, bag size, and inflators. However, there are many other aspects of air bag design that can be varied, e.g., fold pattern, shape, tethering, seam pattern, etc. To the extent AAM was finding that the basic air bag design it was modeling was having difficulty meeting the unbelted 48 km/h (30 mph) test and the rest of the test requirements at issue, it should not have limited potential design changes to vents, bag

size, and inflators. Among other things, AAM should have considered the various design features in the production vehicles that already do well in all of the tests, such as those in the Saturn.

Finally, as documented in the FEA, we believe there are many problems concerning how AAM's relative benefits were calculated.

Because of the significant problems inherent to both of AAM's models, they do not support AAM's contention that a 40 km/h (25 mph) unbelted test would result in fewer fatalities than a 48 km/h (30 mph) test.

We also believe there is an inherent inconsistency between the argument made by AAM and others that we should focus on the actual experience of vehicles with redesigned air bags in estimating benefits, yet also accept the two theoretical benefits models submitted by AAM in analyzing the relative benefits of a maximum test speed of 40 km/h (25 mph) vs. 48 km/h (30 mph). Our testing of vehicles with redesigned air bags strongly indicates that the vast majority of current vehicles with redesigned air bags pass the 48 km/h (30 mph) barrier test with 50th percentile adult male dummies, many by wide margins. If we wanted to ensure that future air bags perform as well, it would follow that we should return to the 48 km/h (30 mph) barrier test. A lower standard would allow degradation of performance. However, the theoretical benefit models assume that vehicles would be redesigned to a 40 km/h (25 mph) test requirement.

A more detailed discussion of the comments concerning benefits is provided in the FEA.

**6. Motor Vehicles Can be Designed to Meet the Unbelted 48 km/h (30 mph) Rigid Barrier Test for Both 50th Percentile Adult Male Dummies and 5th Percentile Adult Female Dummies, and**

**the Requirements to Minimize Risks.**

After carefully considering the comments, we believe that the available data and information show that vehicles can be designed to meet a 48 km/h (30 mph) rigid barrier test for both 50th percentile adult male dummies and 5th percentile adult female dummies while also meeting the requirements to minimize risks.

In this section, we will provide a general discussion of the issues raised by the commenters. A more detailed discussion is presented in a paper prepared by our Office of Research and Development titled "High Speed Unbelted Test Requirements of FMVSS No. 208; Analysis of Issues Raised by Public Comments." A copy of the paper is being placed in the docket. We note that portions of the paper are non-public because they discuss confidential information submitted by manufacturers. Those portions of the paper are not being docketed.

We believe the argument that it is not possible to comply with the 48 km/h (30 mph) rigid barrier test for both the 50th percentile adult male dummies and the 5th percentile adult female dummies is contradicted by tests of current vehicles. We tested a total of 14 MY 1998/1999 vehicles with redesigned air bags in unbelted 48 km/h (30 mph) rigid barrier tests using 50th percentile adult male dummies. We also tested seven of these vehicles in unbelted 48 km/h (30 mph) rigid barrier tests using 5th percentile adult female dummies.

Of the seven vehicles we tested with both unbelted 50th percentile adult male dummies and unbelted 5th percentile adult female dummies, three vehicles passed all of the injury criteria performance limits included in today's final rule for both dummies at both the driver and passenger positions. These three vehicles were the MY 1998 Ford Taurus, the MY 1999 Saturn

SL1, and the MY 1999 Ford Econoline van.[30] Moreover, two of these vehicles, the MY 1999 Saturn SL1 and the MY 1999 Ford Econoline, also passed the low risk deployment requirements for the driver.

The fact that the Saturn and Econoline passed all of these requirements is strong evidence that future vehicles can be designed to do so as well. It is also of particular significance since the Saturn is a small car and the Econoline is a full size van. In designing air bags so they are appropriate for all size occupants and not overly aggressive, small cars are typically more challenging than large cars because of the space limitations and because occupants are closer to the air bag modules. Full size vans pose a greater challenge in these respects than most vehicles because they typically have very short front end structures, resulting in a stiffer crash pulse that requires the vehicle's restraint system to manage an extremely rapid deceleration rate.

We also note that neither the MY 1999 Saturn, the MY 1999 Econoline nor the MY 1998 Taurus had dual-stage air bags. While the use of dual stage air bags is not needed to meet these requirements, it would make it easier to do so. For example, an air bag with reduced pressure might be more suitable for the 5th percentile adult female dummy in the full forward position and a higher pressure air bag for occupants sitting in the mid-track to rear positions.

AAM's and GM's argument that the unbelted 48 km/h (30 mph) barrier test for the 50th percentile adult male dummy requires a deeper air bag that may prevent a vehicle from meeting the unbelted 48 km/h (30 mph) barrier test for the 5th percentile adult female dummy is specifically contradicted by the test results discussed above, most tellingly by the fact that the

---

[30] In addition, the MY 1999 Toyota Tacoma passed all of the injury criteria performance limits included in today's final rule for both dummies at the driver position, and the MY 1999 Acura RL passed all of the injury criteria performance limits included in today's final rule for both dummies at the passenger position.

Saturn has a very small air bag.

We recognize that several of the vehicles we tested at 48 km/h (30 mph) with 5th percentile adult female dummies did not meet all of the injury criteria. Moreover, for some vehicles which passed, the margins of compliance were narrow for some of the injury criteria, e.g., driver Nij for the Econoline. However, it is important to emphasize that none of these vehicles was designed to comply with today's final rule. Thus, the inability of some current vehicles to pass some of the final rule's requirements, or narrow margins of compliance for some vehicles, does not indicate that future vehicles cannot be designed to comply with far larger margins.

We note that we examined some of the driver air bag hardware from these test vehicles and found that there were a significant number of countermeasures used in some of the better performing vehicles that were not used in other vehicles. These include low-force breakout cover, I-tear seam pattern, 4 tether straps, advanced folding pattern, recessed module, energy absorbing steering column, etc. Incorporating some of these design features, as well as dual-level inflators, could reduce the aggressivity to the occupant and improve the trajectory of deployment.

As to the MY 2000 Taurus, Ford did not design that vehicle in the context of an unbelted 48 km/h (30 mph) requirement. However, agency testing of a pre-production MY 2000 Taurus indicates that failures are marginal. Particularly given the experience with the MY 1998 Taurus with redesigned air bags, we believe that Ford could readily redesign the MY 2000 Taurus to meet the unbelted 48 km/h (30 mph) requirements for both 50th percentile adult male dummies and 5th percentile adult female dummies.

We disagree with the suggestion by AAM that the high Nij value for the 5th percentile

adult female passenger dummy in our test of the MY 1999 Toyota Tacoma shows that the air bag size and fill rate needed to assure compliance with the chest injury limits with 50th percentile adult male dummies at 48 km/h (30 mph) necessarily results in noncompliant neck and chest injury reference values for 5th percentile adult female dummies seated closer to the air bag.

First, our 48 km/h (30 mph) test of the Toyota Tacoma using 5th percentile adult female dummies did not result in noncompliant chest injury criteria values for the passenger dummy. Second, our 48 km/h (30 mph) test of the Toyota Tacoma with unbelted 50th percentile adult male dummies resulted in very low chest g's for the passenger dummy, 35.6 g's. Given how far this value is below Standard No. 208's 60 g limit, we do not believe the need to meet the chest g requirement for the 50th percentile adult male dummy would be a limiting factor for the air bag design of this vehicle. Other injury criteria values were also low.

We instead believe the particular deployment characteristics of the Toyota Tacoma passenger air bag caused the high Nij value. The films of this test indicate that the passenger air bag inflates toward the windshield, then wraps around the dummy's head (providing no air bag retarding forces in the chest region), and begins hyperextending the neck. The dummy's head then bottoms out the top of the air bag and gets caught against the windshield while the rest of the chest continues forward. This resulted in a high Nij of 2.29 (calculating Nij according to the formula set forth in today's final rule). We also note that the passenger dummy in the Toyota Tacoma also had a high Nij of 1.82 in a 40 km/h (25 mph) barrier test using unbelted 5th percentile adult female dummies, suggesting that the difficulty was a function of the air bag design rather than a function of the test speed.

As to the argument that it may not be possible for vehicles to meet both the 48 km/h (30

mph) unbelted rigid barrier test for 50th percentile adult male dummies and the low risk deployment tests, we note that the Saturn, Econoline, and MY 1999 Dodge Intrepid passed both requirements for the driver position with single inflation level air bags. The use of dual-level inflators would make it easier to pass the low risk deployment tests, since the requirements of those tests would only need to be met for the lower level.

As to the passenger position, for which the low risk deployment requirements using child dummies will be an option (suppression is the other option), we are aware that considerable progress is being made by vehicle manufacturers and suppliers in meeting the low risk deployment requirements. However, it will not be necessary for vehicles to meet those requirements on the passenger side, since the option of using a weight sensor or similar device to suppress the air bag in the presence of a child is available.[31]

**7. A Maximum Test Speed of 48 km/h (30 Mph) Will Not Necessitate a Return to More Aggressive Air Bags and Thus Will Not Result in Higher Risk to Out-of-Position Occupants**

As we discussed in the SNPRM, it is difficult to respond to the industry argument that the 48 km/h (30 mph) barrier test would prevent continued use of "depowered" air bags because "depowered" is an amorphous, relative concept, not an absolute one. The term simply means "less power than before." Saying that an air bag is depowered is not a statement that the air bag has more or less than some specific pressure rise rate or overall peak pressure of the air bag inflator. Thus, there is no way of examining or testing a particular air bag to determine whether

[31] The final rule also includes, for both the driver and passenger positions, the option of suppressing the air bag when an occupant becomes out-of-position.

it is "depowered."

Further, not all air bags in vehicles certified prior to adoption of the sled test option had the same level of power. Indeed, there was a wide variation in the level of power of those air bags.

Likewise, there is variation in the level of power of redesigned air bags. We note that, as discussed in our report titled "Air Bag Technology in Light Passenger Vehicles," while data provided by nine manufacturers showed a significant reduction in the average peak pressure and pressure rise rate of MY 1998 air bags in comparison to earlier air bags, these parameters increased in approximately 10 percent of the vehicles covered and remained the same in approximately one third of the vehicles covered. This is one reason we prefer the term "redesigned air bag" to "depowered air bag."

In addition, as Parents noted in commenting on the NPRM, many of today's vehicles incorporate an array of air bag design improvements, making it difficult to attribute the apparent decrease in air bag fatalities and injuries to any particular feature or combination of features.

Also, it is important to note that inflator power, whether defined by pressure rise rate or overall peak pressure, does not necessarily determine aggressivity.[32] Aggressivity is a function of many different factors: the characteristics of the inflator, the size and shape of the air bag, the type of air bag material, the air bag cover design, the air bag fold pattern, etc. Thus, in comparing two air bags of different designs with different levels of power, the one with the higher power may be less aggressive than the one with the lower power.

---

[32] As discussed later in this document, we believe that the proper way to assess whether an air bag is overly aggressive is not to simply look at the inflator power, which may indicate little or nothing about actual risk, but to instead to measure the effect of the air bag on a driver dummy positioned directly against the steering wheel or a child dummy positioned directly against the instrument panel at the time of deployment.

With these caveats in mind, we believe the record makes it clear that a maximum test speed of 48 km/h (30 mph) for the rigid barrier test would not necessitate a return to more powerful air bags that would result in higher risk to out-of-position occupants. As discussed below, there are three primary reasons for this conclusion:

(1) Our testing of vehicles with redesigned air bags demonstrates that those air bags have sufficient power to enable vehicles to meet the unbelted 48 km/h (30 mph) barrier test for the adult dummies;

(2) The relatively few vehicles with redesigned air bags that do not currently meet the 48 km/h (30 mph) unbelted test can be designed to meet it without increasing air bag aggressivity.

(3) The overall requirements of today's final rule are likely to require vehicle manufacturers to reduce the aggressivity of current redesigned air bags.

**a. Our Testing of Vehicles with Redesigned Air Bags Demonstrates That Those Air Bags Have Sufficient Power to Enable Vehicles to Meet the Unbelted 48 km/h (30 mph) Barrier Test for the 50th Percentile Adult Male Dummy**

We have tested a total of 14 production vehicles with redesigned air bags to the 48 km/h (30 mph) rigid barrier test. (We tested one of these vehicles, a MY 1999 Blazer, after publication of the SNPRM.) Of the 14 vehicles, 12 met all of the injury criteria performance limits on the driver side, and 13 did so on the passenger side, for the 50th percentile adult male dummy. We note that one of the vehicles which failed on the driver side, the MY 1999 Acura RL, only failed the femur load limit. This failure relates more to the design of the knee bolster than the air bag

design. The other vehicle which failed on the driver side, the MY 1999 Blazer, had a marginal failure for chest g's. The vehicle which failed on the passenger side, the MY 1998 Neon, also had a marginal failure for chest g's.

As discussed in the SNPRM, the vehicles we tested represented a wide range of vehicle types and sizes. In particular, the specific vehicles and their classes included a Saturn (sub-compact car), a Neon (compact car), an Intrepid, Camry, Taurus, and Accord (mid-size cars), and Acura RL (full size car), an Explorer, Cherokee and Blazer (mid-size SUVs), and Expedition (large SUV), a Tacoma (pickup truck), a Voyager (minivan), and an Econoline (full-size van). Also, as noted in the SNPRM, the margins of compliance for these tests of vehicles with redesigned air bags were not very different from those with pre-redesigned air bags.

We believe these test results directly contradict the argument of vehicle manufacturers and several other commenters that a return to the 48 km/h (30 mph) barrier test would prevent continued use of "depowered" air bags and require a return to overly aggressive air bags. These data instead lead to two conclusions.

First, the vast majority of current vehicles with redesigned air bags already pass the 48 km/h (30 mph) barrier test using 50th percentile adult male dummies. Second, given the very high percentage of vehicles which passed, and the wide range of vehicle types which passed, it is reasonable to assume that all vehicles could, over time, be designed to pass the 48 km/h (30 mph) barrier test with the same types of "depowered" air bags.

We also note that air bags that currently have enough power to cushion the 79 kg (171 pound) 50th percentile adult male dummy will not need more power in the future to cushion the much lighter 5th percentile adult female dummy.

Commenters arguing that there is a need to "repower" offered little support for this view. We received a very small amount of confidential data indicating that a few vehicles with redesigned air bags, primarily ones with stiff crash pulses, marginally fail the test with 50th percentile adult male dummies. These commenters, however, did not provide any persuasive analysis as to why so many other vehicles can meet the 48 km/h barrier test with redesigned air bags but theirs cannot.

**b. The Relatively Few Vehicles with Redesigned Air Bags that Do Not Currently Meet the 48 km/h (30 mph) Unbelted Test Can be Designed to Meet it Without Increasing Air Bag Aggressivity.**

Based on available data, the relatively few vehicles that do not currently meet the 48 km/h (30 mph) unbelted test fail it only marginally. There are many ways that these vehicles can be redesigned to meet the test without increasing aggressivity.

Vehicle manufacturers can make many refinements in the designs of their current air bags to improve protectiveness without increasing aggressivity. Greater use can be made of such technologies as innovative folding patterns, recessed modules, dual stage inflators, low-force breakout covers, I-tear seam pattern, 4 tether straps, energy absorbing steering columns, etc. These technologies could be used to offset, or more than offset, any increase in aggressivity that would occur if there were an increase in inflator power.

We disagree with a comment by DaimlerChrysler suggesting that further improvements cannot be made with respect to fold patterns, lighter fabrics and recessed air bags. While we agree that manufacturers have taken significant advantage of these opportunities during the past

decade, as shown in our report titled "Air Bag Technology in Light Passenger Vehicles," we certainly do not agree that every vehicle has taken full advantage of them. For example, less than half of the MY 1998 fleet used recessed modules.

No commenter presented analysis taking account of the many available advanced technologies and showing that use of these technologies would not enable particular vehicles to be designed to meet the unbelted 48 km/h (30 mph) barrier test without making current air bags more aggressive.

One way to improve unbelted protection that does not involve changes to the air bag at all involves improving the crash pulse. As indicated earlier, most of the vehicles which do not pass the unbelted 48 km/h (30 mph) barrier test appear to be relatively stiff, i.e., the fronts of the vehicles do not deform much in a 48 km/h (30 mph) barrier test.

We note that while IIHS did not support a test speed of 48 km/h (30 mph) for the unbelted test, it did argue that increasing the speed of the belted rigid barrier test to 56 km/h (35 mph) would accelerate the improvement of frontal crash protection afforded by light trucks. That organization stated that while many vehicles already perform well in the 56 km/h (35 mph) NCAP test, light trucks have been an exception. IIHS stated that their stiff frames and short front ends (relative to their mass) have led to short crash pulses that make it difficult to design effective, nonaggressive air bag systems. IIHS stated that it expects that one result of subjecting all passenger vehicles to a 56 km/h (35 mph) belted requirement would be the softening of the front ends of light trucks. According to that organization, this would benefit not only the occupants of light trucks, but also the occupants of other vehicles with which the trucks collide.

We note that this design change advocated by IIHS, softening the front ends of light

trucks, would make it easier for these vehicles to meet the 48 km/h (30 mph) unbelted test.

We disagree with a comment from BMW which argued that a "drastic" approach to improving injury values would be to weaken the vehicle structure and soften the crash pulse. That company stated that this could have negative effects on intrusion. We believe it is important for safety for vehicle manufacturers to design vehicles both so that the front of the vehicle deforms in a controlled manner and intrusion is prevented. This typically involves the use of a crush zone and a strong occupant compartment. If the front of a vehicle does not deform in a serious crash, the occupant experiences a much more severe crash event.

We agree with a comment by DaimlerChrysler stating that increasing crush zone size is not an option without limits, but disagree with the implication that modifying crush zones to help meet the 48 km/h (30 mph) unbelted test would deteriorate overall vehicle performance against its market objectives. That company cited the example of longer front overhang destroying the utility of SUVs because of approach angle. However, the record shows that nearly all vehicles already meet the 48 km/h (30 mph) unbelted test, and those that fail do so marginally. Therefore, even slight adjustments in crash pulse would make it easier to meet the unbelted 48 km/h (30 mph) unbelted test.

**c. The Overall Requirements of Today's Final Rule Are Likely to Require Manufacturers to Decrease the Aggressivity of Current Redesigned Air Bags.**

We disagree with the implicit premise that the current risks to out-of-position occupants associated with redesigned air bags are acceptable. For that reason, this final rule is adopting

requirements that are likely to require vehicle manufacturers to reduce the aggressivity of current redesigned air bags.

We believe that the proper way to assess whether an air bag is overly aggressive is not to simply look at the inflator power, which may indicate little or nothing about actual risk, but to instead to measure the effect of the air bag on a driver dummy positioned directly against the steering wheel or a child dummy positioned directly against the instrument panel at the time of deployment. Our rule requires vehicles to meet either low risk requirements in these types of tests or to provide suppression.

To protect drivers, vehicle manufacturers will be required to provide air bags that meet injury criteria performance limits when the air bag deploys with a 5th percentile adult female dummy in two positions directly on the steering wheel.[33] As discussed earlier in this document, our testing shows some vehicles already meet this requirement as well as the 48 km/h (30 mph) unbelted barrier test. However, a number of vehicles with redesigned air bags do not meet this requirement.

To protect children, vehicle manufacturers will have two options.[34] The first option is to suppress air bag deployment automatically whenever a child is present. They could, for example, use weight sensors to turn the air bag off. The second option is to meet injury criteria performance limits when the air bag deploys with a dummy representing a young child in two positions directly against the instrument panel. Few if any vehicles with redesigned air bags meet either of these options.

---

[33] There is also an option to suppress air bag deployment automatically when a driver becomes out-of-position.

[34] There is also a third option to suppress air bag deployment automatically when a child or other occupant becomes out-of-position.

Thus, far from increasing the risks current air bags pose to out-of-position occupants, today's final rule requires vehicle manufacturers to reduce the risks of redesigned air bags.

### 8. Manufacturers Can Meet a 48 km/h (30 mph) Rigid Barrier Test and the Rest of Today's Final Rule Using Technologies that are or will Soon be in Production Vehicles; No Major Technological Breakthroughs are Needed

Some commenters, including IIHS, stated that the agency's rationale for proposing to return to the 48 km/h (30 mph) unbelted test reflects unwarranted faith in technological advances.

IIHS stated that the rationale may be based on the assumption that auto manufacturers will solve the problem of serious and fatal air bag injuries by using appropriate advanced technologies. That organization cited dual-stage air bags in which there is a benign first stage to minimize air bag injuries in low speed crashes and a more powerful second stage than current levels to protect people at higher speeds. That organization argued that this would ignore the fact that people are sustaining serious and fatal air bag induced injuries in high speed crashes.

IIHS also argued that the use of dual-stage inflators, as currently designed, bring new problems along with their partial solutions to the air bag injury problem. That commenter stated that dual-stage inflators provide new challenges to sensors--deployment decisions will need to be made late enough to ensure that the second stage is not needed but not so late that occupants are so far out of position that the first stage is ineffective.

IIHS stated that although dual-stage inflators are not the only advancements to improve air bag performance, IIHS is unaware of any technology without shortcomings. It argued that

even the simplest technology--seat sensors that detect when children are riding in front seats and suppress passenger air bag deployments--are unproven. IIHS argued that it is foolhardy to rely on unproven technology to offset the proven risk of unnecessarily high energy air bag inflation.

Ford commented that a return to the unbelted 48 km/h (30 mph) test would not be practicable until sufficiently robust advanced real time occupant size and position sensing systems and more advanced crash sensing systems are available for use in motor vehicles. According to that company, these advanced sensing systems would serve as technical countermeasures to the risks associated with out-of-position occupants in close proximity to a deploying higher powered bag.

After carefully considering the comments, we disagree with the argument that a return to the 48 km/h (30 mph) unbelted test is dependent on an unwarranted faith in technological advances. We believe there are two problems with this argument.

The first problem is that the arguments incorrectly assume that a return to more aggressive air bags would be needed to comply with the unbelted 48 km/h (30 mph) test. As discussed above, we believe this assumption is incorrect.

The second problem is that the arguments assume that today's final rule requires use of new technologies involving significant uncertainties. This also is incorrect. In fact, all of the requirements of today's final rule can be met using technologies that are already on the road or are soon to be on the road; no major technological breakthroughs are needed.

As discussed earlier in this document, in tests conducted by the agency, the Saturn and Econoline passed the unbelted 48 km/h (30 mph) barrier requirement for 50th percentile adult male dummies and 5th percentile adult female dummies on both the driver and passenger sides,

and the low risk requirements on the driver side. The Saturn and Econoline passed these tests, using single-level air bags, even though they were not designed in light of unbelted barrier test requirements using the 5th percentile adult female dummy or low risk deployment requirements. Particularly given that small cars and full size vans typically offer greater challenges to air bag designers than most vehicles, these test results provide strong evidence that all vehicles can be designed to meet these tests without major technological breakthroughs.

We believe that the use of dual-level inflators would make it easier to meet these requirements for the driver. Also, the use of a weight sensor (or similar device sensing the presence of a child) and/or dual-level inflators would likely be needed to meet the suppression and/or low risk deployment requirements for children on the passenger side.

However, dual-level inflators are not a new technology. In fact, dual-level inflators were first installed in GM vehicles produced in the mid-1970s, about a quarter of a century ago. Dual-level inflators are currently being used in the Ford Taurus, Honda Accord, and several other vehicles.

Simple weight/pattern sensors have been used for years by Daimler Benz and BMW to suppress the passenger air bag when the seat is empty. For the past several years, suppliers have been working to develop more sophisticated weight/pattern sensors (and similar devices) to sense the presence of a child. The Acura RL already includes a device which suppresses side air bags when a child is present.

BMW stated in its comments on the SNPRM that it has developed a vehicle seat occupant detection system that is "ready for production introduction." That commenter stated that the current intent is to use the system for automatic air bag suppression for children in the front seat.

Ford and GM have each publicly indicated that they are developing devices that would suppress the passenger air bag when a child is present.

We note that a number of different suppliers have been working on suppression devices for children, using a variety of technologies. Based on confidential information, we believe that several such devices have been proven to be technologically sound, although refinements are continuing to be made to get them ready for introduction into vehicles.

The information we have about expected introduction dates for weight sensors and similar devices to suppress the passenger air bag for children is confidential. We expect at least one manufacturer to introduce a device which suppresses the air bag for children this year. We expect to see some other manufacturers introducing these devices during calendar year 2001 if not sooner.

For the reasons discussed above, the record indicates that manufacturers can meet a 48 km/h (30 mph) rigid barrier test and the rest of the requirements included in today's final rule by technologies on the road or soon to be introduced on the road. It is not necessary to develop advanced real time occupant size and position sensing systems, although such technologies could be used.

While today's final rule does not require any technological breakthroughs involving significant uncertainties, it does promote technological innovation. Many of the technologies which have been recently introduced or are about to be introduced were developed in light of recent manufacturer efforts to improve air bag performance and our rulemaking activities over the past several years.

Moreover, many different design approaches and technologies can be used to meet the

performance requirements included in today's rule. While we believe the record shows that the requirements included in today's final rule can be met by technologies on the road or about to be introduced on the road, suppliers and manufacturers are continuing work on many different technologies that could be used to meet the requirements of today's rule.

## E. Other Issues

### 1. Location of 5th Percentile Adult Female Dummy

In both the NPRM and the SNPRM we proposed conducting the barrier tests with the 5th percentile adult female dummy in the full-forward seat track position. We stated that we believe the full-forward position to be the worst case position for an individual exposed to a deploying air bag and the most demanding of air bag systems. We also acknowledged in the SNPRM that this position would rarely need to be used, particularly on the passenger-side. We requested comment on whether testing in a seat track position other than full-forward would adequately protect occupants of all sizes while allowing sufficient design freedom.

Consumers Union, CAS, and Advocates all supported our proposed seat track position. They cited the disproportionately high number of women 160 cm (5'2") and under who have died as a result of a deploying air bag and argued that testing under this rule should be required under the most extreme conditions. CAS stated that the only condition under which the agency might consider an exception to this procedure is if adjustable pedals are present in the vehicle that would enable a typical small female to move away from the steering wheel hub. Public Citizen agreed with the agency's position in the SNPRM that if manufacturers can't provide protection in the full-forward position, they have option of moving that position back and making other adjustments, such as adjustable pedals, on the driver side.

The NTSB stated that it believed the full-forward position could be inadequate if an individual could not reach the pedals while sitting against the seat back. It argued that we should position the dummy relative to the accelerator pedal rather than the seat track.

Vehicle manufacturers, including AAM, DaimlerChrysler, Toyota and Honda, averred that the full-forward seating position was too extreme and unrepresentative of driving patterns in the real world. The manufacturers stated that a full-forward seat track could force manufacturers to move the seat track back, which could lead to less storage space, reduced ingress and egress space for rear passengers, and, in smaller vehicles, an inability to properly install rear facing safety restraints in the back seat. Manufacturers also contended that testing in the full-forward position could force them to design smaller air bags since there would be less room for inflation.

The primary argument driving the manufacturers' comments is their assertion that few people ever drive in the full-forward position, as evidenced by the UMTRI study, as well as informal studies of their own. DaimlerChrysler and Honda recommended that the seat track position for the 5th percentile female be in accordance with the vehicle manufacturer's 5th percentile female seating reference position.

We have decided to retain the requirement that the 5th percentile adult female dummy be tested in the full-forward position. As an initial matter, we ran 11 tests of production vehicles at 40 km/h (25 mph) or greater using an unbelted 5th percentile adult female driver and passenger in the full-forward seat track position in a perpendicular rigid barrier test. Of these 11 tests, nine vehicles passed all of the applicable injury criteria on the driver side (5 at 48 km/h (30 mph), 2 at 44 km/h (27.5 mph), and 2 at 40 km/h (25 mph)). On the passenger side, seven out of 11 passed all applicable injury criteria. We tested two vehicles in the same 48 km/h (30 mph) test, but with

the seat moved back 7.6 cm (3 inches) from the full-forward position. We found that this was roughly consistent with the UMTRI seating procedure in one vehicle and significantly further back than the UMTRI positioning would have been for the other. Moving the seat 7.6 cm (three inches) back also placed the dummy's chest approximately 25 cm (ten inches) back from the steering hub. While both dummies on the driver's side passed the applicable injury criteria, one dummy on the passenger side exceeded the maximum allowable values for failed chest g's and femur loads. We also found that during these tests, the dummy on the driver side could not always reach the accelerator pedal. This fact, along with the numerous phone calls the agency has received over the past few years, indicates to us that at least some individuals are driving with the seat in the full-forward seat track position. If a vehicle is designed to be used in a particular position, we believe it is reasonable to assume that the position will be used at least some of the time.

We are cognizant of the manufacturers' concern that today's rule may require them to limit the extent of seat track travel. To the extent this increases occupant protection, this would appear to be a positive move. We note that in some vehicles the seat will slide forward in order to ease access to the back seat, but will then lock into place somewhere further back on the seat track. Since today's rule would not require testing in a seat position that is not fixed in place when the vehicle is driven, we believe this type of design could continue to be used. Of greater concern is the claim that some smaller vehicles will no longer be able to accommodate rear facing child restraints in the rear seat. We strongly believe that in most instances manufacturers can and should design their vehicles to allow adult occupants to ride safely in the front seat and infants to ride safely in the back seat. However, we note that the need to place rear facing child

restraints in the back seat may force the front seat passenger to pull the front seat full forward. In such a circumstance, the passenger will need the protection of a deploying air bag without being exposed to undue risk. This also applies to a passenger who moves the seat full forward because the rear seat is loaded with cargo. These two circumstances argue for rather than against the need to test the front seat in the full-forward position.

We have decided against adopting the NTSB's recommendation that the seating procedure be based on distance from the accelerator pedal rather than seat track position. Our test requirements must be objective. We believe linking the position to distance from the pedal could introduce too many ambiguities into the seating procedure for it to remain sufficiently objective.

### 2. Minimum Test Speed

In the SNPRM we proposed that manufacturers would need to meet the unbelted rigid barrier test at any speed between 29 km/h (18 mph) and 40 to 48 km/h (25 to 30 mph). This range represents a significant change from the belted barrier test and previous unbelted barrier tests, which have required injury criteria to be met at any speed up to 48 km/h (30 mph).

GM and Ford supported the proposed lower test parameter 29 km/h (18 mph). AAM, DaimlerChrysler and Toyota supported a higher minimum test speed. VW and Honda supported a lower minimum test speed. Delphi urged the agency to return to its traditional "any speed between zero and" the maximum test speed, arguing that the minimum test speed will result in an unacceptable safety trade-off for individuals who could be aided by a deploying air bag in lower speed crashes.

The concerns of the vehicle manufacturers opposed to the 29 km/h (18 mph) lower limit

revolve around their ability to meet both the low risk deployment tests at any speed up to 29 km/h (18 mph) and the high speed tests at any speed between 29 km/h (18 mph) and 40 to 48 km/h (25 to 30 mph). These manufacturers argued that the basic premise for dual-stage inflation systems is that the first stage can be tailored to reduce risk for children while offering protection for 5th percentile adult while the second stage protects the 50th percentile male occupant. According to the manufacturers, in many cases the first stage air bag will not be sufficient to satisfy the injury criteria in a test at 29 km/h (18 mph). In order to assure compliance with both the unbelted crash test requirement and a low risk deployment option utilizing a dual-stage air bag system, a manufacturer arguably would either have to drop the threshold for the second stage air bag close to 29 km/h (18 mph) to ensure compliance for the 50th percentile adult male or provide a higher-energy first stage inflator. The commenters asserted that if NHTSA were to impose the proposed speed range for the unbelted tests, we would create a situation that would make compliance with a low risk deployment option impossible, since it would not be possible to assure that only the first stage air bag deploys at 29 km/h (18 mph) for the out-of-position test. Since the reliability of dynamic suppression systems is still unproven, the application of a test requirement that precludes low risk deployment systems would create a problem at the driver position.

On the other end of the spectrum, Delphi has argued that allowing a minimum test speed for the unbelted barrier test may result in serious injuries that could otherwise be avoided. Delphi stated that while it recognized that the proposed minimum test speed was intended to discourage lower air bag threshold speeds, unbelted occupants without an air bag may exceed the neck injury criterion in typical vehicle impacts between 16 and 22.4 km/h (10 and 14 mph).

Delphi believes that NHTSA's objective in encouraging higher air bag threshold speeds is the reduction of injury risk to out-of-position occupants, the same objective addressed by the proposed advanced air bag systems. If the proposed advanced air bag systems are truly effective, Delphi asserts, lower thresholds should mitigate the injury risk that current systems pose. Accordingly, Delphi recommended that vehicle speed ranges be changed to 0 to 40 km/h (0 to 25 mph) for unbelted occupants in all rigid barrier and oblique barrier tests.

We have decided to raise the minimum test speed for the unbelted test from 29 km/h (18 mph) to 32 km/h (20 mph) while decreasing the maximum threshold for the various out-of-position tests from 29 km/h (18 mph) to 26 km/h (16 mph). We believe that this difference in speed between the two tests will be sufficient to resolve manufacturers' concerns with the potential overlap of the low risk deployment and barrier tests. Today's requirement builds in a 6 km/h (4 mph) "grey zone" that will allow manufacturers to deploy both inflator stages, if needed, in all high speed tests, while preserving their ability to deploy only the first stage (or allow for deployment of a combination of benign stages) of the air bag in the low risk deployment tests. We are rejecting DaimlerChrysler's and Toyota's request that we test unbelted dummies only at 48 km/h (25 mph) because we continue to believe a range of speeds is necessary to adequately protect drivers and adult passengers.

As to Delphi's concern that vehicle occupants will be afforded inadequate protection in the real world because of a lower parameter on the unbelted barrier tests, we note that vehicle manufacturers must still certify compliance to the belted test at all test speeds from zero to 48 km/h (30 mph), and must satisfy the low risk deployment criteria for the 5th percentile adult female on the driver's side.

## XI. Improving the Protection of Belted Occupants in Serious Crashes

In the SNPRM, we proposed two crash test requirements, both of which would have to be satisfied, to improve the protection of belted occupants in serious crashes. The first was a belted rigid barrier test; the second was a belted offset deformable barrier test.

### A. Belted Rigid Barrier Test

Standard No. 208 currently includes an up-to-48 km/h (30 mph) belted rigid barrier test (perpendicular and up to ± 30 degrees oblique to perpendicular) using 50th percentile adult male dummies. As indicated earlier, this test represents a vehicle striking a like vehicle moving at the same rate of speed.

In the SNPRM, we proposed to add use of the 5th percentile adult female dummy to this test, but only in the perpendicular mode. We proposed to limit use of this dummy to the perpendicular mode in light of our desire to avoid unnecessary test requirements and because we believed that if a vehicle can pass the perpendicular test with 5th percentile adult female dummies and the oblique tests with 50th percentile adult male dummies, it would also pass the oblique test using 5th percentile adult female dummies.

As noted above, we also indicated that if we reduced the maximum speed of the unbelted test to 40 km/h (25 mph) permanently, we might increase the maximum speed of the belted rigid barrier test from the current 48 km/h to 56 km/h (30 to 35 mph). This is the same speed at which vehicles with belted dummies are tested in existing NCAP tests.

The commenters on the SNPRM supported adding the 5th percentile adult female dummy to the existing belted rigid barrier requirements. Some commenters requested that we consider

deletion of the existing belted oblique crash tests using 50th percentile adult male dummies. Honda stated that it believes that the unbelted oblique tests are sufficient to confirm that air bags offer sufficient protection for belted occupants in oblique crashes.

Most commenters that supported a 40 km/h (25 mph) unbelted rigid barrier test, including AAM, also supported increasing the maximum speed of the belted rigid barrier test from the current 48 km/h (30 mph) to 56 km/h (35 mph). However, these commenters urged that the 56 km/h (35 mph) belted rigid barrier test be phased in after the TEA 21 phase-in period. They also urged that the higher speed test initially be limited to use of the 50th percentile adult male dummy, for which there is a large amount of test data because of NCAP. They urged further that a separate rulemaking be conducted to determine whether it is practicable to meet this test requirement using 5th percentile adult female dummies.

IIHS stated that increasing the speed of the belted rigid barrier test to 56 km/h (35 mph) would accelerate the improvement of frontal crash protection afforded by light trucks. That organization stated that while many vehicles already perform well in the 56 km/h (35 mph) NCAP test, light trucks have been an exception. IIHS stated that their stiff frames and short front ends (relative to their mass) have led to short crash pulses that make it difficult to design effective, nonaggressive air bag systems. IIHS stated that it expects one result of subjecting all passenger vehicles to a 56 km/h (35 mph) belted requirement would be the softening of the front ends of light trucks. According to that organization, this would benefit not only the occupants of light trucks, but also the occupants of other vehicles with which the trucks collide. IIHS stated that to maximize the likelihood that structural changes, rather than more aggressive air bag systems, would be incorporated to meet the new requirements, a long phase-in period should be

considered for light trucks.

While most vehicle manufacturers supported increasing the belted rigid barrier test speed to 56 km/h (35 mph), as long as long lead time is provided, there were exceptions. Volkswagen stated that it believes there is no safety justification for such an increase and that, on the contrary, there could be potentially significant disadvantages to motor vehicle safety. That company stated that the higher crash speed imposes significantly increased energy absorption requirements on vehicle structures and air bag designs, which would lead to more aggressive designs. Volkswagen stated that this would be counterproductive to the concern of vehicle aggressivity/compatibility in the vehicle fleet and protection for the small driver and out-of-position children.

After carefully considering the comments, we have decided that although more stringent belted rigid barrier requirements may be appropriate in the future, we are adopting as final our proposal to use the existing 48 km/h (30mph) belted rigid barrier test with some modifications. As an initial matter, we are requiring tests with the 5th percentile adult female dummy in the perpendicular mode. This will help ensure that vehicle manufacturers design air bags so as to improve protection to belted persons who sit in the full forward position, including short-statured adult female drivers.

We have also decided to accept the recommendation of some commenters to eliminate the existing belted oblique tests using 50th percentile adult male dummies. The purpose of the oblique tests is to ensure that air bags are sufficiently wide to provide protection if an oblique crash results in the occupant moving forward at an angle. We agree that the unbelted oblique tests are more stringent than the belted oblique tests in this respect, since the belts limit occupant

movement, and that the unbelted oblique tests will ensure that air bags are sufficiently wide to provide protection to both belted and unbelted occupants in oblique crashes.

We plan to initiate rulemaking in the near future proposing to increase the upper limit for the belted rigid barrier test from 48 km/h (30 mph) to 56 km/h (35 mph) with both 50th percentile adult male and 5th percentile adult female dummies. Included in that proposal will be a discussion of when to increase the test speed and whether a phase-in would be appropriate. VW's concern regarding the potential negative safety consequences of a 56 km/h (35 mph) test will also be addressed in that rulemaking.

### B. Belted Offset Deformable Barrier Test

In the SNPRM, we proposed to add a new crash test requirement to Standard No. 208, an up to 40 km/h (25 mph) offset deformable barrier test using belted 5th percentile adult female dummies (belted offset test). We proposed this test in an attempt to ensure that vehicle manufacturers upgrade their crash sensing and software systems, as necessary, to better address soft crash pulses. Research conducted by Transport Canada has shown that one of the causes of adverse effects of air bags is late deployment of some air bags in crashes with soft pulses, and the proposed test was one that Transport Canada has been using in its research program. We proposed that the test be conducted with the driver's side of the vehicle engaged with the barrier.

Most commenters supported adding the belted offset test, although some urged that an out-of-position test for the passenger side be developed as an alternative to this test.

AAM stated that it supports the proposed test, but claimed that its added safety benefit is questionable. That commenter stated that the test offers no added safety benefit in a rulemaking which also includes requirements for belted and unbelted 5th percentile adult female dummy

rigid barrier crash testing and protection against air bag-induced injuries with suppression or low risk deployment performance. AAM noted, however, that if a vehicle manufacturer selected the suppression presence option for all of the child dummies, there would be no requirement to address minimizing risks to out-of-position passengers larger than six-year-olds. AAM recommended that an out-of-position test for the passenger side using 5th percentile adult female dummies be developed and proposed in a future rulemaking as an alternative to this test.

AAM also argued that if a sensor system must detect and respond to a soft pulse in an offset deformable barrier regulatory test, it can result in designs with either low thresholds for deployment or in designs which have late deployments in the field. That organization also stated that offset testing with the proposed barrier is not ready for use for the full vehicle fleet in the United States. According to that organization, the European barrier used in the test was never designed for heavier SUVs and light trucks.

General Motors and Ford each supported adding the proposed belted offset test to Standard No. 208 at this time, but urged that a passenger side out-of-position test be developed to either replace it or be provided as an optional alternative to it.

Toyota stated that it generally accepts the proposed offset test as a means to assess sensor timing and out-of-position issues, but expressed concern about the appropriateness of the test for heavier vehicles like SUVs and light trucks. According to that company, these vehicles tend to either override the barrier or deform the face so badly that it essentially becomes an offset rigid barrier test, which does not represent actual car-to-car collisions in the real world.

CAS stated that the proposed test should be included in the final rule. That organization stated that because of the problems air bag crash sensors have encountered in being able to

discriminate between low speed and high speed crashes, this test is necessary to adequately assess sensor performance.

CAS argued, however, that the test should be performed on both the driver and passenger side in order to prevent manufacturers from optimizing their vehicles solely on one side. That organization stated that if NHTSA adopts the test for the driver side only, a manufacturer might choose to add satellite crash sensors to the frontal crush zones of a vehicle only on the driver side. Advocates also expressed concern about requiring the test only with the driver side of the vehicle being struck.

Parents stated that the test should be conducted with unbelted as well as belted occupants, and that this part of the SNPRM improperly favored belted occupants over unbelted ones.

Delphi recommended increasing the speed range specified for the test to 0 to 48 km/h (30 mph) instead of 0 to 40 km/h (25 mph). That commenter noted that, for many vehicles, an air bag might not be required to satisfy the injury criteria at test speeds up to 40 km/h (25 mph). Thus, air bag systems might be designed with sufficiently high thresholds that they do not deploy in this test. Delphi stated that one of the objectives of the test is to evaluate performance in sensing threshold events, since there is a potential for occupants to be out-of-position when the air bag deploys in such situations. Delphi stated that it would be necessary to increase the maximum speed to 48 km/h (30 mph) to cover the sensing threshold for many vehicles and that the significance of the test would be greatly diminished if this is not done.

Consumers Union supported the addition of the proposed test, but urged that the test be conducted at 64 km/h (40 mph), instead of 40 km/h (25 mph). CU questioned how much this test will contribute when it is run at what it views as a low and unchallenging speed. Public Citizen

also supported the addition of the test while stating that a higher speed test, as a supplementary test of structure, intrusion, and sensitivity, would be welcome.

NTSB expressed concern that inclusion of the offset deformable barrier test at the same time as advanced air bag technology is being developed might result in unforeseen problems. While that agency did not identify what those potential problems could be, it stated that it may be desirable to establish a separate schedule or a later phase-in.

DaimlerChrysler stated that it opposes inclusion of the proposed belted offset deformable barrier test in Standard No. 208. That company cited concerns about the European barrier not being appropriate for testing heavier vehicles such as SUVs and light trucks. DaimlerChrysler recommended that the test be removed since advanced air bags, by definition, will be designed to pose less risk to out-of-position occupants. As an alternative, that company recommended replacing the belted offset deformable barrier test with a low risk deployment test for the passenger side.

After carefully considering the comments, we have decided to adopt the belted offset test as proposed. We agree with the suggestion of several commenters that an out-of-position test using 5th percentile adult female dummies should be developed for the passenger side, and will conduct research on that issue. We note, however, that such a test would not necessarily serve as a replacement for a test that is intended to ensure improved crash sensing systems. We also agree with the suggestion of several commenters about the desirability of a high speed offset test to address intrusion and vehicle structure. We will continue to pursue our previously-announced plans to conduct separate rulemaking on the issue of whether to add a high speed offset test to Standard No. 208.

We would like to note again that the main purpose of the belted offset test, at the proposed range of speeds, is to help ensure that vehicle manufacturers upgrade their crash sensing and software systems, as necessary, to better address soft crash pulses. As discussed in the September 1998 NPRM, research conducted by Transport Canada has shown that one of the causes of adverse effects of air bags is late deployment of some air bags in crashes with a "soft crash pulse." In order to reproduce the softer, longer duration crash pulse, it selected the 40 percent offset barrier. It conducted crash tests into the barrier at 8 km/h (5 mph) increments up to 40 km/h (25 mph).

Transport Canada found that at 40 km/h (25 mph), the air bag typically deployed and was sometimes so late that the test dummy would be right on the steering wheel at that time, a "worst case" condition. We noted in the NPRM that the problem of late deployment appeared to exist for only some vehicles. We noted further that it could be addressed by such means as improving computer algorithms and adding crash sensors to a vehicle's crush zone to provide additional and earlier information to use in the decision-making algorithm.

A test that is intended to encourage improved sensing systems does not serve the same purpose as the low risk deployment test suggested by some commenters as an alternative or substitute. If, as a result of an improved sensing system, an air bag that previously would deploy after an occupant moves out-of-position now deploys in a timely manner, it can provide protection. However, if an air bag deploys so late that the occupant has already moved onto the steering wheel, it cannot provide protection. We encourage vehicle manufacturers to respond to this new test requirement by improving sensing systems and not just providing low risk deployment.

As to Delphi's recommendation that we increase the speed range to 48 km/h (30 mph), we note that such a speed is outside the scope of our proposal and could encourage manufacturers to only test the sensors at 48 km/h (30 mph) and not at the lower speeds where a late deployment is more likely. To the extent that Delphi is suggesting that our test may not pick up a late deployment problem for vehicles that are designed with sufficiently high thresholds that the air bag does not deploy in this test, we acknowledge that in some instances a vehicle's air bag system may not deploy in this test. However, our experience has been that the vast majority of air bags deploy in offset barrier crash tests slightly below 40 km/h (25 mph). Additionally, when there is a deployment, we believe crash sensors are more rigorously tested in a 40 km/h (25 mph) test than in a higher speed test. We ran offset tests at both 40 km/h (25 mph) and 56 km/h (35 mph) prior to publication of the SNPRM. In reviewing the test results, we observed that the air bags in the 56 km/h (35 mph) tests deployed significantly more quickly than in the 40 km/h (25 mph) tests. Based on these observations, we believe that a 40 km/h (25 mph) offset deformable barrier test will do a better job of detecting late deployments than a 48 km/h (30 mph) test.

In response to Parents, we note that the improved sensing systems required by this test will benefit both belted and unbelted occupants. The fact that this test is conducted in the belted condition only is not intended to favor belted occupants over unbelted occupants. The belted offset test may represent the worst case scenario since the belt allows the dummy's head and neck to rotate into the path of the deploying air bag. This condition may better test for potential neck injuries than an unbelted test. Additionally, some tests, such as the oblique tests, will be conducted only with unbelted occupants. We have designed the overall matrix of tests to meet the need for safety for all occupants, belted and unbelted, while avoiding unnecessary tests and

compliance costs.

We are not adopting the suggestion made by some commenters that the test be conducted both with the driver side of the vehicle engaged with the barrier and with the passenger side of the vehicle engaged with the barrier. We believe that testing with the driver side of the vehicle engaged with the barrier will be sufficient to help ensure that vehicle manufacturers improve their sensing systems.

We recognize that this test, like any other, has limitations. For example, the test represents only one of many types of soft pulses, and one specific offset configuration. While it would always be possible to identify additional tests that represent potential real world situations, we must strike a balance between ensuring that there are sufficient tests to meet the need for safety and avoiding unwarranted compliance burdens. We believe that the addition of this test with only the driver side of the vehicle engaged with the barrier strikes this balance. However, we will monitor future air bag system designs and will consider changing this decision if we find that manufacturers are implementing sensor systems that optimize performance only for impacts into the driver's side of the vehicle.

We believe that the concerns expressed by commenters about the appropriateness of the test barrier for heavier SUVs and light trucks are not significant with respect to a test conducted at speeds up to 40 km/h (25 mph). Even if bottoming out occurs, the test still represents a relatively mild crash, and air bags should be designed to provide appropriate performance under a wide range of conditions.

Similarly, we believe that AAM's concerns that an offset test can result in designs with either low thresholds for deployment or in designs which have late deployments in the field are

not relevant to a test conducted at speeds up to 40 km/h (25 mph). As noted earlier, the vast majority of existing air bag systems deploy in offset deformable barrier tests below 40 km/h (25 mph). We will consider these concerns further if we separately propose to use the European barrier in a high speed offset test.

As to NTSB's concern that adding this test at the same time as requiring advanced air bags may cause unforeseen problems of an unspecified nature, we note that vehicle manufacturers have been working to address the problem identified by Transport Canada for several years. Moreover, we believe that advanced air bag systems should easily be able to meet this requirement.

## XII. Test Requirements to Minimize the Risk of Injuries and Deaths Caused by Air Bags

The one fact that is common to all persons who are at risk from air bags is that they are extremely close to the air bag at time of deployment. Behavioral changes, such as ensuring that children ride in the back seat and that all occupants are properly restrained, can sharply reduce the number of persons who are in such positions.

However, to minimize air bag risks for the remaining persons who are most likely to be close to the air bag at time of deployment, one of two things must be done: either air bag deployment must be suppressed, or the air bag must be designed to deploy in such a manner that it does not cause a significant risk of injury to persons in such positions. Each of the technologies to minimize air bag risks follows one of these approaches.

As we developed test requirements to minimize air bag risks, we needed to account for the fact that the persons who are potentially at risk vary from infants to adults, and have different potentials for injury. We therefore found it necessary to develop requirements using a variety of

test dummy sizes. Moreover, since we wished to avoid requirements that are unnecessarily design-restrictive, it was necessary to develop a variety of testing options that account for the kinds of effective technological solutions that are under development.

We note that it was never our intention to limit manufacturers to using systems that provide only suppression, where appropriate, or low risk deployment, as opposed to systems that may combine suppression and low risk deployment. Moreover, we recognize that there may be safety benefits to using a combination of approaches and technologies.

Even looking at suppression systems alone, the use of multiple technologies may provide benefits. For example, manufacturers might combine weight and pattern sensing to achieve greater reliability.

Similarly, the combination of suppression and low risk deployment may better achieve the goal of minimizing air bag risks. For example, as Toyota noted, a system designed to suppress the passenger air bag for children below a specified weight would not suppress the air bag for a young child seated on an adult's lap. However, low risk deployment might prevent serious injury in such a situation.

Because it is necessary to test the various types of suppression systems and low risk deployment systems differently, we proposed a variety of testing options that account for the kinds of effective technological solutions that are under development. Where more than one option is specified, a manufacturer must meet at least one option; nothing precludes the manufacturer from meeting more than one. The issue of certifying compliance to more than one option is discussed later in this document.

Each of the test requirements we proposed in the SNPRM is discussed below.

### A. Safety of Infants

Infants in rear-facing child safety seats (RFCSS) and in convertible child restraints in the rear-facing mode are at significant risk from deploying air bags, since the rear-facing orientation of the child seat places their heads extremely close to the air bag cover. This is why we emphasize that infants in these restraints must never be placed in the front seat unless the air bag is turned off. While the current warning labels and educational campaigns have dramatically reduced the number of fatalities to infants over the past two years, we recognize that there are still some parents who ignore this advice and place their children at grave risk from a deploying air bag. SCI data shows that some infant fatalities have occurred because parents did not place their child in a RFCSS properly.

In the SNPRM, in order to address the risks air bags pose to infants in child restraints designed to be used by them, we proposed two alternative test requirements, the selection of which would be at the option of the manufacturer. The two manufacturer options were: (1) test requirements for an automatic air bag suppression feature or (2) test requirements for low risk deployment involving deployment of the air bag in the presence of a 12-month-old Child Restraint Air Bag Interaction (CRABI) dummy in a RFCSS or convertible child restraint in the rear-facing mode.

#### 1. Option 1: Feature (e.g., weight or size sensor) that suppresses the air bag when an infant is present

We proposed that if the automatic suppression feature option were selected, the air bag would need to be suppressed during several static tests using, in the right front passenger seat, a 12-month-old child dummy in child restraints designed to be used for infants. The restraints

would be placed in several specified positions during the static tests. Manufacturers would be required to assure compliance using any of the child restraints included in sections B and C of the list of representative child restraints that we proposed to add as an appendix to Standard No. 208, as well as the car bed listed in section A. The list would be periodically updated to reflect changes in the types and designs of available child restraints.

In order to ensure that the suppression feature did not inappropriately suppress the air bag for small-statured adults, the air bag system would need to be activated during several static tests using a 5th percentile adult female dummy in the right front passenger seat. At the option of the manufacturer, human beings could be used in the place of the 5th percentile adult female dummy. We proposed to permit manufacturers to use human beings in light of concerns that current dummies may not be sufficiently human-like to be recognized by some of the advanced technologies under development. The issue of permitting manufacturers to certify to suppression requirements using human beings is discussed in greater detail later in this notice.

AAM, GM, Toyota, Isuzu and DaimlerChrysler all argued in their comments that the static suppression tests to protect infants were too burdensome, notwithstanding our reduction of the number of child restraints that the agency would use in compliance testing. Concerns were raised in particular about the range of seat back angles and seat track positions, as well as the placement of a blanket on the restraints and testing with the handle and sunshield in a full-up and full-down position. The commenters also recommended that they only be required to assure compliance using a limited number of restraints in each section of the appendix (between one and three). Isuzu further argued that tests should only be conducted with belted restraints. Most of these arguments were repeated in comments on suppression testing for the 3-year-old and 6-

year-old children.

David Breed and IEE offered comments on the technology available for the static suppression systems. David Breed argued that the testing of convertible infant seats in a forward-facing mode would effectively eliminate the low risk deployment option for older children because manufacturers would be forced to rely on a weight-sensing system. According to that commenter, such a restriction could lead to safety trade-offs for older children who could benefit from a benignly deploying air bag.

IEE argued that by testing suppression systems with a variety of child restraints, we are encouraging the use of discriminating systems rather than a non-discriminating system like a universal tag. IEE asserted that the non-discriminating systems are significantly more reliable than any discriminating systems currently available. The possibility that a non-discriminating system, like the Mercedes Baby-Smart, could easily resolve problems with suppression technology was echoed by DaimlerChrysler.

We note that testing performed by NHTSA at VRTC subsequent to publication of the SNPRM demonstrated that it is difficult to place some child restraints usable by infants in several of the proposed positions in some circumstances.

The first such position is testing the unrestrained child restraint at any angle plus or minus 45 degrees from the vehicle seat's longitudinal plane. While achieving this position may be possible in vehicles that do not have contoured seats, in several of the vehicles we examined, the RFCSS flipped toward the center of the seat. As a practical matter, we do not believe parents or caregivers are likely to place a child restraint on the seat at a 45 degree angle. We believe the restraint would be placed roughly along the longitudinal plane, facing either the seat back or the

windshield. Accordingly, we have revised this test procedure to specify placement only at zero degrees of the longitudinal plane.

The proposed position which specified that the restraint be tipped to rest on the dashboard was also difficult to achieve. The intent behind the test was to mimic a situation where, through pre-crash braking, a child restraint slides forward and flips onto the dashboard. Our SCI investigations have reported several instances where this type of movement has occurred, with devastating consequences for the child in the child restraint.

However, this position does not test a condition for which static suppression systems are designed. Some suppression systems are designed to classify occupants and to address positions where parents or caregivers place infants under normal driving conditions. It is exceptionally unlikely someone would drive with an infant's head wedged between the dashboard and the child restraint. Accordingly, we have eliminated this test requirement.

The third condition which proved problematic in some instances was placement of the restraint with the vehicle seat in its full forward position. In smaller vehicles, the restraints often could not be placed in the front seat with the seat full forward. This was a particular problem with convertible restraints, which can be considerably larger RFCSSs. In some instances, the restraint hung suspended between the dashboard and the seat back. In other cases, the restraint had to be positioned at a severe angle in order to achieve contact with the seat cushion. Again, we do not believe parents or caregivers are likely to place a child restraint in a position where the restraint either tips forward onto the seat or where the restraint does not make any contact with the seat. Changes to the test procedures to account for this situation are discussed below.

Toyota and GM argued that the proposed requirements specifying testing of the restraints

at any seat track position and at any seat back angle between the nominal design position and 25 degrees rearward would require up to 40,000 different tests to assure compliance. We believe this argument severely overstates the situation. As long as the restraint fits in the vehicle interior, a suppression system that is entirely seat-based will be able to discriminate the presence of the restraint, regardless of the seat track position. Likewise a seat-based system will be able to detect the restraint regardless of whether the sunshield or handle is in an upright or stowed position or whether the restraint has a blanket on it. Systems that could have difficulty detecting these different conditions are those which have sensors that are not completely incorporated into the seat. Such systems will need to be able to detect where the restraint is located in the vehicle and whether there are any potential impediments to accurately sensing the presence of an infant, like a sunshield, handle or blanket. However, these systems' ability to detect a sunshield, handle, or blanket should not be affected by the belted, or unbelted, condition of the child restraint.

In view of the fact that parents or caregivers who continue to place infants in the front seat may position the vehicle seat in a variety of seat track positions, we continue to believe that there is a need to test suppression systems in a variety of seat track positions. However, we have also concluded that testing the systems at discrete points along the seat track should be sufficient to ensure adequate performance throughout the entire range of seat track positions. Therefore, we have decided to specify test requirements for suppression technology at the vehicle seat's full-rear position, mid-track position and full-forward position. If the child restraint strikes the instrument panel or another portion of the vehicle interior when the seat is in the full-forward position, the vehicle seat will be moved back to the next detent that allows for clearance, or, in the case of automatic seats, until a maximum of 5mm (0.2) of clearance is achieved. A more

complete discussion of this issue is provided later in this document.

Finally, we determined that conducting tests using a belted child restraint with the vehicle seat back 25 degrees rearward of the seat back's nominal design position for the 50th percentile adult male was not always possible. As discussed later in this document, we have decided to limit the vehicle seat back angle for the infant suppression tests to the nominal seat back design position for the 50th percentile male.

We have decided against allowing manufacturers to certify to only a limited number of the seats listed in the appendix. The number of applicable seats has already been honed down considerably from what was proposed in the NPRM. A further reduction could effectively allow manufacturers to design suppression systems that would not protect infants in child restraints representing a reasonable range of such restraints on the market.

We have also decided to retain those test conditions involving unbelted restraints. Unfortunately, not everyone always installs child restraints (including RFCSSs) properly, as indicated by several fatalities in our SCI database. If we failed to test in unbelted conditions, suppression systems could be designed so that they only worked when the seat belt was fastened. Such a system could not protect these infants.

While we understand David Breed's concern about testing convertible restraints in a forward-facing position, this test requirement is necessary and need not preclude low risk deployment for older children. As an initial matter, current air bag designs pose a risk to infants seated in forward-facing convertible child restraints, as indicated by the SCI data. However, advanced designs which eliminate that risk could still be used, even if a manufacturer chose to suppress the air bag for infants in these restraints. For example, we believe manufacturers could

design a system that suppressed the air bag based on weight and pattern recognition that is limited to the expected weights of very young children and child restraints designed for use by infants. It is possible that in some instances this technology could also suppress for a slightly older child in a convertible child seat. However, the manufacturer could also design the air bag system to deploy at a level that is non-injurious to a small child. Certification could be based on the low risk deployment test, and the potential suppression for the older child would provide supplemental protection.

IEE and DaimlerChrysler may be correct that non-discriminating, tag-like systems could offer greater reliability than discriminating systems, assuming that the correct tagged child restraint is also used. However, such systems would not ensure safety for the numerous different child restraint designs and potential restraint positions that are used by the general public. Even making tags widely available, as DaimlerChrysler suggests, would not account for those individuals who do not have a tag on their particular child restraint, either because the restraint is not generally used in a given vehicle, or because they are unaware that the tags are available. Additionally, simply providing the tags would not assure that they were installed on the restraint properly or that the tag was properly aligned when the restraint was set in the vehicle seat.

Technology like the Mercedes BabySmart appears to provide a reliable method of preventing air bag deployments when used properly. While we do not believe that these types of suppression systems alone will adequately meet the needs of motor vehicle safety, we do believe that they remain an excellent supplement to other systems.

Further, belted tests conducted with child restraints that have the lower anchor attachments will need to be conducted both with the vehicle safety belt and, in vehicles with the

corresponding anchors, with the attachments secured in the anchors with the safety belt unfastened. Such a requirement is necessary for various reasons. First, the anchors may fail to place sufficient weight on a seat to adequately test a suppression system. Second, a parent may fail to use the anchor system and use the belt system instead. Third, using a belt with the anchor system could result in damage to the system when the safety belt is cinched to 134 N (30 lb). Finally, the anchor attachments may prevent alignment of the child restraint along the defined vertical planes in low risk deployment tests. We note that Standard No. 213 does not contemplate seating systems where both the safety belt and the lower anchor attachments are used.

### 2. Option 2: Low risk deployment for infants in RFCSS

We proposed to require that, if the low risk deployment option were selected, a vehicle would be required to meet specified injury criteria performance limits when the passenger air bag is deployed in the presence of a 12-month-old CRABI dummy placed in a belted rear-facing child restraint, either a RFCSS or a convertible restraint. As with the proposed test requirements for the suppression option, manufacturers would be required to assure compliance using each child restraint included in sections B and C of the proposed list of representative child restraints, although not with the car bed identified in section A.

In the case of air bags with multiple inflation levels, the injury criteria performance limits would need to be met for any stage or combination of stages which may deploy in the presence of an infant in a rear-facing position in one of the listed restraints in a rigid barrier crash test at speeds up to 64 km/h (40 mph). Our intent was to cover all stages of inflation that could deploy in the presence of an infant in such a restraint.

TRW stated that the requirement that the air bag deploy at the highest output is inconsistent with low risk deployment. That company stated that this will force manufacturers to employ automatic suppression technologies. TRW stated that NHTSA's analysis shows little incremental benefit to children from the addition of suppression technologies. That company stated that NHTSA's analysis also ignores potential for reduction in protection for adult occupants. TRW argued that we should revisit the low risk option.

TRW also stated that if we do not revisit the low risk option, the final rule should be changed to accommodate unresolved technical issues with suppression technologies. That company stated that it has tested various suppression technologies with respect to their ability to classify accurately the proposed range of seating positions and seat belt cinching loads on the specified lists of car seats with pure weight and/or pattern sensing and found problematic issues with each technology.

DaimlerChrysler stated that it does not see any justification for running the threshold compliance test for low risk deployment at 64 km/h (40 mph). That commenter stated that since other test requirements are proposed at a maximum of 48 km/h (30 mph), this test should be run at 48 km/h (30 mph) also. DaimlerChrysler also argued that the proposed threshold compliance test was impracticable because it specified that testing could be conducted with child seats in any of the possible positions used for the suppression tests. That company stated that this would mean that five crashes would have to be performed for each child restraint on the list.

After considering the comments, we continue to believe that it is appropriate to require vehicles that are certified to the low risk deployment option for infants to satisfy the injury criteria for all stages of inflation that could deploy in the presence of an infant in a rear facing

restraint. As we discussed in the September 1998 NPRM, a child in such a restraint would be extremely close to the passenger air bag in any crash, regardless of crash severity. This is not the case with persons in any other risk group. Moreover, manufacturers have been working on suppression devices for this risk group for the longest time, since this was the first risk group that was identified. Since suppression is available for this risk group and since there are no known benefits from deploying an air bag for this group, it is appropriate to expect advanced air bags to essentially eliminate risk of serious injury or fatality resulting from air bag deployment to infants in RFCSS. There is no reason to permit continued use of systems that place infants at significant risk of serious injury or death from the air bag in crashes of any severity level.

We do not believe that any reduction in safety to adults will occur from suppressing the passenger air bag for infants in RFCSS. While suppression of the passenger air bag for older children may raise the issue of a "gray zone" that could affect some adults, we do not believe that will be relevant to infant suppression technology.

We originally proposed to require low risk deployment for all stages of the air bag that may deploy in a crash. The modified proposal to which DaimlerChrysler objects was an effort to accommodate systems which might be designed to always provide a lower level of deployment in the presence of a rear facing restraint, regardless of crash severity.

We disagree with the argument that the proposed test procedure is impracticable. Because the low risk deployment test is only conducted in the presence of a belted child restraint, a manufacturer that designed a system that always provided a lower level of deployment in the presence of a rear facing restraint could determine what level would deploy in a barrier crash test by means other than conducting barrier tests, e.g., by testing the sensor system that determined

whether such a restraint was present.

We note that we specified a barrier crash test at a speed up to 64 km/h (40 mph) because some manufacturers may adopt a threshold higher than 48 km/h (30 mph) for deploying the highest level of inflation for the belted condition. Since these restraints are ordinarily belted, a speed higher than 48 km/h (30 mph) is needed to ensure that we cover all stages of inflation that could deploy in the presence of an infant in such a restraint.

### B. Safety of Young Children

Young children are at special risk from air bags because, when unbelted, they are easily propelled close to the air bag as a result of pre-crash braking. Their small size, weight and strength also makes them more vulnerable to injury when interacting with a deploying air bag. We strongly recommend that children through age 12 ride in the back seat, because the back seat is safer, whether or not a vehicle has air bags.

In the SNPRM, in order to address the risks air bags pose to young children who do ride in the front seat, we proposed requirements using both 3-year-old and 6-year-old child dummies. We proposed three alternative test requirements, the selection of which would be at the option of the manufacturer. Manufacturers could select different options for the 3-year-old and 6-year-old child dummies.

The three manufacturer options were: (1) test requirements for a feature that suppresses the air bag when a child is present, e.g., a weight or size sensor; (2) test requirements for low risk deployment involving deployment of the air bag in the presence of out-of-position 3-year-old and 6-year-old child dummies, and (3) test requirements for a feature that suppresses the air bag when an occupant is out of position.

### 1. Option 1: Feature (e.g., weight or size sensor) that suppresses the air bag when a child is present

Our proposed requirements for an air bag suppression feature (e.g., weight or size sensor) that suppresses the air bag when a child is present were similar to the ones we proposed with respect to a suppression feature for infants. We proposed that if this option were selected, the air bag would need to be suppressed during several static tests using, in the right front passenger seat, a 3-year-old or 6-year-old child dummy. The child dummy would be placed in several specified positions during the static tests. Manufacturers would be required to assure compliance using every child restraint appropriate for a given dummy size included in the proposed list of representative child restraints. The air bag system would be required to be activated during specified tests using a 5th percentile adult female dummy.

We proposed to allow manufacturers to comply with and certify to these suppression requirements using children, instead of 3-year-old and 6-year-old child dummies. Adult females could also be used in the place of 5th percentile adult female dummies for the portions of those test requirements which make sure that the air bag system is activated for adults.

We proposed to permit manufacturers to use human beings to check suppression features in light of concerns that current dummies may not be sufficiently human-like to be recognized by some of the advanced technologies under development. For example, suppression devices that work by sensing the distributed weight pattern of a human being may not recognize the pattern of a test dummy. If a manufacturer selected this option, the suppression requirements would need to be met at each of the relevant positions for any human being within a specified weight/height range for 3-year-old and 6-year-old children, and the air bag system could not be suppressed for

any human being within a specified weight/height range for 5th percentile adult females.

In the SNPRM, we emphasized that these tests simply involve a child or adult assuming specified positions in the vehicle, with a technician checking (typically by looking at a light) whether the air bag would be suppressed or not; these tests do not involve deploying the air bag or moving the vehicle. To ensure absolute safety, we proposed to require manufacturers selecting this option provide a method to assure that the air bag would not deploy during testing; such assurance could be made by removal of the air bag. The manufacturer would also be required to provide a method to assure that the same test results would be obtained as if the air bag had not been deactivated or removed.

By and large, the comments in response to this proposed requirement mirrored those already discussed under static suppression features for infants; i.e., there are too many child restraints, too many angles and too many seat track positions. Additional concerns were voiced about the requirement that child restraints be cinched at a force up to 134 N (30 pounds). Additionally, TRW stated that the task of discriminating between a child weighing up to 66 pounds and a 110-pound adult, while seemingly trivial, becomes more difficult when one takes into account the addition of child seats and seat belt cinching loads.

For the reasons set forth in the prior discussion of the suppression tests for infants, we have decided to conduct tests with the vehicle seat in the full-rear, mid-track and full-forward positions. If the dummy, the child restraint, or the child's legs interfere with the instrument panel or other portion of the vehicle interior in the full-forward position, the vehicle seat will be moved back to the next detent that allows for clearance, or, in the case of automatic seats, until a maximum of 5mm (0.2 in) of clearance is achieved.

Likewise, the seat back angle will be the manufacturer's nominal design position for the 50th percentile male for all tests, including the test with the 5th percentile adult female, except the tests where the child is sitting on the seat and leaning against the seat back (S22.2.2.2 and S24.2.1). A fuller discussion of seat back angle is provided later in this document.

One test position for the 3-year-old child that we have modified is the position where the child is lying on the seat. While conducting tests at VRTC, we discovered that this position was problematic in vehicles with no middle seating position. The 3-year-old test dummy cannot assume a full fetal position in these vehicles. Accordingly, in our tests the dummy's legs and feet were not in contact with the passenger seat. We do not believe that the position needs to be included in the test matrix for a vehicle without a middle seating position because a child would not lie in this position for any length of time. However, in vehicles with a bench seat or with convertible bench seats, where the console can be converted into a middle seat, this position is a likely real world position. Accordingly, we have specified tests for this position only in vehicles with three designated seating positions in the front seat.

We have also dropped the static suppression tests with the 3-year-old and 6-year-old child dummies in the positions specified for the low risk deployment tests. Like the infant test where the child seat was flipped on to the instrument panel, we believe that these positions do not test a condition for which static suppression systems are designed. Additionally, we believe that any system that suppresses when the dummy is sitting on the edge of the seat with its spine vertical, a condition that is still required for both the 3-year-old and the 6-year-old, will respond no differently from when the dummy is placed in either of the low risk deployment options. Thus, even if the dropped tests did represent a position for which static suppression systems are

designed, they would likely be redundant.

Numerous comments were received regarding the cinching procedures for safety belts on child restraints. We have decided to keep the up-to-134 N (30 lb) requirement. Belt systems that cannot be cinched up to this level of force will be cinched at as high a level as possible. In our testing at VRTC, we found that a 134 N (30 lb) tension can be easily achieved. While we continue to caution adults to place their children in the back seat whenever possible, a parent or caregiver who places a child in the front seat should be able to do so as safely as possible without shutting off any available suppression technology. We regularly encourage people to have their child restraints installed by individuals who have been trained to install these restraints properly. We also encourage parents to secure a child seat in a manner that eliminates slack between the restraint and the vehicle seat. We believe that it is appropriate to use a cinching level that can be achieved by an individual who knows how to properly install child restraints. However, we do agree with the commenters that the up-to-134 N (30 lb) tension range is inappropriate for belt-positioning booster seats, since a child could not sustain that amount of belt tension, even if it were possible to achieve with a test dummy. We are specifying that these restraints be installed, and that belts be used, in accordance with the restraint manufacturer's instructions.

Since the 6-year-old child dummy is not tested in child restraints other than booster seats, we believe that the majority of the manufacturers' concerns about the suppression-activation "gray zone" are largely resolved. The 6-year-old child dummy weighs only 23.4 kg (51.6 lb). Likewise, the weight range for the six-year-old child who can be used for compliance testing has an upper parameter of 25.6 kg (56.5 lb). Because of constraints in Standard No. 213, booster seats generally do not weigh more than 4.5 kg (9.9 lb). Accordingly, the combined weight of the

child or dummy and the booster seat should still be significantly below the weight at which suppression systems will assure that air bags are activated to protect adult occupants. As discussed earlier, vehicles with child restraint anchors will need to be tested both with and without any available child restraint anchor attachments secured to the passenger seat.

### 2. Option 2: Low risk deployment for young children

We proposed to require that, if the low risk deployment option were selected, a vehicle would be required to meet specified injury criteria performance limits when the passenger air bag is deployed in the presence of out-of-position 3-year-old and 6-year-old child dummies. We proposed that the test be conducted at two positions which tend to be "worst case" positions in terms of injury risk. In one of these positions, the dummy's chest is on the instrument panel; in the other, the dummy's head is on the instrument panel. We proposed more detailed positioning procedures for these two tests than for many of those proposed for the static suppression tests, since injury measures may vary considerably with position. Under our proposal, in the case of air bags with multiple inflation levels, the injury criteria would need to be met only for the levels that would be deployed in lower severity crashes; i.e., the levels that would be deployed in crashes of 29 km/h (18 mph) or below.

As discussed earlier in this document, some commenters, including AAM and Toyota, argued that the combination of testing for low risk deployment for inflation levels that would be deployed in crashes of 29 km/h (18 mph) or below and testing to ensure protection in unbelted rigid barrier tests beginning at that same speed would limit design flexibility and discourage manufacturers from selecting the low risk deployment option. The reason for this is that the manufacturers claim it is difficult to design dual stage air bags that could both meet the low risk

deployment requirements and the barrier crash test injury criteria, particularly given the gray zone in which either a low level or high level deployment may occur.

On a separate but related issue, AAM recommended that the crash test to determine the air bag deployment level to be used for the low risk deployment test be conducted with a belted dummy matching the size for which the low risk option is certified. AAM stated that this would allow manufacturers to utilize an occupant detection system to govern the deployment that would be used for the low risk deployment test.

TRW stated that the proposed injury criteria performance limits will make it very difficult to employ the low risk deployment option except in vehicles with unique geometry. That commenter stated that this would force the automobile manufacturers to employ suppression technologies.

After considering the comments, we are adopting the proposed low risk deployment tests using 3-year-old and 6-year-old child dummies, with two modifications. First, the positioning procedures for one of the out-of-position tests has been significantly simplified. A fuller discussion of the reason for this change is provided later in the document. Secondly, in order to avoid inadvertently discouraging the development of low risk deployment technologies, the injury criteria will need to be met, in the case of air bags with multiple inflation levels, for the levels that would be deployed in crashes of 26 km/h (16 mph) or below, as well as the relative timing of the multiple inflations, instead of crashes of 29 km/h (18 mph) or below. However, if the air bag did not deploy at all in crashes of 26 km/h (16 mph) or below, the injury criteria will need to be met using the lowest level of inflation.

We believe that this change, coupled with the one discussed earlier in this document to

increase the lower end of the range of speeds for which the unbelted rigid barrier test is conducted from 29 km/h (18 mph) to 32 km/h (20 mph), will facilitate use of the low risk deployment option. As discussed earlier in this document, low risk deployment offers potential benefits over suppression, especially for children older than six years, and we wish to facilitate that option to the extent consistent with safety need. We also note that if manufacturers certify compliance for all levels of inflation that occur in crashes of 26 km/h (16 mph) or below, the same low risk levels of inflation are likely to occur in crashes slightly above that speed.

We are not adopting AAM's recommendation to specify that the crash test to determine the air bag deployment level to be used for the low risk deployment test be conducted with a belted dummy matching the size for which the low risk option is certified. The final rule specifies that this crash test be conducted with an unbelted 50th percentile adult male dummy in the mid-track seat position. An out of position occupant, by definition, would always be unbelted. Determining the level of inflation with belted occupants would allow manufacturers to place technology in a vehicle that would meet the low risk deployment test requirements, but would not adequately protect for the condition that is experienced in the real world. Additionally, while we are only testing the low risk deployment technology on the passenger side with three-year-old and six-year-old child dummies, a benign deployment in low speed crashes could provide ancillary benefits to larger occupants. We are concerned that using the child dummies to determine which stage or combination of stages of the air bag to deploy could unnecessarily limit the benefits of low risk deployment air bags.

As to TRW's concern that the injury criteria performance limits make it difficult to comply with the low risk deployment option, we wish to ensure that low risk deployment air

bags truly are low risk. Thus, the injury criteria limits must be set at a stringent level.

### 3. Option 3: Feature that suppresses the air bag when a child is out of position

As discussed in previous notices, we believe that a feature that suppresses the air bag when an occupant is out of position, either initially or because of moving into such a location during pre-crash braking, needs to be tested very differently from one that suppresses the air bag whenever a child is present. While various static tests can be used to determine whether the latter type of suppression device is effective, they would be of limited utility in testing a feature that suppresses the air bag when an occupant moves into an out-of-position location. This is because one of the key criteria in determining whether the dynamic out-of-position suppression feature is effective is timing; i.e., whether the feature works quickly enough in a situation where an occupant is propelled out of position as a result of pre-crash braking (or other pre-crash maneuvers). We accordingly developed separate requirements for such dynamic suppression devices.

The development of requirements for dynamic suppression devices posed special problems, however. While much work is currently being done on the development of dynamic automatic suppression systems (DASS), the technology is still not mature. In addition, a number of different technologies are currently being considered. Each of these technologies has particular attributes which affect the appropriateness of the means used to evaluate its performance. Given these factors, we were unable to develop a complete set of performance requirements and test procedures that would be appropriate for the range of potential DASS designs.

Accordingly, we proposed to establish very general performance requirements for DASS and a special expedited petitioning and rulemaking process for considering procedures for testing advanced air bag systems incorporating a DASS. Target time limits for each phase of such a rulemaking were proposed. Anyone wishing to utilize such advanced air bags could develop test procedures for demonstrating the compliance of their particular DASS with the performance requirements and submit those test procedures to the agency for our consideration. If we deemed it appropriate to do so after evaluating the petition, we would publish a notice proposing to adopt the test procedure. After considering those comments, we would then decide whether the procedure should be added to Standard No. 208. If we decided to do so, and if the procedure were suitable for the DASS of any other vehicles, then the procedure could be used by the manufacturers of those vehicles as well as by the petitioner. We noted that we intended to minimize the number of different test procedures that are adopted for DASS and to ensure ultimately that similar DASS are tested in the same way.

Comments regarding DASS indicated general support for our proposal. Commenters addressing issues related to the DASS proposal included two manufacturers, DaimlerChrysler and GM, five suppliers, ASCI, Autoliv, Breed Technologies (Breed), Delphi and TRW, two trade groups, AORC and AAM, a public interest group, the Center for Regulatory Effectiveness (CRE) and one private individual (JCW). With one exception, JCW, all commenters agreed that the DASS requirements and test procedure proposed in the NPRM were unworkable and must be abandoned. Two commenters, Breed and ASCI, propounded the use of a sled test and disagreed with our judgment that development of a practical test procedure for evaluating DASS-equipped vehicles is not presently feasible.

Several commenters voiced strong reservations regarding the DASS proposal we put forth in the SNPRM. JCW objected to the elimination of the DASS out-of-position requirements. JCW argued that without some form of suppression to protect people who are in the immediate vicinity of an air bag because of pre-crash braking, the safety potential of advanced air bags will be lost. Breed and ASCI stated that sled tests which accurately reproduce the movements of unrestrained occupants in pre-crash braking are currently available and should be used as a compliance test for DASS systems.

One matter mentioned by a number of commenters concerned the confidentiality of information provided by petitioners seeking adoption and approval of a DASS compliance test procedure. AORC and AAM urged us to consider that manufacturers would be deterred from investing in DASS systems if the specifics of their proprietary technologies were published and made available to the public and to competitors. AAM suggested that this issue might be addressed by not requiring that the identity of the petitioner and the particular automobiles where a DASS system is to be installed be revealed to the public during the course of the petition and review process. Delphi and Autoliv contended that the proposed DASS petition procedures required the submission of too much proprietary information. In particular, Autoliv objected to the proposed requirements that petitioners must furnish a complete description and explanation of a DASS system and a complete description of the logic used by that system. CRE suggested that the only materials that need to be made public during the petition process are those that would allow for comment on the proposed test procedure and not on the specifics of the DASS system at issue. The organization strongly recommended that our final rule emphasize that the "proposed rule" that is being offered for public comment would consist only of a proposed test

procedure that would not include the details of the technology used or the data submitted in support of the proposed test procedure.

In addition to concerns about confidentiality, a number of commenters offered remarks about the expedited rulemaking procedure we proposed for DASS systems. Several commenters requested that the expedited procedures proposed for DASS systems be expanded to include all advanced air bag technologies. Autoliv, DaimlerChrysler, Breed, AORC and Delphi also suggested that the expedited rulemaking procedure be expanded to allow the use of new technologies in areas other than dynamic suppression systems. In regard to the timing of the proposed procedure, AAM suggested that we adopt a procedural timetable similar to that already used for evaluating the adequacy of anti-theft devices under 49 CFR Part 543. AORC and CRE urged us to expedite the regulatory approval process to the maximum extent possible. CRE also suggested that notice and comment could be eliminated altogether. If, CRE contends, initial DASS rulemakings do not stimulate any substantive comments by the public, we would then be in a position to dispense with traditional notice and comment as the procedure would be superfluous.

One commenter, GM, voiced substantial concerns about the effect that initial DASS rulemakings would have on subsequent petitions. In GM's view, the first successful DASS petitioner will define a large number of important conditions for DASS testing and test procedures. GM believes that there will be a very strong incentive for others in the industry to conform to the existing test procedure rather than develop a new or different technology, particularly because subsequent petitioners will face additional burdens in demonstrating that an existing DASS test cannot be used. GM urged us to use the traditional rulemaking process for

the initial DASS petitions and provide adequate time for comment on any DASS proposal.

After review of the comments received in response to the SNPRM, we are adopting the proposal with few modifications. We have not been presented with, and are not aware of, any information indicating that any feasible test procedure now exists for a DASS system. We are also declining to expand the scope of the expedited petition process to other areas of Standard No. 208. Unlike other air bag technologies, DASS technology is still in the early stages of development. Other technologies are more mature, and developments within these areas may be adequately addressed through traditional rulemaking procedures.

The final rule makes several modifications to address confidentiality concerns. As the identity of the supplier or manufacturer would not be relevant to the evaluation of a test procedure and performance standard, we have modified section 552.13(e) to clarify that if a petitioner desires to have its identifying information withheld from public disclosure, it may request that the agency do so pursuant to 49 CFR Part 512. We have determined that the requirements outlined in section 552.14(b)(1) could be construed as demanding that all details of any algorithms and/or system logic be provided to the agency. Accordingly, the final rule provides that the description of the system logic may be limited to a flow chart or similar materials outlining the function of the system. We also wish to emphasize that pursuant to Part 512, petitioners may submit both confidential and non-confidential versions of their petitions and accompanying materials. These materials may include test films, printouts and similar data.

The final rule also makes slight modifications to the procedural timetable for the petition process. In order to alleviate the concerns raised by the precedential effect of the initial DASS petition, we have specified an extended comment period for such a petition. Section 552.15(c) of

the final rule provides that we expect to employ a 30-day comment period in a DASS test procedure rulemaking. However, in the case of an initial petition or a petition raising particularly novel issues, we may provide 60 days for comments. Offering an extended comment period will provide interested parties with additional time to evaluate the proposed test procedure and its implications, particularly in regard to suitability for other DASS concepts or designs under development.

We disagree with the argument that without some form of suppression to protect people who are in the immediate vicinity of an air bag because of pre-crash braking, the safety potential of advanced air bags will be lost. DASS systems represent one approach to minimizing air bag risks. As discussed elsewhere in this document, other approaches include deploying the air bag in a manner that does not cause harm and other types of suppression systems; e.g., suppressing the air bag when children are present.

### C. Safety of Teenage and Adult Drivers

Out-of-position drivers are at risk from air bags if they are extremely close to the air bag at the time of deployment. While any driver could potentially become out of position, small-statured drivers are more likely to be positioned on top of the air bag because they generally sit closer to the steering wheel than larger drivers.

In the SNPRM, in order to address the risks air bags pose to out-of-position drivers, we proposed requirements using 5th percentile adult female dummies. We proposed two alternative test requirements, the selection of which would be at the option of the manufacturer.

The manufacturer options proposed in the SNPRM were similar to those using 3-year-old and 6-year-old child dummies, with one significant exception. Since air bags provide safety

benefits to small-statured drivers, it would not be appropriate to permit manufacturers to suppress air bag deployment under all conditions in the presence of such occupants. Therefore, this type of suppression feature would not be permitted.

The two manufacturer options proposed in the SNPRM were: (1) test requirements for low risk deployment involving deployment of the air bag in the presence of out-of-position 5th percentile adult female dummies, and (2) test requirements for a feature that suppresses the driver air bag when the driver is out of position.

### 1. Option 1: Low risk deployment for drivers

We proposed to require that, if the low risk deployment option were selected, a vehicle would be required to meet specified injury criteria performance limits when the driver air bag is deployed in the presence of an out-of-position 5th percentile adult female dummy. We proposed that the test be conducted at two positions which tend to be "worst case" positions in terms of injury risk. In one of these positions, the dummy's chin is on the air bag module; in the other, the dummy's chin is on the upper rim of the steering wheel. We proposed detailed positioning procedures for these two tests, since injury measures may vary considerably with position.

Under our proposal, in the case of air bags with multiple inflation levels, the injury criteria would need to be met only for the levels that would be deployed in lower severity crashes; i.e., the levels that would be deployed in crashes of 29 km/h (18 mph) or below. A driver would most likely be extremely close to the air bag in lower severity crashes, following pre-crash braking.

The comments on the low risk deployment requirements for small drivers were similar to those on the requirements for young children. Our response is also similar.

We are adopting the proposed low risk deployment tests using the 5th percentile adult female dummy, with the same modifications we made for the tests using child dummies; i.e., simplified positioning procedures will be used, and injury criteria will need to be met, in the case of air bags with multiple inflation levels, for the levels and timing that will be deployed in crashes of 26 km/h (16 mph) or below, instead of crashes of 29 km/h (18 mph) or below, using unbelted 5th percentile adult female dummies. However, if the air bag did not deploy at all in crashes of 26 km/h (16 mph) or below, the injury criteria will need to be met at the lowest level of inflation. This modification will help facilitate low risk designs. Likewise, we are requiring the use of an unbelted 50th percentile adult male dummy seated in the mid-track seat position in the crash test used to determine which stage or combination of stages to fire for the low risk deployment tests. Our rationale for this requirement is the same as for the passenger side: larger occupants should not be deprived of ancillary benefits from more benign air bags in low speed crashes.

### 2. Option 2: Feature that suppresses the air bag when a driver is out of position

The testing of DASS devices for the driver air bag raises the same issues as testing ones for passenger air bags. In the SNPRM, we proposed the same type of requirements for both systems.

The comments on the SNPRM were essentially the same for both types of DASS devices. The issues raised by the commenters are fully discussed under our discussion of DASS devices for passenger air bags, presented earlier in this document.

## XIII. Injury Criteria

In the SNPRM, we proposed injury criteria and performance limits for each size dummy. We placed in the public docket a technical paper which explained the basis for each of the proposed injury criteria, and for the proposed performance limits. The title of the paper was: "Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraints Systems - II."

Standard No. 208 currently specifies five performance requirements for the Hybrid III 50th percentile adult male dummy in barrier crash tests: (1) dummy containment--all portions of the dummy must be contained in the vehicle passenger compartment throughout the test, (2) Head Injury Criterion (HIC) must not exceed 1,000, evaluated over a 36 millisecond (msec) duration (3) chest acceleration must not exceed 60 g's, (4) chest deflection must not exceed 76 mm (3 inches), and (5) forces transmitted axially through the upper legs must not exceed 10 kilonewtons (kN) (2,250 lb).

In the SNPRM, we generally proposed to apply these or similar injury criteria, and a new one addressing neck injury, to all of the dummies and tests, other than static suppression tests, covered by the proposal. However, the criteria and performance limits would be adjusted to maintain consistency with respect to the injury risks faced by different size occupants.

A general discussion of the proposed injury criteria and performance limits, and the comments, is provided below. A more detailed discussion is provided in a supplemental technical paper titled "Supplement: Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems - II" which is being placed in the public docket.

### A. Head Injury Criteria

In the SNPRM, to address the risk of head injury, we proposed limits for the head injury

criterion (HIC) for the 50th percentile adult male, 5th percentile adult female, 6-year-old child, 3-year-old child and 12-month-old infant dummies.

The proposed HIC differed from that currently included in Standard No. 208 in that it would be evaluated over a 15 msec duration instead of 36 msec. This change was based on a recommendation by AAMA. That organization had recommended that the duration for the HIC computations be limited to 15 milliseconds with a limit of 700 for the 50th percentile adult male dummy. This proposed value is consistent with Canadian Motor Vehicle Safety Standard No. 208.

We noted in the SNPRM that the stringency of HIC 15/700 and HIC 36/1000 appears to be equivalent for long duration pulses. This is because while HIC 15 produces a lower numerical value for long duration events, its lower failure threshold, 700, compensates for this reduction. We also noted that for pulse durations shorter than approximately 25 milliseconds, the HIC 15/700 requirement is more stringent than the HIC 36/1000 requirement. We stated that we believed this increased stringency would provide a desirable added measure of safety for the highly scaled, short duration HIC limits proposed for evaluating those impact events where children and small-statured adults are involved.

In the SNPRM we accordingly proposed to employ a 15 millisecond time interval whenever calculating the HIC function and to limit the maximum response of the adult male to 700 and limit the response of the smaller dummies to suitably scaled maximums.

Commenters generally supported our proposal concerning HIC 15. However, AAM recommended that we adopt somewhat higher limits than we proposed for the 5th percentile adult female dummy (779 rather than 700) and the 6-year-old child dummy (723 rather than

700). That organization argued that we were not consistent in applying scaling relationships from the 50th percentile adult male dummy to the other dummies.

After considering the comments, we have decided to adopt the limits we proposed. We note that the data from which the HIC relationship was developed represented an elderly adult population.[35] There is no basis to assume that the population had the dimensions of 50th percentile adult males. We believe it is reasonable to apply the same 700 HIC limit to all persons who may be represented by the original data set, including 5th percentile adult females and 50th percentile adult males.

As to child dummies, in the absence of biomechanics data on the skull fracture and brain injury tolerances for children, we began by utilizing a scaling process to account for differences in both geometric size and material strength. However, after applying the scaling process, judgment must be used to determine if the scaled values are reasonable.

For the 6-year-old child dummy, geometric and material scaling led to a limit of 723, which is higher than the 700 limit for adult dummies. However, in the absence of biomechanical data that substantiate a higher head injury tolerance for young children than for adults, we believe it is prudent and reasonable to limit the HIC value to 700 for the 6-year-old dummy.

### B. Neck Injury Criteria

In the SNPRM, to address the risk of neck injury, we proposed limits for the Nij neck injury criterion for the 50th percentile adult male, 5th percentile adult female, 6-year-old child, 3-year-old child and 12-month-old infant dummies. Nij is a new injury formula that accounts for

---

[35] Hodgson, V.R., Thomas, L.M., "Comparison of Head Acceleration Injury Indices in Cadaver Skull Fracture," SAE Paper No. 710854, Proceedings of the Fifteenth Stapp Car Crash Conference, 1971.

the combination of flexion, extension, tension, and compression.

The sled test option in Standard No. 208 currently addresses the risk of neck injury by means of separate limits on these four measurements as well as shear. We proposed Nij as an improvement over separate limits because it accounts for the superposition of loads and moments, and the additive effects on injury risk.

The most significant comment on this issue came from AAM, which endorsed the Nij concept but recommended the inclusion of additional, more stringent tension/compression limits to independently control these potentially injurious loading modes. AAM also recommended further, minor adjustments to the proposed critical limits depending on whether they are being utilized for in- or out-of-position situations. AAM, IIHS, and NTSB stated that they were concerned that the peak tension and peak compression allowed by the Nij criteria when the moment value is zero are too great.

We believe that there is merit in incorporating AAM's recommended additional tension/compression limits and adjustments to our original Nij proposals because they either mimic our originally proposed requirements very closely or add additional requirements that more stringently control potentially injurious loading modes. In addition, we accept an argument made by AAM that tensed neck muscles mitigate the effects of measured neck loads and will adopt that organization's recommendation for slightly higher neck limits for in-position testing for the adult dummies. However, because one would not expect muscle tensing in a situation simulated by the 5th percentile female out-of-position low risk deployment tests, we are requiring manufacturers to meet more stringent criteria for Nij in those tests.

DaimlerChrysler argued that tension should be the only neck injury criterion with the

current Hybrid III dummy neck because it believes the neck may be inadequate for accurately assessing the potential for flexion/extension neck injury due to air bag loading. Toyota also recommended delaying the use of any neck injury criteria that contains extension. As discussed later in this document, we believe the current Hybrid III neck is adequate for the purposes of this rulemaking. Moreover, we are adopting Nij as the best available neck injury criterion.

### C. Thoracic Criteria

In the SNPRM, to address the risk of thoracic injury, we proposed individual limits on chest acceleration and chest deflection. This is the same approach as is currently used in Standard No. 208. However, we proposed to reduce the current deflection limit for the 50th percentile male dummy from 76 mm to 63 mm (from 3 in to 2.5 in).

To obtain equivalent performance limits for the other size dummies, the mid-size male dummy limits were scaled, taking into account both geometric and material differences. We also considered other factors. We did not propose a chest deflection limit for the 12-month-old CRABI dummy because that dummy does not measure chest deflection.

AAM supported individual limits on chest acceleration and chest deflection but argued that the chest acceleration limit for the 5th percentile adult female dummy should be 73 g's rather than the 60 g's proposed in the SNPRM. This was reiterated by some other commenters as well.

AAM also requested slight adjustments in deflection limits for the 3-year old and 5th percentile adult female dummies. In addition, AAM recommended the use of an additional criterion, rate of sternal deflection, to assess the risk of serious thoracic organ injuries in out-of-position tests. Toyota recommended using the rate of sternal deflection in place of chest acceleration for assessing thoracic injury risk. DaimlerChrysler presented a method using

Kalman filters which it argued would result in a more reliable rate of deflection measures using chest deflection and acceleration measurements.

After considering the comments, we are adopting the proposed 60 g's chest acceleration limit for the 5th percentile adult female dummy. AAM's recommended chest acceleration limit of 73 g's for this dummy was obtained using scaling procedures that only considered the effects of the geometric differences between 50th percentile adult males and 5th percentile adult females. However, we believe the additional effect of decrease in bone strength for the more elderly female population at risk in out-of-position situations should also be taken into account.

The differences between our proposed deflection limits and those recommended by AAM are negligible. AAM recommended a chest deflection limit of 64 mm for the 50th percentile adult male dummy. In order to harmonize with the chest deflection limits used by Transport Canada, we proposed a 63 mm for chest deflection limit for the 50th percentile male. While we used the same scaling factors as the industry, this difference in the limit for the 50th percentile adult dummy accounts for the small differences (<2 mm) between the industry's recommendations and our proposals for some of the other dummies. Because these differences are negligible and because the proposed limit for the 50th percentile adult male dummy is consistent with international harmonization, we are adopting the limits proposed in the SNPRM.

As to AAM's recommendation to use the rate of sternal deflection to assess the risk of serious thoracic organ injuries in out-of-position tests, we believe further analysis and research would be needed before such a new injury criterion could be added to Standard No. 208. We note that vehicle manufacturers are free to voluntarily consider rate of sternal deflection as they design their vehicles.

### D. Other Criteria

In the SNPRM, we proposed to apply a dummy containment requirement to all of the dummies except the 12-month-old infant dummy, and limits on upper leg forces to the 50th percentile adult male and 5th percentile adult female dummies. We believed the dummy containment requirement would not be relevant to the proposed low risk deployment test using the 12-month-old infant dummy, and that limits on upper leg forces would not be relevant to the proposed low risk deployment tests using the 12-month-old infant and 3- and 6-year-old child dummies.

More specifically, with respect to limits on upper leg forces, we proposed to limit the axial loads in the femur for the adult dummies (10 kN for the 50th percentile male and 6.8 kN for the 5th percentile female). AAM and DaimlerChrysler stated that they support slightly more stringent femur limits of 9.1 kN for the 50th percentile male and 6.2 kN for the 5th percentile female.

After considering the comments, we are adopting the axial femur limits for the adult dummies as proposed. The current limit of 10kN specified for the 50th percentile male has been used in Standard No. 208 for many years. AAM has not presented information demonstrating that this value does not adequately ensure protection. Furthermore, AAM has not provided data or an explanation of the method it used to arrive at its recommended femur force limit for the 50th percentile male.

The differences between the limits proposed in the SNPRM and those recommended by AAM are small, and adopting the slightly lower value recommended by AAM will have no effect on the overall safety benefits. We also believe that the slightly higher axial force limits we are

adopting today may provide design flexibility for manufacturers to optimize head, neck and chest protection for the 50th percentile male and the 5th percentile female. Of course, vehicle manufacturers are free to voluntarily meet more stringent limits than those included in Standard No. 208.

## XIV. Lead Time and Effective Date

TEA 21 specifies that the final rule on advanced air bags must become effective in phases as rapidly as practicable beginning not earlier than September 1, 2002, and not sooner than 30 months after the issuance of the final rule, but not later than September 1, 2003. Except as noted below, the phase-in of the required amendments must be completed by September 1, 2005. If the phase-in of the rule does not begin until September 1, 2003, we are authorized to delay the completion of the phase-in until September 1, 2006. As also noted below, other amendments may be phased in later.

### A. Large Manufacturers

In the SNPRM, we proposed the following phase-in schedule, which would apply to all large manufacturers; i.e., those producing more than 5,000 vehicles per year worldwide:

25 percent of each manufacturer's light vehicles manufactured during the production year beginning September 1, 2002;

40 percent of each manufacturer's light vehicles manufactured during the production year beginning September 1, 2003;

70 percent of each manufacturer's light vehicles manufactured during the production year beginning September 1, 2004;

All vehicles manufactured on or after September 1, 2005.

We noted that the proposed date for the start of the phase-in, September 1, 2002, would be 30 months after a final rule that was issued on March 1, 2000. We stated that this proposed date reflected the seriousness of the safety problem being addressed and the statutory requirement that the final rule become effective as rapidly as possible.

We also requested comments on phase-in schedules and percentages other than the proposed 25%-40%-70%-100% schedule. We cited the example of a 40%-70%-100% schedule beginning one year later than the proposed schedule, but ending at the same time. This alternative was like the primary proposal, except that the first year of the proposed phase-in would be eliminated. We noted that this alternative schedule would offer additional leadtime at the beginning of the phase-in, while not compromising the final effective date for all new vehicles. We also noted that with the availability of credits for early compliance, a manufacturer also would have additional time to develop and produce early-complying vehicles to meet the initial phase-in percentages.

We noted that while we had limited discretion in deciding when to make the final rule effective, we also have some discretion to make temporary adjustments in requirements if, in our judgment, such adjustments are necessary or prudent to promote the smooth and effective implementation of the goals of TEA 21 through the introduction of advanced air bags. We noted that the final rule could temporarily reduce the injury criteria or test speeds during the TEA 21 phase-in and then terminate those reductions at the end or after the end of that phase-in.

AAM, GM, DaimlerChrysler and Honda all supported a phase-in that would not begin until September 1, 2003 and that was not fully effective until September 1, 2006. The primary arguments offered for delaying the phase-in were the pending new test dummy regulations and

the remaining uncertainty of the advanced air bag technologies. Honda also asserted that the barrier tests using the 5th percentile adult female test dummy should be delayed until after final dummy specifications and revised seating procedures are issued, perhaps until September 1, 2005.

CEI/CA argued that NHTSA's existing air bag experience should lead it to reject any mandate requiring technology and designs that are still under development. At a minimum, according to CEI/CA, the agency should establish requirements will not take effect until real-world data on such systems exists and has been analyzed. To the extent that it is statutorily constrained on this matter, it should set lead times at the absolute statutory maximum. These concerns are addressed in the section of this document dealing with unintended consequences.

Public Citizen, CU, and CAS stated that manufacturers should not be given undue latitude in meeting the advanced air bag requirements. These groups said that the manufacturers had repeatedly stated during the drafting of TEA 21 that they would need not more than 30 months in which to implement the new designs. The groups also noted that some manufacturers are already introducing some types of advanced air bag technologies. Public Citizen argued that the agency should give greater weight to the command in TEA 21 that the final rule shall take effect as rapidly as possible, the history of manufacturers' assertions of the "impossibility" of complying with new regulatory requirements, the test results of MY1999 vehicles, and the absence of data from manufacturers to substantiate their claim that the technology is not yet available.

The NTSB expressed disappointment that it would be MY 2006 before all new vehicles would be equipped with advanced air bag systems. It suggested that NHTSA encourage

manufacturers to install advanced air bags prior to the established phase-in schedule, perhaps through an incentive program.

We have decided to implement a two-stage phase-in for advanced air bags. In the first phase-in, all portions of the final rule will be implemented, except the 48 km/h (30 mph) unbelted rigid barrier test. The first phase-in will be implemented as follows:

- 35 percent of each manufacturer's light vehicles manufactured during the production year beginning on September 1, 2003 with an allowance of advance credits for vehicles built after the effective date of the final rule;
- 65 percent of each manufacturer's light vehicles manufactured during the production year beginning on September 1, 2004 with an allowance of carryover credits from prior years;
- 100 percent of each manufacturer's light vehicles manufactured during the production year beginning on September 1, 2005 with an allowance of carryover credits from prior years; and,
- All light vehicles manufactured on or after September 1, 2006.

In the second phase-in, the unbelted rigid barrier test at 48 km/h (30 mph) will be implemented. It will be phased in as follows:

- 35 percent of each manufacturer's light vehicles manufactured during the production year beginning on September 1, 2007 with an allowance of advance credits for vehicles built after September 1, 2006;
- 65 percent of each manufacturer's light vehicles manufactured during the production year beginning on September 1, 2008 with an allowance of carryover credits from prior years in the second phase-in;

- 100 percent of each manufacturer's light vehicles manufactured during the production year beginning on September 1, 2009 with an allowance of carryover credits from prior years in the second phase-in; and,
- All light vehicles manufactured on or after September 1, 2010.

We have decided to delay the start of the first phase-in until September 1, 2003 because of the number of new measures that manufacturers will have to take in order to certify a vehicle as complying with the advanced air bag requirements (i.e., meet new injury criteria, meet various test requirements with four new dummies, and meet the suppression and low risk deployment tests associated with air bag risk reduction). We note that the manufacturers' concerns over the pending dummy rulemakings and the seating procedure for the 5th percentile adult female dummy have been largely resolved by now. As an initial matter, all applicable dummies, other than the Hybrid III 3-year-old child and 12-month-old CRABI, have now been incorporated into 49 CFR Part 572. Both of these dummies should be incorporated into Part 572 this month.[36] Additionally, the seating procedure for the 5th percentile adult female is established in today's rule. We are confident that large vehicle manufacturers can meet the phase-in. As required by TEA 21, we are including provisions under which manufacturers to earn credits towards meeting the applicable phase-in percentages if they meet the new requirements ahead of schedule.

### B. Limited line, Small and Multi-Stage Manufacturers and Alterers

#### 1. Limited line Manufacturers

A phase-in generally permits vehicle manufacturers flexibility with respect to which

---

[36] Likewise, the final rule incorporating the offset deformable barrier into 49 CFR Part 587 should be issued later this month.

vehicles they choose to initially redesign to comply with new requirements. However, if a manufacturer produces a very limited number of lines, e.g., one or two, a phase-in would not provide such flexibility. Accordingly, we proposed to permit manufacturers that sell two or fewer carlines in the United States the option of omitting the first year of the phase-in if they achieved full compliance for the second year of the phase-in. We proposed to limit this alternative to manufacturers that produce two or fewer carlines in light of the statutory requirement concerning when the phase-in is to begin. We explained that absent such a limitation, it would technically be possible for the industry as a whole to delay introducing any advanced air bags for a year.

Porsche supported permitting manufacturers that produce two or fewer carlines the option of omitting the first year of the phase-in if they achieve full compliance during the second. In addition, Porsche recommended specifying that the alternative phase-in for limited line manufacturers is available to manufacturers who meet the "two carline or fewer" criteria at any time between publication of the final rule and the start of the phase-in. Porsche argued that such a specification would resolve any possible confusion over whether the provision applies to manufacturers who, during the phase-in, evolve from a two carline manufacturer into a three or more carline manufacturer.

We have decided to permit manufacturers that sell two or fewer carlines in the United States the option of omitting the first year of each phase-in if they achieve full compliance by September 1, 2004, the beginning of the second year of the first phase-in and September 1, 2008, the beginning of the second year of the subsequent phase-in. This option is available only for limited line manufacturers since it would otherwise be possible for the industry as a whole to delay introducing any advanced air bags for a year.

We decline to adopt Porsche's suggestion that this option be available for manufacturers which meet the "two carline or fewer" criterion at any time between publication of the final rule and the start of the phase-in. As manufacturers produce more lines, the rationale for this option diminishes. Therefore, any manufacturer that evolves from a two carline manufacturer into a three or more carline manufacturer during each phase-in will not qualify for the applicable limited line alternative phase-in. We believe that manufacturers will know in advance if they plan to evolve from a two carline manufacturer into a three or more car line manufacturer well before the phase-in and can plan their compliance accordingly.

**2. Small Manufacturers**

To accommodate the needs of small volume manufacturers (SVMs), we proposed giving those manufacturers the option of waiting until the end of the phase-in to meet the new requirements. We explained that we were proposing to treat SVMs differently because of the complexity of the new requirements and the relatively short lead time before the phase-in begins. We explained that even the more streamlined set of requirements proposed in the SNPRM would require significant design changes and significant new testing. However, since the SVM provision would effectively allow SVMs to avoid the phase-in entirely, we also proposed to limit this option to manufacturers that produce fewer than 5,000 vehicles per year worldwide.

The Coalition of Small Volume Automobile Manufacturers (COSVAM) supported permitting SVMs to wait until the end of the phase-in to meet the new requirements. COSVAM stated that SVMs need until the end of the phase-in because they cannot obtain new technology at the same time it is made available to large manufacturers, because they have difficulty getting suppliers to sell to them at all, and because some SVMs source from large manufacturers and

may source parts from a model which will not comply until the end of the phase-in. COSVAM also asked that the definition of small manufacturer for purposes of exclusion from the phase-in requirements be changed to include manufacturers that produce not more than 10,000 vehicles. COSVAM argued that the definition of small volume manufacturer should be based on the agency's overall statutory scheme and not on current production volumes.[37]

We recognize the technical challenges SVMs will face as a result of the requirements included in today's rule. In addition, while we recognize the importance of providing SVMs with sufficient lead time to comply with the new requirements, we note that we do not have unlimited discretion as to how much leadtime we can provide. TEA 21 provides that if the phase-in begins on September 1, 2003, the final rule must become fully effective by September 1, 2006. No exceptions are given for small volume manufacturers. We have decided, therefore, to exercise the discretion we do have and not require SVMs to comply before the end of each phase-in period (September 1, 2006 and September 1, 2010, respectively). However, we are continuing to limit this provision to manufacturers that produce fewer than 5,000 vehicles per year worldwide. We note that COSVAM did not provide any analysis demonstrating a need to increase the number beyond 5,000.

### 2. Multi-Stage Manufacturers and Alterers

Although we received comments in response to the original NPRM requesting that we provide an additional extension for multi-stage manufacturers and alterers beyond the end of the phase-in for large manufacturers, we did not propose such an extension in the SNPRM. We

---

[37] Under 49 U.S.C. 30113(d) and 49 U.S.C. 30113(b)(3)(B)(i) , manufacturers whose total motor vehicle production in the most recent year of production is not more than 10,000 may, on the basis of economic hardship, apply for a temporary exemption from the requirements of any of the Federal motor vehicle safety standards.

explained that we have limited discretion as to how much lead time we can provide, since TEA 21 provides no exceptions for multi-stage manufacturers or alterers. TEA 21 provides that if the phase-in begins on September 1, 2003, the final rule must become fully effective by September 1, 2006.

We stated in the SNPRM that final stage manufacturers are accustomed to completing vehicles within limitations identified by chassis manufacturers so that they can certify their vehicles with limited or no additional testing. Therefore, we stated that the industry should be able to address the issues raised by the advanced air bag rulemaking. We also urged chassis manufacturers to communicate with their multi-stage manufacturer customers as soon as possible concerning any new limitations that may be imposed as a result of the advanced air bag requirements. We stated that the chassis manufacturers should be able to identify the type and likely scope of any such new limitations well before the end of the phase-in.

The Recreation Vehicle Industry Association (RVIA) (a trade association representing more than 95% of the van conversion industry) contended that its members need at least one year of lead time following full implementation of the new requirements for the large manufacturers. RVIA stated that this additional time is needed so that its members can obtain timely information from the chassis manufacturers, since guidance from incomplete vehicle manufacturers is generally not available until at or very near the startup of new or updated model production.

RVIA supported allowing small volume final stage manufacturers and alterers to certify compliance with a generic sled test pulse, arguing that if final stage manufacturers install seating systems within the guidelines established by the chassis manufacturers, further full scale barrier crash testing is no longer necessary and should not be the only method available for determining

compliance. RVIA stated that the potential technical and financial burden of the proposed full scale barrier dynamic testing requirements jeopardized the continued viability of small volume multi-stage manufacturers.

The National Truck Equipment Association (NTEA) supported the proposal to allow manufacturers of multi-stage vehicles to defer compliance until the end of the phase-in period. NTEA explained that given the level of research and testing likely to be required by the final rule, manufacturers of multi-stage vehicles need as much time as possible to generate the compliance information needed to certify these vehicles.

We estimate that several hundred intermediate or final-stage vehicle manufacturers and alterers will be affected by today's rule. Multi-stage manufacturers modify incomplete vehicles (chassis), while alterers modify completed new vehicles that have been certified by their manufacturer as being in compliance with all applicable safety standards. With respect to Standard No. 208, most of the difficulties for multi-stage manufacturers and alterers involve changes to the vehicles' seats. If the advanced air bag system installed by the original vehicle or chassis manufacturer employs the seat as part of the system, by using such features as weight or position sensing components in the seat, any change to the vehicle's seat could affect the manufacturer's original certification. If the original manufacturer uses a weight or pressure system in the seat to turn the air bag off in appropriate circumstance, these manufacturers face a choice of using the original seat as is, relying on a supplier to provide the same sensing technology for their seats, or else certifying in some other way.

We recognize that the set of requirements contained in today's rule will require significant design changes and significant new testing for all cars and light trucks. We also

recognize the importance of providing all manufacturers, including multi-stage manufacturers and alterers, with sufficient lead time to comply with the new requirements. We note, however, that we do not have unlimited discretion as to how much lead time we can provide. According to TEA 21, if the phase-in begins on September 1, 2003, the final rule must become fully effective by September 1, 2006. There are no exceptions for multi-stage manufacturers and alterers.

We appreciate the technical challenges multi-stage manufacturers and alterers will face as a result of the requirements included in today's rule. In an effort to address the needs of these small businesses, we have decided to allow multi-stage manufacturers and alterers to defer compliance until the end of each phase-in period (September 1, 2006 and September 1, 2010, respectively).

We believe that delaying the implementation schedule for multi-stage manufacturers and alterers strikes the appropriate balance between improving air bag safety, particularly for infants, children, and small-statured adults, while accommodating the needs of these manufacturers. We believe that this approach will increase the likelihood that multi-stage manufacturers and alterers will know what type of advanced air bag technology chassis and vehicle manufacturers are using well before they need to comply. This should provide them sufficient time to address any technical issues associated with advanced air bag technology and to generate whatever compliance information may be needed.

## XV. Availability of Original Equipment and Retrofit Manual On-Off Switches

Standard No. 208 currently includes a temporary provision permitting manufacturers to provide as original equipment (OE) manual on-off switches for air bags in vehicles without rear seats or with rear seats too small to accommodate a RFCSS. This provision is scheduled to

expire on September 1, 2000.

Also, on November 11, 1997, we published in the Federal Register (62 FR 62406) a final rule exempting, under certain conditions, motor vehicle dealers and repair businesses from the "make inoperative" prohibition in 49 U.S.C. 30122 by allowing them to install retrofit manual on-off switches for air bags in vehicles owned by people whose request for a switch is authorized by NHTSA. The final rule is set forth as 49 CFR Part 595, Retrofit On-Off Switches for Air Bags.

The purpose of the exemption was to preserve the benefits of air bags while reducing the risk of serious or fatal injury that current air bags pose to identifiable groups of people. In issuing that final rule, we explained that although vehicle manufacturers were beginning to replace current air bags with new air bags having some advanced attributes, i.e., attributes that will automatically minimize or avoid the risks created by current air bags, an interim solution was needed for those groups of people at risk from current air bags in existing vehicles.

In the SNPRM, we proposed to allow both OE on-off switches and retrofit on-off switches to be installed under the same conditions that currently govern such installation in all vehicles produced prior to September 1, 2005, the date we proposed to require all vehicles to have an advanced air bag system. We proposed to prohibit both OE switches in, and retrofit switches for, vehicles manufactured after the end of the phase-in. We noted that while we believed that reliable and safe air bag systems could be developed in a timely manner, thus removing the need for an on-off switch, we were concerned that those individuals who are currently at risk from air bags might lack confidence in the new systems, particularly when they are first introduced. However, we believed this problem would diminish during the course of the

phase-in, as consumers heard about, and became familiar with, advanced air bags.

Comments were submitted by AAM, DaimlerChrysler, Ford, Toyota, AORC, Autoliv, Advocates, NADA, and Parents for Safer Air Bags. Except for NADA, all commenters supported allowing manual on off-switches, both retrofit and OE, after the end of the phase-in. Some of the commenters supported an indefinite allowance, while others supported the agency revisiting the issue at the end of the phase-in. Additionally, Ford urged that we allow shunts, which would permanently deactivate an air bag, rather than retrofit on-off switches for vehicles with advanced air bag systems, stating that the market incentive to continue to produce retrofit switches is too small. NADA supported eliminating retrofit on-off switches for vehicles with advanced air bags, but allowing OE switches as a method of suppression compliance in vehicles where OE switches are currently allowed.

We believe that by the end of the initial phase-in, manufacturers will have developed advanced air bag systems for most vehicles that are sufficiently reliable to obviate the need for manual air bag on-off switches. However, public acceptance of those advanced air bag systems may not be assured. Allowing on-off switches for some period after all vehicles are equipped with advanced air bag systems will provide parents with additional confidence until the reliability of all such systems has been verified based on real-world experience.

We continue to believe, however, that allowing manufacturers to install switches indefinitely would be counter-productive. The switches provide an opportunity for misuse. Adults could turn off their passenger air bag systems even though those systems pose virtually no risk to an adult occupant, particularly one who is belted. In such circumstances, the occupant would not receive the benefit of the air bag in a high-speed crash. The same possibility for

misuse would exist for children in vehicles certified to the low risk deployment option.

Accordingly, we have decided to allow both OE and retrofit air bag on-off switches until September 1, 2012, two years after the end of the second phase-in. This additional time will allow manufacturers to perfect the suppression and low risk deployment systems in all their vehicles. Additionally, it will provide parents with additional time to satisfy themselves that the advanced systems work. Should we decide there is a continuing need for manual on-off switches beyond 2012, we can initiate rulemaking to extend the date at that time.

We note that there will be some need for deactivation of some sort (via on-off switch or permanently) for at-risk individuals who cannot be accommodated through sensors or other suppression technology (such as handicapped individuals or individuals with certain medical conditions). At this point in time, we believe such needs can be best accommodated through the permanent deactivation authorization system currently used by NHTSA. This system allows the use of shunts as suggested by Ford in its comments.[38]

## XVI. Warning Labels, Consumer Information, and Telltale Devices

### A. Warning Labels and Consumer Information

On November 27, 1996, we published in the Federal Register (61 FR 60206) a final rule which, among other things, amended Standard No. 208 to require improved labeling on new vehicles to better ensure that drivers and other occupants were aware of the dangers posed by passenger air bags to children.

After reviewing the comments on the NPRM, we proposed in the SNPRM a replacement

---

[38] Ford had also suggested that shunts be allowed in lieu of on-off switches. These shunts would permanently deactivate the air bag. We believe that allowing permanent deactivation for anyone other than individuals with special needs would not serve a safety need. Accordingly, we are rejecting this option.

for the permanent sun visor label which contained statements taken from the 1996 labels regarding belt use and seating children in the rear seat. We also proposed substituting the word "CAUTION" for the word "WARNING" in the heading of the label. Finally, we proposed a new graphic which showed a cut-away side view of a vehicle with a belted driver and a child in a child seat in the rear. In addition, NHTSA proposed a new temporary label that states that the vehicle meets the new requirements for advanced air bags. These proposals were in response to commenters concerns that some types of warnings should be retained for advanced air bags.

Consistent with our proposal to require labels for vehicles with advanced air bags, we proposed to drop the current definition of "smart passenger air bags" contained in S4.5.5 and an existing option to remove warning labels in vehicles with air bags that meet that definition (S4.5.1).

In order to provide consumers with adequate information about their occupant restraint system, we proposed to require manufacturers to provide a written explanation of the vehicle's advanced passenger air bag system. We indicated that this explanation would probably be included in the vehicle owner's manual, although we requested comments on whether it would be desirable to have this information located elsewhere. Under our proposal, the explanation would need to include a discussion of the proper functioning of the advanced passenger air bag system and provide a summary of the actions that may affect the proper functioning of the system.

Fifteen commenters addressed the proposed changes to the air bag warning labels. Of these, five said little more than an expression of support for the proposal without much elaboration. On the other hand, four commenters representing consumer groups expressed strong

concerns about any changes that "weakened" the warnings concerning air bag until air bags meeting these new requirements are demonstrated to be effective in eliminating the risks associated with current air bags. One commenter also stated that research should be conducted before the air bag warning labels are changed. Additionally, very few commenters addressed our request for comments on the new graphic described above versus the previous graphic, which shows a rear-facing child seat being struck by an air bag.

After reviewing the comments, we have decided to change the proposed label to reduce the perceived "weakening." First, we have decided to continue to use "WARNING" in the heading rather than "CAUTION" as we proposed in the SNPRM. Since no one objected to the proposed graphic, we are adopting the new graphic to help consumers distinguish between vehicles with various generations of air bags.

One commenter asked us to allow the new labels in any vehicle certified to the new requirements, rather than limiting their usage to vehicles manufactured after September 1, 2002. Because manufacturers will be allowed to certify vehicles to the new requirement prior to this date, we are removing this restriction.

One commenter also stated that the labels should be available in languages other than English. While we are not requiring this, as with the current labels, manufacturers may provide translations of the required English language message as long as all the requirements for the English label are met, including size.

A few commenters wanted additional information added to the label related to specific issues with advanced air bags. GM wanted the option of adding instructions to inform users how to properly behave depending on whether the air bag was active or inactive. NTSB wanted to

require information on what actions to take if the telltale is not illuminated. CAS suggested that information should be added explaining how belt use affects air bag performance. Because these types of information are very design specific, we are not changing the warning label to address these comments. However, we are modifying the existing prohibition against other information on the sun visor to allow manufacturers the option of adding information, on a separate label, if they believe it is desirable to supplement the owner's manual information.

With respect to the proposal requiring manufacturers to provide additional information on the performance and design of advanced air bags in the owner's manual, the few commenters who addressed this issue supported the proposal. Therefore, we are requiring the owner's manual to include accurate information on each of the topics proposed in the SNPRM, specifically:

- A presentation and explanation of the main components of the advanced passenger air bag system.
- An explanation of how the components function together as part of the advanced passenger air bag system.
- The basic requirements for proper operation, including an explanation of the occupant actions that may affect the proper functioning of the system.
- A complete description of any passenger air bag suppression system installed in the vehicle, including a discussion of the suppression zone.
- A discussion of the telltale light on the instrument panel, explaining that the light is only illuminated when the advanced passenger air bag system is suppressed, is not illuminated when the advanced passenger air bag system is activated, and

informing the vehicle owner of the method used to indicate that the air bag suppression system is not operating properly.

- An explanation of the interaction of the advanced passenger air bag system with other vehicle components, such as seat belts, seats or other components.
- A summary of the expected outcomes when child restraint systems, children and small teenagers or adults are both properly and improperly positioned in the vehicle, including cautionary advice against improper placement of child restraint systems.
- Information on how to contact the vehicle manufacturer concerning modifications for persons with disabilities that may affect the advanced air bag system.

**B. Telltale Devices**

In the SNPRM, we proposed that vehicles with static suppression systems would be required to have a telltale, located on the dashboard, that indicated when the passenger air bag was off. We also stated that the telltale need not illuminate when the passenger seat was empty, even if the air bag was suppressed under such a circumstance, but that each system needed to be equipped with a mechanism that indicated every circumstance when the air bag was suppressed.

Comments on the telltale were primarily from manufacturers and followed two basic themes. Some commenters argued that the requirement that the telltale be on the dashboard was overly stringent and inconsistent with the telltale location requirements for air bag on-off switches. Others commented that requiring a mechanism to determine all circumstances under which the air bag was suppressed did not make sense in the context of the telltale requirement. Ford also requested that we specifically allow more than one level of illumination to allow for

changing light conditions.

We have expanded the possible locations for the telltale in the final rule. However, we have decided against simply adopting the existing on-off switch location provisions. In response to a petition for rulemaking from a manufacturer, we have allowed on-off switch telltales to be located anywhere within the vehicle interior as long as they are clearly visible to all front seat occupants. We decided to allow such a broad location for these telltales because on-off switches are only in a limited number of vehicles and because the air bags can only be suppressed when the driver or passenger consciously turns the air bag off. With static suppression systems, an individual will have no way of knowing whether the air bag is suppressed other than the telltale. Accordingly, we believe that the telltales should not be placed in a location that is arguably "clearly visible," but may not be easily seen while driving or is susceptible to being covered up. We agree, however, that restricting the telltale to the dashboard may be overly restrictive. We have changed the regulatory text to state that the telltale must be located inside the vehicle in a zone above and forward of the H-point of the driver seat, when that seat is in its forwardmost position. Additionally, the telltale cannot be placed in or immediately adjacent to a storage compartment if use of the compartment could block the telltale from either the driver's or passenger's view. Thus, for example, the telltale could be located on the cover to the glove compartment, or by the rearview mirror, but could not be located behind a cup-holder.

The SNPRM did not require a single level of illumination for telltales. However, it also was not clear that multiple levels of illumination were allowed. We believe there may be a benefit to having multiple levels of illumination based on changes in the ambient light conditions. Accordingly, we have changed the regulatory text to specifically allow multiple

levels of illumination as long as all levels are visible to individuals of all ages.

We are allowing the telltale to be turned off when the passenger seat is empty because we believe many manufacturers may choose to have the default setting for their suppression systems be a suppressed air bag. In such an instance, the air bag would usually be suppressed. We are concerned that the near constant illumination of the telltale could lead people to ignore the telltale. Alternatively, people could attempt to disconnect the telltale so that they did not have to look at it all the time.

In order to accommodate a design where the telltale was not illuminated when the seat was empty, but still allow for compliance testing of all of the proposed child seating positions, some of which could look to a suppression system like the seat was empty, we added a requirement that the vehicle come equipped with a mechanism that would indicate under all circumstances whether the passenger air bag was suppressed. The mechanism need not be contained within the interior of the vehicle, but could be a simple plug-in system where a piece of equipment is plugged into an outlet and provides the needed information. Alternatively, the mechanism could be the telltale that is required for all suppression situations other than an empty seat. In that instance, the telltale would need to illuminate in any of the test positions NHTSA used for compliance purposes.

## XVII. Miscellaneous Issues

### A. Child Restraints Used for Testing Suppression and Low Risk Deployment Features

As discussed earlier in this notice, we proposed in the SNPRM to require manufacturers to assure compliance with tests to minimize the risks from air bags to infants and young children

using any child restraint on a specified list of representative child restraints that was appropriate for a child the size of the applicable dummy. In developing the proposed list of representative child restraints, we attempted to select seats that are produced by various manufacturers while limiting the overall number of restraints. We proposed to add the list of child restraints as an appendix to Standard No. 208, and indicated that we planned to update the list from time to time (with appropriate lead time).

Comments can be broken down into four separate areas: NHTSA should develop a common "footprint" for testing, the proposed list contains too many restraints, the proposed list does not contain enough restraints, and the list is either outdated or insufficiently detailed.

AAM, GM, Volkswagen, DaimlerChrysler and AORC all urged NHTSA to develop a standard "footprint" that could be used to certify compliance with our suppression tests. Takata did not believe a single footprint was necessary, but urged that the number of potential footprints on child restraint systems be severely limited. These same commenters, along with Isuzu, stated that the list of child seats was still too long and should either be reduced or manufacturers should be allowed to certify to no more than three seats in each category, at the manufacturer's option. The CAS argued that the list should be longer, and the American Academy of Pediatrics (AAP) urged us to add an oversized child seat designed for special needs children. Takata noted that the list did not include specific model numbers, and Evenflo noted that some of its seats on the list were no longer available or had been replaced by a different model.

We agree with manufacturers that a common footprint test device would considerably ease their ability to meet the static suppression performance requirements for infants and for three-year-olds and six-year-olds in child restraints. We also agree that our initial proposal to

test with any seat produced over a ten-year period was overly expansive. However, the proposed number of seats in the SNPRM was dramatically reduced from the NPRM. These seats are real designs that are actually in use, not a test device which would never be used by a child. The only way we could guarantee that child restraints matched the footprint of this hypothetical test device would be to require the footprint to be incorporated into all child restraints. Even if we did not require that restraint manufacturers use the specific footprint, we would effectively limit their ability to produce any other type of restraint, since they could not assure parents that their seats would work with a vehicle's suppression system. Accordingly, we believe adopting a uniform test device with a specific footprint is inappropriate and overly design restrictive. Given the relatively small number of restraints on our list, we see no need to develop a specific test device.

Likewise, we do not believe that manufacturers should have the option of certifying to only a limited number of the restraints on the list. We do not believe that requiring compliance with 24 seats is excessive, given the importance of reliability in a suppression system and the fact that the suppression tests are nondestructive. Children sitting in the front seat will not receive the benefit of a suppression system that does not recognize their presence in the seat. If manufacturers believe their planned suppression technology is insufficient to detect a wide variety of child restraints, they will need to either improve or supplement that technology.[39]

We do believe, however, that the seats on the list are adequately representative of both

---

[39] We recognize that a manufacturer choosing the low risk deployment option for infants would be required to assure compliance with the applicable injury criteria with a 12-month-old dummy in each of the restraints listed in sections B and C of Appendix A, making the restraint unusable in subsequent tests. However, we believe the low risk deployment for properly restrained infants to be the most important low risk test in this rulemaking, as an infant's head would always be in close proximity to a deploying air bag.

child restraint designs and manufacturers.[40] Accordingly, we do not agree with the CAS that the list should be expanded. Nor do we believe it is necessary to add an oversized seat, as recommended by the AAP. These larger seats are not representative of seats that are typically found in vehicles and may be used by children who are considerably heavier than an average six-year-old. While these children should receive as much assurance of safety from a deploying air bag as all other children, we believe their needs can be accommodated by other means. Permanent air bag deactivation will continue to be available for individuals with unique medical or physical needs.

Based on Evenflo and Takata's concerns that the proposed list was insufficiently detailed and out-of-date, we have amended the list by replacing restraints that are no longer available and providing model numbers. We have also tightened up the language of Appendix A so that the designated restraints are limited by a production date closer in time to the effective date of the final rule. As stated in the SNPRM, the list will be updated periodically to subtract restraints that are no longer in production and to add new restraints, particularly those that are manufactured in accordance with recent amendments to Standard No. 213, Child Restraint Systems, (64 FR 10786, March 5, 1999), that require child restraints manufactured on or after September 1, 2002, to have components that attach to the lower anchors of a vehicle's child restraint anchorage system. (The March 1999 rule requires the anchorage systems to be installed on a phased-in

---

[40] In no way does the inclusion of a particular restraint on the list represent an endorsement of that restraint by the agency. Restraints have been placed on the list because we believe they are representative of many products on the market, not because they offer a unique design that we believe is somehow superior to other designs. Likewise, the choice of restraint manufacturer is not based on any belief by the agency that a particular manufacturer produces restraints that are superior to those of other manufacturers. Restraints were chosen from a variety of manufacturers so as to adequately survey the design decisions of the entire population of restraint manufacturers.

basis in new vehicles beginning September 1, 2000.) At this time we do not contemplate increasing the overall size of the list. Some period of lead time will be provided so that manufacturers have adequate time to incorporate any needed design changes into their air bag systems.

### B. Dummy Positioning for Static Suppression and Low Risk Deployment Tests

AAM, GM, Toyota, Isuzu and DaimlerChrysler all argued in their comments that the static suppression tests were too burdensome, largely because of the range of seat back angles (from the nominal design position up to 25 degrees rearward of that position) and seat track positions (any position on the seat track or any height for adjustable seats). Breed Technologies stated that it did not believe the low risk test procedures adequately accounted for differences in vehicle geometry and that they were sufficiently ambiguous to lead to variations in procedure by different testing laboratories.

As discussed earlier in this document, in view of the fact that parents or caregivers who place children or child restraints in the front seat will not all use a single seat track position, we have determined that there is a need to test in different seat track positions. However, we have also concluded that there is no need to conduct suppression tests at every possible seat track position. Accordingly, we have decided that for vehicles certified to the suppression option, we will test only at the vehicle seat's full-rear position, mid-track position and full-forward position. In instances in which the infant restraint contacts the dashboard in the full-forward position, the vehicle seat will be moved back to the next detent that allows for clearance, or, in the case of automatic seats, until a maximum of 5mm (0.2 in) of clearance is achieved. Likewise, in tests

involving suppression systems for 3-year-old and 6-year-old children, if the dummy or child would interfere with the dashboard, the vehicle seat will be moved back in a similar manner.

We have also determined that in many of the tests, testing with the seat back positioned 25 degrees rearward of the vehicle seat's nominal design position for the 50th percentile male was problematic. We believe that in many vehicles it may be impossible to properly install a child restraint with the seat back reclined this far back. We also do not believe that there would be any reason to recline a seat that is occupied by a child restraint. Since all of the infant tests involve the use of some type of restraint, we have decided to limit the seat back angle for these tests to the nominal design position for the 50th percentile male. Tests involving the 3-year-old and 6-year-old children or dummies in child restraints present the same concerns and will be addressed in the same way. Likewise, many of the test procedures involving children who are not in any type of restraint are unrealistic if tested with the seat 25 degrees back from the nominal design position. For example, a kneeling child with his chest resting against the seat back would find it difficult to hold his or her position.

The one position where we will recline the seat back is the test where the child is sitting on the seat and is leaning against the seat back (S22.2.2.2, S24.2.1). This test position will be conducted with the seat back at the manufacturer's nominal design position for the 50th percentile male and at 25 degrees rearward of that position so as to test for children who have reclined their seat backs to take a nap. If the vehicle seat does not recline that far, we will test with the seat reclined as far as possible. We agree with manufacturers that parents should not drive with their children in such a position. However, as long as manufacturers design the passenger seat to recline, we believe some parents will allow their children to lie on a reclined

seat.

We have also decided to test whether the air bag system is active when the seat is occupied by a 5th percentile adult female at the seat back position achieved when positioning the fifth percentile adult female dummy in the passenger seat for dynamic tests. This should roughly approximate the nominal design position. Some commenters argued that the reclined position (i.e., 25 degrees rearward of the nominal design position) distributes an adult's weight in such a manner that a suppression system that relied heavily on weight distributed to the seat cushion may be unable to determine whether the occupant is an adult or a child. Other commenters have argued that their suppression systems can adequately detect the total weight of a reclined 5th percentile adult female. We believe that the ability to detect the total weight of the dummy in a reclined position may vary depending on the type of suppression technology used. We also believe that a reclining adult has less need for a deploying air bag than an adult who is upright, and therefor closer to the air bag at the time of deployment.

We have changed the test that determines which stage or combination of stages of the air bag to deploy in the low risk deployment tests. As discussed earlier, the low risk deployment tests will only be conducted at speeds up to 26 km/h (16 mph). Accordingly, this test will be run at 26 km/h (16 mph). If there is no air bag deployment in the test, we will deploy the first stage of the vehicle's air bag when conducting our compliance tests.

Finally, we believe Breed's comments about the low risk deployment positions have merit. We have reduced the number of steps involved in placing the dummies because small adjustments to the procedure at each step, as well as the unique characteristics of the vehicle, could result in a final position that differed significantly from what we want, i.e., the head on the

instrument panel or the chest on the instrument panel. By reducing the number of steps needed to achieve that position, we have reduced the amount of potential variability. The one exception is the low risk deployment test for both child dummies where the head is placed on the instrument panel. We have retained a specific step-by-step procedure for this test, because the location of the air bag module on the instrument panel is so variable that we are currently unable to define a position on the instrument panel that we believe with any confidence represents the worst case scenario. We do, however, have considerable experience with a step-by-step procedure. While we agree that variations in vehicle design may make it difficult to follow the test procedure, we believe that we have modified the procedure in a way that will yield appropriate and consistent results.

### C. Due Care Provision

Since March 1986, Standard No. 208 has included as part of its various crash test requirements a provision stating that:

> a vehicle shall not be deemed to be in noncompliance with this standard if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirement of this standard.

In adding this provision, we cited the complexity of the Standard No. 208 rigid barrier crash test. We stated that, because of this complexity, we believed that manufacturers needed assurance from the agency that, if they had made a good faith effort in designing their vehicles and had instituted adequate quality control measures, the vehicles would not be deemed to be in noncompliance because of an isolated failure to meet the injury criteria.

In the SNPRM, we noted that the "due care provision" is unique to Standard No. 208 and

that, for a variety of reasons, we disfavor including a "due care provision" in Federal motor vehicle safety standards. We explained that the inclusion of such a provision in a safety standard does not fit very well with the overall statutory scheme, since it introduces a measure of subjectivity into the issue of whether a vehicle complies with a standard. We also explained that, based on our experience with Standard No. 208 compliance activities, we do not believe there is an intrinsic need for a "due care provision." However, recognizing that this rulemaking for advanced air bags would require manufacturers to certify their vehicles to a significantly greater number of test requirements in a limited amount of time, we stated that we did not believe that now would be an appropriate time to delete this provision.

Accordingly, in the SNPRM, we proposed to retain the "due care provision" and extend it to the new crash test requirements. We stated that we were not proposing to extend the provision to test requirements that do not involve crashes because these tests are not affected by the variability associated with dynamically induced dummy movement and/or vehicle deformation.

Commenters presented sharply contrasting views concerning the due care provision. Vehicle manufacturers and air bag manufacturers urged that the due care provision be extended to the new static out-of-position tests as well as the new crash tests. They argued that there is as much variability associated with the static out-of-position tests as with crash tests, and argued that the due care provision will help resolve some practicability concerns.

Other commenters, however, argued that the due care provision is not in the public interest. Parents stated that if a vehicle's air bag system fails to meet Standard No. 208, the adverse effects on the public are the same whether or not due care was exercised by the manufacturer. That organization stated that the due care provision works against the public

interest by providing vehicle manufacturers with a means of avoiding the recall of vehicles that fail to comply with Standard No. 208. Parents and Advocates also argued that the due care provision in Standard No. 208 is inconsistent with its statutory counterpart, which only relieves vehicle manufacturers of civil penalty liability if the agency concludes that the manufacturer exercised due care.

Advocates stated that if the due care provision were retained and extended to other crash tests, the provision should be completely sunsetted at the end of the TEA-21 phase-in. Other commenters that opposed the due care provision included Consumers Union, Public Citizen, and CAS.

After considering the comments, we continue to disfavor including a due care provision in the Federal motor vehicle safety standards and do not believe there is a need for the due care provision in Standard No. 208. However, we recognize the history associated with including the due care provision in Standard No. 208 and do not believe that it is appropriate to delete this provision during the phase-in of the complex requirements and tests added by this rulemaking. Accordingly, we have decided to retain the due care provision until the end of the second phase-in, September 1, 2010, by which time all manufacturers will have significant experience with all of the advanced air bag test requirements.

We disagree with the argument that the limited inclusion of the due care provision in Standard No. 208 raises a significant safety issue. We do not believe that including the provision will lead to substantially different results then would be obtained under our general enforcement policy for standards with crash tests. Generally, we do not determine that a noncompliance exists merely because of an isolated test failure, if there is evidence that other tested similar units

have met the standard's performance requirements and there is no indication of the absence of adequate quality control procedures.

For purposes of the final rule, we have made one modification that we believe is in keeping with the principle of applying the due care provision to new tests in a similar manner with how it applies in the existing standard. In addition to extending the due care provision to new crash tests, we are also extending it to out-of-position tests that involve deployment of an air bag. The deployment of the air bag in these tests creates an event that is highly dynamic in nature, similar to that of a crash test. The performance requirements, which require meeting injury criteria performance limits as measured on a crash test dummy, also make these tests similar to crash tests.

We are not extending the due care provision to the static suppression tests. These are relatively simple pass-fail tests which do not involve deployment of an air bag or measurement of injury criteria on test dummies, and, accordingly, we do not believe they raise the same compliance concerns as crash tests. The conditions under which either suppression or activation is required are specific and straightforward, and there are substantial differences between the conditions requiring suppression and those requiring activation. While there will undoubtedly be gray zones associated with suppression devices, those gray zones should be well outside the conditions for which either suppression or activation is required by the standard.

### D. Selection of Compliance Options

In the SNPRM, we proposed to require that where manufacturer options are specified, the manufacturer would be required to select the option by the time it certifies the vehicle and would not thereafter be permitted to select a different option for the vehicle. This would mean that

failure to comply with the selected option would constitute a noncompliance with the standard (as well as a violation of the certification requirement of 49 U.S.C. 30115), regardless of whether a vehicle complies with another option. We also proposed to specify that, upon request, manufacturers would be required to advise NHTSA of the compliance options selected for a given vehicle or vehicle model. On behalf of its members, AAM and AIAM argued in its joint comments that the proposed requirement does not meet the need for motor vehicle safety.

We have decided to adopt the provision proposed in the SNPRM, which is consistent with the approach we have taken in other recent rulemakings in which compliance options have been allowed. Our rationale for this approach was recently set out in some detail in our denial of a petition for reconsideration of an amendment that added a compliance option to Standard No. 201, "Occupant Protection in Interior Impact." 64 FR 69665 (December 14, 1999). We adopt that rationale for purposes of this final rule, but we are adding a short discussion to address a few additional matters.

The final rule adopted by this notice provides numerous compliance options for manufacturers, far more than in any other standard we have previously adopted. For example, in order to reduce the risk of injury to various sizes of children, manufacturers may suppress the passenger air bag, either statically or dynamically, or assure that the air bag deploys in a benign manner. Likewise, manufacturers may use a benignly deploying air bag or a dynamic suppression system to reduce the risk of air bag injury to teenagers and small adult drivers. The existence of phase-ins provides manufacturers with additional options. While they must meet the applicable advanced air bag requirements for a specified percentage of vehicles during each phase-in, they have the option of certifying additional vehicles to those requirements in order to

earn credits that can be applied to the percentages that need to be achieved in later years. Moreover, until September 1, 2006 (the end of the first phase-in), manufacturers may choose to certify compliance for at least a portion of their fleet with one of three different unbelted high-speed test requirements: the sled test of S13,[41] the long-standing 48 km/h (30 mph) unbelted rigid barrier test of S5.1.2(a), or the 40 km/h (25 mph) rigid barrier test of S5.1.2(b). Each of these three options have different injury criteria.

We have provided manufacturers with myriad options to allow and encourage them to develop and implement technologically innovative advanced air bag systems. However, this does not mean that we believe that each option provides exactly the same safety benefits. Rather, we believe that the standard as a whole, including its requirement of an irrevocable choice among compliance options, strikes the proper balance between assuring an appropriate level of safety and allowing an appropriate degree of manufacturer flexibility.

We have found that when some manufacturers are confronted with a compliance test failure indicating an apparent noncompliance with the option that they originally chose at the time they certified the vehicle, they have responded by asserting that their product complies with a different option. As explained in our earlier denial of reconsideration on this subject, such shifting in the asserted basis for compliance creates obvious difficulties for us, both in managing our resources available for compliance testing and in ultimately assessing a vehicle or equipment's compliance. We believe that a system that allows us to effectively allocate our scarce enforcement resources to ensure that our safety standards are being met clearly meets the

---

[41] The text of S13 has been slightly revised to indicate which set of injury criteria must be met.

overall need for motor vehicle safety.

In addition to preventing the unnecessary expenditure of resources, we also believe it is important for manufacturers to honor their certification commitments. The Safety Act does not allow for "recertification" after the certification label has been applied. Nor does it contemplate allowing manufacturers "two bites at the apple." Moreover, there is ample evidence that consumers often choose to purchase a particular vehicle because its manufacturer has advertised that it has certain safety features. In light of consumer interest in and concerns about air bag safety, this consumer practice is likely to continue or even increase in the context of this rule. We believe that consumers should be entitled to expect that manufacturers will produce vehicles that comply with the requirements to which they are certified.

We note that a manufacturer that chooses to install multiple safety features that would independently comply with two or more of the specified compliance options in the standard is not prohibited from doing so. For example, a manufacturer may build a vehicle that meets both the static suppression and the low risk deployment requirements of today's rule. In that case, it may be that a failure to comply with the option to which the vehicle was certified would be inconsequential to motor vehicle safety, such that a notification and remedy (i.e., recall) campaign would not be necessary. However, in view of the fact that not all compliance options provide precisely the same level of safety benefits, such an inconsequentiality determination would not be automatic.

Although it is implicit from the foregoing discussion, we want to explicitly note that S4.8 applies to the decision by a manufacturer as to whether to certify a vehicle as complying with the advanced air bag requirements during each of the two phase-ins. If a manufacturer advises

NHTSA (either in response to a request for compliance information or in a report submitted pursuant to 49 CFR Part 585) that it intends a particular vehicle or model to count as meeting the requirements of S14.1, S14.2, S14.3, or S14.4 during the applicable phase-in, a vehicle that failed to comply with the applicable performance requirements would be deemed to be in noncompliance with the standard, even if other vehicles produced by the manufacturer in the production year in question would have been sufficient to satisfy the specified percentage requirement for that year.

We believe that such a regulatory approach is particularly critical in the context of this rule, since consumers will know whether a vehicle is represented as complying with the advanced air bag requirements from a variety of sources (e.g., the warning label in the vehicle, the owner's manual, manufacturer advertising, dealer sales staff, etc.) and may modify their behavior in reliance upon that representation (e.g., by allowing the smallest child to sit in the front seat to suppress the air bag). If in fact the vehicle does not provide the promised performance (e.g., the suppression system does not function properly), the manufacturer would be required to notify NHTSA of the noncompliance and, unless the noncompliance were found to be inconsequential to motor vehicle safety, to remedy the problem.

### E. Credits for Early Compliance

To encourage early compliance with the advanced air bag final rule, we were directed by TEA 21 to include means by which manufacturers may earn credits toward future compliance. Credits, on a one-vehicle for one-vehicle basis, may be earned for vehicles that are certified as being in full compliance with the final rule before the beginning of each of the applicable phase-in periods. They may also be earned during the phase-ins if a manufacturer's production of

complying vehicles for a model year exceeds the percentage of vehicles required to comply in that year. We are amending 49 CFR Part 585 to specify reporting requirements that will allow us to administer this provision. Credits for the first phase-in may be earned immediately after this final rule becomes effective, but credits for the second phase-in may only be earned starting on September 1, 2006. We are only allowing credits to be earned for vehicles manufactured one year prior to the initiation of the second phase-in because we believe manufacturers should first direct their efforts towards full implementation of the first phase-in, particularly the risk reduction requirements. Consistent with the prior discussion of compliance options, a manufacturer's decision to certify a vehicle to the advanced air bag requirements before or during the phase-ins will be irrevocable, even if the manufacturer would have been able to satisfy the percentage requirements for a given model year with other vehicles in its fleet.

### F. Choice between Complying with Existing and/or New Injury Criteria and Test Requirements

In the SNPRM, we addressed, for vehicles not certified as being in full compliance with the final rule, the relationship of the proposed new injury criteria and performance limits to the existing test requirements of Standard No. 208. We stated that while some of the new and/or modified injury criteria and performance limits would apply to existing tests that are being retained in Standard No. 208, we were not proposing to change the injury criteria and performance limits for vehicles not certified to all of the requirements applicable to vehicles with advanced air bags.

We stated that, as a general matter, vehicles produced between the time the final rule becomes effective and the time the phase-in is complete would be required to comply with and

be certified to all the current requirements and current injury criteria or to all the requirements for advanced air bags and new injury criteria; there would be no opportunity to mix and match.

However, as a possible exception to this, we requested comments on whether we should permit manufacturers to immediately certify their vehicles to whatever set of unbelted crash test requirements applicable to 50th percentile adult male dummies was adopted for the final rule, as an alternative to the currently available sled test or unbelted up-to-48 km/h (30 mph) rigid barrier test. In light of the limitations of the sled test, we stated that, to the extent vehicle manufacturers wished to immediately design and certify vehicles to whatever set of unbelted crash test requirements was included in the final rule, there could be safety benefits.

Several commenters, including AAM, DaimlerChrysler and Toyota, supported permitting manufacturers to begin immediately certifying to the new unbelted test in lieu of the sled test at the manufacturer's option, for vehicles without advanced air bags. In light of the comments and the discussion we presented in the SNPRM, we are including this option in the final rule. Like the sled test, this option will only be available in vehicles that do not have advanced air bag systems. Accordingly, the option will sunset on September 1, 2006. We have also decided to explicitly limit a manufacturer's option to certify to the existing 48 km/h (30 mph) unbelted barrier test to September 1, 2006. This is because the advanced air bag requirements for the second phase-in could be circumvented by meeting the 48 km/h (30 mph) barrier test, but using the old injury criteria for the 50th percentile adult male dummy.

### G. Time Periods for Measuring Injury Criteria During Tests

In the SNPRM, we proposed specific points for the end of the period for measuring injury criteria in both crash tests and low-risk deployment tests. We noted that, for dynamic crash tests,

we historically have not measured injury criteria more than 300 milliseconds after the vehicle impacts the barrier, and we proposed a 300 millisecond time duration for the dynamic crash tests. For the low risk deployment tests, which do not involve a complete vehicle crash and are intended only to address the potential adverse effects of an air bag, we proposed to measure injury criteria for up to 100 milliseconds after the air bag deploys.

We indicated that these time parameters would not apply to the dummy containment requirement. Regardless of the time frame used to measure other injury criteria, all dummies would continue to be required to remain fully contained within the test vehicle until both the vehicle and the dummies have ceased moving.

Comments were received from DaimlerChrysler, Toyota, Nissan, and Autoliv. Other than DaimlerChrysler, the commenters all supported truncating the test data at the point the dummy interacts with the vehicle interior and after the dummy's head had cleared the air bag. In the alternative, Nissan supported truncating the data in both the barrier tests and the low-risk deployment tests at 100ms. DaimlerChrysler, who commented only on the time-frame related to low-risk deployment tests, noted that it was possible for peak injury criteria to be reached after 100 ms because of low output initiator delay times. Accordingly, it suggested that the data for all deployments be truncated at 300 ms or when the dummy ceases to be in contact with the air bag, whichever occurs first.

Traditionally, we have not counted data that is recorded as the result of the dummy's head neck or torso striking the vehicle interior when the dummy is no longer engaged in the air bag. We continue to believe, as apparently do commenters, that the air bag is neither responsible for these injury values nor could the air bag have prevented these interactions with the vehicle

compartment. However, we are concerned that truncating the data to the point at which the occupant is no longer engaged in the air bag is insufficiently objective for compliance purposes. While we intend to retain our existing policy on considering the location of the dummy relative to the vehicle interior and the air bag at the time peak injury measurements are recorded, we have decided to keep the time parameters for measuring data at specific level. Accordingly, data will be collected until 300 ms after the vehicle strikes the barrier in a dynamic crash.

Based on DaimlerChrysler's observation and our knowledge of low risk deployment technologies, we agree that a 100 ms time-frame for the low risk deployment test may be too small. Consequently, the parameters for truncating data for the low risk deployment tests have been changed to the same parameters used for the barrier tests, i.e., 300 ms after the air bag deploys.

### H. Cruise Controls

In the SNPRM, we proposed to require that cruise controls be deactivated when any stage of an air bag system is deployed, and included a brief procedure to test whether this requirement was met. We noted that if the cruise control were not deactivated, it would continue to provide power to the vehicle, which could lead to a runaway condition.

Only Consumers Union supported our proposal, stating a deactivated cruise control is a basic safety measure. AAM and DaimlerChrysler stated that we had not demonstrated a safety need for such a requirement and the proposed test procedure could make cruise control systems less reliable than they are currently. According to AAM, none of its members is aware of a single report of a cruise control remaining operational after an air bag deployment following a crash. DaimlerChrysler also noted that under most crash conditions, the cruise control is usually

already deactivated by the time the air bag deploys, either because the vehicle's speed has fallen below a certain threshold or because the brakes have been applied. Additionally, cruise control systems generally requires a certain level of speed to operate, making compliance testing exceptionally difficult.

We agree with AAM and DaimlerChrysler that there is no need to regulate cruise control interaction with air bags at this time. We also are unaware of any instances where the cruise control remained on after an air bag deployed. It appears that manufacturers have already resolved this potential scenario. Finally, the addition of a test procedure could add additional complexity and potential unreliability to an already complex system. Accordingly, while we believe that the cruise control should deactivate when an air bag deploys, we do not believe this is an area currently in need of regulation.

### I. Rescue Operations

In the SNPRM, we proposed to require that all air bags become deactivated after a maximum one-minute "keep alive" period has elapsed after the vehicle battery power is disconnected. We proposed a brief procedure to test whether this requirement was met. The purpose of this requirement was to ensure that rescue workers have a standardized method and time for deactivating air bags, to neutralize any potential danger they may face. We noted that the air bags in most vehicles are deactivated within a minute or less after battery power is disconnected.

Commenters generally supported the concept of having air bags automatically deactivate one to two minutes after a vehicle's battery power is shut off, although the NTSB argued that the deactivation time should be closer to ten seconds. AAM, Toyota, and DaimlerChrysler

questioned the need for a requirement at all, since most manufacturers already deactivate the air bag within one to two minutes after the power is cut off. These commenters, along with AORC, Nissan, Delphi and TRW, all raised concerns over the proposed test procedure. Specifically, the commenters were concerned that the addition of an air bag firing voltage terminal to measure voltage changes within the air bag electrical system may actually cause unknown air bag deployment problems adversely affecting the system's overall safety effectiveness.

We continue to believe that a short air bag deactivation time would eliminate confusion and unnecessary delays in rescue work. We also believe that a period of one minute or less is appropriate. It is sufficiently short to assist in rescue operations but not so brief as to create design problems for manufacturers. We are concerned, however, that any test procedure that would allow us to objectively measure when the air bag has been deactivated could cause unnecessary complexity in the air bag system and potentially reduce system reliability. As noted in the preamble and cited by commenters, the air bags in most vehicles are deactivated within one minute or less after battery power is disconnected. Since most vehicles already meet the proposed timing, we are not convinced that there is a sufficient need to regulate this issue at this time.

However, we urge manufacturers who do not design their air bag systems to shut off within one minute of power being cut off to work on reducing the time before such deactivation. Given the ability of most manufacturers to meet this time frame in existing vehicles, we do not believe this would pose a significant design challenge. Rescue personnel do not have the time or the resources to determine at a crash scene when an undeployed air bag will deactivate once power is cut off. A measure of uniformity in this area is desirable.

### J. Hybrid III Dummy Neck

In the SNPRM, we requested comments on two issues related to the Hybrid III dummy neck.

First, we noted that there have been crash test situations where the agency has observed high neck moments being generated at the upper load cell of the Hybrid III dummy neck within 20 milliseconds of the initiation of large neck shear loads without observing substantial angular deformation of the dummy neck. We stated that while we believe that these are true loads being generated by the restraint system and not artifacts of an inappropriately designed neck transducer, we were uncertain whether this loading condition is biomechanically realistic. We requested commenters' views on this issue.

Second, we sought comments on the appropriate channel frequency class (CFC) for evaluating data from neck load cells for injury assessment purposes and whether that CFC should depend on the impact environment (e.g., vehicle crash tests, out-of-position tests, etc.).

Several commenters noted that they did observe the high moment/low rotation loading condition and one, DaimlerChrysler, offered test data to suggest that the dummy's neck design does not follow established biomechanical response corridors. However, none of the commenters, including DaimlerChrysler, provided the agency with any additional data to justify or develop alternative dummy neck response requirements that either verify the responses of the current Hybrid III design or provide the basis for improving it.

Because of the need to minimize the likelihood of neck injuries and lack of testing alternatives, we will use the current Hybrid III neck designs in the final rule. However, we will immediately establish new and accelerate existing research and development efforts to further

address this issue.

As to filtering, AAM and DaimlerChrysler stated that they believe that the filters specified by SAE J211 are appropriate for evaluating neck injury and that sources of the spikes/noise need to be identified and eliminated.

We agree with the commenters' suggestion that the SAE filter specifications for the individual neck loads are sufficient for evaluating neck injury potential. The sources of noise do not appear to be inherent in the dummy neck design, but rather are caused by incorrect assembly/maintenance of a specific dummy or by procedural variances which need to be corrected at the testing laboratories.

However, because Nij combines the neck bending moment and the neck axial force which have different channel frequency classes (CFC 600 for moment, CFC 1000 for axial force), we believe it is more appropriate to have a pure channel class frequency of 600 for Nij. Thus, we are specifying that a CFC 600 be used for computing the axial force component of Nij, and CFC 1000 for computing the peak axial neck forces. Because J211 does not require phaseless filters for frequency channel classes above 200, we have specified that all measurements be conducted with phaseless filters.

### K. Seating Procedure for 5th Percentile Adult Female Dummy

Earlier in this notice, we discussed the issue of where the 5th percentile adult female dummy should be located during crash tests; i.e., with the seat full forward or in some other position. A related issue is what seating procedure to use for positioning that dummy.

In the SNPRM, we proposed a seating procedure that was developed considering the work performed by the SAE Hybrid III 5th Seating Procedure Task Group and by NHTSA's

Vehicle Research and Test Center (VRTC). The 50th percentile Hybrid III adult male dummy is the only dummy currently used for Standard No. 208 compliance crash testing. For that testing, the dummy is positioned according to S10 of the standard. As part of that procedure, the H-point of the dummy is located using the manikin and procedures in SAE Standard J826.

For the 5th percentile adult female dummy, we proposed a different seating procedure which does not use a manikin. In tests we conducted for positioning the 5th percentile adult female dummy, it made little difference whether a manikin was used or not. The proposed non-manikin procedure also made it easier to repeatedly position the 5th percentile adult female dummy.

We are adopting the seating procedure we proposed in the SNPRM. Although we have reviewed the proposed SAE seating procedure for the 5th percentile adult female in a dynamic crash test, we have decided against adopting this procedure because it has not yet been adopted by the SAE and may not be adopted, in any form, for some time. If the SAE does ultimately adopt a seating procedure that is different from the one we are adopting today, we will review that procedure and consider replacing our procedure.

### L. Deletion of Tests Between the Initial and Supplemental Proposals

Several commenters raised concerns about the deletion of several tests in the SNPRM that were proposed in the NPRM.

Public Citizen, CAS and the American Academy of Pediatrics (AAP) expressed concern about deletion of rough road tests. AAP stated that the agency's rationale that this is an area that vehicle manufacturers will consider and address in the absence of Federal requirements could be used to justify elimination of all test requirements. AAP stated it does not think it is appropriate

to eliminate safety tests related to obvious potential performance problems, particularly in cases where the consequences of performance failure could easily be the death of infants, children and adolescents.

Commenters also raised concerns about deletion of the proposed vehicle integrity requirements and the option for a full scale dynamic out-of-position test.

We note that we dropped each of these requirements in part because of problems with the proposed test procedures. A specific explanation for dropping each of the requirements is set forth in the SNPRM.

While rough road performance is certainly important, we do not believe there is any evidence that this is likely to be a real world problem. It would also be difficult to develop a test procedure that would assure that a dummy responded like a human to the forces imparted by a rough road. Indeed, the procedure we had proposed in the NPRM turned out to be impractical and did not accomplish its objective. Given our limited resources, we do not believe there is a need at this time to develop test procedures in this area.

As to the option for a full scale dynamic out-of-position test, we believe that other options included in today's final rule accommodate the various advanced air bag technologies under development.

While vehicle integrity is important, this is an area that is not directly related to advanced air bags, and we believe it is best addressed outside of that context.

### M. Consideration of Unintended Consequences

Some commenters raised concerns about the possibility of unintended consequences resulting from use of advanced air bag technologies.

In a joint comment, CEI/CA stated that they were concerned that we had not required extensive real world testing of the complex air bag systems that would be necessary to meet an advanced air bag standard. Those organizations argued that the absence of such data at the time of the original air bag mandate unexpectedly resulted in scores of air bag-induced deaths to children and other occupants.

CEI/CA also expressed concern that there have been large numbers of air bag-related recalls to remedy problems that testing alone failed to anticipate, such as weather-induced deterioration, and production and technological problems. They argued that the fact that these problems arose for the current generation of air bags indicates that the more complex systems envisioned by NHTSA will be even more prone to trouble.

CEI/CA argued that we should give consideration to the possibility of merely approving, rather than mandating, advanced air bags.

As noted above, CEI/CA argued also that NHTSA's existing air bag experience should lead it to reject any mandate requiring technology and designs that are still under development. At a minimum, according to CEI/CA, the agency should establish requirements will not take effect until real-world data on such systems exists and has been analyzed. To the extent that it is statutorily constrained on this matter, it should set lead times at the absolute statutory maximum.

Congressman David M. McIntosh similarly expressed concern that this rulemaking is being conducted too quickly, without real world data on how advanced air bags operate. He characterized the original mandating of air bags as rushing into uncharted territory and said that before repeating that mistake, we should perform extensive real world trials on advanced air bags.

As noted earlier in this final rule, the history of this agency's consideration of air bags is actually a very long one, having begun with a public meeting in 1969. Air bags were not mandated until 1991, when Congress enacted a law mandating that NHTSA amend its occupant protection standard to require the installation of air bags, thus eliminating the option of installing other types of automatic restraint systems such as automatic belts. Between those two events, there were more than 20 years of public proceedings, research projects and analyses conducted by NHTSA on the issue of air bags, research conducted by the vehicle manufacturers, the installation of air bags in 10s of 1,000s of vehicles, and the announcement by vehicle manufacturers of plans for installing them in many more.

To solve the problems that arose in the mid-1990s with many of the air bags installed in motor vehicles, the agency announced a comprehensive plan in November 1996. The plan set forth an array of immediate, interim and long term measures. The immediate and interim measures focused on behavioral changes and relatively modest technological changes. The long term measures focused on more significant technological changes, i.e., advanced air bag technologies. The immediate steps included urging parents to place their children in the rear seat and giving motorists at risk the chance to turn off their air bags, requiring new labels with eye-catching graphics and colors and strong, clear warning messages, permitting the installation of original equipment on-off switches in new vehicles in which young children could not be placed in a child restraint system in a rear seating position, and permitting the installation of retrofit on-off switches to protect people in at-risk groups. Because of the lead time needed for advanced air bag technologies, NHTSA adopted an interim measure to accelerate manufacturer efforts to depower their air bags and make other short term design changes. The agency did this by

permitting manufacturers to certify their vehicles using a sled test instead of a crash test more closely simulating a real world crash. In the long term, the agency said that it would conduct rulemaking to require the installation of advanced air bags.

Since 1996, the agency has been carefully laying the groundwork for completing the implementation of its comprehensive plan by issuing this final rule. As noted above, we have made extensive efforts to gather information and solicit public comments that would help us identify and select a sensible, effective array of requirements for increasing protection and minimizing risk. In February 1997, we held a public technical workshop on advanced air bag technologies. In December 1997, we sent an Information Request (IR) to the vehicle manufacturers to obtain detailed information concerning their changes in air bag design during the 1990s. In April 1998, Jet Propulsion Laboratories completed, at NHTSA's request, a report titled "Advanced Air Bag Technology Assessment." In mid-1998, Congress made the judgment that advanced air bags should be required. It enacted TEA 21 mandating that we amend our occupant protection standard again, this time to require vehicle manufacturers to improve the protection provided by air bags and to reduce the risks associated with them by means that include advanced air bag technologies. Although TEA 21 required only that we seek public comment once on our proposals before taking final action, we asked for public comment twice. We issued a notice of proposed rulemaking (NPRM) in September 1998, and a supplemental notice of proposed rulemaking (SNPRM) in November 1999. To help us thoroughly explore the issues, we proposed or discussed a variety of alternatives and posed a wide-ranging array of questions.

Further, before we decided on what to include in this final rule, we carefully considered

the available information and the public comments, the underlying safety problems, the performance of current motor vehicles, the ability (including lead time needs) of vehicle manufacturers to achieve better performance in future motor vehicles, the air bag technology (including advanced air bag technology) currently available or being developed, the cost of compliance, and other factors. We also carefully considered the comments concerning the costs, benefits and risks associated with each alternative proposal.

As required by the mandate to us in TEA 21, our final rule requires vehicle manufacturers to improve the protection provided by air bags and reduce the risks associated with air bags by means that include advanced air bag technologies. Thus, the final rule is very different from the one issued in 1984. That final rule mentioned advanced air bag technologies as a way of addressing concerns about air bags risks, but did not mandate their use to prevent unintended consequences. This final rule mandates their use.

This final rule does not, however, mandate the use of particular advanced air bag technologies. The requirements in the final rule are performance-based requirements that give vehicle manufacturers the flexibility they requested to choose which type of advanced air bag technology they include in the vehicles.

This final rule establishes requirements and procedures for testing the ability of advanced air bag systems to protect people in moderate to high speed crashes and to avoid creating risks in low speed crashes. There are new detailed test procedures for manufacturers to use in developing and testing their advanced passenger air bag systems to ensure that they either do not deploy at all in the presence of a young child or deploy in a low risk manner. Driver air bags are required to deploy in a low risk manner.

The final rule contains additional complementary measures for reducing the likelihood of unintended consequences for front seat occupants. It retains the existing, strongly worded and brightly colored warning labels urging motorists to place children in the back seat and urging everyone to buckle up. We recognize that some motorists will nevertheless place a child in the front seat. Our final rule requires that if vehicle is equipped with a passenger air bag system that turns the air bag off in the presence of a young child, the vehicle must also have a telltale to inform motorists whether the air bag has been turned off. Further, we have extended the availability of OE air bag switches in vehicles in which child restraints cannot be placed in a rear seat and of retrofit switches for at-risk people.

Finally, we have provided as much lead time as TEA 21 allows for vehicle manufacturers to comply with the advanced air bag requirements mandated by that law.

### N. Reporting Requirements

Also as with previous phase-ins, we proposed amendments to 49 CFR Part 585 to establish reporting requirements to allow us to administer the phase-in and the use of advanced credits. We received no comments on this proposal and have adopted the changes to Part 585, with several modifications to clarify the requirements and to account for the addition of a second phase-in.

### O. Use of Children and Adults for Testing Static Suppression Systems

In the SNPRM we proposed to permit manufacturers to use human beings to check suppression features in light of concerns that current dummies may not be sufficiently human-like to be recognized by some of the advanced technologies under development. If a manufacturer selected this option, the suppression requirements would need to be met at each of

the relevant positions for any human being within a specified weight/height range for 3-year-old and 6-year-old children, and the air bag system could not be suppressed when the seat was occupied by a female within a height/weight range similar to that of a 5th percentile adult female.

In the SNPRM, we emphasized that these tests simply involve a child or adult assuming specified positions in the vehicle, with a technician checking (typically by looking at a light) whether the air bag system would be activated or deactivated; these tests do not involve deploying the air bag or moving the vehicle. To ensure absolute safety, we proposed to require manufacturers selecting this option to provide a method to assure that the air bag would not deploy during testing; such assurance could be made by removal of the air bag.

In general, commenters supported the use of humans under the conditions outlined in the SNPRM at least as a short-term measure. Manufacturers were generally concerned that the use of humans would present objectivity and reliability concerns. All of the manufacturers of vehicles and air bag systems who commented on this option addressed the industry efforts to develop a new test dummy that better replicates the human form than the current anthropomorphic test dummies. AORC, Consumers Union and AAP urged that the air bags be removed during tests with humans, arguing that removal is the only sure way to eliminate risk. GM and BMW were concerned that systems designed to recognize humans might not recognize the anthropomorphic test dummies in the vehicle crash tests.

GM and IEE stated that the ranges of weight and size provided in the SNPRM should be tightened, claiming the given range would create too much variability for a system to accurately detect presence with sufficient reliability. At the same time, the NTSB, AAP, and Trauma Link at the Philadelphia Children's Hospital have suggested that we further expand the height and

weight ranges specified in the SNPRM.

We support the initiative industry has taken in developing a new, more human-like dummy. The prototype for a 5th percentile adult female dummy has already been developed by FTSS with support from various vehicle manufacturers. Based on presentations made to the agency, we believe a prototype for the 6-year-old child dummy will soon follow. Since we have not yet had an opportunity to study these new dummies, we are unable to comment on their suitability for suppression technologies. However, we can note that the dummies currently used in compliance tests were all designed for use in crash tests, and while their overall size and weight is representative of the humans they were designed to replicate, they do not demonstrate the same flexibility, muscle tone or weight distribution as humans. Once the new dummies have been fully developed, we will evaluate their suitability for testing suppression systems. It is our hope that we will soon be able to eliminate the use of humans as a compliance option for suppression systems.

As long as humans can be used to meet the suppression test criteria, it is imperative that the risk to these individuals be eliminated. This may require manufacturers to physically remove the air bag. However, manufacturers may be able to eliminate risk without removing the air bags. If they can do this, we see no need to require that the air bags be removed.

As for GM's and BMW's concerns that systems designed to recognize humans may not recognize dummies for crash tests, we note that we believe vehicles should be designed to protect people rather than test dummies. However, in order to meaningfully test for compliance to our standard, the air bag must fire in a crash test. Accordingly, manufacturers will need to design their systems in such a way that they can meet the crash test requirements with dummies located

in the front seats.

In order to accommodate designs geared to recognition of people rather than inanimate objects, we have provided in S4.12 that manufacturers of vehicles with human recognition systems must provide NHTSA with information and equipment necessary to circumvent the suppression system for vehicle crash tests.

We have decided to keep the height and weight ranges proposed in the SNPRM. As noted above, the use of humans is intended as a temporary measure and will likely only be used until more human-like dummies can be developed. Accordingly, we believe it would be inappropriate to expand the height and weight ranges significantly beyond the height and weight of the applicable dummies. At the same time, we have decided against narrowing the height and weight ranges proposed in the SNPRM. Since suppression systems will ultimately have to work with people, a system that can only detect the presence of an individual within a tightly prescribed range would not perform adequately in the real world.

### P. Small Business Concerns

As discussed later in the *Regulatory Flexibility Analysis* section, the requirements contained in this final rule may have a significant impact on a number of small businesses, including small volume manufacturers, multi-stage manufacturers, alterers, seating system suppliers, air bag sensor and component manufacturers, and dummy manufacturers. Because today's rule will increase the demand for advanced air bag system technology as well as dummies and dummy parts (e.g., accelerometers), we believe that today's rule will have a positive effect on the manufacturers of these products. We expect that today's rule will have a more significant impact on small volume manufacturers, multi-stage manufacturers, alterers, and

seating system suppliers.

In the preliminary regulatory flexibility analysis accompanying the SNPRM, we estimated that the final rule would affect approximately 11 seating systems suppliers which are small businesses. We explained that these suppliers serve a niche market and estimated that they provide seats for less than two percent of the vehicles. We explained that depending on the technology chosen to meet the proposed advanced air bag rule, these suppliers would need to keep up with emerging technology.

Bornemann Products Incorporated, a seating component manufacturer, stated that 98 percent of its sales are to multi-stage vehicle manufacturers who primarily manufacture individual, custom vehicles. Bornemann stated that this rule could completely eliminate the "niche" market of individual custom vehicles. Bornemann stated that since original vehicle manufacturers will be reluctant to allow any changes to their chassis that could affect the air bag system, this rule would have a significant impact on seating system vendors and their suppliers (e.g., fabric and trim suppliers, polyurethane producers, etc.), multi-stage vehicle manufacturers, vendors who supply these manufacturers with items such as carpet, steel and wood, and their employees.

Bornemann stated that NHTSA's estimate of 11 seating companies was incorrect, that the number is closer to 30 and that these 30 businesses have close to $80,000,000 in sales and employ around 2,500 people. Bornemann also estimated that the rule would have an impact on the following small businesses: direct seating system vendors (130 firms and around 5,000 employees); multi-stage manufacturers (around 250 with approximately 14,000 employees); and vendors who supply material for vehicles and seats (around 550 vendors and around 18,000

employees). Bornemann also stated that a temporary exemption from the rule would not lead to a permanent resolution of the problem due to the technical issues involved. Bornemann did not explain what those technical issues were nor did they explain to what extent they could not be addressed. Bornemann also did not discuss what specific differences between existing and future air bag requirements would create technical problems for them nor did they discuss what specific advanced air bag technologies would pose the greatest problems for them.

The Coalition of Small Volume Automobile Manufacturers (COSVAM), RVIA, and NTEA addressed the potential impact the new advanced air bag requirements would have on small volume manufacturers, multi-stage manufacturers, and alterers. A discussion of their specific comments as well as our response to them is included earlier in the section addressing the rule's phase-in requirements.

We appreciate the technical challenges small volume manufacturers, multi-stage manufacturers, alterers, and seating system suppliers will face as a result of the requirements included in today's rule. Therefore, we have considered whether there were any alternatives available that could simplify compliance for small businesses without adversely affecting safety.

RVIA asked that we allow small volume final stage manufacturers and alterers to certify compliance with a generic sled test pulse. As explained earlier in today's rule as well as in both the NPRM and SNPRM, we do not consider sled testing to be an adequate long-term means of assessing the extent of occupant protection that a vehicle and its air bag will provide occupants in the real world. Unlike a full scale vehicle crash test, a sled test does not, and cannot, measure the actual protection that an occupant will receive in a crash. The test can measure the limited performance attributes of the air bag, but not the performance provided by the full air bag

system, much less the combination of the vehicle and its occupant crash protection system. It is that combination that determines the amount of protection actually received in a crash. We also note that it would be inconsistent with the Safety Act to allow multi-stage manufacturers and alterers to certify compliance with a generic sled test pulse. Under the Safety Act, we cannot base the applicability of our safety standards on the circumstances of the manufacturer, such as whether a vehicle is manufactured in one or more stages. Differences in the applicability of standards must be based instead on differences between vehicles, such as the differences between convertibles and sedans.

We note that sled testing is an accepted engineering practice and nothing precludes manufacturers from using sled tests as a basis for their certification. We note, however, that sled testing does not test all of the attributes (such as weight sensing or presence sensing) of the countermeasures that may be used to comply with the requirements of today's rule.

In light of the statutory mandates contained in TEA 21, the only alternative available to address the concerns of small businesses is to increase the lead time for small volume manufacturers, multi-stage manufacturers, and alterers. We note that COSVAM, RVIA, and NTEA all supported such an extension. Further, while we recognize and are sympathetic to the technical challenges small volume manufacturers, multi-stage manufacturers, and alterers will face as a result of the requirements included in today's rule, we emphasize that we have limited discretion as to how much lead time we can provide. TEA 21 provides that if the phase-in begins on September 1, 2003, the final rule must become fully effective by September 1, 2006. No exceptions are given for multi-stage manufacturers, alterers, or small volume manufacturers.

We acknowledge that there is no guarantee that this solution will ultimately solve all the

technical problems of small businesses. We have no control over when manufacturers bring into compliance the vehicles they supply to multi-stage manufacturers during the phase-in period. In addition, we have no control over the particular advanced air bag technology vehicle manufacturers will use to comply with the new requirements (e.g., whether the system will incorporate the seat).

Further, while we recognize that adapting to this technology may not be easy, it is necessary. Keeping pace with technology is not a new problem for these manufacturers. Manufacturers regularly incorporate new technology that improves the safety of their vehicles (e.g., antilock brakes). However, to help minimize the economic impact of this final rule on small businesses, we urge air bag suppliers, chassis manufacturers, and OEMs to provide these manufacturers with as much engineering expertise as possible to help them meet the new requirements, and to keep the overall impacts small.

We note that we are undertaking efforts to address the needs of multi-stage manufacturers, alterers, and the businesses, such as Bornemann, that supply them. We have established a Negotiated Rulemaking Committee to develop recommended amendments to the existing NHTSA regulations (49 CFR Parts 567 and 568) governing the certification of vehicles built in two or more stages to the Federal motor vehicle safety standards. The purpose of the amendments would be to assign certification responsibilities more equitably among the various participants in the multi-stage vehicle manufacturing process. The Committee will develop its recommendations through a negotiation process. It consists of persons who represent the interests that would be affected by any such amendments, such as first-stage, intermediate and final-stage manufacturers of motor vehicles, equipment manufacturers, vehicle converters,

testing facilities, trade associations that represent various manufacturing groups, and consumers. The Committee is addressing several issues that should, when resolved, assist multi-stage manufacturers and alterers in complying with today's requirements. Such issues include, for example: the feasibility and cost effectiveness of alternate methods (e.g., testing, computer modeling, or other as-yet-unspecified methods) to ensure compliance of completed vehicles with requirements of applicable FMVSSs; mechanisms for incorporating alternate methods of ensuring compliance into these regulations; mechanisms for sharing costs of testing; and requirements tailored to the capabilities and circumstances of each class of vehicles.

### Q. Other Issues

#### 1. Ability to comment effectively on SNPRM

The Center for Auto Safety (CAS) has asserted in section I of its unpaginated, electronically-filed December 30, 1999 comments that the agency has engaged in an "information blackout" that has hampered the ability of CAS and others to understand and comment effectively on the SNPRM. In support of this assertion, CAS has cited both NHTSA's refusal to disclose materials submitted with claims of confidentiality by the motor vehicle manufacturers in response to the agency's December 17, 1997 requests for information concerning air bag technology in MY 1990-1998 light passenger vehicles (information requests)[42] and alleged inadequacies in the agency's October 26, 1999 report summarizing those

---

[42] The withheld information is currently the subject of litigation between CAS (represented by Public Citizen Litigation Group) and NHTSA. All of the vehicle manufacturers that received and responded to the information requests , as well as several air bag suppliers, have intervened as defendants. CAS v. NHTSA, D.D.C., No. 99-1759 (GK). The district court issued a decision denying the CAS' motion for summary judgement and granting NHTSA's and the intervenors' cross-motion for summary judgement on February 28, 2000.

materials. Air Bag Technology in Light Passenger Vehicles (R&D Report).[43]

NHTSA disagrees with CAS' general assertion that public commenters lack sufficient information to participate adequately in this rulemaking. The R&D Report is a lengthy document, consisting of a four-page Executive Summary, 37 pages of text and five appendices, that incorporates six tables and 31 figures. It describes and analyzes in some detail, but in general terms that do not disclose the identities of manufacturers or vehicle makes/models, the technology (Section 2.0) and trends (Section 3.0) in air bag technology during the 1990s. In addition, the R&D Report describes out-of-position testing conducted by NHTSA on MY 1996, 1998, and 1999 production vehicles (Section 4.1) and rigid barrier testing of 13 MY 1998 and 1999 vehicles with redesigned air bags (Section 4.2), and discusses evolving air bag fatality trends using data from NHTSA's Special Crash Investigations (SCI) program (Section 5.0). The agency's conclusion that the R&D Report provides commenters with ample information on which to base their comments is borne out by the specificity and sophistication of the comments submitted by CAS.

NHTSA also disagrees with CAS' more specific assertion that the absence of a discussion of air bag deployment thresholds in the R&D Report has inhibited comments on the SNPRM (CAS Comment, Section IA). Neither the SNPRM nor the NPRM on advanced air bags proposed to set a minimum deployment threshold limit. Furthermore, we did not receive information indicating that the vehicle manufacturers changed their deployment thresholds in response to the agency's March, 1997 sled test rule. Thus, commenters do not require specific

---

[43] On December 16, 1999, the agency published a revised version of the R&D Report (Revision 1) that contains minor technical corrections to the October 26, 1999 Report. Revision 1 has been docketed at NHTSA-1997-2814-62.

information about deployment thresholds in order to present arguments in response to the SNPRM, and the deployment threshold issue is not directly relevant to this rulemaking action. Moreover, assuming that commenters wish to discuss deployment thresholds, data on this subject are readily available to commenters from other accessible sources. Data from NHTSA's National Accident Sampling System (NASS) that provides information about the "delta Vs" in actual crashes in which air bags have deployed is publicly available over NHTSA's Website and is widely used. In addition, information in publicly-available reports prepared by SCI provides delta-V information for crashes that have resulted in fatalities. These reports are publicly available and CAS has discussed these materials with specificity in Section IA and Attachment A of its comments.

CAS' charges in sections IB and IC of its comments with respect to alleged absence from the R&D Report of detailed air bag design information, such as information with respect to the location and mounting of air bags, folding pattern details, and information about inflation stages is similarly flawed. Because NHTSA's standards are performance standards rather than design standards, the agency has not proposed specific designs in either the NPRM or SNPRM. Thus, air bag design information at the level of detail desired by CAS is not necessary in order to comment intelligently on the SNPRM. Moreover, contrary to CAS' description, the R&D Report does contain considerable design information. See, e.g., section 3.1 (Trend Analysis) and Appendix A, which includes 45 pages of detailed charts and graphs.

CAS also has objected to the withholding of the manufacturers' crash test performance data (other than data concerning testing performed pursuant to the requirements of Standard No. 208). Again, this data has been subject to litigation between CAS and the agency. But, in the

R&D Report, at section 4 and Appendix D, NHTSA has provided the public with data from agency testing on a variety of vehicles using 5th percentile adult female dummies. CAS is obviously aware of these data; it has cited and discussed them in its comments.

**2. Resubmittal of petition for rulemaking by Donald Friedman and Carl Nash**

In a joint comment, Carl Nash and Donald Friedman stated that they believe that attempting to regulate all aspects of air bags may be counterproductive. They also argued that setting a minimum threshold of approximately 29 km/h (18 mph) and prohibiting late deployments would most protect vehicle occupants. We did not propose to set a minimum threshold as part of this rulemaking. Accordingly, adding such a requirement to the final rule would be outside of the scope of the rulemaking. However, we are requiring that manufacturers meet a low risk deployment test for drivers and for small children if the air bag does not suppress. We believe that these requirements will adequately protect most individuals who could be seriously injured or killed with current air bags. Likewise, we are requiring manufacturers to meet the applicable injury criteria in a 40 km/h (25 mph) offset deformable barrier crash test. As explained earlier in this document, that test is designed to prevent the late deployments to which Friedman and Nash object.

In the SNPRM, we denied a petition by Mr. Friedman and Mr. Nash that would have required manufacturers to develop systems that would further encourage vehicle occupants to use their safety belts. In denying the petition, the agency stated that it does not have the legal authority to require such technology, although we are not discouraging manufacturers from voluntarily using such technology. The basis for our rationale is an amendment made to the

Motor Vehicle Safety Act in 1974 after NHTSA had amended its occupant protection standard to require vehicle manufacturers of vehicles equipped with manual seat belts, instead of automatic protection, to install inducements for belt use. These inducements were either interlocks that prevented one from driving the vehicle unless the safety belt was used or buzzers that sounded continuously until the safety belts were attached.

Friedman and Nash have resubmitted their petition in response to the SNPRM. As noted in the SNPRM, we do not believe we currently have the statutory authority to require such devices. Nor do we believe that requiring any device that is not a buzzer or an interlock is within our authority, given the 1974 amendment. Accordingly, we are denying their resubmission. Nevertheless, we agree with Mr. Friedman and Mr. Nash that in the twenty-five years since that amendment was enacted, patterns of safety belt usage have changed considerably. We are planning to monitor the level of public acceptance and effectiveness of systems that manufacturers are placing in their vehicles to encourage seat belt use. If it appears that these systems are working, it may be appropriate to seek to have the 1974 amendment either changed or repealed.

**XVIII. Benefits and Costs**

The Final Economic Assessment (FEA) provides analyses of the safety benefits from tests that reduce the risk of injury from air bags in low-speed crashes, as well as from tests that improve the overall effectiveness of air bags in high speed crashes. The intent of this rulemaking is to minimize risks caused by air bags to out-of-position occupants, especially infants and children, and to improve occupant protection provided by air bags for belted and unbelted occupants of all sizes. To achieve these goals, we are requiring vehicles to meet test procedures

that broaden the scope of the current standard to ensure that occupants are properly protected under a wider variety of crash circumstances.

The risk of injury from air bags arises when occupants are too close to the air bag when it inflates. Generally, those most at risk from injury are infants, young children, and out-of-position drivers. We estimate that in a fleet fully equipped with pre-model year (MY) 1998 air bags, there would be 46 drivers, 18 infants, 105 children, and 18 adult passengers at risk of being killed by air bags annually because they were out of position when the air bag deployed in low speed (< 25mph delta-v) crashes. We also estimate that if all vehicles had air bags, 38 drivers, 9 infants, 200 children, and 15 adult passengers would sustain serious to critical (MAIS 3-5) nonfatal injury because they were out of position in low severity crashes. A variety of technologies could be used to prevent these deaths and serious injuries, including weight or presence sensors to suppress the air bag, multi-stage inflators, and low risk deployment air bags.

To address these concerns, the new suppression and low risk deployment tests employ crash dummies representing infants, 3-year- old children, 6-year-old children, and 5th percentile female drivers. These tests generally require either that the air bag be suppressed if certain risk conditions exist or that deployments occur at levels that produce a low probability of injury risk.

Of the 187 potential at-risk fatalities, NHTSA estimates that suppression technologies could prevent up to 93 fatalities, low-risk air bags could prevent up to 154 fatalities, and multi-stage inflation systems could prevent up to 179 fatalities when combined with weight sensors used to suppress the air bag. Thus, more than 95 percent of the at-risk population in low speed deployments could be protected by technologies used to meet the test requirements. Of the 262 serious but nonfatal injuries, suppression technologies could prevent 151 injuries, low-risk air

bags could prevent 191 injuries, and multi-stage inflation systems could prevent up to 252 injuries when combined with a weight sensor.

The FEA also analyzes two alternative sets of high speed tests instituted to preserve and enhance air bag protection. Both tests include belted and unbelted frontal rigid barrier tests using 5th percentile female and 50th percentile male crash dummies, 30 degree oblique tests into a rigid barrier using unbelted 50th percentile male dummies, and 40 percent offset frontal deformable barrier tests using 5th percentile female dummies. The primary difference between the two alternatives is their treatment of unbelted occupants. Alternative 1 would require an unbelted 32 to 40 kmph (20 to 25 mph) frontal rigid barrier test, while Alternative 2 would require an unbelted 32 to 48 kmph (20 to 30 mph) frontal rigid barrier test. Chapter I of the FEA provides the detail of the two alternative sets of high speed tests.

Briefly, the analysis found that a fleet of vehicles passing the high speed test of Alternative 1 (with an unbelted test of 20-25 mph) would save 201 to 374 fewer lives annually than a fleet designed to the 48 kmph (30 mph) baseline standard. These air bag systems would prevent from 1,479 to 1,607 moderate to critical severity (MAIS 2-5) nonfatal injuries. Air bags designed to Alternative 2 (with an unbelted test of 20-30 mph) would prevent 43 to 51 additional fatalities annually beyond the 3,253 saved by pre-MY 1998 air bag systems. These air bags would also prevent from 324 to 1,807 moderate to critical severity nonfatal injuries. Most of the difference between Alternative 1 and Alternative 2 is due to the high-speed unbelted test. The 30 mph unbelted test will provide more protection against fatalities in high speed crashes. The agency estimates that a single stage air bag designed to meet a 30 mph test would save from 248 to 413 more lives than one designed to a 25 mph standard. However, the 25 mph test could

result in single-stage air bag designs that would reduce about 1200 more nonfatal injuries than the 30 mph test.

Potential compliance costs for the final rule vary considerably and are dependent upon the method chosen by manufacturers to comply. Methods such as modified fold patterns and inflator adjustments can be accomplished for little or no cost. More sophisticated solutions such as proximity sensors can increase costs significantly. Dynamic presence sensors are not available at this point in time. They have not been refined to the point that they are in use in vehicles and are not required by tests in either Alternative. However, they have the potential to provide more benefits on the passenger side than weight sensors or low risk air bags. Dynamic presence sensors could be used by manufacturers to meet the test requirements in the future. As such, the cost and benefits of these systems have been estimated. The range of potential costs for the compliance scenarios examined in this analysis is $21-$124 per vehicle (1997 dollars). This amounts to a total potential annual cost of up to $1.9 billion, based on 15.5 million vehicle sales per year.

Compliance methods that involve the use of suppression technology have the potential to produce significant property damage cost savings because they prevent air bags from deploying unnecessarily. This saves repair costs to replace the passenger side air bag, and frequently to replace windshields damaged by the air bag deployment. Property damage savings from these requirements could total up to $85 over the lifetime of an average vehicle. This amounts to a potential cost savings of $1.3 billion.

Estimates have been made in the FEA of the net costs per equivalent fatality prevented. Property damage savings have the potential to offset all, or nearly all of the cost of meeting this

final rule. Most combinations of compliance options resulted in positive safety impacts and net costs. For these combinations, the maximum range of cost per equivalent fatality saved is $0.8 million per equivalent fatality saved to $4.1 million per equivalent fatality saved. However, the low end of the range for both Alternative 1 scenarios produced no positive net benefits. For these cases, added costs resulted in either a zero or a negative safety impact.

The range of potential costs per fatality for passenger-side impacts is more favorable than for driver-side impacts. This is due to the potential property damage savings from suppressing air bags for children, and because there are far fewer out-of-position drivers at risk than there are passengers. Passenger side costs for those combinations with both net safety impacts and net costs vary from $1.0 million per equivalent fatality to $2.1 million per equivalent fatality. On the driver's side, costs range from zero to a cost of $2.2 million per equivalent fatality prevented.

## XIX. Rulemaking Analyses and Notices

### A. Executive Order 12866 and DOT Regulatory Policies and Procedures

NHTSA has considered the impact of this rulemaking action under Executive Order 12866 and the Department of Transportation's regulatory policies and procedures. This rulemaking document is economically significant and was reviewed by the Office of Management and Budget under E.O. 12866, "Regulatory Planning and Review." The rulemaking action has also been determined to be significant under the Department's regulatory policies and procedures. NHTSA is placing in the public docket a Final Economic Assessment (FEA) describing the costs and benefits of this rulemaking action. The costs and benefits are summarized earlier in this document.

### B. Regulatory Flexibility Act

We have considered the effects of this rulemaking action under the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) We have prepared a Regulatory Flexibility Analysis (RFA), which is part of the FEA. The RFA concludes that the final rule could have a significant, short-term economic impact on a substantial number of small businesses, but the economic impact on a substantial number of small businesses need not be significant in the long run. Small organizations and small governmental units will not be significantly affected since the potential cost impacts associated with this rule should only slightly affect the price of new motor vehicles.

The rule will directly affect motor vehicle manufacturers, second-stage or final-stage manufacturers, and alterers; and indirectly affect air bag manufacturers, seating system manufacturers, and dummy manufacturers.

There are approximately five main suppliers of air bag systems. The agency does not believe that any are small businesses. In addition, we believe that there may be some second and third tier manufacturers of components of air bags or air bag sensors that are small businesses. We do not believe, however, that there is a substantial number of them. Since today's rule will increase the demand for air bag systems and advanced air bag system technology, we believe that today's rule will have a positive effect on air bag manufacturers and on second and third tier manufacturers of air bag components.

There are several manufacturers of dummies and/or dummy parts. All of them are considered small businesses. While the rule will not impose any requirements on these manufacturers, we expect it will have a positive impact on these types of small businesses by increasing demand for dummies and/or dummy parts (e.g., accelerometers).

For passenger car and light truck manufacturers, we estimate that there are only about

four small manufacturers (SVMs) in the United States. We believe that these manufacturers, which serve a niche market, do not manufacture even 0.1 percent of total U.S. passenger car and light truck production per year. We note that these manufacturers are already required to certify compliance to Standard No. 208's air bag requirements under ISTEA. In the past, many of these manufacturers have petitioned for temporary relief from the air bag requirements on the basis of economic hardship. We anticipate that these manufacturers will encounter difficulty certifying compliance with the requirements being added to Standard No. 208 by today's rule.

In an effort to address the needs of these SVMs, we have decided to allow them to wait until the end of the phase-in to meet the requirements of today's rule. This will give SVMs more time to perform the engineering analysis and generate the compliance data needed to comply with today's rule. Since the requirements in today's rule will enhance the safety of vehicles and air bags for infants, children, small-statured adults and both belted and unbelted occupants, we believe any delays in compliance should be granted in the narrowest of circumstances only. We are, therefore, limiting this option to manufacturers which produce fewer than 5,000 vehicles per year worldwide.

RVIA asked that final-stage manufacturers be given a one-year extension after the end of the phase-in for large manufacturers. RVIA stated that guidance from incomplete vehicle manufacturers is generally not available until at or very near the startup of new or updated model production and that, therefore, final stage manufacturers will need at least one additional year to meet the new requirements.

NTEA supported the proposal to allow multi-stage produced vehicles to be phased in at the end of the phase-in period. NTEA requested that the phase-in period run from September 1,

2003 to September 1, 2006.

In the initial regulatory flexibility analysis, we stated that we knew of 11 businesses that supply seating systems to van converters and others and that are small businesses. In addition, there are about 10 suppliers of seating systems that are not small businesses. The small businesses serve a niche market and provide seats for less than two percent of vehicles. Depending on the technology manufacturers choose to meet the advanced air bag final rule, these suppliers will have to keep up with the technology.

Bornemann Products Incorporated is a small business that provides seating components to second- and final-stage manufacturers and alterers. Bornemann argued that the cost per vehicle and the impact on small businesses could be significant. Bornemann stated that this rule could have a significant impact on the industry that supplies the "niche" market of individual custom vehicles. Bornemann's concerns have been addressed extensively earlier in this document. We refer the reader to that discussion. Additional information concerning the projected impacts of today's rule on small entities is presented in the FEA.

We believe that second- and final-stage manufacturers and alterers will choose to certify compliance in one of two ways. They will either (1) rely on suppliers to provide them with the same technology (weight sensing, seat track sensing, etc.) provided to the OEM manufacturers or (2) purchase the full seat from the OEM and, leaving the technology in place, re-upholster the seat. If they rely on manufacturers to supply them with the same technology, there will be a cost associated with installing the technology in the seat and assuring compliance (e.g., static testing) if they cannot pass through the supplier's certification. There will also be costs associated with certifying compliance with the rigid barrier test.

### C. National Environmental Policy Act

NHTSA has analyzed this proposed amendment for the purposes of the National Environmental Policy Act and determined that it will not have any significant impact on the quality of the human environment.

### D. Executive Order 13132 (Federalism)

The agency has analyzed this proposed amendment in accordance with the principles and criteria set forth in Executive Order 13132. NHTSA has determined that the proposed amendment does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

### E. Unfunded Mandates Act

The Unfunded Mandates Reform Act of 1995 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 expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted for inflation with base year of 1995). This rule will not have a significant expenditure of funds by State, local and tribal governments. However, the cost of the Rule will exceed the expenditure of over $100 million by the private sector. A full assessment of the Rule's costs and benefits is provided in the FRA.

### F. Executive Order 12778 (Civil Justice Reform)

This final rule does not have any retroactive effect. Under section 49 U.S.C. 30103, whenever a Federal motor vehicle safety standard is in effect, a state may not adopt or maintain a safety standard applicable to the same aspect of performance which is not identical to the Federal standard, except to the extent that the state requirement imposes a higher level of performance

and applies only to vehicles procured for the State's use. 49 U.S.C. 30161 sets forth a procedure for judicial review of final rules establishing, amending or revoking Federal motor vehicle safety standards. That section does not require submission of a petition for reconsideration or other administrative proceedings before parties may file suit in court.

### G. Paperwork Reduction Act

In its November 5, 1999 supplemental notice of proposed rulemaking, NHTSA sought public comment on its estimates of the additional collection of information burden imposed on the public as a result of this rulemaking. NHTSA received no comments on the collection of information issues.

This final rule includes the following "collections of information," as that term is defined in 5 CFR Part 1320 Controlling Paperwork Burdens on the Public:

Air Bag Phase-In Reporting Requirements - For the six production years ending on August 31, 2003, August 31, 2004, August 31, 2005, August 31, 2007, August 31, 2008, and August 31, 2009, each manufacturer will be required to report once a year to NHTSA, its annual production of vehicles with advanced air bags. As previously explained, the reporting for the initial phase-in period will end with the information for the production year ending on August 31, 2005 and the reporting for the second phase-in will end with the information for the production year ending on August 31, 2009. The Office of Management and Budget has approved NHTSA's collection of this information, assigning the collection OMB clearance no. 2127-0599. NHTSA estimates that 1,260 burden hours a year (on all vehicle manufacturers) would be imposed as a result of this collection.

Since today's rule specifies a second phase-in period, we will ask OMB to extend

clearance no. 2127-0599 for the additional period of time that the second phase-in period will last. OMB grants extensions of collections for no more than three years at a time. We do not believe that future phase- in report collections will result in burdens on the public of more than 1,260 burden hours (on all vehicle manufacturers) a year.

Air Bag Warning Labels - New air bag warning labels are specified in this final rule. At present, OMB has approved NHTSA's collection of labeling requirements under OMB clearance no. 2127-0512, Consolidated Labeling Requirements for Motor Vehicles (Except the Vehicle Identification Number). This clearance will expire on 6/30/2001, and is cleared for 71,095 burden hours on the public.

For the following reasons, NHTSA estimates that the new air bag warning labels would have no net increase in the information collection burden on the public. There are 24 motor vehicle manufacturers that will be affected by the air bag warning label requirement, and the labels will be placed on approximately 15,500,000 vehicles per year. The label will be placed on each vehicle once. Since, in this final rule, NHTSA specifies the exact content of the labels, the manufacturers will spend 0 hours developing the labels. NHTSA estimates the technical burden time (time required for affixing labels) to be .0002 hours per label. NHTSA estimates that the total annual burden imposed on the public as a result of the air bag warning labels will be 3,100 hours (15.5 million vehicles multiplied by .0002 hours per label). Since the labels specified in this final rule replace existing labels, no additional burden is imposed on manufacturers.

Advanced Air Bag Information in the Owner's Manual - This final rule requires advanced air bag information in the owner's manual that is in addition to the information already required under Standard No. 208. At present, OMB has approved NHTSA's collection of owner's manual

requirements under OMB clearance no. 2127-0541 Consolidated Justification of Owner's Manual Requirements for Motor Vehicles and Motor Vehicle Equipment. This collection includes the burdens that would be imposed as a result of owners' manual information about air bags. This clearance will expire on 10/31/2001 and is cleared for 1,371 burden hours a year on all vehicle manufacturers.

### H. Regulation Identifier Number (RIN)

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

### I. Plain Language

Executive Order 12866 and the President's memorandum of June 1, 1998, require each agency to write all rules in plain language. Standard No. 208 is extremely difficult to read as it contains multiple cross-references and has retained all of the requirements applicable to vehicle of different classes at different times. Because portions of today's rule amend existing text, much of that complexity remains. Additionally, the availability of multiple compliance options, differing injury criteria and a dual phase-in have added to the complexity of the regulation, particularly as the various requirements and options are accommodated throughout the initial phase-in. Once the initial phase-in is complete, much of the complexity will disappear. At that time, it would be appropriate to completely revise Standard No. 208 to remove any options, requirements, and differentiations as to vehicle class that are no longer applicable.

### J. Executive Order 13045

Executive Order 13045 (62 FR 19885, April 23, 1997) applies to any rule that: (1) is determined to be "economically significant" as defined under E.O. 12866, and (2) concerns an environmental, health or safety risk that NHTSA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, we must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by us.

This rulemaking directly involves decisions based on health risks that disproportionately affect children, namely, the risk of deploying air bags to children. However, this rulemaking serves to reduce, rather than increase, that risk.

### K. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act (NTTAA) requires NHTSA to evaluate and use existing voluntary consensus standards[44] in its regulatory activities unless doing so would be inconsistent with applicable law (e.g., the statutory provisions regarding NHTSA's vehicle safety authority) or otherwise impractical. In meeting that requirement, we are required to consult with voluntary, private sector, consensus standards bodies. Examples of organizations generally regarded as voluntary consensus standards bodies include the American Society for Testing and Materials (ASTM), the Society of Automotive Engineers (SAE), and the American National Standards Institute (ANSI). If NHTSA does not

---

[44] Voluntary consensus standards are technical standards developed or adopted by voluntary consensus standards bodies. Technical standards are defined by the NTTAA as "performance-based or design-specific technical specifications and related management systems practices." They pertain to "products and processes, such as size, strength, or technical performance of a product, process or material."

use available and potentially applicable voluntary consensus standards, we are required by the Act to provide Congress, through OMB, an explanation of the reasons for not using such standards.

We have incorporated the out-of-position tests one and two developed by the International Standards Organization (ISO) as part of the proposed low-risk deployment tests for the out-of-position 5th percentile adult female on the driver-side air bag and for the 6-year-old child on the passenger-side air bag. We have reviewed the proposed SAE seating procedure for the 5th percentile adult female in a dynamic crash test. We have decided against adopting this procedure because it has not yet been adopted by SAE and may not be adopted, in any form, for some time. No other voluntary consensus standards are addressed by this rulemaking.

## XX. Glossary

### Air Bags--In General

Air bags are inflatable restraints. Enough gas must be pumped into them to cushion occupants. Otherwise, occupants, especially large ones, could "bottom out" the air bag and hit the vehicle interior in a crash. Thus, the amount of pressure within air bags must be carefully controlled. This is done by controlling both the rate at which gas is pumped into the air bag and the rate at which the gas is released from the air bag through vents or microscopic holes in the fabric itself.

### Categories of Frontal Air Bags

Advanced air bags. Advanced air bags are air bags that minimize the risk of serious injury to out-of-position occupants and provide improved protection to occupants in high speed crashes. They accomplish this either by incorporating various technologies that enable the air bags to adapt their performance to a wider range of occupant sizes and crash conditions and/or by

being designed to both inflate in a manner that does not pose such risk as well as to provide improved protection. Some of these technologies are multi-stage inflators, occupant position sensors, occupant weight and pattern sensors, and new air bag fold patterns. (The inflators and sensors are explained below.)

Redesigned air bags.[45] Redesigned air bags are bag systems used in vehicles that have been certified to the unbelted sled test option instead of the unbelted crash test option in Standard No. 208. Many of the redesigned air bags in MY 1998 and 1999 vehicles have less power than the air bags in earlier model years of that vehicle model. However, the power levels of current air bags vary widely. For example, the redesigned air bags in some current vehicles are more powerful than the unredesigned air bags in some earlier vehicles.

**Inflators**

Inflators are the devices which pump the gas into air bags to inflate them in a crash.

Single stage inflators. Single stage inflators fill air bags with the same level of power in all crashes, regardless of whether the crash is a relatively low or high speed crash.

Multi-stage inflators. Multi-stage inflators (also known as multi-level inflators) operate at different levels of power, depending on which stage is activated. The activation of the different stages can be linked to crash severity sensors. In a vehicle with dual-stage inflators, only the first stage (lowest level of power) will be activated in relatively low speed crashes, while the first and second stages (highest level of power) will be activated in higher speed crashes. As crash severity increases, so must the pressure inside the air bag in order to cushion the occupants.

**Sensors**

---

[45] These air bags are also sometimes called depowered air bags, second generation air bags or next generation air bags.

Many advanced air bag systems utilize various sensors to obtain information about crashes, vehicles and their occupants. This information is used to adapt the performance of the air bag to the particular circumstances of the crash. It is used in determining whether an air bag should deploy and, if it should, and if the air bag has multiple inflation levels, at what level. Examples of these sensors include the following:

Crash severity sensors. Crash severity sensors measure the severity of a crash, i.e., the rate of reduction in velocity when a vehicle strikes another object. If a relatively low severity crash is sensed, only the lowest stage of a dual-stage inflator will fill the air bag; if a more severe crash is sensed, both stages will fill the air bag, inflating it at a higher level.

Belt use sensors. Belt use sensors determine whether an occupant is belted or not. An advanced air bag system in vehicles with crash severity sensors and dual-stage inflators might use belt use information to adjust deployment thresholds for unbelted and belted occupants. Since an unbelted occupant needs the protection of an air bag at lower speeds than a belted occupant does, the air bag would deploy at a lower threshold for an unbelted occupant. (Deployment thresholds are explained below.)

Seat position sensors. Seat position sensors determine how far forward or back a seat is adjusted on its seat track. An advanced air bag system could be designed so a dual-stage air bag deploys at a lower level when the seat is all the way forward than it does when the seat is farther back. This would benefit those short-statured drivers who move their seats all the way forward.

Occupant weight sensors. Occupant weight sensors measure the weight of an occupant. An advanced air bag system might use this information to prevent the air bag from deploying at all in the presence of children.

Pattern sensors. Pattern sensors evaluate the impression made by an occupant or object

on the seat cushion to make determinations about occupant presence and the overall size and position of the occupant. They could also sense the presence of a particular object like a child seat. An advanced air bag system might use this information to prevent the air bag from deploying in the presence of children. An advanced air bag system might utilize both an occupant weight sensor and an occupant pattern sensor.

**Deployment Thresholds**

The term deployment threshold is typically used to refer to the lowest range of rate of reduction in vehicle velocity in a crash at which a particular air bag is designed to deploy.

No-fire threshold. The no-fire threshold is the crash speed below which the air bag is designed to never deploy.

All-fire threshold. The all-fire threshold is the crash speed at or above which the air bag is designed to always deploy.

Gray zone. The gray zone is the range of speeds between the no-fire and all-fire thresholds in which the air bag may or may not deploy.

Vehicles with advanced air bags may have different deployment thresholds for belted and unbelted occupants, e.g., the deployment threshold may be higher if an occupant is belted. (See belt use sensors above.)

**Crash Tests vs. Sled Tests**

In crash tests, instrumented test dummies are placed in a vehicle which is then crashed into a barrier. Measurements from the test dummies are used to determine the forces, and estimate the risk of serious injury, that people would have experienced in the crash.

In sled tests, no crash takes place. The vehicle is placed on a sled-on-rails, and instrumented test dummies are placed in the vehicle. The sled and vehicle are accelerated very

rapidly backward by means of a generic acceleration pulse. As the vehicle moves backward, the dummies move forward inside the vehicle in much the same way that people would in a frontal crash. The air bags are manually deployed at a pre-selected time during the sled test. Measurements from the dummies are used to determine the forces, and estimate the risk of serious injury, that people would have experienced if the vehicle experienced that level of deceleration.

**Fixed Barrier Crash Tests**

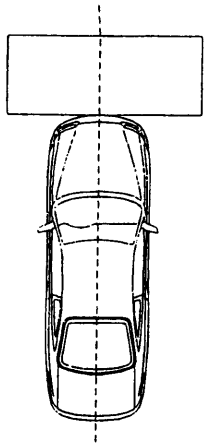
All of the crash tests adopted in this final rule are fixed barrier crash tests, i.e., the test vehicle is crashed into a barrier that is fixed in place (as opposed to moving). The types of fixed barrier crash tests are shown in Figure B1.

Rigid barrier test, perpendicular impact. In a rigid barrier, perpendicular impact test, the vehicle is crashed straight into a rigid barrier that does not absorb any crash energy. The full width of the vehicle's front end hits the barrier.

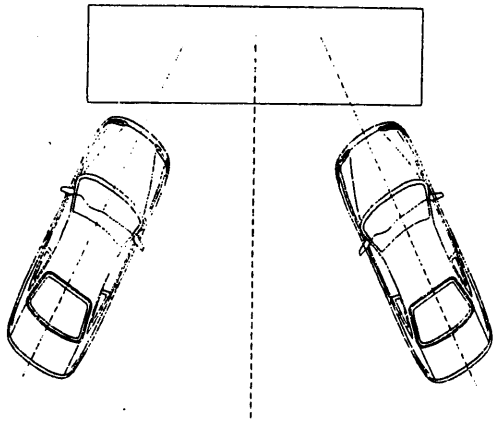
Rigid barrier, oblique impact test. In a rigid barrier, oblique impact test, the vehicle is crashed at an angle into a rigid barrier.

Offset deformable barrier test. In an offset deformable barrier test, one side of a vehicle's front end, not the full width, is crashed into a barrier with a deformable face that absorbs some of the crash energy.

**Figure 3.**
Types of Fixed Barrier Crash Tests



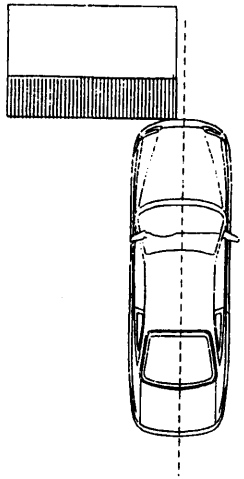
Rigid Barrier Perpendicular Impact



Rigid Barrier, Oblique Impact

Left Deg30 Impact

Right 30 Deg Impact



Deformable Barrier, 40% Overlap Driver Side Engaged

**Crash Pulses**

A crash pulse is the graph or picture of how quickly the vehicle occupant compartment is decelerating at different times during a crash.

Stiff crash pulses. In crashes with stiff pulses, the occupant compartment decelerates very abruptly. An example of a crash with a stiff pulse would be a full head-on crash of a vehicle into a like vehicle. The perpendicular rigid barrier crash test produces a stiff crash pulse.

Soft crash pulses. In crashes with soft pulses, the occupant compartment decelerates less abruptly, compared to crashes with hard pulses. An example of a crash with a soft pulse would be the crash of a vehicle into sand-filled barrels such as those seen at toll booths or at the leading edge of a concrete median barrier. The offset deformable barrier crash test and the 30 degree oblique rigid barrier crash test produce soft crash pulses.

In crashes involving comparable reductions in velocity, an unrestrained occupant would hit the vehicle interior (i.e., steering wheel, instrument panel and windshield) at a much higher speed in a crash with a stiff pulse than in a crash with a soft pulse.

**Belted and Unbelted Tests**

Belted tests use belted dummies, while unbelted tests use unbelted dummies. Despite increases in seat belt use, nearly 50 percent of all occupants in fatal crashes are unbelted. Unbelted tests are intended to evaluate the protection provided these persons, many of whom are teenagers and young adults.

**Static Low Risk Deployment Tests**

Static out-of-position tests are called "static" because the vehicle does not move during the test. These tests are used to measure the risk that an air bag poses to out-of-position occupants. Test dummies are placed in specified positions that are extremely close to the air bag,

typically with some portion of the dummy touching the steering wheel or instrument panel. The air bag is deployed. Measurements from the test dummy are used to determine the forces, and estimate the risk of serious injury, that people would have experienced in the crash.

**Injury Criteria and Performance Limits--In general**

In a crash test, sled test, or static out-of-position test, measurements are taken from the test dummy instruments that indicate the forces that a person would have experienced under the same conditions. Standard No. 208 specifies several injury criteria. For each criterion, the Standard also specifies a performance limit, based on the level of forces that create a significant risk of producing serious injury.

**Injury Criteria**

This final rule adopts performance limits for various injury criteria to address the risk of several types of injuries. Among these injury criteria are:

Head Injury Criterion or HIC. Head Injury Criterion or HIC addresses the risk of head injury;

Nij. Nij addresses the risk of neck injury; and

Chest Acceleration and Chest Deflection. Chest Acceleration and Chest Deflection address the risk of chest injury.

**Test Dummies**

This final rule specifies the use of several test dummies to represent children and adults of different sizes. These dummies are:

12-month old Crash Restraints Air Bag Interaction (CRABI) dummy, representing an infant;

Hybrid III 3-year-old and 6-year-old child dummies, representing young children;

Hybrid III 5th percentile adult female dummy, representing a small woman;

Hybrid III 50th percentile adult male dummy, representing an average-size man.

List of Subjects

49 CFR Part 552

Administrative practice and procedure, Motor vehicle safety, Reporting and recordkeeping requirements.

49 CFR Part 571

Imports, Incorporation by reference, Motor vehicle safety, Reporting and recordkeeping requirements, Tires.

49 CFR Part 585

Motor vehicle safety, Reporting and recordkeeping requirements.

49 CFR Part 595

Imports, Motor vehicle safety, Motor vehicles.

In consideration of the foregoing, NHTSA amends 49 CFR Chapter V as follows:

PART 552--PETITIONS FOR RULEMAKING, DEFECT, AND NON-COMPLIANCE ORDERS

1. The authority citation for Part 552 of Title 49 reads as follows:

Authority: 49 U.S.C. 30111, 30118, and 30162; delegation of authority at 49 CFR 1.50.

2. Sections 552.1 through 552.10 is designated as Subpart A and a new subpart heading is added to read as follows:

Subpart A - General

3. A new subpart B is added to Part 552 to read as follows:

Subpart B - Petitions for Expedited Rulemaking to Establish Dynamic Automatic Suppression System Test Procedures for Federal Motor Vehicle Safety Standard No. 208, Occupant Crash

Protection

Sec.

552.11 Application.

552.12 Definitions.

552.13 Form of petition.

552.14 Content of petition.

552.15 Processing of petition.

Subpart B - Petitions for Expedited Rulemaking to Establish Dynamic Automatic Suppression System Test Procedures for Federal Motor Vehicle Safety Standard No. 208, Occupant Crash Protection

**§552.11 Application.**

This subpart establishes procedures for the submission and disposition of petitions filed by interested parties to initiate rulemaking to add a test procedure to 49 CFR 571.208, S28.

**§552.12 Definitions.**

For purposes of this subpart, the following definitions apply:

(a) Dynamic automatic suppression system (DASS) means a portion of an air bag system that automatically controls whether or not the air bag deploys during a crash by:

(1) Sensing the location of an occupant, moving or still, in relation to the air bag;

(2) Interpreting the occupant characteristics and location information to determine whether or not the air bag should deploy; and

(3) Activating or suppressing the air bag system based on the interpretation of characteristics and occupant location information.

(b) Automatic suppression zone (ASZ) means a three-dimensional zone adjacent to the air bag cover, specified by the vehicle manufacturer, where air bag deployment will be suppressed by the DASS if a vehicle occupant enters the zone under specified conditions.

(c) Standard No. 208 means 49 CFR 571.208.

**§552.13 Form of petition.**

Each petition filed under this subpart shall--

(a) Be submitted to: Administrator, National Highway Traffic Safety Administration, 400 Seventh Street, S.W., Washington, DC 20590.

(b) Be written in the English language.

(c) State the name and address of the petitioner.

(d) Set forth in full the data, views and arguments of the petitioner supporting the requested test procedure, including all of the content information specified by §552.14. Any documents incorporated by reference in the procedure shall be submitted with the petition.

(e) Specify and segregate any part of the information and data submitted that the petitioner wishes to have withheld from public disclosure in accordance with Part 512 of this chapter including, if requested, the name and address of the petitioner.

(f) Not request confidential treatment for the requested test procedure and, to the extent confidential treatment is requested concerning a particular DASS or data and analysis submitted in support of the petition, provide a general non-confidential description of the operation of the DASS and of the data and analysis supporting the petition.

(g) Set forth a requested effective date and be submitted at least nine months before that date.

**§552.14 Content of petition.**

The petitioner shall provide the following information:

(a) A set of proposed test procedures for S28.1, S28.2, S28.3, and S28.4 of Standard No. 208 which the petitioner believes are appropriate for assessing a particular DASS.

(1) For S28.1 of Standard No. 208, the petitioner shall specify at least one specific position for the Part 572, subpart O 5th percentile female dummy that is:

(i) Outside but adjacent to the ASZ, and

(ii) Representative of an unbelted occupant position that is likely to occur during a frontal crash.

(2) For S28.2 of Standard No. 208, the petitioner shall specify at least one specific position for the Part 572 Subpart P 3-year-old child dummy and at least one specific position for the Part 572 Subpart N 6-year-old child dummy that are:

(i) Outside but adjacent to the ASZ, and

(ii) Representative of unbelted occupant positions that are likely to occur during a frontal crash where pre-crash braking occurs.

(3) For S28.3 of Standard No. 208, the petitioner shall specify a procedure which tests the operation of the DASS by moving a test device toward the driver air bag in a manner that simulates the motion of an unbelted occupant during pre-crash braking or other pre-crash maneuver. The petitioner shall include a complete description, including drawings and instrumentation, of the test device employed in the proposed test. The petitioner shall include in the procedure a means for determining whether the driver air bag was suppressed before any portion of the specified test device entered the ASZ during the test. The procedure shall also

include a means of determining when the specified test device occupies the ASZ.

(4) For S28.4 of Standard No. 208, the petitioner shall specify a procedure which tests the operation of the DASS by moving a test device toward the passenger air bag in a manner that simulates the motion of an unbelted occupant during pre-crash braking or other pre-crash maneuver. The petitioner shall include a complete description, including drawings and instrumentation, of the test device employed in the proposed test. The petitioner shall include in the procedure a means for determining whether the passenger air bag was suppressed before any portion of the specified test device entered the ASZ during the test. The procedure shall also include a means of determining when the specified test device occupies the ASZ.

(b) A complete description and explanation of the particular DASS that the petitioner believes will be appropriately assessed by the recommended test procedures. This shall include:

(1) A description of the logic used by the DASS in determining whether to suppress the air bag or allow it to deploy. Such description shall include flow charts or similar materials outlining the operation of the system logic, the system reaction time, the time duration used to evaluate whether the air bag should be suppressed or deployed, changes, if any, in system performance based on the size of an occupant and vehicle speed, and a description of the size and shape of the zone where under similar circumstances and conditions the DASS may either allow or suppress deployment. Such description shall also address whether and how the DASS discriminates between an occupant's torso or head entering the ASZ as compared to an occupant's hand or arm, and whether and how the DASS discriminates between an occupant entering the ASZ and an inanimate object such as a newspaper or ball entering the ASZ.

(2) Detailed specifications for the size and shape of the ASZ, including whether the

suppression zone is designed to change size or shape depending on the vehicle speed, occupant size, or other factors.

(c) Analysis and data supporting the appropriateness, repeatability, reproducibility and practicability of each of the proposed test procedures.

(1) For the procedures proposed for inclusion in S28.1 and S28.2 of Standard No. 208, the petitioner shall provide the basis for the proposed dummy positions, including but not limited to, why the positions are representative of what is likely to occur in real world crashes.

(2) For the procedures proposed for inclusion in S28.3 and S28.4 of Standard No. 208, the petitioner shall provide:

(i) A complete explanation of the means used in the proposed test to ascertain whether the air bag is suppressed or activated during the test.

(ii) A complete description of the means used to evaluate the ability of the DASS to detect and respond to an occupant moving toward an air bag, including the method used to move a test device toward an air bag at speeds representative of occupant movement during pre-crash braking or other pre-crash maneuver.

(iii) The procedure used for locating the test device inside a test vehicle in preparation for testing, including an accounting of the reference points used to specify such location.

(iv) An explanation of the methods used to measure the amount of time needed by a suppression system to suppress an air bag once a suppression triggering event occurs.

(v) High speed film or video of at least two tests of the DASS using the proposed test procedure.

(vi) Data generated from not less than two tests of the DASS using the proposed test

procedure, including an account of the data streams monitored during testing and complete samples of these data streams from not less than two tests performed under the proposed procedure.

(d) Analysis concerning the variety of potential DASS designs for which the requested test procedure is appropriate; e.g., whether the test procedures are appropriate only for the specific DASS design contemplated by the petitioner, for all DASS designs incorporating the same technologies, or for all DASS designs.

**§552.15 Processing of petition.**

(a) NHTSA will process any petition that contains the information specified by this subpart. If a petition fails to provide any of the information, NHTSA will not process the petition but will advise the petitioner of the information that shall be provided if the agency is to process the petition. The agency will seek to notify the petitioner of any such deficiency within 30 days after receipt of the petition.

(b) At any time during the agency's consideration of a petition submitted under this Part, the Administrator may request the petitioner to provide additional supporting information and data and/or provide a demonstration of any of the requested test procedures. The agency will seek to make any such request within 60 days after receipt of the petition. Such demonstration may be at either an agency designated facility or one chosen by the petitioner, provided that, in either case, the facility shall be located in North America. If such a request is not honored to the satisfaction of the agency, the petition will not receive further consideration until the requested information is submitted.

(c) The agency will publish in the Federal Register either a Notice of Proposed Rulemaking

proposing adoption of the requested test procedures, possibly with changes and/or additions, or a notice denying the petition. The agency will seek to issue either notice within 120 days after receipt of a complete petition. However, this time period may be extended by any time period during which the agency is awaiting additional information it requests from the petitioner or is awaiting a requested demonstration. The agency contemplates a 30 to 60 day comment period for any Notice of Proposed Rulemaking, and will endeavor to issue a final rule within 60 days thereafter.

PART 571-FEDERAL MOTOR VEHICLE SAFETY STANDARDS

4. The authority citation for Part 571 of Title 49 continues to read as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30117, and 30166; delegation of authority at 49 CFR 1.50.

5. Section 571.208 is amended by revising S3, S4.5.1 heading, S4.5.1(b)(1), S4.5.1(b)(2), 4.5.1(e), S4.5.1(f), S4.5.4, S5.1, S5.1.1, S5.1.2, S6.1, S6.2, 6.4, S8.1.5, S10.6.1.1, S13 and S13.1, removing S4.5.5, adding S4.1.5.4, S4.2.6.3, S4.7, S4.8, S4.9, S4.10, S4.11, S4.12, S4.13, S6.6, S14 through S29.3(b), new figures 8, 9 and 10 in numerical order, and Appendix A after the figures, to read as follows:

**§571.208 Standard No. 208; Occupant crash protection.**

* * * * *

S3. Application.

(a) This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses. In addition, S9, Pressure vessels and explosive devices, applies to vessels designed to

contain a pressurized fluid or gas, and to explosive devices, for use in the above types of motor vehicles as part of a system designed to provide protection to occupants in the event of a crash.

(b) Notwithstanding any language to the contrary, any vehicle manufactured after March 19, 1997, and before September 1, 2006, that is subject to a dynamic crash test requirement conducted with unbelted dummies may meet the requirements specified in S5.1.2(a)(1), S5.1.2(a)(2), or S13 instead of the applicable unbelted requirement, unless the vehicle is certified to meet the requirements specified in S14.5, S15, S17, S19, S21, S23, and S25.

(c) For vehicles which are certified to meet the requirements specified in S13 instead of the otherwise applicable dynamic crash test requirement conducted with unbelted dummies, compliance with S13 shall, for purposes of Standards No. 201, 203 and 209, be deemed as compliance with the unbelted frontal barrier requirements of S5.1.2.

* * * * *

S4.1.5.4 Passenger cars certified to S14. Each passenger car certified to S14 shall, at each front outboard designated seating position, meet the applicable frontal crash protection requirements of S5.1.2(b)(1) or S5.1.2(b)(2) by means of an inflatable restraint system that requires no action by vehicle occupants. Any vehicle manufactured before September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

* * * * *

S4.2.6.3 Trucks, buses, and multipurpose passenger vehicles certified to S14. Each truck, bus, or multipurpose passenger vehicle with a GVWR of 3,855 kg (8,500 lb) or less and an

unloaded vehicle weight of 2,495 kg (5,500 lb) or less certified to S14 shall, at each front outboard designated seating position, meet the applicable frontal crash protection requirements of S5.1.2(b)(1) or S5.1.2(b)(2) by means of an inflatable restraint system that requires no action by vehicle occupants. Any vehicle manufactured before September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

* * * * *

S4.5.1 Labeling and owner's manual information.

* * * * *

(b) * * *

(1) Except as provided in S4.5.1(b)(2), each vehicle shall have a label permanently affixed to either side of the sun visor, at the manufacturer's option, at each front outboard seating position that is equipped with an inflatable restraint. The label shall conform in content to the label shown in either Figure 6a or 6b of this standard, as appropriate, and shall comply with the requirements of S4.5.1(b)(1)(i) through S4.5.1(b)(1)(iv).

(i) The heading area shall be yellow with the word "WARNING" and the alert symbol in black.

(ii) The message area shall be white with black text. The message area shall be no less than 30 $cm^2$ (4.7 $in^2$).

(iii) The pictogram shall be black with a red circle and slash on a white background. The pictogram shall be no less than 30 mm (1.2 in) in diameter.

(iv) If the vehicle does not have a back seat, the label shown in Figure 6a or 6b may be modified by omitting the statement: "The BACK SEAT is the SAFEST place for children."

(2) Vehicles certified to meet the requirements specified in S19, S21, and S23, shall have a label permanently affixed to either side of the sun visor, at the manufacturer's option, at each front outboard seating position that is equipped with an inflatable restraint. The label shall conform in content to the label shown in Figure 8 of this standard and shall comply with the requirements of S4.5.1(b)(2)(i) through S4.5.1(b)(2)(iv).

(i) The heading area shall be yellow with the word "WARNING" and the alert symbol in black.

(ii) The message area shall be white with black text. The message area shall be no less than 30 $cm^2$ (4.7 $in^2$).

(iii) The pictogram shall be black on a white background. The pictogram shall be no less than 30 mm (1.2 in) in length.

(iv) If the vehicle does not have a back seat, the label shown in Figure 8 may be modified by omitting the statement: "The BACK SEAT is the SAFEST place for CHILDREN."

* * * * *

(e) <u>Label on the dashboard.</u>

(1) Except as provided in S4.5.1(e)(2), each vehicle that is equipped with an inflatable restraint for the passenger position shall have a label attached to a location on the dashboard or the steering wheel hub that is clearly visible from all front seating positions. The label need not be permanently affixed to the vehicle. This label shall conform in content to the label shown in Figure 7 of this standard, and shall comply with the requirements of S4.5.1(e)(1)(i) through

S4.5.1(e)(1)(iii).

(i) The heading area shall be yellow with the word "WARNING" and the alert symbol in black.

(ii) The message area shall be white with black text. The message area shall be no less than 30 $cm^2$ (4.7 $in^2$).

(iii) If the vehicle does not have a back seat, the label shown in Figure 7 may be modified by omitting the statement: "The back seat is the safest place for children 12 and under."

(2) Vehicles certified to meet the requirements specified in S19, S21, and S23, that are equipped with an inflatable restraint for the passenger position shall have a label attached to a location on the dashboard or the steering wheel hub that is clearly visible from all front seating positions. The label need not be permanently affixed to the vehicle. This label shall conform in content to the label shown in Figure 9 of this standard, and shall comply with the requirements of S4.5.1(e)(2)(i) through S4.5.1(e)(2)(iii).

(i) The heading area shall be yellow with black text.

(ii) The message area shall be white with black text. The message area shall be no less than 30 $cm^2$ (4.7 $in^2$).

(iii) If the vehicle does not have a back seat, the label shown in Figure 9 may be modified by omitting the statement: "The back seat is the safest place for children."

(f) Information to appear in owner's manual.

(1) The owner's manual for any vehicle equipped with an inflatable restraint system shall include an accurate description of the vehicle's air bag system in an easily understandable format. The owner's manual shall include a statement to the effect that the vehicle is equipped with an air

bag and lap/shoulder belt at both front outboard seating positions, and that the air bag is a supplemental restraint at those seating positions. The information shall emphasize that all occupants, including the driver, should always wear their seat belts whether or not an air bag is also provided at their seating position to minimize the risk of severe injury or death in the event of a crash. The owner's manual shall also provide any necessary precautions regarding the proper positioning of occupants, including children, at seating positions equipped with air bags to ensure maximum safety protection for those occupants. The owner's manual shall also explain that no objects should be placed over or near the air bag on the instrument panel, because any such objects could cause harm if the vehicle is in a crash severe enough to cause the air bag to inflate.

(2) For any vehicle certified to meet the requirements specified in S14.5, S15, S17, S19, S21, S23, and S25, the manufacturer shall also include in the vehicle's owner's manual a discussion of the advanced passenger air bag system installed in the vehicle. The discussion shall explain the proper functioning of the advanced air bag system and shall provide a summary of the actions that may affect the proper functioning of the system. The discussion shall include, at a minimum, accurate information on the following topics:

(a) a presentation and explanation of the main components of the advanced passenger air bag system.

(b) an explanation of how the components function together as part of the advanced passenger air bag system.

(c) the basic requirements for proper operation, including an explanation of the actions that may affect the proper functioning of the system.

(d) a complete description of the passenger air bag suppression system installed in the

vehicle, including a discussion of any suppression zone.

(e) an explanation of the interaction of the advanced passenger air bag system with other vehicle components, such as seat belts, seats or other components.

(f) a summary of the expected outcomes when child restraint systems, children and small teenagers or adults are both properly and improperly positioned in the passenger seat, including cautionary advice against improper placement of child restraint systems.

(g) a discussion of the telltale light, specifying its location in the vehicle and explaining when the light is illuminated.

(h) information on how to contact the vehicle manufacturer concerning modifications for persons with disabilities that may affect the advanced air bag system.

* * * * *

S4.5.4 Passenger air bag manual cut-off device. Passenger cars, trucks, buses, and multipurpose passenger vehicles manufactured before September 1, 2012 may be equipped with a device that deactivates the air bag installed at the right front outboard seating position in the vehicle, if all the conditions in S4.5.4.1 through S4.5.4.4 are satisfied.

* * * * *

S4.7 Incorporation by reference. Society of Automotive Engineers (SAE) Recommended Practice J211/1 rev. Mar 95, "Instrumentation for Impact Test - Part 1 - Electronic Instrumentation," (SAE J211/1 rev. Mar 95) is incorporated by reference in sections S4.13, S6.6, S13.1, S15.3.6, S19.4.4, S21.5.5, S23.5.5, and S25.4, Department of Defense MIL-S-13192P , 1988, "Military Specification, Shoes, Men's, Dress, Oxford" , Amendment 1, October 14, 1994 (MIL-S-13192P) is incorporated by reference in section S8.1.8, and Department of Defense MIL-

S-21711E, 1982, "Military Specification, Shoes, Women's", Amendment 2, October 14, 1994 (MIL-S-21711E) is incorporated by reference in section S16.2.5, and are thereby made part of this standard. The Director of the Federal Register approved the material incorporated by reference in accordance with 5 U.S.C. 552 (a) and 1 CFR Part 51. A copy of SAE J211/1 rev. Mar 95 may be obtained from SAE at the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096. A copy of SAE J211/1 rev. Mar 95 and copies of MIL-S-13192P and MIL-S-21711E may be inspected at NHTSA's technical reference library, 400 Seventh Street, S.W., Room 5109, Washington, DC, or at the Office of the Federal Register, 800 North Capitol Street, N.W., Suite 700, Washington, DC.

S4.8 Selection of compliance options. Where manufacturer options are specified, the manufacturer shall select the option by the time it certifies the vehicle and may not thereafter select a different option for the vehicle. Each manufacturer shall, upon request from the National Highway Traffic Safety Administration, provide information regarding which of the compliance options it has selected for a particular vehicle or make/model.

S4.9 Values and tolerances. Wherever a range of values or tolerances are specified, requirements shall be met at all values within the range of values or tolerances. With respect to the positioning of anthropomorphic dummies, torso and spine angle tolerances shall be ± 2 degrees unless otherwise stated, and leg, thigh, foot, and arm angle tolerances shall be ± 5 degrees unless otherwise stated.

S4.10 Metric values. Specifications and requirements are given in metric units with English units provided for reference. The metric values are controlling.

S4.11 Test duration for purpose of measuring injury criteria.

(a) For all barrier crashes, the injury criteria specified in this standard shall be met when calculated based on data recorded for 300 milliseconds after the vehicle strikes the barrier. For low risk deployment tests, the injury criteria shall be met when calculated based on data recorded for 300 milliseconds after the air bag is signaled to deploy.

(b) The requirements for dummy containment shall continue until the both the vehicle and the dummies have ceased moving.

S4.12 Suppression systems that do not detect dummies. For vehicles with occupant sensing systems that recognize humans and not dummies, such that the air bag or bags would not function in crash tests, the manufacturer shall provide NHTSA with information and equipment necessary to circumvent the suppression system for the crash test such that the restraint system operates as if 5th percentile adult female humans and 50th percentile adult male humans are seated in the vehicle.

S4.13 Data channels. All data channels used in injury criteria calculations shall be filtered using a phaseless digital filter, such as the Butterworth four-pole phaseless digital filter specified in Appendix C of SAE J211/1, rev. Mar 95, incorporated by reference in S4.7.

* * * * *

S5 Occupant crash protection requirements for the 50th percentile adult male dummy.

S5.1 Frontal barrier crash test.

S5.1.1 Belted test.

(a) Vehicles not certified to S14. Impact a vehicle traveling longitudinally forward at any speed, up to and including 48 km/h (30 mph), into a fixed rigid barrier that is perpendicular to the line of travel of the vehicle, and at any angle up to 30 degrees in either direction from the

perpendicular to the line of travel of the vehicle, under the applicable conditions of S8 and S10. The test dummy specified in S8.1.8 placed in each front outboard designated seating position shall meet the injury criteria of S6.1, S6.2(a), S6.3, S6.4(a), and S6.5 of this standard.

(b) Vehicles certified to S14. Impact a vehicle traveling longitudinally forward at any speed, up to and including 48 km/h (30 mph), into a fixed rigid barrier that is perpendicular to the line of travel of the vehicle under the applicable conditions of S8 and S10. The test dummy specified in S8.1.8 placed in each front outboard designated seating position shall meet the injury criteria of S6.1, S6.2(b), S6.3, S6.4(b), S6.5, and S6.6 of this standard.

S5.1.2 Unbelted test.

(a) Vehicles not certified to the requirements of S14 or S13. At the manufacturer's option, either one of the following unbelted tests shall be met:

(1) Impact a vehicle traveling longitudinally forward at any speed up to and including 48 km/h (30 mph), into a fixed rigid barrier that is perpendicular to the line of travel of the vehicle, and at any angle up to 30 degrees in either direction from the perpendicular to the line of travel of the vehicle, under the applicable conditions of S8 and S10, excluding S10.7, S10.8, and S10.9. The test dummy specified in S8.1.8 placed in each front outboard designated seating position shall meet the injury criteria of S6.1, S6.2(a), S6.3, S6.4(a), and S6.5 of this standard.

(2) Impact a vehicle traveling longitudinally forward at any speed between 32 km/h (20 mph) and 40 km/h (25 mph), inclusive, into a fixed rigid barrier that is perpendicular to the line of travel of the vehicle, and at any angle up to 30 degrees in either direction from the perpendicular to the line of travel of the vehicle, under the applicable conditions of S8 and S10, excluding S10.7, S10.8, and S10.9. The test dummy specified in S8.1.8 placed in each front outboard

designated seating position shall meet the injury criteria of S6.1, S6.2(b), S6.3, S6.4(b), S6.5, and S6.6 of this standard.

(b) Vehicles certified to the requirements of S14.

(1) Vehicles certified to S14.1 or S14.2. Impact a vehicle traveling longitudinally forward at any speed between 32 km/h (20 mph) and 40 km/h (25 mph), inclusive, into a fixed rigid barrier that is perpendicular to the line of travel of the vehicle, and at any angle up to 30 degrees in either direction from the perpendicular to the line of travel of the vehicle, under the applicable conditions of S8 and S10, excluding S10.7, S10.8, and S10.9. The test dummy specified in S8.1.8 placed in each front outboard designated seating position shall meet the injury criteria of S6.1, S6.2(b), S6.3, S6.4(b), S6.5, and S6.6 of this standard.

(2) Vehicles certified to S14.3 or S14.4. Impact a vehicle traveling longitudinally forward at any speed between 32 km/h (20 mph) and 48 km/h (30 mph), inclusive, into a fixed rigid barrier that is perpendicular to the line of travel of the vehicle, or at any angle up to 30 degrees in either direction from the perpendicular to the line of travel of the vehicle, under the applicable conditions of S8 and S10, excluding S10.7, S10.8, and S10.9. The test dummy specified in S8.1.8 placed in each front outboard designated seating position shall meet the injury criteria of S6.1, S6.2(b), S6.3, S6.4(b), S6.5, and S6.6 of this standard.

* * * * *

S6.1 All portions of the test dummy shall be contained within the outer surfaces of the vehicle passenger compartment.

S6.2 Head injury criteria.

(a) (1) For any two points in time, $t_1$ and $t_2$, during the event which are separated by not

more than a 36 millisecond time interval and where $t_1$ is less than $t_2$, the head injury criterion ($HIC_{36}$) shall be determined using the resultant head acceleration at the center of gravity of the dummy head, $a_r$, expressed as a multiple of g (the acceleration of gravity) and shall be calculated using the expression:

$$\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a_r \, dt\right]^{2.5} (t_2 - t_1)$$

(2) The maximum calculated $HIC_{36}$ value shall not exceed 1,000.

(b)(1) For any two points in time, $t_1$ and $t_2$, during the event which are separated by not more than a 15 millisecond time interval and where $t_1$ is less than $t_2$, the head injury criterion ($HIC_{15}$) shall be determined using the resultant head acceleration at the center of gravity of the dummy head, $a_r$, expressed as a multiple of g (the acceleration of gravity) and shall be calculated using the expression:

$$\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a_r \, dt\right]^{2.5} (t_2 - t_1)$$

(2) The maximum calculated $HIC_{15}$ value shall not exceed 700.

* * * * *

S6.4 Chest deflection.

(a) Compressive deflection of the sternum relative to the spine shall not exceed 76 mm (3.0 in).

(b) Compressive deflection of the sternum relative to the spine shall not exceed 63 mm (2.5 in).

* * * * *

S6.6 Neck injury. When measuring neck injury, each of the following injury criteria shall be met.

(a) Nij.

(1) The shear force (Fx), axial force (Fz), and bending moment (My) shall be measured by the dummy upper neck load cell for the duration of the crash event as specified in S4.10. Shear force, axial force, and bending moment shall be filtered for Nij purposes at SAE J211/1 rev. Mar 95 Channel Frequency Class 600 (see S4.7).

(2) During the event, the axial force (Fz) can be either in tension or compression while the occipital condyle bending moment (Mocy) can be in either flexion or extension. This results in four possible loading conditions for Nij: tension-extension (Nte), tension-flexion (Ntf), compression-extension (Nce), or compression-flexion (Ncf).

(3) When calculating Nij using equation (4), the critical values, Fzc and Myc, are:

(i) Fzc = 6806 N (1530 lbf) when Fz is in tension

(ii) Fzc = 6160 N (1385 lbf) when Fz is in compression

(iii) Myc = 310 Nm (229 lbf-ft) when a flexion moment exists at the occipital condyle

(iv) Myc = 135 Nm (100 lbf-ft) when an extension moment exists at the occipital condyle.

(4) At each point in time, only one of the four loading conditions occurs and the Nij value corresponding to that loading condition is computed and the three remaining loading modes shall be considered a value of zero. The expression for calculating each Nij loading condition is given by:

$$Nij = (Fz / Fzc) + (Mocy / Myc)$$

(5) None of the four Nij values shall exceed 1.0 at any time during the event.

(b) Peak tension. Tension force (Fz), measured at the upper neck load cell, shall not exceed 4170 N (937 lbf) at any time.

(c) Peak compression. Compression force (Fz), measured at the upper neck load cell, shall not exceed 4000 N (899 lbf) at any time.

S6.7 Unless otherwise indicated, instrumentation for data acquisition, data channel frequency class, and moment calculations are the same as given for the part 572, subpart E Hybrid III test dummy.

* * * * *

S8.1.5 Movable vehicle windows and vents are placed in the fully closed position, unless the vehicle manufacturer chooses to specify a different adjustment position prior to the time it certifies the vehicle.

* * * * *

S10.6.1.1 If the vehicle has an adjustable accelerator pedal, adjust it to the full forward position. Rest the right foot of the test dummy on the undepressed accelerator pedal with the rearmost point of the heel on the floor pan in the plane of the pedal. If the foot cannot be placed on the accelerator pedal, set it initially perpendicular to the lower leg and then place it as far forward as possible in the direction of the pedal centerline with the rearmost point of the heel resting on the floor pan. If the vehicle has an adjustable accelerator pedal and the right foot is not touching the accelerator pedal when positioned as above, move the pedal rearward until it touches the right foot. If the accelerator pedal still does not touch the foot in the full rearward position, leave the pedal in that position.

S13 Alternative unbelted test available, under S3(b) of this standard, for certain vehicles

manufactured before September 1, 2006.

S13.1 Instrumentation for Impact Test - Part 1 - Electronic Instrumentation. Under the applicable conditions of S8, mount the vehicle on a dynamic test platform at the vehicle attitude set forth in S13.3, so that the longitudinal center line of the vehicle is parallel to the direction of the test platform travel and so that movement between the base of the vehicle and the test platform is prevented. The test platform is instrumented with an accelerometer and data processing system having a frequency response of 60 channel class as specified in SAE J211/1 rev. Mar 95, (see S4.7). The accelerometer sensitive axis is parallel to the direction of test platform travel. The test is conducted at a velocity change approximating 48 km/h (30 mph) with acceleration of the test platform such that all points on the crash pulse curve within the corridor identified in Figure 6 are covered. An inflatable restraint is to be activated at 20 ms +/- 2 ms from the time that 0.5 g is measured on the dynamic test platform. The test dummy specified in S8.1.8, placed in each front outboard designated seating position as specified in S10, excluding S10.7, S10.8, and S10.9, shall meet the injury criteria of S6.1, S6.2(a), S6.3, S6.4(a), S6.5, and S13.2 of this standard.

* * * * *

S14 Advanced air bag requirements for passenger cars and for trucks, buses, and multipurpose passenger vehicles with a GVWR of 3,855 kg (8500 pounds) or less and an unloaded vehicle weight of 2,495 kg (5500 pounds) or less, except for walk-in van-type trucks or vehicles designed to be sold exclusively to the U.S. Postal Service.

S14.1 Vehicles manufactured on or after September 1, 2003, and before September 1, 2006.

(a) For vehicles manufactured for sale in the United States on or after September 1, 2003,

and before September 1, 2006, a percentage of the manufacturer's production, as specified in S14.1.1, shall meet the requirements specified in S14.5.1, S14.5.2(a), S15.1, S15.2(a), S17, S19, S21, S23, and S25 (in addition to the other requirements specified in this standard).

(b) Manufacturers that sell two or fewer carlines, as that term is defined at 49 CFR 583.4, in the United States may, at the option of the manufacturer, meet the requirements of this paragraph instead of paragraph (a) of this section. Each vehicle manufactured on or after September 1, 2004, and before September 1, 2006, shall meet the requirements specified in S14.5.1, S14.5.2(a), S15.1, S15.2(a), S17, S19, S21, S23, and S25 (in addition to the other requirements specified in this standard).

(c) Vehicles that are manufactured in two or more stages or that are altered (within the meaning of 49 CFR 567.7) after having previously been certified in accordance with Part 567 of this chapter are not subject to the requirements of S14.1.

(d) Vehicles that are manufactured by a manufacturer that produces fewer than 5,000 vehicles worldwide annually are not subject to the requirements of S14.1.

S14.1.1 Phase-in schedule.

S14.1.1.1 Vehicles manufactured on or after September 1, 2003, and before September 1, 2004. Subject to S14.1.2(a), for vehicles manufactured by a manufacturer on or after September 1, 2003, and before September 1, 2004, the amount of vehicles complying with S14.5.1, S14.5.2(a), S15.1, S15.2(a), S17, S19, S21, S23, and S25, shall be not less than 35 percent of:

(a) If the manufacturer has manufactured vehicles for sale in the United States during both of the two production years prior to September 1, 2003, the manufacturer's average annual production of vehicles manufactured on or after September 1, 2001, and before September 1,

2004, or

(b) The manufacturer's production on or after September 1, 2003, and before September 1, 2004.

S14.1.1.2 Vehicles manufactured on or after September 1, 2004, and before September 1, 2005. Subject to S14.1.2(b), for vehicles manufactured by a manufacturer on or after September 1, 2004, and before September 1, 2005, the amount of vehicles complying with S14.5.1, S14.5.2(a), S15.1, S15.2(a), S17, S19, S21, S23, and S25 shall be not less than 65 percent of:

(a) If the manufacturer has manufactured vehicles for sale in the United States during both of the two production years prior to September 1, 2004, the manufacturer's average annual production of vehicles manufactured on or after September 1, 2002, and before September 1, 2005, or

(b) The manufacturer's production on or after September 1, 2004, and before September 1, 2005.

S14.1.1.3 Vehicles manufactured on or after September 1, 2005, and before September 1, 2006. Subject to S14.1.2(c), for vehicles manufactured by a manufacturer on or after September 1, 2005, and before September 1, 2006, the amount of vehicles complying with S14.5.1, S14.5.2(a), S15.1, S15.2(a), S17, S19, S21, S23, and S25 shall be 100 percent of the manufacturer's production during that period.

S14.1.2 Calculation of complying vehicles.

(a) For the purposes of complying with S14.1.1.1, a manufacturer may count a vehicle if it is manufactured on or after [the date 30 days after publication of the final rule would be inserted], but before September 1, 2004.

(b) For purposes of complying with S14.1.1.2, a manufacturer may count a vehicle if it:

(1) Is manufactured on or after [the date 30 days after publication of the final rule would be inserted], but before September 1, 2005, and

(2) Is not counted toward compliance with S14.1.1.1.

(c) For purposes of complying with S14.1.1.3, a manufacturer may count a vehicle if it:

(1) Is manufactured on or after [the date 30 days after publication of the final rule would be inserted], but before September 1, 2006, and

(2) Is not counted toward compliance with S14.1.1.1 or S14.1.1.2.

S14.1.3 Vehicles produced by more than one manufacturer.

S14.1.3.1 For the purpose of calculating average annual production of vehicles for each manufacturer and the number of vehicles manufactured by each manufacturer under S14.1.1, a vehicle produced by more than one manufacturer shall be attributed to a single manufacturer as follows, subject to S14.1.3.2.

(a) A vehicle that is imported shall be attributed to the importer.

(b) A vehicle manufactured in the United States by more than one manufacturer, one of which also markets the vehicle, shall be attributed to the manufacturer that markets the vehicle.

S14.1.3.2 A vehicle produced by more than one manufacturer shall be attributed to any one of the vehicle's manufacturers specified by an express written contract, reported to the National Highway Traffic Safety Administration under 49 CFR Part 585, between the manufacturer so specified and the manufacturer to which the vehicle would otherwise be attributed under S14.1.3.1.

S14.2 Vehicles manufactured on or after September 1, 2006. Each vehicle shall meet the

requirements specified in S14.5.1, S14.5.2(a), S15.1, S15.2(a), S17, S19, S21, S23, and S25 (in addition to the other requirements specified in this standard).

S14.3 Vehicles manufactured on or after September 1, 2007, and before September 1, 2010.

(a) For vehicles manufactured for sale in the United States on or after September 1, 2007, and before September 1, 2010, a percentage of the manufacturer's production, as specified in S14.3.1, shall meet the requirements specified in S14.5.1, S14.5.2(b), S15.1, S15.2(b), S17, S19, S21, S23, and S25 (in addition to the other requirements specified in this standard).

(b) Manufacturers that sell two or fewer carlines, as that term is defined at 49 CFR 583.4, in the United States may, at the option of the manufacturer, meet the requirements of this paragraph instead of paragraph (a) of this section. Each vehicle manufactured on or after September 1, 2007, and before September 1, 2010, shall meet the requirements specified in S14.5.1, S14.5.2(b), S15.1, S15.2(b), S17, S19, S21, S23, and S25 (in addition to the other requirements specified in this standard).

(c) Vehicles that are manufactured in two or more stages or that are altered (within the meaning of 49 CFR 567.7) after having previously been certified in accordance with Part 567 of this chapter are not subject to the requirements of S14.3.

(d) Vehicles that are manufactured by a manufacturer that produces fewer than 5,000 vehicles worldwide annually are not subject to the requirements of S14.3.

S14.3.1 Phase-in schedule.

S14.3.1.1 Vehicles manufactured on or after September 1, 2007, and before September 1, 2008. Subject to S14.3.2(a), for vehicles manufactured by a manufacturer on or after September

1, 2007, and before September 1, 2008, the amount of vehicles complying with S14.5.1, S14.5.2(b), S15.1, S15.2(b), S17, S19, S21, S23, and S25, shall be not less than 35 percent of:

(a) If the manufacturer has manufactured vehicles for sale in the United States during both of the two production years prior to September 1, 2007, the manufacturer's average annual production of vehicles manufactured on or after September 1, 2005, and before September 1, 2008, or

(b) The manufacturer's production on or after September 1, 2007, and before September 1, 2008.

S14.3.1.2 Vehicles manufactured on or after September 1, 2008, and before September 1, 2009. Subject to S14.3.2(b), for vehicles manufactured by a manufacturer on or after September 1, 2008, and before September 1, 2009, the amount of vehicles complying with S14.5.1, S14.5.2(b), S15.1, S15.2(b), S17, S19, S21, S23, and S25 shall be not less than 65 percent of:

(a) If the manufacturer has manufactured vehicles for sale in the United States during both of the two production years prior to September 1, 2008, the manufacturer's average annual production of vehicles manufactured on or after September 1, 2006 and before September 1, 2009, or

(b) The manufacturer's production on or after September 1, 2008, and before September 1, 2009.

S14.3.1.3 Vehicles manufactured on or after September 1, 2009, and before September 1, 2010. Subject to S14.3.2(c), for vehicles manufactured by a manufacturer on or after September 1, 2009, and before September 1, 2010, the amount of vehicles complying with S14.5.1, S14.5.2(b), S15.1, S15.2(b), S17, S19, S21, S23, and S25 shall be 100 percent of the

manufacturer's production during that period.

S14.3.2 Calculation of complying vehicles.

(a) For the purposes of complying with S14.3.1.1, a manufacturer may count a vehicle if it is manufactured on or after September 1, 2006, but before September 1, 2008.

(b) For purposes of complying with S14.3.1.2, a manufacturer may count a vehicle if it:

(1) Is manufactured on or after September 1, 2006, but before September 1, 2009, and

(2) Is not counted toward compliance with S14.3.1.1.

(c) For purposes of complying with S14.3.1.3, a manufacturer may count a vehicle if it:

(1) Is manufactured on or after September 1, 2006, but before September 1, 2010, and

(2) Is not counted toward compliance with S14.3.1.1 or S14.3.1.2.

S14.3.3 Vehicles produced by more than one manufacturer.

S14.3.3.1 For the purpose of calculating average annual production of vehicles for each manufacturer and the number of vehicles manufactured by each manufacturer under S14.3.1, a vehicle produced by more than one manufacturer shall be attributed to a single manufacturer as follows, subject to S14.3.3.2.

(a) A vehicle that is imported shall be attributed to the importer.

(b) A vehicle manufactured in the United States by more than one manufacturer, one of which also markets the vehicle, shall be attributed to the manufacturer that markets the vehicle.

S14.3.3.2 A vehicle produced by more than one manufacturer shall be attributed to any one of the vehicle's manufacturers specified by an express written contract, reported to the National Highway Traffic Safety Administration under 49 CFR Part 585, between the manufacturer so specified and the manufacturer to which the vehicle would otherwise be attributed under

S14.3.3.1.

S14.4 Vehicles manufactured on or after September 1, 2010. Each vehicle shall meet the requirements specified in S14.5.1, S14.5.2(b), S15.1, S15.2(b), S17, S19, S21, S23, and S25 (in addition to the other requirements specified in this standard).

S14.5 Barrier test requirements using 50th percentile adult male dummies.

S14.5.1 Rigid barrier belted test. Each vehicle that is certified as complying with S14 shall, at each front outboard designated seating position, meet the injury criteria specified in S6.1, S6.2(b), S6.3, S6.4(b), S6.5, and S6.6 when tested under S5.1.1(b). Any vehicle manufactured before September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

S14.5.2 Rigid barrier unbelted test.

(a) Each vehicle that is certified as complying with S14.1 or S14.2 shall, at each front outboard designated seating position, meet the injury criteria specified in S6.1, S6.2(b), S6.3, S6.4(b), S6.5, and S6.6 when tested under S5.1.2(b)(1). Any vehicle manufactured before September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

(b) Each vehicle that is certified as complying with S14.3 or S14.4 shall, at each front outboard designated seating position, meet the injury criteria specified in S6.1, S6.2(b), S6.3, S6.4(b), S6.5, and S6.6 when tested under S5.1.2(b)(2). Any vehicle manufactured before September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its

manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

S15 Rigid barrier test requirements using 5th percentile adult female dummies.

S15.1 Belted test. Each vehicle that is certified as complying with S14 shall, at each front outboard designated seating position, meet the injury criteria specified in S15.3 of this standard when the vehicle is crash tested in accordance with the procedures specified in S16.1(a) of this standard with the anthropomorphic test devices restrained by a Type 2 seat belt assembly. Any vehicle manufactured before September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

S15.2 Unbelted test.

(a) Each vehicle that is certified as complying with S14.1 or S14.2 shall, at each front outboard designated seating position, meet the injury criteria specified in S15.3 of this standard when the vehicle is crash tested in accordance with the procedures specified in S16.1(b)(1) of this standard with the anthropomorphic test devices unbelted. Any vehicle manufactured before September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

(b) Each vehicle that is certified as complying with S14.3 or S14.4 shall, at each front outboard designated seating position, meet the injury criteria specified in S15.3 of this standard when the vehicle is crash tested in accordance with the procedures specified in S16.1(b)(2) of this standard with the anthropomorphic test devices unbelted. Any vehicle manufactured before

September 1, 2010, shall not be deemed to be in noncompliance with this paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

S15.3 Injury criteria for the Part 572, Subpart O Hybrid III 5th percentile female test dummy.

S15.3.1 All portions of the test dummy shall be contained within the outer surfaces of the vehicle passenger compartment.

S15.3.2 Head injury criteria.

(a) For any two points in time, $t_1$ and $t_2$, during the event which are separated by not more than a 15 millisecond time interval and where $t_1$ is less than $t_2$, the head injury criterion ($HIC_{15}$) shall be determined using the resultant head acceleration at the center of gravity of the dummy head, $a_r$, expressed as a multiple of g (the acceleration of gravity) and shall be calculated using the expression:

$$\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a_r \, dt\right]^{2.5} (t_2 - t_1)$$

(b) The maximum calculated $HIC_{15}$ value shall not exceed 700.

S15.3.3 The resultant acceleration calculated from the output of the thoracic instrumentation shall not exceed 60 g's, except for intervals whose cumulative duration is not more than 3 milliseconds.

S15.3.4 Compression deflection of the sternum relative to the spine, as determined by instrumentation shown shall not exceed 52 mm (2.0 in).

S15.3.5 The force transmitted axially through each femur shall not exceed 6805 N (1530

lb).

S15.3.6 Neck injury. When measuring neck injury, each of the following injury criteria shall be met.

(a) Nij.

(1) The shear force (Fx), axial force (Fz), and bending moment (My) shall be measured by the dummy upper neck load cell for the duration of the crash event as specified in S4.10. Shear force, axial force, and bending moment shall be filtered for Nij purposes at SAE J211/1 rev. Mar95 Channel Frequency Class 600 (see S4.7).

(2) During the event, the axial force (Fz) can be either in tension or compression while the occipital condyle bending moment (Mocy) can be in either flexion or extension. This results in four possible loading conditions for Nij: tension-extension (Nte), tension-flexion (Ntf), compression-extension (Nce), or compression-flexion (Ncf).

(3) When calculating Nij using equation (4), the critical values, Fzc and Myc, are:

(i) Fzc = 4287 N (964 lbf) when Fz is in tension

(ii) Fzc = 3880 N (872 lbf) when Fz is in compression

(iii) Myc = 155 Nm (114 lbf-ft) when a flexion moment exists at the occipital condyle

(iv) Myc = 67 Nm (49 lbf-ft) when an extension moment exists at the occipital condyle.

(4) At each point in time, only one of the four loading conditions occurs and the Nij value corresponding to that loading condition is computed and the three remaining loading modes shall be considered a value of zero. The expression for calculating each Nij loading condition is given by:

$$Nij = (Fz / Fzc) + (Mocy / Myc)$$

(5) None of the four Nij values shall exceed 1.0 at any time during the event.

(b) Peak tension. Tension force (Fz), measured at the upper neck load cell, shall not exceed 2620 N (589 lbf) at any time.

(c) Peak compression. Compression force (Fz), measured at the upper neck load cell, shall not exceed 2520 N (566 lbf) at any time.

S15.3.7 Unless otherwise indicated, instrumentation for data acquisition, data channel frequency class, and moment calculations are the same as given for the Part 572, Subpart O Hybrid III 5th percentile female test dummy.

S16. Test procedures for rigid barrier test requirements using 5th percentile adult female dummies.

S16.1 General provisions. Crash testing to determine compliance with the requirements of S15 of this standard is conducted as specified in the following paragraphs (a) and (b).

(a) Belted test. Place a Part 572 Subpart O 5th percentile adult female test dummy at each front outboard seating position of a vehicle, in accordance with the procedures specified in S16.3 of this standard. Impact the vehicle traveling longitudinally forward at any speed, up to and including 48 km/h (30 mph), into a fixed rigid barrier that is perpendicular within a tolerance of ± 5 degrees to the line of travel of the vehicle under the applicable conditions of S16.2 of this standard.

(b) Unbelted test.

(1) Place a Part 572 Subpart O 5th percentile adult female test dummy at each front outboard seating position of a vehicle, in accordance with the procedures specified in S16.3 of this standard, except S16.3.5. Impact the vehicle traveling longitudinally forward at any speed, from

32 km/h (20 mph) to 40 km/h (25 mph), inclusive, into a fixed rigid barrier that is perpendicular within a tolerance of ± 5 degrees to the line of travel of the vehicle under the applicable conditions of S16.2 of this standard.

(2) Place a Part 572 Subpart O 5th percentile adult female test dummy at each front outboard seating position of a vehicle, in accordance with the procedures specified in S16.3 of this standard, except S16.3.5. Impact the vehicle traveling longitudinally forward at any speed, from 32 km/h (20 mph) to 48 km/h (30 mph), inclusive, into a fixed rigid barrier that is perpendicular within a tolerance of ± 5 degrees to the line of travel of the vehicle under the applicable conditions of S16.2 of this standard.

S16.2 Test conditions.

S16.2.1 The vehicle, including test devices and instrumentation, is loaded as in S8.1.1.

S16.2.2 Movable vehicle windows and vents are placed in the fully closed position, unless the vehicle manufacturer chooses to specify a different adjustment position prior to the time the vehicle is certified.

S16.2.3 Convertibles and open-body type vehicles have the top, if any, in place in the closed passenger compartment configuration.

S16.2.4 Doors are fully closed and latched but not locked.

S16.2.5 The dummy is clothed in form fitting cotton stretch garments with short sleeves and above the knee length pants. A size 7 1/2W shoe which meets the configuration and size specifications of MIL-S-21711E (see S4.7) or its equivalent is placed on each foot of the test dummy.

S16.2.6 Limb joints are set at one g, barely restraining the weight of the limb when

extended horizontally. Leg joints are adjusted with the torso in the supine position.

S16.2.7 Instrumentation shall not affect the motion of dummies during impact.

S16.2.8 The stabilized temperature of the dummy is at any level between 20.6° C and 22.2° C ( 69° F to 72° F).

S16.2.9 Steering wheel adjustment.

S16.2.9.1 Adjust a tiltable steering wheel, if possible, so that the steering wheel hub is at the geometric center when moved through its full range of driving positions.

S16.2.9.2 If there is no setting detent at the mid position, lower the steering wheel to the detent just below the mid position.

S16.2.9.3 If the steering column is telescoping, place the steering column in the mid position. If there is no mid position, move the steering wheel rearward one position from the mid position.

S16.2.10 Driver and passenger seat set-up.

S16.2.10.1 Seat position adjustment.

S16.2.10.1.1 If a seat is adjustable in the fore and aft and/or vertical directions, move the seat to the fowardmost seating position and mid-height position.

S16.2.10.1.2 Establish a reference line on the outboard side of the seat cushion in a horizontal plane.

S16.2.10.1.3 Measure and record the seat cushion angle with respect to the reference line established in S16.2.10.1.2.

S16.2.10.1.4 Adjust the seat vertically as close to the mid-height position as possible. If possible, maintain the seat cushion reference angle measured in the middle and full forward

condition in S16.2.10.1.3.

S16.2.10.2 Lumbar support adjustment. Position adjustable lumbar supports so that the lumbar support is in its lowest, retracted or deflated adjustment position.

S16.2.10.3 Cushion and side bolster adjustment. Position adjustable seat cushion and seat back side bolsters so that they are in the lowest or most open adjustment position.

S16.3 Dummy seating positioning procedures. The Part 572 Subpart O 5th percentile adult female test dummy is positioned as follows.

S16.3.1 General provisions and definitions.

S16.3.1.1 All angles are measured with respect to the horizontal plane.

S16.3.1.2 The dummy's neck bracket is adjusted to align the zero degree index marks.

S16.3.1.3 The term "midsagittal plane" refers to the vertical plane that separates the dummy into equal left and right halves.

S16.3.1.4 The term "vertical longitudinal plane" refers to a vertical plane parallel to the vehicle's longitudinal centerline.

S16.3.1.5 The term "vertical plane" refers to a vertical plane, not necessarily parallel to the vehicle's longitudinal centerline.

S16.3.1.6 The term "transverse instrumentation platform" refers to the transverse instrumentation surface inside the dummy's skull casting to which the neck load cell mounts. This surface is perpendicular to the skull cap machined inferior-superior mounting surface.

S16.3.1.7. The term "thigh" refers to the femur between, but not including, the knee and the pelvis.

S16.3.1.8 The term "leg" refers to the lower part of the entire leg including the knee.

S16.3.1.9 The term "foot" refers to the foot including the ankle.

S16.3.2 Driver dummy positioning.

S16.3.2.1 Driver torso/head/seat back angle positioning.

S16.3.2.1.1 Fully recline the seat back, if adjustable.

S16.3.2.1.2 Install the dummy into the driver's seat. If necessary, move the seat rearward to facilitate dummy installation. If the seat cushion angle automatically changes as the seat is moved from the full forward position, restore the correct seat cushion angle when measuring the pelvic angle as specified in S16.3.2.1.11.

S16.3.2.1.3 Bucket seats. Center the dummy on the seat cushion so that its midsagittal plane is vertical and coincides with the vertical longitudinal plane through the center of the seat cushion.

S16.3.2.1.4 Bench seats. Position the midsagittal plane of the dummy vertical and parallel to the vehicle's longitudinal centerline and aligned with the center of the steering wheel rim.

S16.3.2.1.5 Hold the dummy's thighs down and push rearward on the upper torso to maximize the dummy's pelvic angle.

S16.3.2.1.6 Place the legs at 90 degrees to the thighs. Push rearward on the dummy's knees to force the pelvis into the seat so there is no gap between the pelvis and the seat back or until contact occurs between the back of the dummy's calves and the front of the seat cushion such that the angle between the dummy's thighs and legs begins to change.

S16.3.2.1.7 Gently rock the upper torso relative to the lower torso laterally in a side to side motion three times through a ± 5 degree arc (approximately 51 mm (2 in) side to side) to reduce friction between the dummy and the seat.

S16.3.2.1.8 Before proceeding, attempt to return the seat to the full forward position if it has been moved from that location as specified in S16.3.2.1.2. If, at any step during the seating procedure, a dummy leg contacts the vehicle interior, position the seat at the next detent where there is no contact. If the seat is a power seat, position the seat to avoid contact while assuring that there is a maximum of 5 mm (0.2 in) distance between the vehicle interior and the point on the dummy that would first contact the vehicle interior.

S16.3.2.1.9 While holding the thighs in place, rotate the seat back forward until the transverse instrumentation platform of the head is level to within ± 0.5 degrees, making sure that the pelvis does not interfere with the seat bight. In addition, inspect the abdomen to insure that it is properly installed.

S16.3.2.1.10 If it is not possible to achieve the head level within ± 0.5 degrees, minimize the angle.

S16.3.2.1.11 Measure and set the dummy's pelvic angle using the pelvic angle gage (drawing TE-2504, incorporated by reference in Part 572, subpart O, of this chapter). The angle shall be set to 20.0 degrees ± 2.5 degrees. If this is not possible, adjust the pelvic angle as close to 20.0 degrees as possible while keeping the transverse instrumentation platform of the head as level as possible as specified in S16.3.2.1.9 and S16.3.2.1.10.

S16.3.2.1.12. If the transverse instrumentation platform of the head is still not level, adjust the seat back angle to minimize the angle as much as possible.

S16.3.2.1.13 In vehicles with a fixed seat back, adjust the lower neck bracket to level the head as much as possible.

S16.3.2.2 <u>Driver thigh/knee/leg positioning</u>.

S16.3.2.2.1 Rest the dummy's thighs against the seat cushion to the extent permitted by the placement of the feet in S16.3.2.3.

S16.3.2.2.2 Set the initial transverse distance between the longitudinal centerline of the dummy's knees at 160 to 170 mm (6.3 to 6.7 in), with the thighs and legs of the dummy in vertical planes.

S16.3.2.2.3. If either knee of the dummy contacts the vehicle interior, move the seat rearward to the next detent that provides clearance. If the seat is a power seat, move the seat rearward, while assuring that there is a maximum of 5 mm (0.2 in) distance between the vehicle interior and the dummy knee closest to the vehicle interior.

S16.3.2.3 Driver foot positioning.

S16.3.2.3.1 If the vehicle has an adjustable accelerator pedal, adjust it to the full forward position. Rest the right foot of the test dummy on the undepressed accelerator pedal with the rearmost point of the heel on the floor pan in the plane of the pedal. If the foot cannot be placed on the accelerator pedal, set it initially perpendicular to the lower leg and then place it as far forward as possible in the direction of the pedal centerline with the rearmost point of the heel resting on the floor pan. If the vehicle has an adjustable accelerator pedal and the right foot is not touching the accelerator pedal when positioned as above, move the pedal rearward until it touches the right foot. If the accelerator pedal still does not touch the foot in the full rearward position, leave the pedal in that position.

S16.3.2.3.2 If the ball of the foot does not contact the pedal, change the angle of the foot relative to the leg such that the toe of the foot contacts the undepressed accelerator pedal.

S16.3.2.3.3 Place the left foot on the toe board with the rearmost point of the heel resting on the floor pan as close as possible to the point of intersection of the toe board and the floor pan.

S16.3.2.3.4 If the left foot cannot be positioned on the toe board, place the foot flat on the floor pan as far forward as possible.

S16.3.2.3.5 If the left foot does not contact the floor pan, place the foot parallel to the floor and place the leg as perpendicular to the thigh as possible.

S16.3.2.4 Driver arm/hand positioning.

S16.3.2.4.1 Place the dummy's upper arms adjacent to the torso with the arm centerlines as close to vertical as possible.

S16.3.2.4.2 Place the palms of the dummy in contact with the outer part of the steering wheel rim at its horizontal centerline with the thumbs inside the steering wheel rim.

S16.3.2.4.3 If it is not possible to position the thumbs inside the steering wheel rim at its horizontal centerline, then position them above and as close to the horizontal centerline of the steering wheel rim as possible.

S16.3.2.4.4 Lightly tape the hands to the steering wheel rim so that if the hand of the test dummy is pushed upward by a force of not less than 9 N (2 lb) and not more than 22 N (5 lb), the tape releases the hand from the steering wheel rim.

S16.3.3 Passenger dummy positioning.

S16.3.3.1 Passenger torso/head/seat back angle positioning.

S16.3.3.1.1 Fully recline the seat back, if adjustable.

S16.3.3.1.2 Install the dummy into the passenger's seat. If necessary, move the seat rearward to facilitate dummy installation. If the seat cushion angle automatically changes as the

seat is moved from the full forward position, restore the correct seat cushion angle when measuring the pelvic angle in S16.3.3.1.11.

S16.3.3.1.3 Bucket seats. Center the dummy on the seat cushion so that its midsagittal plane is vertical and coincides with the vertical longitudinal plane through the center of the seat cushion.

S16.3.3.1.4 Bench seats. The midsagittal plane of the dummy shall be vertical and parallel to the vehicle's longitudinal centerline and the same distance from the vehicle's longitudinal centerline as the midsagittal plane of the driver dummy.

S16.3.3.1.5 Hold the dummy's thighs down and push rearward on the upper torso to maximize the dummy's pelvic angle.

S16.3.3.1.6 Place the legs at 90 degrees to the thighs. Push rearward on the dummy's knees to force the pelvis into the seat so there is no gap between the pelvis and the seat back or until contact occurs between the back of the dummy's calves and the front of the seat cushion such that the angle between the dummy's thighs and legs begins to change.

S16.3.3.1.7 Gently rock the upper torso relative to the lower torso laterally side to side three times through a ± 5 degree arc (approximately 51 mm (2 in) side to side).

S16.3.3.1.8 Before proceeding, attempt to return the seat to the full forward position if it has been moved from that location as specified in S16.3.3.1.2. If, at any step during the seating procedure, a dummy leg contacts the vehicle interior, position the seat at the detent where there is no contact. If the seats are power seats, position the seat to avoid contact while assuring that there is a maximum of 5 mm (0.2 in) distance between the vehicle interior and the point on the dummy that would first contact the vehicle interior.

S16.3.3.1.9 While holding the thighs in place, rotate the seat back forward until the transverse instrumentation platform of the head is level to within ± 0.5 degrees, making sure that the pelvis does not interfere with the seat bight. In addition, inspect the abdomen to insure that it is properly installed.

S16.3.3.1.10 If it is not possible to achieve the head level within ± 0.5 degrees, minimize the angle.

S16.3.3.1.11 Measure and set the dummy's pelvic angle using the pelvic angle gage (drawing TE-2504, incorporated by reference in Part 572, Subpart O, of this chapter). The angle shall be set to 20.0 degrees ± 2.5 degrees. If this is not possible, adjust the pelvic angle as close to 20.0 degrees as possible while keeping the transverse instrumentation platform of the head as level as possible as specified in S16.3.3.1.9 and S16.3.3.1.10.

S16.3.3.1.12 If the transverse instrumentation platform of the head is still not level, adjust the seat back angle to minimize the angle as much as possible.

S16.3.3.1.13 In vehicles with a fixed seat back, adjust the lower neck bracket to level the head as much as possible.

S16.3.3.2 Passenger thigh/knee/leg positioning.

S16.3.3.2.1 Rest the dummy's thighs against the seat cushion to the extent permitted by the placement of the feet in S16.3.3.3.

S16.3.3.2.2 Set the initial transverse distance between the longitudinal centerline of the dummy's knees at 160 to 170 mm (6.3 to 6.7 in), with the thighs and legs of the dummy in vertical longitudinal planes.

S16.3.3.2.3 If either knee of the dummy is in contact with the vehicle interior, move the seat rearward to the next detent that provides clearance. If the seats are power seats, move the seat rearward for a maximum distance of 5 mm (0.2 in) between the vehicle interior and the dummy knee closest to the vehicle interior.

S16.3.3.3 Passenger foot positioning.

S16.3.3.3.1 Place the passenger's feet flat on the floor pan as far forward as possible.

S16.3.3.3.2 If either foot does not entirely contact the floor pan, place the foot parallel to the floor and place the legs as perpendicular to the thighs as possible.

S16.3.3.4 Passenger arm/hand positioning.

S16.3.3.4.1 Place the dummy's upper arms in contact with the upper seat back and adjacent to the torso.

S16.3.3.4.2 Place the palms of the dummy in contact with the outside of the thighs.

S16.3.3.4.3 Place the little fingers in contact with the seat cushion.

S16.3.4 Driver and passenger head restraint adjustment.

S16.3.4.1. Place each adjustable head restraint so that the vertical center of the head restraint is horizontally aligned with the center of gravity (CG) of the dummy head.

S16.3.4.2 If the above position is not attainable, move the vertical center of the head restraint to the closest detent below the center of the head CG.

S16.3.4.3 If the head restraint has a fore and aft adjustment, place the restraint in the forwardmost position or until contact with the head is made, whichever occurs first.

S16.3.4.4 If the head restraint has an automatic adjustment, leave it where the system positions the restraint after the dummy is placed in the seat.

S16.3.5 Driver and passenger manual belt adjustment (for tests conducted with a belted dummy)

S16.3.5.1 If an adjustable seat belt D-ring anchorage exists, place it in the manufacturer's design position for a 5th percentile adult female with the seat in the position specified in S16.2.11.1.

S16.3.5.2 Place the Type 2 manual belt around the test dummy and fasten the latch.

S16.3.5.3 Ensure that the dummy's head remains as level as possible, as specified in S16.3.2.1.9, S16.3.2.1.10, S16.3.3.1.9, and S16.3.3.1.10.

S16.3.5.4 Remove all slack from the lap belt. Pull the upper torso webbing out of the retractor and allow it to retract; repeat this operation four times. Apply a 9 N (2 lbf) to 18 N (4 lbf) tension load to the lap belt. If the belt system is equipped with a tension-relieving device, introduce the maximum amount of slack into the upper torso belt that is recommended by the manufacturer. If the belt system is not equipped with a tension-relieving device, allow the excess webbing in the shoulder belt to be retracted by the retractive force of the retractor.

S17 Offset frontal deformable barrier requirements using 5th percentile adult female test dummies.

Each vehicle that is certified as complying with S14 shall, at each front outboard designated seating position, meet the injury criteria specified in S15.3 of this standard when the vehicle is crash tested in accordance with the procedures specified in S18 of this standard with the anthropomorphic test devices restrained by a Type 2 seat belt assembly. Any vehicle manufactured before September 1, 2010 shall not be deemed to be in noncompliance with this

paragraph if its manufacturer establishes that it did not have reason to know in the exercise of due care that such vehicle is not in conformity with the requirements of this paragraph.

S18 Test procedure for offset frontal deformable barrier requirements using 5th percentile adult female dummies.

S18.1 General provisions. Place a Part 572 Subpart O 5th percentile adult female test dummy at each front outboard seating position of a vehicle, in accordance with the procedures specified in S16.3 of this standard. Impact the vehicle traveling longitudinally forward at any speed, up to and including 40 km/h (25 mph), into a fixed offset deformable barrier under the conditions and procedures specified in S18.2 of this standard, impacting only the driver side of the vehicle.

S18.2 Test conditions.

S18.2.1 Offset frontal deformable barrier. The offset frontal deformable barrier shall conform to the specifications set forth in Subpart C of Part 587 of this chapter.

S18.2.2 General test conditions. All of the test conditions specified in S16.2 of this standard apply.

S18.2.3 Dummy seating procedures. Position the anthropomorphic test dummies as specified in S16.3 of this standard.

S18.2.4 Impact configuration. The test vehicle shall impact the barrier with the longitudinal centerline of the vehicle parallel to the line of travel and perpendicular to the barrier face within a tolerance of ± 5 degrees. The test vehicle shall be aligned so that the vehicle strikes the barrier with 40 percent overlap on the left side of the vehicle, with the vehicle's front engaging the barrier face such that the vehicle's longitudinal centerline is offset outboard of the

edge of the barrier face by 10 percent of the vehicle's width ± 50 mm (2.0 in) as illustrated in Figure 10. The vehicle width is defined as the maximum dimension measured across the widest part of the vehicle, including bumpers and molding but excluding such components as exterior mirrors, flexible mud flaps, marker lamps, and dual rear wheel configurations.

S19 Requirements to provide protection for infants in rear facing and convertible child restraints and car beds.

S19.1 Each vehicle certified as complying with S14 shall, at the option of the manufacturer, meet the requirements specified in S19.2 or S19.3, under the test procedures specified in S20.

S19.2 Option 1--Automatic suppression feature. Each vehicle shall meet the requirements specified in S19.2.1 through S19.2.3.

S19.2.1 The vehicle shall be equipped with an automatic suppression feature for the passenger air bag which results in deactivation of the air bag during each of the static tests specified in S20.2 (using the Part 572 Subpart R 12-month-old CRABI child dummy in any of the child restraints identified in sections B and C of Appendix A of this standard and the Part 572 Subpart K Newborn Infant dummy in any of the car beds identified in section A of Appendix A, as appropriate), and activation of the air bag system during each of the static tests specified in S20.3 (using the Part 572 Subpart O 5th percentile adult female dummy).

S19.2.2 The vehicle shall be equipped with at least one telltale which emits light whenever the passenger air bag system is deactivated and does not emit light whenever the passenger air bag system is activated, except that the telltale(s) need not illuminate when the passenger seat is unoccupied. Each telltale:

(a) Shall emit yellow light;

(b) Shall have the identifying words "PASSENGER AIR BAG OFF" on the telltale or within 25 mm (1.0 in) of the telltale; and

(c) Shall not be combined with the readiness indicator required by S4.5.2 of this standard.

(d) Shall be located within the interior of the vehicle and forward of and above the design H-point of both the driver's and the right front passenger's seat in their forwardmost seating positions and shall not be located on or adjacent to a surface that can be used for temporary or permanent storage where use of the storage space could obscure the telltale from either the driver's or right front passenger's view.

(e) Shall be visible to the driver and right front passenger under all driving conditions. The means for providing the required visibility may be adjustable to provide two or more levels of brightness, one of which is substantially discernable to a person, of any age, who has adapted to ambient daytime driving conditions, the other of which is substantially discernable to a driver, of any age, who has adapted to ambient nighttime driving conditions. The means for providing the required visibility may be adjustable manually or automatically, except that the telltale(s) may not be adjusted under any conditions to a level that is not visible, e.g., to the nighttime intensity during daytime driving conditions.

S19.2.3 The vehicle shall be equipped with a mechanism that indicates whether the air bag system is suppressed, regardless of whether the passenger seat is occupied. The mechanism need not be located in the occupant compartment unless it is the telltale described in S19.2.2.

S19.3 Option 2--Low risk deployment. Each vehicle shall meet the injury criteria specified in S19.4 of this standard when the passenger air bag is deployed in accordance with the procedures specified in S20.4.

S19.4 Injury criteria for the Part 572, Subpart R 12-month-old CRABI test dummy.

S19.4.1 All portions of the test dummy and child restraint shall be contained within the outer surfaces of the vehicle passenger compartment.

S19.4.2 Head injury criteria.

(a) For any two points in time, $t_1$ and $t_2$, during the event which are separated by not more than a 15 millisecond time interval and where $t_1$ is less than $t_2$, the head injury criterion ($HIC_{15}$) shall be determined using the resultant head acceleration at the center of gravity of the dummy head, $a_r$, expressed as a multiple of g (the acceleration of gravity) and shall be calculated using the expression:

$$\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a_r \, dt\right]^{2.5} (t_2 - t_1)$$

(b) The maximum calculated $HIC_{15}$ value shall not exceed 390.

S19.4.3 The resultant acceleration calculated from the output of the thoracic instrumentation shall not exceed 50 g's, except for intervals whose cumulative duration is not more than 3 milliseconds.

S19.4.4 Neck injury. When measuring neck injury, each of the following injury criteria shall be met.

(a) Nij.

(1) The shear force (Fx), axial force (Fz), and bending moment (My) shall be measured by the dummy upper neck load cell for the duration of the crash event as specified in S4.10. Shear force, axial force, and bending moment shall be filtered for Nij purposes at SAE J211/1 rev. Mar95 Channel Frequency Class 600 (see S4.7).

(2) During the event, the axial force (Fz) can be either in tension or extension while the occipital condyle bending moment (Mocy) can be in either flexion or extension. This results in four possible loading conditions for Nij: tension-extension (Nte), tension-flexion (Ntf), compression-extension (Nce), or compression-flexion (Ncf).

(3) When calculating Nij using equation (4), the critical values, Fzc and Myc, are:

(i) Fzc = 1460 N (328 lbf) when Fz is in tension

(ii) Fzc = 1460 N (328 lbf) when Fz is in compression

(iii) Myc = 43 Nm (32 lbf-ft) when a flexion moment exists at the occipital condyle

(iv) Myc = 17 Nm (13 lbf-ft) when an extension moment exists at the occipital condyle.

(4) At each point in time, only one of the four loading conditions occurs and the Nij value corresponding to that loading condition is computed and the three remaining loading modes shall be considered a value of zero. The expression for calculating each Nij loading condition is given by:

$$Nij = (Fz / Fzc) + (Mocy / Myc)$$

(5) None of the four Nij values shall exceed 1.0 at any time during the event.

(b) <u>Peak tension.</u> Tension force (Fz), measured at the upper neck load cell, shall not exceed 780 N (175 lbf) at any time.

(c) Peak compression. Compression force (Fz), measured at the upper neck load cell, shall not exceed 960 N (216 lbf) at any time.

S19.4.5 Unless otherwise indicated, instrumentation for data acquisition, data channel frequency class, and moment calculations are the same as given for the Part 572 Subpart R 12-month-old CRABI test dummy.

S20 Test procedure for S19.

S20.1 General provisions.

S20.1.1 Tests specifying the use of a car bed, a rear facing child restraint, or a convertible child restraint may be conducted using any such restraint listed in sections A, B, and C of Appendix A of this standard respectively. The car bed, rear facing child restraint, or convertible child restraint may be unused or have been previously used for static suppression tests only; if it has been used, there shall not be any visible damage prior to the test.

S20.1.2 Each vehicle certified to this option shall comply in tests conducted with the right front outboard seating position at the full rearward seat track position, the middle seat track position, and the full forward seat track position. If the child restraint or dummy contacts the vehicle interior, move the seat rearward to the next detent that provides clearance. If the seat is a power seat, move the seat rearward while assuring that there is a maximum of 5 mm (0.2 in) clearance. All tests are conducted with the seat height, if adjustable, in the mid-height position and with the seat back angle, if adjustable, at the manufacturer's nominal design seat back angle for a 50th percentile adult male as specified in S8.1.3.

S20.1.3 If the car bed, rear facing child restraint, or convertible child restraint is equipped with a handle, the vehicle shall comply in tests conducted with the handle at both the child restraint manufacturer's recommended position for use in vehicles and in the upright position.

S20.1.4 If the car bed, rear facing child restraint, or convertible child restraint is equipped with a sunshield, the vehicle shall comply in tests conducted with the sunshield both fully open and fully closed.

S20.1.5 The vehicle shall comply in tests with the car bed, rear facing child restraint, or convertible child restraint uncovered and in tests with a towel or blanket weighing up to 1.0 kg (2.2 lb) placed on or over the restraint in any of the following positions:

(a) with the blanket covering the top and sides of the restraint, and

(b) with the blanket placed from the top of the vehicle's seat back to the forwardmost edge of the restraint.

S20.1.6 Except as otherwise specified, if the car bed, rear facing child restraint, or convertible child restraint has an anchorage system as specified in S5.9 of FMVSS No. 213 and is tested in a vehicle with a right front outboard vehicle seat that has an anchorage system as specified in FMVSS No. 225, the vehicle shall comply in tests conducted both with the restraint anchorage system attached and unattached to the vehicle seat anchorage system.

S20.1.7 Do not attach any tethers.

S20.2 <u>Static tests of automatic suppression feature which shall result in deactivation of the passenger air bag</u>. Each vehicle that is certified as complying with S19.2 shall meet the following test requirements.

S20.2.1 <u>Belted rear facing and convertible child restraints</u>.

S20.2.1.1 The vehicle shall comply in tests using any child restraint specified in section B and section C of Appendix A of this standard.

S20.2.1.2 Locate a vertical plane through the longitudinal centerline of the child restraint. This will be referred to as "Plane A".

S20.2.1.3 For bucket seats, "Plane B" refers to a vertical plane parallel to the vehicle longitudinal centerline through the geometric center of the right front outboard vehicle seat. For bench seats, "Plane B" refers to a vertical plane through the right front outboard vehicle seat parallel to the vehicle longitudinal centerline the same distance from the longitudinal centerline of the vehicle as the center of the steering wheel.

S20.2.1.4 Facing rear.

(a) The vehicle shall comply in both of the following positions, if applicable:

(1) Without attaching the child restraint anchorage system as specified in S5.9 of FMVSS No. 213 to a vehicle seat anchorage system specified in FMVSS No. 225, align the child restraint system facing rearward such that Plane A is aligned with Plane B.

(2) If the child restraint is certified to S5.9 of FMVSS No. 213, and the vehicle seat has an anchorage system as specified in FMVSS No. 225, attach the child restraint to the vehicle seat anchorage instead of aligning the planes. Do not attach the vehicle safety belt.

(b) While maintaining the child restraint positions achieved in S20.2.1.4(a), secure the child restraint by following, to the extent possible, the child restraint manufacturer's directions regarding proper installation of the restraint in the rear facing mode.

(c) Place any adjustable seat belt anchorages at the vehicle manufacturer's nominal design position for a 50th percentile adult male occupant. Cinch the vehicle belts to any tension from

zero up to 134 N (30 lb) to secure the child restraint. Measure belt tension in a flat, straight section of the lap belt between the child restraint belt path and the contact point with the belt anchor or vehicle seat, on the side away from the buckle (to avoid interference from the shoulder portion of the belt).

(d) Position the Part 572 Subpart R 12-month-old CRABI dummy in the child restraint by following, to the extent possible, the manufacturer's instructions for seating infants provided with the child restraint.

(e) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and close all vehicle doors. Wait 10 seconds, then check whether the air bag is deactivated.

S20.2.1.5 Facing forward (convertible restraints only).

(a) The vehicle shall comply in both of the following positions, if applicable:

(1) Without attaching the child restraint anchorage system as specified in S5.9 of FMVSS No. 213 to a vehicle seat anchorage system specified in FMVSS No. 225, align the child restraint system facing forward such that Plane A is aligned with Plane B.

(2) If the child restraint is certified to S5.9 of FMVSS No. 213, and the vehicle seat has an anchorage system as specified in FMVSS No. 225, attach the child restraint to the vehicle seat anchorage instead of aligning the planes. Do not attach the vehicle safety belt.

(b) While maintaining the child restraint positions achieved in S20.2.1.5(a), secure the child restraint by following, to the extent possible, the child restraint manufacturer's directions regarding proper installation of the restraint in the forward facing mode.

(c) Place any adjustable seat belt anchorages at the vehicle manufacturer's nominal design position for a 50th percentile adult male occupant. Cinch the vehicle belts to any tension from zero up to 134 N (30 lb) to secure the child restraint. Measure belt tension in a flat, straight section of the lap belt between the child restraint belt path and the contact point with the belt anchor or vehicle seat, on the side away from the buckle (to avoid interference from the shoulder portion of the belt).

(d) Position the Part 572 Subpart R 12-month-old CRABI dummy in the child restraint by following, to the extent possible, the manufacturer's instructions provided with the child restraint.

(e) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and close all vehicle doors. Wait 10 seconds, then check whether the air bag is deactivated.

S20.2.2 Unbelted rear facing and convertible child restraints.

S20.2.2.1 The vehicle shall comply in tests using any child restraint specified in section B and section C of Appendix A of this standard.

S20.2.2.2 Locate a vertical plane through the longitudinal centerline of the child restraint. This will be referred to as "Plane A".

S20.2.2.3 For bucket seats, "Plane B" refers to a vertical plane parallel to the vehicle longitudinal centerline through the geometric center of the right front outboard vehicle seat. For bench seats, "Plane B" refers to a vertical plane through the right front outboard seat parallel to the vehicle longitudinal centerline the same distance from the longitudinal centerline of the vehicle as the center of the steering wheel.

S20.2.2.4 Facing rear.

(a) Align the child restraint system facing rearward such that Plane A is aligned with Plane B and the child restraint is in contact with the seat back.

(b) Position the Part 572 Subpart R 12-month-old CRABI dummy in the child restraint by following, to the extent possible, the manufacturer's instructions provided with the child restraint.

(c) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and close all vehicle doors. Wait 10 seconds, then check whether the air bag is deactivated.

S20.2.2.5 Facing forward.

(a) Align the child restraint system facing forward such that Plane A is aligned with Plane B and the child restraint is in contact with the seat back.

(b) Position the Part 572 Subpart R 12-month-old CRABI dummy in the child restraint by following, to the extent possible, the manufacturer's instructions provided with the child restraint.

(c) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and close all vehicle doors. Wait 10 seconds, then check whether the air bag is deactivated.

S20.2.3 Tests with a belted car bed.

S20.2.3.1 The vehicle shall comply in tests using any car bed specified in section A of Appendix A of this standard.

S20.2.3.2 (a) Install the car bed by following, to the extent possible, the car bed manufacturer's directions regarding proper installation of the car bed.

(b) Place any adjustable seat belt anchorages at the vehicle manufacturer's nominal design position for a 50th percentile adult male occupant. Cinch the vehicle belts to any tension from

zero up to 134 N (30 lb) to secure the car bed. Measure belt tension in a flat, straight section of the lap belt between the car bed belt path and the contact point with the belt anchor or vehicle seat, on the side away from the buckle (to avoid interference from the shoulder portion of the belt).

(c) Position the Part 572 Subpart K Newborn Infant dummy in the car bed by following, to the extent possible, the car bed manufacturer's instructions for positioning infants provided with the car bed.

(d) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and close all vehicle doors. Wait 10 seconds, then check whether the air bag is deactivated.

S20.3 Static tests of automatic suppression feature which shall result in activation of the passenger air bag system.

S20.3.1 Each vehicle certified to this option shall comply in tests conducted with the right front outboard seating position at the full rearward seat track position, the middle seat track position, and, subject to S16.3.3.1.8, the full forward seat track position. All tests are conducted with the seat height, if adjustable, in the mid-height position.

S20.3.2 Place a Part 572 Subpart O 5th percentile adult female test dummy at the right front outboard seating position of the vehicle, in accordance with procedures specified in S16.3.3 of this standard, except as specified in S20.3.1, subject to the fore-aft seat positions in S20.3.1. Do not fasten the seat belt.

S20.3.3 Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

S20.3.4 Wait 10 seconds, then check whether the air bag system is activated.

S20.4 Low risk deployment test. Each vehicle that is certified as complying with S19.3 shall meet the following test requirements.

S20.4.1 Position the right front outboard vehicle seat in the full forward seat track position, adjust the seat height (if adjustable) to the mid-height position, and adjust the seat back (if adjustable) to the nominal design position for a 50th percentile adult male as specified in S8.1.3. If the child restraint or dummy contacts the vehicle interior, move the seat rearward to the next detent that provides clearance. If the seat is a power seat, move the seat rearward while assuring that there is a maximum of 5 mm (0.2 in) clearance.

S20.4.2 The vehicle shall comply in tests using any child restraint specified in section B and section C of Appendix A to this standard.

S20.4.3 Locate a vertical plane through the longitudinal centerline of the child restraint. This will be referred to as "Plane A".

S20.4.4 For bucket seats, "Plane B" refers to a vertical plane parallel to the vehicle longitudinal centerline through the geometric center of the right front outboard seat. For bench seats, "Plane B" refers to a vertical plane through the right front outboard seat parallel to the vehicle longitudinal centerline that is the same distance from the longitudinal centerline of the vehicle as the center of the steering wheel.

S20.4.5 Align the child restraint system facing rearward such that Plane A is aligned with Plane B.

S20.4.6 If the child restraint is certified to S5.9 of FMVSS No. 213, and the vehicle seat has an anchorage system as specified in FMVSS No. 225, attach the child restraint to the vehicle seat anchorage instead of aligning the planes. Do not attach the vehicle safety belt.

S20.4.7 While maintaining the child restraint position achieved in S20.4.5, secure the child restraint by following, to the extent possible, the child restraint manufacturer's directions regarding proper installation of the restraint in the rear facing mode. Place any adjustable seat belt anchorages at the manufacturer's nominal design position for a 50th percentile adult male occupant. Cinch the vehicle belts to any tension from zero up to 134 N (30 lb) to secure the child restraint. Measure belt tension in a flat, straight section of the lap belt between the child restraint belt path and the contact point with the belt anchor or vehicle seat, on the side away from the buckle (to avoid interference from the shoulder portion of the belt).

S20.4.8 Position the Part 572 Subpart R 12-month-old CRABI dummy in the child restraint by following, to the extent possible, the manufacturer's instructions for seating infants provided with the child restraint.

S20.4.8 Deploy the right front outboard frontal air bag system. If the air bag system contains a multistage inflator, the vehicle shall be able to comply at any stage or combination of stages or time delay between successive stages that could occur in the presence of an infant in a rear facing child restraint positioned according to S20.2.1 in a rigid barrier crash test at speeds up to 64 km/h (40 mph).

S21 <u>Requirements using 3- year-old child dummies</u>.

S21.1 Each vehicle that is certified as complying with S14 shall, at the option of the manufacturer, meet the requirements specified in S21.2, S21.3, or S21.4, under the test procedures specified in S22 or S28, as applicable.

S21.2 Option 1--Automatic suppression feature. Each vehicle shall meet the requirements specified in S21.2.1 through S21.2.3.

S21.2.1 The vehicle shall be equipped with an automatic suppression feature for the passenger air bag which results in deactivation of the air bag during each of the static tests specified in S22.2 (using a Part 572 Subpart P 3-year-old child dummy and, as applicable, any child restraint specified in section C and section D of Appendix A to this standard), and activation of the air bag system during each of the static tests specified in S22.3 (using a Part 572 Subpart O 5th percentile adult female dummy).

S21.2.2 The vehicle shall be equipped with a telltale light meeting the requirements specified in S19.2.2.

S21.2.3 The vehicle shall be equipped with a mechanism that indicates whether the air bag is suppressed, regardless of whether the passenger seat is occupied. The mechanism need not be located in the occupant compartment unless it is the telltale described in S21.2.2.

S21.3 Option 2–Dynamic automatic suppression system that suppresses the air bag when an occupant is out of position. (This option is available under the conditions set forth in S27.1.) The vehicle shall be equipped with a dynamic automatic suppression system for the passenger air bag system which meets the requirements specified in S27.

S21.4 Option 3--Low risk deployment. Each vehicle shall meet the injury criteria specified in S21.5 of this standard when the passenger air bag is deployed in accordance with both of the low risk deployment test procedures specified in S22.4.

S21.5 Injury criteria for the Part 572, Subpart P 3-year-old child test dummy.

S21.5.1 All portions of the test dummy shall be contained within the outer surfaces of the vehicle passenger compartment.

S21.5.2 Head injury criteria.

(a) For any two points in time, $t_1$ and $t_2$, during the event which are separated by not more than a 15 millisecond time interval and where $t_1$ is less than $t_2$, the head injury criterion ($HIC_{15}$) shall be determined using the resultant head acceleration at the center of gravity of the dummy head, $a_r$, expressed as a multiple of g (the acceleration of gravity) and shall be calculated using the expression:

$$\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a_r \, dt\right]^{2.5} (t_2 - t_1)$$

(b) The maximum calculated $HIC_{15}$ value shall not exceed 570.

S21.5.3 The resultant acceleration calculated from the output of the thoracic instrumentation shall not exceed 55 g's, except for intervals whose cumulative duration is not more than 3 milliseconds.

S21.5.4 Compression deflection of the sternum relative to the spine, as determined by instrumentation shall not exceed 34 millimeters (1.3 in).

S21.5.5 Neck injury. When measuring neck injury, each of the following injury criteria shall be met.

(a) Nij.

(1) The shear force (Fx), axial force (Fz), and bending moment (My) shall be measured by the dummy upper neck load cell for the duration of the crash event as specified in S4.10. Shear force, axial force, and bending moment shall be filtered for Nij purposes at SAE J211/1 rev. Mar95 Channel Frequency Class 600 (see S4.7).

(2) During the event, the axial force (Fz) can be either in tension or compression while the occipital condyle bending moment (Mocy) can be in either flexion or extension. This results in four possible loading conditions for Nij: tension-extension (Nte), tension-flexion (Ntf),compression-extension (Nce), or compression-flexion (Ncf).

(3) When calculating Nij using equation (4), the critical values, Fzc and Myc, are:

(i) Fzc = 2120 N (477 lbf) when Fz is in tension

(ii) Fzc = 2120 N (477 lbf) when Fz is in compression

(iii) Myc = 68 Nm (50 lbf-ft) when a flexion moment exists at the occipital condyle

(iv) Myc = 27 Nm (20 lbf-ft) when an extension moment exists at the occipital condyle.

(4) At each point in time, only one of the four loading conditions occurs and the Nij value corresponding to that loading condition is computed and the three remaining loading modes shall be considered a value of zero. The expression for calculating each Nij loading condition is given by:

$$Nij = (Fz / Fzc) + (Mocy / Myc)$$

(5) None of the four Nij values shall exceed 1.0 at any time during the event.

(b) Peak tension. Tension force (Fz), measured at the upper neck load cell, shall not exceed 1130 N (254 lbf) at any time.

(c) Peak compression. Compression force (Fz), measured at the upper neck load cell, shall not exceed 1380 N (310 lbf) at any time.

S21.5.6 Unless otherwise indicated, instrumentation for data acquisition, data channel frequency class, and moment calculations are the same as given in Part 572 Subpart P 3-year-old child test dummy.

S22 Test procedure for S21.

S22.1 General provisions and definitions.

S22.1.1 Tests specifying the use of a forward facing child restraint, including a booster seat where applicable, may be conducted using any such restraint listed in section C and section D of Appendix A of this standard, respectively. The child restraint may be unused or have been previously used for static suppression tests only; if it has been used, there shall not be any visible damage prior to the test. Booster seats are to be used in the manner appropriate for a three-year-old child of the same height and weight as the three-year-old child dummy.

S22.1.2 Unless otherwise specified, each vehicle certified to this option shall comply in tests conducted with the right front outboard seating position at the full rearward seat track position, the middle seat track position, and the full forward seat track position. If the dummy contacts the vehicle interior, move the seat rearward to the next detent that provides clearance. If the seat is a power seat, move the seat rearward while assuring that there is a maximum of 5 mm (0.2 in) clearance. All tests are conducted with the seat height, if adjustable, in the mid-height position, and with the seat back angle, if adjustable, at the manufacturer's nominal design seat back angle for a 50th percentile adult male as specified in S8.1.3.

S22.1.3 Except as otherwise specified, if the child restraint has an anchorage system as specified in S5.9 of FMVSS No. 213 and is tested in a vehicle with a right front outboard vehicle seat that has an anchorage system as specified in FMVSS No. 225, the vehicle shall comply in tests conducted both with the restraint anchorage system attached and unattached to the vehicle seat anchorage system.

S22.1.4 Do not attach any tethers.

S22.1.5 The definitions provided in S16.3.1 apply to the tests specified in S22.

S22.2 Static tests of automatic suppression feature which shall result in deactivation of the passenger air bag. Each vehicle that is certified as complying with S21.2 shall meet the following test requirements:

S22.2.1 Belted test with forward facing child restraints or booster seats.

S22.2.1.1 Install the restraint in the right front outboard seat in accordance, to the extent possible, with the child restraint manufacturer's instructions provided with the seat for use by children with the same height and weight as the three-year-old child dummy.

S22.2.1.2 Locate a vertical plane through the longitudinal centerline of the child restraint. This will be referred to as "Plane A".

S22.2.1.3 For bucket seats, "Plane B" refers to a vertical plane parallel to the vehicle longitudinal centerline through the geometric center of the right front outboard vehicle seat. For bench seats, "Plane B" refers to a vertical plane through the right front outboard vehicle seat parallel to the vehicle longitudinal centerline the same distance from the longitudinal centerline of the vehicle as the center of the steering wheel.

22.2.1.4 The vehicle shall comply in both of the following positions, if applicable:

(a) Without attaching the child restraint anchorage system as specified in S5.9 of FMVSS No. 213 to a vehicle seat anchorage system specified in FMVSS No. 225 and without attaching any tethers, align the child restraint system facing forward such that Plane A is aligned with Plane B.

(b) If the child restraint is certified to S5.9 of FMVSS No. 213, and the vehicle seat has an anchorage system as specified in FMVSS No. 225, attach the child restraint to the vehicle seat anchorage instead of aligning the planes. Do not attach the vehicle safety belt.

S22.2.1.5 Forward facing child restraint

S22.2.1.5.1 Place any adjustable seat belt anchorages at the vehicle manufacturer's nominal design position for a 50th percentile adult male occupant. Cinch the vehicle belts to any tension from zero up to 134 N (30 lb) to secure the child restraint. Measure belt tension in a flat, straight section of the lap belt between the child restraint belt path and the contact point with the belt anchor or vehicle seat, on the side away from the buckle (to avoid interference from the shoulder portion of the belt).

S22.2.1.5.2 Position the Part 572 Subpart P 3-year-old child dummy in the child restraint such that the dummy's lower torso is centered on the child restraint and the dummy's spine is against the seat back of the child restraint. Place the arms at the dummy's sides.

S22.2.1.5.3 Attach all belts that come with the child restraint that are appropriate for a child of the same height and weight as the three-year-old child dummy, if any, by following, to the extent possible, the manufacturer's instructions for seating children provided with the child restraint.

S22.2.1.6 Booster seat

S22.2.1.6.1 Place any adjustable seat belt anchorages at the vehicle manufacturer's nominal design position for a 50th percentile adult male occupant. For booster seats designed to be secured to the vehicle seat even when empty, cinch the vehicle belts to any tension from zero up to 134 N (30 lb) to secure the booster seat. Measure belt tension in a flat, straight section of the lap belt between the child restraint belt path and the contact point with the belt anchor or vehicle seat, on the side away from the buckle (to avoid interference from the shoulder portion of the belt).

S22.2.1.6.2 Position the Part 572 Subpart P 3-year-old child dummy in the booster seat such that the dummy's lower torso is centered on the booster seat cushion and the dummy's spine is parallel to the booster seat back or, if there is no booster seat back, the vehicle seat back. Place the arms at the dummy's sides.

S22.2.1.6.3 If applicable, attach all belts that come with the child restraint that are appropriate for a child of the same height and weight as the three-year-old child dummy, if any, by following, to the extent possible, the manufacturer's instructions for seating children provided with the child restraint.

S22.2.1.6.4 If applicable, place the Type 2 manual belt around the test dummy and fasten the latch. Remove all slack from the lap belt portion. Pull the upper torso webbing out of the retractor and allow it to retract; repeat this four times. Apply a 9 to 18 N (2 to 4 lb) tension load to the lap belt. Allow the excess webbing in the upper torso belt to be retracted by the retractive force of the retractor.

S22.2.1.7 Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

S22.2.1.8 Wait 10 seconds, then check whether the air bag is deactivated.

S22.2.2 Unbelted tests with dummies. Place the Part 572 Subpart P 3-year-old child dummy on the right front outboard seat in any of the following positions (without using a child restraint or booster seat or the vehicle's seat belts):

S22.2.2.1 Sitting on seat with back against seat back

(a) Position the dummy in the seated position and place it on the right front outboard seat.

(b) In the case of vehicles equipped with bench seats, position the midsagittal plane of the dummy vertically and parallel to the vehicle's longitudinal centerline and the same distance from the vehicle's longitudinal centerline as the center of the steering wheel. In the case of vehicles equipped with bucket seats, position the midsagittal plane of the dummy vertically such that it coincides with the longitudinal centerline of the bucket seat. Position the torso of the dummy against the seat back. Position the dummy's thighs against the seat cushion.

(c) Allow the legs of the dummy to extend off the surface of the seat.

(d) Rotate the dummy's upper arms down until they contact the seat back.

(e) Rotate the dummy's lower arms until the dummy's hands contact the seat cushion.

(f) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

(g) Wait 10 seconds, then check whether the air bag is deactivated.

S22.2.2.2 Sitting on seat with back against reclined seat back. Repeat the test sequence in S22.2.2.1 with the seat back angle 25 degrees rearward of the manufacturer's nominal design position for the 50th percentile adult male. If the seat will not recline 25 degrees rearward of the nominal design position, use the closest position that does not exceed 25 degrees.

S22.2.2.3 Sitting on seat with back not against seat back.

(a) Position the dummy in the seated position and place it on the right front outboard seat.

(b) In the case of vehicles equipped with bench seats, position the midsagittal plane of the dummy vertically and parallel to the vehicle's longitudinal centerline and the same distance from the vehicle's longitudinal centerline as the center of the steering wheel. In the case of vehicles equipped with bucket seats, position the midsagittal plane of the dummy vertically such that it coincides with the longitudinal centerline of the bucket seat. Position the dummy with the spine vertical so that the horizontal distance from the dummy's back to the seat back is no less than 25 mm (1 in) and no more than 150 mm (6 in), as measured along the dummy's midsagittal plane at the mid-sternum level. To keep the dummy in position, a thread with a maximum breaking strength of 311 N (70 lb) that does not interfere with the air bag may be used to hold the dummy.

(c) Position the dummy's thighs against the seat cushion.

(d) Allow the legs of the dummy to extend off the surface of the seat.

(e) Position the upper arms parallel to the spine and rotate the dummy's lower arms until the dummy's hands contact the seat cushion.

(f) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

(g) Wait 10 seconds, then check whether the air bag is deactivated.

S22.2.2.4 Sitting on seat edge, spine vertical, hands by the dummy's sides.

(a) In the case of vehicles equipped with bench seats, position the midsagittal plane of the dummy vertically and parallel to the vehicle's longitudinal centerline and the same distance from the vehicle's longitudinal centerline as the center of the steering wheel. In the case of vehicles

equipped with bucket seats, position the midsagittal plane of the dummy vertically such that it coincides with the longitudinal centerline of the bucket seat.

(b) Position the dummy in the seated position forward in the seat such that the legs are vertical and rest against the front of the seat with the spine vertical. If the dummy's feet contact the floorboard, rotate the legs forward until the dummy is resting on the seat with the feet positioned flat on the floorboard and the dummy spine vertical. To keep the dummy in position, a thread with a maximum breaking strength of 311 N (70 lb) that does not interfere with the air bag may be used to hold the dummy.

(c) Place the upper arms parallel to the spine.

(d) Lower the dummy's lower arms such that they contact the seat cushion.

(e) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

(f) Wait 10 seconds, then check whether the air bag is deactivated.

S22.2.2.5 Standing on seat, facing forward.

(a) In the case of vehicles equipped with bench seats, position the midsagittal plane of the dummy vertically and parallel to the vehicle's longitudinal centerline and the same distance from the vehicle's longitudinal centerline as the center of the steering wheel rim. In the case of vehicles equipped with bucket seats, position the midsagittal plane of the dummy vertically such that it coincides with the longitudinal centerline of the bucket seat. Position the dummy in a standing position on the right front outboard seat cushion facing the front of the vehicle while placing the heels of the dummy's feet in contact with the seat back.

(b) Rest the dummy against the seat back, with the arms parallel to the spine.

(c) If the head contacts the vehicle roof, recline the seat so that the head is no longer in contact with the vehicle roof, but allow no more than 5 mm (0.2 in) distance between the head and the roof. If the seat does not sufficiently recline to allow clearance, omit the test.

(d) If necessary use a thread with a maximum breaking strength of 311 N (70 lb) that does not interfere with the air bag or spacer blocks to keep the dummy in position.

(e) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

(f) Wait 10 seconds, then check whether the air bag is deactivated.

S22.2.2.6 Kneeling on seat, facing forward.

(a) Position the dummy in a kneeling position by rotating the dummy's legs 90 degrees behind the dummy (from the standing position) with the toes pointed rearward as much as possible and with the arms parallel to the spine.

(b) In the case of vehicles equipped with bench seats, position the midsagittal plane of the dummy vertically and parallel to the vehicle's longitudinal centerline and the same distance from the vehicle's longitudinal centerline as the center of the steering wheel. In the case of vehicles equipped with bucket seats, position the midsagittal plane of the dummy vertically such that it coincides with the longitudinal centerline of the bucket seat.

(c) Position the kneeling dummy in the right front outboard seat with the dummy facing the front of the vehicle with its toes at the intersection of the seat back and seat cushion. Position the dummy so that the spine is vertical. Push down on the legs so that they contact the seat as much as possible and then release.

(d) If necessary use a thread with a maximum breaking strength of 311 N (70 lb) that does not interfere with the air bag or spacer blocks to keep the dummy in position.

(e) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

(f) Wait 10 seconds, then check whether the air bag is deactivated.

S22.2.2.7 Kneeling on seat, facing rearward.

(a) Position the dummy in a kneeling position by rotating the dummy's legs 90 degrees behind the dummy (from the standing position) with the toes pointed rearward as much as possible and the arms parallel to the spine.

(b) In the case of vehicles equipped with bench seats, position the midsagittal plane of the dummy vertically and parallel to the vehicle's longitudinal centerline and the same distance from the vehicle's longitudinal centerline as the center of the steering wheel. In the case of vehicles equipped with bucket seats, position the midsagittal plane of the dummy vertically such that it coincides with the longitudinal centerline of the bucket seat.

(c) Position the kneeling dummy in the right front outboard seat with the dummy facing the rear of the vehicle. Position the dummy such that the dummy's head and torso are in contact with the seat back. Push down on the legs so that they contact the seat as much as possible and then release.

(d) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

(e) Wait 10 seconds, then check whether the air bag is deactivated.

S22.2.2.8 Lying on seat. This test is performed only in vehicles with 3 designated front seating positions.

(a) Lay the dummy on the right front outboard seat such that the following criteria are met:

(1) The midsagittal plane of the dummy is horizontal,

(2) The dummy's spine is perpendicular to the vehicle's longitudinal axis,

(3) The dummy's arms are parallel to its spine,

(4) A plane passing through the two shoulder joints of the dummy is vertical,

(5) The anterior of the dummy is facing the vehicle front,

(6) The head of the dummy is positioned towards the passenger door, and

(7) The horizontal distance from the topmost point of the dummy's head to the vehicle door is 50 to 100 mm (2- 4 in).

(b) Rotate the thighs as much as possible toward the chest of the dummy and rotate the legs as much as possible against the thighs.

(c) Move the dummy's upper left arm parallel to the vehicle's transverse plane and the lower left arm 90 degrees to the upper arm. Rotate the lower left arm about the elbow joint and toward the dummy's head until movement is obstructed.

(d) Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

(e) Wait 10 seconds, then check whether the air bag is deactivated.

S22.3 Static tests of automatic suppression feature which shall result in activation of the passenger air bag system.

S22.3.1 Each vehicle certified to this option shall comply in tests conducted with the right front outboard seating position at the full rearward seat track position, the middle seat track position, and, subject to S16.3.3.1.8, the full forward seat track position. All tests are conducted with the seat height, if adjustable, in the mid-height position.

S22.3.2 Place a Part 572 Subpart O 5th percentile adult female test dummy at the right front outboard seating position of the vehicle, in accordance with procedures specified in S16.3.3 of this standard, except as specified in S22.3.1. Do not fasten the seat belt.

S22.3.3 Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

S22.3.4 Wait 10 seconds, then check whether the air bag system is activated.

S22.4 Low risk deployment tests.

S22.4.1 Each vehicle that is certified as complying with S21.4 shall meet the following test requirements with the Part 572, Subpart P 3-year-old child dummy in both of the following positions: Position 1 (S22.4.2) and Position 2 (S22.4.3).

S22.4.1.1 Locate and mark the center point of the dummy's chest/rib plate (the vertical mid-point of the frontal chest plate of the dummy on the midsagittal plane). This is referred to as "Point 1."

S22.4.1.2 Locate the vertical plane parallel to the vehicle longitudinal centerline through the geometric center of the right front air bag tear seam. This is referred to as "Plane D."

S22.4.1.3 Locate the horizontal plane through the geometric center of the right front air bag tear seam. This is referred to as "Plane C."

S22.4.2 Position 1 (chest on instrument panel).

S22.4.2.1 There are no seat track, seat height, or seat back angle requirements.

S22.4.2.2 Place the dummy's midsagittal plane coincident with Plane D.

S22.4.2.3 Initially position the thighs at a right angle to the spine and the legs at a right angle to the thighs. These angles may be adjusted to the extent necessary for the head and torso to attain their final positions.

S22.4.2.4 With the dummy's thorax instrument cavity rear face vertical and Point 1 in Plane C, move the dummy forward until Point 1 contacts the instrument panel. If the dummy's head contacts the windshield and keeps Point 1 from contacting the instrument panel, lower the dummy until there is no more than 5 mm (0.2 in) clearance between the head and the windshield.

S22.4.2.5 Position the upper arms parallel to the spine and rotate the lower arms forward (at the elbow joint) sufficiently to prevent contact with or support from the seat.

S22.4.2.6 Position the legs of the dummy so that the legs are vertical and the feet rest flat on the floorboard (or the feet are positioned parallel to the floorboard) of the vehicle.

S22.4.2.7 Use the seat adjustments (fore-aft, height) to keep the dummy in position. If necessary, thread with a maximum breaking strength of 311 N (70 lb) and spacer blocks may be used to support the dummy in position. The thread should support the torso rather than the head. Support the dummy so that there is minimum interference with the full rotational and translational freedom for the upper torso of the dummy and the thread does not interfere with the air bag.

S22.4.3 <u>Position 2 (head on instrument panel)</u>.

S22.4.3.1 Place the passenger seat in the full rearward seating position. Place the seat back in the manufacturer's nominal design seat back angle for a 50th percentile adult male as

specified in S8.1.3. If adjustable in the vertical direction, place the seat in the mid-height position.

S22.4.3.2 Place the dummy in the front passenger seat such that:

S22.4.3.2.1 The dummy's midsagittal plane is coincident with Plane D. With the thighs on the seat, initially set the thighs perpendicular to the torso and the legs perpendicular to the thighs. Position the upper arms parallel to the torso and rotate the lower arms forward (at the elbow) sufficiently to prevent contact with or support from the seat.

S22.4.3.2.2 The dummy is positioned in the seat such that the legs rest against the front of the seat and such that the dummy's thorax instrument cavity rear face is vertical. If it is not possible to position the dummy with the legs in the prescribed position, rotate the legs forward until the dummy is resting on the seat with the feet positioned flat on the floorboard.

S22.4.3.3 Move the seat forward, while maintaining the thorax instrument cavity rear face orientation until any part of the dummy contacts the vehicle's instrument panel.

S22.4.3.4 If contact has not been made with the vehicle's instrument panel at the full forward seating position of the seat, slide the dummy forward on the seat 190 mm (7.5 in) or until contact is made, whichever is first. Maintain the thorax instrument cavity rear face vertical orientation.

S22.4.3.5 If contact has not been made, apply a force towards the front of the vehicle on the spine of the dummy between the shoulder joints until the head or torso comes into contact with the vehicle's instrument panel.

S22.4.3.6 If necessary, rotate the thighs and rotate the legs and feet so as not to impede the motion of the head/torso into the vehicle's instrument panel.

S22.4.3.7 Rotate the lower arms forward if necessary to prevent contact with or support from the seat.

S22.4.3.8 If necessary, thread with a maximum breaking strength of 311 N (70 lb) and spacer blocks may be used to support the dummy in position. The thread should support the torso rather than the head. Support the dummy so that there is minimum interference with the full rotational and translational freedom for the upper torso of the dummy and the thread does not interfere with the air bag.

S22.4.4 Deploy the right front outboard frontal air bag system. If the frontal air bag system contains a multistage inflator, the vehicle shall be able to comply with the injury criteria at any stage or combination of stages or time delay between successive stages that could occur in a rigid barrier crash test at or below 26 km/h (16 mph), under the test procedure specified in S22.5.

S22.5 Test procedure for determining stages of air bag systems subject to low risk deployment test requirement.

S22.5.1 Impact the vehicle traveling longitudinally forward at any speed, up to and including 26 km/h (16 mph) into a fixed rigid barrier that is perpendicular ± 5 degrees to the line of travel of the vehicle under the applicable conditions of S8 and S10, excluding S10.7, S10.8, and S10.9.

S22.5.2 Determine which inflation stage or combination of stages are fired and determine the time delay between successive stages. That stage or combination of stages, with time delay between successive stages, shall be used in deploying the air bag when conducting the low risk deployment tests described in S22.4, S24.4, and S26.

S22.5.3 If the air bag does not deploy in the impact described in S22.5.1, the low risk deployment tests described in S22.4, S24.4, and S26 will be conducted with the first inflation stage of the air bag system.

S23 Requirements using 6-year-old child dummies.

S23.1 Each vehicle that is certified as complying with S14 shall, at the option of the manufacturer, meet the requirements specified in S23.2, S23.3, or S23.4, under the test procedures specified in S24 or S28, as applicable.

S23.2 Option 1--Automatic suppression feature. Each vehicle shall meet the requirements specified in S23.2.1 through S23.2.3.

S23.2.1 The vehicle shall be equipped with an automatic suppression feature for the passenger frontal air bag system which results in deactivation of the air bag during each of the static tests specified in S24.2 (using a Part 572 Subpart N 6-year-old child dummy in any of the child restraints specified in section D of Appendix A of this standard), and activation of the air bag system during each of the static tests specified in S24.3 (using a Part 572 Subpart O 5th percentile adult female dummy).

S23.2.2 The vehicle shall be equipped with a telltale light meeting the requirements specified in S19.2.2.

S23.2.3 The vehicle shall be equipped with a mechanism that indicates whether the air bag is suppressed, regardless of whether the passenger seat is occupied. The mechanism need not be located in the occupant compartment unless it is the telltale described in S23.2.2.

S23.3 Option 2-- Dynamic automatic suppression system that suppresses the air bag when an occupant is out of position. (This option is available under the conditions set forth in S27.1.)

The vehicle shall be equipped with a dynamic automatic suppression system for the passenger frontal air bag system which meets the requirements specified in S27.

S23.4 Option 3--Low risk deployment. Each vehicle shall meet the injury criteria specified in S23.5 of this standard when the passenger air bag is statically deployed in accordance with both of the low risk deployment test procedures specified in S24.4.

S23.5 Injury criteria for the Part 572 Subpart N 6-year-old child dummy.

S23.5.1 All portions of the test dummy shall be contained within the outer surfaces of the vehicle passenger compartment.

S23.5.2 Head injury criteria.

(a) For any two points in time, $t_1$ and $t_2$, during the event which are separated by not more than a 15 millisecond time interval and where $t_1$ is less than $t_2$, the head injury criterion ($HIC_{15}$) shall be determined using the resultant head acceleration at the center of gravity of the dummy head, $a_r$, expressed as a multiple of g (the acceleration of gravity) and shall be calculated using the expression:

$$\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a_r \, dt\right]^{2.5} (t_2 - t_1)$$

(b) The maximum calculated $HIC_{15}$ value shall not exceed 700.

S23.5.3 The resultant acceleration calculated from the output of the thoracic instrumentation shall not exceed 60 g's, except for intervals whose cumulative duration is not more than 3 milliseconds.

S23.5.4 Compression deflection of the sternum relative to the spine, as determined by instrumentation shall not exceed 40 mm (1.6 in).

S23.5.5 Neck injury. When measuring neck injury, each of the following injury criteria shall be met.

(a) Nij.

(1) The shear force (Fx), axial force (Fz), and bending moment (My) shall be measured by the dummy upper neck load cell for the duration of the crash event as specified in S4.10. Shear force, axial force, and bending moment shall be filtered for Nij purposes at SAE J211/1 rev. Mar95 Channel Frequency Class 600 (see S4.7).

(2) During the event, the axial force (Fz) can be either in tension or compression while the occipital condyle bending moment (Mocy) can be in either flexion or extension. This results in four possible loading conditions for Nij: tension-extension (Nte), tension-flexion (Ntf), compression-extension (Nce), or compression-flexion (Ncf).

(3) When calculating Nij using equation (4), the critical values, Fzc and Myc, are:

(i) Fzc = 2800 N (629 lbf) when Fz is in tension

(ii) Fzc = 2800 N (629 lbf) when Fz is in compression

(iii) Myc = 93 Nm (69 lbf-ft) when a flexion moment exists at the occipital condyle

(iv) Myc = 37 Nm (27 lbf-ft) when an extension moment exists at the occipital condyle.

(4) At each point in time, only one of the four loading conditions occurs and the Nij value corresponding to that loading condition is computed and the three remaining loading modes shall be considered a value of zero. The expression for calculating each Nij loading condition is given by:

$$Nij = (Fz / Fzc) + (Mocy / Myc)$$

(5) None of the four Nij values shall exceed 1.0 at any time during the event.

(b) Peak tension. Tension force (Fz), measured at the upper neck load cell, shall not exceed 1490 N (335 lbf) at any time.

(c) Peak compression. Compression force (Fz), measured at the upper neck load cell, shall not exceed 1820 N (409 lbf) at any time.

S23.5.6 Unless otherwise indicated, instrumentation for data acquisition, data channel frequency class, and moment calculations are the same as given for the Part 572 Subpart N 6-year-old child test dummy.

S24 Test procedure for S23.

S24.1 General provisions and definitions.

S24.1.1 Tests specifying the use of a booster seat may be conducted using any such restraint listed in section D of Appendix A of this standard. The booster seat may be unused or have been previously used for static suppression tests only; if it has been used, there shall not be any visible damage prior to the test. Booster seats are to be used in the manner appropriate for a six-year-old child of the same height and weight as the six-year-old child dummy.

S24.1.2 Unless otherwise specified, each vehicle certified to this option shall comply in tests conducted with the right front outboard seating position at the full rearward seat track position, the middle seat track position, and the full forward seat track position. If the dummy contacts the vehicle interior, move the seat rearward to the next detent that provides clearance. If the seat is a power seat, move the seat rearward while assuring that there is a maximum of 5 mm (0.2 in) distance between the vehicle interior and the point on the dummy that would first contact the vehicle interior. All tests are conducted with the seat height, if adjustable, in the mid-height

position, and with the seat back angle, if adjustable, at the manufacturer's nominal design seat back angle for a 50th percentile adult male as specified in S8.1.3.

S24.1.3 Except as otherwise specified, if the booster seat has an anchorage system as specified in S5.9 of FMVSS No. 213 and is tested in a vehicle with a right front outboard vehicle seat that has an anchorage system as specified in FMVSS No. 225, the vehicle shall comply in tests conducted both with the restraint anchorage system attached and unattached to the vehicle seat anchorage system.

S24.1.4 Do not attach any tethers.

S24.1.5 The definitions provided in S16.3.1 apply to the tests specified in S24.

S24.2 Static tests of automatic suppression feature which shall result in deactivation of the passenger air bag. Each vehicle that is certified as complying with S23.2 shall meet the following test requirements.

S24.2.1 Except as provided in S24.2.2, conduct all tests as specified in S22.2, except that the Part 572 Subpart N 6-year-old child dummy shall be used.

S24.2.2 Exceptions. The tests specified in the following paragraphs of S22.2 need not be conducted: S22.2.1.5, S22.2.2.3, S22.2.2.5, S22.2.2.6, S22.2.2.7, and S22.2.2.8.

S24.2.3 Sitting back in the seat and leaning on the right front passenger door

(a) Position the dummy in the seated position and place the dummy in the right front outboard seat. For bucket seats, position the midsagittal plane of the dummy vertically such that it coincides with the vertical longitudinal plane through the longitudinal center line of the seat cushion. For bench seats, position the midsagittal plane of the dummy vertically and parallel to

the vehicle's longitudinal centerline and the same distance from the longitudinal centerline of the vehicle as the center of the steering wheel.

(b) Place the dummy's back against the seat back and rest the dummy's thighs on the seat cushion.

(c) Allow the legs and feet of the dummy to extend off the surface of the seat. If this positioning of the dummy's legs is prevented by contact with the instrument panel, move the seat rearward to the next detent that provides clearance. If the seat is a power seat, move the seat rearward, while assuring that there is a minimum of 5 mm (0.2 in) distance between the vehicle interior and the part of the dummy that was in contact with the vehicle interior.

(d) Rotate the dummy's upper arms toward the seat back until they make contact.

(e) Rotate the dummy's lower arms down until they contact the seat.

(f) Close the vehicle's passenger-side door and then start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system.

(g) Push against the dummy's left shoulder to lean the dummy against the door; close all remaining doors.

(h) Wait 10 seconds, then check whether the air bag is deactivated.

S24.3 Static tests of automatic suppression feature which shall result in activation of the passenger air bag system.

S24.3.1 Each vehicle certified to this option shall comply in tests conducted with the right front outboard seating position at the full rearward seat track position, the middle seat track position, and, subject to S16.3.3.1.8, the full forward seat track position. All tests are conducted with the seat height, if adjustable, in the mid-height position.

S24.3.2 Place a Part 572 Subpart O 5th percentile adult female test dummy at the right front outboard seating position of the vehicle, in accordance with procedures specified in S16.3.3 of this standard, except as specified in S24.3.1. Do not fasten the seat belt.

S24.3.3 Start the vehicle engine or place the ignition in the "on" position, whichever will turn on the suppression system, and then close all vehicle doors.

S24.3.4 Wait 10 seconds, then check whether the air bag system is activated.

S24.4 Low risk deployment tests.

S24.4.1 Each vehicle that is certified as complying with S23.4 shall meet the following test requirements with the Part 572 Subpart N 6-year-old child dummy in both of the following positions: Position 1 (S24.4.2) or Position 2 (S24.4.3).

S24.4.1.1 Locate and mark the center point of the dummy's rib cage or sternum plate (the vertical mid-point of the frontal chest plate of the dummy on the midsagittal plane). This is referred to as "Point 1."

S24.4.1.2 Locate the vertical plane parallel to the vehicle longitudinal centerline through the geometric center of the right front air bag tear seam. This is referred to as "Plane D."

S24.4.1.3 Locate the horizontal plane through the geometric center of the right front air bag tear seam. This is referred to as "Plane C."

S24.4.2 Position 1 (chest on instrument panel).

S24.4.2.1 There are no seat track, seat height, or seat back angle requirements.

S24.4.2.2 Remove the legs of the dummy at the pelvic interface.

S24.4.2.3 Place the dummy's midsagittal plane coincident with Plane D.

S24.4.2.4 With the dummy's thorax instrument cavity rear face 6 degrees forward of the vertical and Point 1 in Plane C, move the dummy forward until Point 1 contacts the instrument panel. If the dummy's head contacts the windshield and keeps Point 1 from contacting the instrument panel, lower the dummy until there is no more than 5 mm (0.2 in) clearance between the head and the windshield.

S24.4.2.5 Position the upper arms parallel to the spine and rotate the lower arms forward (at the elbow joint) sufficiently to prevent contact with or support from the seat.

S24.4.2.6 Use the seat adjustments (fore-aft, height) to keep the dummy in position. If necessary, thread with a maximum breaking strength of 311 N (70 lb) and spacer blocks may be used to support the dummy in position. The thread should support the torso rather than the head. Support the dummy so that there is minimum interference with the full rotational and translational freedom for the upper torso of the dummy and the thread does not interfere with the air bag.

S24.4.3 Position 2 (head on instrument panel).

S24.4.3.1 Place the passenger seat in the full rearward seating position. Place the seat back in the nominal design position for a 50th percentile adult male (S8.1.3) as specified by the vehicle manufacturer. If adjustable in the vertical direction, place the seat in the mid-height position.

S24.4.3.2 Place the dummy in the front passenger seat such that:

S24.4.3.2.1 The dummy's midsagittal plane is coincident with Plane D. With the thighs on the seat, initially set the thighs perpendicular to the torso and the legs perpendicular to the thighs. Position the upper arms parallel to the torso and rotate the lower arms forward (at the elbow) sufficiently to prevent contact with or support from the seat.

S24.4.3.2.2.2 The dummy is positioned in the seat such that the legs rest against the front of the seat and such that the dummy's thorax instrument cavity rear face is 6 degrees forward of vertical. If it is not possible to position the dummy with the legs in the prescribed position, rotate the legs forward until the dummy is resting on the seat with the feet positioned flat on the floorboard.

S24.4.3.3 Move the seat forward, while maintaining the thorax instrument cavity rear face orientation until any part of the dummy contacts the vehicle's instrument panel.

S24.4.3.4 If contact has not been made with the vehicle's instrument panel at the full forward seating position of the seat, slide the dummy forward on the seat 190 mm (7.5 in) or until contact is made, whichever is first. Maintain the thorax instrument cavity rear face orientation.

S24.4.3.5 If contact has not been made, apply a force towards the front of the vehicle on the spine of the dummy between the shoulder joints until the head or torso comes into contact with the vehicle's instrument panel.

S24.4.3.6 If necessary, rotate the thighs and rotate the legs and feet so as not to impede the motion of the head/torso into the vehicle's instrument panel.

S24.4.3.7 Rotate the lower arms forward if necessary to prevent contact with or support from the seat.

S24.4.3.8 If necessary, thread with a maximum breaking strength of 311 N (70 lb) and spacer blocks may be used to support the dummy in position. Thread should support the torso rather than the head. Support the dummy so that there is minimum interference with the full rotational and translational freedom for the upper torso of the dummy and the thread does not interfere with the air bag.

S24.4.4 Deploy the right front outboard frontal air bag system. If the frontal air bag system contains a multistage inflator, the vehicle shall be able to comply with the injury criteria at any stage or combination of stages and at any time delay between successive stages that could occur in a rigid barrier crash at speeds up to 26 km/h (16 mph) under the test procedure specified in S22.5.

S25 Requirements using an out-of-position 5th percentile adult female dummy at the driver position.

S25.1 Each vehicle certified as complying with S14 shall, at the option of the manufacturer, meet the requirements specified in S25.2 or S25.3 under the test procedures specified in S26 or S28, as appropriate.

S25.2 Option 1-- Dynamic automatic suppression system that suppresses the air bag when the driver is out of position. (This option is available under the conditions set forth in S27.1.) The vehicle shall be equipped with a dynamic automatic suppression system for the driver air bag which meets the requirements specified in S27.

S25.3 Option 2--Low risk deployment. Each vehicle shall meet the injury criteria specified by S15.3 of this standard, except as modified in S25.4, when the driver air bag is statically deployed in accordance with both of the low risk deployment test procedures specified in S26.

S25.4 Neck injury criteria driver low risk deployment tests. When measuring neck injury in low risk deployment tests for the driver position, each of the following neck injury criteria shall be met.

(a) Nij.

(1) The shear force (Fx), axial force (Fz), and bending moment (My) shall be measured by the dummy upper neck load cell for the duration of the crash event as specified in S4.10. Shear force, axial force, and bending moment shall be filtered for Nij purposes at SAE J211/1 rev. Mar 95 Channel Frequency Class 600 (see S4.7).

(2) During the event, the axial force (Fz) can be either in tension or compression while the occipital condyle bending moment (Mocy) can be in either flexion or extension. This results in four possible loading conditions for Nij: tension-extension (Nte), tension-flexion (Ntf), compression-extension (Nce), or compression-flexion (Ncf).

(3) When calculating Nij using equation (4), the critical values, Fzc and Myc, are:

(i) Fzc = 3880 N (872 lbf) when Fz is in tension

(ii) Fzc = 3880 N (872 lbf) when Fz is in compression

(iii) Myc = 155 Nm (114 lbf-ft) when a flexion moment exists at the occipital condyle

(iv) Myc = 61 Nm (45 lbf-ft) when an extension moment exists at the occipital condyle.

(4) At each point in time, only one of the four loading conditions occurs and the Nij value corresponding to that loading condition is computed and the three remaining loading modes shall be considered a value of zero. The expression for calculating each Nij loading condition is given by:

$$Nij = (Fz / Fzc) + (Mocy / Myc)$$

(5) None of the four Nij values shall exceed 1.0 at any time during the event.

(b) <u>Peak tension.</u> Tension force (Fz), measured at the upper neck load cell, shall not exceed 2070 N (465 lbf) at any time.

(c) Peak compression. Compression force (Fz), measured at the upper neck load cell, shall not exceed 2520 N (566 lbf) at any time.

(d) Unless otherwise indicated, instrumentation for data acquisition, data channel frequency class, and moment calculations are the same as given in Part 572 Subpart O 5th percentile female test dummy.

S26 Procedure for low risk deployment tests of driver air bag.

S26.1 Each vehicle that is certified as complying with S25.3 shall meet the requirements of S25.3 and S25.4 with the Part 572 Subpart O 5th percentile adult female dummy in both of the following positions: Driver position 1 (S26.2) and Driver position 2 (S26.3).

S26.2 Driver position 1 (chin on module).

S26.2.1 Adjust the steering controls so that the steering wheel hub is at the geometric center of the locus it describes when it is moved through its full range of driving positions. If there is no setting at the geometric center, position it one setting lower than the geometric center. Set the rotation of the steering wheel so that the vehicle wheels are pointed straight ahead.

S26.2.2 Locate the vertical plane parallel to the vehicle longitudinal axis which passes through the geometric center of the driver air bag tear seam. This is referred to as "Plane E."

S26.2.3 Place the seat in the full rearward seating position. If adjustable in the vertical direction, place the seat in the mid-height position.

S26.2.4 Place the dummy in a seated position with its midsagittal plane coincident with Plane E.

S26.2.5 Initially position the legs at a 90-degree angle to the thighs. The legs may be adjusted if necessary to achieve the final head position.

S26.2.6 Position the dummy's thorax instrument cavity rear face 6 degrees forward (toward the front of the vehicle) of the steering wheel angle (i.e., if the steering wheel angle is 25 degrees from vertical, the thorax instrument cavity rear face angle is 31 degrees).

S26.2.7 Move the seat forward, while retaining the thorax instrument cavity rear face orientation, to the forwardmost seat track position or until any portion of the dummy contacts the steering wheel, whichever occurs first.

S26.2.7 Adjust the height of the dummy so that the bottom of the chin is in the same horizontal plane as the highest point of the air bag module cover (dummy height can be adjusted using the seat height adjustments and/or spacer blocks). If the seat prevents the bottom of the chin from being in the same horizontal plane as the module cover, adjust the dummy height to as close to the prescribed position as possible.

S26.2.8 Slide the dummy forward on the seat until either the head or the torso contacts the steering wheel.

S26.2.9 Use the seat adjustments (fore-aft, height) to keep the dummy in position. If necessary, thread with a maximum breaking strength of 311 N (70 lb) and spacer blocks may be used to support the dummy in position. The thread should support the torso rather than the head. Support the dummy so that there is minimum interference with the full rotational and translational freedom for the upper torso of the dummy and the thread does not interfere with the air bag.

S26.3 <u>Driver position 2 (chin on rim)</u>.

S26.3.1 There are no seat track, seat height, or seat back angle requirements.

S26.3.2 Adjust the steering controls so that the steering wheel hub is at the geometric center of the locus it describes when it is moved through its full range of driving positions. If there is no setting at the geometric center, position it one setting lower than the geometric center. Set the rotation of the steering wheel so that the vehicle wheels are pointed straight ahead.

S26.3.3 Locate the vertical plane parallel to the vehicle longitudinal axis which passes through the geometric center of the driver air bag tear seam. This is referred to as "Plane E."

S26.3.4 Place the dummy in a seated position with its midsagittal plane coincident with Plane E.

S26.3.5 Initially position the legs at a 90-degree angle to the thighs. The legs may be adjusted if necessary to achieve the final head position.

S26.3.6 Position the dummy's thorax instrument cavity rear face 6 degrees forward (toward the front of the vehicle) of the steering wheel angle (i.e., if the steering wheel angle is 25 degrees from vertical, the thorax instrument cavity rear face angle is 31 degrees).

S26.3.7 Position the dummy so that the center of the chin is in contact with the uppermost portion of the rim of the steering wheel. Do not hook the chin over the top of the rim of the steering wheel. Position the chin to rest on the upper edge of the rim, without loading the neck. If the dummy's head contacts the vehicle windshield or upper interior before the prescribed position can be obtained, lower the dummy until there is no more than 5 mm (0.2 in) clearance between the vehicle's windshield or upper interior, as applicable.

S26.3.8 Use the seat adjustments (fore-aft, height) to keep the dummy in position. If necessary, thread with a maximum breaking strength of 311 N (70 lb) and spacer blocks may be

used to support the dummy in position. The thread should support the torso rather than the head. Support the dummy so that there is minimum interference with the full rotational and translational freedom for the upper torso of the dummy and the thread does not interfere with the air bag.

S26.4 Deploy the left front outboard frontal air bag system. If the air bag system contains a multistage inflator, the vehicle shall be able to comply with the injury criteria at any stage or combination of stages or time delay between successive stages that could occur in a rigid barrier crash at speeds up to 26 km/h (16 mph) under the test procedure specified in S22.5.

S27 Option for dynamic automatic suppression system that suppresses the air bag when an occupant is out-of-position.

S27.1 Availability of option. This option is available for either air bag, singly or in conjunction, subject to the requirements of S27, if:

(a) A petition for rulemaking to establish dynamic automatic suppression system test procedures is submitted pursuant to Subpart B of Part 552 and a test procedure applicable to the vehicle is added to S28 pursuant to the procedures specified by that subpart, or

(b) A test procedure applicable to the vehicle is otherwise added to S28.

S27.2 Definitions. For purposes of S27 and S28, the following definitions apply:

Dynamic automatic suppression system or DASS means a portion of an air bag system that automatically controls whether or not the air bag deploys during a crash by:

(1) Sensing the location of an occupant, moving or still, in relation to the air bag;

(2) Interpreting the occupant characteristics and location information to determine whether or not the air bag should deploy; and

(3) Activating or suppressing the air bag system based on the interpretation of occupant characteristics and location information.

Automatic suppression zone or ASZ means a three-dimensional zone adjacent to the air bag cover, specified by the vehicle manufacturer, where the deployment of the air bag will be suppressed by the DASS if a vehicle occupant enters the zone under specified conditions.

S27.3 Requirements. Each vehicle shall, at each applicable front outboard designated seating position, when tested under the conditions of S28 of this standard, comply with the requirements specified in S27.4 through S27.6.

S27.4 Each vehicle shall be equipped with a DASS.

S27.5 Static test requirement (low risk deployment for occupants outside the ASZ).

S27.5.1 Driver (Part 572 Subpart O 5th percentile female dummy). Each vehicle shall meet the injury criteria specified in S15.3 of this standard when the driver air bag is deployed in accordance with the procedures specified in S28.1.

S27.5.2 Passenger (Part 572 Subpart P 3-year-old child dummy and Part 572 Subpart N 6-year-old child dummy). Each vehicle shall meet the injury criteria specified in S21.5 and S23.5, as appropriate, when the passenger air bag is deployed in accordance with the procedures specified in S28.2.

S27.6 Dynamic test requirement (suppression of air bag for occupants inside the ASZ).

S27.6.1 Driver. The DASS shall suppress the driver air bag before the head, neck, or torso of the specified test device enters the ASZ when the vehicle is tested under the procedures specified in S28.3.

(b) For S21.2, instead of using the Part 572 Subpart P 3-year-old child dummy, a human child who weighs between 13.4 and 18 kg (29.5 and 39.5 lb), and who is between 89 and 99 cm (35 and 39 in) tall may be used.

(c) For S23.2, instead of using the Part 572 Subpart N 6-year-old child dummy, a human child who weighs between 21 and 25.6 kg (46.5 and 56.5 lb), and who is between 114 and 124.5 cm (45 and 49 in) tall may be used.

(d) For S19.2, S21.2, and S23.2, instead of using the Part 572 Subpart O 5th percentile adult female test dummy, a female who weighs between 46.7 and 51.25 kg (103 lb and 113 lb), and who is between 139.7 and 150 cm (55 and 59 in) tall may be used.

S29.2 Human beings shall be dressed in a cotton T-shirt, full length cotton trousers, and sneakers. Specified weights and heights include clothing.

S29.3 A manufacturer exercising this option shall upon request--

(a) Provide NHTSA with a method to deactivate the air bag during compliance testing under S20.3, S22.2, S22.3, S24.2, and S24.3, and identify any parts or equipment necessary for deactivation; such assurance may be made by removing the air bag; and

(b) Provide NHTSA with a method to assure that the same test results would be obtained if the air bag were not deactivated.

**Figures to 49 CFR section 571.208**

* * * * *

Label Outline, Vertical and Horizontal Lines Black

Bottom Text and Artwork Black with White Background

Top Text Black with Yellow Background

**Figure 8.** Sun Visor Label Visible when Visor is in Down Position.

Label Outline, Vertical and Horizontal Lines Black

Bottom Text Black with White Background

Top Text Black with Yellow Background

**This Vehicle is Equipped with Advanced Air Bags**

**Even with Advanced Air Bags**

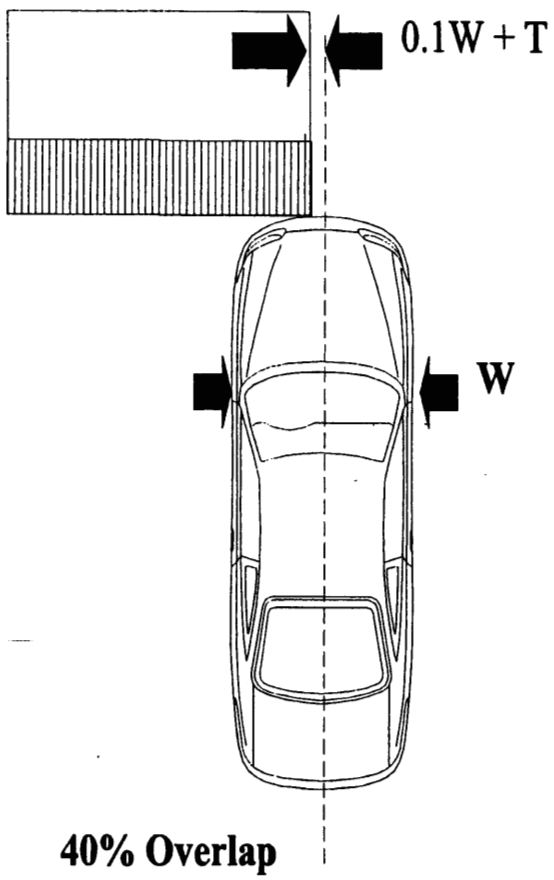
**Children can be killed or seriously injured by the air bag.**

**The back seat is the safest place for children.**

**Always use seat belts and child restraints.**

**See owner's manual for more information about air bags.**

**Figure 9.** Removable Label on Dash.




Legend

---- Longitudinal Centerline of Vehicle

**W** Vehicle Width

**T** Tolerance

**Figure 10.** Configuration for Frontal Offset Deformable Barrier Test

**Appendix A to §571.208 -- Selection of Child Restraint Systems**

A. The following car bed, manufactured on or after December 1, 1999, may be used by the National Highway Traffic Safety Administration to test the suppression system of a vehicle that has been certified as being in compliance with 49 CFR Part 571.208 S19:

Cosco Dream Ride 02-719

B. Any of the following rear facing child restraint systems, manufactured on or after December 1, 1999, may be used by the National Highway Traffic Safety Administration to test the suppression system of a vehicle that has been certified as being in compliance with 49 CFR Part 571.208 S19. When the restraint system comes equipped with a removable base, the test may be run either with the base attached or without the base.

Britax Handle with Care 191

Century 560 Institutional 4590

Century Smart Fit 4541

Cosco Arriva 02-750

Cosco Turnabout 02-772

Evenflo Discovery 209

Evenflo First Choice 204

Evenflo On My Way 207

Evenflo Position Right 200

Graco Infant 8457

Kolcraft Secura 43924

C. Any of the following forward-facing convertible child restraint systems, manufactured on or after December 1, 1999, may be used by the National Highway Traffic Safety Administration to test the suppression system of a vehicle that has been certified as being in compliance with 49 CFR Part 571.208 S19, or S21:

Britax Roundabout 161

Century Encore 4612

Cosco Touriva 02-584

Evenflo Champion 249

Evenflo Medallion 254

Fisher Price Safe-Embrace 79701

Kolcraft Performa 23308

D. Any of the following forward-facing toddler/belt positioning booster systems, manufactured on or after December 1, 1999, may be used by the National Highway Traffic Safety Administration as test devices to test the suppression system of a vehicle that has been certified as being in compliance with 49 CFR Part 571.208 S21 or S23:

Britax Cruiser 121

Century Next Step 4920

Cosco High Back Booster 02-442

Evenflo Right Fit 245

PART 585--ADVANCED AIR BAG PHASE-IN REPORTING REQUIREMENTS

6. The authority citation for Part 585 of Title 49 reads as follows:

AUTHORITY: 49 U.S.C. 322, 30111, 30115, 30117, and 30166; delegation of authority at 49 CFR 1.50.

7. Part 585 is revised to read as follows:

PART 585--ADVANCED AIR BAG PHASE-IN REPORTING REQUIREMENTS

Sec.

585.1 Scope.

585.2 Purpose.

585.3 Applicability.

585.4 Definitions.

585.5 Reporting requirements.

585.6 Records.

585.7 Petitions to extend period to file report.

**§ 585.1 Scope.**

This part establishes requirements for manufacturers of passenger cars and trucks, buses, and multipurpose passenger vehicles with a GVWR of 3,855 kg (8500 lb) or less and an unloaded vehicle weight of 2,495 kg (5500 lb) or less to submit reports, and maintain records related to the reports, concerning the number and identification of such vehicles that are certified as complying with the advanced air bag requirements of Standard No. 208, "Occupant crash protection" (49 CFR 571.208).

**§ 585.2 Purpose.**

The purpose of these reporting requirements is to aid the National Highway Traffic Safety Administration in determining whether a manufacturer has complied with the advanced air bag requirements of Standard No. 208 during the phase-ins of those requirements.

**§ 585.3 Applicability.**

This part applies to manufacturers of passenger cars and trucks, buses, and multipurpose passenger vehicles with a GVWR of 3,855 kg (8500 lb) or less and an unloaded vehicle weight of 2,495 kg (5500 lb) or less. However, this part does not apply to any manufacturers whose production consists exclusively of walk-in vans, vehicles designed to be sold exclusively to the U.S. Postal Service, vehicles manufactured in two or more stages, and vehicles that are altered after previously having been certified in accordance with part 567 of this chapter. In addition, this part does not apply to manufacturers whose worldwide production of motor vehicles is less than 5000 vehicles in a production year.

**§ 585.4 Definitions.**

(a) All terms defined in 49 U.S.C. 30102 are used in accordance with their statutory meaning.

(b) The terms bus, gross vehicle weight rating or GVWR, multipurpose passenger vehicle, passenger car, and truck are used as defined in section 571.3 of this chapter.

(c) For the purposes of this part, vehicles means passenger cars and trucks, buses, and multipurpose passenger vehicles with a GVWR of 3,855 kg (8500 lb) or less and an unloaded vehicle weight of 2,495 kg (5500 lb) or less manufactured for sale in the United States by manufacturers whose worldwide production of motor vehicles is equal to or greater than 5000

vehicles in a production year, and does not mean walk-in vans, vehicles designed to be sold exclusively to the U.S. Postal Service, vehicles manufactured in two or more stages, and vehicles that are altered after previously having been certified in accordance with part 567 of this chapter.

(d) Phase one of the advanced air bag requirements of Standard No. 208 refers to the requirements set forth in S14.1, S14.2, S14.5.1, S14.5.2(a), S15.1, S15.2(a), S17, S19, S21, S23, and S25 of Federal Motor Vehicle Safety Standard No. 208, 49 CFR 571.208.

(e) Phase two of the advanced air bag requirements of Standard No. 208 refers to the requirements set forth in S14.3, S14.4, S14.5.1, S14.5.2(b), S15.1, S15.2(b), S17, S19, S21, S23, and S25 of Federal Motor Vehicle Safety Standard No. 208, 49 CFR 571.208.

(f) Production year means the 12-month period between September 1 of one year and August 31 of the following year, inclusive.

(g) Limited line manufacturer means a manufacturer that sells two or fewer carlines, as that term is defined in 49 CFR 583.4, in the United States during a production year.

**§ 585.5 Reporting requirements.**

(a) Advanced credit phase-in reporting requirements.

(1) Within 60 days after the end of the production years ending August 31, 2000, August 31, 2001, August 31, 2002, and August 31, 2003, each manufacturer choosing to certify vehicles manufactured during any of those production years as complying with phase one of the advanced air bag requirements of Standard No. 208 shall submit a report to the National Highway Traffic Safety Administration as specified below.

(2) Within 60 days after the end of the production year ending August 31, 2007, each manufacturer choosing to certify vehicles manufactured during that production year as complying

with phase two of the advanced air bag requirements of Standard No. 208 shall submit a report to the National Highway Traffic Safety Administration as specified below.

(3) Each report shall –

(i) Identify the manufacturer;

(ii) State the full name, title, and address of the official responsible for preparing the report;

(iii) Identify the production year being reported on;

(iv) Provide the information specified in paragraph (c) of this section;

(v) Be written in the English language; and

(vi) Be submitted to: Administrator, National Highway Traffic Safety Administration, 400 Seventh Street, SW, Washington, DC 20590.

(b) Phase-in reporting requirements.

(1) Within 60 days after the end of the production years ending August 31, 2004, August 31, 2005, and August 31, 2006, each manufacturer shall submit a report to the National Highway Traffic Safety Administration regarding its compliance with phase one of the advanced air bag requirements of Standard No. 208 for its vehicles produced in that production year. Each report shall also specify the number of advance credit vehicles, if any, that are being applied to the production year being reported on.

(2) Within 60 days after the end of the production years ending August 31, 2008, August 31, 2009, and August 31, 2010, each manufacturer shall submit a report to the National Highway Traffic Safety Administration regarding its compliance with phase two of the advanced air bag requirements of Standard No. 208 for its vehicles produced in that production year. Each report

shall also specify the number of advance credit vehicles, if any, that are being applied to the production year being reported on.

(3) Each report shall –

(i) Identify the manufacturer;

(ii) State the full name, title, and address of the official responsible for preparing the report;

(iii) For limited line manufacturers, specify whether the manufacturer has elected to comply with S14.1(a) or S14.1(b), or S14.3(a) or S14.3(b) of 49 CFR 571.208, as applicable;

(iv) Identify the production year being reported on;

(v) Contain a statement regarding whether or not the manufacturer complied with phase one of the advanced air bag requirements of Standard No. 208 or phase two of the advanced air bag requirements of Standard No. 208, as applicable to the period covered by the report, and the basis for that statement;

(vi) Provide the information specified in paragraph (d) of this section;

(vii) Be written in the English language; and

(viii) Be submitted to: Administrator, National Highway Traffic Safety Administration, 400 Seventh Street, SW, Washington, DC 20590.

(c) Advanced credit phase-in report content.

(1) Production of complying vehicles.

(i) With respect to the reports identified in section 585.5(a)(1), each manufacturer shall report for the production year for which the report is filed the number of vehicles, by make and model year, that meet the applicable advanced air bag requirements of Standard No. 208, and to which advanced air bag requirements the vehicles are certified.

(ii) With respect to the report identified in section 585.5(a)(2), each manufacturer shall report the number of vehicles, by make and model year, that meet the applicable advanced air bag requirements of Standard No. 208, and to which advanced air bag requirements the vehicles are certified.

(2) Vehicles produced by more than one manufacturer. Each manufacturer whose reporting of information is affected by one or more of the express written contracts permitted by S14.1.3.2 or S14.3.3.2 of Standard No. 208 shall:

(i) Report the existence of each contract, including the names of all parties to the contract and explain how the contract affects the report being submitted.

(ii) Report the number of vehicles covered by each contract in each production year.

(d) Phase-in report content.

(1) Basis for phase-in production requirements. For production years ending August 31, 2003, August 31, 2004, August 31, 2005, August 31, 2007, August 31, 2008, and August 31, 2009, each manufacturer shall provide the number of vehicles manufactured in the current production year, or, at the manufacturer's option, for the current production year and each of the prior two production years if the manufacturer has manufactured vehicles during both of the two production years prior to the year for which the report is being submitted.

(2) Production of complying vehicles. Each manufacturer shall report for the production year for which the report is filed the number of vehicles, by make and model year, that meet the applicable advanced air bag requirements of Standard No. 208, and to which advanced air bag requirements the vehicles are certified.

(3) Vehicles produced by more than one manufacturer. Each manufacturer whose reporting of information is affected by one or more of the express written contracts permitted by S14.1.3.2 or S14.3.3.2 of Standard No. 208 shall:

(i) Report the existence of each contract, including the names of all parties to the contract and explain how the contract affects the report being submitted.

(ii) Report the number of vehicles covered by each contract in each production year.

**§ 585.6 Records.**

Each manufacturer shall maintain records of the Vehicle Identification Number of each vehicle for which information is reported under § 585.5(c)(1) and (d)(2) until December 31, 2011.

**§ 585.7 Petitions to extend period to file report.**

A petition for extension of the time to submit a report required under this part shall be received not later than 15 days before the report is due. The petition shall be submitted to: Administrator, National Highway Traffic Safety Administration, 400 Seventh Street, SW, Washington, DC 20590. The filing of a petition does not automatically extend the time for filing a report. A petition will be granted only if the petitioner shows good cause for the extension, and if the extension is consistent with the public interest.

PART 595--RETROFIT ON-OFF SWITCHES FOR AIR BAGS

8. The authority citation for part 595 reads as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30117, 30122 and 30166; delegation of authority at 49 CFR 1.50.

9. Section 595.5 is amended by revising paragraph (a) to read as follows:

**§ 595.5 Requirements.**

(a) Beginning January 19, 1998, a dealer or motor vehicle repair business may modify a motor vehicle manufactured before September 1, 2012 by installing an on-off switch that allows an occupant of the vehicle to turn off an air bag in that vehicle, subject to the conditions in paragraphs (b)(1) through (5) of this section.

Issued on:

Rosalyn G. Millman
Acting Administrator

Billing Code 4910-59-P

DRAFT DELIBERATIVE DOCUMENT, DO NOT RELEASE

NHTSA
People Saving People

# FINAL ECONOMIC ASSESSMENT

National Highway Traffic Safety Administration

# *FMVSS NO. 208*
# *ADVANCED AIR BAGS*

Office of Regulatory Analysis & Evaluation
Plans and Policy
March, 2000

# TABLE OF CONTENTS


Executive Summary . . . . . E-1

I. Introduction . . . . . I-1

II. Target Population . . . . . II-1
- A. Fatalities . . . . . II-1
- B. Injuries . . . . . II-14

III. Injury Criteria . . . . . III-1
- A. Summary of NHTSA's ICPL Proposal . . . . . III-3
- B. Injury Risk Curves . . . . . III-6
- C. Injury Criteria and IARVs for Analysis Purposes . . . . . III-26

IV. Test Data and Analysis of Test Data . . . . . IV-1
- A. Static Tests, Out-of-Position . . . . . IV-2
- B. Full-Scale Vehicle Tests (In-Position) . . . . . IV-16
- C. Summary of Pass Rates . . . . . IV-39
- D. Test Procedure Stringency . . . . . IV-44

V. Technology Options and Analysis . . . . . V-1
- A. Discussion of Technologies . . . . . V-1
- B. Out-of-Position Test Technologies . . . . . V-2
- C. High Speed Test Technologies . . . . . V-11
- D. Analysis of Alternative High Speed Tests . . . . . V-12

VI. Potential Benefits . . . . . VI-1
- A. Target Population . . . . . VI-7
- B. Overview of Method . . . . . VI-12
- C. Benefit Estimates . . . . . VI-22
- D. Benefits Summary . . . . . VI-60
- E. Sensitivity Study #1, Safety Belt Use . . . . . VI-65
- F. Sensitivity Study #2, Redesigned Air Bag . . . . . VI-71
- G. Discussion . . . . . VI-72


DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

## TABLE OF CONTENTS - continued


VII. Technology Costs, and Leadtime . . . . . VII-1

A. Technology Cost . . . . . VII-1
B. Property Damage Costs . . . . . VII-21
C. Total and Net Costs . . . . . VII-30
D. Compliance Test Costs . . . . . VII-34
E. Leadtime . . . . . VII-41

VIII. Cost Effectiveness . . . . . VIII-1

IX. Regulatory Flexibility Act and Unfunded Mandates Acts . . . . . IX-1

X. Cumulative Impacts of Recent Rulemakings . . . . . X-1

Appendix A

A. Comparisons of Pre MY 98 to MY 98/99 Air Bags . . . . . A-1
B. 30 Mph Unbelted Barrier Data (MY99 vs. Pre-MY98 & MY98 pre-98 Comparisons) vs. . . . . A-13
C. 30 Mph Unbelted Barrier Comparisons by Specific Make/Model/Year . . . . . A-15
D. Final Rule Full-Forward Seating Procedure vs. 3" Rearward, 5th Percentile Female Dummy . . . . . A-20
E. 27.5 Mph vs. 30 Mph Unbelted FRB, 5th Percentile Female Dummy . . . . . A-24
F. Multi-stage Inflator . . . . . A-26
G. Test Procedure Repeatability/Reproducibility . . . . . A-29
H. Margins by Compliance . . . . . A-33
I. Supplemental Data Full-Scale Crash Data . . . . . A-45

Appendix B

A. Response to Alliance Critique . . . . . B-1
B. Analyses of Crash Data . . . . . B-14
C. Response to IIHS . . . . . B-19
D. Response to Daimler Chrysler . . . . . B-22


DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

# EXECUTIVE SUMMARY

This Final Economic Assessment analyzes the potential impact of new performance requirements and test procedures for advanced air bag systems. Consistent with the National Highway Traffic Safety Administration Re-authorization Act of 1998, which is part of the Transportation Equity Act for the 21st Century (TEA 21), the intent of this rulemaking is to minimize risks caused by air bags to out-of-position occupants, especially infants and children, and to improve occupant protection provided by air bags for belted and unbelted occupants of all sizes. To achieve these goals, NHTSA is requiring vehicles to meet test procedures that broaden the scope of the current standard to ensure that occupants are properly protected under a wider variety of crash circumstances.

## *Test Requirements*

The risk of injury from air bags arises when occupants are too close to the air bag when it inflates. Generally, those most at risk from injury are infants, young children, and out-of-position drivers. To address these concerns, new tests employ crash dummies representing infants, 3-year olds, 6-year olds, and 5th percentile female drivers. There are a variety of tests to protect these at-risk occupants. These tests generally require either that the air bag be suppressed if certain risk conditions exist or that deployments occur at levels that produce a low probability of injury risk. For purposes of this analysis, it is assumed that manufacturers will choose the low-risk deployment option for drivers. On the passenger side, the costs and benefits of two options are examined. Option 1 assumes the automatic suppression test will be met by using a weight sensor

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

for the infant, 3 and 6 year old dummies or a weight and presence sensor. Option 2 assumes a weight sensor for infants and a low-risk air bag for the 3 and 6 year old dummies for the out-of-position tests.

The assessment analyzes two alternative sets of high speed tests to preserve and enhance air bag protection. Each set of tests includes belted and unbelted frontal rigid barrier tests using 5th percentile female and 50th percentile male crash dummies, 30 degree oblique tests into a rigid barrier using unbelted 50th percentile male dummies, and 40 percent offset frontal deformable barrier tests using belted 5th percentile female dummies. The primary difference between the two alternatives is their treatment of unbelted occupants. Alternative 1 would require an unbelted 32 to 40 kmph (20 to 25 mph) frontal rigid barrier test, while Alternative 2 would require an unbelted 32 to 48 kmph (20 to 30 mph) frontal rigid barrier test. Chapter I provides the detail of the two alternative sets of high speed tests.

NHTSA is also upgrading the injury criteria applicable to the existing 50th percentile male dummy, plus applying appropriate injury criteria to each of the new dummies in this rule, used to assess the risk of injury by changing the way head injuries are measured, by including a measure of neck injury, and by reducing the allowable chest deflection during the tests.

***Technical Feasibility***

The agency has tested three vehicles to most of the proposed tests. These are the Dodge Intrepid, the Toyota Tacoma, and the Saturn SL1. The Saturn passed all of the high speed tests

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

(Alternatives 1 and 2) and the out-of-position tests on the driver side. It did not meet the out-of-position tests on the passenger side. However, with the addition of a weight sensor, the agency believes the 1999 Saturn could pass the passenger side out-of-position tests. The Saturn performed better in these tests overall than the Intrepid or Tacoma. The Saturn SL1 has a soft crash pulse and it has a different air bag design than most vehicles with an unusual tether design in the center of the air bag. Overall, the agency believes that with different designs, more advanced sensors, and multi-stage inflators, manufacturers will be able to produce vehicles that pass the final rule's test requirements.

The agency also tested 11 other vehicles to understand how they would perform in different test conditions, most notably, in the high speed unbelted tests. These tests generally support the finding that model year (MY) 1998-99 air bags meet our new injury criteria for unbelted 50$^{th}$ percentile male dummies in a 48 kmph (30 mph) crash and for 5$^{th}$ percentile female dummies in a 32 kmph (25 mph crash). Many of them met our new injury criteria for 5$^{th}$ percentile female dummies in 48 kmph (30 mph) crashes, although there were some instances of failures with these current generation air bags. Nothing in this large body of test data suggests that air bags would require additional power to meet a 48 kmph (30 mph) requirement. The data also suggest that straightforward design changes, including recessing the air bag, improving fold patterns, and installing internal baffles in the air bag to assure safer deployment would allow 50$^{th}$ male and 5$^{th}$ female dummies to meet our injury criteria in 48 kmph (30 mph) belted and unbelted tests. The body of tests suggests that meeting the injury criteria for both the 50$^{th}$ percentile male and 5$^{th}$ percentile female in unbelted 48 kmph (30 mph) rigid barrier tests is technologically feasible.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

*Benefits*

The assessment provides analyses of the safety benefits from tests that reduce the risk of injury from air bags in low-speed crashes, as well as from tests that improve the overall effectiveness of air bags in high speed crashes. The agency estimates that in a fleet fully equipped with pre-model year (MY) 1998 air bags, there would be 46 drivers, 18 infants, 105 children, and 18 adult passengers (187 occupants in total) at risk of being killed by air bags annually because they were out of position when the air bag deployed in low speed [< 32 kmph (25 mph) delta-v] crashes. A variety of technologies could be used to prevent these deaths, including weight or presence sensors to suppress the air bag, multi-stage inflators, and low risk deployment air bags. Of the 187 potential at-risk fatalities, NHTSA estimates that suppression technologies could prevent up to 93 fatalities, low-risk air bags could prevent up to 154 fatalities, and multi-stage inflation systems could prevent up to 179 fatalities when combined with weight sensors used to suppress the air bag. Thus, more than 95 percent of the fatalities seen to date in low speed deployments could be eliminated by technologies used to meet the test requirements.

NHTSA also estimates that a fully air bag equipped fleet would result in serious to critical severity (MAIS 3-5) nonfatal injury caused by air bags to 38 drivers, 9 infants, 200 children, and 15 adult passengers that would be out of position in low speed crashes. Of these 262 serious but nonfatal injuries, suppression technologies could prevent 151 injuries, low-risk air bags could prevent 191 injuries, and multi-stage inflation systems could prevent up to 252 injuries when combined with a weight sensor. Thus, more than 95 percent of the air bag caused injuries in low speed deployments could be eliminated by technologies used to meet the test requirements.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

The analysis found that a fleet of vehicles passing the high speed tests of Alternative 1 (with an unbelted test of 20-25 mph) would save 201 to 374 fewer lives annually than a fleet designed to the 48 kmph (30 mph) baseline standard. These air bag systems would prevent from 1,479 to 1,607 moderate to critical severity (MAIS 2-5) nonfatal injuries. Air bags designed to the high speed tests of Alternative 2 (with an unbelted test of 20-30 mph) would save 43 to 51 additional fatalities annually beyond the 3,253 saved by pre-MY 1998 air bag systems. These air bags would also prevent from 324 to 1,807 moderate to critical severity nonfatal injuries.

Most of the difference between Alternative 1 and Alternative 2 is due to the high-speed unbelted test. The 30 mph unbelted test will provide more protection against fatalities in high speed crashes. Examining only the high speed unbelted test, the agency estimates that an air bag designed to meet an unbelted 30 mph test would save from 248 to 413 more lives than one designed to an unbelted 25 mph standard. However, the 25 mph test could result in single-stage air bag designs that would reduce about 1,200 more nonfatal injuries than the 30 mph test. The less aggressive air bags that can be designed to a 25 mph unbelted test can result in fewer air bag caused injuries at low speeds. Thus, air bags designed to a 30 mph test prevent more fatalities, while single-stage air bags designed to a 25 mph test prevent more injuries. However, we anticipate manufacturers will utilize multi-stage air bags to meet the final rule. Thus, it is unlikely that there will be higher injury benefits for an air bag designed an unbelted 25 mph test.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

*Costs*

Potential compliance costs for the Final Rule vary considerably and are dependent upon the method chosen by manufacturers to comply. Methods such as modified fold patterns and inflator adjustments can be accomplished for little or no cost, given some leadtime. More sophisticated solutions such as proximity sensors can increase costs significantly. Dynamic presence sensors (the technology assumed for the high end costs of Option 1) are not available at this point in time. They have not been refined to the point that they are in use in vehicles and are not required by tests in either Alternative. However, they have the potential to provide more benefits on the passenger side than weight sensors or low risk air bags. Dynamic presence sensors could be used by manufacturers to meet the test requirements in the future. As such, the cost and benefits of these systems have been estimated. The range of potential costs for the compliance scenarios examined in this analysis is $21-$124 per vehicle (1997 dollars). This amounts to a total potential annual cost of up to $1.9 billion, based on 15.5 million vehicle sales per year.

***Property Damage Savings***

Compliance methods that involve the use of suppression technology have the potential to produce significant property damage cost savings because they prevent air bags from deploying unnecessarily. This saves repair costs to replace the passenger side air bag, and frequently to replace windshields damaged by the air bag deployment. Property damage savings from these requirements could total up to $85 over the lifetime of an average vehicle. This amounts to a potential cost savings of $1.3 billion.

*Net Cost Per Fatality Prevented*

Estimates were made of the net costs per equivalent fatality prevented. Property damage savings have the potential to offset all, or nearly all of the cost of meeting this final rule. Most scenarios resulted in positive safety impacts and net costs. For these scenarios, the maximum range of cost per equivalent fatality saved from the scenarios examined in this analysis is $0.8 million per equivalent fatality saved to $4.1 million per equivalent fatality saved. However, the low end of the range for both Alternative 1 scenarios produced no positive net benefits. For these cases, added costs resulted in either a zero or a negative safety impact. This reflects the conflicting impacts on fatalities and injuries that result from the weaker testing requirements of Alternative 1. Lives are not saved in high speed crashes, but nonfatal injuries are prevented in lower speed crashes. The positive impact on nonfatal injuries either totally or partially offset the negative impact on fatalities. Further, in two scenarios, there was both a net cost savings and a net safety benefit. In these two cases, both impacts are positive so there is no cost per equivalent fatality, just positive cost and safety benefits.

The range for passenger-side impacts is more favorable than for driver-side impacts. This is due to the potential property damage savings from suppressing air bags for children (or when the passenger seat is not occupied), and because there are far fewer out-of-position drivers at risk than there are passengers. Passenger side costs for those scenarios with both net safety impacts and net costs vary from $1.0 million per equivalent fatality to $2.1 million per equivalent fatality. On the driver's side, costs range from zero to a cost of $2.2 million per equivalent fatality prevented.

DRAFT DELIBERATIVE DOCUMENT. DO NOT RELEASE

*Conclusions*

Table E-1 summarizes the costs and benefits of the different Alternatives examined in this analysis. Alternative 2 would produce an estimated cost-per equivalent fatality prevented ranging from $800,000 to $1.8 million, but its most favorable result would produce both a net cost savings (due to reduced property damage) of $300 million plus a savings of 339 equivalent fatalities. Alternative 1 could produce a net cost per equivalent fatality of $4.1 million. However, it could also fail to produce added net safety benefits, or even result in a reduction in safety benefits compared to the baseline fleet. Its most favorable result is a net cost savings of $330 million with a savings of 142 equivalent fatalities. Considering that the low and high range of both scenarios examined for Alternative 2 produce higher safety benefits than the best result for Alternative 1, the analysis supports the selection of Alternative 2 for the final rule.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table E-1
Summary of Costs and Benefits

| | Cost Per Vehicle | Total Costs (Billions) | Lifetime Property Damage Savings Per-Vehicle | Total Property Damage Savings (Billions) | Net Consumer Costs (Savings) (Billions) |
|---|---|---|---|---|---|
| Alternative 1, Option 1 | $21-$123 | $0.33 - $1.91 | $12-$85 | $0.19-$1.31 | $0.13-$0.59 |
| | | | | | |
| | | | | | |
| Alternative 1, Option 2 | $24-$64 | $0.37-$0.99 | $12-$85 | $0.19-$1.31 | $0.19-($0.33) |
| | | | | | |
| | | | | | |
| Alternative 2, Option 1 | $21-$124 | $0.33-$1.92 | $12-$85 | $0.19-$1.31 | $0.13-$0.61 |
| | | | | | |
| | | | | | |
| Alternative 2, Option 2 | $24-$65 | $0.37-$1.01 | $12-$85 | $0.19-$1.31 | $0.19-($0.30) |
| | | | | | |
| | | | | Net | |
| | | Annual | Total | Cost Per | |
| | Annual | Nonfatal | Equivalent | Fatality | |
| | Fatalities | Injuries | Fatalities | Saved | |
| | Prevented | Prevented | Prevented | (Millions) | |
| Alternative 1, Option 1 | -237 to -22 | 1667-1859 | -30 to 145 | NS-$4.1M | |
| | | | | | |
| | | | | | |
| Alternative 1, Option 2 | -206 to -24 | 1713-1849 | 0 to 142 | ZS-NC | |
| | | | | | |
| | | | | | |
| Alternative 2, Option 1 | 162 to 230 | 498-2059 | 168 to 342 | $0.8M-$1.8M | |
| | | | | | |
| | | | | | |
| Alternative 2, Option 2 | 204 to 228 | 862-2049 | 231 to 339 | $0.8M-NC | |

NS = Negative safety benefits
NC = No cost, or a net cost savings
ZS = No net safety benefits

Alternative 1 includes: 20-25 mph unbelted test, 0-30 mph belted test, 0-25 mph offset belted test
Alternative 2 includes: 20-30 mph unbelted test, 0-30 mph belted test, 0-25 mph offset belted test
Option 1 includes, passengers up to 6 years old suppression, driver low risk air bag
Option 2 includes, infant suppression, passenger low risk air bag, driver low risk air bag

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE



# I. INTRODUCTION

This assessment accompanies a final rule to upgrade the agency's standard to improve occupant protection provided by air bags. While current air bags have been shown to be highly effective in reducing overall fatalities and injuries, sometimes their deployment has resulted in fatalities to out-of-position occupants, especially children. The final rule seeks both to improve air bag performance and to minimize the risks from air bags.

The final rule provides options to manufacturers to account for the differing kinds of technological solutions that may be used to address this problem, e.g., technologies that enable air bags to deploy in a manner so they do not result in serious injuries or which suppress air bag deployment in the presence of infants or out-of-position occupants.

September 1998, Notice of Proposed Rulemaking:

On September 18, 1998, NHTSA published in the **Federal Register** (63 FR 49958) a notice of proposed rulemaking (NPRM) to upgrade Federal Motor Vehicle Safety Standard (FMVSS) No. 208, Occupant Crash Protection, to require advanced air bags.

The NPRM proposed to add a new set of requirements to prevent air bags from causing injuries and to expand the existing set of requirements intended to ensure that air bags cushion and protect occupants in frontal crashes. There would be several new performance requirements to ensure that the advanced air bags do not pose unreasonable risks to out-of-position occupants.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE



The proposal included options for complying with those requirements so that vehicle manufacturers would be free to choose from a variety of effective technological solutions and to develop new ones if they so desire. With this flexibility, they could use technologies that control air bag deployment so deploying air bags do not cause serious injuries or that prevent air bag deployment if children or out-of-position occupants are present.

To ensure that the new air bags are designed to reduce the chance of causing injury to a broad array of occupants, NHTSA proposed test requirements using dummies representing 12-month-old, 3-year-old and 6-year-old children, 5th percentile adult females, and 50$^{th}$ percentile adult males. Many of the proposed test procedures were new, and comments were specifically requested with respect to their suitability for measuring the performance of the various advanced systems under development.

NHTSA proposed requirements to ensure that the new air bags are designed to cushion and protect a broader array of belted and unbelted occupants, including teenagers and small women. The standard's current dynamic crash test requirements specify the use of 50th percentile adult male dummies only. NHTSA also proposed to specify use of 5th percentile adult female dummies for these tests. The weight and size of these dummies are representative of not only small women, but also many teenagers.

NHTSA also proposed to add a deformable barrier crash test. This proposed new crash test requirement was intended to ensure that air bag systems are designed so that the air bag deploys

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE



earlier in crashes with softer crash pulses, before normally seated occupants, including small-statured ones, move too close to the air bag. NHTSA proposed to use 5th percentile adult female dummies in this test.

NHTSA also proposed to phase out the unbelted sled test option as vehicle crash test requirements for advanced air bags are phased in. Although it was believed that the sled test option has been a useful temporary measure to ensure that the vehicle manufacturers could quickly depower all of their air bags and to help ensure that some protection would continue to be provided, NHTSA did not consider sled testing to be an adequate long-term means of assessing the extent of occupant protection that a vehicle and its air bag will afford occupants in the real world.

Finally, NHTSA proposed new and/or upgraded injury criteria for each of the existing and proposed new test requirements.

November 1999, Supplemental Notice of Proposed Rulemaking:

On November 5, 1999, NHTSA published in the Federal Register (64 FR 60556) a supplemental notice of proposed rulemaking (SNPRM) to upgrade FMVSS 208 to require advanced air bags (Docket No. 1999-6407; Number 1)[1]. Three support documents were published at the same time.

---

[1] To read the docket go to http://dms.dot.gov, click on "search", type in four-digit docket number "6407", click on "search".

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE



These were:

1) "Preliminary Economic Assessment, SNPRM, FMVSS No. 208, Advanced Air Bags" (Docket 1999-6407, Number 2)

2) "Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems II" (Docket 1999-6407, Number 5) and

3) "Updated Review of Potential Test Procedures for FMVSS No. 208"(Docket 1999-6407, Number 6)

NHTSA has analyzed the public comments and also conducted some additional testing. Specific comments are addressed as appropriate throughout this analysis. Many are addressed in Appendix B.

In the supplemental notice of proposed rulemaking (SNPRM) the agency modified its proposal based on information gathered and research conducted. The agency again proposed tests to minimize the risks to infants, children, and other occupants from injuries and deaths caused by air bags (see Figure I-1). The structure of these tests have remained essentially the same for the final rule.

The agency also proposed two alternatives for dynamic frontal crash tests. One of these includes a return to an unrestrained rigid barrier test (in the speed range of 18 mph to a high end between 25 and 30 mph) and adds other requirements to the standard's dynamic frontal crash test requirements to enhance protection for a wider range of occupants. The current dynamic crash

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

test requirements specify use of 50th percentile male dummies. The agency proposed those same requirements also be met using 5th percentile female dummies. In addition, the agency proposed to add a new dynamic offset deformable barrier crash test. This test is intended to ensure that air bags deploy sufficiently early in a crash, before normally seated occupants move too close to the air bag. This up to 25 mph test into an offset deformable barrier using belted 5th percentile female dummies was initially proposed in the NPRM.

The second alternative included a second offset deformable barrier test which must be passed at any speed between 22-35 mph using both 5$^{th}$ female and 50$^{th}$ male unbelted dummies. This test could result in improved vehicle structural integrity. The agency also proposed specifications for the deformable barrier for this test.

<u>The alternatives considered in this Final Economic Analysis</u>

The agency has decided not to include the 22-35 mph offset deformable test using unbelted dummies in the final rule. This test had no support at all from commenters. Commenters had concerns about the variability of the test and concerns about how this test might force them into sensor designs that would result in more air bag deployments than desired. They also stated that the European barrier used in the offset test is not appropriate for testing larger sport-utility vehicles and light trucks.

This analysis examines two specific sets of groupings for the high speed tests. While the agency considered different alternative speeds and different effective dates being phased-in, this analysis

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE



examines only the eventual full implementation considered for this rulemaking, regardless of the effective dates. These are shown as Alternative 1 (see Figure I-2) and Alternative 2 (see Figure I-3). See the leadtime discussion in Chapter VII for the phase-in schedules considered and the eventual final rule dates chosen.

Alternative 1
High Speed Test Requirements

| | | |
|---|---|---|
| 20 to 25 mph unbelted for 5th female | – | perpendicular only |
| 20 to 25 mph unbelted for 50th male | – | perpendicular and +/- 30 degrees |
| 0 to 30 mph belted for 5th female | – | perpendicular only |
| 0 to 30 mph belted for 50th male | – | perpendicular only |
| 0 to 25 mph belted with 5th female | – | offset on driver side |

Alternative 2
High Speed Test Requirements

| | | |
|---|---|---|
| 20 to 30 mph unbelted for 5th female | – | perpendicular only |
| 20 to 30 mph unbelted for 50th male | – | perpendicular and +/- 30 degrees |
| 0 to 30 mph belted for 5th female | – | perpendicular only |
| 0 to 30 mph belted for 50th male | – | perpendicular only |
| 0 to 25 mph belted with 5th female | – | offset on driver side |

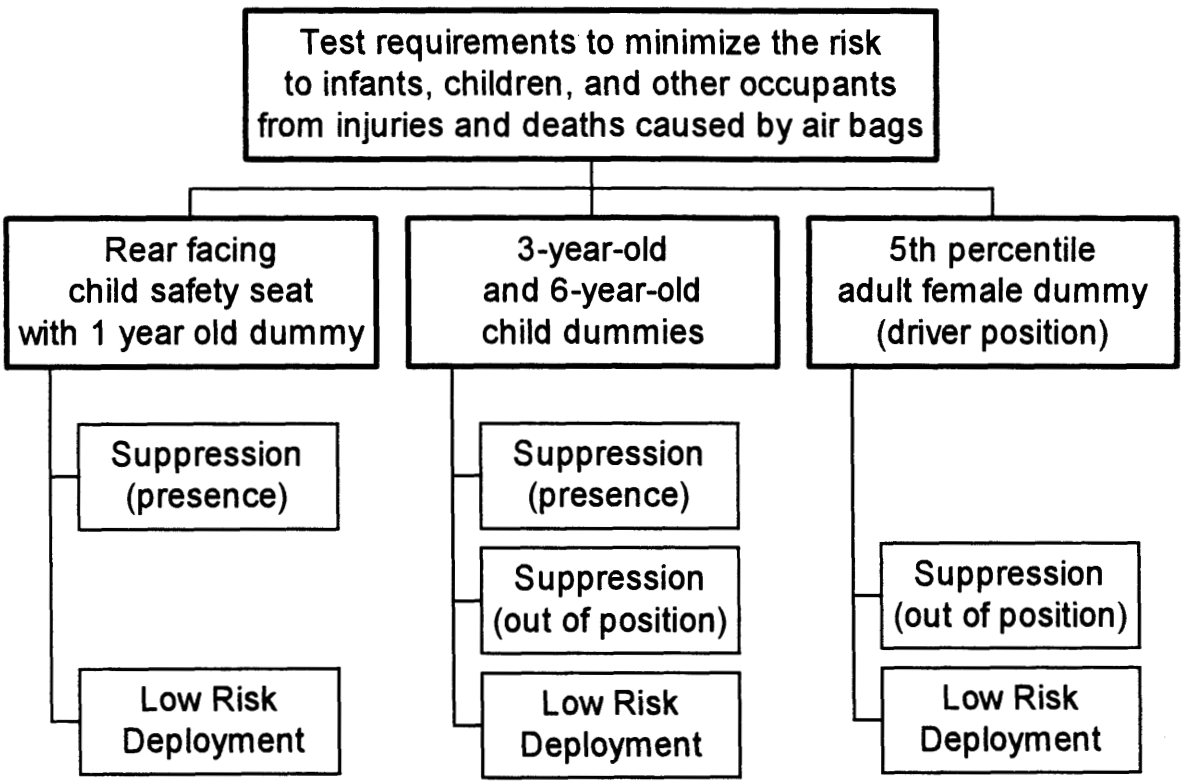
The final rule also establishes new injury criteria for the existing 50th percentile male dummy, as well as injury criteria for the new dummies (12-month old infant, 3-year old child, 6-year old child, and 5th percentile female dummy). The criteria include a few modifications from those proposed in the SNPRM. A detailed discussion of these criteria is provided within the analysis in Chapter III.

DRAFT-DELIBERATIVE DOCUMENT-DO NOT. RELEASE



Figure I-1

Test Requirements to Minimize the Risk to Infants
Children and Other Occupants from Injuries
And Deaths Caused by Air Bags



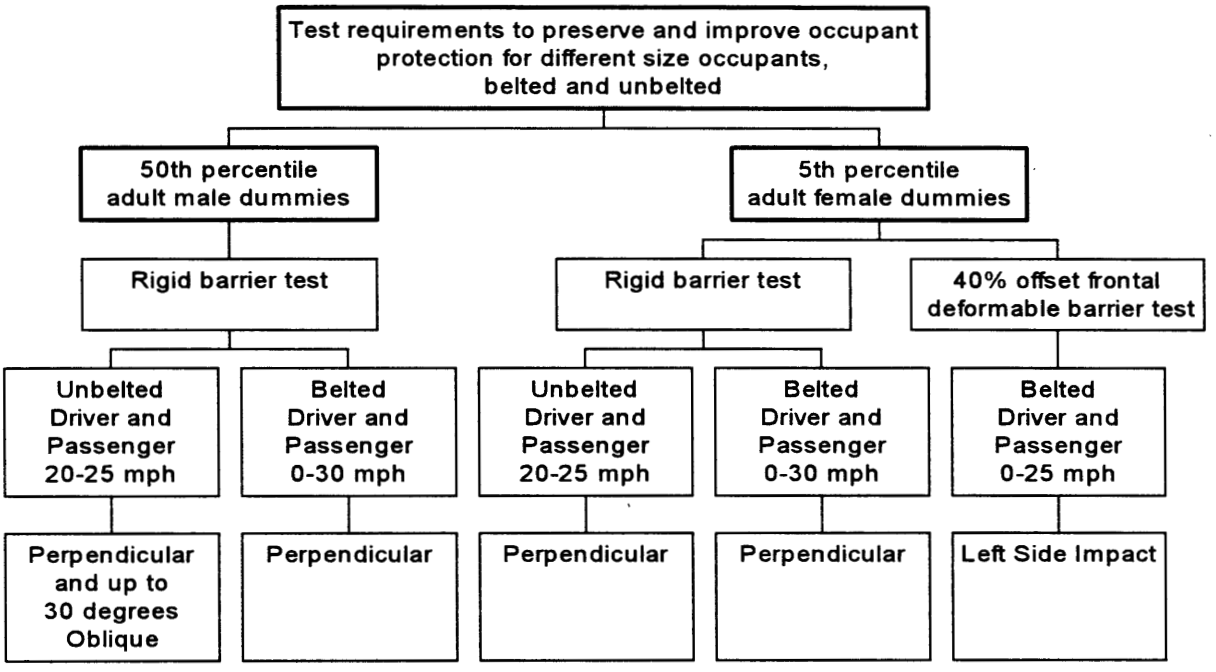
DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE



Figure I-2

High Speed Test Requirements to Preserve and Improve Occupant Protection

Alternative 1



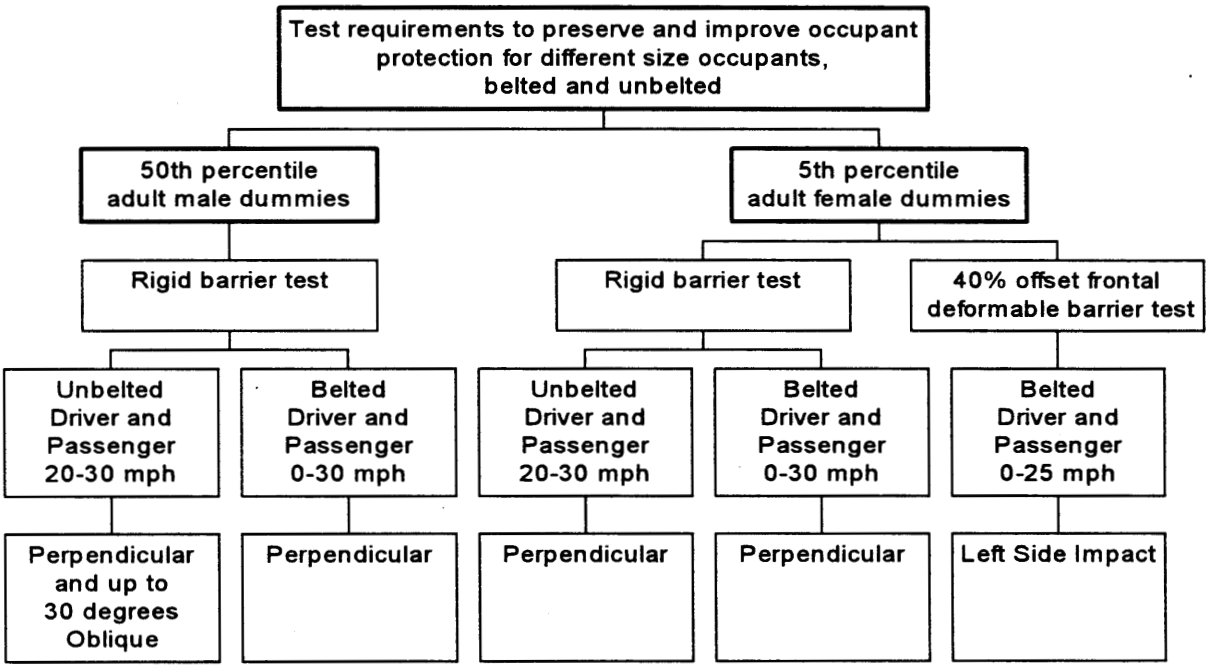
DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE



Figure I-3

High Speed Test Requirements to Preserve and Improve Occupant Protection

Alternative 2



# II. TARGET POPULATION AND SAFETY CONCERNS

Advanced air bags have the potential to improve the benefits of air bag systems and to reduce air bag induced fatalities and serious injuries. This chapter estimates the size of the potential target population that would benefit from advanced air bags. Fatalities and injuries are discussed in separate sections.

## A. Fatalities

Fatalities reported here were derived from NHTSA's 1997 Fatality Analysis Reporting System (FARS). In 1997, there were a total of 18,136 drivers and right front passengers killed in frontal crashes (see Table II-1) which accounted for about 63 percent of fatalities to these occupants. Of the 18,136 fatalities, 14,004 (77 percent) were drivers and 4,132 were right front-seated passengers. The majority (68 percent) of these fatalities were unrestrained occupants[1].

Table II-2 shows these fatalities disaggregrated by impact speeds and belt use. Note that fatal frontal crashes in FARS are categorized by initial or principal point of impacts (IMPACT1 or IMPACT2). Occupants are considered to be in frontal crashes if their vehicles had an area of damage in a 10-2 o'clock direction. Distribution by crash impact speeds was derived from

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

[1]. The restraint use distribution was based on the 1993 to 1997 National Automotive Sampling System (NASS) Crashworthiness Data System (CDS), so that this table would be consistent with Table II-2. Table II-2 provides a distribution of fatalities by delta v. Delta v is only available in NASS-CDS.

Table II-1
1997 Driver and Right Front Passenger Fatalities

| All Impact Modes | Drivers | Right Front Passengers | Total |
|---|---|---|---|
| Passenger Cars | 14,843 | 4,987 | 19,830 |
| Restrained | 5,552 | 1,895 | 7,447 |
| Unrestrained | 9,291 | 3,092 | 12,383 |
| Light Trucks/Vans | 6,937 | 1,969 | 8,906 |
| Restrained | 2,583 | 755 | 3,338 |
| Unrestrained | 4,354 | 1,214 | 5,568 |
| Total | 21,780 | 6,956 | 28,736 |
| Restrained | 8,135 | 2,650 | 10,785 |
| Unrestrained | 13,645 | 4,306 | 17,951 |
| **Frontal Impacts*** | | | |
| Passenger Cars | 9,489 | 2,992 | 12,481 |
| Restrained | 3,036 | 957 | 3,993 |
| Unrestrained | 6,453 | 2,035 | 8,488 |
| Light Trucks/Vans | 4,515 | 1,140 | 5,655 |
| Restrained | 1,445 | 365 | 1,810 |
| Unrestrained | 3,070 | 775 | 3,845 |
| Total | 14,004 | 4,132 | 18,136 |
| Restrained | 4,481 | 1,322 | 5,803 |
| Unrestrained | 9,523 | 2,810 | 12,333 |

Source: NHTSA 1997 Fatality Analysis Reporting System (FARS), 1993-97 Crashworthiness Data System (CDS)
* Frontal crashes are defined as initial or principal impact force from 10-2 o'clock direction.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

the 1993 to 1997 NASS CDS. Because of variations in data elements describing crash characteristics, it is not possible to establish a one-to-one association between FARS and CDS; hence frontal crashes are defined somewhat differently for these two databases. Frontal crashes in the NASS CDS are defined by their principal direction of force (DOF1), their general area of damage (GAD1), and the primary specific horizontal location (SHL1) as either:

GAD1='F' (front),

<u>or</u>

GAD1 = 'L' (left side) or GAD1 = 'R' (right side), and

SHL1 = 'F' (front), and

DOF1=10, 30, 50, 70, 90, 11, 31, 51, 71, 91, 12, 32, 52, 72, 92, 1, 21, 41, 61, 81, 2, 33, 42, 62, 82

or

GAD1 = 'L' (left side) or GAD1 = 'R' (right side), and

SHL1 ^= 'F' (front), and

DOF1=11, 31, 51, 71, 91, 12, 32, 52, 72, 92, 1, 21, 41, 61, 81

Table II-2
Fatalities In Frontal Impacts By Crash Severity

| | Crash Severity (Speed in MPH) | | | | |
|---|---|---|---|---|---|
| **Actual Fatalities (1997)** | **0-25** | **26-30** | **31-35** | **36+** | **Total** |
| **Drivers** | 4,792 | 2,168 | 1,804 | 5,240 | 14,004 |
| Restrained | 1,721 | 493 | 674 | 1,593 | 4,481 |
| Unrestrained | 3,071 | 1,675 | 1,130 | 3,647 | 9,523 |
| **Passengers** | 1,414 | 639 | 532 | 1,547 | 4,132 |
| Restrained | 507 | 145 | 199 | 471 | 1,322 |
| Unrestrained | 907 | 494 | 333 | 1,076 | 2,810 |
| **Total** | 6,206 | 2,807 | 2,336 | 6,787 | 18,136 |
| Restrained | 2,228 | 638 | 873 | 2,064 | 5,803 |
| Unrestrained | 3,978 | 2,169 | 1,463 | 4,723 | 12,333 |

Source: NHTSA 1993-1997 CDS and 1997 FARS.
Note: Fatalities by crash speeds and belt use were derived from 1993-1997 CDS and adjusted to 1997 FARS level.

The agency has estimated that air bags have saved 5,303 lives cumulatively from 1987 through March 1, 2000. In calendar year 1997, about 36 percent of the on-road passenger cars and 28 percent of light trucks/vans were equipped with driver side air bags, and 22 percent of passenger cars and 17 percent of light trucks/vans were equipped with passenger side air bags. Air bags saved an estimated 842 lives in 1997. If one assumes that all passenger vehicles (cars, utility vehicles, light trucks, and vans) had been equipped with air bags, they would have saved an

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

estimated 3,253 lives annually. In total, there would have been 18,978 (18,136 + 842) potential fatalities associated with frontal impacts if no vehicles had air bags in 1997. Potential fatalities are defined as people in frontal crashes that died plus those that would have been fatally injured in the absence of air bags.

Table II-3 shows, by several crash impact speed levels, the potential fatalities, lives that would have been saved, and the remaining fatalities if all vehicles in the fleet were equipped with pre-98 air bag systems. Advanced air bags have the potential to reduce the remaining fatalities. Belt use in Table II-3 is assumed to be the same as found in 1993-1997 CDS fatalities at 32 percent.

As shown in Table II-3, an entire fleet of pre-MY 1998 air bags would save an estimated 3,253 lives annually. Air bags are thus an important source of occupant protection in current passenger vehicles. However, air bags may have adverse effects on occupants who are too close to the air bags when they deploy. Of particular concern are children. As of January 1, 2000, NHTSA's Special Crash Investigation (SCI) Program has identified a total of 169 cases (142 confirmed and 27 still under investigation) of < 25 mph $\Delta v$ in which the deployment of an air bag resulted in fatal injuries to an occupant between 1990 and 1998. Of these 169 fatalities, 17 were infants in rear-facing child safety seats (RFCSS), 79 were children aged one to twelve years old, 63 were drivers, and 10 were adult passengers. These cases were then projected to an annual basis under the assumption that all passenger vehicles were equipped with pre-MY 1998 air bags by multiplying the actual number of incidents by an adjustment factor (f) that adjusts the vehicle fleet to a fleet in which all vehicles have air bags. By assuming that air bag-induced fatalities are proportional to the percentage of the fleet with air bags, the adjustment factor for each year is the ratio of the number of vehicles in operation to the number with air bags, i.e., $f=1/r$ where r is the percentage of the fleet with air bags. The corresponding mathematical formula is:

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table II-3
Estimated Lives Saved and Fatalities Remaining in Frontal Crashes
Assuming the Whole Fleet of Passenger Vehicles Had Air Bags

| Potential Fatalities With No Air Bags | Crash Severity (Speed in MPH) | | | | Total |
|---|---|---|---|---|---|
| | 0-25 | 26-30 | 31-35 | 36+ | |
| **Drivers** | 5,035 | 2,278 | 1,895 | 5,507 | 14,715 |
| Restrained | 1,797 | 514 | 705 | 1,664 | 4,680 |
| Unrestrained | 3,238 | 1,764 | 1,190 | 3,843 | 10,035 |
| **Passengers** | 1,459 | 659 | 549 | 1,596 | 4,263 |
| Restrained | 522 | 150 | 204 | 483 | 1,359 |
| Unrestrained | 937 | 509 | 345 | 1,113 | 2,904 |
| **Total** | 6,494 | 2,937 | 2,444 | 7,103 | 18,978 |
| Restrained | 2,319 | 664 | 909 | 2,147 | 6,039 |
| Unrestrained | 4,175 | 2,273 | 1,535 | 4,956 | 12,939 |
| **Estimated Lives Saved with Full Fleet of Air Bags** | | | | | |
| **Drivers** | 1,133 | 535 | 425 | 381 | 2,474 |
| Restrained | 323 | 93 | 127 | 91 | 634 |
| Unrestrained | 810 | 442 | 298 | 290 | 1,840 |
| **Passengers** | 328 | 154 | 123 | 174 | 779 |
| Restrained | 94 | 27 | 37 | 49 | 207 |
| Unrestrained | 234 | 127 | 86 | 125 | 572 |
| **Total** | 1,461 | 689 | 548 | 555 | 3,253 |
| Restrained | 417 | 120 | 164 | 140 | 841 |
| Unrestrained | 1,044 | 569 | 384 | 415 | 2,412 |
| **Fatalities Remaining with Full Fleet of Air Bags** | | | | | |
| **Drivers** | 3,902 | 1,743 | 1,470 | 5,126 | 12,241 |
| Restrained | 1,474 | 421 | 578 | 1,573 | 4,046 |
| Unrestrained | 2,428 | 1,322 | 892 | 3,553 | 8,195 |
| **Passengers** | 1,131 | 505 | 426 | 1,422 | 3,484 |
| Restrained | 428 | 123 | 167 | 434 | 1,152 |
| Unrestrained | 703 | 382 | 259 | 988 | 2,332 |
| **Total** | 5,033 | 2,248 | 1,896 | 6,548 | 15,725 |
| Restrained | 1,902 | 544 | 745 | 2,007 | 5,198 |
| Unrestrained | 3,131 | 1,704 | 1,151 | 4,541 | 10,527 |

Source: NHTSA 1993-1997 CDS and 1997 FARS.
Note: Fatalities by crash speeds were derived from 1993-1997 CDS and adjusted to 1997 FARS level.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

$$Pd = Ad * f$$

where Pd = projected deaths

Ad = actual number of deaths from SCI cases

f = the ratio of the number of total vehicles to number of vehicles with air bags.

Table II-4 shows actual and projected fatalities by years. The actual fatalities, except calendar year 1998, were those fatalities caused by pre-MY 1998 air bags. For year 1998, fatalities caused by MY-1998 (redesigned) air bags were also included in the projection because many pre-MY 1998 air bags deployed at a greater force and thus would have killed the same occupants if the pre-MY 1998 air bags were installed in the vehicles.

If all passenger vehicles were equipped with air bags, for example in the year 1998 (using the above formula Pd=Ad*f), about 15 (4*1/0.272) infants in RFCSS, 77 (21*1/0.272) children, 11 (3*1/0.272) adult passengers, and 28 (11*1/0.394) drivers would have been killed by air bags (and otherwise probably would not have died if there had been no air bag).

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table II-4
Projected At-Risk Fatalities by Years

| | Portion of Fleet with Air Bags | | SCI Cases as of 08/01/99 | | | | Projected Annual Number | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Driver | Passenger | RFCSS | Children 1-12 Years Old | Adult Passengers | Drivers | RFCSS | Children 1-12 Years Old | Adult Passengers | Drivers |
| 90 | 0.018 | 0.001 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 56 |
| 91 | 0.027 | 0.001 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 148 |
| 92 | 0.050 | 0.003 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 60 |
| 93 | 0.083 | 0.008 | 0 | 1 | 0 | 4 | 0 | 125 | 0 | 48 |
| 94 | 0.128 | 0.026 | 0 | 5 | 0 | 7 | 0 | 192 | 0 | 55 |
| 95 | 0.188 | 0.065 | 3 | 6 | 0 | 5 | 46 | 92 | 0 | 27 |
| 96 | 0.258 | 0.126 | 6 | 19 | 2 | 7 | 48 | 151 | 16 | 27 |
| 97 | 0.328 | 0.201 | 4 | 27 | 5 | 21 | 20 | 134 | 25 | 64 |
| 98 | 0.394 | 0.272 | 4 | 21 | 3 | 11 | 15 | 77 | 11 | 28 |
| 98[1] | 0.068[2] | 0.068 | 0 | 2 | 1 | 1 | See further discussion | | | |

1. This row provides information for 1998 vehicle models with redesigned air bags in calender year 1998. These fatalities are included in the 1998 numbers above.
2. The number is derived by assuming 1998 model vehicles accounted for 7.84 percent of the fleet in operation and 87 percent of these new vehicles were equipped with redesigned air bags, i.e., 0.068=0.0784*0.87.

In late 1996, the agency started a much broader public awareness program on the potential adverse effect of air bags. In addition, the agency required 1998 new vehicles to have air bag warning labels. Increasing public awareness of the air bag occupant safety issue reduced the air bag risk to rear-facing infants and children. As shown in Table II-4, the number of air bag induced fatalities gradually reduced, especially from 1997 to 1998. To take the effectiveness of the public awareness into account and to reduce year by year fluctuation, this analysis uses the weighted average of 1997 and 1998 projected deaths to estimate an annualized baseline fatal population for the at-risk groups. These projected deaths were weighted by the number of on-road operational vehicles in the fleet. There were about 194,653,000 and 198,401,000 passenger vehicles on the road in 1997 and 1998, respectively. The annualized deaths can be written as following:

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Annualized Deaths = $(194{,}653{,}000 * Pd_{97} + 198{,}401{,}000 * Pd_{98})/(194{,}653{,}000 + 198{,}401{,}000)$

where $Pd_{97}$ = projected deaths in 1997

$Pd_{98}$ = projected deaths in 1998.

Because more vehicles were on the road in 1998 than in 1997, the annualized projection thus gave a slightly greater weight to 1998 cases. In total, as shown in Table II-5, there would be approximately18 infants in RFCSS, 105 children aged 1-12, 18 adult passengers, and 46 drivers[2] killed by air bags if all vehicles in the fleet were equipped with pre-MY 1998 air bags. For comparison purpose, the projected annual deaths for MY 1998 air bags are presented here. Note, the projected numbers based on the performance of MY 1998 air bags were derived from analysis of limited SCI data. Following is a detailed description of the analysis.

Table II-5
Estimated Annual At-Risk Fatalities With A Full Fleet of Air Bags
by Air Bag Types

| At-Risk Group | Annual Deaths | |
|---|---|---|
| | Pre-MY 1998 Air Bags* | MY 1998 Air Bags** |
| Drivers | 46 | 15 |
| Adult Passengers | 18 | 5 |
| Children 1 to 12 Years Old | 105 | 35 |
| Infants in RFCSS | 18 | 10 |
| Total | 187 | 65 |

*Annual deaths were projected using 1997 and 1998 fatal cases only.
** Based on judgment and analysis of minimal data.

An analysis of Special Crash Investigation (SCI) Fatalities by Model Year and Investigation Date was undertaken to determine how well the redesigned air bags were performing, based on the

[2] The figures in the table are slightly different from the estimates in the "Preliminary Economic Assessment, FMVSS No.208, Advanced Air Bags" August 1998, NHTSA, because this analysis uses 1997 FARS and 1993-1997 CDS crash data. Also, this analysis used a different projection approach to estimate the annual at-risk population. Finally, the number killed by air bags was projected using later data from the Special Crash Investigation program, up to January 1, 2000.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

minimal data available. Table II-6 shows these data, which compare SCI Cases, including those cases not on the official list yet in ( ). This analysis compares what was known to the SCI team two years and three months (27 months) after the start of the new model year and compares MY 1996 vehicles to MY 1997 vehicles to MY 1998 vehicles over the same length of time (vehicle months on the road). No adjustments are made to this table for increased seat belt use over this period of time. The results indicate that there are still fatalities occurring to out-of-position occupants with the redesigned air bags, but fatalities appeared to have been reduced from 19 in MY 96 and 20 in MY 97, to seven in MY 98 vehicles (two of these were in vehicles with air bags that were not redesigned). Table II-7 shows these data compared to Polk registrations (discussed further at length later in this analysis). The average of MY 96 and MY 97 data is a fatality rate of 1.43. Compared to this, the fatality rate for MY 1998 of 0.48, is 33.6 percent. Part of this reduction comes from redesigned air bags and part of it comes from changes in behavior, including increased overall belt use, putting children in the rear seat, and sitting further away from the steering wheel. One way to get an initial estimate of what part of the reduction in SCI fatality rate is due to redesigned air bags as opposed to changes in behavior is to examine the difference in fatality rates between Table II-7 and its endnote (MY 1998 having a fatality rate that is .35 of the fatality rate for MY 96 and 97 over their first 27 months) and Table II-8 (MY 1998 having a fatality rate that is .56 of the fatality rate over their last 27 months). Comparing these two rates would indicate that about 2/3 of the benefit (1-.56=.44; 1-.35=.65; .44/.65=.677) seen to date is from the redesign of the air bags and 1/3 of the benefit is from changes in behavior. Initial data indicate that redesigned air bags are making good progress towards reducing the out-of-position problem.

The data are not robust enough to have any confidence about how well redesigned air bags are working for the four individual categories of out-of-position occupants (rear facing infants, forward facing children, adult passengers, and drivers). However, the potential difference is

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

significant enough that the agency will perform a sensitivity analysis, assuming redesigned air bags reduce the potential target population to 33.6 percent of its estimated total based on pre-MY 1998 models. For Table II-5, a distribution for the at-risk groups is provided based on the roughly one-third fatality rate. With no infant fatalities in rear facing child safety seats, the estimate of 10 is based on engineering judgment comparing the "aggressiveness" of pre-MY 1998 air bags to MY-1998 air bags, in general.

Table II-6
Special Crash Investigation Cases

| MY and (dates investigated) | Rear Facing Infant Fatals | Forward Facing Child Fatals | Adult Passenger Fatals | Driver Fatals | Total Fatals |
|---|---|---|---|---|---|
| MY 1999 redesigned (15 months) | 0 | 2 | 0 | 0 | 2 |
| MY 1998 redesigned (10/1/97 to 1/1/00) (27 mos.) | 0 | 2 | (1) | 1 + 1 fetus | 4 + 1 fetus |
| MY 1998 not redesigned (10/1/97 to 1/1/00) (27 mos.) | 0 | (1) | 0 | 1 | 2 |
| MY 1997 (10/1/96 to 1/1/99) (27 mos.) | 2 | 6 + (4) = 10 | 1 + (3) = 4 | 2 + (2) = 4 | 20 |
| MY 1996 (10/1/95 to 1/1/98) (27 mos.) | 1 | 9 + (3) = 12 | 0 | 5 + (1) = 6 | 19 |

* Cases under investigation, but not on official list yet.

Table II-7*
SCI Cases per Million Registered Vehicles

| | SCI Fatalities Over the First 27 Months of the MY Life | Total Registrations from Polk (millions of vehicles) | SCI Fatalities per Million Vehicles Registered |
|---|---|---|---|
| MY 1996 (10/01/95 to 11/01/97) | 19 | 13.103 | 1.45 |
| MY 1997 (10/01/96 to 11/01/98) | 20 | 14.174 | 1.41 |
| MY 1998 (10/01/97 to 11/01/99) | 7 | 14.569 (estimated) | 0.48 |

* See endnote at the end of this chapter.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table II-8 presents the similar statistics from the analysis described above but for fatalities that occurred over the last 27 months (10/01/97 to 1/01/00). The comparison indicates fatalities are a little lower over the last 27 month period. The MYs 96-97 averaged 19.5 fatalities (see Table II-7) over the first 27 months and 13.5 fatalities over the last 27 months. Rather than simply use registration data, the number of vehicle months on the road over the 27 month period was calculated taking into account registrations, vehicle miles traveled by age, and the monthly introduction of sales for new models. Thus, the MY 98 vehicles first year sales from October 1997 to October 1998 result in the MY 98 vehicles having less time on the road during this year than the MY 97 or 96 vehicles whose sales are essentially completed before the start of the 27 month period starting October 1997. The data still show that redesigned air bags perform better for out-of-position occupants.

Table II-8
SCI Cases per Million Vehicle Months

| | **SCI Fatalities Over the Last 27 Months (10/01/97-1/01/00)** | **Millions of Vehicle Months Over the Last 27 Months (10/01/97 - 1/01/00)** | **SCI Fatalities per Million Vehicle Months** |
|---|---|---|---|
| MY 1996 | 12 | 24.678 | 0.49 |
| MY 1997 | 15 | 29.851 | 0.50 |
| MY 1998 | 7 | 25.093 (estimated) | 0.28 |

Tables II-7 and II-8 showed that redesigned air bags perform better for out-of-position occupants. However, the reduction in out-of-position occupant fatalities were not impacted by redesigned air bags alone. Parents' behavior change also was a contributing factor. Table II-9 lists the percentages of children that sat in the back seat of vehicles with or without right front seat air bags by calendar year. These statistics were based on all child passengers age 0-12 in passenger cars, survivors plus fatalities, in FARS from 1995 through mid-1999.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table II-9
Percent of Child Occupants in Back Seat

| Calendar Year | Age 0-12 | Age 0 | Age 1-5 | Age 6-10 | Age 11-12 |
|---|---|---|---|---|---|
| In Cars with Dual Air Bags | | | | | |
| 1995 | 67 | 71 | 68 | 67 | 64 |
| 1996 | 69 | 71 | 71 | 67 | 66 |
| 1997 | 74 | 89 | 79 | 70 | 65 |
| 1998 | 78 | 84 | 84 | 75 | 60 |
| 1999 | 77 | 90 | 87 | 73 | 53 |
| In MY 1985-96 Cars without Dual Air Bags | | | | | |
| 1995 | 69 | 61 | 73 | 68 | 60 |
| 1996 | 70 | 65 | 73 | 69 | 62 |
| 1997 | 69 | 67 | 75 | 64 | 64 |
| 1998 | 72 | 72 | 78 | 70 | 61 |
| 1999 | 70 | 74 | 77 | 62 | 63 |

These statistics show that (1) the percent of infants and toddlers riding in the back seat of cars with dual air bags has increased substantially since 1996 - from about 70 to about 90 percent. (2) There are also moderate increases in back-seat occupancy by 1-10 year old children in cars with dual air bags - and 0-5 year old children in cars without dual air bags. (3) Overall, from 1997 to 1998, children (age 0 to 12) riding in the back seat had increased about 4 percentage points for cars with dual air bags and 3 percentage points for cars without dual air bags.

Another analysis to assess the impact of the MY 1998-2000 redesigned air bags on baseline population estimation is to examine the FARS for 1998 and the first 6 months of 1999. Air bag vehicles were broken up into redesigned air bags and those not redesigned using data provided by the manufacturers to NHTSA. Only MY 1995 to MY 2000 were analyzed to reduce the potential for an age effect, anti-lock brake effect and the effect of differences in the fleet brought about by

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

increasing light truck and van sales. The question we were trying to answer is whether the frontal fatality rate increased with the decrease in power in redesigned air bags. Fatalities in frontal crashes to front outboard occupants were compared to fatalities in other crash modes. Testing results at 30 and 35 mph showed no difference for belted occupants and a slight difference for unbelted occupants between redesigned and pre-MY 98 vehicles. Most vehicles met the 30 mph unbelted test anyway. We would expect that no difference could be found without substantially more data. No statistically significant difference was found.

The percent of fatalities that were frontal are:

57.3 % for redesigned air bags (1,051 in frontals and 782 in non-frontals)
57.7 % for not redesigned air bags (3,684 in frontals and 2,699 in non-frontals)

This results in a risk ratio of 0.985 [(1,051/782)/(3,684/2,699)], or a 1.5 percent reduction in frontal fatalities for redesigned air bags. This is not a statistically significant difference.

These pre-MY 1998 air bags, would save 3,253 lives annually, however, 187 occupants would be killed by the air bags. Thus, the net estimated lives saved would be 3,066 (3,253 - 187). Table II-10 summarizes these estimates in detail. It is important to note that the projections were based on all identified (confirmed and unconfirmed) cases. However, there are 5 unconfirmed cases in 1997 and 14 unconfirmed cases in 1998, therefore, the projected annualized at-risk population could be smaller. Equally important is the fact that all the estimates are based on the assumption that, in the future years, there are no changes in occupant demographics, driver/passenger behavior, belt use, child restraint use, or the percent of children sitting in the front seat. As public education programs are more successful in creating better awareness of occupant safety issues, and as auto manufacturers voluntarily phase in improved air bags, the potential negative safety impacts of air bags would be further reduced.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table II-10
Estimated Full Fleet Impacts of Pre-MY 1998 Air Bags on Fatalities

| | Saved | Killed | Net Impacts |
|---|---|---|---|
| **Drivers** | 2,474 | 46 | 2,428 |
| **Passengers** | 779 | 141 | 638 |
| **Adults** | 779 | 18 | 761 |
| **Children** | 0* | 105 | -105 |
| **RFCSS** | 0 | 18 | -18 |
| **Total** | 3,253 | 187 | 3,066 |

* Potentially there are benefits from air bags for correctly positioned children in high severity impacts. Sled test data do show a reduction in injury measures for correctly positioned child dummies with air bags compared to belted child dummies in 30 mph impacts. This does not appear to be the case for infants in rear facing child safety seats. All RFCSS tests have indicated an increased probability of head injury with air bags. Statistical analyses have shown negative effectiveness of air bags for children. This implies that the negative impacts of air bags for children at low speeds are overwhelming the benefits, if any, for children at high speeds. It is impossible to prove that an air bag saved a life in a particular high speed crash, since about 50 percent of unbelted occupants survive (with injuries) in crashes with a change in velocity (delta V) of 30 to 40 mph. Until there are enough data available to do a statistical analysis of the effectiveness of air bags for children at different speeds, the agency cannot estimate the benefits of air bags for children under the age of 12.

## B. Injuries

The injury population assessment uses two data sources: the 1993-1997 CDS and the 1997 General Estimates System (GES)[3]. GES is the main database used by the agency to produce national statistics on nonfatal crashes in the U.S. However, GES is a sample taken directly from police-reported crashes and does not provide in-depth investigations of injury profiles and crash configurations as does CDS. This analysis uses GES to estimate the size of injury populations and CDS to describe crash characteristics such as MAIS injury severity and delta v for crash severity.

CDS contains data on all passenger vehicle crashes where at least one passenger vehicle was towed, while GES is a sample of all police-reported crashes not limited to passenger vehicle tow-away crashes. Therefore, injury counts derived from CDS were adjusted only to the GES CDS-

[3] General Estimates System Coding Manual 1997.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

equivalent level. As with FARS, this adjustment cannot establish a one-to-one association between GES CDS-equivalent crashes and CDS crashes. CDS equivalent frontal crashes in GES are defined by Hotdeck imputed initial point of impact (IMPACT_H) and vehicle damage area (DAM_AREA) as:

IMPACT_H=1 (front), 11 (front right corner), 12 (front left corner)

<u>or</u>

IMAPCT_H=2 (right side) or 3 (left side), and

DAM_AREA has included 1 (front).

In 1997, there were 280,881 driver and right front passenger MAIS 2-5 and 1,650,175 MAIS 1 non-fatal injuries associated with frontal crashes. MAIS 1-5[4] injuries reported in Table II-11 and Table II-12 were adjusted to 1997 GES CDS-equivalent injury levels.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

[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 occupants.

Table II-11
1997 Drivers and Right Front Passengers With MAIS 2-5 Injuries

| All Impact Modes | Drivers | Right Front Passengers | Total |
|---|---|---|---|
| **Passenger Cars** | 258,058 | 77,282 | 335,340 |
| Restrained | 141,546 | 42,285 | 183,831 |
| Unrestrained | 116,512 | 34,997 | 151,509 |
| **Light Trucks/Vans** | 72,591 | 21,573 | 94,164 |
| Restrained | 40,159 | 11,910 | 52,069 |
| Unrestrained | 32,432 | 9,663 | 42,095 |
| **Total** | 330,649 | 98,855 | 429,504 |
| Restrained | 181,705 | 54,195 | 235,900 |
| Unrestrained | 148,944 | 44,660 | 193,604 |
| **Frontal Impacts** | | | |
| **Passenger Cars** | 165,607 | 47,862 | 213,469 |
| Restrained | 94,396 | 27,281 | 121,677 |
| Unrestrained | 71,211 | 20,581 | 91,792 |
| **Light Trucks/Vans** | 52,297 | 15,115 | 67,412 |
| Restrained | 29,809 | 8,616 | 38,425 |
| Unrestrained | 22,488 | 6,499 | 28,987 |
| **Total** | 217,904 | 62,977 | 280,881 |
| Restrained | 124,205 | 35,897 | 160,102 |
| Unrestrained | 93,699 | 27,080 | 120,779 |

Source: NHTSA 1997 National Automotive Sampling System - General Estimated System (NASS-GES) and - 1993-1997 Crashworthiness Data System (CDS)
Note: MAIS 2-5 injuries were derived from 1993-1997 CDS and adjusted to 1997 GES-CDS equivalent level.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table II-12
1997 Drivers and Right Front Passengers With MAIS 1 Injuries

| All Impact Modes | Drivers | Right Front Passengers | Total |
|---|---|---|---|
| **Passenger Cars** | 1,554,059 | 466,118 | 2,020,177 |
| Restrained | 1,153,790 | 346,700 | 1,500,490 |
| Unrestrained | 400,269 | 119,418 | 519,687 |
| **Light Trucks/Vans** | 434,808 | 129,391 | 564,199 |
| Restrained | 320,715 | 95,598 | 416,313 |
| Unrestrained | 114,093 | 33,793 | 147,886 |
| **Total** | 1,988,867 | 595,509 | 2,584,376 |
| Restrained | 1,474,505 | 442,298 | 1,916,803 |
| Unrestrained | 514,362 | 153,211 | 667,573 |
| **Frontal Impacts** | | | |
| **Passenger Cars** | 972,941 | 281,192 | 1,254,133 |
| Restrained | 700,518 | 202,458 | 902,976 |
| Unrestrained | 272,423 | 78,734 | 351,157 |
| **Light Trucks/Vans** | 307,245 | 88,797 | 396,042 |
| Restrained | 221,216 | 63,934 | 285,150 |
| Unrestrained | 86,029 | 24,863 | 110,892 |
| **Total** | 1,280,186 | 369,989 | 1,650,175 |
| Restrained | 921,734 | 266,392 | 1,188,126 |
| Unrestrained | 358,452 | 103,597 | 462,049 |

Source: NHTSA 1997 National Automotive Sampling System - General Estimated System (NASS-GES) and - 1993-1997 Crashworthiness Data System (CDS)
Note: MAIS 1 injuries were derived from 1993-1997 CDS and adjusted to 1997 GES-CDS equivalent level.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Air bags proved to be 10 percent[5] (not statistically significant) effective in reducing MAIS 2-5 injuries. Annually, air bags would reduce about 29,070 MAIS 2-5 injuries. Table II-13 shows three types of MAIS 2-5 injury estimates in frontal crashes by person role (driver, passenger) and crash impact speeds. These estimates are: number of MAIS 2-5 injuries with no air bags (potential MAIS 2-5 injuries), injuries reduced, and number of remaining MAIS 2-5 injuries if the whole fleet had air bags. There would be a total of 261,635 MAIS 2-5 injuries remaining annually if all vehicles had pre-MY 1998 air bags. Advanced air bags would have the potential to further reduce these remaining injuries. Note that the distribution of MAIS 2-5 injuries by person role, crash impact speeds (delta v), and restrained use were derived from 1993-1997 CDS statistics. Of the total shown, MAIS 2 injuries were 66.2 percent, MAIS 3 were 27.5 percent, MAIS 4 were 4.7 percent, and MAIS 5 were 1.6 percent. Belt use in Table II-13 is the same level found in 1993-1997 CDS at 57 percent for AIS 2-5 injuries.

A table like Table II-12 was not derived for MAIS 1 injuries since the agency believed the effectiveness of air bags for AIS 1 injuries is minimal. Many occupants have a red face from "bag slap" which is considered an AIS 1 injury. Thus, the effectiveness of reducing overall AIS 1 injuries with pre-MY 1998 air bag is believed to be minimal.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

[5] The Fourth Report to Congress, Effectiveness of Occupant Protection Systems and Their Use, May 1999.

Table II-13
Estimated MAIS 2-5 Injuries Remaining
Assuming the Whole Fleet of Passenger Vehicles Had Air Bags

| Potential Injuries With No Air Bags | Crash Severity (Speed in MPH) | | | | Total |
|---|---|---|---|---|---|
| | 0-25 | 26-30 | 31-35 | 36+ | |
| **Drivers** | 183,401 | 23,829 | 8,313 | 10,558 | 226,101 |
| Restrained | 112,103 | 8,773 | 4,173 | 4,043 | 129,092 |
| Unrestrained | 71,298 | 15,056 | 4,140 | 6,515 | 97,009 |
| **Passengers** | 52,339 | 6,801 | 2,372 | 3,092 | 64,604 |
| Restrained | 31,992 | 2,504 | 1,190 | 1,177 | 36,863 |
| Unrestrained | 20,347 | 4,297 | 1,182 | 1,915 | 27,741 |
| **Total** | 235,740 | 30,630 | 10,685 | 13,650 | 290,705 |
| Restrained | 144,095 | 11,277 | 5,363 | 5,220 | 165,955 |
| Unrestrained | 91,645 | 19,353 | 5,322 | 8,430 | 124,750 |
| **Estimated MAIS 2-5 Injuries Reduced with Full Fleet of Air Bags** | | | | | |
| **Drivers** | 18,340 | 2,383 | 831 | 1,056 | 22,610 |
| Restrained | 11,210 | 877 | 417 | 404 | 12,908 |
| Unrestrained | 7,130 | 1,506 | 414 | 652 | 9,702 |
| **Passengers** | 5,234 | 680 | 237 | 309 | 6,460 |
| Restrained | 3,199 | 250 | 119 | 118 | 3,686 |
| Unrestrained | 2,035 | 430 | 118 | 191 | 2,774 |
| **Total** | 23,574 | 3,063 | 1,068 | 1,365 | 29,070 |
| Restrained | 14,409 | 1,127 | 536 | 522 | 16,594 |
| Unrestrained | 9,165 | 1,936 | 532 | 843 | 12,476 |
| **MAIS 2-5 Injuries Remaining with Full Fleet of Air Bags** | | | | | |
| **Drivers** | 165,061 | 21,446 | 7,482 | 9,502 | 203,491 |
| Restrained | 100,893 | 7,896 | 3,756 | 3,639 | 116,184 |
| Unrestrained | 64,168 | 13,550 | 3,726 | 5,863 | 87,307 |
| **Passengers** | 47,105 | 6,121 | 2,135 | 2,783 | 58,144 |
| Restrained | 28,793 | 2,254 | 1,071 | 1,059 | 33,177 |
| Unrestrained | 18,312 | 3,867 | 1,064 | 1,724 | 24,967 |
| **Total** | 212,166 | 27,567 | 9,617 | 12,285 | 261,635 |
| Restrained | 129,686 | 10,150 | 4,827 | 4,698 | 149,361 |
| Unrestrained | 82,480 | 17,417 | 4,790 | 7,587 | 112,274 |

Source: NHTSA 1993-1997 NASS CDS and 1997 GES.
Note: Injuries by crash speeds were derived from 1993-1997 CDS and adjusted to 1997 GES CDS-equivalent level.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

In addition to air bag induced fatalities, SCI also identified some cases where children and adults who sit too close to air bags were seriously injured when air bags deployed in low speed impacts. But these SCI cases are by no means comprehensive, and thus might underestimate air bag induced serious injuries if used as the basis to project annual at-risk serious injuries (MAIS 3-5). Instead, the at-risk fatalities were used as the basis. For each MAIS 3-5 injury level, the estimate of annualized at-risk fatalities is multiplied by the ratio (adjustment factors) of injuries to fatalities. The adjustment factors and the ratio of air bag induced injuries to fatalities were derived from 1993-1998 CDS nonweighted cases and SCI cases. The 1998 CDS data were used here to include more air bag induced cases. Because of very small sample size for infants and children, the nonweighted cases were used to derive the ratios of injuries to fatalities. Table II-14 shows that there are an estimated annual total of 9 infants in RFCSS, 200 children, 15 adult passengers, and 38 drivers seriously injured by air bags.

Table II-14
Projected Annualized At-Risk MAIS 3-5 Injuries

| | Projected Annual Number | | | |
|---|---|---|---|---|
| **Year** | **RFCSS** | **Children 1-12 Years Old** | **Adult Passengers** | **Drivers** |
| Baseline (at-risk fatalities) | 18 | 105 | 18 | 46 |
| Adjustment Factors | | | | |
| MAIS 5 | 0.5 | 0.8 | 0.1 | 0.1 |
| MAIS 4 | 0.0 | 0.8 | 0.1 | 0.1 |
| MAIS 3 | 0.0 | 0.3 | 0.6 | 0.6 |
| Projected Injuries | | | | |
| MAIS 5 | 9 | 84 | 2 | 5 |
| MAIS 4 | 0 | 84 | 2 | 5 |
| MAIS 3 | 0 | 32 | 11 | 28 |
| Total MAIS 3-5 | 9 | 200 | 15 | 38 |

Source: SCI cases as of January 1, 2000; 1993-1998 CDS
Note: Baseline is the projected annualized at-risk fatalities.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

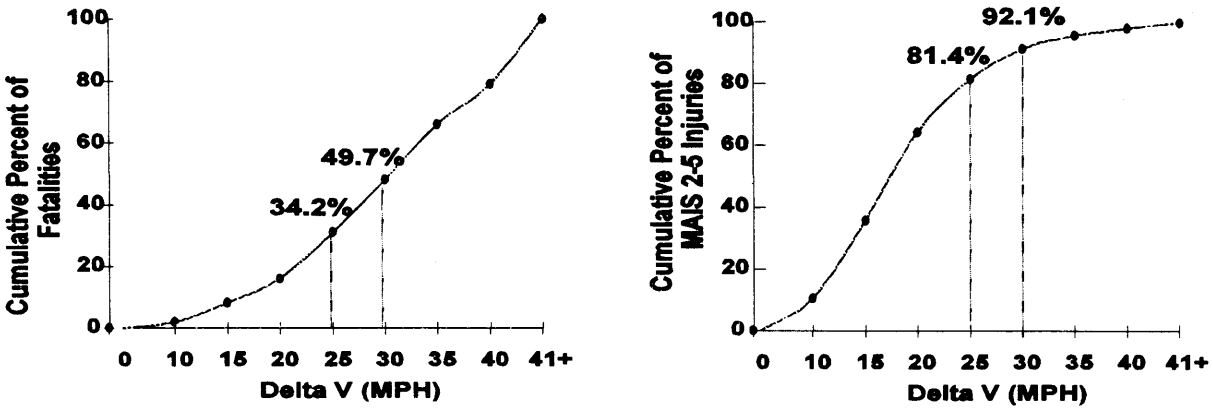
The following Tables II-15 to II-17 show fatalities and different MAIS injury levels by crash severity (delta v) in frontal crashes. Broken out further, Table II-15 presents these statistics for all front-outboard occupants, belted and unbelted combined; Table II-16 presents statistics for unbelted front-outboard occupants; while Table II-17 presents statistics for belted front-outboard occupants. These tables serve as additional background information to make a necessary adjustment of the overall target population and to analyze benefits for these tests. Figure II-1 graphically depicts the cumulative percentages of fatalities and MAIS 2-5 injuries by crash impact speeds (delta v).

Table II-15
Front-Outboard Occupant Fatalities and MAIS 2-5 Injuries
in Frontal Crashes by Crash Impact Speeds

| Delta V (MPH) | Fatal % | Fatal Cumulative % | MAIS 4-5 % | MAIS 4-5 Cumulative % | MAIS 3-5 % | MAIS 3-5 Cumulative % | MAIS 2-5 % | MAIS 2-5 Cumulative % |
|---|---|---|---|---|---|---|---|---|
| 0-10 | 2.0 | 2.0 | 4.3 | 4.3 | 3.9 | 3.9 | 11.4 | 11.4 |
| 11 | 1.0 | 3.0 | 0.7 | 5.0 | 6.1 | 10.0 | 5.7 | 17.1 |
| 12 | 1.9 | 4.9 | 1.2 | 6.2 | 7.6 | 17.6 | 5.6 | 22.7 |
| 13 | 0.4 | 5.3 | 3.3 | 9.5 | 1.6 | 19.2 | 3.4 | 26.1 |
| 14 | 2.5 | 7.8 | 4.5 | 14.0 | 7.2 | 26.4 | 7.7 | 33.8 |
| 15 | 1.7 | 9.5 | 0.7 | 14.7 | 4.4 | 30.8 | 3.5 | 37.3 |
| 16 | 1.8 | 11.3 | 2.7 | 17.4 | 5.5 | 36.3 | 5.8 | 43.1 |
| 17 | 0.9 | 12.2 | 2.5 | 19.9 | 8.9 | 45.2 | 11.7 | 54.8 |
| 18 | 0.3 | 12.5 | 2.0 | 21.9 | 1.7 | 46.9 | 3.6 | 58.4 |
| 19 | 2.6 | 15.1 | 3.0 | 24.9 | 2.9 | 49.8 | 4.5 | 62.9 |
| 20 | 0.9 | 16.0 | 1.9 | 26.8 | 2.5 | 52.3 | 2.0 | 64.9 |
| 21-25 | 18.2 | 34.2 | 22.7 | 49.5 | 19.3 | 71.6 | 16.5 | 81.4 |
| 26-30 | 15.5 | 49.7 | 18.9 | 68.4 | 14.3 | 85.9 | 10.7 | 92.1 |
| 31-35 | 12.9 | 62.6 | 7.0 | 75.4 | 5.8 | 91.7 | 3.9 | 96.0 |
| 36-40 | 13.5 | 76.1 | 16.1 | 91.5 | 4.7 | 96.4 | 2.2 | 98.2 |
| 41+ | 23.9 | 100.0 | 8.5 | 100.0 | 3.6 | 100.0 | 1.8 | 100.0 |

Source: 1993-1997 CDS.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE




Note: Fatalities and MAIS 2-5 injuries with unknown crash impact speeds were excluded in the analysis.

Figure II-1. Percent of Front-Outboard Fatalities/MAIS 2-5 Injuries in Frontal Crashes by Crash Impact Speeds (Delta V)

Table II-16
Front-Outboard Occupant Unbelted Fatalities and MAIS 2-5 Injuries in Frontal Crashes by Crash Impact Speeds

| Delta V (MPH) | Fatal % | Fatal Cumulative % | MAIS 4-5 % | MAIS 4-5 Cumulative % | MAIS 3-5 % | MAIS 3-5 Cumulative % | MAIS 2-5 % | MAIS 2-5 Cumulative % |
|---|---|---|---|---|---|---|---|---|
| 0-10 | 2.8 | 2.8 | 5.8 | 5.8 | 5.6 | 5.6 | 9.9 | 9.9 |
| 11 | 1.2 | 4.0 | 1.0 | 6.8 | 1.7 | 7.3 | 3.4 | 13.3 |
| 12 | 1.4 | 5.4 | 1.3 | 8.1 | 1.8 | 9.1 | 3.0 | 16.3 |
| 13 | 0.4 | 5.8 | 3.4 | 11.5 | 1.5 | 10.6 | 3.6 | 19.9 |
| 14 | 2.9 | 8.7 | 4.4 | 15.9 | 12.0 | 22.6 | 8.2 | 28.1 |
| 15 | 0.7 | 9.4 | 0.6 | 16.5 | 1.4 | 24.0 | 1.9 | 30.0 |
| 16 | 1.3 | 10.7 | 3.2 | 19.7 | 4.7 | 28.7 | 4.0 | 34.0 |
| 17 | 0.5 | 11.2 | 2.2 | 21.9 | 3.9 | 32.6 | 10.0 | 44.0 |
| 18 | 0.3 | 11.5 | 2.0 | 23.9 | 1.4 | 34.0 | 1.6 | 45.6 |
| 19 | 3.3 | 14.8 | 2.0 | 25.9 | 2.8 | 36.8 | 4.1 | 49.7 |
| 20 | 1.3 | 16.1 | 1.0 | 26.9 | 1.7 | 38.5 | 1.4 | 51.1 |
| 21-25 | 17.4 | 33.5 | 20.2 | 47.1 | 26.0 | 64.5 | 23.4 | 74.5 |
| 26-30 | 17.9 | 51.4 | 18.6 | 65.7 | 17.8 | 82.3 | 15.6 | 90.1 |
| 31-35 | 12.0 | 63.4 | 6.2 | 71.9 | 7.3 | 89.6 | 4.5 | 94.6 |
| 36-40 | 14.6 | 78.0 | 19.1 | 91.0 | 6.1 | 95.7 | 2.7 | 97.3 |
| 41+ | 22.0 | 100.0 | 9.0 | 100.0 | 4.3 | 100.0 | 2.7 | 100.0 |

Source: 1993-1997 CDS.
Note: Fatalities and MAIS 2-5 injuries with unknown crash impact speeds were excluded in the analysis.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table II-17
Front-Outboard Occupant Belted Fatalities and MAIS 2-5 Injuries
in Frontal Crashes by Crash Impact Speeds

| Delta V (MPH) | Fatal % | Fatal Cumulative % | MAIS 4-5 % | MAIS 4-5 Cumulative % | MAIS 3-5 % | MAIS 3-5 Cumulative % | MAIS 2-5 % | MAIS 2-5 Cumulative % |
|---|---|---|---|---|---|---|---|---|
| 0-10 | 0.6 | 0.6 | 1.1 | 1.1 | 2.1 | 2.1 | 12.6 | 12.6 |
| 11 | 0.0 | 0.6 | 0.0 | 1.1 | 10.7 | 12.8 | 7.5 | 20.1 |
| 12 | 3.2 | 3.8 | 1.1 | 2.2 | 13.7 | 26.5 | 7.4 | 27.5 |
| 13 | 0.5 | 4.3 | 3.0 | 5.2 | 1.6 | 28.1 | 3.2 | 30.7 |
| 14 | 1.9 | 6.2 | 4.7 | 9.9 | 2.3 | 30.4 | 7.4 | 38.1 |
| 15 | 4.4 | 10.6 | 0.7 | 10.6 | 7.6 | 38.0 | 4.7 | 42.8 |
| 16 | 3.2 | 13.8 | 1.4 | 12.0 | 6.2 | 44.2 | 7.3 | 50.1 |
| 17 | 1.8 | 15.6 | 3.3 | 15.3 | 14.2 | 58.4 | 13.1 | 63.2 |
| 18 | 0.6 | 16.2 | 2.0 | 17.3 | 1.9 | 60.3 | 5.3 | 68.5 |
| 19 | 1.4 | 17.6 | 5.2 | 22.5 | 2.9 | 63.2 | 4.9 | 73.4 |
| 20 | 0.0 | 17.6 | 4.1 | 26.6 | 3.4 | 66.6 | 2.5 | 75.9 |
| 21-25 | 20.8 | 38.4 | 29.2 | 55.8 | 12.7 | 79.3 | 11.1 | 87.0 |
| 26-30 | 11.0 | 49.4 | 19.2 | 75.0 | 10.6 | 89.9 | 6.8 | 93.8 |
| 31-35 | 15.0 | 64.4 | 9.0 | 84.0 | 4.2 | 94.1 | 3.4 | 97.2 |
| 36-40 | 13.2 | 77.6 | 8.6 | 92.6 | 3.1 | 97.2 | 1.8 | 99.0 |
| 41+ | 22.4 | 100.0 | 7.4 | 100.0 | 2.8 | 100.0 | 1.0 | 100.0 |

Source: 1993-1997 CDS.
Note: Fatalities and MAIS 2-5 injuries with unknown crash impact speeds were excluded in the analysis.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Endnote for Table II-7,

A small analysis was performed to examine the potential impact of the increase in belt use between 1996 and 1998 on the apparent change in fatality rates for redesigned MY 1998 air bag vehicles. Results from the National Occupant Protection Use Survey (NOPUS) show that the observed average overall safety belt use in front seat outboard passenger cars and light trucks was 61.3 percent in 1996 and 68.9 percent in 1998. Thus, safety belt use increased during the period. The estimates use the average effectiveness of safety belts for passenger cars and light trucks of about 51 percent (45 percent for passenger cars and 60 percent for light trucks). It is estimated that instead of the 19 fatalities that occurred over the first 27 months of the MY 1996 vehicles shown in Table II-7 with 61.3 percent belt use, that there would have been 18 fatalities if belt use had been 68.9 percent [19/(1-0.51*0.613) = 27.64; 27.64*0.51*0.689 = 9.71; 27.64-9.71 = 18]. The SCI fatalities per million registered MY 1996 vehicles using 18 fatalities instead of 19 would be 1.37 instead of 1.45.

The same calculation for 1997, assuming average belt use in 1997 midway between 1996 and 1998 of 65.1 percent resulted in 19 fatalities and the fatality rate at 1.34 for MY 1997 vehicles. Thus the average SCI fatality rate for MY's 1996/97 would be 1.36 [(1.37+1.34)/2]. Comparing this to MY 1998 rate of 0.48 results in 35 percent (0.48/1.36) rather than the previous estimate of 33.6 percent (0.48/1.43), still roughly one-third as used in the analysis for Table II-5.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

## III. INJURY CRITERIA

This section contains a description of the Injury Criteria and Injury Criteria Performance Limits (ICPL) mandated by the final rule on advanced frontal air bags. NHTSA is requiring separate ICPLs for each dummy size. This section describes how the dummy head, neck, chest and femur responses measured by the dummies relate to human tolerance/injury risk potential and the associated probability of injury. NHTSA is requiring ICPLs for head injury criterion (HIC), neck injury criterion (Nij), chest acceleration (chest g's) and chest deflection for each dummy size in addition to femur axial loads for the adult dummies.

Based on an analysis of the docket comments (99-6407), NHTSA is mandating; (1) the computation of HIC (maximum) be based on a 15 milliseconds (ms) time interval (compared to 36 ms in today's FMVSS 208) and (2) the application of new HIC threshold ICPLs for each dummy size. The final rule promulgates a new neck injury criteria (Nij) formulation employing further revised critical intercept values (compared to the SNPRM) to account for In-Position (tensed neck muscles) and Out-of-Position (untensed neck muscles) as well as new independent peak limits for neck tension and compression. The new peak limits on neck tension and compression adjust the shape of the "Kite"shaped boundary for Nij to a "Hexagonal"shaped boundary.[1] The same neck injury risk curves employed in the SNPRM benefit/cost analysis

[1] The "Kite" shape is based on the computation of Nij for which the measured values are dependent e.g., occur at the same point in time. The independent peak limits creating the "Hexagon" shape, however, are independent of time.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

apply to the subject final rule analysis, despite these adjustments. The ICPL of 1.0 proposed in the SNPRM for Nij is being adopted for the final rule. With the exception of the Nij revised critical intercept values and new peak limits on neck tension and compression, the final rule requires the same $HIC_{15ms}$, chest acceleration, chest deflection and femur load ICPLs as proposed in the SNPRM.

The Combined Thoracic Index (CTI) is not being promulgated as an injury criteria in the final rule. However, the CTI concept of chest injury risk as employed in the SNPRM benefits/ costs analysis is used for the same purposes of analysis in the subject final rule in Chapter VI., Potential Benefits, to calculate chest injury risk reductions and subsequent benefits. For example, the Injury Assessment Reference Value (IARV) of 1.0 as applied to CTI in the benefits analysis section represents a 25 percent probability of an AIS 3+ human chest injury.[2]

In addition, this section includes a discussion of 95th percentile male dummy injury criteria and concomitant IARVs, as these are used for analysis purposes to assess the MY97 (baseline) vs. MY99 (redesigned) Buick Century and Chevy Venture sled buck air bag test series. Although not a promulgated dummy, revised critical intercept values for Nij and the new peak limits for neck tension and compression have been applied to this dummy size for analysis purposes.

[2] ICPLs were proposed in the SNPRM and became part of the final rule, whereas IARVs are used in conjunction with the injury criteria for analysis purposes only.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

The 95th percentile dummy sled test responses are compared to the applicable injury criteria and appropriate IARVs.

NHTSA's National Transportation Biomechanics Research Center (NTBRC) has prepared a separate, supplemental biomechanics document that addresses the industry's comments, discusses each selected ICPL, the associated injury risk functions and the risk tolerance curves.[3]

**A. Summary of NHTSA's ICPL Proposal**

**Head** - After analysis of the comments to the SNPRM Docket 99-6407, the agency is requiring that the HIC (maximum) calculation time interval be changed from 36 ms to 15 ms. This results in a mandated $HIC_{15}$ ICPL value of 700 for the 50th percentile male dummy. In addition, NHTSA is mandating a $HIC_{15}$ of 700 for the 5th percentile female and 6-year-old dummies for the advanced frontal air bag final rule. Also, the agency is mandating $HIC_{15}$=570 and $HIC_{15}$ =390 for the 3-year-old and 12-month-old infant (CRABI) dummies, respectively, which have been scaled from the 50th percentile dummy. Table III-1 shows the ICPLs requirements for each body region by dummy size.

[3] Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems -II, October, 1999, The original document was Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems, June, 1998. See Docket No. NHTSA-1998-4405-9. Supplement: Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems -II, March 2000,

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table III-1
**Injury Criteria and Injury Criteria Performance Levels (ICPLs) for FMVSS No. 208 Final Rule by Anthropomorphic Dummy Size**

| 208 Injury Criteria | Hybrid III Mid-Sized Male | Hybrid III Small Female | Hybrid III 6-Year-Old Child | Hybrid III 3-Year-Old Child | 12-Month-Old Infant (CRABI) |
|---|---|---|---|---|---|
| **Head Criteria** ($HIC_{15ms}$) | 700 | 700 | 700 | 570 | 390 |
| **Neck Criteria** (Nij) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **In-Position** | | | | | |
| **Critical Intercept Values** | | | | | |
| $F_{Z\,CRIT}$: Tension (N) | 6806 | 4287 | | | |
| $F_{Z\,CRIT}$: Compression (N) | -6160 | -3880 | | | |
| $M_{Y\,CRIT}$: Flexion (N-m) | 310 | 155 | | | |
| $M_{Y\,CRIT}$: Extension (N-m) | -135 | -67 | | | |
| **Peak Limits** | | | | | |
| Neck Tension (N) | 4170 | 2620 | | | |
| Neck Compression (N) | -4000 | -2520 | | | |
| **Out-of-Position (OOP)** | | | | | |
| **Critical Intercept Values** | | | | | |
| $F_{Z\,CRIT}$: Tension (N) | | 3880 | 2800 | 2120 | 1460 |
| $F_{Z\,CRIT}$: Compression (N) | | -3880 | -2800 | -2120 | -1460 |
| $M_{Y\,CRIT}$: Flexion (N-m) | | 155 | 93 | 68 | 43 |
| $M_{Y\,CRIT}$: Extension (N-m) | | -61 | - 37 | -27 | -17 |
| **Peak Limits** | | | | | |
| Neck Tension (N) | | 2070 | 1490 | 1130 | 780 |
| Neck Compression (N) | | -2520 | -1820 | -1380 | -960 |
| **Thoracic Criteria** | | | | | |
| $A_C$ Critical Chest Acceler. (g's) | 60 | 60 | 60 | 55 | 50 |
| $D_C$ Critical Chest Deflect (mm) | 63 (2.5") | 52 (2.0") | 40 (1.6") | 34 (1.4") | 30 * (1.2") |
| **Lower Extremity Criterion** | | | | | |
| Femur Axial Loads (Kn) | 10.0 ** | 6.8 | N.A. | N.A. | N.A. |

* The 12-month-old infant (CRABI) dummy is not currently capable of measuring chest deflection. ** The actual femur axial load ICPL is 10,008 Newtons, but this has been rounded to the nearest whole number in Table III-1. N.A. - not applicable. In-position critical intercept values and peak limits reflect tensed neck muscles, whereas OOP critical intercept values and peak limits reflect untensed neck muscles. This concept does not apply to the 12-month-old CRABI infant dummy.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Neck** - NHTSA is mandating the same neck injury criterion (Nij) as proposed in the SNPRM, but with revised In-Position and Out-of-Position critical intercept values and new peak limits on neck tension and compression. The maximum allowable Nij = 1.0 applies regardless of dummy size. Nij is a linear combination of the normalized neck axial load (tension or compression) and normalized neck moment about the occipital condyle. The critical intercept values required to compute the normalized neck axial load (tension or compression) and normalized neck moment are different for each dummy size. The critical intercept values also produce the "Kite" shaped boundary for Nij less than or equal to 1.0 which has been revised in the final rule to a "Hexagonal" shaped boundary. The peak limits of neck tension and compression are used to truncate the upper and lower vertical apexes of the Kite shaped Nij boundary. Figures III-3 illustrates the hexagonal shaped Nij boundary for the in-position (tensed neck muscles) 50$^{th}$ percentile male dummy. Figure III-4 illustrates the hexagonal shaped Nij boundary for In-Position (tensed neck muscles) and Out-of-Position (OOP) (untensed neck muscles) for the 5$^{th}$ percentile female dummies. In order to pass the test, the Nij computation is less than 1.0 within the hexagonal boundary and equal to 1.0 on the boundary line. The OOP limits for neck tension and the neck extension moments are more stringent, compared to the in-position case, so as to reduce the risk of injury for the out-of-position occupant. [Note: The tensed and untensed neck muscle concept does not apply to the 12-month-old infant CRABI dummy.] (See Table III-1)

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

**Chest** - The chest acceleration and chest deflection ICPL values proposed in the SNPRM are required in the final rule for the 50th percentile male, 5th percentile female, 6-year-old child, 3-year-old child and 12-month-old infant dummies. The chest acceleration ICPL of 60 g's for the 50th percentile male dummy reflects about a 65 percent chance of an AIS-3+ injury as shown in Figure III-7. The chest g's limits for the other dummies are scaled for an equivalent level of risk. As described in the SNPRM documentation, the chest deflection threshold values for all the dummies were re-scaled to reflect that the 50th percentile male's maximum allowable chest deflection which was revised from 76 mm (NPRM) to 63 mm (3" to 2.5")(SNPRM and Final Rule). This essentially reduces the risk of an AIS-3+ chest injury from 47 percent (@ 76 mm) to 33 percent (@ 63 mm) as shown in Figure III-8. The maximum deflection thresholds for the other dummy sizes have been scaled from the 50 percentile male dummy. Test data shows this 17 percent reduction (76 mm to 63 mm) in the central chest deflection ICPL is practicable for many of the required full-scale crash test conditions, but may be more problematic for the required static OOP test conditions. [Note: 12-Month-Old Infant (CRABI) dummy does not currently have chest deflection measurement capability.] (See Table III-1)

**Femurs** - FMVSS 208 currently specifies a femur axial compressive load ICPL of 10 kN ( 2,250 lbs.) for the 50th percentile male dummy. In the SNPRM, NHTSA proposed a femur axial compression ICPL of 10 kN (2,250 lbs.) for the 50th percentile male dummy and 6.8 kN (1,530 lbs.) for the 5th percentile female femur, based on scaling of the cross-sectional area of the femur bone. These same values are mandated in the final rule. Femur loads are not included for the

DRAFT DELIBERATIVE DOCUMENT, DO NOT RELEASE

child dummies because the testing configurations specified in the SNPRM for the 6-year-old child dummy, namely OOP testing, do not impose substantial loading on the lower extremities. (See Table III-1)

The scaling methods used to derive the head, neck critical intercept values, chest deflection, chest acceleration, and femur ICPLs by dummy size are described in the previously referred to amended biomechanics report placed in the docket.

**B. Injury Risk Curves**

***Head Injury Criterion ($HIC_{15}$)***

Based on available NCAP data, the $HIC_{15}$ of 700 for the 50th percentile male dummy can be correlated to $HIC_{36}$ of 1000 [$HIC_{15} = 0.7\ HIC_{36}$ ] and is designed to provide protection from head injury (e.g., skull-fracture) for long duration events where there is no head contact with hard vehicle interior points. HIC was developed from short duration, hard rigid surface, cadaveric head drop data and was designed to minimize skull fracture/brain injury due to head contacts with interior compartment components. A short duration impact could include a direct driver head impact with the steering wheel rim/hub or a child's head contacting the unpadded face of the instrument panel. As shown in Table III-1, a maximum $HIC_{15}$ of 700 is required for the 50$^{th}$ percentile male dummy as well as the new 5th percentile female and the new 6-year-old child

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

dummies. In addition, $HIC_{15}$ = 570 is required for the new 3-year-old and $HIC_{15}$ = 390 is required for the new 12-month-old infant (CRABI) dummy.[4]

Prasad and Mertz estimated head injury risk as a function of HIC and employed a 15 ms maximum time interval to calculate HIC.[5] The 15 ms time interval represented a hard rigid impact surface. NHTSA has used the 36 ms maximum time interval to compute HIC because it is believed to closely represent the softer vehicle interior head impact environment and indirectly provides neck tension protection by limiting Z-axis g's.[6] With the new neck criterion (Nij), $HIC_{15}$ was reconsidered. The Prasad/ Mertz HIC values are shown in Table III-2.[7] NHTSA has expanded the Prasad/ Mertz curve to include other AIS levels (see Figure III-1). The lognormal curve values for HIC developed by Hertz of NHTSA are shown in Table III-3 and Figure III-2. The Hertz curves are representative of $HIC_{15}$ as they were derived from short duration head drop data. See the supplemental biomechanics report for a further discussion of $HIC_{15}$ vs $HIC_{36}$ and the scaling factors used to derive ICPL values by dummy size.

---

[4] Originally this dummy was named the Crash Research Air Bag Interaction dummy.

[5] Assessing the Safety Performance of Occupant Restraint Systems, Viano, D.C. and Arepally, S., Biomedical Science Department, GM Research Laboratories, General Motors Corporation, Warren, MI, SAE #902328. The Position of the U.S. Delegation to the ISO Working Group 6 on the Use of HIC in the Automotive Environment, P. Prasad of Ford Motor Company and H. J. Mertz of General Motors Corporation, SAE #851246 and Injury Risk Curves for Children and Adults in Front and Rear Collisions, H.J. Mertz, General Motors, P. Prasad, Ford Motor Co. and A.L. Irwin, General Motors, #973318.

[6] Final Regulatory Evaluation, FMVSS 208 - Front Seat Occupant Protection, Amendment to Provide a New Method for Calculating Head Injury Criterion (HIC), August 1986, Office of Regulatory Analysis, Plans and Policy, NHTSA/DOT.

[7] Final Regulatory Evaluation, Actions to Reduce Adverse Effects of Air Bags, FMVSS 208, DEPOWERING, February 1997, Office of Regulatory Analysis, Plans and Policy, NHTSA/DOT.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table III-2
Expanded Prasad/Mertz Curves
Chance of Specific Injury Level for a Given $HIC_{15}$ Level

| HIC | MAIS 1 | MAIS 2 | MAIS 3 | MAIS 4 | MAIS 5 | FATAL | NO INJURY |
|---|---|---|---|---|---|---|---|
| 50 | 0.3% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% | 99.5% |
| 150 | 8.7% | 2.8% | 1.2% | 0.3% | 0.0% | 0.0% | 87.0% |
| 250 | 21.8% | 7.4% | 2.9% | 0.7% | 0.1% | 0.0% | 67.2% |
| 350 | 33.8% | 13.7% | 5.1% | 1.3% | 0.1% | 0.0% | 45.9% |
| 450 | 40.1% | 21.5% | 8.1% | 2.1% | 0.2% | 0.0% | 28.1% |
| 550 | 39.1% | 29.7% | 11.9% | 3.2% | 0.3% | 0.0% | 15.8% |
| 650 | 33.0% | 36.7% | 16.7% | 4.6% | 0.5% | 0.0% | 8.5% |
| 750 | 25.2% | 40.8% | 22.2% | 6.6% | 0.7% | 0.0% | 4.4% |
| 850 | 17.8% | 41.3% | 28.2% | 9.2% | 1.2% | 0.0% | 2.3% |
| 950 | 12.0% | 38.5% | 33.9% | 12.6% | 1.8% | 0.1% | 1.2% |
| 1050 | 7.8% | 33.5% | 38.4% | 16.8% | 2.8% | 0.2% | 0.6% |
| 1150 | 4.9% | 27.6% | 41.0% | 21.7% | 4.2% | 0.3% | 0.3% |
| 1250 | 3.1% | 21.7% | 41.2% | 27.0% | 6.3% | 0.5% | 0.2% |
| 1350 | 1.9% | 16.5% | 39.2% | 32.1% | 9.3% | 0.8% | 0.1% |
| 1450 | 1.2% | 12.2% | 35.3% | 36.3% | 13.5% | 1.5% | 0.0% |
| 1550 | 0.7% | 8.8% | 30.3% | 38.7% | 18.8% | 2.6% | 0.0% |
| 1650 | 0.5% | 6.3% | 24.9% | 38.7% | 25.1% | 4.6% | 0.0% |
| 1750 | 0.3% | 4.4% | 19.7% | 36.1% | 31.7% | 7.8% | 0.0% |
| 1850 | 0.2% | 3.1% | 15.2% | 31.3% | 37.1% | 13.1% | 0.0% |
| 1950 | 0.1% | 2.2% | 11.4% | 25.4% | 39.9% | 21.0% | 0.0% |
| 2050 | 0.1% | 1.5% | 8.4% | 19.4% | 38.6% | 32.0% | 0.0% |
| 2150 | 0.0% | 1.0% | 6.1% | 14.0% | 33.4% | 45.4% | 0.0% |
| 2250 | 0.0% | 0.7% | 4.4% | 9.7% | 25.6% | 59.5% | 0.0% |
| 2350 | 0.0% | 0.5% | 3.2% | 6.5% | 17.7% | 72.2% | 0.0% |
| 2450 | 0.0% | 0.3% | 2.3% | 4.2% | 11.1% | 82.1% | 0.0% |
| 2550 | 0.0% | 0.2% | 1.6% | 2.7% | 6.5% | 89.0% | 0.0% |
| 2650 | 0.0% | 0.2% | 1.1% | 1.7% | 3.5% | 93.4% | 0.0% |
| 2750 | 0.0% | 0.1% | 0.8% | 1.1% | 1.8% | 96.2% | 0.0% |
| 2850 | 0.0% | 0.1% | 0.6% | 0.6% | 0.9% | 97.8% | 0.0% |
| 2950 | 0.0% | 0.1% | 0.4% | 0.4% | 0.4% | 98.7% | 0.0% |
| 3050 | 0.0% | 0.0% | 0.3% | 0.2% | 0.2% | 99.3% | 0.0% |
| 3150 | 0.0% | 0.0% | 0.2% | 0.1% | 1.0% | 99.6% | 0.0% |

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table III-3
Lognormal Curves Chance of Specific Injury Level for a Given HIC15 Level

| HIC | MAIS 1 | MAIS 2 | MAIS 3 | MAIS 4 | MAIS 5 | FATAL | NO INJURY |
|---|---|---|---|---|---|---|---|
| 50 | 7.6% | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 92.38% |
| 150 | 35.53% | 1.01% | 0.05% | 0.00% | 0.00% | 0.00% | 63.41% |
| 250 | 52.06% | 3.97% | 0.44% | 0.01% | 0.01% | 0.00% | 43.52% |
| 350 | 59.44% | 8.01% | 1.42% | 0.06% | 0.06% | 0.04% | 30.98% |
| 450 | 61.55% | 12.15% | 2.96% | 0.18% | 0.19% | 0.17% | 22.80% |
| 550 | 60.74% | 15.84% | 4.84% | 0.40% | 0.42% | 0.51% | 17.25% |
| 650 | 58.37% | 18.86% | 6.81% | 0.70% | 0.73% | 1.18% | 13.36% |
| 750 | 55.21% | 21.16% | 8.69% | 1.06% | 1.10% | 2.24% | 10.54% |
| 850 | 51.72% | 22.81% | 10.34% | 1.44% | 1.50% | 3.74% | 8.45% |
| 950 | 48.16% | 23.88% | 11.70% | 1.81% | 1.89% | 5.70% | 6.37% |
| 1050 | 44.68% | 24.47% | 12.76% | 2.15% | 2.24% | 8.08% | 5.65% |
| 1150 | 41.35% | 24.67% | 13.47% | 2.44% | 2.55% | 10.83% | 4.70% |
| 1250 | 38.22% | 24.57% | 13.90% | 2.68% | 2.79% | 13.89% | 3.94% |
| 1350 | 35.31% | 24.24% | 14.09% | 2.86% | 2.98% | 17.19% | 3.33% |
| 1450 | 32.62% | 23.73% | 14.06% | 2.98% | 3.10% | 20.68% | 2.84% |
| 1550 | 30.13% | 23.08% | 13.86% | 3.04% | 3.17% | 24.28% | 2.44% |
| 1650 | 27.85% | 22.35% | 13.51% | 3.06% | 3.18% | 27.95% | 2.11% |
| 1750 | 25.76% | 21.55% | 13.05% | 3.03% | 3.16% | 31.62% | 1.83% |
| 1850 | 23.86% | 20.71% | 12.51% | 2.97% | 3.10% | 35.27% | 1.59% |
| 1950 | 22.09% | 19.85% | 11.92% | 2.88% | 3.00% | 38.86% | 1.40% |
| 2050 | 20.48% | 18.99% | 11.29% | 2.77% | 2.89% | 42.35% | 1.23% |
| 2150 | 19.01% | 18.13% | 10.63% | 2.65% | 2.76% | 45.74% | 1.09% |
| 2250 | 17.66% | 17.29% | 9.97% | 2.51% | 2.61% | 49.01% | 0.97% |
| 2350 | 16.42% | 16.46% | 9.31% | 2.36% | 2.46% | 52.14% | 0.86% |
| 2450 | 15.23% | 15.66% | 8.68% | 2.21% | 2.30% | 55.12% | 0.77% |
| 2550 | 14.23% | 14.89% | 8.03% | 2.06% | 2.14% | 57.96% | 0.69% |
| 2650 | 13.27% | 14.14% | 7.42% | 1.91% | 1.99% | 60.65% | 0.62% |
| 2750 | 12.39% | 13.43% | 6.84% | 1.76% | 1.83% | 63.20% | 0.56% |
| 2850 | 11.57% | 12.75% | 6.28% | 1.62% | 1.68% | 65.60% | 0.50% |
| 2950 | 10.82% | 12.10% | 5.75% | 1.48% | 1.54% | 67.86% | 0.46% |
| 3050 | 10.13% | 11.47% | 5.25% | 1.35% | 1.40% | 69.98% | 0.41% |
| 3150 | 9.49% | 10.89% | 4.78% | 1.22% | 1.27% | 71.98% | 0.38% |
| 3250 | 8.89% | 10.33% | 4.34% | 1.10% | 1.15% | 73.84% | 0.34% |

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Figure III-1**
**Prasad/Mertz Expanded**
**Head Injury Probability Curves**

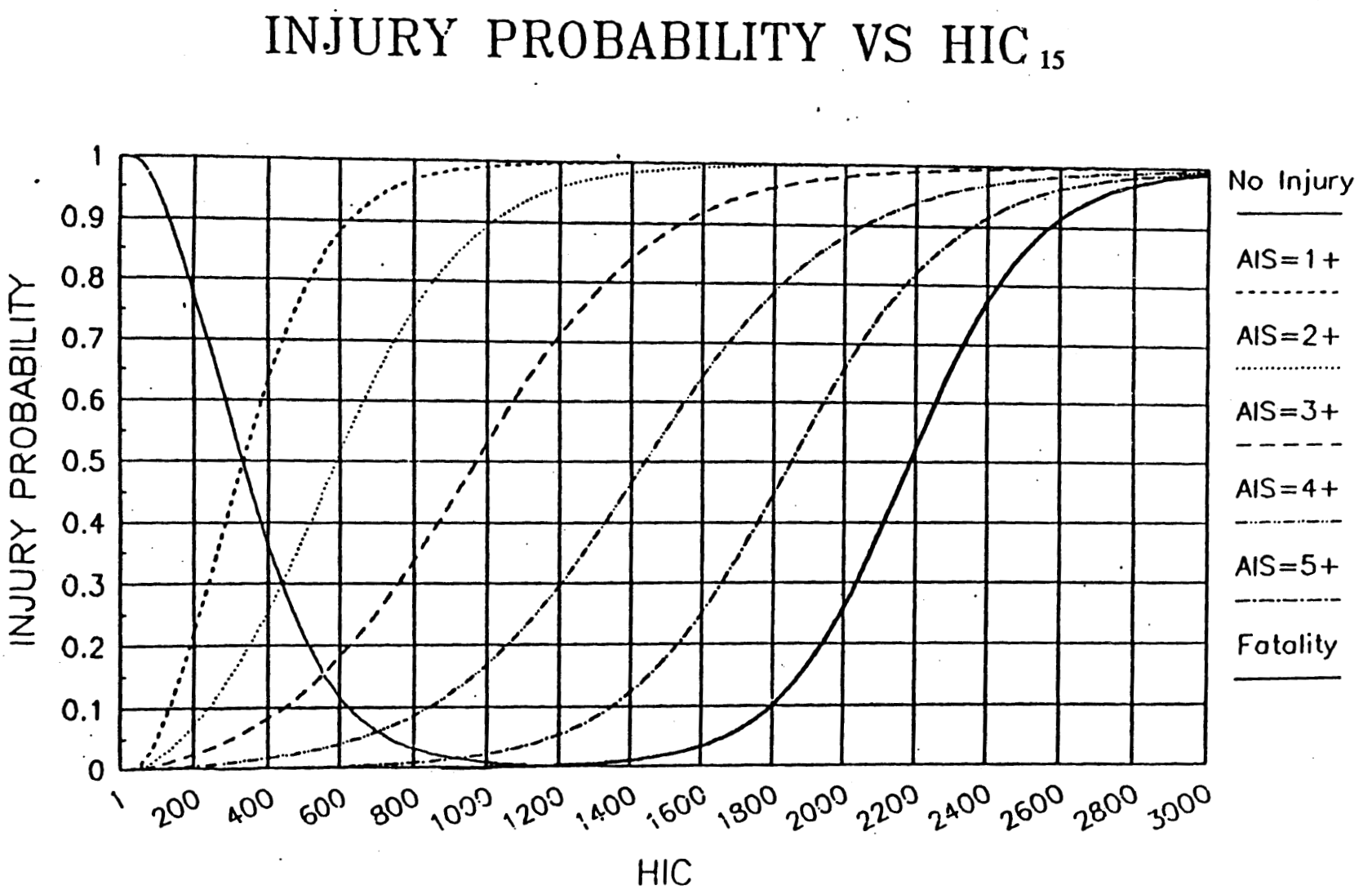
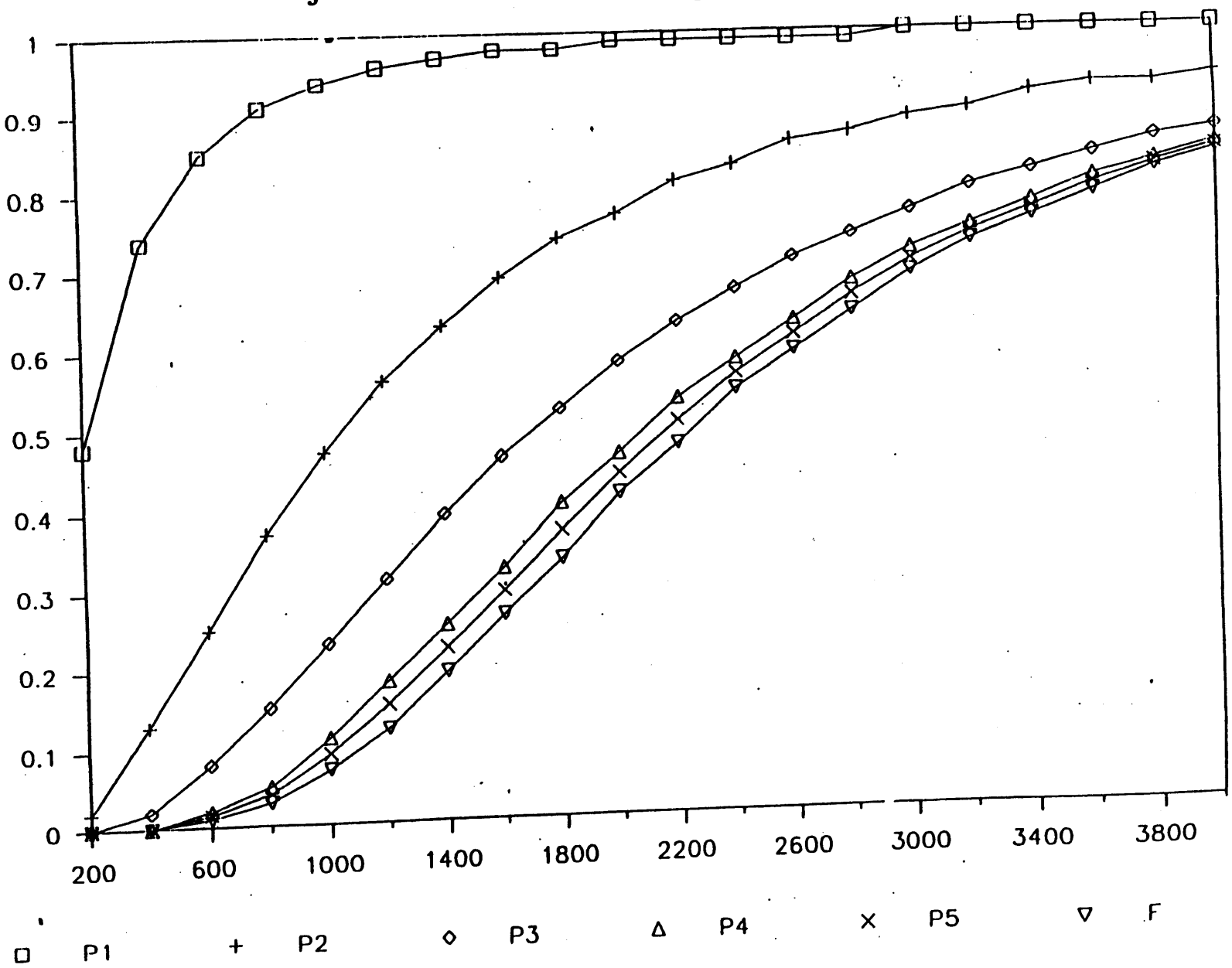


Figure III-2

# Lognormal Head Injury Probability Curves
## Injuries Greater Than or Equal to MAIS Level



*Neck Injury Criterion (Nij)*

NHTSA is requiring the same neck injury criterion (Nij) as proposed in the SNPRM except with revised critical intercept values and new peak limits. The same neck injury risk curves used in the SNPRM apply to the final rule. As shown in Table III-1, the ICPL of 1.0 is required for all dummy sizes. This method combines neck axial tension/compression and neck moments (flexion/ extension) into one ICPL. This criterion employs the summation of normalized neck axial force and normalized neck moment at the occipital condyle. The formulation is $Nij = F_{NZ} + M_{NY}$, where: $F_{NZ} = F_Z / F_{Z\,CRIT.}$ and $M_{NY} = M_Y / M_{Y\,CRIT.}$ The measured neck values are; $F_Z$ = neck axial load (tension or compression) and $M_Y$ = neck bending moment (flexion or extension) at the occipital condyle. $F_Z$ and $M_Y$ are measured at the same point in time. The $F_{Z\,CRIT.}$ and $M_{Y\,CRIT.}$ values by dummy size are shown in Table III-1. Nij can not exceed 1.0 at any point in time. The critical intercept values shown in Table III-1 create a "kite" shaped boundary for both in-position and OOP test conditions. The peak limits for neck tension and compression, also shown in Table III-1, are used to truncate the upper and lower apexes of the "kite" shape thus creating an "hexagon" shaped boundary. Inside the hexagonal shaped boundary Nij is less than 1.0 and on the boundary line Nij = 1.0.

As shown in Table III-1, NHTSA is requiring critical intercept values for axial neck tension/ compression ($F_{Z\,crit.}$) as well as neck flexion/ extension moment ($M_{Y\,crit.}$) to be used in computing Nij for each dummy size. This approach (the so-called "Kite" Method described in the SNPRM ) is based on a dependent relationship between neck axial loads and neck moments in assessing neck injury risk. Prasad and Daniel (SAE #841656) suggested that a linear combination of axial

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

load and bending moment is a better predictor of injury than the individual limits.[8] The neck shear load is only used for the calculation of the My moment at the occipital condyles. Figure III-3 shows an example of the Nij related critical neck values and the formation of a "kite" shape, which has been modified with the peak limits for neck tension and compression, thus creating a hexagonal boundary for Nij less than or equal to 1.0, for the in-position 50th percentile male dummy. Figure III-4 illustrates the hexagonal boundary for Nij less than or equal to 1.0 for the in-position and out-of-position 5th percentile female dummy.

The formulas for Percent Injury Probability at AIS-2+ through AIS-5+ injury, as a function of Nij values are as follows:

AIS-2+ Percent Injury Probability = $[1/(1 + \exp^{(2.0536 - 1.1955*Nij)})] \times 100\%$.

AIS-3+ Percent Injury Probability = $[1/(1 + \exp^{(3.227 - 1.969*Nij)})] \times 100\%$.

AIS-4+ Percent Injury Probability = $[1/(1 + \exp^{(2.693 - 1.196*Nij)})] \times 100\%$.

AIS-5+ Percent Injury Probability = $[1/(1 + \exp^{(3.817 - 1.196*Nij)})] \times 100\%$.

Fatality Percent Injury Probability = $[1/(1 + \exp^{(3.817 - 1.196*Nij)})] \times 100\%$. (Same as AIS-5+)

[8] A Biomechanical Analysis of Head, Neck and Torso Injuries to Child Surrogates Due to Sudden Torso Acceleration, Prasad, P. and Daniel, R.P., 1984 SAE International Congress and Exposition, Paper # 841656.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

PRINT 10 X 10 TO 1 INCH
10TH LINE HEAVY

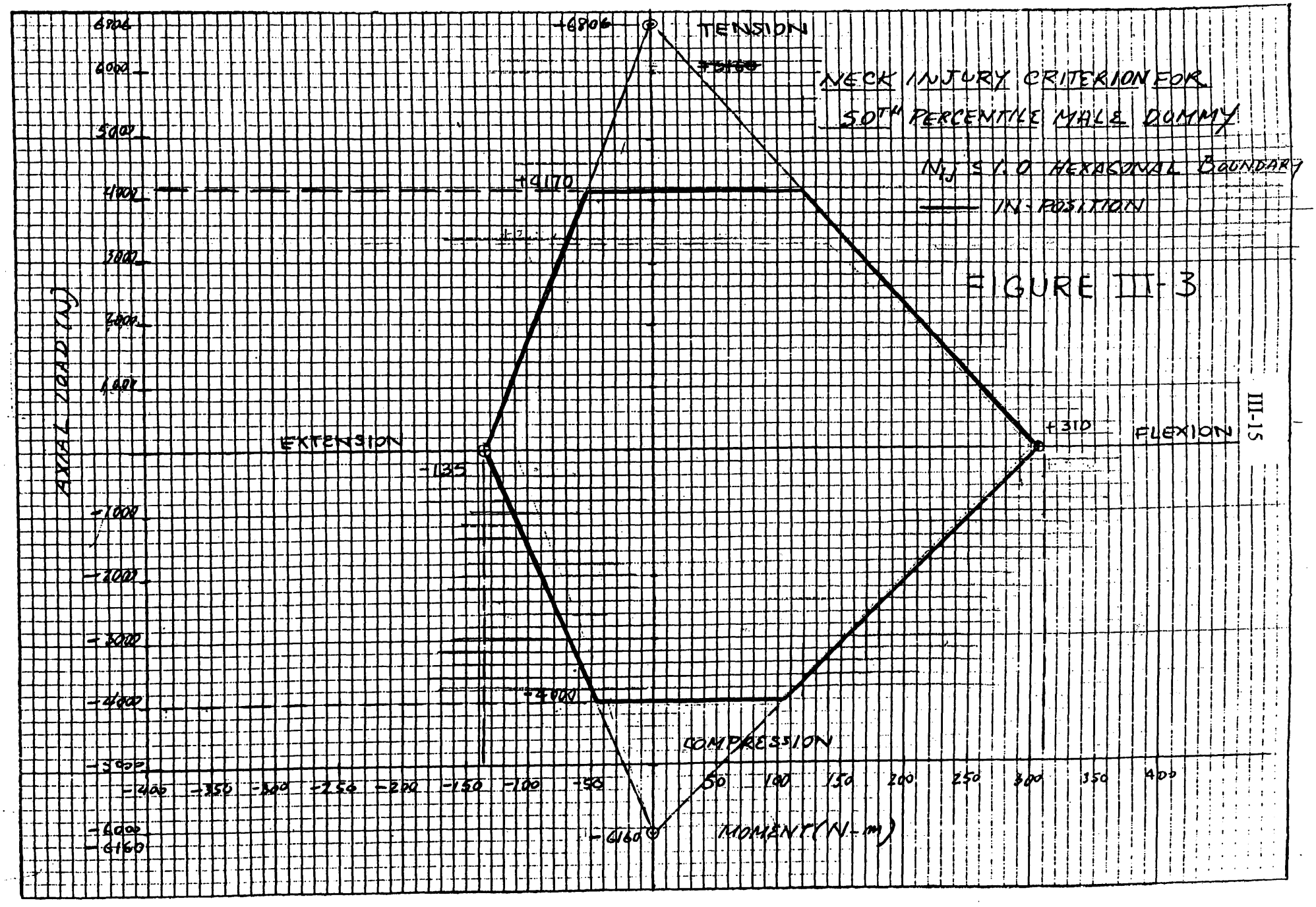



FIGURE III-3

FPI MI 10 X 10 TO 1 INCH
10TH LINE HEAVY

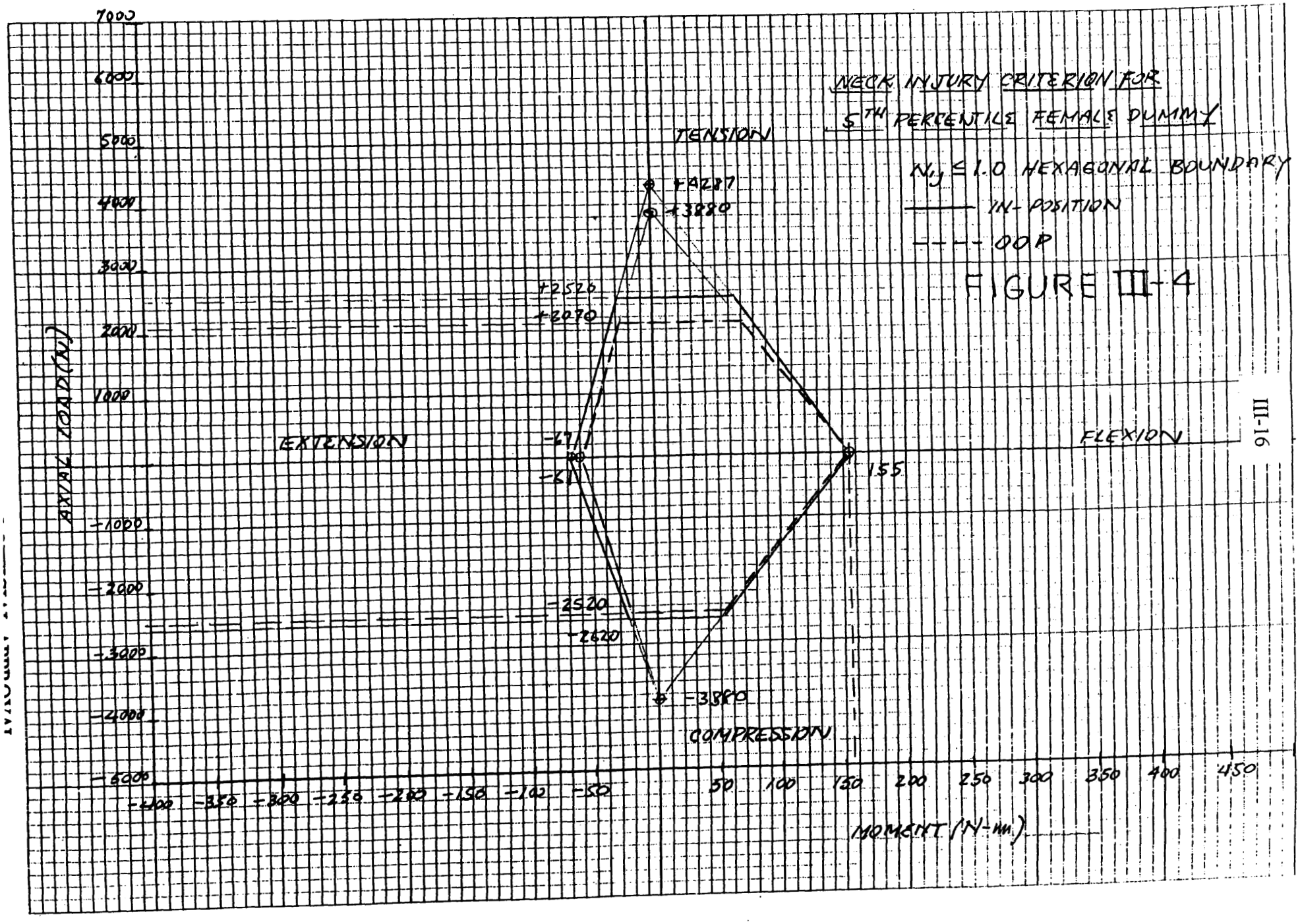



FIGURE III-4

The probability of injury as a function of Nij for a family of risk curves is shown in Figure III-5. The Nij formula is the same regardless of dummy size because the critical values, $F_{Z\ CRIT.}$ and $M_{Y\ CRIT.}$ are scaled.

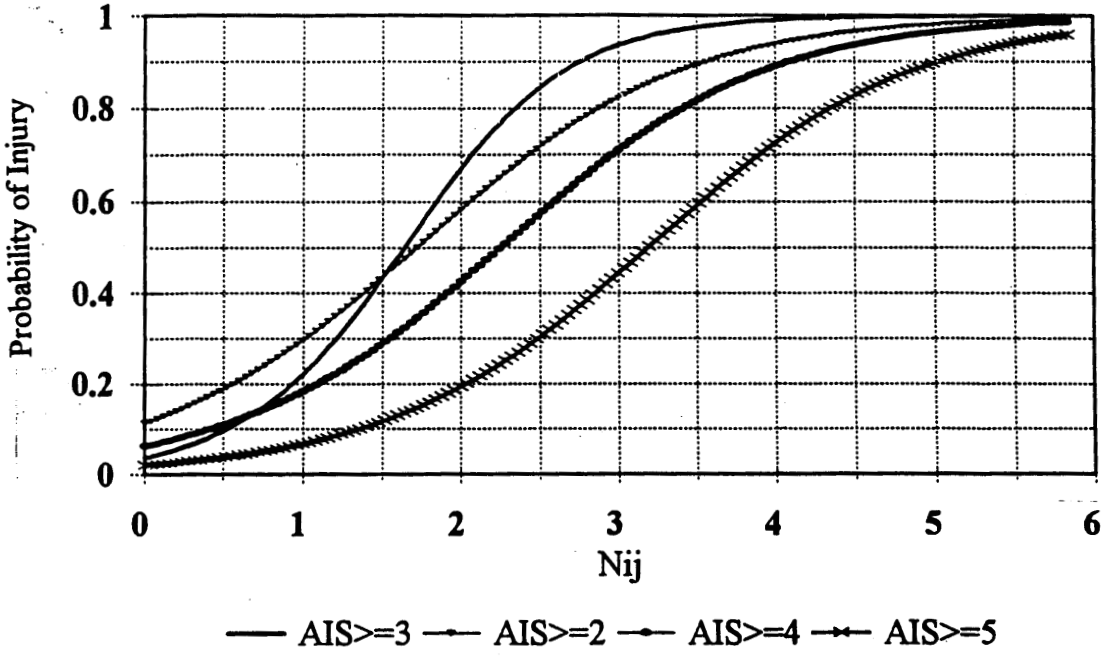
*Nij Calculation*

Regardless of dummy size, NHTSA is requiring that the biomechanical neck injury criteria, Nij (max.), not exceed a value of 1.0 at any point in time. The following procedure is used to compute Nij. The axial force (Fz) tension/compression and the neck flexion/extension moment about the occipital condyle (My) are used to calculate four combined injury predictors, collectively referred to as Nij. Nij (in Index Notation format) represents four combinations of loads that predict injury outcome. These four combined values represent the probability of sustaining each of the four primary types of cervical injuries, namely tension-extension ($N_{TE}$), tension-flexion ($N_{TF}$), compression-extension ($N_{CE}$) and compression-flexion ($N_{CF}$) injuries. Each measurement recorded by the upper neck load cell is first normalized against the critical intercept values for each specific dummy, where the normalized loads and moments can be expressed as: $F_{NZ} = F_Z / F_{ZCRIT.}$, and $M_{NY} = M_Y / M_{Y\ CRIT.}$ and where $F_{Z\ CRIT.}$ and $M_{Y\ CRIT.}$ are the critical intercept values previously discussed in Table III-1 for each specific dummy.

The <u>critical intercept values</u> for calculating the Nij are uniquely specified for each dummy and are defined in Table III-1 for the 50$^{th}$ percentile male, 5$^{th}$ percentile female, 6-year-old child, 3-year-old child and 12-month-old infant (CRABI) dummies. The peak limits on neck tension and

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Figure III-5 **Probability of Injury vs. Nij**



compression create further Nij boundaries. The computed Nij value must fall within or on the hexagonal boundary. Source code for a C++ program to calculate the Nij criteria is included in Appendix of the supplemental biomechanics report. This source code, as well as executable version of the program, is also available from the NHTSA web site at http://www-nrd.nhtsa.dot.gov/nrd10/nrd12. The supplemental biomechanics report describes how the Nij calculation is made.

*Chest Injury Risk Functions and ICPLs*

The chest acceleration and chest deflection ICPLs proposed in the SNPRM for each dummy size have been adopted for the final rule. The mandated 63 mm (2.5") deflection for the 50th percentile male dummy represents a 33 percent chance of an AIS-3+ injury. The chest deflection threshold values for the other dummy sizes have been scaled from this adjusted value to maintain equivalent injury risk at maximum chest displacement. Figure III-6 illustrates the required thoracic injury criteria ($D_C$ & $A_C$) for the 50th percentile male dummy.

Injury probability as a function of chest acceleration based on a 3 ms clip of the spinal acceleration on the 50th percentile male dummy is given below.[9] This acceleration is designated $A_C$ for purposes of the subject Final Economic Assessment (FEA). The chest acceleration threshold values for the other dummy sizes were scaled from the 50th percentile male. The family of chest acceleration risk curves for the 50th percentile male dummy is illustrated in Figure III-7.

[9] The spinal acceleration is measured by accelerometer on the 50th percentile dummy at a point identified as T1. This has been re-designated as chest acceleration $A_C$ for this report.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

AIS-2+ Percent Injury Probability = $[1/(1 + \exp^{(1.2324 - 0.0576 * Ac)})] \times 100\%$.

AIS-3+ Percent Injury Probability = $[1/(1 + \exp^{(3.1493 - 0.0630 * Ac)})] \times 100\%$.

AIS-4+ Percent Injury Probability = $[1/(1 + \exp^{(4.3425 - 0.0630 * Ac)})] \times 100\%$.

AIS-5+ Percent Injury Probability = $[1/(1 + \exp^{(8.7652 - 0.0659 * Ac)})] \times 100\%$.

Injury probability as a function of maximum chest deflection ($D_C$) at the center of the chest for the 50th percentile male dummy is described below. The family of risk curves for chest deflection is illustrated in Figure III-8.

AIS-2+ Percent Injury Probability = $[1/(1 + \exp^{(1.8706 - 0.04439 * Dc)})] \times 100\%$.

AIS-3+ Percent Injury Probability = $[1/(1 + \exp^{(3.7124 - 0.0475 * Dc)})] \times 100\%$.

AIS-4+ Percent Injury Probability = $[1/(1 + \exp^{(5.0952 - 0.0475 * Dc)})] \times 100\%$.

AIS-5+ Percent Injury Probability = $[1/(1 + \exp^{(8.8274 - 0.0459 * Dc)})] \times 100\%$.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

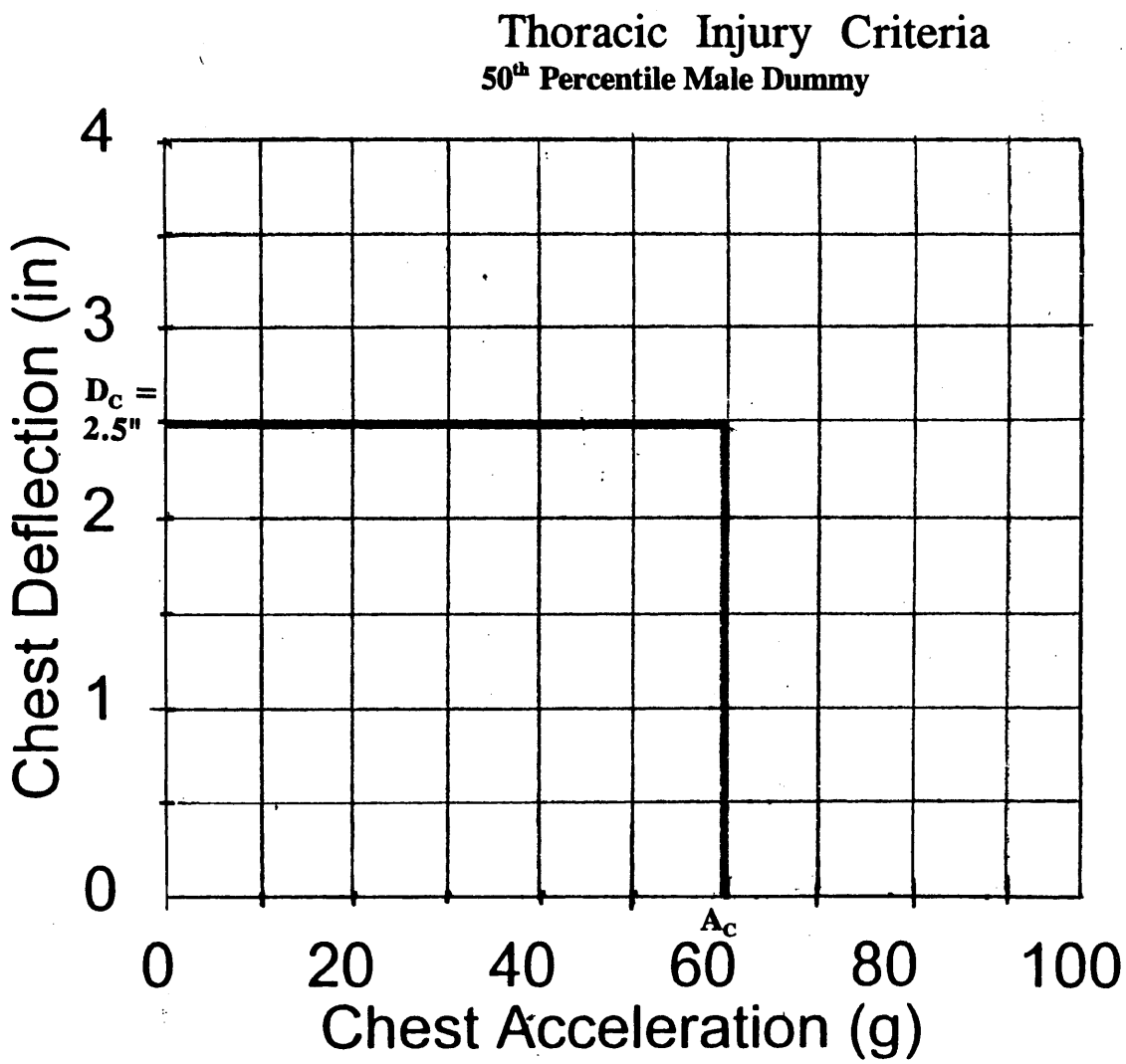



**Figure III-6** **Thoracic Injury Criteria for the 50th Percentile Male Dummy showing Critical Chest Deflection ($D_C$) and Critical Chest Acceleration ($A_C$).**

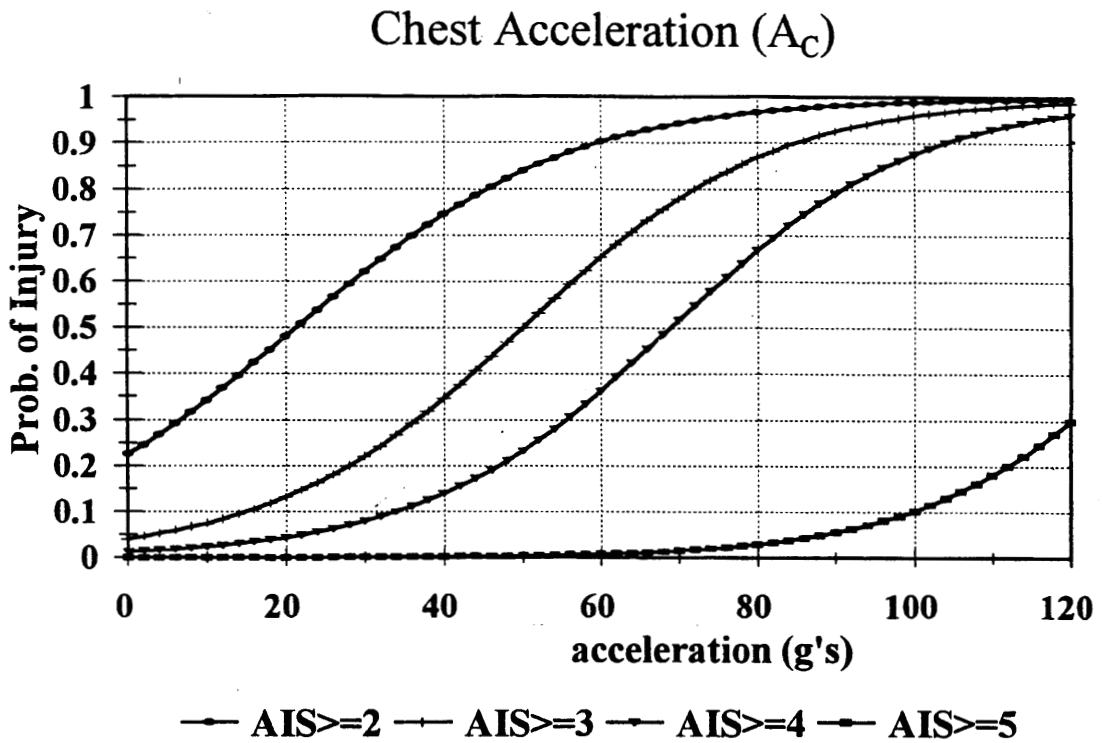



**Figure III-7** Family of Chest Acceleration ($A_C$) Risk Curves for the 50th Percentile Male Dummy

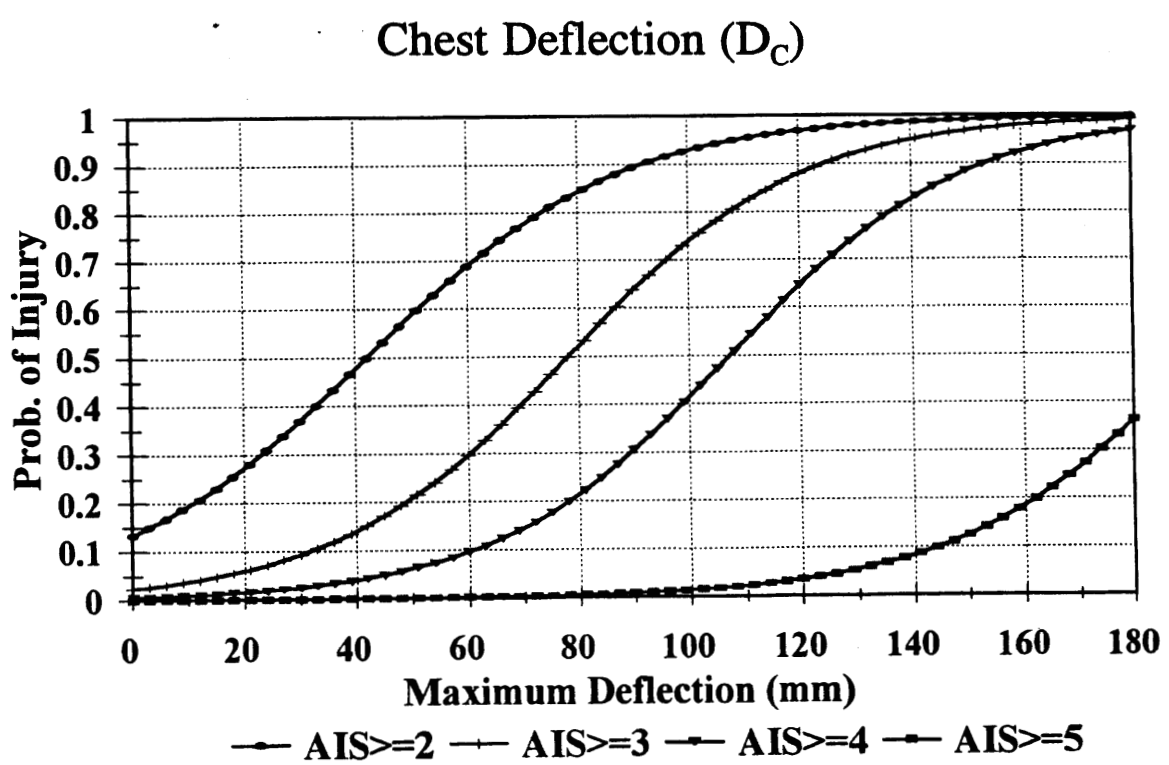



**Figure III-8** Family of Chest Deflection ($D_C$) Risk Curves for the 50th Percentile Male Dummy

***Combined Thoracic Index (CTI) Adopted for Chapter V. Benefits, for Analysis Purposes***

Based on the analysis of the docket comments (98-4405), NHTSA proposed independent chest g's and chest deflection measures for the SNPRM, specifically, 60 g's and 63 mm (2.5 in.) for the 50th percentile male dummy. These independent ICPLs have been adopted for the final rule for the 50th percentile male dummy. The other dummy sizes are scaled from this, based on geometry and material properties. NHTSA proposed a new chest injury criterion called the Combined Thoracic Index (CTI) in the NPRM. Although not adopted for the subject final rule, the agency has adopted the CTI injury risk function for purposes of assessing chest injury risk reduction and subsequent benefits. For the purposes of benefits analysis, rather than assess risk for each independent chest injury criterion, it is more convenient and more correct, to adopt the CTI risk function where the two independent chest injury criterion are combined.

CTI is the summation of the normalized 3 ms clip chest g's and the normalized chest deflection. The normalized 3 ms chest g's is found by dividing the specific dummy chest g's response ($A_{max}$), for a given test, by the chest acceleration critical intercept value ($A_{int}$)for the specific size dummy. The normalized chest deflection is found by dividing the specific dummy chest deflection response ($D_{max}$), for a given test, by the chest deflection critical intercept value ($D_{int}$)for the specific size dummy. The formulation is: $CTI = [(A_{max} / A_{int.}) + (D_{max} / D_{int.})]$, where $A_{max.}$ is the maximum chest acceleration (g's) measured, $A_{int.}$ is the X-axis intercept value (specific to each dummy) for chest acceleration (g's), $D_{max.}$ is the maximum chest deflection (mm) measured and $D_{int.}$ is the Y-

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

axis intercept value (specific to each dummy) for chest deflection (mm). Compared to the NPRM, the constants ($D_{int}$ and $A_{int}$ ) in the CTI formula have been adjusted slightly in response to docket comments (98-4405) as shown in Table III-4.

Compared to other chest injury predictors studied by NHTSA, and based on the agency's cadaveric data, CTI is a better predictor of chest injury than chest acceleration or chest deflection alone. However, there are still questions regarding the interpretation of the data used in the development of CTI. More data and analysis is needed to evaluate the efficacy of a CTI based injury criteria.

Analysis of the cadaveric data indicates that if sternal deflection is plotted along the vertical axis and chest acceleration is plotted along the horizontal axis, a line drawn between the coordinates (0,4) and (90,0) would represent a 50 percent probability of an AIS-3+ injury for the population of cadavers studied (mean age 60 years). Because of the increased fragility of the cadavers and the age difference between the cadaver population studied and the human population, the actual risk of injury for an IARV of 1.0, for example, for CTI is estimated to be a 25 percent probability of an AIS 3+ for the driving population. Table III-4 shows the chest deflection Y-axis intercept ($D_{int}$) and the chest acceleration X-axis intercept ($A_{int}$) to set-up the 50 percent AIS-3+ threshold for each dummy size. Deflection and acceleration limits for each dummy size were obtained using geometric scaling from Mertz along with bone modulus scaling from Melvin.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table III-4
Critical Intercept Values ($D_{int.}$ and $A_{int.}$) for the CTI = 1.0 by Dummy Size
Used for Analysis Purposes Only.

| | **50th Percentile** | **5th Percentile** | **6-Year-Old Child** | **3-Year-Old Child** | **12-Month-Old Infant (CRABI)** |
|---|---|---|---|---|---|
| $D_{int}$ (Chest Deflection, Y-Axis Intercept) | 103 mm (4.0") | 84 mm (3.3") | 64 mm (2.6") | 57 mm (2.2") | 50 mm (2.0") |
| $A_{int}$ (Chest Acceleration, X-Axis Intercept) | 90 | 90 | 90 | 74 | 57 |

Figure III-9 shows an example of $D_{int}$ and $A_{int}$ used to establish the CTI=1.0 threshold for the 50th percentile male dummy. Figure III-10 illustrates the family of CTI risk functions for AIS-2+, 3+, 4+ , 5+ and fatal injury for the 50th percentile male dummy. The formula for percent injury probability at AIS-2+ through AIS-5+ injury, as a function of CTI values are as follows:

AIS-2+ Percent Injury Probability = $[1/(1 + \exp^{(4.847 - 6.036*CTI)})] \times 100\%$.

AIS-3+ Percent Injury Probability = $[1/(1 + \exp^{(8.224 - 7.125*CTI)})] \times 100\%$.

AIS-4+ Percent Injury Probability = $[1/(1 + \exp^{(9.872 - 7.125*CTI)})] \times 100\%$.

AIS-5+ Percent Injury Probability = $[1/(1 + \exp^{(14.242 - 6.589*CTI)})] \times 100\%$.

Fatality Percent Injury Probability = $[1/(1 + \exp^{(14.242 - 6.589*CTI)})] \times 100\%$. (Same as AIS-5+)

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

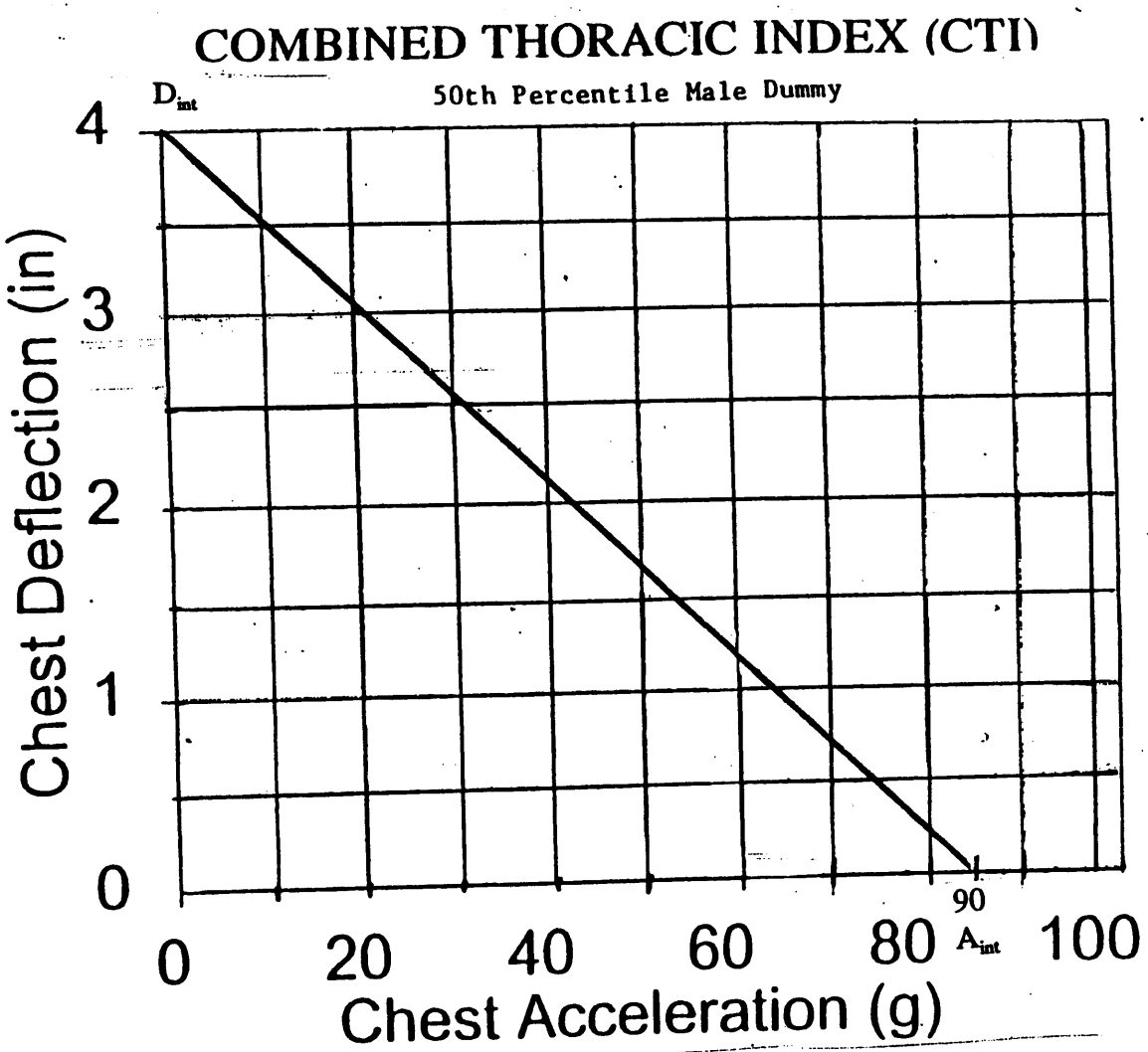



**Figure III-9** Schematic of the Combined Thoracic Index (CTI) for the 50th Percentile Male Dummy showing the critical intercept values for Deflection ($D_{int}$) and Acceleration ($A_{int}$).

DRAFT - DO NOT RELEASE WITHOUT OFFICIAL APPROVAL

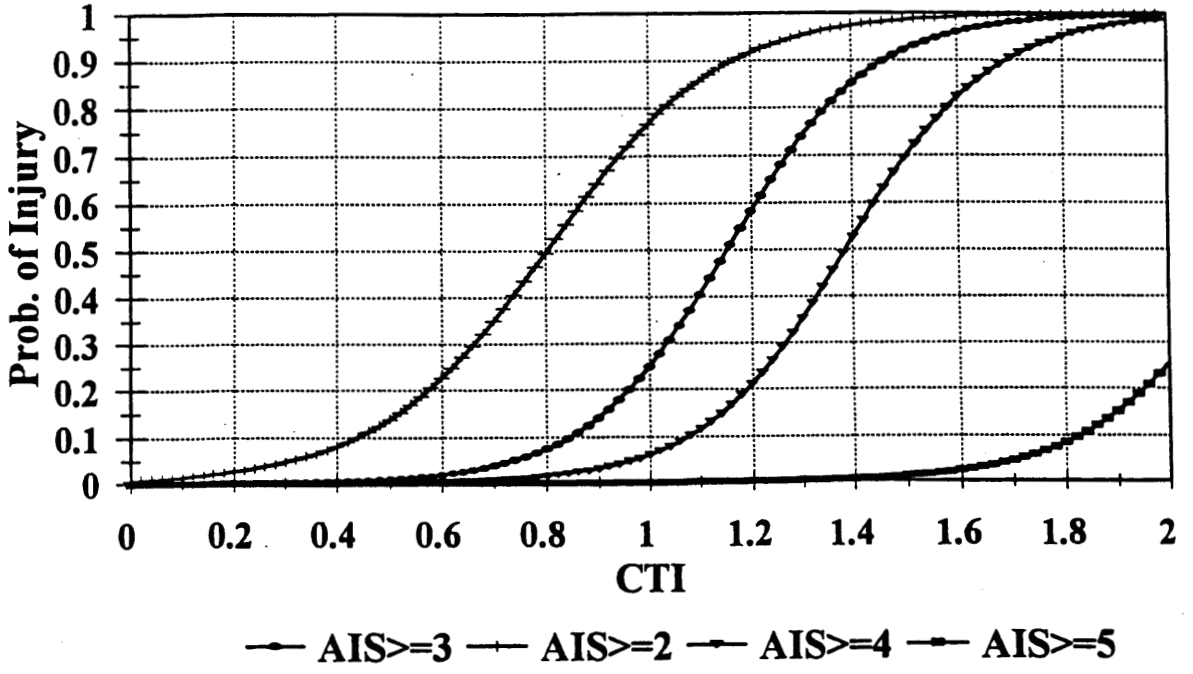



**Figure III-10 Family of CTI Risk Curves**

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

***Femur Risk Function and ICPLs***

As shown in Table III-1, femur axial load limits for the 50th percentile male and 5th percentile female dummies are being mandated in the final rule at 10 kN (2,250 lbs.) and 6.8 kN (1,530 lbs.), respectively. In frontal crashes, particularly with air bags, the dummy knees often make contact and load the instrument panel or knee bolster. NHTSA has estimated that for the 50th percentile dummy, 10 kN (2,250 lbs.) femur axial compression represents a 35 percent risk of an AIS 2+ injury. The AIS-2+ risk function for the 50$^{th}$ percentile male dummy is [$1/1+e^{(5.795-0.5196Fx)}$] times 100%], where Fx is the femur axial load measured in kN. Figure III-11 illustrates this risk function. The 5th percentile femur ICPL of 6.8 kN (1,530 lbs.) was scaled from the 50th percentile dummy values using 5th percentile female femur bone cross-sectional area. NHTSA is not adopting femur ICPLs for the 12-month-old infant (CRABI), the 3-year-old or the 6-year-old child dummies. Lower extremity injuries (femur fractures) are rarely experienced for OOP children.

## C. Injury Criteria and IARVs for Analysis Purposes

***95$^{th}$ Percentile Male Dummy IARVs***

Table A-9, Driver and Passenger Sled Test Data with 95$^{th}$ Percentile Dummies (Chest g's) (Appendix) describes a series of 95$^{th}$ percentile male dummy tests conducted by the agency. These tests at 48, 64, and 72 kmph (30, 40 and 45 mph) compare pre-depowered (1997) and depowered (1999) chest g's results for a Chevy Venture and a Buick Century. In order to interpret the significance of agency sled results it was necessary to derive appropriate IARVs for the 95$^{th}$ percentile dummy based on the same injury criteria required for the other dummies. Similar IARV values for the 95$^{th}$ percentile male dummy are shown in Table III-5.

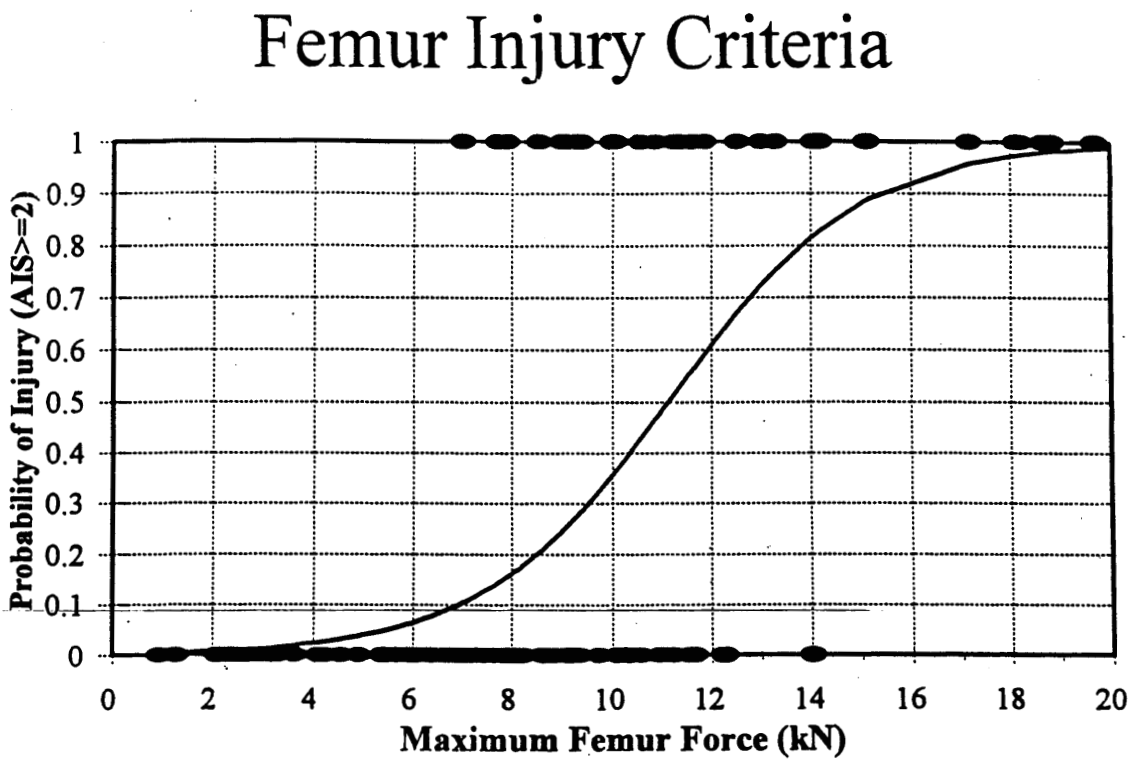



**Figure III-11** Femur Axial Load Risk Curves (> = AIS-2+) for the 50th Percentile Male Dummy

Table III-5
**Injury Criteria and Injury Assessment Reference Values (IARVs) derived for the 95th Percentile Male Dummy, Used for Analysis Purposes Only**

| Injury Criteria | Hybrid III 95th Percentile Male Dummy IARVs |
|---|---|
| **Head Criteria** $HIC_{15ms}$ | 700 |
| **Neck Criteria** Nij | 1.0 |
| **In-Position** | |
| Nij Critical Intercept Values | |
| **Fz crit.** Tension (N) | 8216 |
| **Fz crit.** Compression (N) | -7440 |
| **My crit.** Flexion (N-m) | 415 |
| **My crit.** Extension (N-m) | -179 |
| Peak Limits | |
| Neck Tension (N) | 5030 |
| Neck Compression (N) | -4830 |
| **Out-of-Position** | |
| Nij Critical Intercept Values | |
| **Fz crit.** Tension (N) | 7440 |
| **Fz crit.** Compression (N) | -7440 |
| **My crit.** Flexion (N-m) | 415 |
| **My crit.** Extension (N-m) | -162 |
| Peak Limits | |
| Neck Tension (N) | 3970 |
| Neck Compression (N) | -4830 |
| **Thoracic Criteria** | |
| 1. **T1**: Critical Spine Acceleration (g) | 55 |
| 2. **D**: Critical Chest Deflection (mm) | 70 |
| 3. Combined Thoracic Index (CTI) | |
| CTI Intercept values | |
| **Aint.** Accel. (G) | 83 |
| **Dint.** Deflection (mm) | 114 |
| **Lower Extremity Criteria** | |
| Femur Loads (kN) | 12.7 |

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

# IV. TEST DATA AND ANALYSIS OF TEST DATA

This chapter presents test data available to the agency on the various static and dynamic test procedures mandated by the advanced air bags final rule. The test data, and analysis of the test data, are presented in the following format.

**A. Static Tests (Out-of-Position)**

1. Driver-Side OOP 5th Percentile Female Dummy (MY99, MY98 and Pre-MY98 data)
   a. Position 1 (chin on module)
   b. Position 2 (chest on module)

2. Passenger-side OOP
   a. RFCSS 12-Month-Old Infant (CRABI) Dummy
   b. 6- Year-Old Child Dummy (MY99, MY98 and Pre-MY98)
      (1) Position 1 (chest on module)
      (2) Position 2 (head on module)

**B. Vehicle Tests (In-Position)**

1. Belted Tests
   a. 56 kmph (35 mph), 0 Degree, Belted Barrier Test
      (1) 50th Male

   b. 48 kmph (30 mph), 0 Degree, Belted Barrier Test
      (1) 50th Male.
      (2) 5th Female

   c. 40 kmph (25 mph), Offset Deformable Barrier (ODB), 40% Overlap, Belted Test
      (1) 5th Female

2. Unbelted Tests
   a. 40 kmph (25 mph), 0 Degrees, Unbelted Barrier Test
      (1) 50th Male.
      (2) 5th Female

   b. 48 kmph (30 mph), 0 Degree, Unbelted Barrier Test
      (1) 50th Male.
      (2) 5th Female

   c. 48 kmph (30 mph) +/- 30 Degree (L or R) Oblique Unbelted Barrier Test
      (1) 50th Male

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

## C. Summary of Pass Rates by Required Test Procedure

## D. Test Procedure Stringency

1. Out-of-Position Static Test Procedures
   a. 12-Month-Old Infant (CRABI) Dummy
   b. 5th Percentile Female Dummy
   c. 6-Year-Old Child Dummy
   d. 3-Year-Old Child Dummy

2. In-Position Dynamic Test Procedures
   a. Left vs Right Unbelted Oblique for 50th Percentile Male Dummy
   b. 50th Percentile Male vs 5th Percentile Female Dummy Dynamic and Compliance Equivalency
      (1) BMW Sled Tests, Unbelted
      (2) 48 kmph (30 mph), 0 Degrees, FRB, Unbelted
      (3) 48 kmph (30 mph), 30 Degrees Oblique (L), Unbelted

3. Nij (Final Rule) vs Nij (SNPRM)

## A. Static Tests, Out-of- Position (OOP)

A.1.a. & b. **Driver 5th Percentile Female Dummy**

The final rule requires static out-of-position tests for the driver-side 5th percentile female dummy. Static deployment Position 1 and 2 tests were conducted using the 5th percentile female dummy representing the driver-side. These positions are the same as those proposed in the SNPRM where in Position 1 the dummy's chin is placed on the inflator module and Position 2 the dummy's chest is placed on the inflator module. Table IV-1 shows that $HIC_{15}$, chest g's and chest deflection did not have any failures for all the tests, whereas Nij had failures for both Position 1 and Position 2 testing based on MY98 and pre-MY98 vehicles. Compared to pre-MY98 vehicles, the magnitude of Nij has decreased in MY98 and MY99 and the Nij Pass Rates have subsequently improved. In MY99, the Nij Pass Rate improved to the 67 percent level for Position 1 and to the 100 percent level for Position 2.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Tables IV-2 and IV-3 show the individual Nij values by make/model/year used for the averages shown in Table IV-1.

Table IV-4 shows the individual chest deflection, chest g's and Nij values by make/model for 1996 versus 1998. Table IV-5 shows the same responses for individual MY99 make/models.

***Passenger-Side OOP***

**Convertible Child Safety Seat and 12-Month-Old Infant (CRABI) Dummy**

The new 12-month-old infant (CRABI) test dummy was tested on a 213 sled with and without air bags. The results are organized by common test condition in Table IV-6a. All tests utilized the standard FMVSS 213 sled pulse and 213 seat. The sled tests with air bag deployments used 1997 Ford Taurus or 1998 Ford Explorer air bag modules. These are labeled non-213 configuration, but used the 213 pulse and seat. The HICs measured were an order of magnitude lower using the 12-month-old CRABI dummy compared to previous VRTC tests (shown in the August 1998 PEA) using a 9-month-old dummy (TNO P3/4 dummy). Overall Pass Rates are zero percent for each test condition which are summarized in Table IV-15. In the final rule, the manufacturers have a suppression option for meeting this static OOP test.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table IV-1
Summary of OOP Results by Model Year
Driver-5th Percentile Female Dummy[1]
Numbers in ( ) indicate Pass Rate in Percent

| | $HIC_{15}$ Avg. | Nij Avg. | Chest g's Avg. | Chest Deflect Avg. | What failed? | n |
|---|---|---|---|---|---|---|
| **MY 99 5th Driver** | | | | | | |
| Pos.1 | 67 (100) | 0.91 (67) | 18.2 (100) | 24.7 (100) | 2/6 Nij failures | 6 |
| Pos.2 | 41 (100) | 0.48 (100) | 29.42 (100) | 35.7 (100) | No Failures | 6 |
| **MY 98 5th Driver *** | | | | | | |
| Pos.1 | 53 (100) | 1.41 (0) | 16.6 (100) | 20 (100) | All failed Nij | 5 |
| Pos.2 | 109 (100) | 0.906 (60) | 26.7 (100) | 34.7 (100) | 2/5 failed Nij includes neck C failure | 5 |
| **PRE-MY 98 5th Driver **** | | | | | | |
| Pos.1 | 149 ( 100) | 1.60 (25) | 23.43 (100) | 26.7 (100) | 2/4 failed Nij & neck T 1/4 failed neck T | 4 |
| Pos.2 | 73 (100) | 1.85 (25) | 26.64 (100) | 39.11 (100) | 3/4 failed Nij | 4 |
| | | | | | | |
| 5th % 1CPL | 700 | ≤1.0 | 60 | 52 | | |

* MY 99 and MY 98 are not matched by make/model. ** MY 98 and PRE-98 are matched by make/model. MY 99 and PRE-98 matched make/models were not tested.
Peak Limits for neck compress. (C) & tension (T) were not exceeded in these tests except as noted .

[1] The OOP tests were not conducted with original vehicle seats. The response of the dummy during contact with the seat back in these OOP tests may not be the same as when the test is conducted in the vehicle with original seats. The impact event was assessed up to 300 ms. The maximum injury value before seat back contact was recorded in this table.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table IV-2
Static Out-of Position Driver Tests, Position 1, 5th Percentile Female Dummy
**Max Nij**

| Vehicle | MY 1996 Nij | MY 1998 Nij |
|---|---|---|
| Ford Explorer | **2.76** | **1.20** |
| Ford Taurus | 0.91* | **1.62** |
| Dodge Neon | **2.08** | **1.73** |
| Toyota Camry | 0.66 | **1.27** |
| Honda Accord | -- | **1.24** |

**Bold Numbers** indicate that the mandated ICPL values were exceeded.
-Peak Limits for neck compress. (C) & tension (T) were not exceeded in these tests except as noted. *
Ford Taurus passed Nij, but failed neck T peak limit.

Table IV-3
**Static Out-of Position Driver Tests, Position 1, 5th Percentile Female Dummy**
**Max Nij**

| Make/Model | MY 99 Nij | |
|---|---|---|
| Dodge Intrepid* | 0.71 | |
| Saturn SL1 | 0.26 | |
| Ford Econoline (Van) | 0.98 | |
| Acura 3.5RL ** | **1.34** | |
| Ford Expedition (SUV) | 0.99 | |
| Toyota Tacoma (PU)* | **1.17** | |

* Indicate that sled bucks were used for these static tests.
** Acura 3.5 RL has a single stage inflator on the driver's side and dual stage inflator on the passenger's side.
-MY 99 and pre-MY 98 matched make/models were not available.
-MY 99 and MY 98 are not matched make/models.
- Peak Limits for neck compress. (C) & tension (T) were not exceeded in these tests except as noted .

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table IV-4
Static Out-of Position Driver Tests, Position 2
5th Percentile Female Dummy
Chest and Neck Measurements

| | MY 1996 | MY 1998 |
|---|---|---|
| **Chest Deflection (mm)** | | |
| Ford Explorer | 39.77 | 22.6 |
| Ford Taurus | 43.68 | 38.69 |
| Dodge Neon | 43.32 | 34.43 |
| Toyota Camry | 29.36 | 32.90 |
| Honda Accord | | 44.7 |
| **Chest g's** | | |
| Ford Explorer | 36.4 | 13.95 |
| Ford Taurus | 20.58 | 27.55 |
| Dodge Neon | 31.64 | 34.05 |
| Toyota Camry | 17.96 | 31.74 |
| Honda Accord | | 26.22 |
| **Nij** | | |
| Ford Explorer | **2.23** | **1.07** |
| Ford Taurus | **1.11** | 0.99 |
| Dodge Neon | **2.20** | **1.02** |
| Toyota Camry | 0.73 | 0.80 |
| Honda Accord | | 0.65 |

- **Bold Numbers** indicate that the mandated ICPL values were exceeded.
- Applicable ICPLs are: $HIC_{15}$ = 700, Nij = 1.0, chest g's = 60 g's, chest deflection = 52 mm.
- Peak Limits for neck compress. (C) & tension (T) were not exceeded in these tests except as noted .

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table IV-5
Static OOP Driver Test Position 2
5th Percentile Female Dummy

| | MY 99 |
|---|---|
| **Chest Deflection. (mm)** | |
| Dodge Intrepid* | 47.3 |
| Saturn SL1 | 36.4 |
| Ford Econoline | 33.0 |
| Acura 3.5RL | 29.0 |
| Ford Expedition | 37.0 |
| Toyota Tacoma* | 31.3 |
| **Chest g's** | |
| Dodge Intrepid* | 40.0 |
| Saturn SL1 | 22.9 |
| Ford Econoline | 24.9 |
| Acura 3.5RL | 26.4 |
| Ford Expedition | 32.2 |
| Toyota Tacoma* | 30.2 |
| **Nij** | |
| Dodge Intrepid* | 0.58 |
| Saturn SL1 | 0.37 |
| Ford Econoline | 0.30 |
| Acura 3.5RL | 0.63 |
| Ford Expedition | 0.34 |
| Toyota Tacoma* | 0.66 |

* Indicates sled bucks were used for these static tests.
*MY 99 make/models matched to MY 98 or MY 96 make/models were not available for analysis.
- Peak Limits for neck compression (C) and tension (T) were not exceeded in these tests except as noted.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Tables IV-10, 11 and 12 in the Preliminary Economic Assessment (PEA) August, 1998 contained baseline 213 sled tests with a 9 month-old dummy as well as tests with air bags (mid-mount and top mount).[2] The maximum $HIC_{36}$ using mid-mounted air bags ranged from 2,000-3,000 and the top mounted air bag $HIC_{36}$ was as high as 3,015. The new VRTC test series involving the 12-month-old CRABI dummy shows that HICs have been reduced by about an order of magnitude despite being computed over 15 ms rather than 36 ms. The test conditions in this test series were identical to those referenced in the PEA.[3]

[2] The 9-month dummy employed was designated the TNO P3/4 infant dummy.

[3] Preliminary Economic Assessment, FMVSS No. 208, Advanced Air Bags, August 1998, Office of Regulatory Analysis and Evaluation, Plans and Policy, NHTSA/DOT. Also, Preliminary Economic Assessment, October 1999, SNPRM, FMVSS No. 208, Advanced Air Bags, Office of Regulatory Analysis and Evaluation, Plans and Policy, NHTSA/DOT.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Tables IV-6a
FMVSS No. 213 Sled Tests
12-Month-Old Infant (CRABI) Responses

| Test Condition 1./ | Test # | Child Seat Facing | HIC15 (ICPL ≤390) | Nij (ICPL≤1.0) |
|---|---|---|---|---|
| **Convertible Child Seat w/o Air Bag** (FMVSS 213 pulse and configuration) | 2R<br>5<br>9<br>10<br>11R<br>1R<br>6<br>12 | F<br>F<br>F<br>F<br>F<br>R<br>R<br>R | 239<br>**411**<br>214<br>303<br>232<br>**565**<br>241<br>130 | **1.34***<br>**1.30 ***<br>**1.06***<br>**1.12***<br>**1.14***<br>**1.51***<br>**1.49***<br>1.12 |
| **Convertible Child Seat with Air Bag** (FMVSS 213 pulse but non-213 configuration) 2./ & 3./ | 3M<br>4M<br>7T<br>8T | F<br>R<br>F<br>R | 329<br>**1555**<br>**662**<br>**531** | **1.32**<br>**1.27***<br>**1.03**<br>**1.41** |

**Bold Numbers** exceed the mandated ICPL values.
FMVSS No. 213, Child Restraint Systems.
R = Convertible Child Seat Rearward-Facing. F = Convertible Child Seat Forward-Facing.
1./ For test conditions, see VRTC report on CRABI dummy, Docket NHTSA-99-5156-6.
2./ 1997 Ford Taurus and 1998 Ford Explorer inflators.
3./ #3 and #4 are mid-mount air bags (M) were 1998 Ford Explorer modules. #7 and #8 are top mount air bags (T) were 1997 Ford Taurus modules.
* Asterisk indicates peak limit neck tension failure as well as Nij failure.

NHTSA also conducted a 12-month-old infant (CRABI) low risk deployment test using new inflator technology, namely, - the 1st stage of an experimental (confidential MMY) dual stage inflator. The vehicle's passenger seat was placed full-forward with the seat back set at 30 degrees. The top center of the Century rear facing child safety seat (RFCSS) was aligned with the geometric center of the air bag. The center line of the RFCSS was aligned with the longitudinal center line of the test vehicle. The vehicle safety belts were cinched to secure the RFCSS. The 12-month-old infant dummy was belted in the Century RFCSS. The

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

first stage of an experimental dual power experimental air bag was statically deployed.[4] Table IV-6b shows that all the responses of the 12-month-old infant dummy were low and would pass the mandated ICPL requirements. The Nij calculated per the final rule was less than 1.0 and peak limits for neck compression/tension, out-of-position (OOP), were not exceeded.

Table IV-6b
Low Risk Deployment Test (n=1) with the 12-Month-Old Infant (CRABI) Dummy
1st Stage of Experimental Dual Power Inflator

| Injury Criteria | CRABI Responses | ICPLs | Pass/Fail |
|---|---|---|---|
| $HIC_{15}$ | 321 | 390 | P |
| Neck Tension (N) Peak Limits OOP | 447 | 780 | P |
| Neck Comp. (N) Peak Limits OOP | 195 | 960 | P |
| Nij | 0.47 ($N_{TE}$)* | 1.0 | P |
| Chest g's | 23 | 50 | P |

VRTC Test No. 04200034.
* Peak Limits for neck compression (C) and tension (T) were not exceeded in this test.

**6-Year-Old Child Dummy (Passenger-side)**

The final rule requires static out-of-positions tests for the 6-year-old child dummy. The static deployment OOP Positions 1 and 2 (0 mm clearance) were tested using the 6-year-old child dummy. Positions 1 and 2 were the same as those required in the final rule such that in Position 1 the chest is placed on the module, whereas for Position 2, the head is placed on the module. As

[4] Evaluation of the CRABI 12-Month-Old Infant Dummy and Its Comparison with TNO P3/4, February, 1999, Hagedorn, A.V. and Pritz, H.B., Vehicle Research and Test Center, East Liberty, OH, Docket No. NHTSA-99-5136-6.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

shown in Table IV-7, $HIC_{15}$ passed in either Position 1 or Position 2 tests using MY99 vehicles or test bucks. [Note: Model year 1998 and pre-model year 1998 vehicles are matched. MY98 and MY99 vehicles are not matched by make/model.] Nij, chest g's, and chest deflection, however, did not always pass using Position 1 and Position 2 procedures based on MY98 and 99 vehicles or sled test bucks. Position 2 tests were not conducted in MY98 or pre-MY98. $HIC_{15}$, chest g's and chest deflection have improved with the new redesigned air bags. Similarly, Nij values have improved, but there is still a low Nij Pass Rate in MY98 and 99 vehicles.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table IV-7
Summary of OOP Results by Model Year
Passenger 6-Year-Old Child Dummy
Number in ( ) indicates Pass Rate in Percent

| | $HIC_{15}$ Avg. | Nij Avg. | Chest g's Avg. | Chest Deflect Avg. | What failed? | n |
|---|---|---|---|---|---|---|
| **MY 99 6 Year Old Passenger (0 mm)** | | | | | | |
| Position 1 | 169 (100) | 1.76 (33) | 32.63 (100) | 31.48 (42.9) | 4/7 - Nij (2 failed T) 1/6 neck T 4/7 - Deflect | 7 |
| Position 2 | 246 (100) | 2.05 (28.6) | 48.37 (57.1) | 27.53 (71.4) | 5/7 - Nij (5 failed T) 3/7 - Chest g 2/7 - Deflect | 7 |
| **MY 98 6 Year Old Passenger (0 mm)** | | | | | | |
| Position 1 | 542 (83) | 3.51 (0) | 39.5 (83) | 40.75 (16.7) | 1/6 - $HIC_{15}$ 6/6 - Nij (6 failed T) 1/6 - Chest g 5/6 - Deflect | 6 |
| Position 2 | *** | | | | | |
| **Pre-MY98 6-Year-Old Passenger (0 mm)** | | | | | | |
| Position 1 | 938 (50) | 4.50 (0) | 52.85 (67) | 48.4 (16.7) | 3/6 - $HIC_{15}$ 5/5 - Nij 2/6 - Chest g 5/6 - Deflect | 6 |
| Position 2 | *** | *** | *** | *** | | |
| 6YO ICPLs | 700 | 1.0 | 60 | 40 | | |

* MY 99 vehicles are not matched to MY 98 by make/model. ** MY 98 and Pre-MY 98 are matched by make/model. *** These tests not conducted.
- Peak Limits for neck compression (C) and tension (T) were not exceeded in these tests except as noted.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Tables IV-8a and IV-8b contain the specific 6-year-old dummy responses by make/model for MY96, MY98 and MY99 for static OOP Position 1 with zero clearance. Tables IV-8b and IV-8c show a 100 percent Pass Rate for OOP Positions 1 and 2 for the Acura 3.5RL using the first stage of a two stage inflator.

Table IV-8a
Static Out-of-Position Tests with a 6-Year- Old Child Test Dummy
Position 1 @ 0 mm Clearance from the Air Bag Module

| Vehicle | MY 96 HIC 15 | MY 98 HIC15 | MY 96 Chest g's | MY98 Chest g's | MY 96 Chest Deflect | MY98 Chest Deflect | MY 96 Nij | MY 98 Nij |
|---|---|---|---|---|---|---|---|---|
| Ford Taurus | **2471** | **1854** | 53.8 | **64** | 28 | **50.5** | **3.66** | **2.84** |
| Dodge Neon | 377 | 172 | 35.7 | 22.3 | **43.8** | **41.8** | **3.20** | **2.75** |
| Toyota Camry | **1020** | 213 | **64.6** | 32.8 | **45.4** | 11.3 | **9.06** | **3.79** |
| Dodge Caravan | **1207** | 493 | **82.9** | 30.7 | **50** | **50.6** | N.A. | **3.41** |
| Honda Accord | N.A. | 132 | N.A. | 37 | N.A. | **40.1** | N.A. | **2.11** |
| Ford Explorer | 276 | 387 | 42.5 | 50.2 | **63** | **50.2** | **2.90** | **6.16** |
| Ford Explorer | 278 | - | 37.5 | - | **60.2** | - | **3.70** | - |
| ICPL | 700 | 700 | 60 | | 40 | | ≤1.0 | ≤1.0 |

**Bold Numbers** exceed the mandated ICPL values.
N.A. indicates data Not Available
- Peak Limits for neck compression (C) and tension (T) were not exceeded in these tests except as noted.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table IV-8b
Static Out-of-Position Tests With a 6-Year-Old Child Dummy
Position 1 @ 0 mm Clearance from the Air Bag
Module for MY 99

| MY 99 | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) |
|---|---|---|---|---|
| Dodge Intrepid | 149 | **2.89** | 58.93 | **42.1** |
| Saturn SL1 | 35 | 0.93 | 23.1 | **44.2** |
| Ford Econoline | 428 | --- | 50.3 | **45.1** |
| Acura 3.5RL* | 101 | **1.31** | 19.5 | 10.7 |
| Acura 3.5RL** | 87 | 0.94 | 19.4 | 6.9 |
| Ford Expedition | 42 | **1.04** | 39.2 | **49.8** |
| Toyota Tacoma | 145 | **3.44** | 17.9 | 21.9 |
| ICPLs | 700 | ≤1.0 | 60 | 40 |

**Bold Numbers** exceed the mandated ICPL values.
* Stage 1 fired and then Stage 2 fired with a 40 ms delay.
** Stage 1 fired only
Peak Limits for neck compression (C) and tension(T) were not exceeded except as noted. Saturn SL1 had an Nij of 0.93, but failed neck T peak limit @ 1,799 N.

In their docket comments (Docket No. 99-6407-47), Toyota submitted a tank pressure vs. time performance curve for a Honda Acura dual stage inflator and stated that NHTSA's "Stage 1 fired only" tests shown in Tables IV-8b and IV-8c may be invalid. The performance curve submitted by Toyota shows a second stage firing at approximately 40-42 ms and a sudden increase in pressure. This was the type of inflator believed to be used by NHTSA/VRTC. Toyota indicated the second stage (Stage 2) could fire anywhere from 33 to 110 ms. Honda did not comment on these two tests. The two tests in question are Test No. 4046 (Nij = 0.94) and Test No. 4047 (Nij = 0.93). The times of maximum Nij were 38.1 ms and 21.4 ms, respectively, before the second stage would be deployed.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Therefore, NHTSA concludes that these "stage 1 only fired" tests are representative of a dual stage inflator in which the 2nd stages fires at or greater than 40 ms.

Table IV-8c
Static Out-of-Position Tests With a 6-Year-Old Child Dummy
Position 2 @ 0 mm Clearance from the Air Bag Module for MY 99

| MY 99 | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) |
|---|---|---|---|---|
| Dodge Intrepid | 627 | **3.39** | **68.8** | 39.7 |
| Saturn SL1 | 76 | **2.05** | 44.6 | **43.4** |
| Ford Econoline | 429 | **2.29** | **65.0** | 34.3 |
| Acura 3.5RL* | 113 | 0.93 | 16.0 | 9.0 |
| Acura 3.5RL** | 101 | 0.83 | 17.7 | 3.0 |
| Ford Expedition | 131 | **2.33** | **85.5** | **45.0** |
| Toyota Tacoma | 246 | **2.54** | 41.0 | 18.3 |
| ICPLs | 700 | ≤1.0 | 60 | 40 |

**Bold Numbers** exceed mandated ICPL values.
* Stages 1 fired and then Stage 2 fired with a 40 ms delay.
** Stage 1 fired only.
Peak Limits for neck compression (C) and tension(T) were not exceeded except as noted.

**3-Year-Old Child Dummy Static OOP Tests**

The final rule requires the same static OOP deployment tests (Position 1 and 2 ) as proposed in the SNPRM for the 3-year-old child dummy. The agency did not conduct new, post-August 1998 PEA, Position 1 and 2 tests using the 3- year-old child dummy because of time and resource constraints. The agency believes that if a 6-year-old dummy fails the OOP tests, it is likely that the 3-year-old dummy will also fail. However, if the 6- year-old dummy passes the OOP tests, there is no guarantee the 3-year-old will pass.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

## B. Full-Scale Vehicle Tests (In-Position)

### Belted Test Procedures

**56 kmph (35 mph), 0 Deg., Barrier Test, Belted, 50th Percentile Male Dummy**

As part of its high speed crash test deliberations, NHTSA examined the 35 mph NCAP data base to examine performance differences due to depowered air bag designs. For a limited set of matched pairs (n=14) as shown in Table IV-9a, MY99 and MY98 responses are not significantly different, except for Nij which was lower by 29 percent and 19 percent for the driver and passenger, respectively, for MY99. Given the similarity of the two model years, NHTSA has combined MY98 and MY99 vehicles into a "redesigned" air bag group for further analysis. For the driver and passenger-side Pass Rates in Table IV-15, for example, MY98 and MY99 have been combined.

Table IV-9a
NCAP Test Results
**Average NCAP Test Results for Matched Make/Models**
**Belted @ 56 kmph (35 mph), 50th Percentile Male Dummy**
MY 99 vs MY 98

| | $HIC_{15}$ | Nij ** | Chest g's | Chest Deflection (mm) | Sample Size (n) |
|---|---|---|---|---|---|
| **Drivers** | | | | | |
| MY 99 | 446 | 0.384 | 50 | 37 | 14 |
| MY 98 | 445 | 0.542 | 49 | 37 | 15* |
| **Passengers** | | | | | |
| MY 99 | 379 | 0.429 | 47 | 30 | 14 |
| MY 98 | 368 | 0.531 | 51 | 33 | 15 |
| ICPLs 50th | 700 | 1.0 | 60 | 63 | |

All average responses rounded to the nearest whole number.
* MY 98 had two Ford Windstar Tests, whereas MY 99 had one Windstar.
** Peak Limits for neck compression and tension were not exceeded, except for 1998 Dodge Durango where Nij = 1.04 and neck tension failed the peak limit @ 4,448 N.

Comparing MY99 make/models to matched pre-MY98 make/models, as shown in Table IV-9b, indicates that $HIC_{15}$ decreased 14 and 47 percent and chest g's increased slightly by about 3 g's for both the driver and passenger, respectively. Driver and passenger Nij's decreased 26 percent and 42 percent, respectively, from pre-MY98 to MY99. Chest deflection responses were mixed with no clear trend. Table IV-9b is based on matching MY98 and pre-MY98 make/models to MY99 make/models.

Table IV-9b
NCAP Test Results
**Average NCAP Test Results for Matched Make/Models**
**Belted @ 56 kmph (35 mph), 50th Percentile Male Dummy**
MY 99 vs Pre-MY 98

| **Occupant Position** | **$HIC_{15}$** | **Nij *** | **Chest g's** | **Chest Deflection (mm)** | **N** |
|---|---|---|---|---|---|
| **Driver** | | | | | |
| MY 99 | 532.8 | 0.456 | 56.04 | 39.89 | 5 |
| Pre-MY 98 | 618.2 | 0.620 | 53.62 | 31.42 | 5 |
| **Passenger** | | | | | |
| MY 99 | 352.8 | 0.280 | 50.8 | 26.2 | 5 |
| Pre-MY 98 | 670 | 0.484 | 47.72 | 41.4 | 5 |
| ICPLs 50th | 700 | ≤1.0 | 60 | 63 mm | |

* Peak limits for neck compression and tension were not exceeded for any of these tests.

Table IV-9c is based on matching MY98 make/models and pre-MY98 make/models. Table IV-9c shows very little difference between responses for MY98 and pre-MY98 vehicles, on the average, for the belted 56 kmph (35 mph) fixed rigid barrier test condition.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table IV-9c
NCAP Test Results
**Average NCAP Test Results for MY98 vs Pre-MY98 (Matched Make/Models*)**
**Belted @ 56 kmph (35 mph), 50th Percentile Male Dummy**

| | $HIC_{15}$ | Nij ** | Chest g's | Chest Deflection (mm) | Sample Size (n) |
|---|---|---|---|---|---|
| Driver | | | | | |
| MY1998<br>Pre-MY98 | 376.8<br>404 | 0.476<br>0.462 | 47.89<br>49.1 | 34.55<br>32.5 | 34<br>30-32 |
| Passenger | | | | | |
| MY1998<br>Pre-MY98 | 357.2<br>364.7 | 0.444<br>0.445 | 47.75<br>49.82 | 31.38<br>33.66 | 33<br>30-32 |
| ICPLs | 1000 | 1.0 | 60 | 63 mm | |

* The matched make/models for this table were identified in Appendix A, Table A1., ESV Paper 98-S11-O-01, entitled The Effect of Redesigned Air Bags on Frontal USA NCAP, Park, B.T., Morgan, R.M., and Hackney, J.R., NHTSA/DOT and Lowrie, J.C., Conrad Technologies, Inc.
** Driver & Passenger sides for both MY98 and pre-MY98 had no Nij failures or T/C failures, except on the passenger-side, the 1998 Dodge Ram 1500 had an Nij failure of 1.17 and no T/C failures.

Tables IV-9d and IV-9e compare NCAP results by model year for the driver and passenger, respectively, and show the same comparisons as above based on All Vehicles in the file, rather than matched make/models. Except for Nij, on the average, there has been no substantive change year-to-year in dummy responses. Femur axial loads do not exceed the required ICPL values, except in two or three cases. For the driver and passenger-side, although there are year-to-year fluctuations, there has been a downward trend in Nij from 1996 to 1999. The values in parentheses are Pass Rates (%) used to assess the effect of applying the required 50th percentile male dummy ICPL values to the current fleet. For example, if the decision was made to extend the new, required FMVSS 208

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

ICPLs to the NCAP program, driver and passenger side failures would occur, but at the same rate as earlier years. The combined NCAP Pass Rate for MY1996+1997 was 73.5 percent and MY1998 +1999 was 81 percent (combining both driver and passenger Pass Rates). A decision as to what parts of the new 208 rule will be extended to the NCAP program will be made at a future date.

Table IV-9d
NCAP Test Results
56 kmph (35 mph) NCAP Average Responses & Pass Rates x Model Year
Belted, 50th Percentile Male Dummy
**DRIVER (All Vehicles)**

| MY | $HIC_{15}$ | Nij * | Chest g's | Chest Deflect | Left Femur | Right Femur | N Sample |
|---|---|---|---|---|---|---|---|
| 1996 | 438.6 (91) | 0.498 (97) | 51.2 (91) | 36.6 (100) | 5031 (97)* | 4871 (100) | 33 |
| 1997 | 461 (94) | 0.48 (100) | 50.2 (91) | 29.9 (100) | 4543 (100) | 4759 (100) | 35 |
| 1998 | 418 (94) | 0.51 (98) | 49.0 (96) | 35.8 (100) | 4435 (100) | 4231 (100) | 51 |
| 1999 | 399 (94) | 0.42 (100) | 50 (86) | 34.5 (100) | 4799 (100) | 4565 (100) | 35 |
| ICPL | 700 | 1.0 | 60 | 63 | 10,000 | 10,000 | |

* Peak limits for neck compression and tension were not exceeded except for 1998 Dodge Durango, Nij = 1.04 and peak limit neck tension of 4,448 N

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table IV-9e
NCAP Test Results
56 kmph (35 mph) NCAP Average Responses & Pass Rates X Model Years
Belted, 50th Percentile Male Dummy
**PASSENGER (All Vehicles)**

| MY | $HIC_{15}$ | Nij * | Chest g's | Chest Deflect | Left Femur | Right Femur | N Sample |
|---|---|---|---|---|---|---|---|
| 1996 | 382.1 (94) | 0.546 (94) | 52 (82) | 36.2 (100) | 4687 (100) | 4236 (100) | 33 |
| 1997 | 461 (94) | 0.480 (100) | 50 (91) | 30 (100) | 4543 (100) | 4759 (100) | 35 |
| 1998 | 364 (94) | 0.59 (92) | 49.2 (96) | 32.9 (100) | 4024 (100) | 3559 (100) | 51 |
| 1999 | 379 (94) | 0.392 (100) | 48.0 (97) | 29.2 (100) | 4730 (100) | 4086 (100) | 35 |
| ICPL | 700 | 1.0 | 60 | 63 | 10,000 | 10,000 | |

* Peak limits for neck compression and tension were not exceeded in any of these tests except as noted. 1998 Dodge Durango.

The agency conducted two 56 kmph (35 mph) belted crash tests with the 5th percentile female dummy using a 1988 and 1993 Ford Taurus. As shown in Tables IV-9f, there was a $HIC_{15}$ failure for the 1988 Ford Taurus and an Nij failure for the 1993 Ford Taurus.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table IV-9f
NCAP Test Results
Belted @ 56 kmph (35 mph), 5th Percentile Female Dummy
1988 & 1993 Ford Taurus (NHTSA data)

| Occupant Position | $HIC_{15}$ | Nij ** | Chest g's | Chest Deflection (mm) | Maximum Femur (N) |
|---|---|---|---|---|---|
| **Driver** | | | | | |
| 1988 Taurus* | **1305** | --- | 52.4 | --- | --- |
| 1993 Taurus* | 119 | 0.54 | 53.6 | 35.6 | 3370R |
| **Passenger** | | | | | |
| 1988 Taurus | 484 | --- | 47.3 | --- | --- |
| 1993 Taurus | 508 | **1.57** | 47.1 | 33.1 | 3212R |
| 5th ICPLs | 700 | ≤1.0 | 60 | 52 mm | 6,800 |

**Bold Numbers** indicate test values exceeded the mandated ICPL values for the 5th percentile female dummy.
R indicates right femur had maximum axial load.
* 1988 Ford Taurus did not have air bags, whereas the 1993 Ford Taurus had driver and passenger air bags.
** Maximum values for 1988 Ford Taurus driver-side neck were 203 N (C) and 1,350 N (T). Maximum values for the 1993 Ford Taurus driver-side neck were 918 N (C) and 3,125 N (T). None of the neck independent peak limits were exceeded.

**48 kmph (30 mph), 0 Deg., Barrier Test, Belted, 50th Percentile Male Dummy**

NHTSA is requiring in the final rule a 0-48 kmph (0-30 mph), belted, FRB tests using the 50th percentile male dummy. Based on the 1997-98 NHTSA/ Transport Canada test program, the 48 kmph (30 mph) belted 50th percentile male responses in the August, 1998 PEA consisted of 3 driver (MY98 + pre-MY98 vehicles) and 7 passenger (MY98 + pre-MY98 vehicles) test points with 100 percent Pass Rates. If adjusted to the $HIC_{15}$ and Nij, it is believed the Pass Rates for all responses would remain at 100 percent. Based on the 1998-99 NHTSA/Transport Canada test program using 18 - MY 1999 test vehicles, after applying the new injury criteria and ICPL values, there were no Nij or other response failures. Although compliance data received from GM was incomplete relative to

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

the ICPLs in the final rule (e.g., contained driver and passenger $HIC_{36}$ and chest g's data only) there was a 100 percent Pass Rate for driver and passenger side for a large sample of pre-MY98 and a few MY98 GM make/models. (See Docket No. NHTSA-97-2814-50) These Pass Rates are reflected in Table IV-15, Summary of Pass Rates by Test Procedure.

**48 kmph (30 mph), 0 Deg., Barrier Test, Belted 5th Percentile Female Dummy**

In addition, NHTSA is requiring in the final rule a 0-48 kmph ( 0-30 mph), belted, FRB test using the 5th percentile female dummy. Table IV-10 shows that for the same test condition as above, the 5th percentile female dummy would experience Nij failures on the driver-side and Nij and chest g's failures on the passenger side.

Table IV-10
48 kmph (30 mph) Belted Barrier, 5th Percentile Female Dummy
MY 98 and 99 Combined, Average Responses

| | $HIC_{15}$ * | Nij | Chest g's | Chest Deflection (mm) | Sample (n) |
|---|---|---|---|---|---|
| **Drivers** | 227 (100%) | 0.90 (69%) | 46 (100%) | 29 (100%) | 26 |
| **Passengers** | 239 (100%) | 0.57 (96%) | 43 (96%) | 24 (100%) | 26 |
| **ICPL** | 700 | ≤1.0 | 60 | 52 | |

( ) Number in parentheses are Pass Rates.
- Peak limits for neck compression and tension were not exceeded in any of these tests, except for the 1998 Mazda 626, passenger-side, failed Nij and neck tension and the 1998 Toyota Tacoma, driver-side, passed Nij but failed neck tension.
Note: Table IV-10 includes new NHTSA/Transport Canada test data. For the passenger side, the air bag did not deploy for either the 1998 Honda Civic or the 1999 Hyundai Accent as these test vehicles were purchased without passenger-side air bags.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**40 kmph (25 mph), ODB, 40 Percent Overlap, Belted, 5th Percentile Female Test Dummy**

NHTSA is requiring in the final rule a 40 kmph, offset deformable barrier (ODB) test, with 40 percent overlap, using the belted 5th percentile female dummy in the driver and passenger positions. Outboard seat positions are required to be placed in the full-forward position.[5] As shown in Table IV-11, $HIC_{15}$, chest g's and chest deflection did not exceed the required ICPL values on the driver's side. However, Nij did exceed the required ICPL value of 1.0 on the driver's side (12/16 or 75% for MY99 passed and 8/14 or 57% passed for MY98). On the passenger-side, there were no $HIC_{15}$, chest g's or chest deflection failures. There was a 100 % pass rate for MY99 vehicles based on Nij and an 86% (12/14) pass rate for MY98 vehicles based on Nij.

[5] Commenters argued that the outboard seats should be further back to be consistent with how people actually adjusted their seats in the real-world. They cited the UMTRI study. See "ATD Positioning Based on Driver Posture and Position," Manary, M.A., Reed, M.P., Flannagan, C.A.C., and Schneider, L.W., University of Michigan, Research Institute, SAE Paper #983163. NHTSA tested a vehicle at 48 kmph (30 mph) unbelted, FRB with the seats 3" rearward from the final rule full-forward position, and concluded that overall test stringency was reduced. See the Appendix for crash tests data using a 1999 Acura 3.5 RL and a 2000 Ford Taurus (production model) with seats rearward from full-forward by 3 inches.

DRAFT, DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table IV-11
40 kmph (25 mph) ODB, 40% Overlap, Belted, Left, 5th Percentile Female Dummy
Average Responses for MY98 and MY99 Combined
( ) indicates Pass Rate in Percent.

| | $HIC_{15}$ | Nij * | Chest g's | Chest Deflection (mm) | Sample size (n) |
|---|---|---|---|---|---|
| Driver | 182 (100) | 0.76 (67) | 22 (100) | 18 (100) | 30 |
| Passenger | 114 (100) | 0.46 (93) | 21 (100) | 15 (100) | 30 |
| ICPLs | 700 | 1.0 | 60 | 52 | |

NHTSA/Transport Canada cooperative research data.
- Peak limits for driver-side neck compression and tension were not exceeded in any of these tests except for the 1998 Dodge Neon and the 1998 Honda Accord. Peak limits for the passenger-side neck compression and tension were not exceeded in any of these tests..
- Note: On the passenger-side, air bags did not deploy on the 1999 VW Beetle or the 1999 Toyota Camry.

***Unbelted Test Procedures***

**<u>40 kmph (25 Mph) Unbelted Barrier Test, 50th Percentile Male and 5th Percentile Female Dummies</u>**

NHTSA is requiring in the final rule a 32-40 kmph (20-25 mph), unbelted, FRB test for both the 50th percentile male and 5th percentile female dummy for the first stage of the phase-in. Tables IV-12a shows that for the 5 vehicles tested, the 50th percentile male and 5th percentile female dummies did not exceed any of the required ICPL values on the driver-side, whereas Table IV-12b shows the only passenger-side mandated ICPL exceeded for both dummies was the Nij. This occurred for the same test vehicle - namely the 1999 Toyota Tacoma.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table IV-12a
40kmph (25 mph), 0 degree, Unbelted by Dummy Type
**DRIVER**

| MMY | Dummy Type | $HIC_{15}$ | Nij* | Chest g's | Chest Deflection (mm) | Femur (N) ( L or R Leg) Max. |
|---|---|---|---|---|---|---|
| 1999 Dodge Intrepid | 50th<br>5th | 193<br>99 | 0.288<br>0.294 | 40.1<br>40.5 | 33.0<br>32.1 | 7823R<br>4674R |
| 1999 Toyota Tacoma | 50th<br>5th | 96<br>238 | 0:250<br>0.518 | 42.8<br>50.5 | 46.1<br>40.5 | 7281L<br>4712L |
| 1999 Acura 3.5RL | 50th | 62 | 0.207 | 34.7 | 35.7 | 5912L |
| Confidential MMY | 5th ** | [ ] | [ ] | [ ] | [ ] | [ ] |
| Confidential MMY | 50th ***<br>5th *** | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] |
| ICPLs | 50th | 700 | 1.0 | 60 | 63 | 10,000 |
| ICPLs | 5th | 700 | 1.0 | 60 | 52 | 6,800 |

* Peak Limits for neck compression and tension were not exceeded.
** Single stage inflator
*** 1st stage of dual stage inflator.
[ ] confidential data removed.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table IV-12b
40 kmph (25 mph), 0 degree, Unbelted by Dummy Type
**PASSENGER**

| MMY | Dummy Type | $HIC_{15}$ | Nij * | Chest g's | Chest Deflection (mm) | Femur (N) ( L or R Leg) Max. |
|---|---|---|---|---|---|---|
| 1999 Dodge Intrepid | 50th<br>5th | 83<br>121 | 0.294<br>0.472 | 48.1<br>35.1 | 18.3<br>4.6 | 9017L<br>4324R |
| 1999 Toyota Tacoma | 50th<br>5th | 82<br>143 | **1.01**<br>**1.822** | 23.4<br>34.1 | 15.7<br>3.7 | 5236R<br>5419L |
| 1999 Acura 3.5RL | 50th | 119 | 0.406 | 32.5 | 17.4 | 6215R |
| Confidential MMY | 5th** | [ ] | [ ] | [ ] | [ ] | [ ] |
| Confidential MMY | 50th ***<br>5th*** | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] |
| ICPLs | 50th | 700 | 1.0 | 60 | 63 | 10,000 |
| ICPLs | 5th | 700 | 1.0 | 60 | 52 | 6,800 |

* Peak Limits for neck compression and tension were not exceeded.
** Single stage inflator.
*** 1st stage of inflator used.
[ ] confidential data removed.

**48 kmph (30 Mph) Unbelted Barrier Test** (Matched Pairs MY99 vs Pre-MY98 and Matched Pairs MY98 vs Pre-MY98)

NHTSA is requiring in the final rule a 32-48 kmph (20-30 mph), unbelted, fixed rigid barrier test for the 50th and 5th percentile dummies for the second stage of the phase-in. Pre-MY1998 vehicles were required to meet this test using the 50th percentile male dummy. In addition to the 5th percentile

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

female dummy being added to the test, $HIC_{15}$, Nij and revised chest deflection ICPLs are also being mandated in the final rule. Tables IV-13a and IV-13b show the average responses from the 30 mph test condition as required for the 50th percentile male and 5th percentile female dummies, respectively, using the injury criteria ICPLs required in the final rule. For the redesigned air bags, there was little difference between the MY98 and MY99 responses, on the average. For purposes of analysis, MY98 and MY99 vehicles were not necessarily matched make/models.

Table IV-13a
Summary of 48 kmph (30 mph), Unbelted Barrier Tests, 50th Percentile Dummy
Average Responses

| | $HIC_{15}$ | Nij * | Chest g's | Chest Deflect | Sample (n) |
|---|---|---|---|---|---|
| **Drivers** | | | | | |
| MY 1999 | 183 | 0.291 | 50.52 | 42.76 | 7 |
| MY 1998 | 205 | 0.300 | 47.33 | 39.96 | 9* |
| **Passengers** | | | | | |
| MY 1999 | 230 | 0.360 | 46.89 | 15.99 | 7 |
| MY 1998 | 187 | 0.322 | 50.30 | 15.0 | 9* |
| **ICPL** | 700 | 1.0 | 60 | 63 | |

Sample size information. There were 7 - MY99 (VRTC) including a 1999 Chevy Blazer. For MY98 there were 7 - MY98 (VRTC) and 2 Ford submissions including a confidential MMY and a 1998 Ford Escort (Non-confidential).
* Peak Limits for neck compression and tension were not exceeded in any of these tests.

**48 kmph (30 mph), Unbelted Barrier Test, 5th Percentile Female Dummy**

NHTSA is requiring in the final rule a 32- 48 kmph (20-30 mph), unbelted, fixed rigid barrier test for the 5th percentile female dummy for the second stage of the phase-in. The test data in Table IV-13b represents the 48 kmph (30 mph) test condition for 1-MY 1998, 6 - MY 1999 (VRTC), 1 -

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

confidential MMY (VRTC) and 4 - confidential MMYs tested by [ ]. Nij and chest deflection for the driver-side had Pass Rates of 75 percent and 58 percent, respectively. Nij and chest g's for the passenger-side had Pass Rates of 82 percent and 63.6 percent, respectively.

Table IV-13b
Summary of 48 kmph (30 mph), 0 Degrees, Unbelted Barrier, 5th Percentile Female Dummy
Average Responses for MY98-2000 Vehicles
( ) indicate Pass Rate %

| | $HIC_{15}$ | Nij * | Chest g's | Chest (mm) Deflection | Sample size (n) |
|---|---|---|---|---|---|
| Driver | 125 (100) | 0.720 ( 75 ) | 46.37 (100) | 45.03 (58.33 ) | 12 |
| Passenger | 278 (100) | 0.810 ( 82 ) | 52.66 (63.6) | 10.87 (100) | 11 |
| 5th ICPLs | 700 | 1.0 | 60 | 52 | |

* Peak Limits for neck compression and tension were not exceeded for any of the tests.
The driver sample (n =12) includes 1998 Ford Taurus from the August, 1998 PEA, 1999 Saturn SL1, 1999 Dodge Intrepid, 1999 Toyota Tacoma, 1999 Acura RL, 1999 Ford Econoline, 1999 Chevy Blazer and 5 - confidential MMY tests conducted by [ ] are included in this table. The passenger sample (n=11) has 4 of the above confidential MMY tests. The confidential MMYs were pre-production prototypes.

**48 kmph (30 Mph), +/-30 Degree (L or R) Oblique, Unbelted Test, 50th Percentile Male & 5th Percentile Female Dummies**

NHTSA requires in the final rule a test speed of 32-48 kmph (20-30 mph), for a +/- 30 degree (L or R) oblique unbelted test procedure for the 50th percentile dummy for the second stage of the phase-in. This test at 48 kmph (30 mph) is already required by FMVSS 208 using the 50th percentile male dummy, except that $HIC_{15}$ and Nij are being required in the subject final rule. Oblique tests with the 5th percentile female dummy are not required in the final rule, but response data is shown in Tables IV-14a and IV-14b for comparison purposes. As shown in Tables IV-14a and IV-14b, driver and

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

passenger responses were benign for the 50th percentile male dummy with a 100 Pass Rate for the 30 mph, 30 degree oblique, unbelted test.

For the case of the 50th percentile male dummy, all 4 vehicles studied passed both driver and passenger ICPL requirements. [Similarly, driver and passenger responses were benign for the 5th percentile female dummy, except for the driver-side Nij for the 1999 Dodge Intrepid resulting in a 75 percent Pass Rate (considering all 4 test vehicles) for the 30 mph, 30 degree oblique, unbelted test. The maximum femur axial load occurred predominantly on the impacted or near-side and did not exceed the required ICPLs in these tests. It is difficult to detect any significant differences in stringency between left or right side impacts for either dummy size. For the same MMY test vehicle, the impact-side dummy appears to have the higher responses, but responses were mixed.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table IV-14a
48 kmph (30 Mph), +/-30 Degree Oblique (L or R), Unbelted Barrier Test
50th Percentile Male & 5th Percentile Female Dummies
**DRIVER**

| | **Impact Direction** | **ATD Size** | **$HIC_{15}$** | **Nij *** | **Chest g's** | **Chest Deflection (mm)** | **Maximum Femur (N) (L or R leg)** |
|---|---|---|---|---|---|---|---|
| Confidential MMY | Right | 50th ** | [ ] | [ ] | [ ] | [ ] | [ ] |
| 1999 Dodge Intrepid | Right | 50th<br>5th | 53<br>107 | 0.282<br>0.379 | 34.3<br>36.7 | 24<br>32 | 5624R<br>5644R |
| 1999 Dodge Intrepid | Left | 50th<br>5th | 210<br>86 | 0.272<br>**1.514** | 43.0<br>44.52 | 32.1<br>27.6 | 5666L<br>4249R |
| Confidential MMY | Right | 50th ***<br>5th *** | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] |
| ICPLs | | 50th | 700 | 1.0 | 60 | 63 | 10,000 |
| ICPLs | | 5th | 700 | 1.0 | 60 | 52 | 6,800 |

* Peak Limits for neck compression and tension were not exceeded for any of these tests.
** Single stage inflator.
*** Only the 1st stage of a dual stage inflator fired.
[ ] confidential data removed.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table IV-14b
48 kmph (30 mph), +/-30 Degree Oblique, Unbelted 50th Percentile Male & 5th Percentile Female Dummies
**PASSENGER**

| | Impact Direction | ATD Size | $HIC_{15}$ | Nij * | Chest g's | Chest Deflection (mm) | Maximum Femur (N) (L or R leg) |
|---|---|---|---|---|---|---|---|
| Confidential MMY | Right | 50th ** | [ ] | [ ] | [ ] | [ ] | [ ] |
| 1999 Dodge Intrepid | Right | 50th<br>5th | 233<br>121 | 0.326<br>0.275 | 34.7<br>29.2 | 6.10<br>5.2 | 5180L<br>3658R |
| 1999 Dodge Intrepid | Left | 50th<br>5th | 288<br>123 | 0.321<br>0.410 | 45.5<br>51.0 | 18.9<br>5.82 | 6267L<br>5397L |
| Confidential MMY | Right | 50th***<br>5th *** | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] | [ ]<br>[ ] |
| ICPLs | | 50th | 700 | 1.0 | 60 | 63 | 10,000 |
| ICPLs | | 5th | 700 | 1.0 | 60 | 52 | 6,800 |

* Peak Limits for neck compression and tension were not exceeded in any of these tests.
** Single stage inflator.
*** Only the 1st stage of a dual stage inflator was fired.

Given the range of dummy response variability observed in other crash tests, these test vehicles would still be expected to pass if typical variations occurred as in other tests. This appears to be a very benign test because (1) an oblique impact angle involves a lot of crushed soft sheet metal and a soft crash pulse and (2) the "fire time" was very timely, similar to a full frontal fixed rigid barrier.

General Motors provided 48 kmph (30 mph), +/-30 degree oblique (L+R), unbelted, fixed rigid barrier 50th percentile male dummy compliance data, but this was an incomplete data set (e.g., included driver and passenger $HIC_{36}$ and chest g's only). The GM data was predominantly pre-MY98 and a few MY98 make/models. (See Docket No. NHTSA-97-2814-50)

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

## C. Summary of Pass Rates by Test Procedure

Table IV-15 summarizes the Pass Rates for each of the full-scale vehicle test procedures and the static OOP test procedures either considered in development of the final rule or required in the final rule. Pass rates for crash tests used in the deliberative or decision process such as 35 mph FRB belted tests are also shown. The agency combined MY98 and MY99 vehicles together in order to calculate Pass Rates. For the 25 mph unbelted test Pass Rate, 50th percentile male and 5th percentile female, MY1999 (n=4) test results and 1- confidential MMY pre-production prototype test results were combined. Similarly, for the 30 mph barrier test Pass Rate, using the unbelted 5th percentile female dummy, 1 - MY1998 was combined with 7- MY1999 vehicles and 5 confidential MMY vehicles for a total sample of 12 on the driver-side and 11 on the passenger-side. The confidential MMY in these tests were pre-production prototypes. Also, for the 30 mph, 30 degree oblique, unbelted 50th percentile male crash test Pass Rate, several confidential make/model/year vehicles were combined with NHTSA tests. Some of the pre-MY98 and MY98+99 Pass Rates shown in Table IV-15 were determined using General Motors FMVSS 208 compliance data which was released to Docket No. NHTSA-97-2814-50. The GM data set did not contain Nij. The Pass Rates are used in Chapters VI, Benefits, and VII, Cost and Leadtime, to calculate benefits and costs.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table IV-15
**Summary of PASS RATES by Test Procedure**

| Test Procedure | Pre-MY98 Pass Rate | MY98+99 Pass Rate | Source of Data | Remarks |
|---|---|---|---|---|
| **OOP 5th Percentile Female Driver** | $HIC_{15}$ 700, Nij =1, 60g's, 52mm | $HIC_{15}$ 700, Nij =1, 60g's, 52mm | | |
| | 25% (¼) | 36.4% (4/11) | VRTC tests, Pre-MY98, MY98 & MY99: Position 1 and Position 2 | Pre-MY98 & MY98 all fail Nij MY99- 2/6 fail Nij |
| **Static OOP CRABI*, **** | $HIC_{15}$ 390, Nij ≤1, 50 g's, 30 mm* | $HIC_{15}$ 390, Nij ≤1, 50 g's, 30 mm* | | |
| | 0% in sleds. (a.) (No data in vehicles) | 100% (n=1) (b.) | VRTC 213 sled tests This replaces Table IV-10, 11 & 12 in 8/98 PEA. See Docket 99-5156-6. Static OOP Deployment test. n=1 | (a.) $HIC_{15}$ & Nij failures in sled tests. *** (b.) No ICPL failures in Low Risk Deploy Test. **** |
| **OOP 6-Year-Old Child Passenger** | $HIC_{15}$ 700, Nij ≤1, 60 g's, 40 mm | $HIC_{15}$ 700, Nij ≤1, 60 g's, 40 mm | | |
| | 0% | 7.69% (1/13) | VRTC Pre-MY98 MY 98 + MY 99 Tests Position 1 + Position 2 | MY99 Nij, chest g & deflect. failures. MY98 $HIC_{15}$, chest g, deflect & Nij failures. |
| **35 mph, belted, 50th Percentile Male** | $HIC_{15}$ 700, Nij ≤1, 60 g's, 63 mm | $HIC_{15}$ 700, Nij ≤1, 60 g's, 63 mm | | |
| Driver | 88% (70/80) | 86.9% (73/84) | 1996-1999 NCAP data | $HIC_{15}$, Nij, & chest g's failures. ***** |
| Passenger | 83.9% (68/81) | 89.3% (75/84) | 1996-1999 NCAP data | $HIC_{15}$, Nij, & chest g's failures. ***** |
| **35 mph, belted, 5th Percentile Female** | $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | | |
| Driver | 50% (½) | N.D. | 1988 Ford Taurus, no air bags & 1993 Ford Taurus with air bags. (VRTC) | 1988 Ford Taurus failed $HIC_{15}$ Incomplete data |
| Passenger | 50% (½) | N.D. | 1988 Ford Taurus, no air bags & 1993 Ford Taurus with air bags. (VRTC) | 1993 Ford Taurus failed Nij Incomplete data |
| **30 mph, belted, 50th Percentile Male** | $HIC_{15}$ 700, Nij ≤1, 60 g's, 63 mm | $HIC_{15}$ 700, Nij ≤1, 60 g's, 63 mm | | |
| Driver | 100 % | 100% | n=1, Pre-MY98, 1996 Dodge Caravan n=18 MY1999 T.C. data GM data 1990-98 | No failures |
| Passenger | 100% | 100% | Pre-MY98 Table B-15 PEA June, 1998. n=18, MY1999 T.C. data GM data 1990-98 | No failures |
| **30 mph, belted 5th Percentile Female** | $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | | |
| Driver | 45.5% (10/22) | 65.4% (17/26) | NHTSA/ Transport Canada (Old + New) | Pre-MY98 Nij failures MY 98+99 Nij failures |
| Passenger | 64.3% (9/14) | 92.3% (24/26) | NHTSA/ Transport Canada | No MY99 failures MY98 - 2 Nij& 1 chest g. |

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

| | | | | |
|---|---|---|---|---|
| **25 mph, ODB belted 5th Percentile Female** | $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | | |
| Driver | 36.4% (4/11) | 67% (20/30) | NHTSA/ Transport Canada (97+98) (98+99) | Nij only problem. Left- side impacts n=30 |
| Passenger | 71.43% (5/7) | 93% (28/30) | NHTSA/ Transport Canada (97+98) (98+99) | Nij only problem. Left-side impacts n=30. |
| **25 mph, Unbelted Barrier Tests** | 50th - $HIC_{15}$ 700, Nij ≤1, 60 g's, 63 mm<br>5th - $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | 50th - $HIC_{15}$ 700, Nij≤1 60 g's, 63mm<br>5th - $HIC_{15}$ 700, Nij ≤1, 60 g's, 52 mm | | |
| Driver 50th Male | N.D. | 100% (4/4) | n=4 3 VRTC, 1 confid. | No Failures |
| Driver 5th Female | N.D. | 100% (4/4) | n=4 2 VRTC, 2 confid. | No Failures |
| Passenger 50th Male | N.D. | 75% (3/4) | n=4 3 VRTC, 1 confid. | 1 Nij failure Tacoma |
| Passenger 5th Female | N.D. | 75% (3/4) | n=4 2 VRTC, 2 confid. | 1 Nij failure Tacoma |
| **30 mph , unbelted 50th Percentile Male** | $HIC_{15}$ 700, Nij≤1, 60 g's, 63mm | $HIC_{15}$ 700, Nij≤1, 60 g's, 63mm | | |
| Driver | 100% HIC only (Nij not available, not instrumented) | 88% (14/16) | VRTC 7-MY 1999<br>VRTC 7-MY 1998<br>1 - MY98 Ford Escort<br>1 - Confidential MMY | 1999 Acura Driver Femur failure (13,349 N). Chevy Blazer chest g failure (63.06 g's). |
| Passenger | 100% HIC only (Nij not available, not instrumented) | 94% (15/16) | VRTC 7-MY 1999<br>VRTC 7-MY 1998<br>1- MY98 Ford Escort<br>1- Confidential MMY | 1998 Dodge Neon failed Chest g's (61.4 g's) |
| **30 Mph, Unbelted 5th Percentile Female** | $HIC_{15}$ 700, Nij≤1, 60 g's, 52 mm | $HIC_{15}$ 700, Nij≤1, 60 g's, 52 mm | | |
| Driver | Not available | 42% (5/12) | n=1 MY98, n=6 MY99, n=5 Confidential MMY | 3 Nij & 5 chest deflection failures |
| Passenger | Not available | 45.5% (5/11) | n=1 MY98, n=6 MY99, n=4 - Confidential MMY | 2 Nij & 4 chest g's failures |
| **30 mph, unbelted, 30 deg oblique 50th Percentile Male** | $HIC_{15}$ =700, Nij≤1, 60 g's, 63 mm | $HIC_{15}$ =700, Nij≤1, 60 g's, 63 mm | | |
| Driver | 100% | 100% | GM compliance data 1990-98, see Table IV-14a (NHTSA+Ford) | No failures |
| Passenger | 100% | 100% | GM compliance data 1990-98, see Table IV-14b (NHTSA+Ford) | No failures |

Table IV-15 Footnotes are as follows: T.C. = Transport Canada, N.D. - No data available at this time. *CRABI dummy cannot measure deflection. **Suppression or low risk test option in the final rule. *** 1997 Ford Taurus and 1998 Ford Explorer was full power inflator technology, **** 1st stage of experimental inflator from a confidential MMY, ***** No deflection failures occurred in these NCAP files and there were two femur load failures (1) 1996 Dodge Ram 250 Van and (2) 1998 Ford Escort.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

## D. Test Procedure Stringency

### Static Test Procedures, Out-of-Position

#### a. 12-Month-Old Infant (CRABI) Low Deployment Test

NHTSA conducted one (n=1) static low risk deployment test using the 12-month-old infant (CRABI) dummy which Passed all the mandated injury criteria.

#### b. Static OOP Test (Driver-Side) - Position 1 vs Position 2 Stringency based the 5th Percentile Female Dummy

Considering that the dummy injury responses are equally weighted, and the limited number of data points available, OOP Position 1 would appear to be more stringent than OOP Position 2 based on Nij and $HIC_{15}$, whereas Position 2 would appear to be more stringent than Position 1 based on chest g's and chest deflection. The data supports the idea that these tests are complementary, namely - OOP Position 1 is more of a "worst case" head/neck impact condition, while OOP Position 2 is more of a "worst case" chest impact condition. The agency has a limited number of data points because of resource and manpower constraints.

#### c. Static OOP Test (Passenger-Side) - Position 1 vs Position 2 Stringency based the 6-Year-Old Child Dummy

Recognizing the limited number of data points, OOP Position 2 would appear to be more stringent than Position 1 based on the magnitude of $HIC_{15}$, Nij and chest g's responses.

DRAFT DEPARTMENTAL DOCUMENT - DO NOT RELEASE

**d. Static OOP Test (Passenger-Side) - Position 1 vs Position 2 Stringency based the 3-Year-Old Child Dummy**

This was discussed earlier. Due to limited time and resources, the agency did not conduct any 3-year-old child dummy static OOP tests.

**Dynamic Test Procedures, In-Position**

**a. Left vs Right 48 kmph (30 mph), 30 degree Oblique, Unbelted Test Stringency**

The final rule requires (both left and right side) 48 kmph (30 mph), +/-30 degree oblique unbelted impact tests using the 50th percentile male dummy. This is the same as the current 208 standard, except for the new required $HIC_{15}$, Nij and chest deflection ICPLs. The following GM 208 compliance data compares the two test directions for a limited set of responses. Table IV-16a shows a few selected GM vehicles tested both in the left and right directions, whereas Table 16b compares All Vehicles in the GM file.

Table IV-16a
L vs R, 48 kmph (30 mph), 30 degree Oblique Impacts, Unbelted, 50th Percentile Male Dummy, Average Responses (n=3) Pre-MY98 Make/Models
GM 208 Compliance Data

| | Driver $HIC_{36}$ | Driver Chest g's | Passenger $HIC_{36}$ | Passenger Chest g's | n |
|---|---|---|---|---|---|
| Left-Side Impact Point | 217 | 35.7 | 143 | 30.6 | 3 |
| Right-Side Impact Point | 297 | 34 | 293 | 35 | 3 |

* The sample (n=3) consisted of a 1997 Eldorado/Seville, a 1995-97 Buick Riviera, and a 1995-97 Oldsmobile Aurora. Docket No. NHTSA-97-2814-50

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Although the number of tests are limited, and recognizing that the data available reflects pre-MY98 make/models, there does not appear to be any significant difference between a left (L) or right (R) 48 kmph (30 mph), 30 degree oblique unbelted impacts when using the 50th percentile male dummy.

Table IV-16b
L vs R, 48 kmph (30 mph), 30 degree Oblique Impacts, Unbelted, 50th Percentile Male Dummy, Average Responses - All GM Make/Models, MY1990-98
GM 208 Compliance Data

| — | Driver $HIC_{36}$ | Driver Chest g's | Passenger $HIC_{36}$ | Passenger Chest g's | n |
|---|---|---|---|---|---|
| Left-Side Impact Point | 266.5 | 35.38 | 184.8 | 36.06 | 34-75 |
| Right-Side Impact Point | 156.3 | 34.49 | 191.7 | 35.09 | 41-62 |

* Different make/model/year GM test vehicles made up the Left-side and Right-side impact data sets although there was some overlap in a few cases. Docket No. NHTSA-97-2814-50.

Although the number of tests are limited, and the data available reflects Pre-MY98 make/models, there does not appear to be any significant difference between a left (L) or right (R) 30 mph, 30 degree oblique unbelted impact, when using the 50th percentile male dummy based on All Vehicles. On the average, all responses for the left-side impacts were numerically higher than the right-side oblique impacts. This suggests that the left-side unbelted oblique impact condition might be slightly more stringent, on the average, compared to the right-side oblique impact condition. However, because left-side and right-side impact make/models were not necessarily matched, the higher numerical values could be due to make/model differences.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

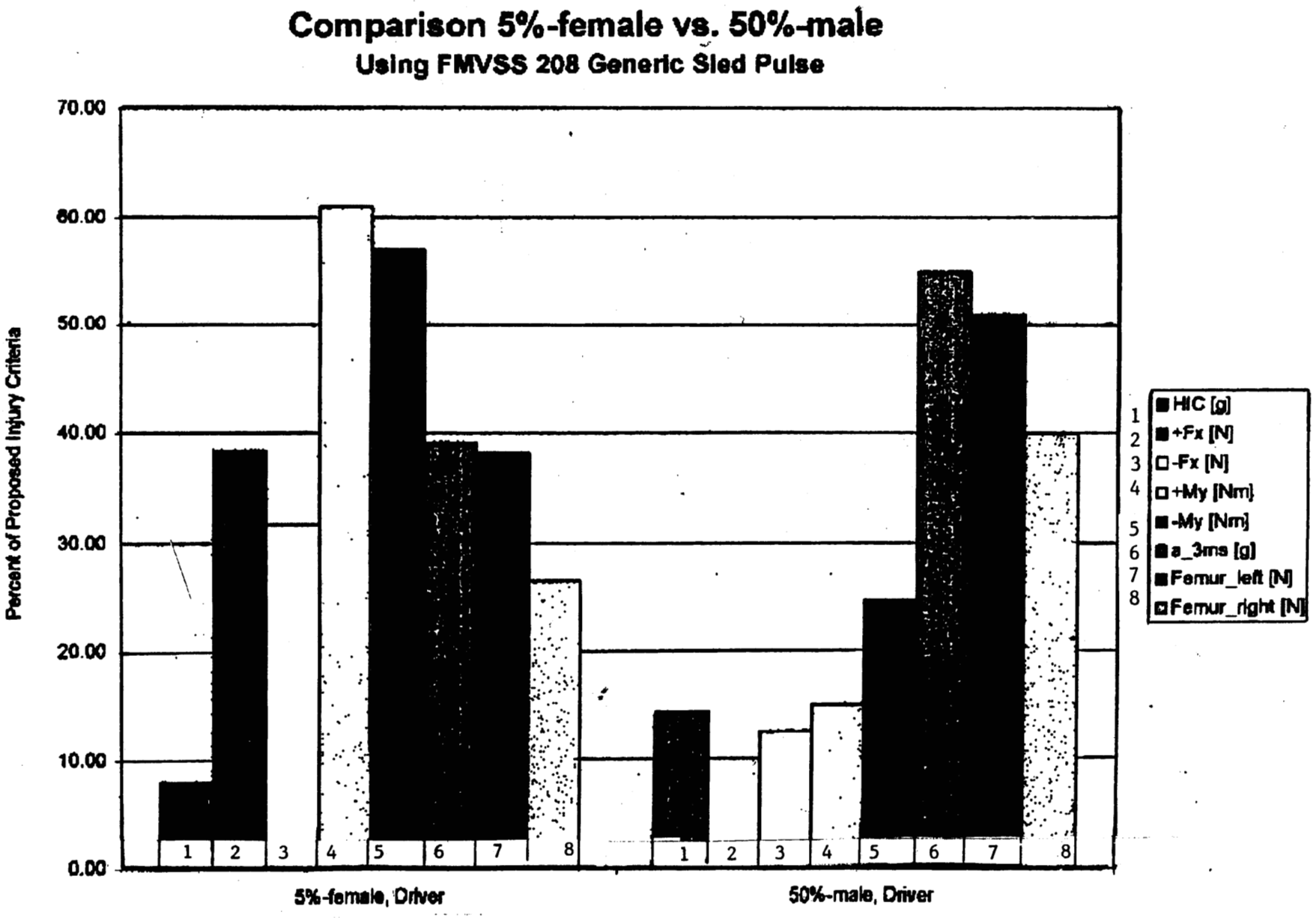
*50th vs 5th Percentile Dummy Dynamic and Compliance Equivalence*

**Sled Tests**

BMW provided a comparison of 50th and 5th percentile dummy responses based on the FMVSS 208 S13 sled test. (See Docket No. 98-4405-59) Figure IV-1 shows a good comparison of the dynamic responses of both dummies under identical, low variability test conditions. This bar chart compares the dynamic equivalence of the two dummies. For example, the 5th percentile dummy is more vulnerable in the areas of fore/aft neck shear and neck moments (extension and flexion) compared to the 50th percentile dummy, whereas the 50th percentile male dummy is more vulnerable in the chest g's area for the same test condition.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

FIGURE IV-1




Source: BMW Docket No. 98-4405-59, 12/15/98

*Full-Scale Vehicle Tests: Dummy Response Comparison*

**30 mph, 0 Degree Fixed Rigid Barrier, Unbelted Test Condition**

Tables IV-17a and IV-17b compare the responses of the 50th percentile male and 5th percentile female dummies for the 30 mph, 0 degree impact, unbelted, fixed rigid barrier test condition using 1999 Saturn SL and 1999 Chevy Blazer test vehicles. The Saturn driver and passenger responses for both dummies were very similar. Using either dummy and the new required injury criteria and associated ICPLs, the subject vehicle would have passed the compliance test. For the Chevy Blazer (Table IV-17b), although the responses for both dummies were very similar, the use of either dummy would have led to non-compliance as the driver chest g's using the 50th percentile dummy exceeded (@ 63.06 g's) the required ICPL value (60 g's) and the passenger Nij using the 5th percentile dummy exceeded (@1.178) the required ICPL value (1.0).

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table IV-17a
**50th Percentile Male vs 5th Percentile Female Dummies**
**48 kmph (30 mph), 0 Degree Fixed Rigid Barrier, Unbelted Test**

| Model Year | Make/ Model | Occupant Position/ ATD | $HIC_{15}$ | Nij * | Chest g's | Chest Deflection | Max. Femur (N)** |
|---|---|---|---|---|---|---|---|
| 1999 | Saturn SL1 | **Driver** 50th | 128 | 0.330 | 36.8 | 46.8 | 5288(L) |
| 1999 | Saturn SL1 | **Driver** 5th | 106 | 0.340 | 37.0 | 31.1 | 3566(L) |
| | | | | | | | |
| 1999 | Saturn SL1 | **Passenger** 50th | 200 | 0.314 | 40.2 | 9.2 | 6374(L) |
| 1999 | Saturn SL1 | **Passenger** 5th | 276 | 0.619 | 44.7 | 15.2 | 3259(R) |

* Peak Limits for neck compression and tension were not exceeded for any of these tests.
** Maximum Femur (Left or Right leg) indicated by parentheses.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table IV-17b
**50th Percentile Male vs 5th Percentile Female Dummies**
**48 kmph (30 mph), 0 Degree Fixed Rigid Barrier, Unbelted Test**

| Model Year | Make/ Model | Occupant Position/ ATD | $HIC_{15}$ | Nij * | Chest g's | Chest Deflection | Max. Femur (N)* |
|---|---|---|---|---|---|---|---|
| 1999 | Chevy Blazer | **Driver** 50th | 153 | 0.335 | **63.06** | 62.35 | 8504R |
| 1999 | Chevy Blazer | **Driver** 5th | 106 | 0.323 | 44.47 | 40.32 | 6131L |
| | | | | | | | |
| 1999 | Chevy Blazer | **Passenger** 50th | 289 | 0.339 | 51.76 | 15.07 | 6019L |
| 1999 | Chevy Blazer | **Passenger** 5th | 255 | **1.178** | 45.7 | 10.92 | 4080R |

* Peak Limits for neck compression and tension were not exceed in any of these tests.
** Maximum Femur (Left or Right leg) indicated by parentheses.
**Bold Numbers** indicate that the required **ICPL** values were exceeded.

**48 kmph (30 mph), 30 Degree Oblique (L), Unbelted, Test Condition**

As shown in Tables IV-14a and IV-14b, for the 1999 Dodge Intrepid (Left Impact Direction), the responses of the 50th and 5th percentile dummies were very similar, except for driver-side Nij failure for the 5th percentile female dummy. The 50th percentile male dummy Nij was 0.272, whereas the 5th percentile female dummy Nij was 1.514. Passenger-side responses were very similar and did not exceed any of the applicable ICPLs. Therefore, for this test vehicle, introduction of the 5th percentile female dummy and concomitant ICPLs would result

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

in a compliance test failure, whereas passage would have occurred with the 50th percentile male dummy alone. [NOTE: The 5th percentile female dummy is included here for comparison purpose only and is not a required test in the final rule.]

Overall, the two dummies appear to be dynamically equivalent as they have very similar responses for the same dynamic test conditions and appear to be equivalent from a compliance point of view. However, there were several cases where the dummies were not equivalent from a compliance point of view. In each of those cases, the 5th percentile female dummy was more vulnerable to failure than the 50th percentile male dummy.

**Final Rule Nij vs SNPRM Nij**

For the in-position, 50th percentile male and 5th percentile female high speed crash tests, the Nij values of the final rule are generally lower than the SNPRM values because the critical neck tension and compression intercept values have been increased. The affected constants appear in the denominator of the Nij formula. Similarly, for the 5th percentile female dummy OOP tests, the Nij values in the final rule are lower compared to the SNPRM. However, for the 6-year-old child dummy out-of-position tests, the Nij values in the final rule are slightly higher compared to the SNPRM. The Nij values for the 6-year-old OOP are slightly higher because the agency used a critical extension moment intercept value of 37 N-m as opposed to the 39 N-m used in the SNPRM. The affected constants appear in the denominator of the Nij formula.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

The final rule requires that neck peak limits can not be exceeded as well as Nij must be less than or equal to 1.0. As a rule, Nij failures are highly correlated with neck tension (T) failures. Neck compression (C) failures are very rare events. The agency found several cases where Nij passed the test, but failed the neck tension peak limit. These cases include the following:

1. 1999 Saturn SL1, 6-year-old, OOP Position 1, Nij = 0.93 and neck T = 1,799 N,
2. 1997 Toyota RAV4, 5th percentile female dummy, 30 mph, belted, passenger-side, Nij = 0.91 and neck T = 2,961 N,
3. 1998 Toyota Tacoma, 5th percentile female dummy, 30 mph, belted, driver-side Nij = 0.77 and neck T = 2,726 N, and
4. 1996 Ford Taurus, 5th percentile female, OOP Position 1, Nij = 0.91, neck T = 2,595 N.

The reason this occurs is that the Nij value can be located above the horizontal neck tension independent peak limit line, but it can be located within the vertical apex of the Kite shaped Nij =1.0 boundary line. There is also a single case where Nij failed and both neck compression and neck tension failed the peak limits. For the 1998 Honda Accord, 6-year-old OOP Position 1 test, Nij ($N_{te}$) = 2.11, neck T = 2,591 N and neck C = 1,899 N. These maximum T and C values occurred at different times in the crash event.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

# V. TECHNOLOGY OPTIONS AND ANALYSES

## A. Discussion of Technologies

The agency knows of a variety of technologies that could be implemented by the manufacturers to meet the various tests. This section discusses those technologies. Based on discussions with vehicle manufacturers, the agency believes many of the technologies could and will be used to meet the variety of tests.

The performance requirements of FMVSS 208 already provide considerable design flexibility for manufacturers. The standard's occupant requirements are performance requirements and do not specify the design of an air bag. Instead, vehicles must meet specific injury criteria performance limits (ICPL) measured on test dummies during barrier crash tests, for example at speeds up to and including 30 mph at any angle up to 30 degrees in either direction from perpendicular, or meet the ICPL in an alternative generic sled test.

While the standard requires air bags to provide protection for properly positioned occupants (belted and unbelted) in relatively severe crashes, and air bags must deploy quickly to provide such protection, the standard does not require the same speed of deployment in the presence of out-of-position occupants, or even any deployment at all. The standard allows for the use of dual or multiple level inflator systems and automatic cut-off devices for out-of-position occupants and rear facing infant restraints. The agency notes that dual level inflator systems can provide the equivalent of a softer air bag for lower speed crashes and/or when occupants are close to the air

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

bag or are belted, and a faster, more powerful air bag to provide protection in severe crashes and/or in crashes with unbelted occupants. The agency also notes that FMVSS 208 does not specify a crash threshold at which air bags must deploy, and that thresholds could be raised substantially for most current vehicles while still meeting the requirements of FMVSS 208. Injury protection at lower speeds can be and has been accomplished with a softer, compliant interior design.

**B. Out-of-Position Test Technologies**

There are essentially two ways to meet the out-of-position tests: **suppression** of the air bag (the air bag is turned off), or a **low risk deployment** of the air bag (dummy test results meet the injury criteria when the air bag is deployed with the dummy on or close to the air bag).

**1. Suppression of the Air Bag**

Using information supplied by various sensors inside the vehicle, a determination would be made by the vehicle's computer controlled occupant protection system that the air bag should not deploy.

**2. Low Risk Deployment**

Low risk deployment of the air bag might be accomplished either by having a single-stage air bag system that is designed to not injure out-of-position occupants or by having two or more stages of air bag deployment. In a dual-stage or multi-stage system, the lowest level of deployment would be a low risk deployment, while higher levels of deployment would be used when the occupant

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

needs more protection. The agency has tested driver air bags that can meet the low risk deployment criteria as a single-stage air bag (4 of 11 MY 98/99 vehicles and 1 of 4 pre-MY 98 vehicles tested met the criteria). On the passenger side, only 1 of 13 vehicle tests met the 6 year old criteria. This vehicle was the only one tested with a dual-stage air bag and it passed the out-of-position tests at the lower level deployment of a dual-stage air bag. This vehicle was not tested using the 3 year old dummy.

It would appear that meeting the injury criteria on the driver side will be easier than meeting the injury criteria on the passenger side using low risk deployment air bags. There are several reasons for this: 1) The current driver side air bags are not as aggressive as passenger side air bags. The driver is usually directly behind the steering column and there is less distance from the steering wheel to the driver than from the instrument panel to the right front passenger. Thus, the air bag for the driver side is smaller and needs less energy to inflate than the right front passenger bag. There is also the possibility of recessing the air bag back from the plane of the steering wheel, allowing it to start to open before contacting the driver. 2) A small child is not as tolerable to injury as an adult, thus the ICPLs are lower on the small dummies (e.g., the 3 year old dummy) than on the 5th percentile female dummy used in the driver position.

***Sensor Technologies***

The sensor technologies being investigated to supply information to the computer logic to determine when and how severely to inflate air bags can be divided into the following categories:

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

1) crash severity sensors

2) occupant weight sensors

3) occupant proximity and motion sensors

4) safety belt use status sensors

5) seat position sensors

**3. Crash Severity Sensors**

Two general types of crash severity sensors are in use today. The design goal is to make an early determination of the crash forces transmitted to the occupant compartment, while ignoring forces that will not require air bag deployment. The trend in the early 90's was towards a system with a single point crash sensor, an electronic accelerometer located in or around the passenger compartment.

The second type of system is the more expensive multi-point sensing system. In this system, electromechanical switches are used in combinations of discriminating sensors and secondary sensors located at different points in the forward part of the vehicle. The discriminating sensors located in the front crush zone activate at a specified change in velocity, while the secondary sensor located further back are used to prevent unwanted air bag deployments from localized damage. Several years ago, most models had multi-point sensing systems. Whether a vehicle needs a multi-point sensing system or can use a single point crash sensor system depends on a variety of factors, including the vehicle crush characteristics over a wide range of crash pulses.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

The offset deformable fixed barrier test may force some manufacturers into using a multi-point sensing system. This system may include a combination of electronic (single point compartment sensors) and electromechanical (crush zone) sensors. Multi-point sensing may be necessary for dual-level inflation in order to get more information about the severity of the collision.

Current air bag systems use the output from the crash severity sensors to determine when to deploy and when not to deploy the air bag. Most systems are set to have a no-fire zone at 8 mph or less and to have an all-fire zone with a change in velocity (delta V) of 15 mph or more. This decision speed is called a threshold. Some manufacturers currently are using different thresholds for unbelted and belted occupants. A higher threshold is used for belted occupants (all fire at 18 mph or higher), since belted occupants are at a lower risk of injury. One of the possible technologies for meeting the up to 25 mph offset test, which has a belted occupant, would be to raise the air bag deployment threshold to have no deployment in this long duration crash pulse test. To make this decision, the manufacturers would attempt to determine the risk of injury at different speeds with and without the air bag for belted and unbelted occupants in particular make/models. The agency has crash tested one vehicle (Chevrolet S-10 pickup) <u>with no air bag</u> at 15 mph and found that the unbelted 3-year-old passenger dummy did not pass the neck criteria. It is not known whether other passive interior changes, such as adding padding, could be used to lower injury risk for unrestrained occupants if the air bag firing threshold were raised.

Designers must consider how a change in the sensors would affect the timing of deployments for higher speed crashes, before raising the lower threshold. Some manufacturers have already

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

increased their deployment thresholds, particularly in other countries that have very high belt usage. A high threshold may be easier to accomplish in particular vehicles because of their design and crash pulse than in other vehicles.

**4. Occupant Weight and Pattern Recognition Sensors**

The purpose of a weight sensor is to measure the size of an occupant by measuring forces on the seat. Some systems also measure the distribution of the occupant on the seat to improve the ability to classify occupants and their location on the seat. Recent technology developments include measuring the pattern of pressure distribution on the seat or deflection of the seat and using this pattern to identify whether there is a child restraint on the seat, the size of the occupant, and whether the occupant is sitting back in the seat or up on the front edge.

Three types of weight sensors are being developed. The first uses resistive strain gauges or load cells, typically near the base of the seat, which indirectly lead to a measurement of weight. The agency does not have a cost estimate for these systems, and is not sure how they could work for a bench seat, but it is believed that they could be less costly than the mat type system for a bucket seat. The second type is a "bladder" type system within the seat cushion that measures pressure. However, neither of these systems have received as much attention as the mat-type electronic pressure sensor system because they cannot provide as much information about the occupant as the pattern recognition technology being developed.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

The third type of system is a weight sensing electronic mat. The electronic mat, which is installed in the seat cushion, is an array of conductive polymeric sensors which change resistance under load. The initial Mercedes-Benz mat was designed to deactivate the air bag when the seat was empty or had a low weight in it. The nominal deactivation threshold was 26 pounds.

The heaviest child dummy in the final rule is the 6-year-old, that weighs about 54 pounds with all the instrumentation. Thus, the final rule could be met by a weight sensor that distinguishes between the 6 year-old dummy and a 5th percentile female dummy at 107.8 pounds.

Pattern recognition sensors evaluate the impression made by an occupant, child restraint, or object on the seat cushion to make a determination about occupant presence and overall size and position of the occupant. They are often combined with a weight sensor to get better information.

**5. Occupant Presence, Proximity, and Motion Sensors**

A wide variety of sensing technologies have been explored by suppliers and manufacturers to detect occupant presence, proximity, and in the case of child restraints, seat position. Technologies being investigated include passive and active infrared, superaural acoustic, capacitive (electric field), radar, and visible imaging. A passenger side system could statically make a determination of a RFCSS, a 3 year old dummy, and a 6 year old dummy where the air bag should be turned off and distinguish these occupants from a 5th percentile female dummy where the air bag should be on. In general, the suppliers and manufacturers are working towardsz a dynamic system updating information every 10 ms or so to make decisions. A dynamic system

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

theoretically can determine that an occupant has moved too close to the air bag (out-of-position), either through pre-impact braking or the movement caused by more minor initial impacts in a multiple impact crash, and is quick enough to turn off the air bag or determine that a low-risk deployment is appropriate. Static detection systems are reportedly going to be used if dynamic systems are not developed in time. However, it is more likely that these more expensive systems with occupant presence and proximity sensing will be used as part of a dynamic system in the future. It may well be that two types of systems may be used in conjunction with each other to eliminate to the extent possible the potential for false readings.

**Capacitive (Electric Field):** This technology senses the dielectric loading of an oscillating electric field set up between sets of electrodes. An electrical field can be used to measure an array of displacement currents. Fixed electrodes can all be installed in the seat cushion or seat back, or they can be installed in the seat and the instrument panel and headliner, each of which can generate an electric field and measure the loading currents out of the electrode and the received currents from the other electrodes. When a person is in the seat, the person screens the electric field because of the body's high internal conductivity, and thereby shunts the displacement current to other receiving electrodes and to the automobile ground return. The electrical characteristics are then interpreted to determine the presence and size of the occupant in the seat. This type of system is currently in production.

**Passive Infrared Systems**: These systems depend on the detection of infrared emission from the skin and face of occupants. The amount of energy emitted is proportional to the 4th power of its

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

absolute temperature. A coarse resolution optical system is required to focus the seat environment onto an infrared sensing array. Infrared emissions must be correlated with conditions of occupancy. Care must be taken so that the system is not fooled by blankets, which are sometimes thrown completely over infants in rear-facing child seats. Infrared emissions overload can come from cigarettes, heat soaked vehicle interiors, hot food and beverages and sunlight. These occurrences must be designed around or a second type of sensing system must be used to assure no false readings.

**Ultrasonic Sensing, Non-imaging Pattern Recognition:** These systems use a broad beam of pulsed ultrasonic waves to illuminate the air bag deployment zone and the seat occupancy zone. These systems attempt to recognize when a seat is unoccupied or the location of the occupant, adult or child, whether still or moving towards the instrument panel. The principle of ultrasonics is based on sonar technology, pulsing a brief, inaudible signal, timing its return, and calculating the distance. Multiple transducers may be placed in the instrument panel, overhead console and trim around the A-pillar, B-pillar or side roof rail. Multiple transducers can be used to obtain the optimal line of sight to the areas of interest, and to recognize and track the movement of the occupant. The ultrasonic system has been designed based on priority inputs and time compression within close target proximity to adequately capture the fact that unrestrained occupants may start into a crash normally seated but, due to pre-crash braking or slow onset types of crashes, may be just moving into close proximity to the instrument panel at the time of the firing command.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Ranging Systems:** These systems rely on bouncing a beam of waves off an object and measuring their transit time from source to target to detector. The wave beam may be acoustic, optical, infrared or radar. Ranging systems can be used to measure proximity of objects to the air bag. The beams are usually narrow, less than 10 degrees and intercept a limited portion of the target.

**Imaging Systems:** These systems provide two-dimensional maps of some reflective feature of the vehicle interior. They may be visible optical or infrared. The two-dimensional images must be interpreted by a computer. An array of light and dark cells within the image must be correlated with hazardous and nonhazardous air bag deployment conditions.

The most advanced systems combine more than one type of sensing system in an attempt to provide reliable occupant detection for a wide variety of occupant types in a wide variety of real world conditions continuously updating dynamically (very close to real time).

**6. Safety Belt Use Sensors**

The driver side already has a restraint-use sensor to activate the warning light and buzzer if the driver is not using the safety belt. While some vehicles have a passenger side restraint use sensor, they are not required. Some manufacturers are installing more reliable safety belt use sensors, moving from a mechanical to a non-mechanical system (known as the Hall effect).

**7. Seat Position Sensor**

Seat position sensors can provide an indication of the position of the driver or passenger. If the

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

seat is pulled all the way forward, the occupant is positioned close to the air bag. They offer a surrogate for a more direct measurement of driver size (the driver seat pulled all the way forward likely indicates a small person). They are available and Ford has already installed them MY 2000 Taurus.

## C. High Speed Test Technologies

### 1. Dual Stage or Multiple Level Inflator

The benefit of a dual stage or multiple level inflator may overlap in both the low risk deployment option and in the high speed tests. Dual stage or multiple level inflators contain two separate initiators and require a control module which can sequence the firing of the stages under the defined conditions. In other words, each stage can be ignited separately, just stage A or just stage B, both stages can be fired together (A and B simultaneously), or stage A can be fired and then stage B can be fired after a time delay. Whether one or two stages fire would be determined by sensor input and algorithms. Sensor input can take many forms; for example: the severity of the crash, the position of the occupant, the size or weight of the occupant, the belt use of the occupant, the seat position of the occupant, etc.

The addition of satellite crash severity sensors (described above) may be necessary to help with the estimation of crash severity for the multi-stage inflator, or may be added for the proposed offset test.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**2. Seat Belt Improvements**

A high speed test, like the 35 mph belted test, could cause some manufacturers to improve their seat belts. Pretensioners and load limiters are the two likely candidates to help manufacturers meet the 35 mph belted test. Pretensioners take slack out of the belt system. Load limiters keep the belt from putting too much load on the chest of the occupant. This technology lets the occupant get to the air bag before allowing loads to build up on the seat belt that could cause chest injuries.

## D. Analysis of Alternative High Speed Tests

***Target Populations Related to High Speed Test Procedures***

In Chapter II, the overall target populations for fatalities and injuries and for out-of-position occupants were estimated. In this section, we will relate the alternative high speed tests considered to target populations.

The objectives of the FMVSS 208 high speed test procedures are to provide crash simulations that are representative of real world crashes that have the potential for serious injury or fatality, and to test how well the vehicle and its restraint system protect outboard front seat occupants in those situations. One of NHTSA's objectives in this rulemaking is to determine what are the appropriate combination of tests to assure that air bags are designed to provide protection in the largest number of crashes causing serious injuries and fatalities, and at the same time to assure that unintended consequences (injuries caused by air bag deployment) are limited.

There were three types of high speed tests that were considered by the agency for this Final Rule:

1) Direct frontal barrier (like the current 30 mph rigid barrier test)

2) Oblique tests (like the current 30 degree angled, 30 mph rigid barrier test)

3) Offset tests (like the proposed Transport Canada 25 mph 40% offset deformable barrier test, the European offset deformable test and the unbelted offset test proposed by IIHS ).

Major factors considered for these tests are:

1) The size of dummy to use in the test (5th female, 50th male, or both)

2) Whether the dummy is belted, unbelted, or both

3) The highest speed of the test and the range of speeds for the test (e.g., up to 30 mph, 20 to 30 mph)

4) Whether to run the oblique or offset tests on the left side (driver side) only or on both the left and right sides of the vehicle.

The types of crashes that could be covered by testing include:

1) a short duration, high deceleration crash pulse as is found in large numbers of potentially fatal crashes (represented best by a direct frontal barrier test),

2) a crash which forces manufacturers to design air bags that are wide enough to provide protection in angled impacts (represented best by an oblique test and to some extent by an offset impact),

3) cover special circumstances like the (25 mph offset crash) that results in some air bag designs deploying very late in the crash sequence, which cause occupants to be out-of-position when the air bag deploys, and

4) provide an incentive to limit aggressivity to a second vehicle to the extent possible.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Alternative tests considered by the agency for the high speed tests for the final rule are:

1) A belted full frontal rigid barrier impact for 5th female and 50th male dummies, either at 30 mph or 35 mph.

2) Oblique belted tests (left and right side up to 30 degrees) at 30 mph or 35 mph

3) An unbelted full frontal rigid barrier impact for 5th female and 50th male dummies, either at 25 mph or 30 mph.

4) Oblique unbelted tests (left and right side up to 30 degrees) at 25 mph or 30 mph

5) Belted 40% offset test (left side) at 25 mph

In the NPRM, a NHTSA research paper examined eight particular alternative FMVSS 208 test procedures. For a discussion of these test procedures the reader is referred to a NHTSA research paper placed in the docket entitled "Review of Potential Test Procedures for FMVSS 208, June 1998".[1] Based on comments to the docket and another year of crash data, this paper was updated and placed in the docket and is entitled "Updated Review of Potential Test Procedures for FMVSS 208, September 1999 ". The agency examined the number of drivers and magnitude of the injury population influenced by each test simulation, crash pulse stiffness, intrusion produced by the test procedure and test procedure lead time. Table V-1 presents a summary of that information.

[1]Review of Potential Test Procedures for FMVSS No. 208, June 1998: Hollowell, W.T, Gabler, C., Summers, S., and Hackney, J. See Docket No. NHTSA-1998-4405-10.

For this table only drivers were considered, right front passengers were not included since there is not a large difference between the driver and passenger in crash types. The target populations and AIS 3+ injuries were projected from NASS data of vehicles with air bags. All target populations in Table V-1 were limited to delta V's of 30 mph (48 kmph). However, the agency is considering some tests at 25 mph, some at 30 mph and other tests at 35 mph. Thus, the target populations are lower at 25 mph and higher at 35 mph. The effect of the different speeds considered on target populations is provided in Table V-2.

NHTSA determined that crash simulations involving an offset moving deformable barrier (MDB) represent the largest number of drivers and serious injuries, do a good job of representing real world crashes and would probably have a positive effect for compatibility. The vehicle-to-MDB tests have the desired stiff crash pulse, with considerable intrusion properties. Unfortunately, the agency believes the vehicle-to-MDB test procedure is a longer term (2-3 years) research and development activity beyond the time frame of the subject advanced air bag rule.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table V-1
Alternative FMVSS 208 High Speed Crash Simulations Considered

| | Test Procedure | Exposed Driver Population* | MAIS-3+ Driver Population | Crash Pulse/ Intrusion | Lead Time |
|---|---|---|---|---|---|
| 1. | Rigid Wall/Full Frontal | 263,981 | 5,054 | stiff / low ( 0 - 6") | Available Now |
| 2. | Rigid Wall Full Frontal Oblique | 378,670 (L+R) | 8,875 (L+R) | soft /high ( > 6") | Available Now |
| 3. | Offset Deformable Barrier | 378,670 (L+R) | 8,875 (L+R) | soft /high ( > 6") | Available Now |
| 4. | Vehicle-MDB Full Frontal | 263,981 | 5,054 | stiff /low ( 0 -6") | 2-3 years |
| 5. | Vehicle-MDB Offset Stiff | 932,907 (L+R) | 20,297 (L+R) | stiff /high (> 6") | 2-3 years |
| 6. | Vehicle-MDB Offset Soft | 378,670 (L+R) | 8,875 (L+R) | stiff /high (> 6") | 2-3 years |

* Drivers in crashes annually at < 30 mph delta V, estimated from NASS-CDS.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

The full frontal rigid barrier test (#1) has a stiff crash pulse promoting the design of frontal structures that manage crash energy and improved occupant restraints. It is believed this procedure has a positive influence on vehicle compatibility. This procedure has a large MAIS-3+ driver target population, but has little, if any, intrusion affects. The oblique rigid wall frontal test (Test #2), currently a part of 208 and the offset test (Test #3) are considered to have soft crash pulses. Preliminary data reviewed by NHTSA indicates good performing vehicles in the offset can have less aggressive vehicle characteristics.

Test #2 (oblique test) and Test #3 (offset test) have slightly larger driver MAIS-3+ target populations than Test #1. With the combination of full frontal and oblique or offset requirements, it is believed that to do well in both tests, a vehicle's structure must not be too stiff (e.g., that the occupant cage must be well designed and the vehicle frontal structure must be optimized for energy dissipation). The agency does not believe this combination of crash tests will adversely influence vehicle-to-vehicle compatibility.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table V-2
Annual Driver Injury Estimates

| | AIS 3+ Injuries* | Fatalities* |
|---|---|---|
| 25 mph Frontal Unbelted | 2,408 | 1,121 |
| 25 mph Oblique Unbelted | 4,733 | 2,408 |
| 30 mph Frontal Unbelted | 3,032 | 1,798 |
| 30 mph Oblique Unbelted | 5,325 | 3,197 |
| | | |
| 25 mph Offset Belted | 3,156 | 1,140 |
| 30 mph Frontal Belted | 2,022 | 852 |
| 30 mph Oblique Belted | 3,550 | 1,514 |
| 35 mph Frontal Belted | 2,118 | 1,125 |
| 35 mph Oblique Belted | 3,720 | 2,000 |

* Target population estimates for drivers injured or killed at < listed delta V and crash type.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Because of the large number of tests to be considered, the agency rated the various tests according to a variety of factors and then considered combinations of tests to identify a set of tests which would promote the most effective air bag performance in the real world with the fewest number of tests. The following tables provide the agency's assessment of the various tests. The first three columns rate the tests by type; does the test have a soft or stiff crash pulse, will it result in more or less than 6 inches of intrusion for current vehicles, and is it a head-on or angled test. Next the agency rated on a scale of 0 to 5 whether the test would force manufacturers to make improvements in their vehicles.

0 - no effect on design for this factor

1 - small effect on design

3 - possible effect

5 - likely effect

For bag volume and depth the ratings are:

1 - small air bag

3 - medium size air bag

5 - large air bag

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

The factors considered included whether the test had an effect on crash sensing, multi-stage inflation, air bag volume depth and width and occupant sensing. These were all considered mutually exclusive for each test, with the exception that occupant sensing and multi-stage inflation are often times linked together.

The tests that drive likely improvements are the 25 mph (40%) belted offset test, which will promote improvements in crash sensing and timing of the air bag. The 5th female in the 30 mph unbelted frontal barrier test would promote designs toward improved occupant sensing and multi-stage inflation. The unbelted oblique test would promote wider air bags. Finally, the unbelted 50th percentile male 30 mph unbelted frontal barrier crash test requires the deepest air bags.

One of the decisions the agency made between the SNPRM and the final rule was to reduce the number of tests by two, by not testing the 5th female dummy in the unbelted oblique +/- 30 degree tests. The agency believes that the 50th male dummy unbelted is a much more severe test of effectiveness of the width of the air bag and oblique tests with the belted 50th or belted and unbelted 5th female dummy are unnecessary.

There are possibly trade-offs in design between meeting the at-risk out-of-position tests and at the same time meeting the high speed tests. Manufacturers could design their vehicles to the minimal performance required in the high speed test in an attempt to get the least aggressive air bag in the out-of-position tests. The agency believes it is possible to have separate design paths for the high speed and out-of-position tests. The target populations are much greater for the high speed tests

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

than for the out-of-position tests. Thus, overall the greatest potential target population and the greatest potential benefit would be to require the strictest test regime for the high speed tests. This would require a high level of performance for air bags in the high speed tests and, at the same time, require the out-of-position test to be passed.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table V-3
BELTED TESTS

| | Crash Pulse | | Intrusion | | Occupant Kinematics | | Driver Target Population | | Improved Crash Sensing | Requires Multi-Stage Inflation | Bag Volume Depth | Bag Volume Width | Required Occupant Sensing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soft | Stiff | <6" | >6" | Head-on | Angle | AIS 3+ | Fatals | | | | | |
| 30 mph Frontal Barrier | | X | X | | X | | 2,022 | 852 | | | | | |
| 50th | | | | | | | | | 1 | 0 | 1 | 1 | 0 |
| 5th and 50th | | | | | | | | | 1 | 0 | 1 | 1 | 0 |
| | | | | | | | | | | | | | |
| 35 mph Frontal Barrier | | X | X | | X | | 2,118 | 1,125 | | | | | |
| 50th | | | | | | | | | 1 | 0 | 1 | 1 | 0 |
| 5th and 50th | | | | | | | | | 1 | 0 | 1 | 1 | 0 |
| | | | | | | | | | | | | | |
| 30 mph Oblique (+/- 30 deg) | X | | | X | | X | 3,550 | 1,514 | | | | | |
| 50th | | | | | | | | | 1 | 0 | 1 | 1 | 0 |
| 5th and 50th | | | | | | | | | 1 | 0 | 1 | 1 | 0 |
| | | | | | | | | | | | | | |
| 25 mph Offset (40%) | X | | X | | X | | 3,156 | 1,140 | | | | | |
| 5th | | | | | | | | | 5 | 0 | 1 | 1 | 0 |

Table V-4
UNBELTED TESTS

| | Crash Pulse | | Intrusion | | Occupant Kinematics | | Driver Target Population | | Improved Crash Sensing | Improved Structural Integrity | Requires Multi-Stage Inflation | Bag Volume Depth | Bag Volume Width | Required Occupant Sensing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soft | Stiff | <6" | >6" | Head | Angle | AIS 3+ | Fatals | | | | | | |
| 25 mph Frontal Barrier | | X | X | | X | | 2,408 | 1,121 | | | | | | |
| 50th | | | | | | | | | 1 | 1 | 0 | 2 | 1 | 0 |
| 5th and 50th | | | | | | | | | 1 | 1 | 0 | 2 | 1 | 0 |
| | | | | | | | | | | | | | | |
| 25 mph Oblique (+/- 30 degree) | X | | X | | | X | 4,733 | 2,408 | | | | | | |
| 50th | | | | | | | | | 1 | 1 | 0 | 1 | 5 | 0 |
| 5th and 50th | | | | | | | | | 1 | 1 | 2 | 1 | 5 | 2 |
| | | | | | | | | | | | | | | |
| 30 mph Frontal Barrier | | X | X | | X | | 3,032 | 1,798 | | | | | | |
| 50th | | | | | | | | | 1 | 1 | 0 | 5 | 1 | 0 |
| 5th and 50th | | | | | | | | | 1 | 1 | 5 | 5 | 1 | 5 |
| | | | | | | | | | | | | | | |
| 30 mph Oblique (+/- 30 degree) | X | | | X | | X | 5,325 | 3,197 | | | | | | |
| 50th | | | | | | | | | 1 | 2 | 0 | 1 | 5 | 0 |
| 5th and 50th | | | | | | | | | 1 | 2 | 3 | 1 | 5 | 3 |

Table V-5
TEST COMBINATIONS

| | Crash Pulse | | Intrusion | | Occupant Kinematics | | Driver Target Populations | | Improved Crash Sensing | Requires Multi-Stage Inflation | Bag Volume Depth | Bag Volume Width | Requires Occupant Sensing | # Of Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soft | Stiff | <6" | >6" | Head-on | Angle | AIS 3+ | Fatals | | | | | | |
| 1 Up to 30 mph Frontal (B) | | X | X | | X | | 13,535 | 6,987 | 1 | 0 | 1 | 1 | 0 | 7 |
| 20-30 mph Frontal (U) | | X | X | | X | | | | 1 | 5 | 5 | 1 | 5 | |
| 5th and 50th all above | | | | | | | | | | | | | | |
| 20-30 mph unbelted 50th +/- 30 | X | | | X | | X | | | 1 | 3 | 1 | 5 | 3 | |
| Degree Oblique | | | | | | | | | | | | | | |
| Up-25 mph Offset (B) 5th L | X | | X | | X | | | | 5 | 0 | 1 | 1 | 0 | |
| | | | | | | | | | | | Total Score #1 = 25 | | | |
| 2 Up to 30 mph Frontal (B) | | X | X | | X | | 12,319 | 5,521 | 1 | 0 | 1 | 1 | 0 | 7 |
| 20-25 mph Frontal (U) | | X | X | | X | | | | 1 | 0 | 2 | 1 | 0 | |
| 5th and 50th all above | | | | | | | | | | | | | | |
| 20-25 mph unbelted 50th +/- 30 | X | | | X | | X | | | 1 | 3 | 1 | 5 | 3 | |
| Degree Oblique | | | | | | | | | | | | | | |
| Up-25 mph Offset (B) 5th L | X | | X | | X | | | | 5 | 0 | 1 | 1 | 0 | |
| | | | | | | | | | | | Total Score #2 = 18 | | | |
| 3 Up to 35 mph Frontal (B) | | X | X | | X | | 13,631 | 7,260 | 1 | 0 | 1 | 1 | 0 | 7 |
| 20-30 mph Frontal (U) | | X | X | | X | | | | 1 | 5 | 5 | 1 | 5 | |
| 5th and 50th all above | | | | | | | | | | | | | | |
| 20-30 mph unbelted 50th +/- 30 | X | | | X | | X | | | 1 | 3 | 1 | 5 | 3 | |
| Degree Oblique | | | | | | | | | | | | | | |
| Up-25 mph Offset (B) 5th L | X | | X | | X | | | | 5 | 0 | 1 | 1 | 0 | |
| | | | | | | | | | | | Total Score #3 = 25 | | | |
| 4 Up to 35 mph Frontal (B) | | X | X | | X | | 12,415 | 5,794 | 1 | 0 | 1 | 1 | 0 | 7 |
| 20-25 mph Frontal (U) | | X | X | | X | | | | 1 | 0 | 2 | 1 | 0 | |
| 5th and 50th all above | | | | | | | | | | | | | | |
| 20-25 mph unbelted 50th +/- 30 | X | | | X | | X | | | 1 | 3 | 1 | 5 | 3 | |
| Degree Oblique | | | | | | | | | | | | | | |
| Up-25 mph Offset (B) 5th L | X | | X | | X | | | | 5 | 0 | 1 | 1 | 0 | |
| | | | | | | | | | | | Total Score #4 = 18 | | | |

# VI. POTENTIAL BENEFITS

This chapter estimates the potential benefits of advanced air bags. These benefits would be achieved from the required tests and new injury criteria using the pre-MY 1998 air bag systems as the base. The benefit calculation are based on limited available laboratory crash tests and the real-world crash data. Most of vehicles tested and vehicle data collected in the real-world crash data had passed the unbelted 30 mph rigid barrier tests. Therefore, the benefit assessment methodology assumes that manufacturers would make as few changes as possible to meet the second phase (30 mph rigid barrier tests) of the proposal. The process and theory is presented in the methodology section. However, different approaches were examined for air bags designed to meet the 25 mph rigid barrier tests. Benefits derived from these approaches assumes that manufacturers would design their air bags to maximize air bag performance in the 25 mph rigid barrier tests, rather than in the 30 mph rigid barrier tests. These approaches for 25 mph rigid barrier tests are presented in the subsections titled "impact of 25 mph rigid barrier unbelted tests". In addition to the benefits assessment, this chapter also provides sensitivity studies to address the impacts of an increased belt use rate and MY 1998 redesigned air bags on the benefits of advanced air bags.

The analysis includes several alternative tests and new injury values to require manufacturers to provide advanced air bag systems that protect various sizes of occupants in a variety of frontal crash scenarios, e.g., different occupant positions, crash severities, crash pulses, and angles. The alternative tests along with the new injury criteria are classified by their general objectives: (1)

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

minimizing the risk of air bag induced fatalities and serious injuries, and (2) improving general occupant protection. Table VI-1 shows conceptually the alternative tests and their applicable target groups.

**Table VI-1**
**Crash Tests by Impact Group**

| Type of Test | Minimize Risks of Air Bag Induced Fatalities & Injuries | | | Preserve and Improve Occupant Protection From High Speed Crash Tests | | | |
|---|---|---|---|---|---|---|---|
| | At-Risk Groups | | | Front-Outboard Occupants | | | |
| | | | | Improved Crash Testing | | Improved Sensor Algorithm | |
| | Infants | Children (1-12 Years Old) | Adults in Close Proximity | 50th Percentile Male[1] | 5th Percentile Female | in Full Frontal[2] Crashes | in Offset Crashes |
| Suppression When Present | x | x[3] | | | | | |
| Suppression When Out-Of-Position | x | x | x | | | | |
| Low Risk Deployment | x | x | x | | | | |
| Up to 30 mph Belted/20 Up to 30 Unbelted Rigid Barrier, 0 and ± 30 Degree With 50th Percentile Male | | | | x | | | |
| Up to 30 mph Belted/20 Up to 20 Unbelted Rigid Barrier, 0 Degree With 5th Percentile Female | | | | | x | | |
| Up to 25 mph Offset With Belted 5th Percentile Female Driver | | | x | | | x | x |
| 20 Up to 25 mph Unbelted 50th Percentile Male | | | x | x | | | |
| 20 Up to 25 mph Unbelted 5th Percentile Female | | | x | | x | | |

1. Population includes those that can be represented by 95th percentile male dummy.
2. Full frontal crashes are defined as those with impact force from the 12 o'clock direction.
3. Because the 6 year old dummy (which weighs about 54 pounds with instrumentation) is the largest used, the test is assumed to protect children only up to 54 pounds.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

This analysis estimates the benefits for these two categories separately. Each category includes two parts: (1) benefits from fatality reduction, and (2) benefits from nonfatal MAIS 2-5 injury mitigation. The general procedure is first to identify the baseline target population and then to estimate the fatal or injury reduction rate/percentage for each test using the pre-MY 1998 injury probability as the base. Crash test results from Chapter IV are used to calculate injury probabilities. The injury reduction rate is applied to the corresponding target population which results in injury reduction benefits.

The benefits of minimizing air bag risks are discussed for three at-risk groups in three parallel sections: RFCSS (infants in rear facing child safety seats), children (1-12 years old), and close-proximity adults. The benefits for improved protection from high speed crash tests are analyzed by injured body regions. The perpendicular (0 degree) and oblique ($\pm$ 30 degrees) rigid barrier tests on restrained and unrestrained 50th percentile males and/or 5th percentile females with the Injury Criteria Performance Limits (ICPLs) would improve overall air bag effectiveness and thus apply to all front-outboard occupants. The offset tests are intended to improve sensors and algorithms for air bag deployment decisions so that the air bag would inflate in time to provide adequate protection to occupants who otherwise would not be protected by late-deploying air bags. The 25 mph offset belted test would impact out-of-position adult fatalities and injuries in full frontal, partial frontal, and offset crashes. Note that full frontal crashes are defined as those crashes with an impact force from the 12 o'clock direction. Partial frontal crashes are defined as those crashes with an impact force from 10, 11, 1, and 2 o'clock directions.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

For each target population group, the analysis provides benefit estimates for the alternative tests and hypothetical air bag systems assumed to pass the tests. The benefit summary section provides benefits for air bag systems assuming to meet a combination of suppression, low-risk deployment, and either of the following alternatives from the high speed crash tests.

Alternative #1 of the high speed crashes includes: a) 20 to 25-mph rigid barrier, perpendicular test with unrestrained 5$^{th}$ percentile females, b) 20 to 25-mph rigid barrier, perpendicular and +/- 30 degrees tests with unrestrained 50$^{th}$ percentile males, c) 0 to 30-mph rigid barrier, perpendicular test with restrained 50$^{th}$, d) 0 to 30-mph rigid barrier, perpendicular test with restrained 5$^{th}$ females, and e) 0 to 25-mph offset test with restrained 5$^{th}$ percentile females.

Alternative #2 includes: a) 20 to 30-mph rigid barrier, perpendicular test with unrestrained 5$^{th}$ percentile females, b) 20 to 30-mph rigid barrier, perpendicular and +/- 30 degrees test with unrestrained 50$^{th}$ percentile males, c) 0 to 30-mph rigid barrier, perpendicular tests with restrained 5$^{th}$ percentile females, d) 0 to 30-mph rigid barrier, perpendicular test with restrained 50$^{th}$ percentile males, and e) 0 to 25-mph offset with restrained 5$^{th}$ percentile females.

The hypothetical systems discussed here are linked together with potential technologies. One is a suppression type system in which air bags would not be deployed under certain situations. For these suppression systems, dynamic suppression and static weight suppression systems will be discussed. The other type is an advanced system that incorporates a higher speed threshold for air bag deployment and a multi-stage inflation system based on crash severity and belt usage. This

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

same system, combined with a 54-pound weight sensor for suppression, will also be examined. The 54-pound weight limit is chosen to correspond to the weight represented by the 6 year old child dummy. Note that the agency does not have a preference for any particular air bag system, but is setting up tests that would allow manufacturers to use alternatives like these to meet the ICPLs. Descriptions of these systems and the tests that each system would be required to pass are as follows:

***Static Weight-Based Air Bag Suppression***

This system is designed mainly to detect the presence of a child using weight as the threshold. Thus, it applies only to passenger side air bags. The passenger side air bags would not be deployed if the front passenger seat weight sensor measures a value below a certain pre-defined weight criterion. For example, the air bag would not be deployed if the passenger weighs 54 pounds or less for the 54-pound static weight suppression system. This type of system could meet the tests for infants in rear facing child safety seats and for 3 year old and 6 year old dummies. The 6 year old dummy, with instrumentation, weighs 53.6 pounds.

***Out-Of-Position Air Bag Suppression***

In this system the air bag will be automatically shut off when an occupant is too close to the air bag module. Proximity sensors, e.g., ultrasound and/or infrared, may be utilized to sense the position of the occupant. This system could meet a suppression test.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

***Multi-Stage Inflation Based on Crash Severity and Belt Use***

Driver and passenger air bags would be inflated at different power levels based on each occupant's restraint system usage and crash severity. For purposes of this analysis, the multi-stage inflation system is defined to have the same operating characteristics as the dual power level system as stated in Table VI-2. These characteristics are analytical assumptions, not NHTSA preferences. If equipped with a weight sensor, the system has the same definition as that stated in Table VI-2. In addition, the air bag would not be fired if the passenger weighs less than or equal to the weight threshold. Note that nothing in the alternative tests require manufacturers to have multi-stage inflation capability or to have the same thresholds as in the example. The stage 1 low level deployment of this type of system is assumed, for analytical purposes, to meet the low risk deployment test for infants, children and adults in close proximity to the air bag. In addition, the second stage of the system is assumed, for analytical purposes, to meet either of the two high speed alternatives as described earlier.

Table VI-2
Benefit Analysis Assumptions for
Multi-Stage Inflation System Based on
Crash Severity and Restraint Use

| **Inflation Power** | **Belted (MPH)** | **Unbelted (MPH)** |
|---|---|---|
| Suppression | < 18 | < 14 |
| Stage 1 Low Level Power | 18-30 | 14-25 |
| Stage 2 Full Power | > 30 | > 25 |

The rest of the chapter is organized as follows: the first section (VI.A) establishes the baseline target fatal/injury population. The second section (VI.B) discusses the methodology for deriving the reduction in fatality and injury rate/percentage points. The third section (VI.C) estimates

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

benefits first for minimizing air bag induced fatalities and serious (MAIS 3-5) injuries and then for improving occupant protection benefits (fatalities and MAIS 2-5 injuries) from high speed crash tests. Benefits for fatalities and MAIS 2-5 injuries are discussed separately for each relevant test, and pre-defined hypothetical air bag systems. The benefit summary section (VI.D) provides overall benefit tables for all the tests and systems. The sensitivity study section (VI.E) provides changes in benefits resulting from increased safety belt usage. Finally, the last section (VI.F) discusses occupant behavior and its potential effects on benefits.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

**A . Target Population**

The pre-1998 baseline population is used to estimate benefits for three reasons: 1) manufacturers introduced the MY 1998 vehicles with redesigned air bags incrementally as opposed to equipping all MY 1998 vehicles with the redesigned air bags when they were introduced. 2) information on the extent and impact of 1998 models with redesigned air bags in the current fleet is inadequate to provide a basis for determining a full-fleet redesigned baseline estimate, and 3) the MY 1998 sled certified air bags may not be what manufacturers would have designed if they had more lead time. So, the current redesigned air bags, as found in MY 1998 vehicles, is probably not a steady, constant baseline.

For each at-risk group, the annualized fatal target population, as described in Chapter II, is projected from those actual fatal cases collected in NHTSA's Special Crash Investigation (SCI) Program as of January 1, 2000 to a projected level assuming all passenger cars and light trucks were equipped with air bags. Each at-risk MAIS 3-5 injury level was adjusted from at-risk

fatalities by multiplying a corresponding factor. The factor is the ratio of MAIS 3-5 injuries to fatalities with air bags recorded as the injury source in the 1993-1998 CDS. Note that at-risk injuries do not include MAIS 2 injuries because MAIS 2 injuries are commonly cited in the crashes. It would overestimate adverse air bag effects if MAIS 2 injuries were estimated and included in the target population.

Improved occupant protection target fatalities and MAIS 2-5 injury populations from high speed crash tests are derived from the 1993-1997 CDS. Pre-MY 1998 air bags were proven to be 10 percent (not statistically significant) effective in reducing MAIS 2-5 injuries. With new tests and injury criteria, the advanced air bags would reduce these injuries further. Therefore, MAIS 2 injuries were included in the target population for the high speed tests. Similarly, the annualized front-outboard occupant fatalities from CDS then are adjusted to the 1997 FARS level to overcome the underreporting problem in CDS for fatalities. The annualized target MAIS 2-5 injury population is adjusted to the 1997 GES CDS-equivalent level to get a better national estimate. This target population is further divided into two subgroups:

1. **Adult front-outboard occupants affected by improved crash testing and injury criteria**. **Fatalities**. The 15,447 adult (excluding 278 child fatalities) front-outboard occupant fatalities in frontal crashes were derived from Table II-3 (15,725 - 278 = 15,447). The 278 child (age 0-12 years old) fatalities were derived by adjusting the annualized child fatalities from 1993-1997 CDS to the 1997 FARS level. These data were derived from 1997 data, which means that incremental benefits will be compared to a fleet of vehicles equipped with pre-MY 1998 air bags. Of these

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

15,447, 12,116 (78 percent) occupants with heights of at least 65 inches are assumed to be represented by the 50th percentile male dummy, and the remaining 3,331 are assumed to be represented by the 5th percentile female dummy.

**MAIS 2-5 Injuries**. The 258,287 adult (excluding 3,348 child MAIS 2-5 injuries) front-outboard occupant MAIS 2-5 injuries in all frontal crashes were derived from Table II-12 (258,287 = 261,635 - 3,348). Of these 258,287, 201,541 (78 percent) occupants are assumed to be represented by the 50th percentile male dummy, and the remaining 56,746 are assumed to be represented by the 5th percentile female dummy. The 3,348 child (age 0-12 years old) MAIS 2-5 injuries were derived by adjusting annualized child fatalities from 1993-1997 CDS to the 1997 GES CDS-equivalent level.

2. **Front-outboard improperly positioned occupants affected by improved sensor capability**. Improperly positioned occupants are defined as those that the air bag did not help as much as it could have if they were properly positioned. These are people that were not killed or injured by the air bag, but potentially could have been saved or their injury levels could have been mitigated to a lesser severity level if the air bag characteristics were in some way improved (e.g., quicker deployment times). There are several factors that may cause an occupant to be improperly positioned, including sitting too close to the air bag, moving toward the air bag while braking, and late air bag deployment. The analysis considers that improperly positioned occupants are part of a target population that would benefit from improved sensors. The probability that an occupant would be improperly positioned is different in full frontal and offset

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

crashes. Nusholtz[1] concluded that about 19 percent of total occupants associated with offset crashes and 1 percent of total occupants associated with full frontal crashes would be out-of-position. However, the paper didn't indicate how different the size of the "out-of-position" population was between fatalities and MAIS 2-5 injuries. To investigate the relationship between fatalities and injuries, data from the 1993-1997 CDS were analyzed. They showed that about 28 percent of unbelted fatalities and 36 percent of unbelted MAIS 2-5 injuries were in vehicles where drivers had made a brake maneuver to avoid a frontal crash. If these occupants were considered to be improperly positioned, the 28 percent unbelted fatalities accounted for 19 percent of all fatalities in frontal crashes. The improperly positioned MAIS 2-5 proportion was slightly less, about 14 percent of all MAIS 2-5 injuries. Because percentages are close and the Nusholtz 19 percent estimate was based on a more rigorous analysis, improperly positioned occupants are assumed, for both fatalities and MAIS 2-5 injuries, to account for 19 percent of total occupants associated with offset crashes and 1 percent of total occupants associated with full frontal crashes. Based on Stucki's[2] paper, offset crashes represent 77.9 percent of all frontal crashes.

**Fatalities**. Thus, there are 2,320 (34 in full frontal: 15,447*0.221*0.01; 2,286 in offset: 15,447*0.779*0.19) projected improperly positioned adult fatalities. Of these 2,320, 1,839 (27 in full frontal; 1,812 in offset) are drivers and 481 (7 in full frontal; 474 in offset) are passengers.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

---

[1] Nusholtz, G., Xu, Lan, & Kostyniuk, G., "Estimation of Occupant Position from Probability Manifolds of Air Bag Fire-Times", SAE # 980643, Air Bag Technology, SP-1333, SAE, 1998.

[2] Stucki, Lee, "Analysis of Crash Data on Drivers With Air Bags in Frontal Crashes to Support a Frontal Offset Test Procedure", 1988-1996 National Analysis Sampling System (NASS), September 3, 1997

**MAIS 2-5 Injuries.** There are 38,796 (569 in full frontal: 258,286*0.221*0.01; 38,227 in offset: 258,286*0.779*0.19) projected improperly positioned adult MAIS 2-5 injuries. Of these 38,796, 30,565 (448 in full frontal; 30,117 in offset) are drivers and 8,231 (121 in full frontal; 8,110 in offset) are passengers.

Table VI-3 summarizes the estimated baseline target population assuming all vehicles in the fleet were equipped with air bags.

Table VI-3
Target Population
Annual Estimates Assuming a Full Air Bag Fleet

| | Minimize Risks of Air Bag Induced Fatalities & Injuries | | | Improve Occupant Protection From High Speed Crash Tests | | | |
|---|---|---|---|---|---|---|---|
| | At-Risk Groups | | | Front-Outboard Occupant Fatalities/Injuries | | | |
| | | | | Improved Crash Testing | | Improved Sensor Algorithm | |
| | Infants | Children (1-12 Years Old) | Adults in Close Proximity | 50th Percentile Male | 5th Percentile Female | In Full Frontal Crashes | In Offset Crashes |
| **Fatalities** | | | | | | | |
| Total | 18 | 105 | 64 | 12,116 | 3,331 | 34 | 2,286 |
| (Drivers) | | | (46) | (10,160) | (2,081) | (27) | (1,812) |
| (Passengers) | (18) | (105) | (18) | ( 1,956) | (1,250) | ( 7) | ( 474) |
| **MAIS 2-5 Injuries** | | | | | | | |
| Total | 9 | 200 | 53 | 201,541 | 56,746 | 569 | 38,227 |
| (Drivers) | | | (38) | (164,827) | (38,664) | (448) | (30,117) |
| (Passengers) | ( 9) | (200) | (15) | ( 36,714) | (18,082) | (121) | ( 8,110) |

Source: NHTSA Special Crash Investigation (SCI) cases as of January 1, 2000, 1997 FARS, 1993-1997 CDS, and 1997 GES

Note: Fatalities derived from 1993-1997 CDS are adjusted to 1997 FARS level; Injuries are adjusted to 1997 GES CDS-equivalent level; At-risk injuries included only MAIS 3-5 injuries.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

**B. Overview of Method**

The basic benefit estimation procedure consists of four steps: (1) establish the fatality and MAIS 2-5 injury probability (p) for each individual injury criterion (i.e., HIC, chest g's, chest deflection, Nij, etc.); (2) calculate the reduction rate/percentage (r); (3) calculate the weighted reduction rate/percentage; and (4) derive benefits. The following is a detailed description of each step.

Step 1: Establish the fatality and MAIS 2-5 injury probability (p). This step derives fatal/injury probabilities (p) for each vehicle test data included in the analysis by injury criterion (i.e., HIC, chest g's, chest deflection, Nij, etc.). The best predictor of fatal injury for chest and neck (Nij) is the AIS-5+ curve. The overwhelming majority of AIS-5 and AIS-6 injuries to the chest and neck result in a fatality. Thus, the AIS-5+ curve is a good proxy measure for fatality. Chapter III provides the algorithms for these curves, based on biomechanical data. Thus, the analysis uses AIS-5+injury curve to derive the fatality probability for Nij and CTI. The probability of a fatality, for example, for a HIC 700 is 1.7 percent (lognormal curve, see Table III-5), and for Nij=1.0 is 6.8 percent (see Figure III-5). And the corresponding MAIS 3-5 injury probability at HIC 700 for head and Nij=1 for neck is 29.5 and 23.0 percent, respectively.

Step 2: Calculate the reduction rate/percentage (r). The process is different for tests that minimize air bag risks and for those that improve air bag benefits. <u>For tests that minimize risk of air bag induced fatalities</u>, for each injury criterion, the average fatality/injury probability of the test results ($p_b$) is first measured against that ($p_a$) of the same tests after setting those tests that failed

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

to the standard ICPLs. The reduction percentage (r) is 1 minus the ratio of $p_a$ to $p_b$. That is, for each injury criterion,

$$r = 1 - p_a/p_b.$$

$p_b$ = average fatality/injury probability of crash test results

$p_a$ = average fatality/injury probability of crash test results after setting those with failed values to the ICPL.

For example, low risk deployment reduction rates for infants were based on HIC values of four 213 tests with a 12 months old CRABI in a child safety seat. The average fatal probability ($p_b$) of the test results for head injury was 24.35 percent based on the lognormal curve. Three of these vehicles failed the HIC 390 ICPL and those HIC values are then set to be 390 (the head ICPL). The value $p_a$ (0.018 percent) is the average fatal probability of this new set of four values (one value didn't change because it already passed the HIC 390). Therefore, the low risk deployment reduction rate for infants is 99.93=(1 - 0.0018/0.2435). The formula is derived based on the assumption that there is a 100 percent chance of being killed or seriously injured by pre-98 model air bags for at-risk groups and current test results corresponding to that 100 percent.

<u>For tests that improve occupant protection</u>, for each injury criterion, the actual percentage reduction (r) in the fatality and injury probabilities for each vehicle tested are calculated. Benefits are realized from improved injury criteria and the various crash test requirements (e.g., 30 mph rigid barrier with 5th percentile female and the 25 mph belted offset test which improves the sensor algorithm). The analysis examines FMVSS 208 tests with unrestrained 50$^{th}$ percentile

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

males, and Transport Canada tests (25 mph offset and 30 mph rigid barrier frontal barrier with restrained 5th percentile females) that failed the proposal injury values. It estimates the fatal/injury reduction percentage for each of these tests if they just meet the proposal injury values. For example, a vehicle in the 30 mph rigid barrier test with a restrained 5th percentile female driver dummy has an Nij=1.2. Then the reduction in the percentage of fatal neck injuries for this vehicle would be 1.7 percent, which is the difference between the fatality probability at Nij=1.2 (8.5 percent) and the fatality probability at Nij=1.0 (6.8 percent; these Nij values are put into the formula for AIS-5+ injuries shown in Figure III-5).

Step 3: Derive the weighted reduction percentage. The weighted reduction percentage is calculated using the following formula:

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

Where $r$ = total percent reduction in fatality/injury probability

$w_i$ = the weights

$r_i$ = the reduction in fatality/injury probability

$k$ = the total reduction percentage calculated.

Again the process and the assumptions made are different for tests that minimize air bag risks than for those that improve air bag benefits. <u>For tests that minimize risk of air bag induced fatalities,</u> $w_i$ is the proportion of various injured body regions in the at-risk population and $r_i$ $(=1 - p_a/p_b)$ is the corresponding reduction percentage. For example, the reduction rate for air bags passing the low risk deployment for children 1 to 12 years old were based on the out-of-position data on a 6

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

years old dummy. About 29 percent ($w_1$) of at-risk children 1-12 years old suffered a fatal head injury, and 71 percent ($w_2$) of these children had a fatal neck injury. So, k=2 (the number of injury criteria assessed) and the combined fatal r is 0.9034 (=0.29*0.9319 + 0.71*0.8917) percent if based on the lognormal injury curve. The numbers 0.9319 and 0.8917 are the reduction percentages for fatal head and neck injuries as described in step 2 previously.

Note that the driver at-risk population can't separate the head and neck injuries, thus it is inappropriate to use the individual head and neck reduction rate. In this case, the fatality/injury probabilities $p_a$ and $p_b$ in the reduction rate formula as in step 2 represent the combined fatal/injury probabilities of head and neck. The combined fatal/injury probability are calculated by assuming that the probabilities for each body region are independent of each other and benefits for different body regions. The calculation can be determined with the following formula:

$$p_a \text{ (or } p_b) = p_1 + p_2 - p_1 * p_2$$

where $p$ = the combined probability of $p_1$ (head probability) and $p_2$ (neck probability).

For $p_b$, $p_1$ and $p_2$ are the average fatality/injury probabilities of head and neck derived from the test results. While for $p_a$, $p_1$ and $p_2$ are the average fatality/injury probabilities of head and neck

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

derived from the same set of tests after setting those that with failed values to ICPLs. The same procedures are applied to calculate the combined probability of an adult having a MAIS 2-5 injury.

For tests that improve occupant protection, the total reduction percentage for each injury criterion (head, chest, and neck) is derived from the sales weighted cumulative percentage of all of the vehicles tested. The percentage point reduction for each vehicle tested is applicable only to the proportion that each vehicle represents within the tests. In other words, by assuming that proportion for each vehicle tested is the vehicle's proportion of on-road exposure, the reduction percentage is weighted by the vehicle's sales volume. The sum of these reduction percentages is the total reduction percentage in fatality/injury probability. The notations of the total reduction equation have a different interpretation:

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

Where $r$ = total percent reduction in fatality/injury probability

$w_i$ = the proportion of the vehicle's sales to the sales of all the vehicles tested

$r_i$ = the reduction in fatality/injury probability from the tested level to the ICPL level for each vehicle

$k$ = the number of vehicles failing to meet the specific injury ICPL

Note that some vehicle tests had a 0.0 percent fatal/injury reduction since they already comply with the ICPLs. Because this process examines each individual injury criterion at different levels, it cannot use the combined probability concept. Head, neck, and chest fatal and MAIS 2-5 injuries are assessed separately, and percentage reductions are applied to head, neck, and chest

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

fatalities/injuries, respectively. The total reduction benefit is the sum of head, neck, and chest reduction benefits.

Step 4: Derive benefits. The last step is to apply the reduction rate/percentage to the corresponding population to estimate benefits:

$$B = TP * r$$

where B = benefits (lives that would be saved or MAIS 2-5 injuries that would be mitigated)

TP = target population of the corresponding test

r = total reduction rate or reduction percentage

The following are additional adjustments that are used to calculate safety impacts:

1. All the infants killed or seriously injured by air bags suffered head injuries, therefore, only the HIC measurement is used for infants.

2. Also based on the SCI cases, all non-infant children suffered fatal or serious neck or head injuries. A combined fatality/injury reduction percentage of head (HIC) and neck injury is calculated for children.

3. The CTI, a combination of chest g's and chest deflection, injury probability curve is used to estimate the risk of chest injury. For each test type, the CTI value of those vehicles that failed to meet the standard (i.e., chest g and chest deflection) would measure against the CTI at the ICPLs.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

For example, if a vehicle tested with a 50th male dummy had a CTI=1.17[3] at chest g 66 g's (failed) and 45 mm chest deflection, the CTI would measure against CTI=1.10 at chest g 60 g's (proposed ICPL) and 45 mm chest deflection. Note that CTI is being used for chest benefit analysis but is not an injury criterion in the final rule.

4. Tests on model year 1998 or 1999 vehicles were used only if there were no tests on pre-MY1998 models.

Table VI-4-A lists the fatality reduction rates for the target population for the alternatives to minimize air bag induced fatalities. Reduction rate estimates shown are based on the Expanded Prasad/Mertz HIC curve, while those based on the lognormal curve are in parentheses. Table VI-4-B lists the injury reduction rates for the at-risk MAIS 3-5 injuries. The estimated reduction rates from low risk deployment for infants were based on the 213 crash tests on 12-month old CRABI with a deployed air bag; for children (1 and 12 years old), rates were based on the out-of-position tests with a six years old dummy right on the air bag module; for drivers, rates were based on out-of-position tests with 5th percentile females. There are no out-of-position test data for adult passengers and thus their reduction rates were adapted from children. The estimated reduction rates from 25 mph offset with a 5th percentile female were based on the Transport Canada (TC) crash test data.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

---

[3] CTI = chest g/90 + chest deflection/103 for the 50th male dummy.

Table VI-4-A
Fatality Reduction Rates For At-Risk Groups

| Type of Tests | Minimize Risks of Air Bag Induced Fatalities | | | |
|---|---|---|---|---|
| | **Infants** | **Children (1-12 Years Old)** | **Adults Passengers in Close Proximity** | **Drivers in Close Proximity** |
| Low Risk Deployment | 99.93% (92.19%)[1] | 90.34% (91.22%) | 90.34%[2] (91.22%) | 52.23% (52.23%) |
| Up to 25 mph Offset, Belted 5th Female | | | 13.26% (13.26%) | 38.37% (38.37%) |

1. Parenthetical values based on lognormal HIC curve, non parenthetical values based on Prasad/Mertz HIC curve.
2. Percentages are assumed to be identical to the estimates for children.

Table VI-4-B
MAIS 3-5 Reduction Rates For At-Risk Groups

| Type of Tests | Minimize Risks of Air Bag Induced MAIS 3-5 | | | |
|---|---|---|---|---|
| | **Infants** | **Children (1-12 Years Old)** | **Adults Passengers in Close Proximity** | **Drivers in Close Proximity** |
| Low Risk Deployment | 60.15% (55.78%)[1] | 76.83% (77.10%) | 76.83%[2] (77.10%) | 51.90% (51.90%) |
| Up to 25 mph Offset, Belted 5th Female | | | 18.83% (18.83%) | 47.82% (47.82%) |

1. Parenthetical values based on lognormal HIC curve, non parenthetical values based on Prasad/Mertz HIC curve.
2. Percentages are assumed to be identical to the estimates for children.

Tables VI-5-A and VI-5-B show the weighted percentage point reduction of fatal and MAIS 2-5 injury probabilities for the improved air bag protection from high speed crash tests. Reduction rate estimates shown are based on the Expanded Prasad/Mertz HIC curve, while those based on the lognormal curve are in parentheses. Based on the previous discussion for the additional CTI adjustment (#3), chest reduction percentages are derived by calculating the weighted reduction in fatality/injury probability from the tested CTI level to the CTI at the standard level. Note that no Nij values were collected for 30 mph unbelted tests with 50th percentile male dummies on pre-MY 1998 vehicle models. Based on Transport Canada 30 mph rigid barrier belted tests on 50th

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

percentile male dummies, the test results are not very different between pre-MY 1998 and MY 1998 vehicle models. Therefore, the MY 1998 tests results are used as a baseline to calculate neck reduction percentages for this test. Also note that the agency had three 30 mph rigid barrier 30 degree oblique tests with unrestrained 50th percentile males (two on right angular and one on left angular). These tests passed the ICPLs, therefore, there was no additional reduction in fatalities or injuries from vehicles that already passed the 30 mph rigid barrier perpendicular tests with 50th percentile males. The estimated reduction rates for the 30 mph, rigid barrier unrestrained tests with 5th percentile population were based on these tests and those failed the 25 mph restrained with 5th percentile females.

All estimates are based on the assumption that all vehicles in the fleet are equipped with pre-MY 1998 air bags and there are no changes in occupant demographics, driver/passenger behavior, belt use, child restraint use, or the percent of children sitting in the front seat. The analysis uses the most current year of crash data (1997 GES, 1997 FARS, and 1993-1997 CDS) and 1997-1998 SCI cases to derive the potential target populations that would be impacted by advanced air bags. This somewhat takes into account the current impacts of factors such as "public safety campaigns" and "air bag warning labels" that have effects on occupant safety. However, the analysis does not estimate the further potential impacts if certain trends continue. It also assumes that the sensors and other mechanical/electronic technologies are 100 percent accurate and reliable in performing their required functions (if these systems were 99.99 percent effective, it would make no difference numerically in the estimates since the target populations are not large enough to make a difference of even one life). Further, it is assumed that sales volumes of

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

vehicles tested represent their proportional distribution of involvement in crashes. Finally, the analysis examines only a 54 pound weight sensor for RFCSS and children.

Table VI-5-A
Percentage Point Reduction of Fatal Probability for
Improved Occupant Protection From High Speed Crash Tests

| Type of Tests | | Front-Outboard Occupant Fatalities | | |
|---|---|---|---|---|
| | | **Head** | **Neck(Nij)** | **Chest** |
| FMVSS 208, Up to 30 mph Rigid Barrier, 0 and ± 30 Degree Unbelted 50th Percentile Male | Drivers | 0.00% (0.00%) | 0.00% | 0.00% |
| | Passengers | 0.00% (0.03%) | 0.00% | 0.00% |
| Up to 30 mph Rigid Barrier, 0 and ± 30 Degree Belted 50th Percentile Male | Drivers | 0.00% (0.00%) | 0.00% | 0.00% |
| | Passengers | 0.00% (0.00%) | 0.00% | 0.00% |
| 20 to 30 mph, Rigid Barrier Unbelted 5th Percentile Female* | Drivers | 0.00% (0.00%) | 3.51% | 0.06% |
| | Passengers | 0.00% (0.00%) | 2.39% | 1.57% |
| Up to 30 mph, Rigid Barrier Belted 5th Percentile Female | Drivers | 0.00% (0.00%) | 3.05% | 0.01% |
| | Passengers | 0.00% (0.00%) | 0.27% | 0.00% |
| Up to 25 mph, Offset Belted 5th Percentile Female | Drivers | 0.00% (0.00%) | 6.19% | 0.00% |
| | Passengers | 0.61% (4.92%) | 1.22% | 0.00% |

* Results were based on unrestrained tests and those failed restrained tests.
Note: Parenthetical values based on lognormal HIC curve, non parenthetical values based on Prasad/Mertz HIC curve.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-5-B
Percentage Point Reduction of MAIS 2-5 Injury
Probability for Improved Occupant Protection From High Speed Crash Tests

| Type of Tests | | Front-Outboard Occupant MAIS 2-5 Injuries | | |
|---|---|---|---|---|
| | | Head | Neck(Nij) | Chest(CTI) |
| FMVSS 208, 20 up to 30 mph Rigid Barrier, 0 and ± 30 Degree Unbelted 50th Percentile Male | Drivers | 0.00% (0.00%) | 0.00% | 0.00% |
| | Passengers | 0.36% (0.14%) | 0.00% | 0.00% |
| Up to 30 mph Rigid Barrier, 0 and ± 30 Degree Belted 50th Percentile Male | Drivers | 0.00% (0.00%) | 0.00% | 0.00% |
| | Passengers | 0.00% (0.00%) | 0.00% | 0.00% |
| 20 to 30 mph, Rigid Barrier Unbelted 5th Percentile Female* | Drivers | 0.00% (0.00%) | 8.98% | 1.57% |
| | Passengers | 0.00% (0.00%) | 5.36% | 2.07% |
| Up to 30 mph, Rigid Barrier Belted 5th Percentile Female | Drivers | 0.00% (0.00%) | 7.40% | 0.27% |
| | Passengers | 0.00% (0.00%) | 0.81% | 0.28% |
| Up to 25 mph, Offset Belted 5th Percentile Female | Drivers | 0.00% (0.00%) | 11.88% | 0.00% |
| | Passengers | 8.41% (3.39%) | 3.44% | 0.00% |

* Results were based on unrestrained tests and those failed restrained tests.
Note: Parenthetical values based on lognormal HIC curve, non parenthetical values based on Prasad/Mertz HIC curve.

## C. Benefit Estimates

### Minimize Risks of Air Bag Induced Fatalities

### 1. Infants in RFCSS

As indicated in Table VI-3, if all vehicles in the fleet were equipped with pre-MY 1998 air bags, a total of 18 infants in RFCSS would be fatally injured by air bags annually. From a telephone

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

survey of the public on child safety seat issues that NHTSA conducted between November 1996 and January 1997, 85 percent said they put the safety seat in the back seat, a 7 percentage point increase over 1994[4]. The analysis of FARS (Table II-9, Chapter II) data showed that the percent of infants and toddlers riding in the back seat of cars with dual air bags has increased substantially since 1996 - from about 70 percent to about 90 percent. The infant fatality numbers in 1997-1998, which are the basis for the 18 fatalities in the target population, may reflect this changing behavior. Therefore, the analysis doesn't make a further adjustment and uses the projected 18 infants in RFCSS as the target population.

The test for RFCSS includes two alternative options: suppression and low risk deployment.

***Suppression***

The suppression test would require that the air bag be shut off whenever a RFCSS is present. Suppression systems could be equipped with weight sensors, ultrasound, or infrared which would detect a RFCSS in the vehicle and shut off the air bag. A system that passes the test and is nearly 100 percent effective would eliminate the 18 RFCSS fatalities annually. In the case of a RFCSS, a static suppression system would be sufficient. For example, a 54-pound-limit static suppression system would suppress inflation of the air bag when the front passenger, and child safety seat, weighs 54 pounds or less. This particular static weight suppression system could prevent all 18 RFCSS fatalities. The dynamic air bag suppression system would not be needed.

[4] 1996 Motor Vehicle Occupant Safety Survey, Volume 5: Child Safety Seat Report, DOT HS 808 634, December, 1997.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Mercedes and BMW have MY 1998 production systems based on a 26 pound suppression threshold that could minimize air bag induced RFCSS fatalities. However, their sales are not enough to reduce the estimate (18*0.985=17.7, rounds to 18).

*Low Risk Deployment*

All the infants killed by air bags suffered head injuries. Thus, the HIC 15 value is a reasonable injury criterion to estimate the probability of an infant being fatally injured by an air bag. The agency proposes HIC 15=390 as head ICPL for infants. At 390 HIC, the probability of an infant being killed is 0.02 percent measured by Prasad/Mertz and 1.7 percent measured by lognormal curves. The estimated reduction rates for the low risk deployment were based on the HIC values from FMVSS 213 tests on 12-month old CRABI. If a low risk deployment system met 390 HIC, and this was sufficiently protective for infants, it would prevent 17-18 infant fatalities by assuming the low risk deployment would eliminate 92.19 to 99.93 percent (Table VI-4-A) of infant fatalities.

One of the systems that could be designed to pass the low risk deployment test, for example, is the multi-stage inflation system based on crash severity and belt use. As described in Table VI-2, the analysis assumes multi-stage air bags would not be inflated if the impact speed is less than 18 mph for belted occupants and the first stage air bag would be inflated with lower force. The first stage low level deployment air bag might be able to meet the low risk deployment tests. For infants, the system must pass at all inflation levels, since the agency is also concerned about infants in RFCSS in high speed crashes (not just those in the SCI cases at 25 mph delta V or less).

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

The second stage power of the multi-stage system may fail the low-risk test for infants. This may also be difficult to accomplish with mid-mounted bags. Systems with top-mounted[5] bags may be more likely to pass than mid-mount bags at higher inflation levels. A total of 13 RFCSS fatalities occurred in crashes with speeds below 18 mph. If the multi-stage system successfully met the test requirements for infants, these 13 RFCSS belted fatalities would all be prevented by this system. If the first stage deployment met the HIC 15 390 requirement, then 5 RFCSS fatalities would be prevented in the first deployment stage. Altogether, the multi-stage inflation system based on crash severity could save 18 infant lives assuming the first stage deployment power passed the low risk deployment test. Because all the RFCSSs with infants in them weigh less than 30 pounds, a multi-stage inflation system equipped with a 54-pound weight sensor would also prevent all 18 infant fatalities if the system meets the injury values.

In summary, as shown in Table VI-6, the rear-facing child safety seat test would have the potential to prevent 18 infant fatalities either by suppression or by the first stage meeting low risk deployment.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

[5] Top-mounted air bags deploy up towards the windshield first and then back towards the occupant. A top-mounted air bag may go over a RFCSS and possibly could meet the injury criteria. A mid-mounted air bag deploys back towards the child restraint initially and it would be very difficult to meet the injury criteria with this type of system, with current air bag technology.

Table VI-6
Estimated Fatality Reduction Benefits of Optional Tests For Rear Facing Child Fatalities

| Air Bag Systems | Lives Saved Per Year |
|---|---|
| **Suppression System** | 18 |
| **Low Risk Deployment System** | 17-18 |
| **- Multi-Level Inflation System*** | 18 |
| **- Multi-Level Inflation System with a 54 Pound Weight Suppression Option*** | 18 |

* The first stage passed the low risk deployment test.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

## 2. Children ( 1 to 12 Years Old )

As shown in the Table VI-3, assuming all vehicles in the on-road fleet have pre-MY 1998 air bags, a total of 105 children would be projected to be killed by air bags annually. The out-of-position tests using the 3-year-old dummy and the 6-year-old dummy together address the air bag-children interaction scenario. Suppression and low risk deployment testing are options to minimize air bag risk.

### *Suppression*

The "suppression with child present" test would require the system to shut off the air bag if the sensors detect a child and ideally also would prevent all 105 child fatalities. However, the suppression test uses only 3- and 6-year-old dummies which do not represent children of all ages up to 12 years old. Here, the analysis uses 54 pounds as the threshold to differentiate children because the instrumented 6-year-old dummy weighs 54 pounds. About 83 of the 105 child fatalities are estimated to weigh 54 pounds or less. Eight (10 percent) of these children are

estimated to be sitting on the lap of an adult passenger and thus would not be identified as children by a weight sensor. For this reason, the "suppression when child present" test is assumed to save only 75 (=83-8) children. However, manufacturers could possibly use a higher weight threshold (e.g., 66 pounds) or more advanced sensors to cover more children without improperly suppressing the air bag when a 5th percentile female is present. If more sophisticated sensor technologies were used and they would accurately detect children, the improved air bag systems could potentially save up to 97 (=105-8) children.

The "suppression when out-of-position" test would require that the system shut off the air bag if the proximity sensors detect that an occupant is too close to the air bag. How effective the system is depends upon whether it is a static or dynamic system. A static system would only suppress when an occupant starts in a "risk zone." A dynamic "suppression when out-of-position" system, if it works perfectly to detect out-of-position children would prevent all of these 105 child fatalities. About 13 percent of children were unbelted and weighed more than 54 pounds. These children would more likely be benefitted only by the dynamic suppression system.

***Low Risk Deployment***

Reduction rates were based on the agency's out-of-position tests with a 6 year old dummy right on the air bag module. As described in the methodology section, children in the SCI cases all suffered severe head and neck injury; therefore only the HIC/Nij value combination is used to assess the benefits. Applying the fatality reduction rates shown in Table VI-4-A to the 105 target child population, an air bag system passing the low risk deployment would eliminate 95-96 child

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

fatalities. Table VI-7 presents the child fatalities that would be reduced if an air bag passes the low risk deployment test.

Table VI-7
Estimated Fatality Reduction Benefits of Low Risk Deployment Test
Children 1-12 Years Old

| | |
|---|---|
| **Target Population** | 105 |
| **Fatality Reduction Rate*** | 0.9034 - 0.9122 |
| **Lives Saved** | 95 - 96 |

* From Table VI-4-A.

The multi-stage inflation system considered in this analysis could potentially pass the low risk deployment at the first stage deployment level. To estimate the benefits that accrue from the multi-stage inflation system based on crash severity, the child data are rearranged by inflation stages corresponding to that of the system and by two different weight categories as shown in Table VI-8. These fatalities all occurred at low-to-moderate speeds (belted ≤ 30 mph, and unbelted ≤ 25 mph); hence there would be no incidents at stage 2.

Table VI-8
Target Fatal Population By Weight and Multi-Stage Air Bag Inflation Stages
Children 1-12 Years Old

| Weight | Suppression* | Stage 1 | Stage 2 | Total |
|---|---|---|---|---|
| **≤ 54 lbs** | 61 | 22 | 0 | 83 |
| **> 54 lbs** | 15 | 7 | 0 | 22 |
| **Total** | 76 | 29 | 0 | 105 |

Source: Projected number from the Special Crash Investigation cases as January 1, 2000
* See Table VI-2 for the definition of stage groups.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

The multi-stage inflation system by crash severity would prevent 76 child fatalities by suppression. By applying the fatality reduction rate to the target population at the first stage, low level deployment, the system would prevent another 26 child fatalities. In total, the system could prevent 102 child fatalities. Table VI-9 presents the benefits of this system for children.

Table VI-9
Estimated Fatality Reduction Benefits of A Multi-Stage System
Children 1-12 Years Old

| | |
|---|---|
| **Lives Saved at the Suppression Stage[1]** | 76 |
| **The First Stage Deployment** | |
| **Target Population** | 29 |
| **Fatality Reduction Rate[2]** | 0.9034 - 0.9122 |
| **Lives Saved** | 26 - 26 |
| **Total Lives Saved** | 102 - 102 |

1. From Table VI-8
2. From Table VI-4-A, low risk deployment.

If the multi-stage system were equipped with a 54-pound weight sensor, 98 (see Table VI-8) children would be saved by suppression either by crash severity or by weights. Note that 8 of those children sat on an adult's lap were in crashes with impact speeds less than 14 mph. These children would be saved by suppression based on crash severity and thus included in those 98 children saved in the suppression stage. The first stage deployment, if it met the low risk deployment test, would prevent another 6 child fatalities. The multi-stage system with a 54-pound weight suppression system would prevent 104 child fatalities. Table VI-10 summarizes the benefits of the system with a 54-pound weight suppression sensor.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-10
Estimated Fatality Reduction Benefits of A Multi-Stage System With a 54-Pound Weight Sensor
Children 1-12 Years Old

| | |
|---|---|
| **Lives Saved by the Suppression Options (by crash severity or a 54 pound limit)[1]** | 98 |
| **First Stage, Low Level Deployment** | |
| **Target Population with Weight > 54 Pounds** | 7 |
| **Fatality Reduction Rate[2]** | 0.9034 - 0.9122 |
| **Lives Saved** | 6 - 6 |
| **Total Lives Saved** | 104 - 104 |

1. From Table VI-8
2. From Table VI-4-A, low risk deployment

3. **Close Proximity Adults**

If all vehicles in the fleet were equipped with pre-MY 1998 air bags, a total of 64 adults (46 drivers and 18 passengers) would be killed annually by the air bags because they were too close to the air bag module when it deployed. Compared to their percent of the population, small stature adults (shorter than or equal to 64 inches) and older adults are disproportionately represented in adult fatalities attributed to air bags. This is because short stature or older drivers (especially females) are more likely to sit close to the steering wheel and are more prone to injury at a given force or acceleration level, and therefore are more at risk. The tests using 5$^{th}$ percentile dummies and accompanying ICPLs provide the best safety measures for these adults in close proximity to the air bag. Virtually all adults weigh more than 60 pounds; thus the 54-pound weight suppression system on the passenger side would have no effect on these adults and would not accrue any benefits for adult passengers. Benefits are estimated separately for drivers and passengers.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

***Drivers***

Of the 64 adults who would be killed by air bags annually, 46 are drivers. Fifteen (33 percent) of these drivers are unrestrained (including drivers with unknown belt usage); thirty-eight (82 percent) are small stature adults with heights of 64 inches or shorter; seventeen (36 percent) are 65 years and older.

***Dynamic Suppression***

If the dynamic suppression-when-out-of-position test worked perfectly, it would prevent all 46 driver fatalities because the air bags would shut off if they detected out-of-position drivers in these low speed crashes. Manufacturers do not appear to be considering dynamic out-of-position systems for drivers currently. (Static suppression is not an option for drivers in the final rule.)

***Low Risk Deployment***

Based on the fatality reduction rate shown in Table VI-4-A, the test would eliminate 52.23 percent of close proximity driver fatalities, i.e., 24 (=46*0.5223) driver fatalities could be prevented. The multi-stage system and systems with modified fold patterns or inflator might meet the low-risk deployment test.

***Up to 25 MPH Offset Belted Test***

This analysis also considers these close-proximity adults to be out-of-position because of late air bag firing. One reason for the 25 mph offset test is to improve the air bag fire time, and thus save these drivers. The reduction rate (38.37 percent) for the 25 mph offset test was based on the TC

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

25 mph offset crash tests with a belted 5th percentile female dummy. Because this test is intended to improve sensor technology, the reduction is applied to all the at-risk adult drivers. The 25 mph offset test would save 18 (=46*0.3837) drivers.

It is assumed that the hypothetical multi-level inflation air bag system could pass the low risk deployment at the first stage of deployment. To estimate the benefits that accrue from the multi-stage inflation system based on crash severity, drivers are classified by height and air bag inflation stages corresponding to those of the system as shown in Table VI-11. Because these fatalities all occurred at low-to-moderate speeds (both belted and unbelted ≤ 25 mph), there were no incidents occurring at stage 2.

Table VI-11
Target Population By Multi-Stage Air Bag Inflation Stages
Drivers in Frontal Crashes

| Driver Groups | Suppression* | Stage 1 | Stage 2 | Total |
|---|---|---|---|---|
| **Represented by 50th Percentile Male** | 12 | 6 | 0 | 18 |
| **Represented by 5th Percentile Female** | 22 | 6 | 0 | 28 |
| **Total** | 34 | 12 | 0 | 46 |

Source: Projected number from the Special Crash Investigation cases as January 1, 2000
* See Table VI-2 for the definition of the stage groups.

The suppression and low level depowering features (stage 1) of the system would prevent a total of 40 (see Table VI-12) driver fatalities based on the assumption that low power deployment would prevent 52.23 percent of driver fatalities and the system passes the low risk deployment.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-12
Estimated Fatality Reduction Benefits of A Multi-Stage System
Drivers in Close Proximity

| | |
|---|---|
| **Lives Saved by the Suppression Stage[1]** | 34 |
| **First Stage Deployment (passed low risk deployment)** | |
| **Target Population** | 12 |
| **Fatality Reduction Rate[2]** | 0.5223 |
| **Lives Saved** | 6 |
| **Total Lives Saved** | 40 |

1. From Table VI-11
2. From Table VI-4-A

### *Passengers*

There would be a projected total of 18 adult passengers killed by air bags if the full fleet were equipped with pre-MY 1998 air bags. Fifteen (83 percent) of the 18 are small stature adults. Twelve (67 percent) of them are 65 years or older.

### *Suppression*

The suppression when out-of-position test would save all 18 adult passenger fatalities because air bags would not be deployed if they detected an out-of-position passenger.

### *Low Risk Deployment*

The reduction rates for the low risk deployment were assumed to be identical to those of children. The low risk deployment test would prevent 16 adult passenger fatalities assuming that the low risk deployment test would eliminate 90.34 to 91.22 percent of fatalities. See Table VI-13.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-13
Estimated Fatality Reduction Benefits of Low Risk Deployment Test
Adult Passengers in Close Proximity

| | |
|---|---|
| **Target Population** | 18 |
| **Fatality Reduction Rate**[1] | 0.9034 - 0.9122 |
| **Lives Saved** | 16 - 16 |

1. From Table VI-4-A.

### *Up to 25 MPH Offset Belted Test*

The reduction rate (13.26 percent) of this test for passengers was based on TC 25 mph offset belted crash tests on 5th percentile females. The offset belted test would prevent 2=(18*13.26) adult passenger fatalities.

The multi-level inflation air bag system may pass the low risk deployment at the first stage deployment level. The multi-stage inflation system based on crash severity would save a total of 17 passengers as shown in Table VI-14.

Table VI-14
Estimated Fatality Reduction Benefits of A Multi-Stage System
Adult Passengers in Close Proximity

| | |
|---|---|
| **Lives Saved by the Suppression Stage** | 9 |
| **First Stage, Low Level Deployment** | |
| **Target Population** | 9 |
| **Fatality Reduction Rate*** | 0.9034 - 0.9122 |
| **Lives Saved** | 8 - 8 |
| **Total Lives Saved** | 17 - 17 |

* From Table VI-4-A.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

## 2. Minimize Risks of Air Bag Induced MAIS 3-5 Injuries

Air bag-induced MAIS 3-5 injuries were projected from at-risk fatalities, therefore, all the descriptive statistics (e.g., percent distribution by age, weights, and etc.) were based on fatalities for at-risk groups. In addition, all the assumptions and limitations for a specific group or a test that were discussed in the fatality benefits also apply to injury benefits. Therefore, the following injury benefit discussions for each test and air bag system do not repeat these statements

### 1. Infants in RFCSS

As indicated in Table VI-3, if all vehicles in the fleet were equipped with pre-MY 1998 air bags, a total of 9 infants in RFCSS would be seriously injured by air bags annually.

#### *Suppression*

A suppression system that passes the suppression test and is nearly 100 percent effective would eliminate the 9 RFCSS MAIS 3-5 injuries annually. In the case of a RFCSS, a static suppression system would be sufficient. For example, a 54-pound static suppression system would suppress inflation of the air bag when the front passenger plus the child safety seat weighs 54 pounds or less. This particular static weight suppression system could prevent all 9 RFCSS MAIS 3-5 injuries.

Mercedes and BMW have MY 1998 production systems based on a 26 pound suppression threshold that could prevent air bag induced RFCSS MAIS 3-5 injuries. However, their sales are not enough to reduce the estimate (9*0.985=8.9, rounds to 9).

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

*Low Risk Deployment*

As discussed in the RFCSS fatality section, the HIC 15 value is the only injury criterion used to estimate the probability of an infant being seriously injured by an air bag. The estimated reduction rates for the low risk deployment were based on the HIC 15 values from FMVSS 213 tests on 12-month old CRABI. The MAIS 3-5 injury reduction rate (Table VI-4-B) is 60.15 percent measured by Prasad/Mertz and 55.78 percent measured by lognormal curves. A low risk deployment system, as shown in Table VI-15, would reduce 5 infant MAIS 3-5 injuries.

Table VI-15
Estimated MAIS 3-5 Injury Reduction Benefits of Low Risk Deployment Test RFCSS

| | |
|---|---|
| **Target Population** | 9 |
| **Injury Reduction Rate**[1] | 0.5578 - 0.6015 |
| **Injuries Reduced** | 5 - 5 |

1. From Table VI-4-B.

The multi-stage inflation system would reduce 6 infant MAIS 3-5 injuries by the suppression stage. Altogether, as shown in Table VI-16 the multi-stage inflation system based on crash severity could prevent 8 infant MAIS 3-5 injuries assuming that the first stage power passed the low risk deployment test. Because all the RFCSSs and infants weigh less than 30 pounds, a multi-stage inflation system equipped with a 54-pound weight sensor would also prevent all 9 infant MAIS 3-5 injuries.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-16
Estimated Fatality Reduction Benefits of A Multi-Stage System
Rear Facing Child MAIS 3-5 Injuries

| | |
|---|---|
| **Injury Reduced by the Suppression Options (by Crash Severity)** | 6 |
| **First Stage, Low Level Deployment** | |
| **Target Population** | 3 |
| **Injury Reduction Rate[1]** | 0.5578 - 0.6015 |
| **Injury Reduced** | 2 - 2 |
| **Total Lives Saved** | 8 - 8 |

1. From Table VI-4-B, low risk deployment

In summary, as shown in Table VI-17, the rear-facing child safety seat test would have the potential to prevent 9 infant injuries by suppression, 5 injuries by low risk deployment, and 8 injuries by the multi-level inflation system.

Table VI-17
Estimated Injury Reduction Benefits of Optional Tests For Rear
Facing Child MAIS 3-5 Injuries

| Air Bag Systems | MAIS 3-5 Injuries Reduced Per Year |
|---|---|
| **Suppression System** | 9 |
| **Low Risk Deployment System** | 5 |
| **- Multi-Level Inflation System** | 8 |
| **- Multi-Level Inflation System with a 54 Weight Sensor Options** | 9 |

## 2. Children ( 1 to 12 Years Old )

A total of 200 children would be projected to be seriously injured by air bags annually. Suppression and low risk deployment testing are options to minimize air bag risk.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

***Suppression***

The "suppression with child present" test would require the system to shut off the air bag if the sensors detect a child and ideally also would prevent all 200 child MAIS 3-5 injuries. Of these 200 children, 158 weighed less than or equal to 54 pounds. Of these 158, 16 children are estimated to be sitting on an adults' lap when the crash occurred and these children would not be detected as a child weighing less than 54 pounds. The 54 pound suppression options would reduce 142 (=158-16) child serious injuries. If manufacturers voluntarily install a higher weight threshold (e.g., 66 pounds) suppression system, it would cover more children without improperly suppressing the air bag when a 5th percentile female is present. Or, if more sophisticated sensor technologies were used and they would accurately detect children, the improved air bag systems could potentially prevent up to 184 (=200-16) child MAIS 3-5 injuries.

The "suppression when out-of-position" test would require that the system shut off the air bag if the proximity sensors detect that a child is too close to the air bag; if it works perfectly it would prevent all of these 200 child MAIS 3-5 injuries.

***Low Risk Deployment***

As described in the fatal benefit section, only the HIC/Nij value combination is used to assess the benefits. Applying the injury reduction rates as shown in Table VI-4-B to the 200 target child injury population, an air bag system passing the low risk deployment test would eliminate 154 air bag-induced injuries. Table VI-18 presents the child injuries that would be reduced if an air bag passes the low risk deployment test.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-18
Estimated MAIS 3-5 Injury Reduction Benefit of Low Risk Deployment Test
Children 1-12 Years Old

| | |
|---|---|
| **Target MAIS 3-5 Injury Population** | 200 |
| **Injury Reduction Rate*** | 0.7683 - 0.7710 |
| **Injuries Reduced** | 154 - 154 |

* From Table VI-4-B.

To estimate the benefits that accrue from the multi-stage inflation system based on crash severity, the child data are rearranged by inflation stages corresponding to that of the system and by two different weight categories as shown in Table VI-19. Note that the injury distribution was based on the distribution of fatalities. These injuries all occurred at low-to-moderate speeds (belted ≤ 30 mph, and unbelted ≤ 25 mph); hence there were no incidents at stage 2.

Table VI-19
Target MAIS 3-5 Injury Population By Weight and Multi-Stage Air Bag Inflation Stages
Children 1-12 Years Old

| Weight | Suppression* | Stage 1 | Stage 2 | Total |
|---|---|---|---|---|
| **≤ 54 lbs** | 117 | 41 | 0 | 158 |
| **> 54 lbs** | 28 | 14 | 0 | 42 |
| **Total** | 145 | 55 | 0 | 200 |

Source: the Special Crash Investigation cases as January 1, 2000 and 1993-1998 CDS.
* See Table VI-2 for the definition of stage groups.

The multi-stage inflation system by crash severity would reduce 145 child MAIS 3-5 injuries by suppression. As discussed previously, by applying the injury reduction rate (Table VI-4-B) to the target population at the first stage, low level deployment, the system would prevent another 42 child injuries. In total, the system could reduce 187 child MAIS 3-5 injuries. Table VI-20 presents the injury benefits of this system for children.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-20
Estimated MAIS 3-5 Injury Benefits of A Multi-Stage System
Children 1-12 Years Old

| | |
|---|---|
| **Injuries Reduced at the Suppression Stage[1]** | 145 |
| **The First Stage Deployment** | |
| **Target Population** | 55 |
| **Injury Reduction Rate[2]** | 0.7683 - 0.7710 |
| **Injuries Reduced** | 42 - 42 |
| **Total Injuries Reduced** | 187 - 187 |

1. From Table VI-19
2. From Table VI-4-B, low risk deployment.

If the system were equipped with a 54-pound weight sensor, 186 child injuries would be prevented by suppression either by crash severity or by weights (28 by crash severity; 158 by the 54 pound weight suppression option). The first stage deployment, if it met the low risk deployment test, would prevent another 11 child injuries. In total, the multi-stage system with a 54-pound weight suppression system would prevent 197 child MAIS 3-5 injuries. Table VI-21 summarizes the benefits of the system with a 54-pound weight suppression sensor.

### 3. Close Proximity Adults

If all vehicles in the fleet were equipped with pre-MY 1998 air bags, a total of 53 adults would be seriously injured by the air bags because they were too close to the air bag module when it deployed. Of the 53 adults MAIS 3-5 injuries, 38 were drivers and 15 were front-outboard passengers.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-21
Estimated MAIS 3-5 Injury Reduction Benefits of A Multi-Stage System
With a 54-Pound Weight Sensor
Children 1-12 Years Old

| | |
|---|---|
| **Injuries Reduced by the Suppression Options (by crash severity or a 45 pound limit)[1]** | 186 |
| **First Stage, Low Level Deployment** | |
| **Target Population with Weight > 54 Pounds** | 14 |
| **Injury Reduction Rate[2]** | 0.7683 - 0.7710 |
| **Injuries Reduced** | 11 - 11 |
| **Total Injuries Reduced** | 197 - 197 |

1. From Table VI-8
2. From Table VI-4-B, low risk deployment

### *Drivers*

### *Dynamic Suppression*

If the dynamic suppression when out-of-position test worked perfectly, it would reduce all 38 driver injuries because the air bags would shut off if they detected out-of-position drivers in these low speed crashes. Manufacturers are not considering dynamic out-of-position systems currently.

### *Low Risk Deployment*

Based on the injury reduction rate shown in Table VI-4-B, the test would eliminate 51.90 percent of close proximity driver MAIS 3-5 injuries, i.e., 20 (=38*0.5190) driver injuries would be reduced. The multi-stage system and systems with modified fold patterns or inflator might meet the low-risk deployment test.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

***Up to 25 MPH Offset Belted Test***

The up to 25 mph offset tests would eliminate 47.82 percent of close proximity driver MAIS 3-5 injuries, i.e., 18 (=38*0.4782) driver injuries would be reduced.

For the multi-stage inflation system based on crash severity, driver injuries are tabulated by height and air bag inflation stages corresponding to those of the system as shown in Table VI-22. Because these injuries all occurred at low-to-moderate speeds (both belted and unbelted ≤ 25 mph), there were no incidents occurring at stage 2.

Table VI-22
Target Driver MAIS 3-5 Injury Population By Multi-Stage Air Bag Inflation Stages

| Driver Groups | Suppression* | Stage 1 | Stage 2 | Total |
|---|---|---|---|---|
| **Represented by 50th Percentile Male** | 10 | 5 | 0 | 15 |
| **Represented by 5th Percentile Female** | 18 | 5 | 0 | 23 |
| **Total** | 28 | 10 | 0 | 38 |

Source: the Special Crash Investigation cases as January 1, 2000; 1993-1998 CDS
* See Table VI-2 for the definition of the stage groups.

The suppression and low level depowering features (stages 1) of the system would reduce a total of 33 (see Table VI-23) driver MAIS 3-5 injuries based on the assumption that low power deployment would prevent 51.90 percent of driver injuries and the system passes the low risk deployment tests.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-23
Estimated MAIS 3-5 Injury Reduction Benefits of A Multi-Stage System
Drivers in Close Proximity

| | |
|---|---|
| **Injuries Reduced by the Suppression Stage[1]** | 28 |
| **First Stage Deployment (passed low risk deployment)** | |
| **Target Population** | 10 |
| **Injury Reduction Rate[2]** | 0.5190 |
| **Injuries Reduced** | 5 |
| **Total Injuries Reduced** | 33 |

1. From Table VI-23
2. From Table VI-4-B

### *Passengers*

There would be a projected total of 15 adult passenger MAIS 3-5 injuries.

### *Suppression*

The suppression when out-of-position test would prevent all 15 adult passenger injuries because air bags would not be deployed if they detected an out-of-position passenger.

### *Low Risk Deployment*

The low risk deployment test would prevent 12 (=15*0.7683 or 15*0.7710) adult passenger MAIS 3-5 injuries assuming that low risk deployment test would eliminate 76.83 to 77.10 percent of injuries.

### *Up to 25 MPH Offset Belted Test*

The up to 25 mph offset tests would prevent 3 (=15*0.1883) adult passenger MAIS 3-5 injuries assuming that the low risk deployment test would eliminate 0.1883 percent of injuries.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

The multi-level inflation air bag system may pass the low risk deployment at the first stage deployment level. The multi-stage inflation system based on crash severity and belt use would prevent 13 of these passenger injuries as shown in Table VI-24

Table VI-24
Estimated MAIS 3-5 Injury Reduction Benefits of A Multi-Stage System
Adult Passengers in Close Proximity

| | |
|---|---|
| **Injuries Reduced by the Suppression Stage** | 7 |
| **First Stage, Low Level Deployment** | |
| **Target Population** | 8 |
| **Injury Reduction Rate*** | 0.7683 - 0.7710 |
| **Injuries Reduced** | 6 - 6 |
| **Total Injuries Reduced** | 13 - 13 |

* From Table VI-4-B.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

## 3. Summary of Benefits From At-Risk Groups

Table VI-25 summarizes the benefits from at-risk groups.

Table VI-25
Fatality and MAIS 3-5 Injury Benefits From At-Risk Groups

| | At-Risk Groups | | | | |
|---|---|---|---|---|---|
| **Fatalities** | **Infants** | **Children** | **Adult Passengers** | **Drivers** | **Total** |
| Baseline Target Population | 18 | 105 | 18 | 46 | 187 |
| Estimated Lives Saved by Suppression | 18 | 75 | 0* | 0* | 93 |
| Estimated Lives Saved by Low Risk Deployment | 17-18 | 95-96 | 16 | 24 | 152-154 |
| Estimated Lives Saved by Multi-Stage Inflation System | 18 | 102 | 17 | 40 | 177 |
| Estimated Lives Saved by Multi-State Inflation System + a 54-Pound Weight Suppression | 18 | 104 | 17 | 40 | 179 |
| **MAIS 3-5 Injuries** | | | | | |
| Baseline Target Population | 9 | 200 | 15 | 38 | 262 |
| Estimated Injuries Reduced by Suppression | 9 | 142 | 0* | 0* | 151 |
| Estimated Injuries Reduced by Low Risk Deployment | 5 | 154 | 12 | 20 | 191 |
| Estimated Injuries Reduced by Multi-Stage Inflation System | 8 | 187 | 13 | 33 | 241 |
| Estimated Injuries Reduced by Multi-State Inflation System + a 54-Pound Weight Suppression | 9 | 197 | 13 | 33 | 252 |

* Not proposed test for this group.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

**Benefits From Improved Occupant Protection From High Speed Crash Tests**

**1. Fatalities**

As described in the method section, the reduction percentage is calculated for each test that failed the proposal injury values. Benefits are derived by applying the reduction percentages to the appropriate target population as shown in Table VI-26. The analysis gave precedence to head injuries if an occupant had a maximum head, chest injury, and neck injury at the same AIS level. These cases were categorized in the head group.

Table VI-26
Target Populations for Improved Occupant Protection From High Speed Crash Tests
Front-Outboard Adult Occupant Fatalities in Frontal Crashes

| | Fatalities Represented by 50th Percentile Male | | | Fatalities Represented by 5th Percentile Female | | | Fatalities Potentially Impacted by Improving Sensor Algorithm | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Head** | **Neck** | **Chest** | **Head** | **Neck** | **Chest** | **Head** | **Neck** | **Chest** |
| **Drivers** | 3,759 | 1,524 | 3,759 | 749 | 375 | 687 | 680 | 294 | 680 |
| **Belted** | 1,242 | 504 | 1,242 | 248 | 124 | 227 | 225 | 97 | 225 |
| **Unbelted** | 2,517 | 1,020 | 2,517 | 501 | 251 | 460 | 455 | 197 | 455 |
| **Passengers** | 958 | 176 | 763 | 313 | 225 | 613 | 192 | 63 | 207 |
| **Belted** | 314 | 58 | 250 | 102 | 74 | 200 | 63 | 20 | 68 |
| **Unbelted** | 644 | 118 | 513 | 211 | 151 | 413 | 129 | 43 | 139 |
| **Total** | 4,717 | 1,700 | 4,522 | 1,062 | 600 | 1,300 | 872 | 357 | 887 |
| **Belted** | 1,556 | 562 | 1,492 | 350 | 198 | 427 | 288 | 117 | 293 |
| **Unbelted** | 3,161 | 1,138 | 3,030 | 712 | 402 | 873 | 584 | 240 | 594 |

Source: 1993-1997 CDS; 1997 FARS
Note: Fatalities were derived from 1993-1997 CDS and adjusted to 1997 FARS level.

The fatal reduction percentages shown in Table VI-5-A are applied to the population in Table VI-26. Table VI-27 shows the fatality reduction benefits. An air bag that passes the 30 mph,

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

unbelted 5th percentile female test would save 19 lives, while the belted test would save 4 lives. The 25 mph offset, belted 5th percentile female test would save 20 to 28 lives.

Note that tests with no additional benefits beyond those already achieved (total 3,253 lives annually) from Pre-MY 1998 air bags are shown as 0 in Table VI-27. For example, the 0 benefits for the 30 mph rigid barrier tests with 50th percentile males indicates that this type test would not accrue additional benefits. All vehicles tested with 50th percentile male dummies met the new neck injury criteria and the other new ICPLs.

**Fatality Impact of Rigid Barrier 25 mph Unbelted Tests**

This section estimates the safety impacts of air bags that are designed to meet the 25 mph rigid barrier unbelted perpendicular and ±30 degree oblique tests. Two different approaches were examined. These approaches reflect the fact that current vehicle fleets have not yet been redesigned based on a 25 mph test requirement. Instead, most vehicles are designed based on the 30 mph frontal barrier test required on all pre-MY1998 vehicles. If manufacturers were to redesign for 25 mph tests during their normal design cycle, the resulting vehicles could perform at a level that maximizes their performance in the 25 mph tests, rather than in the 30 mph frontal barrier test.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-27
Fatalities Reduced by Test Types for
Improved Occupant Protection From High Speed Crash Tests

| | | Head | Neck | Chest | Total |
|---|---|---|---|---|---|
| **20 to 30 mph, Rigid Barrier, 0 and ± 30 Degree Unbelted 50th Percentile Male** | **Drivers** | 0 (0) | 0 | 0 | 0* (0*) |
| | **Passengers** | 0 (0) | 0 | 0 | 0* (0*) |
| | **Total** | 0 (0) | 0 | 0 | 0* (0*) |
| **Up to 30 mph, Rigid Barrier, 0 Degree Belted 50th Percentile Male** | **Drivers** | 0 (0) | 0 | 0 | 0* (0*) |
| | **Passengers** | 0 (0) | 0 | 0 | 0* (0*) |
| | **Total** | 0 (0) | 0 | 0 | 0* (0*) |
| **20 to 30 mph, Rigid, 0 Degree Unbelted 5th Percentile Female**** | **Drivers** | 0 (0) | 9 | 0 | 9 (9) |
| | **Passengers** | 0 (0) | 4 | 6 | 10 (10) |
| | **Total** | 0 (0) | 13 | 6 | 19 (19) |
| **Up to 30 mph, Rigid Barrier, 0 Degree Belted 5th Percentile Female** | **Drivers** | 0 (0) | 4 | 0 | 4 (4) |
| | **Passengers** | 0 (0) | 0 | 0 | 0 (0) |
| | **Total** | 0 (0) | 4 | 0 | 4 (4) |
| **25 mph, Offset belted 5th Percentile Female** | **Drivers** | 0 (0) | 18 | 0 | 18 (18) |
| | **Passengers** | 1 (9) | 1 | 0 | 2 (10) |
| | **Total** | 1 (9) | 19 | 0 | 20 (28) |

* No additional benefits beyond those already achieved from Pre-MY 1998 air bags.
** Results were based on unrestrained tests and those failed the restrained tests.
Note: Parenthetical values based on lognormal HIC curve, Non parenthetical values based on Prasad/Mertz HIC curve.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

The first approach examined existing data broken out by delta-v. Target populations (unrestrained front-outboard occupant potential fatalities) and lives saved were computed for 4 different delta-v categories. These data produced estimates of different effectiveness rates for each speed category. Due to the sample size concerns of air bag cases and the vast unknown delta-v, MAIS 3+ injuries (age 13 and older) from 1993-1998 CDS were used as a surrogate for adult fatalities to estimate the effectiveness of air bags by delta-v levels. This analysis reveals higher effectiveness rates for the speed groupings nearest the speed levels where testing was required in most of the on-road fleet. Current tests are conducted at 30 mph, and effectiveness is lowest for speeds under 20 and over 31 mph, and highest in the range of 21-30. If manufacturers were to design their vehicles to a 25 mph rigid barrier test, it would be the equivalent of designing them to a requirement that is at least 5 mph slower than the 30 mph frontal barrier tests that were required in pre-MY 1998 vehicles. To estimate the results of such a redesign, each speed category was reduced by 5 mph, while effectiveness rates were held constant. New target populations were then derived for each new speed category, and the resulting benefits were calculated by applying the realigned effectiveness rates to their corresponding target populations. Since the new designed air bags were assumed to affect only the unrestrained occupants in frontal crashes, the target population included only the unrestrained front-outboard adult (age 13 and older) occupant potential fatalities. Table VI-28 shows this process and its results. The calculation indicates that 252 fewer fatalities would be prevented if vehicles were designed to a 25 mph standard. Note that effectiveness rates in Table VI-28 were adjusted twice from original rates derived from 1993-1998 CDS. The overall original rate based on CDS was higher than that based on FARS. Therefore, the first adjustment was to inflate the effectiveness rate to the FARS

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

level. The second adjustment was to inflate the air bag effectiveness specifically to unrestrained occupants. The 1998 CDS was included in the analysis to increase the sample of air bag cases.

Table VI-28
Impact of the 25 mph Rigid Barrier Test on Fatalities
Approach 1

| **If All Vehicles Had Pre-MY 1998 Air Bags (Passing the 30 mph, Rigid Barrier Test with 50th Percentile Males)** | | | | **If All Vehicles Had New Designed Air Bags (Passing the Existing Sled Test with 50th Percentile Males)** | | | | |
|---|---|---|---|---|---|---|---|---|
| Delta V | Effective-ness | Target* Population | Lives Saved | Delta V | Effective-ness | Target* Population | Lives Saved | Benefits/ Disbenefits |
| 0-20 | 0.203 | 1,966 | 399 | 0-15 | 0.203 | 1,148 | 233 | |
| 21-25 | 0.290 | 2,126 | 617 | 16-20 | 0.290 | 818 | 237 | |
| 26-30 | 0.222 | 2,228 | 495 | 21-25 | 0.222 | 2,126 | 472 | |
| 31+ | 0.142 | 6,361 | 903 | 26+ | 0.142 | 8,589 | 1,220 | |
| Total | | 12,681 | **2,414** | Total | | 12,681 | **2,162** | **-252** |

Data Source: 1993-1998 CDS, 1997 FARS
* Unrestrained front-outboard adult occupant potential fatalities based on 1997 FARS.

The second approach compared the results of 25 mph unrestrained and 30 mph unrestrained tests for matching make/model vehicles. The ratio of these test results was then used as a proxy measure for the differences that might be attained if the standard were an unrestrained 25 mph test. This is a mathematical approach that assumes that if air bags were designed to a 25 mph standard instead of a 30 mph standard, it would attain the same compliance margin at 25 mph that it actually achieved at 30 mph (400 HIC) and the 30 mph test result would be the ratio between 30 mph and 25 mph. See Table VI-29 for an example of the assumptions used in this analysis.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-29
Example of Methodology Under Approach 2

| Test | Actual HIC Values for Vehicle Designed to 30 mph Test | Assumed HIC Values for Vehicle Designed to 25 mph Test |
|---|---|---|
| 25 mph unrestrained test | 200 | 400 |
| 30 mph unrestrained test | 400 | 800 |

For vehicles designed to a 25 mph rigid barrier test, the adjustment ratios were derived based on two 1999 vehicles, the Dodge Intrepid and the Toyota Tacoma in unbelted 30 mph rigid barrier tests with 50th percentile male dummies. The averaged ratio was then applied to the 30 mph rigid barrier tests on pre-MY 1998 vehicles to derive new risk probabilities. The loss in benefits were derived by comparing the new risks from higher HIC and chest g's values to the baseline measures of HIC and chest g's. Only HIC and chest g's values were used since no Nij values were recorded for pre-MY 1998 vehicles.

Under this approach, the loss in benefits could be as much as 394 lives assuming reduced benefits above 25 mph for unrestrained occupants. If benefits were assumed up to 30 mph, the loss in benefits be as much as 229 lives.

**2. MAIS 2-5 Injuries**

The MAIS 2-5 injury reduction percentages are shown in Table VI-5-B. Benefits are derived by applying the reduction percentages to the appropriate injury target population as shown in Table VI-30.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-30
Target Populations for Improved Occupant Protection From High Speed Crash Tests
Front-Outboard Adult Occupant MAIS 2-5 Injuries in Frontal Crashes

| | **Injuries Represented by 50th Percentile Male** | | | **Injuries Represented by 5th Percentile Female** | | | **Injuries Potentially Impacted by Improving Sensor Algorithm** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Head** | **Neck** | **Chest** | **Head** | **Neck** | **Chest** | **Head** | **Neck** | **Chest** |
| Drivers | 44,503 | 1,648 | 31,317 | 8,893 | 387 | 8,119 | 7,947 | 306 | 5,807 |
| Belted | 25,409 | 941 | 17,881 | 5,077 | 221 | 4,636 | 4,537 | 175 | 3,316 |
| Unbelted | 19,094 | 707 | 13,436 | 3,816 | 166 | 3,483 | 3,410 | 131 | 2,491 |
| Passengers | 10,280 | 367 | 4,406 | 6,690 | 1,808 | 3,436 | 2,552 | 329 | 1,152 |
| Belted | 5,954 | 213 | 2,552 | 3,875 | 1,047 | 1,990 | 1,478 | 191 | 667 |
| Unbelted | 4,326 | 154 | 1,854 | 2,815 | 761 | 1,446 | 1,074 | 138 | 485 |
| Total | 54,783 | 2,015 | 35,723 | 15,583 | 2,195 | 11,555 | 10,499 | 635 | 6,959 |
| Belted | 31,363 | 1,154 | 20,433 | 8,952 | 1,268 | 6,626 | 6,015 | 366 | 3,983 |
| Unbelted | 23,420 | 861 | 15,290 | 6,631 | 927 | 4,929 | 4,484 | 269 | 2,976 |

Source: 1993-1997 CDS; 1997 GES.
Note: MAIS 2-5 injuries were derived from 1993-1997 CDS and adjusted to 1997 GES CDS equivalent level.

Table VI-31 shows the injury reduction benefits. An air bag passing the 30 mph rigid barrier test with unbelted 50th percentile males and meeting the ICPLs would reduce 6 to 16 MAIS 2-5 injuries. An air bag that passes the 30 mph, rigid barrier unbelted 5th percentile test would reduce 141 MAIS 2-5 injuries, while one passing the 30 mph rigid barrier, belted 5th percentile female test would reduce 43 MAIS 2-5 injuries. The 25 mph offset, belted 5th percentile female test would reduce 134-262 MAIS 2-5 injuries.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-31
MAIS 2-5 Injuries Reduced by Test Types for
Improved Occupant Protection From High Speed Crash Tests

| | | Head | Neck | Chest | Total |
|---|---|---|---|---|---|
| **20 to 30 mph, Rigid Barrier, 0 and ± 30 Degree Unbelted 50th Percentile Male** | **Drivers** | 0 (0) | 0 | 0 | 0* (0*) |
| | **Passengers** | 16 (6) | 0 | 0 | 16 (6) |
| | **Total** | 16 (6) | 0 | 0 | 16 (6) |
| **Up to 30 mph, Rigid Barrier, 0 Degree Belted 50th Percentile Male** | **Drivers** | 0 (0) | 0 | 0 | 0* (0*) |
| | **Passengers** | 0 (0) | 0 | 0 | 0* (0*) |
| | **Total** | 0 (0) | 0 | 0 | 0* (0*) |
| **20 to 30 mph, Unbelted 5th Percentile Female**** | **Drivers** | 0 (0) | 15 | 55 | 70 (70) |
| | **Passengers** | 0 (0) | 41 | 30 | 71 (71) |
| | **Total** | 0 (0) | 56 | 85 | 141 (141) |
| **Up to 30 mph, Belted 5th Percentile Female** | **Drivers** | 0 (0) | 16 | 12 | 28 (28) |
| | **Passengers** | 0 (0) | 8 | 6 | 14 (24) |
| | **Total** | 0 (0) | 24 | 18 | 42 (42) |
| **Up to 25 mph, Offset, Belted 5th Percentile Female** | **Drivers** | 0 (0) | 36 | 0 | 36 (36) |
| | **Passengers** | 215 (87) | 11 | 0 | 226 (98) |
| | **Total** | 215 (87) | 47 | 0 | 262 (134) |

* No additional benefits beyond those already achieved from Pre-MY 1998 air bags.
** Results were based on unrestrained tests and those failed the restrained tests.
Note: Parenthetical values based on lognormal HIC curve, non parenthetical values based on Prasad/Mertz HIC curve.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

**Injury Impact of Rigid Barrier 25 mph Unbelted Tests**

This section estimates the impacts of 25 mph unbelted tests on MAIS 2-5 injuries. Two approaches that are similar to those described in the parallel section under fatalities were used to estimate the benefits. The first approach derived the effectiveness rates by delta v levels from adult (age 13 and older) MAIS 2-5 injuries in 1993-1998 CDS. Head, neck, and chest injuries were examined separately from upper extremity injuries. Table VI-32 shows that 1,345 MAIS head, neck, and chest injuries would be reduced if a fleet of vehicles equipped with air bags designed to the 25 mph unbelted standard. Note that this approach compares relative risk of occupants in air bag equipped vehicles to those in vehicles without air bags using non-frontal crashes as the control group. The head, neck, and chest injuries in high speed (30 mph and above) non-frontal crashes were very small (a total of 21 cases with air bags over 6 years). The small sample size resulted a large estimation error, and thus may affect the reliability of the effectiveness for delta v category 30 mph and above.

Table VI-32
Impact of the 25 mph Unbelted Test on MAIS 2-5 Head, Neck, and Chest Injuries
Approach 1

| **If All Vehicles Had Pre-MY 1998 Air Bags (Passing the 30 mph, Rigid Barrier Test with Unbelted 50th Percentile Males)** | | | | **If All Vehicles Had New Designed Air Bags (Passing the 25 mph, Rigid Barrier Test with Unbelted 50th Percentile Males)** | | | | |
|---|---|---|---|---|---|---|---|---|
| Delta V | Effective-ness | Target* Population | Injuries Reduced | Delta V | Effective-ness | Target* Population | Injuries Reduced | Benefits/ Disbenefits |
| 0-20 | 0.016 | 34,520 | 552 | 0-15 | 0.016 | 22,142 | 354 | |
| 21-25 | 0.184 | 14,492 | 2,667 | 16-20 | 0.184 | 12,378 | 2,278 | |
| 26-30 | 0.116 | 7,588 | 880 | 21-25 | 0.116 | 14,492 | 1,681 | |
| 31+ | 0.149 | 5,598 | 834 | 26+ | 0.149 | 13,186 | 1,965 | |
| Total | | 62,198 | **4,933** | Total | | 62,198 | **6,278** | **1,345** |

Data Source: 1993-1998 CDS, 1997 FARS
* Unrestrained front-outboard adult MAIS 2-5 head, neck, and chest injuries based on 1993-1998 CDS.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Most of the upper extremity injuries were MAIS 2 or 3. These injuries occurred in the lower delta v impacts. Therefore, it is even more problematic using this approach to derive air bag effectiveness rates against upper extremity injuries by delta v levels. Instead, the analysis estimates upper extremity injury benefits/disbenefits by MAIS levels. Based on 1993-1998 CDS data, air bags caused 2,570 more AIS 2 upper extremity injuries, but reduced 625 AIS 3 upper extremity injuries. An air bag would deploy with less power if it were designed to the 25 mph unbelted tests, and thus would have the potential to reduce some of the 1,945 upper extremity MAIS 2 injuries. Due to lack of test data, the analysis can not quantify the benefits.

The second approach uses FMVSS 208 test data. Based on the FMVSS 208 tests, MY 1998 air bags have slightly higher HIC and chest g's. Thus, air bags only designed to the 25 mph unbelted tests would lose benefits in the high speed crashes. The analysis estimates that about 504 to 1,215 MAIS 2-5 adult injuries in 26+ mph impacts that were prevented by pre-MY 1998 air bags would not be reduced by the new redesigned air bags. The majority of these were MAIS 3+ injuries. On the other hand, the new redesigned air bags which deployed with a lesser power could reduce MAIS 2-5 injuries in the lower speed crashes as estimated in approach 1.

Judging from both crash tests and real-world crash data, the agency theorizes that single-stage air bags designed to maximize the 25 mph tests would lose benefits in higher speed crashes but gain benefits in lower speed crashes. Figure VI-1 uses the risk probabilities to illustrate the theorized concept. Because the vast majority of MAIS 2-5 injuries (especially MAIS 2 injuries) occur in the lower speed crashes, the benefits accrued from the low speed crashes might outnumber the

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

disbenefits from high speed crashes (see approach 1). However, if the new designed air bags have a much smaller effectiveness against MAIS 2 injuries than against MAIS 3-5 injuries, the potential benefits from low speed crashes might be much smaller. Due to lack of low speed crash test data and statistically significant effectiveness rates of air bags against various injury levels, this approach can not reasonably estimate the total MAIS 2-5 injury benefits/disbenefits of new redesigned air bags.

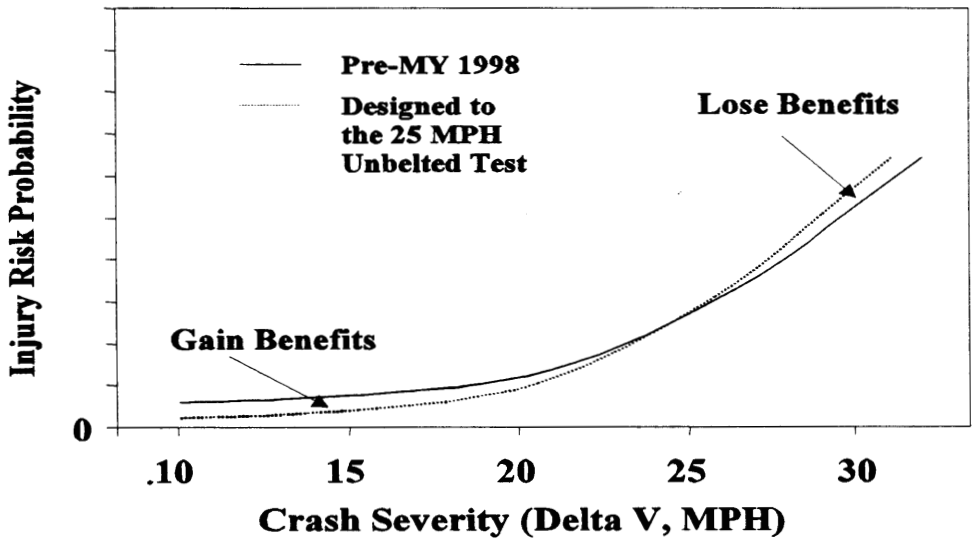



Figure VI-1. Theorized Concept of Risk Probability
Pre-MY 1998 vs Air Bags Designed to 25 MPH Unbelted Tests

The idea shows dual-stage air bags are to gain the benefits of a lower powered air bags at lower crash severity and at the same time not lose the benefits at higher crash severity.

### 3. Summary of Benefits From High Speed Crashes

Table VI-33 summarizes the improved fatality and MAIS 2-5 injury benefits/disbenefits from high speed crash tests. Benefits are additive because this analysis assumes (1) 25-mph offset crashes

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

would improve sensor technology and thus impact those out-of-position occupants. (2) The high speed rigid barrier tests would benefit those properly positioned occupants. And (3) the MAIS 2-5 injury benefits for 25-mph rigid barrier tests were from lower crash severity (in this methodology, there was a loss of benefits at higher speeds and a gain in benefits at lower speeds), while the benefits from the 30-mph rigid barrier tests were from higher crash severity (taking dummy measurements in crash tests down to the ICPLs). These two benefits are mutually exclusive, thus they are additive.

Based on the additive principle, about 201 to 374 lives would not be saved by a fleet of vehicles with air bags passing Alternative #1. However, these air bags would reduce 1,479 to 1,607 MAIS 2-5 injuries. Air bags passing Alternative #2 would save 43 to 51 lives, additional to the 3,253 lives saved by pre-My 1998 models. These air bags would reduce 324 to 1,807 MAIS 2-5 injuries. The high end of benefits comes from the multi-stage inflators.

Most of the difference between Alternative 1 and Alternative is due to the high-speed unbelted test. The 30 mph unbelted test will provide more protection against fatalities in high speed crashes. Based on Table VI-33, a single-stage air bag designed to meet a 30 mph test would save from 248 to 413 more lives than one designed to a 25 mph standard. However, the 25 mph test could result in single-stage air bag designs that would reduce about 1,200 more nonfatal injuries than the 30 mph test. See also Figure VI-2 which illustrates the process to derive the fatality benefits.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-33
Summary of Fatality and MAIS 2-5 Injury Benefits
from High Speed Crash Tests*

| High Speed Tests | Fatalities | | | MAIS 2-5 Injuries | | |
|---|---|---|---|---|---|---|
| | Drivers | Passengers | Total | Drivers | Passengers | Total |
| **20 to 30 mph Rigid Barrier, 0 and ±30 Degree Unbelted 50th Percentile Male** | 0 | 0 | 0** | 0 | 6-16 | 6-16 |
| **Up to 30 mph Rigid Barrier, 0 Degree Belted 50th Percentile Male** | 0 | 0 | 0** | 0 | 0 | 0** |
| **20 to 30 mph Rigid Barrier, 0 Degree Unbelted 5th Percentile Female** | 9 | 10 | 19 | 70 | 71 | 141 |
| **Up to 30 mph Rigid Barrier, 0 Degree Belted 5th Percentile Female** | 4 | 0 | 4 | 29 | 14 | 43 |
| **25 mph Offset, Belted 5th Percentile Female** | 18 | 2-10 | 20-28 | 36 | 98-226 | 134-262 |
| **25 mph Unbelted 50th Male and 5th Female** | -309 to -176 | -85 to -53 | -394 to -229 | 1,036 | 309 | 1,345 |

* All of these test types are additive.
** No additional benefits beyond those already achieved from Pre-MY 1998 air bags.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

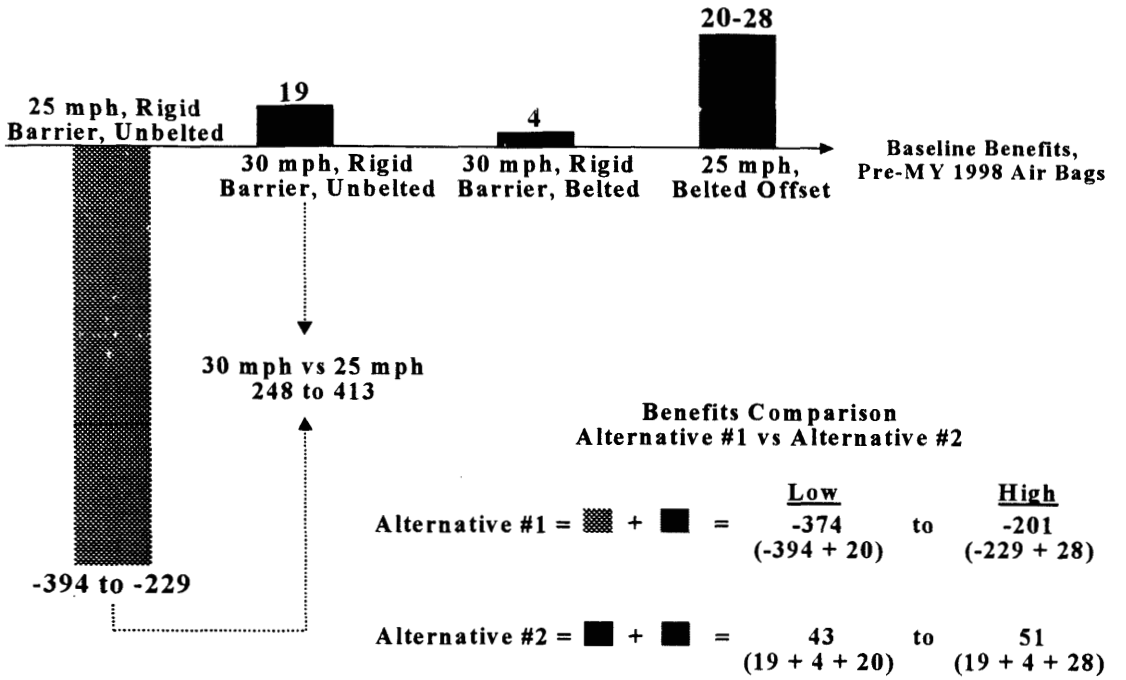



**Figure VI-2 Benefits From High Speed Crashes**

## D. Benefits Summary

This section provides several tables to summarize the fatality/injury benefits/disbenefits discussed above. These benefits included both at-risk groups and improved protection. Tables VI-34 and VI-35 provide estimated fatality and injury benefits for the alternative tests. Benefits for those tests that impacted the at-risk groups were not mutually exclusive, and thus, not all benefits of these test types are additive.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-34
Estimated Incremental Lives Saved Annually by Test Type
Compared to Pre-MY 1998 Air Bag Systems*

| Tests | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **Suppression When Presence** | 0(1) | 18 | 75 | 0(1) | 93 |
| **Suppression When Out-of-Position** | 46 | 0(1) | 105 | 18 | 169 |
| **Low Risk Deployment** | 24 | 17-18 | 95-96 | 16 | 152-154 |
| **20 to 30 mph, 0 and ± 30 Degree Unbelted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 0(2) | 0(2) |
| **Up to 30 mph, 0 and ± 30 Degree Belted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 0(2) | 0(2) |
| **20 to 30 mph, 0 Degree Unbelted 5th Percentile Female** | 9 | 0(1) | 0(1) | 10 | 19 |
| **Up to 30 mph, 0 Degree Belted 5th Percentile Female** | 4 | 0(1) | 0(1) | 0(2) | 4 |
| **Up to 25 mph Offset, Belted 5th Percentile Female** | 36 | 0(1) | 0(1) | 4-12 | 40-48 |
| **25 mph Rigid Barrier** | -278 to -145 | 0(1) | 0(1) | -72 to -40 | -350 to -185 |

* Not all of these test types are additive, see Tables VI-37 and VI-39.
1 Not proposed test for this group.
2 No additional benefits beyond those already achieved from Pre-MY 1998 air bags.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-35
Estimated Incremental MAIS 2-5 Injuries Reduced Annually by Test Type
Compared to Pre-MY 1998 Air Bag Systems*

| Tests | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **Suppression When Presence** | 0(1) | 9 | 142 | 0(1) | 151 |
| **Suppression When Out-of-Position** | 38 | 0(1) | 200 | 15 | 253 |
| **Low Risk Deployment** | 20 | 5 | 154 | 11 | 191 |
| **20 to 30 mph, 0 and ± 30 Degree Unbelted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 6-16 | 6-16 |
| **Up to 30 mph, 0 and ± 30 Degree Belted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 0(2) | 0(2) |
| **20 to 30 mph, 0 Degree Unbelted 5th Percentile Female** | 70 | 0(1) | 0(1) | 71 | 141 |
| **Up to 30 mph, 0 Degree Belted 5th Percentile Female** | 29 | 0(1) | 0(1) | 14 | 43 |
| **Up to 25 mph Offset, Belted 5th Percentile Female** | 54 | 0(1) | 0(1) | 101-229 | 155-283 |
| **25 mph Rigid Barrier** | 1,062 | 0(1) | 0(1) | 320 | 1,382 |

* Not all of these test types are additive, see Tables VI-38 and VI-40.
1 Not proposed test for this group.
2 No additional benefits beyond those already achieved from Pre-MY 1998 air bags.

The following tables show estimated benefits for the air bag systems: a generic system without multi-stage inflation, the multi-stage inflation system, and the multi-stage inflation system with a 54 pound weight suppression option. The generic system was assumed to suppress the passenger side air bag by passenger's weight (<=54 pounds). Tables VI-36 and VI-37 show the benefits for air bag systems passing a combination of suppression, low risk deployment, and Alternative #1 of the high speed crash tests. Tables VI-38 and VI-39 list the benefits for air bag systems passing Alternative #2 of the high speed crashes. Note that the generic system might not pass the low risk

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

deployment for children and adults. Also note that the first stage of the multi-stage inflation system is assumed to pass the low risk deployment for infants, children, and adults. Air bags passing the low risk deployment tests for children and adults would be more benign than those passing the 25-mph rigid barrier tests. Therefore, all the injury benefits accrued from 25-mph rigid barrier tests were included in the multi-stage inflation system.

As shown in Tables VI-36 and VI-37, for air bags passing a combination of suppression, low-risk deployment, and Alternative #1 of the high speed crash tests, 22 to 237 lives that would be saved by pre-MY 1998 air bags would not be saved. However, these air bags would reduce 1,667 to 1,859 MAIS 2-5 injuries. Air bags, as shown in Table VI-38 and VI-39, would save 156-230 lives and reduce 496 to 2,059 MAIS 2-5 injuries if the air bags passed a combination of suppression, low-risk deployment, and Alternative #2 of the high speed crash tests. The multi-stage inflation system with a 54-pound weight sensor would reap the highest benefits in both cases.

Table VI-36
Estimated Incremental Lives Saved Annually
by Air Bag Systems Passing Alternative #1 of the High Speed Crash Tests

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | -260 to -127 | 18 | 75 | -70 to -30 | -237 to -64 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | -251 to -118 | 18 | 102 | -66 to -26 | -197 to -24 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | -251 to -118 | 18 | 104 | -66 to -26 | -151 to -22 |

* Air bag might not pass the low risk deployment for children and adults.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-37
Estimated Incremental MAIS 2-5 Injuries Reduced Annually
by Air Bag Systems Passing Alternative #1 of the High Speed Crash Tests

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | 1,098 | 9 | 142 | 418-546 | 1,667-1,795 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | 1,105 | 8 | 187 | 420-548 | 1,720-1,848 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | 1,105 | 9 | 197 | 420-548 | 1,731-1,859 |

* Air bag might not pass the low risk deployment for children and adults.

Table VI-38
Estimated Incremental Lives Saved Annually
by Air Bag Systems Passing Alternative #2 of the High Speed Crash Tests

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | 49 | 18 | 75 | 14-22 | 156-164 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | 71 | 18 | 102 | 29-37 | 220-228 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | 71 | 18 | 104 | 29-37 | 222-230 |

* Air bag might not pass the low risk deployment for children and adults.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-39
Estimated Incremental MAIS 2-5 Injuries Reduced Annually
by Air Bag Systems Passing Alternative #2 of the High Speed Crash Tests

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | 153 | 9 | 142 | 192-330 | 496-634 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | 1,204 | 8 | 187 | 511-649 | 1,910-2,048 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | 1,204 | 9 | 197 | 511-649 | 1,921-2,059 |

* Air bag might not pass the low risk deployment for children and adults.

## E . Sensitivity Study #1, Safety Belt Use

This section estimates the change in benefits that could result from increased safety belt use. Based on state surveys, in 1997, the average national belt usage rate was 66.9 (base year usage rate) percent. The analysis examines air bag benefits at a increased observed belt usage rate of 85.0 percent (85 percent is the DOT goal for 2000), which corresponds to an 18 percentage point increase over the base rate[6].

To estimate the benefits of advanced air bags at the 85.0 percent belt use rate, the analysis needed to adjust the baseline target population to reflect the impact of increased belt use. Then, the procedure was applied as stated in previous sections, to derive the new benefit of advanced air

[6] The method assumes observed belt use increases to 85 percent, changing the target population for air bags. Under these assumptions, air bags would save 1,072 belted and 1,639 unbelted lives for a total of 2,711 lives with a full fleet of air bags, compared to the 3,253 lives (see Table II-3) at 66.9 percent belt use.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

bags. NHTSA's belt usage software (BELTUSE) program[7] (Blincoe, 1994) was used to derive the incremental benefits. The target population for at-risk and improved occupant protection were input to the program to calculate the incremental safety benefits. The BELTUSE program estimated that 8 fatalities and 9 MAIS 3-5 injuries for at-risk groups and 1,504 adult fatalities and 16,467 adult MAIS 2-5 injuries for improved protection would be saved or prevented by increasing belt use from the base 66.9 percent to 85.0 percent. The difference between the baseline population and the incremental safety belt impacts is the adjusted baseline population.

The benefits of advanced air bags at 85 percent belt use were derived by applying those reduction rates/percentages (Table VI-4-A to VI-5-B) to the adjusted population. Tables VI-40 to VI-45 summarizes the estimated benefits for alternative tests and air bag systems at the 85.0 percent belt use rate.

As shown in Tables VI-42 and VI-43, for air bags passing a combination of suppression, low-risk deployment, and Alternative #1 of the high speed crash tests, -120 to 43 lives would be saved. The same air bags would reduce 1,229 to 1,413 MAIS 2-5 injuries. Air bags, as shown in Table VI-44 and VI-45, would save 148-224 lives and reduce 446 to 1,574 MAIS 2-5 injuries if it passed a combination of suppression, low-risk deployment, and Alternative #2 of the high speed crash tests.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

[7] PC-DOS based software. The program also can be ran under the Microsoft Window environment.

Table VI-40
Estimated Incremental Lives Saved Annually by Test Type
Compared to Pre-MY 1998 Air Bag Systems*
at 85.0 Percent Belt Use Rate

| Tests | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **Suppression When Presence** | 0(1) | 18 | 75 | 0(1) | 93 |
| **Suppression When Out-of-Position** | 42 | 0(1) | 103 | 16 | 161 |
| **Low Risk Deployment** | 22 | 17-18 | 93-94 | 14-15 | 146-149 |
| **20 to 30 mph, 0 and ± 30 Degree Unbelted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 0(2) | 0(2) |
| **Up to 30 mph, 0 and ± 30 Degree Belted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 0(2) | 0(2) |
| **20 to 30 mph, 0 Degree Unbelted 5th Percentile Female** | 6 | 0(1) | 0(1) | 8 | 14 |
| **Up to 30 mph, 0 Degree Belted 5th Percentile Female** | 5 | 0(1) | 0(1) | 0(2) | 5 |
| **Up to 25 mph Offset, Belted 5th Percentile Female** | 32 | 0(1) | 0(1) | 4-12 | 36-44 |
| **25 mph Rigid Barrier** | -188 to -95 | 0(1) | 0(1) | -43 to -22 | -231 to -117 |

* Not all of these test types are additive, see Tables VI-42 and VI-44.
1 Not proposed test for this group.
2 No additional benefits beyond those already achieved from Pre-MY 1998 air bags.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-41
Estimated Incremental MAIS 2-5 Injuries Reduced Annually by Test Type
Compared to Pre-MY 1998 Air Bag Systems*
at 85.0 Percent Belt Use Rate

| Tests | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **Suppression When Presence** | 0(1) | 9 | 142 | 0(1) | 151 |
| **Suppression When Out-of-Position** | 34 | 0(1) | 196 | 14 | 244 |
| **Low Risk Deployment** | 18 | 5 | 151 | 11 | 185 |
| **20 to 30 mph, 0 and ± 30 Degree Unbelted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 4-11 | 4-11 |
| **Up to 30 mph, 0 and ± 30 Degree Belted 50th Percentile Male** | 0(2) | 0(1) | 0(1) | 0(2) | 0(2) |
| **20 to 30 mph, 0 Degree Unbelted 5th Percentile Female** | 49 | 0(1) | 0(1) | 50 | 99 |
| **Up to 30 mph, 0 Degree Belted 5th Percentile Female** | 32 | 0(1) | 0(1) | 15 | 47 |
| **Up to 25 mph Offset, Belted 5th Percentile Female** | 50 | 0(1) | 0(1) | 95-215 | 145-265 |
| **25 mph Rigid Barrier** | 731 | 0(1) | 0(1) | 221 | 952 |

* Not all of these test types are additive, see Tables VI-43 and VI-45.
1 Not proposed test for this group.
2 No additional benefits beyond those already achieved from Pre-MY 1998 air bags.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-42
Estimated Incremental Lives Saved Annually
by Air Bag Systems Passing Alternative #1 of the High Speed Crash Tests
at 85.0 Percent Belt Use Rate

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | -172 to -79 | 18 | 75 | -41 to -12 | -120 to 2 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | -163 to -70 | 18 | 102 | -38 to -9 | -81 to 41 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | -163 to -70 | 18 | 104 | -38 to -9 | -79 to 43 |

* Air bag might not pass the low risk deployment for children and adults.

Table VI-43
Estimated Incremental MAIS 2-5 Injuries Reduced Annually
by Air Bag Systems Passing Alternative #1 of the High Speed Crash Tests
at 85.0 Percent Belt Use Rate

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | 765 | 9 | 142 | 313-433 | 1,229-1,349 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | 772 | 8 | 187 | 315-435 | 1,282-1,402 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | 772 | 9 | 197 | 315-435 | 1,293-1,413 |

* Air bag might not pass the low risk deployment for children and adults.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

Table VI-44
Estimated Incremental Lives Saved Annually
by Air Bag Systems Passing Alternative #2 of the High Speed Crash Tests
at 85.0 Percent Belt Use Rate

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | 43 | 18 | 75 | 12-20 | 148-156 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | 67 | 18 | 102 | 27-35 | 214-222 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | 67 | 18 | 104 | 27-35 | 216-224 |

* Air bag might not pass the low risk deployment for children and adults.

Table VI-45
Estimated Incremental MAIS 2-5 Injuries Reduced Annually
by Air Bag Systems Passing Alternative #2 of the High Speed Crash Tests
at 85.0 Percent Belt Use Rate

| Air Bag Systems | Drivers | Passengers | | | Total |
|---|---|---|---|---|---|
| | | RFCSS | 1-12 Years Children | Adult | |
| **A Generic System without Multi-Stage Inflation with a 54-Pound Weight Sensor*** | 131 | 9 | 142 | 164-291 | 446-573 |
| **Multi-Stage Inflation System Based on Crash Severity and Belt Use** | 856 | 8 | 187 | 385-512 | 1,436-1,563 |
| **Multi-Stage Inflation System Based on Crash Severity With a 54-Pound Weight Sensor** | 856 | 9 | 197 | 385-512 | 1,447-1,574 |

* Air bag might not pass the low risk deployment for children and adults.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

**F. Sensitivity Analysis #2, Redesigned Air Bags**

As shown in Table II-5, based on the minimal amount of data available for MY 1998 redesigned air bags, the estimated 187 at-risk fatalities with pre-MY 1998 air bags could be estimated to be about 65 fatalities with redesigned air bags.

Table VI-6 showed that all 18 infants in RFCSS in the target population for pre-MY 1998 air bags could be saved with suppression, low risk or multi-stage inflator systems. Similarly, all 10 infants in RFCSS in the target population for redesigned air bags could be saved.

Suppression by 54-pound weight limit would save 75 children out of the total target population for pre-MY 1998 air bags of 105. As shown in Tables VI-7 to VI-10, the advanced air bags passing the low risk tests or with the multi-stage inflation would save somewhere between 94 and 104 children 1-12 years old lives. The suppression by weight air bag systems would save 25 children if measured by the redesigned target population of 35 fatalities. While the advanced air bags passing the low risk tests or with the multi-stage inflation would save 31 to 35 children.

For drivers, low risk deployment could save 24 fatalities in the target population for pre-MY 1998 air bags. Table VI-12 shows that an estimated 40 of 46 out-of-position driver fatalities could be reduced by multi-stage inflators. Based on the target population of and test results from redesigned air bags, the low risk deployment could save 8 fatalities (52.23 percent of the target population); and the multi-stage inflators could save about 13 lives.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

For adult passengers, while low risk deployment could save 16 fatalities in the target population for pre-MY 1998 air bags. Multi-state inflators, as shown in Table VI-14, would save an estimated 17 out-of-position driver fatalities could be reduced by multi-stage inflators. All these technologies could save all 5 fatalities in the target population for redesigned air bags (Table II-5).

In summary, the majority of the remaining out-of-position fatalities with redesigned air bags would be saved by technologies developed to pass the alternative tests. Suppression by a 54-pound limit for passengers and low risk deployment for drivers and adult passengers would save 48 (10 infants, 25 children, 5 adult passengers, and 8 drivers) of the 65 fatalities. While the multi-stage inflators with a 54-pound weight suppression option would save 63 (10 infants, 35 children, 5 adult passengers, and 13 drivers) of the 65 fatalities.

**G. Discussion**

A system that reduces the air bag deployment frequency in the lower speed crashes by raising the deployment threshold might minimize the lower speed air bag induced fatalities. However, industry has argued that, because it takes longer to sense a higher speed crash this could increase the number of occupants being improperly positioned especially in higher severity crashes and result in less effective air bags. To compensate for this effect, more efficient sensors and sensor algorithms would be needed. Presumably, manufacturers would not raise deployment thresholds without improving sensors to offset any significant loss in time due to a higher threshold. The agency does not recommend specific solutions, but provides a variety of tests to allow manufacturers to find the best countermeasure.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

As for the suppression systems, one potential concern in disabling the right front passenger air bag when no one or a low weight person is in the right front seat is in not having an air bag for an unbelted driver who could slide to the right and strike the right instrument panel or right side A-pillar. There are a small number of cases without air bags in the NASS files where a crash at 2 or 3 o'clock resulted in an unbelted driver being thrown across the vehicle to the right front side, where the driver sustained injuries. Potentially an air bag could provide benefits in this situation. The agency does not know of a case where an air bag has actually provided a benefit in this type of crash, but it is theoretically possible. Therefore, there could be some small loss in safety for unbelted drivers by suppressing the right front passenger air bag.

The benefit estimates are based on the assumptions that all vehicles in the on-road fleet are equipped with air bags and there are no changes in occupant demographics, driver/passenger behavior, belt use, child restraint use, or the percent of children sitting in the front seat. Behavior modification or changes through public education and safety awareness campaigns could have a positive impact on occupant safety and thus affect the potential benefits of advanced air bags. One such change is increasing safety belt usage. As shown in the sensitive study, at 85 percent belt use rate, the benefits of the advanced air bags would less, yet still a great number of fatalities and injuries can be saved or prevented.

In addition, if more children ride in the back seat, fewer children would be killed by air bags. The statistics cited in Table II-9 indicates this trend. The child fatalities that advanced air bags are intended to eliminate would thus be smaller in number. However, if labels and education result in

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

more children sitting in the rear seat, the agency is concerned that this rulemaking to decrease the threat of injury from air bags in the front seat could result in the belief by many members of the public that the front seat is now safe for children, and more children would then sit in the front seat. The fatality rate is 22 percent lower in the rear seat than the front seat for all occupants and 27 percent lower for children up through age 12. Since air bags are about 11 percent effective overall for occupants over 12 years old, the safety of all occupants (adults and children) is enhanced by sitting in the rear seat. Education efforts will continue to try to keep children in the rear seat.

Another change might be that short or older drivers would be willing to make seating adjustments so that they are as far away from the steering wheel as possible and still feel comfortable while driving. Ford is already providing adjustable pedals on some high volume cars to assist drivers in moving further away from the steering column. This could also reduce the number of air bag induced fatalities and the corresponding potential benefits of advanced air bag systems.

DRAFT - DELIBERATIVE DOCUMENT, DO NOT RELEASE

# VII. TECHNOLOGY COSTS, AND LEADTIME

There are a variety of technologies that could be used by the vehicle manufacturers to meet the final rule. In this chapter we discuss the cost of the different technologies that are in development that could be used to comply with the tests, determine current compliance with the tests, property damage savings from using different technologies, and estimate the compliance test costs. Leadtime is the last section of this chapter.

## A. Technology Costs

There were no comments to the SNPRM docket (6407) regarding costs for specific technologies. Comments relating to costs mainly state that there are too many compliance tests.

Several cost estimates come from NHTSA contractor tear-down studies of costs[1]. Some of the cost estimates come from comments to the docket from 1996 (Docket 74-14-N100). Numbers in parentheses ( ) behind a manufacturer's name indicate their comments to this docket and the comment number. Other cost estimates come from the Jet Propulsion Lab (JPL)[2] analysis and

---

[1] "Report/Comparison Multi-stage Air bag Inflator vs. Single Stage Air bag Inflator", Ludtke & Associates, Docket No. 98-4405 No.3.
"Cost, Weight, and Lead Time Analysis: Tear Down Analysis of Two Existing Air Bag Systems", Bruce C. Spinney, NHTSA, September 1998, Docket No. 98-4405 No. 4.
"Final Report Volume I of Cost, Weight, and Lead Time Analysis: Tear Down Analysis of Two Existing Air Bag Systems" Ludtke & Associates, Docket No. 98-4405 No. 5.
"Final Report Volume II of Cost, Weight, and Lead Time Analysis: Tear Down Analysis of Two Existing Air Bag Systems" Ludtke & Associates, Docket No. 98-4405 No. 6.

[2] "Advanced Air Bag Technology Assessment", Jet Propulsion Lab, April 1998.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

review of advanced air bag technologies (Docket No. NHTSA-1997-2814 ). Finally, a few cost estimates come from confidential responses from an Information Request sent to air bag suppliers.

The agency believes that the 50th percentile male dummy restrained 30 mph barrier test, unrestrained 25 mph barrier test, and unrestrained 30 mph barrier tests can probably be met by the manufacturers without any incremental costs compared to today's air bags. The design challenges for the manufacturers are in meeting these barrier tests while at the same time trying to reduce the potential problems for out-of-position occupants. Similarly, the agency believes that the 5th percentile female dummy restrained at 30 mph and unrestrained at 25 mph can probably be met by the manufacturers without any incremental costs compared to today's air bags. However, the agency believes that in order to meet the 30 mph unbelted barrier test using the 5th percentile female dummy, multi-stage inflators may be necessary. The assumptions in this cost analysis are that adding the out-of-position tests, offset frontal test, and the 5th percentile female dummy in the unbelted 30 mph test will require some manufacturers to make changes in their restraint systems or vehicle structure.

**1. Suppression of the Air Bag**

The principal costs for a suppression system are in the sensing systems and algorithm development. Sensing systems are designed to provide information to be used in the air bag computer logic (algorithms) to determine when to suppress the air bag, or which level of air bag deployment is the best for the combination of occupant size, occupant position, restraint use, and

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

crash type. The agency estimates the internal components to suppress the air bag (just the part of the internal air bag circuitry to be able to turn the air bag off) costs less than $1 per air bag.

The agency is requiring two telltale lights to show when the air bag is turned off, one for the driver side and one for the passenger side air bag. The agency contracted with Troy Design Services to estimate the cost of the passenger-side air bag on/off switch. The estimated cost for the warning light LED, wiring, bezel; and two wire clips were estimated to be $1.49. The addition of a second LED for the driver would add about $0.11 for a total cost of $1.60 (1997 dollars). For this analysis, the cost is delegated to $0.80 for each side (driver and passenger).

**2. Low Risk Deployment**

The cost of meeting the final rule using the low risk deployment depends on the technology option chosen. For the driver side, it is possible that it could be a no cost option, just a different design of the air bag. In general, the agency believes changes in fold patterns, tethering, or venting can probably be done at no incremental cost. Morton (075) stated that an air bag that utilizes different fold patterns and inflators may add very little incremental costs to the current air bag systems.

The agency does not believe it is likely that a no-cost low risk deployment air bag will be forthcoming in the near future for the passenger side, and assumes that at least a multi-stage inflator will be necessary for the passenger side.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

The need for and costs of potentially adding padding or other countermeasures to go along with the low risk deployment option is unknown. No commenter suggested this was necessary.

### 3. Crash Severity Sensors

Tear-down data from three 1992 models (Ford Crown Victoria, Toyota Camry, and Plymouth Acclaim)[3] from NHTSA contractors estimate the average cost of adding two additional sensors at $22.30 (1997 dollars) and 1.36 pounds. The range of costs among the three vehicles was fairly close at $20.80 to $23.90.

### 4. Occupant Weight and Pattern Recognition

Several estimates of costs for weight sensors are available:

A teardown study of the Mercedes-Benz seat switch pad by a NHTSA contractor resulted in the cost estimate of $19.45 (1997 dollars)[4] and 3.7 ounces per seat position. It is anticipated that the

---

[3] Ford/Crown Victoria - DOT HS 807 949, September 1992
"Cost Estimates of Manual & Automatic Crash Protection Systems in Selected 1988-1992 Model Year Passenger Cars" Volume I

Toyota Camry and Tercel - DOT HS 807 950, September 1992
"Cost Estimates of Manual & Automatic Crash Protection Systems in Selected 1988-1992 Model Year Passenger Cars" Volume II

Plymouth Acclaim - DOT HS 807 951, September 1992
"Cost Estimates of Manual & Automatic Crash Protection Systems in Selected 1988-1992 Model Year Passenger Cars" Volume III

[4] "Cost, Weight, and Leadtime Impacts of a Mercedes-Benz "Sensormat" Type Occupant Detection System", NHTSA, April 1997, DOT HS 808 587. This cost was for vehicles with a domestic control module. The Mercedes control module was more sophisticated to begin with and the cost increment for Mercedes was estimated to be $12.30.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

seat switch pad would be useful only for the passenger side. Mercedes-Benz of North America (034) estimated the cost of their seat switch pad to be $17.33 (1997 dollars).

A second tear down study by a NHTSA contractor[5] of a MY 2000 BMW Z3, found a consumer cost of $18.83 (1997 dollars).

General Motors (030) estimated that a weight based system for the passenger side is in the range of $10 to $20 variable cost (1996 dollars), which means on a consumer cost basis, the cost would be roughly $15.40 to $30.80 (e.g., $10 multiplied by 1.01987 to bring it from 1996 dollars to 1997 dollars[6] and by 1.51[7] to go from variable cost to consumer cost).

NEC Technologies (052) estimated the per vehicle cost for the weight sensor was in the range of $35.70, but that these costs would be reduced through mass production.

Saab (067) said that a weight based system would cost $30.60 (1997 dollars),

Morton (075) estimated a weight sensor would cost $20.40 (1997 dollars).

The range of cost estimates are from $15.40 to $35.70. For this analysis, the estimates from

---

[5] Cost, Weight and Lead Time Analysis, Advanced Air Bag Systems, Ludtke & Associates

[6] Based on the Gross Domestic Product Implicit Price Deflator.

[7] Estimate based on historical analysis of 10K reports from domestic vehicle manufacturers.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Mercedes and the NHTSA tear down of the Mercedes and BMW mat type system were used, $17 to $20. However, these systems did not include the pattern recognition technology now being developed. While this information can be collected with a similar mat-type system, there will be an additional cost to develop the algorithm for pattern recognition and introduce it into the system. The agency estimates the costs of a weight sensor with a pattern recognition system to be $19 to $23. The agency has no cost estimates for the system using strain gauges or load cells.

**5. Occupant Presence, Proximity and Motion Sensor Costs**

There are a wide variety of occupant presence, proximity and motion sensors. The final rule does not require dynamic motion sensors. Thus, some of these technologies are mentioned here and are not carried forward in the analysis. Occupant presence sensing, to help determine occupant size and placement is considered a technology that could be used to provide more information for air bag deployment decisions. The agency has cost estimates for some of them. General Motors (030) stated the variable cost of a proximity based system was in the range of $25.50 to $45.90 (1997 dollars) for the passenger side depending on the system requirements. On a consumer cost basis, the costs would be $38.50 to $69.30 for the passenger side.

Automotive Technologies International, Inc. (ATI) (020) has developed an occupant position sensor, the Ultrasonic, Nonimaging Pattern Recognition. ATI claimed that the occupant position sensor was expected to cost between $35.70 and $42.80 for the passenger side.

The JPL study estimated that a system using capacitive presence sensors will cost between $25

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

and $75. JPL also estimated that a system using acoustic and infrared sensor technology costs $35 to $60 dollars. These costs are supplier costs to the original manufacturers and do not include installation. Thus, a consumer cost is likely to be $37.80 to $113.30 for capacitive presence sensors and $52.90 to $90.60 for acoustic and infrared sensor technology. These estimates are for the passenger side seating position only. Adding similar systems to the driver side would cost an additional 50 to 100 percent of the passenger side cost, at this time it does not appear that manufacturers are considering driver side suppression technology.

There are a variety of systems under consideration. There will be intense price competition in this market and the lower priced systems that are reliable will be the ones used in vehicles. The agency estimates initial consumer costs for a presence sensor to be near the low end of costs discussed above, in the range of $40 to $60 for the passenger side. These costs should decrease over time.

**6. Safety Belt Use Sensors**

The driver side already has a restraint-use sensor to activate the warning light and buzzer if the driver is not using the safety belt. Based on a teardown study of cost for the driver side of a Toyota Tercel, the estimated cost for a passenger side sensor is $2.00. Manufacturers are developing more reliable systems for belt use sensors, to move from a mechanical to a non-mechanical system (known as the Hall effect). These systems are estimated to cost $5.00 and could be applied to both driver and passenger side.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**7. Seat Position Sensor**

The agency does not have a teardown cost estimate for a seat-position sensor. It is assumed to cost about $5.00 per seating position.

**8. Dual Stage or Multiple Level Inflators**

In the PEA for the SNPRM (See Docket No. 1999-6407-2), the agency had cost estimates for three inflators based on a contractor's tear-down study of a Chrysler Cirrus/Dodge Stratus single stage pyrotechnic inflator, a BMW single stage pyrotechnic inflator, and a TRW dual stage hybrid air bag inflator. The same contractor has finished two additional hybrid air bag inflators, one on a MY 2000 Taurus and one on a MY 2000 BMW Z3. Table VII-1 presents the updated cost estimates for all of these systems.

Table VII-1
Consumer Cost Estimates - Inflator Costs
(1997 Dollars)

| | **Driver** | **Passenger** | **Total** |
|---|---|---|---|
| Single Stage Chrysler Cirrus - pyrotechnic | $26.89 | $33.91 | $60.80 |
| Dual Stage Taurus - hybrid | $18.16 | 22.64 | $40.80 |
| Single Stage BMW 528i - pyrotechnic | $19.81 | $48.95 | $68.76 |
| Dual Stage BMW Z3 - hybrid | $20.93 | $43.37 | $64.30 |
| Dual Stage TRW - hybrid | $25.14 | $28.51 | $53.65 |

There is quite a difference in cost between the different systems. At first look, one would think a reasonable comparison would be between the Chrysler and the Taurus. However, the Chrysler system used an expensive aluminum canister which significantly raised its costs. The best

comparison is for the BMW systems, since you have the same manufacturer making decisions. However, several things are changing in these cost estimates, single stage versus dual-stage, pyrotechnic inflators versus hybrid inflators, and the fact that the Z3 is smaller and may take a smaller air bag on the passenger side. For the BMW systems, the driver side dual-stage hybrid inflator was $1.12 more expensive than the single stage pyrotechnic inflator, but on the passenger side, the dual-stage hybrid inflator was $5.58 less expensive. Based on two of the first few dual-stage inflators on the market, it appears that the industry is moving toward hybrid inflators.

Whether a manufacturer uses a pyrotechnic inflator or a hybrid air bag inflator is a choice made in the normal course of business. What is needed for this analysis is an estimate of the incremental cost of a dual stage pyrotechnic inflator compared to a single stage pyrotechnic inflator and the incremental cost of a dual stage hybrid inflator compared to a single stage hybrid inflator.

Based on information from our contractor, the agency estimates that the incremental cost for a dual stage pyrotechnic inflator over a single stage pyrotechnic inflator is about $10 per inflator, and incremental cost for a dual stage hybrid inflator over a single stage hybrid inflator is about $2 per inflator.

JPL estimated the costs of different inflators compared to a baseline single stage pyrotechnic inflator with sodium azide propellants. These costs were $10 to $15 for a dual-pyrotechnic inflator, $0 to $8 for a hybrid or heated gas inflator and potentially lower cost for a high pressure stored gas inflator.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Thus, inflator costs vary considerably depending on the technology chosen. If the manufacturers stay with the more widely known and used pyrotechnic technology, the agency estimates the cost increase of a dual-stage pyrotechnic inflator is $10 per side, or $20 per vehicle. If manufacturers determine they can switch to a hybrid or gas system, they could save money compared to the pyrotechnic inflators. However, a dual-stage hybrid system would cost about $2 more than a single-stage hybrid system per side, or $4 per vehicle.

**9. Crash Pulse Changes**

When new models are designed, manufacturers may have the ability to soften the crash pulse and potentially make it easier to meet the high speed tests with less aggressive air bags. Increasing the crush zone in the front of the vehicle, changing the load paths, or changing the materials used in the structure can soften the crash pulse. Some manufacturers advertise these design features and similar-sized vehicles have different crash pulses. The cost and effectiveness of these strategies varies considerably depending upon the specific make/model.

One way to soften the crash pulse is to increase the front end length of the vehicle by about three inches. This countermeasure might be considered for those vehicles with stiff crash pulses, typically small cars and large light trucks. There are several decisions that must be made when considering increasing the front end length. Should the overall length of the vehicle be maintained, either by decreasing the trunk room, cargo space, interior room, or by changing the engine configuration to provide more room in front? These are major decisions that affect how the vehicle looks, its design, and its function. In an attempt to provide a cost estimate for this

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

countermeasure, the agency took previous tear-down study data from Ford F-100 and F-150 pickups[8], and estimated the cost to extend the front of the model by three inches. Based on 1978 economics, adding three inches to the hood, fenders, and frame rails would add $9.40 and 11.7 pounds. Using the GDP, implicit price deflator, in 1997 dollars the cost would be $20.60. The agency also considers secondary weight effects. Secondary vehicle weight refers to weight increases to other parts of the vehicle to compensate for the additional primary weight. These secondary weight increases could conceivably include increases in vehicle structure (to maintain load-carrying ability) or an increase in average engine size ( to maintain acceleration capability). In this case, we would consider the increase in primary weight to the hood and fenders (6.9 pounds), as influencing secondary weights. Historically, the agency has used a secondary weight factor of 0.7 pounds of secondary weight for every pound of primary weight and a cost of $0.95 per pound of secondary weight. Thus, the total weight influence would be 16.5 pounds [11.7 + 0.7(6.9)] and the total cost would be $27.15 [$20.60 + 6.9($0.95)]. As discussed above, this is only one of many ways to change the crash pulse.

There are a variety of potential ways for the manufacturers to meet the alternative test requirements. The cost estimates of these systems vary considerably. Table VII-2 shows the range of cost estimates provided. NHTSA has more confidence in cost estimates that have been

---

[8] See "1980 and 1979 Ford F-150 Light Truck Weight and Material Analysis", Corporate-Tech Planning, March 1980, DOT HS 805-693, and "Development of a Motor Vehicle Materials Historical, High Volume Industrial Processing Rates Cost Data Bank (Light Truck)", John Z. DeLorean Corporation, October 1978, DOT HS 805-161.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

provided by contractor tear-down studies, although there is no guarantee that these technologies are the ones that will actually go in to production. For this analysis, the agency will use the tear-down study cost estimates where provided, and will use the range of estimates provided by docket commenters or JPL when tear-down studies are not available.

**Estimated Vehicle Costs for Meeting Specific Tests and Current Compliance**

Table VII-3 presents costs for meeting specific individual tests. Table VII-5 presents costs for meeting specific individual tests after taking into account current compliance rates and considering the high speed tests discussed below. The manufacturers must meet a combination of tests. In some cases, the same technology could be used to meet both out-of position tests and high speed tests.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table VII-2
Technology Cost Summary
(1997 Dollars)

| Technology | Range of Cost Estimates | Cost Estimates Used in this Analysis |
|---|---|---|
| Suppression of Air Bag -- Internal Circuitry Only | $1 per air bag | $2 per vehicle |
| Telltale light | $0.80 per side | $1.60 per vehicle |
| Low Risk Air Bags | none | $0 to minor<br>Assumed only available for the driver side |
| Two additional sensors for the offset test | $20.80 to $23.90 per vehicle | $22.30 per vehicle |
| Weight or mass sensor with pattern recognition | $15.40 to $35.70 per seat | $19 to $23 per vehicle<br>Assumes only passenger side |
| Occupant Presence Sensors | $35.70 to $113.30 for the passenger side | $40 to $60 for the passenger side |
| Safety Belt Use Sensor | $2.00 to $5.00 per vehicle | $2.00 to $5.00 per vehicle Only needed on passenger side |
| Dual or Multiple Level Inflators | $2 to $15 per air bag | $2 to $10 per side or<br>$4 to $20 per vehicle |
| Crash Pulse Changes | $27.15 per vehicle | $27.15 per vehicle |
| Threshold Changes | none | $0 to unknown |
| Redesigned Air Bag | none | $0 |

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

In this chapter, costs for specific tests are estimated. Chapter VIII combines out-of-position tests and high speed tests into four compliance scenarios and combines costs for specific tests looking at the potential low and high costs of meeting a full compliance scenario.

**The assumptions for Tables VII-3 and VII-5 are:**

1. To meet the suppression with child presence for rear-facing child restraints and 3 year-old and 6 year-old dummies would require the internal circuitry for suppression at $1 for the passenger side, a telltale light at $0.80, and either a weight sensor at $19 to $23, or an occupant presence sensor at $40 to $60. Thus, the total cost is $20.80 to $24.80 for the weight sensor or $41.80 to $61.80 for a presence sensor. Manufacturers may well determine that they want both systems to get the most information on occupant size and position. Thus, it is possible that the potential cost could be as much as the addition of these two systems or $60.80 ($1+0.80+19+40) to $84.80 ($1+0.80+23+60).

Current Compliance - Mercedes and BMW have a weight sensor that turns off the air bag when a low weight or no weight is in the right front passenger seat. It is assumed that this system could be updated to include up to 54 pounds with no additional cost. Sales of vehicles with these systems are estimated to be around 230,000 in the U.S. Thus, applying a factor of .985 (15.27 million/15.5 million) to these estimates results in cost estimates weighted by the percent of the fleet complying of $20.50 to $24.45 for the weight sensor (in Table VII-5) and $41.15 to $60.90 ($41.80 to $61.80 x .985) for a presence sensor.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

2. One method to meet the low risk deployment test would cost $0 to minor costs for the driver side, assuming it is feasible with an air bag that could meet the test using one level of deployment output, for example a redesigned air bag with modified fold patterns and possibly a modified inflator.

If a dual or multi-stage inflation system based on crash severity and restraint use were used it would require a restraint use sensor at $2 to $5 for the passenger side, a dual or multiple level inflator at $4 to $20 per vehicle ($2 to $10 per side), and at the high end of costs, perhaps better crash severity sensing at $22.30 per vehicle ($11.15 per side) and a seat position sensor for the driver side ($5 for the driver side). Thus, the total cost range assuming no current compliance would be $0 to $26.15 ($10 + $11.15 + $5) for the driver side, $4 ($2 + $2) to $26.15 ($5 + $10 + $11.15) for the passenger side, and $4 to $52.30 for both sides.

A second method for meeting the low risk deployment test would be to make improvements in the vehicle's crash pulse. The agency does not believe that manufacturers need to do both crash pulse improvements and multi-stage inflation systems to meet the standard, one of the two countermeasures would suffice. The cost estimate for crash pulse improvements is $27.15 per vehicle. Since this estimate is within the range of $4 to $52.30, we will use the wider range in the cost estimates.

Current Compliance - Based on the pre-MY 98 passing rates in Chapter IV (results of the 25 mph offset test in which 43 percent of the vehicles tested passed), it is estimated that 57 percent of all

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

vehicle systems could require additional sensors for use with the dual or multi-level inflator to better refine speed sensing capabilities. For the average vehicle this would be $12.70 ($22.30 x .57) (assumed to be $6.35 for each side) to the high end of the range. Based on the passing rates in Chapter IV, about 25 percent of the fleet can meet the out-of-position test on the driver side, thus, the driver side average cost for a multi-stage inflator is estimated to be $1.50 to $7.50. No vehicles passed the low risk test on the passenger side. Some manufacturers (20% are assumed with pretensioners) currently have a restraint sensor on the passenger side, thus the average cost per vehicle is $1.60 to $4.00 for a restraint use sensor on the passenger side. Thus, the total cost of a dual or multi-level inflator system is $0 to $18.85 ($7.50 + $6.35 + $5) on the driver side and $3.60 to $20.35 on the passenger side for a total of $3.60 to $39.20 per vehicle (see Table VI-4 for a cost breakdown).

3. To meet the 25 mph belted offset barrier test would require either:

a) different sensors at $0 costs or additional sensors at a cost of $22.30 per vehicle, or

b) dual-stage or multi-stage inflators, which cost $52.30 per vehicle at the high end, as discussed previously.

Current Compliance -

a) If no new sensors are used, the low end of the range of cost is $0. Based on the passing rates in Chapter IV, about 43 percent of the pre-MY 1998 fleet tested passed this test. Thus, the average cost per vehicle, if additional sensors are used, is estimated to be $12.70 ($22.30 x 0.57), or $6.35 per side; or a manufacturer could use

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

b) dual-stage or multi-stage inflators, which after considering current compliance cost $39.20 per vehicle at the high end as discussed previously.

4. Most vehicles can meet the unbelted 5th percentile female dummy frontal barrier test at 25 mph. The agency has 4 MY 98/99 unbelted tests with the 5th female dummy at 25 mph. All four passed on the driver side and three of the four vehicles passed the test on the passenger side. The agency assumes those not in current compliance would require different fold patterns, tethering, or other minor design changes, which the agency believes can be met by all vehicles without incremental costs to the system.

5. To meet the unbelted 5th percentile female dummy frontal barrier test at 30 mph would require different fold patterns, tethering, or other minor design changes, which the agency believes can be met by some vehicles without incremental costs to the system. Other vehicles will require a multi-stage inflator with some type of sensor system to determine when a small female is in the driver seat as opposed to a larger occupant. A variety of sensors could be used to determine when a person, for example, a 5th percentile female, is too close to the air bag. The simplest system is a seat position sensor, which has been added in to the multi-stage inflator high end of the costs at $5 for the driver position. Those sitting too close to the steering wheel would receive

DRAFT DELIBERATIVE DOCUMENT. DO NOT RELEASE

the low level air bag deployment. The estimated cost to meet this test is from $0 to $52.30 per vehicle as discussed previously.

Current Compliance - The agency has tested 12 MY 1999 vehicles at 30 mph unbelted with the 5th female dummy (see Table IV-21). Five of them passed on the driver's side and five passed on the passenger side, but only 3 vehicles passed on both sides. It is assumed that if either dummy does not pass the test, that multi-stage inflators would be added to both the driver and passenger side. Inserting the 75 percent noncompliance rate for additional speed sensors and multi-level inflators into Table VII-4 results in high end cost estimates of $20.85 for the driver side and $19.85 for the passenger side for a total of $40.70. Thus, after current compliance, the cost estimates are assumed to range from $0 to $40.70.

Test results were examined to determine whether any of the three vehicles that met the 5th female unbelted test at 30 mph had failed the 25 mph offset deformable barrier test. Two of the three vehicles that had passed the 5th female unbelted test at 30 mph (Saturn and Taurus) were tested in the 25 mph offset deformable barrier test and both passed that test. Thus, no adjustments were deemed necessary to the passing percentages and resulting cost estimates when test results would be combined in Chapter VIII.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table VII-3
Estimated Per Vehicle Consumer Costs for Meeting Specific Tests
(Not weighted by current compliance rates)
(1997 Dollars)

| Test | Cost |
|---|---|
| Suppression with child presence | Passenger side<br>$20.80 to $24.80 for a weight sensor or<br>$41.80 to $61.80 for a presence sensor<br>$60.80 to $84.80 for both systems |
| Low risk deployment tests | Driver side $0 to $26.15<br>Pass. side $4 to $26.15<br>Total $4 to $52.30<br>Includes at high end - driver side seat position sensor, passenger side safety belt use sensor, both sides multi-level inflator and additional crash sensors |
| 25 mph offset barrier test (belted) | Driver side $0 to $26.15<br>Pass. side $0 to $26.15<br>Total $0 to $52.30 per vehicle,<br>High end assumes same as low risk deployment test |
| 5th percentile female dummy in an unbelted 30 mph barrier test | Driver side $0 to $26.15<br>Pass. side $0 to $26.15<br>Total $0 to $52.30<br>High end assumes same as low risk deployment test |

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table VII-4
Low Risk Deployment Test Costs
**Driver Side**

| | |
|---|---|
| Additional speed sensors | $0 - $11.15 |
| % in Noncompliance | 57% |
| Costs | $0 - $6.35 |
| | |
| Multi-level Inflator | $ 0 - $10 |
| % in Noncompliance | 75% |
| Costs | $0 - $7.50 |
| | |
| Seat Position Sensor | $0 - $5 |
| | |
| Total cost | $0 - $18.85 |

**Passenger Side**

| | |
|---|---|
| Additional speed sensors | $0 - $11.15 |
| % in Noncompliance | 57% |
| Costs | $0 - $6.35 |
| | |
| Multi-level Inflator | $ 2 - 10 |
| % in Noncompliance | 100% |
| Costs | $2 - $10 |
| | |
| Restraint Use Sensor | $2 to $5 |
| % in Noncompliance | 80 |
| Costs | $1.60 to $4 |
| | |
| Total Cost | $3.60 - $20.35 |

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table VII-5
Average Consumer Costs for Meeting Specific Tests
After Considering Current Compliance
(1997 Dollars)

| Test | Cost |
|---|---|
| Suppression with child presence (Passenger side) | Passenger side<br>$20.50 to $24.45 for a weight sensor or<br>$41.15 to $60.90 for a presence sensor<br>$59.90 to $83.50 for both systems |
| Low risk deployment tests | Driver side $0 to $18.85<br>Pass. side $3.60 to $20.35<br>Total $3.60 to $39.20 |
| 25 mph offset barrier test (belted) | Driver side $0 to $18.85<br>Pass. side $0 to $20.35<br>Total $0 to $39.20 |
| 5th percentile female dummy in an unbelted 30 mph barrier test | Driver side $0 to $20.85<br>Pass. side $0 to $19.85<br>Total $0 to $40.70 |

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**B. Property Damage Cost**

Consumers would experience repair cost savings if passenger-side air bags did not deploy in a crash with no one sitting in the right front seating position or, if a weight sensor were used, when there is less than a certain weight in the right front seat. The savings are to society, but they are realized mainly through insurance company payments and to consumers that don't have insurance or may not have collision coverage on their vehicles.

Based on NASS-CDS towaway crashes for 1996, there were 428,000 passenger car and light truck driver deployments. During 1996, the agency estimates there were 49 million passenger cars and light trucks on the road with driver air bags. An analysis of NASS-GES data for MY 1995 and later models indicate that of all police-reported crashes in which an air bag deploys, 82.26 percent are in towaway CDS-type crashes and 17.74 percent are in non-towaway crashes. Thus, the total number of driver air bag deployments in crashes in 1996 are estimated to be 520,300 (100/82.26 x 428,000). This assumes there are no air bag deployments in non-police reported crashes. What is needed for this analysis is a projection of the number of air bag deployments per year when the entire fleet is equipped with air bags and a distribution of air bag deployments over the life of a vehicle so that repair costs that might occur any time over the 20 year lifetime of a passenger car or 25 year life of a light truck can be discounted back to present value.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Since the vehicles in NASS 1996 with air bags are mostly newer vehicles, which drive more mileage than older vehicles, a rate of deployments per average vehicle would be exaggerated. An analysis taking vehicle miles traveled by age of vehicle x scrappage by age of vehicle x the total number of sales by age was compared to the same analysis for vehicles sold with air bags. These analyses were performed for both passenger cars and light trucks separately and were summed. The results of these analyses indicate that in 1996, the number of deployments multiplied by 2.54 would provide an estimate of the total number of deployments if all vehicles in 1996 had air bags. Thus, if all vehicles in 1996 had air bags, there would have been about 1,322,000 deployments in towaway and non-towaway crashes (2.54 x 520,300). In most vehicles currently on-the-road, both the driver and passenger side air bags deploy at the same time.

There were 192.1 million passenger cars and light trucks in the fleet for 1996. In the last assessment, the agency estimated a higher number of air bag deployments based on a projected increase in the number of vehicles in the fleet. However, manufacturers have started to raise the threshold speeds at which air bags deploy and that would lessen the number of deployments in the future. Not knowing the potential impact of raising thresholds, we decided not to increase the annual estimate of deployments based on increasing numbers of vehicles in the fleet. Thus, we estimate there would be about 1.322 million vehicles with air bag deployments annually.

Since all vehicles in the future will have both driver and passenger side air bags, there will be a similar number in both the driver and passenger side, unless there are technologies utilized to reduce deployments in certain situations. Based on NASS 1996, about 68 percent of the time

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

there is no one sitting in the right front seat when the air bag deploys, and about 2 percent of the time the occupant in the right front seat is 6 years old or younger. Assuming a weight sensor by itself could detect weight for children representing those up to about age 6, a weight sensor could result in the suppression of 925,000 right front seat deployments (1.322 million x .70) a year.

Proximity sensors could also determine when no one is in the seating position or when someone is too close to the instrument panel. If the system is set up to suppress the air bag in these situations, a proximity sensor system could also result in cost savings by not deploying the air bag until it is needed.

To bring these estimates from a total fleet basis to an individual vehicle basis, one needs to determine the present discounted value of not having deployments at some time over the lifetime of the vehicle. The multiplier for the 7 percent discount factor is 0.7379 over the lifetime of passenger cars and 0.6956 over the lifetime of light trucks. Assuming 7.5 million sales for passenger cars and 8 million for light trucks by the year 2005 when this rule may become fully effective, the average discount factor is roughly 0.72 over a 22 year life.

If there were an estimated 1,322,000 deployments per year over a steady state sales of 15.5 million per year, 8.5 percent of the fleet will have an air bag deployment over their lifetime.

Based on costs from NHTSA's Vehicle Research and Test Center in replacing air bags during our test programs, the following costs are estimated.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

| | | |
|---|---|---|
| Driver side: | | |
| Air bag | $350 to $500 | |
| Labor (Driver Side) | $50 | Assumed to be one hour at $50 per hour |
| Total Driver Side | $400 to $550 | |
| | | |
| Passenger Side: | | |
| Air bag | $230 to $800 | |
| Instrument Panel | $50 to $300 | |
| Windshield | $600 to $2,000 (not all vehicles need to replace the windshield) | |
| Labor (Pass. Side) | $200 to 250 | Assumed 4 hours without windshield replaced , 5 hours with windshield replaced |
| Total Pass. Side | $480 to $1,300 without the windshield replaced to $1,130 to $3,350 with the windshield replaced. | |

For the passenger side, the lifetime repair cost savings for a weight sensor or presence sensor are estimated to range from $20.60 to $55.70 on the passenger side ($480 to $1,300 x 0.085 deployment rate x 0.72 discount rate x 0.70 unnecessary deployment rate) when the windshield does not have to be replaced and from $48.40 to $143.50 on the passenger side ($1,130 to $3,350 x 0.085 x 0.72 x 0.70) when the windshield does have to be replaced.

Totaled Vehicles - Commenters on the NPRM Preliminary Economic Assessment made the point that when a vehicle is totaled due to a crash, there is no savings to the consumer from not having the air bag deploy. Thus, the commenters indicated that the overall property damage savings of not having the passenger side air bag deploy when no one or small children were sitting in the front right seat, were overestimated.

When there is an air bag deployment, a percentage of the vehicles are totaled (not repaired) and sent to be recycled. If the repair cost of the vehicle, without considering repair costs for the

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

passenger side air bag, would result in the vehicle being totaled anyway, the property damage savings from having a passenger air bag not deploy is meaningless. On the other hand, there are cases where the repair cost for the passenger side air bag, when added to the other repair costs for the vehicle, make the vehicle uneconomical to repair and it is declared a total loss.

Data from State Farm Insurance Company was requested to help quantify what percent of the vehicles would be totaled, and should not be assigned property damage savings. State Farm submitted the following estimates (see Table VII-6) based on data from the dual air bag Ford Taurus[9], which State Farm considered a typical vehicle in terms of air bag deployments and total losses. "Forced into a Total Loss" means that the additional cost of replacing the air bags and repairing subsequent damage to the instrument panel, windshield, etc., from deployment forced the vehicle to be totaled rather than repaired. These data were used in calculations (see Table VII-6 and VII-7) to determine the average influence of vehicles being totaled on potential property damage savings. The results of these calculations are that on average 50 percent of vehicles with deployments are repaired and an additional 10 percent of vehicles would not be forced into being totaled if the passenger side air bag did not deploy. Thus, 60 percent of the estimated property damage savings from not having the passenger side air bag deploy when unwanted would be realized by consumers.

---

[9] The agency did not use these same data for light trucks since the repair rates for light trucks would be different than for passenger cars. For lack of better data, it is assumed that the resulting 60 percent estimate applies to both cars and light trucks.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Thus, after considering that on average 40 percent of the vehicles will be totaled and 60 percent repaired, the lifetime repair cost savings for consumers for a weight sensor or presence sensor are estimated to range from $12.35 to $33.40 (0.6 x $20.60 to $55.70) on the passenger side when the windshield does not have to be replaced and from $29.05 to $86.10 (0.6 x $48.40 to $143.50) on the passenger side when the windshield does have to be replaced.

Table VII-6
Effect of Air Bag Deployment on Total Losses
By Age of Vehicle

| Age of Vehicle | Total Loss | Forced Into A Total Loss | Repaired |
|---|---|---|---|
| 0 | 5% | 3% | 92% |
| 1 | 5 | 5 | 89 |
| 2 | 10 | 18 | 73 |
| 3 | 14 | 18 | 68 |
| 4 | 25 | 19 | 56 |
| 5 | 34 | 26 | 40 |
| 6 | 49 | 30 | 21 |
| 7 | 77 | 19 | 4 |
| 8 | 85 | 15 | 0 |
| 9 | 86 | 14 | 0 |
| 10 | 88 | 12 | 0 |
| 11 | 88 | 12 | 0 |

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table VII-7
Average Percent of Vehicles Repaired
After an Air Bag Deployment

| Passenger Cars | | | | | |
|---|---|---|---|---|---|
| Age | VMT | Survival | Weighted VMT | Air Bag % Repaired | |
| 1 | 14,535 | 1.000 | 14,535 | 0.92 | 13372.2 |
| 2 | 13,924 | 0.993 | 13,827 | 0.89 | 12305.61348 |
| 3 | 12,846 | 0.982 | 12,615 | 0.73 | 9208.78356 |
| 4 | 11,378 | 0.964 | 10,968 | 0.68 | 7458.50656 |
| 5 | 10,749 | 0.935 | 10,050 | 0.56 | 5628.1764 |
| 6 | 10,119 | 0.892 | 9,026 | 0.4 | 3610.4592 |
| 7 | 9,490 | 0.831 | 7,886 | 0.21 | 1656.0999 |
| 8 | 8,860 | 0.753 | 6,672 | 0.04 | 266.8632 |
| 9 | 8,231 | 0.662 | 5,449 | 0 | 0 |
| 10 | 7,601 | 0.568 | 4,317 | 0 | 0 |
| 11 | 6,972 | 0.476 | 3,319 | 0 | 0 |
| 12 | 6,343 | 0.394 | 2,499 | 0 | 0 |
| 13 | 5,713 | 0.323 | 1,845 | 0 | 0 |
| 14 | 5,084 | 0.263 | 1,337 | 0 | 0 |
| 15 | 4,454 | 0.213 | 949 | 0 | 0 |
| 16 | 3,825 | 0.172 | 658 | 0 | 0 |
| 17 | 3,195 | 0.139 | 444 | 0 | 0 |
| 18 | 2,566 | 0.112 | 287 | 0 | 0 |
| 19 | 1,937 | 0.090 | 174 | 0 | 0 |
| 20 | 1,307 | 0.073 | 95 | 0 | 0 |
| | | | | | |
| | | | 106,953 | | 53,507 |
| | | | | | |
| | | | | | 0.500 |

NOTE: 53,507/106,953 = 0.50

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table VII-8
Average Percent of Vehicles Forced into
A Total Loss as a Result of Deployment

| Age | Forced into Total Loss % | Pass. Side % of Total Repair Cost | Pass. Side Forced Into Total Loss | Weighted Pass. Side Forced |
|---|---|---|---|---|
| 1 | 0.03 | 0.65 | 0.0195 | 283.4325 |
| 2 | 0.05 | 0.65 | 0.0325 | 449.36229 |
| 3 | 0.18 | 0.65 | 0.117 | 1475.928324 |
| 4 | 0.18 | 0.65 | 0.117 | 1283.301864 |
| 5 | 0.19 | 0.65 | 0.1235 | 1241.2139025 |
| 6 | 0.26 | 0.65 | 0.169 | 1525.419012 |
| 7 | 0.3 | 0.65 | 0.195 | 1537.80705 |
| 8 | 0.19 | 0.65 | 0.1235 | 823.94013 |
| 9 | 0.15 | 0.65 | 0.0975 | 531.269895 |
| 10 | 0.14 | 0.65 | 0.091 | 392.880488 |
| 11 | 0.12 | 0.65 | 0.078 | 258.856416 |
| 12 | 0.12 | 0.65 | 0.078 | 194.933076 |
| 13 | 0.1 | 0.65 | 0.065 | 119.944435 |
| 14 | 0.08 | 0.65 | 0.052 | 69.528784 |
| 15 | 0.06 | 0.65 | 0.039 | 36.999378 |
| 16 | 0.04 | 0.65 | 0.026 | 17.1054 |
| 17 | 0 | 0.65 | 0 | 0 |
| 18 | 0 | 0.65 | 0 | 0 |
| 19 | 0 | 0.65 | 0 | 0 |
| 20 | 0 | 0.65 | 0 | 0 |
| | | | | |
| | | | | 10,242 |
| | | | | |
| | | | | 0.096 |
| | | | | |

Note: 65% factor is the weighted estimate of the property damage savings from the passenger side compared to both driver and passenger side, since "Forced into a total loss" is determined from a dual air bag car and only the passenger side air bag may not deploy.
Calculated as [(480 + 1300)/2]/[(400 + 500)/2 + (480 + 1300)/2].

10,242/106,953 = 0.096

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Only Mercedes and BMW currently have a weight sensor that turns off the air bag when a low weight or no weight is in the right front passenger seat. It is assumed that this system could be updated to include up to 54 pounds with no additional cost, and that current weight sensor sales are around 230,000 a year in the U.S. Thus, applying a factor of .985 (15.27/15.5 million) to these estimates results in cost estimates weighted by the percent of the fleet complying of $12.15 to $32.90 without replacing the windshield and $28.60 to $84.80 when the windshield must be replaced.

Table VII-9
Estimated Property Damage Savings
(1997 Dollars)

| System | Driver Side | Passenger Side | Total |
|---|---|---|---|
| Suppression with child presence - | $0 | $12.15 to $32.90 w/o replacing windshield<br><br>$28.60 to $84.80 replacing windshield | $12.15 to $32.90 w/o replacing windshield<br><br>$28.60 to $84.80 replacing windshield |
| Suppression when out of position only | negligible | negligible | negligible |
| Low risk deployment test | $0 | $0 | $0 |
| 25 mph offset test | $0 | $0 | $0 |
| 5th percentile female dummy in an unbelted 25 or 30 mph barrier test | $0 | $0 | $0 |

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

## C. Total and Net Costs

It is estimated that the average number of passenger cars and light trucks sold per year affected by this final rule will be 15.5 million[10]. With 15.5 million vehicles potentially being affected, it only takes an average cost of $6.45 to reach the $100 million threshold. Given that several technologies cost more than $6.45, this will be a significant rulemaking.

For each technology a net cost is estimated on a per vehicle basis and a total cost is derived assuming that all vehicles that don't currently have that technology, or pass the test already, use that technology. The net cost calculation comes from taking the consumer cost and subtracting the present discounted value (discounted at 7 percent) of savings from not having to repair vehicles in cases of unnecessary air bag deployments.

For the **suppression with child presence using a weight sensor,** the average costs are estimated to range from $20.50 to $24.45 per vehicle. Property damage savings range from $12.15 to $32.90 without replacing the windshield and from $28.60 to $84.80 when the windshield is replaced. Thus, weight sensors will most likely be cost effective for consumers. The net ranges are from costing $12.30 to saving $12.40 without replacing the windshield and from saving $4.15 to $64.30 for those vehicles needing the windshield replaced. Assuming annual new car and light

[10] The current air bag requirement and this final rule are not applicable to light trucks and vans that are over 8,500 GVWR or 5,500 pounds unloaded vehicle weight. Sales of these vehicles vary considerably from year to year, usually less than 500,000 per year. More than half of these vehicles are equipped with air bags. Sales predictions for MY 2003 and later range between 15.5 and 16 million vehicles annually. Thus, we predict that about 15.5 million vehicles will be affected by these requirements.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

truck sales of 15.5 million units, the total annual net ranges from a cost of $191 million to a cost savings of $192 million if no vehicle needed the windshield replaced after an air bag deployment and from a cost savings of $64 million to $997 million if all vehicles needed the windshield replaced after an air bag deployment.

For the **suppression with child presence based on a occupant position sensor,** the costs are estimated to range from $41.15 to $60.90 per vehicle. Property damage savings range from $12.15 to $32.90 without replacing the windshield and from $28.60 to $84.80 when the windshield is replaced. The net costs could range from $8.25 to $48.75 per vehicle without replacing the windshield and the net costs could be as high as $32.30 and the net savings could be as high as $43.65 for those vehicles needing the windshield replaced after an air bag deployment. Assuming annual new car and light truck sales of 15.5 million units, the total annual net cost could range from $128 to $756 million if no vehicle needed the windshield replaced after an air bag deployment and total annual net cost could be as high as $501 million and the net savings could be as high as $677 million if all vehicles needed the windshield replaced after an air bag deployment.

For the **low risk deployment system** the costs are estimated to be from $3.60 to $39.20, and there are no property damage savings unless a higher threshold is included at the same time, thus the net costs are the same. Thus, total costs for 15.5 million vehicles would be from $56 million to $608 million.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

For the **25 mph offset barrier test** the costs are estimated to be from $0 to $39.20 per vehicle and there are no property damage savings. Thus, the total net costs for a 15.5 million vehicle fleet range from $0 to $608 million.

For the **5th percentile female barrier test** at 30 mph the costs are estimated to be $0 to $40.70 and there are no property damage savings. Thus, the total net costs are $0 to $631 million.

For those technologies that could potentially have a net consumer savings (weight sensors or possibly position sensors for the right front passenger side), one issue is whether the market would result in the voluntary installation of these technologies without a Federal requirement. Two German companies (Mercedes and BMW - which are at the high end of the price market and probably have high air bag crash repair costs) have introduced weight sensors, partially due to the requests of insurance companies in Europe. There are many factors that a manufacturer would consider before adding a feature that added costs, but saved money for the average consumer in the long run. These include: the impact of price increases on new vehicle sales, aftermarket sales (fewer deployments mean less aftermarket parts sales), reliability, consumer perceptions about whether both air bags should have gone off in the crash, and whether American consumers on lower priced vehicles can perceive the long term benefits if they feel they will never be in a severe enough crash to deploy the air bag. Weight sensors and position sensors are new technologies that most consumers haven't been exposed to, and currently aren't aware of their potential benefits. Thus, there is little or no current consumer demand for the product. There may currently be a market failure due to imperfect knowledge by consumers and the fact that new vehicle purchasers

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

would pay for any cost increases due to their installation, but most of the benefits accrue directly to insurance companies through lower collision loss payments. Consumers are dependent upon insurance companies to ultimately pass on these cost reductions to policy holders through premium reductions. Consumers may be uncertain that this will occur. Assuming that competition in the insurance market causes this pass-through to occur, one effect of this proposal may be merely to expedite the installation of some devices that are cost-beneficial for society and would ultimately be demanded by the market anyway. Comments are requested on whether this is likely to be the case, and, if so, how this possibility should be considered in the analysis.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table VII-10
Net Consumer Costs (Savings) Per Vehicle
(1997 Dollars)

| System | Consumer Cost At Time of Purchase | Property Damage (Savings) | Net Consumer Costs (Savings) |
|---|---|---|---|
| Suppression with child presence - with a weight sensor | $20.50 to $24.45 Passenger side | ($12.15 to $32.90) w/o replacing windshield<br><br>($28.60 to $84.80) replacing windshield | $12.30 to ($12.40) w/o replacing windshield<br><br>($4.15 to $64.30) replacing windshield |
| Suppression with child presence - with a presence sensor | $41.15 to $60.90 Passenger side | ($12.15 to $32.90) w/o replacing windshield<br><br>($28.60 to $84.80) replacing windshield | $8.25 to $48.75 w/o replacing windshield<br><br>$32.30 to ($43.65) replacing windshield |
| Low risk deployment test | $3.60 to $39.20 | $0 | $3.60 to $39.20 |
| 25 mph offset test | $0 to $39.20 | $0 | $0 to $39.20 |
| 5th percentile female dummy in an unbelted 30 mph barrier test | $0 to $40.70 | $0 | $0 to $40.70 |

## D. Compliance Test Costs

This section discusses the estimated costs for the agency or for a manufacturer to perform compliance tests. Costs are in 1997 dollars. Most of these tests, or tests like these, are already run by the manufacturers and may not be incremental costs for them. This final rule would standardize a minimum set of tests run by the industry on air bags.

DRAFT DELIBERATIVE DOCUMENT. DO NOT RELEASE

*Vehicle Crash Tests*

In the NPRM, the agency proposed 14 potential vehicle crash test conditions:

12 potential rigid barrier tests: 3 angles (head-on, 30 degrees left and 30 degrees right) for 4 conditions (unbelted 50th male, belted 50th male, unbelted 5th female, and belted 5th female), and 2 potential tests using a deformable offset barrier (left and right side of the vehicle) with belted 5th percentile female dummies. Commenters stated that there were too many vehicle crash test conditions.

For the SNPRM, the agency proposed 9 potential vehicle crash test conditions for both Alternative 1 and Alternative 2.

For the final rule, the agency is requiring 7 potential vehicle crash tests [an unbelted test for the 50th male perpendicular and at +/- 30 degrees (3 tests), an unbelted test for the 5th female, a belted test for the 50th male and 5th female, and an offset test with the 5th female. There are the same number of tests for Option 1 and Option 2. Compliance test costs are:

The final rule includes a barrier test with neck injury criteria. A current compliance test, without neck injury costs about $18,000[11] for one test. With neck injury measurements, it would cost about $18,600 for one test. The current agency standard also provides for an unbelted sled test alternative with the 50th percentile male dummy. Almost all manufacturers are using the sled test. The sled test already includes neck data and costs about $16,000 to run. NHTSA buys a vehicle to

[11] All cost estimates are from NHTSA's costs for a contractor to perform these test.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

make the sled buck for testing. The incremental cost of the barrier test over the sled test is $2,600. Manufacturers can save testing costs by using the sled because they will do multiple tests using the same sled buck.

The costs of running an offset frontal deformable barrier test is also around $18,600. There are also costs for the deformable face, which is destroyed with each test, of $1,025. Thus, the total cost for running the offset test is $19,625.

If the government ran all of these tests for one make/model, it would have to purchase 7 vehicles at an average cost of $20,000 each or $140,000. However, NHTSA need not run all of these crash conditions for a make/model chosen for testing. The compliance test costs for running all seven tests is $131,225 ($18,600 x 6 + $19,625). Total costs for the tests and vehicles would average $271,225 for the high speed vehicle tests.

Currently, the standard requires certification to the 3 belted 50$^{th}$ percentile male dummy tests and a sled test. The total cost of these tests are $151,800 ($18,600 x 3 + $16,000 + 4 vehicles x $20,000). Thus, the potential incremental cost for high speed tests is $119,425 per make/model, if all of the tests were run.

Cost estimates for NHTSA do not reflect the cost estimates for manufacturers. While the average new vehicle price is around $20,000, manufacturers developing all new models may decide to use a few prototype vehicles for development testing purposes. Prototype vehicles can easily cost

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

$200,000. The agency believes that most manufacturers are already running many of the tests required, including the offset tests and have test facilities available to run these tests. Manufacturers must certify that their vehicles meet the standard, but are not required to run the test to prove certification.

***Static Tests***

**Tests for Static Suppression - Passenger Side**

For each set of out-of-position tests there would be a 2 hour set up time to inspect and clothe the dummy, prepare the vehicle, set the cameras, etc. Then, it is estimated to take 30 minutes per test configuration, with three to four different positions, per child restraint. It is also assumed to take 30 minutes to set up the dummy for each of the out-of-position tests that are not in a child restraint. Labor costs are estimated at $31 per hour for technicians and $53 per hour for engineers. It is assumed that one technician and one engineer would run the tests for a total of $84 per hour test cost. The agency would purchase a separate vehicle to do the static tests at an average cost of $20,000.

***Infants***

The 12-month old dummy is put in the child seat, the seat in the vehicle, the handle is moved to different positions, a towel or blanket is put over the top of the infant in a few positions, and the vehicle seat is moved to three different positions. The door must be closed and the light monitored after each change. In addition, the agency is requiring a 5$^{th}$ percentile female dummy test in the right front seat to make certain that the system recycles from the air bag deactivated situation for

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

the child restraint to the air bag activated situation for the adult situation. The agency suspects that manufacturers will use a 5th percentile female, rather than a dummy, as a cheaper quicker solution to this requirement.

The agency has established a specific set of child restraints on the market for its testing:

1) 1 car bed in its nominal design position,

2) 11 different rear facing child restraints, each of which would be tested with and without the base, so a possible total of 22 child restraints each tested at 3 different positions (belted facing rearward, unbelted facing forward, and unbelted facing rearward) for a total of 66 tests,

3) 7 convertible seats each tested at 4 different positions (belted and unbelted, facing forward and rearward) for a total of 28 tests.

Thus, there is a total of 95 tests[12] (1 + 66 + 28). For costing purposes, there is a total of 30 test configurations (1 + 22 + 7).

If all the different child restraints for infants and configurations possible were tested, the total cost would be $1,428 (2 hours set up + 30 x 30 minutes = 17 hours x $84). Is it possible that manufacturers could reduce the number of tests by 60 percent if they use a weight sensor and determine that the belted test is the worst case scenario and they don't have to test the unbelted condition.

[12] The number of tests can be counted in different ways. One could count each of the three vehicle seat positions separately, three towel positions, two handle positions and sun screen positions separately for the infant restraints, and add in the 5th female activation tests, which could increase the numbers by up to 6 times the numbers shown.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

*3-year-old and 6-year-old Dummies*

The testing using the 3-year-old dummy includes 7 convertible seats and 4 booster seats with the dummy in the child seat and an additional 9 tests with the unbelted dummy in different positions for a total of 20 tests. The testing using the 6-year-old dummy includes 4 booster seats with the dummy in the child seat and an additional 4 tests with the unbelted dummy in different positions for a total of 8 tests. Combining the 3-year-old and 6-year-old dummy test for automatic suppression, there are 28 tests. The total cost would be $1,344 (2 hours set up + 28 x 30 minutes = 16 hours x $84).

**Out of Position Test of Low Risk Deployment**

It is estimated to take about 3 hours to set up for this test to place the dummy, hook up the dummy instrumentation, camera coverage, etc. Then it is estimated to take 2 hours per test to position the dummy, run the test, remove and install a new air bag, instrument panel and windshield, and do pre and post photographs. Total labor time is 5 hours or $420 (5 x $84) plus the cost of a new air bag, instrument panel and windshield, if needed of $400 to $550 for the driver side and $1,130 to $3,350 for the passenger side. Two positions are run for the driver side. Two positions are run for the passenger side for both the 3-year-old and 6-year-old dummy, for a total of 4 tests on the passenger side. The total cost for the low risk tests is estimated to be $1,640 [2 x ($420 + $400)] to $1,940 for the driver side and $6,200 to $15,080 for the passenger side for a total of $7,840 to $17,020.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Out of Position Test for Dynamic Suppression**

This is an optional test, which will have to be specified by the manufacturer to provide a fair test of the specific system. For this test, the manufacturer would have to petition the agency to allow a test for it's system. Since the agency doesn't have a test procedure, the cost of the test cannot be estimated. If it involves crashing a vehicle, the test costs would be at least as much as the vehicle crash test costs discussed above.

**Total Testing Costs**

Total testing costs to the agency to run one vehicle through all of the tests, assuming the use of the vehicle crash tests, the static suppression tests for the passenger side, and low risk for the driver side are about $276,000 ($271,225 + $1,428 + $1,344 + 1,940). If the low risk option is chosen by the manufacturer for the driver and passenger side, total testing costs to the agency to run one vehicle through all of the tests are $278,000 to $288,000 ($271,225 + $7,840 to $17,020). These assume eight vehicles must be purchased (seven for the vehicle crash tests and one for out-of-position testing).

This is 80 percent higher than the current cost to the agency to run all of the current potential tests, which cost $151,800. Of course, the agency does not have to run all of these tests, it may only run what it believes might be the worst case conditions to check for compliance.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

**Dummy Costs**

Most manufacturers already own a variety of dummies for use in research testing. The 1998 list costs for fully instrumented dummies are shown in Table VII-11. Not all of the instrumentation is required for this proposal. Several of the load cells and accelerometers provide information that is not required by the proposal on areas such as lower limbs, etc. Cost estimates for the dummies as required in the final rule are also shown in Table VII-11.

Table VII-11
Dummy Costs ($1998)

| | Fully Instrumented Dummy | | | Dummy with Instrumentation In Final Rule | | |
|---|---|---|---|---|---|---|
| | **Dummy** | **Instrumentation** | **Total Costs** | **Dummy** | **Instrumentation** | **Total Costs** |
| CRABI-12 month | $8,300 | $42,500 | $50,800 | $8,300 | $15,500 | $23,800 |
| HIII-3 yr. | 36,400 | 62,300 | 98,700 | 36,400 | 15,500 | 51,900 |
| HIII-6 yr. | 31,200 | 72,900 | 104,100 | 31,200 | 61,400 | 92,600 |
| HIII-5th female | 33,400 | 99,100 | 132,500 | 33,400 | 69,200 | 102,600 |

Note that costs for laboratory overhead and profit are not considered in many of the above test estimates.

## E. Leadtime

The NHTSA Reauthorization Act of 1998 directs the agency to issue a final rule not later than September 1, 1999 and to have a phase-in beginning not earlier than September 1, 2002 and no sooner than 30 months after the issuance of the final rule, and be fully effective by September 1, 2005. However, if the final rule cannot be completed by that date, it must be issued no later than

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

March 1, 2000, and NHTSA is authorized to delay the phase-in starting date to not later than September 1, 2003 and to delay making the final rule fully effective until September 1, 2006.

In the SNPRM, the agency realized the final rule would not be issued until March 1, 2000. The agency proposed that the phase-in start on September 1, 2002 (the beginning of Model Year (MY) 2003, and that the rule be fully effective on September 1, 2005 (MY 2006).

Vehicle leadtime is a complex issue, especially when it involves advanced technology and designs that are still under development. In three different formal actions, the agency has gathered information concerning leadtime. First, the agency held a public meeting on advanced air bags on February 11 and 12, 1997, in Washington D.C. (See Docket NHTSA-97-2814). Second, NHTSA contracted with JPL to conduct an independent analysis (See 97-2814) concerning the readiness of the advanced air bag technologies. Third, the agency contracted Management Engineering Associates (MEA), an engineering management consulting company, to conduct a feasibility study on advanced air bag technologies (See 97-2814).

These three sources of information indicated the same basic time schedules: currently available technological solutions such as seat sensors, seat belt buckle sensors, dual-stage inflators and advanced air bag fold patterns, can be and will be in production between model year 1999 and model year 2002. More sophisticated systems such as dynamic occupant position sensing systems may not be available until after September 1, 2001.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

NHTSA has also held numerous meetings with and sent information requests to the vehicle manufacturers and suppliers. The companies have shared confidential information with the agency about their ongoing development efforts and future product plans. The agency notes that leadtime for technology still under development typically depends on two things: initial development to demonstrate that a concept is feasible, and then further development to apply the technology to a specific vehicle design. These typically involve efforts both by suppliers and by vehicle manufacturers. In this field of technology, it appears that much of the innovative development is being borne by the component suppliers, based on performance specifications defined by the vehicle manufacturers. First the systems are designed, tested and produced in a limited quantities by the component manufacturers. Next these systems are turned over to the vehicle manufacturers. The vehicle manufacturers then conduct prototype design verifications, conduct production level equipment verification and finally complete production and include the systems in their new vehicles. On the average, MEA estimates the vehicle manufacturers' cycle could take 36 months.

The suppliers and vehicle manufacturers have, however, been working on various advanced technologies for several years. Thus, to a large degree, leadtime is dependent on where the suppliers and vehicle manufacturers are currently in their development and implementation efforts. NHTSA believes that different suppliers and vehicle manufacturers are at different stages with respect to designing improved air bags. NHTSA believes that these differing situations can best be accommodated by phasing in requirements for advanced air bags.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Leadtime is examined for different vehicle types.

1) Original vehicle manufacturers - Most of the vehicle manufacturers requested that the agency provide the longest leadtime available under the Act. Many of the manufacturers also requested that if the 35 mph belted test were to be included, that it be phased-in after the requirements for the Act are finished. In addition, they noted that neither they nor NHTSA had any test data for the 5th female dummy at 35 mph belted and that the possibility of adding that test be considered in a future rulemaking. The agency considered a variety of leadtimes for the final rule. Mainly they included a two phase process, where some set of requirements would be required to be met in Phase 1 and a stricter set would be met in Phase 2. Under consideration were:

Phase 1: 25 mph unbelted tests for 5th and 50th dummies, Phase 2: 30 mph unbelted tests for both

Phase 1: 25 mph unbelted tests for 5th and 50th dummies, Phase 2: 35 mph belted test for 50th and a separate rulemaking for the 5th female for a 35 mph belted test.

Phase 1: 30 mph unbelted test for 50th dummy, Phase 2: 30 mph test for the 5th dummy.

Taking into account all of the available information, the agency set the final rule phase-in schedule in accordance with the following implementation schedule having a 25 mph unbelted test during Phase 1 and a 30 mph unbelted test during Phase 2. All of the other tests are included in the Phase 1 period.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Phase-in Alternatives

| Model Year | SNPRM | **Final Rule, Phase 1** |
|---|---|---|
| 2003 | 25% with carryover | 0 |
| 2004 | 40% with carryover | 35% with carryover |
| 2005 | 70% with carryover | 65% with carryover |
| 2006 | 100% fully effective | 100% with carryover |
| 2007 | | fully effective, including small manufacturers, multi-stage and alterers |
| | | **Final Rule, Phase 2** |
| 2008 | | 35% with carryover |
| 2009 | | 65% with carryover |
| 2010 | | 100% with carryover |
| 2011 | | fully effective, including small manufacturers, multi-stage and alterers |

b) Leadtime for limited-line manufacturers. In the SNPRM, the agency proposed a one-year delay for manufacturers selling 2 or less models in the United States. They could choose as an option to have full compliance in MY 2004. For the final rule, this alternative is allowed for MY 2005 for the first phase-in and in MY 2008 for the second phase-in .

c) Leadtime for small manufacturers. As mentioned in Chapter IX, small vehicle manufacturers are typically at the end of the line for these advanced technologies. Part of the reason is their smaller engineering staff and part of the reason is economics. The smaller manufacturers don't have the

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

funds to test out new technologies. Similarly, suppliers are trying to assure a market with larger manufacturers first. Once the suppliers and manufacturers have advanced on the learning curve with a new technology, then it becomes a manageable task for suppliers to consider introducing the technology for smaller manufacturers with different vehicle conditions.

Cosvam stated that limited line manufacturers need until the end of the main phase-in to comply with the final rule. The agency is providing small manufacturers (as defined by having sales of less than 5,000 vehicles worldwide) with as much lead time as possible under the Act by not requiring that all of their vehicles meet the fully effective date until the end of the phase-in or MY 2007 for the first phase-in and MY 2011 for the second phase-in.

d) Leadtime for second-stage manufacturers and alterers. In the SNPRM, the agency proposed that multi-stage manufacturers and alterers be allowed an option of 100% compliance of their fleet at the end of the phase in MY 2006. In the past, commenters such as Atwood Mobile Products (98-4405-#48) requested that second stage manufacturers be given a one year extension after full compliance by the original equipment manufacturers (OEM's) to obtain the information from the OEM's and complete their testing. As discussed in Chapter IX, several additional commenters made the same request to the SNPRM. The agency is providing multi-stage manufacturers and alterers with as much lead time as possible under the Act by requiring that all of their vehicles meet the fully effective date at the end of the phase-in or MY 2007 for the first phase-in and MY 2011 for the second phase-in.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

An issue which is closely related to leadtime for advanced air bags is the time when amendments providing temporary reductions in Standard No. 208's performance requirements should expire. The amendment permitting manufacturers to provide manual on-off switches for air bags in vehicles without rear seats or with rear seats too small to accommodate a rear facing infant seat is scheduled to expire on September 1, 2000. In the final rule, manual on-off switches will not be permitted starting on September 1, 2008 .

The amendment providing a generic sled test alternative to Standard No. 208's unbelted barrier test requirements expires on September 1, 2001. The 1998 Act states; "...the requirements of S13 of Standard No. 208 shall remain in effect unless and until changed by the rule required by this subsection." Thus, the agency must coordinate the timing of advanced air bags, with the existing provisions of S13, allowing the generic sled test to continue until vehicles can meet the advanced air bag requirements. Consistent with the Act, NHTSA is extending the dates so that the temporary amendments are phased out as the upgraded requirements are phased in. During the phase-in, the temporary amendment for the sled test alternative will not be available for vehicles certified to the upgraded requirements, but would be available for other vehicles.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

# VIII COST-EFFECTIVENESS ANALYSIS

The intent of this rulemaking is to minimize risks caused by air bags to out-of-position occupants, and to enhance the overall benefits provided to occupants in most crashes. To achieve these goals, NHTSA is proposing to establish test procedures that broaden the scope of the current standard to ensure that occupants of various sizes and ages are properly protected under a variety of crash circumstances.

Three vehicle crash tests are required to enhance air bag benefits. Two of these tests, the oblique and frontal barrier tests, duplicate the frontal barrier tests that pre-MY1998 vehicles were required to meet, but specify a range of either 20-30 mph (Alternative 2) or 20-25 mph (Alternative 1) for unbelted tests, and up to 30 mph for belted tests. Frontal rigid barrier tests would be conducted for both 50$^{th}$ male and 5$^{th}$ female dummies, in both belted and unbelted modes. The oblique rigid barrier test would be conducted for unbelted 50$^{th}$ male dummies. The third test is a restrained 25 mph offset deformable barrier test, which has been added to simulate the circumstances of an out-of-position occupant in an offset crash and measure crash sensing capabilities at lower speeds. This test would be required for driver's side 5$^{th}$ percentile female belted dummies. Methods for meeting the frontal barrier, offset, and oblique tests include multi-stage inflators, improved sensors, and modified air bag designs.

The current analysis examines two alternative groupings of these tests. These groupings are summarized in Table VIII-A The reader is also referred to Figures I-2 and I-3 in Chapter I.

Table VIII-A
Summary of High Speed Test Requirements for Alternative 1 and Alternative 2

| TYPE | SPEED | BELT | DUMMY | ALT 1 | ALT 2 |
|---|---|---|---|---|---|
| Frontal Rigid Barrier | 0-30mph | Belted | 50th Male | X | X |
| Frontal Rigid Barrier | 0-30mph | Belted | 5th Female | X | X |
| Frontal Rigid Barrier | 20-30mph | Unbelted | 50th Male | | X |
| Frontal Rigid Barrier | 20-30mph | Unbelted | 5th Female | | X |
| Oblique Rigid Barrier | 20-30mph | Unbelted | 50th Male | | X |
| Offset Barrier | 0-25mph | Belted | 5th Female | X | X |
| Frontal Rigid Barrier | 20-25mph | Unbelted | 50th Male | X | |
| Frontal Rigid Barrier | 20-25mph | Unbelted | 5th Female | X | |
| Oblique Rigid Barrier | 20-25mph | Unbelted | 50th Male | X | |

Within each alternative grouping, all of these tests must be passed in order to prove compliance with the requirements to enhance the performance of air bags.

In addition to these new tests, the final rule will upgrade the injury criteria for the existing frontal barrier tests by changing the way head injuries are measured, reducing allowable chest

deflection, and including a measure of neck injury. The final rule also eliminates the sled test alternative to the barrier test.

The risk of injury from air bags arises when occupants are too close to the air bag when it inflates. Generally, those most at risk from injury are infants, children, and small statured adults. To address these concerns, tests employ crash dummies representing infants, 3-year olds, 6-year olds, and 5th percentile female drivers. A variety of tests are required to protect these at-risk occupants. Manufacturers must certify compliance with one of these individual tests for each risk group (infants, children (represented by both 3 and 6 year old dummies), out-of-position drivers). The options for each risk group are summarized in Figure I-1 of this analysis.

As a practical matter then, manufacturers will have to take measures which will assure they can pass the tests designed to enhance air bag safety plus some combination of tests that address the four representative categories of occupants at risk from air bag injuries. For this analysis, these groups of possible solutions will be referred to as "compliance options". Two groups of compliance options have been identified from the basic tests for each Alternative. A basic assumption defining these compliance options is that, where possible, manufacturers would use the same systems to address testing for all risk groups. Thus, for example, multi-stage inflators would provide benefits for all occupants, regardless of age. However, infants would probably not be covered by multi-stage inflators without the use of a RFCSS detection sensor because the final

rule requires rear facing child safety seats to meet a separate low risk deployment test for all inflation levels up to 40 mph. It is thus likely that some form of suppression technology will be required to pass the requirements for infants.

As noted above, compliance with the new tests intended to enhance air bag benefits would be mandatory. Both compliance options include the low speed 5th percentile female dummy offset barrier test and the enhanced criteria frontal barrier tests. A number of technological solutions would enable manufacturers to meet these tests, including added sensors and multi-stage inflators, but manufacturers may meet the enhanced criteria frontal barrier tests with modified air bag designs.

The two optional tests potentially cover different low speed at-risk groups. The test for suppression with child presence (test reference #1 in Tables VIII-1 through VIII-12) can be conducted using the infant, 3 year old, and 6 year old dummies and thus addresses at-risk infants and children. The low-risk deployment test (test ref. #2) could be used to certify compliance for all risk groups. However, at this time the agency does not believe that an infant dummy in a RFCSS could pass the criteria with a low-risk air bag. Thus, a weight sensor has been added to this compliance option. In the NPRM, NHTSA also discussed a dynamic out-of-position test which was conducted using dummies representing all groups except infants. However, this test has been excluded from the final rule analysis because it requires manufacturers to file a separate petition proposing specific test procedures for accessing their particular dynamic system. Thus, the suppression test covers both infants and non-infant children, and the low risk deployment test

covers all categories except infants. The two compliance options examined here represent all logical combinations of these tests that would prove compliance for all basic at-risk groups.

The first compliance option assumes a scenario in which manufacturers meet requirements for out-of-position drivers with low risk deployment (Test ref. #2). For passengers, including infants, weight sensors are assumed (Test #1). Incremental costs for this compliance scenario range from $21 to $122 for Alternative 1, and $21 to $124 for Alternative 2. The range reflects different cost estimates provided by manufacturers or engineering tear-down studies, as well as different approaches to system design. Detailed discussion of the sources for cost estimates for technologies that determine this range as well as for cost ranges associated with other compliance options is included in Chapter VII.

The second compliance option assumes that manufacturers use a weight sensor costing $21 to $24 for infants and meet all other out-of-position requirements by meeting the low risk deployment test (Test #2). Technological solutions which could enable manufacturers to pass the low-risk test include modified air bag fold patterns and/or inflators, and multi-stage inflators. Cost estimates for meeting the low-risk test range from $0 to $39. The total cost estimate for this option ranges from $24 to $65.

In Table VIII-1, a range of cost estimates has been developed for each technology solution grouped under each test option. At the bottom of Table VIII-1, these costs are summarized for each of the compliance options discussed above. This analysis reveals potential compliance costs

ranging from about $21 to $124 per vehicle. The variation in cost is a function of both the technologies used and variation in cost estimates from different sources.

As discussed in Chapter VII, some of the compliance options may result in a significant savings in property damage costs because they prevent unnecessary air bag deployments which result in replacement costs for the air bag and often destroy front windshields as well. Estimates of these savings are summarized in Table VIII-2. Note that the range of estimates in this table and all subsequent tables match the technologies used to derive the range of high and low costs from Table VIII-1, and are not necessarily the highest and lowest possible property damage impacts. This linkage to the range of costs on Table VIII-1 is necessary in order to assure that costs and benefits are consistently associated with the same vehicle changes.

In Table VIII-3, the costs from Table VIII-1 are combined with the present discounted value of property damage savings from Table VIII-2 to produce the net cost or monetary benefit from each technology and compliance option. The results indicate that compliance option 2 under both alternatives has potential property damage savings that could exceed the consumer's cost for changes needed to comply with the tests.

In Table VIII-4, the net per-vehicle costs from Table VIII-3 are multiplied by 15,500,000, the estimated annual steady state sales of passenger cars and LTVs (see Chapter VII), to produce an estimate of the total annual net consumer costs of the alternative new testing requirements. Estimates range from a cost of $612 million to a net savings of $328 million.

In Chapter VI, safety benefits are derived for each alternative test procedure. These benefits are summarized in Tables VI-35 through VI-40. In Tables VIII-5 and VIII-7, those benefits are summarized for the technologies and compliance options used in the previous tables. As with Table VIII-2, the range is defined by the high and low estimates of costs in Table VIII-1, with the range of benefits maximized for those cases where more than one technology had the same cost. Note that in many cases, different technologies are addressing the same problem, but that some address larger target populations. To the extent that these technologies are combined under a specific compliance option, their benefits are thus not additive, and the maximum benefit for that compliance option is defined by the system with the largest safety benefit. For example, under Alternative 1, Compliance Option #2, the high range driver costs include the multi-stage inflators for the low risk deployment test, the frontal barrier test, and the 25mph offset barrier test. However, the 48 lives saved by multi-stage inflators for the 25 mph offset barrier test encompass those that would be saved by the similar equipment installed to meet the other tests. Therefore, the potential benefit from multi-stage inflators are only counted once.

In Tables VIII-6 and VIII-8, the safety benefits from Tables VIII-5 and VIII-7 have been discounted at a 7 percent rate to express their present value. Seven percent is used because it is the rate required for use in Regulatory Evaluations by the Office of Management and Budget (OMB Circular A-94, 10/29/92). The resulting estimates indicate a potential of between 117 and 166 lives saved under Alternative 2, but a potential reduction in benefits of from 16 to 171 lives under Alternative 1. These reductions relative to the pre-MY 1998 baseline are linked to the less demanding 25 mph high speed test required under Alternative 1. In higher speed crashes where

fatalities are more likely, these systems provide less protection. For nonfatal injuries, both Alternatives show potential benefits. These benefits range from 1203 to 1341 injuries prevented for Alternative 1, and from 359 to 1486 for Alternative 2. The seemingly contradictory impact on injuries for Alternative 1 is primarily due to reduced air bag caused injuries at lower speeds from the less aggressive air bags designed to lower speeds under Alternative 1.

As a primary measure of the impact of these alternatives, this analysis will measure the cost per fatality, or fatality-equivalent saved. In order to calculate a cost per equivalent fatality, nonfatal injuries must be expressed in terms of fatalities. This is done by comparing the value of preventing nonfatal injuries to the value of preventing a fatality. Comprehensive values, which include both economic impacts and lost quality (or value) of life considerations will be used to determine the relative value of fatalities and nonfatal injuries. These values were taken from the most recent study published by NHTSA[1]. In Table VIII-9, the process of converting nonfatal injuries is illustrated. The upper part of Table VIII-9 shows the comprehensive values used for each injury severity level, as well as the relative incidence-based weights for two groups of nonfatal injuries, MAIS 2-5 and MAIS 3-5. These are the 2 groupings of injuries measured for the safety enhancement test procedures and the at-risk test procedures respectively. The table shows that an average MAIS 2-5 injury is the equivalent of 0.10 fatalities, and that an average MAIS 3-5 injury is the equivalent of 0.22 fatalities.

---

[1]Blincoe, L.J., The Economic Cost of Motor Vehicle Crashes, 1994, Washington D.C., DOT HS 808 425, July 1996

Because safety benefits are composed of differing portions of these groups for each occupant category within each compliance option, an average impact must be calculated for each separate category. The lower left portion of Table VIII-9 shows the portion of nonfatal injury benefits that are associated with the at-risk group for each occupant category under each compliance option. These portions (Pr) were used to weight the MAIS 3-5 injury equivalent (0.22). The remaining weight (i.e., 1- Pr), were used to weight the MAIS 2-5 injury equivalent (0.10). The results are shown in the lower right portion of Table VIII-9.

In Table VIII-10, the discounted annual nonfatal injuries from Table VIII-8 were multiplied by the factors shown in the lower right of Table VIII-9 to produce estimates of the total discounted fatal equivalents represented by nonfatal injuries. In Table VIII-11, these fatal equivalents are added to the discounted annual fatalities prevented from Table VIII-6 to produce the total fatal equivalents from both fatalities and injuries. The results indicate that from 168 to 342 fatal equivalents might be prevented by advanced air bag systems designed to Alternative 2 requirements. Systems designed to Alternative 1 requirements could save up to 145 equivalent fatalities, but could also prevent up to 30 fewer equivalent fatalities than the pre-MY 1998 requirements.

In Table VIII-12, the total annual costs from Table VIII-4 are divided by the discounted fatal equivalents from Table of VIII-11 to produce estimates of the net cost (or savings) per fatality saved (CPF) for each compliance option. In cases where there are both positive costs and safety benefits, a net cost per fatal equivalent is appropriate. However, in some cases, there is a net cost benefit due to property damage savings, or a negative safety impact. In these cases, CPF

Total fatal equivalents = 147 fatalities + 70.2 nonfatal passengers +13.4 nonfatal drivers = 231 (Table VIII-11)

$185.2 million/231 = $801,840 per equivalent life saved (Table VIII-12)

Note that systems for drivers appear to be far less cost-effective than those for passengers, primarily because the potential safety problem for drivers is small, and because passenger-side systems have potential for property damage savings.

Table VIII-1
Compliance Cost

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | TEST -SYSTEMS | Low | High | Low | High | Low | High |
| | | | | | | | |
| 1 | Suppression w/ Child Presence | | | | | | |
| a | -Weight Sensor | $20.50 | $24.45 | | | | |
| b | -Presence Sensor | $41.15 | $60.90 | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | | | | | | |
| a | - modified fold patterns/inflators | NA | NA | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflators | $3.60 | $20.35 | $1.50 | $18.85 | $5.10 | $39.20 |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | | | | | | |
| a | - modified fold patterns/inflators | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflator | $0.00 | $19.85 | $0.00 | $20.85 | $0.00 | $40.70 |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | | | | | | |
| a | - added sensors | $0.00 | $6.35 | $0.00 | $6.35 | $0.00 | $12.70 |
| b | - Multi-stage inflators | $3.60 | $20.35 | $1.50 | $18.85 | $5.10 | $39.20 |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | | | | | | |
| a | - modified fold patterns/inflators | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflator | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | | | | | | |
| a | -modified fold patterns | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #1** | $20.50 | $103.95 | $0.00 | $18.85 | $20.50 | $122.80 |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+4a | 1a+1b+4b** | 2a+4a | 2b+4b | | |
| 2 | Low Risk Deployment - Driver | +5a+6a** | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #2** | $24.10 | $44.80 | $0.00 | $18.85 | $24.10 | $63.65 |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+2b+4a | 1a+2b+4b | 2a+4a | 2b+4b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +5a+6a | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #1** | $20.50 | $103.45 | $0.00 | $20.85 | $20.50 | $124.30 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 2 | Low Risk Deployment - Driver | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #2** | $24.10 | $44.30 | $0.00 | $20.85 | $24.10 | $65.15 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |

Table VIII-2
Present Discounted Value of Property Damage Saving (7% RATE)

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | TEST -SYSTEMS | Low | High | Low | High | Low | High |
| | | | | | | | |
| 1 | Suppression w/ Child Presence | $12.15 | $84.80 | | | | |
| a | -Weight Sensor | $12.15 | $84.80 | | | | |
| b | -Presence Sensor | | | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | NA | NA | $0.00 | $0.00 | $0.00 | $0.00 |
| a | - modified fold patterns/inflators | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflators | | | | | | |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| a | - modified fold patterns/inflators | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflator | | | | | | |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| a | - added sensors | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflators | | | | | | |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| a | - modified fold patterns/inflators | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflator | | | | | | |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| a | -modified fold patterns | | | | | | |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | $12.15 | $84.80 | $0.00 | $0.00 | $12.15 | $84.80 |
| | **ALT#1, Compliance Option #1** | 1a+4a | 1a+1b+4b** | 2a+4a | 2b+4b | | |
| 4,5,6 | Offset and Frontal Barrier Tests | +5a+6a** | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | $12.15 | $84.80 | $0.00 | $0.00 | $12.15 | $84.80 |
| | **ALT#1, Compliance Option #2** | 1a+2b+4a | 1a+2b+4b | 2a+4a | 2b+4b | | |
| 4,5,6 | Offset and Frontal Barrier Tests | +5a+6a | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |
| | | $12.15 | $84.80 | $0.00 | $0.00 | $12.15 | $84.80 |
| | **ALT#2, Compliance Option #1** | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 3,4,6 | Offset and Frontal Barrier Tests | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | $12.15 | $84.80 | $0.00 | $0.00 | $12.15 | $84.80 |
| | **ALT#2, Compliance Option #2** | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 3,4,6 | Offset and Frontal Barrier Tests | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |

*High and Low estimates represent maximum range of costs.

Table VIII-3
Net Consumer Costs (Savings)

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | TEST -SYSTEMS | Low | High | Low | High | Low | High |
| | | | | | | | |
| 1 | Suppression w/ Child Presence | | | | | | |
| a | -Weight Sensor | $8.35 | ($60.35) | | | | |
| b | -Presence Sensor | $29.00 | ($23.90) | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | | | | | | |
| a | - modified fold patterns/inflators | NA | NA | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflators | $3.60 | $20.35 | $1.50 | $18.85 | $5.10 | $39.20 |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | | | | | | |
| a | - modified fold patterns/inflators | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflator | $0.00 | $19.85 | $0.00 | $20.85 | $0.00 | $40.70 |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | | | | | | |
| a | - added sensors | $0.00 | $6.35 | $0.00 | $6.35 | $0.00 | $12.70 |
| b | - Multi-stage inflators | $3.60 | $20.35 | $1.50 | $18.85 | $5.10 | $39.20 |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | | | | | | |
| a | - modified fold patterns/inflators | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| b | - Multi-stage inflator | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | | | | | | |
| a | -modified fold patterns | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #1** | $8.35 | $19.15 | $0.00 | $18.85 | $8.35 | $38.00 |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+4a | 1a+1b+4b** | 2a+4a | 2b+4b | | |
| 2 | Low Risk Deployment - Driver | +5a+6a** | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #2** | $11.95 | ($40.00) | $0.00 | $18.85 | $11.95 | ($21.15) |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+2b+4a | 1a+2b+4b | 2a+4a | 2b+4b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +5a+6a | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #1** | $8.35 | $18.65 | $0.00 | $20.85 | $8.35 | $39.50 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 2 | Low Risk Deployment - Driver | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #2** | $11.95 | ($40.50) | $0.00 | $20.85 | $11.95 | ($19.65) |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |

*High and Low estimates represent maximum range of costs.

Total Present Discounted Value of Consumer Costs (Savings) (7% RATE)

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | Test Systems | Low | High | Low | High | Low | High |
| 1 | Suppression w/ Child Presence | | | | | | |
| a | -Weight Sensor | $129,425,000 | ($935,425,000) | | | | |
| b | -Presence Sensor | $449,500,000 | ($370,450,000) | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | | | | | | |
| a | - modified fold patterns/inflators | NA | NA | $0 | $0 | $0 | $0 |
| b | - Multi-stage inflators | $55,800,000 | $315,425,000 | $23,250,000 | $292,175,000 | $79,050,000 | $607,600,000 |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | | | | | | |
| a | - modified fold patterns/inflators | $0 | $0 | $0 | $0 | $0 | $0 |
| b | - Multi-stage inflator | $0 | $307,675,000 | $0 | $323,175,000 | $0 | $630,850,000 |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | | | | | | |
| a | - added sensors | $0 | $98,425,000 | $0 | $98,425,000 | $0 | $196,850,000 |
| b | - Multi-stage inflators | $55,800,000 | $315,425,000 | $23,250,000 | $292,175,000 | $79,050,000 | $607,600,000 |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | | | | | | |
| a | - modified fold patterns/inflators | $0 | $0 | $0 | $0 | $0 | $0 |
| b | - Multi-stage inflator | $0 | $0 | $0 | $0 | $0 | $0 |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | | | | | | |
| a | -modified fold patterns | $0 | $0 | $0 | $0 | $0 | $0 |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #1 | $129,425,000 | $296,825,000 | $0 | $292,175,000 | $129,425,000 | $589,000,000 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #2 | $185,225,000 | ($620,000,000) | $0 | $292,175,000 | $185,225,000 | ($327,825,000) |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #1 | $129,425,000 | $289,075,000 | $0 | $323,175,000 | $129,425,000 | $612,250,000 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 2 | Low Risk Deployment - Driver | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #2 | $185,225,000 | ($627,750,000) | $0 | $323,175,000 | $185,225,000 | ($304,575,000) |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |

Table VIII-5
Lives Saved

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | TEST -SYSTEMS | Low | High | Low | High | Low | High |
| | | | | | | | |
| 1 | Suppression w/ Child Presence | | | | | | |
| a | -Weight Sensor | 93 | 93 | | | | |
| b | -Presence Sensor | 93 | 122 | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | | | | | | |
| a | - modified fold patterns/inflators | NA | NA | 24 | 24 | 24 | 24 |
| b | - Multi-stage inflators | 137 | 137 | 40 | 40 | 177 | 177 |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | | | | | | |
| a | - modified fold patterns/inflators | 10 | 10 | 13 | 13 | 23 | 23 |
| b | - Multi-stage inflator | 147 | 147 | 53 | 53 | 200 | 200 |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | | | | | | |
| a | - added sensors | 4 | 12 | 36 | 36 | 40 | 48 |
| b | - Multi-stage inflators | 139 | 147 | 58 | 58 | 197 | 205 |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | | | | | | |
| a | - modified fold patterns/inflators | -72 | -40 | -278 | -145 | -350 | -185 |
| b | - Multi-stage inflator | 52 | 84 | -269 | -136 | -217 | -52 |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | | | | | | |
| a | -modified fold patterns | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #1** | 23 | 96 | -260 | -118 | -237 | -22 |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+4a | 1a+1b+4b | 2a+4a | 2b+4b | | |
| 2 | Low Risk Deployment - Driver | +5a+6a** | +5b+6a** | +5a+6a | +5b+6a | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #2** | 54 | 94 | -260 | -118 | -206 | -24 |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+2b+4a | 1a+2b+4b | 2a+4a | 2b+4b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +5a+6a | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #1** | 107 | 159 | 55 | 71 | 162 | 230 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 2 | Low Risk Deployment - Driver | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #2** | 149 | 157 | 55 | 71 | 204 | 228 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |

Table VIII-6
Present Discounted Value of Lives Saved (7% RATED)

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | TEST -SYSTEMS | Low | High | Low | High | Low | High |
| | | | | | | | |
| 1 | Suppression w/ Child Presence | | | | | | |
| a | -Weight Sensor | 67 | 67 | | | | |
| b | -Presence Sensor | 67 | 88 | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | | | | | | |
| a | - modified fold patterns/inflators | NA | NA | 17 | 17 | 17 | 17 |
| b | - Multi-stage inflators | 99 | 99 | 29 | 29 | 128 | 128 |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | | | | | | |
| a | - modified fold patterns/inflators | 7 | 7 | 9 | 9 | 17 | 17 |
| b | - Multi-stage inflator | 106 | 106 | 38 | 38 | 144 | 144 |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | | | | | | |
| a | - added sensors | 3 | 9 | 26 | 26 | 29 | 35 |
| b | - Multi-stage inflators | 100 | 106 | 42 | 42 | 142 | 148 |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | | | | | | |
| a | - modified fold patterns/inflators | -52 | -29 | -201 | -105 | -253 | -133 |
| b | - Multi-stage inflator | 38 | 61 | -194 | -98 | -157 | -38 |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | | | | | | |
| a | -modified fold patterns | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #1** | 17 | 69 | -188 | -85 | -171 | -16 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #2** | 39 | 68 | -188 | -85 | -149 | -17 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #1** | 77 | 115 | 40 | 51 | 117 | 166 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 2 | Low Risk Deployment - Driver | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #2** | 108 | 113 | 40 | 51 | 147 | 165 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |

Table VIII-7
Nonfatal Injuries Prevented

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | TEST -SYSTEMS | Low | High | Low | High | Low | High |
| | | | | | | | |
| 1 | Suppression w/ Child Presence | | | | | | |
| a | -Weight Sensor | 151 | 151 | | | | |
| b | -Presence Sensor | 151 | 206 | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | | | | | | |
| a | - modified fold patterns/inflators | NA | NA | 20 | 20 | 20 | 20 |
| b | - Multi-stage inflators | 517 | 517 | 1069 | 1069 | 1586 | 1586 |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | | | | | | |
| a | - modified fold patterns/inflators | 85 | 85 | 99 | 99 | 184 | 184 |
| b | - Multi-stage inflator | 602 | 602 | 1168 | 1168 | 1770 | 1770 |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | | | | | | |
| a | - added sensors | 101 | 229 | 54 | 54 | 155 | 283 |
| b | - Multi-stage inflators | 615 | 743 | 1105 | 1105 | 1720 | 1848 |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | | | | | | |
| a | - modified fold patterns/inflators | 320 | 320 | 1062 | 1062 | 1382 | 1382 |
| b | - Multi-stage inflator | 517 | 517 | 1069 | 1069 | 1586 | 1586 |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | | | | | | |
| a | -modified fold patterns | 6 | 16 | 0 | 0 | 6 | 16 |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #1** | 569 | 754 | 1098 | 1105 | 1667 | 1859 |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+4a | 1a+1b+4b | 2a+4a | 2b+4b | | |
| 2 | Low Risk Deployment - Driver | +5a+6a** | +5b+6a** | +5a+6a | +5b+6a | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #2** | 615 | 744 | 1098 | 1105 | 1713 | 1849 |
| 4,5,6 | Offset and Frontal Barrier Tests | 1a+2b+4a | 1a+2b+4b | 2a+4a | 2b+4b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +5a+6a | +5b+6a*** | +5a+6a | +5b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #1** | 343 | 855 | 155 | 1204 | 498 | 2059 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 2 | Low Risk Deployment - Driver | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #2** | 707 | 845 | 155 | 1204 | 862 | 2049 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |

Table VIII-8
Percent Discounted Value of Nonfatal Injuries Prevented (7%RATE)

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| Ref. # | TEST -SYSTEMS | Low | High | Low | High | Low | High |
| | | | | | | | |
| 1 | Suppression w/ Child Presence | | | | | | |
| a | -Weight Sensor | 109 | 109 | | | | |
| b | -Presence Sensor | 109 | 149 | | | | |
| | | | | | | | |
| 2 | Low Risk Deployment | | | | | | |
| a | - modified fold patterns/inflators | NA | NA | 14 | 14 | 14 | 14 |
| b | - Multi-stage inflators | 373 | 373 | 771 | 771 | 1144 | 1144 |
| | | | | | | | |
| 3 | 30 mph, 5th female, Blt. &Unblt. | | | | | | |
| a | - modified fold patterns/inflators | 61 | 61 | 71 | 71 | 133 | 133 |
| b | - Multi-stage inflator | 434 | 434 | 843 | 843 | 1277 | 1277 |
| | | | | | | | |
| 4 | 25 mph Offset Barrier Test | | | | | | |
| a | - added sensors | 73 | 165 | 39 | 39 | 112 | 204 |
| b | - Multi-stage inflators | 444 | 536 | 797 | 797 | 1241 | 1333 |
| | | | | | | | |
| 5 | 25 mph Unblted, 5th fem, 50th male | | | | | | |
| a | - modified fold patterns/inflators | 231 | 231 | 766 | 766 | 997 | 997 |
| b | - Multi-stage inflator | 373 | 373 | 771 | 771 | 1144 | 1144 |
| | | | | | | | |
| 6 | Frontal Barrier Test, 50th male | | | | | | |
| a | -modified fold patterns | 4 | 12 | 0 | 0 | 4 | 12 |
| | | | | | | | |
| | **COMPLIANCE SCENARIOS:*** | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #1** | 411 | 544 | 792 | 797 | 1203 | 1341 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#1, Compliance Option #2** | 444 | 537 | 792 | 797 | 1236 | 1334 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #1** | 247 | 617 | 112 | 869 | 359 | 1486 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+3a+ | 1a+1b+3b** | 2a+3a | 2b+3b | | |
| 2 | Low Risk Deployment - Driver | +4a+6a** | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | **ALT#2, Compliance Option #2** | 510 | 610 | 112 | 869 | 622 | 1478 |
| 3,4,6 | Offset and Frontal Barrier Tests | 1a+2b+3a | 1a+2b+3b | 2a+3a | 2b+3b | | |
| 2 | Low Risk Depl. - Driver & Pass. | +4a+6a | +4b+6a*** | +4a+6a | +4b+6a*** | | |
| 1 | Suppression - Infant | | | | | | |

Table VIII-9
Calculation of Cost Per Equivalent
Fataltiy and Weighted Fatal Equivalents

| Injury Severity | Comp. Value | Property Damage | Travel Delay | Revised Comp. Value | Relative | 1994 PR Incidence | MAIS 2-5 Distribution | MAIS 3-5 Distribution | MAIS 2-5/ Fatality | MAIS 3-5/ Fatality |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| MAIS1 | 10840 | 3263 | 203 | 7374 | 0.0026 | | | | | |
| MAIS2 | 133700 | 3356 | 203 | 130141 | 0.0457 | 335465 | 65.09% | | 0.03 | |
| MAIS3 | 472290 | 5771 | 203 | 466316 | 0.1639 | 155961 | 30.26% | 86.70% | 0.05 | 0.14 |
| MAIS4 | 1193860 | 8346 | 202 | 1185312 | 0.4166 | 17008 | 3.30% | 9.46% | 0.01 | 0.04 |
| MAIS5 | 2509310 | 8018 | 203 | 2501089 | 0.8791 | 6914 | 1.34% | 3.84% | 0.01 | 0.03 |
| Fatal | 2854500 | 9138 | 453 | 2844909 | 1.0000 | | | | | |
| | | | | | | 515348 | 100.00% | 100.00% | 0.10 | 0.22 |
| | | | | | | 179883 | | | | |
| | | | | | | | | | | |

| Percent Injuries from At-Risk Group | | | | Average Weighted Fatal Equivalents | | | |
|---|---|---|---|---|---|---|---|
| Passenger | | Driver | | Passenger | | Driver | |
| Low | High | Low | High | Low | High | Low | High |
| | | | | | | | |
| 28.47% | 29.05% | 2.37% | 2.99% | 0.1364 | 0.1370 | 0.1075 | 0.1082 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 33.98% | 28.09% | 2.37% | 2.99% | 0.1424 | 0.1359 | 0.1075 | 0.1082 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 44.90% | 25.61% | 12.90% | 2.74% | 0.1545 | 0.1332 | 0.1192 | 0.1080 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 29.56% | 24.73% | 12.90% | 2.74% | 0.1376 | 0.1322 | 0.1192 | 0.1080 |

Table III-10
Equivalent Fatalities from Nonfatal Injuries (Discounted @ 7%)

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| | | Low | High | Low | High | Low | High |
| **COMPLIANCE SCENARIOS:*** | | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #1 | 56 | 75 | 85 | 86 | 141 | 161 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #2 | 63 | 73 | 85 | 86 | 148 | 159 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #1 | 38 | 82 | 13 | 94 | 52 | 176 |
| 3,4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #2 | 70 | 81 | 13 | 94 | 83 | 174 |
| 3,4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |

Table VIII-11
Total Equivalent Fatalities (Discounted @ 7%)

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| | | Low | High | Low | High | Low | High |
| **COMPLIANCE SCENARIOS:*** | | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #1 | 73 | 144 | -102 | 1 | -30 | 145 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #2 | 102 | 141 | -102 | 1 | 0 | 142 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #1 | 115 | 197 | 53 | 145 | 168 | 342 |
| 3,4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #2 | 178 | 194 | 53 | 145 | 231 | 339 |
| 3,4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |

Table VIII-12
Net Cost (Savings) Per Equivalent Fatality Saved

| | | Passenger | | Driver | | Combined | |
|---|---|---|---|---|---|---|---|
| | | Low | High | Low | High | Low | High |
| **COMPLIANCE SCENARIOS:*** | | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #1 | $1,772,945 | $2,061,285 | $0 | $292,175,000 | NS | $4,062,069 |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#1, Compliance Option #2 | $1,815,931 | ($4,397,163) | $0 | $292,175,000 | ZS | NC |
| 4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #1 | $1,125,435 | $1,467,386 | $0 | $2,228,793 | $770,387 | $1,790,205 |
| 3,4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Deployment - Driver | | | | | | |
| 1 | Suppression - Passengers | | | | | | |
| | | | | | | | |
| | ALT#2, Compliance Option #2 | $1,040,590 | ($3,235,825) | $0 | $2,228,793 | $801,840 | NC |
| 3,4,5,6 | Offset and Frontal Barrier Tests | | | | | | |
| 2 | Low Risk Depl. - Driver & Pass. | | | | | | |
| 1 | Suppression - Infant | | | | | | |

NS = Negative safety benefits
NC = No cost, or a net cost savings
ZS = No net safety impact

# IX. 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 seq.) requires agencies to evaluate the potential effects of their proposed 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. Section 603(b) of the Act specifies the content of a RFA. 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.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

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 statutes and which minimize any significant economic impact of the final rule on small entities.

1. Description of the reasons why action by the agency is being considered

NHTSA is considering this action to preserve and enhance the benefits of air bags for all occupants while eliminating or minimizing the risk of air bag induced injuries.

The sheer number and variety of available technological opportunities creates special challenges from a regulatory perspective. While the availability of multiple technologies provide more opportunity to the current problem with air bags, it also means that the agency must take special care to ensure that the regulatory language it adopts would not be unnecessarily design-restrictive.

While air bags are highly effective in reducing the likelihood of death or serious injury in motor vehicle crashes, the degree of their effectiveness depends upon the correct combination of the air bags' speed and aggressiveness of inflation and the positioning of the occupant at the time of deployment.

2. Objectives of, and legal basis for, the final rule

The final rule requires that motor vehicles be tested to minimize the risk of air bag injury to (a) drivers which end up too close to the air bag and (b) children if placed in the front passenger-side seat.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

NHTSA has issued this final rule under the authority of the NHTSA Reauthorization Act of 1998 and 49 U.S.C. 322, 30111, 30115, 30117 and 30166; delegation of authority at 49 CFR 1.50. The agency is authorized to issue Federal motor vehicle safety standards that meet the need for motor vehicle safety.

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

The final rule would affect motor vehicle manufacturers, second-stage or final-stage manufacturers, alterers, air bag manufacturers, dummy manufacturers, and manufacturers of seating systems. Business entities are generally defined as small businesses by Standard Industrial Classification (SIC) code, for the purposes of receiving Small Business Administration assistance. One of the criteria for determining size, as stated in 13 CFR 121.201, is the number of employees in the firm. To qualify as a small business in the Motor Vehicles and Passenger Car Bodies (SIC 3711), the firm must have fewer than 1,000 employees. For air bag manufacturers and seating systems suppliers to qualify as a small business in the Motor Vehicle Parts and Accessories category (SIC 3714), the firm must have fewer than 750 employees. Test dummy manufacturers must have fewer than 500 employees to qualify as a small business.

Small vehicle manufacturers

Currently, there are about 4 small motor vehicle manufacturers in the United States. These manufacturers will have difficulty certifying compliance with the tests, just as it is currently hard for them to meet the air bag requirements. Many of these manufacturers have in the past petitioned NHTSA for temporary relief on the air bag rule because of economic hardship. This proposal would

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

add to their difficulties. Much of the air bag work for these small vehicle manufacturers is done by air bag suppliers.

In the SNPRM, NHTSA proposed that manufacturers with production of fewer than 5,000 vehicles per year be able to wait until the end of the phase-in period to meet the new requirements. These small manufacturers typically purchase air bag equipment from suppliers, who are busy supplying larger companies during the phase-in period. The Coalition of Small Volume Automobile Manufacturers (COSVAM) (Docket No. 99-6407-32) supported the proposal for the effective date being at the end of the phase-in period, but suggested that the limit be 10,000 vehicles per year. COSVAM argued that the limit should be based on the overall statutory scheme and not on current production volumes. COSVAM stated that the 1999 production of its member companies ranged from 300 to 4,000 units.

Final stage manufacturers and alterers

There are a significant number (several hundred) of second-stage or final-stage manufacturers and alterers that could be impacted by the final rule. These manufacturers buy incomplete vehicles or add seating systems to vehicles without seats, or take out existing seats and add new seats. Many of these vehicles are van conversions, but there are a variety of vehicles affected. The common thread for these vehicles and most of the problems arise when the seat becomes involved. If an original equipment vehicle manufacturer uses a sensing system in the seat for weight sensing or presence sensing, then the second-stage manufacturer or alterer may need to use seats from the original manufacturer or will have to rely on a supplier to provide the same technology for their seats. If not, then the second-stage

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

manufacturer or alterer may only be able to recover the seat, or they would have to certify compliance in some other way.

The generic sled test has made it easier currently for these manufacturers to certify compliance. The Recreation Vehicle Industry Association (Docket # 99-6407-35) urged NHTSA to continue to allow small volume manufacturers and alterers to certify compliance with FMVSS 208 by means of a generic sled test pulse. The agency realizes that crash testing a number of vehicles is not financially practical for these manufacturers. However, it is up to the manufacturers to determine the best way to assure compliance of their vehicles. Certainly, sled testing is an accepted engineering practice. But it does not test all of the attributes (such as weight sensing or presence sensing) of the countermeasures that may be utilized to meet the final rule. These manufacturers will have a more difficult time and more expense certifying to the final rule with some advanced air bag systems. If they rely on suppliers to provide the same technology, then it involves an additional expense and engineering to get the technology into the seat and probably testing to assure compliance. These costs would have to be passed on to the consumers.

One of their more difficult challenges is getting changed models and the information needed for pass-through certification from the first-stage manufacturer in time to certify vehicles in the beginning of the model year. RVIA requests a one-year extension for compliance after the 100 percent phase-in for regular production. The agency is fulfilling this request to the extent possible. For a discussion of this issue see the leadtime discussion at the end of Chapter VII.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

The National Truck Equipment Association (NTEA) provided the following comments (Docket No. 99-6407-31). NTEA has 1,600 member companies throughout the nation, virtually all of them are small businesses. To demonstrate compliance with FMVSS 208, a final stage manufacturer must primarily rely upon the chassis manufacturers certification of compliance. To pass through compliance, the final stage manufacturer must complete the vehicle in accordance with the chassis manufacturers instructions. In some cases, based on market demands and chassis manufacturers instructions, this may not be possible. Additionally, in the case of vehicles completed from incomplete chassis cabs, such as chassis cowls, chassis cutaways, and strip chassis, such a "pass through" is not available under NHTSA certification regulations. NTEA does not believe there is a significant population of vehicles produced from such non-chassis cab incomplete vehicles which are required to meet FMVSS 208 (that would be at 8,500 lbs. GVWR or less). As a practical matter, the chassis manufacturers need to do a great deal of work to come up with the compliance information for use by multi-stage manufacturers in order for the pass-through to be available. Typically, the chassis manufacturers leave this work for last. If such information is not available, the small businesses will have no means to provide compliance information. Hence, it is vitally important that the chassis manufacturers be given as much time as possible, and NTEA requests that the phase-in start September 1, 2003 and be fully effective September 1, 2006 as allowed in the NHTSA Reauthorization Act of 1998.

Air bag suppliers

There are about five main suppliers of air bag systems. (TRW, Autoliv, Breed, Takata, Delphi.) None of these suppliers would be considered a small business. There might be some second and third tier manufacturers of components of air bags or of sensors that are small businesses, but the agency does

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

not believe there are a substantial number. These final rules should have a positive effect on the air bag manufacturers and on the second and third tier manufacturers of air bag components.

Test dummy manufacturers

The final rule should have a 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. There are currently four manufacturers of dummies or parts of dummies (First Technology Safety Systems, Advanced Safety Technology Corp., UTAMA, and GESAC). All of these would qualify as small businesses with less than 500 employees. There are four manufacturers of load cells (R.A. Denton, First Technology Safety Systems, Sensor Developments, Inc., and Sensotec) and two manufacturers of accelerometers (Endevco and Entran). All of these manufacturers are believed to be small business except Endevco.

Suppliers of seating systems

In the PEA, NHTSA stated that it knows of 11 suppliers of seating systems, that supply seats to van converters and others, that are small businesses. Depending on the technology chosen to meet the final advanced air bag rule, these suppliers will have to keep up with the technology in order to retain their business.

Borneman Products Incorporated (Docket 6407 #57and #65) is a small business seating company and provided substantial comments. Their conclusion is that the cost per vehicle and the impact on small business would be devastating, and not just for seating companies. Borneman estimated the barrier test

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

costs to cover three lines of products for one manufacturer would be at least 12 tests at $62,666 per test for a total of $752,000, assuming no impact simulations and no "failures" in the process. The cost per unit, if Borneman provided a test program for a collection of customers would be $192 to $294.

Borneman argued that this rule could have a devastating impact on an entire industry that supplies a "niche" market of custom individuality vehicles. There are about 30 seating companies that supply products in the multi-stage vehicle market with probably $80 million in sales and 2,500 employees. Supplying them are about 130 firms with about 5,000 employees that produce leathers and fabrics, foam products, steel supplies, recliners and seat tracks. In addition, since seats are the most important component of the custom individuality market, if the ability to provide custom seats is taken away, then the whole market for custom individuality vehicles may eliminated and you would have to consider the suppliers of carpets, fabrics, wood, plastics, steel, etc. that provide products to alterers and multi-stage manufacturers of which there are about 550 vendors with 18,000 employees. Borneman argues that with this rule, you risk eliminating the "niche" light-truck market completely, because it is most likely that the OEM vehicle manufacturers will be reluctant to allow any changes to their chassis, including not only the front seats, but also anything that could impact the air bags and the firing systems. This will reduce the market further than it has been, to virtually nothing as it's known today.

The major alternatives considered for this final rule are whether the high speed rigid barrier test should be at 25 or 30 mph. This does not affect the problems seat manufacturers will have with the new technology added for out-of-position problems, like seat sensors and position sensors. All commenters agree that the agency must reduce the out-of-position problems. Thus, the agency has no choice but to

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

require that all vehicles meet the out-of-position test. Meeting the out-of-position tests cause the biggest problems for small seating companies who supply seats to van conversions etc.

Borneman estimates the cost of complying with the rigid barrier tests. Again, this testing cost is the same, whichever high speed rigid barrier test is chosen. However, these manufacturers don't necessarily need to do rigid barrier testing. Certainly, sled testing is an accepted engineering practice. But sled testing does not test all of the attributes (such as weight sensing or presence sensing) of the countermeasures that may be utilized to meet the final rule. These manufacturers will have a more difficult time and more expense certifying to the final rule with advanced air bag systems than they have had in the past. However, there products must provide the same level of safety as the original vehicle manufacturers' products. The agency believes these manufacturers will have two choices to comply with the standard. Either:

a) They rely on suppliers to provide the same technology (weight sensing, or whatever) to them as was supplied to the OEM manufacturers, then it involves an additional expense and engineering to get the technology into the seat and possibly static testing to assure compliance with the out-of-position tests if the compliance certification can't be passed on from the supplier. They also have to certify compliance for the rigid barrier test, which possibly could consist of a sled test. These costs would have to be passed on to the consumers. or

b) They purchase the full seat from the OEM manufacturers and recover the seat only, keeping the technology in place. This process was used in the past until information from the original vehicle manufacturers on pass through certification became available and design decisions and testing were made. Similarly, they would have to certify compliance.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Keeping up with technology is not a new problem for these manufacturers. This happens all the time and it will occur more and more as new technology is added to seating systems, including side air bags. The job might not be easy, but they will have to keep up to stay in business. The issue to be addressed by the Regulatory Flexibility Act is whether there are alternatives available that can make compliance easier for small business and not impact safety. The only alternative recommended by commenters was to increase the leadtime for multi-stage manufacturers and alterers. The agency has provided a method for these manufacturers to potentially have one more year of leadtime than the original vehicle manufacturers. That is discussed in the leadtime section.

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

The final rule adopts new performance requirements that would enhance the safety of children and small stature adults. Motor vehicle manufacturers would have to certify that their products comply with the final rule. Manufacturers could use any means to determine that their products comply, so long as they exercise due care in making their certification.

With the phase-in leadtime, manufacturers would be required to report to the agency how they met the phase-in schedule. Reporting of compliance is a small cost, simply requiring clerical skills for its preparation, compared to the flexibility it provides manufacturers in meeting the final rule.

5. Duplication with other Federal rules

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

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

6. Description of any significant alternatives to the final rule

NHTSA has provided through the final rule phase-in leadtime schedule the only way it could think of to help out these small businesses which would minimize the economic impact of the final rule on small entities. Consistent with the stated objectives, the agency is allowing for a longer lead time for small manufacturers (those with less than 5,000 vehicle sales worldwide) and multi-stage manufacturers and alterers to reduce their burden to the extent possible.

As discussed above, depending upon what technologies are employed and how they affect front seating systems, this final rule could have a significant economic impact on a substantial number of small businesses in the short run. If seating systems are affected by the new technology and if seating suppliers handle this new technology well, they may be able to supply the same technology as used by the original first-stage manufacturers. Thus, the economic impact on the substantial number of small businesses need not be significant in the long run. Leadtime considerations have been made to help these small businesses in the short run.

**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). The assessment may be included in conjunction with other assessments, as it is here.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

This final rule on advance air bags is not likely to result in expenditures by State, local or tribal governments of more than $100 million annually. However, it is estimated to result in the expenditure by automobile manufacturers and/or their suppliers of more than $100 million annually. Since this final rule allows a variety of methods to comply, which have a variety of costs ranging from at least $20 per vehicle for 15.5 million vehicles, it will easily exceed $100 million. The final cost will depend on choices made by the automobile manufacturers.

These effects have been discussed in the Final Economic Assessment, see for example the chapters on Cost, Benefits and the previous discussion in this chapter on the Regulatory Flexibility Act.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

# X. CUMULATIVE IMPACTS OF RECENT RULEMAKINGS

Section 1(b) II of Executive Order 12866 Regulatory Planning and Review requires the agencies to take into account to the extent practicable "the costs of cumulative regulations". To adhere to this requirement, the agency has decided to examine both the costs and benefits by vehicle type of all substantial final rules with a cost or benefit impact effective from MY 1990 or later. In addition, proposed rules should also be identified and preliminary cost and benefit estimates provided. Besides this rule, in which the costs and benefits are described previously, there are no major outstanding proposals that have quantified costs and benefits.

Costs include primary cost, secondary weight costs and the lifetime discounted fuel costs for both primary and secondary weight. Costs will be presented in two ways, the cost per affected vehicle and the average cost over all vehicles. The cost per affected vehicle includes the range of costs that any vehicle might incur. For example, if two different vehicles need different countermeasures to meet the standard, a range will show the cost for both vehicles. The average cost over all vehicles takes into account voluntary compliance before the rule was promulgated or planned voluntary compliance before the rule was effective and the percent of the fleet for which the rule is applicable. Costs are provided in 1997 dollars, using the implicit GNP deflator to inflate previous estimates to 1997 dollars.

Benefits are provided on an annual basis for the fleet once all vehicles in the fleet meet the rule. Benefit and cost per average vehicle estimates take into account voluntary compliance.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table X-1

COSTS OF RECENT PASSENGER CAR RULEMAKINGS
(Includes Secondary Weight and Fuel Impacts)
(1997 Dollars)

| Description | Effective Model Year | Cost Per Affected Vehicle $ | Cost Per Average Vehicle $ |
|---|---|---|---|
| FMVSS 114, Key Locking System to Prevent Child-Caused Rollaway | 1993 | $8.99 - 18.65 | $0.50 - 1.03 |
| FMVSS 214, Dynamic Side Impact Test | 1994 - 10% phase-in<br>1995 - 25%<br>1996 - 40%<br>1997 - 100% | $65.77 - 640.56 | $59.54 |
| FMVSS 208, Locking Latch Plate for Child Restraints | 1996 | $0.85 - 17.07 | $2.29 |
| FMVSS 208, Belt Fit | 1998 | $3.25 - 16.28 | $1.20 - 1.73 |
| FMVSS 208, Air Bags Required | 1997 - 95%<br>1998 - 100 | $479.52 - 579.42 | $479.52 - 579.42 |
| FMVSS 201, Upper Interior Head Protection | 1999 - 10%<br>2000 - 25%<br>2001 - 40%<br>2002 - 70%<br>2003 - 100% | $35.96 | $35.96 |
| FMVSS 225, Child Restraint Anchorage Systems | 2001 - 20%<br>2002 - 50%<br>2003 - 100% | $2.87 - $6.74 | $5.78 |

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table X-2

BENEFITS OF RECENT PASSENGER CAR RULEMAKINGS
(Annual benefits when all vehicles meet the standard)

| Description | Fatalities Prevented | Injuries Reduced | Property Damage Savings $ |
|---|---|---|---|
| FMVSS 114, Key Locking System to Prevent Child Caused Rollaway | None | 50-99 Injuries | Not Estimated |
| FMVSS 214, Dynamic Side Impact Test | 512 | 2,626 AIS 2-5 | None |
| FMVSS 208, Locking Latch Plate for Child Restraints | Not estimated | Not estimated | None |
| FMVSS 208, Air Bags Required Compared to 12.5% Usage in 1983 | 4,570 - 9,110 | AIS 2-5<br>85,930 - 155,090 | None |
| Compared to 46.1% Usage in 1991 | 2,842 - 4,505 | 63,000 - 105,000 | |
| FMVSS 201, Upper Interior Head Protection | 575 - 711 | 251 - 465 AIS 2-5 | None |
| FMVSS 225, Child Restraint Anchorage Systems – Benefits include changes to Child Restraints in FMVSS 213 | 36 to 50* | 1,231 to 2,929* | None |

* Total benefits for passenger cars and light trucks

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

. Table X-3
COSTS OF RECENT LIGHT TRUCK RULEMAKINGS
(Includes Secondary Weight and Fuel Impacts)
(1997 Dollars)

| Description | Effective Model Year | Cost Per Affected Vehicle $ | Cost Per Average Vehicle $ |
|---|---|---|---|
| FMVSS 202, Head Restraints | 1992 | $44.64 - 108.29 | $5.28 |
| FMVSS 204, Steering Wheel Rearward Displacement for 4,000 to 5,500 lbs. unloaded | 1992 | $5.76 - 28.52 | $1.02 - 1.93 |
| FMVSS 208, Rear Seat Lap/Shoulder Belts | 1992 | $65.95 | $0.39 |
| FMVSS 114, Key Locking System to Prevent Child-Caused Rollaway | 1993 | $8.99 - 18.65 | $0.01 - 0.03 |
| FMVSS 208, Locking Latch Plate for Child Restraints | 1996 | $0.85 - 17.07 | $2.29 |
| FMVSS 108, Center High-Mounted Stop Lamp | 1994 | $14.34 - 21.68 | $14.79 |
| FMVSS 214, Quasi-Static Test (side door beams) | 1994 - 90%<br>1995 - 100 | $64.17 - 80.48 | $59.48 - 74.71 |
| FMVSS 216, Roof Crush for 6,000 lbs. GVWR or less | 1995 | $23.63 - 212.05 | $0.85 - 8.40 |
| FMVSS 208, Belt Fit | 1998 | $3.59 - 16.98 | $6.13 - 8.27 |
| FMVSS 208, Air Bags Required | 1998 - 90%<br>1999 - 100 | $479.52 - 579.42 dual air bags | $478.52 - 597.42 dual air bags |
| FMVSS 201, Upper Interior Head Protection | 1999 - 10%<br>2000 - 25%<br>2002 - 70%<br>2003 - 100% | $35.62 - 78.00 | $54.97 |
| FMVSS 225, Child Restraint Anchorage Systems | 2001 - 20%<br>2002 - 50%<br>2003 - 100% | $2.87 - $6.74 | $5.78 |

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table X-4

BENEFITS OF RECENT LIGHT TRUCK RULEMAKINGS
(Annual benefits when all vehicles meet the standard)

| Description | Fatalities Prevented | Injuries Reduced | Property Damage Savings $ |
|---|---|---|---|
| FMVSS 202, Head Restraints | None | 470 - 835 AIS 1<br>20 - 35 AIS 2 | None |
| FMVSS 204, Steering Wheel Rearward Displacement for 4,000 to 5,500 lbs. unloaded | 12 - 23 | 146 - 275 AIS 2-5 | None |
| FMVSS 208, Rear Seat Lap/Shoulder Belts | None | 2 AIS 2-5 | None |
| FMVSS 114, Key Locking System to Prevent Child Caused Rollaway | None | 1 Injury | Not Estimated |
| FMVSS 208, Locking Latch Plate for Child Restraint | Not estimated | Not estimated | None |
| FMVSS 108, Center High Mounted Stop Lamp | None | 19,200 to 27,400 Any AIS Level | $119 to 164 Million |
| FMVSS 214, Quasi-Static Test (side door beams) | 58 - 82 | 1,569 to 1,889 hospitalizations | None |
| FMVSS 216, Roof Crush for 6,000 lbs. GVWR or less | 2 - 5 | 25-54 AIS 2-5 | None |
| FMVSS 208, Belt Fit | 9 | 102 AIS 2-5 | None |
| FMVSS 208, Air Bags Required Compared to 27.3% Usage in 1991 | 1,082 - 2,000 | 21,000 - 29,000 AIS 2-5 | None |
| FMVSS 201, Upper Interior Head Protection | 298 - 334 | 303 - 424 | None |
| FMVSS 225, Child Restraint Anchorage Systems – Benefits include changes to Child Restraints in FMVSS 213 | 36 to 50* | 1,231 to 2,929* | None |

* Total benefits for passenger cars and light trucks

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

APPENDIX A

## A. Comparisons of Pre-MY to MY 98/99 Air Bags

Chapter II provided some analysis of MY 98 air bags to pre-MY 98 air bags. In particular, estimates were made using SCI cases that the fatality rate for out-of-position (at-risk) occupants for MY 98 air bags is about 35 percent of the fatality rate for pre-MY 98 air bags. In addition, it was estimated that there was no statistically significant difference in overall fatalities between pre-MY 98 and MY 98 air bags. This appendix provides the Polk data analysis used in Chapter II, and it further analyzes additional real world fatality data and compares pre-MY 98 air bag equipped vehicles to redesigned MY 1998-2000 air bag equipped vehicles. It also examines high speed test data to determine how well the MY 98 and MY 99 air bag vehicles perform compared to pre-MY 98 air bags.

### Polk data

Polk has data on the number of registered vehicles. Unfortunately, the latest data available from Polk (July 1, 1998) do not have the total number of MY 1998 vehicles registered, since many MY 1998 vehicles are registered after July 1, 1998. Polk data for July 1, 1997 indicate that there were 13.10 million MY 1996 vehicles registered. Polk data for July 1, 1998 indicate there were 14.17 MY 1997 vehicles registered and 10.05 MY 1998 vehicles registered. Based on the MY 1997 vehicles, the July 1, 1997 Polk data, would have to be multiplied by 1.45 to get an estimate of the total on July 1, 1998. Thus, our best estimate of total registrations for MY 1998, until the July 1,

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

1999 tables are available, would be 14.57 million vehicles (10.05 x 1.45).[1] (See Table A-1) Note that light truck registrations increased significantly from MY 1996 to MY 1998. All of these vehicles were equipped with frontal air bags for both the driver and right front passenger. An estimated 87 percent of the MY 1998 vehicles had redesigned air bags. Since at this time, each VIN number must be looked up by hand to determine whether it was a redesigned air bag or not, in this analysis, all MY 1998 vehicles are taken together without separating them for redesigned air bags.

Table A-1
Polk Data
(In millions)

| | Passenger Cars | Light Trucks | Total |
|---|---|---|---|
| MY 1996 | 7.695 | 5.408 | 13.103 |
| MY 1997 | 8.049 | 6.125 | 14.174 |
| MY 1998 estimated | 8.053 | 6.516 | 14.569 |

[1] Total sales of passenger cars and light trucks in calendar year 1996 and 1997 were essentially the same; 1998 sales were slightly higher. There were 15.14 million sales in 1996, 15.16 million sales in 1997, and 15.55 million sales in 1998. However, calendar year sales do not match model year sales, so the best analysis is to compare fatalities by vehicle model year with registrations by model year. The calendar year data are presented to show that, if anything, the MY 1998 projection of 14.57 million registrations is low and that the fatality rates for MY 98 vehicles shown in the tables might be slightly high.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Analysis of 1998 and the first 6 Months of 1999 FARS Data and Redesigned Air Bags**

The agency conducted several analyses using 1998 and the first 6 months of 1999 FARS data to examine the question of how well MY 1998 redesigned air bags are performing.

**Fatalities in frontal impacts**

An analysis of 1996 to 1998 FARS found essentially the same number of fatalities in frontal impacts for MY 1996 vehicles in 1996 FARS (730), as in MY 1997 vehicles in 1997 FARS (776), as in MY 1998 vehicles in 1998 FARS (732). Passenger car fatalities decreased, while light truck fatalities increased. In addition, frontal impacts were in the range of 48 to 50 percent of fatalities for that group for all three years examined. (See Table A-2)

Table A-2

Fatalities in Frontal Impacts (FARS Data)

| | Passenger Cars | Light Trucks | Total |
|---|---|---|---|
| MY96 in FARS 96 | 448 | 282 | 730 |
| MY97 in FARS 97 | 450 | 326 | 776 |
| MY98 in FARS 98 | 414 | 318 | 732 |

Note: If the number of fatalities were adjusted for belt use increases discussed on Page II-24 between 1996 and 1998, the number of fatalities would be 689 for MY 96 in FARS 96, 753 for MY 97 in FARS 97 and 732 for MY 98 in FARS 98. This would make the fatality rates in Table A-3 be 53 for MY 96 in FARS 96, 53 for MY 97 in FARS 97 and 50 for MY 98 in FARS 98.

DRAFT. DELIBERATIVE DOCUMENT - DO NOT RELEASE

Dividing fatalities in frontal impacts by registered vehicles results in Table A-3. Light trucks have lower fatality rates in frontal impacts than passenger cars. Assuming that our estimate of the number of MY 1998 registered vehicles is reasonable, it appears that fatality rates for both passenger cars and light trucks are lower with MY 1998 vehicles than for MY 1997 or MY 1996.

Table A-3

Frontal Fatalities per Million Vehicles Registered

| | Passenger Cars | Light Trucks | Total |
|---|---|---|---|
| MY96 in FARS 96 | 58 | 52 | 56 |
| MY97 in FARS 97 | 56 | 53 | 55 |
| MY98 in FARS 98 | 51 | 49 | 50 |

Calculated for example:

MY 1996 - 730 fatalities/13.10 million vehicles = 56 fatalities per million vehicles

Based on testing with dummies, past agency assessments indicated the possibility that redesigned air bags may not provide full protection for unbelted occupants during high speed impacts. Thus, the same analysis was performed for drivers and right front passengers and for belted and unbelted occupants. The fatality rate appears to have decreased for unbelted right front seat occupants. With one exception, the fatality rate appears to have decreased or remained the same between MY 1996 and MY 1998. The only exception was belted light truck drivers. In order to get a better understanding of the potential reduction in the fatality rate for unbelted right front seat occupants, the fatalities were divided by ages 0-12 and 13 and over. Table A-4 shows a decrease in child deaths from 35 in MY 96 vehicles to 29 in MY 98 vehicles, but it also shows a larger

DRAFT. DELIBERATIVE DOCUMENT - DO NOT RELEASE

decrease in the number and fatality rate of right front seat occupants of ages 13 and above from 240 deaths in MY 96 vehicles down to 203 deaths in MY 98 vehicles. So, the data indicate the reduction in fatality rates comes mainly from unbelted right front seat occupants age 13 and above. (See Tables A-4 and A-5)

**Driver Fatalities in Frontal Impacts by Weight and Height of the Driver**

Dummy crash test data tend to indicate that redesigned air bags may not be as effective as pre-redesigned air bags in higher speed crashes. The analysis was performed to investigate the theory that redesigned air bags may not have enough power for heavier and taller occupants. Dummy crash test data to date indicate the worst case would be an unrestrained heavier right front passenger, and that the difference for drivers and restrained right front passengers would be minimal. Unfortunately, data on right front passengers by height and weight are not available on FARS. The 1998 FARS data, for the first time, have been linked to State driver license data, allowing the agency to get weight and height of drivers. MY 1998, 1999, and a few MY 2000 vehicles were decoded using the VIN data to determine whether the vehicles had redesigned air bags or not. Thus, an analysis was performed using 1998 and the first 6 months of 1999 FARS data and comparing MY 1995, 1996, and 1997 vehicles before redesign to the redesigned MY 1998, 1999, and a few 2000 vehicles in the file.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table A-4
Fatalities and Rates* in Frontal Impacts (FARS Data)

| | Passenger Cars | | Light Trucks | | Passenger Cars & Light Trucks | | |
|---|---|---|---|---|---|---|---|
| | Belted | Unbelted | Belted | Unbelted | Belted | Unbelted | Total |
| **Drivers** | | | | | | | |
| MY96 in FARS 96 | 148 (19) | 139 (18) | 58 (11) | 110 (20) | 206 (16) | 249 (19) | 455 (35) |
| MY97 in FARS 97 | 156 (19) | 144 (18) | 78 (13) | 139 (23) | 234 (17) | 283 (20) | 517 (36) |
| MY98 in FARS 98 | 138 (17) | 133 (17) | 89 (14) | 140 (21) | 227 (16) | 273 (19) | 500 (34) |
| **Front-Outboard Passengers** | | | | | | | |
| MY96 in FARS 96 | 61 (8) | 100 (13) | 39 (7) | 75 (14) | 100 (8) | 175 (13) | 275 (21) |
| MY97 in FARS 97 | 63 (8) | 87 (11) | 40 (7) | 69 (11) | 103 (7) | 156 (11) | 259 (18) |
| MY98 in FARS 98 | 63 (8) | 80 (10) | 38 (6) | 51 (8) | 101 (7) | 131 (9) | 232 (16) |
| **Total** | | | | | | | |
| MY96 in FARS 96 | 209 (27) | 239 (31) | 97 (18) | 185 (34) | 306 (23) | 424 (32) | 730 (56) |
| MY97 in FARS 97 | 219 (27) | 231 (29) | 118 (19) | 208 (34) | 337 (24) | 439 (31) | 776 (55) |
| MY98 in FARS 98 | 201 (25) | 213 (26) | 127 (19) | 191 (29) | 328 (23) | 404 (28) | 732 (50) |

* Rate (parenthetical values): fatalities per million registered vehicles.
Note: Due to rounding, the sum of fatality rates for belted and unbelted columns, or drivers and passengers, might not be equal to that in the "Total" column. .

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table A-5
Front-Outboard Passenger Fatalities and Rates* in Frontal Impacts (FARS Data)

| | Passenger Cars | | Light Trucks | | Passenger Cars & Light Trucks | | |
|---|---|---|---|---|---|---|---|
| | Belted | Unbelted | Belted | Unbelted | Belted | Unbelted | Total |
| **Child Passengers (Age 0-12)** | | | | | | | |
| MY96 in FARS 96 | 10 (1) | 12 (2) | 5 (1) | 8 (1) | 15 (1) | 20 (2) | 35 (3) |
| MY97 in FARS 97 | 7 (1) | 13 (2) | 5 (1) | 6 (1) | 12 (1) | 19 (1) | 31 (2) |
| MY98 in FARS 98 | 10 (1) | 10 (1) | 3 (0) | 6 (1) | 13 (1) | 16 (1) | 29 (2) |
| **Adult Passengers (Age 13 and Older)** | | | | | | | |
| MY96 in FARS 96 | 51 (7) | 88 (11) | 34 (6) | 67 (12) | 85 (6) | 155 (12) | 240 (18) |
| MY97 in FARS 97 | 56 (7) | 74 (9) | 36 (6) | 62 (10) | 92 (6) | 136 (10) | 228 (16) |
| MY98 in FARS 98 | 53 (7) | 70 (9) | 35 (5) | 45 (7) | 88 (6) | 115 (8) | 203 (14) |

* Rate (parenthetical values): fatalities per million registered vehicles.

Table A-6 shows the effectiveness of air bags by weight data (in pounds) for all drivers, belted and unbelted. Effectiveness was determined by comparing frontal fatalities to non-frontal fatalities of redesigned air bags to those that were not redesigned. The results are different than anticipated. We would have expected the redesigned air bags to be more effective for the lightest group, that probably sits closest to the steering column and the least effective for the heaviest group, that the redesigned air bags might not have enough power for. However, the differences are <u>not</u> statistically significant.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-6
Effectiveness of Air Bags for Driver Fatalities by Weight
Comparing Redesigned vs. Not Redesigned
Based on FARS 1998 and the first Six Months of FARS 1999

| | **<=125 lbs.** | **126 - 175 lbs.** | **176 - 200 lbs.** | **201 + lbs** | **Total** |
|---|---|---|---|---|---|
| Number of frontal fatalities with redesigned | 78 | 278 | 125 | 98 | 579 With Known weight |
| Effectiveness of redesigned vs. Not redesigned | - 32% | 6% | 17% | - 4% | |

A similar analysis was performed with driver height. The shorter drivers (5'4" and less) and taller drivers (6'1" and more) had a lower effectiveness with the redesigned air bag, however, this analysis found no statistically significant difference by driver height. (See Table A-7)

Table A-7
Driver Fatalities by Driver Height
Based on FARS 1998

| | **<= 64 inches** | **65 - 72 inches** | **73+ inches** | **Total** |
|---|---|---|---|---|
| Number of frontal fatalities with redesigned | 132 | 520 | 124 | 776 With Known Height |
| Effectiveness of redesigned vs. Not redesigned | - 19% | 1% | - 6% | |

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Analysis of MY 98/99 redesigned air bags and chest g's**

Chapter IV provides a variety of test data and analysis of redesigned air bags. In past NHTSA analyses,[2] test data were used to project the potential lives saved or not saved by redesigned air bags compared to pre-MY 1998 air bags. The agency focused on chest g's in these analyses, since the biggest impact appeared to be on chest g's, notably the unrestrained passenger chest g's, and since previous agency evaluations showed that chest g's related well to overall injury. This section updates those analyses using the latest information.

***Vehicle Tests***

As shown in Chapter IV, matched pair analysis of belted occupants indicate there is little difference in test scores between the pre-MY 1998 and redesigned MY 98/99 air bags. The agency has 6 unbelted 30 mph vehicle matched pair tests of MY 1998 and pre-MY 1998 air bags and 6 additional vehicle matched pair tests of MY 1999 and pre-MY 1998 air bags. These data can be analyzed in different ways depending on the philosophy used. Taking just simple averages of the 6 vehicles' chest g's for matched pairs, as shown in Table A-8, results in the following (60 g's is the injury criteria performance limit):

[2] "Final Regulatory Evaluation, Actions to Reduce the Adverse Effects of Air Bags, FMVSS No. 208, Depowering", NHTSA, February 1997, (see pages IV-13 and IV-37) and "Preliminary Economic Assessment, FMVSS No. 208, Advanced Air Bags", NHTSA, August 1998 (Docket #98-4405-#2) (see pages VIII-5 to VIII-8)

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table A-8
Comparison of pre-MY 98 to MY 98/99 Vehicles
Chest g's based on 50th Percentile Male Dummy

| | PRE MY 1998 | MY 1998 | MY 1999 | Difference |
|---|---|---|---|---|
| Driver | 47.9 g's | 45.2 g's | | Down 2.7 g's |
| Driver | 41.9 g's | | 48.3 g's | Up 6.4 g's |
| Passenger | 43.8 g's | 48.6 g's | | Up 4.8 g's |
| Passenger | 45.6 g's | | 46.1 g's | Up 0.5 g's |

Source: Tables A-11a to A-11d but excluding one confidential MMY

One could look at these data and decide that there isn't much difference between them. Average driver chest g's were slightly down for the 6 MY 98 vehicles, but up considerably for the 6 MY 99 vehicles. Average passenger chest g's were up considerably for the 6 MY 98 vehicles, but were up only slightly for the 6 MY 99 vehicles. Averaging the 12 MY 98 and MY 99 vehicles, under the assumption that they are all redesigned air bag vehicles, results in the driver chest g's being up an insignificant 1.66 chest g's and passenger chest g's being up 2.84 g's on average. One could argue that there is really no significant difference between the two types of air bags.

On the other hand, one could argue that theoretically even a 1 g difference in chest g's is important for safety and you could calculate this impact on safety. Under this philosophy, these same data were analyzed model by model to determine the impact on fatalities using Method 2 from the February 1997 Depowering analysis. The results for the driver were almost exactly the same. The average impact on driver fatalities, after considering each model separately and

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

averaging them was a 1.72 percent increase in fatalities.[3] Thus, the data show no significant difference in unbelted 48 kmph (30 mph) test data for the driver side comparing pre-MY 98 air bags to redesigned MY 98 and MY 99 air bags. The same analysis for the passenger side indicated an average increase in fatalities of 3.5 percent for redesigned MY 98 and MY 99 air bags compared to matched pre-MY 98 air bags.

Based on the two different methodologies used in the 1997 Depowering analysis, the average 2.84 chest g's increase for the passenger side would result in an estimated 9 to 26 lives not saved (under Method 1)[4] and 49 lives that would not be saved (under Method 2)[5] by MY 98/99 air bags compared to pre-MY 98 air bags.

***Sled Tests***

The agency also performed a group of sled tests using the 95th percentile male dummy to determine whether the MY 98/99 redesigned air bags performed as well as the pre-MY 98 air bags. Table A-9 presents the chest g's data from these tests at 30 and 40 mph. Two sled bucks were used representing a Chevrolet Venture minivan and a Buick Century, equipped with either

---

[3] Method 2 employed Table IV-14 (Page IV-35) from the report "Actions to Reduce the Adverse Effects of Air Bags, FMVSS No. 208, Depowering, February, 1997." The percentage change (+/-) in driver-side chest g's for each make/model was computed using 48 g's as the denominator. Table IV-14 was used to compute the changes (+/-) in fatality percentage. The net difference in fatality percentages across the pre-MY98 models and the MY98+99 models was obtained and computed.

[4] (Model 1) 2.84 g's x .96 to 2.80 = 2.73 to 7.952%
.66 x 1.0273 to 1.0795 = .678 to .7125, [(.678 to .7125) - .66] = .018 to .0525
unbelted passenger fatals in the 31 to 40 cell = 502, 502 x [.018 to .0525] = 9 to 26

[5] (Model 2) Unbelted passenger fatals in the 0-40 mph cells = 1,405
1,405 x .035 = 49

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

MY 1997 or MY 1999 redesigned air bags. Table A-9 presents these data for the driver and right front passenger. While there is one large increase (almost 10 g's) in chest g's for the Buick Century passenger at 30 mph, the rest of the data taken together show no real change in chest g's between the MY 97 and MY 99 redesigned air bags.

However, the agency did find a difference in HIC when the test speed was increased to 45 mph on the sled. While chest g's went down with the redesigned MY 99 air bag, HIC went up dramatically from 904 in the MY 97 Century to 1,731 (the initial impact to the windshield resulted in a HIC of 1,538; upon rebound into the B-pillar the HIC was 1,731) in the MY 99 Century at 45 mph. An analysis of the film from these tests found in both cases the 95$^{th}$ percentile male dummy hit the windshield, but the severity of impact was higher with the redesigned air bag. Based on these two vehicles, one could argue that the redesigned air bags are doing a good job up to around 45 mph. Given the data available to date, there appears to be little difference between the pre-MY 98 air bags and the MY 98/99 air bags in terms of high speed crashes up to 40 mph. With 45 mph delta V sled tests, the Buick Century driver chest g's decreased by 9.2 g's and the passenger chest g's increased 0.70 g's compared to a 40 mph delta V.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-9
Driver & Passenger Sled Test Data with 95th Percentile Dummies
(Chest g's)

| Speed/Model Year | Chevy Venture - Driver | Buick Century - Driver | Chevy Venture - Passenger | Buick Century - Passenger |
|---|---|---|---|---|
| 30 mph | | | | |
| MY 97 | 32.9 | 45.6 | 36.7 | 40.6 |
| MY99 | 36.0 | 44.3 | 33.7 | 50.5 |
| | | | | |
| 40 mph | | | | |
| MY 97 | 64.2 | 54.8 | 44.5 | 51.5 |
| MY 99 | 60.0 | 59.8 | 44.5 | 51.8 |
| | | | | |
| 45 mph | | | | |
| MY 97 | | 61.8 | | 55.8 |
| MY 99 | | 52.6 | | 56.5 |

**B. 30 Mph Unbelted Barrier Data: MY99 vs Pre-MY98 and MY98 vs pre-MY98 Comparisons**

Table A-10a
MY1998 vs Pre-MY98
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy Responses*
**DRIVER**

| Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) | Test Vehicle Sample (n) |
|---|---|---|---|---|---|
| Pre-1998 | 280 | ** | 47.93 | 38.63 | 5-6 |
| 1998 | 205 | 0.300 | 47.34 | 39.96 | 9 |

* Average values shown.
** Pre-98 models did not use dummy neck instrumentation.
Make/models were matched.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-10b
MY1999 vs Pre-MY98
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy Responses*
**DRIVER**

| Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection(mm) | Test Vehicle Sample (n) |
|---|---|---|---|---|---|
| Pre-1998 | 231 | ** | 44.25 | 36.0 | 6 |
| 1999 | 188 | 0.291 | 48.44 | 39.5 | 6 |

* Average values shown.
** Pre-98 models did not use dummy neck instrumentation.
Make/models were matched.

Table A-10c
MY1998 vs Pre-MY98
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy Responses*
**PASSENGER**

| Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) | Test Vehicle Sample (n) |
|---|---|---|---|---|---|
| Pre-1998 | 194 | ** | 43.8 | 20.1 | 4-6 |
| 1998 | 187 | 0.322 | 50.32 | 15 | 9 |

* Average values shown.
** Pre-98 models did not use dummy neck instrumentation.
Makes/models were matched.

Table A-10d
MY1999 vs Pre-MY98
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy Responses*
**PASSENGER**

| Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) | Sample (n) |
|---|---|---|---|---|---|
| Pre-1998 | 247 | ** | 45.7 | 18.74 | 6 |
| 1999 | 230 | 0.360 | 46.1 | 16.2 | 6 |

* Average values shown.
** Pre-98 models did not use dummy neck instrumentation.
Makes/models were matched.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

NOTE: There were 6 - MY99 make/models (VRTC), 7 - MY98 make/models (VRTC) and 2 Ford vehicles, one was a confidential MMY and the other was a 1998 Ford Escort (non-confidential) for a total of 9 MY98 vehicles]. The [confidential MMY ], 48 kmph (30 mph) unbelted tests by VRTC and [ ] are not included in Tables IV-10a -10d.

## C. 30 Mph Unbelted Barrier Comparison by Specific Make/Models (MY99 vs Pre-MY98 and MY98 vs Pre-MY)

Table A-11a
MY99 vs. Pre-MY98 Matched Make/Models
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy
**DRIVER**

| Make Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) |
|---|---|---|---|---|
| Dodge Intrepid<br>Pre-98<br>1999 | <br>239<br>403 | <br>**<br>0.349 | <br>40.6<br>54.4 | <br>33.6<br>44.8 |
| Saturn<br>Pre-98<br>1999 | <br>N.D.<br>128 | <br>**<br>0.330 | <br>33.0<br>36.8 | <br>41.3<br>46.8 |
| Ford Econoline<br>Pre-98<br>1999 | <br>161.7<br>87 | <br>**<br>0.219 | <br>47.3<br>52.1 | <br>31.4<br>37.1 |
| Acura 3.5RL<br>Pre-98<br>1999*** | <br>N.D.<br>154 | <br>N.D.<br>0.241 | <br>N.D.<br>56.9 | <br>N.D.<br>31.8 |
| Ford Expedition<br>Pre-98<br>1999 | <br>201<br>178 | <br>**<br>0.307 | <br>42.2<br>46.73 | <br>27.7<br>28.1 |
| Toyota Tacoma<br>Pre-98<br>1999 | <br>321<br>176 | <br>**<br>0.253 | <br>46.4<br>43.7 | <br>46.0<br>48.4 |

----- Missing data. N.D. = No Data Available. ** Pre-98 neck loads not measured.
*** 1999 Acura 3.5RL femur axial load exceeded mandated ICPL with a value of 13,349N.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table A-11b
MY99 vs. Pre-MY98 Matched Make/Models
48 kmph (30 mph), Unbelted Barrier, 50th Percentile Male Dummy
**PASSENGER**

| Make Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) |
|---|---|---|---|---|
| Dodge Intrepid | | | | |
| Pre-98 | 212 | ** | 52.4 | 19.5 |
| 1999 | 223 | 0.348 | 54.1 | 25.7 |
| Saturn | | | | |
| Pre-98 | 139 | ** | 41.6 | 12.8 |
| 1999 | 200 | 0.314 | 40.2 | 9.2 |
| Ford Econoline | | | | |
| Pre-98 | 120 | ** | 44.6 | 13.5 |
| 1999 | 226 | 0.322 | 45.8 | 7.3 |
| Acura 3.5RL | | | | |
| Pre-98 | N.D. | N.D. | N.D. | N.D. |
| 1999 | 367 | 0.408 | 49.8 | 11.6 |
| Ford Expedition | | | | |
| Pre-98 | 516 | ** | 43.7 | 12.1 |
| 1999 | 132 | 0.310 | 51.0 | 19.6 |
| Toyota Tacoma | | | | |
| Pre-98 | N.D. | N.D. | N.D. | N.D. |
| 1999 | 173 | 0.480 | 35.6 | 23.5 |

--- Missing data
N.D. = No Data available.
**Pre-98 neck values not measured.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-11c
MY98 vs. Pre-MY98 Matched Make/Models
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy
**DRIVER**

| Make Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) |
|---|---|---|---|---|
| Ford Taurus | | | | |
| Pre-98 | 337 | ** | 50.4 | 33.06 |
| 1998 | 181 | 0.265 | 47.2 | 21.9 |
| Dodge Neon | | | | |
| Pre-98 | 170 | ** | 47.3 | 30.37 |
| 1998 | 166 | 0.373 | 43.5 | 24.9 |
| Toyota Camry | | | | |
| Pre-98 | 159 | ** | 49.0 | 46.2 |
| 1998 | 231 | 0.366 | 51.8 | 38.1 |
| Honda Accord | | | | |
| Pre-98 | 500 | ** | 40.2 | N.D. |
| 1998 | 51 | 0.215 | 36.7 | 45.8 |
| Dodge Caravan | | | | |
| Pre-98 | 294 | ** | 47.5 | 44.6 |
| 1998 | 350 | 0.316 | 48.0 | 54.7 |
| Ford Explorer | | | | |
| Pre-98 | 218 | ** | 53.2 | 38.1 |
| 1998 (VRTC) | 272 | 0.214 | 44.4 | 32.3 |
| Confidential MMY | [ ] | [ ] | [ ] | [ ] |

** Nij neck loads not measured.
N.D. = No data available.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

For the driver MY98 vs pre-98MY, for 4 out of 6 vehicles the chest g's decreased an average of -4.8 g's and for 2 out of 6 vehicles chest g's increased an average of +1.65 g's. This is the opposite of the driver for MY99 vs pre-MY98.

Table A-11d
MY98 vs. Pre-98 Matched Make/Models
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy
**PASSENGER**

| Make Model Year | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) |
|---|---|---|---|---|
| Ford Taurus<br>Pre-MY98<br>1998 | 167<br>191 | **<br>0.313 | 45.6<br>48.5 | N.D.<br>8.8 |
| Dodge Neon<br>Pre-MY98<br>1998 | 125<br>297 | **<br>0.379 | 46.1<br>**61.4** | 23.61<br>16.02 |
| Toyota Camry<br>Pre-MY98<br>1998 | 401<br>236 | **<br>0.201 | 47.3<br>35.1 | 16.93<br>16.7 |
| Honda Accord<br>Pre-MY98<br>1998 | 273<br>160 | **<br>0.359 | 40.2<br>45.0 | N.D.<br>13.11 |
| Dodge Caravan<br>Pre-MY98<br>1998 | 70<br>249 | **<br>0.384 | 39.0<br>53.4 | 24.6<br>20.3 |
| Ford Explorer<br>Pre-MY98<br>MY98 (VRTC) | 131<br>186 | **<br>0.254 | 44.6<br>48.2 | 17.0<br>10.3 |
| Confidential<br>MMY | [ ] | [ ] | [ ] | [ ] |

** Nij neck loads not measured.
N.D. = No data available.
**Bold Number** indicate measured value exceeds mandated ICPL.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

**Pass Rates by Response Type: 30 Mph Unbelted Barrier Tests**

Table A-12a
Pass Rate - MY98 vs Pre-MY98
48 kmph (30 mph) Unbelted Barrier, 50th Percentile Male Dummy
**DRIVER**

| Model Year | | n | $HIC_{15}$ | Nij | Chest g's | Chest Deflection |
|---|---|---|---|---|---|---|
| Pre-1998 | Pass Rate % | 6 | 100 | -*-- | 100 | 100 |
| 1998 | Pass Rate % | 9 | 100 | 100 | 100 | 100 |

* Nij data not collected by VRTC
Overall MY98 femur axial load Pass Rate was 100%.

Table A-12b
Pass Rate -MY99 vs Pre-MY98
48 kmph (30 mph), Unbelted Barrier, 50th Percentile Male Dummy
**DRIVER**

| Model Year | | n | $HIC_{15}$ | Nij | Chest g's | Chest Deflection |
|---|---|---|---|---|---|---|
| Pre-1998 | Pass Rate % | 6 | 100 | -*-- | 100 | 100 |
| 1999 | Pass Rate % | 7 | 100 | 100 | 100 | 100 |

* Nij data not collected by VRTC.
** 1999 Acura 3.5 RL left femur axial load of 13,349 N exceeded the ICPL of 10,000N.
Overall MY99 driver-side femur axial load Pass Rate was 83.3% (5/6).

Table A-12c
Pass Rate - MY98 vs Pre-MY98
48 kmph (30 mph), Unbelted Barrier, 50th Percentile Male Dummy
**PASSENGER**

| Model Year | | n | $HIC_{15}$ | Nij | Chest g's | Chest Deflection |
|---|---|---|---|---|---|---|
| Pre-1998 | Pass Rate % | 6 | 100 | --*--- | 100 | 100 |
| 1998 | Pass Rate % | 9 | 100 | 100 | 88.9 ** | 100 |

* Nij data not collected by VRTC.
** 1998 Dodge Neon passenger-side had a chest g's of 61.4 g's.
Overall MY98 passenger-side femur axial load Pass Rate was 100%.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table A-12d
Pass Rate - MY99 vs Pre-MY98
48 kmph (30 mph), Unbelted Barrier, 50th Percentile Male Dummy
**PASSENGER**

| Model Year | | n | $HIC_{15}$ | Nij | Chest g's | Chest Deflection |
|---|---|---|---|---|---|---|
| Pre-1998 | Pass Rate % | 6 | 100 | -*--- | 100 | 100 |
| 1999 | Pass Rate % | 7 | 100 | 100 | 100 | 100 |

* (-----) missing Nij data needed from VRTC.
Overall MY99 passenger-side femur axial load Pass Rate was 100%.

**D. Final Rule Full-Forward Seating Procedure vs. 3" Rearward, 5th Percentile Female Dummy.**

The commenters requested that NHTSA consider a seating position more in line with the UMTRI study and consistent with how people actually adjusted their outboard seats fore/aft in the real-world. As shown in Tables A-13a and A-13b, the agency conducted two 48 kmph (30 mph) unbelted barrier tests with the 5th percentile female dummy using a modified seating procedure. Rather than having the driver and passenger seat full-forward as specified in the SNPRM (same as the final rule), the seats were adjusted rearward about 76 mm (3 inches) from full-forward. Moving the seat back 3" from full-forward matches the UMTRI procedure and provides approximately a 10" clearance between the 5th percentile female dummies chest and the steering wheel. The UMTRI procedure for the seat back angle was also employed in these two tests.[6]

[6] ATD Positioning based on Driver Posture and Position, Manary, M.A., Reed, M.P., Flannagan, C.A.C., and Schneider, L.W., University of Michigan Transportation Research Institute (UMTRI), 1998 SAE International Congress and Exposition, Society of Automotive Engineers, SAE #983163.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-13a
48 kmph (30 mph), 0 Degrees, Unbelted Barrier, 5th Percentile Female Dummy
Responses of a Modified Seating Procedure (3" rearward from full-forward)
Compared to Full-Forward Seating Procedure
**DRIVER**

| | $HIC_{15}$ | Nij* | Chest g's | Chest (mm) Deflection | Max. Femur Loads (N) | Seating Procedure |
|---|---|---|---|---|---|---|
| 1999 Acura 3.5 RL ** (VRTC) Single Stage | 149 | 1.294 | 47.4 | 41.0 | 3908 | SNPRM full-forward (n=1) |
| 1999 Acura 3.5 RL** (VRTC) Single Stage | 68 | 0.735 | 48.44 | 38.9 | 5645 | Modified 3" rearward (n=1) |
| 4- Confidential MMY (Avg.)*** 3- Stage 1 1- Stage 1+2 | [ ] | [ ] | [ ] | [ ] | [ ] | SNPRM full-forward (n=4) |
| 2000 Ford Taurus**** (VRTC) Stage 1 | 158 | 0.426 | 54.44 | 49.5 | 6208 | Modified 3" rearward (n=1) |
| 5th ICPLs | 700 | 1.0 | 60 | 52 | 6800 | |

* Neck compression and tension Peak Limits not exceeded for any of these tests.
Acura 3.5 RLs were tested post-SNPRM (n=1) and 12/13/99 (n=1).
** Single stage inflators for 1999 Acura 3.5 RLs.
*** [ This information is confidential. ]
**** Low Power Mode (Stage 1 + 100 ms gap + Stage 2). A production 2000 Ford Taurus purchased at a dealership. This data can been released.
- The agency is aware that within 100 mm (4") of the seat being full-forward, the [confidential MMY] fires only Stage 1 on the driver-side.
- Peak neck compression/tension limits not exceeded on any of these tests.
[ ] confidential data removed.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-13b
48 kmph (30 mph), 0 Degrees, Unbelted Barrier, 5th Percentile Female Dummy
Responses of a Modified Seating Procedure (3" rearward from full-forward)
Compared to Full-Forward Seating Procedure
**PASSENGER**

| | $HIC_{15}$ | Nij* | Chest g's | Chest (mm) Deflection | Max. Femur Loads (N) | Seating Procedure |
|---|---|---|---|---|---|---|
| 1999 Acura 3.5 RL ** (VRTC) Stages 1+2 | 307 | 0.775 | 55.5 | 12.3 | 4631 | SNPRM full-forward (n=1) |
| 1999 Acura 3.5 RL*** (VRTC) Stages 1+2 | 517 | 0.822 | 48.7 | 10.5 | 6440 | Modified 3" rearward (n=1) |
| Confidential MMY **** (avg.) Stages 1+2 | [ ] | [ ] | [ ] | [ ] | [ ] | SNPRM full-forward (n=3) |
| 2000 Ford Taurus***** (VRTC) Stage 1+2 | 198 | 0.360 | **70.12** | 19.4 | **6850** | Modified 3" rearward (n=1) |
| 5th ICPLs | 700 | 1.0 | 60 | 52 | 6800 | |

* Neck compression and tension Peak Limits not exceeded for any of these tests.
** Inflator Stages 1 + 2 used.
*** High Power Mode (Stages 1 + 2 fired simultaneously)
**** [ This information is confidential.]
***** n=1 2000 Ford Taurus (VRTC) High Power Mode (Stage 1 + 5ms gap + Stage 2). A production 2000 Ford Taurus purchased from a dealership.
- Peak limits on neck compression/tension not exceeded in any of these tests.
[ ] confidential data removed.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Compared to the full-forward test condition (same speed and MMY test vehicles), moving the dummy rearward by 3" should, at least theoretically, reduce overall test stringency. Being further away from the steering wheel or instrument panel reduces the punch-out and membrane interaction affects between the air bag/dummy, but the added 76 mm (3 inches) of space may have contributed to added dummy horizontal velocity. Comparing the same make/model/ years (1999 Aura 3.5RL and confidential MMY), with and without seating procedure changes, $HIC_{15}$ results were mixed (50/50) with some increases, Nij and chest deflection decreased in 3 out of 4 test conditions (75%), chest g's increased in 3 out of 4 test conditions (75%) and femur loads increased in 4 out of 4 test conditions (100%).

For the 1999 Acura 3.5 RL driver-side Nij dropped from 1.294 to 0.735 with the modified seating procedure, whereas the passenger-side Nij slightly increased but still did not exceed the proposed ICPL value. From a compliance point of view, the 1999 Acura 3.5 RL went from failing to comply with the SNPRM seating procedure to passing with the modified procedure.

For the confidential MMY, on the driver-side, all 4 prior tests failed chest deflection with the SNPRM seating procedure but now passed with the modified seating procedure. On the passenger-side of the confidential MMY, two prior tests had failed chest g's, and in the case of the modified seating procedure, this was exacerbated (increased to 70.12 g's), increasing the likelihood of failing chest g's for this model. Overall, the confidential MMY continued to not pass the ICPL values with or without the modified seating procedure.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**E. 44 kmph (27.5 mph), Unbelted, FRB vs 48 kmph (30 mph), Unbelted FRB, 5th Percentile Female Dummy**

NHTSA examined an alternative unbelted FRB test speed between 40 kmph (25 mph) and 48 kmph (30 mph) using the 5th percentile female dummy, namely - 44 kmph (27.5 mph). As shown in Table A-14, NHTSA conducted two full-scale, unbelted fixed rigid barrier tests at 27.5 mph using the 5th percentile female dummy. The driver and passenger seats were positioned full-forward in accordance with the final rule. The 2000 Ford Taurus (production vehicle purchased from a dealer) driver and passenger dummy passed all required ICPL values. The 1999 Acura 3.5 RL passed all mandated ICPL values except the driver-side Nij.

Compared to prior 30 mph unbelted tests using the 5th percentile dummy for the 1999 Acura RL, the 2.5 mph reduction in speed resulted in an overall reduction in dummy responses for the Acura RL with the exception of chest deflection which increased by 7.4 mm (21% increase) for this one test. The 1999 Acura failed to comply at 30 mph but passed at 27.5 mph as driver Nij was reduced from 1.294 to 0.96, respectively. The 1999 Acura passenger-side passed at both test speeds.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-14
44 kmph (27.5 mph) 0 degrees, Unbelted Barrier, 5th Percentile Female Dummy
(Seating Procedure - Seat Full-Forward)

| MMY | Dummy Type | $HIC_{15}$ | Nij* | Chest g's | Chest Deflection (mm) | Femur (N) ( Max.) |
|---|---|---|---|---|---|---|
| 2000 Ford Taurus | **Driver** 5th ** Stage 1 | 101 | 0.819 | 51.77 | 44.95 | 5056R |
| 2000 Ford Taurus | **Passenger** 5th *** Stages 1+2 | 126 | 0.391 | 47.8 | 10.21 | 5129R |
| 1999 Acura 3.5 RL | **Driver** 5th Single Stage | 122 | 0.96 | 38.24 | 42.9 | 4700R |
| 1999 Acura 3.5 RL | Passenger 5th **** Stages 1+2 | 173 | 0.532 | 43.96 | 9.38 | 5129R |
| ICPLs | 5th | 700 | 1.0 | 60 | 52 | 6,800 |

**Bold Numbers** exceed mandated ICPL values.
* Neck compression and tension Peak Limits not exceeded for any of these tests.
** Low Power Mode (Stage 1 + 100 ms gap + Stage 2)
*** High Power Mode (Stage 1 + 5ms gap + Stage 2)
**** High Power Mode ( Stage 1 and Stage 2 fired simultaneously).
- 2000 Ford Taurus test conducted by VRTC (V3225) 12/09/99 at 27.37 mph (actual). Production design purchased at a dealership.
- 1999 Acura 3.5 RL test conducted by VRTC 12/10/99 at 27.63 mph (actual).
- Peak limits for neck compression/tension not exceeded in any of these tests.
**R** = right femur load was the maximum.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

## F. Multi-Stage Inflators

### A. Two Stage Inflators

The purpose of Table A-15 is to compare the magnitude of responses for Stage 1 vs Stages 1+2 for the same crash condition, or static OOP test condition, for several Hybrid III dummy sizes. This table contains several matched pair examples of Stage 1 vs Stage 1+2 inflation levels from which the difference in magnitude of the two inflation levels can be judged for a few specific make models. Stage 1 (only) improves Nij responses compared to Stage 1+2.

The Acura RL has a two stage inflator that can vary inflation force according to crash severity and Mercedes will also introduce two stage inflator technology. By the MY 2000, it is anticipated that BMW and Acura models will have dual threshold restraint systems (higher inflation threshold levels if the occupant is belted) with two stage inflator technology.[7] MY 2000 Ford Taurus will have a dual threshold restraint system with two stage inflator technology. MY 2000 Toyota models are expected to employ 2 stage inflators and GM as well as Chrysler are expected to employ 2 stage inflator technology in MY 2001.[8] TRW's Gen5E crash sensor contains dual-stage air bag inflator interfaces as well as crash-severity algorithm and buckle switch sensing to provide staged inflation capabilities.[9] Its firing squib configuration will allow for personalized deployment of all air bags and pre-tensioners.

---

[7] The 2000 BMW 740 has dual stage inflators. The Washington Times, AutoWeek Section, page E12, January 14, 2000.

[8] Source: IIHS Status Report, Volume 34, No. 4, April 24, 1999.

[9] SAE's Automotive Engineering Magazine, November 1999, page 77.

Table A-15
Dual Stage Inflator Comparison Stage 1 vs Stage 1+2
30mph Unbelted Barrier Crash Tests and Static OOP Position Tests
Seating Procedure per Final Rule

| MY | MM | Test Date | $HIC_{15}$ | Nij | Chest g's | Chest Deflect (mm) | Left Femur (N) | Right Femur (N) |
|---|---|---|---|---|---|---|---|---|
| **Driver 50%-ile** | | | | | | | | |
| **Confid.** | [ ] | 6/28/99, VRTC Stage 1+2 * | [ ] | [ ] | [ ] | [ ] | | [ ] |
| **Driver 5th%F** | | | | | | | | |
| **Confid.** | [ ] | Stage 1 | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Confid.** | [ ] | Stage 1 | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Confid.** | [ ] | Stage 1+2 | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Confid.** | [ ] | 11/16/99, VRTC Stage 1 | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Pass 50th%M** | | | | | | | | |
| **Confid.** | [ ] | 6/28/99, VRTC Stage 1+2 | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Pass. 5th%F** | | | | | | | | |
| **Confid.** | [ ] | Stage 1+2 | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Confid.** | [ ] | Stage 1+2 | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Confid.** | [ ] | 11/16/99, VRTC *Stage 1+2 | [ ] | [ ] | [ ] | [ ] | | [ ] |
| **6-Year- Old Position 1** | | | | | | | | |
| 1999 | Acura RL | 3960014 Stage 1+2 | 191 | **1.31** | 19.5 | 10.7 | | |
| 1999 | Acura RL | 3960015 Stage 1 (repeat) | 88 | 0.94 | 19.4 | 8.2 | | |
| **6-Year-Old Position 2** | | | | | | | | |
| 1999 | Acura RL | 3960016 Stage 1+2 | 113 | 0.93 | 16 | 9.53 | | |
| 1999 | Acura RL | 3960002 Stage 1 | 101 | 0.830 | 18 | 3.02 | | |

Table A-15 Footnotes * VRTC Test #V3150 Stages 1+2 were deployed for both the driver and passenger. ** The confidential MMY tested by VRTC and [ ] were called pre-production prototypes. From a crash dynamics point of view, the [confidential MMY] and the [confidential MMY] are equivalent or identical test vehicles. For [ ], stages 1+2 are about equivalent to a current depowered single stage inflator. **Bold Numbers** indicate measured value exceeded ICPL. [ ] confidential data removed.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

## G. Test Procedure Repeatability/Reproducibility

In the NHTSA/Transport Canada cooperative research program two repeatability test series were conducted for the belted, in-position, 5th percentile female test dummy. For $HIC_{15}$ and Nij, the 40 kmph (25 mph) ODB belted test had more variability than the 48 kmph (30 mph) full frontal barrier test. Table A-16 compares the variability of the ODB test to a 48 kmph (30 mph) full frontal barrier test. It is believed that the higher $HIC_{15}$ and Nij variability in the ODB test is due to; (1) structural crush variability and (2) "fire time" variability. The 40 kmph (25 mph) ODB, 40% overlap, belted test procedure has been mandated specifically to help reduce "fire time" variability and enhance soft pulse crash sensing by leading to improved crash sensor and/or crash data processing algorithm design.

Table A-16
Test Procedure Repeatability
5th Percentile Female Dummy, Belted, 40 kmph (25 mph) ODB & 48 kmph (30 mph) FRB
(Transport Canada)

| Test Speed | Occupant Position | $HIC_{15}$ %CV * | Nij %CV | Chest g's %CV | Chest Deflection %CV | Sample (n) |
|---|---|---|---|---|---|---|
| 25 Mph ODB (L) | Driver | +/-42.8% | +/-55.7% | +/-3.41% | +/-8.90% | 3 - 1998 Cavalier |
| 25 Mph ODB (L) | Pass. | +/-28.8% | +/-20.1% | +/-4.63% | +/-12.3% | 3- 1998 Cavalier |
| 30 Mph | Driver | +/-18.5% | +/-20 % | +/-7.19% | +/-3.50% | 3 - 1999 Cavalier |
| 30 Mph | Pass. | +/-4.19% | +/-10.5 % | +/-8.12% | +/-7.23% | 3 -1999 Cavalier |

* % CV = percent coefficient of variation = Standard Deviation (n-1) divided by the Mean X 100%. This is interpreted as +/- the value. ODB = 40% Offset Deformable Barrier Test, Left-side Impact.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

The delay in inflator fire times due to the soft crash pulse is believed to cause out-of-position risk for occupants.

In prior agency analyses of test procedures (e.g., FMVSS 201, 214,), a %CV <= 5% is considered "excellent" and 5-10 % is considered "good" for repeatability and reproducibility tests. It is known from prior crash test experience to expect a high HIC variability (10-20%) based on Gauthier/Machey 1982 Chevy Citation NCAP repeatability test series.[10] The 40 kmph (25 mph) ODB test had a $HIC_{15}$ variation range of about +/- 29 to +/- 43 percent and Nij variation range of +/-20 to +/- 56 percent. The full frontal test, although at a higher speed, had a lower $HIC_{15}$ variability range of +/- 4 to +/-19 percent and an Nij variability range of +/-11 to +/- 20 percent. The range of %CV values for chest acceleration (4-8%) and chest deflection (3-12%) are reasonable for both of these test procedures. It is important for the manufacturers to understand the variability of the test procedures so they can set their design goals.

**5th Percentile Female Dummy:** Based on the subject belted ODB test data at 25 mph, $HIC_{15}$ and Nij had a variation of +/- 43 percent and +/- 56 percent, respectively. Driver and passenger $HIC_{15}$ may not be easily accommodated without some vehicle re-design effort, whereas Nij may be less of a problem for some make/models. Chest g's and chest deflection can be more easily accommodated with vehicles "as designed."

---

[10] Results, Analysis and Conclusions of NHTSA's 35 Mph Frontal Crash Test Repeatability Program, Machey, J.M. and Gauthier, C.L., Office of Market Incentives, Rulemaking, NHTSA/DOT, 1984 SAE International Congress and Exposition, Detroit, Michigan, SAE Paper No. 840201.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

At 30 mph belted barrier, high Nij variability would be a "marginal" problem on the driver-side, but not on the passenger-side. Chest g's, fortunately had much lower variability (+/- 4-8%) as average chest g's, both belted and unbelted are in the mid to high 40's. Chest deflections are sufficiently low in both belted and unbelted cases that variability is not an issue.

**50th Percentile Male Dummy**: Assuming the 40 kmph (25 mph) ODB variability is the worse case scenario, it appears that the full-scale unbelted barrier data for MY 1998 and 1999 compliance margins would be sufficient to accommodate a 43 percent and 56 percent variability for $HIC_{15}$ and Nij, respectively.

**Test Procedure Reproducibility**

The reproducibility of the confidential MMY data at 48 kmph (30 mph) based on the unbelted 5th percentile dummy was examined. This accounts for crash test response variations due to: (1) vehicle systems, (2) test dummies, (3) test equipment, and (4) test procedures. NHTSA has studied the FMVSS No. 214 dynamic side impact test procedure and found about a +/-10 to +/-20 percent range in reproducibility across TTI(d) and pelvic g's considering both the front driver and rear passenger.[11] The data in Table A-17 was not from a specifically designed repeatability/ reproducibility test series and involved two different test facilities (VRTC and [ ] ) and probably 4 - different 5th percentile female crash test dummies. The unbelted driver-side was much more reproducible than the unbelted passenger-side.

---

[11] Final Regulatory Impact Analysis, New Requirements for Passenger Cars to Meet a Dynamic Side Impact Test FMVSS 214, August 1990, Office of Regulatory Analysis, (NPP-20), NHTSA/DOT, Publication No. DOT HS 807 641.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

As shown in Table A-17, the +/-11.4% for the driver-side chest deflection is critical for the confidential MMY as zero out of 4 tests passed chest deflection. The +/- 45.8% for the passenger-side Nij is critical, as the confidential MMY tested by [ ] recorded an Nij of [confidential data removed]. The +/-14.7% for the passenger-side chest g's is also critical as two out of three tests had chest g's greater than 60 g's [confidential data removed]. However, the +/- 43.5% for passenger-side chest deflection is not critical as responses were significantly below the required ICPL values. The unbelted confidential MMY reproducibility test results are consistent with, and within the range of, the belted Transport Canada repeatability results in Table A-16 above.

Table A-17
Test Procedure Reproducibility
5th Percentile Female Dummy, Unbelted, 48 kmph (30 mph), FRB
Confidential MMY

| Test Speed | Occupant Position | $HIC_{15}$ %CV * | Nij %CV | Chest g's %CV | Chest Deflection %CV ** | Sample (n) |
|---|---|---|---|---|---|---|
| 48 kmph (30 Mph) | Driver | +/-20.3% | +/-10.6% | +/-6.23% | +/-11.4% | n=4 confid. MMYs |
| 48 kmph (30 Mph) | Passenger | +/-28.2% | +/-45.8% | +/-14.7% | +/-43.5% | n=3 confid. MMYs |

* The driver-side had n=3 Stage 1 deployments and n=1 Stage 1+2 deployment. The passenger-side had n=3 Stage 1+2 deployments. All vehicles were pre-production prototypes.
** %CV = percent coefficient of variation = Standard Deviation (n-1) divided by the Mean X 100%. This is interpreted as +/- the value.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Influence on Other 48 kmph (30 mph) Unbelted Tests (neglecting the confidential MMY Tests)**

There were 12 test vehicles at 48 kmph (30 mph), FRB, unbelted 5th percentile female dummy, 4 of which were confidential MMY. For the driver-side unbelted at 48 kmph (30 mph) FRB, the other 8 vehicles can easily accommodate +/- 20% $HIC_{15}$ variability, whereas +/-10.5% for Nij can only be accommodated by 4 out of 8 (50%) of the other vehicles tested. Chest g's and chest deflection variation of +/- 6.23% and +/-11.4%, respectively, would not appear to pose a need for vehicle re-design.

For the passenger-side, unbelted at 48 kmph (30 mph) FRB, the 8 remaining vehicles can easily accommodate a +/- 28% variation in $HIC_{15}$, whereas only 1 out of 8 can accommodate a +/- 45.8% variation in Nij. A passenger-side chest g's variation of +/- 14.7% will not create re-design issues for 6 out of 8 of the remaining test vehicles and a chest deflection variability of +/- 43.5% can easily be accommodated as deflection values are significantly below the mandated ICPL values.

**H. Margins of Compliance**

**Toyota Comments (Docket No. 99-6407-47)**

Toyota submitted confidential unbelted, 48 kmph (30 mph) FRB, 50th percentile male dummy, test data for Model "X" SUV which has been certified to the current FMVSS No. 208 sled test. This data is shown in Tables A-18 (Driver) and A-19 (Passenger). Toyota stated in their comments;

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

"...the driver-side exceeds the IARVs for both chest g's and chest deflection and exceeds the compliance margins" and "...for the passenger side, chest g's and femur loads do not meet the criteria."[12] Toyota concludes "...for the same vehicle subjected to a 40 kmph (25 mph) FRB test for both the driver and passenger side, test results indicate that Model "X" SUV could be certified to meet the requirements."

Table A-18
Model "X" SUV, Unbelted, FRB, 50th Percentile Male Dummy

Confidential DRIVER

| | **48 kmph (30 mph) FRB** | **40 kmph (25 mph) FRB** | **Reduction in Response due to 25 mph Test Speed** |
|---|---|---|---|
| | Percent of IARV | Percent of IARV | Difference in Percentage |
| $HIC_{15ms}$ | [ ] | [ ] | [ ] |
| Neck Tension | [ ] | [ ] | [ ] |
| Neck Compression | [ ] | [ ] | [ ] |
| Neck Flexion Moment | [ ] | [ ] | [ ] |
| Neck Extension Moment | [ ] | [ ] | [ ] |
| Chest g's | [ ] | [ ] | [ ] |
| Chest Deflection | [ ] | [ ] | [ ] |
| Sternal Deflection Rate (SDR) | [ ] | [ ] | [ ] |
| Femur Load (R) | [ ] | [ ] | [ ] |
| Femur Load (L) | [ ] | [ ] | [ ] |

- Model "X" SUV is certified to current 208 sled test [ ] confidential data removed.
- Percentages are approximate from submitted bar-charts.
- Assumes the IARVs referred to by Toyota are the same as SNPRM Injury Criteria.
- **Bold Number** indicates a Compliance Margin (CM) less than the 20 percent suggested by the manufacturers, where Compliance Margin (%) i = $[1 - R_i / ICPL_i]_{DUMMY\ i}$ X 100% and Ri = dummy response value in a particular high speed or static test.

[12] For a 60 g's chest acceleration requirement, a design goal of 48 g's or 20 percent lower than the standard allows has often been cited by the manufacturers.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-19
Model "X" SUV, Unbelted, FRB, 50th Percentile Male Dummy

**Confidential** **PASSENGER**

| | **48 kmph (30 mph) FRB** | **40 kmph (25 mph) FRB** | **Reduction in Response due to 25 mph Test Speed** |
|---|---|---|---|
| | Percent of IARV | Percent of IARV | Difference in Percentage |
| $HIC_{15ms}$ | [ ] | [ ] | [ ] |
| Neck Tension | [ ] | [ ] | [ ] |
| Neck Compression | [ ] | [ ] | [ ] |
| Neck Flexion Moment | [ ] | [ ] | [ ] |
| Neck Extension Moment | [ ] | [ ] | [ ] |
| Chest g's | [ ] | [ ] | [ ] |
| Chest Deflection | [ ] | [ ] | [ ] |
| Sternal Deflection Rate (SDR) | [ ] | [ ] | [ ] |
| Femur Load (R) | [ ] | [ ] | [ ] |
| Femur Load (L) | [ ] | [ ] | [ ] |

- Model "X" SUV is certified to current 208 sled test.
- Percentages are approximate from submitted bar-charts.
- Assumes the IARVs referred to by Toyota are the same as SNPRM Injury Criteria.
- **Bold Number** indicates a compliance margin less than the 20 percent suggested by the manufacturers, where Compliance Margin (%) i = $[1 - R\,i / ICPL\,i]_{DUMMY\,i}$ X 100% and Ri = dummy response value in a particular high speed or static test.

[ ] confidential data removed.

As shown in Tables A-20 and A-21, Toyota also submitted 48 kmph (30 mph) FRB, unbelted, 50th percentile male dummy, crash test data for several test vehicles equipped with depowered air bags. Toyota stated in their comments,

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

"...vehicles X, Y and Z exceed acceptable compliance margins for several IARVs, and in some instances, actually exceed allowable limits. [vehicle X is the same as Model "X" described above.]

Toyota concluded in their comments

"...they can not comply with the 48 kmph (30 mph) unbelted rigid barrier test unless the air bag inflator is **re-powered** to higher levels, therefore, increasing the potential injury risk for "at risk" groups."

Table A-20
48 kmph (30 mph) FRB, Unbelted, 50th Percentile Male Dummy
Percent of SNPRM Injury Criteria
**DRIVER**

| | Model "X" | Model "Y" | Model "Z" | Model "A" |
|---|---|---|---|---|
| $HIC_{15ms}$ | [ ] | [ ] | [ ] | [ ] |
| Nij | [ ] | [ ] | N.D. | N.D. |
| Chest g's | [ ] | [ ] | [ ] | [ ] |
| Chest Deflection | [ ] | [ ] | [ ] | [ ] |
| Femur Load (R) | [ ] | [ ] | [ ] | [ ] |
| Femur Load (L) | [ ] | [ ] | [ ] | [ ] |

-Models X, Y, Z & A are Toyota models currently in production with current generation of depowered air bags.
- Percentages are approximated from submitted bar-chart information.
- **Bold Number** indicates a compliance margin less than the 20 percent suggested by the manufacturers.
[ ] confidential data removed.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-21
48 kmph (30 mph) FRB, Unbelted, 50th Percentile Male Dummy
Percent of SNPRM Injury Criteria
**PASSENGER**

| | Model "X" | Model "Y" | Model "Z" | Model "A" |
|---|---|---|---|---|
| $HIC_{15ms}$ | [ ] | [ ] | [ ] | [ ] |
| Nij | [ ] | [ ] | N.D. | N.D. |
| Chest g's | [ ] | [ ] | [ ] | [ ] |
| Chest Deflection | [ ] | [ ] | [ ] | [ ] |
| Femur Load (R) | [ ] | [ ] | [ ] | [ ] |
| Femur Load (L) | [ ] | [ ] | [ ] | [ ] |

- **Bold Number** indicates a compliance margin less than the 20 percent suggested by the manufacturers.
-Models X, Y, Z & A are Toyota models currently in production with current generation of depowered air bags.
- Percentages are approximated from submitted bar-chart information.
[ ] confidential data removed.

**Toyota on Compliance Margins and Reproducibility (Non-confidential)**

Toyota stated in their comments,

> "... NHTSA asserted in its preamble that adequate compliance margins can be maintained at less than the roughly 20 percent manufacturers suggested [value] w[h]ere required. Toyota believes that NHTSA's assumptions do not account for the practical issues of wide variations in test results, not only vehicle-to-vehicle, but also test lab-to-test lab. Unfortunately, these variations are a real world consequence of vehicle development and compliance testing, and therefore they too must be considered by the manufacturer when certifying compliance."

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Toyota submitted (non-confidential) driver-side 30 mph FRB, unbelted, 50th percentile male dummy, margin of compliance data for 5 **pre-depowered** test vehicles (1992 Camry, 1995 Tercel, 1996 RAV4, 1996 4Runner, and 1994 Celica.) generated by Toyota (#1, #2 & #3), compliance contractor (#1 & #2) and what Toyota calls a "Laboratory." These data are presented in Tables A-22 through A-26.

Table A-22
48 kmph (30 mph FRB), Unbelted, 50th Percentile Male Dummy
Percent of FMVSS 208 Injury criteria
1992 Toyota Camry, Driver

| | Compliance Contractor #1 | Compliance Contractor #2 | Toyota | Max. Diff. Contractor. vs Toyota |
|---|---|---|---|---|
| $HIC_{15ms}$ | 42 | 34 | 15 | +27 |
| Chest g's | **112** | **90** | **95** | +22 |
| Chest Deflection | 58 | 70 | 42 | +28 |

**Bold Numbers** indicate compliance margin is less than the 20 percent suggested by the manufacturers.

Table A-23
48 kmph (30 mph) FRB, Unbelted, 50th Percentile Male Dummy
Percent of FMVSS 208 Injury criteria
1995 Toyota Tercel, Driver

| | Compliance Contractor | Toyota #1 | Toyota #2 | Laboratory | Max. Diff. Contract. vs Toyota | Max. Diff. Lab vs Toyota |
|---|---|---|---|---|---|---|
| $HIC_{15ms}$ | 45 | 41 | 25 | 40 | +20 | +15 |
| Chest g's | **93** | 71 | **95** | **92** | +22 | +21 |
| Chest Deflection | 25 | 30 | N.D. | N.D. | -5 | |

**Bold Numbers** indicate the compliance margins are less than 20 percent suggested by the manufacturers.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Table A-24
48 kmph (30 mph) FRB, Unbelted, 50th Percentile Male Dummy
Percent of FMVSS 208 Injury criteria
1996 Toyota RAV4, Driver

| | Toyota #1 | Toyota #2 | Toyota #3 | Max. In-house Variance (%) |
|---|---|---|---|---|
| $HIC_{15ms}$ | 30 | 40 | 35 | 10 |
| Chest g's | 75 | **88** | **90** | 15 |
| Chest Deflection | 50 | 52 | 48 | 4 |

**Bold Numbers** indicate that the compliance margin is less than 20 percent suggested by the manufacturers.

Table A-25
48 kmph (30 mph) FRB, Unbelted, 50th Percentile Male Dummy
Percent of FMVSS 208 Injury Criteria
1996 4Runner, Driver

| | Compliance Contractor | Toyota #1 | Toyota #2 | Max. Diff. Contractor vs Toyota |
|---|---|---|---|---|
| $HIC_{15ms}$ | 80 | 43 | 15 | +65 |
| Chest g's | **98** | **85** | **82** | +16 |
| Chest Deflection | 34 | 60 | 27 | -26 |

**Bold Numbers** indicate that the compliance margin is less than 20 percent suggested by the manufacturers.

Table A-26
48 kmph (30 mph) FRB, Unbelted, 50th Percentile Male Dummy
Percent of FMVSS 208 Injury criteria
1994 Toyota Celica, Driver

| | Laboratory | Toyota | Max. Diff. Lab vs Toyota |
|---|---|---|---|
| $HIC_{15ms}$ | 35 | 30 | +5 |
| Chest g's | **88** | 65 | +23 |
| Chest Deflection | 58 | 55 | +3 |

**Bold Numbers** indicate that the compliance margin is less than 20 percent suggested by the manufacturers.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

NHTSA agrees with Toyota that there are full-scale crash test reproducibility concerns and that results may vary considerably based on the driver-side for the 5 Toyota pre-depowered air bag designs. The data presented by Toyota clearly shows compliance margins of less than the manufacturer suggested 20 percent, particularly for chest g's. Toyota's Model "X" results shown earlier suggest these smaller or reduced compliance margins for chest g's at 30 mph FRB, unbelted dummy, are not in the certifiable range (based on the industry's definition). In addition, the data clearly shows that compared to Toyota's in-house tests, outside testing sources easily produce results that are almost consistently 20-25 percent higher (up to 65 percent in one case). The data presented by Toyota effectively illustrates the wide variation in crash test results that must be taken into account by automobile designers.

Toyota does not agree with NHTSA that the Toyota Tacoma can easily pass all the pertinent injury criteria for the 30 mph unbelted test condition with large margins. As shown in Table A-27a and Table A-27b, Toyota submitted confidential test data; (1) to show that when NHTSA tested the 2WD 1999 Toyota Tacoma pickup truck it "passed," whereas when Toyota tested the 4WD version of the same MMY, it "failed" and (2) to support their position that there are inadequate margins of compliance and, therefore, the vehicle is not certifiable.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-27a
48 kmph (30 mph) FRB, Unbelted Test Condition
Percent of SNPRM Injury Criteria
1999 Toyota Tacoma Xtracab, 50th Percentile Male & 5th Percentile Female Dummies

**Toyota Data Confidential** **DRIVER**

| | NHTSA 2WD Response | NHTSA 2WD Percent | NHTSA 2WD Response | NHTSA 2WD Percent | Toyota 4WD Response | Toyota 4WD Percent |
|---|---|---|---|---|---|---|
| ATD Type | 50th | 50th | 5th | 5th | 50th | 50th |
| $HIC_{15ms}$ | 176 | 25% | 199 | 28% | [ ] | [ ] |
| $Nij_{(SNPRM)}$ | 0.33 | 33% | 0.48 | 48% | [ ] | [ ] |
| Chest g's | 43.7 | 73% | 52.3 | **87%** | [ ] | [ ] |
| Chest Deflection | 48.4 | 77% | 51.4 | **99%** | [ ] | [ ] |
| $CTI_{(NPRM\ only)}$ | --- | --- | --- | --- | [ ] | [ ] |

**Bold Numbers** indicate a margin of compliance less than the 20 percent suggested by the manufacturers.
[ ] confidential data removed.

Table A-27b
48 kmph (30 mph) FRB, Unbelted Test Condition
Percent of SNPRM Injury Criteria
1999 Toyota Tacoma Xtracab, 50th Percentile Male & 5th Percentile Female Dummies

**Toyota Data Confidential** **PASSENGER**

| | NHTSA 2WD Response | NHTSA 2WD Percent | NHTSA 2WD Response | NHTSA 2WD Percent | Toyota 4WD Response | Toyota 4WD Percent |
|---|---|---|---|---|---|---|
| ATD Type | 50th | 50th | 5th | 5th | 50th | 50th |
| $HIC_{15ms}$ | 173 | 25% | 380 | 54% | [ ] | [ ] |
| $Nij_{(SNPRM)}$ | 0.69 | 69% | 2.65 | **265%** | [ ] | [ ] |
| Chest g's | 35.6 | 59% | 42.2 | 70% | [ ] | [ ] |
| Chest Deflection | 23.5 | 37% | 4.2 | 7% | [ ] | [ ] |
| $CTI_{(NPRM\ only)}$ | --- | --- | --- | --- | [ ] | [ ] |

**Bold Numbers** indicate a margin of compliance less than the 20 percent suggested by the manufacturers.
[ ] confidential data removed.

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

Tables A-27a and 27b show the following:

1. Using the 50th percentile male dummy in the NHTSA (2WD) 1999 Toyota Tacoma test, the vehicle passed on both the driver-side and the passenger-side with margins of compliance greater than 20 percent. Overall, the vehicle passed the proposed SNPRM requirements as stated in the preamble.

2. Using the 5th percentile female dummy in the NHTSA (2WD) 1999 Toyota Tacoma test, the driver-side passed without adequate margins of compliance (less than 20%), and failed on the passenger-side. Overall, the 1999 Toyota Tacoma failed to meet the proposed SNPRM requirements using the 5th percentile female dummy. In the SNPRM, under Alternative 1 of the High Speed Test Requirements, the vehicle would have to pass using both the 50th and 5th percentile male and female dummies unbelted at 30 mph.

3. After analyzing the discrete response data obtained [confidentially] from Toyota for the 4WD version of the 1999 Toyota Tacoma test (50th percentile male dummy), the driver-side passed with adequate margins of compliance, but the passenger-side failed to comply. Overall, the 4WD version of the same make/model /year tested by NHTSA (and passed with adequate margins of compliance), failed to meet the SNPRM requirements using the 50th percentile male dummy.

4. The agency believes that the 2WD and 4WD Toyota Tacoma crash responses using the 50th percentile male dummy should not be compared to assess repeatability/reproducibility because of

DRAFT. DELIBERATIVE DOCUMENT. DO NOT RELEASE

potential crash pulse differences.[13] However, the independently derived margins of compliance should be assessed separately. The average GVWR of these two test vehicles may have varied by 500 lbs. due to the 2WD vs 4WD option alone. In addition, the 4WD option could affect front-end structure. For example, the 1999 Toyota Tacoma Xtracab, with 2WD option, the GVWR range is 2,910 - 4,498 lbs. and, for the 4WD option, the GVWR range is 3,245-5,104 lbs. or an average difference of 471 pounds (4,175 minus 3,704 lbs.).[14] Toyota's submission makes the point that even though the 2WD 1999 Toyota Tacoma might be certifiable at 30 mph using an unbelted 50th percentile dummy, the 4WD version would not be certifiable. Toyota's overriding concern is that if NHTSA returns to 30 mph unbelted barrier test, the manufacturers will be forced to increase inflator pressures beyond current levels and that this will increase risk to all occupants in the real-world crashes, especially OOP children and small adults.

The agency believes that design changes can be made to the Toyota Tacoma to meet the final rule criteria. With the 5th percentile female sitting forward, the air bag comes out high and catches the head area while the unbelted torso and lower body keep moving forward. This results in high neck loads. Changes in the way the air bag unfolds and other advanced air bag improvements can be made to make this vehicle comply.

---

[13] The measured variation (%) between the 2WD and 4WD (NHTSA vs Toyota) 1999 Toyota Tacoma tests results were as follows: the driver-side showed [ %],[ %], [ %] and [ %] variation for $HIC_{15}$, Nij, chest g's and chest deflection, respectively. The passenger-side showed [ %], [ %], [ %] and [ %] variation for $HIC_{15}$, Nij, chest g's and chest deflection, respectively. In addition to vehicle differences, this reflects two facilities and 4 - 50th percentile test dummies. Percent Variation = [1/2 (X2 - X1) / ½ (X2 + X1)] X 100%

[14] 1999 Market Data Book, May 1999, Automotive News, Crain Communications, Inc. Detroit, Michigan

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Ford on Compliance Margins (Confidential) 99-6407-38**

Ford stated in their comments,

[ " " ]

## I. Supplemental Full-Scale Crash Data

### 95th Percentile Male Dummy, Unbelted Full-Scale Crash Data

Table A-28
**Confidential MMY (n=1)**
48 kmph (30 mph) Unbelted Barrier, 95th Percentile Male Dummy Responses
Driver and Passenger

| | $HIC_{15}$ | Nij | Chest g's | Chest Deflection | Max. Femur Load (N) |
|---|---|---|---|---|---|
| Driver | [ ] | [ ] | [ ] | [ ] | [ ] |
| Passenger | [ ] | [ ] | [ ] | [ ] | [ ] |
| 95th IARVs | 700 | 1.0 | 55 | 70 | 10,000 |

**Bold Numbers** indicate applicable IARV is exceeded. Maximum allowable chest deflection, from a mechanical point of view, is approximately 114.3 mm for the 95th percentile male dummy.
[ ] confidential data removed.

Table A-29
Unbelted vs Belted
48 kmph (30 mph), 0 Degree Rigid Barrier, 50th Percentile Male Dummy
Average Responses (n=3) Pre-MY98 Make/Models
GM 208 Compliance Data

| | Driver $HIC_{36}$ | Driver Chest g's | Passenger $HIC_{36}$ | Passenger Chest g's | n |
|---|---|---|---|---|---|
| Unbelted | 316.7 | 46 | 376.7 | 46.7 | 3 |
| Belted | 360 | 44 | 400 | 44.3 | 3 |

* The sample (n=3) consisted of a 1997 Eldorado/Seville, a 1995-97 Buick Riviera, and a 1995-97 Oldsmobile Aurora.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Table A-30
Unbelted vs Belted
48 kmph (30 mph), 0 Degree Rigid Barrier, 50th Percentile Male Dummy
Average Responses - All GM Make/Models, MY1990-98
GM 208 Compliance Data

| | Driver $HIC_{36}$ | Driver Chest g's | Passenger $HIC_{36}$ | Passenger Chest g's | n |
|---|---|---|---|---|---|
| Unbelted | 325.4 | 45.23 | 289.8 | 42.87 | 62-115 |
| Belted | 410.9 | 45.9 | 396.4 | 44.1 | 14-31 |

* Different make/model/year GM test vehicles made up the 0 degree fixed rigid barrier data sets although there was some overlap in a few cases.

Table A-31
40 kmph (25 mph), 30 Degree Oblique, Left Impact
Unbelted, 50th Percentile Male & 5th Percentile Female Dummies
Confidential MMY

| MY | MM | ATD Size | $HIC_{15}$ | Nij | Chest g's | Chest Deflection (mm) | Max. Femur (N) |
|---|---|---|---|---|---|---|---|
| **Driver** | | | | | | | |
| Confidential MMY | | 5th * | [ ] | [ ] | [ ] | [ ] | [ ] |
| | | 50th * | [ ] | [ ] | [ ] | [ ] | [ ] |
| **Passenger** | | | | | | | |
| Confidential MMY | | 5th * | [ ] | [ ] | [ ] | [ ] | [ ] |
| | | 50th * | [ ] | [ ] | [ ] | [ ] | [ ] |
| 5th ICPLs | | | 700 | 1.0 | 60 | 52 | 6,800 |
| 50th ICPLs | | | 700 | 1.0 | 60 | 63 | 10,000 |

* Stage 1 only required for these tests.
[ ] confidential data removed.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Tables A-32 shows 30 mph unbelted barrier test data for the confidential MMY using the 5th percentile female dummy, while Table A-33 shows 30 mph, 30 degree oblique unbelted test data for the confidential MMY using the 5th percentile female dummy. Table A-34 shows 25 mph unbelted barrier test data for the confidential MMY and confidential MMY using the 5th percentile female dummy.

Table A-32
48 kmph (30 mph), Fixed Rigid Barrier, Unbelted, 5th Percentile Female Dummy
**CONFIDENTIAL MMYs**

| **Occupant/Test Vehicle** | **$HIC_{15}$** | **Chest g's** | **Chest Deflection (mm)** | **Nij** |
|---|---|---|---|---|
| **Driver** Test 1 | [ ]* | [ ] | [ ] | [ ] |
| Test 2 | [ ]** | [ ] | [ ] | [ ] |
| Test 3 | [ ]* | [ ] | [ ] | [ ] |
| **Passenger** | | | | |
| Test 2 | [ ]** | [ ] | [ ] | [ ] |
| Test 3 | [ ]** | [ ] | [ ] | [ ] |
| 5th Percentile Female ICPL | 700 | 60 | 52 | 1.0 |

**Bold Numbers** indicate measured values exceeded mandated ICPL.
* Stage 1 only fired. ** Stages 1+2 fired.
[ ] confidential data removed.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Table A-33
48 kmph (30 mph), 30 Degree Oblique, Right Impact, Rigid Barrier
Unbelted, 5th Percentile Female Dummy
**CONFIDENTIAL MMY**

| Occupant/Test Vehicle | $HIC_{15}$ | Chest g's | Chest Deflection (mm) | Nij |
|---|---|---|---|---|
| **Driver*** | [ ] | [ ] | [ ] | [ ] |
| **Passenger*** | [ ] | [ ] | [ ] | [ ] |
| 5th Percentile Female ICPL | 700 | 60 | 52 | 1.0 |

**Bold Numbers** indicate measured values exceeded mandated ICPL.
* Stage 1 only fired.
[ ] confidential data removed.

Table A-34
40 kmph (25 mph) Unbelted Rigid Barrier, 5th Percentile Female Dummy
**CONFIDENTIAL MMY**

| Occupant/Test Vehicle | $HIC_{15}$ | Chest g's | Chest Deflection (mm) | Nij |
|---|---|---|---|---|
| **Driver** | | | | |
| Confidential MMY* | [ ] | [ ] | [ ] | [ ] |
| Confidential MMY** | [ ] | [ ] | [ ] | [ ] |
| **Passenger** | | | | |
| Confidential MMY* | [ ] | [ ] | [ ] | [ ] |
| Confidential MMY** | [ ] | [ ] | [ ] | [ ] |
| 5th Percentile Female ICPL | 700 | 60 | 52 | 1.0 |

**Bold Numbers** indicate measured values exceeded mandated ICPL.
* Single stage inflator. ** Stage 1 fired.
[ ] confidential data removed.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

APPENDIX B

This appendix responds to specific comments provided in response to the "Preliminary Economic Assessment, SNPRM, FMVSS 208, Advanced Air Bags", October 1999.

**A. Response to Alliance (Docket 6407-#40) Critique of PEA:**

**Issue 1**: The Alliance argues that analytical limitations are evident in NHTSA's analysis because the previous analysis where NHTSA predicted negative impacts for the sled test has been proven wrong by real world crash data. The Alliance then states that NHTSA's analysis of the 25 mph requirement will similarly be overestimated.

NHTSA agrees that the projected dis-benefits predicted in its analysis of depowering have not occurred. However, these estimates were a function of NHTSA's assumption that air bags would be depowered by 20-35 percent[1]. AAMA had commented that the average level of depowering would be 20 to 35 percent. This range was also seen in the prototype air bags supplied by the industry for NHTSA testing. In reality, these levels never materialized. Changes made by manufacturers were much more conservative.[2] The current analysis measures impacts for different design changes and is based on a much larger body of data. Therefore, it is not valid to use the results of the sled test analysis to predict the accuracy of the advanced air bag analyses.

---

[1] We characterized the 20-35 percent based on measurable parameters of the air bag, mainly peak pressure, but the change in rise rate percentages were comparable.

[2] Further, extensive testing by NHTSA indicate that redesigned air bags meet the unbelted 30 mph test with the 50th percentile male dummy with, generally, a large compliance margin. This testing contradicts the claims that the 30 mph unbelted test led to the need for high-powered air bags.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

The agency examined the average change in power between MY 1997 and MY 1998 (depowered) air bags based on data submitted to the agency from an Information Request sent to nine automobile manufacturers (for further information see "Air Bag Technology In Light Passenger Vehicles"). The agency believes the most important parameter for out-of-position testing is the rise rate (how fast the gas comes out of the module and fills the air bag). For driver air bags the rise rate was reduced an average of 22 percent between MY 1997 and MY 1998, and for passenger air bags the rise rate was reduced an average of 14 percent.

The agency believes a key parameter for in-position testing (e.g., in 30 mph testing) and for protection is the peak pressure of the air bag. The peak pressure is more important than the rise rate for the in-position testing, since the air bag is already filled or almost filled before the occupant engages the air bag. For driver air bags the peak pressure was reduced an average of 11 percent between MY 1997 and MY 1998, and for passenger air bags the peak pressure was reduced an average of 10 percent.

The agency believes these differences in measured parameters help to explain why the real world crash data show a large reduction in the low speed out-of-position fatalities between MY 1997 and MY 1998 air bags, while at the same time there was no statistical difference in the protection of air bags provided in the real world data at high speeds. We note that there were many other changes made during this time period, including recessing the driver air bag, changes in vent size, fabric porosity, etc, that also probably contributed to improvements in safety.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

Thus, it appears that the manufacturers found a way to reduce the rise rate, the factor most related to out-of-position aggressivity, more than the peak pressure, the factor more related to in-position protection. Peak pressure dropped about 10 percent, not the 20-35 percent predicted in the "Depowering" rule. Based on the data available to date, this appears to have reduced the out-of-position problem, while not having a negative impact on the in-position high speed cases.

**Issue 2**: The Alliance asserts that the agency bases its results on a single dummy in a single crash test in a single direction at a single speed to predict the benefits of advanced air bags in the variety of crash circumstances that occur in the real world. The Alliance cited a Harvard study of air bag effectiveness that criticized past NHTSA analyses as not adequately addressing the diversity in the vehicle fleet and driving public.

The Alliance misunderstood the agency's benefit estimate process. The agency has linked the laboratory dummy readings to real-world crash data and used the relationship to predict the life-saving potential of air bags. For example, through vigorous statistical analysis (Kahane), the agency found pre-MY 1998 air bags have an 11 percent effectiveness against fatalities[3]. This implies that the air bags passing 30 mph RFB unbelted 50$^{th}$ percentile male tests provided a weighted effectiveness of 11 percent across a whole range of impact speeds and diversity of vehicle occupants. The process reflects real world experience. The agency disagrees with the implication in the recent Harvard review. However, the agency acknowledges that to improve air

[3] "Fatality Reduction by Air Bags, Analyses of Accident Data through Early 1996", NHTSA, August 1996, DOT HS 808-470. Overall (all crash modes) air bag fatality effectiveness is estimated to be11 percent, while air bag effectiveness in direct frontal impacts (12 o'clock impacts) is estimated to be 30 percent.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

bag system protection for different sizes of occupants, the agency needs to test dummies representing different sizes of occupants. Thus, the advanced air bags final rule has tests on a family of dummies to address the broader protection issue.

**Issue 3**: The Alliance states that NHTSA does not take into account compliance margins and other real world constraints such as NCAP and alternative crash configurations that manufacturers must address to develop acceptable safety systems.

NHTSA examined the results of a large number of tests of existing air bag systems in MY 1998/99 vehicles with air bags that were redesigned, which only had to meet the sled test. These vehicles were tested under the proposed 30 mph barrier test. In Chapter IV, the agency analyzed the pass/fail test results. We have also analyzed the compliance margins. For the 50$^{th}$ male dummy, 18 vehicles were tested for 5 parameters (Chest Gs, Chest Deflection, HIC, Nij, Femur load) and 2 frontal seating positions (driver and passenger), a total of 180 separate testing cells. In 148 of these, or 82%, the MY 1998/99 vehicles passed the 30mph rigid barrier test with a compliance margin of over 20%. In 26 cases (15%) they passed, but with compliance margins of 20% or less. In 6 cases (3%), there were outright failures. For the 5$^{th}$ female, a total of 12 vehicles were tested for a total of 115 test cells. In the 5$^{th}$ female dummy tests, 94 (82%) of these passed with at least a 20% compliance margin, 7 (6%) passed with a low compliance margin, and 14 (12%) failed. The Alliance views the test failures and passes with less than a 20% margin as an indication of the technical difficulties that would occur under the higher (30mph) standard. NHTSA acknowledges that there will be design challenges for the industry. It is important to

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

remember that none of these air bags systems were designed to pass a compliance test with a 5th percentile female dummy or an Nij criteria. However, the data clearly show that these challenges can be, and in most cases, already have been met in existing vehicle designs. NHTSA acknowledges that there will be costs associated with these design changes, but that is expected and is no basis in itself for rejecting a particular test requirement. NHTSA has clearly not ignored compliance issues, but rather has analyzed them and presented its best estimate of their impacts.

In response to the Alliance argument that other test requirements, such as the 30 mph belted test or NCAP (35 mph belted test), may limit the amount of depowering a manufacturer could do in a "25 mph unbelted test" world, the agency examined NCAP data. NCAP testing has shown that it is harder for light trucks to get better scores than it is for passenger cars, so the agency examined the last two years (1992 and 1993) in which there were a large number of light trucks tested with seat belts alone and no air bags. In 1992 and 1993 there were a total of 22 light trucks tested in NCAP with only seat belts. Eleven of those light trucks passed all of the 208 criteria and eleven did not. Of the eleven that did not pass, all eleven had HIC above 1,000 (36 millisecond) (8 of the 11 were between 1,000 and 1,225 HIC) and 4 vehicles had chest g's above 60 g's (3 of the 4 were at 61 or 62 g's). It is the agency's contention that the safety belt provides most of the benefit in meeting the belted test and that the dummy readings in belted tests would not be affected much by whether the air bag is designed to an unbelted 30 mph test or an unbelted 25 mph test. As shown in Tables IV-9a through IV-9e, the recent average NCAP test results with air

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

bags are well within the FMVSS 208 injury criteria and there was essentially no clear trend in NCAP test scores, except that Nij had decreased some, comparing redesigned air bags with pre-MY 1998 air bags.

**Issue 4**: The Alliance states that NHTSA "assumes" that there will be significant effectiveness at 20 and 25 mph below and 15 mph above the design checkpoint. The Alliance then contrasts this with their own estimates, noting a different distribution of effectiveness rates for different speed ranges.

NHTSA's estimates of effectiveness by delta-V were based on real world data. NHTSA examined the impact of pre-1998 air bags on crashes stratified by delta-V to determine the relationship between design points and effectiveness. NHTSA then applied this same relationship to target populations grouped in 5 mph increments less than the pre-MY 1998 vehicles to estimate the impact on vehicles designed to a 25 mph (rather than a 30 mph) standard. This approach assumes that air bags designed to the lower standard would provide a similar range of performance over a similar range of speeds as was found for the existing fleet designed to the higher standard. By contrast the Alliance opportunities matrix model is based solely on an assumption that a theoretical bell-shaped relationship exists between proximity to the design point and effectiveness. No real world data or crash test data were provided or evaluated to demonstrate the validity of this construct.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Issue 5**: The Alliance states that NHTSA developed effectiveness estimates for a population of MAIS 3+ injuries, but then erroneously applied them to fatalities because the crash distribution of fatalities is different from that of injuries.

Because of the limited sample size in NASS-CDS for fatalities, NHTSA did use MAIS 3+ injuries to develop the relative effectiveness of air bags for different delta-V levels, but these numbers were then normalized to the previously determined effectiveness rate for fatalities (Kahane). We also used AIS 2-5 injuries to represent injuries. The injury curve and effectiveness estimates are different between fatalities and injuries (See Chapter VI).

**Issue 6**: The Alliance states that NHTSA's Approach #2 assumes that injury criteria are related on a multiplicative basis across the whole range of crash severity, and that the agency assumes that all air bags designed to 25 mph will have injury criteria twice the level of 30 mph systems, no matter what the impact speed.

The Alliance misunderstood NHTSA's second approach which compared theoretical air bags designed to 25 mph and 30 mph. At this stage only pre-MY 1998 air bags have established a well known and stable performance which served as the baseline in the PEA analysis. Thus, all the test results were transformed to the equivalents of 30 mph. In addition, the Alliance ignored the statement on page VI-53 that air bags redesigned to the 25 mph tests were assumed to have the same compliance margin as those designed to 30 mph tests. The PEA's second approach analysis also assumed that air bags designed to 25 mph RFB have injury values proportionally

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

higher than those designed to 30 mph RFB if tested in a given high impact speed. The proportion was derived by comparing test results and their compliance margins. The increased risks then were applied only to those fatalities which occurred with impact speeds above 25 mph or 30 mph. In other words, the PEA assumed the injury outcomes would be similar between these two air bag systems in a lower speed crashes (<25 mph). It is clear that the PEA's second approach did not assume injury values for 25 mph air bags are twice as high as the level of '30 mph' systems and did not disregard the crash severity as claimed by the Alliance.

**Issue 7**: The Alliance claims that the PEA ignores or understates the benefits from the high-speed OOP population and cites an IIHS study as indicative of these benefits.

The agency will address the Insurance Institute for Highway Safety (IIHS) comments on this topic later in this appendix.

**Issue 8**: The Alliance states that NASS derived delta-V, which was used in the PEA to estimate effectiveness by speed levels, is inaccurate or understated. The Alliance cites SAE papers that document inaccuracies in the NASS measurements.

NHTSA acknowledges that there may be inaccuracies in NASS delta-V estimates. However, NASS provides the best available estimates of delta V in crashes. They are based on detailed crash reconstruction and crash severity models. The entire world's technical community uses these estimates and methodology, including the Alliance in their two alternative methodologies

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

presented (the MADYMO model and the Opportunities Matrix). It should be noted that if CDS underestimated the delta V, more fatalities and MAIS 3+ injuries would occur in a higher crash severity levels. This means that air bags passing 25 mph RFB might be designed to a smaller population than currently estimated, with a corresponding decrease in benefits.

**Issue 9:** The Alliance states that the PEA did not acknowledge or consider the ramifications of the fact that nearly half of all NASS cases did not have delta-V information.

The PEA acknowledges the high unknown delta V coded in the CDS. In response, multi-year CDS (1993-1997) data were used to reduce sample variation and increase the reliability of delta V distributions.

**Issue 10:** The Alliance criticized the PEA's use of total delta-V because it biases the distribution to higher delta-Vs. The Alliance stated that NHTSA should use longitudinal delta-V to avoid skewing the crash distribution to higher severity levels.

NHTSA disagrees with the Alliance conclusion that longitudinal delta-V should be used. Injury profiles are affected by total delta-V, not just longitudinal delta-V. For this reason NHTSA has consistently used total delta-V to measure safety benefits. Longitudinal delta-V is the appropriate measure when predicting air bag deployment levels, but not for injury severity categories.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

**Issue 11:** The Alliance stated that delta-V should be tabulated only for air bag-equipped vehicles because the baseline target population is restricted to a fully air bag-equipped fleet of vehicles. The Alliance supplied a chart (Figure 7) to demonstrate the difference in injury distribution of air bag equipped and non-equipped vehicles.

NHTSA disagrees with this argument. In the table the Alliance is referring to (Table VI-28), the baseline target population developed is for unrestrained occupants in a fleet of vehicles without air bags. Then, the effectiveness of air bags can be applied to that target population. Because of the small sample size of fatalities with known delta-v, NHTSA used all vehicles to produce a more reliable estimate of the distribution of fatalities by delta V.

**Issue 12**: The Alliance claimed that NHTSA misapplied the FARS "Impact Point" variable when selecting cases for inclusion in frontal crashes. The alliance stated that this variable records the point of impact, but not the direction of impact, and that this results in the inclusion of too many cases in the target population.

Impact point is the only variable available in FARS to determine crash direction categories. There is no "direction of force" data available in FARS. It is standard procedure to use the FARs impact point variable to determine crash direction both within NHTSA studies and in studies by outside organizations such as IIHS. While this may not be a perfect measure, the important point is that the effectiveness rate used by NHTSA (Kahane) is based on this same FARS definition. In

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

order to apply this rate, the target population must match the basis for the rate. If a narrower target population were used, the effectiveness rate would be proportionately higher.

**Issue 13**: The Alliance stated that NHTSA misinterprets the CDS variable "Principal Direction of Force" and that its use results in the inclusion of cases that strike from the a frontal direction but hit the vehicle in a non-frontal area that would not deploy the air bag.

NHTSA agrees that a small number of such cases could be included under the current definition of frontal used in the SNPRM.. In response, the Agency has recalculated injuries in frontal impacts under a new definition that excludes all non-frontal impacts. It should be noted that this had only a minor impact on the estimate of nonfatal injury target population.

**Issue 14**: The Alliance states that the NASS CDS target population only represents 82 percent of police-reported deployment crashes, since 18 percent of GES deployments are in non-towaway crashes. Consequently, they state that the extent of the "at-risk" population in Table II-13 is understated.

The estimates of injuries in Table II-13 were derived from a census of all fatal cases where death was caused by air bags in crashes with delta-V less than 25 mph. NHTSA took the ratio of injuries/fatalities for those cases where the air bag was the source of injury from CDS and applied this ratio to total fatalities to estimate injuries caused by the air bag. The critical element in this definition is not deployments, but rather air bags as the source of injury. There is no reason to

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

believe that the two vary proportionally. Moreover, GES does not contain the AIS codes needed to stratify injuries by severity. CDS is the only source for this data.

**Issue 15**: The Alliance states that the broad FARS and NASS target populations used in the PEA tend to encompass the wide range of impacts in which air bags may deploy, but is too broad for accurate consideration of air bag effectiveness. The Alliance recommends that NHTSA narrow the target populations to include only deployment impacts where air bag effectiveness is expected to improve.

NHTSA agrees that the range of injuries encompassed by the target population should match the effectiveness rates applied to that population. The PEA uses an effectiveness rate that represents the impact of air bags in all frontal crashes (derived from Kahane). Therefore, the target population is appropriate for the effectiveness rate used in the PEA.

**Issue 16**: The Alliance developed a theoretical assessment of the relative impact of various requirements using an opportunities matrix and a conceptual model of the impact of design changes. The Alliance concluded that the 30 mph RFB test with both 50$^{th}$ male and 5$^{th}$ female dummies provides 23% more benefit than this same test with just a 50$^{th}$ male dummy, and that the 25 mph RFB test is 21% better than the 30 mph test.

The Alliance model is an interesting theoretical construct, but since it is entirely assumptive and not based on real world data, its findings are of limited use. One major weakness of the model is

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

that, in essence, it assigns benefits based only on patterns of relative incidence. It does not address the issue of effectiveness per-se, but just assumes benefits will fall to occupants in different categories in a roughly bell-shaped pattern around the design point. The real world crash data used in the PEA contradict the Alliance's assumptive model and produces contrasting conclusions.

The agency used the most current crash data base to perform its safety related analysis. The agency believes that using the most current real-world crash data produces a more accurate assessment of current safety countermeasure systems and potential target populations for improvement.

**Issue 17**: The Alliance provided the results of a conceptual analysis using a MADYMO simulation to determine both the relative impact of different test requirements, and to estimate the compliance ability of various combinations of models of air bag design characteristics. In a meeting on January 14, 2000, Ford Motor Company provided NHTSA with a briefing on the MADYMO model (See Docket 1999-6407-95) . The focus of the meeting was on the assumptions used in the model and the results. Ford provided a submission to the docket showing the presentation materials and additional analyses. At the request of NHTSA, Ford also provided Nij data for the specific cases analyzed in their model. The mathematical analysis is very extensive and has a substantial number of assumptions involved. Starting with a mid-size passenger car and a dual-stage driver air bag, four air bag parameters (vents size, bag size, Stage 1 inflator, and Stage 2 inflator) are changed resulting in 336 different air bag designs. The power of the air bag

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

is a variable, yet the most powerful Stage 1 and 2 combined system is not quite as powerful as the current redesigned air bags.

The first stage of Ford's analysis was to determine whether these designs would pass a group of tests which include: the Canadian 25 mph belted 5th female offset test, the 35 mph belted 50th male NCAP test, out-of-position tests for both the 5th female and 50th male driver, and unbelted 208 type tests for the 5th female and 50th male dummies at 25 and 30 mph. The 35 mph belted NCAP test and the out-of-position test for the 50th male dummy were not proposed in the SNPRM. The criteria for passing these tests include the dummy measurements and do include one injury measurement (neck shear), which was not proposed in the SNPRM. A 20 percent compliance margin is included for those injury criteria proposed in the SNPRM and typically a 10 percent compliance margin for other injury criteria. The higher speed portions of the model were validated using 7 existing tests including tests at 30 and 35 mph with the 5th and 50th dummies with the rigid barrier and the 40% offset test. No tests were run at lower speeds to validate the model at low speeds. The results of the first stage of the MADYMO analysis were a finding that 21 of 336 designs comply with a 25 mph unbelted set of tests, but none of the 336 designs comply with a 30 mph unbelted set of tests. The closest acceptance factor in the 30 mph unbelted test was 107 percent, indicating that the closest design was 7 percent above acceptable. A 100 percent acceptance factor includes either the 10 or 20 percent compliance margin depending upon the test and injury measure. Since their lowest acceptable compliance margin is 10 percent, at least one design (the one at 107 percent) passed all criteria.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

The second stage of the process was to estimate the aggregate AIS 3+ occupant risk using the air bag designs that performed the best in the cadre of tests including the 25 mph and 30 mph unbelted tests. A separate set of assumptions is needed for this task. Ford's assumptions include an involvement frequency by delta V for 12 o'clock distributed impacts based on NASS 1988-96 for AIS 3+ injuries, the assumption that rigid barrier tests represent 30 percent of AIS 3+ injuries and a generic sled-type test would represent 70 percent, that the usage of seat belts decreases as delta V increases, that the 50th male dummy represents 60 percent of injuries while the 5th female dummy represents 40 percent of injuries, that dummy measurements are translated into injuries using an AIS 3+ injury curve for each injury criteria examined, and that the risk of fatality can be estimated using the 3 highest injuries derived from the AIS 3+ injury curve.

The model is an attempt to determine whether the net gains are positive or negative. Ford's results are:

1) For out-of position occupants, a 25 mph air bag would reduce AIS 3+ injury risk by about 50 percent.

2) For in-position occupants, a 25 mph air bag would reduce AIS 3+ injury risk by about 33 percent and overall fatality risk by about 50 percent.

The agency disagrees with several of the assumptions used in the model, including:

1) The selected best design representing the 30 mph air bag design does not meet the final rule criteria because the Nij for the 5th percentile female dummy is over 1.0. The 25 mph air bag does not appear to be a minimal design, it easily passes the criteria at 25 mph. Thus, in our opinion

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

these designs do not represent a valid comparison of a vehicle designed to a 25 mph unbelted standard versus a vehicle designed to a 30 mph unbelted standard. The MADYMO model does not examine other aspects of air bag design, e.g. fold pattern, shape, tethering, seam pattern.

2) Air bags with more power should have been examined, at least to today's level of redesigned air bags.

3) Determining the validity of the model at lower speeds is a critical factor, which was not done.

4) The methodology for determining the impact on fatality risk is different from NHTSA's methodology. We believe fatalities have to be examined separately starting with the distribution of fatalities by delta V, using an AIS 5+ injury curve to estimate the risk of fatality using the dummy measurements. In addition, the 1980 NHTSA data Ford relied upon to determine risk of fatality from the three highest AIS injuries is old (MAIS injury codes have changed some over time). Using old data would have a minor impact on the conclusions.

5) The 5th percentile female dummy does not represent 40 percent of the injuries. NHTSA's analysis of 1993-97 CDS data indicates that the 5th percentile female represents only 21 percent of injuries, roughly half that assumed in Ford's model.

6) NHTSA disagrees with the percent of crashes assumed by Ford to be represented by the rigid barrier and generic sled pulse. Table V-2 in the FEA indicates that 78% of crashes are represented by the rigid barrier tests and 22% are represented by the generic sled test.

7) The agency also notes that the criteria examined in the MADYMO study exceed those proposed in the SNPRM. It is thus unclear how many of the 336 designs would pass the SNPRM proposals. NHTSA notes that at least one vehicle tested by the agency, the Saturn, did pass all of the high speed test requirements proposed in the SNPRM.

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

We took the raw data from the Ford MADYMO model for the 25 mph and 30 mph selected models (HIC, Nij, chest g's, chest deflection) and analyzed it using NHTSA's assumptions. However, we are still concerned that the selected 30 mph design did not meet the Nij criteria with the 5th percentile female dummy. Tables B-1 and B-2 show the raw data from Ford plus the calculated CTI value. Figures B-1 and B-2 show these data graphically. Examining the graphs and comparing the 25 mph air bag results to the 30 mph air bag results, we observe that:

1) For the HIC 15 curve for the 5$^{th}$ percentile female, sometimes the 25 mph air bag gives higher numbers, but usually the 30 mph air bag gives higher numbers. All of the HIC values are very low, with no estimated probability of fatality.

2) For the HIC 15 curve for the 50$^{th}$ percentile male, the 25 mph air bag usually gives higher numbers than the 30 mph air bag. There is a difference in higher speeds in the rigid barrier test.

3) The Nij curves for the 5$^{th}$ percentile female are unusual. Considering that only the Stage 1 inflator is used for the 5$^{th}$ percentile female at all speeds, it seems strange that the Nij would increase and decrease dramatically with increasing speeds. This suggests that the Nij level is more dependent upon the interaction of the dummy and air bag, than on the test speed.

4) The Nij curves for the 50$^{th}$ percentile male intertwine at various speeds and are close together throughout. Unlike the 5$^{th}$ percentile female Nij, curve, the 50$^{th}$ percentile male Nij curves increase as test speed increases.

5) The CTI curves always show higher values with the 25 mph air bag than with the 30 mph air bag. Similarly, chest deflection and chest g's curves show higher values with the 25 mph air bag.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Tables B-3 through B-6 provide the results of NHTSA's analysis using the Ford MADYMO raw data. Each speed from the Ford model was assumed to represent a range of speeds around that point. For instance, the results at 10 mph were assumed to represent the results from 8 to 12 mph. The percent of occupants is taken from unbelted occupants in NASS. Since we are examining the results of two unbelted tests (25 mph vs. 30 mph), no belt use was assumed. Using NHTSA's probability of injury curves, a probability of fatality from the AIS 5+ curve or a probability of AIS 3+ injury from the AIS 3+ curve was determined for HIC, Nij, and CTI for 50$^{th}$ males, 5$^{th}$ females and in both rigid and generic tests. At this point, two separate analyses were performed using different assumptions. In Tables B-3 and B-4, the distribution of injuries by body region for unbelted adult front-outboard occupants at all severity levels with no air bag (as shown in Table B-5) was used to determine a combined probability of fatality or AIS 3+ injury. These are then weighted by male/female and rigid/generic test type to provide a total weighted probability of fatality or injury. Overall, weighted by speed, for fatalities there was no difference between the 25 mph air bag design and the 30 mph air bag design. For AIS 3+ injuries, the probability of injury was 1.63 percent with a 25 mph air bag design and 0.96 percent with a 30 mph air bag design, a 69 percent reduction. This large of a difference seems unlikely.

For Tables B-6 and B-7, occupant injuries were not weighted by body region using data from NASS, but they are combined using the formula shown on Page VI-15. This method allows neck injury to have a larger influence on the final results, and the 5$^{th}$ percentile female Nij estimates from the MADYMO model have a strong influence on the results. The probability of fatality was 2.93 percent with a 25 mph air bag design and 3.02 percent with a 30 mph air bag design, an

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

increase of 2.91 percent. For AIS 3+ injuries, the probability of injury was 10.31 percent with a 25 mph air bag design and 9.15 percent with a 30 mph air bag design, a 12.7 percent reduction.

In conclusion, the agency doesn't believe it has a valid comparison using the selected air bag designs from Ford representing a 25 mph air bag and a 30 mph air bag for two reasons. First, there is no guarantee that the 25 mph air bag is a minimal design that just meets the 25 mph standard. An examination of Table B-1 for the rigid type impact show all dummy measurements well below the injury criteria at 40 kph (25 mph), even well below a 20 percent compliance margin. Thus, it represents a relatively good 25 mph air bag,.one that meets all of the injury criteria at 30 mph (although no one would certify an air bag at 59.33 chest g's). Second, the 30 mph air bag design does not pass the Nij criteria for the 5$^{th}$ percentile female dummy. The 5$^{th}$ percentile female dummy Nij results have a significant influence on the overall results of the analysis. Nonetheless, the agency used its own analysis procedures with the raw data from the MADYMO model and finds results that are significantly different than Ford's results. Ford found that the 25 mph air bag design significantly decreased the risk of fatality (50 percent) and injury (33 percent) compared to a 30 mph air bag design for in-position occupants. NHTSA's analysis of the same raw data, finds the same, or nearly the same, fatality risk between the two air bag designs and a 13 to 69 percent increase in AIS 3+ (serious injury and fatality) risk for the 25 mph air bag design compared to the 30 mph design.

The Alliance MADYMO model is an interesting theoretical construct, but since it is somewhat assumptive and not totally based on real world data, and it does not include designs that totally

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

meet the final rule, its findings are of limited use. The agency's analysis of this information does not agree with Ford's conclusion that an air bag designed to a 25 mph unbelted test will provide more protection than an air bag designed to a 30 mph unbelted test, but shows the opposite.

**Table B-1**
**Rigid Type Impact**

**50th Percentile Male**

Selected 25 mph Design

| Test Speed (kph) | Head HIC 15 | Neck Nij | Chest g's | Chest Deflection mm | CTI |
|---|---|---|---|---|---|
| 16 | 1.01 | 0.15 | 5.37 | 4.68 | 0.11 |
| 24 | 84.60 | 0.30 | 22.71 | 18.11 | 0.43 |
| 32 | 94.47 | 0.34 | 26.74 | 24.06 | 0.53 |
| 40 | 135.67 | 0.35 | 43.47 | 28.93 | 0.76 |
| 48 | 470.14 | 0.71 | 59.33 | 35.32 | 1.00 |
| 56 | 624.91 | 0.60 | 59.43 | 56.54 | 1.21 |

Selected 30 mph Design

| | | | | | |
|---|---|---|---|---|---|
| 16 | 1.01 | 0.15 | 5.37 | 4.68 | 0.11 |
| 24 | 36.33 | 0.31 | 18.18 | 20.37 | 0.40 |
| 32 | 46.23 | 0.29 | 20.20 | 21.55 | 0.43 |
| 40 | 115.48 | 0.43 | 33.21 | 26.31 | 0.62 |
| 48 | 217.19 | 0.51 | 47.55 | 35.29 | 0.87 |
| 56 | 485.51 | 0.69 | 49.12 | 39.18 | 0.93 |

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

**5th Percentile Female**

Selected 25 mph Design

| Test Speed (kph) | Head HIC 15 | Neck Nij | Chest g's | Chest Deflection mm | CTI |
|---|---|---|---|---|---|
| 16 | 87.96 | 0.28 | 13.04 | 24.53 | 0.44 |
| 24 | 158.13 | 0.78 | 27.11 | 26.43 | 0.62 |
| 32 | 146.72 | 0.41 | 29.90 | 29.39 | 0.68 |
| 40 | 183.51 | 0.53 | 33.33 | 31.74 | 0.75 |
| 48 | 153.66 | 0.61 | 40.92 | 49.22 | 1.04 |
| 56 | 284.07 | 1.28 | 51.79 | 53.54 | 1.21 |

Selected 30 mph Design

| | | | | | |
|---|---|---|---|---|---|
| 16 | 87.98 | 0.28 | 13.04 | 24.53 | 0.44 |
| 24 | 162.32 | 0.75 | 26.14 | 22.61 | 0.56 |
| 32 | 209.34 | 0.86 | 27.63 | 23.25 | 0.58 |
| 40 | 236.87 | 1.17 | 30.53 | 27.63 | 0.67 |
| 48 | 159.55 | 0.53 | 32.31 | 32.85 | 0.75 |
| 56 | 176.34 | 0.51 | 46.40 | 43.00 | 1.03 |

**Table B-2**
**Generic Type Impact**

**50th Percentile Male**

Selected 25 mph Design

| Test Speed (kph) | Head HIC 15 | Neck Nij | Chest g's | Chest Deflection mm | CTI |
|---|---|---|---|---|---|
| 16 | 0.69 | 0.09 | 5..35 | 0.01 | 0.06 |
| 24 | 38.37 | 0.38 | 20.18 | 25.32 | 0.47 |
| 32 | 103.53 | 0.48 | 23.49 | 20.68 | 0.46 |
| 40 | 100.66 | 0.33 | 27.85 | 24.34 | 0.55 |
| 48 | 110.92 | 0.39 | 31.56 | 26.44 | 0.61 |
| 56 | 140.64 | 0.57 | 46.13 | 30.64 | 0.81 |

Selected 30 mph Design

| | | | | | |
|---|---|---|---|---|---|
| 16 | 0.69 | 0.09 | 5.35 | 0.01 | 0.06 |
| 24 | 38.13 | 0.38 | 20.22 | 25.23 | 0.47 |
| 32 | 48.65 | 0.31 | 20.03 | 20.02 | 0.42 |
| 40 | 51.50 | 0.33 | 22.06 | 20.38 | 0.44 |
| 48 | 77.45 | 0.35 | 29.57 | 22.03 | 0.54 |
| 56 | 181.18 | 0.40 | 41.17 | 28.80 | 0.74 |

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**5th Percentile Female**

Selected 25 mph Design

| Test Speed (kph) | Head HIC 15 | Neck Nij | Chest g's | Chest Deflection mm | CTI |
|---|---|---|---|---|---|
| 16 | 86.97 | 0.27 | 12.25 | 22.55 | 0.40 |
| 24 | 75.79 | 0.35 | 20.71 | 34.93 | 0.65 |
| 32 | 150.53 | 0.73 | 26.79 | 28.59 | 0.64 |
| 40 | 194.72 | 1.37 | 29.74 | 31.10 | 0.70 |
| 48 | 198.54 | 1.32 | 30.96 | 33.42 | 0.74 |
| 56 | 205.33 | 1.04 | 32.65 | 36.37 | 0.80 |

Selected 30 mph Design

| | | | | | |
|---|---|---|---|---|---|
| 16 | 86.96 | 0.27 | 12.25 | 22.55 | 0.40 |
| 24 | 75.78 | 0.35 | 20.70 | 34.93 | 0.65 |
| 32 | 265.84 | 1.61 | 26.27 | 24.88 | 0.59 |
| 40 | 238.53 | 1.22 | 28.95 | 25.81 | 0.63 |
| 48 | 257.13 | 1.36 | 31.54 | 26.75 | 0.67 |
| 56 | 289.66 | 1.48 | 34.79 | 29.13 | 0.73 |

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

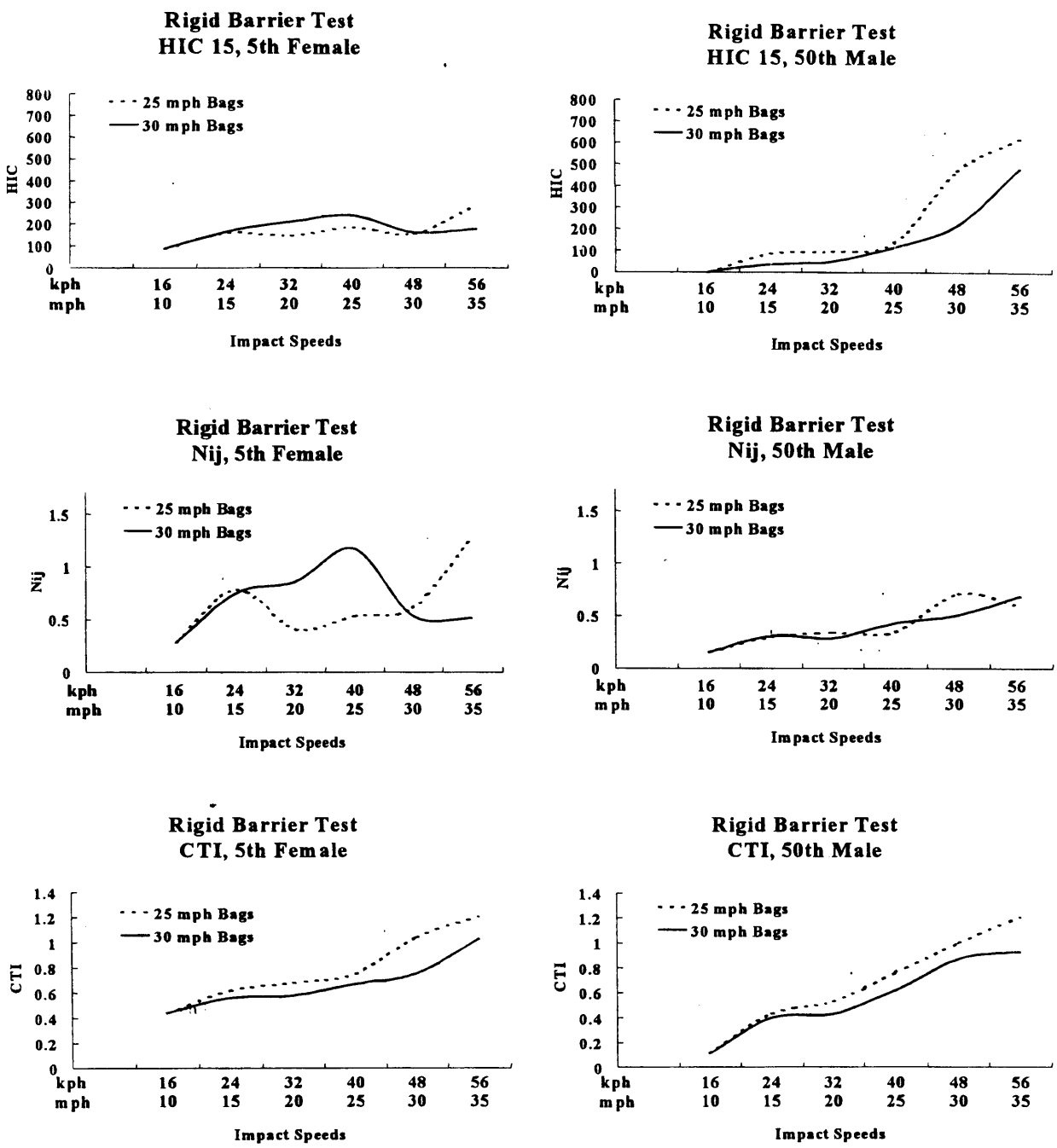



**Figure B-1 Head, Neck, and Chest Injury Values, Rigid Barrier Tests**
**Fords' MADYMO Simulation Data**

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

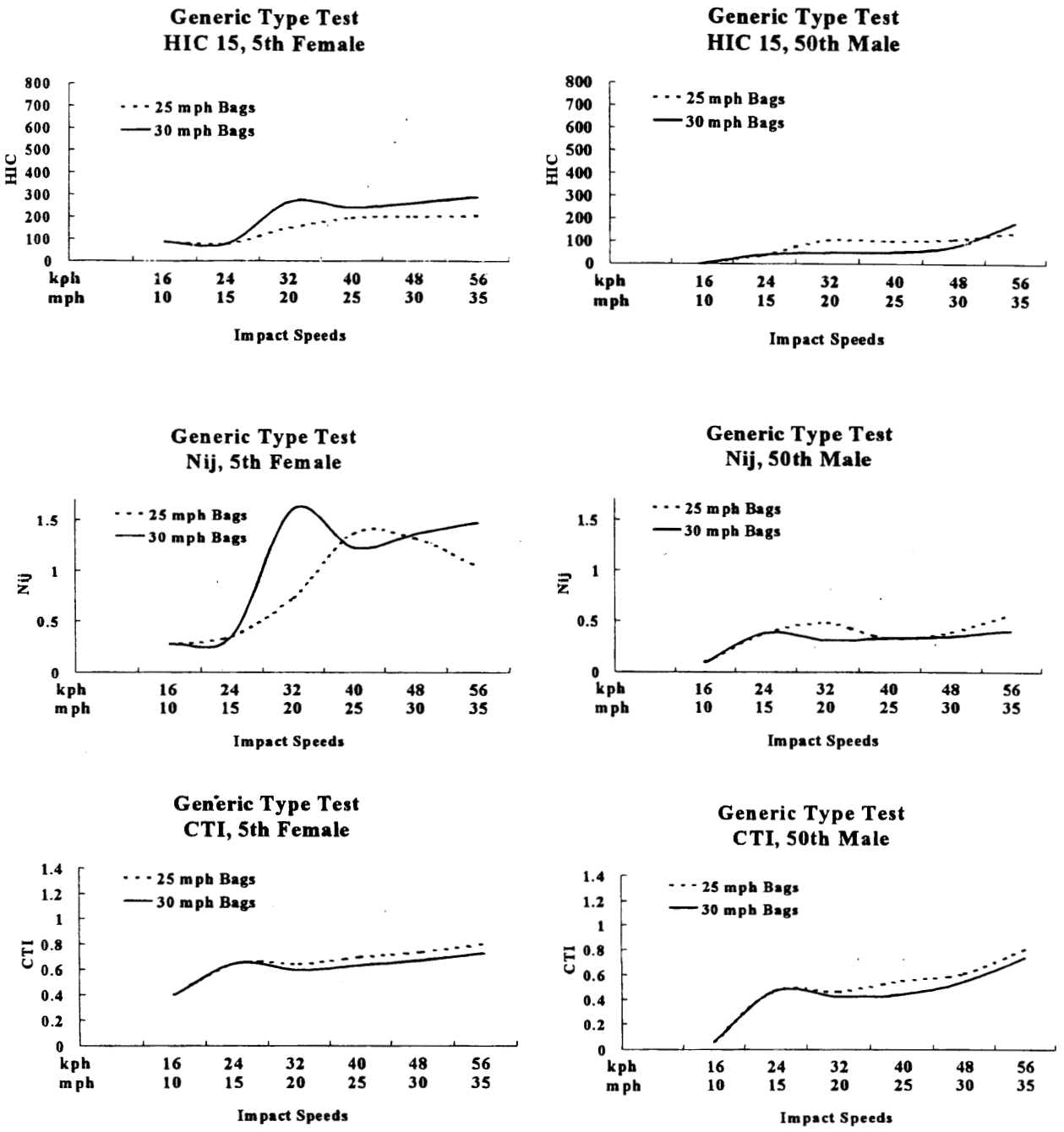



**Figure B-2 Head, Neck, and Chest Injury Values, Generic Type Tests**
**Fords' MADYMO Simulation Data**

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Table B-3**
**Fatality Risk Probabilities**
**25 MPH Bags vs 30 MPH Bags**

Combined Probabilities Were Weighted by Crash Severity, Crash Type, Occupant Status , and Injured Body Region

| 25 MPH Bags | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Combined Probability of Fatalities** | | | | Weighted Combined Probability of Fatalities | | | | |
| Speed | | % of* Occupants | Rigid Barrier Tests | | Generic Tests | | Rigid Barrier Tests | | Generic Tests | | Total*** |
| kph | mph | | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | |
| 13-20 | 8-12 | 26.38% | 0.07% | 0.08% | 0.06% | 0.08% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% |
| 21-28 | 13-17 | 35.05% | 0.14% | 0.24% | 0.15% | 0.15% | 0.05% | 0.08% | 0.05% | 0.05% | 0.06% |
| 29-36 | 18-22 | 15.95% | 0.08% | 0.08% | 0.09% | 0.12% | 0.01% | 0.01% | 0.01% | 0.02% | 0.01% |
| 37-44 | 23-27 | 5.44% | 0.04% | 0.05% | 0.04% | 0.12% | 0.00% | 0.00% | 0.00% | 0.01% | 0.00% |
| 45-52 | 28-32 | 3.08% | 0.34% | 0.29% | 0.23% | 0.64% | 0.01% | 0.01% | 0.01% | 0.02% | 0.01% |
| 53+ | 33+ | 2.35% | 0.35% | 0.64% | 0.27% | 0.45% | 0.01% | 0.02% | 0.01% | 0.01% | 0.01% |
| **Total risk probability for all speeds** | | | | | | | **0.10%** | **0.14%** | **0.10%** | **0.13%** | **0.11%** |
| | | | | | | | | | | | |
| **30 MPH Bags** | | | | | | | | | | | |
| 13-20 | 8-12 | 26.38% | 0.07% | 0.08% | 0.06% | 0.08% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% |
| 21-28 | 13-17 | 35.05% | 0.14% | 0.23% | 0.15% | 0.15% | 0.05% | 0.08% | 0.05% | 0.05% | 0.06% |
| 29-36 | 18-22 | 15.95% | 0.07% | 0.14% | 0.07% | 0.31% | 0.01% | 0.02% | 0.01% | 0.05% | 0.01% |
| 37-44 | 23-27 | 5.44% | 0.04% | 0.09% | 0.04% | 0.10% | 0.00% | 0.01% | 0.00% | 0.01% | 0.00% |
| 45-52 | 28-32 | 3.08% | 0.26% | 0.27% | 0.22% | 0.67% | 0.01% | 0.01% | 0.01% | 0.02% | 0.01% |
| 53+ | 33+ | 2.35% | 0.32% | 0.26% | 0.22% | 0.72% | 0.01% | 0.01% | 0.01% | 0.02% | 0.01% |
| **Total risk probability for all speeds** | | | | | | | **0.10%** | **0.14%** | **0.10%** | **0.16%** | **0.11%** |
| | | | | | | | | | | | |
| **Compared to the 30 mph bags, 25 mph bags increase risk of fatalities for unbelted Occupants by** | | | | | | | | | | | **0.00%** |

* Unbelted adult front-outboard occupants in frontal crashes with no air bags
** Weighted head, neck, and chest risk probabilities
*** Weighted by crash severity (delta v) , crash type (rigid, generic), and occupant status (50th male, 5th female)
Source: 1993-1998 NASS CDS, Ford's MADYMO simulation data

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Table B-4**
**MAIS3+ Injury Risk Probabilities**
**25 MPH Bags vs 30 MPH Bags**

Combined Probabilities Were Weighted by Crash Severity, Crash Type, Occupant Status , and Injured Body Region

| 25 MPH Bags | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Combined Probability of AIS3+ Injuries** | | | | Weighted Combined Probability of AIS3+ Injuries | | | | |
| Speed | | % of* Occupants | Rigid Barrier Tests | | Generic Tests | | Rigid Barrier Tests | | Generic Tests | | Total*** |
| kph | mph | | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | |
| 13-20 | 8-12 | 26.38% | 0.14% | 0.63% | 0.12% | 0.57% | 0.04% | 0.17% | 0.03% | 0.15% | 0.06% |
| 21-28 | 13-17 | 35.05% | 0.76% | 2.11% | 0.39% | 0.63% | 0.27% | 0.74% | 0.14% | 0.22% | 0.32% |
| 29-36 | 18-22 | 15.95% | 0.82% | 1.87% | 0.95% | 1.91% | 0.13% | 0.30% | 0.15% | 0.31% | 0.17% |
| 37-44 | 23-27 | 5.44% | 2.40% | 2.08% | 0.69% | 2.41% | 0.13% | 0.11% | 0.04% | 0.13% | 0.11% |
| 45-52 | 28-32 | 3.08% | 18.51% | 4.38% | 1.64% | 4.35% | 0.57% | 0.13% | 0.05% | 0.13% | 0.39% |
| 53+ | 33+ | 2.35% | 31.74% | 24.82% | 4.78% | 4.96% | 0.75% | 0.58% | 0.11% | 0.12% | 0.58% |
| **Total risk probability for all speeds** | | | | | | | **1.88%** | **2.03%** | **0.52%** | **1.06%** | **1.63%** |
| | | | | | | | | | | | |
| **30 MPH Bags** | | | | | | | | | | | |
| 13-20 | 8-12 | 26.38% | 0.14% | 0.63% | 0.12% | 0.57% | 0.04% | 0.17% | 0.03% | 0.15% | 0.06% |
| 21-28 | 13-17 | 35.05% | 0.36% | 2.13% | 0.39% | 0.63% | 0.13% | 0.75% | 0.14% | 0.22% | 0.23% |
| 29-36 | 18-22 | 15.95% | 0.29% | 3.27% | 0.29% | 4.63% | 0.05% | 0.52% | 0.05% | 0.74% | 0.16% |
| 37-44 | 23-27 | 5.44% | 1.24% | 3.00% | 0.23% | 2.81% | 0.07% | 0.16% | 0.01% | 0.15% | 0.08% |
| 45-52 | 28-32 | 3.08% | 5.84% | 2.51% | 1.20% | 5.12% | 0.18% | 0.08% | 0.04% | 0.16% | 0.14% |
| 53+ | 33+ | 2.35% | 15.90% | 12.48% | 3.34% | 5.83% | 0.37% | 0.29% | 0.08% | 0.14% | 0.30% |
| **Total risk probability for all speeds** | | | | | | | **0.83%** | **1.97%** | **0.34%** | **1.56%** | **0.96%** |
| | | | | | | | | | | | |
| **Compared to the 30 mph bags, 25 mph bags increase risk of AIS3+ Injuries for unbelted Occupants by** | | | | | | | | | | | **69.00%** |

* Unbelted adult front-outboard occupants in frontal crashes with no air bags
** Weighted head, neck, and chest risk probabilities
*** Weighted by crash severity (delta v) , crash type (rigid, generic), and occupant status (50th male, 5th female)
Source: 1993-1998 NASS CDS, Ford's MADYMO simulation data

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

**Table B-5**

**Weighting Factors for Injured Body Region**

| Speed | | Percent of Unbelted Front-Outboard Occupants in Vehicles with No Air Bags by Crash Impact Speeds | | |
|---|---|---|---|---|
| kph | mph | Head | Neck | Chest |
| 13-20 | 8-12 | 65% | 3% | 5% |
| 21-28 | 13-17 | 66% | 5% | 3% |
| 29-36 | 18-22 | 78% | 2% | 6% |
| 37-44 | 23-27 | 59% | 1% | 9% |
| 45-52 | 28-32 | 63% | 7% | 5% |
| 53+ | 33+ | 34% | 6% | 34% |

Source: 1993-1998 NASS CDS

DRAFT DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Table B-6**
**Fatality Risk Probabilities**
**25 MPH Bags vs 30 MPH Bags**

Combined Probabilities Were Weighted by Crash Severity, Crash Type, and Occupant Status

| 25 MPH Bags | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Combined Probability of Fatalities** | | | | Weighted Combined Probability of Fatalities | | | | |
| Speed | | % of* Occupants | Rigid Barrier Tests | | Generic Tests | | Rigid Barrier Tests | | Generic Tests | | Total*** |
| kph | mph | | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | |
| 13-20 | 8-12 | 26.38% | 2.57% | 2.98% | 2.39% | 2.95% | 0.68% | 0.79% | 0.63% | 0.78% | 0.69% |
| 21-28 | 13-17 | 35.05% | 3.05% | 5.30% | 3.35% | 3.24% | 1.07% | 1.86% | 1.17% | 1.14% | 1.22% |
| 29-36 | 18-22 | 15.95% | 3.20% | 3.47% | 3.76% | 5.01% | 0.51% | 0.55% | 0.60% | 0.80% | 0.55% |
| 37-44 | 23-27 | 5.44% | 3.25% | 3.99% | 3.16% | 10.17% | 0.18% | 0.22% | 0.17% | 0.55% | 0.20% |
| 45-52 | 28-32 | 3.08% | 4.96% | 4.42% | 3.39% | 9.64% | 0.15% | 0.14% | 0.10% | 0.30% | 0.15% |
| 53+ | 33+ | 2.35% | 4.54% | 9.40% | 4.18% | 7.10% | 0.11% | 0.22% | 0.10% | 0.17% | 0.13% |
| **Total risk probability for all speeds** | | | | | | | **2.69%** | **3.77%** | **2.78%** | **3.73%** | **2.93%** |
| | | | | | | | | | | | |
| **30 MPH Bags** | | | | | | | | | | | |
| 13-20 | 8-12 | 26.38% | 2.57% | 2.98% | 2.39% | 2.95% | 0.68% | 0.79% | 0.63% | 0.78% | 0.69% |
| 21-28 | 13-17 | 35.05% | 3.09% | 5.12% | 3.35% | 3.24% | 1.08% | 1.79% | 1.17% | 1.14% | 1.22% |
| 29-36 | 18-22 | 15.95% | 3.02% | 5.80% | 3.09% | 13.11% | 0.48% | 0.92% | 0.49% | 2.09% | 0.63% |
| 37-44 | 23-27 | 5.44% | 3.55% | 8.19% | 3.16% | 8.65% | 0.19% | 0.45% | 0.17% | 0.47% | 0.24% |
| 45-52 | 28-32 | 3.08% | 3.91% | 3.99% | 3.24% | 10.06% | 0.12% | 0.12% | 0.10% | 0.31% | 0.13% |
| 53+ | 33+ | 2.35% | 4.83% | 3.95% | 3.44% | 11.44% | 0.11% | 0.09% | 0.08% | 0.27% | 0.11% |
| **Total risk probability for all speeds** | | | | | | | **2.67%** | **4.17%** | **2.65%** | **5.05%** | **3.02%** |
| | | | | | | | | | | | |
| **Compared to the 30 mph bags, 25 mph bags increase risk of fatalities for unbelted Occupants by** | | | | | | | | | | | **-2.91%#** |

* Unbelted adult front-outboard occupants in frontal crashes with no air bags
** Combined head, neck, and chest risk probabilities
*** Weighted by crash severity (delta v) , crash type (rigid, generic), and occupant status (50th male, 5th female)
# Note that the agency does not believe this is a valid comparison of a 25 mph air bag and a 30 mph air bag, since the 25 mph air bag easily meets the injury criteria at 25 mph, but the 30 mph air bag does not meet the Nij requirements. Differences in Nij account for this result.
Source: 1993-1998 NASS CDS, Ford's MADYMO simulation data

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Table B-7**
**MAIS3+ Injury Risk Probabilities**
**25 MPH Bags vs 30 MPH Bags**

Combined Probabilities Were Weighted by Crash Severity, Crash Type, and Occupant Status

| 25 MPH Bags | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Combined Probability of AIS3+ Injuries** | | | | Weighted Combined Probability of AIS3+ Injuries | | | | |
| Speed | | % of* Occupants | Rigid Barrier Tests | | Generic Tests | | Rigid Barrier Tests | | Generic Tests | | Total*** |
| kph | mph | | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | 50th Male | 5th Female | |
| 13-20 | 8-12 | 26.38% | 5.12% | 7.61% | 4.56% | 7.31% | 1.35% | 2.01% | 1.20% | 1.93% | 1.46% |
| 21-28 | 13-17 | 35.05% | 7.84% | 19.06% | 8.46% | 10.05% | 2.75% | 6.68% | 2.97% | 3.52% | 3.46% |
| 29-36 | 18-22 | 15.95% | 8.96% | 12.94% | 10.71% | 17.97% | 1.43% | 2.06% | 1.71% | 2.87% | 1.65% |
| 37-44 | 23-27 | 5.44% | 15.41% | 17.02% | 9.03% | 41.16% | 0.84% | 0.93% | 0.49% | 2.24% | 0.86% |
| 45-52 | 28-32 | 3.08% | 52.87% | 41.06% | 11.20% | 39.91% | 1.63% | 1.26% | 0.34% | 1.23% | 1.33% |
| 53+ | 33+ | 2.35% | 78.69% | 76.09% | 21.48% | 31.35% | 1.85% | 1.79% | 0.50% | 0.74% | 1.55% |
| **Total risk probability for all speeds** | | | | | | | **9.84%** | **14.73%** | **7.22%** | **12.52%** | **10.31%** |
| | | | | | | | | | | | |
| **30 MPH Bags** | | | | | | | | | | | |
| 13-20 | 8-12 | 26.38% | 5.12% | 7.61% | 4.56% | 7.31% | 1.35% | 2.01% | 1.20% | 1.93% | 1.46% |
| 21-28 | 13-17 | 35.05% | 7.29% | 17.85% | 8.46% | 10.05% | 2.56% | 6.26% | 2.97% | 3.52% | 3.28% |
| 29-36 | 18-22 | 15.95% | 7.24% | 22.01% | 7.41% | 51.70% | 1.15% | 3.51% | 1.18% | 8.25% | 1.87% |
| 37-44 | 23-27 | 5.44% | 11.96% | 33.45% | 7.79% | 34.70% | 0.65% | 1.82% | 0.42% | 1.89% | 0.86% |
| 45-52 | 28-32 | 3.08% | 26.35% | 17.09% | 9.45% | 41.11% | 0.81% | 0.53% | 0.29% | 1.27% | 0.70% |
| 53+ | 33+ | 2.35% | 49.20% | 40.26% | 15.62% | 47.71% | 1.16% | 0.95% | 0.37% | 1.12% | 0.98% |
| **Total risk probability for all speeds** | | | | | | | **7.68%** | **15.07%** | **6.43%** | **17.97%** | **9.15%** |
| | | | | | | | | | | | |
| **Compared to the 30 mph bags, 25 mph bags increase risk of AIS3+ Injuries for unbelted Occupants by** | | | | | | | | | | | **12.71%** |

* Unbelted adult front-outboard occupants in frontal crashes with no air bags
** Combined head, neck, and chest risk probabilities
*** Weighted by crash severity (delta v) , crash type (rigid, generic), and occupant status (50th male, 5th female)
Source: 1993-1998 NASS CDS, Ford's MADYMO simulation data

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**B. Analyses of Crash Data**

There were two comments to the docket about analyses of crash data regarding air bags.

1) The University of Michigan, Transportation Research Institute (UMTRI) (Docket No. 6407, #69) provided an analysis of 160 occupants (120 drivers and 40 right front seat passengers). Their conclusions are:

"... depowered airbags are equivalent to pre-depowered airbags in offering protection to both belt-restrained and unbelted front-seat passengers involved in moderate to severe frontal crashes. In addition , the database suggest that, for the most part, depowered airbags are significantly less aggressive during deployment than pre-depowered airbags. However, the data also show that depowered airbags can still cause serious or fatal injuries to child and adult occupants who are in close proximity to the airbag module at the time of deployment."

The UMTRI database did find one case of an unbelted occupant overpowering the depowered air bag. This driver was 6'7" tall, weighed 230 lbs., was involved in a 40-mph impact and suffered serious, but non-fatal injuries.

NHTSA response:

To date, NHTSA's data and findings agree with UMTRI's conclusions.

2) The Insurance Institute for Highway Safety (IIHS) (Docket No. 6407, #67) - IIHS made two claims that prompted the agency to do hard-copy analyses of NASS cases. The claims were:

First, that IIHS is unaware of any cases in which the energy of the deploying air bag was inadequate. Second, that their studies of air bag performance in moderate to severe frontal crashes shows that drivers are dying because of overwhelming intrusion that no air bag design can overcome, ejection, and injury from the air bag itself. IIHS estimates that about 15 percent of the cases they examined were caused by the air bag itself.

NHTSA response:

The agency examined every case of a driver or passenger fatality in NASS (from 1988 through the first six months of 1999) with air bags and known delta V over 25 mph (those under 25 mph are already examined in the Special Crash Investigation file). The selection criteria for the cases included a frontal impact with a known delta V of 25 mph and greater with no rollover and ejections. In addition, the two cases identified by IIHS as an air bag caused fatality with unknown delta V were examined. In all, 57 cases were clinically reviewed by NHTSA (excluding one case that was reviewed but turned out to be an ejection). The cases are summarized below:

37 cases were deemed unsurvivable, 33 from intrusion, 4 from insufficient occupant protection from the air bag/belt system in a high (greater than 40 mph delta V) crash

11 cases in which the air bag probably caused the fatality (one with a redesigned air bag). Ten were drivers and one passenger. The NASS year and case numbers are: [1991, 79-21A; 1993, 6-6A; 1993, 08-133A, 1994, 11-150A; 1995, 09-167A, 1996 08-100A, 1997 6-126 (passenger); 1997 72-103; 1997 82-186; 1998 9-87; 1998 43-88]

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

4 cases of insufficient occupant protection from the air bag/belt system (3 with heavy occupants) (one with a redesigned air bag). These crashes were deemed potentially survivable if the air bag had worked better, with little intrusion and delta V less than 40 mph. The case numbers are:

[1998, 2-154; 1998, 6-147; 1999, 6-38; 1999, 74-13 (redesigned)]

3 cases that had two causes of fatality, intrusion to the chest and the air bag to the head/neck. These people would have died with or without an air bag (one with a redesigned air bag). The case numbers are:

[1995, 5-125A; 1998, 9-144 (redesigned); 1998, 49-83]

1 non-deployment of the air bag

1 reclined passenger, out-of-position, died from injuries caused by the seat belt

A brief description of these 57 cases will be docketed in a paper entitled "A Summary of NASS Cases from 1989-1999 with Air Bag Related Fatalities or Insufficient Occupant Protection".

While the agency found that 11 of 57 cases examined (roughly 19 percent) were air bag caused fatalities, this does not mean that 19 percent of all remaining air bag deployment fatalities are caused by air bags. One has to consider the case selection criteria of only known delta V above 25 mph, no ejections and no rollovers.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

To provide a national estimate based on these cases, we examined the latest two years (1997 and (1998) that had the highest number of air bag caused high speed fatalities. There were three air bag caused high speed fatalities in calendar year 1997 NASS and there were two air bag caused high speed fatalities in calendar year 1998 NASS. These numbers are so sparse that we can not make a reasonable prediction of the number of fatalities they represent nationwide. While NASS is a survey, and predictions can be made from the results, those numbers are hardly reliable from a sample of two or three cases.[4] However, we can be confident that they do not represent 15 percent of all remaining fatalities in air bag deployment cases.

We have found 4 cases in 1998 and 1999 NASS in which we believe the air bag was not strong enough, one with a redesigned air bag, and UMTRI found one such case. In general, these were cases where the occupant went over the top of the air bag, or hit the air bag off-center or on a

---

[4] The combined national weights of the three air bag related fatalities in 1997 NASS were 32.25. In 1997 NASS-CDS, there were 747.2 weighted fatalities in frontal crashes with deployed air bags. Of these 117.3 had a delta V of < 25 mph, 239.34 had a delta V > 25 mph, and 390.66 with unknown delta V. Distributing the unknowns would result in 501.37 with delta V greater than 25 mph. The following factor (501.37/239.24 = 2.1) is used to estimate the number of fatalities caused by air bags in crashes with delta V > 25 mph in 1997 = 32.25 X 2.1 = 68 (42 drivers and 26 passengers).

The combined national weights of the two air bag related fatalities in 1998 NASS were 77.32. In 1998 NASS-CDS, there were 1,757.68 weighted fatalities in frontal crashes with deployed air bags. Of these 122.03 had a delta V of < 25 mph, 603.88 had a delta V > 25 mph, and 1,031.86 with unknown delta V. Distributing the unknowns would result in 1.462.34 with delta V greater than 25 mph. The following factor (1,462.34/603.88 = 2.42) is used to estimate the number of fatalities caused by air bags in crashes with delta V > 25 mph in 1998 = 77.32 X 2.42 = 187 drivers and no passengers.

The next steps in the process are to determine how many air bag caused fatalities there would be in crashes with a delta V > 25 mph if there were a whole fleet of these pre-MY 1998 air bags. Taking the numbers above and dividing them by the portion of the fleet with air bags (see Table II-4) results in estimates of 257 in 1997 and 475 in 1998 fatalities caused by air bags per year in crashes with delta V greater than 25 mph if all vehicles on the road had air bags. Weighting these deaths over the two years gives an average of 367 occupants (303 drivers and 64 passengers). As shown in Table II-3, there are an estimated 15,725 frontal fatalities remaining with a full fleet of air bags. The estimated number of 367 is 2.3 percent of remaining fatalities, not the 15 percent that IIHS discusses.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

corner of the air bag and was not contained by the air bag. Thus, we do not agree with IIHS that there is always sufficient force in the air bag. In fact, there were more high speed cases in this time frame (4 cases in 1998 and the first 6 months of 1999) in which there was insufficient occupant protection provided by the air bag than high speed cases (2 cases) in which there was too much power.

We note that the IIHS cases are predominantly cases of pre-MY 98 air bags causing a fatality in high speed, greater than 25 mph delta V crashes. However, we have also found 1 case of a redesigned air bag that caused a fatal injury: one of the 3 cases in which there was another fatal chest injury caused by intrusion. Thus, the redesigned air bags did not solve all of the out-of-position problems in high speed crashes, just as they did not solve all of the out-of-position problems in lower speed crashes. There are not enough cases to make a projection of how effective redesigned air bags have been in high speed crashes where the occupant is out-of-position.

Finally, we have no data on how well vehicles designed to a 25 mph unbelted standard would perform in high speed crashes. We don't know whether a 25 mph air bag would reduce these air bag caused fatalities or not, particularly on the driver side, which has the most fatalities. Remember: the great majority of current redesigned air bags have been shown to pass a 30 mph unbelted test with 50$^{th}$ percentile male dummies and some already meet the low risk test on the driver side. It does not appear that the redesigned air bags have reduced the number (having found 1 case in the year and a half that these vehicles are on the road), but sample sizes are too

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

small at this point to tell. We do believe that if air bag power is reduced further, we will find many more cases in which the air bag provided insufficient protection in high speed crashes. Chapter VI estimates the potential loss in benefits if vehicles were produced that met a 25 mph standard versus ones that met a 30 mph standard for unbelted testing.

The agency has also identified an additional 12 instances of air bag caused fatalities in crashes with delta V above 25 mph. Eleven of these instances were initially investigated as SCI cases, but were dropped when it was determined that they were higher than 25 mph delta V. One case was investigated as part of the CIREN hospital study project. These 12 instances are not NASS cases, and do not add to the total preliminary estimate in footnote 4 a few pages earlier. They could be considered examples of the estimated annual number of cases of fatalities in high speed crashes caused by air bags.

**C. Analysis of Statement by IIHS to the Transportation Subcommittee, U.S. House of Representatives Appropriations Committee, February 10, 2000**

**ISSUE 1**

IIHS disagrees with the NHTSA Approach 1 in estimating the potential loss in benefits of a 25 mph unbelted rigid barrier test versus a 30 mph unbelted rigid barrier test. IIHS argues that their detailed examination of individual NASS cases provides convincing evidence that the drop-off in the effectiveness estimates for higher crash severities have nothing to do with inadequate air bag performance. Instead, IIHS claims they are caused by intrusion, ejections, or by the air bags themselves. IIHS claims that NHTSA implicitly assumes that the drop-off in effectiveness shown in high speed cases (presumably delta V > 30 mph, since this was the highest group in Approach

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

1), is entirely due to insufficient energy absorption by air bags. IIHS argues that we ignore evidence and that our shifting of the effectiveness curve by 5 mph is "wholly unjustified". IIHS would argue that shifting the effectiveness curve by 5 mph ignores the fact that catastrophic crashes with intrusion are more highly represented in higher delta V crashes. In their opinion, these fatalities are unsurvivable with air bags and would be unaffected by changes in the energy absorbing characteristics of air bags.

NHTSA response:

The agency's analysis of fatalities in air bag vehicles in high speed cases (greater than 30 mph delta V) shows that more than 35 percent are not caused by ejection, intrusion at any level, or injury induced by the air bag.

The agency agrees that effectiveness decreases as delta V increases, partly because of the severe intrusion cases, and our analyses show this. But, severe intrusions[5] are only one piece of a complicated puzzle and severe intrusions only become a significant part of the fatality picture at crashes above 40 mph delta V (based on our estimates, severe intrusion is about 6 percent between 20 and 40 mph delta V and about 18 percent from 40 mph and higher). It is also true that ejections are a larger part of occupant fatalities in frontal crashes at lower speed than at higher speeds and ejections are not typically savable by air bags. To examine this issue, the agency distributed cases without air bags into various cells: those that are theoretically savable by

[5] Severe intrusion is defined as a case in which the interior component that caused the fatality intruded toward the occupant by 12 inches or more, as documented in the basic NASS-CDS data file.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

air bags because they exclusively involved occupant contacts with frontal interior surfaces with zero or less than 12 inches of intrusion; and those not savable by air bags because they involved ejections, contact with interior surfaces to the side or roof, and/or severe intrusion. Table B-8 shows this analysis for vehicles without air bags. These data include MY 1981-99 vehicles in NASS 1991-99, belted and unbelted occupants and include some cases that were run through a separate program to estimate delta V when the NASS file had no estimate of the delta V.

Table B-8
Non Air Bag Vehicles in NASS 1991-99
Cause of Fatalities in Frontal Crashes by Delta V
(In Percent)

| | 0-20 mph (N = 61) | 21-25 mph (N = 74) | 26-30 mph (N = 66) | 31+ mph (N = 317) |
|---|---|---|---|---|
| No Intrusion | 36% | 52% | 52% | 27% |
| Less than 1 ft. of intrusion | 7 | 4 | 12 | 24 |
| Subtotal (Theoretically Savable by Air Bag) | 43 | 56 | 64 | 51 |
| | | | | |
| Ejection | 23 | 28 | 21 | 18 |
| Severe Intrusion More than 1 ft. | 0 | 4 | 5 | 16 |
| Others | 34* | 12 | 10 | 15 |
| Subtotal (Theoretically Not Savable by Air Bag) | 57 | 44 | 36 | 49 |
| | | | | |
| Total | 100% | 100% | 100% | 100% |

* This percentage for "Others" is higher in this speed cell than in higher speed cells because it includes fatalities that occurred below the deployment threshold.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

The point we are trying to make with these data are that severe intrusion crashes increase as delta V increases, however, ejections decrease as a proportion of fatalities in higher speed crashes. The percent of all frontal fatalities that are theoretically savable by air bags are about the same at all levels of speed, close to 50 percent, and it is well above the percentage actually being saved by today's air bags of 15-30 percent. We see no overriding reason why we can't utilize our analysis of shifting delta V by 5 mph to estimate the impacts of the theoretical 25 mph air bags compared to 30 mph air bags.

In response to questions raised by IIHS, we recalculated effectiveness rates for each delta V category based only on crashes that are savable by the air bag. These modified rates were then applied only to the crashes that are savable by the air bag. Then, as before, we shifted the estimated effectiveness curve by delta V for those air bag savable cases, excluding those not savable which include severe intrusion, ejections, and others, down 5 mph and estimated the lives saved by the theoretical 25 mph air bags and compared them to the 30 mph air bags. This method eliminates the non-savable cases that IIHS argued would minimize effectiveness at higher delta V's compared to lower delta V's and make our shift in the effectiveness curve unjustified. The result shown in Table B-9 is an estimated larger number of lives lost under this methodology (-383 lives) for the theoretical 25 mph air bags compared to the 30 mph air bags, than under the methodology used in Chapter VI (-252).

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**Table B-9**
**30 MPH Air Bags vs 25 MPH Air Bags**

| Delta V | Effectiveness [1] | Target Population[1] | % Savable | Savable Population[2] | Effectiveness Savable[3] | Lives Saved[4] |
|---|---|---|---|---|---|---|
| **30 MPH Air Bags** | | | | | | |
| 0-20 | 0.203 | 1966 | 0.43 | 845 | 0.472 | 399 |
| 21-25 | 0.290 | 2126 | 0.56 | 1,191 | 0.518 | 617 |
| 26-30 | 0.222 | 2228 | 0.64 | 1,426 | 0.347 | 495 |
| 31+ | 0.142 | 6361 | 0.51 | 3,244 | 0.278 | 902 |
| **Total** | | | | | | **2,413** |
| **25 MPH Air Bags** | | | | | | |
| 0-15 | | 1148 | 0.22 | 253 | 0.472 | 119 |
| 16-20 | | 818 | 0.55 | 450 | 0.518 | 233 |
| 21-25 | | 2126 | 0.56 | 1,191 | 0.347 | 413 |
| 26+ | | 8589 | 0.53 | 4,552 | 0.278 | 1,265 |
| **Total** | | | | | | **2,030** |
| **Difference** | | | | | | **-383** |

1. See Table VI-28
2. Savable Population = Target Population * % Savable
3. Effectiveness Savable = Effectiveness / % Savable
4. Lives Saved = Effectiveness Savable * Savable Population

The agency believes that the effectiveness of an air bag designed to a 25 mph unbelted test will not be as high as the effectiveness of an air bag designed to a 30 mph unbelted test in high speed crashes. Further, there were no data provided by IIHS or the industry to convince the agency to change this belief. In fact, the Madymo modeling data supplied by Ford (see Docket #6407-95) confirms our belief that vehicles designed to a 25 mph unbelted test will not provide as much benefit in high speed crashes as vehicles designed to a 30 mph unbelted test.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

Air bags save lives; this is not disputed. Our effectiveness estimates, based on NASS data, shown in Approach 1, show that they are saving lives in both low speed and high speed crashes. The agency's argument is that some of those lives currently being saved by air bags in high speed crashes would not be saved if air bags only met a 25 mph unbelted standard.

There are further reasons why the agency believes that air bags designed to a 30 mph unbelted test will save more lives than air bags designed to a 25 mph unbelted test. We believe those killed by air bags are limited to those out-of-position at the time of deployment for two reasons: 1) in 20 or 25 mph in-position testing, the dummy measurements are so low with a 30 mph designed air bag that the probability of fatality is tiny. You are on the flat part of the AIS 5+ injury curves shown in Chapter III, and the possibility of reducing the probability of fatality with an air bag designed to 25 mph for in-position occupants is infinitesimal. 2) An examination of the remaining fatalities with air bag deployments indicate that the 30 mph designed air bags are working very well for in-position occupants in the types of crashes air bags are designed to work in. In other words, we aren't finding many non-ejected fatalities to occupants in low speed crashes, unless the occupant strikes non-frontal interior surfaces or is out-of-position at the time of the air bag deployment. In summary, we don't believe there is any fatality benefit for in-position occupants for 25 mph air bags compared to 30 mph air bags. The number of out-of-position occupants at high speed is uncertain and the benefits of a 25 mph air bag versus a 30 mph air bag for out-of-position occupants, considering that the manufacturers can meet the low-risk air bag on the driver side and have a 30 mph air bag, are unproven and appear very low.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

**ISSUE 2**

IIHS argues that the assumptions used in Approach 2 are questionable because they are based on only two models and unbelted crash tests do not predict unbelted real world crashes.

NHTSA response:

The agency agrees that it only had data on two vehicles to use in Approach 2. The test results and dummy measurements from these two vehicles at 30 mph are in the middle of the larger set of vehicles tested at 30 mph, so they appear to be somewhat representative of the fleet. Finally, the results are consistent with the amount of energy in a 25 mph crash compared to a 30 mph crash. No additional data were provided by IIHS or the industry to rebut these findings.

The IIHS argument that unbelted crash tests do not predict unbelted real world crashes relies on their belief that many unbelted occupants are out-of-position at the time of air bag deployment and either are injured by the air bag or do not get the full protection of the air bag. We simply have not found that many occupants killed by the air bag in high speed cases and the effectiveness we use is from real-world data that includes both cases where the air bag killed out-of-position occupants and cases where the air bag provided less than full protection. Thus, we disagreee with IIHS and believe the unbelted test results do provide a realistic estimate of unbelted occupant benefits.

**D. Analysis of comments from DaimlerChrysler (99-6407-#44)**

Appendix 2, page 4 of 5,

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

a) DaimlerChrysler notes that NHTSA has measured no significant difference in the frontal occupant crash protection between pre'98 MY and the '98-'99 MY vehicles with depowered air bags. They find it "perplexing" that the agency suggests a loss of benefits associated with a 40 km/h (25 mph) unbelted barrier test, when added to the cadre of other proposed test requirements. The agency states the sled test can be likened to a 22 mph rigid barrier test. "If vehicles certified to that test provide as much, if not more, overall protection than vehicles certified to the 30 mph (48 km/h) test, it is illogical to state that making that test requirement more stringent; i.e., raising it to 25 mph (40 km/h), will result in a loss of relative benefits."

NHTSA response:

The unbelted test is really the defining test in terms of the protectiveness of the air bag in high speed collisions. The other cadre of tests define other parameters of the system. Thus, benefits can be estimated based on whether the unbelted test is set at 25 mph or 30 mph. The agency believes that the MY 98/99 vehicles were not depowered as much as they could have been to meet the sled test. The agency believes the manufacturers didn't have enough design time to depower and optimize the air bags. Chrysler admits this in Appendix 5 on page 9 of 67 where they state that the depowered air bags were less-optimized, the only change was in the amount of gas generant, and no change was made to the air bag design to optimize the system. The amount of depowering was only about half as much as the agency thought was possible. Based on depowered air bag prototypes provided by the manufacturers, the agency thought the manufacturers could depower by 20 to 35 percent. However, confidential information supplied by the manufacturers in response to an information request indicated that the average amount of

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

depowering was 16 percent. The low amount of depowering is shown by NHTSA testing. Most of the MY 98/99 vehicles tested were able to pass the 30 mph test with the 50th percentile male dummy. If they had been depowered to the level of the sled test, the agency believes they would not pass the 30 mph test. The agency did estimate a larger disbenefit from the sled test (214 to 722 fewer fatalities saved) than from the 25 mph barrier test (214 to 297 fewer fatalities saved), indicating its belief that the sled test was potentially a less severe test and closer to a 22-25 mph barrier test. These disbenefits were in comparison to pre-MY 98 air bags that were required to meet the 30 mph unbelted barrier test.

b) DaimlerChrysler stated that "... we do not believe it is sound science to use one test condition (full front rigid barrier tests), with a small sample of vehicles, and injury criteria which the agency itself has deleted from further consideration at this time as a regulatory measurement tool (CTI), to derive benefits to the whole fleet of vehicles in all types of crashes."

NHTSA response:

As discussed above, the unbelted test is the defining test of the strength of the air bag. The effectiveness of air bags meeting the 30 mph unbelted test (pre-MY 98) are taken from real world data analysis (Kahane) and estimated to be 11 percent in all types of crashes. Thus, there is a link between test data and real world effectiveness. The unbelted test results from a sample of vehicles are used to make benefits estimates for only unbelted fatalities, not all types of crashes. Whether the analysis uses chest g's and chest deflection separately, or uses the combined CTI does not matter in terms of estimating benefits. The CTI has the best correlation to injury.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE

Analytically it is easier to use one injury curve than two curves, and using the two curves would result in essentially the same benefit estimate as using the CTI.

c) DaimlerChrysler stated that "We are disappointed that the PEA fails to use the real-world findings from vehicles certified to the sled test as its baseline for its analysis, but instead chooses a limited number of laboratory tests. Actual field data should always take precedence over limited laboratory testing..."

NHTSA response:

We agree that field data should take precedence over laboratory testing. Our baseline is field data of pre-MY 98 vehicles, those certified to meet a 30 mph unbelted test. However, we do not agree that we have field data on vehicles designed to the minimum performance requirements of the sled test or vehicles designed to the minimum performance requirements of a 25 mph unbelted barrier test. Our testing shows that most of the MY 98/99 vehicles could meet the 30 mph unbelted test with the 50th percentile male dummy. Thus, the air bags in these vehicles were more protective than ones that could be designed to just meet a 25 mph unbelted barrier test and even more protective than ones that could be designed to just meet the sled test.

Appendix 5, Page 5 of 67

a) DaimlerChrysler stated that NHTSA analysis of depowering air bags involved two methods. Both methods assume that the measurement of small differences in chest acceleration on a 50% Hybrid III dummy in 30 or 35 mph barrier crash tests can predict injury and fatality risks.

DRAFT DELIBERATIVE DOCUMENT DO NOT RELEASE

evaluation[6] showed a good correlation between chest g's and fatality potential.

**Drive K: = NHTSA_NED01_USERS.: **

Manual belts are more effective overall (than air bags alone) in the real world, because they contain the occupant in the seat in a wide variety of crash conditions, they work in multiple impacts, the steering column collapse is not an issue in many lower speed impacts, and they work in crashes from a variety of impact directions.

Appendix 5, pages 8-31 of 67

DaimlerChrysler makes a large number of arguments about the benefits methodology focusing on chest g's used in the February 1997 FRE.

NHTSA response:

While the agency still has faith in these methodologies, they are not the prime methodologies used in the October 1999 PEA. For the most part, DaimlerChrysler questions whether the methodology can be extrapolated from its original data to the test data at hand. This is a matter of subjective opinion. The agency believes its methodology is reasonable, DaimlerChrysler does not. As more data has become available, the agency has changed its methodology to reflect the increase in real world data to get a better estimate of the impacts of the rulemaking.

---

[6] "Correlation of NCAP Performance with Fatality Risk in Actual Head-On Collisions" NHTSA, January 1994, DOT HS 808-061.

DRAFT - DELIBERATIVE DOCUMENT - DO NOT RELEASE