251302

U.S. Department of Transportation

National Highway Traffic Safety Administration

Memorandum

DEPT OF TRANSPORTATION DOCKETS

2003 AUG 11 P 1:33

NHTSA-03-15732-2

Subject: **ACTION**: Preliminary Regulatory Evaluation for Amendment to FMVSS No. 208, 5th Percentile Female Belted Frontal Barrier 56 KM/H (35 MPH) Test

Date: AUG - 7 2003

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

Reply to Attn. of:

To: Docket

THRU: Jacqueline Glassman
Chief Counsel

Attached is a copy of the Preliminary Regulatory Evaluation for Amendment to FMVSS No. 208, 5th Percentile Female Belted Frontal Barrier 56 KM/H (35 MPH) Test. Please submit this report to Docket Number NHTSA-03-15732.

Attachment

DISTRIBUTION
AA/Advanced Research
AA/Applied Research
AA/Enforcement
AA/Rulemaking
Chief Counsel
Senior AA/Traffic Injury Control
Senior AA/Vehicle Safety
Senior AA/Policy & Operations

#

U.S. Department
Of Transportation

People Saving People
http://www.nhtsa.dot.gov

PRELIMINARY REGULATORY EVALUATION

PROPOSED AMENDMENT TO FMVSS No 208 5TH PERCENTILE FEMALE BELTED FRONTAL BARRIER 56 KM/H (35 MPH) TEST

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

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This Preliminary Regulatory Evaluation analyzes the potential impact of new performance requirements for small stature vehicle occupants in frontal crashes.

Proposal

The agency proposes to increase the belted test speed with 5th percentile female dummies from 48 km/h (30 mph) to 56 km/h (35 mph). The May 12, 2000 FMVSS 208 Final Rule requires the 48 km/h (30 mph) belted test with 5th percentile female dummies.

Test Results

The agency has conducted 18 tests with the proposed test condition. Overall 79.1 percent passed the proposal and 20.9 percent failed. Exceeding the neck injury criteria is the most frequent failure mode.

Technical Feasibility

The proposed standard appears technically feasible because 79.1 percent of the vehicles tested passed the performance requirement. Vehicles tested didn't have to meet the May 2000 advanced air bag rule for 5th percentile female at 48 km/h (30 mph), yet 79.1 percent passed at 56 km/h (35 mph).

The agency expects that the countermeasures needed to meet the proposal will be the same countermeasures needed to meet the May 2000 advanced air bag final rule with minor design changes.

Benefits

The proposal would prevent an estimated 5 – 6 fatalities and reduce 2 - 3 MAIS 2-5 non-fatal injuries. The benefits are small because the majority of the changes required to meet this proposal were established in the May 2000 advanced air bag final rule. These additional tests are designed to improve air bag technologies and expand benefits to small stature occupants.

Costs

The total net cost ranges from $0 to $24.56 million. The proposal does not require additional tests, thus there is no compliance cost. Many of the technology countermeasures will be used by the manufacturers when they comply with the May 2000 advanced air bag final rule. Therefore, the cost will most likely be closer to the lower end of the range of estimates.

Leadtime

The agency proposes a phase-in leadtime. The phase-in schedule is the same as that for the 56 km/h (35 mph) test with 50th percentile male dummies required in the May 2000 advanced air bag final rule. The following is the proposed schedule:

Model Year	Production Beginning Date	Requirement
2008	September 1, 2007	35% with carryover credit
2009	September 1, 2008	65% with carryover credit
2010	September 1, 2009	100% with carryover credit
2011	September 1, 2010	Fully effective

CHAPTER I. INTRODUCTION

This preliminary regulatory evaluation accompanies NHTSA's proposal to improve frontal crash protection for small stature occupants. The agency proposes to amend Federal Motor Vehicle Safety Standard (FMVSS) No. 208 "Occupant crash protection" to increase the maximum speed of the rigid barrier tests with belted 5th percentile female dummies from 48 km/h (30 mph) to 56 km/h (35 mph). The proposal requires both belted 5th percentile female driver and passenger dummies meet the injury criteria currently specified in S15.3 *Injury criteria for the 49 CFR Part 572, Subpart O Hybrid III 5th percentile female test dummy* of FMVSS No. 208.

On May 12, 2000, the agency published a Final Rule amending FMVSS No. 208, "Occupant crash protection" to provide advanced air bag protection. One of the provisions in the May 12, 2000 Final Rule requires belted high speed crash tests for both 5th female and 50th male adult dummies. This requirement will be phased-in in two stages[1]. The first stage phase-in requires 0 - 48 km/h (30 mph) belted rigid barrier crash test for both 5th and 50th percentile adult dummies. The second stage phase-in will increase the maximum belted rigid barrier crash test speed to 56 km/h (35 mph) only for

[1] Phase-in Schedule required in the May 12, 2000, Advanced Air Bag Final Rule:

Phase 1		Phase 2	
Model Year	Percentage	Model Year	Percentage
2004	35% with carryover*	2008	35% with carryover
2005	65% with carryover	2009	65% with carryover
2006	100% with carryover	2010	100% with carryover
2007	Fully effective, including small manufacturers, multi-stage and alterers	2011	Fully effective, including small manufacturers, multi-stage and alterers

* On January 31, 2003, the agency amended the 2004 MY phase-in to 20 percent from 35 percent based on petitions from industry.

the 50^{th} percentile male dummy. At the time, the agency had limited knowledge of the practicability of meeting the 56 km/h (35 mph) tests with the 5^{th} percentile female dummy, thus, the May 2000 final rule did not require the 56 km/h (35 mph) tests with the 5^{th} percentile female dummy. However, in the preamble to the May 12, 2000 Final Rule, the agency noted that the agency intended to propose the belted 56 km/h (35 mph) test using the 5^{th} percentile dummy. The leadtime would be the same as the time required for the belted 56 km/h tests with the 50^{th} percentile adult male dummy.

In October of 2000, Congress provided the agency funds to conduct feasibility tests using the 5th percentile adult female dummy in a high-speed crash environment. The agency tested 10 model year 2001 vehicles at 56 km/h (35 mph) into a rigid barrier with belted 5^{th} percentile adult female dummies[2]. In addition, eight more tests with the same test configuration and procedure were conducted through a joint research program with Transport Canada[3]. With these 18 tests, the agency has sufficient data to evaluate the performance of 5^{th} percentile female dummies in the 56 km/h (35 mph) frontal rigid barrier test environment. Based on the test results, the agency believes that the proposal is technologically feasible and has decided to proceed with the rulemaking proposal.

This regulatory evaluation analyzes the impact of the proposal. The evaluation first establishes the safety problem with the small stature occupants based on the real-world crash data. Then, the evaluation discusses the proposed injury criteria and corresponding injury probability risk curves. Next, the evaluation analyzes the laboratory crash test data

---

[2] Beuse, N., Summers, L., Hollowell, T., and Rockwell, T., NHTSA Technical Report. Final Report, Performance of the 5^{th} Percentile Dummy in a 56 KM/H (35MPH) Frontal Barrier Crash, July 2002.
[3] Full report will be provided to the docket when it is available.

to establish the performance of the current fleet. The injury probability curves and the laboratory crash tests were used to derive the fatality/injury reduction rates if the proposal is implemented. Subsequently, the size of the safety problem and the fatality/injury reduction rates are used to estimate the potential benefits of the proposal. Following the benefit estimate, the evaluation examines the costs and the leadtime of the proposal. Finally, the evaluation examines the impacts of the proposal on small business entities.

CHAPTER II. TARGET POPULATION AND SAFETY CONCERNS

Annually, about 1,973 small stature front-outboard adult passenger vehicle occupants die and 352,093 suffer a MAIS 1+ non-fatal injury during a frontal crash. Of these MAIS 1+ injuries, 43,197 had at least one MAIS 2+ injury. Table II-1 summarizes the statistics by MAIS levels. The proposal to increase the belted test speed from 48 km/h (30 mph) to 56 km/h (35 mph) has the potential to improve frontal crash protection for these occupants. Data sources used for the analysis are: 1993 – 2001 Crashworthiness Data System (CDS), the 2001 Fatality Analysis Reporting System (FARS), and the 2001 General Estimates System (GES). FARS and GES were used to derive the overall size of the safety problem. All detailed descriptive statistics were derived from CDS.

Table II – 1
Fatalities and MAIS 1+ injuries for Front-Outboard Passenger Vehicle Occupants Represented by the 5th Percentile Dummy in Frontal Crashes

Fatalities and Injury	Total Number
Fatalities	1,973
MAIS 1	308,896
MAIS 2	30,348
MAIS 3	9,619
MAIS 4	2,637
MAIS 5	593
Total MAIS 1+ Non-Fatal Injuries	352,093
Total MAIS 2+ Non-Fatal Injuries	43,197
Total MAIS 3+ Non-Fatal Injuries	12,849

Source: 1993-2001 Crashworthiness Data System, 2001 Fatality Analysis Reporting System, and 2001 General Estimated System

Small stature adult occupants, represented by the 5th percentile female dummy, are defined here as age 13 and older with height less than 165 centimeters (65 inches). Fatalities and injuries represented by the 5th percentile female dummy were derived from 1993 to 2001 CDS. Due to the small sample size limited to passenger vehicle towaway crashes, CDS has a tendency to underestimate the occupant involvements. Thus, fatalities derived from CDS were adjusted to the level that was reported in the 2001 FARS. FARS is a census of fatalities. The adjustment factor was the ratio of total front-outboard passenger vehicle fatalities from 2001 FARS to the average of those from 1993 - 2001 CDS. The total number of front-outboard passenger vehicle fatalities from 2001 FARS is 28,167 and the corresponding number from CDS is 23,836. The adjustment factor is 1.18 (=28,167/23,836). This factor indicates that fatalities reported in the FARS were 18 percent higher than those reported in the CDS.

The analysis also adjusted CDS-derived injuries. The NHTSA's GES was used for this purpose. GES is a nationally representative sample of police-reported crashes not limited to passenger vehicle towaway crashes as sampled by CDS. The agency uses GES to produce national statistics on nonfatal crashes in the U.S. In this analysis, injuries were adjusted to the 2001 GES CDS-equivalent level. GES CDS-equivalent injuries were those injuries in GES that have the same attributes of CDS, i.e., passenger vehicle occupant injuries in crashes that had at least one passenger vehicle towed. The injury adjustment factor is the ratio of total GES CDS-equivalent occupants to that of 1993 – 2001 CDS average. The total of GES CDS-equivalent occupants is 5,047,448 and the corresponding number from CDS is 4,233,364. The injury adjustment factor is 1.19 (=

5,047,448/4,233,364). Fatalities and injuries reported in Table II-1 are the adjusted figures.

Air bags were proved to be effective against fatalities and MAIS 2-5 injuries. Thus, of particular interest were the 1,973 fatalities and 43,197 MAIS 2-5 injuries. The rest of the chapter examines these fatalities and injuries further.

Table II-2 lists these fatalities and injuries by air bag and belt use status. As shown in Table II-2, the majority of the fatalities were in vehicles without air bags with a similar distribution between belted and unbelted. This distribution is based on the air bag equipped rates and safety belt use reported in 1993 –2001 CDS. Table II-3 shows the statistics. As shown in Table II-3, about 30 percent of fatalities and 38 percent of MAIS 2+ injuries were in an air bag equipped vehicle. The analysis does not differentiate pre-depowered and depowered air bags.

Table II-2
Annual Small Stature Front-Outboard Adult Occupants
By Restraint Types, Person's Type, and Injury Severity
Frontal Crashes

Restraint Use	Fatalities			MAIS 2-5 Injuries		
	Drivers	Right Front Passengers	Total	Drivers	Right Front Passengers	Total
Belted, Air Bags	144	53	197	10,134	4,553	14,687
Belted, No Air Bag	518	192	710	11,028	4,955	15,983
Unbelted, Air Bags	274	101	375	1,192	536	1,728
Unbelted, No Air Bags	504	187	691	7451	3,348	10,799
Total	1,440	533	1,973	29,805	13,392	43,197

Source: 1993 - 2001 CDS.

Table II-3
Percent Air Bag Equipped Vehicles and Belt Use Rate
Front-Outboard Passenger Vehicle Occupant Fatalities and MAIS 2+ Injuries
Represented by the 5th Percentile Dummy in Frontal Crashes

Restraint Use	Fatalities	MAIS 2-5	Fatalities + MAIS 2-5
Air Bag	30%	38%	38%
No Air Bag	70%	62%	62%
Total	100%	100%	100%
Belted	47%	72%	70%
Unbelted	53%	28%	30%
Total	100%	100%	100%

Source: 1993-2001 CDS.

Air bags proved to be 14 percent effective against unbelted fatalities and 11 percent effective against belted fatalities[1]. In addition, air bags were 10 percent effective in reducing MAIS 2-5 injuries[2]. If the whole fleet of the passenger vehicles were equipped with air bags at current safety belt use rates, with the above effectiveness rates, an additional 175 (128 drivers and 47 passengers) lives would be saved and 2,678 (1,848 drivers and 830 passengers) MAIS 2-5 injuries would be reduced. These benefits were from the "No Air Bags" categories in Table II-3. The remaining small stature population that would be impacted by the proposal is derived by excluding these benefits from the target population in Table II-2. Table II-4 lists these remaining fatalities and MAIS 2-5 injuries if the whole fleet of passenger vehicles were equipped with air bags as they were designed and represented in the 1993-2001 CDS files.

---

[1] The Fifth/Sixth Report to Congress, Effectiveness of Occupant Protection Systems and Their Use, DOT HS 809 442, November 2001.
[2] The Fourth Report to Congress, Effectiveness of Occupant Protection Systems and Their Use, May 1999.

Table II-4
Annual Small Stature Adult Passenger Vehicle Occupants
By Restraint Types, Person's Type, and Injury Severity
Assuming A Full Fleet of Air Bags

Restraint Use	Fatalities			MAIS 2-5 Injuries		
	Drivers	Right Front Passengers	Total	Drivers	Right Front Passengers	Total
Belted, Air Bags	605	224	829	20,059	9,013	29,072
Unbelted, Air Bags	707	262	969	7,898	3,549	11,447
Total	1,312	486	1,798	27,957	12,562	40,519

Source: 1993-2001 CDS.

The May 12, 2000 FMVSS 208, advanced air bag final rule requires manufacturers to comply with an array of high speed tests to protect small stature occupants by September 1, 2006 – the last year of the first-stage phase-in. These required tests with 5th percentile dummies are: (1) unbelted, 32-40 km/h (20-25 mph) rigid barrier, (2) belted, up to 48 km/h (30 mph) rigid barrier, and (3) belted, up to 40 km/h (25 mph) offset. These tests would accrue additional benefits to that from current air bags as described above. Table II-5 shows the benefits/disbenefits from these three tests. These benefits were adopted from Tables VI-25 and VI-36 in the Final Economic Assessment, FMVSS 208, Advanced Air Bags, May 2000, except for the 25 mph unbelted rigid barrier test. Table VI-35 and VI-36 in the Final Economic Assessment did not disaggregate the benefits by occupant stature for this specific test. The analysis distributed the benefits based on the ratio of adults occupants represented by the 50th percentile male and 5th percentile female dummies. The ratio is 78:22 which was derived from the 1993-2001 CDS. This means 22 percent of the overall benefits for this test would be for the small stature occupants. However, the analysis didn't distribute any estimated disbenefits to small stature occupants. It is assumed that all the disbenefits were from the large stature occupants. Table II-5 lists the safety benefits for small stature occupants from these three high speed crashes.

Table II-5
Fatality and MAIS 2-5 Injury Benefits from Advanced Air Bags
For Small Stature Front-Outboard Passenger Vehicle Occupants
(High Speed Crash Tests Only)

Tests with a 5th Percentile Required in May 2000, FMVSS 208 Final Rule	Lives Saved			MAIS 2-5 Reduced		
	Drivers	Adult Passengers	Total	Drivers	Adult Passengers	Total
Unbelted, 32-40 km/h (20-25 mph) rigid barrier	0*	0*	0*	234	70	304
Belted, up to 48 km/h (30 mph) rigid barrier	4	0	4	29	14	43
Belted, up to 40 km/h (25 mph) frontal offset	36	4 - 12	40 - 48	54	101 – 229	155 - 283
Total	40	4 to 12	44 -52	317	185 – 313	502 - 630

Source: Final Economic Assessment, FMVSS No. 208, Advanced Air Bags, May 2000.
* No benefits and disbenefits were assumed.

Based on Table II-5, if all passenger vehicles were equipped with the advanced air bags as required in the May 2000, FMVSS No. 208 Final Rule, an additional 44 - 52 (all belted) small stature adult fatalities would be saved and 502 - 630 (198 – 326 belted) MAIS 2-5 injuries would be reduced. After full implementation of the first-stage of FMVSS 208, May 2000 final rule, with full fleet of advanced air bags, it is estimated that frontal crashes will still account for 1,746 – 1,754 small stature occupant fatalities and 39,889 – 40,017 MAIS 2-5 injuries. Of these, 777- 785 fatalities and 28,746 – 28,874

MAIS 2-5 injuries are belted and could benefit from the proposal. Table II-6 disaggregates these fatalities and injuries by their roles (driver, front-right passenger) and restraint types.

Table II-6
Annual Small Stature Front-Outboard Adult Passenger Vehicle Occupants By Restraint Types, Person's Type, and Injury Severity Assuming A Full Fleet of Advanced Air Bags

Restraint Use	Fatalities			MAIS 2-5 Injuries		
	Drivers	Right Front Passengers	Total	Drivers	Right Front Passengers	Total
Belted, Air Bags	565	212-220	777-785	19,976	8,770-8,898	28,746-28,874
Unbelted, Air Bags	707	262	969	7,664	3,479	11,143
Total	1,272	474-482	1,746-1,754	27640	12,249-12,377	39,889-40,017

Source: 1993-2001 CDS.

The proposal is to increase the maximum speed of the belted test with 5th percentile female dummies from 48 km/h (30 mph) to 56 km/h (35 mph). The next step is to examine the injury distribution by crash severity, which is measured by delta v. Table II-7 lists the overall small stature fatalities and MAIS 2-5 injuries by delta v. As shown in Table II-7, about 42 percent of small stature front-outboard vehicle occupant fatalities occurred at crashes severity higher than 48 km/h (30 mph). By contrast, only 5 percent of MAIS 2-5 injuries were associated with those crash severity levels.

The proposal provides head, neck, chest, and femur injury performance criteria. Thus, another relevant statistic is the occurrence of small stature occupants by their injured body region. Table II-8 lists the percentage by injured body regions for all crash severity levels. Note that only a very small number of fatalities in CDS had information on injured body regions. As a result, there were not enough cases to have a meaningful tabulation of fatalities by injured body region. To compensate for this, the analysis uses MAIS 4+ injuries as the surrogate for fatalities.

Table II-7
Small Stature Front-Outboard Adult Passenger Vehicle Occupant Fatalities and MAIS 2-5 Injuries in Frontal Crashes by Crash Severity (Delta V)

Crash Severity Delta V		Fatalities		MAIS 2-5 Injuries	
km/h	mph	Percent	Cumulative Percent	Percent	Cumulative Percent
0 - 24	0 - 15	14	14	50	50
25 – 48	16-30	44	58	45	95
49 – 56	31 - 35	13	71	2	97
57 – 64	36-40	12	83	2	99
65+	41+	17	100	1	100
Total		100		100	

Source: 1993-2001 CDS.

As shown in Table II-8, head, neck, and chest injuries comprised about 68 percent of small stature front-outboard occupant fatalities in frontal crashes. Forty-one percent of the MAIS 2-5 injuries were head, neck, or chest injuries and 33 percent were lower extremity injuries. Of the MAIS 2-5 lower extremity, 5.5 percent were femur injuries.

Table II-8
Small Stature Front-Outboard Adult Passenger Vehicle Occupant Fatalities and MAIS 2-5 Injuries in Frontal Crashes by Injured Body Region

Injured Body Region	Fatalities*	MAIS 2-5 Injuries
	Percent	Percent
Head	44.2	20.8
Neck	0.5	1.5
Thorax	23.1	18.5
Upper Extremity	0.0	18.1
Lower Extremity	0.0	33.0**
Other	32.2	8.1
Total	100.0	100.0

Source: 1993-2001 CDS.
* Using MAIS 4+ injuries as the surrogate
** Femur injuries comprised 5.5 percent of the MAIS 2-5 lower extremity injuries

If limited to frontal crashes with delta v greater than 48 km/h (30 mph), the corresponding fatal and MAIS 2-5 head, neck, and chest injury percentage is 85 and 64 percent, respectively. About 16 percent of the MAIS 2-5 injuries were lower extremity injuries. Of these, 29 percent were femur injuries. Table II-9 shows the percentage distribution by injured body region for crashes with delta v greater than 48 km/h (30 mph).

Table II-9
Small Stature Front-Outboard Adult Passenger Vehicle Occupant Fatalities and MAIS 2-5 Injuries In Frontal Crashes By Injured Body Region
Delta V > 48 km/h (30 mph)

Injured Body Region	Fatalities*	MAIS 2-5 Injuries
	Percent	Percent
Head	44.9	38.7
Neck	7.9	1.3
Thorax	32.0	24.1
Upper Extremity	0.0	15.8
Lower Extremity	0.0	16.4**
Other	15.2	3.7
Total	100.0	100.0

Source: 1993-2001 CDS.
* Using MAIS 4+ injuries as the surrogate
** Femur injuries comprised 28.6 percent of MAIS 2-5 lower extremity injuries

CHAPTER III. INJURY CRITERIA

The chapter consists of two sections. The first section describes the proposed injury criteria and the injury criteria performance limits (ICPLs) for the 56 km/h (35 mph) rigid barrier belted test with 5^{th} percentile female dummies. The proposed injury criteria and the ICPLs are the same as those for in-position tests published in the May 12, 2000, FMVSS 208 Final Rule, Advanced Air Bags. The second section discusses the corresponding injury risk curves. These injury probability curves are used to predict the chance of receiving a specific injury given a certain dummy measurement in a test.

A. Proposed Injury Criteria

The May 2000 advanced air bag final rule requires vehicles to pass a set of tests and meet head, neck, thoracic, and femur ICPLs. The head injury criterion is measured by HIC_{15}. Neck injury criteria are Nij, neck tension, and neck compression. The thoracic criteria are chest acceleration (chest g's) and chest deflection. The femur injury criterion is measured by the femur axial loads (kilo-Newtons - kN). The agency proposes to adopt these injury criteria and performance limits. Table III-1 lists the proposed injury criteria and corresponding ICPLs for the 5^{th} percentile female dummy. The theory, methodology, and scaling methods used to derive these injury criteria and performance limits were described in the injury criteria technical reports in support of the May FMVSS 208 final rule. These reports are in the DOT Docket (see docket number NHTSA-2000-7013-3[1] and NHTSA-1999-6407-5[2]).

Table III-1 Injury Criteria and Injury Criteria Performance Limits for FMVSS No. 208, In-Position Tests with 5th Percentile Female Dummy

FMVSS No 208 Injury		Injury Criteria Performance Limits (ICPLs)
Head Criterion - HIC15ms		700
Neck Criteria		
	Nij	1
	In-Position Neck Critical Intercept Values	
	Tension (N) - $F_{z\,CRIT}$	4287
	Compression (N) - $F_{z\,CRIT}$	-3880
	Flexion (N-m) - $M_{y\,CRIT}$	155
	Extension (N-m) - $M_{y\,CRIT}$	-67
	Peak Limits	
	Tension (N)	2620
	Compression (N)	-2520
Thoracic Criteria		
	Chest Acceleration (g's) - A_c	60
	Chest Deflection (mm) - D_c	52 (2.0")
Lower Extremity Criterion		
	Femur Axial Loads (kN)	6.8 (1,530 lbs)

Head – The head injury criterion (HIC) is based on a 15 milliseconds (ms) time interval calculation (HIC_{15}). HIC_{15} 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. $HIC_{15} = 700$ is the performance limit.

[1] Eppinger, R., Sun, E, Kuppa, S., Saul, R, Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, NHTSA-2000-7013-3, March 2000.
[2] Eppinger, R., et, Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, NHTSA-1999-6407-5, November, 1999.

Neck - Neck criteria are Nij, peak neck tension, and peak neck compression. The Nij criterion combines neck axial force (F_Z) and neck moment (M_Y) into one ICPL. F_Z represents either tension (F_T) or compression (F_C) force. M_Y represents either flexion (M_F) or extension (M_E) moment about the occipital condyles. F_Z and M_Y are calculated from the loads measured by the upper neck load cell. Nij represents four combinations of axial force F_Z (tension/compression) and neck moment M_Y (flexion/extension) to measure four primary types of cervical injuries: tension-extension (N_{TE}), tension-flexion (N_{TF}), compression-extension (N_{CE}), and compression-flexion (N_{CF}), i.e., Nij = (N_{TE}, N_{TF}, N_{CE}, N_{CF}). To calculate Nij, each measurement (F_Z and M_Y) is first normalized, i.e., each measurement was divided by its corresponding critical intercept value. The normalized axial force (F_{NZ}) and moments (M_{NY}) can be expressed as: $F_{NZ} = F_Z / F_{ZCRIT.}$, and $M_{NY} = M_Y / M_{YCRIT.}$, where $F_{Z\,CRIT.}$ and $M_{Y\,CRIT.}$ are the critical intercept values. Table III-1 shows the critical values used to calculate Nij for the 5th percentile female dummy. Nij then is the summation of the normalized neck axial force and normalized neck moment at the occipital condyle, i.e., $Nij = F_{NZ} + M_{NY}$. For example, to calculate N_{TE} (tension-extension), $N_{TE} = F_{NT} + M_{NE} = F_T / F_{T\,CRIT} + M_E / M_{E\,CRIT} = F_T / 3880 + M_E / -67$. The numbers 3880 and –67 are the intercept values for tension and extension, respectively. Nij = 1 is the performance limit regardless of the magnitude of axial force and neck moment. This means the maximum of (N_{TE}, N_{TF}, N_{CE}, and N_{CF}) can't be greater than 1.0. In addition to Nij, compliance to the peak neck tension and peak compression limits is also required. The performance limits for neck tension and compression are 2620 Newtons (N) and –2520 N, respectively.

Thorax – Thoracic injury criteria include chest acceleration (chest g's) and chest deflection. The chest g ICPL is 60g. The chest deflection ICPL is 52 millimeters (mm), which is equivalent to 2.0 inches.

Femurs – Femur axial compressive load represents the injury criterion for lower extremity injury. The femur load ICPL is 6.8 kilo-Newtons (kN) which is equivalent to 1,530 pounds (lbs.).

B. Injury Probability Curves

The injury probability curves are used to estimate the risk of a fatality or injury at a given injury value. The difference between the probabilities of a given set of crash test injury values and of the proposed ICPLs would be used to assess the benefits of the proposed rulemaking. The following figures and formulas show the injury risk curves for head, neck, and thorax injuries for the 5th percentile female dummy. These injury risk curves are adopted from FMVSS No. 208. Note that the majority of the MAIS 1 injuries were skin bruises. We believe the effectiveness of the new proposal for these injuries would be minimal. Thus, the analysis assumes that the new proposal would impact only MAIS 2+ injuries. Therefore, this section provides only MAIS 2+ through 5+ and fatality injury probability risk curves. The development of original injury probability curves was documented in NHTSA's report "Supplement: Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, March 2000[3]."

---

[3] Docket Number NHTSA-2000-7013-3.

Also, see NHTSA report "Final Economic Assessment, FMVSS No. 208, Advanced Air Bags, May 2000" for a summary of the injury probability curves.

Head Injury Criterion (HIC_{15})

The HIC_{15} probability curves are used to measure the chances that a vehicle occupant would receive certain MAIS head injury at a given HIC value. The analysis uses both variations of Prasad/Mertz and Hertz (lognormal)[4] curves to estimate head injury probabilities. The Prasad/Mertz curves were developed by assuming that the injury threshold levels were normally distributed. The mean of the normal distribution is the average of the lowest risk factor of injured specimens and the highest risk factor of uninjured specimens. The lognormal curves were developed using logistic regression and assumed that the injury threshold levels were a lognormal distribution. The slopes of the two sets of curves are very different. Please see the NHTSA's injury criteria technical reports, March 1999 (Docket number NHTSA 1999-6407-5) for the detailed comparison of statistical methodologies that were used to develop these curves.

Prasad/Mertz Probability Curves

The Prasad/Mertz HIC_{15} curves for the 5th percentile female dummy are:

AIS 2+ Percent Injury Probability = $[1 / (1 + \exp^{(2.49 + 140/HIC - 0.00690*HIC)})] \times 100\%$.

AIS 3+ Percent Injury Probability = $[1 / (1 + \exp^{(3.39 + 140/HIC - 0.00531*HIC)})] \times 100\%$.

AIS 4+ Percent Injury Probability = $[1 / (1 + \exp^{(4.90 + 140/HIC - 0.00501*HIC)})] \times 100\%$.

AIS 5+ Percent Injury Probability = $[1 / (1 + \exp^{(7.82 + 140/HIC - 0.00613*HIC)})] \times 100\%$.

[4] The Final Economic Assessment, FMVSS No. 208, Advanced Air Bags, Office of Regulatory Analysis & Evaluation, Plans and Policy, May 2000.

Fatality Percent Injury Probability = $[1 / (1 + \exp^{(12.14 + 140/HIC - 0.00807*HIC)})] \times 100\%$.

The head injury risk at the proposed ICPL level for the 5th percentile female dummy would be equal to the ICPL level for the 50th percentile male dummy required in the FMVSS No. 208. Because both have the same HIC_{15} ICPL of 700, the injury curves for the 5th percentile female dummy are the same as those for the 50th percentile male dummy. Figure III-1 depicts these curves. Tables III-2 shows the probability risk values that are derived from these curves.

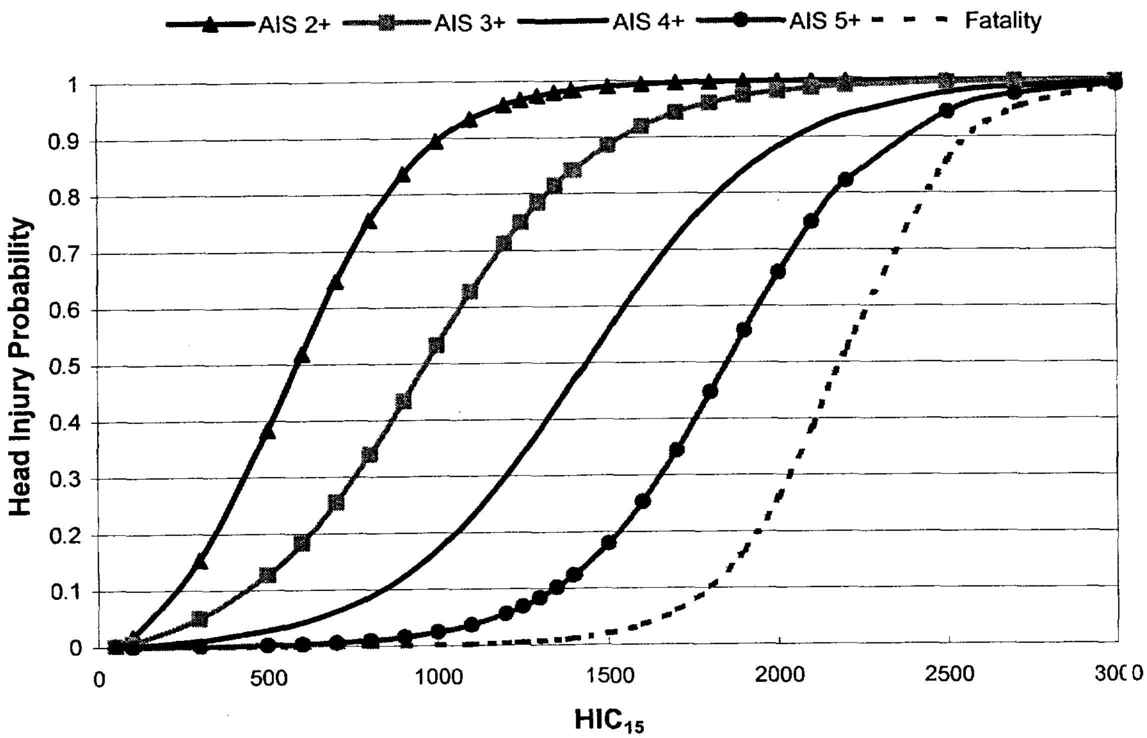

Figure III-1
Head Injury Probability vs HIC_{15} for the 5th Percentile Dummy
(Derived From Prasad/Mertz Curves)

Table III-2
Prasad/Mertz HIC_{15} Probability Risk Values* for 5^{th} Percentile Female Dummy

HIC15	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal	No Injury
50	1.3%	0.4%	0.2%	0.1%	0.0%	0.0%	98.0%
100	7.9%	2.5%	1.1%	0.3%	0.0%	0.0%	88.2%
150	16.9%	5.6%	2.2%	0.6%	0.0%	0.0%	74.6%
200	26.5%	9.4%	3.6%	0.9%	0.1%	0.0%	59.4%
250	34.5%	14.2%	5.3%	1.4%	0.1%	0.0%	44.5%
300	39.4%	19.8%	7.4%	1.9%	0.2%	0.0%	31.4%
350	40.4%	25.7%	9.9%	2.6%	0.2%	0.0%	21.2%
400	38.1%	31.4%	12.8%	3.4%	0.3%	0.0%	13.9%
450	33.6%	36.3%	16.3%	4.5%	0.4%	0.0%	8.9%
500	28.0%	39.8%	20.2%	5.8%	0.6%	0.0%	5.6%
550	22.4%	41.4%	24.3%	7.4%	0.9%	0.0%	3.5%
600	17.3%	41.2%	28.6%	9.4%	1.2%	0.0%	2.2%
650	13.1%	39.4%	32.7%	11.8%	1.6%	0.1%	1.4%
700	9.7%	36.3%	36.3%	14.6%	2.2%	0.1%	0.8%
750	7.1%	32.4%	39.1%	17.7%	3.0%	0.2%	0.5%
800	5.1%	28.1%	40.8%	21.2%	4.1%	0.3%	0.3%
850	3.7%	23.8%	41.4%	25.0%	5.5%	0.4%	0.2%
900	2.6%	19.8%	40.8%	28.8%	7.3%	0.6%	0.1%
950	1.9%	16.2%	39.0%	32.4%	9.6%	0.9%	0.1%
1000	1.3%	13.1%	36.3%	35.4%	12.5%	1.3%	0.0%
1050	0.9%	10.4%	33.0%	37.7%	16.0%	2.0%	0.0%
1100	0.7%	8.2%	29.2%	38.8%	20.1%	3.0%	0.0%
1150	0.5%	6.5%	25.4%	38.6%	24.7%	4.4%	0.0%
1200	0.3%	5.0%	21.6%	37.1%	29.4%	6.5%	0.0%
1250	0.2%	3.9%	18.1%	34.4%	33.9%	9.4%	0.0%
1300	0.2%	3.0%	15.0%	30.8%	37.5%	13.5%	0.0%
1350	0.1%	2.4%	12.2%	26.6%	39.7%	19.0%	0.0%
1400	0.1%	1.8%	9.9%	22.3%	39.9%	26.1%	0.0%
1450	0.1%	1.4%	7.9%	18.1%	37.9%	34.6%	0.0%
1500	0.0%	1.1%	6.3%	14.3%	34.0%	44.3%	0.0%
1550	0.0%	0.8%	5.0%	11.1%	28.6%	54.4%	0.0%
1600	0.0%	0.6%	4.0%	8.4%	22.8%	64.2%	0.0%
1650	0.0%	0.5%	3.1%	6.3%	17.2%	72.9%	0.0%
1700	0.0%	0.4%	2.4%	4.6%	12.4%	80.2%	0.0%
1750	0.0%	0.3%	1.9%	3.4%	8.6%	85.8%	0.0%
1800	0.0%	0.2%	1.5%	2.4%	5.7%	90.1%	0.0%
1850	0.0%	0.2%	1.2%	1.7%	3.7%	93.2%	0.0%
1900	0.0%	0.1%	0.9%	1.2%	2.4%	95.3%	0.0%
1950	0.0%	0.1%	0.7%	0.9%	1.5%	96.8%	0.0%
2000	0.0%	0.1%	0.6%	0.6%	0.9%	97.9%	0.0%

* same as those of 50^{th} male dummy

Based on Table III-2, at the HIC_{15} ICPL level (700), a 5th percentile occupant in a frontal crash would have a 89.4 percent chance of receiving a MAIS 2-5 non-fatal head injury (adding together 36.3% for MAIS 2, 36.3% for MAIS 3, 14.6% for MAIS 4, and 2.2% for MAIS 5) and have about a 0.1 percent chance of receiving a fatal head injury.

Lognormal Probability Curves

Figure III-2 and Table III-3 show the probability risk values derived from the lognormal curves for occupants represented by the 5th percentile female dummy.

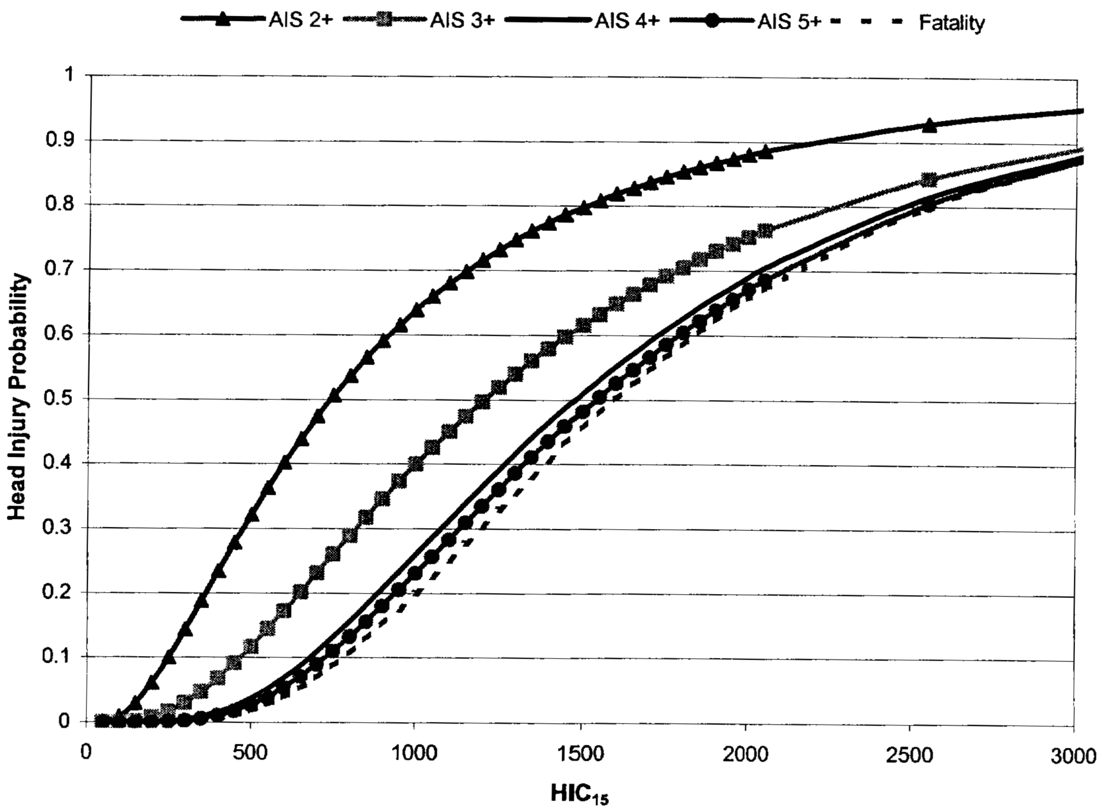

Figure III-2
Head Injury Probability vs HIC_{15} for the 5th Percentile Female Dummy
(Derived From Lognormal Curves)

Table III-3
Lognormal HIC_{15} Probability Risk Values* for 5th Percentile Female Dummy

HIC15	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal	No Injury
50	13.99%	0.07%	0.00%	0.00%	0.00%	0.00%	85.94%
100	33.88%	0.86%	0.04%	0.00%	0.00%	0.00%	65.22%
150	47.45%	2.73%	0.23%	0.01%	0.00%	0.00%	49.58%
200	55.51%	5.35%	0.71%	0.02%	0.02%	0.01%	38.38%
250	59.73%	8.33%	1.50%	0.07%	0.06%	0.04%	30.27%
300	61.40%	11.31%	2.57%	0.16%	0.14%	0.13%	24.29%
350	61.41%	14.10%	3.84%	0.30%	0.27%	0.31%	19.77%
400	60.33%	16.59%	5.22%	0.47%	0.46%	0.63%	16.30%
450	58.57%	18.71%	6.64%	0.68%	0.69%	1.12%	13.59%
500	56.39%	20.47%	8.00%	0.92%	0.96%	1.81%	11.45%
550	53.99%	21.87%	9.27%	1.17%	1.25%	2.73%	9.72%
600	51.47%	22.96%	10.40%	1.42%	1.56%	3.87%	8.32%
650	48.93%	23.74%	11.39%	1.67%	1.85%	5.25%	7.17%
700	46.41%	24.28%	12.21%	1.91%	2.13%	6.84%	6.22%
750	43.95%	24.60%	12.87%	2.12%	2.39%	8.64%	5.43%
800	41.59%	24.72%	13.38%	2.31%	2.62%	10.62%	4.76%
850	39.32%	24.70%	13.73%	2.48%	2.81%	12.77%	4.19%
900	37.16%	24.54%	13.95%	2.62%	2.97%	15.05%	3.71%
950	35.11%	24.26%	14.06%	2.73%	3.10%	17.44%	3.30%
1000	33.18%	23.90%	14.05%	2.82%	3.18%	19.93%	2.94%
1050	31.36%	23.46%	13.95%	2.89%	3.24%	22.47%	2.63%
1100	29.64%	22.98%	13.75%	2.94%	3.26%	25.07%	2.36%
1150	28.01%	22.45%	13.51%	2.95%	3.26%	27.69%	2.13%
1200	26.50%	21.88%	13.19%	2.96%	3.24%	30.31%	1.92%
1250	25.07%	21.29%	12.84%	2.95%	3.18%	32.93%	1.74%
1300	23.72%	20.69%	12.44%	2.93%	3.11%	35.53%	1.58%
1350	22.46%	20.07%	12.02%	2.89%	3.02%	38.10%	1.44%
1400	21.28%	19.45%	11.58%	2.83%	2.93%	40.62%	1.31%
1450	20.16%	18.84%	11.12%	2.77%	2.82%	43.09%	1.20%
1500	19.11%	18.23%	10.65%	2.71%	2.69%	45.51%	1.10%
1550	18.13%	17.61%	10.19%	2.63%	2.57%	47.86%	1.01%
1600	17.21%	17.01%	9.71%	2.56%	2.44%	50.14%	0.93%
1650	16.34%	16.43%	9.24%	2.48%	2.30%	52.36%	0.85%
1700	15.52%	15.85%	8.78%	2.39%	2.17%	54.50%	0.79%
1750	14.75%	15.29%	8.32%	2.31%	2.04%	56.56%	0.73%
1800	14.03%	14.75%	7.87%	2.22%	1.91%	58.55%	0.67%
1850	13.35%	14.21%	7.45%	2.13%	1.77%	60.47%	0.62%
1900	12.70%	13.70%	7.02%	2.04%	1.65%	62.31%	0.58%
1950	12.10%	13.19%	6.62%	1.95%	1.52%	64.08%	0.54%
2000	11.53%	12.71%	6.22%	1.87%	1.40%	65.77%	0.50%

* same as those of 50th percentile male dummy

Based on Table III-3, the lognormal curves, at the HIC_{15} ICPL level (700), a small stature vehicle occupant in a frontal crash would have a 40.53 percent chance of receiving a MAIS 2-5 non-fatal head injury (adding together 24.48% for MAIS 2, 12.21% for MAIS 3, 1.91% for MAIS 4, and 2.13% for MAIS 5), and have about a 6.84 percent chance of receiving a fatal head injury.

Neck Injury Criterion (Nij)

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+)

The Nij values are the normalized numbers adjusted to maintain consistency with respect to the neck injury outcome, thus the Nij probability curves are the same regardless of dummy size. The normalization process is controlled by the intercept values that are used to calculate Nij. The intercept values for the 5^{th} percentile are listed in Table III-1. Figure III-3 depicts the neck injury probability vs Nij. Table III-4 shows the probability values derived by these curves. Note that there was insufficient data to measure fatality risk. The AIS 5+ curve was therefore used as a proxy for fatalities. Also note that these Nij injury curves are the same for all dummies due to the normalized Nij.

At the proposed Nij ICPL level of 1, a 5th percentile occupant in a frontal crash would have a 29.8 percent chance to receive a MAIS 2-5 non-fatal neck injury and have about a 6.8 percent chance to receive a fatal neck injury.

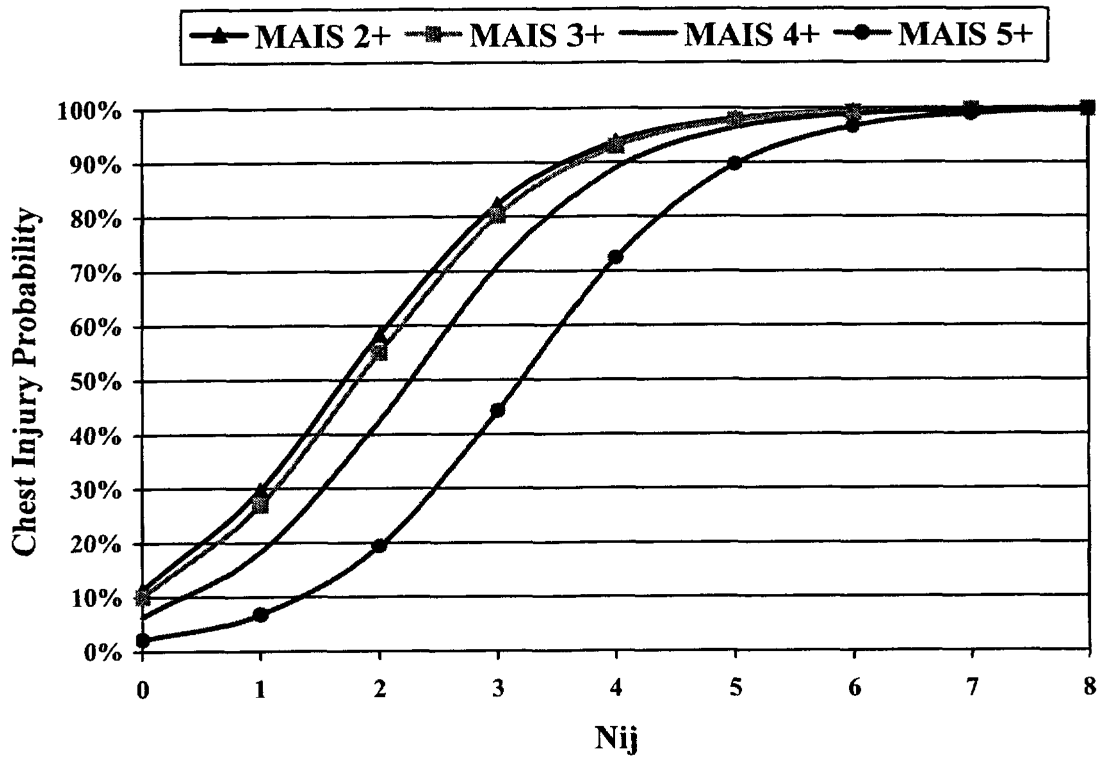

Figure III-3
Neck Injury Probability vs Nij

The analysis only uses Nij and its injury curves to estimate the risk of neck injuries even though the proposal requires neck tension and compression injury criteria for two reasons:

(1) Nij as described previously is a criterion that combines neck axial force (tension/compression) and neck moment (flexion/extension). Nij provides a more comprehensive and robust criterion to assess the overall neck injury severity than the axial force (tension/compression) alone[5].

(2) Based on the crash test data (Chapter IV), a dummy that failed either the neck tension or compression also failed the Nij but not vice versa. This shows that Nij is a more conservative injury criterion to assess the neck injuries.

Thoracic Injury Criteria

Chest acceleration (chest g's) and chest deflection limits are proposed for the 5th percentile dummy.

Chest Acceleration (chest g's)

Injury probability as a function of chest acceleration (chest g's) based on a 3 ms clip of the spinal acceleration on a 5th percentile female dummy is listed below. The chest injury risk at the proposed ICPL level for the 5th percentile female dummy would be equal to that at the ICPL level for the 50th percentile male dummy required in the FMVSS No. 208. Because both have the same ICPL of 60 g's, the mathematical formulas for the

[5] Supplement: Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, March 2000.

chest g's injury probability curves are the same for the 5th percentile female dummy and 50th percentile male dummy[6].

Table III-4
Neck (Nij) Probability Risk Values* for 5th Percentile Female Dummy

Nij	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatality
0.1	1.43%	4.11%	4.67%	2.42%	2.42%
0.2	1.56%	4.53%	5.20%	2.72%	2.72%
0.3	1.70%	4.98%	5.78%	3.05%	3.05%
0.4	1.85%	5.46%	6.41%	3.43%	3.43%
0.5	2.00%	5.95%	7.11%	3.85%	3.85%
0.6	2.15%	6.48%	7.87%	4.31%	4.31%
0.7	2.31%	7.02%	8.69%	4.83%	4.83%
0.8	2.47%	7.59%	9.55%	5.42%	5.42%
0.9	2.62%	8.16%	10.50%	6.06%	6.06%
1.0	2.76%	8.73%	11.50%	6.78%	6.78%
1.1	2.90%	9.30%	12.56%	7.57%	7.57%
1.2	3.03%	9.85%	13.66%	8.46%	8.46%
1.3	3.14%	10.38%	14.82%	9.43%	9.43%
1.4	3.24%	10.86%	16.02%	10.50%	10.50%
1.5	3.31%	11.31%	17.23%	11.68%	11.68%
1.6	3.37%	11.69%	18.46%	12.97%	12.97%
1.7	3.40%	12.01%	19.68%	14.38%	14.38%
1.8	3.40%	12.27%	20.88%	15.91%	15.91%
1.9	3.39%	12.43%	22.03%	17.58%	17.58%
2.0	3.34%	12.51%	23.13%	19.38%	19.38%
2.1	3.28%	12.50%	24.14%	21.31%	21.31%
2.2	3.19%	12.41%	25.04%	23.39%	23.39%
2.3	3.09%	12.22%	25.82%	25.60%	25.60%
2.4	2.97%	11.97%	26.45%	27.94%	27.94%
2.5	2.83%	11.64%	26.93%	30.41%	30.41%
2.6	2.69%	11.24%	27.24%	33.00%	33.00%
2.7	2.54%	10.79%	27.37%	35.69%	35.69%
2.8	2.39%	10.29%	27.32%	38.48%	38.48%

* same for every dummy size

The chest acceleration injury probability curves are:

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

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

[6] The original chest acceleration probability formulas were listed in the "Final Economic Assessment, FMVSS No. 208, Advanced Air Bags, May 2000".

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

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

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

Where, g = chest g's.

Figure III-4 depicts the chest injury probability vs chest g's. Table III-5 shows the probability risk values that are derived from these curves. Note that there was insufficient data to measure fatality risk. The AIS 5+ curve was therefore used as a proxy for fatalities.

As shown in Table III-5, at the proposed ICPL of 60 g's, a 5th percentile female occupant in a frontal crash would have a 90.2 percent chance of receiving a MAIS 2-5 non-fatal chest injury and have about a 0.8 percent chance of receiving a fatal chest injury.

Chest Deflection

The chest deflection injury curves for occupants represented by the 5th percentile female dummy are derived from the 50th percentile male curves[7] by a shifting process. The shifting process is to map the probability of chest injury at 52 mm (2.0") required for the 5th percentile female dummy from that at 63 mm (2.5") for the 50th percentile male dummy.

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

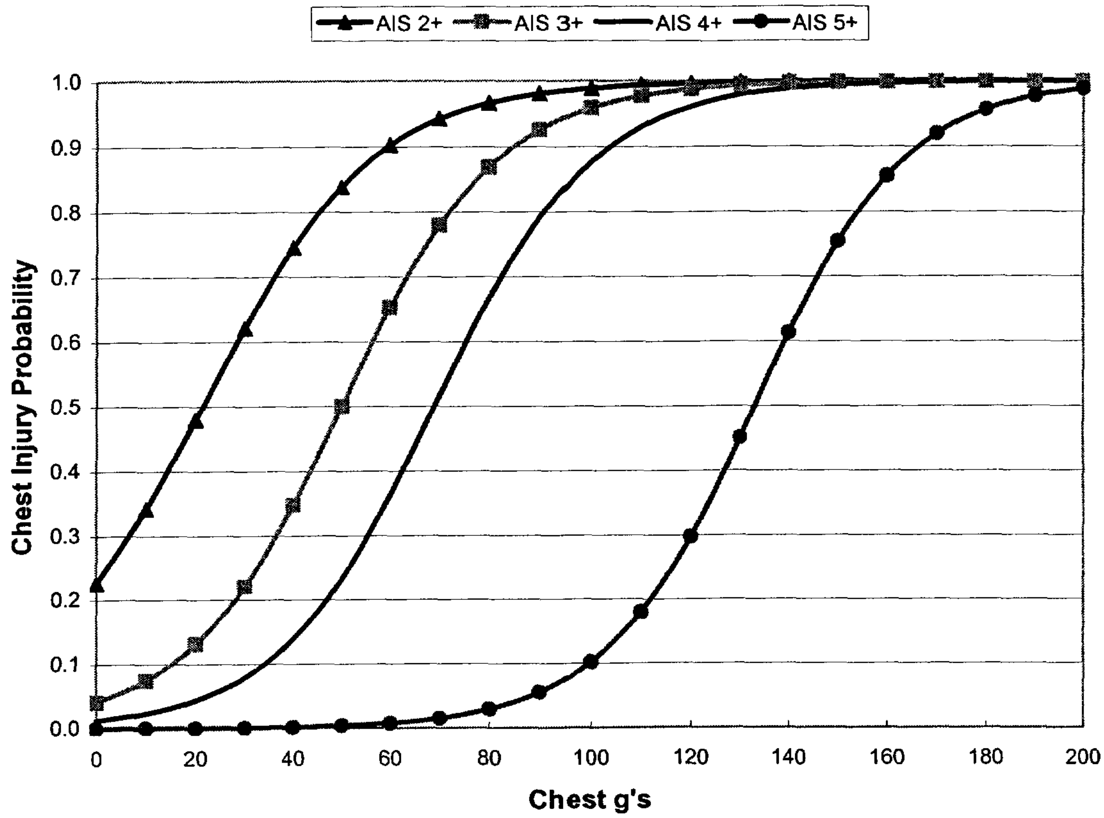

Figure III-4
Chest Injury Probability vs Chest Acceleration (g's) for 5th Percentile Female Dummy

The following are the chest deflection injury curves for the 5th percentile female dummy:

AIS 2+ Percent Injury Probability = $[1 / (1 + \exp^{(1.8706 - 0.05378*d)})] \times 100\%$

AIS 3+ Percent Injury Probability = $[1 / (1 + \exp^{(3.7124 - 0.05755*d)})] \times 100\%$

AIS 4+ Percent Injury Probability = $[1 / (1 + \exp^{(5.0952 - 0.05755*d)})] \times 100\%$

AIS 5+ Percent Injury Probability = $[1 / (1 + \exp^{(8.8274 - 0.05561*d)})] \times 100\%$

Fatality Percent Injury Probability = $[1 / (1 + \exp^{(8.8274 - 0.05561*d)})] \times 100\%$ (same as MAIS 5+ Injury Curve).

Where, d = chest deflection in millimeters (mm).

Table III-5

Chest Acceleration (g's) Probability Risk Values* for 5th Percentile Female Dummy

Chest g's	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatality
0	18.47%	2.83%	1.26%	0.02%	0.02%
10	26.70%	5.07%	2.35%	0.03%	0.03%
20	34.86%	8.75%	4.32%	0.06%	0.06%
30	40.03%	14.18%	7.82%	0.11%	0.11%
40	39.72%	20.86%	13.69%	0.22%	0.22%
50	33.84%	26.74%	22.86%	0.42%	0.42%
52	32.20%	27.55%	25.13%	0.48%	0.48%
60	24.97%	28.96%	35.49%	0.81%	0.81%
70	16.36%	26.22%	50.14%	1.55%	1.55%
80	9.81%	20.12%	63.81%	2.95%	2.95%
90	5.55%	13.52%	73.49%	5.55%	5.55%
100	3.04%	8.26%	77.43%	10.20%	10.20%
110	1.63%	4.76%	75.01%	18.00%	18.00%
120	0.86%	2.65%	66.36%	29.79%	29.79%
130	0.45%	1.45%	52.85%	45.06%	45.06%
140	0.23%	0.78%	37.56%	61.32%	61.32%
150	0.12%	0.42%	24.00%	75.40%	75.40%
160	0.07%	0.22%	14.13%	85.55%	85.55%
170	0.03%	0.12%	7.86%	91.97%	91.97%
180	0.02%	0.06%	4.23%	95.68%	95.68%
190	0.00%	0.04%	2.23%	97.72%	97.72%
200	0.01%	0.02%	1.17%	98.80%	98.80%
210	0.00%	0.01%	0.61%	99.38%	99.38%
220	0.00%	0.01%	0.31%	99.68%	99.68%
230	0.00%	0.00%	0.17%	99.83%	99.83%
240	0.00%	0.00%	0.09%	99.91%	99.91%
250	0.00%	0.00%	0.04%	99.96%	99.96%
300	0.00%	0.00%	0.00%	100.00%	100.00%

* same as those of 50th percentile male dummy

Figure III-5 depicts the chest injury probability vs chest deflection. Note that there was insufficient data to measure fatality risk. The AIS 5+ curve was therefore used as a proxy for fatalities.

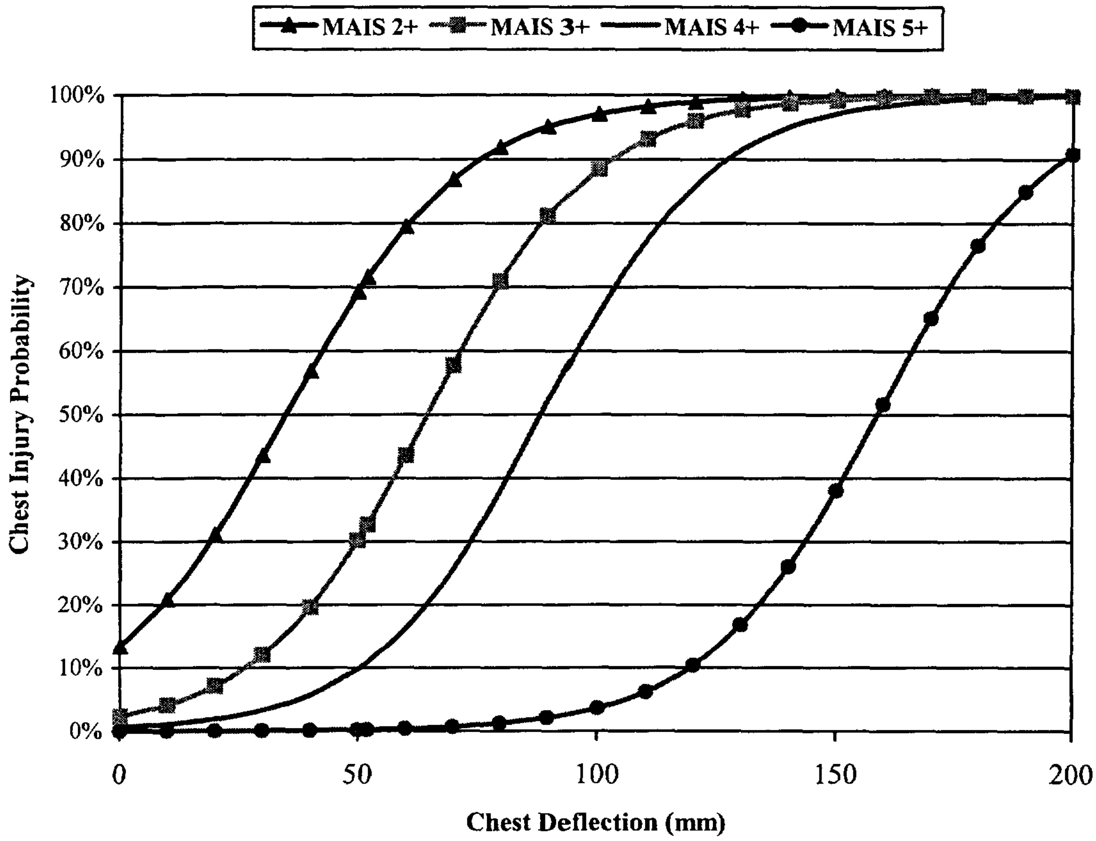

Figure III-5
Chest Injury Probability vs Chest Deflection (mm) for 5th Percentile Female Dummy

At the proposed ICPL of 52 mm, a 5th percentile occupant in a frontal crash would have a 71.6 percent chance of receiving a MAIS 2-5 non-fatal chest and have a very small chance of receiving a fatal chest injury. Tables III-6 shows the probability risk values that are derived from these curves.

Table III-6
Chest Deflection Probability Risk Values for 5th Percentile Female Dummy

Chest Deflection (mm)	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatality
0	10.96%	1.77%	0.59%	0.01%	0.01%
10	16.71%	3.08%	1.05%	0.03%	0.03%
20	23.94%	5.27%	1.86%	0.04%	0.04%
30	31.54%	8.74%	3.25%	0.08%	0.08%
40	37.35%	13.85%	5.63%	0.14%	0.14%
50	39.13%	20.44%	9.58%	0.24%	0.24%
52	38.88%	21.86%	10.62%	0.26%	0.26%
60	35.96%	27.33%	15.81%	0.41%	0.41%
70	29.08%	32.23%	24.89%	0.71%	0.71%
80	21.00%	32.96%	36.72%	1.24%	1.24%
90	13.86%	29.16%	49.97%	2.14%	2.14%
100	8.57%	22.60%	62.25%	3.67%	3.67%
110	5.08%	15.73%	71.24%	6.24%	6.24%
120	2.93%	10.11%	75.55%	10.39%	10.39%
130	1.66%	6.17%	74.75%	16.82%	16.82%
140	0.93%	3.64%	69.01%	26.08%	26.08%
150	0.52%	2.10%	59.09%	38.09%	38.09%
160	0.29%	1.20%	46.64%	51.75%	51.75%
170	0.16%	0.68%	33.92%	65.17%	65.17%
180	0.09%	0.39%	22.95%	76.54%	76.54%
190	0.05%	0.22%	14.66%	85.05%	85.05%
200	0.03%	0.12%	8.99%	90.84%	90.84%
210	0.02%	0.07%	5.37%	94.54%	94.54%
220	0.01%	0.04%	3.16%	96.79%	96.79%
230	0.00%	0.02%	1.84%	98.13%	98.13%
240	0.00%	0.01%	1.06%	98.92%	98.92%
250	0.00%	0.01%	0.61%	99.38%	99.38%
300	0.00%	0.00%	0.04%	99.96%	99.96%

Femur

Only AIS 2+ and AIS 3+ femur injury curves are presented here due to very limited data at higher injury severities. Figure III-6 depicts the femur injury risk against the femur load. Table III-7 lists the corresponding injury values. The proposed ICPL of 6.8 kN (1,530 lbs) for the 5th percentile female dummy would allow small stature occupants to have a 32 percent risk of AIS 2+ and 15 percent risk of AIS 3+ femur injury.

AIS 2+ Percent Injury Probability = $[1 / (1 + \exp^{(4.0307 - 0.47941 * g)})] \times 100\%$.

AIS 3+ Percent Injury Probability = $[1 / (1 + \exp^{(4.9795 - 0.47941 * g)})] \times 100\%$.

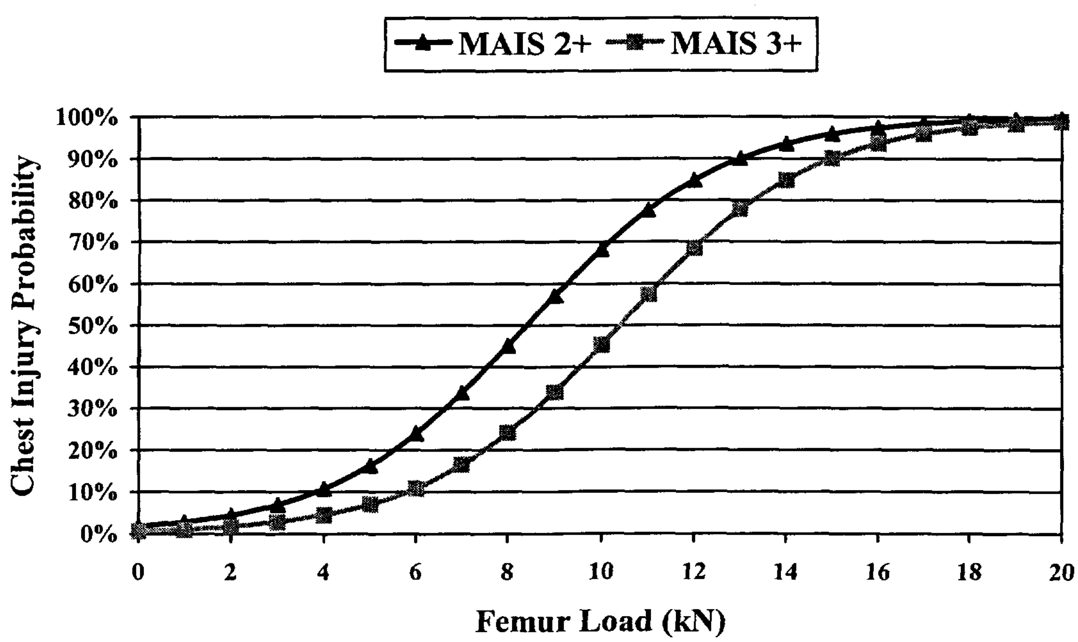

Figure III-6
Femur Injury Probability vs Femur Load (kN) for 5th Percentile Female Dummy

Table III-7
Femur Injury Probability Risk Values for 5th Percentile Female Dummy

Femur Load (kN)	MAIS 2+	MAIS 3+
0	1.75%	0.68%
1	2.79%	1.10%
2	4.43%	1.76%
3	6.96%	2.82%
4	10.78%	4.47%
5	16.33%	7.03%
6	23.97%	10.88%
7	33.74%	16.47%
8	45.13%	24.15%
9	57.05%	33.97%
10	68.21%	45.38%
11	77.61%	57.30%
12	84.84%	68.43%
13	90.04%	77.78%
14	93.59%	84.97%
15	95.93%	90.13%
16	97.44%	93.65%
17	98.40%	95.97%
18	99.00%	97.47%
19	99.38%	98.42%
20	99.62%	99.01%
21	99.76%	99.39%
22	99.85%	99.62%
23	99.91%	99.76%
24	99.94%	99.85%
25	99.96%	99.91%
26	99.98%	99.94%

CHAPTER IV. ANALYSIS OF CRASH TEST DATA

NHTSA's New Car Assessment Program (NCAP) has tested ten 2001 model year vehicles at 56 km/h (35 mph) into a rigid barrier with two belted Hybrid III 5th percentile female dummies (driver and passenger). In addition, NHTSA's Office of Applied Research conducted 8 additional tests through a joint research program with Transport Canada. This chapter analyzes these 18 tests. The 18 tested vehicles consisted of 1 mini passenger car, 3 light passenger cars, 6 medium passenger cars, 5 sport utility vehicles, 2 minivans, and 1 pickup truck. Table IV-1 lists the vehicle make models, their configurations, restraint characteristics, and the date of the final rule used to determine the seating procedures. Seven of these tests used the seating position published in the May 12, 2000 FMVSS 208 Final Rule (65 FR 30690). The remaining 11 tests used the procedure published in the December 18, 2001 FMVSS 208 Final Rule[1], Response to Petitions for Reconsideration. The seating positioning procedure was changed during the course of this testing to facilitate the placement of the dummy in the full forward seat position. As shown in the table, the majority of these vehicles had load limiters and belt pretensioners. Eleven of these vehicles had dual or multi-stage air bag inflators. The 2001 Ford Taurus model was also equipped with a driver seat track sensor.

[1] Also NHTSA Docket Number 01 11110

Table IV-1 56 KM/H (35 MPH) With 5th Percentile Female Dummies Crash Test Matrix of 18 Vehicle Models

Make	Model	Year	Air Bag Inflator Type	Seat Belt Energy Management Feature	Pretensioner	Seating Procedure
Mini Passenger Car (1 Model)						
Geo	Metro	1998	Single Stage	Standard	Standard	Dec 18, 2001
Light Passenger Car (3 Models)						
Honda	Civic	2001	Dual Stage	Standard	Standard	May 12, 2000
Nissan	Sentra	2001	Single Stage	Standard	Standard	May 12, 2000
Toyota	Echo	2001	Single Stage	Standard	Standard	Dec 18, 2001
Medium Passenger Car (6 Models)						
Chevy	Impala	2001	Dual Stage	Standard	Not Equipped	Dec 18, 2001
Ford	Taurus*	2001	Dual Stage	Standard	Standard	May 12, 2000
Honda	Accord	2001	Dual Stage	Standard	Standard	May 12, 2000
Nissan	Maxima	2001	Dual Stage	Standard	Standard	May 12, 2000
Toyota	Camry	2002	Dual Stage	Standard	Standard	Dec 18, 2001
Toyota	Corolla	2003	Dual Stage	Standard	Standard	Dec 18, 2001
Sport Utility Vehicle (5 Models)						
Chevy	Trailblazer	2002	Dual Stage	Standard	Not Equipped	Dec 18, 2001
Dodge	Durango	2001	Single Stage	Standard	Standard	May 12, 2000
Ford	Escape	2001	Single Stage	Standard	Standard	Dec 18, 2001
Jeep	Liberty	2002	Multi-Stage	Standard	Standard	Dec 18, 2001
Saturn	Vue	2002	Single Stage	Standard	Not Equipped	Dec 18, 2001
Minivan (2 Models)						
Dodge	Grand Caravan	2001	Multi-Stage	Standard	Standard	Dec 18, 2001
Ford	Windstar	2001	Dual Stage	Standard	Standard	Dec 18, 2001
Pickup Truck (1 Model)						
Ford	F150	2001	Single Stage	Standard	Standard	May 12, 2000

* equipped with driver seat track sensing and optional adjustable pedals.

Table IV-2 summarizes the pass/fail statistics of these 18 tests. Tables IV-3 and IV-4 list the detail test results including the restraint features. Table IV-3 is for drivers and Table IV-4 is for passengers. These tests were based on the Frontal NCAP test procedure[2] with some modifications. The modifications included adding ballast weight to the test vehicles and additional dummy chalking. The 5th percentile female dummy weighs about 29 kilograms (kg, 63 lbs) less than the 50th percentile male dummy. Therefore, the weight of vehicles tested with two 5th percentile female dummies was about 58 kg (126 lbs) less than those with 50th percentile male dummies. Adding ballast weight was done to compensate for the difference in passenger weights in the cars. The added weight would not affect injury outcome. The purpose of the additional dummy chalking was to mark the dummy-vehicle contact areas to help researchers understand dummy-vehicle interaction.

There are three statistics reported in Table IV-2: the number of vehicles that failed the injury criteria, the raw failure rates, and the weighted failure rate. The raw failure rate is the percentage of test vehicles that failed. The weighted failure rate was derived using the vehicle sales volume as weight. In other words, the analysis assumes that the 18 vehicles tested represented all the on-road operational fleet. The weight for each vehicle tested is the vehicle's relative proportion of on-road exposure.

As shown in Table IV-2, Nij is the most frequent failure mode for drivers. Four out of 18 (22.2 percent, 17.2 percent - weighted) vehicles tested failed the Nij criterion for the

[2] "Submission of the Fronal NCAP's Laboratory Test Procedures", NHTSA Docket NHTSA-99-4962, Comment 37.

drivers. Two of these 4 vehicles failed Nij by a significant margin – one by 70%, the other by 100%. Readers can consult Table IV-3 for the exact test results. HIC_{15} and chest g's are the next frequently failed injury criteria. Each had two vehicles fail, which corresponded to an 11.1 percent failure rate. However, the weighted failure rate was 4.1 percent for HIC and 8.4 percent for chest. All drivers of these 18 vehicles passed the femur ICPL. Overall, 6 out of 18 (33.3 percent, 20.9 percent - weighted) drivers failed one of the proposed injury criteria.

Passengers in these vehicles have lower failure rates. For each of the following injury criteria HIC_{15}, chest g's, and Nij, one vehicle failed the ICPL. All passenger dummies passed the femur ICPL. Overall for passengers, 2 vehicles failed one of the proposed injury criteria. These two vehicles also failed on the driver side. For drivers and passengers combined, 6 out of 18 (33.3 percent, 20.9 percent - weighted) tested vehicles failed either the driver or passenger injury criteria.

Overall, 62.8 percent (weighted percent, 11 out of 18) of the vehicles had dual- or multi-stage air bags; 86.3 (15 out of 18) percent had pretensioners; 8.3 (1 out of 18) percent had a driver seat track sensor. But, none of the 18 vehicles had passenger side seat track sensors.

Table IV-2
Number of Vehicles Failing the Proposed Criteria
56 km/h Rigid Barrier Belted Tests with 5th Percentile Females Dummies
Total Number of Tests: 18

Failures: Raw # Raw % Weighted %	**HIC_{15}**	**Chest g's**	**Chest Deflection**	**Nij**	**Neck Tension**	**Neck Compression**	**Femur Compression**	**All Injury Criteria Combined**
Drivers	2 11.1% 4.1%	2 11.1% 8.4%	0 0.0% 0.0%	4 22.2% 17.2%	1 5.6% 3.1%	0 0.0% 0.0%	0 0.0% 0.0%	6 33.3% 20.9%
Passengers	1 5.6% 2.7%	1 5.6% 2.7%	0 0.0% 0.0%	1 5.6% 3.1%	0 0.0% 0.0%	0 0.0% 0.0%	0 0.0% 0.0%	2 11.1% 5.8%
Combined	3 16.7% 6.8%	2 11.1% 8.4%	0 0.0% 0.0%	4 22.2% 17.2%	1 5.6% 3.1%	0 0.0% 0.0%	0 0.0% 0.0%	6 33.3% 20.9%

Of those 6 vehicles that failed the proposal, 27.6 percent (weighted percent, 2 out of 6) failed both driver and passenger performance. Approximately, 79.8 percent (3 out of 6 vehicles) had dual or multi-stage air bags. About 39.7 percent (1 out of 6) had a driver side seat track sensor. None of these vehicles had a passenger side seat track sensor. About 87.1 percent (5 out of 6) were equipped with pretensioners. The two vehicles that failed both driver and passenger performance did not have the seat track sensors, which accounted for 45.8 percent of the vehicles that failed and were not equipped with a seat track sensor. One vehicle (2002 Chevy Trailblazer) had a dual stage air bag but was not equipped with a pretensioner or seat track sensor. The other one (2001 Dodge Durango) had only a single stage air bag but was equipped with pretensioner.

As mentioned earlier, these tests were based on two seating procedures. Seven of the 18 tests were based on May 2000, Final Rule. The other 11 were based on the December 2001, Final Rule. The seating procedure published in the December 2001, Final Rule facilitated the placement of the dummy in the full forward seating position. None of the 7 vehicles that used the May 12, 2000 seating position procedure achieved the full forward position. By contrast, only 2 (Ford Escape and Toyota Echo) of the 11 test vehicles using December 2001 seating procedure couldn't reach the full forward position. The new seating procedure allows the seats to reach or come fairly close to the full forward position. The procedure permits dummies to sit closer to the air bag modules than the May 2000 procedure. Thus, the test condition using the new seating procedure is considered more stringent. However, the change would probably not affect the current overall pass/fail rate due to fact that those vehicles passing the proposal using the May 2000 seating procedure were passing with a considerable compliance margin. If retested using the new seating procedure, these vehicles would likely still pass the proposal. For more detailed analysis of these tests, please see the NHTSA's report "Performance of the 5^{th} Percentile Dummy in a 56 KMPH (35 MPH) Frontal Barrier Crash", July 2002.

Table IV-3
56 km/h (35 mph) Rigid Barrier Belted Tests With 5th Percentile Female Dummy
Driver Injury Test Outcome

Model Year Model	Test Number	KEY	HIC_{15}	Chest g's	Chest Deflection	Nij	Neck Tension	Neck Compression	Left Femur Compression	Right Femur Compression
ICPL			700	60	52 mm	1	2620N	2520N	6805N	6805N
Mini Passenger Car										
1998 Geo Metro	TC98-003	S,S,S	139	53.1	36.4	**2.00**	2416	632	2000	2538
Light Passenger Car										
2001 Honda Civic	V3610	D,S,S	153	50.5	20.9	0.65	1534	210	1340	1176
2001 Nissan Sentra	V3612	S,S,S	176	39.3	19.3	0.53	1490	129	3034	2729
2001 Toyota Echo	V3647	S,S,S	**794**	53.5	23.2	0.77	2276	1694	540	2036
Medium Passenger Car										
2001 Chevy Impala	V3648	D,S,N	136	37.5	15.7	0.80	1783	279	3252	3404
2001 Ford Taurus	V4150 TC01-225	D,S,S	167	44.0	36.4	**1.01**	1736	294	2308	2317
2001 Honda Accord	V3611	D,S,S	61	39.8	16.4	0.42	1127	118	1724	754
2001 Nissan Maxima	V3643	D,S,S	396	44.9	20.8	0.92	1960	647	2833	3174
2002 Toyota Camry	TC02-218	D,S,S	506	50.8	31.5	0.68	1446	345	633	729
2003 Toyota Corolla	TC03-201	D,S,S	451	48.4	30.8	C.F.	C.F.	C.F.	650	1417

Note: Injury results exceeding the ICPL are in bold.
C.F.: Channel Failure
Key: Air bag inflators (S-single stage, D-dual stage, M-multi-stage), load limiter (S-standard, N-not equipped), and pretensioner (S-standard, N-not equipped).

Table IV-3 -Continued
56 km/h (35 mph) Rigid Barrier Belted Tests With 5th Percentile Female Dummy
Driver Injury Test Outcome

Model Year Model	Test Number	KEY	HIC_{15}	Chest g's	Chest Deflection	Nij	Neck Tension	Neck Compression	Left Femur Compression	Right Femur Compression
ICPL			700	60	52 mm	1	2620N	2520N	6805N	6805N
Sport Utility Vehicle										
2002 Chevy Trailblazer	TC02-220	D,S,N	617	**73.8**	44.2	0.56	1649	341	3939	5945
2001 Dodge Durango	V3642	S,S,S	**837**	58.8	27.9	**1.20**	**2834**	1211	1790	2022
2001 Ford Escape	V3646	S,S,S	289	49.1	14.7	0.94	2411	401	898	1914
2002 Jeep Liberty	TC02-221	M,S,S	245	47.5	29.1	0.60	1735	421	2471	3782
2002 Saturn Vue	TC02-224	S,S,N	130	45.4	32.3	0.51	1340	314	2343	631
Minivan										
2001 Dodge Grand Caravan	V3644	M,S,S	346	**63.0**	28.2	**1.71**	2172	779	2678	2060
2001 Ford Windstar	V3650	D,S,S	113	29.8	19.0	0.28	735	105	1795	450
Pickup Truck										
2001 Ford F150	V4171 TC01-224	S,S,S	239	47.7	37.1	0.48	1289	749	3317	2393

Note: Injury results exceeding the ICPL are in bold.
Key: Air bag inflators (S-single stage, D-dual stage, M-multi-stage), load limiter (S-standard, N-not equipped), and pretensioner (S-standard, N-not equipped).

Table IV-3 -Continued
56 km/h (35 mph) Rigid Barrier Belted Tests With 5th Percentile Female Dummy
Driver Injury Test Outcome

		HIC_{15}	Chest g's	Chest Deflection	Nij	Neck Tension	Neck Compression	Left Femur Compression	Right Femur Compression
Total Number of Data Points		18	18	18	18	18	18	18	18
Number Failed		2	2	0	4	1	0	0	0
Failure Rate (%) for Each Injury Criterion		11.1%	11.1%	0	22.2%	11.1%	0.0%	0.0%	0.0%

Total Vehicles Tested		18
Overall Number of Vehicles Failed		6
Overall Failure Rate		33.3%
Weighted Failure Rate		20.9%

Table IV-4
56 km/h (35 mph) Rigid Barrier Belted Tests With 5th Percentile Female Dummy Passenger Injury Test Outcome

Model Year Model	Test Number	Key	HIC_{15}	Chest g's	Chest Deflection	Nij	Neck Tension	Neck Compression	Left Femur Compression	Right Femur Compression
ICPL			700	60	52 mm	1	2620N	2520N	6805N	6805N
Mini Passenger Car										
1998 Geo Metro	TC98-003	S,S,S	112	46.2	18.3	0.62	893	1179	2815	3771
Light Passenger Car										
2001 Honda Civic	V3610	D,S,S	241	42.3	17.0	0.46	621	194	2270	4320
2001 Nissan Sentra	V3612	S,S,S	348	47.0	15.2	0.29	588	329	2994	2449
2001 Toyota Echo	V3647	S,S,S	359	54.6	21.4	0.85	1497	395	2502	5252
Medium Passenger Car										
2001 Chevy Impala	V3648	D,S,N	146	45.5	12.5	0.29	184	347	3118	3231
2001 Ford Taurus	V4150 TC01-225	D,S,S	104	32.5	25.2	0.33	724	268	3378	2787
2001 Honda Accord	V3611	D,S,S	311	45.1	12.6	0.62	800	480	3766	2903
2001 Nissan Maxima	V3643	D,S,S	318	44.6	17.2	0.82	1319	768	1713	2611
2002 Toyota Camry	TC02-218	D,S,S	281	50.1	34.3	0.31	832	368	1657	705
2003 Toyota Corolla	TC03-201	D,S,S	276	41.8	25.7	0.52	656	504	1760	1882

Note: Injury results exceeding the ICPL are in bold.
Key: Air bag inflators (S-single stage, D-dual stage, M-multi-stage), load limiter (S-standard, N-not equipped), and pretensioner (S-standard, N-not equipped)

Table IV-4 -Continued
56 km/h (35 mph) Rigid Barrier Belted Tests With 5th Percentile Female Dummy Passenger Injury Test Outcome

Model Year Model	Test Number	KEY	HIC_{15}	Chest g's	Chest Deflection	Nij	Neck Tension	Neck Compression	Left Femur Compression	Right Femur Compression
ICPL			700	60	52 mm	1	2620N	2520N	6805N	6805N
Sport Utility Vehicle										
2002 Chevy Trailblazer	TC02-220	D,S,N	**793**	67.4	36.7	0.76	1959	538	2497	2459
2001 Dodge Durango	V3642	S,S,S	325	44.0	20.3	**1.19**	2292	574	2659	3685
2001 Ford Escape	V3646	S,S,S	285	57.1	12.8	0.23	753	534	4108	2224
2002 Jeep Liberty	TC02-221	M,S,S	192	41.7	23.2	0.85	1524	171	3939	4779
2002 Saturn Vue	TC02-224	S,S,N	337	40.8	25.1	0.43	1398	296	2971	2926
Minivan										
2001 Dodge Grand Caravan	V3644	M,S,S	430	56.7	19.6	0.74	1452	170	3815	2417
2001 Ford Windstar	V3650	D,S,S	382	35.4	15.6	0.44	1016	173	2247	2044
Pickup Truck										
2001 Ford F150	V4171 TC01-224	S,S,S	465	48.5	45.1	0.81	1698	773	1471	3876

Note: Injury results exceeding the ICPL are in bold.
Key: Air bag inflators (S-single stage, D-dual stage, M-multi-stage), load limiter (S-standard, N-not equipped), and pretensioner (S-standard, N-not equipped).

Table IV-4 -Continued
56 km/h (35 mph) Rigid Barrier Belted Tests With 5th Percentile Female Dummy
Passenger Injury Test Outcome

		HIC_{15}	Chest g's	Chest Deflection	Nij	Neck Tension	Neck Compression	Left Femur Compression	Right Femur Compression
Total Number of Data Points		18	18	18	18	18	18	18	18
Number Failed		1	1	0	1	0	0	0	0
Failure Rate (%) for Each Injury Criterion		5.6%	5.6%	0	5.6%	0.0%	0.0%	0.0%	0.0%

Total Vehicles Tested		18
Overall Number of Vehicles Failed		2
Overall Failure Rate		11.1%
Weighted Failure Rate		5.8%

CHAPTER V. POTENTIAL BENEFITS

This chapter estimates the potential benefits of the proposed rule. The analysis utilizes the information introduced from previous chapters to derive the estimated benefits. The information includes the real world safety problem, laboratory crash test data, and injury probability curves. The real world safety problem was used to identify the safety population that would be impacted by the proposal. The laboratory test data and injury curves were used to estimate the magnitude of the fatality/injury reduction probabilities if the proposal was implemented. Multiplying the reduction rate to the target population derived the benefits. In addition, the chapter also provides a sensitivity study to examine the impact of increased safety belt use. The base (year 2001) observed belt use rate from state observational use surveys was 75 percent. Because the benefits of the proposal are expected to be small and do not a have wide variation, the sensitivity study only estimates the maximum benefits of the proposal, i.e, at the 100 percent belt use rate level.

The chapter is organized into five sections. The first section describes the benefit estimation methodology. The second section estimates the target population that would be impacted by the 56 km/h (35 mph) crash test speed with 5^{th} percentile dummies. The third section calculates the fatality and MAIS 2-5 non-fatal injury reduction rates. The fourth section estimates the potential benefits. Finally, the fifth section is a sensitivity study.

A. Overview of Methodology

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

Step 1: Identify target population. The target population is the actual fatalities and MAIS 2-5 injuries that would be affected by the proposal. The proposed 56 km/h (35 mph) frontal rigid barrier crash test with belted 5^{th} percentile female dummies is designed to improve the advanced air bag protection for small stature occupants. The advanced air bags, as required in the May 2000, FMVSS No. 208 Final Rule, have to pass the same rigid barrier crash test but at a lower speed - 48 km/h (30 mph). Considering that (a) the proposal only raises the belted test speed from 48 km/h (30 mph) to 56 km/h (35 mph), (b) air bags were proved to affect head, neck, and chest injuries, (c) the proposal requires head, chest, neck, and femur injury criterion performance limits, the target population would be the front-outboard belted small stature adult occupants with a fatal or a MAIS 2-5 head, neck, chest, or femur injury that occurred in a frontal crash with a delta v greater than 48 km/h (30 mph). The air bags have an overall effectiveness measured against all frontal crashes regardless of their delta v levels. Thus, the rule should impact all small stature female occupants in all frontal crashes. However, the baseline target population in this analysis did not include those injuries that occurred in crashes with delta v 48 km/h (30 mph) or less because the analysis assumes that all the benefits from that segment would be accrued by the 48 km/h (30 mph) test requirement in the advanced air bag rule.

Step 2: Estimate the fatality/injury probabilities. For each injury criterion, the corresponding injury probability curves were used to estimate the injury probabilities for each test failing the proposed ICPL. For example, if a dummy measurement of Nij is 1.5, the adult occupant would have an 11.7 percent chance of dying from a neck injury and a 31.9 percent chance of receiving a MAIS 2-5 neck injury. At the proposed ICPL (i.e., Nij=1), the probability of risk a fatal neck injury is 6.8 percent and a MAIS 2-5 neck injury is 23.0 percent.

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

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

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

For example, suppose a crash test failed at Nij=1.5. The fatality and MAIS 2-5 injury reduction rates for this vehicle mode type would be 41.9 [=(11.7-6.8)/11.7] and 27.8 [=(31.9-23.0)/31.9] percent, respectively.

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

$$r \quad = \sum w_i * r_i, \quad i\ 0\ \{1,2,3,...k\}$$

Where r = the total fatality/injury reduction rate

w_i = the proportion of the specific vehicle market share of all the vehicles tested.

r_i = the fatality/injury reduction rate from Step 3

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

Note that both chest g's and chest deflection predict chest injuries, thus only the maximum of these two reduction rates was used for chest injuries, i..e., r_{chest} = maximum of ($r_{chest\ g}$, $r_{chest\ deflection}$)

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

$$B = \sum TP_i * r_i, \quad i\ 0\ \{1, 2, 3\}$$

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

TP_i = head, neck, or chest target injuries

r_i = the corresponding reduction rate from Step 4.

B. Target Population

The target population, as defined in the methodology section, would be the front-outboard belted small stature adult occupants with a fatal or a MAIS 2-5 head, neck, chest, or femur injury that occurred in a frontal crash with a delta v greater than 48 km/h (30 mph) after the full implementation of the first-stage phase-in of FMVSS No. 208, the advanced air bags final rule. However, all the tests demonstrated that the driver and passenger dummies passed the femur ICPL. Therefore, femur injuries were excluded from the actual target population. Table V-1 lists the target population for benefit estimates. The target population is the product of three components: belted population listed in Table II-6, the 31+ mph proportion listed in Table II-7, and the proportion of head, neck, and chest injuries listed in Table II-9.

Annually, after full implementation of the first-stage of the May 2000, advanced air bag final rule, it is estimated that 277 - 280 belted small stature occupant fatalities and 957 - 963 MAIS 2-5 head, neck, and chest injuries will occur in frontal crashes with delta v greater than 48 km/h (30 mph).

Table V-1 Belted Small Stature Front-Outboard Adult Passenger Occupants With a MAIS 2+ Head, Neck, or Chest Injury In Frontal Crashes With Delta V > 48 km/h (30 mph) Full Fleet of Advanced Air Bags

	Fatalities			MAIS 2-5 Injuries		
	Driver	Passengers	All	Drivers	Passengers	All
Head	107	40-41	147-148	402	176-179	578-581
Neck	19	7	26	14	5-6	19-20
Chest	76	28-30	104-106	250	110-112	360-362
Total	202	75-78	277-280	666	291-297	957-963

Source: 2001 Fatality Analysis Reporting System; 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)

C. Fatality and Injury Reduction Rates

The injury probability curves in Chapter III and the 18 tests introduced in Chapter IV were used to derive these reduction rates. For each injury criterion, the reduction rates were first calculated for each vehicle that failed that specific criterion using the formula listed in Step 3 of the methodology section. Afterwards, the weighted reduction rates were calculated using the formula listed in Step 4 of the methodology section. There are two HIC injury probability curves: Prasad and Lognormal. Therefore, there are two sets of reduction rates for head injuries. Table V-2 represents the total fatality and MAIS 2-5 non-fatal injury reduction rates by injury criteria

Table V-2
Fatality and MAIS Injury Reduction Rates for
Small Stature Adult Front-Outboard Occupants
By Injury Criteria

	HIC_{15} Prasad/Mertz (Lognormal)	Nij	Chest g's	Chest Deflection
Fatalities				
Drivers	2.3% (1.4%)	3.8%	2.8%	0.0%
Passengers	1.5% (0.9%)	0.6%	1.0%	0.0%
MAIS 2-5 Injuries				
Drivers	0.2% (0.4%)	2.9%	0.2%	0.0%
Passengers	0.1% (0.0%)*	0.5%	0.1%	0.0%

Note: unless specified, 0.0% means that all the tests have met the ICPLs
* Less than 0.05 percent

As shown in Table V-2, the highest reduction rates were from reducing neck injury values. However, neck injury carries the least weight in the calculation because of the small target population. Also note that both chest g's and chest deflection predict the chest injury, thus, only the maximum of these two reduction rates was used for estimating the chest benefits.

D. Benefits

The potential benefits are estimated by applying the reduction rates for HIC, Nij, and chest as shown in Table V-2 to the corresponding target population in Table V-1. Table

V-3 shows the estimated benefits. The proposal would save 5 - 6 small stature occupants' lives and reduce 2 - 3 MAIS 2-5 injuries.

Table V-3
Estimated Fatality and MAIS 2-5 Injury Benefits
From 56 km/h (35 mph) Rigid Barrier Belted Tests with
5th Percentile Female Dummies

	Fatalities			MAIS 2-5 Injuries		
	Driver	Passengers	All	Drivers	Passengers	All
Head*	1 - 2	1	2 – 3	1 – 2	0	1 – 2
Neck	1	0	1	0	0	0
Chest	2	0	2	1	0	1
Total	4 – 5	1	5 – 6	2 - 3	0	2 - 3

* Used both Prasad/Mertz and lognormal HIC probability risk curves.

E. Sensitivity Study

This section estimates the change in benefits that could result from increased safety belt use. In 2001, the average national belt usage rate was 75 percent based on the state observational belt use surveys. With this belt use rate, the proposal would save 5 – 6 lives. Due to the small benefits, this sensitivity study only estimates the maximum benefits of the proposal, i.e., benefits at 100 percent belt usage rate.

Safety belts are 47 percent effective against fatalities and 53 percent against MAIS 2-5 injuries. These were derived weighted effectiveness rates. The weights were the relative proportion of small stature occupants in passenger cars and light trucks that were derived from 1993-2001 CDS. At the 100 percent belt usage level, with the above effectiveness rates, 47 percent of the unbelted fatalities and 53 percent of the unbelted MAIS 2-5 non-fatal injuries reported in Table II-6 would be prevented by the safety belts. Of the remaining previously unbelted injuries, only the head, neck, and chest injuries that occurred at crashes with delta v greater 48 km/h (30 mph) would be added into the target population. The added proportion in percent for head, neck and chest is:

$$P_a = 100 * P_{delta\ v} * P_{body} * (1 - e)$$

Where P_a = added proportion,

$P_{delta\ v}$ = proportion of occupants in crashes with delta v > 48 km/h (30 mph),

P_{body} = proportion of head, neck, or chest injuries, and

e = corresponding effectiveness rate.

Due to a small sample, the analysis does not calculate these proportions separately for drivers and front-outboard occupants. Instead, these proportions were used for both drivers and front-outboard occupants.

The number of head, neck, and chest injuries that would be added into the target population in Table V-1 for the sensitivity study is:

$$Ap = TP * P_a$$

Where Ap = added population for head, neck, or chest, and

P_a = added proportion for head, neck, or chest

TP = unbelted population from Table II-6

The added population was derived separately for drivers and front-outboard occupants. Based on Table II-7, about 42 percent of these fatalities occurred at crashes with delta v greater than 48 km/h (30 mph). Furthermore, of these fatalities, 44.9 percent were head, 7.9 percent were neck, and 32 percent were chest fatal injuries (Table II-9). Thus,

the P_a for head fatalities = 100 * 0.42 * 0.449 * (1 – 0.47) = 10.0 percent,

the P_a for neck fatalities = 100 * 0.42 * 0.079 * (1 – 0.47) = 1.8 percent, and

the P_a for chest fatalities = 100 * 0.42 * 0.320 * (1 – 0.47) = 7.1 percent.

Similarly,

the P_a for MAIS 2-5 head injuries = 100 * 0.05 * 0.387 * (1 - 0.53) = 9.5 percent.

the P_a for MAIS 2-5 neck injuries = 100 * 0.05 * 0.013 * (1 - 0.53) = 3.2 percent.

the P_a for MAIS 2-5 chest injuries = 100 * 0.05 * 0.241 * (1 - 0.53) = 5.9 percent.

Applying these P_as to the unbelted population in Table II-6 derives the added head, neck, and chest injuries. An additional 183 fatalities and 175 MAIS 2-5 injuries would be added to the target population reported in Table V-1 as the basis for calculating the maximum benefits of the proposal. Table V-4 lists the revised target population.

Applying the reduction rates in Table V-2 to the new target population in Table V-4 derived the maximum benefits. Table V-5 shows the maximum benefits by injury severity, body regions, and person type. The proposal would save a maximum of 7 – 10 lives and eliminate 2 – 3 MAIS 2-5 head, chest, and neck injuries. Note the estimated

MAIS 2-5 benefits didn't increase with the rising safety belt use rate from 70 to 100 percent. This is due to the small reduction rates and the added population was not big enough to derive any additional benefits.

Table V-4 Belted Small Stature Front-Outboard Adult Passenger Occupants With a MAIS 2+ Head, Neck, or Chest Injury In Frontal Crashes With Delta V > 48 km/h (30 mph) Full Fleet of Advanced Air Bags and at 100 Percentage Belt Use

	Fatalities			MAIS 2-5 Injuries		
	Driver	Passengers	All	Drivers	Passengers	All
Head	178	66-67	244-245	474	209-212	683-686
Neck	31	12	43	16	7-8	23-24
Chest	126	47-49	173-175	295	131-133	426-428
Total	335	125-128	460-463	785	347-353	1132-1138

Source: 2001 Fatality Analysis Reporting System; 2001 General Estimated System (GES); 1993-2001 Crashworthiness Data System (CDS)

Table V-5
Estimated Maximum Fatality and MAIS 2-5 Injury Benefits From 56 km/h (35 mph) Rigid Barrier Belted Tests with 5th Percentile Female Dummies

	Fatalities			MAIS 2-5 Injuries		
	Driver	Passengers	All	Drivers	Passengers	All
Head*	2 – 4	1	3 - 5	1 - 2	0	1 - 2
Neck	1	0	1	0	0	0
Chest	3	0 - 1	3 - 4	1	0	1
Total	6 - 8	1 - 2	7 - 10	2 - 3	0	2 - 3

* Used both Prasad/Mertz and lognormal HIC probability risk curves.

CHAPTER VI. COST

The potential costs of this proposal include the compliance cost and technology costs. The compliance cost is the cost to conduct the required tests. The technology cost is the cost of technology countermeasures for vehicles that would fail the proposal.

A. Compliance Cost

The compliance cost is the cost of additional tests required by the proposal. The proposed amendment would not require an additional vehicle test to be conducted by the manufacturer. The manufacturers would replace the maximum 48 km/h (30 mph) rigid barrier belted test with 5^{th} percentile dummies as required in the May 12, 2000 Final Rule with the proposed 56 km/h (35 mph) test. Thus, there would be no additional compliance test costs.

B. Technology Cost

The technology costs would be the cost of technology countermeasures that will be implemented to comply with the proposal. All the vehicles will have to comply with the belted 48 km/h (30 mph) rigid barrier test with 5^{th} percentile dummies by September 1, 2006. Only the costs of the technology improvements needed to meet the higher 56 km/h (35 mph) test level would be associated with this current rule. The analysis used the projected new light vehicle sales in 2005 as the baseline production vehicles and the current pass/fail rate to predict the number of vehicles that would need improvements to comply with the proposal. In 2005, about 15.9 million (M) new light vehicles would be in the U.S market[1]. As shown in Table IV-4, 20.9 percent of the production vehicles would fail the proposal. Applying the 20.9 percent to the 15.9 million, about 3.32 million vehicles would have to change either driver side or passenger side performance to comply with the proposal. All 3.32 million vehicles would need to improve the driver side performance. About 5.8 percent of the vehicles, i.e., 0.92 million (= 15.9 M * 0.058) would have to improve the passenger side performance. These 0.92 million vehicles were included in those 3.32 million vehicles that failed the driver side.

The technology unit costs were based on the agency's two tear down studies. One is on a BMW 528i (Docket No, 98-4405, No 4). The other one is on a BMW Z3[2] (Docket No, 98-4405, No 5). The estimated price reported in these two tear down studies were in 1998 dollars. Increases due to inflation from 1998 to 2002 have been offset to a degree by improvement in production efficiency and by rising economics of scale. The agency believes the 1998 estimates are still a good approximation of what consumers will pay in the market place today. The estimates might be still conservative because of our conservative assumption, i.e., no offshore sourcing of parts and raw materials (see the two BMW tear down studies). Thus, this analysis did not adjust the 1998 dollars and used it as the 2002 dollar values.

[1] Table 6, U.S. Economy, the 25-Year Focus, Winter Issue, Winter 2002
[2] Cost, Weight, and Lead Time Analysis, Advanced Air Bag Systems, Ludtke & Associates

Many of the technology countermeasures that would be used to comply with the proposal are being or will be implemented to meet the belted crash test requirement up to 48 km/h (30 mph). As shown in the crash test data in Chapter IV, many of the vehicles that currently comply with the proposal already had dual- or multi-stage air bags. The majority of them had pretensioners and load limiters. The agency believes that improvement beyond the 48 km/h (30 mph) requirement could involve simple changes in air bag inflation characteristics and seat and safety belt design. These are:

(1) Manufacturers could change fold pattern, vents, or the air bag algorithm to alter the air bag inflation characteristics. The change would effectively modify the timing between primary and secondary stages of deployment. The agency does not have an estimated cost for these changes but they could be a no cost item. On the other hand, manufacturers could make changes that would increase costs.

(2) Changes could be made to the electronic control module. One estimated cost involving the electronic control module the agency has is the cost of going from a single state to dual stage air bags. The BMW 528i was equipped with dual stage air bags while the Z3 had only single stage. The cost of the control module for 528i and Z3 was $158.46 and $155.34. The incremental cost of $3.12 per vehicle would be the improvement cost. These are consumer cost levels.

(3) Manufacturers could use seat track sensors to provide driver seating position data to the air bag control module, which could modulate air bag inflation power accordingly. The agency did not conduct a teardown to estimate the cost of a seat

track sensor. The cost of a sensor is assumed to be $5 per seat. These sensors seem to be only useful for the driver position.

(4) Manufacturers could choose to optimize the restraint systems by (a) adding pretensioners to provide restraining forces on occupants and reduce their forward excursion into the steering wheel or deploying air bag or (b) adding load limiters that would limit the loads on the occupants. The cost of pretensioners was derived from the two tear down studies. The BMW 528i was equipped with pretensions while the Z3 was not. The belt pretensioner cost is about $16.50 (consumer cost) per seat. The agency does not have the costs of the load limiters. The unit cost would be less than that of pretensioners but more than the cost of modifying air bag characteristics.

C. Total Net Cost

The total net cost would depend on the implementation strategies chosen by the manufacturers. Four alternatives are discussed:

(1) Manufacturers could comply with the proposal by simply changing the air bag characteristics as described in (1) in the previous section. There is no extra cost associated with this alternative.

(2) Manufacturers could comply with the proposal by changing electronic control module. The analysis assumes that

a. $3.12 per vehicle and

b. any driver or passenger side air bag that currently failed would need improvement.

About 3.32 million driver side would need to be improved to comply with the proposal. Of these, 0.92 million passenger side air bags also need to be improved. With $3.12 per vehicle, the total net cost would be $10.36 million (= $3.12 M * 3.32).

(3) Manufacturers could comply with the proposal by using seat track sensors and modifying the air bag control module. The analysis assumes that

a. the seat track sensor is $5 per sensor,

b. the cost of modifying air bag inflation module is $3.12 per vehicle,

c. for vehicles that currently fail to comply but have seat track sensors, manufacturers will have to alter the air bag electronic control module.

d. for vehicles that currently fail to comply on the driver side and do not have a seat track sensor, manufacturers will install a driver side seat track sensor and change the air bag electronic control module.

As shown in Chapter IV, 39.7 percent of the vehicles that currently fail are equipped with a driver seat track sensor and 60.3 percent are not. This means:

- 1.32 million vehicles (= 3.32 M * 0.397) need to change the driver air bag inflation characteristics in order to comply with the proposal. Based on the analysis of crash test data (Chapter IV), none of these vehicles failed the passenger side performance. Thus, no improvements were needed for the passenger side air bags. The cost for these vehicles would be $4.12 million (= $3.12 * 1.32 M).

- 2.00 million vehicles (= 3.32 M * 0.603) might need to install a driver side seat track sensor and change the air bag characteristics in order to comply with the proposal. The cost of a sensor and modifying the air bag characteristics would be $8.12 (= $5.00 + $3.12) per vehicle. The total net cost for these vehicles would be $16.24 million (= $8.12 * 2.00 M) for the driver side improvement.

In total, the cost for this alternative would be $20.36 million (= $4.12 M + $16.24 M).

(4) Manufacturers could comply with the proposal by using pretensioners. The analysis assumes:

  a. the pretensioner is $16.50 per seat,
  b. $3.12 per vehicle for changing the air bag electronic control module,
  c. for vehicles that currently fail to comply but have pretensioners, manufacturers would have to change the air bag electronic control module.
  d. for vehicles that currently fail to comply and do not have pretensioners, manufacturers will install the pretensioners for both driver and passenger sides and change the air bag electronic control module.

As shown in Chapter VI, 87.1 percent of those vehicles that failed were equipped with pretensioners and 12.9 percent were not. This means:

- 2.89 million vehicles (= 0.871 * 3.32 M) would need the improved the air bag characteristics to comply with the proposal. With the incremental cost of $3.12 per vehicle, the cost for these vehicles would be $9.02 million (= $3.12 * 2.89 M).

- 0.43 million vehicles (= 0.129 * 3.32 M) might be required to install new pretensioners for both drivers and front-outboard passengers. With $16.50 per seat, the estimated total cost of installing pretensioners would be $14.20 million (= $16.50 * 2 * 0.43 M). In addition, these vehicles need to improve their air bag electronic control modules. With $3.12 per vehicle, the total cost of air bag electronic module improvement is estimated to be $1.34 million (= $3.12 * 0.43 M). The total costs for these vehicles would be $15.54 million (=$14.20 M + $1.34 M).

The estimated total cost for this alternative is $24.56 million (=$9.02 M + $15.54 M)

In summary, the overall cost of the proposal would range from $0.00 to $24.56 million depending on the implementation of the technologies. Table VI-1 summarizes the costs. Manufacturers might use other implementations such as load limiters. However, the agency believes that most technology countermeasures for the proposal will be used to comply with the May 2000, Advanced Air Bag Rule. Thus, a huge portion of the cost would be absorbed by the cost of advanced air bags, and the agency believes the total net cost of the proposal would be in the lower end of the range, represented by changes in the air bag algorithms and control modules. Also note that the pass/fail rate calculations were based on the current production vehicles (2001/2002/2003 model year). However, vehicles certified to the 48 km/h (30 mph) belted rigid barrier crash test requirement with the 5th percentile adult females might perform better than the production vehicles. Thus, this estimate produces a potentially overestimated result and is a conservative assessment in examining the merit of this regulation.

Table VI-1 Summary of Total Net Cost*

Alternative and Description		Unit Cost	Unit Affected	Total Cost
1	Change Air Bag Characteristic (e.g., folding pattern)	$0.0/air bag		$ 0.00 M
2	Change Air Bag Characteristic and Electronic Control Module	$3.12/vehicle	3.32 M	$ 10.36 M
3	Seat Track Sensors + Change Air Bag Characteristic	$5.00/sensor + $3.12/vehicle		
	a. Current failed were equipped with the sensors (39.7%)	$3.12/vehicle	1.32 M	$ 4.12 M
	b. Currently failed were not equipped with sensors (60.3%)	$5.00/sensor + $3.12/vehcile	2.00 M	$ 16.24 M
	Combined (a + b)			$ 20.36 M
4	Pretensioners + Change Air Bag Characteristic	$16.50/pretensioner + $3.12/vehicle		
	a. Current failed with Pretensioners (87.1%)	$3.12/vehicle	2.89 M	$ 9.02 M
	b. Currently failed without Pretensioners (12.9%)	$16.50/pretension + $3.12/vehicle	0.43 M	$ 15.54 M
	Combined (a + b)			$ 24.56 M

* same as the total technology cost. M: million

CHAPTER VII. LEADTIME

The agency proposed different leadtime and effective dates for large vehicle manufacturers, limited line, small multi-stage manufacturers and alterers. The proposed leadtime follows the second stage phase-in requirements for the 56 km/h (35 mph) rigid barrier tests with 50th percentile male dummies stated in the May 2000, Final Rule.

A. Large Manufacturers

The agency proposes that the large manufacturers implement the belted rigid barrier test at 56 km/h (35 mph) using the 5th percentile adult female dummies according to the same phase-in schedule for the 50th percentile dummies. Table VII-1 lists the phase-in schedule.

Table VII-1 Phase-in Schedule for Vehicle Manufacturers

Model Year	Production Beginning Date	Requirement
2008	September 1, 2007	35% with carryover credit
2009	September 1, 2008	65% with carryover credit
2010	September 1, 2009	100% with carryover credit
2011	September 1, 2010	Fully effective

As shown in Table VII-1, the proposed phase-in is:

- 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;

- 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; and,

- All light vehicles manufactured on or after September 1, 2010.

B. Limited Line Manufacturers

The agency permits manufacturers that sell two or fewer carlines in the United States the option of omitting the first year phase-in (September 1, 2007) if they achieve full compliance by September 1, 2008, the beginning of the second year of the phase-in. This option allows limited line manufacturers flexibility.

C. Small Volume Manufacturers

Small volume manufacturers have the option of waiting until the end of the phase-in (September 1, 2010) to comply with the new requirements. Small volume manufacturers are manufacturers that produce fewer than 5,000 vehicles for the *U.S. market* per year.

The agency recognizes the technical challenges that small vehicle manufacturers would face, but the agency does not believe that additional time would be needed to accommodate the belted 5th percentile adult female requirements beyond what is required for the 50th percentile dummies.

D. Multi-Stage Manufacturers and Alterers

The agency permits multi-stage manufacturers and alterers to defer compliance until the end of the phase-in period required for large manufacturers, i.e., September 1, 2010. This approach would increase the likelihood that multi-stage manufacturers and alterers would know what type of advanced air bag technology vehicle manufacturers would be using to comply with the proposal. This also provides multi-stage manufacturers and alterers sufficient time to address any associated technical issues.

CHAPTER VIII COST-EFFECTIVENESS ANALYSIS

This chapter measures the cost per fatality, or fatality-equivalent saved. To calculate a cost per equivalent fatalities, nonfatal injuries must be expressed in terms of fatalities. This is done by comparing the values of preventing nonfatal injuries to the value of preventing a fatality. Comprehensive values, which include both economic impacts and lost of 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]. Table VIII-1 shows the comprehensive costs for each MAIS injury level. The adjusted comprehensive costs were the costs that excluded property damage and travel delay costs. These adjusted costs were used to calculate the relative value of nonfatal injury to a fatality. The figures under "MAIS 2-5 Distribution" were used as weights to calculate the weighted MAIS 2-5 injury relative to a fatality. The table shows that an average MAIS 2-5 injury is the equivalent of 0.0794 fatalities.

Table VIII-1
Calculation of Cost Per Equivalent Fatality and Weighted Fatal Equivalent

Injury Severity	Comp. Cost	Property Damage	Travel Delay	Adjusted Comp. Cost	Relative	2000 PR Incidence	MAIS 2-5 Distribution	Weighted Relative
MAIS 1	15017	3848	777	10392	0.0031			
MAIS 2	157958	3954	846	153158	0.0458	366987	69.19%	0.0317
MAIS 3	314204	6799	940	306465	0.0916	117694	22.19%	0.0203
MAIS 4	731580	9833	999	720748	0.2153	36264	6.84%	0.0147
MAIS 5	2402997	9446	9148	2384403	0.7124	9463	1.78%	0.0127
Fatality	3366388	10273	9148	3346967	1.0000	41821		
Total							100.00%	0.0794

Soruce : Table VIII-9 of The Economic Impact of Motor Vehicle Crashes 2000.

[1] Blincoe, L.J, The Economic Impact of Motor Vehicle Crashes 2000, Washington, DC, DOT HS 809 446, May 2002.

Table VIII-2 lists the safety benefits and corresponding fatal equivalents at the 7 percent discount rate to express their present value. Seven percent is required for Regulatory Evaluations by the Office of Management and Budget (OMB Circular A-94, 10/29/92). The present value (7 percent discounted) is equivalent to a 0.7215 of the initial estimates. The table shows that the proposal could save 4 equivalent fatalities after discounting. From Chapter VI, the estimated cost of the proposal would range from $0.00 million to $24.56 million. The net cost per equivalent fatality would range from $0.00 million (= $0.00 M/4) to $6.14 million (= $24.56 M/4).

Table VIII-2
Initial and Present Discounted (7 Percent Rate) Benefits and Fatal Equivalents

	Benefits*	Fatal Equivalents	Discounted Benefits	Discounted Fatal Equivalents
MAIS 2-5 Injuries	2 - 3	0	1 – 2	0
Fatality	5 – 6	5 – 6	4	4
Total		5 - 6		4

* From Table V-3 of Chapter V.

CHAPTER VII REGULATORY FLEXIBILITY ACT AND UNFUNDED MANDATES REFORM ACT ANALYSIS

A. Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980 (5 U.S.C. §601 et seg.) requires agencies to evaluate the potential effects of their 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. Each RFA must contain:

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

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

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

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

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

(6) Each final regulatory flexibility analysis shall also contain a description of any significant alternatives to the final rule which accomplish the stated objectives of applicable stature 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 considers this action to set the same belt test stringency as that required for the 50th percentile males. The action would improve advanced air bag protection for belted small stature adult occupants in frontal impacts.

The May 12, 2000, FMVSS 208 final rule requires up to 48 km/h (30 mph) high speed belted tests with 5th percentile dummies and up to 56 km/h (35 mph) belted test with 50th percentile male dummies. At the time, the agency did not have sufficient test data to prove the applicability and feasibility of the 56 km/h (35 mph) belted test with 5th percentile female dummies. Currently, the agency has a total of 18 full vehicle test results. Based on these test results, the agency believes that an improvement of the advanced air bag protection for belted small stature adult occupants is feasible.

2. Objectives of, and legal basis for, the final rule

NHTSA is proposing this NPRM under the NHTSA Reauthorization Act of 1998 and 49 U.S.C. 322, 30111, 30115, 30117, and 30666; 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 proposed rule would affect motor vehicle manufacturers, alterers, air bag manufacturers, and manufacturers of seating systems.

Business entities are defined as small businesses using the North American Industry Classification System (NAICS) code, for the purposes of receiving Small Business Administration assistance. One of the criteria for determining size, as stated in 13 CRF 121.201, is the number of employees in the firm. Affected business categories include: a) To qualify as a small business in the Automotive Manufacturing (NAICS 33611), the firm must have fewer than 1000 employees, b) In the Light Truck and Utility Vehicle Manufacturing (NAICS 336112), the firm must have fewer than 1000 employees, c) In the Motor Vehicle Body Manufacturing, the firm must have fewer than 1000 employees, d) In the Motor Vehicle Seating and Interior Trim Manufacturing (NAICS 336360), the firm must have fewer than 500 employees, and e) In the All Other Motor Vehicle Parts Manufacturing (NAICS 336399), the firm must have fewer than 750 employees. The agency does not believe that this final rule will have any significant impact on these businesses because a huge portion of the cost will be absorbed by the advanced air bag final rule.

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

The proposed rule requires a 0-56 km/h (35 mph) rigid barrier test with 5^{th} percentile female dummies. The 56 km/h (35 mph) maximum speed is higher than the 48 km/h (30 mph) maximum test speed required in the May 2000, FMVSS No. 208, Advanced Air Bags Final Rule. Manufacturers would have to certify their products comply with the proposed rule, but there are no new reporting or record keeping requirements.

5. Duplication with other Federal rules

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

6. Description of any significant alternatives to the final rule

NHTSA proposes the same leadtime as required for the belted 56 km/h (35 mph) tests with the 50^{th} percentile adult male dummies. The agency believes manufacturers have anticipated the proposal, based on the preamble published with the May 12, 2000, FMVSS No. 208 Final Rule. The leadtime would be adequate. Thus, there are no significant alternatives.

B. Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditures by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for the year 2002 results in $111 million (109.35/98.1 = 1.11). The assessment may be included in conjunction with other assessments, as it is here.

This proposal is not estimated to result in expenditures by State, local or tribal governments of more than $111 million annually. It is not going to result in the expenditure by the automobile manufacturers and/or their suppliers of more than $111 million annually. The estimated annual cost would range from $0.00 to $24.56 million.

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