NHTSA

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National Highway Traffic Safety Administration

HIGH SPEED UNBELTED TEST REQUIREMENT OF FMVSS NO. 208

ANALYSIS OF ISSUES RAISED BY PUBLIC COMMENTS

Prepared by the

Office of Research and Development
National Highway Traffic Safety Administration

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1.0 Performance of vehicles in 48 kmph (30 mph) barrier tests for both 50th percentile adult male dummies and 5th percentile adult female dummies

1.1 Discussion of Public Comments

Some vehicle manufacturers stated concerns about the practicability of meeting the 48 kmph (30 mph) rigid barrier tests with the 5th female and 50th male dummies. The Alliance of Automobile Manufacturers (AAM) stated "...very little testing has been done with these same vehicles at 30 mph with 5th percentile female unbelted dummies. The little testing that has been done has produced a 50 percent failure rate. This testing illustrates the design tensions that the industry has been emphasizing."[2, p. 9] Ford stated "Both Ford and the agency have tested the 5%ile and 50%ile unbelted dummies at 30 mph in a 2000MY Taurus equipped with Ford's state-of-the-art restraint technologies and demonstrated the difficulty of balancing requirements with a 30 mph test." [3, p.3] Honda stated "The consideration of rigid barrier tests for the 5th percentile female dummy should be separated and conducted later, along with the issuance of the final 5th percentile dummy specifications and a revised seating procedure for that dummy." [4, p. 3] The AAM also stated "Air bag force and depth parameters are constrained when balancing designs for both 5th female and 50th male size occupants. The greater air bag depth that is required for higher speed unbelted 50th male testing conflicts with the forward sitting 5th female condition and causes undesirable interaction between the occupant and deploying air bag. The higher air bag force that results from a 30 mph rigid barrier unbelted test speed may produce restraints that exceed injury parameters such as chest acceleration for the 50th if air bag depth is reduced for the 5th female. A 25 mph unbelted test speed rather than 30 mph would allow both restraint force and air bag depth to be set at appropriate balanced levels for 5th female and 50th male size occupants." [2, Annex 1, p. 4] General Motors (GM) provided similar illustrations in their docket comments [5, Attachment 1]. GM stated there is a need to balance the following trade-offs: "5th Female Has Lower Inflation Induced Neck Loading with Shallower Air Bag" and "Unbelted 50th Male Has Lower Chest Acceleration & Femur Force with Deeper Air Bag".

Consumers Union stated "In NHTSA's own tests, two of four vehicles tested, the MY 1999 Saturn SL1 and the MY 1998 Ford Taurus, passed all the injury criteria performance limits for the driver and passenger using both unbelted 5th percentile female and unbelted 50th percentile male dummies in the rigid barrier crash tests at 30-mph. If these vehicles can pass these tests even <u>before</u> they have been reconditioned under a revised Standard 208, we believe other vehicles can be engineered to do so, as well." [6, p. 6] Public Citizen similarly pointed out the performance of the MY 1999 Saturn SL1 and the MY 1998 Ford Taurus in the 48 kmph (30 mph) unbelted 50th male and 5th female rigid barrier crash tests in their comments [7, p. 6] Public Citizen further stated "Although certain redesigned vehicles failed to pass the injury criteria levels in 30 mph unbelted barrier tests for both the 50th percentile male and 5th percentile female, it is important to remember, as NHTSA stated in the SNPRM, that these vehicles were not designed to comply with these particular tests. Rather, the manufacturers of these vehicles only had to comply with the very modest demands of the interim sled test." [7, p. 7]

1.2 Review of Data

48 kmph (30 mph) unbelted 50th male rigid barrier crash tests: NHTSA conducted fourteen 48 kmph (30 mph) unbelted 50th male rigid barrier crash tests on a wide range of production MY 1998/1999 vehicle types and sizes. In particular, the 14 production vehicles included: one sub-compact car, one compact car, four mid-size cars (representing high sales volume vehicles), one full-size car, three mid-size sport utility vehicles, one full-size sport utility vehicle, one pickup truck, one minivan, and one full-size van. The individual vehicle makes and models and their respective crash test results are listed in Appendix A, Tables A-1 and A-2. On the driver side 12 out of 14 vehicles were able to able to meet all the dummy injury criteria and 13 out of 14 were able to meet all the criteria on the passenger side.

Additionally Ford Motor Company provided NHTSA with two pre-production prototype MY 2000 Taurus/Sable vehicles. NHTSA used one pre-production prototype MY 2000 Ford Taurus vehicle in a 48 kmph (30 mph) unbelted 50th male rigid barrier crash test. The crash test results are listed in Appendix A, Tables A-1 and A-2. On the driver side, the dummy failed the chest G criteria with a value of 61.8 G (IARV = 60 G) and the right femur load with a value of 10491 N (IARV = 10008 N). On the passenger side, the dummy passed all the injury criteria (most with a 20% compliance margin).

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

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40 kmph (25 mph) unbelted 50th male rigid barrier crash tests: NHTSA also conducted three 40 kmph (25 mph) unbelted 50th male rigid barrier crash tests with a subset of vehicles from those tested at

48 kmph (30 mph). The individual vehicle makes and models and their respective crash test results are listed in Appendix A, Tables A-3 and A-4. On the driver side 3 out of 3 vehicles were able to able to meet all the dummy injury criteria with a 20% margin of compliance and 2 out of 3 were able to meet all the criteria on the passenger side (one with a 20% margin of compliance). However, the third vehicle, the MY 1999 Toyota Tacoma, resulted in a passenger Nij of 1.01. [A discussion of this failure is included in Section 1.4.1].

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

48 kmph (30 mph) unbelted 5th female rigid barrier crash tests: NHTSA also conducted seven 48 kmph (30 mph) unbelted 5th female rigid barrier crash tests on a subset of the production vehicles tested with 50th males. The individual vehicle makes and models and their respective crash test results are listed in Appendix A, Tables A-5 and A-6. On the driver side 5 out of 7 vehicles were able to meet all the 5th female dummy injury criteria and 4 out of 7 were able to meet all the criteria on the passenger side. Of the 7 vehicles tested, 3 met all of the criteria at both seating positions.

Additionally, NHTSA used the second pre-production prototype MY 2000 Taurus/Sable vehicle provided by Ford Motor Company in a 48 kmph (30 mph) unbelted 5th female rigid barrier crash test. The crash test results are listed in Appendix A, Tables A-5 and A-6. On the driver side, the dummy failed the chest deflection criteria with a value of 54.4 mm (IARV = 52 mm); however the rest of the criteria were met with a 20% margin. On the passenger side, the dummy failed the chest G criteria with a value of 68.6 Gs (IARV = 60 Gs); however the rest of the criteria were met with a 20% compliance margin. NHTSA noted that the seating position for the 5th female in this vehicle positioned the driver dummy extremely close to the air bag module (compared with the other vehicles tested). Additional tests were conducted by NHTSA to evaluate the effects of seating position on the 5th female driver. The results are discussed in Section 1.3.1).

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

40 kmph (25 mph) unbelted 5th female rigid barrier crash tests: NHTSA also conducted two 40 kmph (25 mph) unbelted 5th female rigid barrier crash tests. The individual vehicle makes and models and their respective crash test results are listed in Appendix A, Tables A-7 and A-8. On the driver side both vehicles were able to meet all the 5th female dummy injury criteria (most all with a 20% compliance margin) and one of the two vehicles was able to meet all the criteria on the passenger side with a 20% compliance margin. The other vehicle, the MY 1999 Toyota Tacoma, again failed the passenger Nij criteria with a value of 1.82. [Further discussion of this failure is provided in Section 1.4.1].

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

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Driver low risk deployment data: NHTSA conducted driver side low risk deployment tests on eleven MY 1998-1999 production vehicles. The individual vehicle makes and models and their respective test results are listed in Appendix A, Tables A-9 and A-10. Four of the 11 vehicles (MY 1999 Saturn SL1, MY 1999 Dodge Intrepid, MY 1999 Ford Expedition, MY 1999 Ford Econoline van) passed all the driver low risk deployment requirements. [Note, these passing vehicles were 4 of the 6 MY 1999 vehicles tested. However, 2 out of 4 passing vehicles had marginal passing Nij values of 0.98 and 0.99 in Position 1.]

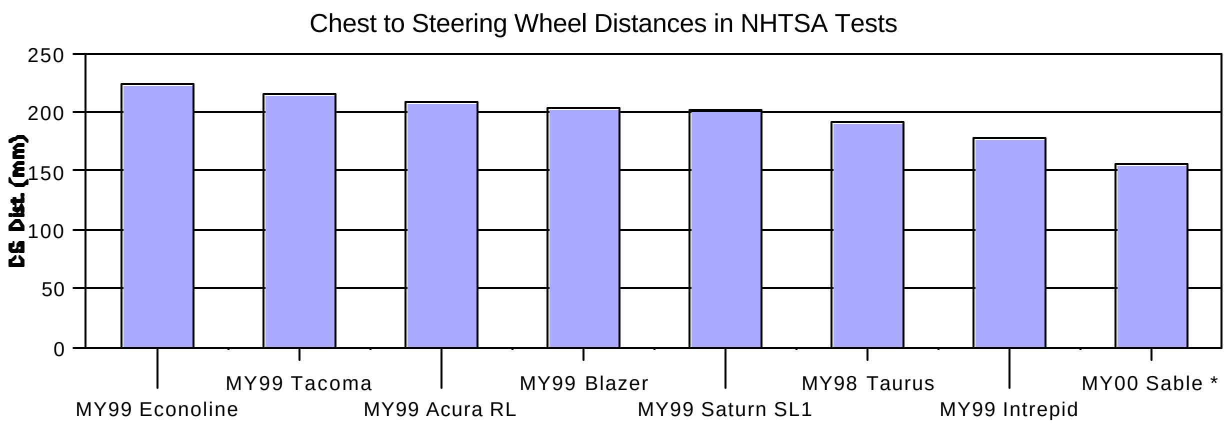
Passing 5th female/50th male combinations: Honda stated in their comments "For many vehicles, even with advanced air bag technology, it may not be possible to meet the unbelted, 30-mph rigid barrier test for the 50th percentile male dummy and comply with all of the out-of-position tests also proposed." [4, p.2] However, 4 out of 4 MY 1999 vehicles that passed the driver side low risk deployment tests proposed (vehicles listed in previous paragraph) also passed the 48 kmph (30 mph) unbelted requirement with the 50th male. Three of these 4 vehicles were also tested in the 48 kmph (30 mph) unbelted crash test with 5th female dummies. Two of the 3 vehicles, the MY 1999 Saturn SL1 and the MY 1999 Ford Econoline, were able to meet all the injury criteria requirements in both the 5th female and 50th male 48 kmph (30 mph) unbelted rigid barrier tests and the driver low risk deployment tests. The MY 1999 Saturn SL1 accomplished this with a 20% margin of compliance. The third vehicle, the MY 1999 Dodge Intrepid, had injury criteria failures on the driver and passenger side in the 48 kmph (30 mph) unbelted 5th female rigid barrier crash test.

Other results demonstrated that the MY 1998 Ford Taurus passed all the 48 kmph (30 mph) unbelted rigid barrier crash tests with both the 5th female and 50th male driver and passenger dummies. However, this vehicle was not able to pass the driver low risk deployment test.

The MY 1999 Toyota Tacoma passed all the 48 kmph (30 mph) unbelted rigid barrier crash tests with both the 5th female and 50th male *driver* dummies, and the MY 1999 Acura RL passed all the 48 kmph (30 mph) unbelted rigid barrier crash tests with both the 5th female and 50th male *passenger* dummies.

1.3 Analysis of 5th Female Driver Failure Modes in 48 kmph (30 mph) Unbelted Rigid Barrier Tests

1.3.1 5th Female Driver Chest Deflection Failures



* MY00 Sable was a pre-production prototype.

Figure 1: Pre-test Chest to Steering Wheel Distances for the 5th Female Driver in NHTSA Tests

In review of the crash test results of the 48 kmph (30 mph) unbelted 5th female rigid barrier crash tests conducted by NHTSA, two of the vehicles (MY 1999 Intrepid and the pre-production prototype MY 2000 Taurus/Sable) had driver chest deflection readings that exceeded the IARV of 52 mm (2 in.). These two vehicles also had the smallest chest-to-steering wheel (CS) distance for the 5th female in the full-forward seat position of the sample of vehicles tested by NHTSA. (A comparative chart is provided in Figure 1.) The average CS distance for the 8 vehicles tested was 197 mm (7.8 in.) The pre-production prototype MY 2000 Taurus/Sable had a CS value of 155 mm (6.1 in.) and the MY 1999 Intrepid had a CS value of 178 mm (7.0 in.) prior to conducting the test.
Therefore, the small space between the dummy's chest and the steering wheel and the failing chest deflection readings raised concern as to whether the air bag was deploying sufficiently between the dummy and the lower steering wheel rim.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

To investigate this further NHTSA repeated the 48 kmph (30 mph) unbelted 5th female rigid barrier crash test with a production MY 2000 Ford Taurus with the driver dummy positioned 76.2 mm (3 in.) rearward of the full-forward seat position. The 76.2 mm (3 in.) was chosen because it yielded

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approximately the same seating distance as the UMTRI positioning procedure [1] for this vehicle**.** The crash test results are listed below in Table 1.

Table 1: Comparison of Unbelted 5th Female Driver Injury Criterion using Full-forward Seating and 76.2 mm (3 in.) Rearward of Full-forward Seating in a 48 kmph (30 mph) rigid barrier test.

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2620 N	Neck Compr. IARV = 2520 N	Max. Femur IARV = 6805 N
Pre-production	V3212	46.9	**54.4**	84	0.59 NTE	1249	93	4379 (R)
MY 00 Ford Taurus (seated 76.2 mm or 3 in.	V3224	54.4	49.5	157	0.43 NTE	1108	84	6208 (R)

The chest deflection reading was reduced from the failing value of 54.4 mm (2.1 in.) to a passing value of 49.5 mm (1.9 in.). However, the 5th female driver chest acceleration was increased from 46.9 G to 54.4 G. Overall, the 5th female driver dummy passed all the injury criteria with the seat moved back 76.2 mm (3 inches).

There are a variety of countermeasures that could be explored to correct the driver chest deflection failures. Two that are directly linked to the agency's test results are: 1) to move the driver further back from the steering wheel by changing the full-forward seating position or by using adjustable pedals, and 2) to redirect the way the air bag unfolds so that it catches the 5th female's chest before hitting the steering wheel rim.

1.3.2 5th Female Driver Neck Failures

In the 2 out of 7 vehicles that had driver neck (Nij) failures, one vehicle, the MY 1999 Acura RL, was also re-tested in a 48 kmph (30 mph) unbelted 5th female rigid barrier crash test to evaluate whether moving the seat back 76.2 mm (3 in.) would mitigate the driver Nij failure. Results from this test showed that all the driver injury measures, including Nij, were now passing the injury criteria requirements. Nij was reduced from 1.29 to 0.74. Chest deflection, chest Gs and HIC15 were approximately the same in both tests (and were below the IARVs). The results are detailed in Table 2.

The results of this test and of the MY 2000 Ford Taurus test with the seat moved back 76.2 mm (3 in.) demonstrated that seat position can have a significant effect on the unbelted 5th female driver injury

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[1] The UMTRI positioning procedure is referenced in NHTSA Docket 1998-4405-69 and is based on the actual driving postures of drivers whose stature matches the 5th female Hybrid III adult dummy.

measures in a 48 kmph (30 mph) rigid barrier crash test.

Table 2: Comparison of Unbelted 5th Female Driver Injury Criterion using Full-forward Seating and 76.2 mm (3 in.) Rearward of Full-forward Seating in a 48 kmph (30 mph) rigid barrier test.

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2620 N	Neck Compr. IARV = 2520 N	Max. Femur IARV = 6805 N
MY 99 Acura RL	V3211	47.4	41.1	149	**1.29 NTE**	1656	58	3908 (R)
MY 99 Acura RL (seated 76.2 mm or 3 in.	V3244	48.4	38.9	68	0.74 NTE	1195	180	5645 (R)

1.3.3 Other Driver Air Bag Countermeasures

NHTSA also examined some of the driver air bag hardware from the vehicles crash tested by NHTSA and found that there were a significant number of countermeasures taken in some of the vehicles that performed well. These include: low-force breakout cover, I-tear seam pattern, 4 tether straps (as opposed to other designs with 2 or no tether straps), advanced folding pattern, recessed air bag module, energy absorbing steering column, etc. These design features may reduce the aggressivity to the occupant and improve the trajectory of the deployment.

1.4 Analysis of 5th Female Passenger Failure Modes in 48 kmph (30 mph) Unbelted Rigid Barrier Tests

1.4.1 5th Female Passenger Neck Failures

The passenger dummy in the MY 1999 Tacoma has failed or has nearly failed the neck injury criteria in almost every unbelted rigid barrier test NHTSA has conducted on this vehicle both at 48 kmph (30 mph) and at 40 kmph (25 mph). (Table 3 is a collection of the crash test results. Most all other non-neck related injury measures were below a 20% compliance margin.) The high Nij reading of 1.01 is particularly unusual for the 50th male dummy at 40 kmph (25 mph).

Film review of the MY 1999 Toyota Tacoma crash tests suggested that the deployment characteristics of the air bag against the vehicle interior typically results in the dummy's head being hyperextended backwards, compressed against the bag/windshield or twisted backwards while the chest keeps moving forward. This results in high neck readings on the dummy. Figures 2-4 are taken from the 48 kmph (30 mph) unbelted 5th female rigid barrier test (NHTSA Test # V3119). Figure 2 is a photograph of the initial deployment, Figure 3 is a photograph of the dummy's head

Figure 2: Passenger air bag of MY 1999 Toyota Tacoma; Initial air bag deployment trajectory toward head/neck region of the dummy.

Figure 3: The forward head motion being retarded by the passenger air bag.

Figure 4: The passenger dummy's head hyperextends rearward as the chest continues forward.

being stopped against the air bag pressure, and Figure 4 is a photograph of the dummy's head being hyperextended backwards by the air bag as the dummy's chest continues forward.

Table 3: Unbelted Passenger Results from Rigid Barrier Crash Tests of MY 1999 Toyota Tacomas

Crash Test Speed	Dummy Type	Chest G IARV = 60 G	Chest Defl. IARV = 63 mm (50th) or 52 mm (5th)	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Tension IARV = 4170 N (50th) or 2620 N (5th)	Compr. IARV = 4000N (50th) or 2520N (5th)	Max. Femur IARV = 10008N (50th) or 6805 N (5th)
48 kmph	50th male	35.6	23.5	173	0.48	3038	766	6372 (R)
40 kmph (25 mph)	50th male	23.4	15.7	82	**1.01 NCE**	547	2899	5236 (R)
48 kmph	5th	42.2	4.2	380	**2.29**	**3921**	1042	5974 (L)
40 kmph (25 mph)	5th female	34.1	3.7	143	**1.82 NTE**	2203	985	5419 (L)

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

There are a variety of countermeasures that could be explored to correct the 5th female passenger neck failures. For example, having the air bag catch the chest earlier in the event could mitigate the loading the head/neck complex receives from the air bag being compressed against the windshield.

The MY 1999 Toyota Tacoma is only one of the 2 out of 7 vehicles that failed the 5th female passenger Nij requirements. The other vehicle was the MY 1999 Chevrolet Blazer, which has a mid-mounted air bag system that initially deploys toward the chest (Figure 5), then fills upward to cover the chest and the head/neck (similar to the MY 1999 Saturn SL1; however this air bag did not have an internal bias flap to divert the flow of gas to the sides). As the 5th female dummy translates forward in the crash, there appears to be little restraint effect by the knee bolsters. The dummy's head appears to continue forward and contact the windshield through the air bag (Figure 6). (This is also corroborated by the head x acceleration trace). The dummy's head then appears to slide down the windshield and catches the chin on the instrument panel (in the area of the grab handle) resulting in a Nij reading of 1.18 (Figure 7). (Figure 8 is a photograph of the grab handle on the passenger side instrument panel).

The kinematics from this test do not suggest that depowering this air bag further would improve the neck injury measures resulting in the 5th female passenger. Less gas in the air bag would potentially make the head/neck bottom out the air bag further against the windshield.

Figure 5: MY 1999 Chevrolet Blazer (NHTSA Test # V3222); Initial passenger air bag deployment toward the chest

Figure 6: Dummy head-to-windshield contact through the passenger air bag.

Figure 7: Chin-to-instrument panel contact resulting in high passenger dummy Nij.

Figure 8: View of the grab handle on the passenger side instrument panel of the MY 1999 Chevrolet Blazer.

1.4.2 5th Female Passenger Chest G Failures

The other failure mode for the 5th female passenger in the 48 kmph (30 mph) rigid barrier crash test was chest Gs. Only 1 out of 7 production vehicles failed the chest G criteria with a value of 62.2 Gs (IARV = 60 Gs). In 5 out of 6 of the other vehicles, the chest Gs were below a 20% margin of compliance. The pre-production prototype MY 2000 Taurus/Sable also failed the passenger chest Gs with a value of 68.6 Gs. (Appendix A, Table A-6 has the complete test results).

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

1.5 Analysis of Comments

1.5.1 Deep vs. Shallow Air Bags

The AAM provided a figure in their docket comments illustrating 5th female and 50th male compatibility issues for driver dummies and deploying air bags (Figure 9). According to the AAM, the figure illustrates the balance in air bag performance requirements between the 5th percentile female and 50th percentile male in the 48 kmph (30 mph) unbelted rigid barrier test, and the potential for a practicable solution made possible by the 40 kmph (25 mph) unbelted rigid barrier test. The comments state that in a 48 kmph (30 mph) unbelted test, a "Deep bag exceeds the 5th neck IARV (Depth is too high)" and a "Shallow bag exceeds 50th IARV (Force is too high)." [2, Annex 1]

There is no dispute that significantly reducing the size of the air bag will limit the occupant protection provided to the 50th male in the high speed unbelted rigid barrier crash test. NHTSA had concerns about this during the air bag sled test rulemaking.

However, in the seven 48 kmph (30 mph) unbelted 5th female rigid barrier crash tests conducted by the agency, 5 out of 7 of the vehicles passed all the injury criteria for the 5th female driver and did not have neck/thoracic failures (as the figure implies). Furthermore, the Saturn SL1, which passed the 48 kmph (30 mph) rigid barrier crash tests with both the 5th female and 50th male dummies was one of the smaller driver air bags (approximately 42 liters in volume and 610 mm (24 inch) in diameter). This demonstrates that the air bag size does not have to be overly voluminous as the AAM has suggested.

1.5.2 "One Size Fits All" Air Bags

The AAM model (Figure 9), appears to be an attempt at optimizing a "one size fits all" air bag for two different dummy sizes. Using a single stage inflator, and a fixed air bag depth, this would be equivalent to

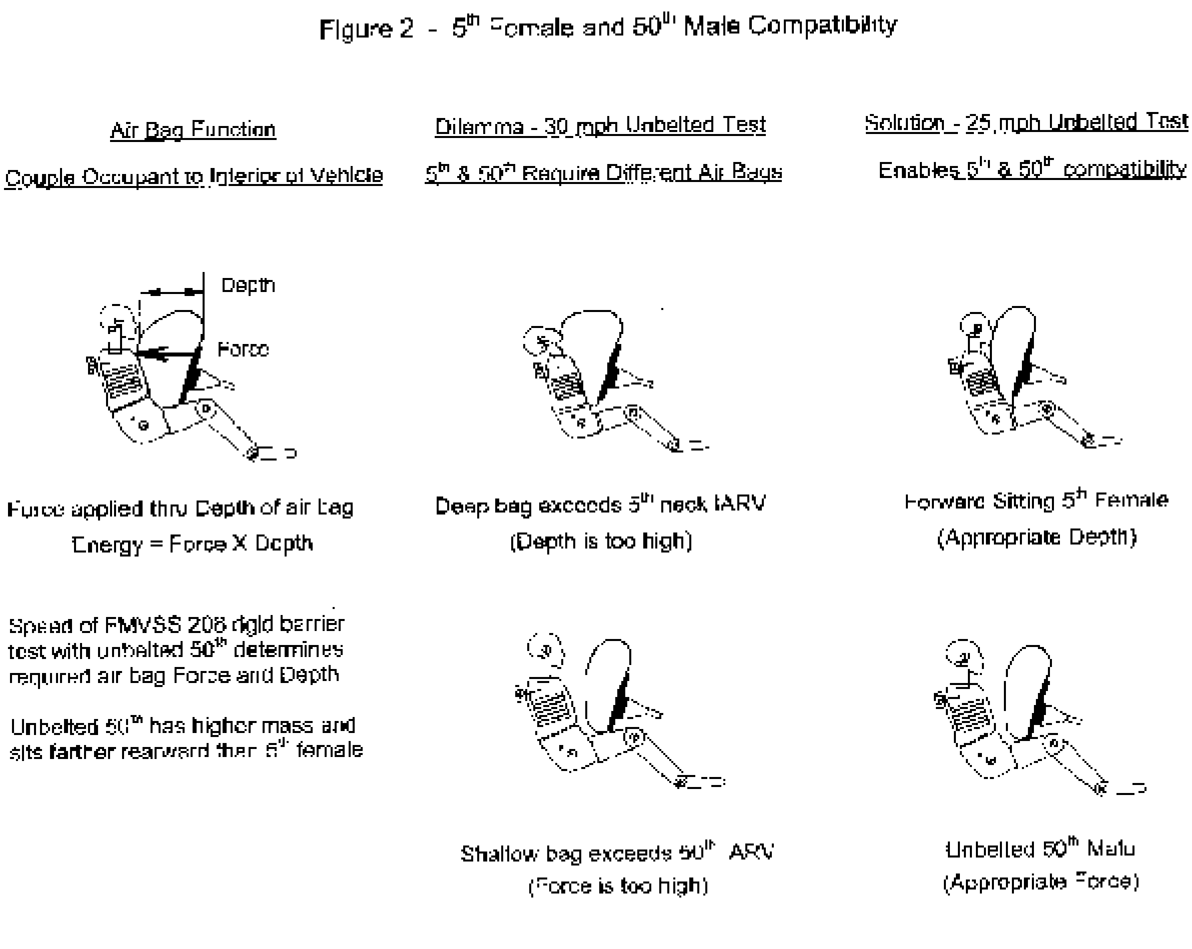

Figure 9: Figure from AAM comments to FMVSS No. 208 SNPRM
(NHTSA Docket 1999-6407-40, Annex 1, Figure 2)

optimizing an air bag that would work for both sized occupants. While this is achievable, as evidenced by the performance of the MY 1999 Saturn SL1 and other vehicles, this would be the most simplistic approach to balancing the requirements for the 5th female and 50th male.

A further improvement would be to maintain a constant air bag depth and adjust the force of the air bag to an energy level that is appropriate for that particular occupant. Energy = Force x Depth. This could be achieved, for example, through the use of multistage inflation and occupant seat track or seat weight sensing. Seat track sensors are in production vehicles today and can provide an estimate of occupant size by gaging seat track location. The MY 2000 Ford Taurus/Mercury Sable vehicles currently demonstrate this feature.

Theoretically, further improvements could be made in tailoring the air bag depth by using techniques such as breakaway or force-limiting tethers. For a large occupant, a larger inflation force (strong enough to break/stretch the tethers) could be used to manage the energy; whereas a smaller inflation force (too weak to break/stretch the tethers) could be used to control the force and the distance.

1.5.3 AAM's MY 1999 Toyota Tacoma Example

The AAM made the following statement "...the agency's test of the Toyota Tacoma resulted in a Nij of 2.65 in the 5th female passenger dummy, nearly 3 times the allowable injury reference value. The air bag size and fill needed to assure compliance with the chest injury limits with the 50th percentile male dummy at 30 mph results in noncompliant neck and thorax injury reference values for the 5th percentile female seated closer to the air bag." [2, p. 10]

There are a number of disputable issues with this argument. First, NHTSA's test of the MY 1999 Toyota Tacoma did not result in noncompliant thorax injury reference values for the unbelted 5th percentile female seated closer to the air bag. The chest Gs were 42.2 Gs (IARV = 60 Gs) and the chest deflection was an extremely low value of 4.2 mm or 0.2 in.(IARV = 52 mm or 2 in.). The specific injury measures are listed in Table 4 below.

Table 4: 48 kmph (30 mph) Rigid Barrier Test Results of the MY 1999 Toyota Tacoma with Unbelted 5th Female Passenger

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2620 N	Neck Compr. IARV = 2520 N	Max. Femur IARV = 6805 N
MY 99 Toyota Tacoma	V3119	42.2	4.2	380	**2.29 NTE**	**3921**	1042	5974 (L)

Second, NHTSA's crash test data does not support the assertion that the problems with the 5th female passenger in the MY 1999 Toyota Tacoma 48 kmph (30 mph) rigid barrier test are a result of the "...air bag size and fill needed to assure compliance with the chest injury limits with the 50th percentile male dummy at 30 mph". NHTSA's test of the MY 1999 Toyota Tacoma into a rigid barrier at 48 kmph (30 mph) showed that the unbelted 50th male passenger dummy resulted in 35.6 chest Gs in this test. This is extremely low, has significant compliance margin, and does not appear to be the limiting factor for air bag design in this vehicle. The specific injury measures for this test are listed in Table 5 below.

Table 5: 48 kmph (30 mph) Rigid Barrier Test Results of the MY 1999 Toyota Tacoma with Unbelted 50th Male Passenger

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 63 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Tension IARV = 4170 N	Compr. IARV = 4000 N	Max. Femur IARV = 10008 N
MY 99 Toyota Tacoma	V3128	35.6	23.5	173	0.48 NTF	3038	766	6372 (R)

Third, based on the analysis of the agency's set of MY 1999 Toyota Tacoma rigid barrier tests (Section 1.4.1), the passenger air bag in this vehicle resulted in high Nij values for <u>both</u> the 5th female and 50th male dummies. The fact that both the 5th female and 50th male dummies were experiencing high Nij values (particularly at 40 kmph or 25 mph) does not effectively illustrate the design constraints manufacturers must balance between the two dummy sizes. It instead suggests that these repeatable high neck readings may be a potential design issue with this respect to this particular air bag restraint system.

1.5.4 MY 2000 Ford Taurus/Mercury Sable

Ford stated that both Ford and the agency have tested the 5th female and 50th male unbelted dummies at 48 kmph (30 mph) in the MY 2000 Ford Taurus, equipped with Ford's state-of-the-art restraint technologies, and demonstrated the difficulty of balancing requirements with a 48 kmph (30 mph) test. NHTSA's crash results (Appendix A, Tables A-1, A-2, A-5 and A-6) agree that both the 5th female and 50th male dummies had failures in the 48 kmph (30 mph) rigid barrier crash tests conducted with *pre-production prototype* MY 2000 Taurus/Sable vehicles. However, the previous **MY 1998** Ford Taurus did not have difficulties in these two types of tests. It passed most all of the injury criteria with a 20% compliance margin.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

NHTSA's crash testing of an additional MY 2000 Taurus/Sable vehicle also demonstrated how moving the seat back 76.2 mm (3 in.) could afford the air bag more room to deploy and reduce the chest deflection readings. (Reference: Section 1.3.1). The 5th female chest-to-steering wheel distance for the MY 1998 Ford Taurus test was 191 mm (7.5 in.), whereas the chest-to-steering wheel distance for the MY 2000 Taurus/Sable test was 155 mm or (6.1 in.).

Discussion: Many of the vehicles tested by NHTSA may not have been fully designed or optimized based on the performance of the 5th female dummy, much less the 50th male dummy + the 5th female dummy. Two vehicles can pass the 48 kmph (30 mph) unbelted 5th female and 50th male rigid barrier test requirements and driver low risk deployment tests, without having been redesigned to meet the new requirements of the advanced air bag final rule.

2.0 Would reinstating the 48 kmph (30 mph) barrier test require larger, more powerful air bags that would result in higher injury risk for out-of-position occupants?

2.1 Discussion of Public Comments

A number of commenters stated that reinstating the 48 kmph (30 mph) barrier test would require larger, more powerful air bags. Some of these commenters further suggested that these larger more powerful air bags would result in higher injury risk for out-of-position occupants.

For example, AAM stated that "...the occupant's kinetic energy is proportional to the square of velocity, a 5 mph increase in rigid barrier impact speed from 25 mph to 30 mph results in more than 40% additional kinetic energy. As rigid barrier test speed is increased, the occupant's energy must be dissipated over a greater distance to avoid the higher forces that may exceed the injury assessment values. Therefore, a higher rigid barrier impact speed drives a larger air bag...greater air bag volume requires more gas from the inflator to fill the air bag and develop the pressure needed for appropriate restraint force at a given occupant displacement." [2, Annex 1, p. 3, 4] Similarly, Isuzu stated "...if the impact speed of the unbelted barrier test using 50th percentile adult male dummies were set at 30 mph, the air bag's fore-aft dimensions would have to be increased, which would surely result in a greater air bag volume and a greater inflator output." [8, p. 1]

DaimlerChrysler stated "...raising the speed of the unbelted rigid barrier tests back to 30 mph (48 km/h) will work against the objectives of TEA-21, since air bags will necessarily need to be made significantly more powerful once again...even the introduction of new technology will not permit the return to that test while maintaining reductions in risk to children and others." [9, p. 3, 4] Ford stated "If the 30 mph rigid fixed barrier test returns as a regulatory-driven requirement, the "Personal Safety System", including the dual-stage air bag inflators, would need to be redesigned (repowered) for many vehicle programs to accommodate the increased level of crash severity." [3, p. 3]

Honda stated "In order to meet the proposed new requirements in an unbelted, 30-mph rigid barrier test, we would have to adopt a higher output inflator." [4, p. 2] Toyota stated "...a return to the 30 mph unbelted test requirement will require increased inflator power levels in the airbag systems of many vehicles to ensure sufficient margins of compliance for 50% male testing...manufacturers will be forced to increase inflator pressures beyond current levels and will increase risk to all occupants in real world crashes, especially OOP (out-of-position) children and small adults." [10, p. 1] Delphi Automotive Systems stated "An increase in test speed requires an addition in energy to the airbag system and increases the tradeoff considerations for the belted, unbelted, and out of position occupants even with multi-stage airbag modules." [11, p. 2]

Other commenters expressed concerns about returning to a 48 kmph (30 mph) test. For example, the NTSB stated "We are concerned that the 30 mph unbelted crash test procedures being considered by NHTSA could result in a return to higher energy air bags." [12, p. 1] NADA stated "... it could cause manufacturers to rely unnecessarily on powerful single or dual stage inflators that pose increased inflation-related risks to certain out-of-position occupants.” [13, p. 2]

However, Consumers Union stated “We continue to be skeptical, therefore, about the industry’s argument that if 50th percentile males are given maximum protection in high-speed crashes, the cost of that protection comes at the expense of small adults and children, who will be endangered by the more powerful bag.” [6, p. 3] Consumers Union cited examples of NHTSA’s vehicle crash testing and stated “...even before a comprehensive redesign in the air bag system contemplated in this rulemaking, a wide variety of vehicles with so-called “depowered” bags already can pass the more stringent 30-mph unbelted rigid barrier test. Contrary to the industry argument, air bags in many varieties of vehicles apparently do not need to be repowered or made “overly aggressive” in order to pass current Standard 208 requirements.” [6, p. 5]

Other commenters discussed the inadequacy of power levels required to meet the 40 kmph (25 mph) rigid barrier test. For example, Public Citizen stated “One indicator of the inadequacy of 25 mph is the statement by General Motors in the 1980's that it could pass a 25 mph barrier crash test with “friendly interiors” and no air bag at all!” [7, p. 6] Syson-Hille and Associates asked “How can a manufacturer claim that the mid 1990's airbag test requirements were too stringent, when they could have met more stringent requirements with ***NO*** airbag or safety belt, ten years before?” [14, p. 3]

2.2 The Need to Increase Air Bag Power

48 kmph (30 mph) unbelted 50th male rigid barrier crash tests: The industry’s argument that reinstating the 48 kmph (30 mph) rigid barrier crash test will require larger, more powerful air bags that would result in higher injury risk for out-of-position occupants is contradicted by NHTSA’s crash testing of MY 1998 and MY 1999 vehicles. This data demonstrates that vehicles with “redesigned” air bags “certified to the sled test” are able to meet the 50th male injury criteria in most of the high speed unbelted tests without the need to “repower” or enlarge the air bag size. In NHTSA’s 48 kmph (30 mph) rigid barrier crash tests of MY 1998 and MY 1999 vehicles, 12 of the 14 “depowered or sled certified” air bag-equipped vehicles were able to meet all the dummy injury criteria on the driver side and 13 of the14 were able to meet all the criteria on the passenger side. Therefore, for the large majority of vehicles tested, an increase in inflation power is not needed to meet the injury criteria requirements for the unbelted 50th male dummy.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

Driver low risk deployment tests: Four out of six MY 1999 vehicles that passed the 48 kmph (30 mph) unbelted 50^{th} male rigid barrier crash test were also able to meet the driver low risk deployment tests with the small female dummy using single stage air bags.[2] [Four out of six met Position 1 requirements (2 with marginal Nij readings) and 6 out of 6 met Position 2 requirements. The specific test results are in Attachment 1, Tables A-9 and A-10.] The four passing vehicles also represent a range of vehicle classes: a sub-compact car, a mid-size car, a large size SUV and a full-size van. Therefore, these single stage air bag systems demonstrate the amount of latitude that manufacturers will have in designing the inflation (or power) levels so as to not be aggressive to out-of-position occupants. Multi-stage inflation technology could also provide improvements above and beyond these single stage air bags by providing a higher level of inflation only when needed (i.e. in high severity crashes, or for unbelted occupants of larger stature, etc.), and only a partial level of this inflation in other circumstances (i.e, in crashes of lower severity or for belted occupants sitting close to the air bag, etc.). Providing a partial level of inflation (or power) in crashes of low severity, for example, would also increase a manufacturer's ability to certify a vehicle using the low risk deployment crash test procedure.

2.3 The Need to Increase Air Bag Volume

The commenters did not provide any data demonstrating that air bag volumes have decreased significantly as a result of vehicles being "sled certified" (or depowered) and that an increase in volume would be necessary to comply with a 48 kmph (30 mph) rigid barrier. In NHTSA's report "Air Bag Technology in Light Passenger Vehicles" [1, p. A-22], the average driver air bag volume of fully inflated air bags (for the fleet sampled [3]) only dropped approximately <u>1.3 percent</u> from 55.1 liters in MY 1997 to 54.3 liters in MY 1998 (as a result of depowering). The report states that over the 9 year time frame (MY 1990-1998) the average volume of the fully inflated driver air bag system was relatively stable between 54 and 57 liters. Therefore, there is little indication that driver air bag volume has changed dramatically as a result of depowering (or certifying to the sled test). Future driver air bag systems certified to the long-standing 48 kmph (30 mph) rigid barrier crash test should not have to be dramatically increased in volume.

On the passenger side, however, the report states that there has been a downward trend in the volume of the fully inflated passenger air bags of the Information Request (IR) fleet. From 1993 to 1998, there was a 26 percent decrease in the average volume of the fully inflated air bag. However, the IR report combines mid and top mounted passenger air bag systems which can be designed very differently. The IR report also cautions the following: during the first few years of the IR there were relatively few

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[2] The seventh MY 1999 vehicle, the Chevrolet Blazer, was not tested by NHTSA using the low risk deployment test procedure.

[3] The total IR fleet sampled represented MY 1990 through MY 1998 vehicles from nine vehicle manufacturers.

vehicles equipped with passenger air bags compared to the later years, only two manufacturers offered these devices in the first year or two, and there were no LTVs in the IR fleet equipped with passenger air bags until MY 1994. Therefore, looking at the later MY data, the report notes that the rate of decrease in volume on the passenger side has leveled off during the past 3 years. Specifically between MY 1997 and MY 1998, the average passenger air bag volume of fully inflated air bags (for the fleet sampled) only dropped approximately 2.6 percent from 125.6 liters in MY 1997 to 122.4 liters in MY 1998. Therefore, a dramatic decrease in average volume between MY 1997 (rigid barrier-certified or pre-depowered) passenger air bags and MY 1998 (sled-certified or depowered) passenger air bags was not evidenced by this data.

2.4 Demonstration of a Small Volume Air Bag System Providing Good Performance

As a final note, the fact that larger air bags are not necessarily needed to comply with a reinstated 48 kmph (30 mph) rigid barrier unbelted test requirement is further illustrated by the agency's testing of the MY 1999 Saturn SL1. As previously noted, the MY 1999 Saturn SL1 passed the 48 kmph (30 mph) rigid barrier crash tests with a 20% margin of compliance using both the 50th male and 5th female dummies. This vehicle also passed the driver low risk deployment tests with a 20% margin of compliance. However, the MY 1999 Saturn SL1 driver air bag system has a relatively small bag volume of approximately 42 liters, considerably lower than the IR fleet average of 54.3 liters for MY 1998. Similarly, the passenger air bag of the MY 1999 Saturn SL1 has a relatively small bag volume of approximately 85 liters. This is considerably smaller than the IR fleet average of approximately 122.4 liters for MY 1998. Therefore, this contradicts the argument that air bag volumes need to be substantially increased when a vehicle with air bags in approximately the smallest 5th percentile of the IR fleet met all the 48 kmph (30 mph) unbelted 50th male and 5th female high speed rigid barrier requirements with a 20% margin of compliance as well as the low risk deployment tests on the drivers side.

Discussion: The need to increase inflation power has been contradicted by the majority of "depowered" or "sled certified" vehicles (over a broad range of vehicle classes) that have been tested in 48 kmph (30mph) rigid barrier crash tests by the agency. The industry supplied no data to show that more power was necessary to pass the tests. The majority of the vehicles currently pass the unbelted 50th male injury criteria requirements without the need to repower their air bags. Furthermore, two thirds (4 out of 6) of the MY 1999 vehicles tested in the driver low risk deployment test passed all the requirements (with single stage air bags), showing that more power does not need to be taken out of the bag to pass the driver low risk deployment test and a repowering of the air bag is not needed for the 48 kmph (30 mph) tests. On the passenger side, passing the child low risk deployment test procedures is much more difficult to achieve using MY 1998/1999 single-stage passenger air bag systems (Reference data: Appendix A, Table A-11 and A-12). If further improvements in reducing injury measures in the child low risk deployment test procedures can not be achieved using advanced air bag technology (such as dual stage inflators), some type of occupant suppression system may be necessary to suppress the passenger air bag for children while high speed inflation levels equivalent to the MY 1998/1999 vehicles could be maintained for meeting the 48 kmph (30 mph) rigid barrier tests. Additionally, large changes in average air bag volume did not result between the pre-MY 1998 "48 kmph (30 mph) rigid barrier certified or pre-depowered" fleet and the MY 1998 "sled certified or depowered" fleet data provided by manufacturers in the IR. Thus, the need to significantly increase the volume of the air bags to meet the 48 kmph (30 mph) rigid barrier test is contradicted by this data.

3.0 Are there any implications of 48 kmph (30 mph) barrier test for out-of-position occupants in high speed crashes?

3.1 Discussion of Public Comments

Comments were submitted by the Insurance Institute for Highway Safety (IIHS) [15, p. 5]. IIHS stated "In the real world, the positions of unbelted occupants are unpredictable. Unlike the unbelted barrier test, in which dummies always are sitting back in the seat in a position to ride down a fully inflated air bag, unbelted people in high-speed crashes often are close to their airbags during inflation because of braking before impact, previous but less severe impacts, or late firing of the air bags. As a result, only some unbelted occupants in severe real-world crashes will benefit from airbags that certify to the more severe 30 mph barrier test; other occupants likely will be out of position and potentially will be injured when airbags deploy."

The University of Michigan, Transportation Research Institute (UMTRI) [16, p. 1] provided an analysis of crash investigations involving 160 occupants (120 drivers and 40 right front seat passengers) who were located in a 1998 or later model vehicle where and when a depowered or next-generation air bag deployed. Their conclusions were: "... depowered airbags are equivalent to pre-depowered airbag in offering protection to both belt-restrained and unbelted front-seat passengers involved in moderate to severe frontal crashes. In addition, the database suggest that, for the most part, depowered airbags are significantly less aggressive during deployment than pre-depowered airbags. However, the data also show that depowered airbags can still cause serious or fatal injuries to child and adult occupants who are in very close proximity to the airbag module at the time of deployment."

3.2 Review of Real World NASS Data

The agency examined every case of a driver or passenger fatality in NASS (from 1988 through the first six months of 1999) with air bags and known delta V over 40 kmph (25 mph). [Note: those under 40 kmph (25 mph) are already examined in NHTSA's Special Crash Investigation file]. The selection criteria for the cases included a frontal impact with a known delta V of 40 kmph (25 mph) or greater with no rollover and ejections. In addition, the two cases identified by IIHS as an air bag caused fatality with unknown delta V were examined. In all, 57 cases were clinically reviewed by NHTSA (excluding one case that was reviewed but turned out to be an ejection). The results of the case review are summarized in NHTSA's Final Economic Assessment (FEA) [21, Appendix B]. The FEA states "While the agency found that 11 of 57 cases examined (roughly 19 percent) were air bag caused fatalities, this does not mean that 19 percent of all remaining air bag deployment fatalities are caused by air bags. One has to consider the case selection criteria of only known delta V above 25 mph, no ejections and no rollovers."

3.3 Analysis of Comments

The low risk deployment test procedure does not specifically guarantee that air bags will be designed to deploy in a benign manner in high severity crashes. The low risk deployment option attempts to ensure a benign deployment in crash severities up to and including approximately 26 kmph (16 mph). However, in higher severity crashes, the low speed offset deformable crash test is required and is aimed at improving crash sensors and preventing late deployment events in soft crashes up to and including 40 kmph (25 mph) and the 32 kmph (20 mph) to 48 kmph (30 mph) unbelted 5^{th} female rigid barrier crash test is required and designed to limit the aggressivity of the air bag system to occupants sitting full-forward. As an alternative to the low risk deployment test procedure, there is also a Dynamic Automatic Suppression System option included in the final rule which permits the certification of advanced sensing systems to protect out-of-position occupants in a dynamic environment, such as those resulting in high severity crashes.

IIHS did not propose a test procedure to address the concern they raised about out-of-position occupants in high severity crashes. They simply supported the 40 kmph (25 mph) rigid barrier crash test that provides a crash pulse only marginally more severe than the 48 kmph (30 mph) sled test (to avoid a hypothesized return to "re-powered" air bags).

However, simply reducing the severity of the high speed unbelted test requirement can not guarantee the fact that out-of-position occupants will not be killed by the air bag in high severity crashes. The FEA states that "...we have also found 1 case of a redesigned air bag that caused a fatal injury: one of the 3 cases in which there was another fatal chest injury caused by intrusion. Thus, the redesigned air bags did not solve all of the out-of-position problems in high speed crashes, just as they did not solve all of the out-of-position problems in lower speed crashes. There are not enough cases to make a projection of how effective redesigned bags have been in high speed crashes where the occupant is out-of-position."

IIHS also made the claim in their docket comments that they are unaware of any cases in which the energy of the deploying air bag was inadequate. We have found 4 cases in 1998 and 1999 NASS in which we believe the air bag was not strong enough, one with a redesigned air bag, and UMTRI found one such case. Thus, we do not agree with IIHS that there is always sufficient force in the air bag. In fact, there were more high speed cases in this time frame (4 cases in 1998 and the first 6 months of 1999) in which there was not enough power in the air bag than high speed cases (2 cases) in which there was too much power.

<u>Discussion</u>: There is concern that air bag deployments in high severity crashes may present risks to out-of-position occupants; the agency has found 11 NASS cases that were air bag-caused fatalities. However, simply reducing the severity of the high speed unbelted test requirement can not guarantee that out-of-position occupants will not be killed by the air bag in high severity crashes. The agency has found 1 case of a redesigned air bag that caused a fatal injury. Therefore, redesigned air bags have not solved all of the out-of-position problems in high speed crashes, just as they did not solve all of the out-of-position problems in lower speed crashes. At this point, there are not enough cases to make a projection of how effective redesigned bags have been in high speed crashes where the occupant is out-of-position. The agency has also found 4 cases in 1998 and 1999 NASS in which we believe the air bag was not

strong enough (including one with a redesigned air bag and UMTRI found one such case). Over the same time period there were fewer high speed cases in which there was too much power in the air bag than high speed cases in which there was not enough power.

4.0 What are the practical implications of 40 kmph (25 mph) vs. 48 kmph (30 mph) for manufacturer choices about air bag design and technology, e.g., on size of air bag, use of dual level inflators, etc.?

4.1 Discussion of Public Comments

Vehicle manufacturers cited a number of practical implications that either support the selection of a 40 kmph (25 mph) unbelted rigid barrier test or support opposition to the 48 kmph (30 mph) unbelted rigid barrier test.

As discussed in Section 2.1, vehicle manufacturers generally commented that the 48 kmph (30 mph) unbelted test will necessitate increasing the inflator power levels in many air bag systems to ensure sufficient margins of compliance with the 50^{th} male, and that this higher test speed will increase air bag volume because it will require a deeper air bag to restrain the occupant over a greater distance. Consequently, higher inflation pressures will be required for the high and low levels of inflation since the low level must provide enough gas to fill the bag's larger volume. For example, BMW stated "...we will be left with only one means to adjust an air bag system to decrease these (injury) values without compromising vehicle structural integrity - by increasing the ride down time or the length time the dummy is in contact with the air bag. Increasing the ride down time is achieved by enlarging volume and raising the deployment speed of the air bag. The larger volume brings the bag closer to the occupant, while the greater speed gets the bag out sooner; both would be needed to bring the 30 mph injury values down to a level that would be necessary for compliance." [17, p. 2] IIHS also stated "When compliance becomes difficult, it will be far too easy for manufacturers to meet the 30 mph unbelted test requirement by increasing airbag inflation energy (or the second stage of the airbags)." [15, p. 6]

In support of a 40 kmph (25 mph) unbelted rigid barrier test, Autoliv stated "Use of a 25 mph test as opposed to a 30 mph test will reduce the deployment energy needed for the restraint system to meet the injury criteria. The lower energy system reduces the potential risk for upper arm injuries and other incidental contacts with the air bag as well as providing greater flexibility in meeting the driver side low risk deployment option. This could be tied in with seat position sensing and/or occupant weight sensing, occupant position sensing and crash severity sensing. The use of dual level inflators would also then allow the higher output for larger occupants." [19, p. 3] The AAM also stated that "A 25 mph unbelted test speed rather than 30 mph would allow both restraint force and air bag depth to be set at appropriate balanced levels for 5^{th} female and 50^{th} male size occupants." [2, Annex 1, p. 4] This was similarly reflected in GM's comments [5, Attachment 1, p. 8]

However, some commenters pointed out that a 40 kmph (25 mph) unbelted rigid barrier test may not require an air bag at all. Syson-Hille stated "In 1984, GM held a media safety briefing at the GM proving grounds (GM, 1984) where the results of 40 KPH (25 MPH) testing of Chevrolet Cavaliers were displayed...GM demonstrated that even the Cavalier could meet all the 208 injury criteria 'without belts or airbags' at 40 KPH." [14, p. 3] Public Citizen similarly stated "One indicator of the inadequacy of 25 mph is the statement by General Motors in the 1980's that it could pass a 25 mph barrier crash test with 'friendly interiors' and no air bag at all!" [7, p. 6]

Public Citizen also discussed advanced technologies that could be used to overcome the "tradeoff" manufacturers claimed they need to balance between the 48 kmph (30 mph) unbelted 5th female and unbelted 50th male rigid barrier requirements. These included: "...dual or multi-level inflators, innovative folding patterns and air bag shapes, lighter-weight fabrics, tethers, pedal extenders, moving modules, deep dish steering wheels, collapsible steering columns, knee bolsters, stitching that keeps bags narrow to protect in low-level inflation and separates to protect occupants in higher-impact crashes, top mounted vertically deploying air bags, chambered air bags (bag inside a bag), and occupant position sensors that adjust deployment level or suppress deployment altogether." [7, p. 8]

4.2 Analysis of Comments

4.2.1 Air Bag Design and Technology to Meet the 48 kmph (30 mph) Unbelted Rigid Barrier Crash Test

A common theme throughout the industry comments was the fact that a return to the 48 kmph (30 mph) rigid barrier crash test would result in the need to increase the air bag volume (fore/aft dimensions), increase air bag inflator power and increase air bag inflation speed to meet compliance margins with the unbelted 50th male rigid barrier crash test. [Refer to Section 2.0 for a discussion on "would reinstating the 48 kmph (30 mph) barrier test require larger, more powerful air bags..."]. However, NHTSA's crash testing of MY 1998-1999 vehicles with "depowered or sled certified" air bag systems has shown that they are mostly able to meet the 48 kmph (30 mph) unbelted 50th male rigid barrier crash test without the need to increase the power or volume of the air bag system.

Manufacturers did not dispute the reliability of seat track sensors, seat belt sensors, or other technologies that may be used in high severity crashes to optimize restraint performance for different occupant sizes and restraint use. Seat track sensors and seat belt sensors are in current production vehicles and can be used with multistage inflators to modulate the air bag deployment.

Therefore, for a 48 kmph (30 mph) unbelted rigid barrier requirement, a dual stage air bag regulated by an occupant detection system (i.e. seat track sensing, occupant weight or position sensing) to differentiate between the 5th female and 50th male rigid barrier crash tests could be used (similar to the MY 2000 Ford Taurus strategy), or else a benign single-stage air bag could be used (similar to the MY 1999 Saturn SL1 strategy). The Saturn SL1 makes use of an extensive list of countermeasures to reduce aggressivity during the deployment process. On the passenger side, for example, the passenger air bag has a bias flap which controls and diverts the flow of gas away from the occupant. However, the MY 1999 Saturn SL1 was not able to meet the child out-of-position tests on the passenger side (Reference: Appendix A, Tables A-11 and A-12) and would need some type of occupant sensing technology to suppress the air bag for children.

4.2.2 Air Bag Design and Technology to Meet the 40 kmph (25 mph) Unbelted Rigid Barrier Crash Test

Manufacturers stated that a 40 kmph (25 mph) unbelted test will allow for a shallower air bag which may be more appropriate for the 5^{th} female in the full-forward seat position, may also reduce risks to out-of-position occupants, and still provide protection for the unbelted 50^{th} male in the 40 kmph (25 mph) unbelted rigid barrier test. However, designing the air bag size based upon the smallest 5^{th} percentile of the population that sits in the full-forward seat position can not be in the best interest of overall occupant protection (especially when the industry has cited studies that infer that small occupants rarely use the full-forward seat position).

The large compliance margins resulting in the 40 kmph (25 mph) unbelted rigid barrier test with the 50^{th} male using current air bag designs could be used to reduce the air bag size further to pass low risk deployment requirements and high speed rigid barrier requirements with the small female dummy. Reducing the air bag size may eliminate the need for seat track sensing and/or occupant position sensors that current production vehicles rely upon to distinguish between occupants sitting in the forward-most seat track positions and those sitting further back.

Due to the reduced crash severity of a 40 kmph (25 mph) test, manufacturers could more easily comply with driver out of position tests and a single stage ("one size fits all") air bag. Agency tests have shown that current MY 1999 air bags have demonstrated compliance in driver low risk deployment tests while satisfying the 40 kmph (25 mph) unbelted 5^{th} female and unbelted 50^{th} male rigid barrier requirements. [Reference: Crash test data on the MY 1999 Dodge Intrepid (Appendix A, Tables A-3, A-4, A-7, A-8, A-9, and A-10)].

5.0 Should different consideration be given to cars vs. light trucks and vans (LTVs) with respect to the high speed unbelted requirement?

5.1 Discussion of Public Comments

Two commenters mentioned compliance margin difficulties in meeting the 48 kmph (30 mph) unbelted 50th male rigid barrier test with all LTV vehicle packages of a given make/model (i.e. 2wd vs. 4wd, extended cab, etc.). Ford stated in their comments to the FMVSS No. 208 Notice of Proposed Rulemaking (NPRM) on advanced air bags "...Ford conducted a barrier crash test of a different variant of the 1998 Explorer at 30 mph. That crash test found substantially different dummy criteria than the agency's test, including a driver chest acceleration of 58 g, compared to the agency's test result of 44 g. One probable reason for this difference in dummy criteria is the different powertrain configuration in the Ford test, although other factors such as test speed had some influence." [18, Attachment 1] Toyota stated in their comments to the SNPRM "...NHTSA asserted that a Toyota Tacoma easily passed all the pertinent injury criteria for the 30 mph unbelted test condition with large margins. However, Figures 4.1-4.2 compare NHTSA's testing to Toyota's internal testing of a vehicle in the same model line, although equipped differently than NHTSA's test vehicles (4wd vs. 2wd, extra cab, etc.). As evidenced by Figure 4.2, the vehicle can no longer meet the requirements with any certifiable margin of compliance." [10, p. 2]

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

Additionally, Daimler Chrysler provided comments on the limitations that manufacturers have in improving vehicle crush zones. Daimler Chrysler stated "Qualitatively, crush zones are not optimized solely with respect to barrier crash speeds. System performance has been optimized while considering all vehicle requirements. Modifications to the crush zone to meet the unbelted 30 mph (48 km/h) rigid barrier test could deteriorate overall vehicle performance against its market objectives. For example, longer front overhang and crush zones could provide greater ride down and allow a greater time to fire the air bag for some off-road SUV's, but at the same time destroy their utility with an unacceptable approach angle. Similarly, longer overhang would severely compromise the urban maneuverability or cargo capacity of delivery vans. Thus, increasing crush zone size is not an option without limits." [9, Appendix 1, p.3]

Public Citizen stated "NHTSA's research contradicts the manufacturers' claim that the rigid barrier test forces light trucks and vans (LTVs) to be stiffer than passenger cars to meet Standard 208 by showing that vehicles with a wide range of front structural designs were able to pass the test, not just those that are structurally more forgiving. NHTSA tests showed that manufacturers have a great deal of latitude with respect to the design of the front end of cars: '[O]verall, the automakers have exercised great design latitude in how the rigid barrier requirement is met...In general stiffness increases with weight, but for any given weight there is a wide range of average frontal stiffness values...vehicles display a substantial variation in the amount of crush, or front-end crumple, designed into the front structure. In general, LTVs crumple much less than a passenger car of the same weight. The result is that LTVs are substantially stiffer, and less forgiving in a crash, than are passenger cars of the same weight.'" [7, p. 9]

5.2 Review of LTV Crash Test Data

Vehicle manufacturers have claimed that in order for LTVs to pass the 48 kmph (30 mph) unbelted 50th male rigid barrier test requirement, they will need to make air bags more aggressive, which increases the risk for out-of-position occupants. The following is a review of NHTSA's crash test data.

48 kmph (30 mph) unbelted 50th male rigid barrier crash tests: NHTSA conducted seven 48 kmph (30 mph) unbelted 50th male rigid barrier crash tests on a variety of LTV platforms. The platforms included: a MY 1998 Plymouth Voyager, a MY 1998 Ford Explorer (4L), a MY 1999 Ford Expedition, a MY 1999 Toyota Tacoma, a MY 1999 Ford Econoline, a MY 1998 Jeep Grand Cherokee and a MY 1999 Chevrolet Blazer. On the driver side 6 out of 7 LTV platforms were able to able to meet all the dummy injury criteria and 7 out of 7 were able to meet all the criteria on the passenger side. The specific results are included in Appendix A, Tables A-1 and A-2.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

40 kmph (25 mph) unbelted 50th male rigid barrier crash tests: NHTSA conducted one 40 kmph (25 mph) unbelted 50th male rigid barrier crash test with an LTV. The vehicle was a MY 1999 Toyota Tacoma. All injury criteria for driver and passenger were passing with a 20% margin of compliance except for passenger Nij. This resulted in a value of 1.01. [Refer to Section 1.4.1 for further discussion on passenger Nij failures resulting in the MY 1999 Toyota Tacoma]. The specific test results are included in Appendix A, Tables A-3 and A-4.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

48 kmph (30 mph) unbelted 5th female rigid barrier crash tests: NHTSA also conducted a subset of three 48 kmph (30 mph) unbelted 5th female rigid barrier crash tests with LTVs. The vehicles included: a MY 1999 Toyota Tacoma, a MY 1999 Chevrolet Blazer, and a MY 1999 Ford Econoline van. On the driver side 3 out of 3 vehicles were able to meet all the all the dummy injury criteria and 1 out of 3 was able to meet all the criteria on the passenger side. The 2 vehicles with failures on the passenger side, the MY 1999 Toyota Tacoma and the MY 1999 Chevrolet Blazer, had exceeded the Nij criteria. [These Nij failures were discussed in Section 1.4.1].

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

40 kmph (25 mph) unbelted 5th female rigid barrier crash tests: NHTSA conducted one 40 kmph (25 mph) unbelted 5th female rigid barrier crash test with an LTV. The vehicle was a MY 1999 Toyota Tacoma. All driver and passenger injury criteria were passed (most with a 20% margin) with the exception of passenger Nij. The Nij reading was 1.82 (IARV = 1.0). [Refer to Section 1.4.1 for further discussion on passenger Nij failures resulting in the MY 1999 Toyota Tacoma].

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

Driver low risk deployment data: NHTSA conducted driver side low risk deployment tests on 4 types of LTVs. The LTVs included: a MY 1999 Ford Expedition, a MY 1999 Ford Econoline, a MY 1999 Toyota Tacoma, and a MY 1998 Ford Explorer]. Two of the 4 vehicles, the MY 1999 Ford Expedition and the MY 1999 Ford Econoline van, passed all the driver low risk deployment requirements. (Nij measurements in low risk deployment Position 1 were marginally passing for both vehicles).

Passing 5th female/50th male combinations: The MY 1999 Econoline van, was tested in the driver low risk deployment test and the 48 kmph (30 mph) unbelted 50th male and unbelted 5th female rigid barrier crash tests. The results demonstrated that this vehicle was able to meet all the injury criteria requirements in all three types of tests on the driver side and meet the unbelted high speed requirements with the unbelted 50th male and unbelted 5th female on the passenger side.

The MY 1999 Ford Expedition also met all the injury criteria in the driver low risk deployment test and the 48 kmph (30 mph) unbelted 50^{th} male rigid barrier crash test. Unfortunately, due to time constraints, a MY 1999 Ford Expedition was not tested in a 48 kmph (30 mph) unbelted *5^{th} female* rigid barrier crash test to determine whether it would meet the injury criteria requirements.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

5.3 Compliance Margins

NHTSA's test of a MY 1999 Toyota Tacoma in a 48 kmph (30 mph) unbelted 50^{th} male rigid barrier crash test resulted in most injury criteria passing with a 20% margin of compliance. (The injury criteria exception was a driver left femur force of 8839 N (IARV = 10008 N) which had an 11% margin of compliance). Toyota commented that they internally tested a vehicle of the same model line, although equipped differently (4wd vs. 2wd, extra cab, etc.). Toyota stated that the vehicle no longer meets the requirements with any certifiable margin of compliance.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

NHTSA's test of the MY 1998 Ford Explorer in a 48 kmph (30 mph) unbelted 50^{th} male rigid barrier crash test passed all driver and passenger injury criteria with approximately a 20% margin of compliance. In response to the FMVSS No. 208 NPRM on advanced air bags (NHTSA-1998-4405-90), Ford stated that "...Ford conducted a barrier crash test of a different variant of the 1998 Explorer at 30 mph. That crash test found substantially different dummy criteria than the agency's test, including a driver chest acceleration of 58 G, compared to the agency's test result of 44 g. One probable reason for this difference in dummy criteria is the different power train configuration in the Ford test, although other factors such as test speed had some influence." [18, Attachment 1] NHTSA's crash test speed was 47.0 kmph (29.2 mph) and Ford's was 48.3 kmph (30.0 mph).

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

Discussion: LTVs are a growing portion of the vehicle fleet and consumers are purchasing LTVs with different option packages. These different option packages, such as 4L vs. 5L engine, 2wd vs. 4wd, and regular cab vs. extended cab may result in different 48 kmph (30 mph) high speed crash test performance. However, there is no restriction under FMVSS that requires all option packages of a given LTV model to have the same air bag system. If there is "significant" variation in occupant protection provided across a spectrum of option packages (such as a 32% increase in chest Gs due to increased engine mass, stiffness, etc.), manufacturers should not attempt to use a single air bag system for all option packages; they instead should design occupant restraint systems that are appropriate for each vehicle.

5.4 Improved Vehicle Crush Zones

One way to reduce the aggressivity of air bags is to improve the vehicle crush zone to reduce the amount of force transmitted to the occupant. However, vehicle manufacturers claim that FMVSS No. 208 testing for LTVs into a rigid barrier causes the structure to be stiff. The claim is that since LTVs weigh more on average than passenger cars, and have more kinetic energy to be dissipated in a crash, LTV structures need to be made stiffer in order to absorb this extra energy.

This claim was evaluated in NHTSA's report "Updated Review of Potential Test Procedures for FMVSS No. 208" [20, p. 4-4]. The paper states "...To evaluate this claim, the frontal stiffness of a passenger car was compared with the stiffness of an LTV of equal mass. Figure 4-3 compares the frontal stiffness of a 1996 Ford Taurus with a 1995 Ford Ranger pickup truck. Both vehicles were certified to the FMVSS No. 208 barrier test, and both vehicles are of approximately the same mass (1750 kg). However, note that the Ranger is substantially stiffer than the Taurus. At 250 mm of crush, the Taurus exerts approximately 250 kN of force while the Ranger exerts approximately 720 kN - nearly three times higher than the Taurus. Accordingly, there is no merit to the claim that LTVs must be stiffer because of their mass. The Taurus and Ranger are of equal mass, yet the Ranger design is decidedly stiffer and thus more aggressive. LTVs are not made stiffer because of the FMVSS 208 rigid barrier test. In fact, examination of NCAP results show that LTVs with less aggressive structures perform better in the NCAP full frontal rigid barrier test."

Vehicle manufacturers claim that trucks must also be stiffer for functional and utility reasons, such as ramp angle for sport utilities, carrying capacity and suspension ruggedness, etc. They claim that modifications to the crush zone to meet the unbelted 48 kmph (30 mph) rigid barrier crash test could deteriorate overall vehicle performance in achieving its market objectives. However, NHTSA's report "Updated Review of Potential Test Procedures for FMVSS No. 208" [20, Appendix, Table C-1 or plotted in Figure 4-2, Page 4-3] shows how vehicle manufacturers have great design latitude in how the rigid barrier requirement is met and how for any given vehicle weight, there is a wide range of average frontal stiffness values. Crash pulse improvements also may include shape modifications which do not necessarily affect stiffness. Therefore, vehicle manufacturers are not bound to only adjusting the energy absorbed by the restraint system in vehicle design.

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

Discussion: NHTSA's 48 kmph (30 mph) unbelted 50th male LTV rigid barrier crash tests have demonstrated that most of the LTVs tested are able to meet the injury criteria requirements with MY 1998-1999 "depowered" or "sled certified" air bag systems. Of the limited testing NHTSA has conducted with LTVs, the MY 1999 Econoline van already meets the high speed requirements for the unbelted 50th male and unbelted 5th female and the low risk deployment test procedure on the driver side. Similarly, the MY 1999 Ford Expedition also passed the 48 kmph (30 mph) unbelted 50th male rigid barrier test requirements and the driver low risk deployment test requirements. However, for some vehicles, modifications to the front structure of the vehicle and/or the occupant restraints may be required in order to absorb crash energy and cushion the load on the occupants. For other vehicles, improvements may be needed in the deployment characteristics of the passenger air bag or improvements to the knee bolsters for smaller occupants, such that large hyperextensions of the head/neck complex do not result.

6.0 Plans for Suppression System Implementation by Vehicle Manufacturers

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

7.0 References

[1] "Air Bag Technology in Light Passenger Vehicles", prepared by the Office of Research and Development, National Highway Traffic Safety Administration, October 26, 1999.

[2] Alliance of Automobile Manufacturers Comments to SNPRM, December 23, 1999, NHTSA Docket 1999-6407-40.

[3] Ford Motor Company Comments to SNPRM, December 22, 1999, NHTSA Docket 1999-6407-38.

[4] American Honda Motor Company, Inc. Comments to SNPRM, December 29, 1999, NHTSA Docket 1999-6407-59.

[5] General Motors Corporation Comments to SNPRM, December 22, 1999, NHTSA Docket 1999-6407-30.

[6] Consumers Union Comments to SNPRM, December 23, 1999, NHTSA Docket 1999-6407-52.

[7] Public Citizen Comments to SNPRM, December 30, 1999, NHTSA Docket 1999-6407-74.

[8] Isuzu Motors America, Inc. Comments to SNPRM, December 23, 1999, NHTSA Docket 1999-6407-43.

[9] DaimlerChrysler Corporation Comments to SNPRM, December 23, 1999, NHTSA Docket 1999-6407-44.

[10] Toyota Technical Center, USA, Inc. Comments to SNPRM, December 23, 1999, NHTSA Docket 1999-6407-47.

[11] Delphi Automotive Systems Comments to SNPRM, December 28, 1999, NHTSA Docket 1999-6407-77.

[12] National Transportation Safety Board Comments to SNPRM, January 3, 2000, NHTSA Docket 1999-6407-79.

[13] National Automobile Dealers Association Comments to SNPRM, December 30, 1999, NHTSA Docket 1999-6407-66.

[14] Syson-Hille and Associates Comments to SNPRM, December 27, 1999, NHTSA Docket 1999-6407-46.

[15] Insurance Institute for Highway Safety Comments to SNPRM, December 30, 1999, NHTSA Docket 1999-6407-67.

[16] The University of Michigan Transportation Research Institute (UMTRI) Comments to SNPRM, December 30, 1999, NHTSA Docket 1999-6407-71.

[17] BMW of North America, Inc. Comments to SNPRM, December 28, 1999, NHTSA Docket 1999-6407-72.

[18] Ford Motor Company Comments to NPRM, December 17, 1998, NHTSA Docket 1998-4405-90.

[19] Autoliv ASP, Inc. Comments to SNPRM, December 21, 1999, NHTSA Docket 1999-6407-33.

[20] "Updated Review of Potential Test Procedures for FMVSS No. 208", Prepared by the Office of Vehicle Safety Research, October 1999.

[21] "Final Economic Assessment, FMVSS No. 208 Advanced Air Bags", Prepared by the Office of Regulatory Analysis & Evaluation, Plans and Policy, National Highway Traffic Safety Administration, February, 2000.

Appendix A

Table A-1: 48 kmph (30 mph) Rigid Barrier Tests with Unbelted 50th Male Driver

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 63 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 4170 N	Neck Compr. IARV = 4000 N	Max. Femur IARV = 10008 N
MY 99 Dodge Intrepid	V3126	54.4	44.8	403	0.35 NTE	2039	208	7786 (R)
MY 99 Toyota Tacoma	V3128	43.7	48.4	176	0.25 NTF	1203	981	8839 (L)
MY 99 Acura 3.5 RL	V3125	56.9	31.8	154	0.24 NTF	756	104	**13349** (L)
MY 99 Saturn SL1	V3127	36.8	46.8	128	0.33 NTF	1123	207	5288 (R)
MY 99 Ford Econoline	V3123	52.1	37.1	87	0.22 NTF	1357	544	6198 (L)
MY 99 Ford Expedition	V3124	46.7	28.1	178	0.31 NTF	1361	183	6612 (R)
MY 99 Chevrolet Blazer	V3245	**63.1**	62.3	152	0.34 NTF	2189	202	8504 (R)
MY 98 Ford Taurus	V2832	47.2	21.9	181	0.27 NTF	1577	125	5556 (L)
MY 98 Dodge Neon	V2838	43.5	24.9	166	0.37 NTF	1265	293	7336 (R)
MY 98 Toyota Camry	V2837	51.8	38.1	231	0.37 NTF	1052	303	6115 (L)
MY 98 Honda Accord	V2836	36.7	45.8	51	0.22 NTF	824	259	7622 (R)
MY 98 Ford Explorer4L	V2839	44.4	32.3	272	0.21 NTE	1071	768	6033 (R)
MY 98 Plymouth	V2773	48.0	54.7	350	0.32 NTF	2096	206	7309 (L)
MY 98 Jeep Gr. Cherok.	V2830	46.1	41.6	189	0.38 NTF	2071	178	7366 (L)
Pre-production Prototype MY 00 Ford Taurus	V3150	**61.8**	58.4	159	0.28 NTF	1701	57	**10491** (R)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

Table A-2: 48 kmph (30 mph) Rigid Barrier Tests with Unbelted 50th Male Passenger

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 63 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Tension IARV = 4170 N	Compr. IARV = 4000 N	Max. Femur IARV = 10008 N
MY 99 Dodge Intrepid	V3126	54.1	25.7	223	0.35 NCE	957	1285	7890 (R)
MY 99 Toyota Tacoma	V3128	35.6	23.5	173	0.48 NTF	3038	766	6372 (R)
MY 99 Acura 3.5 RL	V3125	49.8	11.6	367	0.41 NCF	481	952	7676 (R)
MY 99 Saturn SL1	V3127	40.2	9.2	200	0.31 NTE	2023	615	6374 (L)
MY 99 Ford Econoline	V3123	45.8	7.3	226 [4]	0.32 NTF	630	634	8039 (R)
MY 99 Ford Expedition	V3124	51.0	19.6	132	0.31 NCF	926	1375	6975 (R)
MY 99 Chevrolet Blazer	V3245	51.8	15.1	289	0.34 NTF	1782	746	6019 (L)
MY 98 Ford Taurus	V2832	48.5	8.8	191	0.31 NCF	1305	990	5697 (L)
MY 98 Dodge Neon	V2838	**61.4**	16.0	297	0.38 NTF	2211	873	6606 (L)
MY 98 Toyota Camry	V2837	35.1	16.7	236	0.20 NTE	742	771	5273 (R)
MY 98 Honda Accord	V2836	45.0	13.1	160	0.36 NCF	413	976	4677 (L)
MY 98 Ford Explorer 4L	V2839	48.2	10.3	186	0.25 NCF	594	1009	6339 (R)
MY 98 Plym. Voyager	V2773	53.4	20.3	249	0.38 NTF	1354	674	8025 (R)
MY 98 Jeep Gr. Cherok.	V2830	49.2	12.2	84	0.41 NTF	1003	553	7921 (R)
Pre-production Prototype MY 00 Ford	V3150	52.6	7.0	268	0.52 NCF	400	2357	7278 (R)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

[4] Head z acceleration signal is bad. HIC15 computations did not include it.

Table A-3: 40 kmph (25 mph) Rigid Barrier Tests with Unbelted 50th Male Driver

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 63 mm	HIC15 IARV = 700	Final Rule Nij IARV=1.0	Neck Tension IARV = 4170 N	Neck Compr. IARV = 4000 N	Max. Femur IARV = 10008 N
MY 99 Dodge Intrepid	V3147	40.1	33.0	193	0.29 NTE	1545	194	7823 (R)
MY 99 Toyota Tacoma	V3146	42.8	46.1	96	0.25 NTF	1176	694	7281 (L)
MY 99 Acura 3.5 RL	V3145	34.7	35.7	62	0.21 NTF	426	440	5912 (L)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

Table A-4: 40 kmph (25 mph) Rigid Barrier Tests with Unbelted 50th Male Passenger

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 63 mm	HIC15 IARV = 700	Final Rule Nij IARV=1.0	Neck Tension IARV = 4170 N	Neck Compr. IARV = 4000 N	Max. Femur IARV = 10008 N
MY 99 Dodge Intrepid	V3147	48.1	18.3	83	0.29 NTF	1322	809	9017 (L)
MY 99 Toyota Tacoma	V3146	23.4	15.7	82	**1.01** NCE	547	2899	5236 (R)
MY 99 Acura 3.5 RL	V3145	32.5	17.4	119	0.41 NCF	371	802	6215 (R)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

Table A-5: 48 kmph (30 mph) Rigid Barrier Tests with Unbelted 5th Female Driver

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2620 N	Neck Compr. IARV = 2520 N	Max. Femur IARV = 6805 N
MY 99 Saturn SL1	V3113	37.0	31.1	106	0.31 NTF	990	20	3566 (L)
MY 99 Dodge Intrepid	V3118	56.6	**52.8**	139 [5]	**1.36 NTE**	1615	150	4778 (R)
MY 99 Toyota Tacoma	V3119	52.3	51.4	199	0.39 NTF	1328	490	6172 (R)
MY 98 Ford Taurus	V2905	48.2	35.5	202	0.58 NTE	1648	255	4490 (R)
MY 99 Acura RL	V3211	47.4	41.1	149	**1.29 NTE**	1656	58	3908 (R)
MY 99 Ford Econoline	V3213	43.1	25.5	110	0.93 NTE	1497	418	4911 (L)
MY 99 Chevrolet Blazer	V3222	44.5	40.3	105	0.32 NTF	1093	191	6131 (L)
Pre-production	V3212	46.9	**54.4**	84	0.59 NTE	1249	93	4379 (R)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

[5] The curve for z head acceleration has a spike at approximately 100 msec.

Table A-6: 48 kmph (30 mph) Rigid Barrier Tests with Unbelted 5th Female Passenger

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2620 N	Neck Compr. IARV = 2520 N	Max. Femur IARV = 6805 N
MY 99 Saturn SL1	V3113	44.7	15.2	276	0.62 NTF	1802	67	3259 (R)
MY 99 Dodge Intrepid	V3118	**62.2**	13.1	302	0.56 NCE	1441	612	5078 (L)
MY 99 Toyota Tacoma	V3119	42.2	4.2	380	**2.29 NTE**	**3921**	1042	5974 (L)
MY 98 Ford Taurus	V2905	39.6	5.8	236	0.85 NCE	807	1182	5878 (R)
MY 99 Acura RL	V3211	55.5	12.3	306	0.78 NCE	827	925	4630 (R)
MY 99 Ford Econoline	V3213	42.2	15.7	210	0.29 NTF	798	219	4473 (R)
MY 99 Chevrolet Blazer	V3222	45.7	10.9	255	**1.18 NCE**	1303	267	4080 (R)
Pre-production	V3212	**68.6**	12.4	315	0.45 NCF	839	490	4186 (R)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

Table A-7: 40 kmph (25 mph) Rigid Barrier Tests with Unbelted 5th Female Driver

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2620 N	Neck Compr. IARV = 2520 N	Max. Femur IARV = 6805 N
MY 99 Dodge Intrepid	V3122	40.5	32.1	99	0.30 NTF	900	227	4674 (R)
MY 99 Toyota Tacoma	V3115	50.5	40.5	238	0.52 NTF	1409	441	4712 (L)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

Table A-8: 40 kmph (25 mph) Rigid Barrier Tests with Unbelted 5th Female Passenger

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2620 N	Neck Compr. IARV = 2520 N	Max. Femur IARV = 6805 N
MY 99 Dodge Intrepid	V3122	35.1	4.6	121	0.47 NCE	759	322	4324 (R)
MY 99 Toyota Tacoma	V3115	34.1	3.7	143	**1.82 NTE**	2203	985	5419 (L)

[Additional information withheld pursuant to 5 U.S.C. §552(b)(4)]

Table A-9: Driver Low Risk Deployment Test, Position 1

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2070 N	Neck Compr. IARV = 2520 N
MY 98 Honda Accord	B3791	15	19	N/A	**1.24**	1667	4
MY 98 Toyota Camry	B3787	15	19	30	**1.27**	1537	4
MY 98 Dodge Neon	B3793	24	26	32	**1.73**	1759	255
MY 98 Ford Taurus	B3783	15	17	133	**1.62**	1446	4
MY 98 Ford Explorer	B3782	14	19	16	**1.20**	1338	88
MY 99 Saturn SL1	B4002	20	26	28	0.26	89	3
MY 99 Toyota Tacoma	B4004	22	22	107	**1.17**	336	17
MY 99 Ford Econoline	B4005	14	22	13	0.98	141	18
MY 99 Acura 3.5 RL	B4008	18	30	221	**1.34**	162	7
MY 99 Ford Expedition	B4009	11	20	8	0.99	136	8
MY 99 Dodge Intrepid	B4011	24	27	24	0.71	172	16

Table A-10: Driver Low Risk Deployment Test, Position 2

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 52 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 2070 N	Neck Compr. IARV = 2520 N
MY 98 Honda Accord	B3792	26	45	60	0.65	1621	13
MY 98 Toyota Camry	B3788	32	33	28	0.80	1387	55
MY 98 Dodge Neon	B3794	34	34	433	**1.02**	774	**3670**
MY 98 Ford Taurus	B3784	28	39	14	0.99	1143	10
MY 98 Ford Explorer	B3779	14	22	8	**1.07**	815	74
MY 99 Saturn SL1	B4001	23	36	61	0.37	103	13
MY 99 Toyota Tacoma	B4003	30	31	59	0.66	204	18
MY 99 Ford Econoline	B4000	25	33	66	0.30	64	12
MY 99 Acura 3.5 RL	B4007	26	29	40	0.63	116	11
MY 99 Ford Expedition	B4010	32	37	9	0.34	72	10
MY 99 Dodge Intrepid	B4006	40	47	10	0.58	88	43

Table A-11: Six-Year-Old Hybrid III Child Dummy, Low Risk Deployment Test, Position 1

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 40 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 1490 N	Neck Compr. IARV = 1820 N
MY 98 Honda Accord	B3760	37	40	132	**2.11**	**2591**	**1899**
MY 98 Toyota Camry	B3754	33	11	213	**3.79**	**3351**	330
MY 98 Dodge Neon	B3744	22	**42**	172	**2.75**	**3111**	222
MY 98 Ford Taurus	B3739	**64**	**50**	**1854**	**2.84**	**7352**	59
MY 98 Ford Explorer	B3765	50	**50**	387	**6.16**	**4612**	6
MY 98 Dodge Caravan	B3771	31	**51**	493	**3.41**	**3971**	516
MY 99 Saturn SL1	B4037	23	**44**	35	0.93	**1799**	97
MY 99 Toyota Tacoma	B4038	18	22	145	**3.44**	**3509**	201
MY 99 Ford Econoline	B4039	50	**45**	428	N/A	N/A	N/A
MY 99 Acura 3.5 RL (stage 1+2 w/ 40 msec delay)	B4045	19	11	193	**1.31**	1213	249
MY 99 Acura 3.5 RL	B4046	19	7	87	0.94	1223	113
MY 99 Ford Expedition	B4044	39	**50**	144	**1.04**	1296	285
MY 99 Dodge Intrepid	B4048	59	**42**	149	**2.89**	**3479**	61

Table A-12: Six-Year-Old Hybrid III Child Dummy, Low Risk Deployment Test, Position 2

Vehicle	Test #	Chest G IARV = 60 G	Chest Defl. IARV = 40 mm	HIC15 IARV = 700	Final Rule Nij IARV = 1.0	Neck Tension IARV = 1490 N	Neck Compr. IARV = 1820 N
MY 99 Saturn SL1	B4036	45	**43**	76	**2.05**	**2548**	192
MY 99 Toyota Tacoma	B4041	41	18	246	**2.54**	**4048**	359
MY 99 Ford Econoline	B4040	**65**	34	429	**2.29**	**2820**	5
MY 99 Acura 3.5 RL	B4035	18	3	101	0.83	1125	1482
MY 99 Acura 3.5 RL	B4047	16	9	113	0.93	1143	1497
MY 99 Ford Expedition	B4043	**86**	**45**	131	**2.33**	**3436**	459
MY 99 Dodge Intrepid	B4042	**69**	40	627	**3.39**	**4834**	239

Appendix B

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

Appendix C

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

[Information withheld pursuant to 5 U.S.C. §552(b)(4)]

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