

**AN ANALYSIS OF THE RESULTS OF NHTSA TESTS
USING THE TWG RECOMMENDED PROCEDURES
FOR EVALUATING OCCUPANT INJURY RISK FROM
DEPLOYING SIDE AIRBAGS**

Prepared
by the
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of the
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EXECUTIVE SUMMARY

Between August 2000 and October 2001, The National Highway Traffic Safety Administration (NHTSA) ran 177 tests to evaluate the efficacy of the test procedures developed by the Side Airbag Out-of-Position Technical Working Group (TWG). Their findings were presented at the first follow-up industry-wide review of the TWG Procedures in October of 2001 and were documented in a report, dated January 18, 2002, and titled "Side Air Bag Research: Static Testing of Side Impact Air Bags Using Three and Six Year Old Hybrid III Dummies and the 12 Month CRABI Dummy". At the industry-wide review, the TWG chartered a Subcommittee, known as the Comparison of Procedures Subcommittee (CoPS) to evaluate the NHTSA's test data and to report back to the TWG with any recommended modifications to the test procedures.

The NHTSA report described several additional test positions, which were claimed to increase the likelihood of identifying airbags that may produce more severe loads to out-of-position occupants when compared with the TWG procedures. The NHTSA report also concluded that two of the vehicles evaluated in their test program exceeded injury thresholds using the NHTSA procedures, but did not with the TWG procedures (Geo Prizm and Volvo S-80, neither of which had been designed to meet the TWG Procedures since they were built before the Procedures were written).

In light of these conclusions, the CoPS performed a detailed analysis of the NHTSA test data and documentation. This review indicated that the NHTSA author's conclusions were not supported by that data.

First, the data review indicated that the Geo Prizm results, in fact, did not exceed any injury thresholds. The value stated in the NHTSA report as having been exceeded was the Neck Twist Moment. But, the CoPS found that the value for the Neck Twist Moment in the report differed from the value found in the raw data. Thus, the claim appears to have been reported in error.

Second, the NHTSA test program did not include all of the TWG tests for the side airbag in the Volvo S-80, and the some of the tests that were performed were not done as specified in the TWG procedures. If the full set of TWG tests had been performed, and/or if the tests had been performed as intended, the TWG Procedures may have reached the same conclusion as the NHTSA tests. However, a complicating factor remained in that the Neck Twist Moment value exceeded in the NHTSA tests, is an injury research value, not an injury reference value. It cannot be said that an airbag that exceeds a research value fails or doesn't pass the TWG recommendations.

The CoPS also found that the additional NHTSA test positions do not represent significantly different test positions, but rather are minor variations of one of the TWG Positions. These positions are therefore, likely to be considered by manufacturers as part of their "due care" testing.

Nevertheless, the NHTSA went through considerable effort and clearly gave considerable thought to their evaluation of the TWG procedures. The following recommendations were made based on other details in the NHTSA report:

Recommendations

- The CoPS recommends that the TWG consider modifying the TWG Procedures section on general considerations to add wording that specifically calls out, for example, altering seat track adjustment or seatback angle in such a way as to achieve the intent of each TWG test position.

Endnote

The CoPS concluded that the fact that the NHTSA ran 177 tests and had a single, inconclusive discrepancy between the TWG Procedures and the NHTSA's modified Procedures, is indicative of, and reaffirms, the robustness of the TWG Procedures.

Foreword

On August 8, 2000, the Side Airbag Out-of-Position Injury Technical Working Group (hereafter, TWG or the TWG) published a document titled "Recommended Procedures For Evaluating Occupant Injury Risk From Deploying Side Airbags". The document represented an industry-wide consensus on voluntary test procedures and injury "reference values" to help assure that the risk of injury from deployment of side impact airbags remains very low. It also included a set of "research values" for additional injury parameters that manufacturers were recommended to monitor as they develop new side airbag systems. The TWG concluded that side airbags designed in accordance with all the test procedures and meeting the injury reference values would have very low OOP injury risk. All manufacturers agreed to design future airbag systems according to these recommendations.

The National Highway Traffic Safety Administration (NHTSA) subsequently ran a test program to evaluate the TWG procedures under a variety of conditions, and with a number of different vehicles from a cross-section of manufacturers and vehicle classes. As part of this research NHTSA also created and tested some of its own positions to determine whether the TWG procedures were sufficiently robust. The purpose of the NHTSA testing was to assess whether additional test positions might need to be specified.

Preliminary data from the NHTSA tests were presented by Alope Prasad at the first follow-up industry-wide review of the TWG procedures on October 25, 2001, sponsored by the members of the TWG. Although generally supportive of the TWG test procedures, Mr. Prasad reported that NHTSA had found two vehicles whose side airbags would pass all the TWG tests but not certain additional tests designed by NHTSA. As a result of that claim, a subcommittee of the TWG was chartered, now known as the Comparison of Procedures Subcommittee (hereafter, CoPS). The mission of the CoPS was to evaluate the NHTSA's test data and to report back to the TWG with any recommended modifications to the test procedures. This document represents the results of that evaluation.

The NHTSA Conclusions

Activities of CoPS necessarily waited until NHTSA data were available for review. These data were subsequently published in a report titled "Side Air Bag Research: Static Testing of Side Impact Air Bags Using Three and Six Year Old Hybrid III Dummies and the 12 Month CRABI Dummy" by Alope K. Prasad and Randa R. Samaha from the NHTSA, and Allison E. Loudon from the Transportation Research Center, Inc. and dated January 18, 2002. The crash dummy sensor data and high-speed video data were made available electronically via the NHTSA website on March 22, 2002. In that report, NHTSA reported the following conclusions, reprinted verbatim and *in toto* here:

1. *TWG procedures are generally capable of discriminating air bag systems over a wide variety of systems.*
2. *Certain TWG positions may not be attainable in some vehicles. This would indicate that a set of generic positions may not be suitable for all vehicles. Variations based on SAB location, deployment path, and bag size and shape may be necessary.*
3. *Certain TWG positions are not expected to produce any significant loads on the dummies*

- in the vehicles included in this study.*
4. *Several vehicles exceeded injury thresholds with the NHTSA procedures but did not with the TWG procedures.*
 5. *Some additional positions increase the likelihood of identifying air bags which may produce more severe, and potentially injurious, loads on OOP occupants:*
 - a. *NHTSA Seat-02-3 and NHTSA Seat-07-3: locates the head CG closer to the air bag*
 - b. *NHTSA Door-04-3 and NHTSA Door-06-3: adds leaning sideways condition for 3 YO in door mounted systems (not included in TWG procedures)*
 - c. *NHTSA Seat-04-6 and NHTSA Seat-05-6: adds leaning sideways condition for 6 YO in door mounted systems (not included in TWG procedures)*
 - d. *NHTSA Door-01-6: adds back against the door condition for 6 YO in door mounted systems (not included in TWG procedures)*
 6. *Tests with in-position, properly restrained occupants in forward and rear facing child restraints did not produce high loads.*
 7. *High loads are possible in out of position children in belt positioning boosters in vehicles with door mounted bags, even in the rear seat.*
 8. *Considerable efforts were spent in locating the correct replacement parts for the side air bag systems (module, mounting hardware, etc.).*

Not all of these conclusions indicate any difficulty for the TWG recommended test procedures. The last bullet point reflects logistical difficulties unrelated to the adequacy of test procedures. Conclusions 1 and 6 generally confirm the position of the TWG, that the procedures will discriminate side airbag system injury risk to OOP occupants and that tests of injury potential from inadvertent deployment for in-position children are not useful. Conclusion 3 reflects the fact that the location of seats and side airbags in some vehicles will mean that some test positions are not dangerous for OOP occupants. However, these positions are included in the TWG's recommendations for completeness, because other side airbag systems do (or could, with foreseeable changes in design) pose a risk for these test positions.

Of concern to CoPS were conclusions 2, 7, and particularly 4 and 5, which suggest that, although generally adequate, there might be some need to improve, change, or add to the recommended test procedures. These issues are the focus of this report.

Before delving into the body of this report, it is important to clarify the meaning of the word "passing" when used in connection with the TWG procedures. "Passing" the TWG procedures implies that the full battery of tests prescribed for a specific type of airbag system had been performed (e.g., for a seat mounted side airbag all 7 tests were performed and "passed" without a single failure). Specifically, "passing" the TWG procedures also requires that all dummy responses, in the given battery of tests, remained below injury **reference** values. As noted above, while the TWG procedures also provide injury **research** values as a means to further understand the performance of the airbag system, as of the writing of these procedures, these values remain preliminary because they have not been fully proven in the scientific community. For this reason, using the TWG procedures, the decision to modify an airbag system based on the injury **research** values was left to the discretion of the manufacturers. These issues are both important because, as will be seen in the detailed discussion below, NHTSA's conclusion 4, that "*Several*

vehicles exceeded injury thresholds with the NHTSA procedures but did not with the TWG procedures,” refers to thresholds for research rather than reference injury measures and rests on an incomplete inventory of TWG tests.

NHTSA TEST RESULTS

To evaluate the robustness of the TWG Procedures, the NHTSA performed selected TWG tests and some tests with its own positions. There were only two vehicles in which initial review of the data suggested that these air bag systems would have met or "passed" the TWG Procedures but not the NHTSA modified procedures. For all other vehicles tested, the end result was the same; that is, air bag systems that failed to meet the NHTSA tests also failed to meet some part of the set of applicable TWG tests (although not necessarily for the same injury measures). As a result, in these cases the NHTSA modified procedures did not add any additional discrimination capability.

The CoPS review focused on the two vehicles in which NHTSA tests using the NHTSA procedures appeared to identify problems that were not identified in NHTSA tests using the TWG procedures. The two vehicles were the 1999 Chevy/Geo Prizm and the 1999 Volvo S-80. It is important to note that neither of these vehicles (nor any of the remaining vehicles tested by NHTSA) was developed using the TWG procedures because they were designed before the procedures were available.

For both the Prizm and the S80, the discrepancy between tests with the NHTSA Positions and tests with the TWG Positions occurred for the Neck Twist Moment (M_z) in the 3-year-old child dummy. The value exceeded for the 1999 Chevy/Geo Prizm was the Lower Neck Twist Moment (NHTSA Position Seat 03-3/Test A01_34). The value exceeded for the 1999 Volvo S-80 was the Upper Neck Twist Moment (NHTSA Position Seat 10-3/Tests A01_73 and A01_178). It should be noted that the both the upper and lower Neck Twist Moments are injury *research* values, not injury *reference* values. However, because these research values were said to differ greatly between the TWG and NHTSA test positions, the source of the discrepancy was examined further to see if it nevertheless suggested the need for some change in the TWG test procedures.

COMPARISON OF TWG TESTS AND NHTSA TESTS

The first analysis done by the CoPS was to determine which tests had been run by the NHTSA and compare those to the tests recommended by the TWG Procedures. Table 1 shows an excerpt from the NHTSA report of all of the tests listed that were done for the 3-year-old child dummy in the Prizm and S-80. Table 2 shows the complete set of tests for a seat-mounted airbag as defined by the TWG Procedures.

As seen in Tables 1 and 2, the NHTSA performed only two of the seven required TWG tests. The TWG specifies three positions alone to assess the risk of neck injury to a small child from the deploying airbag (Positions 3.3.2.1, 3.3.2.3 and 3.3.2.4) . TWG Position 3.3.2.1 was the only one of these three positions that was run in the NHTSA test series. Tests 3.3.2.3 and 3.3.2.4 were

Table 1
All Tests Run by the NHTSA on the Chevy/Geo Prizm and Volvo S-80

Test ID	Test Position	Vehicle	Bag Type	Test Type
A01_07	TWG 3.3.2.2	1999 Prizm	Seat	Chest
A01_19	TWG 3.3.2.2	1999 Prizm	Seat	Chest
A01_151	TWG 3.3.2.2	1999 Prizm	Seat	Chest
A01_08	TWG 3.3.2.1	1999 Prizm	Seat	Neck/Head
A01_34	NHTSA Seat-03-3	1999 Prizm	Seat	Neck/Head
A01_72	TWG 3.3.2.2	1999 S-80	Seat	Chest
A01_73	NHTSA Seat-10-3	1999 S-80	Seat	Neck/Head
A01_178	NHTSA Seat-10-3	1999 S-80	Seat	Neck/Head
A01_74	NHTSA Seat-03-3	1999 S-80	Seat	Neck/Head
A01_75	NHTSA Seat-04-3	1999 S-80	Seat	Neck/Head
A01_76	NHTSA Seat-07-3	1999 S-80	Seat	Neck/Head
A01_152	TWG 3.3.2.1	1999 S-80	Seat	Neck/Head
A01_153	TWG 3.3.2.1	1999 S-80	Seat	Neck/Head

not run by the NHTSA for either the Chevy/Geo Prizm or Volvo S-80. TWG Position 3.3.2.2 is a test intended primarily to examine interaction of the deploying airbag with the dummy's chest and resulted in all dummy responses below the limit values. Thus, until tests with the remaining TWG Positions have been conducted and the data reviewed, **it would appear premature to conclude that the NHTSA tests with the TWG Procedures gave conflicting results since not all of the TWG tests were run. Had the full set of TWG tests been conducted it is possible that one of the other head/neck interaction tests would have produced neck loads that exceeded one or more TWG injury reference or research values.**

Nevertheless, the CoPS agreed to examine the results of the tests that were performed.

- Chevy/Geo Prizm Data Analysis

Figure 1 shows the neck load results of the Chevy/Geo Prizm in TWG Position 3.3.2.1 (Test A01_08) and NHTSA Position Seat 03-3 (Test A01_34) as reported by the NHTSA. The data show that the lower neck twist moment was exceeded by a result that was 1.7 times the limit value. This was the only value in any of the Prizm tests that exceeded the limit value. In fact, this data point appeared to stand alone in the bar graphs of the results. Given this interesting finding, the time-history data provided by the NHTSA (Figure 2) was examined. Based on that data, the peak lower neck twist moment was approximately 10 Nm, as shown in Figure 2. The limit value of 17 Nm had, in reality, not been exceeded.

The source of this error is not known to the CoPS (transcription, typographical, etc), but the time-history data are the primary source of all resulting injury indices and are presumably the most accurate. **Thus, contrary to the conclusion in the NHTSA report, the NHTSA revised position in the Chevy/Geo Prizm did not identify any significant additional OOP injury risk compared with the baseline TWG Position.**

Table 2
Tests Recommended for Seat Mounted Airbags by TWG Procedures

DUMMY	SECTION	TEST POSITION	BODY REGION MONITORED	TESTS RUN BY THE NHTSA
Hybrid III 3-year-old	3.3.2.1	Forward facing on booster seat	Head, neck	■
	3.3.2.2	Rearward facing	Head, neck, thorax	■
	3.3.2.3	Lying on seat, head on armrest	Head, neck	
	3.3.2.4	Lying on seat	Head, neck	
Hybrid III 6-year-old	3.3.2.5	Forward facing on booster seat	Head, neck	
SID-IIs	3.3.2.6	Inboard facing	Head, neck, thorax, abdomen, pelvis	
	3.3.2.7	Arm on armrest w/instrumented arm	Arm, forearm	

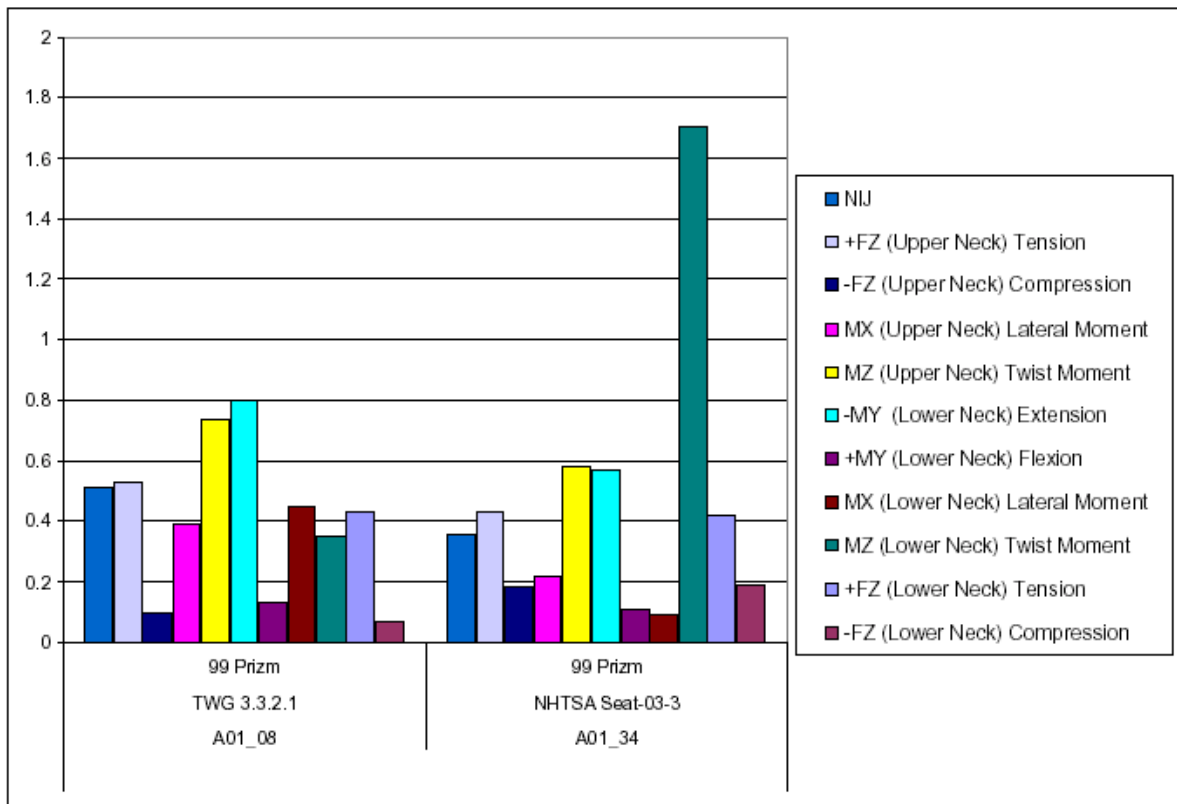


Figure 1. Results reported by the NHTSA for Tests A01_08 and A01_34.

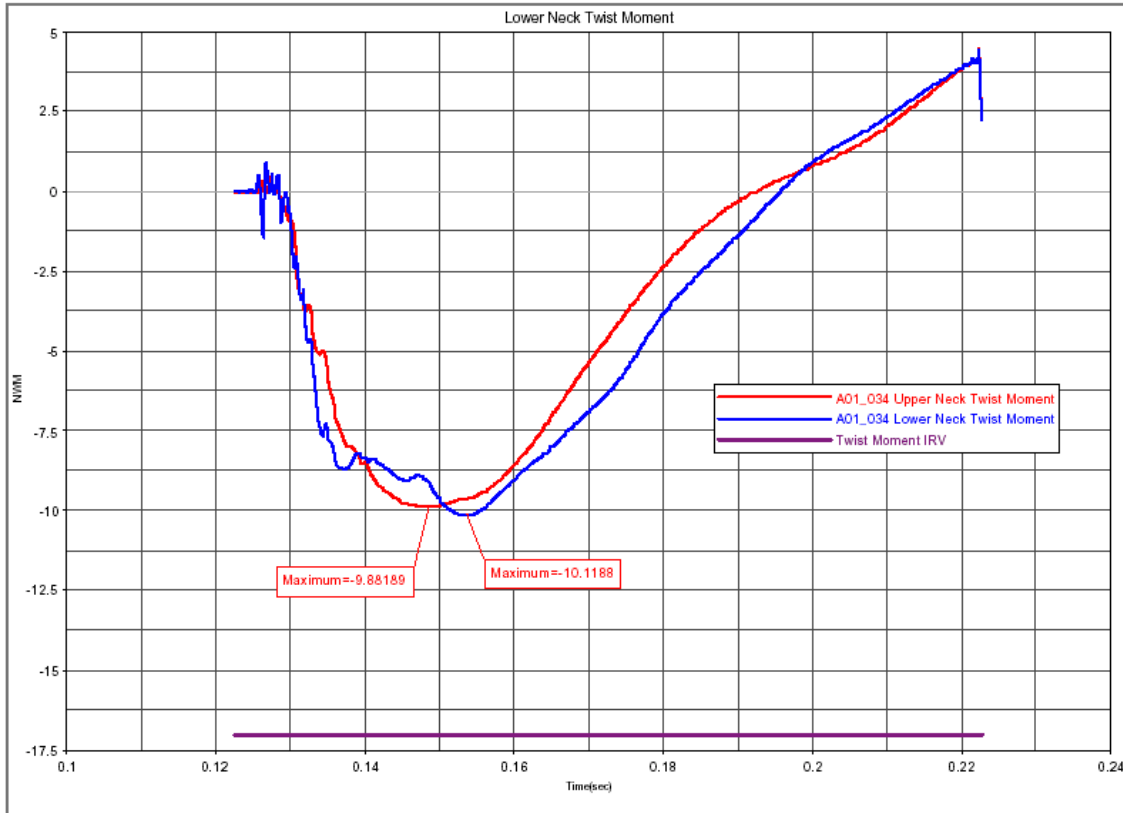


Figure 2. Neck twist moment time-history data from test A01_34 compared with the limit value (straight line at bottom of graph).

- Volvo S-80 Data Analysis

Figure 3 shows the neck load results of the Volvo S-80 in TWG Position 3.3.2.1 (Tests A01_152 and A01_153) and in NHTSA Position Seat 10-3 (Tests A01_73 and A01_178). In both tests with the NHTSA positions, the upper neck twist moment research value was exceeded. In addition, the lower neck extension moment was close to the research value in Test 73. The data were not close to any of the reference or research values in either test with the TWG positions. This difference led us to dig deeper into the data and to request the time-history data and high-speed video data from these tests. This was provided by the NHTSA on their website and also by CD-ROM.

From a review of the photographic documentation of the NHTSA's evaluation of TWG Position 3.3.2.1, it appears that the dummy was not positioned as specified for TWG position 3.3.2.1. Figure 4 shows the test setups for the tests A01_152 and A01_153 (NHTSA's TWG tests). Several important observations can be made when reviewing these photographs. First, TWG Position 3.3.2.1 instructions call for the laboratory to setup the test such that:

6. With the vehicle door closed and the dummy's right arm raised (to clear armrest), slide the pelvis and upper torso outboard until pelvis or torso contact the door. The neck/torso junction may shift down no more than 20 mm during the process.

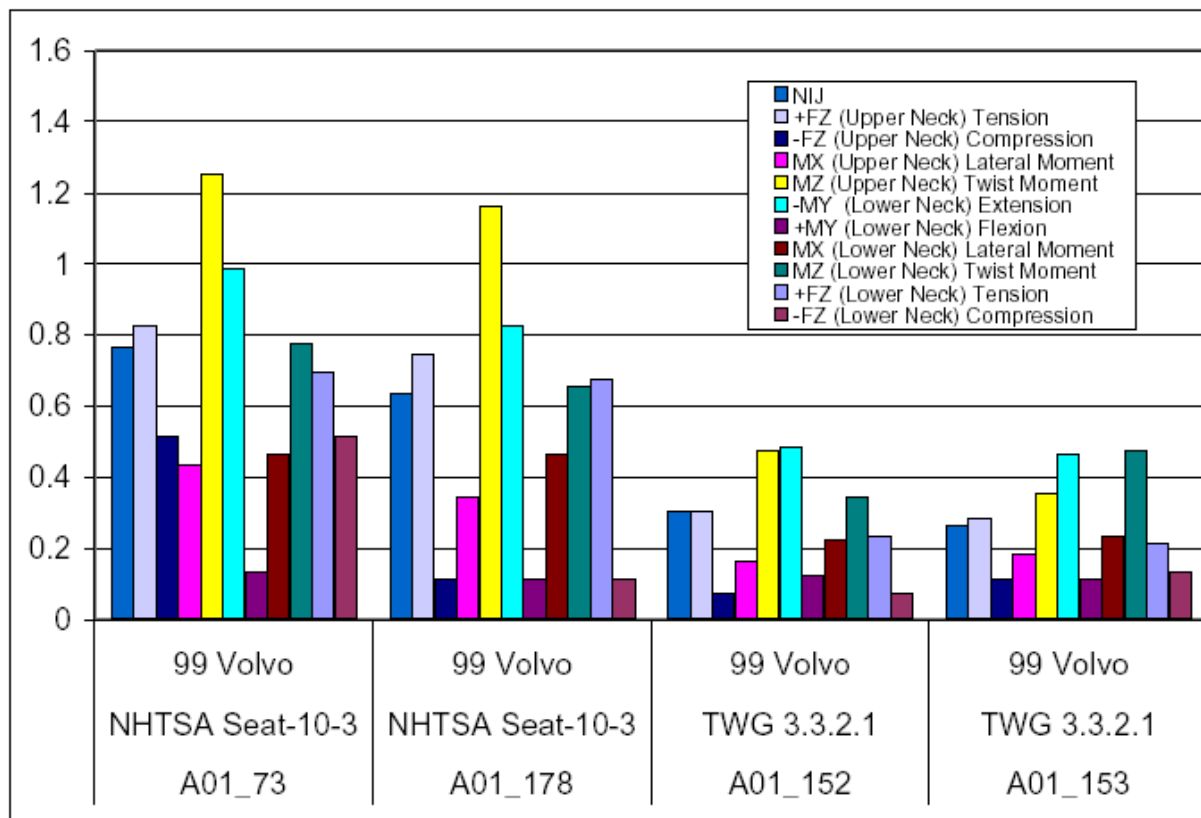


Figure 3. Results reported by the NHTSA for Tests A01_73, A01_178, A01_152 and A01_153.

7. Place the right arm on the armrest.

Neither of these conditions was met in the NHTSA tests (see photographs of dummy position for Tests A01_152 and A01_153).

In short, the NHTSA tests did not accurately reflect the TWG position by not bringing the torso or pelvis into contact with the door and by not placing the arm on the armrest. Much of this was noted in details of the NHTSA report. However, **since the TWG Procedures were not carried out as intended, the conclusion that the NHTSA Positions were more discriminating may not be accurate.**

Figure 5 shows the TWG Position 3.3.2.1 setup as depicted in the TWG Procedures document dated August 8, 2000. The seat back position is clearly more upright in TWG Position 3.3.2.1 than in the NHTSA Position Seat 10-3. Further examination of the differences between TWG Position 3.3.2.1 and NHTSA Position 10-3 revealed them to be identical except for the seat back recline (one notch more recline in the NHTSA position than the TWG position). **Thus, this NHTSA Position does not represent a significantly different test position, but rather is a minor variation of TWG Position 3.3.2.1.**



Figure 4. Test setups in NHTSA tests.



Figure 3.3.2.1.1 Forward Facing Hybrid III 3-year-old Child Dummy on Booster Block Leaning Against Door Trim Panel

Figure 5. TWG Positioning for test 3.3.2.1.

Still, one might argue that using these test variations, the NHTSA did find a few positions that produced dummy loads higher than those obtained with TWG Position 3.3.2.1. In fact, as noted in the Foreword to this report, the NHTSA concluded that: *"Some additional positions increase the likelihood of identifying air bags which may produce more severe, and potentially injurious, loads on OOP occupants (see Appendix):*

- *NHTSA Seat-02-3 and NHTSA Seat-07-3: locate the 3 YO head CG closer to the air bag*
- *NHTSA Door-04-3 and NHTSA Door-06-3: add leaning sideways condition for 3 YO in door mounted systems (not included in TWG procedures)*
- *NHTSA Seat-04-6 and NHTSA Seat-05-6: add leaning sideways condition for 6 YO in door mounted systems (not included in TWG procedures)*
- *NHTSA Door-01-6: adds back against the door condition for 6 YO in door mounted systems (not included in TWG procedures)*

While the CoPS agree with that basic conclusion, **this does not indicate that the NHTSA procedures are more robust than the TWG Procedures as a whole.** The TWG Procedures are, by their very nature, generic so that all manufacturers may have a template by which to perform their tests. Thus, when the TWG developed its procedures it anticipated that minor

deviations from the nominal position might actually represent a worse condition for that specific vehicle/air bag system. As a result, the TWG included in its procedure the following precautionary statements:

Section 2 **Scope of Recommendations**

“The test procedures in this report provide as comprehensive an evaluation as possible for current state-of-the-art air bag designs. However, only sound engineering judgment can guarantee the comprehensive evaluation of any design. Additional tests, with slight variations of the recommended dummy positions, may be needed to ensure the robustness of the occupant interaction measures”.

Section 3.3 **Test Procedures**

“In general, these test positions have been chosen to represent nominal ‘worst case’ occupant positions, relative to the side airbags. They represent potentially dangerous rather than common positions occurring among the traveling public. Each manufacturer should evaluate whether that is the case for their particular system and modify the test positions as appropriate.”

Then, the NHTSA Positions, which are relatively minor variations of the baseline TWG Positions, are likely to be considered by manufacturers as part of their “due care” testing.

Still, the NHTSA obviously gave considerable thought to the ways in which airbag loading might interact with a dummy under various conditions. And, their tests did reveal a parameter (seat back angle) that was not explicitly discussed in the TWG document. The CoPS agrees that this parameter could be helpful in guiding manufacturers as to potential modifications to the TWG Positions that could result in more severe loading to the dummy. **The CoPS, therefore, recommends that the TWG consider modifying the TWG Procedures section on general considerations to add wording that specifically calls out, for example, altering seat track adjustment or seatback angle in such a way as to achieve the intent of each TWG test position.**

OTHER CONCLUSIONS FROM THE NHTSA PRESENTATIONS AND REPORTS

In the presentation to the TWG in October 2001, the NHTSA commented on the lack of tests in the TWG procedures that use the 12-month old CRABI dummy or the 95th percentile male dummy. The CoPS examined this issue and found that the rationale for these omissions is indicated in the August 2001 Revision of the TWG Procedures document as follows:

- Page 6, 1st paragraph, last 2 sentences: *“For infants and toddlers (1-2 years), it is expected that the majority will increasingly be restrained in appropriate child restraints. The location of these restraints place them out of the path of deploying side airbags.”* (NHTSA's own tests revealed that "Tests with in-position, properly restrained occupants in forward and rear facing child restraints did not produce high loads").

- Page 6, 1st paragraph, 3rd sentence: *“The Side Airbag Out-of-Position Injury Technical Working Group focused principally on the risk of injury to small women, adolescents, and children. Even these occupants have low risk of injury from side airbag systems because the small size of side airbags means that occupants must be in the deployment path and near the module when the airbags deploy. Large adults and infants are expected to be at even lower risk due to size and/or position in the vehicle seat.”*

- Page 6, 2nd paragraph, last sentence: *“These observations led the Technical Working Group (TWG) to conclude that the risk of side airbag inflation injury can be assessed using dummies representing the small female (and adolescents), the 6-year-old child, and the 3-year-old child. However, the TWG encourages vehicle manufacturers and their suppliers to verify whether these conclusions are appropriate for a given vehicle configuration. If a particular system places a larger adult’s head nearer the airbag deployment area than achieved by the small female or places a restrained child in a child seat in the deployment path, then this new risk should be assessed.”*

In addition, several of the procedures require the small female dummy to be raised up in the seat to "maximize the head/neck interaction by positioning the head in the path of the deploying airbag". The procedure uses the 5th percentile female specifically in this position because, while the 95th percentile male is easier to get into the position, the injury reference values for the 5th percentile female are actually lower than those for the 95th percentile male. That makes the use of the 5th percentile female more conservative.

In summary, the dummies selected by the TWG were specifically chosen because they represent vehicle occupants known to be at greatest risk of injury in the positions tested. The procedures call for sound engineering judgment to be used and other dummy sizes to be included if it is believed that they would represent a more severe interaction than the prescribed tests.

GENERAL DISCUSSION

Regulatory versus Due Care Views

There appears to be a different emphasis in the application of the TWG Procedures between the NHTSA and the TWG signatories. With a regulatory emphasis, every test is spelled out in great detail and must be performed precisely as prescribed in the regulation. With a due care emphasis, the intent of each test is assessed before it is performed. If engineering judgment indicates that a slight variation of the procedure would result in a test that better matches the intent, then the modified test is run instead. The TWG procedures have been developed with the due care emphasis in mind.

Robustness of the Procedures

It appeared that the NHTSA judged the Prizm based on one test with each Position. Transport Canada has run a number of tests, which showed that some interactions are not consistent. For example, Transport Canada routinely takes care to clean and powder the dummy's head skin and

to route any cables out of the anticipated path of the deploying airbag. Yet, in some tests they have noted high dummy twist moments while in other nominally identical tests they have not.

Given the above, the CoPS recommends addition of a qualifier in the appropriate place in the TWG Procedures document that states that if a manufacturer runs a single test and the results of some of the measurements are "close to the limit values", then the airbag design should be re-evaluated in the context of other testing performed, including in-position testing, to ascertain if there is a need to redesign it. The CoPS also recommends that the definition of "close to the limit values" be left up to the manufacturer.

Research versus Reference Values

The goal of the TWG in establishing research values was not to imply that they would eventually be part of the reference values, nor that they hold the same weight as reference values. The central purpose was that these measurements should be taken IN CASE problems began to turn up for airbags that meet the reference values. It is generally believed that such data would be useful in understanding that situation.

Such a finding might also justify additional research and development activity that would be necessary to support these research values. Thus, evidence that some airbags might exceed some research values by some amount is not necessarily worrisome. The only time this might be an issue, is if the amount by which the research value is exceeded is very large. Again, it is generally believed that this would be an indication to an automaker that additional testing and/or research was necessary, and it probably would not occur without exceeding or coming very close to at least one of the other values in one of the recommended tests.

With that understanding, **it cannot be said that an airbag that exceeds a research value fails or doesn't pass the TWG recommendations.** It is important to note that these voluntary guidelines are more comprehensive than most existing regulations. For example, the FMVSS and CMVSS, have only 2 out-of-position driver test positions. Likewise, the TWG procedures and limit values follow from significantly more research, typically with larger sample sizes, than most existing regulations.

In addition, the TWG has committed to reconvening periodically to review the state of research. The TWG has agreed to review new information that comes to light through continuing research and to incorporate such information into the TWG procedures document as appropriate. The October 2001 meeting and this report are clear demonstrations of that commitment.

Finally, it is the considered opinion of the CoPS that, the fact that the NHTSA ran 177 tests and had a single, inconclusive discrepancy between the TWG Procedures and the NHTSA's modified Procedures, is indicative of, and reaffirms, the robustness of the TWG Procedures.

CONCLUSIONS AND RECOMMENDATIONS

The NHTSA went through considerable effort and clearly gave considerable thought to their evaluation of the TWG procedures. The following conclusions and recommendations are based on a detailed review of the results of those tests as reported by the NHTSA.

Conclusions

- The NHTSA ran only 2 of the 4 recommended tests for seat-mounted airbags using the Hybrid III 3-year-old dummy. It would appear premature to conclude that the NHTSA tests with the TWG procedures gave conflicting results since all of the TWG tests were not run. Had the full set of TWG tests been conducted it is possible that one of the other head/neck interaction tests would have produced neck loads that exceeded the injury research values too.
- Contrary to the conclusion in the NHTSA report, the NHTSA revised position in the Geo Prizm did **not** identify any significant additional OOP risk compared with the baseline TWG position.
- Since **the TWG Procedures were not carried out as intended**, the conclusion that the NHTSA Procedures gave different results from the TWG Procedures for the Volvo S-80 may not be accurate.
- NHTSA Positions 04-3, 07-3 and 10-3 do not represent significantly different test positions, but rather are minor variations of TWG Position 3.3.2.1, and are therefore, likely to be considered by manufacturers as part of their "due care" testing.
- The dummies selected by the TWG were specifically chosen because they represent vehicle occupants known to be at greatest risk of injury in the positions tested. The procedures call for sound engineering judgment to be used and other dummy sizes to be included if it is believed that they would represent a more severe interaction than the prescribed tests.
- It cannot be said that an airbag that exceeds a research value fails or doesn't pass the TWG recommendations
- The fact that the NHTSA ran 177 tests and had a single, inconclusive discrepancy between the TWG Procedures and the NHTSA's modified Procedures, is indicative of, and reaffirms, the robustness of the TWG Procedures.

Recommendations

- The CoPS, recommends that the TWG consider modifying the TWG Procedures section on general considerations to add wording that specifically calls out, for example, altering seat track adjustment or seatback angle in such a way as to achieve the intent of each TWG test position.

APPENDIX - Excerpts from TWG Procedures Document Dated August, 2000

3.3.2.1 Forward Facing Hybrid III 3-Year-Old Child Dummy on Booster Block (Passenger Positions with Seat-Mounted Airbags)



Figure 3.3.2.1.1 Forward Facing Hybrid III 3-year-old Child Dummy on Booster Block Leaning Against Door Trim Panel

The intention of this test is to maximize the head/neck interaction by aligning the neck with the top of the side airbag module. Modifications of the positioning sequence may be required to achieve this goal. The booster foam block dimensions are 300 mm deep by 450 mm wide by 75 mm thick. The foam has a density of 40-80 g/l. A typical foam material is expanded polypropylene (EPP). Locate and mark on the seat cushion two points for heel placement at 20-50 mm from the leading edge of seat cushion and 75 mm from the centerline on each side. Center the foam block on seat cushion so that it contacts the seat back bolsters. Do not tape or otherwise attach the booster to the seat. The dummy positioned in the vehicle is shown in Figure 3.3.2.1.1. Specific positioning instructions are as follows:

1. Seat the dummy on the outboard edge of foam block, aligning the spine with the leading edge of the seat bolster (forward most contour line).
2. Place the dummy's head in between seat bolster and B-pillar.
3. Place heels at heel placement points (previously marked on seat cushion).
4. With feet held in position, slide pelvis forward and parallel to the centerline of the vehicle, until the head/neck junction (i.e., lower edge of the skin at the base of the head) is aligned vertically with the top edge of the airbag module (line A, not shown).
5. Reposition heels over placement points, if necessary.
6. With the vehicle door closed and the dummy's right arm raised (to clear armrest), slide the pelvis and upper torso outboard until pelvis or torso contact the door. The neck/torso junction may shift down no more than 20 mm during the process.
7. Place the right arm on the armrest.
8. Flex the left arm such that the upper arm contacts with the seatback and the fingertips contact the booster seat.
9. Deploy the side airbag(s) and record the following dummy channels: head acceleration (A_x, A_y, A_z) and upper and lower neck forces and moments ($F_x, F_y, F_z, M_x, M_y, M_z$).

NHTSA Version of TWG Test 3.3.2.1

NHTSA Seat-03-3:



- Seat the dummy on the outboard edge of seat, aligning the spine with the leading edge of the seat bolster (forward most contour line).
- Place the dummy's head in between the seat bolster and B-Pillar.
- Place the heels at the placement points (20-50 mm from leading edge of cushion and 75 mm from the centerline of each side).
- Holding feet in position, slide the pelvis forward and parallel to the centerline of the vehicle, until head/neck junction (lower edge of the skin at the base of the head) is aligned vertically with the top of the airbag module. If this cannot be achieved, leave the dummy at this point.
- Reposition heels to the placement points, if necessary.
- Slide the dummy over until it touches the armrest or B-Pillar, keeping the dummy in the same plane.
- Place the outboard arm near or on the armrest.
- Bend the inboard arm so that the upper arm contacts the seatback and the fingertips contact the booster seat.

NHTSA Variation of TWG Test 3.3.2.1 with Increased Seatback Angle

NHTSA Seat-10-3:



- Adjust the seatback one notch rearward of the baseline seat back angle, making the seatback more reclined.
- Place the foam block booster on the seat between the bolsters.
- Seat the dummy on the outboard edge of the foam block, aligning the spine with the leading edge of the seat bolster (forward most contour line).
- Place the heels at the placement points (20-50 mm from leading edge of cushion and 75 mm from the centerline of each side).
- Holding feet in position, slide the pelvis forward and parallel to the centerline of the vehicle, until the head touches the seatback.
- Slide the dummy over until it touches the armrest or B-Pillar, keeping the dummy in the same plane.
- Reposition heels to the placement points, if necessary.
- Place the outboard arm near or on the armrest.
- Bend the inboard arm so that the upper arm contacts the seatback and the fingertips contact the foam block.

NHTSA Variation of TWG Test 3.3.2.1 with Dummy Leaning More Sideways

NHTSA Seat-07-3:



- Place dummy in center of seat.
- Lean dummy sideways until head hits armrest and / or door.
- Place legs at the centerline of the seat and space them slightly apart (~40 to 50 mm foot to foot).
- Slowly pull the pelvis forward by pulling the legs until the head hits the seatback.
- The head should rest between the door and the seatback.
- The dummy should be adjusted until the head CG is vertically aligned with the centerline of the airbag module.

3.3.2.3 Hybrid III 3-Year-Old Child Dummy Lying on Seat with Head on Armrest (Passenger Positions with Seat-Mounted Airbags)



Figure 3.3.2.3.1 Hybrid III 3-Year-Old Child Dummy Lying Across Seat with Head on Door Trim Panel

The intention of this test is to maximize the head interaction by aligning the head with the vertical centerline of the airbag module. Modifications of the positioning sequence may be required to achieve this goal. A foam block, which is wide enough to support the dummy across the full width of its back (approximately 300 mm), is used to support the dummy's weight. The remaining dimensions of the block should be chosen to let dummy's head touch the armrest without applying a significant downward force. The foam's density should be 40-80 g/l. A typical foam material is expanded polypropylene (EPP). The dummy's position in the vehicle is shown in Figure 3.3.2.3.1. Specific positioning instructions are as follows:

1. Place the dummy on the seat lying on its back with its arms at its sides so that its left arm contacts the seatback.
2. Adjust the seat to its lowest and rearmost position.
3. Bending the dummy at the waist, slide it inboard/outboard until the back of the head can touch the armrest. Support the dummy's back with a wedge-shaped foam block so that the head remains in a neutral position (i.e., head should not be forced into flexion or extension) and does not exert a significant downward force ($< 5\text{N}$) on the armrest.
4. Adjust the dummy's arm closest to the front edge of the seat so that it is parallel to the torso and rests on the foam block with the fingertips just touching the seat cushion.
5. Adjust the upper arm on the seat back side to an orientation 45 degrees forward of the torso centerline and the forearm on the same side to an orientation 90 degrees to the upper arm.
6. Deploy the side airbag(s) and record the following dummy channels: head acceleration (A_x, A_y, A_z) and upper and lower neck forces and moments ($F_x, F_y, F_z, M_x, M_y, M_z$).

NHTSA Variation of TWG Test 3.3.2.3

NHTSA Seat-04-3:



- Place the dummy on the seat perpendicular to the seat centerline, lying on its back, with its arms at its sides, so that its left arm contacts the seatback.
- Bending the dummy at the waist, slide it inboard/outboard until the back of the head can touch the armrest. (Seat may be adjusted to obtain this.) Support the dummy's back with a wedge-shaped foam block so that the head remains in a neutral position.
- Slide the pelvis forward along the centerline of the seat until the head contacts the seatback.
- Pull the head towards the door, as far as possible, to rest the head on the armrest.
- Slightly bend the dummy's knees and rest its feet on the edge of the seat.