

Air Bag Inflation and Passenger Safety

It is a well-documented fact that air bags save lives when the driver and passenger are properly belted and the air bag functions as intended. One concern with air bag function is the occasional delay before inflation. If inflation does not begin soon after impact, severe neck injuries and even fatalities are possible. The National Highway Traffic Safety Administration (NHTSA) has developed criteria for predicting the probability of serious neck injury in front end crashes. The neck injury criterion - abbreviated N_{ij} - is a number that is calculated based on the amount of tension force exerted upon the neck and the extension moment of the neck during a crash. An N_{ij} value of 1.4 corresponds to a 30% chance of sustaining a severe neck injury. The NHTSA recommends values less than 1.4.

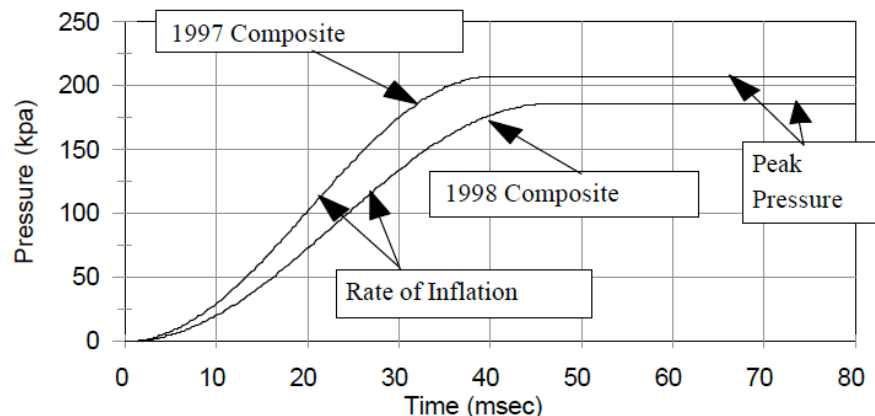
In one research study, a test dummy was placed in an automobile and three tests were conducted to determine the tension force (unit: Newton), extension moment (unit: Newton•meter), and N_{ij} value. All three tests involved a front-end crash of a car at 18 mi/hr. In test 1, an air bag was not used. In test 2, an air bag was inflated in the usual manner - 37.5 milliseconds (ms) after impact. In test 3, the air bag inflation was delayed, occurring 100 ms after impact. The results of the study are shown in **Table 1**.

Table 1: The Effect of Delay of Inflation

	Test 1	Test 2	Test 3
Time Delay of Inflation (ms)	--	37.5	100
Tension (N)	617	1057	4172
Extension moment (N•m)	11.8	14.3	82.6
Calculated N_{ij} Criterion	0.2	0.4	2.0

A second concern pertains to the aggressiveness with which the air bag inflates. In some cases, the inflation is so violent that it can cause injury – particularly to children and smaller adults. The automobile industry has addressed this concern by reducing the amount of gas released into the air bag. This is reflected by their internal pressure when fully inflated. Beginning in 1998, manufacturers began to reduce the pressure to which air bags were filled. **Figure 1** compares typical air bags from 1997 cars to 1998 cars. The plotted values represent an average of the data provided by 11 different automobile manufacturers.

Figure 1: Peak Pressure and Inflation Rate for 1997 and 1998 Air Bags



Sources:

Table 1:

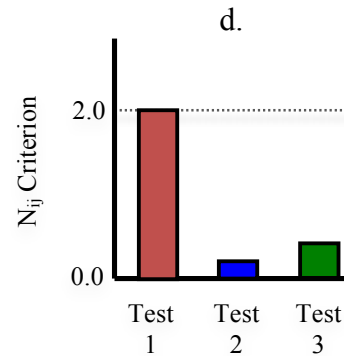
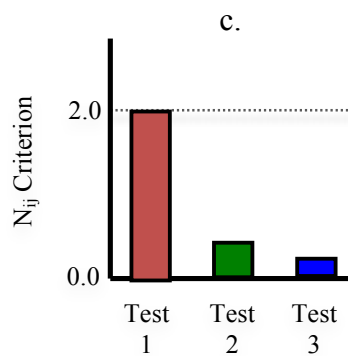
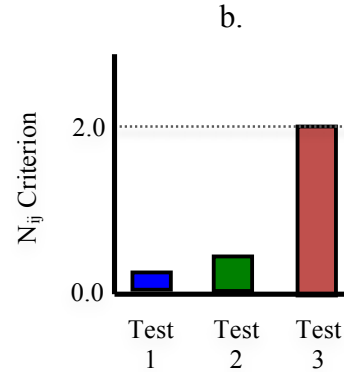
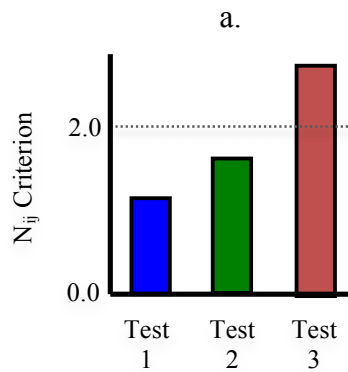
From p. 26 of "Biomechanical Analysis of Late Airbag Deployment in Motor Vehicle Crashes", Anthony Sances, Jr., Srirangam Kumaresan, William Broadhead , Kurt Weiss; presented June 25-29, 2003 at the Summer Bioengineering Conference; see <http://www.tulane.edu/~sbc2003/pdfdocs/0139.PDF>.

Figure 1:

"Air Bag Technology in Light Passenger Vehicles", by Office of Research and Development of the National Highway Traffic Safety Administration. June 27, 2001. See http://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/Crashworthiness/Air%20Bags/rev_report.pdf.

Questions:

1. Which graphic below correctly represents the data in **Table 1** regarding the effect of the delay time before air bag inflation on the neck injury criterion (N_{ij})? (**Test 1** = no air bag; **Test 2** = air bag with 37.5 ms delay; **Test 3** = air bag with 100.0 ms delay.)



2. Based on the study that led to **Table 1** data, which one of the following collisions and air bag characteristics would be most likely to result in the most severe neck injury?
- A front-end crash at 18 mi/hr with no air bag present in the car.
 - A front-end crash at 18 mi/hr with an air bag that inflates 25 ms after impact.
 - A front-end crash at 18 mi/hr with an air bag that inflates 38 ms after impact.
 - A front-end crash at 18 mi/hr with an air bag that inflates 100 ms after impact.
3. Which one of the following conclusions is suggested by the data in **Table 1**?
- Air bags do more harm than they do good.
 - A passenger can have his/her life saved by using a properly functioning air bag.
 - An improperly functioning air bag can cause a severe neck injury in a front-end vehicle crash.
 - Air bags deploy too soon; a small delay in deployment may decrease the likelihood of a severe neck injury.
4. Which of the tests represented in **Table 1** do not satisfy the NHSTA safety recommendations that pertain to the prevention of neck injuries?
- Test 1** only
 - Test 3** only.
 - Both **Test 1** and **Test 2**.
 - All three tests.

5. Which of the following safety suggestions would represent an appropriate response to the data presented in **Table 1** and why?
 - a. Air bags should be required in all cars since the **Test 1** data indicates a lowered N_{ij} safety criterion.
 - b. Air bags should be designed to inflate instantly since both **Test 2** and **Test 3** led to N_{ij} values that were unsafe.
 - c. Air bags should be designed to inflate more rapidly since the delay of inflation in **Test 3** led to an excessively high N_{ij} value.
 - d. Air bags should be designed to inflate 37.5 ms after impact (or close to it) in order to avoid the high N_{ij} values associated with delayed inflation.

6. In **Figure 1**, air bag inflation rates are best represented by the _____.
 - a. slope of the rising line on the graph
 - b. the time that the line on the graph maintains its maximum pressure
 - c. *height* (i.e., maximum pressure) to which the line on the graph rises
 - d. the time that it takes the line of the graph to reach its maximum pressure

7. The data in **Figure 1** is considered *composite data*. What does this indicate about the data?
 - a. The data is based on cars that are made of composite materials as opposed to a traditional steel body.
 - b. The data is based on values that were known at that particular change; such data may now be outdated.
 - c. The data represents an average of the data provided by several car manufacturers for several models.
 - d. The data is based on information provided by a single company and does not include averages of multiple companies.

8. Which one of the following statements is consistent with the data in **Figure 1**?
 - a. Air bags in 1998 cars were inflated in less time than those of 1997 cars.
 - b. Air bags in 1998 cars were inflated at lower rates than those of 1997 cars.
 - c. Air bags in 1998 cars were filled to greater volume than those of 1997 cars.
 - d. Air bags in 1998 cars were filled to greater pressures than those of 1997 cars.

9. Based on this passage, which one of the following is a concern of automobile safety advocates?
 - a. Most states' speed limits exceed the recommended 18 mi/hr limit for cars.
 - b. Cars made after 1997 do not provide a sufficient amount of pressure in their inflated air bags.
 - c. Aggressive air bag inflation can cause harm to children and adults of small physical stature.
 - d. Passengers in cars traveling at speeds in excess of 18 mi/hr have a 30% chance of a severe neck injury if an accident occurs.