

# Airbag Durability: A Performance Analysis of 6~9 year Old Field Exposed Airbags

**James A. Augustitus**  
Airbag Testing Technology Inc.

## ABSTRACT

Airbags are designed and integrated as part of the occupant safety system for vehicles. The vehicle manufacturers target their vehicles for a 15-year lifetime. With this in mind, in the USA airbag modules are designed for a minimum 15-year life span. The module is designed and tested to meet strict vehicle original equipment manufacturer (OEM) specifications to accomplish the required performance life. This paper focuses on an evaluation of some airbag modules after field exposure of 7 to 9 years with a comparison to equivalent new airbag modules. Performance oriented testing indicates that the long-term design goals are being met.

## INTRODUCTION

Vehicle manufacturers set forth specifications that airbag suppliers use to develop their products. These specifications, although slightly different for each manufacturer, are the basis for the products surviving in the vehicle environment. Most manufacturers dictate their specifications or standards so that the airbag will survive field exposure for a minimum of 15 years and always provide the necessary occupant protection in the event of an accident. (There are some airbags designed for markets other than the USA that have design lives of only 9 to 10 years, we will not consider these modules in this study). The requirements and specifications include temperature and humidity variations, shock and vibration, and various combinations of these to mimic field conditions including extremes. Throughout the design and development

process these requirements are constantly evaluated and re-evaluated. Through concept definition, design verification (DV) and process verification (PV) the development team certifies the capability of the airbag product to perform its functions using test plans. These test plans include adequate numbers of parts for testing to verify target quality levels. After production begins, lot acceptance testing (LAT) continues to certify that the airbag meets all the vehicle manufacturers requirements and therefore will perform for the 15-year life requirement as an active element in the occupant protection system.

How well the airbag modules will meet the 15-year minimum life expectation was the subject of our evaluation/comparison. Although we did not have access to 15-year-old product, we were able to gain access to modules that had experienced 6 to 9 years of field exposure. It was felt this was an adequate start to understand the effectiveness of the OEM specifications in meeting their lifetime expectations.

The modules used for this evaluation were Ford Taurus driver-side modules. These were selected because of availability in the salvage or recycling market. ~his is directly related to the Ford Taurus being one of the better selling vehicles in the 1992 thru 1994 time period) By contacting various sources we purchased twenty-nine Taurus 1992 model year driver-side modules (92M) and twenty-nine Taurus 94 model year driver-side modules (94M) selected at random. We then purchased 5 new service modules of each type from Ford Dealers. These were new service parts supplied by the OEM for field service use.

## PREPARATION AND TESTING

Prior to conducting the tests, it was felt prudent to verify that each of the field-exposed modules met the requirements that the new airbag must pass during manufacture. This testing consisted of electrical testing and a special test to confirm the modules had not been subjected to flood conditions while in the field. The field-exposed modules had igniter resistance and igniter insulation resistance measured for each module. Then pre-test photos were taken. A careful examination was also made to confirm that structural integrity of the modules was not compromised during removal from the donor vehicle. Finally, a special test was run to confirm that the modules had not been subject to water submersion such as in a flood. Similar electrical tests were run on the new modules. A comparison of the data for both the field-exposed and the new modules verified that in their static state, these modules had similar characteristics, and yield tested metrics that were the same.

The question of how to make the comparison was initially challenging. Airbags were developed and are tested as part of a specific vehicle's occupant protection system. The system is subject to the Federal Law referred to as FMVSS 208 and includes the specific vehicle environment (seats, belts, knee restraints etc). Actual evaluation of the occupant protection system requires test dummies to be used within a vehicles interior layout at either a sled test facility or barrier test facility. We did not have access to either of these types of test facilities. The dilemma of evaluating the air bag modules was resolved by taking another approach. This alternate approach involved evaluating the forces related to airbag deployment. The source of the lab equipment for accomplishing the force evaluation was the Insurance Corporation of British Columbia (ICBC), Research Center in Vancouver, British Columbia, Canada. ICBC had developed a pendulum device, which allows measurement of airbag reaction forces and timing with respect to ignition. The ICBC lab facilities were rented to conduct pendulum tests on both the new and field-exposed air bags.

Figure 1- ICBC Pendulum Device

ICBC Pendulum Test Fixture



The pendulum device was based on a similar in concept used in Europe. Figure 1, shows this device. This pendulum can be characterized as a reaction device. The airbag module is mounted within the frame using a special mounting fixture attached to a load cell. A 12-volt firing circuit simultaneously controls the video recording system, the data collection system and ignites the airbag module. The hi-speed video system includes proper lighting. The data collection system is LabView. Prior to conducting each test series a calibration was run for the load cell and associated instrumentation. This consisted of a special pad applied to the load cell and the pendulum arm released from a specific repeatable position.

When the airbag is ignited the bag portion of the module expands from the gas generated in the inflator. The air bag was mounted on an adapter plate and attached to the load cell support within the pendulum fixture. A space (83mm) was provided between the air bag cover and the pendulum mass. This gap was designed to minimize the interaction of the cover opening impacting on the pendulum mass. Even with this space, the Taurus cover upper flap did impact the pendulum surface because it is a 1/3—2/3 cover. (The cover opens 2/3rds upward and 1/3rd downward when the steering wheel is in the nominal straight-ahead position.) As the bag expands it contacts the pendulum surface and accelerates the pendulum arm mass.

The data collected was as follows:

- a. The force generated at the bag mounting area using the load cell that the air bag module is mounted to.
- b. The acceleration of the pendulum arm from an accelerometer mounted on the arm in the mass area.
- c. Rotation of the pendulum arm using a potentiometer mounted at the arm pivot point.
- d. A video of the event perpendicular to the pendulum test fixture. A review of the video allows the definition of the cover bulge to be first gas generation.

Prior to activating the airbag module, the temperature was recorded using an infrared optical pyrometer to determine if any temperature effects would occur. (A data review indicated no significant temperature effects in the range of ambient temperatures of 20°C to 25°C)

The actual test sequence requires re-confirming the igniter resistance followed by activating the air bag. Simultaneously, the data collection process is triggered and the high-speed video is started. In each test, the igniter resistance prior to activating the airbag was reconfirmed to be identical to the value that was measured during the initial testing of the modules. The

firing circuit used had no effect on the airbag igniter. All field-exposed and new modules deployed normally with respect to the electrical activation of the modules.

After the test, the temperature of the module is recorded by directing the pyrometer at the rear of the module in the inflator area (this data was not considered valid because of the difficulty in getting a consistent reading). The module was then removed from the test fixture and allowed to cool down.

After cool down, each module was carefully examined for post-test damage and the module was photographed. Any anomalies were noted. For the 92M Taurus testing, a number of bag tears were noted. After reviewing the high-speed videos and test hardware, it was determined that testing without the steering wheel was a contributing factor. This effect was random while testing and occurred on both field-exposed and new modules.

Tests of the 94M modules resulted in minor bag damage (small tears of 10mm or less) on all tests. Since this occurred on both new and field-exposed modules and they were all tested without a steering wheel, there will be no further comment.

## Results

The purpose of our tests was to compare field-exposed airbag modules with new OEM service modules. With this in mind we chose to look at the total force generated during the airbag deployment. Total force was defined as the sum of the force measured at the airbag mounting system at the rear of the airbag and the force experienced by the acceleration of the pendulum. These two components are:

1. The load cell force
2. The force generated in accelerating the pendulum mass (Identified as  $F=MA$  for the pendulum).

A spreadsheet for this force data was developed and the results were graphically reviewed. There are sets of results for each group of tests in the Appendix.

As with any set of data, there exists variation. Part of this variation is related to the inherent variation in the processes used to produce propellant and inflators in the production environment. Also, because of the small number of samples (5 modules), the OEM data can have a significant standard deviation.

Figure 2 shows both sets of data on the same graphical presentation for 92M modules. Figure 3 shows both sets of data on the same graphical presentation for 94M modules. The thick lines are the new modules and the thin lines are the field-exposed modules. By comparing these graphs for 92M, it appears that the field-exposed modules and the new modules exhibit similar force patterns during deployment. Similar results exist for the 94M tests in Figure 3. The separate results for field-

exposed modules and new modules are shown in Figures 4 - 7.

The visual comparison of the force curves does not scientifically indicate if the field-exposed airbag modules perform the same as the new modules. A method of comparing the force data from these two groups for each year's products must be used to come to such a conclusion. What must be determined is do the field-exposed test results represent the performance of the original airbag design (assumed to be the new service modules).

The best way to compare the data of the field-exposed modules with the new is by statistical methods. By using the Statgraphics statistical analysis program, an analysis was made to determine if the field-exposed module performance data and the new module performance data could be considered as representing the same group or population of force curves. What is being determined is whether the two sets of data (field-exposed versus new modules) represent the same or different populations.

The statistical tests used include the F-test in the ANOVA table to determine whether there are any significant differences amongst the means of the two sets of data. If there are, the Multiple Range Tests will tell which means are significantly different from each other. If there is concern about outliers, the Kruskal-Wallis Test compares medians rather than means. These approaches will look at the data from the perspective of a single population for all the 92M data (new and field-exposed) and all the 94M data (new and field-exposed).

The results of these tests are as follows:

### ANOVA Table-Analysis of Variance

94M Data Analysis					
Source	Sum of Squares	Df	Mean Square	F-ratio	P-Value
Between Groups	2.55973 E8	34	7.52861 E6	0.84	0.7206
Within Group	1.88036 E9	210	8.95408 E6		
Total (corr.)	213633E9	244			

92M Data Analysis					
Source	Sum of Squares	Df	Mean Square	F-ratio	P-Value
Between Groups	6.63433 E7	32	2.07323 E6	0.24	1.0000
Within Group	1.68133 E9	198	8.49155 E6		
Total (corr.)	1.74767 E9	230			

The ANOVA table decomposes the variance of the data into two components: a “between-group” component and a “within-group” component. The F-ratio (94M), which is equal to 0.840803, is a ratio of the “between-group” estimate to the “within-group” estimate. Since the P-value of the F-test is greater than or equal to 0.05, there is not a statistically significant difference between the means of the variables at the 95.0% Confidence Level. The F-ratio (92M) is 0.24 and the P-value at 1.000 is greater than 0.05, there is no statistical difference at 95.0% Confidence Level.

### Variance Check

94M Data Analysis	
Cochran's C test: 0.0723523	J P-Value: 0.591533
Bartlett's test: 1.19283	J P-Value: 0.419146
Bailey's test: 16.2564	

92M Data Analysis	
Cochran's C test: 0.0760605	P-Value: 0.585195
Bartlett's test: 1.05262	P-Value: 0.999957
Bailey's test: 5.28554	

The three statistics displayed in the table test the null hypothesis that the standard deviations within each of the other data columns are the same. Of particular interest are the two P-values. Since the smaller of the P-values is greater than or equal to 0.05, there is not a statistically significant difference amongst the standard deviations at the 95% level.

### Results of the Kruskal-Wallis Test

94M Results
Test Statistic 28.1521
P-Value= 0.79299

92M Results
Test Statistic= 11.6309
P-Value 0.999634

The kruskal-Wallis test, tests the null hypothesis that the medians within each group of data columns is the same. The data from all the columns (each module is a column) is first combined and ranked from smallest to largest. The average rank is then computed for the data in each column. Since the P-Value is greater than or equal to 0.05, there is not a statistically significant difference amongst the medians at the 95.0% confidence level.

The results of all the tests indicate no statistically significant difference at the 95% confidence level in the data sources; therefore they are from the same

population of data. The result of all the statistical analysis is that the new modules for both years appear to come from the same population as the field-exposed modules. This would indicate that the field exposure has not affected the module performance.

The original intent of the airbag module design process was to develop airbag modules that could effectively provide occupant protection for 15 years. The modules for which we ran these tests appear to have passed the half way point in reaching the objective with no appearance of performance degradation for providing force output which can be directly and closely related to the occupant performance aspect of the airbag module.

### CONCLUSION

After reviewing the performance of field-exposed airbag modules, it can be said that 6 to 9 years of field exposure seems to have little if any effect on the output of these supplemental restraints. This reinforces the specifications and design requirements used in their development. Field-exposed airbags which are confirmed to meet the original manufacturer's specifications and which are tested for flood-water exposure can be expected to perform in an accident situation in the same way as new modules. Since field-exposed modules are part of the entire occupant safety system, it is expected they should provide the performance portion of this function as they were designed.

Air bags are designed and integrated as part of the occupant safety system for vehicles. The vehicle manufacturers target their vehicles and systems for a 15-year lifetime. This work verifies the 6-9 years range for that effort with respect to these airbag modules.

### CONTACT

**Jim Augustitus**  
**Airbag Testing Technology, Inc**  
**6759 Olen St**  
**Utica, MI 48317-2231**  
**e-mail [jimaugustitus@airbagtesting.com](mailto:jimaugustitus@airbagtesting.com)**  
**Ph 810-731-9151 Fax 413-521-2326**  
**[www.airbagtesting.com](http://www.airbagtesting.com)**

# APPENDIX

92M TOTAL FORCE - NEW & FIELD EXPOSED

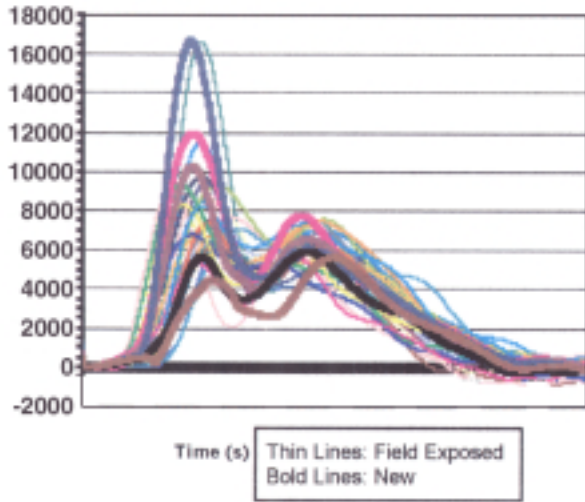


Figure 2

94M TOTAL FORCE - FIELD EXPOSED

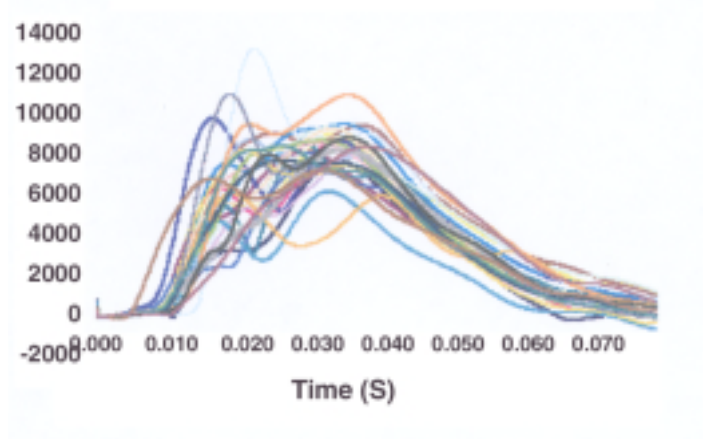


Figure 4

94M TOTAL FORCE - NEW & FIELD EXPOSED

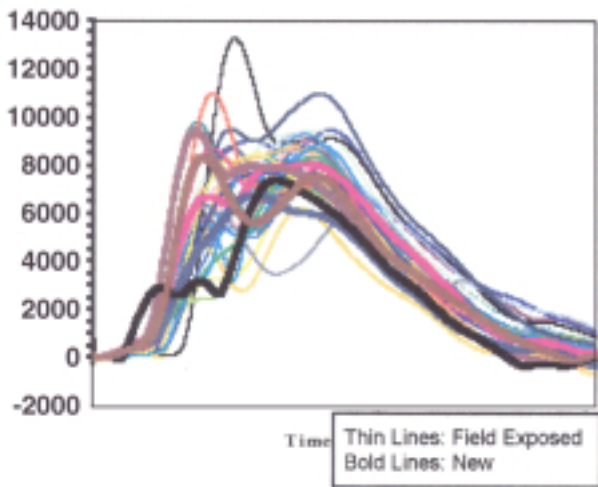


Figure 3

92M TOTAL FORCE - NEW &

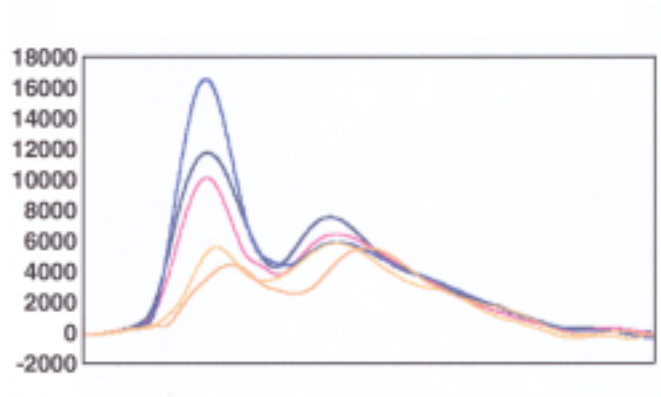


Figure 5

94M TOTAL FORCE - NEW

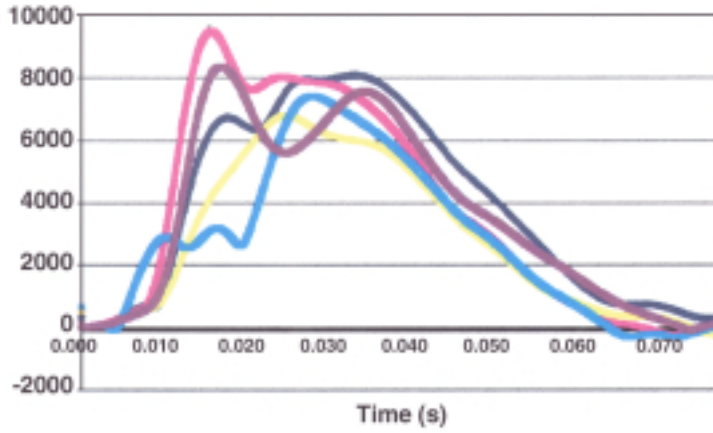


Figure 6

92M TOTAL FORCE - FIELD EXPOSED

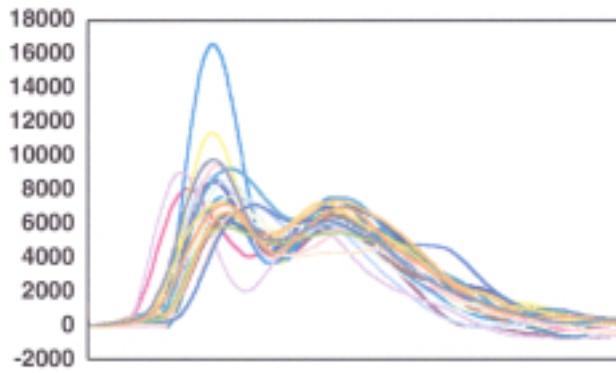


Figure 7