

**EXPLORATORY STUDY OF AN AIRBAG CONCEPT
FOR A LARGE TOURING MOTORCYCLE:
FURTHER RESEARCH**

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ABSTRACT

Honda presented feasibility research on one concept of motorcycle mounted airbag at the 16th ESV conference in 1998. The results of nine impact test pairs showed reduced injuries in four cases, no changes in three, and increased injuries in two. In the tests, most of the changes in injury occurred at dummy/ground contact.

A modified prototype airbag system was designed which mainly involved an enlarged airbag with a larger output inflator. This was tested in the latter two impact configurations to try to solve the injury increasing phenomena. The tests confirmed that the modified airbag system did not increase injuries.

Important factors yet to be considered include: various sizes and positions of rider, various opposing objects and vehicle types, reliability and environmental exposure of the airbag system on motorcycles, and other factors.

INTRODUCTION

Honda began its research on motorcycle rider protection in the 1960's (Ref.1). Recently, Honda has been conducting exploratory research on motorcycle mounted airbags.

A prototype airbag system including a sensor system was fabricated and mounted on a Honda GL1500 large touring motorcycle. The reason why this model was chosen as a base motorcycle for this study was that it seemed to have potential for airbag feasibility from a technical viewpoint (e.g., fuel tank beneath seat, large size and mass, upright riding position).

The prototype airbag system was evaluated with 6 impact configurations involving 12 full scale crash tests (FST's) and 200 impact configurations involving 400 computer simulated crash tests, based on ISO 13232 (Ref.2). Using the latter Standard, its rider protection performance was evaluated. Additional 5 configurations involving 8 FST's were also conducted.

Honda presented these results in the 1998 ESV paper (Ref.3). The summary results are shown below.

The findings were that:

- The airbag resulted in decreased injuries in four test pairs (comparing with and without airbags), increased injuries in two test pairs, and little or no injury change in three out of nine test pairs;
 - Most of the changes in injury due to the airbag occurred at dummy/ground contact as a result of changes in dummy motion with the airbag;
 - And other detailed findings.
- In the future more research would be needed to clarify:
- Evaluation methods, especially neck injury assessment and also a larger sample of ground contact injuries by means of computer simulation;
 - Further study of impacts in which the airbag was found to be harmful, in order to identify possible remedies;
 - Future study of many other crash and non-crash situations, and airbag injury benefits and risks in those situations;
 - Exploration of the applicability of airbags to other sizes and types of motorcycles.

It is intended to continue to study these topics, with the goal of improving motorcycle rider passive safety.

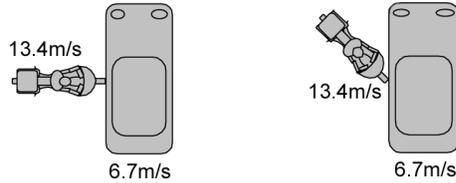
This paper describes further study of impacts in which the airbag was previously found to be harmful. This theme is also part of the Advanced Safety Vehicle (ASV) project conducted in Japan from 1996 to 2000.

IMPROVEMENT OF THE PROTOTYPE AIRBAG SYSTEM

Adverse Phenomena with the Previous Airbag

The adverse phenomena reported in the 1998 ESV paper with the prototype airbag occurred in two configurations of FST as described below and shown in Figure 1(a) and 1(b). In both cases, although the airbag absorbed most of the kinetic energy of the dummy, the dummy continued moving in an oblique, forward direction relative to the motorcycle due to the large yaw motion of

the motorcycle and landed on its head after a half somersault in the air. For explanation of that phenomenon, the dummy and motorcycle motions in the test configuration B are shown in Figures 2 and 3. Figure 2 shows upper view, which indicates the yaw motion of motorcycle. Figure 3 shows the dummy departing from the motorcycle and landing on its head. It was observed that the effect of the airbag on dummy motion increased the potential for serious neck injury on ground contact.



(a) Configuration A (b) Configuration B

Figure 1. Configurations with adverse phenomena.



(a) Just after impact



(b) Motorcycle yaw motion

Figure 2. Motorcycle motion in configuration B.



(a) Dummy departing from the airbag



(b) Dummy landing

Figure 3. Dummy motion in configuration B.

Specification of the Modified Airbag

We thought that increasing airbag performance with regard to dummy restraint would have a potential to solve the adverse phenomena when the airbag was forced to move laterally by motorcycle yaw motion. Namely, it was thought that an increase of the restraint capability of the airbag is required under the condition of dummy deviating laterally from the airbag center, and therefore the airbag width was increased.

The study resulted in the modified airbag design with greater width, larger volume, a more powerful inflator, and so on. Shape and specifications of the modified prototype airbag in comparison with the previous one are shown in Figure 4, and Table 1, respectively.



(a) Modified airbag (b) Previous airbag
Figure 4. Shape of prototype airbag.

Table 1. Prototype airbag specifications

	Modified Airbag	Previous Airbag
Inflated Volume (liters)	140	120
Height (mm)	650	630
Width (mm)	750	500
Length (mm)	620	615
Vent holes diameter (mm)	40 x 2holes	50 x 2 holes
Inflator (kPa)	565	450

Static Inflation Test

Since a larger airbag was adopted, a more powerful inflator was needed. Static inflation tests were conducted to select the inflator and to confirm inflation time and other characteristics.

As a result, the inflator of 565kPa output was chosen and it was confirmed that the airbag inflation could be completed before the dummy reached the airbag, by using the sensing system reported in the 1998 ESV paper (Ref. 3). The airbag inflation sequence is shown in Figure 5. The airbag inflated such that it was performing effectively within 40 to 50msec.

Fundamental Performance Check by Sled Test

The modified airbag system was subjected to sled tests, and the vent hole size was re-tuned because the newly chosen inflator was different from the previous one in gas flow characteristics. Test acceleration time histories were set to simulate those of full scale crash test where the motorcycle crashes into the front of a stationary ISO Standard Corolla at 13.4m/s. Figure 6 shows the acceleration time history of the sled floor.

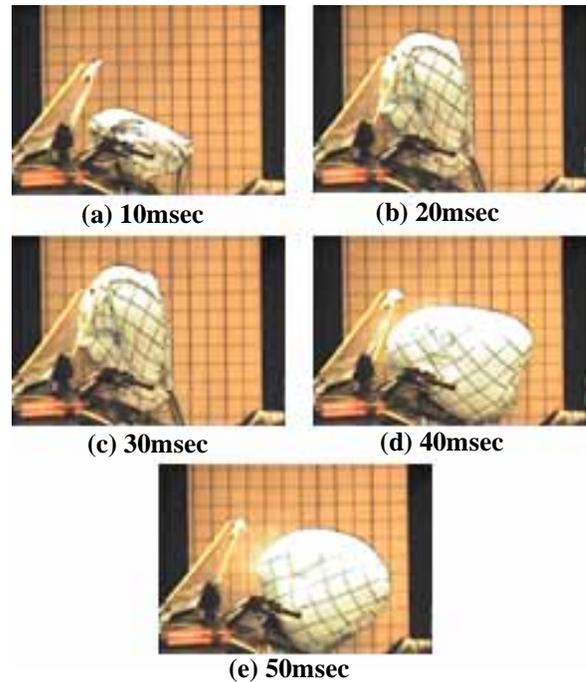


Figure 5. Inflation of modified prototype airbag.

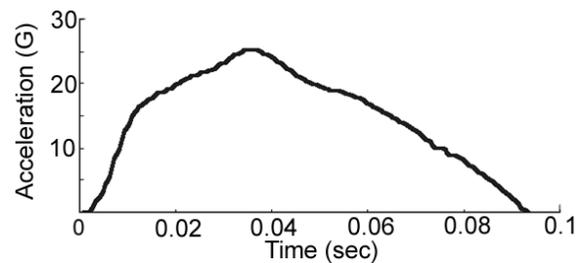


Figure 6. Sled floor acceleration.

The performance evaluation criteria in this sled test with the modified airbag were to have the same effect on the dummy, as that of the previous airbag. This is because we recognized that the previous airbag had good restraint and energy absorption characteristics when the dummy was caught at the center of the airbag during small yaw motions of the motorcycle.

As the result of sled tests with airbags having several sizes of vent holes, a modified airbag with two 40mm diameter vent holes was selected because it showed effects, which were similar to those of the previous airbag. Figure 7 shows the front-most positions of the dummy against the motorcycle and airbag with the modified airbag and with the previous airbag. Time histories of internal pressure and dummy chest acceleration are shown in Figures 8 and 9, respectively.



(a) Modified airbag



(b) Previous airbag

Figure 7. Dummy motion in sled tests.

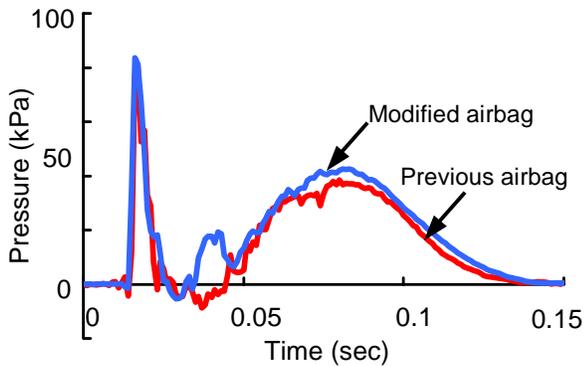


Figure 8. Airbag internal pressure.

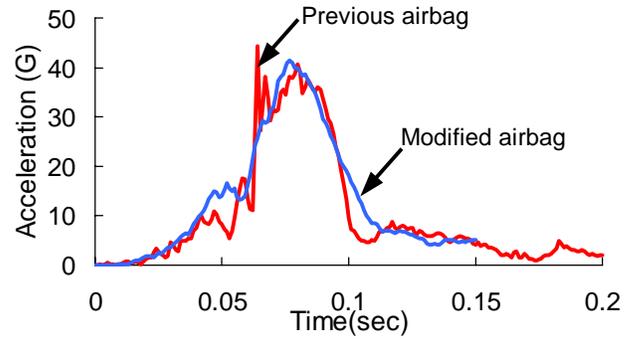


Figure 9. Dummy chest acceleration.

Specifications of Motorcycle for FST's

The specifications of the test motorcycle were the same as those reported in the 1998 ESV paper except for the modified airbag. A photo of the test motorcycle and the specifications are shown in Figures 10 and Table 2, respectively.



Figure 10. Test motorcycle with modified prototype Airbag.

Table 2. Test motorcycle specifications

Manufacturer		Honda
Model, Year		GL1500, 1996
Weight (empty, average)	(kg)	376
Length x Width x Height (overall)	(mm)	2615 x 955 x 1495
Wheel base	(mm)	1690

Test Method for FST's

To check whether the adverse phenomena were solved with the modified airbag, FST's were conducted in the two impact configurations shown in Figure 1

Test methods and injury evaluation methods were based on ISO 13232. Per ISO 13232, a Toyota Corolla sedan was used as the opposing vehicle. An ISO 13232 Motorcycle Anthropomorphic Test Device (MATD) dummy was used for measuring injuries. A copy of the newly designed MATD neck (Ref.4), which was proposed and approved by ISO/TC22/SC22/WG22, was used.

Injury Analysis Methods

By using the data acquired with the ISO 13232 MATD dummy in the FST's, Abbreviated Injury Scale (AIS) values for the head, chest, abdomen and legs, Neck Injury Indices (NII) for the neck and Normalized Injury Cost (NIC) as a total body injury index were calculated. The latter was calculated by combining injuries of all body regions in accordance with ISO 13232. AIS value indicates the injury severity with integer numbers. AIS=1 indicates a minor injury and AIS=6 a maximum or fatal injury. NIC = 0.0 corresponds to "no injury", and NIC = 1.0 corresponds to a significant likelihood of fatal injury. For the neck, ISO 13232 includes a method to calculate the NII value, but NII hasn't been fully validated yet and so strictly speaking it is not possible to evaluate the injury level by converting NII to AIS or to combine NII into NIC.

The rationale for ISO 13232 (Part 5, Clause H.3.8) states in a general way that:

"[NII] values near or above 1.0 are interpreted as likely neck fracture or dislocation; with significant likelihood of spinal cord damage, which at the C1/A0 location, has a fatal propensity."

In the interest of proceeding with exploratory airbag research, a conservative or worst case assumption regarding neck injury probability was made. Given the criticality of neck injury and the aforementioned uncertainties, it was assumed for the purposes of this research, that NII values greater than 1.0 would correspond to "certain, fatal neck injury." As for this research, when NII value was 1.0 or more, it was regarded as AIS=6 and NIC=1.0, and in the case of NII being below 1.0, it was regarded as AIS=0 and not combined into NIC.

Results of FST's

Figure 11 shows the dummy posture when it fell to the ground in the two impact configurations shown in Figure 1. With the previous prototype airbag, the dummy left the

motorcycle by contacting the airbag obliquely, and fell onto the ground head first in test configurations A and B. With the modified prototype airbag, the dummy contacted the ground with its head and shoulder at almost the same time in both test configurations. The dummy's kinetic energy being absorbed by the airbag, the result was that the dummy was decelerated along with motorcycle, then fell onto the ground together with motorcycle. From the foregoing, it was observed that the effect of the airbag on the dummy was clearly improved with the modified prototype airbag.



(a) Configuration A (Modified airbag)



(b) Configuration B (Modified airbag)

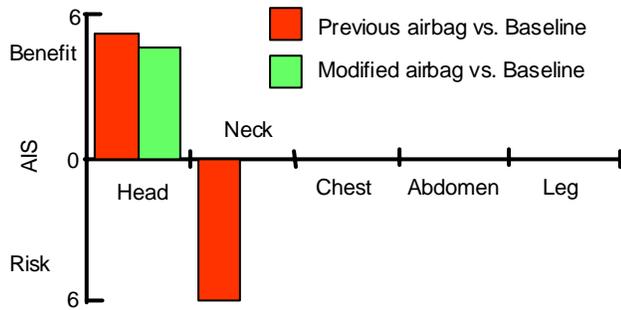
Figure 11. Dummy motion at ground contact.

Test results for two configurations of FST's are shown in Figures 12 and 13 using injury evaluation indices. Changes of AIS and NIC from the baseline motorcycle were indicated by interpreting a reduction of an index as a "Benefit" and an increase as a "Risk". These are compared with those of the previous prototype airbag. While the previous prototype airbag resulted in fatal neck injuries in

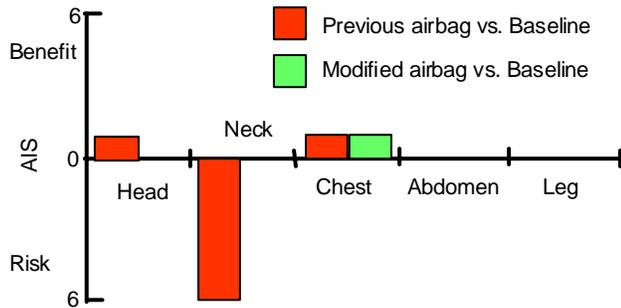
two configurations of FST, the modified prototype airbag resulted in no injury increase in any body region including the neck.

In terms of NIC, the total body injury index, the previous prototype airbag showed an overall injury increase by NIC=0.3 in configuration A and an injury increase by NIC=1 in configuration B. The modified prototype airbag showed an injury reduction by NIC=0.7 in configuration A and no injury change in configuration B.

It could be judged from the above that the injury increase phenomenon which was a key concern with the previous airbag was solved by the modified airbag.

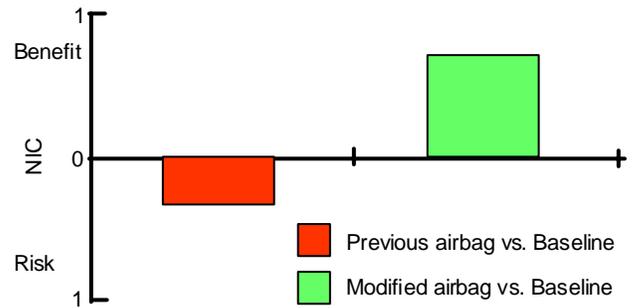


(a) Configuration A

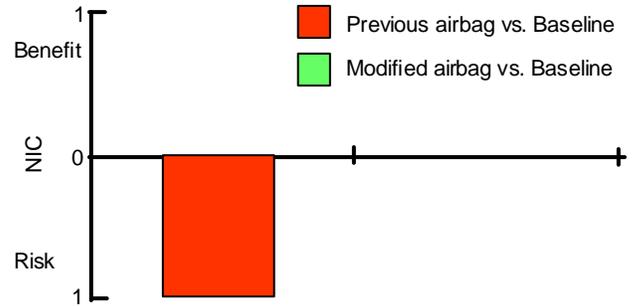


(b) Configuration B

Figure 12; Dummy injury change by body region (AIS)



(a) Configuration A



(b) Configuration B

Figure 13. Dummy injury change for whole body (NIC).

FINDINGS AND RECOMMENDATIONS

The effect of the modified prototype airbag system was confirmed in two configurations of full scale crash tests in which increased injury phenomena occurred in the previous exploratory study of an airbag concept for a large touring motorcycle of Honda.

The new findings were that:

- The adverse phenomena which occurred during large yaw motions of the motorcycle can be solved by enlarging the airbag:
 - Width by 50%
 - Volume by approximately 20%.

In the future more research is needed to clarify:

- Evaluation methods, especially neck injury assessment and also a larger sample of ground contact injuries by means of computer simulation;
- Airbag effects with other rider sizes and riding positions;
- Inflation or non-inflation of the airbag under various crash conditions and in non-crash conditions, and their benefits and risks;
- Reliability and environmental exposure of a

- motorcycle airbag system;
- Maintenance, repairing, use or misuse, tampering and disposal of a motorcycle airbag;
 - Exploration of the applicability of airbags to other sizes and types of motorcycles.

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