DEVELOPMENT OF A COUNTERMEASURE AIRBAG TO MINIMISE THE RISK OF SERIOUS INJURY FROM INTERACTION WITH AN ADJACENT OCCUPANT OR FAR-SIDE INTERIOR IN SIDE IMPACT CRASHES

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ABSTRACT

In current production vehicles, passive safety systems for the protection of vehicle occupants exposed to side impact crashes have primarily been designed to reduce the risk of injury to the occupant seated on the struck side of the vehicle from interaction with the intruding structure and/or external objects. However, occupants involved in side impact crashes may also be injured due to interaction with an adjacent occupant, and a single occupant seated on the non-struck side of a vehicle may be injured due to interaction with the vehicle far-side interior.

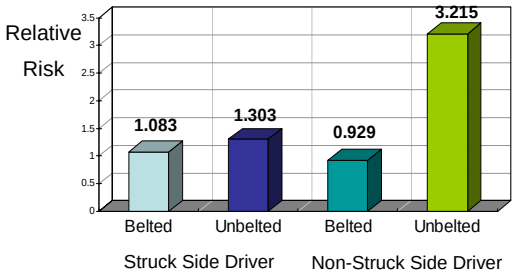
This paper reports on the results of a 32 km/h full scale vehicle-to-pole side impact crash test conducted using a small hatchback vehicle mounted on a carrier sled at 75 degrees to the direction of travel. A single WorldSID dummy was positioned on the non-struck side of the vehicle and a countermeasure airbag was deployed on the inboard side of each front row seat. The countermeasure airbags used in this test are designed to provide side support to vehicle occupants involved in side impact crashes to limit lateral excursion and reduce the likelihood of serious injury due to interaction with an adjacent occupant or vehicle far-side interior.

The results of this single occupant test are compared to results obtained from an earlier investigation of occupant-to-occupant interaction, in which the countermeasure airbags were observed to reduce the risk of head injury from occupant interaction. In the single dummy occupant test reported in this paper, the countermeasure airbags successfully prevented the dummy from interacting with the pole and intruding far-side interior of the vehicle.

INTRODUCTION

According to the results of analysis of NASS/CDS from 1993 to 2006 by Gabler et al in 2008, the relative risk of non-struck side driver is increased to 3.2 times when driver is with an unbelted right front passenger as compared to the belted driver [2][3].

Figure 1. Relative risk of driver in side impact crash from 1993 to 2006 NASS/CDS



$$\text{Risk} = \frac{\text{Number of MAIS 3+ Drivers Exposed to Side Crash}}{\text{Number of Drivers Exposed to Side Crash}}$$

$$\text{Relative Risk} = \frac{\text{Risk of MAIS3+ with Right Front Passenger}}{\text{Risk of MAIS3+ without Right Front Passenger}}$$

Current Seat Belt Systems for Side Impact

In 1991 Mackay et al found the conventional seat belt system was not designed for protection in far side crashes [1]. The observations from real world crashes indicate that the occupants slipped out of the shoulder belt approximately 35% of the time. The belt system could therefore be improved to enhance the restraint performance for occupants on both the struck side and non-struck side.

Figure 2. Seat belt system without the pretension function.

Side support airbag and belt pretensioner as Countermeasures

The countermeasure airbags used in this test are designed to provide side support to vehicle occupants involved in side impact crashes to limit lateral excursion and reduce the likelihood of serious injury due to interaction with an adjacent occupant or vehicle far-side interior.

The side support airbag was designed by Autoliv, Sweden. The size of container is 90 x 120 x 200 (Depth x Width x Height). The volume of side support airbag (SS Bag) is about 3 liters. The pressure of proto stage SS bag is 2 bars.

And the seat belt pretensioner is activated in 9 msec from start the crash. The designated stroke of the pretensioner is 100 mm.

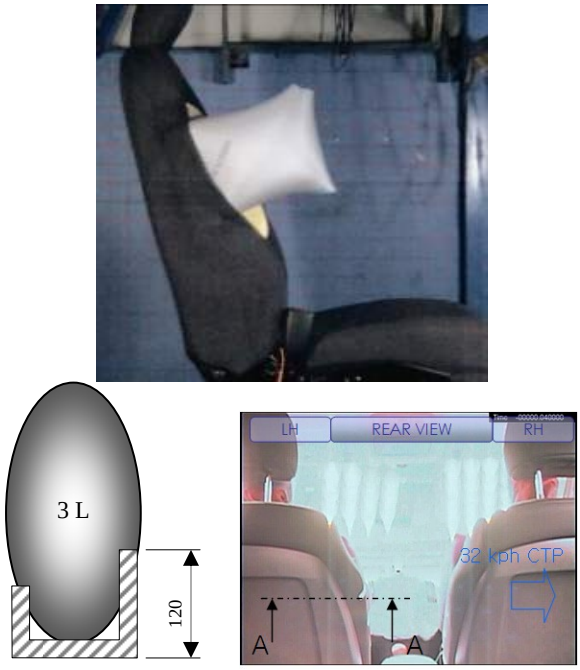


Figure 3. Side support airbag manufactured by Autoliv.

Table 1. Dimension of side support airbag

Items	Description
Container Size	90 x 120 (H 200)
Bag Volume	3 Liters
Bag Pressure	2 Bars
Time to deploy	10 msec
Vent	Non

Figure 4. Seat belt system with the pretension function.

CRASH TESTS, Test 1 and Test 2

Newland et al studied the impact injury risk from the occupant-to-occupant interaction in side impact crashes in 2008 [2]. They found that the occupant interaction indicating risk of serious head injury to both the driver and front seat passenger was observed in vehicle to pole side impact. The results show that despite the introduction of countermeasures to protect struck side occupants from contact to intruding structure or external objects, these occupants may be severely injured by impacting adjacent occupants. The feasibility of a potential countermeasure, developed to offer protection for two adjacent occupants as well as a single occupant seated on the non-struck side, was investigated through analysis of the dummy injury responses produced in pole side impact tests, with and without the countermeasure installed. The countermeasure was observed to reduce the risk of head injury from occupant interaction.

Table 2. Configuration of side impact crash tests for Test 1 and Test 2

Items	Description
Vehicle Impact Speed	32 kph
Pole diameter	254 mm
Impact angle	75 degrees
Test Dummies	Two WorldSIDs
Impact Type	Car-to-Pole

Table 3. Restraint system conditions

Items	Test 1	Test 2
Side airbag for thorax and pelvis	X	X
Curtain airbag for head	X	X
Pyrotechnic seat belt pretensioner		X
Side Support airbag		X

Figure 5. shows the movement of dummies in different configurations. In Test 1 without countermeasure, driver was impacted by the intruding vehicle interior first. The driver was rebounded to passenger side. And then HIC was recorded over 8,000 on both dummies in second impact. But in Test 2 with countermeasure, driver and passenger were well protected by side support airbag and seat belt pretensioner.

Figure 5. Worldsid trajectory, Test 1 (left) and Test 2 (Right).

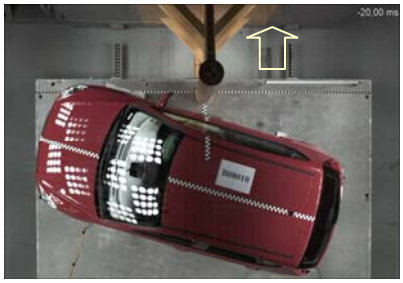


Figure 6. 32 kph car-to-pole side impact crash.

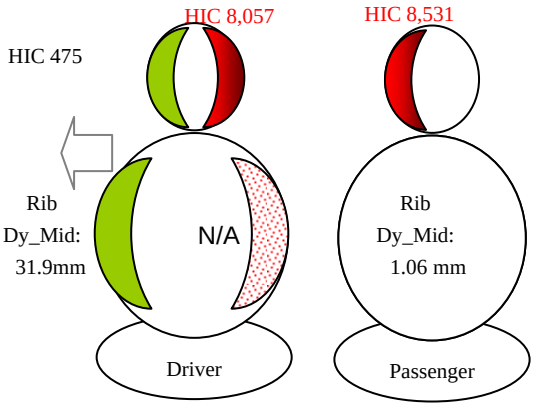


Figure 7. Dummy Injuries, Test 1

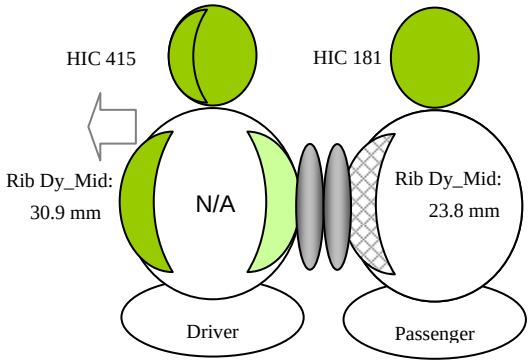


Figure 8. Dummy Injuries, Test 2

CRASH TESTS – Occupant to Far-side interior

Following the study reported by Newland et al [2], another 32 km/h full scale vehicle-to-pole side impact crash tests has been conducted using the same small hatchback vehicle mounted on a carrier sled at 75 degrees to the direction of travel. A single WorldSID dummy was positioned on the non-struck side of the vehicle and a countermeasure airbag was deployed on the inboard side of each front row seat. The countermeasure airbags used in this test are designed to provide side support to vehicle occupants involved in side impact crashes to limit lateral excursion and reduce the likelihood of serious injury due to interaction with an adjacent occupant or vehicle far-side interior.

Figure 9. 32 kph car-to-pole side impact crash.

Figure 10. WorldSID trajectory, Occupant to Far-side interior.

Figure 10. shows the movement of dummy in almost same configuration with Test 2. In this occupant to far-side interior, driver was resisted by the side support airbag. HIC was recorded just 48.9 and rib displacement was just 4.3 mm.

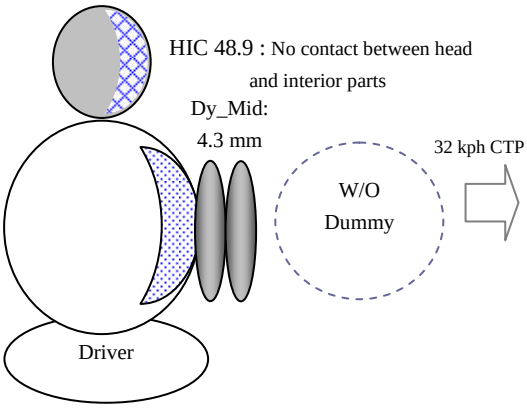


Figure 11. Dummy injuries, Occupant to far-side interior.

ANALYSIS OF CRASH TEST

The main focus of this test was to confirm the avoidance of severe contact between the head and interior parts. To develop the side support airbag, we considered the severe condition of no occupant on the struck side and there is an occupant on the non-struck side.

In this test there are no contact between head and vehicle interior parts. And the injuries of dummy were very low.

CONCLUSIONS

The results of this single occupant test are compared to results obtained from an earlier investigation of occupant-to-occupant interaction, in which the countermeasure airbags were observed to reduce the risk of head injury from occupant interaction. In the single dummy occupant test reported in this paper, the countermeasure airbags successfully prevented the dummy from interacting with the pole and intruding far-side interior of the vehicle.

To develop the side support airbag for production, we have to consider many possible scenarios. In addition, the kinematic of the WorldSID was further analyzed for its biofidelity in this single occupant crash simulation which could lead to further verification by utilizing cadaver testing.

REFERENCES

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