STUDY ON IMPROVING OCCUPANT INJURY PERFORMANCE FOR FMVSS214 SIDE POLE IMPACT

Young Woong Kim
Byung Ryul Ham
In Ho Choi
Han Il Bae
Hyundai Motor Co. & KIA Motors Corp
Korea
Paper No. 09-0100

ABSTRACT

NHTSA(National Highway Traffic Safety Administration) has published an update to the FMVSS214 regulation which includes the Pole Impact test configuration using the ES-2re and SID-IIs dummy. This updated standard adds a new side pole test requirement in addition to modifying the test procedure used to perform dynamic side impact testing. This paper shows a new technique to improve the occupant injury performance during the Pole Impact test.

INTRODUCTION

NHTSA announced a final rule for FMVSS(Federal Motor Vehicle Safety Standard) No. 214, “Side impact protection” (72FR51908, No, NHTSA-29134)1) using ES-2re(50th Percentile Dummy) and SID-IIs(5th Percentile Dummy). This final rule modified the test procedure and adopted technically advanced test dummies (ES-2re and SID-IIs) to enforce detailed requirements on the enhanced injury criteria which are the force, displacement and acceleration of the head, chest, pelvis and abdomen of occupant dummies. (Figure 1)

In addition to the MDB(Moving Deformable Barrier) dynamic FMVSS214 side impact test, new protocol requires a 75-degree oblique pole test in two different configurations so as to improve an occupant protection for the various side impact crashes. (Figure 2)

![Figure 1. Dummy Injury Criteria](image1)

![Figure 2. Updated FMVSS214 Side Impact Test Procedure](image2)

This paper focused on improving an occupant injury performance under the side pole impact test by optimizing a side-airbag performance. Following factors are considered in this study.
1) Dummy structure mechanism of ES-2re and SID-IIs
2) Packaging space for a side-airbag deployment
3) Relation between side-airbag pressures and occupant injuries

This study shows that the deployment performance and airbag pressure are the two most important factors to improve occupant injuries in a pole impact test. Analyzing relation between airbag pressure and occupant injuries provided methodology to secure the optimal airbag deployment. This paper suggests guidelines to get a proper deployment space of the side-airbag to improve occupant injuries and discusses the relationship between occupant injuries and airbag pressures.
STRUCTURES OF A SIDE IMPACT DUMMY

ES-2re

The ES-2 dummy is a side impact test device designed to the specifications of the EURO NCAP. It represents a 50th percentile adult male without lower arms based on ES-1 dummy. The ES-2 has an improved rib module to fix the significant problem known as “Flat Top” which is one of the structural defects in ES-1. It means a higher possibility of RDC and VC measurement in ES-1(2). ‘Flat-Top’, once it happens, is a period of a constant rib deflection maintained over 10~15ms time duration (Figure 3). It is rarely reported in 90 degree loading tests like EuroNCAP side impact, but in US oblique side impact test, ‘Flat top’ often occurs and it is also observed in oblique component test. 3)

ES-1 dummy’s RDC can be diminished by inserting a bracket in a seat back frame for pushing the back plate of dummy, as shown in Figure 4. 4)

ES-2re shows an improved biofidelity by using the rib extension so that “Flat Top” problem is eliminated. 5)

SID-IIs

NHTSA issued a final rule announcing the agency’s regulation on anthropomorphic test devices to add specifications and qualification requirements for the 5th percentile adult female crash test dummy named SID-IIs. The SID-IIs is used for the oblique pole test and moving deformable barrier test on the FMVSS214 final rule. (Figure 6)

RELATION BETWEEN SIDE-AIRBAG PRESSURES AND AN OCCUPANT INJURY

The oblique pole test in upgraded FMVSS214 was developed to provide protection for the head, chest, abdomen and pelvis during pole test. This pole test simulates a vehicle crashing sideways into narrow fixed object like a narrow pole or tree. In the vehicle-to-pole crash, there are three main
energy absorbers, structure, trim and airbag. (Figure 7)
Unlike usual MDB test, vehicle structure is not a main energy absorbing part due to less interaction between dummy and vehicle even if seat belt works. Hence, a side-airbag and door-trim should be optimized to improve an occupant injury.
In this paper, we analyzed a relationship between a side-airbag and occupant injuries and considered a new strategy to improve occupant injuries.

SAB (Side Impact Airbag) Analysis

The side impact airbag is a major safety device that functions to absorb side impact energy during the load of certain criteria to protect occupants. We developed it through the following sequence as shown in Figure 8.

Figure 8. Side Impact Airbag Configuration

The side impact analysis airbag model needs a validation analysis including tank test, drop test and static deployment test. (Figure 9)

5th & 50th Percentile Pole Impact

In this paper, we analyzed a relation between side-airbag pressure and occupant injuries in the mid-sized SUV during an oblique pole crash. The airbag pressure change was represented by mass flow rate (5%, -20% ~ +20%). Airbag on this analysis model is a 2-chamber type airbag which widely used to protect occupant in a side crash. (Figure 10)

Figure 10. 2-Chambar Type Airbag

5th percentile oblique pole test evaluates head acceleration, lower spine acceleration and pelvic force. Analysis results are as follow. (Figure 11)
According to these results, spine and pelvic injury were increased due to airbag pressure (mass flow rate) increase. 5th percentile adult female dummy, represent 44kg’s smaller stature occupants, reacts to the airbag pressure more sensitively. Hence, occupant injuries increase in proportion to the side-airbag pressure until airbag bottoming-out condition. In the case of non bottoming-out condition, 5th percentile dummy’s spine and pelvic injury will be improved as side-airbag pressure decrease. 50th percentile oblique pole test results, including head acceleration, rib deflection, abdominal force and pelvic force, are depicted in Figure 12.

In conclusion, occupant injuries of 5th and 50th percentile oblique pole test get worse in proportion to the side-airbag pressure increase. Within non bottoming-out condition, we can improve occupant injuries by diminishing airbag pressure through an increased airbag-volume capacity and vent-hole.

**PACKAGING SPACE FOR THE SAB (SIDE IMPACT AIRBAG) DEPLOYMENT**

Occupant injuries are mainly affected by an airbag
performance especially the deployment condition during an oblique pole test. An airbag deployment performance can be improved by increasing an airbag deployable space or airbag pressure. In case of increasing airbag pressure, there is a limit because it causes higher abdominal and pelvic injury owing to airbag stiffness. Hence, it is the best way for improving occupant injuries to enlarge the airbag deployable space during crash event. Following is the analysis method for securing an airbag deployable space.

As shown in Figure 14, airbag deployment performance gets worse under a smaller airbag deployable region ‘A’. ‘A’ will be getting smaller during the side impact crash. Therefore, a fully deployment of an airbag should precede the contact between a door trim and a seat. Contact time between a door trim and a seat can be measured by an acceleration sensor on the same position of a door inner panel, so that a door intrusion can be shown as below. (Equation 1) (Figure 15)

\[
DoorIntrusion = \int_0^T (RHDoorVelocity - LHDoorVelocity)
\]

(1).

Contact time between a door trim and a seat, \( \alpha \), should be larger than summation of a TTF(Time to Fire) and an airbag deployment time (\( \beta \)). (Equation 2)

\[
\alpha \geq (T + \beta)
\]

(2).

As a result, reducing TTF or \( \beta \) for a deployment time of an airbag or delaying a contact time (\( \alpha \) ) results in the fully deployment condition of an airbag. It improves occupant injuries in side impact. Another way of improvement is to reduce armrest (B) and seat back foam size (C). It will cause to enlarge an airbag deployable region (A). (Equation 3)

\[
A \geq A'
\]

(3).

CONCLUSIONS

This paper suggests techniques of an improvement on an oblique pole crash and it can be summarized as follows.

(1) Airbag pressure affects occupant injuries especially an occupant’s chest injury. Occupant injuries usually increase in proportion to airbag pressure under an oblique pole crash. Therefore, we should find an optimal pressure of a side-airbag to improve occupant injuries by controlling an airbag-volume capacity and vent-hole size.

(2) To improve a deployment performance of SAB, following three conditions should be satisfied; increasing deployment speed of an airbag, delaying contact time between a door trim and a seat and maintaining a gap between a door trim and a dummy.

REFERENCES


