

AIRBAG: IS IT AN EFFECTIVE OCCUPANT PROTECTION SYSTEM?

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ABSTRACT

The role of airbag as an occupant protection system is very significant. In case of serious frontal crashes, airbags can perform well enough to provide additional protection. Airbags save and/or kill people involved in a crash depending on the way they deploy and the position of the passenger when the crash occurred. Hence, understanding the process of airbag deployment is very crucial. Some significant facts related to air bag deployment are discussed in this paper. Many factors influence the effectiveness of airbags. Hence, the effectiveness of airbags is discussed at length and the variation in the effectiveness due to different factors and in different applicable conditions is presented. One of the more recent problems being widely discussed is the child-airbag interaction. A few facts regarding this issue are outlined and the possibilities for a positive interaction between children and airbags are discussed. The concept of future airbags (smart airbags and side airbags) has been introduced. It has been concluded that airbags are an efficient occupant protection system, if used with necessary precautions.

INTRODUCTION

There have been 3.8 million airbag deployments from the late 1980s to October 1999, with driver side deployments accounting to 3.3 million and passenger side deployments constituting 0.5 million. As of October 01, 1999, 89 million vehicles are equipped with airbags, out of which 57 million are cars (about 45 percent of cars on the road) and 32 million light trucks (about 41 percent of light trucks) (*1*).

An Overview

Airbags have reduced driver deaths by 14 percent and passenger deaths by 11 percent. The most widely accepted method of statistical analysis, called the double pair comparison studies are employed, for calculation of lives saved. The process involves a mathematical analysis of the real-world fatality experience of vehicles with airbags compared with vehicles without airbags (*1*).

Statistics of airbags

As of March 01, 2000, the estimated gross number of lives saved by airbags is in the range of 4496-5303 drivers and 807 right-front passengers (2). The estimate of airbag benefits from late 1980s through March, 2000 is shown in Figure 1.

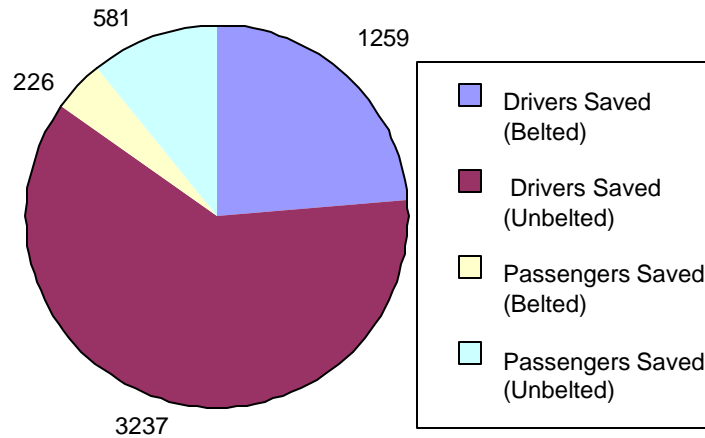


FIGURE 1 Estimated airbag benefits (1)

Although relatively rare, inflating airbags have also caused deaths and serious injuries. In the last decade, the total number of fatalities involving airbags is 194 and the total number of seriously injured drivers, passengers, and children are 128 (2). The estimated airbag deaths have been shown in Figure 2.

Purpose

The focus of this paper is to emphasize the effectiveness of airbags. The child-airbag interaction has been an issue of concern in the last decade and hence an emphasis has been placed on this issue. Airbag on/off switches and their installation has also been a controversial issue recently. A discussion on smarter airbags and side airbags has been included. The overall purpose is to reiterate the fact that airbags are an efficient occupant protection system if used properly with due considerations to the risk involved.

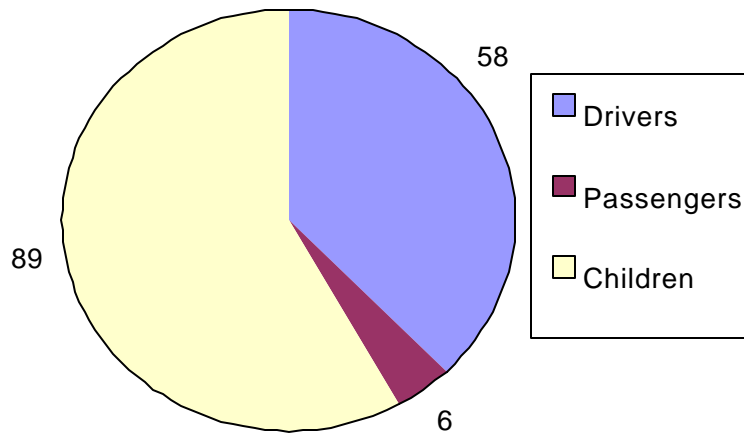


FIGURE 2 Estimated airbag deaths (2)

An airbag is not a soft, billo wy pillow. An airbag inflates, immediately after a serious crash, in a fraction of a second and becomes an energy-absorbing buffer between people in the vehicle and the hard interior surfaces of vehicles (3). To do its important job of protection, an airbag comes out of the dashboard at up to 200 miles per hour faster than the blink of an eye (4). Air bags are mounted in the steering wheel and the right front instrument panel and are designed to protect people in serious frontal crashes. The air bags help people by preventing their heads and chests from hitting the steering wheel, instrument panel, or windshield. In case of frontal crashes, even the occupants wearing seat belts move forward towards the steering wheel, instrument panel, or windshield. Airbags provide additional protection to occupants wearing seat belts by preventing them from hitting the hard interior surfaces. The design of most of the airbags is such that they inflate in crashes equivalent to hitting a solid barrier at 10-12 mph (3).

Present Scenario of Airbags

According to a study of real-world crashes conducted by the National Highway Safety Administration (NHTSA), the combination of seat belts and airbags is 75 percent effective in preventing serious head injuries and 66 percent effective in preventing serious chest injuries. As mentioned earlier the airbag provides a cushion and keeps the occupant’s head, neck and chest from hitting the hard interiors of a vehicle. In order to perform well, an airbag must deploy quickly and forcefully. After the airbag bursts through its cover and begins to inflate, the force is the greatest in the first 2-3 inches. Those first 2-3 inches are the ‘risk zone’. The force of the airbag decreases as the bag inflates farther (5).

Positioning too close to the airbag or failure to use proper restraints may result in serious injury or death. The risk is the same for both children and adults (5). In the first few milliseconds of inflation the force is very high and can seriously injure anyone struck by the inflating airbag. In most of the deaths caused by airbags, people involved were unbelted or improperly belted which allowed them to move on top of, or extremely close to the inflating airbags. Most of the adults (drivers and right-front passengers) killed by airbags were not properly restrained. Most of the deaths related to inflating airbags have been children. All older children killed by airbags were either unbelted or improperly belted and most of the infants were in rear-facing restraints in the front-seat (3).

A driver of any size and age needs to buckle up and sit at least 10 inches away from the steering wheel to avoid serious injury risk from an inflating airbag. On the passenger side, there's no significant airbag injury risk for belted adults sitting back in the seat (6). The back is the safest for children of any age. A recent study by IIHS found that children in back are 36 percent less likely to be killed in crashes (3).

FACTORS INFLUENCING THE EFFECTIVENESS OF AIRBAGS

The effectiveness of airbags is influenced by type of crash, type of occupant protection system employed along with airbag. The effectiveness of airbags is different when used alone and when used in conjunction with an active occupant protection. Also, the characteristics of drivers and front-seated passengers such as age, and height have a significant impact on the effectiveness of airbags.

Type of Crash

Airbags significantly reduce the likelihood of fatal injury in the most severe type of crashes, both purely frontal and head-on collisions (7). Airbags are so designed that they do not deploy in side impact crashes and rollover crashes. The airbags have little effect in case of non-frontal or side impact crashes (5). The description of a frontal and a non-frontal crash is explained with respect to Figure 3.

Head on Collision

A crash is considered head-on or purely frontal if the point of impact is 12:00 (Figure 3) (7).

Side Impact

If the initial point of impact is in between 10:00 and 2:00 (Figure 3), the crash is considered a non-frontal crash (7).

Airbag Plus Active Occupant Protection System

The most common active occupant protection system in use is the seat belt.

Seat Belts

When occupants are belted, the airbag offers increased additional protection to occupants from hitting the hard interiors of the vehicle in case of a frontal crash. Airbags in conjunction with lap-shoulder belts are proven lifesavers for adults in case frontal crashes (7).

Driver

The factors to be considered are age and height (7).

Age

Younger drivers (age 14-50) seem to experience more benefits from airbags than older drivers (50 or older) (7).

Height

Shorter drivers (especially short women) have occasionally exhibited problems in maintaining the safe distance of 10 inches between the breastbone and the cover of the airbag (7).

Front-Seated Passenger

The most significant factor is the age of the passenger in front (7).

Age

Children (age 0-12) are proven to be at a great risk of injury or death from airbags if seated in the front-seat with a passenger airbag (7).

Conclusions

Based on real-world crash experience, it is now clear that the frequency of fatal airbag induced injuries is not inconsequential. A review of the validity of early life saving forecasts for airbags states that

- In the case of airbag effectiveness the early analyses did not include the truth within the uncertainty intervals. It should have been realized that technologies often perform differently in controlled settings than in uncontrolled ones.
- In case of early estimates of airbag effectiveness, no attempt was made to quantify the number of occupants who might be killed by adding deployment energy to crashes.

- In case of airbags, it is now obvious that welfare of children and elderly were unintentionally overshadowed by preoccupation with the protection of the presumed sensitive group (unbelted adult males).
- Based on real-world injuries caused by airbags, NHTSA now recognizes that it is not sufficient to require airbags and expect that this “passive” device will work optimally. It is recognized that the so-called passive safety devices may have diminished effectiveness and unexpected risks, when human behavioral complications are ignored.
- As technology changes, estimates of risk and benefit should be subjected to refinement and validation over time (8).

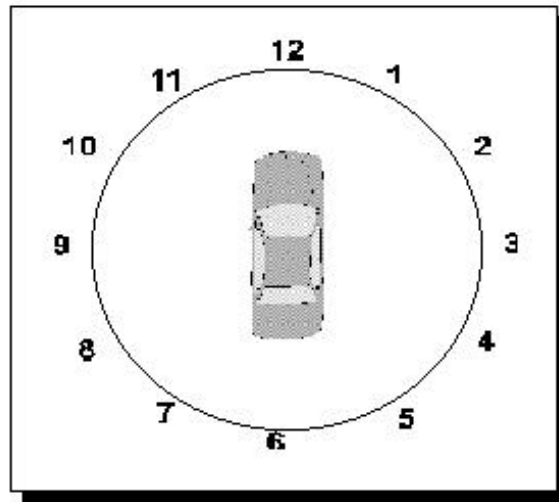


FIGURE 3 Description of point of impact (7)

CHILD-AIRBAG INTERACTION

Most deaths from inflating airbags have been children (3). The unintended adverse effects of an inflating airbag pose the greatest risk to infants in rear-facing restraints and unbelted/unrestrained children in the front seats of vehicles with passenger airbags (9).

The Problem

Most deaths from inflating airbags have been children (3). The unintended adverse effects of an inflating airbag pose the greatest risk to infants in rear-facing restraints and unbelted or unrestrained children in the front

seats of vehicles with passenger airbags (9). When an infant in a rear-facing restraint is placed in the front seat with a passenger airbag, the infant's head is too close to the bag. The enormous speed, with which the airbag inflates, exerts force against the back of the restraint and can cause serious, even fatal, head injuries to the infant (3).

Most of the older children killed by airbags are either unbelted or improperly belted. Even though belted, when a child leans forward, for example, to fiddle with the radio, the child's head can be too close to the airbag. Hence even belted children can be at risk in the front seat with a passenger airbag (3).

Figure 11 illustrates the risk to which the infants in rear restraints are subjected to by an inflating airbag, when placed in a front seat with passenger airbag.



FIGURE 11 An illustration of hazard to a child in rear facing restraint seat placed in the front seat with a passenger airbag (9)

Possible Solutions

Steps that can avoid the risk of death/injury from an airbag

- Infants in rear facing restraints should never ride in the front seat of a vehicle with a passenger side airbag.
- Small children should ride in a rear seat in child safety seats approved for their age and size.
- Children 12 and under should ride buckled up in a rear seat.
- If a child over one year and under 13 should ride in the front seat with a passenger side airbag, the child must be placed in a front facing safety seat, a booster seat, or a correct fitting lap/shoulder belt and the seat be moved as far back as possible (4).

The back seat has always been the safest for children even before airbags and now this is even more important. A recent IIHS study found that children riding in back are 36 percent less likely to be killed. Only when transporting too many small children and not possible to place all of them in the back, should a child ride upfront.

Then it should be made sure that the seat is all the way back and the child is securely buckled up in a lap/shoulder and sitting all the way back in the seat (3).

FUTURE AIRBAGS

Smart airbags and side airbags are the significant developments in airbag technology in recent years. The smart airbags are designed keeping in mind the problem posed by present airbags to children and also to short adults. The side airbags are intended to improve the effectiveness of airbags in side impact crashes.

Smart Airbags

It was predicted that the smart airbag systems would arrive in phases in the mid-'98 model year. Phase one was likely to include a weight sensor, variable crash severity sensor, seat buckle sensor, dual/variable output inflator and rear-facing child detection. Phase two was likely to add complete occupant sensing to determine exact position, weight, and presence of a child seat (10).

The Need

Recently released statistics from the NHTSA predict that currently designed passenger side airbags in the U.S. will kill one child a week. The immediate solution is wearing a seat belt and staying as far away as possible from the airbag. The short-term solutions studied by both the government safety groups and automakers include on/off switches and high/low power inflators. But the long-term solution for which both the government and automakers agree is “smart” airbags (10).

The Technology

A design change that will lower injury risk would be to reduce the airbag inflation energy. This won't eliminate the risks, particularly for children (3). These are called “depowered” airbags as they deploy with less force than the current airbags (5). By definition, a true, smart airbag is one that can detect the size and position of the occupant it is designed to protect. It can also detect the severity of the crash that deploys it. Using that information, the airbag provides maximum protection by adapting its inflation rate according to the prevalent conditions. It will also be smart enough not to deploy at all if it detects the presence of a child (10).

Considerations

According to Bill Eagelson, manager of occupant protection and impact dynamics at Ford's Environmental and Safety engineering, “There is a big difference between something being concept ready and its actual implementation and adoption into mass production”. Both automakers and regulators should realize the time

constraint. For any hope of getting a safer airbag into cars, the decision must be made now. If the automakers don't have time to perform tests, and suppliers don't have time to tool-up for production, the 1998 models may fulfill NHTSA's grim prophecy of losing a child each week to airbag deployment. Regardless of the good intentions of the regulators, a restraint should be exercised to avoid pushing a technology into production that promises something it isn't ready to deliver (10).

Side Airbags

Significant supplemental safety benefits can be provided to adults, by side airbags, in side impact crashes (11). These are designed to produce energy-absorbing buffers between people and the vehicle doors that can be driven into them in side impact crashes. These are smaller than frontal ones. Most side airbags are designed to protect people's chests, and are likely to provide some head protection also. They can be mounted in doors, seats, and roof rails. Side airbags are expected to offer increased protection from the fronts of striking vehicles and also intruding objects such as trees, poles (3).

CONCLUSIONS AND RECOMMENDATIONS

Regardless of size or age, anyone close to or on top of an inflating airbag is at risk. Hence the position of the occupant is very important. An airbag is effective and will do its job properly only when the occupant is at least 10 inches from the airbag when it is inflating.

The following ABCs will allow airbags to perform as an effective occupant protection system:

- Always slide the seat back as far as possible and sit back
- Buckle everyone
- Children 12 and under ride properly restrained in the back seat

Before going into mass production, the regulators and automakers should do a thorough investigation into the performance of smart airbags. A technology that isn't yet ready to deliver should not be pushed into production. The initial estimates of airbag benefits were overestimated by overconfidence and the same should not be repeated with the so-called "smart" airbags.

Airbags aren't alternatives to safety belts, but are designed to work with belts and provide additional protection in serious frontal crashes. Airbags and belts work together as a system, and one without the other isn't as effective (11).

Very few people need an on/off switch. By turning off an airbag, one is forgoing the important protection provided by the airbag in case of a serious frontal crash. After knowing the facts, it becomes clear that leaving the airbags intact is almost always the best (11).

The final conclusion of K. M. Thompson, et al. is taken as one of the conclusions of this paper. From the perspective of risk-analysis, a consideration to the variability in the population's susceptibility to risk and benefit as well as the degree of uncertainty in the estimates of risk and benefit is very critical to the engineer. This has been revealed by the airbag case study. Hence technologies that result in maximizing benefits, minimizing risks, and promoting warranted public confidence should be aimed at by reducing bias and overconfidence in estimation (8).

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