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Air Bags: Debunking The Myths… It's Not Rocket Science, Or Is It?

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Air bags in vehicles have become quite commonplace. They are neatly tucked away and mostly unseen, so most people don't give them much thought… until there's a crash. Then, people start asking questions. "Why didn't my air bag deploy?" "Why did my air bag deploy?" "After the impact, my air bag was smoking… was it on fire?" "The air bag is supposed to cushion me… why did it break my nose and glasses?" "What happened to Tiger Woods? Why didn't his vehicle have an air bag for his lower legs?" "How do knee air bags work?" It's not rocket science, or is it?

A LITTLE HISTORY

The first automotive barrier crash test, conducted at GM in 1934, was an early milestone in vehicle safety. In the late '40s and early '50s, seat belts began being offered in cars, and the first patents for early air bag designs were filed in 1951 (Figure 1). The inventors of those original air bag devices were limited by compressed air or gas technology of that time; but compressed gas could not fill the bags fast enough, and crash sensing had not been invented yet. So, the concept of automotive air bags stayed "deflated" for several years.

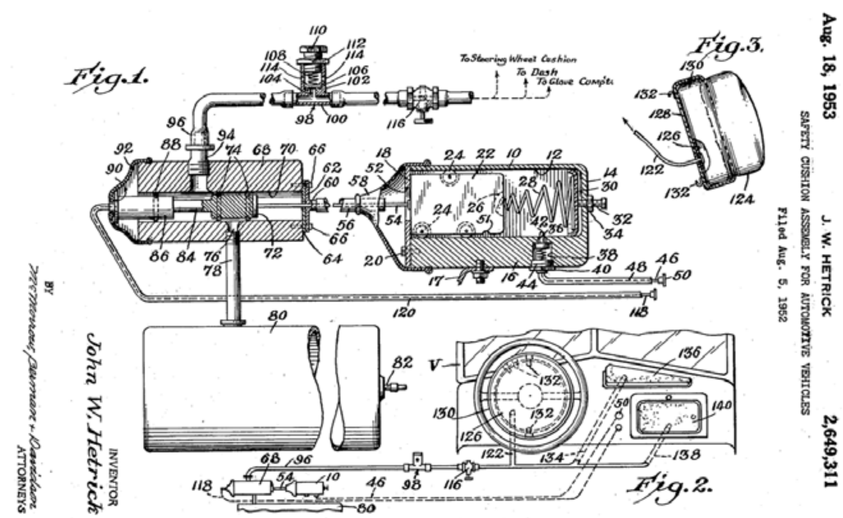

Figure 1. Early patent of automotive air bags

Then, in the late '60s, Allen Breed developed a ball-in-tube electromechanical sensor that could detect a crash and close a circuit to deploy an air bag. Also, at about that time, aerospace companies like Talley and Thiokol had been researching solid propellant applications for rocket boosters, military aircraft pilot ejection systems… and automotive air bags.

Breed's sensor designs and some aerospace rocket science led the way to the actual implementation of air bags in passenger vehicles. Ford and GM began installing air bags in automotive

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test fleets in the early '70s, and the first passenger air bag was sold to the public in the 1973 Oldsmobile Toronado. In 1981 at the Geneva Motor Show, Mercedes-Benz announced a driver air bag and pyrotechnic passenger belt tensioner for the new S-Class (Figure 2). Automatic seat belts or air bags were required in US passenger vehicles in the late '80s. After initially fighting their implementation – like a lot of auto industry leaders -- Lee Iacocca decided to gamble and offered driver air bags as standard equipment on several Chrysler models. The bet paid off, and the industry found that "safety sells." The rest, as they say, is history.

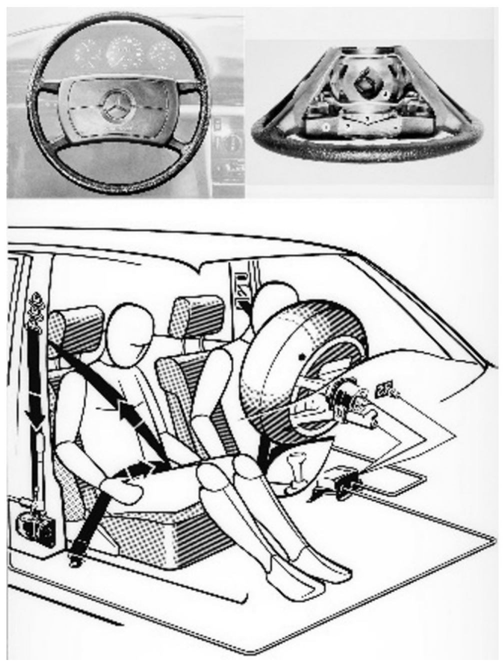

Figure 2. Mercedes-Benz circa 1981

AIR BAG MYTH #1

"My air bag didn't deploy, so it must have been defective."

Air bags are very reliable. The automotive industry was very cautious before finally embracing air bag technology. Air bags were – and still are – carefully designed, tested, and vetted. Since they are inherently dangerous, special precautions are taken to make sure they work as intended. Also, air bags are only intended to deploy in certain situations.

Air bags are not set to inflate based primarily on the speed of the vehicle. Deployment depends on the object struck, the impact direction, and how rapidly the vehicle changes speed or slows down. Is the struck object fixed or moving, rigid or deformable, narrow or wide?

Early air bag systems were designed to only function in frontal or near-frontal crashes. Later, side impact air bags were developed. Then, rollover air bags were introduced to complement and utilize the side air bags. More recently, knee air bags, inflatable seat belts, rear impact air bags, and others are being developed and introduced. Some vehicles have active head restraints or "deployable" headrests for rear impacts, but those devices currently are mechanically activated and do not use air bag technology. Crash sensors detect impact "forces" or roll characteristics. Deployment thresholds are then used to determine if the air bags should inflate (Figure 3, next page).

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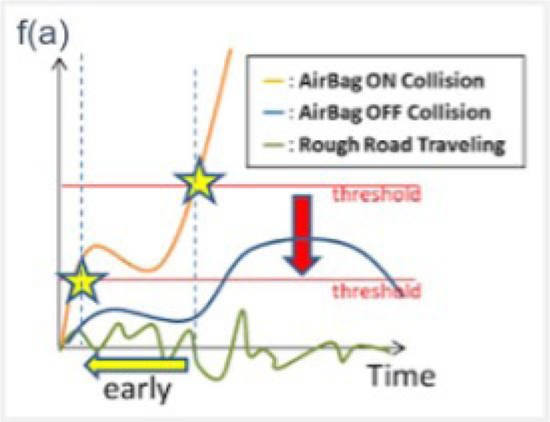

Figure 3. Deployment thresholds (Okamura, et.al., 26ESV-19-000248)

Air bags are designed to inflate only if the applicable deployment threshold is exceeded. Deployment thresholds are mostly based on crash severity, usually some function of acceleration (or deceleration). The threshold is set to deploy air bags only in moderate to severe crashes to reduce the potential for serious injuries. More advanced vehicle restraint systems use thresholds based on crash severity, driver and passenger belted status, front seat position, and front passenger occupant size and weight.

Most vehicles built since the late 1980s have air bags. For those vehicles equipped with air bags, nearly all will have one or more frontal air bags. The most common is the driver frontal air bag located in the steering wheel. A larger frontal air bag for the outboard front passenger is also very common. More recent examples of frontal air bags include knee air bags for the driver and outboard front passenger. Frontal air bags are designed for frontal and near-frontal crashes and are not intended to deploy in rear impacts, rollovers, or many side impacts.

Side air bags are set to inflate in side impacts and sometimes rollover crashes. Air bags for side impacts must deploy very early and fast because the gap between the occupant and door is small, and that gap often "closes" rapidly due to the intruding vehicle or object. Side impact sensors are usually solid-state accelerometers or pressure sensors in the doors or side pillars. Like frontal air bags, most side air bags are vented and quickly deflate. Since rollover crashes can last up to 6 seconds or more, rollover air bags need to stay inflated for about 6 seconds and are, therefore, coated and sealed. Some side curtain air bags are designed only for side impacts. Other side curtain air bags have been developed for side impacts and rollover crashes.

Each vehicle model is relatively unique with its own specific size, weight, and structure. Therefore, each vehicle model has its own unique crash "signature" and reacts to crashes differently than other models. To account for this, the air bag sensor system for each vehicle model is calibrated specifically for that vehicle model, and that model only. Many tests and various simulations are conducted and used for air bag sensor calibrations. In addition to standard frontal, angular, side, rear, and rollover crash tests, rough road and other abuse tests like curb impacts and undercarriage strikes are used.

Vehicle crashes can be very complicated and somewhat chaotic events, so it is very difficult and often impossible to replicate actual crashes with tests. Many crashes include multiple impacts and directions and are a small collection of different events. Some develop very quickly, while others develop slowly over several seconds. Due to thorough design and development, air bag sensor calibration is usually quite robust

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and can assess most crashes and make the proper decision to deploy or not deploy. Although rare, air bag systems can and do occasionally fail to deploy or deploy inadvertently. Before concluding a defect occurred, the conditions of the crash and the vehicle specifications must be carefully examined.

AIR BAG MYTH #2

"Air bags pop out after the car stops, like in the movies."

For most of us, we realize what we see on the big screen is not always completely accurate. Hollywood often takes liberties with physics, with science, with technology, and with air bags. Although not meant to be authentic, one of my favorite portrayals is the Jiffy Pop popcorn air bag by Saturday Night Live (SNL) (Figure 4).

Figure 4. Jiffy Pop air bag (SNL)

Air bags usually deploy a fraction of a second after impact. For example, during a 30-mph frontal barrier test, the occupant begins moving relative to the vehicle in about 15 milliseconds (0.015 second). The occupant continues to move about 5 inches over the next 30 milliseconds. Since a typical driver frontal air bag inflates in about 30 milliseconds, the decision window for air bag deployment is the first 15 milliseconds during that type of crash. So, for a 30-mph frontal, deployment occurs after about 15 milliseconds, air bag inflation in about 30 milliseconds, occupant ride-down over another 50 milliseconds, and occupant rebound back into the seat in about 100 milliseconds or more. The vehicle comes to a brief stop and begins to rebound in about 90 milliseconds, just before the occupant reaches maximum ride-down. The vehicle rebounds or bounces back and comes to rest "long" after the air bag has deployed.

According to various sources, the duration of an eye blink is 100 to 400 milliseconds. Air bags deploy in 30 to 60 milliseconds… "less than the blink of an eye."

AIR BAG MYTH #3

"Air bags are soft cushions or pillows."

As just described, air bags inflate very fast. As they unfold and deploy, the filling bag front can reach speeds of 100 to 200 mph. Also, most are designed to protect belted and unbelted occupants. To restrain an occupant in a moderate-to-severe crash, an air bag may need to exert a force of 1,000 to 3,000 pounds or more on the occupant. That means the air bag must pressurize and be quite firm for a short time. The air bag is usually porous or vented and allows gas to quickly escape to properly manage the occupant's energy and allow the occupant to "ride down" the air bag (Figure 5).

Figure 5. Air bag ride-down (phandwc.com)

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Air bags are designed to help stop an occupant with a substantial amount of kinetic energy in a crash. Crash forces can be quite high, so the air bag must be firm, not soft. Occasionally, drivers break their eyeglasses or nose when contacting the air bag. The air bag must also deflate rapidly in a controlled fashion to avoid excessively high forces that could seriously injure the occupant.

AIR BAG MYTH #4

"My car has air bags, so I don't need to wear a seat belt."

Seat belts are primary restraints. Air bags are designed to be supplemental restraints. While air bags will provide some protection for unbelted occupants, air bags alone cannot prevent all injuries. Air bags work best when used in conjunction with seat belts.

Unbelted occupants will normally experience much more movement or "excursion" during a crash, when compared to a belted occupant. For example, a front seat unbelted occupant will travel forward and hit his knees on the lower dash panel, known as the knee bolster, during a frontal crash. Knee bolsters are typically steel or structural plastic panels covered by trim. They are designed to absorb occupant crash energy, but they are relatively hard and rigid. Also, an unbelted occupant is much more likely to penetrate through, miss, or slide off the air bag and strike an interior component like the header, A-pillar, or windshield.

Even worse, an unbelted occupant can easily be ejected from the vehicle during a crash (Figure 6). Ejection from the vehicle is extremely dangerous. It is much safer to remain inside the vehicle during a crash. It is not safer to be thrown clear of the vehicle (another myth). According to National Highway Traffic Safety Administration (NHTSA) (safercar.gov), only two percent of all crashes involved a rollover, but rollovers accounted for 35 percent of all traffic fatalities due to partial or full occupant ejection and other factors.

Figure 6. Occupant ejection through windshield (abcnews.go.com)

AIR BAG MYTH #5

"My air bag was smoking, so it must have been on fire."

All air bags are inflated by gas-generating devices that include some type of ignition train. An igniter or "squib" is a small "micro" gas generator that starts the inflation process. The squib produces a small amount of hot gas that ignites booster material, which in turn produces more hot gas that ignites the main solid propellant. The propellant converts to harmless nitrogen gas and fills the bag. Hybrid-technology air bag inflators use a smaller amount of solid fuel to heat compressed gas that expands and fills the bag.

Some smoke or widely dispersed particulates are produced

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as a byproduct of air bag inflator ignition and deployment. Most of the heavy particulates are trapped by filters in the inflator, but some of the smallest particulates pass by the filters and enter the bag as smoke. Since the bag is typically stitched and semi-porous or vented, some of the smoke exits the bag during deflation. That smoke is visible inside the vehicle but is mostly harmless. The smoke is a normal byproduct; it does not mean the air bag was on fire.

Early air bag cushions were made from state-of-the-art fabric at that time. Since fabric long-term aging and friction were concerns, the air bag cushions were often coated with cornstarch or talcum powder to keep the fabric soft and lubricated. With the advancement of better fabrics over time, the use of cornstarch or talcum powder on air bags was abandoned many years ago.

WHAT HAPPENED TO TIGER WOODS

As you likely heard, 45-year-old Tiger Woods was involved in a very serious car crash recently. He was reportedly traveling north on a curvy downhill stretch of road in Los Angeles County, on his way to a TV shoot with other celebrities. Tiger was driving a 2021 Genesis GV80 SUV.

Police said the Genesis contacted the dividing median and struck a wooden sign before crossing two southbound lanes. The Genesis then reportedly struck a curb and some trees, causing it to overturn and roll several times. There was heavy impact damage to the front end and light-to-moderate damage on the rear quarter panels and rear end.

The Genesis driven by Tiger was equipped with 10 air bags, including a front center air bag for side impacts (Figure 7). At least eight of the 10 air bags deployed during the crash. The driver steering wheel and knee air bags deployed due to the frontal impact. The left and right side-curtain air bags and front and rear seat side air bags also deployed for rollover protection.

Figure 7. Genesis GV80 (hooniverse.com)

Tiger was reportedly belted. Although he was protected with a driver knee air bag, Tiger still sustained multiple serious fractures to his lower right leg, ankle, and foot. His injuries were possibly caused by intrusion of the driver footwell. Tiger did not sustain any significant injuries to his head, chest, or vital organs. He can attribute his survival – from what could have been a fatal crash – to the vehicle's overall structural integrity and crashworthiness, his seat belt usage, and air bag protection and safety containment.

IN CLOSING

First invented in the early 1950s, air bags have been in production vehicles since the '70s and '80s. Although the general concept seems rather simple, air bags are very sophisticated and complicated devices. Special sensing and gas-generating technologies had to be developed to implement air bags. A lot of that technology is tightly

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packaged and hidden away inside the vehicle. For various reasons, there are several misconceptions or myths about air bags. This article attempted to dispel some of those myths with factual and detailed information… and rocket science.

ABOUT THE AUTHOR

John G. Bauer is a forensic mechanical engineer, certified traffic crash reconstructionist, and vehicle occupant restraints expert for Rimkus in Raleigh, North Carolina. His experience includes 25 years in the automotive industry, most of that designing and developing seat belts and air bags. He conducted vehicle crash testing and simulations to optimize passenger safety. He has 11 US patents and was a featured speaker and author for the Society of Automotive Engineers. Since becoming a forensic expert, Mr. Bauer has consulted on various transportation-related matters and reconstructed hundreds of traffic accidents. He has investigated Takata air bag recalls, go-cart and ATV rollovers, and wheelchair accessible vans with safety restraints failures. He was retained as a seat belt expert for a high-profile fatal accident of a young boy on a 168-foot high water slide at the Schlitterbahn Waterpark in Kansas City, KS, in 2016. He enjoys vehicle and home restoration, golf, boating, and other activities with his family and friends.

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