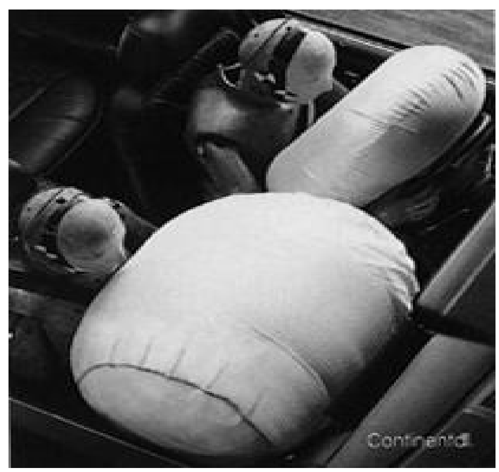
Vehicle Safety

Introduction

Airbags were first introduced in the early 1970's and since then, vehicles, as well as their safety features, have developed rapidly. Since model year 1998, all new cars have been required to have air bags on both driver and passenger sides (light trucks came under the rule in 1999). There are many safety features located within the vehicles found on the road today and many more advancements can be expected. However, while these "safety" features are great for protecting the passenger upon impact they can be very hazardous to rescuers, and possibly the passengers, while working to extricate the patients from the vehicle. The dangerous possibilities of airbags were demonstrated by the injuries sustained by two firefighters from Ohio during an extrication. Both rescuers were injured when the multiple airbags deployed during extrication, seriously injuring one of the rescuers.

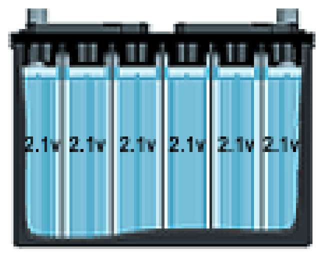
The following information is current as of late fall 2004. The automobile manufacturing industry has made great strides in the safety features of today's automobiles and will continue to make advancements in this field. All firefighter/rescuers must make every attempt to stay current with the technology of today and tomorrow.

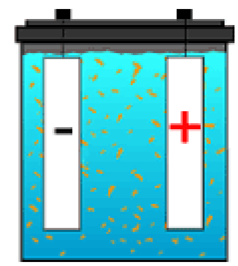


Batteries

Batteries used to be located under the hood either on the passenger side of the driver's side, however with modern day vehicles this is no longer the case. In today's vehicles batteries can be found under the hood, in the trunk, under the rear passenger seat, and just about anywhere else the manufacturer can find a place to put the battery.

Car batteries are lead-acid batteries. A car's battery is designed to provide a very large amount of current for a short period of time. This surge of current is needed to turn the engine over during starting. Once the engine starts, the alternator provides all the power that the car needs. A car battery may go through its entire life without ever being drained more than 20 percent of its total capacity. Used in this way, a car battery can last a number of years. To achieve a large amount of current, a car battery uses thin plates in order to increase its surface area.

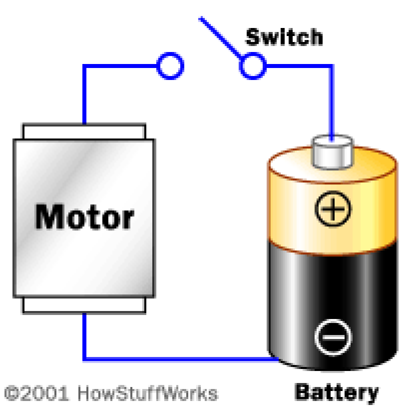




A car battery typically has two ratings:

- **CCA** (Cold Cranking Amps) - The number of amps that the battery can produce at 32 degrees F (0 degrees C) for 30 seconds
- **RC** (Reserve Capacity) - The number of minutes that the battery can deliver 25 amps while keeping its voltage above 10.5 volts

If you look at any battery, you'll notice that it has two terminals. One terminal is marked (+) or positive (usually red), while the other is marked (-) or negative (usually black). In an AA, C or D cell (normal flashlight batteries), the ends of the battery are the terminals. In a large car battery, there are two heavy lead posts that act as the terminals.



Electrons collect on the negative terminal of the battery. If you connect a wire between the negative and positive terminals, the electrons will flow from the negative to the positive terminal as fast as they can (and wear out the battery very quickly). This can be dangerous, especially with large batteries. Normally, some type of load would be connected to the battery using the wire. In automobiles the load is the motor.

Inside the battery itself, a chemical reaction produces the electrons. The speed of electron production by this chemical reaction (the battery's internal resistance) controls how many electrons can flow between the terminals. Electrons flow from the battery into a wire and **must**

travel from the negative to the positive terminal for the chemical reaction to take place. This is why a battery can sit on a shelf for a year and still have plenty of power. Unless electrons are flowing from the negative to the positive terminal, the chemical reaction does not take place. Once you connect a wire, the reaction starts.

Voltage

In any battery, the same sort of electrochemical reaction occurs so that electrons move from one pole to the other. The actual metals and electrolytes used control the b of the battery -- each different reaction has a characteristic voltage. For example, here's what happens in one cell of a car's lead-acid battery:

- The cell has one plate made of lead and another plate made of lead dioxide, with a strong sulfuric acid electrolyte in which the plates are immersed.
- Lead combines with SO4 to create PbSO4 plus one electron.
- Lead dioxide, hydrogen ions and SO4 ions, plus electrons from the lead plate, create PbSO4 and water on the lead dioxide plate.
- As the battery discharges, both plates build up PbSO4 (lead sulfate), and water builds up in the acid. The characteristic voltage is about 2 volts per cell, so by combining six cells you get a 12-volt battery.

A lead-acid battery has a nice feature -- the reaction is completely reversible. If you apply current to the battery at the right voltage, lead and lead dioxide form again on the plates so you can reuse the battery over and over. In a zinc-carbon battery, there is no easy way to reverse the reaction because there is no easy way to get hydrogen gas back into the electrolyte.

Capacitors

Capacitors were placed into vehicles to solve the problem of the vehicle battery being destroyed early in a crash and therefore no power was available to deploy the supplemental restraint systems. While these capacitors solved the problem of power loss they created a problem in that they can hold a back-up power supply for up to 30 minutes. This back-up power supply can lead to the deployment of the supplemental restraint systems during the patient extrication. The best way to attempt to prevent this is to disable the capacitor's power source – the battery.

When disabling the battery the battery should be disconnected or cut on the negative side then the positive side. If disconnecting the cables, push them away from the terminal so that they will not go back into contact. If cutting the cables it is best to cut them in two places therefore placing a gap in the wire so that they cannot reconnect.

Even after disconnecting the battery there is no guarantee that the airbags have been deactivated. As mentioned before the capacitor can hold a charge up to 30 minutes. The length of time each model of vehicle will hold a charge varies from 0 seconds to 30 minutes. Even after the capacitor has been discharged there are several factors that may allow for discharge of the airbags:

- Static electricity or delivering electrical power to the airbag system at any time
- Aftermarket accessories with battery back up power
- Vehicle and electrical fires
- Mechanical airbags (Volvo 850, 960 & 70 series side impact, front airbags 1993-1995 Cherokee, & pre 1996 Jaguar)
- Dual or multi stage airbags with live 2nd igniter
- Crushing or damaging the airbag computer module or SRS unit/DERM

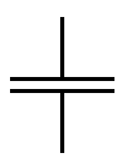
<u>How capacitors work</u>

In a way, a capacitor is a little like a battery. Although they work in completely different ways, capacitors and batteries both store electrical energy. Inside the battery, chemical reactions produce electrons on one terminal and absorb electrons at the other terminal.

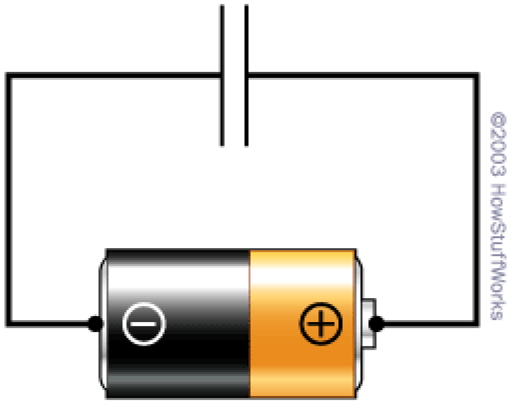
A capacitor is a much simpler device, and it cannot produce new electrons -- it only stores them.

Like a battery, a capacitor has two terminals. Inside the capacitor, the terminals connect to two metal plates separated by a dielectric. The dielectric can be air, paper, plastic or anything else that does not conduct electricity and keeps the plates from touching each other. You can easily make a capacitor from two pieces of aluminum foil and a piece of paper. It won't be a particularly good capacitor in terms of its storage capacity, but it will work.

In an electronic circuit, a capacitor is shown like this:



When you connect a capacitor to a battery, here’s what happens:

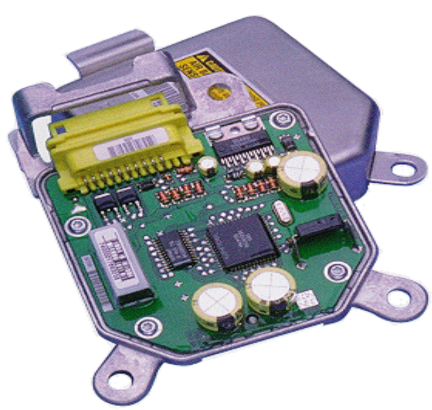


- The plate on the capacitor that attaches to the negative terminal of the battery accepts electrons that the battery is producing.
- The plate on the capacitor that attaches to the positive terminal of the battery loses electrons to the battery.

Once it's charged, the capacitor has the same voltage as the battery (1.5 volts on the battery means 1.5 volts on the capacitor). For a small capacitor, the capacity is small. But large capacitors can hold quite a bit of charge (think METRO). You can find capacitors as big as soda cans, for example, that hold enough charge to light a flashlight bulb for a minute or more. When you see lightning in the sky, what you are seeing is a huge capacitor where one plate is the cloud and the other plate is the ground, and the lightning is the charge releasing between these two "plates." Obviously, in a capacitor that large, you can hold a huge amount of charge!

Control Module

The control module is where the capacitor is typically housed and will frequently have a master sensor for the supplemental restraint system (this may be the only sensor in the vehicle). The control module is also known as the Diagnostic Energy Reserve Module (DERM), Central Processing Unit (CPU), Electronic Control Unit (ECU), the computer or the "Brain." The control module may be found in several locations; under the center console, in the dashboard, in the passenger footwell area, etc.



GM 'black box' SDM air bag module. Mounted under center console. 2001 Cadillac DTS shown.

In addition to housing the capacitor this “black box” records the following information:

Vehicle speed (in five one-second intervals preceding impact)
Engine speed (in five one-second intervals preceding impact)
Brake status (in five one-second intervals preceding impact)
Throttle position (in five one-second intervals preceding impact)
Driver's seat belt state (On/Off)
Passenger's airbag enabled or disabled state (On/Off)
Airbag Warning Lamp status (On/Off)
Time from vehicle impact to airbag deployment
Maximum Delta-V (DV) for near-deployment event
Delta-V (DV) vs. time for frontal airbag deployment event
Time from vehicle impact to time of maximum Delta-V (DV)
Time between near-deploy and deploy event (if within 5 seconds)

Sensors

Sensors are used to send a signal to the control module in a crash. Some vehicles have a single sensor located in the control module while other vehicles have a number of sensors located throughout the vehicle.

The sensor is the device that tells the bag to inflate. Inflation happens when there is a collision force equal to running into a brick wall at 10 to 15 miles per hour (16 to 24 km per hour). A mechanical switch is flipped when there is a mass shift that closes an electrical contact, telling the sensors that a crash has occurred. The sensors receive information from an accelerometer built into a microchip.

Front Airbags

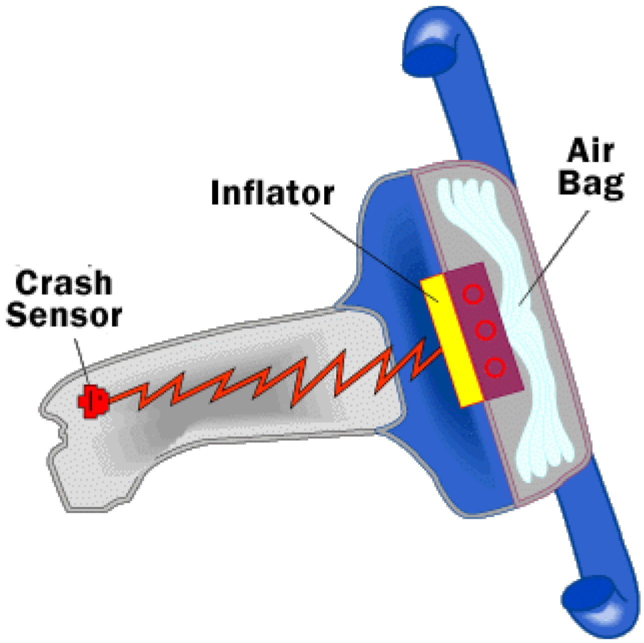
What an air bag wants to do is to slow the passenger's speed to zero with little or no damage. The constraints that it has to work within are huge. The air bag has the space between the passenger and the steering wheel or dash board and a fraction of a second to work with. Even that tiny amount of space and time is valuable, however, if the system can slow the passenger evenly rather than forcing an abrupt halt to his or her motion.

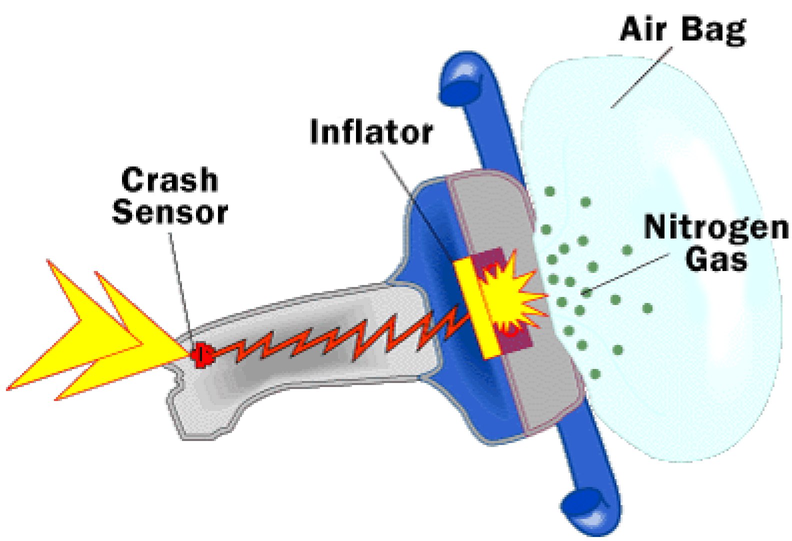
There are three parts to an air bag that help to accomplish this feat:

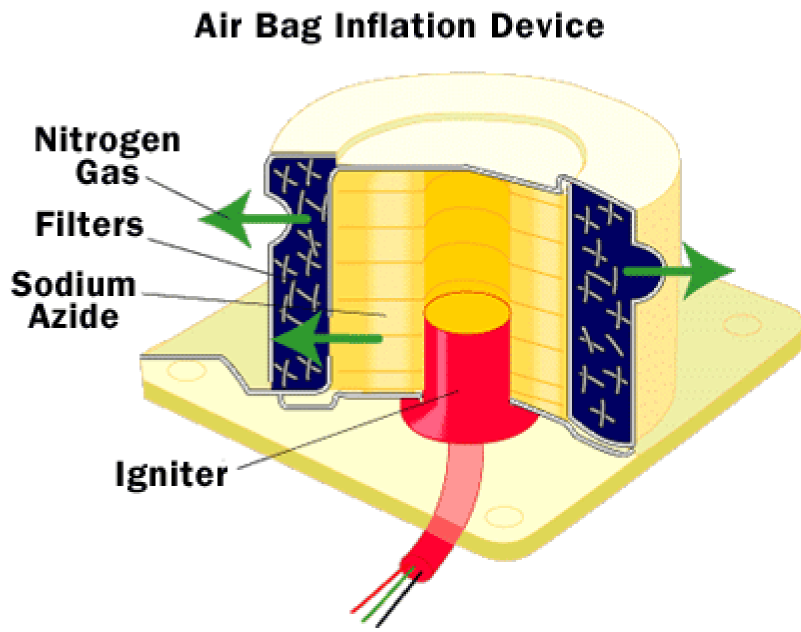
- The bag itself is made of a thin, nylon fabric, which is folded into the steering wheel or dashboard
- The sensor

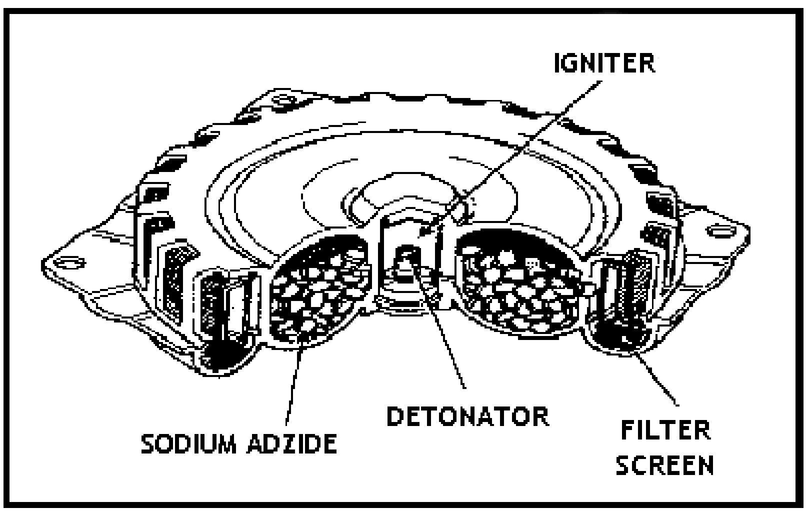
- The air bag's inflation system reacts sodium azide (NaN_3) with potassium nitrate (KNO_3) to produce nitrogen gas. Hot blasts of the nitrogen inflate the air bag.

The inflation system is not unlike a solid rocket. The air bag system ignites a solid propellant, which burns extremely rapidly to create a large volume of gas to inflate the bag. The bag then literally bursts from its storage site at up to 200 mph (322 kph) -- faster than the blink of an eye! A second later, the gas quickly dissipates through tiny holes in the bag, thus deflating the bag so you can move. The latest generation of frontal airbags deploy with 20-to-35 percent less force than earlier versions.









This is a diagram of a typical inflator assembly behind the steering wheel

Even though the whole process happens in only one-twenty-fifth of a second, the additional time is enough to help prevent serious injury. The powdery substance released from the air bag, by the way, is regular cornstarch or talcum powder, which is used by the air bag manufacturers to keep the bags pliable and lubricated while they're in storage.

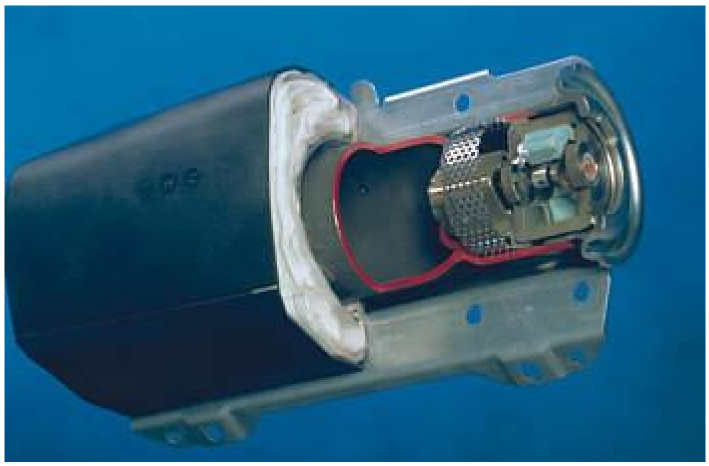
AT NO TIME SHOULD ANY POST MANUFACTURED DEVICE BE PLACED OVER ANY AIRBAG.

A view of the rear of this frontal airbag clearly shows the two separate inflator modules. This airbag is designed to fire only one inflator in a low-speed collision, leaving responders faced with a “dead” airbag with a “live” charge remaining.

Passenger Side Airbag

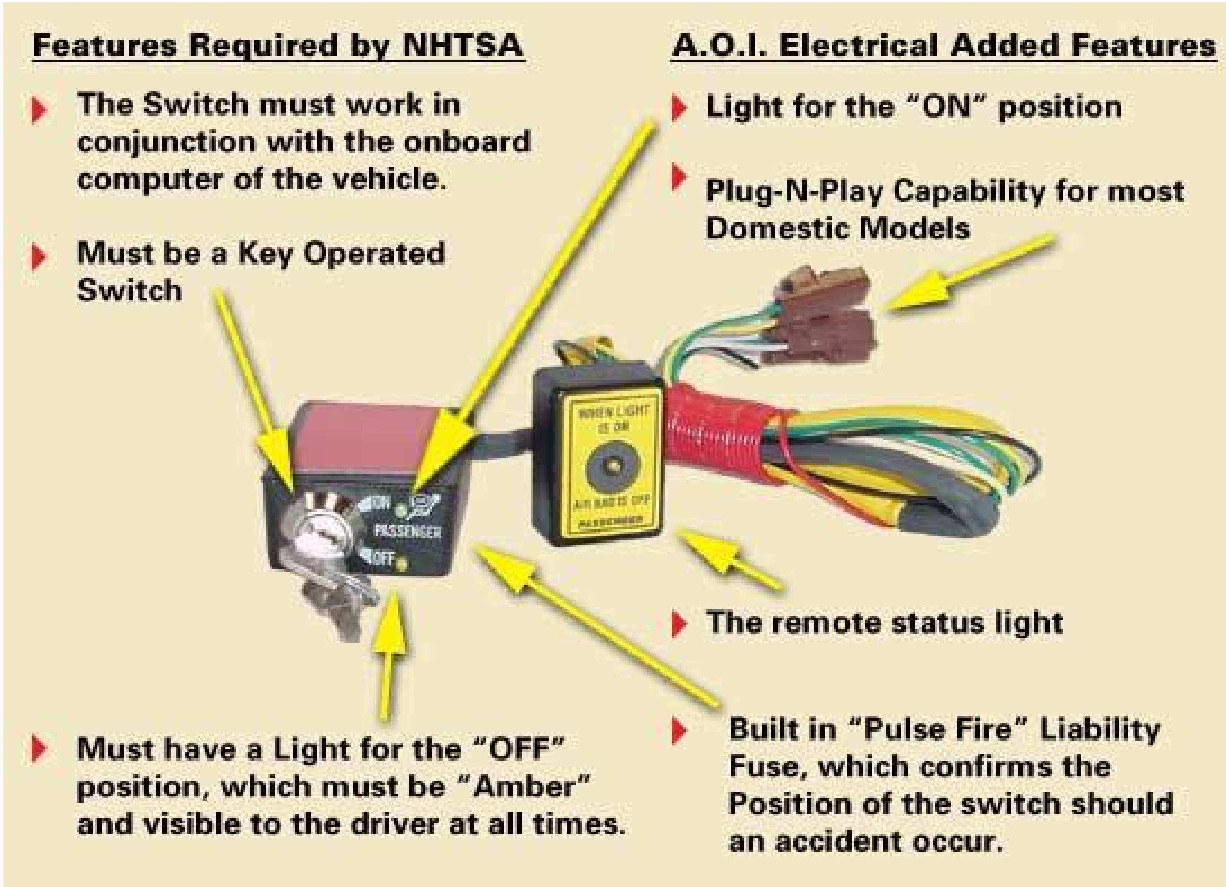
In September of 1997, a mandate was issued for vehicle manufacturers to provide a front impact air bag for the passenger side of the vehicle. Several manufacturers had already introduced this passenger protection system beginning in 1990. By 1995 passenger side airbags were a common vehicle addition.

The passenger bag is mounted in the top of the dash on the passenger side of the vehicle. Below is a Photographic cross section of a Passenger Side Airbag Module



Some vehicles are equipped with an airbag switch allowing them to deactivate the passenger airbag. If during an extrication a vehicle is found to be equipped with this switch an attempt should be made to switch it to "off." While this does not guarantee that the bag will not deploy it is an extra step that should be taken to protect the patient, your crew, and yourself.

While some vehicles are manufactured with a switch as pictured above, other vehicles may contain after market switches pictured below.



Side Airbags

Side impact bags were first introduced by Volvo in 1995 and have rapidly increased in popularity. At the same time side impact airbags have had a lot of bad publicity because of multiple injuries and deaths related to side impact airbags. There are several different types of side impact airbags, included are:

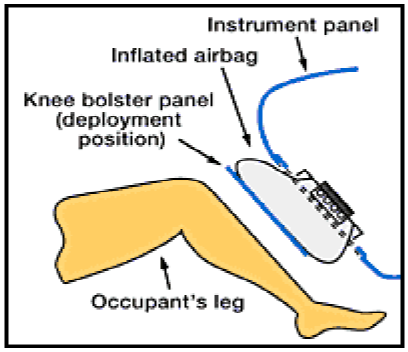
The Head-Thorax Bag

Inflatable Curtain

Inflatable Tubular Structure

USE EXTREME CAUTION WHEN CUTTING THE C POST OF A VEHICLE WITH CURTAIN AIRBAGS! CUTTING THE FIRING MECHANISM MAY CAUSE UNDEPLOYED CURTAIN BAGS TO DEPLOY

Leg ProtectionBags

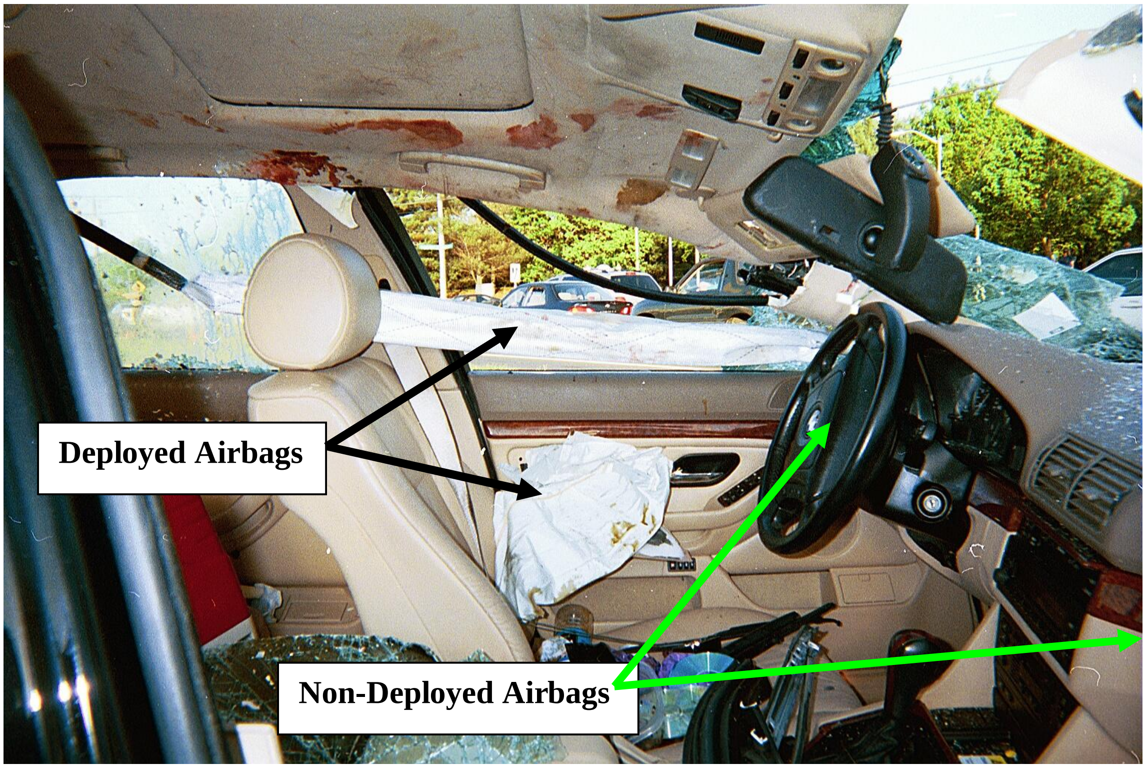


Autoliv has developed a new airbag in cooperation with Renault. The Anti-Sliding-Bag is installed in the front edge of the seat cushion to reduce the risk of the occupant sliding under the seat belt in a crash.

Without the Anti-Sliding-Bag

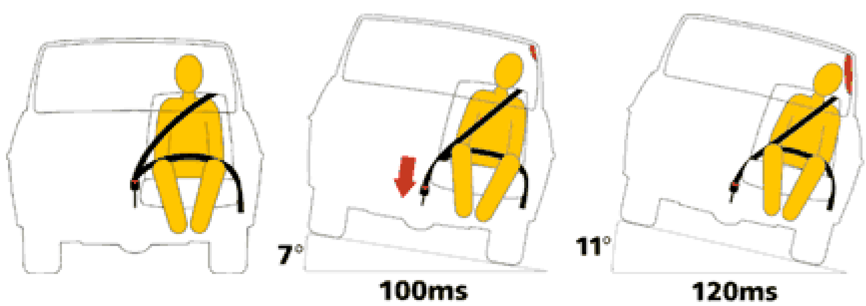
With the Anti-Sliding-Bag

Inflatable Carpet (InCa) is a new protection system under development which will protect the car occupant's feet, ankles and lower legs in frontal crashes by removing the feet from the intruding foot well of the vehicle.



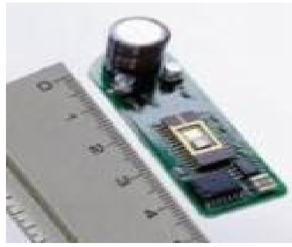
Be Aware, not all airbags deploy together. Treat ALL airbags as live airbags!

Rollover Protection



To maintain the clearance between the occupant's head and the roof of the vehicle, the vehicle can be equipped with a Belt-in-Seat system where the shoulder belt is attached to the backrest of the seat instead of to the pillar between the doors. The rollover also uses a new and very advanced micro-processed sensor which will trigger the seat belt pretensioners (to further increase the clearance between the roof and the occupant's head) and the Inflatable Curtains to help prevent the occupant's head from hitting that side of the vehicle or the ground. The Inflatable Curtain will also help prevent occupants from being ejected from the vehicle, which is very common in rollovers, especially among unbelted occupants.

Micro processed sensor



A roll-over protection system, fitted as standard, which extends to a height of 265 millimeters within 0.25 seconds if a sensor detects an impending rollover or crash.

Pretensioners

Pretensioners are incorporated into the belt assemblies to remove slack from the seat belt during a collision. Within milliseconds of a crash, the pretensioner is activated and increases the tension of the seat belt system around the occupant. This is what keeps you from bouncing around and keeps you in the proper position to benefit from the airbag if the crash is severe enough to trigger them. It contains an inertial reel with a pendulum device that senses sudden deceleration and automatically locks the belt in a crash. Currently there are three types of pretensioners in use today.

Mechanical

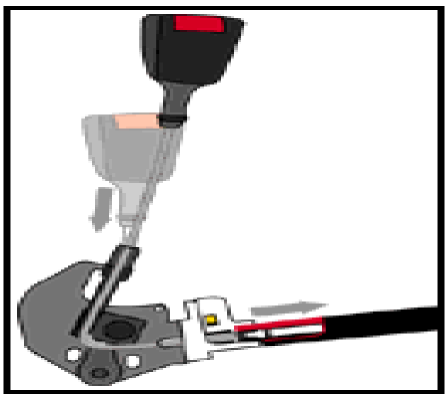
Mechanical pretensioners use an inertial wheel with a pendulum device that moves under the rapid deceleration of the crash to lock the belt into place. Such mechanisms can often be detected by giving a sudden tug on the belt. A mechanical pretensioner will automatically lock the belt into place, with the intent of limiting occupant travel in the event of a crash.

Electrical

Electrical pretensioners replace the mechanical means of sensing deceleration (the pendulum) with an electrical device that may or may not be tied into the airbag ignition circuits.

Pyrotechnic

Pyrotechnic pretensioners use electrically triggered pyrotechnics that tighten the seatbelt a prescribed amount upon sensing a crash event. These devices can operate on either the buckle or ratchet side of the seatbelt mechanism. These are the most highly technical type of pretensioner, and also the most expensive. These will be the focus of this report.

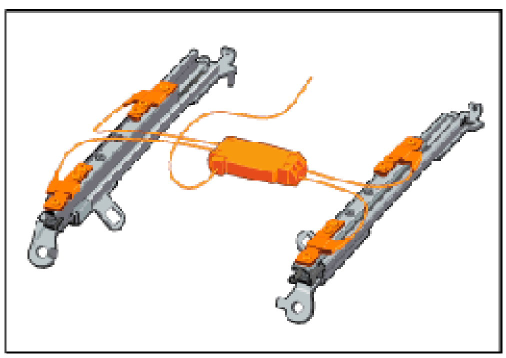


Smart Systems

1. Ultra-sonic sensors
2. Weight sensors
3. Buckle sensors
4. Adaptive inflators
5. Hand Placement sensor
6. Seat position sensors

The Smart Airbag of the future is not just the airbag, but a redesign of the components in the current airbag systems. Features include:

- **Weight Sensors** This is a new sensor for the passenger seat to classify the weight and to determine what type of occupant is in the seat (adult or child).



- **Infrared Occupant Detection** This system will use Infra-red beams (just like in your TV remote control) to detect the distance the passenger is from the airbag and adapt the force of deployment accordingly.
- **Capacitive Reflective Occupant Sensing** These sensors will be located in the seat backs and in the dash to identify the distance you and or your passengers are from the dashboard. These sensors will be able to discriminate between a human occupant and inanimate objects like your groceries. This alone will save thousands of dollars in the cases where the driver is the only occupant in the front seat.

- **Updated SENSORS** The updated SENSORS will have the capabilities of deploying the seatbelt pretensioners faster, so in a crash situation you will be in the best position to benefit from the airbag deployment.

- **Centralized Electronic Control Unit** The new control units will be able use all the input from the new sensor technology and thru new software deploy what you need when you need it.

In addition, so-called "smart" frontal airbags on some vehicles are able to deploy at different degrees of force, depending on the severity of the crash and the weight of the occupant. Some vehicles come with suppression systems that prevent airbags from deploying if sensors detect a child in the front passenger seat. Such airbags will be required in all vehicles on a phased-in basis, beginning in 2004.

New Vehicle Construction

Today's cars and trucks are specifically designed and built to help passengers survive a wide range of types and severities of collisions. So-called "crumple zones" at the front and rear of a vehicle are engineered to absorb and redirect crash forces. Hoods are engineered to collapse so they won't be forced through the windshield. Doors are designed to remain intact and overlap upon impact so passengers will be able to exit the vehicle. Doors are also are equipped with more-secure hinges and latches so they won't spring open to eject passengers. Heavier firewalls and specially designed engine mounts help send components down and under the passenger area, so they won't come crashing into the front seat. Windshields are specially laminated to help prevent not only injuries from shattering glass, but ejection from the vehicle in a collision.

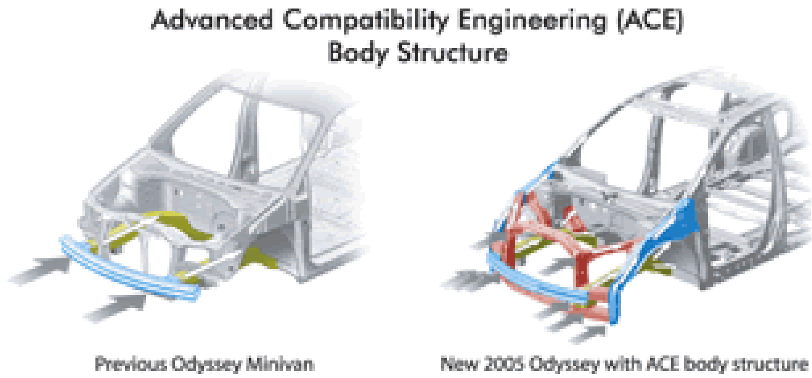
Stronger passenger compartments, reinforced by race-carlike "safety cage" structures offer cocoonlike protection to help keep the occupant area intact in an accident. Padded, energy-absorbing materials and other interior design elements further help reduce injuries. Head restraints, now being added to rear as well as front seats, help prevent whiplash injuries. Some automakers, including Volvo, Saab, and General Motors, have introduced head restraints that move slightly under certain crash conditions to help further reduce neck injuries. Still, all else being equal, the laws of physics dictate that a larger and heavier car will provide its passengers with better protection in a crash than would a smaller and lighter vehicle.

The massive developments in the area of vehicle safety construction have meant that both extrication techniques and equipment have had to change in order to keep up with the advances in the automotive industry. It is critical for rescuers to keep up to date on the advances in vehicle safety systems and construction as well as the advances by the manufacturers of extrication equipment. Only with a strong working knowledge of these components as well as many hours of hands-on training and experience will a rescuer be able to perform competent and efficient extrication.

A great place to keep up on the advances in new car construction and safety systems is automotive manufacturer's web sites, the mechanics at area new car sales offices, and yearly auto shows. The information you learn at these locations could help save the life of a patient or even your own. The following are some of the changes that have occurred in new model vehicles, however, between the time of this being written and you reading this there have probably been additional improvements and modifications.

- Increased amount and types of metals used in posts as well as the number of bends
- Boron rod reinforced dashboard area
- Reinforced wheel and engine deflection systems that deflect the wheels and motor under the car and away from the passenger compartment area
- Crumple zones that absorb the energy of the impact (more damage, less injuries)
- Micro alloys and boron steel being used to improve the strength to weight ratio
- High Strength Low-Alloy or Ultra High Strength Low-Alloy steel being used to reinforce roof and pillar structures
- Side and rear glass – may have two panes of tempered glass, be laminated glass, bulletproof glass, or lexan
- Body materials consists of high impact plastic, carbon fiber, aluminum and other composite materials. These changes lead to more crumpling and shattering of material rather than bending. At times it may be easier to remove exterior panels to access purchase points. Carbon fiber is very difficult to cut/shatter and its dust particles and combustion by-products are hazardous

This picture demonstrates double panes of tempered glass.

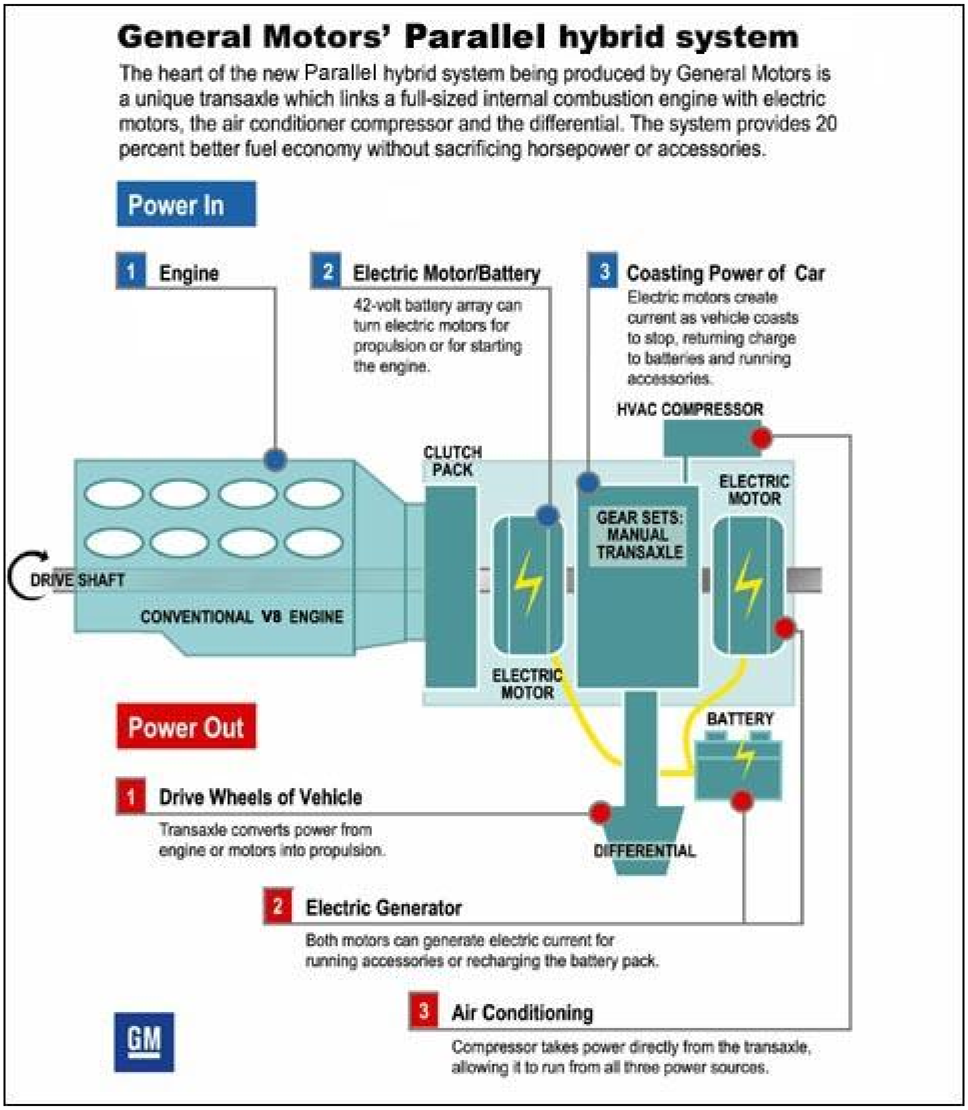


The above picture shows the improvements in passenger safety through stronger materials that absorb the impact.

The above picture shows high impact plastic exterior panels as well as a deep door that will hamper rescuers accessing the U bolt.

The above picture shows new car construction that has eliminated the upper portion of the “B” post.

Alternate Powered Vehicles

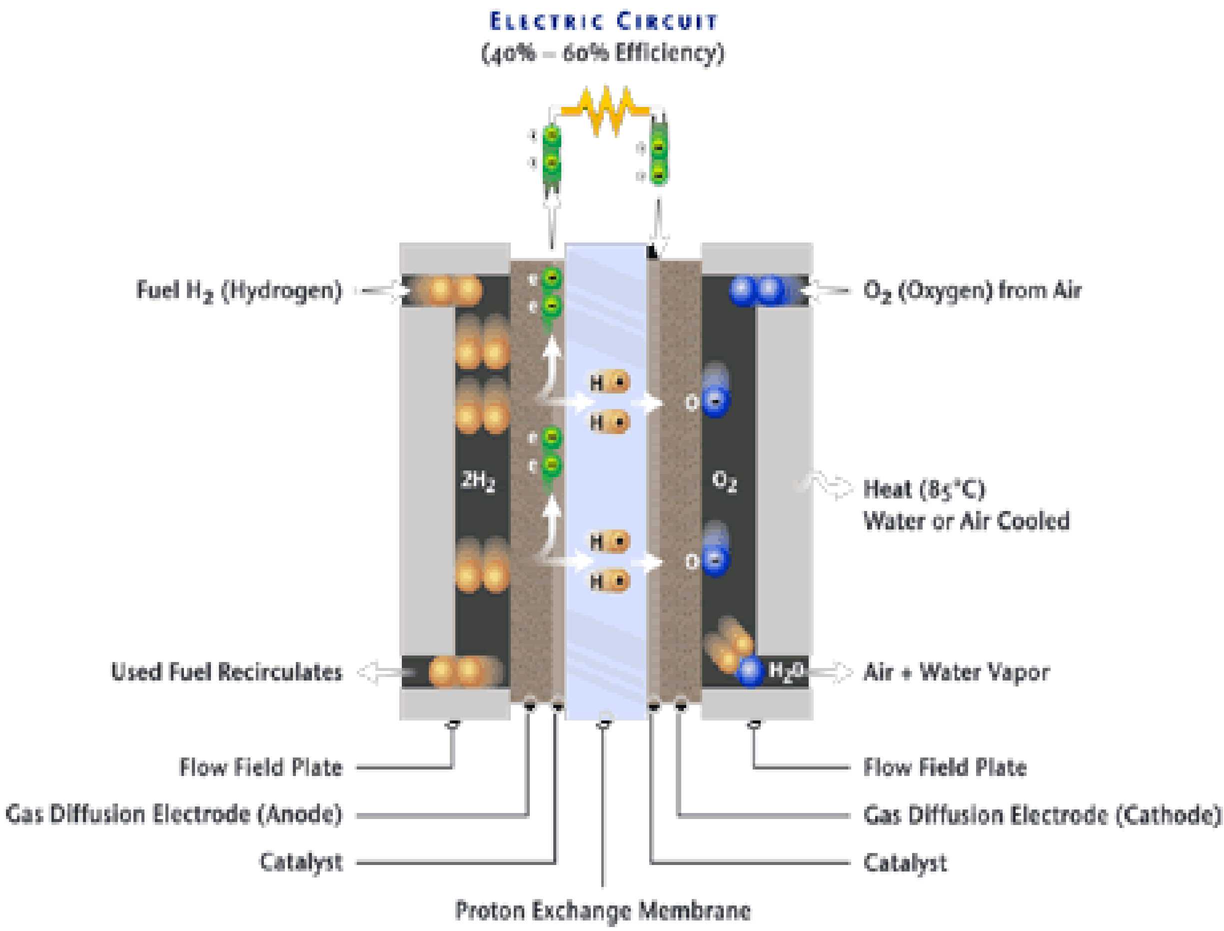


Displacement on Demand uses the oil pump system for hydraulic pressure to activate the system. Four control valve solenoids then act together to achieve seamless transition between four and eight cylinder operation.

Three large lead-acid batteries are positioned under the rear seat to store power.

Electric Power from Hydrogen Fuel

1. Fuel cells create electricity through an electrochemical process that combines hydrogen and oxygen.
2. Hydrogen fuel is fed into the anode of the fuel cell. Helped by a catalyst, hydrogen atoms are split into electrons and protons.
3. Electrons are channeled through a circuit to produce electricity.
4. Protons pass through the polymer electrolyte membrane.
5. Oxygen (from the air) enters the cathode and combines with the electrons and protons to form water. Water vapor and heat are released as byproducts of this reaction.



Natural Gas Vehicle

Above is a picture of the tank that holds the compressed natural gas. This tank is located between the rear passenger seat and the trunk and can be accessed easily from the trunk.