AUTOMOBILE ENGINEERING
(5ME6.2A)

DEPARTMENT

OF

MECHANICAL ENGINEERING

(Jaipur Engineering College and Research Center, Jaipur)

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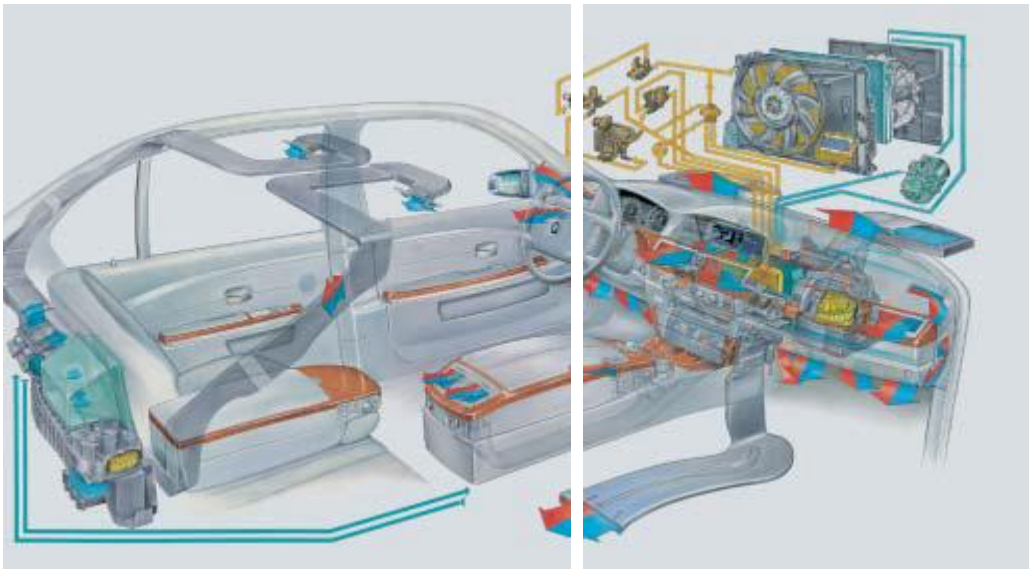
UNIT-5

AUTOMOTIVE AIR CONDITIONING AND AUTOMOTIVE SAFETY

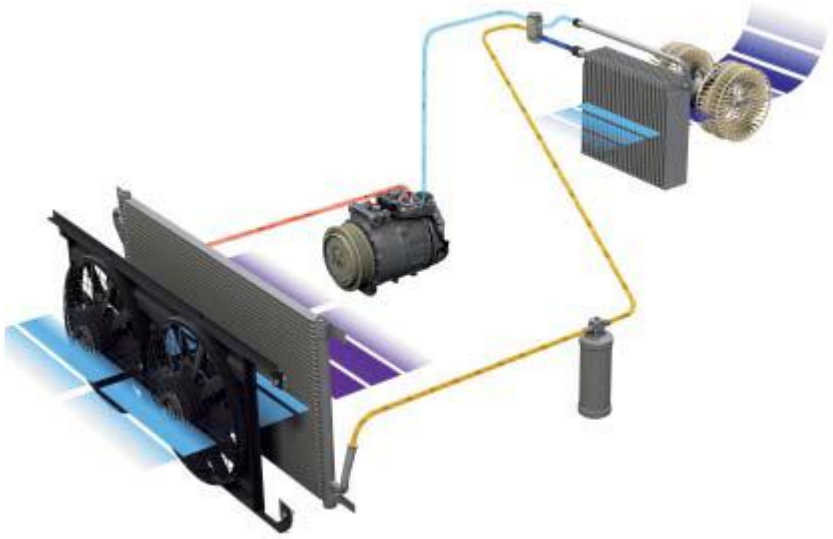
INTRODUCTION

Although the air conditioning system and the engine cooling system are two separate systems, they influence one another.Air conditioning system operation places additional load onto the engine cooling system and the coolant temperature rises.

The additives contained in the coolant do not only protect against frost, but also against engine overheating. The proper coolant composition increases the boiling point of the medium to above 120 °C. An enormous performance reserve. This is particularly important in the summer, when air conditioning system and cooling system are heavily burdened by ambient temperatures and long trips. The best approach is to check the coolant during air conditioning service as well.



AIR CONDITIONING CIRCUIT



Refrigerant circuit with expansion valve

How the air conditioning system with expansion valve works For controlling the climate in the vehicle interior,refrigerant circuit as well as coolant circuit are required. A mixture of cold and warm air allows the generation of the desired climate conditions - completely independently from outer conditions. As a result, the air conditioning system becomes an important factor for safety and driving comfort.

The individual components of the refrigerant circuit are connected by tubes and/or aluminium pipes and thus form a closed system. Refrigerant and refrigerant oil circulate in the system, driven by the compressor.

The circuit has two sides:

- The section between the compressor and the expansion valve is the high pressure side (yellow/red).
- The section between the expansion valve and the compressor is the low pressure side (blue).

The gaseous refrigerant is compressed by the compressor (thereby significantly increasing its temperature) and pressed under high pressure through the condenser. This removes heat from refrigerant - it condensates and changes its state from gas to liquid.

The filter dryer, the next unit, removes contaminants and air from the liquid refrigerant as well as humidity. This ensures system effectiveness and protects the components from damage caused by contaminants.

Condenser fan

COMPONENTS OF THE AIR CONDITIONING SYSTEM

Compressors

The air conditioning compressor is usually driven by the engine via a belt or ribbed V-belt. The compressor compresses and transports the refrigerant in the system. There are different designs available.

The refrigerant is sucked in as a gas at low temperature from the evaporator; it is then compressed. It is then forwarded in a gaseous state at high temperature and high pressure to the condenser.

The compressor can be dimensioned depending on the size of the system. The compressor is filled with special oil to provide lubrication. Some of the oil circulates through the air conditioning system with the refrigerant.

Condensers

The capacitor is needed in order to cool the refrigerant that is heated up by the compression in the compressor. The hot refrigerant gas flows into the condenser and transfers heat to the surroundings via the pipe and fins. As it cools down, the state of the refrigerant changes again from gaseous to liquid.

How they work

The hot refrigerant gas flows on top into the condenser and transfers heat to the surroundings via the pipe and fins. Due to cooling down the refrigerant exists the condenser at the lower connection in liquid state.

Effects of failure

A defective condenser may exhibit the following symptoms:

- Poor cooling performance
- Failure of the air conditioning system
- Continuously running condenser fan

Causes for occurring faults can be:

- Leaks at the connections or caused by damage
- Insufficient heat exchange due to contamination

Troubleshooting

Test steps for fault elimination:

- Check condenser for contamination
- Check for leaks
- Pressure test on the high and low pressure sides

Filter dryer

The filter elements of the air conditioning system are either referred to as filter dryers or accumulators, depending on the type of system. The task of the filter dryer is to remove mpurities from the refrigerant and to dehumidify it.

How they work

The liquid refrigerant enters the filter dryer, flows through a hygroscopic drying medium and leaves the filter dryer again as a liquid. The upper part of the filter dryer serves as a compensation chamber; at the same time, the lower part serves as refrigerant storage in order to compensate fluctuations in pressure in the system.

Depending on its design, the filter dryer can only remove a certain amount of humidity - then the drying medium is saturated and no longer in a position to absorb further humidity.

Effects of failure

A failure of the filter dryer may exhibit the following symptoms:

- Poor cooling capacity
- Failure of the air conditioning system

Causes for the failure of the filter dryer can be:

- Aging
- Defective filter pad inside
- Leaks at the connections or caused by damage

Troubleshooting
The following steps are to be considered during troubleshooting:
- Verify maintenance intervals (every 2 years)
- Leak test/correct fit of the connections/damage
- Pressure test of the high and low pressure sides

Expansion valve/orifice tube
The expansion valve represents the point of separation between the high pressure and low pressure sections in the refrigerant circuit. It is installed in upstream of the evaporator. To achieve optimum cooling capacity in the evaporator, the refrigerant flow is controlled by the expansion valve depending on the temperature. As a result, complete evaporation of the liquid refrigerant is ensured and gaseous refrigerant arrives at the compressor only. Expansion valves may differ in their design.
How they work
The liquid refrigerant - arriving through the filter dryer from the condenser - flows through the expansion valve and is injected into the evaporator. The evaporating refrigerant releases evaporation cold. This causes the temperature to drop. To achieve optimum cooling capacity in the evaporator, the refrigerant flow is controlled by the expansion valve depending on the temperature.
At the end of the evaporator, the refrigerant is transported through the expansion valve to the compressor. If the refrigerant temperature increases at the end of the evaporator, it expands in the expansion valve. This results in an increase of the refrigerant flow (injection quantity) to the evaporator. If the refrigerant temperature lowers at the end of the evaporator, the volume in the expansion valve decreases. As a result, the expansion valve reduces the refrigerant flow to the evaporator.
Effects of failure
A defective expansion valve can manifest itself as follows:
- Poor cooling capacity
- Failure of the air conditioning system
There are a number of possible causes of failure:
- Temperature problems due to overheating or icing
- Contaminations in the system
- Leaks at the component or the connection pipes
Troubleshooting
The following test steps should be followed in the case of a malfunction
- Visual inspection
-Acoustic test
- Check connection pipes for tight and correct fit
- Check components and connections for leak-tightness
- Temperature measurement on the line system
- Pressure measurement with the compressor switched on and the engine running

Evaporator
The evaporator is used to exchange heat between the ambient air and the refrigerant in the air conditioning system.
How they work
The expansion valve and/or orifice tube injects the highly pressurized liquid refrigerant into the evaporator. The refrigerant expands. The resulting evaporation cold is discharged to the

environment via the large surface of the evaporator and routed to the vehicle interior through the ventilation airflow.
Effects of failure
A defective evaporator exhibits the following symptoms:
- Poor cooling performance
- Failure of the air conditioning system
- Poor ventilation performance-
Causes for failure of the evaporator can be:
- Pipes blocked in the evaporator
- Evaporator leaking (at the connection, caused by damage)
- Evaporator contaminated (air passage disturbed)
Troubleshooting
The following test steps should be considered during troubleshooting:
- Check evaporator for contamination
- Inspect evaporator for damage
- Check connection pipes for correct fit
- Leak test
- Pressure measurement with the compressor switched on and the engine running
- Temperature measurement on the input and output line

Pressure switches and switches
Pressure switches are responsible for protecting the air conditioning system against damagecaused by too high or too low pressures. There are low pressure switches, high pressure switches and trinary switches. The trinary switch comprises the high pressure switch and the low pressure switch and an additional switch contact for the condenser fan.
How they work
The pressure switch (pressure monitor) is normally installed on the high pressure side of the air conditioning system. In the case that the pressure is too high (approx. 26-33 bar) it switches the power supply to the compressor clutch off. If the pressure is reduced (approx. 5 bar), its switches the power supply on again. If the pressure is too low (approx. 2 bar), the power supply is interrupted as well in order to avoid compressor damage due to insufficient lubrication. The third switch contact in the trinary switch controls the electrical condenser fan in order to ensure optimum refrigeration condensation in the condenser.
Effects of failure
A defective or failing pressure switch can manifest itself as follows:
- Insufficient cooling performance
- Frequent switching on and off of the compressor clutch
Air conditioning system without function. There are a number of possible causes of failure:
- Contact fault at electrical connections
-Contaminations in the system
-Damage to the housing caused by vibrations or accidents
Troubleshooting
Test steps for fault diagnostics:
- Visual inspection
- Check connector block for correct fit
- Inspect component for damage
-Pressure measurement with the compressor switched on and the engine running

- Component test in the disassembled condition with nitrogen gas cylinder, pressure reducer and Multimeter

Ventilation fan

The ventilation fan is used to ventilate the passenger car. It ensures clear visibility and a pleasant interior climate. Major pre-requisites for safe and comfortable driving.

Fittings and tubes

Fittings and tubes connect the single components carrying refrigerant. The fittings are pressed onto the tube end using a special tool. This tool is available in a variety of designs.

Condenser fan

The condenser fan helps to ensure the optimal liquefaction of the refrigerant no matter what operating state the vehicle is in. It is mounted upstream or downstream of the condenser and/or engine cooling system as an additional or combination fan

AUTOMOTIVE SAFETY

Design of vehicle body for safety

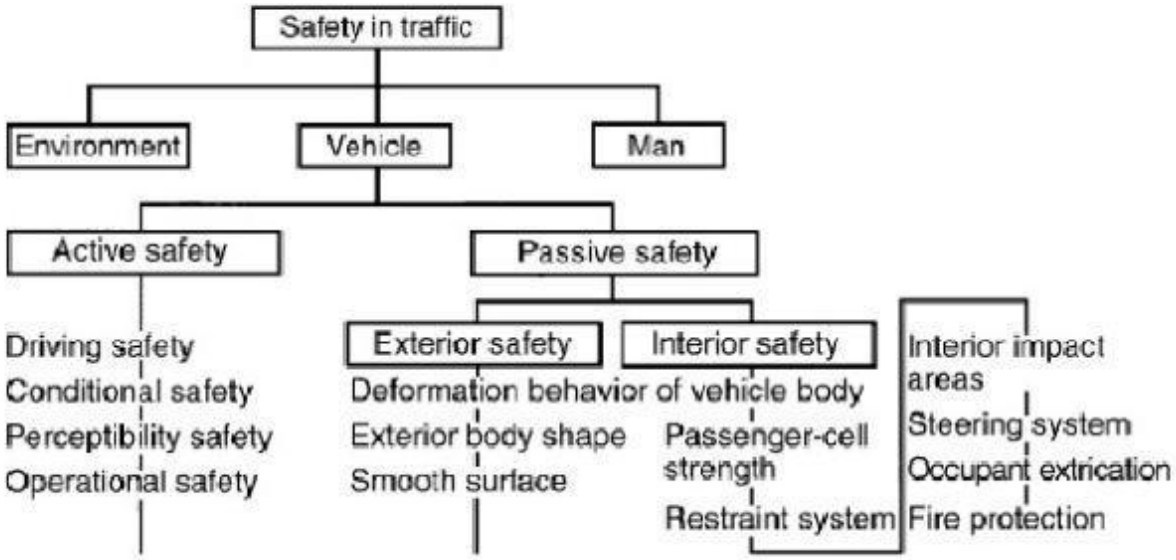
The safety of a vehicle and its passengers can be improved by properly designing and selecting the material for vehicle bodies. The vehicle body structure is subjected to static and dynamic service loads during the life cycle. It also has to maintain its integrity and provide adequate protection in survivable crashes. At present there are two designs of vehicle body constructions: 1. Body over frame structure and 2. Uni body structure.

Necessary features of a safe vehicle body:

1. Deformable yet stiff front structure with crumple zones to absorb the crash kinetic energy from frontal collisions
2. Deformable rear structure to safeguard rear passenger compartment and protect the fuel tank
3. Properly designed side structures and doors to minimize intrusion in side impact and prevent doors from opening due to crash loads
4. Strong roof structure for rollover protection
5. Properly designed restraint systems with working in harmony with the vehicle structure
6. Accommodate various chassis designs for different power train locations and drive train configurations

Safety Requirements

Overall safety can be classified a s given below: In this unit we are going to study about vehicle safety.



Active safety:

Prevention of accidents

Driving safety

It is the result of a harmonious chassis and suspension design with regard to wheel suspension, springing, steering and braking, and is reflected in optimum dynamic vehicle behavior.

Conditional safety

It results from keeping the physiological stress that the vehicle occupants are subjected to byvibration, noise, and climatic conditions down to as low a level as possible. It is a significant factor in reducing the possibility of mis actions in traffic. Vibrations within a frequency range of 1 to 25 Hz (stuttering, shaking, etc.) induced by wheels and drive components reach the occupants of the vehicle via the body, seats and steering wheel. The effect of these vibrations is more or less pronounced, depending upon their direction, amplitude and duration. Noises as acoustical disturbances in and around the vehicle can come from internal sources (engine, transmission, prop shafts, axles) or external sources (tire/road noises, wind noises), and are transmitted through the air or the vehicle body. The sound pressure level is measured in dB(A) (see Motor-vehicle noise measurements and limits).Noise reduction measures are concerned on the one hand with the development of quiet-running components and the insulation of noise sources (e.g., engine encapsulation), and on the other hand with noise damping by means of insulating or anti-noise materials. Climatic conditions inside the vehicle are primarily influenced by air temperature, air humidity, rate of airflow through the passenger compartment and air pressure (see Environmental stresses for additional information).

Perceptibility safety

- Measures which increase perceptibility safety are concentrated
- Lighting equipment (see Lighting),
- Acoustic warning devices (see Acoustic signaling devices),

- Direct and indirect view (see Main dimensions) (Driver's view: The angle of obscuration caused by the A-pillars for both of the driver's eyes binocular must not be more than 6 degrees).

Operating safety

Low driver stress, and thus a high degree of driving safety, requires optimum design of the driver surroundings with regard to ease of operation of the vehicle controls.

Passive safety:

Reduction of accident consequences.

Exterior safety

The term "exterior safety" covers all vehicle-related measures which are designed to minimize the severity of injury to pedestrians and bicycle and motorcycle riders struck by the vehicle in an accident. Those factors which determine exterior safety are:

- Vehicle-body deformation behavior,
- Exterior vehicle body shape.

The primary objective is to design the vehicle such that its exterior design minimizes the consequences of a primary collision (a collision involving persons outside the vehicle and the vehicle itself).The most severe injuries are sustained by passengers who are hit by the front of the vehicle, whereby the course of the accident greatly depends upon body size. The consequences of collisions involving two-wheeled vehicles and passenger cars can only be slightly ameliorated by passenger-car design due to the two-wheeled vehicle's often considerable inherent energy component, its high seat position and the wide dispersion of contact points. Those design features which can be incorporated into the passenger car are, for example:

- Movable front lamps
- Recessed windshields wipers,
- Recessed drip rails,
- Recessed door handles.

Interior safety

The term "interior safety" covers vehicle measures whose purpose is to minimize the accelerations and forces acting on the vehicle occupants in the event of an accident, to provide sufficient survival space, and to ensure the operability of those vehicle components critical to the removal of passengers from the vehicle after the accident has occurred. The determining factors for passenger safety are:

- Deformation behavior (vehicle body),
- Passenger-compartment strength, size of the survival space during and after impact,
- Restraint systems,
- Impact areas (vehicle interior),
-- Steering system,
- Occupant extrication,
- Fire protection.

Laws which regulate interior safety (frontal impact) are:

- Protection of vehicle occupants in the event of an accident, in particular restraint systems
- Windshield mounting
- Penetration of the windshield by vehicle body components

- Parcel-shelf and compartment lids

Rating-Tests:

- New-Car Assessment Program (NCAP, USA, Europe, Japan, Australia),
- IIHS (USA, insurance test),
- ADAC, ams, AUTO-BILD.

Seat belt

A seat belt, sometimes called a safety belt, is a safety harness designed to secure the occupant of a vehicle against harmful movement that may result from a collision or a sudden stop. As part of an overall automobile passive safety system, seat belts are intended to reduce injuries by stopping the wearer from hitting hard interior elements of the vehicle, or other passengers (the so-called second impact), are in the correct position for the airbag to deploy and prevent the passenger from being thrown from the vehicle. Seat belts also absorb energy by being designed to stretch during an impact, so that there is less speed differential between the passenger's body and their vehicle interior, and also to spread the loading of impact on the passengers' body. The final, so-called 'third impact' after a passenger's body hits the car interior, airbag or seat belts, is that of the internal organs hitting the ribcage or skull. The force of this impact is the mechanism through which car crashes cause disabling or life threatening injury. The sequence of energy dissipating and speed reducing technologies - crumple zone - seat belt - airbags - padded interior, are designed to work together as system, to reduce the force of this final impact

Types of seat belts

- Lap seat belt
- Three points seatbelt

Lap:

Adjustable strap that goes over the waist. Used frequently in older cars, now uncommon except in some rear middle seats. Passenger's aircraft seats also use lap seat belts to prevent injuries.

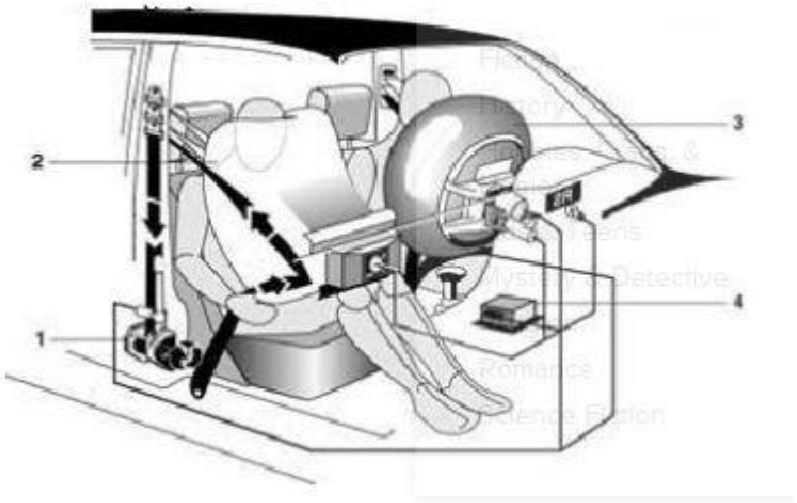
Sash:

Adjustable strap that goes over the shoulder. Used mainly in the 1960s, but of limited benefit because it is very easy to slip out of in a collision.

Three-point:

Similar to the lap and shoulder, but one single continuous length of webbing. Both three-point and lap-and-sash belts help spread out the energy of the moving body in a collision over the chest, pelvis, and shoulders. Volvo introduced the first production three-point belt in 1959. The first car with three point belt was a Volvo PV 544 that was delivered to a dealer in Kristian stad on August 13, 1959. The three point belt was developed by Nils Bohlin who earlier had worked on ejection seats at Saab. Until the 1980s, three-point belts were commonly available only in the front seats of cars; the back seats had only lap belts or diagonal belts. Evidence of the potential for lap belts to cause separation of the lumbar vertebrae and the sometimes associated paralysis, or "seat belt syndrome", has led to a revision of passenger safety regulations in nearly all developed countries requiring that all seats in a vehicle be equipped with three-point belts. Since September 1, 2007, all new cars sold in the U.S. require a lap and shoulder belt in the center rear.

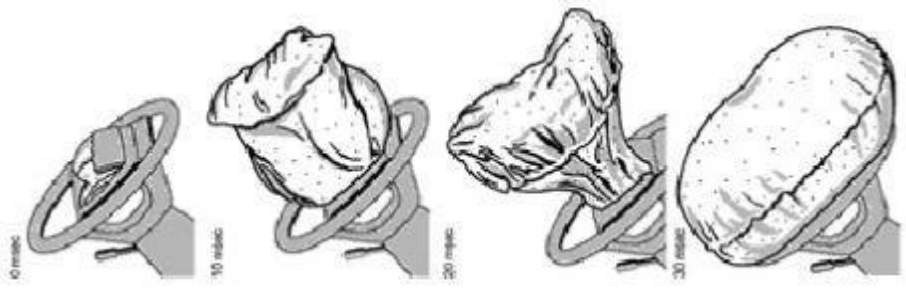
Seat belts and seat-belt tighteners



Occupant protection systems with belt tighteners and front airbags

1 Belt tightener, 2 Front airbag for passenger, 3 Front airbag for driver, 4 ECU
Function:
The function of seat belts is to restrain the occupants of a vehicle in their seats when the vehicle hits an obstacle. Seat-belt tighteners improve the restraining characteristics of a three-point inertia-reel belt and increase the protection against injury. In the event of a frontal impact, they pull the seat belts tighter against the body and thus hold the upper body as closely as possible against the seat backrest. This prevents excessive forward displacement of the occupants caused by mass inertia.

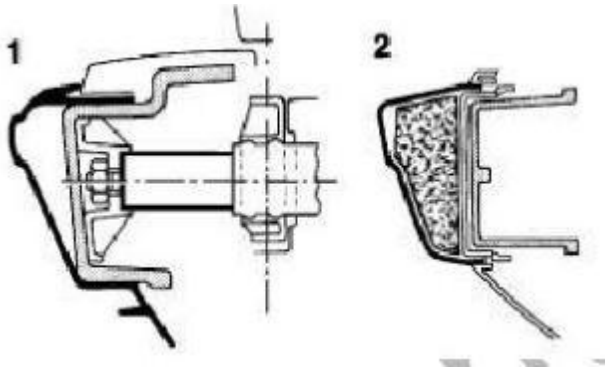
Air Bags, Electronic System for activating air bags:
Function:
The function of front airbags is to protect the driver and the front passenger against head and chest injuries in a vehicle impact with a solid obstacle at speeds of up to 60 km/h. In a frontal impact between two vehicles, the front airbags afford protection at relative speeds of up to 100 km/h. A belt tightener alone cannot prevent the head from hitting the steering wheel in response to severe impact. In order to fulfill this function, depending on the installation location, vehicle type and structure-deformation response, airbag shave different filling capacities and pressure build-up sequences adapted to the specific vehicle conditions. In a few vehicle types, front airbags also operate in conjunction with "inflatable knee pads", which safeguard the "ride down benefit", i.e. the speed decrease of the occupants together with the speed decrease of the passenger cell. This ensures the rotational forward motion of the upper body and head which is actually needed for optimal airbag protection, and is of particular benefit in countries where seat-belt usage is not mandatory.



Operating concept:
To protect driver and front passenger, pyrotechnical gas inflators inflate the driver and passenger airbags in pyrotechnical, highly dynamic fashion after a vehicle impact detected by sensors. In order for the affected occupant to enjoy maximum protection, the airbag must be fully inflated before the occupant comes into contact with it. The airbag then responds to upper-body contact with partial deflation in a response pattern calculated to combine "gentle" impact-energy absorption with non-critical (in terms of injury) surface pressures and decelerative forces for the occupant. This concept significantly reduces or even prevents head and chest injuries. The maximum permissible forward displacement before the driver's airbag is fully inflated is approx.12.5 cm, corresponding to a period of approx. 10 ms + 30 ms = 40 ms after the initial impact (at 50 km/h with a solid obstacle) (see Fig. "Deceleration to standstill"). It needs 10 ms for electronic firing to take place and 30ms for the airbag to inflate.
In a 50 km/h crash, the airbag takes approx. 40 ms to inflate fully and a further 80...100 ms to deflate through the deflation holes. The entire process thus takes little more than a tenth of a second, i.e. the batting of an eyelid.

Bumper design for safety
The front and rear of the vehicle should be protected in such a manner that low-speed collisions will only damage the vehicle slightly, or not at all. Prescribed bumper evaluation tests (US Part 581, Canada CMVSS 215, and ECE-R 42) specify minimum requirements in terms of energy absorption and installed bumper height. Bumper evaluation tests in accordance with US Part 581

(4 km/h barrier collision, 4 km/h pendulum tests) must be passed by a bumper system whose energy absorber is of the no-damage absorber type. The requirements of the ECE standard are satisfied by plastically deformable retaining elements located between the bumper and the vehicle body structure. In addition to sheet steel, many bumpers are manufactured using fiber-reinforced plastics and aluminum sections.



Bumpers 1. Shock-absorber system, 2 Energy-absorbing PUR-foam systems

Exterior trim, impact strips:
Plastics have become the preferred materials for external impact strips, trim, skirts and spoilers, and particularly for those components whose purpose is to improve the aerodynamic characteristics of the vehicle. Criteria used in the selection of the proper material are flexibility, high-temperature shape retention, and coefficient of linear expansion, notched-bar toughness, resistance to scratches, and resistance to chemicals, surface quality and paint ability.

AUTOMOTIVE NIGHT VISION SYSTEM

. The term “automotive night vision” refers to a number of systems that help increase driver awareness when it’s dark out. These systems extend the perception of the driver beyond the limited reach of the headlights through the use of thermographic cameras, infrared lights, heads up displays, and other technologies. Since automotive night vision can alert drivers to the presence of potential hazards before they become visible, these systems can help prevent accidents.

How Does Night Vision Work in Cars

Automotive night vision systems are broken into two basic categories, which are referred to as active and passive. Active night vision systems uses infrared light sources to illuminate the darkness, and passive systems rely on the thermal radiation that is emitted from cars, animals,

and other potential hazards. The systems both rely on infrared data, but each one has its own benefits and drawbacks.

Active Automotive Night Vision Systems

Active systems are more complex than passive systems because they use infrared light sources. Since the infrared band falls outside the visible spectrum, these light sources don't cause oncoming drivers to suffer from temporary night blindness like high beam headlights can. That allows the infrared lights to illuminate objects that are significantly further away than headlights are able to reach.

Since infrared light isn't visible to the human eye, active night vision systems use special cameras to relay the extra visual data.

Some systems use pulsed infrared lights, and others use a constant light source. These systems don't work very well in adverse weather conditions, but they do provide high contrast images of vehicles, animals, and even inanimate objects.

Passive Automotive Night Vision Systems

Passive systems don't use their own light sources, so they rely on thermographic cameras to detect thermal radiation.

This tends to work very well with animals and other vehicles since they emit a lot of thermal radiation. However, passive systems have trouble picking up inanimate objects that are about the same temperature as the surrounding environment.

The range of passive night vision tends to be significantly higher than the range of active night vision, which is due to the limited power of the light sources used by the latter systems. The image quality produced by the thermographic cameras also tends to be poor when compared to active systems, and they don't work very well in warm weather.

How Does Infrared or Thermographic Information Help

There are a number of types of night vision displays that can relay infrared or thermographic information to the driver. The earliest night vision systems used heads up displays, which projected warnings and alerts on the windshield within the driver's field of vision. Other systems use an LCD that's mounted on the dash, in the instrument cluster, or integrated into the head unit.

What Vehicles Have Night Vision Systems

Automotive night vision systems have been around since 1988, but they are still found primarily in luxury vehicles. The technology is typically optional equipment, and it can be quite expensive.

The first night vision systems were introduced by GM, but a number of other automakers now have their own versions of the technology.

Mercedes, Toyota, and Toyota's Lexus badge all offer active systems. Other automakers, such as Audi, BMW and Honda, offer passive options. General Motor's Cadillac badge also offered a passive night vision system, but the option was discontinued in 2004.

There are also a number of systems available in the aftermarket.

Does Night Vision Really Help Reduce Accidents?

According to the European Commission for the Automobile Industry, nearly 50 percent of all accidents occur at night.

Since the same study showed about 60 percent less traffic at night, it's clear that a disproportionate number of accidents occur between dusk and dawn. Since night vision isn't widely available, there is no conclusive data. A study performed by the National Highway Transportation Safety Administration even revealed that some people are willing to drive faster at night with the aid of these systems, which could lead to more accidents.

However, other technologies that increase nighttime visibility have been shown to reduce accidents. Since technologies like adaptive headlights have helped reduce nighttime accidents, it's possible that a wider adoption of night vision could have similar effects.

Night vision systems can detect objects that are more than 500 feet away, but traditional headlights typically only illuminate objects that are about 180 feet away. Since the stopping distance of a car can easily be longer than 180 feet, it's clear that the proper use of a night vision system can help an alert driver avoid certain collisions.

GLOBAL POSITIONING SYSTEM

What is GPS

The Global Positioning System (GPS) is a satellite-based navigation system made up of at least 24 satellites. GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription fees or setup charges. The U.S. Department of Defense (USDOD) originally put the satellites into orbit for military use, but they were made available for civilian use in the 1980s.

How GPS works

GPS satellites circle the Earth twice a day in a precise orbit. Each satellite transmits a unique signal and orbital parameters that allow GPS devices to decode and compute the precise location of the satellite. GPS receivers use this information and trilateration to calculate a user's exact location. Essentially, the GPS receiver measures the distance to each satellite by the amount of time it takes to receive a transmitted signal. With distance measurements from a few more satellites, the receiver can determine a user's position and display it electronically to measure your running route, map a golf course, find a way home or adventure anywhere.

To calculate your 2-D position (latitude and longitude) and track movement, a GPS receiver must be locked on to the signal of at least 3 satellites. With 4 or more satellites in view, the receiver can determine your 3-D position (latitude, longitude and altitude). Generally, a GPS receiver will track 8 or more satellites, but that depends on the time of day and where you are on the earth. Some devices can do all of that from your wrist.
Once your position has been determined, the GPS unit can calculate other information, such as:

- Speed
- Bearing
- Track
- Trip distance
- Distance to destination
- Sunrise and sunset time
- And more

How accurate is GPS

Today's GPS receivers are extremely accurate, thanks to their parallel multi-channel design. Our receivers are quick to lock onto satellites when first turned on. They maintain a tracking lock in dense tree-cover or in urban settings with tall buildings. Certain atmospheric factors and other error sources can affect the accuracy of GPS receivers. Garmin GPS receivers are typically accurate to within 10 meters. Accuracy is even better on the water.
Some Garmin GPS receiver accuracy is improved with WAAS (Wide Area Augmentation System). This capability can improve accuracy to better than 3 meters, by providing corrections to the atmosphere. No additional equipment or fees are required to take advantage of WAAS satellites. Users can also get better accuracy with Differential GPS (DGPS), which corrects GPS distances to within an average of 1 to 3 meters. The U.S. Coast Guard operates the most common

DGPS correction service, consisting of a network of towers that receive GPS signals and transmit a corrected signal by beacon transmitters. In order to get the corrected signal, users must have a differential beacon receiver and beacon antenna in addition to their GPS.

Other GPS Systems

There are other similar systems to GPS in the world, which are all classified as the Global Navigation Satellite System (GNSS). GLONASS is a satellite constellation system built by Russia. The European Space Agency is creating Galileo, while China is creating BeiDou. Most Garmin receivers track both GLONASS and GPS, and some even track BeiDou. You can expect a more reliable solution when you track more satellites. You could be tracking nearly 20 with newer Garmin products.

The GPS Satellite System

The 31 satellites that currently make up the GPS space segment are orbiting the earth about 12,000 miles above us. These satellites are constantly moving, making two complete orbits in less than 24 hours. They travel at speeds of roughly 7,000 miles an hour. Small rocket boosters keep each satellite flying on the correct path.

Here are some other interesting facts about the GPS satellites:

- The official USDOD name for GPS is NAVSTAR
- The first GPS satellite was launched in 1978.
- A full constellation of 24 satellites was achieved in 1994.
- Each satellite is built to last about 10 years. Replacements are constantly being built and launched into orbit.
- A GPS satellite weighs approximately 2,000 pounds and is about 17 feet across with the solar panels extended.
- GPS satellites are powered by solar energy, but they have backup batteries onboard, in case of a solar eclipse.
- Transmitter power is only 50 Watts or less.

What's the signal

GPS satellites transmit at least 2 low-power radio signals. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects, such as buildings and mountains. However, modern receivers are more sensitive and can usually track through houses.

A GPS signal contains 3 different types of information:

- **Pseudorandom code** is an I.D. code that identifies which satellite is transmitting information. You can see which satellites you are getting signals from on your device's satellite page.
- **Ephemeris data** is needed to determine a satellite's position and gives important information about the health of a satellite, current date and time.
- **Almanac data** tells the GPS receiver where each GPS satellite should be at any time throughout the day and shows the orbital information for that satellite and every other satellite in the system.

GPS Signal Errors Sources

Factors that can affect GPS signal and accuracy include the following:

- **Ionosphere and troposphere delays:** Satellite signals slow as they pass through the atmosphere. The GPS system uses a built-in model to partially correct for this type of error.
- **Signal multipath:** The GPS signal may reflect off objects such as tall buildings or large rock surfaces before it reaches the receiver, which will increase the travel time of the signal and cause errors.
- **Receiver clock errors:** A receiver's built-in clock may have slight timing errors because it is less accurate than the atomic clocks on GPS satellites.
- **Orbital errors:** The satellite's reported location may not be accurate.
- **Number of satellites visible:** The more satellites a GPS receiver can "see," the better the accuracy. When a signal is blocked, you may get position errors or possibly no position reading at all. GPS units typically will not work underwater or underground, but new high-sensitivity receivers are able to track some signals when inside buildings or under tree-cover.
- **Satellite geometry/shading:** Satellite signals are more effective when satellites are located at wide angles relative to each other, rather than in a line or tight grouping.
- **Selective availability:** The U.S. Department of Defense once applied Selective Availability (SA) to satellites, making signals less accurate in order to keep 'enemies' from using highly accurate GPS signals. The government turned off SA in May of 2000, which improved the accuracy of civilian GPS receivers