

# 5

# CLIMATE CONTROL



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THE SYSTEMS USED IN A CAR TO RAISE OR LOWER THE TEMPERATURE IN THE PASSENGER CABIN ARE BASED ON HEAT TRANSMISSION BY MEANS OF HEAT EXCHANGERS, WHICH ARE CROSSED BY FRESH OR RECIRCULATED AIR BEFORE PASSING TO THE PASSENGER CABIN THROUGH ITS DUCTS.

THE REACTION TIME OF A DRIVER DEPENDS ON HIS OR HER COMFORT LEVEL, ONE OF THE MOST INFLUENTIAL FACTORS IN THIS RESPECT IS BODY TEMPERATURE.

WHEN THE EXTERIOR TEMPERATURE IS HIGHER THAN THAT OF THE BODY, THE BODY CANNOT LOSE HEAT; CONVERSELY, IF THE TEMPERATURE IS TOO COLD IT CANNOT GENERATE SUFFICIENT ENERGY TO MAINTAIN ITS NORMAL TEMPERATURE.

AS THE HUMAN BODY IS ALWAYS PRODUCING ENERGY, THE IDEAL AMBIENT TEMPERATURE IS SOME 15 DEGREES BELOW NORMAL BODY TEMPERATURE, WHICH IS AROUND 21 OR 22 DEGREES CELSIUS.

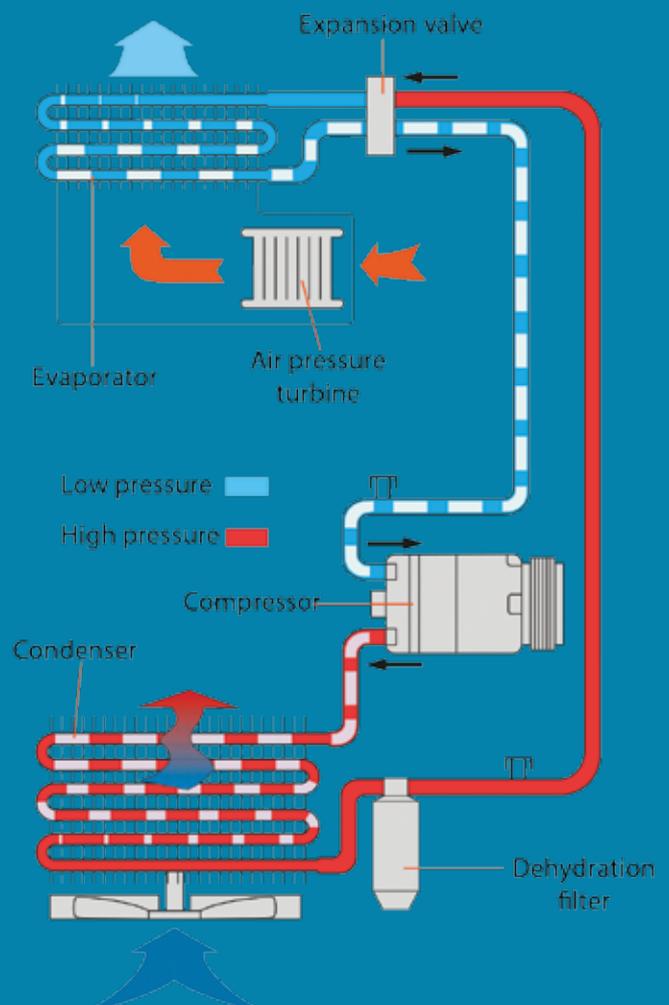
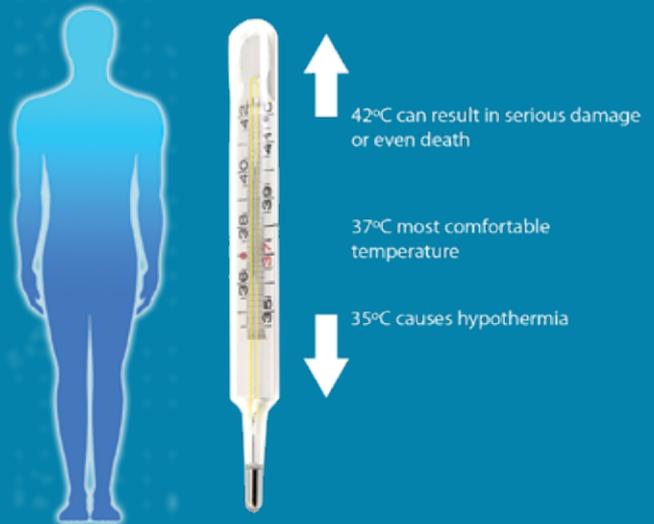
A MATERIAL'S STATE CAN BE CHANGED BY SUPPLYING IT WITH OR REMOVING ENERGY FROM IT. IF YOU HEAT WATER IN A RECEPTACLE, THE LIQUID TURNS TO WATER VAPOUR I.E. IT PASSES TO THE GASEOUS STATE. IF THE WATER VAPOUR IS COOLED, IT WILL REVERT TO A LIQUID AND IF IT IS FURTHER COOLED IT WILL BECOME A SOLID.

AS A GENERAL RULE, THE AIR CONDITIONING SYSTEM IN A CAR WORKS ON THE COMPRESSION PRINCIPLE APPLIED TO FLUORINATED GASES AS THEIR PROPERTIES ARE IDEAL FOR THE OPERATION OF CLIMATE CONTROL SYSTEMS.

THE COMPRESSOR, DRIVEN BY THE ENGINE, COMPRESSES THE GASEOUS REFRIGERANT FROM THE EVAPORATOR, THIS INCREASES ITS TEMPERATURE AND PRESSURE.

THE HOT AND COMPRESSED GAS IS COOLED IN THE CONDENSER BY THE FLOW OF FRESH AIR. AS IT LOSES HEAT IT LIQUEFIES. ONCE A LIQUID, THE REFRIGERANT FROM THE CONDENSER ACCUMULATES IN THE FILTER-DRIER TANK WHERE ANY MOISTURE OR IMPURITIES ARE REMOVED.

FROM THE FILTER-DRIER, THE REFRIGERANT IS CONDUCTED TO THE EXPANSION VALVE, WHERE THE COOLED AND LIQUEFIED REFRIGERANT IS ALLOWED TO PASS TO THE EVAPORATOR. HERE IT EXPANDS AND EVAPORATES. THE CHANGE OF STATE OF THE REFRIGERANT FROM LIQUID TO GAS IN THE EVAPORATOR EXTRACTS HEAT FROM THE FRESH AIR, COOLING IT AS IT PASSES OVER THE EVAPORATOR FINS.



TO COMPLETE THE COOLING CIRCUIT, THE REFRIGERANT AT LOW PRESSURE AND IN A GASEOUS STATE IS DRAWN IN BY THE COMPRESSOR AND COMPRESSED AGAIN.

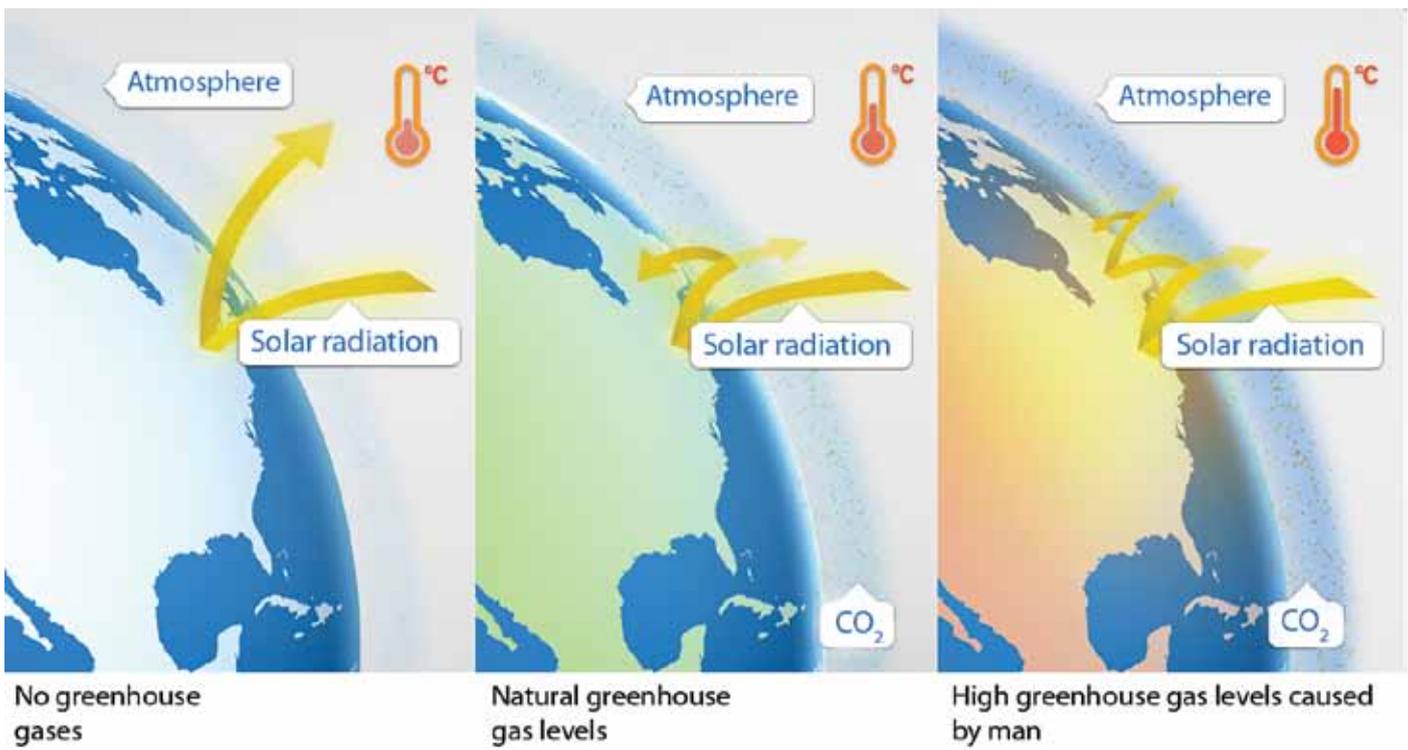
DUE TO THE CHANGES OF THE REFRIGERANT'S STATE BY THE DIFFERENT COMPONENTS IN THE COOLING CIRCUIT, AN IDEAL TEMPERATURE IS MAINTAINED IN THE PASSENGER CABIN AS A RESULT OF THE PASSAGE OF AIR THROUGH THE EVAPORATOR.

## ENVIRONMENTAL IMPACT OF FLUORINATED GASES

There are various factors involved in providing good conditions for life on Earth. One of the essential factors is the function of the atmosphere, as it provides the necessary oxygen for respiration as well as ensuring an ambient temperature suitable for life.

Two of the elements that achieve this in the atmosphere are the greenhouse effect and the ozone layer.

### The greenhouse effect



This is a natural process that occurs in the atmosphere, as a result the average temperature on the Earth's surface is some 15° instead of the -18°C that it would otherwise be, it depends on the distance on the surface of the earth with respect to the sun, this is essential for the natural balance.

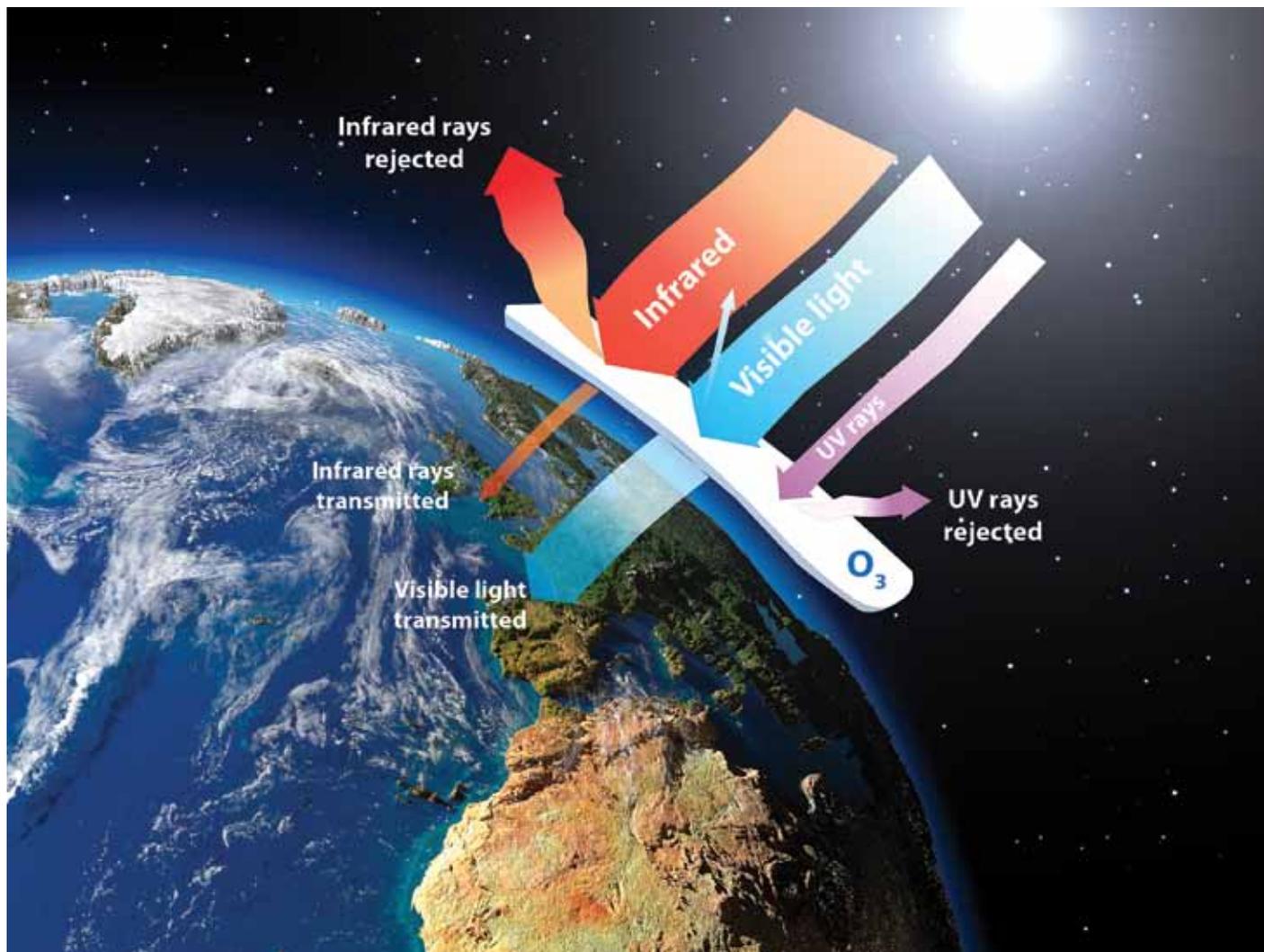
Percentage of the main gases that contribute to the greenhouse effect	
CO <sub>2</sub>	55%
CFC, HFC, HCFC	24%
CH <sub>4</sub>	15%
Nitrous Oxide	6%

## The ozone layer

It forms naturally as a result of ultraviolet rays breaking down oxygen molecules ( $O_2$ ) into two atoms which join to undissociated oxygen molecules to form ozone molecules ( $O_3$ ). This process is mostly carried out at 25 kilometres from Earth, to form what is called the ozone layer.

Some elements such as chlorine are capable of breaking down ozone in

an unnatural way. The uncontrolled emissions of CFCs to the atmosphere have caused what are called the holes in the ozone layer.



## EUROPEAN REGULATIONS RELATING TO FLUORINATED GASES

In 2006, in order to fulfil the Kyoto Protocol commitments, the European Union published Regulation (EC) No 842/2006, of 17 May on certain fluorinated greenhouse gases, which regulates the use of HFCs, PFCs and SF<sub>6</sub>, all those with a global warming potential (GWP) between 120 and 22,200 times greater than carbon dioxide (CO<sub>2</sub>).

Directive 2006/40/EC of 17 May, relating to emissions from air conditioning in motor vehicles, similarly regulates part of the automotive sector with respect to fluorinated gases.

Also published was Regulation (EC) 1005/2009 on substances that deplete the ozone layer, which prohibits the use of CFCs and HCFCs for recharging, including the reuse of gas in the maintenance of climate control systems that use refrigerants with CFCs or HCFCs.

Each country establishes its own legislation for certifying personnel who carry out the following operations:

- Installation of air conditioning systems in vehicles where it is not fitted as standard.
- Maintenance and servicing, including leak checks, charging and recovery of fluorinated gases.
- Handling of gas containers.

This certification is not required of the company or workshop but the personnel who carry out these operations MUST have it.

Only companies or workshops who have qualified personnel can purchase fluorinated gas based refrigerants.

Applicable regulations	
<b>Regulation (EC) 842/2006</b>	The purpose of this regulation is to reduce HFC, PFC and SF6 emissions that contribute to global warming.
<b>Regulation (EC) 307/2008</b>	It is derived from the above and establishes the minimum requirements and conditions for the mutual recognition of certificates required by persons who handle fluorinated gases in vehicles.
<b>Regulation (EC) 1494/2007</b>	It regulates the form and requirements for labelling products that contain fluorinated gases.
<b>Regulation (EC) 1005/2009</b>	It regulates the use of CFCs and HCFCs.
<b>Directive 2006/40/CE</b>	It relates to emissions from air conditioning systems in motor vehicles and amends Directive 70/156/EEC.

## DEVELOPMENT OF AIR CONDITIONING

Although the operating principle of an air-conditioning system has not changed a great deal since its beginnings, there have been developments in the type of refrigerant gas and the components used.

The first developments relate to compressors, the vane type are disappearing, the spiral type mainly used in hybrid and electrical vehicles have improved technology and lastly the piston type now use several pistons.



*Vane compressor*



*Spiral compressor*



*Piston compressor*



Another significant development is designed to control the calibration step before the evaporator, by replacing the thermostats with two or four way expansion valves, which improves the efficiency of the system.



The demand for non-polluting refrigerant gases is increasing. R12 has been replaced by R134a, and recently all vehicles manufactured since 2011 are required by the regulations to use R1234yf, the latter being a less harmful greenhouse gas.



The majority of electronic components in an air conditioning system are designed to provide more comprehensive management of the system, and particularly to the input of variable capacity compressors in order to reduce engine loads with the consequent reduction in fuel consumption.

# MAIN AIR CONDITIONING COMPONENTS

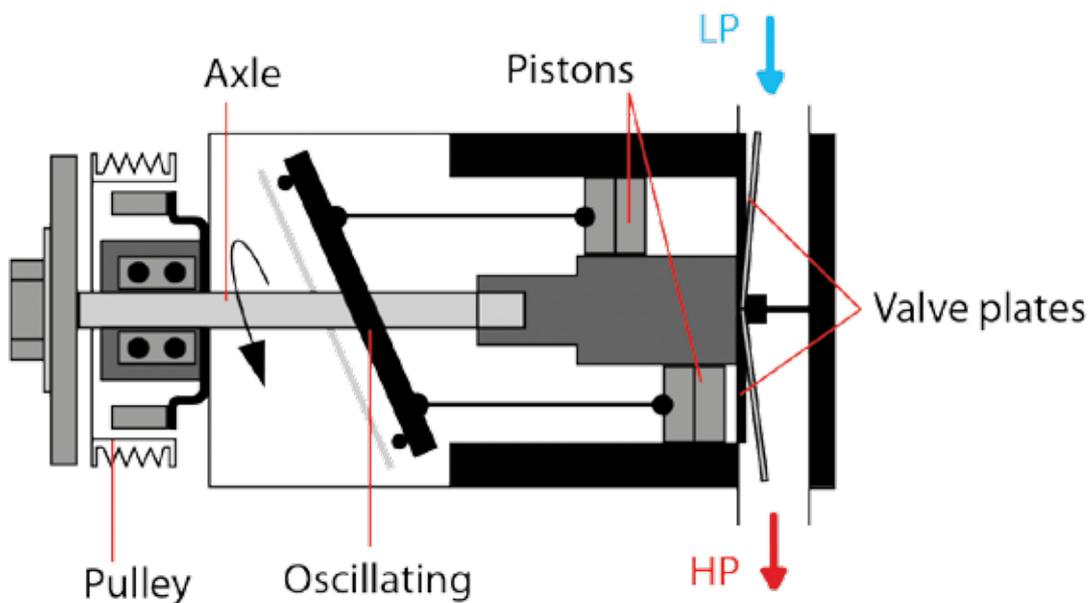
## Compressor

This component compresses the gas in order to increase the refrigerant fluid pressure in the circuit. It is normally driven by the engine through an auxiliary belt. The compressor is driven by an electric motor in hybrid and electric vehicles.

### Piston compressor

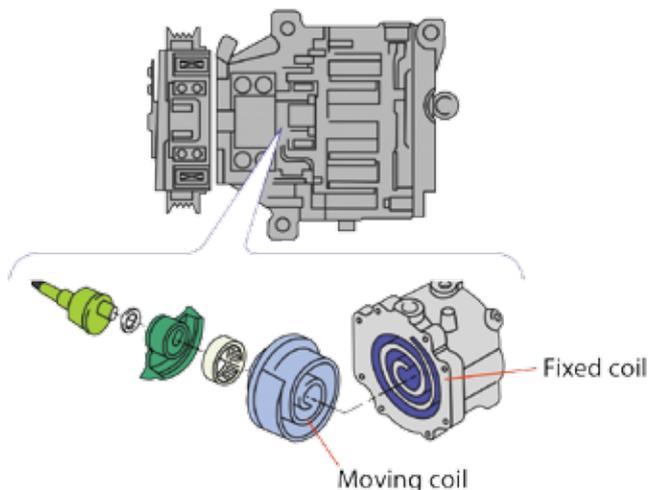
It is currently the most widely used, it is characterised by an internal series of pistons and an oscillating inclined or wobble plate.

The operating principle of this compressor is as follows. The inclined disc rotates concentrically with the shaft to generate an internal axial movement of the pistons that carry out the suction and compression phases. The valve plates are located in both compressor covers, these allow the suction and discharge phases in each cylinder to follow automatically.

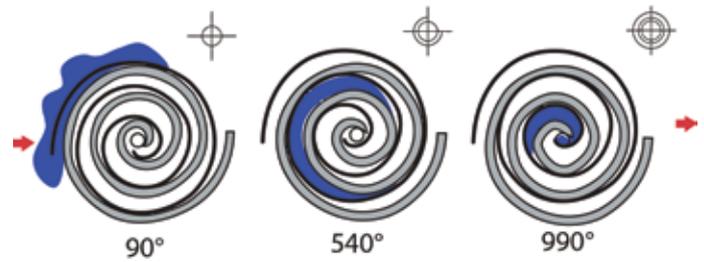


### Spiral or scroll compressor

This compressor is essentially composed of two spirals, one fixed and the other moving, which is driven by the compressor's input shaft.



Its operation is based on the transfer of a volume of gas from the outer area the spiral (where the intake is) to its centre, which produces a gradual reduction in the size of the chamber.



## Exchangers

Basically, the air conditioning circuit has two heat exchangers: the condenser and the evaporator, these are responsible for the transmitting the heat of the internally circulating fluid.

### The condenser

This is the heat exchanger located in the engine compartment and is usually fixed in front of the cooling radiator, its purpose is to cool the liquid that circulates through it.



From the manufacturing point of view, there are several ways in which condensers can be made depending on the technology used. The most common are condensers with copper pipes and aluminium fins, those with a meshed flat tube coil construction and parallel flow condensers.



*Coil condenser*



*Parallel flow condenser*

### The evaporator

This is located in the climate control unit. This is the main component in the low pressure circuit, the refrigerant fluid arrives at the evaporator in two states, part liquid and part gas, as the drop in pressure lowers the boiling point temperature.



There are three different types of construction technologies applied to evaporators:



*Coil evaporators are made of a flat tube with numerous internal channels.*



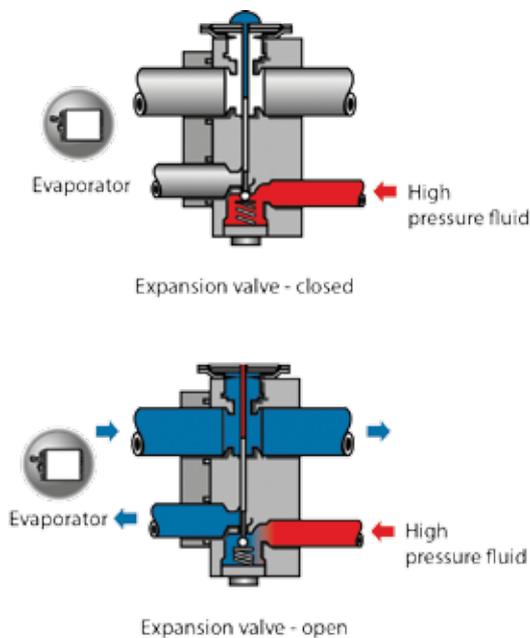
*Tube evaporators are made up of a series of parallel tubes, which are arranged in several sections and joined at the ends with welded elbows.*



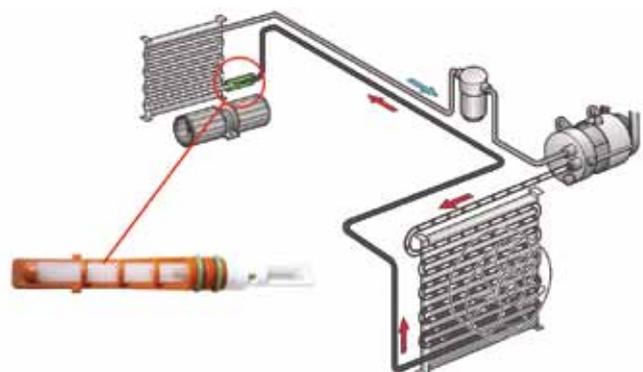
*Plate evaporators are made up of a series of parallel plates.*

## Expansion valve

It is one of the components that separate the high from the low pressure sides. It is located near the evaporator. Its purpose is to regulate the passage of the fluid in its liquid state in the high pressure circuit, so that it vaporises on the low pressure side.



Instead of the expansion valve, there may be another device called the throttle or orifice valve. This type of valve does not allow the flow to be regulated, therefore it must be used in conjunction with a variable capacity compressor so the fluid flow can be regulated. It has a calibrated orifice which allows the passage of a certain percentage of refrigerant. This causes a drop in pressure and the fluid expands.



## Filter-dryer



The filter-drier is located in the high pressure circuit and its main functions are to act as a reservoir for the fluid in its liquid state, filter impurities from the circuit before they reach the expansion valve and to remove, as far as is possible, moisture from the circuit as this could be very harmful.



Some models have a sight glass that indicates, in case of bubbles, the existence of vapour in the high pressure circuit before the expansion valve, either due to it being low on gas, moisture in the circuit or an expansion is occurring in the filter itself.



In some air conditioning installations there is another type of filter-drier called the accumulator or collector tank. The difference between this and the above system is that it is installed in the low pressure circuit, as it works at a much lower pressure. Therefore there is no sight glass as, due to its location, the fluid is in the gaseous state in the filter.

## Safety devices

In addition to the functional air conditioning components, safety valves and pressure sensors are installed in the refrigerant fluid circuit to protect it.

### Relief valve in the compressor

This is a safety valve that releases part of the fluid to the outside when the pressure exceeds 30 bar in the high pressure circuit in order to protect the various components. It is normally fitted on the compressor.



### Pressure sensors

The purpose of the pressure sensors is to prevent breakdowns in the circuit components, and especially the compressor if there is an excess or faulty pressure level. It can be located in the high or low pressure circuit.

The high pressure sensor is usually installed before or after the condenser, depending on the equipment manufacturer. The low pressure sensor is located in the low pressure tube between the evaporator and the compressor.

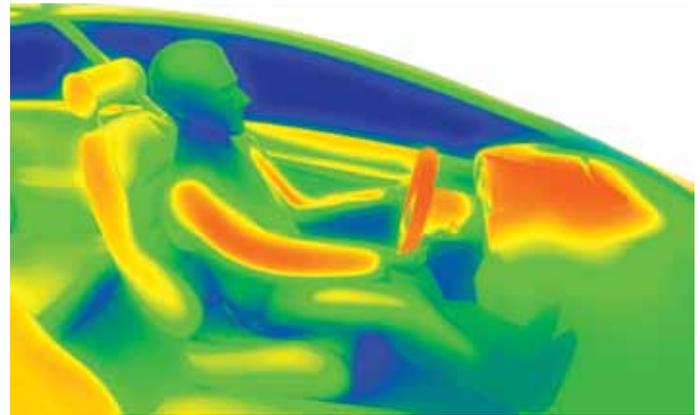


# CLIMATE CONTROL

The purpose of climate control in a vehicle is to attain the level of thermal comfort required by the occupants. This is achieved by distributing the correct flow, temperature and humidity percentage through the ventilation outlets at all times.

Over time, the climate control method has notably progressed. In the past, a manual climate control system was used, the driver manually controlled the activation of the compressor, regulated the temperature, air speed, etc. To improve the comfort of the occupants, electronically controlled climate control was introduced. This has a control unit that fully manages the air flow and temperature. The driver simply sets the desired temperature.

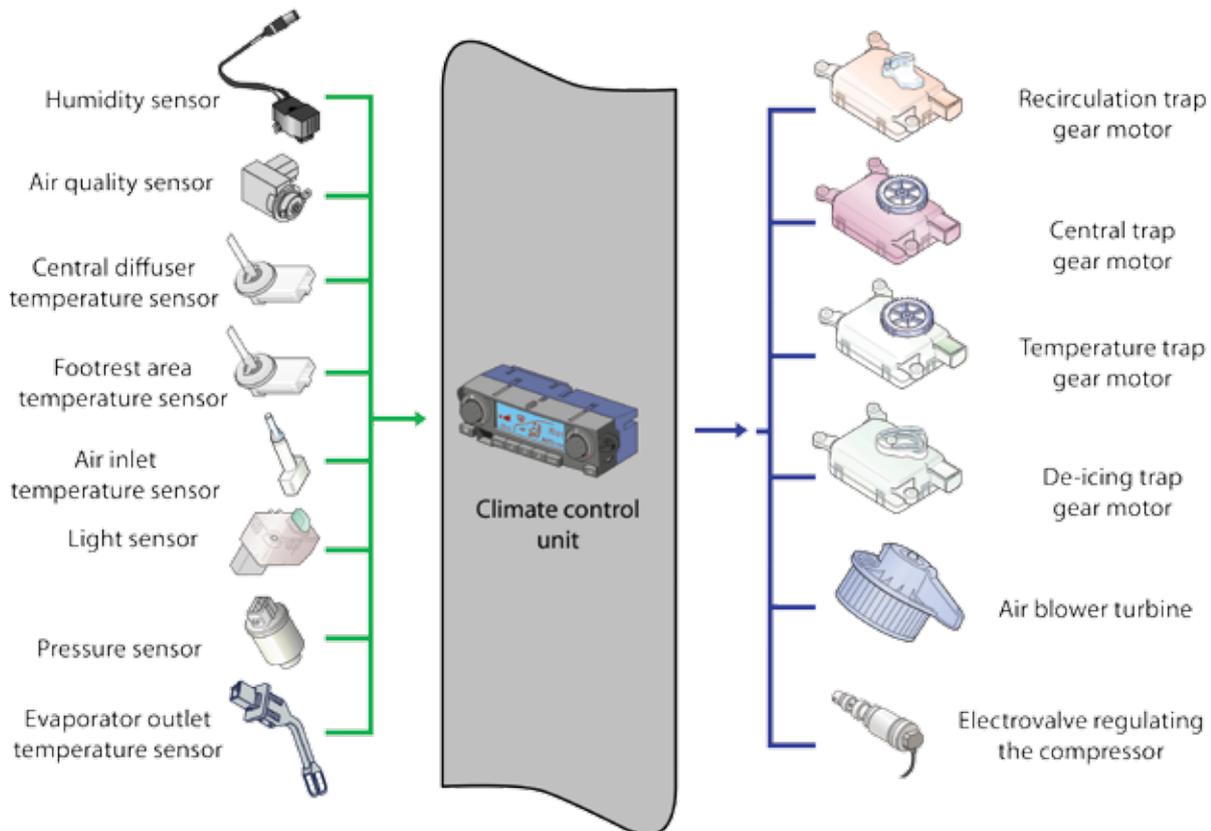
Climate control has become more sophisticated to the point where it is possible to regulate the temperature for each seat separately to obtain a different level of thermal comfort in each section. These are dual zone, three zone and up to four zone.



## Electronic management

An automatic climate control system has a control unit that manages, according to the driver's requirements, the various actuators based on information from sensors installed at various points in the climate control system as a whole.

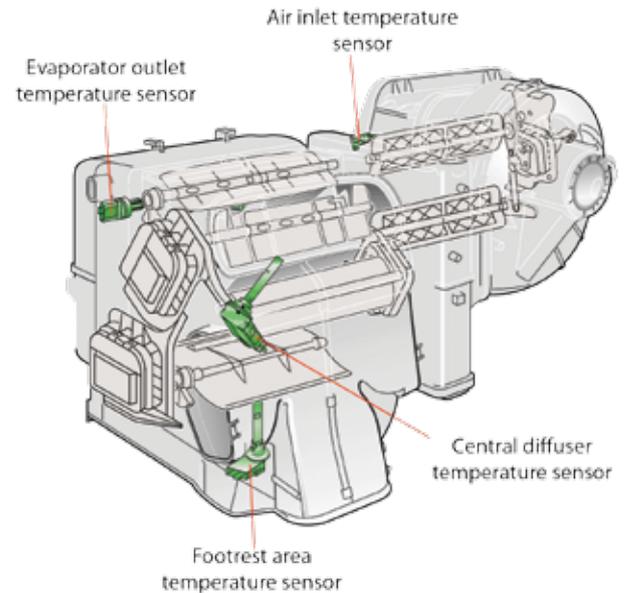
The following schematic shows the operating principle of an automatic climate control system.



# Climate control system sensors

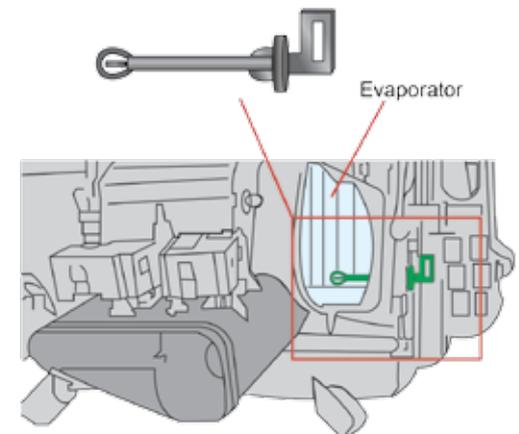
As the climate control system is responsible for a mix of temperatures and their distribution through the ventilation outlets, its main informants are the temperature sensors which are arranged strategically to improve its efficiency.

All these sensors are normally the NTC type, their resistance decreases as the temperature increases. The most important are the evaporator temperature sensor, the exterior temperature sensor, the passenger cabin temperature sensor, the air duct temperature sensor and the engine temperature sensor.



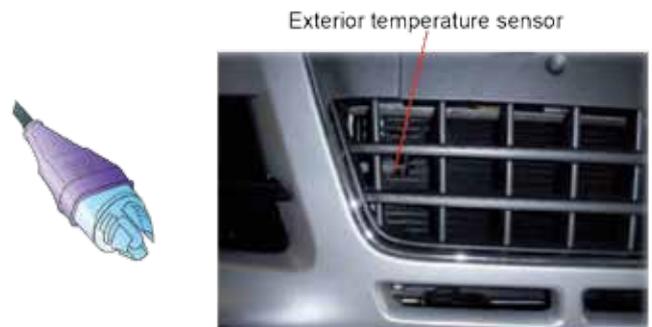
## Evaporator temperature sensor

This is located in front of the evaporator fins in the coldest area. Its information is essential for preventing the formation of ice in the evaporator.



## Exterior temperature sensor

This is located in the front bumper or in one of wing mirrors. Their information is essential for the safety of the compressor. Because if it detects an ambient temperature lower than 5°C, it shuts down the compressor to prevent its breakage.



## Engine temperature sensor

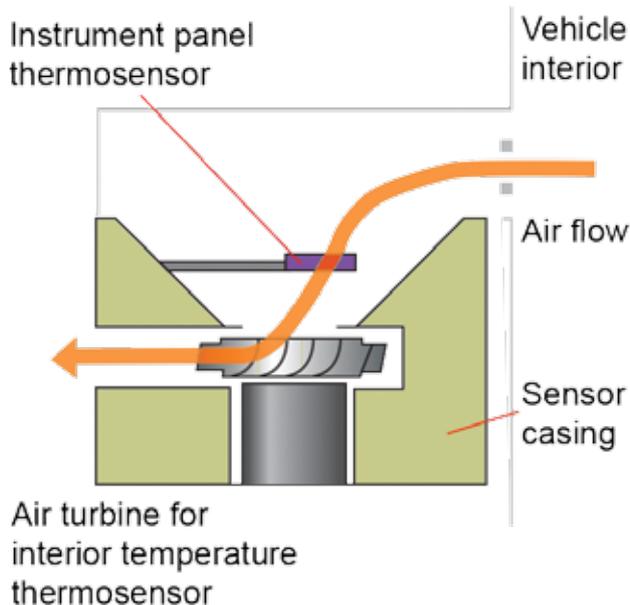
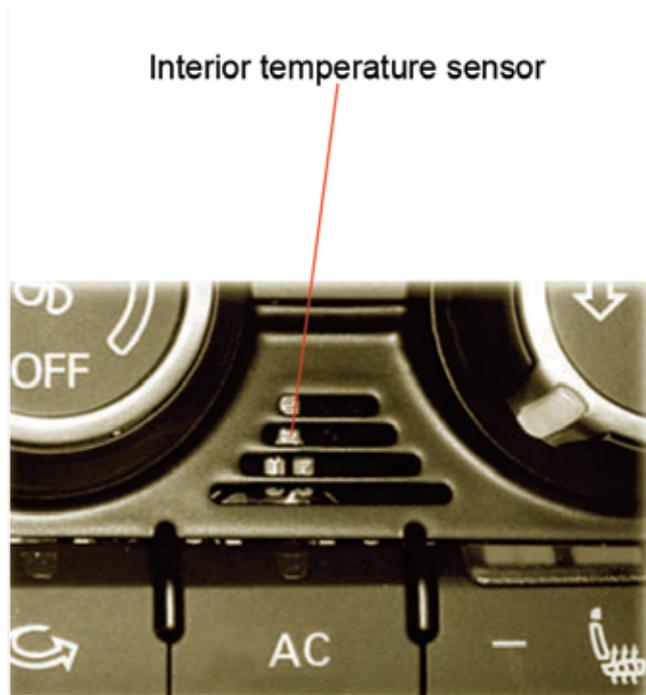
The engine control unit provides the information from this sensor. If the engine overheats, it shuts down the air conditioning compressor.



## Passenger cabin temperature sensor

This is usually located in the dashboard area, it has a small fan so it can draw in air from the passenger cabin and circulate it through the sensor.

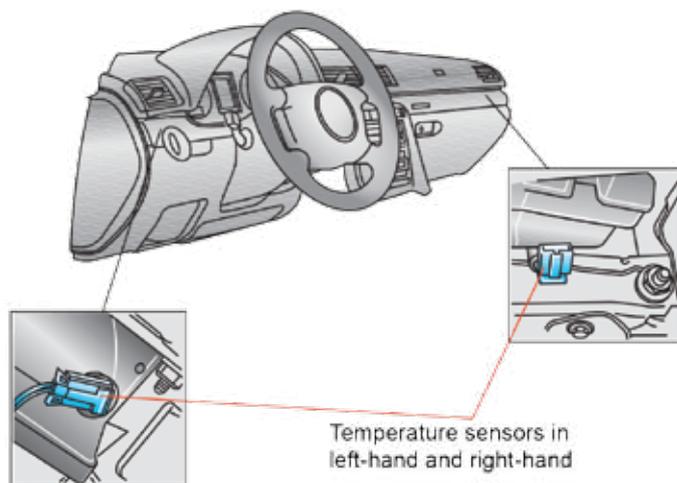
This information ensures the unit achieves the temperature in the passenger cabin desired by the occupants.



## Air duct temperature sensors

These are responsible for measuring the temperatures in the various ventilation outlets. The number and location of the sensors depend on the type of climate control system and its layout in the vehicle.

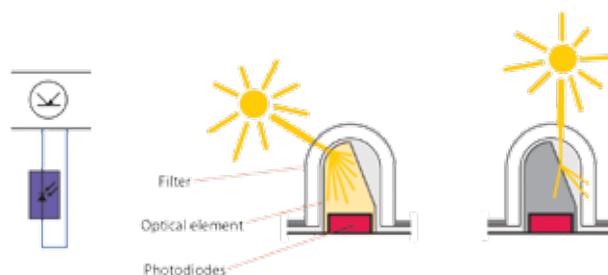
For more complete climate control, solar radiation, air quality and humidity sensors are also included.



## The solar radiation sensor

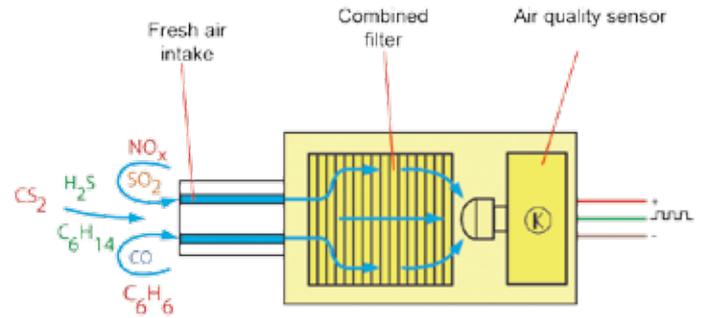
This is usually located on the top of the dashboard. It detects the solar gain in the passenger cabin and informs the climate control unit so that it can adjust the temperature in the affected area.

Its operation is based on the use of one or more photodiodes, which allow a greater flow of current with higher solar incidence. There are more of these sensors in more complex climate control units, such as the dual zone or four zone, to provide greater accuracy on each side.



## The air quality sensor

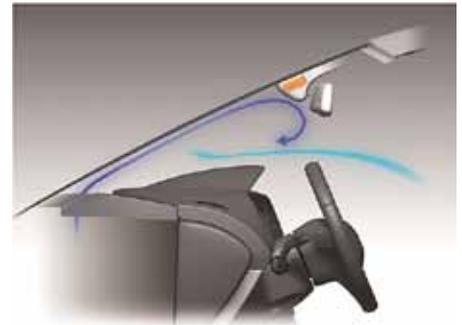
This is located at the inlet to the climate box. Its purpose is to detect harmful substances or gases entering the passenger cabin that may have come from combustion. If so, the recirculation servomotor is activated which closes the air inlet flap.



## The humidity sensor

This sensor measures the relative humidity of the air and temperature directly on the inside of the windscreen and determines the dew point temperature based on these values. Normally it is located behind the rear-view mirror.

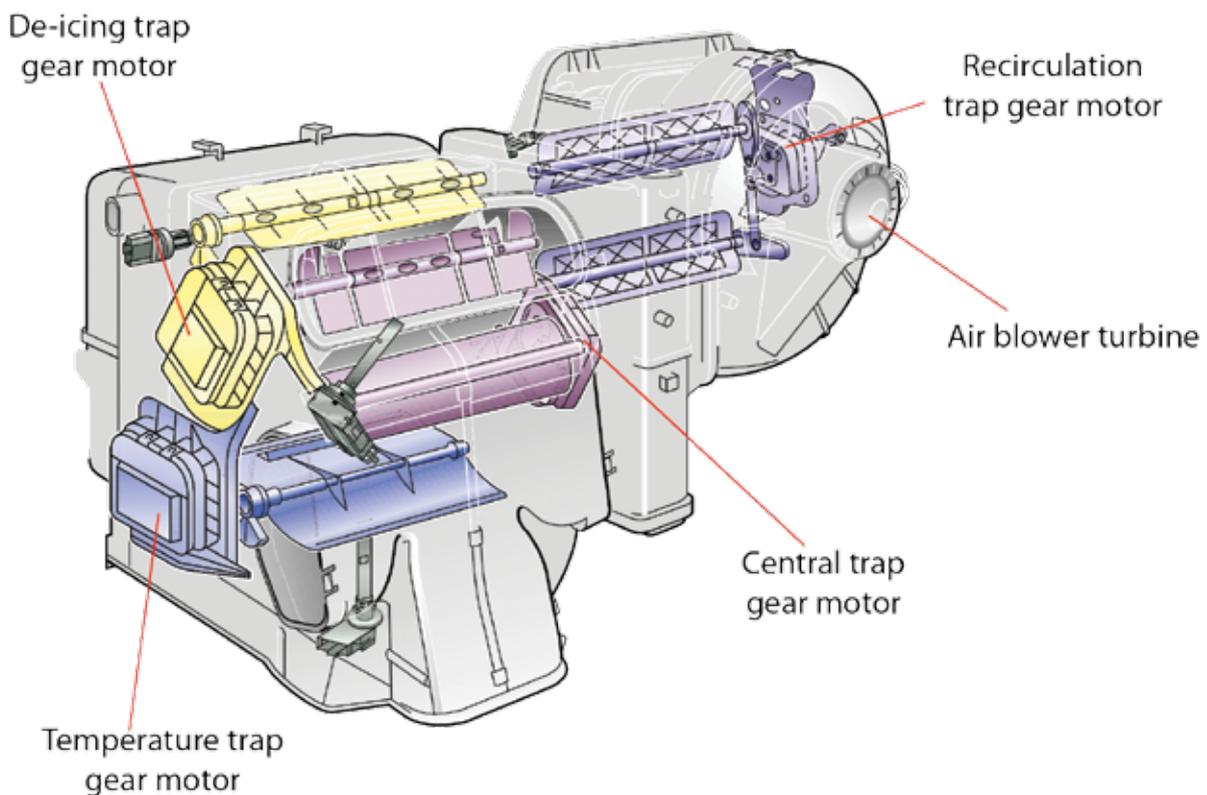
As a result of weather conditions, road visibility could get worse due to misting of the windscreen. Using information from this sensor, the control unit manages the supply of air to the windscreen to prevent misting.



## Climate control system actuators

The climate control system has several electric motors that actuate the flaps and the air blower turbine. All these elements are located within the climate control unit, which is usually divided into two parts, one is respon-

sible for the air input and flow and the other for distributing it to the different areas.

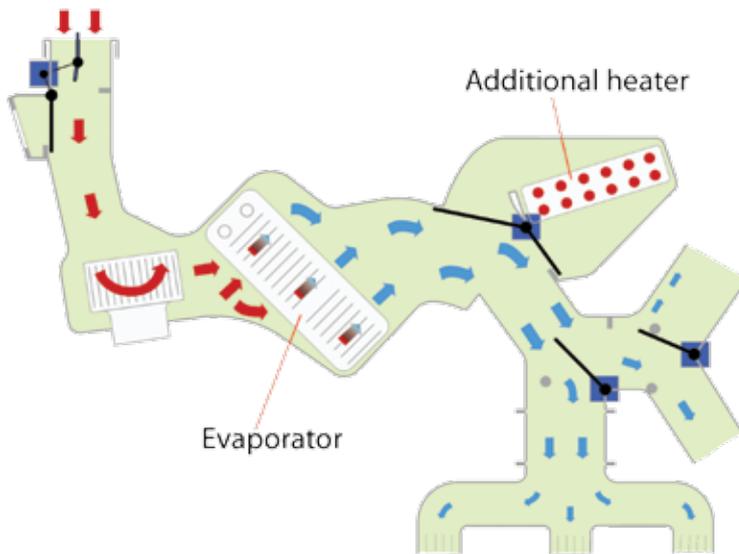
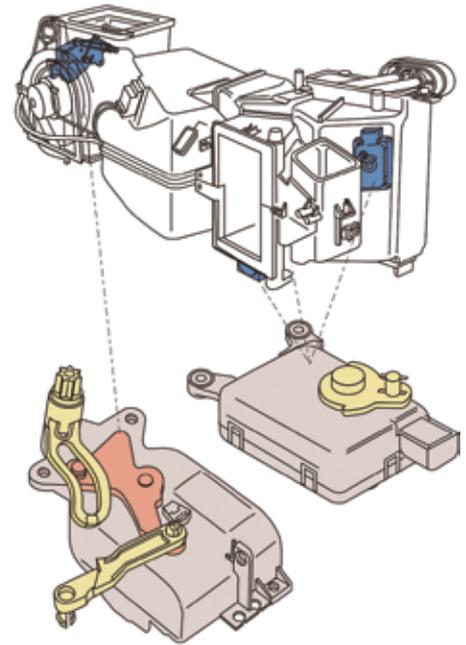


## Gear motors

These open and close the flaps inside the climate box, allowing fresh or hot air to enter the passenger cabin. The main motor driven flaps are those for recirculation, flow and air mixing.

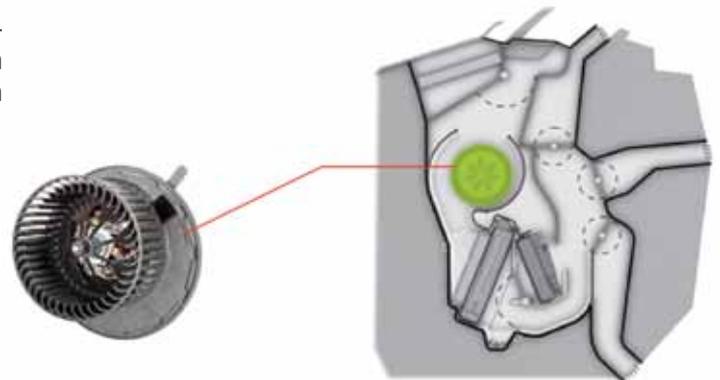
To move these flaps, stepper motors may be used in some models. The control unit regulates the position of these without the need for position sensors.

The air flows through different ducts inside the climate box depending on the heating needs of the occupants. When cold air is required, this air directly crosses the evaporator. Otherwise, the air passes through an additional heater by means of a mixing flap. Finally, the desired air flow is distributed through the different ventilation outlets.



## Air blower turbine

This is located inside the climate box. This blows fresh air into the passenger cabin, after it first passes through the ventilation ducts. The fan rotation speed can be controlled either by the driver or, when operating in automatic mode, by the climate control system control unit.



# COMMON FAILURES

While the air-conditioning is in operation, the elements and components are subject to various loads, the majority of these are related to the temperature and pressure at which they work. Some of the components can leak, seize or break.

One of the most common problems that occurs with air conditioning is the existence of bad odours coming from the ventilation outlet. This is caused by the presence of moisture around the evaporator as a result of air condensing as it passes through the evaporator fins. The odour worsens as a result of the development of mould and bacteria. This problem can be resolved without dismantling the evaporator using a cleaning product that is applied in the form of an aerosol.

Directions for use:

1. Dry the surface of the evaporator using the vehicle's heating system. In order to do so you will need to turn the heating or climate control temperature to maximum with the air distributor in the low position.
2. Leave the system to run for approximately 10 minutes with the fan on maximum in recirculation mode.
3. Once all moisture has been removed, turn the climate control system to a low heat without allowing the air conditioning to kick in.
4. Next, apply the spray to the air intake inlet and the ventilation outlets. Leave the cleaner to work for 10 minutes with the climate control system in recirculation mode.
5. After cleaning, dry the evaporator and the inside of the climate control casing in the same way outlined in the first step.
6. To finish, open the vehicle's doors and allow to ventilate out in the open for 10 minutes.

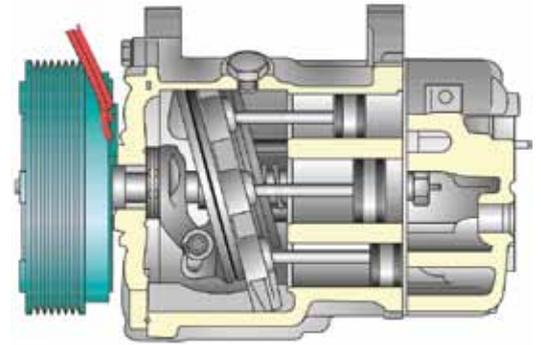
Very low air pressure in the diffuser outlets is another common problem. This is usually due to the filter becoming saturated with pollen, either as a result of poor maintenance or heavy use in dusty environments. This problem can be resolved by replacing the filter.



## Piston compressor



- Seizure or internal breakage
- Refrigerant leaks
- Low compressor efficiency
- Fault in the electromagnetic clutch



- Seizure or internal breakage may be due to lack of lubrication or the presence of refrigerant fluid in the liquid state.
- Using a special ultraviolet light, visually inspect the areas where a refrigerant leak may occur.
- With the charging station connected to the circuit, check the high and low pressures.
- Check if the voltage at the coil is correct, as well as its resistance and its insulation to earth.



- In case of seizure or internal breakage, the compressor must be replaced.
- When the compressor has external leaks, the affected seals must be replaced if the manufacturer supplies them.
- If the pressures are not correct due to wear of one of the compressor's internal components, repair is possible if the manufacturer supplies the spare parts, if not, the compressor must be replaced.
- If the coil is severed or its insulation grounded, the electromagnetic clutch must be replaced.

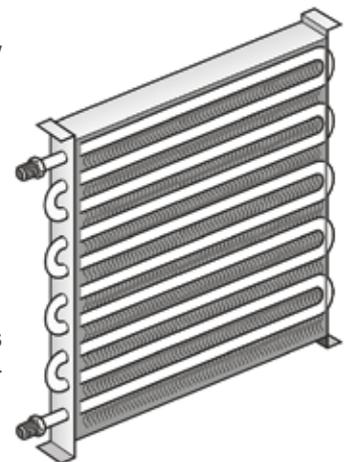
## Condenser



Holes due to possible corrosion on the surface of the condenser, fins clogged by foreign bodies, or leaks in the input and output connectors.



Inspect the appearance and fastening of the condenser and that the air channels are free of foreign bodies. Check whether the connector welds have not deteriorated and verify the tightening torque.



If there are holes, replace the condenser. If it is not properly fastened, correct its position. When the condenser is clogged, remove the foreign bodies from the fins. If the connectors are loose, replace the o-rings. When the connectors have weld problems, replace the condenser.

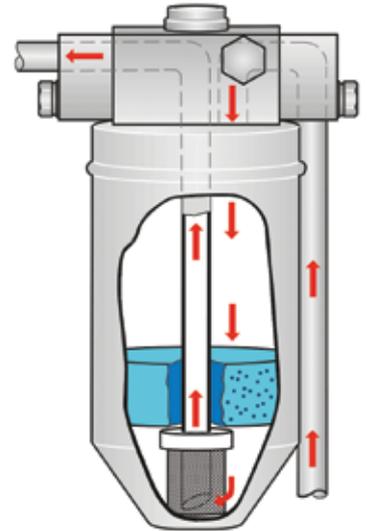
## Filter - dryer



Saturated filter and circuit clogged.



When the filter is clogged, it does not allow the necessary quantity of liquid to flow and acts as an expansion valve. To confirm this fault, touch the inlet and outlet tubes to see if they are at different temperatures.



In case of clogging, replace the filter.

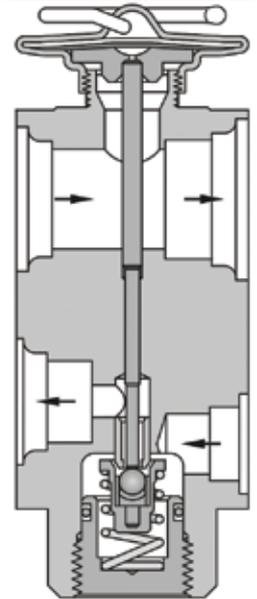
## Expansion valve



Internal clogging, valve stuck in open or closed position.



With the help of a charging station, check the pressures in the high and low pressure circuits to see if the valve is operating correctly. Ensure the valve and fittings are leak tight. Using an infrared digital thermometer, check the temperature of the input and output tubes of the expansion valve.



When there is clogging or dirt present, the expansion valve must be replaced. If the difference between the input and output temperature of the expansion valve is minimal, it means that the valve is open or the gas charge is insufficient. In this case, recharge the gas to see if the valve works correctly, if not, it must be replaced.

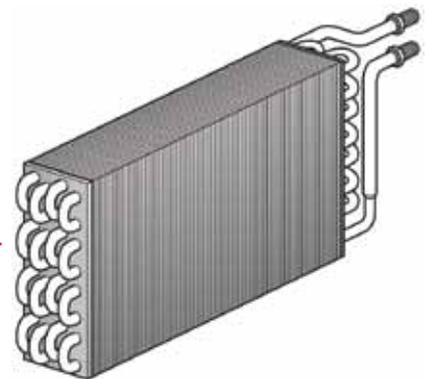
## Evaporator



Holes due to corrosion on the surface of the evaporator, fins clogged with dirt, leaks in the inlet and outlet connectors. Bad smells in the passenger cabin due to bacteria on the surface of the evaporator.



Check if the evaporator is not leaking, check for dirt on the fins. Check whether the welding of the connectors has not deteriorated and their tightening torque.



If there are holes, replace the condenser. Any dirt should be cleaned off. If the connectors are loose, replace the o-rings. When the connectors have weld problems, replace the evaporator.

# TECHNICAL NOTES

Below is the list of the most common faults that occur in the climate control system. Depending on the manufacturer and the different models, the number of faults occurring over the years can be considerable.

These faults are selected from the online platform: [www.einavts.com](http://www.einavts.com). This platform has a series of sections that indicate the make, model, range, affected system and subsystem, these can be selected separately depending on the type of search you wish to carry out.

## VAG GROUP

AUDI, SEAT, SKODA, VW	
Symptoms	01273 - Inoperative / Short-circuit to positive. Intermittent mechanical failure. It is observed that the air conditioning does not work. The cold air fan does not work.
Cause	This is a fault in the fan motor brushes.
Solution	The cold air fan must be replaced.

## VAG GROUP

AUDI, SEAT, SKODA, VW	
Symptoms	P1672/18080: Radiator fan 1 activation device, Inoperative/short-circuit to earth. P0480/16864: Radiator fan 1 activation device, electrical fault. Injection fault light on.
Cause	Entry of dust into the radiator fan 2 (small fan).
Solution	Check that both fans are activated and deactivated at the same time by activating with the diagnostic tool, by turning the air conditioning on and off or by heating the engine to approximately 90°C. If only one fan is activated or they are not synchronised, check the installation. Replace the affected fan if there is no fault in the wiring.

## FIAT

STILO (192) 1.8 16V (192_XC1A) (192 A4.000)	
Symptoms	P1531 - Air conditioning relay in engine control unit. C1101 - CAN (NCM) network, invalid signal at the brake node. ESP warning light on at first start-up or while running. NOTE: This technical note only affects vehicles with chassis numbers from 367397 to 433908.
Cause	Incompatibility between the ECU software and the air conditioning system which gives some of the signals received by the ECU as invalid.
Solution	Reprogram the ECU with updated software.

## RENAULT

CLIO III (BR0/1, CR0/1), MEGANE II (BM0/1_, CM0/1_), SCENIC II (JM0/1_)	
Symptoms	DF1070: Cold loop. The climate control system does not cool the passenger cabin.
Cause	Damaged compressor connector.
Solution	Check if the compressor plate rotates freely by hand, if it does, replace the climate control compressor connector and delete the memorised DF.

**TOYOTA**

## AURIS

Symptoms	B1421 - Open circuit or short-circuit in the sunlight sensor on the passenger side. Air at ambient temperature comes out of the ventilator on the right-hand side and it cannot be adjusted. NOTE: Code B1421 (Sunlight sensor) is stored by default if the climate control system diagnostic is carried out in the workshop. To ensure that the sensor is not faulty, carry out the diagnostic outside the workshop using natural light.
Cause	Bent mixing flap on the right-hand side.
Solution	Replace the flap by part reference 04007-44142. For more information consult your usual technical adviser. For spare parts consult your usual distributor. NOTE: For this model, there is no breakdown of the climate assembly, therefore you must use the part reference provided.

**OPEL**

## ASTRA H

Symptoms	Between 1500 and 2000 RPM, the air conditioning compressor becomes noisy.
Cause	The air conditioning compressor is of the variable capacity type regulated by means of a solenoid valve. The operation of the compressor is not being correctly regulated from the climate control control unit (ECC), causing internal noise in the compressor.
Solution	Reprogram the climate control unit (ECC) with updated software. Recharge the refrigerant in the air conditioning circuit and test the system.

**LAND ROVER**

## RANGE ROVER II (LP) 4.6 (46 D)

Symptoms	The climate control/heating system cools or heats too much.
Cause	Fault in the fan microswitch for the passenger cabin temperature sensor.
Solution	Replace the temperature sensor with an upgraded version. Consult your usual distributor.



## an eye on automotive technology

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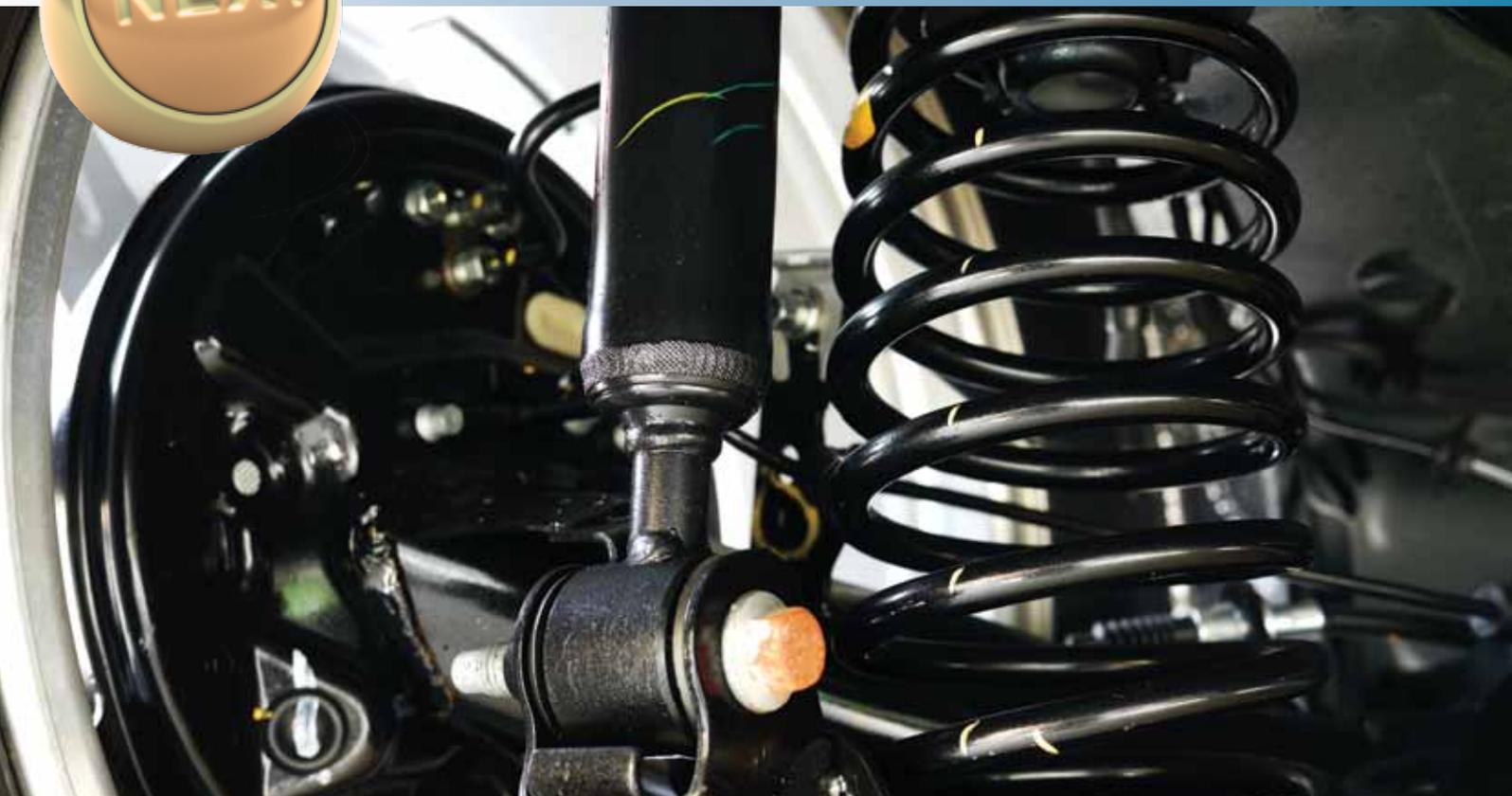
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## ride control



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