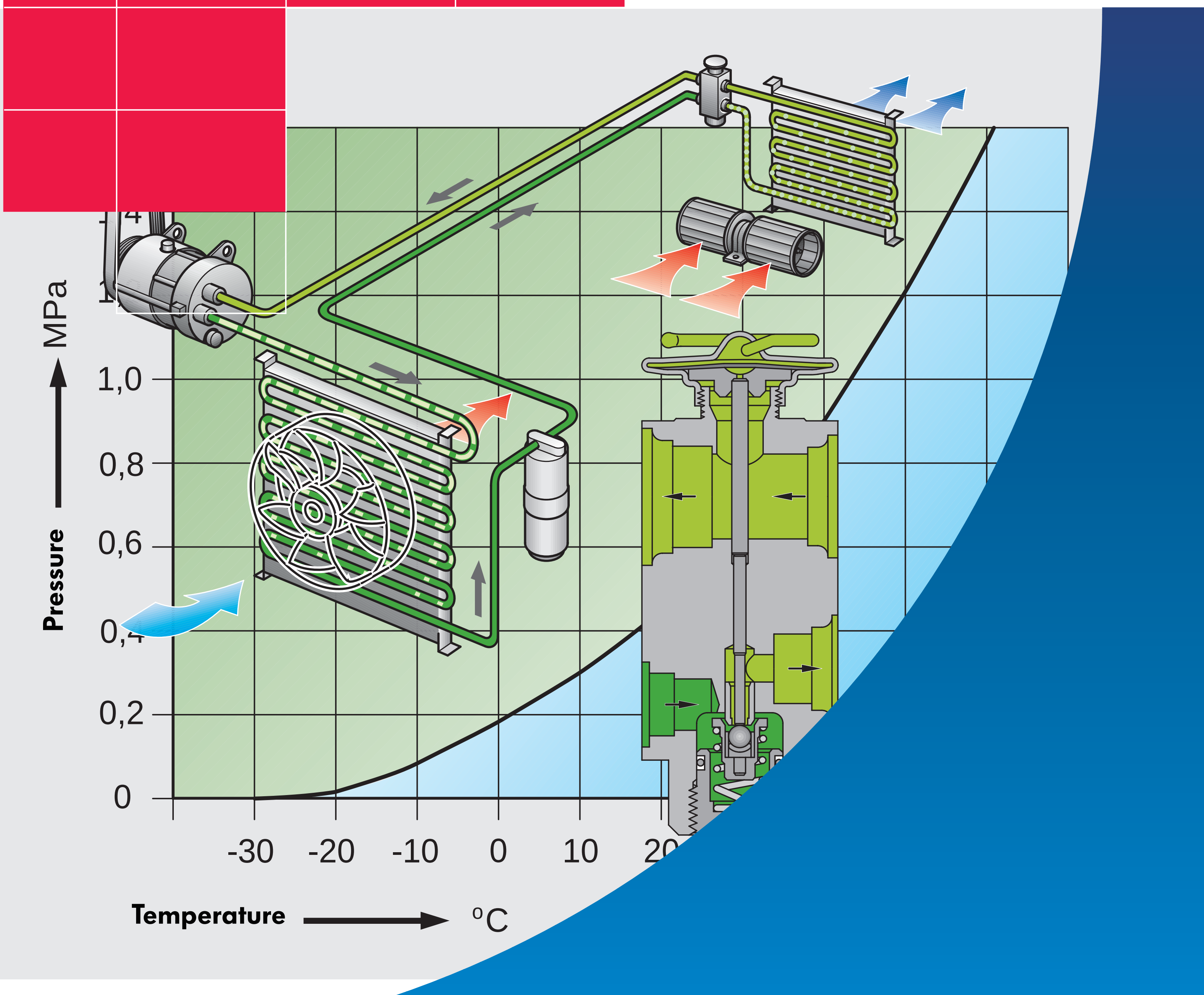
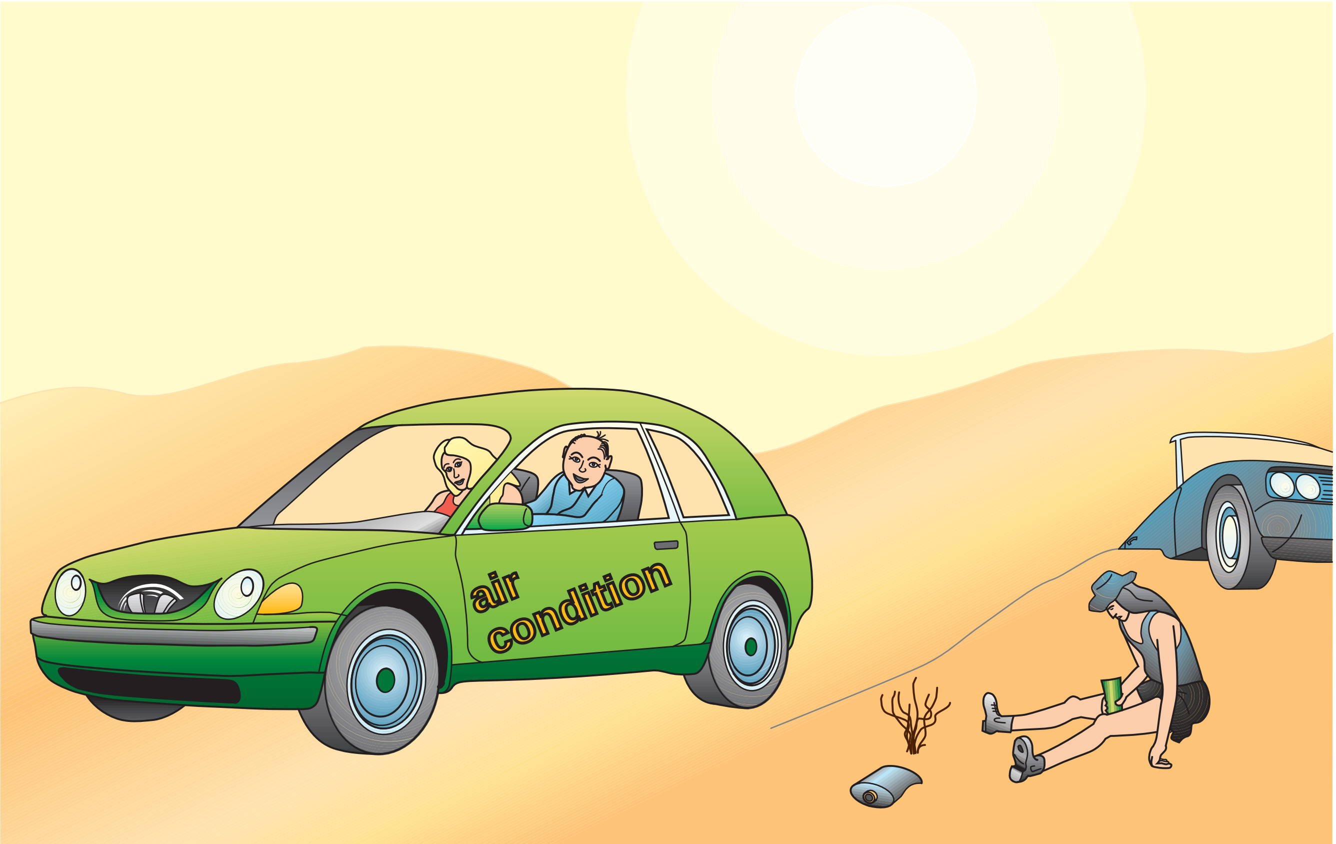
Service.

Self-Study Programme 208

Air Conditioner in the Motor Vehicle

Fundamentals





Air conditioning systems have long ceased to be regarded as luxury equipment.
Air conditioners have become a factor in active safety, and today can almost be considered as an integral part of a vehicle's safety specification.

10 years ago, only about 10 percent of all newly registered vehicles were fitted with an air conditioning system. By 1996, air conditioners were being installed as standard in more than one in four newly registered vehicles.

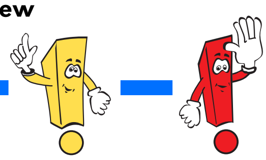
Customer demand for air conditioning is rising continually.

The design of the refrigerant circuit of an air conditioner is identical in all vehicles.
Air conditioner refrigerant circuits only vary in respect of how they are adapted to meet refrigeration requirements.

In this Self-Study Programme, you will familiarise yourself with the basic purpose and design of an air conditioner.
You will learn the functions of the component parts in the refrigeration process, the special characteristics of the refrigerant and why air conditioners require special service specifications.

The component parts shown in the following SSP are common to most air conditioners.

**Please note that the figures specified are given by way of example only.
Depending on refrigeration requirements, the absolute values vary from vehicle to vehicle.**

New  **Important Note**

The Self-Study Programme is not a Workshop Manual!

Please always refer to the relevant Service Literature for all inspection, adjustment and repair instructions.
Service literature.

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Why air conditioning?

People feel comfortable at a certain ambient temperature and atmospheric humidity.

As a component part of active safety, the driver's well-being is a key factor in driving ability.

The “in-car climate“ has a direct bearing on the driver, fatigue-free driving and driving safety.

A comfortable interior temperature is dependent upon the prevailing ambient temperature and upon sufficient air flow:

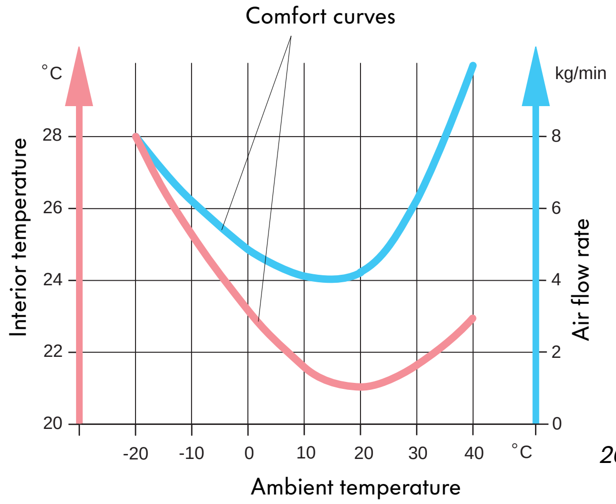
Low ambient temperature, e.g. –20 °C
➡ Higher interior temperature 28 °C
High air flow rate: 8 kg per min.

High ambient temperature, e.g. 40 °C
➡ Low interior temperature 23 °C
High air flow rate: 10 kg per min.

Moderate ambient temperature, e.g. 10 °C
➡ Low interior temperature 21.5 °C
Low air flow rate: 4 kg per min.

Even modern heating and ventilation systems have difficulty maintaining a pleasant climate inside a vehicle at high ambient temperatures. Why?

– In strong sunlight in particular, the heated cabin air can only be exchanged for air with ambient temperature.
– In addition, the air temperature usually rises en route from the intake point to the air outlet.
– Opening a window or sliding roof or setting a higher fan speed for greater comfort will usually result in a draught and expose the occupants to other nuisances such as noise, exhaust gases and pollen.



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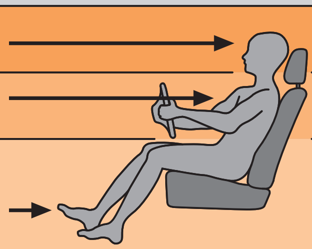
High levels of atmospheric humidity put the body under considerably greater physical strain.

Temperatures in a mid-range passenger car
where: driving time 1 h
ambient temperature 30°C
sunlight penetration into car

Area	with air conditioning	without air conditioning
Head	23 °C	42 °C
Chest	24 °C	40 °C
Feet	28 °C	35 °C



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Effects of an unfavourable vehicle interior temperature on humans

Scientific studies conducted by the WHO (World Health Organization) have shown that one's ability to concentrate and reactions are impaired when under stress.

Heat puts a strain on the body.

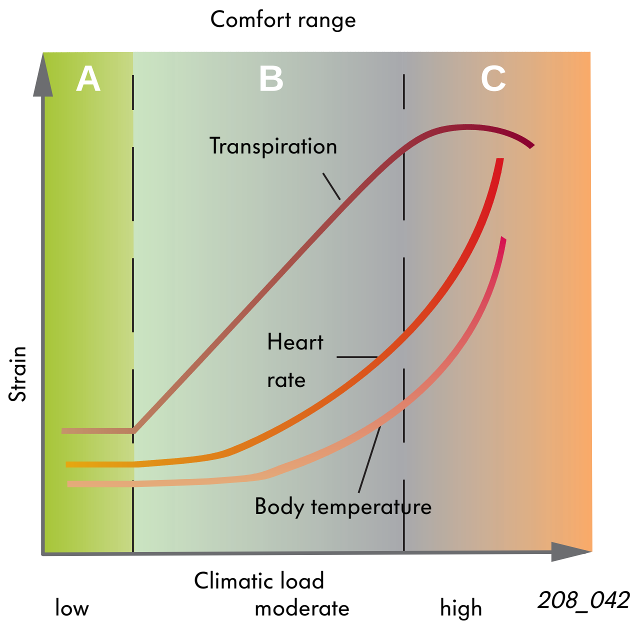
The best temperature for the driver is between 20 and 22 °C.
This is equivalent to climatic load A, the "comfort range".

Strong sunlight can increase the interior temperature by more than 15 °C above the ambient temperature– particularly in the head area.
This is where the effects of heat are most dangerous.

The body temperature rises and the heart rate increases.
Heavier perspiration will typically occur, too.
The brain is not receiving enough oxygen.
Also refer to "climatic load range B".

Climatic loads in range C put an excessive strain on the body.
Physicians specialising in traffic-related illnesses refer to this condition as “climatic stress“.

Studies have shown that an increase in temperature from 25 to 35 °C reduces one's sensory perception and powers of reasoning by 20%. It has been estimated that this figure is equivalent to a blood alcohol concentration of 0.5 millilitres alcohol level.



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The air conditioner - a system which keeps the air temperature at a level comfortable to humans, as well as purifying and dehumidifying the air -– was created in order to reduce or eliminate completely such stress.

With the help of an air conditioner it is possible to produce at the air outlets a temperature which is much lower than high outside air temperatures.
This is possible both when the vehicle is at a standstill and when it is in operation.

A technical side-effect of air conditioning is that the air is dehumidified and cleaned at the same time. However, this is just as important as the reduction in temperature.
The pollen filter and activated charcoal filter also help to clean the air entering the vehicle.
People with allergic illnesses benefit greatly from being able to breathe clean air.

In-vehicle air conditioning is

- a real safety element

- a functional accessory not only for expensive tastes

Physics of the cooling system

Applied physics

Laws

Many substances are known to exist in three aggregate states.

Take water for example: solid – liquid – vapour.
The principle of cooling follows this law.

Even in ancient times there was a need for cooling. One of the first methods used to cool foodstuffs was to store them in an “icebox“.

The ice (water in a solid aggregate state) absorbs the heat of the foodstuffs, thereby cooling them down.

The ice melts as a result, assuming another aggregate state, namely that of a liquid (water).

If the water is heated further, it will boil and evaporate.
The water is now in the gaseous state.

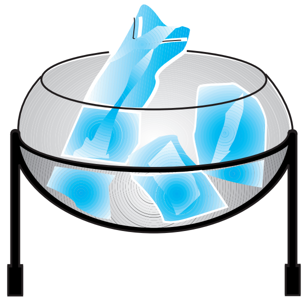
The gaseous substance can be converted back to a liquid by cooling it and will become a solid again if cooled further.
This principle is applicable to almost all substances:

- A substance absorbs heat when it is converted from a liquid to a gas.

- A substance gives off heat when it is converted from a gas to a liquid.

- Heat always flows from the warmer substance to the colder substance.

Air conditioners utilise the effects of heat exchange, a process in which a substance changes state at certain points.



Ice – solid

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Ice – becomes a liquid when it absorbs heat

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Water – becomes a gas when it absorbs heat

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Law

Freezing point,
e.g. water becomes ice,
Boiling point
e.g. water becomes steam

Pressure and boiling point

If the pressure is changed using a liquid, the boiling point changes.
All liquids behave similarly.

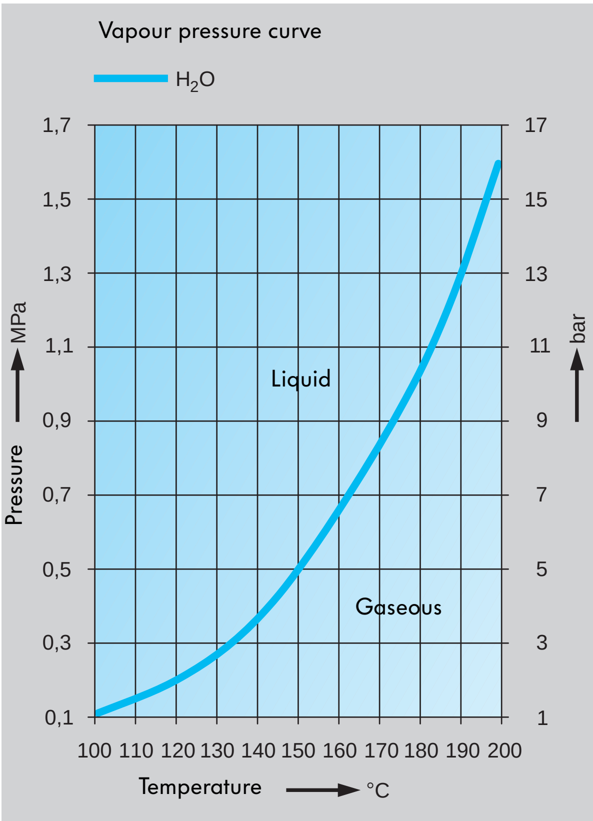
Boiling point	H_2O/water	=	100 °C
	Machine oil	=	380 - 400 °C

The lower the pressure, the lower the temperature at which water boils (evaporates).

The evaporation process is also used in vehicle air conditioners.
A substance with a low boiling point is used for this purpose.
This substance is known as a refrigerant.

Boiling point	Refrigerant R12	–29.8 °C
	Refrigerant R134a	–26.5 °C

(The boiling points specified for liquids in the table always refer to an atmospheric pressure of 0.1 MPa = 1 bar.)



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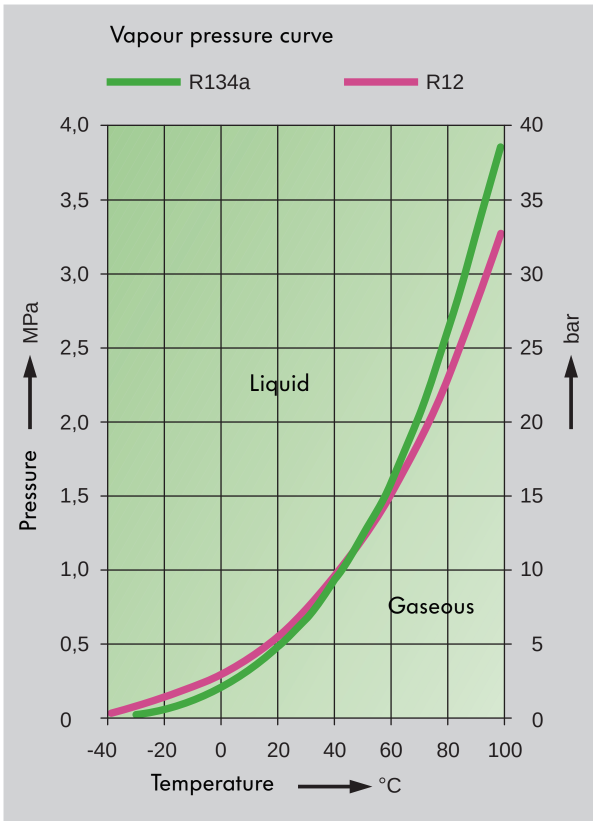

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What does a vapour pressure curve tell us?

We can draw the following conclusions from the vapour pressure curve for the two refrigerants R134a and R12 (R12 is no longer used) and water:

- **At a constant pressure, the vapours become a liquid through temperature reduction (in the air conditioner circuit, this process takes place in the condenser = liquefier),**
- **The refrigerant goes from a liquid state to a vapour state through pressure reduction (in the air conditioner circuit, this process takes place in the evaporator).**

The refrigerant

R 134a

The refrigerant with a low boiling point used for vehicle air conditioners is a gas.

As a gas, it is invisible.
As a vapour and as a liquid, it is colourless like water.

Refrigerants may not be combined with each other. Only the refrigerant specified for the system in question may be used.

Refrigerant **R12** – Dichlordifluormethane
chem. formula CCl_2F_2

a chlorinated hydrocarbon (**CFC**)
harmful to the environment!

Refrigerant **R134a** – Tetrafluorethane
chem. formula $CH_2F\text{-}CF_3$

a fluorocarbon (**FC**)
environmentally friendly!

With regard to vehicle air conditioners, the sale and filling of refrigerant R12 were banned in Germany with effect from 1995 and July 1998 respectively.

Ordinance banning halogens

In current automotive air conditioners, only refrigerant R134a is used.

R134a

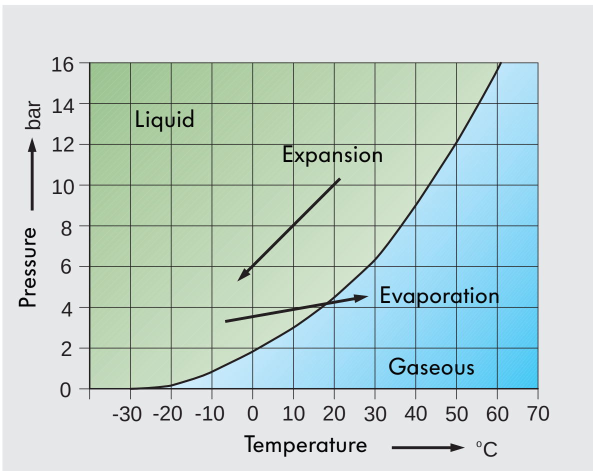
- R134a – a fluorocarbon contains no chlorine atoms - unlike refrigerant R12 - which cause depletion of the ozone layer in the earth's atmosphere when they split.

- The vapour pressure curves of R134a and R12 are very similar.
  R134a has the same refrigeration capacity as R12.

  It is possible to adapt air conditioners which now may no longer be filled with R12 to R134a with a special conversion kit (Retrofit method).

  The systems converted in this way are no longer able to match their original refrigeration capacity.

Depending on the pressure and temperature conditions in the refrigerant circuit, the refrigerant will either be a gas or a liquid.



Vapour pressure curve of R134a

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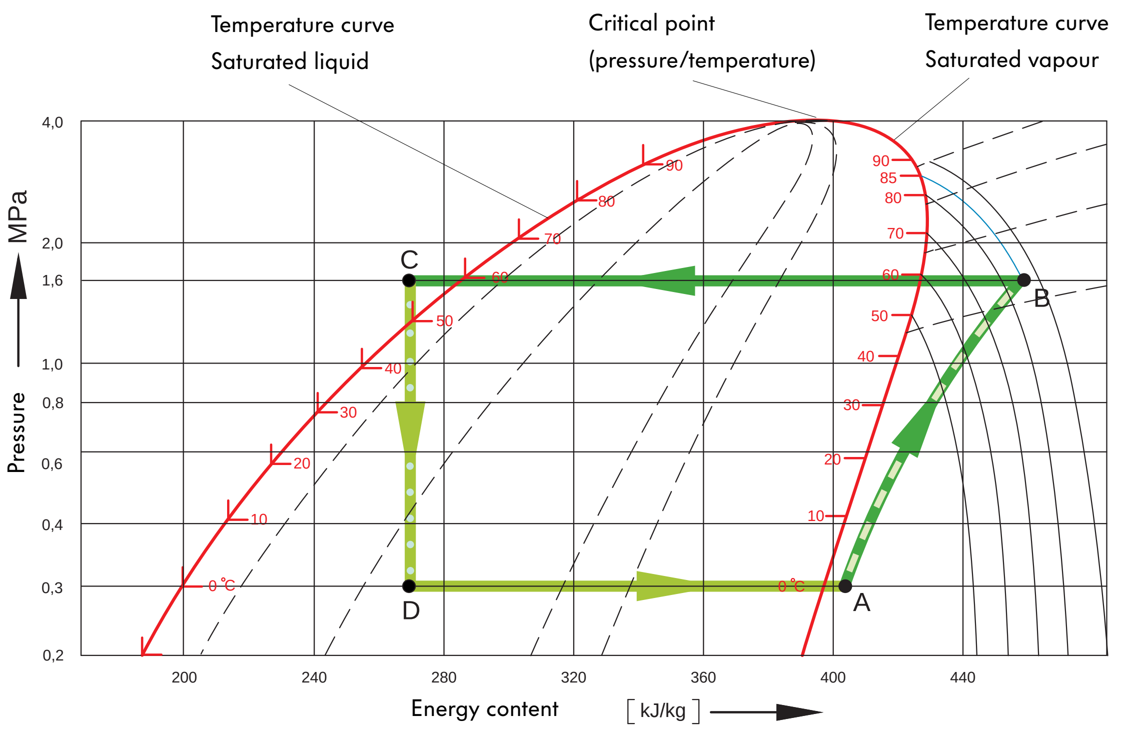
State of refrigerant R134a in the cycle in an air conditioner

In addition to the vapour pressure curve, the cycle shows the change of state of the refrigerant under pressure and temperature in addition to the energy balance at which the refrigerant returns to its original state.
The diagram is an excerpt from the state diagram of refrigerant R134a for a vehicle air conditioner.
Different absolute values are possible in dependence upon the demand of a vehicle type for refrigeration capacity.

The energy content is a key factor in the design of an air conditioner.
It shows what energy is required (evaporator heat, condenser heat) to achieve the intended refrigeration capacity.

Physical data of R134a:

Boiling point:	–26.5 °C
Freezing point:	–101.6 °C
Critical temperature:	100.6 °C
Critical pressure:	4.056 MPa
	(40.56 bar)



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A — B Compression in the compressor, pressure and temperature rise, gaseous, high pressure, high temperature

B — C Condensation process in the condenser, high pressure, temperature reduction, the liquid leaves the condenser slightly cooled

C — D Expansion = sudden pressure relief, results in evaporation

D — A Evaporation process (heat absorption) in the evaporator.
Transition path from vapour state to gaseous state (low pressure)

Temperature curve at point B

For a glossary refer to page 72.

The refrigerant

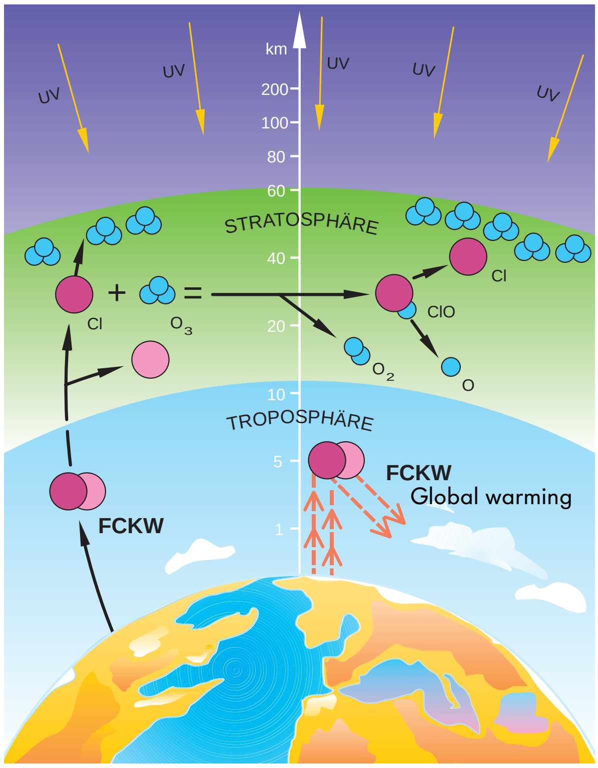
Refrigerants and ozone layer

Ozone protects the earth's surface against UV radiation by absorbing a large proportion of these rays.
UV rays split ozone (O_3) into an oxygen molecule (O_2) and in an oxygen atom (O).
Oxygen atoms and oxygen molecules from other reactions combine again to form ozone.
This process takes place in the ozonosphere, a part of the stratosphere at an altitude of between 20 and 50 km.

Like R12, chlorine (Cl) is a constituent of a CFC refrigerant .
If handled improperly, the R12 molecule will rise up to the ozone layer– since it is lighter than air–.

UV radiation liberates a chlorine atom in the CFC, and this atom reacts with the ozone.
In the process, the ozone decomposes leaving an oxygen molecule (O_2) and chlorine monoxide (ClO), which then reacts again with oxygen and liberates chlorine (Cl). This cycle can repeat itself as many as 100,000 times.

However, free oxygen molecules (O2) cannot absorb UV radiation.



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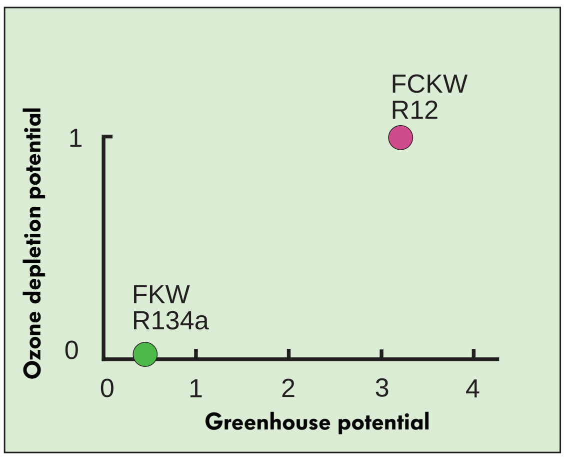
Reaction between CFC and ozone in the atmosphere (CFC = FCKW)

Refrigerants and global warming

The sunlight impinging upon the earth's surface is reflected in the form of infrared radiation.
However, trace gases – most importantly CO_2 – reflect these waves in the troposphere.
This causes the earth's atmosphere to heat up,– a phenomenon which is commonly referred to as "global warming". CFCs are heavily responsible for the increasing trace gas concentration.

1 kg of R12 has the same greenhouse effect as 4000 tons of CO_2.

R134a only makes a small contribution to global warming.
Its ozone depletion potential is nil.



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Refrigerant oil

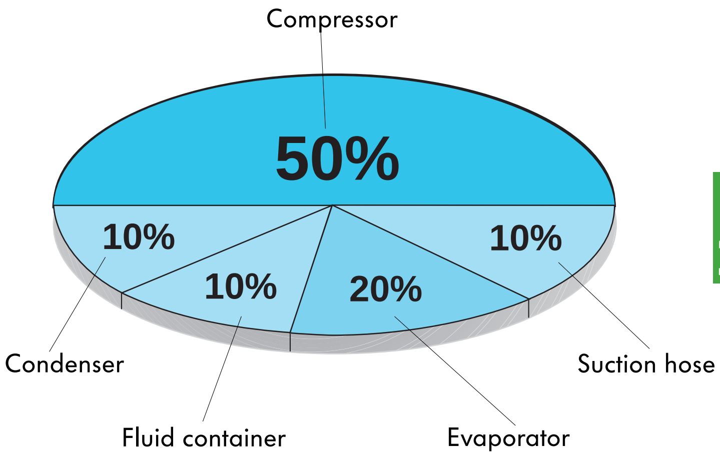
A special oil – the refrigerant oil – free of impurities such as sulphur, wax and moisture is required to lubricate all the movable parts in the air conditioner.

The refrigerant oil must be compatible with the refrigerant itself, because some of the refrigerant oil mixes with the refrigerant in the refrigerant circuit. In addition, the refrigerant oil must not attack the seals used in the system.

No other oils may be used, as they lead to copper plating, the build-up of carbon deposits and the formation of residues which can cause premature wear and irreparable damage to movable parts.

A special synthetic oil is used for the R134a refrigerant circuit. This oil may only be used for this particular refrigerant, since it does not mix with other refrigerants.

Also, the refrigerant oil can only be adapted to a specific compressor type.



Distribution of oil quantity in the refrigerant circuit (roughly)
The filling quantity of refrigerant varies according to the design of the units used in a particular type of vehicle.

R
134a

The refrigerant for R134a

Designation: **PAG** = Polyalkylene glycol

Properties:

- high solubility in combination with refrigerant
- good lubrication properties
- acid free
- highly hygroscopic (water-attracting)
- cannot be mixed with other oils

N.B.:

- must not in be used in older refrigeration systems
  filled with refrigerant R12,
  since it is incompatible with R12

Important notes:

– Do not store in the open (highly hygroscopic).
– Always keep oil tanks closed to protect them against the ingress of moisture. Close opened drums immediately.
– Do not use old refrigerant.
– **Dispose of as toxic waste.**
  Refrigerant may not be disposed of together with engine oil or gear oil because of its chemical properties.

The cooling system

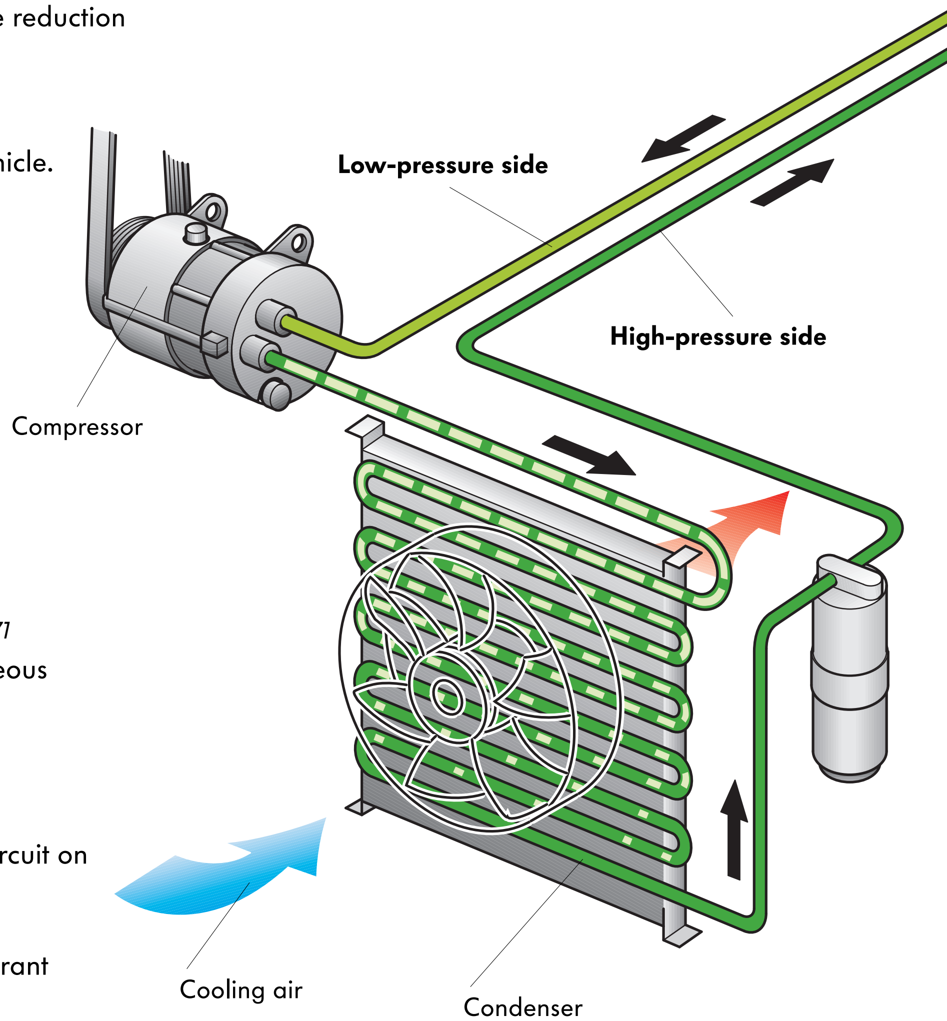
The principle of the refrigerant circuit

The cooling process and the technical conditions

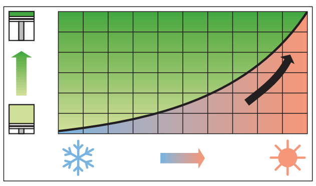
We know that:
Too cool down an object, heat must be given off.
A compression refrigeration system is used in motor vehicles for this purpose. A refrigerant circulates in the closed circuit, continually alternating changing from a liquid to a gas and vice versa. The refrigerant is:

– compressed in the gaseous state,
– condensed through heat dissipation
– and evaporated through pressure reduction and heat absorption.

Cool air is not produced, heat is extracted from the air flow in the vehicle.



How does this process work?



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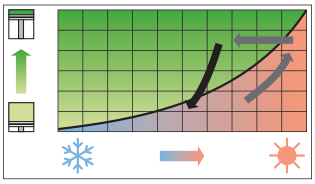
The **compressor** induces cold, gaseous refrigerant at a low pressure.

The refrigerant is compressed in the compressor, causing it to heat up.
The refrigerant is pumped into the circuit on the high-pressure side.

In this phase, the refrigerant is in a gaseous state, has a high pressure and a high temperature.



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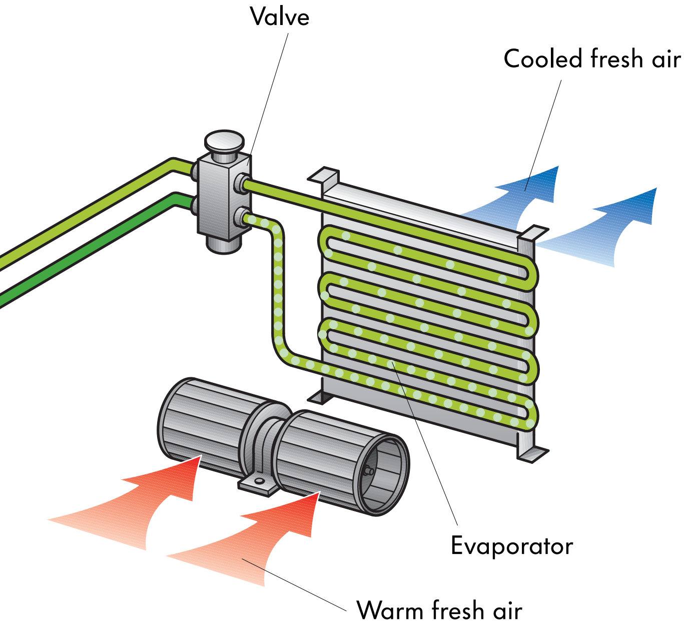
The compressed liquid refrigerant continues to flow up to a narrowing. This narrowing can be in the form of a restrictor or an expansion valve. Once the refrigerant reaches the narrowing, it is injected into the evaporator causing its pressure to drop (low-pressure side).

Inside the **evaporator**, the injected liquid refrigerant expands and evaporates. The evaporation heat required for this purpose is extracted from warm fresh air which cools down when it passes through the evaporator fins. The temperature inside the vehicle is reduced to a pleasant level.



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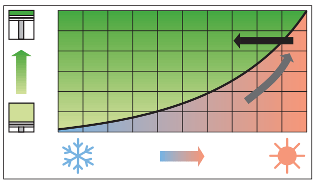
In this phase, the refrigerant
is in a vapour state,
under low pressure and
at low temperature.



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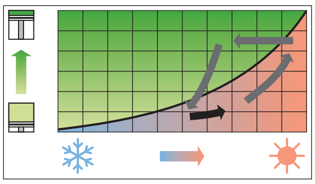
The refrigerant follows the short path to the **condenser** (liquefier).
Heat is now extracted from the compressed, hot gas in the condenser by the air flowing through (headwind and fresh air blower).
The refrigerant condenses and becomes a liquid when it reaches its melting point (pressure-dependent).

In this phase, the refrigerant
is therefore
in a liquid state,
has a high pressure
and a medium temperature.



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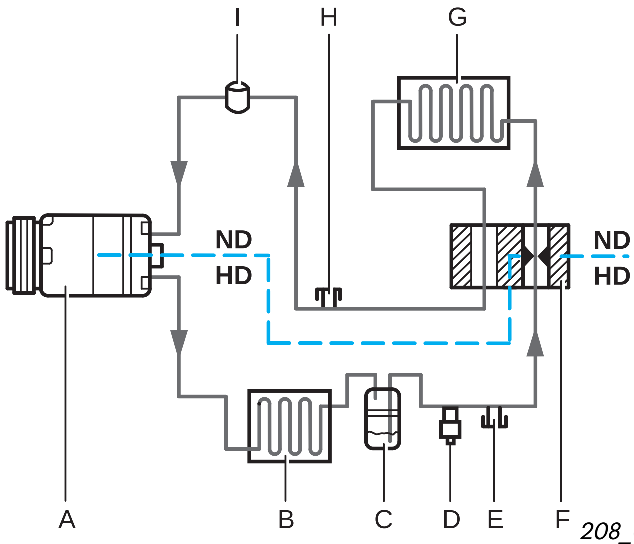
Now in the gaseous state again, the refrigerant emerges from the evaporator.
The refrigerant is again drawn in by the compressor and passes through the cycle once again.
Thus, the circuit is closed.

In this phase, the refrigerant
is again
gaseous,
has a low pressure
and a low temperature.

The cooling system

Refrigerant circuit with expansion valve



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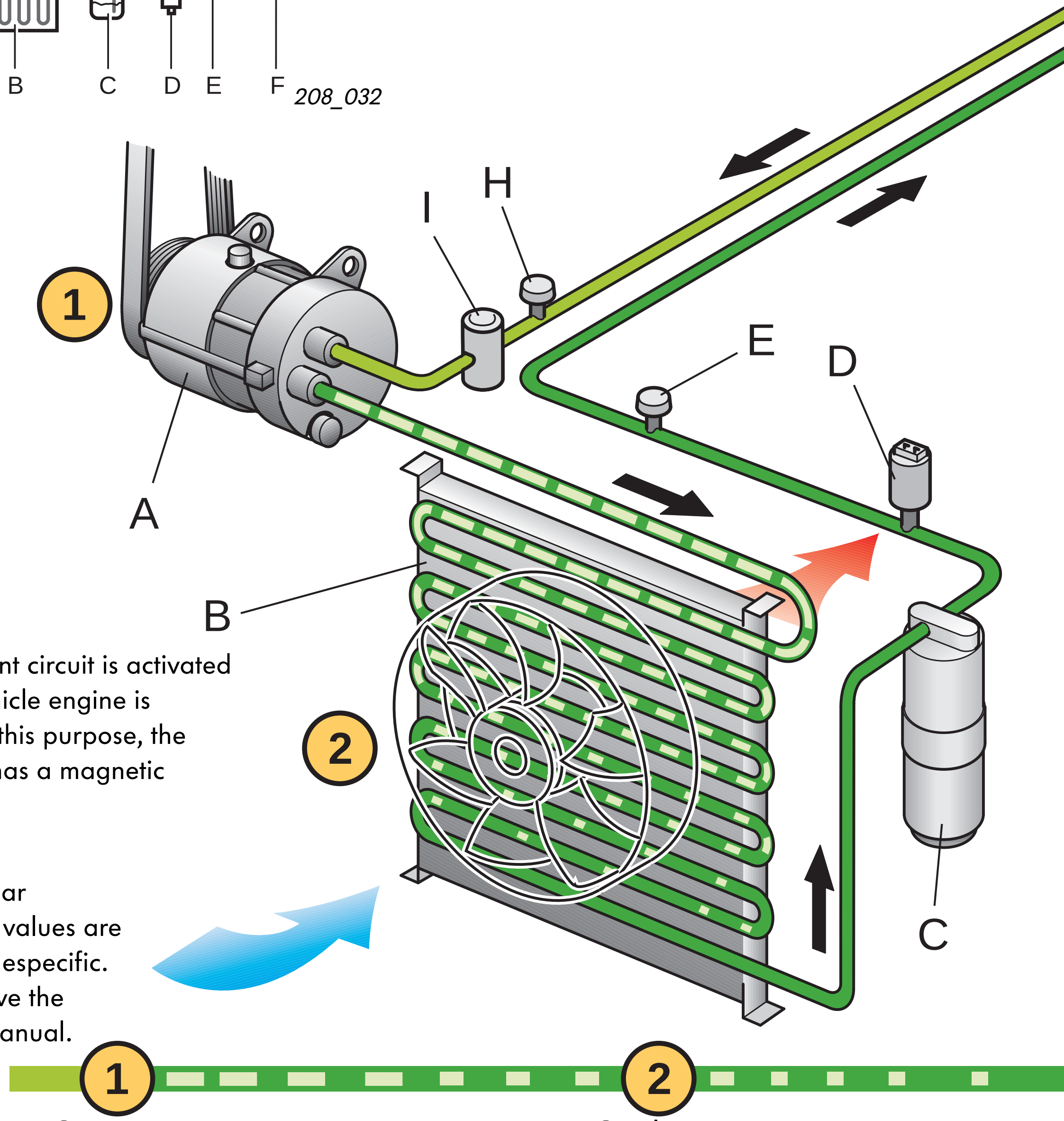
Working pressure HD = High-pressure
ND = Low pressure

In technical documents such as Workshop Manuals, the components are represented in a diagrammatic form.



The refrigerant circuit is activated when the vehicle engine is running. For this purpose, the compressor has a magnetic clutch.

1 MPa = 10 bar
The absolute values are always vehiclespecific. Please observe the Workshop Manual.

Pressures and temperature in the circuit (example)

Compression ratio
at approx. 1.4 MPa (14 bar)
Temperature approx. 65 °C

Condensation
Pressure approx. 1.4 MPa (14 bar)
Temperature reduction: 10 °C

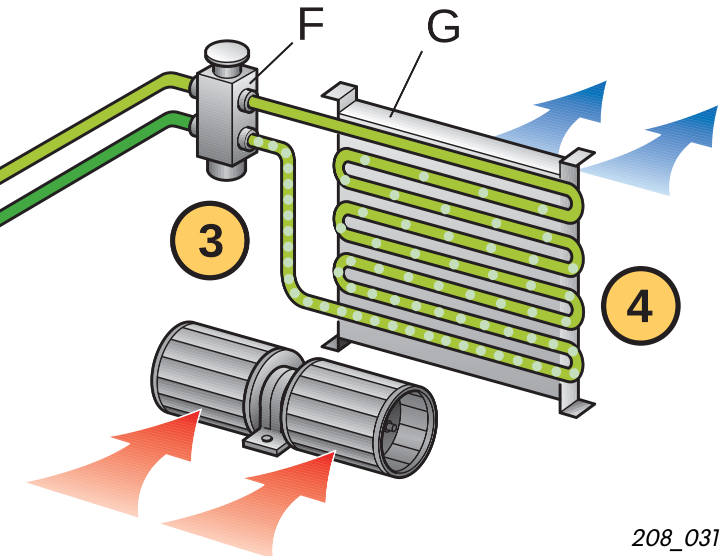
Legend

High pressure

Low pressure

The components:

A Compressor with magnetic clutch
B Condenser
C Fluid container with drier
D High-pressure switch
E High-pressure service connection
F Expansion valve
G Evaporator
H Low-pressure service connection
I Damper (vehicle-specific)



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The refrigerant circuit may not be opened for safety reasons.
If it is necessary to open the refrigerant circuit in order to perform repair work on the vehicle, the refrigerant must be drawn off beforehand using a suitable service station.

The refrigeration capacity of a vehicle air conditioner is dependent upon the car-specific installation conditions and the vehicle category (passenger cars, vans).

The components A to H exist in every circuit. Additional connections can be provided for service work, temperature sensors, pressure switches in the high- and low-pressure circuit and oil drain screws depending on the circuit design and requirements. The layout of components within the circuit also differs from one vehicle type to another.
Some systems have a damper before the compressor in order to dampen refrigerant vibrations.

The pressures and temperatures in the circuit are always dependent on momentary operating state. The specified values are intended as a rough guideline only. They are reached after 20 min. at an ambient temperature of 20 °C and at engine speeds of between 1500 and 2000 rpm.

At 20 °C and when the engine is at a standstill, a pressure of 0.47 MPa (4.7 bar) will build up inside the refrigerant circuit.

The components of the refrigerant circuit with expansion valve will now be examined more closely (for details of the refrigerant circuit with restrictor refer to page 28).

Expansion
from approx. 1.4 MPa (14 bar) to approx. 0.12 MPa (1.2 bar), Temperature: from approx. 55 °C to –7 °C

Evaporation
Pressure: approx. 0.12 MPa (1.2 bar)
Temperature: approx. –7 °C

208_033

The cooling system

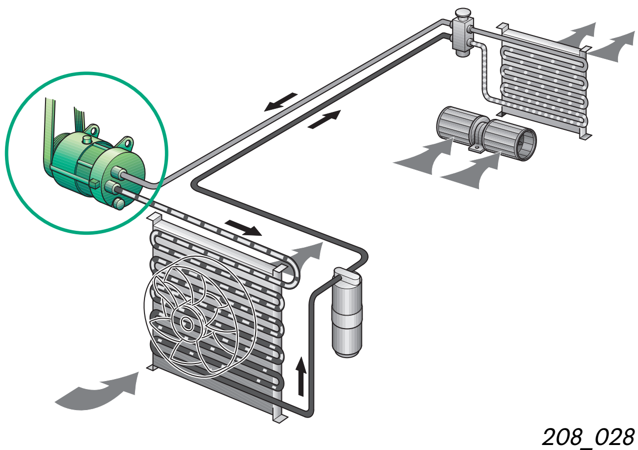
The compressor

The compressors used in vehicle air conditioners are oil-lubricated displacement compressors. They operate only when the air conditioner is switched on, and this is controlled by means of a magnetic clutch.

The compressor increases the pressure of the refrigerant. The temperature of the refrigerant rises at the same time.

Were there to be no pressure increase, it would not be possible for the refrigerant in the air conditioner to expand and therefore cool down subsequently.

A special refrigerant oil is used for lubricating the compressor. About half of it remains in the compressor while the other half is circulated with the refrigerant.
A pressure shut-off valve, which is usually attached to the compressor, protects the system against excessively high pressures.



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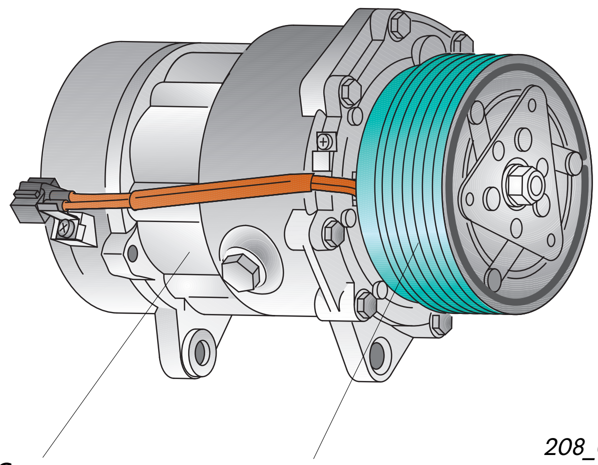
The compression process

The compressor draws in cold, gaseous refrigerant through the evaporator under low pressure .

It is "vital" for the compressor that the refrigerant be in a gaseous state, because liquid refrigerant cannot be compressed and would destroy the compressor (in much the same way as a water shock can damage an engine).

The compressor compresses the refrigerant and forces it towards the condenser as a hot gas on the high-pressure side of refrigerant circuit.

The compressor therefore represents the interface between the low-pressure and high-pressure sides of the refrigerant circuit.



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Mode of operation of compressor

Compressors for air conditioners operate according to various principles:

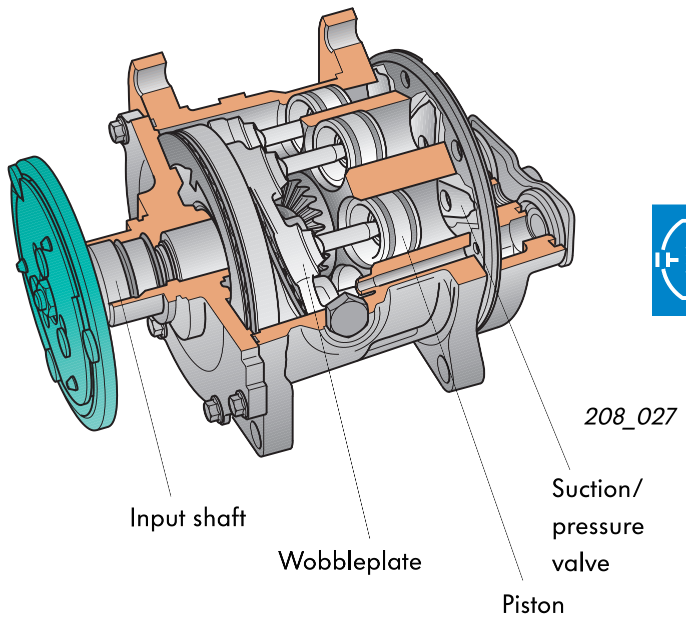
- Reciprocating compressors
- Coiled tube compressors
- Vane-cell compressors
- Wobbleplate compressors

Wobbleplate compressors will now be examined in more detail.

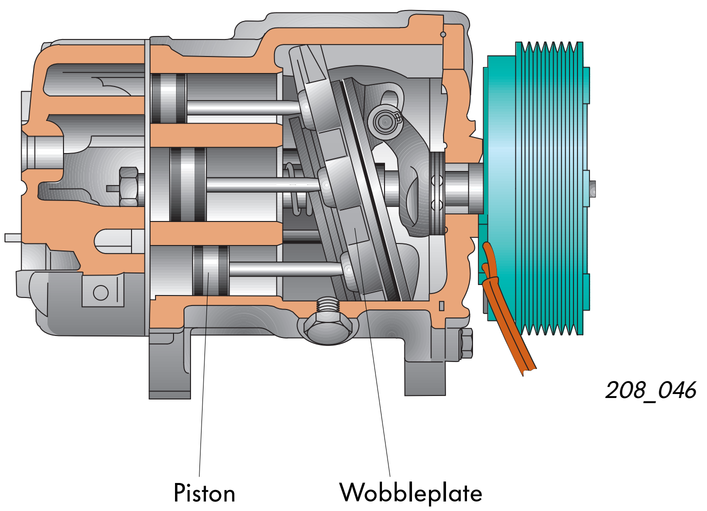
The turning motion of the input shaft is converted to an axial motion (= piston stroke) by means of the wobbleplate.
Depending on compressor type, between 3 and 10 pistons can be centred around the input shaft.
A suction/pressure valve is assigned to each piston.
These valves open/close automatically in rhythm with the working stroke.
An air conditioner is rated for the max. speed of the compressor.
However, the compressor output is dependent on engine rpm.
Compressor rpm differences of between 0 and 6000 rpm can occur.
This affects evaporator filling as well as the cooling capacity of the air conditioner.
Controlled-output compressors with a variable displacement were developed in order to adapt compressor output to different engine speeds, ambient temperatures or driver-selected interior temperatures.

Compressor output is adapted by adjusting the angle of the wobbleplate.

In constant-displacement compressors, compressor output is adapted to the demand for refrigeration by switching the compressor on and off periodically via the magnetic clutch.



Wobbleplate compressor (non-self-regulating)
Angle of wobbleplate constant
Displacement constant



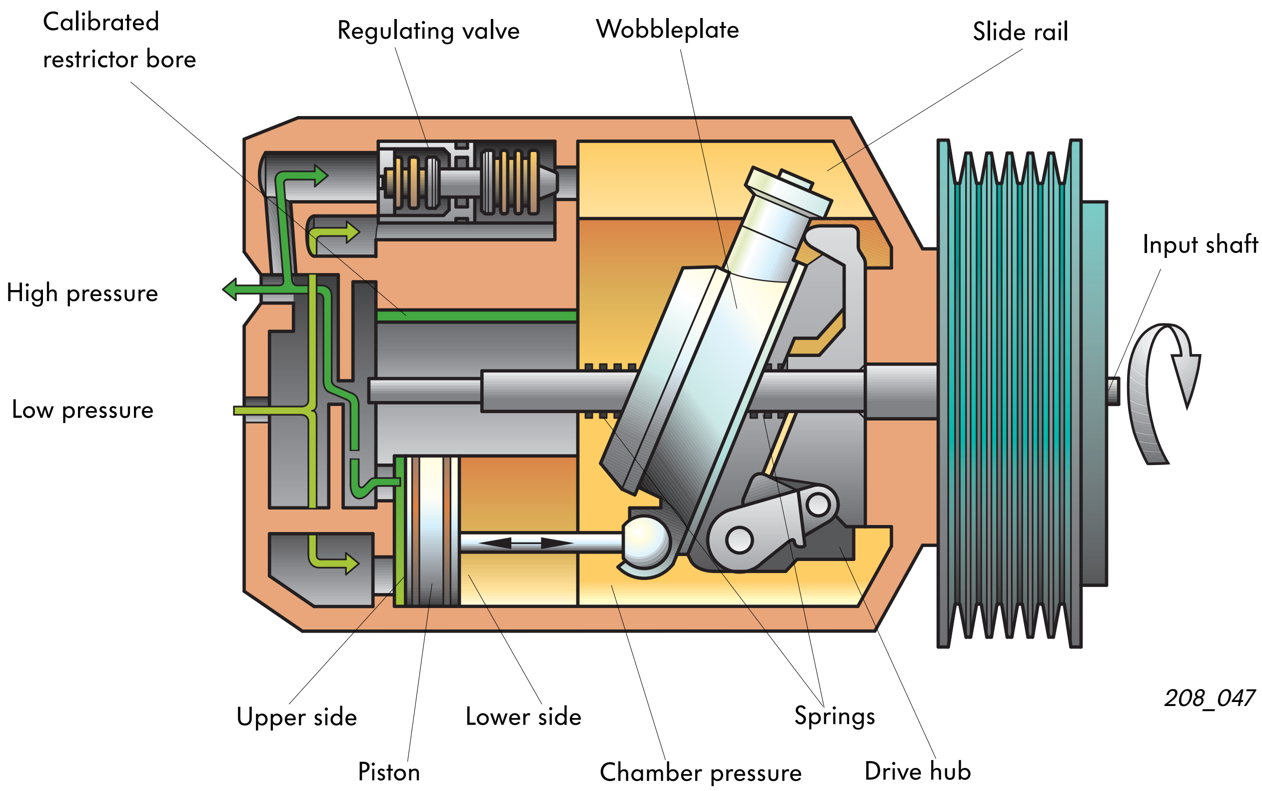
Wobbleplate compressor (self-regulating)
Angle of wobbleplate variable
Displacement variable

The cooling system

**The self-regulating compressor
runs continously in air condition mode**

Control range of compressor

➡ All control positions between upper stop (100 %) and the lower stop (approx. 5 %) are adapted to the required delivery rate by altering the chamber pressure.
The compressor is on continuous duty during the control cycle!



208_047

The turning motion of the input shaft is transmitted to the drive hub and converted to axial motion of the piston via the wobbleplate. The wobbleplate is located longitudinally in a slide rail.

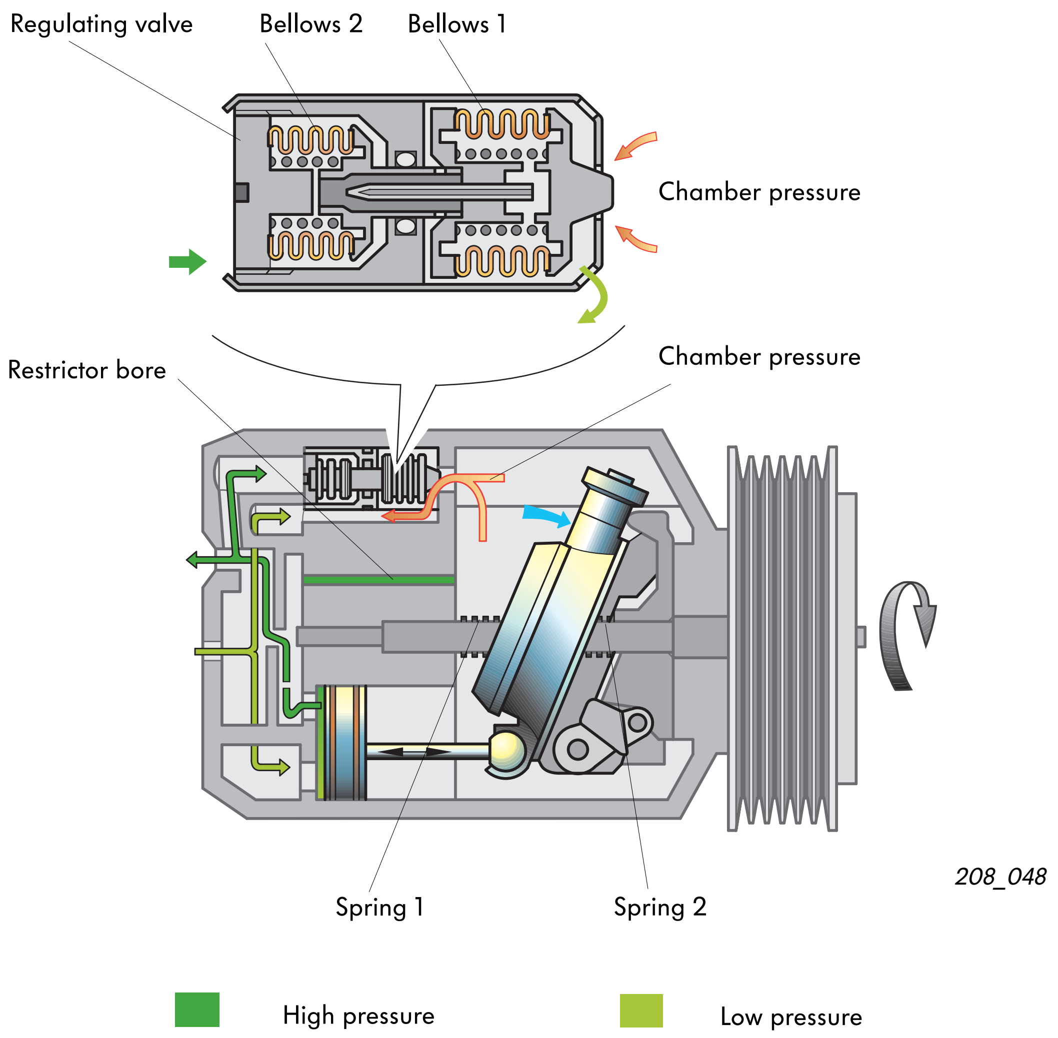
The piston stroke and the delivery rate are defined by the inclination of the wobbleplate.

Inclination – dependent on the chamber pressure and hence the pressure conditions at the base and top of the piston.
The inclination is supported by springs located before and after the wobbleplate.

Chamber pressure – is dependent upon the high and low pressures acting upon the regulating valve and by the calibrated restrictor bore.

High pressure, low pressure and chamber pressure are equal when the air conditioner is off.
The springs before and after the wobbleplate set it to a delivery rate of about 40%.
The advantage of output control is that it eliminates compressor cut-in shock, which often manifests itself in a jolt while driving.

High delivery rate for high cooling capacity - low chamber pressure



The high and low pressures are relatively high.

– Bellows 2 is compressed by the high pressure .

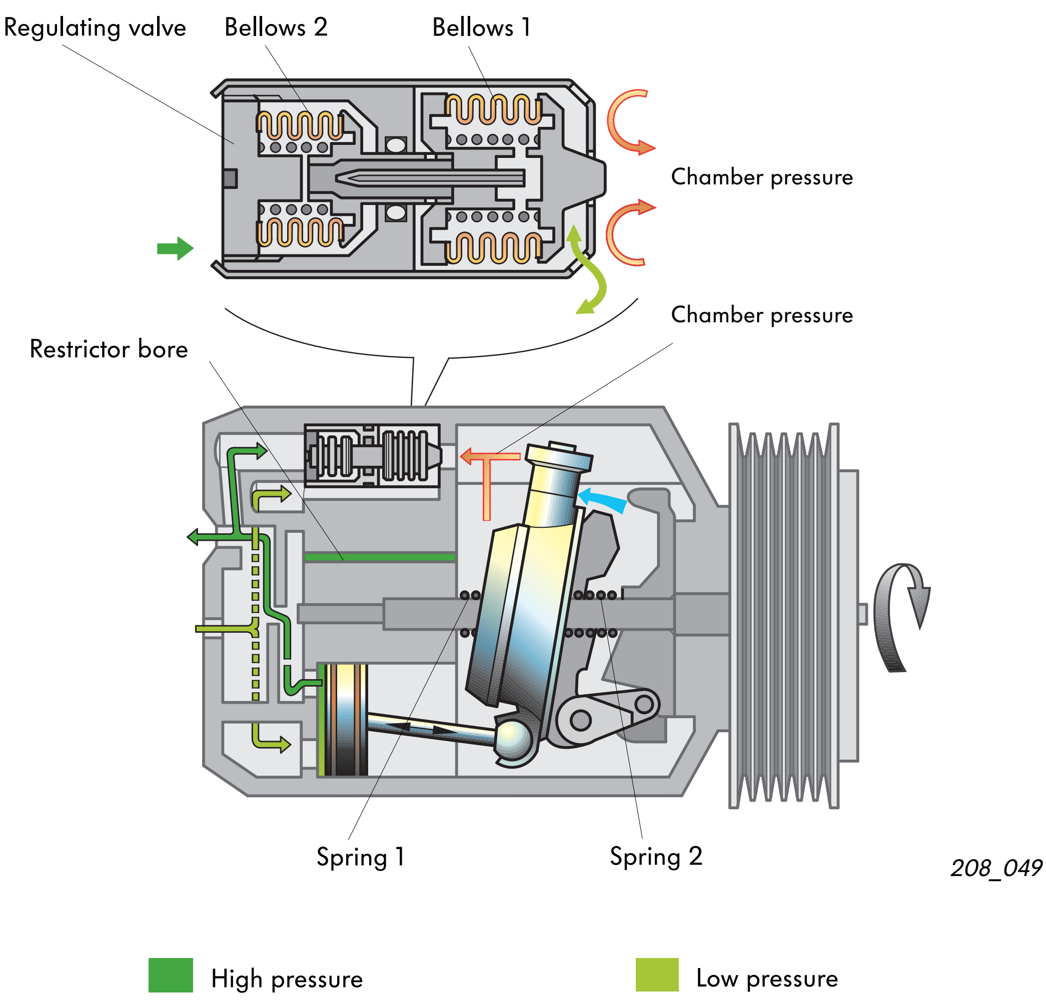
– Bellows 1 is also compressed by the relatively high low pressure.

– Regulating valve opens. Chamber pressure is reduced via the low-pressure side.

– The combined force resulting from the low pressure acting upon the upper sides of the piston and the force of spring 1 is greater than the combined force resulting from the chamber pressure acting upon the lower sides of the piston and the force of spring 2.

➡ Inclination of wobbleplate increases
= large stroke with high delivery rate

Low delivery rate and low cooling capacity - high chamber pressure



The high and low pressures are relatively low.

- Bellows 2 opens out.
- Bellows 1 also opens out as a result of the relatively low pressure.
- Regulating valve closes.
  The low-pressure side is closed against the chamber pressure.
- Chamber pressure rises via the calibrated restrictor bore.
- The combined force resulting from the low pressure acting upon the upper side of the piston and the force of spring is greater than the combined force resulting from the chamber pressure acting upon the lower sides of the piston plus the force of spring 2.

➡ Inclination of wobbleplate decreases
= small stroke with low delivery rate.

Magnetic clutch

The drivetrain is connected between the compressor and vehicle engine while the engine is running by means of the magnetic clutch.

Design

The clutch comprises

- Belt pulley with bearing
- Spring plate with hub
- Magnetic coil

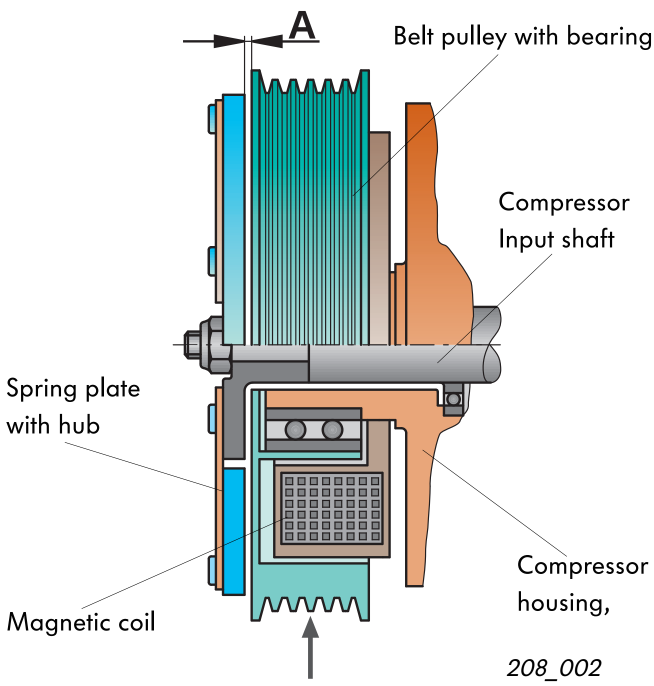
The hub of the spring plate is permanently mounted the compressor input shaft. The belt pulley is mounted in a pivot bearing on the housing of the compressor at the shaft output. The magnetic coil is permanently connected to the compressor housing. There is an open space “A“ between the spring plate and the belt pulley.

Function

The vehicle engine drives the belt pulley (Arrow) by means of the ribbed V-belt.
The belt pulley follows on freely when the compressor is switched off.

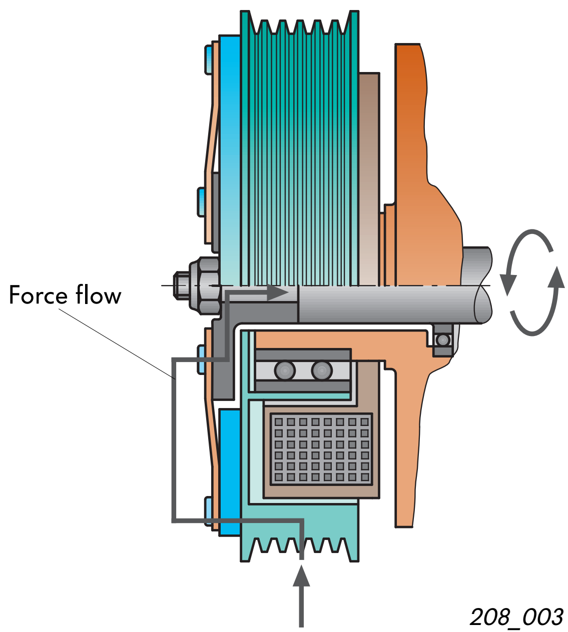
When the compressor is connected, voltage is present at the magnetic coil. A magnetic force field is created. This force field draws the spring plate towards the rotating belt pulley (the open space “A“ is bridged) and makes a positive connection between the belt pulley and the input shaft of the compressor.
The compressor runs on.
The compressor runs on until the electrical circuit to the magnetic coil is opened.
The spring plate is then retracted by the belt pulley by means of springs.
The belt pulley again runs without driving the compressor shaft.

Schematic diagram of clutch switched off



208_002

Schematic diagram of clutch switched on



208_003

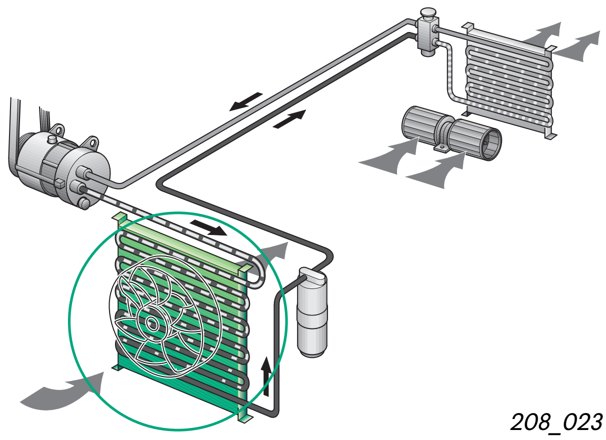
For compressor switch-on and switch-off conditions– refer to Air conditioning function control.

The condenser

The condenser is the "cooler" of the air conditioner.

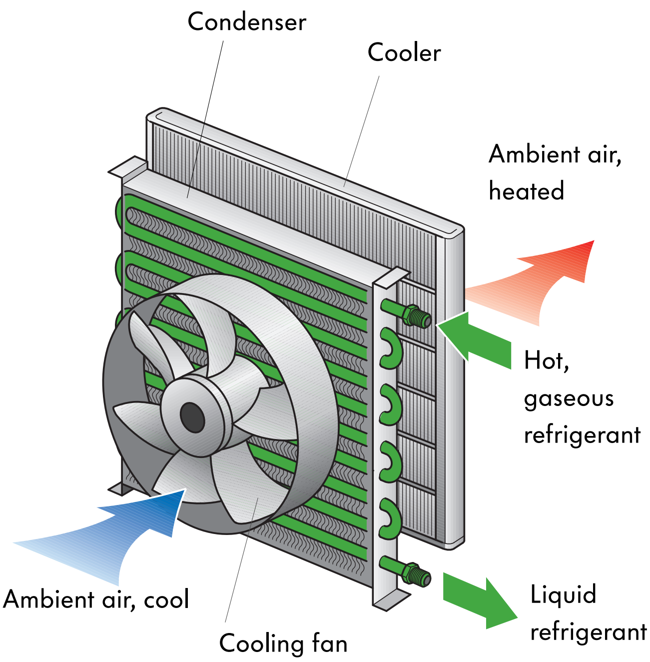
Design of condenser

The condenser comprises a tube coil which is securely attached to fins creating a large cooling surface which facilitates heat transfer.
The condenser cooled by the cooling fan after the air conditioner is switched on in order to ensure that the refrigerant is circulated. The condenser is always installed upstream of the cooler.
This increases the efficiency of the condenser.



208_023

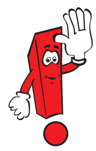
Heat is exchanged in the condenser through air cooling. The air is cooled by the headwind and by the cooling fan – an auxiliary fan may still be in use depending on type. The fan usually starts up when the air conditioner is switched on. This is not the case if pressure sender G65 is fitted; in this case, fan switch-on will then be delayed until a specific pressure is reached.
Impurities in the condenser reduce air flow and can also impair condenser capacity and engine cooling.



208_024

Function of condenser

Hot, gaseous refrigerant coming from the compressor at a temperature of approx. 50 - 70 °C is injected into the compressor.
The tubes and fins of the condenser absorb heat.
Cool ambient air is ducted over the condenser, absorbing heat in the process and thereby cooling down the refrigerant.
When the refrigerant cools down, it condenses at a specific temperature and pressure and becomes a liquid. At the bottom of the compressor, the refrigerant emerges from the condenser as a liquid.



The condenser is often referred to as "liquefier" in regard to its working method.

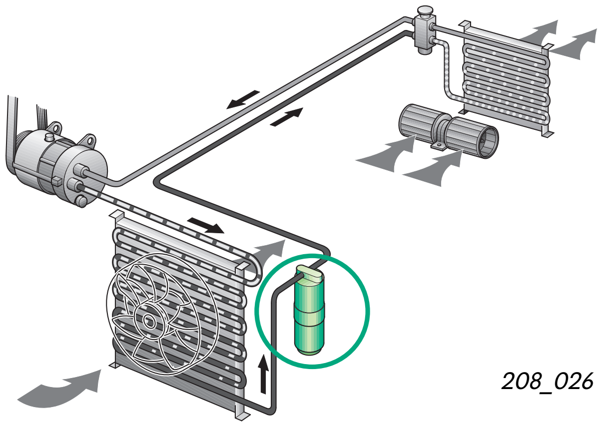
The fluid container and drier

In the refrigerant circuit with expansion valve, the fluid container serves as a refrigerant expansion tank and reservoir.

Different amounts of refrigerant are pumped through the circuit when operating conditions such as the thermal load on the evaporator and condenser and compressor rpm are variable.

The fluid container is integrated in the circuit in order to compensate for these fluctuations.

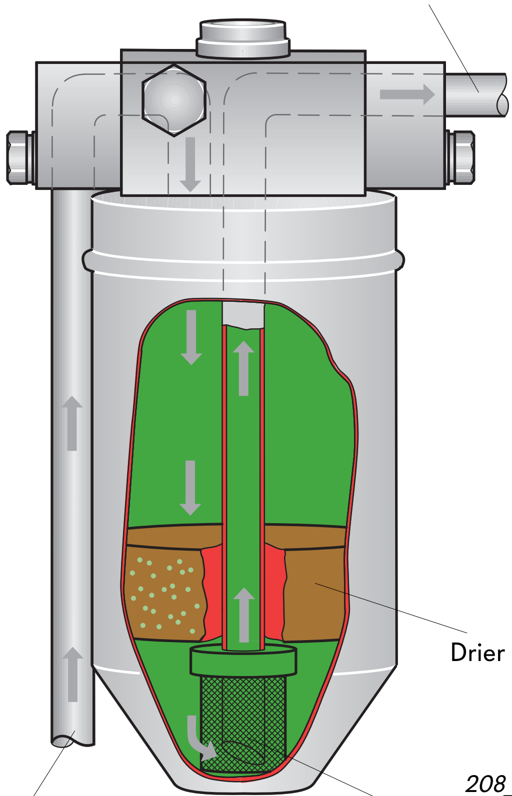
The drier binds chemically moisture which has entered the refrigerant circuit during installation. The drier can absorb between 6 and 12 g of water, depending on type. The amount of water that can be absorbed is temperature-dependent. The amount of water absorbed increases as the temperature drops. Abraded material from the compressor, dirt arising from installation work and similar is also deposited.



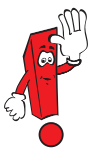
208_026

Function

The liquid refrigerant coming from the condenser enters the container at the side. The refrigerant is collected in the container, then it flows through the drier and along the riser to the expansion valve in an uninterrupted flow containing no bubbles.



208_025



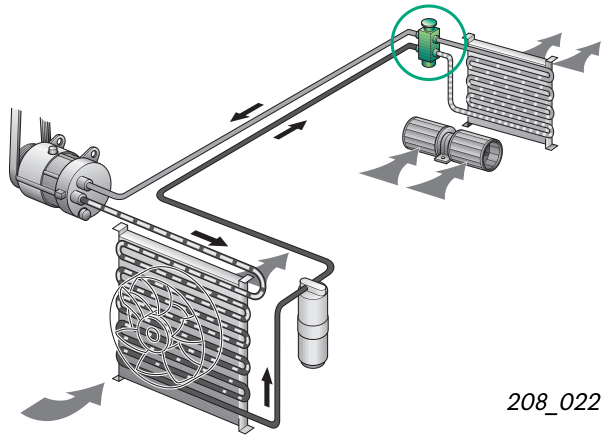
The fluid container is replaced every time the refrigerant circuit is opened. The fluid container must be kept closed as long as possible prior to installation in order to minimise absorption of moisture from the ambient air in the drier.

Expansion valve

The expansion valve is the point where the refrigerant in the evaporator expands and cools down. It forms the interface between the high-pressure side and low-pressure side of the refrigerant circuit.

The expansion valve is used to regulate the refrigerant flow to the evaporator – in dependence upon the temperature of the refrigerant vapour at the evaporator outlet.–

No more refrigerant than is necessary to maintain a steady “refrigerating climate“ in the evaporator is expanded in the evaporator.



208_022

The closed control loop

The refrigerant flow is controlled by the expansion valve in dependence upon temperature.

– When the temperature of the refrigerant leaving the evaporator rises, the refrigerant in the thermostat expands. The flow rate of the refrigerant to the evaporator at the globe valve increases.

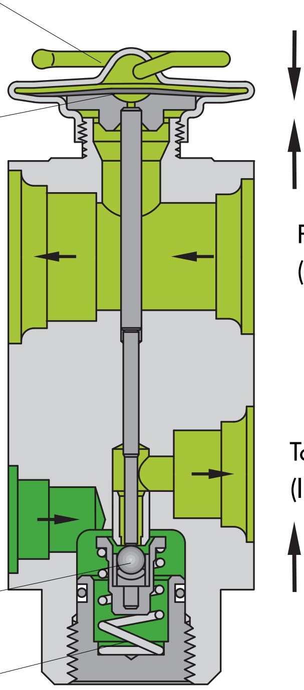
– When the temperature of the refrigerant leaving the evaporator drops, the refrigerant volume in the thermostat decreases. The flow rate to the evaporator at the globe valve is reduced.

There are three forces at play in the thermostatic expansion valve:

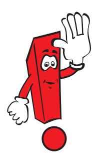
1. The pressure in the sensor line is dependent on the temperature of the superheated refrigerant. This pressures acts upon the membrane as an opening force ($P_{Fü}$).

2. The evaporator pressure (P_{Sa}) acts upon the membrane in the opposite direction.

3. The pressure exerted by the regulating spring (P_{Fe}) acts in the same direction as the evaporator pressure.



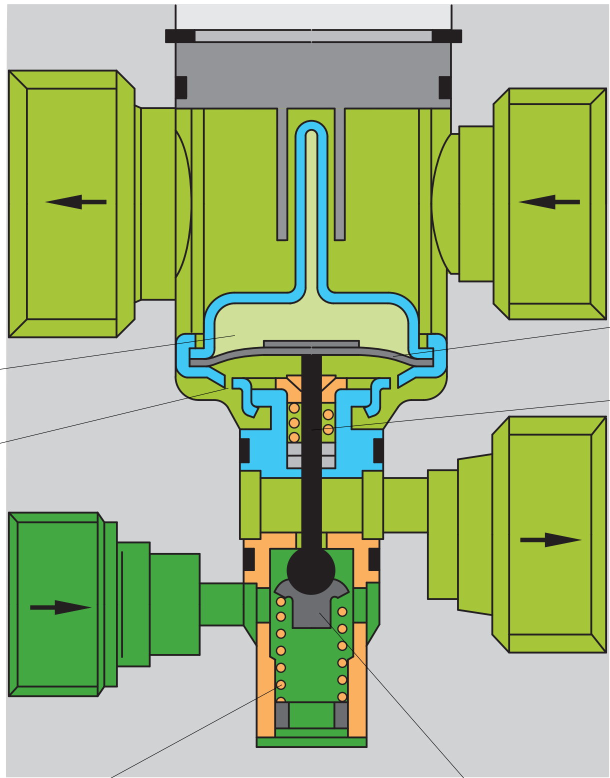
208_015



The expansion valves are set.
Their settings may not be altered.
Do not bend the sensor line, because it is filled with a special gas.

Expansion valve – new generation

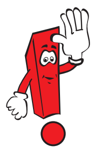
This expansion valve is also positioned between the high-pressure side and low-pressure side of the refrigerant circuit directly upstream of the evaporator.



208_017

The expansion valve is heat-controlled. It has a control unit with a thermal head and a globe valve.
The thermal head on one side of the membrane has a special gas filling. The other side is connected to the evaporator outlet (low pressure) via pressure-equalising holes.
The globe valve is push rod actuated.
The pressure of the special gas, and therefore also the amount of refrigerant injected, is dependent upon the temperature on the low-pressure side.

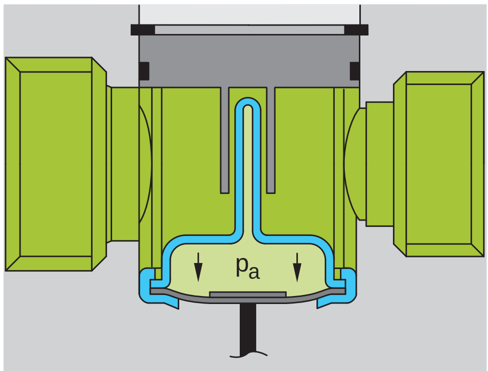
The expansion valve is always fitted with thermal insulation.



Fitting the valve without thermal insulation will alter the set control characteristic.

The cooling system

A increase in cooling load increases the temperature at the evaporator outlet causing
the pressure (p_a) of the gas filling in thermal head to rise

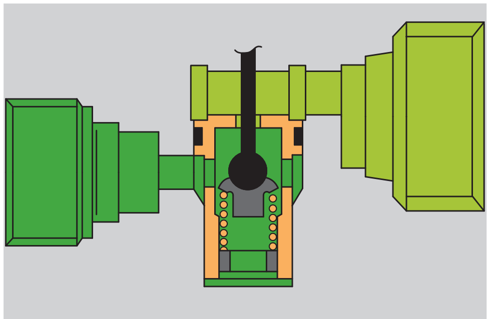


208_018

The globe valve cross-section is enlarged
via diaphragms and the push rod.

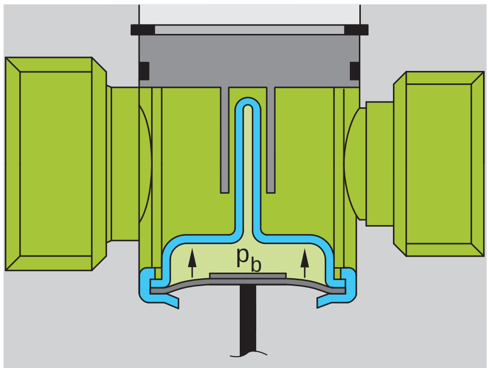
Refrigerant flows to evaporator and absorbs heat at the transition from high pressure to low pressure

Heat is extracted from the air flowing through the evaporator



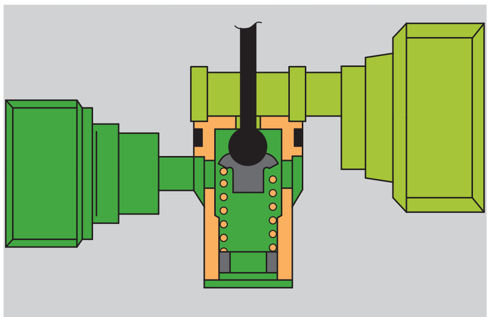
208_019

When the temperature of the refrigerant at the evaporator outlet drops, the
pressure (p_b) in the thermal head drops



208_020

The cross-section of the globe valve, and therefore also the flow rate to evaporator, will again be reduced.



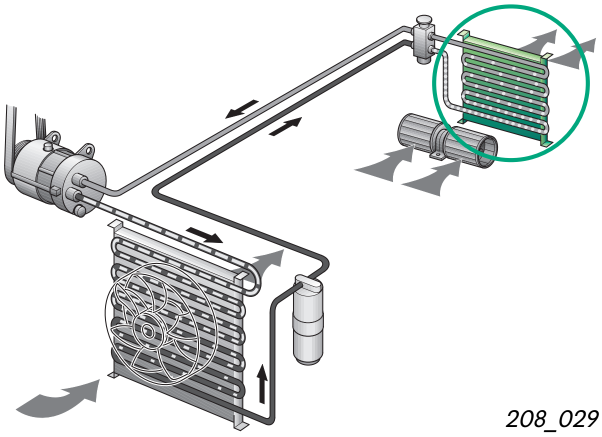
208_021

The valve opening ratio is dependent upon the temperature at the evaporator outlet (low pressure).
Pressure equalisation is controlled.

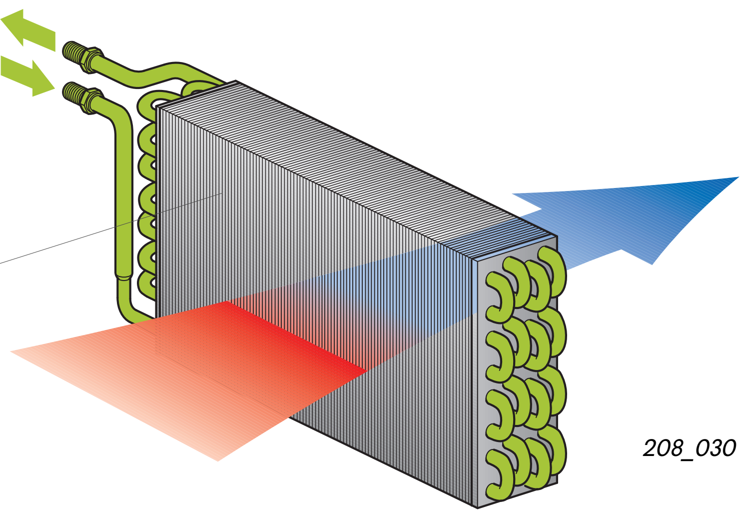
The evaporator

The evaporator operates according to the same principle as a heat exchanger.

It is an integral part of the air conditioner in the heater box. When the air conditioner is switched on, heat is extracted from the air which flows through the fins of the cold evaporator. This air is cooled, dried and cleaned in the process.



208_029



208_030

Function

The refrigerant released by the expansion valve expands in the evaporator, cooling the evaporator down considerably.

The refrigerant becomes a gas (boiling point).

When the refrigerant in the evaporator boils, the temperatures are well below the freezing point of water.

The refrigerant extracts the heat required for evaporation from its surroundings – which is the air flowing through the evaporator in this case.

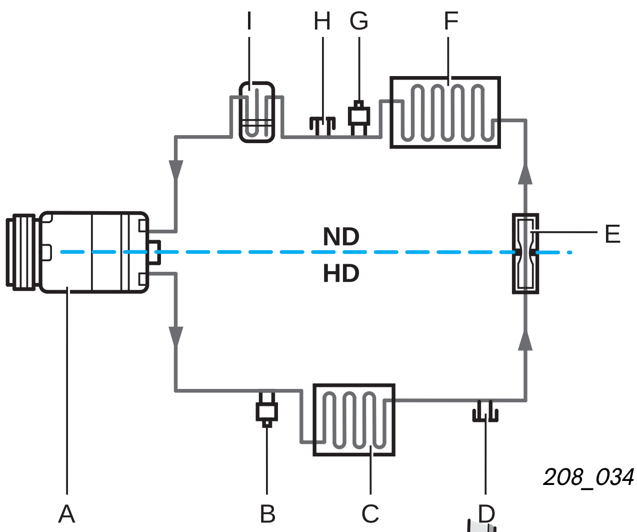
This air is channeled into the passenger cabin in a “cooled" state.

Moisture in the cooled air collects at the evaporator in the places where the air temperature drops below the dewpoint temperature, i.e. it condenses. Condensation water is produced.
The air is “dried“.
This improves the climate and air quality inside the vehicle noticeably.
Deposits of matter suspended in the air build up at the evaporator in addition to moisture.
The evaporator also "purifies" the air.

Pools of water below a stationary vehicle (condensation) are therefore not an indication of a fault.

The cooling system

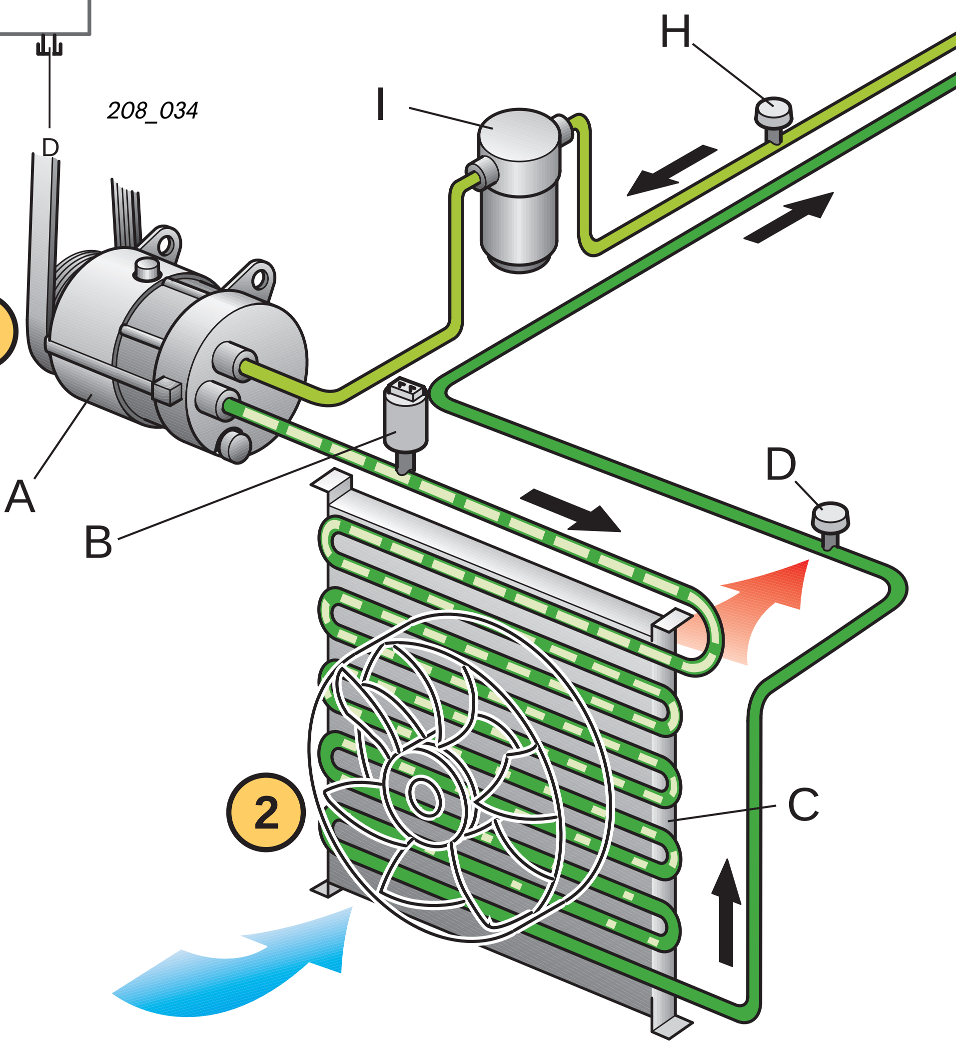
Refrigerant circuit with restrictor

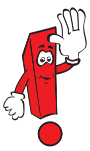


Working pressure HD = high pressure
ND = low pressure

Schematic diagram of a refrigerant circuit with restrictor

208_034





1 MPa = 10 bar

Pressures and temperatures in the circuit

Compression ratio
Max. pressure 2 MPa (20 bar)
Max. temperature 70 °C

Condensation
Max. pressure 2 MPa (20 bar)
Temperature reduction: approx. 10 °C

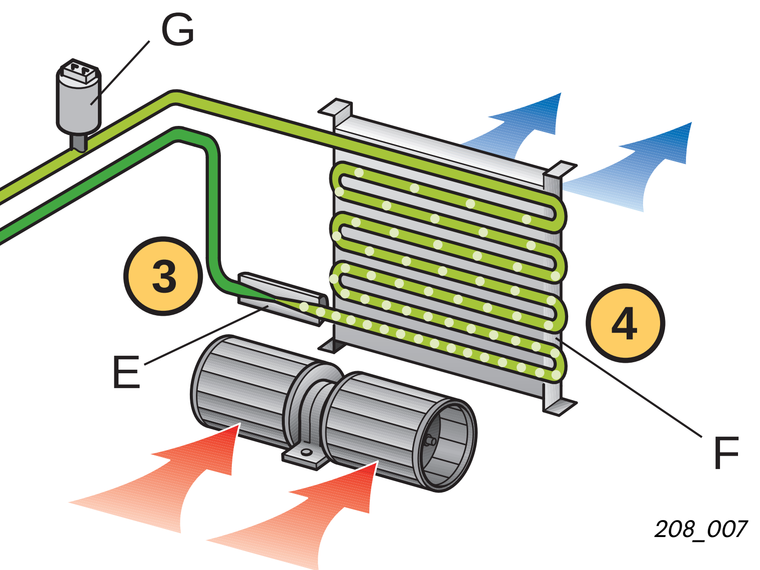
Legend

High pressure

Low pressure

The component parts:

A Compressor with magnetic clutch
B Low-pressure switch
C Condenser
D High pressure service connection
E Restrictor
F Evaporator
G Low-pressure switch
H Low-pressure service connection
I Collecting tank



208_007

In contrast to the circuit with expansion valve, the liquid refrigerant is injected into the evaporator through a restrictor.

In restrictor-regulated air conditioners, a collecting tank is fitted at the low-pressure side in place of the fluid container on the high-pressure side.

This collecting tank serves as a reservoir and protects the compressor (fluid shock). Also refer to page 31.

All other components are identical to those used in the circuit with expansion valve.

Additional connections for service work or sensors for monitoring functions can be integrated in the circuit, depending on circuit design and necessity.

The pressures and temperatures are dependent upon the momentary operating state of the refrigerant circuit. The specified values are achieved after a specific period depending on the ambient temperature (refer to Workshop Manual).

208_033

Expansion
from 2 MPa (20 bar) to > 0.15 MPa (1.5 bar)
Temperature: from 60 °C to > –4 °C

Evaporation
Max. pressure > 0.15 MPa (1.5 bar)
Temperature: > –4 °C

The restrictor

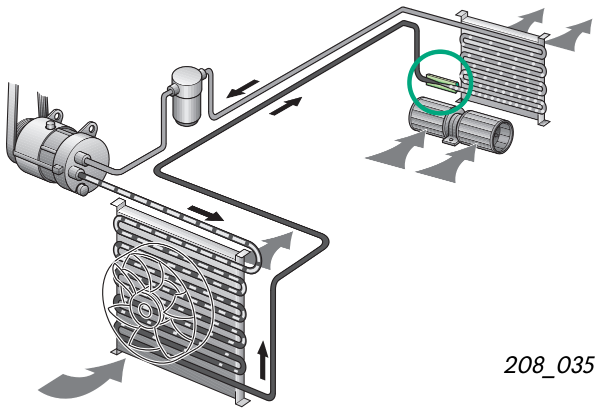
The restrictor is a narrowing in the refrigerant circuit located directly upstream of the evaporator. This narrowing "restricts" the flow of the refrigerant.

The refrigerant is warm under high pressure upstream of the restrictor.

The pressure of the refrigerant drops rapidily when it passes the restrictor.

The refrigerant is cold at low pressure.

The restrictor is therefore the "interface" between the high-pressure and low-pressure sides of the refrigerant circuit. A seal ensures that the refrigerant only passes the restrictor at the narrowing.



208_035

Tasks

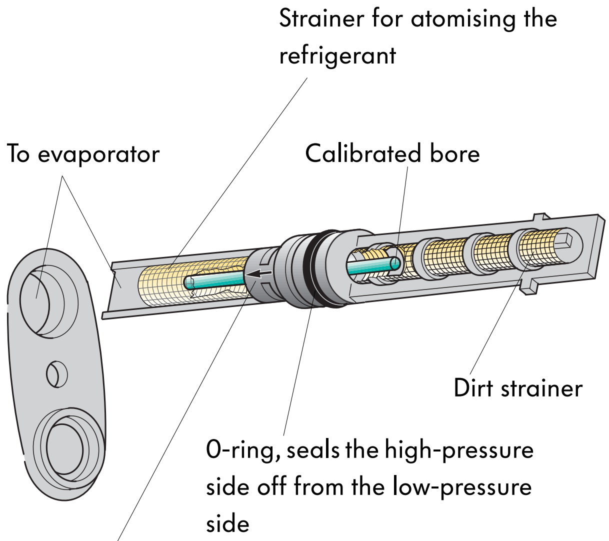
– To determine the flow rate of the refrigerant by means of a calibrated bore. The amount of refrigerant which can flow through this bore is limited by the pressure in the refrigerant circuit.

– To maintain the pressure on the high-pressure side of the refrigerant circuit and keep the refrigerant in a liquid state when the compressor is running.

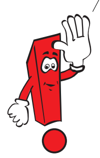
– The pressure in the restrictor drops. The refrigerant cools down before it enters the evaporator through partial evaporation.

– Atomisation of the refrigerant.

The restrictor has a dirt strainer upstream of the narrowing.
A strainer for atomising the refrigerant before it reaches the evaporator is located downstream the narrowing.



208_016



Please note the installation position!
The arrow on the restrictor points to the evaporator.

The collecting tank

There is a collecting tank in the low-pressure part of air conditioners with restrictor. This tank is installed in a warm location in the engine compartment (post-evaporation).

It serves as an equalising vessel and reservoir for the refrigerant and refrigerant oil and also protects the compressor.

The gaseous refrigerant coming from the evaporator enters the tank. If there are traces of moisture in the refrigerant, they are bound in the integrated drier.

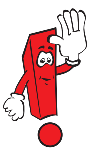
The refrigerant collects in the upper part of the plastic cap and is certain to be in a gaseous state when it is drawn in by the compressor through the U-tube.

As a result, the compressor draws in gaseous refrigerant only, and no liquid droplets. Protection of the compressor against damage is thereby ensured.

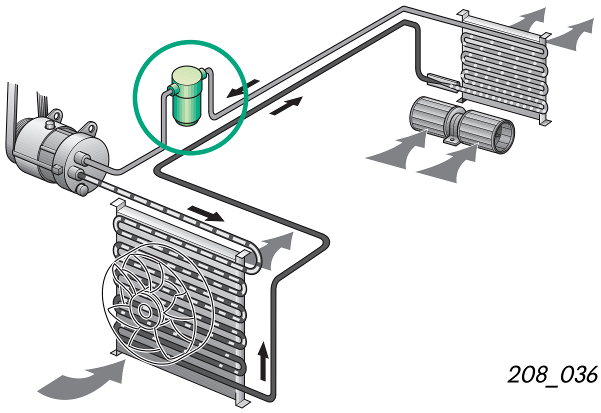
The refrigerant collects at the base of the collecting tank.

The refrigerant drawn in by the compressor absorbs refrigerant through a hole in the U-tube.

A filter strainer prevents the ingress of impure refrigerant through this hole.



The collecting tank must be kept closed as long as possible prior to installation (leave the sealing plugs on the connections) in order to minimise moisture absorption from the ambient air in the drier.



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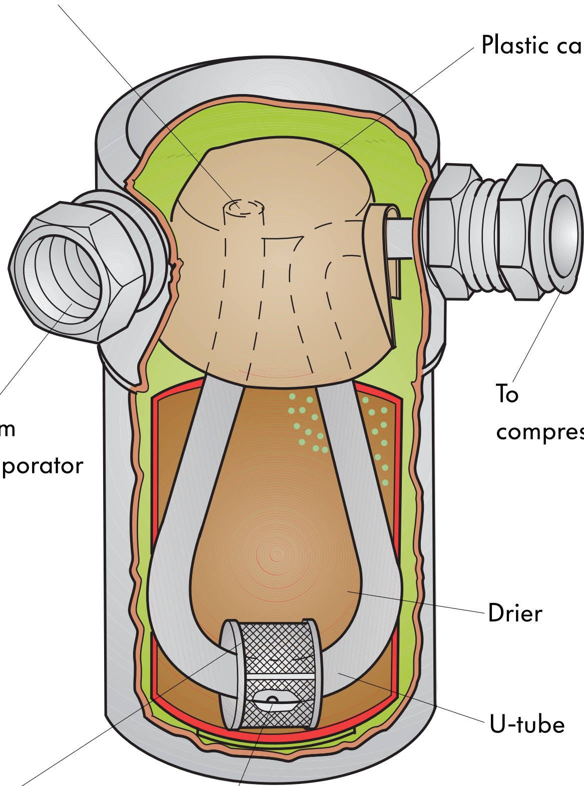
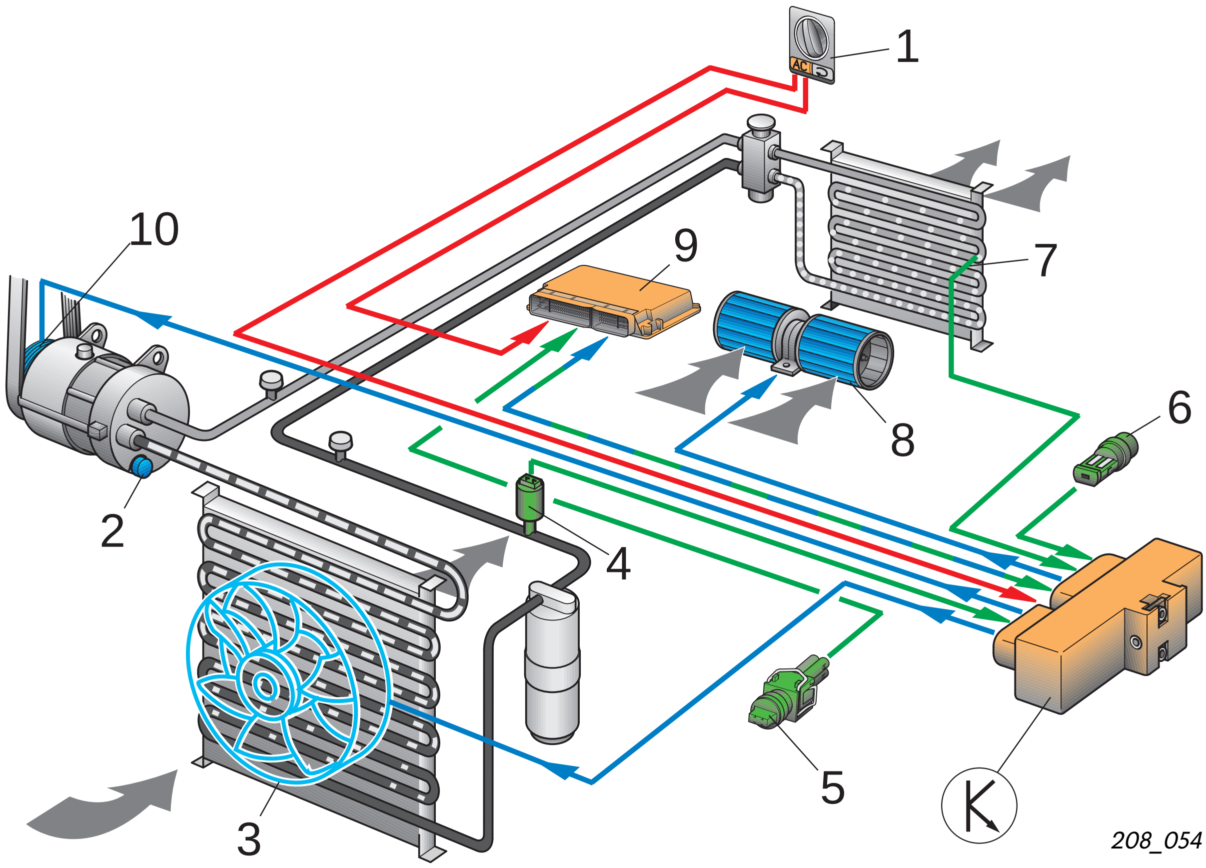


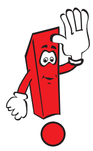
208_037

System control



An air conditioner will only function if all system components are working properly. Failure of one of these components could cause the working pressures to change. In this case, it is not possible to rule out consequential damage to the system and the engine. To avoid this, there are monitoring devices in the refrigerant circuit.

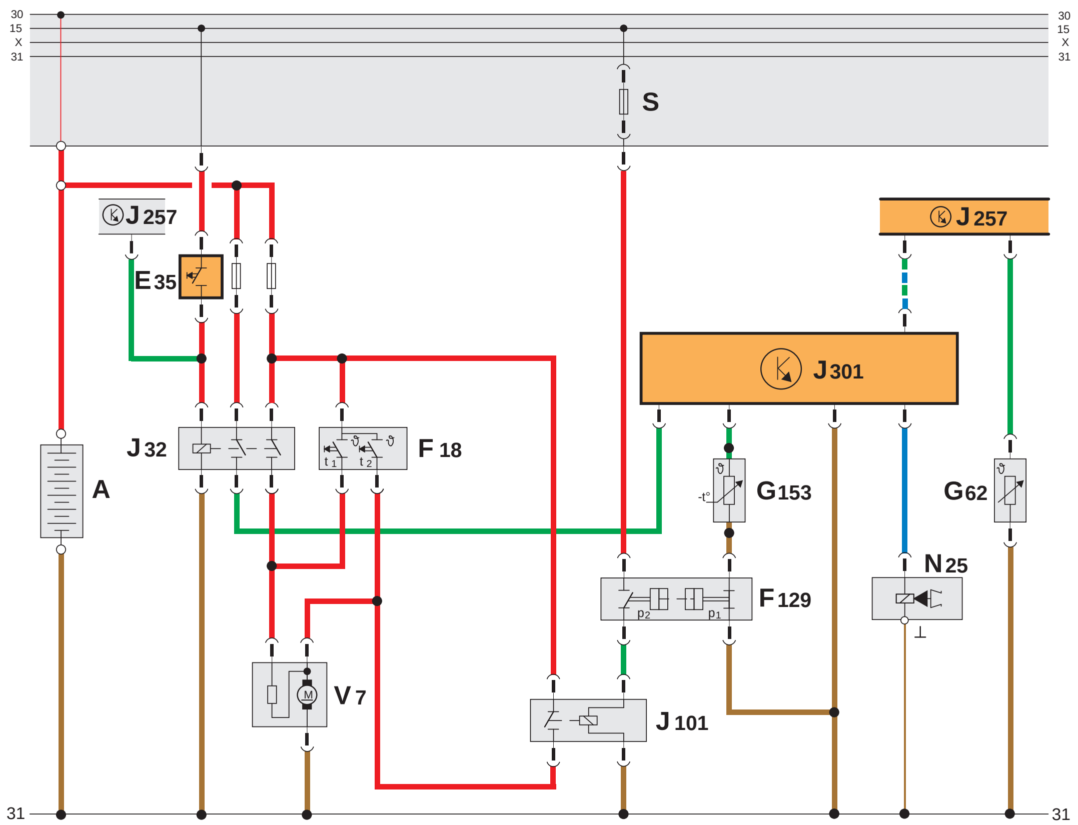
A control unit processes the signals from the monitoring devices and controls the periodic switch-off and switch-on of the compressor and the speed of the fan. This ensures that the pressure level in the refrigerant circuit always adapts itself to the normal values.
In systems equipped with an open-loop compressor, the signals from the monitoring device are also used for adaptation to demand for cooling.
(switch-on and switch-off the air conditioner in accordance with demand for refrigeration. Icing of the evaporator is avoided at the same time.)
The diagram shows the basic layout of the air conditioner.



The air conditioner does not necessarily have to have all the components shown in the diagram. Neither do these components have to be connected in this way.
The diagram shows the system control of a simple manual air conditioner.

1 Air conditioner switch
2 Pressure relief valve at compressor
3 Radiator fan
4 Air conditioner pressure switch
5 Coolant temperature sender
6 Radiator fan thermo switch
7 Evaporator temperature sender
8 Fresh air blower
9 Engine control unit
10 Magnetic clutch

K Air conditioner control unit (and/or radiator fan control unit, depending on system type)



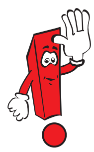
208_055

A	Battery
E35	Air conditioner switch
F18	Radiator fan thermo switch
	t_1 = 95 °C
	t_2 = 103 °C
F129	Pressure switch for air conditioner
	P_1 = 0.2 MPa (2 bar)/3.2 MPa (32 bar)
	P_2 = 1.6 MPa (16 bar)
G62	Coolant temperature sender
G153	Evaporator temperature sender
J32	Air conditioner relay
J101	Radiator fan 2nd speed relay
J257	Mono-Motronic control unit
J301	Air conditioner control unit
N25	Air conditioner magnetic clutch
V7	Radiator fan
S	Fuse

Simple functional example showing how the compressor (via magnetic clutch N25) and radiator fan are switched on and off.

Colour codes:

- Positive
- Negative
- Input signal
- Output signal
- Bidirectional signal

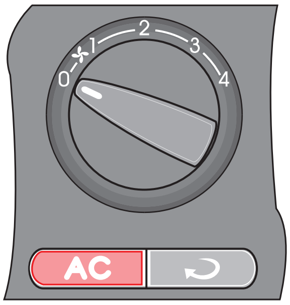


In the new-generation air conditioners, there is a high pressure sender in place of the pressure switch for air conditioner (refer to page 36).

System control

Components of the safety systems

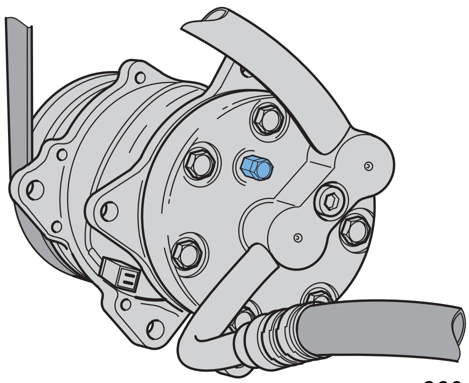
Air conditioner switch E35



208_068

Switch for switching on the air conditioner – the magnetic clutch makes the connection to the compressor.
In automatically controlled systems, the radiator fan and the fresh air blower start simultaneously.
In manual air conditioners, the fresh air blower must be switched to the 1st speed.
A signal indicating that the air conditioner has been switched on is transmitted to the engine control unit, and engine idling speed is increased (to compensate for load resulting from compressor work).
The switch may be located downstream of an ambient temperature switch.
This ensures that the air conditioner cannot start when the temperature is below 5 °C.

Pressure relief valve

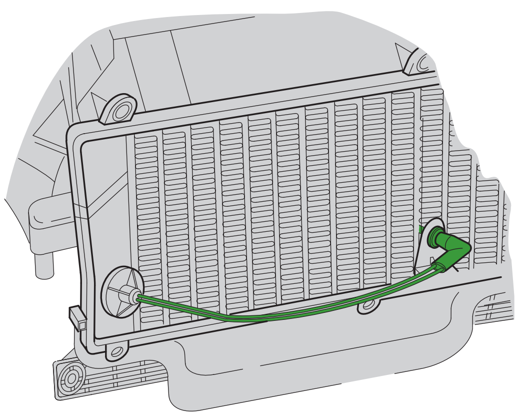


208_056

The valve (previously: bursting seal) is attached directly to the compressor or fluid container. The valve opens at a pressure of approx. 3.8 MPa (38 bar) and closes when the pressure drops (approx. 3.0 - 3.5 MPa/30 - 35 bar).
Depending on type, a plastic disc which ruptures as soon as the valve lifts can be attached.

In this case, the cause of the excess pressure in the system must be determined.
The bursting seal should only be replaced when the system is empty.

Evaporator temperature sender G153



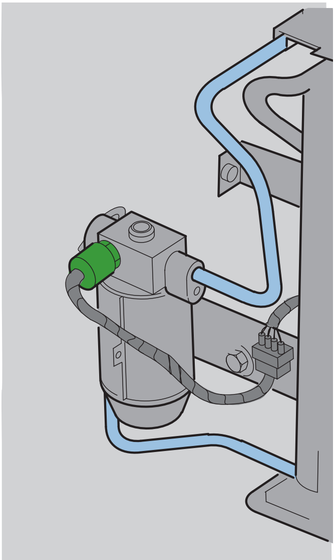
208_061

The evaporator temperature sender measures the temperature between the cooling fins of the evaporator. The sender signal is transmitted to the air conditioner control unit. When the evaporator temperature drops too low, the compressor is switched off.
The compressor is switched off at approx. –1 °C to 0 °C and switched on at approx. +3 °C
Icing of the evaporator by freezing condensation water is prevented.

In some systems, evaporator temperature switch E33 is used in place of this sender. The power supply to the magnetic clutch is opened directly by means of this switch.

Other systems control this function by means of an ambient temperature switch.

Pressure switch F129



208_057

To monitor and/or limit the pressure conditions in the closed refrigerant circuit, high-pressure and low-pressure switches are installed on the high pressure side.

If unacceptable pressures build up inside the system, the compressor will be switched off via the magnetic clutch.

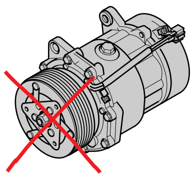
The pressure switch can be directly integrated in the line or attached to the fluid container.

Pressure switch F129 is a 3-way combination switch for:

- safeguarding the cooling air flow (fan circuit)
- safeguarding the pressure conditions.

The pressure switch operates in the following conditions:

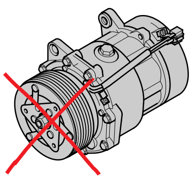
$p > 3{,}2$ MPa =



208_058

- it switches off the magnetic clutch via the air conditioner control unit at an excess pressure of approx. 2.4 to 3.2 MPa (24 to 32 bar). This excess pressure can be caused by a dirty condenser, for example.

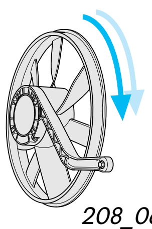
$p < 0{,}2$ MPa =



208_059

- it switches off the magnetic clutch via the air conditioner control unit when the pressure drops below a minimum value (0.2 MPa/ 2bar) . This can be caused by loss of refrigerant, for example.

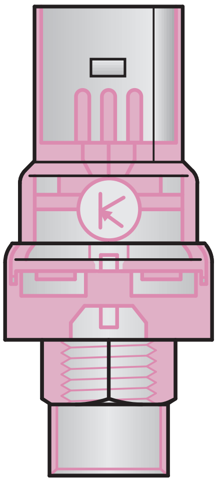
$p > 1{,}6$ MPa =



208_060

- it switches the fan one speed higher at 1.6 MPa (16 bar) excess pressure. As a result, condenser performance is optimised.

High pressure sender G65



208_062

- A new generation of senders for monitoring the refrigerant circuit.
- Air conditioner pressure switch F129 has been replaced by an electronic pressure sensor. The evaluation electronics in the air conditioner and engine control units have been adapted accordingly.
- Like pressure switch F129, the high pressure sender is integrated in the high pressure line.

It registers the refrigerant pressure and converts the physical quantity of pressure to an electrical signal.
Unlike the air conditioner pressure switch, the sender registers not only the defined pressure thresholds, it also monitors the refrigerant pressure throughout the working cycle.

Signal utilisation
in the engine control unit
in the radiator fan control unit

These signals indicate the load being exerted on the engine by the air conditioner and the pressure conditions in the refrigerant circuit. The next higher stage of the cooling fan and the magnetic clutch of the compressor are activated and deactivated via the radiator fan control unit.

Substitute function

If the radiator fan control unit fails to detect any signals, then the compressor will be switched off for safety reasons.

Advantages

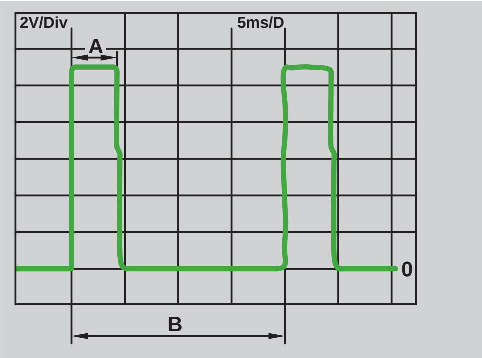
- The idling speed of the engine can be adapted exactly to the power consumption of a specific compressor.
- The radiator fan speed activation and deactivation cycles are staggered with a short time delay.
  As a result, changes in the speed of the cooling fan are barely perceptible at idling speed. This enhances comfort especially in vehicles with engines with low power outputs.

Self-diagnosis “fault message“

The fault in the high pressure sender is stored to the fault memory of the **engine electronics** .

e.g.: 00819 high pressure sender G65
“Signal too low“

Function of high pressure sender



208_109

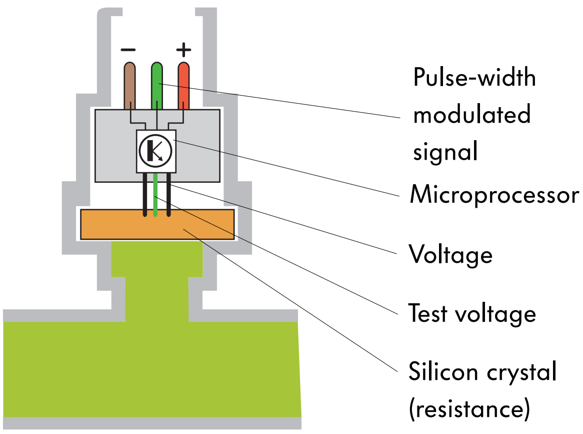
The refrigerant pressure is applied to a silicon crystal. Depending on the pressure level, the crystal will be more or less "deformed".

The silicon crystal, together with a microprocessor, is integrated in the sensor and supplied with voltage.

One of the properties of the silicon crystal is that its electrical resistance changes when it is deformed. Depending on the pressure characteristic, a test voltage picked off at the silicon crystal also changes as a result.

The test voltage is conducted to the microprocessor and converted to a pulse-width modulated signal (A = pulse width, B = signal distance).

At low pressure

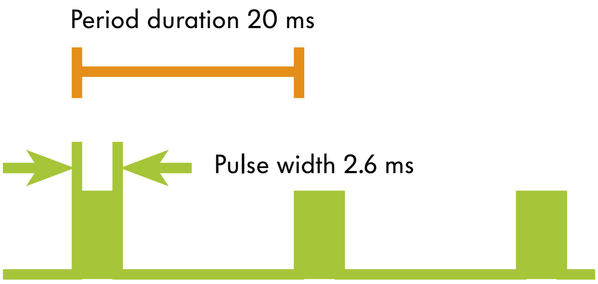


208_063

At a low pressure, the crystal undergoes minimal "deformation".
The voltage applied is therefore only opposed to a low electrical resistance.

The voltage change is small.

Pulse width signal



208_064

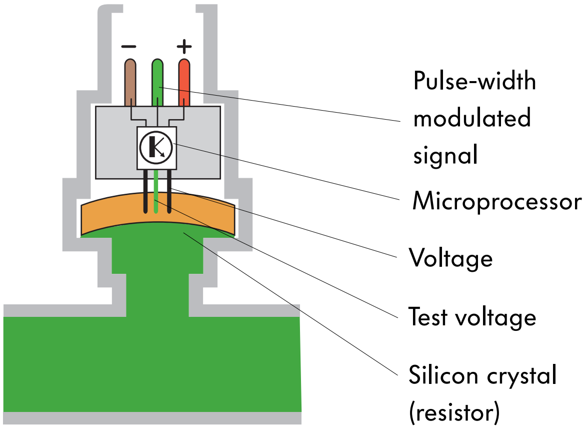
The microprocessor of the high pressure sender outputs a small pulse width at low pressures.

Pulse width signals are generated at a frequency of 50 Hz per second.
This is equivalent to a period duration of 20 ms = 100%.

At a low pressure of 0.14 MPa (1.4 bar), the pulse width is 2.6 ms.
This is equivalent to 13% of the period duration.

System control

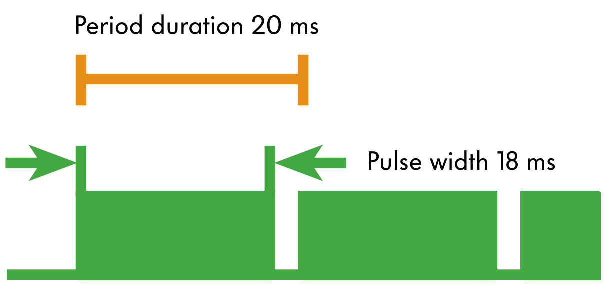
At high (increasing) pressure



208_065

At high (increasing) pressure, the crystal is “deformed“ more, so the change of resistance is larger. The test voltage decreases proportionately.

Pulse width signal



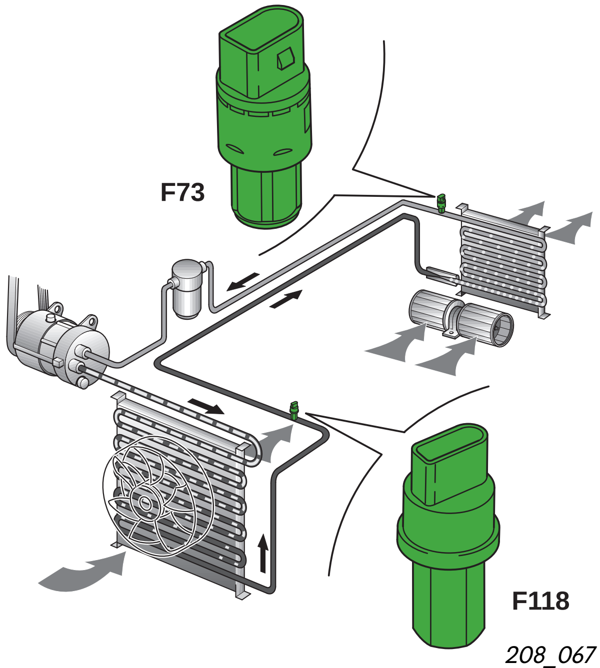
208_066

The pulse width increases in proportion to the increasing pressure.

At a high pressure of 3.7 MPa (37 bar), the pulse width is 18 ms. This is equivalent to 90% of the period duration.

Using the digital memory oscilloscope of the new vehicle diagnosis system VAS 5051, it is possible to visualise the pulse width signal.

Disconnected safety switch in the refrigerant circuit with restrictor



208_067

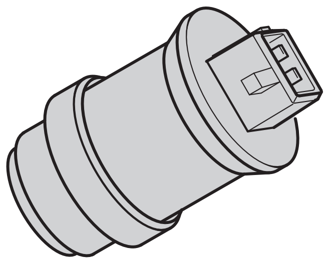
In the refrigerant circuit with restrictor, the low pressure and the high pressure are often monitored by two separate safety switches.

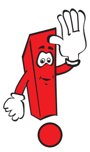
Low pressure
Air conditioner low-pressure switch F73 switches off the compressor when the pressure drops below approx. 0.17 MPa (1.7 bar) in the refrigerant circuit, for example.
(This pressure drop can occur if the refrigerant level in the circuit is too low.
The compressor is protected.)

High pressure
Magnetic clutch high-pressure switch F118 switches off the compressor when the pressure exceeds approx. 3.0 MPa (30 bar) for example.

The absolute values should always be regarded as being system-specific.

Coolant temperature switch with pilot lamp


208_069



In vehicles with extended electronic sensor evaluation via the control unit combination of the vehicle, this additional check is no longer necessary. The signal generated by the primary monitoring device is utilized.

The compressor constitutes an additional load for the engine.

To avoid overheating the coolant when the engine is under heavy load, e.g. when travelling uphill, the additional compressor load is switched off.
For this purpose, the coolant temperature is monitored additionally by a coolant temperature switch with a pilot lamp.
(The primary monitoring device is the coolant temperature sender with indicator lamp in the dash panel insert.)
The compressor cuts out at approx. 119 °C and cuts in at approx. 112 °C.

Various switches with pilot lamp are used depending on vehicle type, e.g.

F18 - Radiator fan thermo switch
F163 - Air conditioner cut-off thermo switch.

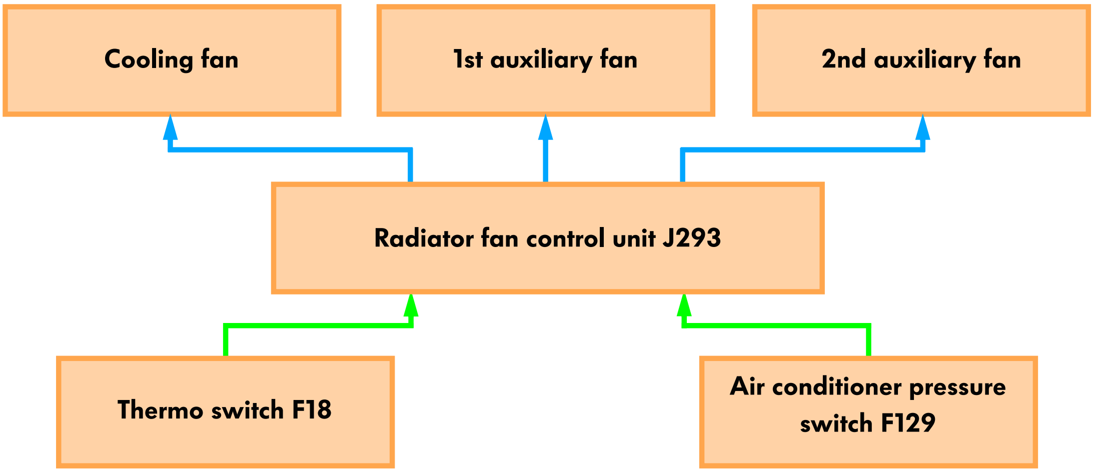
Cooling fan circuit

Circuit connecting fan to engine/ condenser cooling system

shown using the VW Golf/Audi A3 as an example

Fan operation is a basic condition for proper functioning of an air conditioner (refrigerant circuit) and the engine (coolant circuit). Condenser performance will be impaired if there is no cooling. Proper functioning of the air conditioner is no longer assured. In air conditioning, a second or third fan is often also used.

These fans provide the necessary fresh air flow through the radiator and condenser.
The fan control regulates radiator fan control unit J293
depending on the temperature of the coolant and the pressure in the refrigerant circuit.
The absolute values are always vehicle-specific!



Example: Check functions

Coolant temperature
The signal generator is radiator fan thermo switch F18.
The thermo switch is located in the vehicle radiator.

Speed 1	ON	92 .. 97 °C
	OFF	84 .. 91 °C
Speed 2	ON	99 .. 105 °C
	OFF	91 .. 98 °C

Pressure in refrigerant circuit
The signal generator is air conditioner pressure switch F129 or the high pressure sender G65.
F129 switches the fan(s) to speed 2at a pressure of approx. 1.6 MPa (16 bar) (also refer to page 35).

Example: 2-fan combination

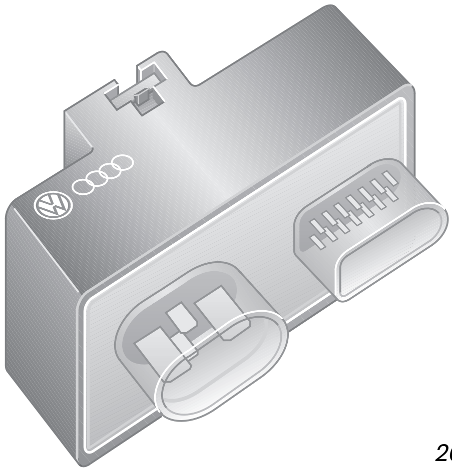
- The air conditioner is switched on, therefore the compressor is switched on and the pressure in the refrigerant circuit is greater than 0.2 MPa (2 bar).
  = both fans run at speed 1

- High pressure in the refrigerant circuit is greater than 1.6 MPa (16 bar) and/or coolant temperature is above 99 °C
  = both fans run at speed 2

- If the pressure in the refrigerant circuit drops below 1.6 MPa (16 bar) and the coolant temperature is below 99 °C
  = both fans will again run at speed 1

- When the engine is being operated without the air conditioner, only the cooling fan will be running. The fan will be running at speed 1 or 2 depending on coolant temperature.

Radiator fan control unit J293



208_070

The radiator fan control unit is integrated in the vehicle control system.

Incoming signals in the basic version:
- from thermo switch F18
- from pressure switch F129
- from operating and display unit E87 (with automatic air conditioner)

Tasks

To convert the incoming signals
- To switch the cooling fan on and off
- To switch the compressor magnetic clutch on and off.

New generation

Expanded functions of a new generation:

Radiator fan control unit J293 has been developed technically and adapted functionally to the new high pressure sender G65.

It is fitted together with the high pressure sender and, as a distinguishing feature, has modified plug connections.

The control unit evaluates the pulse-width modulated signal from the high pressure sender. The overall pressure range of the refrigerant pressure is monitored continously in this way.

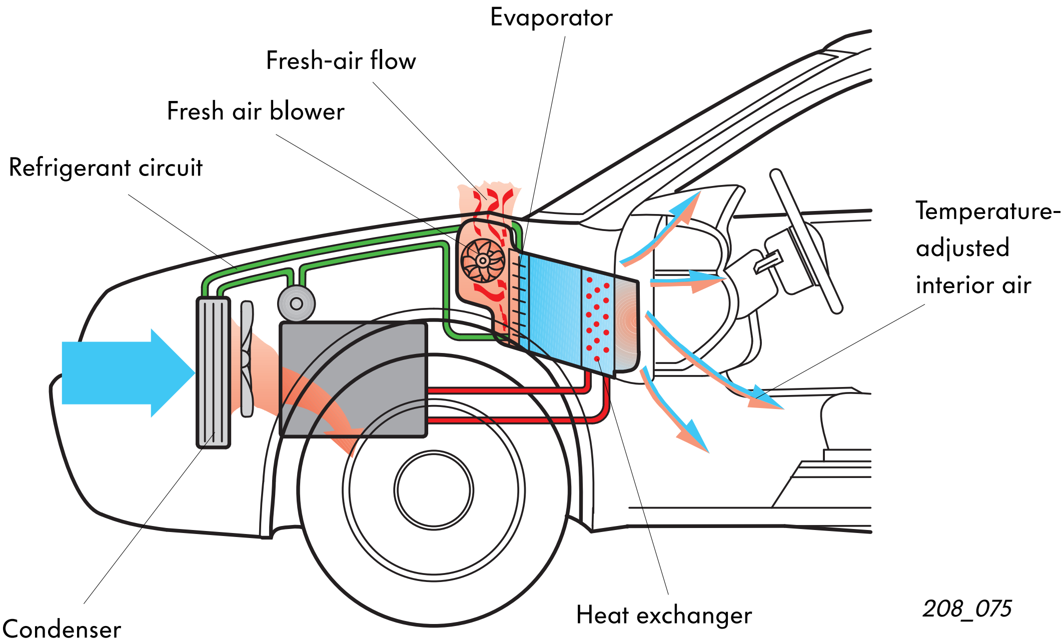
Functions

- To switch the radiator fan speeds and the magnetic clutch of the air conditioner compressor on and off
- Bidirectional signal interchange with the engine and gearbox control unit
- Monitoring the coolant temperature
- with timer module for activating coolant run-on pump V51 (e.g. 1.8-ltr. 5 V engine 165 kW)

There are also circuit variants where the functions of the control units are assumed by an air conditioner control unit.
Integration in their control system is always vehicle-specific.
For details, please refer to the current flow diagram.

Temperature control

Manual control



208_075

Why temperature control?

- The fresh-air flow cooled down at the evaporator is pumped into the passenger cabin by means of the fresh air blower.
- This air is usually cooler than necessary (blower capacity is designed for maximum cooling, however the prevailing ambient temperatures are usually moderate).
- To attain a pleasant interior temperature, a portion of the cold fresh air flow is therefore ducted over the heat exchanger the heating system and heated up.
- Temperature fluctuations can also be caused by different ambient temperatures, road speeds, coolant temperatures, fresh air supplies etc.
- In the case of simple manual air conditioners, the driver has to regulate the temperature.

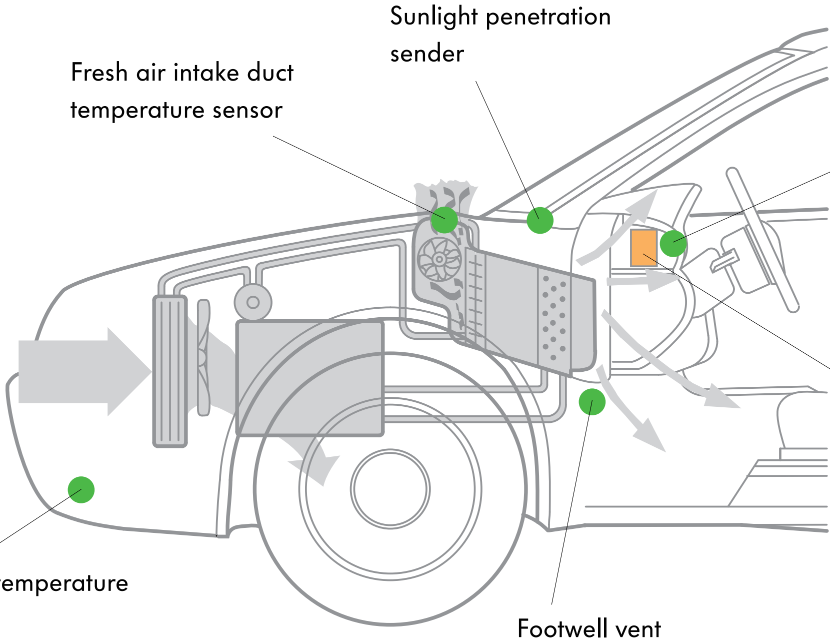
What is regulated?

- Registration of actual values, i.e. temperature sensing.
- Setpoint/actual value comparison, i.e. the driver performs an individual evaluation. The driver defines the comfort temperature, i.e. whether too warm or too cold.
- Based on the evaluation, the driver decides whether
  - the temperature needs to be adjusted
  - in what direction
  - by how much

  and makes this adjustment manually.

The driver is, in the figurative sense, both the controller and the actuator.
The driver adjusts the temperature flap.

Automatic control



Automatic air conditioners relieve the driver of this task.

They have the advantage that they can include many more parameters in the control system and calculate the thermal result of your adjustment in advance.

Various names are used to describe electronic air conditioner controls:
– Digital temperature control
– Climatronic
– Air conditioner with automatic control

What they all have in common is:
– a control unit
– ambient temperature sensor (one or two)
– interior temperature sensor
– additional senders (not in every system), e.g. sunlight penetration sender
– Positioning motors on the heater/air conditioner

The diagram shows the positions of the sensors.

The digital control unit is the master station.
It processes all input signals from the sensors (information sender), interference-suppresses them and feeds them to the microcomputer in the control unit.

The microcomputer calculates the output signals in accordance with the pre-programmed setpoints.

The output signals are fed to the actuators via output stages.
The actuators are the positioning motors on the heater/air conditioner.
Suitable positioning motors are assigned to the flaps.

Air conditioners of the current generation are linked to other vehicle control units either directly or via the CAN-BUS. Information on road speed, on engine speed and on ´time parked´ are also included in the evaluation of the air conditioner control unit in this way.

Temperature control

System overview of an electronically controlled air conditioner

(the temperature is regulated evenly at the left- and right-hand sides of the passenger cabin as shown using the Golf as an example. An identical system is used in the Audi A3)

Sensors
(for system control and temperature control)

Sunlight penetration
photo sensor G107

Temperature sensor
Dash panel
Temperature sensor G56
Blower V42

Ambient temperature
sensor G17

Temperature sensor
Fresh air intake duct temperature
sensor G89

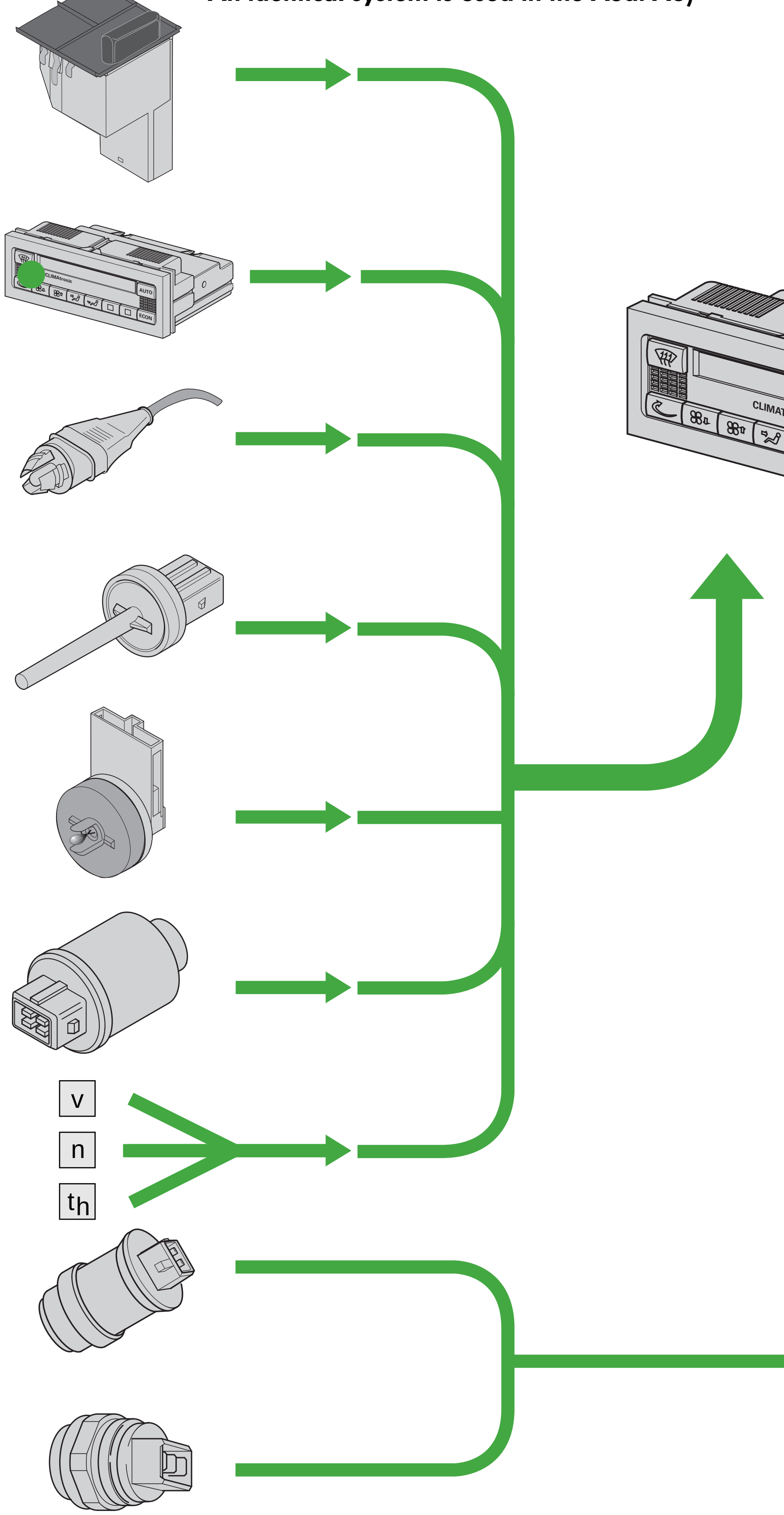
Footwell vent
temperature sender
G192

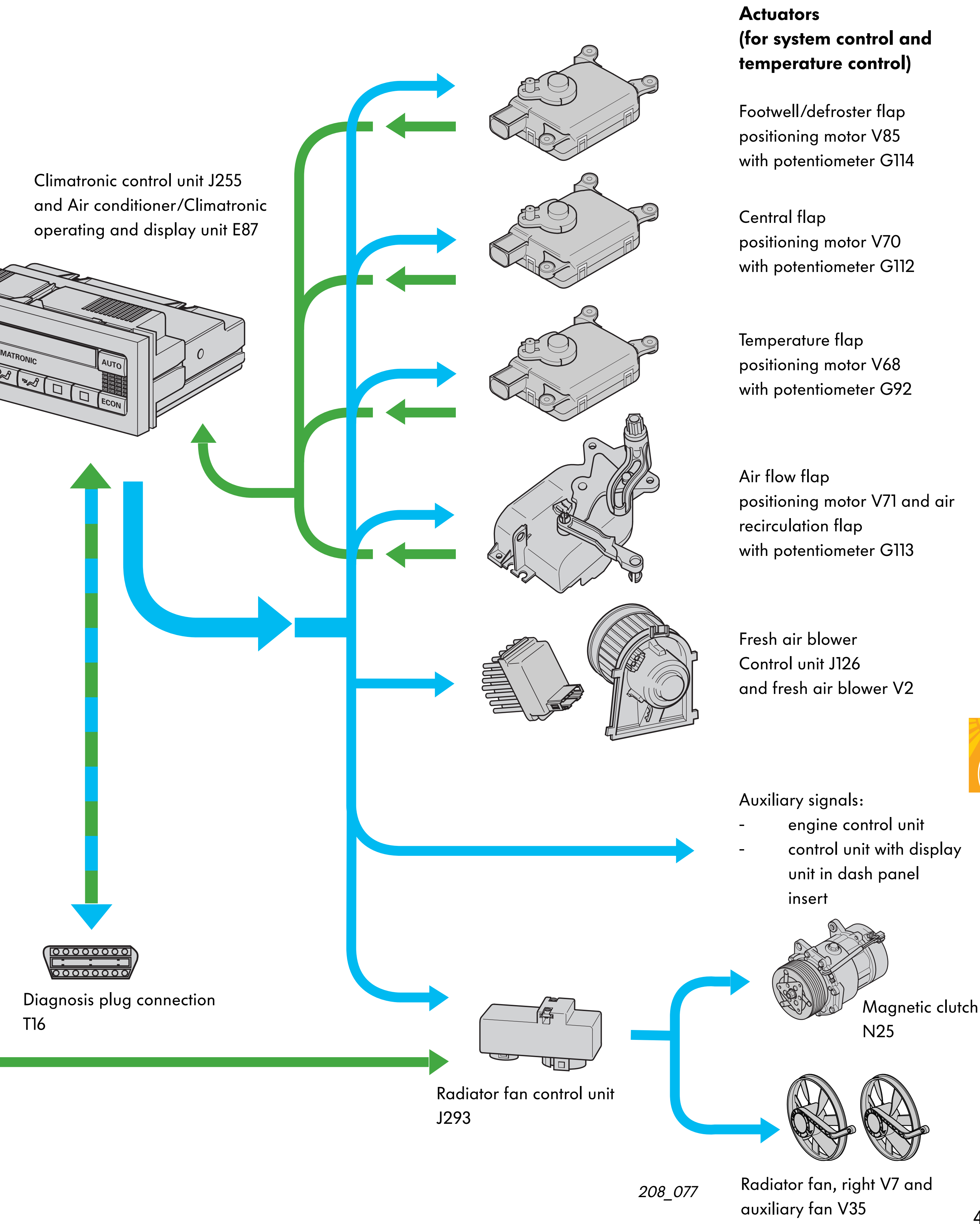
Air conditioner
pressure switch F129

Auxiliary signals:
- road speed signal
- engine speed signal
- 'time parked' signal

Coolant temperature warning switch
(overheating) F14

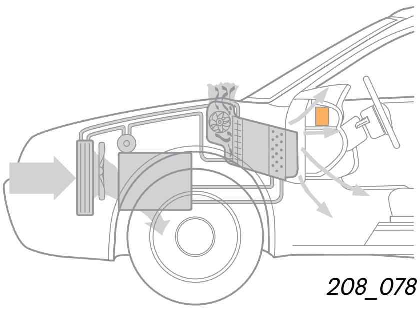
Radiator fan
thermo switch F18




Actuators
(for system control and temperature control)
Footwell/defroster flap positioning motor V85 with potentiometer G114
Central flap positioning motor V70 with potentiometer G112
Temperature flap positioning motor V68 with potentiometer G92
Air flow flap positioning motor V71 and air recirculation flap with potentiometer G113
Fresh air blower Control unit J126 and fresh air blower V2
Auxiliary signals:
- engine control unit
- control unit with display unit in dash panel insert
Climatronic control unit J255 and Air conditioner/Climatronic operating and display unit E87
MATRONIC
AUTO
ECON
Diagnosis plug connection T16
Radiator fan control unit J293
Magnetic clutch N25
Radiator fan, right V7 and auxiliary fan V35
208_077

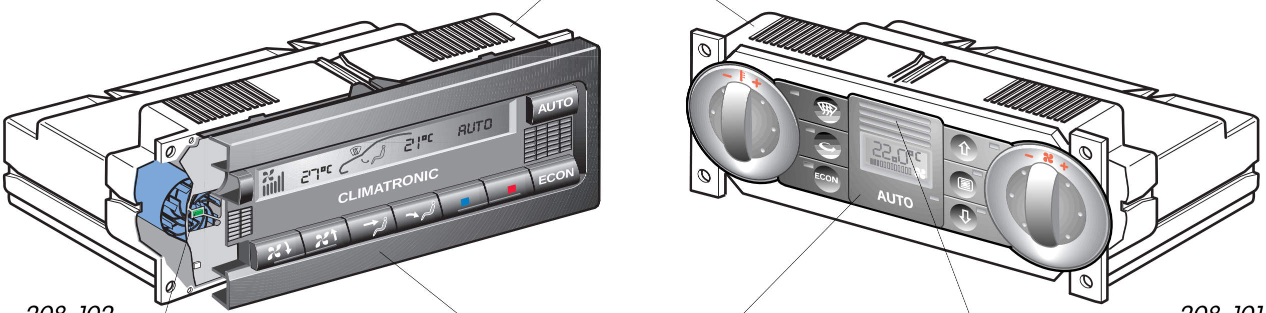
Temperature control

Control unit with operating and display unit



208_078

Control unit



208_102

208_101

Dash panel temperature sensor G56

Operating and display unit E87

Dash panel temperature sensor G56

Climatronic control unit with operating and display unit

Control unit with operating and display unit of Audi TT Coupé

Design

The control unit is combined with the operating and display unit which is adapted to the design of the vehicle in question.

A vehicle interior temperature sensor is also integrated in the control unit.

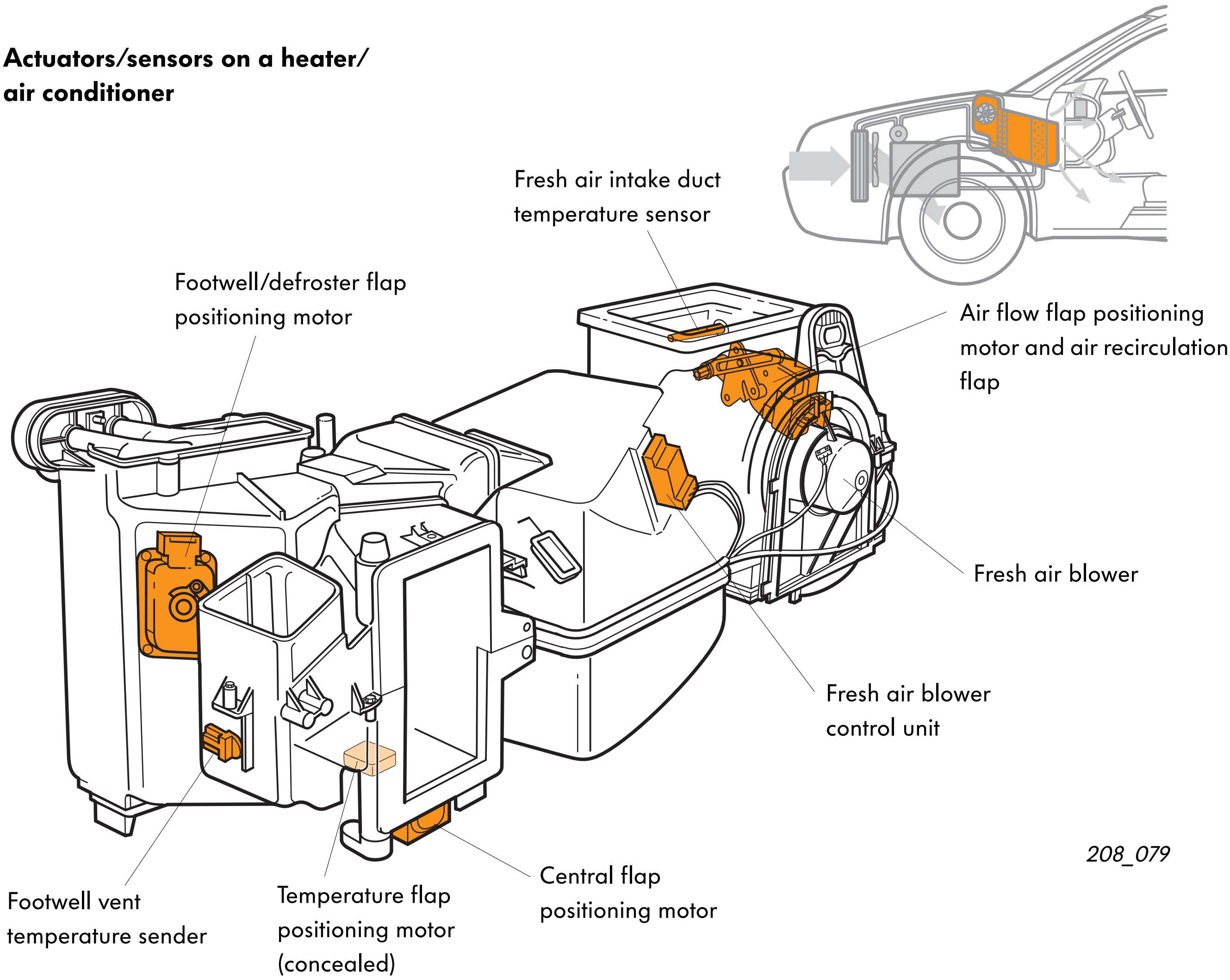
Function

The control unit receives information from the electrical and electronic components (sensors). These signals are processed by the control unit in accordance with the setpoints. The output signals of the control unit then control the electrical actuators.

The control unit is equipped with a fault memory. Failure of a component or an open circuit can be detected quickly via the self-diagnosis.

No matter what fault occurs, the control unit will remain in operation and maintain the temperature settings in emergency mode.

Actuators/sensors on a heater/ air conditioner



A positioning motor is assigned to each flap for air ducting in the heater/air conditioner.

The air flow flap and air recirculation flap are driven by a positioning motor. These flaps are adjusted separately by a driving pulley with two guide rails.

In other systems, the air recirculation flap can also be adjusted by means of vacuum and solenoid valves.

In this case, the fresh air blower and fresh air blower control unit are separate components.

However, they can also be combined to a unit.

Temperature control

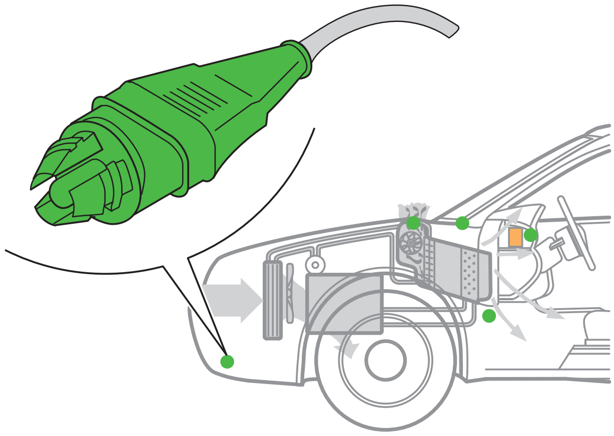
The main temperature sensors

Ambient temperature sensor G17

The temperature sensor is positioned in the vehicle front section.
It registers the actual ambient temperature.

Signal utilisation
The control unit controls the temperature flap and the fresh air blower in dependence upon the temperature.

Effects of signal failure
If the signal fails, the measured value of the second temperature sensor (temperature sensor in fresh air intake duct) is utilised.
If this signal also fails, the system continues to operate by assuming a substitute value of +10 °C. Air recirculation is not possible.
The temperature sensor has self-diagnostic capability.



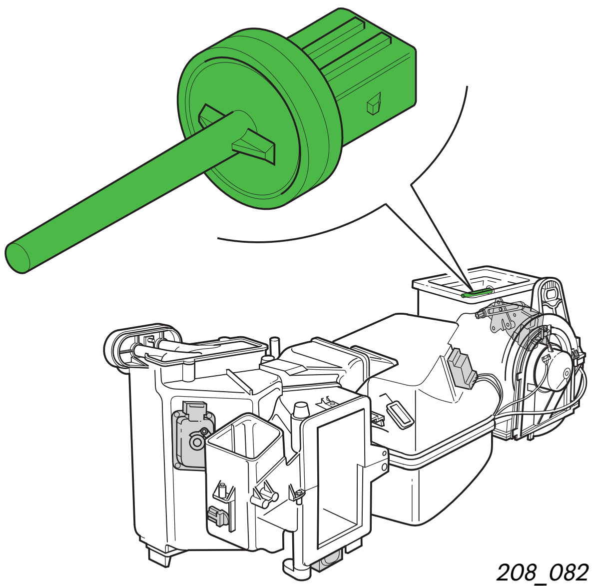
208_081

Fresh air intake duct temperature sensor G89

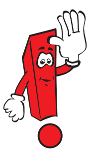
The temperature sensor is located directly inside the fresh air intake duct.
It is the second actual ambient temperature measuring point.

Signal utilisation
The control unit controls the temperature flap and the fresh air blower in dependence upon the temperature.

Effects of signal failure
If the signal fails, the measured value of the first temperature sensor (ambient temperature sensor) located in the vehicle front section is utilised. The temperature sensor has self-diagnostic capability.



208_082



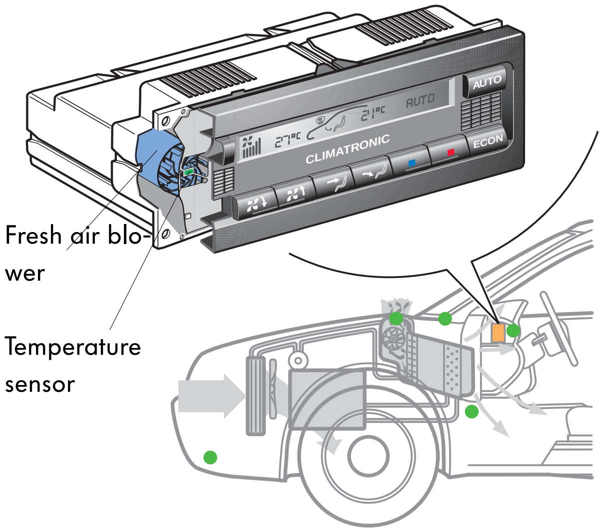
Both temperature sensors always process the lowest value.

Dash panel temperature sensor G56 with temperature sensor blower V42

The temperature sensor is usually integrated directly in the control unit and transfers the actual interior temperature to the control unit.
It is located in the air stream of a fresh air blower which is used to draw off interior air.
The fresh air blower is activated by the operating and display unit.
It draws off the interior air in order to avoid measurement errors at the temperature sensor.

Signal utilisation
The measured value is used for comparison with the setpoint.
The temperature flap and the fresh air blower are controlled accordingly.

Effects of signal failure
In the event of signal failure, a substitute value of +24 °C is assumed. The system remains in operation.
The temperature sensor has self-diagnostic capability.



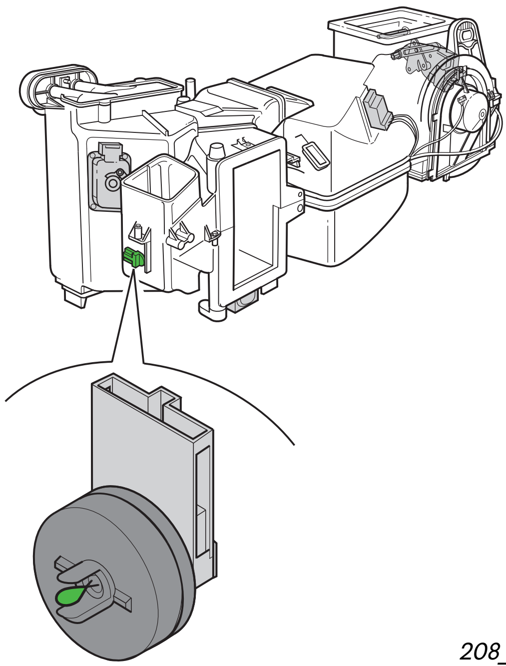
208_083

Footwell vent temperature sender G192

The temperature of the air flowing out of the heater/air conditioner (and into the vehicle interior) is measured. The temperature is registered with a temperature-dependent resistance.
The electrical resistance increases as the temperature drops.

Signal utilisation
The signal is evaluated by the control unit. The signal is used to control the defrost/footwell air distribution and the volumetric capacity of the fresh air blower.

Effects of signal failure
In the event of signal failure, the control unit calculates a substitute value of +80 °C.
The system remains in operation.
The sender has self-diagnostic capability.


208_084

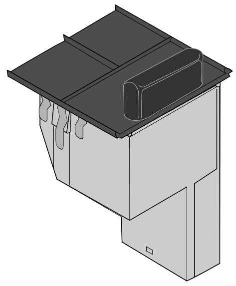
Temperature control

Sunlight penetration photo sensor G107

Air conditioner temperature is controlled by means of photo sensors.

They register the direct sunlight exposure of the vehicle occupants.

Depending on air conditioner type, they can measure sunlight penetration via one or two sensors and separately for the left- and right-hand sides of the vehicle.

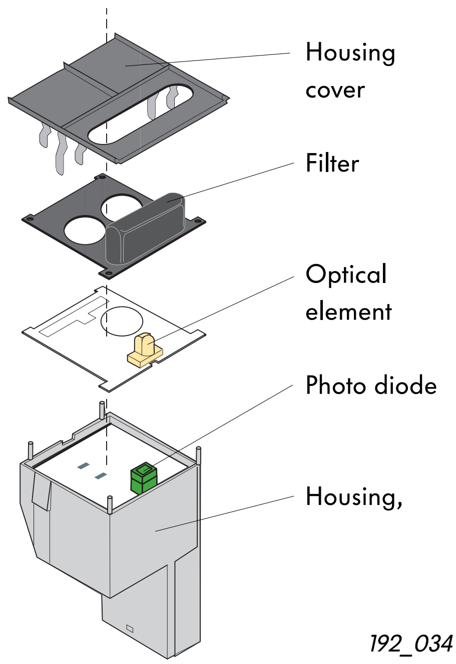


192_093

Function
The sunlight passes through a filter and an impinges upon an optical element on the photo diode. The filter functions in much the same way as sunglasses and protects the optical element against UV radiation.

Photo diodes are light-sensitive semiconductor elements. When there is no incident light, only a small current can flow through the diode. This current increases when the photo diode is exposed to sunlight. The stronger the incident sunlight, the higher the current.

When the current increases, the air conditioner control unit recognises that the sunlight is stronger and regulates the interior temperature accordingly. The temperature flap and fresh air blower are controlled accordingly.



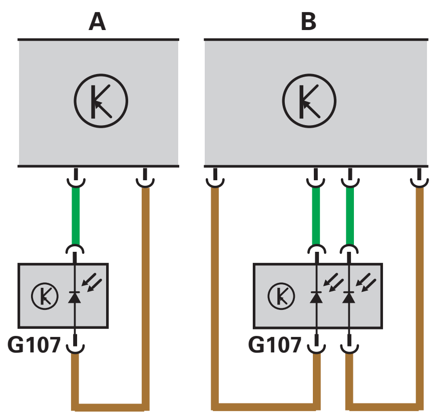
192_034

In the version with two sensors, the side of the vehicle exposed to stronger sunlight is cooled more (refer to page 58).

Effects of signal failure
The control unit utilises an assumed fixed value for sunlight penetration.

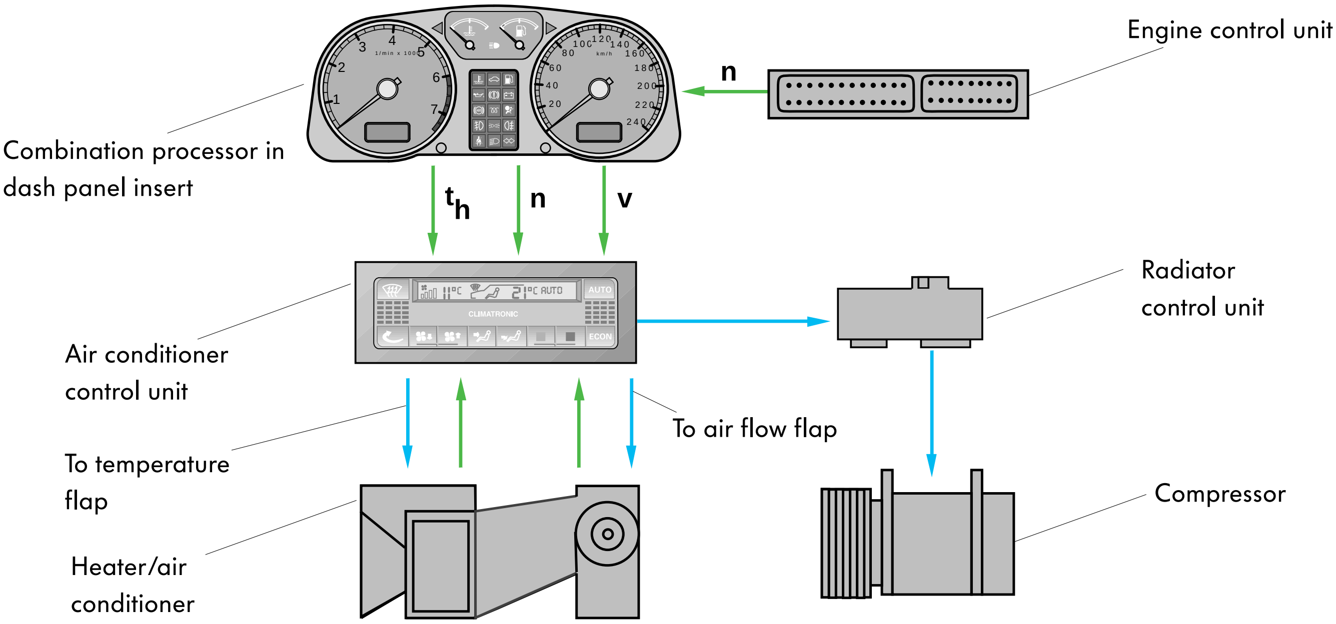
Electrical circuit

Ⓚ	Air conditioner control unit
G107	Photo sensor
A	1 sensor
B	2 sensors



208_088

Auxiliary signals for temperature control



208_087

With regard to temperature control, additional information enhances comfort and is utilised for system control.
These auxiliary signals are supplied by other vehicle control units and are processed by the air conditioner control unit.
Important signals are:

- 'Time parked 't_h
- Road speed v
- Engine speed n

'Time parked' signal th

Time parked=the time between switching off the ignition and restarting the engine
This signal is utilised for adjusting the temperature flap. When the engine is restarted, the control unit processes the ambient temperature values stored before turning off the engine.

Changes in measured data (e.g. due to radiant heat) are disregarded for control purposes.
The comfort temperature is set quickly and exposure to subnormal temperatures is avoided.

Road speed signal v

Is required to control the air flow flap.
The signal generated by the speedometer sender is utilised and implemented in the control unit. At higher road speeds, the cross-section of the fresh air inlet is reduced in order to keep the air flow into the passenger cabin as steady as possible.

Engine speed signal n

This signal provides information to the air conditioner control unit on actual engine operation. It is required for system control (to switch off the magnetic clutch), e.g. if there is no engine speed signal, the compressor is switched off.

Temperature control

Positioning motor

In a manual air conditioner, air-ducting flaps such as

- the temperature flap
- the central flap
- the footwell/defrost flap

are adjusted individually by the driver by means of Bowden cables.

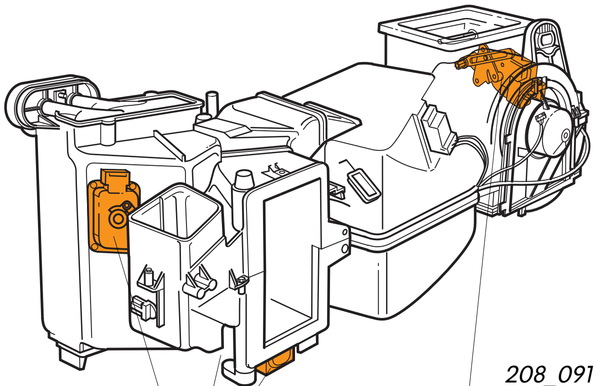
In the automatically controlled air conditioner, the flaps are operated by electrically activated positioning motors. The air recirculation flap is also positioning motor operated.

The positioning motors are always positioned level with the flap axis on the heater/air conditioner .

All motors receive the corresponding control signals from the air conditioner control unit.

Each positioning motor has a potentiometer. The potentiometer signals the position of the flap to the control unit in the form of a feedback value.

Thus, the electrical output signals are converted to mechanical quantities by means of positioning motors (actuators).



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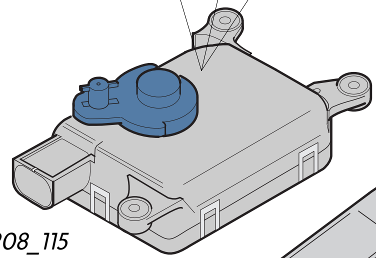
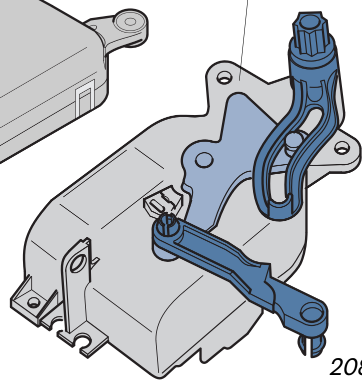


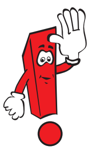
208_115

1 positioning motor each for
- temperature flap
- central flap
- footwell/defrost



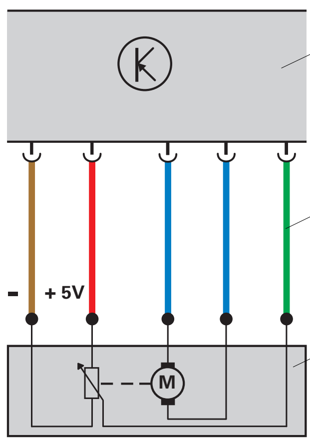
208_116

Positioning motor for fresh air recirculation flap and air flow flap



The flaps have different adjustment mechanisms.
The arrangement of the cranks and angle of rotation are always referred to a particular flap.

Electrical circuit



Air conditioner control unit

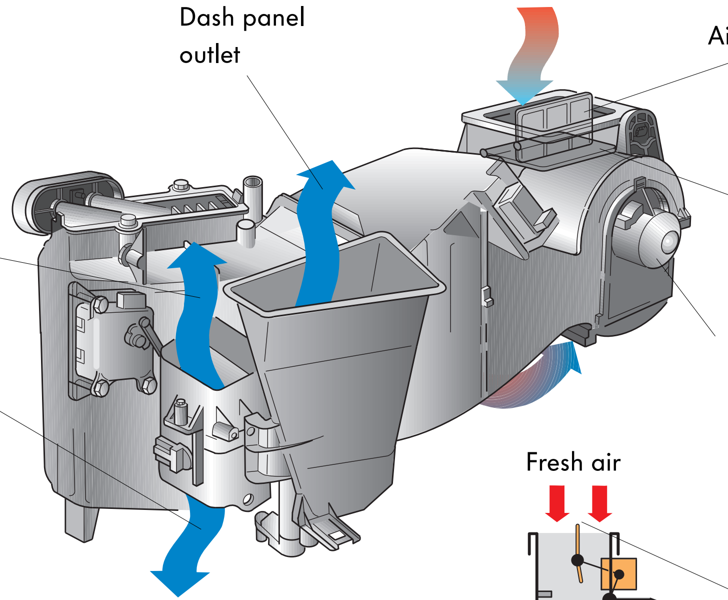
Sender information

Positioning motor with potentiometer

208_092

Air ducting

The heater/air conditioner



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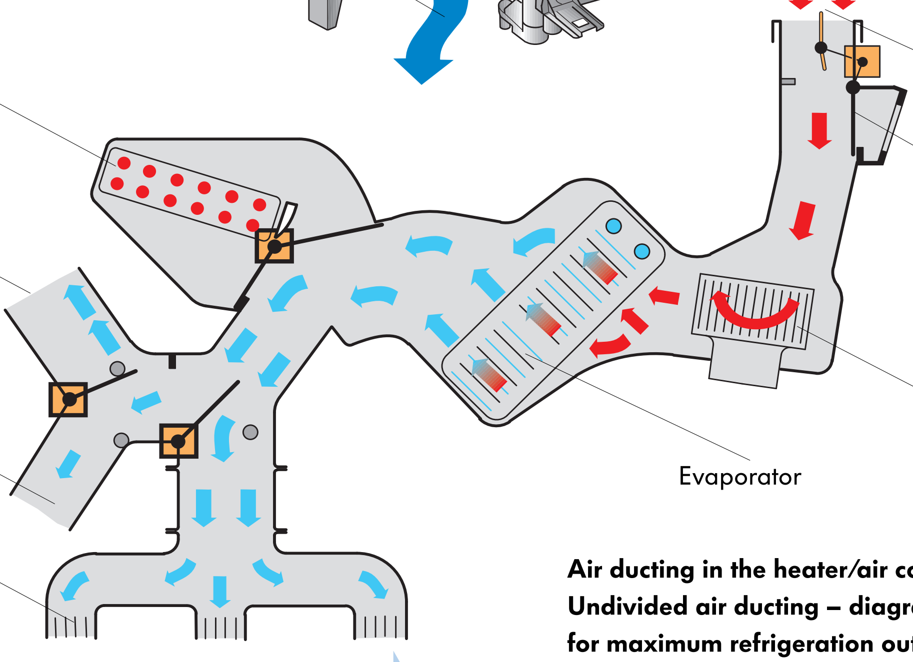


208_112

Air ducting in the heater/air conditioner
Undivided air ducting – diagram – for maximum refrigeration output

Air conditioning mode

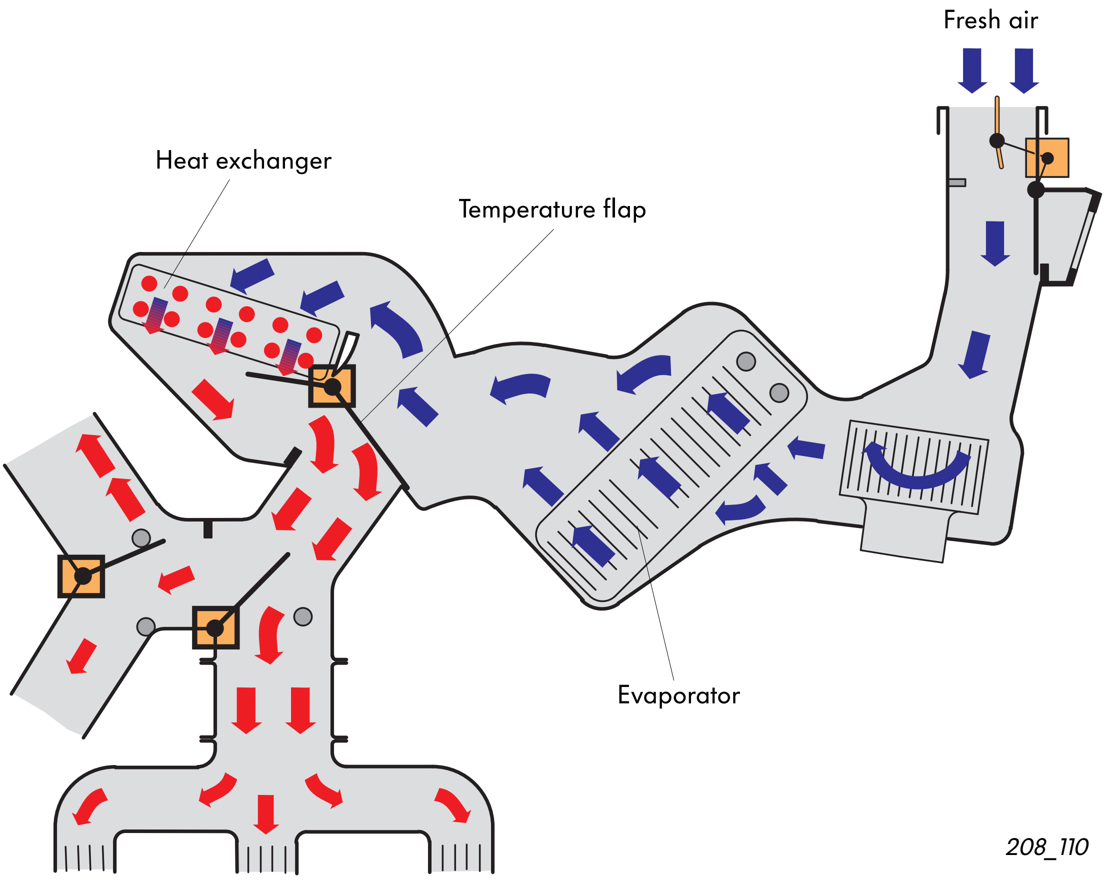
Very warm fresh air is ducted to the air outlet via the evaporator. The channel to the heat exchanger is closed.

Air ducting and distribution are always dependent upon the design of the heater/air conditioner and by the required level of driving comfort.

A basic distinction is made between
– undivided air inflow into the passenger cabin
– divided air inflow for the left- and right-hand sides of the passenger cabin.

The latter version, of course, requires more sensors, actuators and air flaps.

Temperature control



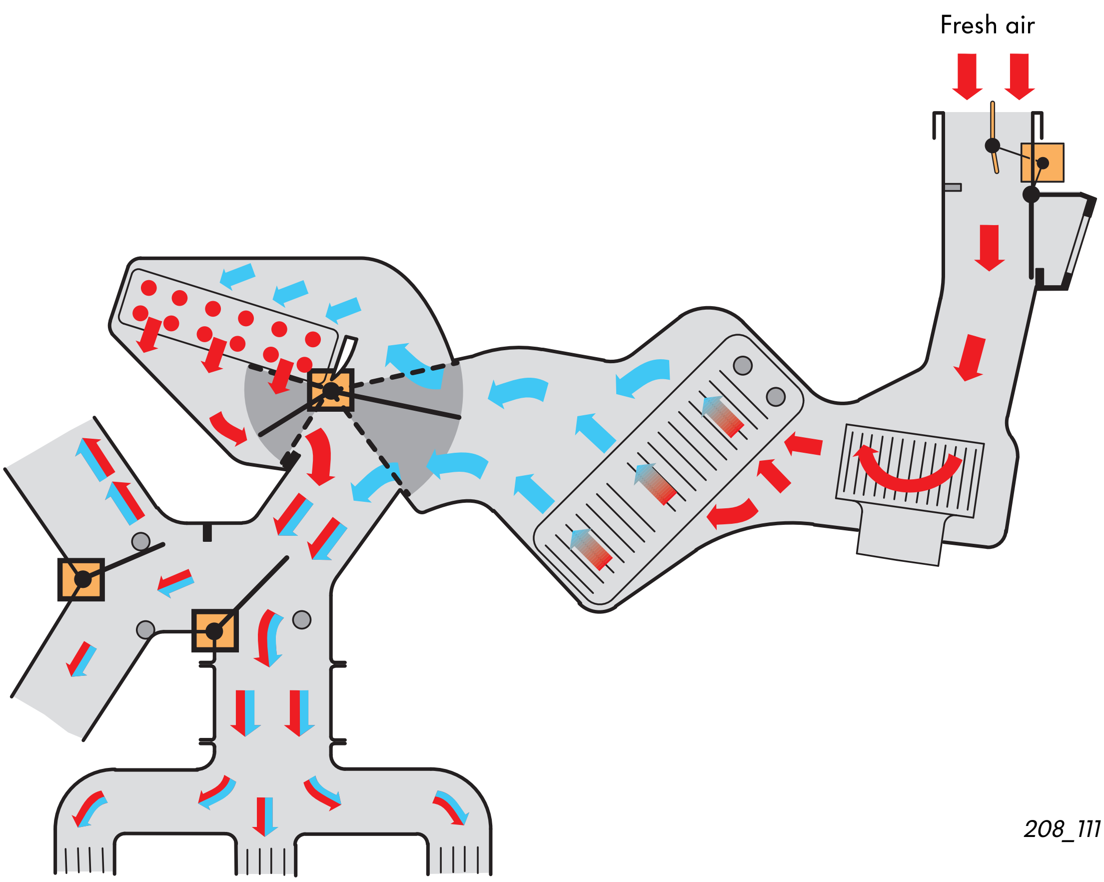
Air ducting in the heater/air conditioner
Undivided air ducting – diagram–
for maximum heat output

Air conditioner OFF,
heating ON

Very cool fresh air flows through the evaporator; evaporator is not working.
Fresh air is passed over the heat exchanger and heated.

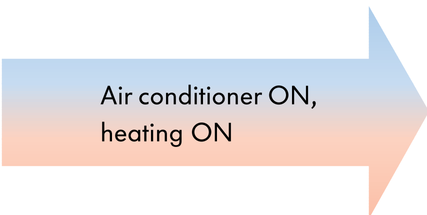
All heaters/air conditioners are basically designed as shown in the diagram:

– Air inlet for ambient air
– Air inlet for air recirculation mode (if provided)
– Fresh air blower
– Evaporator (for cooling the air down)
– Heat exchanger (for heating the air up)
– Regulating flaps and ducts for selective air ducting (footwell, defrost, dash panel outlet).

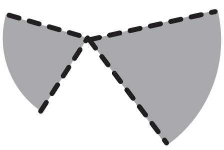


208_111

Air ducting in the heater/air conditioner
Undivided air ducting – diagram–
for mixed operation

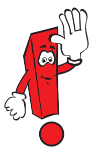


Warm fresh air flows through the evaporator in order to cool down. The fresh air is too cool, therefore a partial air flow is ducted over the heat exchanger in order to attain the individually selected vent temperature.



= individual adjustment range

208_114



Air conditioning mode can be selected even if the fresh air is cool and moist. The fresh air passing over the evaporator is dehumidified and the windows are demisted.

Temperature control

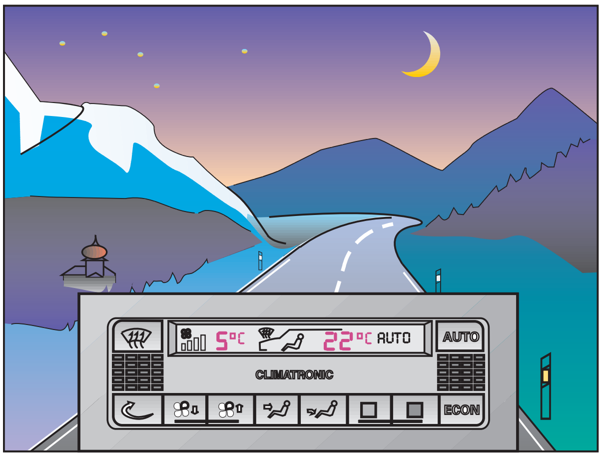
Different ambient temperatures

Constant interior temperature

through

Automatic flap control and

switching the air conditioner on and off



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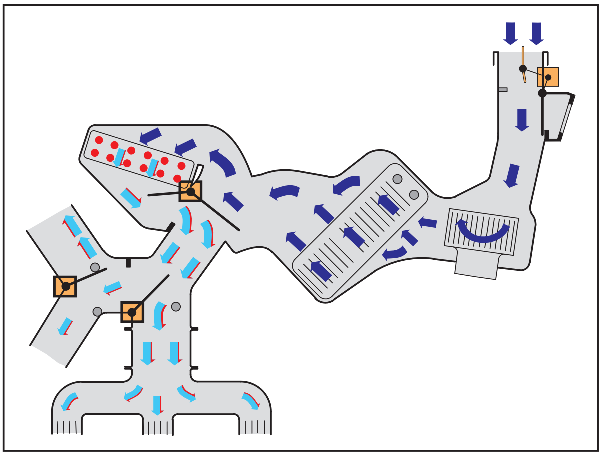

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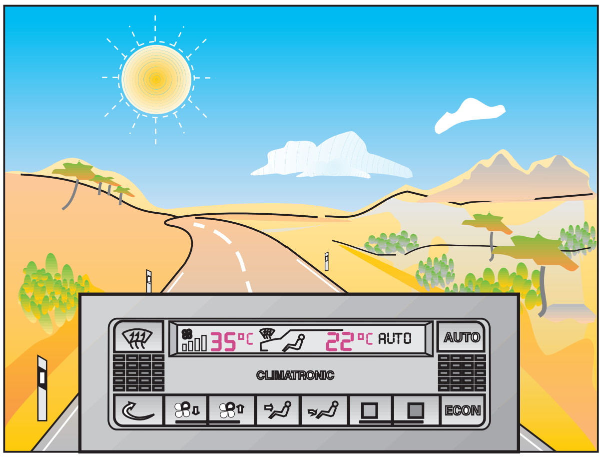

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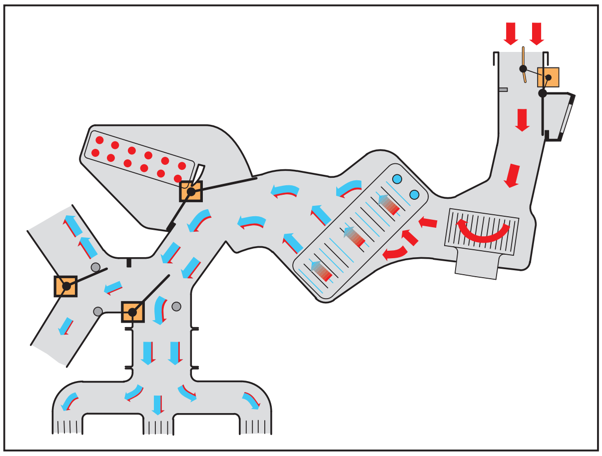

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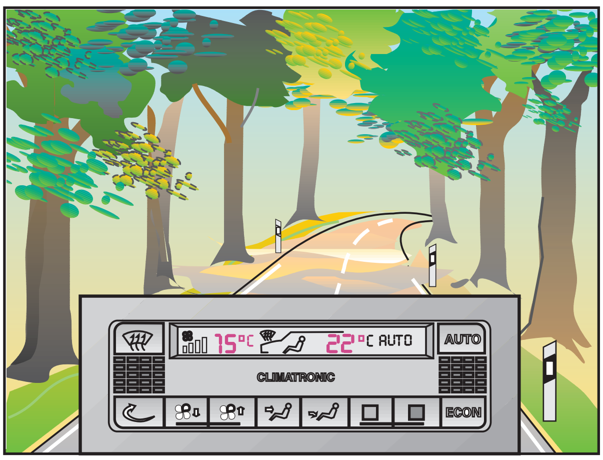

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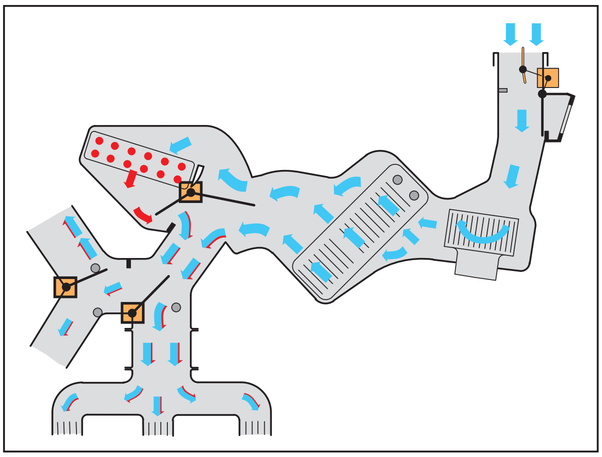
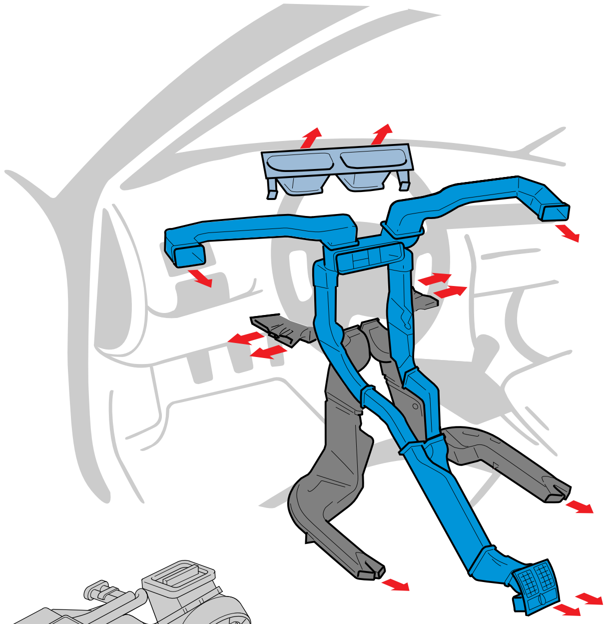


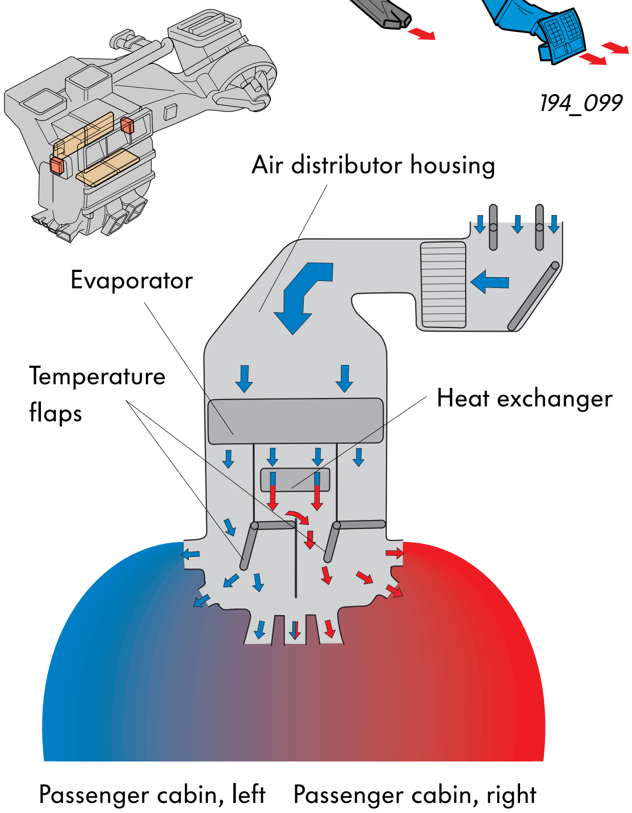
208_099

Air distribution – split into two separate air flows in the automatic system

(example: Audi A6)



194_099



208_100

In this case, air distribution inside the vehicle is regulated by air-side flaps in the air conditioner (in the Audi A8, air distribution is regulated on the water side).

Depending on flap control, the air flow is ducted to the individual air outlets.

All flaps are actuated electrically by the positioning motors.

The flaps are adjusted either automatically according to program flow, or manually at the operating and display unit.

The temperature flaps

In this version, the temperature for the left- and right-hand sides of the passenger cabin can be adjusted independently.

In the air distributor housing, the air flow is divided into cold/warm and passenger cabin left/right.

Depending on temperature requirements, the proportion of warm and cold air for the passenger cabin can be adjusted with the temperature flaps.

The temperature flaps are actuated by
– a positioning motor for the left-hand side of the passenger cabin
– a positioning motor for the right-hand side of the passenger cabin.

Temperature control

System overview a electronic regulated air conditioner

(with separate air-side temperature control for the left- and right-hand sides of the passenger cabin, as shown using the Audi A6 as an example)

Sensors

Sunlight penetration
photo sensors G107

Dash panel
temperature sensor G56
with temperature sensor
blower V42

Ambient temperature
sensor G17

Temperature sensor
Fresh air intake duct G89

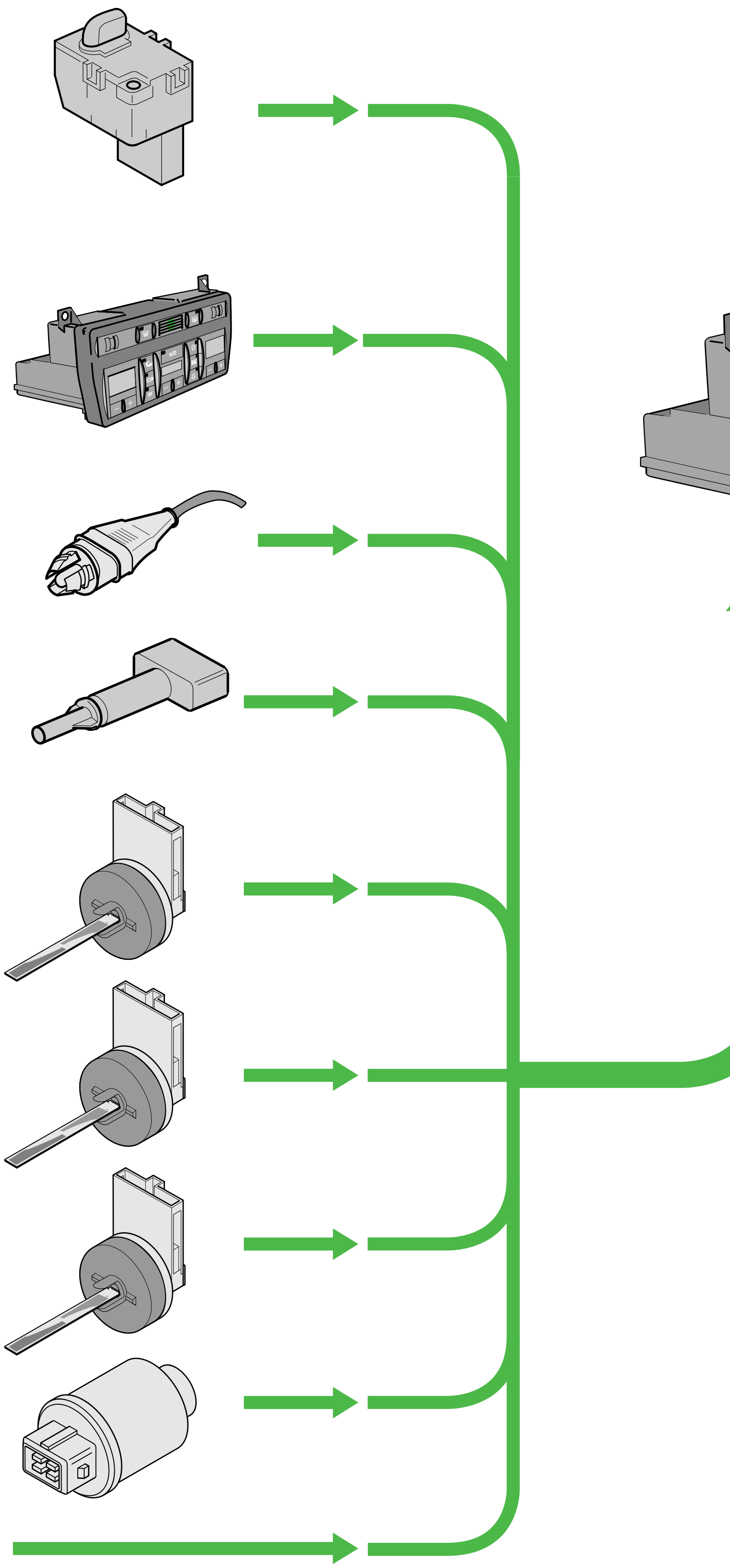
Vent temperature sender, right
G151

Vent temperature sender, left
G150

Footwell vent temperature sender
G192

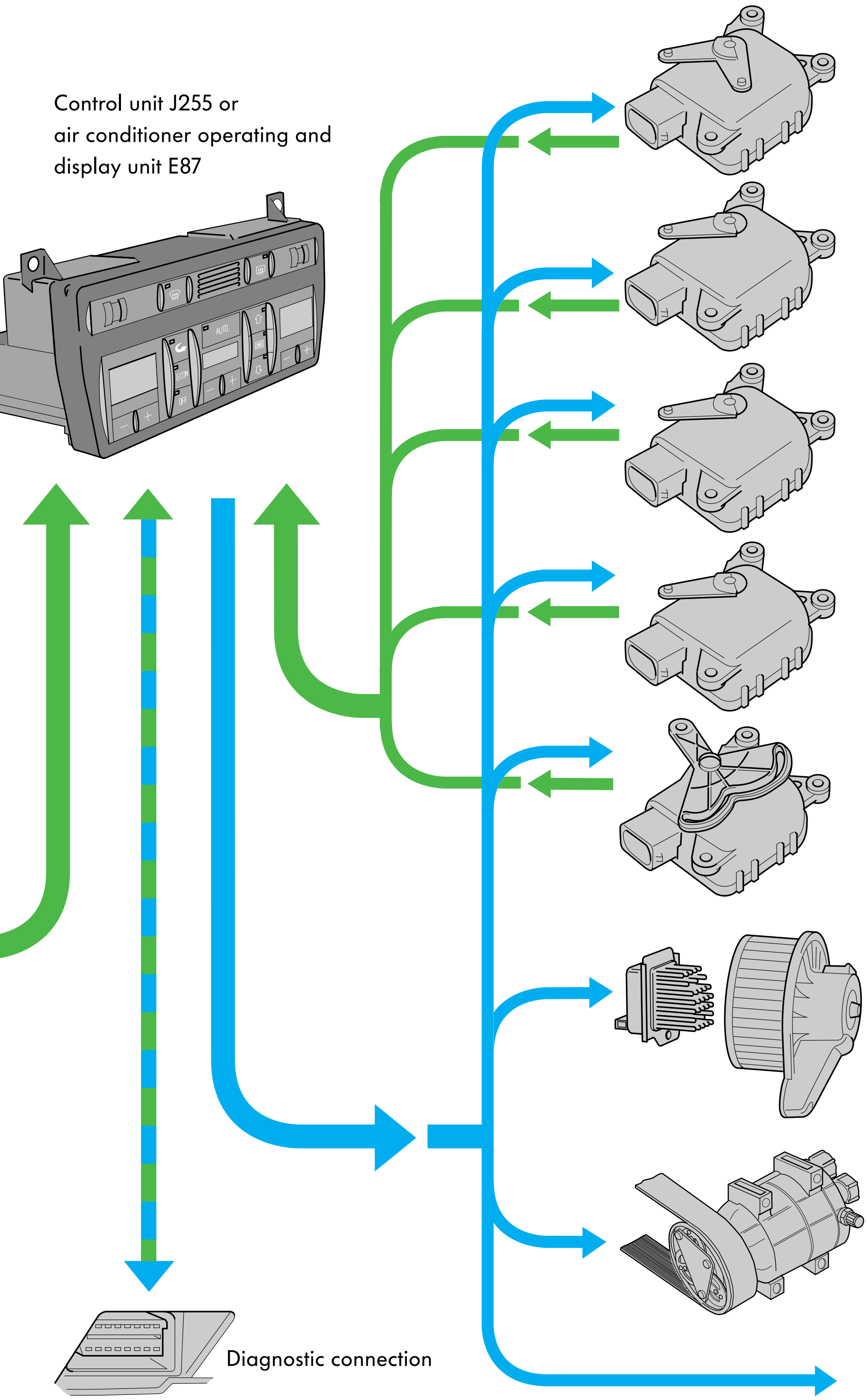
Air conditioner pressure switch F129

Auxiliary signals



The temperature can be set differetly for the left- and right-hand sides to between 18 °C and 29 °C.

The temperature flaps for left/right temperature distribution are located in the air distributor housing



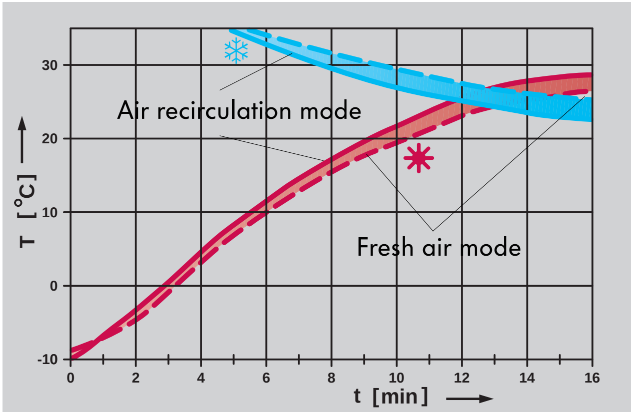
194_072

Temperature control

Air recirculation mode

What do we mean by air recirculation mode?

The air conditioner processes two types of air, namely ambient air and cabin air (air recirculation).
In air recirculation mode, the air used for cooling the passenger compartment is not extracted from the outer atmosphere, rather from the vehicle interior.
Therefore, the system only recirculates and controls the temperature of the air which is available inside the vehicle.

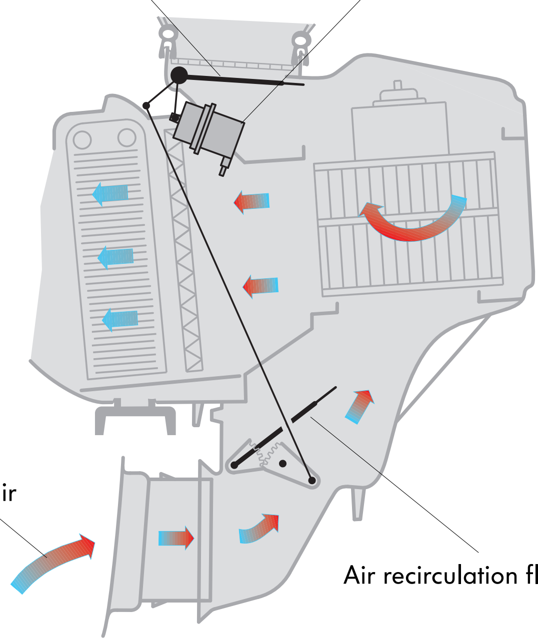


208_089

Average values for vehicle temperature reduction/ increase in the air recirculation and fresh air modes

Why air recirculation mode?

Air recirculation mode is the quickest way to cool down the vehicle interior. This is done by recycling the cabin air, which is always cooler. When heating the vehicle interior, the converse effect occurs, i.e. the air is heated more rapidly.
An advantage of air recirculation is that the evaporator output or compressor drive output required is more than halved in air recirculation mode.
In addition to rapid cooling/heating, air recirculation mode can be used to avoid breathing in polluted ambient air (unpleasant odours, pollen).

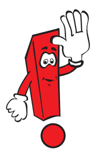


208_117

Vehicle air conditioning
in air recirculation mode – pneumatically operated

Does air recirculation mode have any draw-backs?

In air recirculation mode, there is no air exchange. The air will be “used up“.
Therefore, air recirculation mode should not be used any longer than is necessary, and for no more than 15 minutes.
In air recirculation mode, the atmospheric humidity in the passenger cabin rises due to moisture released with the air respired by the occupants. When the dew point of the interior air exceeds the temperature of the windows, the windows will inevitably mist up.



In the Defrost setting, therefore, air recirculation mode is automatically disabled.

Manual air recirculation mode

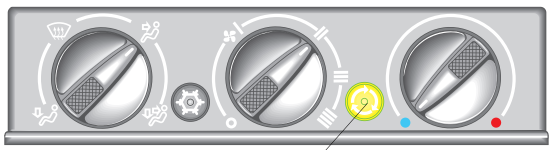
With the manual air conditioner, the driver is responsible for controlling and operating air recirculation mode.
The driver decides on when and for how long.

After pressing the air recirculation button, the flaps are adjusted pneumatically with vacuum.

With automatic air conditioners, too, air recirculation mode is mainly selected manually by the driver.
In this case, the fresh air/air recirculation flap is adjusted electrically by means of a positioning motor.

What both systems have in common is
- Fresh air flap closed
  = air recirculation flap open
- Fresh air flap open
  = air recirculation flap closed

The air recirculation flap positioning motor is also used to adjust the air flow flap.

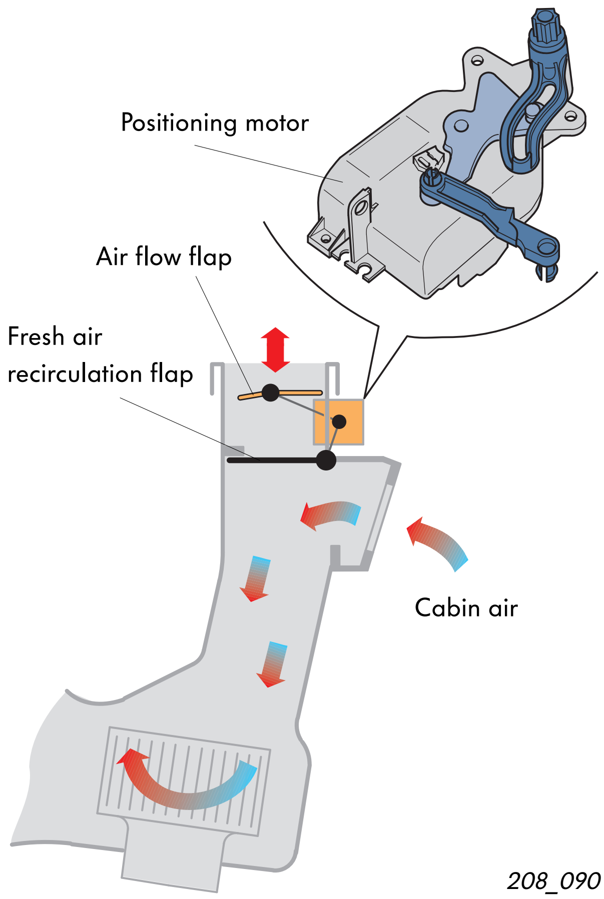


208_118

Air recirculation button – manual air conditioner

207_043

Air recirculation button – automatic air conditioner



208_090

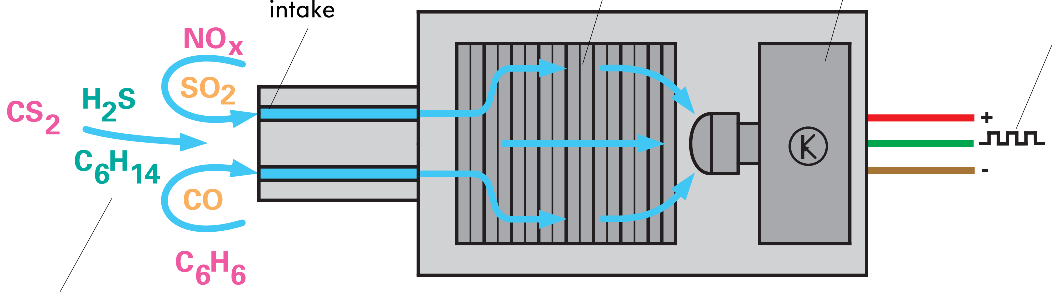
Vehicle air conditioning
in air recirculation mode – electrically operated

Several versions of automatic air conditioners already control air recirculation mode automatically.
As soon as pollutants enter the ambient air, the fresh air supply is blocked.

These systems have additional system components.

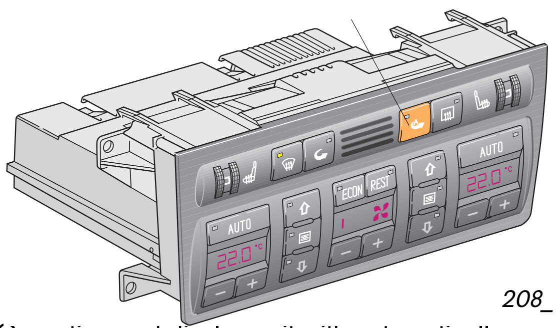
Temperature control

Automatically controlled air recirculation mode



208_105

In systems with a manually operated air recirculation mode, the changeover is logically not performed by the driver until an odour nuisance occurs, by which time the air inside the vehicle will have already been fouled.
In systems with an automatic air recirculation mode, the vehicle ventilation system will be closed as soon as pollutants in the air have been detected (by a sensor), i.e. before an odour nuisance occurs. The automatic air recirculation function can be switched on and off manually.



208_108

Operating and display unit with automatically controlled air recirculation mode

The system components

- Air quality sensor G238
  An electronic component which is located in the area of the fresh air intake upstream of the combination filter.
- Combination filter
  The combination filter replaces the dust and pollen filter. It comprises a particle filter containing activated charcoal.

The operating principle

A gas sensor detects pollutants in the ambient air. When a high pollutant concentration occurs, the air conditioner control unit implements the signal which the gas sensor generates by changing over from fresh air mode to recirculation mode.
If the pollutant concentration drops below a given threshold, then fresh air is again supplied to the vehicle interior.

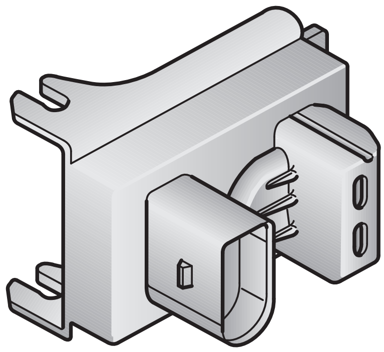
What pollutants are detected?

The primary pollutants contained in the exhaust gases of the petrol engine are:
CO - Carbon monoxide
C_6H_{14} - Hexane
C_6H_6 - Benzene
C_7H_{16} - n-heptane

In exhaust gases of diesel engines:
NO_X - Nitrogen oxides
SO_2 - Sulphur dioxide
H_2S - Hydrogen sulphide
CS_2 - Carbon bisulphide

Air quality sensor G238

The sensor operates, in principle, in much the same way as a lambda probe.
The metering element is a mixed oxide sensor which uses semiconductor technology (stannic oxide - SnO_2).
The sensitivity of the air quality sensor is increased by catalytic additives of platinum and palladium.
The operating temperature of the sensor is approx. 350 °C. Its power consumption of 0.5 watts is very low.



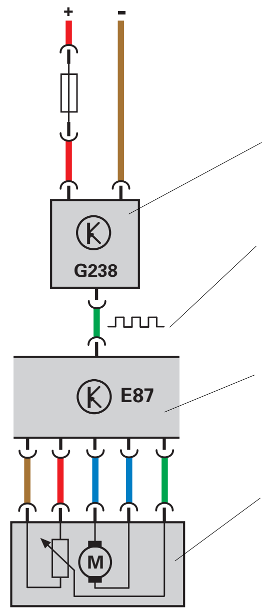
208_106

Air quality sensor G238

The evaluation electronics in the sensor

The evaluation electronics integrated in the ultrasonic sensor module react to changes in sensor conductivity.
High sensitivities are achieved.

The system is self-learning.
The electronics determine the average pollutant concentration in the ambient air and sends information on the type and quantity of the materials by means of a digital square-wave signal to the air conditioner control unit.



208_107

The control unit now closes the air recirculation flap at peak pollution levels depending on the ambient temperature and air pollution level.

This ensures that the ventilation system does not remain stuck in air recirculation mode in heavily polluted areas.

Regardless of the electronic evaluation, several systems switch to air recirculation mode when the wash/wipe system is operated.

Ambient temperature	Air pollution level	Air recircula-tion
> +2 °C	Low rise	yes min. 25 sec.
> +2 °C	Low	no
+2 °C ... –5 °C	Higher rise	yes
< –5 °C	Higher rise	max. 15 sec.
ECON mode compressor off		max. 15 sec.
Defrost mode		no
Warm-up phase of sensor approx. 30 sec.		no

Service

The air quality sensor is wear-free.
The combination filter must be replaced after service intervals.

Safety precautions for working on air-conditioned vehicles and handling refrigerant R134a

Set codes of conduct and safety precautions must be observed when working on air-conditioned vehicles and handling refrigerants in order to ensure that no-one is endangered by leaking refrigerant.

Work performed incorrectly can also damage the air conditioner itself and should therefore be avoided at all costs in the interests of proper customer care.

Wear protective gloves

Wear protective goggles

Naked flames, exposure to direct sunlight and smoking are prohibited.

208_085

Important!

General servicing work on the vehicle should be prepared and performed in such a way that the vehicle refrigerant circuit is not opened (e.g. radiator/ engine removal).
Direct contact with refrigerant should be avoided at all costs in order to avoid skin damage (frostbite).
Escaping refrigerant has a temperature of – 26 °C.
If it is necessary to open the refrigerant circuit in order to perform repair work on the vehicle, bring the vehicle to a service station for air conditioners. At the service station, the refrigerant circuit will be emptied by expert personnel.

These are the only workshops which have the equipment required to draw off refrigerant properly. The refrigerant will also be processed in an environmentally friendly manner and can be reused.

What is the correct code of conduct when refrigerant discharged accidentally from the refrigerant circuit comes into contact with the skin?

If liquid refrigerant comes into contact with the eyes, rinse eyes thoroughly with water for 15 minutes.
Then apply eye drops and contact a doctor even if no eye irritation has occurred.
Inform the doctor that refrigerant was the cause.

In the event of skin contact, remove wet clothing immediately and rinse the areas of skin affected with copious amounts of water.

Neither welding or brazing or soldering work may be performed on parts of the filled air conditioner.

This also applies to welding and brazing/ soldering work on the vehicle if there is a danger of parts of the air conditioner heating up. During spot painting work, the object temperatures in the drying oven or preheating zone may not exceed 80 °C.

Why not?

Heating produces a higher excess pressure in the system which can cause the pressure relief valve to open. During electrical welding work, invisible ultraviolet rays can penetrate the refrigerant hoses and degrade the refrigerant.

What is the correct code of conduct?

Damaged or leaky parts of the air conditioner may not be repaired by welding or brazing/ soldering them. Such parts must always be renewed. Draw refrigerant out of the refrigerant circuit with the service station beforehand.

Work may only be performed on the refrigerant circuit in well-ventilated rooms. Refrigerant may not be stored in shafts or at basement windows.

Why not?

Refrigerant is a colourless and odourless substance. It is also heavier than air, and therefore displaces oxygen and can flow down into lower regions. If refrigerant escapes even though all the applicable safety precautions have been observed, there is an unforeseeable risk of suffocation in badly ventilated rooms or assembly pits.

208_119

Although refrigerant is not highly flammable, it is not permitted to smoke or performe welding or soldering or brazing work in a room filled with refrigerant.

Why?

The high temperature of an open flame or a hot object will cause chemical fission of the refrigerant gas. Inhalation of the resulting toxic fission products will lead to dry coughing and nausea.

What is the proper code of conduct?

If a person breathes in refrigerant vapours in a high concentration, bring the victim out into the open air immediately.
Contact a doctor.
If the victim is having difficulty breathing, provide the victim with oxygen.
If the victim has impaired breathing or is no longer breathing, bend the victim's head back and administer artificial respiration.

Why service station for air conditioners and special equipment?

The refrigerant circuit is in a closed system.
To ensure that the system functions properly:

- the refrigerant must be clean
- the refrigerant may not contain any moisture
- the piping must be evacuated and dry before being filled
- only refrigerant resistant original spare parts may be used.

To avoid damaging the environment and physical injury,

- the refrigerant circuit may not be filled in the open air
- the refrigerant must be disposed of in an environmentally friendly manner.

The equipment developed specially for air conditioners conforms to these requirements.
This equipment is expensive, however, and is therefore not available nationwide rather only at service station for air conditioners.

Working on the refrigerant circuit calls for

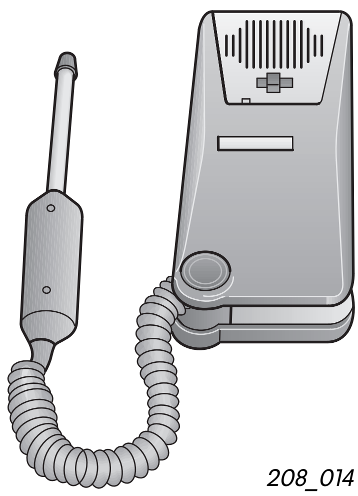
- a special knowledge of proper repairs
- a knowledge of the safety regulations and the Pressure Vessel Code
- verification of appropriate qualifications (country-specific).

This specialist personnel at the service station for air conditioners meet the above requirements.

What equipment does the service station for air conditioners have for carrying out work expertly and in an environmentally friendly manner?

The leak detector for inspection work on the vehicle –

A possible cause of insufficient cooling output is loss of coolant due to leaky lines.
Minor leaks (external damage) can only be verified by means of suitable leak detecting equipment, due to the minute quantity of refrigerant which is discharged. Leaks with less than 5 grammes of refrigerant loss per annum can be detected using this equipment.



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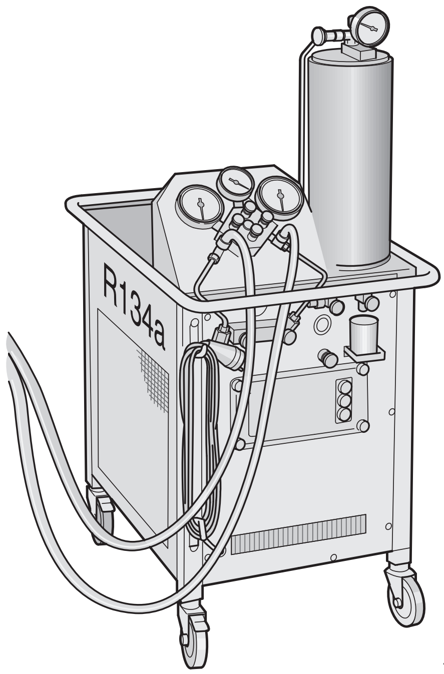
An all-in-one system for checking, drawing off, evacuating and filling – the Service Recycling Station

This station meets all the requirements relating to the maintenance, testing and commissioning of vehicle air conditioners in refrigeration terms.

Various makes of station are available.
A station comprises various individual units:
Filling cylinder, pressure gauges, vacuum pump, shut-off valve, filling hoses.
Quick-connect adapters for the service connections in the high- and low-pressure areas of the refrigerant circuit.

The stations can be used to empty, evacuate and fill the vehicle air conditioner.
The extracted refrigerant is recycled (dried and cleaned by removing suspended matter) in the station and refilled after being repaired.



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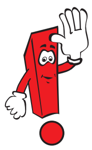
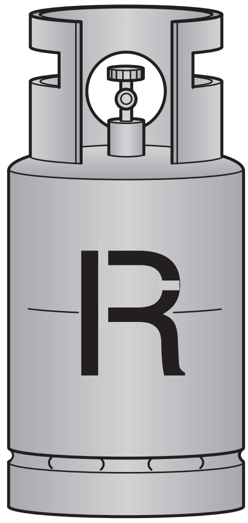


Under the government ordinance prohibiting the use of CFCs and halogens, it is not permitted to perform work on air conditioners without the recycling station.
Recycling stations may only be operated by expert personnel.

For refrigerant disposal – the recycleable bottle

Refrigerant which contains excessive amounts of impurities, e.g. due to internal mechanical damage to the compressor, should not be cleaned. This refrigerant is drawn off in a separate extractor station with a recycleable bottle, which is evacuated on delivery and then disposed of.

Recycleable bottles may only be filled up to 75 % of the specified filling weight (expansion of the refrigerant upon exposure to heat must be possible). Therefore, they must be weighed using a calibrated weigher while being filled (observe the Pressure Vessel Code).

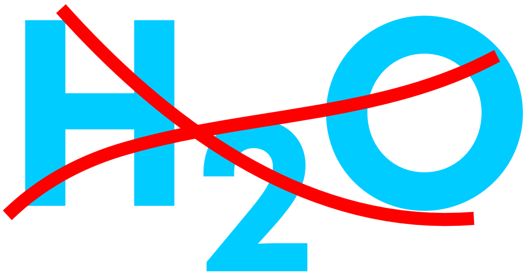


208_086

General information on function influencing factors

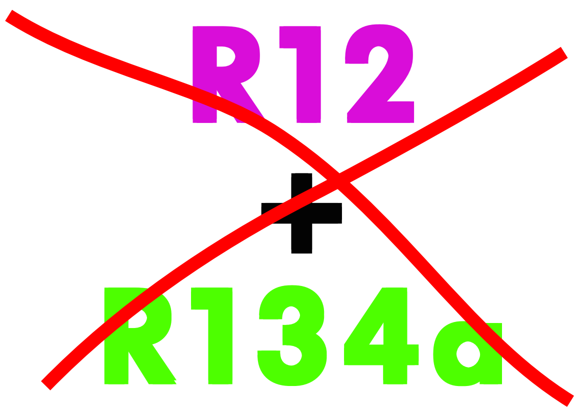
Mechanical faults (e.g. damage to the compressor) can reduce the cooling capacity of the air conditioner, as can chemical or physical influences.
The refrigerant in particular can have an effect on the functioning of the air conditioner by virtue of its properties. Therefore, a knowledge of general relationships is also important to everyday servicing, and not only for the specialists working at the service station for air conditioners.

Refrigerant and moisture



Only small amounts of water can be dissolved in the liquid refrigerant. However, refrigerant vapour and water vapour will mix in any proportion.
If the drier in the fluid tank or collecting tank has already absorbed 6 - 12 grammes of water,– i.e. a relatively small quantity, – it may not function properly depending on type. Any existing water is entrained into the refrigerant circuit. This water reaches the nozzle of the expansion valve or the restrictor and freezes.
This will reduce the cooling output of the air conditioner.
Water will damage the air conditioner irreparably because it combines with other impurities to form acids at high pressures and high temperatures.

Refrigerant + refrigerant



Refrigerants may not be mixed with one another (their chemical and physical properties are different and they contain different oils).
Only the refrigerant specified for a particular air conditioner may be used.
Air conditioners which can no longer be supplied with R12 according to the ordinance prohibiting the use of halogens must be converted in compliance with special guidelines.

Refrigerants and plastics

Refrigerant can dissolve certain plastics. These dissolved plastics can be deposited in the expansion valve or at the restrictor after they cool down.
The valve will become obstructed.
Therefore, always use original spare parts at seals.

Refrigerants and metals

Refrigerant R134a is chemically stable in its pure state. It does not attack iron and aluminium. Contamination of the refrigerant, e.g. with compounds of chlorine, however, can lead to certain metals and plastics being attacked. This can result in obstruction, leaks or deposits at the compressor piston. Therefore, always use R134a compatible original spare parts.

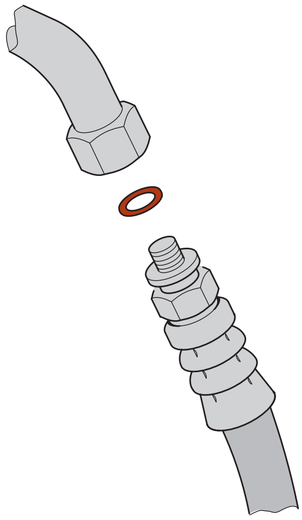
For this reason, air conditioners can only be converted from refrigerant R12 to R134a, including refrigerant oil, according to special guidelines of the manufacturer (retrofit-process).

Refrigerant circuit and impurities

A refrigerant circuit filled with refrigerant R134a can be cleaned:
in order to remove impurities, moisture or old refrigerant, the refrigerant circuit is cleaned with dried compressed air and then demoisturised with nitrogen.

This is necessary when
– the refrigerant circuit was opened during its normal lifetime (e.g. after an accident),
– there is doubt regarding the amount of refrigerant oil contained in the circuit,
– the compressor has to be replaced due to internal damage.

The gas mixture emerging from component parts of the refrigerant circuit must be drawn off using workshop suction apparatus.



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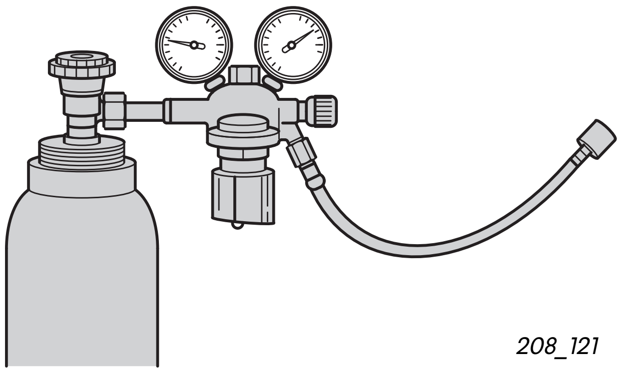
Always use original spare parts.

Conversion from refrigerant R12 to R134a



208_121

Fault diagnosis through pressure testing

For service work, there are terminals for the Service Recycling Station in the low-pressure and high-pressure ranges

- for filling
- for emptying
- for evacuating and
- for pressure testing.

To perform a pressure test, the pressure gauges of the station are connected. The pressure test is performed with the air conditioner switched on.

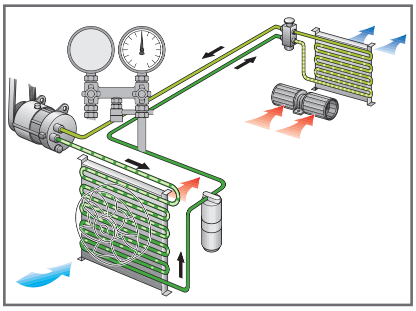
A pressure test involves intervening in the refrigerant circuit via the service connections.
The hoses of the pressure gauges will always contain residual refrigerant. Therefore, pressure tests may only be performed at air conditioner service points by specialist personnel.

The ambient temperature when the engine is not running always affects the pressure in the refrigerant circuit.

Using the test data for the high-pressure side and the low-pressure side, the system can identify whether an air conditioner is operating properly when the engine is running.

The measured values must be compared with the test data of the vehicle-specific refrigerant circuit according to the Workshop Manual, as they vary greatly from one vehicle type to another.

The pressure diagrams show the tolerance ranges for systems with an expansion valve and systems with a restrictor.



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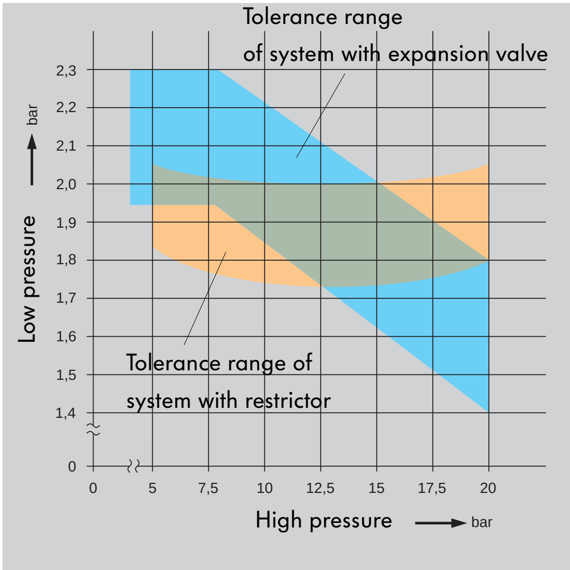
High-pressure service connection



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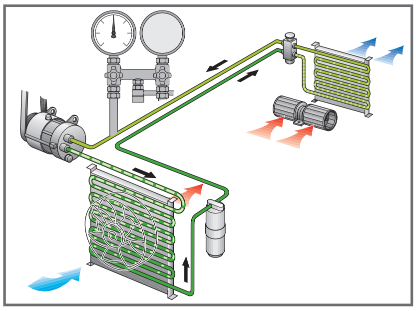


208_011

Low-pressure service connection

Fault diagnosis through self-diagnosis

Not all air conditioners have self-diagnostic capability.

Self-diagnosis is used very little in the case of manual air conditioners (they have either no or very few sensors/actuators/control units).

In some manual air conditioners, however, the circuit for the compressor and the sensors of the safety cut-out are registered by the self-diagnosis.

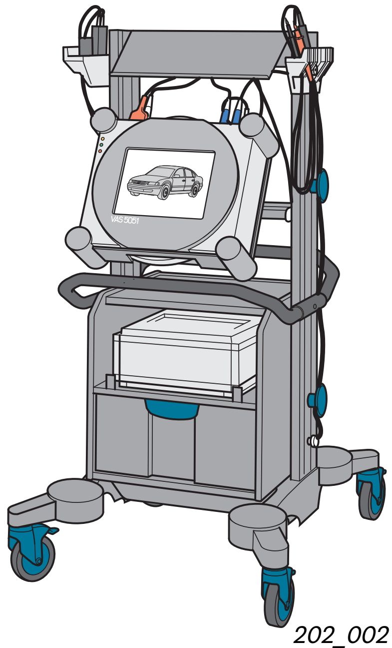
Automatic air conditioners with control units usually have self-diagnostic capability.

The address word for the self-diagnosis:

08 - Air conditioner/heating electronics

Self-diagnosis can be performed with
Vehicle Diagnostic, Testing and Information System VAS 5051,
with Vehicle Systems Tester V.A.G 1552 or with Fault Reader V.A.G 1551.

Faults which impair the operation of an automatic
air conditioner are stored in the fault memory of the air conditioner control unit.
In some systems, e.g. CLIMATRONIC, faults of this type are indicated on the display unit when the ignition is switched on (all the symbols flash for several seconds).



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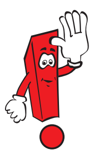


The self-diagnosis functions and the self-diagnosis procedure are explained in detail in the Workshop Manual for the heating and air conditioning system of the vehicle type.
Self-diagnosis can be performed by any workshop, because the refrigerant circuit is not affected by this procedure (i.e. it is not opened).

Key cooling system terminology

The cooling system air-conditions the vehicle interior using the laws of physics. A chemical medium, the refrigerant, is used for heat exchange.

The principles of cooling engineering are easier to understand with a knowledge of the key terms:

Heat	→	an energy form	–	measurable by the temperature in degrees
			–	by the quantity of energy in Joules (calories) can be stored or
		states can change	=	slight temperature rise (heat absorption)
		or	=	slight temperature decrease (heat dissipation)
			=	always propagates towards lower temperatures.

Cold → is in fact only a low degree of heat. Temperatures below the freezing point of water are generally referred to as cold.

Critical point → above this point, there is no interface between liquid and vapour. A substance is always in a vapour state above the critical point. If a gas is heated above the critical point, liquefaction will no longer be possible.

Boiling point → The temperature at which a substance changes from a liquid to a gas. The boiling point is pressure-dependent; the boiling point increases as pressure increases.

Dew point → the temperature at which the saturation point is reached as the result of cooling of a gas with a specific water vapour content. When the gas cools down further, some of its vapour content precipitates on the cooling surface in the form of a "condensate“.

Condensation → this time the change of state is from a gas to a liquid.

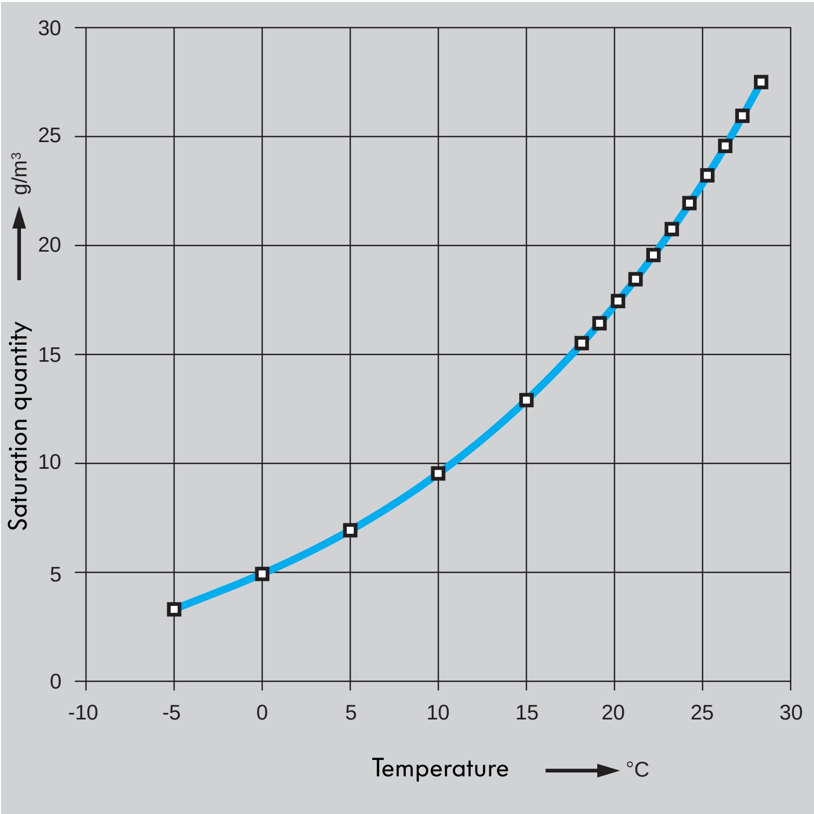
Refrigerant → the chemical medium used for the heat exchange process. Depending on the pressure and temperature conditions, the refrigerant exists in a gaseous or liquid state in the air conditioner. The refrigerant cools down when it expands.

Cooling through expansion → if pressurised gas can suddenly expand via a valve,
— it will cool down in the process, e.g. when deflating the tyres.
The pressurised air flowing out of the valve is cool.

Water vapour content of the air

Saturation quantity of water vapour in air at
100% relative humidity and normal air pressure

Temperature °C	Quantity (g/m^3)
-5	3.25
0	4.85
5	6.80
10	9.41
15	12.84
18	15.39
19	16.32
20	17.32
21	18.35
22	19.44
23	20.61
24	21.81
25	23.07
26	24.41
27	25.79
28	27.26



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Absolute atmospheric humidity → (g/m^3) is the water content in 1 m^3 of air.

Relative atmospheric humidity → given in %, the ratio of water vapour quantity in the air to max. possible water vapour quantity in air.

re table → The table shows how many g of water per m^3 the air can hold at various temperatures. 100% saturation is shown. The higher the temperature, the larger the quantity of water in the air.
The rule of thumb is: at a temperature of 10 to 30 °C, the water content in the air in g/m^3 is roughly the same as the temperature in °C.

Service.

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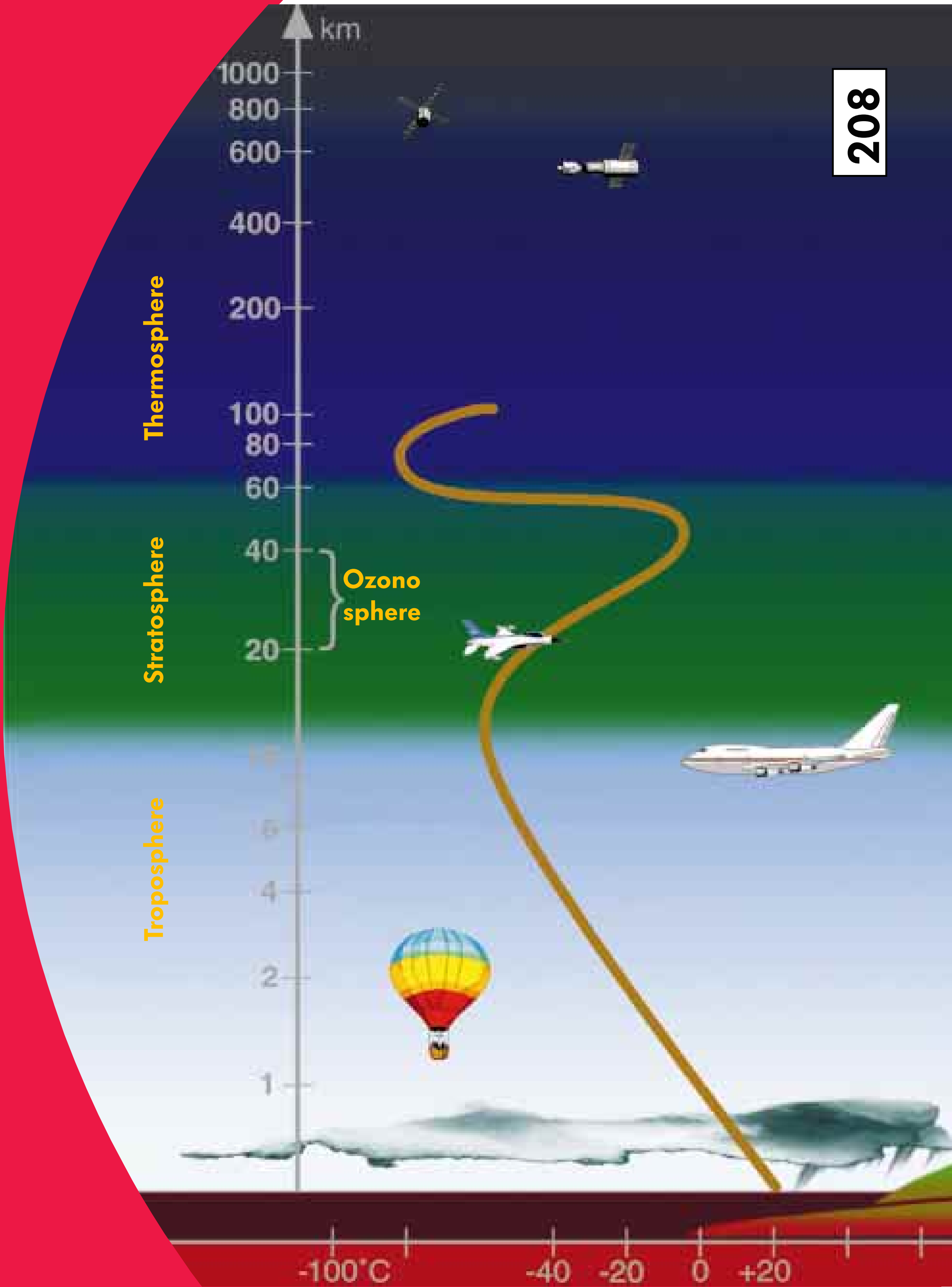

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