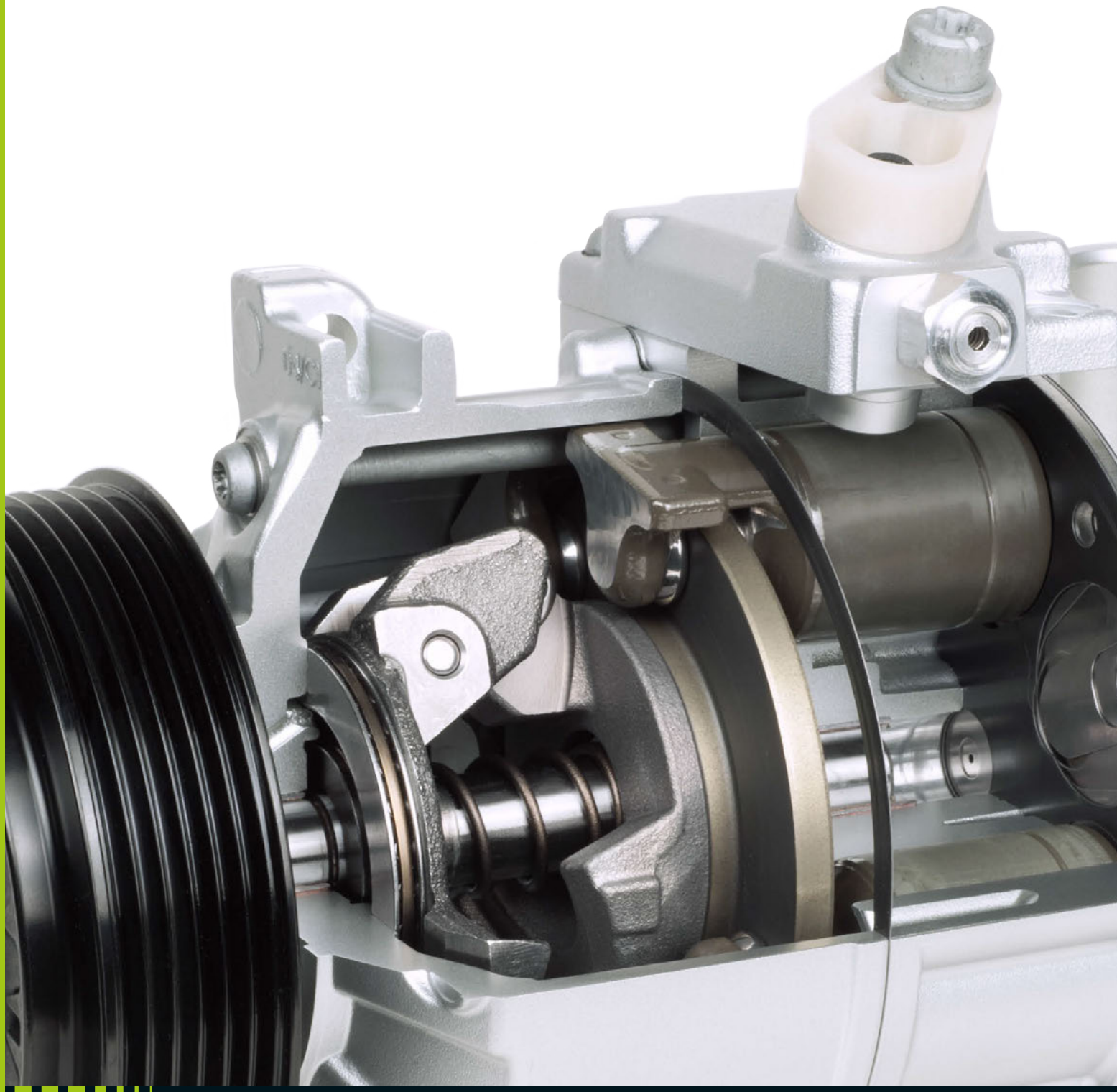
Air conditioning

The A/C system

Thermal comfort loop



Technical handbook valeoscope

Valeo, your Air Conditioning Multi-specialist

As one of the world's leaders & multi-specialist in Air Conditioning and cabin filtration systems, Valeo offers you:

- its full knowledge in A/C loop design, including all its components,
- a complete Aftermarket product offer with more than 2,500 part numbers,
- A unique Air Quality product range, composed of a full Passengers Car & Truck Cabin Air Filter range (including latest polyphenol technology) and purifying solutions **ClimPur**™ & **ClimSpray**™
- a full range of garage tools, accessories and consumables,
- a full range of services: training, technical support, point of sales material, logistics «speed, service and quality».

Valeo

Table of Contents

Foreword

Our Multi-specialist expertise is rooted in our genes.

As one of the leading automotive system designer and manufacturer, nothing is more natural for Valeo than to deliver 14 product lines for passenger cars and 8 product lines for heavy duty, serving all distribution channels from carmakers network to independent aftermarket and modern distribution, in more than 120 countries all over the world.

The A/C market

Yesterday considered as luxury equipment, the air conditioning widely became more democratic today and now equips 90% of new vehicles in Europe. As a consequence, inquiries for Air Conditioning maintenance and repair follow the same evolution and are a real opportunity for workshops to increase their revenues.

In this framework of important and continuous growth, Valeo Service is proud to present you the 2013 Air Conditioning technical handbook,the first step to a fully renewed technical collection. More and more customers are expecting to be advised on what they are paying for; Systems expertise is today a prerequisite and makes a real difference between the recognised workshops and the others. From the Kyoto protocol to thermal comfort rules, system overview and interactions between components, this book will allow you to rediscover the air conditioning system. More focussed operations on the A/C system will be treated through technical bulletins and videos.

Valeo: From original equipment leadership to aftermarket excellence

1 Disclaimer

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To the extent that this documentation and this training documentation are provided free of charge, we will not be liable for any loss or damage of whatsoever nature.

2 Valeo, the air-conditioning multi-specialist

Valeo is an independent industrial Group fully focused on the design, production and sale of components, integrated systems and modules for the automotive industry, mainly for CO_2 emissions reduction. Valeo ranks among the world's top automotive suppliers. The Group has 125 plants, 21 research centres, 40 development centres, 12 distribution platforms, and employs 72,600 people in 29 countries worldwide.
Valeo has 4 Business Groups, comprising 16 Product Groups, supplying the Original Equipment Market (O.E.M.) and the Aftermarket.

The 4 Business Groups are: Powertrain Systems, Thermal Systems, Comfort and Driving Assistance Systems and Visibility Systems.

Climate Control product portfolio is part of Valeo's Thermal Systems Business Group.

11,8 Billions euros sales (at end December 2012)
72,600 Employees
125 Production sites
21 Research centres
40 Development centres

Valeoscope library

Technical handbooks

Air Conditioning
Ref: 998321

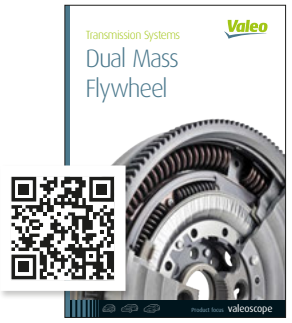
Lighting Systems
Ref: 998542

Product focus

Transmission Systems
Clutch HEC-SAT
Ref: 998121

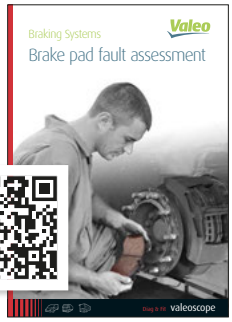
Transmission Systems
Clutch Hydraulics
Ref: 998123

Transmission Systems
Clutch KIT4P
Ref: 998102



Transmission Systems
Dual-Mass Flywheel DMF
Ref: 998120

Diag & Fit



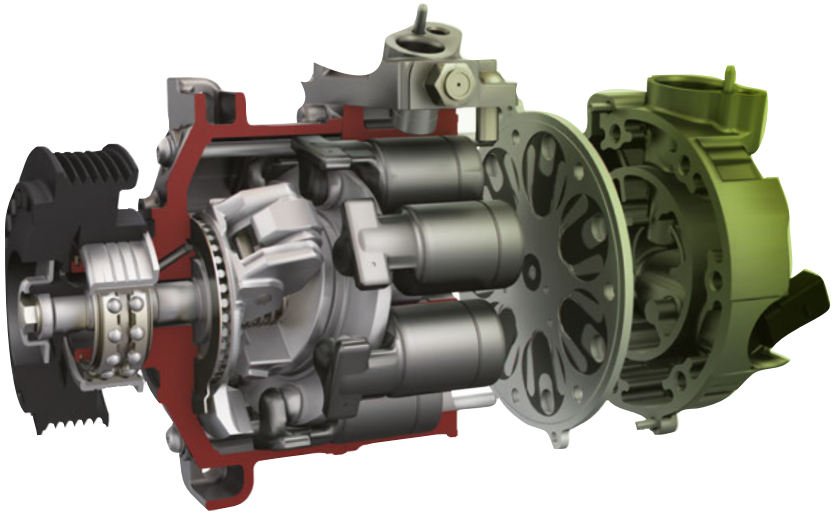
Truck Brake Pad
Ref: 957100

Valeo compressors

The compressor is the driving element of the refrigerated loop since it ensures the circulation of the refrigerant in the A/C loop.

Valeo compressor range 2013

- *5% increase in car parc coverage, 54 new part numbers, 77% car parc coverage in Europe*
- ***Valeo is the O.E. supplier for the new Renault Clio IV, for Volkswagen Golf V & VI, for Dacia Logan, Sandero, Duster & Lodgy (2012) including for Mercedes-Benz & Volvo applications***
- *New Ranges: 32 European & **22 Asian** to include Hyundai i30 1.4/1.6 (2006), Kia Picanto 1.1/1.0/1.1 CRDi (2004), Kia Sorento 2.5 CRDi (2002)...*



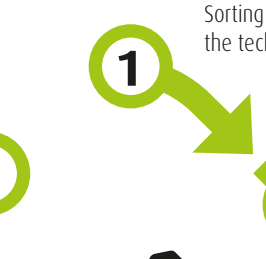
Best-in-class remanufacturing process

O.E. Process: *100% traceability*

Final Test for 100% of the production
Leak test, functional test, fill up with Nitrogen to ensure stock safety

Core collection or received from customers
Sorting done according to the technical part number

Disassembling
Pump line / clutch line



Washing / fountain wash / tribofinition

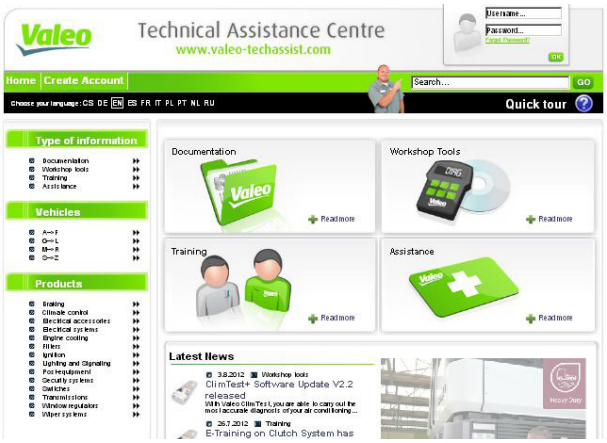
Remanufacturing and control of sub-components
45 visual, electric and functional controls

Replacement of wear parts
Injection of new components to ensure durability (all O'rings, seals, bearings)

Replacement of forbidden materials legislation (Cd, Cr^{+6})

3

valeo-techassist.com



Valeo TechAssist is a web based application, specifically developed for repair workshops, automotive spare parts distributors and technical trainers.

Valeo TechAssist is available at any time, and available in 10 languages today. Just connect to the website www.valeo-techassist.com.

Valeo TechAssist is not only a technical database but also a learning platform and a forum of information. It covers passenger cars and all Valeo product lines.

The information in Valeo Techassist is structured in four comprehensive domains:

1.Product documentation

2.Technical assistance

3.Workshop tools

4.Technical training

You will benefit from Valeo Techassist throughout the workshop service process:

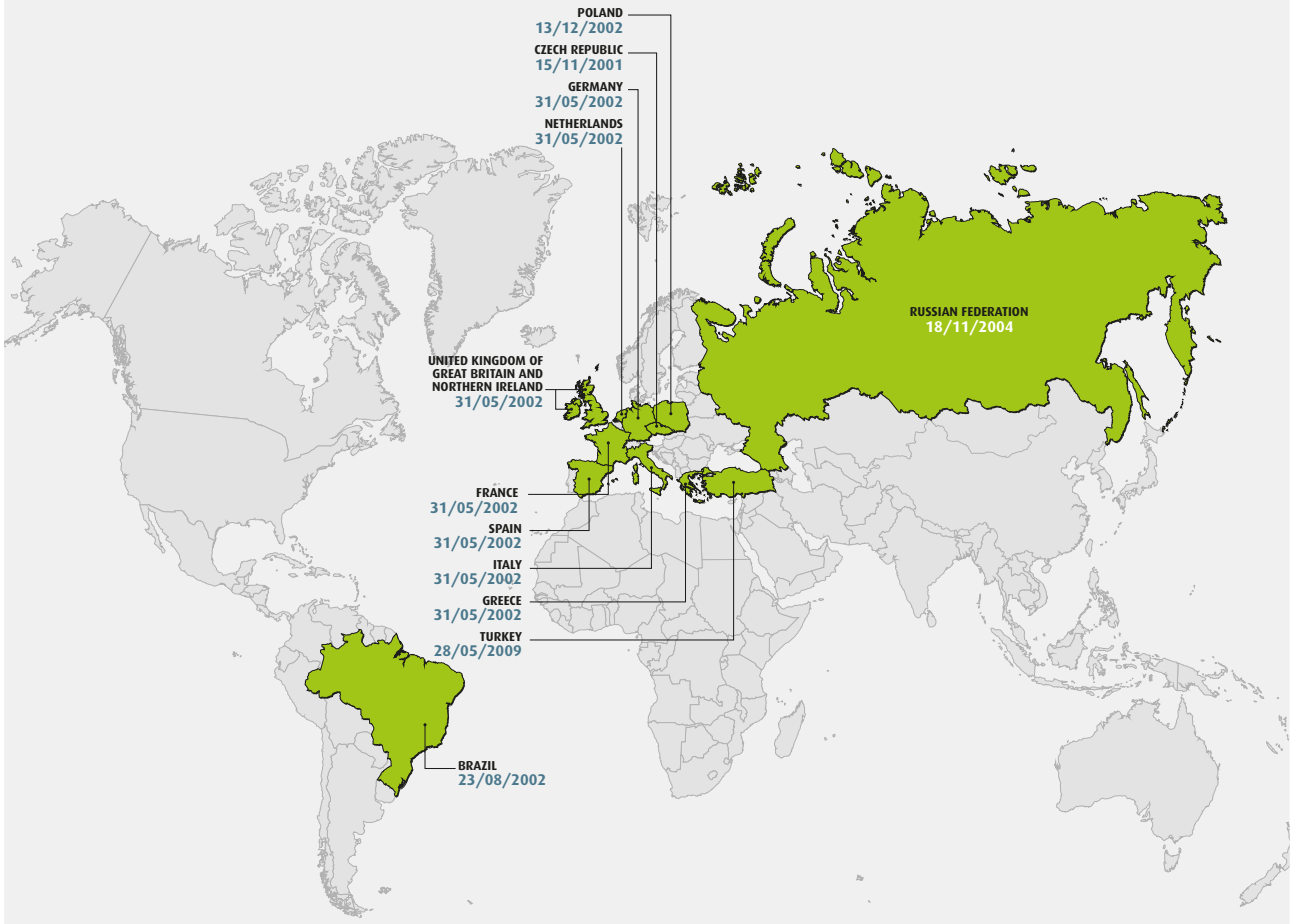
- Get product information: product data sheets provide you details on top of the catalogue information.
- Find common failures: step-by-step failure diagnosis guides about typical faults.
- Keep you updated about Valeo Service products: full access to all Technical Service Bulletins.
- Find help when it is needed: answers to frequently asked questions and details of how to get in contact with the Valeo Service technical hotline.
- Use Valeo workshop tools efficiently: retrieve user manuals, service manuals and software updates on Valeo Service tools.
- Learn about new technologies: online training modules (e-learning) and self reading documents about the most modern product technologies.

In addition, you have access to some advanced features:

- Add comments to any document: provide your personal feedback to Valeo Service and contribute to the service enrichment.
- Fill in your evaluation: provide feedback on your satisfaction.
- Write a fitting testimony: share your experience with other users.

4 Regulations on the A/C business

Ratification dates of Kyoto protocol



4.1 The Kyoto commitment

Refrigerant fluids do have an impact on our planet by increasing the greenhouse effect.

Many countries have signed the Kyoto Protocol and committed to reducing the effects of A/C systems **by securing their air conditioning servicing practices and by tracing the refrigerant business in the automotive industry.**

The objective was to reduce overall emissions of greenhouse gases by at least 5% to below 1990 levels in the commitment period 2008 to 2012.

Kyoto Protocol Ratification
The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change (http://unfccc.int/2860.php)

The Kyoto Protocol was adopted in Kyoto, Japan, December 1997.
The Kyoto Protocol entered into force on 16 February 2005.

Deployment dates and local rules vary from country to country, but basic common rules must be applied by all.

- Assessment of the first phase by end of 2012
- Next objective is to reach -20% in 2020 vs 1990 (Europe decision No 406/2009/CE) and -50% by 2050

4.2 Kyoto Protocol basic rules

Countries may implement the Kyoto protocol in many different manners but the aim is common to all.

4.2.1 Fluid volume traceability

- Refrigerant must be traced at distribution level
- Refrigerant must be traced at garage level

4.2.2 Garage equipment and people competency

Garages must be well prepared to proceed to refrigerants manipulations

- All the appropriate tools must be available in the workshop
- People must be skilled in A/C servicing

4.2.3 Maintenance procedures

- The A/C loop refill is only authorised if the loop is not leaking
- An empty loop cannot be refilled prior to a full leak diagnosis
- Refrigerant degassing is forbidden

4.2.4 A/C system evolution

Since the Kyoto Protocol, players in the A/C market have committed to reducing the effects of refrigerants on global warming and ozone depletion.
Two indicators are used to assess the effects of refrigerants on Earth ozone depleting and global warming:

- **The ODP – Ozone Depleting Potential**
- **The GWP – Global Warming Potential**

5 Air Conditioning well-being in the cabin all year long

Air conditioning is used both in the summer and the winter; all year round. It enhances comfort at the wheel and sharpens the driver's reflexes.

This is a result of the various functions that air conditioning fulfills.

Air conditioning makes for greater well-being, because:

- The temperature is just right
- The air is filtered
- The humidity in the air is under control

Air conditioning makes for improved safety because the driver's vigilance is enhanced. It helps to overcome:

- Irritation and lack of attention
- Poor visibility, helping to improve the driver's reaction time.

In summer:
The air conditioning cools down the hot air entering the vehicle in order to obtain the required temperature inside the cabin (usually around 22°C) and to maintain this temperature, despite changes in the ambient conditions (day, night, rain, sun, etc.), using the regulation functions.

In autumn, winter and spring:
The air conditioning dries the air. This function can be used to demist the windscreen and other windows in the cabin, thereby improving safety. Ideal demisting performance is achieved by combining the conditioned air with the heating.

Vehicles are used in hot and cold temperate climates. These notions characterise a geographical zone and a season.
The ambient climatic conditions are measured by two thermodynamic quantities:

- Temperature
- Humidity

6 Thermal comfort

6.1 The thermal regulation machine in the human body

Human beings are warm-blooded, which means that their internal body temperature must stay close to 37°C (±0.5°C).

When conditions become uncomfortable, the human body reacts by calling on a number of physiological mechanisms that help to achieve a state of thermal stability:

- **Vasoconstriction** helps to regulate blood circulation by reducing the flow of heat to the limbs, while **dilatation** does the opposite
- **Shivering** causes the body temperature to rise and changes the conditions of the heat exchanges between the skin and the exterior air (goose pimples)
- **Perspiring** cools down the body by evaporation through the surface of the skin.

The temperature

Heat exchanges between the exterior environment and our bodies take place through our skin.
If the temperature of the ambient air is higher than 32.2°C, then this means the transferring of heat is no longer sufficient to keep the body at 37°C, in which case the sweat glands take over and produce perspiration on the surface of our skin.
As this sweat evaporates, our skin cools down.

6. Thermal comfort

Humidity

Very humid ambient air (60% and above) is almost saturated with water. Our skin can no longer release all the perspiration and we start to feel hot again.
On the other hand, if the humidity of the air is 30%, then 70% of its capacity to store water vapour remains available. Perspiration evaporates more easily, helping to keep the body cool.

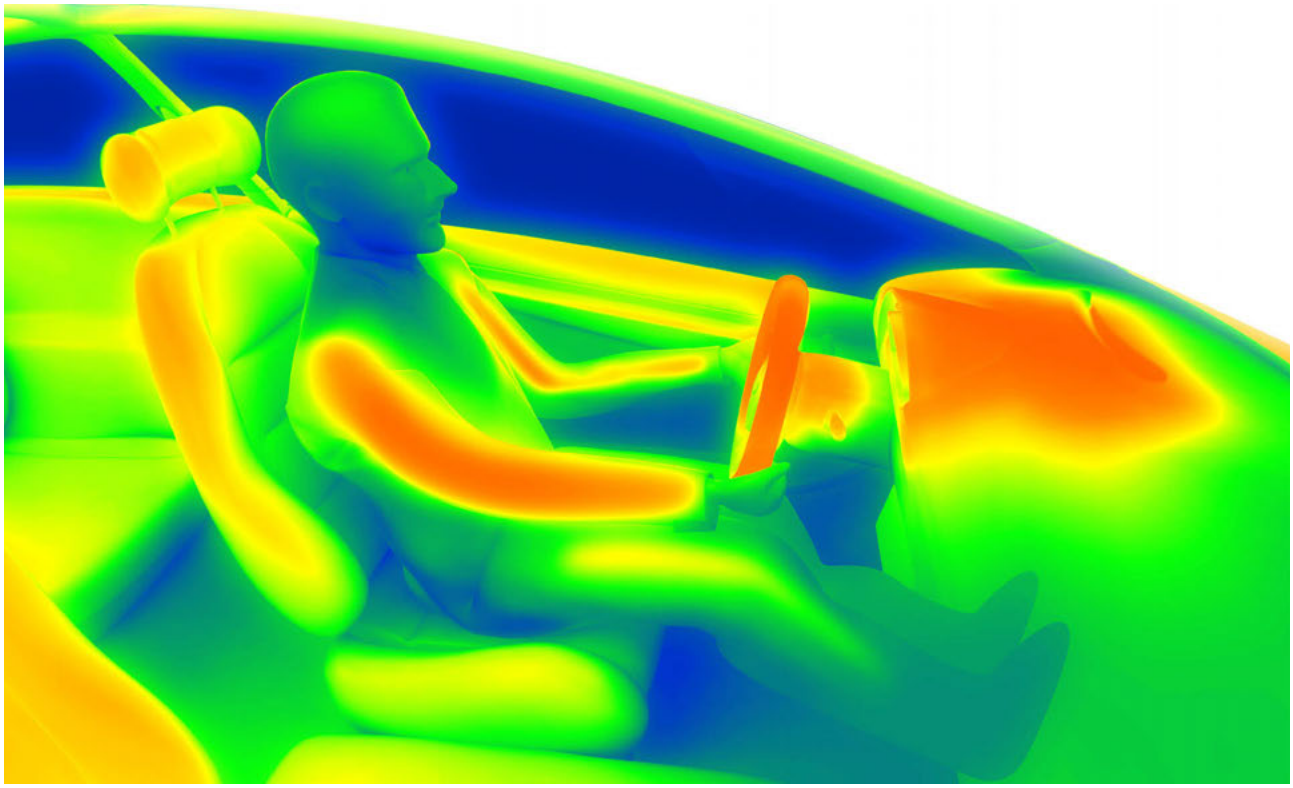
Thermal balance

Thermal comfort is achieved when the flows of energy to which the human body is exposed are balanced. The heat generated inside the body, which depends on our activity, must offset the energy flows with our environment.

These flows correspond to the following mechanisms:

- The production of energy (metabolism), part of which is dissipated as heat
- Conduction between the inner body and the surface of the skin
- Heat exchanges through the lungs, by emitting water vapour and a rise in the temperature of the air we breathe out
- Exchanges of mass, through the evaporation of sweat
- Convective exchanges between the skin and the ambient air
- Direct solar radiation or radiation reflected by objects

Thermal comfort is achieved when we reach a state of thermal neutrality. We feel neither too warm nor too cold. In physical terms, this state of neutrality means that the thermal flows created by metabolism and the exchanges with the exterior are in equilibrium.



6.2. Physiological comfort

The notion of physiological comfort is highly subjective. Nevertheless, our perception of hot atmospheres is determined by the temperature and the humidity of the air.

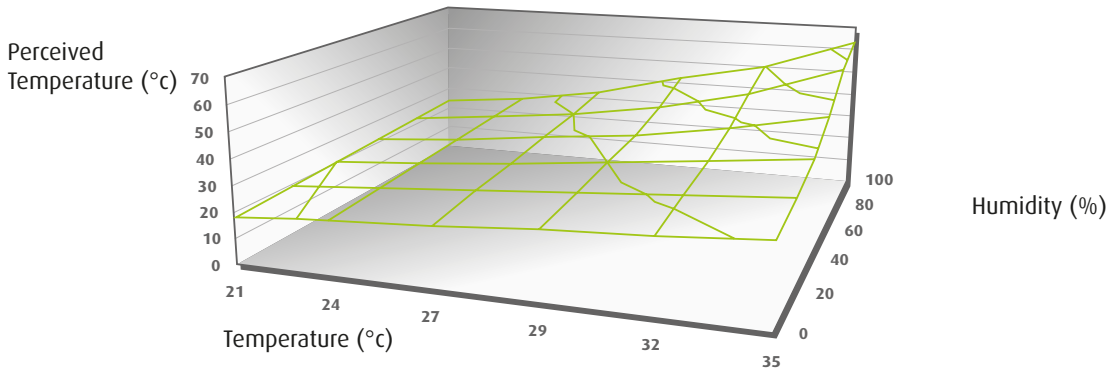
The definition of comfort refers to certain combinations more often than others.
For example, dry air is more comfortable than humid air. This is the perfect example of apparent temperature.

The figure below illustrates how humidity influences our perception of temperature, and therefore, of our comfort.

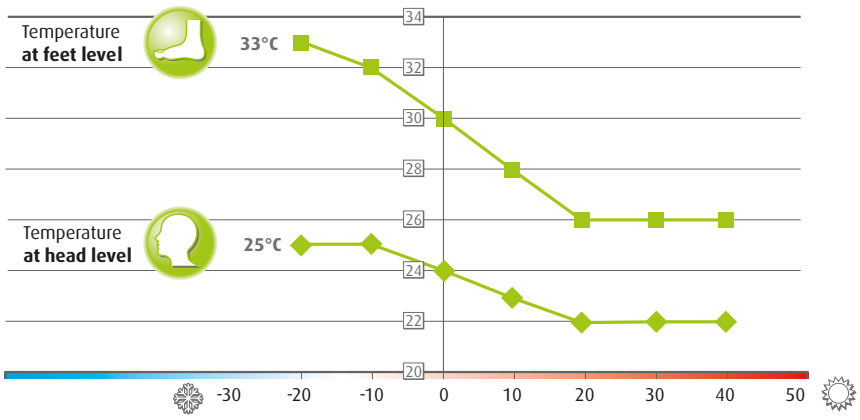
Analyses of the behaviour of vehicle occupants have identified the average comfortable temperatures.
The designers of air heating and cooling systems use these values to define the characteristics and design of their systems.
The following figure illustrates the need to adapt average foot and head temperatures to the temperature outside the vehicle.

Note that, in winter, the difference between the head and foot temperatures produced by the system is greater, in order to achieve optimal comfort for the occupants.

Human perceived temperature versus humidity



Heat distribution versus seasons



TIME FOR CHANGE

Clim FILTER™ SUPREME

Innovative, first cabin air filter to neutralise allergens

92% efficiency

For your well-being, safety and correct functioning of your A/C system:

- replace ClimFilter™ Supreme regularly every year of every 15,000 km
- keep the windows closed to avoid allergens entering the cabin

Protects you against:

- **harmful particles** (pollen, dust, spores, ashes, bacteria, soot...) > 0.1µm
- **unpleasant odours**
- **harmful gases** (ozone, nitrogen dioxide, toluene, butane, sulphur dioxide...)
- entrance of **pollen allergens** into the cabin by their neutralisation at the filter surface

For the most precious air circuit - yours!

Automotive technology, naturally Valeo

Air conditioning comfort and safety

The role of the air conditioning system is not limited to setting a comfortable temperature for the vehicle's occupants. The system also makes an important, and often neglected, contribution to their safety.

Defrosting / demisting

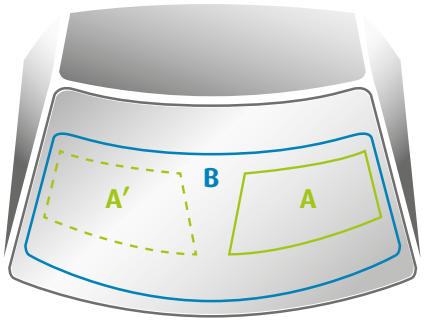
The heating system also defrosts and demists the vehicle's windows, making for better visibility and improved safety.

- The design of the air distribution system, and in particular the layout of the vents and air outlets, plays a crucial role in keeping the windows, and especially the side windows, free of mist.
- The air conditioning system helps to eliminate mist on the windows.
- The visibility zones of a windscreen must meet given standards which are taken into consideration in the vehicle's design.

Every vehicle shall be equipped with a system for removing frost and ice from the glazed surfaces of the windscreen. The windscreen defrosting system shall be effective enough to ensure adequate visibility through the windscreen in cold weather.

Regulations applying to defrosting zones, as per the standard 78/317 CEE (Europe).

Defrost regulation



The efficiency of the system shall be verified by determining the defrosted area of the windscreen periodically after starting the engine, the vehicle having been kept in a cold chamber for a certain amount of time.

- 20 minutes after the start of the test period, the area A must be 80% defrosted
- 25 minutes after the start of the test period, the area A' (passenger side) must be 80% defrosted
- 40 minutes after the start of the test period, the area B must be 95% defrosted

Electric heated windscreens are a good example of how defrost time and visibility can be perfected. They have an immediate effect and they do not impair the occupants' comfort since they are silent and do not generate strong air flows.
But they remain relatively rare, except in cold climates, and their use also depends on the levels of comfort proposed to customers.

8 Introduction to air conditioning systems

8.1 The role of air conditioning

We have all felt the discomfort of being too hot in a car, even in temperate climates.
The only solution until relatively recently consisted in turning up the ventilation in order to speed up the circulation of air inside the cabin.

Surveys have shown that, from the physiological perspective, increasing the ventilation can, to a certain extent, compensate for a rise in temperature.

For example, a temperature of 24°C in still air is equivalent to a temperature of 30°C in air that is moving at 1.5 m/s, with a relative humidity of 50% in both cases. But this remedy is no more than an interim measure that quickly becomes insufficient, as soon as certain temperature and humidity limits are exceeded.

In reality, even the very best ventilation systems make no difference above 30°C and 70% relative humidity. And the higher speed of the air flow often results in intolerable sensations on long journeys. The required level of comfort under any climatic conditions can only be achieved with an air cooling system.

The main role of air conditioning can be defined as follows:

«To guarantee the climatic comfort of the occupants by treating the air and providing controls that are easy to use.»

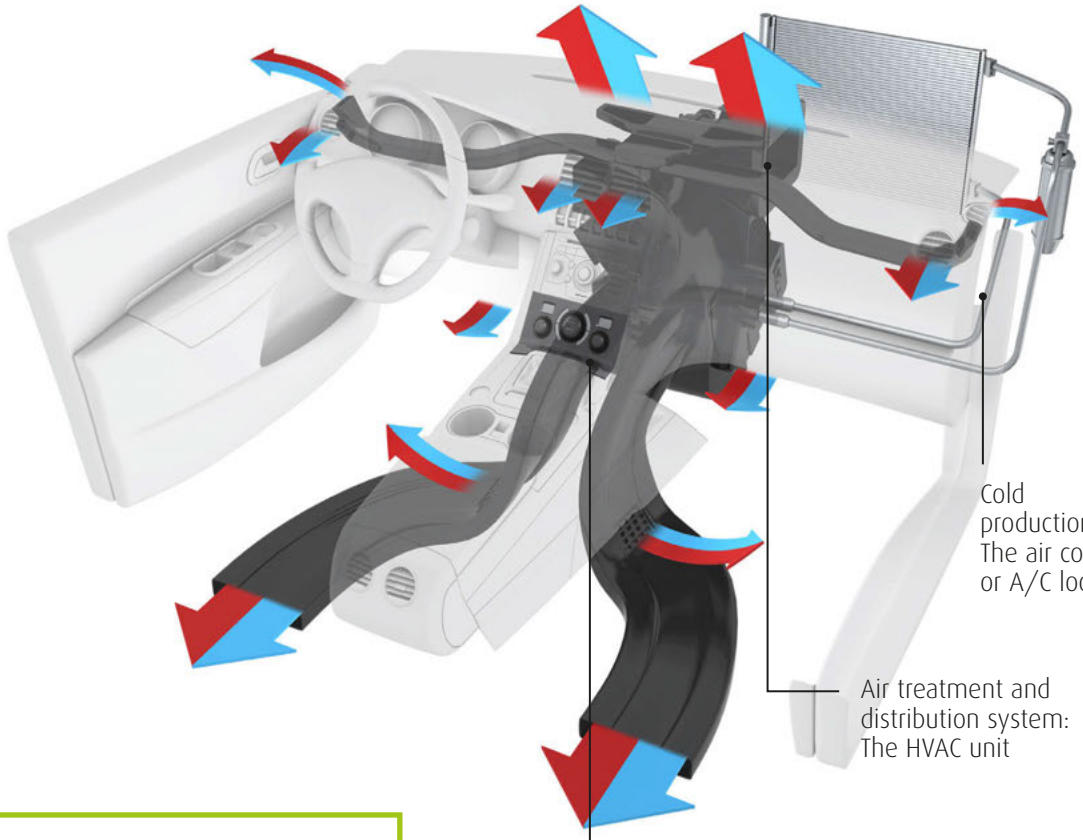
Climate control also fulfills another function: «To make sure that the visibility through the cabin's windows is quite clear.»

Cold production system :
The air conditioning or A/C loop

8.2 Overview of the air conditioning system

Vehicles are fitted with air conditioning systems for purposes of thermal comfort and safety.
The basic principle consists of circulating a flow of thermally treated air inside the cabin.
The air conditioning system fulfills the following functions:

- Treatment and distribution of air: the air circuit and the air conditioning
- Production of cold: the air conditioning or A/C loop
- Control of the system : the control panel and the air conditioning Electronic Control Unit (ECU)



Air treatment and distribution system: The HVAC unit

Control of the system: the control panel and the A/C Electronic Control Unit

9 The Heating Ventilation Air Conditioning unit (HVAC)

The HVAC can be driven manually via cables or automatically via electric micro-motors.

HVAC module for Nissan Leaf

The HVAC is located in the vehicle cabin, under the instrument panel.

For big vehicles & Sport Utility Vehicles, some additional units are used:

- Booster (blower unit) to improve the air flow rate
- Rear HVAC located mostly in the boot

The rear HVAC can be: a rear heater (heating & ventilation functions) or a rear cooler (cooling & ventilation function) or both. For vans & minibuses, some HVAC units are located in the ceiling.

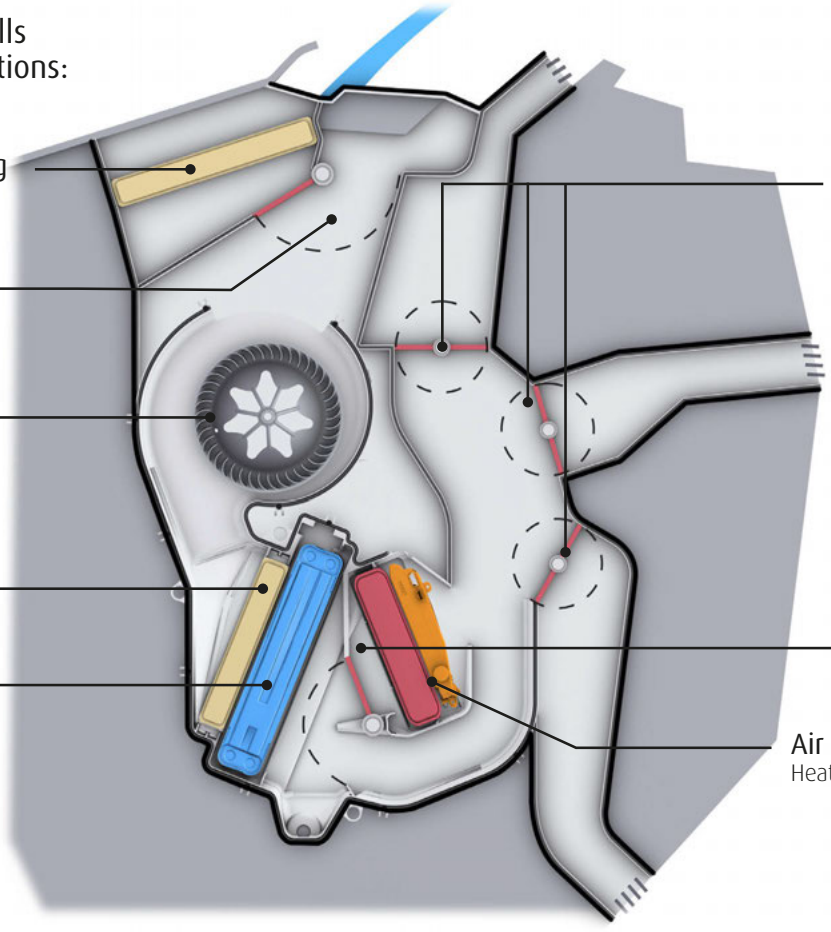
Did you know that:

On Electric Vehicles (EV's) and hybrid cars the additionnal heater located in the HVAC may be high voltage driven.

All appropriate measures must be taken prior to servicing this part

See the orange cable on Nissan Leaf HVAC

The HVAC unit fulfills the following functions:



HVAC: Heating Ventilation Air Conditioning

9. The Heating Ventilation and Air Conditioning unit (HVAC)

9.1 Air circulation

Air is the main component of an HVAC circuit.

Outdoor air inlet

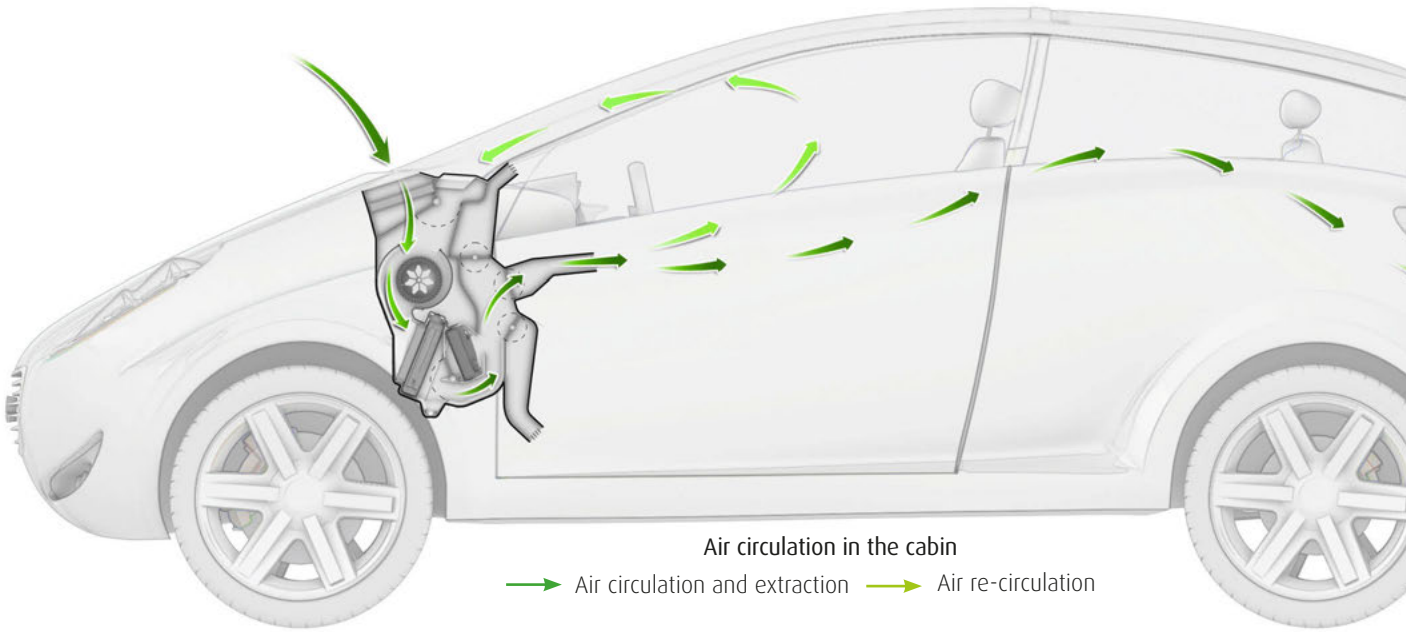
9.2 Capturing the outdoor air

The outdoor air enters the cabin through an air inlet between the windscreen and the bonnet, in a part of the bodywork known as the water separator that acts as a seal between the air conditioning system and the bodywork.
The air inlet is protected by a vent grill that prevents foreign bodies - leaves, insects, debris or even small animals - from entering the system.

The air inlet is located in a zone that is insensitive to dynamic pressure. The cross section must be large enough to avoid excessive loss of head. The hot air that is warmed by the bonnet or comes from the engine compartment must not be drawn in, and the path of the air must not disrupt the air flow at the blower inlet.

9.3 Extracting the air from the cabin

The air inside the cabin must be renewed. Once it has been captured and treated, the air must be expelled by extractors.



Air circulation in the cabin

→ Air circulation and extraction → Air re-circulation

The air extractors are made up of rubber membranes that act as valves. They open to let the air out of the cabin, then close again when the vehicle is at a standstill to prevent the outdoor humidity from entering the cabin.

Air extractors can be located:

- At the rear of the vehicle (behind the bumpers)
- In the wheel arches
- In the bodywork at the rear (in the quarter lights)
- In the centre pillar (on some 3 door hatchback applications)

9.4. Re-circulating the air

We have already seen that the air inside the cabin must be renewed. However, under certain conditions it may be important to isolate the cabin from any ingress of air from the outside. This is what the re-circulation system does.

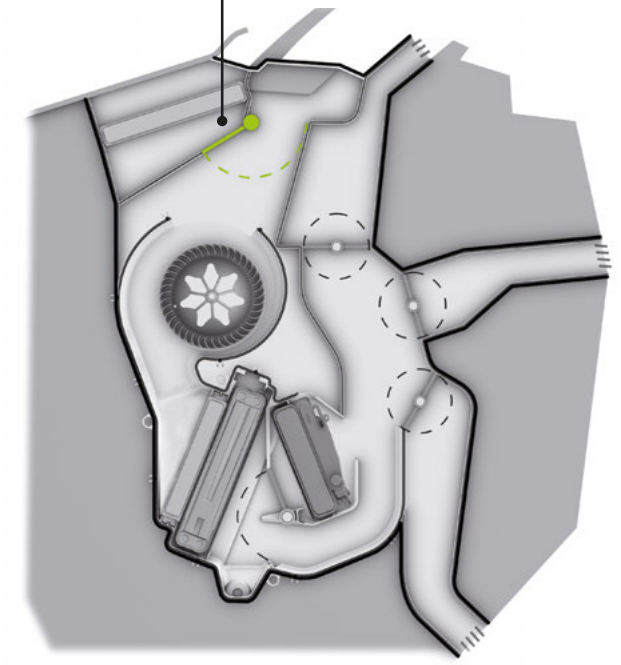
Re-circulation consists of reusing the air inside the cabin while preventing any outside air from entering the cabin.

The role of the re-circulation system is to:

- Allow the occupants to isolate themselves from the outside when in polluted environments
- Quickly converge towards conditions of thermal comfort when starting the system (this last feature is generally not known by end users)

Air exhausters

The re-circulation flap



The recycling function is located just after the HVAC air inlet

The re-circulation status can be fully open, fully closed or a mix between fresh and internal cabin air.

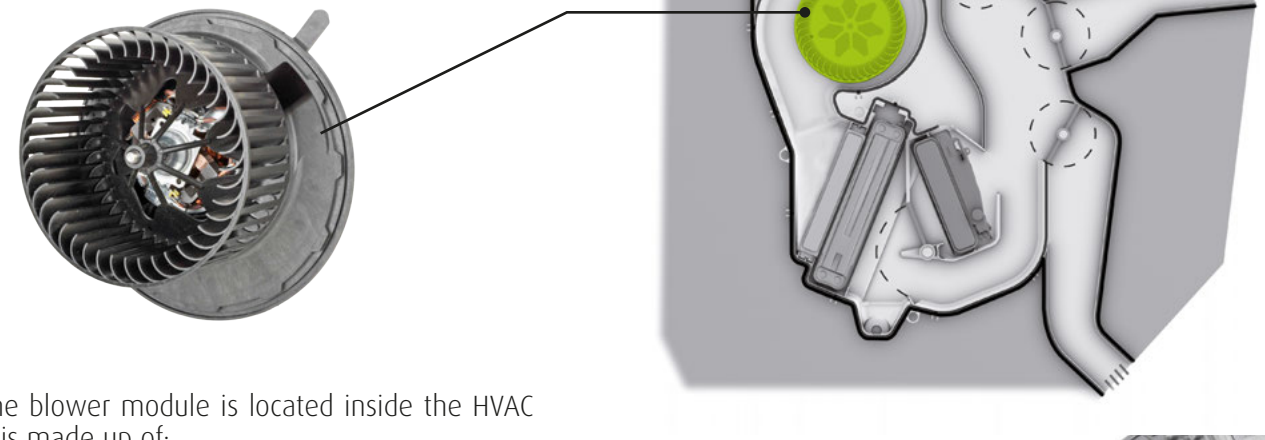
But the re-circulation can only be used for a limited length of time, or the windows may mist up and the occupants may suffer from a dry throat and eyes.

On automatic A/C systems the re-circulation flap is controlled by an actuator.
For maximum comfort the re-circulation function can be combined with an Air Quality Sensor.
The re-circulation actuation must be very reactive to avoid pollution entering the cabin.

9. The Heating Ventilation and Air Conditioning unit (HVAC)

9.5 Propelling the air

The air in the cabin is propelled by a motor driven fan, more commonly known as a blower.



The blower module is located inside the HVAC it is made up of:

- A fan
- A drive motor
- A power control device

The blower is designed on the basis of:

- The thermal power to be drawn from the heat exchangers in order to achieve the right flow rate
- The head loss in the circuit, in order to set the pressure.

Blower Types

Single inlet blower
and integrated electronics

Double inlet blower

Blower with housing

Blower control

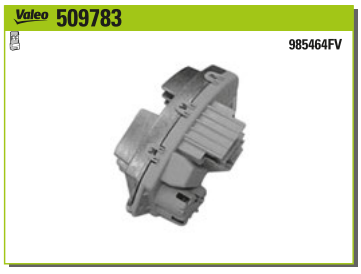
Resistive types

Ceramic type

Wounded type

Electronic types

Linear type



PWM type

The ventilation power is adjusted by a device that controls the blower speed. Two types of adjusting devices are used:

- Passive resistive devices that are adjusted in steps and contain two or three resistors corresponding to three or four speeds. The resistors are made of wire coils or mounted on a ceramic support.
- Power transistors for continuous adjustment.

The type of control device is determined by the system architecture.

9. The Heating Ventilation and Air Conditioning unit (HVAC)

9.6 Filtering particles suspended in the air

The air conditioning system is exposed to large quantities of exhaust gases, soot, dust particles, pollen and allergens.
Pollutants and particles must be trapped before air enters the cabin.

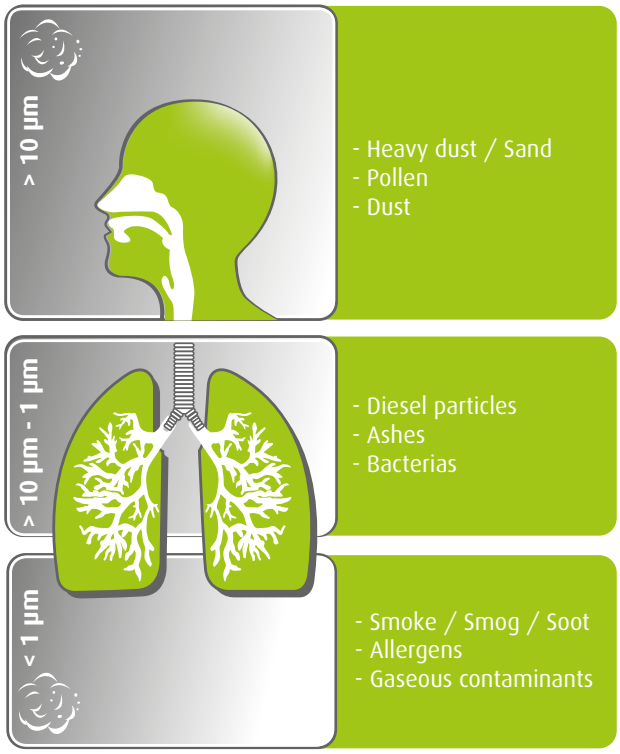
The largest particles (leaves, insects, etc.) are captured by the air inlet grille, which has a mesh measuring a few millimeters and acts as a preliminary filter.

The smaller the particle size the higher the risk for the occupants, particles smaller than 2.5µm are the most dangerous.
A cabin filter is built into the air conditioning system to trap those particles.

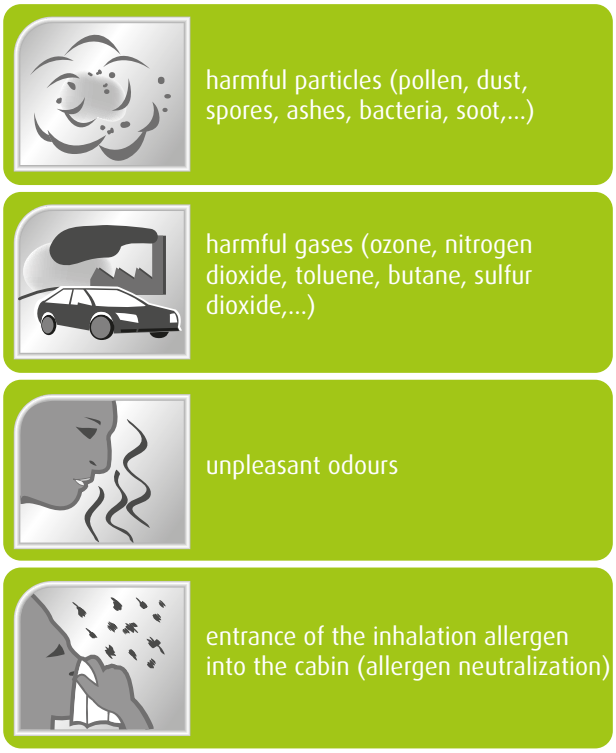
The cabin air filter functions :

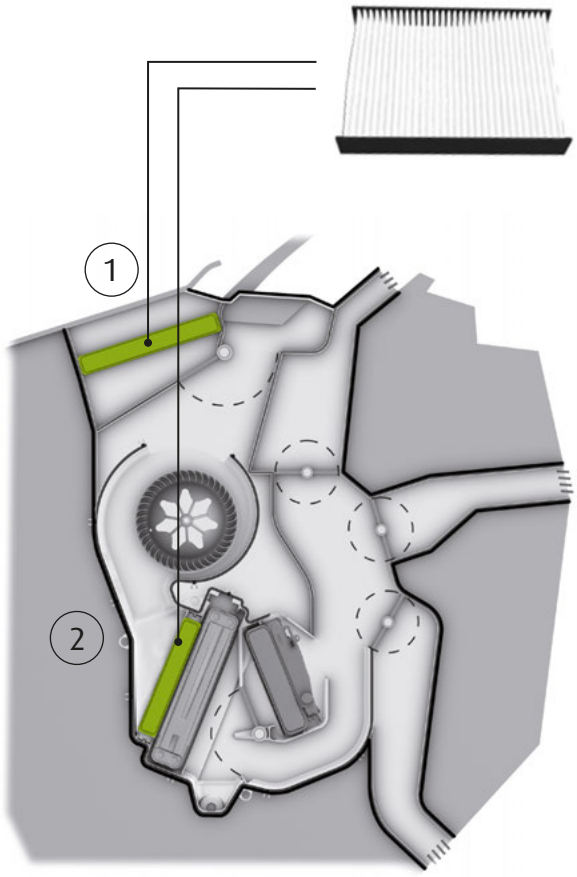
1. Car occupant's protection
   - Cleans the air from particles, gas, allergens, pollution

2. A/C system optimum functionality
   - Prevents from contamination of the heating and A/C system
   - Ensures maximum performances to the system
   - Prevents the soiling of the windows for a better visibility



PROTECTS AGAINST





Filter location:

The shape and the size of the filter depends on the HVAC architecture, it is located either:

1. In the air inlet before the blower
2. In the HVAC unit between blower & evaporator

10.6.1 Cabin air filter technologies

3 types of technology:

- Particle filter - PA
- Combined filter with active carbon - CA
- Filter with polyphenol and active carbon (neutralising allergen) – PCA

Particle filter

Combined filter

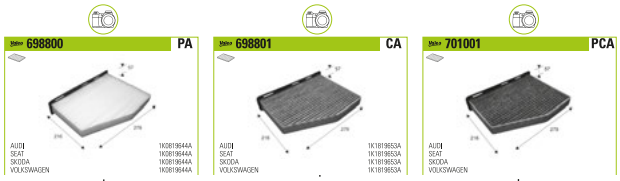
Polyphenol filter

STANDARD

PREMIUM

ULTIMATE

A/C				OE PA Valeo	OE CA Valeo	PCA Valeo
VOLKSWAGEN (.../...)						
Golf VI Cabriolet	+/-		05/12 ▸	1K0819544B	698800	1K1819653B	698801	701001



9. The Heating Ventilation and Air Conditioning unit (HVAC)

9.6.2 Cabin air filter performances

Filter performance is defined according to the following parameters :

- **Efficiency & dust holding capacity**
  The efficiency is the ratio of particles that are trapped by the filtration process.
  The efficiency is specified for a defined particle size. In practice, a cabin filter must be capable of trapping 100% of particles measuring 10µm in diameter and between 10% and 30% of particles measuring 0.25µm in diameter.

The dust holding capacity is the quantity of solid particles a filter can retain before a defined flow resistance is reached, that is to say before the filter is to be changed.

- **Pressure drop**
  The difference in flow resistance upstream and downstream of the filter, is related to the air flow resistance created by the filter; it is also known as “head loss”.

The head loss depends on the filter soiling. The filter must produce the lowest possible head loss to optimise the air conditioning system performances.

- **Gas absorption level**
  This feature is applicable to active carbon filters (CA and PCA), it reflects the amount of gas that is absorbed by the filter media.

The cabin air filter design is a trade-off between the pressure drop and the dust holding capacity, this to assure the appropriate air flow in the cabin as well as an efficient filtration process.

The service life of a filter corresponds to the maximum amount of particles before clogging occurs.
The service life varies according to the use conditions (surrounding pollution, frequent use of the A/C system...)

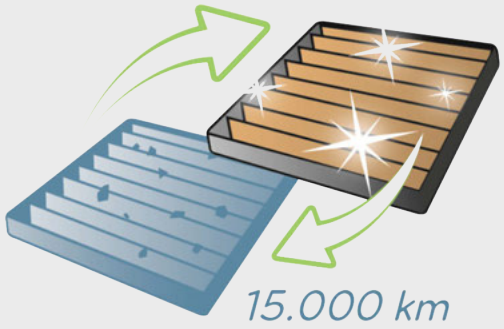
9.6.3 Cabin air filter Installation instructions

The installation instructions are always contained in the filter packaging.

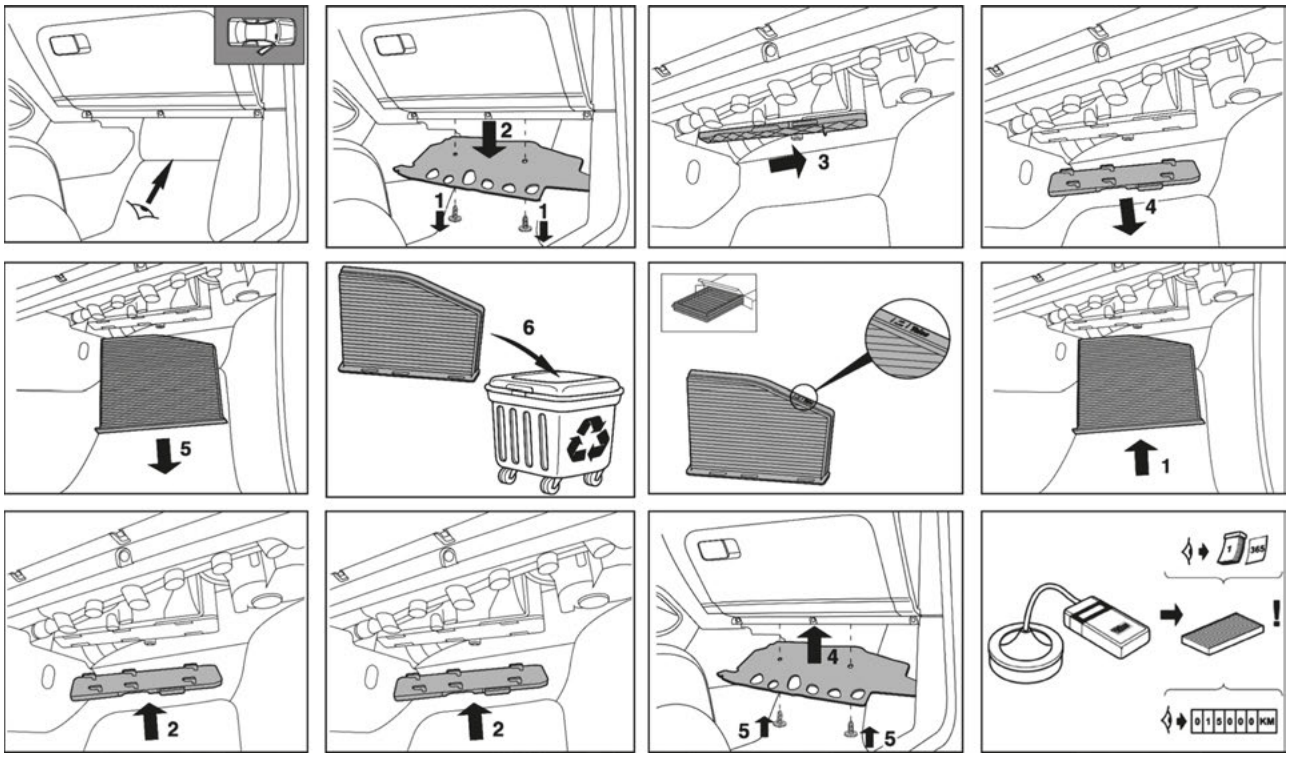
Advantages:

- Locate the position of the cabin air filter
- Apply the Valeo method for an optimal installation, save time and money
- Avoid mistakes when installing (e.g. the wrong way round)
- Benefit from the know-how of Valeo, Europe's top cabin climate control specialist

Valeo recommends to replace the cabin air filter once a year or every 15,000 km.



Cabin air filter fitting instruction | **Valeo P/N 701001 for VOLKSWAGEN GOLF V/VI (10/03>09/2012) and VOLKSWAGEN TOURAN (02/2003>)**



9. The Heating Ventilation and Air Conditioning unit (HVAC)

9.7 Heating

This is the primary role of air conditioning. All vehicles are fitted with heating systems.
The engine cooling liquid is traditionally used as the energy source for heating purposes.
Part of the heat produced by the engine is channelled to the cabin via the heating radiator.
An additional electric heating device is sometimes mounted on the system to provide additional heat in some transient phases.

The heating components are located inside the HVAC after the blower

9.7.1 The heater core

- An air/water exchanger (uses engine cooling liquid energy)
- Increases the cabin temperature
- Demists & defrosts the glasses

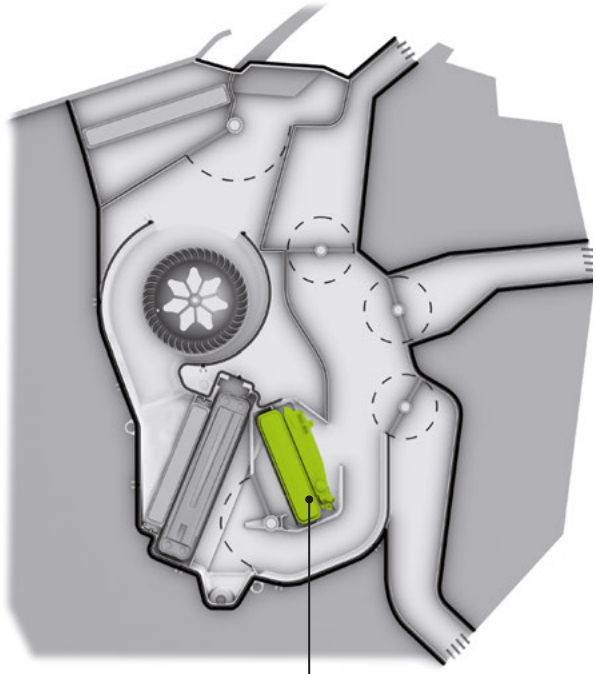
9.7.2 The PTC

PTC stands for Positive Temperature Coefficient
PTC's are self regulated electric heaters used complementary to the heater core

Located mostly after the heater core or sometimes in ducts (feet heater)

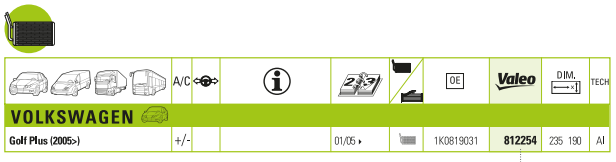
PTC's have been introduced on climate control systems to compensate a lack of heat on high efficiency engines.

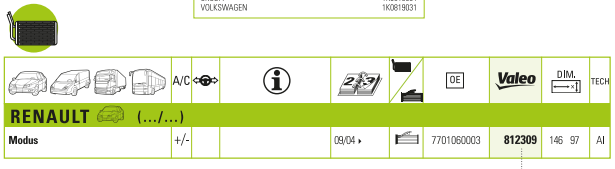
Different types
- Relay controlled or smart devices controlled via a digital communication line (Lin Bus)



PTC

Heater core





9.8 Cooling and dehumidifying the air

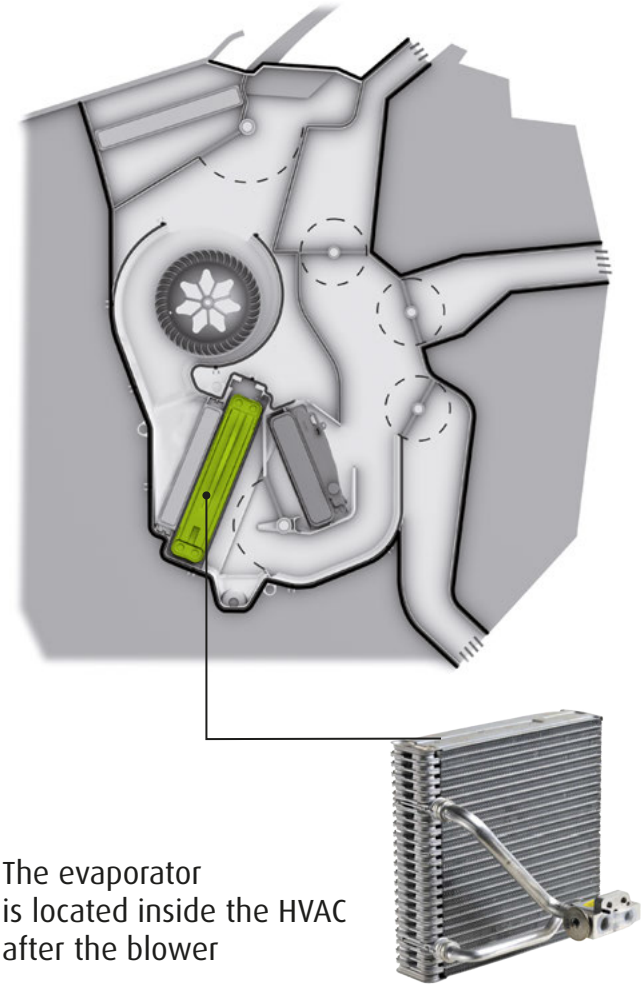
The cold is produced by the evaporator, which acts as a heat exchanger to cool down the outdoor air entering the cabin.

The outdoor air cools down as it passes through the fins on the evaporator and transfers its heat to the refrigerant. The cool air is then blown into the cabin at temperatures of between 2°C and 10°C.
Air conditioning is often thought of as a means of cooling down the air, but one of its most important roles is to dehumidify the air.

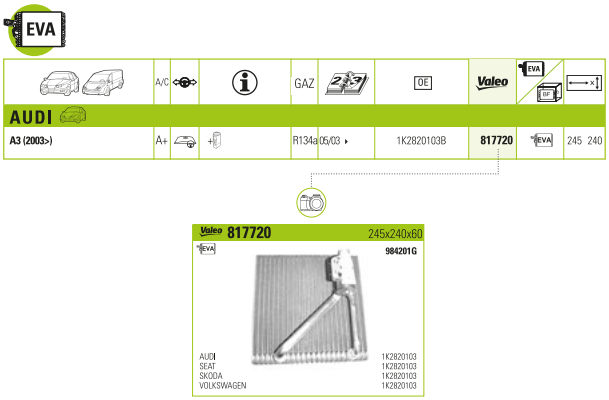
In cold weather, it is important to reduce the humidity levels in the cabin. Several occupants will quickly produce mist on the vehicle's windows.

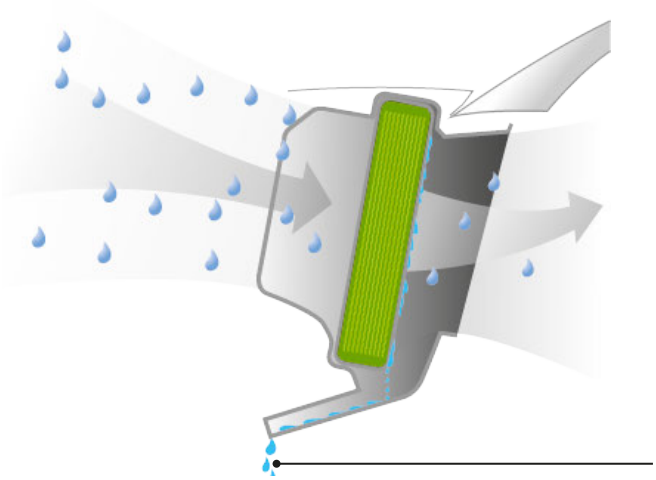
Evacuation of condensates

Air moisture can be extracted effectively by a process of condensation on the evaporator fins. The condensates (water) are then collected and evacuated beneath the car.



The evaporator is located inside the HVAC after the blower





Condensates are evacuated beneath the car

9. The Heating Ventilation and Air Conditioning unit (HVAC)

9.9 Hot/cold mix

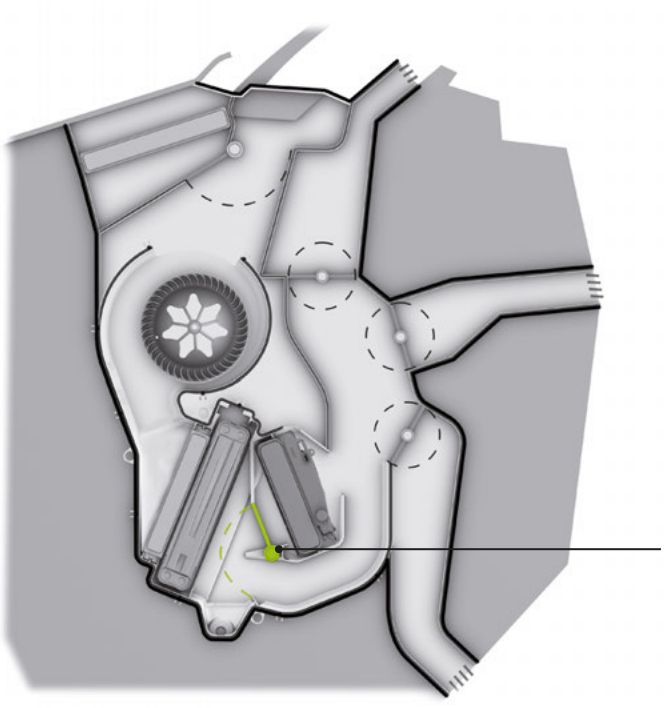
The control of the hot/cold mix depends on the system architecture.
In most cases the HVAC is designed with an air mixing solution, but the temperature can also be controlled by the water flow rate in the heater core.

9.9.1 By air mixing

In manual air conditioning systems, the air is mixed using flaps inside the HVAC. The flaps are actuated from the control panel using cables.

Automatic air conditioning systems apply the same principle, but they are fitted with motor-driven mixing flaps.

The mix of hot and cold air is permanently adjusted in order to regulate the temperature in the cabin to the set point.



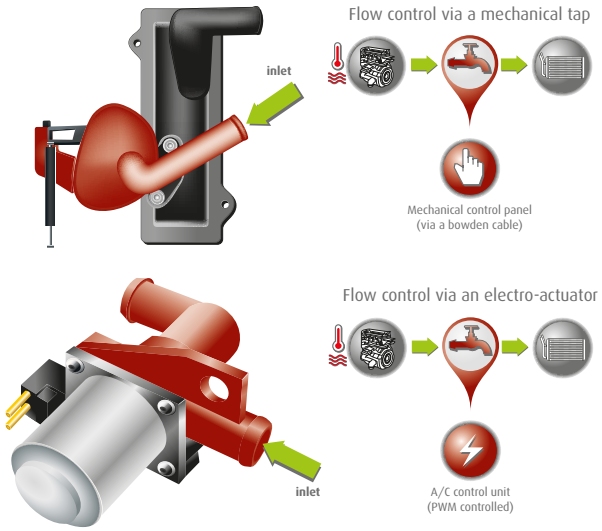
The mixing function is located inside the HVAC at the junction of hot and cold air streams

9.9.2 By adjusting the hot water flow

Some systems can adjust the hot temperature by acting on the flow rate of hot water in the heating radiator.

This variant exists in both manual and automatic air conditioning systems and uses either a mechanical valve controlled by a cable, or electrovalves controlled by the air conditioning ECU.

Heat control in the heater core



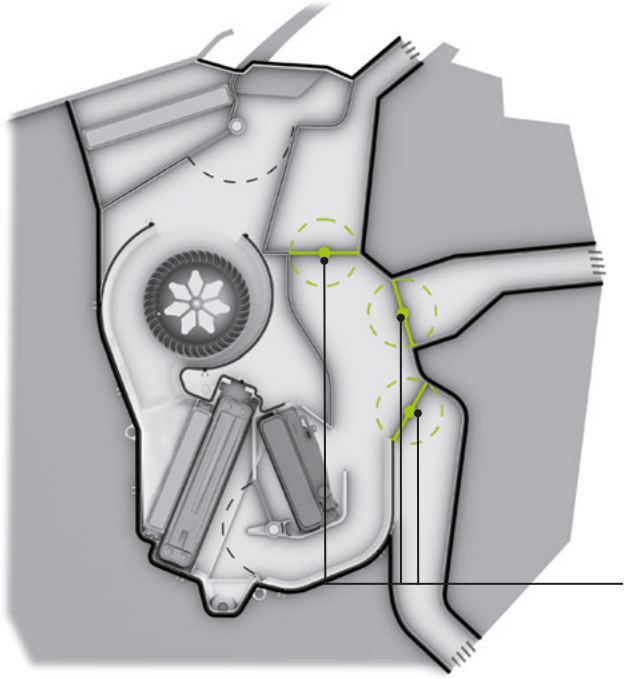
9.10 Air distribution

The air distribution is determined by the system architecture.

The air in the unit is directed to the main outlets by using doors and cinematic parts (actuator, levels, cables, central gear ...)
Some HVACs are separated in distribution, so that the passenger can have a different setting from the driver.

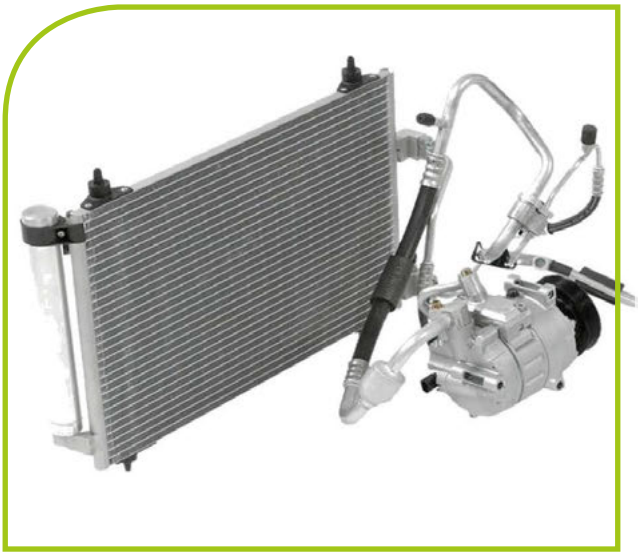
- In manual air conditioning systems, flaps inside the device are used to control the head/lap/foot air distribution. The flaps are actuated from the control panel using cables.

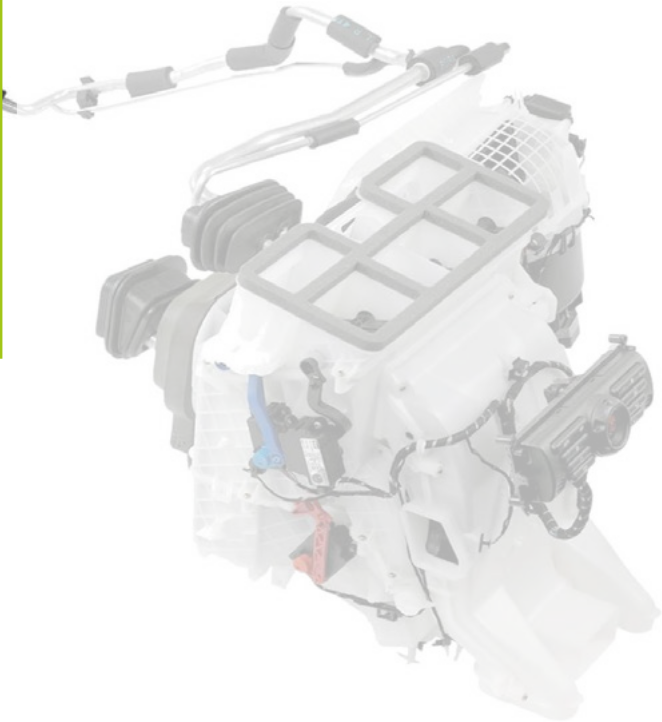
- Automatic air conditioning systems apply the same principle, but they are fitted with motor-driven mixing flaps that adapt the air distribution to the context and the history of system usage.



The distribution function is located inside the HVAC after the mixing function

10 The Air conditioning Loop





In air conditioning systems, the cold is produced by the A/C loop, or cold loop.

As its name indicates, this system is a loop that repeats a thermodynamic cycle, in which a number of heat exchanges take place.

These heat exchanges use a refrigerant fluid to extract the heat from the cabin, cool it down and expel it outside the vehicle.

10.1 The refrigerant fluid

10.1.1 Refrigerant families

There are three families of refrigerant fluids:
CFC, HCFC and HFC.
Classifications refer to the chemical composition of the refrigerants.

HFC - HydroFluoroCarbon indicates that the refrigerant is comprised of hydrogen, fluorine, and carbon. Common HFC refrigerants are R134a.

Environmental demands to protect the ozone layer and reduce the greenhouse effect have gradually excluded certain refrigerants from the market. The ODP and the GWP are the two selection criteria.

The Global-warming potential

The Global-warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere.
The GWP compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide (the CO_2 GWP is 1).

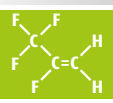
A refrigerant's GWP is calculated over a specific time interval: GWP100 refers to a period of 100 years.

The GWP100 for R134a is 1,430; this means that R134a will trap 1,430 times more heat than carbon dioxide over the next 100 years.
That is to say, 1 gram of R134a has the same impact as 1.43 kg of CO_2 over the next 100 years.
A/C players are all working on system evolutions to reduce the impact of refrigerants on our planet as much as possible.

The ozone depletion potential

The ozone depletion potential (ODP) of a refrigerant is the relative amount of degradation it can cause to the ozone layer.
Since 2001, those refrigerants authorized for automotive A/C applications have no impact on the ozone layer (ODP=0).

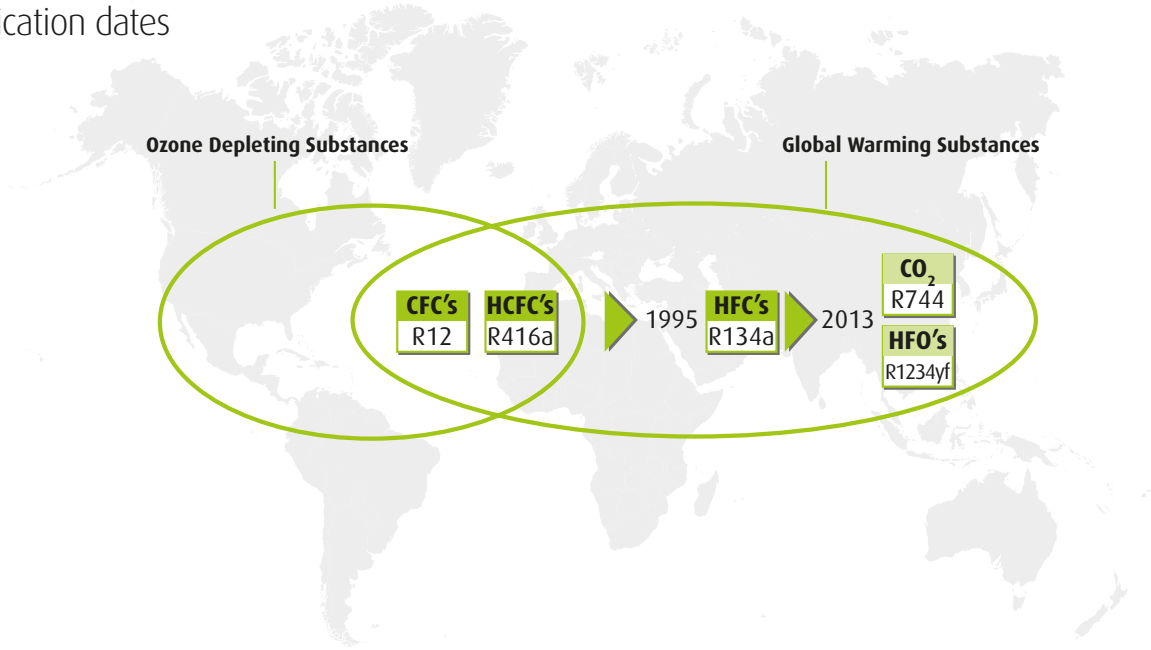
Refrigerants families

Refrigerant family	CFC (ChloroFluoroCarbons)	HCFC Blend (HydroChloroFluoroCarbons)	HFC (HydroFluoroCarbons)	HFOs (HydroFluoroOlefin)	CO_2
Refrigerant name	R12 Dichlorodifluoromethane	R416a R134a/124/600 (59.0/39.5/1.5)	R134a Tetrafluoroethane	R1234yf Tetrafluoropropene	R744 Carbon Dioxide
Molecular geometry	CCl_2F_2	Refrigerant blend	CH_2FCF_3	$CF_3CF=CH_2$	CO_2
					O=C=O
GWP$_{100}$ (Global Warming Potential)	10,890	1,100	1,430	4	1
ODP (Ozone Depleting Potential)	1	0.008	0	0	0

ODPs and GWPs according to UNEP (United Nations Environment Programme)

10. The Air conditioning Loop

10.1.2 Developments and application dates

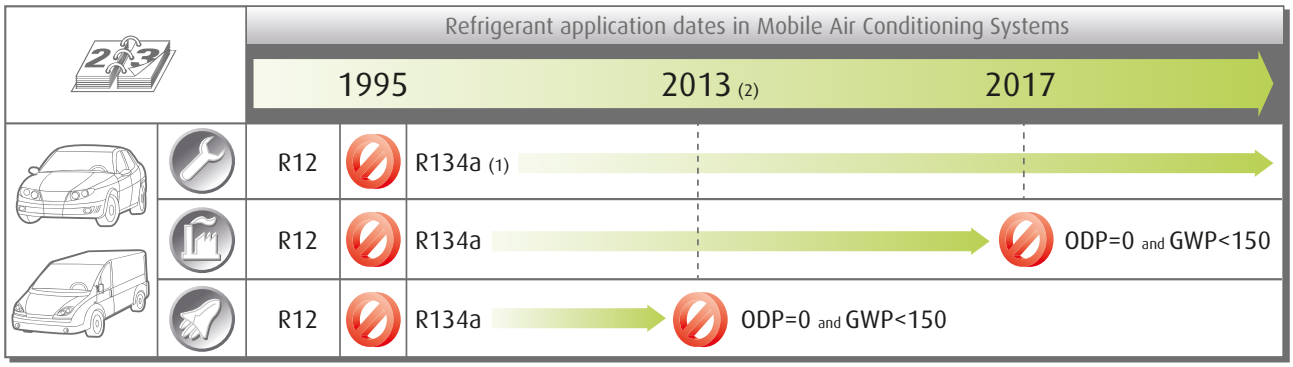


The R12 refrigerant is a CFC, and has been banned since 1995.
The R416a refrigerant is a HCFC, it has been used for R12 refrigerant retrofitting only, and its use has remained relatively limited.

CFCs and HCFCs made way for the R134a HFC, wich represented a major step forwards in the reduction of impacts on the planet.

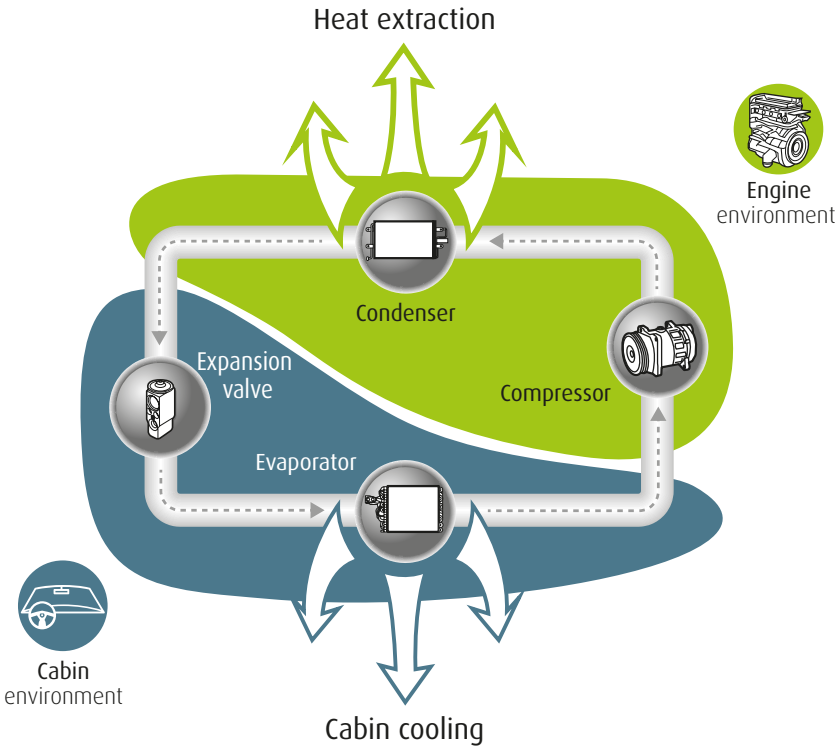
As part of its policy to drastically reduce GWP, the European Commission has defined a new transition phase starting in January 2013 that requires new models to use refrigerants with a GWP of less than 150.

No changes are required to vehicles already on the road or in production at that time, provided that the year of production is no later than 2017.
The date for the exclusion of R134a from the air conditioning system maintenance market has not yet been set.



(1) The R416a has also been temporarily used for retrofitting the A/C loops (2) Partially engaged in 2011 and postponed to January 2013

A/C servicing In production New models



10.2 The simplified loop

The A/C loop uses the principle of the change of state of refrigerant fluids in order to bring about heat exchanges.

In a heat exchange the thermal flow is always from hot to cold. This principle applies to the two heat exchangers in the A/C loop: the evaporator and the condenser.

Two changes in the state of the refrigerant fluid in the exchangers are produced by controlling the pressure in the A/C loop.

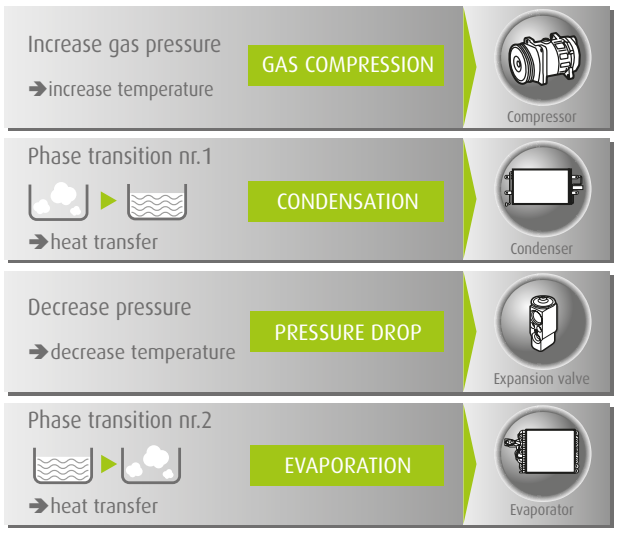
- The higher the pressure, the higher the temperature at which the change in state occurs.

The three states of the refrigerant fluid in the loop are LIQUID, DIPHASIC and GASEOUS. In the intermediate diphasic state, the fluid is partly gaseous and partly liquid.

The state of the refrigerant changes in the course of the exchanges of energy in the condenser and the evaporator.

- These changes of state in the evaporator and the condenser are determined by two components of the loop: the compressor and the expansion valve.
- The changes in the state of the fluid from liquid to gas and vice versa allow large quantities of heat to be transferred at a constant temperature.

Pressures in the condenser and the evaporator change permanently according to the thermal exchanges that take place with the outdoor air.



10. The Air conditioning Loop

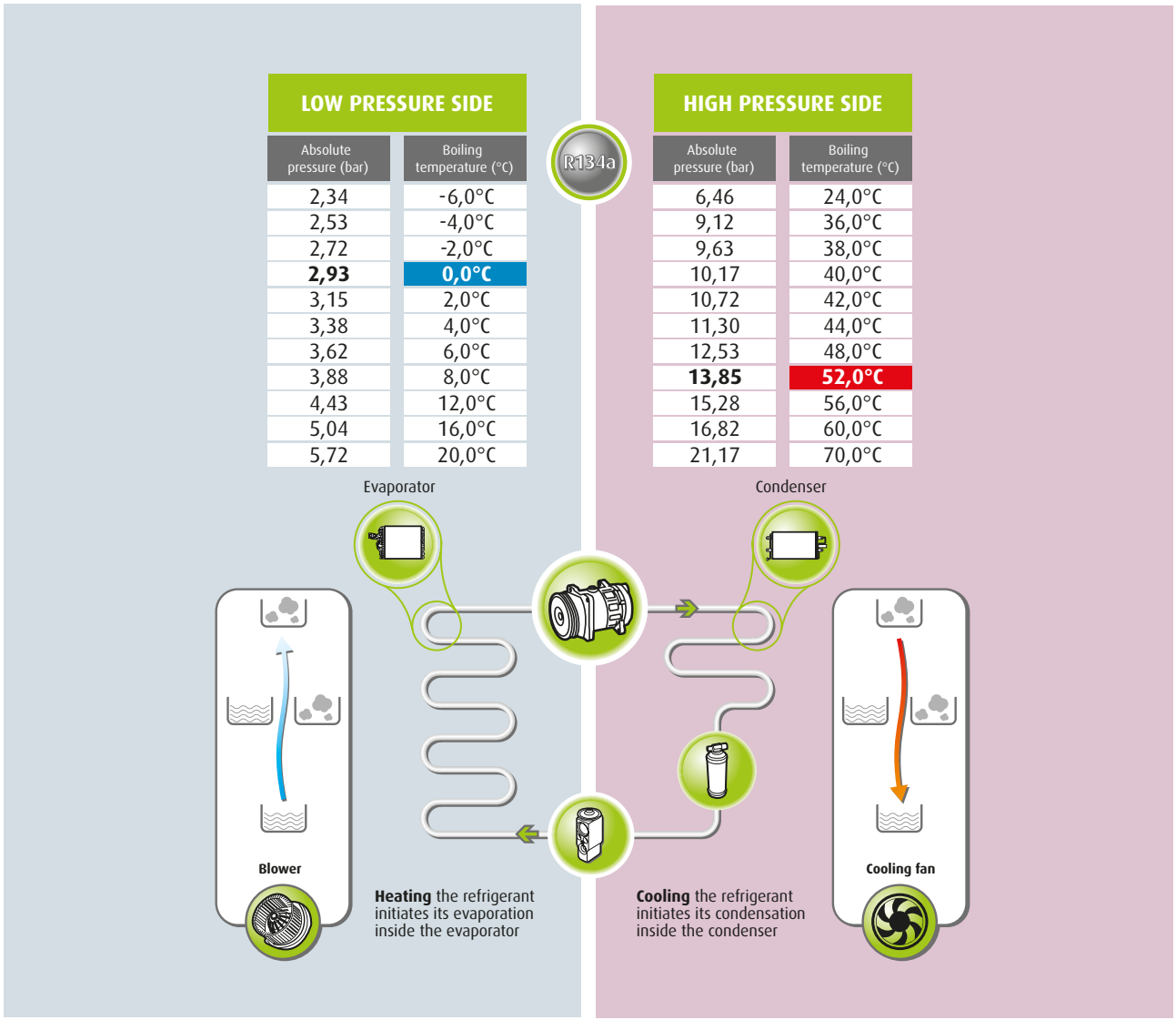
10.2.1 Boiling temperature vs pressure

The boiling point of the refrigerant governs heat exchanges in the condenser and in the evaporator: the refrigerant will evaporate or condense depending on the heat exchange direction.

- Two phase changes (evaporation / condensation)
- Two phase changes at two different pressures
- Two heat exchanges in two heat exchangers (evaporator / condenser)

1. The fluid in the EVAPORATOR evaporates during the thermal exchange with the hot air from the exterior environment, thereby cooling down the cabin.

2. The fluid in the CONDENSER condenses during the thermal exchange with the cooler air from the exterior environment, thereby expelling the heat to the exterior.



10.2.2 The complete loop

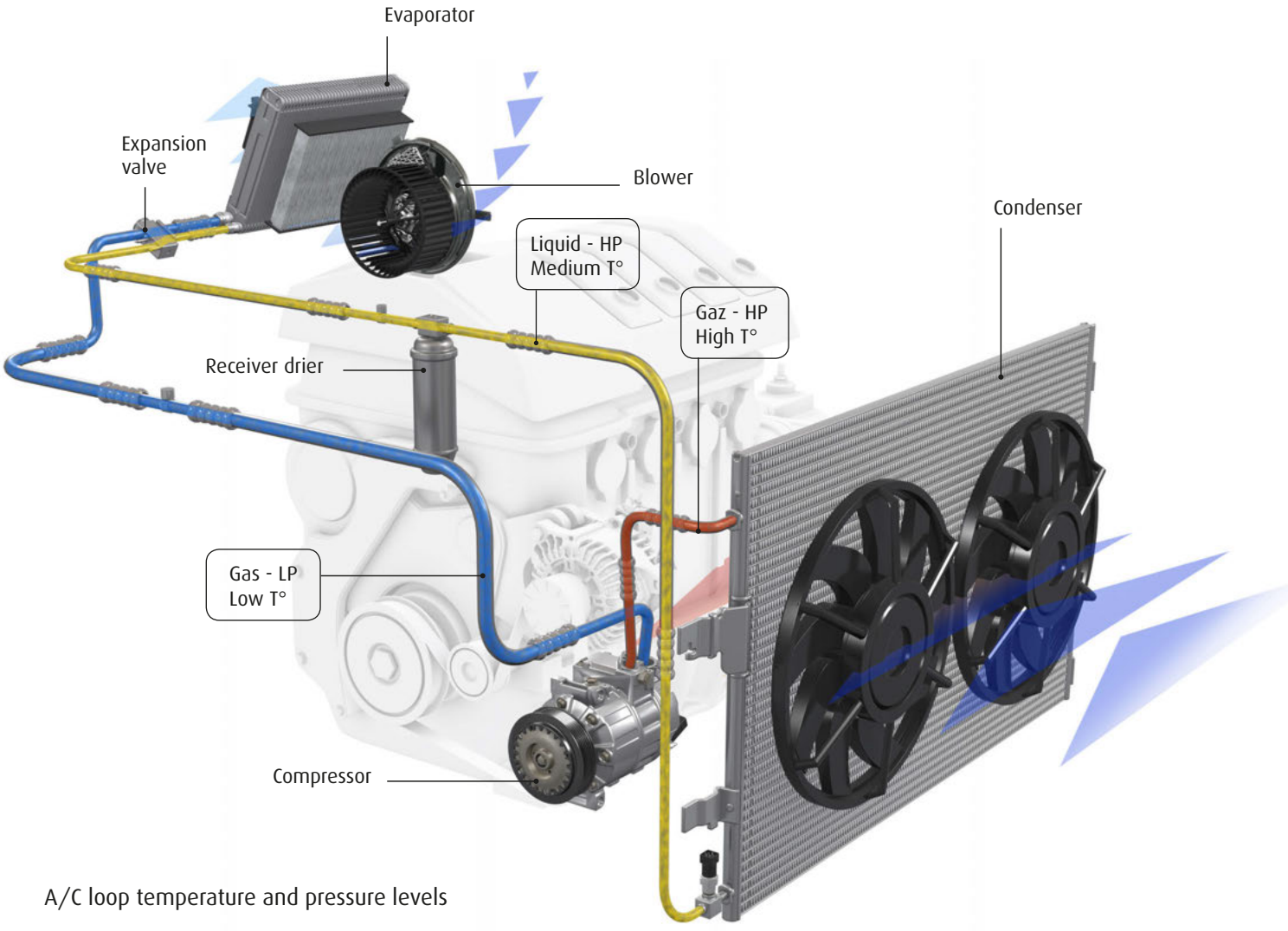
The air conditioning loop is made up of:

Five main components:
The compressor, the condenser, the filter or receiver drier, the expansion valve and the evaporator.

Two safety devices:
The pressure switch and the evaporator probe.

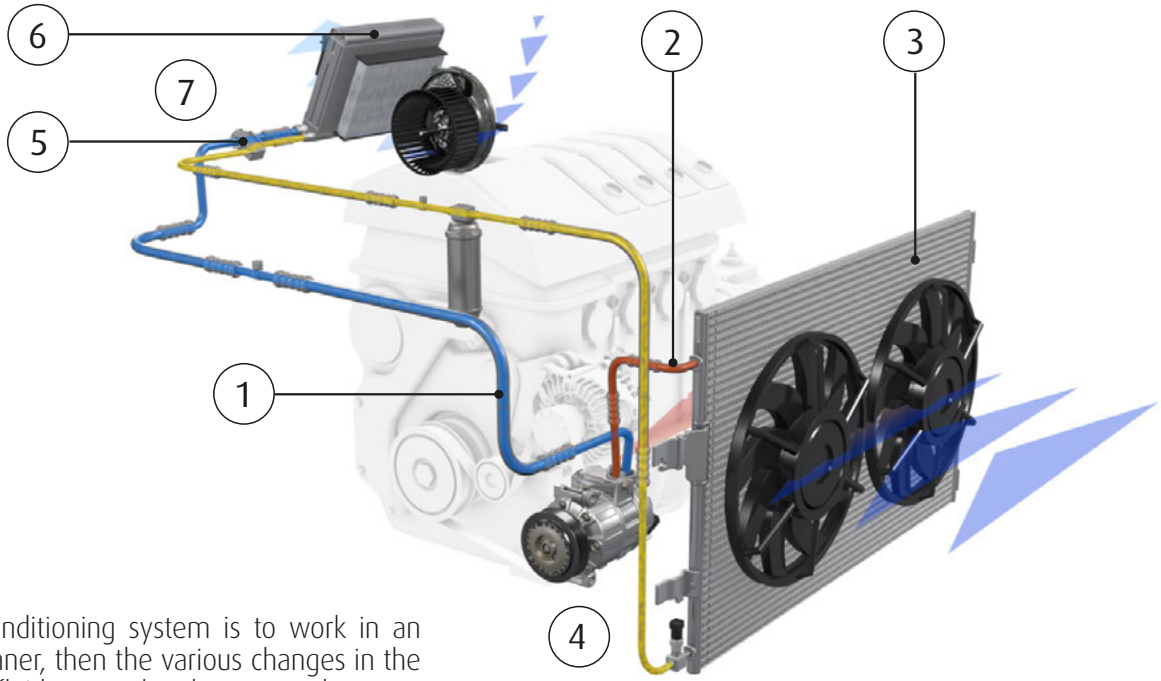
Two ventilation devices:
The cooling fan, which feeds air to the condenser, and the blower, which blows air into the cabin.
One element that filters the air entering the cabin:
The cabin air filter.

The figure below shows temperatures, pressures and fluid state in the A/C loop.
Pressure and temperature values change according to heat exchanges in the two exchangers and, in more general terms, also depends on the state of the system at a given point in time.



A/C loop temperature and pressure levels

10. The Air conditioning Loop



If the air conditioning system is to work in an optimal manner, then the various changes in the state of the fluid must take place correctly.

1. The fluid must reach the compressor in a 100% GASEOUS state. It is at low pressure (LP) and at low temperature. The diameter of the pipe is at its largest at this point.

2. The fluid is compressed in the compressor, changing from low to high pressure (HP). Its temperature rises significantly, but it remains in the same gaseous state.

3. The fluid then enters the condenser, which transforms it from the 100% GASEOUS state to the 100% LIQUID state by expelling the heat. The refrigerant temperature drops but the pressure is still high at this stage.

4. The fluid enters the receiver drier, where it is filtered and dried, but it does not undergo any changes in terms of state, pressure or temperature.

5. It then goes to the expansion valve, which transforms the fluid from the high pressure liquid state, to the low pressure DIPHASIC state. This process results in a sharp drop in temperature, equal to the boiling point of the fluid, depending on the compressor suction level.

6. The fluid then flows to the evaporator, where it cools the air from the exterior passing through it. The outdoor air yields its heat and enters the cabin at a low temperature and in a slightly dehumidified state. The refrigerant absorbs enough heat in the evaporator to change to the GASEOUS state, its temperature rises but pressure remains unchanged.

7. The refrigerant then returns to the starting point and absorbs enough heat in the evaporator.

The quantity of refrigerant fluid in the A/C loop obviously influences the performance of the system. This volume is specific to each application and can be found in the Valeo fluids database.

The quantity of refrigerant fluid and the condition of the components (leakage, corrosion, noise...) must be checked when servicing the Air Conditioning system.

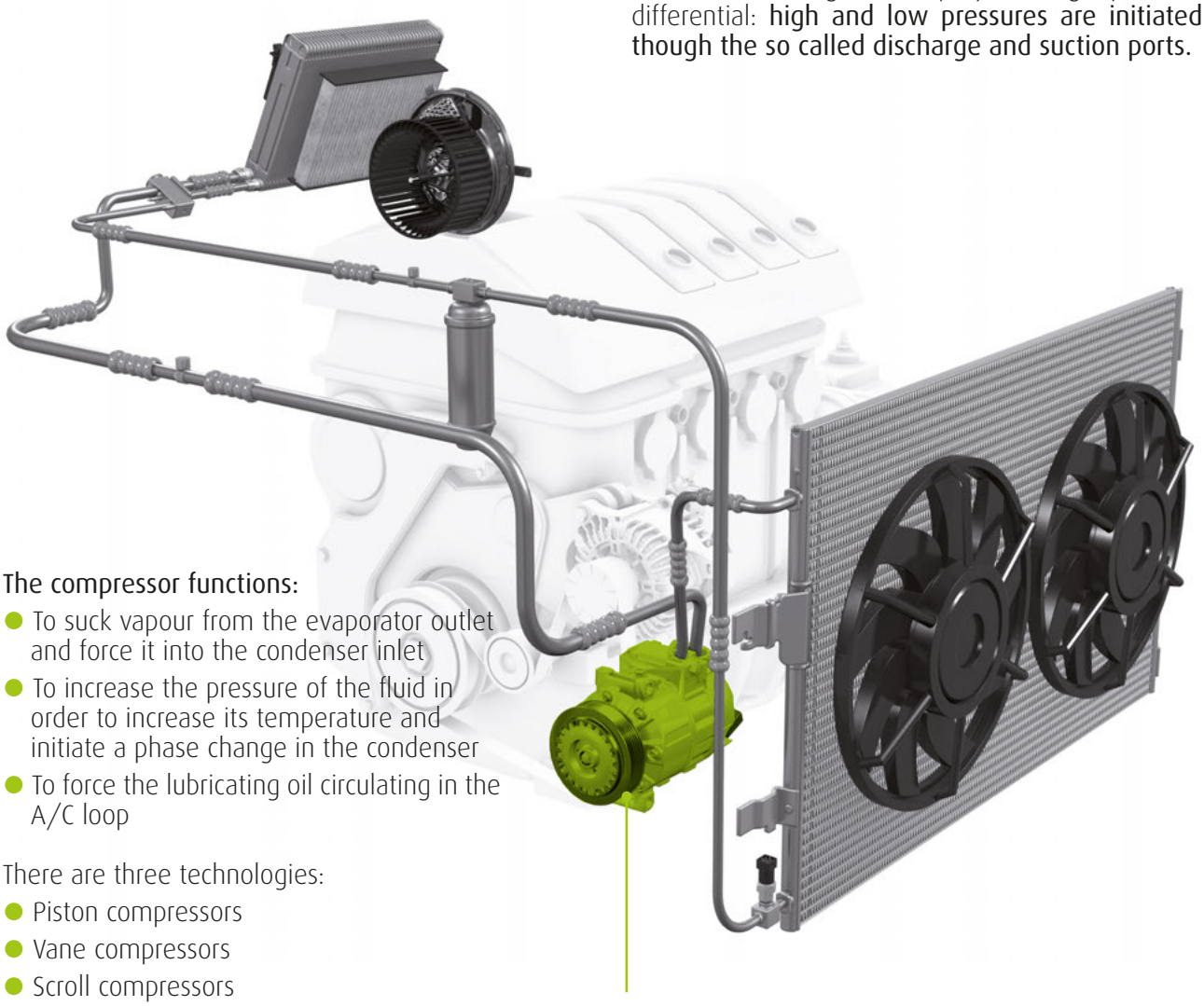
Valeo has the right diagnostic and repair tools for every situation encountered when maintaining and repairing air conditioning systems.

11

The components of the A/C Loop

11.1 The compressor

The compressor is a pump, which causes refrigerant to flow through the loop by creating a pressure differential: **high and low pressures are initiated though the so called discharge and suction ports.**



Compressor

The compressor functions:

- To suck vapour from the evaporator outlet and force it into the condenser inlet
- To increase the pressure of the fluid in order to increase its temperature and initiate a phase change in the condenser
- To force the lubricating oil circulating in the A/C loop

There are three technologies:

- Piston compressors
- Vane compressors
- Scroll compressors

11. The components of the A/C Loop

11.1.1 Piston compressors

Piston compressors work by transforming the rotational movement of the shaft into linear movement of the pistons.

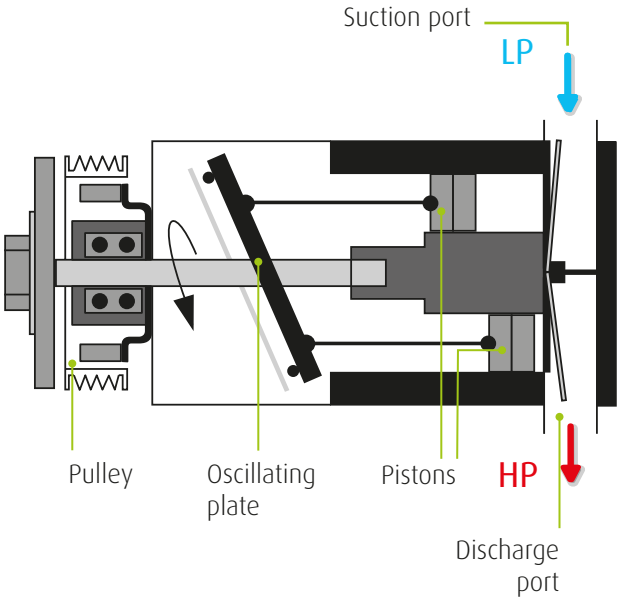
There are three subfamilies of piston compressors:

- Crank shaft
- Swash plate type
- Wobble plate type

The crank shaft family is more specific to bus applications.

The swash plate and wobble plate families are common in light vehicles.
There are two variants, the fixed-cylinder compressors and the variable-cylinder compressors

Fixed-cylinder compressors
The oscillating plate remains at the same angle, irrespective of the conditions of use.
This variant cannot adjust the cooling power of the system precisely and only the complete compressor shutdown cycles are possible.

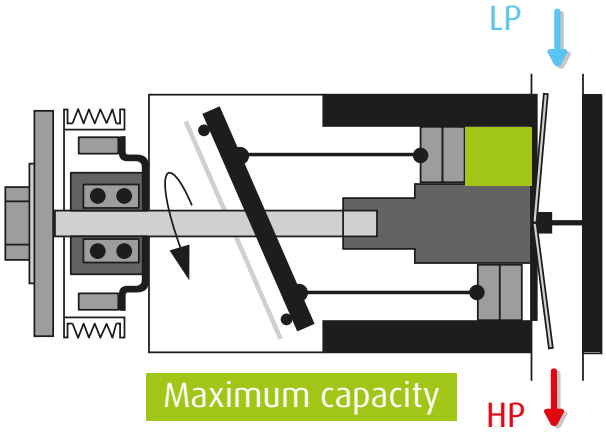


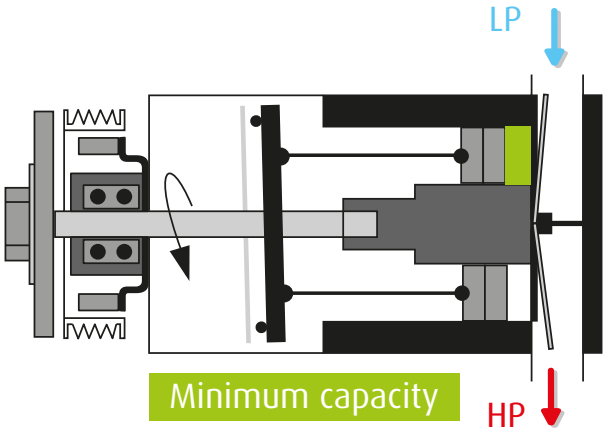
The refrigerant suction occurs in the compressor suction port.
It is part of the A/C loop Low Pressure circuit (LP)

The refrigerant discharge occurs in the compressor discharge port.
It is part of the A/C loop High Pressure circuit (HP)

Variable-cylinder compressors

The pistons are displaced by a variable-angle oscillating plate.
This angle depends on the energy requirements and the pressure and temperature at the inlet and in the compressor shell.
The greater the need for cold, the larger the cylindrical capacity (maximum plate angle).



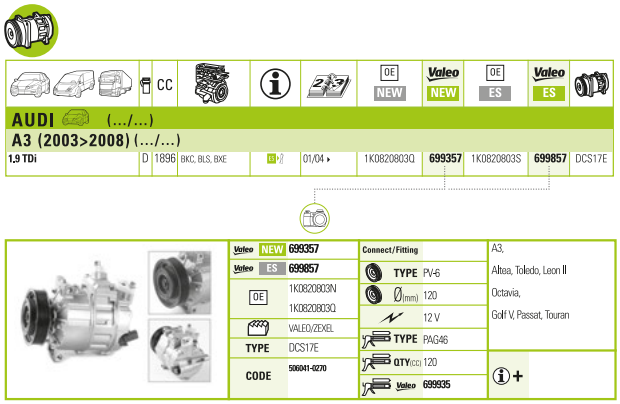


Variable-cylinder compressors offer a number of advantages:

- Reduced vehicle energy consumption
- No surges when starting and stopping
- Smooth changes in the can temperature

The flow is regulated by changing the stroke of the pistons by varying the angle of the oscillating plate.

- The angle of the plate is determined by the pressure inside the compressor housing.
- The position of the oscillating plate is controlled by a valve.
- This valve may be controlled internally using a pressure-sensitive element, or by an external electrovalve controlled by an electronic control unit (ECU)

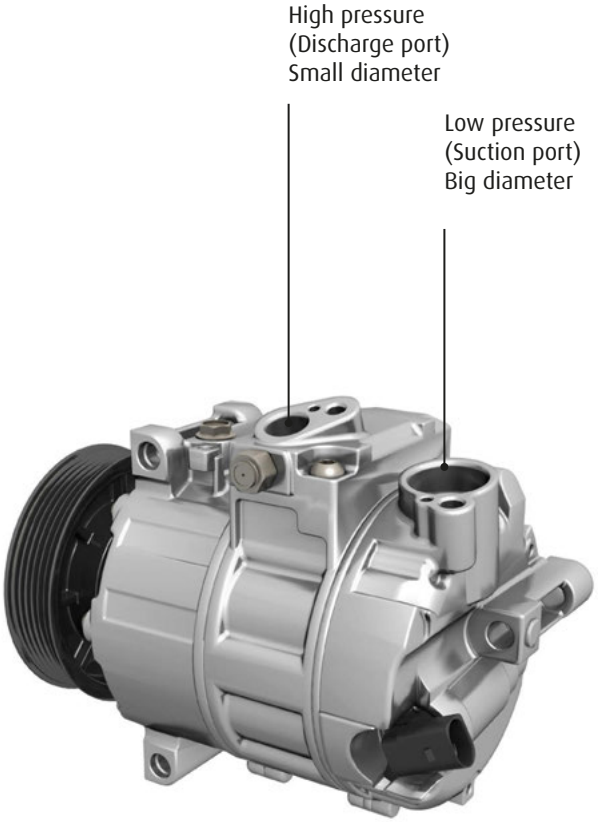


11. The components of the A/C Loop

11.1.2 Vane compressors

The operation of vane compressors is based on the rotation of the rotor and the reduction of the space available for the refrigerant trapped between the vanes.
The contact between the vanes and the stator is sealed by the centrifugal force applied to the vanes at high speed.

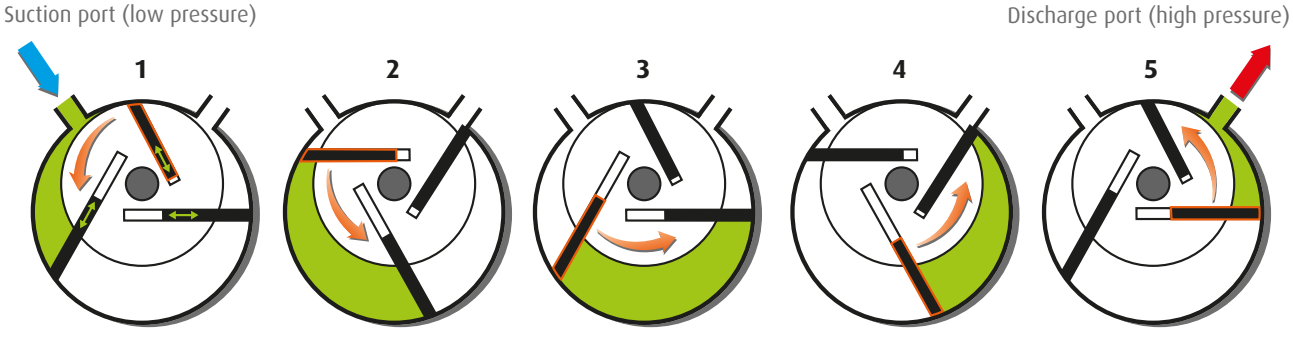
The capacity between two vanes is variable. The gas is sucked in by the increase in volume before the inlet tube.
The gas is then trapped between two vanes and conveyed towards the outlet tube. The volume is reduced in this zone and the gas is released into the outlet pipe.



11.1.3 The compressor ports

As a general rule the compressor ports can be distinguished based on their diameters

- Low Pressure (Suction port): Big diameter
- High Pressure (Discharge port): Small diameter
  Nevertheless some compressor does not follow this rule, the port functions are then indicated by letters
- S for Suction
- D for Discharge



Vane compressor (off-centre rotor)

11.1.4 The suction level

The compressor suction level establishes the fluid phase change conditions inside the evaporator; this is a crucial parameter for heat exchange and cooling performance.

The suction pressure (low pressure of the A/C loop) is initiated by the compressor to ensure the appropriate evaporation process inside the evaporator (not less than 3 bars for R134a refrigerant).

Control of the suction level:

Less compressor suction implies:

- Higher evaporator pressure, thus higher refrigerant boiling temperature
- Higher evaporator temperature
- Reduced thermal exchanges with the ambient air

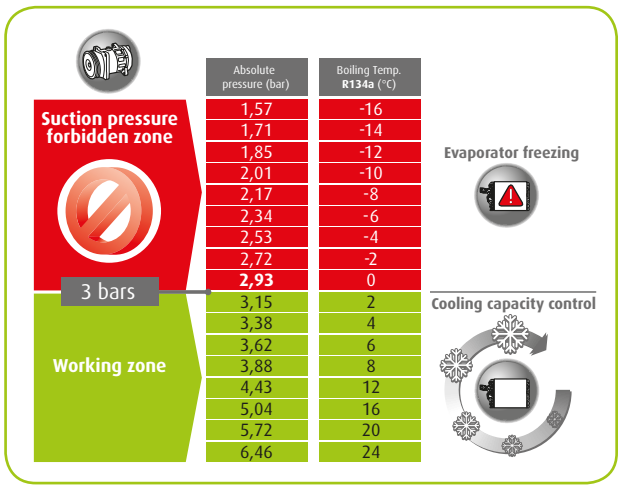
More compressor suction implies:

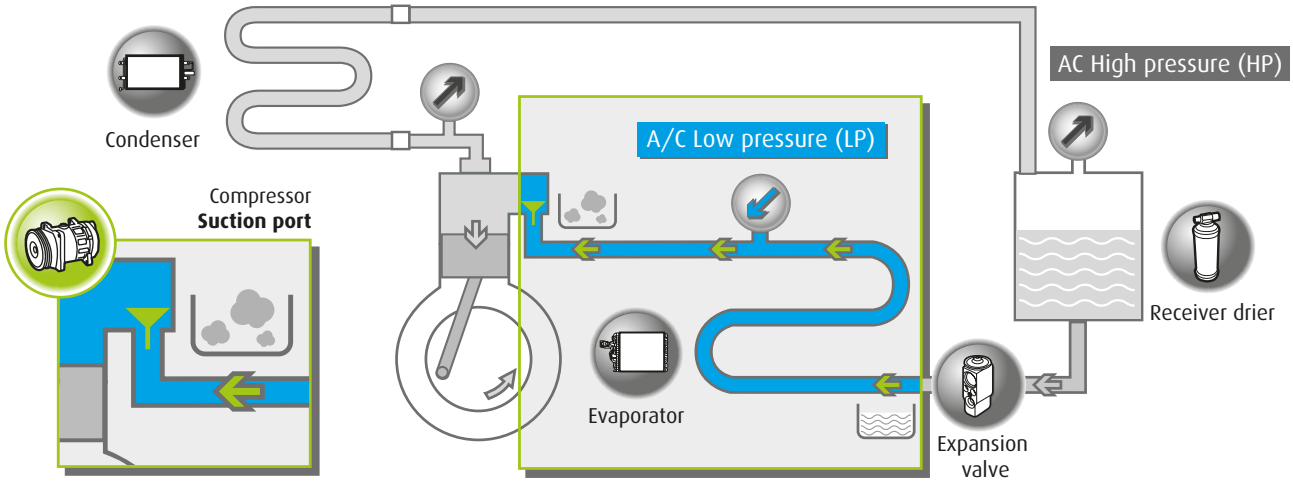
- Lower evaporator pressure, thus lower refrigerant boiling temperature
- Lower evaporator temperature
- Increased thermal exchanges with the ambient air

11.1.5 Suction pressure limits

Increasing the fluid suction reduces the pressure inside the evaporator.

- Too low a pressure would generate too low a temperature at the evaporator surface and a risk of freezing.
- Freezing at evaporator surface would block the air flow, jeopardising heat exchanges and thus the fluid evaporation.
- This would lastly put the compressor in danger, as it could digest liquid refrigerant via the suction port.





11. The components of the A/C Loop

11.1.6 Evaporator freeze... a compressor killer !!

The temperature at the evaporator surface is conditioned by three main parameters:

- The compressor suction pressure (set by the co pressor)
- The flow of refrigerant in the evaporator (set by the Thermal eXpansion Valve-TXV)
- The air flow rate through the evaporator fins

Evaporator freezing

If one of these parameters differs from the authorised limits, freezing may occur and may disable the refrigerant changing from liquid to gas.
A massive return of liquid refrigerant to the suction port jeopardises the compressor.

11.1.7 How to avoid the evaporator freezing

Evaporator freezing can be avoided by the system itself, as well as good practices during the A/C loop servicing.

Good practices:

- A restricted filter-drier, a low refrigerant charge or a faulty Thermal eXpansion Valve can lead to evaporator freezing.

- A restricted air flow through the evaporator (cabin air filter or blower issue) can lead to freezing as well.

A yearly maintenance preserves the A/C loop performances.
Air inlet, cabin air filter, and blower performances are some of the fundamental points to be checked during servicing

How does the system manages the freezing of the evaporator?

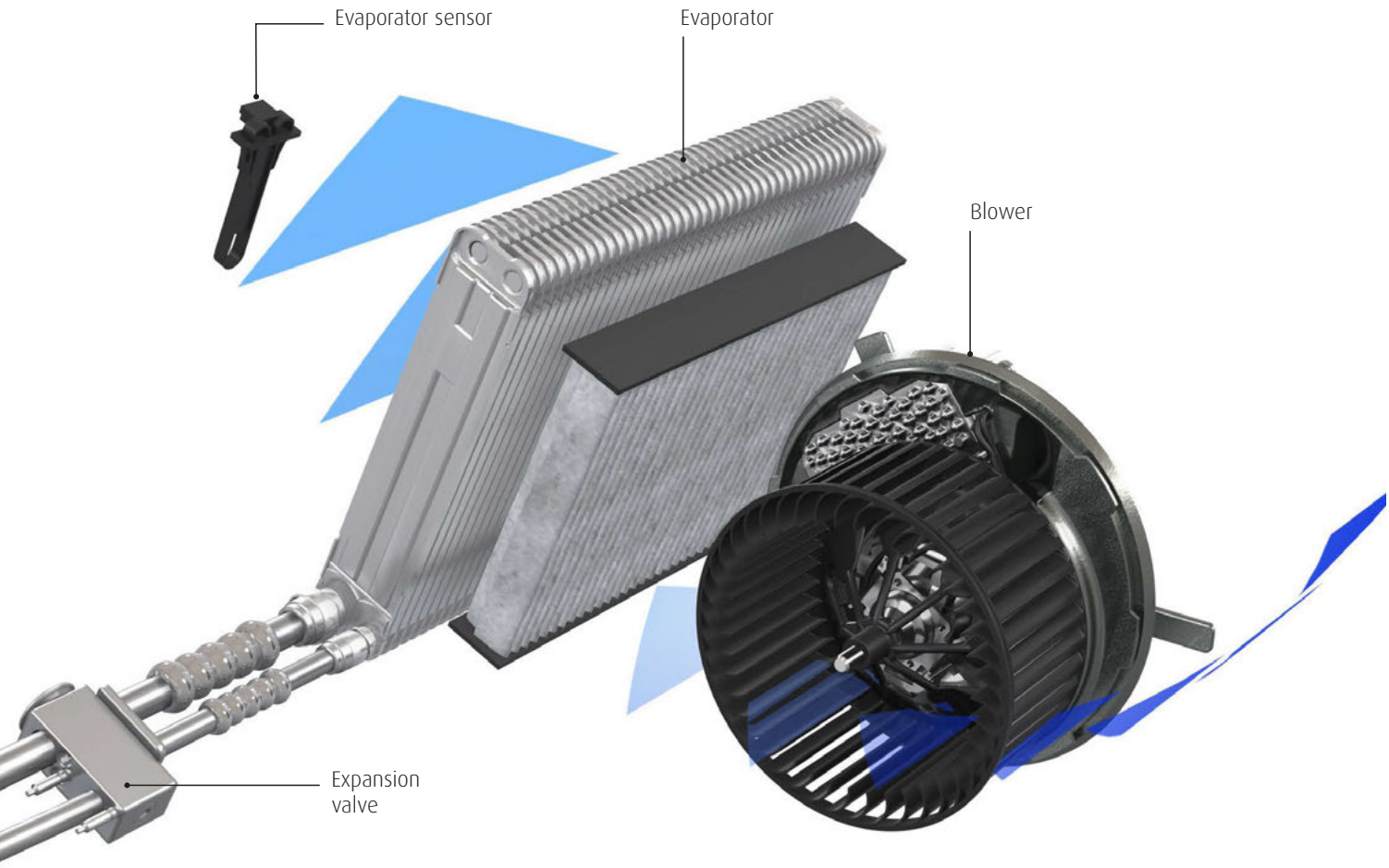
This depends on the compressor technology, and can be achieved by:

Controlling the suction level

- The suction pressure can be controlled only on variable capacity compressors

Monitoring the evaporator temperature

- In fixed-cylinder compressors, the suction pressure cannot be adjusted. The compressor must be stopped when its temperature approaches 0°C to prevent the evaporator from freezing.



On VARIABLE capacity compressors the suction level can be adapted depending on the thermal needs:

- To provide the appropriate comfort
- To consume the optimum energy and reduce fuel consumption

The suction pressure level is set to the appropriate level and limited to 3 bars.

On FIXED capacity compressors the suction level can NOT be adapted.
It is mandatory to monitor the evaporator temperature and stop the compressor immediately before freezing occurs; this is the role of the evaporator sensor, the compressor is then disabled via the electromagnetic clutch pulley.

11. The components of the A/C Loop

11.2 A/C loop lubrication

Oil circulates throughout the whole A/C loop:

- Compressor
- Condenser
- Expansion valve or orifice tube
- Evaporator
- Receiver drier or Accumulator

The oils used in air conditioning fulfill the following functions:

- Lubricating the compressor
- Cooling the compressor
- Improving the sealing of the compression parts
- Expelling impurities from the loop by circulation
- Improving the sealing of the joints in the loop

The two main families for the automotive air conditioning market are:

- Synthetic Polyalkylene glycol oils (PAG)
- Synthetic Polyolester oils (POE), used for electric compressors in hybrid vehicles.

11.2.1 Oils and compressor technologies

Mechanically driven compressors

- 3 types of synthetic oil
- All Polyalkylene glycol (PAG)
- ISO46 - ISO100 - ISO125

Electrically driven compressors

- 1 type of synthetic oil
- Polyolester (POE)

11.2.2 Oil and refrigerant types

The traditional oil for R134a applications cannot be used for the new HFO1234YF refrigerant.
A new generation of PAG oil has been developed to be compatible for both uses.

Oils are hygroscopic (readily absorbing moisture from the air).
The mix of humidity, refrigerant and oil produces acid matter in the air conditioning loop.
Over time, these acids corrode the circuit.
Therefore it is essential to extract these acids and other residues in regular maintenance operations and to renew the refrigerant and the oil.

Similarly, bottles of fresh oil, and any other containers, must not be left open or they will absorb humidity themselves.

11.2.3 Oils in the catalogue

The volume and viscosity of the oils to be used are shown in the table of vehicle products.

			GAZ					Valeo
VOLKSWAGEN								
GOLF V / GOLF PLUS	Denso	2003-2008	R134a	525 g ±25	PAG	ISO 46	180 cc ±10	**699935**
GOLF V / GOLF PLUS	Sanden	2003-2008	R134a	525 g ±25	PAG	ISO 46	110 cc ±10	**699935**

11.3 The condenser

Role:
The condenser is a heat exchanger.

The condenser:

- Extracts the heat contained in the refrigerant fluid
- Expells the heat extracted from the cabin to the exterior of the vehicle
- Transforms the refrigerant fluid from the gaseous to the liquid state through a process of condensation

11. The components of the A/C Loop

Operation:

Refrigerant side
1. upstream of the condenser, the vapour discharged by the compressor enters at:

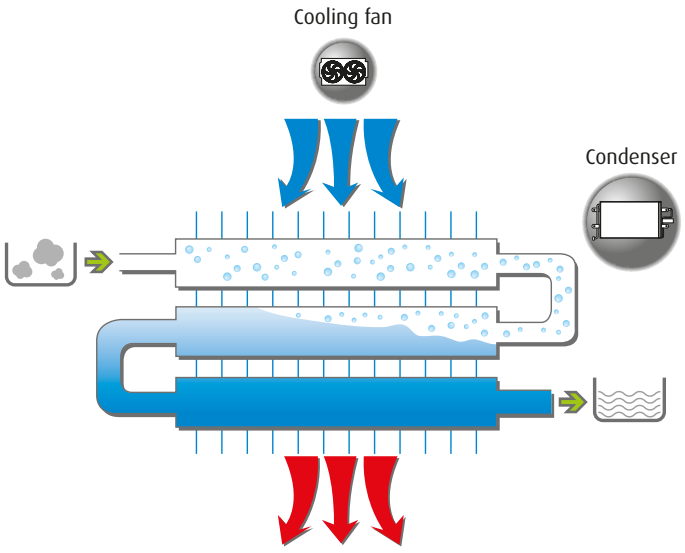
- High temperature (from 60°C to 120°C)
- High pressure (from 10 to 20 bars)

2. in the condenser, the refrigerant fluid yields its heat in the following processes:

- Desuperheating (drop of 20°C to 30°C)
- Condensation (liquefaction of the vapour at constant temperature and pressure)
- Subcooling (liquid saturated with a drop of 5°C to 10°C) relative to the condensation temperature

3. downstream of the condenser, the refrigerant is in the liquid phase, at:

- Medium temperature (from 45°C to 55°C)
- High pressure (from 9 to 20 bars)



Heat is expelled from the condenser.
A phase change occurs.

Air side
1. upstream of the condenser, the incoming air is tepid (from 20°C to 35°C).

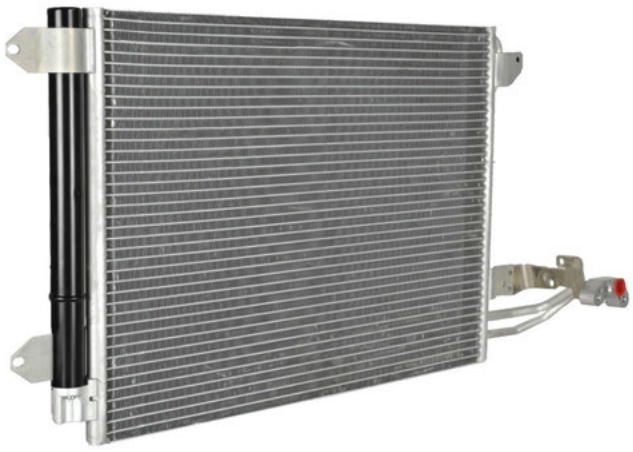
2. in the condenser, the air stream gradually heats up by absorbing the heat yielded by the refrigerant fluid.

3. downstream of the condenser, the outgoing air is warmer than the incoming air (from 50°C to 65°C).

Replacement:
In the event of an accident, impact or leak, the condenser must be replaced.

The most common problems with condensers are:

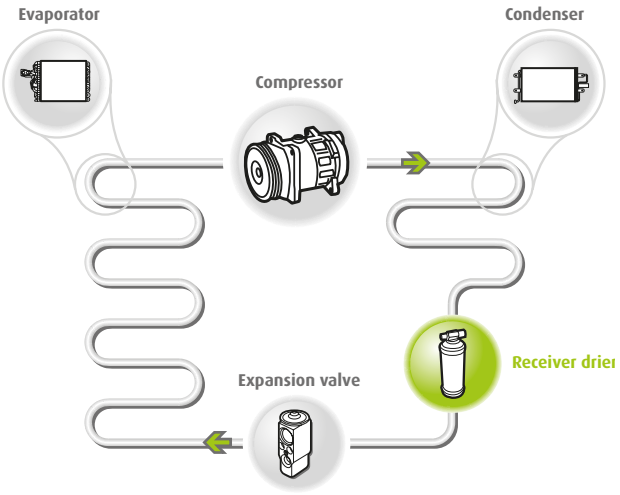
- perforation due to impacts or corrosion
- fins clogged or damaged by insects, soiling or high-pressure cleaners
- Leaks from the inlet and outlet couplings
- insufficient performance caused by adaptable products



The condenser

11.4 The receiver drier

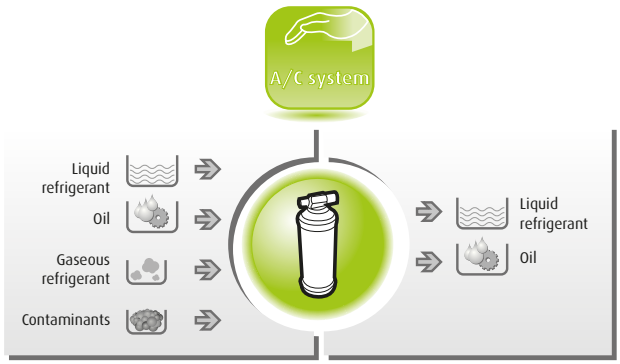
The receiver drier protects the components of the system; it is located on the high pressure side of the circuit between the condenser outlet and the expansion valve inlet.



Receiver drier

Roles:

1. To retain moisture and contaminants from the system (during the receiver drier's life time)
2. To finalise and secure the condensation of the fluid
3. To compensate for the variations of fluid volume
4. To ensure oil return to the compressor



Recommendations for replacement:

The receiver drier must be replaced every 3 years.

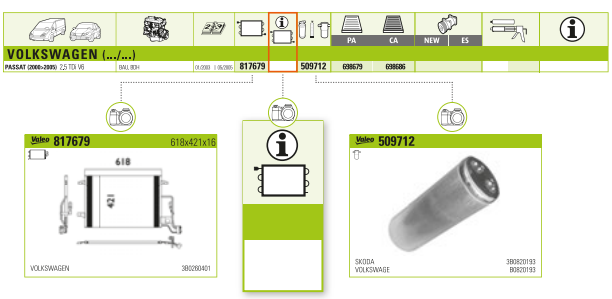
Regularly replacing the filter prevents serious failures and the costly replacement of the other components in the air conditioning system.
The receiver drier must be replaced whenever the circuit is opened.

11. The components of the A/C Loop

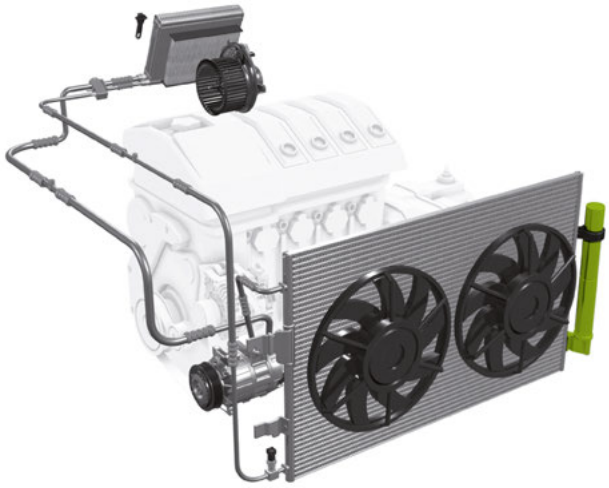
There are three installation variants for receiver driers:

Option 1
In-line receiver drier
located in-line downstream of the condenser

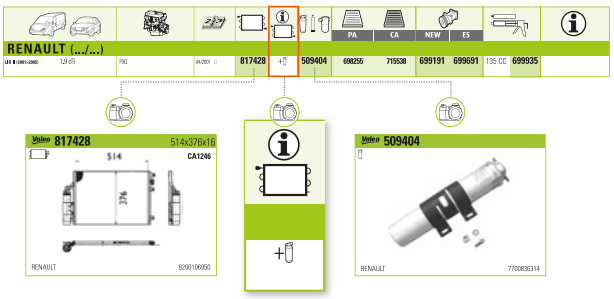
Example of an application in the Valeo Air Conditioning catalogue. This example shows that when the condenser 817679 is replaced, the receiver drier 509712 **is not** supplied with the condenser, so it must be ordered separately. This option is shown in the Information column (I), which is empty.



Option 2
Receiver drier fixed on the condenser

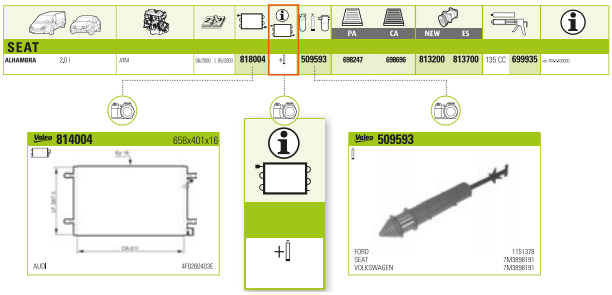


Example of an application in the Valeo Air Conditioning catalogue. This example shows that, when the condenser 817428 is replaced, the receiver drier 509404 **is** supplied with the condenser. It is mounted on the condenser in production. This option is shown in the Information column (I), which contains the pictogram of the receiver drier.



Option 3
Cartridge drier

Example of an application in the Valeo Air Conditioning catalogue. This example shows that, when the condenser 818004 is replaced, the receiver drier 509593 **is** supplied with the condenser. It is mounted on the condenser in production. This option is shown in the Information column (I), which contains the pictogram of the drier cartridge.



The IRD 'Integrated Receiver Drier'.
Both option 2 and option 3 integrate the receiver drier in the condenser refrigerant path. The IRD is not just about integration: it allows reaching a much higher level of condensation in the condenser in the long run despite refrigerant level fluctuations.

What you need to know to become N°1. Recommendations on the receiver drier.

The receiver drier must be replaced whenever the air conditioning loop is opened. For example, after an accident in which the condenser was damaged, the receiver drier must be replaced, or the desiccator will no longer retain the humidity in the circuit. It will become saturated with humidity.

Due to its very role, the receiver drier is hygroscopic. Therefore it is essential to obey the basic rules when replacing it on a vehicle or the new receiver drier may be damaged.
Receiver driers are fitted with compulsory plugs that must be removed as late as possible, i.e. just before they are installed.

Warning! If the receiver drier is not replaced, the operation of the loop will deteriorate and the risk of a breakdown will occur (blocked expansion valve, impurities in the circuit, etc.).

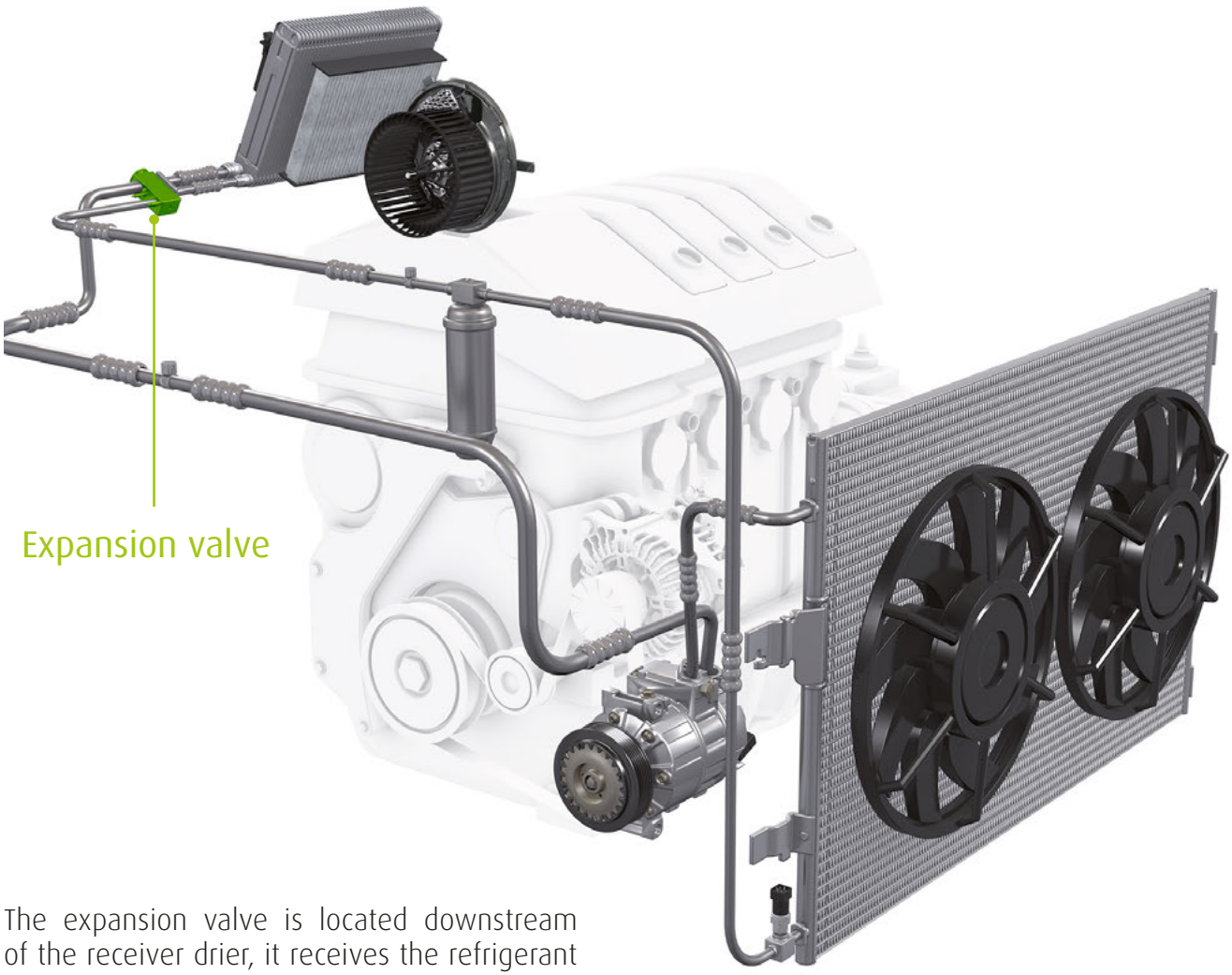
In any case, the receiver drier must be installed in the loop at the very last moment, just before the vacuum procedure.

11. The components of the A/C Loop

11.5 The expansion valve

Roles:

- Controls the drop in pressure for refrigerant evaporation & cold generation
- Controls the flow rate of the fluid in the evaporator
- Controls the evaporator output temperature (superheating)

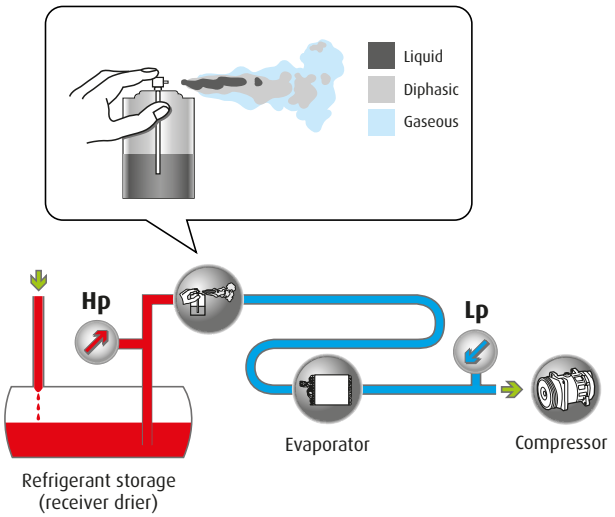


The expansion valve is located downstream of the receiver drier, it receives the refrigerant fluid in a 100% liquid state and after it has been filtered.

11.5.1 Simplified description

Operation:
The expansion valve reduces the pressure of the refrigerant fluid upstream of the evaporator. This drop in pressure produces cold. It also transforms the fluid from the liquid to the diphasic state.

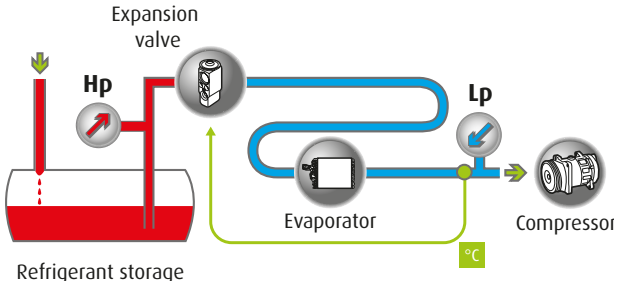
The diphasic fluid is then sprayed into the evaporator. The expansion valve is always attached to the evaporator.



11.5.2 Real description

The expansion valve is a regulation device. It is controlled according to the temperature of the refrigerant at the evaporator outlet.

The expansion valve measures the temperature of the fluid at the evaporator outlet. This temperature is determined by the heat exchanges taking place inside the evaporator and varies according to the conditions inside and outside the cold loop (volume of fluid, temperature, pressure).

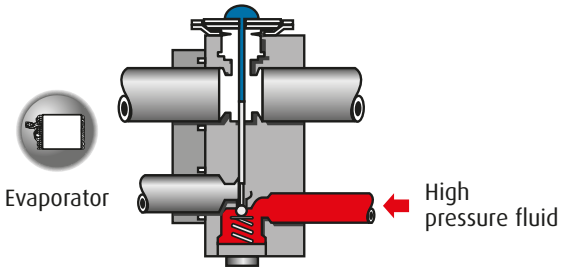


Based on the temperature information, the expansion valve adjusts the volume of fluid injected into the evaporator, therefore, according to the thermal requirements of the system (thermal load of the evaporator). The expansion valve is designed specifically for each new application of the A/C loop.

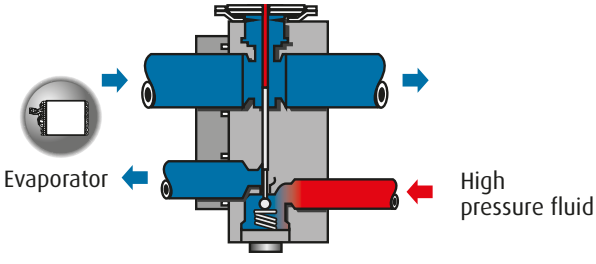
The expansion valve is a precision component that is complex and sensitive to the residue and acid flowing through the air conditioning loop.
A blocked expansion valve can result in either a significant loss of cold or the destruction of the compressor (frozen evaporator).
Regular system maintenance is essential to guarantee the longevity of the expansion valve, therefore, it is essential to replace the receiver drier.

Refrigerant flow in the expansion valve

In hot summer weather, the expansion valve lets more fluid enter the evaporator in order to produce a greater heat exchange.
The expansion valve permanently checks that the change in the state of the fluid in the evaporator occurs properly.



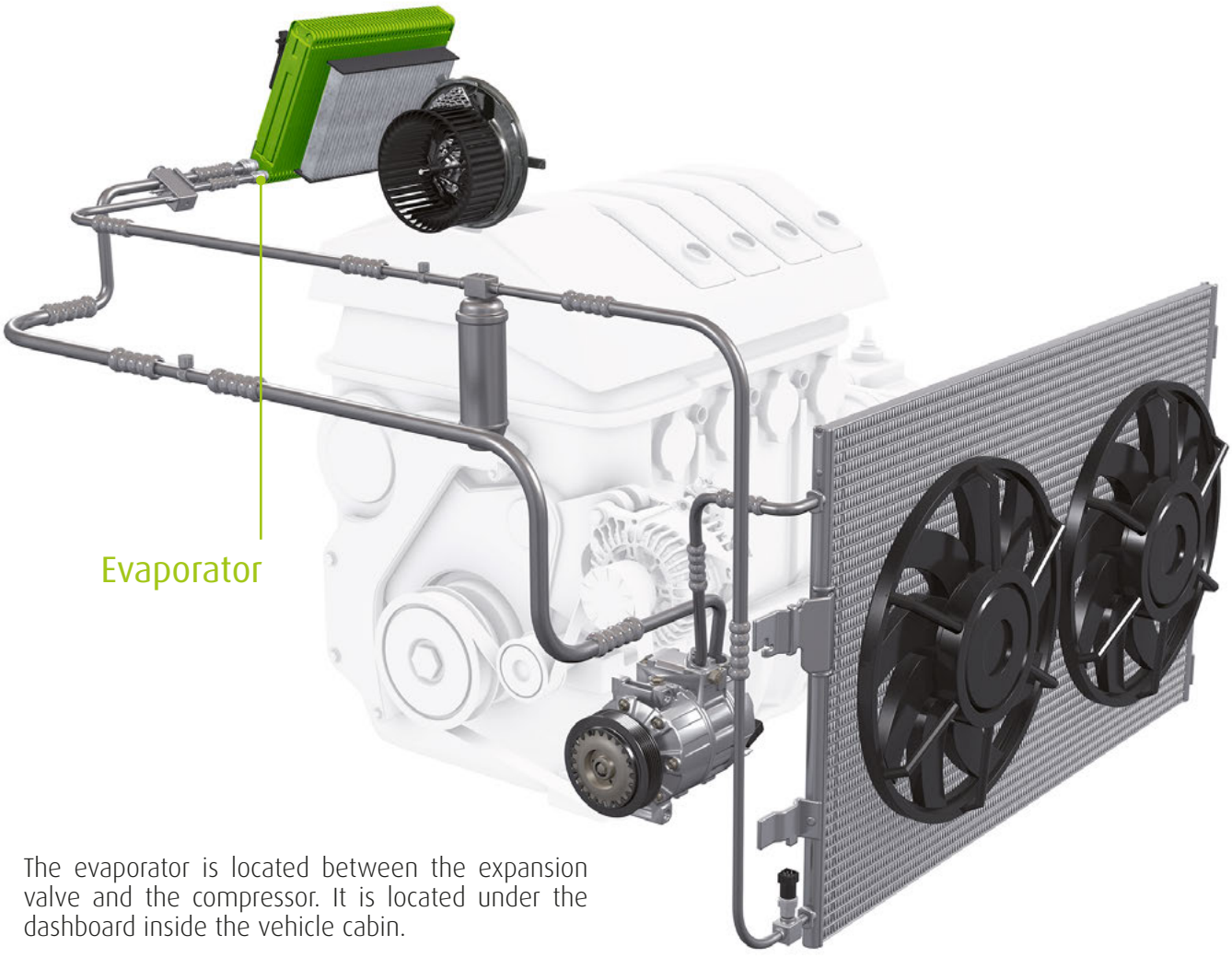
Expansion valve - **closed**



Expansion valve - **open**

11. The components of the A/C Loop

11.6 The evaporator



The evaporator is located between the expansion valve and the compressor. It is located under the dashboard inside the vehicle cabin.

Roles:
It fulfills two main functions:

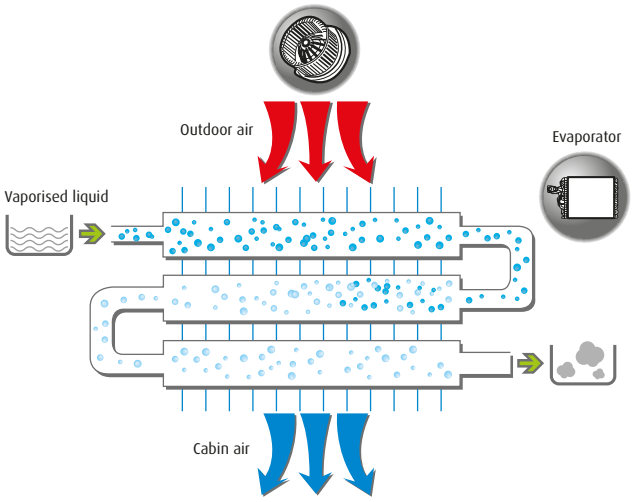
- To cool the air entering the cabin,
- To dehumidify the air entering the cabin in order to demist the windscreen quickly

Operation:

The evaporator is a heat exchanger into which the refrigerant fluid is sprayed in order to absorb the heat in the air stream to be cooled.

It cannot be dissociated from the expansion valve.

The pressure of the refrigerant fluid is reduced by the expansion valve before it enters the evaporator. In the evaporator, heat is exchanged between the cold fluid and the air entering the cabin.



Heat is exchanged between the outdoor air and the cold surface of the evaporator, air is cooled.
A phase change occurs from liquid to gaseous.

In the course of the heat exchange with the air entering the cabin, the state of the refrigerant gradually changes inside the evaporator.

At the evaporator outlet, the change in state is total and the fluid is 100% gaseous.

Design:

The evaporator is designed according to the volume of the cabin and the specific demands of the applications.

The expansion valve and the evaporator form an essential duo in the production of cold in the loop.

The evaporator

Practical advice:

The evaporator must be replaced if it is clogged, pierced or contaminated with persistent mould. The most common problems with evaporators are:

- Perforation due to corrosion
- Fins blocked by soiling or frost
- Leaks from the couplings

When replacing the evaporator, always replace the receiver drier and the expansion valve/orifice tube.

11. The components of the A/C Loop

11.7 Hoses

Roles:

- The A/C hoses route the fluid and connect the loop components together.
- Composition: a rigid part (aluminum or steel tube), a flexible part (rubber hose), fittings and seals, noise absorbers (mufflers), valves

The hoses are a mix of rigid and flexible tubing

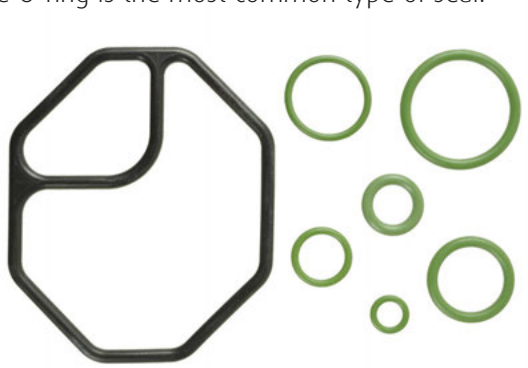
- Assembly is done via crimping
- Aluminum parts allow weight reduction
- Flexible tubing ensures vibration durability
- Temperature range is from -40°C to +135°C

The hoses support additional features

- Diagnostic and maintenance coupling systems
- Pressure sensors

Seals

Roles:
Seals ensure the tightness of the A/C loop ;
they make an essential contribution to the longevity of the system.
The O-ring is the most common type of seal.



The O-ring is the most common type of seal.

Operation:
Seals acts in a number of different ways, depending on the design of the sealing system: joints can be sealed by contact, compression or crushing.

Seals are installed in every connection between each components of the A/C loop (compressor, condenser, receiver drier, expansion valve and evaporator) or the various options that may be installed on the hoses (pressure switches, valves, etc.).

The loop lubrication is key to system tightness; O-Rings must be lubricated to be fully efficient

- As O-Rings must be lubricated to properly, a long period without activation of the A/C system can generate fluid leakage.

Practical advice:
Recommendations on seals.

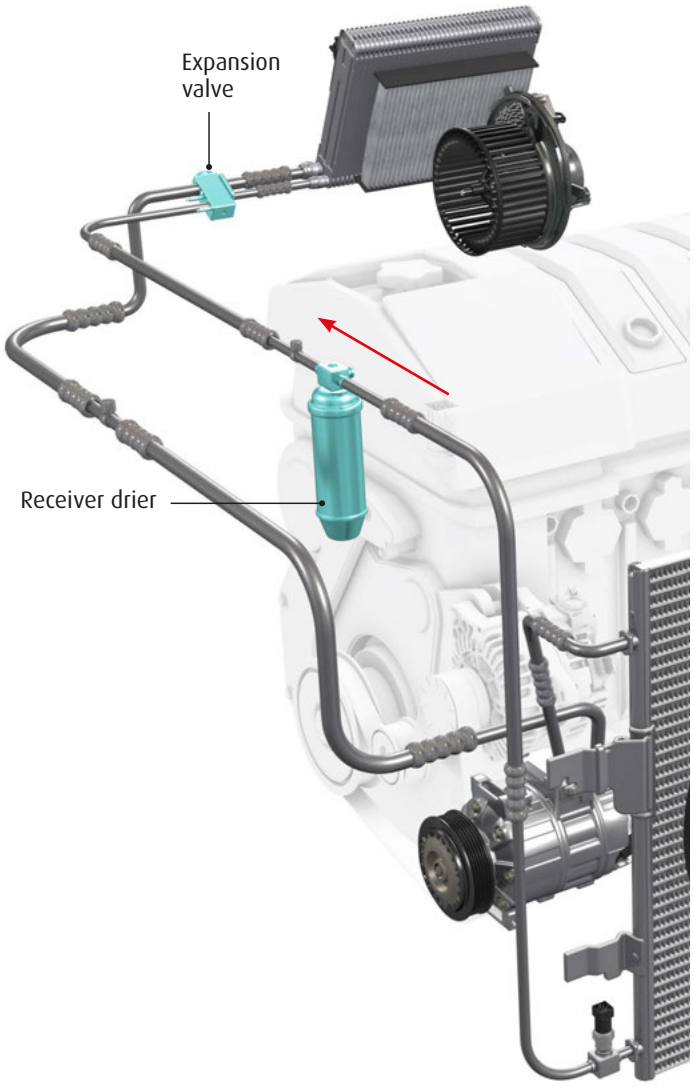
The O-ring must always be oiled before it is installed, with the same oil as used in the compressor, in order to make a perfect seal.

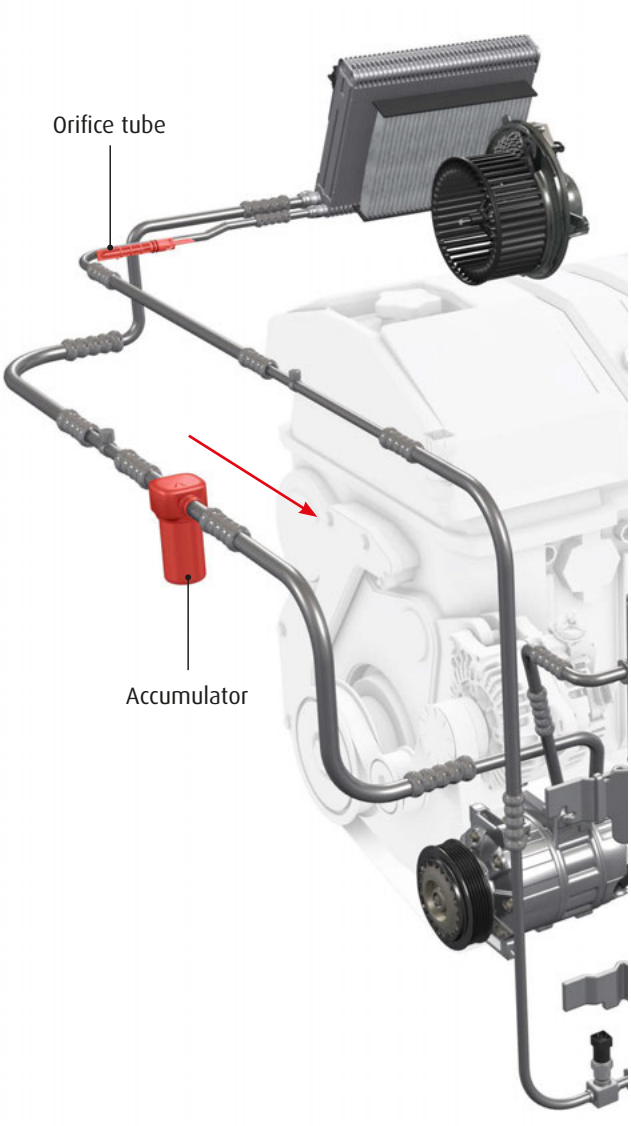
11.8 Variants on air conditioning loops

The expansion function can also be fulfilled by an orifice tube instead of the expansion valve.

11.8.1 Circuit with an orifice tube and accumulator

This circuit works in the same way as a conventional circuit in terms of pressure, fluid states and temperature.
The expansion valve is replaced by an orifice tube.
The receiver drier is replaced by an accumulator.





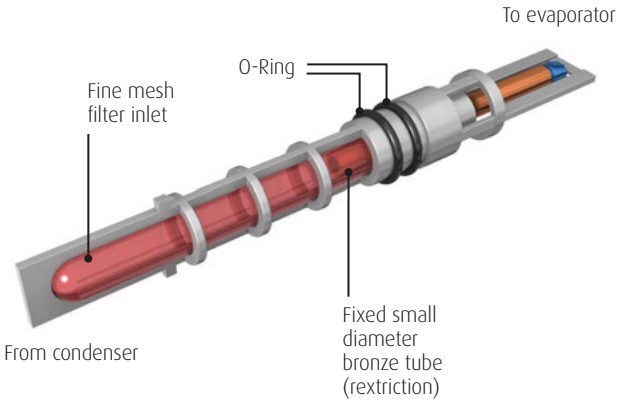
11. The components of the A/C Loop

11.8.1.1 The orifice tube

Operation:
The orifice tube is a tube with a given length and cross-section which expands the refrigerant but, unlike the expansion valve, is unable to regulate flow rate and superheating.
The orifice tube is always associated with an accumulator at the evaporator outlet.

Orifice tubes are made up of three main parts:

- A metal tube with a chamfered inlet
- A plastic tube body
- An inlet and outlet filter



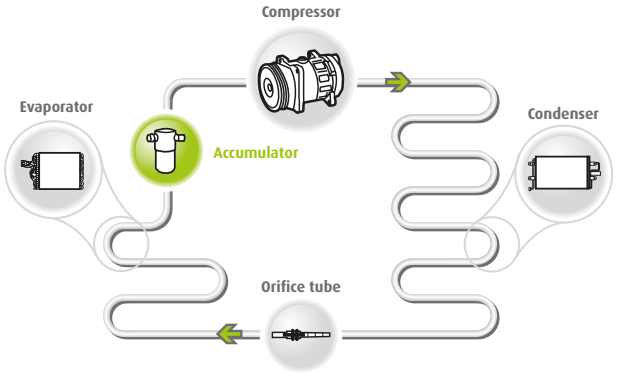
Replacement:

If the A/C loop is contaminated, then the orifice tube becomes clogged.
In this case, replace the orifice tube. The orifice tube must always be replaced when another important part of the circuit is replaced (compressor, condenser, evaporator, receiver drier).

Warning !
Flush the A/C loop before installing a new orifice tube.

11.8.1.2 The accumulator

The accumulator has a similar function to the receiver drier but works on the gaseous side of the A/C loop.
The accumulator protects the components of the system; it is located on the low pressure
side of the circuit between the evaporator outlet and the compressor suction port.



Roles:
1. To provide compressor protection, preventing compressor failure due to liquid slugging
2. To retain moisture and contaminants from the system (during the accumulators life time)
3. To ensure oil return and assure that only refrigerant is returning to the compressor.

Advice on replacing accumulators:

The accumulator is a drier filter that must be replaced every 3 years or whenever the circuit is opened.

11.8.1.3 Loops variants in Valeo A/C catalogue

The A/C loop variant is indicated in the Valeo catalogue, both receiver drier and accumulator circuits are shown via a pictogram.
Both type of expansion devices, orifice tube and expansion valve are visible as well.

Accumulator and Orifice tube

		cc				OE	Valeo	
AUDI (.../...)								
S6 (94>97)								
2.2 Turbo 20V, 2.2 i Turbo 20V	E	2226	AAN		07/94 ▸ 07/97	4A0820191AB	**508882**	
4.2 i V8 32V	E	4172	AEC, AHK		07/94 ▸ 10/97	4A0820191AB	**508882**	

	A/C					OE	Valeo	
AUDI								
S6 (94>97)	+		Yellow-White/Jaune-Blanc (X5)		07/94 ▸ 10/97	8A0820177AA	**508971**	
S8 (2006>2007)	+				06/06 ▸	4B0820177	**508971**	

Receiver drier and Expansion valve

		cc				OE	Valeo	
AUDI								
TT (2006>)								
2.0 TFSi	E	1984	BWA	Kit	08/06 ▸	1K0298403A	**509790**	
Quattro 3.2 i V6 24V	E	3189	BUD	Kit	08/06 ▸	1K0298403A	**509790**	

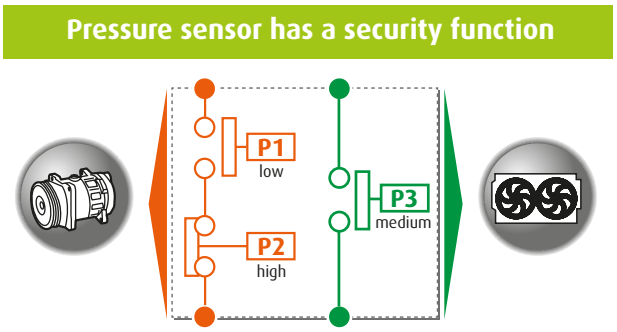
	A/C					OE	Valeo	
AUDI								
TT (2006>)	+				08/06 ▸	1K0820679	**509901**	

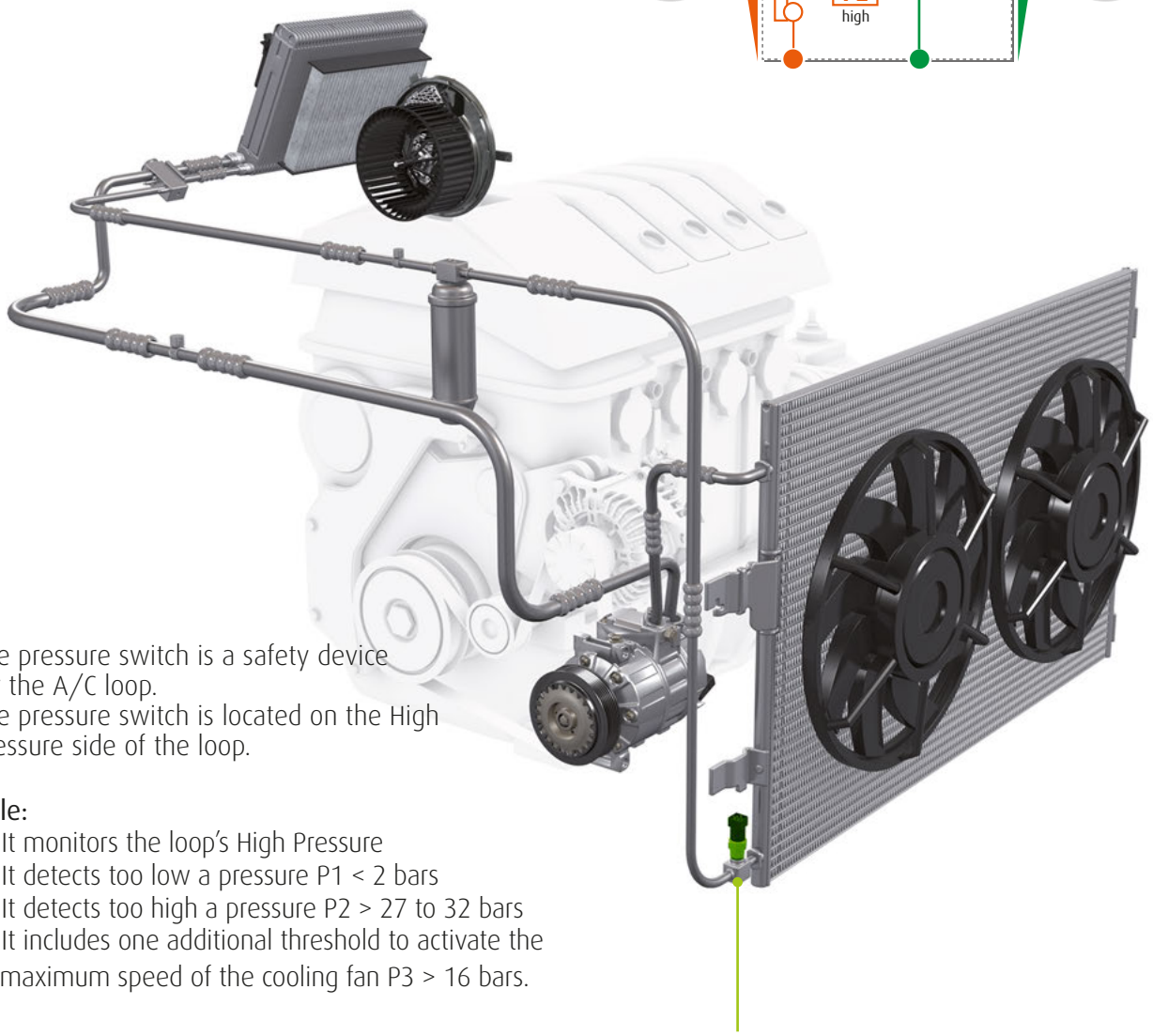
11. The components of the A/C Loop

11.9 Safety devices

11.9.1 The pressure switch (pressostat)

The pressure switch monitors the A/C loop high pressure level; it enables or disables the compressor according to two pressure thresholds.
One additional circuit controls the cooling fan; it secures the condensation process by forcing the air flow through the condenser.

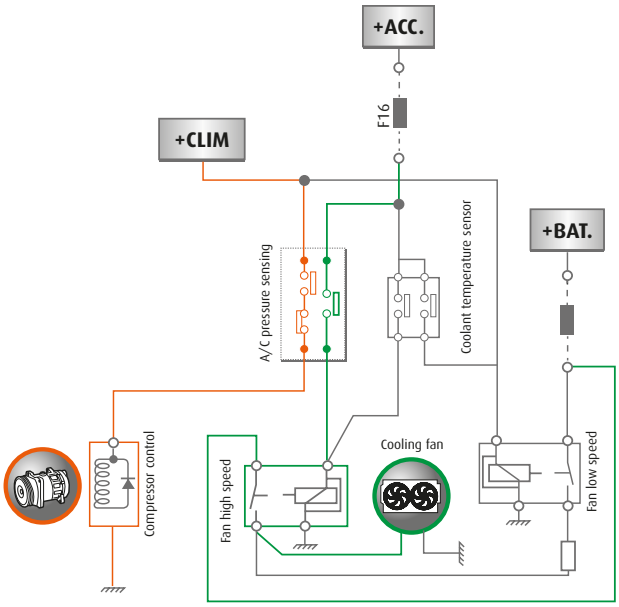




The pressure switch is a safety device for the A/C loop.
The pressure switch is located on the High Pressure side of the loop.

Role:

- It monitors the loop's High Pressure
- It detects too low a pressure P1 < 2 bars
- It detects too high a pressure P2 > 27 to 32 bars
- It includes one additional threshold to activate the maximum speed of the cooling fan P3 > 16 bars.

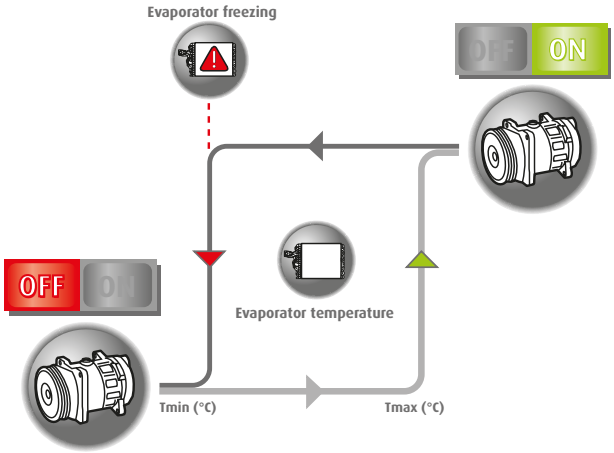


11.9.2 The evaporator sensor

The evaporator sensor is a temperature detector.

Role:

- Sensing the evaporator temperature
- Preventing the freeze of the evaporator by stopping cold generation



The compressor generally disengages when the detected temperature achieves -1°C, and re-engagement occurs at 4°C

Location:

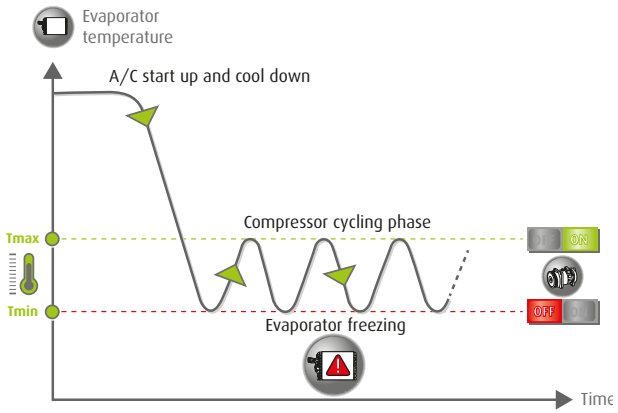
Option1: The sensor is located in the air stream where the air leaves the evaporator

Option2: The sensor is plugged on the evaporator's fins and located in the coldest area

Compressor cycling process

When the air temperature is below or equal to the target value Tmin (about -1°C), the surface of the evaporator may freeze.

The sensor detects this temperature and sends it to the control system, which switches off the compressor.



This causes a drop in the production of cold by the evaporator and a gradual rise in the temperature on its surface.

The sensor then detects this increase in the temperature and authorises the compressor to restart when the temperature reaches Tmax.

A/C loops fitted with variable-cylinder and external control compressors do not need an evaporator sensor. The thermal power is adjusted in order to:

- Avoid freezing on the evaporator
- Provide greater comfort
- Improve the efficiency of the system
- Reduce the vehicle fuel consumption

12 Why regular A/C servicing?

The air conditioning system must be regularly serviced or the system performance will quickly deteriorate.
Poor maintenance can result in major system breakdowns that are costly to repair.

The A/C loop's state of health can be evaluated thanks to temperatures, pressures and parameters like condenser subcooling and evaporator superheating.

The performance of an air conditioning system is strongly impacted by the humidity in the loop (condition of the receiver drier), insufficient air flow and the quantity of refrigerant.

12.1 The consequences of humidity

Humidity in an air conditioning loop can result in:

- A blocked expansion valve and the formation of an ice plug.
- The deterioration of brazed assemblies, corrosion.
- Hydrolysis of the oil.

When humidity is present, the oil chemically decomposes by hydrolysis and forms organic acids. These acids corrode the metals and deposits form that can clog certain sensitive parts of the loop..

Simple action can be taken to prevent humidity in the A/C loop:

- Always follow an efficient vacuum procedure, covering optimum vacuum level and appropriate vacuum time according to the maintenance operation
- Secure the seals of all the parts whenever the loop is opened to prevent the ambient humidity from entering the loop.
- Effectively filter the refrigerant fluid in the loop in the extraction phase.
- Replace the drier element every 3 years, whenever the loop is opened and in the event of major repairs or an accident.

12.2 The consequences of insufficient air flow

The flow of air passing through the cabin determines the thermal exchanges in the system and, therefore, the performance of the air conditioning.

Obstructing or reducing the air flow will immediately impact the comfort of the occupants and have a damaging effect on the reliability of the system components.

When servicing the system, it is essential to check the complete air circuit, from capture to extraction:

- Extraction of any residue (leaves, etc.) from the air inlet circuit.
- Replacing the cabin air filter.
- Checking that the extractors are not blocked.

12.3 The consequences of a lack of refrigerant

The heat exchanges are produced by the change in state of the refrigerant fluid.
System performance will deteriorate if the refrigerant level is too low.

- It is advisable to regularly operate the compressor in order to lubricate the various seals in the loop. This reduces the risk of leaks and helps to maintain the system performance.
- Irrespective of the type of circuit, it is essential to operate the compressor for at least 1 or 2 minutes per month all year long.

It is essential to check the sealing of the A/C loop during servicing operations.

Valeo has a range of tools to test sealing and detect leaks.

Warning!
If a major leak occurs in the system, never refill with fluid without first identifying the reason and origin of the leak.

12. Why regular A/C servicing?

12.4 Expert practices

The maintenance and repair of the A/C loop must be considered as an operation on the whole system. The failure of one component can have a serious impact on the rest of the loop so it is important to combine certain operations in order to guarantee the performance and reliability of the replaced parts.

Take the compressor, for example. In order to extend the Valeo warranty to the new part, the operator must perform the following operations:

- Flush the loop to eliminate any metal residue from the components
- Replace the receiver drier

Associated functions and actions / Replaced device	A/C loop							Air flow		Air quality treatment	
	Expansion	Filtration and protection	Lubrication	Leak detection	Tightness	Decontamination	Vacuum conditioning	Cabin ventilation	Air filtration	A/C system cleaner	Cabin purifier
			Oil	**UV dye tracer**	**O'rings / gaskets**	**A/C station** flushing	**A/C station** vacuum pump	**Blower**	**ClimFilter™**	**ClimPur™**	**ClimSpray™**
Compressor	✓	✓	✓	✓	✓	(1) ✓	T ≥ 45 minutes ✓	Check ✓	Check ✓	✓	✓
Condenser		✓	✓	✓	✓	(2) ✓	T ≥ 90 minutes **Crash** ✓ / T ≥ 45 minutes **Maintenance** ✓	Check ✓	Check ✓	✓	✓
Receiver drier			✓	✓	✓	✓	T ≥ 45 minutes ✓	Check ✓	Check ✓	✓	✓
Evaporator			✓	✓	✓	✓	T ≥ 45 minutes ✓	Check ✓	Check ✓	✓	✓
Hose			✓	✓	✓	✓	T ≥ 45 minutes ✓	Check ✓	Check ✓	✓	✓

✓ Depending on the individual case ✓ Mandatory action

(1) Valeo warranty only applies if flushing has been done properly
(2) Flushing required in case of crash only

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The A/C market

Yesterday considered as luxury equipment, the air conditioning widely became more democratic today and now equips 90 % of new vehicles in Europe. As a consequence, inquiries for Air Conditioning maintenance and repair follow the same evolution and are a real opportunity for workshops to increase their revenues.

In this framework of important and continuous growth, Valeo Service is proud to present you the 2013 Air Conditioning technical handbook, the first step to a fully renewed technical collection.

From the Kyoto protocol to thermal comfort rules, system overview and interactions between components, this book will allow you to rediscover the air conditioning system. More focussed operations on the A/C system will be treated through technical bulletins and videos.

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