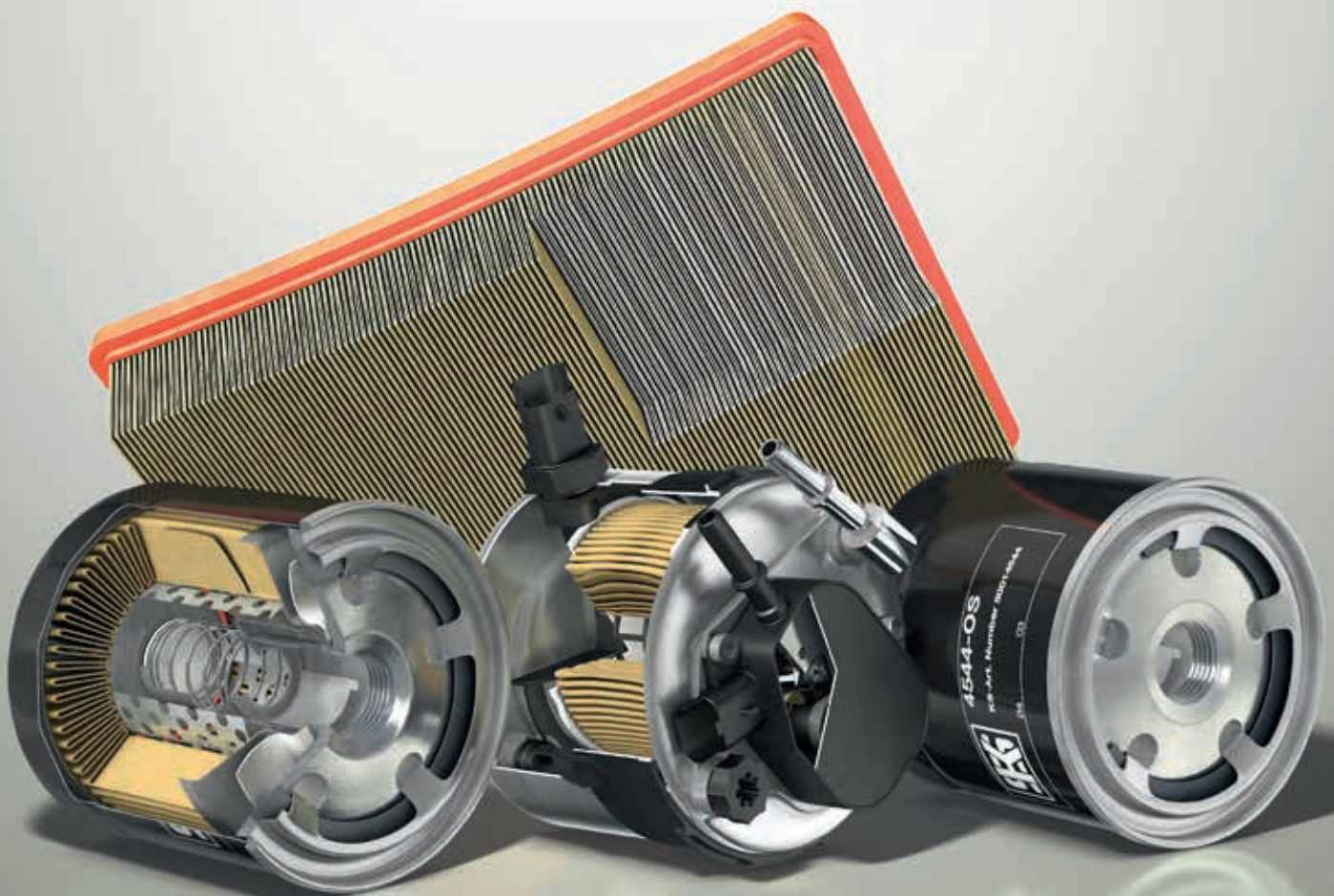




MOTORSERVICE
RHEINMETALL AUTOMOTIVE

Technical filter brochure

SERVICE
TIPS & INFO



KOLBENSCHMIDT

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EngineComponents

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The extent to which the technical methods and repair information described here will apply to future engine generations cannot be predicted and must be verified in individual cases by the engineer servicing an engine or the workshop operator.

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1.1 General information

They lead a life in the shadows, but are more important than any comfort feature: Filters. Filters purify the substances that are necessary for proper engine operation. Neglecting change intervals or using poor quality filters often results in substantial costs down the line. Filtration has become very extensive in modern vehicles due to the constantly rising requirements on the engines. High customer demands, as well as stringent environmental regulations, are further factors that have a great influence on the development of filter technology.

The engine filter is responsible for preventing impurities and foreign bodies from entering the inside of the engine along with the air, oil and fuel.

In engine technology, different types of filters are used for the various substances to be filtered. They differ with respect to their function, structure, and maintenance intervals.

There are numerous filtration methods: Dirt particles can be removed using

- fine-meshed plastic or
- metal sieves,
- fine-porous paper, felt and fleece or
- through centrifugal forces.

1.2 Kolbenschmidt filter classification

The Kolbenschmidt range of filters comprises air, oil and fuel filters for passenger cars, trucks, and for utility vehicle applications. According to the type of application, the filters are classified as follows:

Designation	Filter type
AC (air cabin)	Standard cabin filter
ACC (air cabin with activated carbon)	Cabin filter with activated carbon
AD (air dryer)	Air dryers for brake systems
AP (air panel)	Panel air filter
AR (air round)	Round air filter
CS (coolant spin on)	Coolant filters
FC (fuel cartridge)	Fuel filter cartridge
FP (fuel pipe (inline))	Fuel pipe filter
FS (fuel spin-on)	Spin-on fuel filter
FX (fuel metalfree)	Fuel filter cartridge, metal-free
OC (oil cartridge)	Oil filter cartridge
OH (oil hydraulic)	Oil hydraulic filter
OS (oil spin-on)	Spin-on oil filter
OT (oil transmission)	Automatic gear oil filter
OX (oil metalfree)	Oil filter cartridge, metal-free
OZ (oil centrifuge)	Oil centrifuge filters

Filter classification

1.3 Explanations of Kolbenschmidt item numbers

Kolbenschmidt uses two number groups for filters: In addition to the standard eight-digit Kolbenschmidt number, there is also a short number. This consists of three or four digits plus two or three letters. The digits identify the filter, the letters explain the filter type (see 2.). The eight-digit Kolbenschmidt number appears in all documents, such as delivery notes and invoices, for example. The first five digits are always "50 013" or "50 014"; the last three or four identify the filter and are the same as the digits of the short number.

Examples:

- Oil filter cartridge
095-OC = 50 013 095
- Cabin filter with activated carbon
4027-ACC = 50 014 027



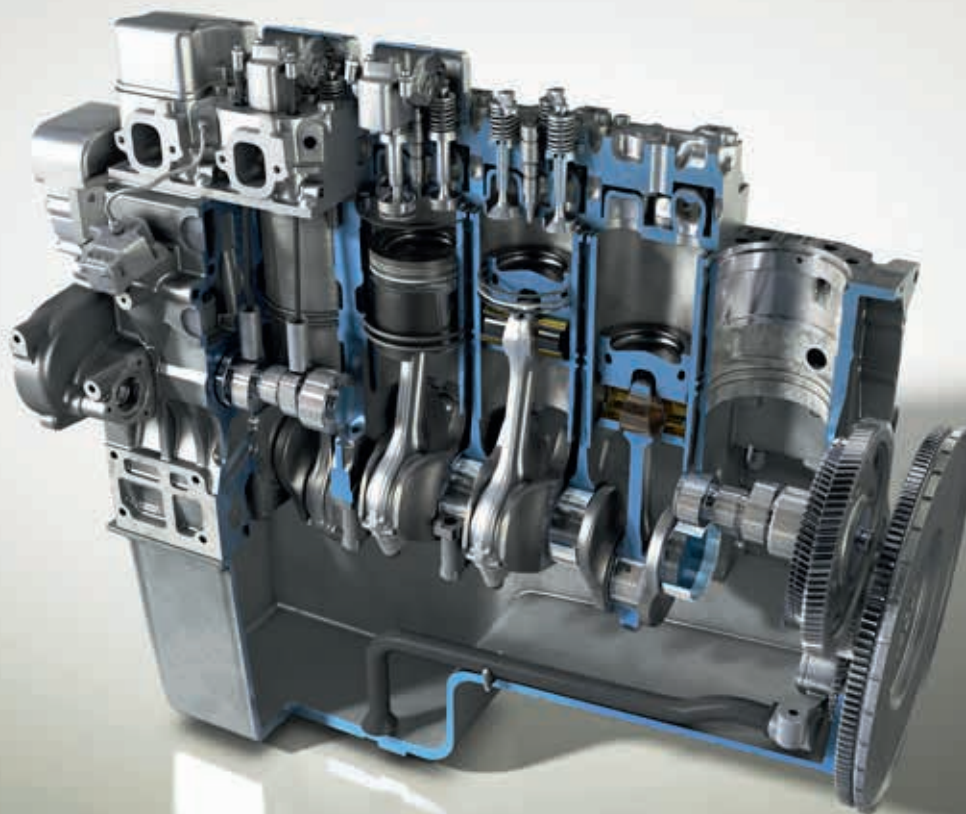
Air filters

1.4 The wear in the combustion engine

Whenever moving parts come into contact or mesh, they cause friction which must be avoided.

As a suitable lubricant, mineral or synthetic oil is used which forms a sliding film between the moving machine parts. This ultra-thin separation film acts as a buffer to prevent a direct contact and to allow the parts to slide. This lubrication can only be carried out effectively if the oil remains clean. Even impurities of microscopic size may not be carried because, as abrasive particles, they significantly accelerate the abrasive wear on the engine parts.

Critical points within the engine are the running surfaces of the cylinder liners, pistons, piston rings, valves, gaskets, crankshafts and connecting rod bearings. Foreign bodies can enter the engine directly in the form of sand or sand particles with the fuel or the intake air. Foreign bodies in the system can also indirectly promote wear and cause problems during operation – in the form of fine metal abrasives, residues of incomplete combustion or small fibres, plastic or rubber particles.



Engine sectional view

1.5 Wear on engine components due to impurities in the system



New part



Damaged part

Significant wear on the sliding lands of the oil control ring.
Result: Increased oil consumption



New part



Damaged part

Significant scoring on the main bearing caused by an abrasive mass of oil and dirt particles.
Result: Engine damage



New part



Damaged part

Piston with clear wear marks: Significant abrasion on the piston skirt coating. The lack of sliding film may lead to piston malfunction or even piston seizure.

1 | Introduction



Fig. 1



Fig. 2

Significant wear in the area of the 1st ring groove (Fig. 2): The elevated clearance (Fig. 2) leads to reduced compression, resulting in performance losses.



Fig. 3



Fig. 4

New cylinder liner (Fig. 3) with clearly visible cross-hatching: This surface, produced using a honing tool, improves the oil adhesion on the inner wall of the cylinder.

Cylinder liner with scoring on the inner wall (Fig. 4). The honed surface can no longer be detected. Result: Increased oil consumption

2.1 Basic information

When talking of filtration in modern vehicles, the main focus lies on depth filters. These special filter elements are used if particles are to be removed from liquids (oil and fuel) or gases (air) to 100 % where possible. The separation of particles is carried out in the depth structure of the

medium on the surface of the individual fibres.

These impurities can be dust, metal abrasion or soot particulates from incomplete combustion. In addition to the solid particles, filters also have to remove

water residues in the fuel lines, as well as oil drops resulting from the blow-by-gas of the crankcase ventilation.

2.2 Filtration effects

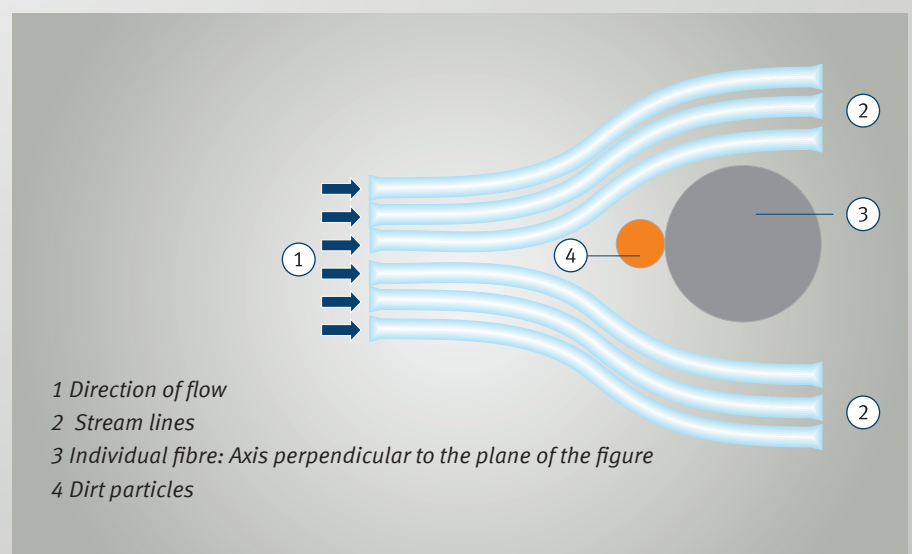
A variety of different methods are used to separate dirt particles. These effects will be explained in the following chapters: They mainly depend on the size of the particle to be separated, as well as on the properties of the liquid or gas containing them. Physical effects, such as centrifugal or electrostatic forces, also play a major role in the separation process.

In the following figures, the filter medium is represented as an individual fibre perpendicular to the plane of the figure. Air, oil and fuel move in a laminar flow around the fibre and are shown by simple path curves (streamlines). The blocking effect is the most important separation mechanism in the filtration of oil and fuel. In air filtration, the inertia and diffusion

effects also play a part in addition to the barrier effect.

2.3 Inertia effect

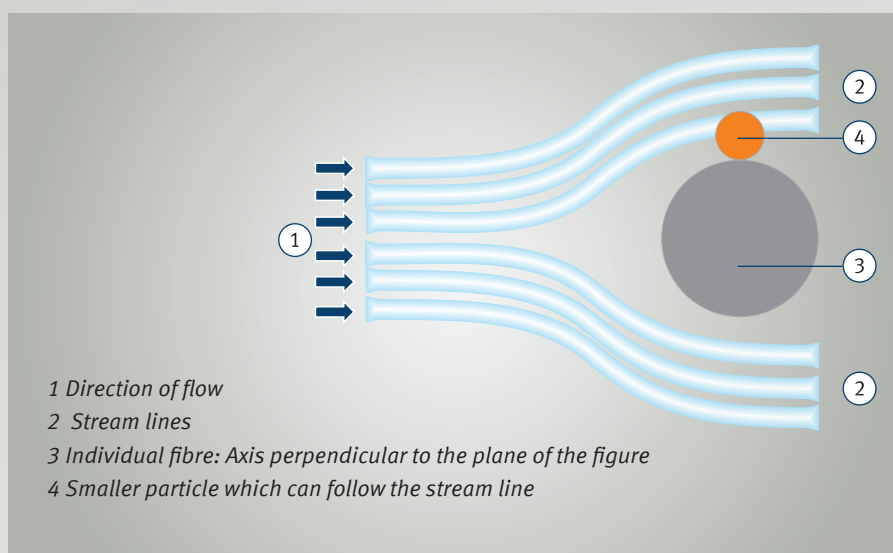
The inertia effect is based on the fact that dirt particles with a larger mass approaching the fibre leave their streamline path as a result of inertia and directly collide with the fibre.



Inertia effect

2.4 Barrier effect

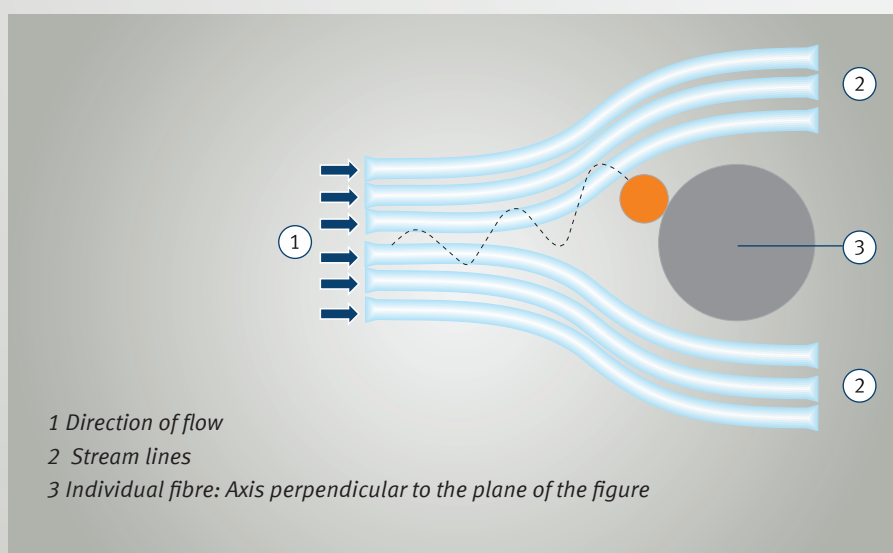
In the barrier effect, the particles can follow the streamline path due to their size. But if they get too close to and come into contact with the fibre, they adhere to it (Van-der-Waals forces).



Barrier effect

2.5 Diffusion effect

The diffusion effect is used to filtrate very small dirt particles with a diameter of less than 0.5 mm: They move on irregular paths (Brownian movement), collide with a fibre more or less accidentally and adhere to it.



Diffusion effect

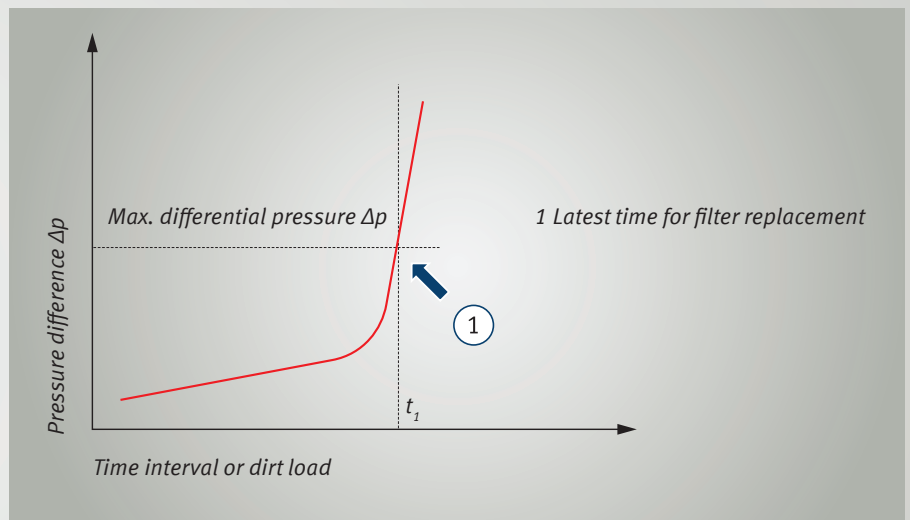
3.1 Basic information

When using a new filter, dirt particles first settle on the fibre surface. With increasing soiling, the thickness of this dirt layer increases and causes a decrease in the

pore volume of the filter. But as the pore volume decreases with the flow remaining constant, the pressure difference rises.

3.2 Pressure difference over time

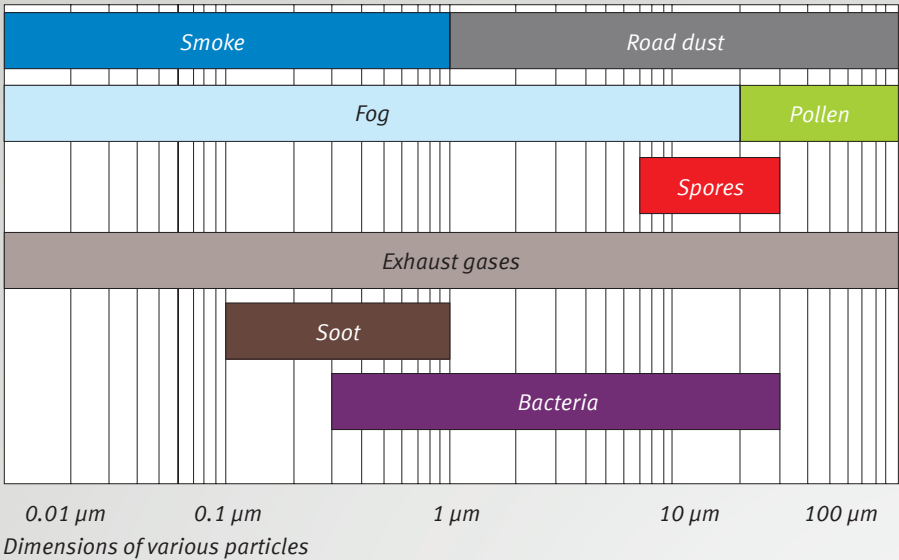
The course of the pressure difference Δp over the operating time or dirt load is shown in the diagram: The rather slow increase in the pressure difference is a typical phenomenon with depth filters. Only when the pore volume of the filter is nearly exhausted does the pressure difference rapidly increase. This is when the filter should be replaced. The time t_1 is defined in the specification of the car manufacturer.



Pressure difference

3.3 Dimensions of various particles

Filters usually have to collect microscopic particulates. The following figure illustrates the different sizes of typical dirt particles which a filter has to collect.



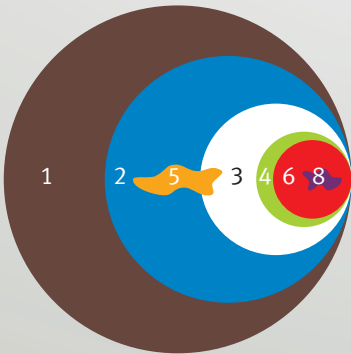
3.4 Proportions

In order to illustrate the dimensions of filtered particles even better, dirt particles and pollens are shown in comparison with the cross-section of a human hair.

1 Human hair	(~70 μm)
2 Minimum the human eye can see	(~40 μm)
3 White blood cells	(~25 μm)
4 Pollen	(~10 μm)
5 Dirt particles	
6 Red blood cells	(~7 μm)
7 Bacteria	(~2 μm)

Sizes of dirt particles

Proportions dirt particles



4.1 Basic information

Since paper is the number one filter medium in motor vehicle technology, it will be examined more closely in the following chapter. This brochure does not include a

detailed description of filtration methods using fine-meshed sieves, felt or fleece fabrics. Depending on the application, high quality filter paper differs in the

composition of the fibre and pore structure, as well as in its fineness. The three most important filter media are cotton, cellulose and plastic fibres.

4.2 Requirements

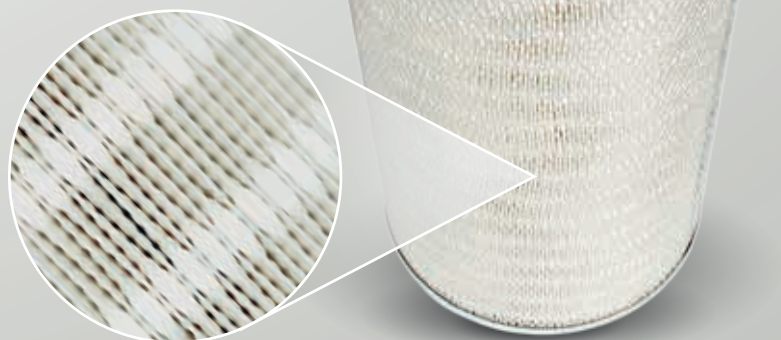
- A high pulsation stability at any dynamic load
- Insensitivity to water (e.g. in case of heavy rain or spray), engine oils, crankcase gases and fuel vapours
- High thermal stability, as temperatures up to 80 °C are possible on the filter element during vehicle operation

In order to counteract these mechanical, climatic and thermal loads, the filter papers are impregnated: The paper is soaked in modern synthetic resins and then subjected to a heat treatment. During this process, the pore volume, pore size and fibre structure of the original material must remain unchanged.

4.3 Forming

In order to accommodate the maximum possible filter surface in a cartridge, the paper is formed during heat treatment. In this production method, a certain pleat shape is forced onto the paper by making use of the paper's thermoplastic behaviour between 20 and 100 °C so that the pleat shape is preserved even during curing.

This pleat geometry makes it possible to obtain an effective filter surface area of approx. 10 m² in a utility vehicle cartridge, for example. In order to prevent the pleats from sticking to each other in the engine environment, pleat spacers are formed into the paper. There is also the option of giving each individual pleat a corrugation, thus preventing the paper from bridging.



Pleat geometry

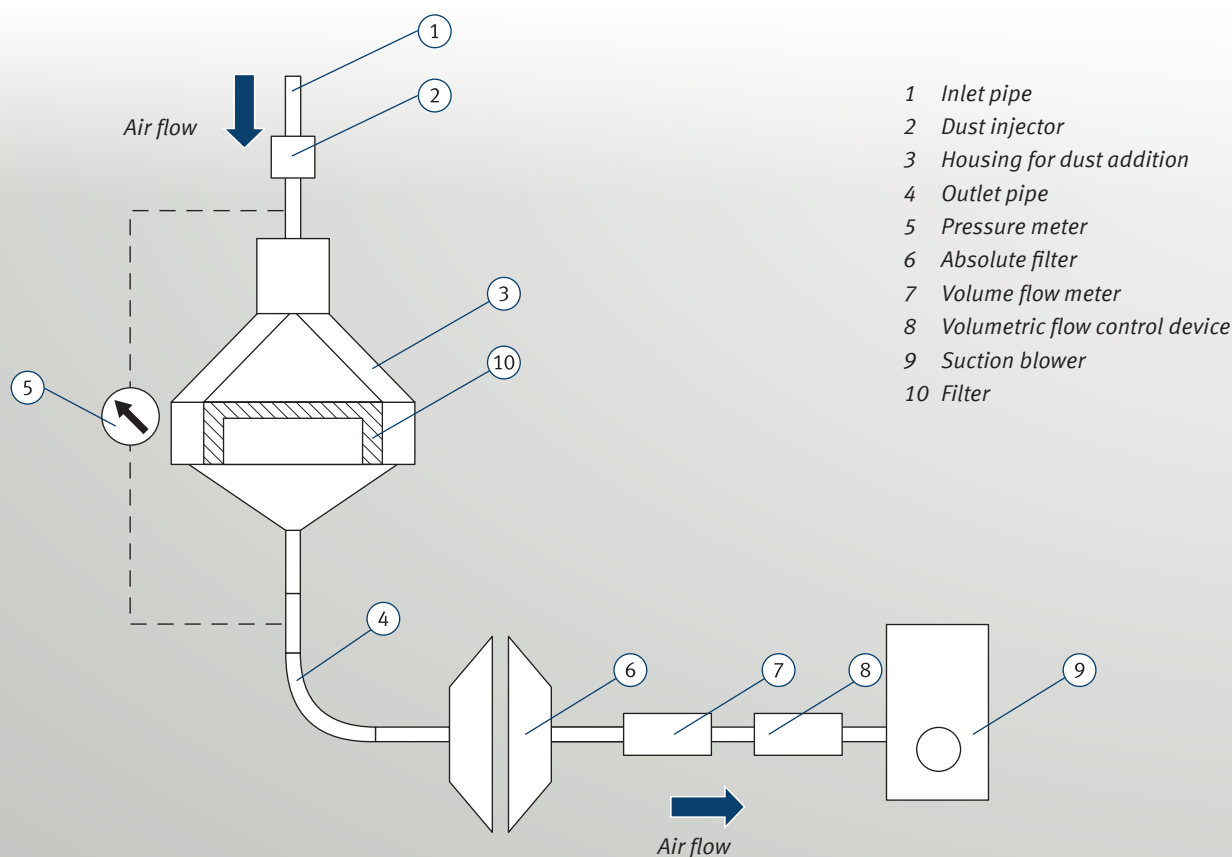
4.4 Quality testing of filter papers

The filter paper is subjected to strict quality controls. One of the most important test procedures is the so-called bubble test. Put simply, this test consists of soaking the test paper with a precisely defined liquid and subjecting it to different test pressures.

The first air bubble can be mathematically assigned to the largest pore. When the test piece is completely covered with air bubbles, this indicates the average distribution of pore sizes. This is because: "Large pores require low pressure loads, small pores require high pressure loads." This method is also used to determine the differential pressure.

The test is relatively simple to execute, but its results are still very exact. It is important to remember, however, that the test only provides comparative values with other papers. In addition, separation tests with test particles are carried out (direct method according to DIN ISO 5011). The following illustration shows the test set-up for the determination of the filtration efficiency and the dust capacity of filter elements.

The correct filter paper for each application can be defined precisely from the results.



Test set-up to determine the filtration efficiency

5.1 Basic information

When talking about air filters (suction filters) in modern engine manufacture, the main focus lies on the so-called dry filters, the generic term for a variety of exchangeable paper filters. Dry filters work in a different way than wet or oil bath filters,

where liquids are used to separate dust particles from the intake air. The paper filter has gained acceptance for air intake, mainly because it can ensure higher and - above all - stable filtration efficiency for all load ranges. Additional advantages are the easy

maintenance and the independence of the installation position. The paper filter also scores points from an environmental standpoint.

5.2 Task/function

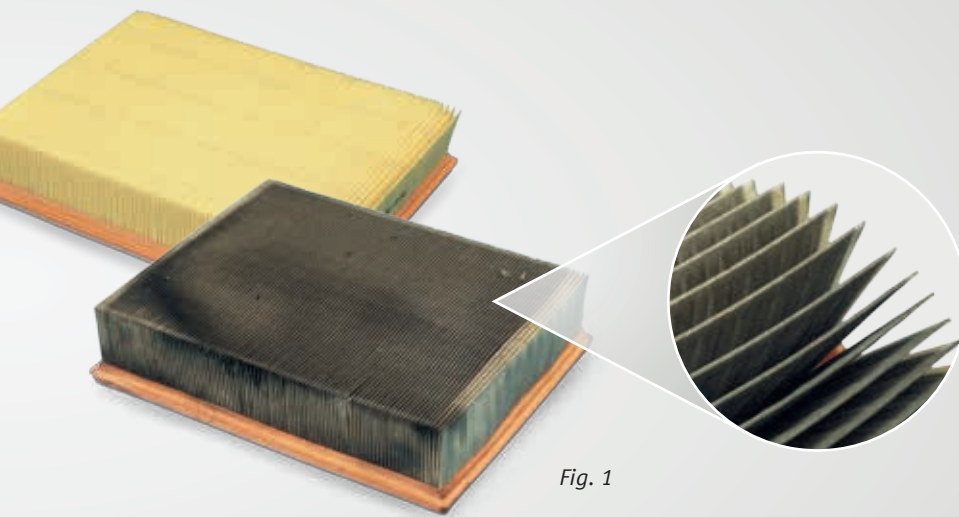


Fig. 1

The dirt film which has settled on the filter over a mileage of 15,000 km is clearly visible (Fig. 1). Minute dirt particles settle in the depth structure of the filter paper. Consequences: richer fuel-air mixture, elevated pollutant emission, reduced engine performance.

Air filters purify the intake air and dampen the intake noise of the engine. Another function – especially in passenger cars – is pre-heating the intake air and controlling the temperature. This regulation is key for the operating behaviour of the engine and the exhaust gas composition.

This short numerical example illustrates the capacity and importance of the filter element:

Depending on the landscape, weather conditions, ground and road properties and the use of the motor vehicle, the amount of dust per m^3 of air may range from 1 to 10 mg. On unpaved roads or on construction sites, it may even reach 40 mg.

Assuming that a supply of approximately 14 kg of air is necessary for the complete combustion of one litre of fuel (petrol engine), one gets an idea of how many dust particles have to be filtered out.

This amount of dust, together with the lubricant, can form an abrasive mass which inevitably leads to considerable wear on the pistons, piston rings and running surfaces of the cylinder liners.

5.3 Consequential damage

Failure to replace air filters in time leads to a richer fuel-air mixture due to the increasing flow resistance and thus to higher pollutant emissions, as well as reduced engine performance.

Fine dust particles that pass the filter paper contribute to siltation in the engine and may deposit on the air mass sensor.

This component is installed on the clean air side of the suction filter and is responsible for metering the fuel quantity (increasing fuel consumption).

If dirt particles get into the inside of the combustion chamber, the durability of the combustion engine is reduced, since the engine bearings, pistons, piston rings and

running surfaces of the cylinder liners wear out due to the increased abrasive effect.

5.4 Passenger car air filter design

Air filters for passenger cars come in two different models: panel filters and round filters (round and oval elements). The type of filter suitable in any specific case mainly depends on the application of the basic rules of filter technology.

For their position in the vehicle, the spot with the lowest possible dust or water supply is chosen. The filter elements have a high filtration efficiency, irrespective of the load. They are easy to replace according

to the maintenance intervals specified by the vehicle manufacturer. There is a wide range of engines on the market, and each vehicle requires filters which fulfil the requirements of the engine and installation space exactly. Kolbenschmidt offers air filter models to suit virtually any vehicle.

Filter housings and filter elements are optimally coordinated and adjusted to the engine type and its intake system.

One special design is the panel filter with protective fleece (Fig. 4). In addition to the filter paper, the filter is protected by a fleece for rough filtration. This design is predominantly used in areas with a heavy dust load.

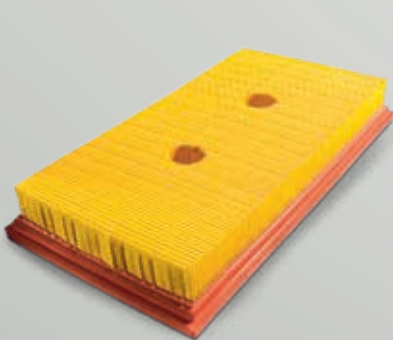


Fig. 1:
AP air filter, panel



Fig. 2:
AP air filter, round



Fig. 3:
AR round air filter for trucks

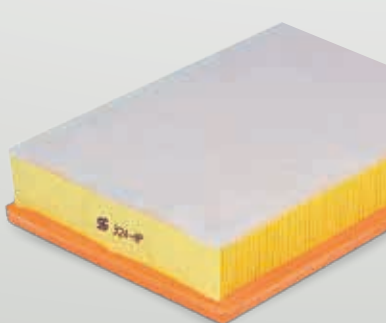


Fig. 4:
Air filter, panel with protective fleece

5.4.1 Utility vehicle air filter design

Due to the higher flow rates and less critical edge sealing on the filter housing, cylindrical round filters with a steel or plastic mesh are predominantly used in utility vehicles.

In the utility vehicle sector, filters are divided into single-stage and multi-stage air filters. In contrast to single-stage filters, multi-stage filters are frequently equipped with an upstream cyclone-type pre-separator.

The cyclone-type pre-separator takes advantage of the effect of centrifugal forces: The air flow is set into rotation by a specially designed rotor disk with so-called baffles. Due to the centrifugal forces, the dirt particles are flung towards the wall of the housing. From there, they are either routed to the outside or are collected in a collector tank, depending on the design of the filter.

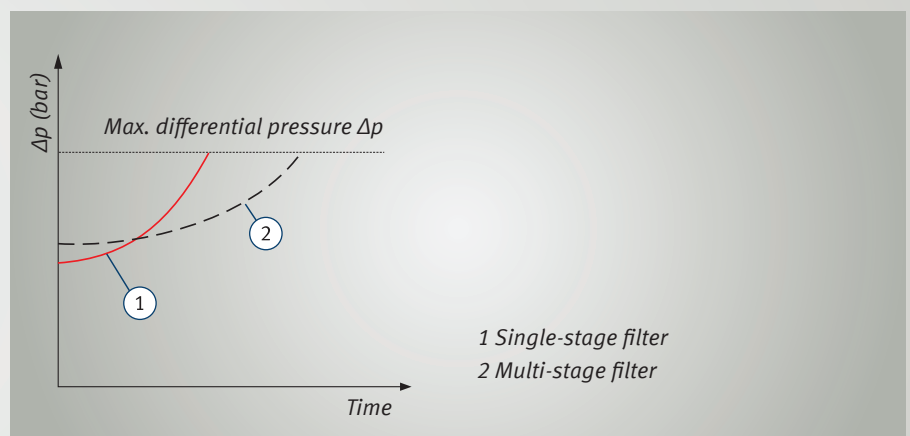
This pre-separator helps to prolong the service life.

Both filter types are usually integrated in one housing. The multi-stage filter is mainly used in construction and agricultural machines.

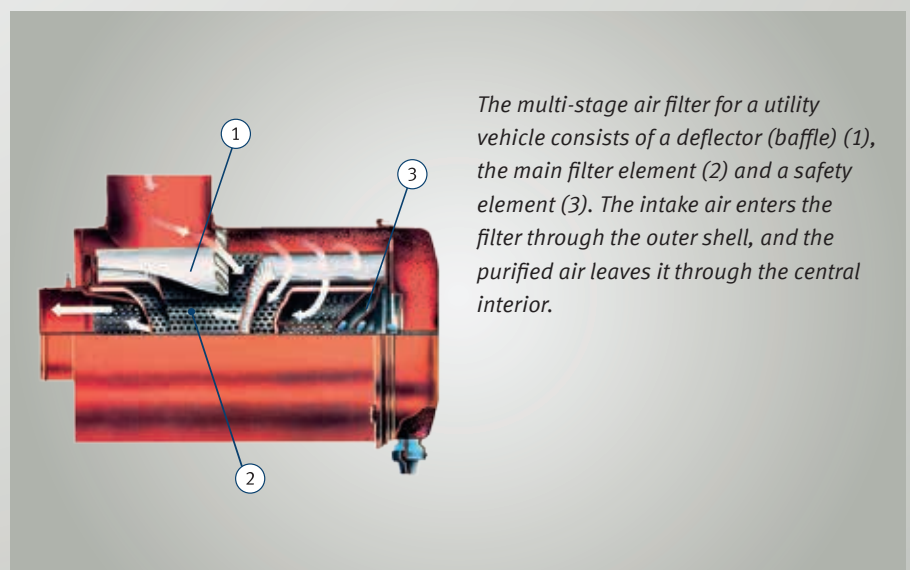
Especially in construction machines, some filters are equipped with an additional secondary element (safety element). It is used to protect the engine when the main element is being serviced or if the engine is damaged. The secondary element may not be inserted without the main filter and should be exchanged with every third replacement of the main element.

In utility vehicles, the air intake is often located above or beside the driver's cabin. This helps to keep the amount of dust in the intake air as low as possible and thus extends the maintenance intervals.

In modern trucks, the filter housings are frequently designed larger than is necessary for filtration. This helps to reduce the intake noise considerably. Since these filters combine the tasks of filtration and noise absorption, they are called silenced filters.



Different service lives



Multi-stage utility vehicle air filter

5.5 Mounting instructions for filter replacement

The following points must be observed when replacing an air filter:

- Never replace the air filter with the engine running.
- Make sure that no dirt particles get into the air ducts when removing the old filter.
- Do not try to clean the old filter using compressed air.
- Choose the right filter. Serious damages may otherwise occur on the engine due to different sealing and permeation properties.
- Follow the instructions given by the manufacturer when installing the new filter.

- Before installation, clean the cover and housing of the new filter using a clean, soft cloth. Do not use a brush or other instruments that might whirl up dirt particles.
- Examine all gaskets for damage. Even small cracks or deformations can lead to considerable contamination. If in doubt, replace the gaskets.
- Place the filter element in the centre.
- When mounting the cover, make sure that there is no gap between the cover and the housing because unfiltered air may otherwise enter the combustion chambers.



Note:

In case of frequent travel on very dusty roads, the air filter insert must be exchanged more often than prescribed under normal circumstances.



Air filters

5.6 Handling mistakes

The filter may not be cleaned using compressed air under any circumstances (Fig. 1 and 2). This would press the microscopic dirt particles even further into the depth structure of the filter paper, resulting in an even lower flow rate. In addition, the filter paper may tear due to the high air pressure.

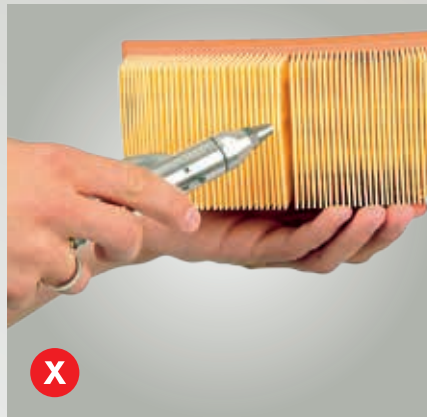


Fig. 1



Fig. 2

When handling the filter, also take care that the paper pack and the sealing face are not destroyed (Fig. 3 and 4).

For this reason, the filter should not be beaten. Insufficient sealing or cracks in the filter paper will result in foreign bodies entering the inside of the engine, which could cause serious damage.



Fig. 3



Fig. 4

Spoiled or deformed filters may not be fitted under any circumstances (Fig. 5 and 6).



Fig. 5

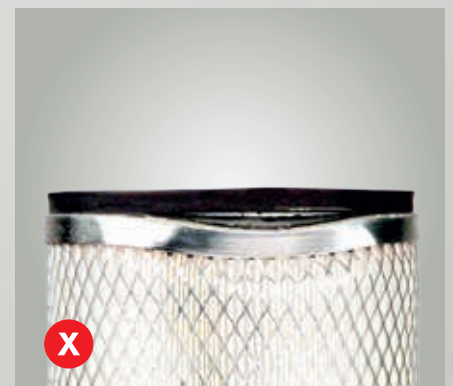


Fig. 6

6.1 Basic information

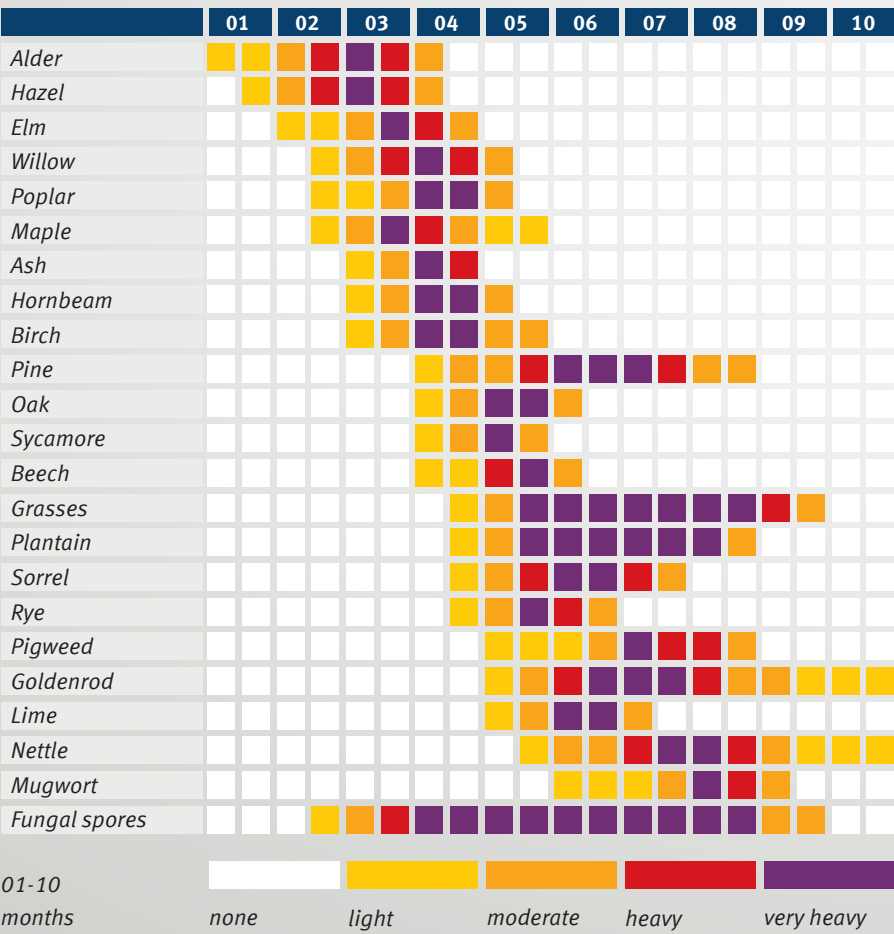
The first blossoms of springtime bring with them particularly high concentrations of airborne pollen. This is a big problem for allergy sufferers, causing them to battle with runny noses, coughing, shortness of breath and other discomforts. Recent studies indicate that persons with allergies have a significantly higher risk of accidents (up to 30 %).

Not just pollen, but above all the mixture of soot particulates, spores, bacteria and toxic fumes (such as benzene, lead, ozone etc.) pose a hazard for the vehicle occupants. Tests have shown that, without an effective filter, the concentration of suspended particles and harmful substances in the cabin of a vehicle can be up to six times higher than in the open air.

The Kolbenschmidt cabin filter protects the occupants from harmful particles and gases that ordinarily enter the vehicle via the blower: dust, soot and other foreign particles are taken in and absorbed up to 99.5 %. A constant supply of fresh, clean air helps to make the journey pleasant and relaxing for the driver and passengers alike.

Installing a Kolbenschmidt cabin filter means comfortable, safe driving:

- without watery eyes
- without coughing and
- without the urge to sneeze.



6.2 Fresh air supply in the vehicle

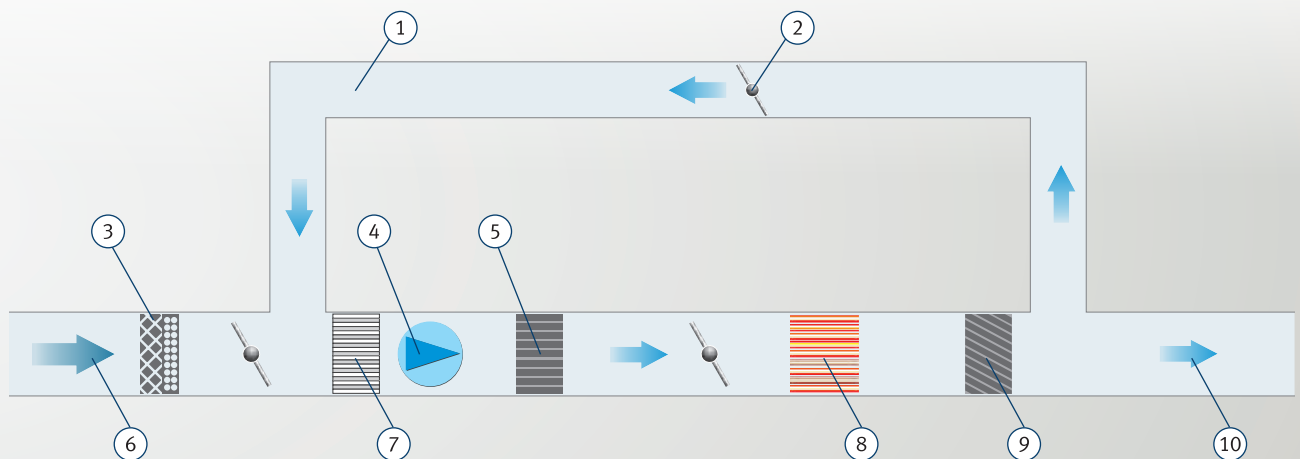
Human concentration and abilities are very strongly influenced by the quality and temperature of the surrounding air. A constant supply of filtered fresh air to the passenger compartment is therefore essential. This air may be heated or cooled depending on the ambient temperature.

The cabin filter is a key part of the air ventilation cycle. It is installed in the air

inlet port of the blower and filters foreign particles such as dust, pollen, soot, etc. out of the air. It has been installed as standard for some years now, and ensures clean fresh air inside the vehicle.

Cabin filters are available in various shapes, sizes and versions to suit different vehicles: rectangular, keystone shaped and round, with and without plastic housing or foam seal.

In order to illustrate the arrangement in the air intake duct, a schematic diagram of an air conditioning system is shown below. The design of an ordinary heating system is similar, but without a condenser.



Design of an air conditioning system

- | | | |
|--|----------------|---|
| 1 Recirculation mode | 4 Blower | 8 Heating / heat exchanger |
| 2 Valve | 5 Condenser | 9 Mixing chamber |
| 3 Air grille with water droplet separator attached | 6 Outside air | 10 Fresh air to the passenger compartment |
| | 7 Cabin filter | |

Fresh air operation

Outside air is drawn through the blower. The air grille keeps out leaves, insects and other large material and particulate. The cabin filter installed after that in the duct filters dust, pollen, soot and other foreign particles before the purified air reaches the condenser. It is cooled down here, causing water to condense and be removed to the

outside via run-off tubes. The dry, cool air is subsequently warmed on the heat exchanger to the cabin temperature selected by the driver. From there, it passes through various throttles and nozzles to the desired locations in the cabin.

Recirculation mode

In this operating mode, the air is drawn exclusively from the passenger compartment. After passing through the cabin filter and condenser, the purified air is then returned to the cabin. This operating mode is used primarily in traffic jams or when driving in tunnels.

6 | Cabin filters

6.3 Types

There are two types of cabin filter at Kolbenschmidt: the standard filter (AC) and the activated carbon filter (ACC), also referred to as the combination filter.

Designation	Filter type
AC (air cabin)	Standard cabin filter
ACC (air cabin with activated carbon)	Cabin filter with activated carbon

6.4 Standard filter (AC)

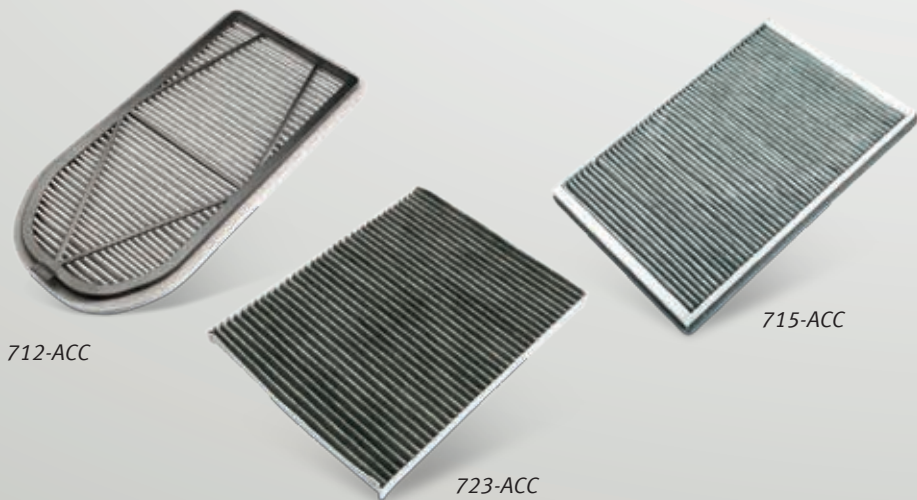
The standard filter chiefly absorbs solid particles such as pollen, spores, soot, specks of dust, tyre wear particles, etc. from the outside air. It achieves this by means of a specially developed filter medium.



6.5 Activated carbon filter/combination filter (ACC)

In addition to solid particles, the activated carbon filter also filters harmful gases such as nitrogen oxide, sulphur dioxide, ozone and hydrocarbons, and keeps 95 % of these out of the cabin. The activated carbon layer can filter out and absorb the smallest particulates.

Unpleasant odours are also contained, so that smells when driving through tunnels or in traffic jams, for example, are kept to a minimum.



The activated carbon filter consists of various media arranged in layers: a carrier medium, which gives the filter more mechanical stability, a filter medium and an activated carbon layer (Fig. 1).

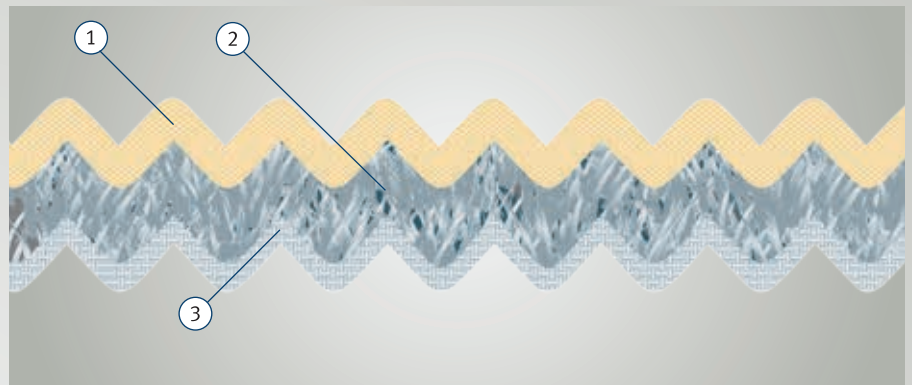


Fig. 1: Sectional view of a combination filter

- 1 Filter medium
- 2 Activated carbon layer
- 3 Carrier medium

The filtration principle of an activated carbon filter is represented schematically in Fig. 2 below: When air passes through, the filter medium retains the solid materials, while the activated carbon layer binds gases and odours.

The combination filter is a frequent alternative to the standard filter. Vehicles previously equipped with an ordinary standard filter can therefore be retrofitted with an activated carbon filter of the same geometry without difficulty. Due to its more comprehensive filtering action, increasing numbers of vehicles today are fitted with an activated carbon filter as standard.

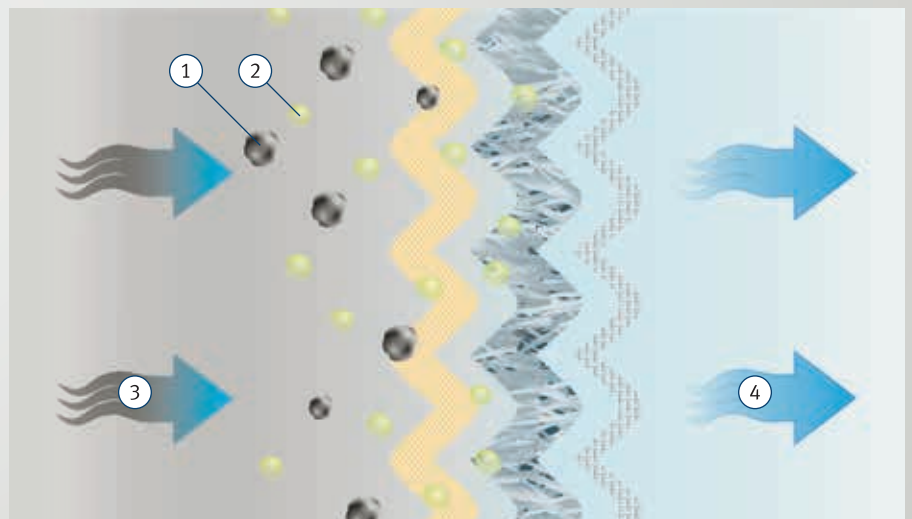


Fig. 2: Filtration principle of an activated carbon filter (combination filter)

- 1 Dirt particles
- 2 Gas molecules
- 3 Dirty air from outside
- 4 Clean air for the interior

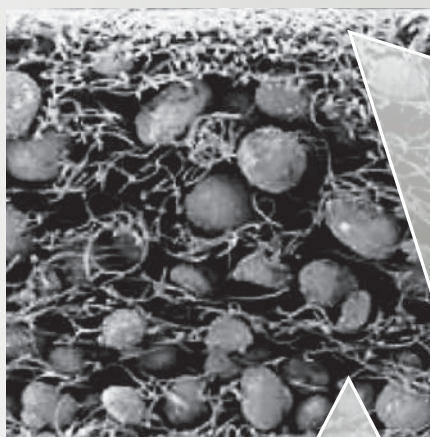
6.6 Filter medium/activated carbon

Activated carbon is a pure, natural product produced from coal, peat, wood or coconut shells. The porous structure characteristic of this mechanical filter develops during the activation process. During carbonization of the raw materials, many small pores are created, which are clogged with tar-like substance. Steam (500 to 800 °C) is used to volatilize these tars, freeing the pores and also enlarging them.

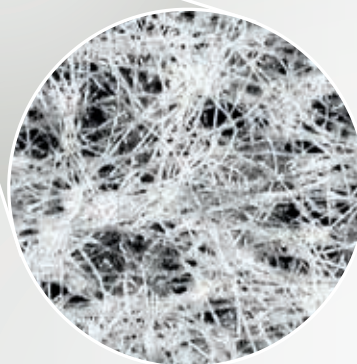
This porous surface offers a much higher surface area for filtering than comparable materials (~ 1000 m² per gram of activated carbon). For the Kolbenschmidt cabin filters, only activated carbon from coconut shells is used, because of its high mechanical stability and resistance to abrasion.

The following illustration shows a cross section of an activated carbon filter under a microscope; in the detailed view, both the active carbon grain and its surface form can be seen.

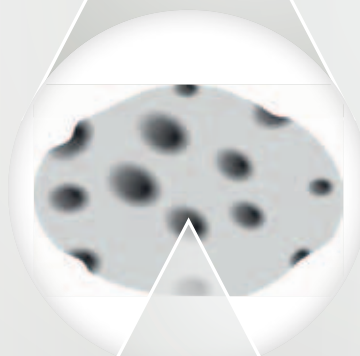
Location and surface of an activated carbon grain



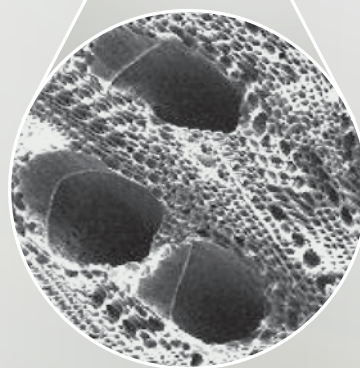
*Cross section of an
activated carbon filter:
Location of the grains*



*Detail:
Micro-fibre layer*



Activated carbon grain



*Surface of an activated
carbon grain*

6.7 Change interval and consequential damage

Since the cabin filter has a limited service life, it is important to replace it on a regular basis. After a certain time, it is saturated, i.e. it cannot absorb more particles and it

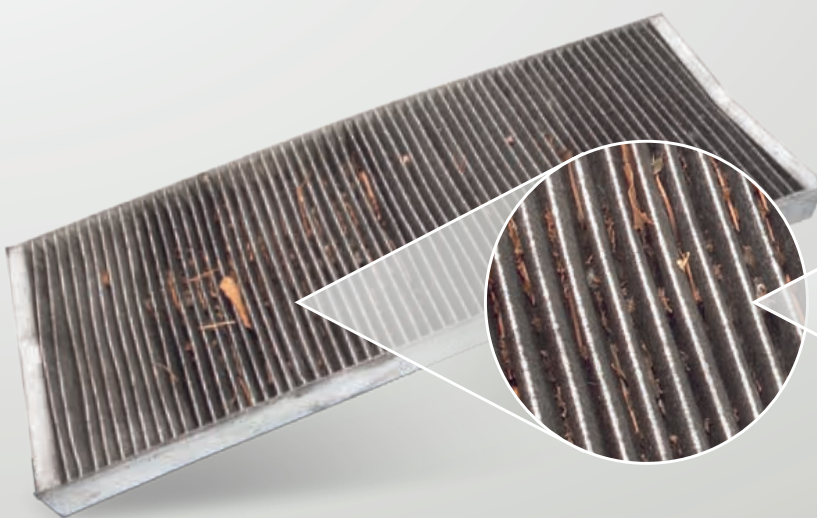
ceases to function. Vehicle manufacturers have stated one year or a mileage of 15,000 km as a guideline.



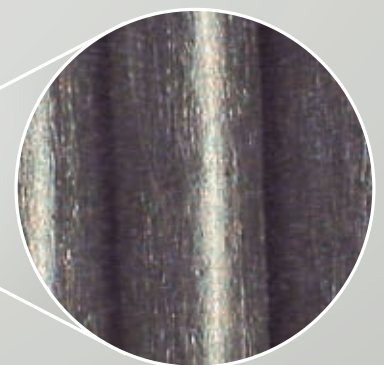
New filter



Subsurface structure – light and clean



Used filter



Subsurface structure – dark and dirty

6 | Cabin filters

If the maximum pollutant absorption capacity has been achieved, the normal flow of fresh air is impeded, because the air flow is greatly reduced. Despite running the blower at high settings, the windows fog up and streaks form.

The lower air flow also poses difficulties for the blower, because it must work against the higher resistance of the clogged filter. A filter saturated with dust and other dirt particles also leads to a disagreeable, musty smell in the vehicle cabin and is an ideal breeding ground for microorganisms such as bacteria and moulds.

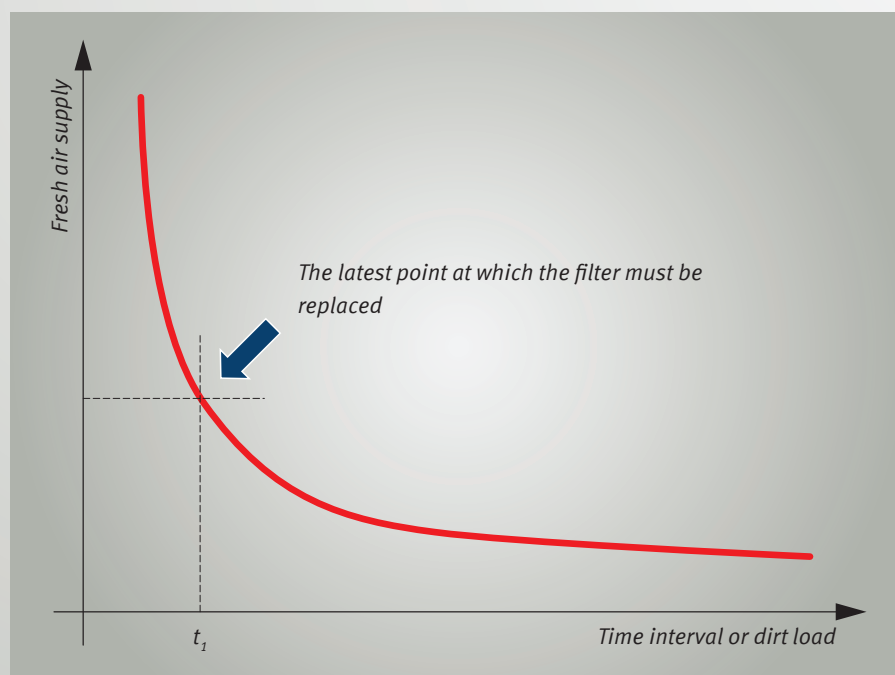
If the filter is also damaged, the condenser gets contaminated to a greater degree, reducing the cooling efficiency of the air conditioner and possibly leading to premature failure. The consequence of this is higher repair costs.

Furthermore, bacterial and mould pass unhindered through the blower to the cabin and create a health hazard for its occupants. The seats and interior lining also become disproportionately dirty as a result.

The benefits of a pollen filter can be realized only if the windows and roof of the vehicle remain closed.

In summary, we recommend that the cabin filter be changed without delay at the following indications (or sooner):

- Fogged windows despite a high fan setting (streak formation)
- Poor performance of the air conditioning system or the blower
- A musty smell
- Tiredness of the occupants
- Contamination of the cockpit and interior lining



Effects on the fresh air supply

6.8 Installation instructions for filter replacement and handling errors

For the most part, the filters are readily accessible near the water jacket in the engine compartment (see Fig. 1). In modern vehicles, they are also sometimes placed in the cockpit area.

Cabin filters may only be replaced by a qualified expert.



Note:

The cabin filter for passenger cars may not be cleaned or blasted with compressed air. This has the effect of embedding microscopic dirt particles more deeply in the depth structure of the filter paper. The consequence of this is reduced flow. In addition, there is a risk of tearing the filter medium and destroying the activated carbon layer.



Fig. 1: Replacing the cabin filter

7 | Air dryers for brake systems

7.1 Basic information

The air dryer for brake systems provides a special kind of filtration. It is used, above all, in the compressed air supply system of

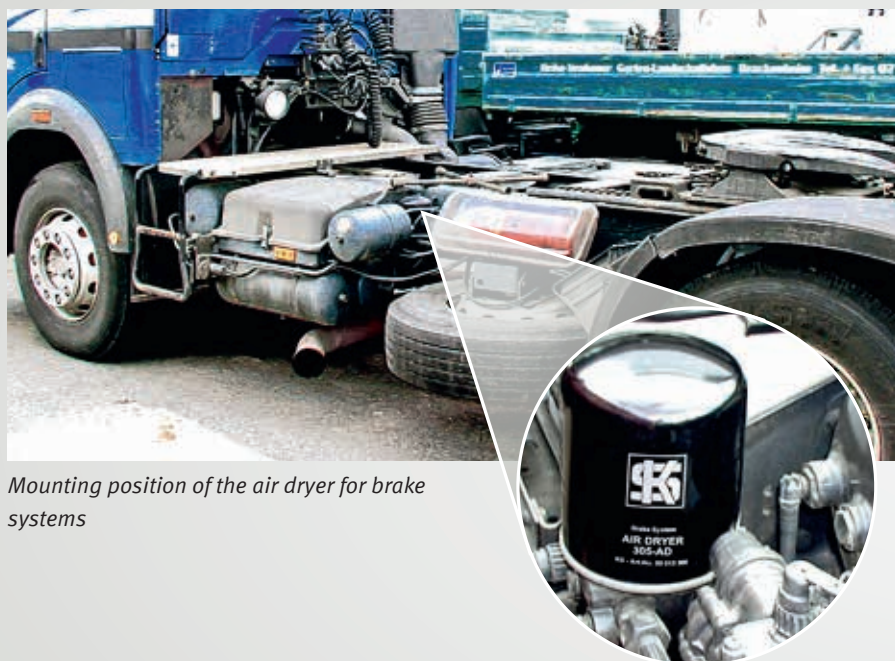
medium and heavy utility vehicles. Because compressed air is used to provide the energy for numerous control and regulating

processes in modern vehicles, the air dryer for brake systems is classed as a safety component on the vehicle.

7.2 Function

The compressed air required for braking is generated by the compressor, which is driven by the engine. The compressed air then flows from the compressor to the single-chamber air dryer for brake systems with pressure regulator. Here, the compressed air is dried by specially developed granulate, and the integrated pressure regulator limits the pressure in the brake system to a set value.

Next, the compressed air enters a compressed air tank, which is equipped with a condensate sensor and a safety valve for monitoring the air drying process.



Mounting position of the air dryer for brake systems

7.3 Consequential damage

If water and oil enter the reservoirs and thus the brake system, the consequences will be dangerous and costly damage: The moisture damages the valves, causes corrosion in the pipes and receptacles, and at sub-zero temperatures the complete system may freeze. The oil impairs the function of the valves and thus causes the brake response to deteriorate. This causes an increased load on the brake pads and they wear faster.

In order to prevent this potential damage and costs, the use of a Kolbenschmidt air dryer for brake systems is highly recommended. The durability of the individual components is improved, and the vehicle downtime is reduced.

The air dryer for brake systems should therefore be exchanged regularly as well!



8.1 Basic information

Fuel filters are a crucial part in modern, highly sophisticated fuel supply systems. Since they come in various designs, the

different fuel systems will be explained first.

8.2 Structure of different fuel systems

Petrol engines

With petrol engines, we distinguish between direct and indirect injection.

Indirect injection (intake manifold):

Electromagnetic injection valves are used to inject the fuel into the intake manifold or directly into the cylinder. Injection pressures of 3-4 bar are currently used, and the fuel pressure is kept constant by a pressure regulating valve. The nominal flow rate of the fuel filter is designed much higher than necessary for the actual fuel consumption.

Direct injection:

For direct injection, substantially higher injection pressures are necessary. The supply system in these systems consists of a low- and a high-pressure circuit. The low-pressure circuit has an integrated electric fuel pump and is only used to feed the high-pressure circuit. This prepressure is usually approx. 3.5 bar.

A high-pressure pump is used to take the fuel, which has a pressure of up to 120 bar, to a pressure reservoir which is directly connected to the injection valves. The high pressure and the number of additional components such as the pressure reservoir, sensor and control valves mean that these filters are much finer than those for manifold injection.



Diesel engines

The combustion process in a diesel engine differs considerably from that of a petrol engine. The diesel engine always operates with internal mixture formation and self-ignition of the air-fuel mixture. The term "internal mixture formation" refers to the process of converting liquid fuel into an ignitable mixture after injection.

In order to achieve a better and more efficient combustion process, the fuel is directly injected into the cylinder in virtually all modern diesel engines.

Pump-nozzle injectors and common rail technology are the most widespread fuel injection systems here.

Pump-nozzle injectors:

In the pump-injector nozzle system, each cylinder head has a pump-nozzle injector. It contains the following components in its housing

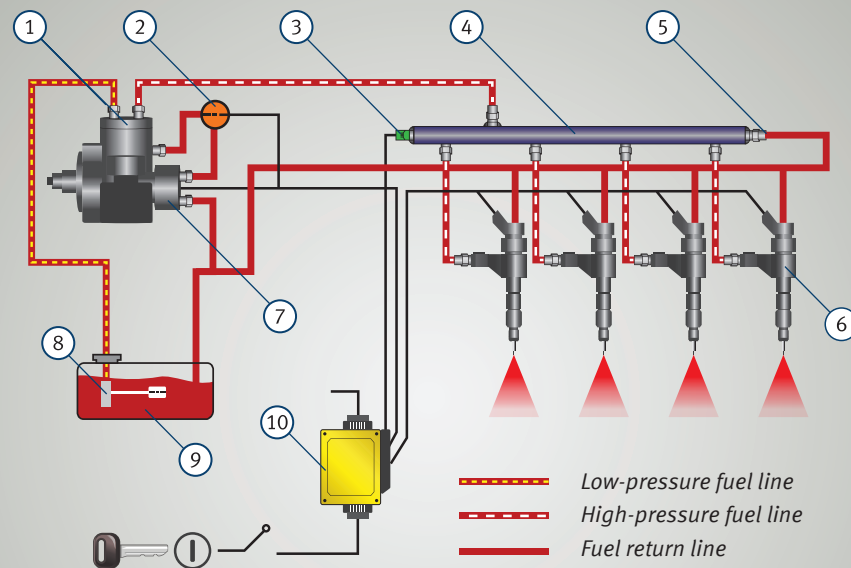
- the high-pressure piston pump element,
- the solenoid valve to control the injection process, as well as
- the injection nozzle with the injection valve.

This system is suitable for injection pressures of up to 2000 bar.

Common rail:

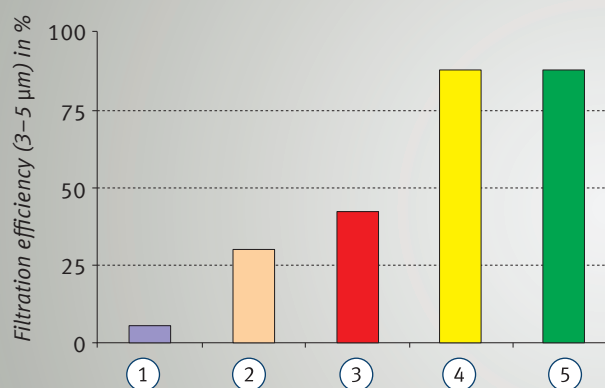
Common rail technology uses a high-pressure injection system with electric control with a shared distributing pipe known as the common rail. The fuel is fed to the combustion chambers by injectors which are controlled by solenoid valves. With a high-pressure radial-piston pump, pressures of up to 1600 bar can be reached.

Due to the use of these modern systems, it has become necessary to increase the fineness of fuel filters considerably (Fig. 1).



- | | |
|-------------------------|-----------------------------|
| 1 High-pressure pump | 6 Injectors |
| 2 Fuel filter | 7 Pressure regulating valve |
| 3 Pressure sensor | 8 Fuel pump |
| 4 Common rail | 9 Fuel tank |
| 5 Pressure relief valve | 10 ECU |

Fig. 1: Common rail



- | |
|------------------------|
| 1 Carburettor |
| 2 Indirect injection |
| 3 Direct injection |
| 4 Pump-nozzle injector |
| 5 Common rail |

Recommended minimum filter units for petrol and diesel engines

8 | Fuel filters

8.3 Task/function

To guarantee the performance of the engine, the fuel filter must effectively protect the fuel system against impurities such as dirt, rust, dust and water contamination. Protecting the high-quality fuel injection system is a vitally important task, particularly in modern diesel injection

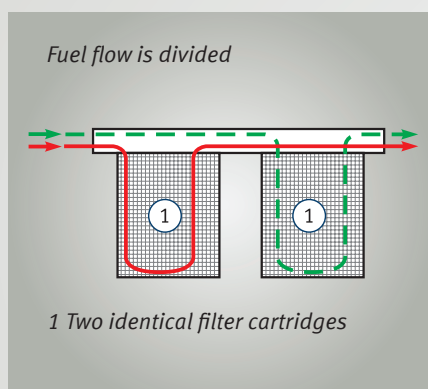
engines. Even particulates in the order of $5 - 20 \mu\text{m}$ in size can lead to considerable damage or failure of the engine.

The fuel filter has a finer filter paper than the oil filter since the components of the fuel supply system have smaller running

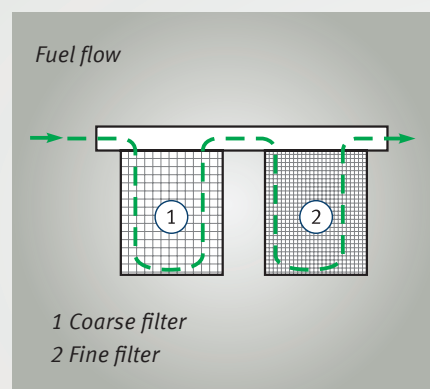
clearances. In order to prevent even minute dirt particles from entering the pipe circuit, bypass valves are not allowed in fuel filters.

8.4 Arrangement of the filters

According to their arrangement, fuel filters are divided into single-stage, multi-stage and parallel filters. With a multi-stage filter, a coarse filter (sieve filter made from metal or plastic) is mounted in front of the fine filter. The parallel filter consists of two identical filter cartridges. Its main advantage over an individual filter is that it allows a greater flow.



Parallel filters



Multi-stage filters

8.5 Consequential damage

Fuel filters must be replaced regularly. If the filter is clogged, the fuel supply of the engine is insufficient and leads to reduced performance. Difficulties in starting occur, the engine stutters and runs out-of-true; there is not enough fuel for acceleration.

If a filter is used which is not suitable for the corresponding application or if the filter installed has quality deficiencies or imperfections, a higher amount of dust can enter the filter element. In petrol engines, this leads to faults in the carburettor or fuel

injection system and causes wear on these components. In diesel engines, the extremely sensitive injection elements are damaged and fail.

8.6 Design

The range of Kolbenschmidt fuel filters includes spin-on oil filters, filter cartridges and fuel pipe filters.



FS spin-on fuel filter



FP fuel in-line filter



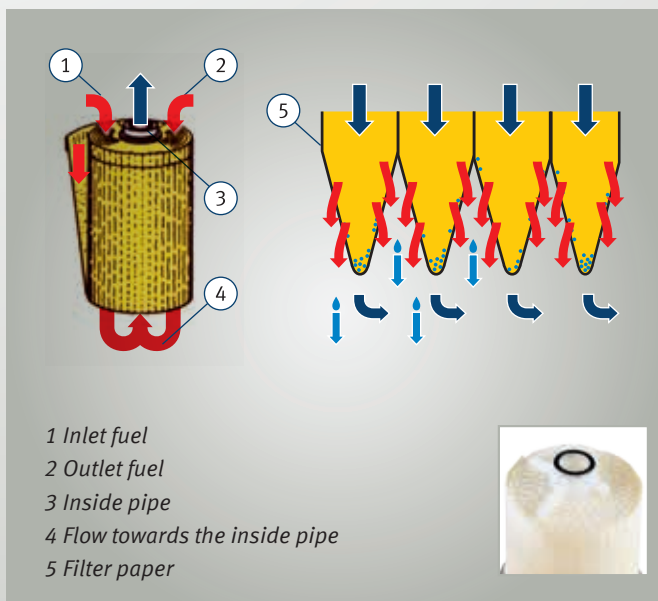
FC/FX fuel filter cartridge

With respect to the arrangement in the housing, the paper cartridges are divided into spiral filters (axial filters) and star filters (radial filters). In axial filters, the paper is wound around a tube. The paper strips are arranged in such a way that they form open V-shaped bags in which the dirt particles are collected. The fuel in the inlet

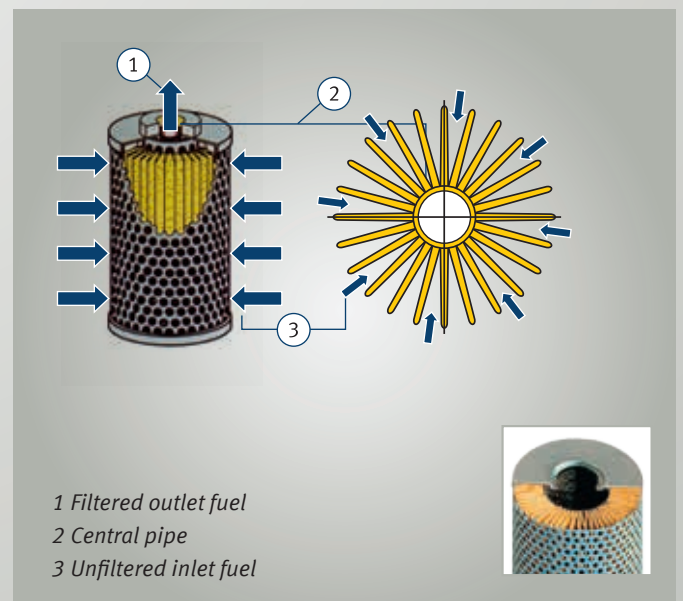
flows through the filter axially from top to bottom and the purified fuel flows out through the central pipe.

In radial filters, the paper is arranged in a star form around a tube of perforated metal. The fuel radially flows through the filter to the inside, and dirt particles are retained on

the paper surface. The filtered fuel is drained through the openings of the inner pipe.



Axial filter



Radial filter

8 | Fuel filters

8.6.1 Fuel filter cartridge

Filter cartridges can be replaced individually, and are located in a separate housing which is mounted on the engine. During filter replacement, the housing gasket is unscrewed and only the filter element is replaced. Modern filter cartridges are made of materials that are suitable for thermal recycling. Cartridges from paper and felt are used as filter elements.

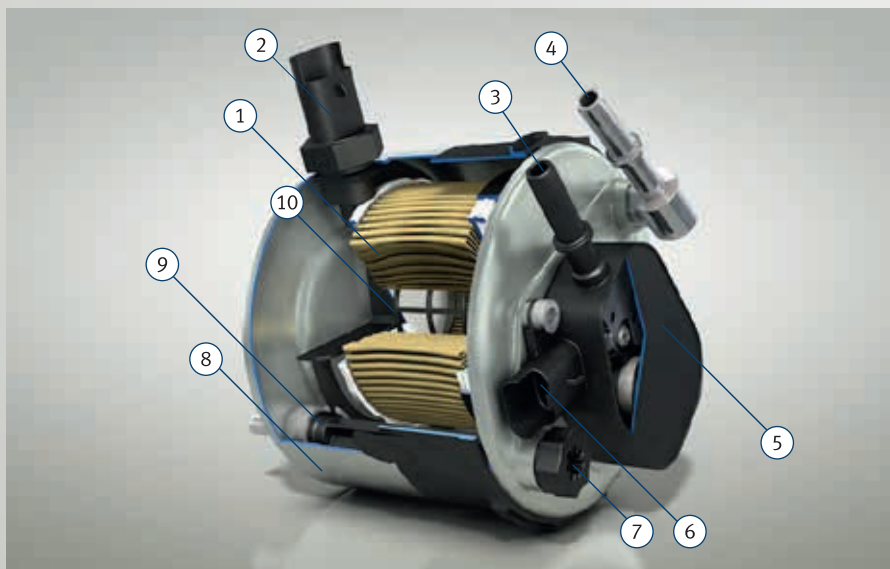


Filter cartridge from paper



Filter cartridge from felt

8.6.2 Fuel pipe filters (inline)



Structure of a fuel filter

- 1 Filter medium
- 2 Water level sensor
- 3 Fuel entry point
- 4 Fuel exit point
- 5 Heating module
- 6 Water drain plug
- 7 Electrical connection
- 8 Pressure-stable filter housing
- 9 Water drainage channel
- 10 Protective cage

The inline filters are available as sieve or paper filters and are inserted into the fuel line. Depending on the application, the filter housing is made of aluminium, sheet steel, or plastic.

Sieve filters are e. g. used as prefilters in the fuel tank or in the fuel pump. They consist of a fine wire or polyamide mesh with mesh sizes that vary from 40 to 60 μm .

For fine filtration, paper filters between 6 and 10 μm are used. They are usually mounted by just slipping them onto the fuel line.

Water separation function:

Because of its very high surface tension, the resulting condensation water in the fuel tank (humidity) is initially held on the dirt side. After the rise in the differential pressure it gets through the pores onto the clean side, where it forms larger droplets. Because of their higher specific weight, these enter the water reservoir.

The reservoir can be emptied by opening the water outlet screw. On some vehicles, the water level can be identified using a sensor.

8.6.3 Spin-on fuel filters

The filters consist of a housing with a filter element, which are replaced as a unit during maintenance. The filters are normally mounted in the engine compartment or under the vehicle between the fuel tank and the engine.

In passenger cars, filters with water drain plugs and an integrated pressure regulating valve are used in addition to the standard,

replaceable cartridge filters. For utility vehicles, other designs are offered with integrated extra functions such as:

- valves or sensors to control the pressure and temperature,
- electric heaters,
- heat exchangers, or
- water sensors with a water collection chamber.



Spin-on fuel filter

8.7 Mounting instructions for filter replacement

Always take the utmost care when working on the fuel system. The fuel system often remains under pressure for a long time after the engine was stopped!

- Observe the change intervals recommended by the manufacturer.
- Always observe the mounting instructions given by the vehicle manufacturer.

- Use suitable tools for filter replacement.
- Pay close attention to the flow direction when installing fuel-line filters. The flow direction is marked with an arrow and should point away from the fuel tank towards the engine.



Note:

When replacing the fuel pump, always replace the filter too. Replacing the relatively cheap filter helps prevent large and expensive repairs!

9 | Urea filters

In modern exhaust treatment systems, urea filters are responsible for protecting the system components against wear.

Particularly in the utility vehicles sector, SCR (selective catalytic reduction) converters are increasingly being used, which can reduce the proportion of nitrogen oxides by up to 90%. To do this, the SCR process uses an environmentally friendly 32.5 percent urea-water solution, which is stored in a separate tank in the vehicle (trade name "AdBlue").

This urea solution is injected into the exhaust gas flow by a pump or injector and generates a chemical reaction in the catalytic converter. The urea is converted into ammonia, which causes the nitrogen oxides contained in the exhaust gas to be

converted into nitrogen and water.

To guarantee an increased feed unit service life, urea filters are used to filter the urea solution. The fineness and service life of this kind of filter correspond to those of a diesel fuel filter.



Urea filters

10 | Coolant filters

Coolant filters protect the engine by filtering out impurities and releasing the additives in the filter into the cooling system at a controlled rate. These additives, also known as inhibitors, are used up over time, however. For this reason, it is very important to adhere to the regular maintenance intervals as specified by the vehicle manufacturer.



Coolant filters

11.1 Task/function

Filter systems in the engine oil circuit are very important components in modern vehicles. They considerably contribute to reaching the desired engine life.

While the air filter has the function of keeping wear-enhancing dirt particles from entering the engine, the oil filter is used to filter out the particles that have already

entered the engine. These impurities may include abraded metal, dust particles from the combustion air, soot and corroded metals.

Oil filters have no influence on chemical or physical changes in the oil during engine operation because they are not capable of removing liquid or dissolved particles. But they help to prevent an early wear of the engine's sliding surfaces. Within the

maintenance intervals, they preserve the function of the engine oil since they have a positive influence on its viscosity and pumpability.

Because an increasing number of hydraulic systems are becoming important in modern vehicles, oil filters have also gained a foothold in this area. They are being used ever more frequently in the field of steering hydraulics in particular.



OS spin-on oil filter



OC/OH oil filter cartridge



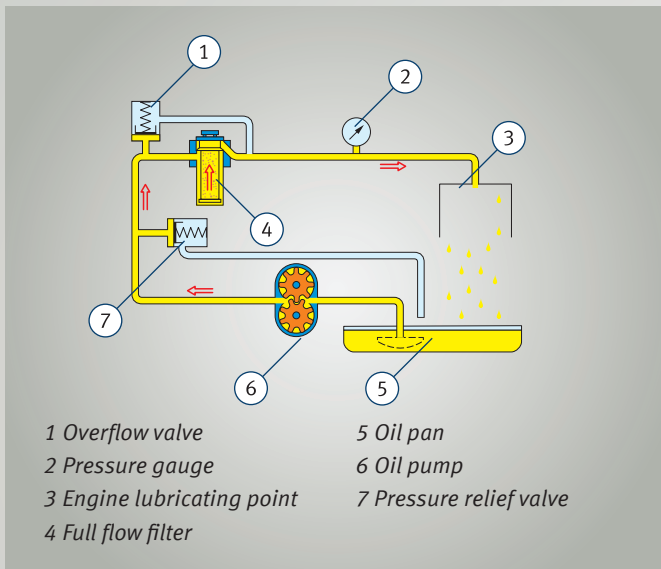
OX oil filter cartridge, metal-free

11 | Oil filters

11.2 Arrangement

According to their arrangement in the oil circuit, we distinguish between full flow and bypass filters as well as a combination system.

11.2.1 Full flow oil filters

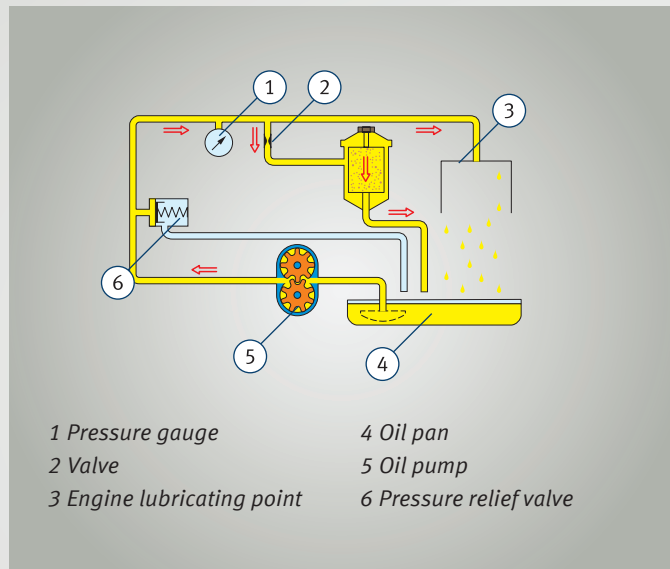


The main oil duct is responsible for the oil supply of the engine bearings, whereas the connecting rod bearings and pistons are supplied with oil by the crankshaft. In addition, oil is also fed to the cylinder head in order to lubricate the camshaft and the operating elements of the valves.

In a charged engine, part of the oil is used to lubricate the turbocharger.

Full flow filters are popular, because they enable the entire oil flow to be conveyed through the filter element. This ensures that impurities can be filtered out the very first time they pass through the filter. This arrangement has the disadvantage, however, that the filter has to accommodate the entire flow rate. Full flow filters must have a bypass valve and should always be mounted behind the pressure regulating valve in the oil circuit.

11.2.2 Bypass flow oil filters



The bypass filter is situated in a section that runs parallel to the main flow (bypass flow). This line is mounted between the lubricating points and the supply pump. Due to an upstream valve, only a part of the oil supply (5 – 10 %) passes through this filter. This means that only partly cleaned oil reaches the lubricating points. Because of its low feed and flow rate, the bypass filter does not reach the highest possible rate of filtration. It should therefore be regarded as a fine filter with a high degree of separation.

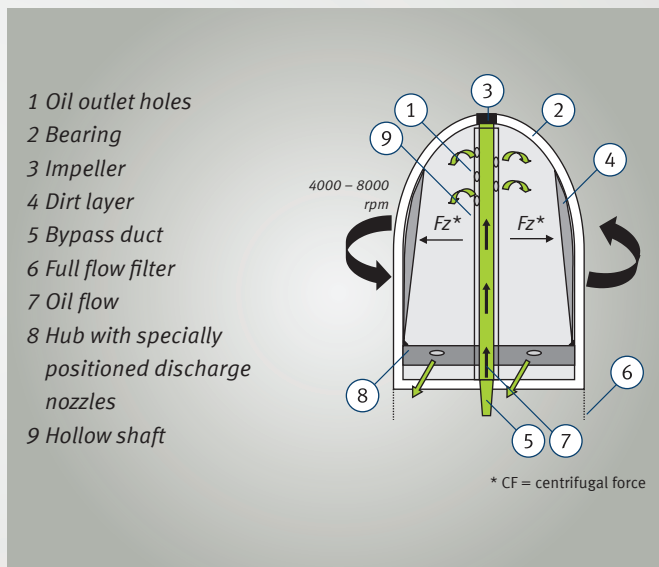
11.2.3 Oil filters in a combination system

If bypass filters are used in combination with full flow filters, a very effective filtration is achieved: The finest particulates, which are allowed through by the full flow filter, are filtered out by the bypass filter. The bypass filter ensures extremely thorough cleaning with a high level of separation. In utility vehicles and construction machinery, the open jet centrifuge (oil centrifuge filter) is primarily used as a bypass filter. The oil, which is

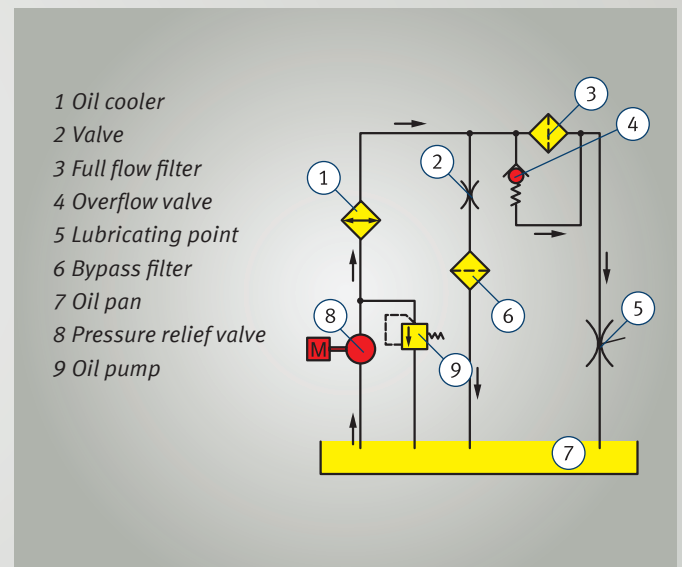
diverted from the main duct into a bypass duct, flows through the hollow shaft of the impeller into the interior of the filter via suitably arranged holes. Specially positioned discharge nozzles in the floor allow the oil back out of the centrifuge.

This process releases recoil forces that cause the impeller to rotate. Here, speeds of 4000 to 8000 rpm can be reached, depending on the pressure and

temperature. The centrifugal forces generated during this rotation fling the dirt particles in the oil onto the inside wall of the impeller. They remain stuck there until the centrifuge is replaced at the next specified maintenance interval.



Free jet centrifuge



Oil filter in the combination system



Oil filters

11.3 Consequential damage

Abrasive dirt particles that have entered the inside of the engine due to insufficient filtration may cause scores on pistons and piston rings as well as bulgy cylinder wear. This mainly affects the sharp edges of the piston rings (see chapter 1.5, Wear on engine components). Due to insufficient sealing of the combustion chamber, the pressure in the crankcase is increased by combustion gases that pass the piston. This excess pressure causes a loss of oil at the

sealing points and oil leakages at the intake valve guides.

Another consequence is reduced compression and engine performance. The connecting rod and crankshaft bearings can also be substantially affected by the abrasive effects of the dirt particles. A higher bearing clearance caused by abrasion reduces their supporting capacity and may lead to bearing damage.

11.4 Spin-on oil filters

Spin-on oil filters consist of a filter bowl (made from sheet steel), a filter element and a flanged or welded on filter cover. The whole filter element is exchanged when replacing the filter. Many replaceable cartridge filters are additionally equipped with a so-called bypass valve (overflow valve) as well as an anti drain valve. This type of filter is used in passenger cars, as well as in utility vehicles.

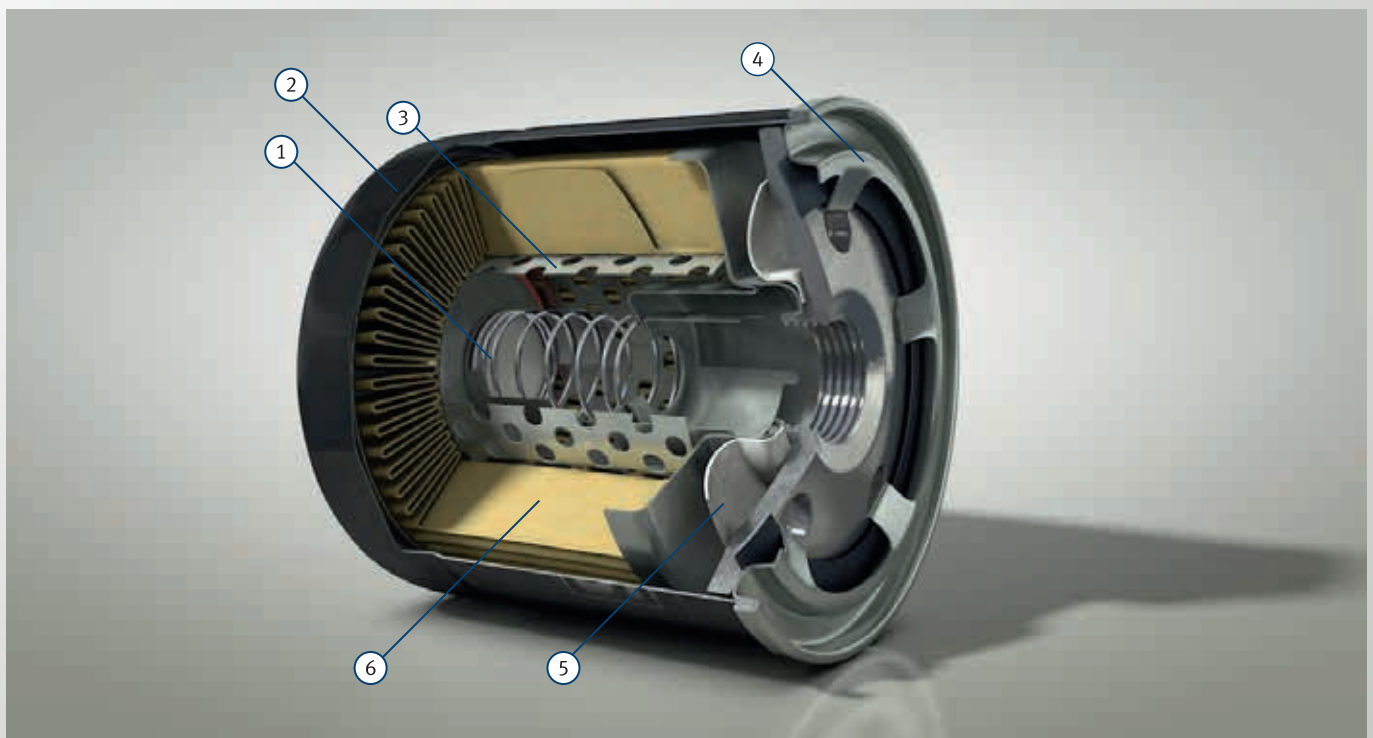
Bypass valve

The bypass valve is also known as overflow valve. It opens a direct passage to the oil circuit in case of elevated oil pressure. This allows unfiltered oil to reach the circuit, but this is better than completely interrupting the lubricating oil supply. The bypass valve can be installed in front of the full flow valve or - as in many Kolbenschmidt filters - directly into the filter element. The adjustment value of the opening pressure is approx. 1–2 bar in practice depending on the application.

The set value can be exceeded during the cold running phase of the engine (highly viscous oil) or if the filter is very dirty and has reached the end of its service life.

Anti drain valve

The anti drain valve is another design characteristic of replaceable cartridge filters. It may be inserted in the supply or outlet line, depending on the installation position of the oil filter. It prevents the oil filter from running empty when the engine idling.



Structure of a spin-on oil filter

1 Bypass valve

2 Filter bowl

3 Supporting pipe

4 Filter cover

5 Anti drain valve

6 Filter medium

11.5 Housing filters

In contrast to the spin-on oil filter, the filter housing is either bolted to the engine, or it is an integral part of the crankcase here. Only the filter cartridge is replaced with this type of filter. In modern vehicles, these filters are made of metal-free materials. Thanks to their environmentally-friendly disposal, these filters are gaining more and more importance.

Advantages of metal-free filters at a glance:

- Only the filter cartridge is replaced during a service. The filter housing and valves remain permanently on the engine block.
- Clean replacement of the filter cartridge, the skin does not come into contact with used oil.
- Coordinated with extended maintenance intervals.
- Conservation of resources through utilisation of recycling material. The filter cartridge only consists of the filter medium and thermoplastic end disks.
- Energetic recovery of the filter cartridge. The energy stored in the filter cartridges is recovered during combustion.
- Drastic reduction of service and disposal costs. The metal- and glue-free filter cartridges do not have to be subjected to an expensive disassembly process. The complete filter cartridge is suitable for thermal recycling.



Housing filter

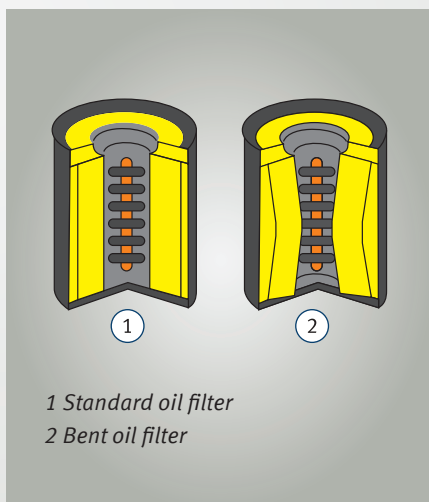
11.6 Failure of the oil filter due to excess pressure

If a filter is bent or swollen, poor filter quality is often assumed. However, this is very rarely the case. A deformed filter is mostly a symptom of problems in the oil circuit.

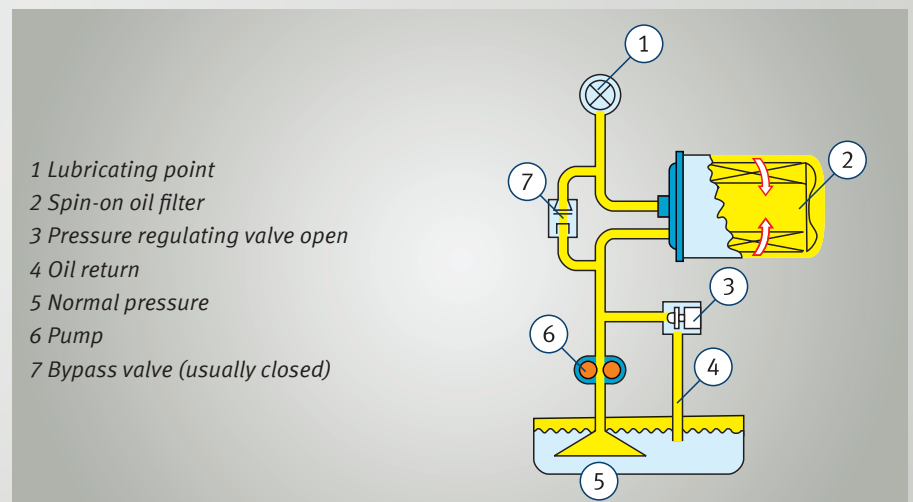
The fault is often caused by the pressure regulating valve, which is usually integrated in the oil pump. The oil pump supplies the required oil pressure in the lubricating system to form the lubricating film between the engine compartments. The task of the pressure regulating valve is to keep the pressure in the lubricating system at a particular value. After the valve is opened,

the pressure in the lubricating system remains almost constant. If the pressure regulating valve is jammed or reacts slowly when the engine is started, an inadmissible excess pressure is generated in the system.

If the valve does not open at all, the pressure continues to increase and deforms the weakest part in the system – the filter: The gasket is cracked and the fold breaks if the filter is mounted very tightly. Since this usually also causes a leakage of engine oil, the engine must immediately be stopped to prevent more serious damage.



Deformed oil filter



Functional diagram of a lubricating system

11.7 Mounting instructions for filter replacement

No oil change without filter replacement:

With each oil change, the oil filter must always be replaced.

- Drain the engine oil with the engine at operating temperature so that the oil pan is emptied completely and as many foreign bodies as possible are washed out.
- Use special spanners as releasing tools.
- Completely remove all fragments of gaskets from the engine's mounting face and carefully clean the mounting faces.

- Thoroughly clean the filter housings of filter cartridges.
- Always use new gaskets which are included in the scope of supply. If the old gasket is re-used, proper sealing cannot be ensured.
- Spread engine oil onto the gaskets. Never use lubricating grease for this. Components in the grease can attack the O-rings in the filter.
- Do not twist the filter when putting it onto the thread.

- Check that all gaskets are correctly fitted before tightening.
- Only screw the filters manually, do not use tools.
- Check the oil level.
- Start the engine and check the circuit for leaks during idling.



The gear oil filter is responsible for preventing foreign bodies from entering the automatic transmission unit.

Special oils for automatic transmission units must satisfy additional requirements to oils for manual gearboxes. As well as lubricating tooth surfaces, planet gears and the bearing sliding surfaces, the oil is also used for operating brake bands and clutches. The transmission of torque from the pump to the turbine impeller is also a task of the transmission oil.

Through the optimal filtration of wear-inducing substances, such as metal swarf caused by abrasion, the transmission filter extends the service life of the transmission and improves performance.



Gear oil filters

13 Concluding remarks

Kolbenschmidt filters are produced using continuously monitored state-of-the-art manufacturing processes. Only these stringent measures can ensure that they meet the high requirements of modern precision engines. In the field of filters in particular, the quality is not obvious at first glance. It is not easy to see if a filter will meet the desired performance requirements. All Kolbenschmidt filters at least fulfil the OE requirements. This ensures optimal protection for the engine and a long service life.

The paper used for Kolbenschmidt filters is impregnated and subjected to pressure-proof glueing or clasping.

The pleat geometry, specifically designed for each application, ensures regular spacing between the pleats and an optimal utilization of the filter surface. In constant controls during the manufacturing process, Kolbenschmidt filters have to demonstrate their quality at any time. They are reliable and efficient. Precise processing methods ensure optimal fit precision: Mounting is easy because the gaskets and O-rings needed for installation are included in the scope of supply.

With Kolbenschmidt filters you avoid premature abrasive engine wear, prevent high fuel consumption and poor engine performance, as well as poor emission figures.



Note:

So, remember to change filters regularly.

A wide product range of reliable first-class Kolbenschmidt filters is available for European vehicle applications.

So choose Kolbenschmidt oil filters, air filters and fuel filters.

Glossary

Absolute filter

Component in the testing procedure according to DIN ISO 5011: Downstream filter installed to separate the amount of dust that has passed through the test piece.

Additive

Chemical substance added to liquids to obtain certain properties or to improve performance characteristics.

Anti drain valve

Valve that prevents the oil from flowing back through the inlet hole after the engine has stopped.

bar

Metric measuring unit of pressure:
1 bar = 10² kPa.

Blow-by-gas

Leakage gas flow that enters the crankcase due to insufficient sealing between the pistons, piston rings, and cylinder wall.

Brownian molecular movement

Irregular zigzag motion of microscopic particles (e.g. dust particles) when suspended in gases or liquids, discovered by English botanist Robert Brown; the motion is caused by irregular collisions with the molecules of the surrounding medium.

Burst pressure

Pressure difference at which a filter or filter component is destroyed due to the internal pressure load.

Bypass valve

Also called overflow valve. Usually installed in the filter, the bypass valve offers protection in case of excess pressure.

Centrifugal force

The force that acts outwards on any body as it rotates and is directed away from the axis of rotation.

Differential pressure Δp

Pressure difference between the filter inlet and outlet.

Dirt-holding capacity

amount of dirt a filter medium can hold before reaching a specified differential pressure.

Filter fineness

Diameter of particulates which are just small enough to pass through the pores of the filter medium.

Filter service life

Usage period of a filter or element until maintenance or replacement.

Filtration efficiency

Percentage of particles a filter can separate.

A distinction is made between:

- Total degree of separation: Refers to all dirt particles without distinction between different grain sizes.
- Fractional degree of separation: This measurement unit requires the indication of the distribution of grain sizes.

μm (micron/micrometer)

Metric measuring unit 1 μm = 0.001 mm.

Van-der-Waals forces

forces of attraction between neutral molecules, especially in case of close approximation.

Viscosity

Glutinous nature of liquids resulting from an internal friction between molecules, temperature-dependent.

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