Technical Filter Booklet

TECHNICAL

FILTER BOOKLET

Foreword

Technical competence and professionalism in engine repair can only be achieved by using high-quality products. The range of KS products comprises of high-quality engine components which ensure optimum operation as well as well-balanced interplay in the engine - even in extreme situations. In view of the constantly rising demands of engine technology, the highest possible quality requirements are met.

Important notes

Although every care has been taken in compiling the information in this filter brochure, it is not binding. We cannot accept legal liability for any inaccuracies. In particular, changes in specifications by vehicle or engine manufacturers or changes in designations cannot be excluded. Please contact our Technical Customer Service in such cases. Should there be any mistakes in the brochure, please point them out to us so that they can be corrected for future publications. The parts listed in this filter brochure are spare parts, not original parts.
Figures, schematic drawings and other indications are for illustration purposes only, they are not intended as a basis for installation, scope of delivery or design. No part of this publication may be reproduced in any form without obtaining prior written consent from KS and without quoting KS as a reference.
Subject to change without notice.

Index **Page**

1 They lead a life in the shadows, but they are more important than any luxury accessories:

Filters

Filters purify the substances that are necessary for proper engine operation. A failure to observe the maintenance intervals or a lack of filter quality frequently lead to enormous follow-up costs. 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.

1.1 General remarks

Generally speaking, filters have the function of preventing impurities and foreign matter from entering the inside ot the engine together 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 by using

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

1.2 KS filter classification

The KS 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:

OS	oil spin-on	spin-on oil filter
OC	oil cartridge	oil filter cartridge
OH	oil hydraulic	hydraulic oil filter
OX	oil metalfree	oil filter cartridge, metal-free
E...	ENERGETIC®	ENERGETIC®
AP	air panel	panel air filter
AR	air round	round air filter
AD	air dryer	air dryer
FS	fuel spin-on	spin-on fuel filter
FC	fuel cartridge	fuel filter cartridge
FP	fuel pipe (inline)	fuel pipe filter
FX	fuel metalfree	fuel filter cartridge, metal-free

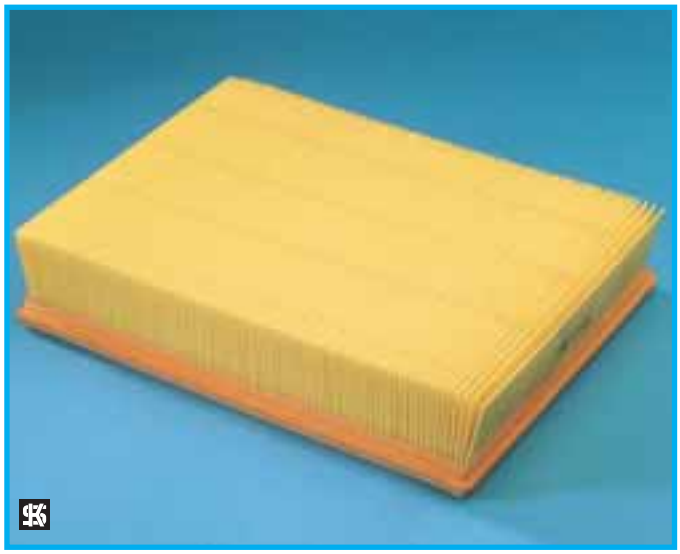
1.3 Wear in an internal combustion engine

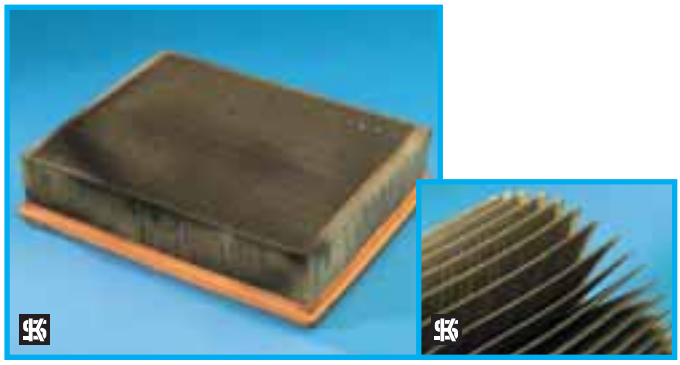
Whenever moving parts come into contact or mesh, they cause friction which must be avoided. As a suitable lubricant, mineral or synthetic oil is used which forms a sliding film between the machine parts. This ultra-thin separation film acts as a buffer to prevent a direct contact and to allow an easy sliding of the parts. Of course, this lubrication is only possible if the oil does not contain contaminants. Even impurities of microscopic size may not be carried because, as abrasive particles, they enormously accelerate the abrasive wear of the engine parts.
Critical spots within the engine are the cylinder barrels, pistons, piston rings, valves, gaskets, crankshafts and connecting rod bearings.

Impurities can enter the engine directly in the form of sand or sand particles with the fuel of the intake air.
In addition, the engine creates its own contaminants in the form of fine metal abrasives, residues of incomplete combustion or small fibres, plastic or rubber particles. These impurities also have a wear-enhancing effect on the system and may even cause operation failures.

Sectional view of an internal combustion engine

1.4 Wear of engine components due to impurities in the system



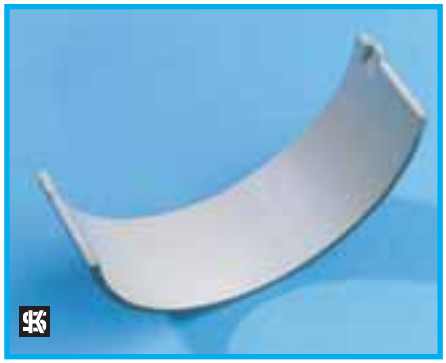


The dirt film which has settled on the filter during a mileage of 15,000 km is clearly visible. Minute dirt particles settle in the depth structure of the filter paper. Consequences: richer fuel-air mixture, elevated pollutant emission, lower engine performance.

New component

Damaged component

Enormous wear on the edges of the oil scraper ring.
Consequence: elevated oil consumption.



Strong scoring on the main bearing, caused by an abrasive mass consisting of oil and dirt particles.
Consequence: engine failure

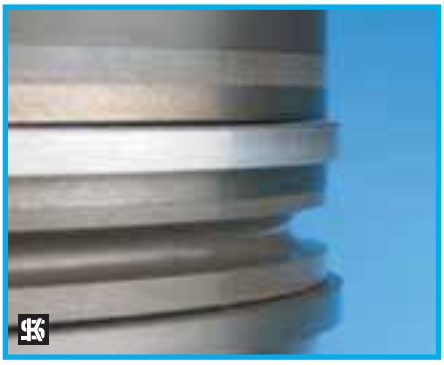
WEAR IN AN INTERNAL COMBUSTION ENGINE

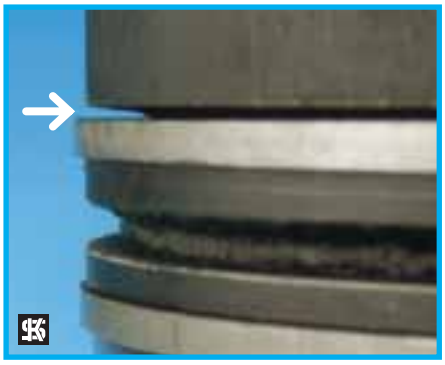
New component

Damaged component

Used piston with clear signs of wear. Strong abrasion of the graphite film on the piston body.

The missing sliding film may lead to piston malfunction or even piston seizing.





Marked wear in the area of the 1st ring groove. The elevated clearance leads to a lower compression, causing a loss of power.

New cylinder sleeve with a clearly visible cross hatch. This surface, produced by using a honing tool, improves the oil adhesion on the inside wall of the cylinder.

Cylinder sleeve with scoring on the inside wall. The honing pattern is not perceptible any more.

Consequence: elevated oil consumption

2 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) at 100%. The separation of particles is carried out in the depth structure of the medium on the surface of the individual fibres.

These impurities may include dust, metal abrasion or soot particles resulting from an incomplete combustion process. In addition to the solid particles, the filters also have to remove water residues in the fuel pipes as well as oil drops which result from the blow-by-gas of the crankcase air vent ventilation/ recirculation system.

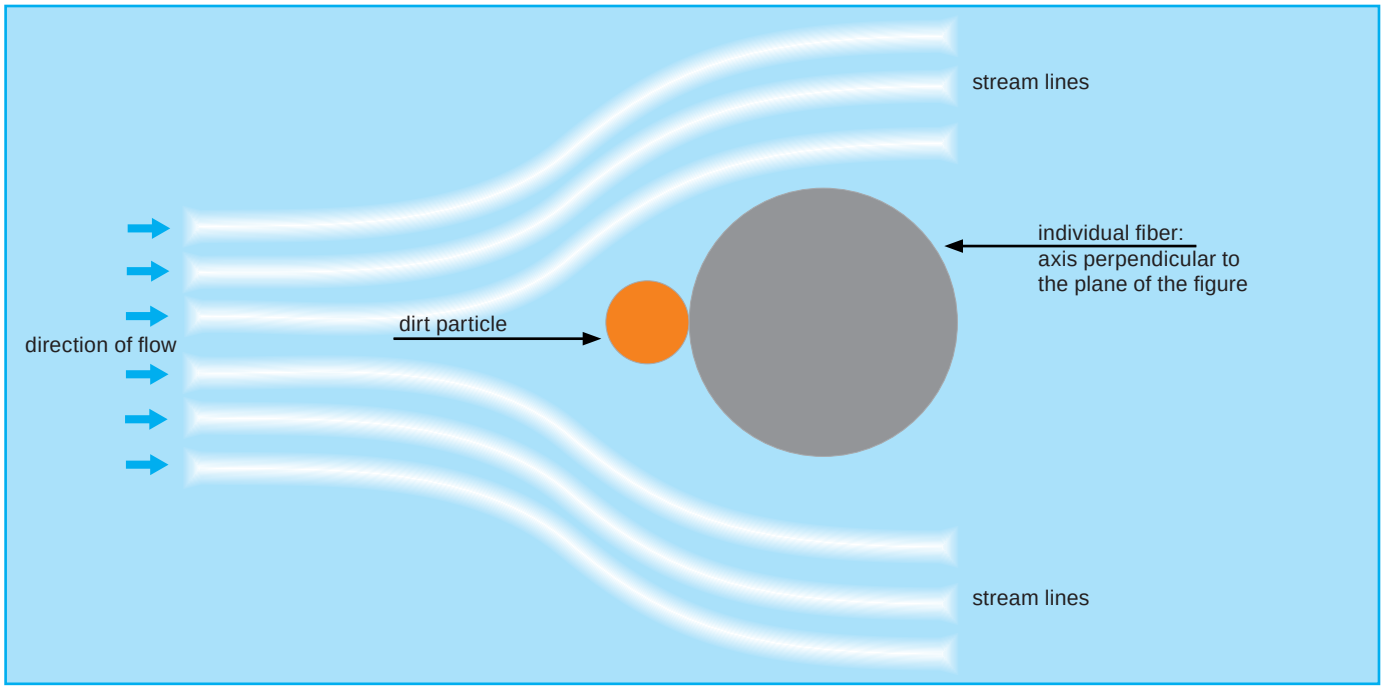
2.1 Filtration effects

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 barrier effect is the most important separation mechanism in the filtration of oil and fuel. In air filtration, the inertia and diffusion effects also play roles in addition to the barrier effect.

2.2 Inertia effect

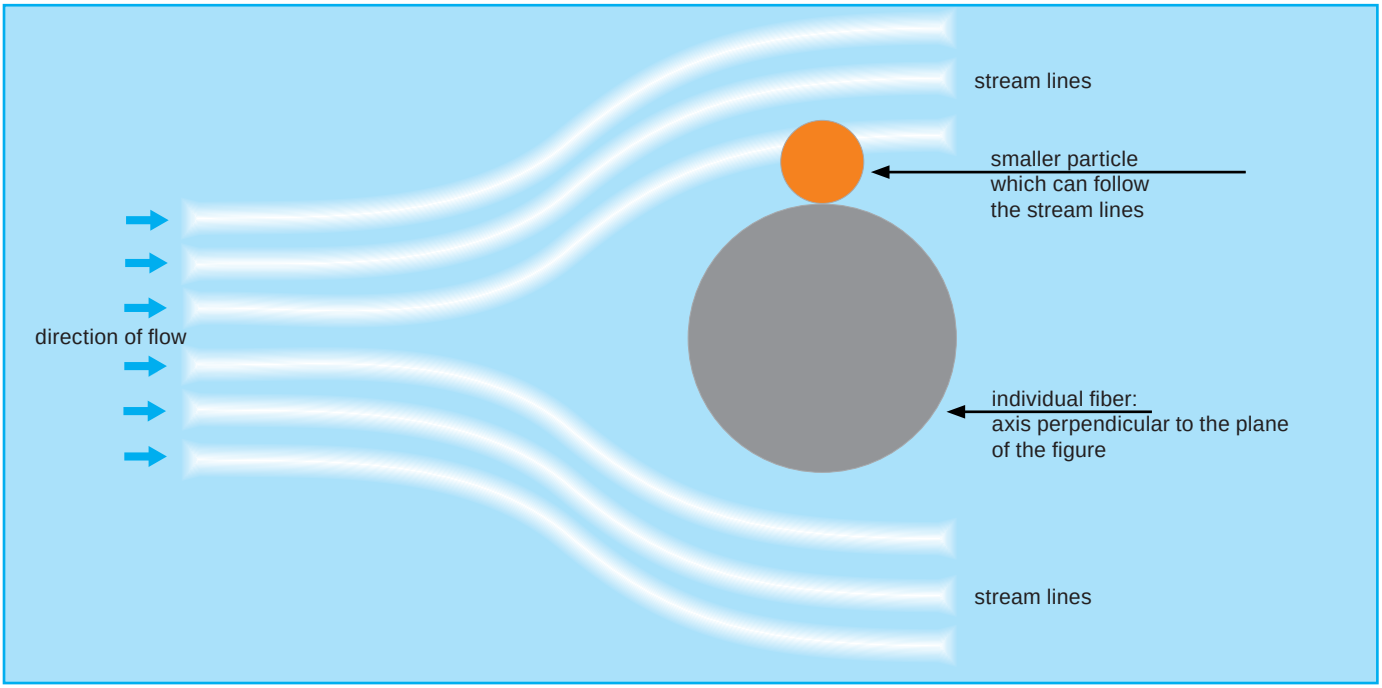
The inertia effect is based on the fact that dirt particles with a larger mass approaching the fibre leave their streamline path as a result of inertia and directly collide with the fibre.



Inertia effect

2.3 Barrier effect

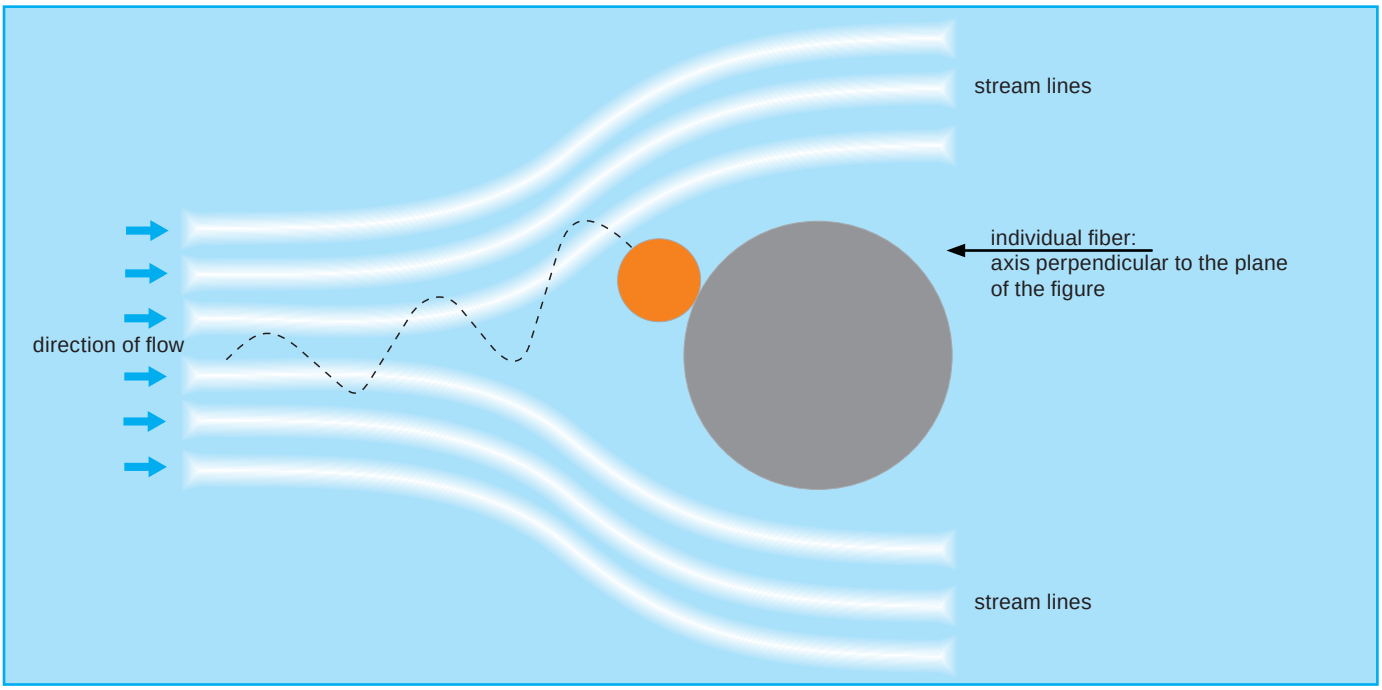
In the barrier effect, the particles can follow the streamline path due to their size. But if they get too close to and come into contact with the fibre, they adhere to it (Van-der-Waals forces).



Barrier effect

2.4 Diffusion effect

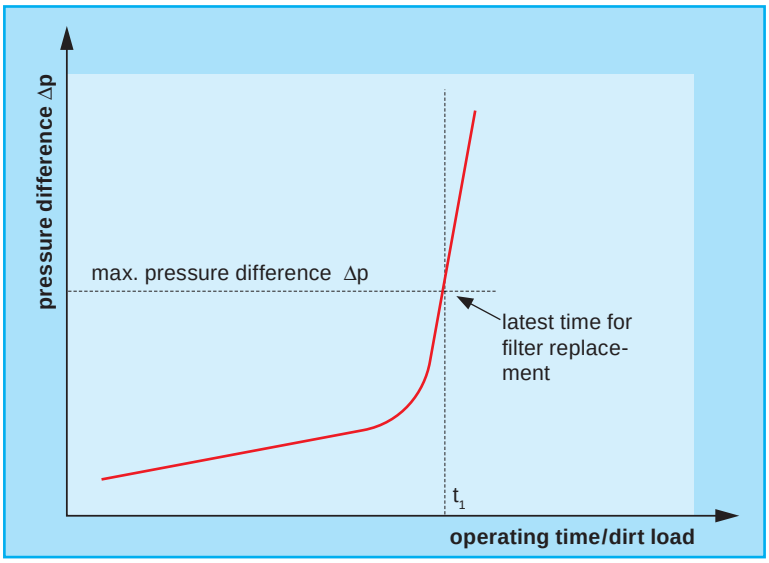
The diffusion effect is used to filtrate very small dirt particles with a diameter of less than 0.5 µm: They move on irregular paths (Brownian movement), collide with a fibre more or less accidentally and adhere to it.



Diffusion effect

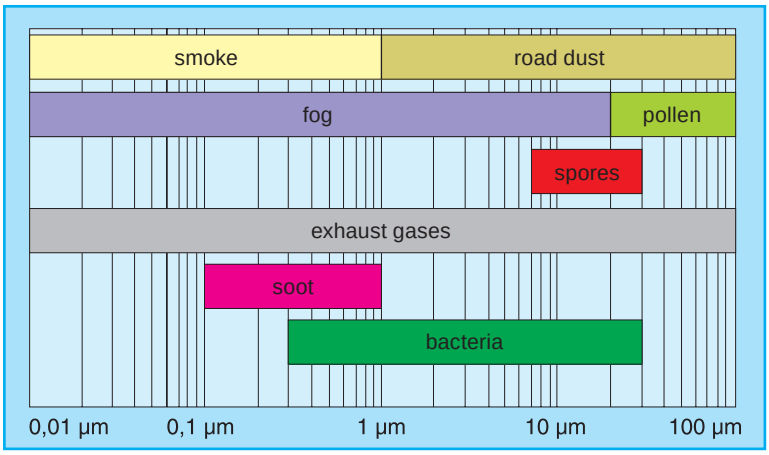
When using a new filter, dirt particles first settle on the fibre surface. With increasing contamination, the thickness of this dirt layer increases and causes a decrease in the pore volume. But with the pore volume decreasing and the flow remaining constant, the pressure difference rises.

The development of the pressure difference Δp is illustrated in the following diagram as a function of the operating time and the dirt load:



Development of the pressure difference

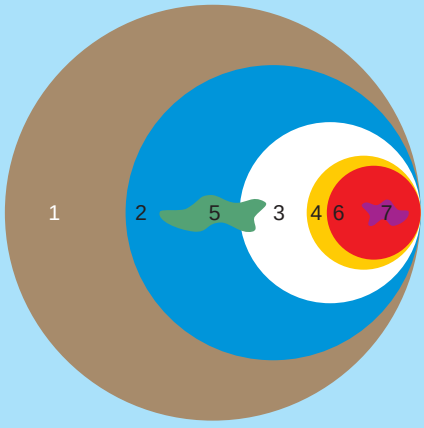
The rather slow increase in the pressure difference is a typical phenomenon with depth filters. Only when the pore volume of the filter is nearly exhausted does the pressure difference rapidly increase. This is when the filter should be replaced. The time t_1 is specified in the data sheets by the car manufacturer.



Dimensions of various particles

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

1	human hair	(~70 µm)
2	minimum human vision	(~40 µm)
3	white blood corpuscle	(~25 µm)
4	pollen	(~10 µm)
5	dirt particle	
6	red blood corpuscle	(~7 µm)
7	bacterium	(~2 µm)



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.

4 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.
The types of timbers most often used to produce filter paper are oak, maple and alder among the hardwoods; spruce and ceder woods predominate in the range of softwoods. Depending on the application, high quality filter paper differs in the composition of the fiber and pore structure as well as in its fineness. The three most important filter media are cotton, cellulose and plastic fibers.

4.1 Requirements on the filter paper

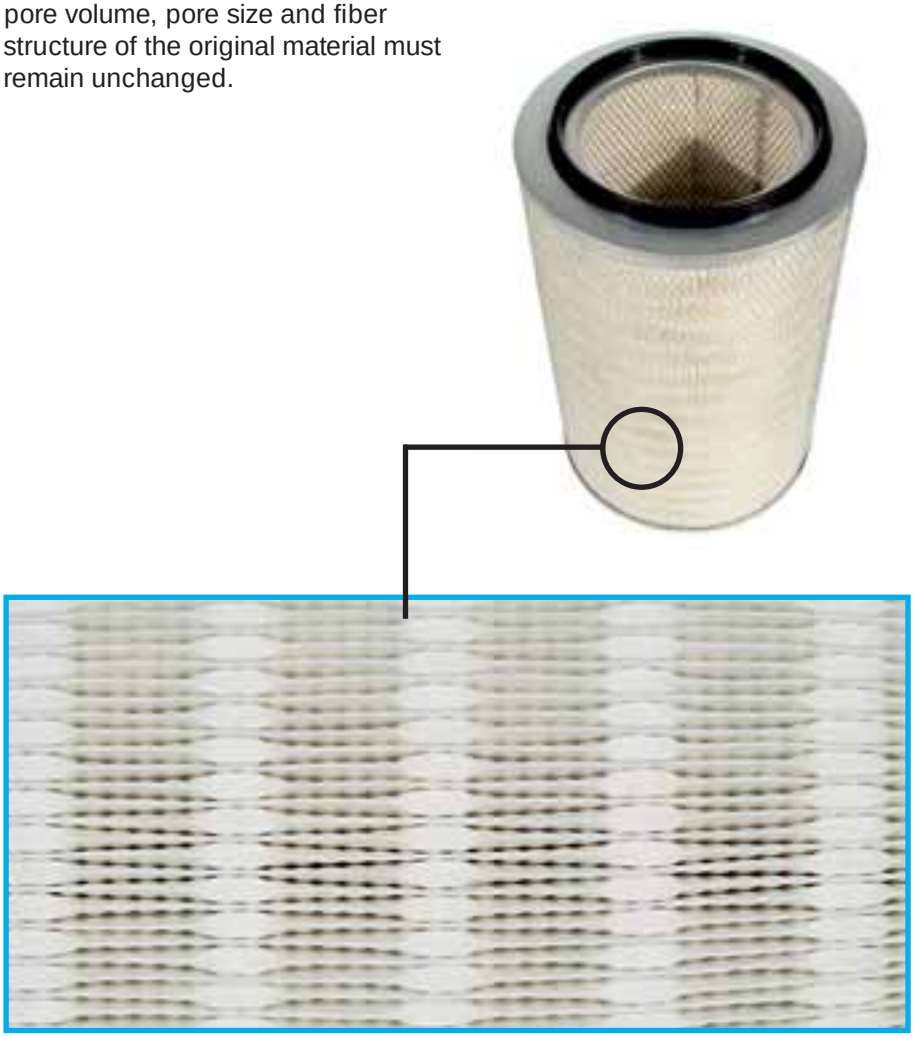
The requirements on the filter medium are

- a high pulsation stability at any dynamic load
- insensitiveness to water (e. g. in case of heavy rain or spray), engine oils, crankcase gases and fuel vapors, as well as
- a high thermal stability, since the filter element may be exposed to temperatures of up to 80°C during 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 fiber structure of the original material must remain unchanged.

4.2 Forming

In order to accommodate a maximum filter surface in a cartridge, the paper is formed during heat treatment. In this operating procedure, a certain pleat shape is forced onto the paper by making use of the paper‘s thermoplastic behavior between 20 und 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 truck filter 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. Another possibility consists in giving each pleat a corrugation, thus preventing the paper from bridging.

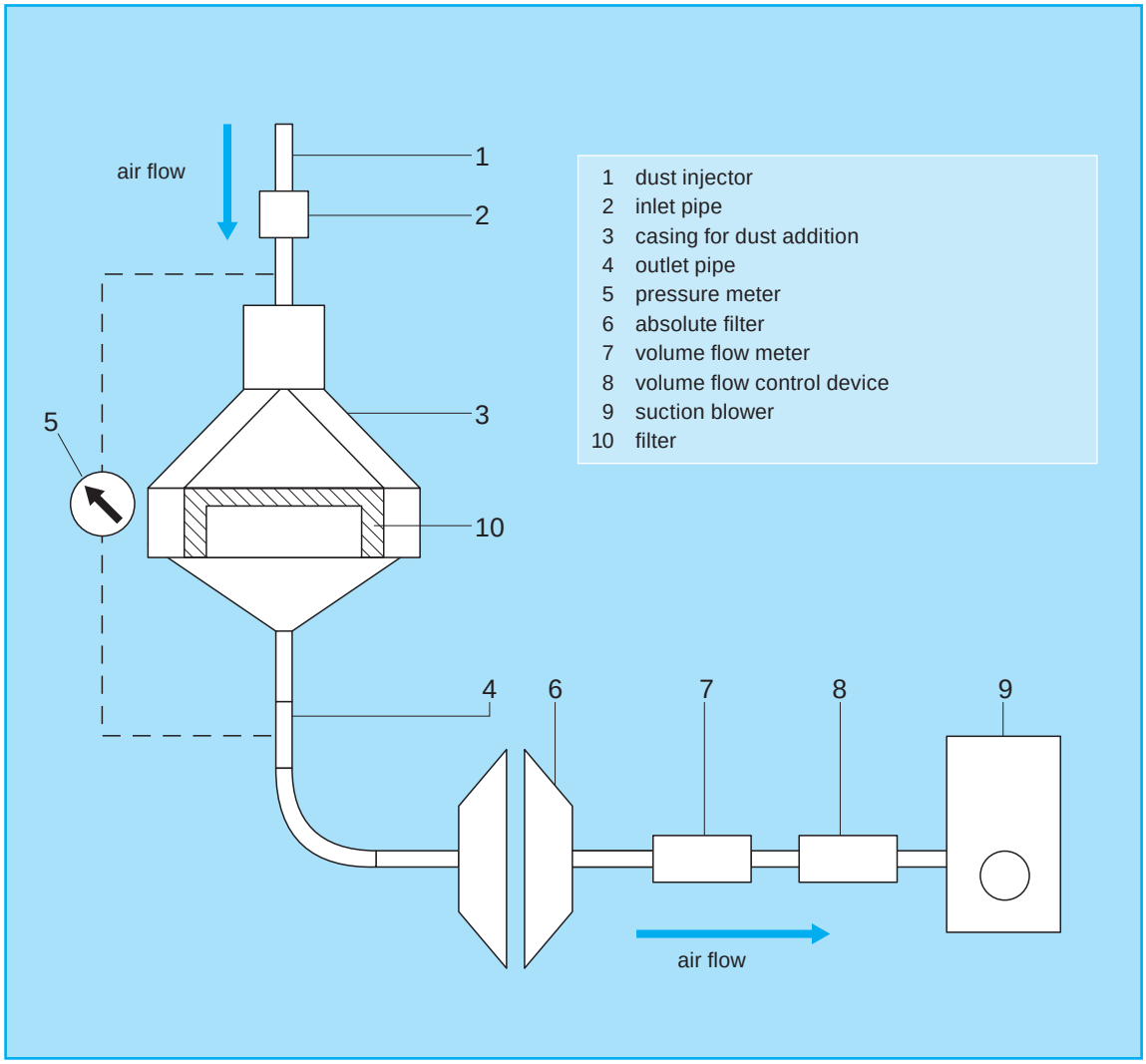


Pleat geometry

4.3 Quality testing of filter papers

The filter paper is subjected to rigid quality controls.
One of the most important test procedures is the so-called bubble test. Putting it simply, this test consists of soaking the test paper with a precisely defined liquid and subjecting it to different test pressures. Exact documentation of the test conditions is very important. The first air bubble can mathematically be assigned to the largest pore. When the test piece is completely covered with air bubbles, this indicates the average distribution of pore sizes. The reason: „Large pores require low pressure loads, small pores require high pressure loads."

This method is also used to determine the pressure difference. The test is relatively simple to execute, but its results are still very exact. It has to be kept in mind, 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 figure shows the test set-up for the determination of the degree of separation and the dust capacity of filter elements.



Test set-up to determine the separation degree

5 When talking about air filters (inlet filters) in today's engine technology, the main focus lies on the so-called dry filters, the generic term for a variety of exchangable paper filters.
Dry filters are based on the opposite operating principle than wet or oil bath filters, where liquids are used to separate dust particles from the inlet air.
The paper filter has gained acceptance mainly because it can ensure higher and - above all - stable separation degrees for all load ranges. Additional advantages are the easy maintenance and the independence of the installation position. From the environmental standpoint, too, the paper filter is increasingly gaining acceptance.

5.1 Task / function

It is the general task of air filters to purify the inlet air and to muffle the inlet noise of the engine. Another function - especially in passenger cars - consists in pre-heating the inlet air and controlling the temperature. This regulation is essential for the operating behavior of the engine and the composition of exhaust gases.
A short numerical example will illustrate the capacity and importance of the filter element: Depending on the landscape, weather conditions, soil and road properties and the use of the 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 liter of fuel (spark ignition 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 a considerable wear of the pistons, piston rings and cylinder barrels.

5.2 Consequential damage

A failure to replace air filters in time leads to a richer fuel-air mixture and thus to a higher emission of pollutants as well as a lower 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 inlet filter and is responsible for proportioning the amount of fuel (increasing fuel consumption).
If dirt particles get into the inside of the combustion chamber, the lifetime of the engine is reduced since the plain bearings, pistons, piston rings and cylinder barrels wear out due to the increased abrasive effect.

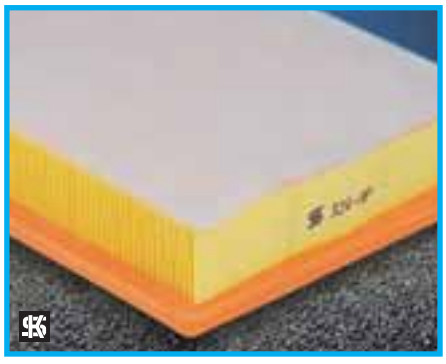
5.3 Design

5.3.1 Air filters for passenger cars

Air filters for passenger cars come in two different designs: as panel filters and as round filters (round and oval elements). The type of filter which is suitable for 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 separation degree which is independent of the load. Their replacement is simple and is determined by the maintenance dates specified by the vehicle manufacturer.
There is a wide range of engines on the market, and each vehicle requires filters which exactly fulfill the requirements of the engine and installation space. KS offers air filters with suitable designs for virtually any vehicle. Filter casings and filter elements are optimally matched and adjusted to the engine type and its inlet system.
A special design for a panel filter is shown in the picture below. 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.

Panel air filter

Round air filter



Panel air filter with protecting fleece

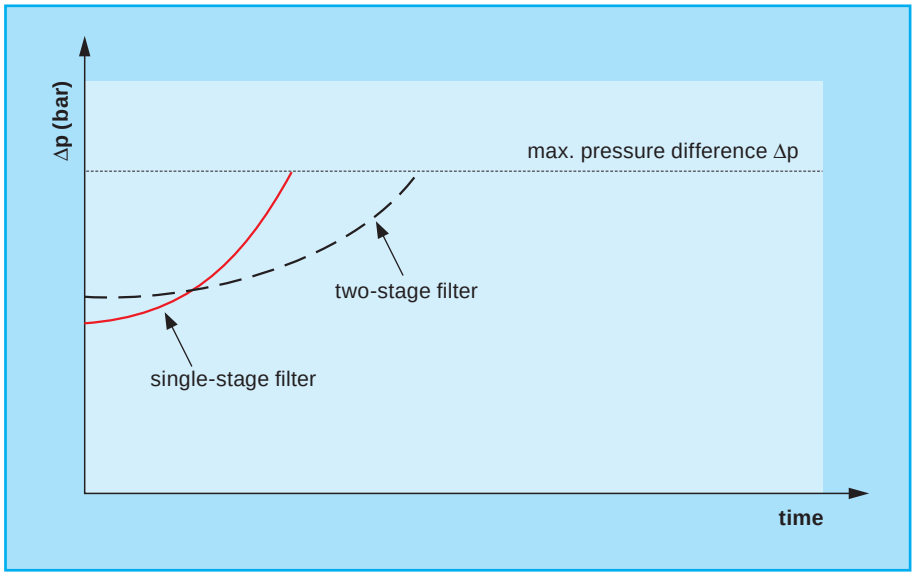
5.3.2 Air filters for commercial vehicles

Due to the higher flow rate and less critical sealing of the filter casing periphery, cylindrical round filters with a steel or plastic mesh are predominantly used in commercial vehicles. These filters are divided into single-stage and two-stage air filters. In contrast to single-stage filters, two-stage filters are equipped with a cyclone-type cleaner as a pre-separator.
The cyclone cleaner takes advantage of the effects of centrifugal forces: The air stream is set into rotation by a specifically designed rotor disk with so-called baffles. Due to the centrifugal forces, the dirt particles are precipitated towards the wall of the casing. 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 casing.

The two-stage filter is mainly used in construction and agricultural machines.

Air filter for commercial vehicles



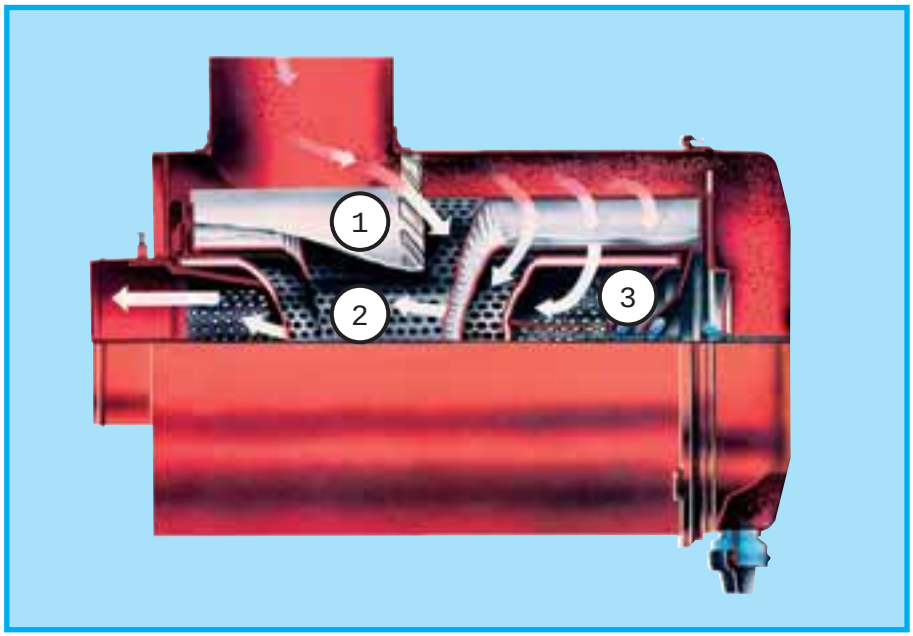
Different service lives

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 damaged or being serviced. The secondary element may not be inserted without the main filter and should be exchanged with every third replacement of the the main element.

In commercial vehicles, the air intake is often located above or beside the driver‘s cabin. This helps keeping the amount of dust in the intake air as low as possible and thus extends the maintenance intervals. In modern trucks, the filter casings are frequently designed larger than necessary for filtration. This measure helps reduce the intake noise considerably.

Since these filters combine the tasks of filtration and suppression of noise, they are called silenced filters.

A two-stage air filter for a commercial vehicle is shown in the following figure. It consists of a deflector (baffle) (1), the main filter element (2) and a safety element (3). The intake air enters the filter through the outer shell, and the purified air leaves it through the interior.



Two-stage air filter

5.4 Mounting instructions for filter replacement

Please keep in mind the following advice when replacing an air filter:

- Never exchange 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 by 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.
- Bevor installation, clean the cover and casing of the new filter using a clean and soft cloth. Do not use a brush or other instruments that might whirl up dirt particles.
- Examine all gaskets for damages. Even small cracks or deformations can lead to considerable contamination. If in doubt, replace the gaskets.
- Place the filter element in the center of the system.
- When mounting the cover, make sure that there is no gap between the cover and the casing because unfiltered air may otherwise enter the combustion chambers.

Important note:

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

5.5 Handling mistakes

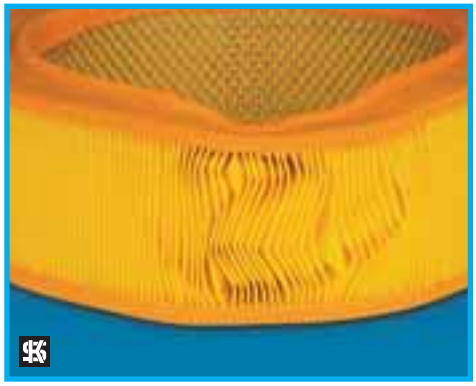
The filter may not be cleaned by using compressed air under any circumstances. This would press the microscopic dirt particles even further into the depth structure of the filter paper, resulting in an even lower flow rate. In addition, the filter paper may tear due to the high air pressure.

When handling the filter, also pay attention that

a) the paper pack and

b) the sealing area are not destroyed.

In case of insufficient sealing or cracks in the filter paper, foreign matter will enter the inside of the engine and may cause serious damages.



Filters with the defects mentioned above may not be installed under any circumstances.

AIR DRYER

6 The air dryer serves for a special type of filtration. It is mainly employed in compressed-air systems for medium-size and heavy commercial vehicles. Since compressed air is used as an energy carrier for many control processes, it must be ensured that the humidity of the air does not cause corrosion in the pipes and tanks or even paralyzes the whole system at freezing temperatures. The air dryer is therefore one of the safety-relevant components in the vehicle.

Mounting position of the air dryer

6.1 Function

The compressed air necessary for braking is produced by the compressor which is powered by the engine. It then flows from the compressor to the one-chamber air dryer provided with a pressure control device. The compressed air is dryed using a specifically developed granulate, and the pressure in the braking system is limited to a specified value by an integrated pressure control system.
Then the compressed air flows into a compressed-air tank which is equipped with a condensed water sensor to monitor the drying process, as well as a safety valve.

Granulate developed especially to remove humidity from the air

6.2 Consequential damage

If water and oil enter the tanks and thus the braking system, the consequences will be dangerous and costly damages: The moisture damages the valves, causes corrosion in the pipes and tanks, and at sub-zero temperatures the complete system may freeze. The oil affects the function of the valves and delays the response of the brakes. The brake linings are therefore used in excess and wear faster.
In order to prevent these potential damages and costs, the use of a KS air dryer is highly recommended. The life time of the individual components rises, and the vehicles have fewer downtimes.

Therefore, the air dryer should be exchanged regularly as well!

7 Fuel filters are a crucial part in today's highly sophisticated fuel supply systems. Since they come in various designs, the different fuel systems will be explained at first.

7.1 Structure of different fuel systems

7.1.1 Spark-ignition engines

In modern spark-ignition engines, we distinguish between direct and indirect injection.

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

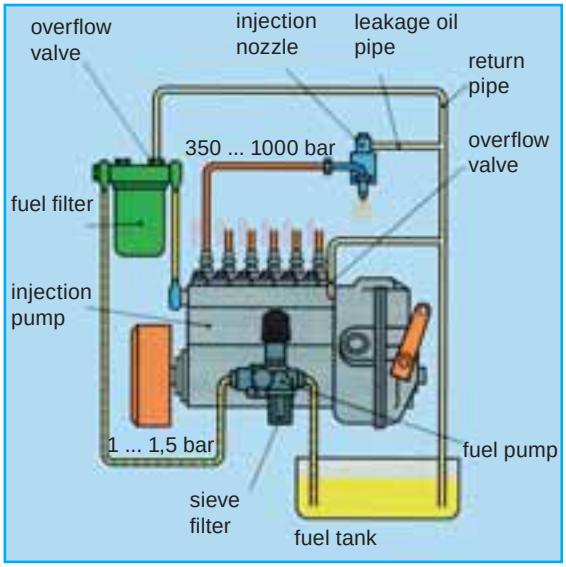
Direct injection:
For direct injection, substantially higher injection pressures are necessary. The supply system in these systems consists of a low- and a high-pressure circuit. The low-pressure circuit has an integrated electric fuel pump and is only used to feed the high-pressure circuit. The preliminary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

Because of the high pressures and the large number of additional components such as the pressure reservoir, sensor or control valves, these filters are much finer than the filters used in indirect injection.

7.1.2 Diesel engines

The combustion process in a Diesel engine differs considerably from that of a spark-ignition engine. The diesel engine always operates with internal mixture formation and self-ignition of the fuel-air mixture. The term „internal mixture formation" refers to the process of converting liquid fuel into an ignitable mixture after injection. In order to obtain a better and more efficient combustion process, the fuel is directly injected into the cylinder in virtually all modern Diesel engines. Pump-nozzle as well as common-rail technology are the state-of-the art injection systems today.



Simple Diesel injection

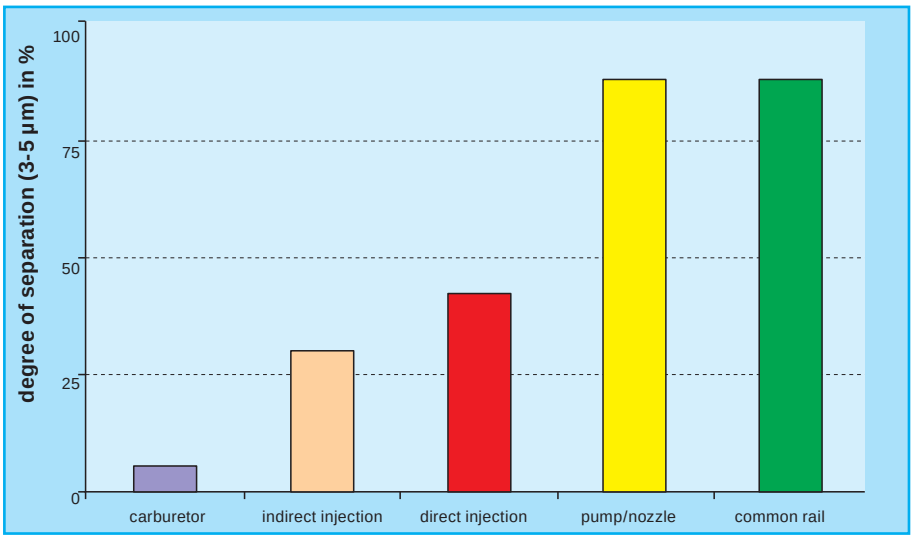
Pump-nozzle system:
In the pump-nozzle system, each engine cylinder has a pump-nozzle element. It contains the following components in its casing :

- 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:
The common-rail technology uses a high-pressure injection system with electric control and a common fuel 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.



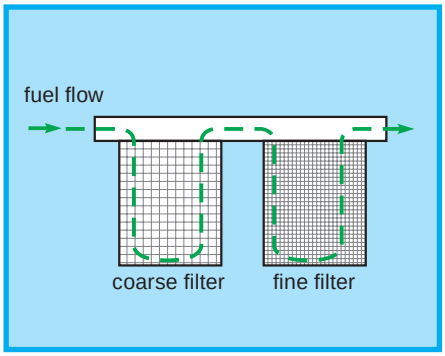
Recommended minimum filter fineness in spark-ignition and Diesel engines

7.2 Task / function

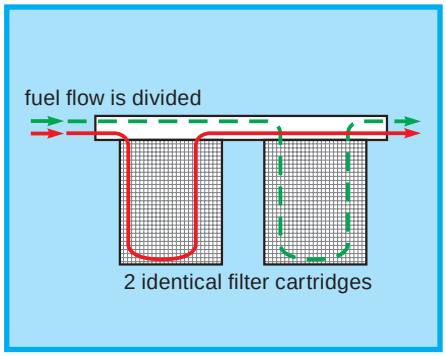
The fuel filter has the function to protect the fuel system from impurities such as dirt, rust, dust and water contaminants in order to guarantee a proper engine performance. The protection of high-quality injection systems is especially important in modern Diesel engines. Even particles with dimensions in the range of 5-20 microns may lead to serious damages, including engine breakdown.
The fuel filter has a finer filter paper than the oil filter since the components of the fuel supply system have smaller clearances. In order to prevent even minute dirt particles from entering the pipe circuit, by-pass valves are not allowed in fuel filters.

7.3 Arrangement of the filters

According to their arrangement, fuel filters are divided into one-stage, two-stage and parallel filters.
In a two-stage filter, a coarse filter (sieve filter of metal or plastic) is mounted in front of the fine filter.
The parallel filter consists of two identical filter cartridges. It has the advantage of allowing a higher flow rate than the one-stage filter.



Two-stage filter



Parallel filter

7.4 Consequential damage

Fuel filters have to be exchanged regularly. If the filter is clogged, the fuel supply of the engine is insufficient and leads to a loss of power. Difficulties in starting occur, the engine stutters and runs irregularly; 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 enters the filter element. In spark-ignition engines, this leads to faults in the carburetor or injection system and causes wear on these components. In Diesel engines, the extremely sensitive injection elements are damaged and fail.

7.5 Design

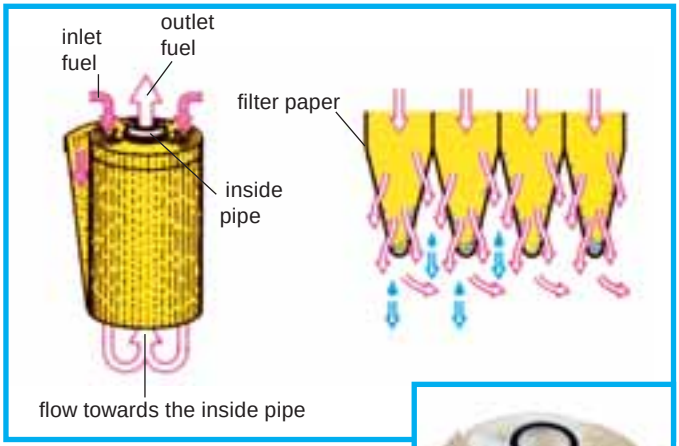
The range of KS fuel filters includes spin-on filters, filter cartridges, and fuel pipe filters.


Spin-on fuel filter

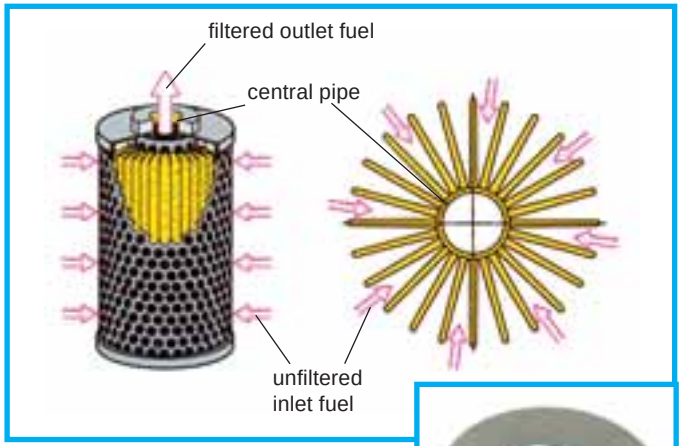

Fuel filter cartridge


Fuel pipe filter (inline)

With respect to the arrangement in the casing, the paper cartridges are divided into spiral filters (axial filters) and star filters (radial filters).
In axial filters, the paper is wound around a pipe. The paper strips are arranged in such a way that they form open V-shaped bags in which the dirt particles are collected. The inlet fuel axially flows through the filter from top to bottom, and the purified fuel is drained upwards through the central pipe.
In radial filters, the paper is arranged in a star form around a pipe 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 inside pipe.



Axial filter



Radial filter

7.5.1 Fuel filter cartridge

They can be exchanged individually and are installed in an extra casing which is mounted on the engine.
When replacing the filter, the cover of the casing is unscrewed, and only the filter element is exchanged.
Modern filter cartridges are made of materials that are suitable for thermal recycling (see chapter 9, metal-free filter cartridges)
Cartridges from paper and felt are used as filter elements.

Filter cartridge from paper

Filter cartridge from felt

7.5.2 Fuel pipe filters (inline)

Fuel pipe filters are designed as sieve or paper filters and are installed in the fuel pipe. Depending on the application, the filter casing 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 whose width varies 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 pipe.

7.5.3 Spin-on fuel filters

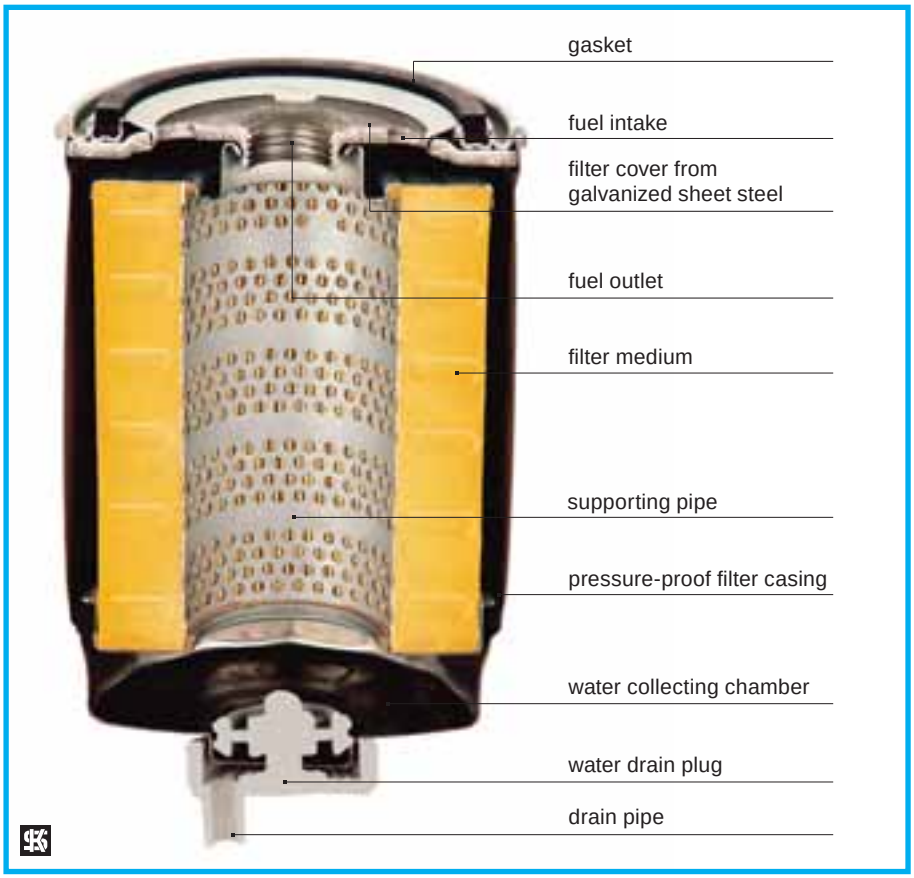
Spin-on fuel filters consist of a casing with a filter element, which are exchanged as a unit during maintenance. The filters are normally mounted in the engine compartment or under the vehicle between the fuel tank and the engine.

In passenger cars, filters with a water drain plug and an integrated pressure control valve are used in addition to the standard, replaceable cartridge filters. For commercial vehicles, special 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.

Water separation:

Due to its high surface tension, the water is first retained on the soiled side. After a rise in the pressure difference, it passes through the pores to the clean side, where it forms larger drops. Because of their higher specific gravity, the drops fall into the water collection chamber. By opening the water drain plug, the water can be drained. In some vehicles, a sensor gives information on the water level.



Structure of a Diesel spin-on filter

7.6 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 exchange 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-pipe filters. The flow direction is marked with an arrow and should point away from the tank towards the engine.

Important note

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

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

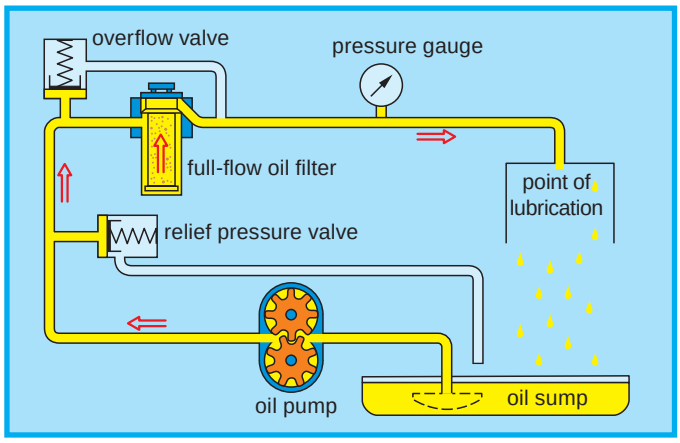
8.1 Task / function

While the air filter has the function to keep 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 wear metals, dust particles from the combustion air, soot and corroded metals.
Oil filters do not have an 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 functionability of the engine oil since they have a positive influence on its viscosity and pumpability.
Since hydraulic systems are playing an evermore important role in modern vehicles, oil filters have entered this area, too. Especially in hydraulic steering system, they are increasingly used.

8.2 Arrangement

According to their arrangement in the oil circuit, we distinguish between full-flow and partial-flow oil filters as well as a combination of both.

8.2.1 Full-flow oil filters



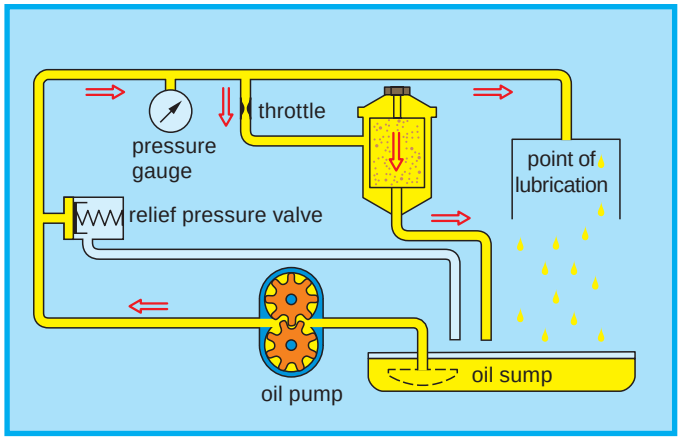
Full-flow oil filters

The main oil gallery is responsible for the oil supply of the plain 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 oil filters are preferably used because all of the oil has to pass through the filter element. It is thus ensured that impurities can already be filtered out during the first filtration process.
This arrangement has the disadvantage, however, that the filter has to accomodate the whole oil flow.
Full-flow oil filters must have a by-pass valve and should always be mounted behind the pressure control valve.

8.2.2 Partial-flow oil filters

The partial-flow filter is installed in a pipe arranged in parallel to the full flow pipe.
This pipe is mounted between the lubricating points and the feed pump.
Due to an upstream throttle, only a part of the oil supply (5 -10%) passes through this filter.
Therefore, only partially purified oil reaches the lubricating points.

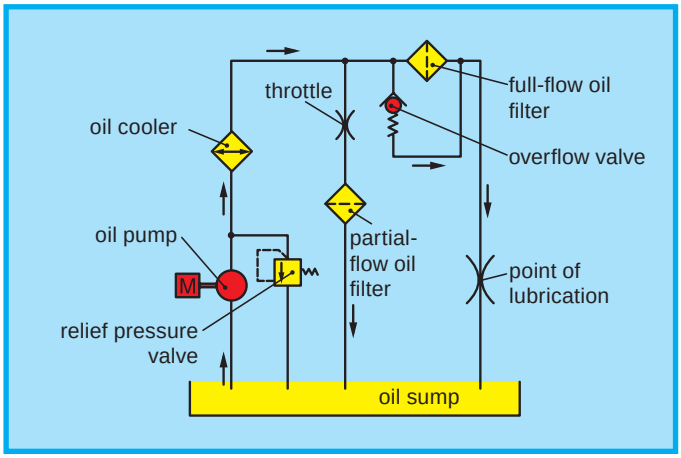
Because of its low feed and flow rate, the partial-flow filter does not reach the highest possible rate of filtration. It should therefore be regarded as a fine filter with a high degree of separation.



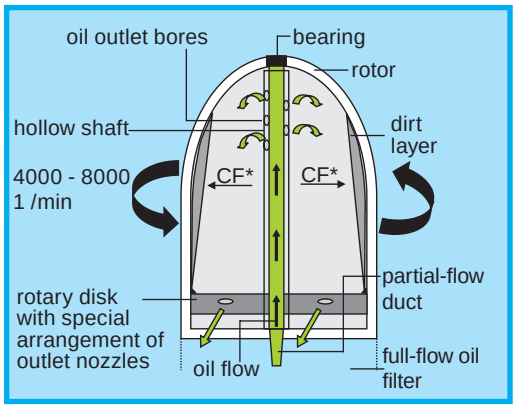
Partial-flow oil filters

8.2.3 Oil filters in a combination system

If partial-flow filters are used in combination with full-flow filters, a very effective filtration is achieved: Minute particles that have passed the full-flow filter are removed by the partial-flow filter. The partial-flow filter offers a very intense purification with a high degree of separation. As a partial-flow filter, the free-jet centrifuge (oil splash filter) is mainly used in commercial vehicles and building machinery.
The oil which is diverted from the full-flow channel to the partial-flow channel flows through the hollow rotor shaft into the inside of the filter through several bores. It leaves the centrifuge through specifically designed discharge nozzles.
In this process, reaction forces are released which set the rotor into rotation. Depending on the pressure and temperature, the rotor can reach a speed between 4000 and 8000 1/min. Due to the centrifugal forces emerging during rotation, the dirt particles in the oil are thrown towards the inside wall of the rotor, where they remain stuck until the centrifuge is exchanged during maintenance.



Oil filters in a combination system



Free jet centrifuge CF = centrifugal force

8.3 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 4, Wear on engine components).
Due to an 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 spots and oil leakages at the intake-valve guides. Another consequence is the reduction of compression and engine power. The connecting-rod and crankshaft bearings can also be substantially affected by the abrasive effects of the dirt particles.
A higher clearance of the bearings caused by abrasion reduces their supporting capacity and may lead to bearing damage.

8.4 Design

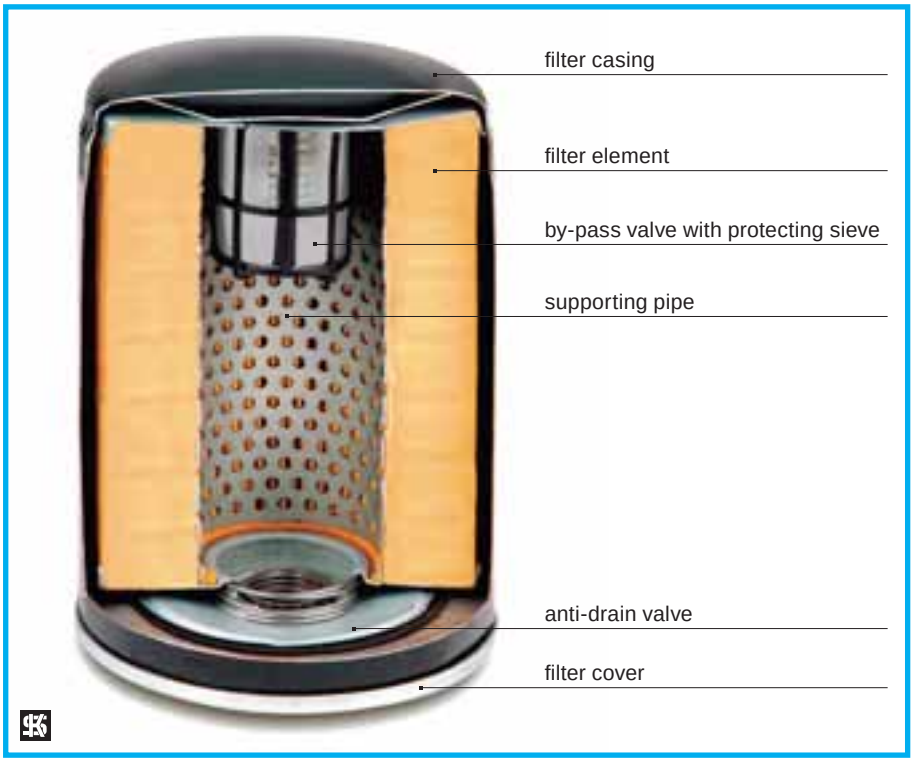
Oil filters are available with two different designs - as spin-on filters and casing filters.


Spin-on oil filter


Oil filter cartridge/ hydraulic oil filter

8.4.1 Spin-on oil filters

The spin-on oil filter consists of a filter casing (from sheet steel), a filter element and a cover which is usually flanged or welded to the filter. The whole filter element is exchanged when replacing the filter. Many replaceable cartridge filters are additionally equipped with a so-called by-pass valve (overflow valve) as well as a anti-drain valve. This type of filter is used in passenger cars as well as in commercial vehicles.



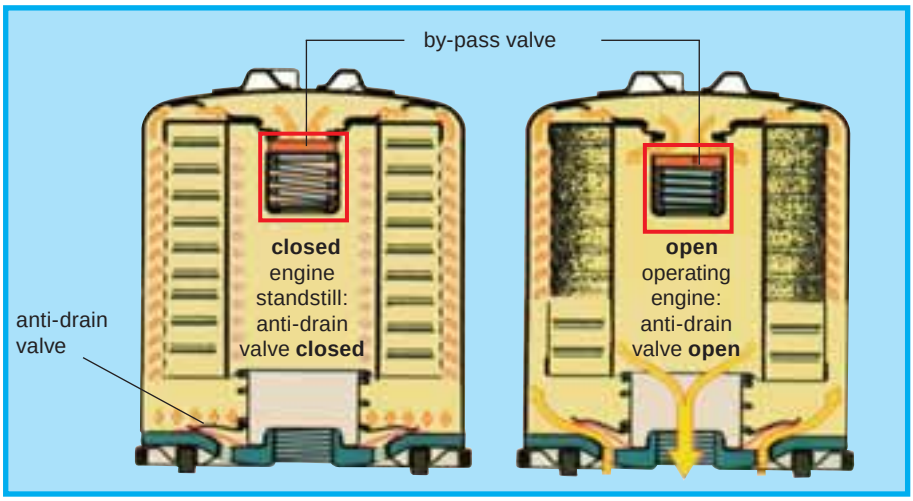
Structure of a spin-on oil filter

By-pass valve

The by-pass valve, also called overflow valve, has the function to open a direct passage to the oil circuit in case of an elevated oil pressure. Although unfiltered oil is fed to the circuit, this is still better than a complete interruption of the lubricating oil supply. The by-pass valve can be installed in front of the full-flow valve or - as in many KS filters - directly into the filter element. The set 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 constructive feature of replaceable-cartridge filters. Depending on the installation position of the oil filter, it may be integrated into the intake or drain pipe. It prevents the oil filter from running dry during a standstill of the engine.



Function of a by-pass valve and anti-drain valve

8.4.2 Casing filters

In contrast to the spin-on filter, the casing of these filters is screwed onto the engine or constitutes an integrated part of the crankcase.

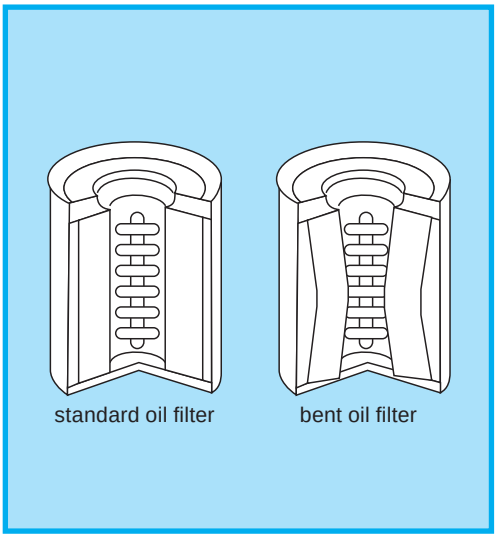
Only the cartridge is exchanged in this type of filter. In modern vehicles, these filters are made of metal-free materials. Due to their environmentally friendly disposal, these filters are gaining more and more importance (see chapter 9, Metal-free filter cartridges).

8.5 Failure of the oil filter due to excess pressure

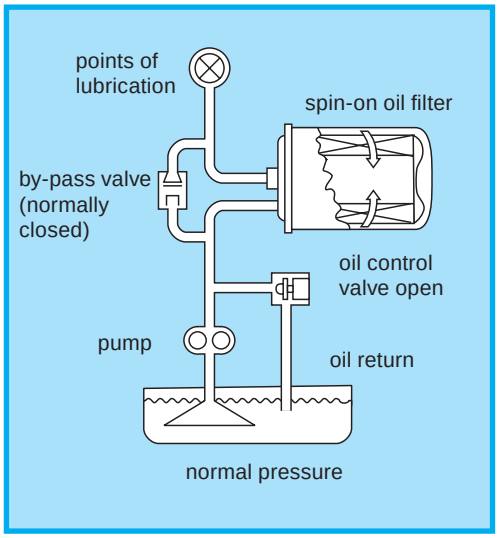
If a filter is bent or swollen, a lack of filter quality is often assumed. However, this is only very rarely the case. A deformed filter mostly is a symptom for problems in the oil circuit. The fault is often caused by the pressure control valve, which is usually integrated in the oil pump. The oil pump provides the required oil pressure for the lubrication system in order to build up a lubricating film between the high-duty engine parts.

The pressure control valve has the function to maintain the pressure in the lubricating system at a certain value.
After the valve is opened, the pressure in the lubricating systems remains almost constant.
If the pressure control valve is jammed or reacts slowly when the engine is started, an inadmissible excess pressure is caused 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



Operating principle of a lubricating system

8.6 Mounting instructions for filter replacement

No oil change without filter exchange: Whenever exchanging the oil, also exchange the oil filter.

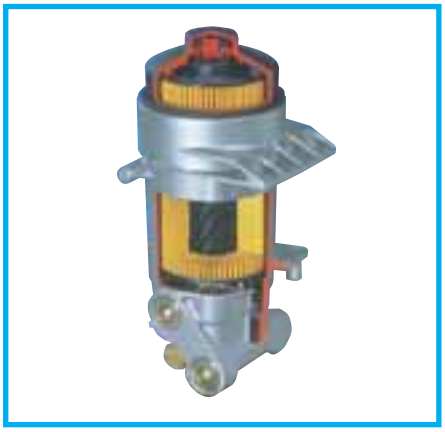
- Drain the engine oil with the engine at operating temperature so that the oil sump is emptied completely and the largest possible amount of foreign matter is washed out.
- Use special spanners for dismounting.
- Completely remove all gaskets residues from the engine‘s mounting face and carefully clean the mounting faces.
- Thoroughly clean the filter casings of filter cartridges.
- Always use new gaskets which are included in the scope of delivery. If the old gasket is reused, proper sealing cannot be ensured.
- Spread engine oil onto the gaskets. Never use lubricating grease for this. Its components might attack the O-rings of the filter.
- Do not twist the filter when putting it onto the thread.
- Examine all gaskets for correct fit before tightening.
- Only screw the filters manually, do not use tools.
- Check the oil level.
- Start the engine and check the circuit for leakages in idling position.

With the filter concept of the ENERGETIC® series, Ing. Walter Hengst GmbH & Co. KG has developed a system that offers advantages for all types of installations. The system follows a modular principle and covers a wide variety of applications. The advantages of the ENERGETIC® series at one glance:

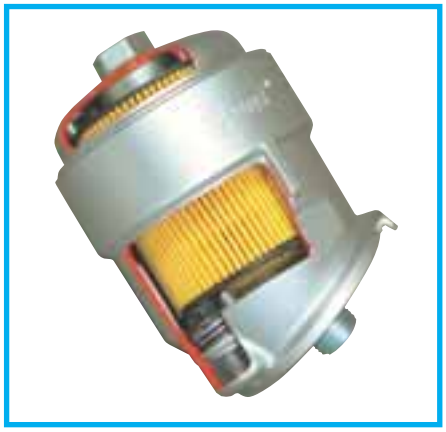
- Only the filter cartridge is exchanged during service. The filter casing and valves remain on the engine block for their whole service life.
- Clean replacement of the filter cartridge, the skin does not come into contact with waste oil.
- Designed for extended maintenance intervals.
- Protection of resources by using recycled materials. The filter cartridge only consists of the filter medium and thermoplastic end disks.
- Energetic utilization of the filter element. The energy stored in the filter elements is recovered during combustion.
- Substantial reduction of service and disposal costs. The metal- and glue-free filter elements do not have to be subjected to an expensive disassembly process. The complete filter element is suitable for thermal recycling.

Mounting examples for ENERGETIC® filters

AUDI V6 TDI
photo: Hengst Filterwerke



BMW M73-V12
photo: Hengst Filterwerke



OPEL X18XE-1
photo: Hengst Filterwerke

In the meantime, a variety of metal-free filters with the same advantages have been developed by KS.

Metal-free filter cartridge

ENERGETIC® is a registered trade mark of Ing. Walter Hengst GmbH & Co. KG / Münster, Germany

CONCLUDING REMARKS

10 KS filters are produced using continuously monitored state-of-the-art manufacturing processes. Only by these stringent measures can it be ensured that they meet the high requirements of modern precision engines. Especially in the field of filters, the quality is not perceptible at first glance. It is not easy to see if a filter will meet the desired performance requirements. All KS filters at least fulfill OE requirements. This ensures optimum engine protection and a long service life. The paper for KS 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 optimum utilization of the filter surface. In constant controls during the manufacturing process, KS filters have to demonstrate their quality at any time. They are reliable and efficient. Precise processing methods ensure an exact fit: Mounting is easy because the gaskets and O-rings needed for installation are included in the scope of delivery. With KS filters you avoid early abrasive engine wear, prevent high fuel consumption and poor engine performance as well as poor emission figures.

So, remember to exchange filters regularly.

For European vehicle applications, a wide range of reliable first-class KS filters is available.

Therefore: KS oil filters, KS air filters and KS fuel filters

For your information

All filters and the air dryer, together with all identification numbers, dimensions and applications, can be found in the filter catalogue and on the MSI CD ROM.

The current filter catalogue as well as the MSI CD ROM can be obtained from the local KS distributors.

Absolute filter
component in the testing procedure according to DIN ISO 5011: downstream filter which is 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

bar
measurement unit of pressure: 1 bar = 10^2 kPa

Burst pressure
pressure difference at which a filter or filter component is destroyed due to the inside pressure load.

Blow-by gas
leakage 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.

By-pass valve
also called overflow valve. Usually installed in the filter, the by-pass 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

Degree of separation
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

Dirt-holding capacity
amount of dirt a filter medium can hold before reaching a specified pressure difference

Filter fineness
diameter of particles which are just small enough to pass through the pores of the filter medium

Filter service life
service time of a filter or other component until maintenance or replacement

µm (micron)
metrical measurement unit: 1 µm = 0.001 mm

Pressure difference Δp
pressure difference between the filter inlet and outlet

Anti-drain valve
valve that prevents the oil from flowing back through the inlet hole after the engine has stopped

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

MOTOR SERVICE INTERNATIONAL

KOLBENSCHMIDT PIERBURG

MSI Motor Service
International GmbH

Untere Neckarstraße
D-74172 Neckarsulm
Phone +49 71 32-33 33 33
Fax +49 71 32-33 28 64

Alfred-Pierburg-Straße 1
D-41460 Neuss
Phone +49 21 31-5 20-0
Fax +49 21 31-5 20-6 63

info@msi-motor-service.com
www.msi-motor-service.com

50 003 596-02 09/02

4 028977 397691