

The background of the entire page is a high-contrast, close-up photograph of engine components. A large, polished, curved metal part, likely a piston crown or a valve cover, dominates the center. To its right, a portion of a pleated air filter is visible. In the foreground, a metal rod with a flange and a timing belt are partially shown. The lighting is dramatic, with strong highlights and shadows, emphasizing the metallic textures and industrial nature of the components.

**MAHLE**

*Driven by performance*

# MAHLE PRODUCT RANGE

PRODUCT INFORMATION

AFTERMARKET



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**WHERE  
THERE ARE CARS,  
THERE IS MAHLE.**



# The MAHLE Group

In the beginning there was innovation: the first light-alloy piston in 1921 was the prelude to the MAHLE success story in all aspects of the combustion engine. This was followed by many more market-defining innovations: for example, the first aluminium engine block to be series-produced using low-pressure die casting in 1976, the production of assembled camshafts in 1985, the start of production for pistons with cooled ring carriers for passenger car diesel engines in 2000, the first multifunctional oil filter modules with plastic tubing in 2003, the first MAHLE complete engine in 2004, the manufacture of the first fast-switching EGR valve prototypes for diesel engines used in customer trials in 2009, and the development of a range extender for increasing the cruising range of electric vehicles in 2010.

As a development partner to the international automotive and engine industry and ranking among the top three systems suppliers, we are not only represented in every second vehicle today, but also on the racing circuits, where racers equipped with MAHLE products regularly cross the finish line in leading positions—for instance, in Formula 1, the 24 Hours of Le Mans, or in truck racing.

Approximately 3,000 engineers work in eight R&D centres worldwide on new and intelligent solutions for the combustion engine of the future with the aim of securing and extending this innovative advantage. Those engineers develop innovative products that are manufactured at over 100 production locations by around 49,000 employees and are sold all over the world. In doing so, MAHLE has a local presence in all major world markets.

All of our customers benefit from this global presence—customers from the original equipment sector and the aftermarket alike. It makes no difference whether MAHLE manufactures a product for the automobile industry or for the independent aftermarket: our products always meet the same high standards. The automotive industry, trade, and repair shops can therefore be assured that a product from

**MAHLE®**  
ORIGINAL

**PC**  
PERFECT  
CIRCLE®

**KNECHT**  
FILTER®

**CLEVITE®**



*All MAHLE production locations are certified by renowned vehicle manufacturers—and by all relevant certification authorities.*

the MAHLE Group is a product that can always be relied on—guaranteed. We supply the aftermarket with a comprehensive range of products under the brand names MAHLE Original, Perfect Circle, Knecht, and Clevite, the engine components brand for U.S. commercial vehicle applications.

## Best references—worldwide

A brief look at our original equipment customer list underlines the fact that more than 140 renowned engine and vehicle manufacturers decide in favour of engine components and filters from MAHLE. Here a small selection:

Alfa Romeo, Audi, BMW, Case, Caterpillar, Chevrolet, Citroën, CNHTC, Cummins, Dacia, DAF, Daihatsu, Detroit Diesel, Deutz, Dongfeng, Ducati, Ferrari, Fiat, Ford, Freightliner, General Motors, Harley Davidson, Honda, Hyundai, Isuzu, Iveco, Jaguar, John Deere, Kia, Komatsu, Lancia, Land Rover, Mack Trucks, Magna Steyr, MAN, Maserati, Mazda, Mercedes-Benz, Mitsubishi, MWM International, Navistar International, New Holland, Nissan, Opel, Paccar, Perkins, Peugeot, Porsche, Renault, Renault Trucks, Saab, Scania, Seat, Škoda, Smart, Steyr, Stihl, Subaru, Suzuki, Toyota, Vauxhall, Volkswagen, Volvo, Yamaha.



**OUR COMPETITION DOESN'T WANT TO  
BURN THEIR FINGERS  
IN THE  
FORMULA 1.**



# Pistons

Our pistons have to withstand extreme pressures, as their working conditions have become significantly tougher in recent years. For example, the thermal loads (with temperatures in the combustion chamber reaching 2,600°C) and the average ignition pressures have greatly increased. Also the inertial force loads have increased due to high-speed concepts and a tendency to larger piston strokes. Naturally, the demands on our pistons have risen progressively at the same time: they should be lighter, consume less oil, and be absolutely safe—even under extreme conditions such as hot and cold load capacity testing and thermo-shock endurance testing.

The effects of these demands: the overall height or compression height of the pistons has decreased continuously. New solutions such as the ECOFORM® piston concept developed by MAHLE allow further weight reductions. And with MONOTHERM pistons, which are single-piece steel pistons that are machined accordingly, it is possible in the meantime to achieve the same weight as with pistons made from aluminium. However, significant improvements have also been made with aluminium pistons such as the MAHLE pistons with cooled ring carriers.



*The only series manufacturer of pistons in the Formula 1: MAHLE.*

We also benefit greatly in this field from our successes in motorsport—after all, we are the only series manufacturer who is gaining its experience from Formula 1. As the world's largest manufacturer of pistons, MAHLE is operating an intensive research programme for future products, and already today offers solutions for almost every engine—fast, reliable, and around the globe. With our pistons, we offer aftermarket customers the opportunity to benefit from products of the original equipment sector and from the inherent safety of products that have been tried and tested in practice under the most gruelling conditions. A promise you can count on.



*On the piston crown, you will find the company or trade mark, the maximum piston diameter, the mounting clearance, and the fitting direction according to the respective specifications of the engine manufacturer.*



## The optimum piston for every engine.

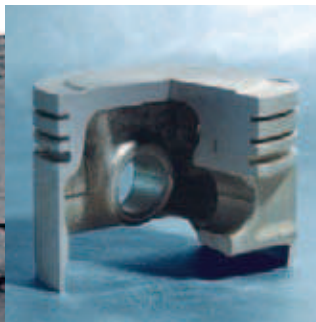
### **ECOFORM® pistons with pivoted side cores**

Weight-optimised pistons for passenger car petrol engines. These pistons offer low weight with high structural rigidity thanks to a special casting technology.



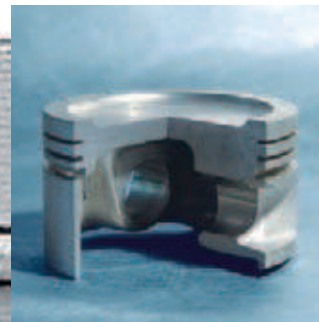
### **AUTOTHERMATIK®/HYDROTHERMATIK® pistons**

These pistons are used predominantly in passenger car petrol and diesel engines subjected to heavy loads. They feature cast-in steel strips, but are not slotted. This gives the piston a uniform body with greater strength.



### **AUTOTHERMIK®/HYDROTHERMIK® pistons**

These smooth-running pistons are mainly used in passenger car engines. They feature cast-in steel strips and are slotted at the transition from the ring belt to the skirt area.



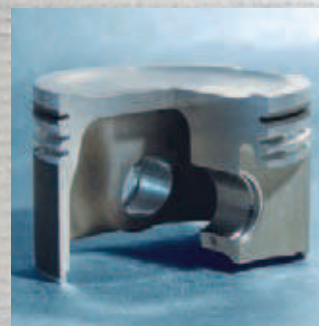
### **Cast solid-skirt pistons**

Piston crown, ring belt, and skirt form a robust unit. Such pistons have a long service life and are used in petrol and diesel engines. Their applications range from model engines to large engines.



### **Forged solid-skirt pistons**

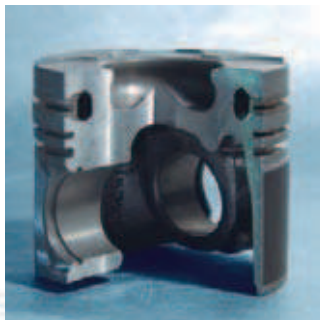
These pistons are predominantly fitted in series production engines subjected to heavy loads, as well as in motorsport engines. The manufacturing process gives these pistons increased strength and allows for smaller wall cross sections and a reduction in piston weight.





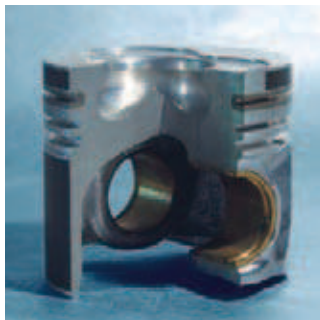
#### **Pistons with cooled ring carrier**

With these pistons, the ring carrier and cooling gallery are combined to form one system in a special manufacturing process. This provides the pistons with significantly improved heat transfer properties at the first ring groove.



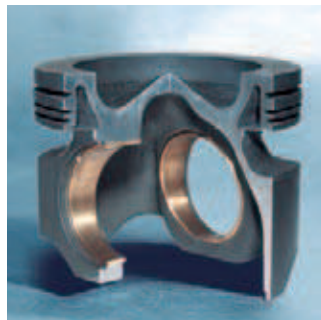
#### **Ring carrier pistons with pin bore bushings**

These pistons for diesel engines feature ring carriers made of special cast iron that are cast into the piston. This increases wear resistance, particularly in the first groove. Pin bore bushings made from a special material increase the pin bore's load capacity.



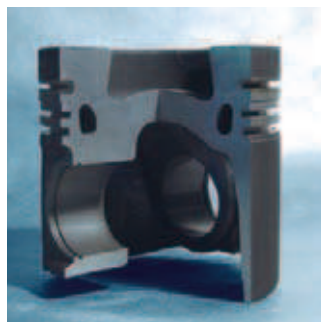
#### **MONOTHERM pistons**

This single-piece, forged steel piston has an extremely high structural rigidity and was developed for modern combustion chambers with pressures of more than 250 bar. The version with connected skirt in combination with a short piston pin makes its weight comparable to that of an aluminium piston.



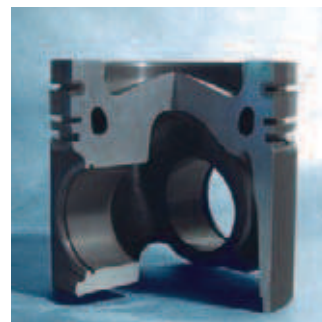
#### **Ring carrier pistons with cooling gallery and crown reinforcement**

These pistons are used in diesel engines subjected to heavy loads. For added protection and in order to prevent cracks on the bowl rim and the crown, these pistons feature a special hard-anodised layer (HA layer) on the piston crown.



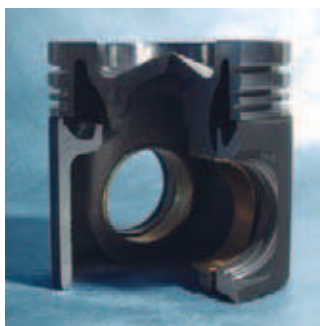
#### **Ring carrier pistons with cooling gallery**

Ring carrier pistons with cooling gallery are used where particularly high operating temperatures arise. To reduce the high temperatures in the piston crown and ring belt, intensive cooling is achieved by circulating oil in the cooling gallery.



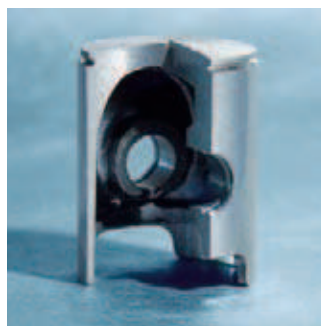
#### **FERROTHERM® pistons**

These pistons comprise a steel piston crown and an aluminium piston skirt that are connected with the piston pin. Due to increased strength and a low wear rate, these pistons make it possible for diesel engines subjected to particularly high loads to comply with low exhaust and emissions limits.

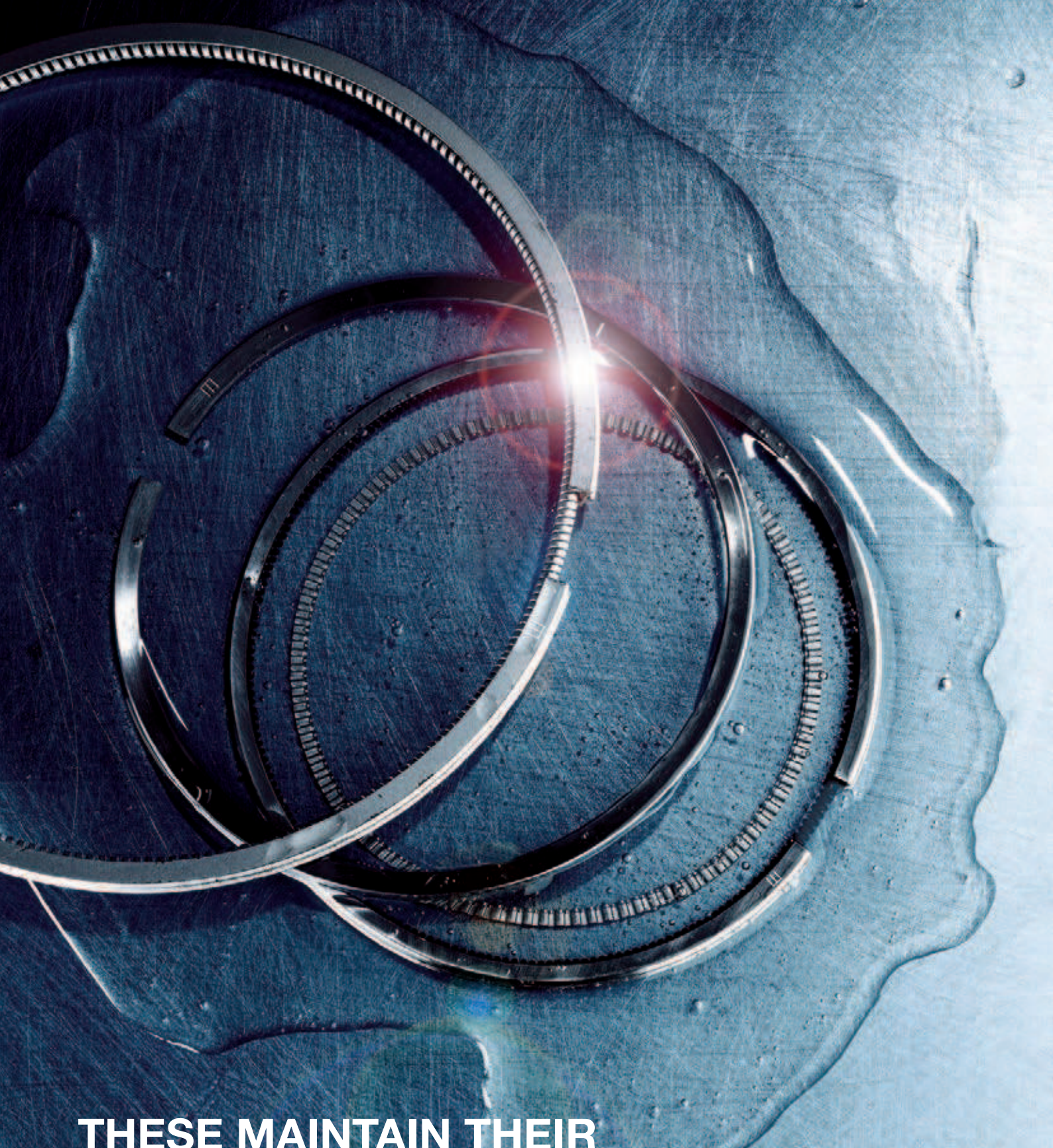


#### **Two-stroke pistons**

Pistons made from special aluminium alloys. These are resistant to the high mechanical and thermal loads of two-stroke engines.







THESE MAINTAIN THEIR

**SEAL**

—THIS YOU CAN COUNT ON.



# Piston ring sets

In modern engines and for high continuous performance, our piston rings take reliable and precise care of the welfare of their carriers. As the leading manufacturer of pistons, we consistently work to optimise the performance and running properties of our piston rings. And we set quality standards also in this field with state-of-the-art production facilities. With decades of experience in development and production, we can assure optimum interplay between our pistons and piston rings, and can meet the highest demands.

Piston rings have three important functions in modern engines:

- They seal the combustion chamber from the crankcase.
- They limit and regulate oil consumption.
- They dissipate the heat that is taken up by the pistons during combustion to the cooled cylinder working surfaces.

In order to satisfy these requirements, the piston rings must fit tightly to the cylinder wall over their entire circumference, even if the cylinder deviates slightly from its ideal form. Due to the high inertial forces and combustion pressures, as well as the high wear-producing loads, the piston rings have to satisfy high demands with respect to piston ring material (strength/temperature stability) as well as surface finish and shape.

## The ideal ring set for every piston

We offer different versions of piston ring sets in original equipment quality, or especially for engines that have already been running with the aim to reduce compression losses and to regulate oil consumption. We can supply piston ring sets for almost every petrol and diesel engine for passenger cars as well as for commercial vehicles, at diameters from 60 to 160 mm.

## Materials

Only high-grade materials are used for our piston rings. For normal or heavy loads, lamellar graphite cast iron materials are used, and for the highest demands, nodular graphite cast iron materials or steel materials are employed.

## Ring face coatings

Special coatings can be applied to the ring face of piston rings to increase resistance to wear and scuffing. For instance, chromium coatings or plasma spray coatings of metallic or ceramic materials are used for this purpose.



The MAHLE "N" piston ring set offers you the piston rings that are also used as original equipment. The MAHLE "V" piston ring sets have been developed especially for engines that have been running for some time.



It is essential that the TOP markings are observed. Rings with TOP markings have to be fitted with these markings facing upwards towards the piston crown.







**WE ARE  
STRICT WITH OUR  
TOLERANCES.**



# Cylinder liners

The steadily rising demands on internal combustion engines require continuous improvements also in the area of cylinder working surfaces. The precise matching of the honed cylinder liners with the pistons and piston rings leads to improved results in the engine. It is therefore necessary for cylinder liners made from cast iron to have optimum surfaces that contribute to lower oil consumption and low blow-by, reduce wear, and allow shorter running-in times and therefore enable a longer service life.

MAHLE produces cylinder liners for international engine manufacturers, both for series production and the aftermarket—always according to the same strict quality standards. We manufacture our cylinder liners with very strict tolerances, thereby ensuring, among other things, that the cylinder liners can be optimally fitted into the engine block. Additional important quality characteristics of our cylinder liners are the materials, structure, and surface quality. In close co-operation with engine manufacturers, we determine the composition of the melt, the treatment of the melt, and the machining process.

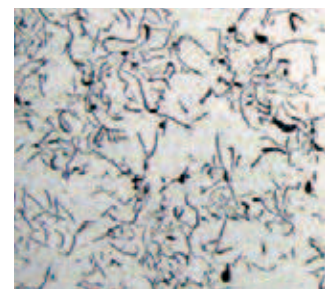
## Materials

In addition to aluminium, cast iron alloy is used as a material for cylinder liners.

Lamellar graphite cast iron is alloyed with phosphorus. Additional alloy materials improve the wear properties and can strengthen the matrix due to bainite and very fine perlite formations.

## Honing methods

Good honing has a positive effect on piston ring wear, particle emissions, oil consumption, and friction. With further developments and innovations in the honing of cylinder liners, it is attempted to keep the running-in phase of the cylinder (engine) as short as possible and to achieve improved tribological properties. An important prerequisite for good and regular honing of the cylinder liners is high material quality. This entails, cast materials free of voids, with homogeneous structure, and uniform hardness, as well as suitable pre-machining of the bore.



Lamellar graphite.

## Honing

Method of machining, in which the tool carries out reciprocating and rotating movements. With this method, a cylinder form error below 10 µm and an even surface roughness can be achieved.

## Tribology

The science of friction, lubrication, and wear of bodies in relative motion.

## The most important honing methods in single processing steps

Description	Honing process					Application
	Version	1 <sup>st</sup> operation	2 <sup>nd</sup> operation	3 <sup>rd</sup> operation	4 <sup>th</sup> operation	
Normal honing	1	Diamond	Diamond			Series petrol pass. car Series diesel pass. car Series commercial vehicle
	2	Diamond	Ceramic			
	3	Ceramic	Ceramic			
Plateau honing	1	Diamond	Diamond	Diamond		Series petrol pass. car Series diesel pass. car Series commercial vehicle
	2	Diamond	Diamond	Diamond		
	3	Diamond	Ceramic	Ceramic		
Brush honing	1	Diamond	Diamond	Brushing		Series passenger car/ commercial vehicle
	2	Diamond	Ceramic	Brushing		
Liquid honing		Diamond	Diamond	Liquid honing	Microfinishing	Series diesel pass. car
Laser honing	1	Diamond	Laser structure	Ceramic	Ceramic	Experimental/ motorsport
	2	Diamond	Diamond/ceramic	Laser structure		





**OUR**  
**BEARING LAYERS**  
**ARE EXTREMELY**  
**ROBUST.**



# Bearings

Bearings form the basis for a largely wear-free and low-friction partnership between the engine casing or connecting rod and the rotating shafts such as the crankshaft, camshaft, rocker arm shaft, and balancer shaft. The mechanical stress in internal combustion engines is extremely high. Our bearings thus have to meet a number of quality characteristics: they have to be fatigue-resistant, adaptable, highly loadable, and wear- and corrosion-resistant.

In co-operation with engine manufacturers, we develop and test the bearings for every single engine type. Ongoing fundamental research and further development of materials and production technologies ensure economically and technically optimised products of the highest quality.

Our product range encompasses bearing shells, flanged bearings, bushings, and thrust washers with diameters from 27 to 140 mm, as well as bushes with diameters from 6 to 105 mm.

## Types



### Solid bearings

Solid bearings are made completely from a special bearing metal that consists of special alloys.



### Two-component bearings

Two-component bearings are used for low to medium loads in petrol and naturally aspirated diesel engines in passenger cars. They consist of a steel backing, an intermediate layer, and a layer of bearing metal. Mainly aluminium alloys are used as bearing metal.



### Three-component bearings

Three-component bearings are predominantly used in high-performance engines. They consist of the steel support shell, a bearing layer, a barrier layer, and the overlay. The performance of these bearings is enhanced by sputtering. Sputter bearings are special three-component bearings with significantly increased hardness, load capacity, and wear resistance thanks to a special production process (sputtering). These properties make sputter bearings ideal for supercharged engines with intercooling, and can now also be found increasingly in passenger car diesel engines.

## Materials and production methods

Material development is extremely important in order for bearings to meet the high demands. Thanks to years of experience and development work, MAHLE has at its disposal a large number of bearing alloys such as aluminium and bronze alloys. Depending on the application, our bearings consist of a high-strength steel backing that is coated with different bearing metals. With regard to their applications, the bearing materials are chosen such that their properties compliment one another optimally.

During the production process, we use different coating methods depending on the relative bearing loads, for instance.



We offer you a comprehensive range of bearings, available under the brands MAHLE Original and—in Europe—Perfect Circle.

## Sputtering

Coating method that works on the principle of cathode sputtering, in which atoms are knocked out from a metal cathode due to the impacting ions from a gas discharge process. The resulting atomised metal condenses on the running surface of the bearing as a uniform layer.







SMALL CAUSE,  
**BIG EFFECT.**



# Valve train components

Not many components in engines are under as much load and tribological stress as valves and their attached parts. At temperatures of up to 800°C, the red-hot exhaust valves strike the valve seats more than 70 times per second and must withstand the hot and corrosive exhaust gases that surround them. At every valve lift, enormous acceleration and retractive forces occur due to the strong valve springs.

Valves form a closed system together with valve seat inserts and valve guides, which has to withstand highest loads and stresses. We thus have not only valves in our product range, but also their tribological partners, valve seat inserts and valve guides. The combined development of these products in one system allows us to attain advantages with respect to wear characteristics and cost of the components.

## Any kind of valve

MAHLE manufactures valves for internal combustion engines at several production locations worldwide. Our product range includes valves of diverse designs and types for passenger cars and commercial vehicles with stem diameters from 5 to 12 mm and valve lengths from 80 to 210 mm. Thanks to the extensive technical expertise, high productivity, and the outstanding quality of these products, MAHLE is now one of the world's most important valve manufacturers.

We employ state-of-the-art production technologies as part of our large-volume production to secure our quality standards. For example, we use plasma powder methods in raw part production, or high-speed grinding methods for mechanical finishing. In order to make valves resistant to high loads, our valves feature hard-faced seats, are hardened, chrome-plated, or nitrided according to the respective requirements. A wide range of materials is available for every application. For special applications with extreme demands, sodium-filled valves are also available to reduce thermal loads.

## Valve guides and valve seat inserts

The valve guides centre the valves on the valve seats and compensate for the lateral forces acting on the valve shafts. In addition, they need to dissipate the generated heat towards the cylinder head. Depending on the engine design, identical or different valve guides are used for the intake and exhaust side. The range of materials reaches from grey cast iron and brass to sintered materials of various alloys.

The valve seat insert together with the valve seals the combustion chamber from pressure loss. In addition, it is responsible for heat transfer and prevents the valves from impacting into the softer cylinder head material. Valve seat inserts are predominantly made from chromium-steel alloys. Sinter materials are now being used to an increased extent.

## Tribology

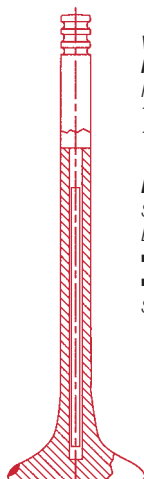
*The science of friction, lubrication, and wear of bodies in relative motion.*



**Materials**  
Austenitic steels  
Martensitic steels

**Types**  
Mono-metal valves  
Bi-metal valves

**Valve seat**  
Plasma powder facing  
Induction hardening

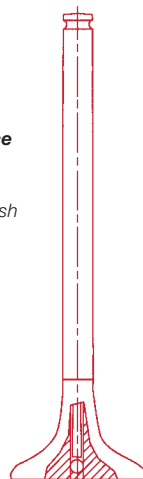


**Valve tip induction hardening**  
Profile hardening  
Through hardening  
Tip surface hardening

**Hollow valves**  
Stem size: >6 mm  
Bore sealing:  
■ Laser welding  
■ Friction welding  
Sodium filling

**Fillet profile**  
Turned, ground  
Contour-forged

**Head top surface**  
Machined  
Forged  
With or without dish



**Valve tip geometry**  
1–3 grooves  
Special designs

**Valve length**  
80–210 mm

**Valve head diameter**  
18–65 mm

**Valve stem diameter**  
5–12 mm

**Surface treatment**  
Salt bath-nitrided  
Hard chrome-plated  
(coating thickness: 3–35 µm)

*The greatest challenge is to determine the design of the valves. Our valves are designed for a wide variety of operating conditions in order to withstand the extreme mechanical, chemical, and thermal loads, and to assure optimum heat dissipation.*

**WE  
TURBOCHARGE.**





# Exhaust gas turbochargers

Exhaust gas turbochargers represent a key technology to enhance performance, reduce fuel consumption, and lower exhaust emissions, which is why MAHLE is a long-standing business partner to international automotive and engine manufacturers in the development and production of high-performance turbocharger components. Our far-reaching competence in engine components opens up specific potentials to increase efficiency, because this essentially depends on how well the components involved—such as the turbocharger, fuel injection technology, variable valve train, exhaust gas recirculation, and intercooling—are harmonised.

## MAHLE OE technologies for the aftermarket

Nearly every diesel engine rolling off the production line in Europe, North America, and Japan features turbocharging technology. Turbochargers are also being increasingly fitted in passenger car petrol engines to increase efficiency. This market segment is posting enormous growth rates even in the automotive spare parts field as a consequence. We have therefore made the innovative MAHLE Original turbocharger technologies available to trade and repair shops. The focus for turbochargers was initially on commercial vehicles: by 2013, approximately 70 per cent of all fast-moving applications will be covered; the product range is being constantly expanded. Since the start of 2012, the first MAHLE Original passenger car turbochargers have been available. In the passenger car segment, the MAHLE Original turbocharger product portfolio is being expanded successively, among others, for Volkswagen, Renault, BMW, and Mercedes-Benz. It is scheduled that around 95 per cent of all passenger car fast movers will be included by 2014. Moreover, a corresponding mounting kit is available or is being prepared for every turbocharger.

MAHLE Original turbochargers are state of the art and manufactured in line with standards applicable across the Group, using the latest processes in ultra-modern facilities:

- High-speed compressor wheels provide greater balancing precision, optimised stability, and reduced running noise.

- Double piston rings on the rotor shaft reduce oil consumption and enhance protection against foreign particles.
- Turbine housings made of high-tech materials achieve greater thermal stability and longevity.
- Functionally process-controlled centre housings attain progressive balancing of the rotor shaft, enhanced running performance, reduced abrasion, and less noise emission.
- Electron-welded rotor shaft and wheels guarantee high strength.

## Cutting-edge quality through integrated development and manufacturing processes

The highest development and manufacturing skills are needed to ensure high efficiencies over a broad engine map area at speeds of far more than 300,000 rpm and exhaust gas temperatures in excess of 1,000°C. MAHLE thus employs the latest simulation tools in the initial phase of its integrated development processes, for example, to ensure the required thermo-dynamic and thermo-mechanical component properties.

Computer-controlled production equipment guarantees the utmost of precision when machining casing components, as well as the no-compromise casting quality and balancing accuracy of the turbines. This ensures that you can rely on the long-lasting, consistent performance of MAHLE Original turbochargers even under extreme conditions—to satisfy the high quality standards we place on all of our products.



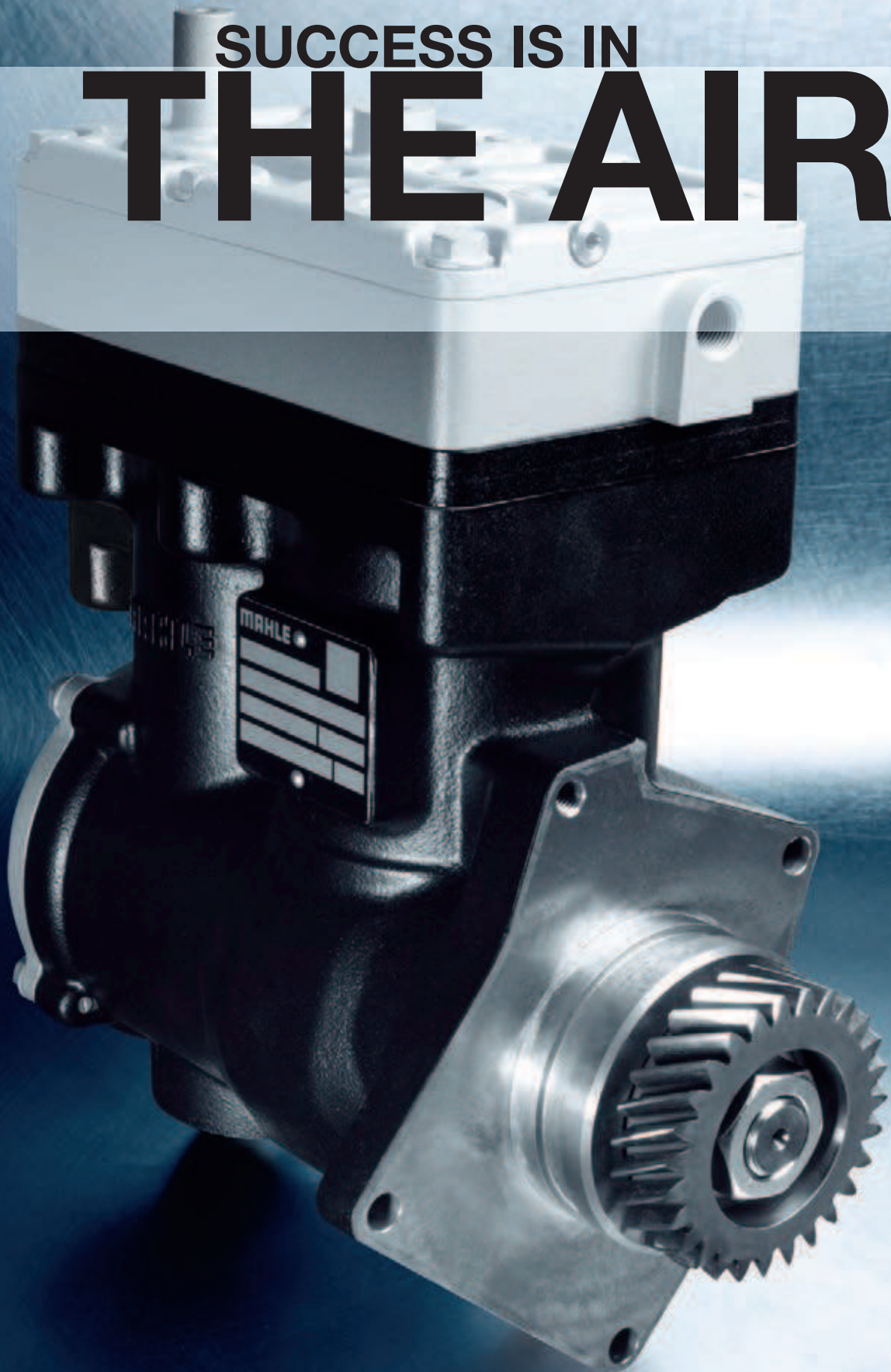
MAHLE Original exhaust gas turbocharger.



MAHLE Original turbocharger add-on kit.



SUCCESS IS IN  
**THE AIR.**





# Air compressors

Air compressors form the core of the pneumatic system in a vehicle. They enable the function of numerous safety and comfort systems in commercial vehicles. Examples include the brake system, the air suspension, the pneumatic gearshift system, the air-sprung seat, the pneumatic opening and closing of the doors as well as the kneeling feature in a city bus, and the raising and lowering of loading ramps.

Apart from conventional single-stage air compressors, which only have one pressure chamber, an increasing number of two-stage air compressors—just like the ones in the MAHLE product range—are being installed.

## The multi-stage air compressor

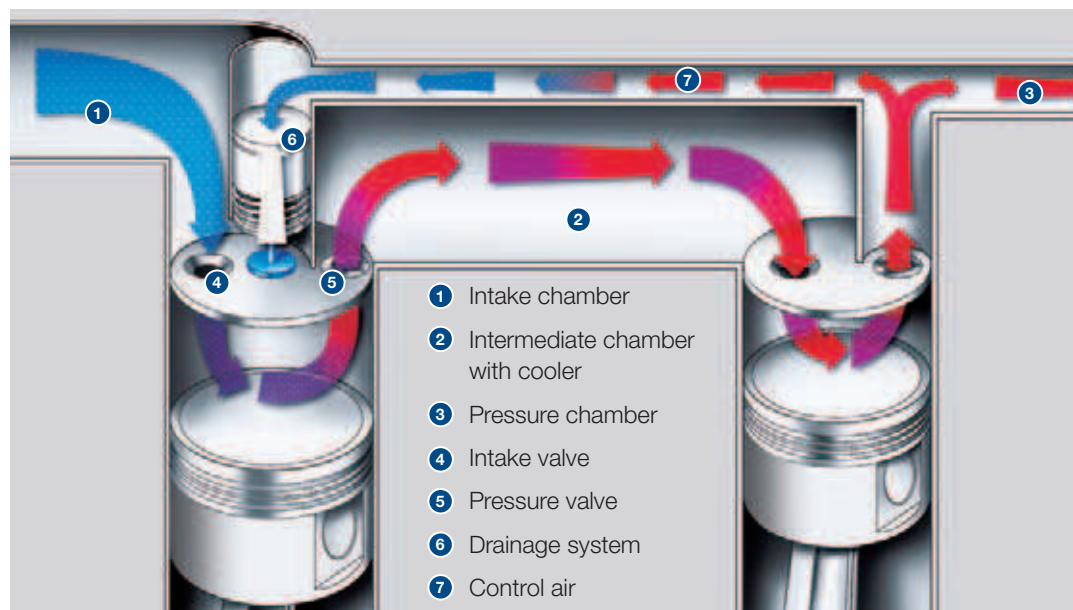
Air compressors from MAHLE have three chambers: intake chamber, intermediate chamber, and pressure chamber. This design enables the air to

be cooled as it passes through the first to the second compressor stage (intercooling). The availability of air is increased as is the energy efficiency, as a consequence thereof, because two-stage air compressors achieve reduced consumption even during delivery operation. For non-delivery operation, the newly developed drainage system significantly reduces fuel consumption. During intercooling, the temperature of the compressed air is lowered, which provides for an extension of switch-on time by up to 80 per cent and thus raises the delivery rate per hour for an equivalent displacement. This enables a downsizing compared with conventional single-stage air compressors—while significantly reducing fuel consumption. Additional benefits: improved air quality, from which the vehicle's complete air system benefits, combustion-enhanced operation, and a reduced load for the engine oil, whereby oil cracking and the formation of harmful by-products are prevented.

## MAHLE Original air compressors—advantages at a glance

- Increased energy efficiency
- Significant reduction in fuel consumption
- Energy recovery during braking and overrunning
- Extended switch-on time (up to 80 per cent)
- Improved air quality and combustion-optimised operation, thus increasing maintenance intervals and service life
- No harmful by-products arising from engine oil cracking
- Increased pressure level possible—operation up to at least 15 bar
- External control of the drainage system is unnecessary
- Available in grey cast iron or cast aluminium, tailored exactly to the vehicle application
- Replacing a single-stage 1-cylinder or 2-cylinder air compressor with a multi-stage MAHLE Original compressor: a fast return on investment despite the somewhat increased purchase price thanks to reduced fuel consumption and increased service life

## Multi-stage air compressor with intercooling



During the first stage, the intake air is compressed to approximately 5.0 bar and then cooled in an intermediate chamber. The air is then compressed in the second stage to final pressure or cut-out pressure of the vehicle system (in this example: 12.5 bar).





FOR THESE MANAGERS,  
**DEGREE CELSIUS**  
IS THE MEASURE  
OF ALL THINGS.



# Thermostats

To operate efficiently while minimising wear and emissions, a combustion engine requires the temperature to remain as constant as possible within a specified range. Thermostats are used exactly for that purpose, as they regulate the engine temperature with coolant. They are equipped with a wax core. As the coolant temperature increases, the wax starts to liquefy and expand. This activates a dowel pin, which in turn controls a valve that opens the flow of coolant. When the engine temperature drops, as does the coolant temperature, the wax solidifies and interrupts the coolant circuit.

## Map-controlled thermostats

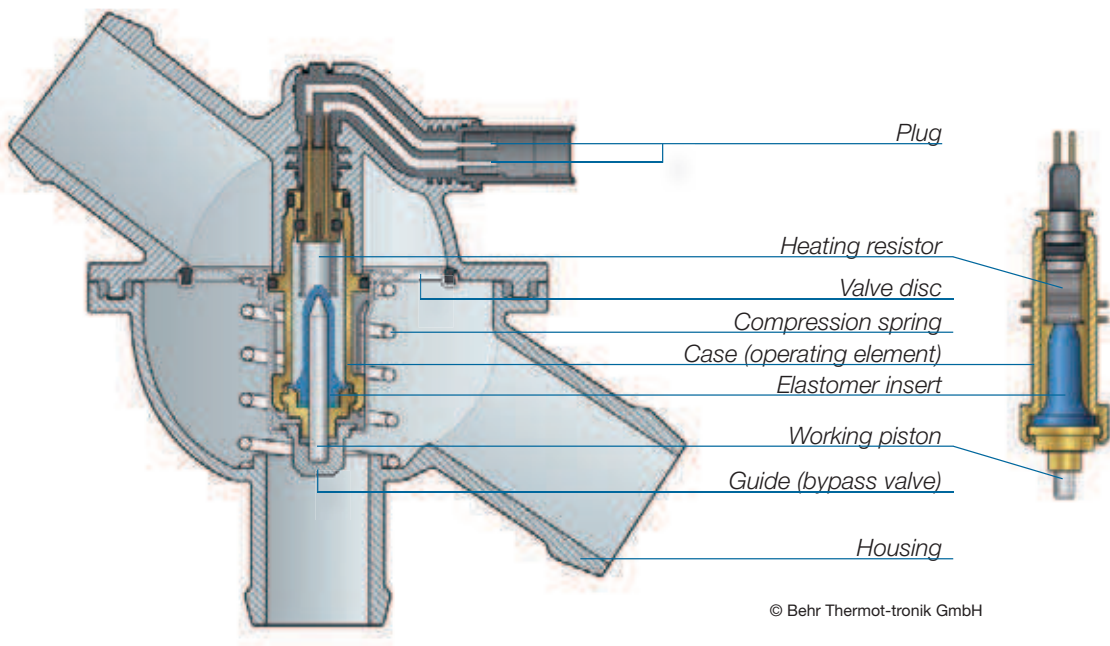
Engine efficiency can be further enhanced with the use of map-controlled thermostats: an electrical heating resistor is additionally integrated in

the operating element's expansion material. Consequently, these thermostats can be electrically activated, and thereby have a considerably faster effect on the engine temperature to keep the engine within the optimum range in various load and operating conditions. The result: improved engine output, a longer service life, as well as reduced consumption and emissions. An operating map stored in the engine control unit defines when and how heat is added.

MAHLE Aftermarket offers a variety of different thermostats and other components for regulating temperature: from expansion elements, thermostat inserts, thermal switches, and thermocouples to integrated, housing, and sleeve valve thermostats, transmission oil, and EGR thermostats all the way to map-controlled thermostats.

## No wear—yet important revenue mainstays

Thermostats are not standard wearing parts. There is, however, considerable demand for spares. When carrying out any work that requires access to the cooling system (whether due to an accident or as part of repair or maintenance work), the temperature managers should always be replaced at the same time. Because any loss of functionality or even complete failure can have severe consequences. If the thermostat is always open, the engine will be cooled too much. If the thermostat is always closed, then the engine will not be cooled at all and will overheat.



Cross section of a map-controlled thermostat with electrical connections and heating resistor integrated in the wax element.



WE HAVE THE ANTIDOTE FOR

**HOT AIR.**





# Intercoolers

During turbocharging in combustion engines, the intake air is highly compressed by the turbocharger and thus reaches temperatures of up to 200°C. The compressed air is therefore cooled before it is channelled into the combustion chamber. As a consequence, the density of the charge air increases even further—more oxygen is thus made available for combustion. This enables an increase in performance along the whole speed range and a reduction of fuel consumption and emissions—and therefore compliance with current and future emission standards, such as Euro 6 (applies to commercial vehicles from 2013 and to passenger cars from 2014). At the same time, intercooling contributes to relieving the thermal load of the engine and its components as well as to a more homogenous engine operating temperature.

Two different systems can be used for this purpose:

- Direct intercooling: the charge air is fed to the front end of the vehicle after exiting the compressor, flows through the intercooler that is cooled by the surrounding air (air flow), and is then channelled back to the engine's intake section.
- Indirect intercooling: the charge air is cooled by a cooling agent that in turn is cooled by surrounding air via a separate low-temperature coolant circuit.

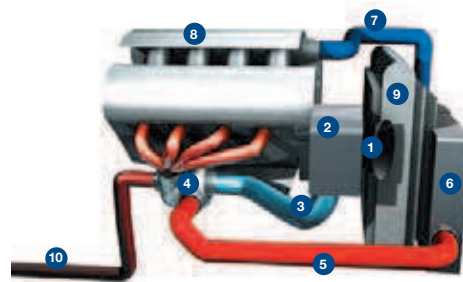
Important: The intercooler cannot be cleaned. In order to increase its efficiency, it often contains so-called turbulence inserts—winding nooks and crannies that make the mechanical removal of contamination impossible. The use of liquid cleaning agents is not recommended since these can damage the materials. Consequently, it is necessary to replace the intercooler not only after it has been damaged mechanically through external impact, but also in the case of turbocharger damage, for example, as oil and metal particles may accumulate in the intercooler. The contamination might not only lead to decreased engine output, but also to serious consequential damages. When oil and metal particles exit the

intercooler towards the combustion chamber, there is a risk of catastrophic engine failure.

## The air system: many components, one specialist

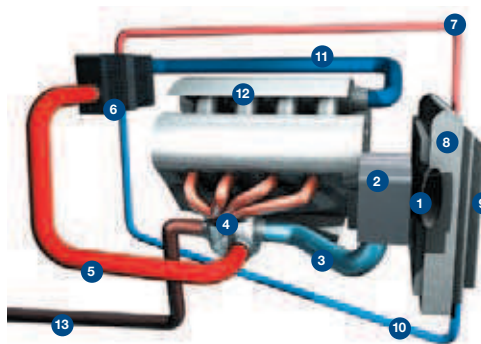
From 2013, our product range will be expanded to include intercoolers for a variety of passenger car and commercial vehicle applications. As a result, our customers will be able to source components for the complete air system from MAHLE Aftermarket: from turbochargers and turbocharger mounting kits to air filters all the way to intercoolers—all in original equipment quality, of course.

### Direct intercooling



- 1 Air supply intake manifold
- 2 Air filter housing with air mass flow meter
- 3 Low-pressure line
- 4 Turbocharger
- 5 Hot charge air line
- 6 Intercooler
- 7 Cooled air supply
- 8 Intake pipe/air distributor
- 9 Engine coolant cooler
- 10 Exhaust system (exhaust pipe)

### Indirect intercooling



- 1 Air supply intake manifold
- 2 Air filter housing with air mass flow meter
- 3 Low-pressure line
- 4 Turbocharger
- 5 Hot charge air line
- 6 Intercooler, indirect
- 7 Low-temperature coolant circuit from the intercooler
- 8 Engine coolant cooler
- 9 Low-temperature coolant cooler
- 10 Low-temperature coolant circuit to the intercooler
- 11 Cooled air supply
- 12 Intake pipe/air distributor
- 13 Exhaust system (exhaust pipe)



The image features three different types of air filters arranged on a dark blue, textured surface. At the top is a black rectangular pleated filter with three rows of white pleats. Below it to the left is an orange rectangular panel filter with a grid of circular holes. To the right and slightly in front of the panel filter is another orange rectangular pleated filter. The text is overlaid on the bottom half of the image, partially covering the filters.

**A GOOD SET OF  
LUNGS:  
VITAL FOR THE SPRINT  
AND THE LONG HAUL.**



## Air filters

Clean air intake is one of the most important conditions for optimal engine power, high torque, low fuel consumption, and minimised pollutant emissions. With MAHLE air filters up to 99.9 per cent of dust, soot, and tire wear particles are filtered out. At the same time, an optimal air/fuel mixture is assured. The high particle uptake capacity ensures long service life even under extreme conditions such as heat, cold, or chemical influences. Our quality filters prevent premature wear of the valves, cylinder working surfaces, piston rings, bearings, and other engine components. To ensure perfect and lasting filter performance, all filters must be replaced within the replacement intervals stipulated by the vehicle manufacturers.

In the passenger car sector, round and panel elements are fitted in air filter housings mounted to

the engine or chassis and are stabilised with glue beads at the dirty side and support grits at the clean side, depending on the specifications of the vehicle manufacturer. For dust-rich areas, an additional pre-cleaner in the form of a foam mat is placed at the dirty side. For higher surface loads, metal or plastic support studs are used.

In commercial vehicles, robust and at the same time weight-optimised air filter systems made from recyclable plastic are used that also serve to reduce air intake noise. In order to achieve a large filter surface at high stability, they are mostly designed in a cylindrical shape. To improve efficiency, radial sealing and axial supports are employed. Additional safety inserts in the form of special fleece cylinders protect the clean side of the filter element during maintenance and replacements.

### **Our air filters are completely sealed**

*Uncleaned air in the intake passage can contaminate the air flow mass meter and distort the measuring results, cause malfunctions of the fuel injection, and contribute to wear of engine components. To prevent bypass air, our filter cartridges are fitted in exactly and the seals are selected carefully.*

*PUR seals made from specially developed PU foam ensure continuous sealing between dirty and clean side. These seals are resistant to aging, chemical effects, and are temperature-stable. Their flexibility is designed to fit exactly to the geometry of the sealing area.*







RUNNING LIKE A  
**WELL-OILED**  
MACHINE.



## Oil filters

The engine oil reduces friction and wear of the engine, cools the engine components, protects the inside of the engine from corrosion, and seals the combustion chamber with a thin oil film between piston, piston ring, and the working surface of the cylinder, as well as in further crucial areas of the engine. The oil is thus constantly subjected to stress: combustion residues, dust, carbon, soot, abrasion particles, and condensates can contaminate the oil and promote premature wear of engine components.

MAHLE oil filters reliably prevent dirt particles from entering the lubricant circuit and maintain oil quality as well as the performance and efficiency of the engine. Thanks to stable pleat geometry, cold-start stability is assured. Load peaks of up to 20 bar are compensated through the high pressure resistance of the housing. A pressure relief valve guarantees the oil supply under all conditions—for viscous oil as it is encountered during

cold start or at low temperatures, and also for strongly contaminated filter elements when the replacement intervals have been exceeded. An anti-drain valve prevents the draining of the filter when the engine is switched off and secures fast oil supply when the engine is started. High-grade sealing materials and custom-fit connecting pieces guarantee the reliable separation between contaminated and filtered oil.

An important condition for the correct functioning of the oil filters, however, is that filters are replaced within the maintenance intervals stipulated by the vehicle manufacturer.

### Oil filter cartridges

With filter cartridges from the OX and OX-Eco range, we offer particularly economical solutions for repair shops: instead of replacing the complete filter, only the dirty filter element has to be exchanged. An ecologically sensible solution that saves material and disposal costs. In the OX-Eco version, the cartridges are metal-free and can therefore be fully incinerated. Oil filter cartridges are available for all oil filters with housings that can be split.



Oil filter cartridges: the ecologically sensible and economical solution.

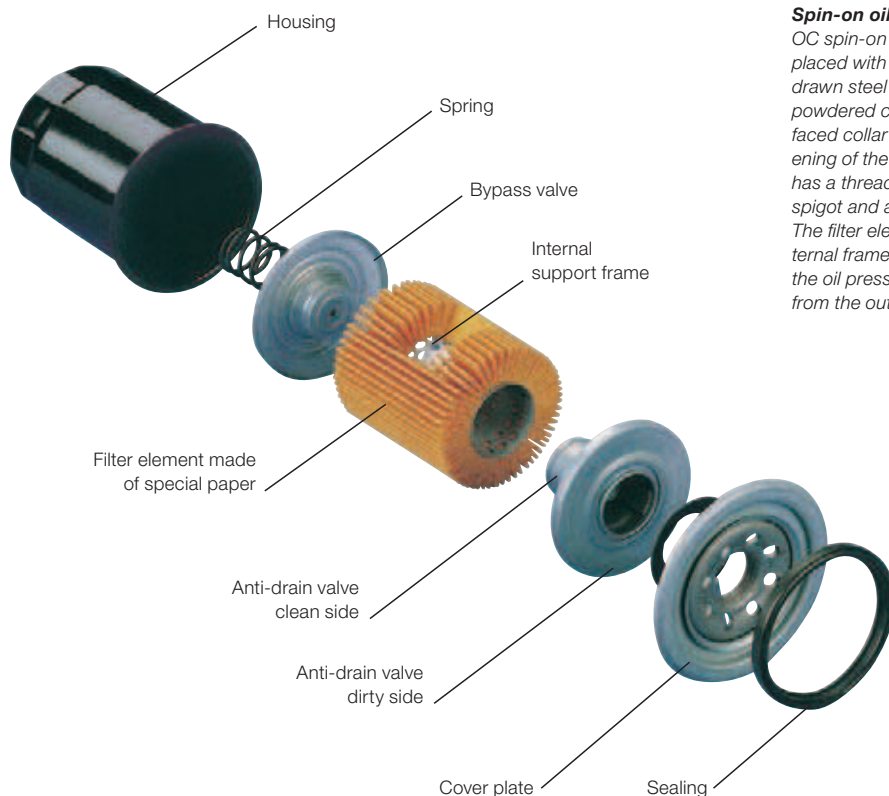
### More efficient replacement

#### Spin-on oil filters

OC spin-on oil filters can be replaced with ease. The deep-drawn steel sheet housing with powdered coating has a multi-faced collar to facilitate fast loosening of the filter. The cover plate has a thread for the screw-on spigot and a groove for the seal. The filter element features an internal frame as support against the oil pressure that is directed from the outside to the inside.



The new MAHLE oil filter module for commercial vehicles is highly versatile in terms of integration on both the oil and coolant side. Thanks to the high level of integration, the number of interfaces and sealing points has been reduced. Both weight and costs have been lowered by employing high-performance plastics.





WE TAKE CARE OF  
**ANY DIRT**  
LEFT OVER.



## Fuel filters

Modern fuel injection concepts require extremely clean, homogeneous, and pulsation-free fuel supply. However, foreign particles can get into the fuel during the production and transport process and must be filtered out. MAHLE fuel filters hold back foreign particles reliably. Thanks to high-quality filter media, the fuel system is protected from smallest dirt particles, and therefore from corrosion damage. This safeguards the engine function and assures the efficient operation of the vehicle. The required constant fuel supply is achieved with pressure regulation and recirculation of the surplus fuel from the injection pump to the tank. Pulsation damping compensates for the pressure fluctuations caused by the fuel pump. Our fuel filters comply with the correspondingly high safety standards of the vehicle manufacturers and ensure sealing tightness even in the event of accidents.

An important condition for the correct functioning of the fuel filter is that filters are replaced within the maintenance intervals stipulated by the vehicle manufacturer.

### Diesel fuel filters

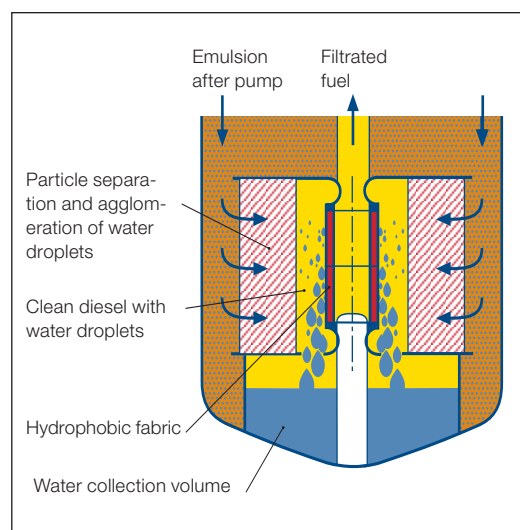
In order to prevent paraffin separation and clogging of the filter at low ambient temperatures, our fuel filters rely on pre-warming with electric heating elements or recirculation of fuel that has been warmed by the engine.

For newer generations with even higher requirements, MAHLE has opted for two separate process stages during water separation.

The first filter phase consists of a cellulose filter medium with an untreated melt-blown contact surface for increasing the dirt absorption capacity. This melt-blown contact surface optimally

causes the many small droplets to coalesce into larger ones. The particle filter designed in the form of a pleat star agglomerates even the finest water droplets.

The second filter phase comprises a water separator, whose hydrophobic fabric divides the now barely stable emulsion, thus separating the water. As this occurs on the clean side of the filter, it is referred to as a clean-side water separation.



Schematic diagram of a two-stage filter element with integrated water separator.

### Inline fuel filters

Inline fuel filters are mounted in line with the fuel line, as the name indicates. They are made from steel sheet with corrosion protection, stainless steel, aluminium, or plastic. Optional functions such as pressure regulation, pre-heating, cooling, and water separation are available.



New and innovative: the fuel filter module developed by MAHLE specifically for commercial vehicle applications. The multi-stage patented MAHLE filter element provides effective water separation. In the first stage, the solid particles are filtered out. In the following stages, the microfine droplets coalesce to form larger droplets and the water is separated. MAHLE has developed the automatic water disposal system BlueDrain® specifically for diesel fuel with a high water content, which will be available in the future as both a stand-alone system and an integrated system unit in MAHLE fuel filter modules.



The image features two automotive air filters against a textured blue background. One filter is positioned in the foreground, angled towards the viewer, showing its pleated surface. A second filter is partially visible behind it to the left. A semi-transparent horizontal band across the middle of the image contains the text "DESIGNED FOR FRESH AIR." in a bold, sans-serif font. The filter itself is a rectangular, pleated unit with a light-colored frame and a darker, pleated filter media.

**DESIGNED FOR  
FRESH AIR.**



## Cabin air filters

Cabin air filters are very efficient. During only one hour of driving, an air volume of up to 100,000 litres is blown into the vehicle interior. All the more important is the regular replacement of the filters. MAHLE recommends changing the filters every 15,000 km—at least once per year. Because if the cabin air filter fails or when it is clogged up, the pollutant concentration in the interior of the vehicle can increase up to six times of that of the outside air. MAHLE cabin air filters supply the driver and passengers reliably with cleaned air to breathe and thus safeguard their health, well-being, and power of concentration even in the event of smog or a high pollen count. They also reduce the load on the blower, protect heating and climate control from contaminations, improve air circulation, and prevent dangerous misting up of the windows. In addition, the inside of the windows and fittings remain clean for a longer period of time.

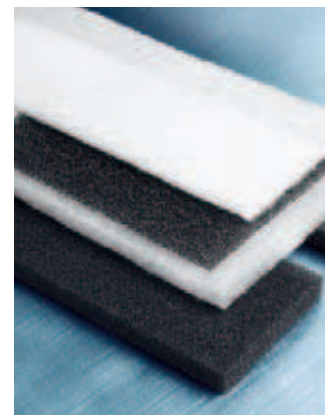
The pleat geometry of our cabin air filter elements is designed to provide a long service life. The low flow resistance minimises the load on the blowers. Thanks to the accurate fit of the filter elements into the housing, bypass air is eliminated.

Our cabin air filters do not produce harmful emissions, as solvent-free methods are used for their manufacture.

### Cabin air filters with activated carbon (LAK)

Cabin air filters with activated carbon keep back harmful exhaust fumes, dirt, and dust, as well as high ozone concentrations and unpleasant smells. The media block used in these filters comprises three layers: an activated carbon layer is embedded in two layers of fleece. The use of adhesives containing solvents is consistently avoided.

Depending on the vehicle type, pure activated carbon canisters (LKK) are also available, which can be used to supplement conventional cabin air filters.



*In vehicles with an increased service life and that are operated in heavily contaminated surroundings, an additional pre-filter (LAP) made of polyester foams or fleece matting is frequently used. By absorbing coarse particles, these pre-filters prevent the surface of the cabin air filters from clogging up prematurely. As a consequence, the tool life of our LA/LAK filters is prolonged considerably.*







**WE WORK  
BEST UNDER  
PRESSURE.**



# Air drying cartridges

## **Especially for commercial vehicles**

Many control and closed-loop control processes in commercial vehicles work with compressed air, as is the case in brake systems, for instance. Air contains moisture, however, which in turn can cause damage in piping and containers, contaminate lubrication films, and freeze at low temperatures. Air dryers are used in order to assure failure-free operation of the safety systems. They remove moisture from the air, prevent corrosion in pipes and containers, and guard against premature wear and malfunction.

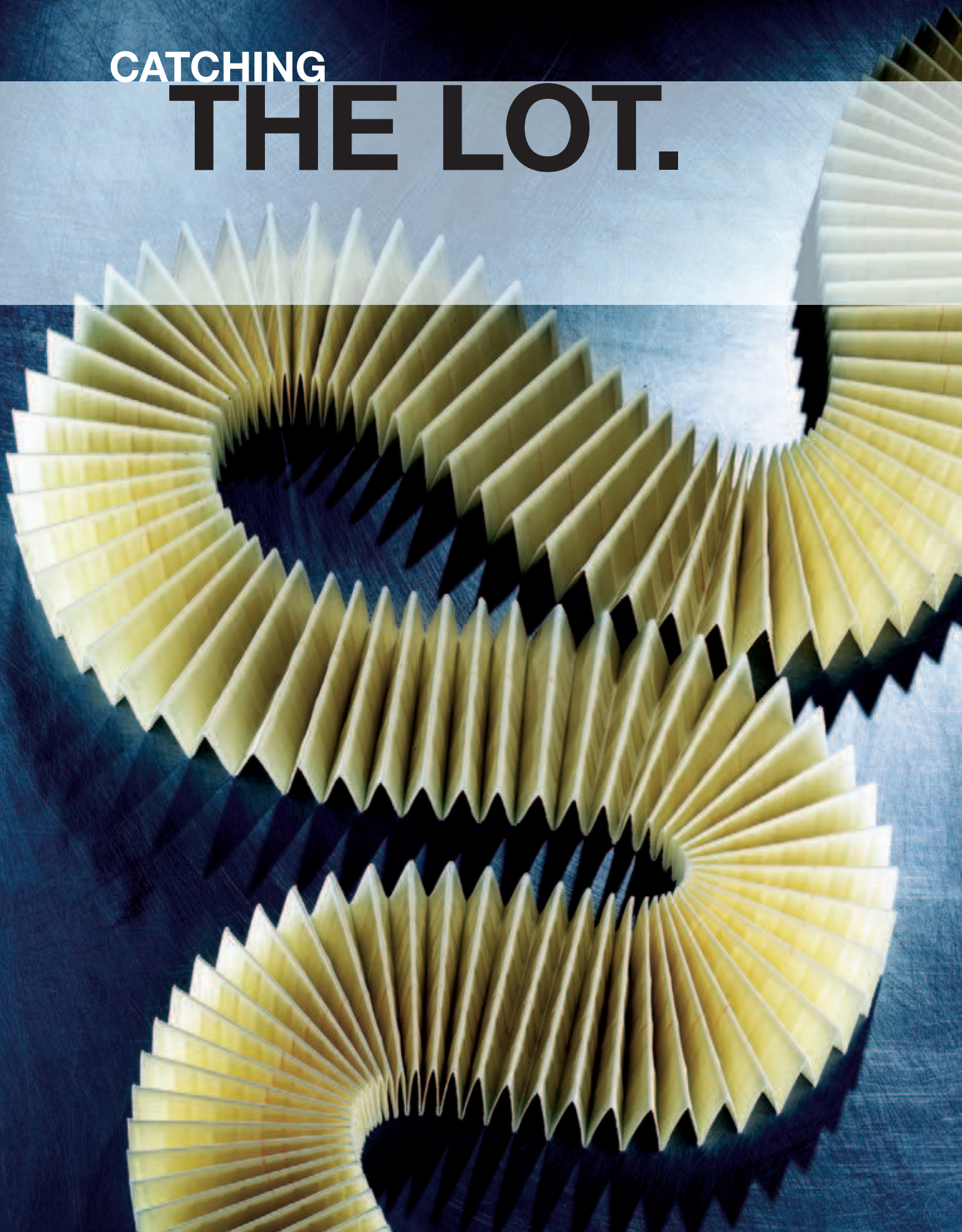
To guarantee the operational safety of the air brake system, it is imperative that air dryers are replaced according to the regulations of the manufacturer.

Air dryer cartridges from MAHLE operate irrespective of the temperature. They contain a drying agent that is regenerated under system control. At the same time, contamination and condensation water are removed from the pre-filter. Our air dryer cartridges are resistant to corrosion on both the inside and outside, and work reliably even under the most difficult of conditions.





# CATCHING THE LOT.





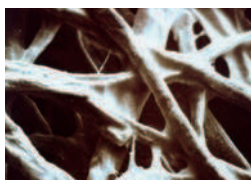
## Filter media

Our filter media range consists of specially treated papers, fleeces, or multi-layer filter media, depending on the specification and application.

### Filters made of paper

The paper for our filters is made of high-grade cellulose fibres impregnated with special resins. The material is treated in a special production process: special pre-warming prepares the paper for the embossing of vertical ridges. The paper is then folded according to the respective requirements. Afterwards the impregnation is cured to make the paper mechanically stable and resistant to chemical and thermal influences. The outcome: filters with stable pleat geometry that prevent the dreaded forming of blocks (see right column) even under high loads and ensure that air, oil, or fuel can flow freely through the paper at all times. The fineness of the filters can reach 1  $\mu\text{m}$ , depending on the requirements, and offers safe conditions for highest dirt elimination.

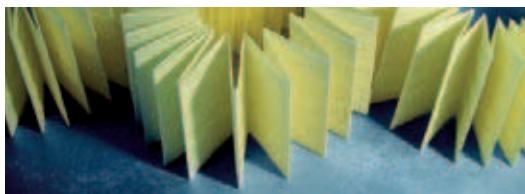
Filters made of paper are used in air, fuel, oil, and hydraulic filters.



The impregnated cellulose fibres under the microscope.



Filter paper after embossing.



Readily pleated paper for use in filters.

### Filter fleeces

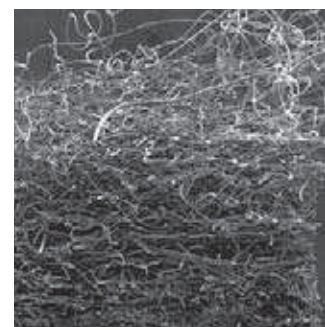
Fleeces, on the other hand, consist of plastic fibres with thicknesses in the  $\mu\text{m}$  range: the finer the fibres, the better the collection. The fleeces are applied in layers, whereby the density and fineness of the fibres increase from the dirty to the clean side. This so-called funnel effect allows efficiencies of up to 99.9 per cent with low flow resistance.

For some years now, fleece has been used for cabin air filters as well as for new developments in the oil filter sector. Recently, fleece has also been increasingly used in air filters—with the advantage of up to 40 per cent increase in filter performance and longer service life. Fleece also finds application to an ever greater extent in fuel filters, mostly combined with stabilising base paper.

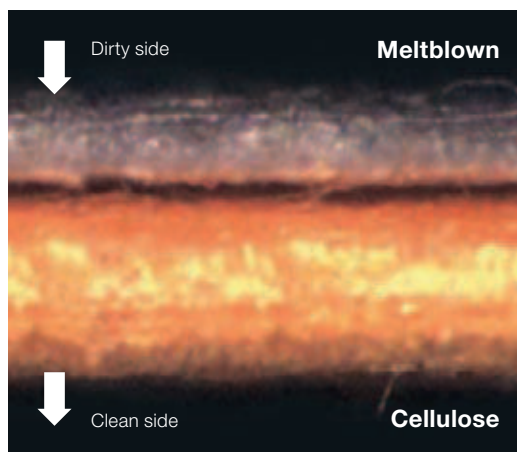
### Multi-layer filter media

These media are combinations of fleece and paper that have been fused in a complex production process. They are characterised by a dirt collection capacity that is up to 40 per cent higher than that of conventional paper filters at a dirt collection efficiency of 3 to 5  $\mu\text{m}$ .

Multi-layer filter media are used for modern diesel fuel injection systems (in turbo diesel direct injection, common rail, or pump injector technology).



Funnel effect of the filter fleece: density and fineness of the fibres increase from the dirty to the clean side.



Multi-layer filter medium with plastic fleece at the dirty side and paper at the clean side.

### Block forming in air filters—an expensive phenomenon

When the pleat geometry is insufficiently stable and the folds are too close together, no air or not enough air can flow through the filter in these areas. This increases the flow resistance, the filtration deteriorates, the life span of the filter is reduced, and the fuel consumption and pollutant emissions increase significantly.

In order to prevent loss of stability and shape, our filter papers are impregnated with special resins as part of a complex treatment process.



EVERYTHING ELSE THAT COMES  
**WITH ALL OF OUR  
PRODUCTS.**



## Global network

The best vehicle spare parts are of little use if they are not available at the right place at the right time. In more than a dozen logistics centres and numerous regional bases at strategic locations in Europe, North and South America, as well as Asia, MAHLE Aftermarket is therefore striving to provide an optimal flow of goods and consequently the best possible availability. This forms the basis for the worldwide supply network of the international MAHLE Aftermarket organisation.

Engine components from MAHLE are among the most sought-after products on the automotive parts market, by genuine buyers and thus by forgers, too. Engine component packaging now comes with the new MAHLE security label, thus allowing you to quickly verify whether a part is genuine or a counterfeit. It combines several security features, such as VeoMark and MAPP code, that are linked together to provide the maximum possible protection against counterfeiting.

Apart from product quality and availability, however, there are other matters to be considered. For example, comprehensive customer care and advice, or a convincing package of services. At MAHLE Aftermarket, this starts with the extensive supply of information, which includes our up-to-date online catalogue and popular customer information system CIS. Furthermore, we offer our customers a demand-based training programme and practical sales material.

In addition, we are involved in repair shop co-operations and participate in individual advertising campaigns.

Comprehensive public relations and our presence in the relevant trade and consumer media also assure that we are widely recognised and contribute to the excellent image of our brands.





# MAHLE AFTERMARKET. AN INTERNATIONAL NETWORK.

THE WORLDWIDE DISTRIBUTION NETWORK ASSURES OPTIMUM AVAILABILITY.



■ Logistics centre  
● Sales office





Stockholm, SE

■ Krotoszyn, PL

■ Obninsk, RUS

● Stuttgart, DE

■ Schomdorf, DE

● Kiew, UA

FR

■ Izmir, TR

● Dubai, AE

■ Gurgaon, IN

■ Chennai, IN

■ Shanghai, CN

■ Tokyo, JP

■ Singapore, SG











# **MAHLE**

*Driven by performance*

[www.mahle-aftermarket.com](http://www.mahle-aftermarket.com)

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