BEHR HELLA SERVICE

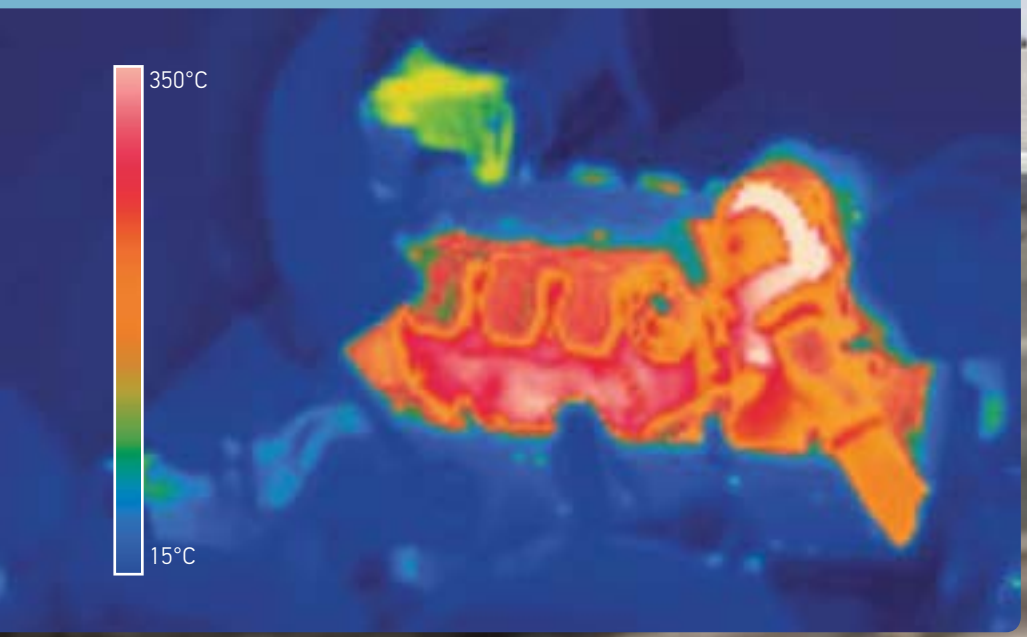
SOPHISTICATED: ENGINE COOLING FOR PASSENGER CARS

Repairs to the engine cooling system can heat up emotions.

The customers' demands of the garage are plain and simple.
Low-cost and quick repairs. Ultimately a cooling fault does not constitute engine damage.

The demands of the engine cooling system are of a totally different nature.
Due to the tremendous pressure to perform in the overall cooling system, the individual components require quality spare parts that are designed precisely for the particular engine. Otherwise it could lead to follow-on repairs or the engine could even overheat. In this brochure we demonstrate why the cooling system merits the special attention of the garage and the vehicle owner. Helping people and technology stay in the green zone.

Engine with heated components.

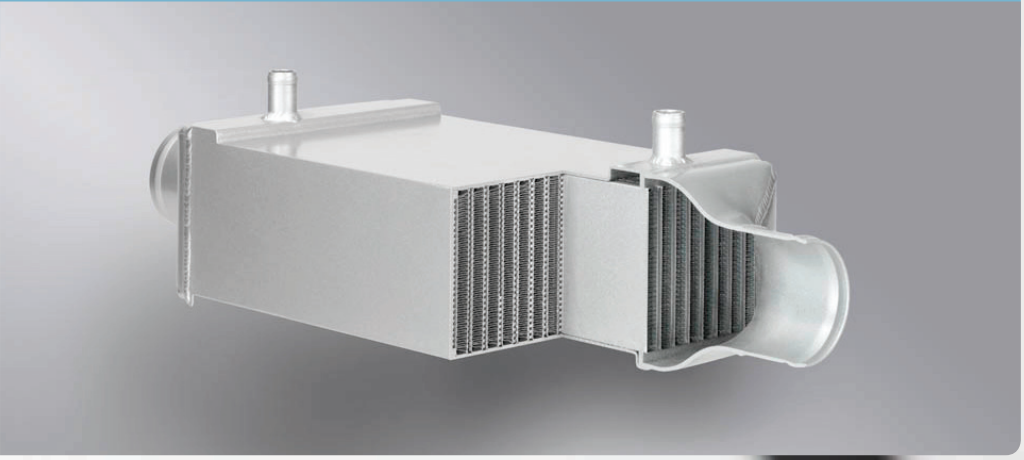


Cooling systems are not just an efficient solution against hot air.

Modern cooling systems make a significant contribution to the reduction of emissions and consumption.
Due to demands for greater efficiency and cost-effectiveness, as well as factors such as greater load-carrying capacity, turbocharger technology, vehicle heating systems and air conditioning systems, classic engine cooling has evolved into a complex engine cooling system.
In order to be able to adhere to the stricter emissions laws that will apply in the future, an increase of the operating temperature by approx. 10% is required. Only thus can optimized combustion be guaranteed. However, increased temperature also means increased cooling performance, enabling the engine to stably achieve its mileage performance.

This is why parts in original equipment quality are the first choice for maintenance and repairs.
An engine cooling system can consist of various components. It is a sensitive system where all the components function together under heat and high pressure like a well-rehearsed team. All the modules are completely harmonised with each other for new passenger vehicles. Their level of performance and safety can be retained by using parts in original equipment quality. Technology competence, performance, accuracy of fit and material quality are in tune.

Indirect charge air cooler in section.



Detailed view of coolant radiator.

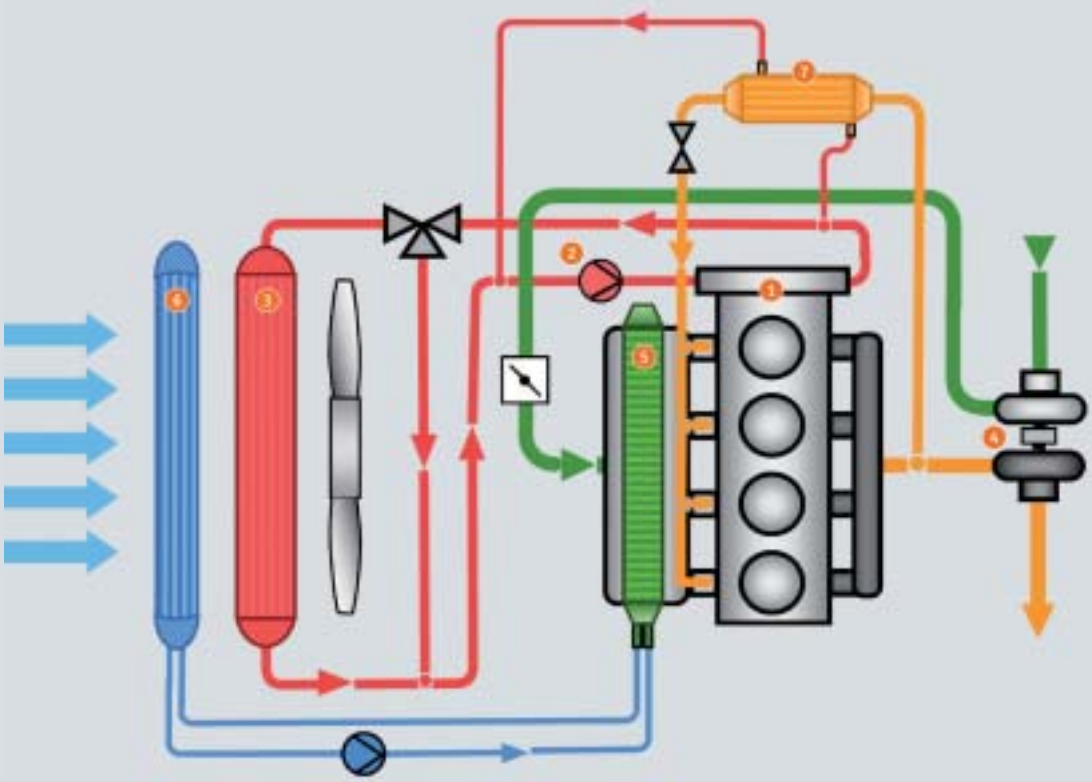
Charge air

Exhaust gas

Main cooling circuit

Low temperature coolant circuit

1. Engine block
2. Coolant pump
3. Coolant radiator
4. Turbocharger
5. Charge air cooler
6. Low-temperature coolant radiator
7. Exhaust gas cooler



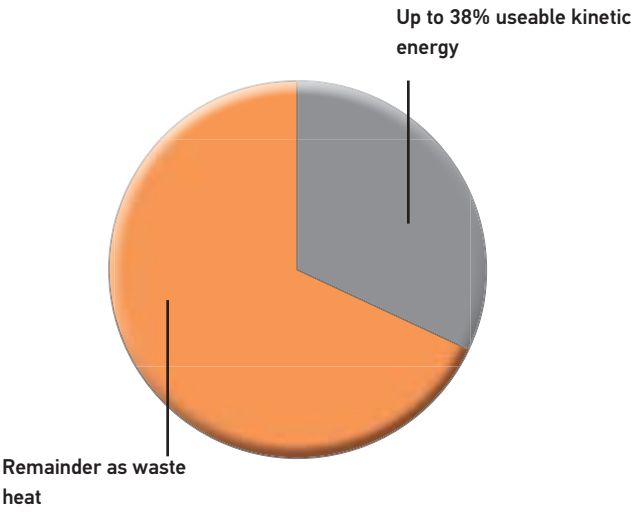
Schematic layout of the coolant circuits for a modern engine with cooled exhaust gas recirculation and an integrated, indirect charge air cooling system.

Interesting facts about engine cooling systems.

Engine cooling is a complex system that does far more than simply cool the engine. The role of engine cooling has constantly expanded in recent years.

Over the next couple of pages we provide a brief outline of the most important elements regarding the function and structure of the different vehicle components:

The engine's waste heat is essentially dissipated via two routes: via the exhaust gas and the coolant. About one third of the fuel energy is lost via the exhaust gas as heat. A quarter of the energy is used mainly to heat the engine block 1, whilst only a third of the energy actually goes into the drive. The main purpose of engine cooling is to protect the engine and its metal parts against overheating. The engine cooling control system helps to quickly heat up the engine, e.g. after a cold start in winter. The vehicle interior is also supplied with the required heat through the hot coolant from the engine cooling circuit. These are the traditional functions of the cooling system. Three circuits perform all these functions: Coolant, air and exhaust gas.



Coolant

The engine and its components heat up considerably during use, as fuel is burnt with air in the cylinder. The engine is cooled by the engine oil and the coolant (see pages 14 and 15 for handling the coolant). A coolant pump ❷ pumps the coolant through the cooling circuit, which cools the engine block and the cylinder heads. In high-performance engines, heat dissipation via the oil pan is not enough. In this case, the coolant also dissipates heat from the engine oil via an engine oil cooler.

The coolant is re-cooled by the ambient air in the coolant radiator ❸ at the front end of the vehicle by flowing through the parallel pipes of the radiator. Extremely thin corrugated fins between the individual pipes increase the surface area around which the ambient air flows, similar to a wall-mounted radiator, so that the air can absorb as much heat as possible from the coolant. The corrugated fins have slits to increase this effect even further. These "gills" ensure that the air is constantly moving and so can dissipate more heat.

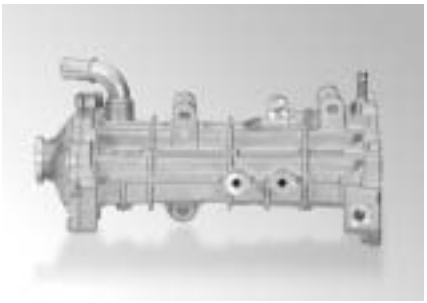
The coolant flow is controlled using thermostats that react to the temperature. They open and close depending on the temperature of the coolant. If the coolant is still too cold, such as during a cold start in winter, the thermostat stays closed. The coolant flow is not passed via the coolant radiator and so heats up the engine more quickly, and the unit reaches the operating temperature more quickly. The thermostat valve only opens and switches on the radiator above a specific temperature. Other thermostat valves in the circuit control when and how much coolant is provided at a specific operating point to other components such as the engine oil cooler and the power-steering oil cooler, as well as the interior heating system.

Air

In the past, turbocharging was used to increase the engine performance without changing the cylinder capacity or the number of cylinders. Today, turbocharging is used to provide the same performance with a smaller engine, thereby saving fuel.

In turbocharged engines, the combustion air is heavily compressed before entering into the combustion chamber. It heats up during this process and thus must be cooled in a charge air cooler. Previously the charge air was cooled in a direct cooler. It was compressed in the turbocharger ❹ and redirected via long hoses into the cooler module where it was cooled in a charge air cooler that was in turn cooled by the ambient air. The charge air was then redirected to the combustion chamber along long hoses.

This approach takes up installation space and, more significantly, lowers the charge air pressure. Once it has travelled along the pipes, the charge air does not have the same pressure it had immediately at the compressor. The answer to this problem is indirect charge air cooling ❺. In indirect charge air cooling, the charge air is cooled by an additional low temperature coolant circuit with its own low temperature coolant radiator ❻ at the front end of the vehicle which is independent of the main cooling circuit. Advantage: The charge air cooler can be installed next to the engine. The charge air pressure is now retained and the engine responds better.



Exhaust gas recirculation cooler

Exhaust gas

Cooled exhaust gas is typically recirculated to the combustion chambers in diesel engines in order to reduce emissions of nitrogen oxides. The exhaust gas "dilutes" the fuel/air mixture. This lowers the combustion temperature. As nitrogen oxides are mainly produced at high combustion temperatures, this also reduces pollutant emissions. For this to function, the exhaust gas must be cooled by the coolant in the exhaust gas cooler ❼ (depending on engine load) from approx. 450°C to 800°C to at least 150°C to 200°C. All this heat must also be absorbed by the coolant and dissipated via the coolant radiator.

However, even this is not enough to comply with future emissions regulations, as exhaust gas must be cooled down to approx. 60°C to 70°C. To be able to guarantee such temperatures, the exhaust gas is cooled in a second stage using a low temperature coolant circuit.

Summary

The role of engine cooling has constantly expanded in recent years and continues to expand.
The low temperature circuit and the air conditioning, for example, are responsible for cooling lithium-ion batteries in hybrid vehicles. Therefore, thermal management will actually become more and more important.

Behr Hella Service: Your reliable thermal management expert.

Behr Hella Service combines outstanding service competence with a high-quality and extensive product range.
Engine cooling and vehicle air conditioning go hand-in-hand with thermal management, along with the OE product expertise of Behr as one of the leading providers in this field together with the worldwide sales organisation of Hella. The Behr Hella Service joint venture offers the perfect combination of price, performance and quality.

Your advantages are our strengths.
The garage benefits from top-quality products, security of supply and extensive service competence — not just in relation to the supply of parts. Behr Hella Service supports the garages and the independent aftermarket through the provision of technical information, training and campaigns. Benefit from our many years of experience in vehicle air conditioning and engine cooling for passenger cars, transporters and commercial vehicles: Reliable and durable products together with professional and extensive services from Behr Hella Service.

Behr quality, exclusive from Behr Hella Service in the independent aftermarket.

Behr — an experienced systems partner to the international automotive industry. Quality since 1905.
Through its renowned competence as an original equipment manufacturer, Behr has produced genuine quality products for more than 100 years, offering optimal safety through the use of cooling system products. Behr components are perfectly attuned and achieve an unrivalled level of cooling efficiency. They not only protect the engine against costly damage caused by overheating but also provide for optimal performance, environmental sustainability and engine design life. Behr's many years of experience and extensive know-how guarantee the exceptional quality of all its products.

Leading research and development competence for well-engineered system components.
Behr's success is founded on innovation. The far-reaching research and development form the basis of this, enabling Behr to develop innovative and high-quality products. The latest software during product development helps establish performance, reliability and quality as the key factors. This continues in the extensive tests under real-life conditions that are carried out using in-house testing facilities such as an engine test station or the ultra-modern climatic wind tunnel.

Innovative production expertise.
Behr guarantees the ultimate quality of all its products through company-wide advanced production technologies. High-accuracy development delivers precise accuracy of fit for all Behr components. Comprehensive quality assurance systems also guarantee the longevity and reliability of all its products.

Product testing in the climatic wind tunnel.

Modern manufacturing technologies.

Tightness testing on the finished product.

Air current flow measurement in the quality lab.

On the safe side with the ultimate quality offered by Behr Hella Service.

Coolant radiator
The most important component of a cooler module is the coolant radiator. It comprises of the radiator block and water tank with all the necessary connections and attachment elements. The heat generated by the engine combustion is absorbed by the coolant and discharged to the outside air via the radiator. Coolant radiators are installed in the air flow of the vehicle front.

Oil cooler
Motor oil cooler/gear oil cooler ensure an almost constant temperature range. The intervals between oil changes can be extended and the design life of the engine increases. Behr's latest model is a compact and powerful stack-disc oil cooler. Since it manages without coolant housing and is made completely of aluminium, its outstanding features are its low weight and low design space requirements.

Coolers for exhaust gas recirculation
The effect of exhaust gas recirculation is mainly due to the fact that the exhaust gas has a greater heat capacity and lower oxygen content than air. This reduces the combustion temperatures in the cylinder. Temperatures are reduced even further by cooling the exhaust gas and the charge air. Since the formation of NOx depends heavily on these temperatures, a combination of cooled exhaust gas recirculation and charging with intercooling enables the limits of the Euro 6 standard to be met.

Visco® fans
Fans and fan drives which efficiently provide cooling air are required for heat dissipation in addition to powerful coolers. Visco® fans consist of a fan wheel and a Visco® clutch. They are used with engines installed longitudinally and are installed in front of the cooler in the direction of travel.

Interior heat exchanger
The interior heat exchanger is located in the vehicle interior beneath the dashboard. The air flow produced by the interior blower is routed through the heat exchanger, which has coolant flowing through it. The heated air is then discharged into the vehicle interior.

Reserve tank
The reserve tank is used to trap the expanding coolant from the coolant circuit.

Engine cooling product range

Electrical booster heater (PTC)
On account of the high efficiency of modern, direct injection engines, dissipated heat is no longer sufficient for heating up the vehicle interior quickly on cold days. PTC booster heaters, which are installed in the direction of travel in front of the heat exchanger, make it possible to heat up the vehicle interior more quickly. They are made up of several temperature-dependent, electrically-controlled resistors. Energy is taken from the vehicle electric system without delay and directly transferred to the vehicle interior as heat via the blower air flow.

Visco® clutch
The Visco® clutch has the task of making the frictional connection to the fan wheel depending on the temperature, and influencing its speed. The drive torque is transferred by means of wear-free viscous friction to the fan wheel, the continuously variable speed of which is set on the basis of the operating conditions. In the case of the electrically-driven Visco® clutch, control takes place directly via sensors. Requirement-based cooling optimises the coolant temperature, engine noise and fuel consumption.

Charge air cooler
More performance throughout the speed range, lower fuel consumption, improved engine efficiency, lower exhaust gas values, reduced thermal load on the engine – there are many reasons for cooling the combustion air of charged engines with charge air coolers.

Condensers/coolant radiator fans
A condenser or coolant fan consists of an electric motor with flange-mounted fan wheel. They are mounted before or after the condenser or radiator. They remove heat from the refrigerant or coolant via the generated air flow. An additional or more powerful fan is usually used in vehicles with an air conditioning system.

Water-pump kit
The water pump is powered mechanically. It transports the coolant through the circuit and builds up the system pressure. The water pump is usually connected to the drive by belts.

Coolant and antifreeze — Q&A.

Why does the cooling system need antifreeze and additives in the summer too?

→ Antifreeze not only protects against freezing but also against overheating.
→ Additives protect against the build-up of limescale deposits and corrosion.

Coolant is the generic term for the fluid contained in the cooling system. A coolant is a mixture of water, antifreeze (glycol) and additives. It does more than just protect the engine and the components of the cooling system against freezing. The task of the coolant is to absorb the engine heat and redirect it back into the ambient air via the cooler. As the boiling point of glycol is much higher than water, the boiling point can be raised to up to 135°C by using the right mixing ratio for the coolant (see "What is the right mixing ratio ...") and a system pressure of 1 to 2 bar. This contributes significantly towards high performance reserves for the coolant, as the average coolant temperature for modern engines is approximately 95°C, which is below the boiling point of pure water (100°C). Additives in the coolant form a protective layer on the metal surfaces of the cooling system components and prevent limescale deposits and corrosion. The cooling system therefore requires a sufficient amount of antifreeze and additives — even in summer.

Why does the coolant need to be replaced at specific intervals?

→ The additives contained in the coolant are subject to a certain amount of wear.

I.e. they are used up to such an extent that they no longer fulfil their intended requirements sufficiently. If, for example, the corrosion protection additives are used up, this can cause the coolant to turn brown. The frequency for replacing the coolant depends on the quality of the coolant and is specified by the vehicle manufacturer. Some vehicle manufacturers do not specify a replacement frequency, whereas others specify a frequency in years (3–5) or kilometres (100,000–250,000). As a rule, the coolant should be changed if pollution (oil, corrosion) has occurred and in the case of vehicles which are not filled with Long Life coolant. Under normal operating conditions, a three-yearly interval is recommended.

What is the right mixing ratio of water to antifreeze?

→ The ideal mixing ratio of water to antifreeze should be 60:40 to 50:50.

The vehicle manufacturer's specifications for the mixing ratio and the coolant specification should always be followed. A typical mixing ratio of water and antifreeze should be 60:40 to 50:50. This usually corresponds to antifreeze protection from –25°C to –40°C. The minimum mixing ratio should be 70:30 and the maximum mixing ratio 40:60. Further increasing the antifreeze share (e.g. 70%) does not lower the freezing point any further. In contrast, undiluted antifreeze freezes at -13°C and does not discharge sufficient engine heat. This can result in the engine overheating.

Can antifreeze agents be mixed together?

→ Different types of antifreeze agent must not be mixed together.

Antifreeze agents and their additives are adapted to the respective materials of the engine and cooling system. A cast-iron motor requires different additives to an aluminium motor, and a heat exchanger made from non-ferrous metal requires different additives to an aluminium heat exchanger. Mixing different types of antifreeze together can cause considerable damage in extreme cases. For example, antifreeze agents G11 and G12 by Audi/VW must not be mixed together due to their incompatibility. Otherwise it could result in serious damage to the engine. However, the new G12^{+}/G12^{++} can be used together with G11 and G12 without any problems. Therefore, before filling and topping up a cooling system, the vehicle manufacturer's guidelines with regard to specification and mixing ratio must be observed.

Does the cooling system need to be serviced?

→ The cooling system components and the coolant should be checked regularly.

The cooling system and the air conditioning system should be checked regularly. The visible cooling system components (radiator, hoses, reserve tank and coolant pump belt) must all be inspected visually. Are the connections firm? Is the belt sufficiently tensioned or damaged? Are the cooler discs clogged

(insects etc.)? Is coolant leaking out? In addition to checking the coolant level, the antifreeze content and the level of purity, functional tests must also be carried out on the thermostat, cooling fans and any electrical valves. As the additives wear out the coolant (see also "Why does the coolant need to be replaced?"), it should be replaced at specific intervals. Thus, as the cooling system and the air conditioning system mutually influence each other and the components are often positioned close to each other, it is recommended that both systems are checked/serviced.

Can the coolant be topped up with clean tap water?

→ Yes, provided that the degree of hardness is lower than 3.6 mmol/l (20°dH, German degree of hardness).

Tap water can be used to fill and top up the cooling system — up to a degree of hardness of 3.6 mmol/l, which is the equivalent of the German degree of hardness of 20dH (hard water). The use of demineralised (distilled) water is only required if the degree of hardness is greater than 3.6 mmol/l.

This is general information. Vehicle and system-specific manufacturer details must be observed separately.

Practical tips from the garage:

If the cooling system does not have any performance reserves, even low deficiencies can cause the engine to overheat. Here are some examples of possible causes:

→ Thermostats often work imprecisely due to mechanical defects.
→ Water pumps that are damaged or are no longer fully functional are not replaced or are replaced too late.
→ The radiator is leaking.
→ Temporary overheating can result in coolant leaks on hose connections or the cylinder head. Coolant is leaking!
→ Radiator hoses or discs are defective.
→ Neglected cooling system: Limescale and sludge build up and the coolant cannot circulate quickly enough. The result: Insufficient engine cooling.
→ Insects and stubborn dirt block the coolant radiator externally.

Consumed (left) and fresh (right) coolant.

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