BEHR HELLA

S E R V I C E

SOPHISTICATED: ENGINE COOLING FOR COMMERCIAL VEHICLES.

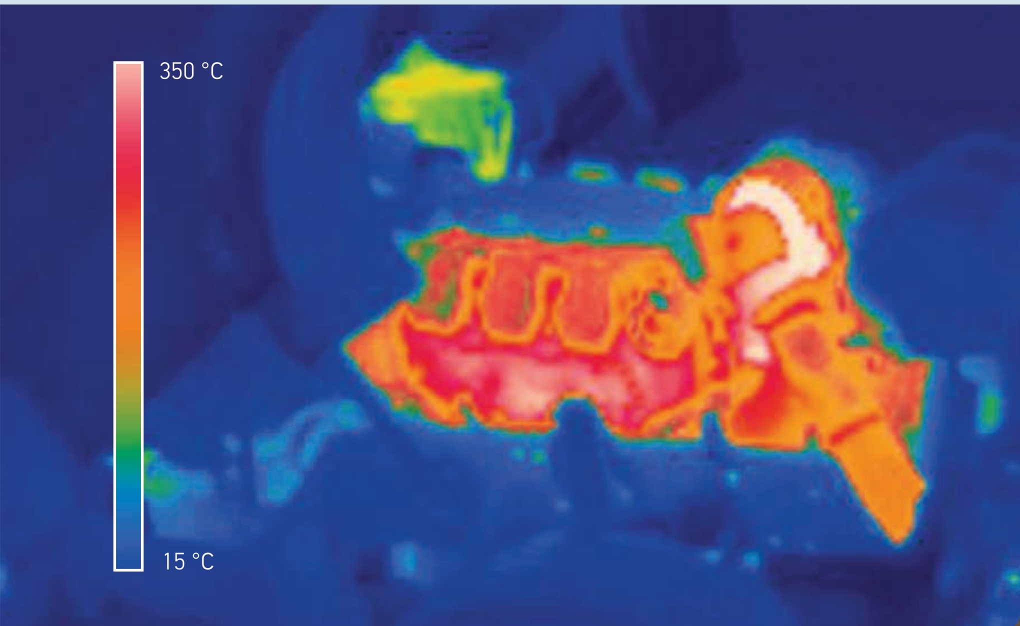
www.behrhellaservice.com

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.

Commercial vehicle diesel engine with heated components.



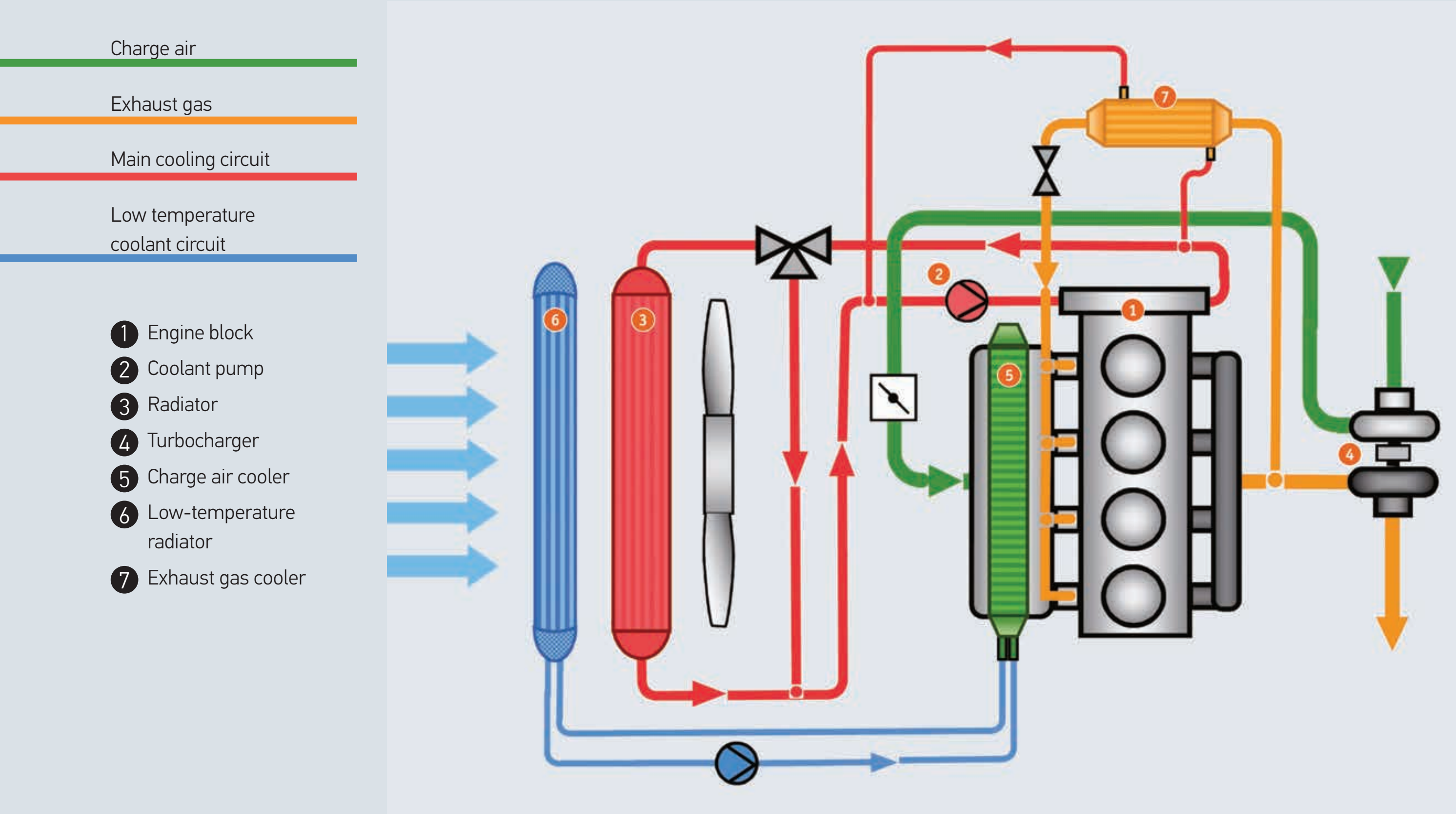
Cooling systems are not just an efficient solution against hot air.

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 payloads, turbocharger technology, vehicle parking heaters and air conditioning systems, classic engine cooling has evolved into a complex engine cooling system. An increase in operating temperature of approx. 10% is necessary for compliance with future, more stringent emission laws. Only in this way can optimized combustion be guaranteed. Increased temperature also means increased cooling performance, enabling the commercial vehicle diesel 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 consists of various components. It is a sensitive system in which all the components function together under heat and high pressure like a well-rehearsed team. In a new vehicle, all the modules are fully harmonized with each other. 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.

Charge air cooler in detail.

Detailed view of coolant radiator.



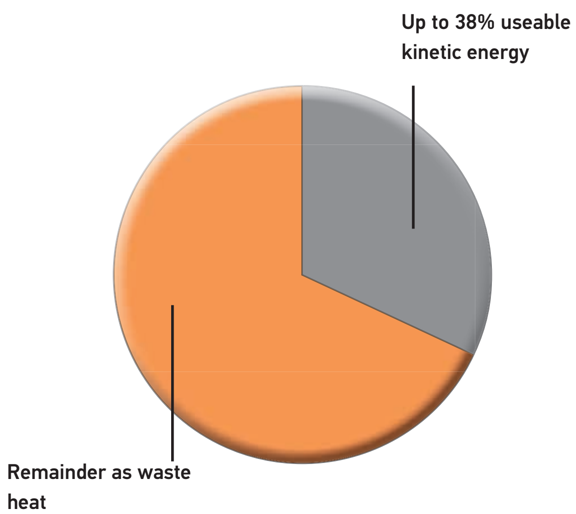
Schematic layout of the coolant circuits for a modern engine with cooled exhaust gas recirculation and an integrated, indirect charge air cooling system.

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.
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 ❶, 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 ❸ is re-cooled by the ambient air in the radiator 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.

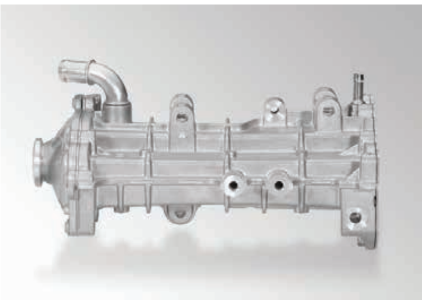
The coolant flow is controlled using thermostats that react to the temperature. They open and close depending on the temperature of the coolant. If the coolant is still too cold, such as during a cold start in winter, the thermostat stays closed. The coolant flow is not passed via the coolant radiator 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 has to 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 has to be cooled by the coolant in the exhaust gas cooler ❼ (depending on engine load) from between 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 commercial vehicles, transporters and passenger cars: 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.

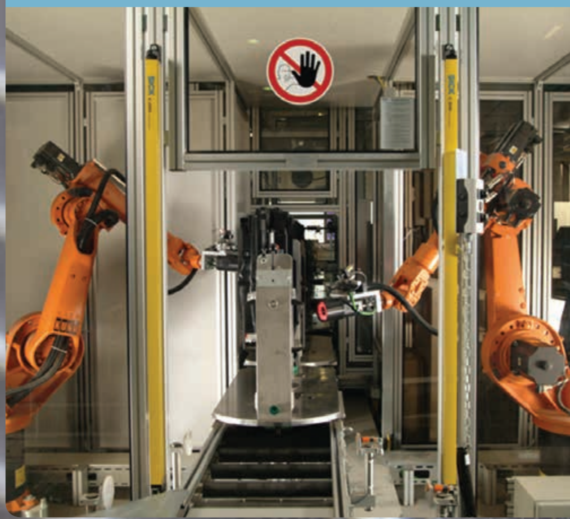
Behr — an experienced systems partner to the international automotive industry. Quality since 1905.
Through is renowned competence as an original equipment manufacturer, Behr has produced genuine quality products for more than 100 years, offering optimal safety through the use of cooling system products. 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. The many years of experience and extensive know-how of Behr 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.

Nothing substitutes for high quality. Except even higher quality.

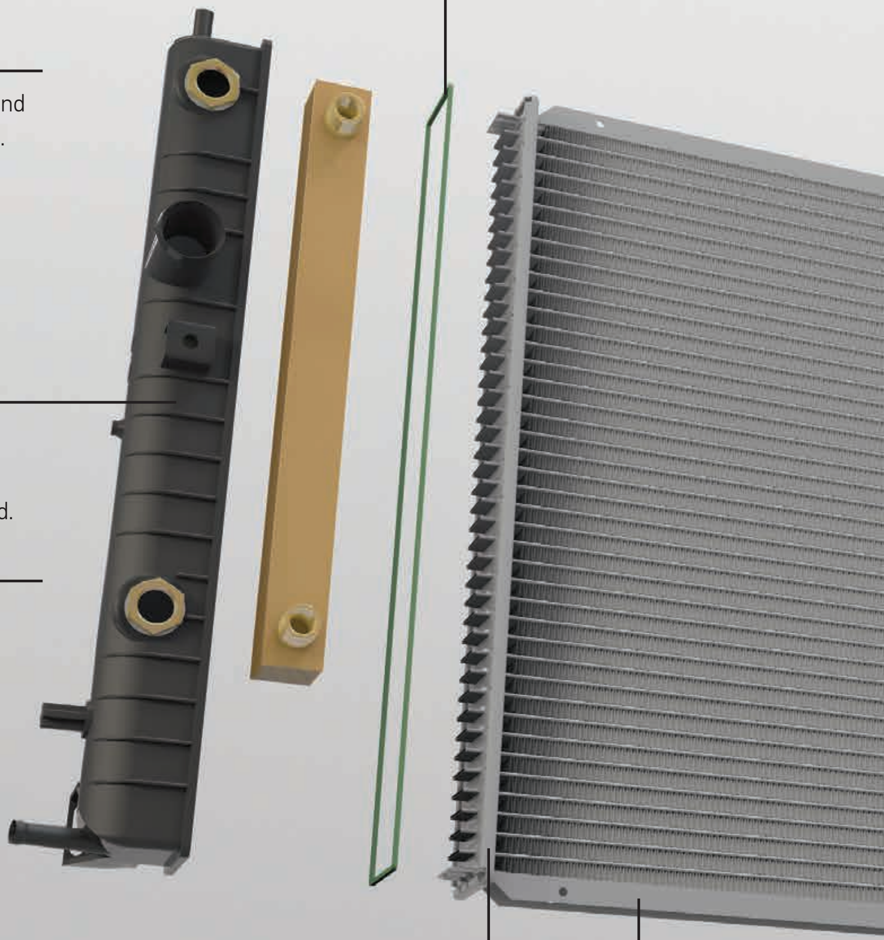
Not all radiators are alike. Cheap imitations may look like a good alternative, but in the complex cooling systems of modern engines there may great differences compared to original equipment quality radiators.

And some of them may have a dramatic impact: High-quality radiators feature sufficient power reserves in terms of flow rate and heat dissipation. Up to a certain point, they can compensate for age-related phenomena such as reduced flow caused by deposits or a drop in efficiency due to contaminated surfaces. Cheap imitations, by contrast, frequently reach their performance limits far earlier. This is due to savings in material or design flaws – turbulence inserts, for example, which are not visible from the outside but often installed in original equipment quality radiators, are often missing.

Seals

Seals are critical for avoiding a loss of coolant. High-quality radiators therefore feature durable, resistant seals.

Poorly fitted seals result in a loss of coolant and may crack when the material becomes brittle. Both may be the result of cost savings during production.



Radiator tank

The radiator tank is the gateway to the coolant radiator. Only with premium materials can a long design life be guaranteed.

Cheap imitations often use cheaper plastics, which tend to break and become leaky more quickly.

Side panels and bottom

A premium radiator also has a premium frame: all the components in high-quality radiators guarantee durability and stability.

Design flaws in cheap imitations can frequently be seen not just in the materials used but also in an insufficiently accurate fit of the individual components.

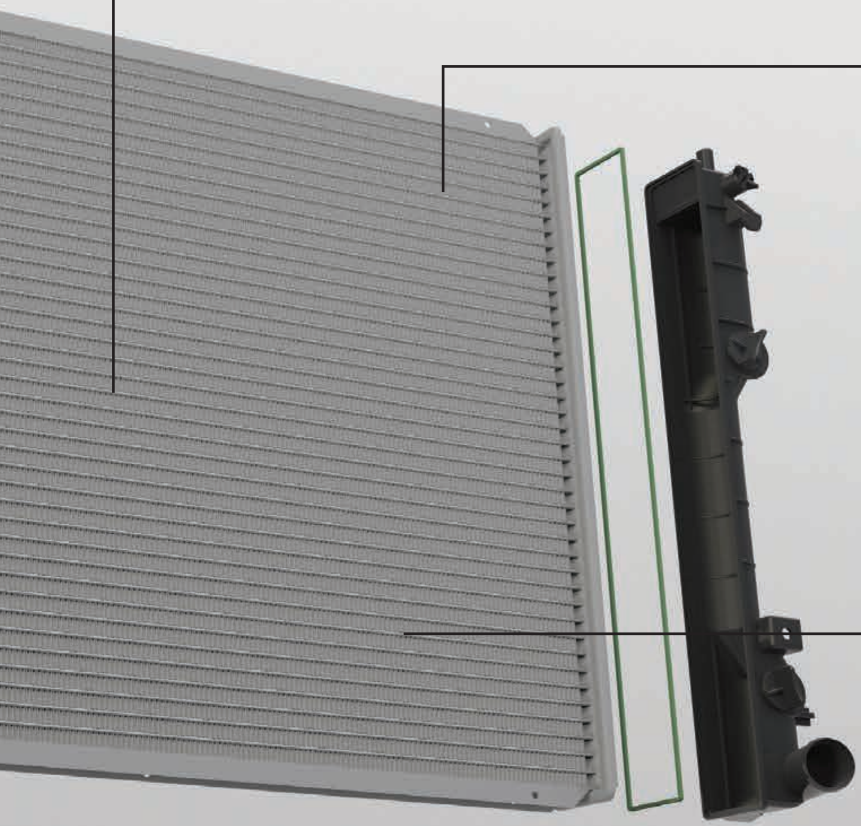
Especially in “full load operation” (for example with heavy loads/ high tonnage or on ascents), cheap imitations may cause the engine to overheat. The consequences then range from vehicle failure due to loss of coolant all the way to serious engine damage, which in turn is associated with complex overhauls, unnecessary downtime and high costs.

The use of “substandard” materials can lead to premature material fatigue (in the form of leaks caused by cracks, all the way to damage to the radiator tank or the coolant circulation). Unsuitable materials are also less resistant to salt water and corrode faster. If the radiator fins break away as a consequence, the inevitable result is poorer heat dissipation and the associated risk of overheating.

Flow and heat dissipation

+ Up to a certain level, high-quality radiators can even compensate for age-related phenomena (such as reduced flow caused by deposits or a drop in efficiency due to contaminated surfaces).

– Cheap imitations frequently reach their performance limits far earlier. This is due to material savings and design flaws.



Cooling fins (block)

+ Premium radiator blocks feature materials which are resistant to corrosion and salt water. For durable, consistent cooling performance.

– An insufficient resistance to salt water accelerates corrosion and thus the loss of radiator fins – in turn resulting in poorer heat dissipation.

Cooling pipes

+ To improve cooling performance, coils, wave-shaped bent strips or other specially developed structures made of aluminum or plastic (known as turbulence inserts), can be pushed into the pipes.

– Cheap imitations frequently do without turbulence inserts – which can significantly reduce their cooling performance.

Desired turbulence.

The true value is often hidden below the surface – and this is also true of thermal management.
Turbulence inserts can be used in lots of different forms in coolant radiators, heat exchangers and intercoolers. They are often invisible from the outside, because they are inserted into the pipes of a radiator and perform their work unseen.

Greater motion ensures better cooling.
Inside mechanically joined radiators, these turbulence inserts, e.g. coils, wave-shaped bent strips or other specially developed structures made of aluminum or plastic, are pushed into the cooling pipes. By contrast, punched aluminum strips are used in the case of soldered radiators.

In both cases, the use of turbulence inserts makes the coolant "swirl" in the pipes, potentially increasing cooling performance.

Illustration of turbulence in cooling pipes with turbulence inserts (upper pipe) and without inserts (lower pipe).

If a commercial vehicle driver notices one or more of the following issues in his vehicle, the cause may be a substandard radiator spare part:

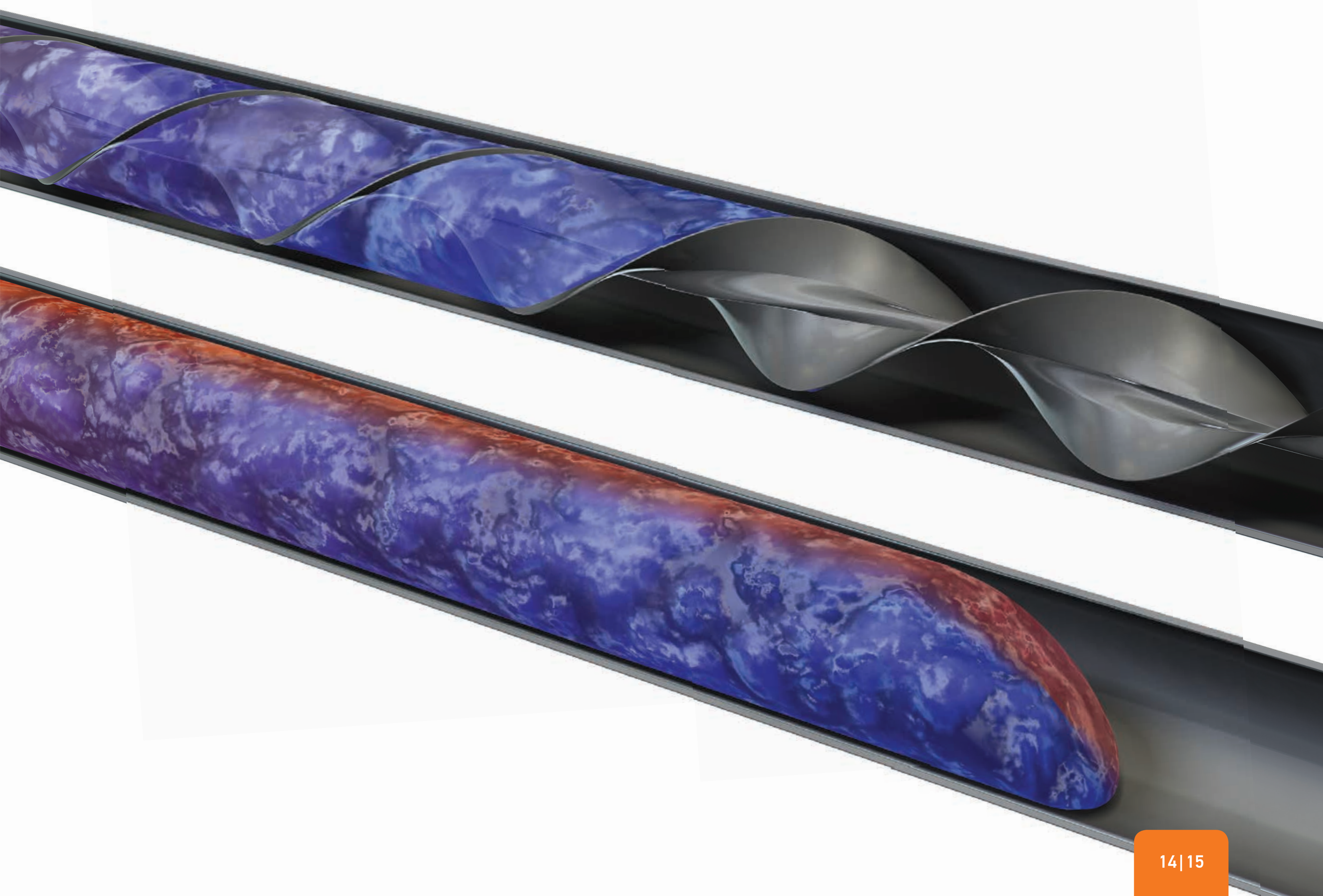
→ **Higher fuel consumption in the full-load range**
Possible cause: due to poor cooling performance, the engine is not running in its ideal thermal range.

→ **The fan starts up excessively often**
Possible cause: relatively weak cooling performance (with noticeable impact on acoustics and fuel consumption).

→ **Speed must be reduced frequently to return the engine to its normal temperature range**
Possible cause: the cooling system is operating with reduced efficiency. Insufficient engine cooling must be compensated for with an adapted driving style.

→ **Retarder switches off by step frequently or its performance is considerably reduced; the service brake is put under greater stress**
Possible cause: coolant temperature is no longer in optimum range, the retarder oil can thus no longer perform its cooling function sufficiently.

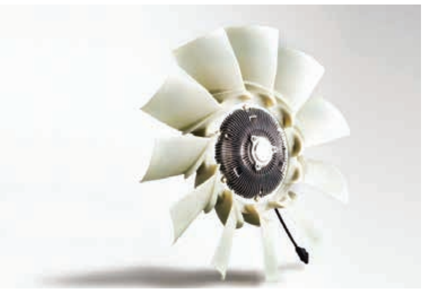
→ **Cooling performance is frequently less than ideal**
Possible cause: installed components have reached their performance limits and reduce the efficiency of the cooling system (with potentially increased engine wear).



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

Radiator
The most important component of a cooler module is the 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. Radiators are installed in the air flow of the vehicle front.

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.



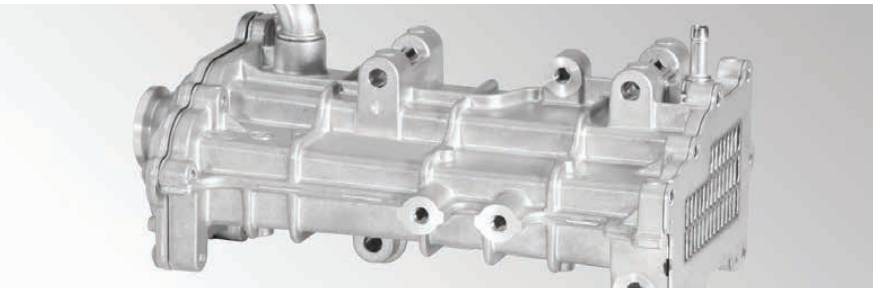
Visco® fans
Fans and fan drives which efficiently provide cooling air are required for heat dissipation in addition to powerful coolers. Visco® fans consist of a fan wheel and a Visco® clutch. They are used with engines installed longitudinally and are installed in front of the radiator in the direction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

Expansion tank
The expansion tank is used to trap the expanding coolant from the coolant circuit.

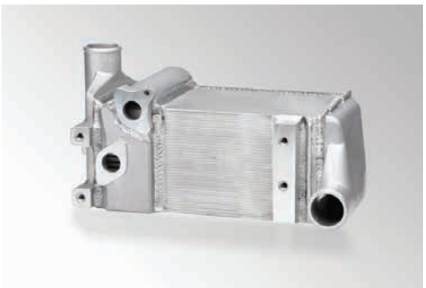
Engine cooling product range

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 reduced even further by cooling of 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.

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.



Oil coolers for hydrodynamic retarders
Here, the movement energy of the crankshaft is transferred into the thermal energy of the hydraulic oil which leads to a reduction in the vehicle speed. The heated hydraulic oil then flows through an oil cooler. This part of the retarder feeds the thermal energy via a coolant to the vehicle's main cooling circuit.

Coolant and anti-freeze — 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 yearly interval is recommended.

What is the right mixing ratio of water to antifreeze?

→ The ideal mixing ratio of water to antifreeze is 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 to antifreeze is 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 must not be mixed together.

Antifreeze 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 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, expansion 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.

Practical tips from the commercial vehicle 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 cooler 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.

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

Consumed (left) and fresh (right) coolant.

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