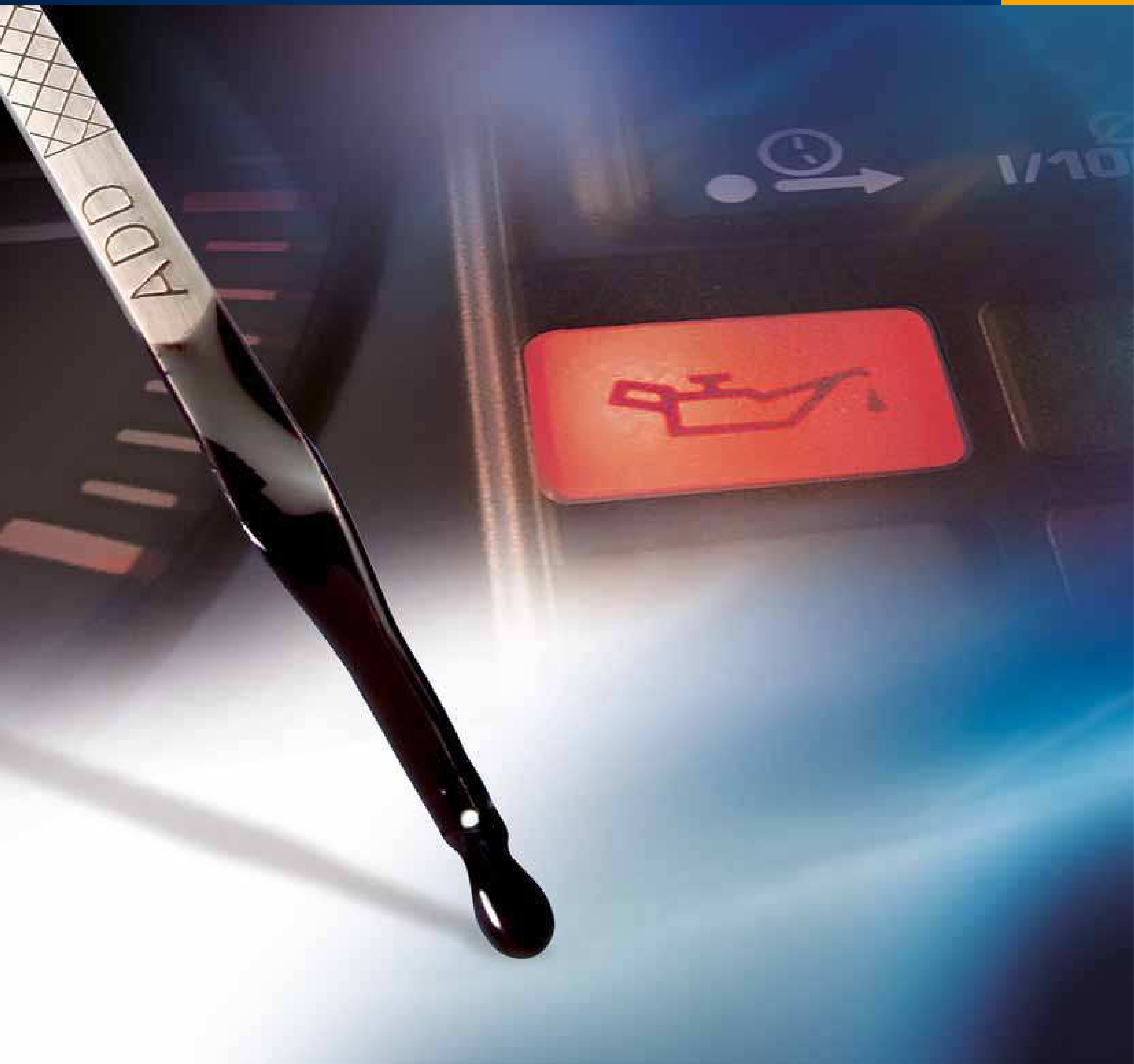
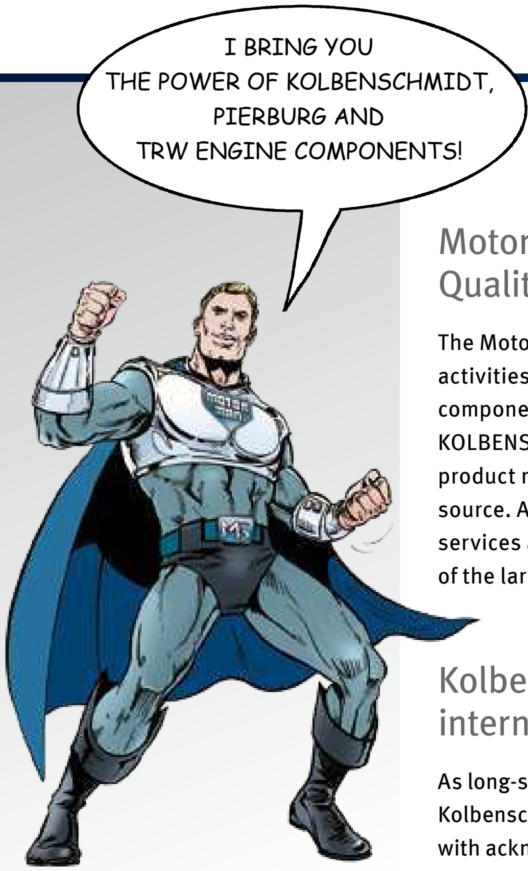
Oil consumption and oil loss

SERVICE
TIPS & INFOS





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TRW EngineComponents

PIERBURG

2nd edition 01.2010
Article No. 50 003 605-02
ISBN 978-3-86522-219-0

Edited by:
Motor Service Technical Market Support

Layout and production:
Motor Service Marketing
DIE NECKARPRINZEN GmbH, Heilbronn

Published by:

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

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1 | Oil consumption general

As most motorist know, an engine needs oil for a long and healthy life. However, they tend to worry less about the importance of regular oil level checks. The dreadful question of oil consumption tends to take us by surprise, and usually only arises after the dipstick comes out dry “yet again”.

Before we can start to look for the reasons behind the oil loss, it is first necessary to define various terms in more detail. Normally, the term “oil consumption” is always used in a very general sense. However, in the workshop it is necessary to make a distinction between the oil loss and the actual oil consumption.

A specialist only uses the term “oil consumtion” to describe the quantity of oil which enters into the combustion chamber where it is then burned or coked. The term “oil loss” is used when the engine is losing oil due to a leak.

Calculation example for trucks

A truck consumes around 40 litres of fuel per 100 km.
This equates to 400 litres of fuel per 1000 km.

0.25 % of 400 litres of fuel equals 1 litre of oil consumed.
0.5 % of 400 litres of fuel equals 2 litres of oil consumed.

Calculation example for cars

A car consumes around 8 litres of fuel per 100 km.
This equates to 80 litres of fuel per 1000 km.

0.1 % of 80 litres of fuel equals 0.08 litres of oil consumed.
0.5 % of 80 litres of fuel equals 0.4 litres of oil consumed.

1.1 When is oil consumption excessive?

Opinions on what constitutes excessive oil consumption differ widely in practice and from one country to another. However, the widespread assumption or expectation that an engine consumes no oil or must not consume any oil is essentially incorrect for the reasons set out above.

Every engine manufacturer has guideline values and limits for the oil consumption of each of their engines. If excessive oil consumption is suspected, the relevant engine manufacturer should be consulted for these guideline values and limits for oil consumption. In many cases, workshop manuals and operating instructions also provide information about the oil consumption of an engine.

If no precise oil consumption specifications are provided by the engine manufacturer, oil consumption for trucks can be expected to be between 0.25 % and 0.5 % of the actual fuel consumption.

For small car engines, oil consumption is between 0.1 % and 0.5 % of the fuel consumption.

Due to their operating principle, diesel engines consume more engine oil than petrol engines. Turbocharged engines also require more oil than those without a turbocharger due to the turbocharger lubrication.

However, it is clear that oil consumption is at its lowest after the running-in phase and increases over the service life of the engine. The minimum values should therefore be viewed as being applicable for new engines and the maximum values for engines that have already completed around 2/3 of their service life. Engines on which only partial repairs have been carried out (e.g. replacement of pistons or only piston rings) should not be expected to fall below the maximum values either. In fact, the reverse is all too often true. All parts of an engine wear out at the same rate. If only 10 % of them are replaced, in an ideal situation only 10 % of the desired improvement from the partial repair is actually achieved.

Engine oil is one of the most important fluids in an internal combustion engine. Without oil the engine cannot operate properly. With this in mind, we take a look below at the four primary functions of engine oil.

Lubrication
The oil is responsible for minimising friction between metallic surfaces. This is achieved by means of a lubricating film which is generated between the moving parts of the engine during operation. This lubricating film significantly reduces friction. Less friction means less wear and less heat generated. The lifetime of the components is increased several times. Damage such as piston seizure or bearing damage are avoided, and the fuel consumption is lowered.

Here, it is important that the viscosity of the oil at low temperatures is not too high in order to enable the engine to be started without problems from cold. However, at high temperatures the oil should not become too thin-bodied, as otherwise the desired oil film can tear, resulting in a loss of lubrication. Another function of the oil film between the rings and the cylinder liner is to provide a fine seal between the combustion chamber and the crankcase.

Cooling
Following a cold start, a piston will reach its operating temperature after just a few seconds. It can take a few minutes for the whole cylinder block to reach its operating temperature. The length of this period will depend on the ambient temperature, the engine type and the driving style. Once the engine has reached its operating temperature, it needs to be cooled so that it does not overheat. Air and water are the two cooling media most people think of first in this context. However, the engine oil provides a large proportion of the cooling, particularly inside the engine. The pistons in modern engines have cooling ducts which are rinsed with oil via the splash jets. This method provides additional cooling for the piston crown.

Avoiding corrosion and sludge deposits
Finally, the engine oil also plays the role of preventing corrosion and sludge deposits. Aggressive substances are generated during the combustion process, which are then neutralised by the lubricating oil. Combustion residue and foreign bodies (for example after opening up the engine during an inspection) are transported through the oil flow to the oil filter. They can either be filtered here or collect as deposits in the sump.
In order to ensure good oil flow and a good cleaning function, a high-quality oil which satisfies the requirements of the vehicle manufacturer is important.

All in all, there are many different tasks which have to be met by the engine oil. You should always make sure that there is enough oil in the engine, as at least some of this will be consumed or will escape via leaks during operation.

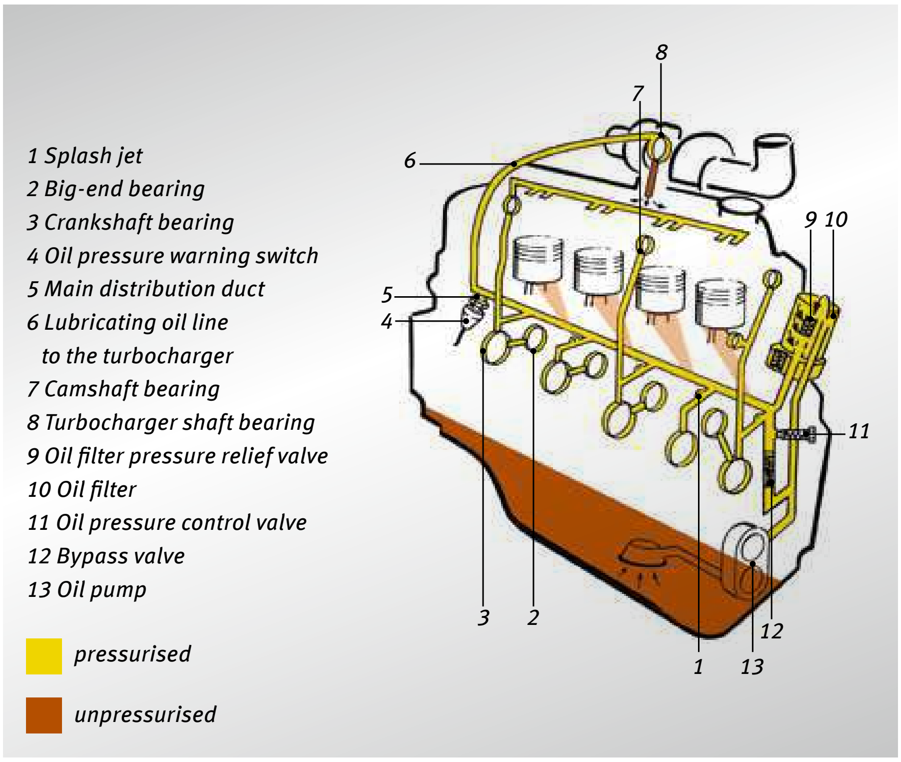

Fig. 1

3.1

...excessive bearing clearance in the turbocharger

If the bearings in the turbocharger are worn then the impeller seals will no longer be able to provide a perfect seal because of the increased bearing clearance. Engine oil is then sucked in and burned in the combustion chamber together with the air/fuel mixture.
The bearings in the turbocharger are subject to high loads during driving operation. Wear is usually caused by high engine mileage, contaminated or unsuitable engine oil or inadequate lubrication.

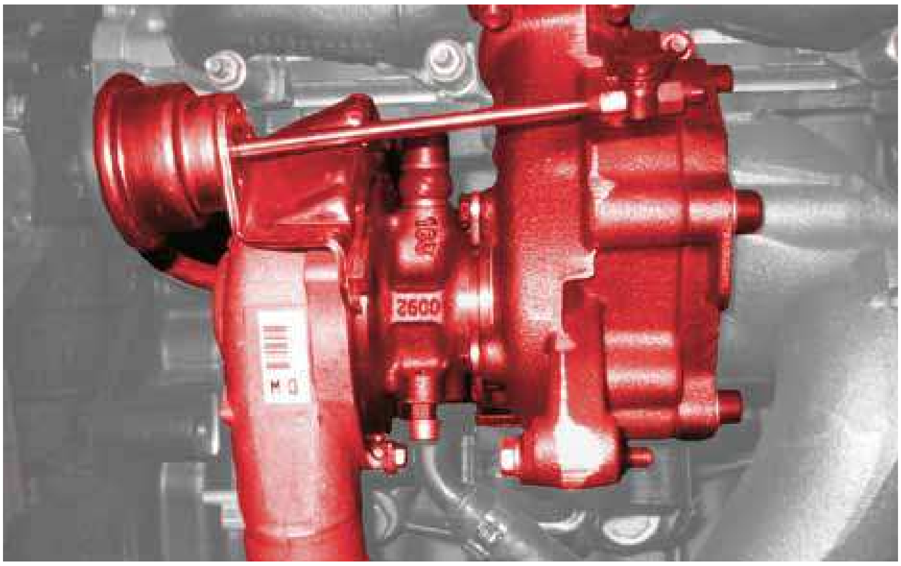

Fig. 1

3.2

...a blocked oil return line on the turbocharger

If the oil return line from the turbocharger to the cylinder block becomes too hot then the oil will coke in the line. The reason for overheating of this nature could be the quality of the oil or poor overall cooling of the engine as a whole. Coking of the return line prevents an unpressurised return of the oil to the sump. The resulting high oil pressure causes oil to escape at the impeller bearings of the turbocharger. The oil enters the intake tract and is then sucked into the combustion chamber together with the intake air and burned.

The reason for overheating is often incorrectly routed oil pressure lines, which might for example be too close to the exhaust manifold. Non-insulated lines and incorrectly mounted heat shields can also lead to the unwanted overheating.

Important note:
When overhauling an engine or replacing the turbocharger, always check the condition of the oil supply line and the oil return line of the turbocharger and replace any lines as required.


Fig. 2

3.3

...a worn fuel injection pump

The lubrication of the moving parts of an in-line injection pump is usually performed via the oil circuit of the engine. When elements of the pump become worn, engine oil can enter the working chambers elements between the cylinder and the piston of the pump during the downward stroke of the pump piston (from TDC to BDC). There the engine oil is mixed with the diesel fuel and injected into the combustion chamber during the fuel injection process and is then burned.

Important note:
When performing engine repairs because of increased fuel consumption on a diesel engine with an in-line injection pump, always check the in-line injection pump as well. This is usually done on a pump test bench with the pump removed from the vehicle.

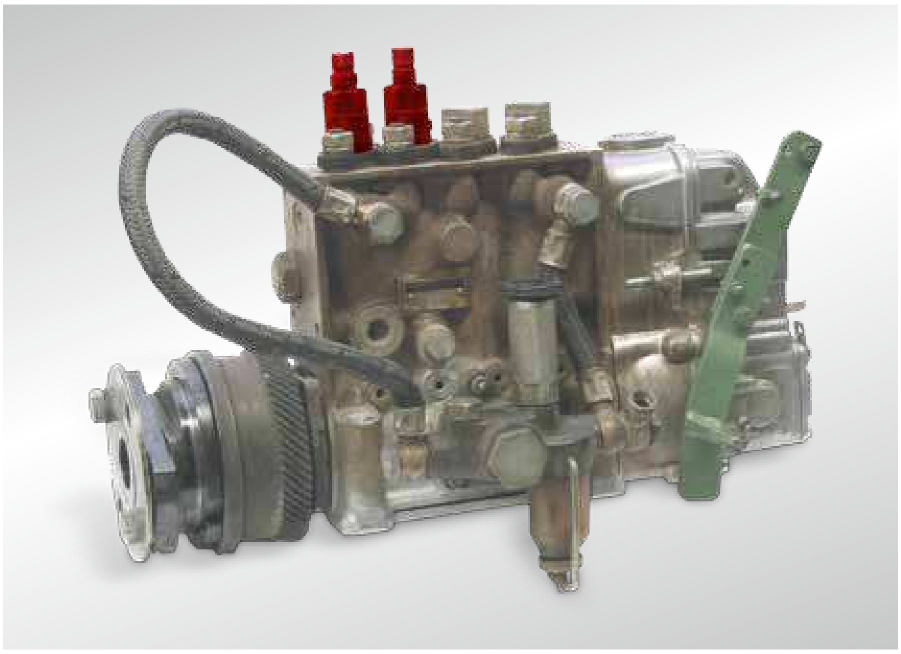

Fig. 3

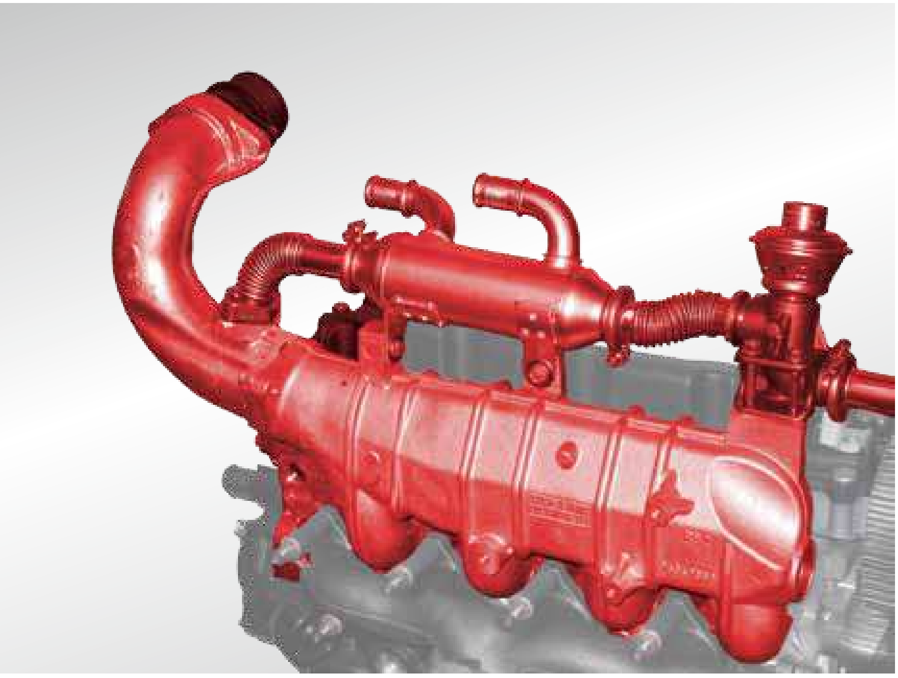

Fig. 4

3.4

...oil escaping into the intake system

The sucked in intake air has a long path until it reaches the combustion chamber. In between there are many joints and connecting points which are sealed by means of gaskets or rubber hosing. If these become porous and/or leaky, then unfiltered and contaminated air is sucked in at these points. This air then reaches the combustion chamber. Inadequate intake air filtration resulting from missing, defective or unsuitable air filters has the same effect.
The dirt/contamination entering the cylinder in this way quickly causes mixed friction and thus increased wear on the cylinder running surfaces, pistons and piston rings. This results in increased oil consumption.

3.5

...worn valve stem seals and valve guides

The valve stem seal has the task of preventing the oil from entering or exiting the valve guide. If the clearance between the valve and the valve guide is too great or the valve stem seal has been damaged during installation then increased quantities of oil will escape at this point. In this way the oil can reach the intake or exhaust tract where it is then either burned or discarded.

Tip: We recommend replacing the seals after every repair, as they become worn after prolonged operation and the material hardens when it is old. In this context, please have a look at the assembly tool for valve stem seals and the cleaning set for valve guides in our tools catalogue.

Fig. 1

3.6

...errors during installation of the cylinder head

Incorrect and inappropriate installation of the cylinder head can cause component distortion which may lead to leaking points in the oil circuit in the area of the combustion chamber. This allows oil to flow past the cylinder head gasket and via the oil supply galleries to the combustion chamber, without any oil loss being in evidence to the outside. The oil is then also burned in the combustion chamber.

Tip: In order to prevent distortion, the tightening specifications such as tightening sequence, tightening torque and tightening angle must be satisfied. You can find this information in the workshop manuals provided by the vehicle manufacturer, on the packing note provided by the seal/gasket supplier or also in our catalogue Valves and Accessories / Camshafts / Cylinder Heads.

Fig. 2

3.7

...excess pressure in the crankcase

All engines generate so-called “crankcase blow-by gases”. This term is used to describe gases which are forced past the piston rings into the crankcase as a result of high combustion pressures.
If ”crankcase blow-by gases” are generated at an increased rate because of wear to pistons, piston rings and valves, this can result in such a high pressure in the crankcase that the oil in the entire engine is forced out through the seals/ gaskets. The valve stem seals are a good example here. Under high levels of excess pressure they are subjected to much greater loads. As a result, increased quantities of oil can be forced along the valve guide into the exhaust tract or intake tract. This means increased fuel consumption. In otherwise sound engines, an increased pressure in the crankcase due to “blow-by gases” can also be caused by a defective positive crankcase ventilation valve.

High quantities of “blow-by gases” can also act as a carrier for the oil mist present in the crankcase. The increased emission of “blow-by gases” also transports greater quantities of oil mist to the positive crankcase ventilation connection in the intake tract. In this way, the oil reaches the combustion chamber where it is then burned.

Tip: Prior to final installation, always check that the positive crankcase ventilation system is clean and in perfect working order.

Fig. 3

Fig. 4

3.8

...excessively high oil levels

If the oil level is too high the crankshaft will splash more into the oil, creating more oil mist in the process. If the oil being used is unsuitable, contaminated or old then this splashing can cause the oil to foam. Together with the “crankcase blow-by gases” and the increasing levels of oil mist being generated, this then rises through the positive crankcase ventilation system towards the intake tract. If the engine is not equipped with an oil separator, this is then sucked back in by the intake system and burned in the combustion chamber. Even on engines with complex oil separation systems, the effects of the oil foaming up can render these systems useless.

3.9

...combustion faults and fuel flooding

In the event of faulty combustion due to the combustion chamber being flooded with fuel, unburned fuel remains in the combustion chamber. Any deposits of unburned fuel on the cylinder walls result in mixed friction. The consequence of this is high and rapid wear of pistons, piston rings and cylinder running surfaces.

Possible causes on petrol engines:

- mixture too rich
- turbocharger defective
- incorrect ignition timing
- faults in the ignition system

Possible causes on diesel engines:

- defective or leaking injector nozzles
- incorrect start of delivery
- defective turbocharger
- incorrect piston protrusion
- defective fuel injection pumps

Fig. 1

3.10

...incorrect piston protrusion

If after an overhaul the piston protrusion is not within the tolerance range specified by the manufacturer of the engine, the piston may strike the cylinder head if the piston protrusion is too large. The crankshaft drive is subjected to increased loads as a result. This can cause damage to the crankshaft, pistons and connecting rods. As an additional problem on diesel engines, the injector nozzles can start to vibrate as a result of the impacts. These vibrations then act on the needle of the injector nozzle, which then fails to close completely as a result. As a consequence, fuel enters the combustion chamber after the actual combustion process has finished, causing combustion faults. In addition, uncombusted fuel is deposited on the cylinder wall and destroys the film of lubricant, resulting in increased wear of pistons, piston rings and cylinder running surfaces.

Important note:

Check the piston protrusion in accordance with the information in our catalogue “Pistons / Cylinders / Assemblies”. Please note that both the diameter and the height of the piston will vary until it reaches operating temperature. Checking the pistons for freedom of movement by rotating the crankshaft after installation therefore only offers very limited information about whether or not the piston protrusion is within the specified tolerance. During installation you should aim to achieve values closer to the lower tolerance limits. Oil carbon deposits and other deposits on the piston crown can alter the gap dimensions at TDC during the course of time.

Fig. 2

3.11

...irregular maintenance

If the service intervals recommended by the manufacturer are not met then old, contaminated oil will be left in the engine for too long. As the lubricating effects deteriorate with time, there is an increasing risk of excessively high wear.

In addition to making sure that the oil change intervals are adhered to, it is also essential that the key adjustment values and test values are checked and if necessary corrected during the course of maintenance work. This will extend the service life and is a prerequisite for ensuring optimum operating conditions.

Tip: The engine should be maintained in accordance with the manufacturer's recommendations and specifications.

Fig. 3

Fig. 4

3.12

...the use of low-quality mineral oils

Reliable operation of the engine cannot necessarily be guaranteed in all operating situations if unsuitable or low-quality engine oil is used. Wear inside the engine will increase in situations such as cold starts or during operation with overly high temperatures.

The chosen oil should correspond to the manufacturer's recommendations. If the oil is lacking in key properties, for example if it has insufficient additives or the additives are not right for the engine, then there is an increased risk of wear and an associated risk of premature engine damage.

The risk of wear can be significantly reduced by using the correct engine oils as approved by the engine manufacturer.

3.13
...cylinder distortion

Cylinder distortion is evident from an uneven contact pattern with highly polished individual areas on the dry cylinder liner (Fig. 1).

Spotted, uneven contact patterns on the outer wall of the cylinder liner and in the cylinders is always an indication of cylinder distortion. If the cylinder is distorted the piston rings can neither provide a perfectly tight seal for the oil nor the combustion gases. This means that the piston rings cannot scrape off the oil at the points where the cylinder is distorted, as a result of which the oil is pushed into the combustion chamber where it is burned.

At the same time the pressure in the crankcase increases as a result of the combustion gases flowing past the piston rings. This excess pressure causes oil loss at the sealing points and oil leaks at the intake valve guides (see sections 3.7 and 4.3).

Causes:
- uneven and/or incorrect tightening of the cylinder head bolts
- deposits or dirt in the cooling system
- uneven cylinder block / cylinder head mating faces
- dirty or distorted threads on the cylinder head bolts
- unsuitable cylinder head gaskets
- faulty shoulder supports
- contact corrosion (frictional corrosion)

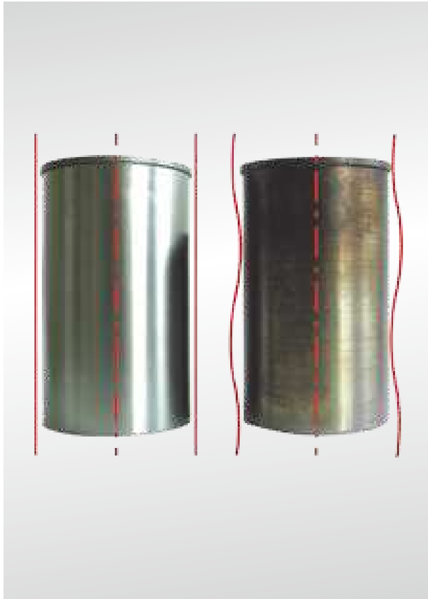

Fig. 1

Fig. 2

3.14
...machining faults during drilling and honing

If the surface of the cylinder is not machined correctly then no oil film is established between the piston ring and the running surface (oil film thickness 1–3 µm). The direct contact between the piston ring and the running surface results in high wear. The increased friction of the piston rings generates additional heat instead of dissipating the heat from the piston to the engine block. Key factors which influence the quality of the machined surface are the honing angle, the roughness values and the graphite exposure rate (refer to the next page).

3.15

...the graphite exposure rate being too low

On grey cast iron cylinder blocks, a key factor key factor for the formation of the oil film and also for the emergency running properties of the cylinder running surface is the exposure rate of the graphite veins. A perfect surface finish with an exposure rate of at least 20% enables oil to collect in the valleys of the profile and in the graphite veins, as a result of which the oil film is more resistant under higher loads and the emergency running properties are significantly improved.

Open graphite veins can absorb engine oil similarly to a sponge and then release the oil as and when it is required. If the finish is too fine and smooth, particularly when diamonds are used for finish honing, this usually indicates metal smearing during machining.

With metal smearing, the graphite veins and channels are closed during plateau honing, or they have been closed off with fine swarf (Fig. A). This makes oil absorption impossible. This layer is only removed when the engine is run in, when it is carried away by the piston rings under high wear. After a certain amount of time the composition of the cylinder surface returns to normal, but the piston rings are worn out. This means that the oil consumption of the engine will tend to increase rather than decrease after the running in phase. Even though the cause of this problem is not the piston rings themselves, it can be remedied by installing a new set of piston rings. This restores the improved lubrication properties and eliminates the oil consumption.

Honing brushes can offer help with this problem. Therefore hone brushing should be the last stage in machining the cylinder surface. Honing brushes consist of nylon fibres with silicon crystals. Without changing the dimensions, the brushing process cleans the valleys in the surface, removes swarf blocking the graphite veins and removes the peaks to create a plateau (Fig. B). Brushing technology thus provides a surface which responds much better during the run-in phase and supports the formation and protection of the oil film right from the start.

Tip: In order to help with the assessment of individual results, we offers a special service for engine reconditioners. Completed cut-outs of cylinder walls are analysed in terms of the honing angle, roughness and graphite exposure rate. The resulting honing certificate attests to the honing quality and indicates whether any processes could still be improved and, if so, which.

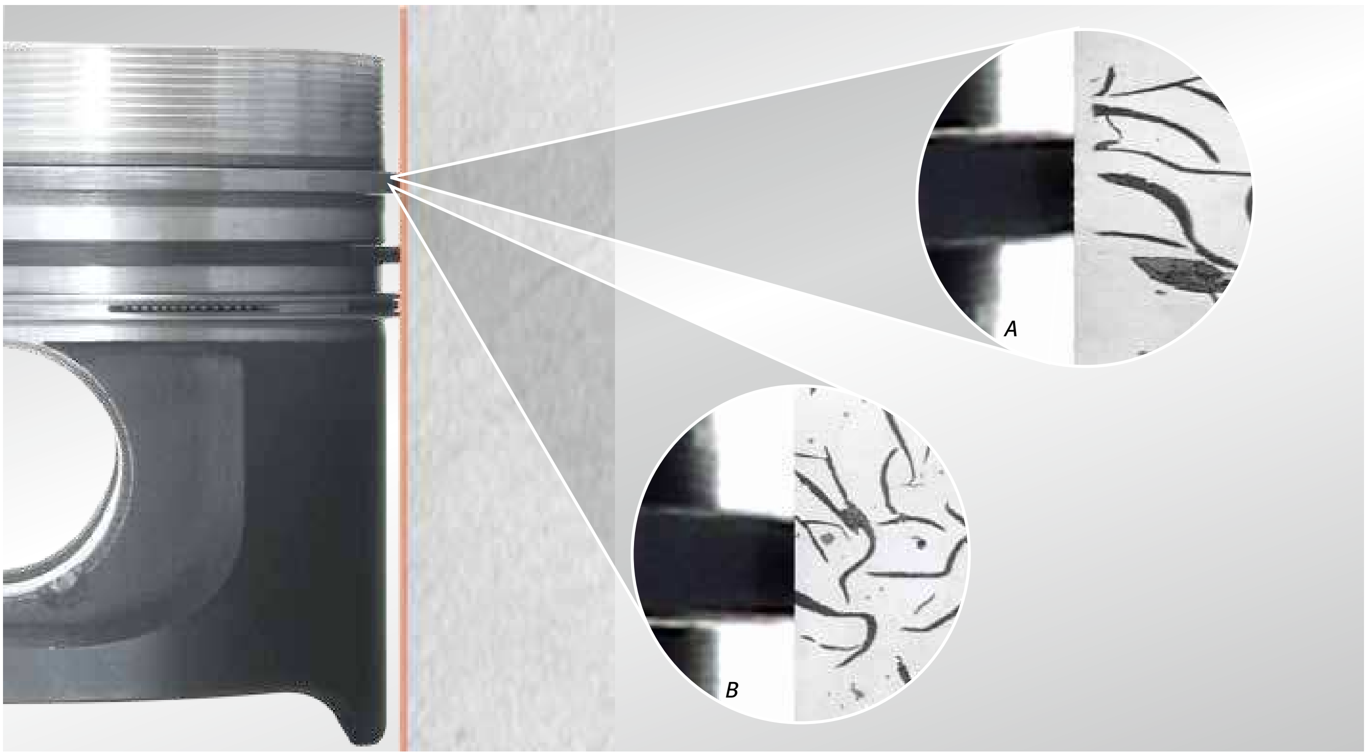

Fig. 3

3.16

...twisted/distorted connecting rods

The connecting rods play the most significant role in defining how the pistons run. Alignment errors due to twisting or distortion cause the pistons to perform a pendulum motion in the longitudinal axis of the engine, thereby causing the pistons to strike opposite sides of the cylinders in turn. Oil escapes through the gaps resulting from the motion of the pistons and reaches the combustion chamber. In the worst case scenario the pistons act like a pump, forcing even more oil upwards.

Important note:
Whenever piston damage is found you should always check the dimensional accuracy and alignment of the connecting rods.

Fig. 1

3.17

...broken/jammed/ incorrectly installed piston rings

The piston rings perform many tasks and are thus key components for the function of the engine. The main role of the piston rings is to provide a seal between the combustion chamber and the crankcase. If the piston rings cannot perform this function properly because they have not been correctly installed, the required sealing function will only be partially achieved, or possibly not at all. The oil is then no longer scraped off the cylinder wall as it should be and reaches the combustion chamber where it is burned.

If in addition faults occur in the combustion process and there is an associated dilution of the oil, the viscosity and the lubricating performance of the oil are decreased even further. This means even greater wear and oil consumption.

Causes:

- broken piston rings
- jammed piston rings
- incorrectly installed piston rings (the TOP mark must always face upwards)
- over-stretching during installation
- incorrectly assembled oil rings (example: three-part oil scraper ring)

Caution:
Always use the installation pliers to install the piston rings.

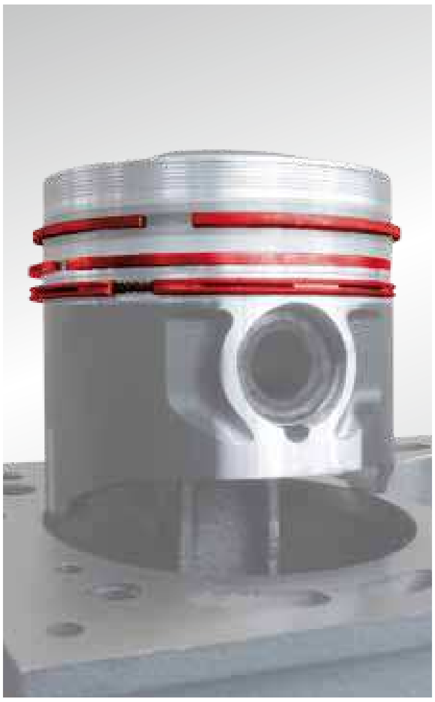

Fig. 2

4.1

...incorrect, excessive or forgotten sealant

Sealants are one of the more unsung construction elements in the engine. However, if they fail to work exactly as required the entire system can be endangered.

In a modern engine, sealants provide sealing for the various systems, both to the outside and internally between the different systems. For this purpose, sealant needs to be applied to the mating faces of various components.

In many cases sealants need to withstand high pressures. Accordingly, excessive application of sealant can also cause leaks.

Furthermore, sealant residue which is pressed from the sealing surfaces into the engine compartment can cause contamination or blockages of oil and water circuits. For this reason, some of the modern sealants dissolve when they come into contact with oil.

Caution:
When using sealants it is important that the temperature stability and application area are matched to the particular application.

Fig. 3

4.2

...overlooked foreign bodies on sealing surfaces

Foreign bodies between the gasket or seal and the component prevent proper seating. In the worst case this will lead to distortion of the components. However, there is a much greater risk that a leakage can occur if there is a loss of surface pressure on flat gaskets.
If the sealant is applied to dirty surfaces, for example to oily surfaces, then the resulting connection may not be tight and oil may escape at these points. Residue of old sealant which is not completely removed can also cause the same fault.

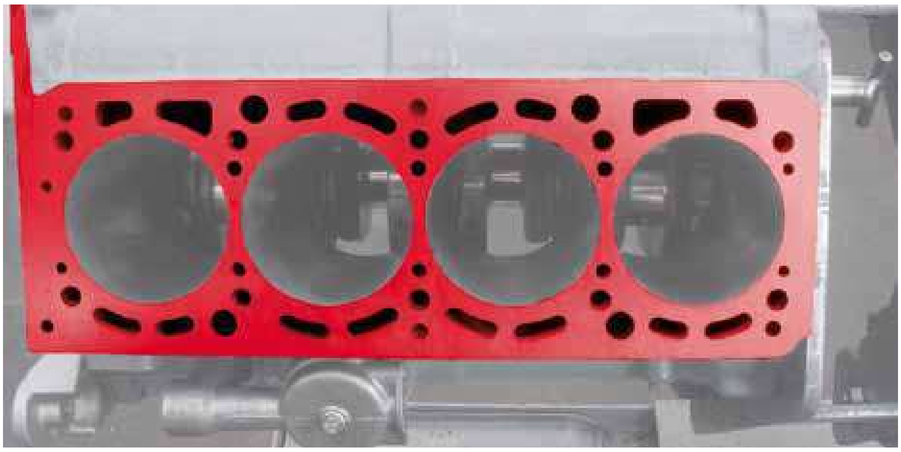

Fig. 4

Tip: Overlooked foreign bodies are one of the most common and most annoying faults. Always clean the relevant parts with particular care prior to assembly (cylinder head, sump, valve cover).

The sealing surfaces must generally be cleaned with a solvent (thinner, brake cleaning fluid) before applying a sealing compound or when using paper seals.

4.3
...leaking radial oil seals

Radial oil seals consist of a highly load-resistant sleeve made of a plastic compound, inside which a corrosion-proof stainless steel spring is embedded. This spring ensures a high and durable elasticity, compensates for cold flow and wear on the sealing lip and applies defined sealing forces. In order to ensure that the radial oil seal performs properly, it is essential that the spring is correctly installed.

The leak-tightness of the radial oil seal also depends to a great extent on the properties of the shaft running on the seal.

If there is any eccentricity on the shaft or there are any running marks on the oil seal running surface, the preload of the sealing spring will not be sufficient to ensure optimum sealing of the rubber sealing lips. In this case the oil seal running surface on the crankshaft can be reworked with a protective shaft sleeve.

As a general rule, this type of oil seal cannot withstand increased oil pressure. Any excess pressure in the crankcase therefore also places a load on the radial oil seals, and in some cases this can cause a leak.

Fig. 1

4.4
...surface faults at the mating face

If the surfaces of the components are defective or even distorted, i.e. they are not flat and level, then it is no longer possible for the gasket to provide a proper seal.

If any of the mating faces are defective, then after tightening the components down this will result in gaps between the gaskets/seals and the mating faces, through which for example the oil or cooling fluid could escape or reach the combustion chamber.

Tip:
- **Check the surface with a straightedge and refinish the surface again if required.**
- **Observe the specified minimum thickness for the cylinder head and cylinder block in accordance with the manufacturer's guidelines**
- **Observe the specified cylinder head gasket thickness (piston protrusion)**
- **Check the roughness – the effectiveness of the gasket also depends on the roughness of the surface on which it rests**

Fig. 2

4.5
...defective vacuum pumps

If the diaphragm in the vacuum pump is defective, this can have the effect that engine oil is allowed to enter into the vacuum system. This engine oil remains in the vacuum system and leads to failure of the accessories.

Fig. 3

4.6
...excessively high oil pressure

If the oil pressure is too high, the mating faces cannot withstand this higher pressure.

There can be various reasons if the oil pressure is too high:

- Oil lines and oil filters can become blocked by dirt and contamination.
- The oil circuit can be hampered by a defective oil non-return valve or oil pressure control valve.
- Blocked oil filters without a bypass valve.
- Malfunctions in the oil circuit due to the use of incorrect parts, such as incorrect non-return valves or hoses.
- Use of the incorrect engine oil.

Fig. 4

5 | Running in phase

Modern engines are so highly developed that many could be excused for thinking that the concept of “running in” was a relict from days gone by. However, the owner’s manuals of many new vehicles still contain instructions on running in the engines – and note, these are instructions, not recommendations.

The first kilometers with a reconditioned engine are crucial in the subsequent development of the oil consumption. During this phase any bearings and shafts operating with tight clearance tolerances, high rotational speeds and/or under heavy loads are at particular risk. Together with the cylinder liner, components which undergo translational movements (i.e. parallel movements back and forth) such as pistons and piston rings are among the most sensitive engine components. As modern materials are becoming increasingly resistant to wear, component pairings take a certain amount of time to adapt to each other.

Fig. 1

According to a traditional “rule of thumb”, a new engine should be treated with care for at least the first 1000 km. Motor Service recommends giving freshly reconditioned engines an even longer period of special care. A longer running in period is even required for surfaces and mating faces which have been produced under perfect conditions so that, together with the parts which have been renewed, they have time to settle. Practical experience has shown that the best time for the first oil and filter change is after 500 km. Engines which are initially run with a special running in oil are then changed over at this point to a multi-grade oil recommended by the manufacturer.

Fig. 2

Any dirt particles, swarf or sealant residue which has collected up to this point is removed from the oil circuit. The second oil service after around 5000 km marks the end of the running in phase. After this point the standard service intervals apply in accordance with the relevant manufacturer’s recommendations.

While the engine is being run in, its operation should be restricted to the mid-speed range and it should not be run under maximum load. Very low engine speeds should also be avoided in order to ensure a good supply of oil. As the piston rings are not yet sealing to optimum effect, there may be increased oil consumption at higher engine speeds. In order to optimise the machining of the surfaces and make the running in phase easier for the piston rings, we recommend the process of plateau honing or, better still, so-called “plateau brushing” (see section 3.15).

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