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Engine Mechanical

Model: N52 and N54

Production: from 9/2006

OBJECTIVES

After completion of this module you will be able to:

- Understand the basic mechanical features of the N52KP and N54
- Understand the mechanical differences between the current BMW engines
- Describe the operation of VALVETRONIC II, double VANOS, and volume controlled oil pumps

Engine Construction

Innovative Solutions

The **N52** engine concept allowed for a substantial weight savings of 10Kg (22 lbs.) over its predecessor the M54. The primary contributors to the total weight savings are the use of an innovative composite magnesium-aluminum crankcase and a lightweight exhaust manifold. The magnesium bedplate and cylinder head cover also played a significant role in overall weight reduction.

The overall lightweight engine package allows for and improved power to weight ratio as well as an improvement in fuel consumption.

Crankcase

Since magnesium cannot be used in all areas of engine construction, the N52 crankcase is a composite design. The crankcase consists of an aluminum/silicon insert which is cast inseparably in a magnesium alloy.

The crankcase is a two piece design with a separate bedplate also cast from magnesium. An additional design change from previous designs is the timing cover which is now cast as an integral part of the engine block.

The aluminum silicon insert provides the threaded connections for the transmission mounting, cylinder head and crankshaft main bolts. The insert provides the coolant passages as well. This is to prevent coolant contact with the magnesium portion of the engine block.

Magnesium - New Material in Engine Construction

Until now, magnesium has not been explored as an option for a material for engine construction. Recently, the realization is that the weight savings potential of aluminum has been exploited to its fullest. This is one of the primary factors in the decision to use magnesium as engine building material. The light weight and low density of magnesium make it an outstanding option to aluminum.

Magnesium, which has very good casting properties, makes it possible to manufacture large components with high surface quality. Despite the high accuracy of the cast parts, subsequent machining of function areas is, however, in the majority of cases unavoidable.

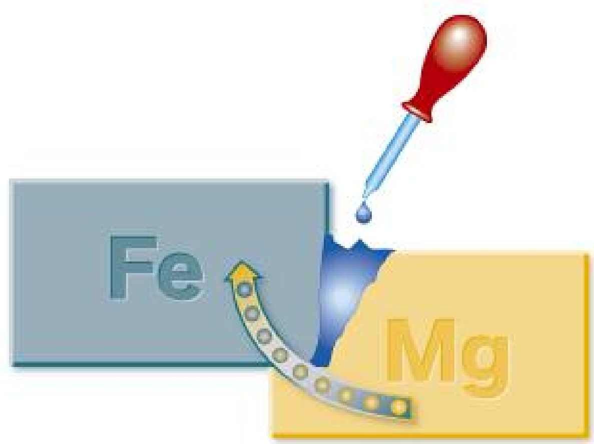
These excellent properties are, however, offset by several problematic aspects in the use of magnesium and its alloys. The former serious problem of corrosion has in the meantime been substantially alleviated by the development of distinctly more corrosion resistant alloys. The alloy used for the N52 is designated AJ62.

Nevertheless, a distinct corrosion risk still exists if the material-specific fundamentals described in the following are disregarded. Non-approved materials that come in contact with magnesium must not be installed.

This means only genuine BMW spare parts must be installed. The materials of the add-on parts must either be compatible with AJ62 or shielded by a seal/gasket from the magnesium casing. For these reasons, it is important to strictly adhere to the corresponding information provided in the repair instructions.

Electrochemical Properties of Magnesium

Metals are divided into noble (precious) and base metals. Gold, for example, is a noble metal and sodium a very base metal. The other metals are distributed over this division. When two metals such as iron and magnesium get in contact with each other and are placed in an electrically conductive liquid, e.g. a salt solution, the base metal will break down or dissolve and go into solution.



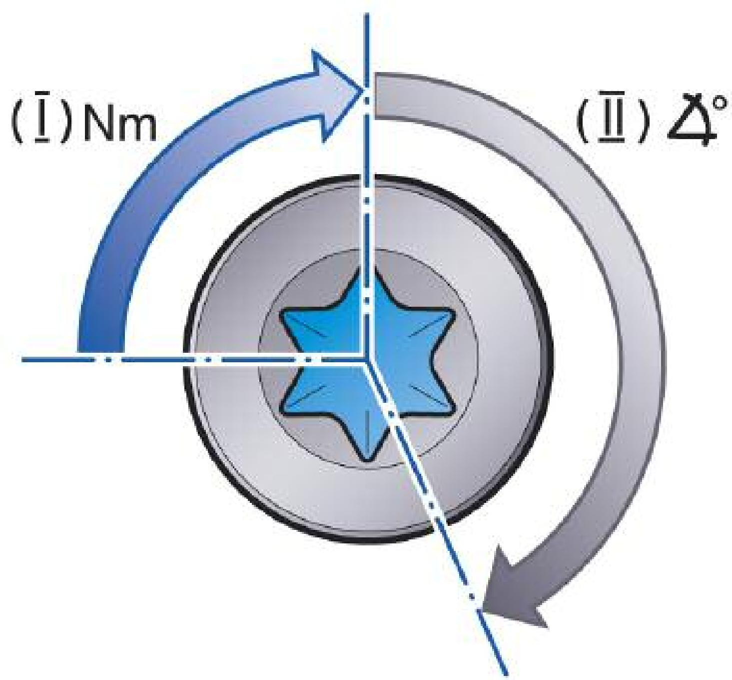
At the same time, electric current flows from the noble metal to the base metal. Under certain conditions, the base metal will deposit itself on the noble metal.

Bolts

As with the **N52**, the **N54** continues to use the aluminum bolts for most fastening duties. Even though the N54 is an all aluminum crankcase, the aluminum bolts are used to reduce any confusion. This decreases the possibility of any incorrectly installed bolts of the wrong material (steel vs. aluminum). Of course, the **N52KP** and **N51** still retains the use of aluminum bolts as well.

The same rules apply to the handling and installation of aluminum bolts as in the past. Strict adherence to repair instructions is required to ensure proper connections.

Be sure to use the proper torque/tightening angle sequence as indicated in the "tightening torques" section of TIS.



The use of magnesium is a new concept for production passenger vehicles. BMW has developed special processes for the development of the N52 crankcase. A special magnesium alloy (AJ62) is used which has excellent properties which reduce the possibility of corrosion and allow favorable machining characteristics.

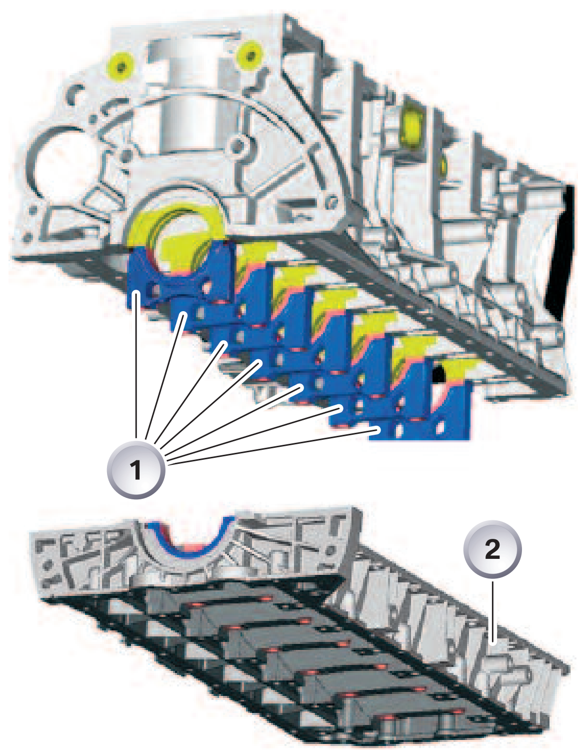
The cylinder bore consists of an Alusil structure, there are no iron cylinder liners as with previous 6 cylinder designs. The cylinder bores cannot be machined, however this design still allows for planing of the deck surface if needed.

Bedplate

The **N52** engine uses a split crankcase, the upper section is made from a **composite magnesium/aluminum** structure. The lower portion, which is used to increase rigidity, is designed as a bedplate structure made from magnesium.

There are sintered steel inlays (arrow) for the main bearings to take up forces which would not be suitable for magnesium alone.

Between the bedplate and crankcase, a liquid sealer is injected under high pressure into a machined groove. This process is critical in service applications.



Index	Explanation
1	Bedplate inlays
2	Bedplate

Of the three new 6-cylinder engines introduced in 2007, the **N54** has the most changes in comparison with the N52. Beginning with the crankcase, the N54 engine uses an **all aluminum** alloy block with cast cylinder liners. The aluminum crankcase is pressure cast and differs from the "insert" design of the N52. This design is in contrast to the previous composite magnesium/aluminum crankcase on the N52. The construction of the N54 crankcase is to accommodate the increased torque output of the turbocharged N54.

All aluminum (AL226 alloy) crankcase - N54

Dimensionally, the N54 crankcase is the same as the N52 and continues to use the 2-piece crankcase with bedplate. There are some slight differences regarding the bolt pattern for the transmission mounting. This requires a new engine mounting bracket when installing on to the engine stand.

Gaskets and Seals

The gasket design on the new engines is mostly similar to the N52. The N54 uses a specific head gasket for use with the turbocharged application. The head gasket is a multi-layered design which does not have the protruding lip as on the N52. This lip is not needed due to the fact that the cylinder head is aluminum and contact corrosion is not an issue.

The split crankcase still uses the injected sealant carried over from the N52.

Piston and Connecting Rods

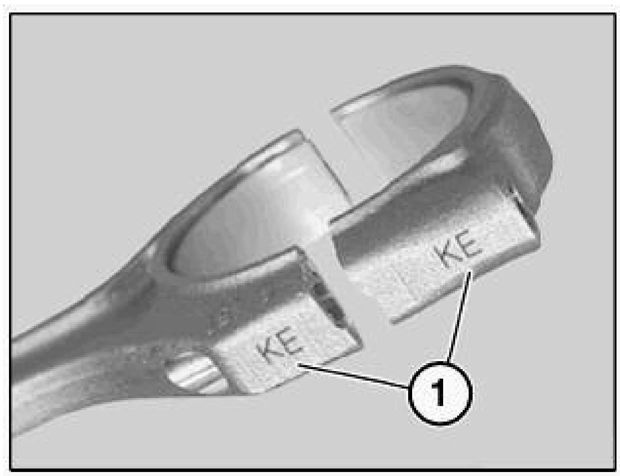
As with the cylinder head, the piston designs differ between engines. Special pistons are used for compatibility with the direct injection system. The piston crown is modified to meet the mixture formation and higher compression requirements.

As in the past, the underside of the pistons are cooled with oil spray jets.

The **N51** engine uses a lower compression ratio and accordingly uses a different piston design. The N52KP uses the same design as the N52 engine.

The connecting rods on all of the NG engines have been stiffened with a thicker beam on the rod. This design has also been in production since the N52 (6/06).

The connecting rods are weight optimized by tapering the "small end" of the rod. This method reduces weight without reducing strength.



The "**big end**" of the connecting rod is "**cracked**" to create to proper centering of the bearing cap without the use of dowel pins. This further contributes to the overall weight reduction. Each connecting rod uses pairing codes (1) to allow the correct rod cap to be matched to the connecting rod.

The connecting rods are divided into weight categories and can only be replaced as a set.

Crankshafts

While a cast iron crankshaft is used in the N52KP, N51 and N55. The **N54**, **N63** and **N74** all use a **forged steel crankshaft**.

To reduce weight, the main bearings diameter of the crankshaft have been reduced and contain an integrated sprocket for the oil pump. See the specific engine training material for further details.

Differential Intake Air Control (DISA) N52

The torque developed in an engine greatly depends on the quality of the fresh gas charge during the induction stroke.

Oscillations are induced in the intake air mass during the induction strokes of the individual cylinders, i.e. by the downward movement of the pistons. These oscillations are in turn superimposed by oscillations that arise from pressure peaks as soon as the moved air mass of an intake cylinder comes up against the closing intake valves.

When two oscillations are superimposed, the resulting oscillation is known as the resonance oscillation or sympathetic vibration. The resonance can be an amplification or an attenuation of the initial oscillation or vibration.

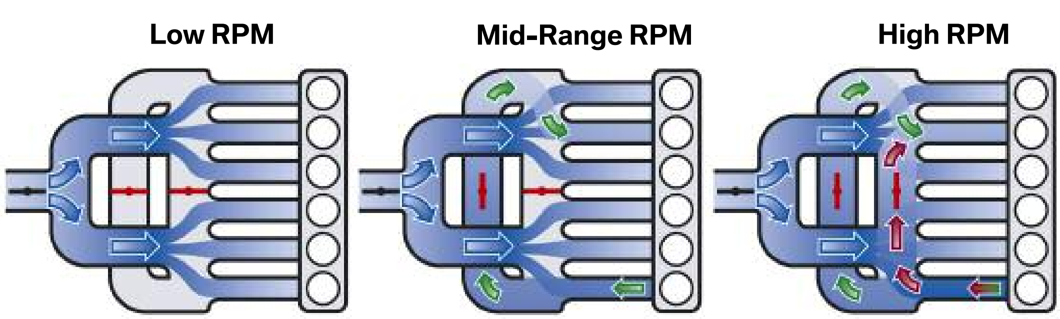
Whether a pressure peak or a pressure hole is applied before the intake valves at the cylinder at the start of the induction stroke depends on the path the superimposed oscillations have covered in the intake area and on the engine speed, i.e. the gas speed.

The desire for high torque over a broad engine speed range necessitates an increasingly diverse range of air intake systems for internal combustion engines. The geometry and control of the intake manifold therefore have a considerable influence on the quality of the charge cycle. An intake manifold with a fixed length would provide an optimum cylinder charge only at a certain engine speed.

The options of boosting torque over a defined engine speed window are limited. Since the N52 reaches a maximum engine speed of 7,000 rpm, the previous 2-stage DISA in the M54 would produce a torque lag in the mid engine speed range. The N52 is thus equipped with a 3-stage DISA in order to provide high torque also in the medium engine speed range.

The result of these three stages is illustrated in the diagram below. The switched stages of the DISA achieve a high torque over the entire engine speed range. This principle is realized by means of an intake manifold changeover facility with two DISA actuators and an overflow pipe in the intake area.

In contrast to the previous system that was controlled with vacuum, the two DISA actuators are now operated by electric motors.



Cylinder Head Cover

The cylinder head cover of the **N52** is cast from **magnesium alloy**. The cylinder head cover provides an important mounting point for the VVT motor. All of the bolts which attach the cylinder head cover to the cylinder head are made from aluminum.

When performing repairs which involve the removal of the cylinder head cover be sure to replace the bolts and use the proper torque/angle procedure as outlined in the repair instructions.

While the N52 uses a magnesium cylinder head cover, the newer engines 6 cylinder engines use a plastic cover. The N52KP and N51 use the same basic design to accommodate the VVT motor and new crankcase ventilation system. In comparison, the N54 uses a completely different design. This is due to the lack of VALVETRONIC and the modified crankcase ventilation system.

The cylinder head cover of the N55 is a new development. The accumulator for the vacuum system, all crankcase ventilation components and the blow-by channels are integrated into the cylinder head cover.

N52 Cylinder head cover

N54 Cylinder head cover

N55 Cylinder head cover

Cylinder Head

As far as cylinder head designs are concerned, all four of the 6-cylinder engines use a different cylinder head. While all of the heads are made from aluminum, they differ due to the design requirements. For example, the N54 does not use VALVETRONIC and requires accommodation for the fuel injectors for direct injection. The N52KP engine uses a cylinder head which is mostly identical to the N52. The N51, which is a SULEV II design, uses a lower compression ratio and therefore a different cylinder head with a modified combustion chamber. Finally, the N55 uses VALVETRONIC III instead of VVT II with HDE injection.

Cross-section of N54 Cylinder Head

The N54 cylinder head features the injector and spark plugs arranged in the center of the combustion chamber surrounded by the intake and exhaust valves. This arrangement is typical of a direct injection engine and has been implemented into most current BMW engines cylinder head designs. Engines that use this design are the N54, N55, N63, S63 and N74.

Please refer to the individual engine training information or repair instructions for further information.

Valvetrain

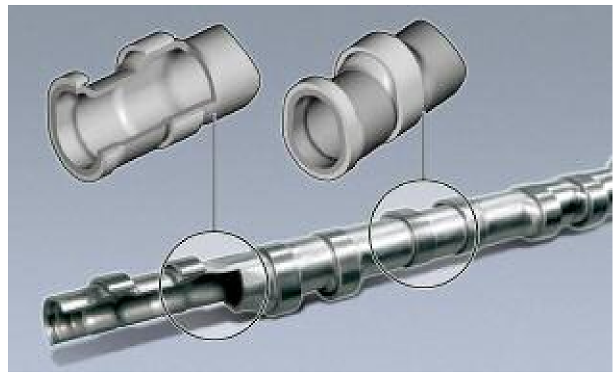
With regard to the valvetrain changes, the intake valves still use the 5mm stem from the N52. However, the exhaust valves have been upgraded to a 6mm valve stem for increased durability. The 6mm exhaust stem has also been in production on the current N52 since 3/06.

Although most current BMW engines have solid construction valves the N55 exhaust valve stems are hollow, filled with sodium and are 6mm in diameter. In addition, the valve seat of the exhaust valves are reinforced.

Camshafts

Recent advancements in engine technology have brought about new camshaft designs. Most engine variants take advantage of the lightweight, hydroformed camshafts from the N52. The lightweight camshafts are manufactured in an internal high pressure forming process called hydroforming.

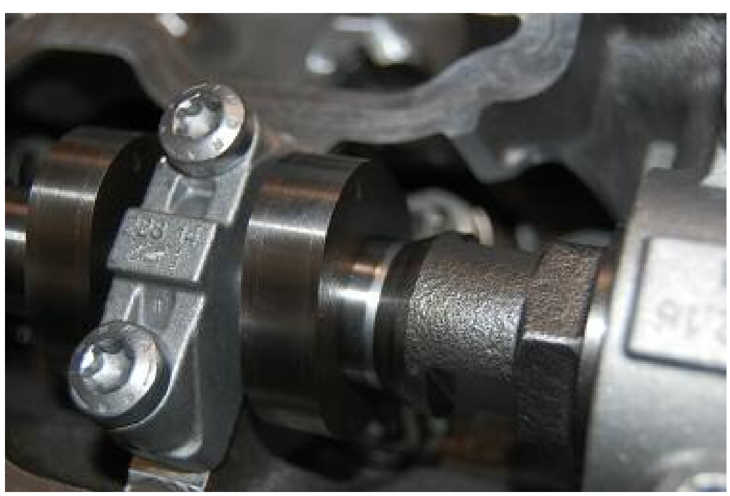
Lightweight hydroformed camshaft



Only **lightweight hydroformed** camshafts are used on the **N55** engine. The exhaust camshaft features bearing races and is encapsulated in a camshaft housing.
The camshaft housing reduces oil foaming during operation.

The **N63** and **N74** engines have assembled camshafts, of the type as used on the M73 engine. These camshafts are assembled from individual components rather than machined from a solid cast iron blank. All components are shrink-fitted on to the shaft. This technology not only provides a reduction in manufacturing costs, but also a considerable weight savings.

Note: For supply and production reasons, it is possible that lightweight hydroformed camshafts as well as cast camshafts or a mixture of both were installed in N51, N52 and N54 engines.



VANOS

All current BMW engines use the **infinitely variable double VANOS** system which was first introduced on the M52B20TU engine. The design is similar to that of two-setting intake VANOS; the main difference is that in addition to the timing of the intake camshaft, the timing of the exhaust camshaft can also be varied. The system allows for infinite variation of timing of both camshafts according to the control commands from the engine management ECU.

The advantages of infinitely variable double VANOS are:

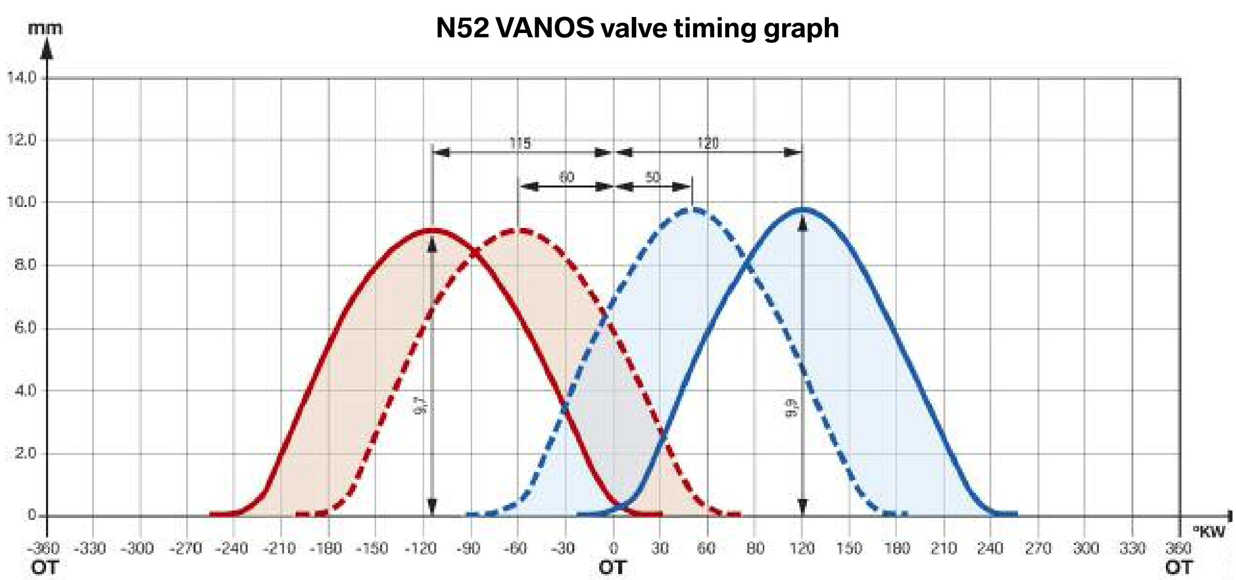
- Higher torque at low and medium engine speeds.
- Smaller quantity of residual exhaust when idling due to smaller valve overlap resulting in improved idling.
- Internal exhaust recirculation in the medium power band in order to reduce nitrogen oxide emissions.
- Faster warm-up of catalytic converters and lower raw emission levels after a cold start.
- Reduction of fuel consumption.

The possible adjustment range of the double VANOS system is clearly identifiable by the blue/red shaded areas

The infinitely variable double VANOS system is used on all current engines. The main, and sometimes only, change to the system is that each engine uses different spread ranges (check engine specifications for the individual cam spread).

As with the previous systems, the VANOS units should not be mixed up as the spread ranges for the intake and exhaust are different and engine damage could result.

N52 VANOS valve timing graph



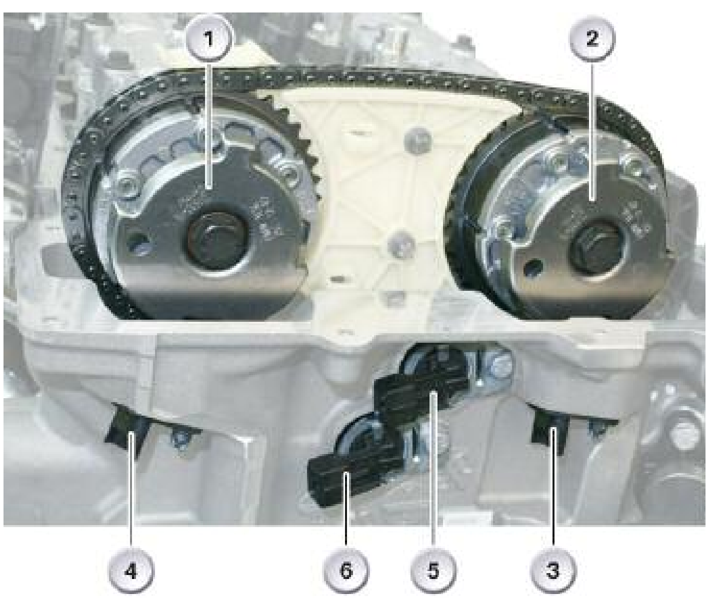
The infinitely variable double VANOS system of the N52 uses hydraulic oscillating motor type VANOS units for the intake and the exhaust cams. Although they have identical function, the oscillating motor VANOS units are a further development of the variable vane type motor VANOS units used on previous systems. They are designed as an integrated component in the chain drive and are mounted with a central bolt on the respective camshaft. When de-pressurized, a coil spring holds the VANOS unit in the base position.

N52 Hydraulic oscillating motor/VANOS unit

Index	Explanation
1	Front plate
2	Locking pin
3	Oil channel
4	Casing with ring gear
5	Pressure chamber for advancing
6	Oscillating rotor
7	Pressure chamber for retarding
8	Oil channel

The VANOS units are controlled by oil pressure from the 4/3 proportional solenoid valves. The valves are located in the front of the cylinder head and are controlled by the ECM. The ECM regulates the VANOS based on factors such as engine RPM, load and coolant temperature.

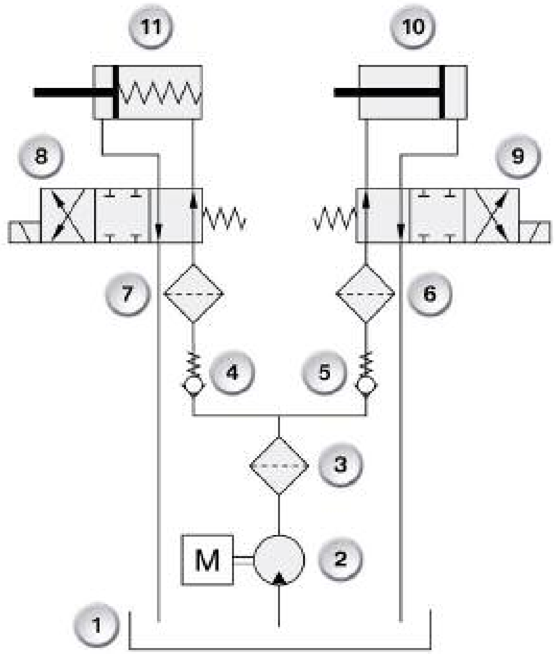
N52 VANOS system



Index	Explanation
1	VANOS unit, Exhaust
2	VANOS unit, intake
3	Intake camshaft sensor
4	Exhaust camshaft sensor
5	VANOS solenoid valve
6	VANOS solenoid valve

Hydraulic Circuit Diagram

N52 VANOS system hydraulic circuit



Index	Explanation	Index	Explanation
1	Sump	7	Filter
2	Oil pump	8	Solenoid valve
3	Oil filter	9	Solenoid valve
4	Non-return valve	10	Hydraulic vane motor
5	Non-return valve	11	Hydraulic vane motor
6	Filter		

The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there separately for the intake and exhaust camshafts through a non-return valve (5) fitted between the cylinder head and the crankcase, into a fine filter (6) on the solenoid valve, and into the solenoid valve (9). The solenoid valves direct the flow of oil so as to apply pressure to either one side or other of the pressure chamber in relevant hydraulic vane motor (10 or 11).

The position of the intake and exhaust camshafts is adjusted by a hydraulic vane motor on each camshaft.

The two seals between camshaft and camshaft bearing are required to ensure a reliable supply of oil. The solenoid valves are attached to the cylinder head by mounting brackets. The mounting brackets must not be bent; observe repair instructions. The adjustment time for 60 ° of crankshaft rotation is approx. **300 ms**.

That figure is true of all VANOS systems with hydraulic vane motor or oscillating motor.

Volume Controlled Oil Pump

The high oil volume demands of the VANOS system creates a need for an oil pump that can deliver a high volume of oil when needed. Also, the pump needs to be able to cut back on the oil delivery volume when the requirements are not as great.

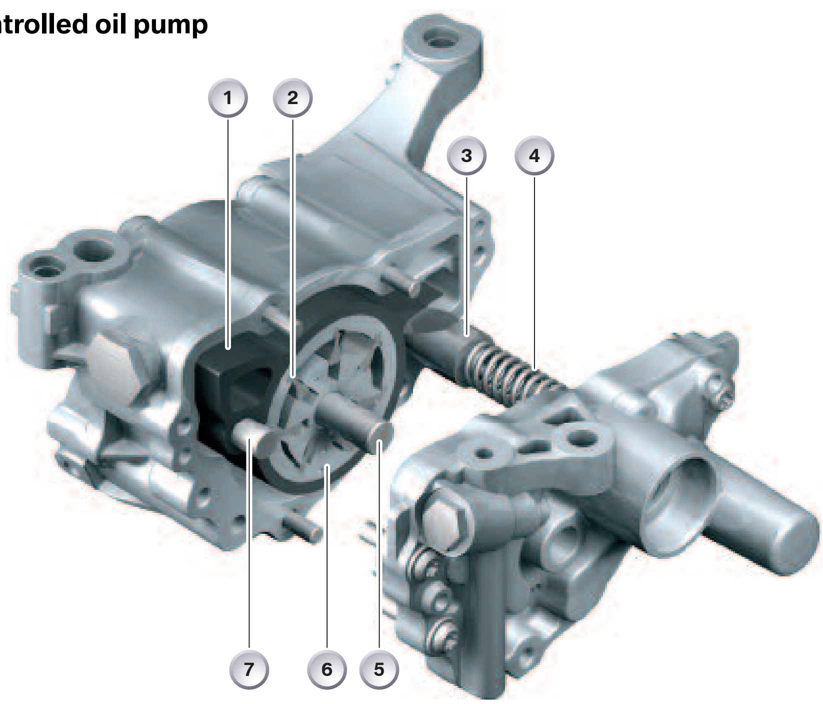
This occurs when the VANOS is not as active, for instance during cruise situations.

This oil pump is a "volume controlled" design which not only meets the oiling requirements, but also contributes to improved fuel economy and emissions.

The advantages of a volumetric-flow controlled oil pump:

- Favorable space/efficiency ratio
- Provides sufficient hydraulic pressure and volume for valve control systems
- Reduced volumetric flow fluctuations
- Hydraulic energy not converted into thermal loss
- Reduction of premature oil aggiing
- Reduced sound emissions

N52 volume controlled oil pump

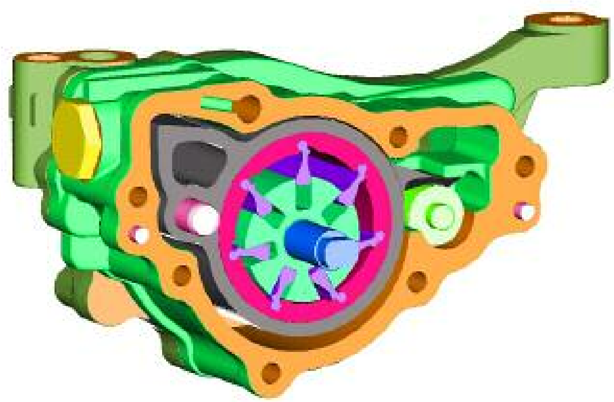


Index	Explanation	Index	Explanation
1	Vane	5	Pump Shaft
2	Slide Valve	6	Rotor
3	Control Piston with Pendulum Support	7	Pivot
4	Compression Spring		

The N52 engine was the first to be equipped with a volumetric-flow controlled oil pump. This type of pump delivers only as much oil as is necessary under the respective engine operating conditions. The pump minimizes the oil flow delivered in low load operating ranges. This reduces the fuel consumption of the engine and slows down the oil wear rate.

The pump is designed as a slide valve-type vane pump. In delivery mode, the pump shaft is positioned off-center in the housing and the vanes are displaced radially during rotation. As a result, the vanes form chambers of differing volume. The oil is drawn in as the volume increases and, conversely, expelled into the oil channels as the volume decreases.

Control Piston with Pendulum Support



Oil Pump Operation

The crankshaft drives the oil pump with a chain. The applied oil pressure acts on the control piston/pendulum support against the force of a compression spring. The pendulum support varies the position of the slide valve according to the applied oil pressure. When the pump shaft is positioned towards the center of the slide valve the changes in volume are small and the delivered volume is low. When the pump shaft is located off center, the changes in volume and the delivered quantity are greater. If the oil required by the engine increases, for example during VANOS control intervention, the pressure in the lubricating system drops therefore it is also reduced at the control spool. In response, the pump increases the delivery volume and re-establishes the pressure conditions. When the oil required by the engine decreases, the pump correspondingly reduces the delivery quantity towards the zero-delivery direction.

The oil pump used in the N55 engine is a further development of the shuttle slide valve volume control oil pump. The activation of the oil pump is adapted by the engine management and controlled through an oil pressure control valve. See the N55 engine training material for more information.

NOTES PAGE

VALVETRONIC II

With the introduction of the N52, the 6-cylinder engine is now also equipped with the load control system based on the valve timing gear. The VALVETRONIC I system that was used on the 8-cylinder and 12-cylinder engines already achieved a substantial increase in efficiency. BMW has further developed this concept with the VALVETRONIC II.

The results of this further development are:

- Increased engine dynamics.
- Increased efficiency.
- Improved emission values.

These results underscore BMW-specific standards. This engine that features the following optimizations further enhances the Ultimate Driving Machine.

- The top engine speed has been increased to 7,000 rpm.
- The specific power output has been increased to 63.4 kW/l (85 hp/liter).
- The specific engine torque is 100 Nm/l over a broad engine speed range.
- Distinctly increased valve acceleration values and friction-optimized transmission elements result in an even more responsive engine.
- CO_2 emissions reduced.
- Compliance with the world's most stringent exhaust emission regulations.

Design/Function

The VALVETRONIC II consists of the fully variable valve lift control combined with the variable camshaft control (double VANOS). The valve lift is controlled only on the intake side while the camshaft is adjusted also on the exhaust side.

The throttle-free load control is implemented by variable valve lift of the intake valve, variable valve opening timing of the intake valve and variable camshaft spread of the intake and exhaust camshaft.

In terms of this load control principle, VALVETRONIC II corresponds to the VALVETRONIC I introduced on the N62 engine. (See the N52 training material for more information)

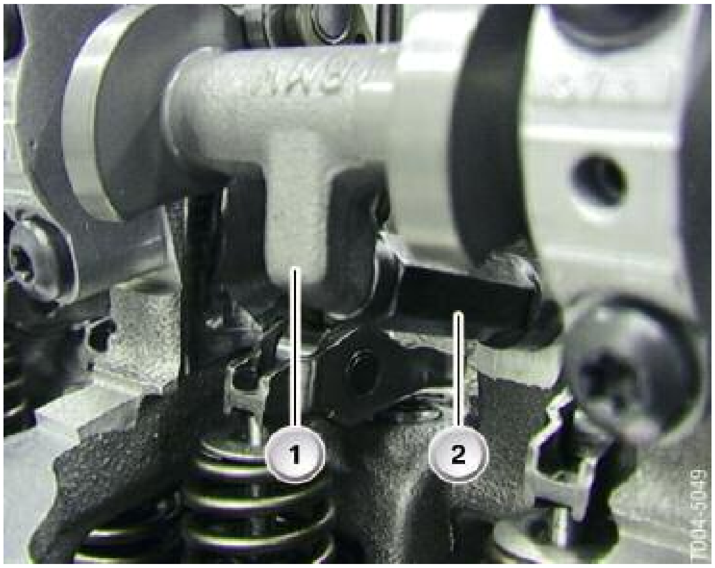
System optimization includes modification of the valve gear kinematics, a modified actuator motor and the adapted spread range of the VANOS units.

The main differences are:

- The plain bearing on the intermediate lever to the eccentric shaft has been replaced by a roller bearing, thus reducing the friction in the valve timing gear.
- Guidance of the intermediate lever is more precise. Only one spring is now required to guide and hold the intermediate lever.
- The moved mass of the valve timing gear has been reduced by 13%.
- The lift range of the intake valves has been improved. The **maximum** lift has been increased to **9.9 mm** but more importantly the **minimum** lift has been further reduced to **0.18 mm**.

The overall result is supported by further improvements in the intake manifold and exhaust dynamics.

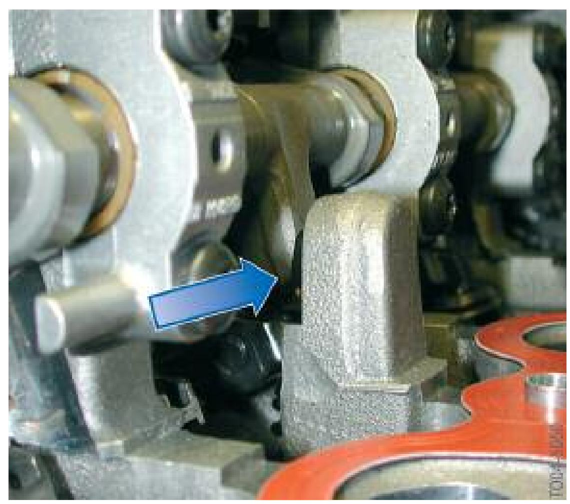
In the minimum valve lift position, the eccentric-shaft stop (1) is in contact with the cylinder-head stop (2) which is screwed into the cylinder head. That way, the minimum valve lift is mechanically limited.



Index	Explanation
1	Eccentric-shaft stop
2	Cylinder-head stop

The maximum valve lift is also limited by a mechanical stop as can be seen from the following illustration.

A stop routine can be implemented between the mechanical stops in order to detect the positions of the mechanical stops. For this purpose, the eccentric shaft is adjusted from zero lift to full lift. The stop routine is executed only when the motor electronics determines implausible values during the engine start procedure. The stop routine can also be initiated by the diagnosis systems.



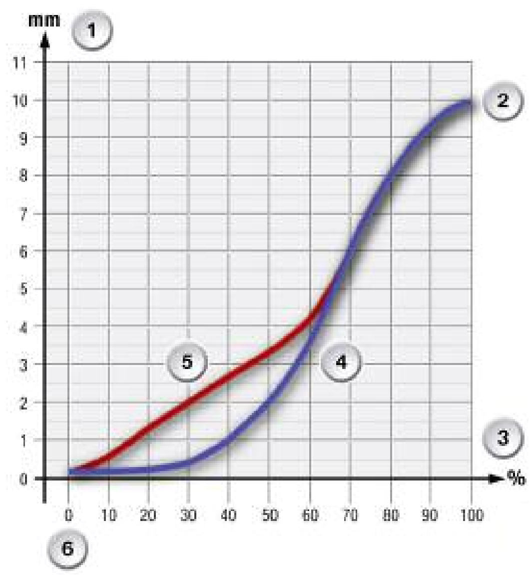
VALVETRONIC II is used on N52 and N51.

VALVETRONIC III was introduced with the N55 where it is combined with double VANOS, Direct Injection and Turbocharging (TVDI). Refer to the N55 training material for more information.

Phasing
Because VALVETRONIC II, is a very fast and precise torque control system a "Phasing" procedure is implemented to assist adjustment in the lower valve lift range. Both of the intake valves of a cylinder open together up to a lift of 0.2 mm. Past that point Valve 1 begins to lead (advance) Valve 2 which opens with a slight delay relative to Valve 1. Valve 2 catches up to Valve 1 again at a lift of approx. 6 mm. From there on, they open together again. The phasing is made possible by a slight variation in the profiles of the two cams on the eccentric shaft of a cylinder.

This opening characteristic has a favorable effect on the inflow of gasses into the cylinder. By keeping the opening cross section of the intake valves small a distinctly higher flow rate at a constant intake volume is achieved. In connection with the geometry in the upper area of the combustion chamber, this higher flow rate is used to mix the air/fuel mixture more effectively.

Intake valve lift curve



Index	Explanation
1	Valve lift (in mm)
2	Maximum valve lift at full power
3	Output (in %)
4	Inlet valve 2
5	Inlet valve 1
6	Minimum valve lift when idling

The N52KP and N51 retain the already proven VALVETRONIC system with an optimized VVT motor as of 2007.

Initially turbocharged engines did NOT use VALVETRONIC, as is the case of N54, N63 and N74. This is due to the fact that the VALVETRONIC system is designed to reduce pumping losses. It improves volumetric efficiency by optimizing the air charge. A turbocharger system is also designed to increase volumetric efficiency by reducing pumping losses. Therefore, there was no need for both of these systems to be employed on the same engine. However with the introduction of the N55 engine turbocharging, direct injection and double VANOS were combined for the first time with the third generation VALVETRONIC system (TVDI) to enhance even further the efficiency of the engine without sacrificing performance.

See the N55 training material or the Engine Technology section for more information.

Vacuum Pump

As with the N62 engine, the N52 has little vacuum available in the intake manifold to operate certain components due in part to the use of the VALVETRONIC system.

The vacuum pump supplies vacuum to the brake booster and the exhaust flap damper and wastegate valve (on turbocharged engines). Thanks to the vacuum pump the exhaust flap damper system no longer requires a vacuum storage reservoir because its operation is no longer affected by variations in intake manifold vacuum.

Although the vacuum pump of N52/N51 is single stage, the vacuum pump used on later engines (N54, N55, N63 and N74) is designed as a **two-stage** pump and therefore has two connections. The first stage is for the brake booster and the second for the secondary loads.

The N51, N52, N54 and N55 engines use a vacuum pump driven by the timing chain drive.The N63 drives the vacuum pump via the rear of the intake cam while the N74 drives it via the front of the exhaust cam.

N63 Vacuum pump location

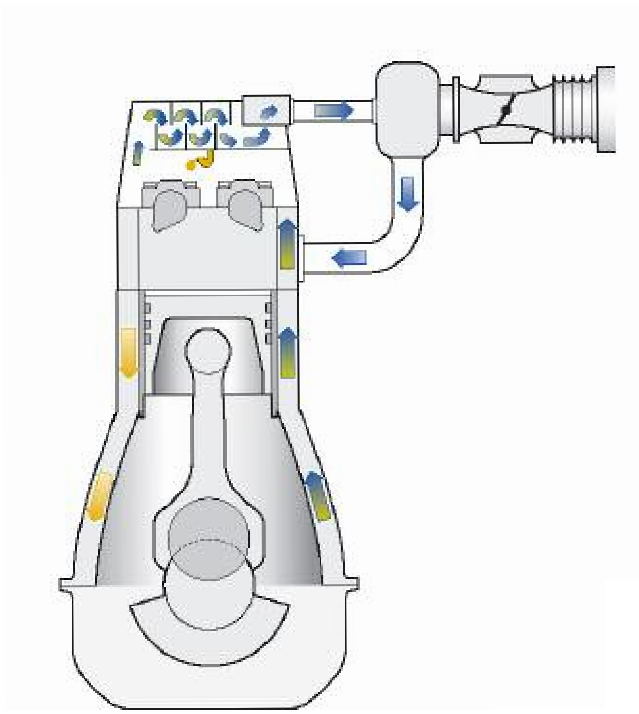
N52 Vacuum pump location

N54/N55 Vacuum pump location

Crankcase Ventilation

There are two basic methods for ventilating the crankcase which have been in used by BMW engines. One of the methods uses a crankcase ventilation valve and the other does not. In either case, the crankcase vapors must be metered into the intake and the oil must be separated from the vapors.

The basic crankcase ventilation system is shown below. It features the “labyrinth” method of oil separation which uses a maze of channels to divide the crankcase vapor from the liquid oil. The vapors can enter the engine through a “calibrated” orifice, while to liquid oil returns back into the engine or oil sump.



The N52KP and N51 engines use a crankcase ventilation valve and the “labyrinth” method of oil separation.

The N54 engine does not use a crankcase ventilation valve and oil is separated using the “cyclonic method” of the cyclone separators.

The crankcase ventilation systems on turbocharged engines operate in two modes. One mode is for turbocharged operation (Boost mode) and the other is for “naturally aspirated mode” (under low load and deceleration).

The N63 and N74 engine crankcase ventilation operate in accordance with the same principle as on the N54 engine with some differences. In the case of the N63 engine, each cylinder bank has its own crankcase breather.

The N55 uses a different design principle from all previous engines. The operation is described in detail in the N55 training material.

N54 Crankcase Ventilation

The crankcase ventilation system of the N54 engine is unique due to the fact that this is a turbocharged engine. This means the intake manifold pressure will be higher than that of a naturally aspirated engine. This presents new challenges regarding the design of the crankcase ventilation system.

The basic description of the system is as follows:

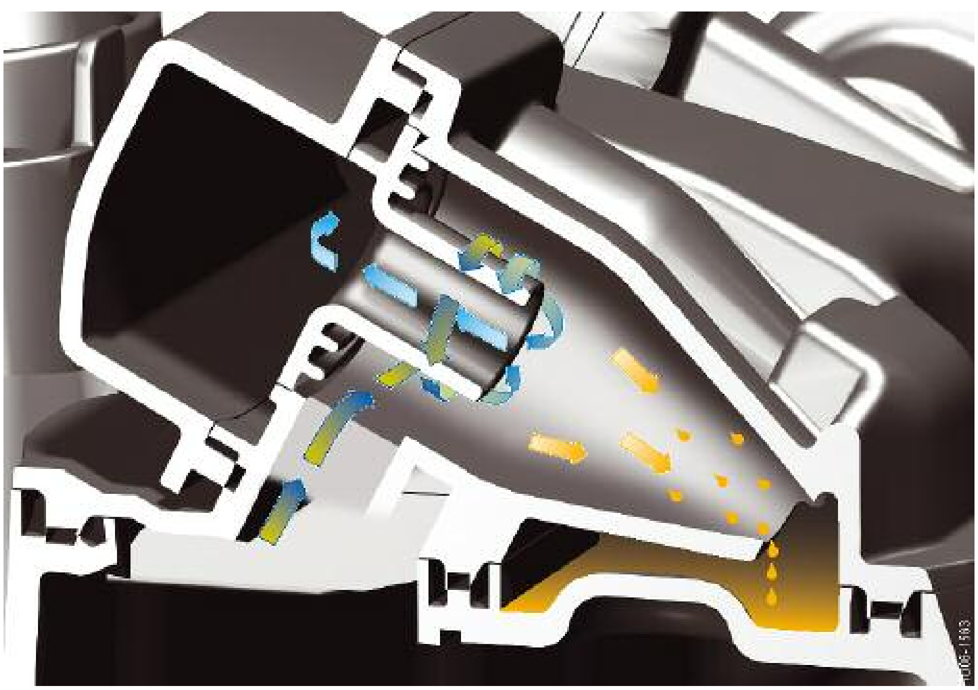
- The system uses a calibrated orifice to meter crankcase vapors into the engine.
- Liquid oil is separated from the crankcase vapors is done by “cyclonic” action.
- There are 2 channels for crankcase vapors depending upon the manifold pressure.
- Most of the system components are integrated into the cylinder head cover.

One of the most important features is the fact that most of the system components are integrated into the plastic cylinder head cover. This allows engine heat to warm the crankcase vapors which prevents any potential freezing of any water vapor trapped in the system. In contrast to the N52, there is only one heating element located at the intake manifold inlet.

Cyclone Separator

A cyclone oil separator is used in the N54 engine. Here, four of the described cyclones are integrated into the oil-separator housing. The oil mist drawn in from the crankcase is set into a spinning motion in the cyclone. As a result of the centrifugal forces, the heavier oil settles on the cyclone walls and from there drips into the oil drain.

The lighter blow-by gases are sucked out from the middle of the cyclone. The purified blow-by gases are then fed to the air-intake system.



Crankcase Ventilation System Function

The crankcase ventilation system of the N54 must be capable of venting the crankcase during two different modes of engine operation. When the engine is in deceleration, the intake manifold pressure is low (high vacuum). During acceleration or idling, the intake manifold pressure is higher (low vacuum). Therefore the system operates differently in these modes. This is what is unique about the crankcase venting system on the N54.

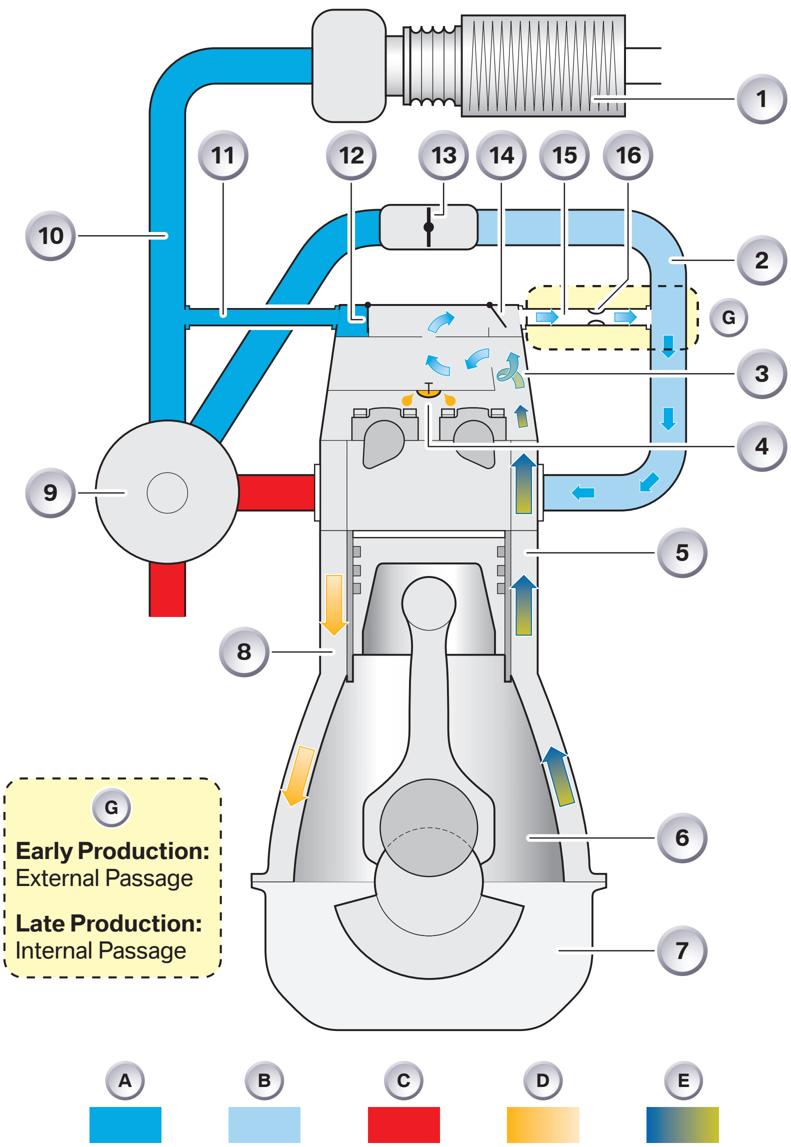
Index	Explanation	Index	Explanation
1	Check valve, charge air suction line	3	Check valve, manifold and pressure restrictor
2	Ventilation, turbocharged operation	4	Ventilation, naturally aspirated mode (decel)

Operation with Low Manifold Pressure

When the engine has low manifold pressure such as in decel, the crankcase vapors are routed through a channel (15) between the cylinder head cover and intake manifold. The liquid oil is separated before the channel in the cyclonic separators (3) in the cylinder head cover. The liquid oil returns to the engine via the oil discharge valve (4).

The channel contains a pressure restrictor (16) which regulates the flow of crankcase vapors. During deceleration, the crankcase vapors (E) are directed via a check valve (14) which is located in the cylinder head cover. The check valve is opened when low pressure is present in the intake manifold (throttle closed).

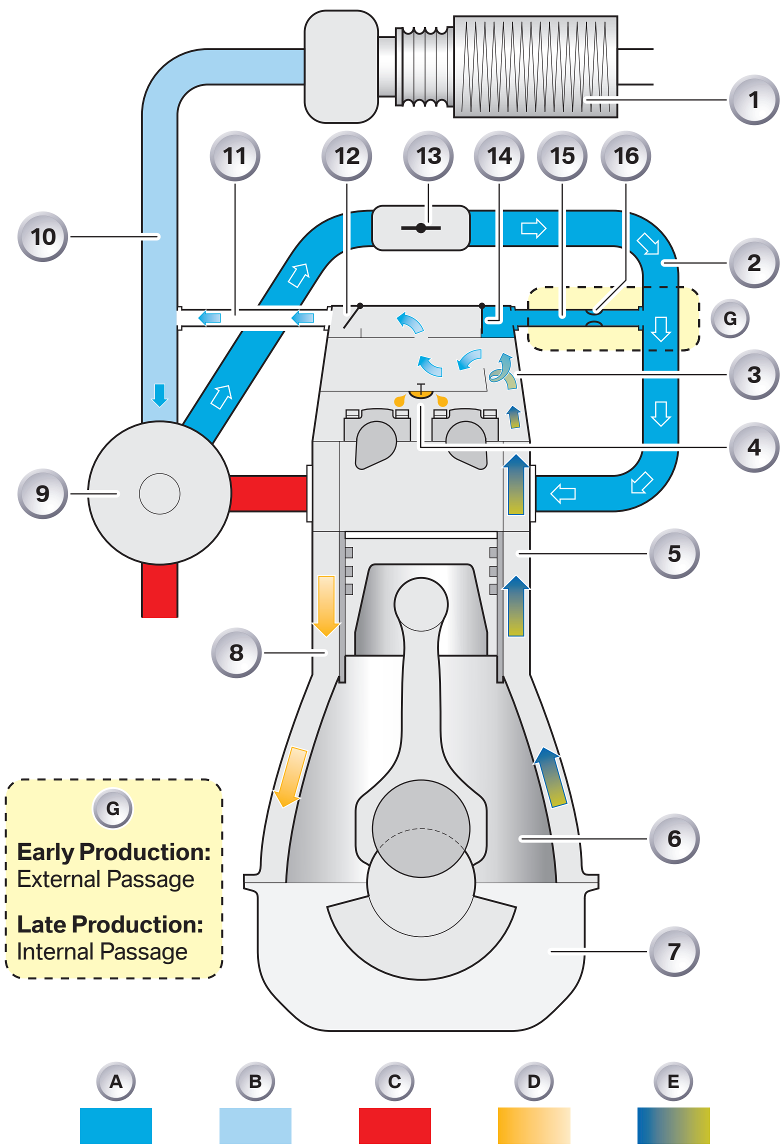
Also, a PTC heater has been integrated into the intake manifold inlet. The inlet pipe is connected to the channel (15) and prevent any moisture from freezing at the inlet.



Index	Explanation
A	Overpressure
B	Low Pressure (Vacuum)
C	Exhaust gas
D	Liquid oil
E	Blow-by gases (Crankcase vapors)
1	Air cleaner
2	Intake manifold
3	Cyclone separators
4	Oil discharge valve
5	Venting channel
6	Crankshaft cavity
7	Oil sump
8	Oil return channel
9	Turbocharger
10	Clean air pipe
11	Line to clean air pipe
12	Check valve (non-return) to intake
13	Throttle valve
14	Check valve to clean air pipe
15	Channel to intake manifold
16	Pressure restrictor

Operation with High Manifold Pressure

When in turbocharged mode, the pressure in the intake manifold increases and then closes the check valve (14). Now, a low pressure is present in the charge air suction line (10). This causes a low pressure in the hose (11) leading to the manifold check valve (12). The crankcase vapors (after separation) are directed through the check valve (12) into the charge air suction line (10) and ultimately back into the engine. The check valve (12) also prevent boost pressure from entering the crankcase when the intake manifold pressure is high.



Index	Explanation
A	Overpressure
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8	Oil return channel
9	Turbocharger
10	Clean air pipe
11	Line to clean air pipe
12	Check valve (non-return) to intake
13	Throttle valve
14	Check valve to clean air pipe
15	Channel to intake manifold
16	Pressure restrictor

Be aware that any check valve failure could cause excessive oil consumption possibly accompanied by blue smoke from the exhaust. This should not be mistaken for a failed turbocharger. Always perform a complete diagnosis of the crankcase ventilation system, before replacing any turbocharger or associated components.

Crankcase Ventilation N52KP and N51

The crankcase ventilation system on the N52KP and N51 uses a crankcase ventilation valve which is incorporated into the cylinder head cover. Oil is separated via an internal labyrinth which is also incorporated into the cylinder head cover.

This system, like the N54, also benefits from the integral components. This design allows engine heat to warm the crankcase vapors which decreases the likelihood of any moisture freezing in the system during conditions of low ambient temperature.

Note: For further information regarding the crankcase ventilation system of a specific engine please refer to the appropriate training information (on ICP) or repair instruction (in ISTA).

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Cooling System

The engine cooling system undertakes the classic task of carrying heat away from the engine and maintaining a defined operating temperature as constant as possible. The addition of turbocharging also requires cooling of the turbo/turbos.

The cooling system of the N54 engine consists of a radiator circuit and an isolated oil cooling circuit. The fact that there is an isolated oil-cooling circuit ensures that heat is not introduced via the engine oil into the engine's coolant system.

The use of an **Electric Water Pump (EWP)** allows the engine and turbo to be cooled even when the engine is off (N52, N51, N54 and N55). See the N54 system on the next page.

The N63 and N74 engines feature conventional coolant pumps that are driven by the belt drive. This pump cannot be used to continue cooling the turbochargers after the engine has been shut down. In this case an auxiliary pump is used.

N54 Cooling System Overview

The structure of the coolant circuit of the N54 is the same as that of the N52 engine. The engine is flushed through with coolant in accordance with the cross-flow concept. Cooling output can be influenced as a function of load by activating the following components:

- Electric fan
- Electric coolant pump
- Map thermostat

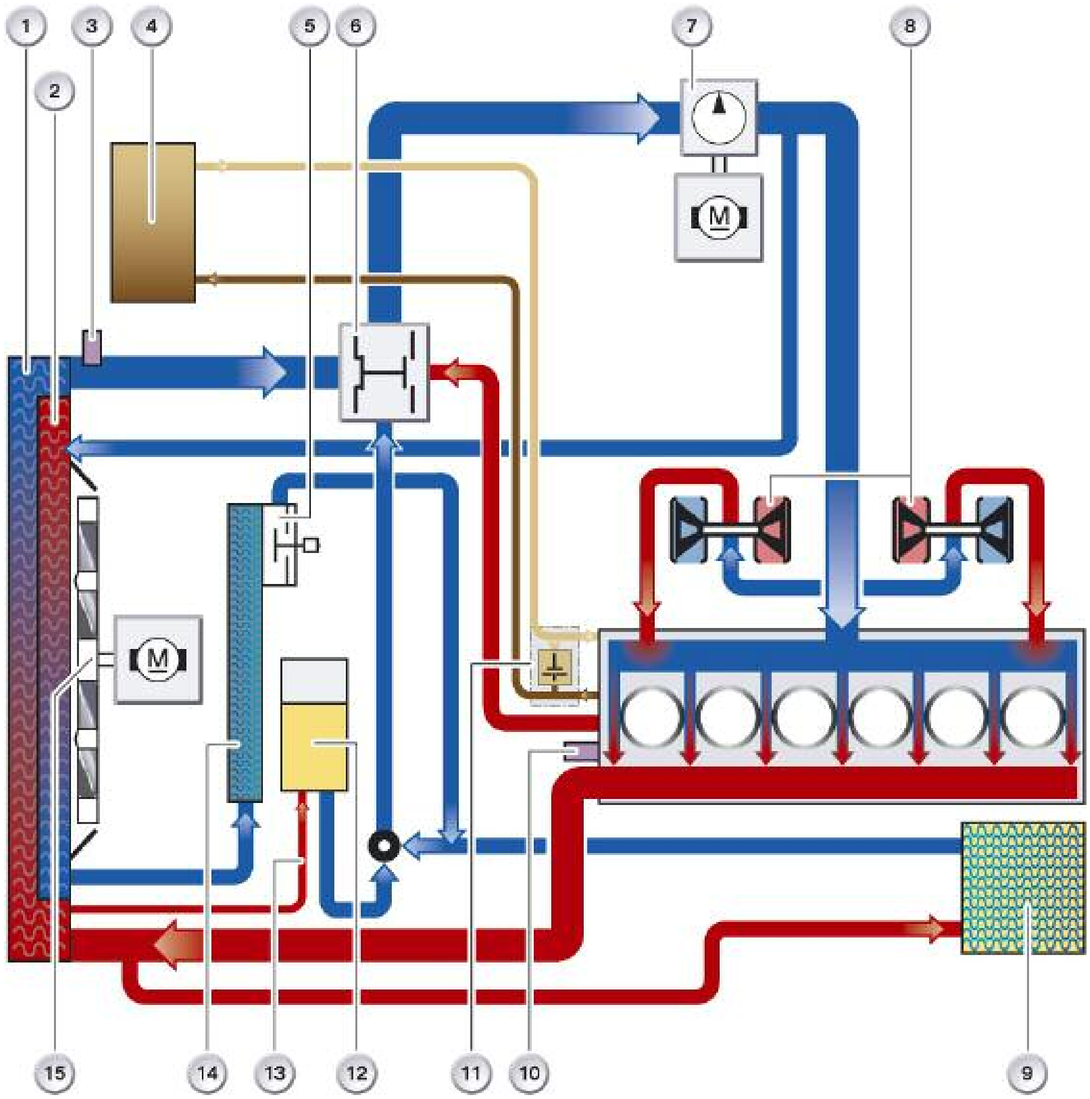
It is also possible in an N54 engine in conjunction with an automatic gearbox to utilize the lower area of the radiator to cool the gearbox by means of the gearbox-oil cooler. This is achieved as in the N52 engine with control sleeves, which are introduced into the radiator tank.

Radiator

Design measures have been used to increase the performance of the radiator itself. The performance of a radiator is dependent on its radiation surface. However, the intercooler still had to be installed underneath the radiator, and this meant that is was necessary to compensate for the smaller flow area available.

Compared with the N52 engine, the radiator used in the N54 engine has a block depth which has been increased to 32 mm. In addition, the water pipes are situated closer together than in previously used radiators. The upshot of this is an increase in the utilizable radiation surface.

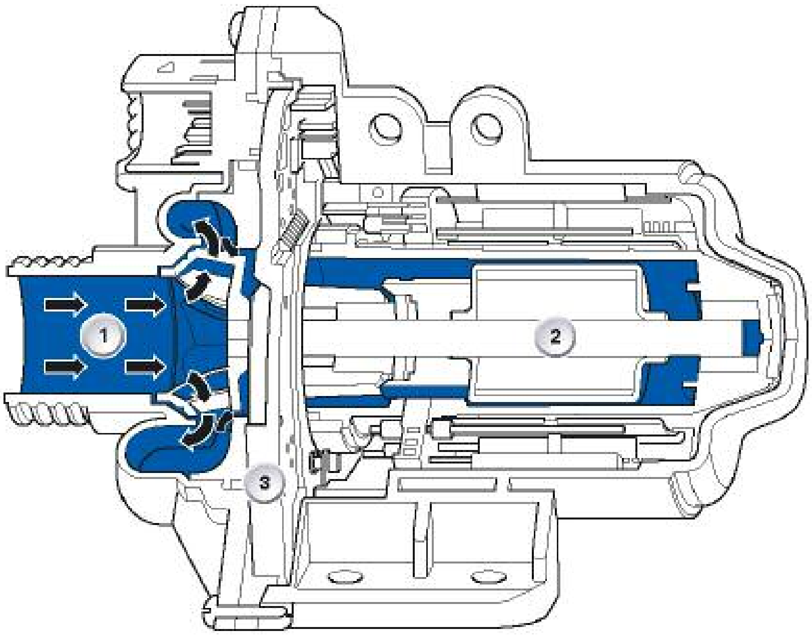
N54 Electric Water Pump Diagram



Index	Explanation	Index	Explanation
1	Radiator	9	Heat exchanger
2	Gear-box oil cooler	10	Outlet temperature sensor, cylinder head
3	Outlet temperature sensor	11	Thermostat, engine oil cooler
4	Engine oil cooler	12	Coolant expansion tank
5	Thermostat for gearbox oil cooler	13	Vent line
6	Map thermostat	14	Gearbox oil cooler
7	Electric coolant pump	15	Fan
8	Exhaust turbocharger		

Electric Coolant Pump

The coolant pump of the N54 engine is an electrically driven centrifugal pump with a power output of 400W and a maximum flow rate of 9000 l/h. This represents a significant increase in power of the electric coolant pump used in the N52 engine, which has a power output of 200 W and a maximum flow rate of 7000 l/h.



Index	Explanation	Index	Explanation
1	Pump	3	Electronics for coolant pump
2	Motor		

The power of the electric wet-rotor motor is electronically controlled by the electronic module (3) in the pump. The electronic module is connected via the bit-serial data interface (BSD) to the MSD80 engine control unit.

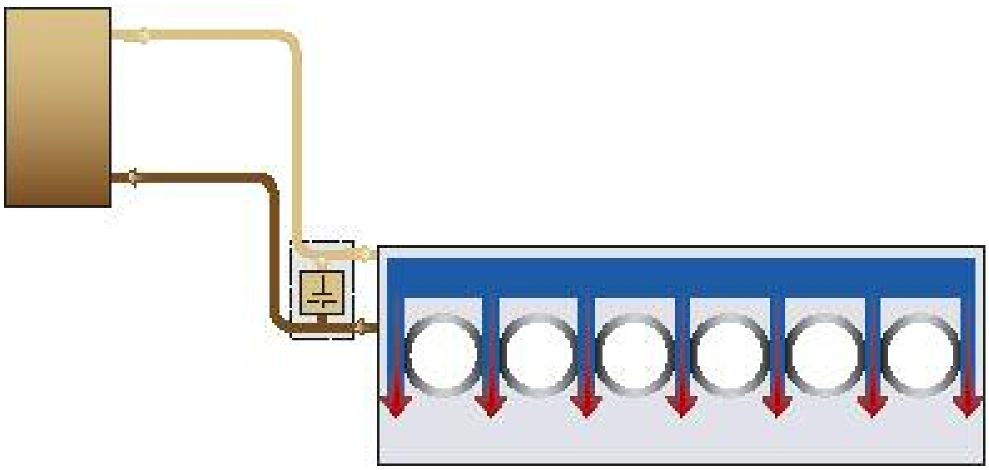
The engine control unit uses the engine load, the operating mode and the data from the temperature sensors to calculate the required cooling output. Based on this data, the engine control unit issues the corresponding command to the electric coolant pump.

The electric coolant pump regulates its speed in accordance with this command.
The system coolant flows through the motor of the coolant pump, thus cooling both the motor as well as the electronic module. The coolant lubricates the bearings of the electric coolant pump.

The pump must be filled with coolant when removed for service to prevent any corrosion. The pump impeller must be turned by hand before installation to ensure the pump is not seized.

Engine-oil Cooling

The N54 engine is equipped with a high performance engine-oil cooler. The pendulum-slide pump delivers the oil from the oil sump to the oil filter. A thermostat flanged to the oil-filter housing admits the oil to the engine-oil cooler. The engine-oil cooler is located in the right wheel arch in the E92. The thermostat can reduce the resistance opposing the oil by opening the bypass line between the feed and return lines of the engine-oil cooler. This ensures that the engine warms up safely and quickly.



If a separate oil to air cooler is not installed, an auxiliary radiator in conjuction with an oil to coolant heat exchanger is used to cool the engine oil.

The auxiliary radiator is connected to the radiator by means of parallel coolant lines, thus increasing the cooling surface area. This system is combined with an oil-to-coolant heat exchanger mounted on the oil filter housing. (See component “C” in the previous graphic.)

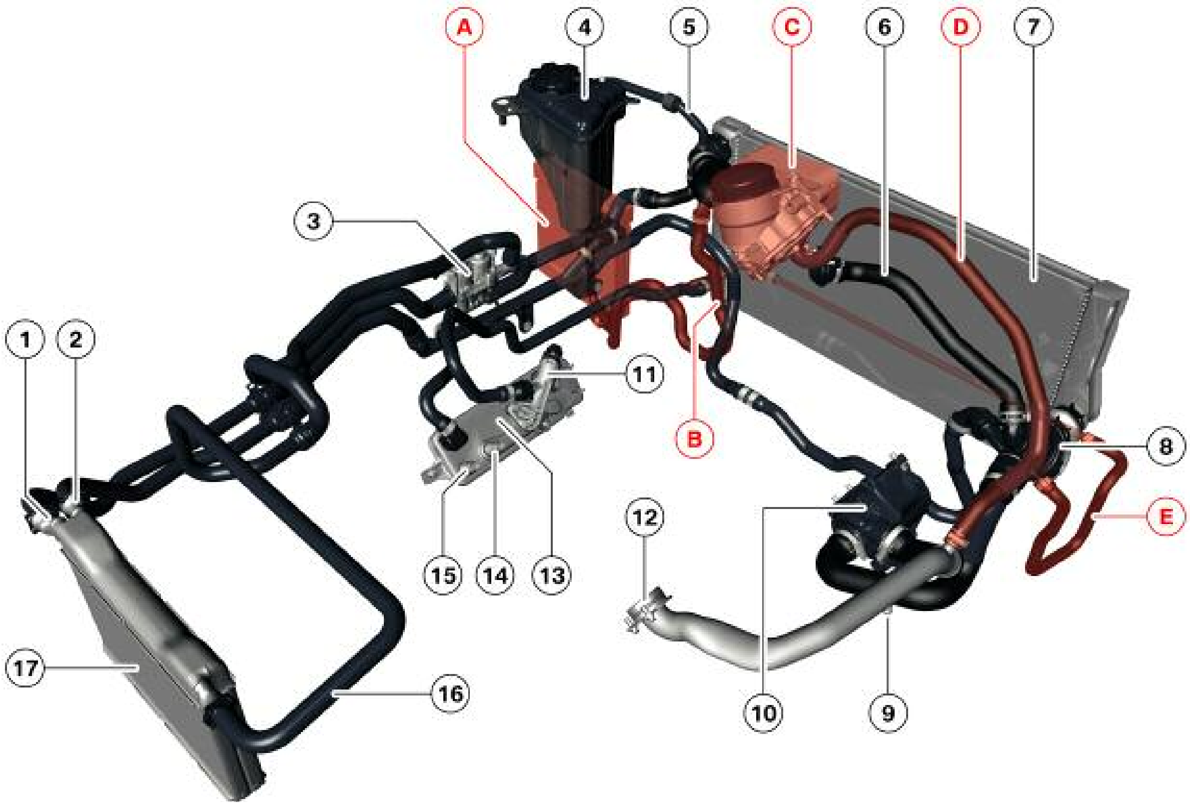
Auxiliary coolant pump for turbocharger cooling

Turbo engines that use conventional (mechanical) water pumps (N63, N74) are equipped with an additional electrically operated coolant pump with an output of 20 W. Although it is used during normal engine operation to assist turbocharger cooling this pump’s main function is to carry away the heat build-up from the turbochargers after the engine has been shut down.

The heat input into the engine is calculated based on the injected fuel quantity. This function is similar to the heat management function on 6-cylinder engines explained in the following pages

The after-running period of the auxiliary electric coolant pump can extend up to 30 minutes. The electric fan also cuts in to improve the cooling effect. As in previous systems, the electric fan runs for a maximum of 11 minutes, however, it now operates more frequently.

F10 N55 cooling circuit



Index	Explanation	Index	Explanation
A	Auxiliary radiator	7	Bypass line for small cooling circuit
B	Coolant feed line to auxiliary radiator	8	Thermostat
C	Oil-to-coolant heat exchanger	9	Electric coolant pump
D	Coolant feed line to oil-to-coolant heat exchanger	10	Exhaust turbocharger supply line
E	Coolant return line from auxiliary radiator	11	Thermostat for transmission oil cooling
1	Zone 1 feed line, heating heat exchanger	12	Coolant feed line to engine block
2	Zone 2 feed line, heating heat exchanger	14	Transmission oil-to-coolant heat exchanger
3	Coolant valve	15	Connection, transmission oil line
4	Expansion tank	16	Connection, transmission oil line
5	Equalization line	17	Return, heating heat exchanger
6	Radiator		

Please refer to the individual engine training information or repair instructions for further information.

Heat Management

The engine control unit of the N54 engine controls the coolant pump according to requirements:

- Low output in connection with low cooling requirements and low outside temperatures.
- High output in connection with high cooling requirements and high outside temperatures.

The coolant pump may also be completely switched off under certain circumstances, e.g. to allow the coolant to heat up rapidly during the warm-up phase. However, this only occurs when no heating is required and the outside temperature is within the permitted range.

The coolant pump also operates differently than conventional pumps when controlling the engine temperature. To date, only the currently applied temperature could be controlled by the thermostat.

The software in the engine control unit now features a calculation model that can take into account the development of the cylinder head temperature based on load.
In addition to the characteristic map control of the thermostat, the heat management system makes it possible to use various maps for the purpose of controlling the coolant pump. For instance, the engine control unit can adapt the engine temperature to match the current operating situation.

This means that four different temperature ranges can be implemented:

- 108°C ECO mode
- 104°C Normal mode
- 95°C High mode
- 90°C High + map-thermostat mode

The control system aims to set a higher cylinder-head temperature (108°C) if the engine control unit determines ECO (economy) mode based on the engine performance.
The engine is operated with relatively low fuel consumption in this temperature range as the internal friction is reduced.

An increase in temperature therefore favors slower fuel consumption in the low load range. In HIGH and map-thermostat mode, the driver wishes to utilize the optimum power development of the engine. The cylinder-head temperature is reduced to 90°C for this purpose. This results in improved volumetric efficiency, thus increasing the engine torque. The engine control unit can now set a certain temperature mode adapted to the respective operating situation. Consequently, it is possible to influence fuel consumption and power output by means of the cooling system.

The temperatures specified only ever represent a target value, the attainment of which is dependent on many factors. These temperatures are first and foremost not attained precisely.

The consumption-reducing and power increasing effects arise in each case in a temperature spectrum. The function of the cooling system is to provide the optimal cooling output according to the boundary conditions under which the engine is being operated.

Intelligent Heat Management Options

The previous section dealt with the various temperature ranges in which heat management is effected. However, an electrically driven coolant pump makes available even further options. For instance, it is now possible to warm up the engine without recirculating the coolant or to allow the pump to continue to operate after turning off the engine to facilitate heat dissipation. The advantages offered by this type of pump are listed in the following table:

Consumption	• Faster warm-up as coolant is not recirculated until needed • Increased compression ratio due to greater cooling output all full load as compared to similar engines without this option
Emissions	• Faster engine warm-up by drastically reduced pump speed and the lower volumetric flow of coolant • Reduced friction • Reduced fuel consumption • Reduced exhaust emissions
Power Output	• Component cooling independent of engine speed • Requirement controlled coolant pump output • Avoidance of power loss
Comfort	• Optimum volumetric flow - Heating capacity reduced as required - Residual heat with engine stationary
Component Protection	• After-running of electric coolant pump = improved heat dissipation from engine switch off point. Allows protection of turbochargers by reduced oil “coking” during heat soak.

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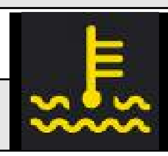
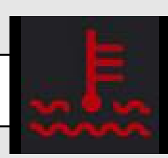
System Protection

In the event of the coolant or engine oil being subject to excessive temperatures while the engine is running, certain functions in the vehicle are influenced so that more energy is made available to the engine-cooling system, i.e. temperature-increasing loads are avoided.

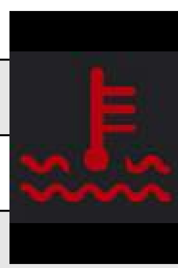
These measures are divided into two operating modes:

- Component protection
- Emergency

Measures and displays for engine oil temperature

Engine oil temp (T-oil C)	Operating mode	Display in Cluster	Power output reduction, Air conditioning	Power output reduction, Engine	Torque converter clutch lockup
148			Start 0 %	Start 0 %	
149			–		
150	Component Protection		–		
151	Component Protection		–	From here = clear reduction	
152	Component Protection		End - 100 %		
153	Component Protection				
154	Component Protection				
155	Component Protection				
156	Component Protection				
157	Component Protection			End @ 90 %	
158	Emergency				Active
159	Emergency				Active
160	Emergency				Active
161	Emergency				Active
162	Emergency				Active
163	Emergency				Active

Measures and displays for coolant temperature

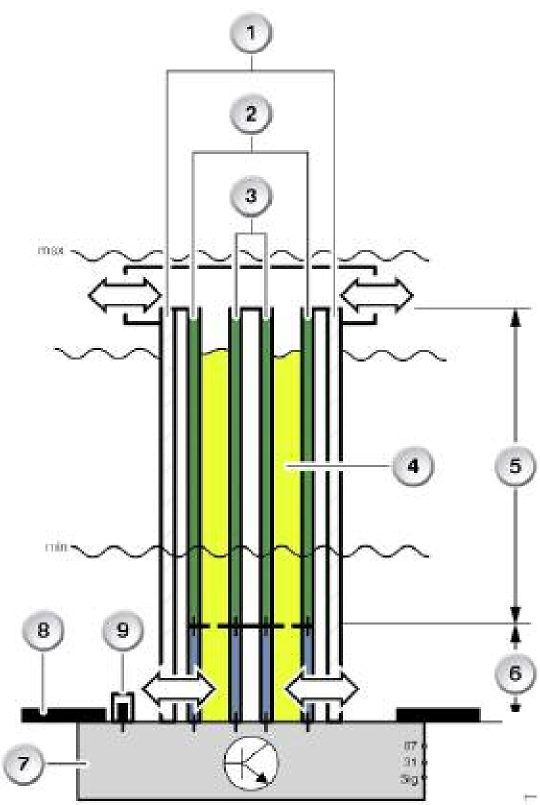
Coolant (T-Coolant)	Operating mode	Display in Cluster	Power output reduction, Air conditioning	Power output reduction, Engine	Torque converter clutch lockup
115					
116					
117	Component Protection		Start 0 %	Start 0 %	
118	Component Protection		–	From here = clear reduction	
119	Component Protection		–	–	
120	Component Protection		End - 100 %	–	
121	Component Protection			–	
122	Component Protection			–	Active
123	Component Protection			–	Active
124	Component Protection			End @ 90 %	Active
125	Emergency				Active
126	Emergency				Active
127	Emergency				Active
128	Emergency				Active
129	Emergency				Active

Electronic Oil Condition Monitoring

There is no dipstick including the guide tube on the N52 engine. This represents a convenience function for the customer while enabling more accurate recording of the engine oil level.

The engine oil level is measured by an oil condition sensor (OZS) and indicated in the central information display (CID). The engine oil temperature and the oil condition are also registered or calculated by the oil condition sensor. The signal from the oil condition sensor is evaluated in the ECM. The evaluated signal is then routed via the PT-CAN, SGM and the K-CAN to the instrument cluster and to the CID.

Registering the engine oil level in this way ensures the engine oil level in the engine does not reach critically low levels thus protecting the engine from the associated damage. By registering the oil condition, it is also possible to determine when the next engine oil change is due. Over filling the engine with oil can cause leaks - a corresponding warning is therefore given.



Index	Explanation	Index	Explanation
1	Housing	6	Oil Condition Sensor
2	Outer Metal Tube	7	Sensor Electronics
3	Inner Metal Tube	8	Oil Pan
4	Engine Oil	9	Temperature Sensor
5	Oil Level Sensor		

Function of the Oil Condition Sensor

The sensor consists of two cylindrical capacitors arranged one above the other. The oil condition is determined by the lower, smaller capacitor (6). Two metal tubes (2 + 3), arranged one in the other, serve as the capacitor electrodes. The dielectric is the engine oil (4) between the electrodes. The electrical property of the engine oil changes as the wear or aggiing increases and the fuel additives break down.

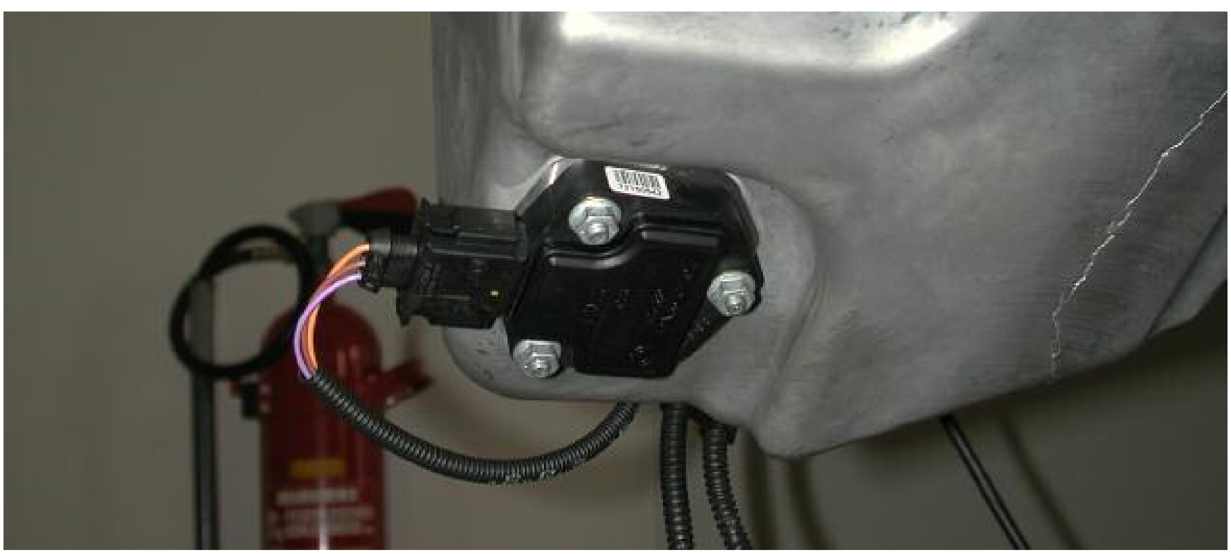
The capacitance of the capacitor (oil condition sensor) changes in line with the change in the electrical material properties of the engine oil (dielectric). This means that this capacitance value is processed in the evaluation electronics (7) integrated in the sensor to form a digital signal.

The digital sensor signal is transferred to the DME as an indication of the status of the engine oil. This actual value is used in the DME to calculate the next oil change service due.

The engine oil level is determined in the upper part of the sensor (5). This part of the sensor is located at the same level as the oil in the oil pan. As the oil level drops (dielectric), the capacitance of the capacitor changes accordingly. The electronic circuitry in the sensor processes this capacitance value to form a digital signal and transfers the signal to the DME.

A platinum temperature sensor (9) is installed at the base of the oil condition sensor for the purpose of measuring the engine oil temperature.

The engine oil level, engine oil temperature and engine oil condition are registered continuously as long as voltage is applied at terminal 15. The oil condition sensor is powered via terminal 87.



Faults/Evaluation

The electronic circuitry in the oil condition sensor features a self-diagnosis function. A corresponding error message is sent to the DME in the event of a fault in the oil condition sensor.

Electronic Oil Level Indicator

The oil level is measured in two stages:

- Static oil level measurement while the vehicle is stationary
- Dynamic oil level measurement during vehicle operation

Static oil level measurement at engine OFF

This is only a reference measurement as the oil condition sensor (OZS) is flooded when the engine is turned off and can only detect the minimum oil level. The oil level is measured correctly only when the engine is running (see Dynamic oil level measurement).

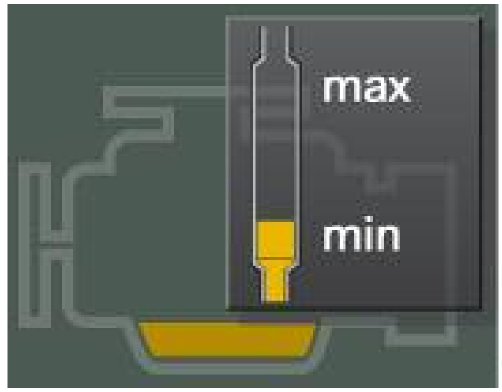
After switching on the ignition, the static oil level measurement provides the driver with the opportunity of checking whether there is sufficient engine oil for safely and reliably starting the engine.

1. It is important that the vehicle is parked horizontally otherwise the oil level measurement may be incorrect.
2. Select on-board computer function "Service" -> "Oil level".

If there is sufficient engine oil for safe and reliable engine start, a graphic appears in the CID in the form of an engine with a green oil sump.

If the oil level is close to minimum, the graphic appears with a yellow oil sump and an oil dipstick that represents the low oil level in yellow.

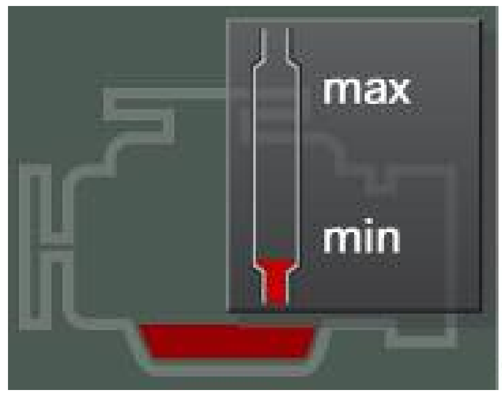
A top-up request +1 liter additionally appears as a text message. The display will not change if less than 1 liter of oil is topped up. MAX is indicated only after topping up a quantity of 1 liter.



If the oil level drops below minimum, the graphic appears with a red oil sump and an oil dipstick that represents the low oil level in red.

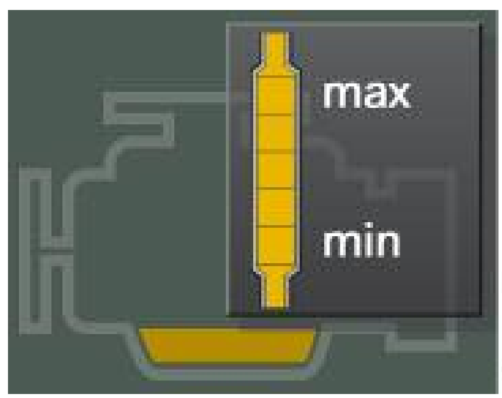
A top-up request +1 liter will additionally appear as a text message.

The display will not change if less than 1 liter of oil is topped up. MAX is indicated only after topping up a quantity of 1 liter.



If the oil level is above maximum, the graphic appears with a yellow oil sump and an oil dipstick that represents the high oil level in yellow.

A text message is also displayed for the driver.

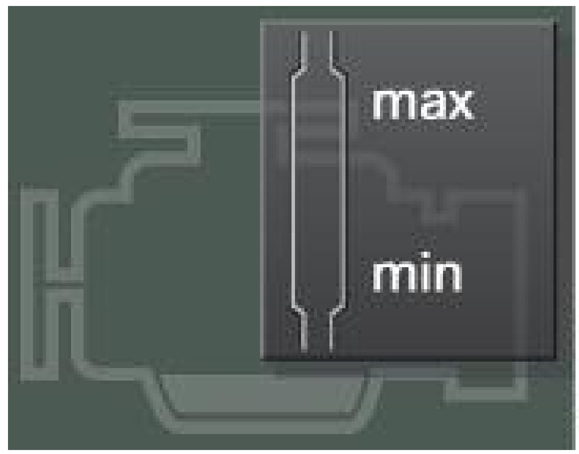


Dynamic oil level measurement during vehicle operation

Always perform the dynamic oil level measurement (approximately 5 minutes driving time) after an oil change. The oil level could be misinterpreted as the oil level last stored is initially displayed after an oil change.

No oil level is initially stored after replacing or reprogramming the engine control unit. "Oil level below min" is therefore displayed. The correct oil level is indicated after running the engine for approximately 5 minutes.

1. Start engine.
2. Select on-board computer function - “Check oil level".
3. The oil level is measured. A clock symbol may appear while the level measurement is running. The clock symbol appears for up to 50 seconds after starting the engine when there is no measured value or the long-term value last stored is not within the tolerance range of the currently measured oil level.



Dynamic oil level measurement begins when following values are reached:

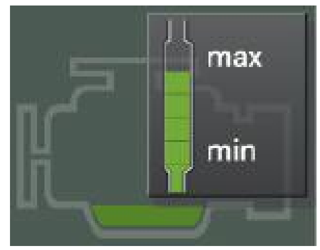
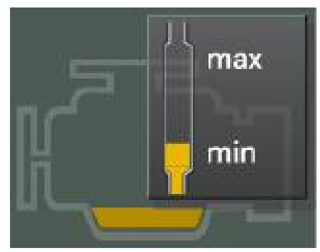
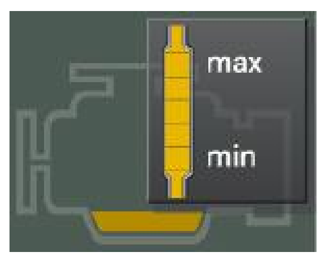
- Engine temperature > 60°C
- Engine speed > 1000 rpm
- Transverse and longitudinal acceleration < 4-5 m/s2

The transverse acceleration signal is supplied by the DSC. The longitudinal acceleration is calculated from the speed and time factors.

- Increase < 5% after covering a distance of approximately 200 m. The increase value is detected by the ambient pressure sensor in the DME.

On reaching this value, the oil level indicator is updated approximately 5 minutes after starting vehicle operation. The oil level is then continuously measured. The indicator is updated at 20 minute intervals. The "Check oil level" menu in connection with the dynamic oil level measurement is exited while driving (vehicle speed > 0) approximately 15 seconds after the oil level is displayed.

Display Options

Significance	Remark	Display
Oil OK with engine stationary	The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range.	
Oil level OK at idle speed	The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range. A further graphic showing a dipstick appears above the displayed graphic. It shows the oil level in green.	
Oil level too low	The oil level appears in the CID in the form of a graphic together with the request to top up with 1 liter of oil. If the oil is not topped up, this request is repeatedly indicated until the minimum oil level is exceeded.	
Oil level too high	The oil level appears in the CID in the form of a graphic together with the indication that the maximum oil level has been exceeded. The excess engine oil must be extracted in the workshop down to the maximum limit. If no oil is extracted, this request will be repeated until the oil level drops below the maximum limit. This represents an advantage that extends beyond the user friendliness of the monitoring system. Over filling of the engine that can cause leaks is indicated as a warning in the instrument cluster.	
Service	There is a problem with the measurement system if SERVICE appears in the display. In this case, the oil level is forecast from the oil consumption last measured and shown in the display. It is not necessary to immediately visit a workshop. The remaining kilometers are shown in the service menu. In the event of the instrument cluster failing, the oil level can also be read out with the diagnosis tester.	

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