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## N73B60 Engine

**Subject** **Page**

# N73B60 Engine

**Model: E66 - 760Li**

**Production: MY 2003**

**Objectives:**

After completion of this module you will be able to:

- Explain the function of the throttle valve(s).
- List the function of the low temperature area in the radiator.
- Describe the cooling circuit flow.
- Expalin how the initial VANOS sprocket to hub position is retained when oil pressure is not present.
- Describe what conditions are necessary for the Auxiliary Air Flaps to be opened.
- List the Valvetronic components that are different as compared to the N62.
- Locate the engine oil thermostat and understand how it functions.

# N73B60 Engine

## Purpose of the System

The N73 engine is a complete new BMW development from the NG Series (New Generation) as a B60 (6 liter). The N73B60 will be used in the E66 as a 760Li (USA).

KT-9760

The BMW 760Li will set new standards in terms of performance and driving dynamics in the 12-cylinder market segment as well as significantly reduce fuel consumption.

For the first time at BMW, Valvetronic technology (combination of Bi-VANOS and variable intake valve lift) is supplemented by direct injection (DI).

In addition, the N73 cylinder heads use 4 valve technology.

The combination of these cutting edge technologies provides low fuel consumption and maximum power output and torque, making the N73 the best engine in its class.

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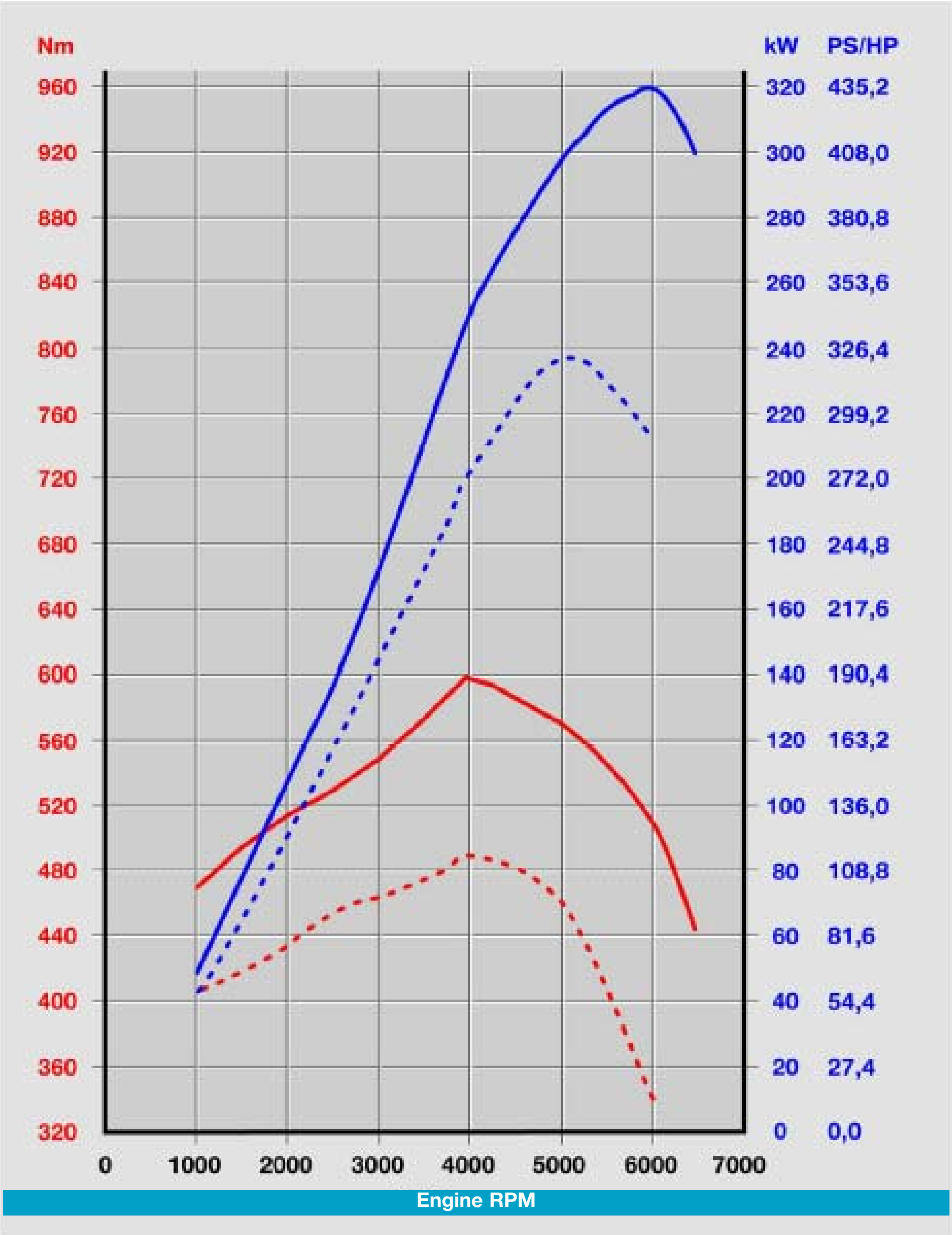
## Technical Data

| Technical Data Comparison | N73B60 | M73B54 |
|---|---|---|
| V-angle configuration | 12 cyl. V / 60° | 12 cyl. V / 60° |
| Displacement (cm 3) | 5972 | 5379 |
| Bore / Stroke (mm) | 89 / 80 | 79 / 85 |
| Cylinder spacing (mm) | 98 | 91 |
| Crankshaft main bearing diam. (mm) | 70 | 75 |
| Conrod big end diam. (mm) | 54 | 48 |
| Power output (kW/HP)<br>at engine speed (rpm) | 320 / 438<br>6000 | 240 / 326<br>5000 |
| Torque (Nm)<br>at engine speed (rpm) | 600<br>3950 | 490<br>3900 |
| Idle speed (rpm)<br>Maximum engine speed (rpm) | 550<br>6500 | 600<br>6500 |
| Compression ratio | 11.3 : 1 | 10 : 1 |
| Valves per cylinder | 4 | 2 |
| Intake valve diam. (mm) | 35 | 42 |
| Exhaust valve diam. (mm) | 29 | 36 |
| Intake valve lift (mm) | 0.3 - 9.85 | 10.3 |
| Exhaust valve lift (mm) | 9.7 | 10.3 |
| Engine weight (kg) | 280 | - |
| Fuel requirement | Premium unleaded | Premium unleaded |
| Knock control | Yes | Yes |
| Injection pressure (bar) | 50 - 120 | 3.5 |
| Digital Motor Electronics (ECM) | 2x MED 9.2.1 & Valvetronic ECU with 2x HDEV ECU | 2x ME 5.2 & EML IIIs |
| Emission compliance level | LEV | LEV |
| Firing order | 1-7-5-11-3-9-6-12-2-8-4-10 | 1-7-5-11-3-9-6-12-2-8-4-10 |
| Fuel consumption savings compared with M73 | 12 % | - |
| Maxmimum regulated vehicle speed (km/h / mph) | 250 / 155 | 250 / 155 |

## Power and Torque Output - N73B60 / M73B54




N73B60 ———
M73B54 -----

# Fresh Air System

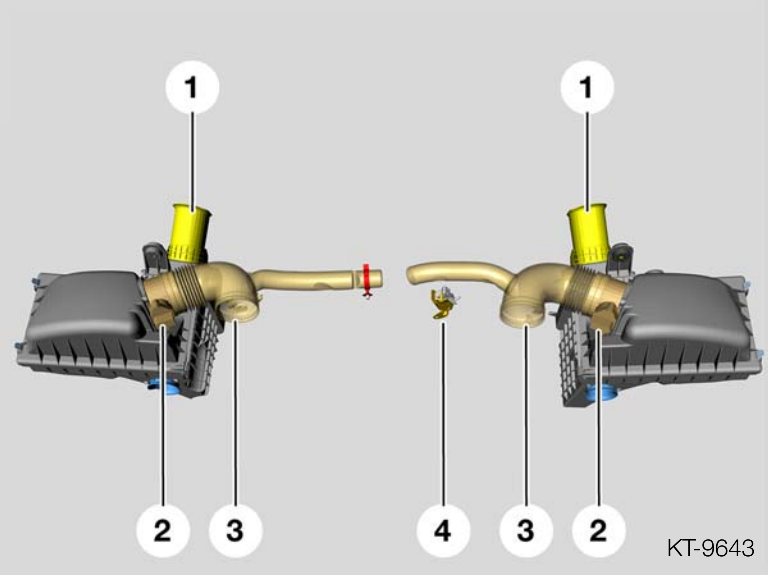
## Air Routing

A separate air cleaner housing is used for each cylinder bank. Air is supplied from the area between the headlights and cooling module via the intake snorkel (1) from the radiator fresh air duct.

The air cleaner volume is approximately 10.5 litres for each air cleaner housing.

The replaceable (as specified by the recommended service) air cleaner element is reinforced by a sheet metal grille.

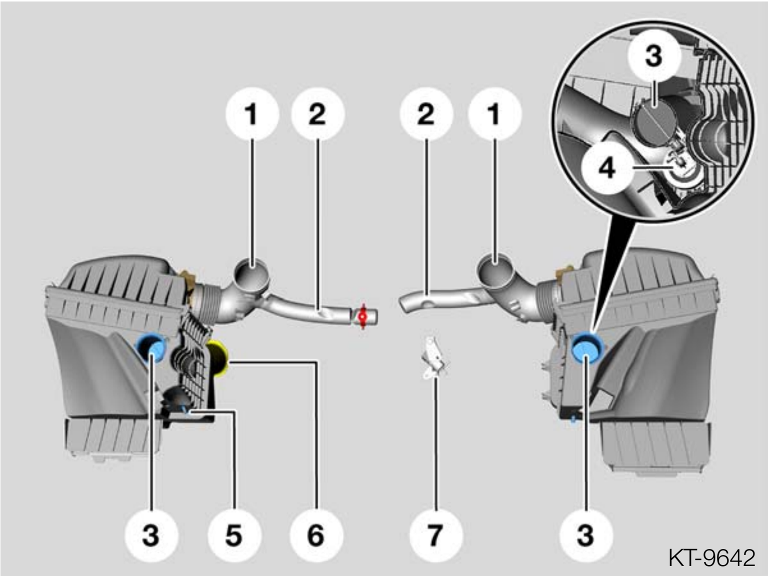
1. Intake snorkel
2. Hot-film air mass sensor (HFM)
3. Air duct to throttle
4. Solenoid valve for auxiliary air flaps



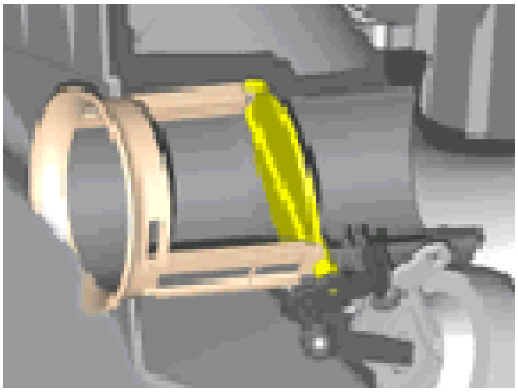

Each air cleaner housing incorporates an auxiliary air flap in its side wall (3 below). The auxiliary air flaps supply the engine with enough air volume to attain the maximum performance. The auxiliary air flaps are closed in the lower rpm ranges so that only cooler ambient air is drawn in for hot idling and stop and go driving.

The auxiliary air flaps are actuated by diaphragm cells (4 below) which are located inside the air cleaner housings. Both diaphragm cells are supplied with vacuum from a common solenoid valve (7 below).

1. Air duct to throttle
2. Intake resonator
3. Auxiliary air flap
4. Diaphragm cell
5. Diaphragm cell vacuum connection
6. Intake snorkel
7. Solenoid valve for auxiliary air flaps



The auxiliary air flaps are fully opened by the ECM:



- In driving position “D” with kickdown operation from 3500 rpm
- In driving position “S” from 3000 rpm and simultaneous full load recognition.

10-15% additional air is drawn in from the engine compartment when the auxiliary air flaps are open. It is not necessary to draw in additional cold air from outside the engine compartment since the engine compartment is adequately ventilated at full load.

## Throttle Valves

The throttle valves (one per cylinder bank) on the N73 are not necessary for engine load control. This is carried out by the intake valves variable lift adjustment.

- Throttle Valve Housing with Throttle Valve.
- Throttle Valve Actuator
- Two Throttle Valve Potentiometers

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The tasks of the throttle valves are:

*Starting the engine*

Airflow is controlled by the throttle valves during the starting procedure and idle when the air temperature is between 0 ºC and 60 ºC, .

If the engine is at operating temperature, it will be switched to non-throttle mode approximately 60 seconds after start up. In cold conditions however, the engine is started with the throttle valve fully opened because this has a positive effect on the starting characteristics.

*Ensuring a constant vacuum of 50 mbar in the intake manifold*

This vacuum is needed to exhaust the blow-by gases from the crankcase and the fuel vapors from the activated charcoal filter.

*The backup function*

If the Valvetronic system should fault, the throttle valve implements conventional load control).

## Intake Manifold

The intake system is a complete component constructed of magnesium in a shell type design and has separate manifold chambers for each cylinder bank.

1. Intake manifold pressure sensors
2. Captured gaskets
3. Pressure control valves for crankcase ventilation
4. Throttle valves


The individual parts of the intake system are bonded and bolted to each other, providing considerable weight reduction (separating the shell halves is not permitted).

The entire intake system is protected against corrosion by a dip coating procedure. The fastening bolts of the add on parts are also coated and must be replaced in the event of damage, to prevent corrosion and pitting.

All of the gaskets (2) are secured by retainers (captured) to provide ease of installation. The intake system is isolated from the engine by rubber elements on the fastening bolts.

An intake manifold pressure sensor (1) is used for each cylinder bank. Recording the manifold differential pressure is necessary for the correct throttle position (synchronization) so that a manifold differential pressure of 50 mbar can be balanced on each bank.

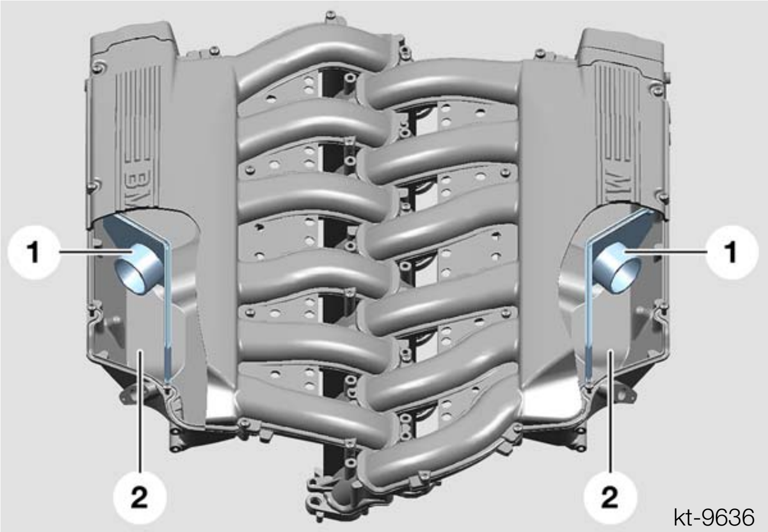
Both sides of the induction system are fitted with a pressure control valve (3) for crankcase ventilation which is distributed to both banks.

*Note:* When replacing the spark plugs, it is necessary to remove the entire intake system to avoid damaging the spark plugs during installation. The spark plugs must be replaced every 100,000 miles in US vehicles.

The intake system has an integrated intake noise resonator for each cylinder bank. The intake noise resonators reduce the intake pulsation noises caused by the intake valves opening and closing.

The manifold chamber on each cylinder bank has been fitted with a partition and an additional resonance chamber (2).

Each resonance chamber is connected by a pipe (1) with the remaining manifold chamber (on its side of the engine).



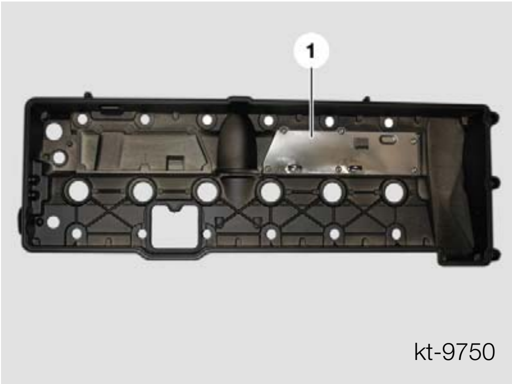

### Crankcase Ventilation

The crankcase vapors (a result of combustion blow-by gasses) are led out of the crankcase and back into the combustion chamber via the intake manifold. The blow-by gasses contain droplets of oil which must be separated. The oil is returned to the sump while the blow-by gasses are led into the intake manifold for combustion.

The engine performance is affected by the introduction of crankcase vapors into the combustion process, particularly in idle speed ranges. This influence is monitored by lambda regulation.

The crankcase vapors are carried from the crankcase and into the cylinder head covers through labyrinth separators (1 - two per cylinder head).

The oil which accumulates on the walls of the labyrinth separators flows into the cylinder head via a siphon and from there back to the sump.



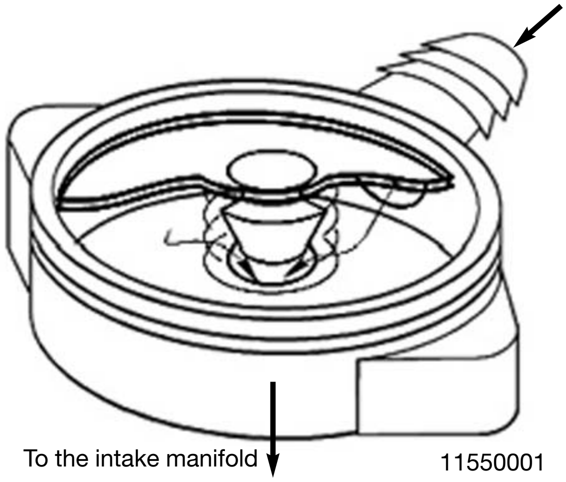

The remaining vapors are passed to the engine for combustion via the pressure control valves in the intake manifold (one per cylinder bank). The throttle valve is controlled so that there is always a minimum of 50 mbar vacuum in the intake manifold. The pressure control valve regulates the crankcase pressure to a low 0 - 40 mbar.

## Pressure Control Valves

The pressure control valves (one per cylinder bank) vary the vacuum applied to the crankcase ventilation depending on engine load. The valve is balanced between spring pressure and the amount of manifold vacuum. The oil vapors exit the separator labyrinth in the cylinder head covers. The oil vapors are drawn into the intake manifold, regulated by the pressure control valves.

At idle when the intake manifold vacuum is high, the vacuum decreases the valve opening and only allows a small amount of crankcase vapors to be drawn into the intake manifold.

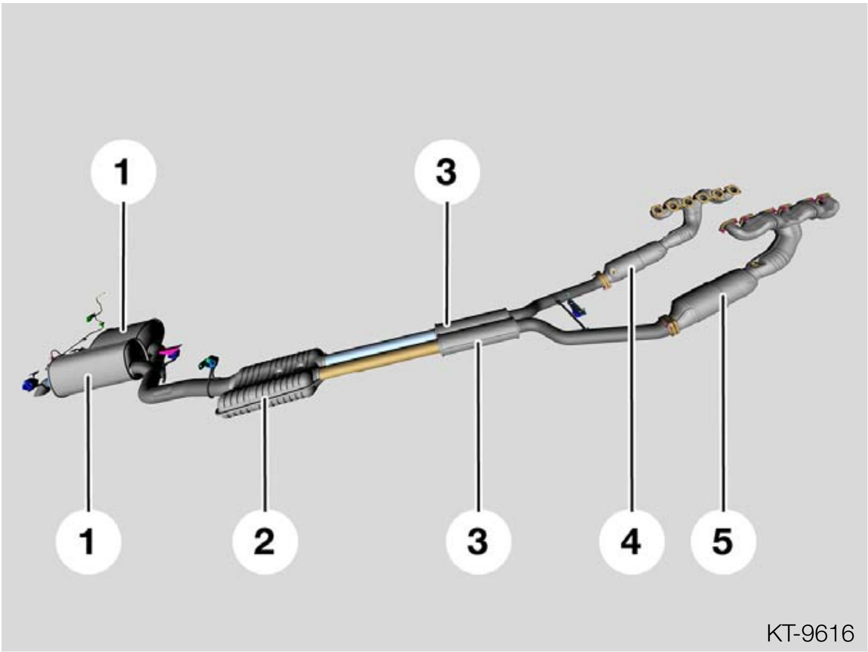
At part to full load conditions when intake manifold vacuum is lower, the spring opens the valve and additional crankcase vapors are drawn into the intake manifold.




## Exhaust System

The exhaust system is completely redesigned for the N73B60 engine. It has been optimized for cylinder filling, scavenging, sound level and rapid catalytic converter activation. Because the catalytic converters are in the exhaust manifolds (situated close to the engine), the response temperature is reached very quickly.

1. Rear silencer
2. Center silencer
3. Front silencer
4. Exhaust manifold with catalytic converters, cylinders 7 -12
5. Exhaust manifold with catalytic converters, cylinders 1 - 6



### Silencers

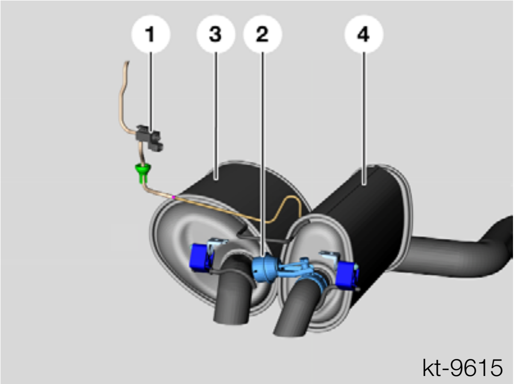
- A 2.8 liter capacity front silencer has been fitted for each cylinder bank.
- A single 12.5 liter center silencer is fitted downstream of the two front silencers.
- The resonator type rear silencers have capacities of 12.6 and 16.6 liters (4 and 3 below).

### Exhaust Flap

The 12.6 liter rear silencer (4) is fitted with an exhaust flap to keep noise to a minimum at engine idle speed and low rpm. The exhaust flap is opened allowing additional flow when:

- The transmission gear is engaged ***and***
- The engine speed is above 1,500 rpm

A vacuum-controlled diaphragm (2 - actuator mounted on the silencer) opens and closes the exhaust gas flap.



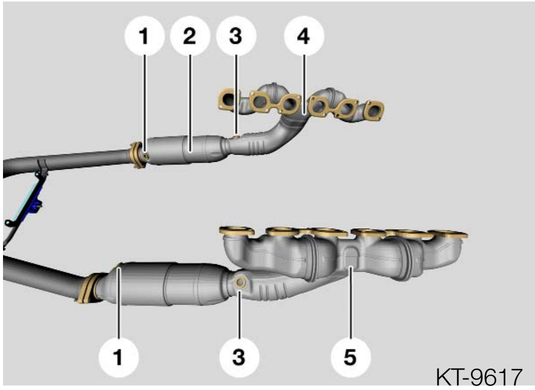

The exhaust flap is opened with vacuum, and is sprung closed by the actuator (when vacuum is not present). The procedure is carried out using a solenoid valve (1) which is electrically controlled by the ECM.

The efficiency of the flap is based essentially on two effects:

- Minimization of the cross-section and the outlet level at low exhaust flow rates
- Large cross-section with low backpressure at high speeds and loads

*Notes:*

## Exhaust Manifold with Catalytic Converter




Each cylinder bank is equipped with a six into one exhaust manifold (4 and 5). The manifold and the catalytic converter housing together form one component.

Two ceramic-substrate catalytic converters are arranged one behind the other in the catalytic converter housing (2).

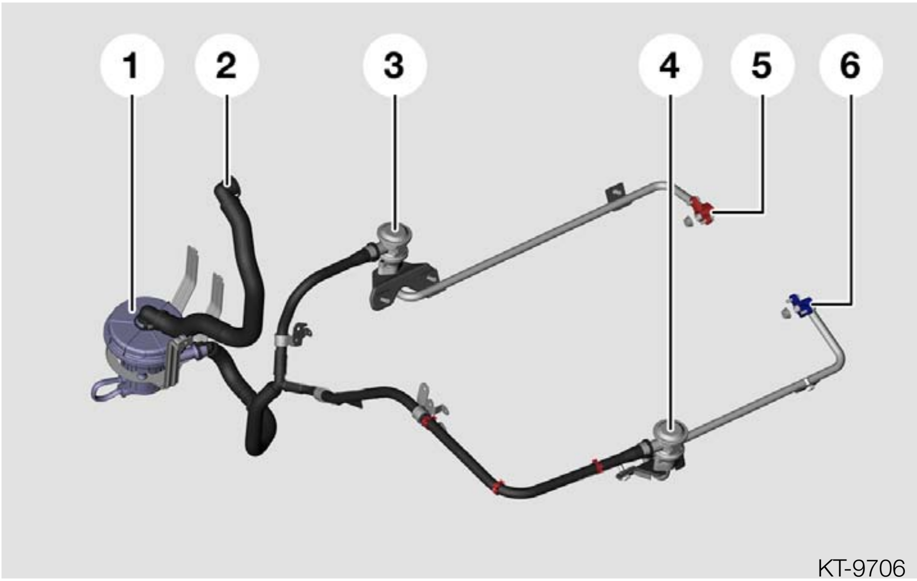
The mounting for the broadband planar oxygen sensors (Bosch LSU 4.2) and the secondary oxygen sensors is located in front of (3) and behind (1) the catalytic converter.

## Secondary Air System

Injecting additional air (secondary air) into the cylinder head exhaust track during the warm-up phase initiates a thermal secondary combustion which results in a reduction of the non-combusted hydrocarbons (HC) and carbon monoxide (CO) in the exhaust gas.

The energy generated during this process heats up the catalytic converter faster during the warm-up phase, and increases it's conversion rate. The activation temperature of 250º C is reached in a few seconds.

1. Secondary air pump
2. Fresh air inlet from air cleaner housing
3. Non-return valve cylinder bank 1 - 6
4. Non-return valve cylinder bank 7 - 12
5. Connection to cylinder head 1- 6
6. Connection to cylinder head 7 -12



## Secondary Air Pump (SLP)

The electrically-operated secondary air pump is mounted to the vehicle body. The pump draws out filtered fresh air from the air cleaner housing during the warm-up phase and supplies it to the two secondary air Non-return Valves.

Once the engine has been started, the secondary air pump is supplied with voltage by the ECM via the secondary air pump relay. It remains switched on until the engine has taken in a certain amount of air.

The *ON* period may be a maximum of 90 seconds and it depends on the following engine operating conditions:

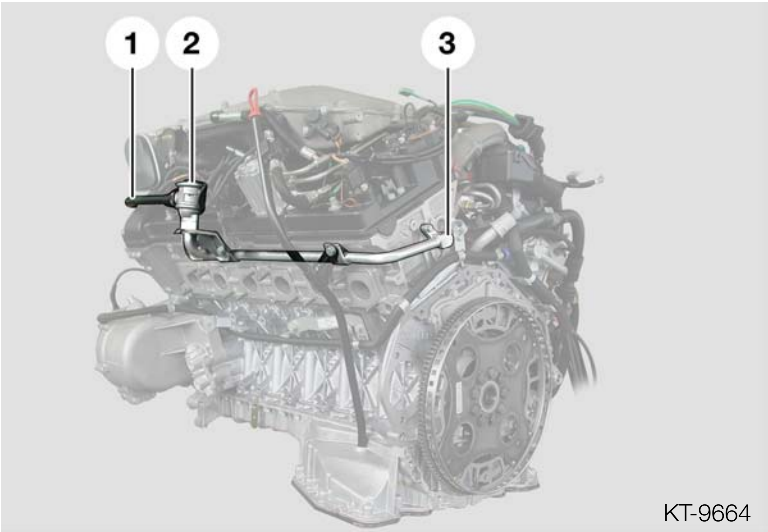
- Coolant temperature (from -10º C to approximately 60º C)
- Air mass and temperature (from HFM)
- Engine speed

## Non-Return Valves (SLV)

One non-return valve is mounted on each cylinder head. The non-return valves are opened by the pressure generated from the secondary air pump. The secondary air is led through a pipe to the secondary air ducts (integral in the cylinder heads) for distribution into the exhaust ports.

The non-return valves are sprung closed when the secondary air pump is deactivated. This prevents exhaust vapors, pressure and condensation from flowing back into the secondary air pump.

1. Secondary air pump connection
2. Non-return valve (SLV)
3. Connection to cylinder head



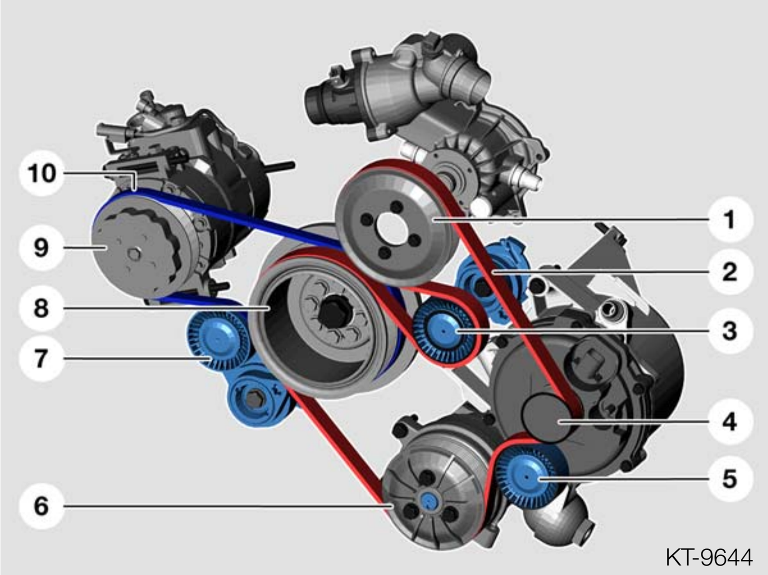
## Ancillary Components and Drive Belts

### Drive Belts

The belt drive has two components and is subdivided into the main and A/C drives. Both belts are driven by the crankshaft pulley.

A four rib belt is used to drive the air conditioning compressor and a six rib belt is used for the main drive. Each drive belt has a maintenance free tensioning unit with tensioning pulley and torsioner.

1. Water pump pulley
2. 6 rib main drive belt
3. Main drive belt tensioner
4. Alternator
5. Deflection pulley
6. Power steering and dynamic drive pump
7. A/C compressor drive belt tensioner
8. Crankshaft pulley
9. A/C compressor
10. 4 rib A/C compressor drive belt




*To remove the drive belts:*

The tensioning pulley is pushed back using a Torx tool in the recess provided (1) and fixed in this position by inserting a locking pin as shown (2).


The following ancillary components are the same as the N62:

- Liquid cooled alternator (180 A)
- Clutch less A/C compressor

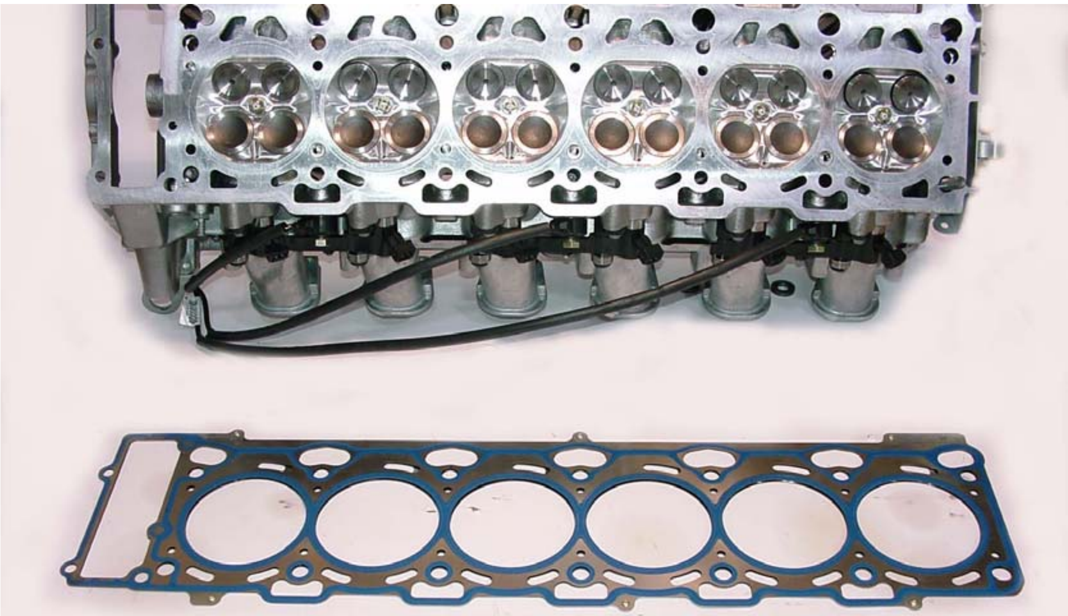
The compact gear reduction starter motor is located on the right side of the engine underneath the exhaust manifold (2.0 kW output).

## Cylinder Heads

The two N73 cylinder heads are a new development from BMW and have been adapted to the new direct injection system. The cylinder heads are equipped with Valvetronic valve gear and bi-VANOS. The inlet camshaft and the Valvetronic eccentric shaft are jointly guided by a bridge support.

The ports for the high pressure fuel injectors are located on the intake side. The engine is equipped with a high pressure fuel pump for each cylinder head. Each cylinder head has a bucket-tappet drive on the exhaust camshaft for the high pressure fuel pump.

The secondary air ducts for subsequent exhaust gas treatment are integrated in the cylinder heads. The cylinder heads are cooled by the "cross-flow" principle. The cylinder heads are made from aluminum and are manufactured using gravity die-casting.



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**Cylinder Head Gaskets**

The cylinder head gasket is a triple layer steel gasket with rubber coating. This gasket version is already established in previous engines (N62). A four layer repair gasket is available if the cylinder-head surface is machined.

The cylinder head bolts for the N73 engine are M10x160 necked-down "stretch" bolts.

***Note: These bolts should always be replaced when repairs are performed.***

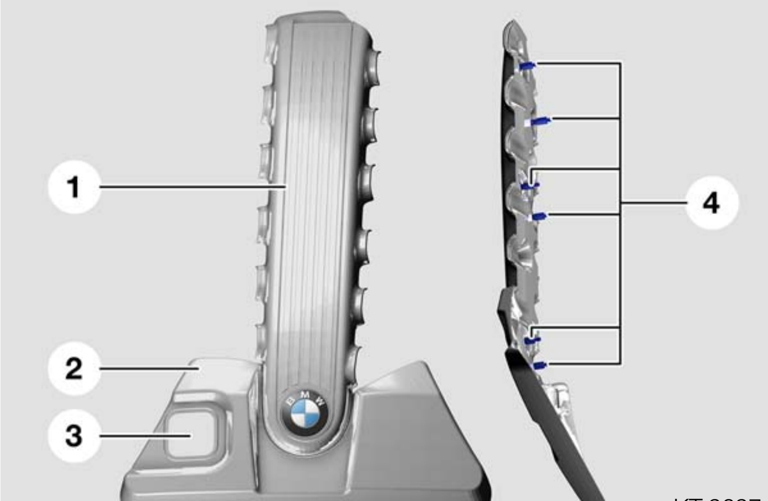
The lower part of the timing chain housing is bolted to the cylinder head using two M8x45 bolts.

## Engine Cover

The engine is equipped with a design cover (1) on the intake system.

There is also a front shield (2) situated between the radiator cover and the design cover with an opening for the oil filler neck (3).

The cover is a "push fit" with retaining pins (4) into rubber grommets on the intake manifold.

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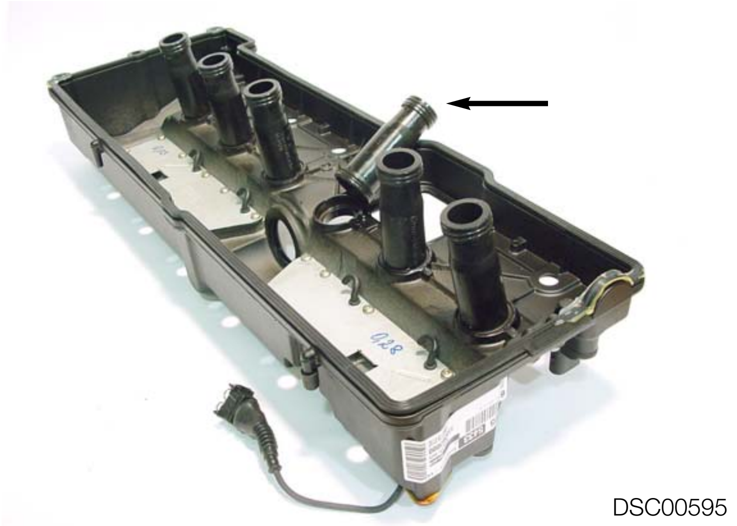
## Cylinder Head Covers

The cylinder head covers are made from plastic. The retaining sleeves for the ignition coils have molded-on gaskets.

The sleeves must be replaced if any hardening or damage is visible on the gaskets.

The sleeves are secured between the cylinder head cover and cylinder head (arrow showing one removed).



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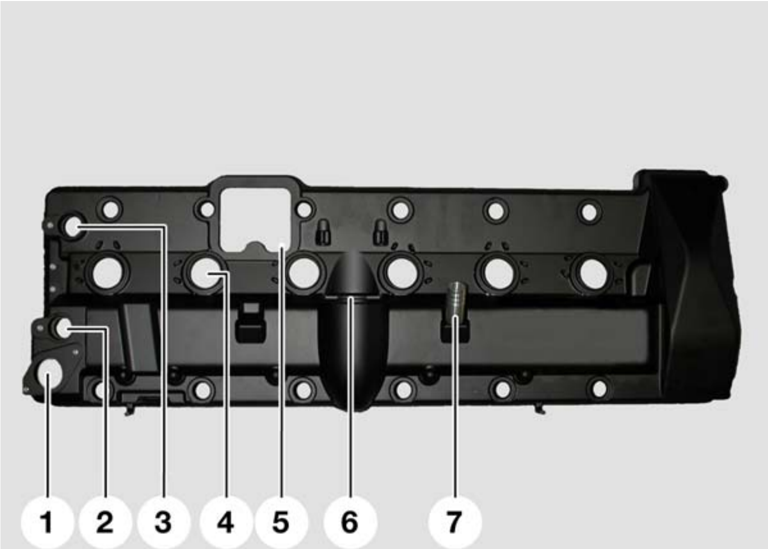
1. Bore for Valvetronic Sensor
2. Bore for intake camshaft sensor
3. Bore for exhaust camshaft sensor
4. Opening for ignition coils
5. Cutout for high pressure pump drive
6. Cutout for Valvetronic motor
7. Outlet for crankcase ventilation

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## Valvetronic

The mixture control is influenced by the throttle valve and is not optimal in all the different load ranges. This is particularly true in the idle to part-load ranges, since the throttle valve is only opened slightly in these ranges. The consequences are less than optimal cylinder filling, torque and increased fuel consumption.

Technical measures were previously introduced; such as the optimization of air/fuel mixing, introduction of bi-VANOS and the steady improvement of mixture control all depend on the throttle valve. This is where the unique Valvetronic design comes in.

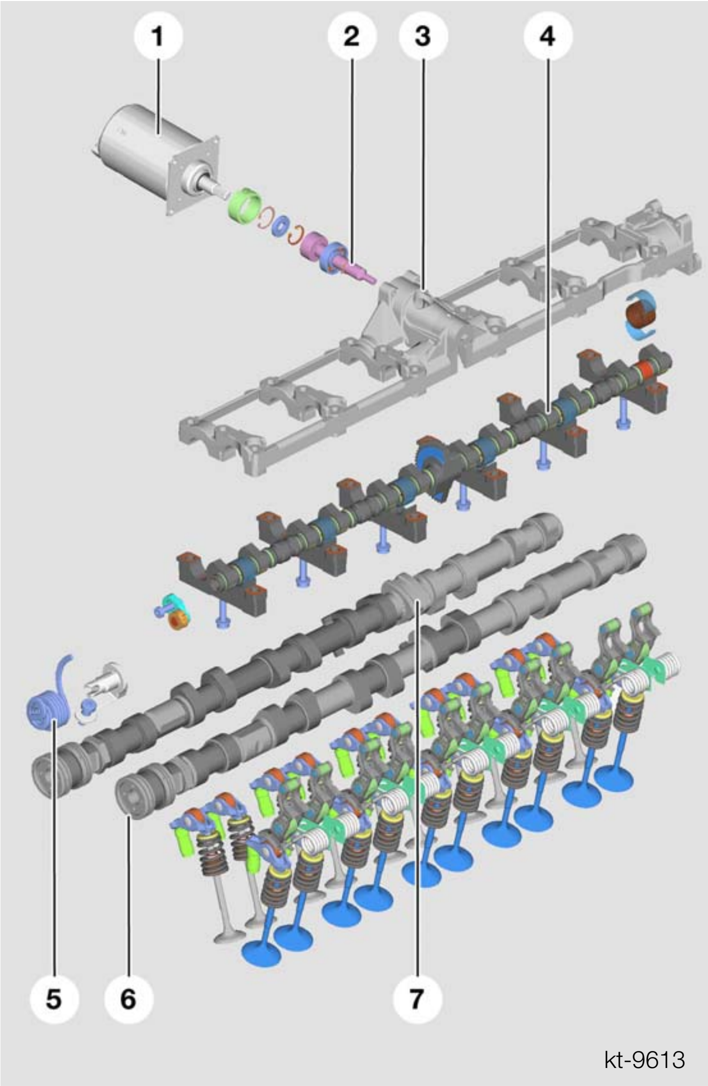
The Valvetronic system simultaneously varies the valve opening time and the intake valve opening lift between 0.3 mm and 9.85 mm, according to engine speed and load. This means that the air volume is controlled according to engine requirements. This type of volume control makes the typical throttle valve control unnecessary.

The valve gear is essentially the same as the N62 engine and has been adapted to the geometry of the N73 (with two more cylinders).

1. Valvetronic motor *
2. Intermediate shaft *
3. Bridge support *
4. Eccentric shaft
5. Torque compensation spring *
6. Intake camshaft
7. Exhaust camshaft with “triple” cam lobe for high pressure pump *

* Modifications have been made to these components making them different from the N62.

*Note:* To remove the cylinder head, it is necessary to remove the intermediate shaft (requiring a special tool) in order to gain access to the cylinder head bolts.



## Physical considerations:

On engines with throttle valve control, the throttle valve is slightly open in the idling and part-load ranges. This results in the formation of up to 500 mbar vacuum in the intake manifold, which prevents the engine from aspirating freely and in turn prevents optimum cylinder filling. The Valvetronic system with an open throttle valve largely counteracts this disadvantage. The air-mass flow to the intake valves is unrestricted. The full ambient pressure is available directly at the intake valves for cylinder filling and scavenging.

The Valvetronic system primarily controls the fill by adapting the valve opening time and the valve lift (short opening time/small valve lift = lower fill, and vice versa). During the valve opening phase the engine aspirates more freely via the intake valves even with small valve lifts vs. a throttle valve which is continuously blocked.

The slower cylinder filling from the intake valves with partial lift results in more turbulence in the combustion chamber, thus faster and better mixture control and more efficient combustion. At lower engine speeds this effect is intensified by opening the intake valves later, after top dead center (ATDC) using VANOS. This increases vacuum in the combustion chamber which accelerates filling and turbulence when the intake valves are opened.

***In summary,*** the additional variability of the Valvetronic system results in optimization of cylinder filling and scavenging throughout the engine's entire operating range. This has a positive effect on output, torque and a decrease in fuel consumption and exhaust emissions.

*N73 Features:*
- Valve lift adjustment
- Bi-VANOS (intake and exhaust)
- Mixture control and ignition control
- Direct fuel injection (DI)

*The main benefits of these features are:*
- Improved cylinder filling
- Improved mixture control
- Improved combustion procedure

*This results in:*
- Improved engine idling
- Improved engine torque
- Improved engine torque curve
- Fewer pollutant emissions

***These benefits result in a clear improvement in performance and fuel consumption reduction (12% as compared to the M73) for the driver.***

## Principle of Operation

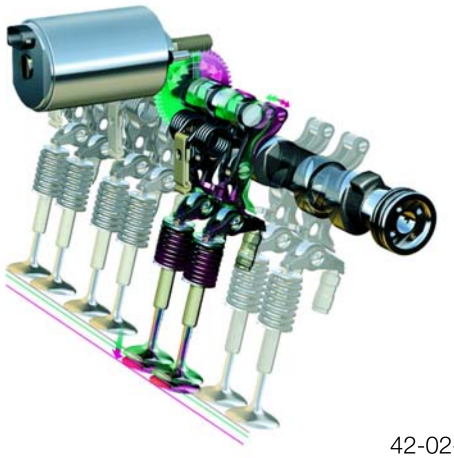
*The Valvetronic system is a combination of VANOS and valve lift adjustment.* This combination of abilities allows the ECM to control when the intake valves are opened and closed, and also the opening lift. The intake air flow is set by adjusting the valve lift while the throttle valve is fully opened. This further improves cylinder filling and reduces fuel consumption.

Each cylinder head in the N62 engine has a Valvetronic assembly. This Valvetronic assembly consists of a bridge support with eccentric shaft, intermediate levers with retaining springs, drag lever and the intake camshaft.

In addition, the following components belong to the Valvetronic system:

- A Valvetronic motor for each cylinder head
- A Valvetronic control module
- A Valvetronic position sensor for each cylinder head

The intake valve lift can be infinitely adjusted between 0.3 mm and 9.85 mm.



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The cylinder heads are precision manufactured together to ensure precise flow rate and uniform distribution. The valve gear components on the intake side are precisely matched together to the tightest limits.

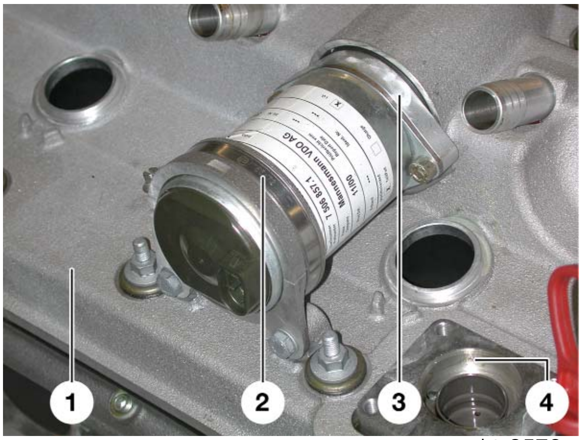
## System Components

### Valvetronic Motors

The main distinguishing features from the N62 are:

- Because of the tighter vee angle (60º), the Valvetronic motors are attached to the cylinder heads on the exhaust side.

- An intermediate shaft connects the Valvetronic motors with the Valvetronic eccentric shaft.

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1. Cylinder head cover
2. Motor mounting/isolating element
3. Intermediate flange
4. Mounting for high pressure fuel pump

The Valvetronic motor is rubber mounted at the rear (1 lower left) to isolate it from the cylinder head cover.  The Valvetronic motor is secured to the bridge support by the intermediate flange and has a hexagon drive (2 lower left), which engages into the intermediate shaft (7 lower right).

The intermediate shaft is mounted in the bridge support and is engaged by its spindle in the eccentric shaft teeth. This design provides ease of removal if the motor/gear fails.


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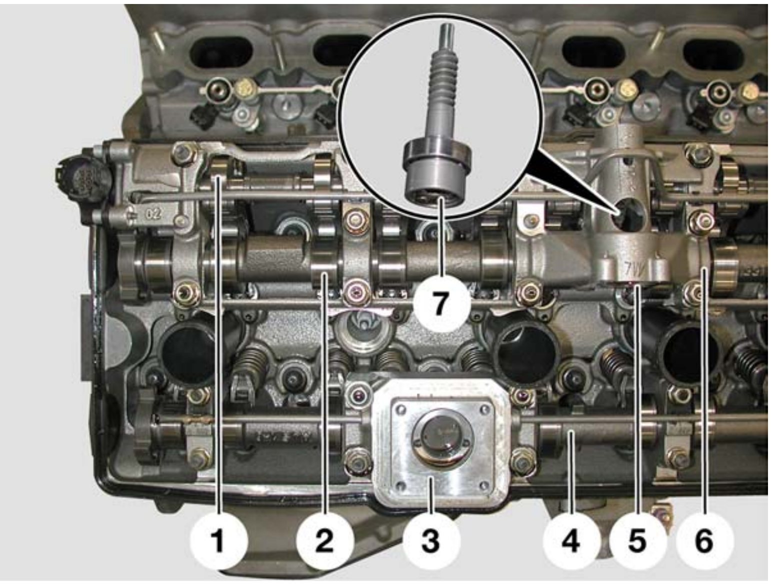


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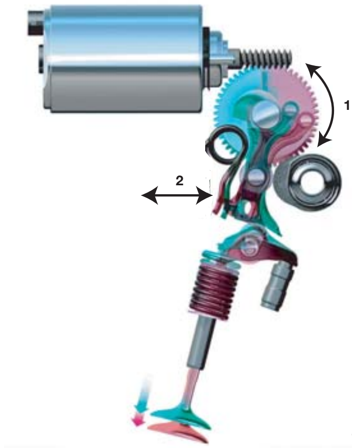
Diagram shown to the right:

1. Eccentric shaft
2. Intake camshaft
3. Mounting for high pressure fuel pump
4. Exhaust camshaft
5. Bridge support with receptacle for intermediate shaft and Valvetronic motor
6. Bridge support
7. Intermediate shaft

The Valvetronic motor worm gear rotates the eccentric shaft clockwise or counterclockwise at a very quick rate (1).  The motors are capable of traveling from minimum to maximum lift in 300 milli-seconds.

Due to the progressive "lobe" on the eccentric shaft, this rotation positions the intermediate lever (2) closer or further to the camshaft lobe.

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## Eccentric Shafts

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The eccentric shafts (one per cylinder head) are driven by the Valvetronic motors and are supported by caged needle bearing assemblies for a smooth rotation.

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To assist in maintaining the set positions and counter the valve train torque, a torque compensation spring (rectangular cross section) is mounted on the end of the shaft for tension.

Magnets are fitted in the (removable) magnetic wheel at the end of the eccentric shaft.  Together with the position sensor, the Valvetronic Control Module determines the exact shaft position.  The eccentric shaft sensor is mounted through the cylinder head cover (one per cylinder head) at the back.

43-02-38

The magnetic wheel is secured to the shaft by a bolt and is indexed by a tab (arrow) to prevent incorrect installation.

## Intermediate Lever and Roller Finger

The intermediate lever is positioned further (minimum valve opening) or closer (maximum valve opening) to the camshaft by the the progressive “lobe” on the eccentric shaft as it is rotated.  This offers a variable ratio effect for valve actuation. The roller finger is used to actuate the intake valve.

43-02-33

The intermediate levers and roller fingers are matched (by classification) to ensure uniform valve lift.

***Note: When disassembling/assembling the valvetrain, the intermediate levers and roller fingers must be returned to the original positions to prevent uneven cylinder charging which can result in rough idle and engine performance complaints.***

*Refer to the Repair Instructions!*

## Valve Lift

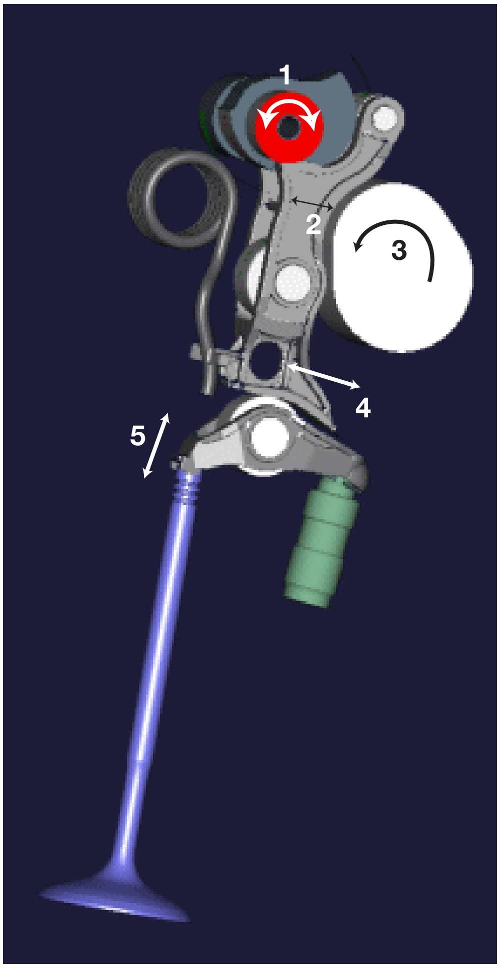
The Valvetronic motor worm gear rotates the eccentric shaft clockwise or counterclockwise at a very quick rate (1).

Due to the progressive "lobe" on the eccentric shaft, this rotation positions the intermediate lever (2) closer or further to the camshaft lobe.

As the camshaft is rotating (3), the cam lobe will pivot the intermediate lever (4) and the "heel" of the intermediate lever will depress the roller finger. A spring is located on each intermediate lever to maintain constant contact with the camshaft.

The roller finger is cushioned by the HVA and will open the intake valve (5).

The Valvetronic system varies the valve opening lift between 0.3 mm and 9.85 mm by rotating the eccentric shaft during engine operation to increase or decrease intake (flow) into the cylinder based on throttle request.



43-02-31

* This is an assembly that affects all of the intake valves (per cylinder head) to work in unison.

*Notes:*

## Bi-VANOS (Variable Camshaft Adjustment)

The N73 features compact infinitely variable vane-type VANOS for the intake and exhaust camshafts. The VANOS unit is easy to remove and install. The VANOS unit is designed as an integral component of the chain drive and is secured to the respective camshaft with a central bolt.

The intake camshafts adjustment ranges are 63º (as compared with the crankshaft). The exhaust camshafts adjustment ranges are 60º.

The VANOS unit gear teeth are different as compared to the N62 (roller chain like M73). The VANOS unit for the cylinders 1-6 exhaust shaft has mounting provisions for the vacuum pump drive.

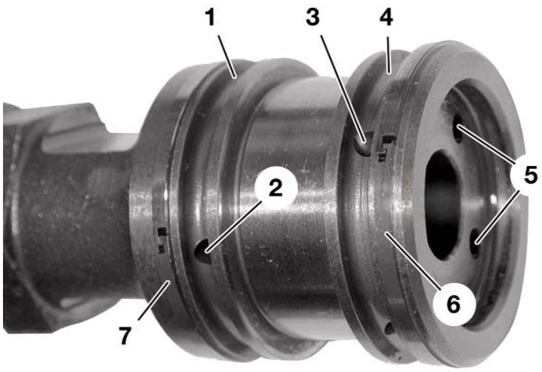
A spring plate is fitted between the VANOS unit and the vacuum pump drive to reduce wear (3). The ***VANOS units are labeled "In/Out"*** for intake and exhaust installation positions.

**VANOS Units Cylinder Bank 7-12**

The VANOS units are supplied with oil via ports in the camshafts. The oil ports are located on the left and right of the thrust bearing.

Depending on the individual VANOS adjustment direction, the VANOS is supplied with oil via either the rear oil ports (1 & 2) or the front oil ports (3 & 4). The oil moves through the camshaft to the VANOS units.

1&2. Rear Oil Duct with Four Holes
3&4. Front Oil Duct with Four Holes
5. Front Oil Duct Outlets
6&7. Hook Sealing Washer.




42-02-40

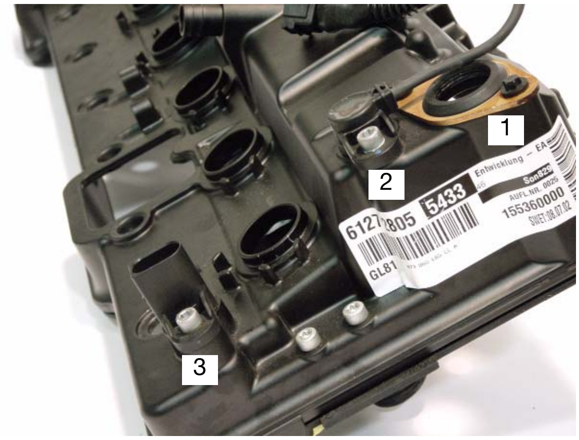
**VANOS Oil Ports**

## Camshaft Sensors

The camshaft sensors (Hall effect) are mounted through the cylinder head cover. There are two sensors per cylinder head to monitor the intake and exhaust camshaft positions.

The sensors monitor the impulse wheels attached to the ends of the camshafts.

1. Valvetronic Position Sensor opening
2. Intake Camshaft Position Sensor
3. Exhaust Camshaft Position Sensor



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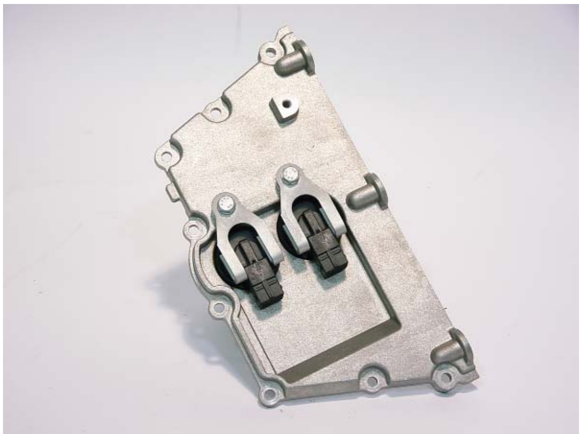
**Camshaft Sensors**

## Solenoid Valves

The VANOS solenoid valves are mounted through the upper timing case front covers.

There are two solenoids per cylinder head to control the oil flow to the camshaft ports for the intake and exhaust VANOS units.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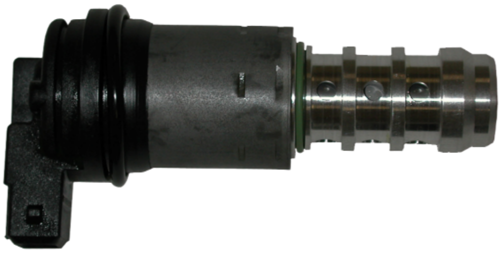
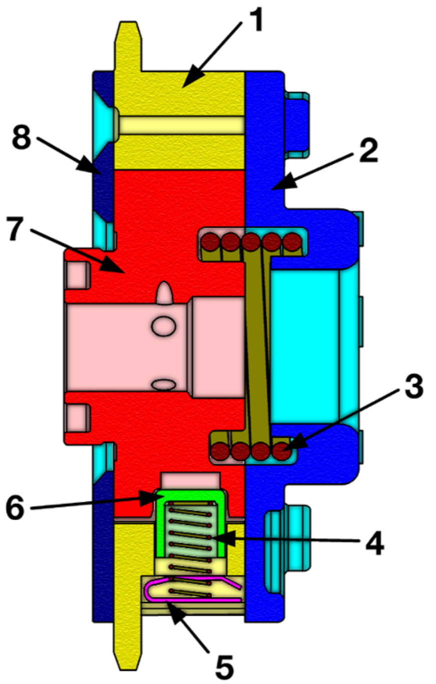
The 4/3 way proportional solenoid valve is activated by the ECM to direct oil flow.

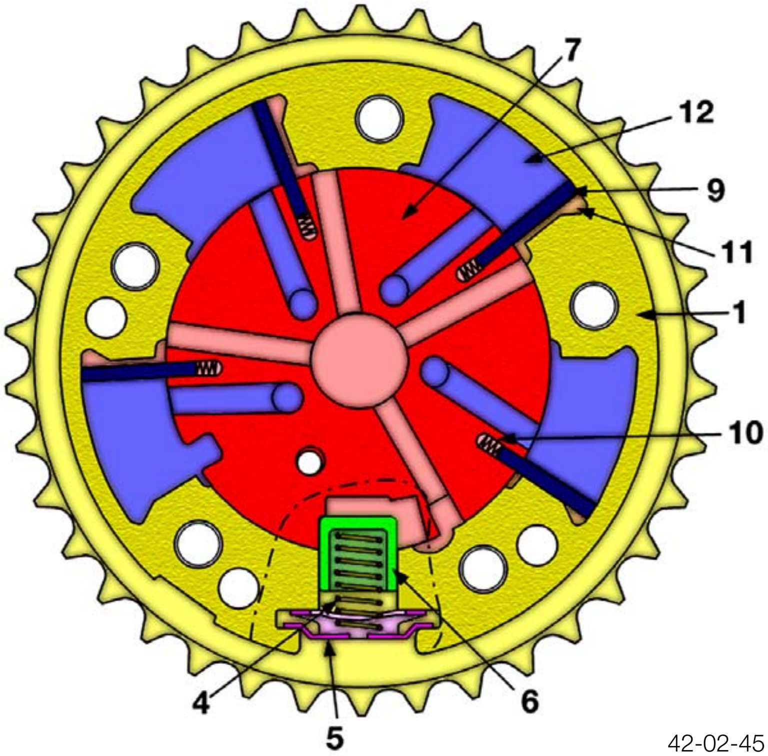
The solenoid valve is sealed to the front cover by a radial seal and secured by a retaining plate.


42-02-42

## VANOS Sectional Views




42-02-49




42-02-45

**VANO'S Components**

1. Housing with Sprocket
2. Front Plate
3. Torsion Plate
4. Lock Spring
5. Retaining Plate for Lock Spring
6. Spring Loaded Locking Pin
7. Hub
8. Black Plate
9. Blade
10. Spring
11. Pressure Chamber A
12. Pressure Chamber B

### *Mechanical Layout:*

The figures above show a sectional view of one VANOS unit. The VANOS unit is secured by a central bolt through the hub (7) to the camshaft. The timing chain connects the crankshaft with the housing of the unit.

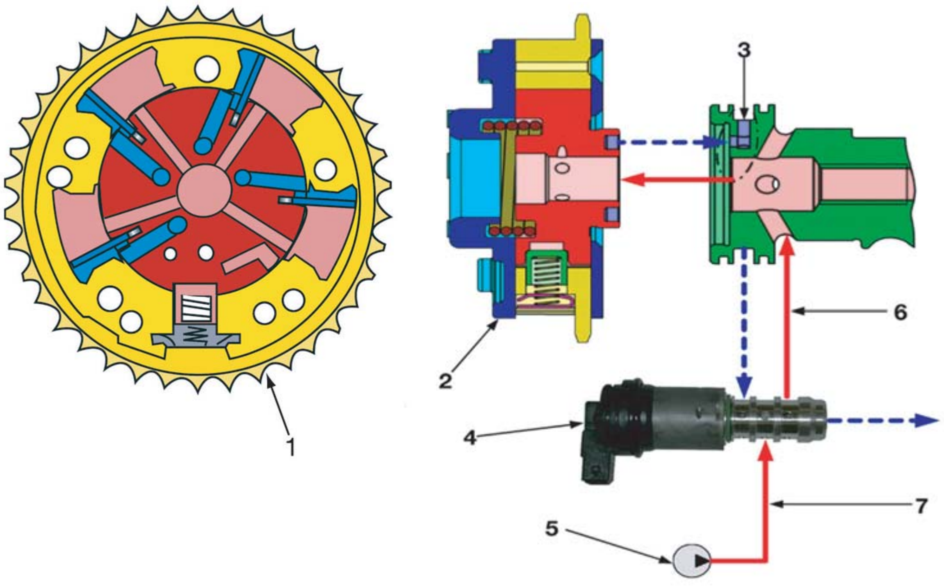
There is a recess in the hub in which the locking pin (6) engages without oil pressure (sprung). When the solenoid valve is activated to supply oil pressure to the VANOS unit, the locking pin is compressed and releases the VANOS for adjustment.

The internal blades (9) are spring loaded (10) to provide a seal between the oil pressure chambers (11 and 12). The torsion spring (3) acts against the camshaft torque.

## *Hydraulic Actuation:*

When oil pressure is applied to chamber A, the blades are forced away from the VANOS housing (counterclockwise). The blades are keyed into the hub which results in the hub position being rotated in relation to the housing (with sprocket). The hub is secured to the camshaft which changes the camshaft to sprocket relationship (timing).

The example below shows the ***adjustment*** procedure together with the pressure progression based on the VANOS unit for the exhaust camshafts.




43-02-45

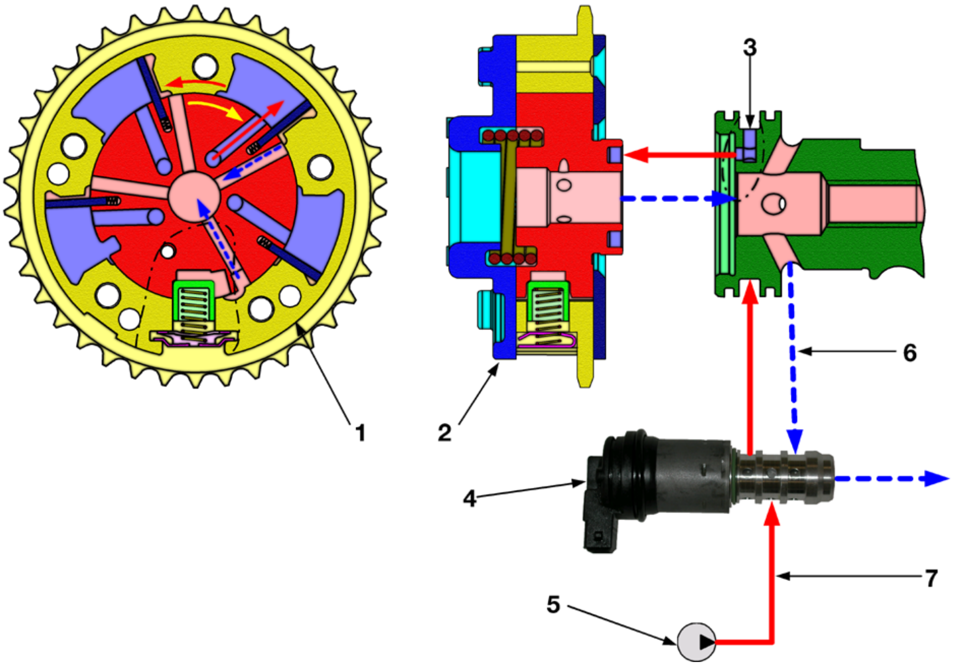
**Hydraulic Actuation - Chamber A**

1. Front View of Vanos Unit
2. Side View of Vanos Unit
3. Camshaft Oil Port (Chamber B)
4. Solenoid Valve
5. Engine Oil Pump
6. Supplied Oil from Pump (Switched Through Solenoid)
7. Supplied Oil Pressure (From Engine Oil Pump)

During this adjustment chamber B is open (through the solenoid) to allow the oil to drain back through the cylinder head (internal reservoir).

When the solenoid valve switches over, oil pressure is applied to chamber B. This forces the blades (and hub) in a clockwise direction back to the initial position, again changing the camshaft timing.

The example below shows the ***reset*** procedure together with the pressure progression based on the VANOS unit for the exhaust camshafts.




**Hydraulic Actuation - Chamber B**

42-02-44

1. Front View of VANOS Unit
2. Side View of VANOS Unit
3. Camshaft Oil Port (Chamber B)
4. Solenoid Valve
5. Engine Oil Pump
6. Oil Return (Switched through Solenoid)
7. Supplied Oil Pressure (From Engine Oil Pump)

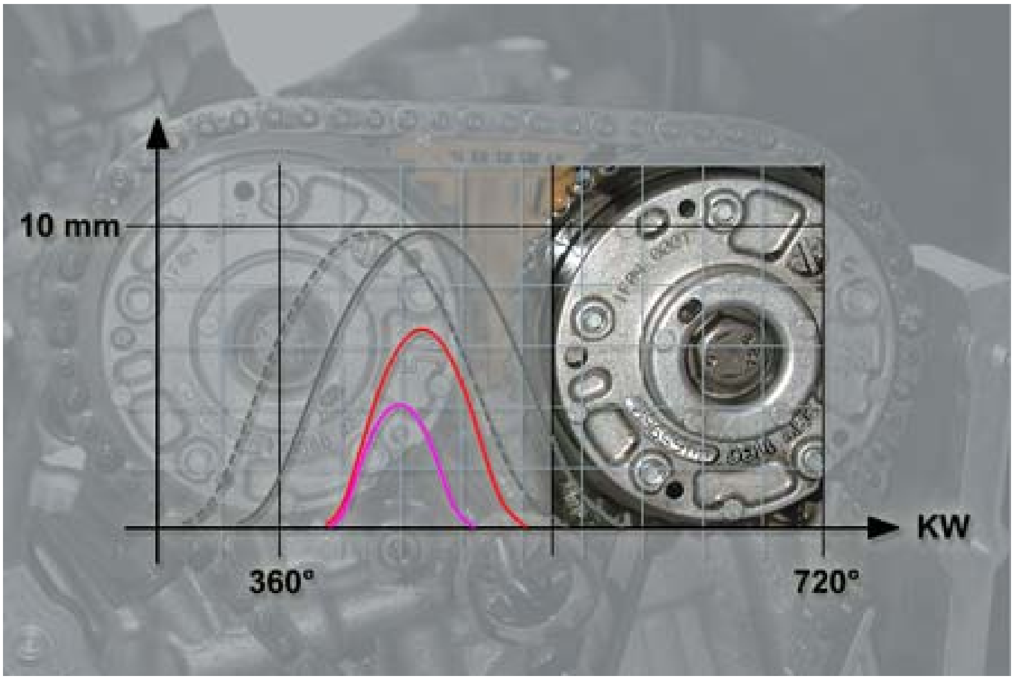
During this adjustment chamber A is open (through the solenoid) to allow the oil to drain back through the cylinder head (internal reservoir).

*Notes:*

The chart below shows the VANOS unit camshaft adjustment possibilities (horizontal line). The valve lift adjustment has also been incorporated (vertical line).

The special feature of Valvetronic is that the air mass drawn in the cylinders can be easily determined by the valve lift and closing time. The air mass can then be limited, thus the term "load control".

With the help of VANOS, the valve closing point can be easily selected within a defined range. With valve lift control, the opening duration and cross section of the valve opening can also be easily selected within a defined range.




**Vacuum pump**

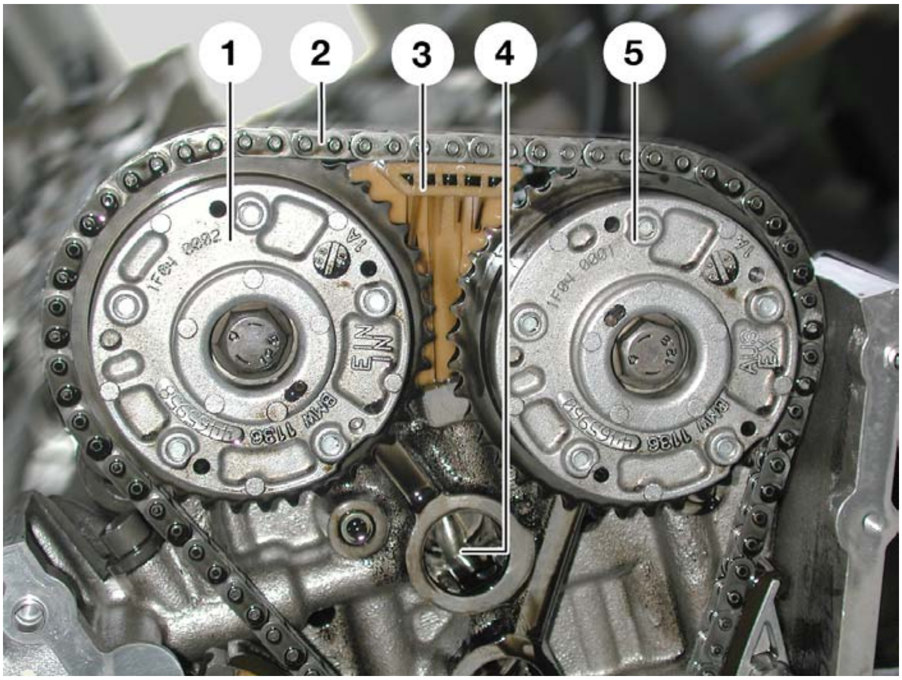
The N73 engine requires a vacuum pump for the vacuum assisted brake booster (large hose). With the throttle valve open while the car is being driven, additional vacuum is needed.

The N73 vacuum pump has a second vacuum connection (small hose) for the exhaust flap adjustment. The vacuum pump is driven by cylinders 1-6 exhaust camshaft via the VANOS unit. The pump is lubricated through an oil gallery from the cylinder head.

43-02-03

## Chain Drive

The N73 camshafts are driven by roller type chains, one for each cylinder bank. The use of two separate roller chains reduces the strain on the individual chains, which significantly increases the service life. The N73 chain links are 1.5 mm shorter than the M73. The oil pump is driven by a separate roller chain. The chain tensioner assemblies are the same as the N62.




KT-9745

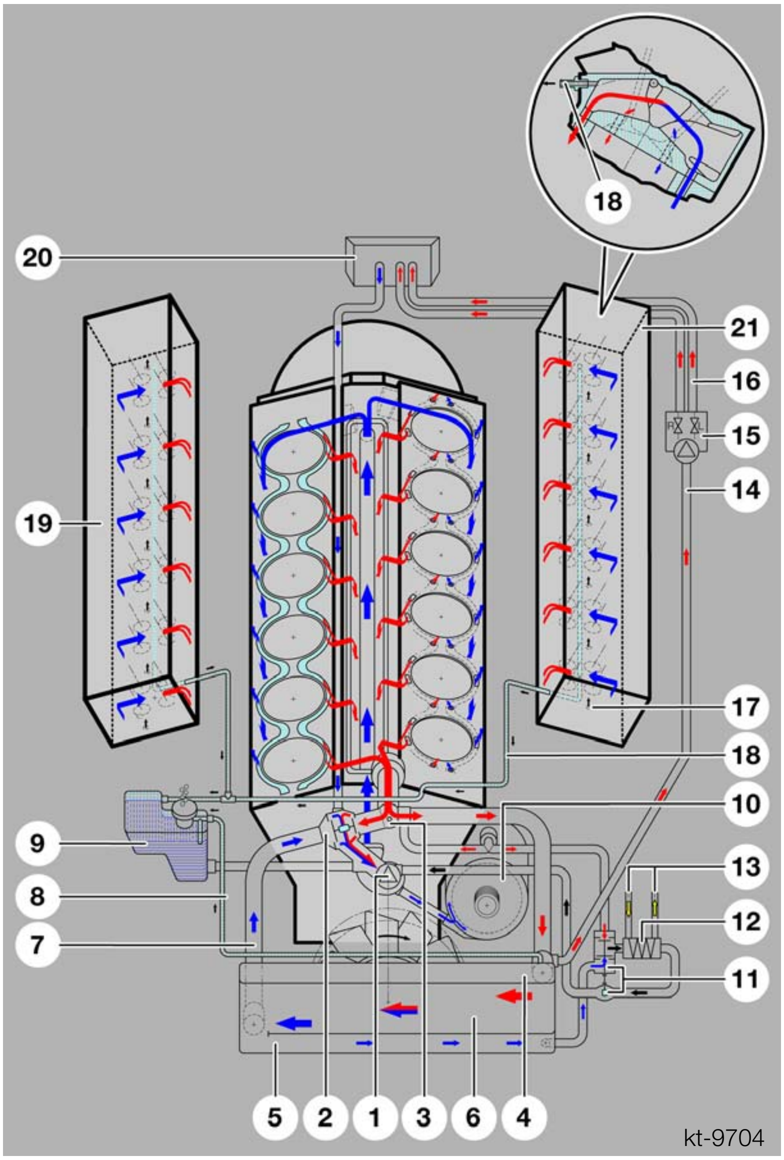
**Chain Drive - Cylinder Bank 7-12**

1. Exhaust VANOS unit
2. Roller drive chain
3. Upper guide rail
4. Intake VANOS solenoid port
5. Intake VANOS unit

*Notes:*

# Cooling System

## Coolant Circuit - 14.94 Liter (15.8 Quart) Capacity




**Cooling System (Circuit Flow)**

1. Water pump
2. Thermostat housing with MAP thermostat
3. Coolant temperature sensor
4. Radiator
5. Partition wall (low temperature area)
6. Radiator (high temperature area)
7. Return flow (cool)
8. Radiator vent line
9. Coolant reservoir
10. Water cooled alternator
11. Thermostat for transmission oil heat exchanger
12. Oil/water heater exchanger for automatic transmission
13. Transmission oil line connections
14. Heater supply hose (hot)
15. Water valves / electric pump
16. Heater inlet hoses
17. Holes (cylinder jacket venting)
18. Cylinder head vent hose
19. Cylinder head, bank 1-6
20. Heater core(s)
21. Cylinder head, bank 7-12

## Coolant Circuit

The coolant flow has been optimized allowing the engine to warm up as quickly as possible after a cold start as well as even and sufficient engine cooling while the engine is running. The cylinder heads are supplied with coolant in a cross-flow pattern. This ensures more even temperature distribution to all cylinders.

The cooling system ventilation has been improved and is enhanced by using ventilation ports in the cylinder heads and in the radiator. The air in the cooling system accumulates in the reservoir/expansion tank. When a pressure of 2 bar is reached in the expansion tank, the air is bled out by the pressure relief valve in the reservoir cap.

*Note:* The ventilation ports in the front of the cylinder heads provide quicker “self bleeding” during a routine coolant exchange. The complex cooling system and the small ventilation ports require that time should be allowed after the cooling system has been filled for the air to escape.

## Coolant flow in the Engine Block (similar to N62)

Reference diagram on page 30 - The coolant flows from the water pump through the feed pipe in the engine's V and to the rear of the engine block. This area has a cast aluminum cover. From the rear of the engine, the coolant flows to the external cylinder walls and from there into the cylinder heads.

The coolant then cross flows through the cylinder heads (exhaust to intake) into the engine block inner coolant jacket into the engine “V” and through the return connection to the thermostat housing. When the coolant is cold it flows from the thermostat (closed) directly into the water pump and back to the engine (recirculating for faster warm up).

When the engine reaches operating temperature (85 ºC-110 ºC), the thermostat opens the entire cooling circuit to include the radiator.

The coolant flows to the rear of the engine block, from there through the side channels to the cylinder walls and then into the cylinder heads (lower left picture). The cast aluminum cover at the rear of the engine block (with sealing bead) is shown on the lower right.

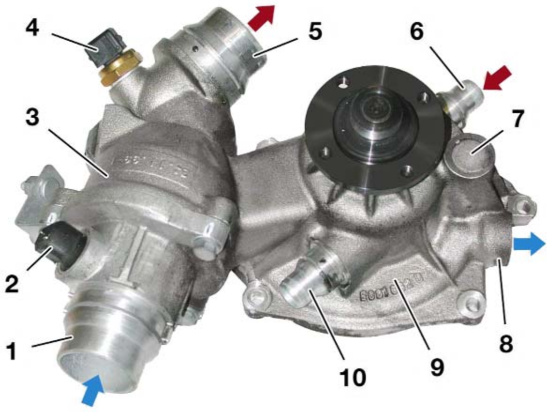
42-02-59

42-02-58

**Water Pump/Thermostat Housing**

The water pump is combined with the thermostat housing and is bolted to the timing case lower section.

1. Map-controlled themostat (radiator cool return flow).
2. Electrical connection for Thermostat Heating element.
3. Thermostat Mixing Chamber
4. Temperature Sensor (hot coolant from engine)
5. Radiator in-flow (hot coolant from engine)
6. Heat exchanger (transmission oil return flow)
7. Leakage Chamber (evaporation space)
8. Alternator in-flow (cool supply)
9. Water Pump
10. Expansion Tank Connection




42-02-60

**Water Pump / Thermostat Housing**

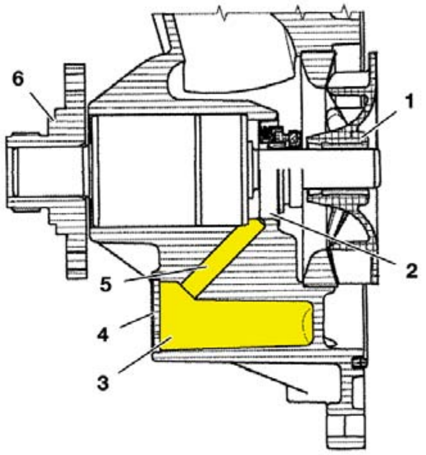
*Caution during installation of the water pump:* The impeller is made from reinforced plastic.

## Leakage Restraint System in the Water Pump

The water pump has a leakage restraint system for the functional leakage from the pump shaft piston ring type seal. The coolant which escapes through the pump shaft sliding ring seal usually accumulates and evaporates through a hold in the leakage chamber (evaporation area).

If the sliding ring seal is faulty, the leakage chamber fills completely with coolant. Sliding ring seal leakages can be detected by monitoring the fluid level in the leakage chamber (inspection hole).

1. Impeller
2. Sliding Ring Seal
3. Leakage Chamber / Evaporation Space
4. Leakage Chamber Cover
5. Delivery from the sliding ring seal to the leakage chamber
6. Hub of pulley and viscous clutch




**Water Pump**

42-02-61

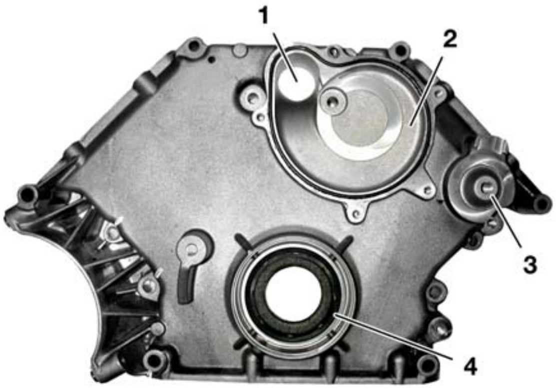
*Note:* In the past, fully functional water pumps were often replaced because the functional sliding ring seal leakage which is necessary for water pump operation resulted in evaporation residues being left on the external walls of the water pump.

The leakage restraint system has the advantage in that the coolant escaping from the sliding ring seal (normal, functional leakage) evaporates without a trace and cannot be mistakenly identified as a water pump defect during visual inspections.

## Timing Chain Cover Lower Section

The waterpump mounts to the lower section to channel coolant to the engine block.

1. Coolant to Engine
2. Rear Water Pump Housing in Lower Section
3. Mount for Drive Belt Tensioner Pulley
4. Crankshaft Radial Seal




**Timing Chain Cover Lower Section**

42-02-62

## Map-Controlled Thermostat

The map-controlled thermostat allows the engine to be cooled relevant to operating conditions. This reduces fuel consumption by approximately 1% per 10º C temperature increase. The map-controlled thermostat function is the same as previous engines (N62).

1. Radiator Return Flow To Thermostat
2. Connection for Thermostat Heating Element
3. Temperature Sensor
4. Radiator in-flow (hot coolant from engine)

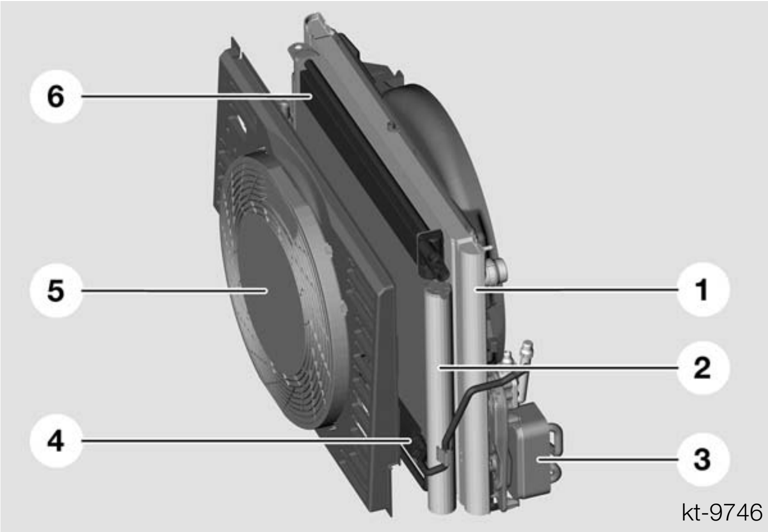
42-02-63

**Maped-Controlled Thermostat**

## Cooling Module

The cooling module contains the following main cooling system components:

1. Engine cooling radiator
2. Air conditioning condenser
3. Transmission oil/water heat exchanger
4. Power steering cooler
5. Electric fan
6. External engine oil cooler



kt-9746

## Radiator

The radiator is made from aluminum and is divided into a high-temperature section and a low-temperature section by a partition wall (see page 30). The coolant first flows into the high-temperature section and then back to the engine, cooled.

Some of the coolant flows through an opening in the radiator partition wall to the low-temperature section where it is cooled further. The coolant then flows from the low-temperature section (when the ÖWT thermostat is open) into the oil/coolant heat exchanger.

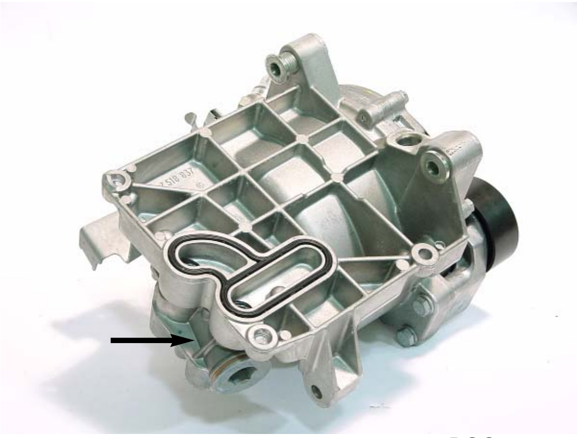
## Coolant Reservoir

The reservoir/expansion tank is mounted on the right hand wheel housing (engine compartment). *Note:* The expansion tank should never be filled above the "Max" marking. Excess coolant is expelled by the pressure relief valve in the cap as it heats up. Avoid overfilling the expansion tank because the cooling circuit design ensures very good "self bleeding".

## Engine Oil Cooling

The cooling module of the E65/E66 has been expanded for the N73 to include an external engine oil cooler (6). The engine oil cooler is located in front of the engine coolant radiator above the A/C condenser.

The engine oil flows from the oil pump through a channel in the crankcase to a connection on the alternator support. The alternator support has an oil thermostat (arrow to the right).



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A wax element in the oil thermostat opens the supply flow to the engine oil cooler from an oil temperature of 100 ºC to 130 ºC.

A partial amount of engine oil will permanently bypass the oil thermostat, even when it is fully open and flows uncooled through the engine.

The engine oil cooler helps to keep the engine oil temperature below 150 ºC. Cooling the engine oil provides a uniform oil temperature and ensures a long service life for the oil.

## Transmission Oil/Coolant Heat Exchanger

The transmission oil/coolant heat exchanger ensures that the transmission oil is heated up quickly and also that it is appropriately cooled. When the engine is cold, the transmission oil/coolant heat exchanger thermostat switches into the engine's recirculated coolant circuit. This allows the transmission oil to heat up as quickly as possible (with the engine coolant).

When the return flow water temperature reaches 82 ºC, the thermostat switches the transmission oil/coolant heat exchanger to the low-temperature coolant radiator circuit (refer to page 30) to cool the transmission oil.

## Electrically Operated Fan

The electric fan is integrated in the cooling module and is mounted directly in front of the radiator. The fan speed is regulated by the ECM.

## Viscous Coupling Fan

The viscous coupling fan is driven by the water pump. The noise output and the performance of the fan coupling and the fan wheel have been optimized as compared with the E38 M73. The viscous coupling fan is used as the final level of cooling and switches on at an air temperature of 92 ºC.

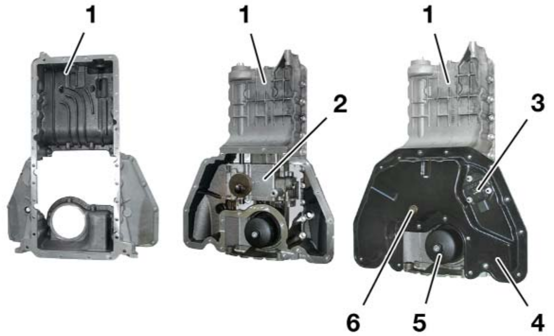
*Notes:*

# Engine Block

## Oil Sump

The oil sump consists of two parts. The upper section of the oil sump is made from cast aluminum and is sealed to the crankcase with a rubber-coated sheet steel gasket. This section of the oil sump has a cross shaped cut out oil filter element recess. The upper section of the oil sump is inter connected to the oil pump and is sealed with a sealing ring. The double panel (noise insulation) lower section of the oil sump is flanged to the upper section of the oil sump.

1. Upper Section of The Oil Sump
2. Oil Pump
3. Oil Level / Condition Sensor
4. Lower Section of The Oil Sump
5. Oil Filter Housing
6. Oil Drain Plug




**Oil Sump Components**

42-03-65

## Crankcase

The crankcase is a one-piece “open deck” design and is made entirely from AluSil. In mass production, the cylinder bores are finished by an etching procedure. This involves etching out a thin aluminium layer from the cylinder walls. By doing this, the high strength silicon crystals are exposed. The silicon crystals form a high strength running surface for the pistons.

*Open Deck: Exposed cylinder coolant jacket*

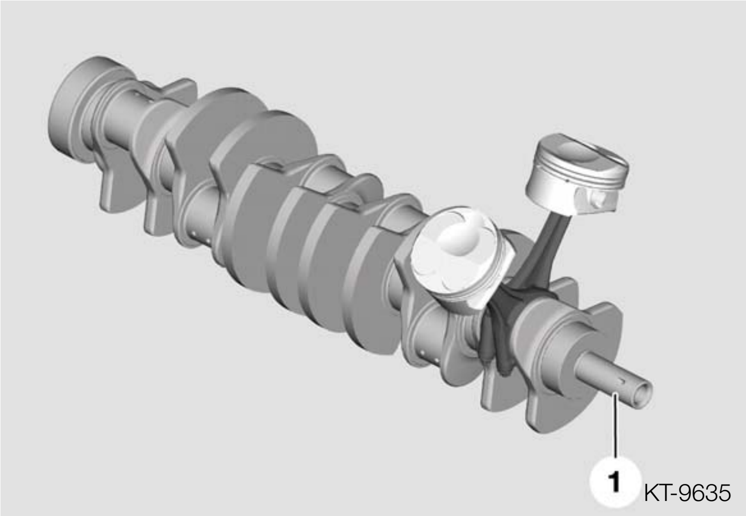
kt-9588

## Crankshaft

The N73 uses a forged steel crankshaft (1 - front).

Each crankshaft throw has two counterweights for balancing the moving masses (12 counterweights in total).

The crankshaft is supported by seven main bearings, the seventh is the thrust bearing.




**Crankshaft**

## Crankshaft Thrust Bearing

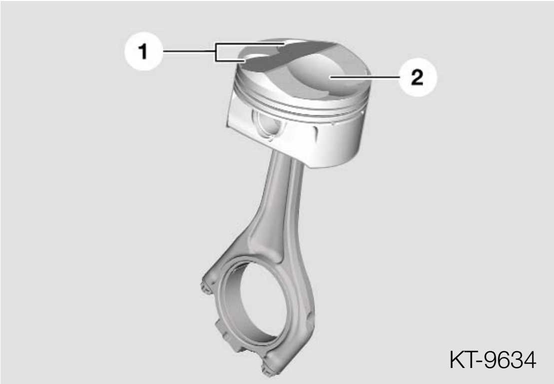
The thrust bearing halves are multiple pieces that are assembled as one part for the the number seven main bearing at the rear of the engine.


## Piston and Connecting Rod

The iron coated cast aluminum alloy pistons are "domed" with valve reliefs in the crowns (1). The recess (2) directs the combustible mixture directly under the spark plug and prevents the combustion chamber from being divided into two parts.

Piston rings:
- First piston ring groove = square ring
- Second piston ring groove = taperface ring
- Third piston ring groove = two-part oil control ring

*Note:* Due to the shaping of the piston crown and the wrist pin offset, the pistons are cylinder bank specific (crown index arrow always points to the front of the engine).




The forged steel connecting rod and cap is separated by the familiar "cracked" process. The large end is angled at 30° allowing sufficient articulation in a very compact space. The pistons are cooled by oil jets spraying under the exhaust side of the piston crown.

## Flywheel

43-02-04

The lightweight flywheel is constructed as a laminated assembly. The starter ring gear is also the increment wheel for engine speed and crankshaft positioning/misfire detection.

The ring gear is hot riveted directly to the flexplate (6). The flywheel diameter is 320 mm.

## Vibration Damper

43-02-03

The vibration damper is a torsional vibration absorber (axial design). The outer edge of the damper has a notch (1) to accept the locating tool when positioning the crankshaft for initial setting.

The locating tool inserts into the raised mount in the front cover (2). ***Refer to the Repair Instructions for the proper valvetrain timing procedure.***

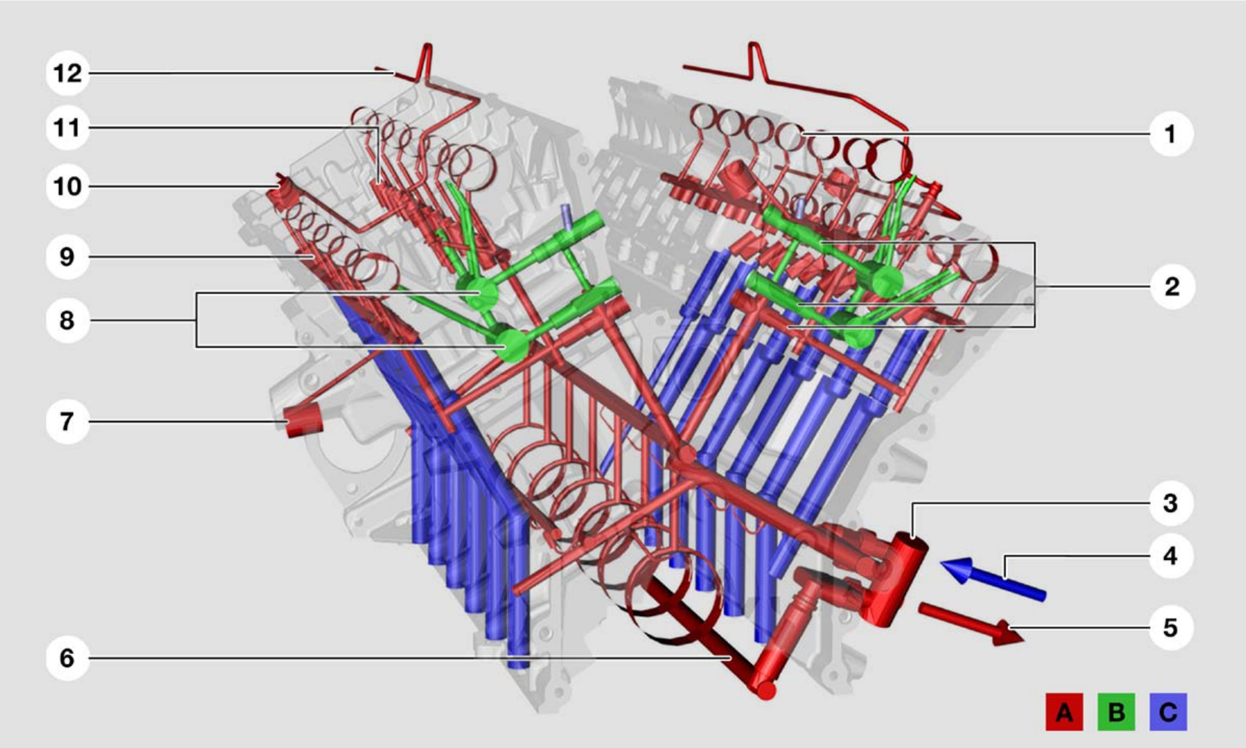
## Engine Mounting

The engine is secured by two hydraulic damping mounts that are located on the front axle carrier (structure and function are the same as the E65/E66 N62).

*Notes:*

## Lubrication System

### Oil Cicuit (view from engine front)




KT-9632

A. Oil pressure from oil pump
B. Oil supply to VANOS units
C. Oil return
1. Oil supply to intake camshaft
2. Oil non-return valves
3. Oil circuit in oil thermostat
4. Oil return from oil cooler
5. Oil supply to oil cooler
6. Oil supply from oil pump
7. Oil supply , chain tensioner
8. Oil supply , VANOS solenoid valves
9. Oil supply to exhaust camshaft
10. Oil supply to high pressure injection pumps
11. Oil supply to HVA elements
12. Oil supply to Valvetronic eccentric shaft

The engine oil is supplied by the oil pump to the lubrication points in the engine block and is pumped into the cylinder heads. The following components in the crankcase and cylinder head are supplied with engine oil:

*Crankcase*

- Crankshaft bearings
- Oil jets for piston cooling
- Oil jet for the drive chain (bank 7-12)
- Tensioning rail for drive chain (bank 1-6)

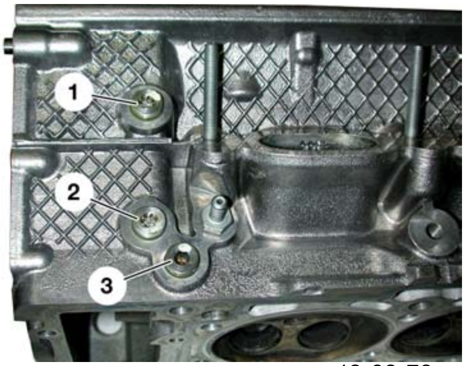
*Cylinder head*

- Chain tensioner
- Guide rail on cylinder head
- Hydraulic valve adjustment elements (HVA)
- VANOS supply
- Camshaft bearings
- Overhead oil tubes for the valve gear

## Oil Non-return Valves

Three oil non-return valves are inserted into each cylinder head from the outside. This prevents the engine oil from draining out of the cylinder head and the VANOS units.

1. Oil Check Valve for VANOS Intake
2. Oil Check Valve for VANOS Exhaust
3. Oil Check Valve for Cylinder Head Oil Supply




42-02-72

*Note: The non-return valves are accessible from the outside, therefore; cylinder head removal is not necessary when changing the valves. The valves are different in design and should not be mixed up on installation.*

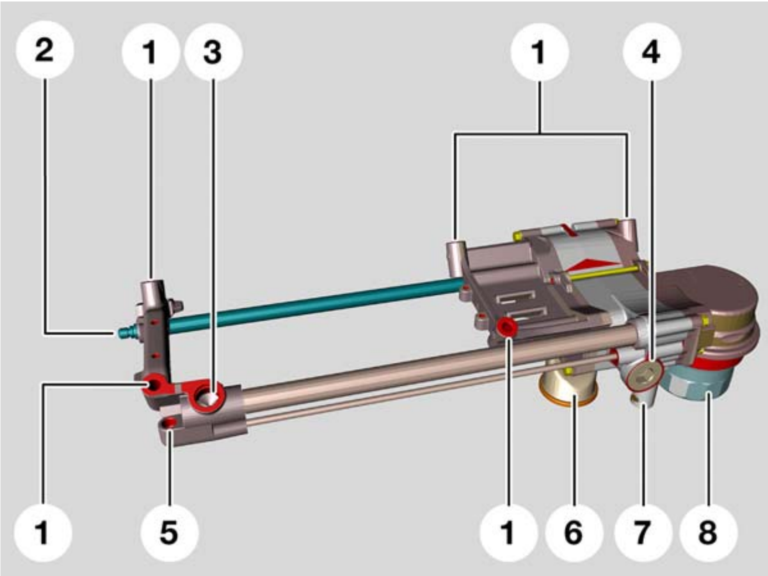
## Oil Pressure Switch

The oil pressure switch is located on the right front engine block (above the A/C compressor).

## Oil Pump

The oil pump is mounted at an angle to the crankshaft bearing cap and is driven by the crankshaft using a roller chain. The oil pump is a two-stage gear oil pump with two gear clusters.

1. Mounting points
2. Oil pump drive shaft
3. Oil pressure from pump to engine
4. Control valve (Pump Stage/Pressure Control)
5. Oil pressure control tube from the engine to the control valve.
6. Oil pickup strainer
7. Pressure relief valve (over 15 Bar)
8. Oil filter



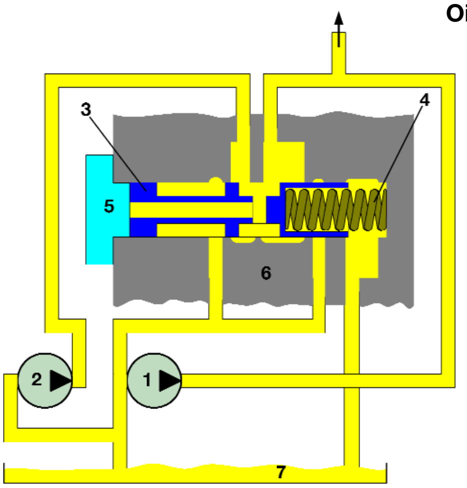

**Oil Pump** KT-9614

Stage two (both pump supply circuits) is only active in the lower engine speed range (up to approx. 2,000 rpm) to provide sufficient oil pressure for the VANOS at high oil temperatures. Stage two is deactivated hydraulically at a pressure of 2 bar.

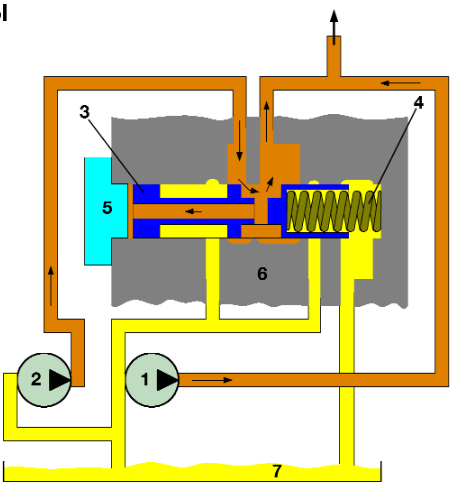
## Oil Pressure Control

1. Oil Pump Stage 1
2. Oil Pump Stage 2
3. Pressure Control Valve Piston
4. Pressure Control Valve Spring
5. Sealing Plug
6. Oil Pump Housing
7. Oil Sump

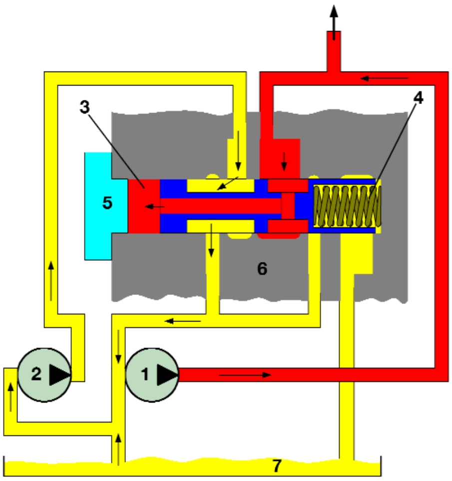
**Oil Pressure Control**



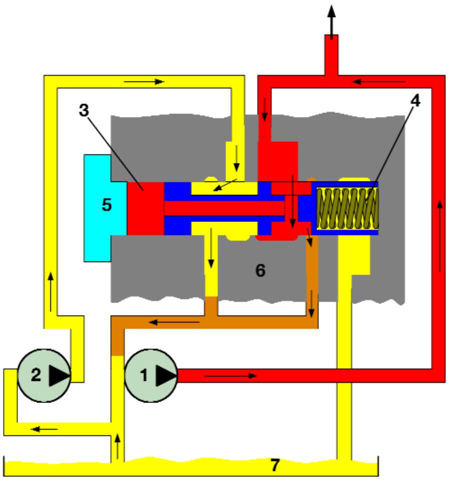

*Oil pressure control valve in initial position, without pressure.*




*Stage two = Both pump supply circuits activated with oil pressure less than 2 bar.*




*Stage two deactivated = Oil pressure above 2 bar, pressure control valve opens channel for stage two to oil sump.*



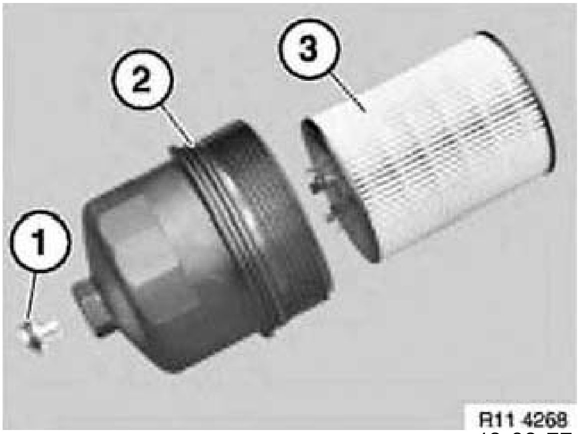

*Main pressure control = Oil pressure above 6 bar, pressure control valve opens channel for stage one (slightly) to oil sump relieving excessive pressure.*

## Oil Filter

The canister type oil filter (3) is located under the engine by the oil sump. The support for the oil filter is integrated in the rear oil pump cover.

The oil filter housing (2 with o-ring) is threaded into the rear of the oil pump cover through an opening in the oil sump.

***A drain plug is integrated in the oil filter housing for draining the filter assembly before the housing is removed (1 with o-ring).***

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The filter element support dome contains an over pressure relief valve. If the filter element is blocked, this valve allows a bypass of unfiltered engine oil around the element to the supply lubrication to the engine.

## Pressure Control

The oil pressure control valve in the oil pump has two functions:

1. Deactivates stage two oil pump circuit above 2 bar. Stage two is only active in the lower speed range. This is to ensure that there is always sufficient oil pressure for the VANOS units even at high oil temperatures and low speeds. The oil pump power consumption is reduced by deactivating stage two.

2. Monitoring the required oil pressure for the engine. The piston in the control valve is moved by a spring against the engine control pressure which is returning from the engine. This means that precise monitoring of the actual engine oil pressure is possible.

***A separate pressure relief valve in the oil pump automatically opens at the maximum pressure of approximately 15 bar. This prevents damage in the oil pump especially at low oil temperatures.***

## Technical Data - Lubrication System

**The recommended oil is BMW High Performance 5W-30 Synthetic Oil**
 * P/N 07 51 0 017 866

| Oil Capacity in Liters (quarts) | Explanation |
|---|---|
| 8.5 (9.0) | Filling capacity with oil filter change |

| Oil Pressure in Bar | Explanation |
|---|---|
| 1.0 | Minimum oil pressure @ 20º C |
| 4.0 - 8.0 | Maximum oil pressure @ 20º C |

| Oil Delivery Capacity | Explanation |
|---|---|
| 9 - 12 liters/minute | At idle speed (550 rpm) @ 20º C |
| 50 - 55 liters/minute | At maximum engine speed (6500 rpm) @ 20º C |

## Review Questions

1. What is the function of the throttle valve(s)?

2. What are the conditions that will result in stage two oil supply?

3. What does the term “cracked” connecting rod mean?

4. What does the low temperature area refer to in the cooling system?

5. What is minimum and maximum valve lift provided by the Valvetronic system?

6. What is chamber A and chamber B used for in the Bi-VANOS system?
   A:
   B:

7. What retains the initial VANOS sprocket to hub position when oil pressure is not present?

8. Under what conditions are the Auxiliary Air Flaps fully opened by the ECM?

9. What Valvetronic components are different as compared to the N62?

10. Where is the engine oil thermostat located?