2007-08 ENGINE

Engine - SI Techniques - 6-Cylinder (N52)

11 ENGINE

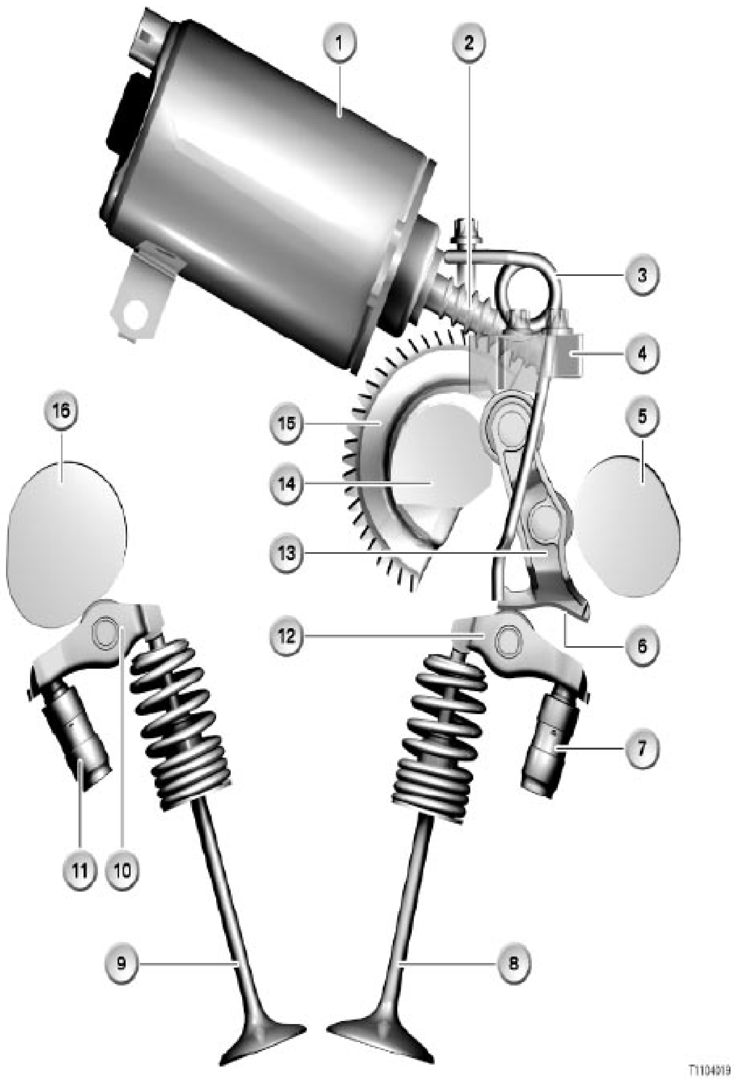
N52 ENGINE, VALVETRONIC: E60, E61, E63, E64, E65, E66, E87, E90, E91

The Valvetronic consists of fully variable control of the valve lift combined with the variable camshaft control unit (VANOS).

As of the N52 engine, the 6-cylinder petrol engine is equipped with Valvetronic. The advantages this technology are:

- Enhancement of engine dynamics
- Improvement in the emission values

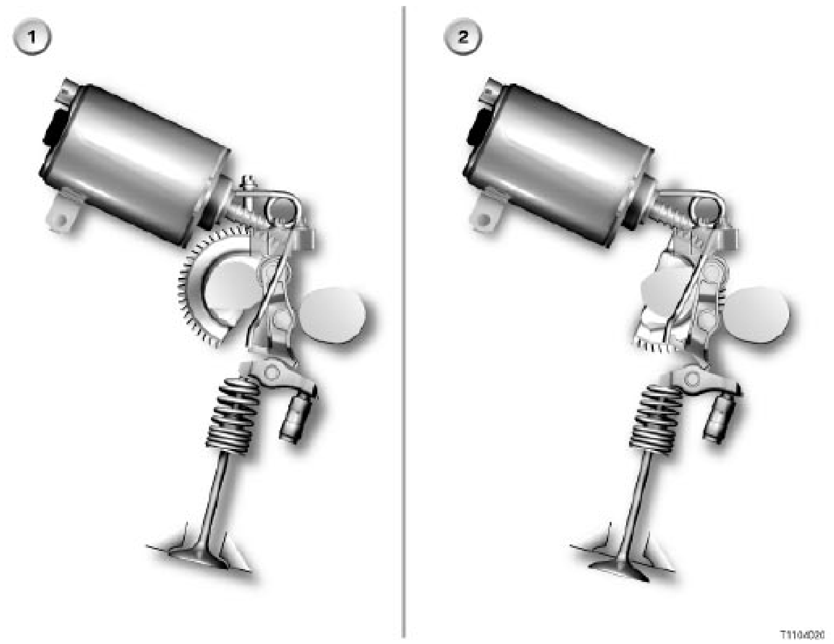
Design



Item	Description	Item	Description
1	Electric servomotor	2	Worm shaft
3	Return spring	4	Gate block
5	Inlet camshaft	6	Ramp
7	Hydraulic valve clearance adjustment for inlet valve	8	Inlet valve
9	Outlet valve	10	Roller cam follower, exhaust valve
11	Hydraulic valve clearance adjustment for exhaust valve	12	Roller cam follower, inlet valve
13	Intermediate lever	14	Eccentric shaft
15	Worm wheel	16	Exhaust camshaft

Fig. 1: Identifying Engine Valvetronic Components
Courtesy of BMW OF NORTH AMERICA, INC.

The fully variable valve timing



Item	Description	Item	Description
1	Setting for minimum valve lift	2	Setting for maximum valve lift

Fig. 2: Identifying Fully Variable Valve Timing
Courtesy of BMW OF NORTH AMERICA, INC.

The fully variable valve lift timing is implemented with the following components:

- Electric servomotor
- Eccentric shaft
- Intermediate lever
- Return spring
- Roller cam follower

The actuator motor is fitted above the camshafts in the cylinder head. The actuator motor adjusts the eccentric shaft. The worm shaft of the electric motor engages in the work gear attached to the eccentric shaft. After adjustment, the eccentric shaft does not have to be locked in any special way, as the worm gear has an adequate self-regulation system. The eccentric shaft adjusts the valve lift on the inlet side. The intermediate lever changes the transmission coefficient between the camshaft and roller cam follower. In the full load position, the valve lift and opening duration are at the maximum. In the idle position, the valve lift and opening duration are at the minimum. The roller cam followers and associated intermediate levers are split into 4 groups. To this end, an ID code is stamped in the components. Each pair always has the same class. The assignment of the roller cam followers and intermediate levers ensures that the cylinders are evenly filled, even with minimum lift.

Advance

In the lower range of motion of the valves, the possibility for harmonization by means of so-called advance is supported.

The inlet valves of a cylinder are opened synchronously up to a lift of 0.2 mm. As of this lift, valve 1 begins to advance. Valve 2 opens with a slight delay a little later. Valve 2 catches up with valve 1 with a stroke of approx. 6 mm. From then on, they open synchronously. These response characteristics favor the gas mixture flowing into the cylinders. The cross section of the inlet valve openings has been kept small to achieve a significantly higher flow rate with the intake volume remaining the same. This flow rate is used for better mixing of the intake mixture.

N52 ENGINE, DIGITAL MOTOR ELECTRONICS: E60, E61, E63, E64, E65, E66, E87, E90, E91

Design

The DME control unit MSV70 has 2 connections.

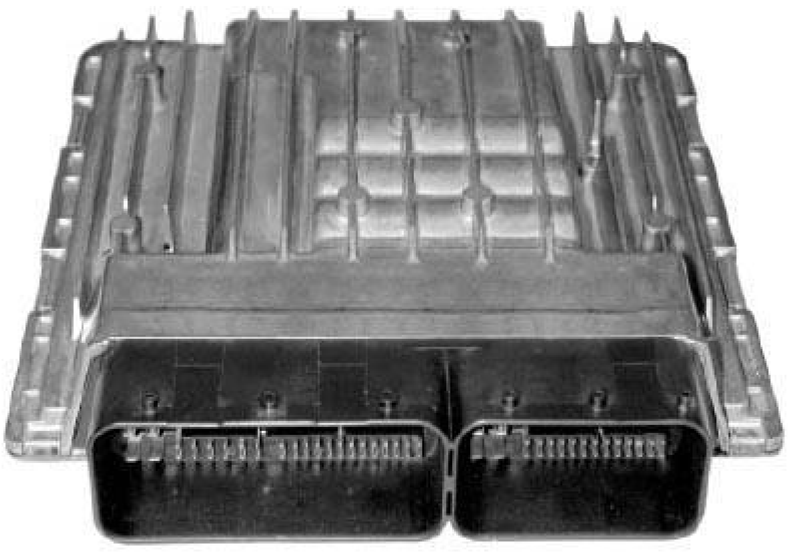


Fig. 3: Identifying Engine, Digital Motor Electronics
Courtesy of BMW OF NORTH AMERICA, INC.

Functions

The digital engine electronics MSV70 regulate the following functions:

- Ignition control unit
- Control of the injection system
- Control of the Valvetronic
- Control of the engine temperature
- Control of the electrical coolant pump
- Knock control
- Lambda control system
- Control of the tank ventilation

- Control of the air-conditioning compressor via the IHKA control unit
- Control of the differential air intake control (DISA)
- Electrical air flap control
- Control of the electrical fuel pump
- Cruise control system
- Control of the alternator
- Activation of the engine breather
- Registering the engine oil quality and oil level
- Energy management
- Signal evaluation and calculation of substitute program and emergency running
- Self-diagnosis

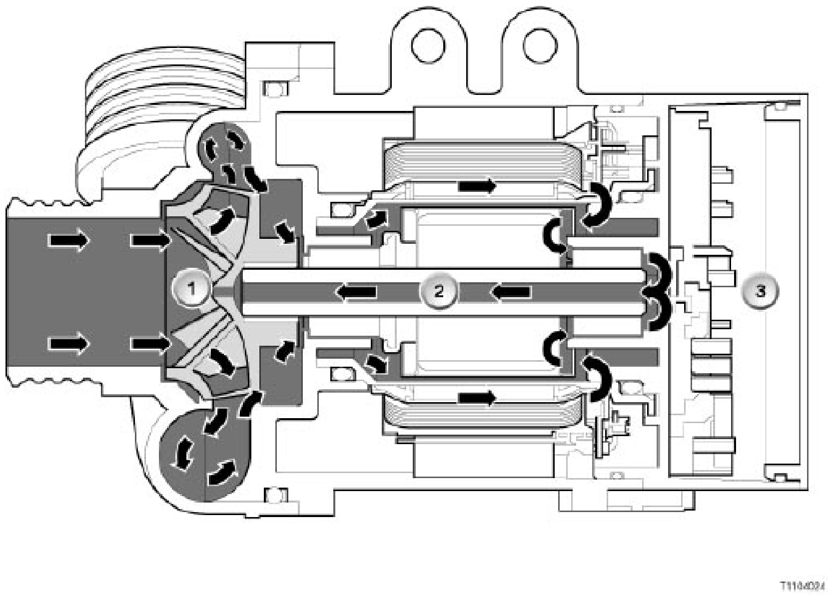
N52 ENGINE, ELECTRIC COOLANT PUMP: E60, E61, E63, E64, E65, E66, E87, E90, E91

Fast heating-up of the engine after a cold start significantly lowers fuel consumption and helps comply with exhaust threshold values.

High engine temperatures after stopping the engine can lead to a reduction in the engine service life. These function requirements can only be implemented with conventional cooling concepts with a high level of overhead and a great many compromises.

An electrically driven water pump delivers exactly the amount of coolant required in each operating condition. A low coolant flow volume with a cold engine enables rapid warm-up. Pumping after stopping the engine leads to a significant reduction in the engine temperature in the engine's afterheating phase.

Design



Item	Description	Item	Description
1	Pump	2	Engine
3	Control electronics in the electrical coolant pump		

Fig. 4: Engine, Electric Coolant Pump Operation Diagram
Courtesy of BMW OF NORTH AMERICA, INC.

How it works

The coolant pump of the N52 engine is an electrically driven pump. The power output of the electric motor is controlled electronically by control electronics.

These control electronics are connected to the Digital Engine Electronics (DME) across the bit-serial data interface. The DME uses the load, the operating range and the data from the temperature sensors to determine the required cooling output. The DME provides the control electronics with the corresponding control signals to control the coolant pump. The motor of the coolant pump is rinsed with coolant. This lubricates the bearings of the electrical coolant pump.

N52 ENGINE, ENGINE BLOCK: E60, E61, E63, E64, E65, E66, E87, E90, E91

The 6-cylinder engine is available with a number of different power outputs. Depending on the type or national version, the cylinder capacity and power output are adapted.

Fig. 5: Identifying Engine Block
Courtesy of BMW OF NORTH AMERICA, INC.

Design

Crankcase

1. Crankcase, upper section
2. Bedplate Magnesium cannot be used in certain areas, for example in the cylinder bushes. This is why the crankcase is of composite design. The aluminum-silicon insert holds the bolt connections to the gearbox, cylinder head and crankshaft bearings as well as to the cooling ducts. This means that the magnesium cannot come into contact with the coolant and the water it contains.

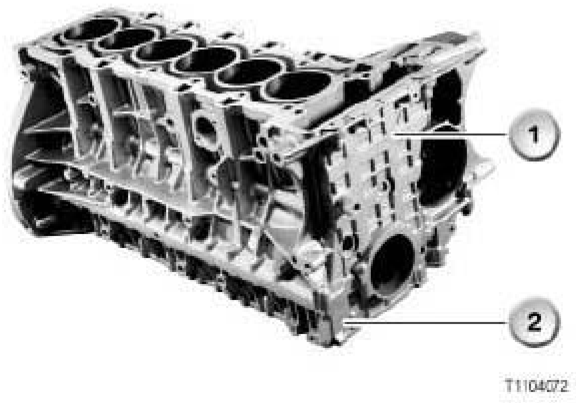


Fig. 6: Identifying Crankcase, Upper Section And Bedplate
Courtesy of BMW OF NORTH AMERICA, INC.

1. Aluminum-silicon alloy insert in crankcase

2. Magnesium-aluminum alloy crankcase

The crankcase consists of an aluminum-silicon insert, inseparably and seamlessly cast in with a magnesium alloy. This magnesium alloy has been developed by BMW.

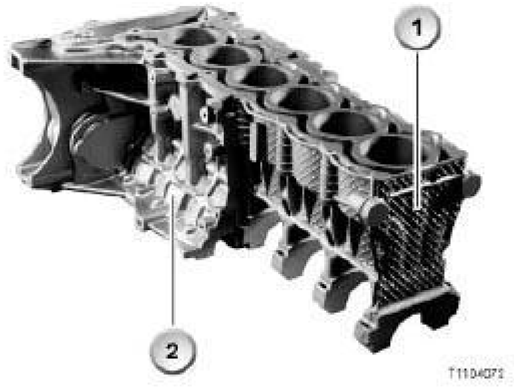


Fig. 7: Identifying Magnesium-Aluminum Alloy Crankcase
Courtesy of BMW OF NORTH AMERICA, INC.

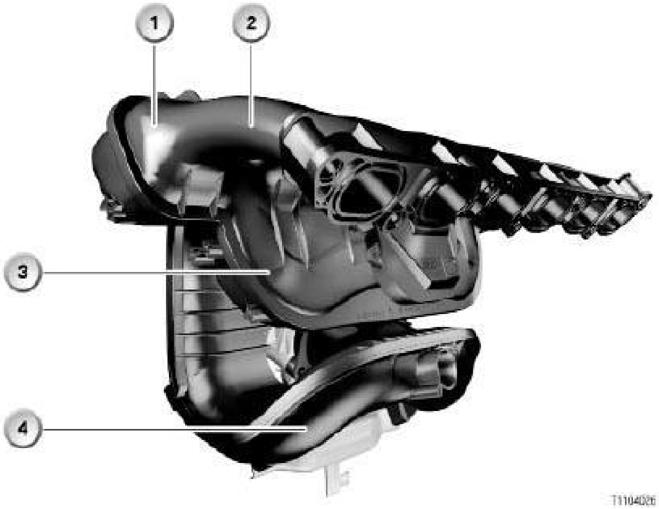
Bedplate

A split crankcase is used in the N52. The upper part consists of a magnesium-aluminum composite construction. To increase the rigidity, the lower part has been designed as a bedplate. This bedplate is also made of magnesium. To hold the main mounting forces, inserts made of sintered steel are used.

Fig. 8: Identifying Split Crankcase
Courtesy of BMW OF NORTH AMERICA, INC.

N52 ENGINE, INTAKE MANIFOLD: E60, E61, E63, E64, E65, E66, E87, E90, E91

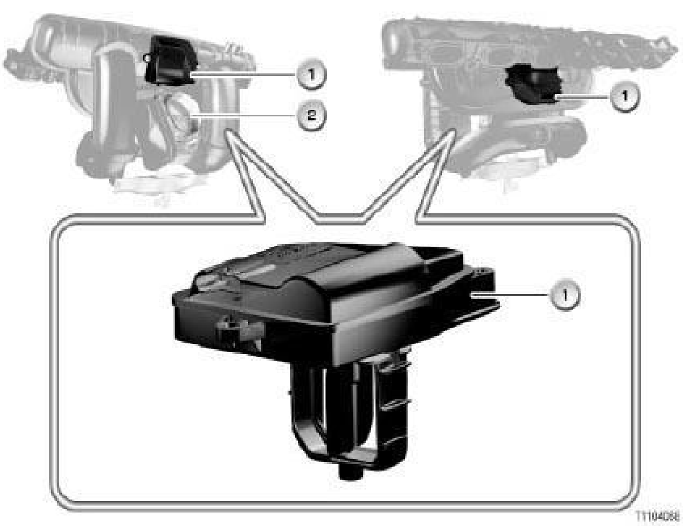
Design



Item	Description	Item	Description
1	Collector for intake air	2	Resonating pipe
3	Overshoot pipe	4	Resonance pipe

Fig. 9: Identifying Engine Intake Manifold And Components
Courtesy of BMW OF NORTH AMERICA, INC.

DISA actuator motor



Item	Description	Item	Description
1	DISA actuator motor	2	Throttle valve

Fig. 10: Identifying DISA Actuator Motor
Courtesy of BMW OF NORTH AMERICA, INC.

The actuator forms a unit with the drive. The actuator is driven by an electric motor and gearing. The control electronics are integrated in the DISA actuator motor. The DME controls the DISA actuator motor by means of a pulse-modulated signal. There are only 2 possible positions. The actuator can be closed or opened. When activated, the actuator moves the flap to each end position.

Depending on the engine concerned, engines are fitted with the following number of DISA actuator motors:

- N52 engine with 2 DISA actuator motors
- N52 engine with 1 DISA actuator motor
- N52 engine without a DISA actuator motor

How it works

The power and dynamics of an engine depend heavily on the quality of the cylinder filling. The intake air mass oscillates due to the piston motion. These oscillations are overlapped in turn by oscillations from pressure peaks.

To guarantee optimum air intake, the N52 engine has a three-stage differentiated air intake system (DISA).

The air intake guide is realized by a switchover mechanism in the inlet pipe with two DISA actuator motors and an overshoot pipe in the intake area.

The DISA actuator motors are each driven by an electric motor. The two DISA actuator motors are of different sizes. DISA actuator motor 2 is fitted in the overshoot pipe and DISA actuator motor 1 is fitted in the collector for intake air in front of the resonating pipe.

1st stage - idling/lower engine speed range

At idle speed and in the lower engine speed range, the DISA actuator motors 1 and 2 are closed.

The intake air flows past the throttle valve into the resonance pipe. In the resonance pipe, the intake air mass splits. The air is fed via the collector pipe and resonating pipes into the individual cylinders. In this way, three cylinders are provided with a comparably high air mass.

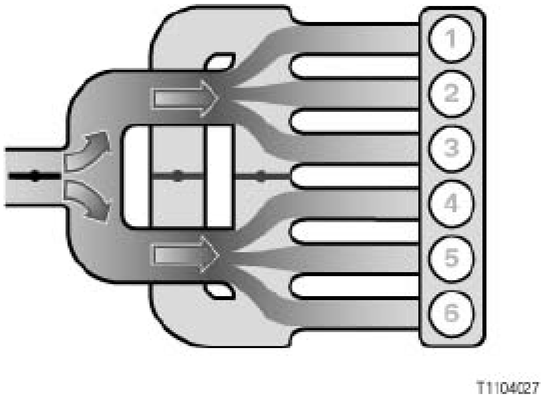


Fig. 11: DISA Actuator Motor Operation (1st stage - idling/lower engine speed range)
Courtesy of BMW OF NORTH AMERICA, INC.

2nd stage - medium engine speed range

In the medium engine speed range, DISA actuator motor 2 is opened.

In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak at the closing inlet valves. This pressure peak is passed on via the resonating and collector pipes to the in next cylinder in the firing order. This improves the filling of the next cylinder to be charged.

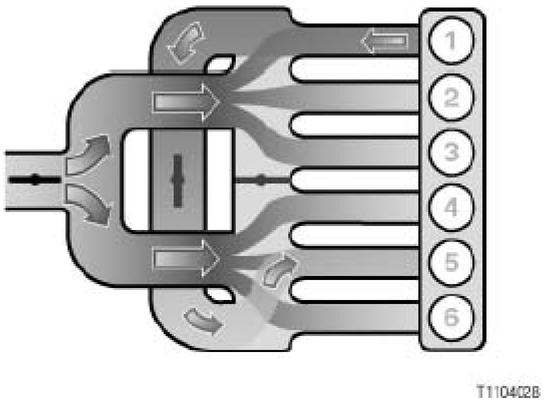


Fig. 12: DISA Actuator Motor Operation (2nd Stage - Medium Engine Speed Range)
Courtesy of BMW OF NORTH AMERICA, INC.

3rd stage - upper engine speed range

In the upper engine speed range, both DISA actuator motors are opened.

In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak in front of the closing inlet valves. The intake air mass is now fed via the resonating, overshoot and collector pipes.

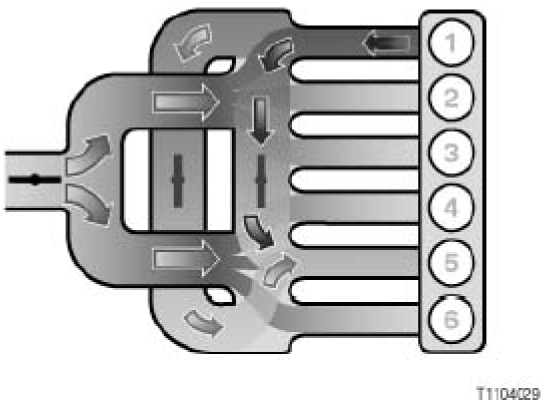
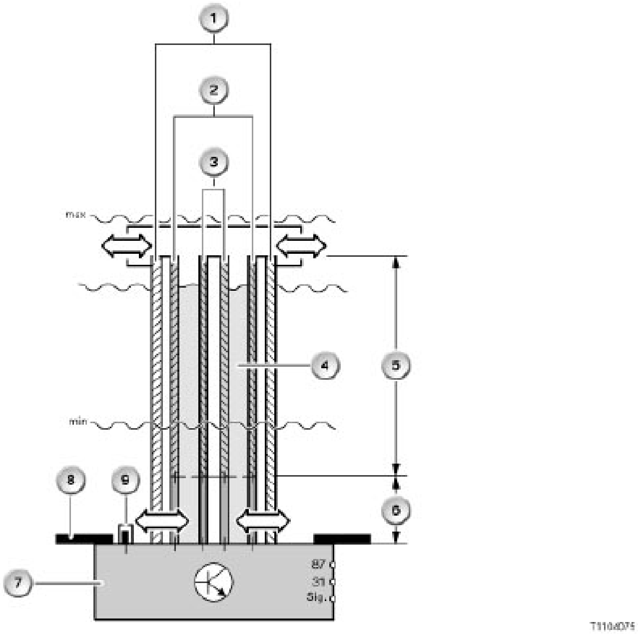


Fig. 13: DISA Actuator Motor Operation (3rd Stage - Upper Engine Speed Range)
Courtesy of BMW OF NORTH AMERICA, INC.

N52 ENGINE, OIL CONDITION SENSOR: E60, E61, E63, E64, E65, E66, E87, E90, E91

Design



Item	Description	Item	Description
1	Housing	2	Outer tube
3	Inner tube	4	Engine oil
5	Oil level measuring range	6	Engine oil condition measuring range.
7	Evaluation electronics	8	Oil pan
9	Temperature sensor		

Fig. 14: Identifying Engine Oil Condition Sensor Design
Courtesy of BMW OF NORTH AMERICA, INC.

How it works

The oil condition sensor consists of two cylinder capacitors arranged one above the other. The engine oil quality is measured by the lower, smaller capacitor.

Two metal tubes are arranged one inside the other as capacitor electrodes. The engine oil is located between the electrodes as an electrical non-conductor (insulator). The electrical material property of the engine oil changes with increasing wear and dissipation of the fuel additive. The changed electrical material properties of the engine oil change the capacitance of the capacitor. This capacitance value is processed in the integrated electronic evaluation unit into a digital signal. The digital sensor signal is passed on as an indication of the engine oil quality to the digital engine electronics (DME). This actual value is processed in the DME to calculate the next engine oil service.

The oil level is determined in the top of the sensor. This part of the sensor is located at the height of the oil level in the oil pan. As the oil level falls, the capacitance of the capacitor falls accordingly. This capacitance value is processed by the electronic evaluation unit into a digital signal and also sent to the DME.

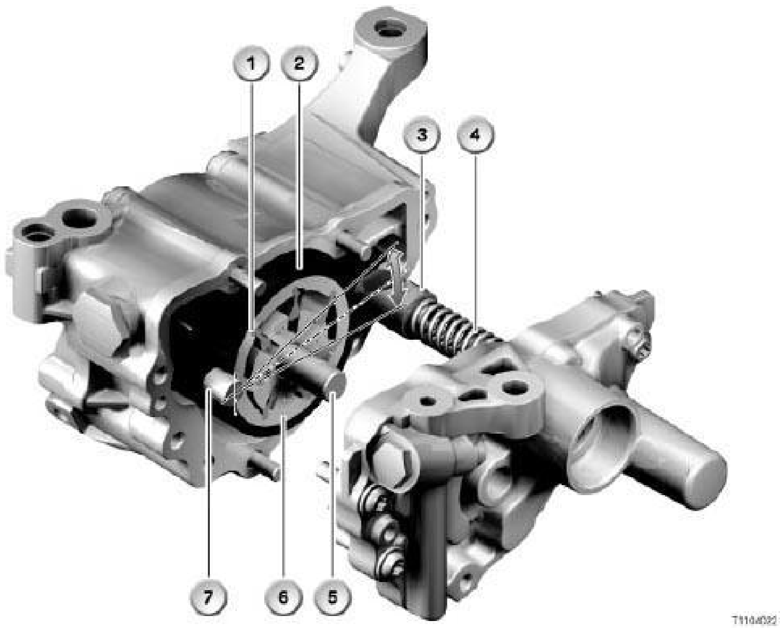
A temperature sensor has been fitted to the electronic evaluation unit to measure the engine oil temperature. The oil level, engine oil temperature and engine oil quality are measured continuously from ignition ON.

N52 ENGINE, OIL PUMP: E60, E61, E63, E64, E65, E66, E87, E90, E91

The oil pump must ensure reliable oil supply under all operating conditions. The N52 engine has a volume-flow-regulated oil pump. This pump only delivers exactly as much oil as each operating range of the engine requires.

Design

The oil pump in the N52 engine is a pendulum slide cell pump.

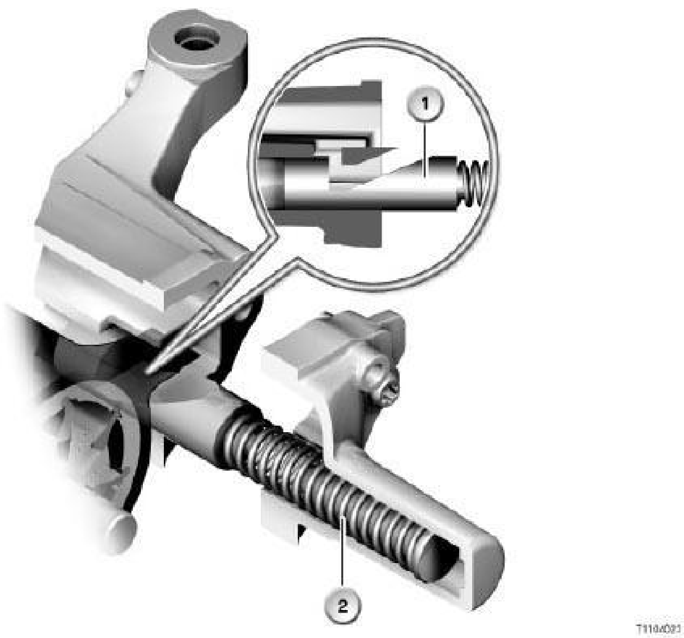


Item	Description	Item	Description
1	Impeller	2	Pendulum slide
3	Control piston	4	Pressure spring
5	Pump shaft	6	Rotor
7	Rotational axis		

Fig. 15: Identifying Engine Oil Pump Components
Courtesy of BMW OF NORTH AMERICA, INC.

How it works

The oil pump is driven by a chain from the crankshaft. The oil pressure generated affects the control piston with oblique thrust surface (hinged bracket) against the force of a compression spring. The hinged bracket varies the location of the pendulum slide. If the pump shaft is located centrally on the pendulum slide, changes in volume and the delivery capacity will be small. If the pump shaft is located away from the middle, changes in volume and the delivery capacity will be larger. If the oil requirement of the engine rises, the pressure in the lubricating system falls and thus also at the control piston. The pump increases the delivery volume and restores the pressure conditions. If the oil requirement of the engine falls, the pump regulates a low delivery volume towards zero delivery accordingly.



Item	Description	Item	Description
1	Control piston	2	Pressure spring

Fig. 16: Identifying Control Piston And Pressure Spring
Courtesy of BMW OF NORTH AMERICA, INC.

N52 ENGINE

E60, E61, E63, E64, E65, E66, E87, E90, E91

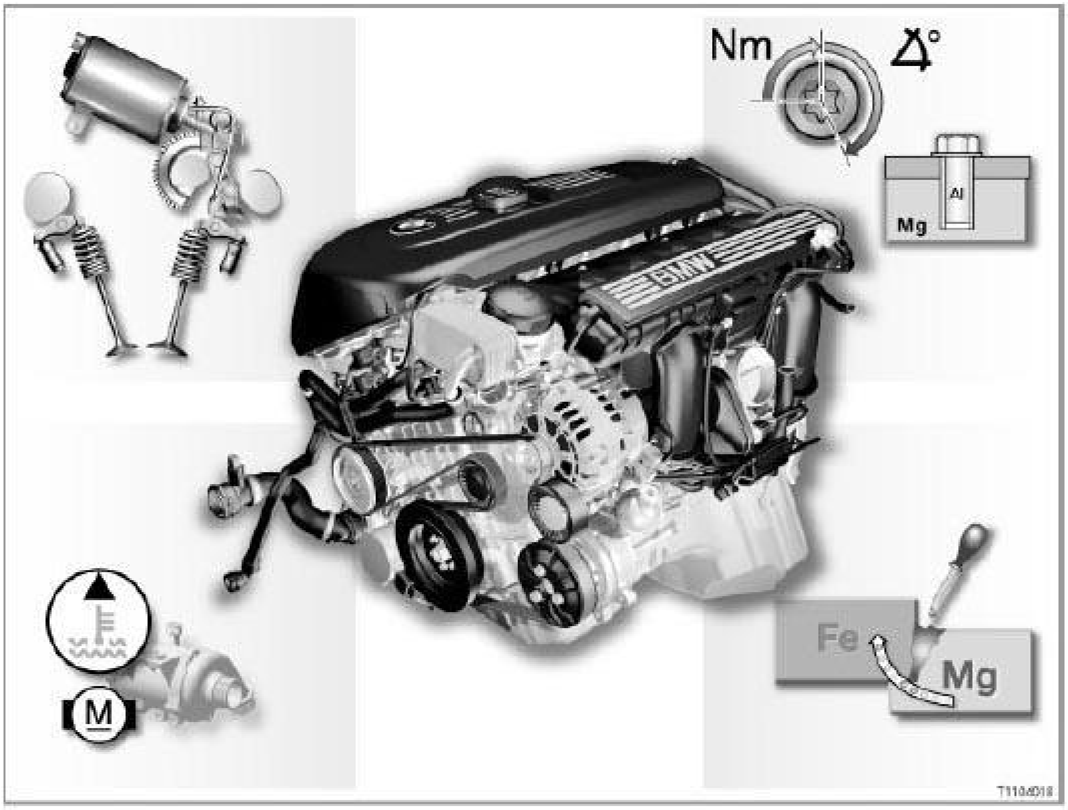


Fig. 17: Identifying Engine
Courtesy of BMW OF NORTH AMERICA, INC.

Introduction

The new 6-cylinder N52 spark-ignition engine represents the start of a new generation of engine at BMW. Consistent lightweight construction methods and the development of other innovations have created an outstanding engine.

Brief description of components

- Crankcase made of magnesium-aluminum composite

  The crankcase consists of an aluminum-silicon insert, inseparably and seamlessly cast in with a magnesium alloy.

- Innovative Valve Gear Valvetronic

  The Valvetronic consists of fully variable control of the valve lift combined with the variable camshaft control unit

- Volume-flow-regulated oil pump

  The new volume-flow-regulated oil pump delivers exactly the oil volume that is actually required.

- Electrical coolant pump

  The coolant pump driven by an electric motor is regulated irrespective of the engine speed.

- Three-phase differential air intake control

  The three-phase differential air intake control (DISA) ensures even cylinder fill levels.

- Oil condition sensor

  For the N52 engine, the dipstick and its guide pipe are eliminated.

  The N52 engine has an oil condition sensor.

- Digital engine electronics MSV70

  The digital engine electronics (DME) control and regulate the engine functions.

- Cylinder head cover made of magnesium
- Switchover to single-belt drive
- Highly temperature-resistant exhaust manifold

System functions

The following system functions are described:

- Volume-flow-regulated oil supply
- Oil level check, engine oil quality check and engine oil temperature check
- Valvetronic
- Heat management

Volume-flow-regulated oil supply

The N52 has a volume-flow-regulated oil pump. This pump only delivers as much oil as each operating range of the engine requires. A conventional oil pump would have to be approximately three times the size of that in the N52 engine. This oil pump would also require more driving power accordingly.

No superfluous oil is supplied for ranges with a smaller load. The fuel consumption of the engine is reduced and wear to the oil is slowed down. A pendulum slide cell pump is used. The pump shaft is located off-center in the housing during pump activation. The impeller shifts radially during rotation. This means that the chambers on the impeller form different volumes. The oil is taken into the enlarging volume. The oil is pumped into the oil ducts at the reducing volume.

Oil level check, engine oil quality check and engine oil temperature check

The oil level is measured by the oil condition sensor and shown in the Central Information Display (CID). This protects the engine from excessively low oil level and the associated engine damage. Excessive oil filling of the engine, which can lead to leaks, is displayed as a check control message.

The oil condition sensor also registers the engine oil quality. This means that the system is able to compute exactly when it is necessary to change the engine oil. Condition Based Service (CBS) allows the engine oil to be changed in line with needs.

The engine oil temperature is also detected or calculated by the oil condition sensor. The signal from the oil condition sensor is evaluated in the DME. The evaluated signal is routed via the PT-CAN and K-CAN bus to the instrument cluster and to the CID.

Valvetronic

The Valvetronic consists of fully variable control of the valve lift combined with the variable camshaft control unit (VAN OS).

The valve lift is only regulated on the inlet side, but the camshaft is also adjusted on the exhaust side. Valvetronic is controlled by:

- a variable valve lift of the inlet valve
- a variable opening duration of the inlet valve
- a variable camshaft control of the inlet and exhaust camshaft

(double VANOS)

The system is optimized by adapting the valve gear, changing the actuator motor and varying the camshaft timing control. Major innovations are:

- On the intermediate lever, the plain bearing to the eccentric shaft has been replaced by a roller bearing. This reduces the friction in the valve gear.
- The guide of the intermediate lever is more precise. Only one spring is required to guide and retain the intermediate lever.
- The moved mass of the valve gear has been reduced by 13%.
- The range of motion of the inlet valves has been improved. The maximum lift has risen to 9.9 mm, but above all the minimum lift has been further reduced to 0.18 mm.

Heat management

The possibilities of conventional cooling systems are used for the cooling system with electrical coolant pump.

The following components are influenced by the heat management:

- Electrical coolant pump
- Mapped thermostat
- Digital engine electronics (DME)

The cooling output of the system is adapted by means of a freely variable volumetric flow of the coolant.

The heat management determines the current cooling requirement and regulates the cooling system accordingly. If necessary, the coolant pump can even be switched off altogether, for example to heat up the coolant quickly during the warm-up phase.

If the engine is not running but very hot, the coolant pump will also work while the vehicle is out of use. Cooling output can thus be called up regardless of engine speed.

The heat management now permits various characteristic maps to be used as a basis for controlling the coolant pump, over and above the map thermostat. In this way, the engine control unit can adapt the engine temperature to the driving characteristics.

The engine control unit regulates the following temperature ranges:

- 112 °C = Economy
- 105 °C = Normal
- 95 °C = High
- 80 C = High and regulation by the map thermostat

If the vehicle handling causes the engine control unit to detect the economical operating range Economy, the DME regulates to a higher temperature (112 C).

In this temperature range, the engine is operated with a relatively fuel requirement. The friction inside the engine is reduced at higher temperature. The temperature increase thus favors lower fuel consumption in the low load range.

In the High and regulation by the map thermostat mode, the driver wants to use optimized power output development of the engine. To achieve this, the temperature in the cylinder head is lowered to 80 °C. This lowering leads to a better cylinder filling, which leads in turn to an increase in engine torque. The engine control unit can now regulate a certain operating range, adapted to the relevant driving situation. This makes it possible to use the cooling system to influence consumption and performance.

Vacuum supply

All models

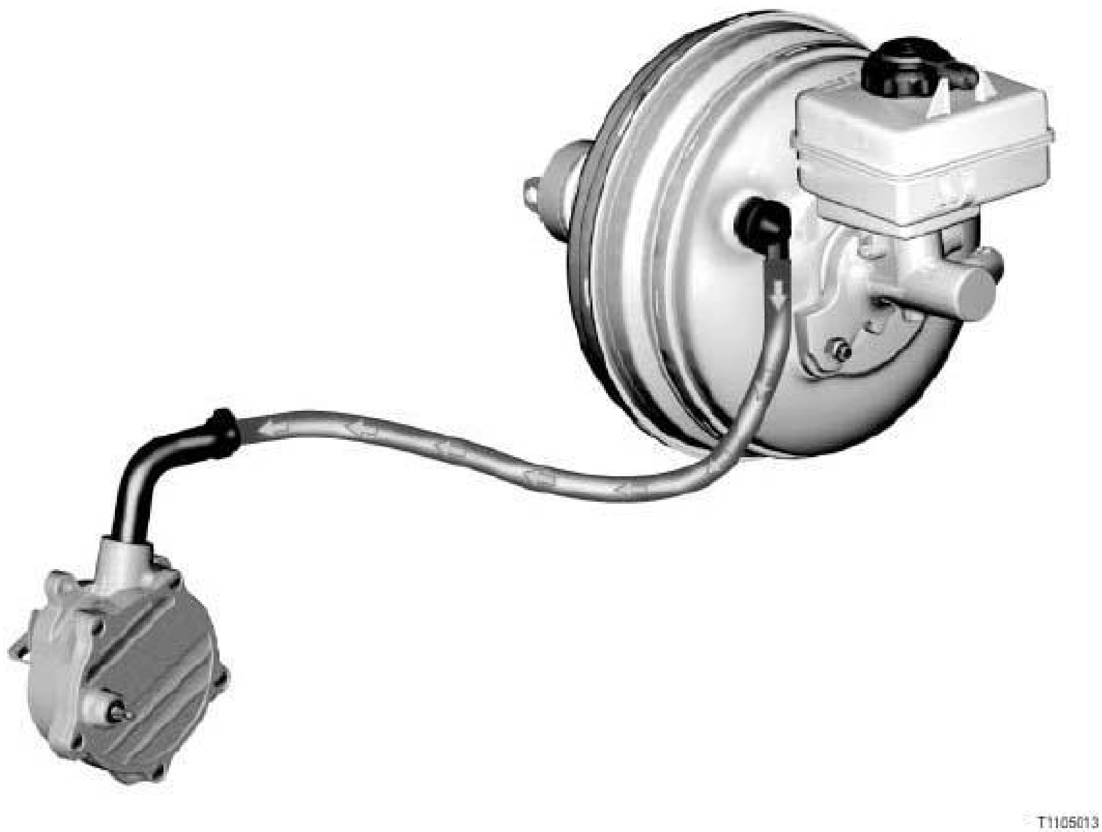


Fig. 18: Identifying Vacuum Supply Design
Courtesy of BMW OF NORTH AMERICA, INC.

Introduction

Vacuum is principally used for the brake booster.

The vacuum in the inlet pipe depends on the varying engine load.

Diesel engines do not normally have any vacuum in the inlet pipe. Vacuum on diesel engines is provided by a pump that generates the required vacuum.

On spark-ignition engines with Valvetronic, the throttle valve is almost always open when driving. This means that there is a lower low air pressure in the intake manifold.

Spark-ignition engines with low vacuum in the inlet pipe also have a pump that generates additional vacuum.

Brief description of components

The following components are involved in the vacuum supply system:

- **Mechanical vacuum pump**

  A mechanic vacuum pump is fitted to diesel engines and spark-ignition engines with Valvetronic. The vacuum pump is mechanically driven by the engine, e.g. via the exhaust camshaft.

- **Suction-jet pump**

  As a rule, the suction-jet pump boosts the vacuum in the inlet pipe.

- **Electric vacuum pump**

  On some engines, an electric vacuum pump is fitted for additional vacuum supply.

  In certain temporary operating situations, the vacuum in the inlet pipe may be too low. In such cases, the inlet pipe vacuum cannot be adequately boosted by the suction-jet pump. In these situations, the electric vacuum pump ensures that sufficient vacuum is available.

  Reason: After a cold start, an operating situation occurs in which there is very little inlet pipe vacuum due to the higher load. The electric vacuum pump is actuated for a certain time. This ensures that the brake is sufficiently boosted when maneuvering.

  After a cold start, the DME will actuate the electric vacuum pump **once only** for max. 60 seconds.

  The electric vacuum pump is actuated in the following situations:

  - Engine-running signal from DME
  - Coolant temperature below 60 °C

  The electric vacuum pump is a vane-cell pump.

- **Throttle valve**

  The throttle valve changes the cross-sectional area of the inlet pipe. This creates an inlet pipe vacuum behind the throttle valve, especially in overrun mode.

- **DME or DDE: Digital engine electronics or digital diesel electronics**

  The DME or DDE actuates the components needed for system functions (e.g. solenoid valves, electric switching valves, electropneumatic pressure converters).

System functions

The system functions of the vacuum system are described using the following examples:

- Power assist for brakes
- Actuation of exhaust flaps
- Adjustment of variable turbine geometry
- Actuation of controlled damping mounts
- Exhaust gas recirculation

- Drawing off of blow-by gases from crankcase
- Blowing out activated charcoal filter

Power assist for brakes

The brake booster amplifies the force excerpted at the brake pedal. To do this, the brake booster stores part of the vacuum generated by the engine. The vacuum then amplifies the force generated by pressure on the brake pedal.

Actuation of exhaust flap

A controlled electropneumatic exhaust flap is fitted in the exhaust system. The exhaust flap enhances active sound-damping. The exhaust flap is closed by vacuum.

Adjustment of variable turbine geometry

The variable turbine geometry controls the boost pressure via adjustable guide vanes. The guide vanes are actuated by vacuum.

Actuation of controlled damping mounts

In the basic setting, there is no vacuum at the control component on the mount. The bypass in the mount is closed. Hydraulic fluid flows back and forth through a ring channel between the upper and lower chambers in the mount. The mount acts like a conventional hydraulic bearing. The mount has hard damping. If a vacuum is applied to the mount's control component, the bypass will open. The hydraulic fluid then flows back and forth between the chambers through a larger cross-sectional area. The mount has softer damping.

Exhaust gas recirculation

With exhaust gas recirculation, part of the exhaust gas is take from behind the exhaust manifold. This is then fed back into the engine through the intake air duct. The exhaust gas recirculation pipe is located at the inlet to the intake manifold.

If a vacuum is applied to the exhaust gas recirculation valve, the exhaust gas recirculation pipe will open. The level of vacuum is determined by the opening in the exhaust gas recirculation valve.

Exhaust gases flow through a connecting pipe to the exhaust manifold and into the intake manifold.

Drawing off of blow-by gases from crankcase

The crankcase ventilation system uses vacuum to bleed the blow-by gases out of the engine block.

Blow-by gases are the small portion of the cylinder fill that passes by the piston rings and into the crankcase during compression. If the blow-by gases are not bled from the engine block through the crankcase ventilation system, they will accumulate in the crankcase. The blow-by gases would then apply pressure on the pistons from below. This would have a negative effect on the downward movement of the pistons in the intake stroke and operating stroke.

Blowing out activated charcoal filter

The fuel tank vent hose is connected to an activated charcoal filter. Vapors from the fuel tank are collected in the activated charcoal filter. The activated charcoal filter is connected to the intake manifold by a pipe. A fuel evaporation control valve is fitted in this pipe. When the fuel evaporation control valve is opened, the vacuum in the manifold draws in fresh air. At the same time, the fresh air blows out the fuel vapors collected in the activated charcoal filter.

