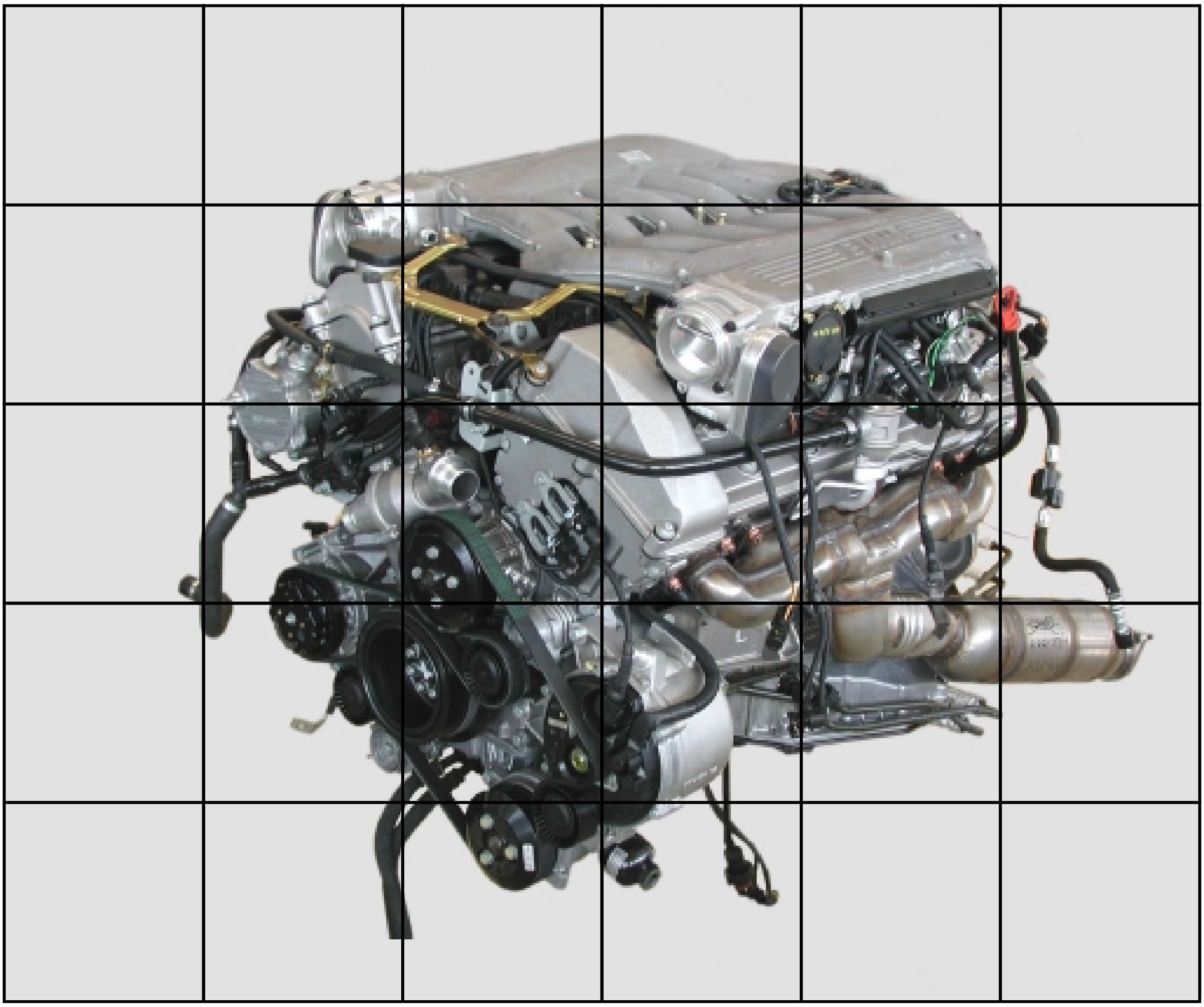
BMW

Service Training

N73 Engine

Seminar Working Material



NOTE
The information contained in this training course manual is intended solely for participants of the BMW Service Training course.
Refer to the relevant "Technical Service" information for any changes/ supplements to the Technical Data.

VS-42 MFP-HGK-BRK-N73-Motor

Contents

N73 Introduction

The N73 engine is a complete BMW new development and belongs to the NG (New Generation) Series.

The N73 will be used for the first time in the E65/E66 as a 760i/760Li. Its launch onto the market is scheduled for Autumn 2002.

For the first time at BMW, Valvetronic technology is supplemented by petrol direct injection.

The BMW 760i will set new standards in terms of performance and driving dynamics in the market segment of 12-cylinder luxury saloons and in so doing significantly undercut its competitors in fuel consumption.

Compared with GDI engines with lean concept and $DeNo_x$ catalytic converter, the BMW Valvetronic + DI concept with lambda=1 exhaust-gas technology has one significant advantage: it is not dependent on the sulphur content of the available fuel and therefore has the potential for worldwide application without the accompanying reduction in consumption.

The N73 is the best engine in its class. An engine with comparable technology is not currently available on the market.

KT-9760

Fig. 1: 760Li (E66 with N73)


KT-9765

Fig. 2: N73B60

- Technical data

Technical data	N73B60	M73B54
Configuration/vee angle	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 dia. (mm)	70	75
Conrod big-end bearing dia. (mm)	54	48
Power output (kW/HP) at engine speed (rpm)	320/435 6000	240/326 5000
Torque (Nm) at engine speed (rpm)	600 3950	490 3900
Idle Breakaway speed (rpm)	550 6500	600 6500
Compression ratio	11,5	10
Valves/cylinder	4	2
Intake valve dia. (mm)	35	42
Exhaust valve dia. (mm)	29	36
Inlet valve lift (mm)	0.3-9.85	10.3
Exhaust valve lift (mm)	9.7	10.3
Engine weight (kg) (construction group 11 to 13)	280	
Fuel system (RON)	98	98
Fuel (RON)	91-98	91-98
Knock control	Yes	Yes
Injection pressure (bar)	50-120	3.5
Digital Motor Electronics	2x MED 9.2.1 + Valvetronic ECU + 2x HDEV ECU	2x ME 5.2 + EML 3S
Emission regulation, Germany Rest of world	EU4 EU3	EU3 EU3
Firing sequence	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 saving compared with M73	12%	-
Vmax (km/h) E65	250	250

Full-load diagram

N73B60

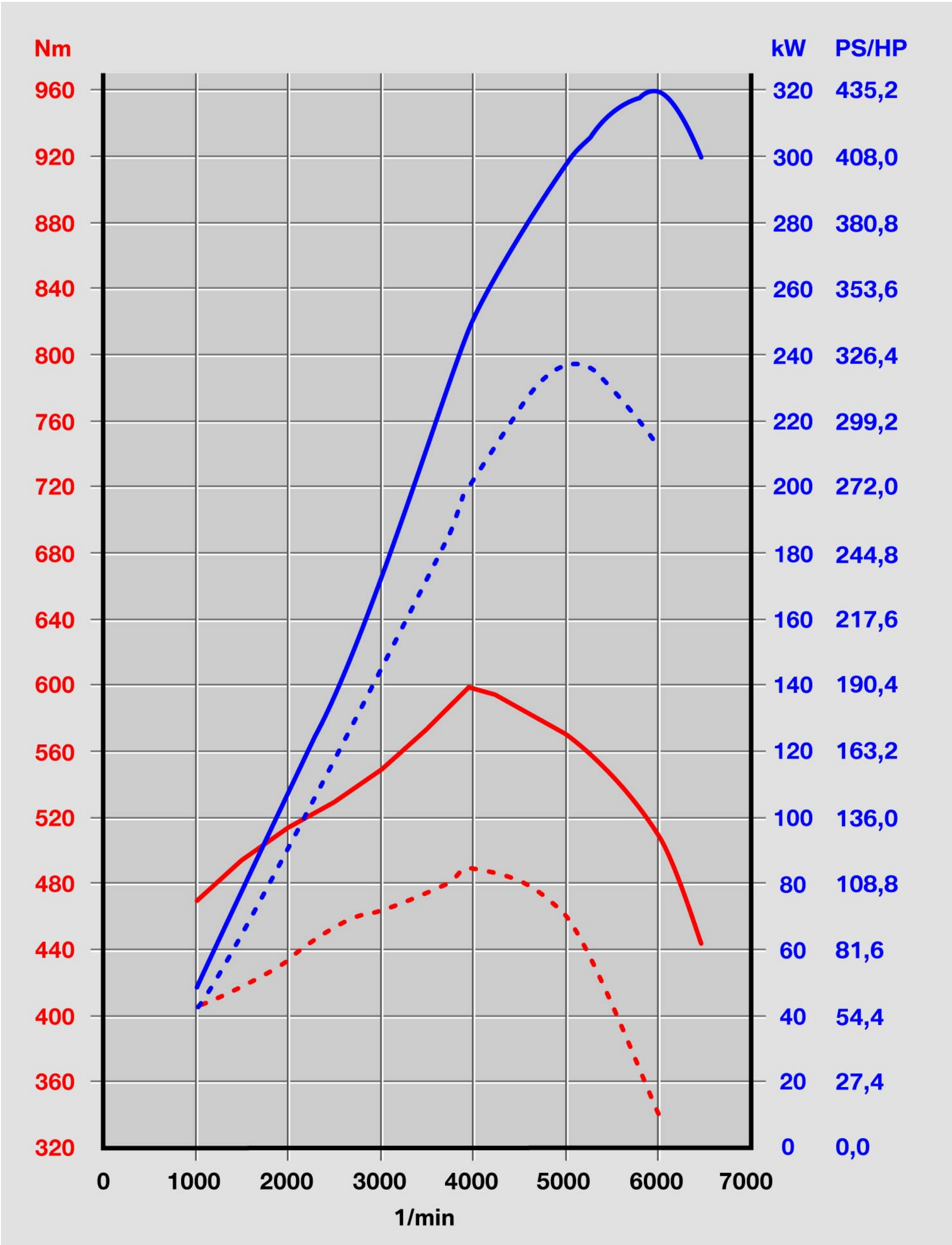


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Fig. 3: 760Li (E66 with N73)

- Basics of direct injection

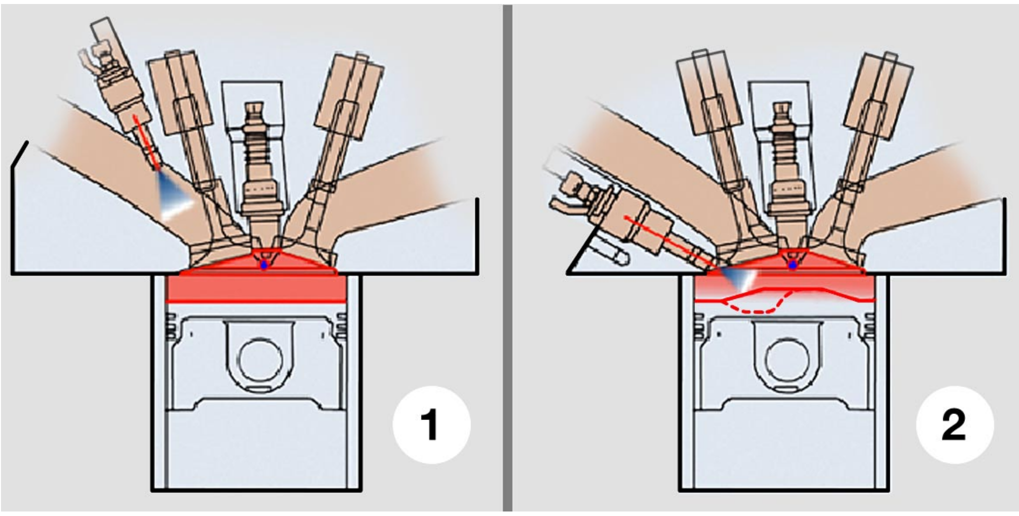

Fig. 4: View of manifold and direct-injection processes

Index	Explanation
1	Manifold injection
2	Direct injection

With direct injection, the fuel is injected at high pressure (between 30 and 100 bar) directly into the combustion chamber (see fig. above).

There are essentially two possible concepts of petrol direct injection, namely homogeneous and stratified mixture formation, which demonstrate distinct strengths and weakness in terms of consumption and exhaust-gas treatment (emissions).

The differences are created by the different mixture-formation processes.

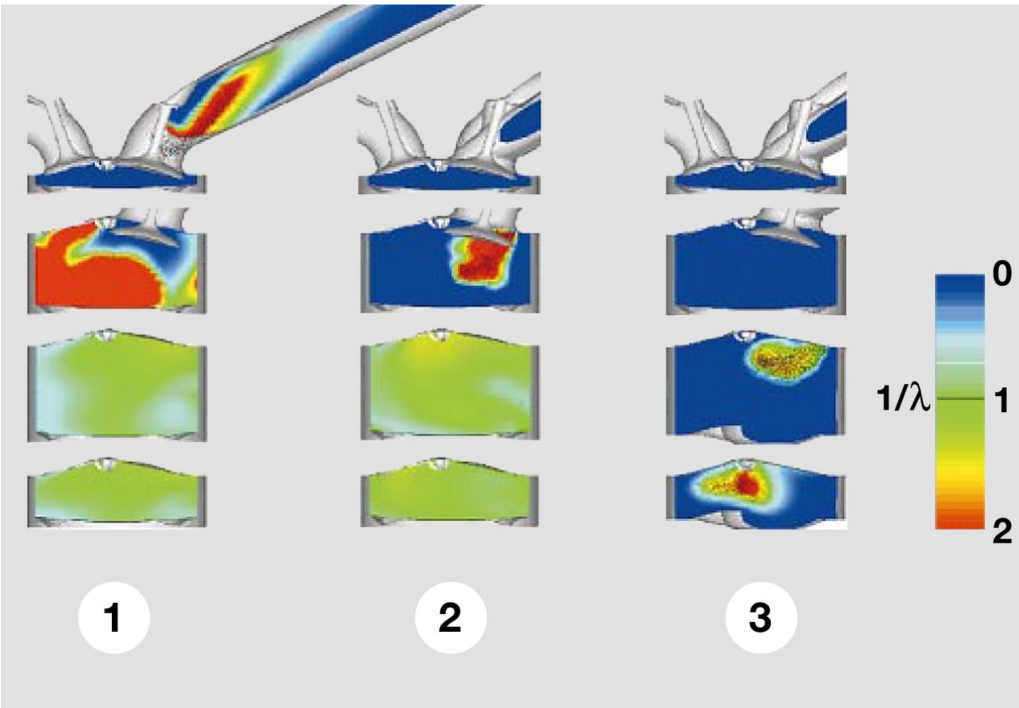

Fig. 5: Comparison of mixture formation

Index	Explanation
1	Manifold injection
2	Homogeneous direct injection
3	Stratified direct injection

The above figure (Comparison of mixture formation) shows the chronological sequence of mixture formation for direct injection in homogeneous and stratified modes in comparison with manifold injection. The mixture composition is shown as an air/fuel ratio for four points in time.

The colours represent the relevant local air/fuel ratio according to the scale.

Manifold injection

With manifold injection (1), injection already begins before the intake process. Injection into the intake manfild creates a comparatively long mixture-formation time. In this way, there is already an extensively homogeneous mixture in the cylinder at the end of the intake process.

Direct injection (homogeneous mixture formation)

With direct injection, the fuel injector leads directly into the combustion chamber.

Injection takes place during the induction stroke. In this way, an extensively homogeneous (λ=1) mixture is achieved by the ignition point. The mixture-formation and thus the combustion sequence is similar to a conventional engine with manifold injection.

Because the fuel is first introduced into the cylinder and vaporised there, the cylinder charge is cooled, thereby increasing efficiency by approx. 2%.

This also improves the knock characteristics with the result that the compression ratio can be increased.

Advantages

If the air/fuel ratio is stoichiometrically (λ=1, i.e. 1 kilogramme of fuel to 14.8 kilogrammes of air) regulated

- a conventional exhaust-gas treatment system with three-way catalytic converter can be used

  and

- sulphur-free fuel can be dispensed with, without any impaired function.

Direct injection with charge stratification

The main advantage of direct injection is that it permits stratified lean-burn operation in part-load mode:

The fresh charge is drawn in unthrottled, as in a diesel engine. The fuel is only injected at a late stage of the compression phase, where a roughly stoichiometric mixture is only created in the area of the spark plug.

The desired unthrottled operation is possible because a combustible mixture is only needed in a tightly restricted area and the main part of the combustion chamber can consist of an extremely lean mixture.

Disadvantages

- The associated oxygen excess during lean-burn operation however prevents the possibility of reduction in the catalytic converter and therefore precludes conventional exhaust-gas treatment with a three-way catalytic converter.
- To safeguard the operation of a $DeNo_x$ catalytic converter that would then be needed, it would be necessary to use low-sulphur fuel, which is currently only available to a limited extent worldwide.

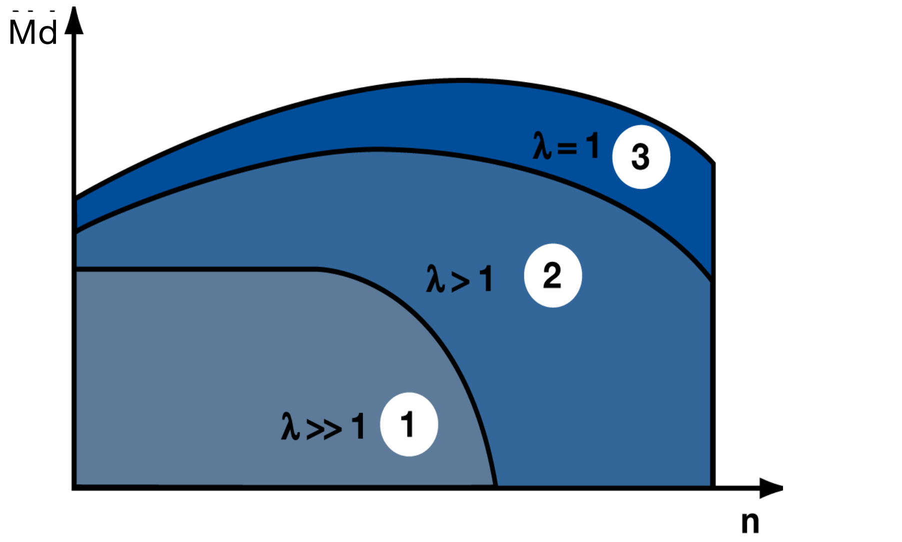

Fig. 6: Possible modes of petrol direct injection

Index	Explanation
Md	Engine torque
n	Engine speed
1	Lean, charge stratification
2	Lean, homogeneous
3	Homogeneous

As the above chart shows, the use of load stratification (1) is only possible in a limited load and speed range. Over and above this load and speed range, the engines can only be operated in homogeneous mode (2-3).

Through the deployment of Valvetronic, the N73 engine in the middle torque/speed range (1) demonstrates the same consumption advantages as engines of other manufacturers with charge stratification.

Because large-capacity engines are mainly operated in the lower to middle load and speed range, it is only advisable to use load stratification in these engines.

Smaller-sized engines are mainly operated in the high load and speed range and thus in homogeneous mode.

N73 Engine Mechanical System

Introduction

New features supplementing previous BMW developments

In addition to the N42 and N62 engines already established, the N73 engine rounds off the top end of the range of New Generation (NG) engines.

The NG engines are distinguished by the following technologies:

Valvetronic, consisting of

- bi-VANOS
- variable valve-lift adjustment of intake valves

4-valve technology

The N73 also deploys a **petrol direct injection system**.

Fresh-air system

- Air ducting

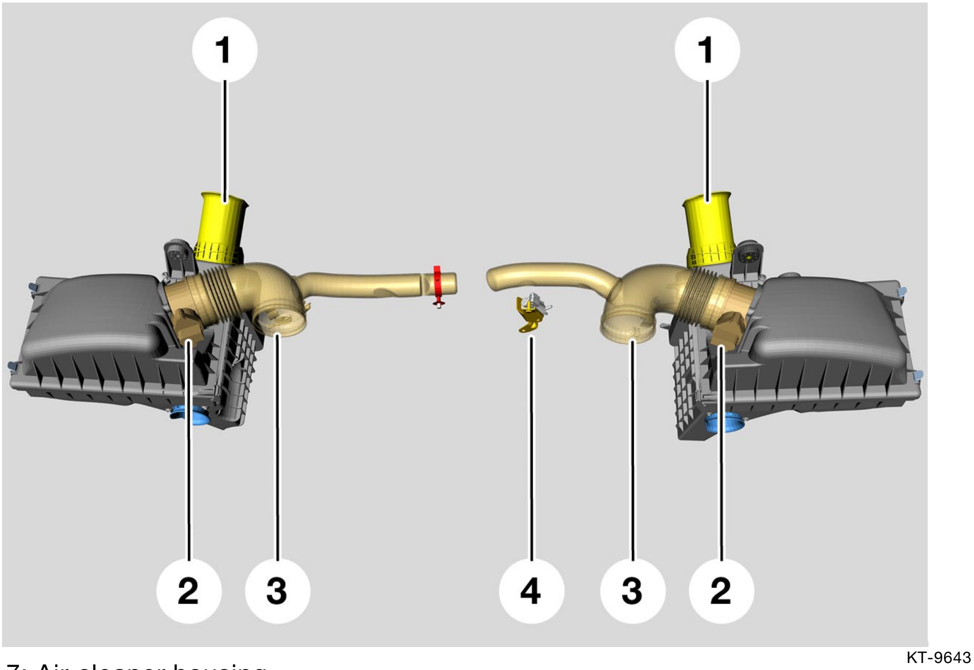

Fig. 7: Air-cleaner housing

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

A separate air-cleaner housing is installed for each cylinder bank. Air is supplied on either side between the headlight and cooling module via the intake snorkel (1) from the radiator fresh-air duct.

The air-cleaner volume is approx. 10.5 litres for each air-cleaner housing. The air-cleaner element has been reinforced by a sheet-metal grille.

The air-cleaner element has to be replaced every 100,000 km.

Auxiliary air flaps

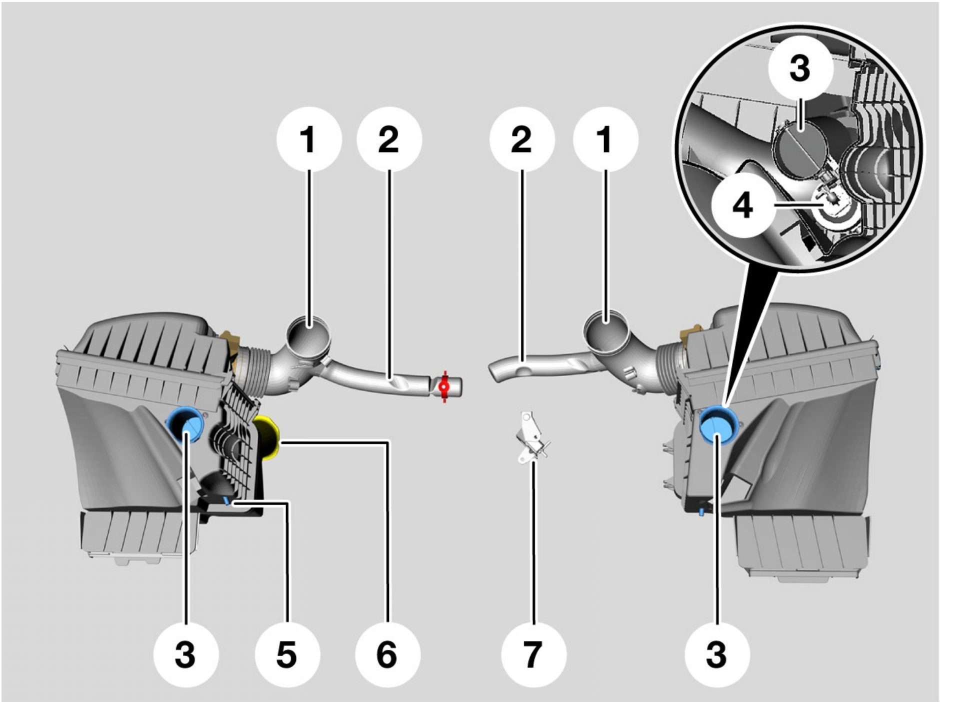

Fig. 8: Air-cleaner housings with auxiliary air flaps

Index	Explanation
1	Air duct to throttle
2	Intake-noise resonator
3	Auxiliary air flap
4	Diaphragm cell
5	Connection for vacuum line to diaphragm cell
6	Intake snorkel
7	Solenoid valve for auxiliary air flaps

Each air-cleaner housing incorporates an auxiliary air flap in its side wall (3).

The auxiliary air flaps are needed to supply the engine with enough air for it to reliably attain the maximum performance figures.

For acoustic and space reasons, the basic cross-section of the intake snorkel could not be enlarged.

The auxiliary air flaps are closed in the lower speed ranges so that no heated air is admitted in hot idling mode and stop-and-go driving. The auxiliary air flaps are actuated by diaphragm cells (4) which are located inside the air-cleaner housings.

Both diaphragm cells are supplied with vacuum pressure by a common solenoid valve (7).

The auxiliary air flaps are fully opened by the DME

- 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.

Throttles

A throttle is used for each cylinder bank.

The throttles are not needed for engine-load control. This is effected by variable valve-lift adjustment of the intake valves.

The functions of the throttles are:

- **Engine starting:**
  The air flow is regulated by the throttles during the starting sequence and at idle at temperatures between 0 °C and 60 °C. The engine is switched to non-throttle mode after 60 seconds.

- **Cold starting:**
  In cold weather conditions, it is started with the throttles fully opened as this has a positive effect on the starting performance.

- **Carbon-canister purging and blow-by gases:**
  The throttles are located after the air flow and thus generate a constant vacuum pressure of 50 mbar. This vacuum pressure is needed to extract the blow-by gases from the crankcase and the fuel vapours from the carbon canister.

- **Limp-home function:**
  In the event of a Valvetronic failure, the throttles take over the limp-home function (conventional load control) for the engine.

- Induction system

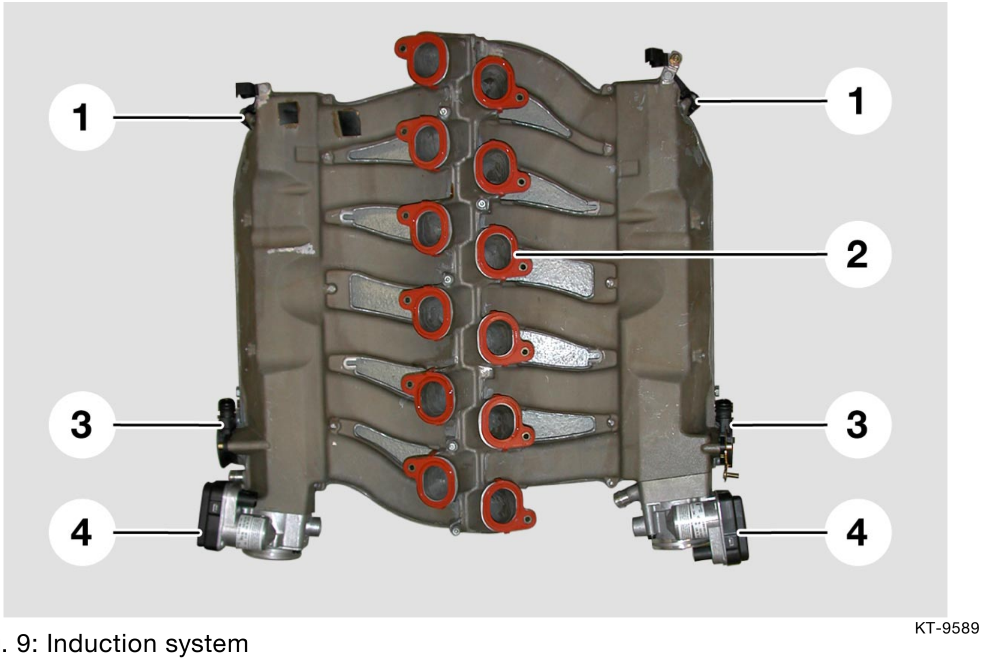

Fig. 9: Induction system

Index	Explanation
1	Intake-manifold pressure sensor
2	Gaskets
3	Pressure control valve for crankcase ventilation
4	Throttle housing with servomotor

The induction system is a complete structural component of a magnesium shell-type design. The individual parts of the induction system are bonded and bolted to each other. The use of magnesium has resulted in a considerable reduction in weight compared with aluminium.

The entire induction system is protected against corrosion by a coat of paint (dip-coating procedure). If the paint coat suffers damage of any kind, the damaged areas will develop corrosion and pitting, which will result in the failure of the relevant components.

The fastening bolts of the add-on parts are likewise provided with a paint coat and must be replaced in the event of repair.

All the gaskets (2) and bolts are secured by retainers against falling out during installation.

The induction system is acoustically isolated from the engine by rubber elements on the fastening bolts. The induction system has separate unconnected manifold chambers for each cylinder bank.

An intake-manifold pressure sensor (1) is used for each cylinder bank. The intake-manifold pressure is the control variable for the position of the throttles. This enables the MED 9.2.1 to adjust the intake-manifold vacuum pressure of 50 mbar (see Crankcase ventilation).

Note

When replacing the spark plugs, it will be necessary to remove the entire induction system in order to avoid damaging the ignition coils.

The spark plugs must be replaced every 120,000 kilometres in ECE vehicles and every 100,000 miles in US vehicles.

Intake-noise resonators

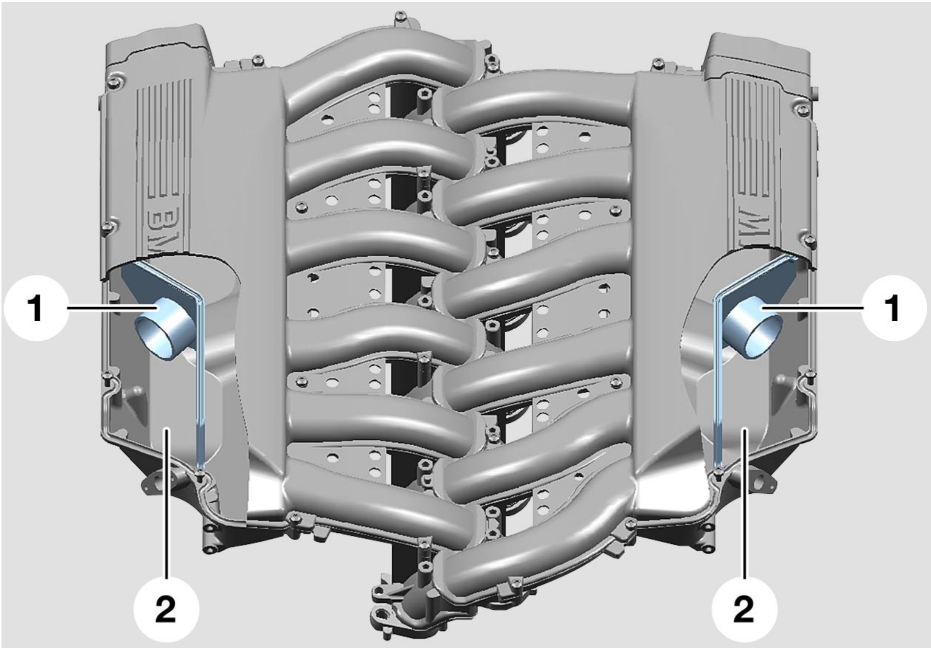

Fig. 10: Induction system with intake-noise resonators

Index	Explanation
1	Partition with opening to manifold chamber
2	Resonance chamber

The induction system has an integrated intake-noise resonator for each cylinder bank.

The use of intake-noise resonators reduces the intake pulsation noises caused by opening and closing of the intake valves.

For this purpose, the manifold chamber on each cylinder bank has been fitted with a partition and thus an additional resonance chamber (2) has been integrated in each cylinder bank. Each resonance chamber is connected by way of a pipe (1) with the remaining manifold chamber (on its side of the engine).

- Crankcase ventilation

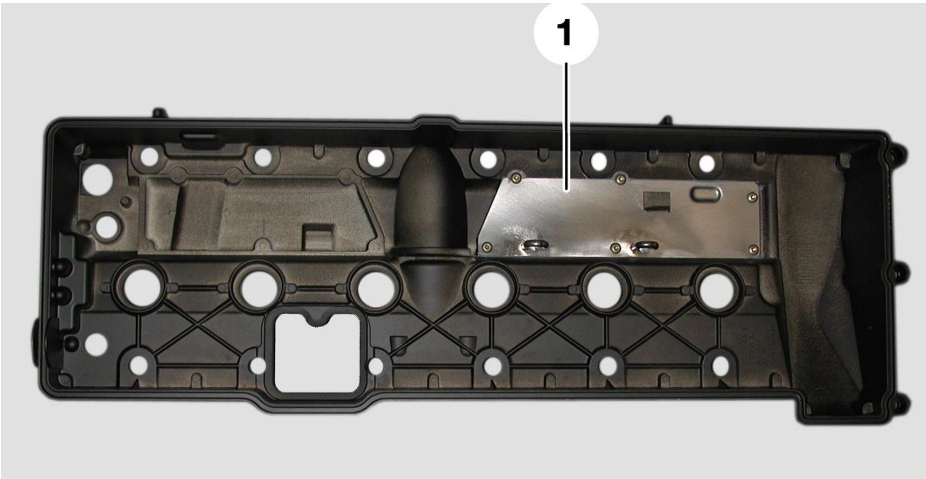

Fig. 11: Cylinder-head cover

Index	Explanation
1	Labyrinth oil separator

The crankcase emissions generated during combustion (blow-by gases) are routed out of the crankcase into labyrinth oil separators (1) in the two cylinder-head covers.

The oil condensate that collects on the walls of the labyrinth separators returns to the oil pan through the oil return holes. The remaining gases are routed through the pressure control valves into the engine induction system for combustion.

Both sides of the induction system are fitted with a pressure control valve for each cylinder bank (see Induction system). The pressure control valve is connected by way of a tube to the cylinder-head cover.

The pressure control valve maintains a vacuum pressure of 0 to 40 mbar in the crankcase.

Pressure control valve

The pressure control valve contains a diaphragm in its plastic housing which is pressurised on the one hand by the pressure level of the vacuum to be regulated (p.KG) and by the force of a spring and on the other hand by atmospheric pressure (p.UMG).

Permanently connected to the diaphragm is a valve plate with a conical valve, which in conjunction with a fixed-housing throttle edge and depending on the diaphragm position reduces the strongly fluctuating intake-manifold pressure to the almost constant vacuum level in the crankcase.

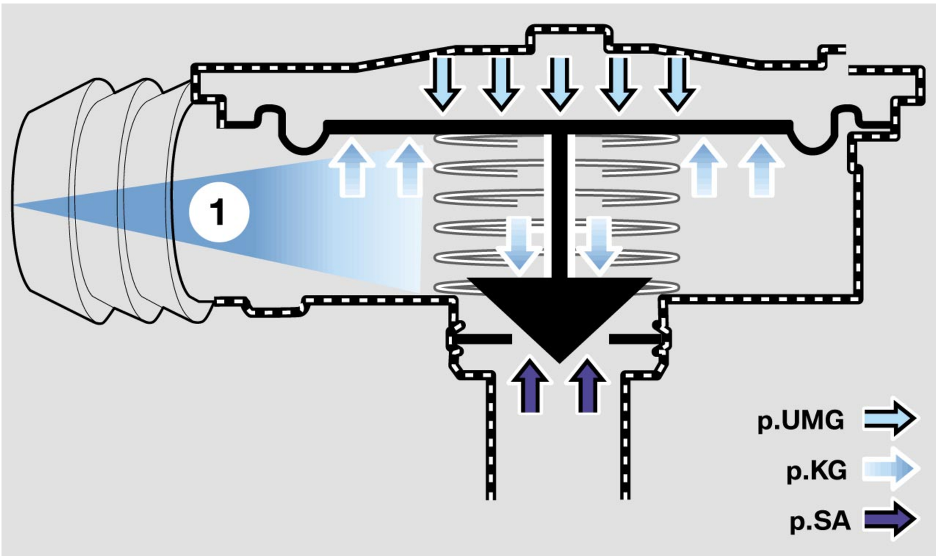

Fig. 12: Pressure control valve

Index	Explanation
p.UMG	Ambient pressure
p.KG	Crankcase pressure (output variable, control variable)
p.SA	Intake-manifold pressure (input variable)
1	Blow-by gas (disturbance variable)

Exhaust system

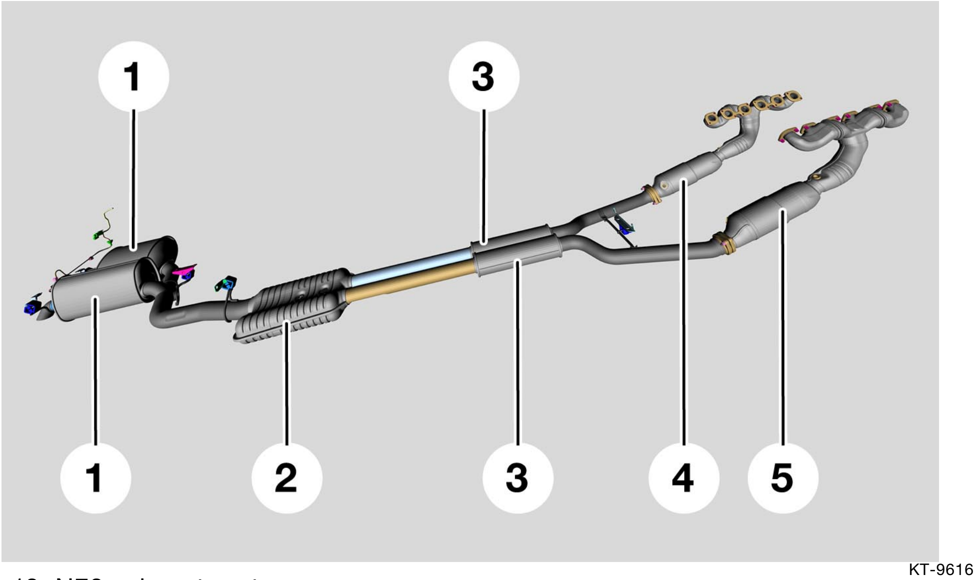

Fig. 13: N73 exhaust system

Index	Explanation
1	Rear silencer
2	Centre silencer
3	Front silencer
4	Exhaust manifold with catalytic converters, cylinder bank 7-12
5	Exhaust manifold with catalytic converters, cylinder bank 1-6

A front silencer of absorption design with a volume of 2.8 litres is fitted for each cylinder bank.

Both front silencers are assigned a centre silencer of absorption design with a volume of 12.5 litres.

The rear silencers are of reflection design and have volumes of 12.6 and 16.6 litres.

Because the catalytic converters in the exhaust manifolds are situated close to the engine, they very quickly reach their response temperature. It has thus been possible to dispense with the electric catalytic-converter heater known from the M73.

- Exhaust manifolds with catalytic converters close to engine

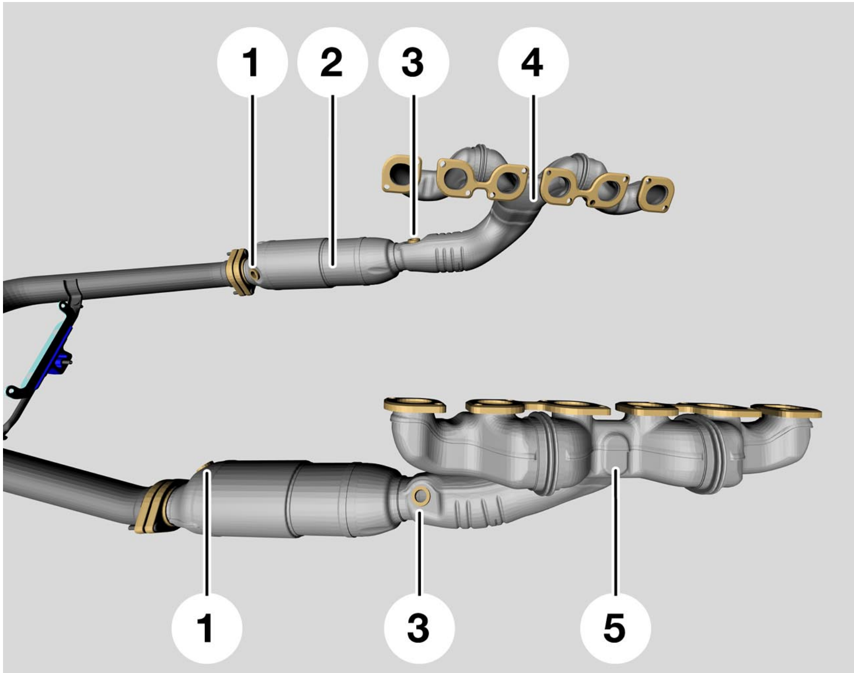

Fig. 14: Exhaust manifolds with catalytic converters

Index	Explanation
1	Threaded connection for monitor sensors
2	Catalytic-converter housing
3	Threaded connection for planar broad-band oxygen sensors
4	Exhaust manifold, cylinder bank 7-12
5	Exhaust manifold, cylinder bank 1-6

A "six-into-one" exhaust manifold is mounted for each cylinder bank. The manifold and the catalytic-converter housing are integrated into a single component.

The converter housing accommodates two ceramic-substrate catalytic converters of different diameters one after the other.

The mounts for the planar broad-band oxygen sensors (Bosch LSU 4.2) are located in the front pipe ahead of the catalytic converter.

The mounts for the monitor sensors (Bosch LSU 25) are located after the catalytic converter in the outlet funnel.

- Exhaust flap

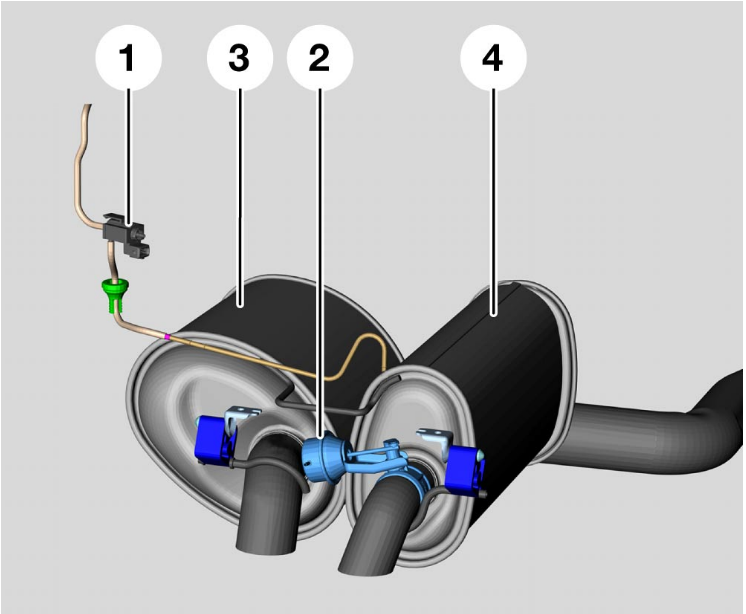

Fig. 15: Rear silencers with exhaust flap

Index	Explanation
1	Solenoid valve
2	Diaphragm cell for exhaust flap
3	Rear silencer
4	Rear silencer

For the purpose of noise optimisation when the engine is idling and at speeds close to idling, the rear silencer is fitted with an exhaust flap, which controls the route of the exhaust gases.

The exhaust flap is closed at low speeds and open at full load and higher speeds (approx. 1500 rpm). The relevant opening speed is stored as a function of load and speed in a DME program map.

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

- Minimisation of the cross-section and thus the orifice level at low exhaust flow rates
- Large cross-section with low backpressure at high speeds and loads
- When the flap is closed, a rear silencer acts as a Helmholtz resonator (cf. E39)

Helmholtz is the inventor of this type of resonator. Low-frequency vibrations are strongly damped when the flap is closed.

- Secondary-air system

General

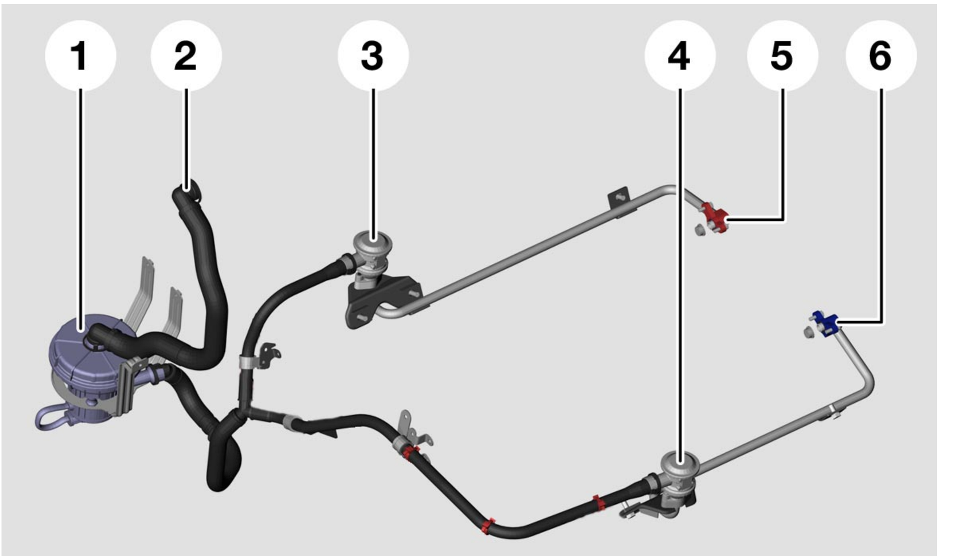

Fig. 16: N73 secondary-air system

Index	Explanation
1	Secondary-air pump
2	Fresh-air line from air-cleaner housing
3	Secondary-air valve, cylinder bank 1-6
4	Secondary-air valve, cylinder bank 7-12
5	Connection to cylinder head, cylinder bank 1-6
6	Connection to cylinder head, cylinder bank 7-12

Injecting additional air (secondary air) into the exhaust tract in the cylinder head during the warm-up phase facilitates thermal afterburning, an operation which reduces the unburnt hydrocarbons HCs and carbon monoxide CO contained in the exhaust gas.

The energy generated during this process heats up the catalytic converter faster during the warm-up phase, and increases its conversion rate. The catalytic-converter light-off temperature of approx. 250 °C is already reached a few seconds after the engine is started.

Secondary-air pump (SLP)

The electrically operated secondary-air pump is mounted to the body in the engine compartment. The pump draws in filtered fresh air from the air-cleaner housing during the warm-up phase and delivers it to the two secondary-air valves.

After the engine is started, the pump is supplied with system voltage by the DME via the secondary-air-pump relay. It remains activated until the engine has attained a specific air mass.

The ON period is max. 90 seconds and is dependent on the following engine operating conditions:

- Coolant temperature (from -10 °C to approx. +60 °C)
- Air mass
- Engine speed

Secondary-air valves (SLV)

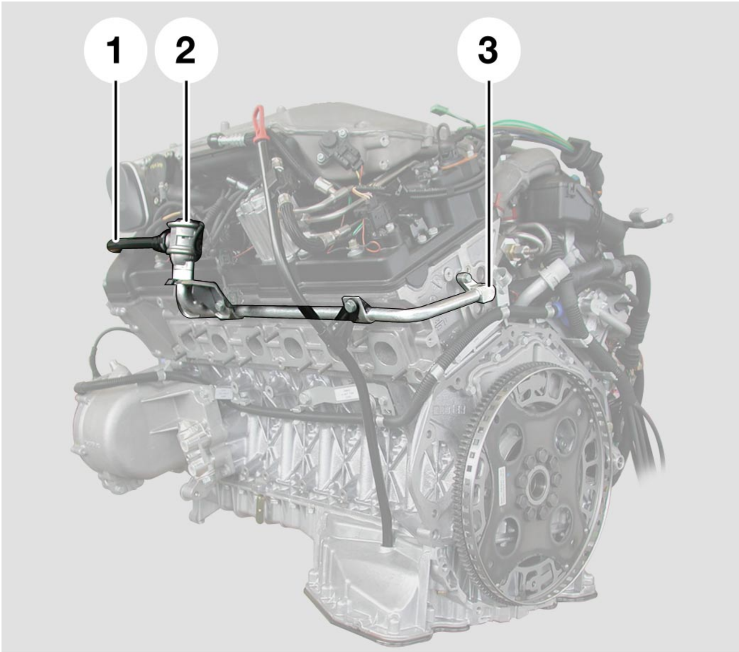

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Fig. 17: Secondary-air ducting

Index	Explanation
1	Connection to secondary-air pump
2	Secondary-air valve
3	Line to cylinder head

For each cylinder bank, a secondary-air valve (SLV) is side-mounted to the cylinder heads.

The secondary-air valve is opened by the air pressure generated by the secondary-air pump. The secondary air is then routed through a pipe to the secondary-air passages in the cylinder head.

The valve closes as soon as the secondary-air pump shuts down and thereby prevents exhaust gas from flowing back to the secondary-air pump.

- Oxygen-sensor closed-loop control

A total of four oxygen sensors are installed in N73 engines.

Ahead of both catalytic converters, there is a planar broad-band oxygen sensor (continuous curve) which controls the air/fuel mixture.

For each cylinder bank, there is after the catalytic converters a monitor sensor (discontinuous curve) which monitors the function of the catalytic converter.

This monitoring means that if the exhaust-gas concentration is too high, the MIL (malfunction indicator lamp) lights up and a diagnostic trouble code is stored.

Ancillary components and belt drive

- Belt drive

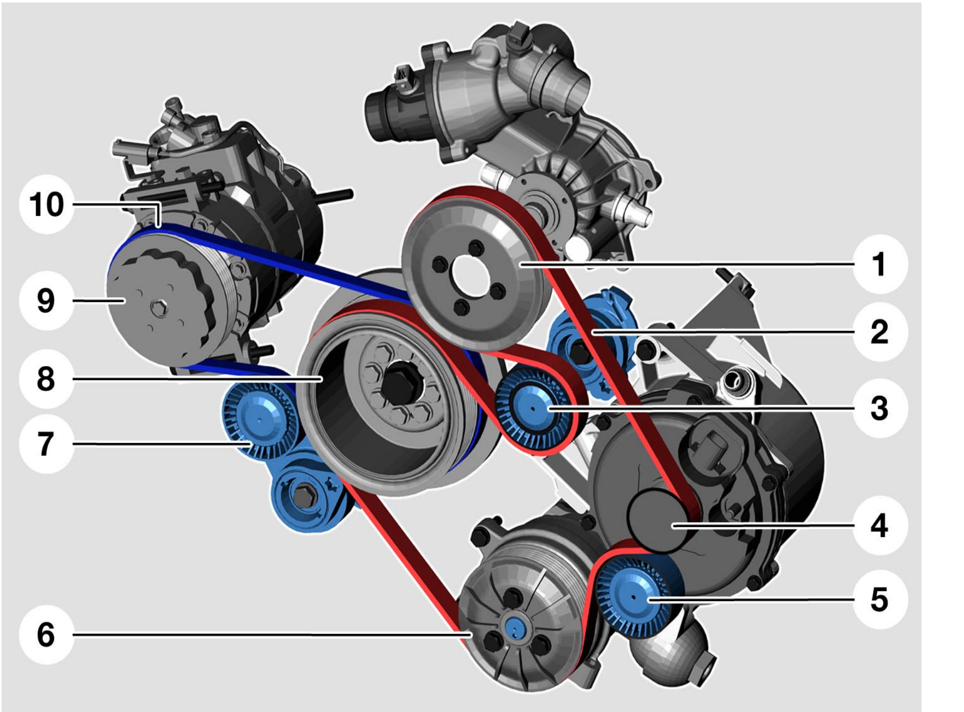


Fig. 18: Belt drive

Index	Explanation	Index	Explanation
1	Belt pulley, coolant pump	6	Power-steering and dynamic-drive pump
2	6-ribbed V-belt, ancillary drive	7	Tensioning unit, A/C-compressor drive
3	Tensioning unit, ancillary drive	8	Crankshaft pulley
4	Alternator	9	A/C compressor
5	Deflection pulley	10	4-ribbed V-belt, A/C compressor drive

The A/C belt drive uses a 4-ribbed V-belt while the main drive uses a 6-ribbed V-belt.

Each belt drive is provided with a tensioning unit with tensioning pulley and torsion tensioner.
The belt drive needs no maintenance.

The following ancillary components are of the same design as those in the N62:

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

The starter motor is located on the right side of the engine underneath the exhaust manifold and is designed as a compact reduction-gear starter with 2.0 kW power output.

Cylinder heads

General

The bores for the high-pressure fuel injectors are located on the intake side.

The high-pressure fuel pump is driven by a triple cam via bucket tappets on both exhaust camshafts.

The cylinder heads are made from aluminium in a gravity-diecasting procedure.

Cylinder-head gaskets

The cylinder-head gasket is a three-layer steel gasket with rubber coating.

A four-layer repair gasket is available if the cylinder-head lower face is remachined.

Cylinder-head bolts

The cylinder-head bolts for the N73 engine are designed as standard as M10x160 stress bolts. These bolts should always be replaced when repairs are carried out.

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

- Engine cover

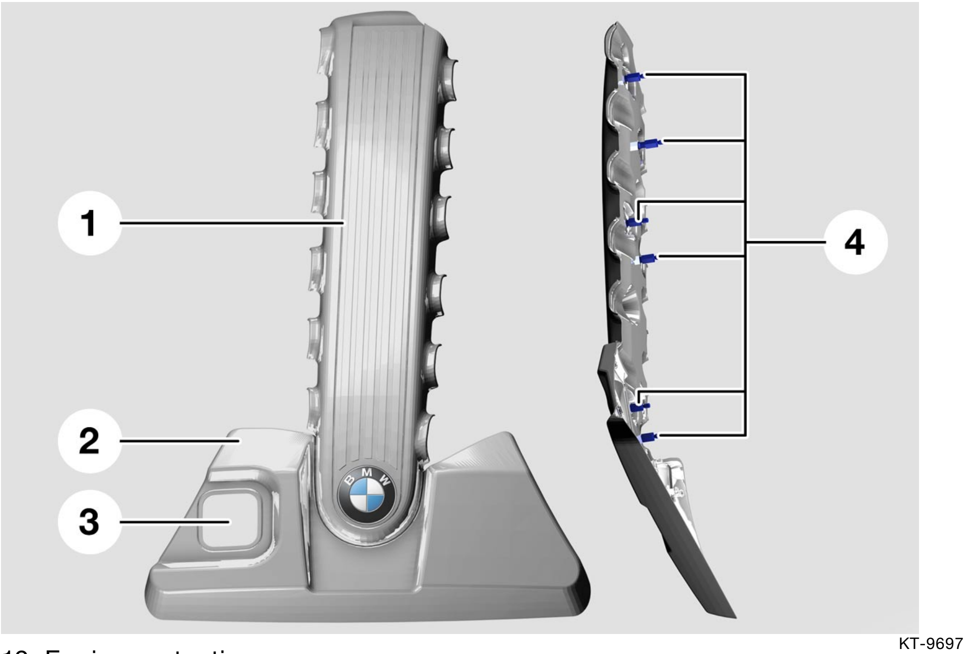


Fig. 19: Engine protective covers

Index	Explanation
1	Design cover
2	Front shield
3	Opening for oil filler neck
4	Retaining pins

The engine is equipped with a design cover (1) on the induction system. There is also a front shield (2) situated between the radiator cover and the design cover.

The covers are attached to the induction system in rubber grommets and not bolted down.

- Cylinder-head covers

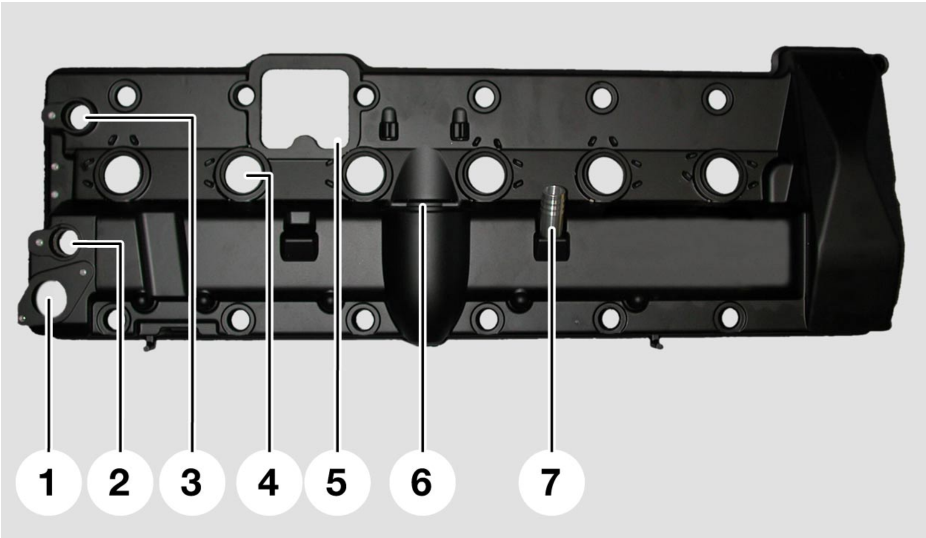


Fig. 20: N73 cylinder-head cover

Index	Explanation
1	Bore for eccentric-shaft-sensor connector
2	Bore for intake-camshaft position sensor
3	Bore for exhaust-camshaft position sensor
4	Bores for rod-type ignition coils
5	Cutout for high-pressure-pump drive
6	Cutout for Valvetronic motor
7	Connection for crankcase ventilation

The cylinder-head covers are made from aluminium and are provided with a coating to protect against corrosion.

- Valve gear

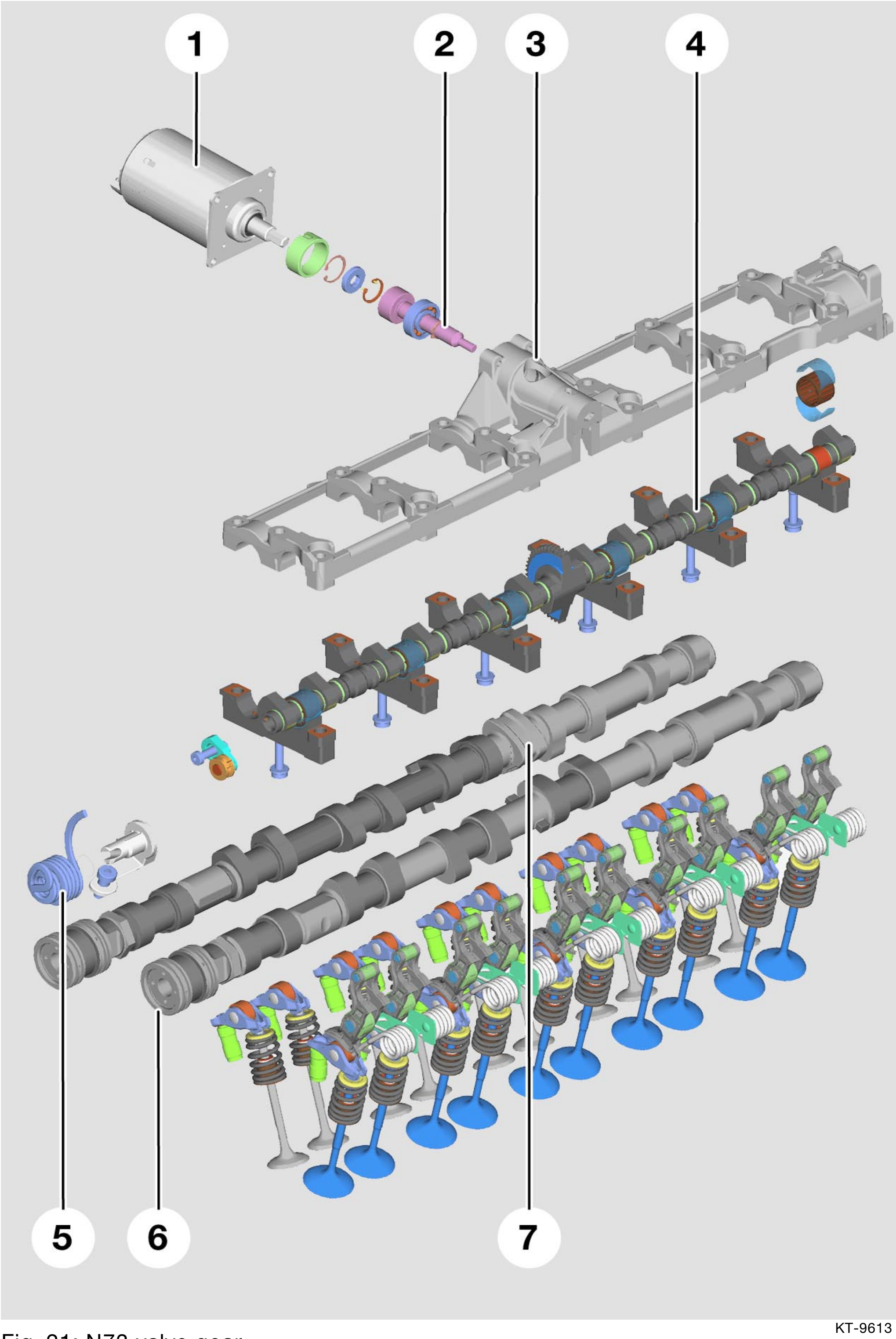


Fig. 21: N73 valve gear

Index	Explanation
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 for H.P. pump

The valve gear is essentially the same as that of the N62 engine.

Structural modifications have been made to the N62 mainly in the following areas:

- Bridge support with intermediate shaft for Valvetronic motor
- Torque compensation spring with rectangular cross-section
- Exhaust camshaft with triple cam for driving the high-pressure pumps

Note

To remove the cylinder head, it will be necessary to remove the intermediate shaft in order to gain access to the cylinder-head bolt underneath. A special tool is needed to remove the intermediate shaft.

Camshafts

The camshafts are made from chilled cast iron and hollowed to reduce their weight. They are fitted with balancing weights to compensate for imbalance in the valve gear.

The exhaust camshafts have a triple cam to drive the high-pressure pumps (see overview of valve gear).

- Valvetronic

The Valvetronic facilitates fully variable control of the valve lift of the intake valves. The Valvetronic of the N73 is already known from the N62.

Valvetronic motors

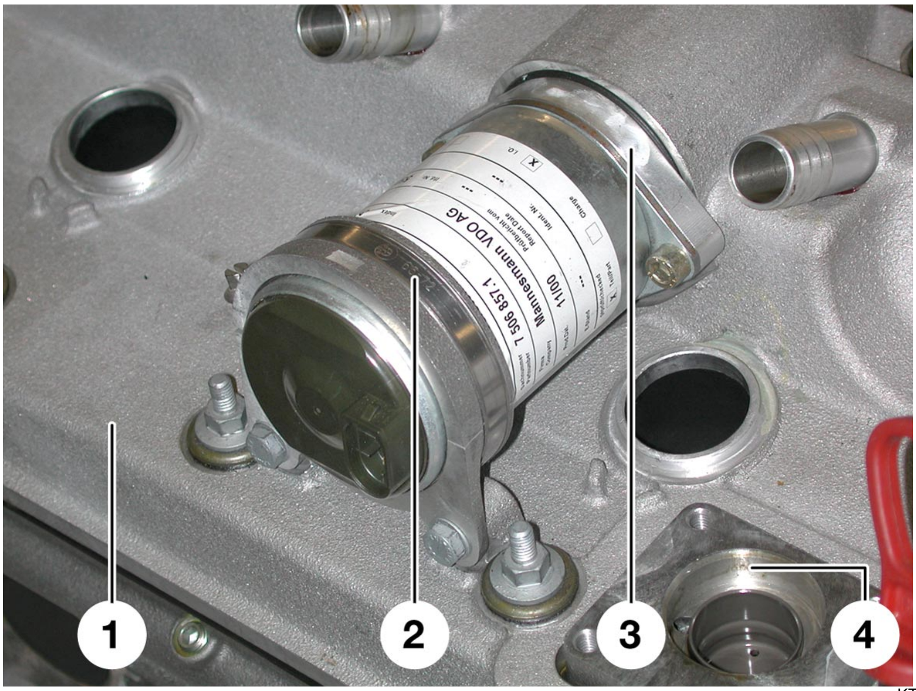


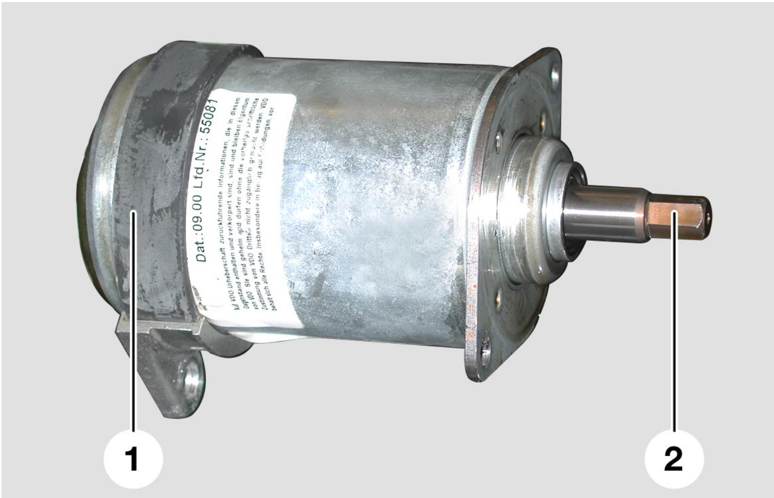
Fig. 22: Valvetronic motor, cylinder bank 1-6

Index	Explanation
1	Cylinder-head cover
2	Motor mounting with isolating element
3	Intermediate flange
4	Take-up for H.P. fuel pump with bucket tappet

Because of the tighter vee angle of 60°, the Valvetronic motors in the N73 are attached to the cylinder heads on the exhaust side.

The Valvetronic motor is secured to the bridge support by way of the intermediate flange and has a hexagon drive, which engages the receptacle for the intermediate shaft.

The Valvetronic motor is rubber-sprung in the rear mounting (2) and thereby acoustically isolated from the cylinder-head cover.



KT-9574

Fig. 23: Valvetronic motor with hexagon drive

Index	Explanation
1	Isolating element
2	Hexagon head

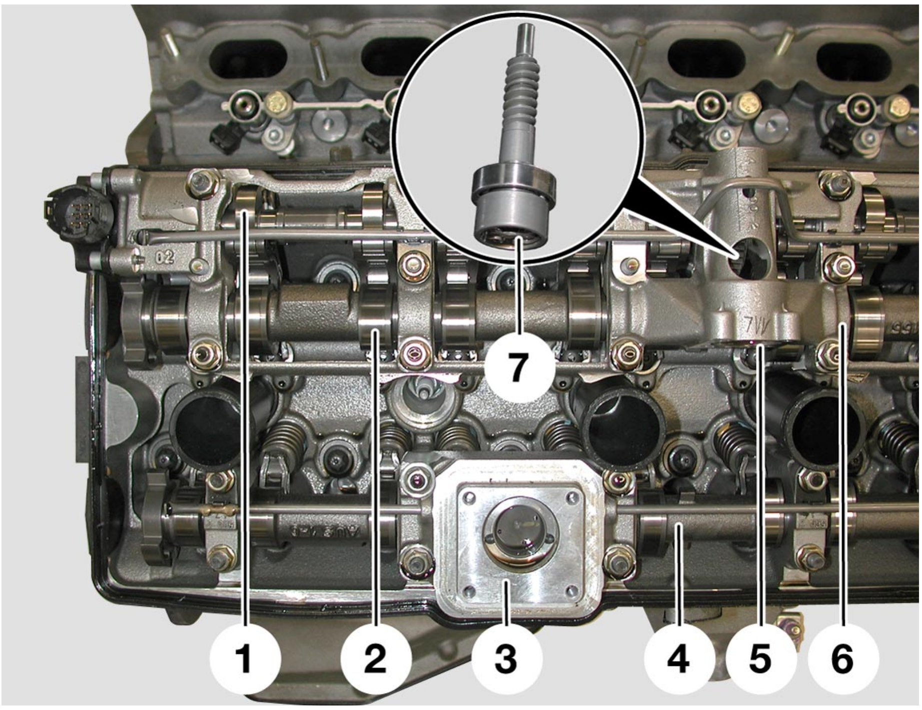


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Fig. 24: Bridge support with intermediate shaft

Index	Explanation
1	Eccentric shaft
2	Intake camshaft
3	Take-up for H.P. fuel pump
4	Exhaust camshaft
5	Bridge support with receptacle for intermediate shaft and Valvetronic motor
6	Bridge support
7	Intermediate shaft

The intermediate shaft is double-mounted in the bridge support and engages with its spindle in the eccentric-shaft teeth.

Bi-VANOS (variable camshaft control)

The intake and exhaust camshafts are equipped with infinitely variable vane-type VANOS, a feature which is already established in NG engines.

The camshaft adjustment range is 63° crank angle in 300 ms for the intake camshafts and 60° crank angle in 300 ms for the exhaust camshafts.

The teeth of the VANOS units have been designed to accommodate the sleeve-type chains used in the N73.

The VANOS unit for the exhaust camshaft of cylinders 1-6 has a mounting for the vacuum-pump drive.

The VANOS units are supplied with oil through bores in the camshafts.

The VANOS solenoid valves and the VANOS position sensors are of the same design as those in the N62 engine.

- Vacuum pump

The N73 engine requires a vacuum pump because of the low manifold air pressure caused by the use of Valvetronic. Because the throttles are fully open under normal driving conditions, insufficient intake-manifold vacuum is created for brake boosting.

The vacuum pump generates a vacuum, which is needed for brake boosting, to actuate the exhaust flap and to actuate the auxiliary air flaps.

The vacuum pump, which is of the same design as that of the N62, is driven by the exhaust camshaft via the VANOS unit (cylinder bank 1-6).

- Chain drive

In the M73 engine, the entire valve gear is driven by a sleeve-type chain. In the N73 engine, the camshafts for each cylinder bank are driven by a separate sleeve-type chain. The sleeve-type chain is guided over the upper guide rail.

Because of the perfect mass balance and the short ignition interval (firing sequence), it has been possible in the N73 engine to dispense with tooth-type chains for the purpose of noise reduction (as with N62).

The use of two separate sleeve-type chains reduces the strain on the individual chains, a factor which increases their service life significantly.

The oil pump is driven by a separate sleeve-type chain.

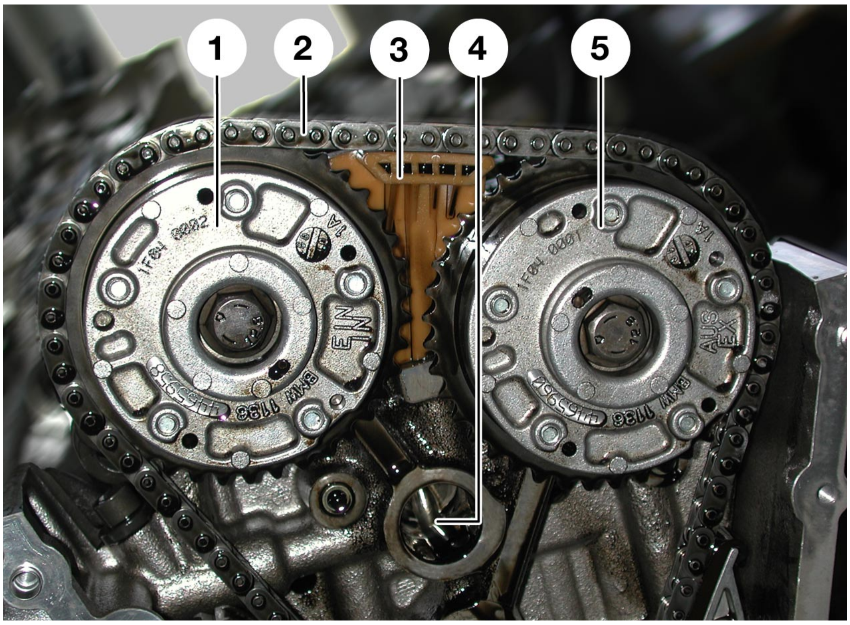

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Fig. 25: N73 upper timing-chain guide

Index	Explanation
1	Exhaust VANOS
2	Sleeve-type chain
3	Upper guide rail
4	Solenoid valve, intake VANOS
5	Intake VANOS

Cooling system

- Coolant circuit

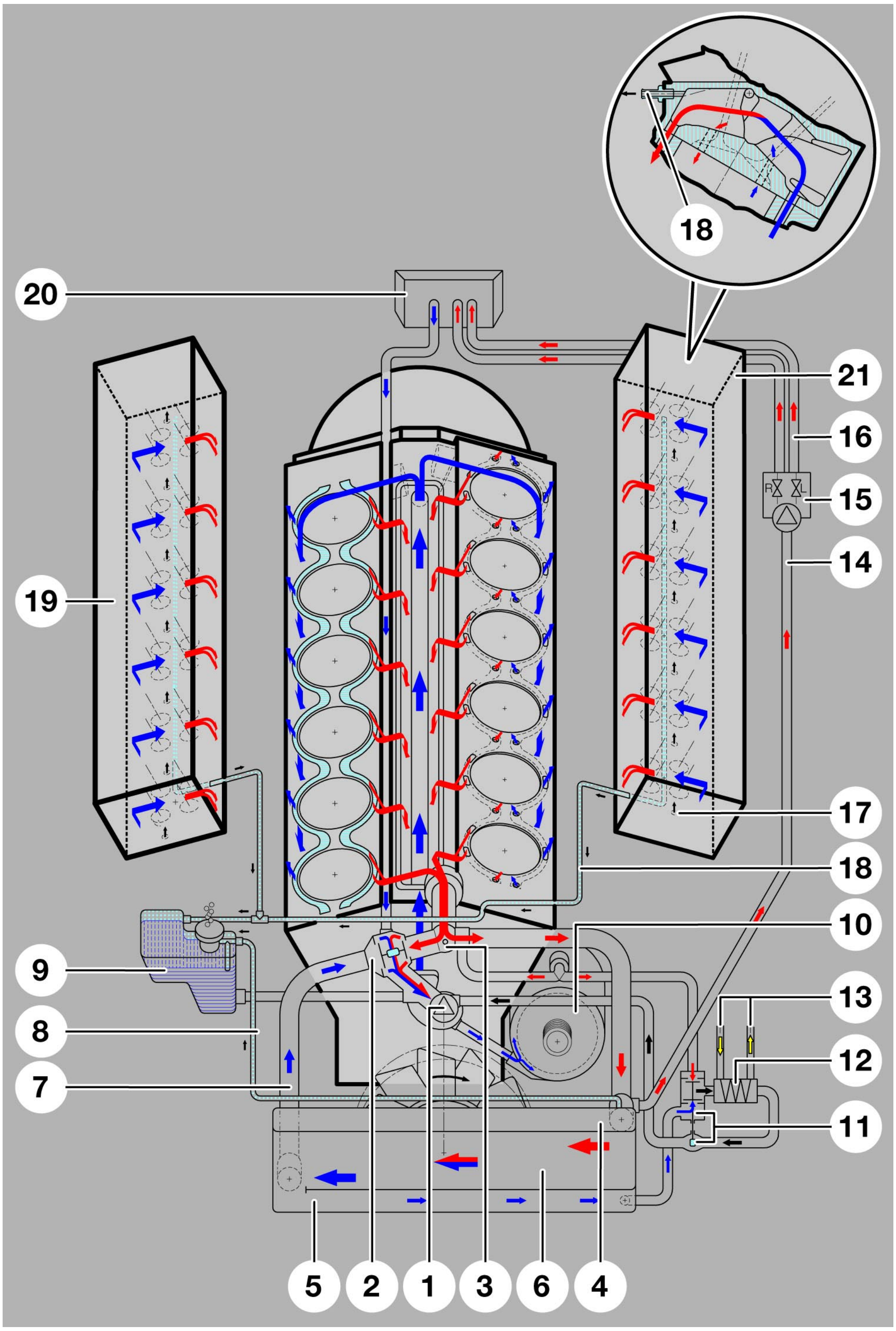

Fig. 26: N73 coolant circuit

Index	Explanation
1	Coolant pump
2	Thermostat housing with map thermostat
3	Temperature sensor
4	Coolant heat exchanger
5	Radiator, low-temperature area
6	Radiator, high-temperature area
7	Radiator return flow
8	Radiator vent line
9	Expansion tank
10	Alternator, water-cooled
11	Thermostat for transmission oil-to-water heat exchanger
12	Transmission oil-to-water heat exchanger
13	Transmission oil-to-water heat exchanger, transmission-oil connection
14	Heating delivery line
15	Heating valves with electric water pump
16	Heating heat exchanger in-flow
17	Holes for crankcase ventilation
18	Cylinder-head vent line
19	Cylinder head, cylinder bank 1-6
20	Heating heat exchanger
21	Cylinder head, cylinder bank 7-12

The N73 coolant circuit has been developed in accordance with the modular-design principle of the NG V engine family and corresponds in terms of layout with that of the N62.

- Map cooling

General information

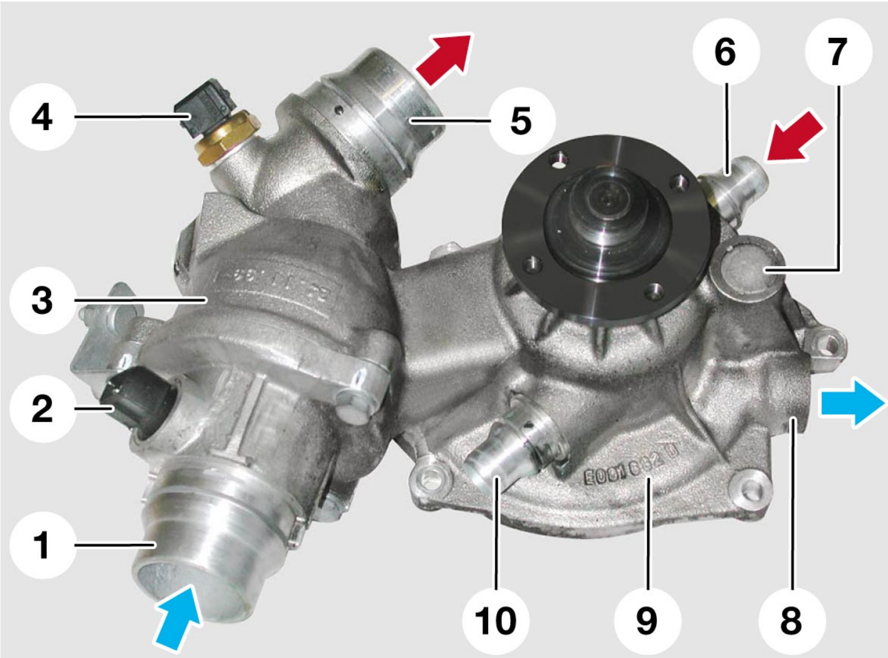

Fig. 27: Water pump with map thermostat

Index	Explanation
1	Map thermostat (radiator return)
2	Electrical connection for map-thermostat heating element
3	Thermostat mixing chamber (in water pump)
4	Temperature sensor (engine outlet temperature)
5	Radiator in-flow
6	Heat exchanger transmission oil return flow
7	Leakage chamber (evaporation space)
8	Alternator in-flow
9	Water pump
10	Expansion tank connection

The water pump with map thermostat is identical to that of the N62.

The map thermostat and the water pump are integrated in a common housing.

The coolant temperature is regulated as a function of the engine-load signal and the vehicle speed with the aid of the map thermostat. The coolant temperature can be increased specifically in the part-load range by means of this regulation.

The map thermostat is regulated by the DME as a function of a program map.

This map is determined by the following factors:

- Engine load
- Engine speed
- Vehicle speed
- Intake temperature
- Coolant temperature

By increasing the coolant and thus the component temperature in the part-load range, i.e. in the engine's thermostat control range, it is possible to achieve significant consumption and emission benefits (approx. 1% reduced consumption per 10 °C temperature increase).

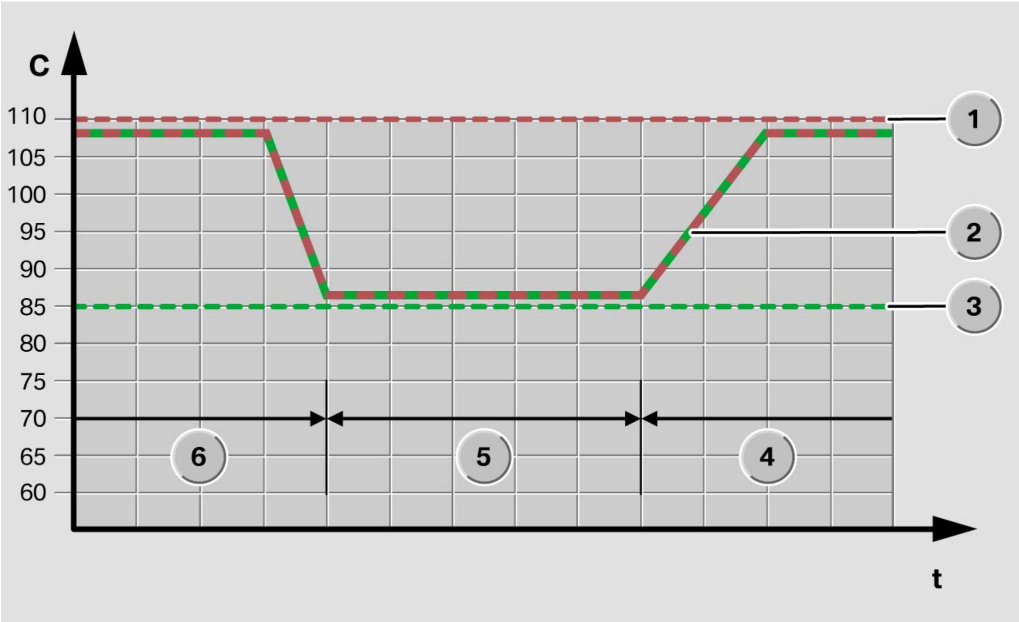

Fig. 28: Control characteristic of map cooling

Index	Explanation
t	Time
1	110° thermostat
2	Map thermostat
3	85° thermostat
4+6	Part load
5	Full load

Function of a conventional thermostat

Regulation of engine cooling by a conventional thermostat is determined exclusively by the coolant temperature. This form of regulation can be divided into three operating ranges:

- Thermostat closed:
  The coolant flows around the engine only.
  The cooling circuit is closed.
- Thermostat fully adjusted (open):
  The entire coolant flows through the radiator.
  The maximum cooling output is thereby exploited.
- Thermostat control range:
  A partial flow of coolant passes through the cooler. The thermostat maintains a constant engine inlet temperature in the control range.

Function of map thermostat

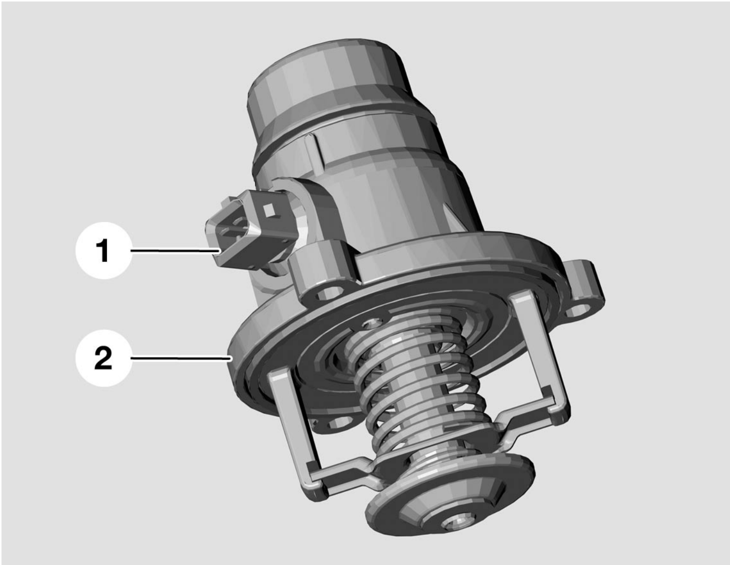

Fig. 29: Map thermostat

Index	Explanation
1	Electrical connection for heating element
2	Thermostat cap

The function and the essential mechanical design of the map thermostat are the same as those of a conventional thermostat. However, the expansion element (wax element) also incorporates a heating element.

The map thermostat is an integral thermostat, i.e. thermostat and thermostat cap form a single unit.

The thermostat cap (2) is made from diecast aluminium and also incorporates an electrical connection (1) for the heating element connected to the thermostat expansion element.

Control function

The map thermostat is adjusted in such a way as to open without intervention by the integrated heating element at a coolant temperature at the thermostat of 103 °C (this temperature value is stamped on the thermostat plate).

Since the thermostat is installed at the engine inlet, this is the temperature at which the coolant enters the engine.

As the coolant is heated in the engine, approx. 110 °C is measured at the engine outlet (installation location of the coolant temperature sensor for DME and instrument cluster) at this operating point.

This is the engine operating temperature at which the map thermostat starts to open without control intervention.

In the event of a control intervention by the DME, the heating element integrated in the thermostat is energised (12 V).

This heats up the expansion element, which determines as a function of the temperature the extent to which the thermostat opens. Because the expansion element is heated, the thermostat now opens at lower coolant temperatures than would be the case without this additional heating (thermostat control range 80 °C to 103 °C).

In the event of a control intervention, the expansion element of the map thermostat is heated to a higher temperature than that demonstrated by the coolant currently flowing past.

If the coolant temperature exceeds 113 °C at the engine outlet, heating of the map thermostat is activated by the DME regardless of the other parameters.

In the event of a map-control failure (e.g. open circuit in the supply lead), the engine is operated in the higher temperature range. Damage to the engine in this operating state is prevented by the other DME control functions (e.g. knock control, activation of auxiliary fan).

- Cooling module

Engine-oil/air cooler

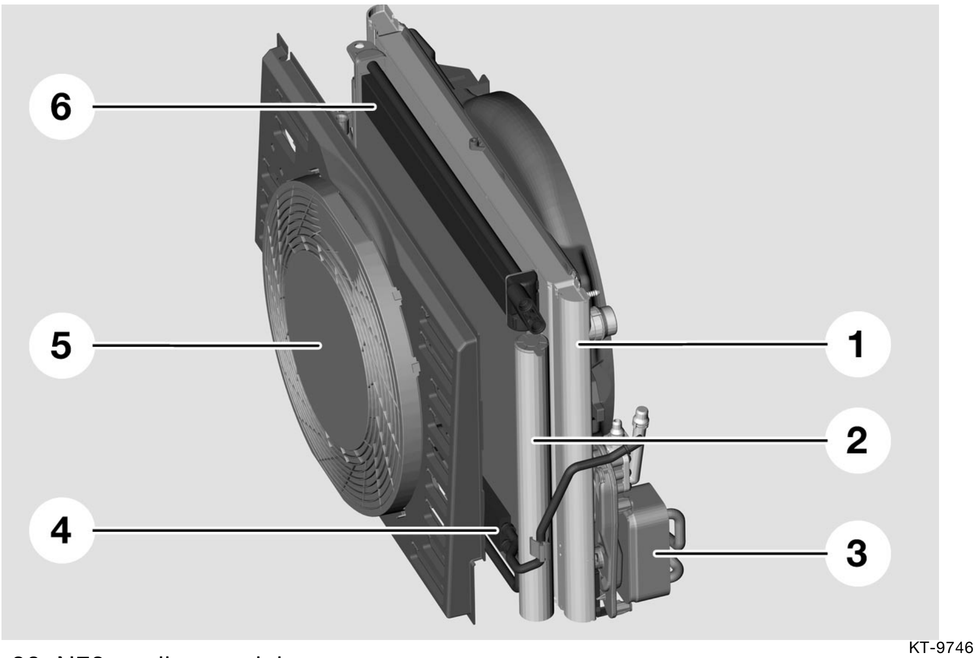

Fig. 30: N73 cooling module

Index	Explanation
1	Engine-coolant radiator
2	A/C condenser
3	Transmission-oil cooler
4	Power-steering cooler
5	Fan shroud
6	Engine-oil cooler

The cooling module of the E65 has been expanded for the N73 to include an engine-oil cooler (6). The engine-oil cooler is located in front of the engine-coolant radiator (1) above the A/C condenser (2).

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. A wax element in the oil thermostat opens the supply flow to the engine-oil cooler continuously from an oil temperature from 100 °C to 130 °C.

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

Using the engine-oil cooler helps to keep the engine-oil temperature below 150 °C. Cooling the engine oil provides a uniform oil temperature and ensures a high service life for the oil.

Engine block

- Crankcase

General

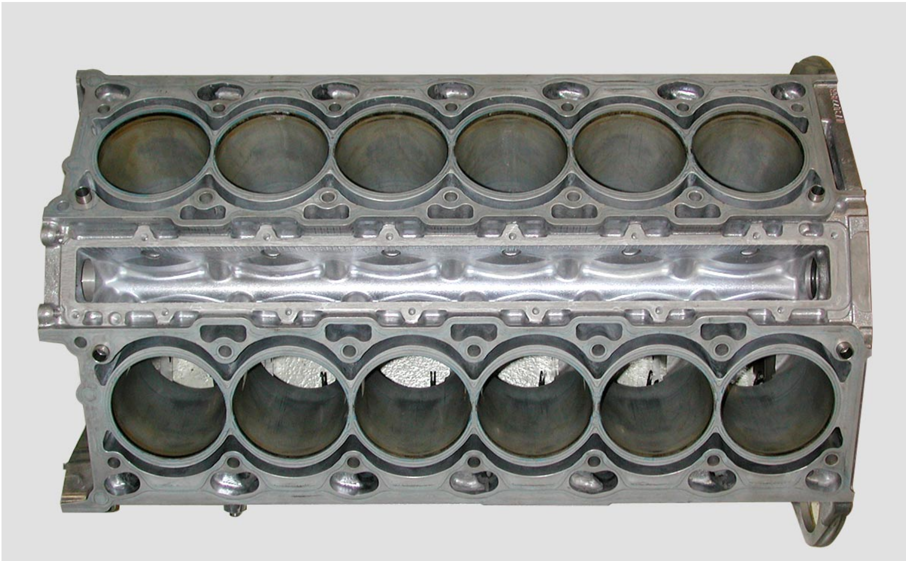

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Fig. 31: Aluminium engine block

The crankcase is similar in design to that of the N62 engine.

It is built as a single component in open-deck form and is made up entirely of AluSil. Open-deck means that the water jacket of the cylinder block is open at the top.

The iron-coated pistons run directly in the uncoated cylinder bores.

Treatment of cylinder bores

Thanks to a special cooling process in the manufacture of the crankcase, a large amount (compared with the base material) of silicon crystals settle down on the cylinder bores. In mass production, the cylinder bores are treated by means of an etching procedure. This procedure involves aluminium being etched out between the silicon crystals.

The silicon crystals form a high-strength running surface for the pistons.

The cylinder bores can be remachined twice in maintenance service. Pistons of repair stages 1 and 2 are available for this purpose.

Machining in maintenance service takes the form of exposure honing. This involves removing the aluminium content with a soft aluminium strip from the cylinder walls, which exposes the silicon crystals of the AluSil on the treated surface.

Note

It is only possible to remachine the cylinder bores with special machining equipment and therefore such work can only be performed in engine repair shops.

- Crankshaft

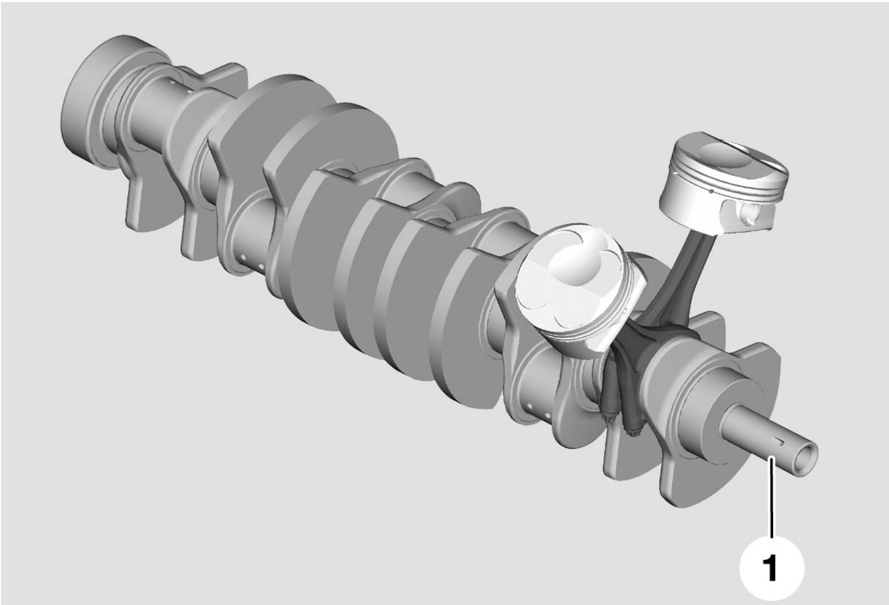

Fig. 32: N73 crankshaft

Index	Explanation
1	Mounting for crankshaft sprocket wheel

The crankshaft is made from forged steel. Its material and dimensions satisfy the high standards of comfort required of the vehicle (acoustics, vibrations).

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

Crankshaft bearings

KT-7676

Fig. 33: Crankshaft thrust bearing

A built step bearing is used at the transmission end as the thrust bearing.

The crankshaft is supported in seven bearings, the seventh serving as the thrust bearing.

- Pistons and connecting rods

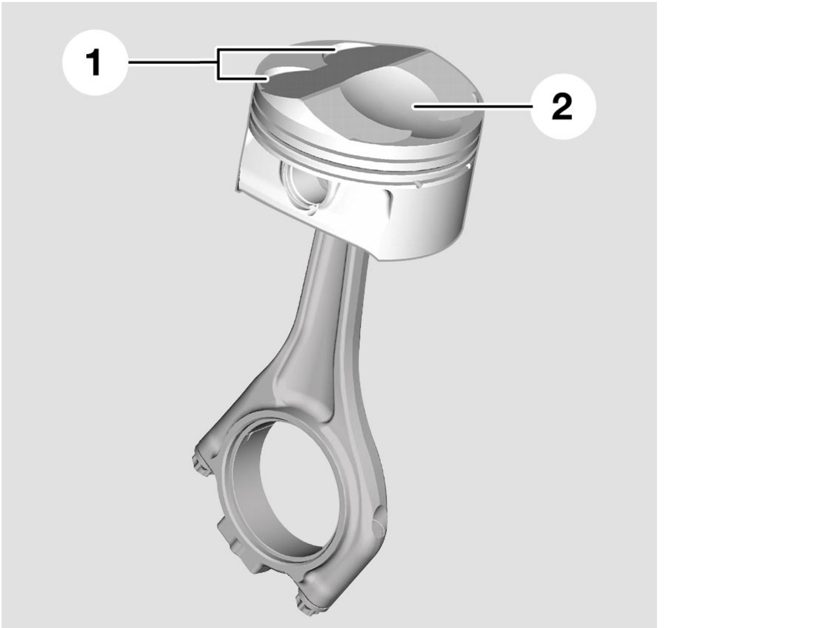

Fig. 34: Piston with connecting rod

Index	Explanation
1	Valve reliefs
2	Piston recess

The cast piston is a weight-optimised pent-crown piston with incorporated valve reliefs in the piston crown. The recess (2) in the pent crown has two functions:

- It brings about a homogeneous mixture formation in the combustion chamber
- It prevents the combustion chamber from being divided into two parts

The pistons are made of a high-temperature, iron-coated aluminium alloy and equipped with three piston rings:

1st piston-ring groove = plain compression ring

2nd piston ring groove = taperface ring

3rd piston-ring groove = two-part oil control ring

The forged steel connecting rod is cracked (identical part N62).

It has been possible to design a highly compact crank area thanks to the 30° oblique split of the big connecting-rod eye.

The pistons are cooled by oil jets on the exhaust side of the piston crown.

The pistons are available in two oversizes if the cylinders have to be remachined.

Because of the shaping of the piston crown and the piston-pin offset, the pistons are designed specifically for each cylinder bank and must not be mixed up (see also the arrow on the piston crown, which always points in the direction of travel).

- Oil pan

The N73 oil pan as with the N62 comprises two parts.

The oil-pan top section is made from diecast aluminium and sealed with a rubber-coated sheet-steel gasket against the crankcase.

The oil-pan bottom section made from double sheet metal is bolted to and sealed against the top section by a rubber-coated sheet-metal gasket.

The bottom section has a circular cutout for accommodating the oil-filter element.

The top section is sealed against the oil pump by a sealing ring.

- Flywheel

The flywheel is designed as a composite metal flywheel. Here the starter ring gear and the incremental wheel (for recording the engine speed and identifying the crankshaft position) are hot-riveted directly to the driver disc.

The speed sensor is positioned if possible in direct proximity to the power output from the crankshaft to the transmission. This facilitates the sensing of rotational irregularity for the purpose of detecting misfiring in individual cylinders.

The flywheel diameter is 320 mm.

- Vibration damper

The torsional-vibration damper is built to an axially isolated design and serves to reduce the torsional crankshaft vibrations to a minimum.

- Engine suspension

The engine suspension is provided by means of two hydraulic damping engine mounts.

The engine mounts are located on the front axle carrier. The structure and function of the engine mounts are the same as those of the E38/M73.

Lubrication system

- Oil circuit

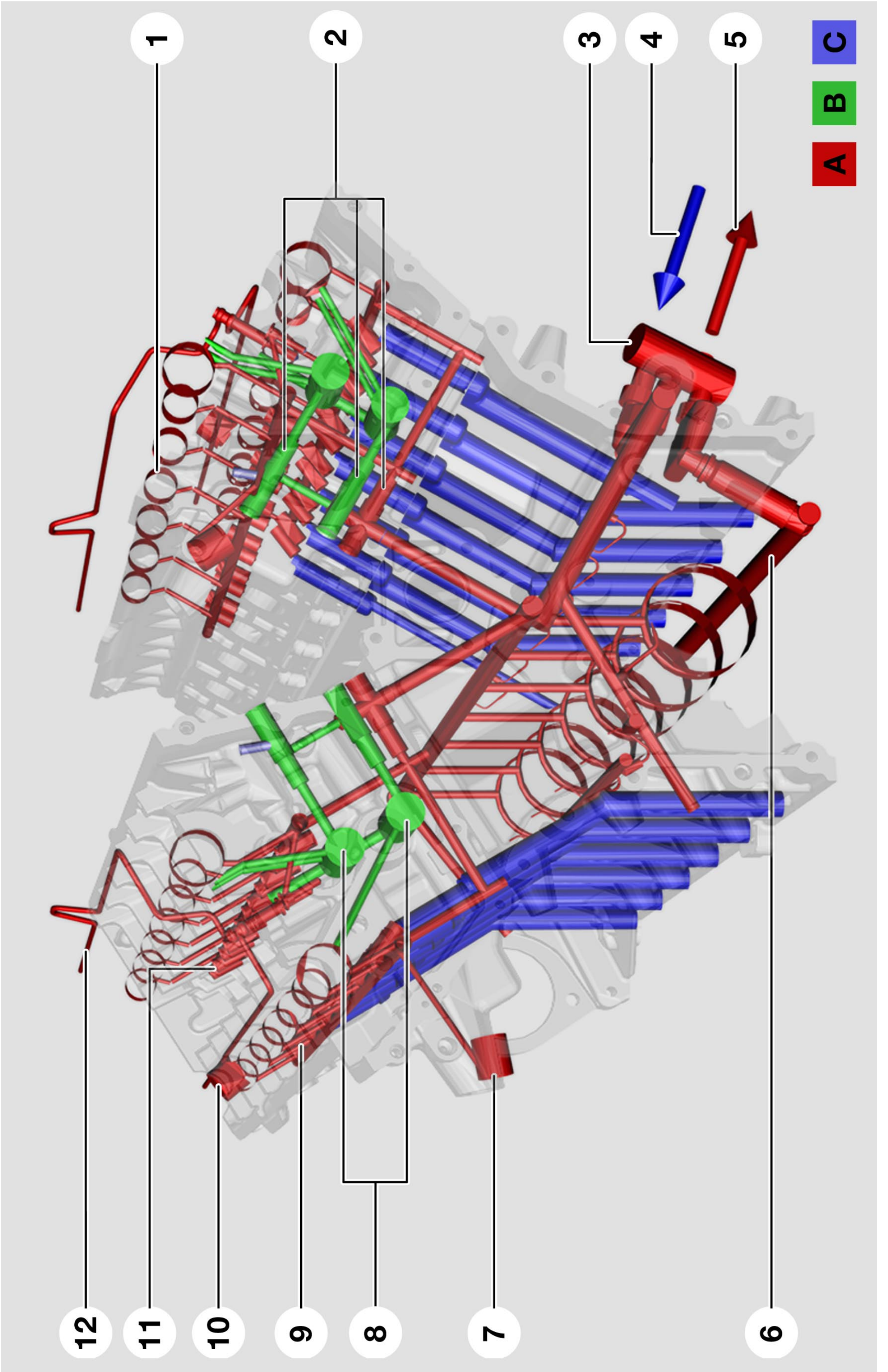

Fig. 35: N73 oil circuit

Index	Explanation
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 from oil cooler
5	Oil to oil cooler
6	Oil from oil pump
7	Oil supply, chain tensioner
8	Oil supply, VANOS solenoid valves
9	Oil supply to exhaust camshafts
10	Oil supply to high-pressure injection pumps
11	Oil supply to HVA elements
12	Oil supply to Valvetronic eccentric shaft

- Oil pump

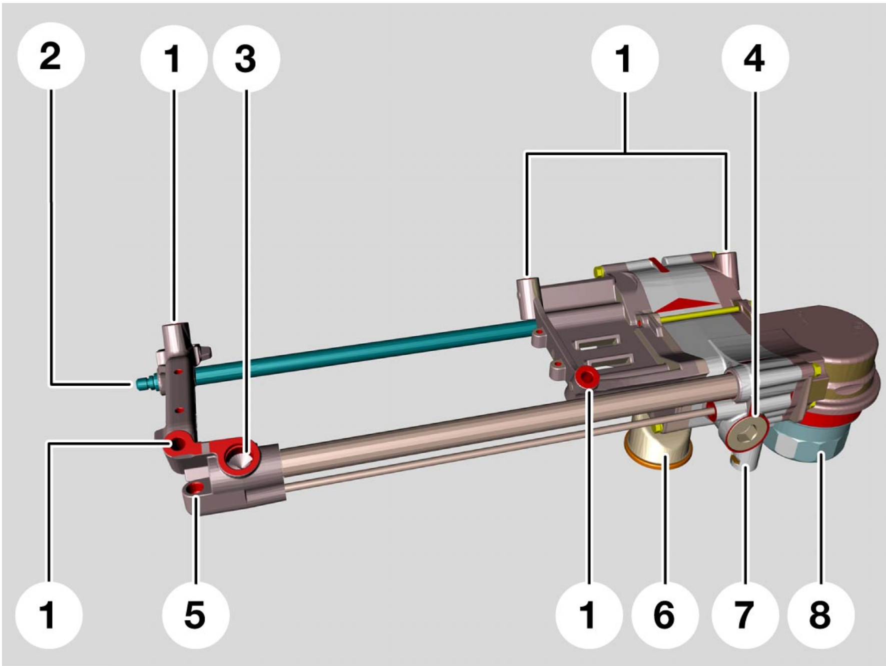

Fig. 36: N73 oil pump

Index	Explanation
1	Mounting thread
2	Oil-pump drive shaft
3	Oil pressure from oil pump to engine
4	Control valve
5	Oil pressure control cable from engine to control valve
6	Oil intake strainer
7	Pressure relief valve
8	Oil filter

The oil pump is mounted with an angled screw connection to the crankshaft bearing caps and driven by the crankshaft via a sleeve-type chain.

A two-stage gear oil pump with two gear pairs connected in parallel serves as the oil pump.

Stage 2 is hydraulically deactivated at approx. 2 bar. It is only active in the lower speed range up to approx. 2000 rpm in order always to make sufficient oil pressure available to the VANOS at high oil temperatures.

N73 Engine Management

Introduction

The N73 engine has a total of 5 control units fitted for managing the engine functions:

- One MED 9.2.1 engine control unit for each cylinder bank
- One Valvetronic control unit
- One high-pressure fuel-injector (HDEV) control unit for each cylinder bank

The control units are connected to each other via the local CAN (loCAN).

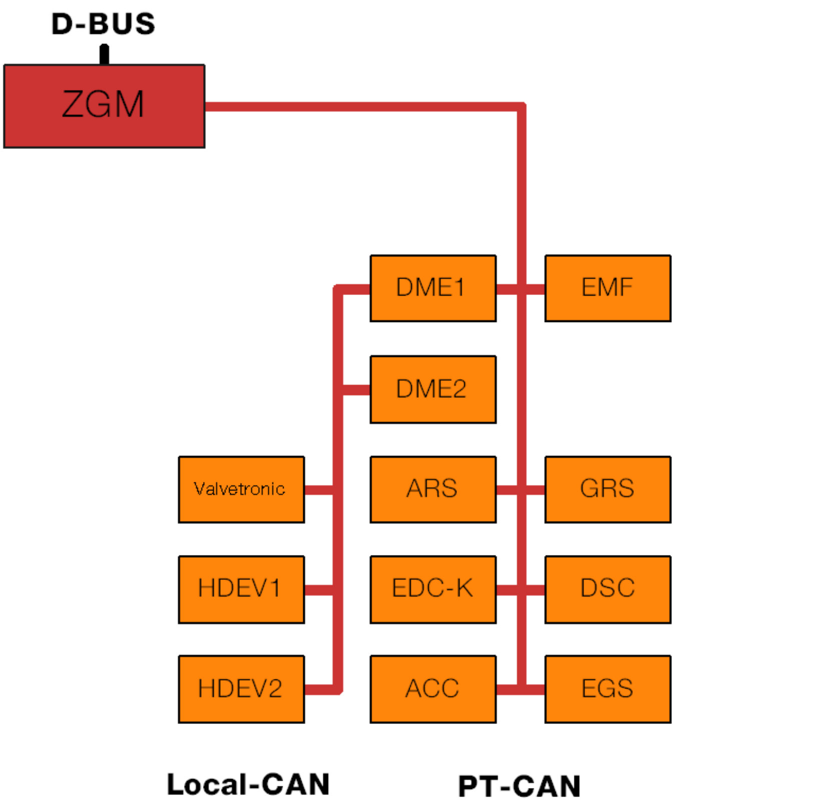

Fig. 37: Engine control units, bus connection

The engine control unit is a further development of the ME 9.2 engine-management system, which is used in the N62 and N42 NG engines.

- Components

All the components of the MED 9.2.1 engine-management system for the N73 engine are itemised in the following list.

Sensors

- Accelerator-pedal module (FPM)
- 2 hot-film air-mass flow sensors (HFM)
- Knock sensor 1 (cylinders 1-2)
- Knock sensor 2 (cylinders 3-4)
- Knock sensor 3 (cylinders 5-6)
- Knock sensor 4 (cylinders 7-8)
- Knock sensor 5 (cylinders 9-10)
- Knock sensor 6 (cylinders 11-12)
- Crankshaft sensor (KWG)
- Oxygen sensor after cat. 1 (LSH1)
- Oxygen sensor after cat. 2 (LSH2)
- Oxygen sensor before cat. 1 (LSV1)
- Oxygen sensor before cat. 2 (LSV2)
- Temperature sensor, radiator water outlet (NTC1)
- Water temperature sensor (NTC2)
- Camshaft position sensor, exhaust camshaft 1
- Camshaft position sensor, exhaust camshaft 2
- Camshaft position sensor, intake camshaft 1
- Camshaft position sensor, intake camshaft 2
- 2 Valvetronic eccentric-shaft sensors
- 2 pressure sensors, induction system
- Oil-condition sensor (OEZS)
- Ambient-pressure sensor in engine control unit
- 2 rail-pressure sensors

Relays

- DME relay
- Starter-motor relay
- Secondary-air-pump relay
- 2 Valvetronic-motor relays
- Power-supply relay, ignition coils 1-12

Actuators

- 2 electronic throttles (EDK)
- Solenoid valve for auxiliary air flaps
- High-pressure fuel injectors 1-12
- Electronic fan
- Electronics-box fan
- Secondary-air pump (SLP)
- Tank vent valve (TEV)
- VANOS solenoid valve, exhaust camshaft 1
- VANOS solenoid valve, intake camshaft 1
- VANOS solenoid valve, exhaust camshaft 2
- VANOS solenoid valve, intake camshaft 2
- Rod-type ignition coils 1-12
- Map thermostat
- Return shutoff valve
- Fuel-quantity control valve

Switches

- Brake-signal switch
- Oil-pressure switch

Control units

- DME 1 = master
- DME 2 = slave
- Valvetronic control unit
- 2 HDEV control units

Interfaces

- PT-CAN High (powertrain CAN)
- PT-CAN Low (powertrain CAN)
- LoCAN High motor (local CAN motor)
- LoCAN Low motor (local CAN motor)

- MED 9.2.1 engine management

Function

An MED 9.2.1 control unit is used for each cylinder bank. Both control units are of the same design and classified into master and slave by the programming.

The master control unit receives the input signals which are output by a sensor or switch only:

- Accelerator-pedal module
- Oil-condition sensor
- Alternator
- Coolant temperature
- Oil pressure

and transmits these signals via the loCAN to the slave control unit.

All further input signals are transmitted directly to the control unit responsible for the relevant cylinder bank (see MED 9.2.1 overview).

Output signals which relate to not just one cylinder bank (e.g. electric fuel pump or exhaust flap) are transmitted by the master control unit to the corresponding actuators.

The signal of the crankshaft sensor is transmitted simultaneously to both control units.

Layout

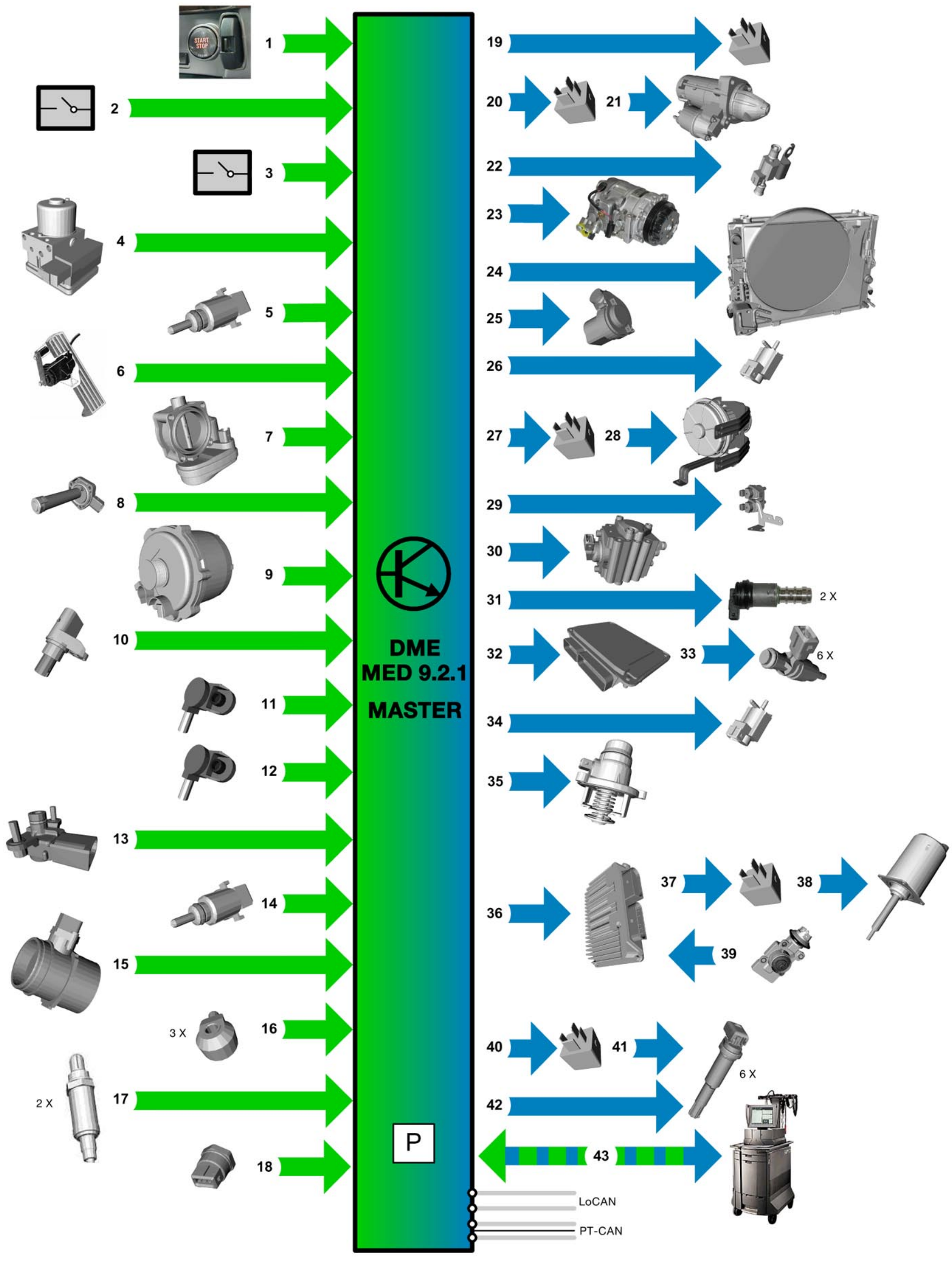

Fig. 38: MED 9.2.1 master

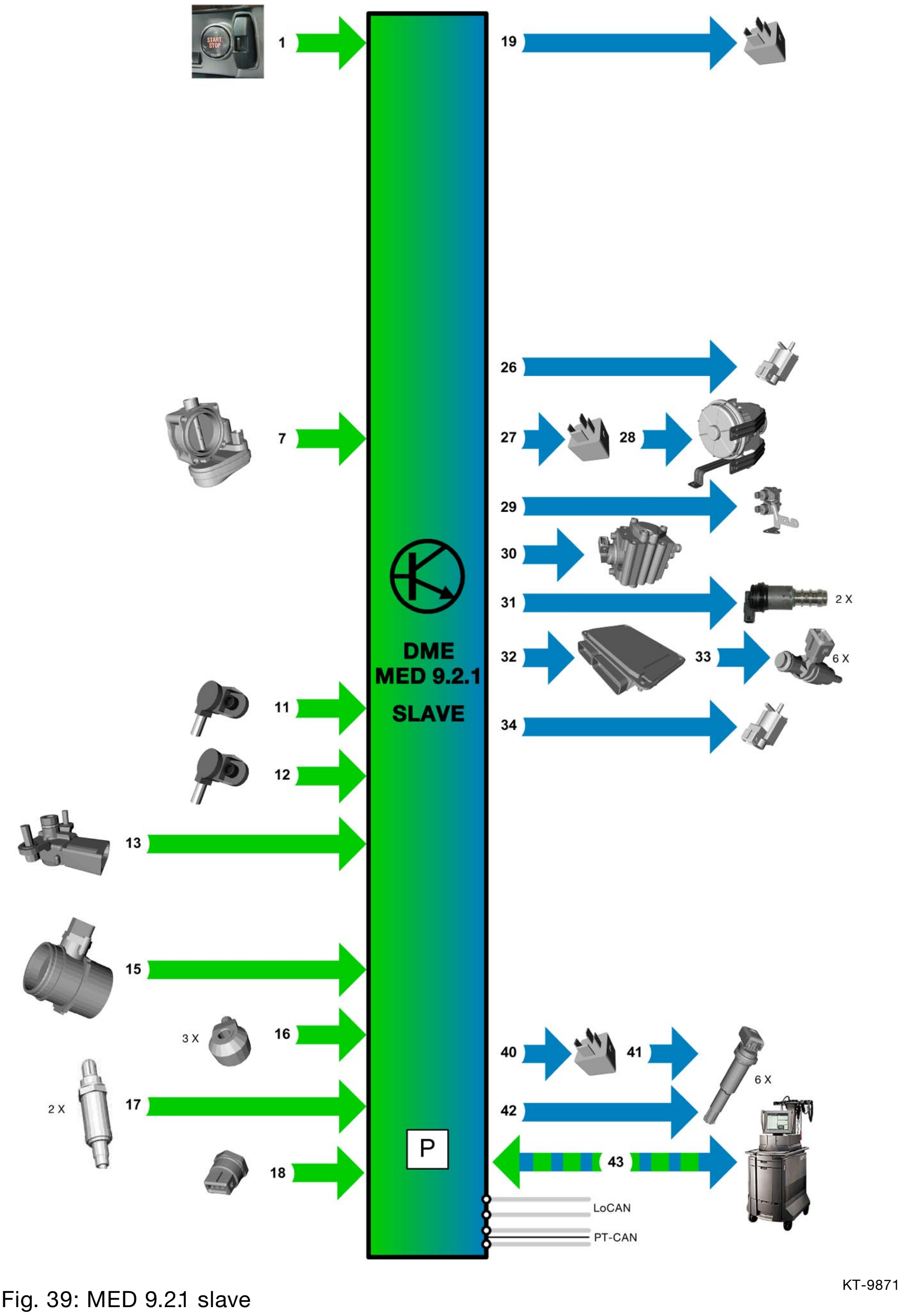

Fig. 39: MED 9.2.1 slave

Index	Description
1	- Start/Stop button with insert for remote control - CAS (Car Access System) - Electronic immobiliser (EWS) integrated in CAS
2	Brake-signal switch
3	Clutch switch
4	DSC module incl. functions: ASC, DTC, ABS
5	Temperature sensor, radiator water outlet
6	Accelerator-pedal module (FPM)
7	Electronic throttle (EDK)
8	Oil-condition sensor (OEZS)
9	Alternator
10	Crankshaft sensor (KWG)
11	Intake-camshaft position sensor
12	Exhaust-camshaft position sensor
13	Pressure sensor, induction system
14	Coolant temperature sensor
15	Hot-film air-mass flow sensor
16	3 knock sensors
17	Oxygen sensor before catalytic converter Oxygen sensor after catalytic converter
18	Rail-pressure sensor
19	DME relay
20	Start relay
21	Starter motor
22	Return shutoff valve
23	Clutch-free A/C compressor
24	Electric fan
25	Electronics-box fan
26	Solenoid valve, exhaust flap
27	Relay, secondary-air pump
28	Secondary-air pump
29	Tank vent valve (TEV)
30	Fuel-quantity control valve (MSV) in H.P. pump (HDP)
31	VANOS solenoid valve, exhaust camshaft VANOS solenoid valve, intake camshaft
32	High-pressure fuel-injector control unit
33	High-pressure fuel injectors (HDEV)
34	Solenoid valve, auxiliary air flap
35	Heater, map thermostat
36	Valvetronic control unit
37	Valvetronic relay
38	Valvetronic motor
39	Valvetronic eccentric-shaft sensor
40	Relay, rod-type ignition coils
41+42	Rod-type ignition coils
43	Diagnostic cable
DME MED 9.2.1	Engine control unit
P	Ambient-pressure sensor in DME control unit

The ME 9.2 engine-management system of the NG engines served as the basis for development of the MED 9.2.1 engine-management system.

The main distinguishing features from the ME 9.2 are:

- Extended computer capacity (additional 1 MB flash)
- Modified oxygen-sensor chip which permits detailed diagnosis of the oxygen sensors
- One MED 9.2.1 control unit for each cylinder bank
- The high-pressure fuel injectors are activated by means of a high-pressure fuel-injector (HDEV) control unit for each cylinder bank
- Omission of variable induction-system activation (N62)
- Three knock sensors for each cylinder bank
- Activation of the auxiliary air flaps in the air-cleaner housing
- Signal, rail-pressure sensor
- Signal, fuel-quantity control valve

Operation

Additional functions:

- Three knock sensors for each cylinder bank
- Activation of the auxiliary air flaps in the air-cleaner housing
- Signal, rail-pressure sensor
- Signal, fuel-quantity control valve

The MED 9.2.1 regulates the injected fuel quantity. For this purpose, the MED 9.2.1 receives the rail pressure from the rail-pressure sensor and regulates this pressure with the aid of the fuel-quantity control valve in line with the value defined by the program map. This ensures that a defined quantity of fuel is injected over the injection period.

- Valvetronic control unit

Function

The Valvetronic control unit controls valve-lift adjustment as prompted by the MED 9.2.1.

Design

The Valvetronic control unit is powered by way of the main relay. The relay is located in the electronics box.

Operation

The Valvetronic control unit is connected via the loCAN to the MED 9.2.1. Data communication is conducted over this line.

- HDEV control unit

Function

The HDEV control unit activates and powers the new high-pressure fuel injectors.

Design

The HDEV control unit is supplied with system voltage via the DME relay. The use of clocked output stages and high-performance capacitors serves to increase the output voltage of the HDEV control unit to 85 V - 100 V.

A current flows in the output stage up to a specific cut-off value. This cut-off creates an induced voltage, e.g. 85 V, which is then charged to the high-performance capacitors (booster).

Operation

The high-pressure fuel injectors are activated by this capacitor current with a current intensity of 2.8 A to 16 A.

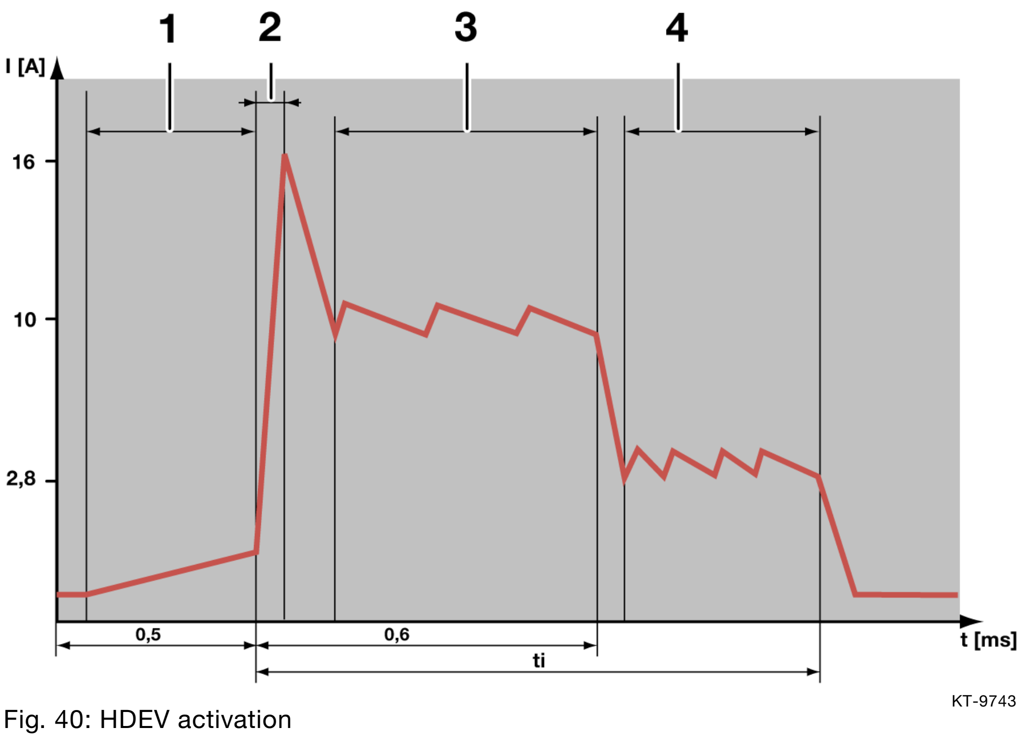

Fig. 40: HDEV activation

Index	Explanation
1	Premagnetisation time
2	Booster phase
3	Starting-current phase
4	Holding-current phase

To activate the high-pressure fuel injectors, the MED 9.2.1 control unit is connected to the HDEV control unit by way of a line for each fuel injector. The data line is comparable with the activation line of normal fuel injectors in a spark-ignition engine. The data line delivers the injection time to the HDEV control unit, which activates the fuel injectors.

The safest way of checking the function of the fuel injectors is by measuring the current. The oscilloscope must depict a pattern (see fig. HDEV activation) which shows the premagnetisation, the booster current and - depending on the injection time ti - the starting phase.

- High-pressure fuel injectors (HDEV)

Function

The design of high-pressure fuel injectors is essentially the same as that of conventional fuel injectors.

Design

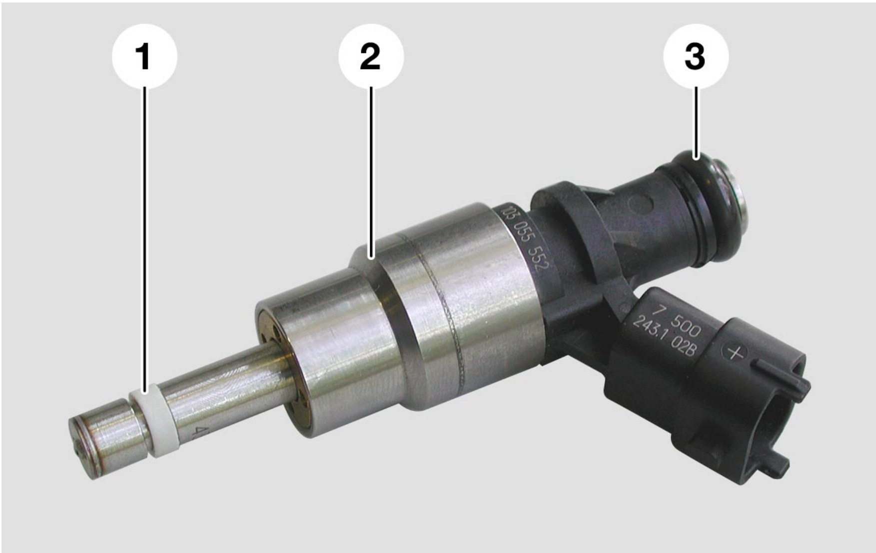

Fig. 41: High-pressure fuel injector HDEV

Index	Explanation
1	Teflon ring
2	Valve seat
3	O-ring

The high-pressure fuel injectors are secured by a taper (2) in the cylinder head and sealed by a Teflon ring (1) against the combustion chamber.

Fig. 42: Position of fuel injector (1) in cylinder head

The high-pressure fuel injectors are arranged on the intake side at a 30° angle to the cylinder head and reach directly into the combustion chamber between the two intake valves (1).

Each fuel injector incorporates a single-hole nozzle with a spray angle of 70° to the piston crown.

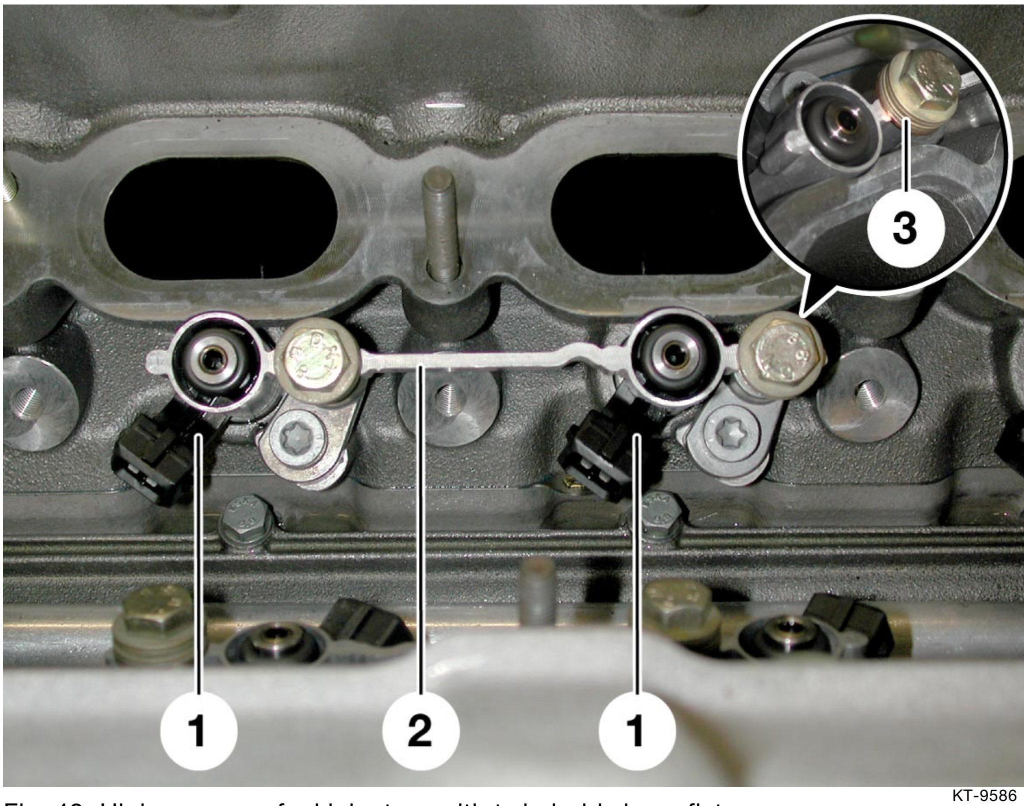

Fig. 43: High-pressure fuel injectors with twin hold-down fixture

Index	Explanation
1	High-pressure fuel injectors
2	Twin hold-down fixture
3	Disc springs

The installed position and mounting pressure are maintained by a twin hold-down fixture (2) (one hold-down fixture for every two fuel injectors). The twin hold-down fixtures are bolted to the cylinder head with disc springs (3); the correct mounting pressure is ensured by the contact pressure of the disc springs.

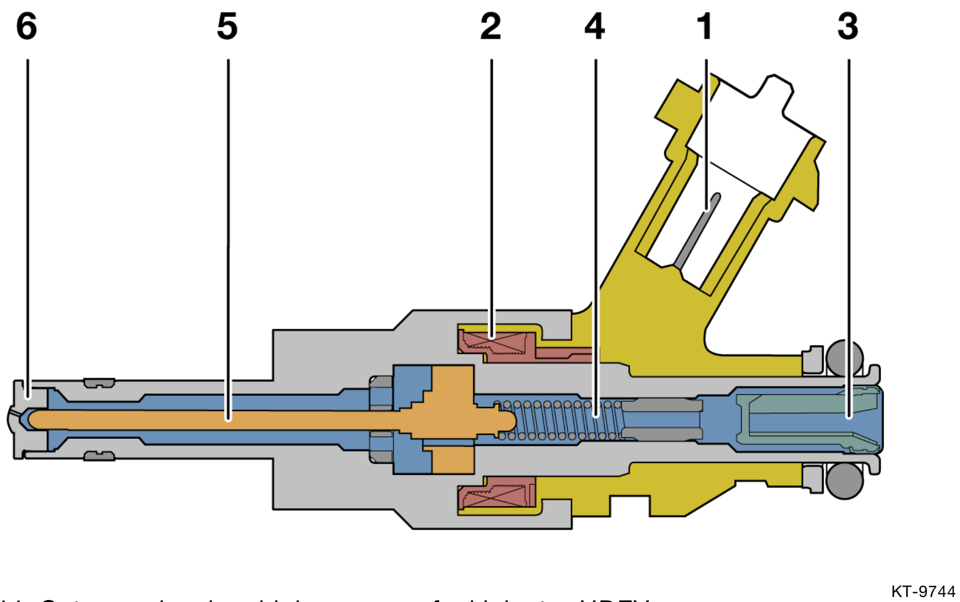

Fig. 44: Cutaway drawing, high-pressure fuel injector HDEV

Index	Explanation
1	Electrical connection
2	Solenoid coil
3	Fuel port
4	Pressure spring
5	Nozzle needle
6	Single-hole nozzle

Operation

To open the high-pressure fuel injector, the nozzle needle (5) is lifted off its seat by the solenoid coil (2).

Because of the high injection pressure of up to 100 bar, the pressure spring (4) has been designed to accommodate a pressure force of 30 newtons (5 newtons for conventional fuel injectors).

The pressure spring forces the nozzle needle onto its seat swiftly during the closing operation and with sufficient contact pressure.

- Rail-pressure sensor

Function

The rail-pressure sensor must measure the current pressure in the rail

- with sufficient accuracy and
- in a suitably short period of time

and deliver a voltage signal to the control unit in accordance with the prevailing pressure.

Design

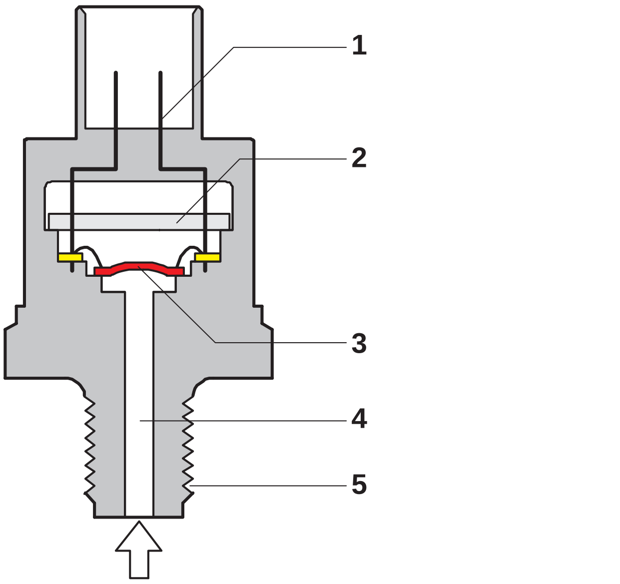

Fig. 45: Rail-pressure sensor - cross-section

Index	Explanation
1	Electrical connection
2	Evaluation circuit
3	Diaphragm with sensor element
4	High-pressure port
5	Mounting thread

The rail-pressure sensor consists of the following components:

- An integrated sensor element
- A PCB with electrical evaluation circuit
- A sensor housing with electrical plug connection

The fuel flows through the high-pressure port to a sensor diaphragm. This diaphragm incorporates a sensor element (semiconductor device), which serves to convert the deformation caused by the pressure into an electrical signal.

Connecting wires send the generated signal to an evaluation circuit, which makes the conditioned measuring signal available to the control unit via the connections.

Operation

The rail-pressure sensor is equipped with a sensor diaphragm (semiconductor device).

This pressure increase in the rail brings about a deformation of the sensor diaphragm (approx. 1 mm at 500 bar). This deformation causes a change in the resistance and creates a voltage variation in the resistance bridge that is supplied with 5 volts.

According to the system pressure applied, the rail-pressure sensor outputs a voltage signal (0.5-4.5 V) to the DME. The sensor signal rises in a linear fashion as the rail pressure increases from 0.5 V (0 bar) to 4.5 V (140 bar).

Precise measurement of the rail pressure is essential to proper system operation. For this reason, the permitted tolerances for pressure measurement with the pressure sensor are also very small.

The measuring accuracy in the main operating range is 30 bar, i.e. approx. ±2% of the final value. If the rail-pressure sensor malfunctions, the fuel-quantity control valve is activated with a limp-home function by the control unit.

- Fuel-quantity control valve (MSV)

Function

The fuel-quantity control valve is installed in the high-pressure pump (HDP) and serves to regulate the HDP delivery rate as a function of load and engine speed.

Design

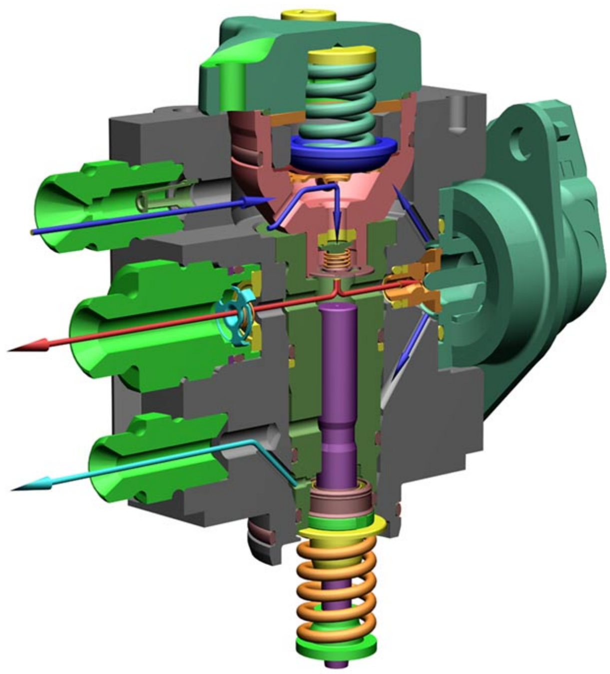

Fig. 46: High-pressure pump with fuel-quantity control valve (right)

The fuel-quantity control valve opens a channel from the pump high-pressure chamber to the feed area.

Operation

The fuel-quantity control valve is activated by the MED 9.2.1 with system voltage and thereby closed. Activation is effected by the MED 9.2.1 as a function of load and engine speed.

When the pump plunger is in BDC position, the valve is energised by the pump and thereby closed.

The valve is de-energised as soon as the injection pressure calculated by the DME is reached during the upwards travel of the pump plunger. The valve is now opened to allow excess fuel to return to the feed area.

This switching is repeated three times per camshaft rotation since the drive cam for the pump has three elevations (see Valve gear).

The injected fuel quantity is adjusted by the fuel injectors (injection time) and the fuel-quantity control valve (injection pressure).

- Return shutoff valve

Function

The return shutoff valve prevents a pressure drop in the system while the engine is stopped.

Design

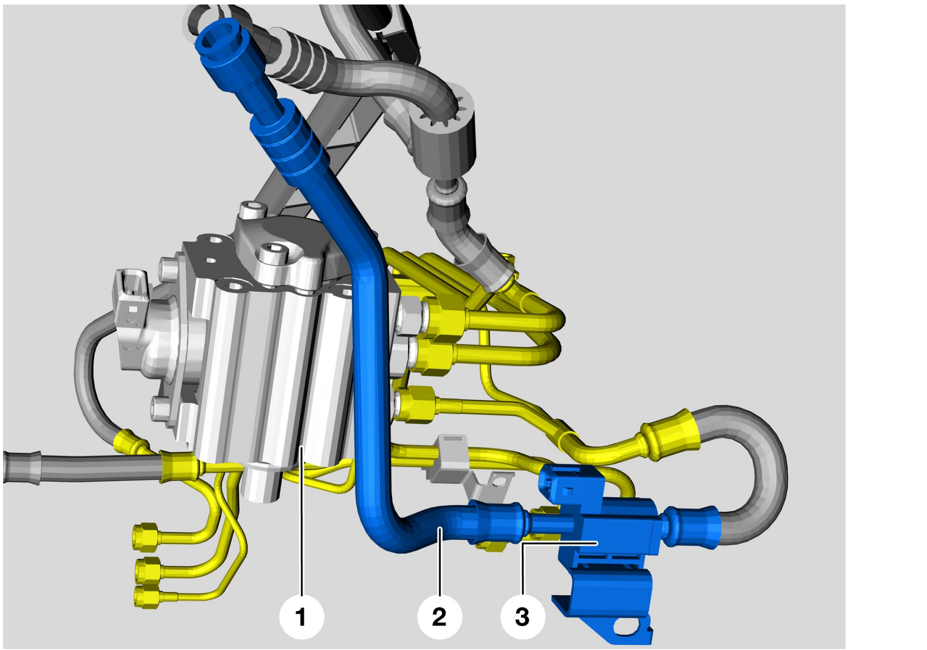

Fig. 47: Return shutoff valve

Index	Explanation
1	High-pressure pump
2	Leakage line
3	Return shutoff valve

The return shutoff valve is located in the leakage line.

Operation

The return shutoff valve is supplied with system voltage via terminal 87 and activated by the DME on the ground side.

While the engine is running, this valve is energised by the DME and allows leakage fuel to return to the tank.

After the engine is started, the valve is energised with a delay so as to prevent a pressure drop in the feed area of the high-pressure pump. A pressure drop in the high-pressure pump would result in vapour pockets.

E65 Fuel System N73

Introduction

- General

For the E65 with N73 engine, minor modifications have been made to the fuel system so as to adapt it to the new direct injection system.

Only the changes with respect to the E65-N62 are discussed in this chapter.

New features supplementing previous BMW developments

The following modifications have been made to the E65 fuel system:

- Insertion of a leakage line
- Electric fuel pump with increased delivery

- Design

System overview

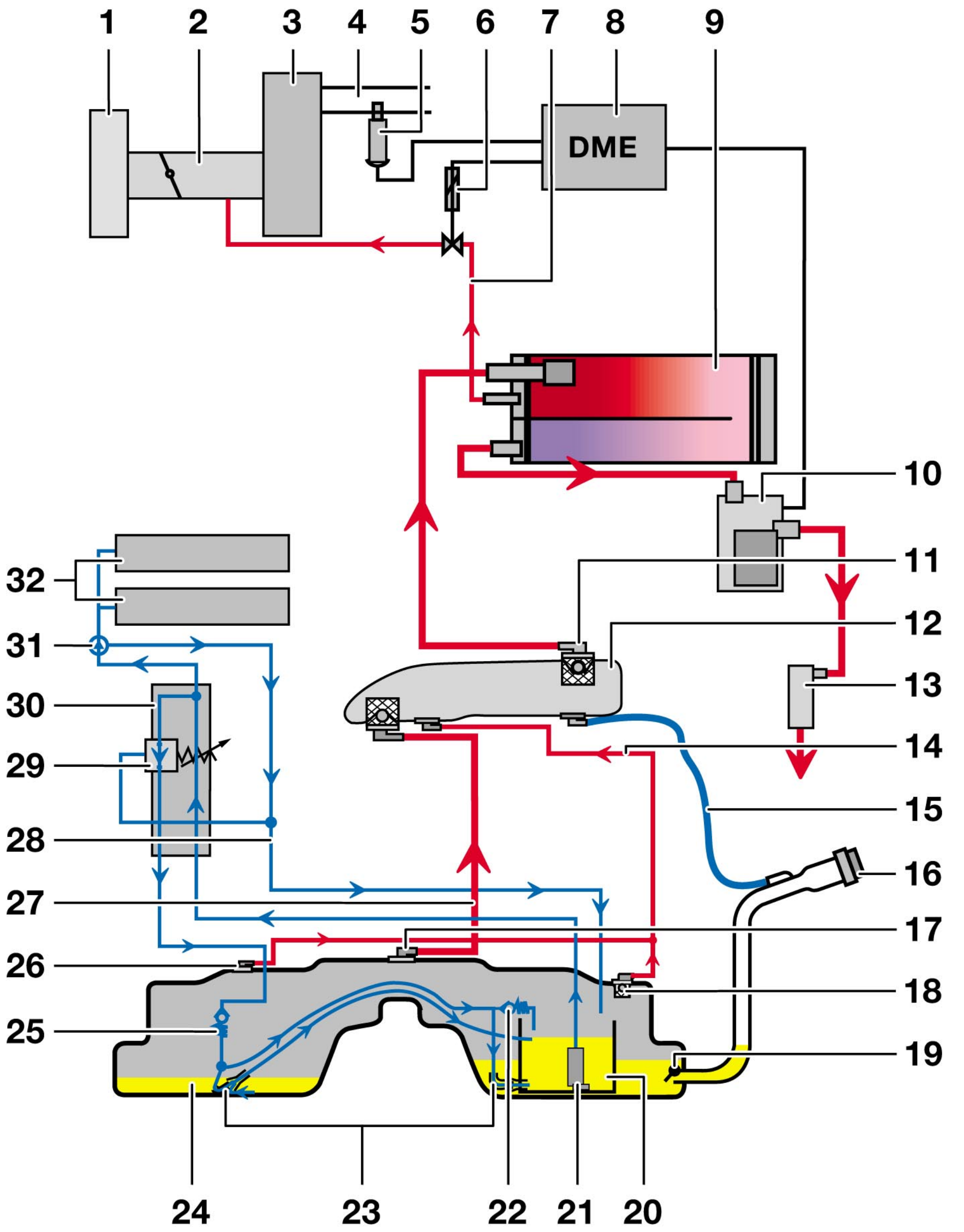

Fig. 48: E65 fuel system with N73 engine

Index	Explanation
1	Air cleaner
2	Intake pipe
3	Engine
4	Exhaust system
5	Oxygen sensor
6	Tank vent valve
7	Purge air
8	DME 9.2.1
9	Carbon canister
10	Tank-leak diagnostic module
11	Roll-over valve
12	Expansion tank
13	Dust filter
14	Service ventilation
15	Pressure test lead
16	Fuel tank cap
17	Filler vent valve
18	Service vent valve (float valve)
19	Anti-spitback flap
20	Surge chamber
21	Electric fuel pump (EKP)
22	Pressure-limiting valve
23	Suction-jet pumps
24	Fuel tank
25	Outlet protection valve
26	Service vent valve (float valve)
27	Refuelling breather
28	Leakage line
29	Pressure regulator
30	Fuel filter
31	High-pressure fuel pump (HDP)
32	Fuel rails

Components

- Fuel filter with pressure regulator

Design

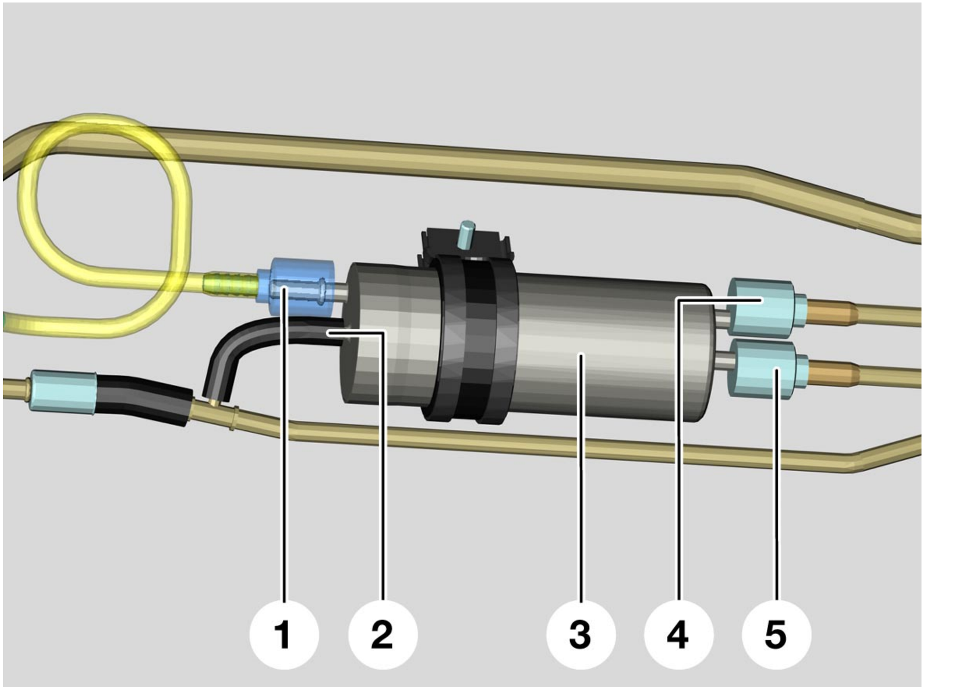

Fig. 49: Fuel filter with pressure regulator

Index	Explanation
1	Connection to high-pressure pump
2	Reference-pressure connection to leakage line of H.P. pumps
3	Fuel filter with pressure regulator
4	Fuel feed
5	Fuel return

Operation

A modified fuel filter with pressure regulator is fitted in the N73 engine. The line connections have been fitted with quick-release couplings on account of the increased feed pressure (6 bar) from the electric in-tank fuel pump EKP.

The reference-pressure line of the pressure regulator is connected to the leakage line of the high-pressure pumps. The diaphragm of the pressure regulator is supplied with atmospheric pressure via this connection.

In the event of an internal leak in the pressure regulator, any fuel that escapes is discharged via the leakage line. This prevents the fuel from escaping into the environment.

This connection has dispensed with the need for the line to the intake pipe (ahead of the throttle) used for the N62.

- Electric fuel pump (EKP)

Function

To supply both high-pressure pumps adequately, the N73 engine requires an increased feed pressure from the fuel pump in the tank.

Operation

A roller-cell pump (EKP Bosch 3.1) with an increased delivery pressure of 6 bar is used in the N73 engine.

As in the N62 engine, the electric fuel pump is situated in the fuel tank and activated by the DME in accordance with engine demand.

N73 Fuel System

Introduction

A petrol direct injection system is used for the first time in the N73 engine series.

The fuel mixture is prepared homogeneously, i.e. the air/fuel ratio is regulated stoichiometrically (λ=1) as in manifold injection.

Thanks to the use of this homogeneous operating mode, it is possible to use a conventional exhaust-gas treatment system with three-way catalytic converter and sour fuel (i.e. containing sulphur).

This enables the engine to be used worldwide.

System overview

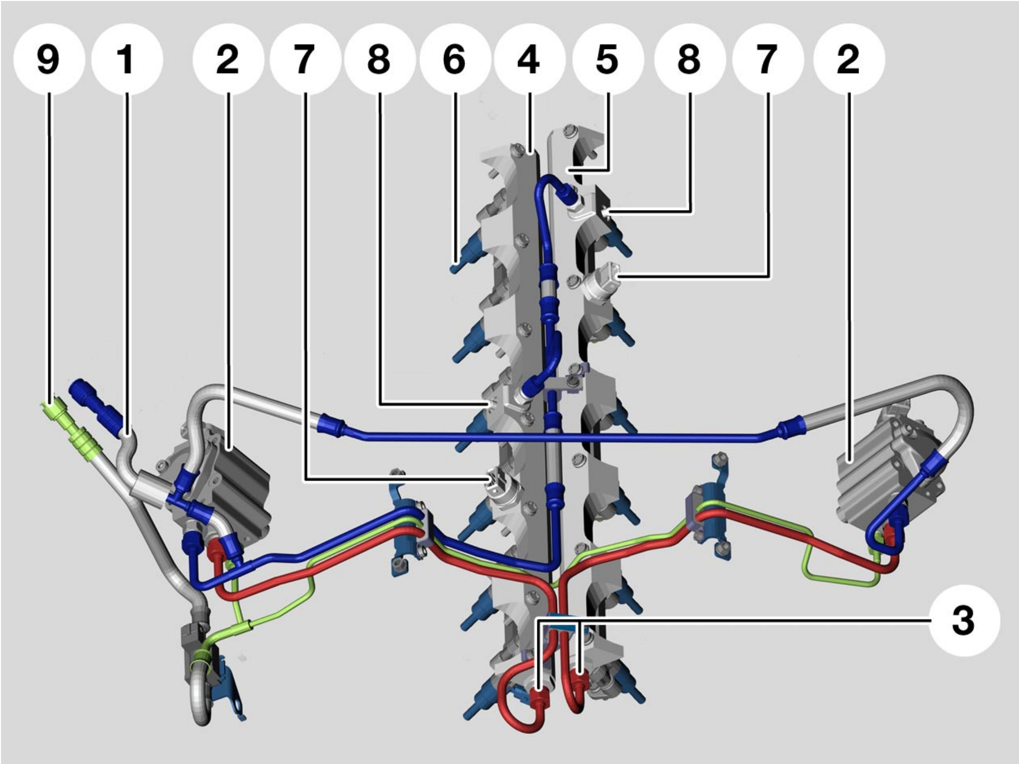

Fig. 50: High-pressure injection system

Index	Explanation	Index	Explanation
1	Feed line	6	High-pressure fuel injectors
2	High-pressure pumps	7	Rail-pressure sensors
3	High-pressure line	8	Pressure-limiting valves
4	Rail, cylinders 7-12	9	Leakage line
5	Rail, cylinders 1-6		

Each rail is supplied with fuel by a high-pressure pump (HDP), which is driven via a bucket tappet by a triple cam on the exhaust camshaft.

The two high-pressure pumps themselves are supplied with fuel by the electric fuel pump (EKP), which is located in the fuel tank.

The high-pressure fuel injectors are connected to a pressure accumulator (rail) for each cylinder bank. The two rails are not interconnected.

Components

- High-pressure pumps (HDP)

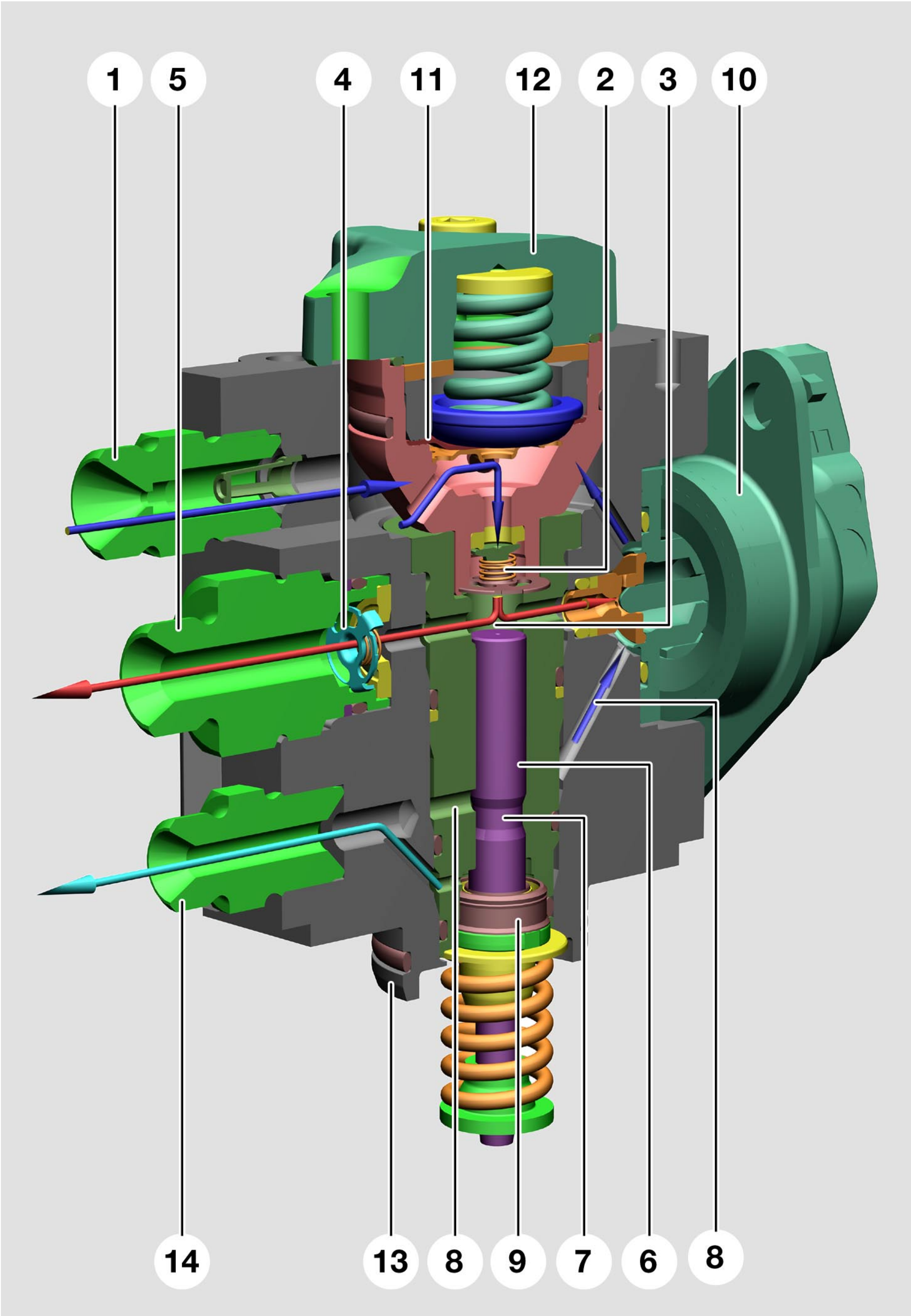

Fig. 51: High-pressure pump (HDP)

Index	Explanation
1	Port, feed line
2	Inlet valve
3	High-pressure chamber
4	Outlet valve
5	Port, high-pressure line
6	Pump plunger
7	Annular groove in pump plunger
8	Connection to feed area
9	Sealing ring
10	Fuel-quantity control valve
11	Diaphragm
12	Pressure attenuator
13	Drive mounting flange with sealing ring
14	Port, leakage line

The pumps are mounted on the cylinder heads and driven via bucket tappets by triple cams on the exhaust camshafts.

Each pump has three connecting lines:

- Feed line (1)
- High-pressure line (5)
- Leakage line (14)

Feed area

Fuel is delivered to each high-pressure pump through the feed line at a pressure of 6 bar from the electric in-tank fuel pump EKP via a T-branch. In the pump, the fuel passes through the inlet valve (2) into the high-pressure area (3).

High-pressure area

The fuel pressure is established in the high-pressure area.

The fuel is then delivered through the high-pressure line to the rail. The outlet valve (4) prevents the fuel from flowing from the rail back into the high-pressure pump.

Leakage area

For hydrodynamic separation of the components, a small amount of fuel (max. 1 litre per hour) flows past the pump plunger to the sealing ring (9).

The sealing ring provides a seal between the fuel side of the pump and the engine oil at the pump drive.

To relieve the pump pressure (up to 120 bar) at the sealing ring, the fuel pressure built up at the sealing ring is reduced in two stages, at which point the fuel returns through the leakage line to the tank.

In the annular groove (7) of the pump plunger, the pump pressure is reduced down to 6 bar as the annular groove has a connection (8) to the feed area of the pump by way of the fuel-quantity control valve (MSV).

Below the annular groove, the fuel flows past the pump plunger to the gasket ring. Here the fuel pressure is reduced virtually to ambient pressure, at which point the fuel returns through the leakage line to the tank.

Fuel-quantity control valves MSV

The fuel-quantity control valve (10) is installed in the high-pressure pump (HDP) and serves to regulate the HDP delivery rate as a function of load and engine speed.

This valve opens a channel from the high-pressure chamber (3) to the feed area. This allows excess fuel to return to the feed area.

The operation of the fuel-quantity control valve is described in more detail in the N73 engine-management system.

Pressure attenuator

The excess fuel delivered by the high-pressure pump is returned through the fuel-quantity control valve into the pump feed area. The pulsations generated in the pump in the process are absorbed by the spring of the pressure attenuator (12).

The pressure attenuator is separated by a diaphragm (11) from the pump feed area.

- Pressure accumulator (rail)

The fuel is stored intermediately in the rail at a pressure between 30 and 100 bar before being distributed to the fuel injectors. The connection between the rail and each fuel injector is provided by a brass bushing.

The O-ring of the fuel injector is designed so that it can move inside the brass bushing. This facilitates length and position compensation between the rail and the fuel injector.

Pressure-limiting valve

Each rail incorporates a pressure-limiting valve which is connected by way of a line to the high-pressure-pump fuel feed.

This valve opens from a pressure of 125 bar in order to prevent damage to the injection system. The valve can open briefly

when no fuel is required by the fuel injectors during inertia fuel shutoff,

or

- during the afterheating phase when the hot engine is turned off.

Glossary

Index	Explanation
AKF	Carbon canister
BSD	Bit-serial data interface
CAN	Controller Area Network
DME	Digital Motor Electronics
DMTL	Tank-leak diagnostic module
DISA	Differentiated induction system
EKP	Electric fuel pump
FGR	Cruise control
HDEV	High-pressure fuel injector
HVA	Hydraulic valve-clearance compensation
HFM	Hot-film air-mass flow sensor
ISIS	Intelligent Safety Integration System
MSV	Fuel-quantity control valve
MIL	Malfunction Indicator Lamp
OEZS	Oil-condition sensor
OBD	On-board diagnosis
ÖWT	Oil-to-water heat exchanger
PWM	Pulse width modulation
PT-CAN	Powertrain CAN
SBSR	Satellite, B-pillar, right
SLP	Secondary-air pump
SLV	Secondary-air valve
TEV	Tank vent valve
VANOS	Variable camshaft control
ZGM	Central Gateway Module