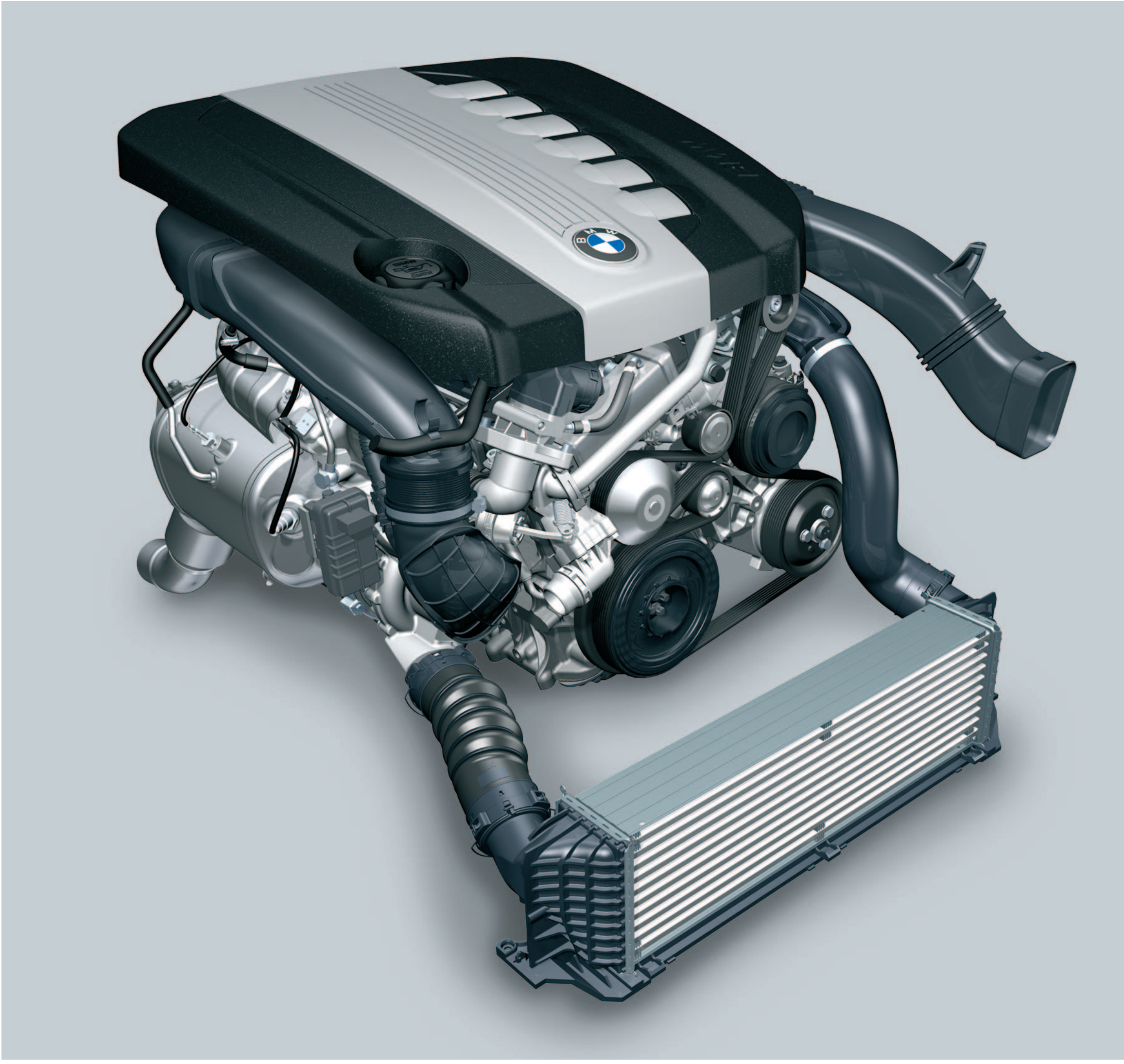
Technical Training - Product Information.
N57 Engine.



BMW Service

The information contained in the Product Information and the Workbook form an integral part of the Technical Training materials.

Refer to the latest relevant BMW Service information for any changes/supplements to the Technical Data.

Information status: June 2008

Contact: conceptinfo@bmw.de

Product Information.
N57 Engine.

Rear-mounted chain drive system

Vacuum pump in sump

Complies with EURO 5 and EURO 6

Notes on this Product Information

Symbols used

The following symbols are used in this Product Information to improve understanding and to highlight important information:

⚠ contains important safety guidance and information that is necessary for proper system functioning and which it is imperative to follow.

◄ identifies the end of a note.

Information status and national variants

BMW vehicles satisfy the highest requirements of safety and quality. Changes in terms of environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be differences between the details provided in this Product Information and the vehicles available during the training course.

This document essentially refers to left-hand-drive vehicles.
On right-hand-drive vehicles, some controls and components are arranged differently from what is shown in the illustrations in this Product Information. There may also be other differences due to variations in equipment between individual countries or markets.

Additional sources of information

Further information on the individual topics can be found in the following:

- the Owner's Handbook
- the Integrated Service Technical Application.

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Product Information and reference work for practical purposes

General information

This Product Information is intended to provide you with information on the design and function of the N57 engine.

This Product Information is designed as a working reference and complements the specified content of the technical training course. The Product Information is also suitable for private study.

As preparation for the technical training course, this Product Information provides an insight into the new N57 6-cylinder diesel engine. In conjunction with practical exercises carried out in the training course, the Product Information will enable course participants to carry out servicing work on the N57 engine.

Previous technical and practical knowledge of the current range of BMW diesel engines will make it easier for you to understand the systems described here and their functions.

Please remember to work through the SIP (Service Information Programme) on Diesel Engine Basics.
The basic knowledge it provides will facilitate understanding of this Product Information.

Existing SIPs

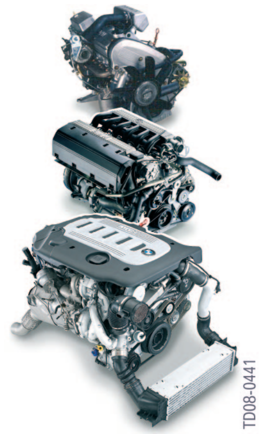
- Diesel Engine Basics.

Models.
N57 Engine.

Engine variants

Models with N57 engine as at autumn 2008.

Model	Series	Engine	Engine capacity in cm^3	Stroke/bore in mm	Power output in kW/bhp at rpm	Torque in Nm at rpm
330d	E90	N57D30O0	2,993	90/84	180/245 4,000	520 1,750 - 3,000
330d	E91	N57D30O0	2,993	90/84	180/245 4,000	520 1,750 - 3,000
330d	E92	N57D30O0	2,993	90/84	180/245 4,000	520 1,750 - 3,000
730d	F01	N57D30O0	2,993	90/84	180/245 4,000	540 2,000 - 2,750



The list of models shows in which vehicles which engine variants are currently used and have been used in the past.

History

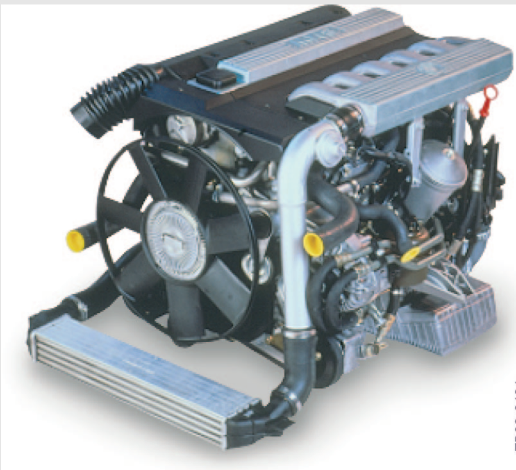
Figures marked *, *1, etc. relate to the similarly marked model series.

6-cylinder diesel engine

Engine	M21D24S
Series	E28* E30
Models	324d 524d
Power output in kW/bhp at rpm	60/82 63/86* 4,600
Torque in Nm at rpm	152 2,500
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,443
Stroke/bore in mm	81/80
Compression ratio	22 : 0 23 : 0*
Valves/cylinder	2
Period used	9/85 - 12/90 09/86 - 12/87*
Engine management	Mechanical DDE2

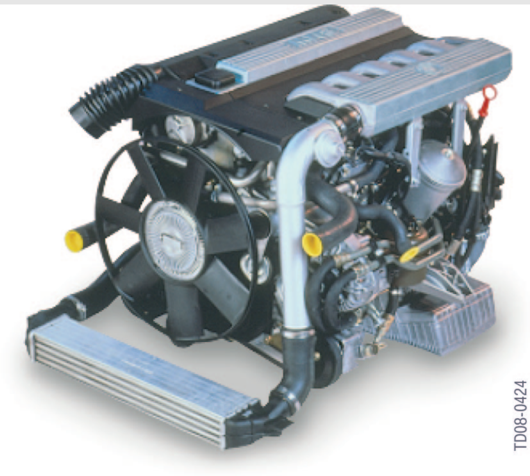
TD08-0420

Engine	M21D24T
Series	E28 E30* E34
Models	324td 524td
Power output in kW/ bhp at rpm	85/115 4,800
Torque in Nm at rpm	210 2,400 222* 1,750*
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,443
Stroke/bore in mm	81/80
Compression ratio	24 : 1* 25 : 1
Valves/cylinder	2
Period used	9/83 - 9/91
Engine management	Mechanical DDE1



TD08-0424

Engine	M51D25UL
Series	E34 E36
Models	325td 525td
Power output in kW/ bhp at rpm	85/115 4,800
Torque in Nm at rpm	222 1,900
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,497
Stroke/bore in mm	82.8/80
Compression ratio	22 : 1
Valves/cylinder	2
Period used	9/91 - 12/95
Engine management	DDE2 DDE2.1



TD08-0424

Engine	M51D25OL
Series	E34 E36
Models	325tds 525tds
Power output in kW/ bhp at rpm	105/143 4,800
Torque in Nm at rpm	260 2,200
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,497
Stroke/bore in mm	82.8/80
Compression ratio	22 : 1
Valves/cylinder	2
Period used	9/91 - 12/95
Engine management	DDE2 DDE2.1

TD08-0428

Engine	M51D25UL TU
Series	E36* E39
Models	325td 525td
Power output in kW/ bhp at rpm	85/115 4,800
Torque in Nm at rpm	222*/230 1,900
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,497
Stroke/bore in mm	82.8/80
Compression ratio	22 : 1
Valves/cylinder	2
Period used	2/96 - 9/02
Engine management	DDE2.1 DDE2.2

Engine	M51D25OL TU
Series	E36 E38 E39
Models	325tds 525tds* 725tds*
Power output in kW/ bhp at rpm	105/143 4,800/4,600*
Torque in Nm at rpm	260/280* 2,200
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,497
Stroke/bore in mm	82.8/80
Compression ratio	22 : 1
Valves/cylinder	2
Period used	2/96 - 9/02
Engine management	DDE2.1 DDE2.2

Engine	M57D25O0
Series	E39
Models	525d
Power output in kW/ bhp at rpm	120/163 4,000
Torque in Nm at rpm	350 2,000-3,000
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,497
Stroke/bore in mm	82.8/80
Compression ratio	17.5 : 1
Valves/cylinder	4
Period used	3/00 - 9/03
Engine management	DDE4.0

TD08-0429

Engine	M57D30O0
Series	E38 E39 E46/3 E46/4 E53
Models	330d 530d 730d*1*2 X5 3.0d*1
Power output in kW/ bhp at rpm	135/184 4,000
Torque in Nm at rpm	390/1,750-3,200 410/2,000-3,000*1 430/2,000-2,500*2
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,926
Stroke/bore in mm	88/84
Compression ratio	18 : 1
Valves/cylinder	4
Period used	10/98 - 4/04
Engine management	DDE4.0 DDE4.1*1*2

TD08-0430

Engine	M57D25O1
Series	E60 E61
Models	525d
Power output in kW/ bhp at rpm	130/177 4,000
Torque in Nm at rpm	400 2,000-2,750
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,497
Stroke/bore in mm	75.1/84
Compression ratio	17 : 1
Valves/cylinder	4
Period used	4/04-3/07
Engine management	DDE5.0

Engine	M57D30O1
Series	E46/2 E46/3 E46/4 E53 E60 E61 E65 E83
Models	330d 530d*[1] 730d X3 3.0d* X5 3.0d*
Power output in kW/ bhp at rpm	150/204 160/218* *[1] 4,000
Torque in Nm at rpm	410/1,500-3,250 500/2,000-2,750* *[1]
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,993
Stroke/bore in mm	90/84
Compression ratio	17 : 1
Valves/cylinder	4
Period used	9/02-9/06
Engine management	DDE506 DDE508*[1] DDE509* *[1]

Engine	M57D30U2
Series	E60 E61 E90 E91 E92 E93
Models	325d 525d
Power output in kW/ bhp at rpm	145/197 4,000
Torque in Nm at rpm	400 1,300-3,250
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,993
Stroke/bore in mm	90/84
Compression ratio	17 : 1
Valves/cylinder	4
Period used	9/06 to date
Engine management	DDE606

TD08-0431

Engine	M57D30O2
Series	E60 E61 E65 E66 E70 E83 E90 E91 E92 E93
Models	330d 530d 630d 730d*[2] 730Ld*[2] X3 3.0d* X3 xDrive30d* X5 3.0d*[1] X5 xDrive30d*[1]
Power output in kW/ bhp at rpm	160/218* 170/231*[2] 173/235*[1] 4,000
Torque in Nm at rpm	500/1,750-3,000* 520/2,000-2,750*[1.2]
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,993
Stroke/bore in mm	90/84
Compression ratio	17 : 1
Valves/cylinder	4
Period used	3/05 to date
Engine management	DDE626

TD08-0432

Engine	M57D30T1
Series	E60 E61
Models	535d
Power output in kW/ bhp at rpm	200/272 4,400
Torque in Nm at rpm	560 2,000-2,250
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2993
Stroke/bore in mm	90/84
Compression ratio	16.5 : 1
Valves/cylinder	4
Period used	9/04-3/07
Engine management	DDE606

Engine	M57D30T2
Series	E60 E61 E63 E64 E83 E70 E90 E91 E92
Models	335d 535d 635d X3 3.0sd X3 xDrive35d X5 3.0sd X5 xDrive35d
Power output in kW/ bhp at rpm	210/286 4,400
Torque in Nm at rpm	580 1,750-2,250
Number of cylinders and configuration	In-line 6
Engine capacity in cm^3	2,993
Stroke/bore in mm	90/84
Compression ratio	17 : 1
Valves/cylinder	4
Period used	9/06 to date
Engine management	DDE626

Introduction.
N57 Engine.

Highlights

The N57 is a logical development from the N47 engine. For instance, the N47 already featured rear-mounted chain drive system designed to satisfy future pedestrian impact severity reduction requirements and a vacuum pump relocated inside the sump.

Another modification was the repositioning of the auxiliary units on the left-hand side of the engine. By having the auxiliary units all on one side, space is created on the right-hand side of the engine for locating exhaust treatment components close to the engine. There is also sufficient space for the Top model turbocharger assembly (N47 Top engine).

It has also been possible to reduce the height of the cylinder head by 29 mm compared with the predecessor model. The inlet ports now run parallel and the intake system with integral swirl flaps is an ultra-compact design.

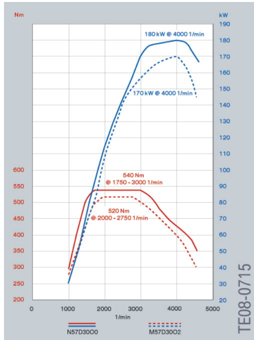
Below the sound insulation cover on the F01, sufficient space is allowed at the rear for an air intake muffler and the engine-mounted unfiltered and filtered air ducting. The individual power options vary in this regard only in terms of the size of the filter element.

In order to minimize the complexity of application adaptations, instead of the engine-mounted air intake muffler, the E9x models use the unfiltered air ducting and the vehicle-mounted air intake muffler from the M57D30T2 engine.

The 3rd-generation common-rail system with an injection pressure of up to 1,800 bar, a new CP4.2 high-pressure pump and piezo-electric fuel injectors complete the fuel-system modifications.

As on the N47 engine, the exhaust system has an electric EGR valve flange-mounted on the "hot" side and a bypass in the EGR cooler so that the EURO 5 emission limits can be reliably complied with. Thus on volume production launch, the N57 engine will already meet the EURO 5 emission requirements not due to come into force until 01/01/2011.

For compliance with the EURO 6 emission limits, additional use of an active exhaust treatment system will be necessary. Depending on flywheel weight class (vehicle weight) and resistance to motion, either an NOx-accumulator catalytic converter or an SCR (selective catalytic reduction) system supplemented by low-pressure exhaust recirculation will be used. Those two systems are explained in the "M57D30T2 US Engine" documentation and, therefore, are not described in further detail at this point.



Following on from the 4-cylinder diesel engine, a new 6-cylinder diesel engine has now also been introduced. After 10 years and two major upgrades, the 6-cylinder diesel engine is now being replaced by an entirely new design, the N57. The N57 engine has many components that have already been used in volume production on the N47 engine.
With even more power and torque combined with lower fuel consumption and lighter weight, it is ideally equipped to continue the success story.

Objectives

- Increased power and torque
- Ability to derive performance versions
- Reduction of CO_2 emissions
- Compliance with EURO 5 and upgradability to EURO 6 and LEVII/Bin5 (USA)
- Reduction of weight and dimensions with a view to compliance with future requirements regarding exhaust treatment and pedestrian impact severity reduction
- Modular design and use of identical components from the N47 models.

Technical data

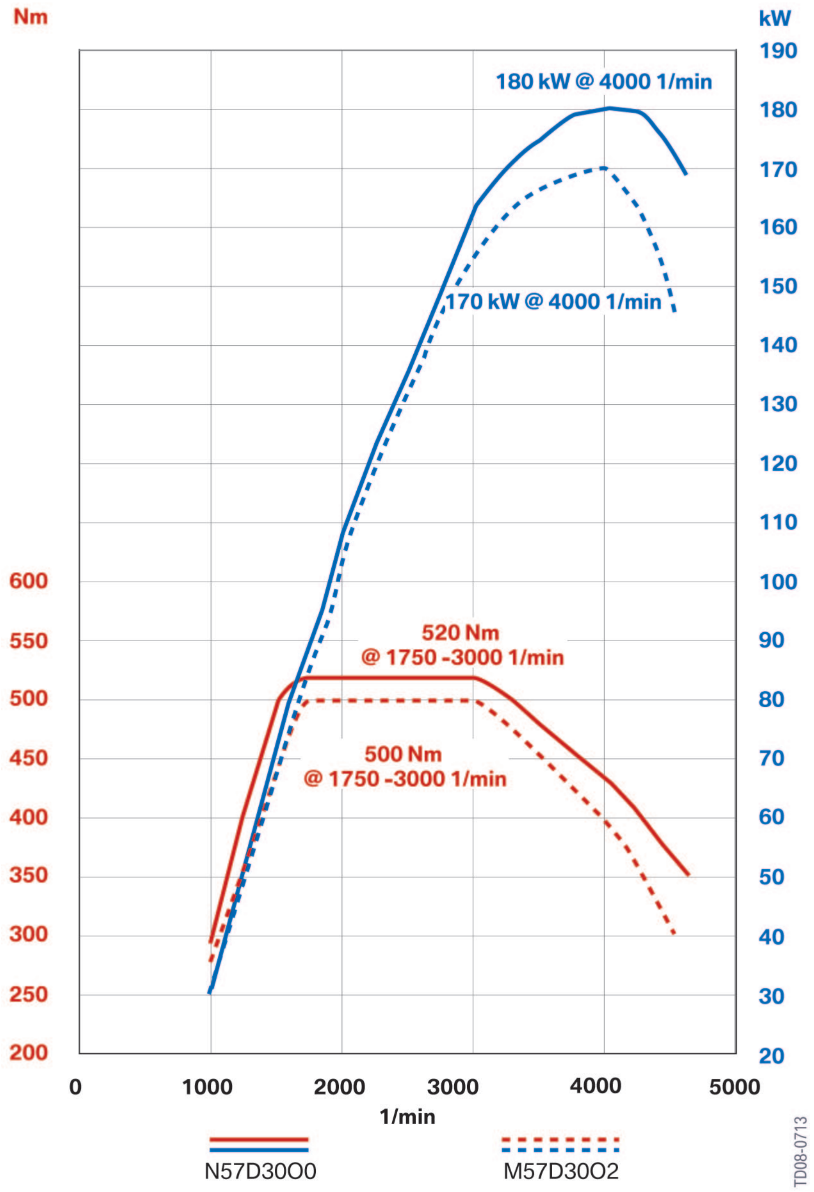
Designation	M57D30O2	M57D30O2	M57D30O2
Model	**330d**	**730d 730Ld**	**X5 xDrive30d**
Configuration	6 inline	6 inline	6 inline
Displacement [cm^3]	2,993	2,993	2,993
Stroke/bore [mm]	90/84	90/84	90/84
Power output [kW/bhp] at [rpm]	170/231 4,000	170/231 4,000	173/235 4,000
Torque [Nm] at [rpm]	500 1,750-3,000	520 2,000-2,750	520 2,000-2,750
Engine speed limit [rpm]	4,600	4,600	4,600
Power output per litre [kW/l]	56.8	56.8	57.8
Compression ratio ε	17.0 : 1	17.0 : 1	17.0 : 1
Cylinder spacing [mm]	91	91	91
Valves/cylinder	4	4	4
Inlet-valve dia. [mm]	25.9	25.9	25.9
Exhaust-valve dia. [mm]	25.9	25.9	25.9
Crankshaft main bearing journal dia. [mm]	60	60	60
Crankshaft big-end bearing dia. [mm]	45	45	45
Engine management	DDE626	DDE626	DDE626
Emissions standard	EURO 4	EURO 4	EURO 4

Designation	**N57D30O0**	**N57D30O0**	**N57D30O0**
Model	**330d**	**730d**	**330d**
Configuration	6 inline	6 inline	6 inline
Displacement [cm^3]	2,993	2,993	2,993
Stroke/bore [mm]	90/84	90/84	90/84
Power output [kW/bhp] at [rpm]	180/245 4,000	180/245 4,000	180/245 4,000
Torque [Nm] at [rpm]	520 1,750 - 3,000	540 1,750 - 3,000	520 1,750 - 3,000
Engine speed limit [rpm]	5,000	5,000	5,000
Power output per litre [kW/l]	60.1	60.1	60.1
Compression ratio ε	16.5 : 1	16.5 : 1	16.5 : 1
Cylinder spacing [mm]	91	91	91
Valves/cylinder	4	4	4
Inlet-valve dia. [mm]	27.2	27.2	27.2
Exhaust-valve dia. [mm]	24.6	24.6	24.6
Crankshaft main bearing journal dia. [mm]	55	55	55
Crankshaft big-end bearing dia. [mm]	50	50	50
Engine management	DDE7.3	DDE7.3	DDE7.3
Emissions standard	EURO 5	EURO 5	EURO 6

Performance graph

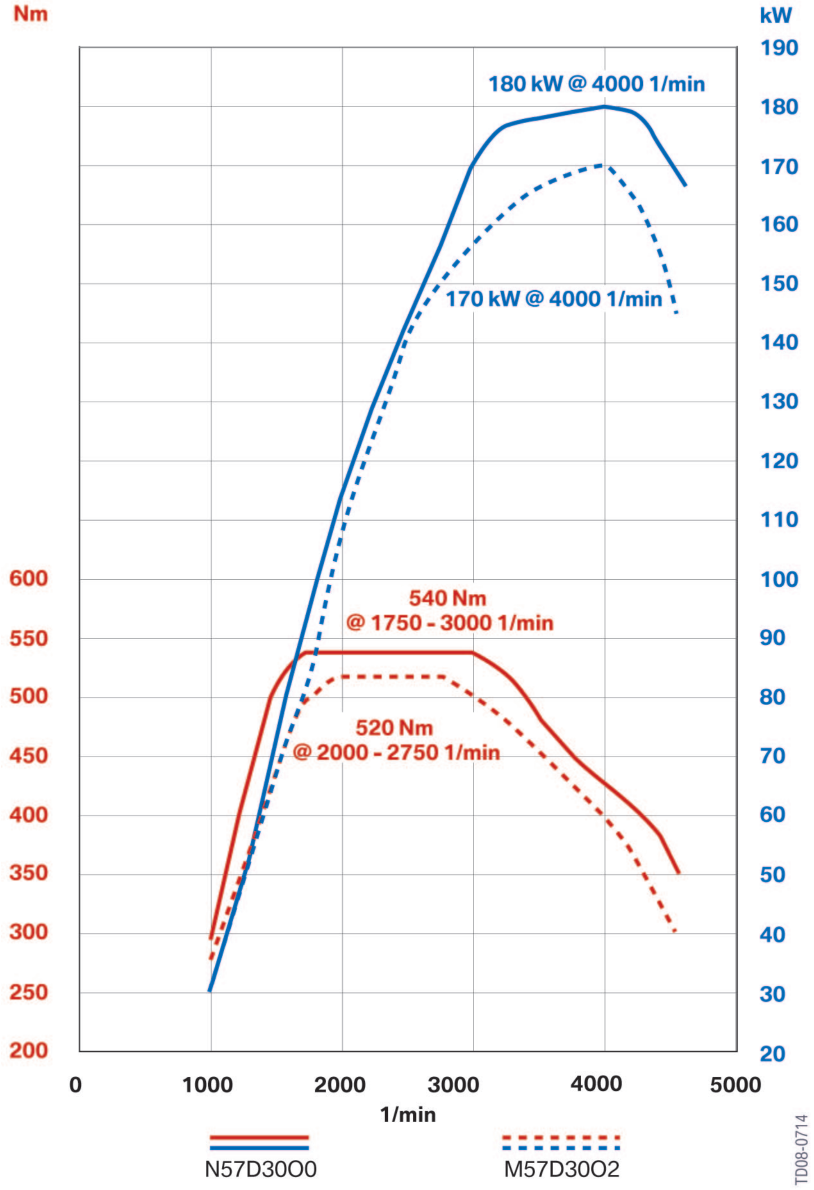
Compared with its predecessor, the N57 engine is distinguished by an increase in overall performance and a more muscular torque curve.

330d



1 - Performance graph for 330d E90 with N57D30O0 engine compared with 330d E90 with M57D30O2 engine

730d



2 - Performance graph for 730d F01 with N57D30O0 engine compared with 730d E65 with M57D30O2 engine

Summary of design features

Variant structure

The basic concept means that the engine casing components can be developed and produced according to the same standards both for the 4-cylinder and the 6-cylinder diesel engines.

Differentiation is achieved by way of turbocharging, fuel injection and exhaust treatment systems.

Thus the N47 engines and the N57 engine share the following features:

- Standardized combustion chamber
- Same cylinder spacing
- Same engine height
- Same attachment arrangements (e.g. gearbox)
- Standardized auxiliary units.

The table below summarizes the changes implemented on the N57 engine. Distinctions are made in various categories.

- "New development" denotes a technology that was not used on the predecessor engine.
- "Identical component" denotes a component that was designed for the N47 engine and is also used on the N57 engine.
- "Identical concept" denotes a component that is based on the same design concept on the N47 and the N57 engines but which has been adapted for the N57 engine.

Component	New development	Identical component on N47 engine and N57 engine	Identical concept on N47 engine and N57 engine	Remarks
Pistons and connecting rods	●	●		Optimized for new generation of diesel engines
Main and big-end bearings	●	●		Dimensioned for the various performance ratings (e.g. N47TOP)
Valvegear components	●	●		Use of reduced-friction and weight-optimized components
Fuel pump	●	●		The fuel pump is a regulated-pressure design
Fuel filter heater	●	●		The fuel filter heater is controlled by the digital diesel engine management
Fuel injectors and high-pressure fuel lines	●	●		New generation of fuel injectors adapted for the high injection pressures. The higher-performance and the "Top" line models have piezo-electric injectors.

Component	New development	Identical component on N47 engine and N57 engine	Identical concept on N47 engine and N57 engine	Remarks
Glow plugs	●	●		Use of ceramic glowplugs with temperatures up to 1,300 °C.
Chain sprockets and guides	●	●		The crankshaft has integral sprockets for driving the timing chain and the oil pump. The guides are identical on the N47 and N57 engines.
Auxiliary unit mounting bracket	●	●		All auxiliary units are positioned on the intake side of the engine. The auxiliary unit mounting bracket is identical on all E9x models. On the F01 a new mounting bracket with sliding bushes is used.
Auxiliary units	●	●		The auxiliary units are adapted to the vehicle concerned.
Drive belts, belt tensioner and guide pulleys	●	●		Different belt tensioners are used according to vehicle model. A two-sided belt is used.
Throttle body and exhaust recirculation valve (EGR valve)	●	●		New-design components are used for both engine casing assemblies (N47 and N57 engines). On the N47 engine, a bypass valve is fitted in some cases dependent on gearbox version and performance rating. The N57 engine always has a bypass valve.
Sensor system	●	●		The same, new-design sensor system is used both on the N47 engine and the N57 engine.
Crankcase	●		●	The crankcase is an entirely new design and employs an identical concept for both engines. Rigidity has been increased so as to be able to meet future requirements as well. A reinforcing plate further increases strength. The aluminium crankcase has thermally joined cast iron cylinder liners. The crankshaft main bearing caps are provided with a raised profile on the joint face.
Crankshaft drive system	●		●	The crankshaft drive system has been adapted to the higher engine power output. At the same time, however, great emphasis was placed on lightweight design.

Component	New development	Identical component on N47 engine and N57 engine	Identical concept on N47 engine and N57 engine	Remarks
Cylinder head	●		●	For the first time, the cylinder head is a two-piece design.
Valvegear	●		●	For the first time, the valves are parallel with the cylinder axes.
Chain drive system	●		●	The chain drive system on the N47 engine has been moved to the flywheel-end to make space for pedestrian impact severity reduction.
Combined oil and vacuum pump	●		●	By combining the oil and vacuum pumps, it has been possible to reduce the component height in the pedestrian impact severity reduction zone.
Camshafts	●		●	The composite camshafts run on bearings mounted in a separate carrier plate and are manufactured using the Presta process.
Rotational vibration damper	●		●	The rotational vibration damper is adapted to the particular requirements of the engine.
Cylinder head cover	●		●	The cylinder head cover incorporates the pressure-controlled crankcase venting system and spring-plate separator.
Intake manifold	●		●	The intake system is an ultra-compact design and incorporates the electrically operated and monitored swirl flaps.
Oil module	●		●	The oil module is made of plastic and incorporates the oil/coolant heat exchanger. The number of plates in the oil/coolant heat exchanger is dependent on the required cooling capacity.
High-pressure pump	●		●	The model used is the CP4.1 or 4.2. The CP4.1 is a single-piston HP pump, the CP4.2 a twin-piston HP pump. The high-pressure pumps can generate injection pressures up to 2,000 bar.
High-pressure accumulator	●		●	The high-pressure accumulator is designed for the high fuel pressures.
Control unit	●		●	The latest-generation engine management is used.

Component	New development	Identical component on N47 engine and N57 engine	Identical concept on N47 engine and N57 engine	Remarks
Wiring loom	●		●	The wiring loom is optimized and identical for the different transmission variants. Thus a supplementary wiring loom is used according to transmission variant.
Exhaust manifold	●		●	The exhaust manifold has been given an extra connection for a temperature sensor and is an air-gap insulated pressed-steel design.
Turbocharger	●		●	The VNT turbocharger is operated by an electrically actuated charge-pressure adjuster. A Step3 turbocharger is used.
Oxidation catalytic converter and diesel particle filter	●		●	The oxidation catalytic converter and the diesel particulate filter are located in a shared housing close to the engine. These components vary according to engine model but are identical across vehicle models.
Oil level indication		●		The oil level is measured by an oil condition sensor.

Engine identification

Engine designation

In the technical documentation, the engine designation is used for unique identification of the engine.

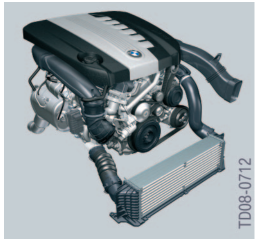
The following version of the N57 engine is described:

- N57D30O0.

In the technical documentation you will also find the abbreviated engine designation, i.e. N57, that only indicates the engine type.

This means:

Index	Explanation
N	BMW Group "New Generation"
5	6-cylinder engine
7	Direct diesel injection
D	Diesel engine
30	3.0-litre capacity
O	Upper power output stage
0	New development



For the purposes of unique identification there is an engine identification code marked on the crankcase. In the documentation and descriptions of the engine, the engine designation is used, which differs from the identification code by its last 2 characters.

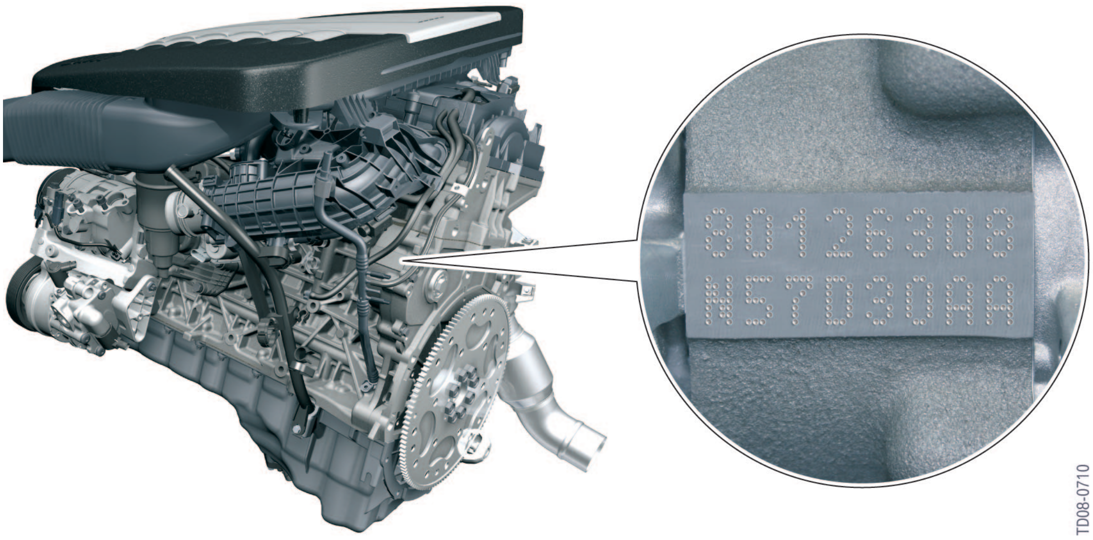
Engine identification code and serial number

The engines are marked on the crankcase with an engine identification code for unique identification. This engine identifier is also required for approval by the authorities. The definitive part of the code is the first seven characters.

With the N47 engine, the engine identifier has, for diesel engines too, been changed so as to comply with the new standard whereby the first six positions are the same as the engine designation. That new standard also applies to the N57 engine.

The engine serial number is a consecutive number that permits unique identification of every single engine.

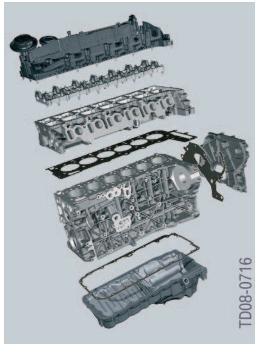
The engine identification code and serial number are marked on the crankcase on the bracket for the high-pressure fuel pump.



1 - Engine identification code and serial number on the N57 engine

System components.
N57 Engine.

Engine mechanical system



The engine mechanical systems can essentially be divided into the three subassemblies, engine casing components, crankshaft drive system and valvegear. Those three subassemblies are closely interlinked and have to be matched to one another.

Overview

The engine mechanicals can be subdivided into three major systems:

- **Engine casing components**

  Functions of the engine casing components:

  - Containing the forces generated by operation of the engine
  - Sealing functions for the combustion chamber, engine oil and coolant
  - Holding the crankshaft drive system, valvegear and other components.

  By reducing the height and length, space has been created under the bonnet for the purposes of pedestrian impact severity reduction.

- **Crankshaft drive system**

  The crankshaft drive system, also known as the power unit, is a function group that converts the combustion chamber pressure into kinetic energy. In the process, the crankshaft converts the linear motion of the pistons into a rotary motion. The crankshaft drive system represents the optimum in terms of work utilization, efficiency and technical practicability for the task in question.

  Nevertheless, the following technical limitations and design challenges have to be dealt with:

  - Engine speed limitation due to inertial forces
  - Uneven power delivery over the course of an operating cycle
  - Generation of torsional vibrations that place stresses on the crankshaft and drive train
  - Interaction of the various frictional surfaces.

- **Valvegear**

  The valvegear is made up of the following components:

  - Camshafts
  - Transmitting elements (roller cam followers)
  - Valves (complete valve assemblies)
  - Hydraulic valve clearance adjustment (HVA).

  Like all current BMW diesel engines, the N57 engine has a **DOHC** valvegear layout.

  This stands for "**d**ouble **o**ver**h**ead **c**amshaft" and means that the engine has overhead valves with two camshafts located above the cylinders. One camshaft is used for the intake valves, the other for the exhaust valves.

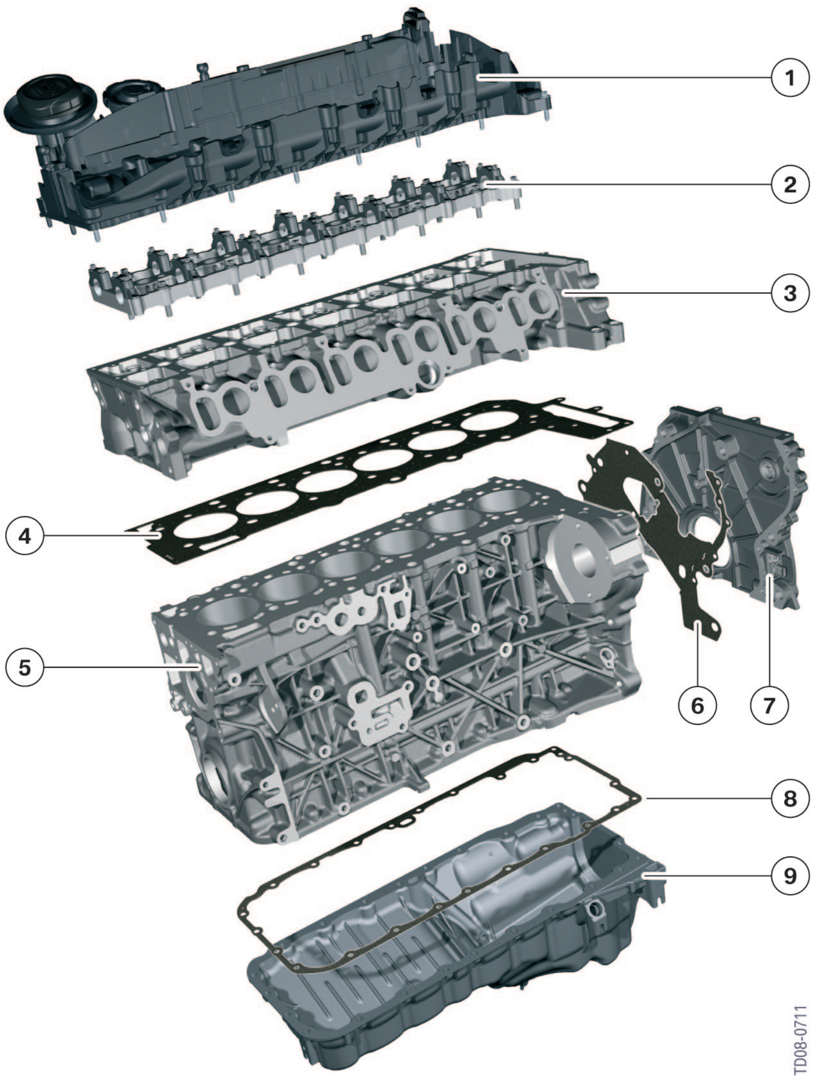
  On the N57 engine, as on all current BMW diesel engines, the action of the cams is transferred from the camshaft to the valves by roller lever tappets.

  In order that the correct amount of play is maintained between camshaft cam and the cam follower (roller lever tappet), the N57 is equipped with hydraulic valve clearance adjusters (HVA).

Those three systems are in a state of constant interaction with one another. That interaction has a very significant effect on engine characteristics.

Firing order:
1-5-3-6-2-4

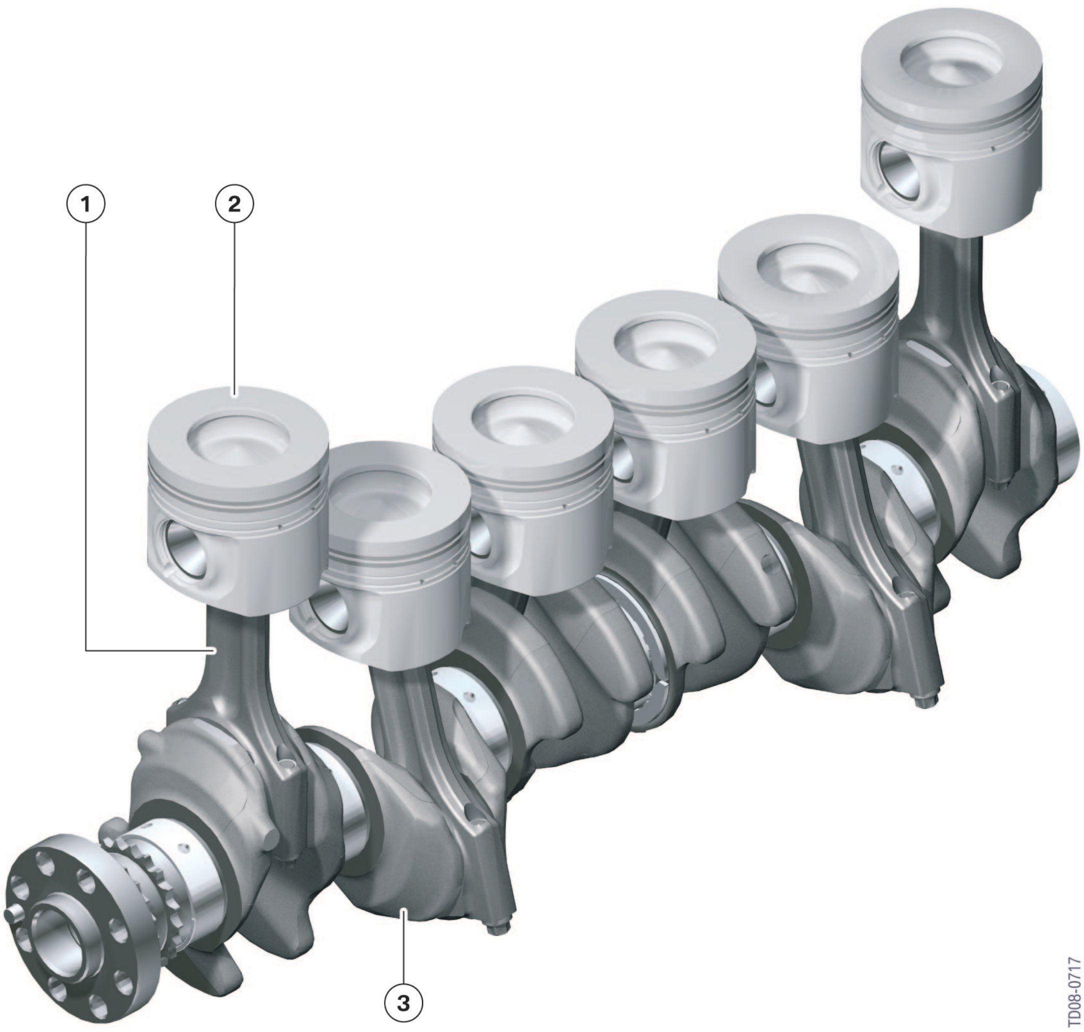
Engine casing components



1 - N57 engine casing components

Index	Explanation	Index	Explanation
1	Cylinder head cover	6	Sprocket cover gasket
2	Camshaft carrier plate	7	Sprocket cover
3	Cylinder head	8	Sump gasket
4	Cylinder head gasket	9	Sump
5	Crankcase		

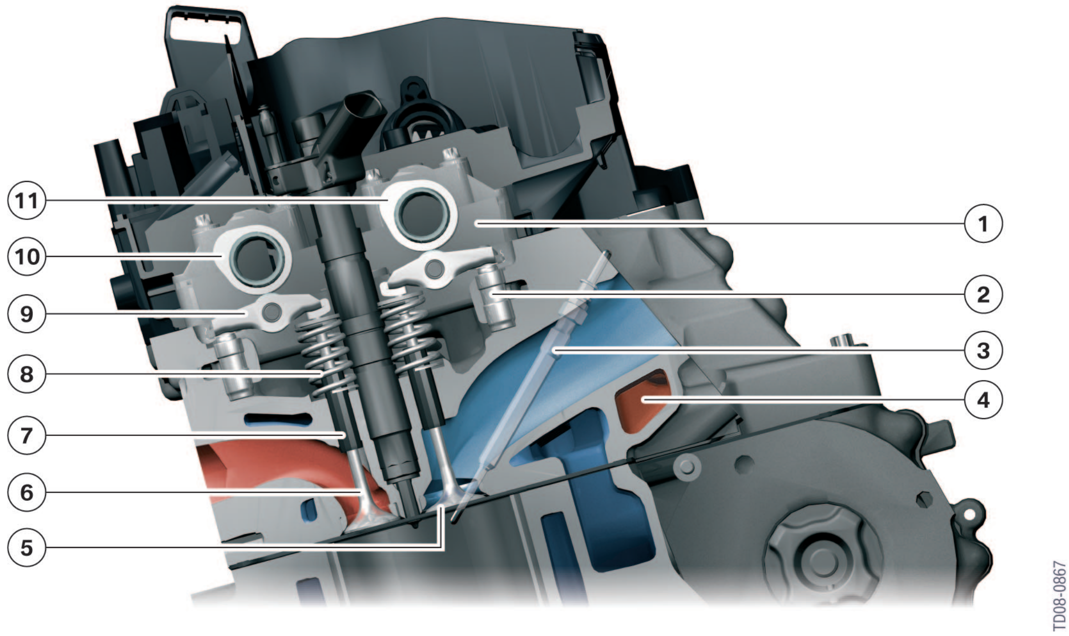
Crankshaft drive system



2 - Crankshaft drive system, N57 engine

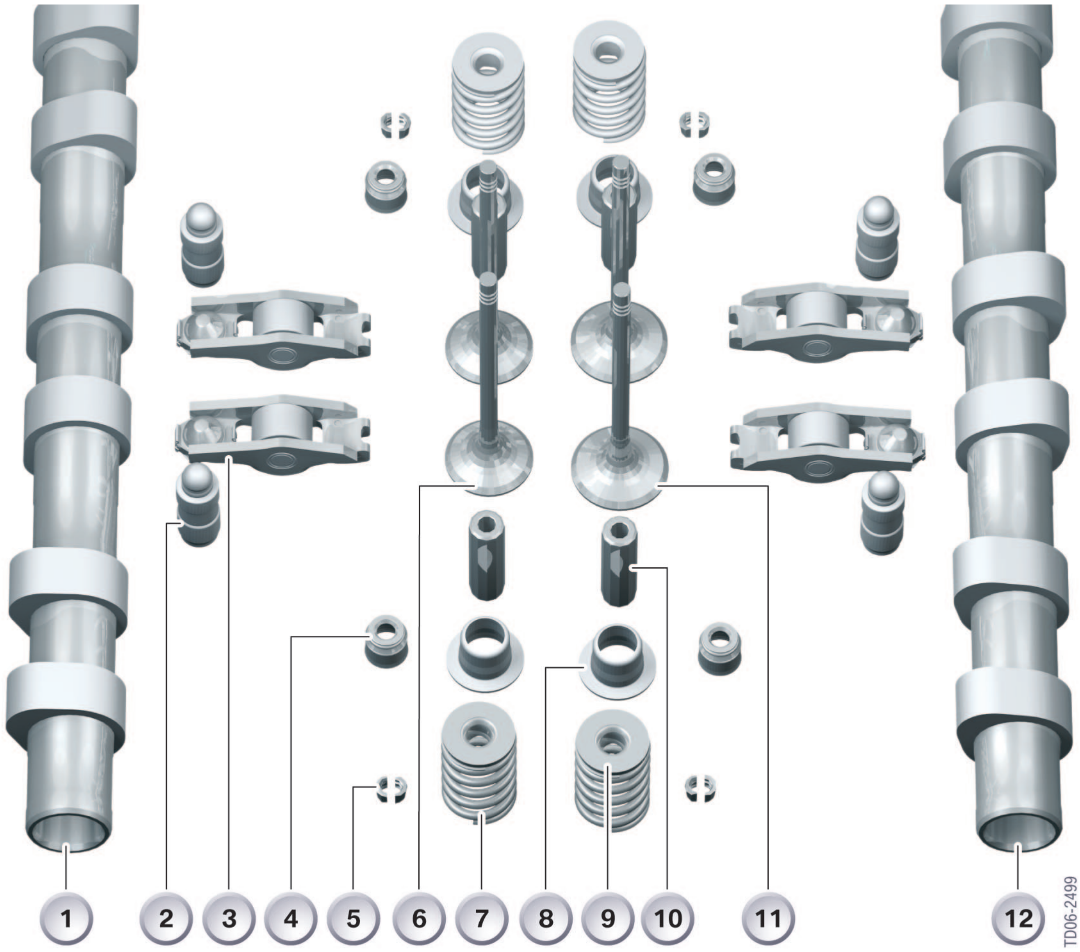
Index	Explanation	Index	Explanation
1	Connecting rod	3	Crankshaft
2	Piston		

Valvegear



3 - Valvegear, N57 engine

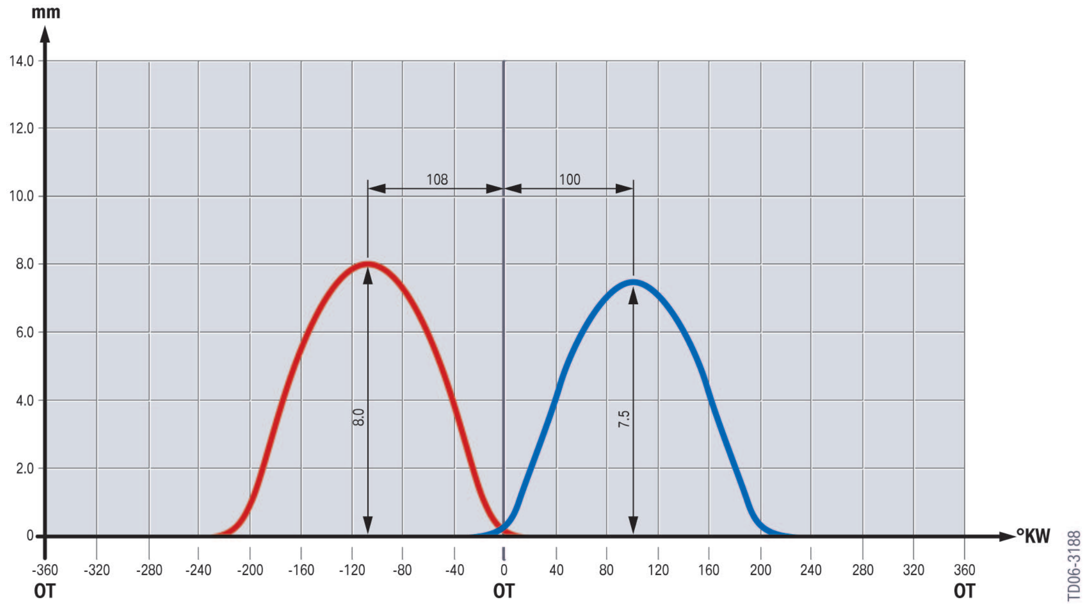
Index	Explanation	Index	Explanation
1	Camshaft carrier plate	7	Valve guide
2	Hydraulic valve clearance adjuster, HVA	8	Valve spring
3	Glow plug	9	Roller lever tappet
4	Exhaust recirculation channel	10	Exhaust camshaft
5	Inlet valve	11	Inlet camshaft
6	Exhaust valve		



4 - Valvegear components, N57 engine

Index	Explanation	Index	Explanation
1	Inlet camshaft	7	Valve spring
2	Hydraulic valve clearance adjuster	8	Lower valve spring retainer
3	Roller lever tappet	9	Upper valve spring retainer
4	Valve stem seal	10	Valve guide
5	Valve collets	11	Exhaust valve
6	Inlet valve	12	Exhaust camshaft

Lower valve spring retainer (8) and valve stem seal (4) form a single component.



5 - Timing graph, N57 engine

		M57D30O2 Inlet	N57D30O0 Inlet	M57D30O2 Exhaust	N57D30O0 Exhaust
Valve diameter	[mm]	27.4	27.2	25.9	24.6
Max. valve lift	[mm]	7.5	7.5	7.5	8.0
Lobe separation	[°crankshaft]	100	100	108	108
Open period	[°crankshaft]	216.0	216.0	222.0	221.8

The diameter of the inlet valve has been very slightly reduced in comparison with the M57D30O2. Using the same timings, improvements in air inflow characteristics have been achieved by optimizing the inlet ports.

The diameter of the exhaust valve has been reduced by comparison with the predecessor. Nevertheless, a greater valve lift produces better flow characteristics during ejection. The opening duration has been marginally reduced. The stem diameter is 5 mm.

Crankcase

Overview

The special features of the N57 engine crankcase are:

- Crankcase made of aluminium
- Chain drive located on the force transmitting side
- Main bearing caps made of sintered metal
- Closed-deck design
- Main bearing pedestal with side walls that extend downwards and individual main bearing caps
- Main bearing caps with raised-profile joint face
- Dry, thermally joined, cast-iron cylinder liners.

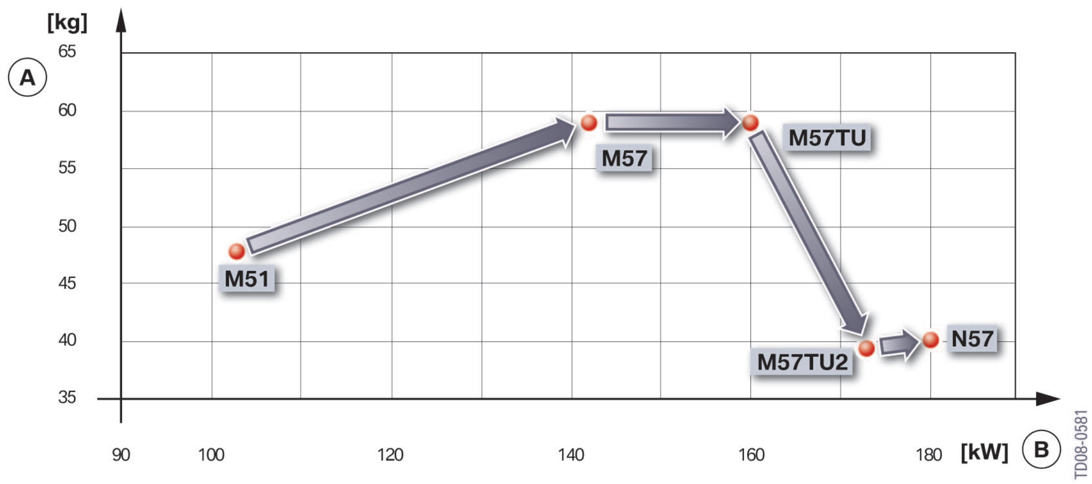
Like the M57TU2 engine, the N57 engine has a new crankcase design made of high-strength aluminium-silicon alloy with thermally joined cylinder liners made of grey cast iron, whereas the M57TU1 engine still had a cast-iron engine block.

The crankcase is one of the heaviest individual components anywhere on the vehicle. It is also located in a position critical to driving dynamics, i.e. above the front axle. For this reason, it makes sense to exploit any potential for weight reduction to the maximum.

The density of aluminium alloys is about a third that of cast iron. However, that cannot be converted one-for-one into a weight advantage because the lower strength of the material means the crankcase has to be made thicker. Nevertheless, its use still sees a remarkable advantage in terms of weight. Indeed, the crankcase of the M57TU2 engine was 36 % lighter than that of the M57TU1 despite the fact that the power output was higher.

The webs on the outer walls are designed for minimum noise emission and weight.

The crankcase of the N57 engine is manufactured at the Landshut plant using the low-pressure chilled casting method.



6 - Development of crankcase weight and engine output

Index	Explanation	Index	Explanation
A	Weight of the crankcase	B	Engine output

Engine	Power output	Weight of the crankcase
M51	105 kW	48 kg
M57	142 kW	59 kg
M57TU	160 kW	59 kg
M57TU2	170 kW	38 kg
N57	180 kW	40 kg

Other properties of aluminium alloys are:

- Good heat conductivity
- Good chemical resistance
- Positive strength qualities
- Good machinability.

Pure aluminium is not suitable as a casting material for crankcases because its strength properties are inadequate. For that reason, the heat-treated alloy AlSi7CuMg0,5, already thoroughly proven on the M57TU2 engine, is used for the crankcase of the N57 engine. The top land of the piston has been made higher, as a result of which the height of the crankcase has also been increased. For that reason, the crankcase is marginally heavier than that of the M57TU2. Another reason for the slight increase in weight is fact that it has been dimensioned for future requirements.

Deck

The N57 engine has a crankcase with a closed-deck design.

While this design does have certain disadvantages in respect of cylinder cooling in the TDC range, its benefits outweigh those of the open-deck design what with the greater rigidity of the deck and thus less deck deformation, less cylinder twist and better noise characteristics.

Main bearing pedestals

The design of the main bearing pedestal area is therefore of particular importance because this is where the forces acting on the crankshaft bearings are absorbed.

On the N57, the dividing line is below the centre of the crankshaft with the side walls extending downwards. Individual main bearing caps are used.

This design provides high rigidity and is cost-effective to manufacture.

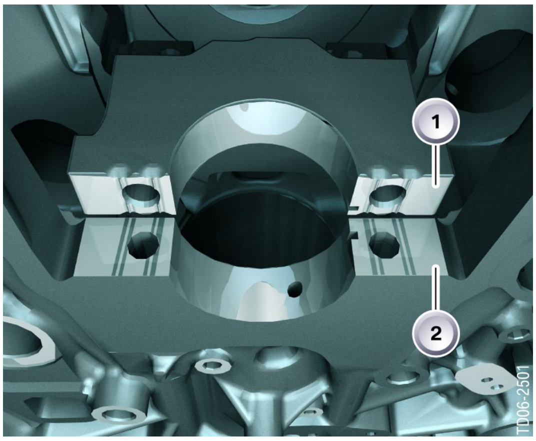
Bearing pedestal

The bearing pedestal is the top half of a crankshaft main bearing in the crankcase. Bearing pedestals are always cast integral with the crankcase.

On the N57 engine, there are venting holes in the bearing pedestals above the crankshaft. Those venting holes or pulsation bores are drilled.

When the engine is running, the air and vapour inside the crankshaft cavity are continuously in motion. The action of the pistons has a pump-like effect on those gases. The ventilation windows reduce these losses because they facilitate pressure compensation in the entire crankcase.

Main bearing caps



7 - N47 engine main bearing cap with indent fit

Index	Explanation
1	Main bearing cap
2	Main bearing pedestal

The main bearing caps form the matching lower halves of the bearing pedestals and are bolted to them. When the crankcase is manufactured, the bearing pedestals and caps are machined as one.

On the N57 engine, as on the N47 engine, the main bearing caps have a raised profile (on the joint face with the bearing pedestal). When the main bearing bolts are first tightened, that profile creates a matching indentation in the bearing pedestal joint face, which produces a positively interlocking joint in the transverse and axial directions.

This technology was first used on the M67TU engine.

This positioning method ensures there is an absolutely flush surface junction between the bearing pedestal and main bearing cap in the bore for the main bearings even after dismantling and reassembly.

The main bearing cap is made of an extremely rigid, sintered iron material.

Cylinders

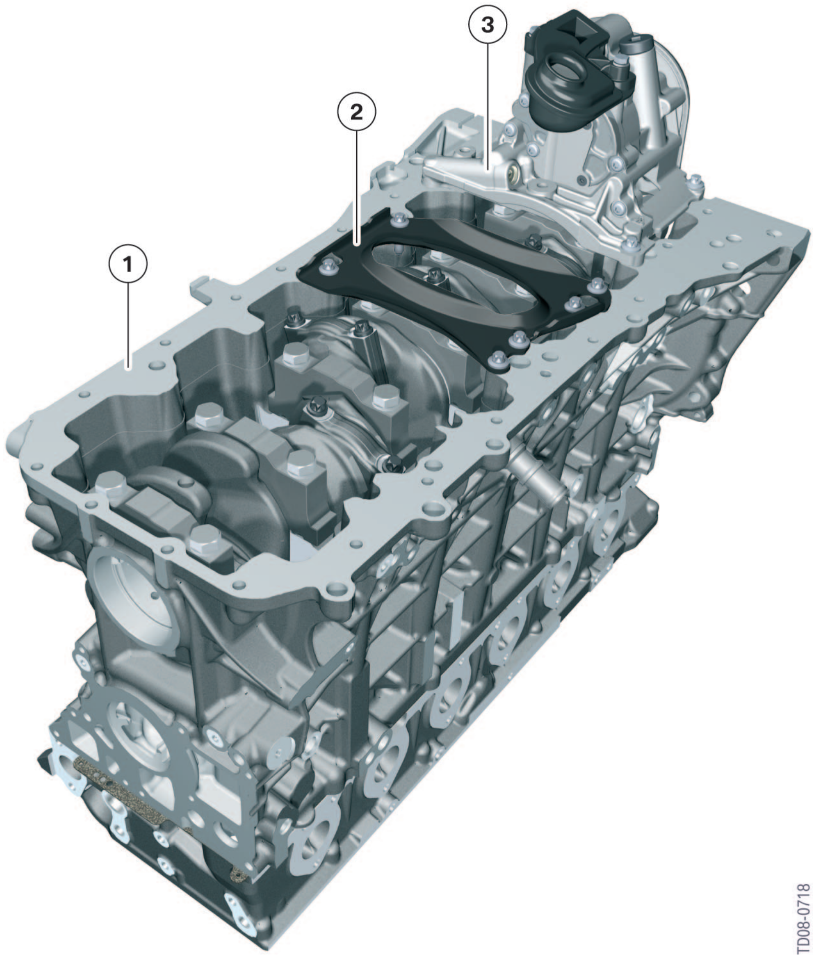
As part of the combustion chamber, the cylinder is subjected to high thermal loads and pressures. With its finely machined surface, the cylinder liner provides good anti-friction and sealing characteristics in conjunction with the piston rings. In addition, the cylinder carries the heat to the crankcase or directly to the coolant.

Since the aluminium alloy of which the crankcase is made is unsuitable for such requirements, the N57 engine is fitted with cylinder liners.

These are made of grey cast iron and are thermally joined. Thermally joined means that the cold cylinder bushes are inserted into the heated crankcase. As it cools, the crankcase contracts, thereby ensuring firm seating of the cylinder bushes.

The cylinder liners on the N57 are what are known as dry liners. This means that the cylinder bush has no direct contact with the water jacket. The water jacket is completely enclosed by the crankcase cast.

Reinforcing plate



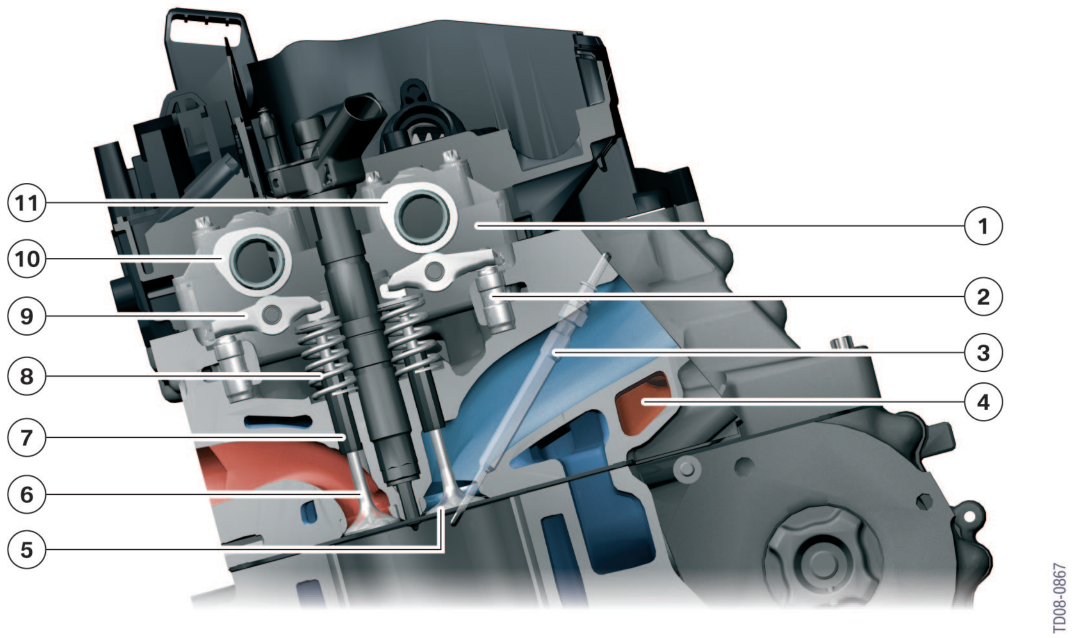
8 - Crankcase with reinforcing plate
N57 engine

Index	Explanation	Index	Explanation
1	Crankcase	3	Oil pump
2	Reinforcing plate		

Additional crankcase rigidity is provided by a reinforcing plate bolted to the bottom of the crankcase. That reinforcing plate is required to cope with the lateral stresses that occur on the crankcase mounting attachment points when driving over a pothole. Without a reinforcing plate, the crankcase could break at the attachment points to the engine mounting bracket or at the junction between the bearing pedestal and the side wall. The reinforcing also provides benefits in terms of noise reduction.

Cylinder head and cover

Overview



9 - Valvegear, N57 engine

Index	Explanation	Index	Explanation
1	Camshaft carrier plate	7	Valve guide
2	Hydraulic valve clearance adjuster	8	Valve spring
3	Glow plug	9	Roller lever tappet
4	Exhaust recirculation channel	10	Exhaust camshaft
5	Inlet valve	11	Inlet camshaft
6	Exhaust valve		

The distinguishing technical features of the N57 engine cylinder head are as follows:

- Material: AlSI7MgCu0.5
- Two-piece cylinder head with camshaft carrier plate
- Crossflow cooling
- Integral exhaust recirculation channel
- Four valves per cylinder
- Parallel valve arrangement (axes parallel with the cylinder axes)
- Tangential and swirl ports
- Reduced height.

Cylinder head

The cylinder head of the N57 engine largely matches the standards of the current diesel engines. A special feature, however, is that the cylinder head comprises two large cast parts. The camshafts are integrated inside their own camshaft carrier.

A cylinder head is described as two-piece if it comprises two cast parts. Bolts, bearing caps and small attachment parts are not included.

In the case of the N57 cylinder head, those two parts are the main casting, essentially the actual cylinder head, and a carrier plate for the camshafts.

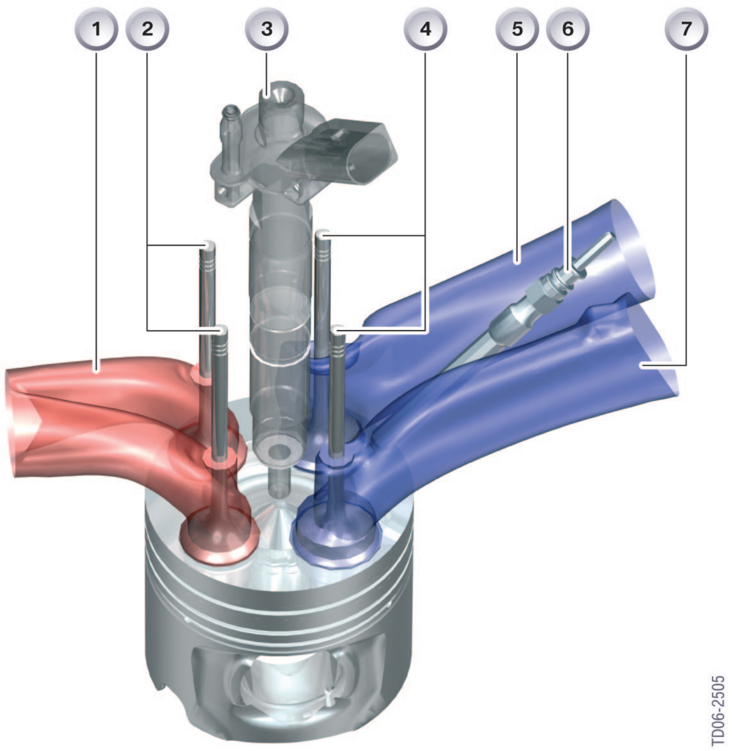
Both camshafts are mounted in this camshaft carrier. This design simplifies the manufacturing process.

The camshaft carrier is made of the aluminium silicon alloy AlSi9Cu3(Fe).

Valves

The N57 engine has four valves per cylinder. Ever since the M47 engine, all BMW diesel engines have always used this valve configuration because it enables more efficient charge replacement and higher cylinder charge levels in direct-injection engines.

The reason being a greater overall valve surface area and thus a better flow cross section than is the case with two valves. Only the four-vpc cylinder head enables central positioning of the fuel injector. This combination is necessary to ensure high specific output with low exhaust emissions.



10 - Inlet and exhaust ports in the cylinder head of the N57 engine

Index	Explanation	Index	Explanation
1	Exhaust ducts	5	Swirl duct
2	Exhaust valves	6	Glow plug
3	Fuel injector	7	Tangential duct
4	Inlet ducts		

Gas exchange ducts

With the four-valve concept, the engine has two inlet and two exhaust ducts in the cylinder head.

The inlet ducts can be distinguished as being the swirl duct and the tangential duct, which are designed to provide optimum mixture preparation and cylinder charging. The swirl duct and tangential duct branch off before they exit the intake manifold and pass through the cylinder head as separate ducts.

The two exhaust ports for each cylinder merge before they exit the cylinder head so that a single exhaust port feeds into the exhaust manifold for each cylinder.

Cooling method

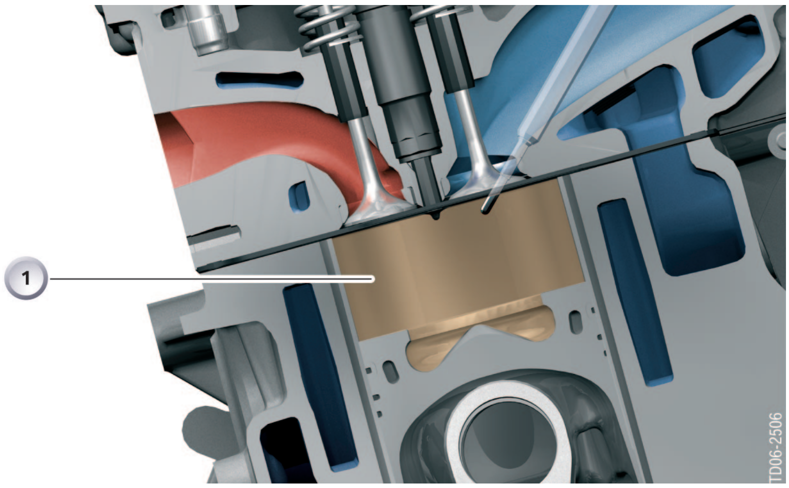
The cooling topic is described in a separate section. However, cylinder heads are distinguished according the method of cooling adopted as there are a variety of different design concepts.

- Crossflow cooling
- Longitudinal flow cooling
- Combination of the two.

The N57 engine, like all current BMW diesel engines, has a cylinder head with crossflow cooling.

With crossflow cooling, the coolant flows from the hot exhaust side of the cylinder head to the cooler inlet side. This offers the advantage of even heat distribution throughout the cylinder head. This prevents additional pressure losses in the coolant circuit.

Combustion chamber ceiling



11 - Combustion chamber shape N57 engine

Index	Explanation	Index	Explanation
1	Combustion chamber		

As the ceiling of the combustion chamber, the cylinder head forms the upper boundary of the cylinder. Together with the piston geometry, it determines the shape of the combustion chamber. The combustion chamber is the space bounded by the cylinder head, the piston and the sides of the cylinder. The shape of the combustion chamber is crucial to mixture preparation.

In order to cope with the ignition pressures of up to 180 bar, the cylinder head is heat treated. The heat treatment produces a harder, wear-resistant surface, greater material strength and minimizes internal component stresses.

The N57 engine has a flat combustion chamber ceiling. In contrast with the M57 engine, the inlet and exhaust valves are parallel to one another.

Cylinder head cover

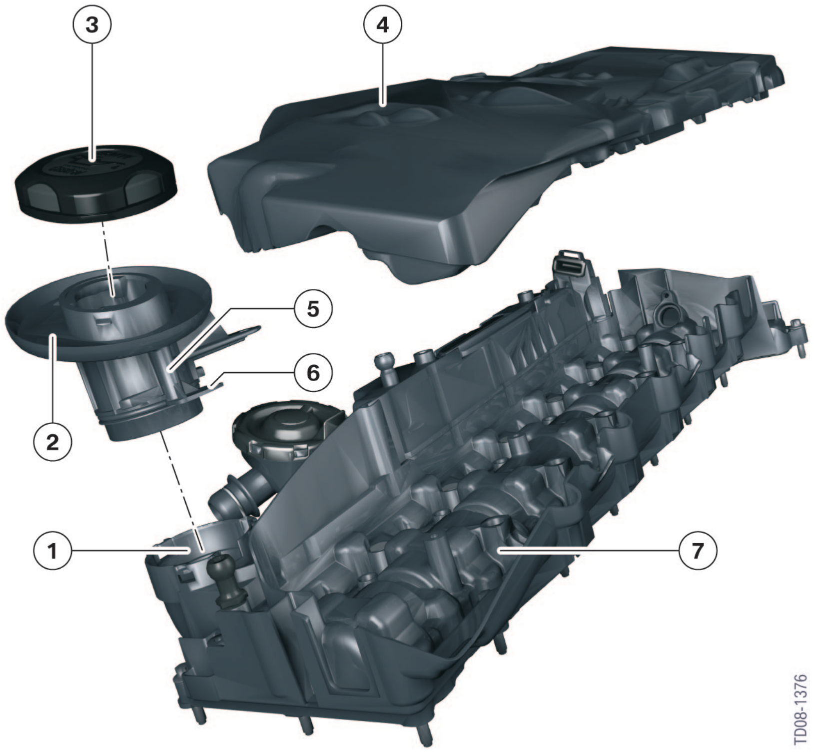
The cylinder head cover of the N57 engine performs the following tasks:

- Sealing the top of the cylinder head from the outside
- Sound insulation
- Accommodating the blow-by gas vent pipe from the crankcase, the oil separation system and the pressure regulating valve for the crankcase venting system
- Holding the fuel rail
- Retention of the camshaft sensor
- Retention of the oil filler neck
- Retention of line feed-throughs.

To achieve good sound insulation, the cylinder head cover is partially isolated from the cylinder head. This is achieved by using elastomer gaskets and semi-isolated fixing-screw holes.

The cylinder head cover of the N57 engine is made of plastic.

The use of plastic as the material for the manufacture of cylinder head covers helps to save weight over aluminium versions. In addition, it is a material that has outstanding sound insulation properties and can be formed into very complex geometrical shapes.



12 - Socket-fit oil filler neck

Index	Explanation	Index	Explanation
1	Socket	5	Channel
2	Oil filler neck	6	Retaining tab
3	Oil filler cap	7	Cylinder head cover
4	Foam cover		

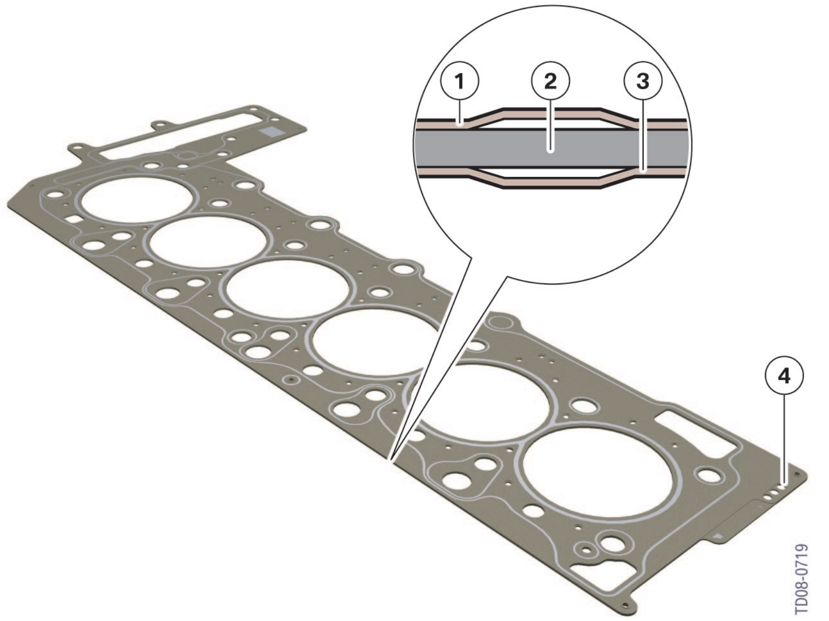
In order to reduce variant diversity, a socket-fitting oil filler neck (2) secured by a retaining tab (6) and a screw is used. As a result, the cylinder head cover (7) is identical on all N57 engines.

As already featured on the N47 engine, around the top of the oil filler neck there is a lip for catching spilt engine oil, which then drains back into the cylinder head cover through a channel (5).

All diesel engines feature a new standardized oil filler cap for the oil filler neck.

A foam cover (4) on top of the cylinder head cover reduces noise emission by 1 - 2 dB.

Cylinder head gasket



13 - Cylinder head gasket N57 engine

Index	Explanation	Index	Explanation
1	Outer spring steel layer	3	Outer spring steel layer
2	Intermediate layer with welded sealing lips	4	Coding for identifying gasket thickness

The cylinder head gasket must be capable of sealing off four zones from each other. Those zones are:

- Combustion chamber
- Atmosphere
- Engine oil channels
- Coolant channels.

A three-layer metal gasket is used on the N57 engine.

Metal gaskets are used in engines subjected to high loads. Such gaskets consist of multiple layers of sheet steel. The main characteristic of a metal gasket is that the sealing properties are essentially determined by beads and sealing lips integrated in the spring steel layers. The deformation properties of the metallic cylinder head gasket firstly enable optimum adaptation to the components in the cylinder head area and, secondly, a high degree of resilience that compensates for component deformation. Such deformation is caused by thermal and mechanical stresses.

The two spring steel layers (functional layers) of the cylinder head gasket are made from spring steel strip. The sealing lips are welded onto the intermediate layer (spacer layer). In some cases, additional coatings are applied to the cylinder head gasket to optimize its function.

The cylinder head gasket is available to order in three different thicknesses, which depend on the piston projection concerned. The thickness of the cylinder head gasket is indicated by holes, whereby one hole indicates the thinnest and three holes the thickest gasket.

Sump

14 - Sump, N57 engine

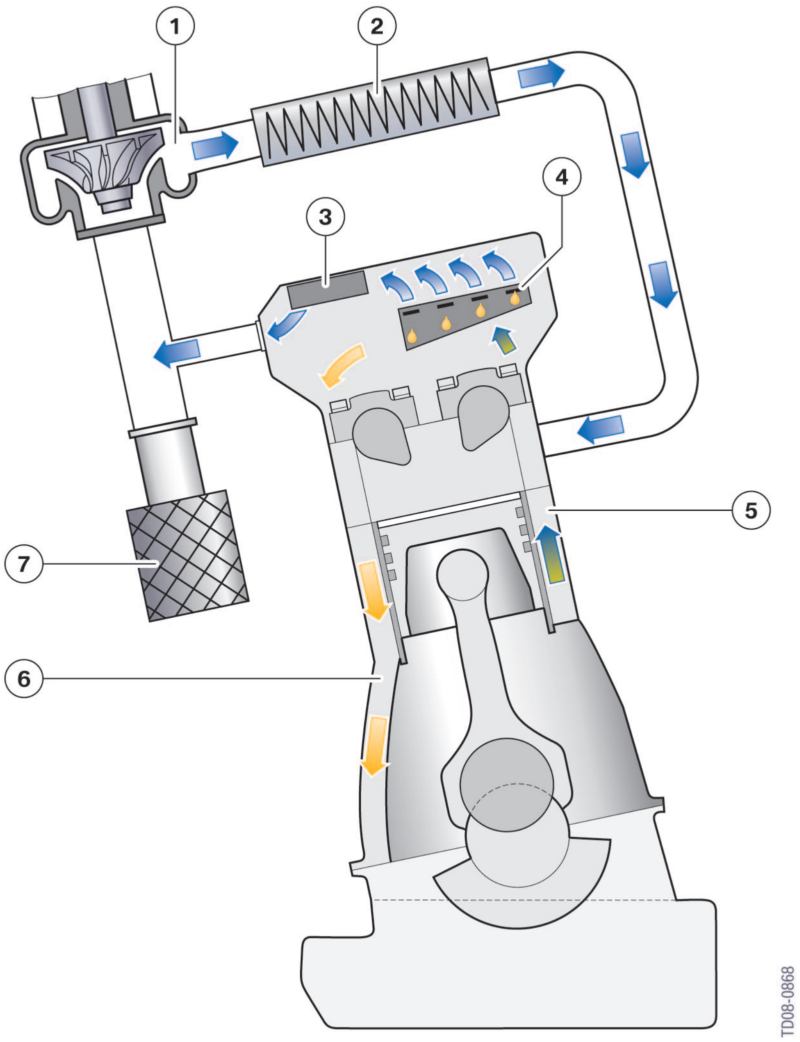
The sump forms the lower extremity of the engine casing components. On the N57, as on all BMW engines, the sump flange is lower than the centre of the crankshaft.

A girder-type seal with an elastomer strip is used for the sump. The girder material is aluminium.

⚠ To ensure that the seal functions correctly, no oil is permitted to come into contact with the rubber coating during assembly. There would be a risk of the seal sliding off the sealing surface. Therefore, the flange surfaces must be cleaned immediately prior to assembly. In addition, it must be ensured that all oil has been allowed to fully drain out of the engine so that it neither drips onto the flange surfaces nor the seal during assembly. ◄

Crankcase venting

Overview



15 - Vacuum-controlled crankcase venting on N57 engine

Index	Explanation	Index	Explanation
1	Exhaust turbocharger	5	Blow-by channel
2	Intercooler	6	Oil return channel
3	Pressure regulating valve	7	Air cleaner
4	Spring plates		

When the engine is running, blow-by gases escape from the cylinders into the crankshaft cavity.

Those blow-by gases contain unburned fuel and all the constituents of the exhaust. In the crankshaft cavity, they mix with the engine oil that is present in the form of oil vapour.

The extent of blow-by is dependent on load. Pressure is created inside the crankshaft cavity and, due to the motion of the pistons, is also dependent on engine speed. This overpressure is also present in all spaces that connect to the crankshaft cavity (e.g. oil return, chain cavity, etc.) and if not released would force oil out through the sealed joints.

The crankcase venting system prevents that from happening. It channels blow-by gases that are largely free of engine oil into the filtered-air pipe upstream of the turbocharger and the separated engine oil droplets back into the sump through an oil return pipe. The crankcase venting system also ensures that excess pressure is not created in the crankcase.

Design

The N57 engine is equipped with a vacuum-controlled crankcase venting system. A regulated negative pressure of approx. 38 mbar is maintained.

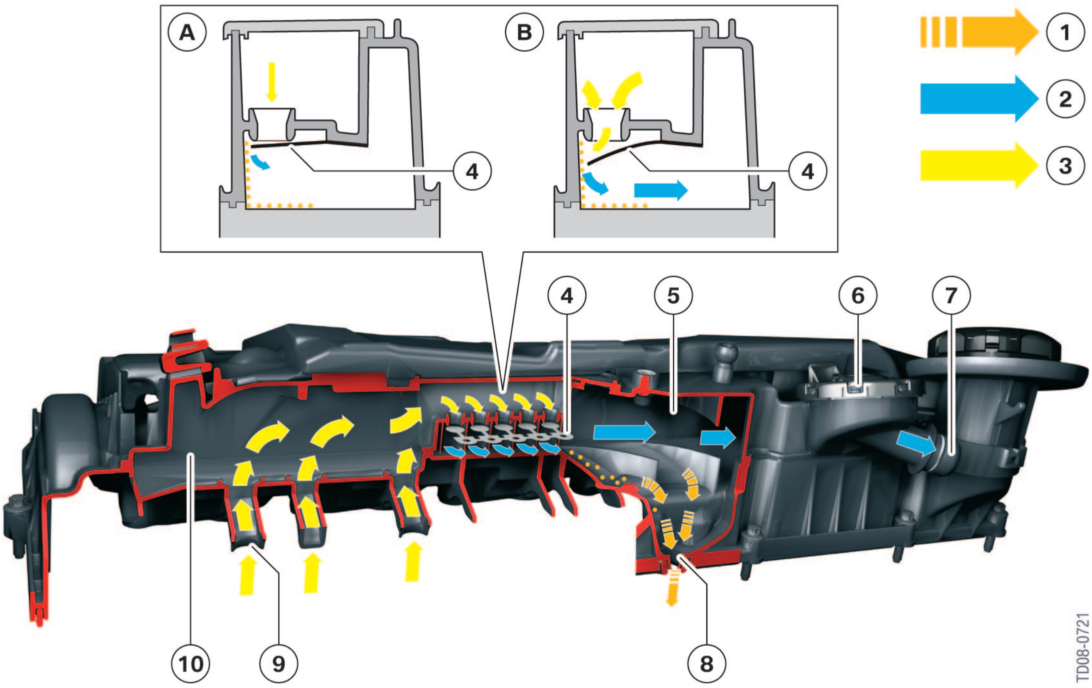
Pre-loaded metal spring plates (known as variable-aperture separators) regulate the air mass flow rate, thereby ensuring optimum oil separation from the blow-by gas in all engine operating situations.

A negative pressure is created in the purified air pipe due to the suction of the exhaust turbocharger.

As a result of the pressure difference relative to the crankcase, the blow-by gas is drawn into the cylinder head.

In the cylinder head, the blow-by gas first enters the plenum chamber. The purpose of the plenum chamber is to ensure that no oil spray, e.g. from the camshafts, enters the crankcase venting system. Thus, a degree of initial separation already takes place in the plenum chamber. The oil that deposits on the wall here flows back into the cylinder head.

The blow-by gas flows from the plenum chamber to the spring-plate separators. The spring plates are forced open by the flow of blow-by gas so that the blow-by gas passes through. Since the aperture size is relatively small, the flow velocity of the blow-by gas is accelerated. And since the blow-by gas flow is then deflected by approx. 180°, the fluid contained in the blow-by gas is thrown against the surrounding walls by centrifugal force and runs down them into a drain channel and back into the sump. The spring plates are opened to a greater (B) or lesser (A) degree depending on the quantity of blow-by gas so that optimum oil separation is achieved regardless of blow-by gas flow rate. The spring-plate separator has brought about an improvement in the separation quality under all operating conditions but especially at low blow-by gas flow rates. The cleaned blow-by gas flows through the pressure regulating valve and into the filtered-air pipe upstream of the turbocharger.



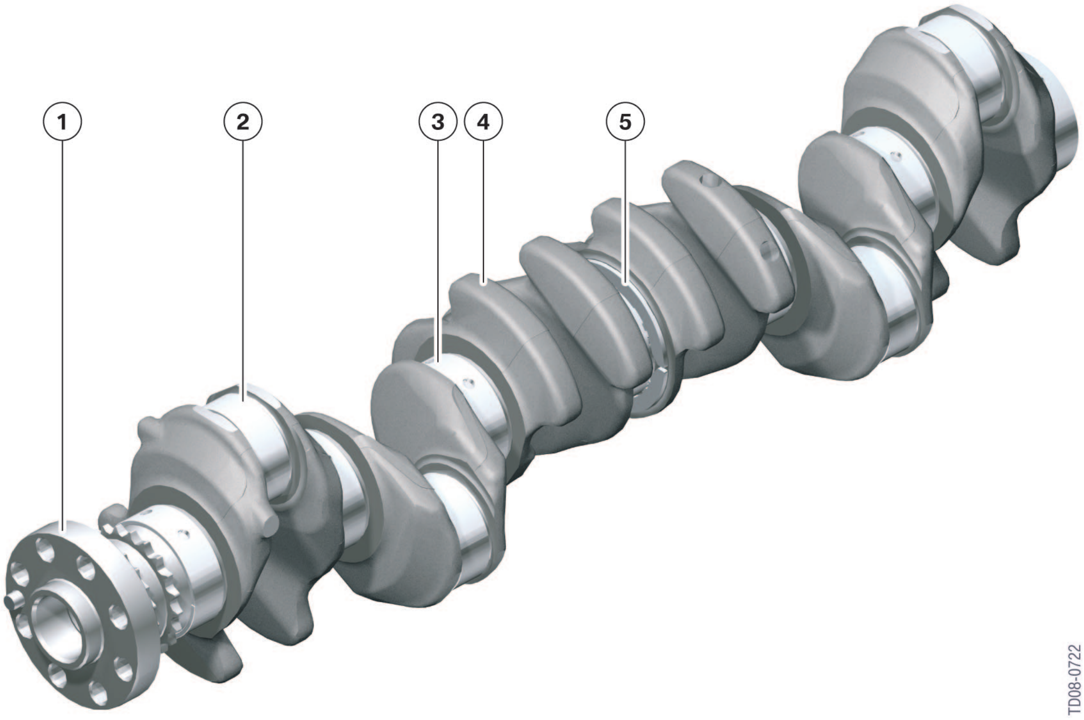
16 - Oil separation in the cylinder head cover of the N57 engine

Index	Explanation	Index	Explanation
A	Low blow-by gas flow rate	5	Channel to pressure regulating valve
B	High blow-by gas flow rate	6	Pressure regulating valve
1	Oil droplets	7	Blow-by gas infeed into filtered-air pipe
2	Air flow	8	Oil return channel
3	Blow-by gas flow	9	Blow-by gas inflow
4	Spring plate	10	Plenum chamber

Crankshaft and bearings

Crankshaft

		M57TU2	N57
Material		C38modBY	C38modBY
Manufacture		Forged	Forged
Diameter of the main bearing journal	[mm]	60	55
Diameter of the big-end bearing journal	[mm]	45	50
Crank pin offset	[°]	120	120
Number of counterweights		12	8
Number of main bearing points		7	7
Position of thrust bearing		6	4



17 - Crankshaft, N57 engine

Index	Explanation	Index	Explanation
1	Output flange	4	Counterweight
2	Big-end bearing journal	5	Thrust bearing contact face
3	Main bearing journal		

Counterweights create a balance of inertial forces around the crankshaft so as to produce even rotation of the shaft. They are designed so as to counterbalance some of the oscillating (up-and-down) inertial forces as well as the rotational (revolving) inertial forces.

The crankshaft of the N57 engine has eight counterweights.

The N57 engine has a forged crankshaft made of C38modBY. BY stands for controlled cooling from the forging heat in the air and makes for uniform joints. The material specifications are the same as those of the M57 engine.

The surface treatment of the crankshaft is the same as on the M57 engine. In order to achieve the required hardness, the crankshaft is induction hardened. This forms an especially hard surface layer approximately 1.5 mm thick.

Advantages of forged crankshafts compared to cast:

- Forged crankshafts are more rigid and have better vibrational properties
- Especially when combined with an aluminium crankcase, the crankshaft drive system must be as rigid as possible because the crankcase itself is made of material with a lower rigidity
- Forged crankshafts have better wearing characteristics at the bearing journals.

In summary: the strength of a forged crankshaft is significantly greater than that of a cast one. A cast crankshaft would not be able to cope with the loads to which it is subjected in the N57 engine.

Bearings

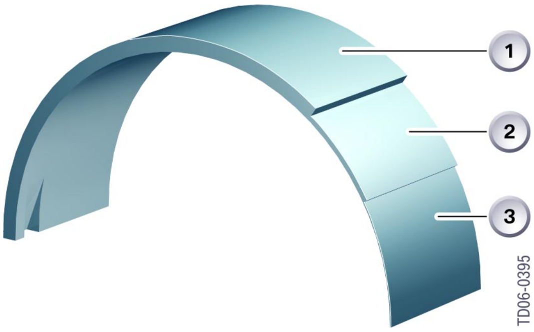
The main bearings support and hold the crankshaft in the crankcase. The side subjected to load is in the bearing cap. The force that occurs as the result of the combustion pressure is taken up at this point.

The bearing surfaces are provided with a special bearing material. Resistance to wear is ensured if the surface of the bearing shell and the journal are separated by a film of oil. That means that an adequate supply of oil must be guaranteed. This takes place on the unladen side, i.e. from the bearing pedestal. The bearing shells are supplied with lubricating engine oil through oil bores.

There are two oil bores in the bearing shells. That is because, on the N47 engine, the oil bores in the main bearing pedestals alternate between the left and right-hand sides, whereas the bearing shells are all identical parts.

An annular groove in the upper shell improves the distribution of the oil. However, such a groove reduces the contact area of the bearing and therefore the effective pressure on it. In effect, the bearing is divided into two halves each with a smaller capacity. For that reason, the oil grooves are generally only in the area not subjected to the main force of the load. The lubricating oil also helps to cool the bearing.

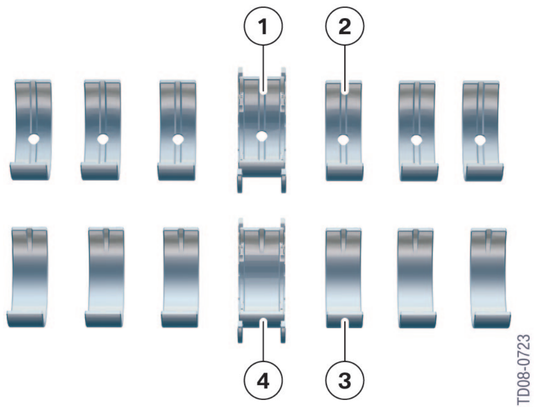
The highly stressed crankshaft main bearings are designed as trimetal bearings. The steel support shell, the unleaded bronze and the bearing metal layer made of a tin-copper alloy form the basis for a wear-resistant main bearing able to bear high loads.



18 - Tri-metallic bearing, N57 engine

Index	Description
1	Steel supporting shell
2	Bronze
3	Bearing-metal layer

⚠ Careful handling of bearing shells is extremely important because the ultra-thin bearing metal layer is very easy to damage. ◄



19 - Crankshaft bearings, N57 engine

Index	Description
1	Thrust bearing shell in the main bearing pedestal
2	Bearing shell in the main bearing pedestal
3	Bearing shell in the main bearing cap

Index	Description
4	Thrust bearing shell in the main bearing cap

On the N57 engine, two composite bearing shells are fitted to locate the crankshaft. Consequently, the crankshaft benefits from 360-degree axial location and, therefore, excellent stability with regard to axial float.

⚠ It is important that lubrication with engine oil is ensured. When thrust bearings fail, overheating is generally the cause.

A worn thrust bearing causes noise to be produced, mainly in the area of the vibration damper. Another fault pattern can take the form of crankshaft sensor errors, which on vehicles with automatic transmission is evident in the form of jerky gearshifts. ◄

The thrust bearing on the N57 engine takes the place of the fourth main bearing, i.e. in the centre of the crankshaft. This has the benefit of promoting uniform thermal expansion. The steel of the crankshaft and the aluminium of the crankcase have different thermal expansion coefficients, i.e. their thermal expansion differs with differences between their temperature. If the thrust bearing were at the end of the crankshaft, the difference in expansion relative to the crankcase across the entire length of the crankshaft would be very big. However, since the thrust bearing is in the centre, thermal expansion is distributed symmetrically in both directions. The difference in expansion at either end of the crankshaft is then only half as big.

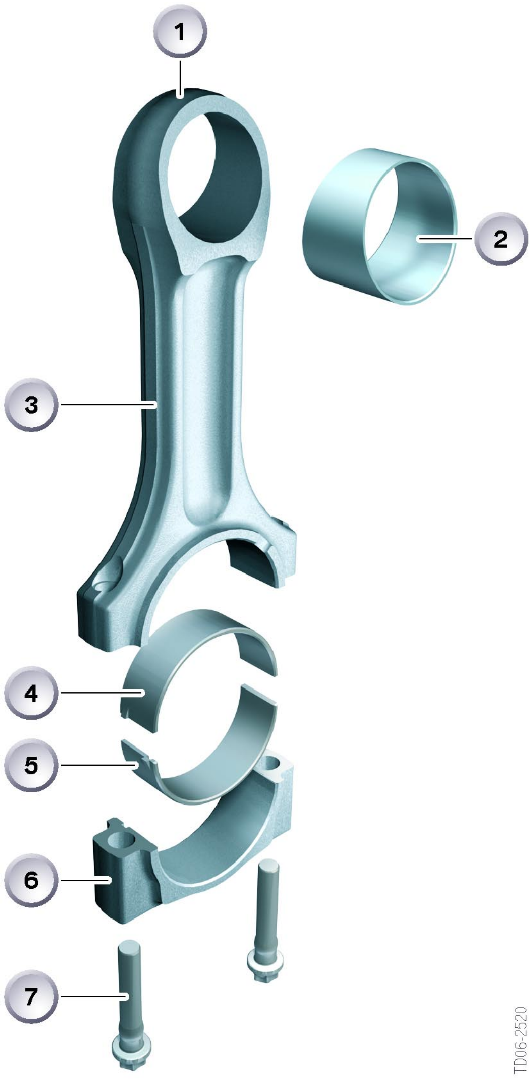
Connecting rods and bearings

Connecting rod

As connecting rods are subjected to very high rates of acceleration, their weight has a direct effect on the engine dynamics. In respect of the response of the engine, utmost importance is therefore assigned to optimizing the weight of the connecting rods.

The following are some of special features of the N57 connecting rods:

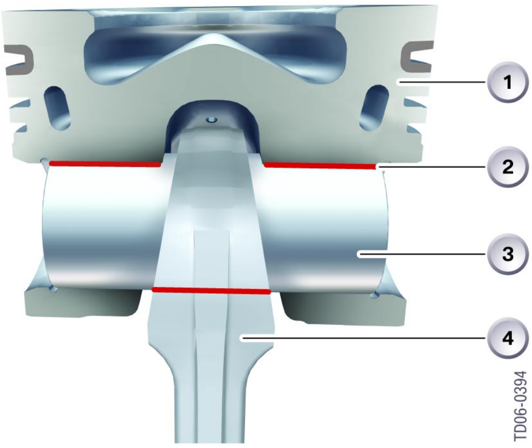
- Con-rod half of big-end bearing sputter-coated (see Diesel engine mechanicals Product Information)
- Cracked connecting rod made of C70 forged steel
- Trapezoid connecting rods



20 - Connecting rod, N57 engine

Index	Explanation
1	Small end
2	Plain bearing
3	Con rod shaft
4	Con-rod bearing shell
5	Bearing-cap bearing shell
6	Big-end bearing cap
7	Connecting rod bolt

A trapezoid connecting rod has a small end with a trapezium-shaped cross-section. Firstly, this enables a further weight reduction because material is removed on the "unstressed" side of the small end, while the side that bears the majority of the force retains its full width or is even wider. Secondly, it allows the gudgeon pin boss spacing to be reduced, which means there is less flexing of the gudgeon pin.



21 - Trapezoidal connecting rods

Index	Explanation
1	Piston
2	Load-bearing surface
3	Gudgeon pin
4	Con-rod shaft

The connecting rods of the N57 engine are manufactured by drop forging and then cracked.

⚠ If a big-end bearing cap is fitted the wrong way round or on the wrong connecting rod, the fracture face pattern of both parts is damaged and the bearing cap will not self-centre. In that case the complete con-rod set has to be replaced with entirely new parts. ◄

⚠ You will find detailed information on connecting rod connections, such as tightening specifications, in the TIS. ◄

The connecting rods are some of the moving masses in the engine and therefore have an effect on engine operation. This effect is a particularly complex one because the big end moves in a circular motion while the small end moves back and forth in a straight line.

To ensure the engine runs evenly, the connecting rods must match a specified weight to within very tight tolerances. In the past an extra machining allowance was built in and was then machined down as required. With modern manufacturing processes, the production parameters can be so precisely controlled that the components can be produced within a satisfactory weight tolerance.

To gain even further control over the influence of the connecting rods on engine operation, the connecting rods are classified into weight categories.

These weight categories are classified separately according to the weight of the big and small end and then combined (see the following table).

		Weight of the small end				
Weight of the big end	Class A	A1	A2	A3	A4	A5
	Class B	B1	B2	B3	B4	B5
	Class C	C1	C2	C3	C4	C5
	Class D	D1	D2	D3	D4	D5
	Class E	E1	E2	E3	E4	E5

The combination provides the weight class (e.g. A1, C2, etc.). A weight class has a tolerance of ±4 g. This divides into ±2 g for the big end and ±2 g for the small end.

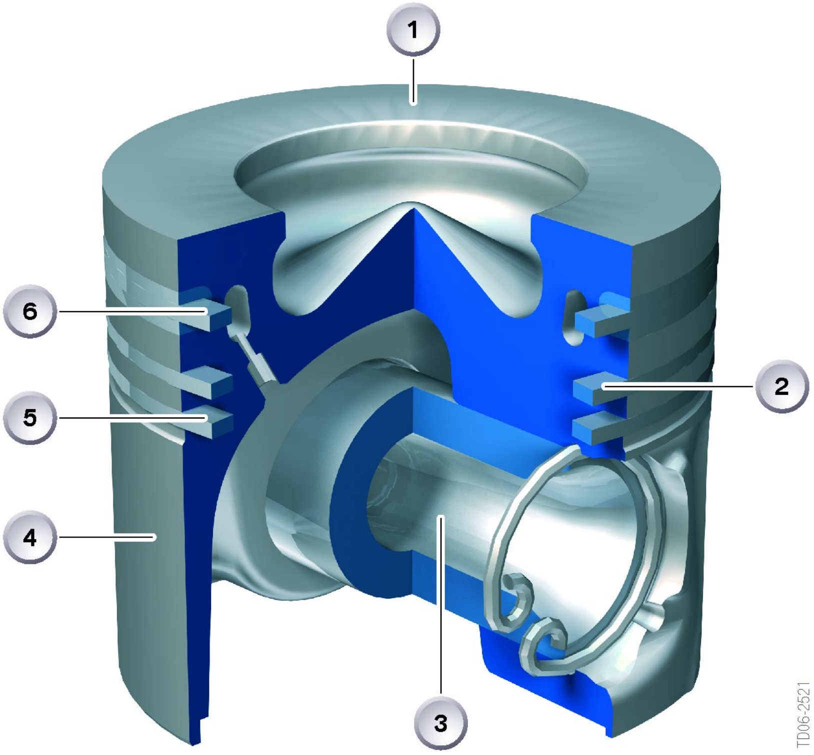
⚠ In any one engine, all the connecting rods must be the same weight class. ◄

Pistons, piston rings and gudgeon pins

Piston

Like all BMW diesel engines, the N57 engine has a full-skirt piston, which is very similar in design to that of the M57 engine.

While the diameter of the piston is the same as on the M57TU2 engine, the overall height is greater and compression height has also been increased. The pistons are made by Mahle.



22 - Piston, N57 engine

Index	Explanation	Index	Explanation
1	Piston crown	4	Piston skirt
2	2nd piston ring	5	3rd piston ring
3	Gudgeon pin	6	1st piston ring

One of the differences from the familiar pistons is that there are no valve recesses as the valves are aligned perpendicular to the piston crown.

This is what is known as dead space reduction. Since the piston crown has no valve pockets, air flows out of the gap between the piston crown and the cylinder better during compression.

Full-skirt pistons are used due to the high loads that occur on the diesel engine. This design promotes straighter travel of the piston inside the cylinder thanks to the long, continuous contact surface.

Ring belt

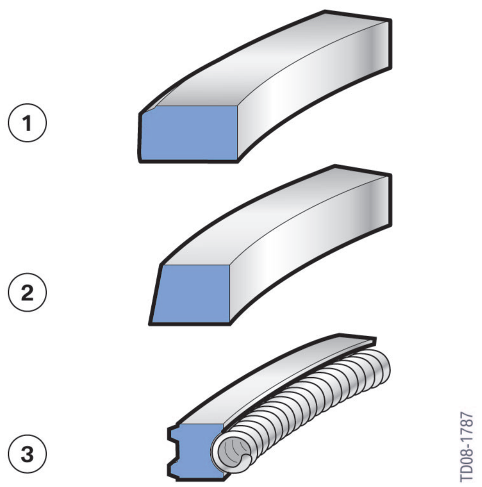
The ring belt is also commonly referred to as the piston ring zone. It includes the grooves for accepting the piston rings, the fire land and the piston cooling duct.

Both the top land height and the ring land widths have been increased in comparison with the M57TU2 engine.

The first piston ring groove is a ring carrier. This is made of cast iron and is much more resistant to the friction and impact wear promoted by the high combustion pressures than the aluminium-silicon alloy of the piston. The ring carrier is cast into the piston and forms a metal connection with it, which prevents it from coming loose on impact and promotes the transfer of heat.

On the inside of the piston, the cooling duct runs directly behind the first piston ring groove. This is supplied with spray oil through a bore; the oil is then able to flow away through a second bore.

Piston rings



23 - Piston ring set, N57 engine

Index	Explanation
1	Plain compression ring with sharp lower edge
2	Taper face compression ring
3	Double chamfer ring with tubular spring

Piston rings are classified into different types according to their function.

- Compression rings
- Oil control rings.

Like all BMW diesel engines, the N57 engine has two compression rings and an oil control ring.

The **plain compression ring** is seated in the first position and is used only for its compression qualities. Its upper outer edge has a small chamfer. The outside surface is polished and slightly crowned.

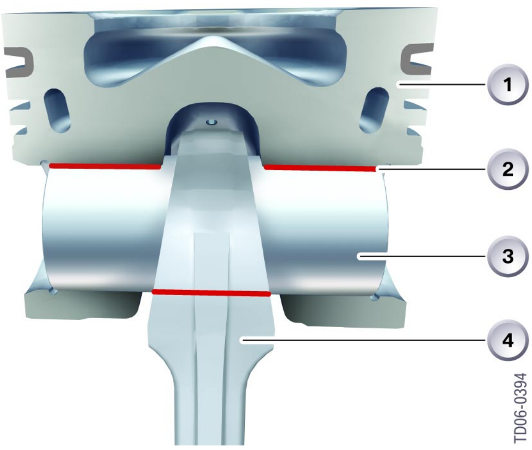
The **taper-faced ring** is also a compression ring. Even when removed, the taper-faced ring can be seen to have a slightly tapered contact face. This results in a shorter run-in time.

⚠ Taper-faced rings must not be fitted the wrong way round. Incorrect installation leads to engine damage ◄

The **bevelled ring with hose spring** is purely an oil scraper ring. A high surface contact pressure, which arises as a consequence of the two slide lands and of the chamfer in particular, promotes the oil scraping effect. Small bores around the circumference make it easier for the scraped up oil to be carried away into the annular groove of the piston. This contains four small bores for the return of the oil. The hose spring (cylindrical spring) amplifies the surface contact pressure and mould filling capacity. The spring, which is seated in a rounded groove in the cast ring, acts evenly around the entire circumference, which, among other benefits, helps to achieve the high levels of flexibility afforded by this design. The contact face of the ring is coated with chrome.

⚠ A damaged or broken oil control ring cannot be identified once fitted. The effects only come to light after a certain period of use. ◄

Gudgeon boss



24 - Trapezoidal connecting rods

Index	Explanation
1	Piston
2	Load-bearing surface
3	Gudgeon pin
4	Con-rod shaft

Combustion pressure is transferred to the connecting rod by the gudgeon boss and then to the crankshaft. This makes them the part of the piston that is subjected to the heaviest loads. The loads are reduced by an increase in the area of the gudgeon seat. This is made possible by a trapezoidal connecting rod as shown in the following graphic.

Gudgeon pin

The gudgeon pin connects the piston to the connecting rod. Due to its rapid to-and-fro movements with the piston, the gudgeon should only have a low mass otherwise high acceleration forces would be required. The alternating loads, unfavourable lubrication conditions and the minimal play in the gudgeon-pin bosses/small ends place particularly high demands on the gudgeon pins.

A tubular, floating-bearing design has established itself as the standard for the gudgeon pin. The gudgeon pins on the N57 engine are made of 16MnCr5 case-hardened steel.

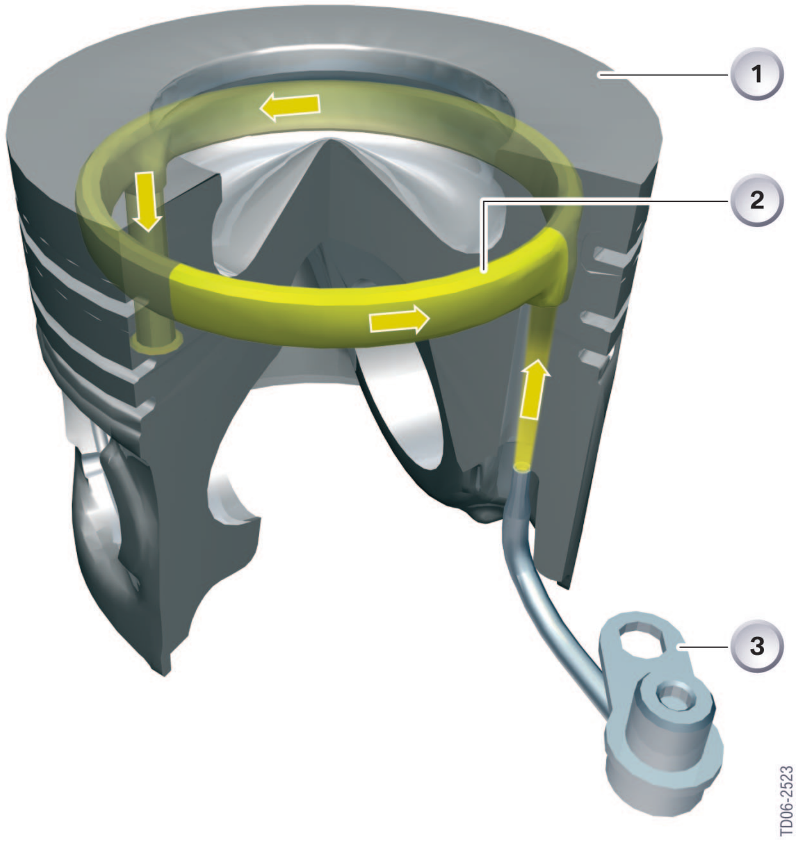
Lateral float is prevented by appropriate means of securing the gudgeon pin. These consist of radially-sprung steel rings (circlips), which are fitted in the associated grooves in the gudgeon eyes.

The piston is already designed for EURO 5 compliance, having a compression ratio of 16.5:1. When the EURO 5 technology is introduced on the N47 engine, it too will use the same pistons.

Cooling

There is a cooling duct (annular channel) in the piston ring zone to carry heat away from the piston crown effectively.

An oil spray nozzle supplies the underside of the piston with cooling oil. It is precisely joined with a bore hole in the piston that leads to the cooling duct. The movement of the piston causes the oil to circulate and has a "shaker effect". The oil in the channel oscillates and thereby improves the cooling effect because more heat can be transferred to the oil. The oil flows back into the crankcase cavity through a drain hole.



25 - Cooling channel in piston of N57 engine

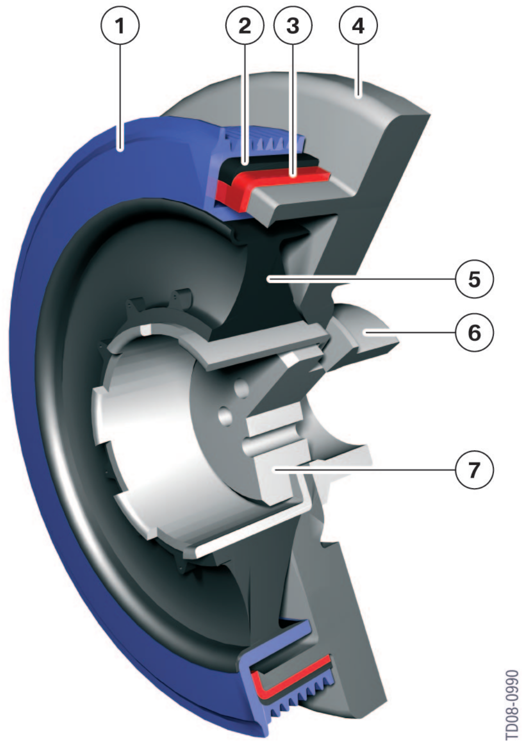
Index	Explanation	Index	Explanation
1	Piston crown	3	Oil spray nozzle
2	Cooling duct		

Rotational vibration damper

Overview

A rotational vibration damper is used on the belt-drive system of the N57 engine.

Rotational vibration damper for belt drive system



26 - Rotational vibration damper

Index	Explanation
1	Belt pulley
2	Vulcanization layer
3	Plain bearing
4	Housing
5	Decoupling rubber
6	Flange
7	Hub

The rotational vibration damper consists of a base plate (4) which holds an inertia ring that is able to rotate relative to the base plate. The inertia ring is surrounded by high-viscosity oil. The hub is bolted to the front end face of the crankshaft.

The rotational vibration damper reduces rotational vibration of the crankshaft. This reduces the load on the crankshaft and the driven auxiliary equipment.

The rotational vibration damper is important not only in terms of how smoothly the engine runs but also with regard to even and low-wear drive transmission to the belt drive system.

The belt pulley (1) is isolated from the hub (7) by the rubber isolator (5). The decoupling rubber allows for more powerful twist and reduces residual irregular rotation and thus the load on the belt drive. The belt pulley is mounted by plain bearing (3).

⚠ The engine should not be allowed to run without the drive belt fitted as the rotational vibration damper could be damaged as a result. ◄

Camshaft drive system (timing gear)

Overview

The special features and specifications of the chain drive system on the N57 engine are as follows:

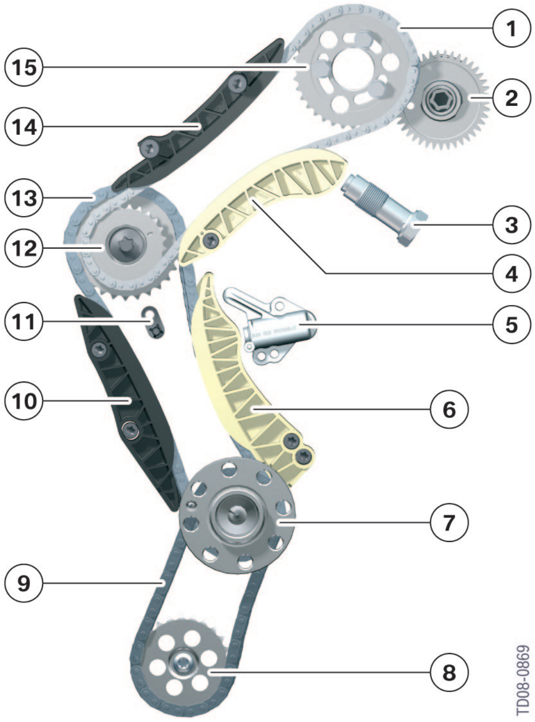
- Chain drive system mounted on flywheel-end of engine
- Two-section system for driving the high-pressure pump and camshafts
- Use of simplex sleeve-type chains
- Oil/vacuum pump driven by second chain
- Plastic tensioning and guide rails
- Hydraulic chain tensioners.

As on the N47 engine, the chain drive system on the N57 engine is mounted on the flywheel end, i.e. the rear, of the engine.

Due to the fact that the timing gear is mounted at the rear, the engine is lower at the front. That is of benefit for the passive safety features for minimizing pedestrian impact severity. It creates more space between the engine and the bonnet. Thus, in the event of a crash, there is more room for the bonnet to deform and absorb the impact.

Another benefit is that rotational vibrations are significantly reduced due to the inertial mass of the transmission at this end. This results in an enormous relief of load on the chain drive.

One of the consequences of this arrangement is that various components are installed in unconventional locations or positions, e.g. oil pump, camshaft sensor, etc.



27 - Chain drive system, N57 engine

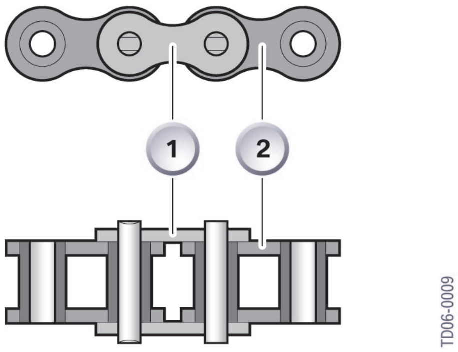
Index	Explanation
1	Upper chain
2	Exhaust camshaft gear
3	Upper chain tensioner
4	Upper tensioning rail
5	Lower chain tensioner
6	Lower tensioning rail
7	Crankshaft
8	Oil/vacuum pump sprocket
9	Oil/vacuum pump chain
10	Lower chain guide
11	Oil spray nozzle
12	High-pressure pump sprocket
13	Lower chain
14	Upper chain guide
15	Inlet camshaft sprocket

Transmission ratio

Sprocket	N47 engine		N57 Engine	
	Number of teeth	**Transmission ratio**	**Number of teeth**	**Transmission ratio**
Oil pump	24	0.88	23	0.91
Crankshaft	21	0	21	0
High-pressure pump	21	1	28	0.75
High-pressure pump	20	1	24	0.75
Camshaft	40	0.5	36	0.5

Chain design

All the chains on the N57 engine are simple bush chains.



28 - Bush chain

Index	Explanation
1	Outer link with pin
2	Inner link with press-fitted pins

With a **bush chain** the teeth of the sprocket always make contact with the fixed bushes in the same place. Therefore, correct lubrication of timing gear systems that use this type of chain is essential. Bush chains have a larger pivot surface area than a roller chain with the same pitch and breaking strain. A larger pivot surface area means a lower pivot surface pressure and therefore less wear on the pivots.

Chain sprockets

The tooth profile of the sprockets has been standardized for sleeve-type chains. The correct tooth profile is of major significance in ensuring safe operation of the timing gear. The sprockets used have low-profile teeth and a wide tooth spacing. This facilitates smooth chain infeed and outfeed even at high chain velocities.

Chain tensioner and guide

The chain is subject to stretching for a variety of reasons. It results either from the operating conditions (heat expansion) or is due to wear.

The chain tensioner makes sure that the slack side of the chain is preloaded with a specific tension in all engine operating modes. In addition, it performs a damping action and reduces vibrations to a permissible level.

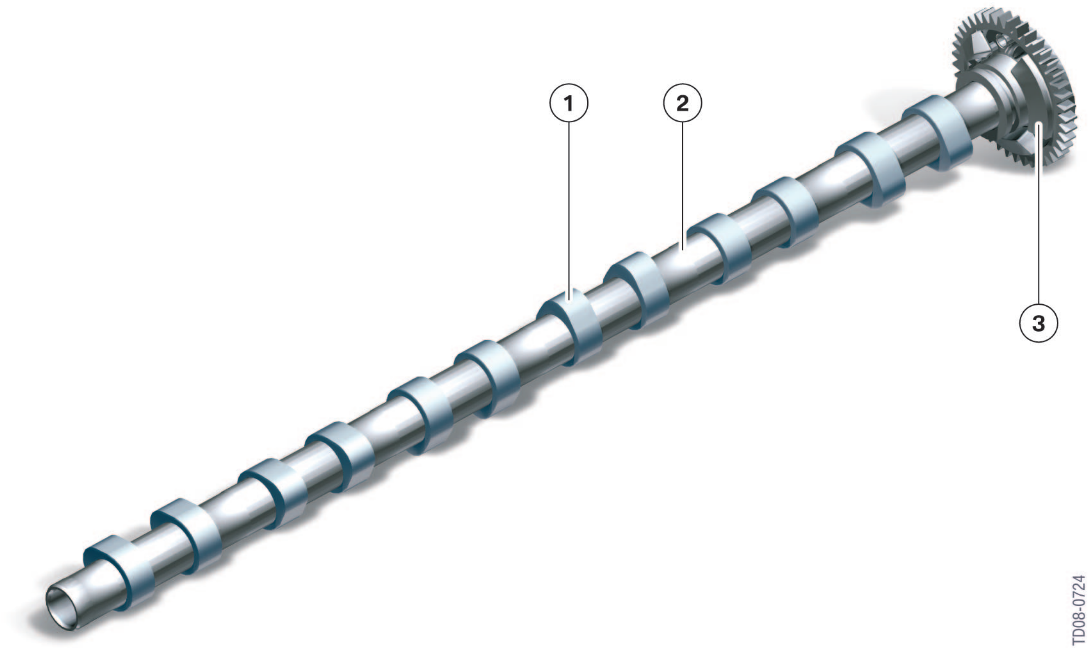
Like all BMW diesel engines, the N57 uses hydraulic chain tensioners.

Camshafts

Overview

The main component of the camshaft is the cylindrical shaft. Positioned at intervals along it are the cams and on the end is the camshaft gear. The valve actuating forces are braced by the camshaft bearings in the camshaft carrier plate. As with all BMW diesel engines, on the N57 engine the camshaft tube runs directly in the camshaft bearings. The tube is ground at those points. The bearings are supplied with pressurized oil for lubrication through an oil bore in the camshaft carrier plate. Axial float of the camshaft is controlled by the thrust ring on the camshaft gear and the thrust bearing slot in the camshaft carrier plate.

The N57 engine is fitted with the now familiar composite camshafts first used on the M57TU2 engine. They are made using the Presta method in common with the camshafts on all BMW diesel engines.



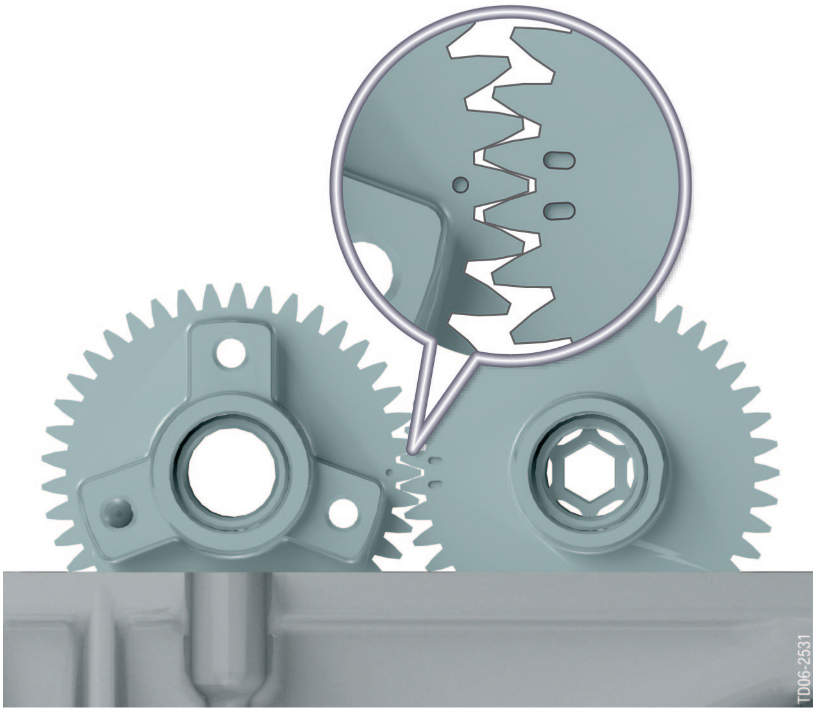
29 - Camshaft, N57 engine

Index	Explanation	Index	Explanation
1	Cam	3	Tooth and camshaft sensor wheel
2	Shaft		

The inlet camshaft is driven by a sprocket which is chain-driven by the crankshaft. The exhaust camshaft is driven by direct gear-to-gear transmission from the inlet camshaft. The camshaft gears are integral components of the camshafts and permanently attached to them. Markings on the camshaft gears facilitate correct positioning of the camshafts relative to one another when fitting.

The inlet camshaft gear also has raised lugs so that it serves simultaneously as the reluctor ring for the camshaft sensor.

The twin-flatted collar for accepting the special tool for positioning the camshaft relative to the crankshaft when fitting is integral with the camshaft. On the N57 engine, the special tool is only placed on the exhaust camshaft.



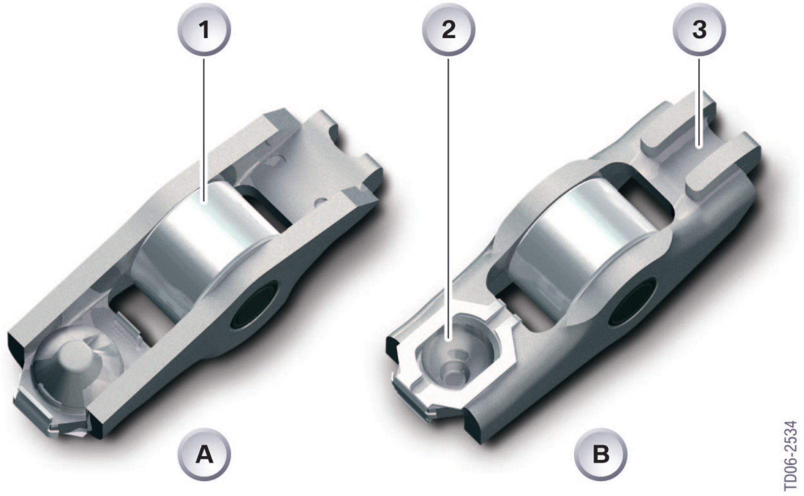
30 - Camshaft gear alignment markings
N57 engine

The camshaft sprocket is bolted to the camshaft gear of the inlet camshaft. Slots are provided for adjusting the valve timing. A new feature is that the sprocket can be bolted in place without turning the camshaft out of position. To that end, the three bolts are not spaced evenly 120° apart (see graphic above).

To brace the camshaft when fitting the sprocket, an Allen-key socket in the centre of the camshaft gear on the exhaust camshaft is used.

Roller lever tappets and valve clearance adjustment

Roller lever tappets



31 - Roller lever tappets, N57 engine

Index	Explanation	Index	Explanation
A	Roller lever tappet, top view	2	Hemispherical recess for resting on HVA adjuster
B	Roller lever tappet, bottom view	3	Actuating face that presses on the valve
1	Needle-bearing roller for following cam		

The roller lever tappets are pressed-steel components. Due to fact that the force of the cam acts against a roller, they reduce frictional losses compared with straightforward lever tappets or bucket tappets, especially in the lower rev band that is of significance for lowering fuel consumption.

The new design has achieved a significant reduction in height and a weight saving of approximately 14 %.

Valve clearance adjustment

Like all current BMW diesel engines, the N57 has hydraulic valve clearance adjustment. It is identical to that used on the M57TU2 engine.

Valves, valve guides and valve springs

Overview

The valves form a single assembly together with the valve guides and valve springs. The valve performs its sealing function in combination with the valve seat insert.

On the N57 engine, the valve stem seal forms a single unit with the lower valve spring retainer.

Valves

Valves can be distinguished as being monometal valves or bimetal valves. Both types are used on the N57 engine. Monometal valves are used as inlet valves, while bimetal valves are used as exhaust valves due to the much higher thermal load to which they are subjected.

Monometallic valves are made of a single material and formed into the desired shape by forging.

With bimetal valves, the valve shaft and valve head are manufactured separately and subsequently joined by friction welding. This has the advantage that the most suitable material can be chosen in each case for the stem and head. Bimetal valves are used for exhaust valves because that advantage is of particular benefit on the exhaust valves. The valve head can then be made of a material that is suited to extreme temperatures, while the stem can be made of a very hard-wearing material. The valve heads in the N57 engine are made of a special steel (nickel alloy) also known as Nimonic (NiCr20TiAl).

Valve collets

On the N57 engine, as with all BMW diesel engines, non-compression fixings are used.

Valve spring

The N57 engine is fitted with valve springs of the standard design, i.e. symmetrical, cylindrical springs with round wire cross section. With this type of spring the coil spacing is symmetrical at both ends of the spring and the coil diameter is constant. The progression of the spring characteristic (the spring force increases the more the spring is compressed) is achieved by the partial contact between spring coils over the spring travel.

Belt drive and auxiliary equipment

The belt drive system is responsible for driving the auxiliary units without slipping under all load conditions.

On the N57 engine, the auxiliary units are:

- Alternator
- Coolant pump
- A/C compressor
- Power steering pump.

A maximum torque of approximately 41 Nm and a maximum of output 21 kW are transferred to the belt drive (under full load and maximum equipment electrical load).

Particular value is placed on noise-free running and a long service life.

The layout of the system selected must be such that noises, particularly "V-belt squeal", caused by slippage between belt and pulley, are avoided.

⚠ It is essential that auxiliary equipment be fitted in the correct position during assembly. A belt pulley alignment error would result in belt noise and ultimately belt damage.

Observe the procedure in the repair instructions ◄

Versions

On the N57 engine, there are a number of possible versions of the belt drive system. This depends on the following equipment:

- Dynamic Drive
- Electromechanical power steering (EPS).

In either case, the belt drive is a single belt drive whereby all auxiliary equipment is driven by a single belt.

E9x with electromechanical power steering:

- Two-sided poly-V belt with 6 vees
- Mechanical belt tensioner with tensioning force of 320 N
- Additional guide pulley.

E9x with power steering pump:

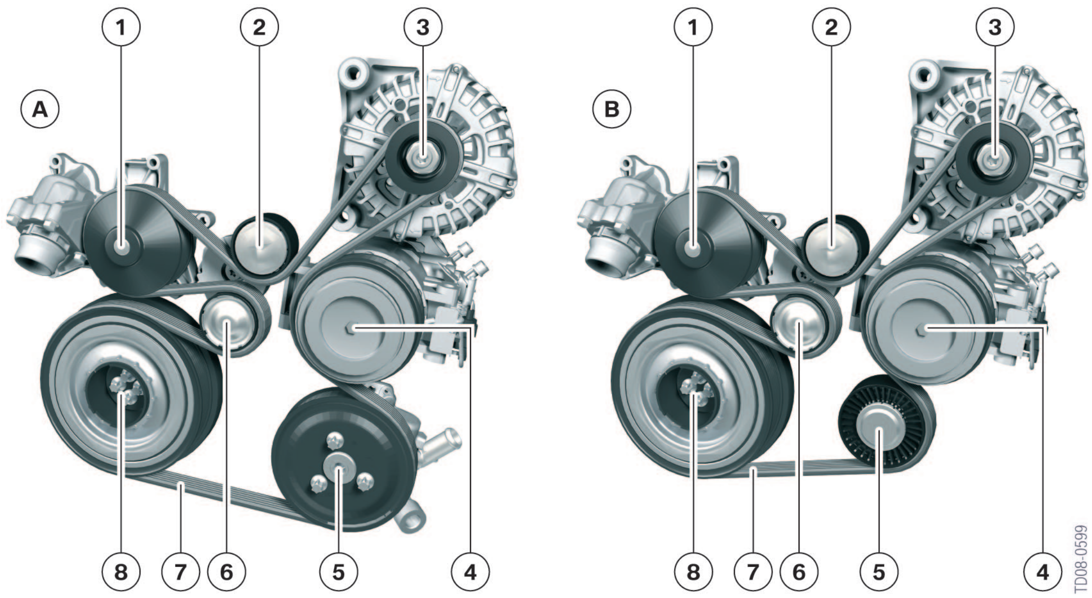
- Two-sided poly-V belt with 6 vees
- Mechanical belt tensioner with tensioning force of 320 N.

F01 with power steering pump:

- Two-sided poly-V belt with 7 vees
- Mechanical belt tensioner with tensioning force of 320 N.

F01 with Dynamic Drive:

- Two-sided poly-V belt with 7 vees
- Mechanical belt tensioner with tensioning force of 450 N.



32 - Variations of belt drive system on N57 engine

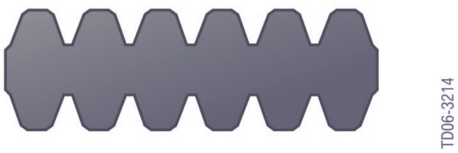
Index	Explanation	Index	Explanation
A	With A/C* and hydraulic power steering**	4	A/C compressor
B	With A/C* and EPS	5	Power steering pump
1	Coolant pump	6	Tensioning pulley
2	Deflection pulley	7	Double-sided drive belt
3	Alternator	8	Rotational vibration damper

*) A/C = Air-conditioning or automatic climate control; **) Hydraulic power steering = power steering pump/tandem pump

Drive belt (poly-V belt)

The drive belt is a two-sided poly-V belt with vees on the inside and the outside.

The inside of the belt is therefore no longer the only side used to drive the auxiliary equipment; the outside of the belt is used too. In this case, it is the air-conditioning compressor that is driven by the outside.



33 - Cross section of a double-sided poly-V-belt

Model	6 vees	7 vees
E9x	X	
F01		X

The benefit of using a double-sided belt is that an additional deflection pulley is no longer required. In addition, the belt drive can have a more flexible and compact design. This also makes it possible to realize a belt drive layout in which all of the auxiliary equipment is located on the left-hand side of the engine.

Tensioning pulley

Due to thermal expansion and tension, the poly-V belt stretches of the course of its service life.

To ensure that the poly-V-belt can transfer the correct amount of torque throughout its service life, it must be held in constant contact with the belt pulleys by a specific amount of force. To this end, the belt tension is strengthened by an automatic tensioning pulley, which compensates for belt elongation over the course of its service life.

Thus the basic belt drive system has a tensioning pulley preloaded with a force of 320 N. That tensioning pulley is identical to the component used on the N47 engine.

The belt drive system for the F01 with Dynamic Drive has a tensioning pulley preloaded with a force of 450 N.

With the Z-type tensioner, the tensioner housing extends into the area behind the belt drive. The initial tension is created by a leg spring. At the same time, the tensioning pulley is friction damped.

The tensioning pulley is located on the unladen side of the belt before the rotational vibration damper in the conventional way.

Deflection pulleys

The deflection pulleys ensure that the necessary arc of belt contact is achieved at all items of auxiliary equipment. This is the only way to achieve non-slip operation.

All versions of the belt drive system on the N57 engine always have a guide pulley between the coolant pump and the alternator.

Auxiliary unit mounting bracket

The E9x models are fitted with the familiar auxiliary unit mounting bracket as used on the N47 engine.

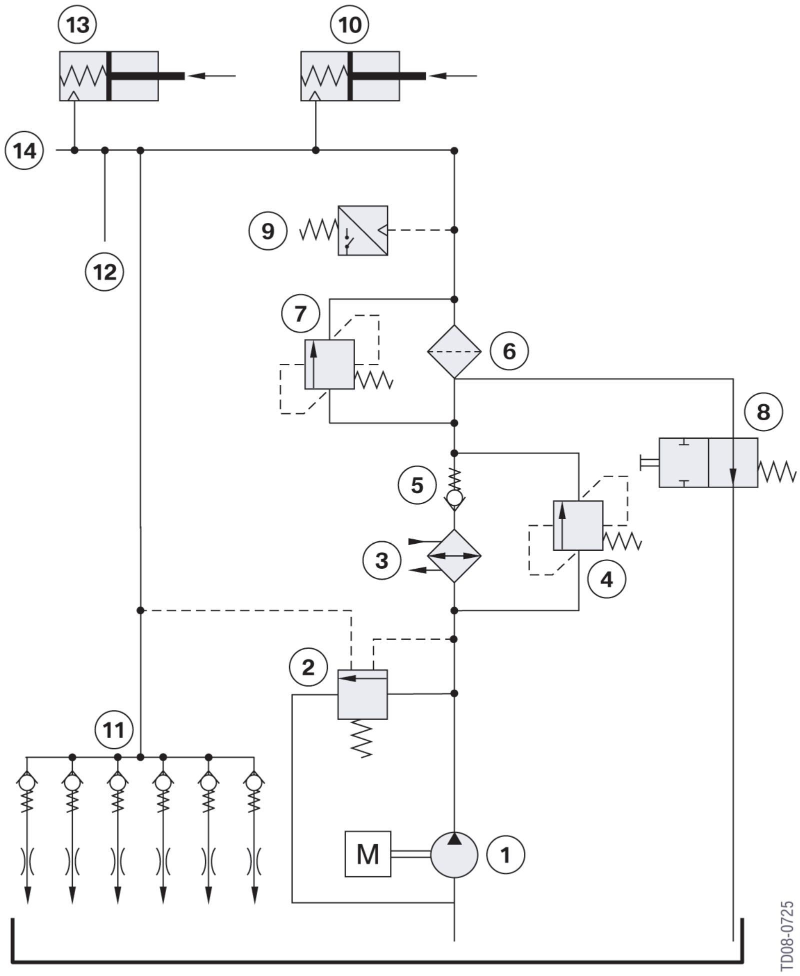
A new component is used on the F01. The auxiliary unit mounting bracket for the F01 is equipped with sliding bushes. This concept has already been used on the E70 for fixing the power steering pump.

⚠ Detailed information on fitting the auxiliary unit mounting bracket can be found in the Repair Instructions. If it is fitted incorrectly, failure of the belt drive system can result. ◄

Oil system

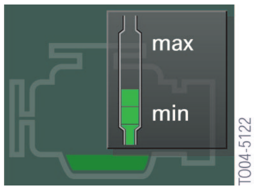
Overview

Oil circuit



34 - Oil circulation system, N57 engine

Index	Explanation	Index	Explanation
1	Oil pump	8	Oil filter outlet valve
2	Pressure limiting valve	9	Oil pressure switch
3	Engine oil-to-coolant heat exchanger	10	Lower chain tensioner
4	Heat exchanger bypass valve	11	Oil spray nozzles with piston cooling valves
5	Non-return valve	12	Lubrication points in the crankcase
6	Oil filter	13	Upper chain tensioner
7	Filter bypass valve	14	Lubrication points in the cylinder head



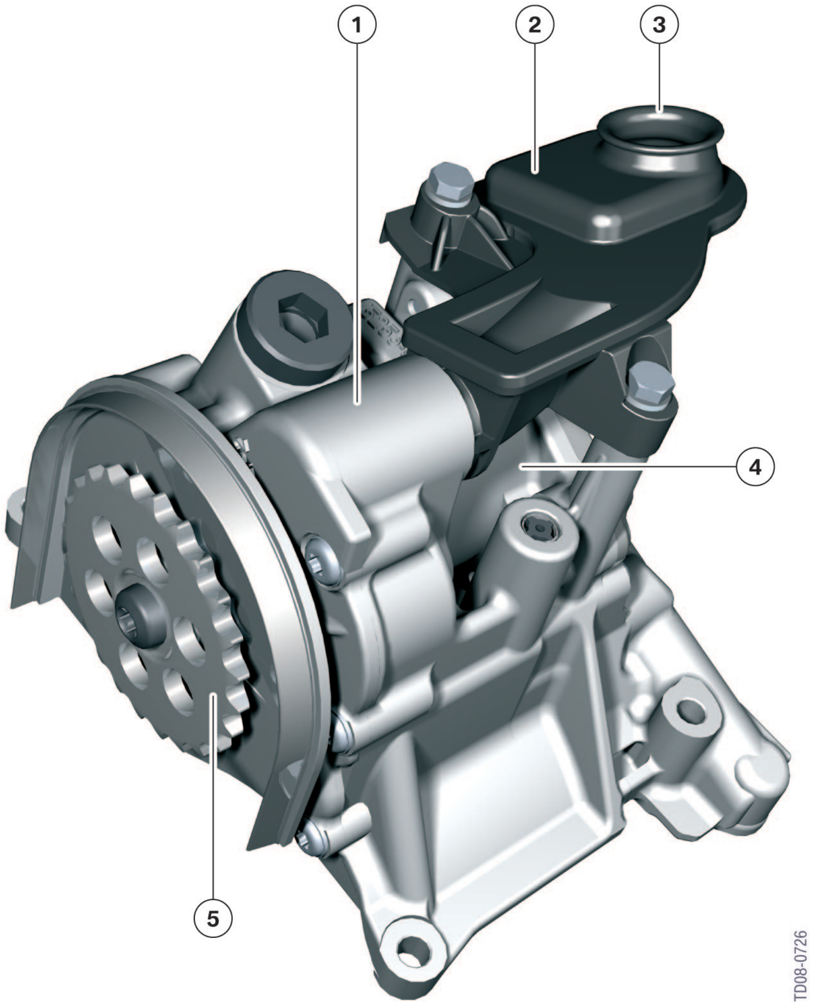
Engine oil must fulfil many diverse tasks. Modern internal combustion engines, and especially the powerful BMW diesel engines, place extreme demands on the engine oil. Such demands can only be met by the appropriate grades of oil. The tasks performed by the oil include lubrication, cooling, microsealing, cleaning, corrosion-proofing and power transmission.

From the sump to the oil filter

Intake pipe

An oil filter is integrated in the intake pipe to keep coarse particles of dirt out of the oil pump.

On the N57 engine the pump intake pipe is a separate component that is bolted onto the oil pump and differs according to sump/model.



35 - Oil/vacuum pump and intake pipe on N57 engine

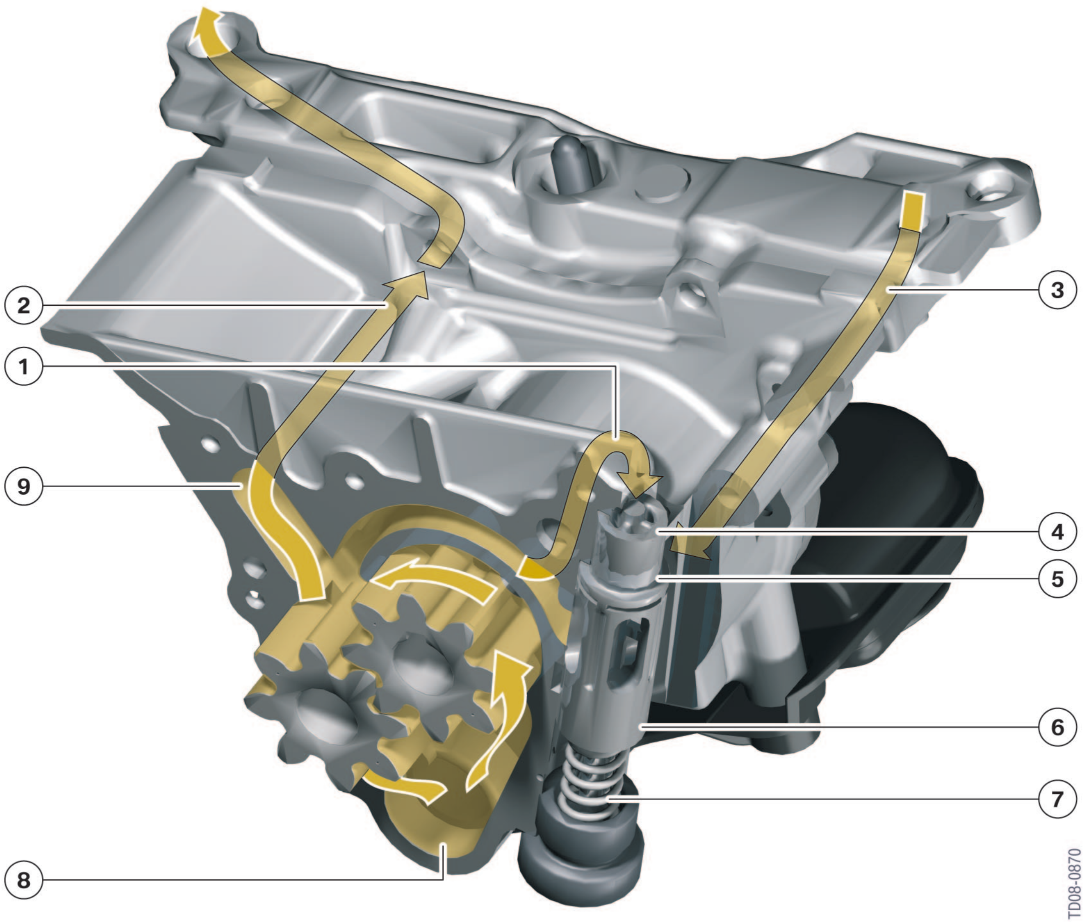
Index	Explanation	Index	Explanation
1	Oil pump	4	Vacuum pump
2	Intake pipe	5	Oil/vacuum pump sprocket
3	Intake snorkel		

Pressure limiting valve

The pressure limiting valve protects against excessively high oil pressure, e.g. when starting the engine with the oil cold. It protects the oil pump, oil pump drive, oil filter and oil cooler.

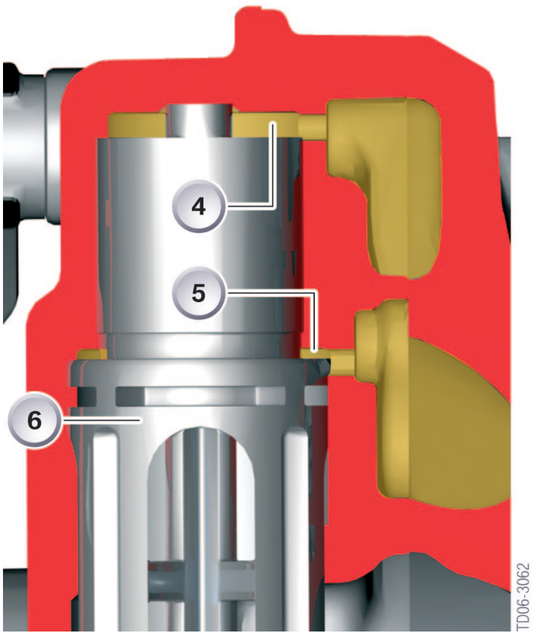
The pressure limiting valve is located on the pressure side between the oil pump and oil filter. On the N57 engine, it is located in the oil pump body.

The opening/limit pressure on the N57 engine is 3.7 bar at an oil temperature of 100 °C and an engine speed of 4,000 rpm.



36 - Oil pump and pressure limiting valve, N57 engine

Index	Explanation	Index	Explanation
1	Oil to upper control chamber	6	Control piston
2	Unfiltered oil channel (to oil filter)	7	Compression spring
3	Filtered oil channel (to lower control chamber)	8	Intake side
4	Upper control chamber	9	Pressure side
5	Lower control chamber		



37 - Control chambers in pressure limiting valve on N57 engine

Index	Explanation
4	Upper control chamber
5	Lower control chamber
6	Control piston

The pressure limiting valve on the N57 has a special feature. On previous diesel engines, oil acted on the pressure limiting valve downstream of the filter. On the N57 engine, the oil acts on the pressure limiting valve not only downstream of the filter but also immediately downstream of the pump.

The oil is taken in by the spur-gear oil pump and delivered to pressure side (9). A duct carries oil (1) from pressure side (9) to upper control chamber (4) of the pressure limiting valve, causing pressure to build up downstream of the oil pump and upstream of the oil filter.

The remaining oil flows through unfiltered oil duct (2) to the oil filter and finally into the main oil duct. Oil returns to the oil pump housing through clean oil duct (3) and from there supplies lower control chamber (5) of the pressure limiting valve through an oil bore. As a result, the system pressure of the oil circuit is present in the control chamber (downstream of the oil filter).

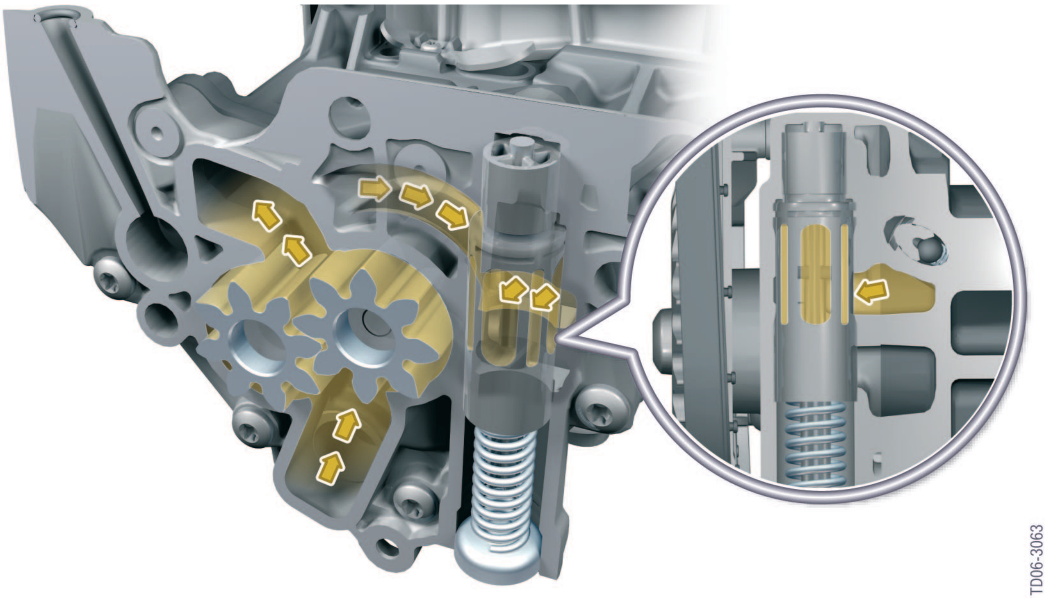
The control chambers are bordered on one side by control piston (6), which is acted on by a return spring (7).

At low oil pressures, the pressure limiting valve is closed.

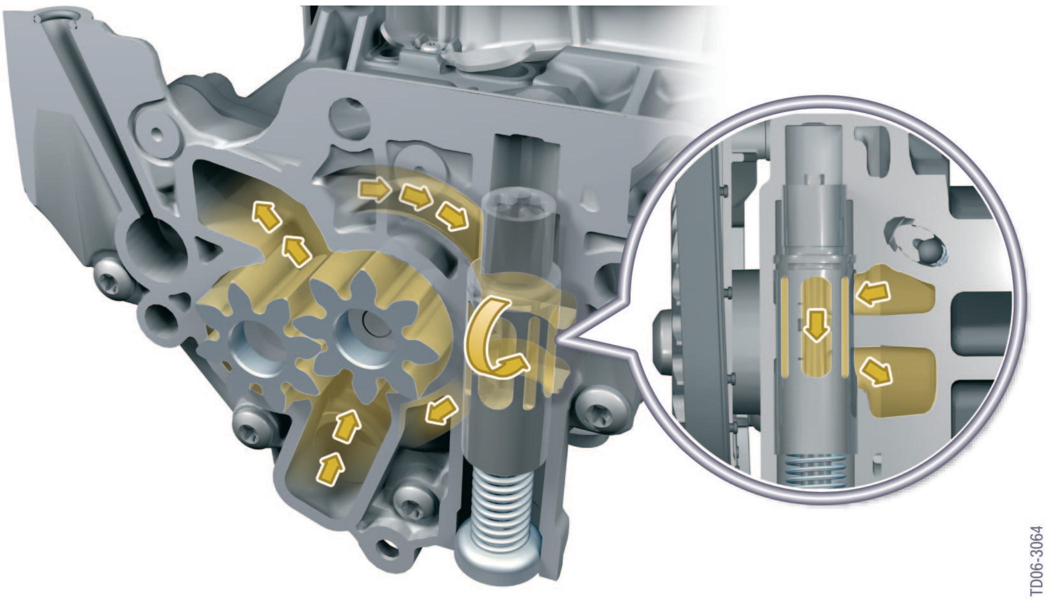
The spring force of the return spring determines the opening pressure of the pressure limiting valve.

If the system pressure in the oil circuit increases, and thus in the control chamber, the control piston is moved against the spring force. Due to the special shape of the control piston, a connection between the pressure side of the spur-gear oil pump and the intake section is opened.

The oil circuit is for all intents and purposes closed briefly. As a consequence of the pressure ratios, a certain amount of oil flows from the pressure side and into the intake section. The more the control piston opens, the greater the volume of oil that flows away. This causes a drop of pressure in the system. Since the control piston is opened by system pressure, there is a return to equilibrium. In that way, the pressure in the system cannot exceed a desired maximum limit which is determined by the force of the compression spring.



38 - Pressure limiting valve closed, N57 engine



39 - Pressure limiting valve open, N57 engine

The reason why oil acts on the control piston directly downstream of the pump and also downstream of the filter is because:

- Because the valve is connected to the oil circulation system downstream of the filter, it is subjected to the actual oil pressure in the system and not the pressure between the oil pump and the filter.

  If the oil filter is dirty, the pressure downstream of the filter drops, whereas the pressure directly downstream of the pump increases. If the pressure limiting valve were to respond only to the pressure downstream of the pump, it would open in that situation even though the maximum system pressure had not been reached. In extreme cases, this could result in an undersupply of lubricating points.

- If the control piston were to be controlled only by oil downstream of the oil filter, a very high pressure would build up in the engine oil circuit during a cold start (at extremely low temperatures and thus with a correspondingly viscous oil) until the oil reached the pressure limiting valve and the pressure were regulated down.

  The high pressure could lead to damage of components and, due to the increased drive output required for the oil pump, also cause a deterioration in the starting characteristics of the engine.

The superposition of two pressures at the pressure limiting valve helps to achieve optimum component protection and, at the same time, ensure a reliable supply of lubricating points and good cold-start characteristics.

Oil pump

The oil pump plays a central role on modern internal combustion engines like the N57. The high power and enormous torque produced even at low engine speeds demand that a high rate of oil flow is ensured. This is necessary for reasons of high component temperatures and bearings being subjected to high loads.

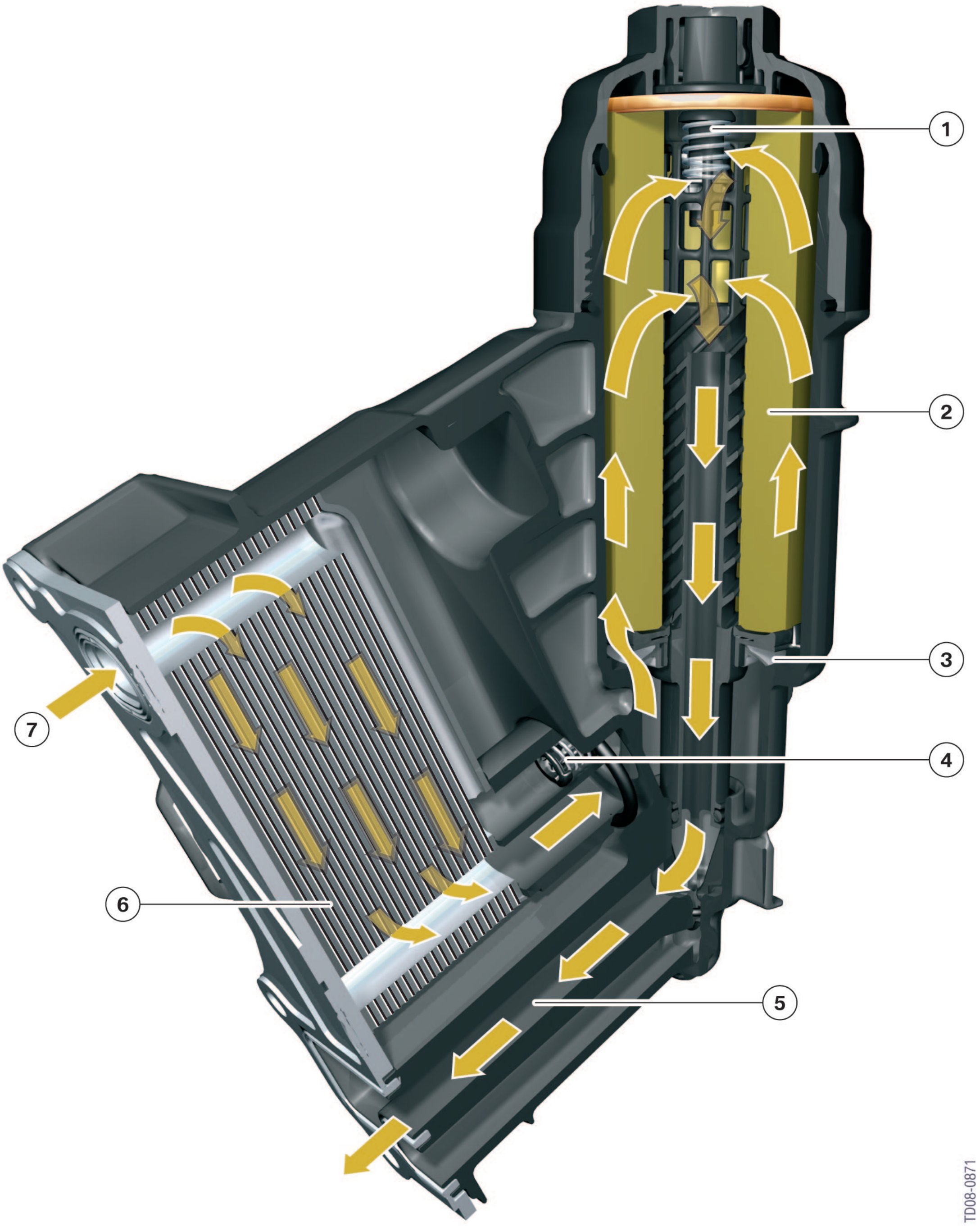
On the other side, a demand-oriented oil pump is required in order to achieve low fuel consumption.

There are different types of oil pumps to meet these requirements. The N57 engine uses the gear-type oil pump familiar from the N47 engine.

The oil pump (OP) on the N57 engine is driven by a chain running off the crankshaft (CS) with a transmission ratio of i = 21:23 (CS:OP); its theoretical delivery rate is 18.6 cm^3 per revolution of the oil pump. The delivery rate of the N47 oil pump was 16 cm^3 per oil-pump revolution. The higher delivery rate compared to the N47 engine has been achieved by a wider gear set and a different transmission ratio.

On the N57 engine, the oil pump forms a single unit with the vacuum pump. They share the drive of the crankshaft, but they are separate in their function.

Oil filtration and oil cooling



40 - Oil filter module, N57 engine

Index	Explanation	Index	Explanation
1	Filter bypass valve	5	Main oil duct
2	Oil filter	6	Engine oil-to-coolant heat exchanger
3	Non-return valve	7	Unfiltered oil duct
4	Heat exchanger bypass valve		

Oil filter

The N57 engine is fitted with the full-flow oil filter used on all BMW engines. The entire volume of oil delivered by the oil pump flows through the full-flow oil filter. With the launch of the N57 engine, the N47 will also be fitted with an oil module made completely of plastic with integral oil-to-coolant heat exchanger. The oil module differs on the N47 and N57 engines and also according to transmission type and national variant.

Non-return valve

The oil flows through the oil pump into the oil filter, passing through a non-return valve in the process. That valve prevents the oil filter from running dry when the engine is switched off because it only allows the oil to flow through in one direction and prevents it flowing back in the other direction.

This ensures that the lubricating points are supplied with oil when the engine is started. The oil must overcome a non-return valve opening pressure of approx. 0.2 bar. If the oil ducts have run dry, particularly after the vehicle has been parked up for a long period, there may be noises or even poor engine operation shortly after the engine has started.

The non-return valve is a silicon lip attached to the oil filter element. Thus, the non-return valve is replaced every time the oil filter element is replaced.

Filter bypass valve

In order to ensure that oil is supplied to the lubrication points even if the filter is clogged, there is a filter bypass valve (short-circuit valve) mounted parallel to the filter at the top. If the difference in oil pressure upstream and downstream of the filter increases to more than 2.5 bar due to a clogged filter, the filter bypass valve opens and the oil is able to reach the lubrication points (albeit unfiltered).

At low outside temperatures, the cold oil can be so viscous that it clogs up the oil filter. In that situation too, the filter bypass valve will open.

Oil-to-coolant heat exchanger

In high-performance engines that are subject to high thermal stresses, there is a risk of the lubricating oil becoming too hot when the engine is under load. For that reason, the N57 engine has an oil-to-coolant heat exchanger. The oil/coolant heat exchanger heats the oil rapidly in the warm-up phase and then provides sufficient cooling.

Oil and coolant flow in opposite directions through the oil/coolant heat exchanger through plates at multiple levels. In this way, heat is transferred from one liquid to the other.

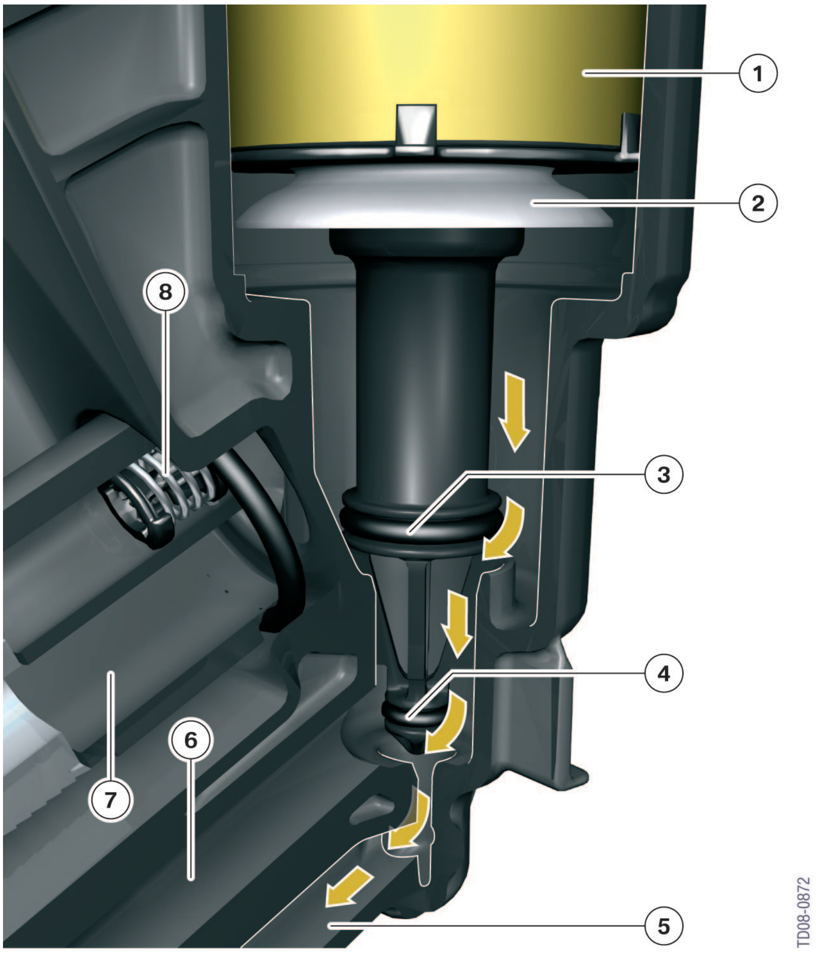
Heat exchanger bypass valve

The heat exchanger bypass valve has the same function as the filter bypass valve. If the oil pressure increases due to a clogged oil/coolant heat exchanger, the heat-exchanger bypass valve opens at a differential pressure of 2.0 bar and the oil is still able to reach the lubrication points (albeit unfiltered).

Drain valve

The drain valve (4) returns the oil to the sump via a return channel (5) when the oil filter is changed. The valve is in the form of a ring seal that is attached to the bottom of the guide tube and seals off the passage to the return channel when the oil filter housing is closed.

If the oil filter cover is opened in order to replace the oil filter, the guide tube with the oil filter element fitted over it moves upwards. The piston with the seal is pulled out of the return duct and oil flows to the sump.

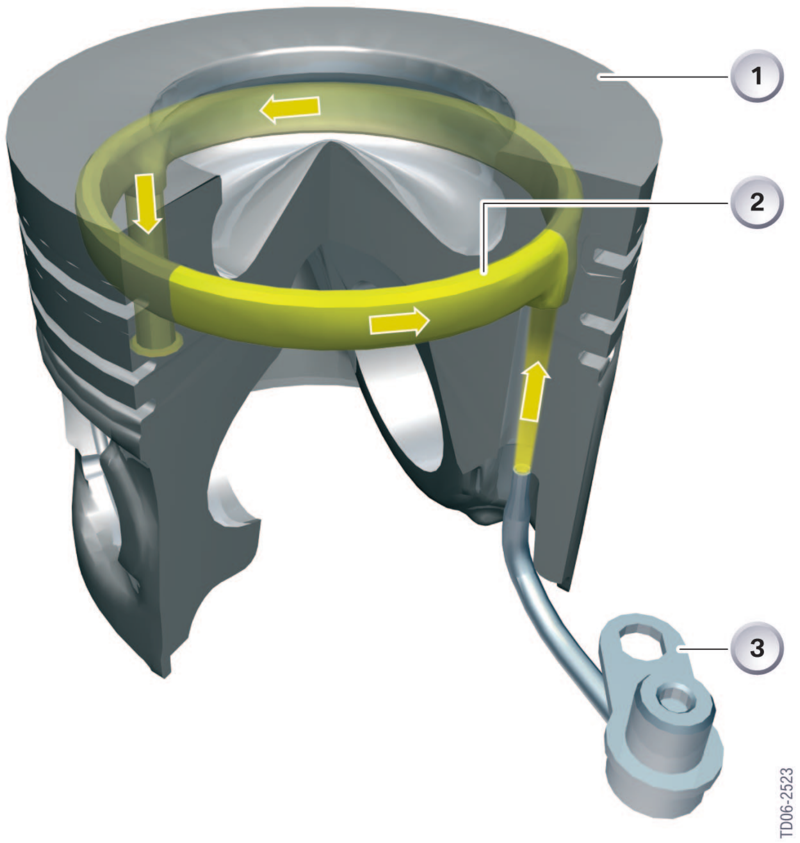


41 - Oil filter and drain valve N57 engine

Index	Explanation	Index	Explanation
1	Oil filter	5	Return duct
2	Non-return valve	6	Main oil duct
3	Seal	7	Heat exchanger bypass valve
4	Outlet valve	8	Unfiltered oil duct

Oil spray nozzles and piston cooling valves

Oil spray nozzles for piston cooling



42 - Oil spray nozzle for piston cooling

Index	Explanation	Index	Explanation
1	Piston crown	3	Oil spray nozzle for piston cooling
2	Piston cooling duct		

The oil spray nozzle supplies the cooling channel in the piston crown with oil. It sprays oil precisely into the cooling duct, where the oil collects. The movement of the piston causes the oil to circulate and has a "shaker effect". In the process, the oil vibrates in the duct and thereby improves the cooling effect. The oil returns again through further bores.

⚠ Exact positioning of the oil spray nozzles is necessary in order to achieve optimum cooling.

Bent or damaged oil spray nozzles must be replaced with new ones, otherwise there is a risk of engine damage.

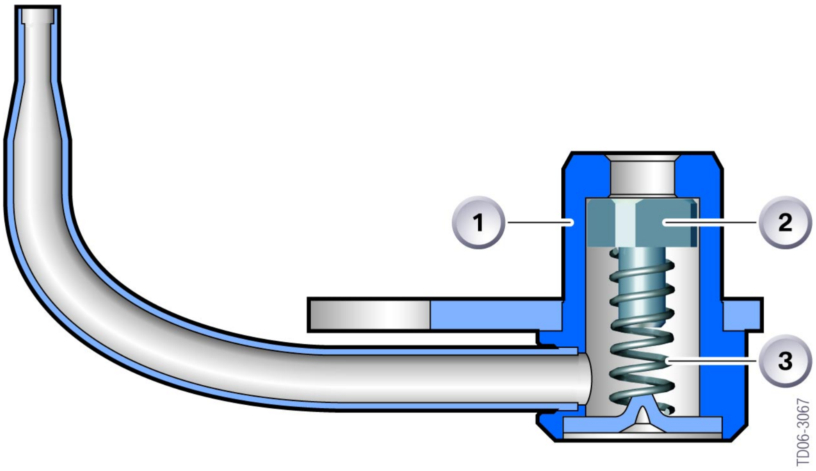
The oil spray nozzles are positioned precisely with the aid of a special tool. Please observe the repair instructions. ◄

Piston cooling valve

The piston cooling valve is generally located upstream of the oil spray nozzles. On the N57 engine, each oil spray nozzle has its own piston cooling valve.

The piston cooling valves ensure that the oil spray nozzles do not begin to work until a defined pressure of 1.2 bar is reached. There are various reasons for this:

- The spray oil would not even reach the piston crown if the oil pressure were too low.
- At insufficient pressure levels, it prevents a further loss of pressure through the oil spray nozzles, which could mean oil failing to reach the lubricating points.
- With the engine switched off, it prevents the oil ducts from running dry as a consequence of oil draining from the oil spray nozzles and, during an engine start, prevents there being no oil at the lubricating points.



43 - Piston cooling valve in the oil spray nozzle for piston cooling

Index	Explanation	Index	Explanation
1	Housing	3	Spring
2	Piston		

The piston (2) is held against the opening in the valve body (1) by the spring (3). That seals off the inlet port and no oil can enter the oil spray nozzle. Only above a defined oil pressure does the piston move against the spring force and allow the oil to reach the oil spray nozzles.

The piston has a square cross-sectional area with rounded edges, which act as the slideway in the cylinder. When the piston cooling valve is closed, the end face acts as a sealing face. When the valve opens, oil is able to flow between the cylinder wall and the flat sides of the piston.

Oil spray nozzle for lubricating timing chain

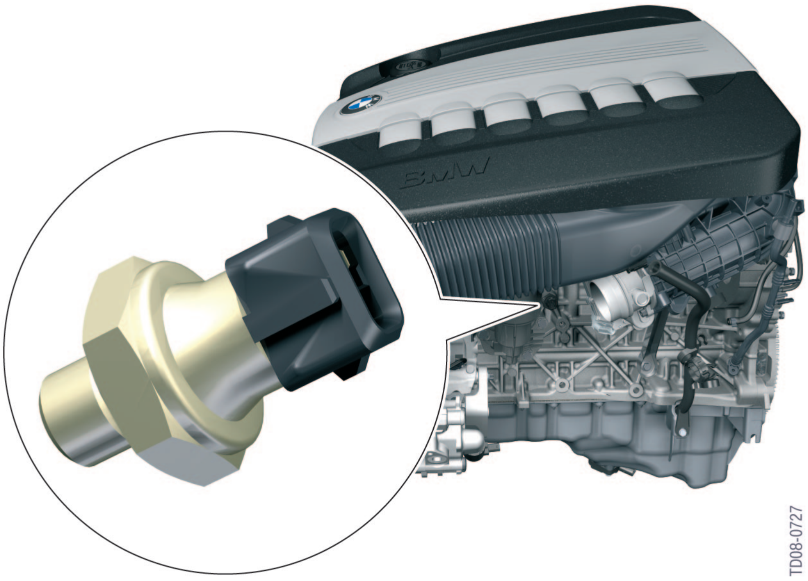
The chain drive is lubricated by an oil spray nozzle. This is a plastic part that is screwed into the crankcase in the timing case. At sufficient oil pressures, oil is sprayed through three bores onto the two timing chains (timing chain between crankshaft and high-pressure pump, timing chain between high-pressure pump and camshaft).

⚠ If the timing chain is dropped into the crankcase when being fitted, there is a risk of damaging the oil spray nozzle for lubricating the timing chain. ◄

Oil monitoring

Oil pressure switch

The oil pressure switch is located on the engine block below the oil filter.



44 - Oil pressure switch location N57 engine

The purpose of the oil pressure switch is to monitor the lubrication system. The oil pressure switch connects the oil pressure indicator light to earth. The oil pressure switch is held closed by a spring and can be opened by oil pressure. The oil pressure indicator light lights up if the oil pressure is too low to open the oil pressure switch. The spring defines the pressure value above which the oil pressure switch should open. On the N57 engine, that pressure is approximately 0.2 to 0.5 bar.

⚠ Red indicator lamp comes on and an audible signal sounds while the vehicle is in motion (e.g. engine oil pressure too low):

- Stop immediately and turn off the engine.
- Check oil level, top up oil if necessary.
- If the engine oil level is OK, contact your nearest BMW Service. ◄

⚠ If the oil pressure switch connector is not plugged in, there is no oil pressure warning and the oil pressure indicator lamp can not be switched on. ◄

Oil condition sensor

A QLT (Quality/Level/Temperature) oil condition sensor is used on the N57 engine. The oil condition sensor is able to determine oil quality as well as level and temperature. On the M57TU2 engine, a temperature and level sensor was used.

The information about engine oil quality is not used on the N57 engine. The engine oil quality is not taken into account in the CBS data.

The oil level and oil temperature are recorded continuously while Terminal 15 is switched on. The oil condition sensor is powered via Terminal 87.

The electronic circuitry of the oil condition sensor has a self-diagnosis function. If a fault is detected on the component, a fault message to that effect is sent to the digital diesel engine management module.

⚠ Yellow indicator lamp comes on and an audible signal sounds:

- Comes on while driving:
  The oil level is at the absolute minimum - top up engine oil as soon as possible. Until then, do not drive more than approx. 50 km.
- Comes on after switching off the engine:
  Top up engine oil at the next opportunity, e.g. refuelling stop.
- Comes on immediately after turning on the ignition and before starting the engine:
  There is a fault in the electrical oil level measuring system. Have checked by your BMW Service. ◄

⚠ You will find the procedure for measuring the oil level in the Owner's Handbook.

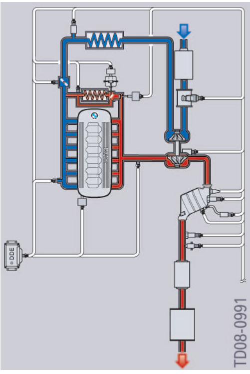
The oil consumption depends on the driving profile and operating conditions. ◄

Complaints about oil consumption can often be a result of using the wrong measurement procedure. The precise oil consumption measurement procedure is detailed in the Repair Instructions.

⚠ An oil consumption measurement should not be carried out until at least 7,500 km have been covered because it is only after that distance that the engine running-in phase is more or less complete and the oil consumption has stabilized. ◄

Oil dipstick

There is also an oil dipstick for checking the oil level when servicing. The oil dipstick tube is made of plastic.

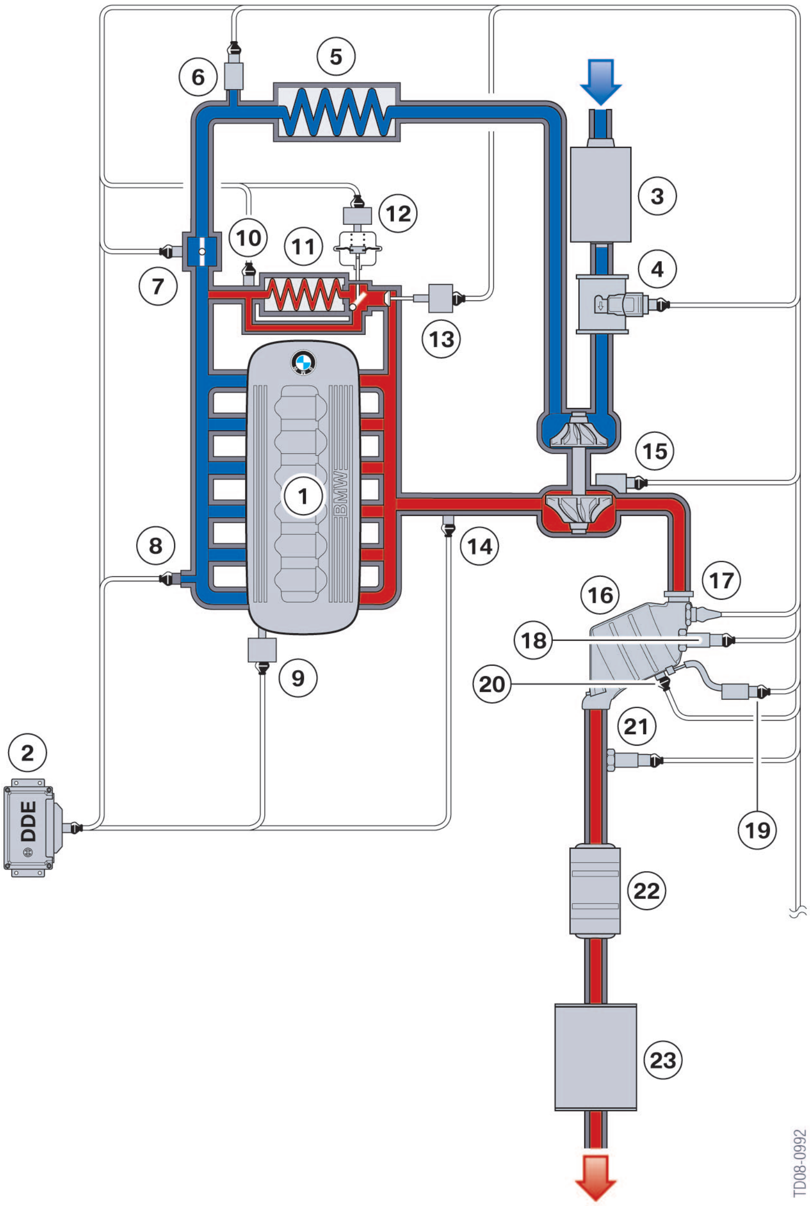


The air intake system can be divided into two component groups. The air intake duct, intercooler and, with some exceptions, the intake muffler are specific to the vehicle and differ according to vehicle model variations even with the same engine. The turbocharger and the intake manifold including swirl flaps, throttle body and various sensors are specific to the engine. The exhaust system is specific to the vehicle apart from the turbocharger and the exhaust manifold and differs according to vehicle model and variant.

Air intake and exhaust system

Overview

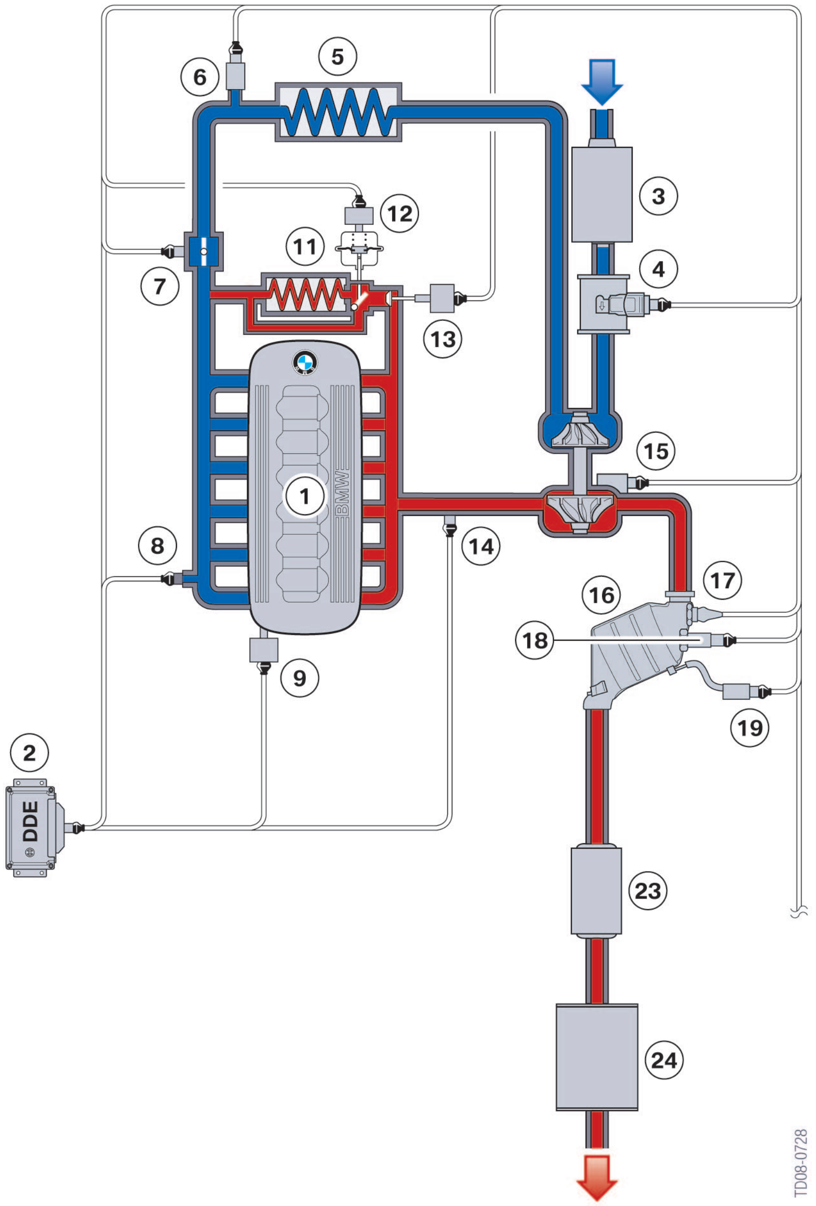
N57 engine for EURO 6 on E90



45 - Air intake and exhaust system on N57 engine for EURO 6 on E90

Index	Explanation	Index	Explanation
1	N57 Engine	13	EGR valve with position sensor
2	Digital diesel engine management module	14	Exhaust back-pressure sensor upstream of turbocharger
3	Intake silencer (air cleaner)	15	Charge pressure adjuster
4	Hot-film air mass meter (HFM)	16	NO_x accumulator catalytic converter and diesel particulate filter
5	Intercooler	17	Exhaust temperature sensor upstream of NO_x accumulator catalytic converter
6	Charge-air temperature sensor	18	Oxygen sensor upstream of NO_x accumulator catalytic converter
7	Throttle valve	19	Exhaust back-pressure sensor downstream of NO_x accumulator catalytic converter
8	Charge pressure sensor	20	Exhaust temperature sensor downstream of NO_x accumulator catalytic converter
9	Swirl flap regulator	21	Oxygen sensor downstream of diesel particulate filter
10	EGR temperature sensor	22	H_2S blocking catalytic converter
11	EGR cooler	23	Rear silencer
12	Bypass valve		

N57 engine for EURO 5 on E90

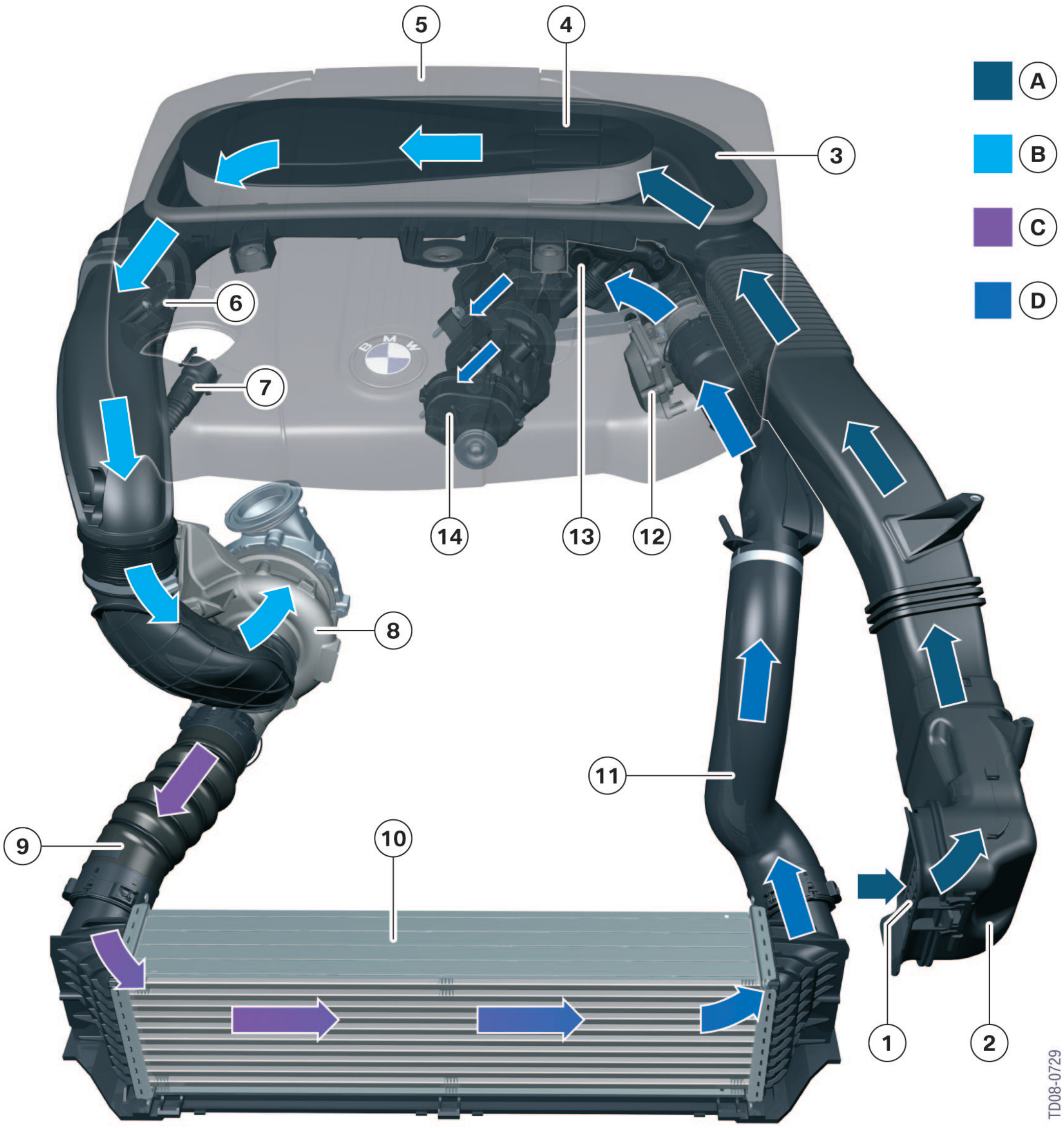


46 - Air intake and exhaust system on N57 engine for EURO 5 on E90

Index	Explanation	Index	Explanation
1	N57 Engine	12	Bypass valve
2	Digital diesel engine management module	13	EGR valve with position sensor
3	Intake silencer (air cleaner)	14	Exhaust back-pressure sensor upstream of turbocharger
4	Hot-film air mass meter (HFM)	15	Charge pressure adjuster
5	Intercooler	16	Oxidation catalytic converter and diesel particle filter
6	Charge-air temperature sensor	17	Exhaust temperature sensor upstream of oxidation catalytic converter
7	Throttle valve	18	Oxygen sensor upstream of oxidation catalytic converter
8	Charge pressure sensor	19	Exhaust back-pressure sensor downstream of oxidation catalytic converter
9	Swirl flap regulator	23	Centre silencer
11	EGR cooler	24	Rear silencer

Air intake system

Overview



47 - N57-engine air intake system on F01

Index	Explanation	Index	Explanation
A	Unfiltered air	6	Hot-film air mass flow sensor
B	Purified air	7	Blow-by gas connection
C	Heated charge air	8	Exhaust turbocharger
D	Cooled charge air	9	Charge-air pipe
1	Coarse filter	10	Intercooler
2	Intake snorkel	11	Charge-air pipe
3	Unfiltered-air section of air intake muffler	12	Throttle valve
4	Filter element	13	Intake manifold
5	Air intake muffler cover	14	Swirl flap regulator

The unfiltered air (A) drawn in passes through a coarse filter (1) into the air intake duct (2) and the unfiltered air section of the air intake muffler (3) to the filter element (4). The filter element filters the unfiltered air passing through it, which then becomes filtered air (B). The filtered air passes from the air intake muffler via the hot-film air mass flow sensor (6) and the filtered-air duct to the turbocharger (8). At the same time, blow-by gases are fed into the purified air pipe through blow-by gas connection (7). In the exhaust turbocharger, the purified air is compressed and thereby heated. The compressed, heated charge air (C) is forced along the charge-air pipe (9) to the intercooler (10).

From the intercooler, the cooled charge air (D) travels on via the charge-air pipe (11) to the throttle body (12). Depending on the position of the throttle valve, cooled charge air (D) flows into intake manifold (13). The exhaust recirculation also feeds into the intake manifold. From the intake manifold, the cooled charge air passes into the cylinder via the tangential port or the swirl port depending on the position of the swirl flap positioner (14).

⚠ If the purified air pipe downstream of the blow-by gas connection is heavily oiled, this could imply increased blow-by gas levels. The cause is usually a leak in the engine (e.g. crankshaft seal) or extraneous air taken in through the vacuum pipes. A consequential symptom would then be an oily exhaust turbocharger, which does not mean that there is a fault with the exhaust turbocharger itself. ◄

Unfiltered air duct

The unfiltered air duct comprises the unfiltered air snorkel and the unfiltered air pipe. Both are designed with the crash safety of pedestrians in mind. This entails the use of especially soft materials and yielding connections.

The unfiltered-air duct on the E9x with N57 engine is referred to as an unfiltered-air cowl. This has a large surface area, but is exceptionally flat. The air is drawn in by the cooling module.

Air intake muffler on E9x

On the E9x models, the air intake muffler is rigidly attached to the vehicle. The housing is designed in such a way that it can "give" in the event of an impact from above (passive safety feature for reducing pedestrian impact severity). This means that it compresses by several centimetres.

The air filter element is designed to be changed at every 3rd oil change. In very dusty conditions, it may need to be changed more frequently.

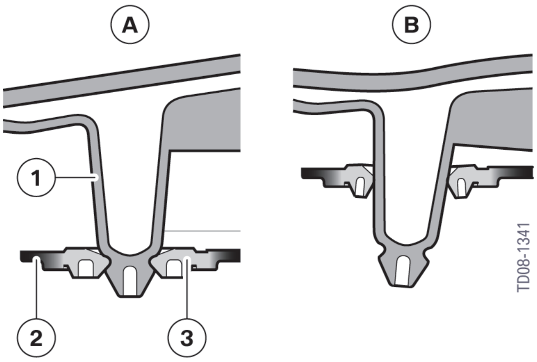
Air intake muffler on F01

The air intake muffler has been combined with the engine cover. On the F01 the air intake muffler is made completely of plastic and designed to be deformable. In that way, the area between engine and bonnet is utilized to optimum effect.

The cover of the air intake muffler is provided with specially developed post fixings and made of plastic. The mating components for the fixings are discs made of Elastollan in the lower part of the housing.

The plastic post fixings are cone shaped and taper towards the bottom.

If the bonnet is depressed as a result of a crash impact, the cover is pressed down by the bonnet and the post fixings are forced downwards through the Elastollan discs. As a result of the choice of material and the shape, the force required increases relative to travel so that optimum crash safety is provided. So that the filter element does not form a hindrance, it too is designed to be deformable.



48 - Crash function of post fixings on F01

Index	Explanation
A	Post fixing in normal condition
B	Post fixing after crash impact
1	Post
2	Lower section of air intake muffler
3	Elastollan disc

The air filter element is designed to be changed at every 3rd oil change. In very dusty conditions, it may need to be changed more frequently.

Hot-film air mass flow sensor

The hot-film air mass meter is located directly downstream of the intake silencer. It is secured to its housing. The digital HFM6 already used in other engines is fitted.

The HFM signal is used for calculating the fuel injection volume and the exhaust recirculation rate.

Exhaust turbocharger

The exhaust turbocharger compresses the intake air. In this way, significantly more oxygen can be delivered to the combustion chamber.

The operation of the exhaust turbocharger is described in the Exhaust system section.

Intercooler

The temperature of the air increases as the air is compressed in the exhaust turbocharger. This causes the air to expand. This effect undermines the benefits of the exhaust turbocharger because less oxygen can be delivered to the combustion chamber. The charge-air cooler cools the compressed air, the air's density increases and thus more oxygen can be delivered to the combustion chamber.

The charge-air cooler is located at the bottom end of the cooling module.

Charge-air temperature sensor

The charge-air temperature sensor records the temperature of the compressed fresh air. It is located in the boost-pressure pipe, directly upstream of the throttle valve. The charge-air temperature is used as a substitute value for calculating the air mass.

This is used to check the plausibility of the value of the HFM. If the HFM fails, the substitute figure is used to calculate the fuel injection volume and the exhaust recirculation rate.

The electrical function is described in the Engine electrical system section.

Throttle valve

A throttle valve is required on all diesel engines equipped with a diesel particulate filter system. By restricting the intake air flow, the throttle valve ensures that the higher exhaust temperatures required for regenerating the diesel particulate filter are achieved.

The throttle valve is closed while the engine is stopping to prevent the engine from shaking during the stopping process. After the engine has stopped, the throttle valve is reopened.

Another function protects the engine against damage from over-revving. If the digital diesel engine management module detects the engine revving up without the fuel injection volume having been increased, the throttle valve is closed to limit the engine speed.

Intake manifold

The intake manifold is made of plastic. Inside it, the air is branched off the individual cylinders. In addition, the runners to each individual cylinder divide further into swirl-port and tangential-port runners. On the N57 engine, both runners are routed along the side of the cylinder head.

The swirl duct ensures reliable swirl in the combustion chamber, and the tangential duct ensures optimum cylinder charge, which is why the tangential duct is also referred to as a charge duct. The swirl flaps are located in the tangential ducts.

The swirl duct is identifiable by its almost rectangular cross section, while the tangential duct is round.

Charge pressure sensor

The charge-pressure sensor is required for controlling the charge pressure. With the aid of the charge-pressure sensor, the charge pressure is monitored on the basis of a data map stored on the DDE control unit.

Swirl flaps

The swirl flaps close the tangential ducts so that, at low engine speeds, a more powerful swirl of air is generated in the combustion chamber. With increasing engine speed, they open to ensure cylinder charging through the tangential ducts.

The swirl flaps are adjusted by a linkage driven by a DC motor. The control of the DC motor and the control parameters are described in the Engine electrical system section.

Exhaust system

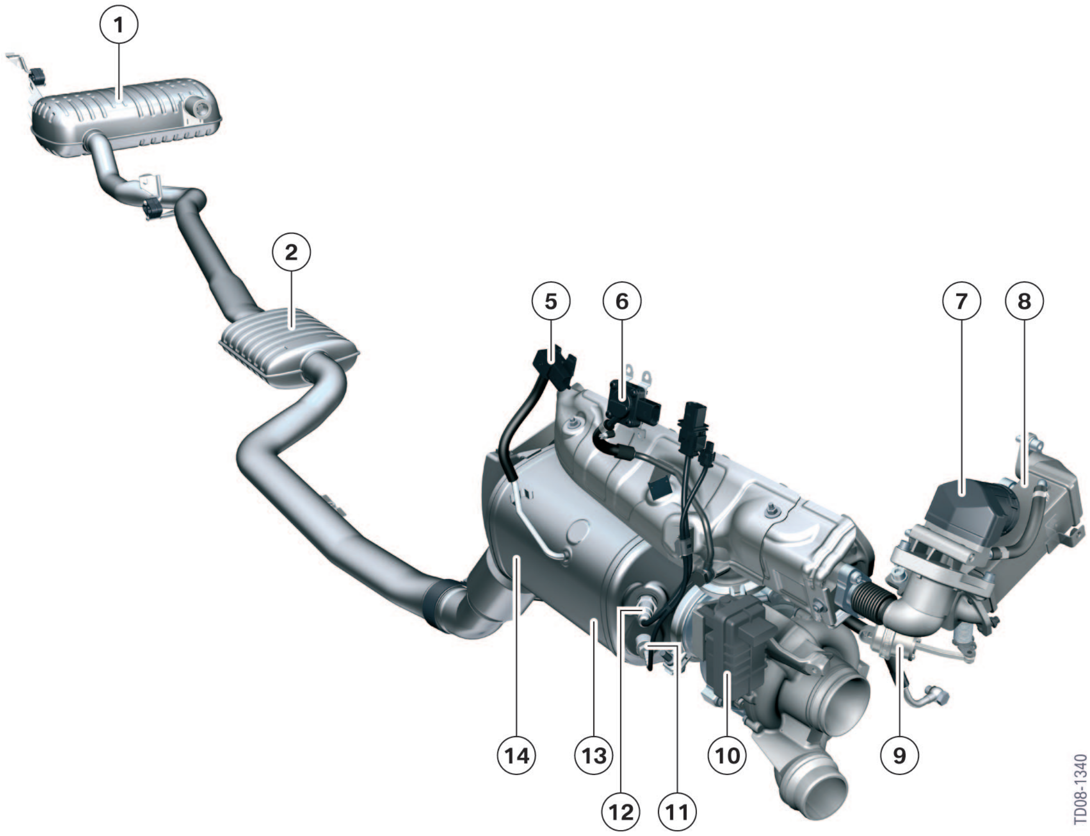
The exhaust treatment system is identical in function to that of the M57TU2 engine with diesel particulate filter.

However, there are differences arising from compliance with the EURO 5 and EURO 6 emission standards. Thus, new components have been added and familiar components modified.

The N57 engine, too, has a variable nozzle turbine (VNT) turbocharger with an electric charge-pressure adjuster.

The oxidation catalytic converter and the diesel particulate filter are located in one housing close to the engine.

Exhaust system for EURO 5 on E90 with N57D30O0 engine



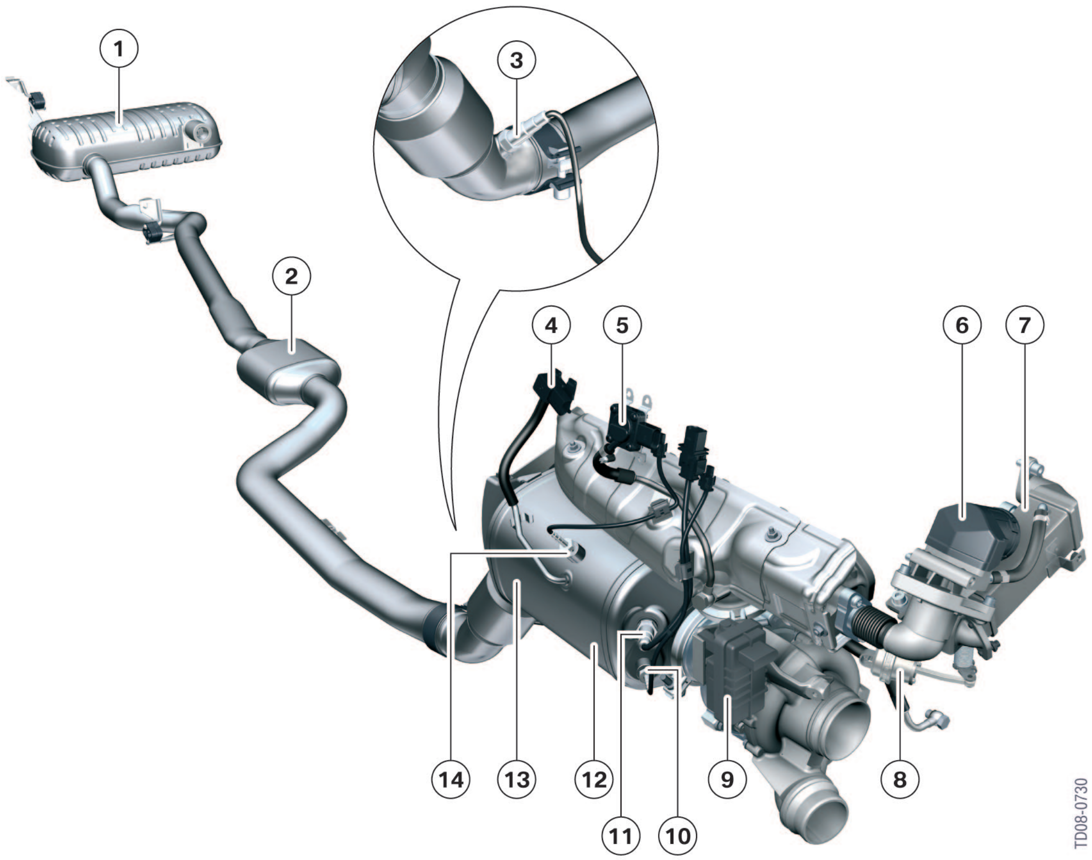
49 - Exhaust system with EURO 5 technology on N57 engine in E90

Index	Explanation	Index	Explanation
1	Rear silencer	9	Bypass-valve vacuum unit
2	Centre silencer	10	Charge pressure adjuster
5	Exhaust back-pressure sensor downstream of oxidation catalytic converter	11	Exhaust temperature sensor upstream of oxidation catalytic converter
6	Exhaust back-pressure sensor upstream of turbocharger	12	Oxygen sensor upstream of oxidation catalytic converter
7	EGR valve	13	Oxidation catalytic converter
8	EGR cooler	14	Diesel particle filter

The exhaust system for the EURO 5 version comprises the following components:

- Bypass valve
- EGR valve
- Exhaust back-pressure sensor upstream of turbocharger
- Charge pressure adjuster
- Exhaust temperature sensor upstream of catalytic converter
- Oxygen sensor upstream of catalytic converter
- Exhaust back-pressure sensor upstream of diesel particulate filter.

Exhaust system for EURO 6 on E90 with N57D30O0 engine



50 - Exhaust system with EURO 6 technology on N57 engine in E90

Index	Explanation	Index	Explanation
1	Rear silencer	8	Bypass-valve vacuum unit
2	H_2S blocking catalytic converter	9	Charge pressure adjuster
3	Oxygen sensor downstream of diesel particulate filter	10	Exhaust temperature sensor upstream of NO_x accumulator catalytic converter
4	Exhaust back-pressure sensor downstream of NO_x accumulator catalytic converter	11	Oxygen sensor upstream of NO_x accumulator catalytic converter
5	Exhaust back-pressure sensor upstream of turbocharger	12	NO_X accumulator catalytic converter
6	EGR valve	13	Diesel particle filter
7	EGR cooler	14	Exhaust temperature sensor downstream of NO_x accumulator catalytic converter

Additional components for EURO 6 version:

- EGR temperature sensor
- Exhaust temperature sensor downstream of NO_x accumulator catalytic converter
- Oxygen sensor downstream of diesel particulate filter
- NO_x accumulator catalytic converter instead of standard catalytic converter

- H_2S blocking catalytic converter in place of centre silencer.

Exhaust manifold

The N57 engine has a cast six-into-one exhaust manifold. At the front end is the outlet for the exhaust gas recirculation. The routing of the runners is designed so that, despite the connection for the turbocharger having been moved one cylinder further forwards, the efficiency of charge replacement is not impaired. Because of the higher stresses, a new casting material known as SIMO1000+ has been developed with the assistance of the supplier.

Exhaust turbocharger

The N57 engine introduces a new VNT-control turbocharger with a boost pressure of up to 2.5 bar absolute pressure.

The variable turbine geometry makes it possible to alter the flow conditions for the turbine wheel in relation to the engine operating point. The turbocharger is a Honeywell/Garrett unit with electrically actuated VNT.

The advanced design of the impeller and turbine wheels has made it possible to optimize the turbocharger thermodynamics.

Exhaust treatment system

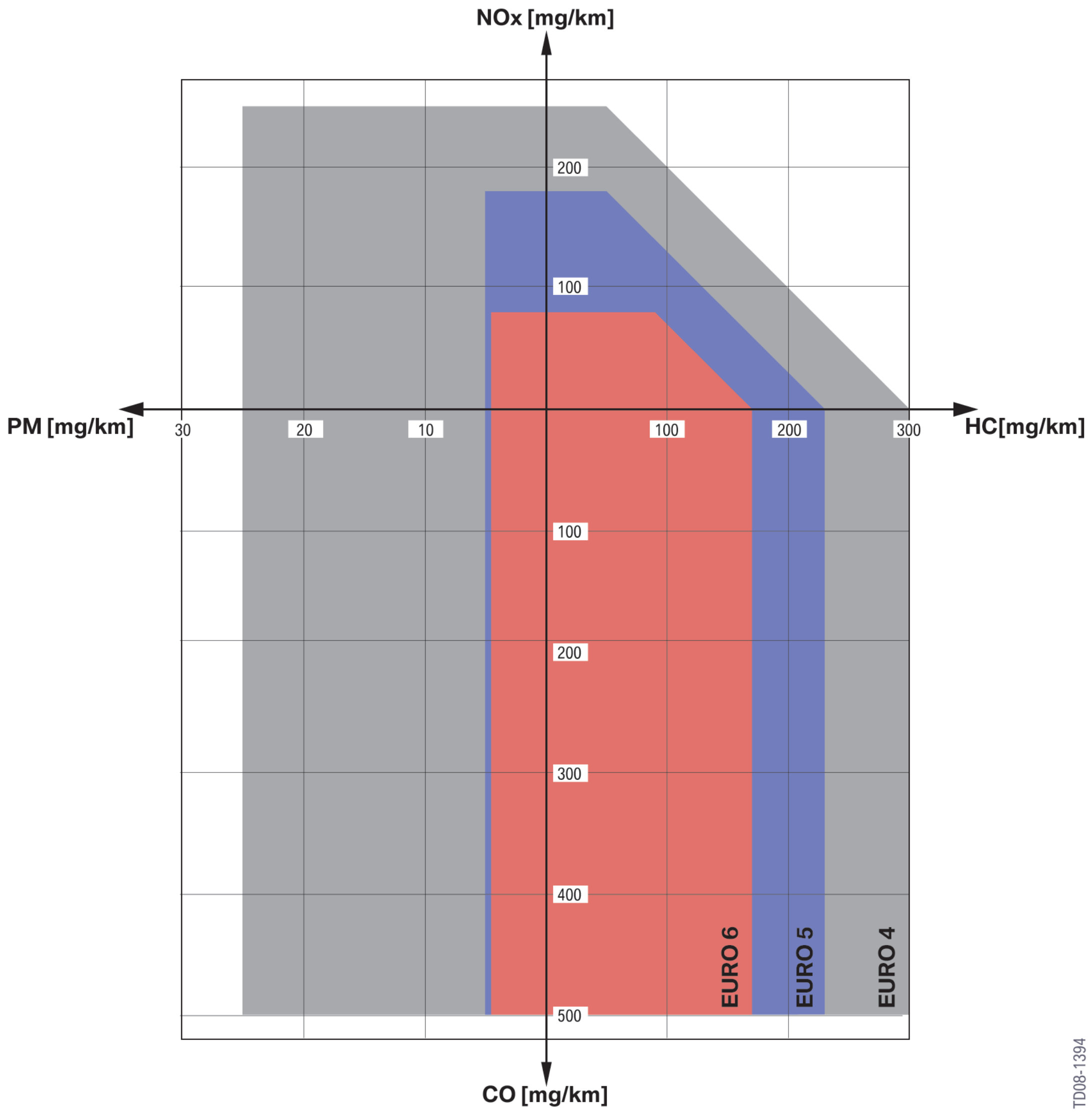
The N57 engine meets the EURO 5 emission requirements as standard. The N57 engine in the E90 can be ordered with the EURO 6 rating as an option.

Legislation	CO [mg/km]	NO_x [mg/km]	$HC+NO_x$ [mg/km]	PM* [mg/km]	PN* [per km]
EURO 4	500	250	300	25	-
EURO 5	500	180	230	5	-
EURO 5+	500	180	230	4.5	6.0×10^{11}
EURO 6	500	80	170	4.5	6.0×10^{11}

PM* = Particulate mass
PN* = Particulate numbers

With the introduction of the EURO 5+ standard, a new mass measurement method has also been introduced. At the same time, it defines the maximum permissible number of particulates.

Different exhaust treatment systems are fitted depending on the required exhaust emission standard compliance.



51 - Comparison of EURO 4, EURO 5 and EURO 6 exhaust emission limits

System description

Thus the EURO 5 version has the familiar oxidation catalytic converter and a diesel particulate filter combined within the same casing. As usual, the oxidation catalytic converter is upstream of the diesel particulate filter.

The EURO 6 version requires an active exhaust treatment system due to the lower nitrogen oxides limit.

Thus, instead of the oxidation catalytic converter, an NO_x accumulator catalytic converter with the appropriate sensor systems is used. As well as reducing nitrogen oxides, the NO_x accumulator catalytic converter also performs the function of an oxidation catalytic converter.

Downstream of it is the familiar diesel particulate filter. In addition, the centre silencer is replaced by an H_2S blocking catalytic converter.

Without the H_2S blocking catalytic converter, the sulphur removal process would produce an unpleasant odour. The H_2S blocking catalytic converter converts hydrogen sulphide, H_2S, into odourless sulphur dioxide, SO_2.

Coating of the various treatment systems

Model	Transmission	Component	Filter volume in l	Coating in g/dm^3 (g/ft^3)	Platinum (Pt) weight in g	Palladium (Pd) weight in g	Rhodium (Rh) weight in g	Ratio Pt:Pd:Rh
E90 EURO 5	Mechanism	Catalytic converter	1.974	5.65 (160)	7.44	3.72	0	2:1:0
	Mechanism	Particulate filter Zone 1	1.949	2.47 (70)	4.13	0.69	0	6:1:0
	Mechanism	Particulate filter Zone 2	1.949	0.71 (20)	1.18	0.20	0	6:1:0
E90 EURO 5	Automatic	Catalytic converter	1.974	5.12 (145)	6.74	3.37	0	2:1:0
	Automatic	Particulate filter Zone 1	1.949	1.52 (43)	2.54	0.42	0	6:1:0
	Automatic	Particulate filter Zone 2	1.949	0.71 (20)	1.18	0.20	0	6:1:0
E90 EURO 6	Mechanism	NO_x accumulator catalytic converter	1.974	3.88 (110)	6.97	0	0.70	10:0:1
	Mechanism	Particulate filter Zone 1	1.949	2.47 (70)	4.13	0.69	0	6:1:0
	Mechanism	Particulate filter Zone 2	1.949	0.71 (20)	1.18	0.20	0	6:1:0
	Mechanism	H_2S blocking catalytic converter	0.988	No noble metals	Iron ceolith			0:0:0
F01 EURO 5	Automatic	Catalytic converter	1.974	5.12 (145)	6.74	3.37	0	2:1:0
	Automatic	Particulate filter Zone 1	1.949	1.52 (43)	2.54	0.42	0	6:1:0
	Automatic	Particulate filter Zone 2	1.949	0.71 (20)	1.18	0.20	0	6:1:0

The diesel particulate filter has two coating zones. That means that the coating in the catalytic converter inlet is thicker than in the outlet. The reason is that the exhaust entering the catalytic converter is hotter and, therefore, the effect is greater with a thicker coating in the catalytic converter inlet.

Description of function of EURO 6 system

In lean-burn mode (λ > 1), the nitrogen oxides, NO_x, produced are stored as barium nitrate, $Ba(NO_3)_2$, in the NO_x accumulator catalytic converter. By referring to a stored NO_x emissions model, the digital diesel engine management can detect when the NO_x accumulator catalytic converter needs to be regenerated.

Regeneration is achieved by running the engine with a rich mixture (λ ≈ 0.93) for a short time. This provides the engine with sufficient reducing agents (H_2, CO and HC) with a low oxygen concentration (< 1 %). The stored nitrates and the reducing agents react to form N_2, H_2O and CO_2. Completion of reduction when the NO_x accumulator catalytic converter has been emptied is detected by the oxygen sensor (λ ≈ 1 changes to λ ≈ 0.9 when the NO_x accumulator catalytic converter is empty).

The sulphur contained in the fuel is also stored in sulphate form in the NO_x accumulator catalytic converter and thus affects the efficiency of the NO_x accumulator catalytic converter. In contrast with nitrogen, the sulphur can only be removed from the NO_x accumulator catalytic converter at high temperatures (> 600 °C). To that end, the engine is also run for a short time with a rich mixture during particulate filter regeneration.

Chemical function of catalytic converter

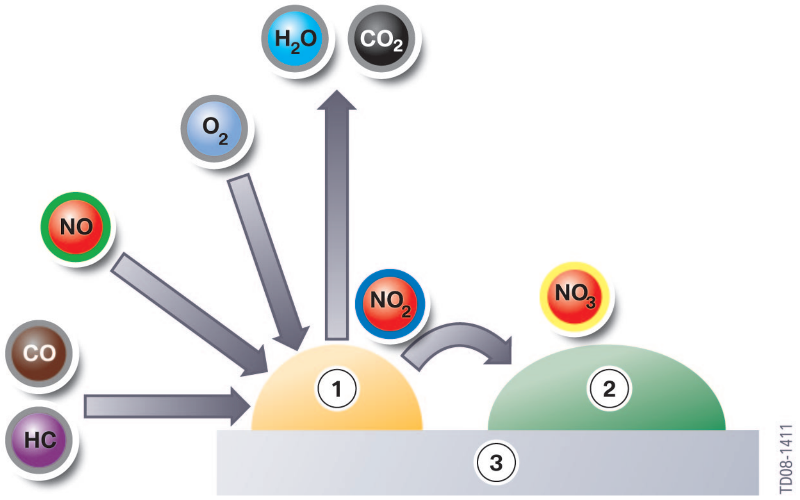
The engine-side oxidation catalytic converter ensures the conversion of the following exhaust gas constituents across the entire operating range:

- $2NO + O_2 \rightarrow 2NO_2$
- $2CO + O_2 \rightarrow 2CO_2$
- $C_xH_y + (x+y/4)O_2 \rightarrow xCO_2 + {}^y/_2\, H_2O$
- ($2SO_2 + O_2 \rightarrow 2SO_3$) dependent on sulphur content of fuel!

Soot particles flow through the oxidation catalytic converter unimpeded. Due to the high oxygen content of the exhaust gas, the oxidation catalytic converter starts to work at approximately 170 °C. Above around 350 °C, the particle emissions begin to increase again. Sulphates form due to the sulphur content of the fuel (sulphur-oxygen compounds). A reduction in the sulphur content of the fuel contributes to a reduction in particulate formation and thus to a lowering of particulate mass. The particulates are almost entirely composed of carbon (C).

Chemical function of NO_x accumulator catalytic converter

The NO_x accumulator catalytic converter operates within a temperature range of 220 °C to 450 °C, i.e. between those temperatures it is able to absorb, discharge and convert nitrogen oxides. The desulphurization process requires an even higher temperature range of 650 °C to 720 °C. Those temperatures are monitored by the exhaust temperature sensor. Control and monitoring of nitrogen oxide regeneration is based on a computation model stored in the engine management module and on the measured data from downstream oxygen sensor.



52 - NO_x storage

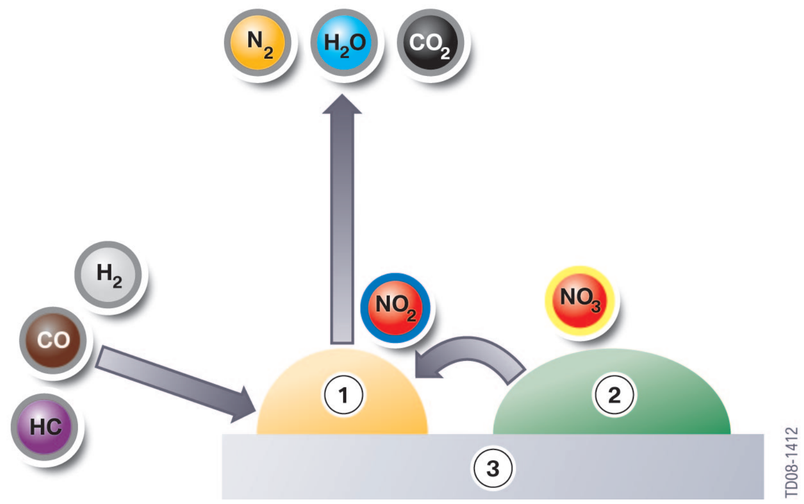
Index	Explanation	Index	Explanation
1	Catalytic component - platinum	3	Wash-coat
2	Storage component barium carbonate, $BaCO_3$		

The graphic shows the procedure for storing the nitrogen oxides contained in the exhaust gas. The conversion of the exhaust components containing carbon, CH and CO, with a high residual oxygen content to H_2O and CO_2 familiar from the oxidation catalytic converter takes place on the catalytic component (1). If necessary, the nitrogen oxides are highly oxidized and stored in the form of NO_2 in the storage component (2). During that storage process, the barium carbonate $BaCO_3$ in combination with the nitrogen dioxide NO_2 and oxygen O_2 is converted to barium nitrate $Ba(NO_3)_2$.

- $2NO + O_2 \rightarrow 2NO_2$
- $2CO + O_2 \rightarrow 2CO_2$
- $C_xH_y + (x+y/4)O_2 \rightarrow xCO_2 + {}^{y}/_{2}\, H_2O$
- ($2SO_2 + O_2 \rightarrow 2SO_3$) dependent on sulphur content of fuel!

Storage of nitrogen dioxide NO_2 and sulphur trioxide SO_3 in the NO_x accumulator catalytic converter. This process releases carbon dioxide CO_2 and converts barium carbonate $BaCO_3$ to barium sulphate $BaSO_4$.

- $3O_2 + 2NO_2 + 2BaCO_3 \rightarrow 2Ba(NO_3)_2 + 2CO_2$
- $SO_3 + BaCO_3 \rightarrow BaSO_4 + CO_2$



53 - NO_X discharge and reduction

Index	Explanation	Index	Explanation
1	Catalytic component platinum and rhodium	3	Wash-coat
2	Storage component barium nitrate $Ba(NO_3)_2$		

In order to be able to remove the stored nitrogen oxides from the storage component and subsequently convert them, the engine is run with a rich mixture at $\lambda = 0.93$. Higher levels of CO, HC and H_2 occur in this operating mode.

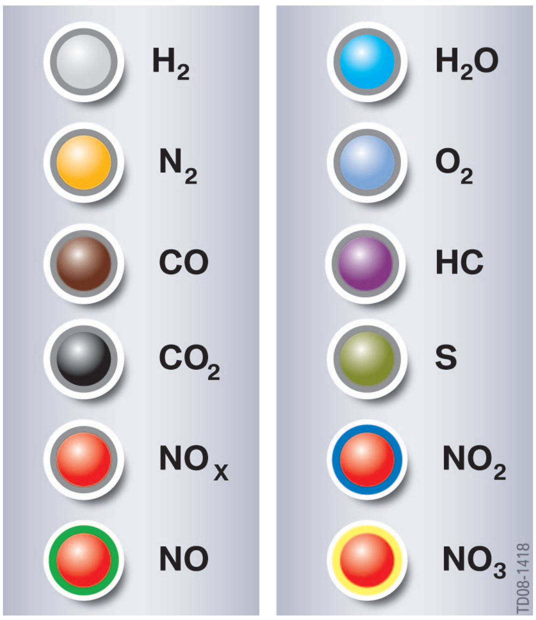
Regeneration takes place every 5 - 10 minutes. The engine is run with a rich mixture for approx. 3 seconds, during which time the stored nitrogen dioxide NO_2 is converted by hydrogen H_2, carbon monoxide CO and hydrocarbon HC and released.

The familiar conversion of the exhaust components hydrogen H_2, hydrocarbon HC and carbon monoxide CO that contain carbon to water vapour H_2, carbon dioxide CO_2 nitrogen N_2 and oxygen O_2 using the nitrogen oxides NO_2 released by the reduction of barium nitrate $Ba(NO_3)_2$ takes place on the catalytic component (1).

- $2Ba(NO_3)_2 + H_2 + 2CO + C_xH_y$ -> $2BaCO_3 + xCO_2 + 2N_2 + y/2H_2O + (4-x-y/4)O_2$

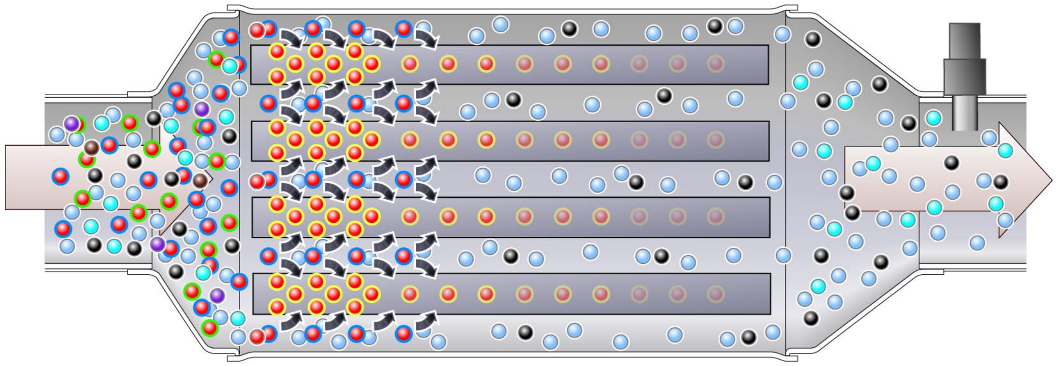
Every 1,000 km the NO_X accumulator catalytic converter is desulphurized. That is done by raising the temperature to approx. 650 - 720 °C while running a rich mixture. The desulphurization always takes place at the same time as particulate filter regeneration.

- $BaSO_4 + CO_2$ -> $SO_3 + BaCO_3$



54 - Symbols - exhaust components

Process in NO_x accumulator catalytic converter



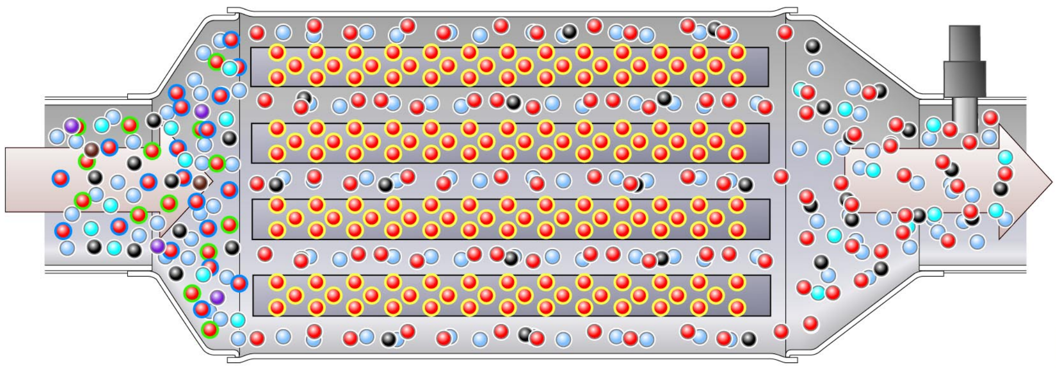
55 - NO_X storage

Storage:

The exhaust produced in lean-burn mode is characterized by nitrogen oxide (NO) content and high levels of oxygen (O_2).

The consequence of that for conversion of the exhaust in the oxidation catalytic converter is that the nitrogen oxides can not be reduced to a sufficient degree.

The exhaust gasses rich in nitrogen oxide therefore represent the raw emissions for the NO_X accumulator catalytic converter. They are stored on the wash-coat in the storage component in order to be converted in a subsequent process.



56 - Saturation

The capacity for storing nitrogen oxide in the storage material is limited. No further nitrogen oxide can be accepted when the storage material is completely transformed into barium nitrate.

This saturation situation is an extremely important operating point for the engine management. The engine management detects that saturation by means of a model-assisted procedure. The amount of stored NO_X is calculated taking into account the catalytic converter temperature, the past driving profile and the stored figure for the thermal ageing of the accumulator catalytic converter.

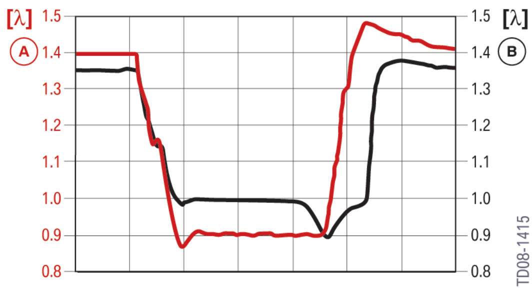
57 - Discharge and conversion

Discharge:

When the NO_x accumulator catalytic converter reaches saturation, the digital diesel engine management initiates discharge of the nitrogen oxides. To that end, the engine is switched to a slightly rich mixture of λ = 0.93. Discharge takes place, as described above, by the conversion of the barium nitrate to barium carbonate. The nitrogen oxides are then converted at the catalytic component of the storage catalytic converter.

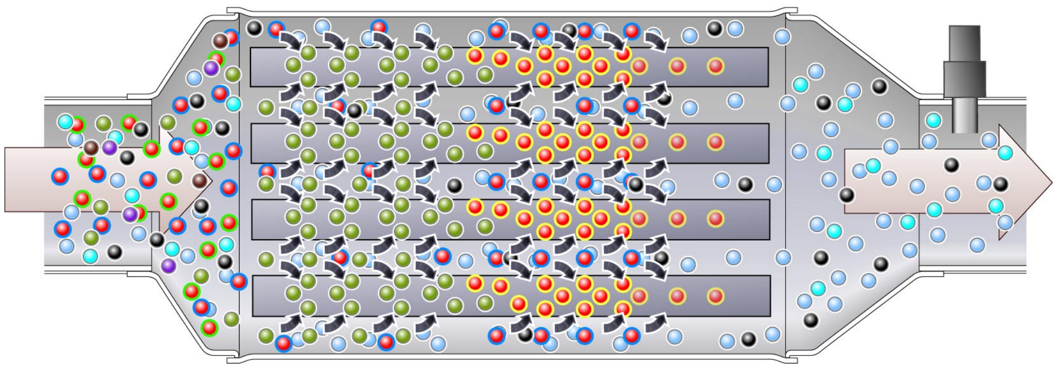
The end of this conversion process represents a further important operating point as the engine management has to know when it can end the rich-mixture running phase.

During the process, the residual oxygen content downstream of the diesel particulate filter is measured by a constant-characteristic oxygen sensor. The oxygen sensor measures the oxygen concentration in the exhaust and signals "rich-mixture changeover" from λ = 1 to λ = 0.93 when the discharge phase is complete.



58 - Rich-mixture changeover from λ = 1 to λ = 0.93

Index	Explanation
A	Signal from oxygen sensor upstream of NO_x accumulator catalytic converter
B	Signal from oxygen sensor downstream of diesel particulate filter

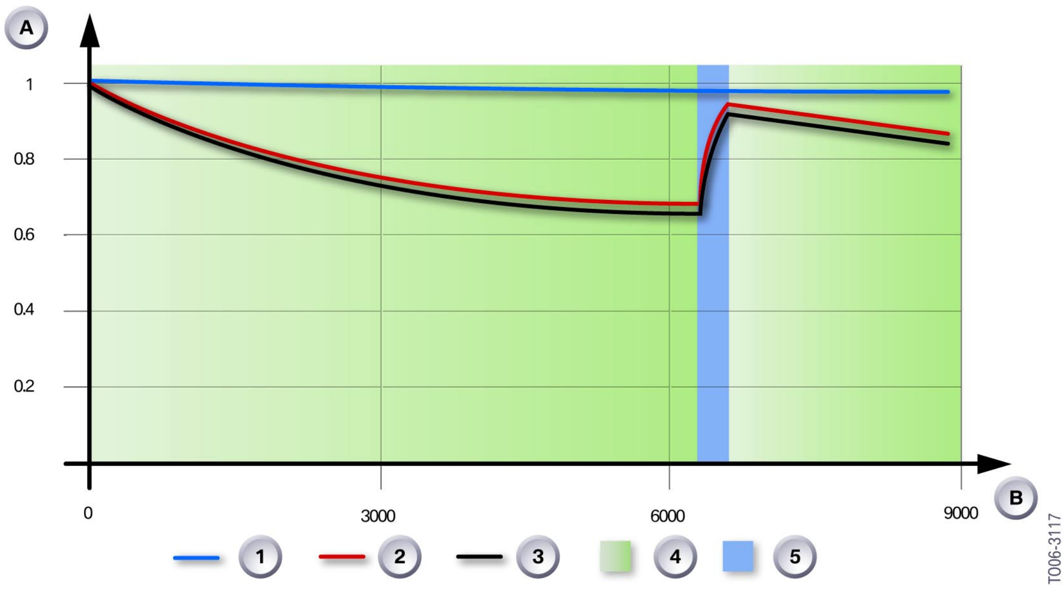


59 - Sulphurization

The sulphur (S) contained in the fuel reduces the storage capacity of the NO_x accumulator catalytic converter. The sulphur forms a chemical compound with the storage agent in the catalytic converter. The barium carbonate and the sulphur combine to form barium sulphate with the result that the barium carbonate can not absorb any more nitrogen oxides.

This process can continue to such an extent that the entire storage capacity is lost. This sulphurization process is detected by the engine management in that an initiated reduction phase does not result in effective reduction of nitrogen oxides.

When such sulphurization is detected, the catalytic converter temperature must be raised to between approx. 650 °C and 720 °C to allow the barium sulphate to be converted back to barium carbonate and consequently to discharge the sulphur stored in the storage component.



60 - Storage capacity of NO_x accumulator catalytic converter TD08-1413

Index	Explanation	Index	Explanation
A	Storage capacity	3	Total storage reduction
B	Distance (km)	4	Sulphurization
1	Thermal ageing	5	Desulphurization
2	Storage capacity reduction through sulphurization		

The graph shows that the total storage capacity depends both on the thermal ageing and the degree of sulphurization. The storage capacity is increased by the desulphurization process.

⚠ The ability of the NO_X accumulator catalytic converter to absorb nitrogen oxides and therefore its ageing depends on:

- Fuel quality in terms of freedom of sulphur
- Operating temperatures of the catalytic converter

◄

Chemical function of diesel particulate filter

The diesel particulate filter ensures the conversion of the following exhaust gas constituents:

- $C + 2NO_2 \Rightarrow CO_2 + 2NO$
- $C + O_2 \Rightarrow CO_2$
- $2CO + O_2 \Rightarrow 2CO_2$

Chemical function of H_2S blocking catalytic converter

The process of desulphurizing the NO_x accumulator catalytic converter also produces hydrogen sulphide H_2S as a by-product. A characteristic of hydrogen sulphide is its very unpleasant odour. It smells strongly of rotten eggs.

It would be unreasonable to subject other road users behind the car to such unpleasant odours. Therefore, measures have been taken to reduce the smell to a minimum or eliminate it altogether.

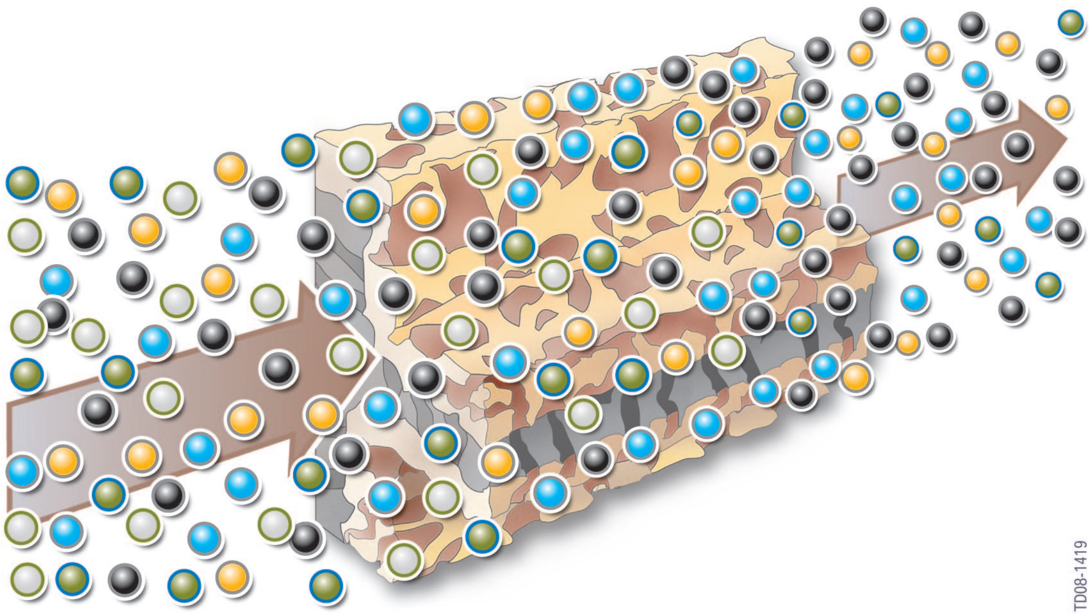
Those measures involve the use of what is called an H_2S blocking catalytic converter. The H_2S blocking catalytic converter is fitted in place of the centre silencer

By appropriate control of the rich-mixture phases during "desulphurization" of the NO_x accumulator catalytic converter, odourless sulphur dioxide SO_2 is mainly produced.

The remaining hydrogen sulphide H_2S in the exhaust is converted to water vapour H_2O and sulphur dioxide SO_2 by a chemical reaction in the H_2S blocking catalytic converter.

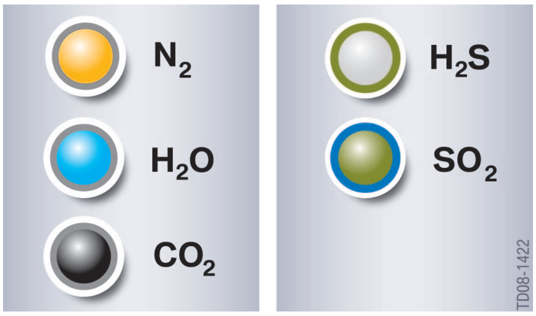
The H_2S blocking catalytic converter essentially consists of iron ceolith.

- $2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$



61 - Function of H_2S blocking catalytic converter

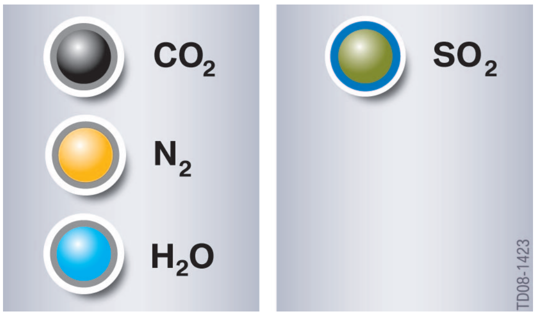
Exhaust constituents upstream of H_2S blocking catalytic converter



62 - Exhaust constituents upstream of H_2S blocking catalytic converter

Index	Explanation
N_2	Nitrogen
H_2O	Water vapour
CO_2	Carbon dioxide
H_2S	Hydrogen sulphide
SO_2	Sulphur dioxide

Exhaust constituents downstream of H_2S blocking catalytic converter



63 - Exhaust constituents downstream of H_2S blocking catalytic converter

Index	Explanation
CO_2	Carbon dioxide
N_2	Nitrogen
H_2O	Water vapour
SO_2	Sulphur dioxide

Exhaust recirculation system

Exhaust recirculation

The exhaust gas recirculation is a measure for reducing the emission of nitrogen oxide (NO_x). Nitrogen oxides are produced in large amounts if combustion takes placed with an air surplus and at very high temperatures. Oxygen combines with the nitrogen in the combustion air to form nitrogen monoxide (NO) and nitrogen dioxide (NO_2).

The exhaust gas recirculation is occasionally required at idling speed but always in the partial load range because this is where the diesel engine works with a particularly high air surplus.

The recirculated exhaust gas, which is mixed with the fresh air and acts as an inert gas, serves to achieve the following:

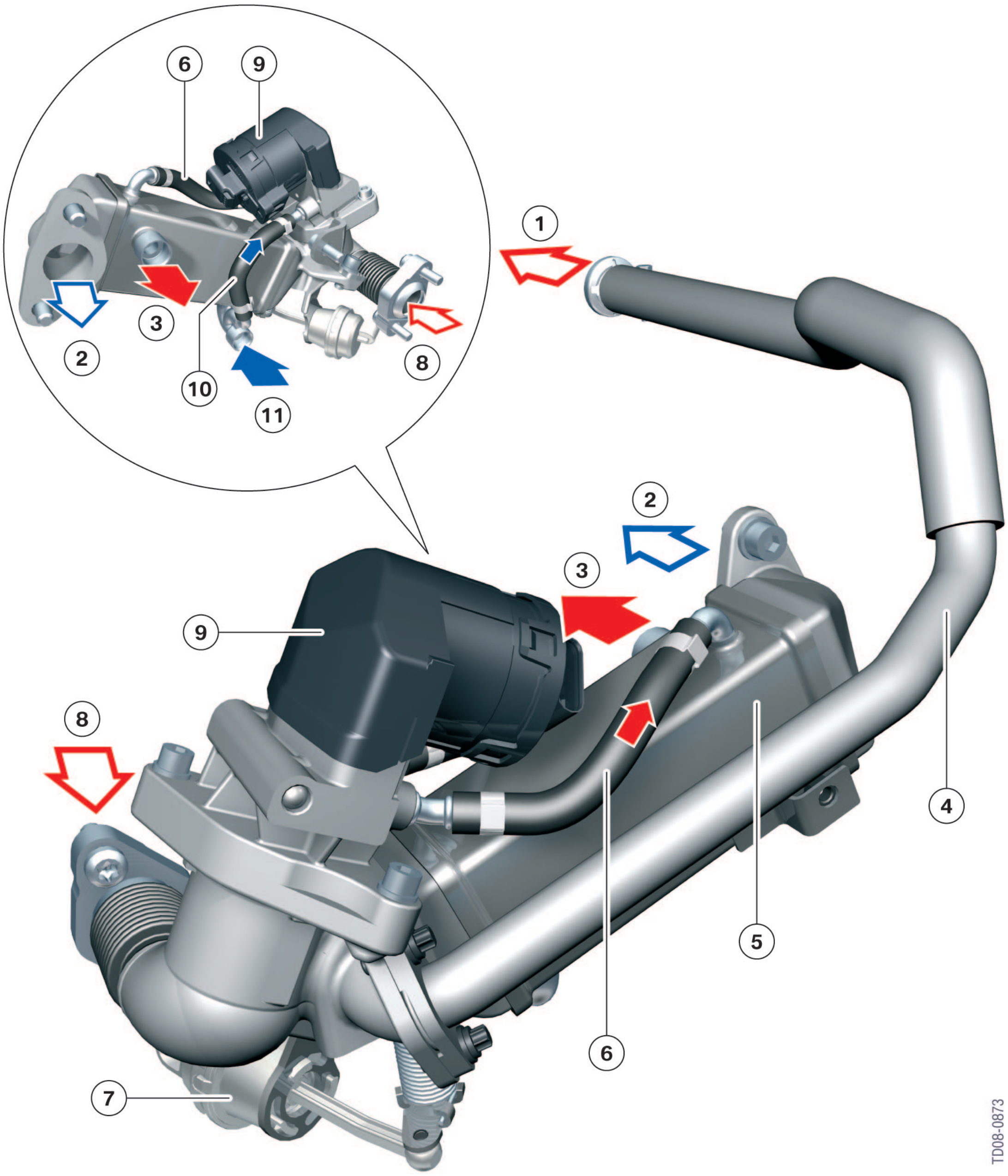
- a lower oxygen and nitrogen concentration in the cylinder,
- a reduction in the maximum combustion temperature of up to 500 °C. This effect is increased still further if the recirculated exhaust gases are cooled.

The exhaust recirculation system on the N57 engine starts from the exhaust manifold. There is a connection at the forward end for this purpose. Connected here is the EGR valve, which controls the volume of recirculated exhaust gas.

Located downstream of the EGR valve is the EGR cooler. Its design differs depending on the power class and equipment. The EGR valve and the EGR cooler are contained in the EGR module.

The EGR duct from the EGR cooler to the intake manifold is cast into the cylinder head. At the intake manifold, the exhaust gas is ultimately mixed with the fresh air.

A new feature is the external bypass pipe. The external bypass pipe makes it possible to feed hot exhaust directly into the intake air so as to bring the catalytic converter up to temperature even more quickly during the warm-up phase.



64 - EGR module on N57 engine

Index	Explanation	Index	Explanation
1	Connection to intake manifold for hot exhaust	7	Bypass valve
2	Connection to cylinder head for cooled exhaust	8	Connection to exhaust manifold for exhaust feed to EGR
3	Coolant return	9	EGR valve
4	EGR bypass pipe	10	Coolant supply to EGR valve
5	EGR cooler	11	Coolant supply
6	Coolant return from EGR valve		

EGR valve

The EGR valve controls the return of exhaust gas to the air intake system. It is located upstream of the EGR cooler and therefore subjected to high thermal loads. For that reason, the EGR valve is connected to the cooling system.

The EGR valve is electrically operated by a stepper motor and closed by the force of a spring. An electrically operated EGR valve first featured on the M67 engine.

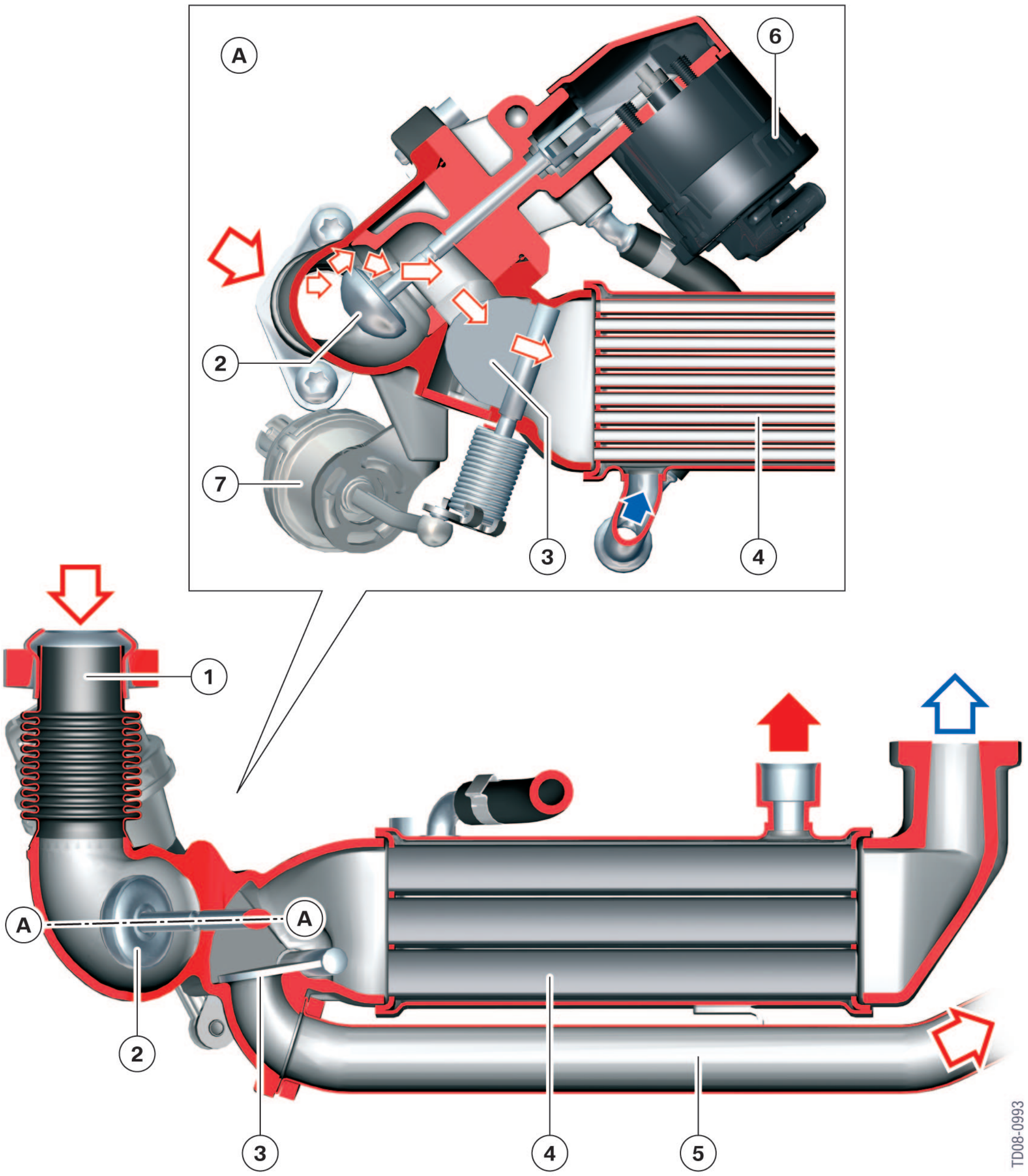
The EGR valve has an integral position sensor. The position sensor enables the exhaust recirculation rate to be very precisely adjusted.

The EGR valve is controlled by the digital diesel engine management and its position reported back to the DDE control unit. For that purpose the DDE control unit has five leads that connect to the EGR valve.

EGR cooler

The use of an EGR cooler increases the efficiency of exhaust gas recirculation. The cooled exhaust gas is able to draw off more thermal energy from the combustion and thus reduce the maximum combustion temperature.

The EGR cooler on the N57 engine is mounted downstream of the EGR valve. The engine's coolant flows through it. The exhaust is fed through the cooler jacket in multiple flat pipes (approximately rectangular cross-section). In the process, its thermal energy is transferred to the coolant.



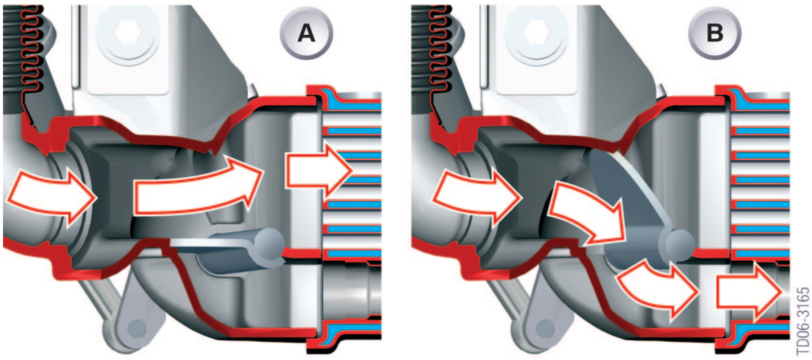
65 - EGR cooler with bypass

Index	Explanation	Index	Explanation
A	Section A-A	4	EGR cooler jacket
1	EGR supply from the exhaust manifold	5	Bypass
2	EGR valve	6	EGR valve
3	Bypass valve	7	Bypass-valve vacuum unit

The EGR cooler has a bypass valve which allows the exhaust to bypass the EGR cooler when required.

This is useful in the engine warm-up phase for bringing the catalytic converter up to its operating temperature more rapidly.

The bypass valve is adjusted by a vacuum canister. There are two states only: open and closed. The vacuum canister is controlled by an electropneumatic changeover valve, which in turn is controlled by the DDE control unit.



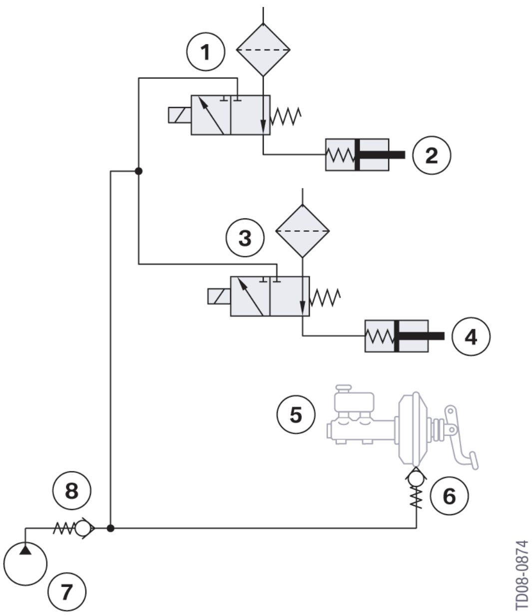
66 - Bypass valve closed and open

Index	Explanation	Index	Explanation
A	Bypass valve closed	B	Bypass valve open

When there is no vacuum, the bypass valve is closed, i.e. the exhaust flows through the EGR cooler. If vacuum is then applied, the bypass valve opens the bypass (which directs the exhaust past the EGR cooler straight to the intake manifold) and simultaneously closes off the inlet to the EGR cooler.

Vacuum system

Overview



67 - Vacuum system, N57 engine

Index	Explanation
1	Electropneumatic changeover valve
2	Engine mounting
3	Electropneumatic changeover valve
4	Bypass-valve vacuum unit
5	Brake servo unit
6	Non-return valve
7	Vacuum pump
8	Non-return valve

The vacuum system is another system in addition to the electrical system for operating a number of components.

A vacuum pump creates the vacuum for use by the system.

The negative pressure is circuited to a vacuum canister for the control of components. The vacuum canister converts the negative pressure into motion.

Electropneumatic changeover valves are used to connect the vacuum to the vacuum canister. These ones are controlled electrically.

A non-return valve prevents the vacuum being lost through the vacuum pump when the engine is switched off.

Vacuum pump

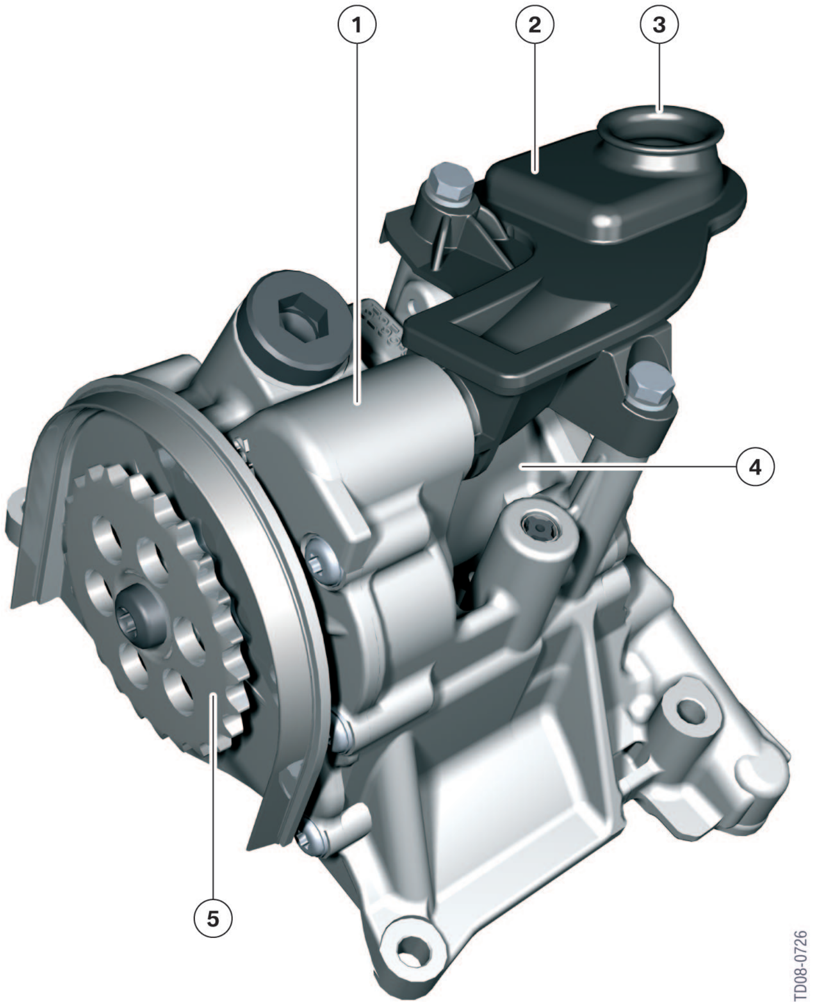
The vacuum pump on the N57 engine is fitted inside the sump and forms a single unit together with the oil pump and the reinforcing plate.

The reason for the unusual installation location is to reduce the engine height dimension. It was designed in this manner with passive pedestrian safety in mind.

The pump is a vane-type pump with aluminium housing (AlSi9Cu3) with a steel rotor and a plastic vane. It is chain-driven together with the oil pump by the crankshaft.

The vacuum pump is capable of creating a vacuum of 500 mbar (absolute) in less than 5 seconds.

The negative pressure duct passes through the oil pump housing and the crankcase. At the outlet of the crankcases, the main negative pressure line is connected to the brake force amplifier and the other consumers. Mounted directly on that connection is the non-return valve.



68 - Oil/vacuum pump N57 engine

Index	Explanation	Index	Explanation
1	Oil pump	4	Vacuum pump
2	Intake pipe	5	Oil/vacuum pump sprocket
3	Intake snorkel		

Electropneumatic changeover valve

The electropneumatic changeover valve has connections for vacuum and ambient pressure.

The vacuum in the system is connected through to the vacuum canister according to the control signals from the digital diesel engine management.

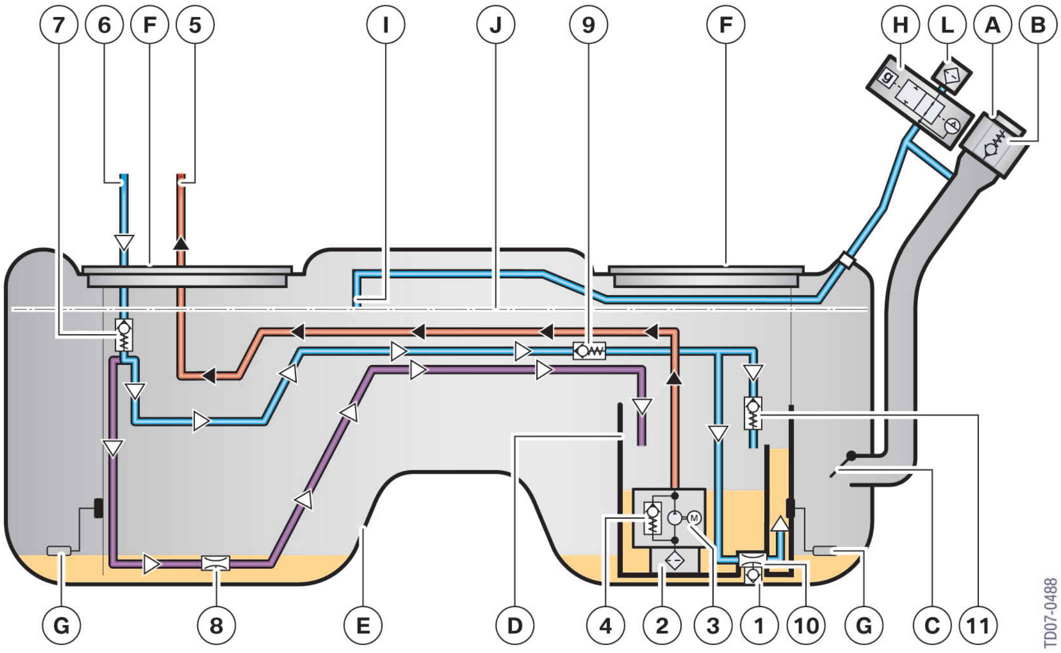
A simple "on/off" control mode is used.

On the N57 engine, the bypass valve and the controllable engine mountings are switched by an electropneumatic changeover valve.

Fuel system

E9x

System overview



69 - Fuel tank on E9x with diesel engine

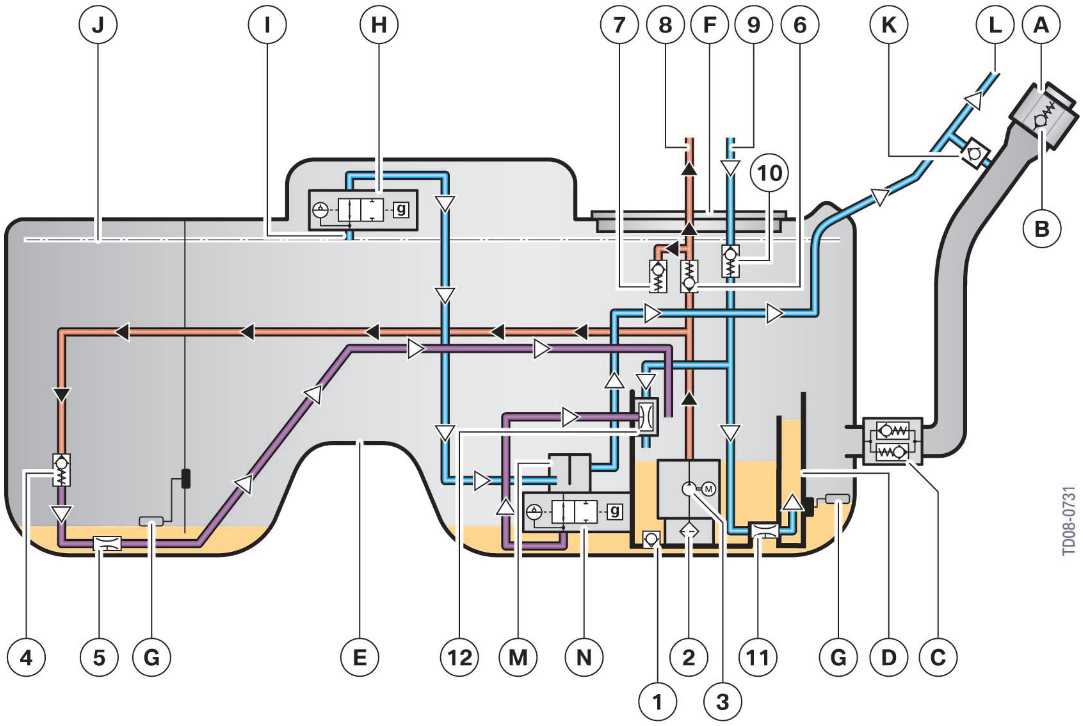
Index	Explanation	Index	Explanation
A	Fuel filler cap	1	Initial filling valve
B	Pressure relief valve	2	Suction strainer
C	Non-return valve	3	Fuel pump
D	Swash chamber	4	Pressure limiting valve
E	Fuel tank	5	Feed line
F	Service cover	6	Return line
G	Lever-type sensor	7	Anti-drain valve
H	Tank venting valve	8	Venturi pump
I	Connection	9	Non-return valve
J	Maximum fill level	10	Venturi pump
K	Non-return valve	11	Pressure limiting valve
L	Filter	11	Pressure limiting valve

The E9x models use the familiar fuel system for diesel engines. More information can be found in the basics course "Aftersales Training - Diesel Fuel System Product Information".

The fuel system is vehicle-specific and carries the fuel from the fuel tank to the engine. The fuel system is adapted to suit the particular vehicle model and can differ substantially from one model series to another. The functions of the fuel system can be subdivided into fuel storage, fuel supply and fuel tank venting.

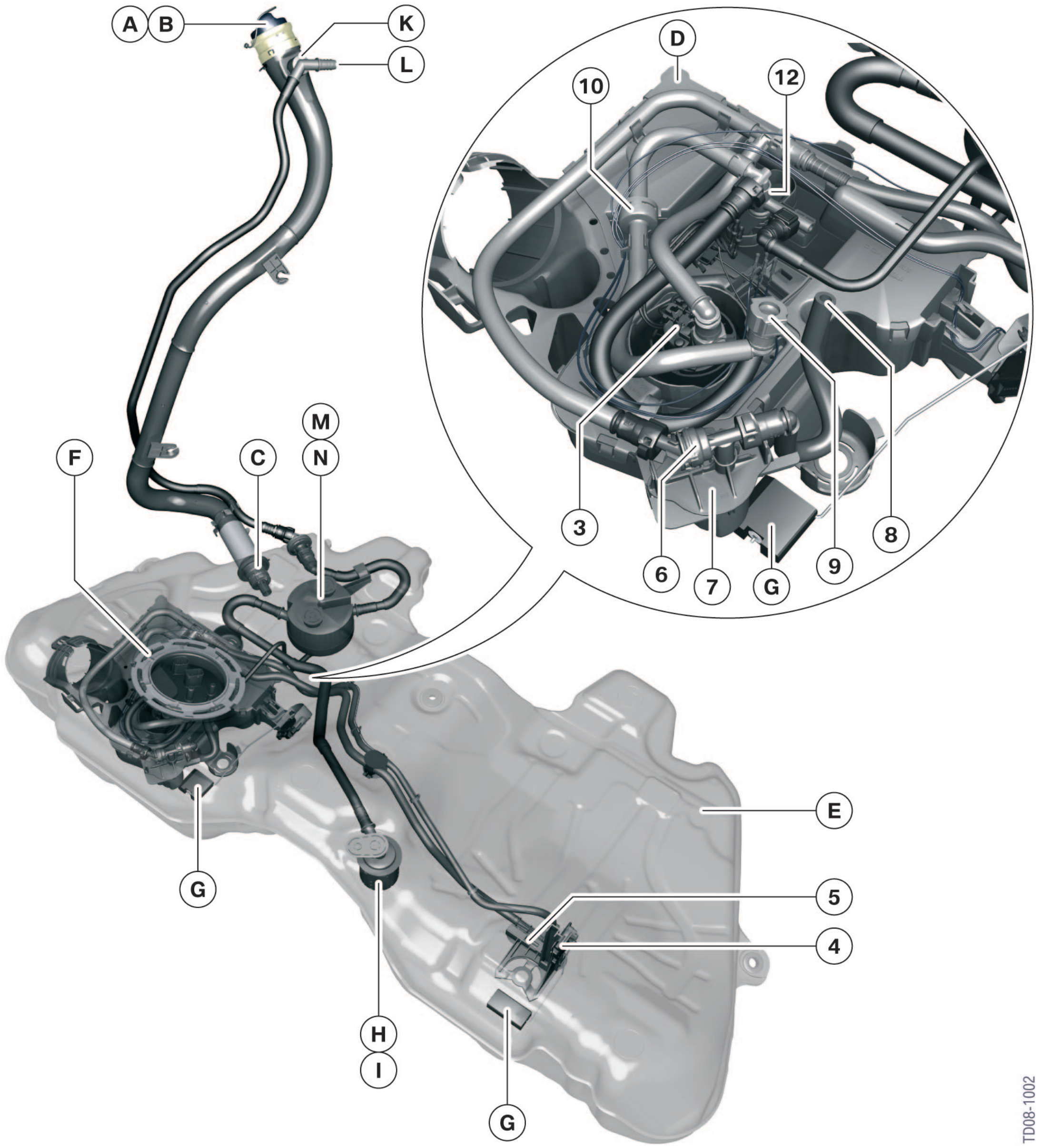
F01

System overview



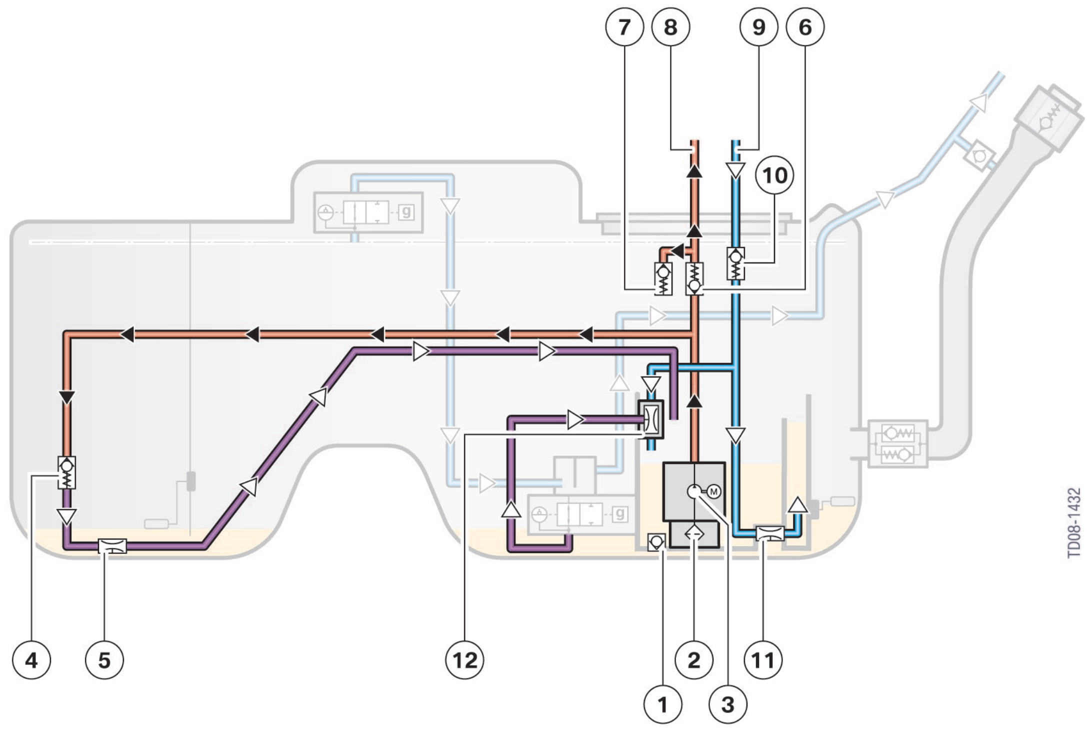
70 - Fuel tank on F01 with diesel engine

Index	Explanation	Index	Explanation
A	Fuel filler cap	1	Initial filling valve
B	Pressure relief valve	2	Suction strainer
C	Non-return valve with pressure relief valve	3	Fuel pump
D	Swash chamber	4	Non-return valve
E	Fuel tank	5	Venturi pump
F	Service cover	6	Anti-drain valve
G	Lever-type sensor	7	Pressure limiting valve
H	Tank venting valve	8	Feed line
I	Connection	9	Return line
J	Maximum fill level	10	Anti-drain valve
K	Non-return valve	11	Venturi pump
L	Vent to atmosphere	12	Venturi pump
M	Fluid trap		
N	Overturn safety valve		



71 - Fuel tank on F01 with diesel engine

Fuel delivery



72 - Fuel supply system on F01 with diesel engine

Index	Explanation	Index	Explanation
1	Initial filling valve	7	Pressure limiting valve
2	Suction strainer	8	Feed line
3	Fuel pump	9	Return line
4	Non-return valve	10	Anti-drain valve
5	Venturi pump	11	Venturi pump
6	Anti-drain valve	12	Venturi pump

The fuel tank is divided into two chambers because of the space available in the vehicle. The fuel supply system has two delivery units that are accommodated in the right and left fuel tank halves.

The initial filling valve (1) ensures fuel enters the swash chamber when refuelling if the swash chamber is completely empty.

The fuel is drawn through the intake filter (2) into the fuel pump (3) and via the feed line (8) to the fuel filter. The fuel pump sits inside the swash chamber. A pressure limiting valve (7) is incorporated in the feed line inside the fuel tank.

Another line branches off after the fuel pump to the left half of the fuel tank and carries the fuel from the left half of the fuel tank via a non-return valve (4) and the venturi pump (5) to the swash chamber.

The non-return valve (4) ensures that the fuel can not flow back from the right half to the left half of the fuel tank when the engine is switched off. The return system remains completely filled with fuel.

⚠ When the engine is switched off, the feed line is depressurized as the pressure can escape through the high pressure pump and the return line. As no air can get into the pipe provided there are no leaks in the system, this pipe does not empty either. After the fuel pump is switched off, the fuel pressure/ temperature sensor is checked for plausibility by the digital diesel engine management. ◄

The fuel required for lubrication and function of the high-pressure system flows back to the fuel tank via the return line (9). The fuel returning via the return line is split between two pipes after passing through the anti-drain valve (10). The anti-drain valve prevents the fuel tank draining if fuel pipes on the engine or underbody are damaged. It also prevents the return line "emptying" when the engine is not running.

One of the pipes carries the fuel via a venturi pump (11) to the swash chamber, taking with it the surrounding fuel from the right half of the fuel tank into the swash chamber. A branch line leads to another venturi pump (12) which draws the fuel out of the fluid trap and delivers it to the swash chamber as well.

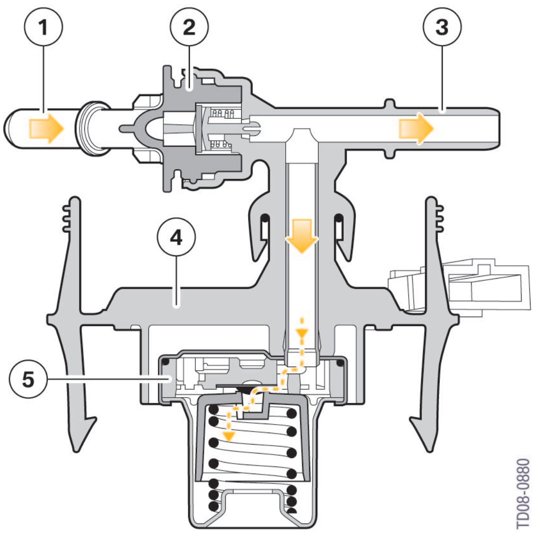
Fuel pump

The electric fuel pump is controlled by the electronic fuel pump module (EKPS) module by means of a PWM signal. The EKPS in turn receives its instructions from the digital diesel engine management. Previously, those control commands were based on engine load and speed. Now the regulation is pressure-sensitive.

For that purpose, there is a combined pressure/temperature sensor in the fuel line directly upstream of the high-pressure pump. This allows the electric fuel pump to be controlled on demand. This reduces the energy consumption of the fuel pump, which improves fuel economy.

The fuel pump for E9x models has an integral pressure limiting valve. The fuel pump on F01 does not have an integral pressure limiting valve. Instead, a separate pressure limiting valve fitted in the fuel tank is used. The fuel pump is a gear pump.

Pressure limiting valve



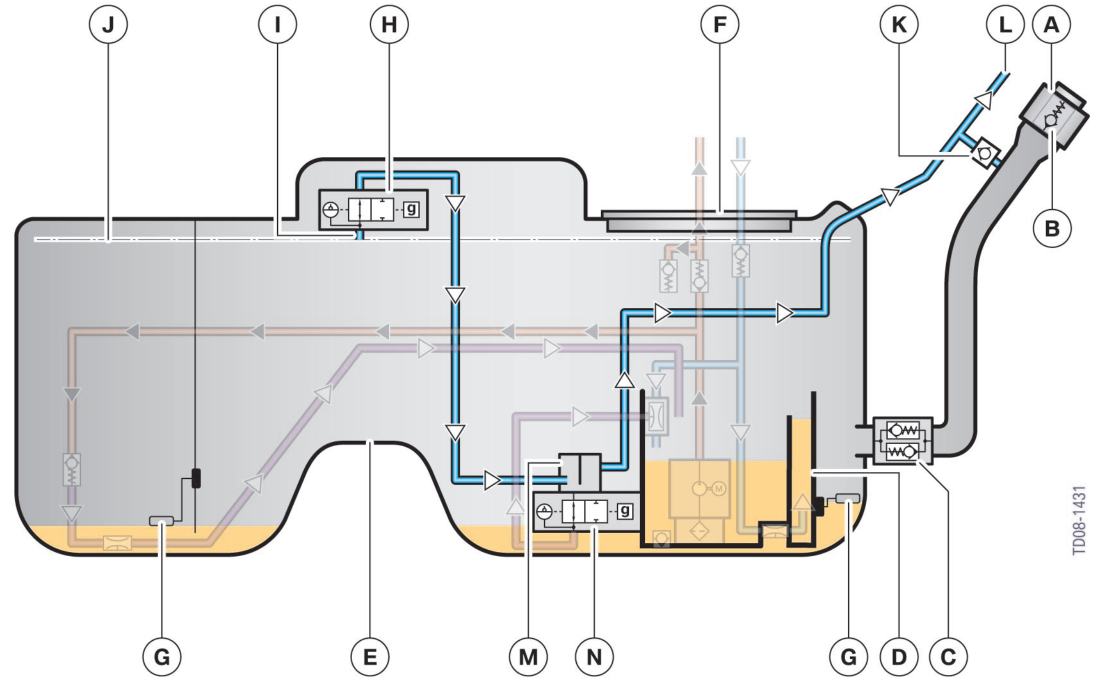
73 - Pressure limiting valve and anti-drain valve on F01 with N57 Motor

Index	Explanation
1	Connection from electric fuel pump
2	Anti-drain valve
3	Connection to fuel filter
4	Housing
5	Pressure limiting valve

The pressure limiting valve is connected to earth via the connector contacts on the service cover. In that way, the build up of electrostatic charge on the valve is prevented.

The pressure limiting valve ensures that the pressure in the feed line does not exceed approx. 6.7 bar. Consequently, excessive pressure in the feed line is prevented. Such pressures would otherwise occur if the fuel filter were clogged and place unnecessarily high stresses on the fuel system feed.

Fuel tank venting



74 - Fuel tank venting system on F01 with diesel engine

Index	Explanation	Index	Explanation
A	Fuel filler cap	H	Tank venting valve
B	Pressure relief valve	I	Connection

Index	Explanation	Index	Explanation
C	Non-return valve with pressure relief valve	J	Maximum fill level
D	Swash chamber	K	Non-return valve
E	Fuel tank	L	Vent
F	Service cover	M	Fluid trap
G	Lever-type sensor	N	Overturn safety valve

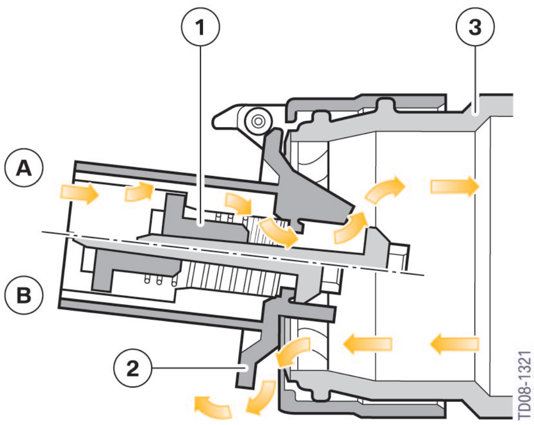
There is a pressure relief valve (B) integrated in the fuel filler cap (A) in order to protect the fuel tank (E) against excess pressure. At the lower end of the fuel filler neck there is a non-return valve incorporating a pressure relief valve (C). The non-return valve prevents the fuel splashing back into the fuel filler neck. The non-return valve is closed and held tightly sealed by a spring. The pressure relief valve ensures that if there is a pressure build-up inside the fuel tank, the excess pressure can escape through the fuel filler pipe and the pressure relief valve in the fuel filler cap.

The components inside the fuel tank can be accessed by removing the service cover (F).

The two lever-type sensors (G) detect the fuel level in the tank.

The swash chamber (D) makes sure that the fuel pump always has enough fuel to draw on. The swash chamber is permanently attached to the fuel tank and can not be separately replaced.

Non-return valve



75 - Non-return valve on F01

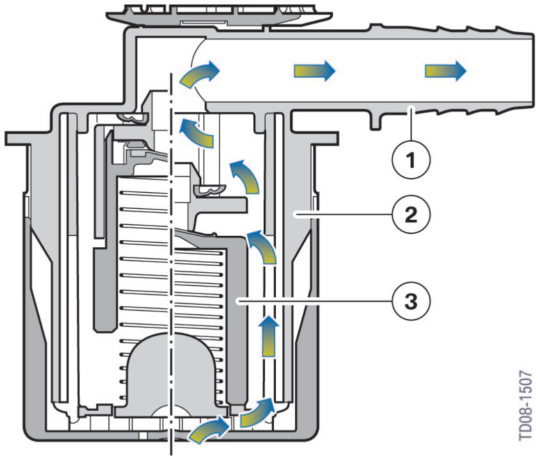
Index	Explanation
A	Pressure relief valve open
B	Pressure relief valve closed
1	Pressure relief valve
2	Non-return valve
3	Fuel filler neck

The non-return valve forms a tight seal when closed. A force of 0.15 N is required to open the non-return valve. That force is easily exceeded using any method of refuelling.

The non-return valve on the F01 incorporates a pressure relief valve. The purpose of the pressure relief valve is to prevent excessive pressure inside the fuel tank. If the pressure inside the fuel tanks rises above 150 mbar ± 20 mbar, the pressure relief valve opens and the pressure can escape through the fuel filler pipe and the vent pipe/pressure relief valve in the fuel filler cap.

The pressure relief valve in the non-return valve is used for the first time on the F01 because the vent pipe is not completely protected by the bodywork and could, therefore, be crushed and consequently closed off in the event of a crash.

Tank venting valve



76 - Tank venting valve

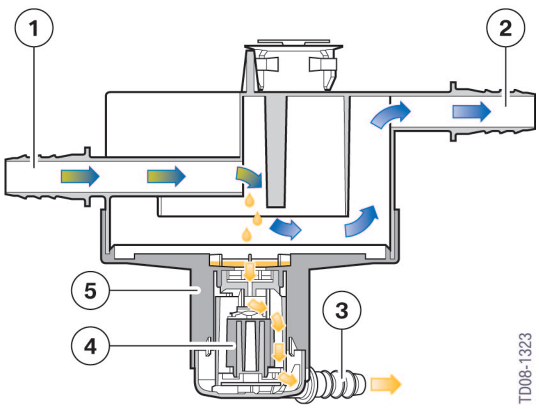
Index	Explanation
1	Connection to fluid trap
2	Housing
3	Float/Overturn safety valve

The tank venting valve has several functions. It vents the fuel tank when the vehicle is being driven and when the tank is being filled. It also performs a pressure-relief function.

When the tank is being filled, the float (3) in the tank venting valve rises as the fuel level rises and ultimately closes off the vent port causing the fuel to rise up the fuel filler pipe so that the fuel pump nozzle shuts off.

When the vehicle is in use, the pressure can increase as a result of rising temperatures. In that case, the pressure can escape through the connection to the fluid trap (1). The fluid trap catches entrained fuel, which is drawn off when the fuel pump is running.

Fluid trap



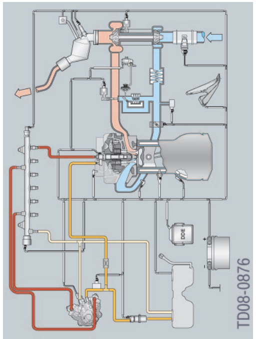
77 - Fluid trap

Index	Explanation
1	Tank venting valve connection
2	Vent connection
3	Venturi pump connection
4	Float (overturn safety valve)
5	Housing

When the fuel tank is full, the fluid trap is fully immersed in the fuel. It is possible for a certain amount of fuel to enter the fuel tank venting system through the tank venting valve (1). The fluid trap, which is positioned at the lowest point of the fuel tank venting system, traps that fuel and it is then drawn off through the venturi pump connection (3) by a venturi pump fitted close to the fuel pump and delivered to the swash chamber. As result, no fuel can escape from the fuel tank even if the vehicle overturns.

A float (4) in the fluid trap makes sure that no fuel can enter the fluid trap via the return pipe when the fuel level in the tank is high. The float is also designed to incorporate an overturn safety valve (4) so that it seals off the fuel tank from the vent pipe if the vehicle overturns.

Excess pressure is released into the atmosphere through the vent connection (2) and a vent pipe.

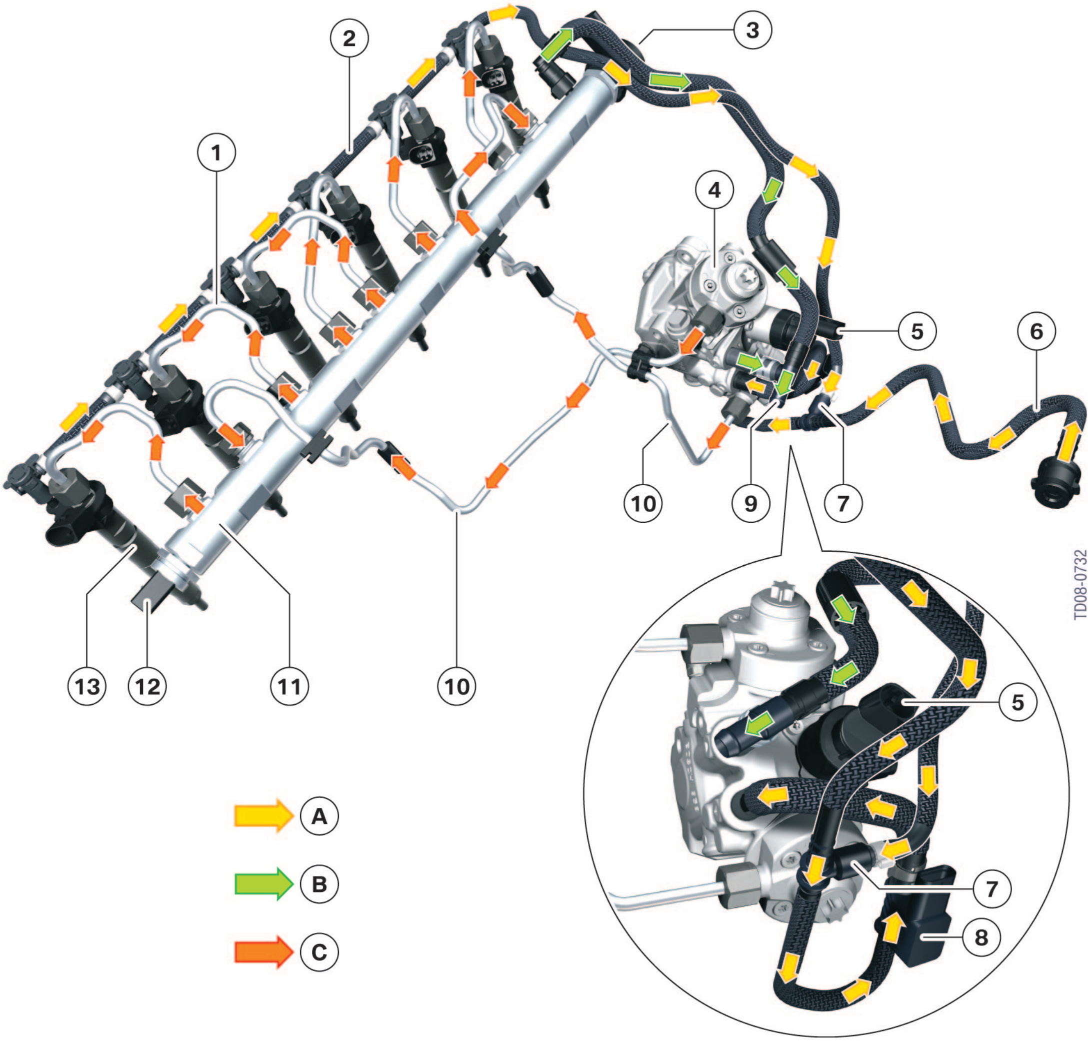


The fuel conditioning system is responsible for delivering and metering the correct amount of fuel for combustion. The fuel conditioning system is subdivided into a low-pressure section, a high-pressure section and an electrical control system.

Fuel conditioning system

System overview, N57D30O0 engine

N57D30O0 6-cylinder diesel engine



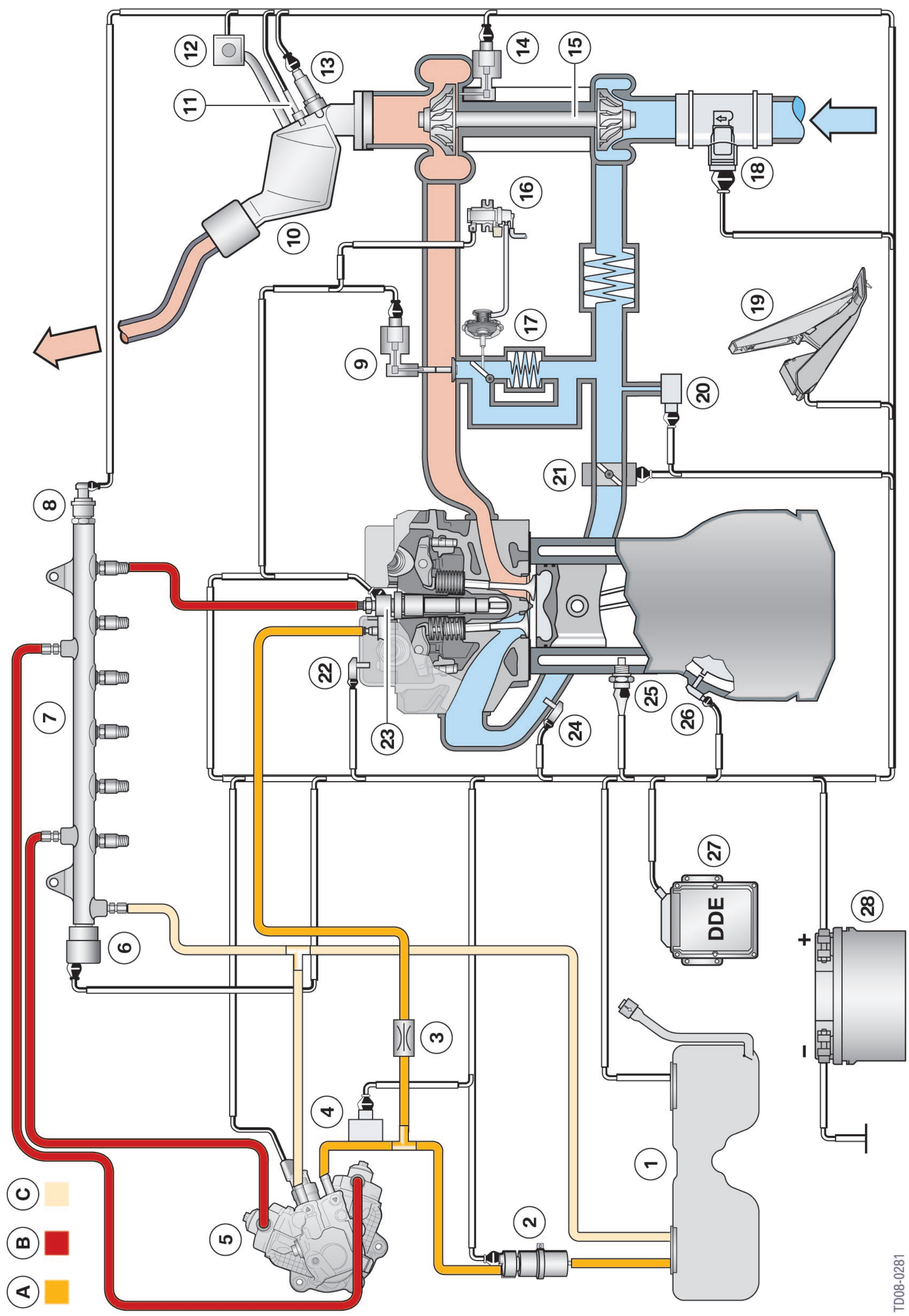
78 - Common-rail system with piezo-electric injectors on N57D30 O0 engine

Index	Explanation	Index	Explanation
A	Fuel feed (low pressure)	6	Fuel feed from fuel tank
B	Fuel return	7	Throttle
C	Fuel high pressure	8	Fuel pressure/temperature sensor
1	High-pressure line from the rail to the injector	9	Fuel return to fuel tank
2	Oil leakage pipe	10	High-pressure line from the high-pressure pump to the rail
3	Fuel-rail pressure regulating valve	11	Rail (high-pressure accumulator)
4	High-pressure pump	12	Fuel-rail pressure sensor
5	Volume control valve	13	Piezo-injector

Common-rail system

The N57 engine has a common-rail fuel injection system.

Engine	Fuel system	Fuel injectors	Maximum pressure
N57D30O0	Common rail 3rd generation	Piezo-electric	1,800 bar



79 - System overview, N57D30O0 engine for EURO 5

Index	Explanation	Index	Explanation
A	Fuel feed	14	Charge-pressure regulator
B	Fuel high pressure	15	Exhaust turbocharger
C	Fuel return	16	Electropneumatic changeover valve
1	Fuel tank	17	Bypass valve
2	Fuel filter and filter heater	18	Hot-film air mass flow sensor
3	Throttle	19	Accelerator pedal module
4	Fuel pressure/temperature sensor	20	Charge-air temperature sensor
5	High-pressure pump with volume control valve	21	Throttle valve
6	Fuel-rail pressure regulating valve	22	Camshaft sensor
7	Rail	23	Piezo-injector
8	Fuel-rail pressure sensor	24	Charge pressure sensor
9	EGR valve	25	Coolant temperature sensor
10	Oxidation catalytic converter and diesel particle filter	26	Crankshaft sensor
11	Exhaust temperature sensor	27	Digital diesel engine management module
12	Exhaust back pressure sensor	28	Battery
13	Oxygen sensor		

High-pressure pump

CP4.2

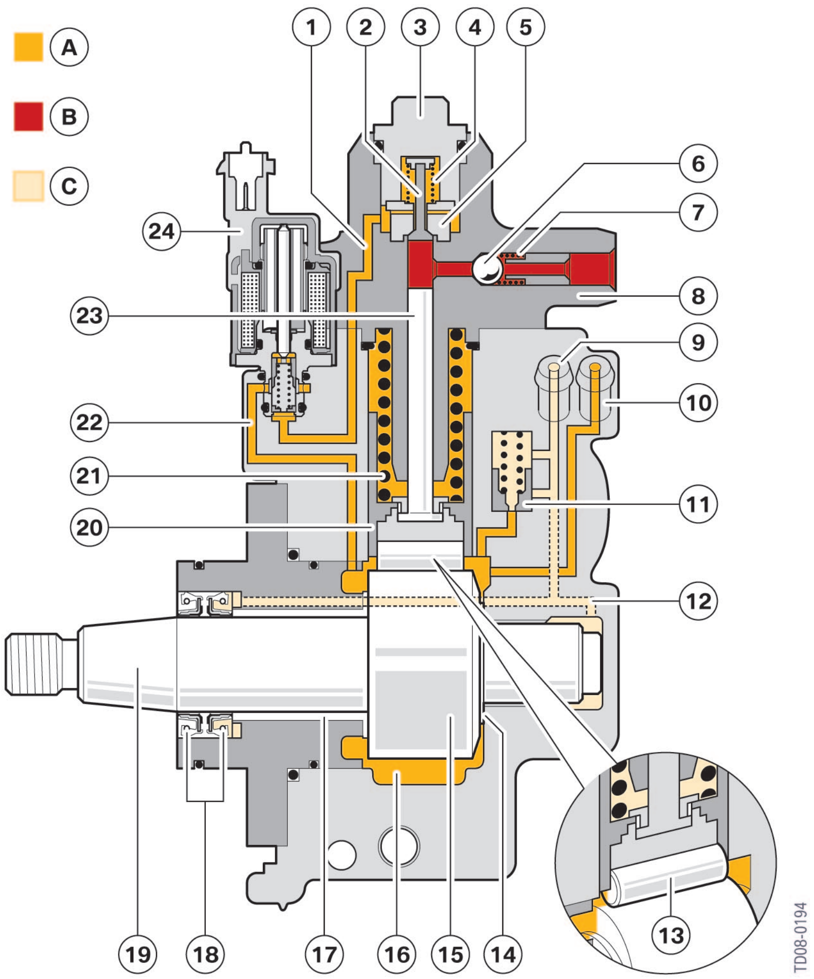
The N57 engine is fitted with a new high-pressure pump. It is a twin-piston pump with the designation CP4.2.

The high-pressure pump is located on the force transmitting side and is driven by the timing chain of the crankshaft.

It is capable of generating a pressure of 2,000 bar.

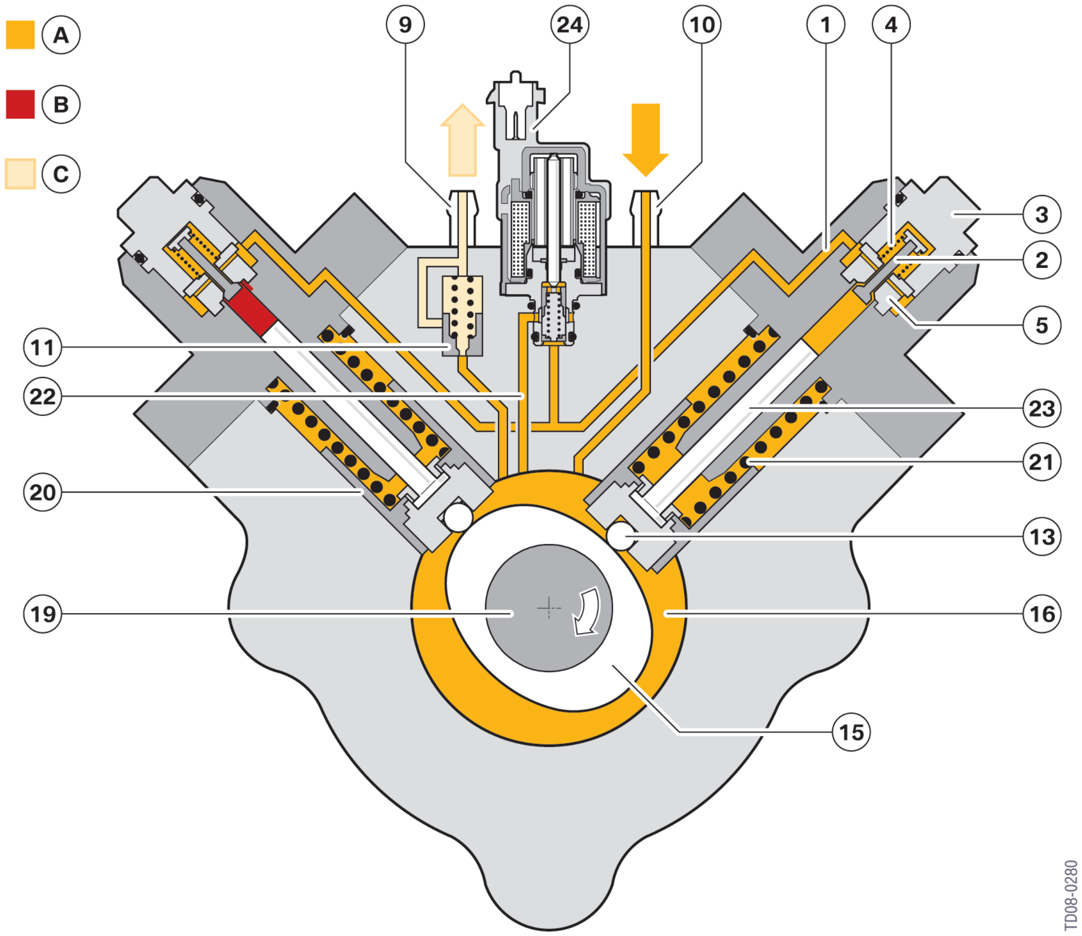
The transmission ratio from the crankshaft to the high-pressure pump is chosen so that fuel delivery is synchronized with combustion. That means that at the point of fuel injection into the cylinder, fuel is always simultaneously pumped into the fuel rail, thereby reducing fluctuations in fuel-rail pressure and, therefore, in injection pressure.

⚠ If work is carried out on the chain drive system on the N57 engine, the high-pressure pump has to be correctly positioned relative to the crankshaft. The precise procedure is detailed in the Repair Instructions. ◄



80 - High-pressure pump CP4.2

Index	Explanation	Index	Explanation
A	Fuel feed	12	Return duct
B	Fuel high pressure	13	Roller
C	Fuel return	14	Thrust washer
1	Low-pressure channel	15	Twin-lobe cam
2	Valve poppet	16	Camshaft chamber
3	Sealing plug	17	Bearing sleeve
4	Spring	18	Shaft seal
5	Valve seat	19	Camshaft
6	Ball	20	Tappet
7	Spring	21	Spring
8	Connection	22	Low-pressure channel
9	Connection	23	Piston
10	Connection	24	Volume control valve
11	Fuel overflow valve		



81 - High-pressure pump CP4.2

The power required to drive the CP4 has been reduced by 20 % compared with the CP3 by introducing roller tappets.

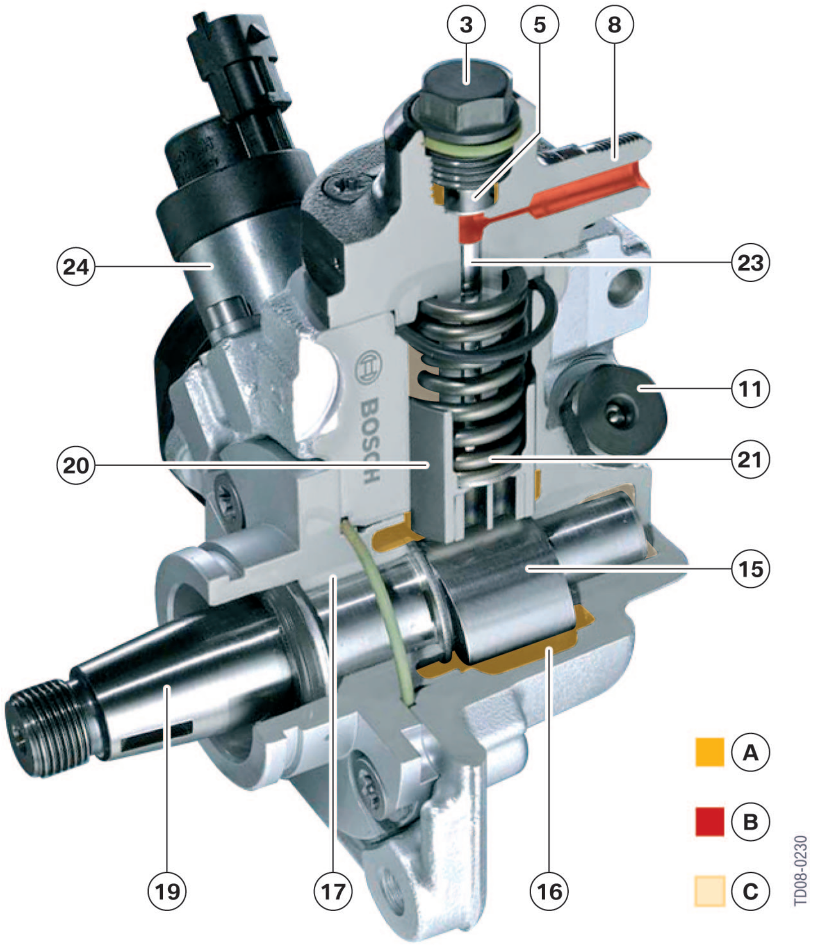
For lubrication of the high-pressure pump, fuel enters through the inlet connection (10) from the fuel feed (A) and passes into the camshaft chamber (16). The fuel passes via the bearing sleeve (17) and return channels (12) to the outlet connection (9) and back into the fuel return (C).

A fuel overflow valve (11) also returns excess pumped fuel to the fuel return (C) via the outlet connection (9).

From the camshaft chamber, the fuel passes via the low-pressure channel (22) to the volume control valve (24) and as a regulated flow from there through another low-pressure channel (1) to the valve seat (5). The spring (21) acts against the tappet (20), and indirectly the piston (23), so that the roller (13) is held in contact with the twin-lobe cam (15). The spring force is strong enough to keep the tappet roller in contact with the twin-lobe cam in all operating situations.

When the tappet and the piston are moved downwards by the force of the spring (4), the valve poppet (2) is forced open by the pressure of the incoming fuel and/or the pressure drop created by the downward movement of the piston. The fuel can then flow into the cylinder.

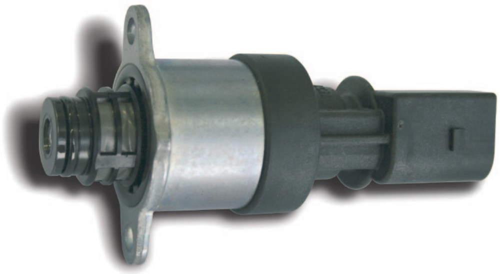
When the piston moves upwards, the valve closes again and the pressure inside the cylinder rises. When the pressure in the cylinder reaches the required high fuel pressure (B), the ball (6) is forced back against the force of the spring (7) and the fuel-rail pressure. The fuel can then be delivered to the fuel rail via the high-pressure connection (8).



82 - High-pressure pump CP4.2

Index	Explanation	Index	Explanation
A	Fuel feed	16	Camshaft chamber
B	Fuel high pressure	17	Bearing sleeve
C	Fuel return	19	Camshaft
3	Sealing plug	20	Tappet
5	Valve seat	21	Spring
8	Connection	23	Piston
11	Fuel overflow valve	24	Volume control valve
15	Twin-lobe cam		

Volume control valve



83 - Volume control valve

The volume control valve (metering unit) is also integrated in the CP4.2 high-pressure pump. It is a solenoid valve that controls the volume of fuel supplied by the high-pressure pump by characteristic mapping. Surplus fuel is directed into the return line back to the fuel tank.

In this way, the high-pressure pump does not generate unnecessarily high levels of pressure in partial load mode that would then be relieved by the rail-pressure regulating valve. This reduces the drive output of the high-pressure pump and thus the consumption of the engine.

The control of the volume control valve is described in the Engine electrical system section.

Rail (high-pressure accumulator)

The purpose of the rail is to provide fuel under high pressure for injection at all cylinders.

It is designed in such a way that, even when large volumes of fuel are drawn, the pressure inside is kept at a virtually constant value. This ensures that the injection pressure remains virtually constant when the injector is opened.

The spring effect of the fuel produced by the high pressure is utilized to conserve the accumulator effect.

This also helps to damp out pressure pulsations arising from pumping.

The N57 engine has a welded fuel rail that is seated in the cylinder head cover.

It is essentially a thick-walled pipe that provides means of retention for high-pressure lines, the rail-pressure sensor and the rail-pressure regulating valve.

Fuel-rail pressure sensor

The rail-pressure sensor is located at the forward end of the rail. It has the purpose of measuring the pressure in the rail and delivering a corresponding signal to the DDE.

The fuel-rail pressure sensor operates by means of a sensor diaphragm that is deformed by the pressure acting on it. This diaphragm converts the deformation into an electrical signal that is sent to an analyser circuit. From there, the processed signal is sent to the DDE.

Fuel-rail pressure regulating valve

The rail-pressure regulating valve is able to adjust the pressure in the rail to the correct level. To do so, it opens if the pressure is excessive and allows fuel into the return line until the desired pressure is present.

If the pressure is too low, it closes and seals the high-pressure section.

In new-generation common rail systems, the rail-pressure regulating valve no longer has to be responsible for this task in normal operation. The pressure in the rail is adjusted by the volume control valve in the meantime, thanks to which it was possible for the pumping work of the high-pressure pump to be reduced, especially in the partial load range.

In this case, the rail-pressure regulating valve is used if the driver spontaneously releases the accelerator pedal and, consequently, too much pressure is present in the rail.

It is also used during a cold start. In this case, the volume control valve allows the maximum volume of fuel into the high-pressure pump so that the fuel is heated by the pumping action. The excess pressure is then relieved by the rail-pressure regulating valve.

Fuel injectors

Piezo-injector

The higher-power engines are equipped with the piezo-electric injectors used on the M67TU/M57TU2 since 2005.

The hydraulic function of the piezo-electric injector is identical in principle with that of the solenoid-valve injector. The only difference is that the valve that releases the fuel return line is not a solenoid valve. It is controlled by a piezo-electric element known as a switching valve.

The piezo-electric element is located inside the actuator module. When controlled, it produces the movement necessary to open the switch valve.

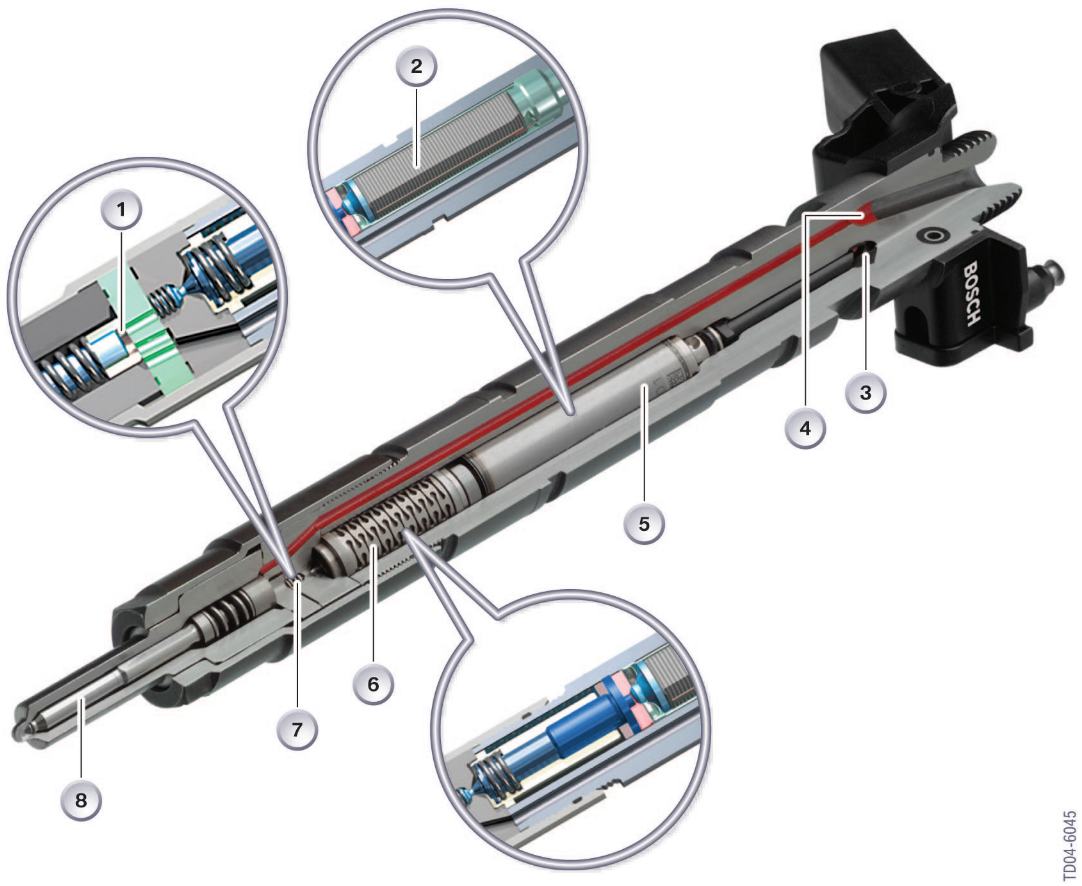
Circuited between the two elements is the coupler module, which functions as a hydraulic compensating element, e.g. to compensate for temperature-related length expansions.

When the injector is controlled, the actor module expands. This movement is transferred to the switch valve by the coupler module. When the switch valve opens, the pressure in the control chamber drops and the injector pintle opens the nozzle in exactly the same way as with a solenoid-valve injector.

The benefits of the piezo-electric injector are that it offers considerably faster control response, which results in greater metering accuracy.

In addition, the piezo-electric injector is smaller, lighter and has lower power consumption.

The N57 engine uses piezo-electric injectors of a more advanced design which are even more compact and lighter.



84 - Sectional view of the piezo-electric injector

Index	Explanation	Index	Explanation
1	Control chamber	5	Actor module
2	Piezo-element	6	Coupler module
3	High-pressure supply	7	Switch valve
4	Leakage oil return	8	Nozzle needle

Leakage oil

A certain amount of leakage oil occurs in the injectors due to the design of the system. On the one hand, this is fuel that flows away as a control volume when the switch valve or outlet restrictor opens. On the other hand, a certain amount of fuel is always forced past the switch valve or outlet restrictor as a result of the pressure in the injector.

This volume flows into the leakage oil line that is connected to each injector.

In the upper power class, the leakage oil is directed into the supply line to the high-pressure pump. The reason for this is that the switching valve in the piezo-electric injector needs a certain back-pressure to work correctly.

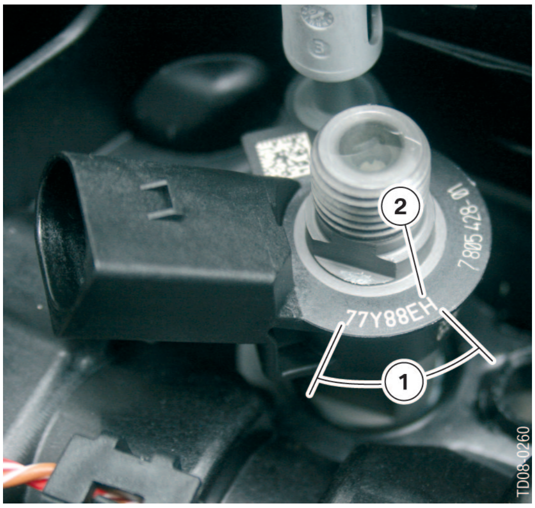
Correct function demands a return pressure of 10 bar which is achieved by means of the flow restrictor in the fuel return from the injectors.

Injector volume adjustment

Piezo-electric injectors carry a calibration code indicating not only the hydraulic tolerances but also information concerning the stroke characteristics of the injector. This is a separate classification for injector voltage calibration.

This information is necessary due to the individual voltage requirement of each injector. The injector is assigned to a voltage requirement class. This replaces the seventh digit of the injector's numeric hydraulic calibration code.

A piezo-electric injector thus has only six-digits for the hydraulic calibration code (due to higher-precision manufacture of the piezo-electric injectors) and a seventh digit for the injector voltage calibration.



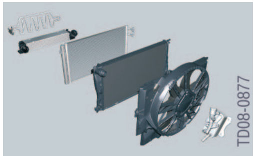
85 - Piezo-electric injector volume calibration code

Index	Explanation
1	Seven-digit code (calibration code)
2	Injector voltage calibration

High-pressure fuel lines

⚠ The high-pressure fuel lines are intended to be discarded if dismantled or removed. However, they can be re-used. The condition is that they are tightened to the specified torque and then form an absolutely 100 % leakproof seal. If any leaks are identified, the high-pressure line concerned must be replaced. ◄

Cooling system



The functions of a modern diesel engine cooling system can be subdivided into engine cooling, oil cooling, recirculated-exhaust cooling and charge-air cooling.

Overview

There are various functions performed by the engine's cooling system:

- Engine cooling
- Engine-oil cooling
- EGR cooling (exhaust gas recirculation)
- Charge-air cooling.

The engine's central cooling system is the coolant circuit.

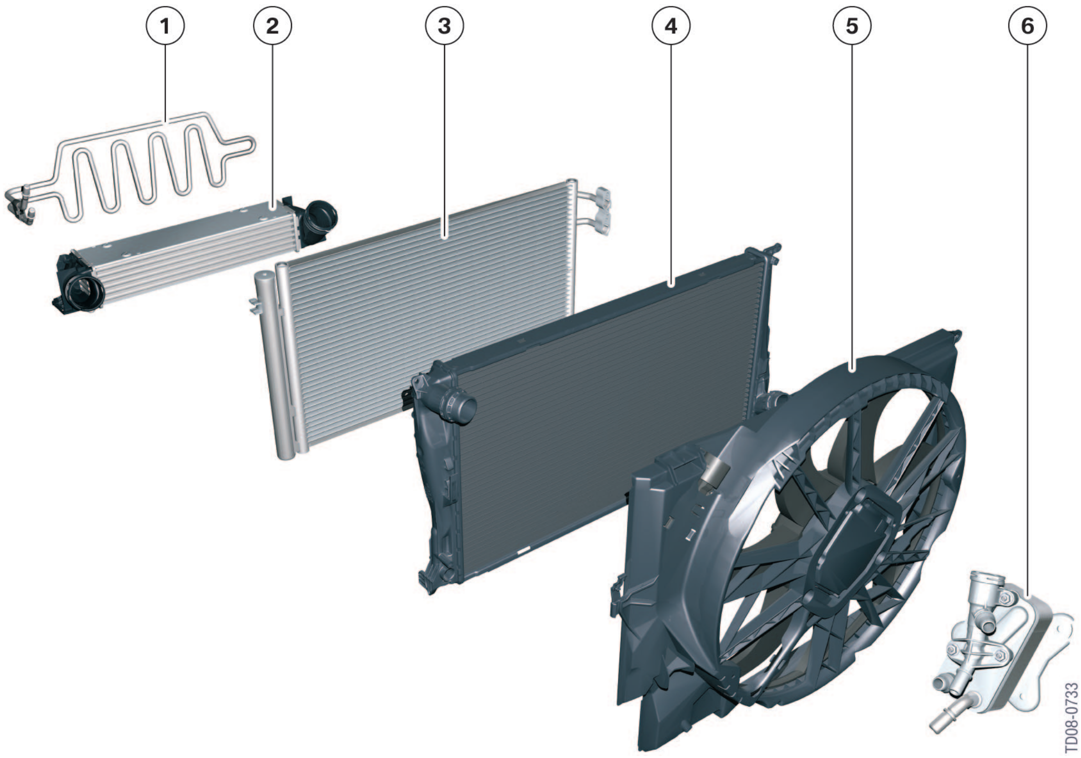
Cooling module

The charge-air cooler and, if hydraulic power steering is fitted, the power steering cooler are fitted directly in the cooling module. These heat exchangers transfer heat directly to the air.

The components of the cooling module are:

- Electric fan
- Radiator
- Air-conditioning condenser
- Intercooler
- Power steering cooler.

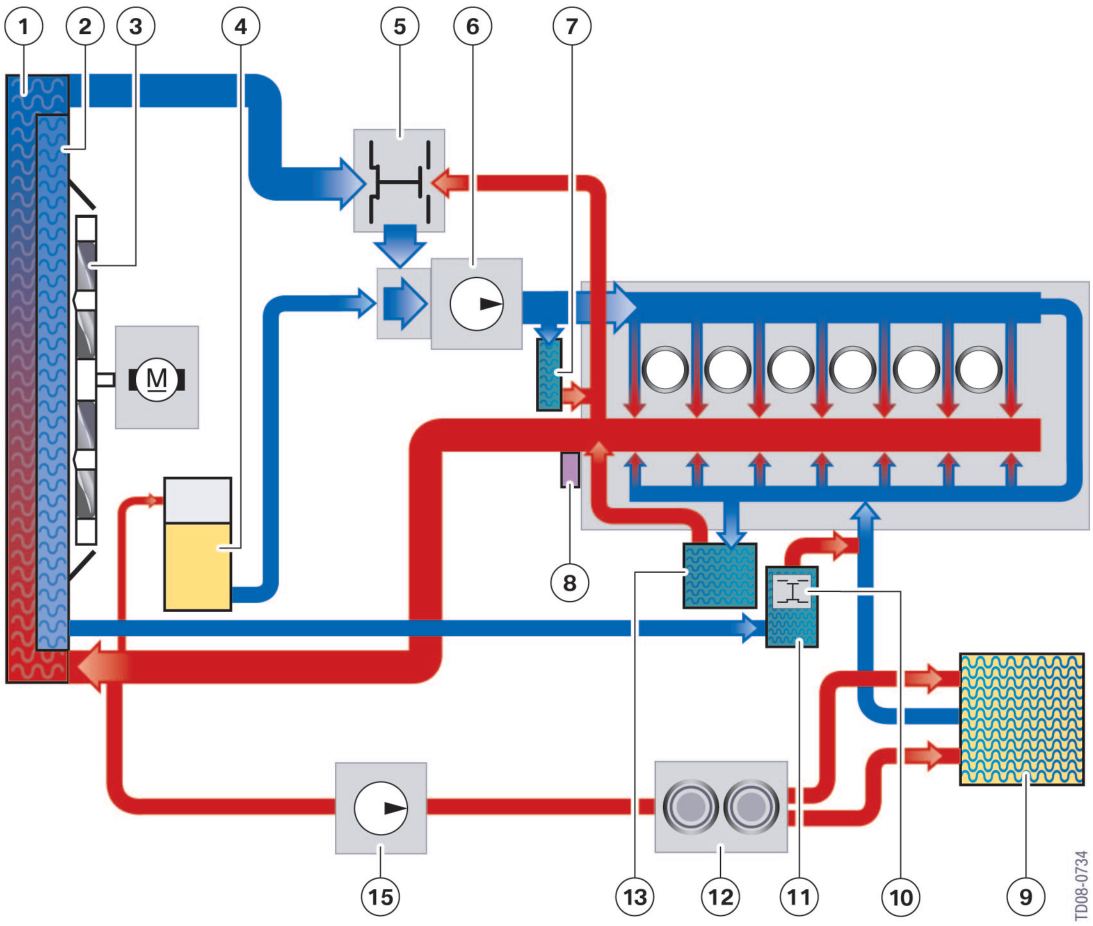
The air-conditioning condenser and power steering cooler are components of the cooling module that are not part of the engine. For that reason, they are not described in any more detail at this point.



86 - Cooling module, N57 engine

Index	Explanation	Index	Explanation
1	Power steering cooler	4	Radiator
2	Intercooler	5	Electric fan
3	Air-conditioning condenser	6	Transmission oil-to-coolant heat exchanger (mounted on engine and not part of cooling module)

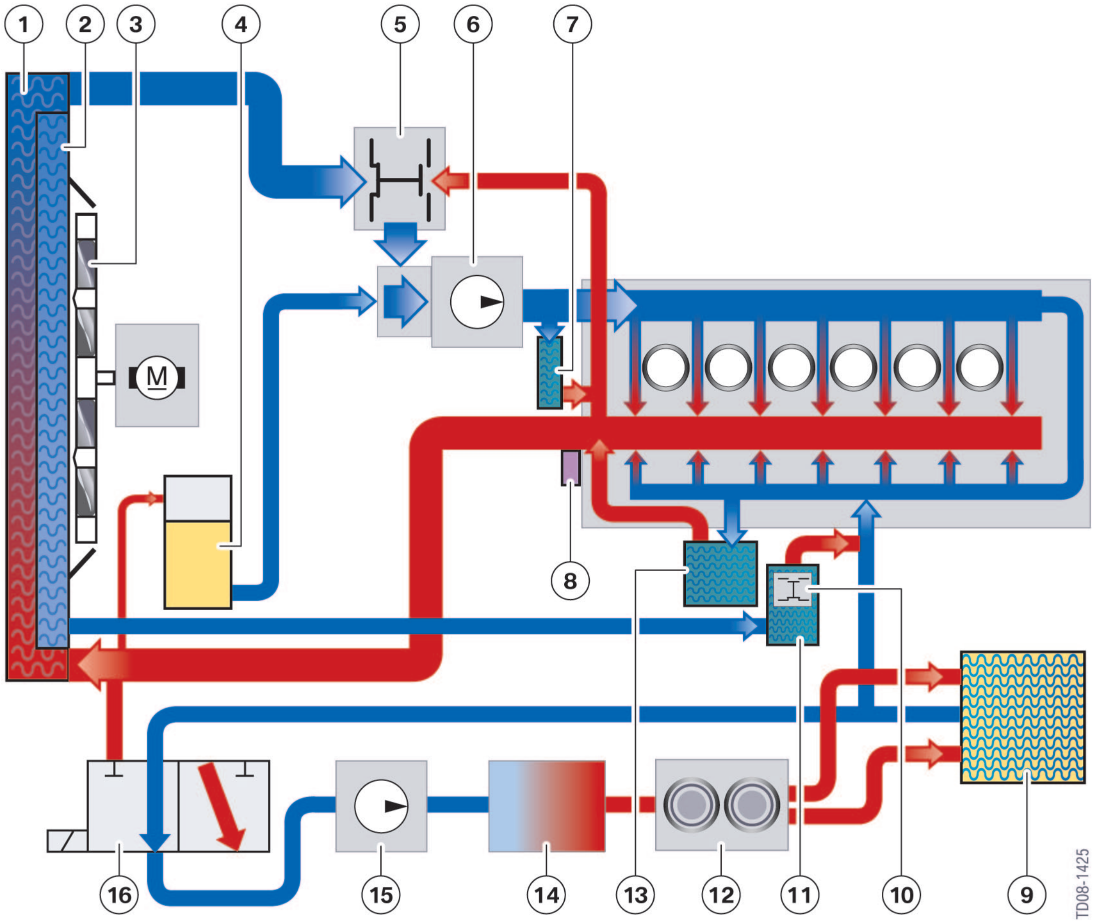
E90 cooling circulation system



87 - E90 cooling circulation system with N57 engine

Index	Explanation	Index	Explanation
1	Radiator (coolant-to-air heat exchanger)	8	Coolant temperature sensor at engine outlet
2	Radiator low-temperature zone	9	Heater matrix
3	Electric fan	10	Thermostat in the transmission oil cooler
4	Expansion tank	11	Transmission oil cooler (transmission oil-to-coolant heat exchanger)
5	Thermostat	12	Coolant valves
6	Coolant pump	13	Engine-oil cooler (engine oil-to-coolant heat exchanger)
7	EGR cooler	15	Auxiliary coolant pump

E90 cooling circulation system with auxiliary heater



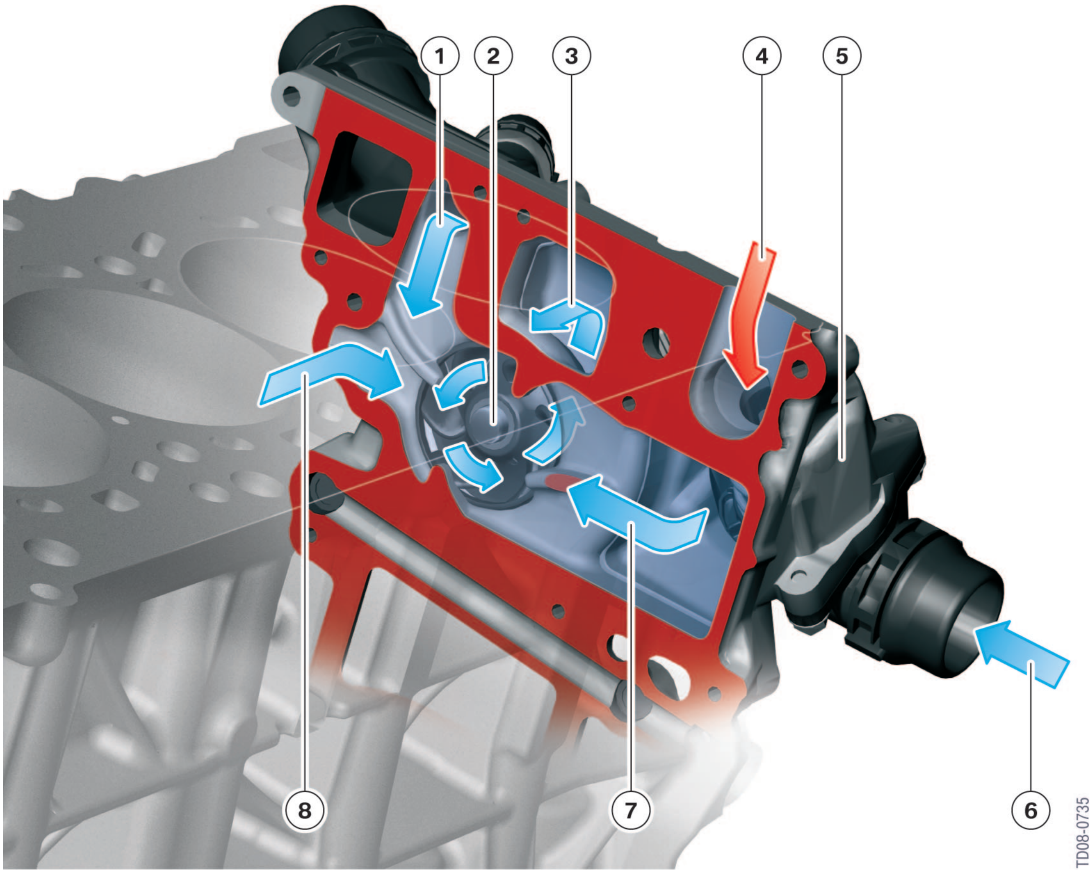
88 - E90 cooling circulation system with auxiliary heater, N57 engine

Index	Explanation	Index	Explanation
1	Radiator (coolant-to-air heat exchanger)	9	Heater matrix
2	Radiator low-temperature zone	10	Thermostat in the transmission oil cooler
3	Electric fan	11	Transmission oil cooler (transmission oil-to-coolant heat exchanger)
4	Expansion tank	12	Coolant valves
5	Thermostat	13	Engine-oil cooler (engine oil-to-coolant heat exchanger)
6	Coolant pump	14	Auxiliary heater
7	EGR cooler	15	Auxiliary coolant pump
8	Coolant temperature sensor at engine outlet	16	Changeover valve

⚠ An important function is performed by the changeover valve (16). The changeover valve ensures that only the passenger compartment, and not the engine, is heated when the auxiliary heater is in operation. A control fault or a fault on the changeover valve itself could result in the entire engine being heated up as well. Such a situation would result in the engine being difficult to start and not running smoothly immediately after starting. The changeover valve also ensures that, when the engine is running, the passenger compartment is heated up more quickly by allowing all the coolant to be heated and brought up to temperature when the engine is running. ◄

Coolant cooling

Coolant pump



89 - Coolant pump, N57 engine

Index	Explanation	Index	Explanation
1	Inflow from expansion vessel	5	Thermostat
2	Coolant pump	6	Radiator return
3	Supply to crankcase	7	Supply of thermostat
4	Return from cylinder head, and engine-oil cooler	8	Return from heater and transmission-oil cooler

The coolant pump on the N57 engine forms a single unit with the thermostat. The housing of the coolant pump is made of aluminium alloy AlSi9Cu3; the impeller and the thermostat cover are made of plastic.

The impeller, which is located in the water jacket, is bearing-mounted on a shaft. The water jacket is sealed off from the outside by a slide ring on the shaft. For this to work correctly, there must be some leakage between the shaft and the slide ring. This improves the sliding properties. This is known as the functional leakage of the slide ring seal.

On the N57 engine, as on the M57TU2, that leakage is directed into the belt pulley and may give rise to minor traces of coolant.

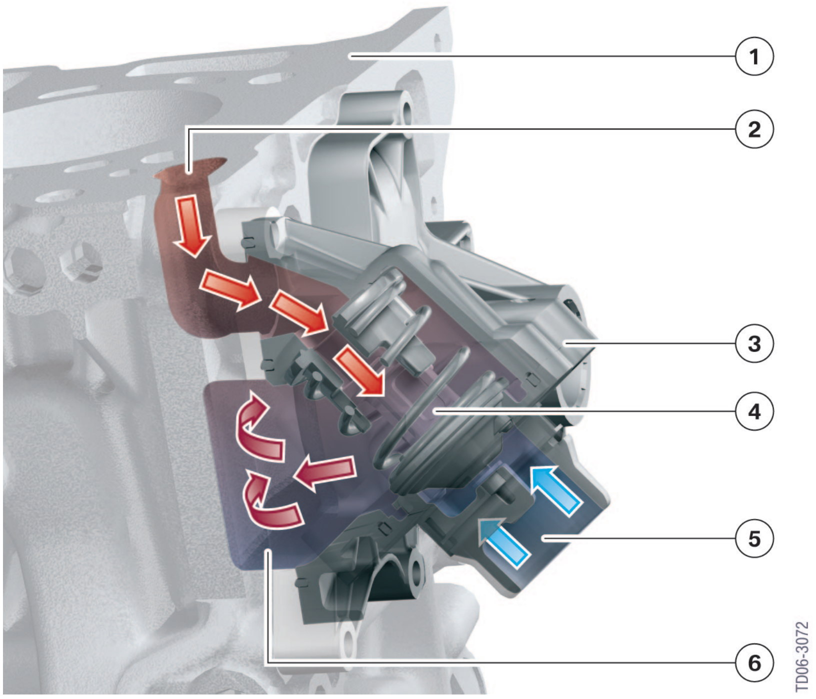
⚠ In the past, coolant pumps would often be replaced due to the presence of coolant traces. However, minor traces of coolant are acceptable due to the functional leakage of the slide ring seal.

The maximum permissible coolant leakage is 800 mg/h, which corresponds to one drop with a diameter of a little over 1 cm per hour. ◄

Thermostat

On the N57 engine, the engine temperature is controlled by a conventional thermostat. This means that only the coolant temperature determines regulation of engine temperature.

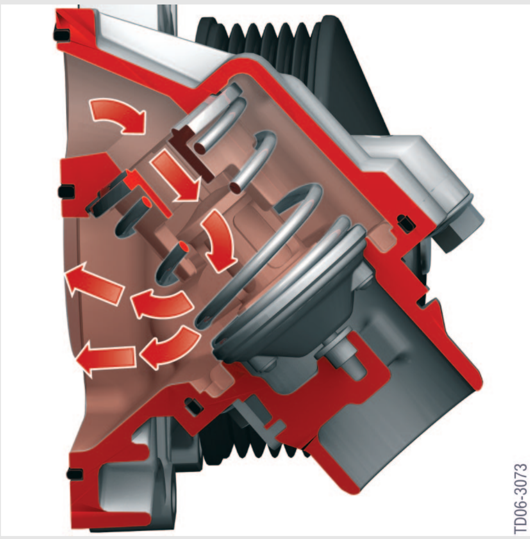
The only difference from the N47 engine is the thermostat cover, which has the coolant hose connection on the side. The following illustrations show the thermostat on the N47 engine.



90 - N47 engine thermostat

Index	Explanation	Index	Explanation
1	Crankcase	4	Wax element
2	Hot coolant from the cylinder head	5	Radiator return
3	Thermostat housing	6	Supply to the coolant pump

Operating ranges of the thermostat

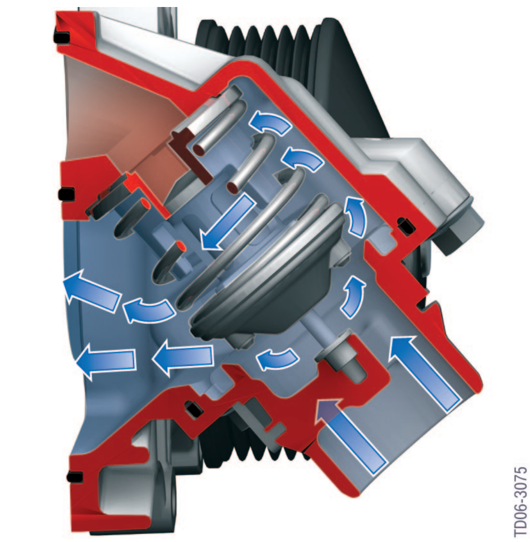


Thermostat closed

The coolant temperature is below the opening temperature of the thermostat.

The coolant circulation system is short-circuited. The coolant only flows inside the engine and not through the coolant radiator.

Opening point: approximately 88 °C

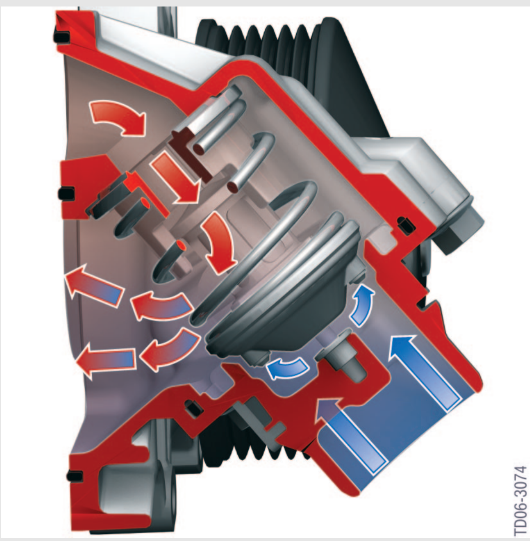


Thermostat open

The coolant temperature is above the full opening temperature of the thermostat.

All the coolant flows through the coolant radiator. This makes use of the maximum cooling output.

Full opening temperature: 100 °C



Thermostat regulation range

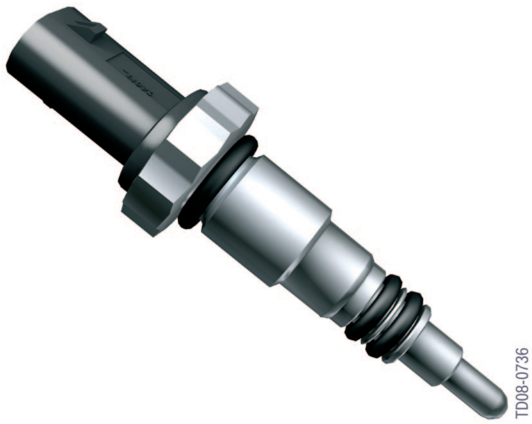
The coolant temperature is between the initial opening temperature and the fully open temperature.

The extent to which the coolant is divided depends on the coolant temperature. One part flows through the coolant radiator, the rest remains in the engine.

This method of regulation means that maximum cooling capacity can be achieved at high temperatures, while at very low temperatures cooling can largely be avoided.

Additionally, the engine can be brought up to normal operating temperature more rapidly following a cold start.

Coolant-temperature sensor (at engine outlet)



91 - Coolant temperature sensor

The coolant-temperature sensor is located in the coolant outlet of the engine, i.e. at the hottest part of the coolant circuit.

It signals the coolant temperature to the digital diesel engine management, which uses the figure as the basis for a variety of functions, e.g. fan control, engine emergency mode, displays (Check Control message), etc.

The coolant temperature sensor is connected to earth by the DDE. The second connection is connected to a voltage divider circuit in the DDE.

The resistor has a negative temperature coefficient (NTC). This means that the resistance decreases as temperature increases.

The resistor is part of a voltage divider circuit that receives a 5 V supply from the DDE. The electrical voltage at the resistor is dependent on the coolant temperature. There is a table stored in the DDE that specifies the corresponding temperature for each voltage value; the table is therefore a solution to compensate for the non-linear relationship between voltage and temperature.

The resistance changes in relation to temperature from 76 kΩ to 42 Ω, corresponding to a temperature of -40 °C to 150 °C.

Radiator

The coolant radiator is designed in such a way that it can transfer the heat given off in the engine to the ambient air reliably under all possible operating and environmental conditions. Accordingly, the size of the coolant radiator is matched to the vehicle and the equipment.

Like its predecessor, the N57 engine has a radiator made of aluminium.

Expansion tank

The expansion tank is divided into several chambers that are interconnected only by relatively small passages. This contributes to the stability of the expansion tank because it is subjected to high pressure during engine operation.

⚠ Never open the cover on the expansion tank while the engine is hot.

The reason for this is not only a risk of scalding. In the higher parts of the coolant circulation system (e.g. cylinder head), gas bubbles can form as a consequence of the drop in pressure. Sufficient heat dissipation would no longer be guaranteed at this point, which would result in overheating. ◄

The expansion vessel for the N57 engine contains, as normal, a visual fill-level indicator and an electrical fill-level sensor. Both function as floats.

The visual fill-level indicator indicates the actual fill level in the expansion tank when the expansion tank cap is open. A minimum and a maximum mark indicate the optimum fill level.

The electrical fill-level sensor is a reed switch. It is simply a switch that triggers an indicator lamp in the instrument cluster if the fill level in the expansion tank drops below the minimum level. However, it only switches at a level significantly below the minimum mark of the visual fill-level indicator.

Description	Volume
Total capacity of expansion vessel	2.2 l
Upper limit position of visual fill-level indicator	1.7 l
Maximum mark of visual fill-level indicator	1.3 l
Minimum mark of visual fill-level indicator	1.0 l
Switch point of electrical fill-level sensor	0.4 l

Electric fan

The electric fan improves the cooling output of the cooling module. It ensures sufficient engine cooling event at low speeds. It is located at the rear end of the cooling module and sucks cooling air through the individual components on demand. For this reason, the electric fan is also known as a suction ventilator.

⚠ When you carry the electric fan, do not hold it in the fan ring as this could break. ◄

Sickle-shaped fan blades promote low-noise operation in exactly the same way as the uneven blade distribution on the largest fan. Balance clips on the fan blades ensure the necessary true running. Only a maximum of five of these may be fitted.

Different electric fans are fitted, depending on the vehicle, power class and equipment.

The following are used:

- 300 W; diameter 419 mm; 7 blades
- 400 W; diameter 488 mm; 6 blades
- 600 W; diameter 500 mm; 7 blades

Oil-to-coolant heat exchangers

Engine oil-to-coolant heat exchanger

The engine oil/coolant heat exchanger is fitted to the crankcase almost in the centre of the inlet side of the engine. It is located in the same housing as the oil filter.

The coolant flows from the water jacket in the crankcase into the engine oil/coolant heat exchanger. This is an area that rapidly supplies the heat exchanger with heated coolant when the engine is cold; during operation, however, it provides a uniformly well cooled coolant.

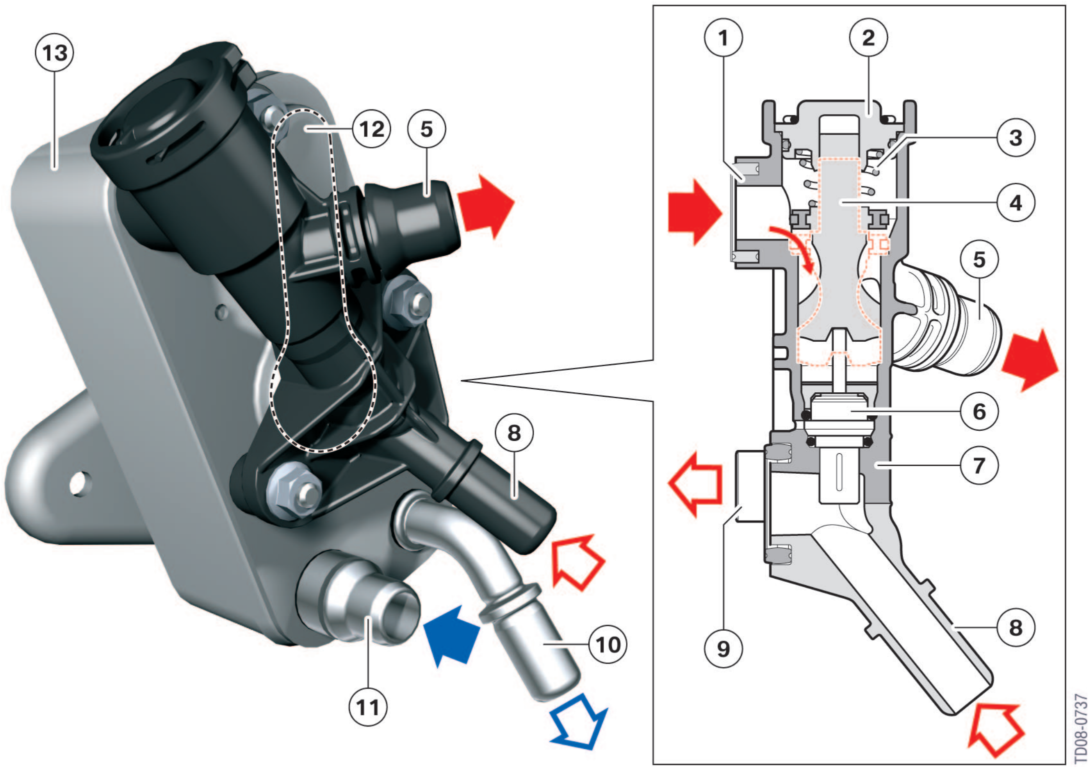
From the engine oil/coolant heat exchanger, the coolant flows back into the crankcase. Depending on the position of the thermostat, it then flows directly into the radiator or to the thermostat in the small coolant circuit.

Transmission oil-to-coolant heat exchanger

If the vehicle is equipped with an automatic transmission, an additional oil/coolant heat exchanger is used for the purpose of cooling the transmission oil.

The transmission oil-to-coolant heat exchanger (also called the transmission oil cooler) is located next to the engine oil-to-coolant heat exchanger and connected to the engine coolant circulation system by coolant hoses. It is connected to the gearbox by two transmission oil pipes.

So that the transmission oil can be brought quickly up to temperature and then kept at an optimum temperature, the transmission oil-to-coolant heat exchanger is fitted with a thermostat.



92 - Transmission oil-to-coolant heat exchanger TD08-0737

Index	Explanation	Index	Explanation
1	Heat exchanger-to-thermostat connection	8	Transmission oil inlet
2	Thermostat housing cover	9	Transmission oil inlet-to-thermostat connection
3	Spring	10	Transmission fluid outlet
4	Thermostat plate	11	Coolant infeed
5	Coolant outlet	12	Transmission oil channel
6	Thermostat (wax element)	13	Transmission oil-to-coolant heat exchanger
7	Thermostat housing		

The thermostat (6), also called the wax element, is located in the transmission oil inlet (8). The transmission oil temperature thus acts directly on the thermostat.

When the transmission oil is cold, the wax in the thermostat contracts and the spring (3) presses the thermostat valve plate (4) into the closed position. No coolant can flow from the transmission oil-to-coolant heat exchanger (13) to the coolant outlet (5). Since no heat is being carried away by the coolant, the transmission oil heats up rapidly.

Upwards of a transmission oil temperature of approximately 93 °C, the thermostat begins to open and coolant flows past the thermostat valve plate (4) to the coolant outlet (5).

By the time a transmission oil temperature of 101 °C has been reached, the thermostat has fully opened. The maximum volume of coolant then flows through the transmission oil-to-coolant heat exchanger so as to achieve maximum cooling of the transmission oil.

Due to hysteresis, the thermostat does not close again fully until the transmission oil temperature has dropped to 88 °C.

Exhaust gas recirculation cooler (EGR cooler)

Current BMW diesel engines are equipped with an exhaust gas recirculation system to reduce NO_x in the exhaust gas. The EGR cooler increases the efficiency of exhaust gas recirculation.

The recirculated-exhaust cooler is located on the front end of the cylinder head. It is supplied with coolant from the cooling jacket in the crankcase directly downstream of the coolant pump. The coolant flows through the EGR cooler and, in the process, around the pipes carrying the recirculated exhaust gas. Heat is transferred to the coolant. After passing through the EGR cooler, the coolant flows into the cylinder head.

Intercooler

The main purpose of turbocharging in a diesel engine is to boost output. Since more air is delivered to the combustion chamber as a consequence of "forced aspiration", it is also possible to have more fuel injected, which leads to high output yields.

However, because the air heats up as it is compressed, and therefore expands, the quantity of oxygen that can be delivered to the combustion chamber diminishes again. That effect is counteracted by the intercooler because it increases the density of the compressed air, and therefore its oxygen content per unit volume, by cooling it down.

The charge-air cooler is located in the cooling module underneath the coolant radiator. Compressed air flows through the charge-air cooler in several plates, around which cooling air is circulated.

Engine electrical system

Connection to vehicle electrical system

The way in which the N57 engine connects to the vehicle electrical system depends on the model. Thus on the E9x, the DDE main relay is operated by the DDE control unit and on the F01 by the Junction box module. The reason for the different arrangement on the F01 is that it means all electrical devices can be disconnected from the power when the bus switches to sleep mode.

Another new feature on the F01 is that the EGS electronic transmission control unit normally communicates with the DDE via the PT-CAN2. In the event of a fault, communication is switched to the PT-CAN. Consequently, the driver is not aware of any effects, which previously would have involved activation of the transmission emergency mode and driving in 3rd gear.

The wiring loom for the N57 engine is a modular design with 5 modules:

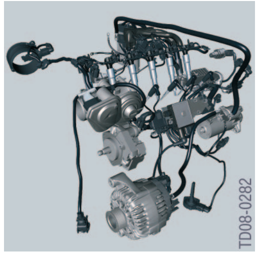
- Engine sub-loom
- Injector sub-loom
- Transmission sub-loom
- Glowplug sub-loom
- B+ sub-loom.

The mechanical connection verification introduced on the N47 engine also sets new standards of connection reliability on the N57 engine.

⚠ More information on connection to the vehicle electrical system can be found in the following Product Information documents:

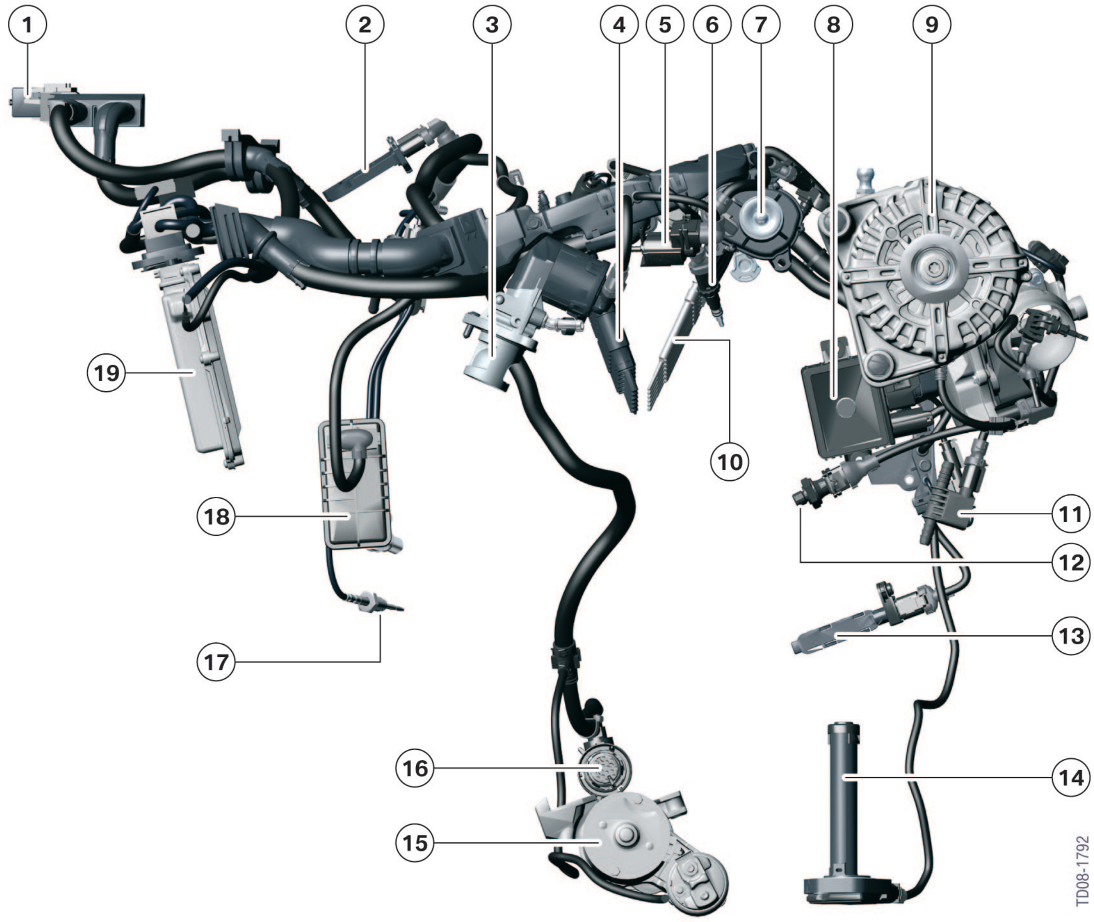
- F01/F02 Energy management
- F01/F02 Power supply, and
- F01/F02 Bus systems.

◄



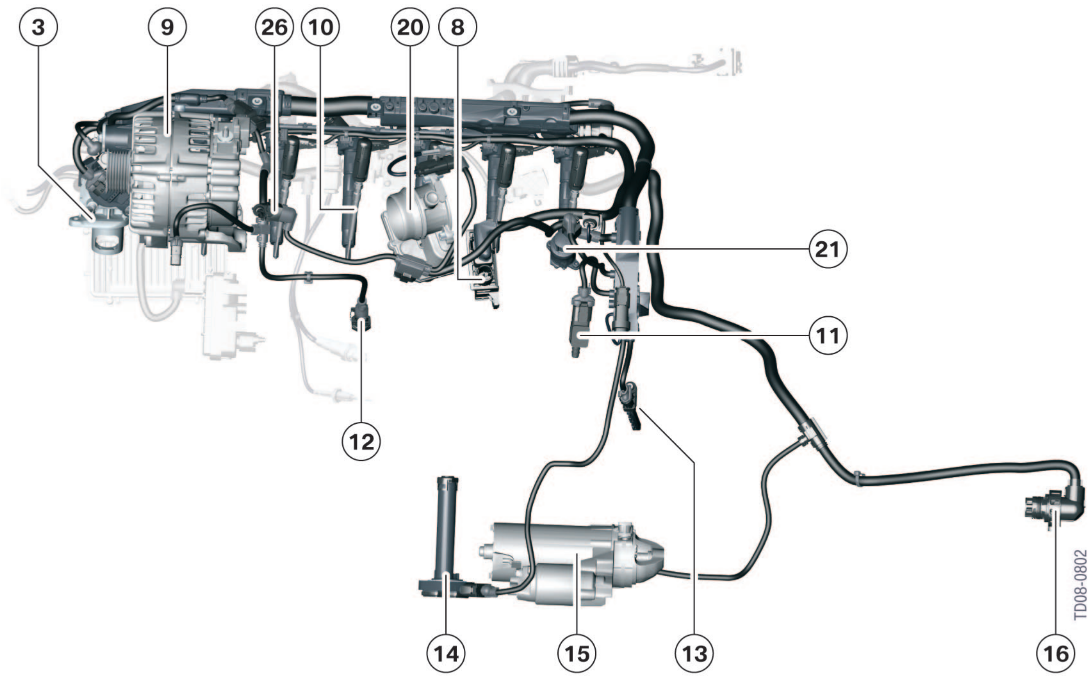
The digital diesel engine management module incorporates the engine management functions. Thus it is responsible for analysing the signals from the sensors on the engine/vehicle and for controlling the actuators on the engine.

Wiring loom routing, N57 engine in F01



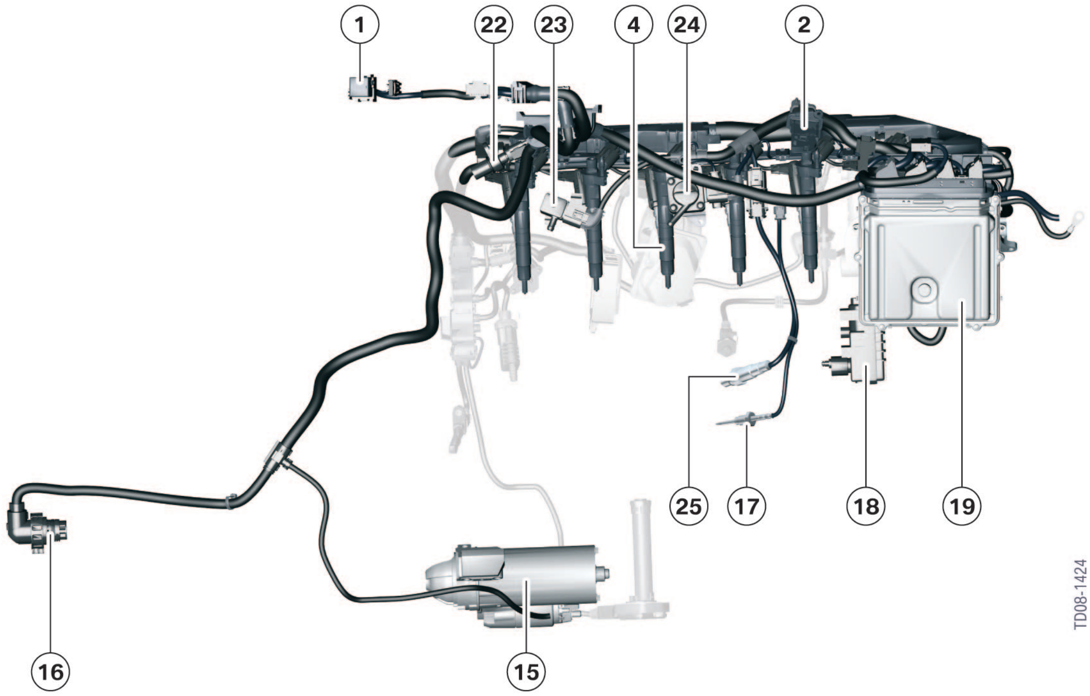
93 - Wiring loom on N57 engine in F01, front view

Index	Explanation	Index	Explanation
1	DDE main relay	11	Fuel pressure/temperature sensor
2	Hot-film air mass flow sensor	12	Oil pressure switch
3	EGR valve and sensor	13	Crankshaft sensor
4	Piezo-injector	14	Oil level sensor
5	Electropneumatic changeover valve EGR bypass valve	15	Starter
6	Coolant temperature sensor	16	Automatic transmission connection
7	Swirl flap positioner and sensor	17	Exhaust temperature sensor upstream of oxidation catalytic converter
8	Glowplug control unit	18	Charge pressure adjuster
9	Alternator	19	DDE control unit
10	Glow plug		



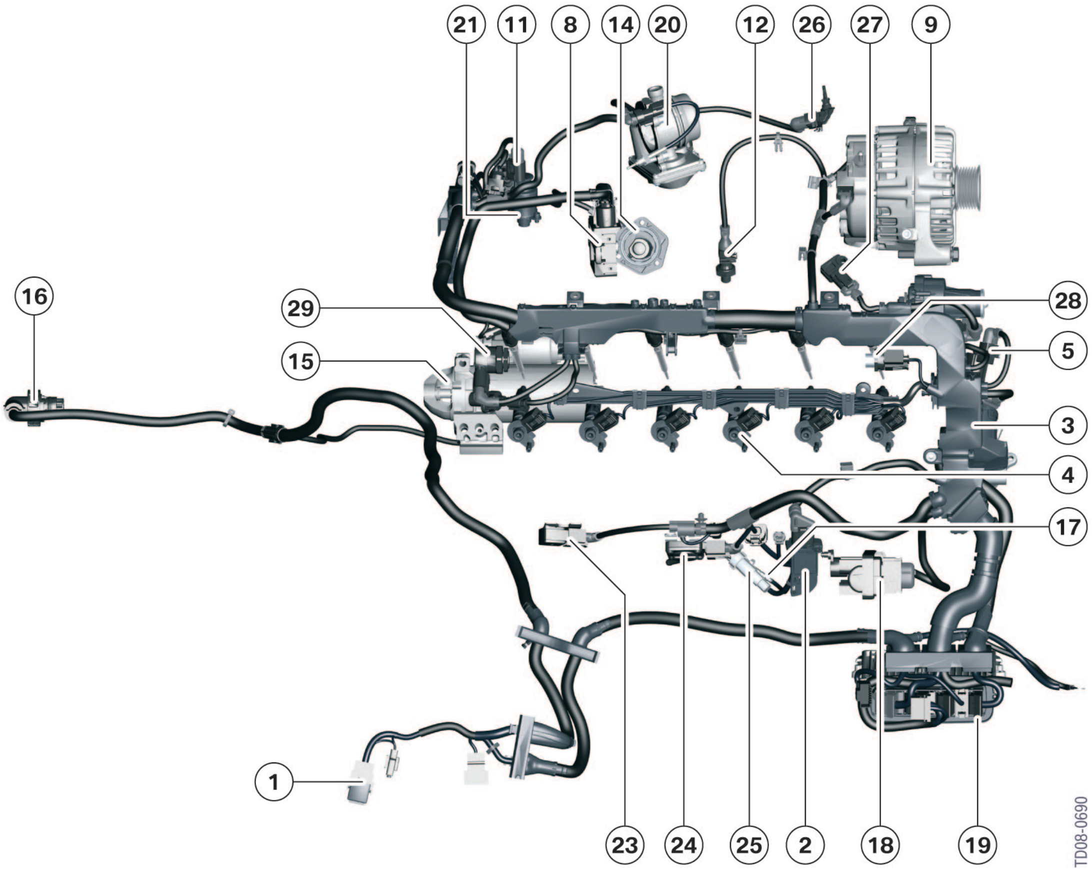
94 - Wiring loom on N57 engine in F01, view from left

Index	Explanation	Index	Explanation
3	EGR valve and sensor	14	Oil level sensor
8	Glowplug control unit	15	Starter
9	Alternator	16	Automatic transmission connection
10	Glow plug	20	Throttle valve positioner and sensor
11	Fuel pressure/temperature sensor	21	Volume control valve
12	Oil pressure switch	26	Charge-air temperature sensor
13	Crankshaft sensor		



95 - Wiring loom on N57 engine in F01, view from right

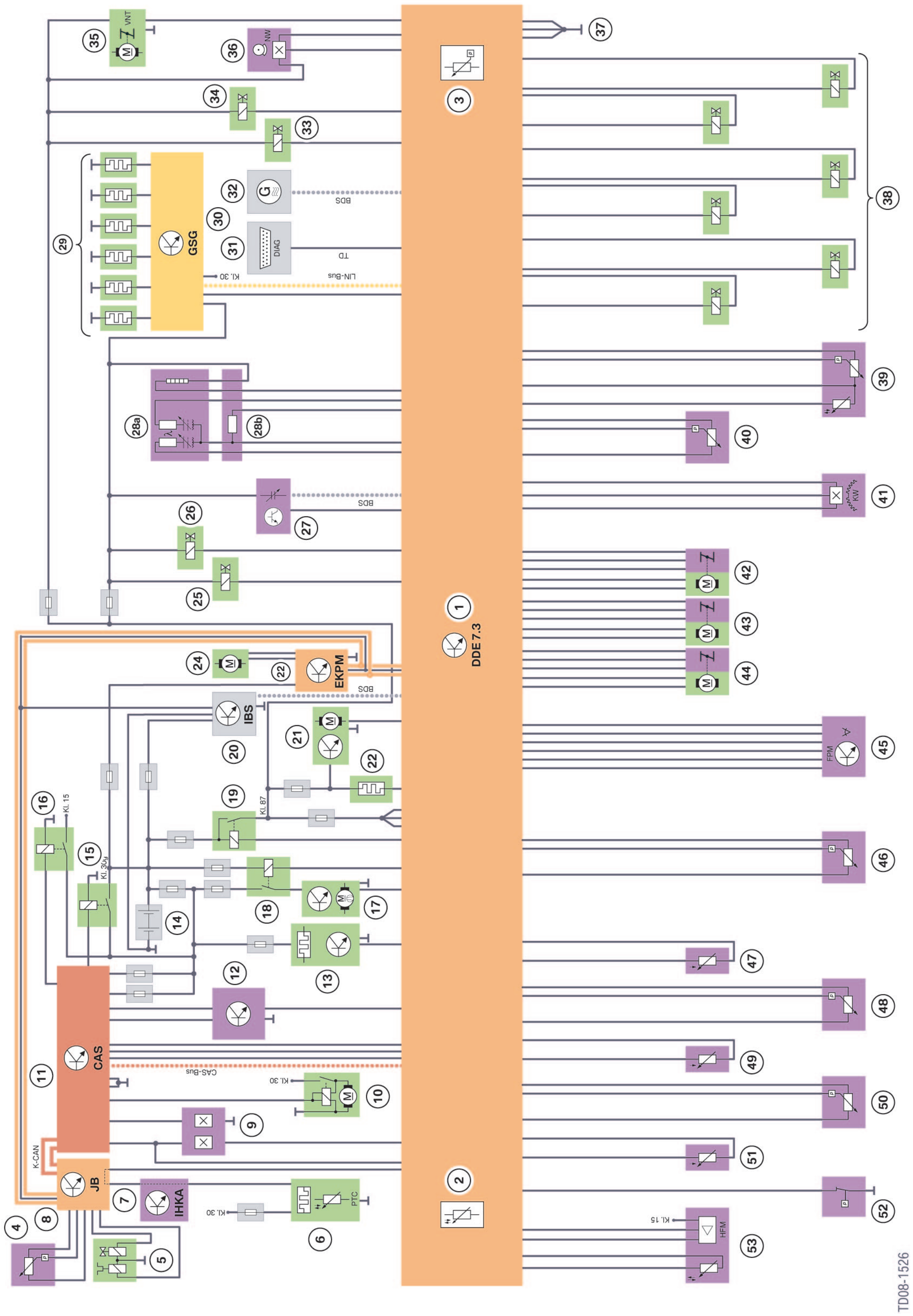
Index	Explanation	Index	Explanation
1	DDE main relay	18	Charge pressure adjuster
2	Hot-film air mass flow sensor	19	DDE control unit
4	Piezo-injector	22	Camshaft sensor
15	Starter	23	Exhaust back-pressure sensor downstream of oxidation catalytic converter
16	Automatic transmission connection	24	Exhaust back-pressure sensor upstream of turbocharger
17	Exhaust temperature sensor upstream of oxidation catalytic converter	25	Oxygen sensor



96 - Wiring loom on N57 engine in F01, top view

Index	Explanation	Index	Explanation
1	DDE main relay	17	Exhaust temperature sensor upstream of oxidation catalytic converter
2	Hot-film air mass flow sensor	18	Charge pressure adjuster
3	EGR valve and sensor	19	DDE control unit
4	Piezo-injector	20	Throttle valve positioner and sensor
5	Electropneumatic changeover valve EGR bypass valve	21	Volume control valve
8	Glowplug control unit	23	Exhaust back-pressure sensor downstream of oxidation catalytic converter
9	Alternator	24	Exhaust back-pressure sensor upstream of turbocharger
11	Fuel pressure/temperature sensor	25	Oxygen sensor
12	Oil pressure switch	26	Charge-air temperature sensor
14	Oil level sensor	27	Charge pressure sensor
15	Starter	28	Fuel-rail pressure sensor
16	Automatic transmission connection	29	Fuel-rail pressure regulating valve

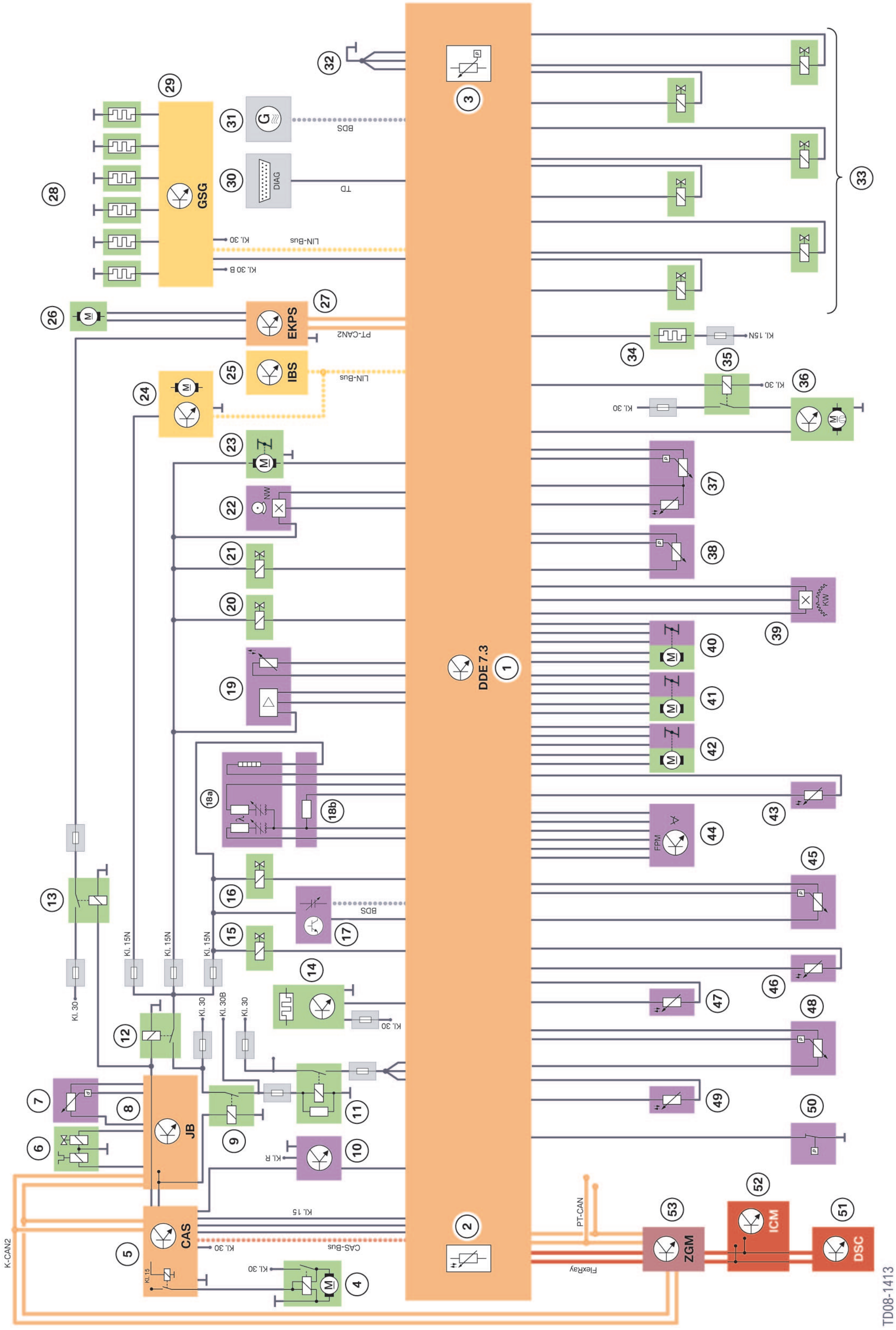
System circuit diagram for N57 engine in E9x for EURO 5



97 - System circuit diagram for N57 engine in E9x

Index	Explanation	Index	Explanation
1	DDE control unit (digital diesel engine management)	28a	Oxygen sensor (primary oxygen sensor with continuous characteristic)
2	Temperature sensor in DDE control unit	28b	Oxygen sensor connector
3	Ambient pressure sensor in DDE control unit	29	Glow plugs
4	Refrigerant pressure sensor	30	Glowplug control unit
5	A/C compressor	31	Diagnostics socket
6	Electric auxiliary heater	32	Alternator
7	Automatic climate control	33	Fuel-rail pressure regulating valve
8	Junction box	34	Volume control valve
9	Brake light switch	35	Charge pressure adjuster
10	Starter	36	Camshaft sensor
11	Car Access System (CAS)	37	Ground connection
12	Clutch module	38	Piezo-injectors
13	Fuel filter heater	39	Fuel pressure/temperature sensor
14	Battery	40	Fuel-rail pressure sensor
15	Relay, Terminal 30g	41	Crankshaft sensor
16	Relay, Terminal 15	42	EGR valve and sensor
17	Electric fan	43	Throttle valve positioner and sensor
18	Electric fan relay	44	Swirl flap positioner and sensor
19	DDE main relay	45	Accelerator pedal module
20	Intelligent battery sensor	46	Exhaust back-pressure sensor upstream of turbocharger
21	Vent flap controller	47	Coolant temperature sensor
22	Engine breather heater	48	Exhaust back-pressure sensor upstream of oxidation catalytic converter
23	Electronic fuel pump control	49	Charge-air temperature sensor
24	Electronic fuel pump	50	Charge pressure sensor
25	Electropneumatic changeover valve, engine mounting	51	Exhaust temperature sensor upstream of oxidation catalytic converter
26	Electropneumatic changeover valve, bypass valve	52	Oil pressure switch
27	Oil condition sensor	53	Hot-film air mass flow sensor

System circuit diagram for N57 engine in F01 for EURO 5



98 - System circuit diagram for N57 engine in F01

Index	Explanation	Index	Explanation
1	DDE control unit (digital diesel engine management)	27	Electronic fuel pump controller
2	Temperature sensor in DDE control unit	28	Glowplugs
3	Ambient pressure sensor in DDE control unit	29	Glowplug control unit
4	Starter	30	Diagnosis connector
5	Car Access System (CAS)	31	Alternator
6	A/C compressor	32	Ground connection
7	Refrigerant pressure sensor	33	Piezo-injectors
8	Junction box	34	Engine breather heater
9	Terminal 30B relay	35	Electric fan relay
10	Clutch module	36	Electric fan
11	DDE main relay	37	Fuel pressure/temperature sensor
12	Terminal 15N relay	38	Fuel-rail pressure sensor
13	Terminal 15N relay	39	Crankshaft sensor
14	Fuel filter heater	40	EGR valve and sensor
15	Electropneumatic changeover valve, engine mounting	41	Throttle valve positioner and sensor
16	Electropneumatic changeover valve, bypass valve	42	Swirl flap positioner and sensor
17	Oil condition sensor	43	Coolant temperature sensor
18a	Oxygen sensor (primary oxygen sensor with continuous characteristic)	44	Accelerator pedal module
18b	Oxygen sensor connector	45	Exhaust back-pressure sensor upstream of turbocharger
19	Hot-film air mass flow sensor	46	Exhaust temperature sensor upstream of oxidation catalytic converter
20	Fuel-rail pressure regulating valve	47	Charge-air temperature sensor
21	Volume control valve	48	Charge pressure sensor
22	Camshaft sensor	49	Exhaust back-pressure sensor downstream of oxidation catalytic converter
23	Charge pressure adjuster	50	Oil pressure switch
24	Air vents	51	Dynamic Stability Control
25	Intelligent battery sensor	52	Integrated Chassis Management
26	Electric fuel pump	53	Central Gateway Module

Control unit

DDE7.3

99 - DDE control unit

The DDE (digital diesel engine management) control unit is the computing and control centre of the engine management system. Sensors on the engine and other parts of the vehicle provide the input signals for the DDE control unit. Actuators carry out the commands from the DDE control unit. The DDE control unit computes the appropriate control signals for the actuators from the input signals and the algorithms and data maps stored on the control unit.

The DDE control unit is not a watertight design and is therefore fitted in a protected position inside the E-box.

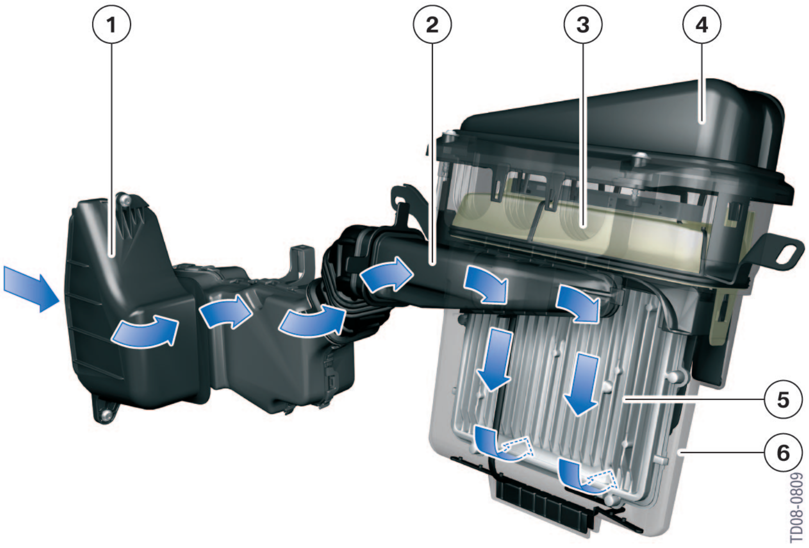
Functioning of the DDE control unit is guaranteed at an electrical system power supply voltage of between 6 volts and 16 volts.

An ambient pressure sensor and a temperature sensor are integrated in the DDE control unit.

The ambient pressure sensor makes it possible for the density of the ambient air to be precisely determined - a variable that is used in numerous diagnostic functions. Furthermore, it is needed if the cylinder charge is being calculated from the substitute variables in the event of a hot-film air mass meter fault, example.

The temperature sensor measures the temperature inside the control unit. If the temperature there increases to excessively high levels, the multiple injection, for example, is reduced in order to cool down the output stages a little and to maintain the temperature inside the control unit within a non-critical range.

Air cooling system on F01



100 - Air-cooled engine management module on F01

Index	Explanation	Index	Explanation
1	Front end inlet	4	Electronics box cover
2	Inlet duct	5	DDE control unit
3	Sealing mount	6	Electronics box

On the F01, the DDE control unit is housed in a separate electronics box (6) in a forward position on the right. The connections are separated from the ventilated section of the electronics box by a watertight sealing mount (3). The lower section of the electronics box, and therefore the DDE control unit (5), are air-cooled.

Functions

Power supply on E9x

The power management is the most important component in the energy management system. Power management is realized in the form of software in the engine control unit. The power management controls the alternator voltage while the engine is running.

A sufficient battery charge level is maintained with the aid of the intelligent battery sensor. Thus the power draw of electrical devices can be reduced or they can be switched off altogether as required on the basis of the electrical system voltage.

The DDE control unit receives the Terminal 15 ON signal from the CAS control unit via a separate connection. The DDE control unit activates the DDE main relay in response. As a result, the DDE main relay supplies power to other DDE control unit inputs. The DDE main relay also ensures the supply of power to other components. For memory functions, the DDE control unit requires a permanent power supply from Terminal 30. The earth connection of the DDE is provided by several pins that are interconnected inside the control unit. The battery voltage is constantly monitored by the DDE control unit. A corresponding fault code is entered in the memory at a battery voltage of < 2.5 V or $>$ 24 V. Diagnosis of the electrical system voltage is not activated until 3 minutes after the engine has been started. In this way, effects of the starting procedure or a jump start on the battery voltage will not be interpreted as a fault.

Power supply on F01

For the F01, modifications have been made to the power supply system. The DDE main relay is no longer controlled by the DDE control unit but rather by way of the Car Access System and the Terminal 30B relay.

Terminal 15 is fed from the CAS to the DDE control unit by two separate leads, as are Terminal 15 WUP and Terminal 15_3. Terminal 15_3 is used to switch off fuel injector operation in a safety-critical situation.

Those modifications result in functional changes in the sequences for starting and switching off the engine.

Air supply

The DDE control unit provides a pulse-width modulated signal for the electric charge-pressure adjuster. The operating range of the signal is between 10 % and 95 %, where 10 % means that the vanes are open and 95 % means that they are closed.

The mass flow rate of the intake air is measured by the hot-film air mass flow sensor (HFM).

The measured air mass flow rate is the basis for calculating the exhaust recirculation rate.

The air mass is also used in the calculation of the limit volume. The limit volume is the maximum permissible volume of fuel that may be injected under full load before smoke development would occur.

Swirl flaps provide a better air swirl effect. The result is to improve exhaust emission values.

The controllable swirl flaps are located in the tangential ducts of the intake manifold and are closed or opened depending on the operating condition. The electrically controllable swirl flaps are opened by the swirl flap regulator with increasing engine speed.

The swirl flaps are **closed** under the following conditions:

- at low engine speeds **and**
- low injection volumes (data-map controlled).

The swirl flaps generally remain **open** if:

- coolant temperature < 15 °C **or**
- intake air temperature < 15 °C.

The swirl flap positioner is a stepper motor that is controlled by the DDE control unit by means of a PWM signal. The stepper motor operates the adjustment rod and the swirl flaps close.

An integrated sensor signals the position of the swirl flaps to the DDE control unit.

Injector volume adjustment

When the injectors are manufactured, individual data is collected on the specific characteristics of each one. This is how the tolerance ranges of their hydraulic properties are determined.

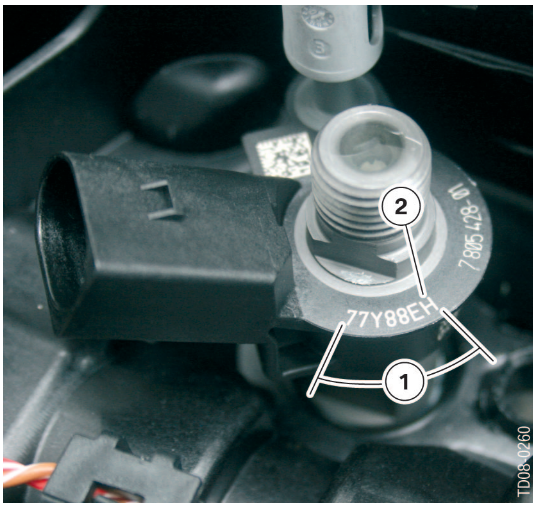
A correction value is then defined for the pre-injection and main injection.

Piezo-electric injectors carry a calibration code indicating not only the hydraulic tolerances but also information concerning the stroke characteristics of the injector. This is a separate classification for injector voltage calibration.

This information is necessary due to the individual voltage requirement of each injector. The injector is assigned to a voltage requirement class. This replaces the seventh digit of the injector's numeric hydraulic calibration code.

A piezo-electric injector thus has only six-digits for the hydraulic calibration code (due to higher-precision manufacture of the piezo-electric injectors) and a seventh digit for the injector voltage calibration.

When an injector is replaced, that calibration figure must be programmed on the DDE control unit using the BMW diagnosis system.



101 - Piezo-electric injector volume calibration code

Index	Explanation
1	Seven-digit code (calibration code)
2	Injector voltage calibration

Volume-balancing control

The DDE control unit detects fluctuations in engine speed. The control duration of the injectors is corrected based on these engine speed fluctuations. The volume-balancing control equalizes the injection volume of all cylinders.

Zero volume calibration

The zero-volume calibration is a continual learning process. This learning process is required to enable precise pre-injection for each individual injector. Compliance with exhaust emission requirements demands precise metering of the very low pre-injection volume. Due to the injector volume drift, zero-volume calibration has to be carried out constantly.

A small amount of fuel is injected into each cylinder when the engine is overrunning. That quantity is gradually increased until the DDE control unit detects a slight increase in engine speed. That change enables the DDE control unit to detect when each cylinder starts to work. The volume of fuel injected during the zero-volume calibration sequence is used by the DDE control unit as the base figure for the pre-injection data map.

Mean volume adaptation

Mean volume adaptation is a learning process whereby the fuel/air ratio (lambda value) is corrected by adjusting the air mass flow rate or exhaust recirculation rate. Unlike the other processes, this process affects all injectors equally rather than the individual injector.

An injection volume averaged across all cylinders is calculated from the lambda value measured by the oxygen sensor and the air mass flow rate measured by the hot-film air mass flow sensor. That figure is compared with the injection volume specified by the DDE control unit.

If a discrepancy is identified, the air mass flow rate is adjusted to match the actual injection volume by adjusting the EGR valve. The correct lambda value is set in turn.

Mean volume adaptation is not an "instantaneous" control operation but an adaptive learning process. In other words, the injection volume error is learned over time and recorded as an adaptive data map that is permanently stored in the control unit's EEPROM.

That data map in the EEPROM has to be reset (wiped) if the following components are replaced:

- Hot-film air mass flow sensor
- Injector(s)
- Rail-pressure sensor.

The data map is reset by a function on the BMW diagnosis system.

⚠ Mean volume adaptation has to be reset if one of the following components has been replaced:

- Air-mass sensor
- Fuel-rail pressure sensor
- Oxygen sensor.

◄

Fuel filter heater

A new feature is that the fuel filter heater is controlled by the DDE control unit. It is switched on and off as a function of the temperature and the pressure in the fuel feed and of the power consumption of the electric fuel pump.

The temperature signal comes from the combined fuel pressure/temperature sensor upstream of the high-pressure pump. If the fuel temperature is below a defined level but the specified pressure is not achieved despite greater power consumption by the fuel pump, the fuel filter heater is switched on.

If the target pressure is not reached above a defined fuel temperature, the DDE control unit stores a fault code memory entry indicating a blocked filter.

Electric fan

The DDE control unit signals the required cooling capacity to the electric fan by a PWM signal with a duty factor of between 9 and 95 %. The electric fan is fitted with an output stage that controls the fan according to that requirement by adjusting the fan speed. The pressure sensor for the air conditioning system also has an influence on the drive of the electric fan.

Oxygen control

An optimum fuel-air mixture is necessary for complete and problem-free combustion.

Modern catalytic converters therefore achieve a conversion rate of 98 % up to virtually 100 %, i.e. the percentage of converted pollutants. The optimum composition of the fuel-air mixture is controlled by the Digital Diesel Electronics (DDE). The required information relating to the composition of the exhaust gas is supplied by the oxygen sensors.

The broadband oxygen sensor upstream of the catalytic converter constantly measures the residual oxygen in the exhaust gas. The fluctuating residual oxygen levels are passed to the DDE control unit as voltage signals.

The DDE control unit uses them as the basis for adjusting the mixture composition.

The EURO 6 version has a second oxygen sensor downstream of the diesel particulate filter. That second oxygen sensor enables the system to detect whether the NO_x accumulator catalytic converter needs to be regenerated.

Lambda adaptation

Lambda adaptation (mixture adaptation) serves the purpose of adjusting component tolerances and ageing phenomena that have an influence on the fuel-air mixture. Factors such as secondary air and fuel pressure also affect lambda adaptation (partial adjustment). For these reasons, no exact control limits can be specified for a specific fault. The following distinctions are made in terms of lambda adaptation:

- Additive mixture adaptation
- Multiplicative mixture adaptation.

Additive mixture adaptation is effective at idle speed or the near idle speed range. Its influence decreases as the engine speed increases. Multiplicative mixture adaptation is effective over the entire characteristic map. One of the main factors is the fuel pressure.

The service function "Reset adaptation data" can be used to reset the adaptation data and the equipment option settings to their factory settings. It will then be necessary to relearn the adaptation values. A longer period of vehicle operation between idle speed and partial load is required in order to learn the values for mixture adaptation.

Exhaust gas recirculation (EGR)

Under certain engine operating conditions, a certain amount of exhaust is fed back into the intake manifold by the EGR valve for the purposes of reducing exhaust emissions.

Exhaust recirculation is only active at low engine speeds and loads:

- Engine speed < approx. 2,600 rpm
- Injection volume < approx. 50 mg/stroke.

The volume of the recirculated exhaust gas influences the mass of the intake fresh air: The more exhaust gas is recirculated, the less fresh air is taken in. It is known how much fresh air mass the engine takes in at any given operating point with EGR switched off. The reduction in the intake fresh air mass caused by the exhaust gas recirculation is therefore a measure of the volume of the recirculated exhaust gas. The system is controlled in such a way that the specified air mass flow rate for the operating situation is drawn in.

The EGR control method for systems up to EURO 5 is described in more detail below.

The DDE control unit calculates a target fresh air mass for each operating point from the following influencing variables:

- Engine speed
- Injected quantity
- Coolant temperature
- Atmospheric pressure
- Intake air temperature
- Reduction in the exhaust gas recirculation caused by idling for longer than 5 minutes.

The DDE control unit can not precisely determine the mass flow rate of the recirculated exhaust because the hot-film air mass-flow sensor only measures the flow rate of the intake air and has a wide tolerance band for system design reasons. The exhaust recirculation rate is controlled by operating the EGR valve but without an exhaust recirculation sensor and relatively imprecisely. The oxygen sensor detects whether too much or too little exhaust is being recirculated. The exhaust recirculation rate is then readjusted according to the information from the oxygen sensor.

The EURO 6 version brings with it an additional component in the form of an EGR temperature sensor.

The EGR temperature sensor and the exhaust back-pressure sensor upstream of the turbocharger in conjunction with the charge-pressure sensor make it possible to exactly control the exhaust recirculation rate. Thus substantially improved control of the quantity of recirculated exhaust and, therefore, of the NO_x content of the exhaust is possible.

Glow system

The glow system ensures reliable cold start characteristics and smooth engine operation when the engine is cold.

The DDE control unit sends the glowplug temperature request to the glowplug control unit. The glowplug control unit carries out the request, controlling the glowplugs by means of a pulse-width-modulated signal. In addition, the glowplug control unit sends back diagnostic and status information to the DDE control unit via a LIN bus connection.

The LIN bus is a bidirectional data interface that operates according to the master-and-slave principle. The DDE control unit is the master.

Each of the six glowplug circuits is individually diagnosable.

When the glowplug control unit is first switched on, the electrical resistance of the glowplugs at the start of the glowplug heating sequence is analysed. A glowplug that is already hot has a significantly higher resistance than one that is cold. If the system detects that the glowplugs are hot on the basis of their resistance, less power is applied at the start of the glowplug heating sequence. If, on the other hand, the system detects that the glowplugs are cold, the maximum power is applied at the start of the glowplug heating sequence. This function is called dynamic repeat glowplug heating. It prevents too much power being applied in a second glowplug heating sequence to a glowplug that is already hot from the first glowplug heating sequence and thereby overheating it.

The DDE control unit determines the required glowplug temperature on the basis of the following engine operating data:

- Engine speed
- Intake air temperature
- Injected quantity
- Ambient pressure
- System voltage
- Starter enable status signal.

To activate glowplug heating, the DDE control unit signals the required glowplug temperature to the glowplug control unit.

Operating modes:

- **Preheating:**
  Preheating is activated after Terminal 15 is switched on.
  The glowplug indicator lamp on the instrument cluster is only switched on at coolant temperatures of ≤ 10 °C. The preheating sequence is terminated when:
  - the engine speed threshold of 42 rpm is exceeded (starter motor is operated)

    or
  - the preheating time has elapsed. The preheating time is dependent on the coolant temperature and is defined by a stored characteristic curve.

Coolant temperature in °C	Preheating time in seconds
< -35	3.5
-25	2.8
-20	2.8
-5	2.1
0	1.6
5	1.1
30	1.1
> 30	0

- **Start standby heating:**
  If the preheating sequence is terminated by expiry of the preheating time, start standby heating is activated. The start standby heating sequence is terminated:
  - after 10 seconds of start standby heating have elapsed

    or
  - when the engine speed threshold of 42 rpm is exceeded.
- **Start heating:**
  The start heating sequence is activated every time the engine is started if the coolant temperature is below 75 °C. Start heating begins when the engine speed threshold of 42 rpm is exceeded. Start heating is terminated:
  - when the maximum start heating time of 60 seconds has elapsed

    or
  - when the engine starting sequence is completed

    or
  - when the coolant temperature exceeds 75 °C.
- **Emergency heating:**
  In the event of a loss of communication between the DDE control unit and the glowplug control unit for more than 1 second, emergency heating mode is activated for 3 minutes. The glowplug control unit then adopts safe settings in order to prevent damage to the glowplug system.

- **Hidden heating:**
  Up to a coolant temperature of 30 °C, preheating and start standby heating are carried out as so-called hidden heating.

  Hidden heating is carried out a maximum of four times, after which it can only be re-enabled when the engine is started.

  Hidden heating is triggered by the following signals:

  - Driver's seat occupancy
  - Driver's seatbelt buckle
  - Valid key
  - Terminal R
  - Brake operated (F01 only)
  - Clutch operated.
- **Medium power band heating:**
  Once the engine is running and the coolant temperature remains below 75 °C, medium power band heating may be activated in order to improve emission characteristics. Operation of the glowplugs is dependent on the engine speed and load.

The glowplug control unit incorporates the power output stages for controlling the glowplugs. The glowplug control unit does not have its own fault memory. If the glowplug control unit detects faults in the glowplug system, it signals them to the DDE control unit via the LIN bus. Those faults are then stored in the DDE fault memory.

If the permissible operating temperature of the glowplug control unit is exceeded, it disables glowplug heating of any kind in order to prevent damage.

The ceramic glowplugs are operated by a voltage of between 7.0 and 10.0 volts. Up to 10 volts can be applied for a short period for rapid heating purposes. To maintain the glowplug temperature, the glowplugs are controlled by a PWM signal. That produces an effective voltage at the glowplugs that is lower than the electrical system voltage.

⚠ The ceramic glowplugs are sensitive to shocks and bending. Glowplugs exposed to such stresses could be damaged prior to use. ◄

⚠ If they are not cooled by the flow of air, as occurs when the engine is running, the glowplugs can be damaged or destroyed by voltages over 7 volts. ◄

Electronic immobilizer (EWS)

The electronic vehicle immobilizer serves the purpose of preventing theft and enabling vehicle start-up.

It is equipped with a newly developed electronic vehicle immobilizer (4th generation). This new development makes use of a new and modern encryption process.

Each vehicle is assigned a 128 bit long secret code. This secret code is stored in a BMW database so that it is known only to BMW. The secret code is programmed onto the Car Access System (CAS) control unit and the DDE control unit and locked.

Once stored in the control units, the secrete code can no longer be deleted or changed. This means each control unit is assigned to a specific vehicle. The CAS control unit and the DDE control unit identify themselves to each other using the secret code and the same algorithm. Another function is shutdown of the fuel injectors by the CAS control unit via Terminal 15_3.

The CAS control unit activates the starter by means of a relay located in the control unit only if the identification data are correct. At the same time, the CAS control unit sends a coded authorization signal (variable code) to the DDE control unit to start the engine. The DDE control unit authorizes the start request only if a correct authorization signal is received from the CAS control unit. These procedures may cause a slight delay in start-up (up to half a second).

⚠ If there is a fault in the Car Access System or the digital diesel engine management, a specific procedure must be followed. The required control unit must be ordered precisely for the specific vehicle. The vehicle data (vehicle identification number) are required for this purpose. EWS matching is not necessary after replacing the control units. ◄

Diesel particle filter

Since introduction of the new CBS strategy for BMW diesel vehicles (first introduced with DDE6 on E70 as of 09/2006) the remaining mileage of the diesel particulate filter can be read by means of control unit functions. Since the diesel particulate filter is no longer part of the CBS system, two new faults are used to indicate limited remaining life.

- Fault 452A is registered if the diesel particulate filter has exceeded the major part of the maximum mileage and serves to inform/request the BMW service workshop to change the filter.
- Fault 4D4A is registered if, despite indication of the necessity to change the filter, no action is taken and the diesel particulate filter's maximum mileage is exceeded.

EURO 6 function

Vehicles that meet EURO 6 requirements have the following additional sensors:

- Exhaust temperature sensor upstream of diesel particulate filter
- EGR temperature sensor
- Oxygen sensor downstream of diesel particulate filter.

The exhaust temperature sensor upstream of the diesel particulate filter enables even more precise control of particulate filter regeneration.

Filter regeneration requires an exhaust temperature of 240 °C. Initiating filter regeneration below 240 °C would result in white smoke emission due to surplus hyrocarbon (HC). The exhaust temperature sensor upstream of the oxidation catalytic converter makes it possible to prevent regeneration until the temperature exceeds 240 °C.

The exhaust temperature upstream of the diesel particulate filter is registered for the purposes of controlling post-injection and thereby the exhaust temperature itself upstream of the diesel particulate filter. With the aid of the exhaust temperature sensor upstream of the diesel particulate filter, the temperature is regulated by way of the post-injection volume to a level of between approx. 580 °C and 610 °C depending on vehicle model.

The EGR temperature sensor is required in order to be able to precisely determine the mass flow rate of the recirculated air. Using it in conjunction with the hot-film air mass-flow sensor and the exhaust back-pressure sensor upstream of the turbocharger, the recirculated air mass flow rate can be precisely determined. As the recirculated exhaust can also be fed back into the intake manifold uncooled in order to raise the temperature, measuring the temperature of the recirculated exhaust also serves as a safety feature for the intake system which protects it from excessive temperatures. Such measures are required because the engine has to be run intermittently for up to 3 seconds with a rich mixture of lambda ≈ 0.93 in order reduce nitrogen oxides and sulphating of the NO_X accumulator catalytic converter.

Sensors

Clutch module

102 - Clutch module

On vehicles with manual transmission, the clutch module on the clutch pedal detects the position of the clutch. The clutch module consists of a Hall sensor and evaluator electronics.

The clutch module has connections for the 12-volt power supply, Terminal R and earth. A signal lead connects to the DDE control unit. The clutch switch sends a signal of 0 volts to the DDE control unit when the clutch pedal is not depressed, and 12 volts when the clutch pedal is depressed.

Accelerator pedal module

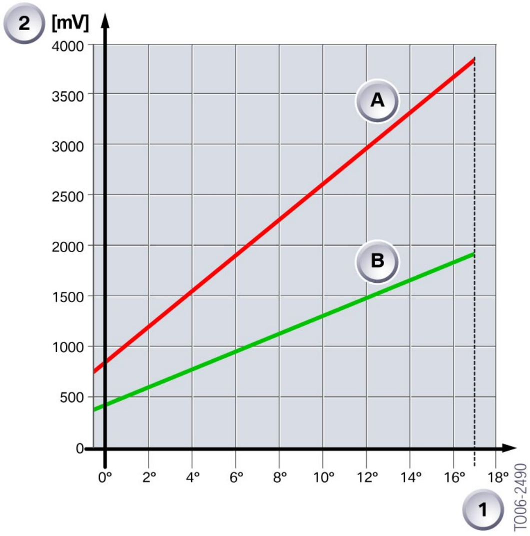
103 - Accelerator pedal module

The accelerator pedal module provides the DDE control unit with the signal indicating the engine power output desired by the driver.

The accelerator pedal module operates in accordance with the magnetoresistive principle. Two Hall-effect angle sensors are used to facilitate monitoring and fault detection.

The two Hall-effect angle sensors separately receive their 5 V power supply voltage from the DDE control unit, through which they are also connected to earth. The output from the sensors is an analogue voltage signal which is sent to the DDE control unit.

The signal of the Hall angle sensor 1 (A) is greater than the signal from Hall angle sensor 2 (B) by a factor of 2.



104 - Signal progression of accelerator pedal module

Index	Explanation
1	Operating angle in degrees
2	Pedal position voltage in mV
A	Hall angle sensor 1
B	Hall angle sensor 2

The DDE control unit monitors the input signals from the two Hall-effect angle sensors and compares them for plausibility.

Crankshaft sensor

105 - Crankshaft sensor

The crankshaft sensor informs the DDE control unit of the position of the crankshaft. The signal from the crankshaft sensor is one of the most important variables for engine management.

Since the introduction of the automatic engine stop/start function, a new sensor that can detect reverse rotation has been used.

It is what is known as an active speed sensor that functions according to the Hall effect. The sensor has its own analyser chip.

With the active crankshaft sensor, pairs of magnetic poles perform the function of the ridges on a reluctor ring. It can therefore be referred to as a multi-pole sensor ring, as already used in the M57TU2. On the multipolar sensor wheel, the tooth gap of the incremental gear is represented by a pair of poles twice as long.

There are three Hall elements in the sensor, arranged next to each other in a housing. The signals of the first and third Hall-effect sensors produce a differential signal for determining the signal frequency and the clearance to the multi-pole sensor ring. A clockwise or anti-clockwise direction of rotation can be detected thanks to the time offset between the signal of the centre element and the differential signal.

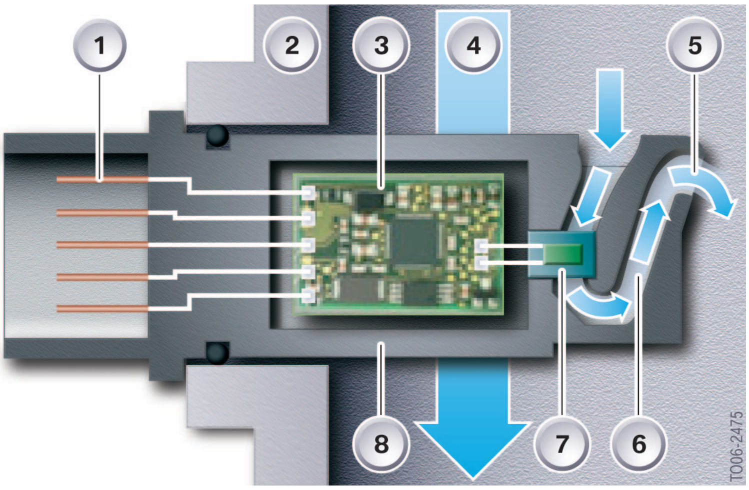
Hot-film air mass flow sensor

106 - Hot-film air mass flow sensor

The HFM 6 hot-film air mass-flow sensor is located in the filtered-air pipe downstream of the air intake muffler. The HFM measures the air mass taken in by the engine. It is used to register the actual air mass flow rate for the purposes of calculating the exhaust recirculation rate and the fuel limit volume.

There is also an intake air temperature sensor in the HFM. The temperature is analysed by the HFM and sent to the DDE control unit as a PWM signal.

A pulse width of 22 % equates to a temperature of -20 °C and a pulse width of 63 % equates to a temperature of 80 °C.



107 - Sectional view of hot-film air mass meter

Index	Explanation	Index	Explanation
1	Electrical connections	5	Partial flow for measurement, exhaust
2	Measurement tube housing	6	Labyrinth
3	Electronic evaluator	7	Sensor measuring cell
4	Mass air flow	8	Sensor housing

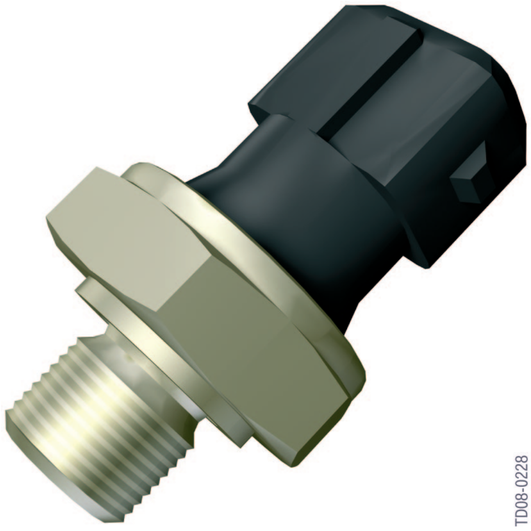
A labyrinth (6) makes sure that only the actual air mass is recorded. Thanks to the labyrinth, backflow and pulsation are not registered. In this way, the HFM determines the actual air mass irrespective of the air pressure and backflow.

An electrically heated sensor measuring cell (7) protrudes into the air flow (4). The sensor measuring cell is always kept at a constant temperature. The air flow absorbs air from the measuring cell. The greater the mass air flow, the more energy is required to keep the temperature of the measuring cell constant.

The evaluator electronics (3) digitizes the sensor signals. That digitized sensor signal is then transmitted in frequency-modulated form to the DDE control unit. In order to be able to compensate for temperature influences, the air mass signal is referred to the variable temperature signal.

The HFM is connected to the electrical system power supply and earth via the DDE control unit.

Oil pressure switch

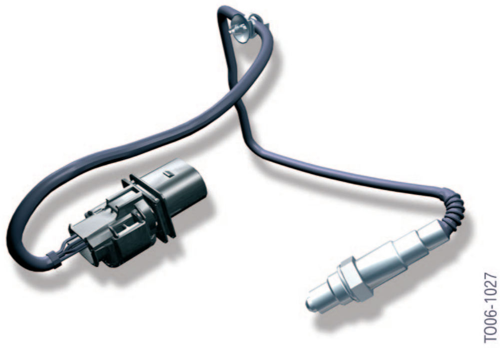


108 - Oil pressure switch

The oil pressure switch serves the purpose of monitoring the lubrication system. The oil pressure indicator lamp lights up if the oil pressure is below a defined level. That level is between 0.2 and 0.5 bar.

The oil pressure switch is connected to the DDE control unit by a signal lead. When the switch is off, that lead carries 12 volts from the DDE control unit, and when the switch is on, 0 volts, as the switch completes to earth.

Oxygen sensor



109 - Control sensor with rising characteristic

The oxygen sensor is an indispensable component for controlling and measuring the composition of exhaust gas with the aim of conforming to legally stipulated emission values. This is achieved by measuring the residual oxygen content in the exhaust gas.

For optimum combustion, a diesel engine is operated with a fuel-air ratio of $\lambda > 1$, i.e. rich in oxygen. $\lambda = 1$ signifies a mixture of 1 kg of fuel to 14.5 kg of air.

The oxygen sensor is located at the inlet to the shared housing of the diesel particulate filter (DPF) and oxidation catalytic converter.

The oxygen sensor is connected by 5 lines to the connector housing. The following connections lead into the housing:

- Pump current, positive
- Pump current and Nernst voltage, negative
- Heating, negative
- Heating, positive
- Nernst voltage, positive.

⚠ A compensating resistor that compensates for production tolerances is integrated in the oxygen sensor connector. This resistor is connected to a free contact. ◄

The EURO 6 version has an additional oxygen sensor downstream of the diesel particulate filter. Its function is described in more detail in the section on the air intake and exhaust system under the heading "Process in NOx accumulator catalytic converter".

Fuel pressure/temperature sensor

TD08-0169

110 - Fuel pressure/temperature sensor

Fuel temperature and pressure are recorded by a combination sensor that is located in the fuel feed directly upstream of the high-pressure pump.

This component has only one connection to earth which is shared by the individual sensors. For the fuel-pressure sensor, there is a power supply. In addition, each sensor has one signal output. The combination sensor therefore has four connections.

The fuel temperature sensor measures the fuel temperature upstream of the high-pressure pump. It is used for the purposes of protecting the engine against overheating and calculating the injection volume.

The fuel temperature sensor is connected to earth via the DDE control unit. The second connection is connected to a voltage divider circuit in the DDE control unit.

It contains a temperature-dependent resistor that protrudes into the fuel and assumes its temperature.

The resistor has a negative temperature coefficient (NTC). This means that the resistance decreases as temperature increases.

The resistor is part of a voltage divider circuit that receives a 5 V supply from the DDE control unit. The electrical voltage at the resistor is dependent on the fuel temperature. Stored on the DDE control unit is a table that lists the corresponding temperature for every voltage level and thus represents the non-linear relationship between electrical voltage and temperature.

The resistance changes in relation to temperature from 75.5 kΩ to 87.6 Ω, corresponding to a temperature of -40 °C to 120 °C.

The fuel temperature sensor measures the pressure in the fuel low-pressure system upstream of the high-pressure pump. The fuel pressure is referred to by the DDE control unit for the purposes of demand-based control of the electric fuel pump.

The fuel-pressure sensor is connected to earth via the DDE control unit, which also provides its 5-volt power supply. It sends a voltage signal to the DDE control unit.

A metal diaphragm in the sensor converts the fuel pressure into a travel variable. This path is converted into a voltage signal by four pressure-sensitive resistors.

Charge-air temperature sensor

111 - Charge-air temperature sensor

The charge-air temperature sensor is located in the air duct downstream of the charge-air cooler, directly upstream of the throttle valve.

The DDE control unit provides the earth connection for the charge-air temperature sensor. A second connection is connected to a voltage divider circuit in the DDE control unit.

The intake temperature sensor contains a temperature-dependent resistor that protrudes into the flow of intake air and assumes the temperature of the intake air.

The resistor has a negative temperature coefficient (NTC). This means that the resistance decreases as temperature increases.

The resistor is part of a voltage divider circuit that receives a 5 V supply from the DDE control unit. The electrical voltage at the resistor is dependent on the air temperature. Stored on the DDE control unit is a table that lists the corresponding temperature for every voltage level and thus represents the non-linear relationship between voltage and temperature.

The resistance varies according to temperature between 76 kΩ and 88 Ω, corresponding to a temperature range of -40 °C to 120 °C.

Charge pressure sensor

112 - Charge pressure sensor

The boost-pressure sensor is located on the intake manifold and measures the pressure (absolute) inside it. It is provided with a 5-volt power supply and connected to earth by the DDE control unit.

The charge pressure data is communicated to the DDE control unit via a signal line.

The useful signal for the boost pressure fluctuates depending on the pressure. The sensing range of approx. 0.1 - 0.9 V corresponds to a charge pressure of 50 kPa (0.5 bar) to 300 kPa (3 bar).

The sensor serves the purpose of controlling the boost pressure.

Exhaust back-pressure sensor (upstream of diesel particulate filter)

113 - Exhaust back pressure sensor

The exhaust back pressure sensor is located on the cylinder head cover outside the exhaust system. It is connected to the exhaust pipe directly upstream of the shared housing of the oxidation catalytic converter and diesel particulate filter (DPF) by a hose and a pipeline.

The exhaust back pressure sensor measures the pressure in the exhaust system upstream of the DPF. If the exhaust back-pressure rises above the permissible level of 750 mbar positive pressure, the DDE control unit initiates regeneration of the DPF.

The exhaust back-pressure sensor has three connector pins that are connected to the DDE control unit. The DDE control unit connects it to earth and provides it with a power supply of 5 V. The third pin is used to send the voltage signal to the DDE control unit.

In the exhaust back pressure sensor, a sheet diaphragm converts the exhaust back pressure into a path dimension. This path is converted into a voltage signal by four pressure-sensitive resistors. The sensing range of the exhaust back-pressure sensor is 600 to 2,000 mbar absolute, which corresponds to a voltage of 1.875 V to 4.5 V.

The signal is checked for plausibility by comparison with the engine speed, injection volume, consumption and operating time.

⚠ If the exhaust back-pressure sensor fails, the DDE control unit initiates filter regeneration every 500km and a fault is registered on the DDE control unit. ◄

Exhaust back-pressure sensor (upstream of turbocharger)

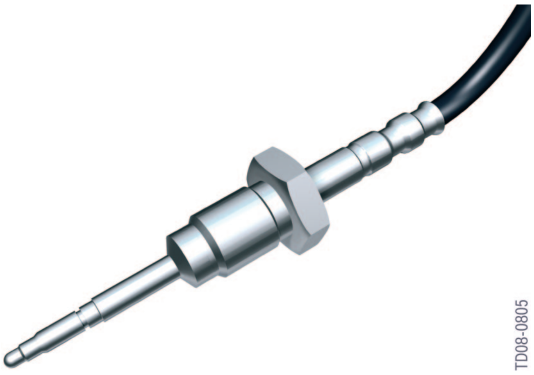
114 - Exhaust back-pressure sensor upstream of turbocharger

The exhaust back-pressure sensor upstream of the turbocharger is required by the DDE control unit for optimum control of the exhaust recirculation rate. With the aid of the exhaust back-pressure sensor and the exhaust temperature sensor, the DDE control unit can control the exhaust recirculation rate even more precisely and efficiently.

The exhaust back-pressure sensor is connected to the exhaust manifold by a hose. The reason it is not directly attached to the exhaust manifold is the possibility of high exhaust-system temperatures and dirt that might contaminate the sensor element. The hose connection has to face downwards. The sensor is mounted on the engine. The exhaust back-pressure sensor measures the pressure upstream of the turbocharger. Its method of operation is identical to that of the exhaust back-pressure sensor upstream of the diesel particulate filter.

Absolute pressure	Voltage
1.0 bar	Approx. 1.0 V
5.0 bar	Approx. 4.5 V

Exhaust temperature sensor



115 - Exhaust temperature sensor

The first exhaust temperature sensor is immediately adjacent to the oxygen sensor at the inlet of the oxidation catalytic converter/ DPF. The exhaust temperature sensor is used by the DDE control unit for the purposes of controlling regeneration of the DPF.

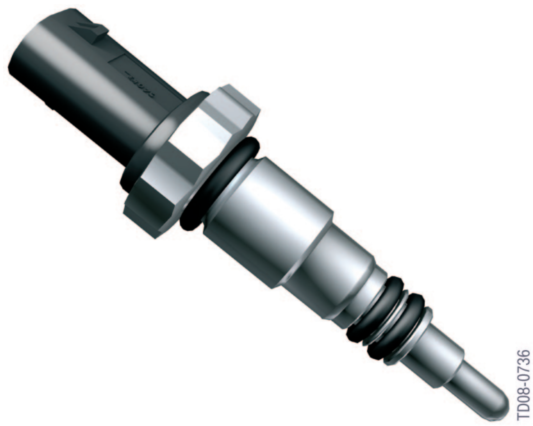
The exhaust temperature sensor contains a temperature-dependent resistor with a negative temperature coefficient (NTC). This means that the resistance decreases as temperature increases.

The resistor is part of a voltage divider circuit that receives a 5 V supply from the DDE control unit. The electrical voltage at the resistor is dependent on the exhaust temperature. Stored on the DDE control unit is a table that lists the corresponding temperature for every voltage level and thus represents the non-linear relationship between electrical voltage and temperature.

The resistance varies according to temperature between 96 kΩ and 32 Ω, corresponding to a temperature range of -40 °C to 800 °C.

The second exhaust temperature sensor is located upstream of the diesel particulate filter and enables even more precise control of particulate filter regeneration.

Coolant temperature sensor



116 - Coolant temperature sensor

The coolant temperature sensor is located on the forward side of the cylinder head. It records the temperature of the coolant at the engine outlet. This value is used for the engine temperature.

It is connected to earth via the DDE control unit. The second connection is connected to a voltage divider circuit in the DDE control unit.

The functional principle of the coolant temperature sensor is identical to that of the intake temperature sensor.

The resistor has a negative temperature coefficient (NTC). This means that the resistance decreases as temperature increases.

The resistor is part of a voltage divider circuit that receives a 5 V supply from the DDE control unit. The electrical voltage at the resistor is dependent on the coolant temperature. Stored on the DDE control unit is a table that lists the corresponding temperature for every voltage level and thus represents the non-linear relationship between electrical voltage and temperature.

The resistance varies according to temperature between 75.7 kΩ and 41.7 Ω, corresponding to a temperature range of -40 °C to 150 °C.

Fuel-rail pressure sensor

117 - Fuel-rail pressure sensor

The fuel-rail pressure sensor screws into the stainless-steel fuel rail. The pressurized fuel is buffered in the rail and distributed to the high pressure fuel injectors.

The fuel pressure is transmitted through the high pressure connection to the diaphragm with sensor element. The deflection of the diaphragm is converted by the sensor element into an electrical signal. The analyser circuit pre-processes the signal and sends an analogue voltage signal to the DDE control unit. The voltage signal is applied in linear form as the fuel pressure increases.

The signal from the fuel-rail pressure sensor is an important input signal for the DDE control unit for the purposes controlling the volume control valve (component of the high-pressure pump).

The sensor is provided with a 5-volt power supply and connected to earth by the DDE control unit. The sensor signal is transmitted to the DDE control unit via a signal line. The evaluation signal fluctuates depending on the pressure.

If the fuel-rail pressure sensor fails, the DDE control unit switches to emergency-mode control of the volume control valve.

Camshaft sensor

118 - Camshaft sensor

A camshaft sensor that operates in accordance with the Hall principle is used for the purpose of detecting the camshaft position.

On the N57 engine, the camshaft sensor is located on the inlet camshaft. For this purpose, a camshaft sensor wheel is mounted directly on the drive gear on the camshaft.

With the aid of the camshaft sensor, the DDE control unit can determine whether cylinder number 1 is in the compression/ignition phase or exhaust/induction phase.

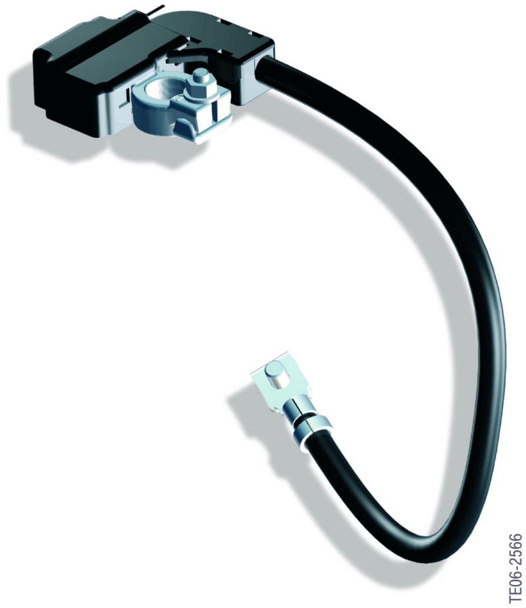
This deduction cannot be made from the crankshaft position. Correct assignment is necessary for the purpose of controlling the fuel injection accordingly.

The 5 V power supply is provided by the DDE control unit and the earth connection is on the sensor. The sensor supplies the DDE control unit with a digital signal via the signal lead.

The camshaft sensor operates in accordance with the principle of the conventional crankshaft sensor (not of the active sensor). The camshaft sensor wheel however, is fundamentally different.

A special aperture pattern facilitates emergency operation in the event of the crankshaft sensor failing. The resolution of the camshaft sensor signal, however, is too inaccurate to replace the crankshaft sensor during normal operation.

Intelligent battery sensor



119 - Intelligent battery sensor

The intelligent battery sensor (IBS) assesses the current quality of the battery. The IBS has its own analyser chip and is part of the battery negative terminal.

The IBS regularly (cyclically) measures the following values:

- Battery voltage
- Charging current
- Discharge current
- Battery temperature.

The software on the IBS controls its function and communication with the DDE control unit. When the vehicle is being driven, the IBS sends the data to the engine management via the serial data interface (BSD) on E9x models or the LIN bus on the F01.

When the vehicle is stationary, the measured values are scanned cyclically in order to save energy. The IBS is programmed to wake up every 40 seconds. The time taken by the IBS to perform a measurement cycle is approx. 50 milliseconds. The measured values are entered in the closed-circuit current histogram resident in the IBS. In addition, the state of charge (SoC) is also partially calculated. The DDE reads the histogram the next time the vehicle is started. If the quiescent current limit has been exceeded, a fault is registered on the DDE control unit. The data is transmitted via the serial data interface (BSD) on E9x models or the LIN bus on the F01.

The IBS calculates the battery indicators as the basis for the state of charge and health of the battery. The battery indicators are the charging current, discharge current, voltage and temperature of the vehicle battery.

The charging/discharge current of the battery are balanced.

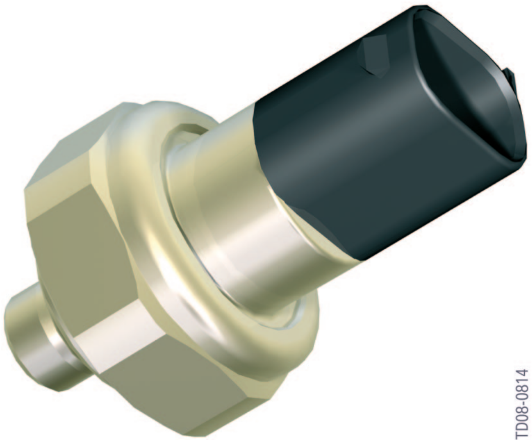
The charge level of the battery is permanently monitored and the information is sent to the DDE control unit if the charge level is insufficient for the demand.

The current progression is calculated while starting the engine in order to determine the battery's state of health.

The closed-circuit current in the vehicle is monitored.

The IBS features self-diagnosis capabilities.

Refrigerant pressure sensor



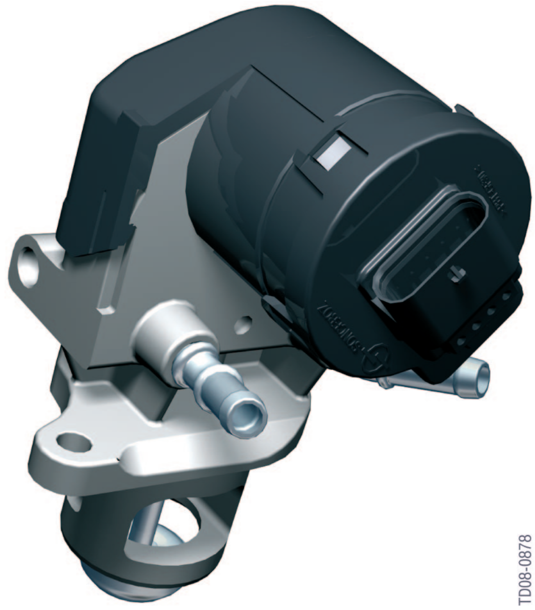
120 - Refrigerant pressure sensor

The refrigerant pressure sensor is located in the pressure line of the refrigerant circulation system.

When the climate control is in cooling mode, the high refrigerant pressure is detected by a refrigerant pressure sensor and analysed by the Junction box module and converted into a pressure signal. That signal is converted into a digital signal and sent to the IHKA control unit via the bus. In response to demand, the IHKA control unit sends a request via the bus link for the electric fan to be switched on or off.

Likewise, the signal to switch the compressor clutch on or off is also sent via the PT-CAN to the junction box.

Exhaust recirculation sensor



121 - EGR valve and sensor

The distance by which the EGR valve opens is registered by the exhaust recirculation sensor. This makes it possible to meter the EGR rate more accurately.

The exhaust recirculation sensor is integrated in the body of the electric EGR valve.

The sensor is provided with a 5-volt power supply and connected to earth by the DDE control unit. It produces a voltage signal according to the position of the electric motor.

The voltage progression is proportional to the opening travel of the EGR valve.

With the aid of this sensor, the DDE control unit is able to achieve optimum control of the exhaust recirculation rate.

EGR temperature sensor

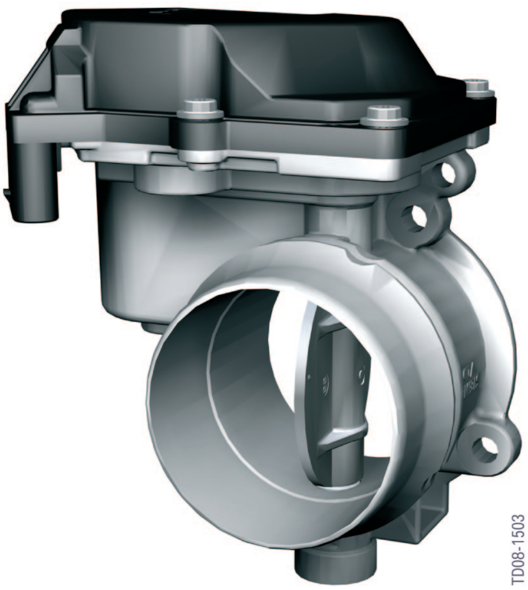
122 - EGR temperature sensor

The EGR temperature sensor contains a temperature-dependent resistor with a negative temperature coefficient (NTC).

The resistor is part of a voltage divider circuit that receives a 5 V supply from the DDE control unit. The electrical voltage at the resistor is dependent on the recirculated-exhaust temperature. Stored on the DDE control unit is a table that lists the corresponding temperature for every voltage level and thus represents the non-linear relationship between electrical voltage and temperature.

The resistance varies according to temperature between 96 kΩ and 32 Ω, corresponding to a temperature range of -40 °C to 800 °C.

Throttle valve sensor



123 - Throttle valve sensor

To achieve optimum control of the throttle valve, its exact position must be recorded on a continual basis. To that end, the position of the throttle valve is monitored by a magnetoresistive proximity sensor in the throttle valve positioner.

The position sensor is provided with a 5-volt power supply and connected to earth by the DDE control unit. The throttle valve position is signalled to the DDE control unit via a data line.

Oil condition sensor

124 - Oil condition sensor

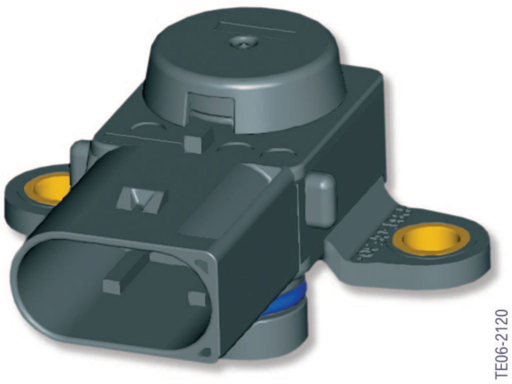
The oil condition sensor is only used to detect the oil level. There is no adjustment of the oil-change interval on the basis of the detected oil condition. The electronic circuitry of the oil condition sensor is capable of self-diagnosis. If a fault is detected on the component, a fault message to that effect is sent to the digital diesel engine management module.

The oil condition sensor has power and earth connections. Data communication with the DDE control unit takes place via a serial data interface (BSD) on the E9x or the LIN bus on the F01.

Sensors for MSA

The MSA is initially only used on the E9x with manual transmission.

Brake negative pressure sensor



125 - Brake negative pressure sensor

The brake vacuum sensor is required for the automatic engine stop/start function (MSA).

The brake negative pressure sensor is used to ensure that there is always sufficient negative pressure available for the brake power assistance in connection with the automatic engine start-stop (MSA) function. If the pressure falls below a defined value, the engine is started by the MSA.

The brake negative pressure sensor is located next to the brake force amplifier.

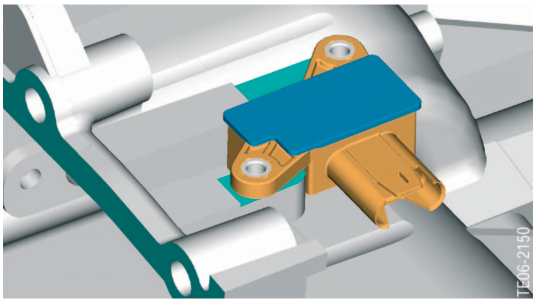
It is connected to earth via the DDE control unit, which also provides its 5-volt power supply.

Inside the sensor, a sheet diaphragm converts the negative pressure into a path dimension. That travel is converted into the voltage signal by four pressure-sensitive resistors and then sent to the DDE control unit.

Zero gear sensor

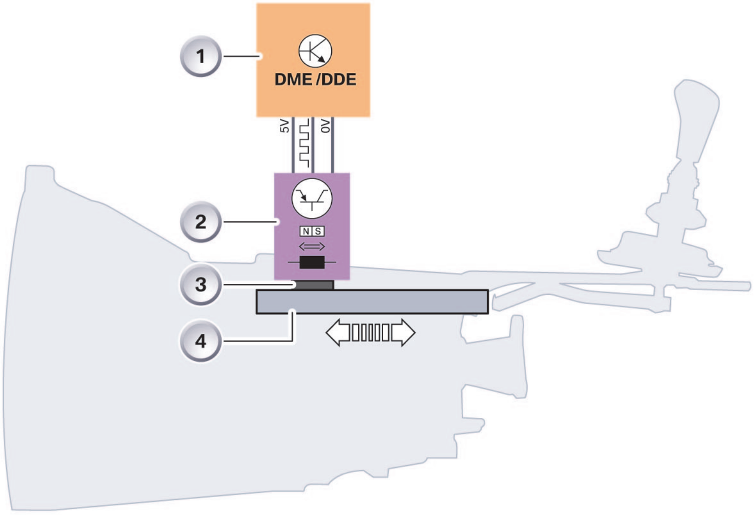
The neutral gear sensor is also required for MSA.

It makes sure that the MSA only starts the engine if no gear has been engaged.



126 - Zero gear sensor

The neutral gear sensor is fitted to the top of the transmission housing and its purpose is to detect the gear-lever neutral position. It is a PLCD sensor (permanent magnetic linear contactless displacement sensor).



127 - Method of operation of neutral gear sensor

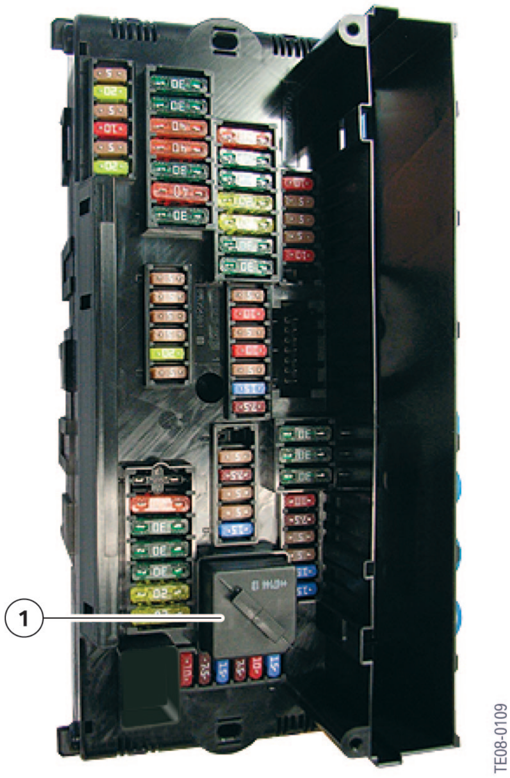
Index	Explanation	Index	Explanation
1	Digital diesel engine management module (DDE)	3	Magnet
2	Zero gear sensor	4	Selector rod

As the gear lever moves, the selector rod is shifted and so too the magnet in the transmission. Using the PLCD sensor, the DDE control unit is able to detect the position of the gear lever.

More detailed information on the neutral gear sensor is provided in the Product Information document on the automatic engine stop/start function.

Actuators

Terminal 30B relay

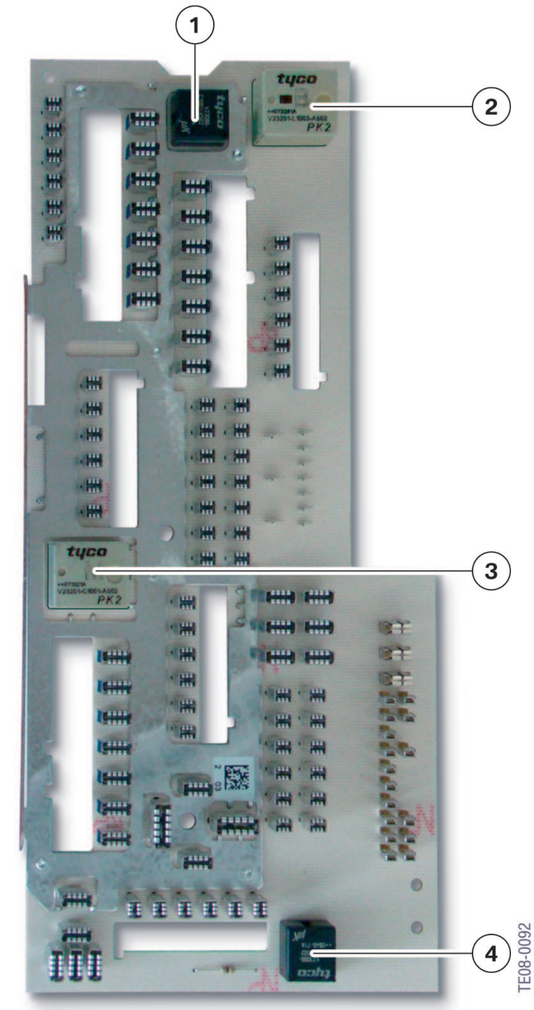


128 - Front fuse board on F01/F02

Index	Explanation
1	Terminal 30B relay

On the F01, the Terminal 30B relay is controlled by the CAS.

Terminal 15N relay



129 - Front fuse box on F01/F02

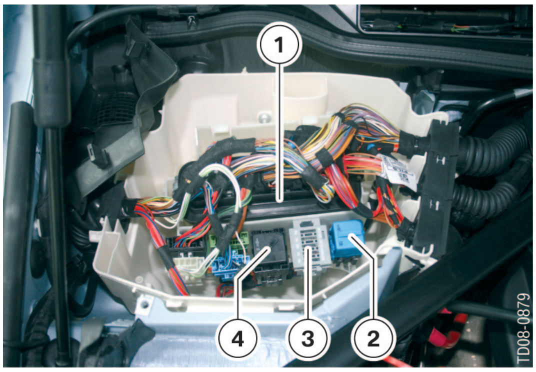
Index	Explanation
1	Terminal 30F relay (bistable)
2	Headlamp washer relay
3	Terminal 15N relay
4	Horn relay

The Terminal 15N relay is soldered to the PCB. If it fails, the entire fuse board has to be replaced.

Relays

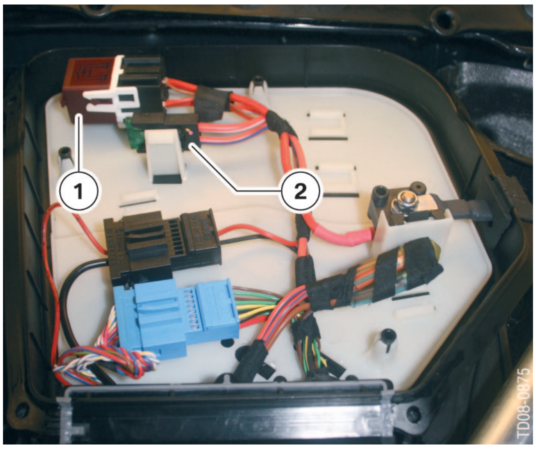
Several relays for the engine management are integrated in the front power distribution box:

- DDE main relay
- Terminal 15F load-shedding relay.



130 - Electronics box on E9x with N57 engine

Index	Explanation
1	DDE control unit
2	DDE main relay
3	Engine electronics fuse carrier
4	Electric fan



131 - Power distribution box on F01 with N57 engine

Index	Explanation
1	DDE main relay
2	Engine electricals fuse board

On the F01, the DDE main relay is operated by the Terminal 30B relay.

The DDE control unit simultaneously receives the Ignition ON signal from the CAS.

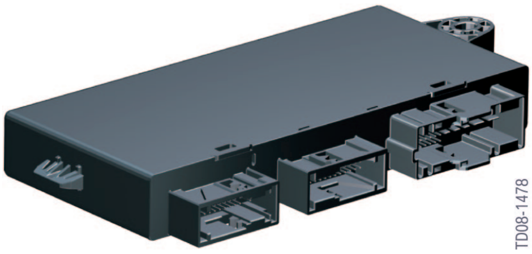
Various components are supplied with power by the DDE main relay.

If the ignition is switched off, the CAS does not switch off the Terminal 30B relay until a certain time delay has elapsed. The reason for this is that adaptations etc. are stored in the non-volatile memory in the control unit after deactivation of Terminal 15 in order to make them available again after switching on the ignition.

The DDE main relay is connected to the system power supply from Terminal 30 and to earth via the CAS.

On the E9x, the DDE main relay is operated in the familiar manner by the DDE control unit itself.

Car Access System control unit



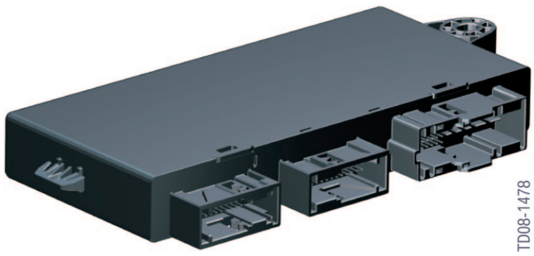
132 - Car Access System control unit

On the E9x, the Car Access System control unit (CAS control unit) is connected to the DDE control unit via the PT-CAN and the Junction box module. On the F01, it is connected via the K-CAN2, the ZGM and the PT-CAN2. The electronic immobilizer is implemented as a combination of Car Access System and digital diesel engine management functions. In addition, the CAS control unit is also connected to the DDE control unit by the CAS bus and another lead for controlling the starter motor.

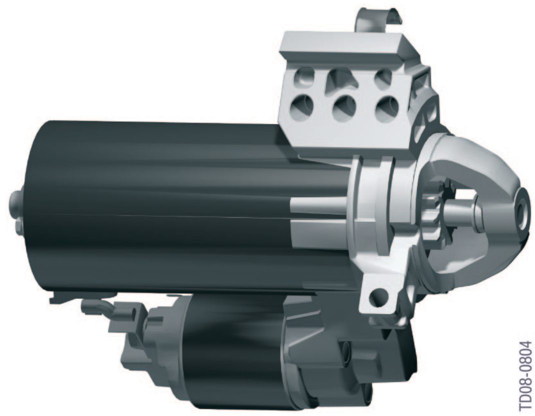
The CAS control unit also supplies the Terminal R and Terminal 15 signals.

Start disabling relay

The start disabling relay is integrated in the CAS control unit.



133 - Car Access System control unit



134 - Starter

The starter is activated by the CAS. The DDE control unit has a connecting lead to the CAS for the purpose. If the 12-volt system power supply is applied to that lead by the DDE control unit, the CAS system detects that the digital diesel engine management is requesting that the engine be started. If the lead is connected to earth, the CAS detects that the digital diesel engine management wants to terminate the starting sequence.

The CAS control unit switches the start disabling relay according to the request and immobilizer clearance.

Piezo-injector

135 - Piezo-injector

The higher-performance N57 engines are fitted with piezo-electric fuel injectors.

With a piezo-electric injector, the movement of the valve is not brought about by a solenoid coil but rather by a piezo-electric element.

A piezo-electric element is an electromechanical converter, i.e. it consists of a ceramic material that converts electrical energy directly into mechanical energy (force/ travel).

In the case of the piezo-electric element in the injector, a voltage is applied to it so that the crystal expands. To achieve greater travel, the piezo-electric element is made up of 264 layers.

If a piezo-electric element is isolated from the power source while it is charged, it will retain its charge - in a similar way to a capacitor. In other words, if the injector were disconnected from the control unit while activated, the piezo-electric element would remain expanded and continuous injection of fuel would result. To prevent that happening, the piezo-electric element is connected in parallel with a resistor through which it can discharge itself in less than a second.

Electric fan

136 - Electric fan

The electric fan has its own output stage. It is controlled by the DDE control unit by means of a PWM signal. This signal indicates the target value for the cooling output required. The controller of the electric fan converts this into a corresponding speed.

The electric fan is driven by a DC motor, the output of which depends on the vehicle and equipment fitted.

The DDE control unit transmits control commands by means of frequency and pulse-width modulation on the data lead.

The frequency indicates to the fan whether to operate in normal mode or overrun mode. The overrun is required in order to continue cooling a hot engine after it is switched off if the outside temperature is high.

The PWM specifies the function. Thus, with a pulse width of 0 % - 5 % the active function is maintained. With a pulse width of 5 % - 7 % the control unit is activated but the fan does not start. With a pulse width of 7 % - 93 % the fan runs at a proportionally increasing speed. From 97 % - 99 % interface diagnosis takes place and the previously executed function remains active. Above 99 % the previously executed functions are maintained.

Fuel filter heater

137 - Fuel filter heater

The fuel filter heater fits into the fuel filter housing and is fixed by a securing clip. The fuel flows through the fuel filter heater into the fuel filter. Activation is based on the signals from the fuel pressure/temperature sensor and the power consumption of the fuel pump.

The fuel filter heater is switched on when **all** the following conditions are met:

- Fuel pressure below a defined level due to cold, viscous fuel
- Raised fuel-pump power consumption
- Temperature below a specific limit (2 °C).

Since "winter-grade diesel" remains free-flowing even at low temperatures, the fuel filter heater is not normally active when running on winter-grade diesel.

The fuel filter heater has connections for the 12-volt power supply and earth. It is switched on and off via a data line by the DDE control unit.

If the target pressure is not reached above a defined fuel temperature, the DDE control unit stores a fault code memory entry indicating a blocked filter.

At a fuel temperature of -20 °C and a fuel flow rate of approx. 100 l/h, the temperature of the fuel is raised by approx. 8 °C.

Engine breather heater (cold climates only)

TD08-0810

138 - Engine breather heater

The engine breather heater is required in countries with very cold winter temperatures in order to prevent the breather hose "freezing up". The engine breather heater is always active and is connected to a 12-volt power supply and earth.

It uses a PTC element, the resistance of which increases with temperature, thus making it inherently safe.

At an ambient temperature of 25 °C, the PTC element has a resistance of approx. 15 Ω.

On the E9x, the power supply is brought via the DDE main relay and a fuse. The connection to earth is provided by the DDE control unit.

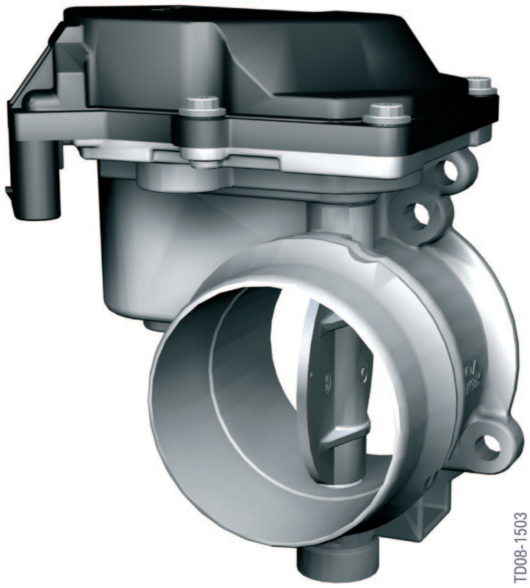
On the F01, the power supply is taken from the Terminal 15N relay. The connection to earth is provided by the DDE control unit.

Throttle valve actuator

The throttle valve actuator is mounted on the intake manifold.

The DC motor is controlled by a PWM signal with a pulse duty factor of 5 to 95 %. At 5 %, the throttle valve is open; at 95 %, it is closed.

The electric motor generates a force acting against the integral spring in proportion to the pulse width. That holds the throttle valve in a particular position.



TD08-1503

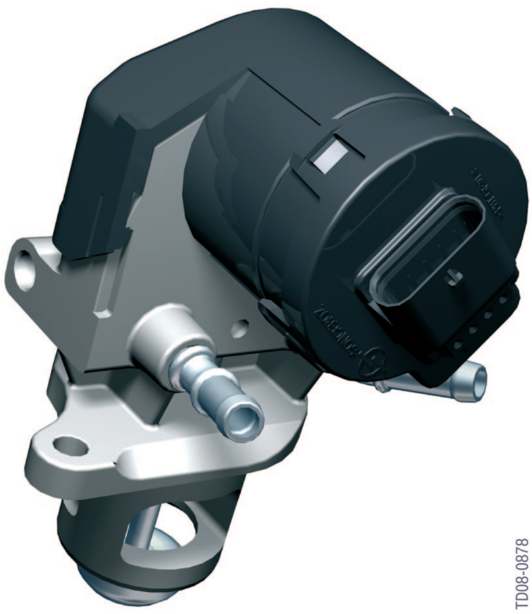
139 - Throttle valve actuator

When no current is applied, the throttle valve is held fully open by the force of the spring in the throttle positioner.

The throttle valve is also used for diesel particulate filter regeneration and to counteract shaking during engine switch-off. Another function which prevents engine over-revving has also been introduced. If the digital diesel engine management module detects the engine revving up without the fuel injection volume having been increased, the throttle valve is closed to limit the engine speed.

An H-bridge is used for activation which makes it possible to drive the motor in the opposite direction. The H-bridge in the DDE control unit is monitored by the diagnosis system.

EGR valve



140 - EGR valve

As has been the case since the M67TU engine, the EGR valve is electrically operated.

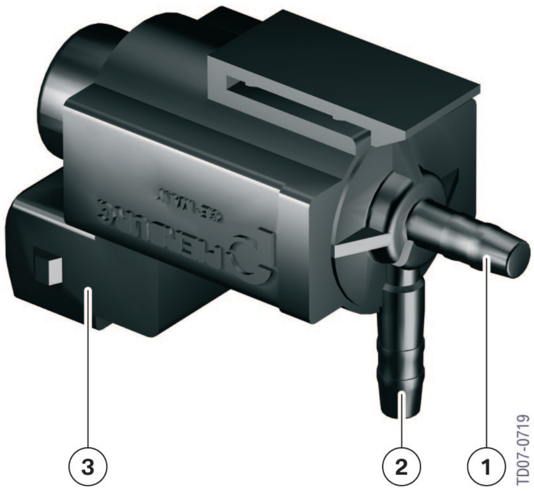
Electric operation enables the exhaust recirculation rate to be very precisely controlled. Since the electronic circuitry can not withstand such high temperatures as the vacuum-operated EGR valves, the electric EGR valves are cooled.

A spring in the valve-motor housing holds the EGR valve closed when no electric current is applied. Control of the valve by a pulse-width modulated signal enables any valve aperture to be set.

The electric motor is controlled by pulse-width modulation of a 12 volt supply that completes to earth.

A sensor is integrated in the housing in order to detect the valve position. The position sensor has 3 connector pins that are connected to the DDE control unit.

Electropneumatic changeover valve for bypass valve and engine mounting



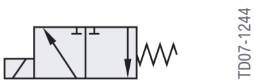
141 - Electropneumatic changeover valve

Index	Explanation
1	Vacuum connection
2	Vacuum outlet
3	Electrical connector socket

The electropneumatic changeover valve is used for components that are switched between two positions. The electropneumatic changeover valve connects either zero vacuum or maximum available vacuum from the vacuum connection (1) to the vacuum outlet (2).

The electropneumatic changeover valve is used for the bypass valve and the switchable engine mountings.

The electropneumatic changeover valve is controlled by the DDE control unit.



142 - Circuit diagram symbol Electropneumatic changeover valve

Fuel-rail pressure regulating valve

TD07-1604

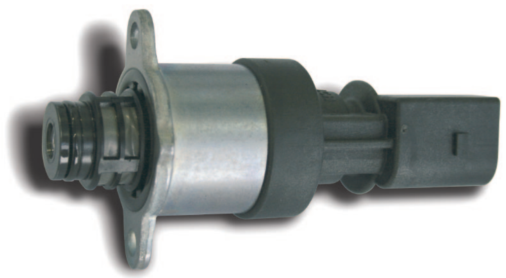
143 - Fuel-rail pressure regulating valve

The fuel-rail pressure regulating valve is screwed into one end of the fuel rail.

The fuel-rail pressure regulating valve is controlled by the DDE control unit using a PWM signal.

When no electric current is applied, the fuel-rail pressure regulating valve maintains a fuel rail pressure of approx. 100 bar. The opening pressure of the fuel-rail pressure regulating valve increases according to the control signal applied (pulse width).

Volume control valve



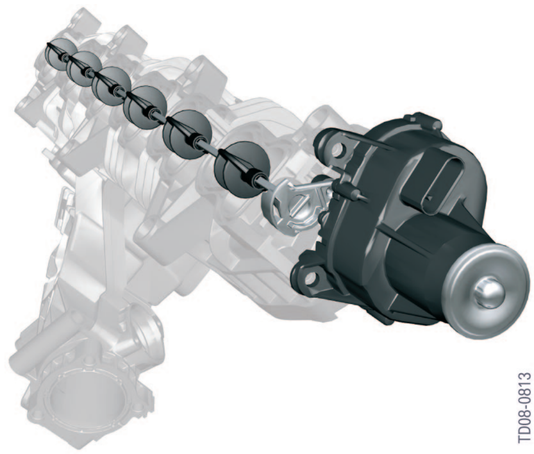
TD07-1605

144 - Volume control valve

The volume control valve is integrated in the fuel high-pressure pump. It limits the volume of fuel for each pump piston according to demand. Consequently, only as much fuel as is actually required by the fuel rail is used for generating the fuel pressure.

The volume control valve is map-controlled by a PWM signal.

Swirl flap regulator



TD08-0813

145 - Swirl flap regulator

The swirl flaps are adjusted by a DC motor. This is located at the forward end of the intake manifold.

The DC motor is controlled by a PWM signal with a pulse duty factor of 5 to 95 %. At 5 %, the swirl flaps are open; at 95 %, they are closed.

The electric motor generates a force acting against the integral spring in proportion to the pulse width. That holds the swirl valves in a particular position.

When no current is applied, the swirl valves are held fully open by the force of the spring in the swirl valve positioner.

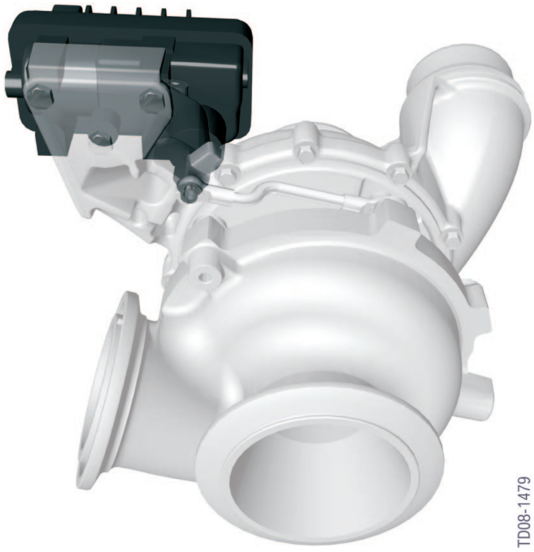
The position of the swirl flaps is measured contactlessly by the swirl flap sensor located inside the housing of the swirl flap regulator.

The swirl flap sensor makes it possible to control the swirl flaps with greater precision, which in turn makes it possible to reduce pollutant emissions.

The swirl valve sensor is a Hall-effect sensor. It is provided with a 5-volt power supply and connected to earth by the DDE control unit.

The sensor sends an analogue signal to the DDE control unit.

Charge pressure adjuster


TD08-1479

146 - Charge pressure adjuster

The N57 engine, too, has a turbocharger with variable nozzle turbine (VNT) geometry. The charge pressure adjuster electrically adjusts the turbine vanes. This achieves a more accurate regulation of the boost pressure by comparison with pneumatic adjustment.

The positioner motor is controlled by the DDE control unit by means of a PWM signal. The position regulator and the diagnostics function are integrated in the servomotor.

In the event of a malfunction, the PWM signal from the internal position regulation of the servomotor is directed to earth for 0.5 to 2 seconds (depending on the fault message). From that, the DDE control unit detects a fault with the electric vane adjustment.

The positioner motor has connections for the 12-volt power supply and earth. A data lead provides the control signal from the DDE control unit.

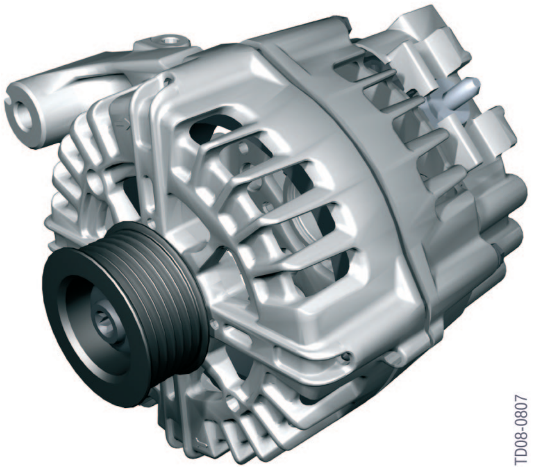
Vent flaps


TD08-1480

147 - Vent flaps

As part of the EfficientDynamics (emission reduction) measures, vent flaps are used depending on the equipment options fitted. The active vent flap control function is performed by the DDE control unit. The integral control unit on the positioner motor has connections for the 12-volt power supply and earth. Another lead carries the pulse-width modulated signal from the DDE control unit for controlling the positioner motor. If the active vent flap control system diagnoses faults, the lead to the DDE control unit is connected to earth. A fault is then registered on the DDE control unit.

Alternator

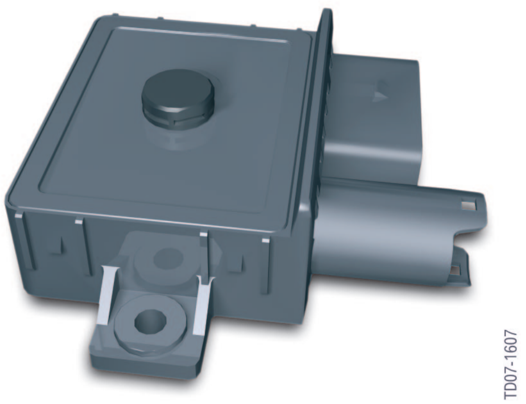


148 - Alternator

The alternator exchanges data with the DDE control unit through a bit-serial data interface. The alternator sends information to the DDE control unit, such as model and manufacturer. This allows the DDE control unit to adapt regulation of the alternator to match the actual alternator model installed.

The alternator is connected to the DDE control unit by the BSD serial data interface. Data exchange is bidirectional. The DDE control unit is therefore aware of the status of the alternator and is able to actively control it.

Glowplug control unit (GSG)



149 - Glowplug control unit

The glow system comprises the following components:

- Glowplug control unit with connection to the digital diesel engine management
- Ceramic, rapid-start glowplugs.

The N57 engine is fitted with a new ceramic glowplugs. They are distinguished by higher temperatures, lower power consumption and rapid response times.

The tip of this type of glowplug is made of a ceramic material that is able to produce a temperature of 1,300 °C (predecessor: 1,000 °C).

Ceramic glowplugs also offer long service life characteristics. However, they must be handled with care because the ceramic tip is very fragile.

The rapid-start glowplugs are designed for a voltage of 5.3 to 7.8 volts. During the glow-plug start-assist stage, there may even be a voltage equivalent to the on-board supply voltage for a short time.

The diagnosable glowplug control unit communicates with the DDE control unit via the LIN bus.

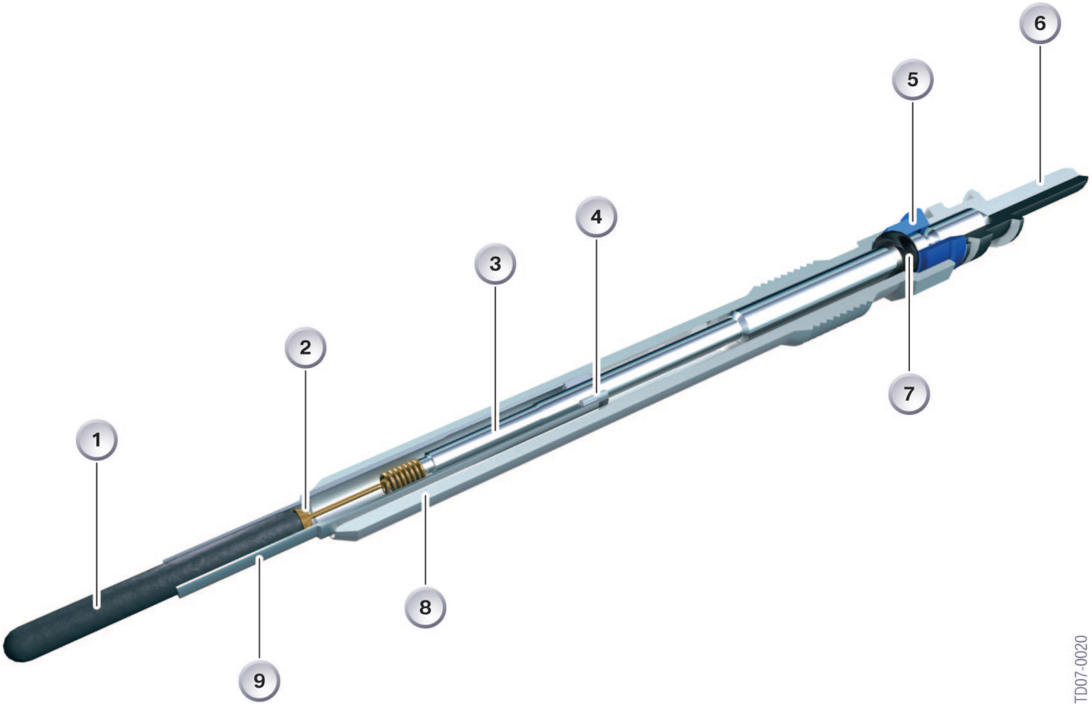
The glowplug control unit is also connected to Terminal 15/Terminal 30B and by an additional "high-power connection" to Terminal 30.

The preheater control unit's mechanical and electrical layout enable it to be fitted close to the engine. This reduces the length of the leads from the glowplug control unit to the glowplugs.

The required heating output is determined by the DDE on the basis of specific operating conditions such as engine temperature, speed and load, and signalled to the glowplug control unit via the LIN bus. The glowplug control unit implements the request and sends back diagnostic and status information to the DDE control unit on request.

The glowplug control unit receives the glowplug heating instructions for the various glowplug heating functions, e.g. start heating, heating while the engine is running or diagnostic heating, from the DDE control unit.

Glow plug



150 - Glow plug

The glowplugs are controlled by the glowplug control unit by means of a pulse-width-modulated signal. Each glowplug is switched on and off individually by a dedicated output stage. By virtue of pulse width modulation, the effective voltage (useful voltage) at the glowplugs can be varied in such a way that a constant temperature of approximately 1,300 °C is achieved across the engine's entire operating range.

Thanks to the PWM control, the voltage at the glow plugs is kept constant so that voltage fluctuations in the vehicle electrical system have no effect on the glow plugs and their temperature.

In clocked mode, the glow plugs are not all switched on and off simultaneously but in succession in order to prevent malfunctions in the vehicle electrical system caused by very high currents as a result of periodic switching on and off.

System components

Engine mechanical system

Sump

⚠ To ensure that the seal functions correctly, no oil is permitted to come into contact with the rubber coating during assembly. There would be a risk of the seal sliding off the sealing surface. Therefore, the flange surfaces must be cleaned immediately prior to assembly. In addition, it must be ensured that all oil has been allowed to fully drain out of the engine so that it neither drips onto the flange surfaces nor the seal during assembly. ◄

Crankshaft and bearings

⚠ Careful handling of bearing shells is extremely important because the ultra-thin bearing metal layer is very easy to damage. ◄

⚠ It is important that lubrication with engine oil is ensured. When thrust bearings fail, overheating is generally the cause.

A worn thrust bearing causes noise to be produced, mainly in the area of the vibration damper. Another fault pattern can take the form of crankshaft sensor errors, which on vehicles with automatic transmission is evident in the form of jerky gearshifts. ◄

Connecting rods and bearings

⚠ If a big-end bearing cap is fitted the wrong way round or on the wrong connecting rod, the fracture face pattern of both parts is damaged and the bearing cap will not self-centre. In that case the complete con rod set has to be replaced with entirely new parts. ◄

⚠ You will find detailed information on connecting rod connections, such as tightening specifications, in the TIS. ◄

⚠ In any one engine, all the connecting rods must be the same weight class. ◄

Pistons, piston rings and gudgeon pins

⚠ Taper-faced rings must not be fitted the wrong way round. The rebate must be at the bottom. Incorrect installation leads to engine damage ◄

⚠ A damaged or broken oil control ring cannot be identified once fitted. The effects only come to light after a certain period of use. ◄

Rotational vibration damper

⚠ The engine should not be allowed to run without the drive belt fitted as the rotational vibration damper could be damaged as a result. ◄

Belt drive and auxiliary equipment

⚠ It is essential that auxiliary equipment be fitted in the correct position during assembly. A belt pulley alignment error would result in belt noise and ultimately belt damage.

Observe the procedure in the repair instructions ◄

⚠ Detailed information on fitting the auxiliary unit mounting bracket can be found in the Repair Instructions. If it is fitted incorrectly, failure of the belt drive system can result. ◄

Oil supply

Oil spray nozzles and piston cooling valves

⚠ Exact positioning of the oil spray nozzles is necessary in order to achieve optimum cooling.

Bent or damaged oil spray nozzles must be replaced with new ones, otherwise there is a risk of engine damage.

The oil spray nozzles are positioned precisely with the aid of a special tool. Please observe the repair instructions. ◄

⚠ If the timing chain is dropped into the crankcase when being fitted, there is a risk of damaging the oil spray nozzle for lubricating the timing chain. ◄

Oil monitoring

⚠ Red indicator lamp comes on and an audible signal sounds while the vehicle is in motion (e.g. engine oil pressure too low):

- Stop immediately and turn off the engine.
- Check oil level, top up oil if necessary.
- If the engine oil level is OK, contact your nearest BMW Service. ◄

⚠ If the connector for the oil pressure switch is not connected, no oil pressure warning can be signalled. ◄

⚠ Yellow indicator lamp comes on and an audible signal sounds:

- Comes on while driving:
  The oil level is at the absolute minimum - top up engine oil as soon as possible. Until then, do not drive more than approx. 50 km.
- Comes on after switching off the engine:
  Top up engine oil at the next opportunity, e.g. refuelling stop.
- Comes on immediately after turning on the ignition and before starting the engine:
  There is a fault in the electrical oil level measuring system. Have checked by your BMW Service. ◄

⚠ You will find the procedure for measuring the oil level in the Owner's Handbook.

The oil consumption depends on the driving profile and operating conditions. ◄

⚠ An oil consumption measurement should not be carried out until at least 7,500 km have been covered because it is only after that distance that the engine running-in phase is more or less complete and the oil consumption has stabilized. ◄

Air intake and exhaust systems

Air intake system

⚠ If the purified air pipe downstream of the blow-by gas connection is heavily oiled, this could imply increased blow-by gas levels. The cause is usually a leak in the engine (e.g. crankshaft seal) or extraneous air taken in through the vacuum pipes. A consequential symptom would then be an oily exhaust turbocharger, which does not mean that there is a fault with the exhaust turbocharger itself. ◄

⚠ The ability of the NO_X accumulator catalytic converter to absorb nitrogen oxides and therefore its ageing depends on:

- Fuel quality in terms of freedom of sulphur
- Operating temperatures of the catalytic converter.

◄

Fuel supply system

Fuel delivery

⚠ When the engine is switched off, the feed line is depressurized as the pressure can escape through the high pressure pump and the return line. As no air can get into the pipe provided there are no leaks in the system, this pipe does not empty either. After the fuel pump is switched off, the fuel pressure/temperature sensor is checked for plausibility by the digital diesel engine management. ◄

Fuel conditioning system

High-pressure pump

⚠ If work is carried out on the chain drive system on the N57 engine, the high-pressure pump has to be correctly positioned relative to the crankshaft. The precise procedure is detailed in the Repair Instructions. ◄

High-pressure fuel lines

⚠ The high-pressure fuel lines are intended to be discarded if dismantled or removed. However, they can be re-used. The condition is that they are tightened to the specified torque and then form an absolutely 100 % leakproof seal. If any leaks are identified, the high-pressure line concerned must be replaced. ◄

Cooling system

Overview

⚠ An important function is performed by the changeover valve. The changeover valve ensures that only the passenger compartment, and not the engine, is heated when the auxiliary heater is in operation. A control fault or a fault on the changeover valve itself could result in the entire engine being heated up as well. Such a situation would result in the engine being difficult to start and not running smoothly immediately after starting. The changeover valve also ensures that, when the engine is running, the passenger compartment is heated up more quickly by allowing all the coolant to be heated and brought up to temperature when the engine is running. ◄

Coolant cooling

⚠ In the past, coolant pumps would often be replaced due to the presence of coolant traces. However, minor traces of coolant are acceptable due to the functional leakage of the slide ring seal.

The maximum permissible coolant leakage is 800 mg/h, which corresponds to one drop with a diameter of a little over 1 cm per hour. ◄

⚠ Never open the cover on the expansion tank while the engine is hot.

The reason for this is not only a risk of scalding. In the higher parts of the coolant circulation system (e.g. cylinder head), gas bubbles can form as a consequence of the drop in pressure. Sufficient heat dissipation would no longer be guaranteed at this point, which would result in overheating. ◄

⚠ When you carry the electric fan, do not hold it in the fan ring as this could break. ◄

Engine electrical system

Connection to vehicle electrical system

⚠ More information on connection to the vehicle electrical system can be found in the following Product Information documents:

- F01/F02 Energy management
- F01/F02 Power supply, and
- F01/F02 Bus systems.

◄

Functions

⚠ Mean volume adaptation has to be reset if one of the following components has been replaced:

- Air-mass sensor
- Fuel-rail pressure sensor
- Oxygen sensor.

◄

⚠ The ceramic glowplugs are sensitive to shocks and bending. Glowplugs exposed to such stresses could be damaged prior to use. ◄

⚠ If they are not cooled by the flow of air, as occurs when the engine is running, the glowplugs can be damaged or destroyed by voltages over 7 volts. ◄

⚠ If there is a fault in the Car Access System or the digital diesel engine management, a specific procedure must be followed. The required control unit must be ordered precisely for the specific vehicle. The vehicle data (vehicle identification number) are required for this purpose. EWS matching is not necessary after replacing the control units. ◄

Sensors

⚠ A compensating resistor that compensates for production tolerances is integrated in the oxygen sensor connector. This resistor is connected to a free contact. ◄

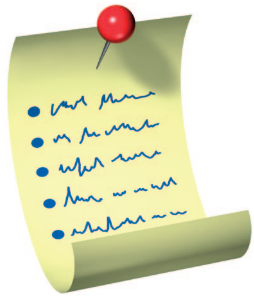
⚠ If the exhaust back-pressure sensor fails, the DDE control unit initiates filter regeneration every 500 km and a fault is registered on the DDE control unit. ◄

Summary.
N57 Engine.

Points to remember

The table below summarizes the most important information on the subject of Basic Engine Principles, Engine Mechanical Systems.

This list outlines the main points in concise form and provides the opportunity for revising the essential details provided in this Product Information.

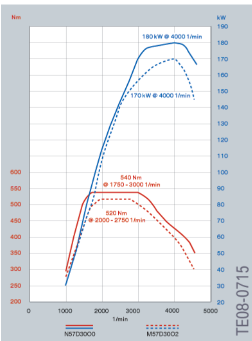


Points to remember for everyday theoretical and practical applications.

Models

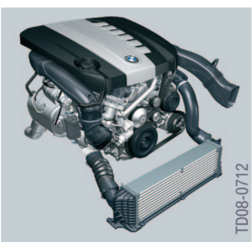
The list of models shows in which vehicles which engine variants are currently used and have been used in the past.

Introduction



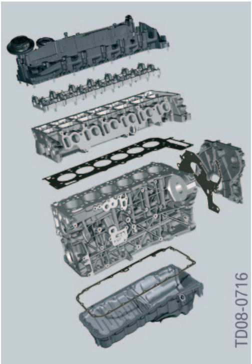
Following on from the 4-cylinder diesel engine, a new 6-cylinder diesel engine has now also been introduced. After 10 years and two major upgrades, the 6-cylinder diesel engine is now being replaced by an entirely new design, the N57. The N57 engine has many components that have already been used in volume production on the N47 engine. With even more power and torque combined with lower fuel consumption and lighter weight, it is ideally equipped to continue the success story.

System overview



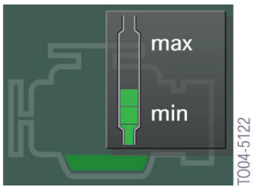
For the purposes of unique identification there is an engine identification code marked on the crankcase. In the documentation and descriptions of the engine, the engine designation is used, which differs from the identification code by its last 2 characters.

Engine mechanical system



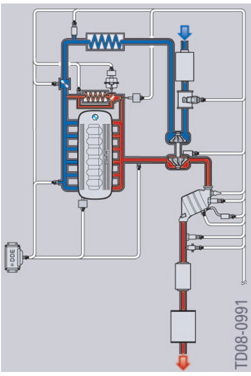
The engine mechanical systems can essentially be divided into the three subassemblies, engine casing components, crankshaft drive system and valvegear. Those three subassemblies are closely interlinked and have to be matched to one another.

Oil supply



Engine oil must fulfil many diverse tasks. Modern internal combustion engines, and especially the powerful BMW diesel engines, place extreme demands on the engine oil. Such demands can only be met by the appropriate grades of oil. The tasks performed by the oil include lubrication, cooling, microsealing, cleaning, corrosion-proofing and power transmission.

Air intake and exhaust systems

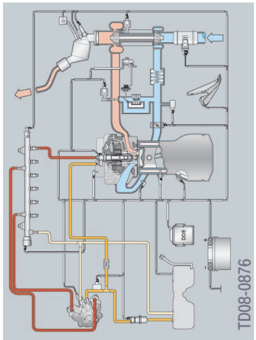


The air intake system can be divided into two component groups. The air intake duct, intercooler and, with some exceptions, the intake muffler are specific to the vehicle and differ according to vehicle model variations even with the same engine. The turbocharger and the intake manifold including swirl flaps, throttle body and various sensors are specific to the engine. The exhaust system is specific to the vehicle apart from the turbocharger and the exhaust manifold and differs according to vehicle model and variant.

Fuel supply system

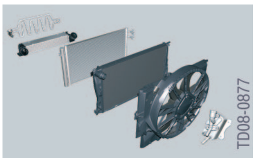
The fuel system is vehicle-specific and carries the fuel from the fuel tank to the engine. The fuel system is adapted to suit the particular vehicle model and can differ substantially from one model series to another. The functions of the fuel system can be subdivided into fuel storage, fuel supply and fuel tank venting.

Fuel conditioning system



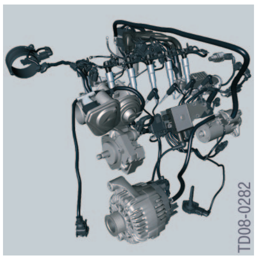
The fuel conditioning system is responsible for delivering and metering the correct amount of fuel for combustion. The fuel conditioning system is subdivided into a low-pressure section, a high-pressure section and an electrical control system.

Cooling system



The functions of a modern diesel engine cooling system can be subdivided into engine cooling, oil cooling, recirculated-exhaust cooling and charge-air cooling.

Engine electrical system



The digital diesel engine management module incorporates the engine management functions. Thus it is responsible for analysing the signals from the sensors on the engine/vehicle and for controlling the actuators on the engine.

Test questions.
Diesel engine mechanicals.

Questions

This section provides you with the opportunity to check what you have learnt.

It contains questions on the subject of the engine mechanical systems presented in this document. One or more answers may be correct in each case.

Consolidating and assessing what you have learned.

1. Which of the following statements about the N57D30O0 engine are correct?

☐ It is a 6-cylinder diesel engine with a capacity of three litres.

☐ It is a new development.

☐ It is the higher-performance version.

☐ It is derived from the 4-cylinder engine.

☐ It is a direct-injection diesel engine.

2. Which of the following statements about the crankcase venting system are correct?

☐ The crankcase venting system is implemented in the form of five cyclonic filters and a pressure regulating valve.

☐ It uses a spring-plate separator.

☐ The crankcase venting system is vacuum-controlled.

3. Why is the chain drive system mounted on the flywheel end of the engine?

☐ It makes the engine lower at the front and so improves passive safety for reducing pedestrian impact severity.

☐ The high-pressure pump had to be moved to the rear to make space for auxiliary units at the front.

☐ It relieves the chain drive system of rotational vibration stresses.

4. Does the high-pressure pump have to be positioned correctly relative to the crankshaft?

☐ Yes

☐ No.

5. What is the special feature of the oil pump?

☐ It is a data-map controlled oil pump.

☐ The oil pump forms a single unit with the vacuum pump.

☐ The oil pump is a controlled-volumetric-flow design.

☐ The pressure limiting valve has a stepped piston on which the oil pressure acts upstream and downstream of the filter.

6. **Which of the following statements about the bypass valve in the recirculated-exhaust cooler are correct?**

- ☐ Recirculating uncooled exhaust brings the oxidation catalytic converter up to temperature more quickly.
- ☐ The bypass valve diverts the coolant through a bypass pipe that bypasses the recirculated-exhaust cooler.
- ☐ The bypass valve diverts the exhaust through a bypass pipe that bypasses the recirculated-exhaust cooler.
- ☐ The bypass around the recirculated-exhaust cooler enables the coolant temperature to be better controlled.

7. **What is the function of the pressure regulating valve in the crankcase venting system?**

- ☐ The purpose of the pressure regulating valve is to ensure that a constant level of positive pressure is maintained inside the crankcase.
- ☐ The purpose of the pressure regulating valve is to ensure that a constant level of negative pressure is maintained inside the crankcase.

8. **Which of the following statements about the EURO 6 version are correct?**

- ☐ The NO_x accumulator catalytic converter reduces nitrogen oxide levels.
- ☐ The NO_x accumulator catalytic converter reduces hydrogen sulphide levels.
- ☐ The H_2S blocking catalytic converter reduces hydrogen sulphide levels.
- ☐ It uses additional components in the form of an EGR temperature sensor, an exhaust temperature sensor and a second oxygen sensor.

9. **Which of the following statements about the fuel system are correct?**

- ☐ The fuel pressure/temperature sensor is checked for plausibility after the fuel pump is switched off.
- ☐ The fluid trap prevents fuel escaping from the fuel tank vent pipe.
- ☐ The fluid trap incorporates an overturn safety valve.
- ☐ The non-return valve in the fuel filler pipe incorporates an overturn safety valve.
- ☐ The fuel pump has a pressure relief valve to protect the feed line against excessive pressure.

10. **Where is the transmission oil-to-coolant heat exchanger located?**

- ☐ The transmission oil-to-coolant heat exchanger is mounted on the engine block.
- ☐ The transmission oil-to-coolant heat exchanger is mounted on the cooling module.

11. **Which of the following statements about the engine electricals are correct?**

- ☐ The DDE main relay is controlled by the DDE control unit.
- ☐ The DDE main relay on the E9x is controlled by the DDE control unit.

- ☐ The second oxygen sensor is required for NO_x accumulator catalytic converter regeneration.

12. Which glowplug system operating modes are there on the N57 engine?

- ☐ Preheating
- ☐ Start standby heating
- ☐ Start heating
- ☐ Emergency heating
- ☐ Hidden heating
- ☐ Idle speed heating
- ☐ Medium power band heating
- ☐ Full power heating

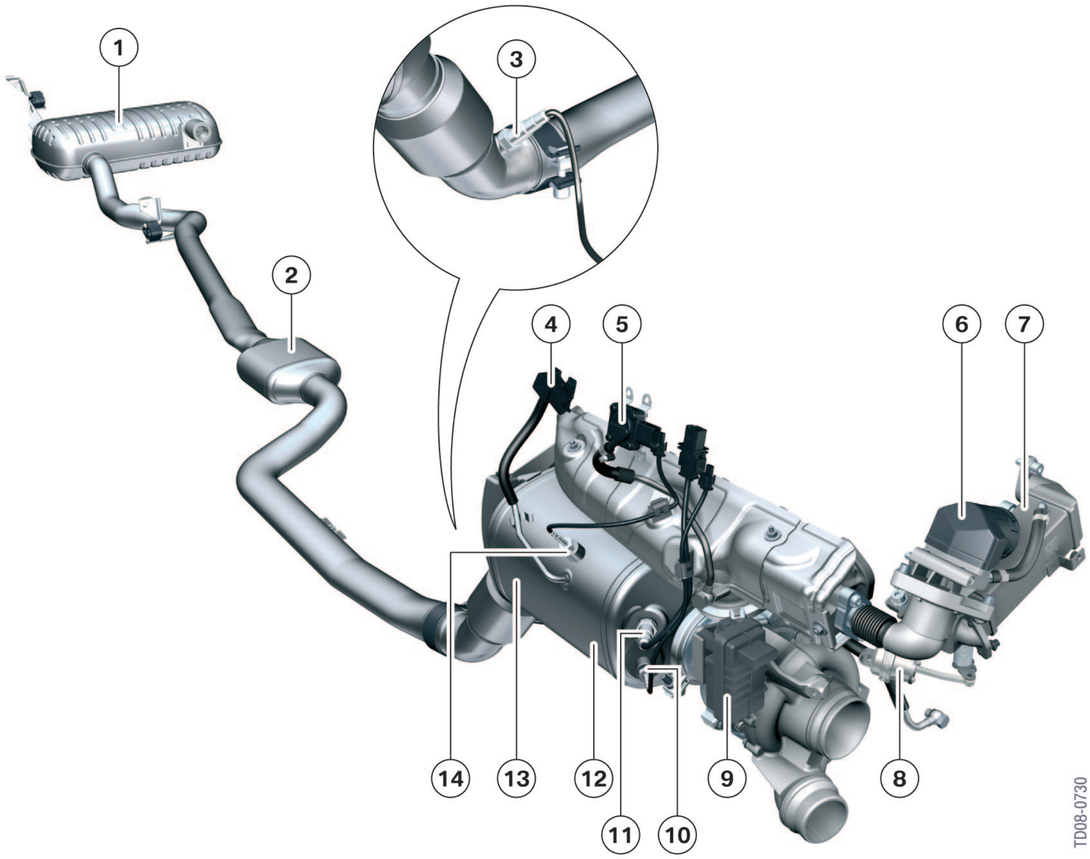
13. Why is a flow restrictor fitted in the oil leakage line on the piezo-electric injectors?

- ☐ So that the switching valve on the piezo-electric injector functions properly.
- ☐ To prevent too much leakage oil flowing back into the fuel tank.
- ☐ To maintain the necessary switching pressure of approx. 10 bar in the piezo-electric injector.

14. Why is an electrically operated EGR valve used?

- ☐ The electrically operated EGR valve enables the exhaust recirculation rate to be very precisely controlled.
- ☐ So that the recirculated exhaust can be cooled using the EGR valve cooler.
- ☐ Because the EGR valve is now fitted on the hot side and a vacuum-controlled EGR valve would not withstand the high temperatures.

15. Match the components of the EURO 6 exhaust system listed below to the index numbers on the illustration.



Index	Explanation	Index	Explanation
	Rear silencer		EGR bypass valve vacuum unit
	Exhaust back-pressure sensor downstream of NO_x accumulator catalytic converter		VNT regulator
	NO_x accumulator catalytic converter		Exhaust temperature sensor downstream of NO_x accumulator catalytic converter
	Oxygen sensor downstream of diesel particulate filter		Exhaust temperature sensor upstream of NO_x accumulator catalytic converter
	EGR cooler		EGR valve
	Exhaust back-pressure sensor upstream of turbocharger		Oxygen sensor upstream of NO_x accumulator catalytic converter
	H_2S blocking catalytic converter		Diesel particle filter

Check it!

Answers to questions

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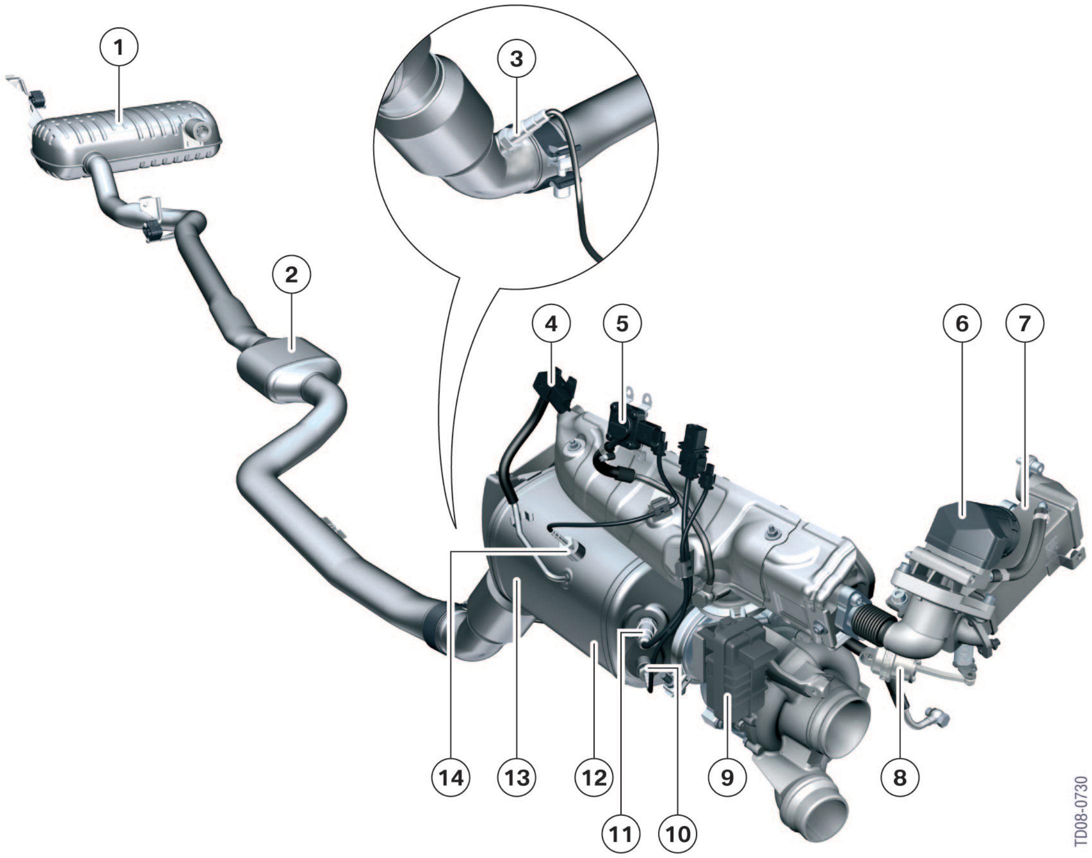

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12	NO_x accumulator catalytic converter	14	Exhaust temperature sensor downstream of NO_x accumulator catalytic converter
3	Oxygen sensor downstream of diesel particulate filter	10	Exhaust temperature sensor upstream of NO_x accumulator catalytic converter
7	EGR cooler	6	EGR valve
5	Exhaust back-pressure sensor upstream of turbocharger	11	Oxygen sensor upstream of NO_x accumulator catalytic converter
2	H_2S blocking catalytic converter	13	Diesel particle filter

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