

# Reference Manual



# N57TU ENGINE



## Technical Training

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**Technical training.**  
Product information.

## **N57TU Engine**



**BMW Service**

Edited for the U.S. market by:  
**BMW Group University**  
Technical Training

ST1306

7/1/2013

# General information

## Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:



---

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

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## Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as the result of the equipment specification in specific markets or countries.

## Additional sources of information

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

- Owner's Handbook
- Integrated Service Technical Application.

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The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

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# N57TU Engine

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# N57TU Engine

## 1. Introduction

The N57TU engine is based on the N57 engine **which was not available in the US** but has been used in other markets for some time. The differences between the N57TU engine and N57 engine are essentially the same as the differences between the N47TU engine and N47 engine. This document deals exclusively with the adaptations/changes made with regard to the N57TU engine. The N57TU 6 cylinder engine replaces the (M57D30T2) 6 cylinder which was first introduced to the US market in 2009 with the E90 335d and the E70 xDrive35d.

The N57TU engine was installed in the F10 535d and 535d xDrive 2014 models from 7/2013 start production and was also installed on the new 2014 X5 model xDrive35d (F15) introduced in September of 2013.

Model	Series	Engine	Start of production
535d	F10	N57D30O1	7/13
535d xDrive	F10	N57D30O1	7/13
X5 xDrive35d	F15	N57D30O1	9/13

**The N47TU and the N57TU engine are considered second generation BMW diesel engines (in the US market). The exhaust after-treatment systems and components of the N47TU and the N57TU have been especially design to comply with current (ULEV II) US market emission regulations and thus differ from those used with the previous US diesel (M57D30T2) engine.**

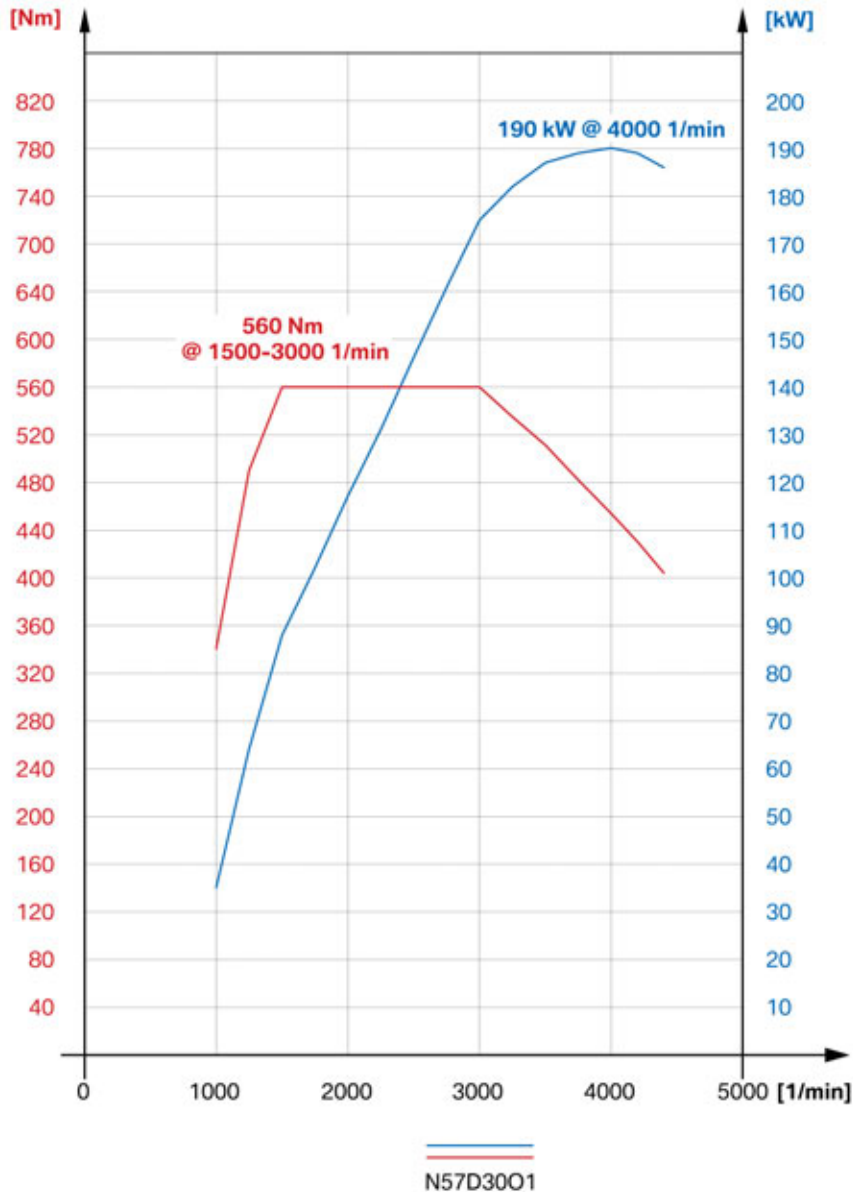


# N57TU Engine

## 1. Introduction

### 1.1. Technical data

The N57TU engine technical data is described in the following table.



Full-load diagram of F10 BMW 535d with N57D3001 engine

Engine specifications	Unit	N57D3001 (F10/535d xDrive)
Design		Inline 6
Displacement	[cm <sup>3</sup> ]	2993
Bore/stroke	[mm]	84/90
Power output at engine speed	[kW (HP)] [rpm]	190 (255) 4000

# N57TU Engine

## 1. Introduction

Engine specifications	Unit	N57D3001 (F10/535d xDrive)
Power output per liter	[kW/l]	63.48
Torque at engine speed	[Nm/ft-lb] [rpm]	560/413 1500 – 3000
Compression ratio	[ε]	16.5 : 1
Valves per cylinder		4
Fuel consumption complying with EU	[l/100 km]	5.7
CO <sub>2</sub> emissions	[grams per kilometer]	150
Digital Motor Electronics		DDE7.41
Exhaust emissions legislation		ULEV II
Maximum speed	[km/h/mph]	250/155
Acceleration 0 – 60 mph	[s]	6.0
Vehicle curb weight DIN/EU	[kg]	1790/1865

## 1.2. Engine identification

### 1.2.1. Engine designation

In the technical documentation, the engine designation is used to ensure unambiguous identification of the engine. Frequently, however, only a short designation is used.

This short form is used so an engine can be identified as belonging to a specific engine family. The N57 engine family to which several engines, such as the N57D30T0, N57D30O0, N57D30U0 and N57D30K0, belong is therefore frequently mentioned. The initial redesigned version is therefore referred to as the N57TU engine and is currently the only N57 available in the US market.

Position	Meaning	Index	Explanation
1	Engine developer	M, N P S W	BMW Group BMW M Sport BMW M GmbH Bought-in engines
2	Engine type	1 2 4 5 6 7 8	4-cylinder in-line engine (e.g. N18) 4-cylinder in-line engine (e.g. N20) 4-cylinder in-line engine (e.g. N47) 6-cylinder in-line engine (e.g. N57) V8 engine (e.g. N63) V12 engine (e.g. N74) V10 engine (e.g. S85)
3	Change to the basic engine concept	0 1 – 9	Basic engine Changes, e.g. combustion process

# N57TU Engine

## 1. Introduction

Position	Meaning	Index	Explanation
4	Working method or fuel type and possibly installation position	B D H	Gasoline engine longitudinal installation Diesel engine longitudinal installation Hydrogen internal combustion engine longitudinal installation
5 + 6	Displacement in 1/10 liter	30	3.0 liters displacement
7	Performance class	K U M O T	Lowest Lower Middle Upper TOP
8	Revision relevant to approval	0 1 – 9	New development Redesign

### Breakdown of N57D30O1 engine designation

Index	Explanation
N	BMW Group Development
5	4-cylinder in-line engine
7	Direct fuel injection and exhaust turbocharger
D	Diesel engine longitudinal installation
30	3.0 liters displacement
O	Upper performance class
1	1. Redesign

# N57TU Engine

## 1. Introduction

### 1.2.2. Engine identification

The engines have an identification mark on the crankcase to ensure clear identification and classification. The engine identification is also required for approval by the authorities. The engine number can be found on the engine, above the engine identification. This consecutive number, in conjunction with the engine identification, permits clear and definite identification of each individual engine. The first six digits correspond to the engine designation.

Position	Meaning	Index	Explanation
1	Engine developer	M, N P S W	BMW Group BMW M Sport BMW M GmbH Bought-in engines
2	Engine type	1 2 4 5 6 7 8	4-cylinder in-line engine (e.g. N18) 4-cylinder in-line engine (e.g. N20) 4-cylinder in-line engine (e.g. N47) 6-cylinder in-line engine (e.g. N57) V8 engine (e.g. N63) V12 engine (e.g. N74) V10 engine (e.g. S85)
3	Change to the basic engine concept	0 1 – 9	Basic engine Changes, e.g. combustion process
4	Working method or fuel type and possibly installation position	B D H	Gasoline engine longitudinal installation Diesel engine longitudinal installation Hydrogen internal combustion engine longitudinal installation
5 + 6	Displacement in 1/10 liter	30	3.0 liters displacement
7	Type test concerns (changes that require a new type test)	A B – Z	Standard Acc. to requirements, e.g. RON87



N57TU engine, engine identification and engine number

TD10-1782

# N57TU Engine

## 1. Introduction

Index	Explanation
27117547	Running engine number
N	BMW Group Development
5	6-cylinder in-line engine
7	Direct fuel injection and exhaust turbocharger
D	Diesel engine longitudinal installation
30	3.0 liters displacement
A	Standard

### 1.3. Design features

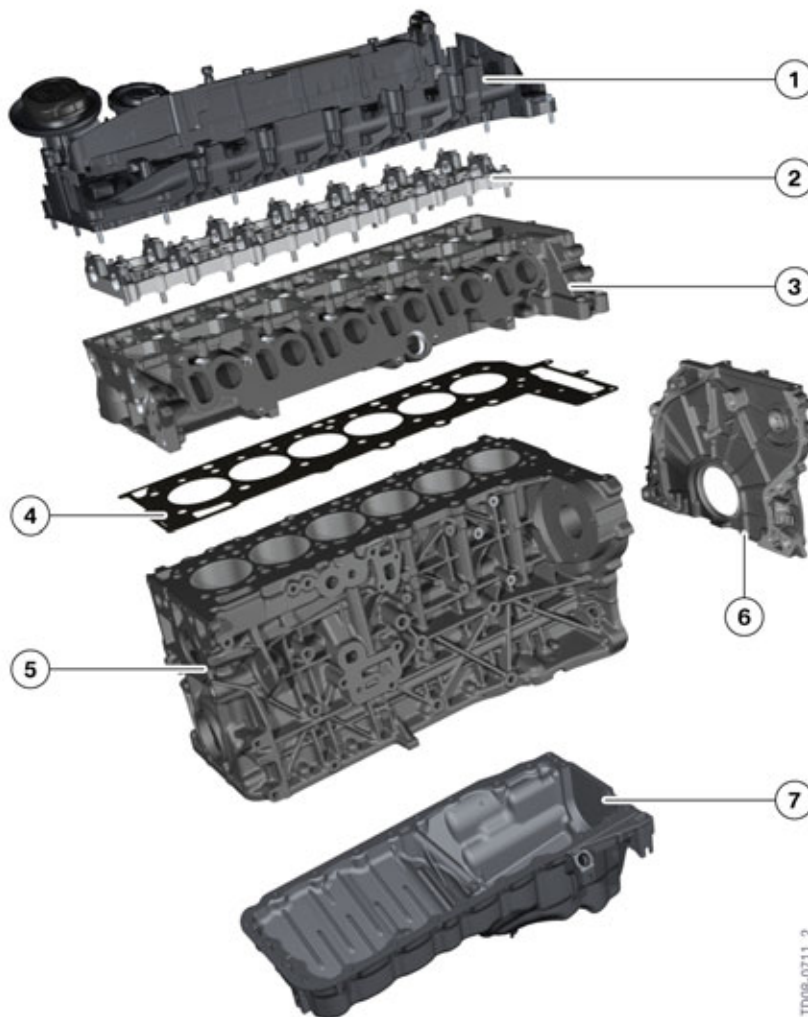
System	Comment
Engine mechanics	<ul style="list-style-type: none"><li>• Optimized crankcase</li><li>• Modified cylinder head</li><li>• Weight-optimized crankshaft</li><li>• New piston</li></ul>
Belt drive	<ul style="list-style-type: none"><li>• New low-friction belt drive with modified arrangement of components</li></ul>
Oil supply	<ul style="list-style-type: none"><li>• New oil filter module with integrated transmission oil-to-coolant heat exchanger</li></ul>
Intake air system	<ul style="list-style-type: none"><li>• Adaptation of intake silencer to modified geometry</li></ul>
Exhaust emission system	<ul style="list-style-type: none"><li>• Exhaust-gas recirculation redesigned</li></ul>
Fuel preparation	<ul style="list-style-type: none"><li>• New injectors deliver a fuel pressure of up to 1800 bar</li></ul>
Engine electrical system	<ul style="list-style-type: none"><li>• New sensors and modified control unit</li></ul>

# N57TU Engine

## 2. Engine Mechanical

### 2.1. Crankcase

The aluminium crankcase of the N57TU engine is a new engineering design that is based on the crankcase of the N57 engine (not available in the US). This new design was necessary as the engine support required additional connection points. The oil pressure switch needed to be repositioned and a new oil passages for the oil module supply was required. In addition, the crankcase is exposed to higher loads due to the increased power of the N57TU engine family. This has been taken into account by making changes to details and geometry to enhance its strength. The familiar oil filter module (from the N47TU engine) with integrated engine and transmission oil coolers is also used. For more information, refer to “Oil supply”.



N57TU engine block components

TD008-0711\_2

# N57TU Engine

## 2. Engine Mechanical

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Index	Explanation
1	Cylinder head cover
2	Camshaft carrier plate
3	Cylinder head
4	Head gasket
5	Crankcase
6	Timing case cover
7	Sump

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**Loctite 5970 silicone gasket is used (no actual gasket is installed) on the sump and timing case cover of the rear wheel drive 535i models with the N57TU.**

**The xDrive models with the N57TU use gaskets instead of the sealant.**

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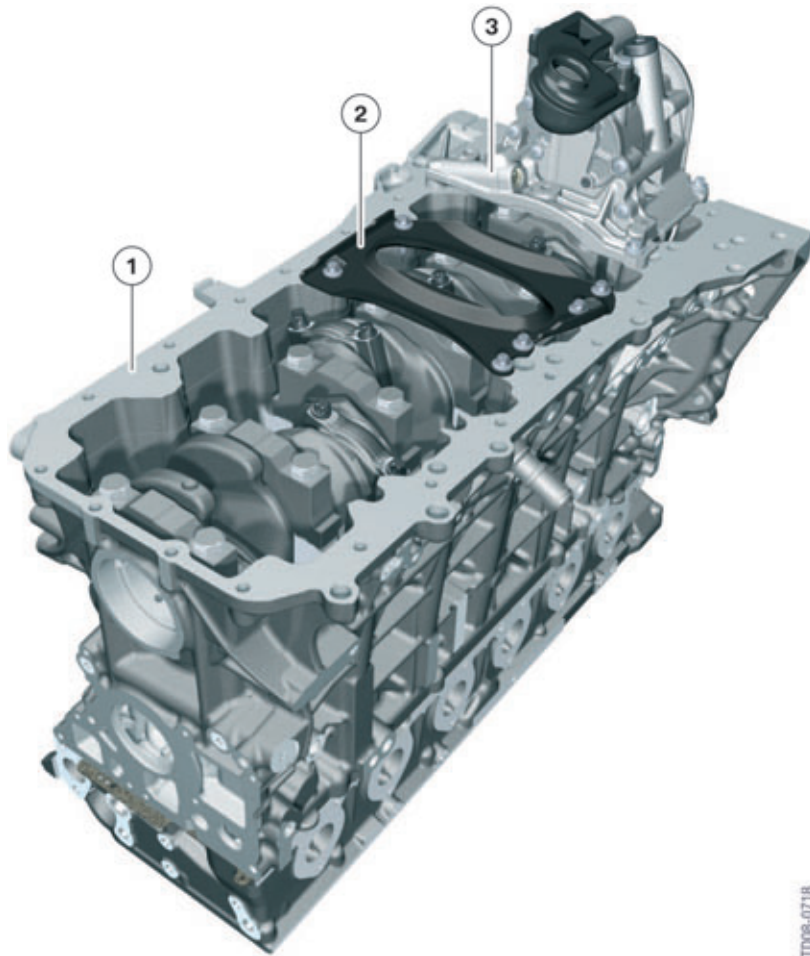
The special features of the N57TU engine crankcase are:

- Crankcase made of aluminium.
- Chain drive located on the force transmitting (flywheel) 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.

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.

# N57TU Engine

## 2. Engine Mechanical



TD009-0718

N57TU crankcase with reinforcing

Index	Explanation
1	Crankcase
2	Reinforcing plate
3	Oil pump

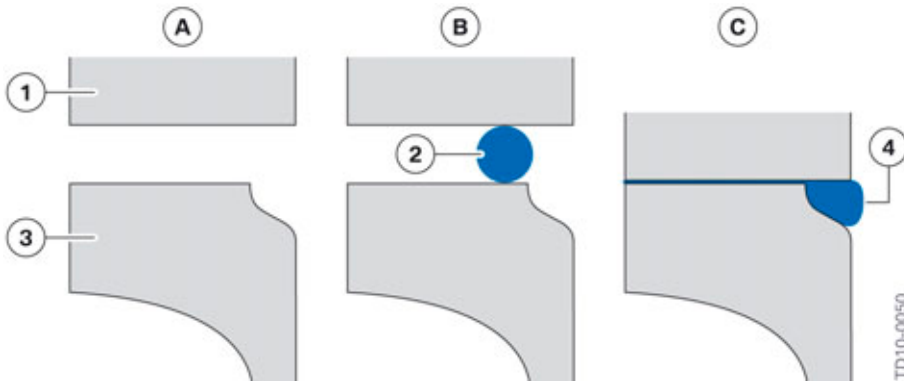
### 2.2. Oil sump

As with the N47TU the engine oil sump gasket surface was converted to use a silicone Loctite gasket 5970. The oil sump of the **N57TU (rear wheel drive model only)** was machined with chamfer to use the silicone gasket. This chamfer is located on the inside of the flange, which serves as a defined reservoir for the excess silicone.



# N57TU Engine

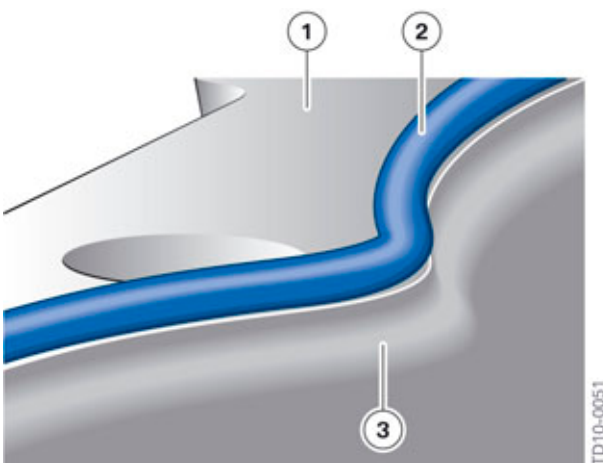
## 2. Engine Mechanical



Schematic diagram, oil sump gasket

Index	Explanation
A	Components without silicone bead
B	Components with silicone bead
C	Components bolted with silicone bead
1	Crankcase
2	Silicone bead
3	Oil sump with chamfer
4	Emergence of silicone through the screw connection into the provided space in the oil sump

A bevel is necessary when using a surface sealant to ensure that sealing compound that encroaches is deposited in a controlled manner in the designated space where it cannot detach due to splashing of oil.



Positioning, silicone bead

# N57TU Engine

## 2. Engine Mechanical

Index	Explanation
1	Oil sump sealing surface
2	Silicone bead
3	Chamfer on inside of oil sump



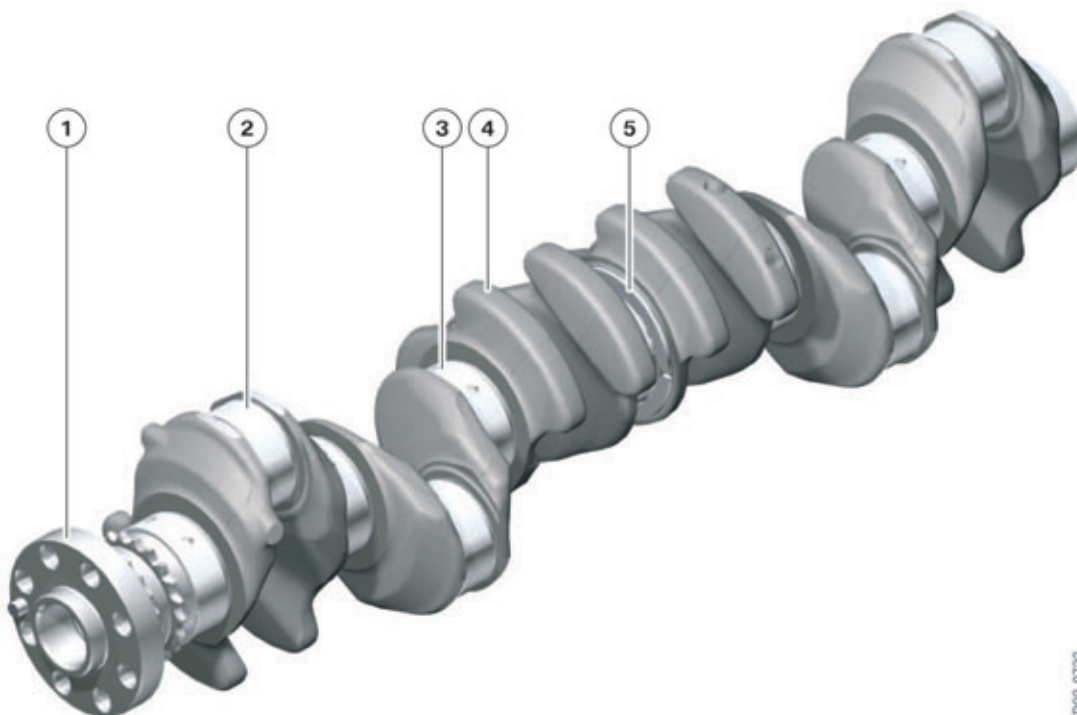
Loctite 5970 silicone gasket is used (no actual gasket is installed) on the sump and timing case cover of the rear wheel drive 535i models with the N57TU.

The xDrive models with the N57TU use gaskets instead of the sealant.



Please refer to the repair instructions for proper procedure and torque specifications.

### 2.3. Crankshaft



N57TU crankshaft

TD06-0722

# N57TU Engine

## 2. Engine Mechanical

Index	Explanation
1	Output flange
2	Rod bearing journal (big-end)
3	Main bearing journal
4	Counterweight
5	Axial bearing thrust surface

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 N57TU engine has eight counterweights.

The N57TU 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 (M57D30T2) 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 N57TU engine.

Crankshaft specifications	Unit	N57TU
Material		C38modBY
Type		Forged
Main bearing journal diameter	[mm]	55
Rod bearing (big-end) diameter	[mm]	50
Crank pin off-set	[°]	120
Number of counterweights		8
Number of main bearings		7
Position of thrust bearing		4



**Always refer to the proper repair instructions for more information and follow the special bearing classification procedure when servicing the crankshaft and bearings on BMW engines.**

# N57TU Engine

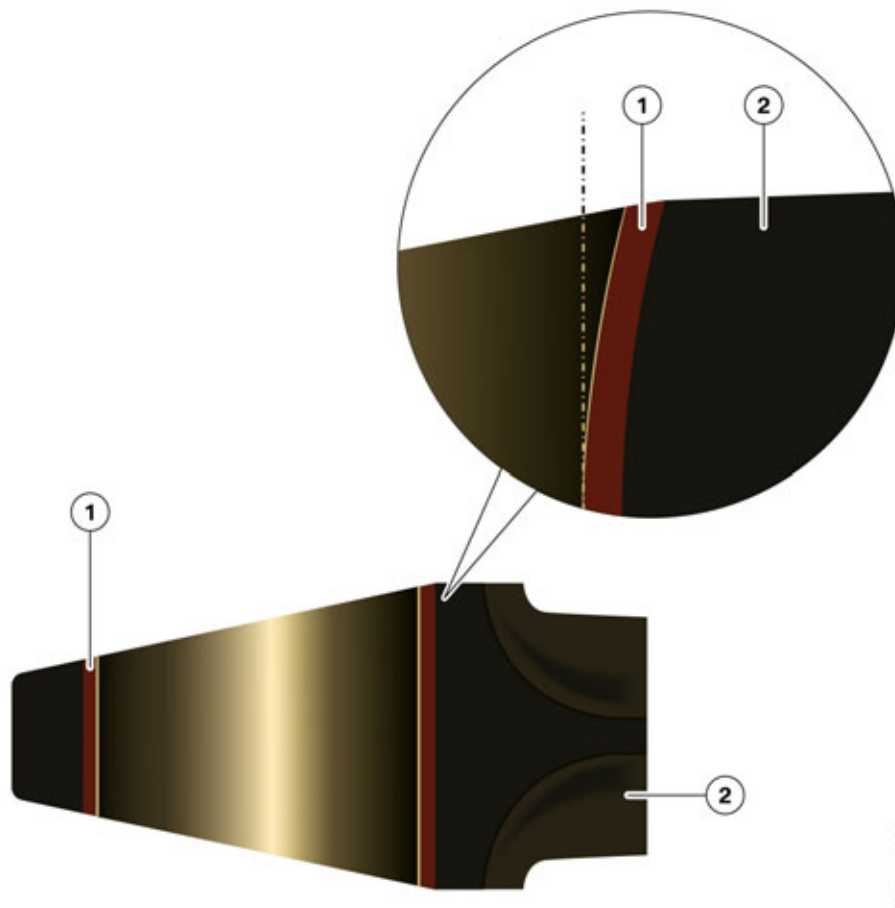
## 2. Engine Mechanical

### 2.4. Piston

The pistons have been adapted to the new requirements due to the use of solenoid type injectors. The combustion chamber and injector are always harmonized with one another.

### 2.5. Connecting rod

The shaped hole in the small connecting rod eye is familiar technology that already features in the N55 and N47TU engines. The shaped hole reduces edge load by allowing the force acting on the piston via the wrist pin to be distributed optimally across the surface of the cylinder liner.



N57TU engine, small connecting rod eye

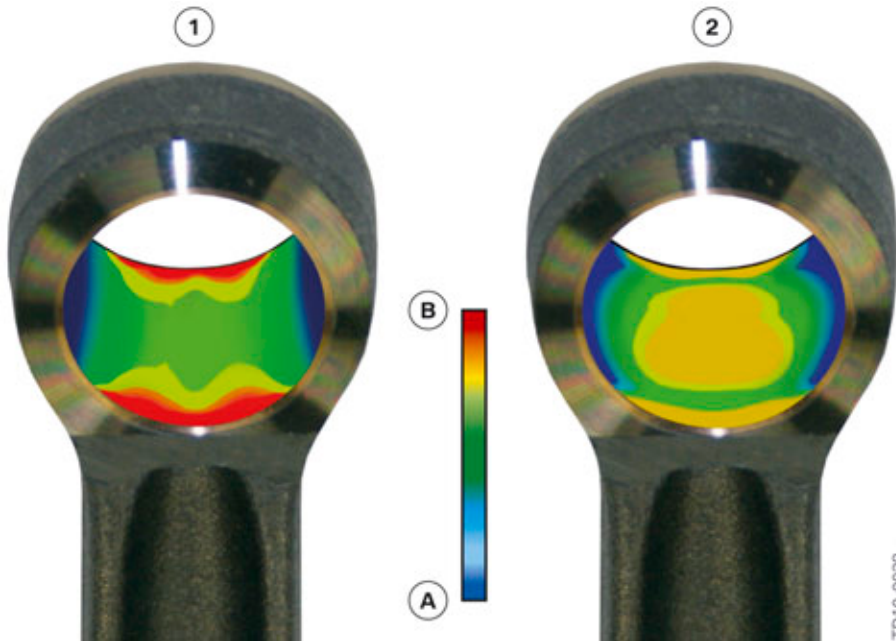
Index	Explanation
1	Bushing
2	Connecting rod

The graphic on the following page shows (on the left side) the surface load for a normal connecting rod without a shaped bore. Due to the pressure on the piston, most of the force is transferred via the wrist pin to the edges of the small connecting rod eye bushing.

# N57TU Engine

## 2. Engine Mechanical

If a shaped hole is introduced into the small connecting rod eye (graphic on the right) the force is distributed across a larger surface and the load on the edge of the bushing reduces considerably. The force is now transmitted via a larger surface.



N57TU engine, small connecting rod eye

Index	Explanation
A	Low surface load
B	High surface load
1	Without shaped bore
2	With shaped bore

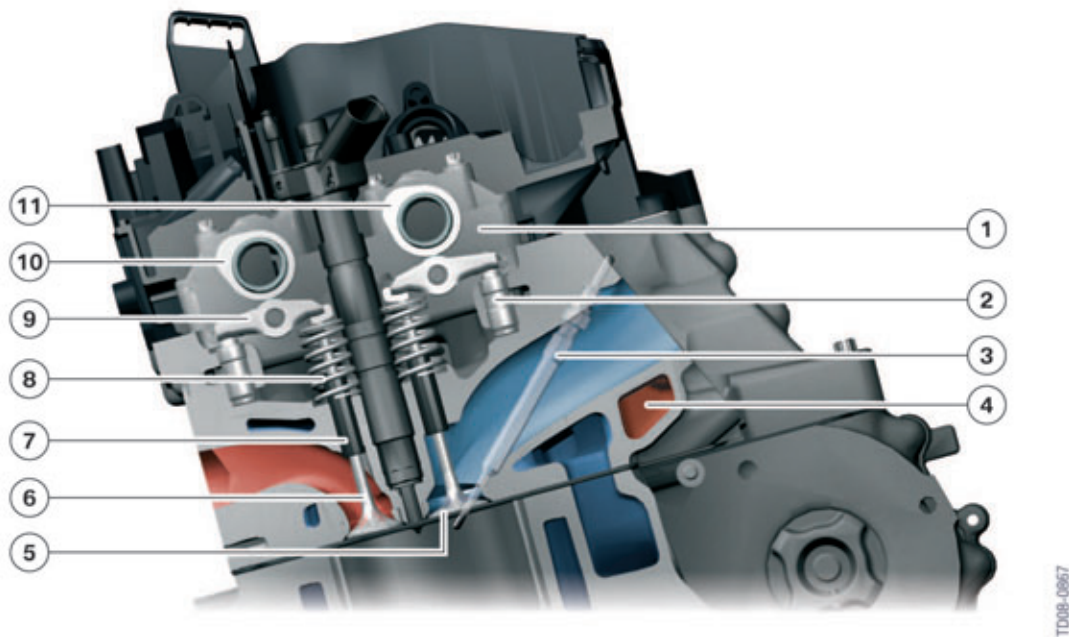
### 2.6. Cylinder head

The distinguishing technical features of the N57TU engine cylinder head are as follows:

- Material: AISI7MgCu0.5
- Two-piece cylinder head with camshaft carrier plate
- Cross-flow cooling
- Integral exhaust recirculation channel
- Four valves per cylinder
- Parallel valve arrangement (axes parallel with the cylinder axes)
- Tangential and swirl ports
- Reduced height

# N57TU Engine

## 2. Engine Mechanical



N57TU Cylinder head cut away with view of the valvetrain

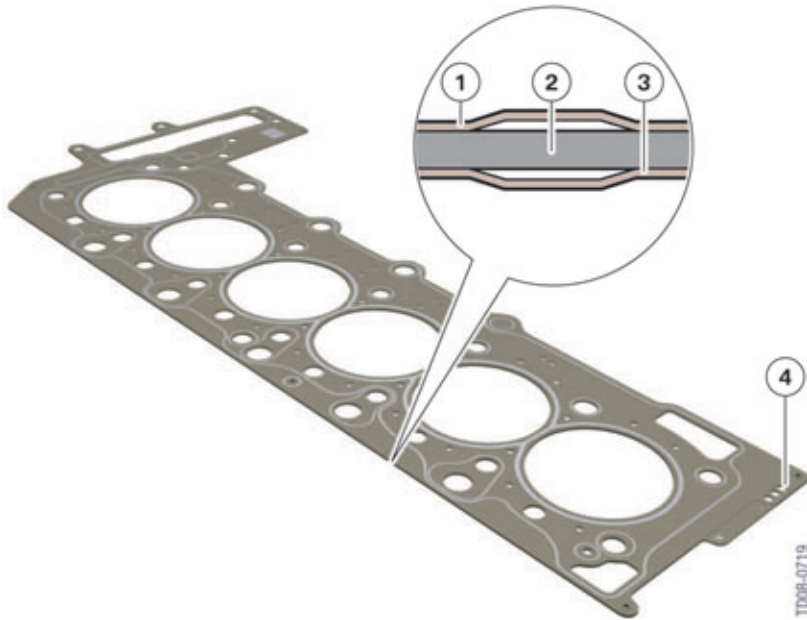
Index	Explanation
1	Camshaft carrier plate
2	Hydraulic valve clearance adjuster
3	Glow plug
4	Exhaust recirculation channel
5	Intake valve
6	Exhaust valve
7	Valve guide
8	Valve spring
9	Roller cam follower
10	Exhaust camshaft
11	Intake camshaft

The cylinder head of the N57TU engine largely matches the standards of the current diesel engines. A special feature, however, is that the cylinder head is comprised of two large cast parts. The camshafts are integrated inside their own camshaft carrier. In the case of the N57TU cylinder head, those two parts are the main casting of actual cylinder head, and a carrier plate for the camshafts. Both camshafts are mounted in this camshaft carrier. This design simplifies the manufacturing process.

# N57TU Engine

## 2. Engine Mechanical

### 2.7. Cylinder head gasket



N57TU head gasket

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

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

- Combustion chamber
- Atmosphere
- Engine oil passages
- Coolant passages

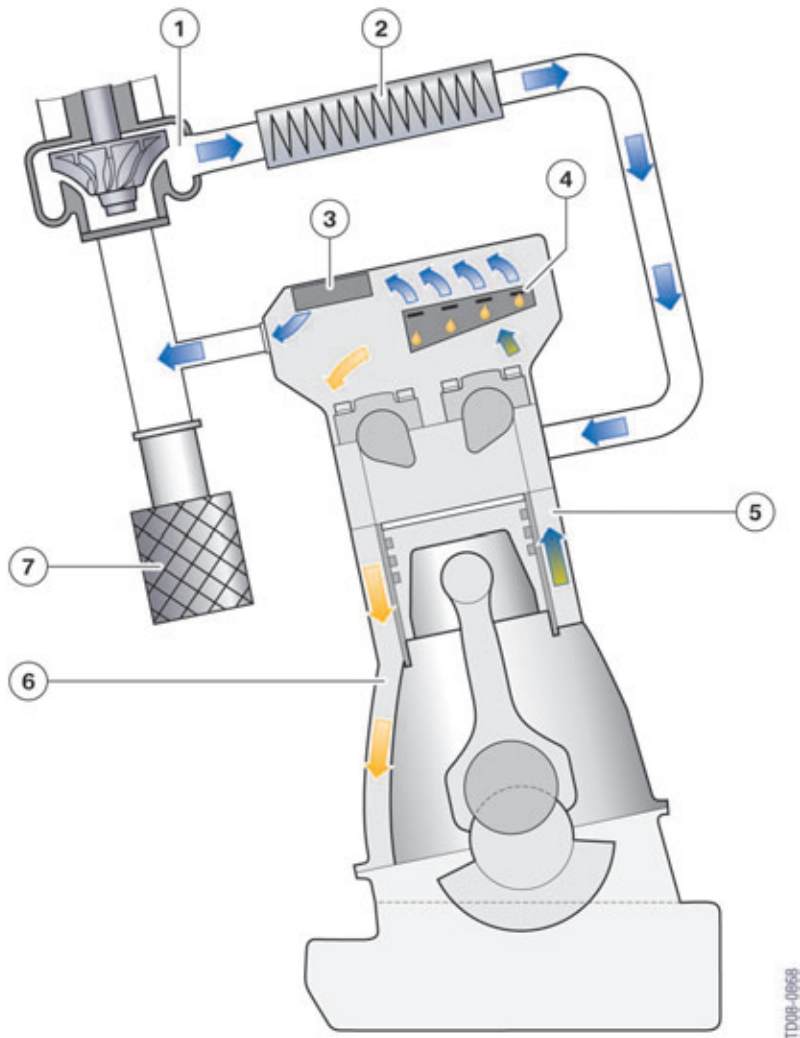
A three-layer metal gasket is used on the N57TU engine.

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.

# N57TU Engine

## 2. Engine Mechanical

### 2.8. Crankcase ventilation



N57TU crankcase ventilation

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



# N57TU Engine

## 2. Engine Mechanical

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 vapor.

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. The separated engine oil droplets work their way back into the sump through an oil return pipe. The crankcase venting system also ensures that excess pressure is not created in the crankcase.

The N57 engine is equipped with a vacuum controlled crankcase venting system with a regulated negative pressure of about 38 mbar (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.

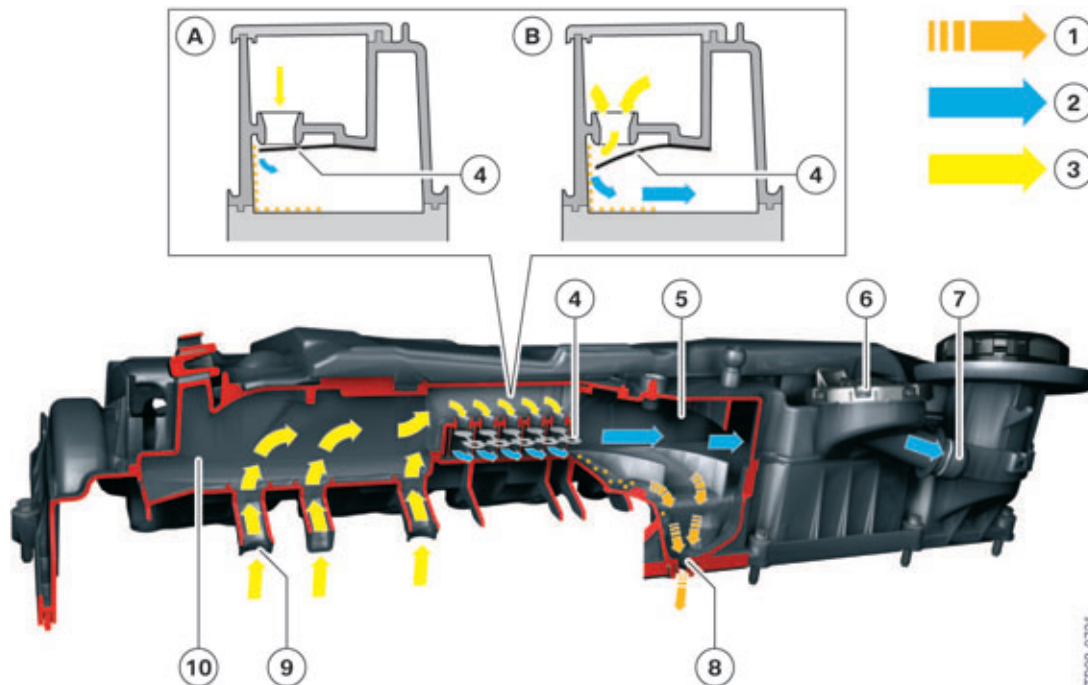
As a result of the pressure difference relative to the crankcase, the blow-by gas is drawn into the cylinder head.

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 about 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.

# N57TU Engine

## 2. Engine Mechanical



N57TU oil separation in the cylinder head

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

# N57TU Engine

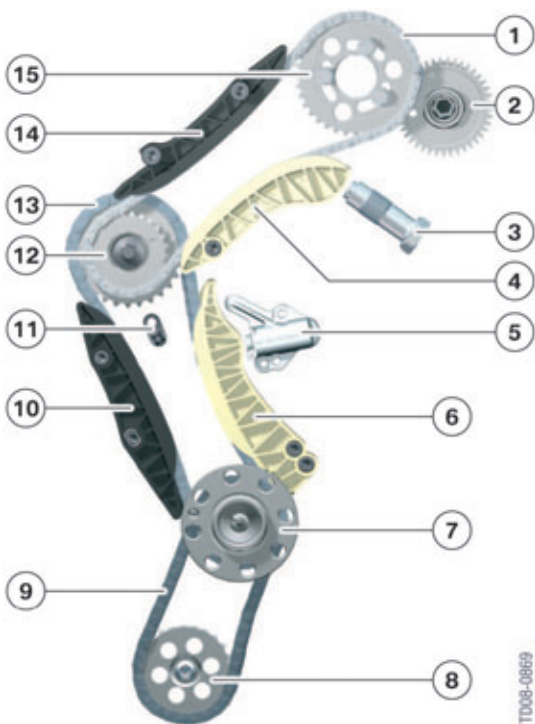
## 2. Engine Mechanical

### 2.9. Camshaft drive system

The special features and specifications of the chain drive system on the N57TU engine are as follows:

- Chain drive system mounted on flywheel side 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 N47TU engine, the chain drive system on the N57TU 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. This is of benefit for the passive safety features for minimizing pedestrian impact severity. It creates more space between the engine and the hood. Thus, in the event of a crash, there is more room for the hood to deform and absorb the impact therefore minimizing the injury to the pedestrian. 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.



N57TU chain drive

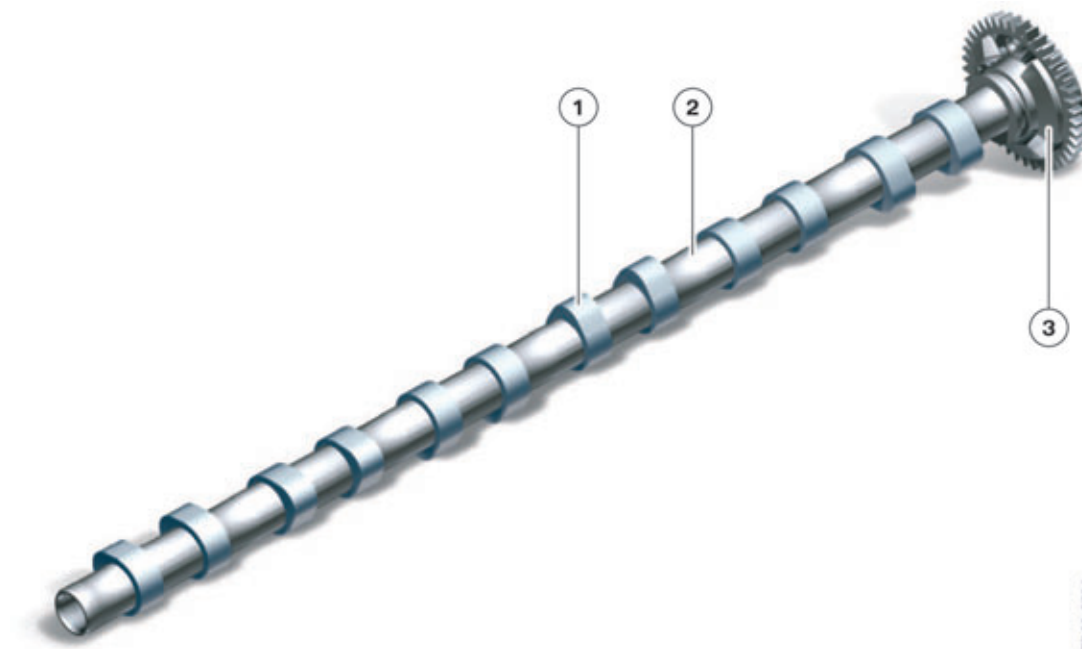
# N57TU Engine

## 2. Engine Mechanical

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 rail
11	Oil spray nozzle
12	High-pressure pump sprocket
13	Lower chain
14	Upper guide rail
15	Intake camshaft sprocket

### 2.10. Camshafts and timing

The N57TU engine is fitted with the now familiar composite camshafts. They are made using the Presta method in common with the camshafts on all BMW diesel engines.



N57TU camshaft

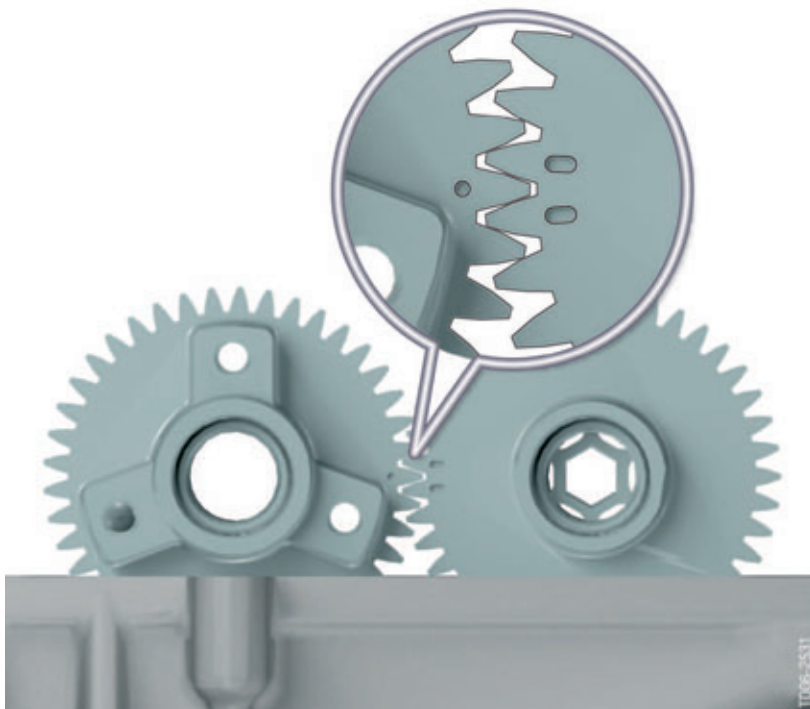
TD08-0724

# N57TU Engine

## 2. Engine Mechanical

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

The intake 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 intake camshaft. The camshaft gears are integral components of the camshafts and are permanently attached to them. Markings on the camshaft gears facilitate the correct positioning of the camshafts relative to one another when fitting. The intake 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 N57TU engine, the special tool is only placed on the exhaust camshaft.



N57TU timing gear alignment

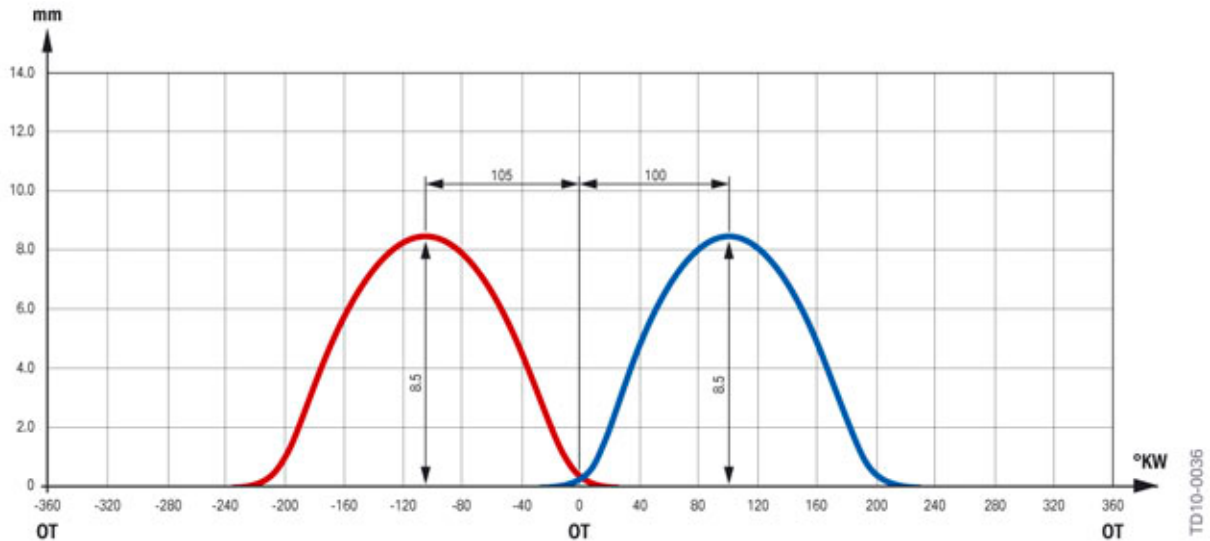
The camshaft sprocket is bolted to the camshaft gear of the intake camshaft. Slots are provided for adjusting the valve timing. A new feature is that the sprocket can be bolted in place without turning the camshaft out of position. To that end, the three bolts are not spaced evenly 120° apart (see graphic above). To brace the camshaft when fitting the sprocket, an Allen-key socket in the center of the camshaft gear on the exhaust camshaft is used.

# N57TU Engine

## 2. Engine Mechanical

### 2.10.1. Timing

The N57TU engine timing has remained the same when compared to the N47TU engine.



N57TU engine, timing diagram

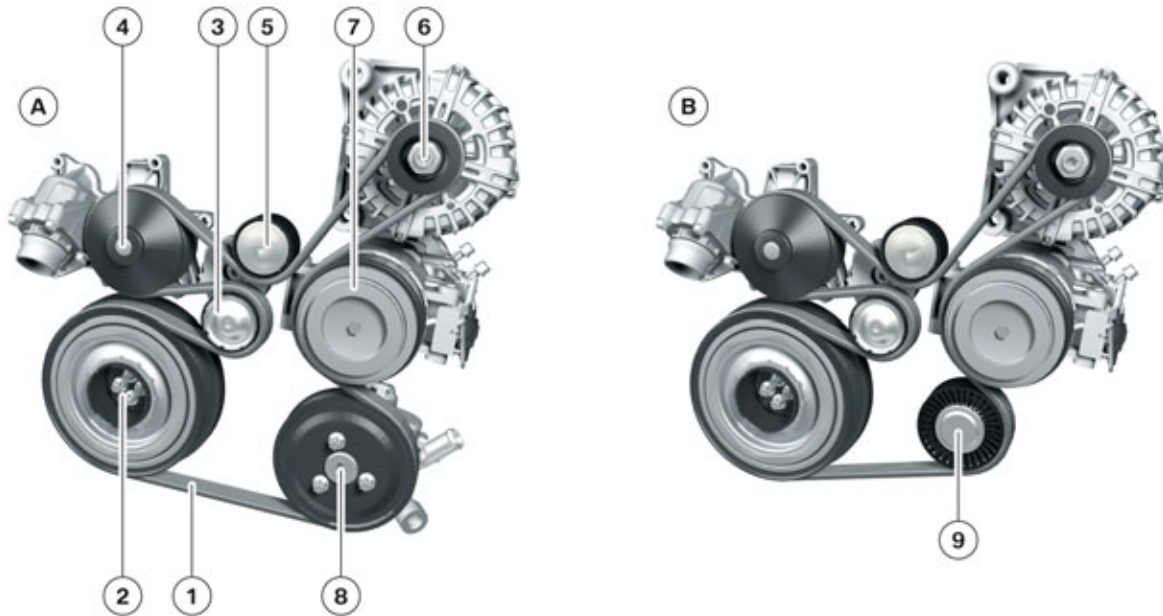
		N57TU intake	N57TU exhaust
Valve diameter	[mm]	27.2	24.6
Max. valve lift	[mm]	8.5	8.5
Spread	[crankshaft degrees]	100	105
Valve opens	[crankshaft degrees]	352.4	140.7
Valve closes	[crankshaft degrees]	567.1	363.9
Valve opening period	[crankshaft degrees]	214.7	223.1

# N57TU Engine

## 3. Belt Drive

The layout of the belt drive and assemblies has been redesigned.

### 3.1. N57 engine



TD10-0008

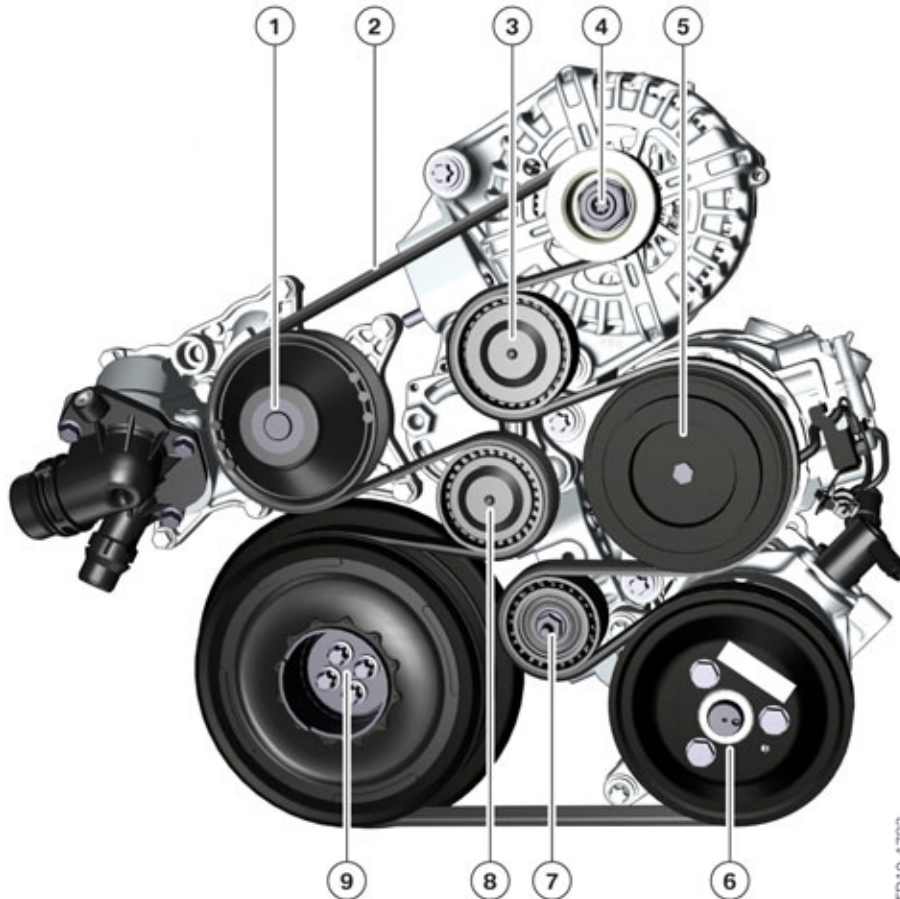
N57 engine, belt drive variants

Index	Explanation
A	With air conditioning and hydraulic steering
B	With air conditioning and electromechanical power steering
1	Drive belt, double-sided
2	Torsional vibration damper
3	Tensioning pulley
4	Coolant pump
5	Deflecting element
6	Alternator
7	Air conditioning compressor
8	Power steering pump
9	Deflecting element

# N57TU Engine

## 3. Belt Drive

### 3.2. N57TU engine



TD10-1783

N57TU engine, drive belt variant with power steering pump

Index	Explanation
1	Coolant pump
2	Drive belt, single-sided
3	Deflecting element
4	Alternator
5	Air conditioning compressor
6	Power steering pump
7	Deflecting element
8	Tensioning pulley
9	Torsional vibration damper



# N57TU Engine

## 3. Belt Drive

The component carrier with optimized connection to crankcase is also new. As the intake of the differentiated air intake system has been moved to the front of the engine, the assemblies had to be moved down. Less installation space is now available for the belt tensioner and the assemblies due to this downwards displacement.

The direction of rotation of the air conditioning compressor has also been reversed as a result of these changes. The deflecting element is mounted on the belt tensioner. The belt tensioner features a hexagon head so it can be locked and unlocked. The new belt guide has been introduced as a result of these changes and the belt provides support on one side only. It has also been possible to reduce the belt tensioning force by around 100 Nm.

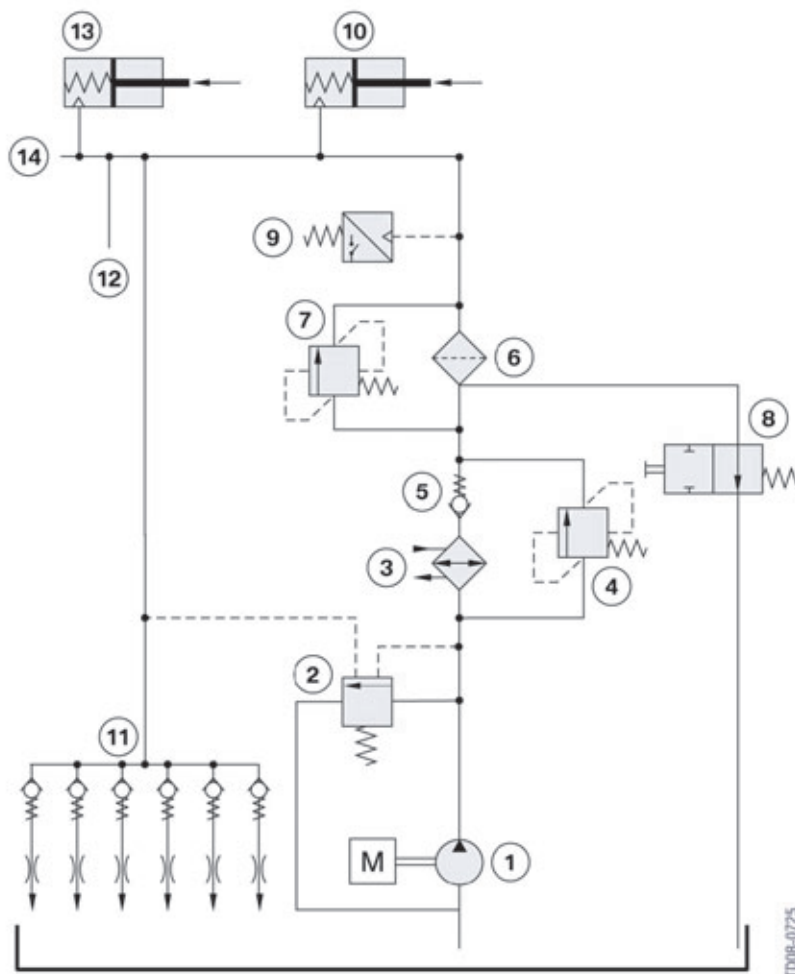
# N57TU Engine

## 4. Oil Supply

### 4.1. Oil circuit

The N57TU engine is equipped with a forced-feed lubrication system. The system corresponds to the design and operation of the N47TU lubrication system.

In a forced-feed lubrication system, the oil pump takes in oil from the sump through an intake pipe and pumps it onwards into the circuit. The oil flows through the full-flow oil filter and then passes into the main oil channel, which runs parallel to the crankshaft in the engine block. Branch galleries lead to the main bearings of the crankshaft. The crankshaft has corresponding holes to feed oil from the main bearings to the crank pins and connecting rod journals. Part of the oil is branched off from the main oil gallery and fed to the corresponding lubrication points in the cylinder head. The oil ultimately returns to the sump. Either it passes through return channels or it simply drips back there freely.



N57TU engine oil circuit

# N57TU Engine

## 4. Oil Supply

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

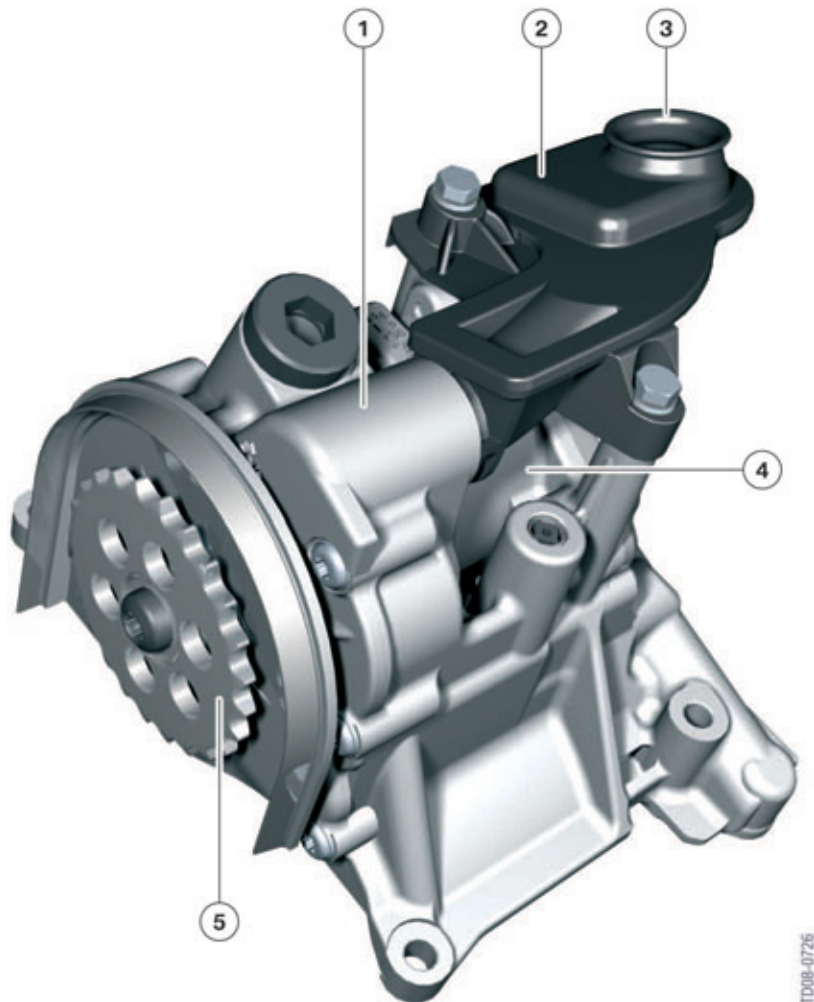
### 4.2. Oil pump

The oil pump takes the oil from the oil pan via the intake pipe or oil pickup pipe. The intake pipe is positioned such that the intake opening is below the oil level under all operating conditions. The intake pipe is fitted with an oil screen that keeps coarse dirt particles away from the oil pump. The intake pipe is a separate component and is bolted onto the oil pump.

As with the N47TU engine, the N57TU also combines the oil and vacuum pump which are also chain-driven by the crankshaft.

# N57TU Engine

## 4. Oil Supply



N57TU combination oil/vacuum pump

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

The oil pump plays a central role in the N57TU engine, as it does in all modern combustion engines. 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 N57TU engine uses the gear-type oil pump familiar from the N47TU engine.

The oil pump (OP) on the N57TU engine is driven by a chain running off the crankshaft (CS) with a gear ratio of  $I = 21:23$  (CS:OP); its theoretical delivery rate is 18.6 cm<sup>3</sup> per revolution of the oil pump. The delivery rate of the N47TU oil pump is 16 cm<sup>3</sup> per oil-pump revolution. The higher delivery rate

# N57TU Engine

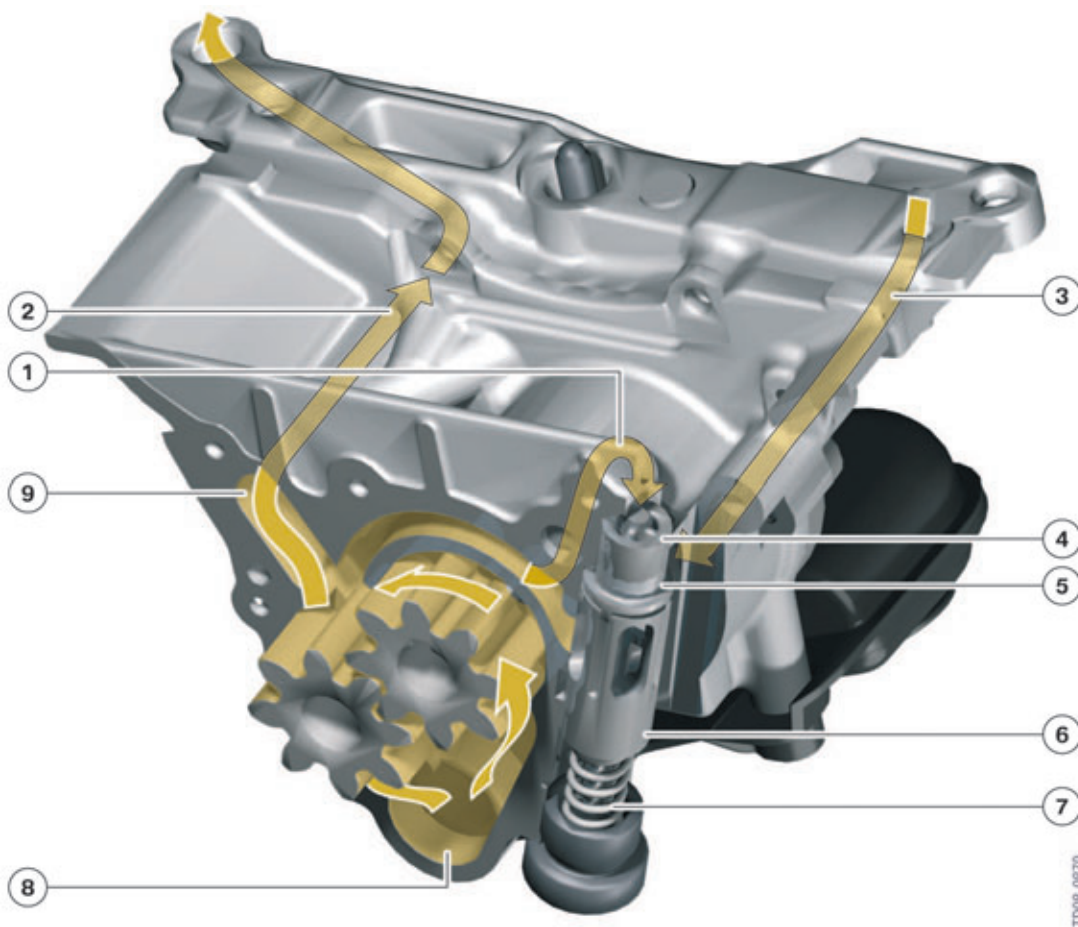
## 4. Oil Supply

compared to the N47TU engine has been achieved by a wider gear set and a different gear ratio. On the N57TU engine, the oil pump forms a single unit with the vacuum pump. Both pumps share the drive of the crankshaft, but they are separate in their function.

The reason for the unusual installation location of the vacuum pump 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 (See the Vacuum system section for more information)

### 4.2.1. 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.



N57TU oil pump with pressure relief valve

# N57TU Engine

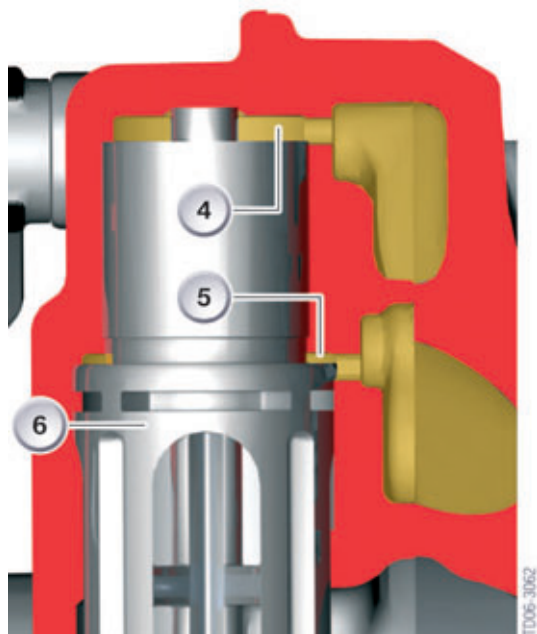
## 4. Oil Supply

Index	Explanation
1	Oil to upper control chamber
2	Unfiltered oil duct (to the oil filter)
3	Clean (filtered) oil duct (to the lower control chamber)
4	Upper control chamber
5	Lower control chamber
6	Control piston
7	Return spring
8	Intake side
9	Pressure side

The pressure limiting valve on the N57TU has a special feature. On previous diesel engines, oil acted on the pressure limiting valve downstream of the filter. 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 the pressure side (9). A duct carries oil (1) from the 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 located on one side by control piston (6), which is acted on by a return spring (7).



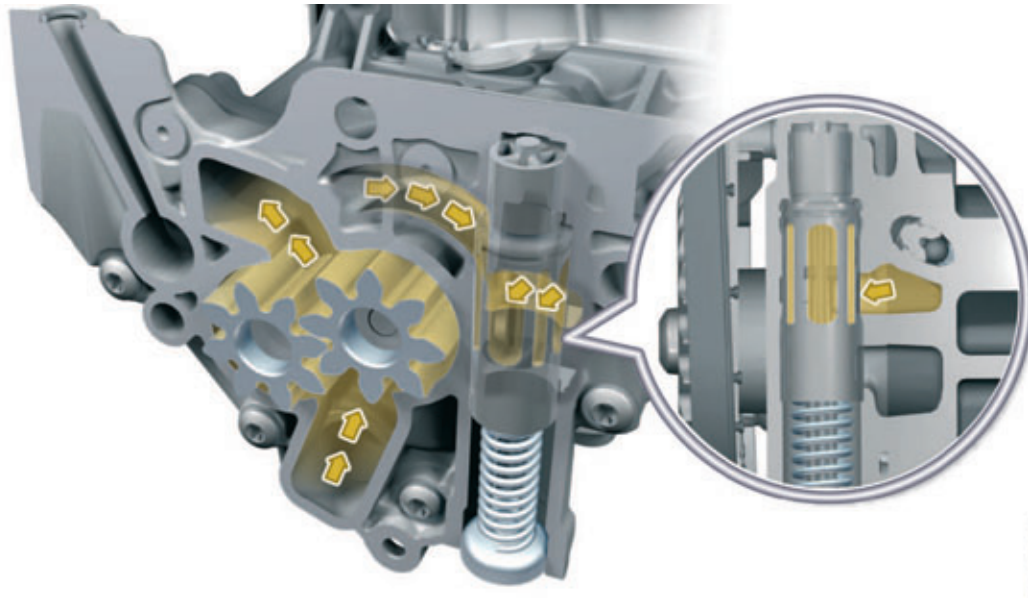
Control chambers in the pressure limiting valve of the N57TU

# N57TU Engine

## 4. Oil Supply

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

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

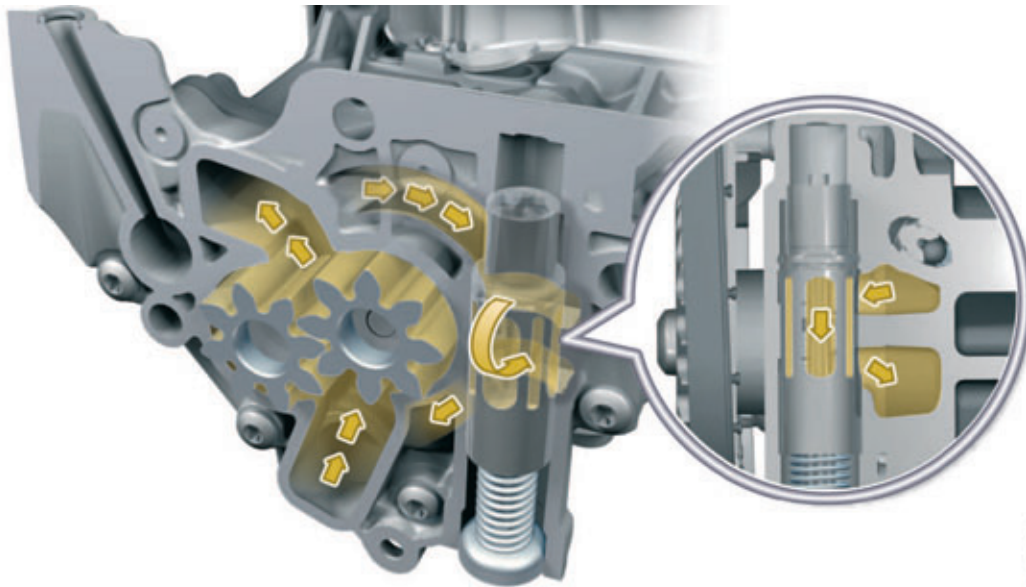


Pressure limiting valve closed

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.

# N57TU Engine

## 4. Oil Supply



Pressure limiting valve open

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.

The reason why oil acts on the control piston directly downstream of the pump and also downstream of the filter is 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 a lack of oil at 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 superimposed 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.

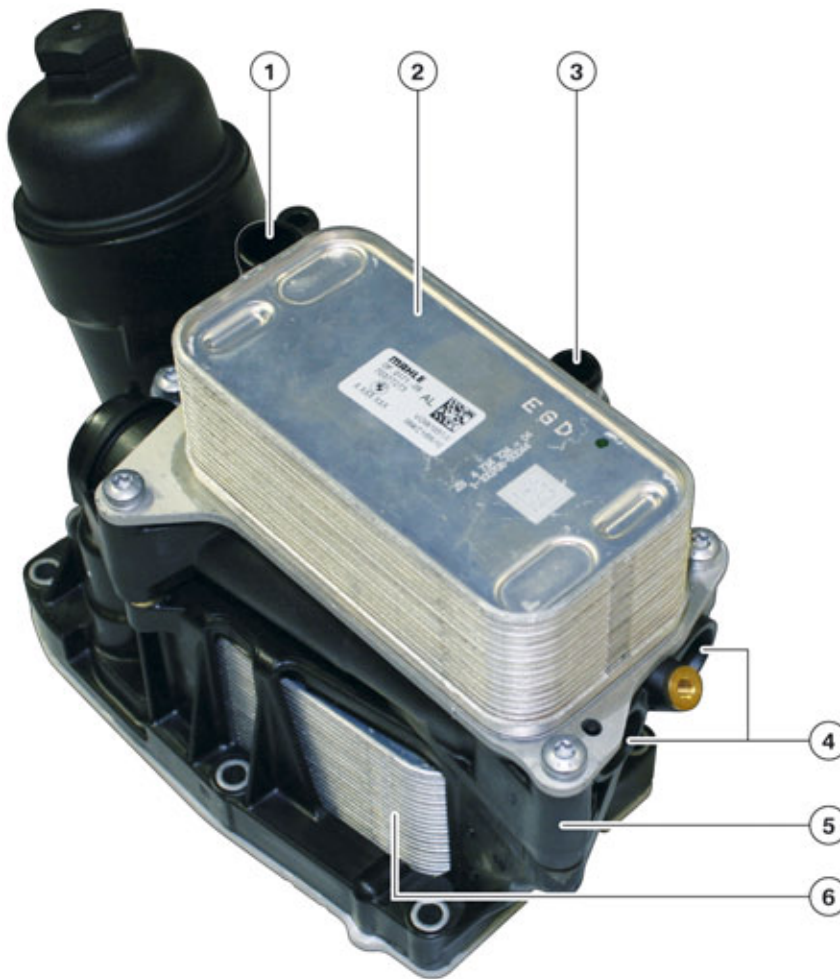


# N57TU Engine

## 4. Oil Supply

### 4.3. Oil filter module

The oil filter module of the N57TU can also be found in the N47TU engine. This is a further example of BMW using more and more common parts across vehicle platforms. The only discernible difference between this and versions installed in other engines is that the engine oil-to-coolant heat exchanger or transmission oil-to-coolant heat exchanger on the oil filter module varies. The housing with all valves, filter element, gaskets and retaining elements remains the same. In addition, the transmission oil-to-coolant heat exchanger has been integrated for the first time.

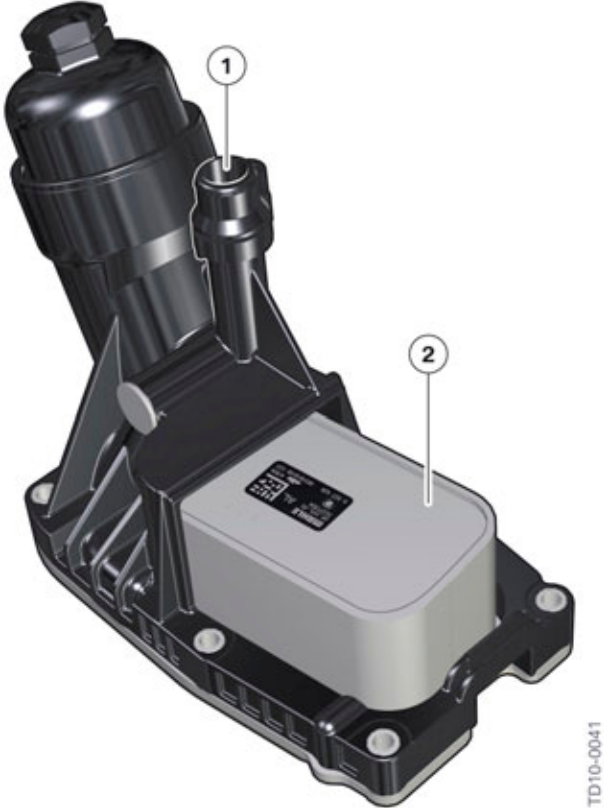


N57TU engine, oil filter module with automatic transmission (featuring transmission oil-to-coolant heat exchanger)

Index	Explanation
1	Connecting branch for heater return
2	Transmission oil-to-coolant heat exchanger
3	Coolant connection from radiator
4	Connection for transmission oil lines
5	Oil filter module housing
6	Engine oil-to-coolant heat exchanger

# N57TU Engine

## 4. Oil Supply



N57TU engine, oil filter module with manual gearbox

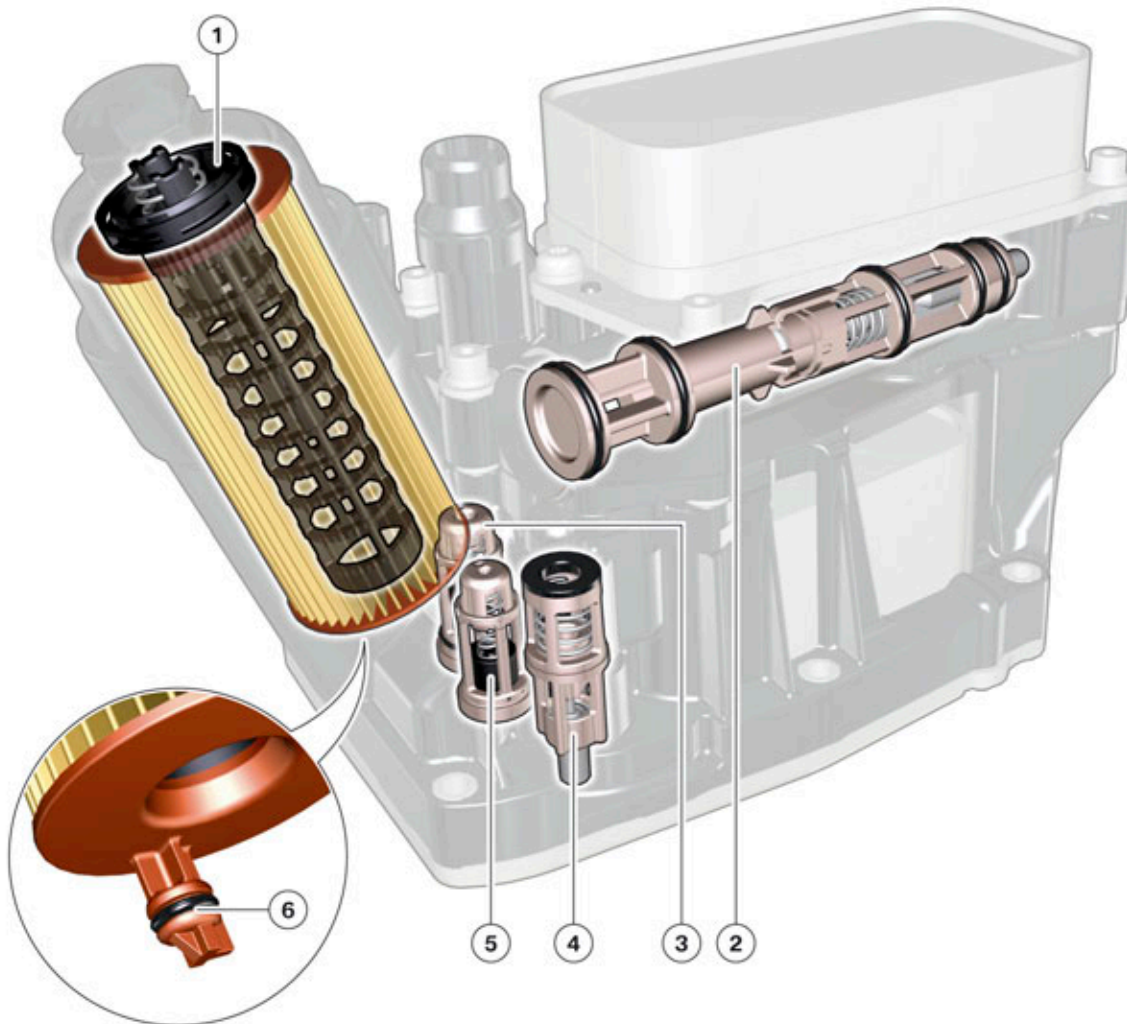
Index	Explanation
1	Connecting branch for heater return
2	Engine oil-to-coolant heat exchanger

# N57TU Engine

## 4. Oil Supply

### 4.3.1. Transmission oil cooling

A transmission oil cooling system is used in vehicles with automatic transmission. Extensive changes have been made to the transmission oil cooling, these are described in more detail below.



TD10-0042

N57 engine, valves and thermostats

Index	Explanation
1	Filter bypass valve
2	Thermostat for transmission oil cooling
3	Non-return valve
4	Auxiliary heating thermostat for transmission oil
5	Heat exchanger bypass valve
6	Discharge valve

# N57TU Engine

## 4. Oil Supply

### Filter bypass valve

When a filter is blocked, the filter bypass valve ensures that engine oil reaches the lubrication points of the engine. It opens when the differential pressure upstream and downstream of the oil filter is  $2.5 \text{ bar} \pm 0.3 \text{ bar}$ .

### Thermostat for transmission oil

A thermostat that controls the transmission oil temperature is also integrated in the oil filter module. Transmission oil flows round the transmission oil thermostat. If the temperature of the transmission oil rises to  $\geq 88 \text{ }^\circ\text{C}$  ( $190 \text{ }^\circ\text{F}$ ), the transmission oil thermostat opens to allow coolant to pass from the low-temperature cooler of the cooling system to the transmission oil-to-coolant heat exchanger. At the same time, the transmission oil thermostat blocks the cooling circuit that runs from the cylinder crankcase via the auxiliary heating thermostat for transmission oil. The transmission oil is now cooled.

### Non-return valve

The non-return valve ensures that the engine oil ducts and oil filter housing do not run empty when the engine is at a standstill. It opens the inlet of the oil pump when the pressure exceeds  $0.1 \text{ bar} \pm 0.03 \text{ bar}$ .

### Auxiliary heating thermostat for transmission oil

An important new feature is the auxiliary heating thermostat which is integrated into the oil filter housing and ensures that the transmission oil heats up more rapidly. When the engine coolant temperature is  $< 80 \text{ }^\circ\text{C}$  the transmission oil auxiliary heating thermostat is closed. Coolant does not flow through the transmission oil-to-coolant heat exchanger.

When the engine coolant temperature reaches  $\geq 80 \text{ }^\circ\text{C}$ , the transmission oil auxiliary thermostat opens and allows coolant to flow from the engine via the transmission oil thermostat thus allowing the warm coolant to heat up the transmission oil.

Advantages for the transmission:

- Heated with excess engine heat
- Warms up more quickly
- Lower friction loss
- Higher degree of shifting comfort is available much more quickly

### Heat exchanger bypass valve

The heat exchanger bypass valve has the same function as the filter bypass valve. If the oil pressure increases as a result of a blocked oil-to-water heat exchanger, the heat exchanger bypass valve opens at a pressure of  $2.5 \pm 0.3 \text{ bar}$  thus allowing un-cooled oil to reach the lubricating points.

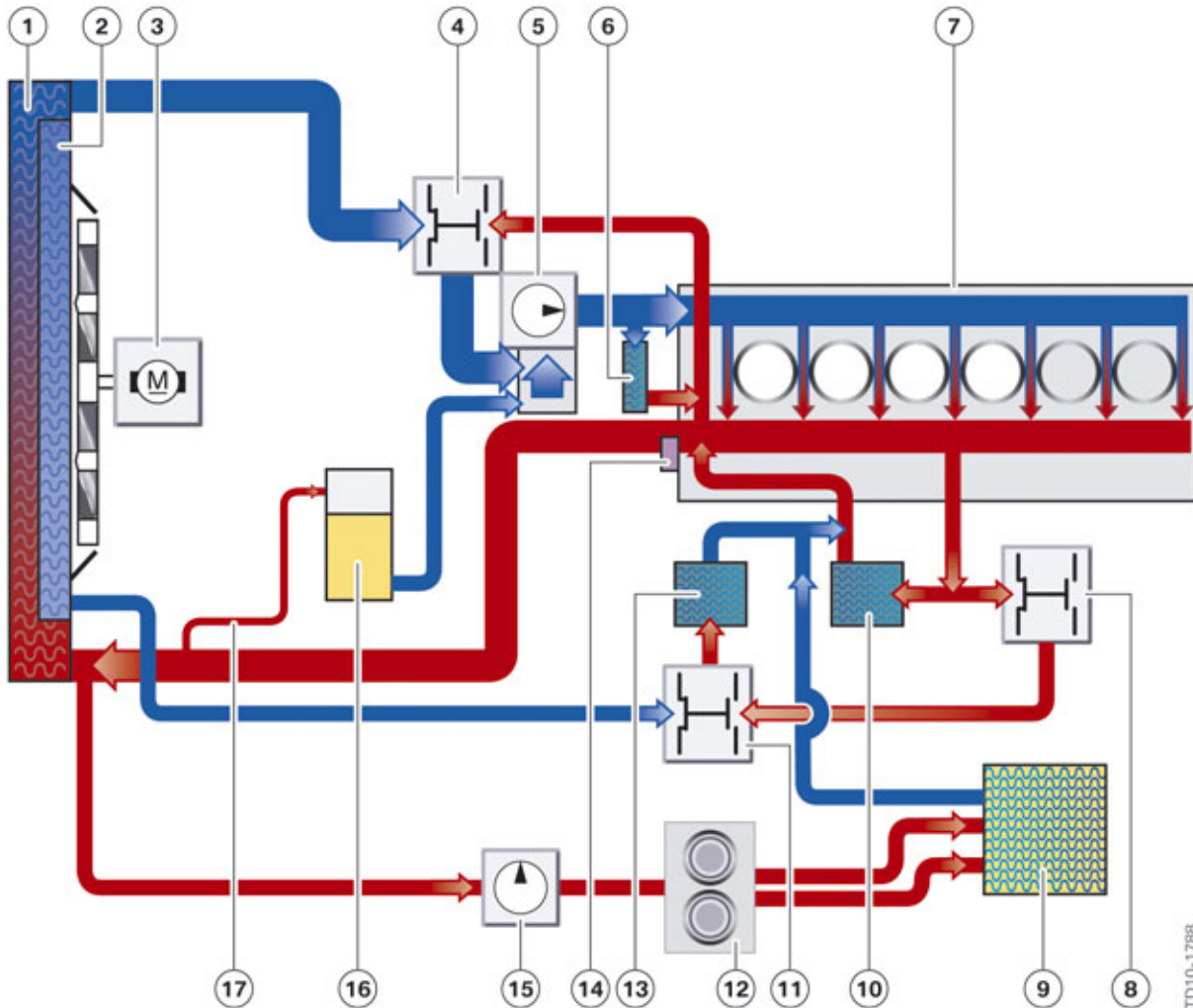
### Discharge valve

The discharge valve is integrated on the oil filter and is thus changed when the oil filter is replaced.

# N57TU Engine

## 4. Oil Supply

### Function of cooling circuit



N57TU engine, cooling circuit

Index	Explanation
1	Radiator
2	Radiator, low temperature range
3	Electric fan
4	Thermostat
5	Coolant pump
6	Exhaust-gas recirculation cooler
7	Engine housing
8	Auxiliary heating thermostat for transmission oil
9	Heat exchanger
10	Engine oil-to-coolant heat exchanger

# N57TU Engine

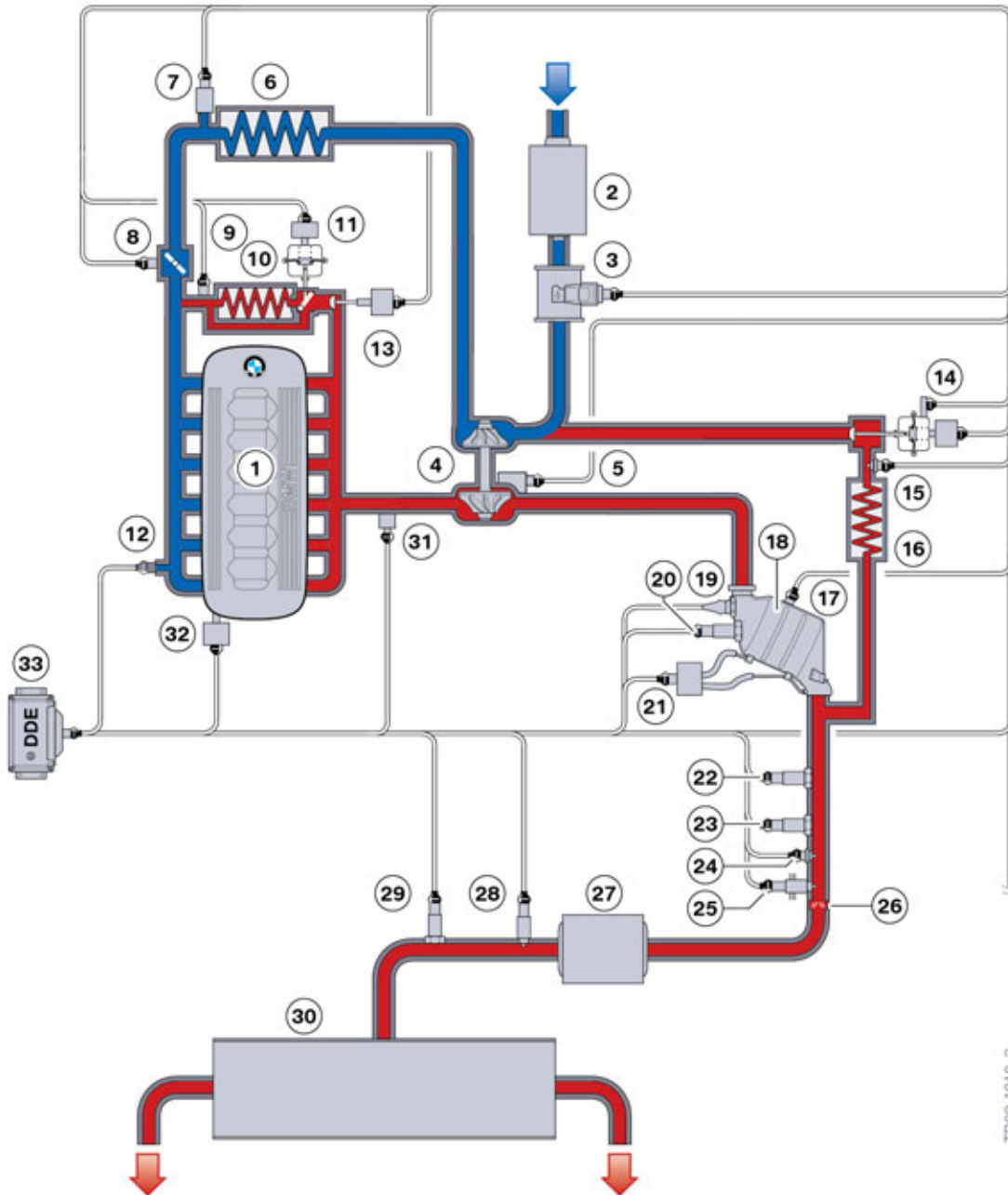
## 4. Oil Supply

<b>Index</b>	<b>Explanation</b>
11	Thermostat for transmission oil
12	Coolant valve
13	Transmission oil-to-coolant heat exchanger
14	Coolant temperature sensor
15	Auxiliary water pump
16	Expansion tank
17	Tank ventilation line

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

In terms of their basic design, the intake air, exhaust and emission systems are very similar to the previous diesel engine. The N57TU system corresponds to the second generation diesel engine emission controls which is also used with the N47TU. There are however some differences, especially with regard to the Low pressure EGR system (not installed on the 4 cylinder).



N57TU engine, intake air and exhaust emission system with ULEV II (F10, F15)

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

Index	Explanation
1	N57TU engine
2	Intake silencer
3	Hot film air mass meter
4	Turbocharger (VNT)
5	Boost pressure (VNT) actuator
6	Charge air cooler
7	Charge-air temperature sensor
8	Throttle valve
9	Exhaust-gas recirculation temperature sensor
10	Exhaust-gas recirculation cooler
11	Bypass flap
12	Boost pressure sensor
13	Exhaust-gas recirculation valve with position sensor
14	Bypass flap (Low pressure EGR)
15	Exhaust-gas recirculation temperature sensor (Low pressure EGR)
16	Exhaust-gas recirculation cooler (Low pressure EGR)
17	Exhaust-gas temperature sensor downstream of NO <sub>x</sub> storage catalyst
18	NO <sub>x</sub> storage catalyst and diesel particulate filter
19	Exhaust-gas temperature sensor upstream of NO <sub>x</sub> storage catalyst
20	Oxygen sensor upstream of NO <sub>x</sub> storage catalyst
21	Exhaust gas differential pressure sensor, NO <sub>x</sub> storage catalyst and diesel particulate filter
22	Oxygen sensor downstream of diesel particulate filter
23	NO <sub>x</sub> sensor upstream of the SCR catalytic converter
24	Exhaust-gas temperature sensor upstream of the SCR catalyst
25	Metering module
26	Mixer (SCR)
27	SCR catalytic converter
28	Particulate matter sensor
29	NO <sub>x</sub> sensor downstream of the SCR catalytic converter
30	Rear silencer
31	Exhaust back-pressure sensor upstream of exhaust turbocharger
32	Swirl-flap actuator
33	Digital Diesel Electronics



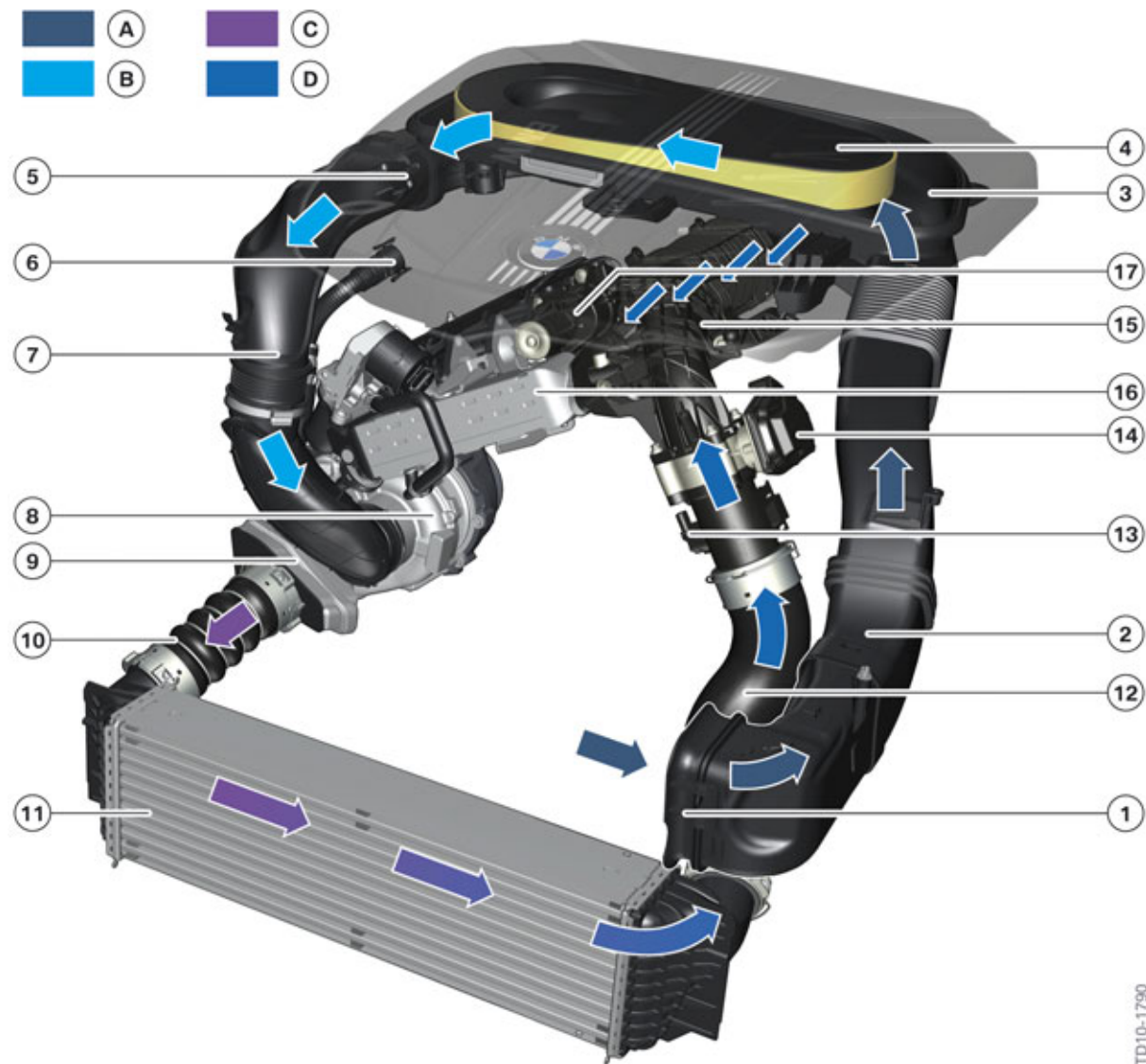
# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

### 5.1. Intake air system

The most obvious changes are those that have been made to the intake air system. The throttle valve is now located at the front on the engine. The intake air system has been modified, which means it has also been possible to reduce the line length as the charge air from the charge air cooler is now introduced into the differentiated air intake system (4) at the front of the engine directly via the throttle valve (2) and mixing tube (3).

A resonator is installed at the output of the exhaust turbocharger in the section that leads to the charge air cooler. The resonator optimizes exhaust-gas turbocharger noise.



N57TU engine, intake-air system

TD10-1790

# N57TU Engine

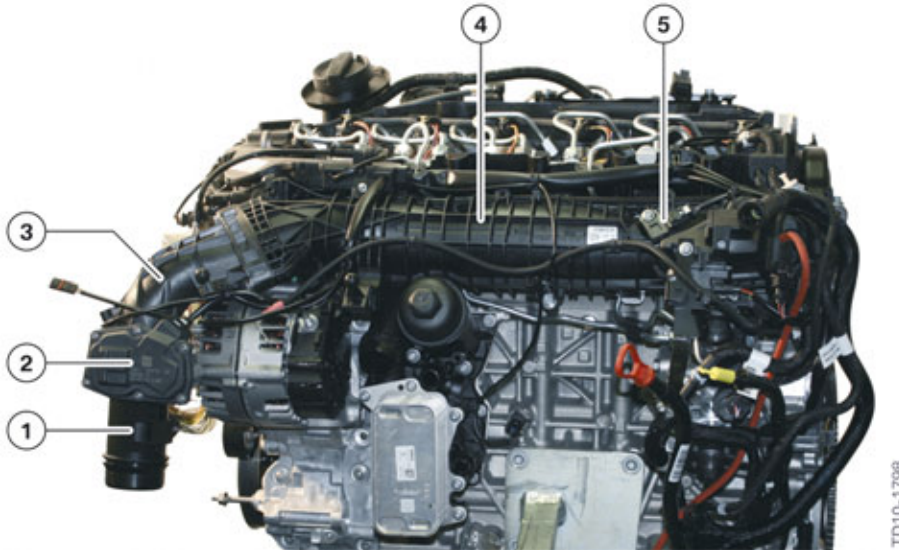
## 5. Intake Air, Exhaust and Emission Sys.

<b>Index</b>	<b>Explanation</b>
A	Fresh air
B	Purified air
C	Heated charge air
D	Cooled charge air
1	Coarse filter
2	Unfiltered air pipe
3	Intake silencer, unfiltered air section
4	Filter element
5	Hot film air mass meter
6	Connection for blow-by gases
7	Clean air pipe
8	Exhaust turbocharger
9	Silencer
10	Charge air pipe
11	Charge air cooler
12	Charge air pipe
13	Charge-air temperature sensor
14	Throttle valve
15	Intake manifold
16	Exhaust-gas recirculation cooler
17	Swirl-flap actuator

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

### 5.1.1. Intake manifold



N57TU engine, differentiated air intake system

Index	Explanation
1	Charge air pipe
2	Throttle valve
3	Mixing tube
4	Intake manifold
5	Charging pressure sensor

The differentiated air intake system has been redeveloped in order to meet the requirements brought about by the changes to the charge air routing. The exhaust-gas recirculation cooler is now therefore connected directly to the differentiated air intake system. With the N57 engine, the exhaust-gas is still recirculated via the cylinder head into the differentiated air intake system.

The swirl flaps have also been modified. Up till now, the swirl flaps were integrated in the differentiated air intake system. If the swirl flaps or the swirl flap mechanism developed a fault or were damaged, it was necessary to replace the entire differentiated air intake system.

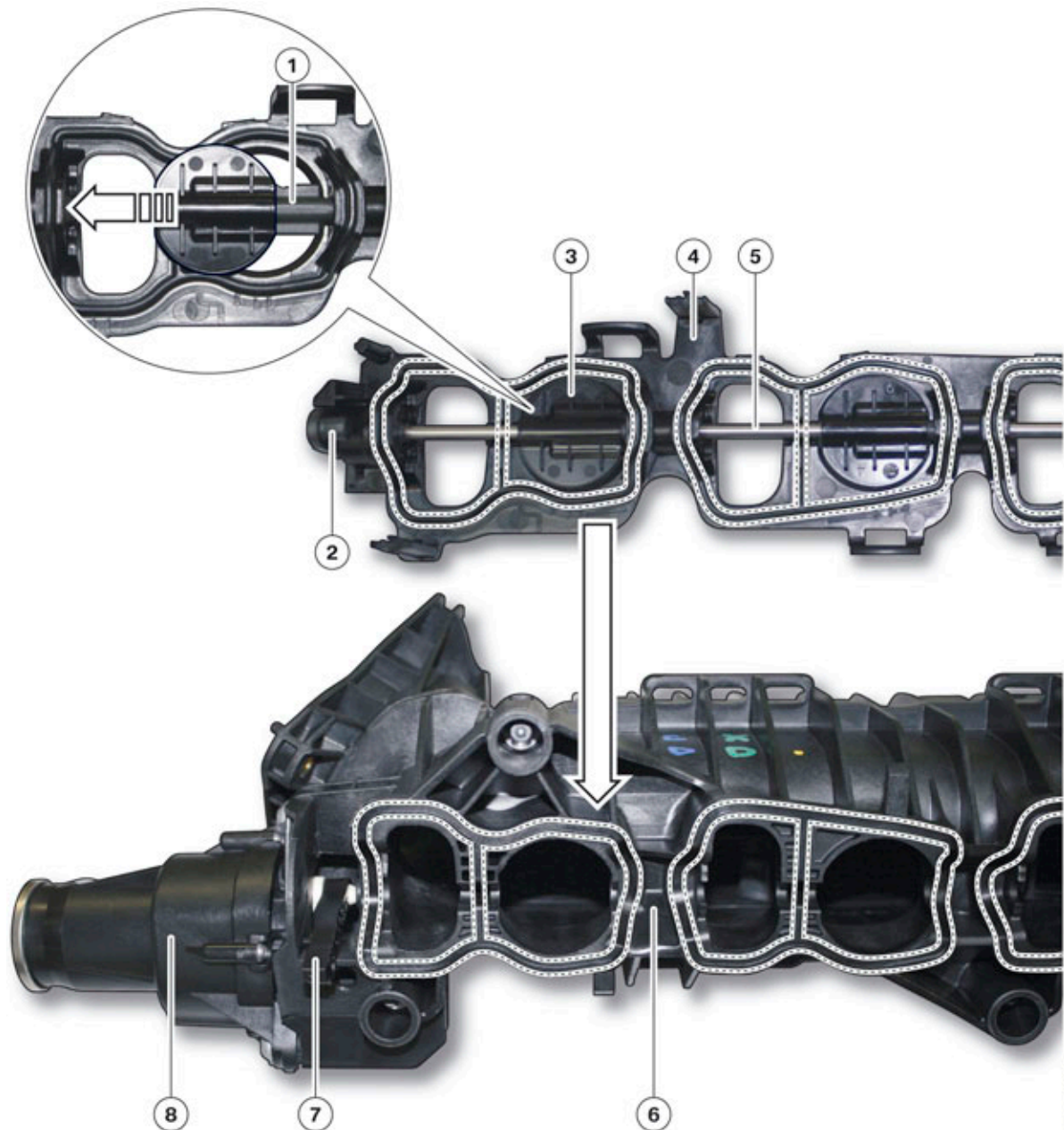
The swirl flaps are now integrated in the gasket between the differentiated air intake system and the cylinder head. The gasket has a three-dimensional construction and is clipped onto the differentiated air intake system.



**When mounting the gasket, the swirl flaps must be in the correct position as they will otherwise be damaged when the differentiated air intake system is installed on the cylinder head.**

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.



N57TU engine, differentiated air intake system with gasket

Index	Explanation
1	Flap support (can be made visible by moving the loose swirl flap)
2	Lever
3	Swirl flap
4	Gasket support

TD10-0006

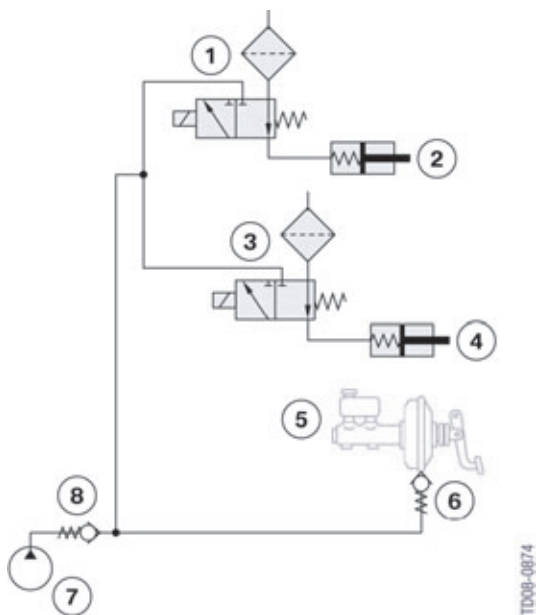
# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

Index	Explanation
5	Shaft
6	Intake manifold
7	Connecting lever
8	Swirl-flap actuator

### 5.2. Vacuum system

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



N57TU vacuum system diagram

Index	Explanation
1	Electro-pneumatic changeover valve (EUV)
2	Motor mount vacuum unit
3	Electro-pneumatic changeover valve (EUV)
4	EGR bypass valve vacuum unit
5	Brake booster
6	Non-return valve
7	Vacuum pump
8	Non-return valve

A vacuum pump creates the vacuum for use by the engine systems. The negative pressure is connected to the vacuum canister of each control components. The vacuum canister converts the negative pressure into motion. Electro-pneumatic changeover valves (EUV) are used to connect the

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

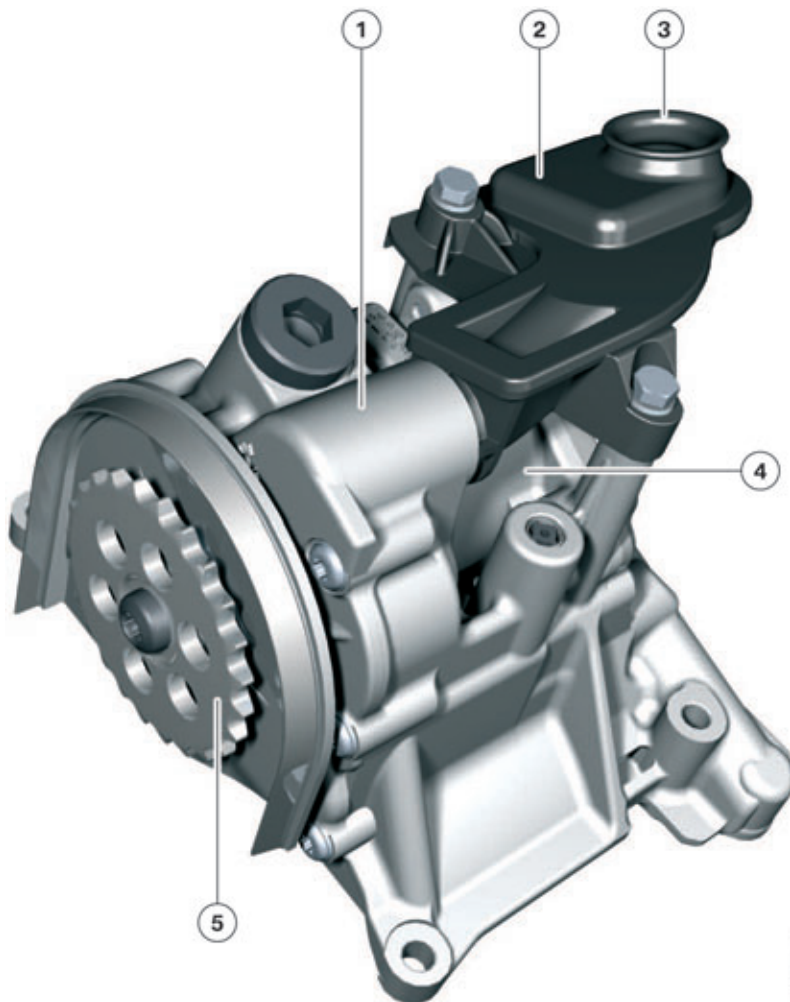
vacuum to the vacuum canister to operate the components which are ultimately controlled electrically via the DDE. A non-return valve prevents the vacuum from being lost through the vacuum pump when the engine is switched off.

### 5.2.1. Vacuum pump

The vacuum pump on the N57TU 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.



N57TU oil/vacuum pump

TD08-0726

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

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

### 5.2.2. Electro-pneumatic changeover valve (EUV)



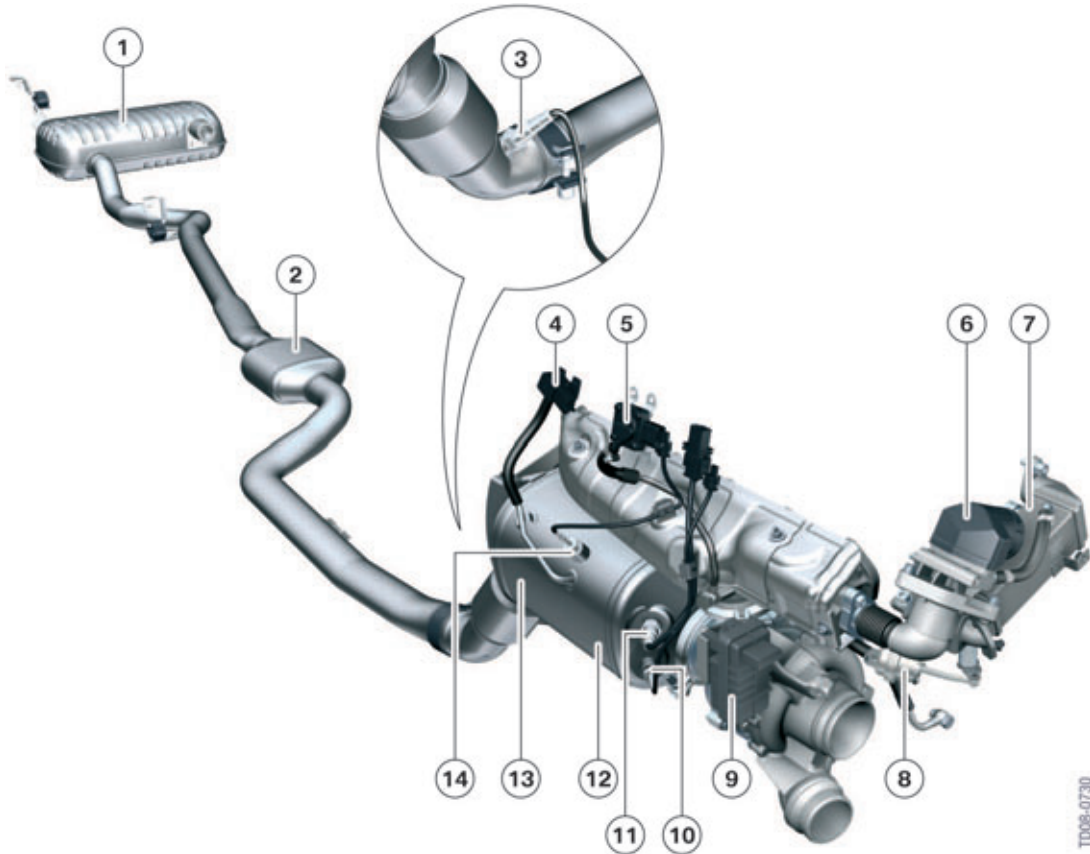
Electro-pneumatic changeover valve (EUV)

The electro-pneumatic changeover valve (EUV) 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 N57TU engine, the EGR cooler bypass valve and the controllable engine mounts are switched by an electro-pneumatic changeover valve.

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

### 5.3. Exhaust emission system



N57 EURO 6 exhaust after-treatment components shown (not for U.S.)

Index	Explanation
1	Rear silencer
2	SCR catalyst (Not all SCR shown here)
3	Oxygen sensor downstream of the diesel particulate filter
4	Exhaust back-pressure sensor downstream of the NOx storage catalytic converter
5	Exhaust back-pressure sensor upstream of the turbocharger
6	EGR valve
7	EGR cooler
8	EGR cooler bypass valve vacuum unit
9	Boost pressure control valve
10	Exhaust temperature sensor upstream of the NOx storage catalytic converter



# N57TU Engine

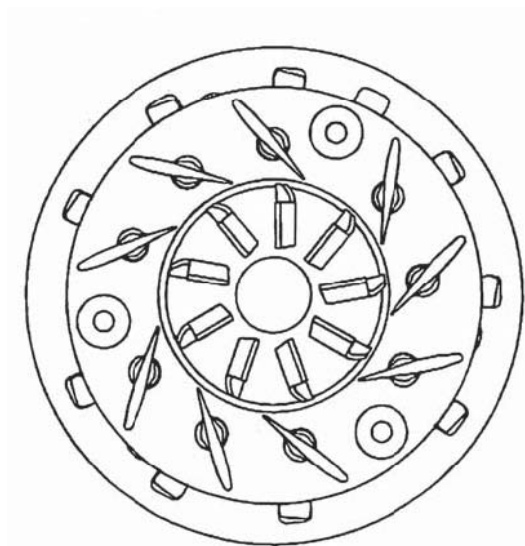
## 5. Intake Air, Exhaust and Emission Sys.

Index	Explanation
11	Oxygen sensor upstream of the NOx storage catalytic converter
12	NOx storage catalytic converter
13	Diesel particulate filter
14	Exhaust temperature sensor downstream of the NOx storage catalytic converter

The N57 engine exhaust illustration shown above is NOT for the US market and only used as an example.

### 5.3.1. Exhaust turbocharger (VNT)

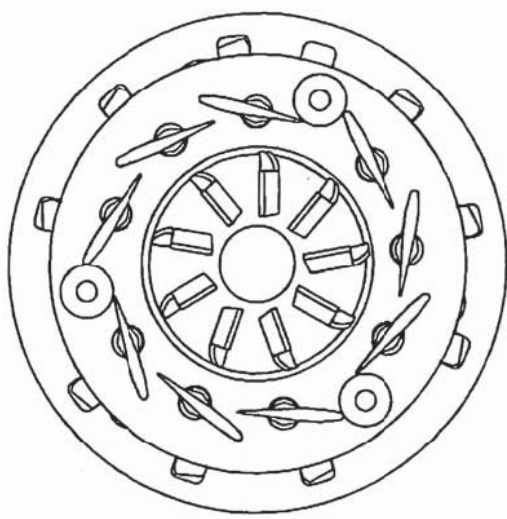
The variable geometry exhaust turbocharger of the N57TU is referred to as a Variable Nozzle Turbine (VNT) and is also installed in the N47TU engine. Variable nozzle turbine makes it possible to alter the gas flow that drives the turbine wheel in relation to the engine operating point by varying the cross-flow section in the turbine wheel inlet housing using variable guide vanes.



VNT vanes open

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.



VNT vanes closed

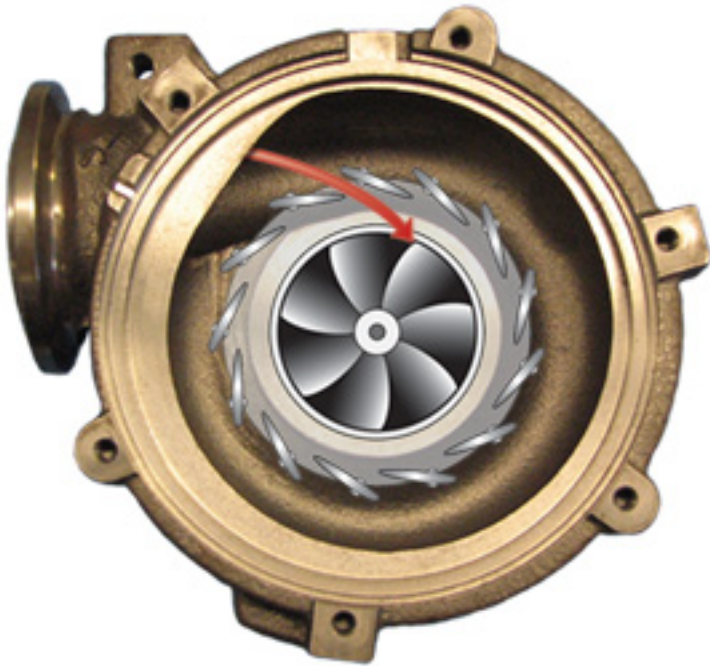
The variable nozzle vanes (located inside the turbine housing) are arranged completely around the turbine wheel. These VNT actuator vanes move in unison to vary the cross-flow section (see graphic on the next page) directing the exhaust gas flow and angle of attack to turn the turbine wheel. As the flow rate of the exhaust gas and the exhaust gas pressure acting on the turbine wheel increases, the transfer of energy to the turbine wheel and compressor is therefore increased, enhancing efficiency particularly at low engine speeds.

These vanes are adjusted by the (electrically controlled) boost pressure regulator (VNT actuator). As the turbine speed and boost pressure are directly dependent on the position of the actuator vanes and this is regulated by the DDE via the boost pressure regulator (VNT actuator) there is no need for a wastegate valve.

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

When the VNT vanes are in the “**closed**” position (see graphic below) the transfer of energy to the turbine wheel and compressor is increased due to an increase in exhaust gas pressure and an optimum angle of attack. This results in maximum turbine speed and boost pressure (especially at low engine speeds). This increase in boost pressure allows for a higher injection rate to be authorized by the DDE.



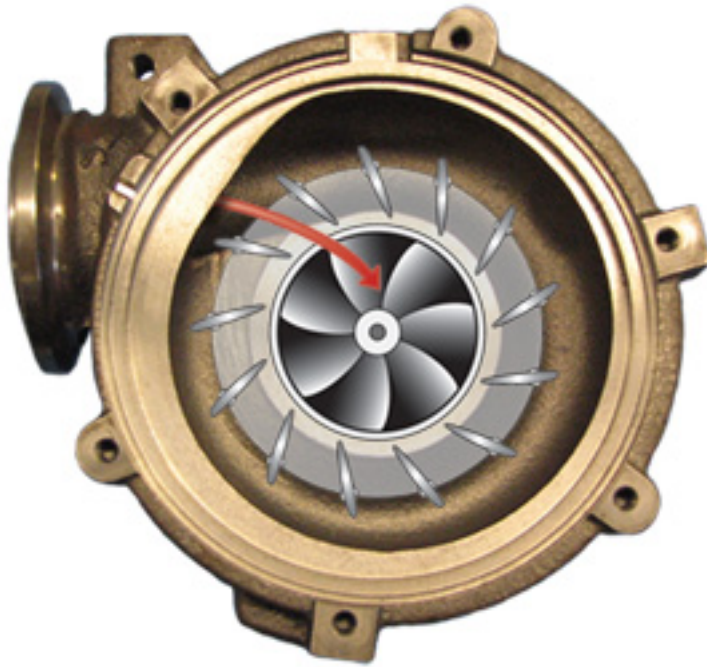
VNT vane mechanism “closed”

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

When the VNT vanes are in the **“open”** position (see graphic below) the transfer of energy to the turbine wheel and compressor is decreased as the flow rate and exhaust gas pressure driving the turbine decreases. This is due to a reduction in exhaust gas pressure and a less than optimum angle of attack which results in a decrease in turbine speed and boost pressure.

Therefore as the engine speed increases, the vanes are gradually opened so that the energy transfer always remains in equilibrium at the desired boost-pressure depending on engine speed and load requirements.



VNT vane mechanism “open”

The boost-pressure regulator (VNT actuator) is controlled by the DDE by means of a pulse-width modulated signal.

A control rod turns the adjustment ring, which in turn moves the VNT actuator vanes.

The VNT provides an additional degree of freedom in the optimization of thermodynamic behavior by comparison with a conventional exhaust turbocharger (which has a permanently constant cross-flow section) with the additional benefit that the VNT turbocharger does not need a wastegate valve.

The control of the boost-pressure regulator is described in more detail in the “Engine electrical system” section of this training material.

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

Advantages of VNT system:

- High torque at both high and low engine speeds.
- Continuous and optimum adjustment for all engine speeds.
- No "wastegate valve" required, the exhaust energy is better utilized, less back-pressure in conjunction with the same compressor work.
- Low thermal and mechanical load facilitates improved optimization of engine power output.
- Low emission values also at very low engine speeds.
- Optimized fuel consumption over the entire engine speed spectrum.

### Boost pressure control



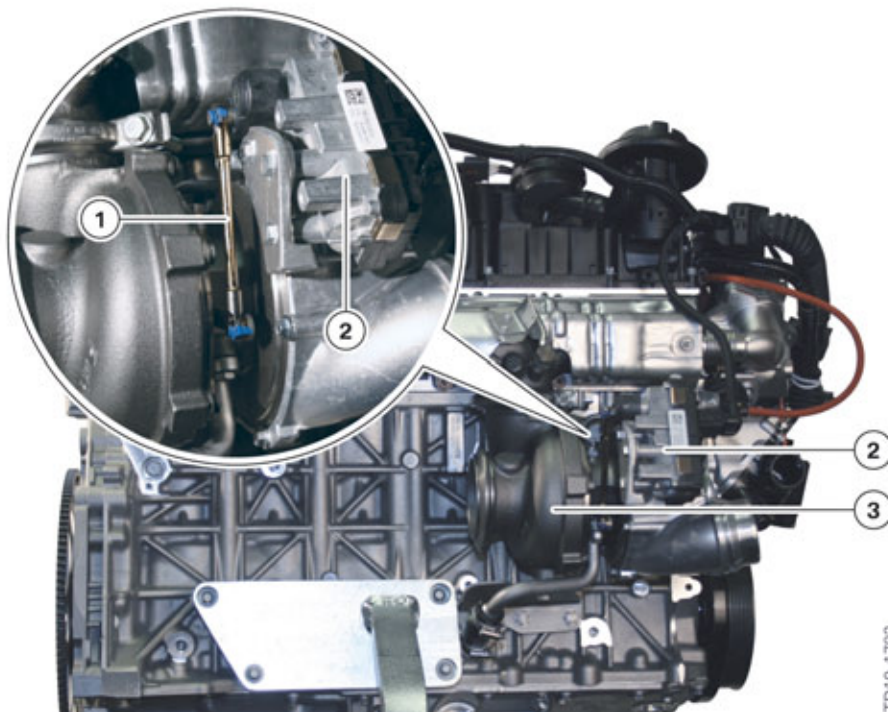
N57TU engine, VNT actuator control

The variable nozzle vanes of the (VNT) are adjusted electrically via the boost pressure regulator also referred to as VNT actuator. This achieves a more accurate regulation of the boost pressure in comparison with vacuum regulated systems. The VNT boost pressure regulator controls the boost pressure up to 2.2 bar absolute pressure (N57). The servomotor is controlled by the DDE via 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 ground for 0.5 to 2 seconds (depending on the fault message). From this, the DDE detects a fault with the electrical vane adjustment.

The control rod is not designed to be adjustable. The control rod is installed on the shaft of the adjustment lever for the VNT vanes and the VNT actuator.

# N57TU Engine

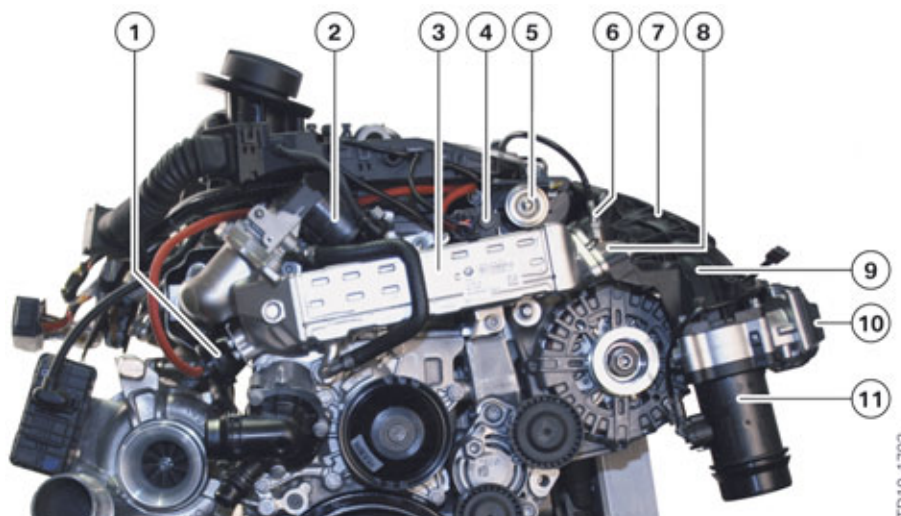
## 5. Intake Air, Exhaust and Emission Sys.



N57TU engine, VNT actuator control mechanism

Index	Explanation
1	Control rod
2	Variable nozzle turbine (VNT) actuator
3	Exhaust turbocharger

### 5.3.2. Exhaust-gas recirculation



N57TU engine, exhaust-gas recirculation

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

Index	Explanation
1	Bypass flap
2	Coolant cooled exhaust-gas recirculation valve
3	Exhaust-gas recirculation cooler with integrated bypass
4	Electro-pneumatic changeover valve for bypass flap
5	Swirl-flap actuator
6	Exhaust-gas recirculation temperature sensor
7	Intake manifold
8	Exhaust-gas recirculation pipe
9	Mixing tube
10	Throttle valve
11	Charge air pipe

The exhaust-gas recirculation has been optimized and its geometry has been modified so that the exhaust gases are introduced into the differentiated air intake system either cooled or un-cooled (depending on operating temperature). The exhaust gases are introduced into the differentiated air intake system via an exhaust-gas recirculation pipe that projects into the mixing tube at the end of which a plate is fitted to prevent hot exhaust gases from damaging the mixing tube.

As with the previous 6 cylinder US market engine (M57D30T2) the N57TU also uses a Low pressure EGR system especially in combination with heavier vehicles as X5 models. Please refer to the “Diesel Technology” training material available on TIS and ICP for more information.



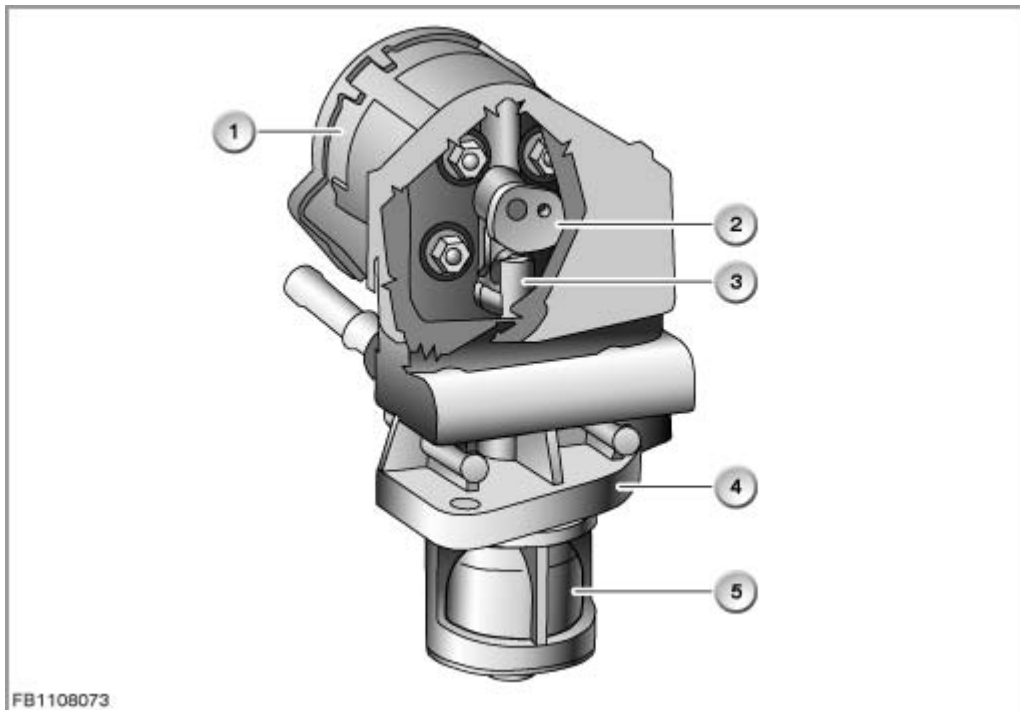
**For further information regarding the N57TU Exhaust gas recirculation (EGR) system functions refer to the ST1210 “ Diesel Technology” training material available on TIS and ICP.**

### 5.3.3. EGR valve/actuator

The exhaust-gas recirculation valve actuator is opened or closed electrically by the DDE control unit. To ensure optimized control of the exhaust-gas recirculation rate, the exact position must be continuously detected. The position of the exhaust-gas recirculation actuator is monitored by a non-contact hall effect sensor. The servomotor for the exhaust-gas recirculation actuator is a direct current motor. The position sensor is a hall effect sensor. The hall effect sensor determines the revolutions of the servomotor. This is used to calculate the position of the exhaust-gas recirculation actuator.

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.



FB1108073

Electronic EGR valve/actuator

Index	Explanation
1	Exhaust gas recirculation actuator
2	Cam disc
3	Bucket tappet
4	Housing
5	Valve seat



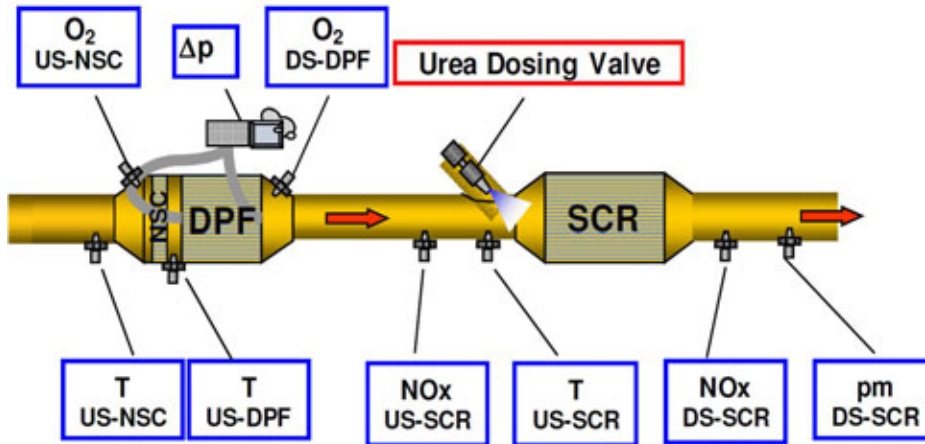
For further information regarding the N57TU Exhaust gas recirculation (EGR) system refer to the “Engine Control Functions” section of this training material.



# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

### 5.3.4. Exhaust after-treatment



N57TU exhaust after-treatment components for the US market.

Index	Explanation
T US-NSC	Temperature sensor up stream of the NOx Storage Catalyst
O <sub>2</sub> US-NSC	O <sub>2</sub> sensor up stream of the NOx Storage Catalyst
NSC	NOx Storage Catalyst
Δp	Differential pressure sensor
T US-DPF	Temperature sensor up stream of the Diesel Particulate Filter
O <sub>2</sub> DS-DPF	O <sub>2</sub> sensor down stream of the Diesel Particulate Filter
NOx US-SCR	NOx sensor up stream of the Selective Catalytic Reduction
UDV	Urea Dosing Valve
T US-SCR	Temperature sensor up stream of the Selective Catalytic Reduction
SCR	Selective Catalytic Reduction
NOx DS-SCR	NOx sensor down stream of the Selective Catalytic Reduction
pm DS-SCR	Particulate matter sensor down stream of the Selective Catalytic Reduction



**The exhaust after-treatment systems and components of the N47TU and the N57TU have been especially design to comply with current (ULEV II) US market emission regulations and thus are different from those used with the previous US diesel (M57D30T2) engine.**

A more powerful system for exhaust gas treatment is required to meet increasingly stringent emissions regulations in spite of lower exhaust temperatures with high efficiency diesel engines.

Where the pervious system used an oxidation catalyst there is now a NOx Storage Catalyst (NSC) installed. The NSC is a NOx adsorption (storage) catalyst which incorporates the precious metals Platinum, Palladium and Rhodium and is installed in the same housing as the Diesel Particulate Filter (DPF).

# N57TU Engine

## 5. Intake Air, Exhaust and Emission Sys.

There is also now an additional O<sub>2</sub> sensor (downstream of the DPF). It is used to monitor the function of the NSC and to determine whether it needs to be regenerated.

In addition, for the first time there is also a particulate matter sensor (located down stream of the SCR) to monitor the actual particulate matter (soot) that escapes the system at all times. This sensor is used to determine and manage the efficiency of the diesel particulate filter (DPF) in order to maintain the soot emission levels well below the mandated guidelines.

The combination of a NO<sub>x</sub> Storage Catalyst (NSC) and SCR catalyst has significant advantages for the exhaust gas after-treatment due to the efficiency of the NSC especially under lean conditions.

The new system also incorporates the second generation SCR system (SCR 2). The system now uses a dosing control unit (DCU) to monitor and deliver the AdBlue fluid into the SCR system and several redesigned components.



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**See the “Sensors and actuators” section of this training material and the ST1210 “Diesel Technology” training material available on TIS and ICP for more information regarding the new generation exhaust after treatment system.**

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# N57TU Engine

## 6. Fuel Preparation

The fuel preparation system is the system which provides and meters the correct amount of fuel for combustion.

Although the fuel preparation has been modified when compared to the M57 (US engine). It is very similar to that used on the N47TU engine with the main difference being the larger 2 piston CP4.2 high pressure pump used.

The main functions of the fuel preparation system are:

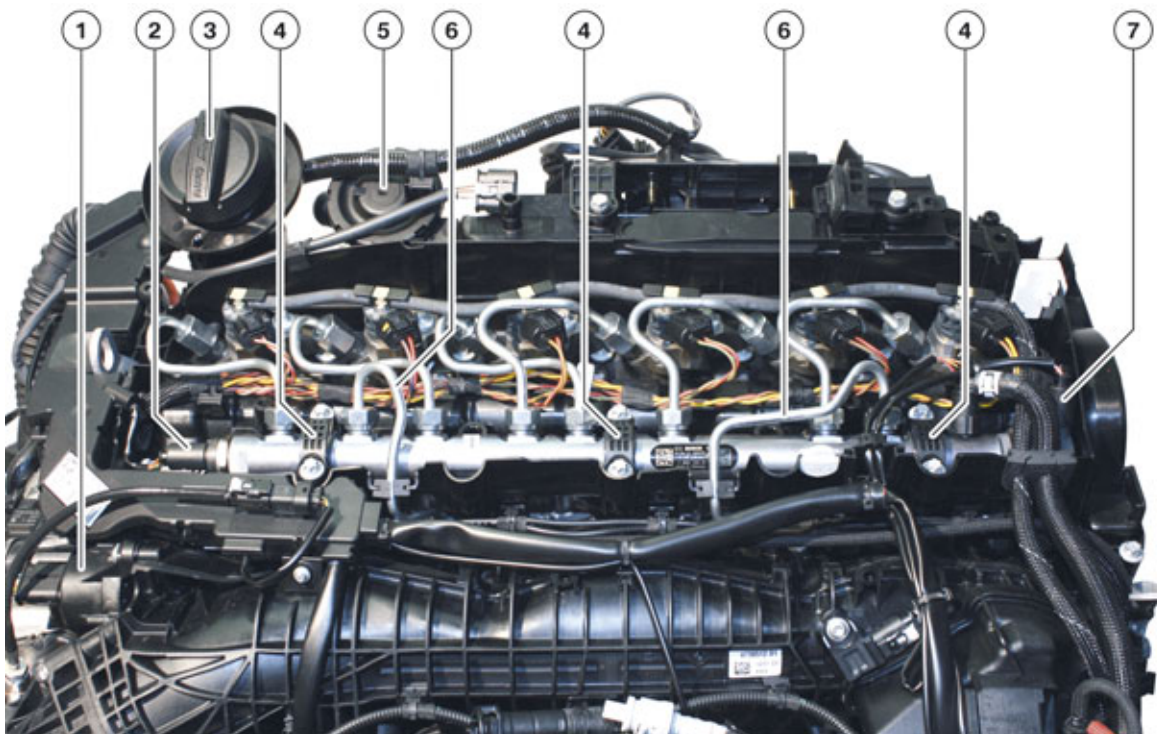
- Providing the required pressure
- Injecting the required fuel quantity (fuel quantity control)
- Setting the required start of injection (injection start control).

In order to comply with the more stringent emission limits for diesel engines, modern injection systems inject with ever higher pressures and with ever greater precision. The common rail system satisfies these requirements to optimum effect. In the common rail system the fuel is stored in the rail under high pressure and is injected via injectors on a map-controlled basis into the combustion chambers.

The fuel preparation system is comprised of the fuel rail and the following main components:

- High pressure pump (CP 4.2)
- Leakage oil line
- Injectors

These features correspond to the features of the N47TU engine.



TD10-1794

N57TU engine, top view

# N57TU Engine

## 6. Fuel Preparation

Index	Explanation
1	Swirl-flap actuator
2	Rail pressure sensor
3	Standard oil filler cap
4	Holder, high-pressure accumulator (rail)
5	Crank case vent valve
6	High pressure line between high pressure pump and rail
7	Rail pressure regulating valve

The injection system primarily comprises:

- **Low-pressure area:** The low-pressure area is divided into the fuel feed and the fuel return.
- **High-pressure area:** The high-pressure area contains the high-pressure pump, the high pressure lines, the rail and the injectors.
- **Electronic control:** The electronic control comprises the sensors and actuators such as the fuel filter heating, the fuel pressure/temperature sensor, the rail pressure sensor, the fuel quantity control valve and the injectors.

### 6.1. High pressure pump

The function of the high-pressure pump is to bring the fuel from the fuel supply to the required pressure level in line with the current demand. This must be performed in all operating ranges and over the entire service life. The high-pressure pump permanently generates the system pressure for the rail (high-pressure accumulator). It is based on the design and operation of the CP4.1 single piston pump used on the N47TU engine.

The N57TU engine is fitted with a twin-piston high pressure pump with the designation CP4.2.

The high-pressure pump is located on the flywheel side (rear) of the engine and is driven via the timing chain by the crankshaft with 1:1 ratio. Although it is capable of generating a pressure of 2000 bar, the N57TU uses 1800 bar of injection fuel pressure.

The gear 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.



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**When work is carried out on the chain drive, the high-pressure pump in the N57TU engine must be positioned in relation to the crankshaft. Refer to the repair instructions for the exact procedure.**

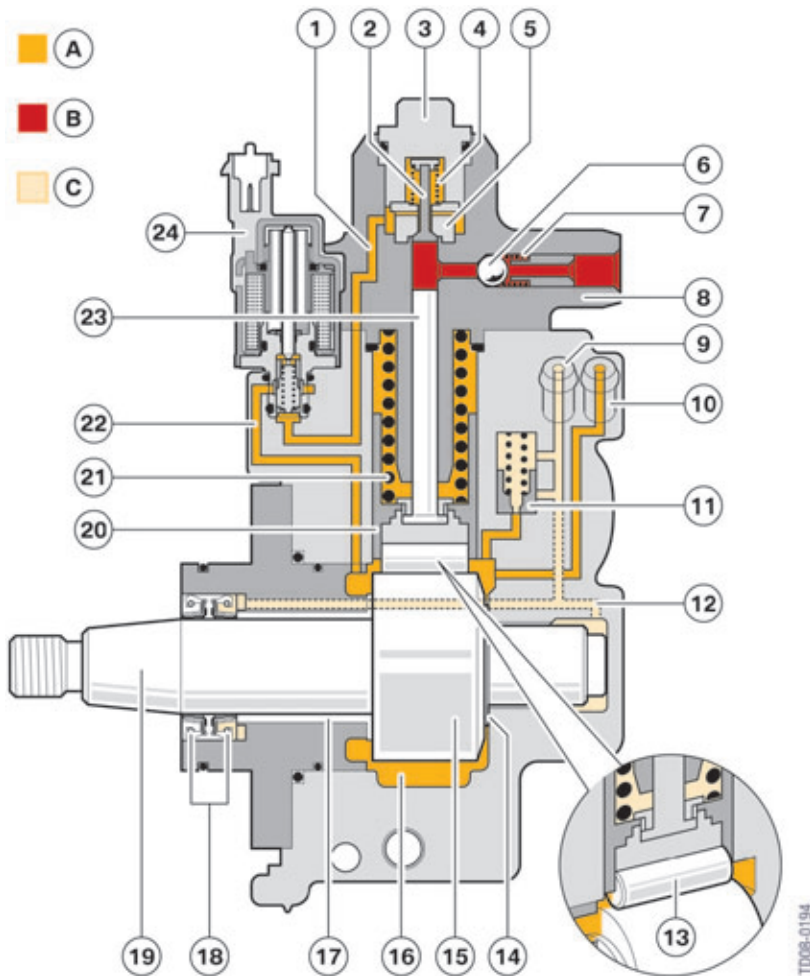
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# N57TU Engine

## 6. Fuel Preparation



The pump is lubricated by the fuel. For this reason gasoline must not be used as a flow improver in the winter months. The high-pressure pump and eventually the engine may otherwise be damaged.



N57TU High pressure pump Bosch CP4.2

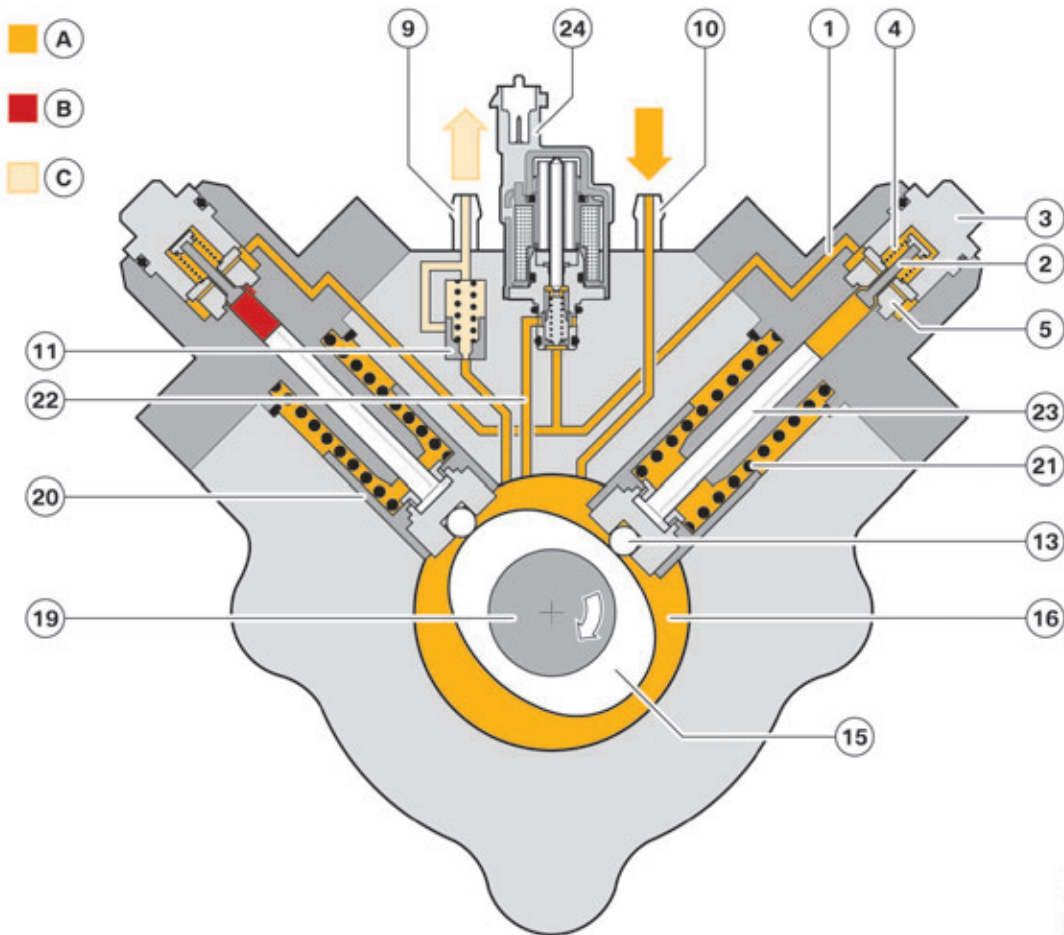
# N57TU Engine

## 6. Fuel Preparation

<b>Index</b>	<b>Explanation</b>
A	Fuel supply
B	Fuel high pressure
C	Fuel return
1	Low-pressure channel
2	Valve plunger
3	Screw sealing plug
4	Spring
5	Valve seat plate
6	Ball
7	Spring
8	Connecting branch
9	Connecting branch
10	Connecting branch
11	Fuel overflow valve
12	Return channel
13	Roller
14	Thrust washer
15	Double cam
16	Camshaft chamber
17	Bearing bushing
18	Radial shaft seal
19	Camshaft
20	Tappet
21	Spring
22	Low-pressure channel
23	Piston
24	Fuel quality control valve (volume control valve)

# N57TU Engine

## 6. Fuel Preparation



N57TU High pressure pump Bosch CP4.2

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

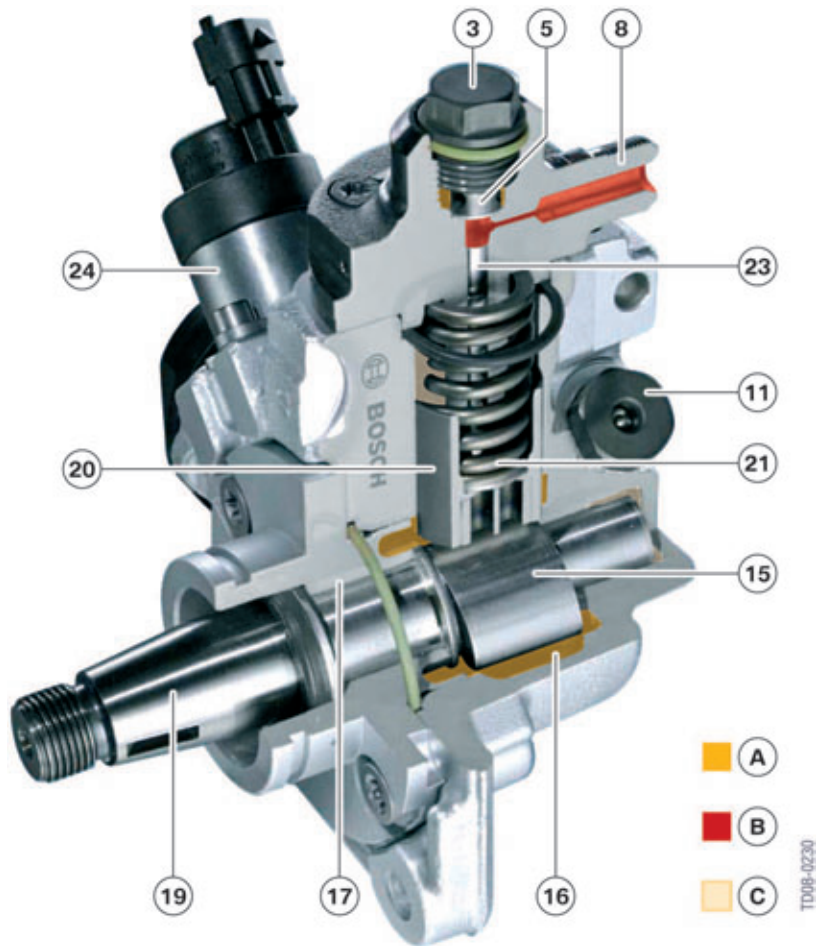
For lubrication of the high-pressure pump, fuel enters through the inlet connection (10) from the fuel feed (A) and passes into the camshaft chamber (16). The fuel passes via the bearing sleeve (17) and return channels (12) to the outlet connection (9) and back into the fuel return (C).

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).

# N57TU Engine

## 6. Fuel Preparation



N57TU High pressure pump Bosch CP4.2 cut away

Index	Explanation
A	Fuel supply
B	Fuel high pressure
C	Fuel return
3	Screw sealing plug
5	Valve seat plate
8	Connecting branch
11	Fuel overflow valve
15	Double lobe cam
16	Camshaft chamber
17	Bearing bushing
19	Camshaft



# N57TU Engine

## 6. Fuel Preparation

Index	Explanation
20	Tappet
21	Spring
23	Piston
24	Fuel quality control valve (volume control valve)

### 6.1.1. Fuel quantity control valve



Fuel quantity control valve CP4.2

The fuel-quantity control valve (also known as flow regulating valve) is mounted on the CP4.2 high-pressure pump. The fuel-quantity control valve is controlled using a pulse-width-modulated signal. The DDE controls the fuel-quantity control valve at various pulse-duty factors while the fuel-quantity control system is active. The system adjust rail pressure to the specified level as calculated by the DDE. The fuel-quantity control valve regulates the fuel flow from the low-pressure side to the high-pressure side of the high-pressure pump. This is how the desired fuel-rail pressure is achieved. Progressive reductions in the amount of fuel that the fuel-quantity control valve allows to flow to the high-pressure side produce corresponding reductions in the level to which the high-pressure pump charges the cylinders. The consequence is that less rail pressure is built up. The high-pressure pump generates pressure to maintain a constant level in the rail.

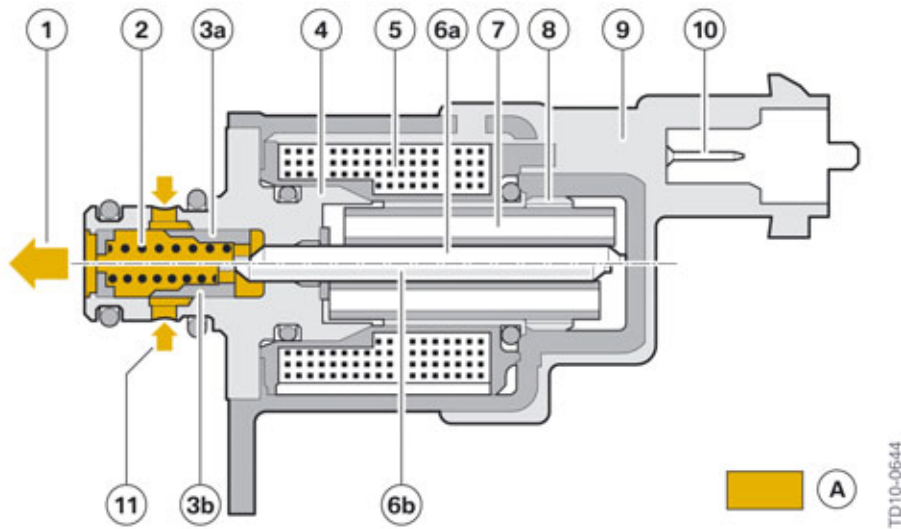
Two valves are employed to maintain the pressure within the fuel rail at the required level:

- Fuel quantity control valve
- Rail-pressure control valve (see corresponding description of operation)

When volumetric flow regulation is active, the DDE controls the fuel-quantity control valve (flow regulating valve) by means of a variable pulse duty factor in order to set the rail pressure to the level calculated by the DDE. The fuel-quantity control valve controls the flow of fuel into the high pressure pump from the low-pressure side, thereby controlling fuel-rail pressure as required. The less fuel the flow regulating valve allows to flow into the high pressure side, the less the radial cylinder of the high-pressure pump is filled. The consequence is that less rail pressure is built up.

# N57TU Engine

## 6. Fuel Preparation



Fuel quantity control valve cutaway CP4.2

Index	Explanation
A	Fuel supply (feed)
1	Fuel to pump element
2	Spring
3a	Plunger (in open state)
3b	Plunger (in closed state)
4	Ferro-magnet core
5	Solenoid coil
6a	Tappet (in the opened state)
6b	Tappet (in the closed state)
7	Armature
8	Bearing
9	Housing
10	Electrical connection
11	Fuel supply (feed)

The fuel quantity control valve is activated by the Digital Diesel Electronics with pulse-width modulation according to the calculated fuel requirement. On activation the tappet (6) is moved by the armature (7) actuated by magnetic force. The plunger (3) is displaced by the tappet. The plunger is pressed by the spring (2) against the tappet. The plunger, depending on its position, opens the fuel supply (11). This fuel quantity control reduces the power demand of the high-pressure pump. It delivers only the amount of fuel needed to generate the rail pressure determined from a characteristic map. The graphic below shows the plunger in its closed state (3b) and the associated tappet (6b). Also shown are the plunger in its opened state (3a) and the associated tappet (6a).

# N57TU Engine

## 6. Fuel Preparation

### 6.1.2. Volumetric flow regulation functional description

Depending upon conditions, one of the following 3 available closed-loop control strategies is used to adjust the rail pressure to the correct level:

- Volumetric flow regulation by the quantity control valve: The quantity control valve only allows the amount of fuel to flow into the high pressure pump from the low-pressure side that is required in order to generate the required fuel rail pressure. The high-pressure pump cylinder is not completely filled with fuel. The higher the control signal current, the lower the rail pressure that is generated. The rail-pressure regulating valve is not supplied with current for the maximum pressure. The rail-pressure regulating valve is supplied with slightly higher current than would be necessary for setting the target pressure.
- Pressure regulation by the rail pressure control valve: The high-pressure pump provides a constant supply of highly-pressurised fuel to the rail. The rail pressure regulating valve diverts excess fuel arriving in the rail into the return line. The higher the control signal current, the higher the rail pressure that is maintained. The flow regulating valve is set to maximum flow.
- Combined closed-loop control with simultaneous regulation from the rail pressure regulating valve and the quantity control valve: At extremely low fuel-injection quantities of less than roughly 4 mg (on trailing throttle/overrun) the rail pressure regulating valve must discharge a certain amount of fuel from the high-pressure system. The reason is that the high-pressure pump cannot run with zero delivery. This means that the high-pressure pump supplies fuel to the high-pressure system even when the quantity control valve (flow regulating valve) is closed. This would lead to excessive rail pressure and thus to a control deviation.

The two control methods are used under the following engine operating conditions:

- During engine starts: Pressure regulation is always active.
- When the engine is running: At a coolant temperature below 1 °C (34 °F), the pressure regulation is always active. Once the coolant temperature rises above 15 °C (59 °F) the combined closed-loop control system assumes operation.

### Fault handling

If activation of the flow regulating valve is interrupted or has a short circuit to ground, the flow regulating valve switches to full delivery. The DDE detects the fault, limits the fuel injection rate and switches to pressure regulation. As of a fuel temperature of 60 °C (140 °F), the DDE reduces the fuel injection rate and the rail pressure to protect the rail-pressure regulating valve against overheating. In the event of a short circuit to positive, the engine shuts down.

# N57TU Engine

## 6. Fuel Preparation

### 6.1.3. Rail pressure sensor



Rail pressure sensor

A diaphragm with strain resistors is integrated in a metal housing. The measuring range of the sensor is dependent on the thickness of the diaphragm. The thicker the diaphragm, the higher the measurable pressure. The rail pressure sensor detects the current pressure in the rail. The pressure in the rail is of crucial importance to fuel injection. This measurement must be performed with great precision and within a suitably short period of time. If the rail pressure sensor fails, a fault is stored in the Digital Diesel Electronics and pressure regulation is activated "blind" by means of default values.

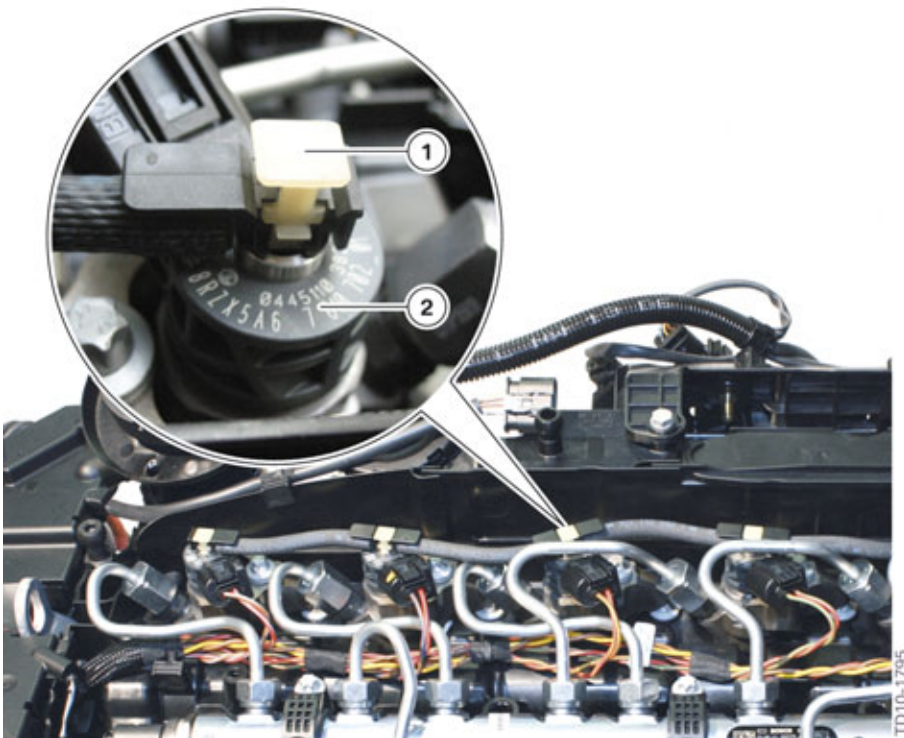
For more information regarding the rail pressure sensor see the "Sensor section" of this training manual or refer to the repair instructions in ISTA.

### 6.2. Leakage oil line

The leakage oil line and return connector of the N57TU engine are new. The return connector must be in the open position in order to be able to connect the leakage oil line to the injectors. The connector is then plugged into the injector return and the latch mechanism is pushed in. The return connector is thus secured to prevent it from being pushed out. The return connector must be opened (see graphic) in order to open the connection.

# N57TU Engine

## 6. Fuel Preparation



N57TU engine, leakage oil line

Index	Explanation
1	Return connector open
2	Injector

### 6.3. Injector

As with the N47TU the new solenoid injectors (common rail injector CRI2.5) are installed on the N57TU. They are produced by Bosch and operated with up to 1800 bar fuel pressure. Along with the increased maximum pressure, the number of possible switching actuations over the service life was also increased by 50%. It has multiple injection capability and also allows the implementation of very short switching times. The new solenoid injector delivers improved HC and CO emissions with the same power and consumption data as the 1800 bar piezo injector. An additional advantage of the solenoid type injector is the low manufacturing costs compared to piezo injectors.

The nozzle geometry has also been adapted to satisfy the more exacting requirements of exhaust emissions legislation.

# N57TU Engine

## 6. Fuel Preparation

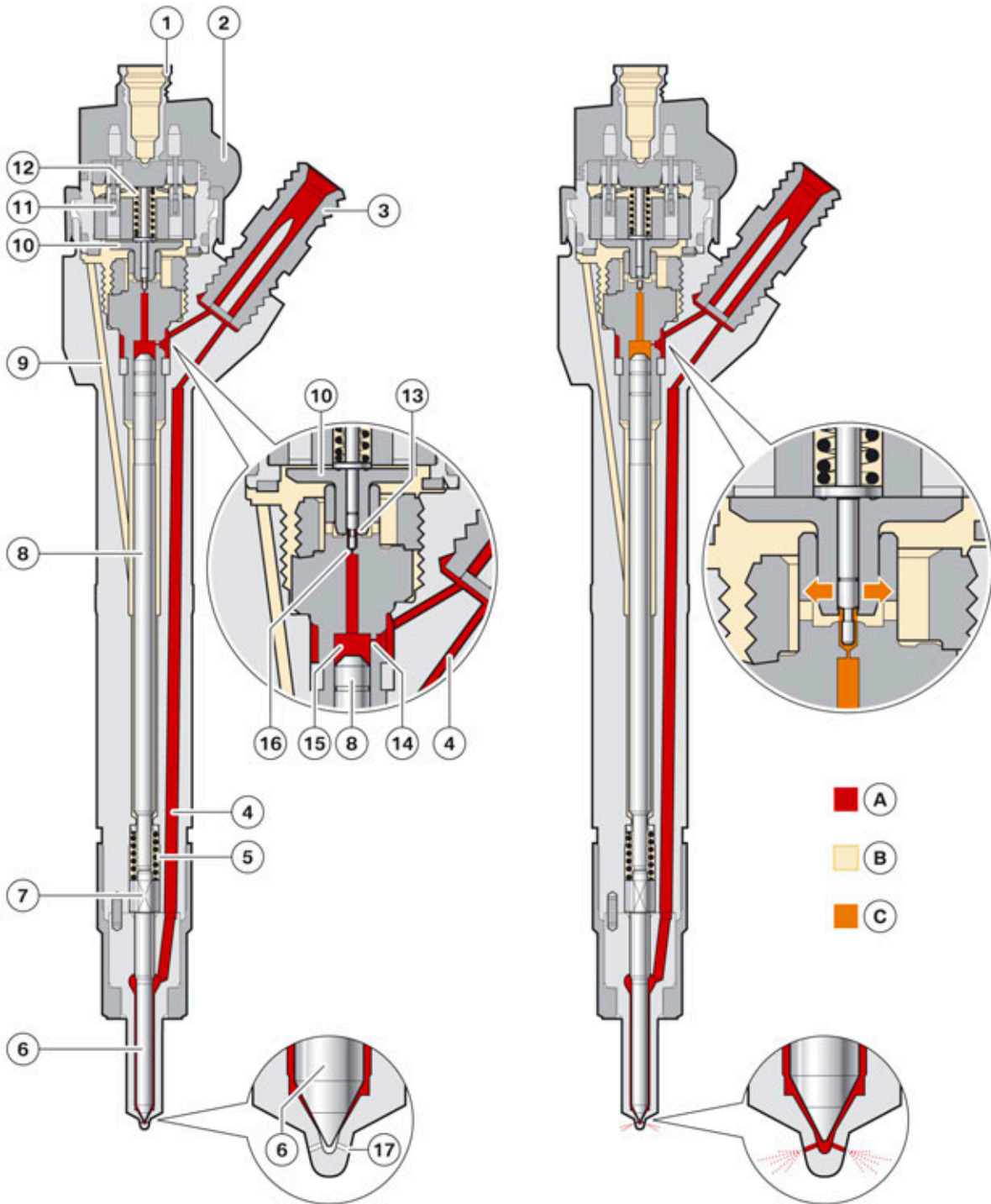
### 6.3.1. Injector CRI2.5

#### Design

Important modifications were done on the solenoid valve injector when compared with the N57 engine (not available in the US). Instead of a ball shaped control valve a ring design is now used. The main concern is the permanent leakage of the pressure compensated valve. With the new shape, a larger valve lift is achieved with low opening cross-section.

# N57TU Engine

## 6. Fuel Preparation



Injector CRI2.5

TD10-0049

# N57TU Engine

## 6. Fuel Preparation

Index	Explanation
A	Fuel high pressure
B	Fuel return line
C	Reduced fuel high pressure
1	Connection, fuel return line
2	Electrical connection
3	High-pressure connection with filter
4	Inlet channel
5	Nozzle needle spring
6	Nozzle needle
7	Coupler
8	Valve control plunger
9	Leakage oil line
10	Armature
11	Solenoid coil
12	Armature spring
13	Control valve
14	Inlet throttle
15	Control space
16	Outlet throttle
17	Hole-type nozzle

The behavior of the CR12.5 injector is determined decisively by the control valve (13). The new injector should enable higher valve dynamics and simultaneously higher pressures. With the conventional ball valve this was not possible, because a reduction of the valve seat diameter to increase the operating pressure resulted in lower valve opening cross-sections for the control of the nozzle needle. Therefore the valve lift must be enlarged (at the cost of dynamics) which is not favorable with regards to injection rate and multiple fuel injection.

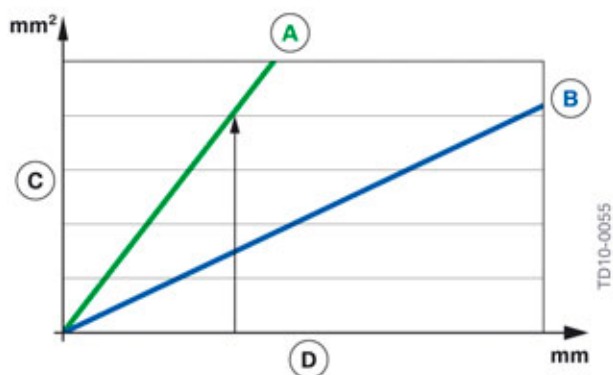
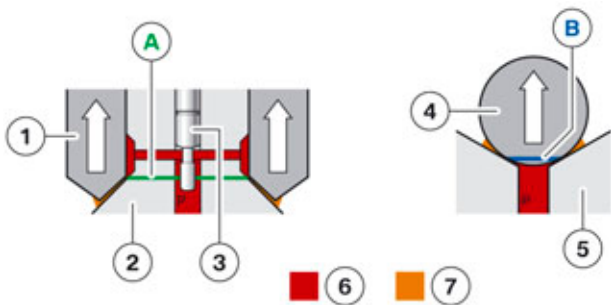
So that higher fuel injection pressure with simultaneously increased dynamics (multiple fuel injections) can be achieved, a pressure compensating valve was developed. Through this design the hydraulic forces within the seat diameter are captured by a fixed element. The advantage of this valve is an opening cross-section three times as large with the same valve lift.

Very short switching times can therefore be implemented with a small valve lift and simultaneously multiple fuel injections in very short time intervals. These modifications were necessary, since up to three pre-injections are required for emissions and noise reduction. However with regard to exhaust re-treatment there are currently up to four post-injections being used.



# N57TU Engine

## 6. Fuel Preparation



Comparison between valve opening cross-sections of CRI2.2 and CRI2.5

Index	Explanation
A	Pressure-balanced valve CRI2.5
B	Ball valve CRI2.2
C	Opening cross-section
D	Valve lift
1	Control valve
2	Valve seat
3	Anchor bolt
4	Ball
5	Valve seat
6	Fuel high pressure
7	Reduced fuel high pressure (discharged fuel)

### 6.3.2. Injection volume calibration

Due to the tolerance during manufacture of the injectors, the actual injected fuel volume deviates only slightly from the calculated fuel volume. This deviation is determined after manufacturing each injector by measurements in several operating conditions. For each injector an adjustment value (code) is generated from these measurements. For vehicle assembly, the compensation value of each injector is stored in the control unit after the installation of the Digital Diesel Electronics.

# N57TU Engine

## 6. Fuel Preparation

The compensation values are assigned to the individual cylinders according to the installation of the injectors. The DDE corrects the calculated injection quantities slightly with these compensation values and so reduces the cylinder specific deviations of the injection volume.



Injection volume calibration, injector CRI2.5

Index	Explanation
1	Seven-position code (adjustment value)



**When injectors are replaced or exchanged, it is essential to ensure that the alphanumeric code printed on each injector is assigned in the Digital Diesel Electronics to the correct cylinder.**

# N57TU Engine

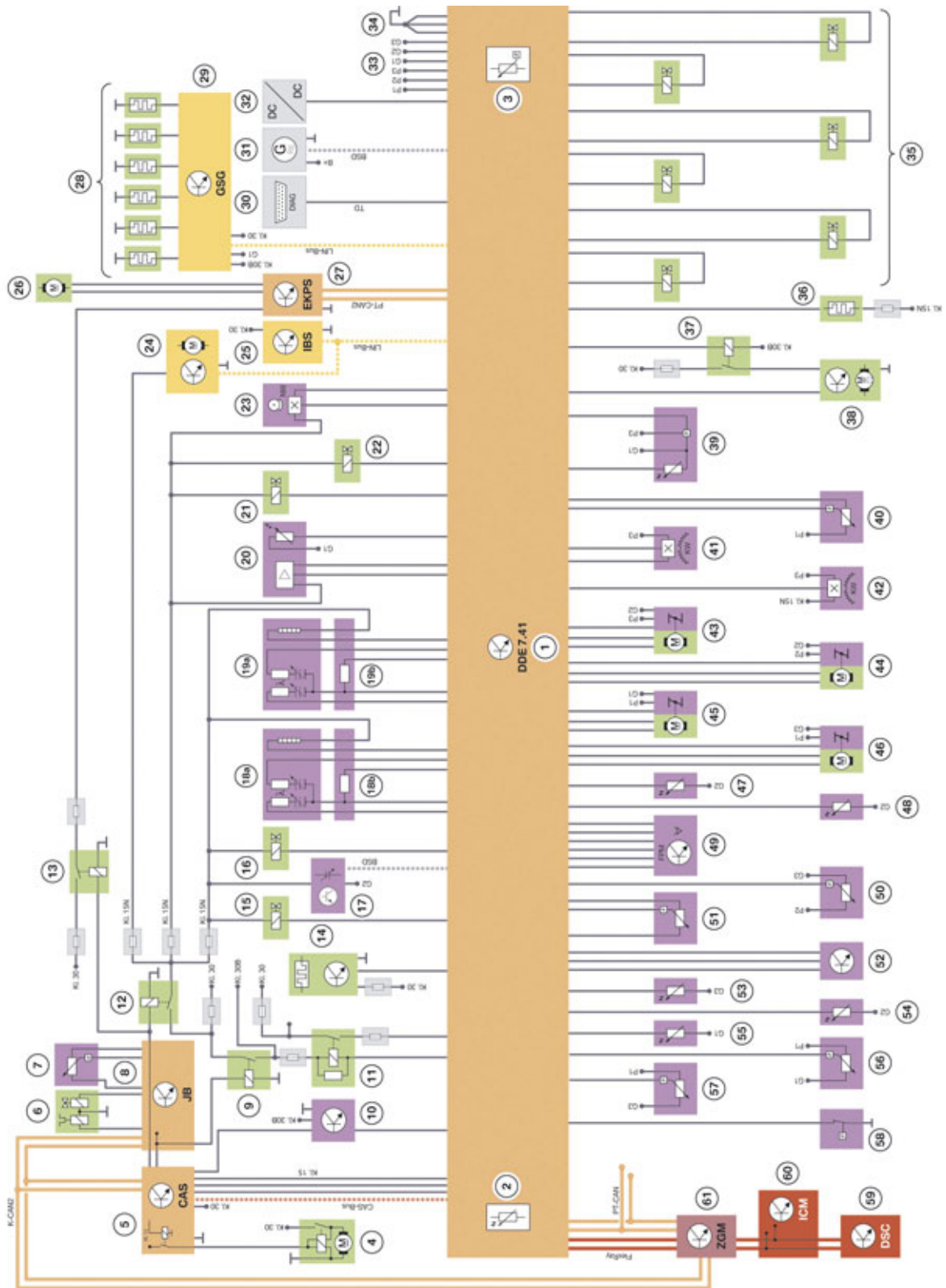
## 7. Engine Electrical System

The engine electrical system has been redesigned compared to the first generation. Some new sensors have been installed, but in general most are the same as the sensors used in the (M57D30T2) engine in terms of their function and operating principle. The components for the automatic engine start-stop function are specially identified in the table. The DDE7.41 assumes the function of activating and evaluating the sensors and actuators.

**Note: The two NO<sub>x</sub> sensors and the PM sensor are not shown in the following DDE wiring illustration (IPO) because they have their own control units which communicate with the DDE via Lo-CAN.**

# N57TU Engine

## 7. Engine Electrical System



N57TU engine, DDE 7.41 system wiring diagram with EURO 6 and ULEVII version

TD10-1797

# N57TU Engine

## 7. Engine Electrical System

Index	Explanation
1	Digital Diesel Electronics (DDE)
2	Temperature sensor in the DDE control unit
3	Ambient pressure sensor in the DDE control unit
4	Starter motor
5	Car Access System
6	Air conditioning compressor
7	Refrigerant pressure sensor
8	Junction box
9	Relay, terminal 30B
10	Clutch module (Not for US)
11	DDE main relay
12	Relay, terminal 15N
13	Relay, terminal 15N
14	Fuel filter heating
15	Electro-pneumatic changeover valve, engine mount
16	Electro-pneumatic changeover valve, exhaust-gas recirculation bypass flap
17	Oil level sensor (oil condition sensor)
18a	Oxygen sensor upstream of NO <sub>x</sub> catalyst storage [control sensor with continuous characteristic curve]
18b	Connector, oxygen sensor
19a	Oxygen sensor downstream of diesel particulate filter [control sensor with continuous characteristic curve]
19b	Oxygen sensor connector
20	Hot film air mass meter
21	Rail pressure regulating valve
22	Fuel quantity control valve
23	Camshaft sensor
24	Air flaps (Not for US)
25	Intelligent battery sensor
26	Electric fuel pump
27	Electronic fuel pump control
28	Glow plugs
29	Preheating control unit
30	Diagnostic connector
31	Alternator
32	DC/CD converter

# N57TU Engine

## 7. Engine Electrical System

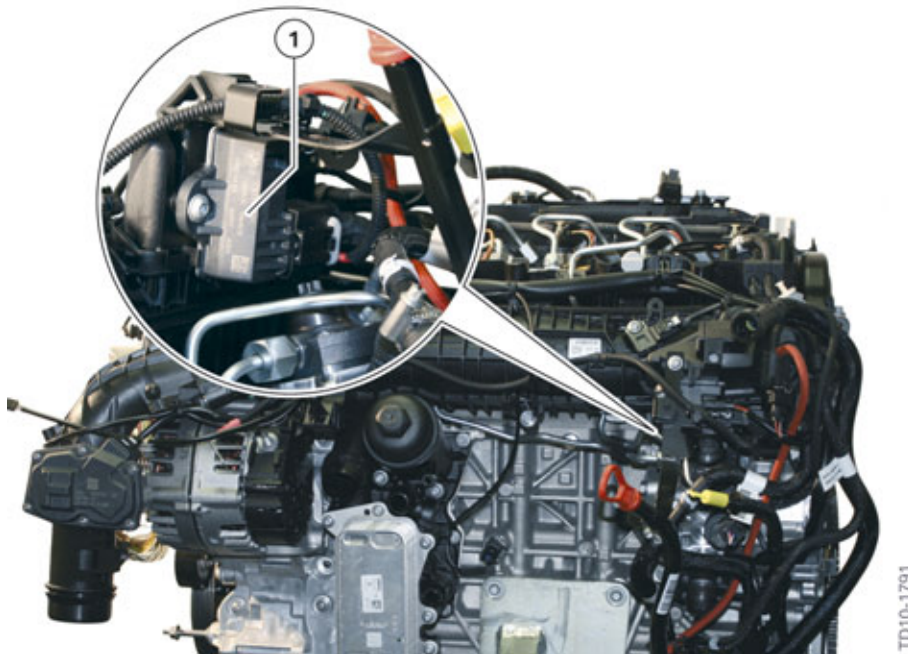
<b>Index</b>	<b>Explanation</b>
33	P1 sensor supply
33	P2 sensor supply
33	P3 sensor supply
33	G1 sensor earth (ground)
33	G2 sensor earth (ground)
33	G3 sensor earth (ground)
34	Ground connection
35	Solenoid valve injectors
36	Engine ventilation heating (version for cold countries)
37	Relay for electric fan
38	Electric fan
39	Fuel pressure and temperature sensor
40	Rail pressure sensor
41	Crankshaft sensor
42	Transmission speed sensor
43	Charging pressure actuator
44	EGR valve and exhaust recirculation sensor
45	Throttle-valve actuator and throttle valve sensor
46	Swirl-flap actuator and swirl-flap sensor
47	Coolant temperature sensor
48	Charge-air temperature sensor
49	Accelerator pedal module
50	Exhaust back-pressure sensor upstream of exhaust turbocharger
51	Brake vacuum sensor (for automatic engine start-stop function)
52	Zero-gear sensor (for automatic engine start-stop function)
53	EGR temperature sensor
54	Exhaust-gas temperature sensor upstream of diesel particulate filter
55	Exhaust-gas temperature sensor upstream of oxidation catalytic converter
56	Charging pressure sensor
57	Exhaust gas differential pressure sensor upstream and downstream of diesel particulate filter
58	Oil pressure switch
59	Dynamic Stability Control
60	Integrated Chassis Management
61	Central gateway module

# N57TU Engine

## 7. Engine Electrical System

### 7.1. Preheating control unit

The preheating control unit is now secured to the differentiated air intake system which has significantly improved its accessibility.



N57TU engine, differentiated air intake system

Index	Explanation
1	Preheating 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 N57TU engine is fitted with 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 glowplug 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.

# N57TU Engine

## 7. Engine Electrical System

The pre-heater 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.



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**Glow plug identification must be performed when the preheating control unit or glow plugs are replaced.**

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### 7.1.1. Glow plug

The service function offers two functions which are required for repairs to the preheating system:

- Before replacing glow plugs: **activate the safety data record.**  
Before replacing glow plugs, it is necessary to activate the safety data record with the service function. This is necessary to ensure that, in the event of a terminal change, the preheating control unit in the interest of safety activates the new glow plugs with the safety data record.
- Once the glow plugs or preheating control unit have been replaced: **perform glow element identification procedure.**  
After replacing glow plugs or the preheating control unit, it is necessary to perform glow plug identification with the service function.  
The service function ensures that the correct data record for the installed glow plugs is activated in the preheating control unit. An incorrect data record may possibly remain active if glow plug identification is not performed. This may result in functional restrictions during glowing or damage to the glow plugs.  
The following are checked:
  - Does the preheating control unit identify all the glow plugs?
  - Are the correct glow plugs installed?
  - Is the correct data record activated in the preheating control unit?

#### Reason

Different glow plug types are used in the N47TU and N57TU engines, depending on the power variant.

The following tables shows which individual glow plug types are used in which engine:

Engines	BERU CGP (ceramic)	BOSCH GLP5 (ceramic)
N47D2001		X
N57D3001	X	



# N57TU Engine

## 7. Engine Electrical System

There are different data records for the preheating control unit to enable the different glow plug types to be activated with the correct voltage profile in each case. As well as the data records for correct operation of the glow plugs, the preheating control unit also contains the so-called safety data record. The safety data record is configured in such a way that, in the event of a fault or incorrect installation, all the glow plug types can be energized without the risk of damage. There are two methods for identifying the glow plug types in the preheating control unit:

- 1 Identification is initiated automatically with each full heating cycle after a terminal change. But in this case, the preheating control unit can only distinguish between metallic and ceramic glow plugs. Identification is aborted if the preheating control unit detects an excessive voltage fluctuation or the signal for starter motor intervention becomes active. If an incorrect glow plug type is identified more than once, the preheating control unit activates the safety data record. If only one glow plug of the incorrect type is identified, the preheating control unit removes this glow plug from further preheating operations in the current driving cycle and does not activate the safety data record.
- 2 A special test preheating can be initiated by way of the service function. Here the safety data record is always activated if all the glow plugs are not clearly identified.



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**Glow plug identification must be performed when the preheating control unit or glow plugs are replaced.**

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### 7.2. Sensors and actuators

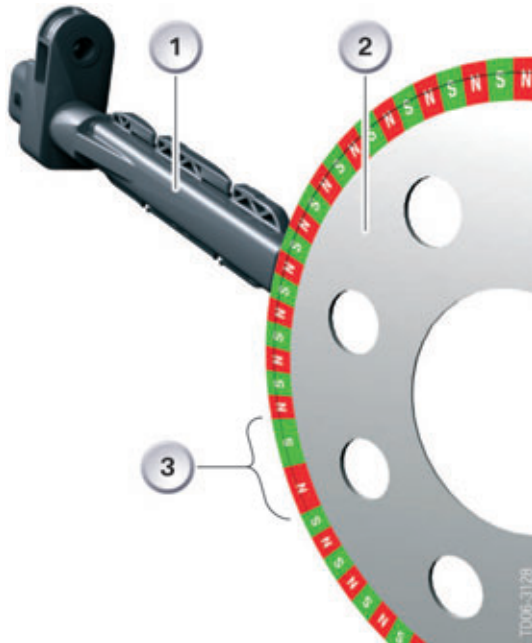
#### 7.2.1. Crankshaft sensor

The crankshaft sensor informs the DDE of the position of the crankshaft. The signal from the engine speed sensor is one of the most important variables in the engine management.

The N57TU engine is equipped with a sensor that is able to detect reversed rotation. This is necessary for the automatic engine start-stop (MSA). The operation is identical to the conventional crankshaft sensor

# N57TU Engine

## 7. Engine Electrical System



N57TU Active crankshaft sensor

Index	Explanation
1	Active crankshaft sensor
2	Multipolar sensor wheel
3	Pole pair as “tooth gap”

The sensor is what is known as an active speed sensor, also functioning in accordance with the Hall principle. The sensor has its own evaluation logic.

With this speed sensor, pairs of magnetic poles assume the function of the teeth of an incremental gear. It can therefore be referred to as a multipolar sensor wheel, as already used in gasoline engines. 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 element produce a differential signal for determining the signal frequency and the air gap to the sensor wheel. A clockwise or anti-clockwise direction of rotation can be detected thanks to the time offset between the signal of the center element and the differential signal.

The additional signals of the air gap and the direction of rotation are output using the pulse width of the digital signal.

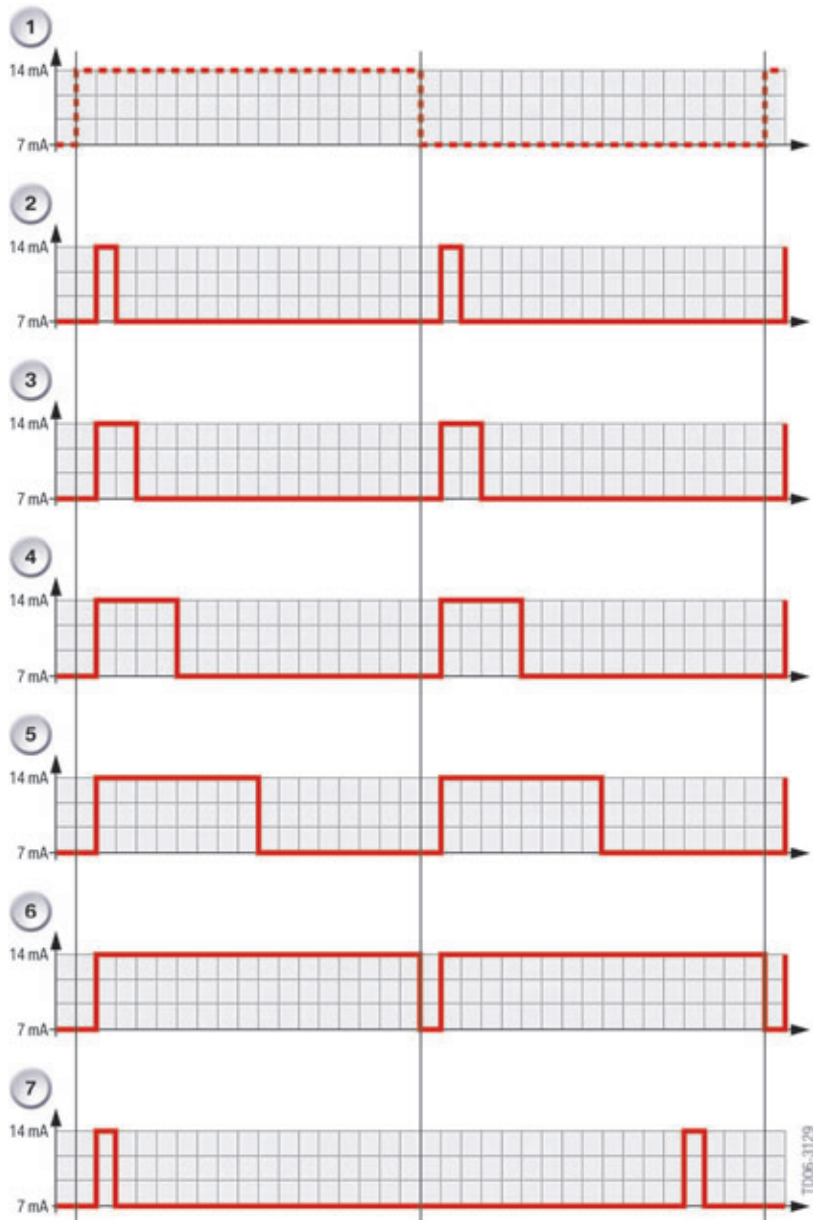
The signals processed in the sensor are sent to the control unit on the combined ground and data line. On the data line, it is not the voltage level that is decisive but the current flow. There is a self-repeating data telegram that uses two different currents.

The 14 mA level contains the information about the speed, direction of rotation and the air gap. The 7 mA level acts as the evaluation current for the fault code memory.

Unlike the sensors used to date (on non MSA vehicles), a pulse indicating sensor availability is sent approximately every 740 ms when the vehicle is stationary.

# N57TU Engine

## 7. Engine Electrical System



Crankshaft sensor with multipolar sensor wheel

Index	Explanation
1	Maximum signal length of the sensor
2	Speed signal
3	Speed, direction of rotation: counterclockwise
4	Speed, direction of rotation: clockwise
5	Speed, counterclockwise direction of rotation + air gap width
6	Speed, clockwise direction of rotation + air gap width
7	Basic signal with engine stopped (740 ms)

# N57TU Engine

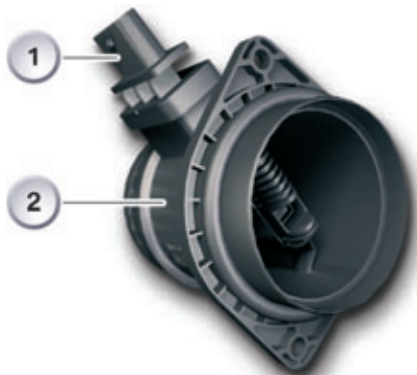
## 7. Engine Electrical System

### 7.2.2. Camshaft sensor



The N57TU camshaft sensor operates according to the Hall principle as with all BMW engines. The camshaft sensor is installed on the rear of the cylinder head cover above the intake camshaft. A camshaft sensor trigger wheel is mounted on the intake camshaft for this purpose. The Digital Diesel Electronics uses the camshaft sensor to detect whether the 1st cylinder is in the compression phase or the gas exchange stroke. This assignment cannot be made from the crankshaft position. Assignment is necessary so that fuel injection can be regulated accordingly. The DDE supplies the sensor with 5 V and ground. The sensor supplies a digital signal via the signal line to the DDE. A special pattern allows emergency operation if the crankshaft sensor fails. The resolution of the camshaft sensor signal is, however, too inaccurate to replace the crankshaft sensor during normal operation.

### 7.2.3. Hot-film air mass meter



Hot-film air mass meter

Index	Explanation
1	HFM
2	Measurement tube

# N57TU Engine

## 7. Engine Electrical System

The HFM 6 hot-film air mass meter is located downstream of the intake silencer and is fitted directly to its cover. The HFM measures the air mass taken in by the engine. This is used to record the actual air mass, which in turn is used to calculate the exhaust gas recirculation rate and the fuel limit volume.

There is also an intake air temperature sensor in the HFM. The temperature evaluated by the HFM and sent to the DDE as a PWM signal. A pulse width of 22% equates to a temperature of -20 °C (-4 °F) and a pulse width of 63% equates to a temperature of 80 °C (176 °F).

**See the N47TU training material for more information.**

### 7.2.4. Rail pressure sensor

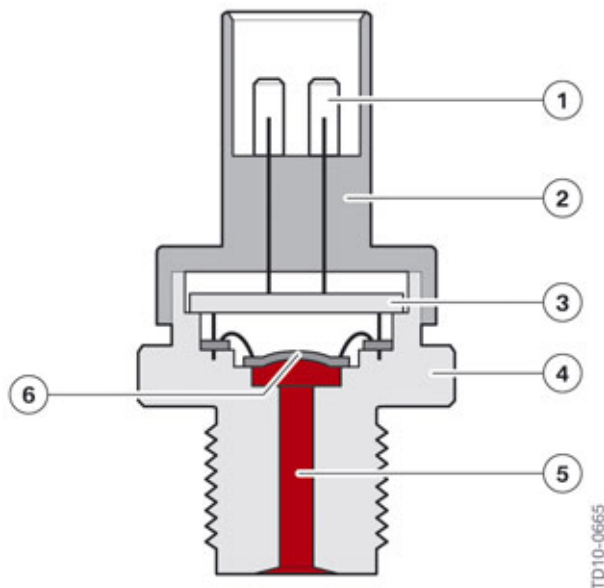


Rail pressure sensor

The rail pressure sensor consists of strain resistors which are incorporated on a diaphragm (6). One side of this diaphragm is in contact with the fuel high pressure (5), with the fuel pressure acting on the diaphragm. The diaphragm is deflected depending on the extent of the pressure. The resistors on the diaphragm alter their resistance under the mechanical strain created. The bridge voltage is amplified, temperature influences compensated and the pressure characteristic line arise by a bridge circuit and electronics (3) for signal processing in the sensor. The output voltage for the Digital Diesel Electronics ranges between 0 and 3.3 V. As is the case with the temperature sensor, the Digital Diesel Electronics stores a characteristic curve which assigns a corresponding pressure to each voltage value. The accuracy is  $\pm 2\%$  of the end value.

# N57TU Engine

## 7. Engine Electrical System



Rail pressure sensor, sectional view

Index	Explanation
1	Electrical connection
2	Plastic housing
3	Electronics
4	Metal housing
5	Fuel high pressure
6	Diaphragm

### 7.2.5. Boost-pressure sensor



Boost pressure sensor

The boost-pressure sensor is located on the intake manifold and measures the pressure (absolute) inside it. It is supplied with 5 Volts and connected to ground by the DDE.

# N57TU Engine

## 7. Engine Electrical System

The boost pressure information is sent to the DDE on a signal line. The useful signal for the boost pressure fluctuates depending on the pressure.

The measuring range of approximately 0.1 - 0.9 V corresponds to a boost pressure of 50 kPa (0.5 bar) to 300 kPa (3 bar). The sensor serves the purpose of controlling the boost pressure.

### 7.2.6. 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.



Charge-air temperature sensor

The DDE connects the charge-air temperature sensor to ground and to a voltage divider circuit (in the DDE).

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 5 Volts from the DDE. The electrical voltage at the resistor is dependent on the air 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 149 k $\Omega$  to 161  $\Omega$ , corresponding to a temperature of -40 °C to 130 °C (-40 °F to 266 °F).

**Note: These specifications may vary. Please refer to the appropriate repair information for the most up to date repair instructions.**

### 7.2.7. Coolant temperature sensor

The coolant temperature sensor is located on the front 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 ground by the DDE. The second connection is connected to a voltage divider circuit in the DDE.

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.

# N57TU Engine

## 7. Engine Electrical System

The resistor is part of a voltage divider circuit that receives 5 Volts from the DDE. The electrical voltage at the resistor is dependent on the air 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 216 k $\Omega$  to 41.7  $\Omega$ , corresponding to a temperature of -55 °C to 150 °C (-58 °F to 302 °F).

**Note: These specifications may vary. Please refer to the appropriate repair information for the most up to date repair instructions.**

### 7.2.8. Oxygen sensor

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 fuel with 14.7 kg air.

The oxygen sensor is located at the inlet to the shared housing of the diesel particulate filter (DPF) and NO<sub>x</sub> storage catalytic converter.

The control sensor with rising characteristic is a type LSU 4.9 broadband oxygen sensor supplied by Bosch. This broadband oxygen sensor is installed upstream of the NO<sub>x</sub> storage catalytic converter close to the engine.

The oxygen concentration in the exhaust gas can be determined over a large range with the broadband oxygen sensor. The broadband oxygen sensor is capable of providing accurate measurements not only at  $\lambda = 1$  but also at  $\lambda < 1$  (rich) and  $\lambda > 1$  (lean). The broadband oxygen sensor supplies a distinct, steady-state electrical signal from  $\lambda = 0.7$  to  $\lambda = \infty$  ( $\lambda = \infty = \text{air}$ ).

The DDE corrects the mixture composition through fuel injection based (in part) on the feedback of the O<sub>2</sub> sensor and the air mass (HFM). 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 fuel with 14.7 kg air.

The DDE also compares this information to data points in a characteristic map that refers to the mean quantity value adaptation (MMA). The mean quantity adaptation serves to adapt the exhaust-gas recirculation more precisely to tolerance in the fuel injection rates.

The  $\lambda$  oxygen sensor measures the fuel-air ratio. In the event of deviations, the DDE adapts the exhaust-gas recirculation rate to suit the change in air/fuel ratio. The mean quantity adaptation is not a rapid control operation, but is instead an adaptive learning procedure. An oxygen sensor deviation is "learned" in a characteristic map and stored for a sustained period in the DDE control unit.

The exhaust after-treatment system also incorporates a second O<sub>2</sub> sensor located downstream of the diesel particulate filter. It is also an LSU 4.9 broadband oxygen type sensor. This second oxygen sensor enables the system to monitor and detect whether the NO<sub>x</sub> storage catalytic converter needs to be regenerated.

**Note: The new system uses the two oxygen sensors and the two NO<sub>x</sub> sensors of the SCR system to monitor the entire exhaust after-treatment system for plausibility and fault detection.**



# N57TU Engine

## 7. Engine Electrical System



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**For more information regarding the exhaust after-treatment refer to the “Second generation diesel engine emission controls” in the ST1210 Diesel Technology training material available on TIS and ICP.**

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### 7.2.9. NOx sensors

As with the M57D30T2 engine, the N57TU also uses Selective Catalyst Reduction system (SCR) for reducing NOx emissions.

As with the previous SCR system SCR 2 also incorporates two NOx sensor (one upstream and one downstream of the SCR Catalyst).

The nitrogen oxide sensor consists of the actual measuring probe and its own corresponding control unit. The control unit communicates via the Lo-CAN with the engine control unit.

In terms of its operating principle, the nitrogen oxide sensor can be compared with a broadband oxygen sensor. The measuring principle is based on the idea of basing the nitrogen oxide measurement on oxygen measurement.

#### Functional description

The sensor system of the nitrogen oxide sensor consists of a solid electrolyte made of ceramic based on zirconium dioxide. Above a temperature of approximately 300°C, this material becomes conductive for oxygen ions. The installed heating element provides for the necessary operating temperature. The mixture of O<sub>2</sub> and nitrogen oxide in the exhaust gas reaches the nitrogen oxide sensor after the nitrogen oxide catalyst storage. The nitrogen oxide sensor consists of two chambers. A pump cell regulates the oxygen concentration to a specific value by pumping oxygen out of or into the first chamber. Through the application of a voltage, the oxygen molecules are split into ions and diverted through the solid electrolyte. The remaining nitrogen oxide then goes on to the second chamber. The oxygen concentration is then further reduced with a second pump cell in the second chamber. The remaining nitrogen oxide is split into oxygen and nitrogen at a catalytic element at the third pump cell. The released oxygen leads to a pump current which is proportional to the concentration of nitrogen oxide in the exhaust gas. The evaluation electronics generate the output signals based on the physical measured values. The control unit communicates via the Lo-CAN with the engine control unit.

### 7.2.10. Particulate matter sensor

Diesel particulate filter is an essential component of the exhaust after-treatment system for all current BMW diesel engines. Monitoring and diagnosis of the DPF (as with all emission systems) is required in order to insure its efficiency. This was done (in the previous system) via a differential pressure measurement which determines the pressure drop in the DPF. As the regulatory mandates regarding the OBD diagnosis of the DPF are constantly being updated the pressure method is not sufficient to meet the tighter regulations.

The particulate matter sensor was installed for the first time in combination with the second generation BMW diesel engines (N47TU and N57TU) which were introduced to the US market as of 7/2013. This sensor is in compliance with much more stringent US emission OBD diagnosis regulations and is a further enhancement to BMW Efficient Dynamics strategy.

# N57TU Engine

## 7. Engine Electrical System



Particulate matter sensor

The particulate matter sensor is integrated into the exhaust system downstream of the DPF and enables a constant diagnosis of the particulate filter (DPF).

In vehicles with the N47TU and N57TU the PM sensor is located after the SCR. Due to its location, the sensor needs to stand up to many exhaust hazards including ammonia and urea from the SCR system. This location also affects the sensor's ability to reach its necessary dew point. During this time the sensor sits idle and cannot be used to detect particulates.

The PM sensor is very similar to a NO<sub>x</sub> sensor with regard to the construction of the body and that it also uses its own control unit. It has a 24 mm spin nut and an upper assembly to protect the wiring. Its internal sensing element is installed in the sensing tube and protected by a outer heat shield tube which helps to guide exhaust gas flow to the sensing element.

The evaluation electronics generate the output signals based on the physical measured values. The control unit communicates via the Lo-CAN with the engine control unit.

### **PM sensor operation**

The sensor function is based on resistance measurements. Soot particles in the exhaust gas are absorbed into the sensor and collect on the sensing element. These soot particles are electrically conductive and form a conductive path between the electrodes of the sensing element through which an electric current is flowing. This decreases the resistance across the electrodes and increases the current flow. The increase in current flow is measured against a baseline threshold current. The amount of time that the current takes to reach this threshold current is then compared. The PM sensor control unit forwards this measured current feedback via the Lo-CAN to the DDE. The DDE then compares the amount of time that the signal takes to reach the specified threshold current, and based on this, evaluates the efficiency of the DPF.

Therefore if the current signal reaches the pre-set threshold before the predetermined time the DPF has failed.

# N57TU Engine

## 7. Engine Electrical System

The sensing element is regenerated regularly by heating to burn off the (conductive) soot accumulated on the sensor element. This is done via an integrated heater to restore the initial resistance across the electrodes in order to “zero” the baseline and prepare the sensor to test another soot sample.



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**For more information refer to the “Second generation diesel engine emission controls” in the ST1210 Diesel Technology training material available on TIS and ICP.**

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### 7.2.11. Exhaust gas temperature sensor

The exhaust gas after-treatment system of the N47TU and N57TU engines uses three exhaust temperature sensors (besides the EGR temperature sensor). One located directly next to the oxygen sensor at the inlet to the NSC/DPF, a second is bolted to the NSC/DPF housing (down stream of the NSC just before the DPF). The third is located just before the SCR near the dosing valve. The first two exhaust temperature sensors are used by the DDE to monitor the efficiency of the NSC and to regulate regeneration of the DPF. The third sensor is used to send exhaust temperature feed back to the DDE with regard to the SCR system.

All three exhaust temperature sensors are of the same type and operate as on previous engines. They contain a temperature-sensitive 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 5 Volts from the DDE. The electrical voltage at the resistor is dependent on the air 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 96 k $\Omega$  to 32  $\Omega$ , corresponding to a temperature of -40 °C to 800 °C (-40 °F to 1472 °F).



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**These specifications may vary. Please refer to the appropriate repair information for the most up to date repair instructions.**

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### 7.2.12. Fuel temperature and pressure sensor

Fuel temperature and pressure are monitored by a combination sensor that is located in the fuel supply directly upstream of the high-pressure pump. The combination sensor has four connections: The ground connection is shared by the individual sensors. The fuel-pressure sensor has a power supply and each sensor has one signal output.

#### Fuel temperature sensor

The fuel temperature sensor measures the fuel temperature upstream of the high-pressure pump. It is used for engine overheating protection and calculating the injection volume. The fuel temperature sensor is connected to ground and to a voltage divider circuit in the DDE. 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 5 Volts from the DDE. The electrical voltage at the resistor is dependent on the fuel temperature. There is a table stored in

# N57TU Engine

## 7. Engine Electrical System

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 75.5 k $\Omega$  to 87.6  $\Omega$ , corresponding to a temperature of -40 °C to 120 °C (-40 °F to 248 °F).



**These specifications may vary. Please refer to the appropriate repair information for the most up to date repair instructions.**



Fuel temperature/pressure sensor

### Fuel pressure sensor

The fuel temperature sensor measures the pressure in the fuel low-pressure system, upstream of the high-pressure pump. The fuel pressure is used by the DDE as a basis for the on-demand control of the electric fuel pump. The DDE connects the fuel pressure sensor to ground and supplies with a voltage of 5 V. It delivers a voltage signal to the DDE. A sheet diaphragm converts the fuel pressure into a path dimension. This path is converted into a voltage signal by four pressure-sensitive resistors.

### 7.2.13. Exhaust back-pressure sensor upstream of exhaust turbocharger

The exhaust back-pressure sensor upstream of the exhaust turbocharger is new. The new exhaust back-pressure sensor is manufactured by Denso.

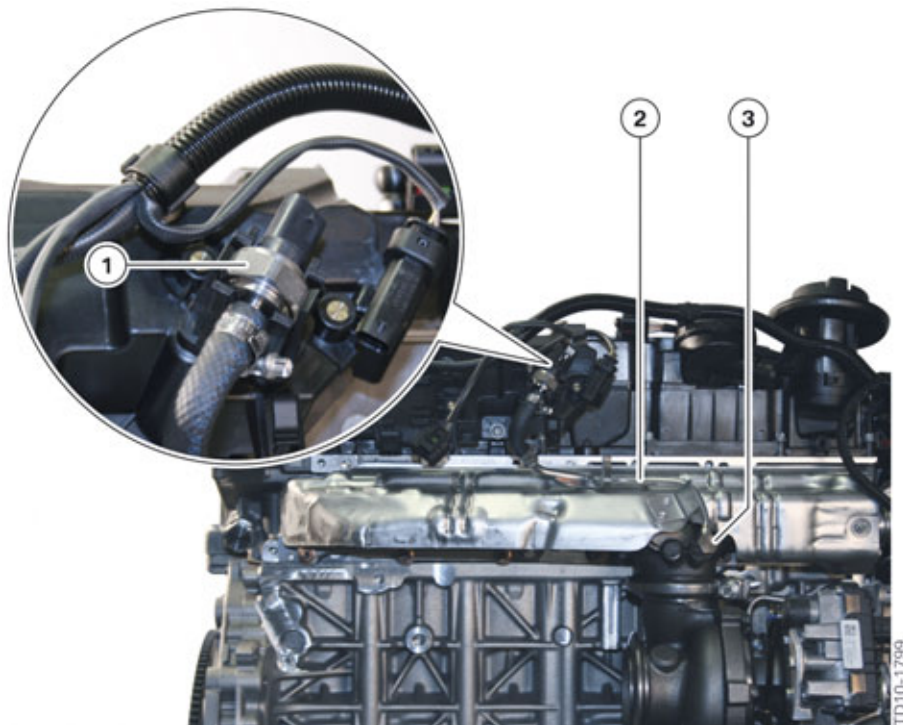
The exhaust back-pressure sensor measures the pressure in the exhaust emission system, upstream of the exhaust turbocharger. This information is required for optimum control of the exhaust-gas recirculation rate. The Digital Diesel Electronics (DDE) can control the exhaust-gas recirculation rate more precisely and efficiently via the exhaust back-pressure sensor and exhaust-gas temperature sensor.

The exhaust back-pressure sensor is connected to the exhaust manifold via a pipe and a hose. The reason for the distance from the exhaust manifold is that the temperature of exhaust emission system can be very high and dirt contamination may accumulate on the sensor element. The connection to the hose must point downwards. The exhaust back-pressure sensor is connected to the Digital Diesel Electronics (DDE) via three pins. The DDE provides the ground and a voltage of 5 volts. The voltage signal arrives at the DDE via the third pin.

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## 7. Engine Electrical System

Absolute pressure	Voltage
100 kPa (1.0 bar)	about 1.0 volts
500 kPa (5.0 bar)	about 4.5 volts



N57TU engine, exhaust back-pressure sensor

Index	Explanation
1	Exhaust back-pressure sensor
2	Connecting pipe
3	Connection to exhaust manifold

### 7.2.14. Throttle valve actuator

The throttle valve actuator is mounted on the intake manifold.

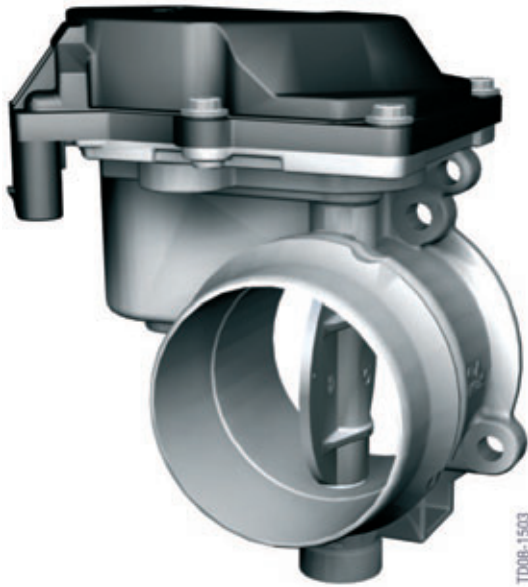
The DDE control unit calculates the position of the throttle valve from the position of the accelerator pedal and from the torque requirement of other control units. The throttle valve actuator is opened and closed electrically by the DDE control unit.

It is controlled by the DDE by means of a PWM signal with a pulse duty factor of 5 to 95%.

The throttle valve is also used for diesel particulate filter regeneration and to counteract shaking during engine switch-off.

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## 7. Engine Electrical System



Throttle valve actuator

### **Position sensor**

To achieve optimum control of the throttle valve, its exact position must be constantly recorded. The throttle valve position is monitored contactlessly in the throttle valve actuator by 2 Hall sensors. The position sensor is supplied with 5 Volts and connected to ground by the DDE. Two data lines guarantee redundant feedback of the throttle valve position to the DDE. The second signal is output as the inverse of the first. The DDE evaluates the plausibility of the signal through subtraction.

### **Actuator motor**

The actuator motor for operating the throttle valve is designed as a DC motor. It is driven by the DDE on demand. 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 is monitored by the diagnostics system. When no power is applied to the drive unit, the throttle valve is set, spring-loaded, to an emergency operation position

# N57TU Engine

## 8. Engine Control Functions

### 8.1. Air supply

In the diesel engine, the DDE requires information about the air mass taken in so that it can control various functions. 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 electrically controlled swirl flaps are located in the tangential ducts of the intake manifold (integrated in the gasket between the differentiated air intake system and the cylinder head). They are closed or opened depending on the operating condition. The electrically controllable swirl flaps are opened by the swirl flap actuator 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:

- The coolant temperature is  $< 15\text{ }^{\circ}\text{C}$
- The intake air temperature is  $< 15\text{ }^{\circ}\text{C}$

The swirl flap actuator is a stepper motor that is controlled by the DDE control unit by means of a PWM signal. The stepper motor operates the connection lever and the swirl flaps close. An integrated sensor signals the position of the swirl flaps to the DDE control unit.

#### 8.1.1. Boost-pressure control

The N57TU engine is boosted by an exhaust turbocharger. Adjustable guide vanes are pivoted on the outside around the turbine wheel on the exhaust side. The driving power which the exhaust gas exerts on the turbine is influenced by these guide vanes and thereby the desired boost pressure is set.

A boost pressure actuator on the turbine housing actuates the adjustable guide vanes via a control rod.

The Digital Diesel Electronics sends a pulse-width-modulated signal to the boost pressure actuator. The operating range of the signal is between 10% and 95%, where 10% means “guide vanes open” and 95% “guide vanes closed”. The electronics in the boost pressure actuator converts the pulse-width modulated signal into a setting angle and activates the servomotor.

A feedback of the set position is detected via the integrated travel feedback in the boost pressure actuator by the DDE. The boost pressure actuator itself is capable of self diagnosis and signals an existing fault to the DDE.

# N57TU Engine

## 8. Engine Control Functions

### 8.2. Fuel supply

#### 8.2.1. Fuel injection

The N57TU engine is equipped with high-pressure fuel injection with common rail pressure accumulator.

The common rail has the following advantages:

- Optimum fuel preparation for each individual cylinder.
- Adaptation of injection time to engine operating conditions (engine speed, load, temperature).
- Cylinder-selective injection correction in response to load change (the injection time can be corrected by post-injection, extending or shortening the time during the induction stroke).
- Cylinder-selective switch-off possible.
- Diagnostics of each individual injector is possible

Common rail injection offers these advantages due to the fact that all cylinders are supplied with fuel independently of each other.

#### 8.2.2. High-pressure control

The fuel quantity (flow) control valve establishes the fuel supply from the low pressure side to the high pressure side of the high-pressure pump, thus achieving the required rail pressure. The fuel quantity control valve is forced open hydraulically as from a defined pressure on the high pressure side of the high-pressure pump. The less fuel that the fuel quantity control valve allows into the high-pressure side, the less the radial cylinder/cylinders of the high-pressure pump will be filled. This results in a reduction in rail pressure. The signal from the rail pressure sensor is an important input signal for the DDE for the control of the volume control valve. During a cold start, the pressure in the rail is not controlled by the fuel quantity control valve but by the rail-pressure regulating valve in the rail.

The high-pressure pump therefore always generates maximum pressure, which causes the fuel to heat up. The rail-pressure regulating valve also relieves excess pressure in the rail if the accelerator pedal is suddenly released.

In the event of the rail pressure sensor failing, the DDE controls the volume control valve in emergency mode.

**See “Volumetric flow regulation functional description” and the “Fuel quantity control” section of this training manual for more information.**

#### 8.2.3. Injector volume calibration

At the end of the injector manufacturing process, measuring data is recorded for each individual injector. 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. This correction value is printed on the injector as a seven-digit numerical code. In the event of an injector replacement, this correction value must be programmed into the DDE using the diagnostic system.



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## 8. Engine Control Functions

### 8.2.4. Volume calibration 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 calibration control equalizes the injection volume of all cylinders.

### 8.2.5. 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.

### 8.2.6. 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.

The mean volume adaptation is not an "instantaneous" regulation but an adaptive learning process. In other words, the injection volume error is taught into an adaptive characteristic map that is permanently stored in the EEPROM of the control unit.

A replacement of the following components requires a reset (delete) of this characteristic map:

- HFM
- Injector(s)
- Rail-pressure sensor

The characteristic map is reset by a function in the BMW diagnostic 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 (upstream of the NSC)

# N57TU Engine

## 8. Engine Control Functions

### 8.3. Exhaust emission system

#### 8.3.1. 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 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.

Second generation diesel engines (N47TU and N57TU) use a Nox storage catalyst in place of (the previously used) oxidation catalyst. Both oxidation and reduction processes occur in the NSC catalytic converter. Oxygen (O<sub>2</sub>) is required for oxidation while carbon monoxide CO is required for reduction. The pollutants CO, HC, NO<sub>x</sub> and the reduction catalysts O<sub>2</sub> and CO must be present in a certain ratio in order to facilitate the highest possible conversion rate.

The system uses a second oxygen sensor located downstream of the diesel particulate filter. This second oxygen sensor enables the system to detect whether the NO<sub>x</sub> storage catalytic converter needs to be regenerated.



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**For more information regarding the NO<sub>x</sub> storage catalytic converter refer to the “Second generation diesel engine emission controls” in the ST1210 Diesel Technology training material available on TIS and ICP.**

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#### 8.3.2. 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 near the 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.

# N57TU Engine

## 8. Engine Control Functions

The service function "Reset adaptation data" can be used to reset the adaptation data and the equipment options back 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.

### 8.3.3. Exhaust gas recirculation (EGR)

As with previous BMW diesels the N57TU also uses an Exhaust Gas Recirculation System.



EGR valve

A calculated volume of exhaust gas based on the prevailing operating condition is fed back to the intake manifold by the EGR valve to reduce emissions.

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.

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

- Engine speed
- Injected quantity
- Coolant temperature

# N57TU Engine

## 8. Engine Control Functions

- 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 (up stream of the NSC) 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 EGR temperature sensor and the exhaust back-pressure sensor upstream of the turbocharger in conjunction with the boost pressure sensor make it possible to precisely control the exhaust recirculation rate. Thus substantially improved control of the quantity of recirculated exhaust and, therefore, of the NO<sub>x</sub> content of the exhaust is possible.

### Function

The exhaust-gas recirculation actuator is opened or closed electrically by the DDE control unit. To ensure optimized control of the exhaust-gas recirculation rate, the exact position must be continuously detected. The position of the exhaust-gas recirculation actuator is monitored by a non-contact hall effect sensor.

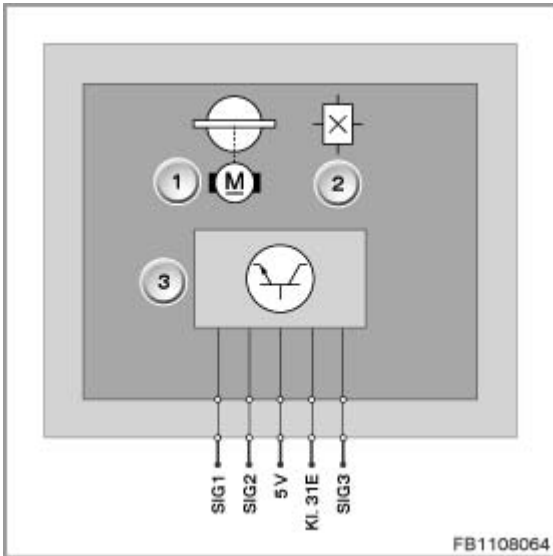
The mean quantity adaptation (MMA) serves to adapt the exhaust-gas recirculation more precisely to fine tune the fuel injection rates. The air ratio measured by the oxygen sensor and the air mass measured by the hot-film air-mass meter are used to determine a mean fuel injection rate across all cylinders. This value is compared with the fuel injection rate specified by the DDE control unit. If there is a deviation, the air mass is adapted to the actual fuel injection rate by adjusting the exhaust-gas recirculation actuator in such a way that the correct air ratio is set.

The mean quantity adaptation is not a rapid control operation, rather an adaptive learning procedure. That means that the fuel injection rate error is learned in an adaptive characteristic map that is stored permanently in the DDE control unit.

The servomotor for the exhaust-gas recirculation actuator is a direct current motor. The position sensor is a hall effect sensor. The hall effect sensor determines the revolutions of the servomotor. This is used to calculate the position of the exhaust-gas recirculation actuator.

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## 8. Engine Control Functions



Electronic EGR valve

Index	Explanation
1	Exhaust gas recirculation actuator
2	Electronic component with evaluation electronics
3	Hall effect sensor
SIG 1	Activation of EGR actuator, positive terminal
SIG 2	Activation of EGR actuator, negative terminal
5 V	Hall effect sensor voltage
Terminal 31E	Hall effect sensor ground
SIG 3	Hall effect sensor signal

### Diagnosis

Observe the following nominal values for the exhaust-gas recirculation actuator:

Variable	Value
Servomotor supply voltage	12 Volts
Activation frequency for servomotor	1300 hz
Servomotor blocking current	5 A
Hall effect sensor supply voltage	4.5 to 5.5 V
Hall effect sensor power consumption	20 mA
Temperature range of the Hall effect sensor and servomotor	-40 °C to 140 °C (-40 °F to 284 °F)

# N57TU Engine

## 8. Engine Control Functions

If the hall effect sensor fails, the following behavior is to be expected:

- Fault entry in the engine control unit
- Emergency operation with substitute value (limited engine torque)
- Check Control message

If the servomotor fails, the following behavior is to be expected:

- Fault entry in the engine control unit
- No exhaust-gas recirculation
- Check Control message



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**If the exhaust-gas recirculation (EGR) valve is replaced, the adaptation of exhaust-gas recirculation actuator service function must be run in ISTA.**

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**For more information regarding exhaust emission systems please refer to ST1210 “Diesel Technology” training material available on TIS and ICP.**

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