

Reference Manual



B46 ENGINE



Technical Training

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Technical training.
Product information.

B46 Engine



BMW Service

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Technical Training

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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.

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 a 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.

Contact:

Sebastian Riedel

Tel.: +49 (0) 89 382 65044

E-mail: sebastian.rs.riedel@bmw.de

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1. Introduction

This document describes the special features of the new 4-cylinder engine and serves to support the technical service. Due to the huge similarities, between the B38 Top engine and B46, the two engines are described in this one document. Some images shown relate to the 3-cylinder engine. The differences compared to the 4-cylinder engine are shown and described separately. However, the similarities are not repeated. The engines are distinguished as follows in this document:

- B38 = 3-cylinder engine
- B46 = 4-cylinder engine
- Bx8 = 3 and 4-cylinder engine

1.1. Engine designation

In the technical documentation, the engine designation is used to ensure unambiguous identification of the engine. Frequently, only a short designation is used, which is explained in the following table.

Position	Meaning	Index	Explanation
1	Engine developer	B	BMW Group engine
2	Engine type	3	3-cylinder in-line engine
		4	4-cylinder in-line engine
3	Change to the basic engine concept	6	SULEV/Turbo-Valvetronic Direct Injection (TVDI)
		8	Turbo-Valvetronic Direct Injection (TVDI)
4	Working method or fuel and installation position	A	Gasoline engine, transversal installation
5 + 6	Displacement in 1/10 liter	15	1.5 liter displacement
		20	2.0 liter displacement
7	Performance classes	K	Lowest
		U	Lower
		M	Middle
		O	Upper
		T	Top
		S	Super
8	Revision relevant to approval	0	New development
		1	First revision
		2	Second revision

B46 Engine

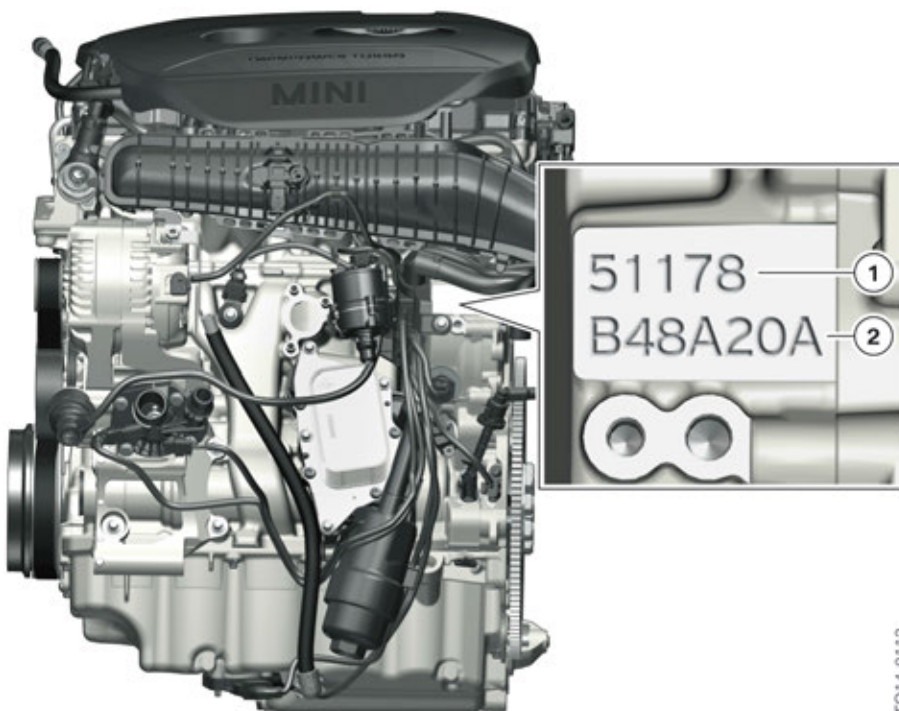
1. Introduction

1.2. Engine identification

The 7-digit engine identification is on the crankcase. The first six digits of the engine identification are derived from the engine type. Only the seventh digit is different. The seventh digit of the engine identification is the test number of the type approval certification.

The consecutive engine number is embossed above the engine identification. Using these two numbers the engine can be clearly identified by the manufacturer.

1.2.1. 4-cylinder engine



Engine identification for B46 engine

Index	Explanation
1	Engine number
2	Engine identification

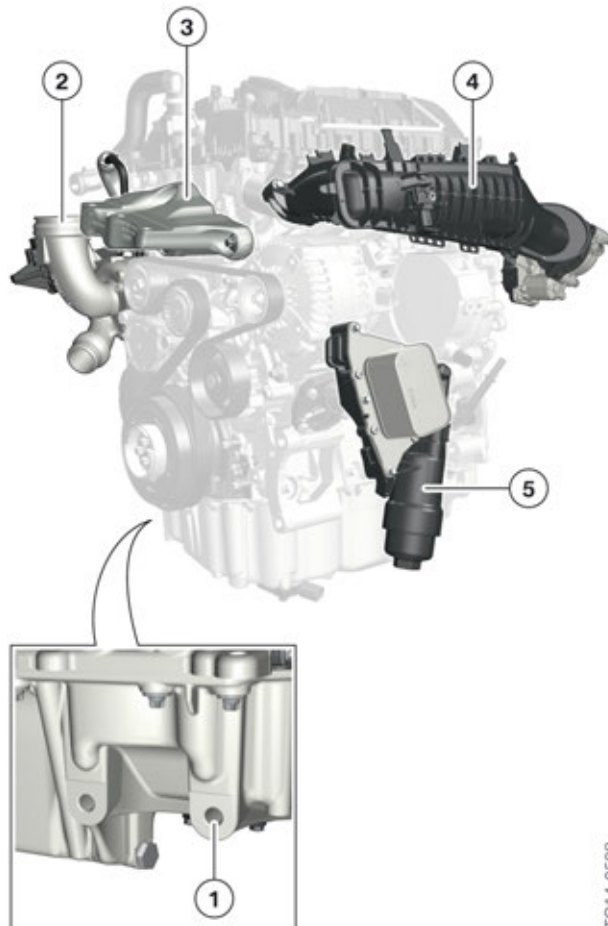
B46 Engine

1. Introduction

1.3. Highlights

1.3.1. Installation positions

Depending on the drive concept, the installation positions of the new engines vary in the different vehicles.



Transverse mounting position, B38 Top engine

Index	Explanation
1	Connection for anti-roll bar link
2	Compressor on intake side, curved
3	Engine mount
4	Intake system in the direction of the transmission
5	Oil filter module, suspended

B46 Engine

1. Introduction

This following drive and installation variants are available:

- Transverse mounting
Front-wheel drives
Four-wheel drives
- Automatic transmission

1.3.2. Advantages

Benefits due to lower number of cylinders:

- less weight
- fewer moving masses
- less spatial requirement
- reduction of internal engine friction

The B46 engine is based on the familiar N20 engine. The familiar TVDI¹ technology is used in all new engines. An offset or axial offset, as used in the N20 engine, is not used with the new B46 engine.

The new engine generation is mainly characterized by lower fuel consumption and fewer exhaust emissions (ULEV II). To achieve low fuel consumption, a map-controlled oil pump, characteristic map thermostat and injection system with direct-rail and electric arc wire-sprayed cylinder barrels, among others, are used. All engines also receive an automatic engine start-stop function and intelligent alternator control as a further EfficientDynamics measure.

¹TVDI technology consists of:

- T = Turbocharger
- V = Valvetronic
- DI = Direct-Injection (direct fuel injection)

1.3.3. Overview of technical features

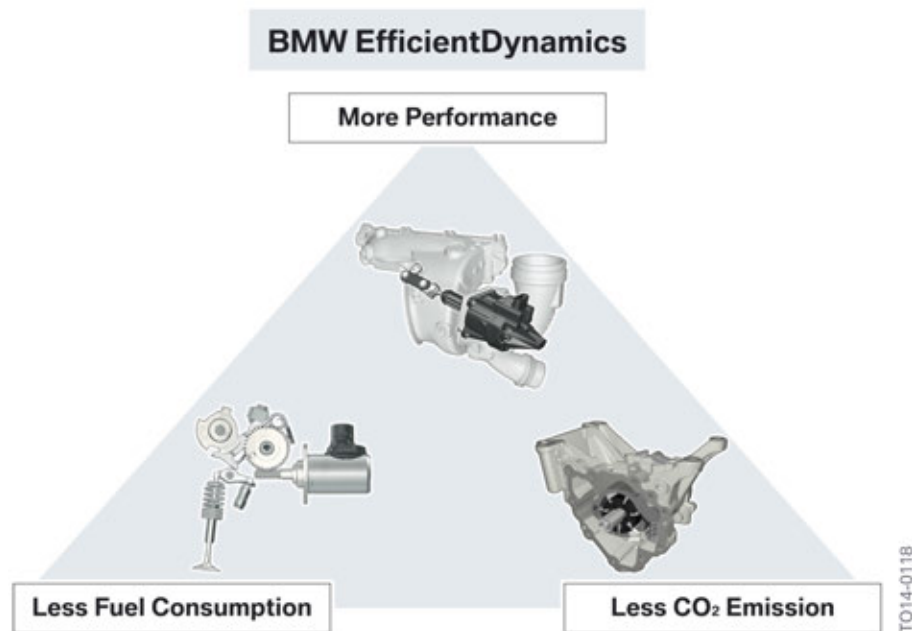
	B46A20
Map-controlled oil pump	Yes
Electric arc wire-sprayed cylinder barrels	Yes
Twin-scroll exhaust turbocharger	Yes
Electrically adjustable wastegate valve	Yes
Direct rail	Yes
Double VANOS	Yes
Valvetronic	Yes

B46 Engine

1. Introduction

1.4. Modular design

The EfficientDynamics strategy of the N engine generation has resulted in a large number of different technologies finding their way into the BMW engine world. The strategy for the simplification of inspection work is also pursued with the B engine generation.



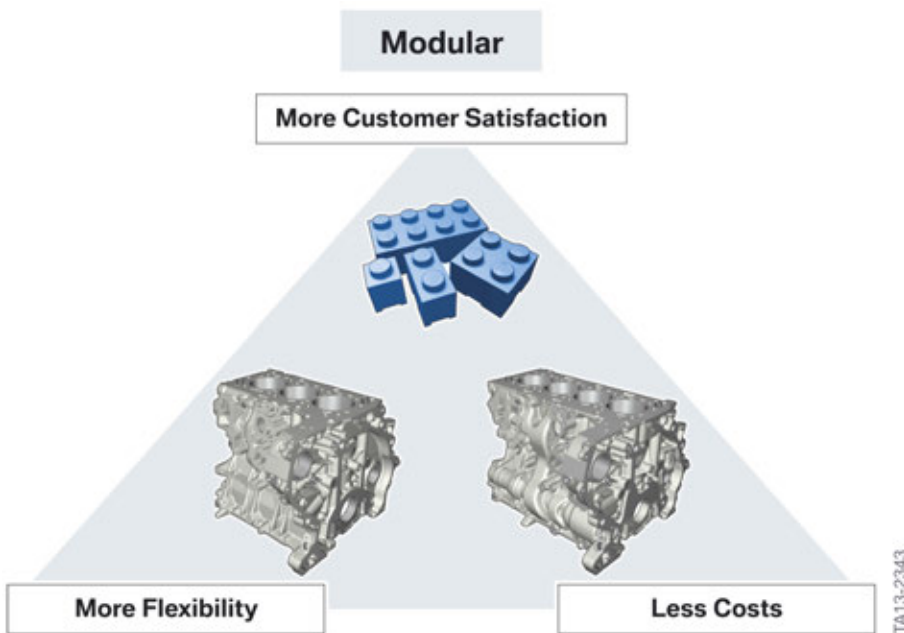
BMW EfficientDynamics strategy of the Bx8 engine generation

Designation	Explanation
BMW EfficientDynamics	BMW EfficientDynamics strategy
More performance	More performance
Less fuel consumption	Less fuel consumption
Fewer CO ₂ emissions	Less carbon dioxide emissions

BMW EfficientDynamics also stands for more power, less consumption and less carbon dioxide emissions in the new engine generation. With the additional modular strategy, other objectives such as lower costs, greater production flexibility, as well as enhanced customer satisfaction, are now also being pursued.

B46 Engine

1. Introduction



Modular strategy of Bx8 engine generation

Designation	Explanation
Modular	Modular strategy
Enhanced customer satisfaction	Enhanced customer satisfaction
Greater flexibility	Greater flexibility
Less costs	Less costs

The modular strategy aims for different effects throughout the product development process and product life cycle. This allows development and manufacturing costs, for example, to be lowered by using uniform processes. In production, the complexity of the manufacturing process planning and implementation is reduced. In Service, the warehousing is simplified as a result of the reduction of part variety, and the safe handling of products is increased.

B46 Engine

1. Introduction

1.4.1. TwinPower Turbo

All B46 engines are equipped with the established TwinPower Turbo Technologies.



TwinPower Turbo Technology, B46 engine

TwinPower Turbo means that the following technologies are used:

- VANOS
- Valvetronic
- Direct fuel injection
- Turbocharging

1.5. Technical data

	B46A20M0
Power output in [hp] at [rpm]	231 4700 – 6000
Torque in [Nm] at [rpm]	350 1250
Design/Number of cylinders	Row 4
Displacement in [cm ³]	1998
Bore / stroke in [mm]	82/94.6
Compression ratio	11 : 1
Valves per cylinder	4
Used as of	07/2014
Model	X1

B46 Engine

1. Introduction

1.5.1. Model overview

The table below provides an overview of the BMW models in which the new engines are used:

BMW models	Engine
X1	B46A20M0

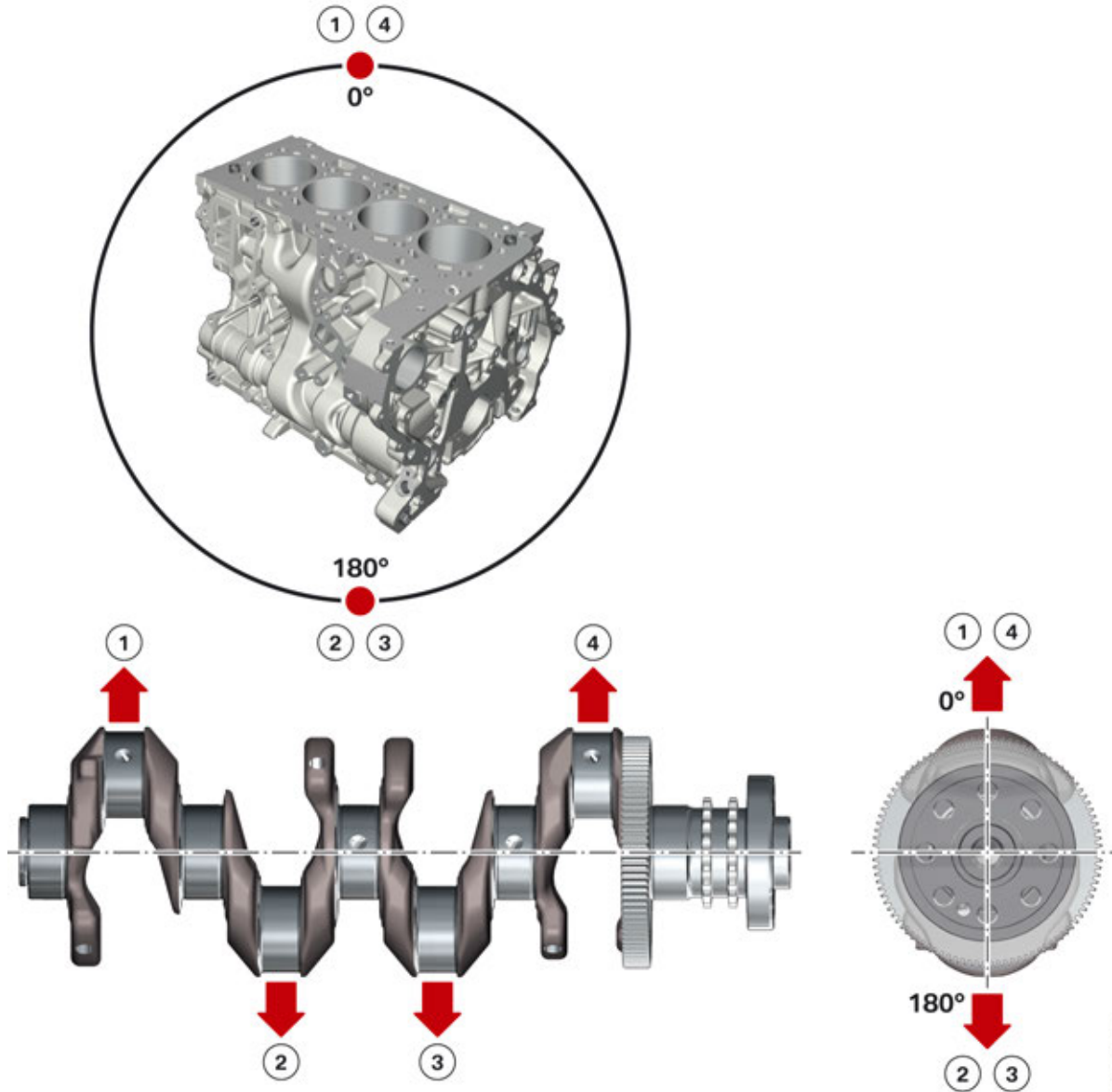
1.6. Engine acoustics

In order to understand the origin of the acoustic differences, we must take a look at the engine mechanics and compare the design features of the engine. The following graphics illustrate the origin of the different acoustics.

B46 Engine

1. Introduction

1.6.1. Comparison



Firing interval of B46 engine

Index	Explanation
1	Connecting rod bearing journal, cylinder 1
2	Connecting rod bearing journal, cylinder 2
3	Connecting rod bearing journal, cylinder 3
4	Connecting rod bearing journal, cylinder 4

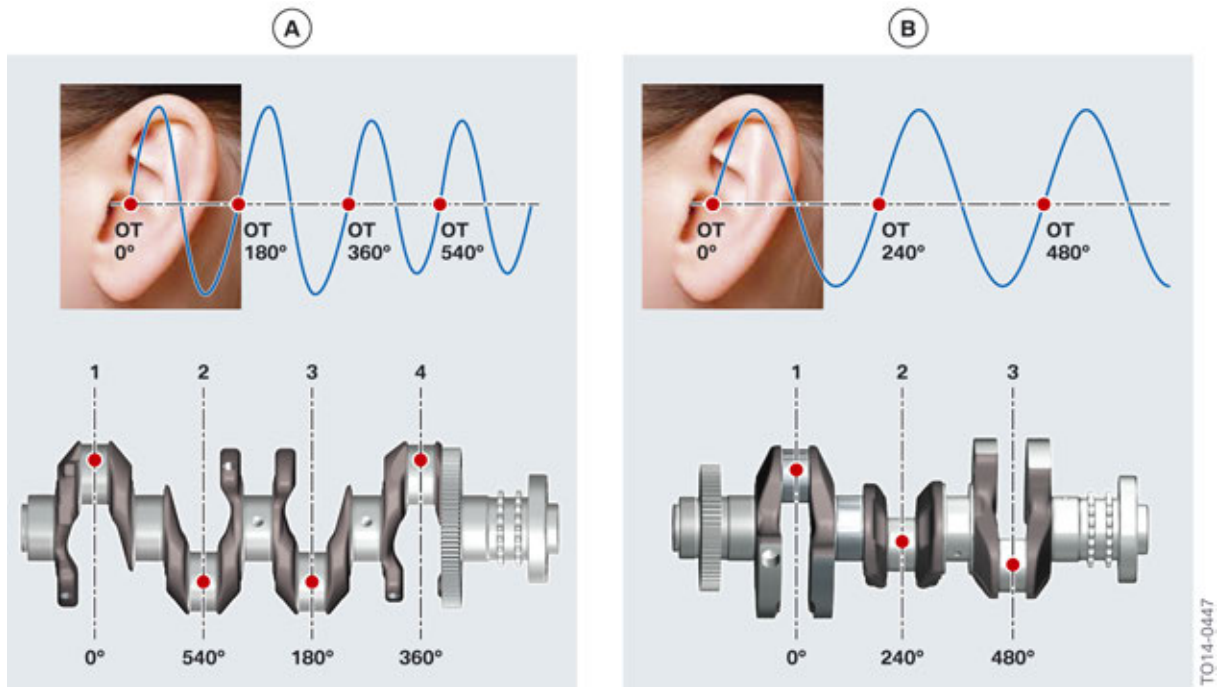
TA13-1625

B46 Engine

1. Introduction

The graphic shows a 4-cylinder in-line engine with a firing interval of 180° and a firing order of 1-3-4-2. One crankshaft revolution (360°) results in two work cycles for the 4-cylinder in-line engine.

The acoustic differences therefore have their origin in the different firing intervals.



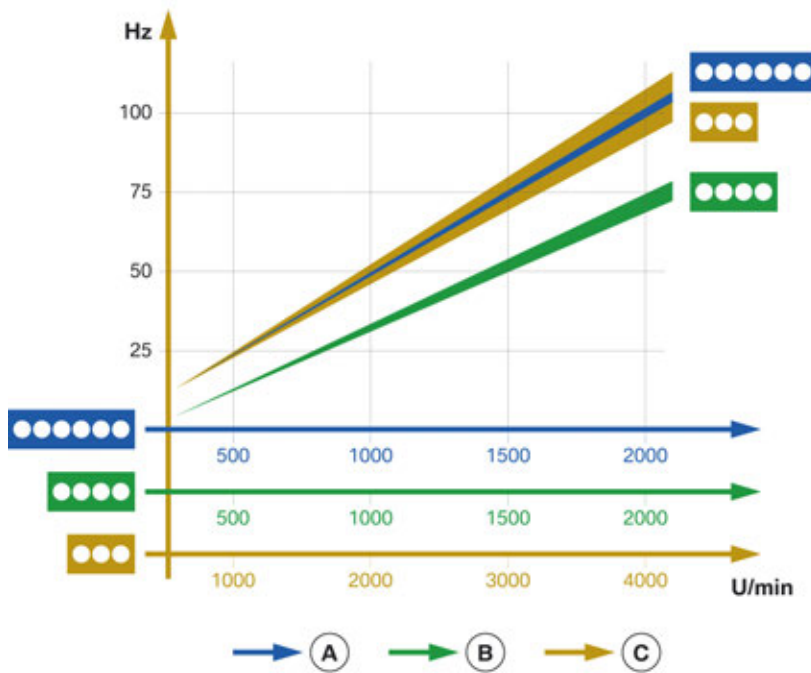
Acoustic oscillations of the Bx8 engines

Index	Explanation
A	Acoustic oscillation of the 4-cylinder in-line engine
B	Acoustic oscillation of the 3-cylinder in-line engine

If one compares the acoustic oscillations of the two engines as a result of the ignition process, there are two different engine sounds. The sound of the 4-cylinder in-line engine is perceived as harmonious and smooth.

B46 Engine

1. Introduction



TA13-2344

Acoustic diagram showing comparison between 3, 4 and 6-cylinder engine

Index	Explanation
A	6-cylinder in-line engine
B	4-cylinder in-line engine
C	3-cylinder in-line engine
Hz	Dominant firing frequency [f]
rpm	Revolutions per minute

The dominant firing frequencies [f] can be calculated as follows:

- 6-cylinder in-line engine (firing order 3)
 $f = \text{Engine speed} : 60 \cdot 3$
- 4-cylinder in-line engine (firing order 2)
 $f = \text{Engine speed} : 60 \cdot 2$
- 3-cylinder in-line engine (firing order 1.5)
 $f = \text{Engine speed} : 60 \cdot 1.5$.

Overview of firing interval

Engine	Number of cylinders	Firing order	Firing interval
4-cylinder engine (B46)	4	1-3-4-2	180°

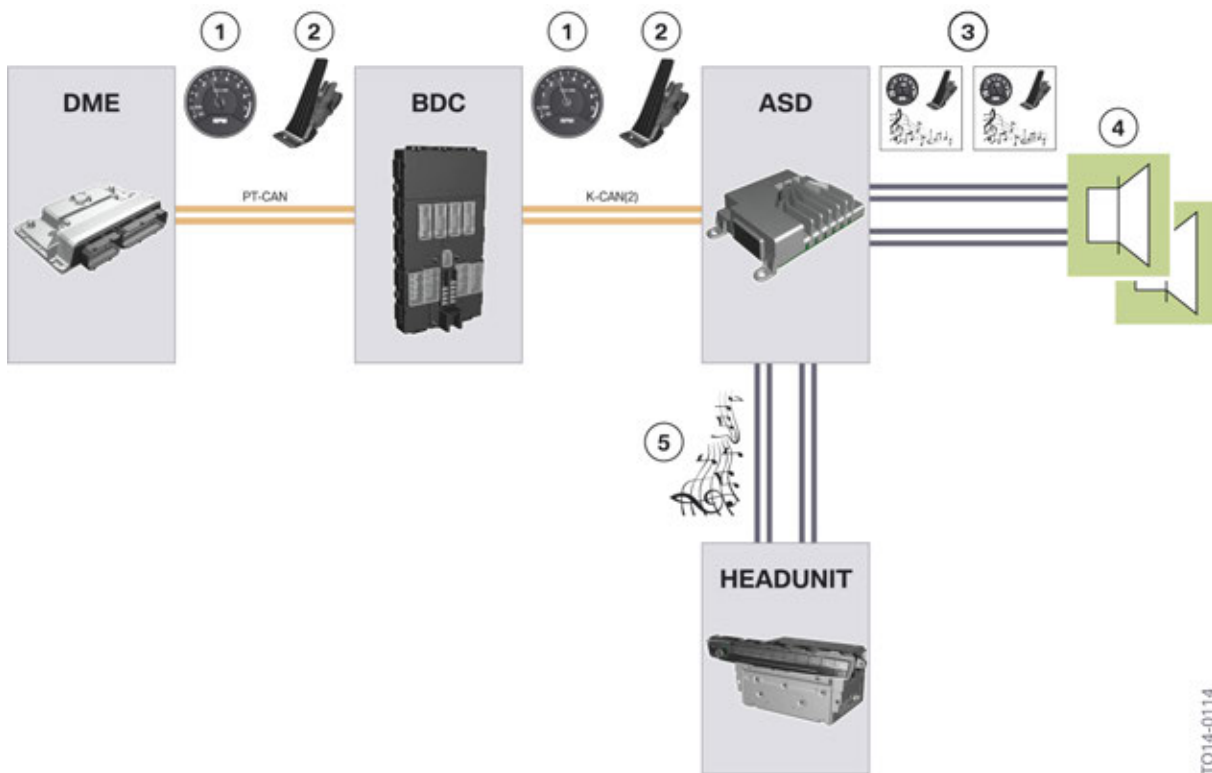
B46 Engine

1. Introduction

1.6.2. Active Sound Design

The acoustics of the engine can be adapted using the hi-fi system. With the help of the audio system installed in the vehicle, the vehicle sound pattern is supported by the use of the Active Sound Design. The sound pattern is achieved with the reinforcement of the acoustic components, which are generated by the engine.

The following graphic provides a system overview.



TO14-0114

Bus structure of Active Sound Design

Index	Explanation
1	Engine speed
2	Load
3	Audio signal of the Active Sound Design (ASD)
4	Speaker
5	Audio signal of the headunit
ASD	Active Sound Design
BDC	Body Domain Controller
DME	Digital Motor Electronics
Headunit	Control unit for entertainment and infotainment functions
K-CAN/K-CAN2	Body controller area network (2)
PT-CAN	Powertrain controller area network

B46 Engine

1. Introduction

The Digital Motor Electronics (DME) engine control unit sends information about the engine speed and load via the PT-CAN to the Body Domain Controller (BDC). The Body Domain Controller (BDC) transmits this information from the PT-CAN to the K-CAN/K-CAN2. Via the K-CAN/K-CAN2 the information reaches the Active Sound Design (ASD) control unit. The Active Sound Design (ASD) control unit generates an audio signal with this information. This audio signal is modulated to the audio signal of the headunit and forwarded to the loudspeakers. An engine sound corresponding to the driving condition is output to the driver via the speaker.

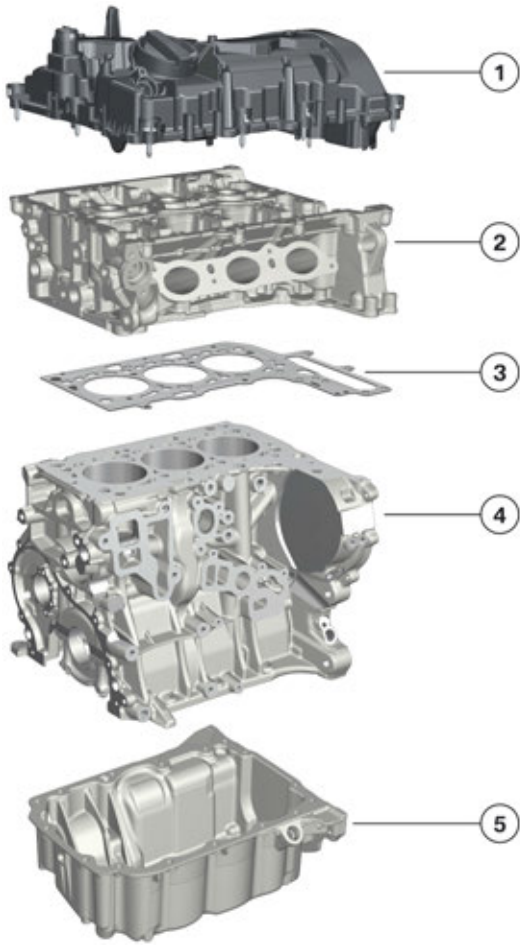


The Active Sound Design (ASD) can be muted up to the next terminal change via the ISTA diagnosis system. It is not possible to deactivate the Active Sound Design permanently.

B46 Engine

2. Engine Mechanical

2.1. Engine housing



TO14-0122

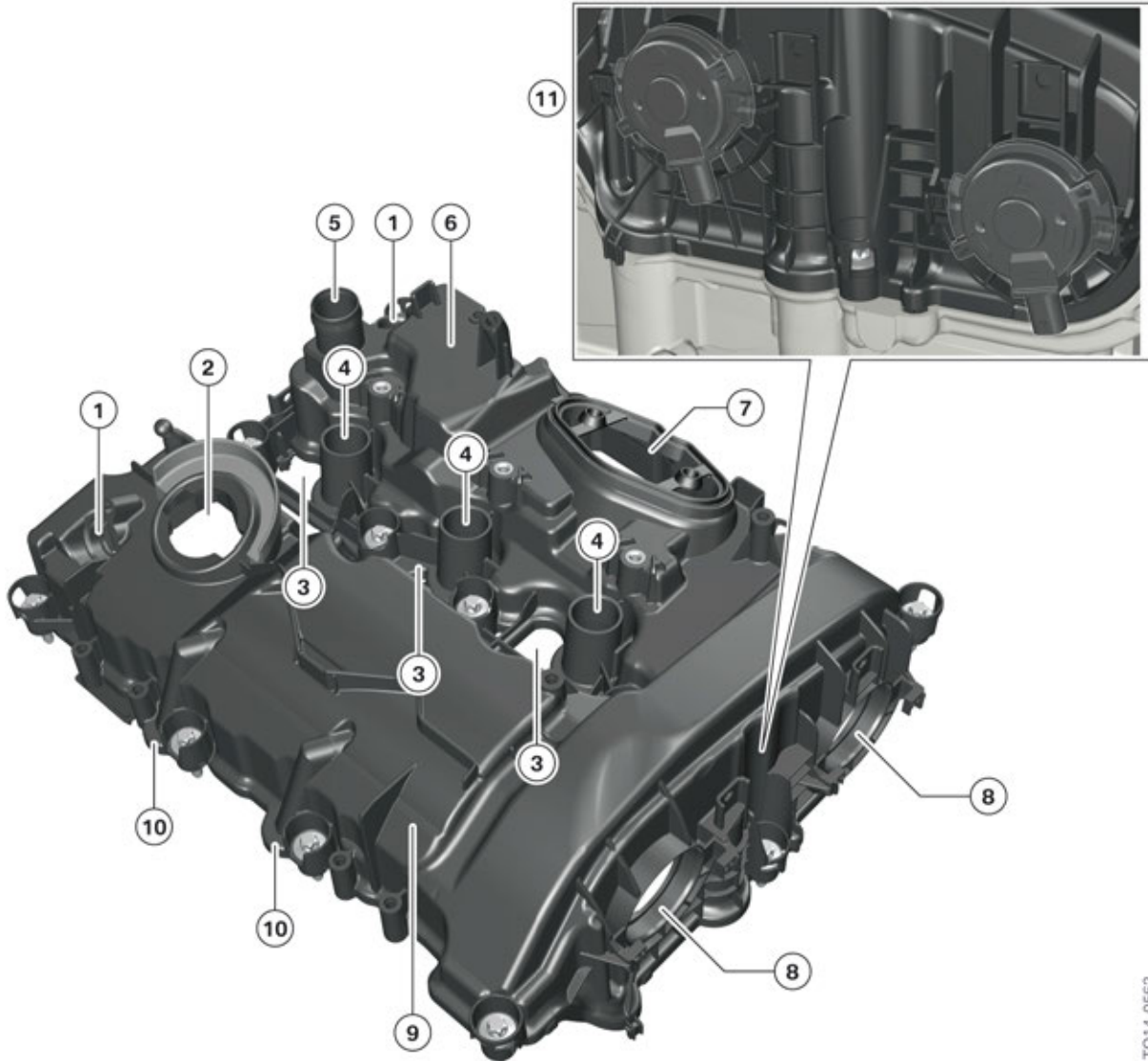
Engine housing of B38 engine

Index	Explanation
1	Cylinder head cover
2	Cylinder head
3	Cylinder head gasket
4	Crankcase
5	Oil sump

B46 Engine

2. Engine Mechanical

2.1.1. Cylinder head cover



Cylinder head cover B38 engine

TO14-0562

Index	Explanation
1	Mountings of camshaft sensors
2	Oil filler neck
3	Recesses for injectors
4	Mountings for ignition coils
5	Blow-by channel, turbocharged operation
6	Oil separator, turbocharged operation
7	Mounting for high pressure pump

B46 Engine

2. Engine Mechanical

Index	Explanation
8	Mountings of VANOS solenoid valve actuators
9	Oil separator, naturally aspirated engine operation
10	Blow-by channel, naturally aspirated engine operation
11	Bayonet fitting with retaining clips

As is the case with the existing N20 engine, the B46 engine also has a recess for mounting the VANOS solenoid valve actuators in the cylinder head cover. In contrast to the N20 engine, the VANOS solenoid valve actuators are not screwed on, and instead are fastened using a bayonet fitting and retaining clips.

Tasks of crankcase ventilation:

- Regulation of the internal engine pressure.
- Cleaning the blow-by gases to remove engine oil.
- Recirculation of the cleaned blow-by gases in the intake area.

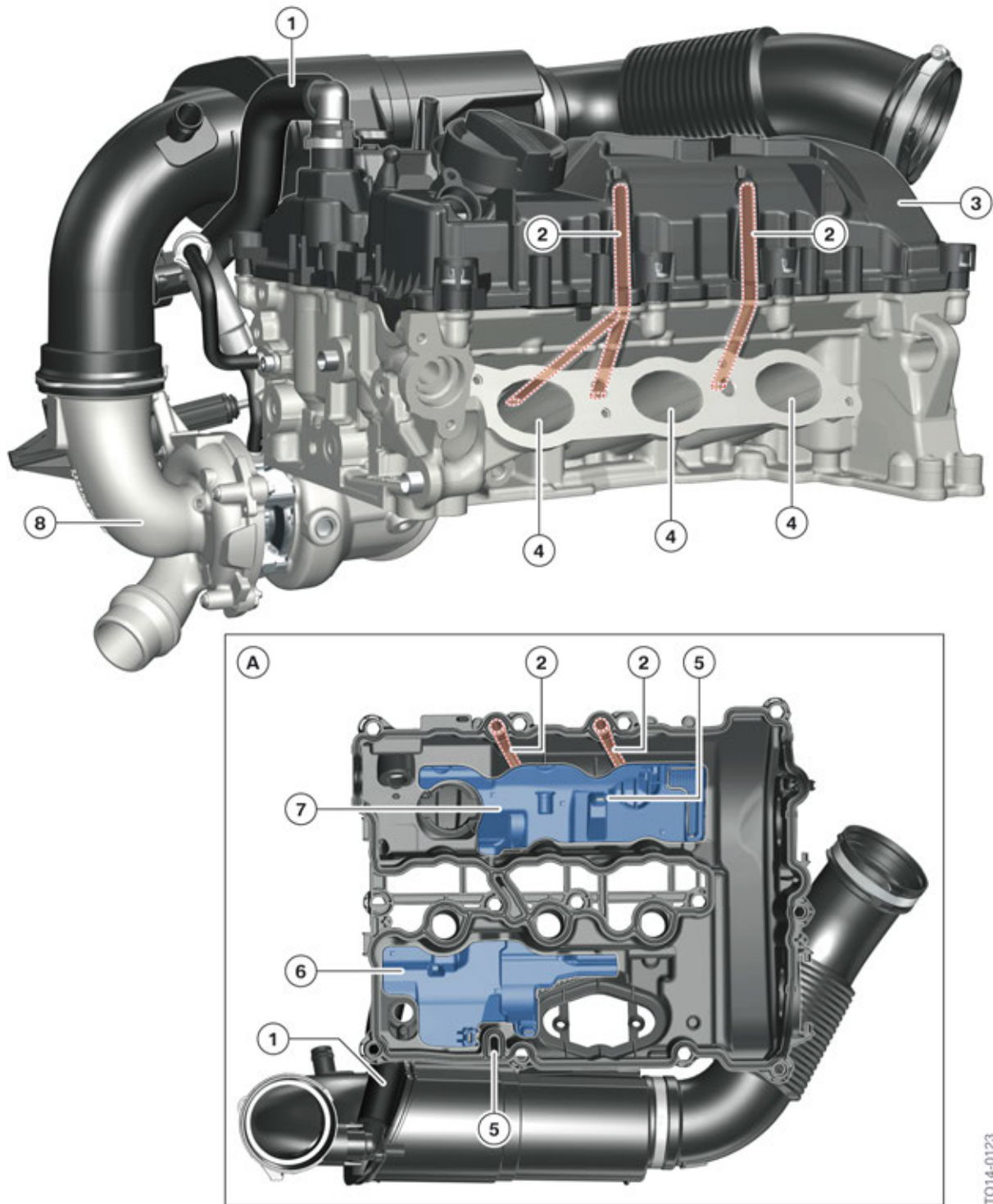
When the engine is in operation, gases (referred to as "blow-by gases") from the combustion chamber pass through the cylinder walls and enter the crankcase. These blow-by gases contain unburned fuel and all elements of the exhaust gas. In the crankcase they are mixed with engine oil which is available there in the form of oil mist.

The volume of the blow-by gases is dependent on the engine speed and the load. Without crankcase ventilation excess pressure would arise in the crankcase. This excess pressure would be present in all cavities connected to the crankcase (e.g. oil return duct, chain shaft, etc.) and lead to oil leakage at the seals.

The crankcase ventilation prevents this. It routes the extensively engine oil-free blow-by gases to the clean air pipe and the separated droplets of oil flow back to the oil sump via an oil return pipe. In addition, the crankcase ventilation, in combination with a pressure control valve, ensures a low vacuum in the crankcase.

B46 Engine

2. Engine Mechanical



Crankcase ventilation, B38 engine

TO14-0123

B46 Engine

2. Engine Mechanical

Index	Explanation
A	Cylinder head cover, view from below
1	Blow-by channel into clean air pipe (turbocharged operation)
2	Blow-by channel upstream of the intake valves (naturally aspirated engine operation)
3	Cylinder head cover
4	Intake ports
5	Oil return
6	Oil separator (turbocharged operation)
7	Oil separator (naturally aspirated engine operation)
8	Exhaust turbocharger

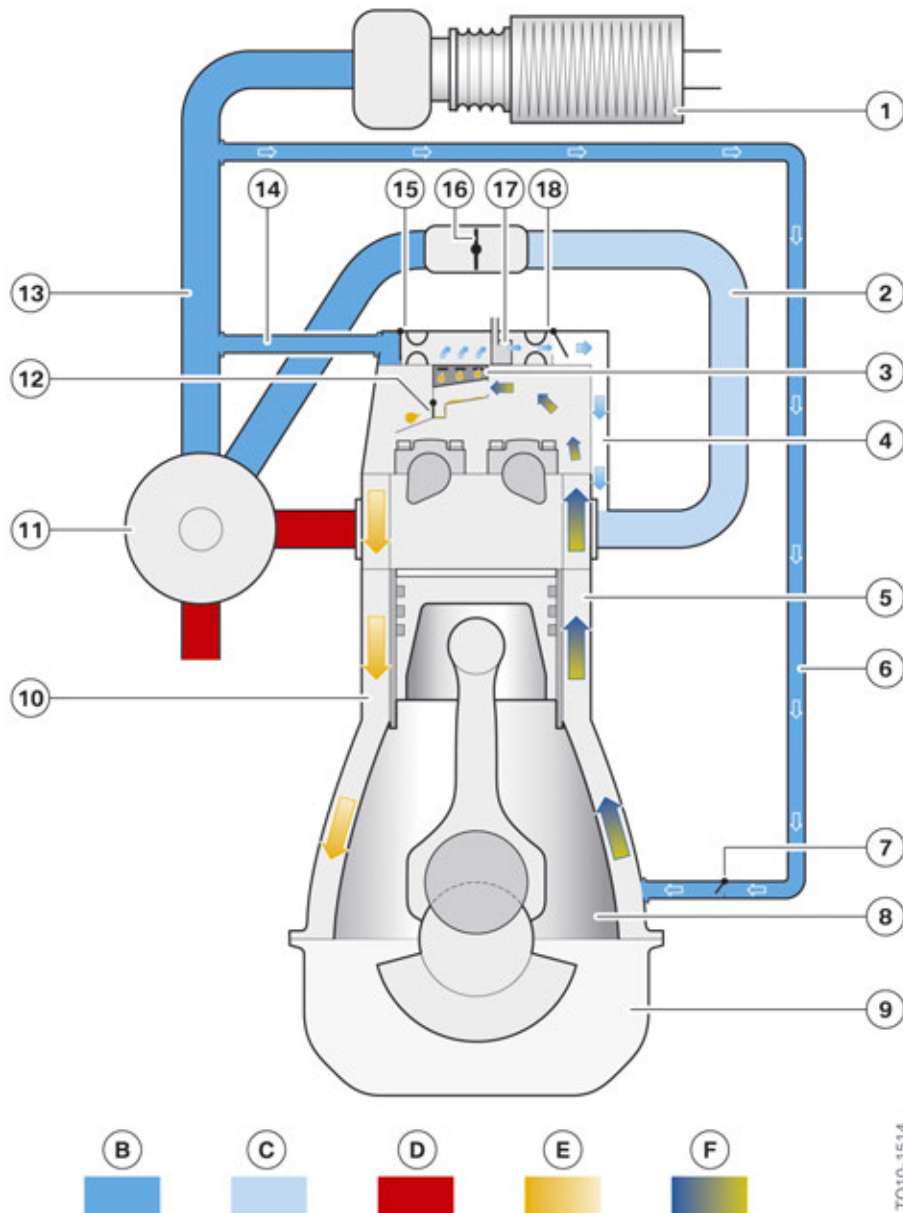
The crankcase ventilation in B46 engine has a two-stage design. This means that, depending on the load condition, the blow-by gases are routed via different channels.

Naturally aspirated engine operation

During naturally-aspirated engine operation, the blow-by gases upstream of the intake valves are routed to the intake port.

B46 Engine

2. Engine Mechanical



Crankcase ventilation, naturally aspirated operation of Bx8 engine

Index	Explanation
B	Ambient pressure
C	Vacuum
D	Exhaust gas
E	Oil
F	Blow-by gas
1	Air filter
2	Intake manifold

B46 Engine

2. Engine Mechanical

Index	Explanation
3	Separator
4	Blow-by channel upstream of the intake valves
5	Blow-by channel upstream of crankcase
6	Purge air line
7	Non-return valve
8	Crank chamber
9	Oil sump
10	Oil return
11	Exhaust turbocharger
12	Non-return valve, oil return
13	Clean air pipe
14	Hose to clean air pipe
15	Non-return valve with restrictor
16	Throttle valve
17	Pressure control valve
18	Non-return valve with restrictor

The fine oil mist is separated from the blow-by gases with the assistance of a separator and the oil droplets formed are routed back to the oil sump via the oil return.

The throttle valve is closed during naturally-aspirated engine operation. This produces a vacuum in the intake system, which draws in the blow-by gases via blow-by channels cast into the cylinder head directly upstream of the intake valves. In systems controlled by Valvetronic, the throttle valve is also lightly shut in these operating conditions to guarantee the engine ventilation function.

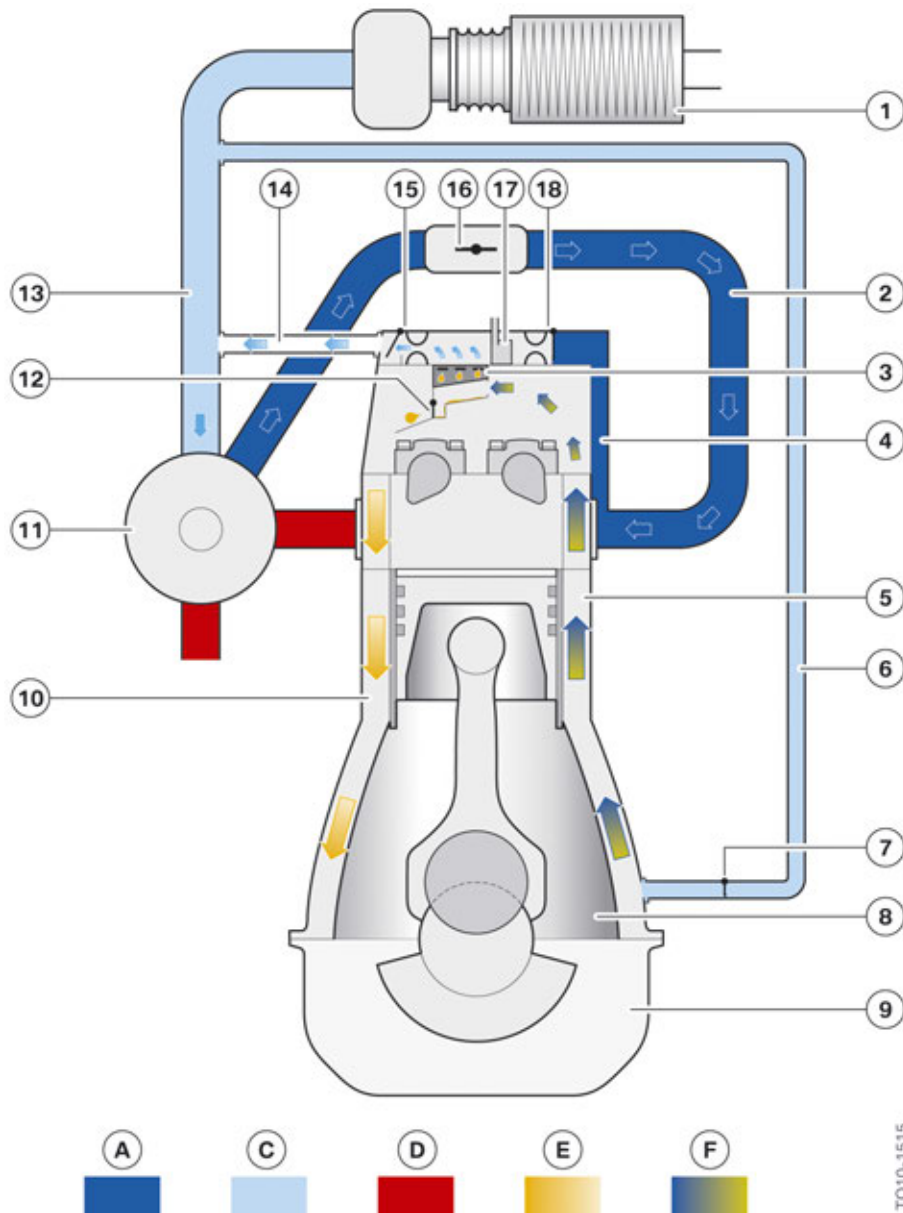
A purge air line, which is connected to the clean air pipe ahead of the exhaust turbocharger and to the crankcase, routes fresh air via a non-return valve directly into the crankcase chamber. The bigger the vacuum in the crankcase, the bigger the air mass introduced into the crankcase. This purging prevents the pressure control valve from icing up.

Charged operation

As a significant overpressure prevails in the intake pipe during turbocharged operation, the blow-by gases cannot be introduced upstream of the intake valves in the intake port. The blow-by gases are therefore introduced into the clean air pipe in this operating condition.

B46 Engine

2. Engine Mechanical



Crankcase ventilation with turbocharged operation of B46 engine

Index	Explanation
A	Charging pressure
C	Vacuum
D	Exhaust gas
E	Oil
F	Oil and blow-by fuel-air mixture
1	Air filter
2	Intake manifold

B46 Engine

2. Engine Mechanical

Index	Explanation
3	Separator
4	Blow-by channel upstream of the intake valves
5	Blow-by channel upstream of crankcase
6	Purge air line
7	Non-return valve
8	Crank chamber
9	Oil sump
10	Oil return
11	Exhaust turbocharger
12	Non-return valve, oil return
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14	Hose to clean air pipe
15	Non-return valve with restrictor
16	Throttle valve
17	Pressure control valve
18	Non-return valve with restrictor

The fine oil mist is separated from the blow-by gases with the assistance of a separator and the oil droplets formed are routed back to the oil sump via the oil return.

The cylinder head cover is connected to the clean air pipe by a hose. During turbocharged operation, a vacuum is produced in the clean air pipe. This vacuum draws the blow-by gases into the clean air pipe via the hose.



Always ensure absolute cleanliness when filling the engine with engine oil. Clean the oil filler neck before you screw on the sealing cap. Engine oil residue at the sealing cap may lead to misdiagnosis at the crankcase ventilation.

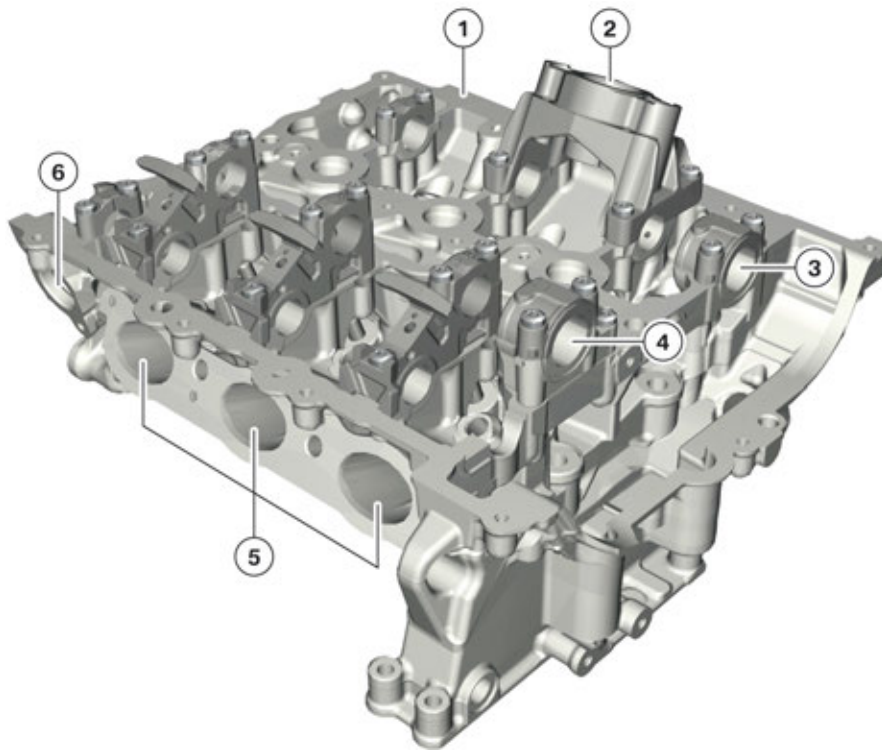
2.1.2. Cylinder head

Technical features:

- Material: AlSi7MgCu0.5
- Coolant cooling according to the cross-flow principle
- Four valves per cylinder
- Mounting of the valve gear
- Mounting of the Valvetronic and the Valvetronic servomotor
- Mounting of the high pressure pump

B46 Engine

2. Engine Mechanical



TO14-0124

Cylinder head of B38 engine

Index	Explanation
1	Cylinder head
2	Mounting, high pressure pump
3	Axial bearing, exhaust camshaft
4	Axial bearing, intake camshaft
5	Intake ports
6	Mounting, Valvetronic servomotor

Cooling concept of cylinder head

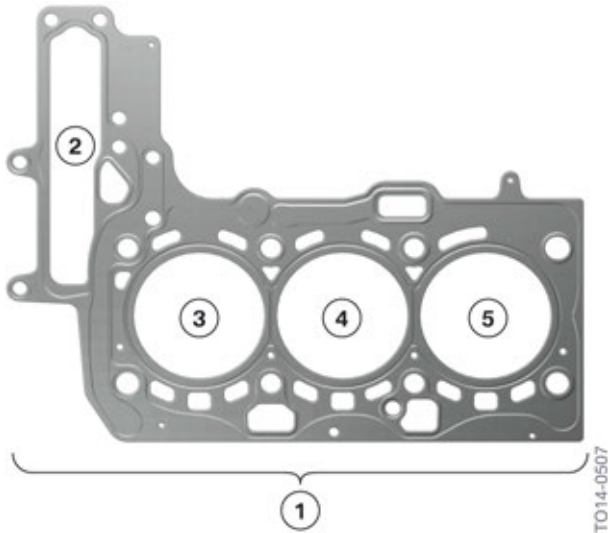
The B46 engine has a cylinder head with cross-flow cooling. In the case of cross-flow cooling, the coolant flows from the hot exhaust side to the cooler intake side. This has the advantage of providing uniform heat distribution in the overall cylinder head. Loss of pressure in the cooling circuit is also prevented.

Cylinder head gasket

In order to satisfy the high demands of the B46 engine, a triple-layer spring steel gasket is used as the cylinder head gasket.

B46 Engine

2. Engine Mechanical



Cylinder head gasket in B38 engine

Index	Explanation
1	Spring steel gasket
2	Sealing area of the chain shaft
3	Sealing area, combustion chamber, cylinder 3
4	Sealing area, combustion chamber, cylinder 2
5	Sealing area, combustion chamber, cylinder 1

The cylinder head gasket is produced in two different thicknesses. The thickness of the gasket can only be checked via the part number.



If a cylinder head gasket has already been used it must not be used again.

2.1.3. Crankcase

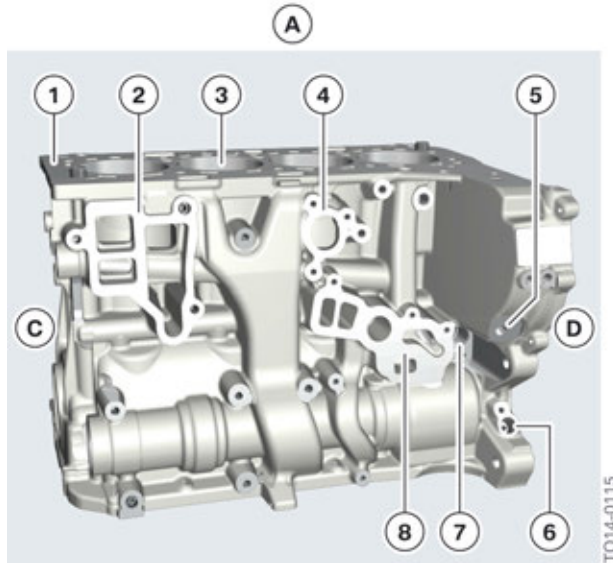
Overview

	Unit	B46A20M0
Displacement	[cm ³]	1998
Hole	[mm]	82
Stroke	[mm]	94.6
Single cylinder volumes	[cm ³]	499.6
Compression ratio		11 : 1
Distance between cylinders	[mm]	91

B46 Engine

2. Engine Mechanical

Overview



Side view of crankcase, B46 engine

Index	Explanation
A	Crankcase of B46 engine
C	Belt drive side
D	Transmission side
1	Closed Deck
2	Sealing surface, coolant pump (transverse installation)
3	Cylinder barrels (LDS = electric arc wire sprayed)
4	Coolant outlet
5	Bore hole for oil pressure sensor
6	Bore hole for vacuum duct
7	Bore hole, solenoid valve
8	Sealing surface, oil filter module

Characteristics of crankcase:

- Heat-treated all aluminium crankcase made from AlSiMgCu 0.5
- Electric arc wire-sprayed cylinder barrels
- Weight-optimized main bearing cap of crankshaft with embossing teeth
- Closed-deck design
- Deep Skirt
- Oil ducts for the use of a map-controlled oil pump
- Support of counterbalance shaft(s) in cored tunnel

B46 Engine

2. Engine Mechanical

Electric arc wire spraying (LDS)



Electric arc wire spraying method, Bx8 engine

The cylinder barrels of the B46 engine are coated by means of an electric arc wire spraying process. In this procedure a conductive metal wire is heated until it melts. The melt is then sprayed onto the cylinder barrels at high pressure. This layer of ferrous material is roughly 0.3 mm thick, extremely wear-resistant and facilitates an efficient transfer of heat from the combustion chambers to the crankcase, and from there to the coolant ducts.

Advantages:

- Lower weight
- High wear resistance
- Good heat dissipation to the crankcase
- Lower internal engine friction thanks to excellent sliding properties

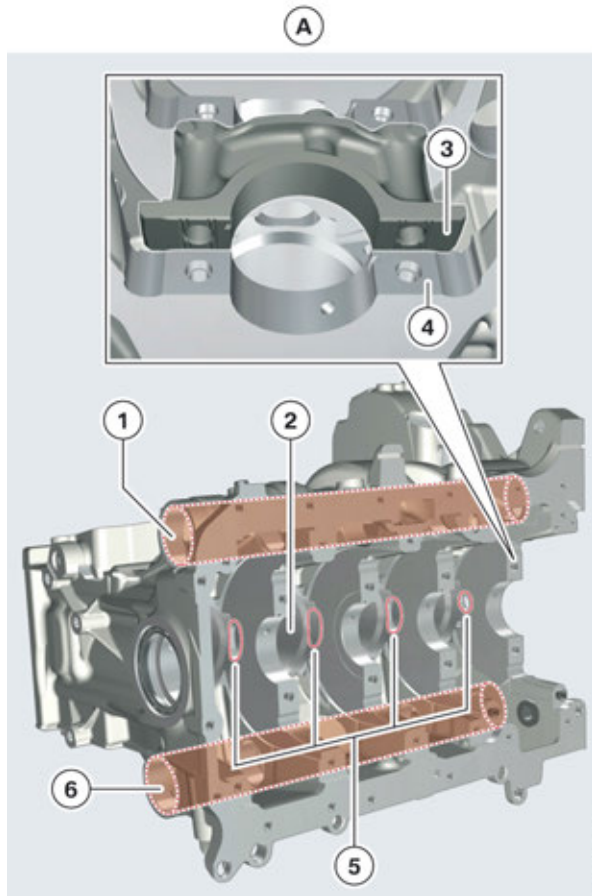


Due to the thin material application during the electric arc wire-spraying procedure, subsequent processing of the cylinder barrels is not possible.

B46 Engine

2. Engine Mechanical

Bearing, counterbalance shaft



Crankcase from below, Bx8 engine

Index	Explanation
A	Crankcase of B46 engine
1	Position of counterbalance shaft 1
2	Cylinder barrel (coated by electric arc wire spraying)
3	Embossed main bearing cap
4	Main bearing seat
5	Ventilation holes
6	Position of counterbalance shaft 2

In the 4-cylinder engine, these forces are reduced by two counter-rotating counterbalance shafts. For more information, refer to the chapter on Counterbalance shafts.

Closed Deck

With the closed-deck design, the coolant ducts around the cylinder are closed from above and provided with coolant bore holes.

B46 Engine

2. Engine Mechanical

Deep Skirt

With the "deep skirt" concept, the side walls extend far downwards. This lends the crankcase a high degree of stability and considerable flexibility in terms of the piston stroke length.

Embossed crankshaft bearing cap

The weight of the main bearing cap of the crankshaft has been further optimized for the new B46 engine. When the impression connection is made the main bearing cap is designed with a profile. When the main bearing bolts are tightened for the first time, this profile pushes into the surface of the bearing block on the crankcase side.



Exchange of the main bearing cap, or positioning in another bearing position on the crankshaft, is not permitted and will lead to engine damage.

Ventilation holes

The combustion chambers are connected via ventilation bore holes at the bottom end of the cylinder barrels. The air flows, which arise as a result of the upward and downward movement of the pistons, can thus escape easier via the ventilation bore holes. In addition, as the displacement of air volume has been simplified by using the ventilation bore holes, the piston can move up and down more easily. This reduces the internal friction of the engine and ensures the engine operates more efficiently.

2.1.4. Oil sump

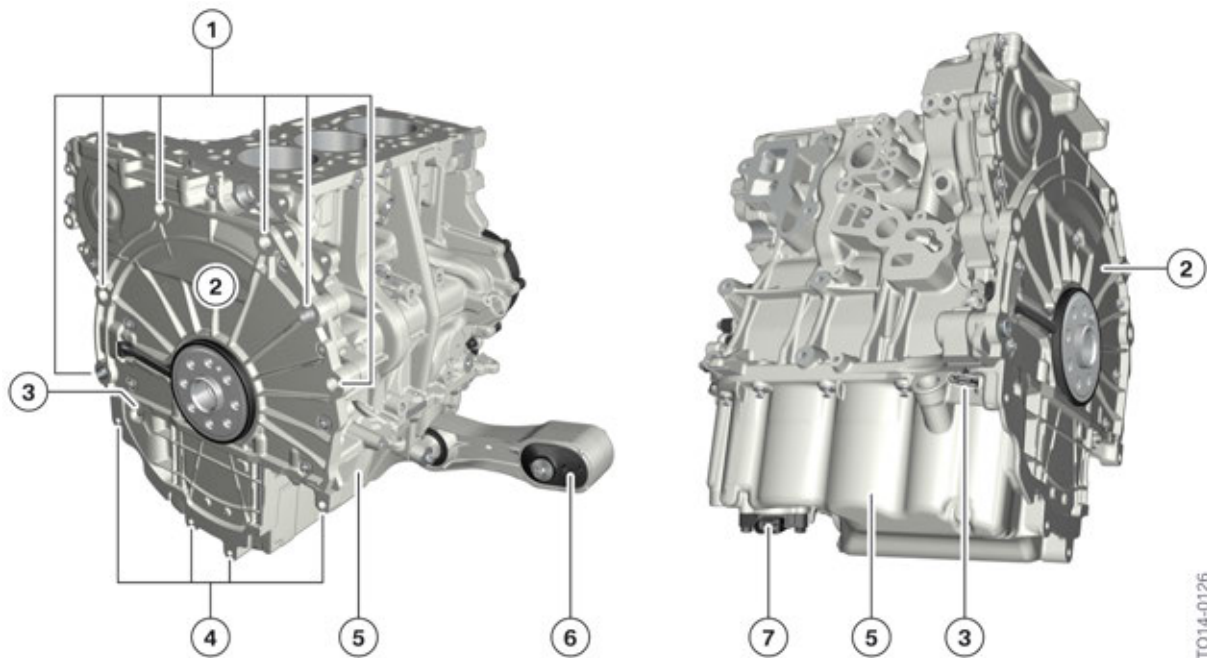
The oil sump is manufactured from die-cast aluminium.

Tasks:

- Collecting vessel for engine oil.
- Collection area for returning engine oil.
- Reinforcing component in the engine-transmission combination.
- Fixture for the oil-level sensor and oil drain plug.
- Connection of the anti-roll bar link for transverse mounting.

B46 Engine

2. Engine Mechanical



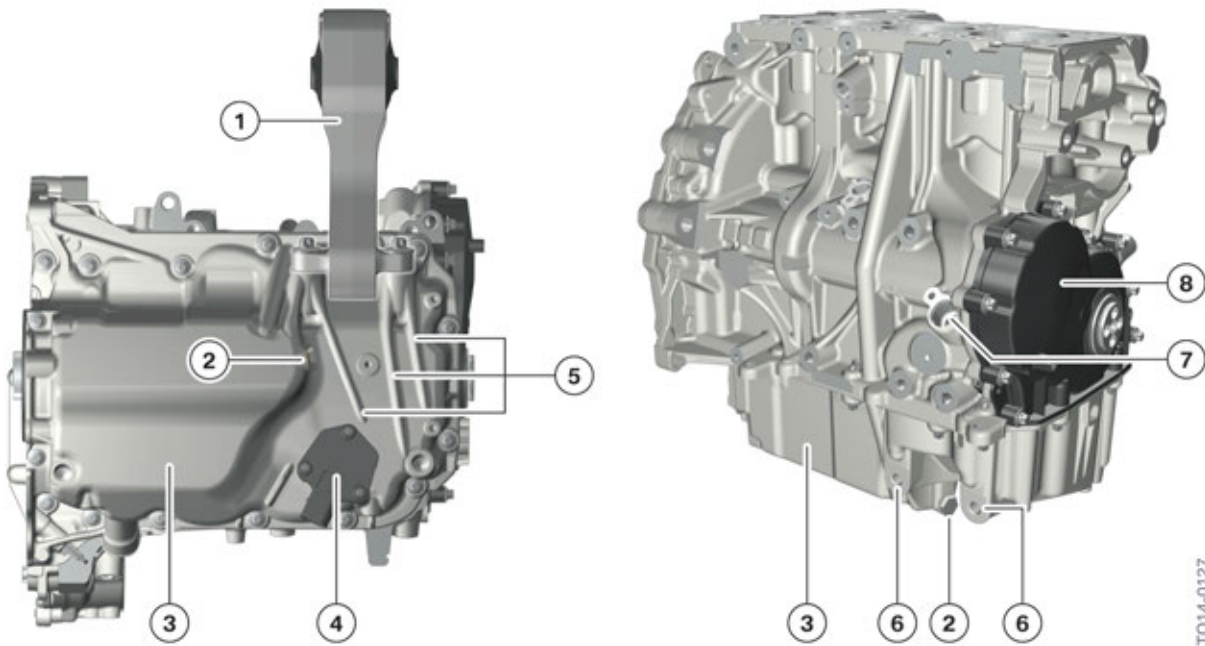
Side view of B38 engine

Index	Explanation
1	Attachment points, crankcase at transmission
2	Timing case cover
3	Seal plug for bore hole of the holding fixture
4	Attachment points, oil sump at transmission
5	Oil sump
6	Anti-roll bar link (only for transverse mounting)
7	Oil level sensor

The engine can be disconnected via a bore hole in the oil sump for adjusting the timing. When installing the oil sump with the transmission removed, make sure that the transmission contact surface of the oil sump and the timing case cover are in one plane. Always use the corresponding special tool. If a gap arises between the two areas when tightening the mounting bolts of the transmission, it causes damage to the oil sump.

B46 Engine

2. Engine Mechanical



Oil sump of B38 engine

Index	Explanation
1	Anti-roll bar link (only for transverse mounting)
2	Oil drain plug
3	Oil sump
4	Oil level sensor
5	Reinforcing ribs
6	Connection of anti-roll bar link at oil sump
7	Oil return to oil sump
8	Crankcase end cover (belt side)

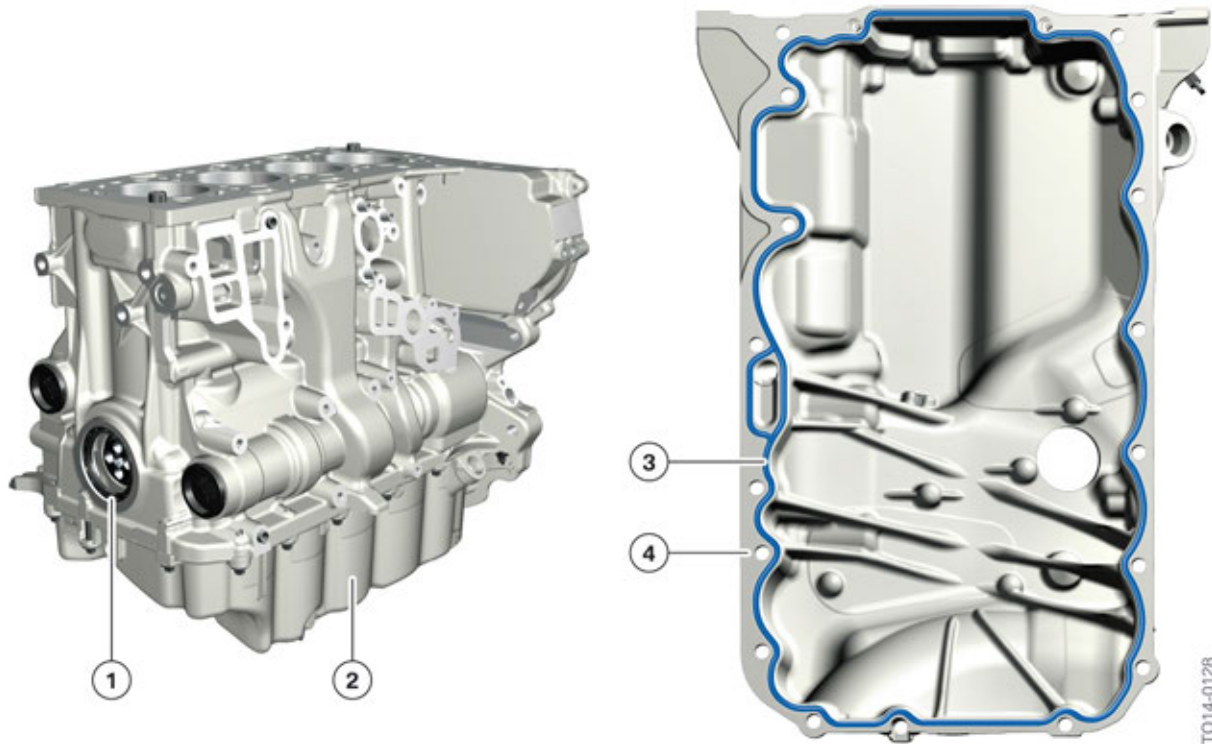
The engine oil flows from the oil circuit back to the oil sump via the return line of the exhaust turbocharger.

The B46 engine does not have an oil dipstick. The oil level is monitored electronically at all times with the assistance of the oil-level sensor and can be requested via the on-board computer.

B46 Engine

2. Engine Mechanical

Sealing B46 engine



Oil sump gasket B46 engine

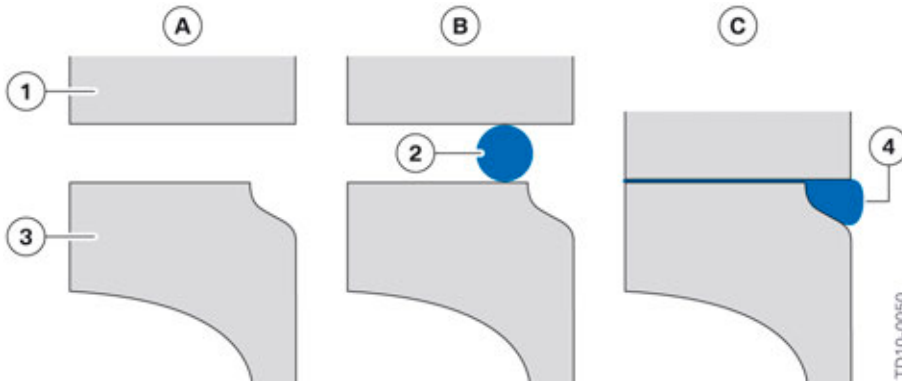
Index	Explanation
1	Radial shaft seal
2	Oil sump
3	Silicone bead
4	Sealing surface, oil sump

TO14-0128

B46 Engine

2. Engine Mechanical

A crankcase end cover is not required with the B46 engine. The silicone bead must be applied around the entire sealing surface area of the oil sump.



Schematic diagram for oil sump sealing

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 bevel
4	Silicone discharge

In order to seal with sealant, a bevel is required around the inner edge of the flange. Excess sealing compound can be discharged in a controlled manner into the space provided when screwing. Removal of the sealing compound by oil splashes is thus prevented.

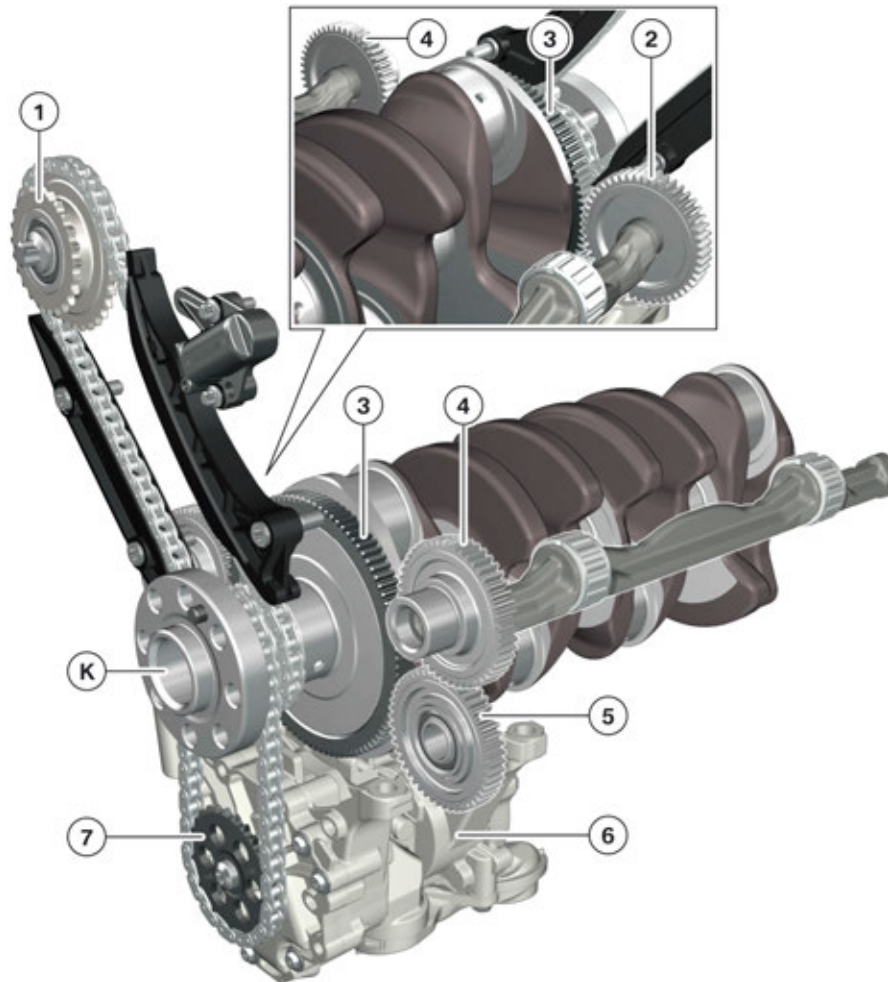
B46 Engine

2. Engine Mechanical

2.2. Crankshaft drive

2.2.1. Crankshaft

Overview of crankshaft of B46 engine



Crankshaft of B46 engine

Index	Explanation
K	Transmission side, crankshaft
1	Camshaft sprocket, intermediate shaft
2	Gear, counterbalance shaft 1
3	Crankshaft gear

B46 Engine

2. Engine Mechanical

Index	Explanation
4	Gear, counterbalance shaft 2
5	Intermediate gear (change in direction of rotation of counterbalance shaft 2)
6	Oil and vacuum pump
7	Oil pump sprocket

In the B46 engine both the timing chain and the drive for the counterbalance shafts are located on the transmission side of the crankshaft.

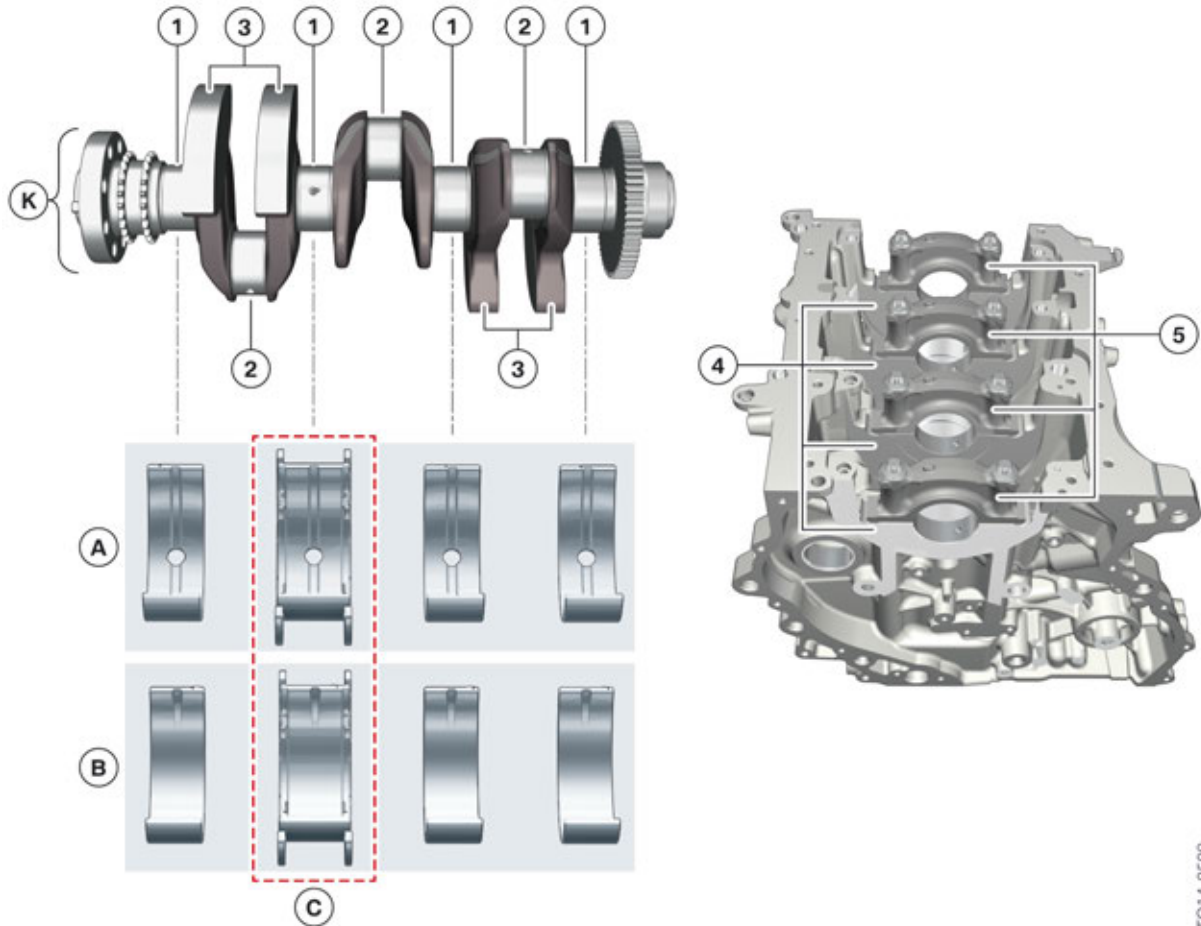
Technical data, crankshaft

Characteristics	Unit	B46 engine
Material		C38+N2
Manufacture		Forged
Diameter of the main bearing journal	[mm]	50
Width of the main bearing journal	[mm]	25
Diameter of the connecting rod bearing journal	[mm]	50
Width of connecting rod bearing journal	[mm]	24
Stroke of the connecting rod bearing journal	[mm]	94.6
Throw angle	[°]	180
Number of counterweights		4
Number of main bearing positions		5
Position of the thrust bearing		Bearing 3

B46 Engine

2. Engine Mechanical

Crankshaft bearing in B38 engine



Overview of bearing shells at the B38 engine

TO14-0509

Index	Explanation
A	Bearing shell in main bearing seat
B	Bearing shells in main bearing cap
C	Axial guide bearing
K	Transmission side
1	Crankshafts, main bearing
2	Connecting rod bearing journal
3	Counterweights
4	Main bearing seat
5	Main bearing cap

The crankshaft is mounted using different bearing shells. The bearing shells in the low-load zone of the bearing seat have oil holes and a peripheral groove for fresh oil supply. The highly stressed bearing shells in the area of the main bearing cap have no oil holes or grooves.

B46 Engine

2. Engine Mechanical



Due to the very low tolerances, special attention must be paid to cleanliness when handling bearing shells.

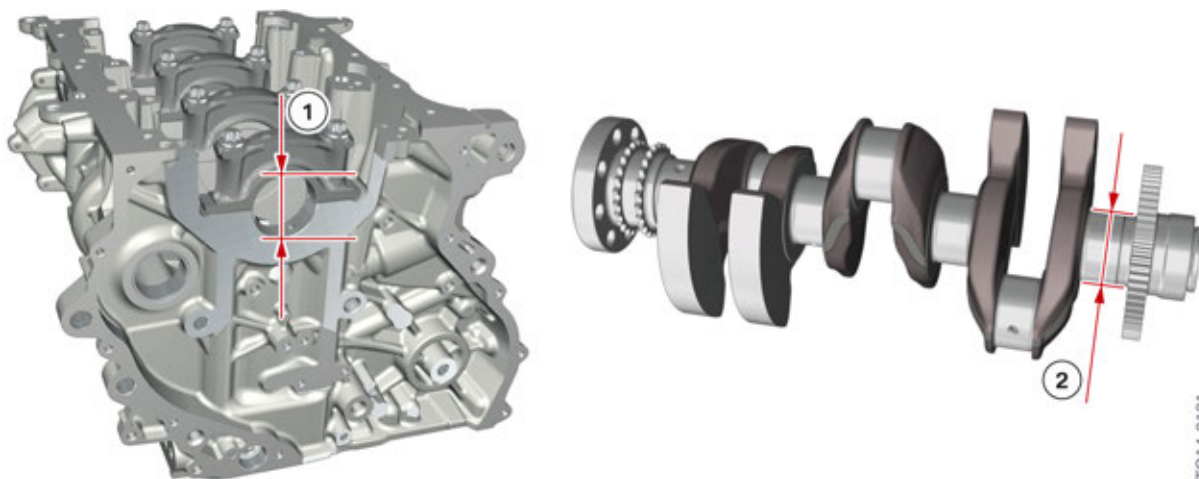
The axial guide bearing is located in the center bearing area of the crankshaft. This bearing holds the crankshaft in the axial direction and must absorb forces in the longitudinal direction which, for example, can arise during the operation the clutch.



Before the completion of the engine, check the side clearance in accordance with the repair instructions. Excessive side clearance may cause electrical faults or damage to the components.

Identifying the bearing shells

So that the crankshaft can carry out its main task effectively, incorporation of the lifting movement and conversion to a rotational movement, it must be positioned correctly. The dimension to be adjusted can also be called a fit and is generated using crankshaft bearing shells with varying degrees of thickness.



Crankshaft bearing in B38 engine

Index	Explanation
1	Hole
2	Shaft

A distinction is made between three types of fit in the design:

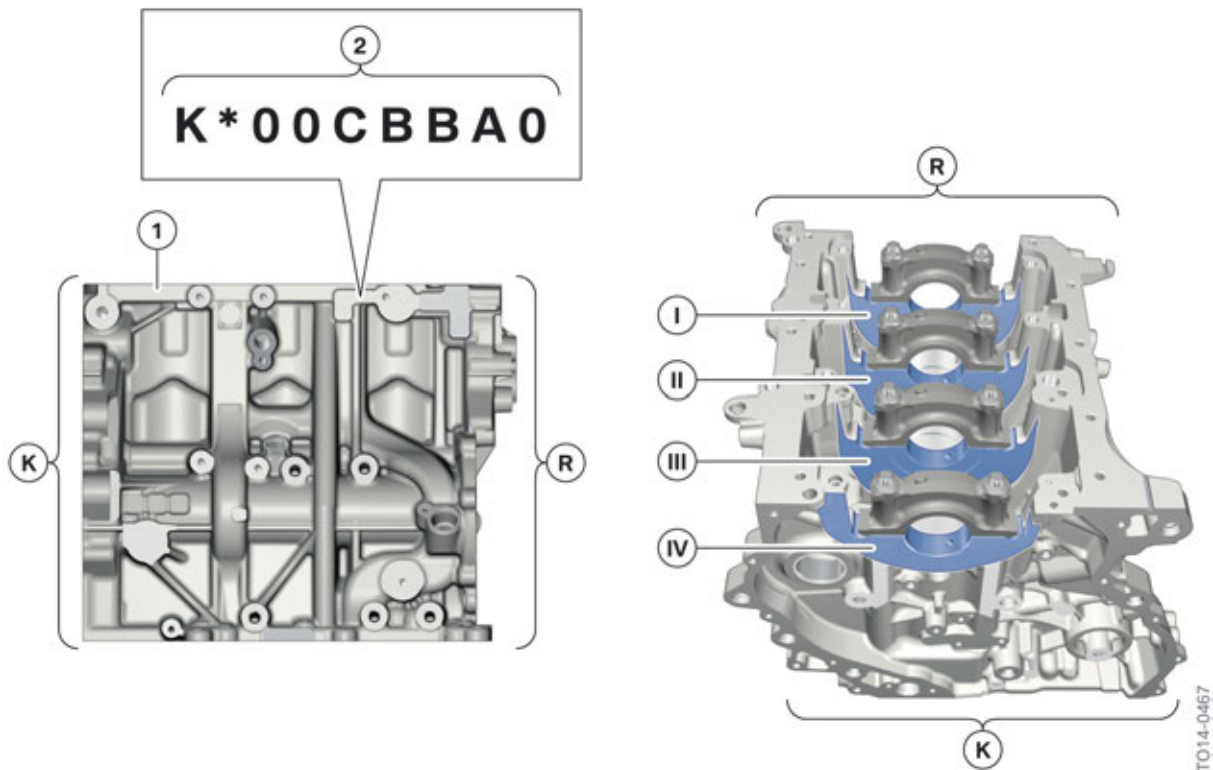
- Clearance fit
- Transition fit
- Interference fit

B46 Engine

2. Engine Mechanical

The fit is viewed as an accurate relationship between the bore hole and the shaft. The crankcase represents the bore hole and the crankshaft represents the shaft. This is why the numbers for the classification of the bearing shells are located on the crankcase and the crankshaft. In the case of a dimension being adjusted, this is a so-called clearance fit. A clearance fit is characterized by the fact that in each case the minimum dimension of the bore hole is greater than the maximum dimension of the shaft. This creates the necessary play between the shaft and the bore hole, which is needed for the bearing of the crankshaft.

Bearing shell classification on the bearing seat



Bearing shell classification on the bearing seat, B38 engine

Index	Explanation
I	Bearing seat 1
II	Bearing seat 2
III	Bearing seat 3
IV	Bearing seat 4
K	Transmission side
R	Belt side
1	Crankcase
2	Stamped letters

The stamped letters on the crankcase are used to determine the bearing shell sizes of the bearing seat.

B46 Engine

2. Engine Mechanical

The following letters are used for the classification:

- A = highest possible play (thinnest bearing shell)
- B = medium play (medium bearing shell)
- C = lowest possible play (thickest bearing shell).

The letter K stands for the transmission side of the crankcase. It also specifies the counting order for the assignment.

If there is a K before the stamped letters, then the first letter of the code refers to the bearing shell of bearing seat 4, which is located on the transmission side. The subsequent letters, read from left to right, refer to the bearing seat 3, 2 and 1. The positions marked with "0" are placeholders for larger engines and are simply omitted.

Using the previous graphic for reference, the following combination is obtained:

Assignment:

- Transmission side = K
- Bearing seat 4 = C
- Bearing seat 3 = B
- Bearing seat 2 = B
- Bearing seat 1 = A.

If the stamped letters are not preceded by "K", then the first letter of the code refers to the bearing shell of bearing seat 1, which is located opposite the transmission side on the belt side. The subsequent letters, read from left to right, refer to bearing seat 2, 3 and 4.

When assigning the letters without "K", the following combination is obtained:

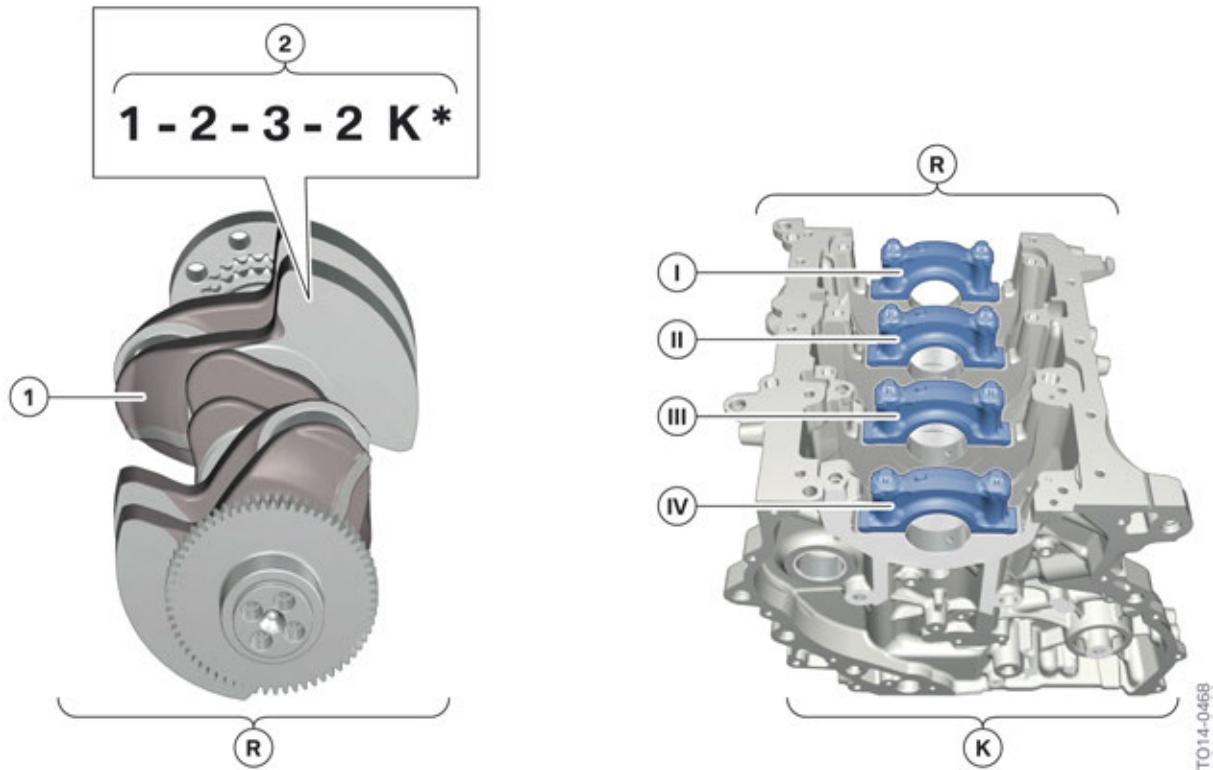
Assignment:

- Bearing seat 1 = C
- Bearing seat 2 = B
- Bearing seat 3 = B
- Bearing seat 4 = A.

B46 Engine

2. Engine Mechanical

Bearing shell classification on main bearing cap



Bearing shell classification on main bearing cap, B38 engine

Index	Explanation
I	Main bearing cap 1
II	Main bearing cap 2
III	Main bearing cap 3
IV	Main bearing cap 4
K	Transmission side
R	Belt side
1	Crankshaft
2	Stamped digits

The stamped digit on the crankshaft determines the bearing shell sizes of the main bearing cap.

The following numbers are used for the classification:

- 1 = highest possible play (thinnest bearing shell)
- 2 = medium play (medium bearing shell)
- 3 = lowest possible play (thickest bearing shell).

B46 Engine

2. Engine Mechanical

In the case of the crankshaft, the letter K also defines the assignment of the bearing position. The digit next to the K is to be assigned to the main bearing cap 4 which is on the transmission side. The subsequent digits, read from left to right, refer to the main bearing cap 3, 2 and 1.

Using the previous graphic for reference, the following combination is obtained:

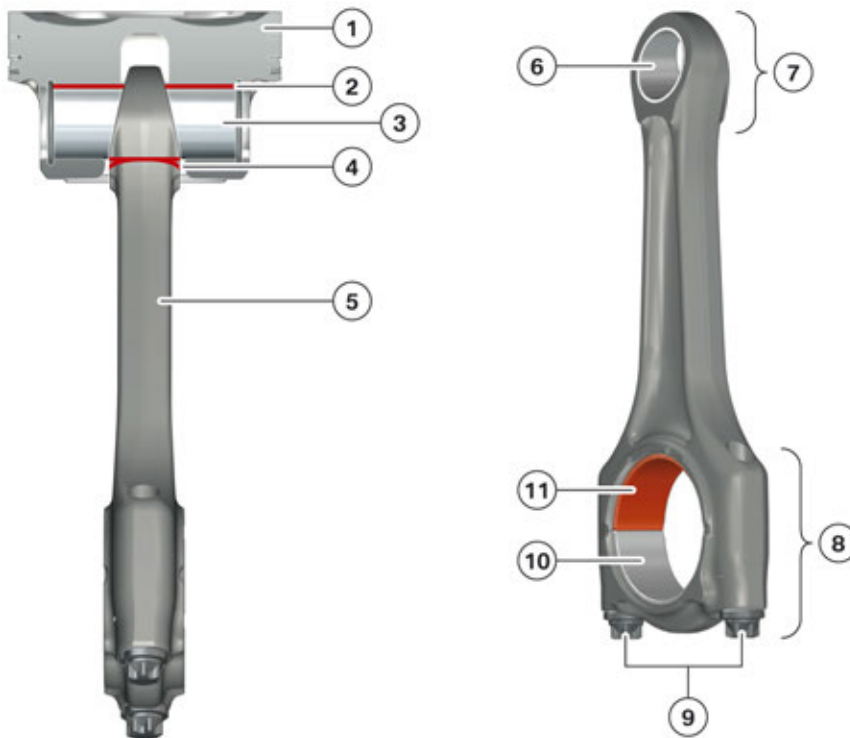
Assignment:

- Main bearing cap 1 = 1
- Main bearing cap 2 = 2
- Main bearing cap 3 = 3
- Main bearing cap 4 = 2
- Transmission side = K.

Deciphering the combination of letters and digits

The letter and digit combination of the main bearing shells can be decrypted using a table in the repair instructions. The correct bearing shell sizes are determined with help of the color codes.

2.2.2. Connecting rod



Connecting rod of B46 engine

B46 Engine

2. Engine Mechanical

Index	Explanation
1	Piston
2	Force-transmitting surface
3	Wrist pin
4	Connecting rod bearing bush with shaped bore hole
5	Connecting rod
6	Connecting rod bush
7	Small connecting rod eye (trapezoidal shape)
8	Large connecting rod eye (cracked)
9	Connecting rod bolts of the connecting rod bearing cap
10	Connecting rod bearing shell of the connecting rod bearing cap
11	Connecting rod bearing shell of the connecting rod (IROX-coated)

The familiar drop-forged cracked connecting rods are used.



If a connecting rod bearing cap is mounted the wrong way round or on another connecting rod, the fracture structure of both parts is destroyed and the connecting rod bearing cap is not centered. In this event the entire connecting rod set must be replaced with new parts. In Service please observe the specified jointing torques and angle of rotation specifications in the repair instructions.

Weight classification

To guarantee smooth engine running, the connecting rods are divided into weight classes. The large and small connecting rod eyes are weighed separately and divided into various classes according to their weight.



In Service only connecting rods of the same weight class can be used. This is why only a full set of connecting rods is available in the event of a replacement. This set comprises the corresponding number of connecting rods of a weight classification.

Irox-coating

In order to comply with the increasingly stringent exhaust emission regulations, most combustion engines nowadays are equipped with an automatic engine start-stop function. This has led to a huge increase in starting cycles.

To ensure the engine runs smoothly, it is important that sufficient lubricating oil is supplied to the bearing positions of the crankshaft. If the oil supply can be ensured, solid body contact will not occur between the connecting rod bearing journal and connecting rod bearing shell due to the thin lubricating film.

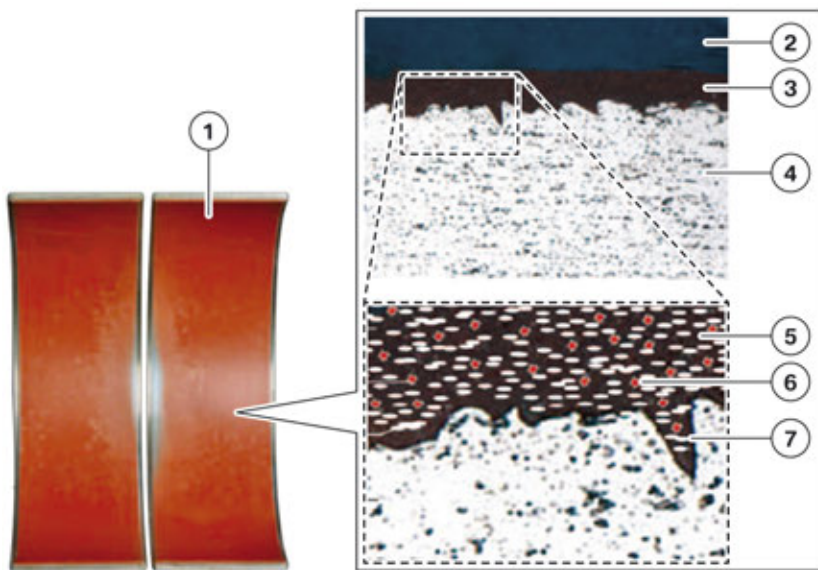
B46 Engine

2. Engine Mechanical

If the engine is now stopped, it will not be possible for the mechanically-driven oil pump to maintain the oil supply. The oil film between the bearing positions flows off. Solid body contact occurs between the connecting rod bearing journal and connecting rod bearing shell. Once the engine is restarted, it takes a certain amount of time for the lubricating film to fully re-establish itself. The connecting rod bearing shell may be subject to wear in this short period. The Irox-coating reduces this wear to a minimum.

The IROX-coated bearing shells are only located on the connecting rod side as here the load acts mainly on the bearing shells. The bearing shell caps are equipped with a bearing shell without IROX coating.

The IROX ball bearings are red due to their special coating.



TO14-0130

Detailed magnification of the Irox-coating of the Bx8 engine

Index	Explanation
1	Irox-coated bearing shell
2	Oil film
3	Irox-coating
4	Bearing shell
5	Binding resin
6	Hard particle
7	Solid lubricant

The Irox-coating is applied to a conventional bearing shell. It consists of a binding resin matrix made of polyamide-imide with embedded hard particles and solid lubricants. The polyamide-imide ensures, in combination with the hard particles, that the bearing shell surface is so hard that material loss is no longer possible. The solid lubricants reduce surface friction and replace the oil film which briefly no longer exists between the bearing shell and the connecting rod bearing journal during the starting phase.

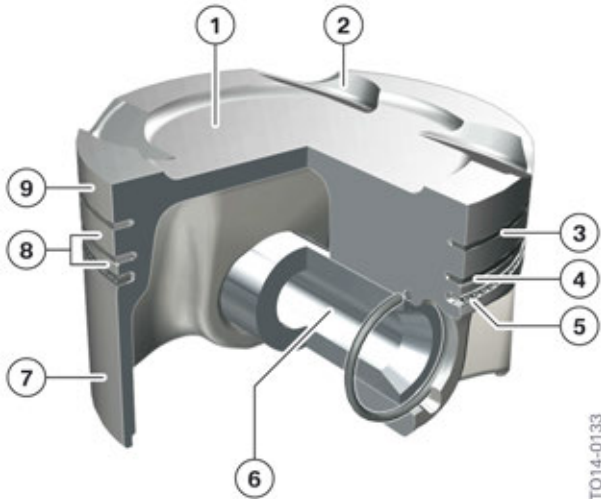
B46 Engine

2. Engine Mechanical

Bearing shell classification of connecting rod bearing

The connecting rod bearing shells are available in one standard size. It is therefore not necessary to follow a procedure similar to that used with the main bearing shells of the crankshaft.

2.2.3. Piston



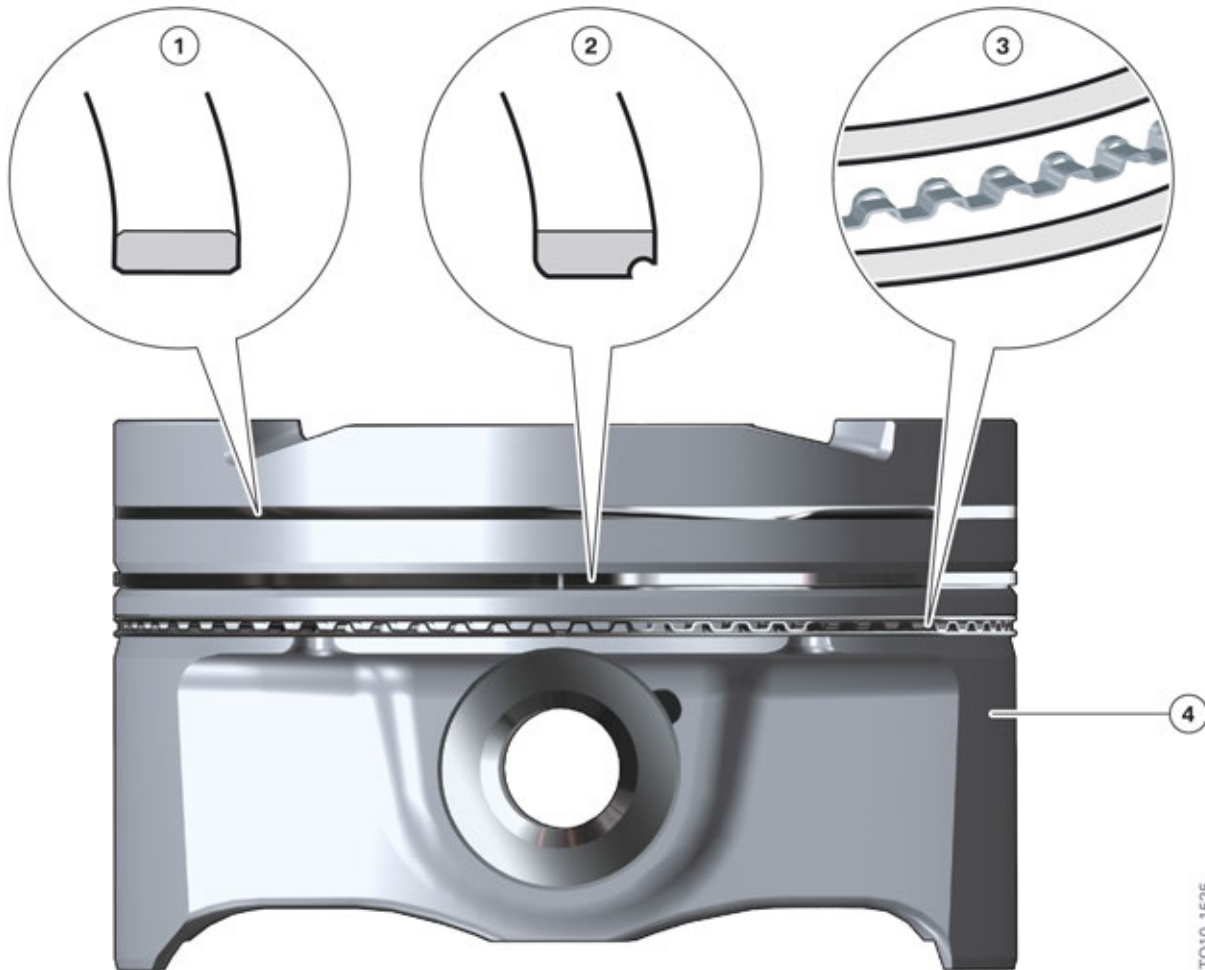
Piston of Bx8 engine

Index	Explanation
1	Piston crown
2	Valve relief
3	1st piston ring
4	2nd piston ring
5	3rd piston ring
6	Gudgeon pin
7	Piston skirt
8	Ring bar
9	Fire land

B46 Engine

2. Engine Mechanical

Piston rings



Piston rings of Bx8 engine

Index	Explanation
1	Plain compression ring
2	Stepped compression ring
3	Oil scraper ring
4	Piston

To perform their functions, it is necessary for the piston rings to touch the cylinder wall and the edge of the piston groove. Contact with the cylinder wall is effected by the radially acting spring force of the ring. The oil scraper ring is supported by an additional ring.

The piston rings rotate in the grooves while the engine is running and thereby alter the position of the gap. This stems from the lateral force which acts on the piston rings during change of contact. This process removes deposits from the ring grooves. It also prevents the piston ring gap from cutting into the cylinder barrel.

The B46 engine has two compression rings and one oil scraper ring.

B46 Engine

2. Engine Mechanical

The plain rectangular compression ring sits in the first piston ring groove and is used as a plain compression ring.

The taper faced piston ring is also a compression ring. A sharp wiper edge develops through the lug for controlling the oil supply. The undercut of the lug implies that the oil scraped from the running edge is diverted and an oil blockage does not form there, which would otherwise reduce the scraping effect.

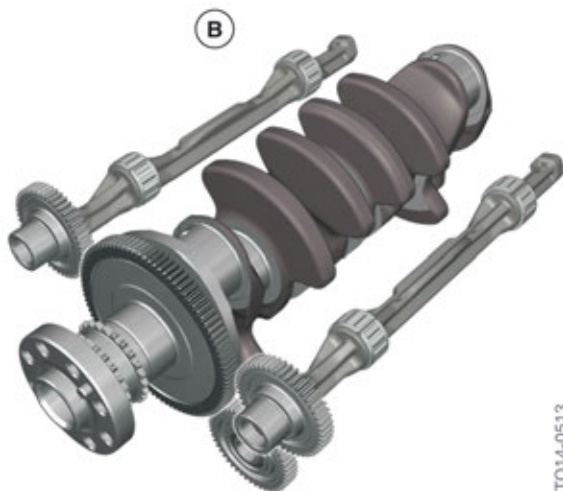
The oil scraper ring is a steel band ring with spring. The two lands and in particular the chamfer create a high surface contact pressure, which promotes the oil-scraping effect.



The plain rectangular compression ring and the taper faced piston ring have a Top mark. When installing the two piston rings the Top mark must be facing in the direction of the piston crown.

2.2.4. Counterbalance shafts

Due to the operating principle of the piston engine, undesired oscillations occur at the engine housing when driving, which can be transmitted to the vehicle interior. To counteract this negative effect, BMW has already been installing so-called counterbalance shafts in more recent engine generations. Up till now, their role was to cancel out free inertia forces and therefore increase ride comfort. In addition to the inertia forces, so-called 'free moments of inertia' also exist, which can also adversely effect ride comfort. Depending on the engine design and number of cylinders, varying degrees of free inertia forces and free moments of inertia occur.



Counterbalance shaft system of the B46 engine

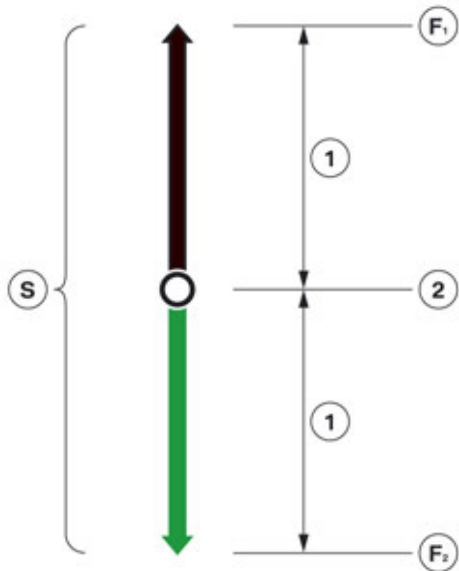
Index	Explanation
B	Counterbalance shafts for the reduction of free inertia forces in the B46 engine

The mass balance is used to offset structural imbalances. The task of the mass balance is to improve the running and noise characteristics of the engine, by neutralizing the free inertia forces and torques. For this reason a brief description of the special features of forces and torques is provided below.

B46 Engine

2. Engine Mechanical

Forces



Static force

TA13-2336

Index	Explanation
F_1	First force with upwards operating direction
F_2	Second force with downwards operating direction
S	Static
1	Intensity of force
2	Point of action

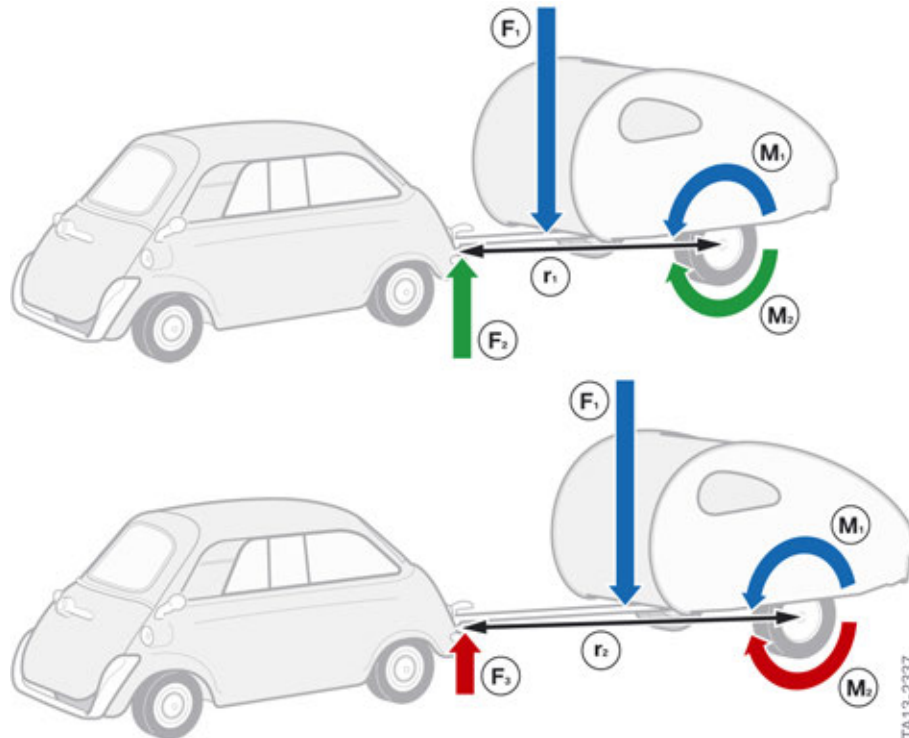
Forces are invisible and can only be noticed by their effects. They consist of a point of action and an operating direction. Their state can be dynamic or static. The forces are shown as an arrow (vector). The arrowhead provides information on the operating direction of the force. At the other end of the arrow (vector), opposite the arrowhead, is the point of action. The intensity of the force is determined by the arrow length (vector length). The physical unit of force is [N] and the symbol is [F].

The previous graphic shows two forces acting in exactly opposite directions with the same intensity. The system is balanced (static) as both forces cancel each other. When observed from the outside, a reaction cannot be determined.

B46 Engine

2. Engine Mechanical

Torques



Static torque

Index	Explanation
F_1	Contact force [F]
F_2	Large counterforce [F]
F_3	Small counterforce [F]
M_1	Contact torque [M]
M_2	Counter-torque [M]
r_1	Small lever arm [r]
r_2	Large lever arm [r]

Torques occur if a force is transmitted at its point of action via a lever arm. The physical unit of torque is [Nm] and its symbol is [M]. The lever arm and the force acting at the point of action are decisive for the size of the torque. The following mathematical context emerges:

- $M = F \cdot r$

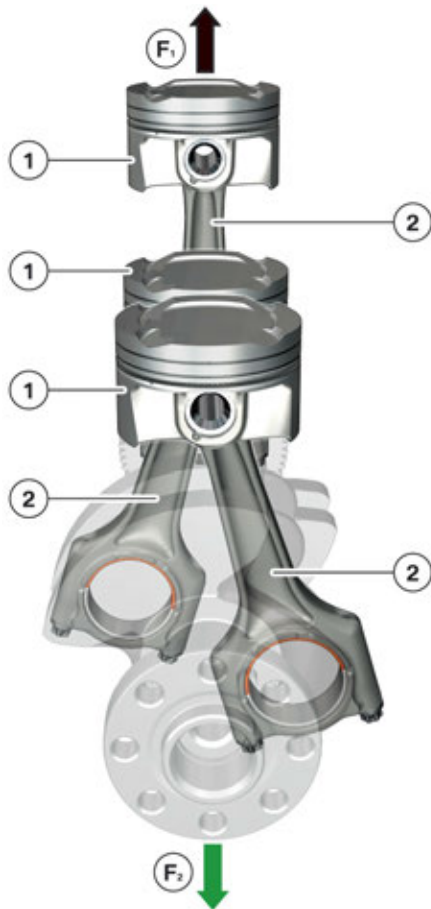
The previous graphic shows two torques which cancel each other out. If the contact force is increased, without increasing the counterforce to the same degree, the two torques are no longer at equilibrium. The pendant would fall to the floor. To re-establish the static equilibrium of the system, either the counterforce has to be increased or the lever arm extended at which the counterforce acts.

B46 Engine

2. Engine Mechanical

Oscillating and rotating forces

The upwards and downwards movement of the pistons, as well as the connecting rods, is called an oscillating force and the rotational movement of the crankshaft is called a rotating force. These two different forces also cause the undesired oscillations when the engine is running.



TO14-0134

Oscillating forces in the B38 engine

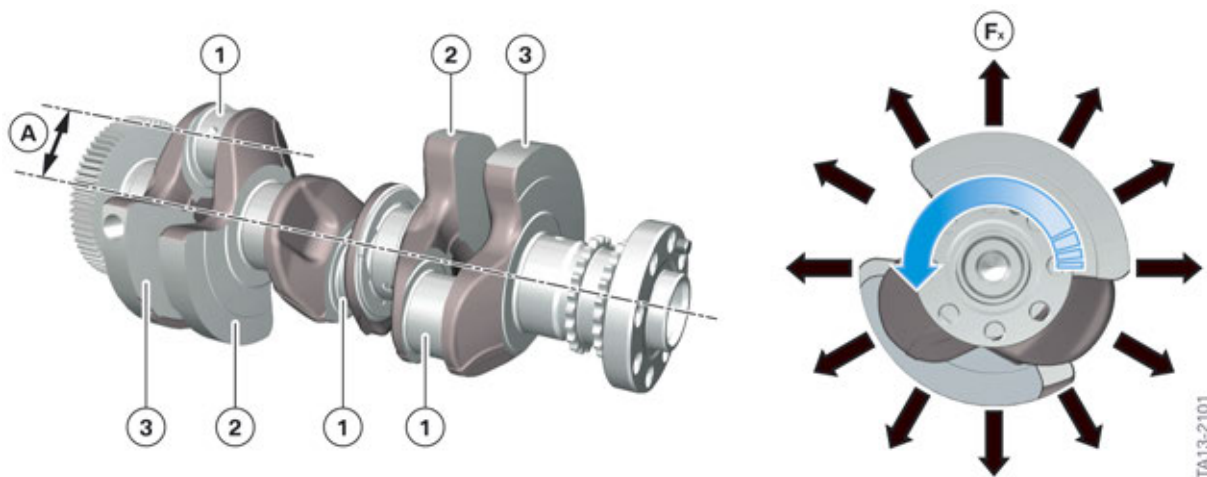
Index	Explanation
F_1	Force directed upwards
F_2	Force directed downwards
1	Piston
2	Connecting rod

Oscillating forces occur in the piston engine when the direction changes at bottom and top dead center. Due to the inertia of the piston and the connecting rod, the force is directed either upwards or downwards. The following therefore applies: the lower the mass of the piston and the connecting rod, the lower the corresponding oscillating forces will be.

B46 Engine

2. Engine Mechanical

In order to reduce the fuel consumption according to the EfficientDynamics strategy, the power output per liter is increased. Through the use of exhaust turbochargers more power is obtained from the same displacement. This means the pistons and the connecting rod are exposed to higher ignition pressures and must have a more solid design. The masses of the components subsequently increase, and thus the oscillating forces.



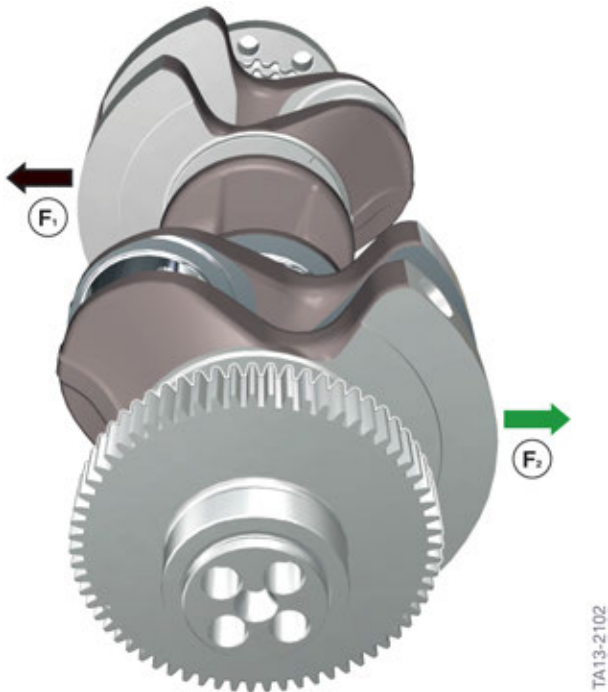
Rotating forces in the B38 engine

Index	Explanation
A	Piston stroke (offset of connecting rod bearing journal)
F_x	Rotating forces
1	Connecting rod bearing journal
2 + 3	Counterweights

To produce a rotating movement of the crankshaft from the stroke of the piston, the connecting rod bearing journals that support the large connecting rod eye are not located on the axis of rotation of the crankshaft. An imbalance when turning the crankshaft occurs by the offset of the connecting rod bearing journals. The arising imbalance is counteracted by the use of counterweights.

B46 Engine

2. Engine Mechanical



Counterweights of crankshaft of B38 engine

Index	Explanation
F_1	Force of the crankshaft weight directed to the left
F_2	Force of the crankshaft weight directed to the right

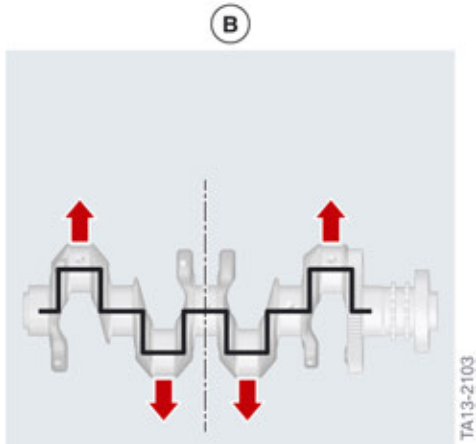
The rotating inertia forces can be completely neutralized with help of the counterweights at the crankshaft. Some of the weight at the crankshaft is also used to reduce the oscillating inertia forces (change of direction of the piston and connecting rod). If the entire oscillating inertia forces are reduced by counterweights at the crankshaft, the forces or torques (depending on the design and number of cylinders) in the top and bottom dead center of the pistons are neutralized. However, this would also mean that in the piston intermediate position (piston between top dead center and bottom dead center) the inertia forces of the counterweights work in a lateral direction. The result would be vibrations which are transmitted via the crankshaft bearing to the crankcase and finally to the entire vehicle.

This conflict can be resolved through the use of counterbalance shafts, as well as clever weight classification of the counterweights at the crankshaft.

B46 Engine

2. Engine Mechanical

Oscillating torques



Oscillating torques

Index	Explanation
B	4-cylinder engine

This example shows why the design plays a role in which forces or torques occur during engine operation.

In contrast, the forces which occur at the crankshaft of the 4-cylinder engine when the engine is running cancel each other out. Free moments of inertia therefore do not occur.

Order

The inertia forces are divided into "orders". The more frequently an inertia force occurs during each crankshaft revolution (360°), the greater its order of magnitude will be.

The free inertial forces and torques categorized as follows:

- Inertia forces, 1st order
- Inertia forces, 2nd order
- Inertia torques, 1st order
- Inertia torques, 2nd order.

The following table provides an overview of the arising forces and torques depending on the design and number of cylinders

	Inertia forces, 1st order	Inertia forces, 2nd order	Inertia torques, 1st order	Inertia torques, 2nd order
4-cylinder in-line engine	—	X	—	—
6-cylinder in-line engine	—	—	—	—

B46 Engine

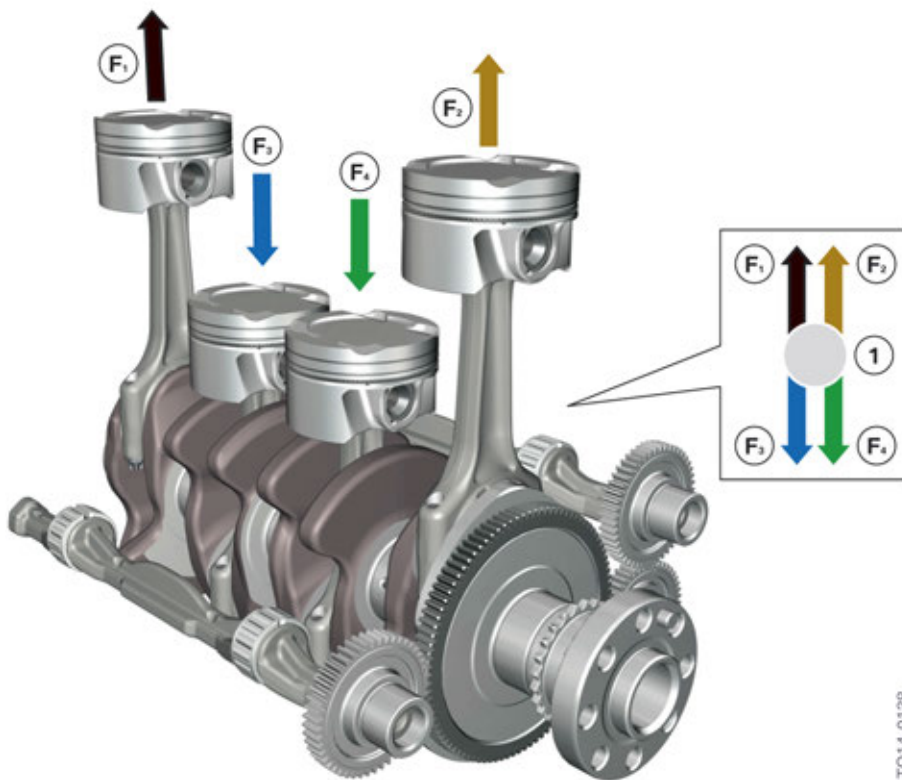
2. Engine Mechanical

The table provides information on which forces and torques occur and their order of magnitude. Free inertial forces and moments of inertia of the first order are the most noticeable. Free inertia forces and moments of inertia of the second order are perceived as much less troublesome. The greater the order of magnitude is therefore, the more it can be disregarded for the purposes of mass balancing.

The table shows that the best engine design in terms of smooth running is the 6-cylinder in-line engine. All forces cancel each other out. Therefore, with this engine design no additional measures for neutralizing the rotating or oscillating masses have to be implemented.

2.2.5. Counterbalance shaft of B46 engine

Free inertia forces of the 2nd order occur in the 4-cylinder in-line engine. The following graphic shows how the forces of the 1st order cancel each other.



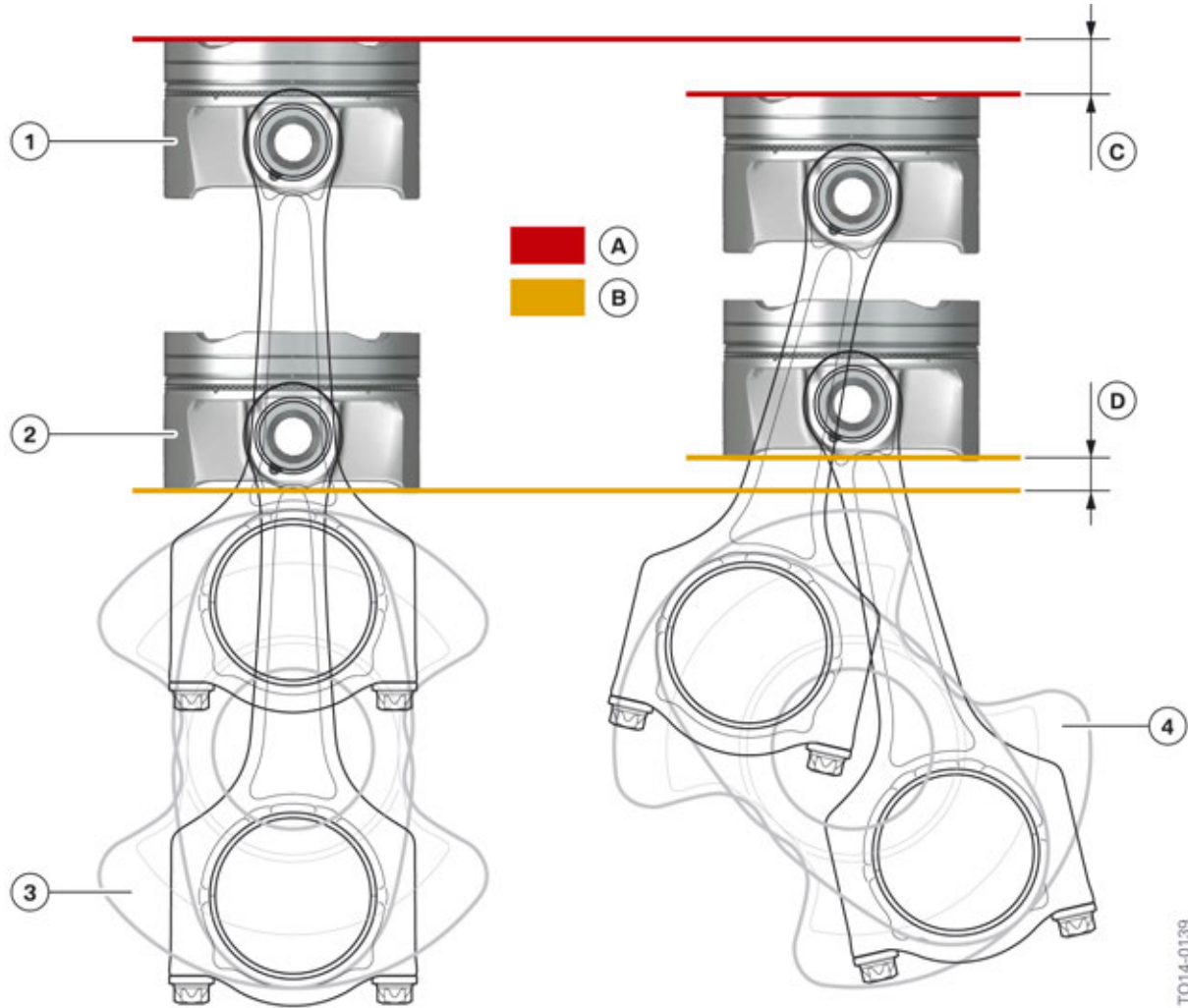
Free inertia forces, 1st order, B46 engine

Index	Explanation
F_1	Oscillating and rotating inertia force with operating direction 0° crank angle
F_2	Oscillating and rotating inertia force with operating direction 0° crank angle
F_3	Oscillating and rotating inertia force with operating direction 180° crank angle
F_4	Oscillating and rotating inertia force with operating direction 180° crank angle
1	Inertia forces in equilibrium (static)

B46 Engine

2. Engine Mechanical

If you take a look at the crankshaft from the front, then all forces of the 1st order cancel each other. However, inertia forces of the 2nd order occur, which can be explained as follows:



Free inertia forces, 2nd order, B46 engine

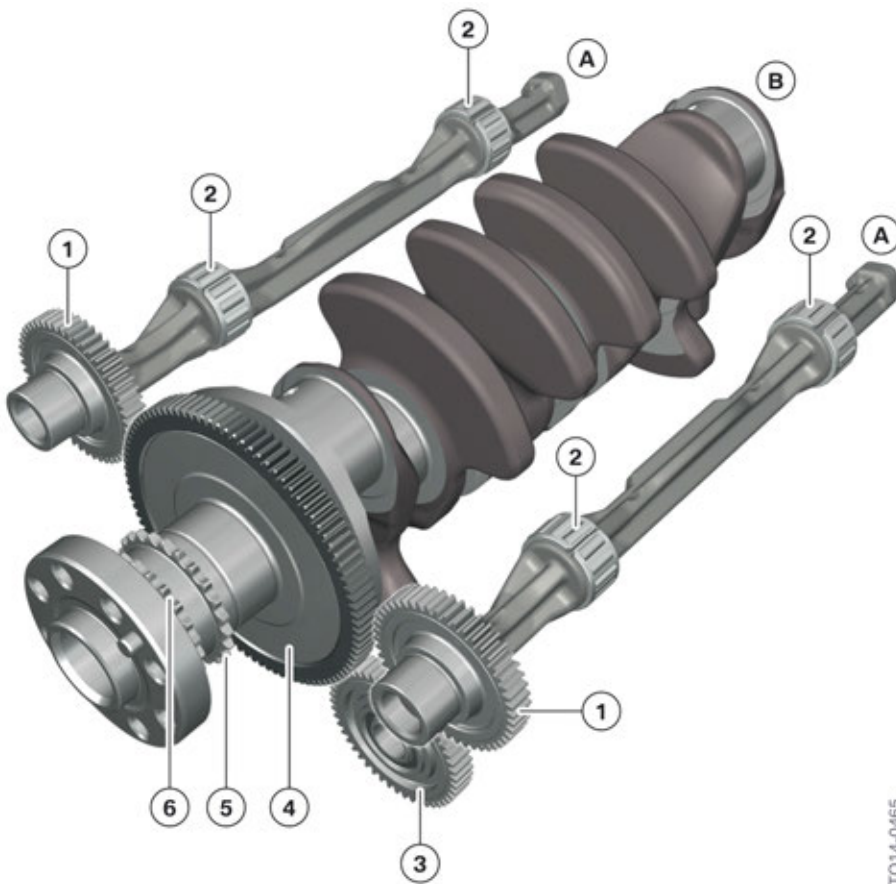
Index	Explanation
A	Position line, piston 1
B	Position line, piston 2
C	Stroke, piston 1
D	Stroke, piston 2
1	Piston 1
2	Piston 2
3	Crankshaft angle 0°
4	Crankshaft angle 45° after top dead center

TO14-0139

B46 Engine

2. Engine Mechanical

As can be seen in the previous graphic, both pistons are at top or bottom dead center at the same time. If the crankshaft is rotated 45° counter-clockwise and the two piston positions are compared, it becomes clear that the paths covered by both pistons differ. Piston 1, which started from the top dead center position, covers a greater distance than piston 2 from the bottom dead center position. As both pistons cover a different distance in the same period, they must have travelled at different speeds. This speed difference affects the acceleration and deceleration of the oscillating masses, thus leading to undesired oscillations. As this process occurs twice per crankshaft revolution, these are referred to as free inertia forces of the 2nd order.



TO14-0465

Overview of counterbalance shafts, B46 engine

Index	Explanation
A	Counterbalance shaft
B	Crankshaft
1	Straight tooth gearing
2	Needle bearing
3	Intermediate gear
4	Output drive gear, crankshaft
5	Output pinion, timing chain
6	Output pinion, chain, oil pump

B46 Engine

2. Engine Mechanical

The B46 engine has two counterbalance shafts which rotate at twice the speed of the crankshaft. The gears of the counterbalance shafts have 48 teeth. The gear of the crankshaft has 96 teeth.

A correct setting of the two counterbalance shafts is a prerequisite for reduction of the oscillations. Using a special tool the counterbalance shafts can be secured in their specified installation position in Service.

A gear between the crankshaft and the counterbalance shaft effects the change of rotational direction of the right counterbalance shaft. In the new condition, the tooth flanks of the idler gear have a special coating. This coating helps adjust the tooth backlash between the counterbalance shaft and the crankshaft during installation in Service. An incorrectly adjusted tooth backlash can lead to running noises of the gears when the engine is running.



A newly coated idler gear must be installed for setting the counterbalance shafts. The repair instructions must be followed.

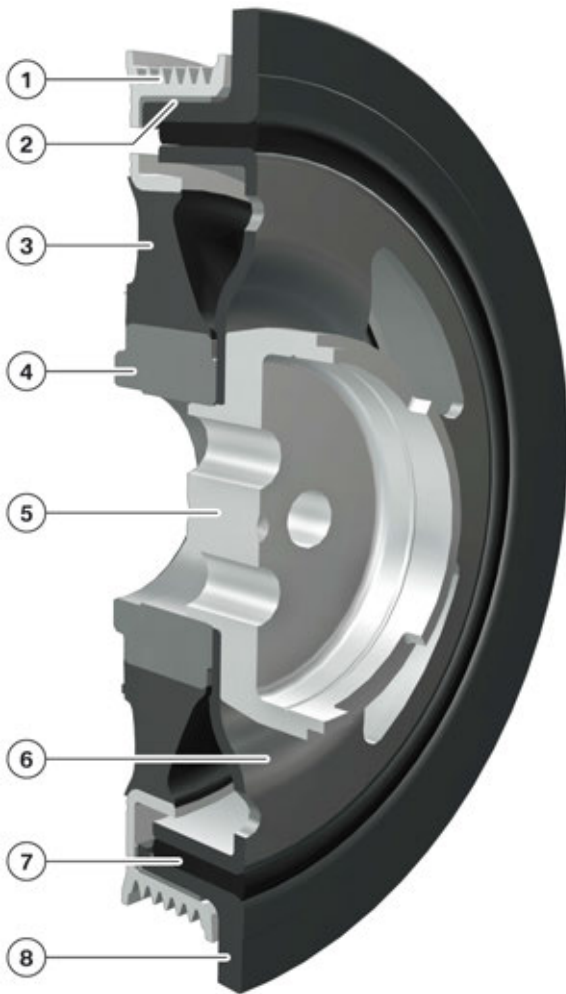
2.2.6. Torsional vibration damper

A torsional vibration damper is used on the belt drive of B46 engine. The torsional vibration damper assumes the following tasks:

- Reduction of the torsional oscillations of the crankshaft.
- Reduction of the rotational deformity of the supporting components.

B46 Engine

2. Engine Mechanical



TA13-2106

Variant of a torsional vibration damper, B46 engine

Index	Explanation
1	Belt pulley
2	Plain bearing
3	Belt pulley rubber isolation element
4	Uncoupled belt pulley hub
5	Pressure hub
6	Vibration damper hub
7	Vibration damper rubber part
8	Flywheel

B46 Engine

2. Engine Mechanical

Vibration damper

The vibration damper comprises a hub, a rubber element, which acts as a spring, and a flywheel, which serves as weight. The rotary oscillations of the crankshaft are reduced by the combined action of the spring and mass element. This reduces the load of the crankshaft and the noises emitted by the engine.

Uncoupled belt pulley

The uncoupled belt pulley is important for smooth low-wear drive of supporting components. The belt pulley is uncoupled from the hub by the rubber isolation element. The rubber isolation element permits greater rotation, and reduces the remaining rotational imbalance and thereby the load on the drive belt. The belt pulley is supported by the plain bearing.



To avoid damage to the torsional vibration damper, the engine must not be operated without drive belts.

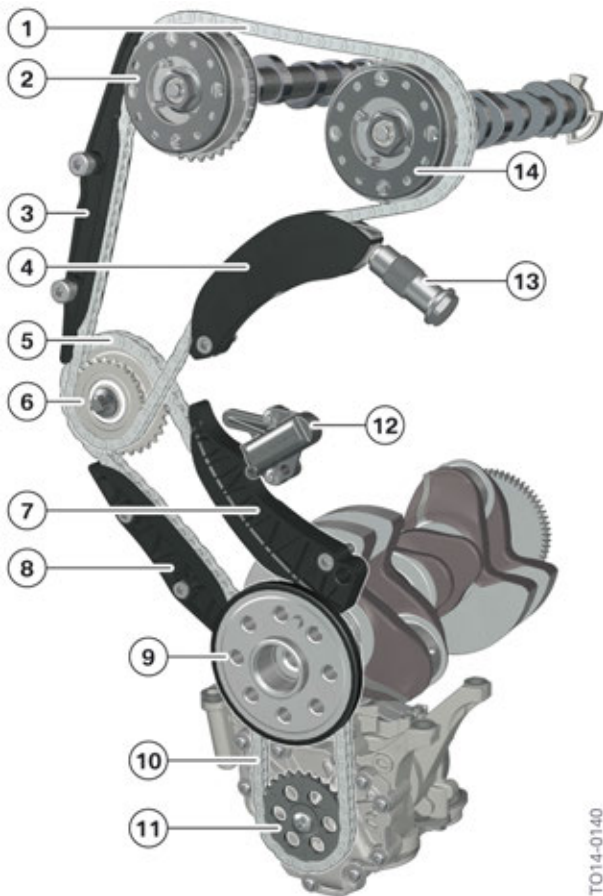
2.2.7. Chain drive

Features:

- Chain drive at the side of the engine emitting the forces.
- Two-part chain drive for drive of camshafts, synergy parts for the diesel engines.
- Simple sleeve-type chains.
- Electric motor of the combined oil-vacuum pump via a separate chain.
- Plastic tensioning rails and guide rails.
- Hydraulic chain tensioner with spring preload.

B46 Engine

2. Engine Mechanical



Chain drive, Bx8 engines

Index	Explanation
1	Upper timing chain
2	VANOS with intake camshaft sprocket
3	Upper guide rail
4	Top tensioning rail
5	Lower timing chain
6	Camshaft sprocket, intermediate shaft
7	Bottom tensioning rail
8	Lower guide rail
9	Crankshaft
10	Chain oil-vacuum pump
11	Oil-vacuum pump camshaft sprocket
12	Lower chain tensioner
13	Upper chain tensioner
14	VANOS with exhaust camshaft sprocket

B46 Engine

2. Engine Mechanical

The chain drive is on the transmission side. The inertia of the transmission at this engine end significantly reduces the rotary oscillations and also therefore the loads acting on the chain drive.

The B46 engine is equipped with a two-part chain drive. With this arrangement, the bottom timing chain drives the camshaft sprocket of the intermediate shaft. The drive torque is simply diverted to the top timing chain via the intermediate shaft.

Sufficient lubrication of the bottom timing chain is ensured by the oil mist in the crankcase and the engine oil that drips off.

The combined oil-vacuum pump is also driven by the crankshaft via a separate drive chain.



The screw connection of the oil and vacuum pump camshaft sprocket has a left-hand thread.

Lubrication of top chain drive



Lubrication of top chain drive, B46 engine

TO14-0565

B46 Engine

2. Engine Mechanical

Index	Explanation
1	Upper guide rail
2	Top tensioning rail
3	Upper timing chain
4	Top chain tensioner with oil spray nozzle
5	Spray pattern

The timing chain is always tensioned on the unloaded side. This is performed by a tensioning rail on which a chain tensioner acts. The upper timing chain is lubricated by an oil spray nozzle in the top chain tensioner. There is an opening in the tensioning rail to ensure that oil reaches the top timing chain.

2.3. Valve gear

2.3.1. Variants

Two different technologies are used in the area of the valve gear.



Valve gear, B38 B46 engine.

Index	Explanation
A	Double VANOS
B	Valvetronic

The following table provides an overview of the technology used in the B46 engine:

Engine	Double VANOS	Valvetronic
B46A20M0	Yes	Yes

B46 Engine

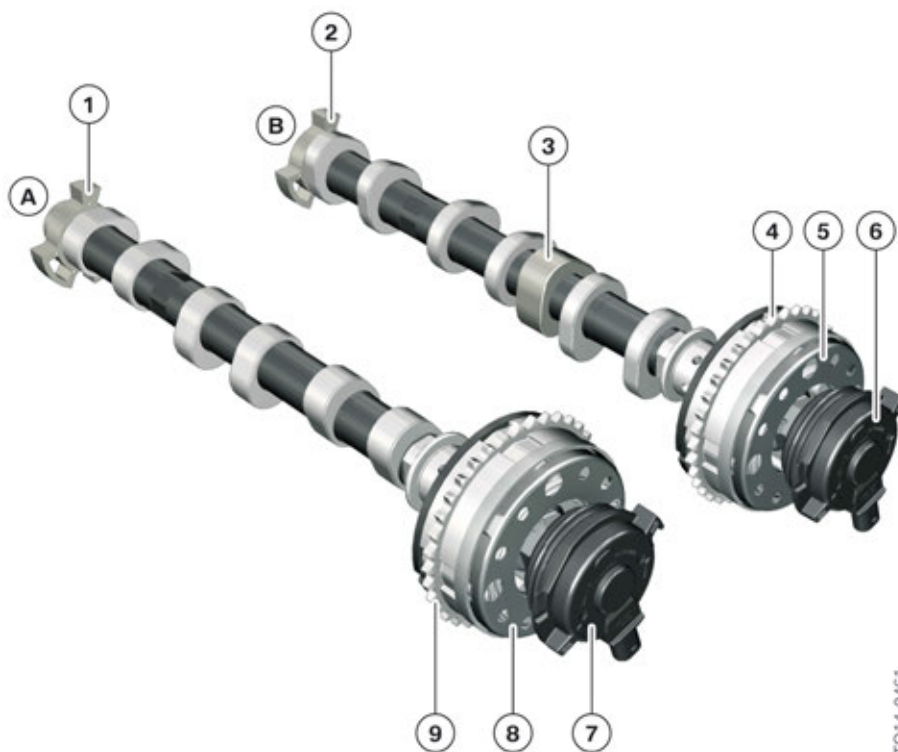
2. Engine Mechanical

2.3.2. VANOS

The valve overlap times have a significant impact on the characteristics of the engine. An engine with smaller valve overlap therefore tends to have a high maximum torque at low engine speeds but the maximum power which can be achieved at high engine speeds is low. The maximum power achieved with a large valve overlap on the other hand is higher, but this is at the expense of the torque at low engine speeds.

The VANOS provides a solution. It makes a high torque possible in the low and medium engine speed range and a high maximum power in the higher engine speed ranges. A further benefit of the VANOS is the option of internal EGR. This reduces the emission of harmful nitrogen oxides NO_x, particularly in the partial load range. The following is also achieved:

- Faster heating up of catalytic converter.
- Lower pollutant emissions during cold start.
- Reduction in consumption.



Double VANOS, Bx8 engine

Index	Explanation
A	Intake camshaft
B	Exhaust camshaft
1	Increment wheel, intake camshaft
2	Increment wheel, exhaust camshaft
3	Triple cam for high pressure pump drive system

B46 Engine

2. Engine Mechanical

Index	Explanation
4	Exhaust camshaft sprocket
5	VANOS unit, exhaust side
6	VANOS solenoid valve actuator, exhaust
7	VANOS solenoid valve actuator, intake
8	VANOS unit, intake side
9	Intake camshaft sprocket

Reason for using the double VANOS

The advantages of a Valvetronic are lower charge cycle losses and therefore potential for reducing fuel consumption by adopting an appropriate driving style. However, in contrast to throttle valve-controlled systems, Valvetronic cannot reduce charge-cycle losses in the full load range.

VANOS unit

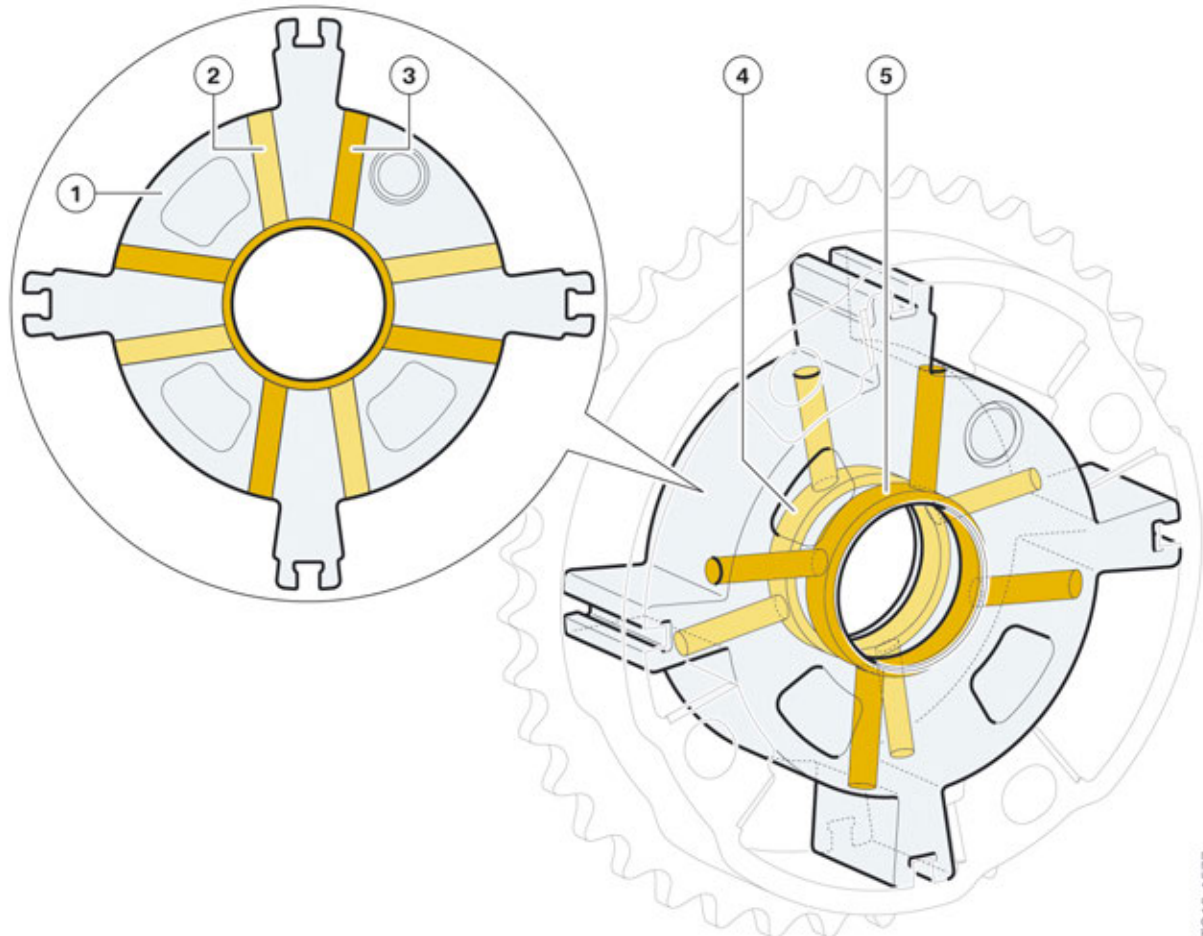
With older VANOS systems, such as that used in the N55 engine, the VANOS units were controlled by separate VANOS solenoid valves integrated into oil ducts in the cylinder head.

The oil ducts in the cylinder head are reduced and the adjustment speed is increased by using a VANOS solenoid valve unit and a mechanical VANOS central valve, which is located inside the VANOS unit.

B46 Engine

2. Engine Mechanical

The following graphic shows the oil ducts in the VANOS unit:



VANOS unit, intake camshaft, Bx8 engine

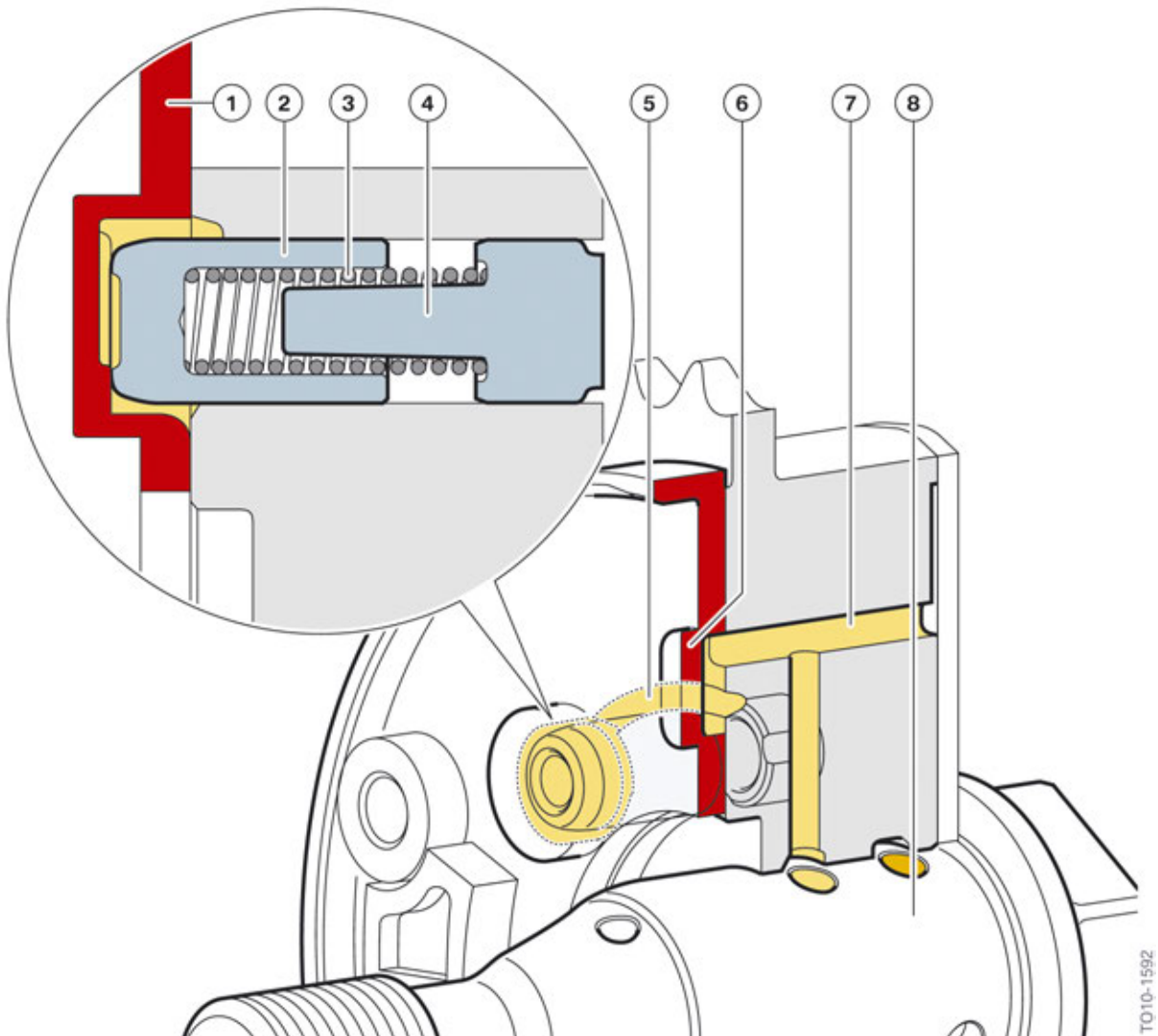
Index	Explanation
1	Rotor
2	Oil duct for timing advance
3	Oil duct for timing retardation
4	Oil duct for timing advance
5	Oil duct for timing retardation

The intake camshaft can be “advanced” with the ducts shaded light yellow; the VANOS unit can be “retarded” with the ducts shaded dark yellow.

TO10-1577

B46 Engine

2. Engine Mechanical



Locking pin, Bx8 engine

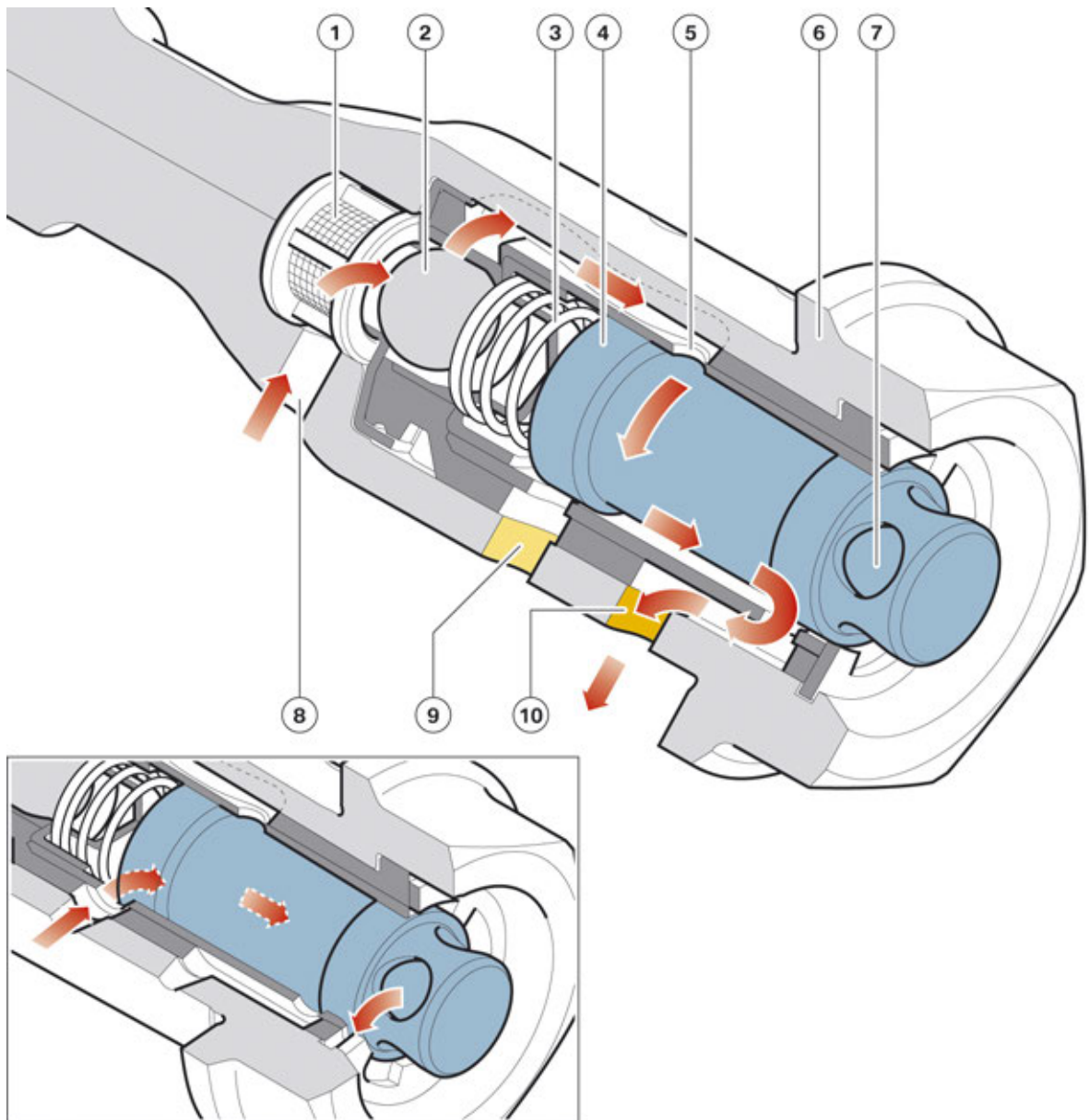
Index	Explanation
1	Locking cover
2	Locking pin
3	Locking spring
4	Cartridge
5	Oil duct
6	Locking cover
7	Oil duct
8	VANOS central valve

B46 Engine

2. Engine Mechanical

The locking pin ensures that the VANOS unit adopts a clear, locked position in the depressurized state. The locking spring ensures the unit is locked by continuously pushing the locking pin into the locked position when the actuator is de-energized. The VANOS unit is blocked in this condition. The timing can be adjusted in this way. This is important when the engine is started to ensure exact timing. The oil pressure which is present for timing advance simultaneously unlocks the locking pin via oil ducts in the VANOS unit. If the camshaft is to be "advanced", the locking pin is then forced by the applied oil pressure against the locking spring towards the cartridge and the locking cover is released for VANOS adjustment.

The following graphic shows the oil flow rate in the VANOS central valve which is used to control the camshaft adjustment:



VANOS central valve, intake camshaft, Bx8 engine

TO10-1593

B46 Engine

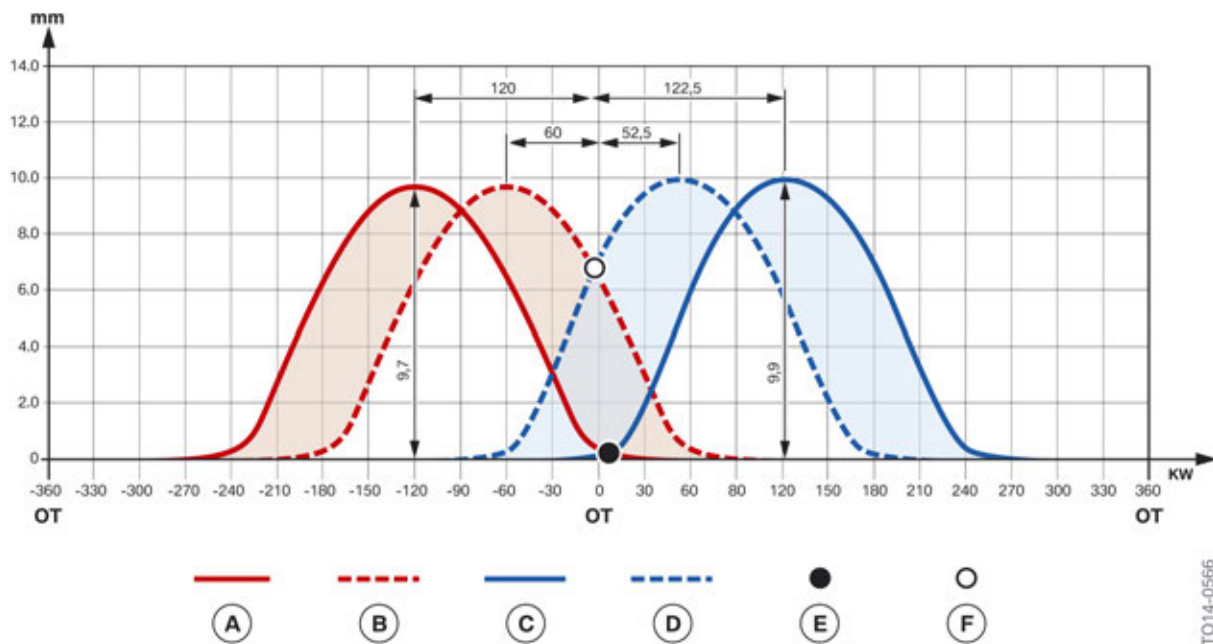
2. Engine Mechanical

Index	Explanation
1	Filter
2	Ball
3	Spring
4	Piston
5	Sleeve
6	Housing
7	Opening in plunger
8	Oil supply from main oil duct
9	Bore to oil duct in VANOS (timing advance)
10	Bore to oil duct in VANOS (timing retardation)

The VANOS unit is secured to the camshaft by the VANOS central valve. The oil flow into the VANOS unit is simultaneously controlled by this VANOS central valve. The system is actuated by a solenoid actuator with its own piston that pushes on and displaces the piston of the VANOS central valve. The oil flow is controlled by means of the plunger.

The previous graphic shows the de-energized VANOS central valve. The locking pin blocks the VANOS unit.

Timing diagram



Variable valve overlap, Bx8 engine

TO14-0566

B46 Engine

2. Engine Mechanical

Index	Explanation
1	Valve travel
2	Spread, exhaust camshaft
3	Spread, intake camshaft
4	Degree crankshaft
A	VANOS solenoid valve, exhaust, de-energized
B	VANOS solenoid valve, exhaust, duty cycle 100 %
C	VANOS solenoid valve, inlet, de-energized
D	VANOS solenoid valve, inlet, duty cycle 100 %
E	Smallest valve overlap in idle
F	Maximum valve overlap in partial load



The following is to be expected if the VANOS unit drops out:

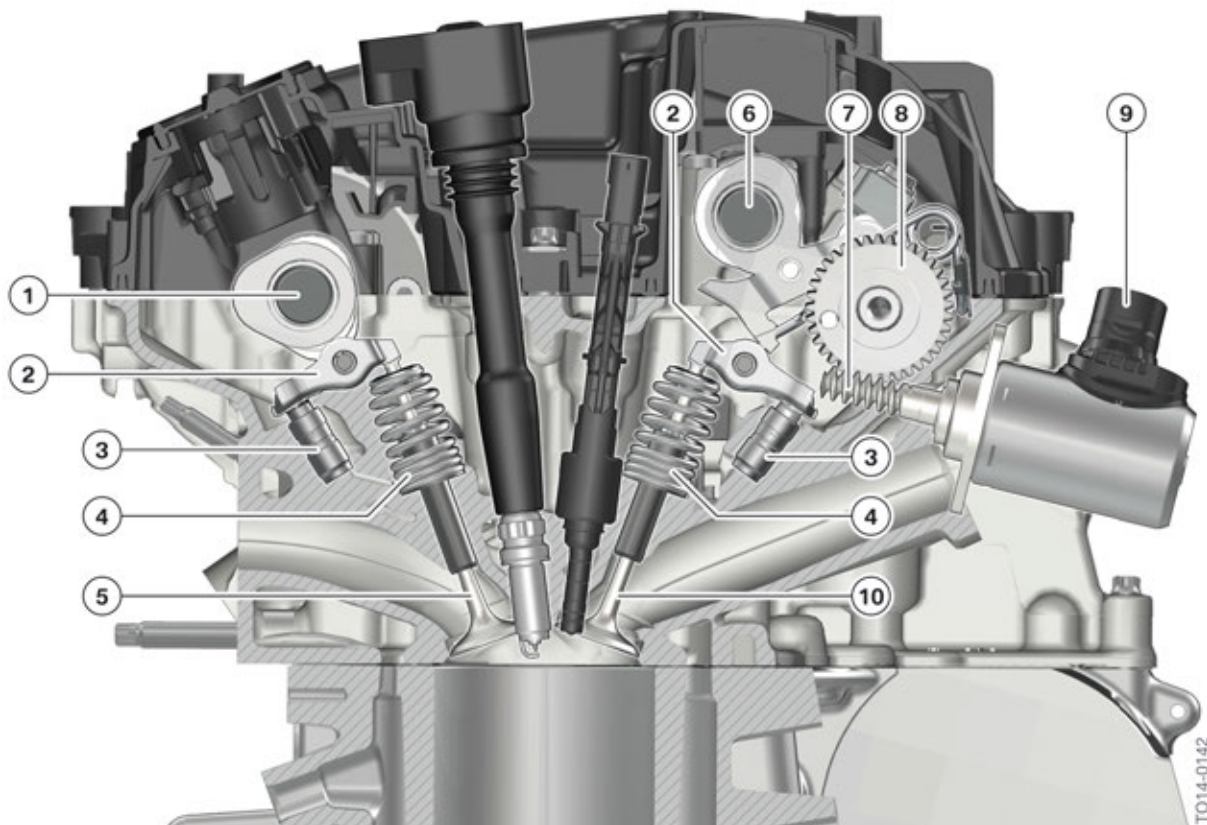
- Emergency operation.
- Fault code entry in the Digital Motor Electronics (DME).

2.3.3. Valvetronic

The Valvetronic has been further developed for use in the new B46 engine. The fourth-generation Valvetronic is used in the engine. A distinguishing feature is the Valvetronic servomotor which is visible from the outside.

B46 Engine

2. Engine Mechanical



Valvetronic 4th generation, Bx8 engine

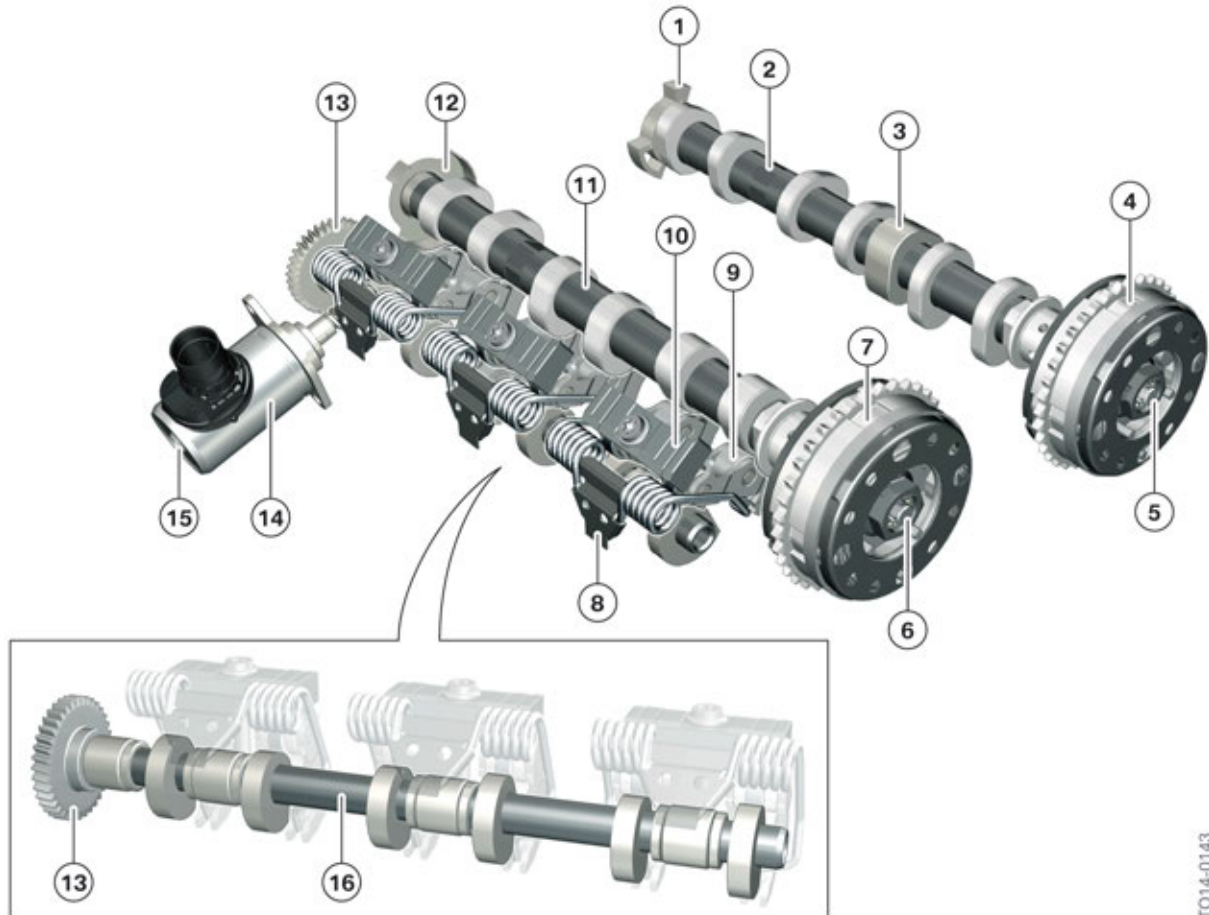
Index	Explanation
1	Exhaust camshaft
2	Roller cam follower
3	Hydraulic valve clearance compensation element
4	Valve spring
5	Exhaust valve
6	Intake camshaft
7	Worm gear
8	Eccentric shaft
9	Electrical connection, Valvetronic servomotor
10	Intake valve

The Valvetronic comprises a fully-variable valve lift control and a double VANOS. It operates according to the principle of throttle-free load control. With this system, a throttle valve is only used to stabilize the engine operation at critical operating points and to ensure a slight vacuum for the engine ventilation. A very small vacuum can be produced in the intake pipe by slightly tilting the throttle valve, which allows treated blow-by gases to be introduced into the intake port during naturally-aspirated engine operation.

B46 Engine

2. Engine Mechanical

The following graphic provides an overview of the design of the Valvetronic:



Valvetronic, Bx8 engine

TO14-0143

Index	Explanation
1	Increment wheel, exhaust camshaft
2	Exhaust camshaft
3	Triple cam for high pressure pump drive system
4	VANOS unit with exhaust camshaft sprocket
5	VANOS central valve, exhaust side
6	VANOS central valve, intake side
7	VANOS unit with intake camshaft sprocket
8	Return spring with insert plate
9	Intermediate lever
10	Gate
11	Intake camshaft
12	Increment wheel, intake camshaft

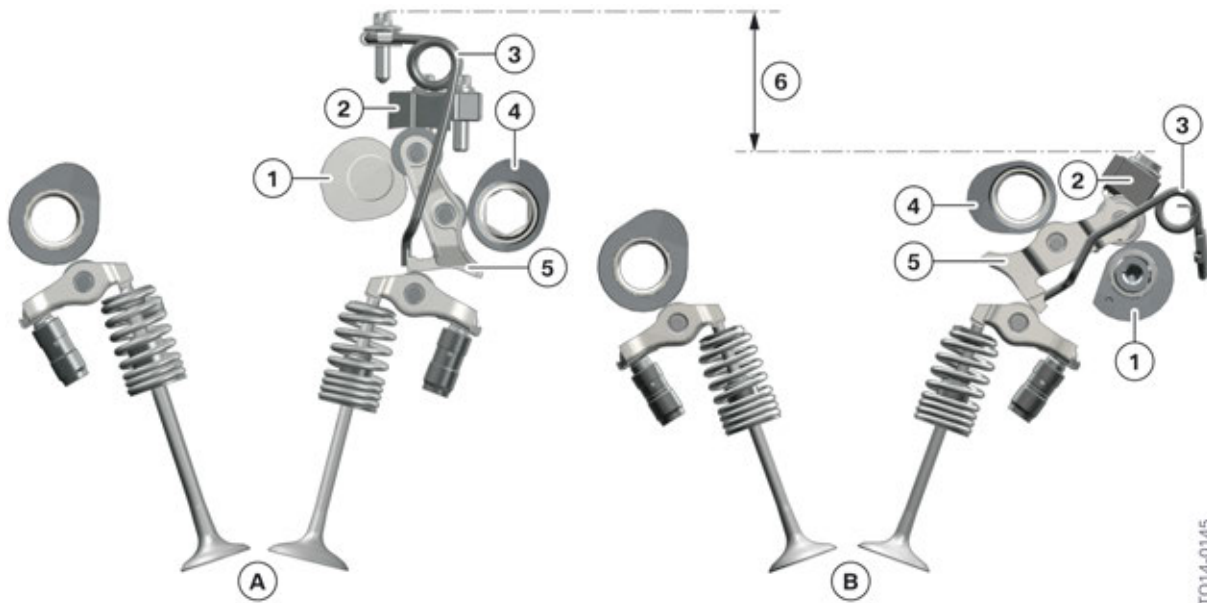
B46 Engine

2. Engine Mechanical

Index	Explanation
13	Drive pinion, eccentric shaft
14	Valvetronic servomotor
15	Hexagon socket (Inbus)
16	Eccentric shaft

The following components of the Valvetronic were reworked for use in the B46 engine:

- Assembled eccentric shaft
- Adjustment range increased from 190 ° (N20/N55) to 253 ° (B46)
- Smaller worm gear ratio of 37:1
- Thinner lighter sliding blocks with only one screw connection
- Return spring inserted and not screwed
- Oil spray nozzle for lubrication of worm gear omitted
- Smaller more powerful Valvetronic servomotor.



Comparison of Valvetronic N20 with B46 engine

Index	Explanation
A	Valvetronic, N20 engine
B	Valvetronic, B46 engine
1	Eccentric shaft
2	Gate

B46 Engine

2. Engine Mechanical

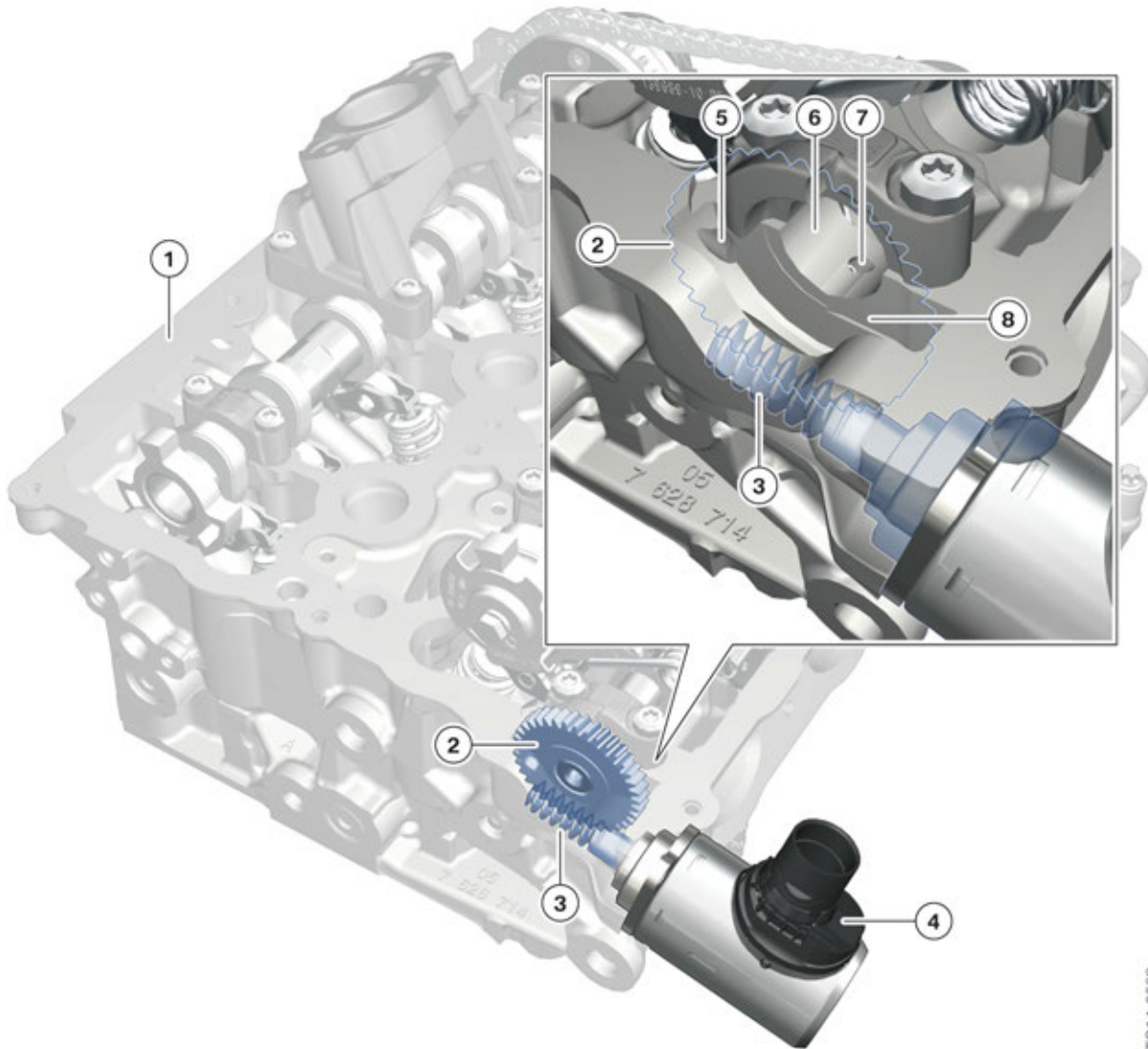
Index	Explanation
3	Return spring
4	Camshaft
5	Intermediate lever
6	Height of installation space

By reworking the Valvetronic, it has, most importantly, been possible to significantly reduce the installation space. A considerable height advantage has been gained by swapping round the intake camshaft and the eccentric shaft. The new position of the intermediate lever and gate simplifies the application of force in the cylinder head. The gate is therefore only attached to the bearing support with one screw and is positioned via two precise contact surfaces in the cylinder head. The return spring for the intermediate lever between the cylinder head and bearing position is self-supporting and does not require its own attachment point. The eccentric shaft is, as is already the case with the camshaft, an "assembled" design.

B46 Engine

2. Engine Mechanical

Lubricating oil supply to the Valvetronic worm gear



TO14-0568

Lubricating oil supply to the Valvetronic worm gear, B46 engine

Index	Explanation
1	Cylinder head
2	Drive pinion of the eccentric shaft
3	Worm gear of Valvetronic servomotor
4	Valvetronic servomotor
5	Outlet bore hole
6	First bearing position of eccentric shaft
7	Inlet bore hole
8	Oil chamber

B46 Engine

2. Engine Mechanical

Due to the fast adjustment speeds of the eccentric shaft of less than 300 milliseconds from minimum to maximum stroke and the wide adjustment range from 0.2 millimeters (minimum) to 9.9 millimeters (maximum) valve lift with a small transmission ratio, sufficient lubrication between the worm gear of the Valvetronic servomotor and drive pinion of the eccentric shaft must be ensured. The lubricating oil reaches the oil chamber via an inlet bore hole at the first bearing position of the eccentric shaft. Here, the oil volume rises to the lower edge of the outlet bore hole. The excess oil flows back to the oil circuit via the outlet bore hole. The gearing of the worm gear is now supported in the oil bath and is therefore lubricated at all times.

Information on disassembly and installation work

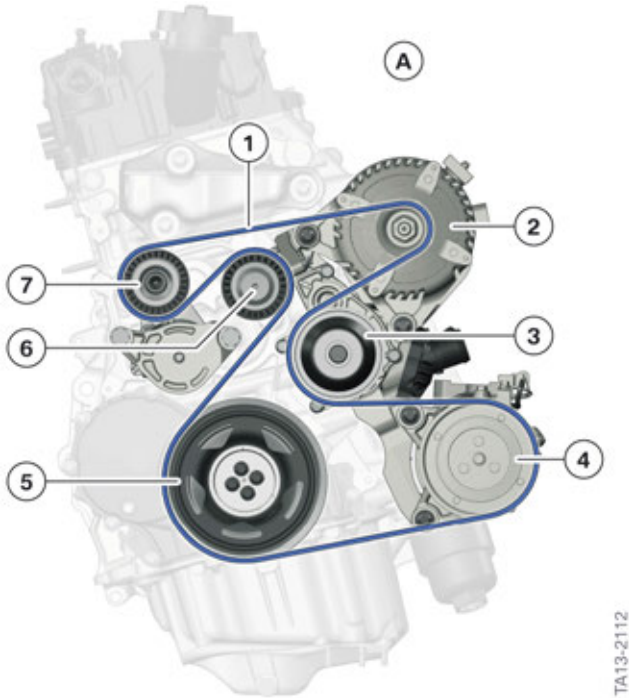
As numerous changes have been made, a new special tool is used to remove the return springs.

The hexagon socket on the Valvetronic servomotor is for manual adjustment of the worm gear. This is necessary if the Valvetronic servomotor needs to be removed, for example. To avoid damage to the worm gear, it must be greased prior to start-up using a special lubricant (Longtime PD part number: 83 19 2 160 340). The Valvetronic in the Digital Motor Electronics (DME) can be taught-in using the teach-in routine in ISTA. During this process, the limit positions of the system are determined once again and stored in the Digital Motor Electronics (DME). The precise procedure for removing the Valvetronic is described in the current repair instructions.

B46 Engine

2. Engine Mechanical

2.4. Belt drive



Belt drive, transverse-mounted B46 engine

Index	Explanation
A	With air conditioning compressor
1	Ribbed V-belt
2	Alternator
3	Coolant pump
4	Air conditioning compressor
5	Torsional vibration damper
6	Deflecting element
7	Tensioning pulley

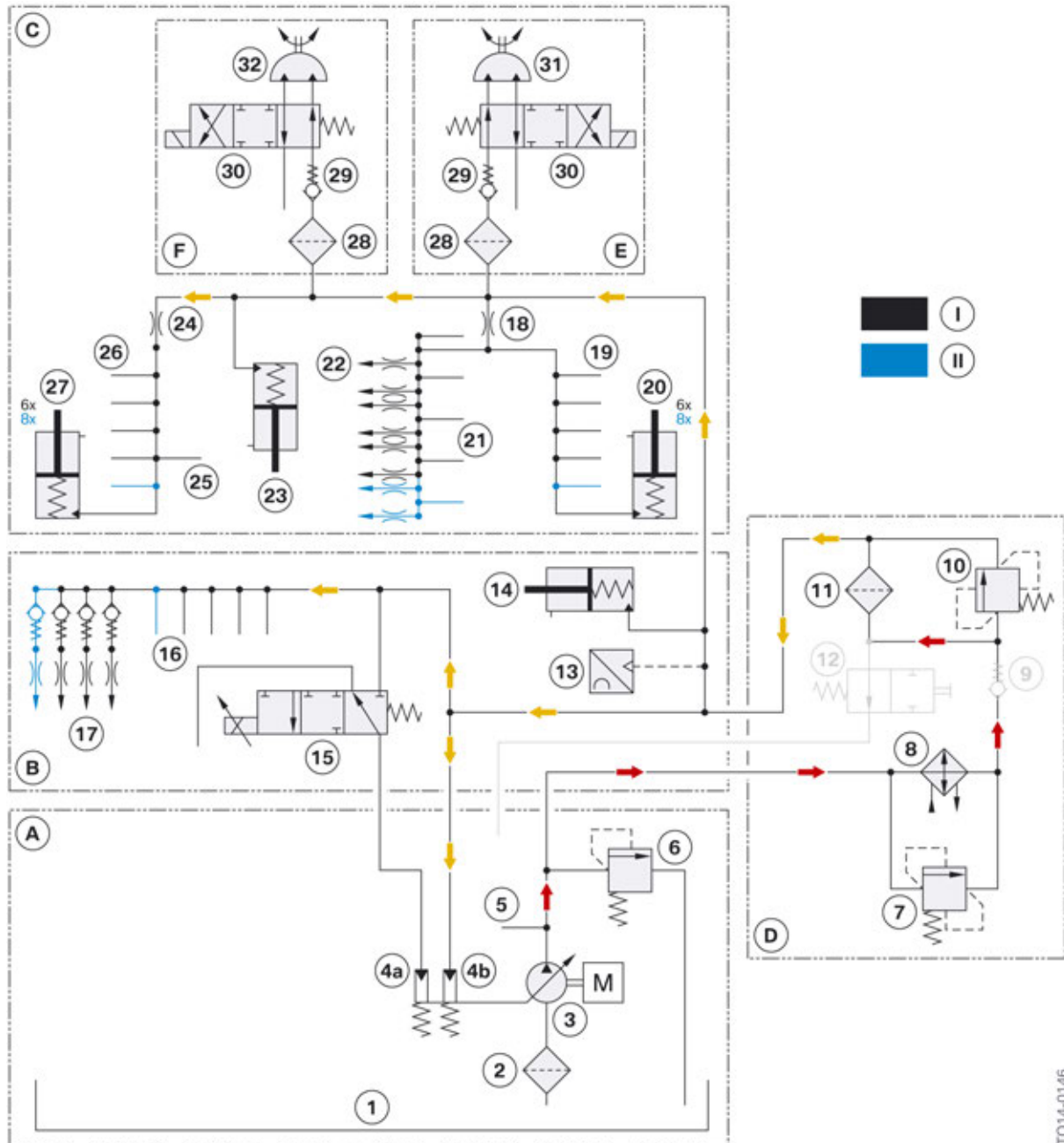
The length of the drive belt changes due to thermal expansion and ageing. So the drive belt can transmit the required torque, it must be continuously in contact with the belt pulley at a defined pressure. To this end the belt tension is exerted by an automatic tensioning pulley which compensates for belt elongation over the full service life.

A standard belt with 6 ribs is used.

B46 Engine

3. Oil Supply

3.1. Oil circuit



Hydraulic circuit diagram, B38 engine

TO14-0146

Index	Explanation
A	Oil pump
B	Crankcase
C	Cylinder head
D	Oil filter module

B46 Engine

3. Oil Supply

Index	Explanation
E	VANOS unit, intake camshaft
F	VANOS unit, exhaust camshaft
I	3-cylinder engine
II	4-cylinder engine
1	Oil sump
2	Intake pipe with filter
3	Oil and vacuum pump
4 a	Map-controlled control chamber (normal operation)
4 b	Second-level control chamber (emergency operation)
5	Oil supply of vacuum pump
6	Pressure limiting valve (built-in to pump)
7	Oil-to-water heat exchanger, bypass valve
8	Engine oil-to-coolant heat exchanger
9	N/A
10	Filter bypass valve
11	Oil filter
12	N/A
13	Oil pressure sensor
14	Chain tensioner, bottom
15	Map-controlled valve
16	Lubricating oil supply to crankshaft bearing shells of bearing seat
17	Oil spray nozzles for piston cooling
18	Throttle
19	Lubrication points on intake camshaft
20	Hydraulic valve clearance compensation
21	Lubricating points, eccentric shaft
22	Oil spray nozzles, intermediate lever
23	Chain tensioner, top
24	Throttle
25	Lubrication point, high-pressure pump
26	Lubricating point, exhaust camshaft
27	Hydraulic valve clearance compensation
28	Oil strainer, solenoid valve

B46 Engine

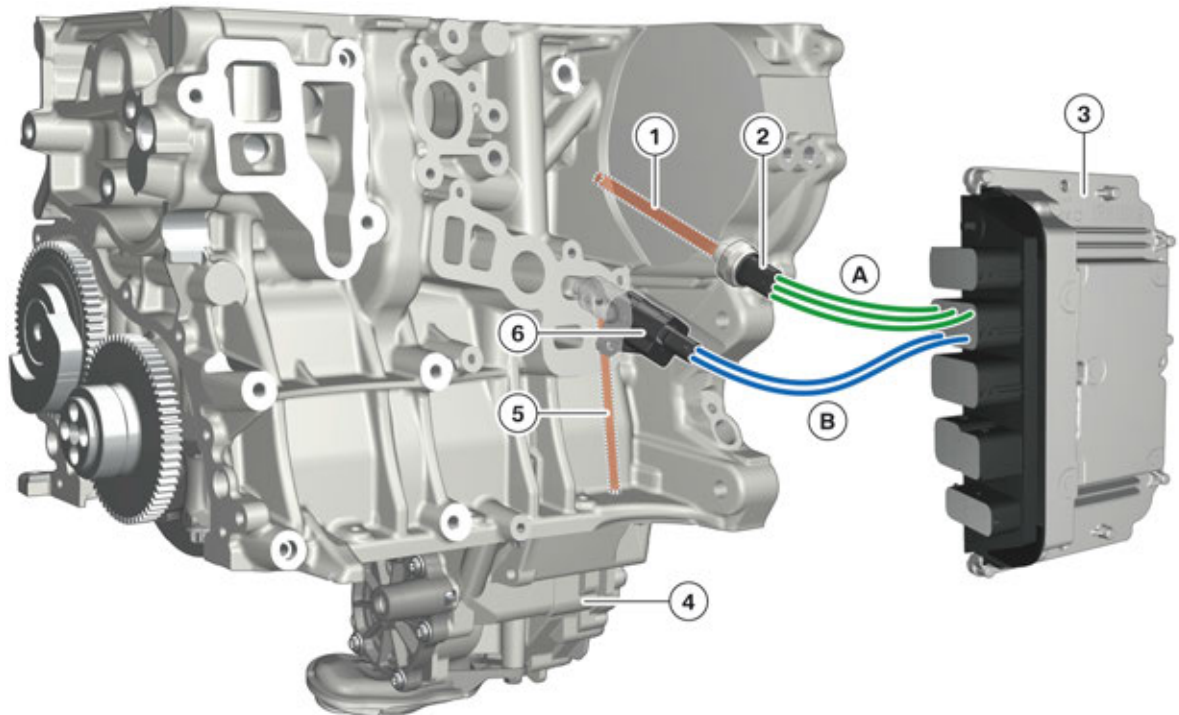
3. Oil Supply

Index	Explanation
29	Non-return valve
30	Solenoid valve
31	VANOS swivel rotor (intake camshaft)
32	VANOS swivel rotor (exhaust camshaft)

With force-fed circulation lubrication the oil is drawn out of the oil sump by the oil pump through an intake pipe and forwarded into the circuit. The oil passes through the engine oil cooler with an integrated full-flow oil filter and from there into the main oil duct, which runs in the engine block parallel to the crankshaft. Branch ducts lead to the crankshaft main bearings. There are bore holes between the main bearings of the crankshaft and the connecting rod bearing journal which admit the oil to the lubricating points of the connecting rod bearing.

Some of the oil is diverted from the main oil duct and directed to the cylinder head to the relevant lubricating points and adjustment units. When the engine oil flows through the consumers, it either returns to the oil sump via the return ducts or it drips back freely.

3.2. Map control



System overview of map-controlled oil supply of Bx8 engine

TO14-0147

B46 Engine

3. Oil Supply

Index	Explanation
A	Oil pressure sensor signal
B	Activation of map-controlled control valve
1	Main oil duct to the oil pressure sensor
2	Oil pressure sensor
3	Digital Motor Electronics (DME)
4	Oil pump
5	Oil duct to map-controlled control chamber of oil pump
6	Map control valve

The B46 engine is equipped with the familiar map-controlled oil pump which is already used. The actual oil pressure is recorded via an oil pressure sensor and forwarded to the Digital Motor Electronics (DME). The Digital Motor Electronics performs a target/actual comparison based on the stored characteristic maps. The map-controlled control valve is activated by means of a pulse-width modulated signal until the nominal pressure stored in the characteristic map has been reached. During this process, the delivery rate of the oil pump varies according to the oil pressure in the oil duct to the map-controlled control chamber.

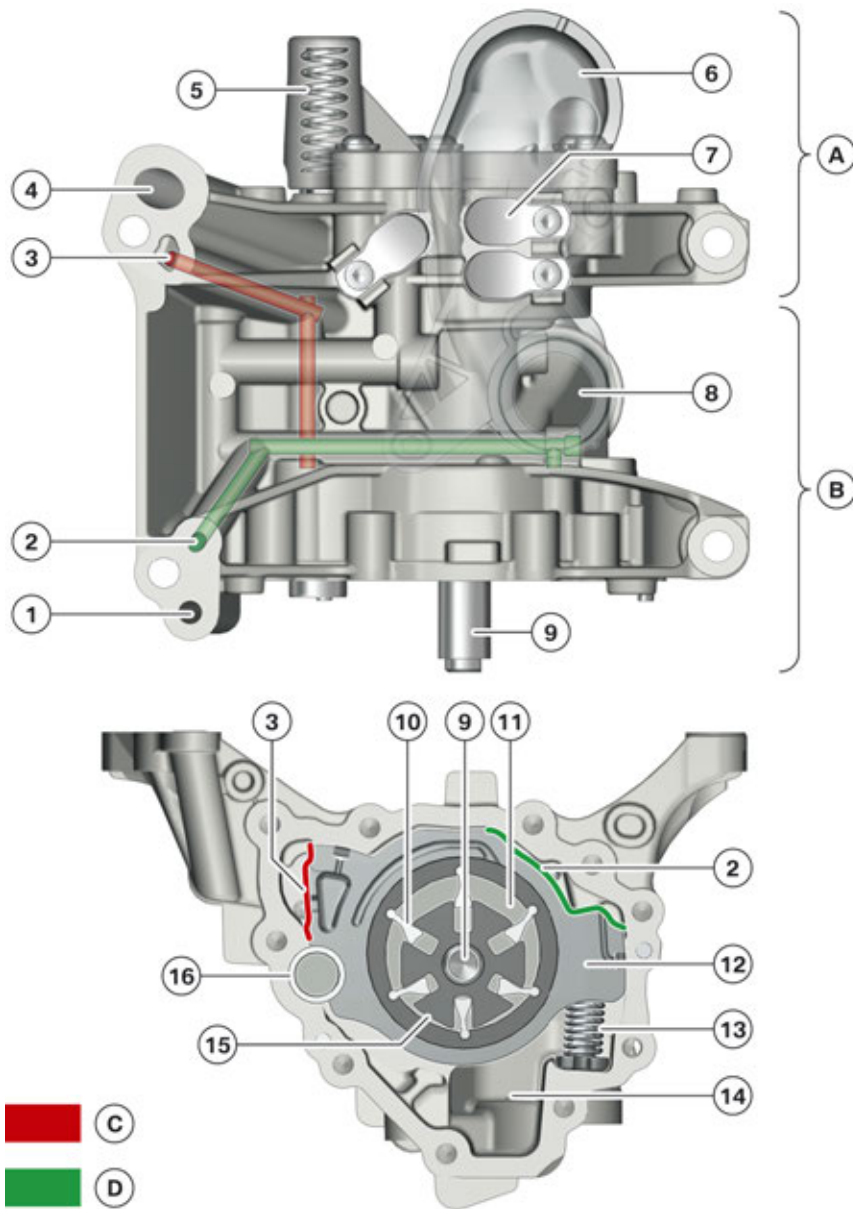
3.3. Oil pump

The oil pump plays a central role in modern combustion engines. Due to the high power and enormous torque which is present even at low engine speeds, it is necessary to ensure a reliable oil supply. This is necessary on account of the high component temperatures and heavily loaded bearings. To achieve low fuel consumption, the delivery rate of the oil pump must be adapted to the requirements.

The oil pump is driven by the crankshaft via a chain.

B46 Engine

3. Oil Supply



Design of oil pump, B46 engine

TO14-0569

Index	Explanation
A	Vacuum pump
B	Oil pump
C	Second-level control area (emergency operation)
D	Map-controlled control area (normal operation)
1	Vacuum duct to vacuum pump
2	Oil duct to map-controlled control chamber
3	Oil duct to second-level control chamber

B46 Engine

3. Oil Supply

Index	Explanation
4	Oil pressure channel, pump output
5	Pressure-limiting valve
6	Intake pipe with filter
7	Discharge valves, vacuum pump
8	Oil intake port
9	Pump shaft
10	Rotor with pendulum
11	Suction side
12	Adjusting ring
13	Adjusting ring spring (2x)
14	Pump input
15	Major thrust face
16	Bearing tube (center of rotation)

A vacuum pump is integrated into the oil pump housing.

A rotor with pendulum rotates as shown in the graphic on the pump shaft. A crescent-shaped cavity arises through the eccentric position. During this process, the oil is drawn into the expanding chamber (intake side) and is delivered via the contracting chamber (pressure side).

When the engine is in operation, oil pressure is admitted to the map-controlled control surface and the second-level control surface of the oil pump. Depending on the oil pressure, the adjusting ring is pushed via the center of rotation at the bearing tube to varying degrees of force against the adjusting ring springs. The change in eccentric position of the adjusting ring changes the size of the chamber, and therefore also the intake and pressure power of the oil pump.

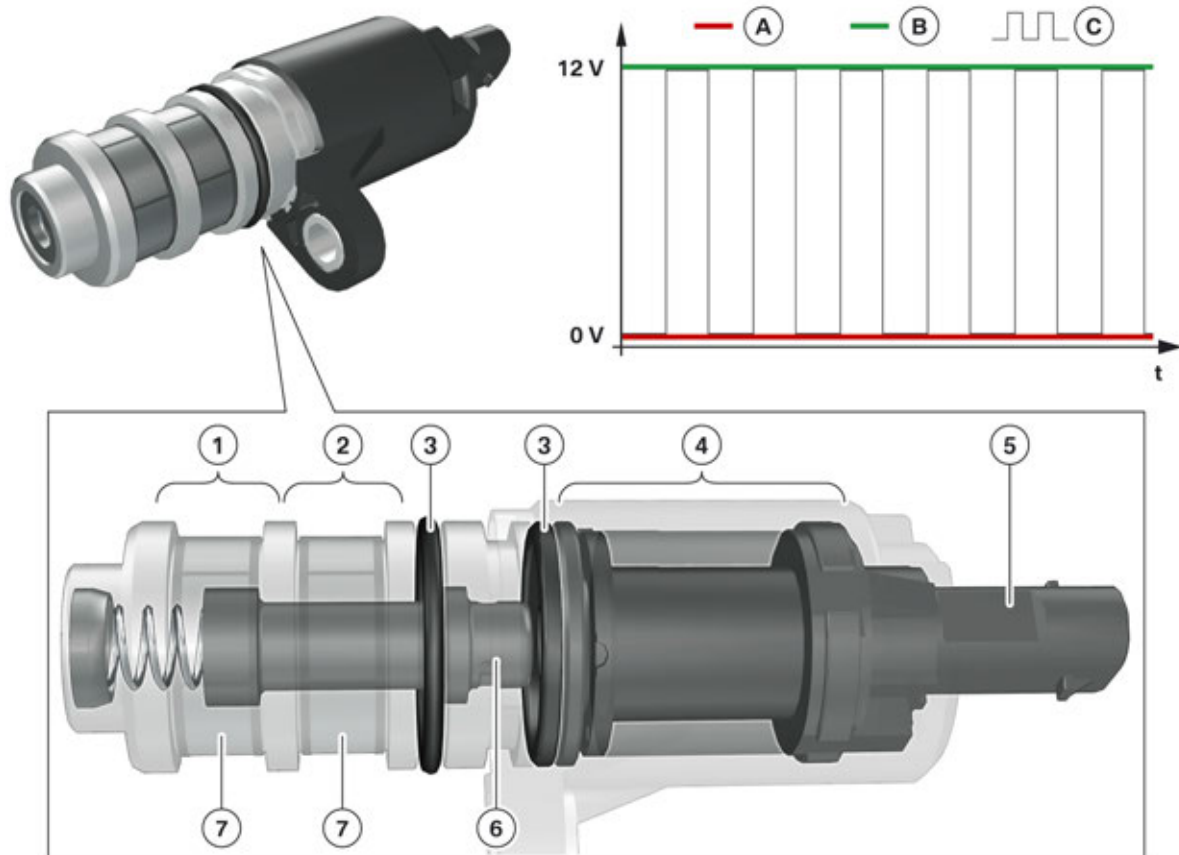
To prevent overloading of the oil pump, a filter is installed upstream of the pump inlet. The maximum oil pressure of the oil circuit at the pump outlet is restricted by a pressure limiting valve. The opening pressure of the pressure limiting valve is 11.4 +/- 1.4 bar.

B46 Engine

3. Oil Supply

3.3.1. Map control valve

The map-controlled control valve is a proportional valve which can control the oil pressure steplessly.



Map-controlled control valve, B46 engine

TO14-0590

Index	Explanation
A	Voltage curve, maximum delivery rate
B	Voltage curve, minimum delivery rate
C	Voltage curve, 50 % delivery rate
1	Oil duct from the oil filter
2	Oil duct to oil pump
3	Sealing ring
4	Solenoid coil
5	Electrical connection
6	Valve spool
7	Filter

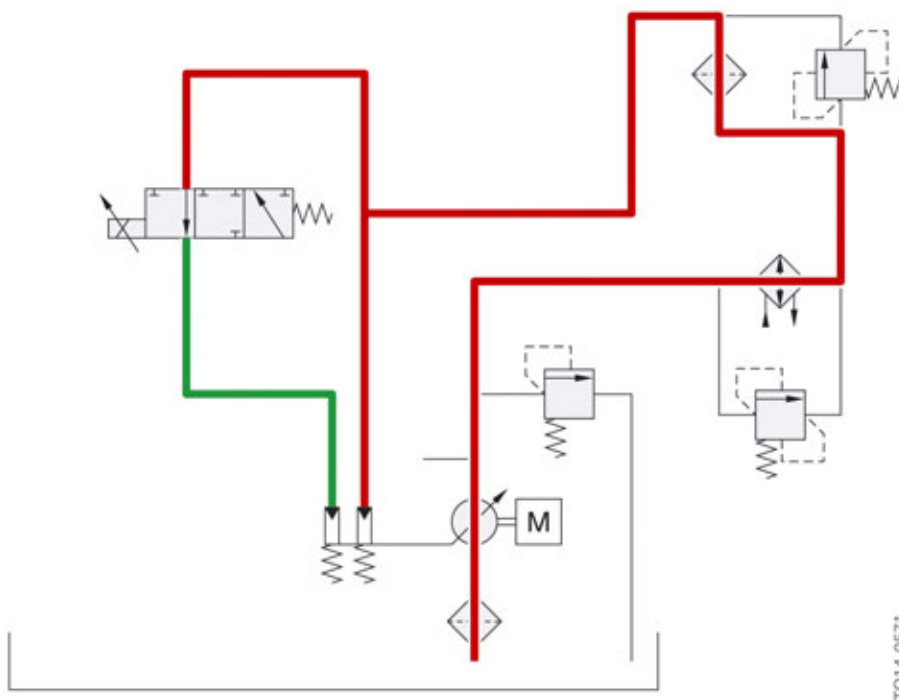
B46 Engine

3. Oil Supply

The oil pressure sensor is connected to the main oil duct and delivers the actual oil pressure at the Digital Motor Electronics (DME). The Digital Motor Electronics calculates the required nominal oil pressure based on the engine speed and fuel injection rate. A pulse-width modulated signal is sent to the map-controlled control valve based on the determined setpoint deviation. Depending on the pulse-width modulated signal, the width of the valve spool opening in the map-controlled control valve varies. Depending on the available opening cross-section, more or less engine oil can flow from the oil duct of the oil filter into the oil duct and to the oil pump. This oil flow changes the position of the adjusting ring in the oil pump, and therefore the delivery rate of the pump.

3.3.2. Normal operation

The oil pump has two separate control loops in order to guarantee normal operation (map-controlled control operation) and emergency operation (second-level control operation).



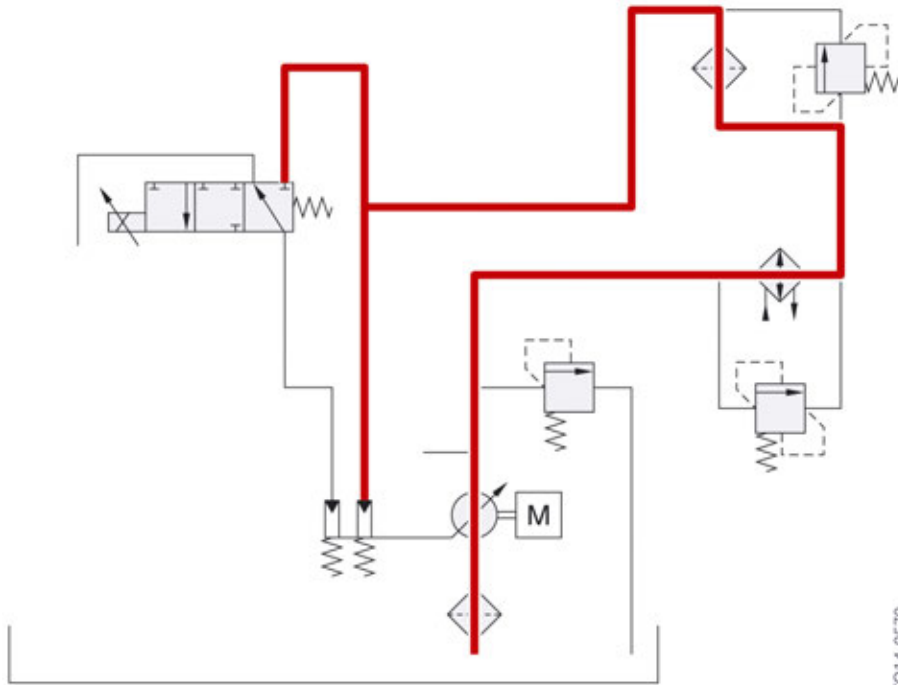
Oil circuit during normal operation, B46 engine

This control loop operates with an external map-controlled valve. The map-controlled control valve controls the oil pressure in the map-controlled control chamber via a software in the Digital Motor Electronics. If the oil pressure in the map-controlled control chamber increases, the adjusting ring further compresses the adjusting ring spring and the pump eccentricity is reduced. This results in a lower volumetric flow.

B46 Engine

3. Oil Supply

3.3.3. Emergency operation

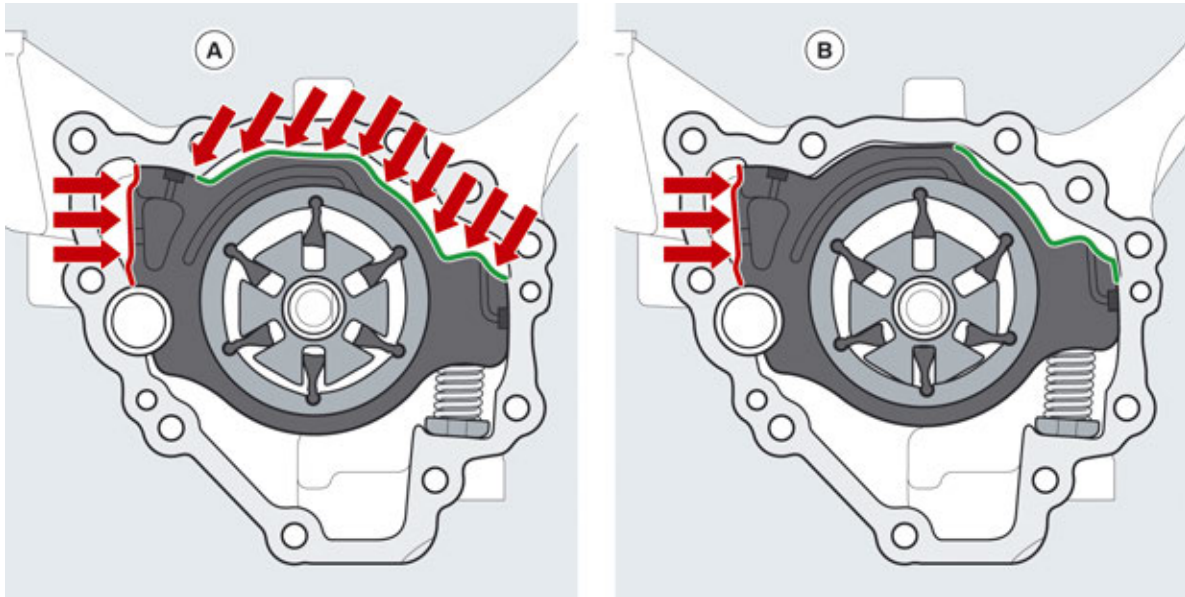


Oil circuit during emergency operation, B46 engine

During emergency operation, the system operates without the map control by the Digital Motor Electronics. The map-controlled control valve is de-energized in this operating condition and is therefore closed. The purpose of the emergency operation is to maintain the oil pressure in the oil pump at a consistently high level. The oil pressure is guided directly from the main oil duct to the second-level control chamber. This leads to an adjustment of the adjusting ring against the adjusting ring spring and thus a reduction of the volumetric flow. As it contains no actuators, intervention in this control system is not possible and it also cannot be switched off.

B46 Engine

3. Oil Supply



Operating principle of oil pump control system, B46 engine

Index	Explanation
A	Normal operation
B	Emergency operation

3.4. Suction pipe

The oil pump draws oil from the oil sump through the intake pipe. The suction pipe is positioned so that the suction opening is below the oil level under all operating conditions. The intake pipe incorporates an oil strainer, which prevents coarse dirt particles from getting into the oil pump.



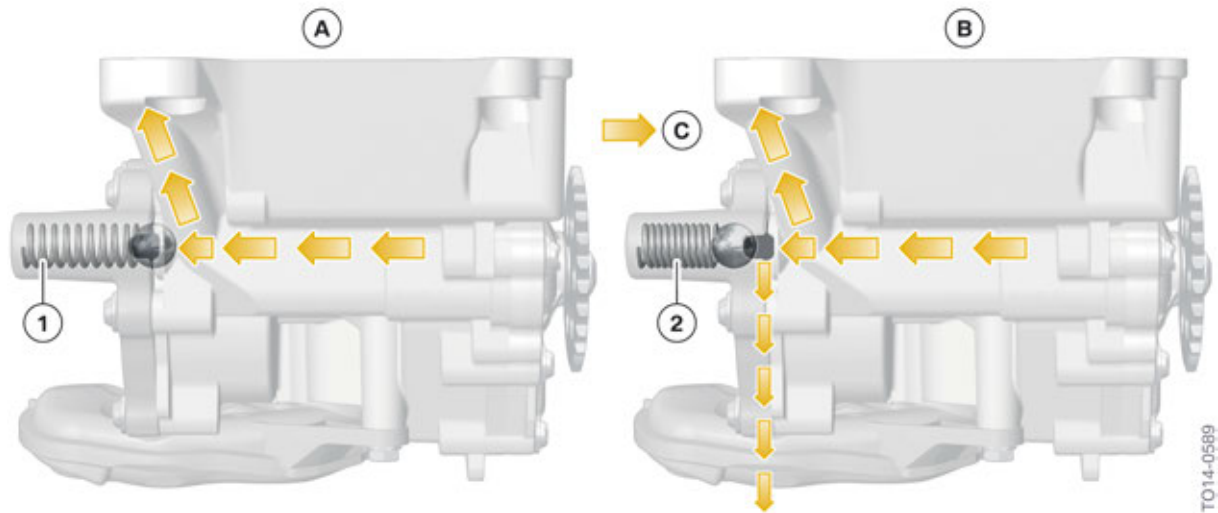
Intake pipe in B46 engine

The intake pipe is a separate component which is screwed on to the oil pump.

B46 Engine

3. Oil Supply

3.5. Pressure-limiting valve



Pressure limiting valve in oil circuit in B46 engine

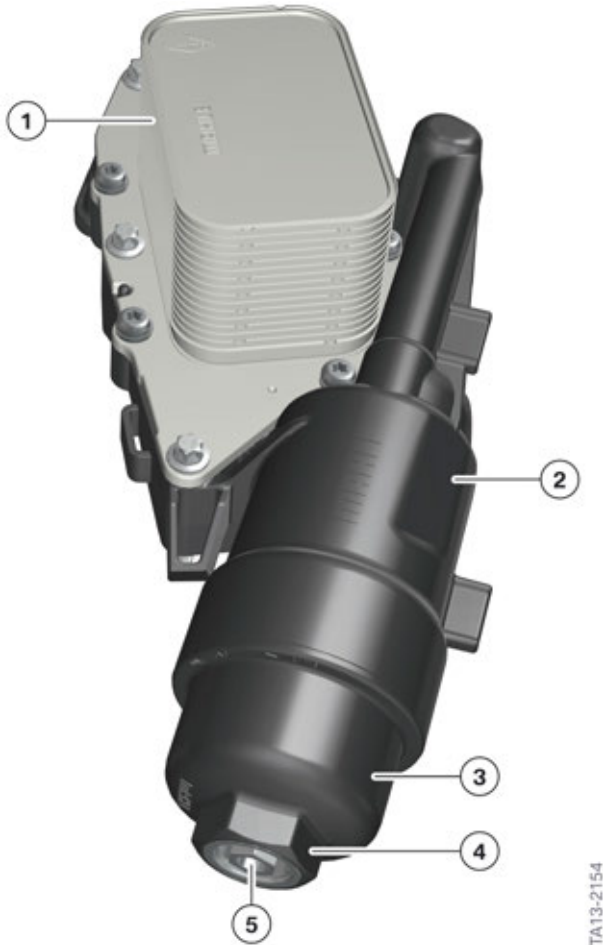
Index	Explanation
A	Oil pressure $< 11.4 \pm 1.4$ bar
B	Oil pressure $> 11.4 \pm 1.4$ bar
C	Engine oil volumetric flow
1	Pressure limiting valve closed
2	Pressure limiting valve open

The pressure limiting valve is responsible for protecting the oil pump and the oil circuit against overloading. This valve opens at an oil pressure of > 10 bar and directs the excess engine oil back to the oil sump. This valve is used if necessary when starting the engine at cold ambient temperatures (values < 0 °C), as the viscosity of the engine oil is very high here.

B46 Engine

3. Oil Supply

3.6. Oil filter module



Oil filter module

TA13-2154

Index	Explanation
1	Engine oil-to-coolant heat exchanger
2	Oil filter housing
3	Oil filter cover
4	Hexagon head for opening the oil filter cover
5	Hexagon head for opening the oil drain plug

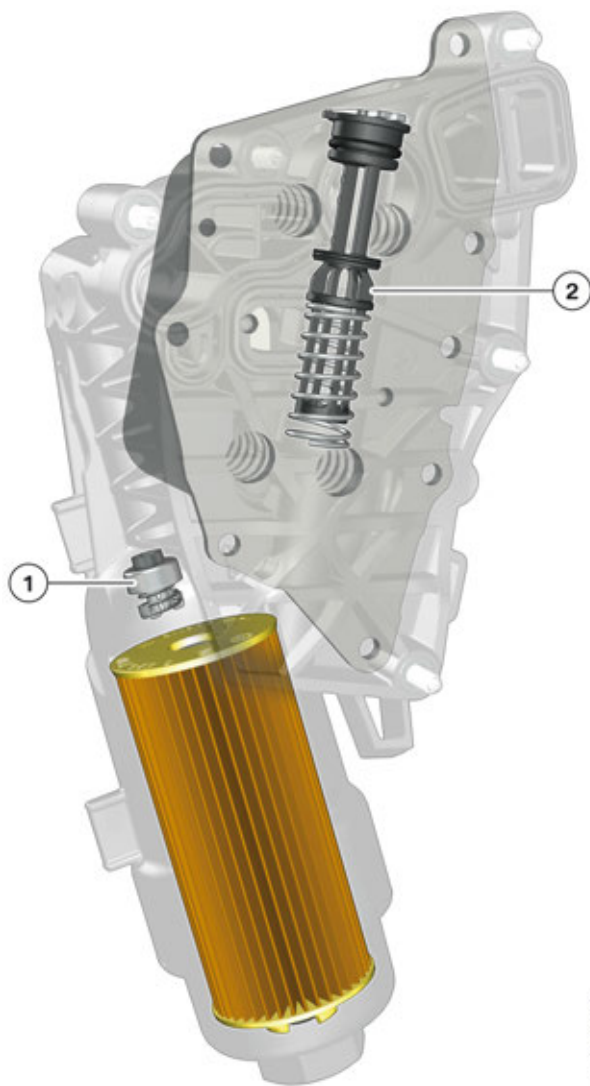
Due to the construction space, the oil filter housing is suspended in the transverse mounting. The inspection is carried out from the bottom of the vehicle. Using an oil drain plug the Service employee can drain the engine oil from the oil filter module before opening the oil filter cover.

B46 Engine

3. Oil Supply



In Service, the specified torques for the oil drain plug and the oil filter cover must be observed. The two O-rings must be replaced each time the oil filter cover and the oil drain plug are opened. Both O-rings are included in the oil filter service kit.



TA13-2156

Valves of the oil filter module

Index	Explanation
1	Filter bypass valve
2	Heat exchanger bypass valve

A non-return valve is not required thanks to the suspended mounting. The filter cannot run empty after the engine is stopped due to its position.

B46 Engine

3. Oil Supply

3.6.1. 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 $2.5 \text{ bar} \pm 0.3 \text{ bar}$.

3.6.2. Heat exchanger bypass valve

The heat exchanger bypass valve has the same function as the filter bypass valve. If, on account of a blocked oil-to-water heat exchanger, the oil pressure rises, the heat exchanger bypass valve opens at an oil pressure of $2.5 \text{ bar} \pm 0.3 \text{ bar}$ and the lubricating oil can flow uncooled to the lubrication points.



To ensure the engine runs perfectly, only engine oils approved by BMW can be used.

B46 Engine

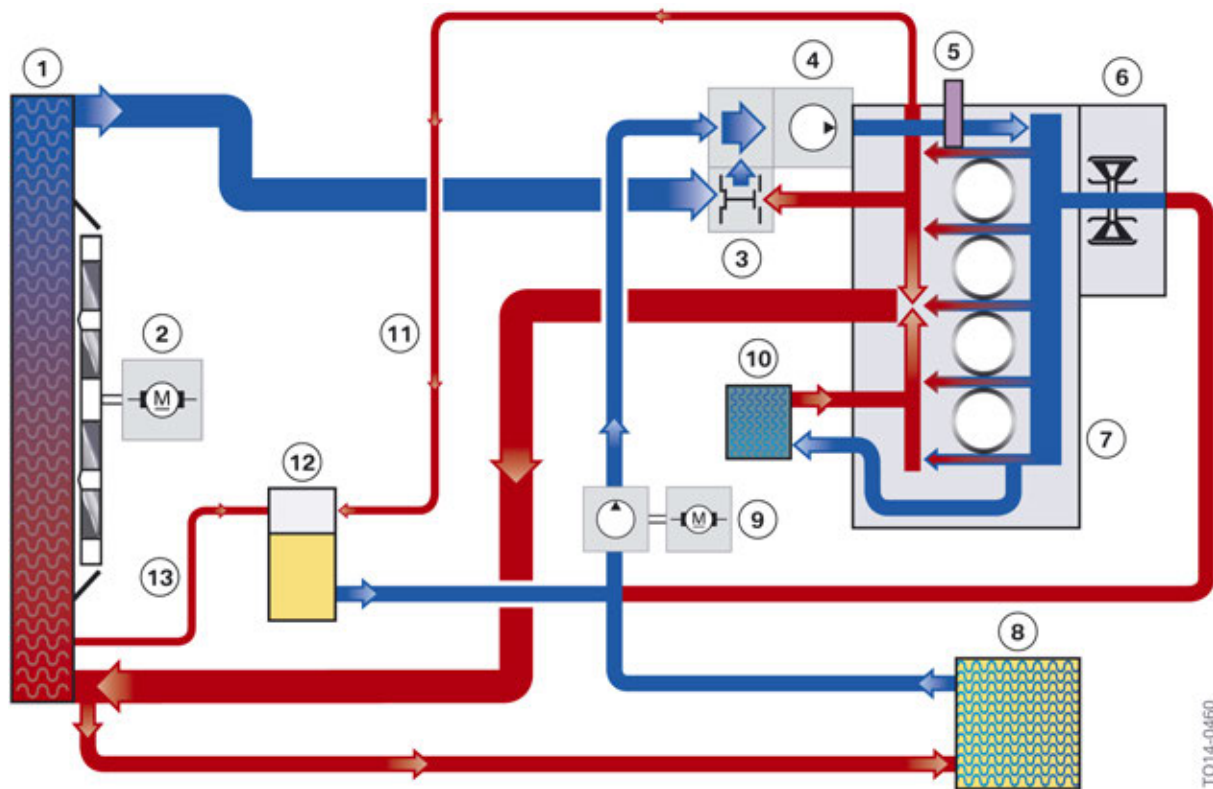
4. Cooling System

In order to protect the thermally loaded engine components, the engine oil and the transmission oil from overheating, they are cooled using coolant. A mechanical coolant pump circulates the coolant in the cooling circuit. The heat quantities introduced to the coolant are emitted to the ambient air again using a radiator. An electric fan assists the radiator output.

The coolant in the B46 engine is mainly circulated via a mechanical coolant pump. Several engines are also equipped with an electrical overrun pump which maintains a trickle of coolant to the bearing seat cooling system of the exhaust turbocharger.

The following graphics provide an overview of the different cooling circuits.

4.1. Cooling circuit, B46 engine



Cooling circuit, B46 engine

Index	Explanation
1	Radiator
2	Electric fan
3	Map thermostat
4	Coolant pump
5	Coolant temperature sensor
6	Coolant-cooled exhaust turbocharger
7	Engine housing

B46 Engine

4. Cooling System

Index	Explanation
8	Heat exchanger
9	Electric coolant pump (20 W)
10	Engine oil-to-coolant heat exchanger
11	Tank ventilation line from the cylinder head
12	Expansion tank
13	Ventilation line of the radiator

4.1.1. Special features

- Coolant-cooled exhaust turbocharger
- Mechanical coolant pump
- Electric coolant pump
- Characteristic map thermostat

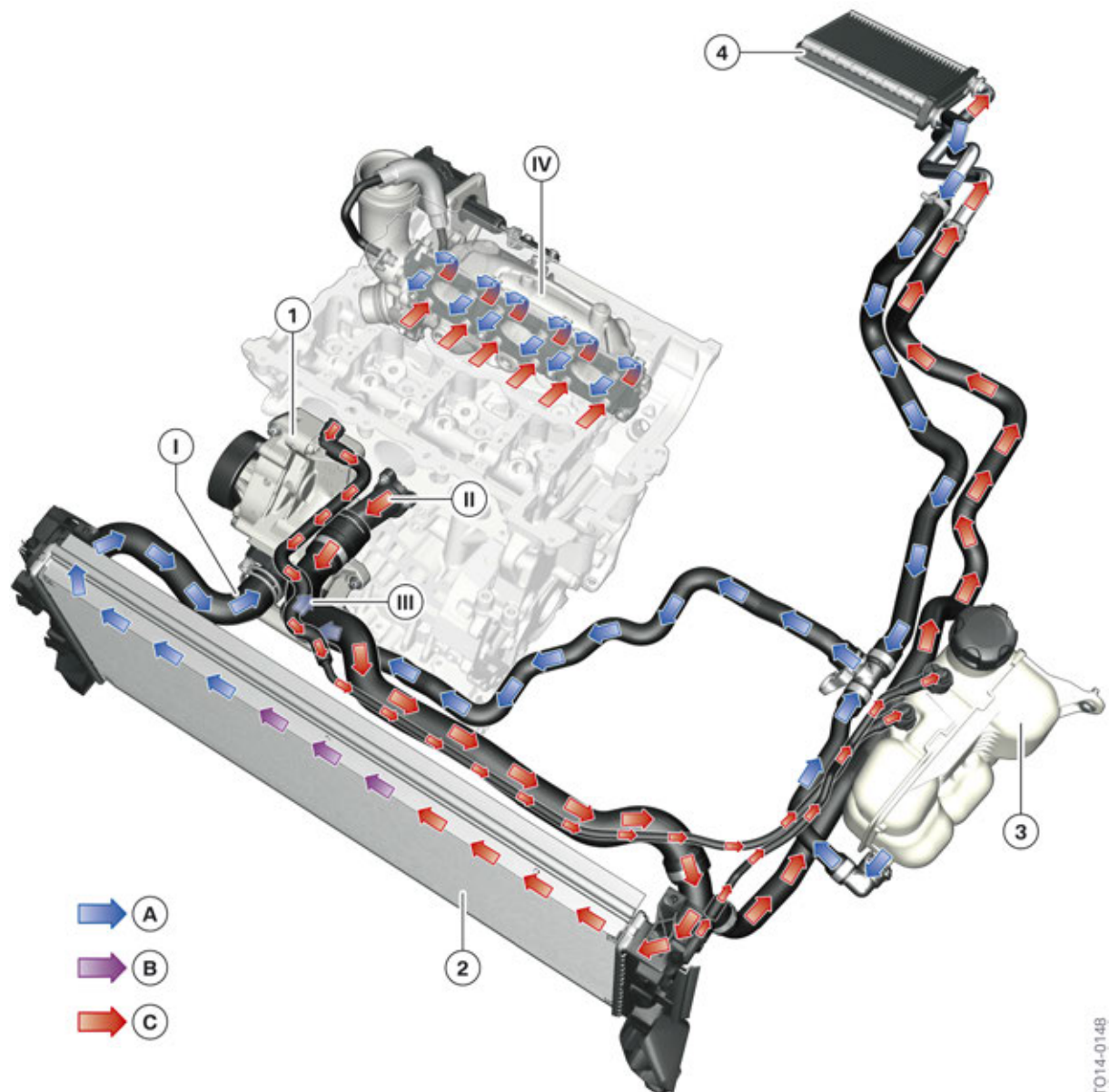
Due to the twin-scroll technology, the B46 engines are equipped with a steel manifold. 'Twin-scroll' means that the exhaust flows are routed via two separate channels to the exhaust turbocharger. The heat produced is absorbed by the coolant which is supplied via a coolant connection on the exhaust turbocharger. When the motor is not running, post-cooling of the exhaust turbocharger is possible with the assistance of an electric coolant pump (20 W). This prevents a build-up of heat in the area of the exhaust turbocharger.

For more in-depth explanations on the exhaust turbocharger, refer to the chapter Intake air and exhaust emission system.

B46 Engine

4. Cooling System

4.2. System overview, vehicle



Vehicle cooling circuit, B38 engine

Index	Explanation
A	Coolant cooled down
B	Coolant warmed up
C	Coolant heated up
I	Cooled coolant to coolant pump
II	Heated coolant from engine to radiator
III	Cooled coolant to thermostat

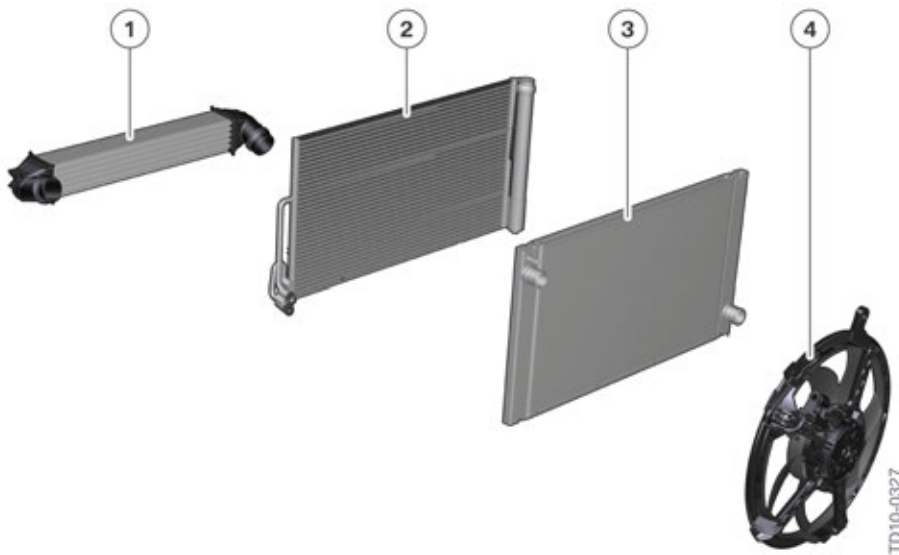
TO14-0148

B46 Engine

4. Cooling System

Index	Explanation
IV	Coolant flow via exhaust turbocharger
1	Coolant pump
2	Radiator
3	Expansion tank
4	Heat exchanger

4.3. Cooling module



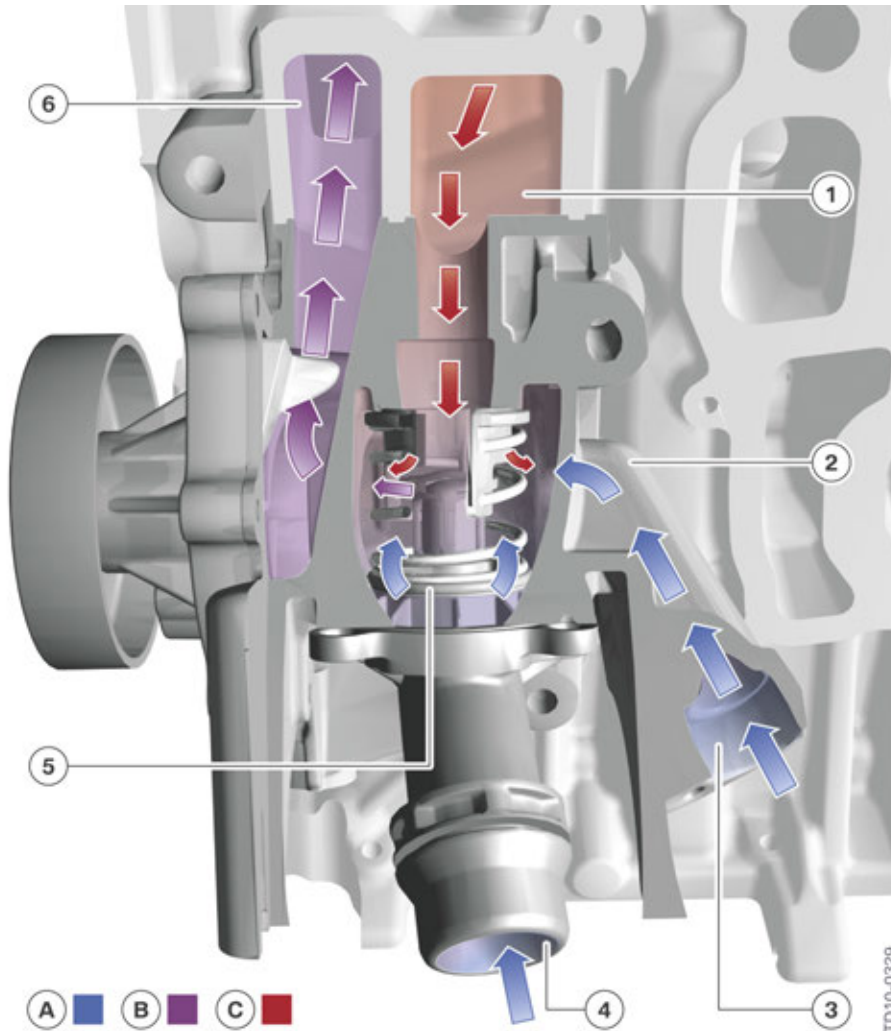
Cooling module

Index	Explanation
1	Charge air cooler
2	A/C condenser
3	Radiator
4	Electric fan

B46 Engine

4. Cooling System

4.4. Coolant pump



Coolant pump with characteristic map thermostat

Index	Explanation
A	Cooled coolant
B	Warmed coolant
C	Heated coolant
1	Coolant duct from the crankcase
2	supporting component carrier
3	Inlet from expansion tank and heat exchanger
4	Feed from radiator
5	Map thermostat
6	Coolant duct to the crankcase

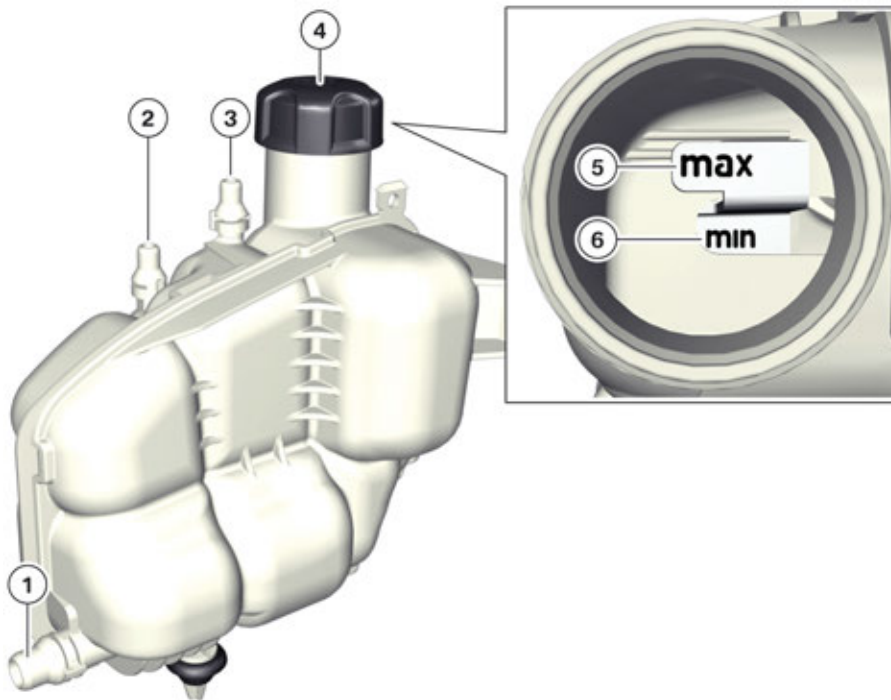
B46 Engine

4. Cooling System

The coolant pump forms one unit with the characteristic map thermostat. The coolant pump housing is made from the aluminium alloy ALSi9Cu3, the impeller and the thermostat cover are made of plastic.

The Digital Motor Electronics controls the cooling circuit via a map-controlled thermostat.

4.5. Expansion tank



Expansion tank

TA13-2233

Index	Explanation
1	Coolant line, coolant expansion tank output
2	Tank ventilation line from the cylinder head
3	Ventilation line of the radiator
4	Sealing cap
5	Visible filling level indicator "Maximum"
6	Visible filling level indicator "Minimum"

The expansion tank is used as a reservoir for the coolant. The expansion tank ensures that there is always a sufficient quantity of coolant available in the cooling circuit.

In the sealing cap there is a pressure relief valve which restricts the pressure in the system.

The sealing cap must never be opened when the engine is hot. The reason for this is not just the risk of burning. In higher areas of the cooling circuit, such as the cylinder head, gas bubbles may form as a result of the loss of pressure. Sufficient heat dissipation is no longer guaranteed at these points. This would result in overheating.

B46 Engine

4. Cooling System

There is a visible filling level indicator in the expansion tank. The filling level can be read when the tank is open. The filling level should be between maximum and minimum for correct filling.

4.6. Coolant

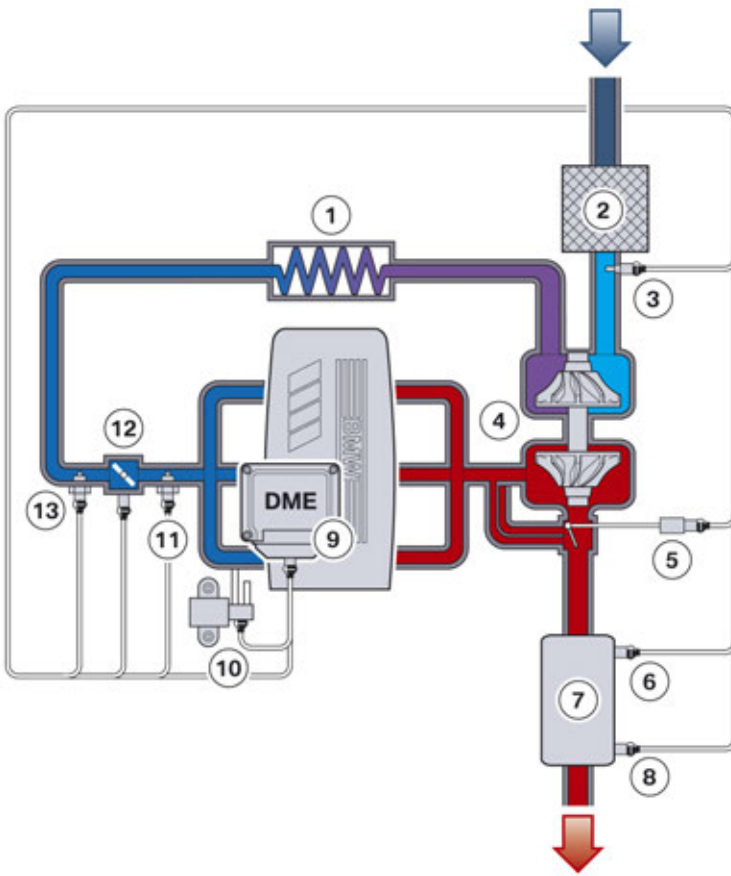
The familiar coolant with a silicone base is used. The coolant is not subject to a change interval. The filling is designed for the entire service life of the engine. For work which requires an opening of the cooling circuit the coolant must be replaced. The precise procedure for ventilating the cooling circuit can be found in the current repair instructions.



The cooling system must only be filled with BMW-approved coolant. If the wrong coolant is used, damage to the coolant pumps, coolant hoses, radiators and cylinder head gasket may subtly creep in.

B46 Engine

5. Intake Air and Exhaust System



TO10-1560

System overview of intake air and exhaust emission system in the B38 engine

Index	Explanation
1	Charge air cooler
2	Intake silencer
3	Hot film air mass meter
4	Exhaust turbocharger
5	Actuator of electrically adjustable wastegate valve
6	Broadband oxygen sensor upstream of catalytic converter (control sensor)
7	Catalytic converter
8	Voltage-jump sensor downstream of catalytic converter (monitoring sensor)
9	Digital Motor Electronics (DME) (MEVD 17.2.3)
10	Tank vent valve
11	Intake manifold pressure sensor
12	Throttle valve
13	Charge-air temperature and charge-air pressure sensor

B46 Engine

5. Intake Air and Exhaust System

Index	Explanation
A	Fresh air
B	Purified air
C	Heated charge air
D	Cooled charge air
1	Engine ventilation heating (only with cold-climate version)
2	Blow-by channel into clean air pipe (turbocharged operation)
3	Clean air pipe with resonator
4	Air filter housing
5	Hot film air mass meter
6	Throttle valve unit
7	Charge air temperature and charging pressure sensor
8	Connection for carbon canister regeneration line
9	Unfiltered-air snorkel
10	Charge air hose
11	Intake manifold pressure sensor
12	Intake manifold
13	Charge air cooler
14	Charge air hose
15	Purge air line
16	Exhaust turbocharger compressor, inlet side

The air duct of the differentiated air intake system differs depending on the installation position. This documentation only deals with the air duct in the transverse-mounted Bx8 engine.

The intake unfiltered air reaches the intake silencer with air cleaner via the unfiltered air line with intake air grille. The unfiltered air is filtered in the intake silencer with air cleaner and becomes clean air. Then the clean air is directed to the exhaust turbocharger via the hot film air mass meter and the clean air pipe with resonator. The blow-by gases from the crankcase are also introduced, depending on the load condition, into the clean air pipe upstream of the exhaust turbocharger, or into the intake ports directly.

The clean air is compressed and heated in the exhaust turbocharger. The compressed, warm charge air is further directed to the charge air cooler in the charge air hose. From the charge air cooler the now cooled charge air is directed to the throttle valve via an additional charge air hose and the adapter pipe with charge air temperature and charging pressure sensor. The cooled charge air is taken to the intake air system via the throttle valve.

5.1.1. Intake silencer

The intake silencer is mounted on the engine and contains the air cleaner. Air which has been inducted up to the air filter is referred to as fresh air. After leaving the air filter the cleaned air is referred to as clean air.

B46 Engine

5. Intake Air and Exhaust System

5.1.2. Charge air cooling



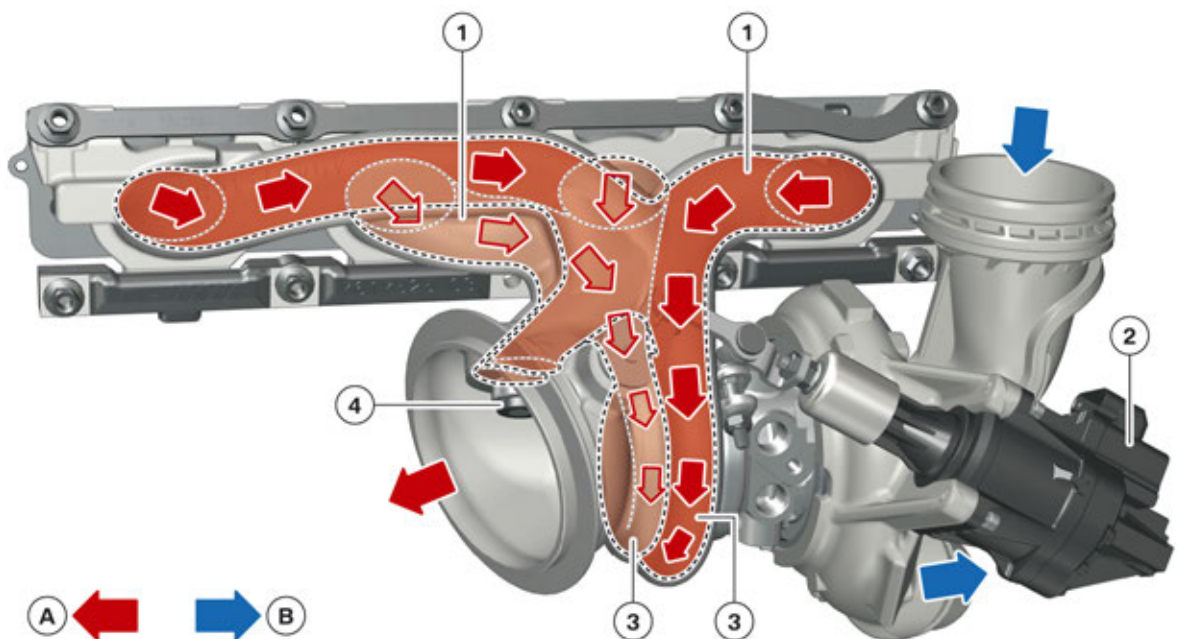
Charge air cooler

Because the air heats up during compression in the exhaust turbocharger and thus expands, the amount of oxygen which can be routed into the combustion chamber is reduced again. The charge air cooler has a counteractive effect in that it cools the compressed air. The density is thus increased and the oxygen content per volume is also increased. The charge air cooler is located in the cooling module below the radiator. It is an air-air heat exchanger. The compressed air flows through the charge air cooler in several plates, around which for their part the cooling air flows.

5.2. Exhaust emission system

5.2.1. Exhaust turbocharger

Exhaust turbocharger in the B46 engine



Exhaust turbocharger in the B46 engine

B46 Engine

5. Intake Air and Exhaust System

Index	Explanation
A	Turbine side
B	Compressor side
1	Exhaust duct
2	Actuator of electrically adjustable wastegate valve
3	Twin-scroll
4	Electric wastegate valve

The exhaust turbocharger of the B46 engine is a twin-scroll exhaust turbocharger. To facilitate a fast and direct response, the exhaust flows from cylinders 1 and 4, and 2 and 3 are merged and routed to the compressor via two separate channels. This principle is referred to as pulse turbocharging.

The exhaust manifold and exhaust turbocharger housing have been designed as one common cast part and cannot be replaced individually.

The charging pressure is adjusted via an electrical actuator.

5.2.2. Blow-off valve

A blow-off valve is not used in current models. Pressure peaks, caused by sudden load shedding due to the inertia of the turbine of the exhaust turbocharger, can be avoided by careful tuning of the Digital Motor Electronics software. With foresighted charging pressure control, pressure peaks can be predicted and reduced by quick adjustment of the electrically-adjustable wastegate valve. Assisted by a delayed load control of the Valvetronic (in the minimum lift direction) or the throttle valve (in the closed direction), the remaining charge air which is produced can be routed to the exhaust emission system via the engine. This form of control thus prevents the exhaust turbocharger shaft from being exposed to excessive torsional stress due to high pressure peaks.

5.2.3. Charging pressure control

The charging pressure in B46 engines is controlled via an electrically adjustable wastegate valve.

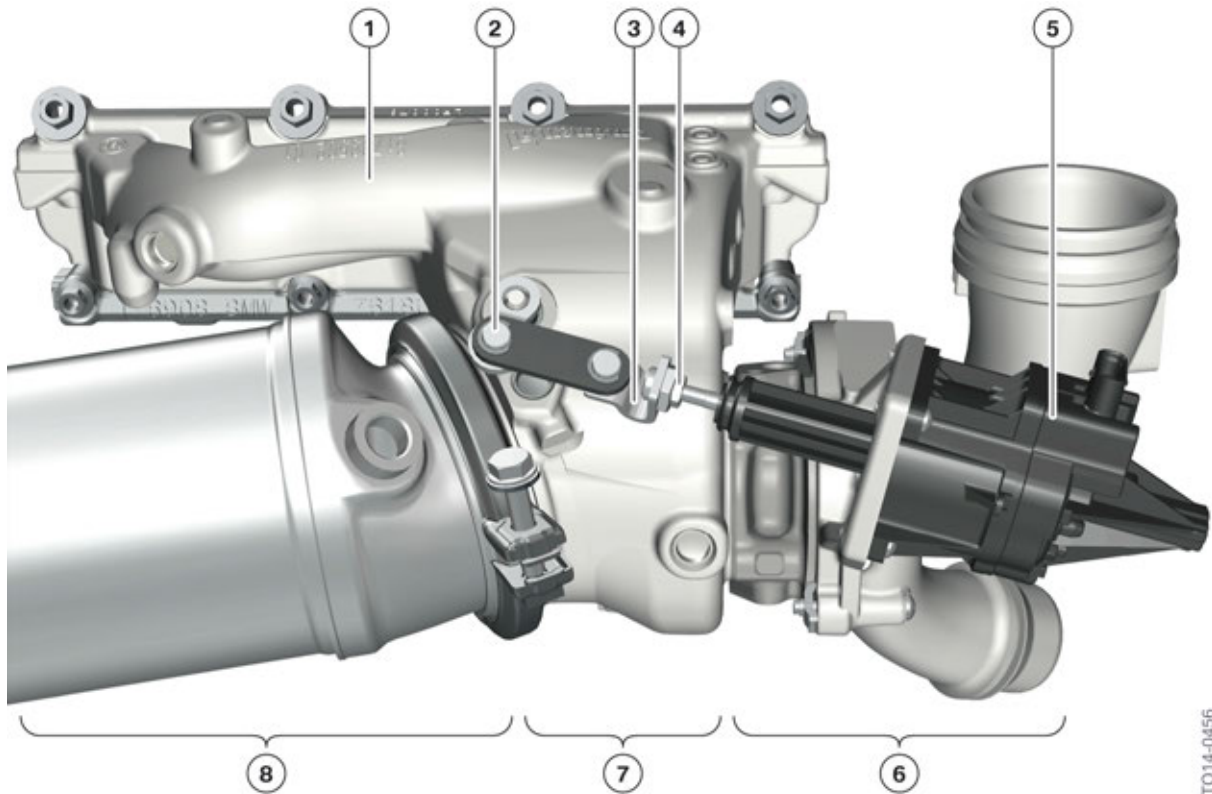
Electrified adjustment

In contrast to a vacuum-controlled charging pressure control, the following components are not required:

- Vacuum unit
- Vacuum lines
- Electro-pneumatic pressure converter
- Vacuum reservoir

B46 Engine

5. Intake Air and Exhaust System



Overview of electrically adjustable wastegate valve, B38 engine

TO14-0456

Index	Explanation
1	Exhaust manifold
2	Wastegate valve
3	Adjusting linkage
4	Lock nut
5	Actuator of electrically adjustable wastegate valve
6	Exhaust turbocharger, compressor side
7	Exhaust turbocharger, turbine side
8	Catalytic converter

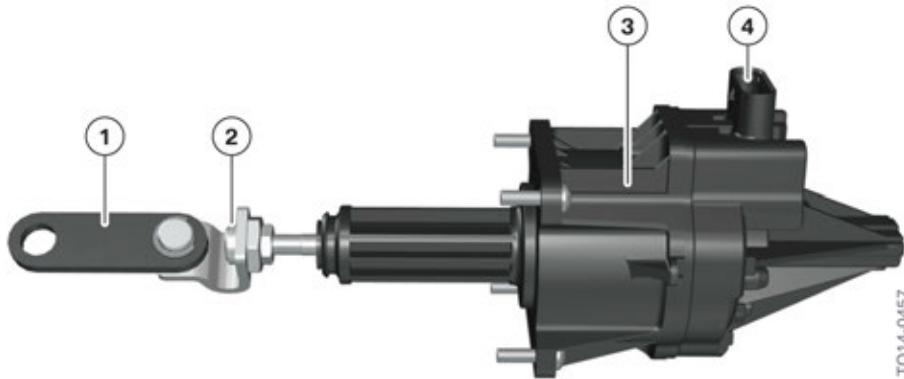
Advantages of electrical activation

- Faster control speed
- More precise control
- Simpler diagnosis
- Fewer components
- Larger opening angle of wastegate valve

B46 Engine

5. Intake Air and Exhaust System

Operating principle



Actuator of electrically adjustable wastegate valve

Index	Explanation
1	Stroke linkage
2	Adjustment linkage
3	Actuator
4	Electrical connection

A direct current motor and a sensor are located in the actuator of the electrically adjustable wastegate valve, resulting in a total of five electrical connections. The wastegate valve is opened or closed by a lifting movement of the linkage.

The actuator of the electrically adjustable wastegate valve can be replaced separately in Service. Each time the adjusting linkage is activated, the system must be re-adjusted with the assistance of the BMW diagnosis system ISTA. This measure is not required when replacing the entire exhaust turbocharger as the linkage is supplied preset.



If the actuator is replaced individually, a teach-in routine must be performed using the BMW diagnosis system ISTA.

B46 Engine

5. Intake Air and Exhaust System



Sensor signal to electrically adjustable wastegate valve

Index	Explanation
A	Wastegate valve closed
B	Wastegate valve opened
1	Actuator of electrically adjustable wastegate valve
2	Digital Motor Electronics (DME)

The sensor is used to determine the position of the wastegate valve. The wastegate valve can move to any required position between maximum open and maximum closed. When the sensor signal or actuator drops out, the wastegate valve adopts the open position to allow charging pressure to build up. This ensures the journey continues with reduced engine performance.



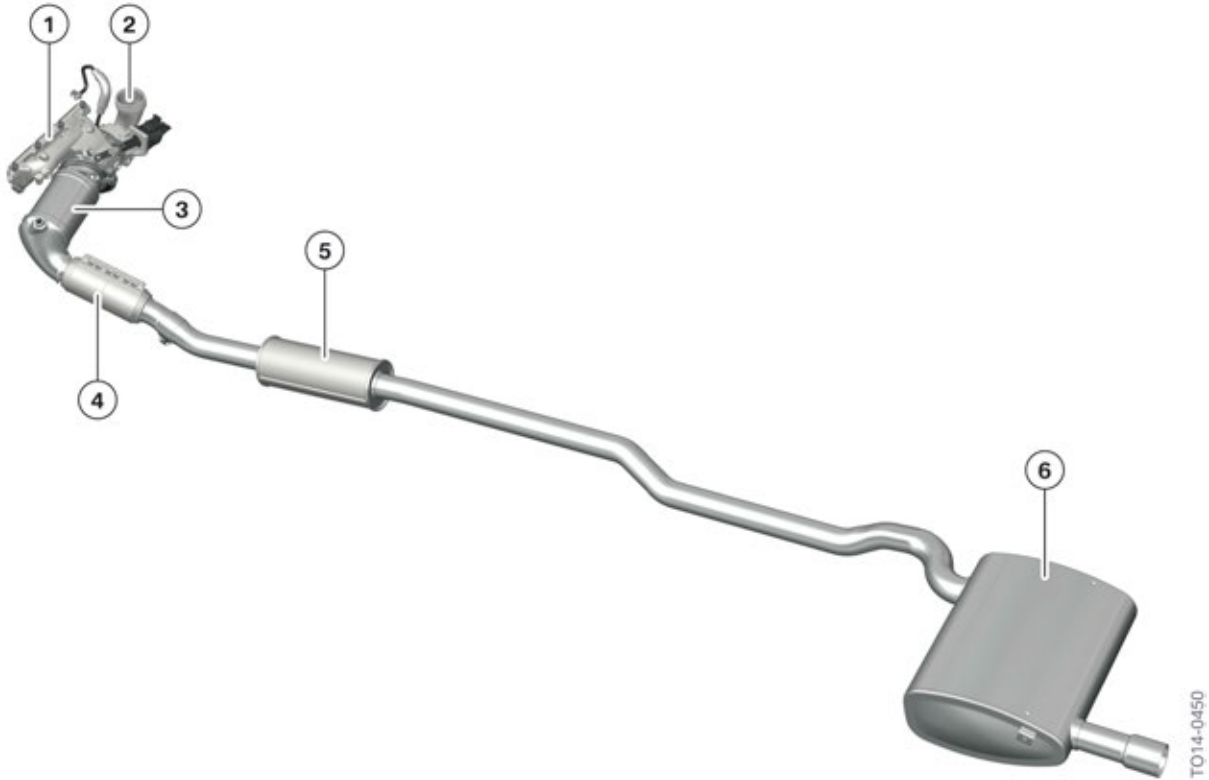
As the position sensor is a linear Hall sensor, a resistance measurement for testing the sensor is not permitted.

TO14-0455

B46 Engine

5. Intake Air and Exhaust System

5.2.4. Exhaust system



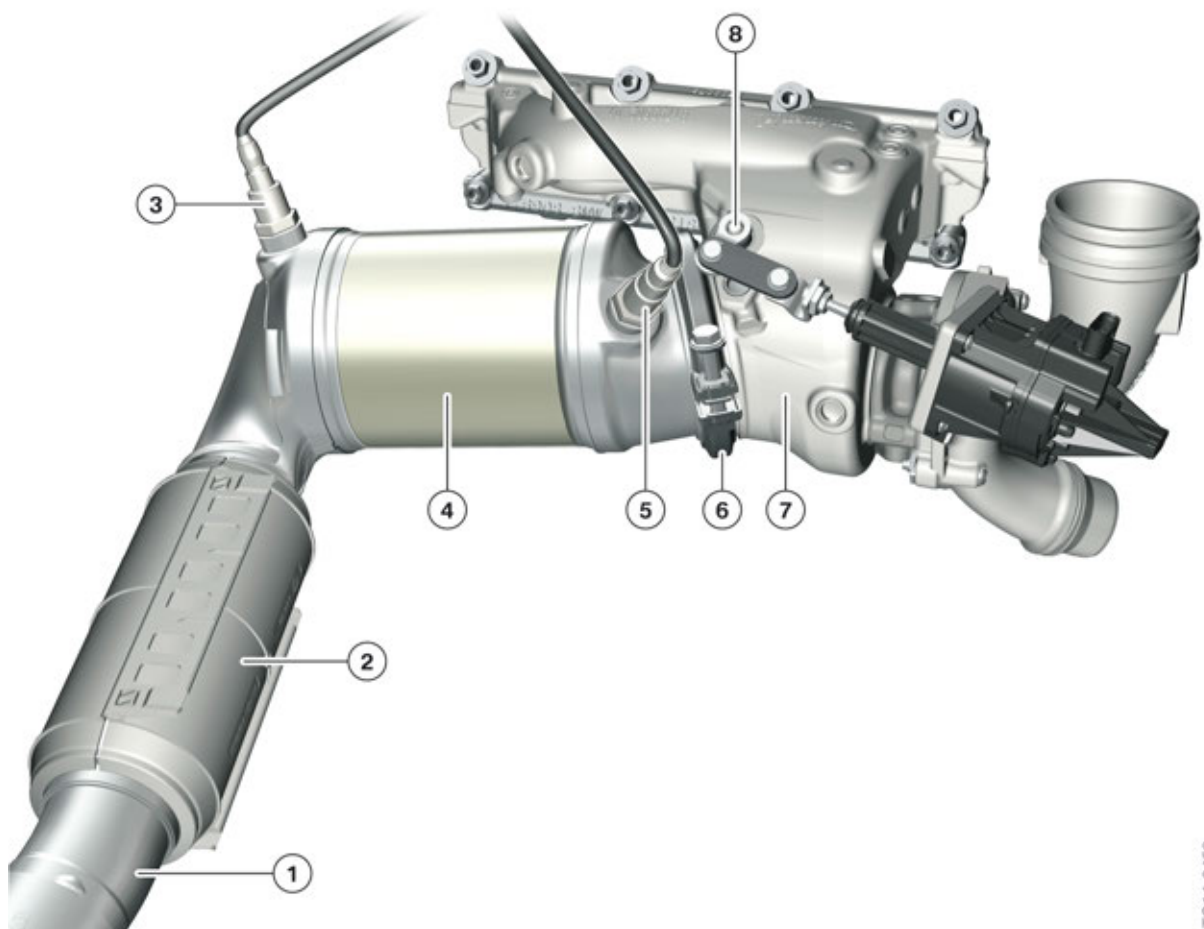
Overview of exhaust emission system of the Bx8 engine in the F48

Index	Explanation
1	Exhaust manifold
2	Exhaust turbocharger
3	Catalytic converter
4	Decoupling element
5	Center silencer
6	Rear silencer

The B46 engine satisfies the exhaust gas emission regulations of the ULEV II exhaust emission standards when introduced on the market.

B46 Engine

5. Intake Air and Exhaust System



Exhaust gas treatment, B38 engine

TO14-0459

Index	Explanation
1	Exhaust pipe
2	Decoupling element
3	Monitoring sensor (voltage-jump sensor)
4	3-way catalytic converter
5	Control sensor (broadband oxygen sensor)
6	Clamp
7	Turbine housing
8	Wastegate valve

B46 Engine

5. Intake Air and Exhaust System

Measures for reduction of exhaust gas emissions

- Precise and fast charging pressure control.
- Catalytic converter heating during cold start.
- Positioning of catalytic converter near engine.
- New LSF Xfour voltage-jump sensor by Bosch.

Catalytic converter heating

When starting the combustion engine from cold, the wastegate valve is opened as wide as possible and the ignition point is adjusted to retard. The retarded ignition point delays the combustion process which in turn supports the heat input for heating of the catalytic converter. As the turbine housing is short, it has been possible to position the catalytic converter very close to the wastegate valve. As the exhaust gas flows into the catalytic converter at the perfect angle and because of its position close to the engine, the catalytic converter reaches its operating temperature very quickly. If the wastegate valve is opened when cold, pulsation of the exhaust gas may cause vibrations in the wastegate valve, which are perceived as noise. This is not due to a defective component, and is normal running noise. This noise becomes less audible as the temperature of the component increases.

Control sensor

With a stoichiometric air/fuel ratio ($\lambda=1$), the proportion of oxygen in the exhaust gas is ideal for conversion of the pollutants in the 3-way catalytic converter. By measuring the oxygen content in the exhaust gas, the oxygen sensor of the Digital Motor Electronics delivers important information for mixture preparation.

A broadband oxygen sensor with the designation LSU ADV has been specially developed for engines with exhaust turbochargers and is used as the control sensor. One of the major characteristics of broadband oxygen sensors is their extensive measuring range. The measuring range of the LSU ADV is from a lambda of $\lambda=0.65$ to $\lambda=\text{air}$.

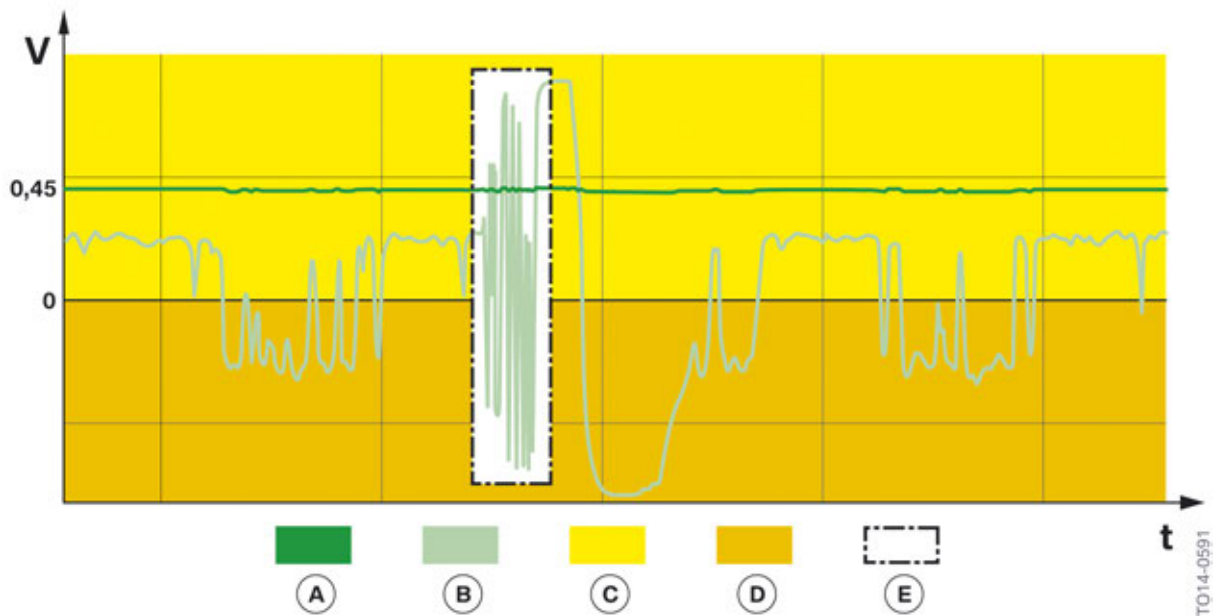
The broadband oxygen sensor LSU ADV is a combination of a measuring cell and pump cell. There is a small diffusion gap between these two cells which serves as a measuring chamber and is connected to the exhaust gas duct. The measuring cell operates according to the principle of a voltage-jump sensor and measures the residual oxygen content in the exhaust gas. If the fuel-air mixture is too lean ($\lambda > 1$), the control electronics applies voltage to the pump cell so that oxygen ions are pumped out of the diffusion gap. If the mixture is too rich ($\lambda < 1$), oxygen ions are pumped into the diffusion gap by activating the pump cell accordingly. The pump flow required to control the pump cell is directly proportional to the oxygen concentration and therefore serves as the control variable for the air ratio.

The control strategy has been devised so that the oxygen concentration in the area of the diffusion gap corresponds to an air ratio of $\lambda = 1$. As this control method is extremely fast and incredibly accurate, the voltage value of the measuring cell always remains at a constant level (450 mV).

The following graphic shows the two voltage curves of the measuring cell and the pump cell when the engine is in operation:

B46 Engine

5. Intake Air and Exhaust System



Voltage signal, LSU ADV broadband oxygen sensor

Index	Explanation
A	Signal voltage, measuring probe
B	Control voltage, pump sensor
C	Positive control voltage
D	Negative control voltage
E	Press on accelerator
t	Time
V	V

In the positive range of the control voltage ($U > 0 \text{ V}$), there is excess oxygen in the area of the diffusion gap ($\lambda > 1$). The engine is running slightly too lean. The pump cell pumps oxygen out of the diffusion gap in order to maintain the level of 450 mV in the measuring cell constant.

In the negative range of the control voltage ($U < 0 \text{ V}$), there is insufficient oxygen in the area of the diffusion gap ($\lambda < 1$). The engine is running slightly too rich. The pump cell pumps oxygen into the diffusion gap in order also to maintain the level of 450 mV in the measuring cell constant.

An integrated heating element ensures that the broadband oxygen sensor quickly reaches its operating temperature.

B46 Engine

5. Intake Air and Exhaust System

Connections, broadband oxygen sensor

- Positive terminal of pump cell
- Negative terminal of pump cell and measuring cell
- Heating minus
- Heating plus
- Positive terminal of measuring cell

Monitoring sensor

A new voltage-jump sensor with the designation LSF Xfour is used as the monitoring sensor. The new oxygen sensor has the following benefits:

- Sturdier design
- Small installation space
- Higher measuring accuracy
- Faster control readiness

The oxygen sensor is suitable for engine start-stop operation. In this case, the sensor must be heated throughout the entire stop phase. The voltage required during the heating phase is 7.5 volts and the heating current is around 1 ampere.

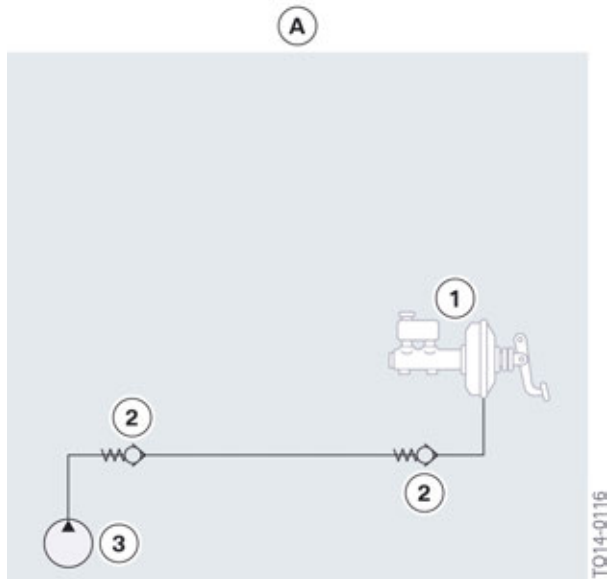
Engine operation	Air ratio	Sensor voltage
Rich operating phase	$\lambda=0.98$	0.9 V
Lean operating phase	$\lambda=1.02$	0.1 V

B46 Engine

6. Vacuum Supply

The main purpose of the vacuum system is to generate the vacuum for the brake servo.

6.1. System overview



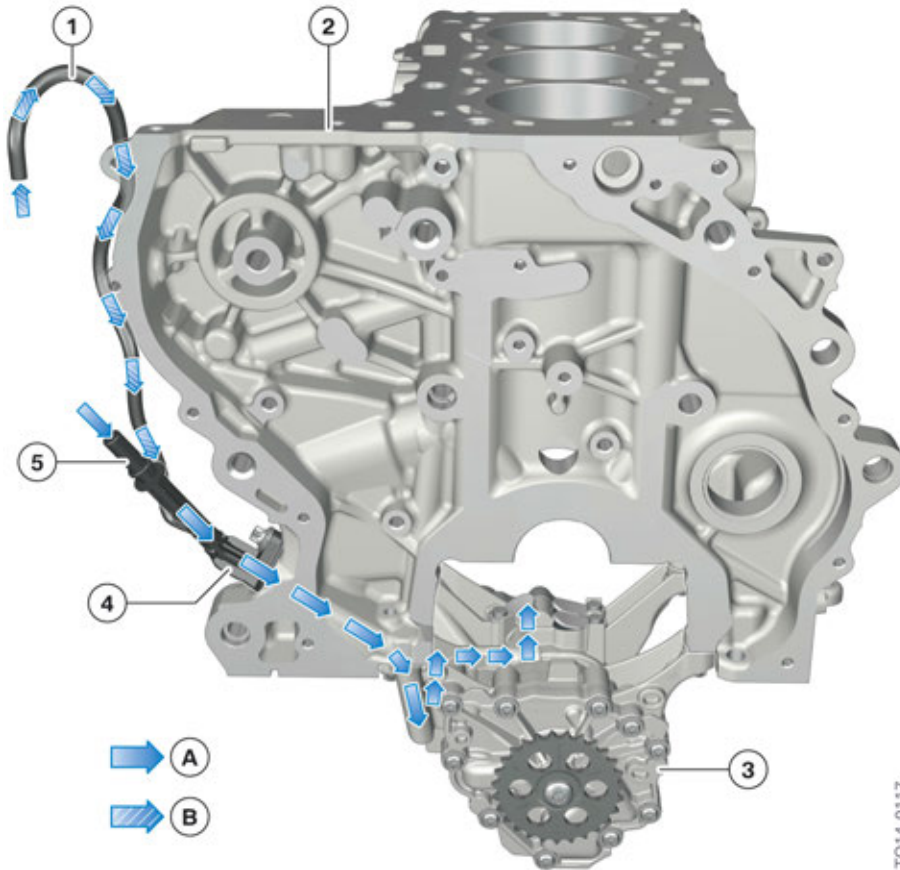
Schematic representation of vacuum supply

Index	Explanation
A	B46 engine
1	Brake servo
2	Non-return valve
3	Vacuum pump

B46 Engine

6. Vacuum Supply

6.2. Vacuum pump



Installation location of vacuum pump, Bx8 engine

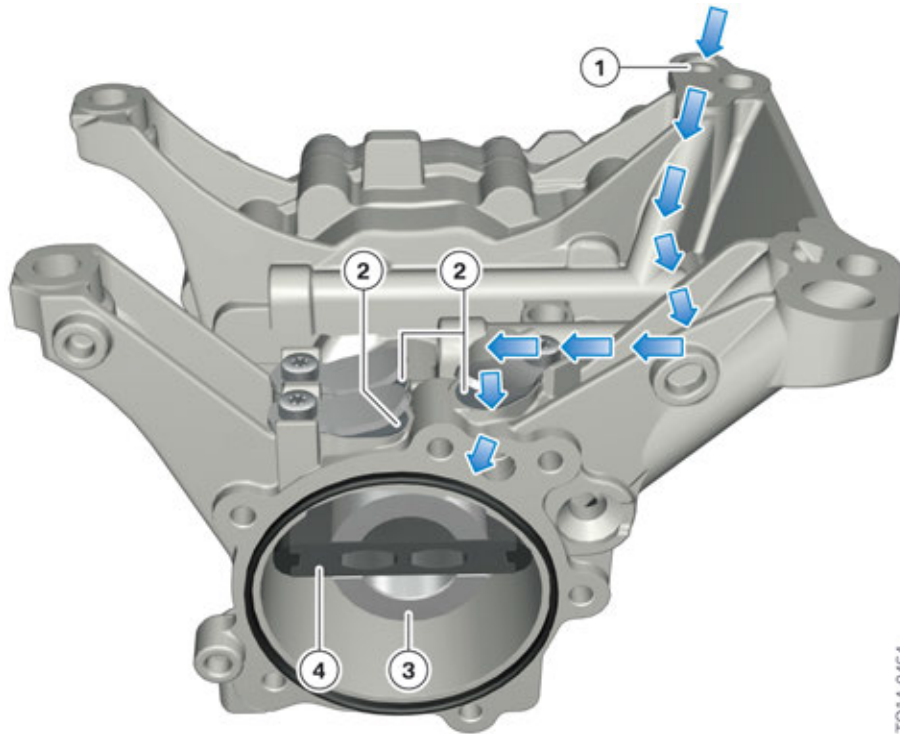
Index	Explanation
A	Vacuum, secondary volume
B	Vacuum, main volume
1	Vacuum line for auxiliary consumer
2	Crankcase
3	Oil pump
4	Non-return valve
5	Vacuum line for main consumer (brake servo)

With the B46 engine, the low pressure pump and oil pump are installed together in one housing.

The vacuum duct leads to the vacuum pump, passing through the transmission end of the crankcase. There is a plastic connection at the output of the crankcase to which the various consumers are connected. There is a non-return valve inside the plastic connection.

B46 Engine

6. Vacuum Supply



Vacuum pump in the B46 engine

Index	Explanation
1	Vacuum duct
2	Exhaust valves
3	Steel rotor
4	Plastic vane

There is a steel rotor with a plastic vane on the inside of the vacuum pump. It is driven together with the oil pump by the crankshaft via a chain.

The evacuating output of the vacuum pump is 500 mbar vacuum (absolute) in less than six seconds.

As the running surfaces of the vacuum pump are coated with oil, the volume of air drawn in cannot be released into the atmosphere. The air volume delivered by the vacuum pump is transferred to the crankcase via discharge valves. From here, it reaches the air intake system via the crankcase ventilation.



Leaks in the vacuum system lead to a reduced brake power assistance.

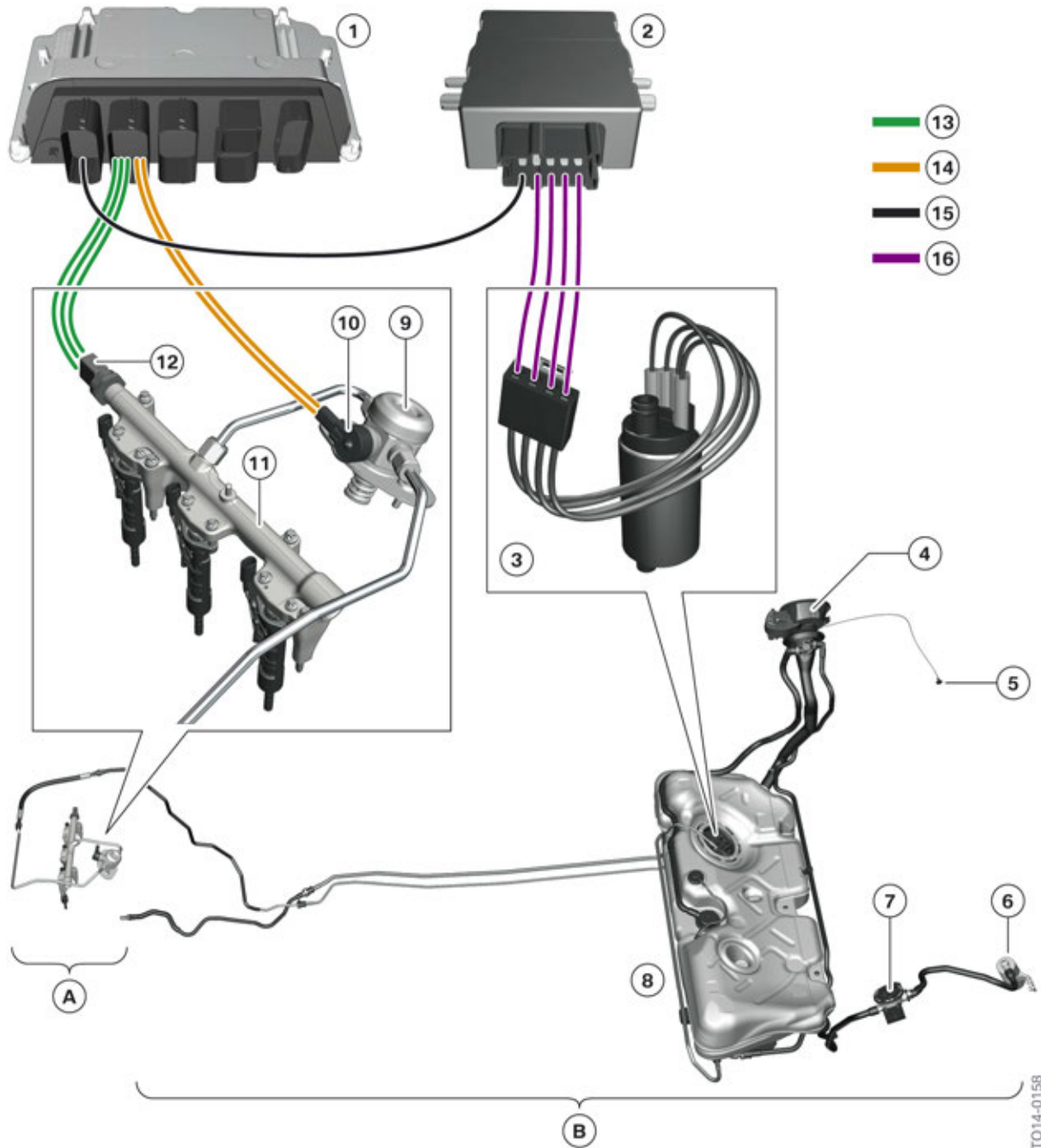
B46 Engine

7. Fuel System

The fuel system is made up of the fuel supply and fuel preparation systems. The fuel supply includes the fuel tank with all mounted parts and the fuel lines up to the engine compartment.

The fuel filter lines in the engine compartment and all the fuel system parts on the engine belong to the fuel preparation system.

The fuel supply is described in the respective product information bulletins for the models.



Fuel system, Bx8 engine in the F56

B46 Engine

7. Fuel System

Index	Explanation
A	Fuel preparation
B	Fuel supply
1	Digital Motor Electronics (DME)
2	Fuel pump control module
3	Electric fuel pump
4	Fuel filler neck
5	Emergency release
6	Dust filter
7	Fuel tank leak diagnosis system
8	Fuel tank
9	High-pressure pump
10	Quantity control valve
11	Rail (high-pressure accumulator)
12	High-pressure sensor
13	Sensor line, rail pressure sensor
14	Actuating wire, quantity control valve
15	PWM data line
16	Actuating wire, electric fuel pump (three-phase line U, V, W)

7.1. Fuel pump control module

In contrast to the EKPS control unit previously used, the new gas engines have a fuel pump control module. The fuel pump control module is not shown in the control unit overview. The fuel pump control module is responsible for processing information about the necessary fuel pressure from the Digital Motor Electronics (DME) and for activating the electric fuel pump according to these requirements via a three-phase AC voltage.

7.2. Electric fuel pump

The electric fuel pump is activated as required. The requirements are calculated by the Digital Motor Electronics (DME). The request regarding the extent of the fuel low pressure is sent to the fuel pump control module with the assistance of a pulse-width modulated signal (PWM signal). The fuel pump control module processes the pulse-width modulated signal and with help of an inverter generates a three-phase AC voltage U, V, W to activate the three-phase motor of the electric fuel pump according to requirements.

If the PWM data line is disconnected, the electric fuel pump is activated with the maximum system performance. If a PWM data line is interrupted, this only leads to a fault code entry. The customer is not informed about this status, by the illumination of a warning and indicator light, for example. The electric fuel pump is designed for continuous full load operation and is also not damaged if the PWM data line is interrupted for an longer period.

B46 Engine

7. Fuel System

There is no fuel pressure sensor in the low-pressure range of the fuel system. The fuel low pressure is calculated in the Digital Motor Electronics based on a mathematical model. The power consumption of the electric fuel pump also provides information on the fuel low pressure. If the power consumption is high, this means that a high fuel - low pressure exists and if the power consumption is low, this means that a lower fuel - low pressure prevails.

The following table provides information on the technical data of the electric fuel pump.

	Technical data
Engine speed range	2600 – 6000 rpm
Pressure area	2.0 - 6.5 bar
Supply voltage	12 V
Delivery rate at 3200 rpm and 3.5 bar	> 80 liters/60 minutes
Delivery rate at 4250 rpm and 6.3 bar	> 105 liters/60 minutes
Delivery rate at 5600 rpm and 5.3 bar	> 190 liters/60 minutes



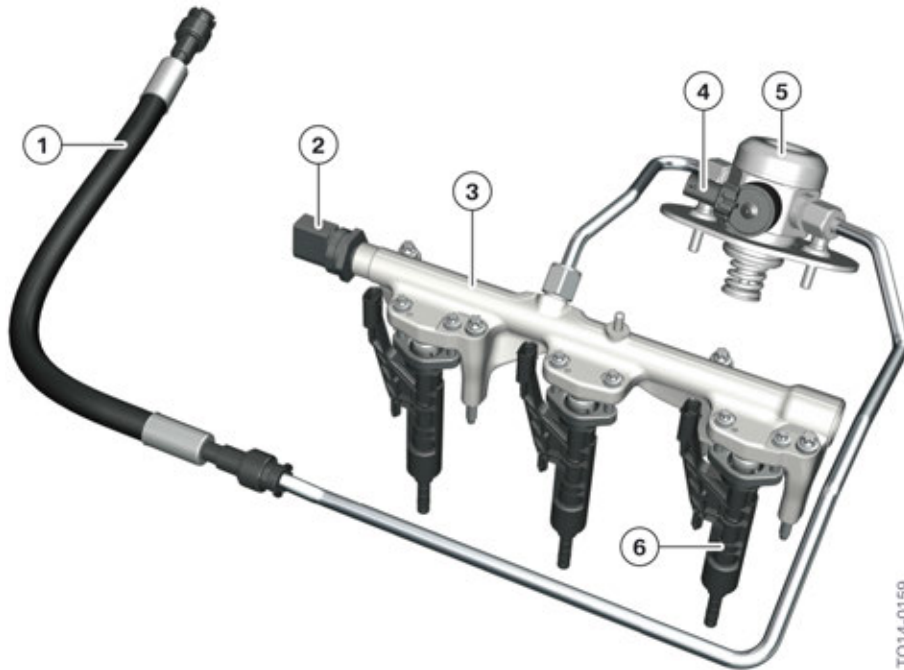
The electric fuel pump becomes impermissibly hot with excessive dry running > 1 minute.
There is a risk of a component fault!

B46 Engine

7. Fuel System

7.3. Fuel preparation

The fuel preparation has been modified to meet the requirements of emission legislation. A new direct rail which has been developed to which the injectors are now screwed.



Overview of fuel preparation

Index	Explanation
1	Fuel delivery line
2	Rail pressure sensor
3	Quantity control valve
4	High-pressure pump
5	Direct rail
6	Solenoid valve injector

The direct injection system is similar to the N20 and N55. A single-piston reciprocating pump with integrated quantity control valve is used.

The direct rail represents a departure from the familiar systems used up till now. With this system, the high pressure lines have been omitted and the injectors are attached to the rail directly.

Directly connecting the solenoid valve injectors to the rail has the following advantages:

- Less volume needs to be available for high-pressure injection.
- Fewer interfaces and therefore less problematic with respect to leaks.
- Short cycle times during production due to compact design.

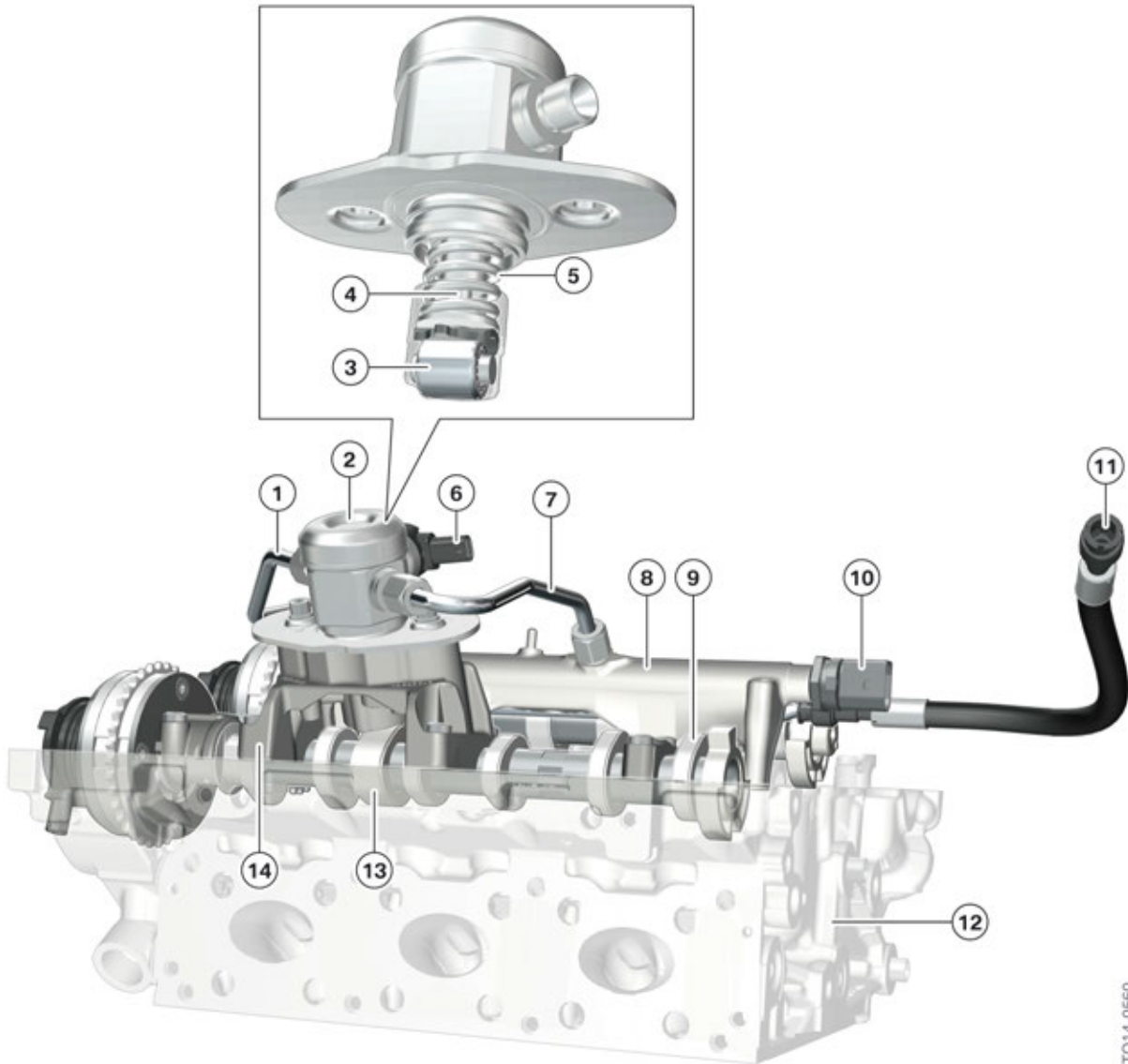
B46 Engine

7. Fuel System



Strict cleanliness must be observed when carrying out any work on the fuel system!

7.3.1. Fuel high-pressure pump



TO14-0560

Overview of fuel high-pressure pump

Index	Explanation
1	Fuel feed line to high pressure pump
2	High-pressure pump
3	Roller tappet
4	Pump piston

B46 Engine

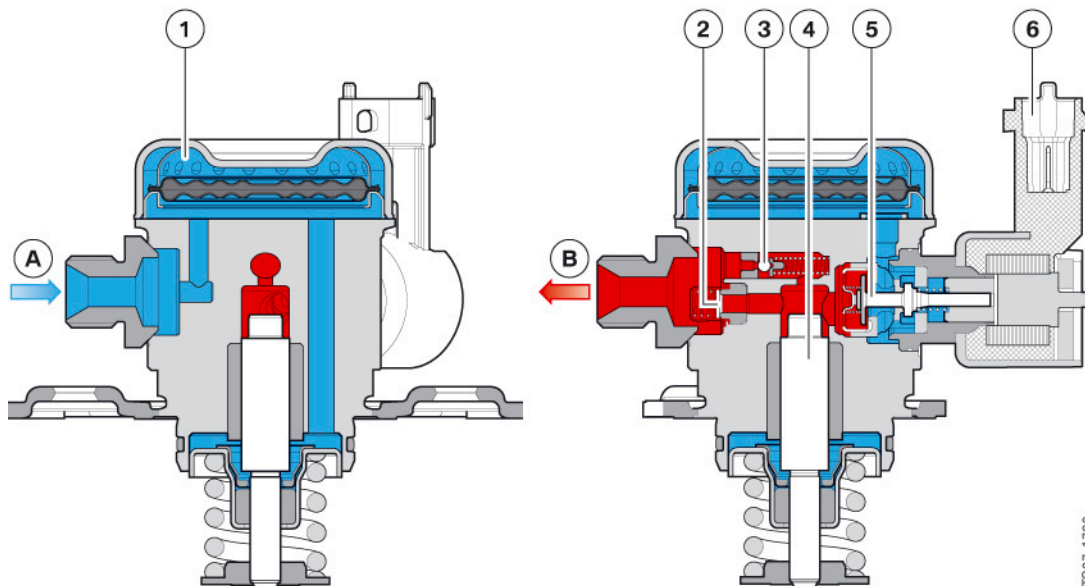
7. Fuel System

Index	Explanation
5	Spring
6	Quantity control valve
7	High pressure line to rail
8	Rail
9	Exhaust camshaft
10	Rail pressure sensor
11	Snap fastener, fuel feed line
12	Cylinder head
13	Actuating cam, high pressure pump
14	Bearing bracket, high pressure pump

The familiar single-piston high pressure pump by Bosch is used. The high pressure pump is driven by a triple cam which is attached to the exhaust camshaft. Fuel low pressure is supplied to the high pressure pump via the fuel feed from the electric fuel pump.



Due to the high fuel pressures, the fuel lines must never be detached when the engine is in operation. When removing the high pressure pump, follow the specifications in the current repair instructions. Excessive tilting of the pump can damage the pump piston!



Bosch high-pressure pump

TD07-1790

B46 Engine

7. Fuel System

Index	Explanation
A	Low-pressure connection
B	High-pressure connection
1	Balancing chamber
2	High-pressure non-return valve
3	Pressure-limiting valve
4	Pump piston
5	Quantity control valve
6	Electrical connection of quantity control valve

The quantity control valve at the high pressure pump adjusts the fuel pressure in the rail. The maximum pressure in the rail is 200 bar. The high pressure pump contains a pressure limiting valve which opens at a pressure of 245 bar. The quantity control valve is activated via a pulse-width-modulated (PWM) signal and assumes the open position in the de-energized state. This means the pump piston of the high pressure pump cannot compress the fuel.

It follows that the high pressure pump cannot build up pressure in the high-pressure fuel system when the quantity control valve is removed. In this situation, the maximum fuel low pressure (6.5 bar) would be present in the rail during an engine start. The system would be in emergency operation. To ensure the engine remains capable of running in this state, the opening period of the solenoid valve injectors has been extended and the idle speed increased. Although the vehicle remains drivable, the maximum engine performance is not available.

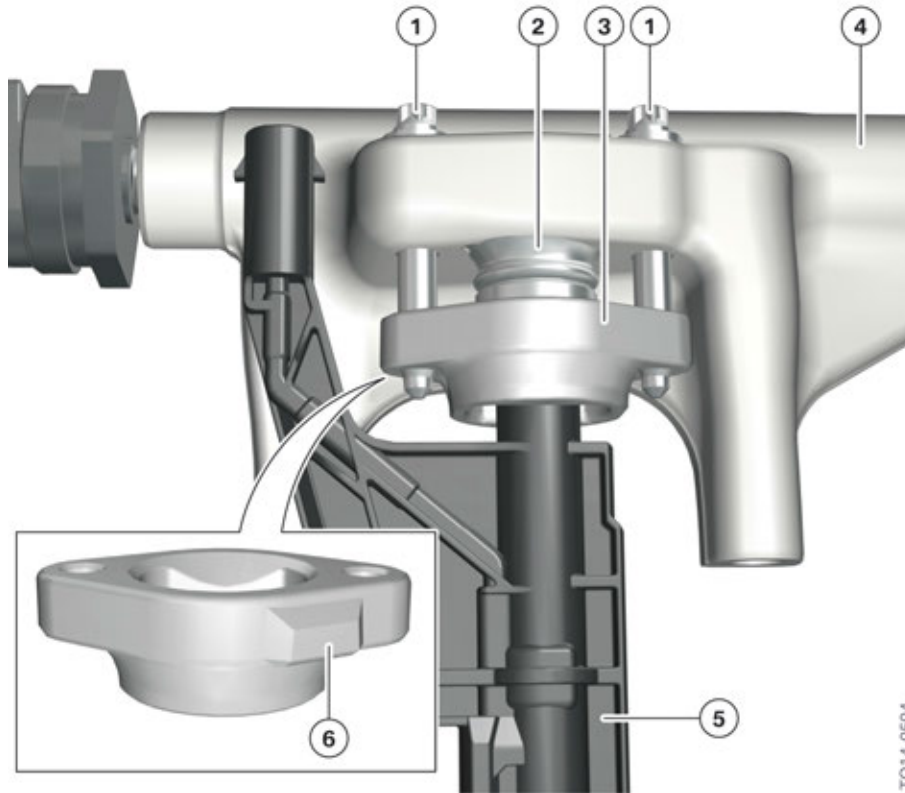


The quantity control valve is not resistant to continuous current. A permanent current supply with 12 V direct current voltage would render the component defective.

B46 Engine

7. Fuel System

7.3.2. Direct rail



Mounting the injectors

Index	Explanation
1	Mounting bolts
2	Plastic sleeve
3	Holding clamp with bayonet fitting
4	Rail
5	Solenoid valve injector
6	Casting lug

The solenoid valve injectors are fastened to the holding clamp with a bayonet fitting. There is a plastic sleeve between the holding clamp and direct rail. This is not designed to collect escaping fuel. Its only purpose is to carry out a helium pressure test during pre-assembly at the factory in order to check the tightness. After the initial assembly, this plastic sleeve is of no relevance to the engine operation. When the solenoid valve injectors are replaced, the plastic sleeves are no longer required and do not need to be reinserted.

When manufacturing the holding clamp, casting lugs are produced when the component is detached from the tool. Due to the low installation tolerances, when installing the solenoid valve injectors it must be ensured that these casting lugs point in the direction of the exhaust manifold. If they are pointing in the wrong direction (towards the intake pipe), this can lead to mechanical contact between the holding clamp and cylinder head cover.

B46 Engine

7. Fuel System

The mounting bolts of the holding clamp must be replaced each time they are released.

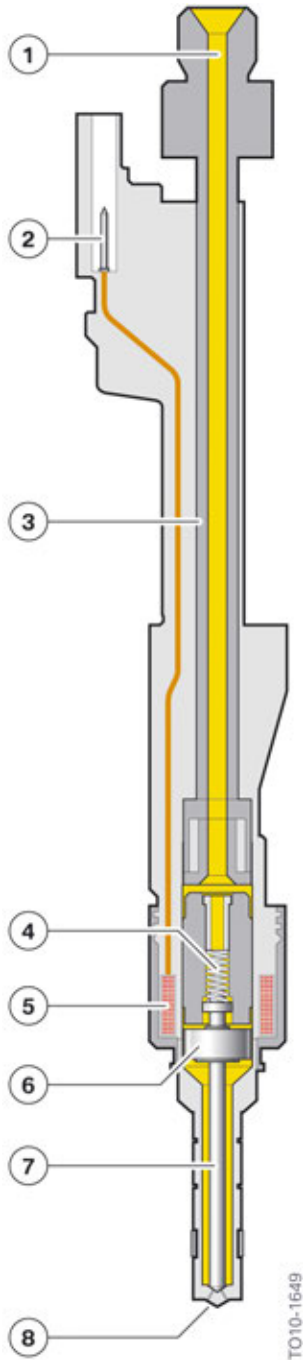


The shank of the solenoid valve injectors is sensitive to high tensile forces and rotational angles. When removing and installing the solenoid valve injectors, the procedure in the current repair instructions must be followed! If the solenoid valve injectors are damaged, fuel may be discharged.

B46 Engine

7. Fuel System

7.3.3. Solenoid valve injector



Solenoid valve injector HDEV 5.2

B46 Engine

7. Fuel System

Index	Explanation
1	Fuel line connection
2	Electrical connection
3	Stem
4	Compression spring
5	Solenoid coil
6	Armature
7	Nozzle needle
8	6-hole nozzle

As is already the case with the N55 and N20 engines, the new B46 engine is equipped with the Bosch HDEV 5.2 solenoid valve injector. The designation of the injectors is a combination of the following:

- HDEV = high-pressure fuel injection valve
- 5 = generation designation
- 1 = maximum fuel injection pressure of 150 bar
- 2 = maximum fuel injection pressure of 200 bar

If current is supplied to the solenoid coil, a magnetic field is produced which attracts the magnet armature. The magnet armature runs upwards on the nozzle needle. The linear travel of the magnet armature in the direction of the solenoid coil carries the nozzle needle along with it and the nozzle bores are released in the direction of the combustion chamber.

The repair instructions that are currently valid must be followed when removing and installing the injectors in Service. If the rotational angle at the shank of the injector is too large, this can lead to damage and therefore leaks in the fuel system.

A special fuel additive is recommended in markets with a poor fuel grade to prevent coking of injectors in direct injection systems. The additive is added to the fuel in the fuel tank from where it arrives at the injectors.



Coking at the injectors is reduced by using a BMW-approved additive (part no. 83 19 2 183 738).

ULEV II measures at the solenoid valve injector

Due to the more stringent exhaust gas emission regulations which are required to meet the ULEV II exhaust emission standards, technical changes had to be made to the solenoid valve injectors.

As is the case with diesel fuel passenger cars which has been dealt with previously, in addition to the limit value for particulate mass (PM), the limit value for the particle concentration (PN) is also stipulated in the ULEV II exhaust emission standards for gas passenger cars.

The reason for this is that in modern gas engines with direct injection no homogeneous fuel/air mixture arises in comparison to engines with intake pipe fuel injection. There are therefore more particles in the exhaust gas (particulate matter).

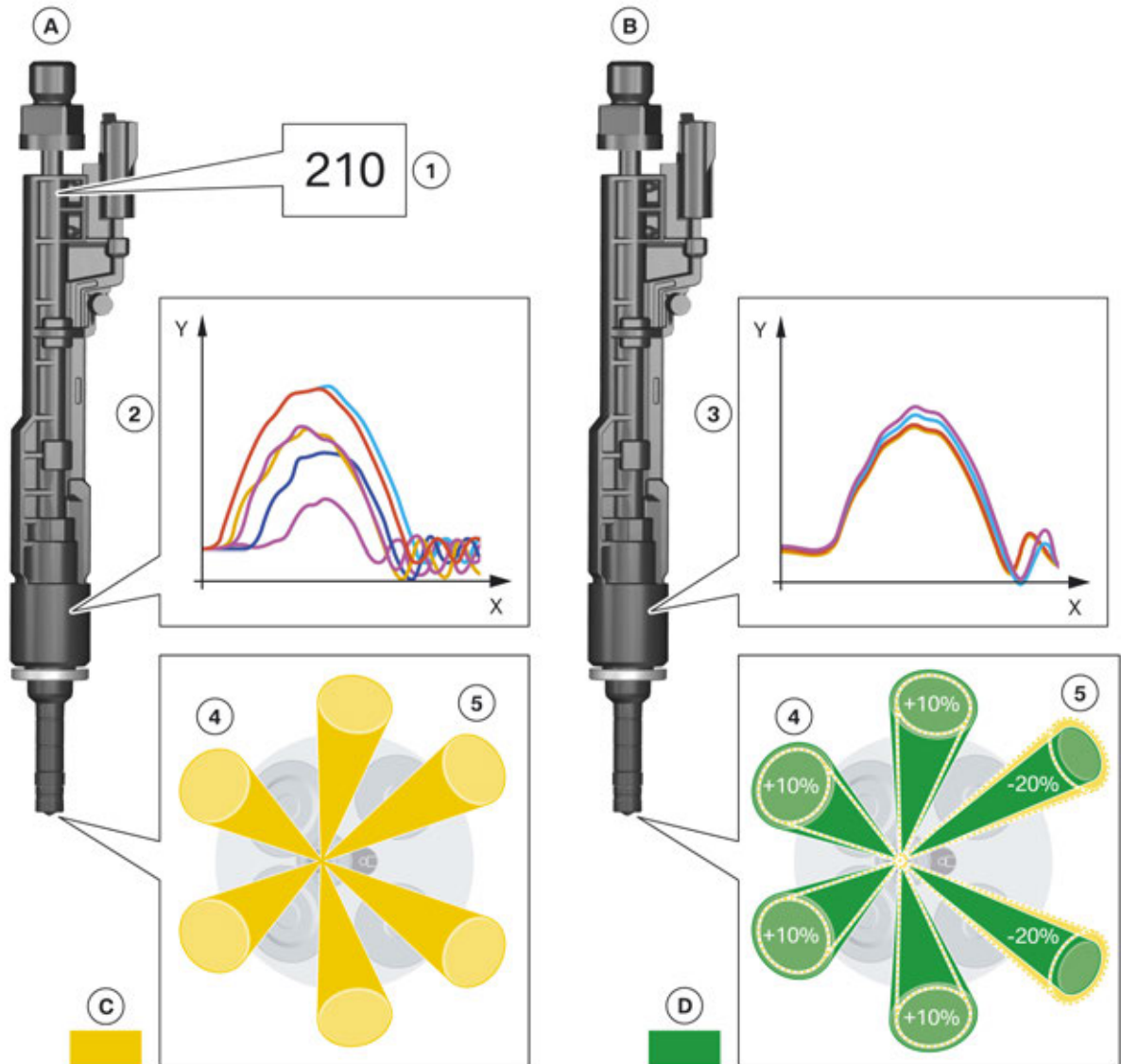
B46 Engine

7. Fuel System

Different diameters of laser-manufactured bore holes are used with the new high-pressure fuel injection valves, for example. The fuel quantity of the two spray jets in the exhaust direction is reduced by 20 %, which increases the other spray jets by 10 % respectively.

The solenoid valve injectors can only be used in a predefined position in the injector shaft of the cylinder head. This ensures correct alignment of the injection pattern in the combustion chamber.

The following graphic illustrates the differences between the ULEV and ULEV II version:



ULEV II measures, solenoid valve injector

TO14-0501

B46 Engine

7. Fuel System

Index	Explanation
A	Solenoid valve injector ULEV
B	Solenoid valve injector ULEV II
C	Even nozzle bore geometry
D	Uneven nozzle bore geometry
X	Opening period
Y	Needle travel
1	Injection quantity compensation code
2	Conventional operation
3	Automatic operation
4	Spray pattern, intake valve side
5	Spray pattern, exhaust valve side

High-pressure fuel injection valves with solenoid coils do not have a linear behavior pattern across the entire service life, mainly in the area of minimal quantity fuel injection. This means over the service life the fuel injection rates vary from one injector to another injector. Although the high-pressure fuel injection valves are adapted during start-up via the injection quantity compensation code in the Digital Motor Electronics, in order to compensate for possible manufacturing tolerances of the individual high-pressure fuel injection valves in the Digital Motor Electronics, and to adapt all injectors in relation to one another, this only happens once during start-up (injection quantity compensation). During conventional operation, the parameters for activation of the injectors, such as current and activation duration, are the same for all injectors throughout the entire operating time and cannot be individually adapted. Another adaptation during the entire operating time is no longer possible. This would lead to breaches of the strict exhaust gas emissions legislation, such as ULEV II, during the operating time.

An automatic operation allows precise dosing of fuel, particularly when using extremely small injection quantities. Analysis of the voltage and current curve in injector mode allows conclusions to be drawn about the movement of the needle. The most important information in relation to the movement of the needle is the needle travel and opening period. The fuel injection rate can be determined from these two variables. It has therefore been possible to omit printing of an injection quantity compensation code on the ULEV II solenoid valve injectors.

Controlled Valve Operating (CVO)

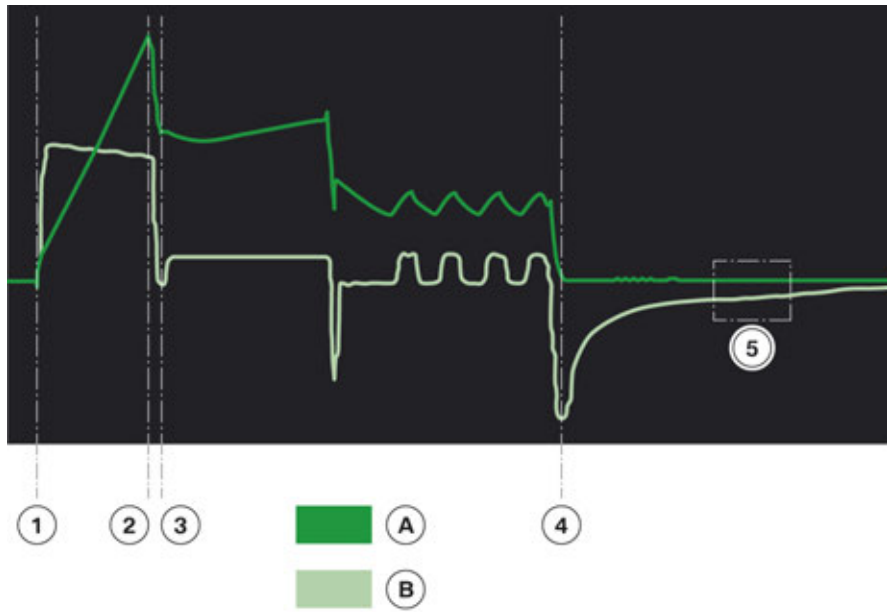
A software in the Digital Motor Electronics permanently ensures automatic operation of the solenoid valve injectors throughout the entire operating time.

The basic principle of this CVO function is that the precise opening period of the high-pressure fuel injection valves is determined. The Digital Motor Electronics can determine the precise opening period based on the following parameters:

- Power consumption of the high-pressure fuel injection valve
- Voltage of the high-pressure fuel injection valve

B46 Engine

7. Fuel System



Current and voltage curve of the solenoid valve injector

Index	Explanation
A	Current flow
B	Voltage curve
1	Start of activation
2	Nozzle needle, opening start
3	Nozzle needle, fully open
4	End of activation
5	Nozzle needle closing

These current and voltage values change in the event of a needle movement in the high-pressure fuel injection valve, for example:

- Armature mists up - when the needle valve is withdrawn from the valve seat.
- Armature moves - needle valve moves in direction of open position.
- Armature stationary - needle valve comes to rest at the maximum open position.
- Reverse movement.
- Armature moves - needle valve moves in direction of closed position.
- Armature suffers impact and is braked hydraulically - needle valve closed.

With these values, calculated from current and voltage values from the above mentioned needle movements, the Digital Motor Electronics can determine the actual opening period of the high-pressure fuel injection valves. If the precise opening periods are known, the Digital Motor Electronics can also determine the exact fuel injection rate based on this information.

B46 Engine

7. Fuel System

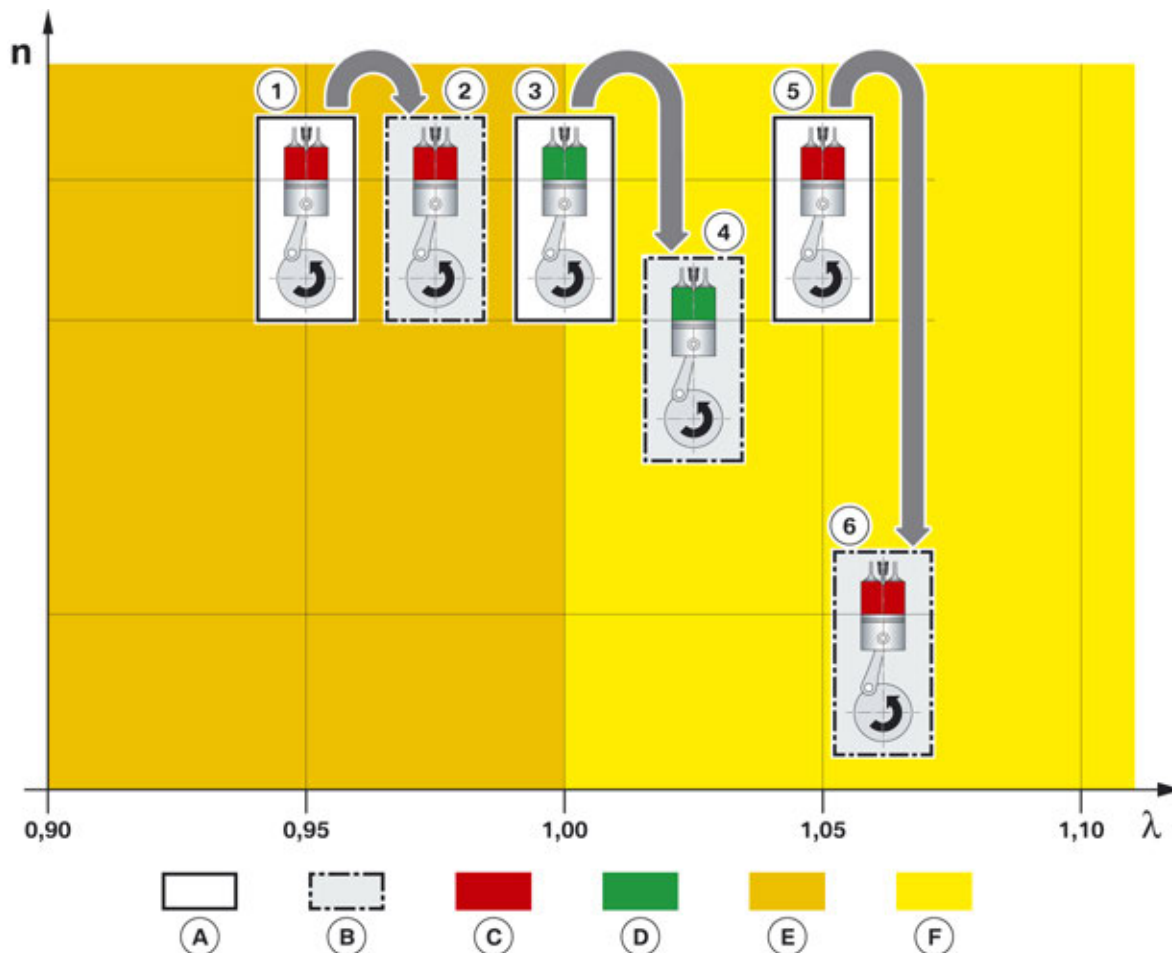
If variable fuel injection rates are now to be used, the Digital Motor Electronics can vary the fuel injection rate throughout the opening period by activating the respective high-pressure fuel injection valve individually. The Digital Motor Electronics thus has the option to adjust all high-pressure fuel injection valves to the same nominal fuel injection rate.

This measure guarantees the same nominal fuel injection rate in all cylinders, especially in the range where extremely small amounts are injected, as well as at idle speed, so that the exhaust re-treatment can always work efficiently. This measure inside the engine reduces exhaust emissions and therefore ensures compliance with the existing exhaust emission standards.

Cylinder Imbalance Monitoring (CIM)

The "Cylinder Imbalance Monitoring" function is an additional software function in the Digital Motor Electronics which monitors the correctness of the mixture preparation. The primary aim is to determine, with the assistance of this function, age-related operating time impairments of the fuel and intake area. Conclusions can be drawn about the air flow differences and different fuel injection rates, for example. These kind of differences are normally attributable to age-related leaks of the intake-components and pressure fluctuations in the rail or coking of the injectors.

The following graphic illustrates the operating principle of the Cylinder Imbalance Monitoring software:



Cylinder Imbalance Monitoring function

B46 Engine

7. Fuel System

Index	Explanation
A	Cylinder in normal operation
B	Test cylinder with higher air/fuel ratio
C	Cylinder outside the tolerance
D	Cylinder inside the tolerance
E	Rich range
F	Lean range
n	Speed of crankshaft
λ	Air ratio
1	Cylinder in rich range
2	Test cylinder speed constant
3	Cylinder in ideal range
4	Test cylinder speed slightly slower
5	Cylinder in lean range
6	Speed of test cylinder significantly slower

The function is cyclically actuated by the Digital Motor Electronics. During this process, the air/fuel ratio is increased for each cylinder in succession during engine operation. At the same time as the air/fuel ratio in the test cylinder is increased, the remaining cylinders are enriched in order to maintain the overall lambda value of the exhaust gas passage within the range $\lambda=1$. This ensures perfect functionality of the 3-way catalytic converter.

If a test cylinder is operated when the air/fuel ratio is too low, a slight increase will not bring about a change in the crankshaft speed.

When the air/fuel ratio in a test cylinder is increased in the ideal range, this brings about a slight change in speed at the crankshaft.

If a test cylinder is operated when the air/fuel ratio is too high, the speed at the crankshaft drops rapidly.

The engine speed variations at the crankshaft are not evaluated directly, but rather the changes in smooth running during engine operation. Rough running of the cylinders in relation to one another is balanced out by a so-called 'cylinder balancing control'. The test cylinder in the rich range therefore brings about a minor change in rough running and the test cylinder in the lean range brings about a major change in rough running.

Mixture errors determined are stored as a fault code entry in the Digital Motor Electronics. The fault code entry provides information about which cylinder is affected and the rich or lean value determined. The driver is informed about the error via a malfunction indicator lamp.

B46 Engine

7. Fuel System

Service note

When replacing the injector, the taught-in values of the CVO function and CIM function must be reset. This is done with the assistance of the BMW diagnosis system ISTA. Adjustment functions are available in the service functions. In order to inform the Digital Motor Electronics about the injector replacement, every ULEV II solenoid valve injector with the same dummy value (215) is taught in. Once the teach-in procedure has been successfully completed, the stored adaptations are reset and new adaptations are taught in via the CVO and CIM function.



When the solenoid valve injectors are replaced, they must be started up with the assistance of the BMW diagnosis system ISTA.

B46 Engine

8. Engine Electrical System

8.1. Digital Motor Electronics (DME)

Different variants of the Digital Motor Electronics MEVD 17.2.3 are used, depending on the charge cycle method. The hardware of the throttle valve-controlled engine control units is therefore not the same as the hardware of the Valvetronic-controlled engine control units.

The control unit number is made up of the following:

- M = engine electronics
- E = electrical load control (without cable)
- V = Valvetronic control
- D = direct fuel injection
- 17 = control unit generation
- 2 = Bosch-internal project number for BMW
- 3 = control unit index

The Digital Motor Electronics is the computing and switching center. Sensors on the engine and the vehicle deliver the input signals and actuators implement the commands. The Digital Motor Electronics calculates the corresponding activation signals for the actuators from the input signals, and also the computing models and characteristic maps stored.

The operating voltage range of the Digital Motor Electronics is between 6 and 16 volts.

An ambient pressure sensor and a temperature sensor are integrated in the Digital Motor Electronics.

The ambient pressure sensor permits precise determination of the density of the ambient air. This information is required for various diagnostic functions. In addition, in the event of a failure of the hot film air mass meter, a precise substitute value can be calculated for the cylinder filling with the help of additional input variables.

The temperature sensor measures the temperature inside the control unit. If the temperature there rises too sharply, multiple fuel injection is reduced for example, in order to cool the output stages slightly and to keep the temperature inside the control unit in a non-critical range.

B46 Engine

8. Engine Electrical System

Index	Explanation
1	Engine electronics Valvetronic direct fuel injection MEVD 17.2.3
2	Temperature sensor
3	Ambient pressure sensor
4	Starter motor
5	Brake light switch
6	Body Domain Controller (BDC)
7	Air conditioning compressor
8	Refrigerant pressure sensor
9	Fuel pump control module
10	Electric fuel pump
11	N/A
12	Relay, terminal 15N
13	Relay, Valvetronic
14	Relay, ignition and fuel injection
15	Diagnostic module for tank leaks (DMTL)
16	Relay, terminal 30B
17	Relay for electric fan
18	Electric fan
19	Map thermostat
20	Electric coolant pump (20 W)
21	Tank vent valve
22	VANOS solenoid valve, intake camshaft
23	VANOS solenoid valve, exhaust camshaft
24	Map-controlled valve, oil pump
25	Quantity control valve
26 – 29	Injectors, 4-cylinder engine
30 – 33	Ignition coils, 4-cylinder engine
34	Engine ventilation heating (cold-climate version only)
35	Earth connections
36	Actuator for electrically adjustable wastegate valve
37	Oxygen sensor after catalytic converter (LSF Xfour voltage-jump sensor)
38	Oxygen sensor before catalytic converter (LSU ADV broadband oxygen sensor)
39	Diagnostic socket
40	Intake-manifold pressure sensor after throttle valve

B46 Engine

8. Engine Electrical System

Index	Explanation
41	Rail pressure sensor
42	Charge air temperature and charging pressure sensor upstream of throttle valve
43	Knock sensor
44	Knock sensor
45	Hot film air mass meter
46	Gear sensor
47	Camshaft sensor, intake camshaft
48	Camshaft sensor, exhaust camshaft
49	Crankshaft sensor
50	Accelerator pedal module
51	Electromotive throttle actuator
52	Coolant temperature sensor
53	Oil pressure sensor
54	Valvetronic servomotor
55	Oil level sensor
56	Alternator
57	Dynamic Stability Control (DSC)

8.3. Map ignition

The B46 engine is equipped with an inductive ignition system with static ignition distribution. Each cylinder has a separate ignition coil which is inserted directly into the cylinder head cover.

To achieve optimum consumption and minimum pollutant emissions and the highest possible torque, the ignition point must be perfectly adjusted.

The following factors influence the ignition point:

- Engine speed
- Engine torque
- Charging pressure
- Current air ratio
- Coolant temperature
- Intake air temperature
- Fuel grade
- Operating condition (engine start)

B46 Engine

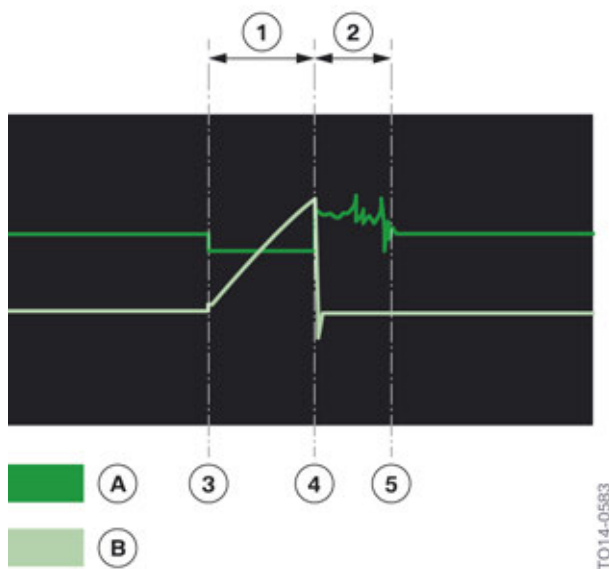
8. Engine Electrical System

These variables are recorded by the Digital Motor Electronics via sensors, processed with the assistance of different characteristic maps and output as control signals to the ignition coils.

8.3.1. Diagnostic functions

As faults in the area of the ignition system directly affect the quality of the exhaust gas, the ignition processes are monitored by the Digital Motor Electronics. During this process, the combustion period for the ignition of each individual cylinder is evaluated as a priority. The voltage difference of the primary coil at terminal 1 and terminal 15 is determined and evaluated by carrying out a measurement within the Digital Motor Electronics. An increased voltage difference is measurable while an ignition spark is present. The period of this voltage difference is referred to as 'combustion period'. The combustion period is not evaluated during the following operating conditions:

- During the starting operation
- Vehicle voltage < 12 volts



Current and voltage curve of ignition

Index	Explanation
A	Voltage curve
B	Current flow
1	Charging time of primary coil
2	Combustion period of ignition spark
3	Start of charging of primary coil
4	Start of ignition
5	End of ignition

B46 Engine

8. Engine Electrical System

Combustion period too short

The minimum thresholds for the combustion period are determined by the Digital Motor Electronics depending on the engine speed and load. When these minimum thresholds are undercut and misfiring also occurs, a fault code entry "Combustion period too short" is stored in the Digital Motor Electronics.

Combustion period outside the tolerance

The current combustion period of all individual cylinders is read in and combined to obtain a mean value. As the speed and load is the same in all cylinders, the calculated mean value is similar to the individual values read in. By comparing the individual values with the mean value obtained, the Digital Motor Electronics (DME) can draw conclusions about the combustion period. If an individual value exceeds or undercuts the minimum thresholds stored, a fault code entry "Combustion period outside the tolerance" is stored in the Digital Motor Electronics.

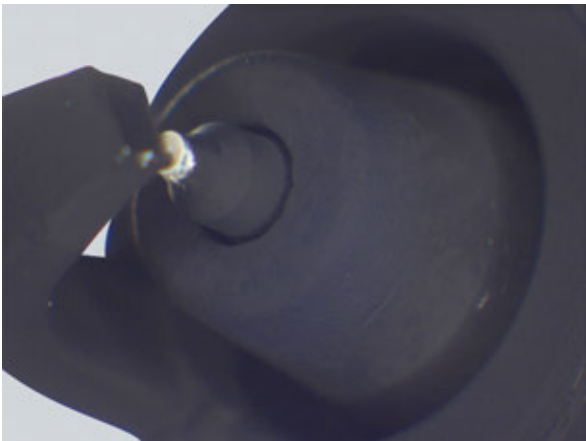
Note for Service

Fault code entries with the note "Combustion period too short" or "Combustion period outside the tolerance" are not necessarily always attributable to a defect in one or several ignition coils. Combustion period abnormalities can be identified via the diagnosis entry in the Digital Motor Electronics, their causes can be found in many different engine systems.

The following can cause deterioration of the combustion period:

- Contact resistances at the engine wiring harness of the ignition coil.
- Poor plug-in contact at the connector of the ignition coil.
- Coil resistance of ignition coils outside the permissible range.
- Ignition sparks inside silicone hose of the ignition coil.
- Heavily carbon fouled spark plug(s).

The following graphic shows a heavily sooted spark plug.



Heavily carbon fouled spark plug

The fault code entry "Combustion period too short" is frequently caused by one or several heavily carbon fouled spark plug(s). The carbon loading leads to deterioration of the ignition spark and therefore a very short combustion period.

B46 Engine

8. Engine Electrical System

Increased soot loading at the spark plugs accompanied by a reduction in the combustion period may be caused by the following:

- Fault in the mixture preparation
 - leaks at the air intake system
 - fault at the injector
 - fault at the high pressure pump
 - deposits in the area of the intake valves
- Fault in the engine electrical system
 - fault in the area of the coolant temperature sensor
 - fault in the area of the oxygen sensor
 - fault in the area of the hot film air mass meter
- Large number of cold starts
 - frequent catalytic converter heating phases
 - few self-cleaning phases of the spark plugs

With the fault code entry "Combustion period", a potential component fault at the relevant coil can be confirmed or disproved by cross-swapping the ignition coil.

If misfiring occurs following component errors, different test modules in the workshop and diagnosis system ISTA can be processed. As the causes of faults in the ignition system are many and varied, the various test and diagnosis instructions in the test module must be followed. If a faulty component is replaced without eliminating the actual cause, this will only remedy the problem in the short term.

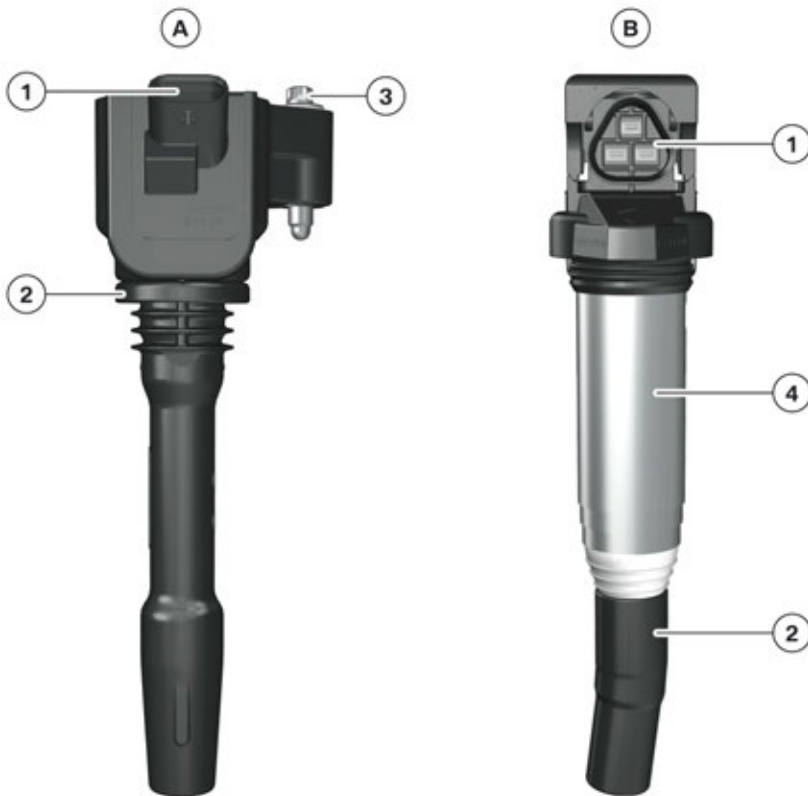
8.3.2. Ignition coils

Overview of ignition coils

The following graphic provides an overview of the different ignition coils currently used with the various BMW engines:

B46 Engine

8. Engine Electrical System



T014-0575

Overview of ignition coils

Index	Explanation
A	Compact ignition coil (manufacturer: Eldor)
B	Rod ignition coil (manufacturer: Delphi)
1	Electrical plug-in contact
2	Silicone hose
3	Mounting bolt
4	Rear closure plate

The table below provides an overview of the engines in which the various ignition coils are used:

Engine	Compact ignition coil	Rod ignition coil
B46	X	
N20		X
N55		X
N63 TU2		X
N74 TU		X

B46 Engine

8. Engine Electrical System

Compact ignition coil



Ignition coil, Bx8 engine

Index	Explanation
1	Manufactured for BMW
2	BMW part number
3	Supplier
4	Supplier code
5	Production date
6	Terminal 15
7	Terminal 4a
8	Silicone hose
9	Serial number
10	Terminal 1
11	Mounting bolt

The primary and secondary coil required to raise the ignition voltage can be found in the area of the electrical plug-in contact. The transfer factor achieved by both coils is around 1:80.

B46 Engine

8. Engine Electrical System

When servicing the ignition coils, observe the following:

- A slight rotational movement when pulling out and inserting the ignition coils makes disassembly and installation easier.
- There must be no sign of contamination by oil or other fluids in the area of the electrical plug-in contact.
- The pins of the electrical plug-in contact must not be bent.
- There must be no sign of cracking on the silicone hose.
- The spring which transmits the ignition spark must be positioned at the center of the silicone hose.
- The silicone hose of the ignition coils must not come into contact with fuel or mineral oils.
- The specified torque of the mounting bolt must be observed.
- Prior to disassembly of the ignition coil, remove the plug-in contact from the engine wiring harness, as the ignition coils cannot be operated without spark plugs.



The ignition coils are not fuel-resistant. All ignition coils should therefore be removed before opening the fuel system. Fuel residues must be removed before inserting the ignition coils in the spark plug shaft.

8.3.3. Spark plugs

The position of the spark plug electrode in the combustion chamber is therefore particularly important. To avoid coating the spark plug electrode with fuel, it is positioned geometrically between the fuel-injection spray of the injector.

A change interval applies for spark plugs and they must be renewed in accordance with the manufacturer's specifications. To avoid damage and ensure perfect function of the spark plugs, the prescribed tightening torques must be observed.

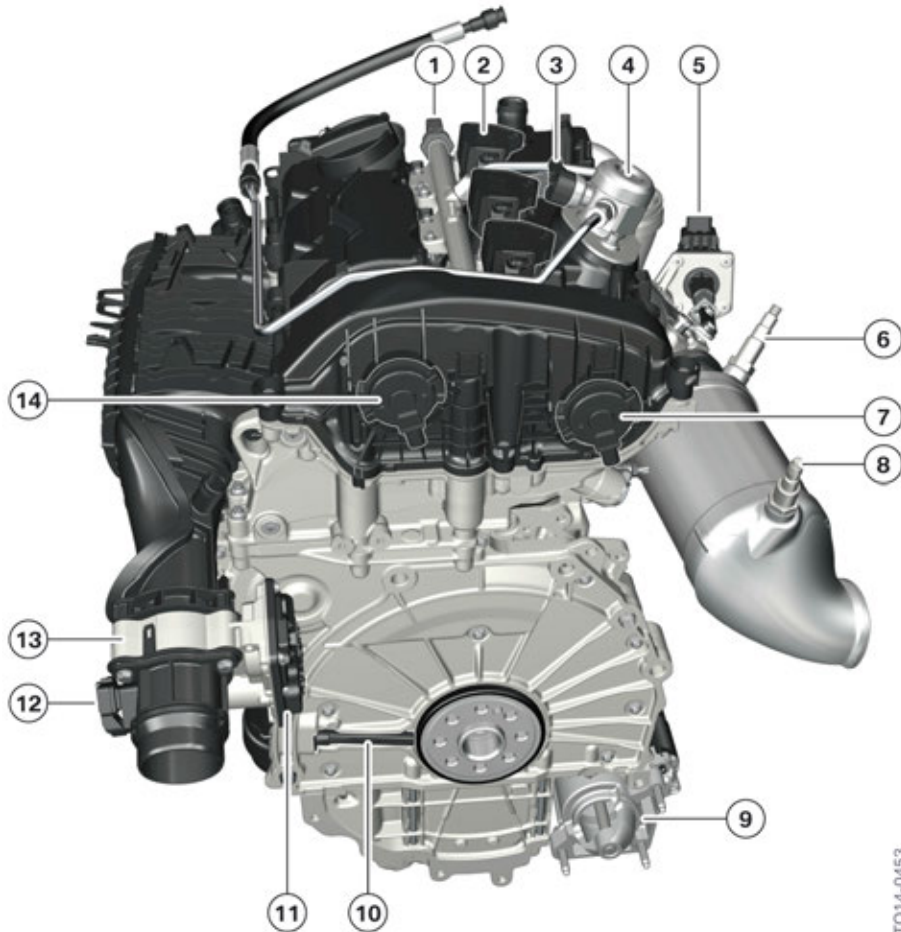
8.4. System overview for engine electrical system

The sensors and actuators are already known from other engines and are therefore not described in detail in this documentation. The following graphics provide an overview of the different installation positions of the sensors.

B46 Engine

8. Engine Electrical System

8.4.1. Transmission side



System overview for electrical system in the B38 engine, transmission side

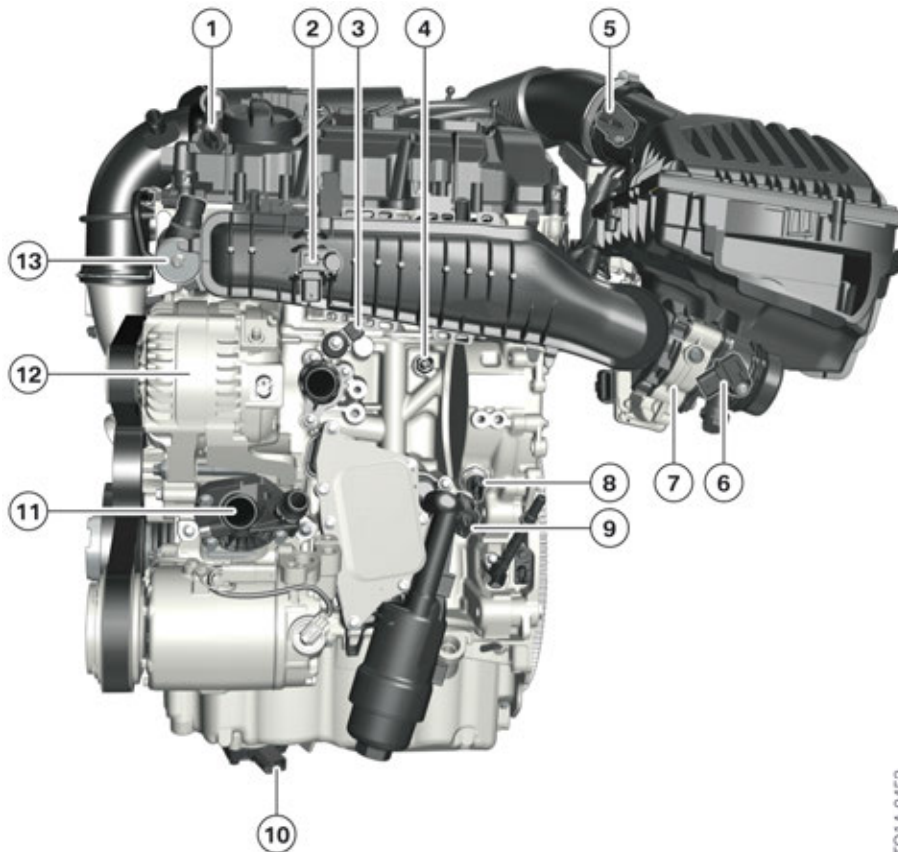
Index	Explanation
1	Rail pressure sensor
2	Ignition coil
3	Quantity control valve
4	High-pressure pump
5	Actuator of electrically adjustable wastegate valve
6	Broadband oxygen sensor before catalytic converter
7	VANOS exhaust camshaft
8	Voltage jump, oxygen sensor after catalytic converter
9	Pinion starter
10	Crankshaft sensor, crankshaft

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8. Engine Electrical System

Index	Explanation
11	Electromotive throttle controller
12	Combined charging pressure and temperature sensor
13	Throttle valve unit
14	VANOS intake camshaft

8.4.2. Side view



TO14-0452

System overview for electrical system in the B38 engine, top view

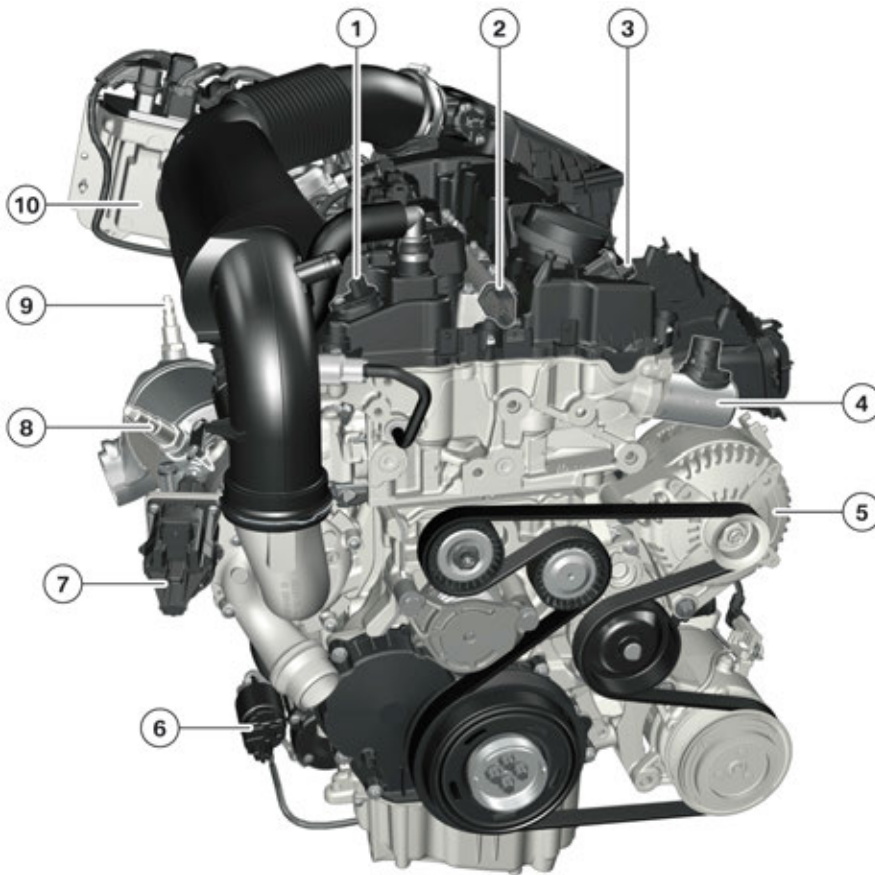
Index	Explanation
1	Camshaft sensor, intake camshaft
2	Intake manifold pressure sensor
3	Knock sensor
4	Coolant temperature sensor
5	Hot-film air mass meter
6	Combined charging pressure and temperature sensor
7	Throttle valve unit

B46 Engine

8. Engine Electrical System

Index	Explanation
8	Oil pressure sensor
9	Map-controlled control valve of the vane-type compressor
10	Combined oil quality and oil-level sensor
11	Map thermostat
12	Local interconnect network bus connection
13	Valvetronic servomotor with integrated position sensors

8.4.3. Belt side



TO14-0451

System overview for electrical system in the B38 engine, belt side

Index	Explanation
1	Camshaft sensor, exhaust camshaft
2	Rail pressure sensor
3	Camshaft sensor, intake camshaft
4	Valvetronic servomotor with integrated position sensors
5	Generator with intelligent generator control

B46 Engine

8. Engine Electrical System

Index	Explanation
6	Solenoid switch, pinion starter
7	Actuator of electrically adjustable wastegate valve
8	Broadband oxygen sensor before catalytic converter
9	Voltage jump, oxygen sensor after catalytic converter
10	Digital Motor Electronics (DME)



Bayerische Motorenwerke Aktiengesellschaft
Qualifizierung und Training
Röntgenstraße 7
85716 Unterschleißheim, Germany