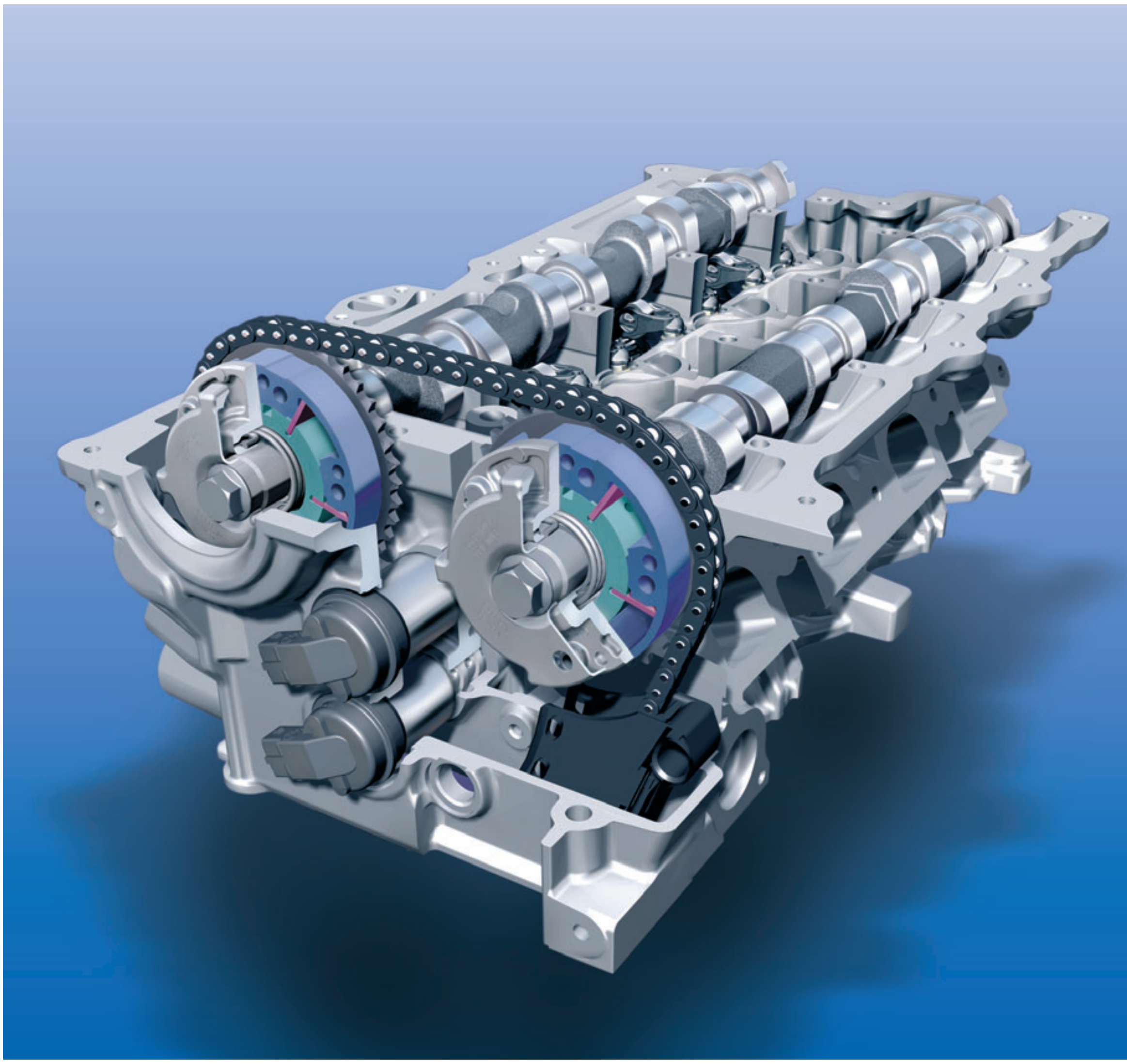
Product Information
VANOS



BMW Service

Aftersales Training

The information contained in the Product Information and the Workbook form an integral part of the training literature of BMW Aftersales Training.

Refer to the latest relevant BMW Service information for any changes/supplements to the technical data.

Information status: June 2005

conceptinfo@bmw.de

Basic Engine Principles
VANOS

Improved exhaust-emission performance

Reduced consumption

Increased power and torque

Notes on this product information

Symbols used

The following symbols are used in this product information to facilitate better comprehension and to draw attention to important information.

⚠ contains information for better understanding of the described systems and their functions.

◄ identifies the end of an item of information.

Status of product information

In view of the constant further developments in the design and equipment of BMW vehicles deviations may arise between this product information and the vehicles made available as part of the training course.

The background material refers exclusively to left-hand drive vehicles. The controls are in part arranged differently in right-hand drive vehicles than shown on the graphics in the product information.

Additional information sources

You will find further information on the individual topics in following documentation:

- Owner's Handbook
- BMW diagnostic system
- Workshop systems documentation
- SBT BMW Service Technology

Contents
VANOS

Objectives
VANOS

Product information and reference work for practical applications

Please remember to work through the SIP (Service Information Programme) on this subject.
Basic knowledge ensures certainty and reliability in theory and practice.

General

This Product Information is intended to provide you with information on the design, function and operation of variable camshaft timing (VANOS) on BMW vehicles.

The Product Information is conceived as a reference work and supplements the seminar content imparted by BMW Aftersales Training. The Product Information is also suitable for private study.

As a means of preparation for the technical training course, this Product Information provides an insight into the VANOS system used on the current BMW models. The Product Information, in conjunction with practical exercises carried out in the training course, will enable the participants to carry out servicing work on the VANOS system used on BMW models.

Technical and practical background knowledge of the current BMW models will simplify your understanding of the systems described here and their functions.

Existing SIPs

- N42 Engine
- N52 Engine
- N62 Engine
- N73 Engine

Models
VANOS

Variable camshaft timing


VANOS has been used on BMW vehicles since 1992. Now, all petrol engines are equipped with double VANOS.

Overview table

Engine	Inlet VANOS	Exhaust VANOS	Fully variable valve timing	Engine management	Opening angle °cr Inlet/exhaust	Spread, inlet °cr	Spread, exhaust °cr	Start of series production	Power in bhp/kW at rpm
M50B20TU	X_1	-	-	MS40.1	228°/228°	80° to 105°	-105°	09/ 1992	150/110 5900
M50B25TU	X_1	-	-	ME3.3.1	228°/228°	85° to 110°	-101°	09/ 1992	191/141 5900
M52B20	X_1	-	-	MS41.0	228°/228°	±40°	-105°	09/ 1994	150/110 5900
M52B25	X_1	-	-	MS41.0	228°/228°	85° to 110°	-105°	05/ 1995	170/125 5500
M52B28	X_1	-	-	MS41.0	228°/228°	90° to 115°	-105°	01/ 1995	193/142 5300
M52B20TU	X_3	X_3	-	MS42	228°/228°	80° to 120°	-80° to -105°	12/ 1997	150/110 5900
M52B25TU	X_3	X_3	-	MS42	228°/228°	80° to 120°	-80° to -105°	03/ 1998	170/125 5500
M52B28TU	X_3	X_3	-	MS42	228°/228°	80° to 120°	-80° to -105°	03/ 1998	193/142 5500
M54B22	X_3	X_3	-	MS43	228°/228°	80° to 120°	-80° to -105°	04/ 2000	170/125 6100
M54B22 (Z4)	X_3	X_3	-	MS45	228°/228°	80° to 120°	-80° to -105°	04/ 2000	170/125 6100
M54B25	X_3	X_3	-	MS43	228°/228°	80° to 120°	-80° to -105°	09/ 2000	192/141 6000
M54B25 (Z4)	X_3	X_3	-	MS45	228°/228°	80° to 120°	-80° to -105°	09/ 2000	192/141 6000
M54B30	X_3	X_3	-	MS43	240°/228°	86° to 126°	-80° to -105°	09/ 2000	231/170 5900
M54B30 (Z4)	X_3	X_3	-	MS45	240°/228°	86° to 126°	-80° to -105°	09/ 2000	231/170 5900
M62B35TU	X_2	-	-	ME7.2	238°/228°	84° to 124°	-97°	09/ 1998	245/180 5800
M62B44TU	X_2	-	-	ME7.2	238°/228°	84° to 124°	-104 °	09/ 1998	286/210 5400
M62B46 (X5)	X_2	-	-	ME7.2	249°/249°	84° to 124°	-108°	09/ 2001	347/255 5700

Engine	Inlet VANOS	Exhaust VANOS	Fully variable valve timing	Engine management	Opening angle °cr Inlet/exhaust	Spread, inlet °cr	Spread, exhaust °cr	Start of series production	Power in bhp/kW at rpm
N40B16	X_3	X_3	-	ME9.2	236°/248°	75° to 135°	-75° to -135°	09/ 2001	115/85 6100
N42B18	X_3	X_3	X_A	ME9.2	258°/250°	60° to 120°	-60° to -120°	12/ 2001	115/85 5500
N42B20	X_3	X_3	X_A	ME9.2	258°/250°	60° to 120°	-60° to -120°	09/ 2001	143/105 6000
N45B16	X_3	X_3	-	ME9.2	236°/248°	60° to 120°	-60° to -120°	03/ 2004	116/85 6100
N45B16	X_3	X_3	-	ME9.2	239°/247°	60° to 120°	-60° to -120°	09/ 2004	116/85 6000
N46B18	X_3	X_3	X_A	MEV9.2	250°/258°	60° to 120°	-60° to -120°	03/ 2004	116/85 5500
N46B20	X_3	X_3	X_A	MEV9.2	250°/258°	60° to 120°	-60° to -120°	03/ 2004	143/105 6000
N46B20UL	X_3	X_3	X_A	MEV9.2	250°/247°	60° to 120°	-60° to -120°	12/ 2004	129/95 5750
N46B20OL	X_3	X_3	X_A	MEV9.2	250°/258°	60° to 120°	-60° to -120°	09/ 2004	150/110 6200
N52B25UL	X_3	X_3	X_B	MSV70	255°/263°	55° to 125°	-60° to -115°	03/ 2005	/130 5800
N52B25OL	X_3	X_3	X_B	MSV70	255°/263°	55° to 125°	-60° to -115°	03/ 2005	218/160 6500
N52B30UL	X_3	X_3	X_B	MSV70	255°/263°	50° to 120°	-60° to -115°	03/ 2005	218/160 6500
N52B30OL	X_3	X_3	X_B	MSV70	255°/263°	50° to 120°	-60° to -115°	09/ 2004	258/190 6600
N62B36	X_3	X_3	X_A	ME9.2	282°/254°	60° to 120°	-60° to -120°	11/ 2001	272/200 6200
N62B44	X_3	X_3	X_A	ME9.2	282°/254°	60° to 120°	-60° to -120°	11/ 2001	333/245 6100
N62B44 (X5)	X_3	X_3	X_A	ME9.2.1	282°/254°	60° to 120°	-60° to -120°	09/ 2003	320/235 6100
N62B48 (X5)	X_3	X_3	X_A	ME9.2.2	282°/254°	60° to 120°	-60° to -120°	04/ 2004	360/265 6200
N62B40TU	X_3	X_3	X_A	ME9.2.2	282°/254°	60° to 120°	-60° to -120°	03/ 2005	306/225 6300
N62B48TU	X_3	X_3	X_A	ME9.2.2	282°/254°	60° to 120°	-60° to -120°	03/ 2005	367/270 6200

Engine	Inlet VANOS	Exhaust VANOS	Fully variable valve timing	Engine management	Opening angle °cr Inlet/exhaust	Spread, inlet °cr	Spread, exhaust °cr	Start of series production	Power in bhp/kW at rpm
N73B60	X_3	X_3	X_A	2x ME9.2.1	282°/254°	60° to 120°	-63° to -126°	01/ 2003	435/327 6000
S50B30	X_4	-	-	ME3.3	260°/260°	80° to 122°	-108°	09/ 1992	286/210 7000
S50B30GT	X_4	-	-	ME3.3	264°/264°	80° to 122°	-108°	1995	295/217 7100
S50B32	X_5	X_5	-	MSS50	260°/260°	70° to 130°	-76° to -114°	09/ 1995	321/236 7400
S54B32 E36/7	X_5	X_5	-	MSS54	260°/260°	70° to 130°	-83° to -128°	05/ 2001	325/239 7400
S54B32	X_5	X_5	-	MSS54	260°/260°	70° to 130°	-83° to -128°	07/ 2000	343/252 7900
S54B32HP	X_5	X_5	-	MSS54HP	260°/260°	70° to 130°	-83° to -128°	01/ 2003	360/265 7900
S62B50	X_5	X_5	-	MSS52	252°/248°	74° to 134°	-76° to -136°	09/ 1998	440/294 6600
S85B50	X_5	X_5	-	MSS65	268°/260°	79° to 145°	-91° to - 128°	09/ 2004	507/373 7750

X_1 = Two-setting inlet VANOS

X_2 = Infinitely variable inlet VANOS

X_3 = Infinitely variable double VANOS

X_4 = Infinitely variable high-pressure inlet VANOS

X_5 = Infinitely variable high-pressure double VANOS

X_A = With VALVETRONIC electronic control unit

X_B = VALVETRONIC II

Variable camshaft timing

Control of charge cycle

In addition to using the throttle valve to control the flow of clean mixture drawn into the engine, there are other means of altering the clean mixture and the amount of residual exhaust in the cylinder:

- Variable timing of inlet and exhaust valves,
- Exhaust recirculation,
- Variable intake-manifold geometry (dynamic cylinder charging) and
- Turbocharging.

This document covers variable timing of the inlet and exhaust valves with the aid of VANOS.

Variable timing

When configuring valve timing, it is important to bear in mind that the behaviour of the gases flowing into and out of the cylinder changes enormously according to engine speed or throttle valve position. Therefore, if fixed timing is used, the charge cycle can only be optimized for a specific operating range. Variable timing enables the charge cycle to be adapted to different operating ranges and thus engine speeds.

Since the early days of the 1929 3/15 and its DA1 engine, the average rated speed has increased from 3000 rpm to today's 6200 rpm. Now, infinitely variable double VANOS is standard on BMW petrol engines and is the most technically advanced system offered by the automotive technology market anywhere in the world.

History

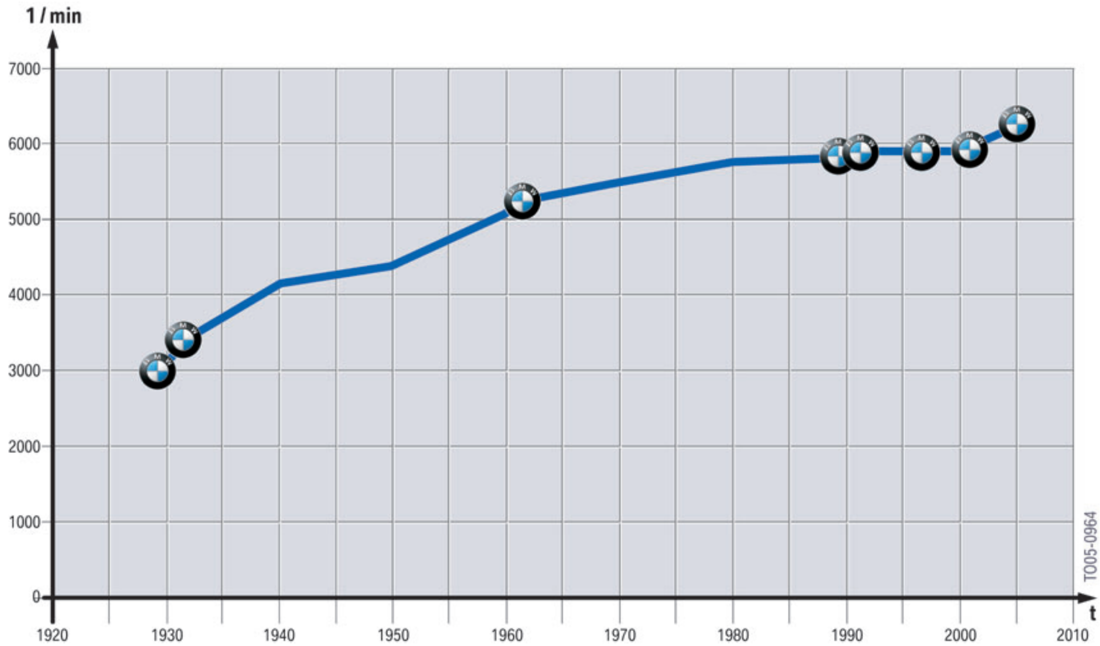
Valve-gear technologies on BMW petrol engines

The technological development status of valve gear is determined essentially by speed stability and usable valve-gear variability.

Between 1929, when series production of BMW motor vehicles first started, and the introduction of the BMW M50B20 4-valve-per-cylinder engine in 1989, the rated speed increased from 3000 rpm to approx. 5900 rpm. In 1992, the first partially variable valve gear was used in series production in the form of variable camshaft timing. The VANOS system has undergone consistent advancement from switchable inlet VANOS to infinitely variable double VANOS with broadened adjustment range. This has enabled improvements in function to be achieved at full power, medium power and idling speed, as well as in pollutant emissions. An interesting aspect in that connection is the increase in the maximum rated speed, which has risen much more dramatically than the average figures shown on the graph below reveal. The very highest maximum rated speeds are achieved only by racing engines:

- In 1992, 7000 rpm by the S50B30
- In 2000, 7400 rpm by the S50B32
- In 2005, 7900 rpm by the S54B32

The graph below shows the historical development of rated speed (average across all petrol engines in the range) and the times at which new valve gear technologies were introduced on BMW petrol engines:

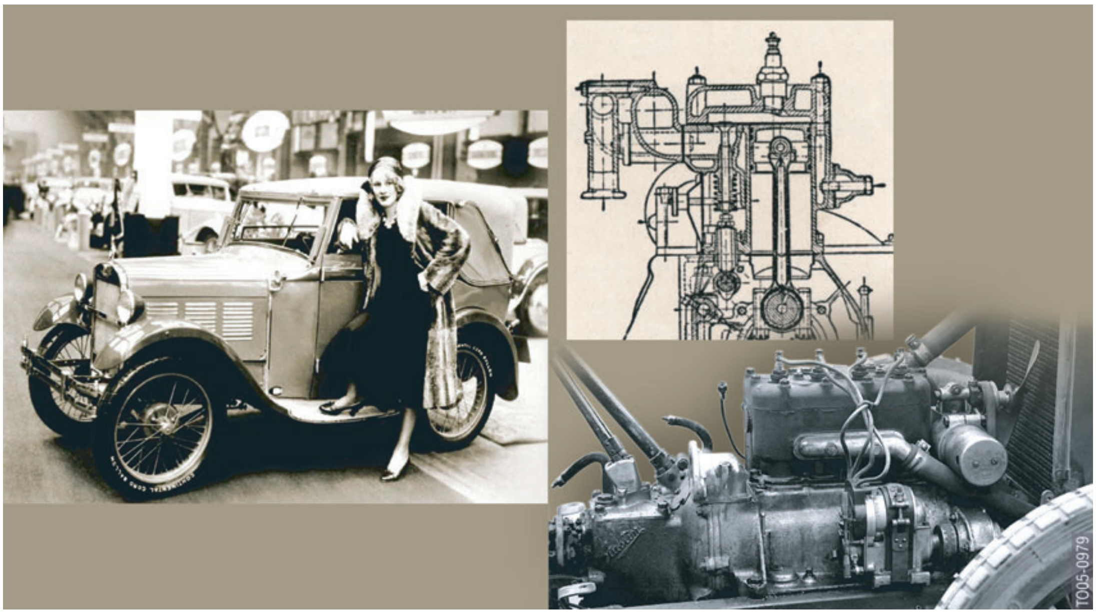


1 - History of valve gear technologies

Index	Explanation	Index	Explanation
1929	2 side valves per cylinder, block-mounted camshaft	1992	4 valves per cylinder, overhead camshaft, inlet VANOS
1932	2 overhead valves per cylinder, block-mounted camshaft	1997	4 valves per cylinder, overhead camshaft, double VANOS
1962	2 valves per cylinder, overhead camshaft	2001	4 valves per cylinder, overhead camshaft, VALVETRONIC
1989	4 valves per cylinder, overhead camshaft	2005	4 valves per cylinder, overhead camshaft, VALVETRONIC

1929

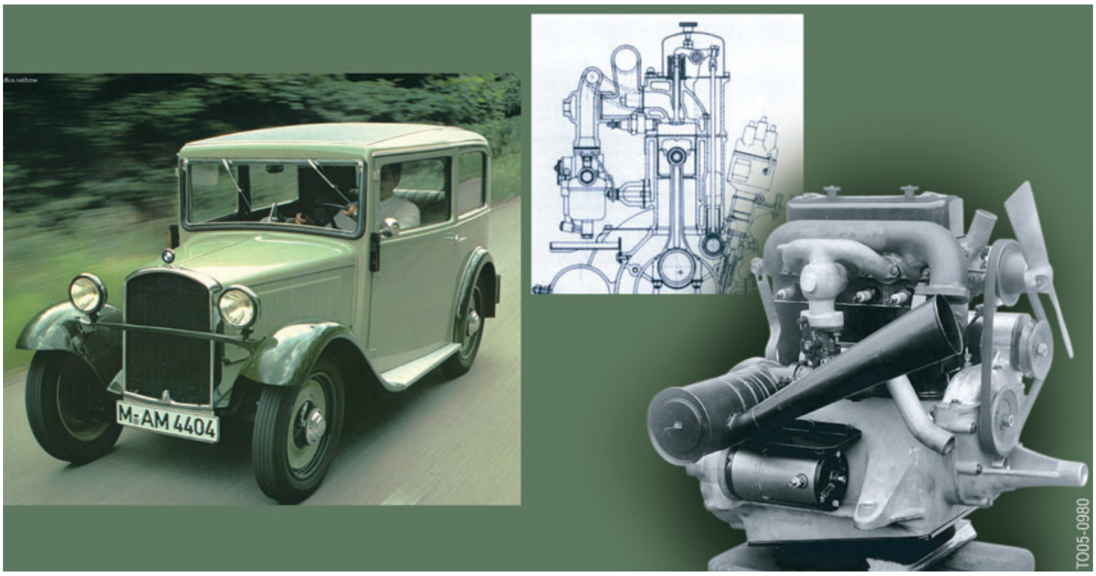
- BMW 3/15, 2 side valves per cylinder, block-mounted camshaft



2 - 1929: 3/15 with DA1 engine

1932

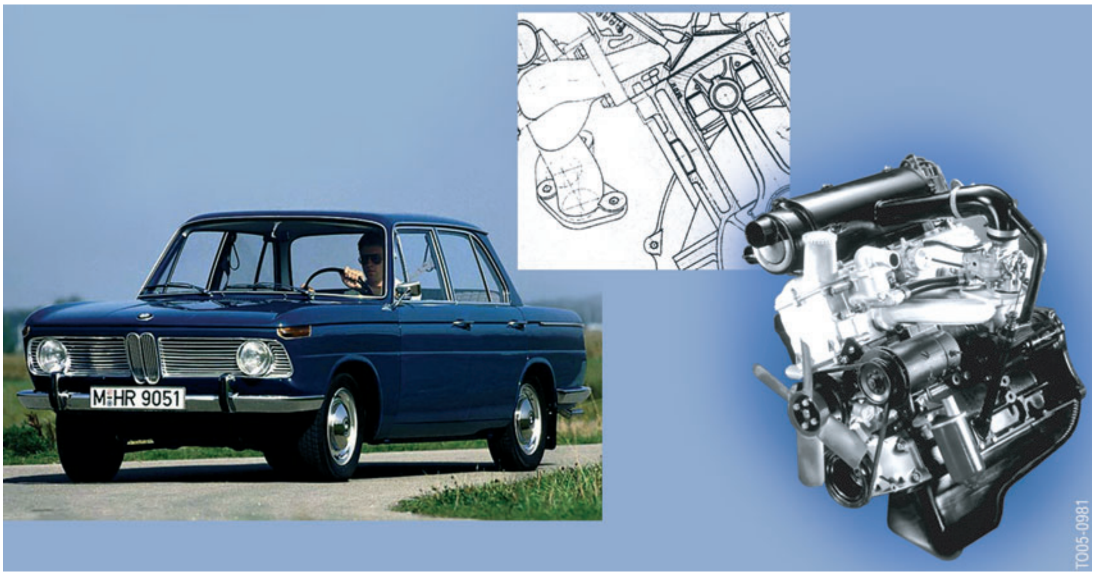
- BMW 3/20 with M68a, 2 overhead valves per cylinder, block-mounted camshaft



3 - 1932: 3/20 with M68 engine

1962

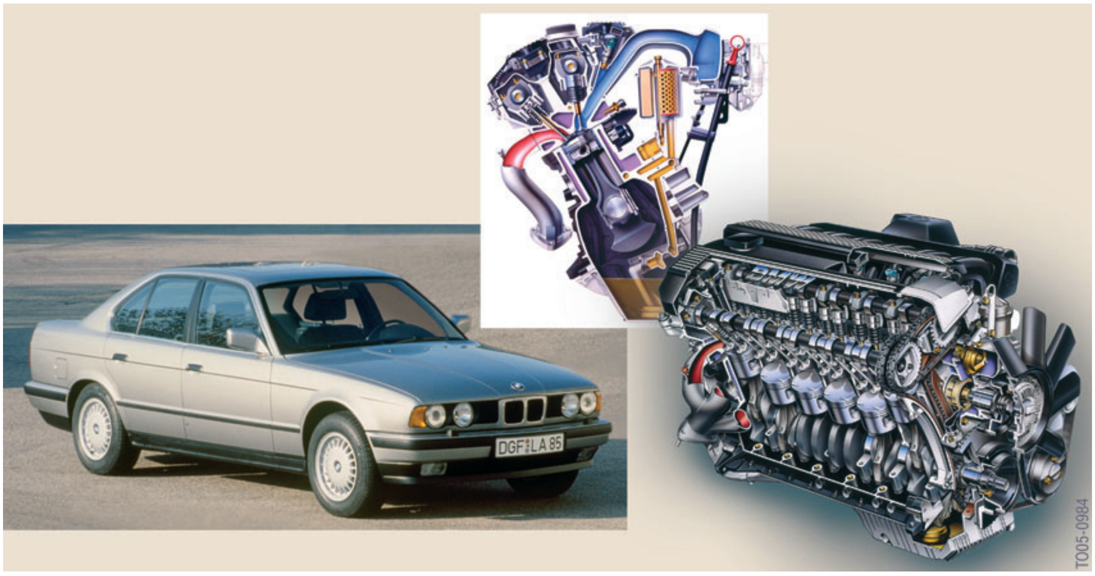
- BMW 1500 with M115, 2 overhead valves per cylinder, overhead camshaft (ohc)



4 - 1962: 1500 with M115 engine

1989

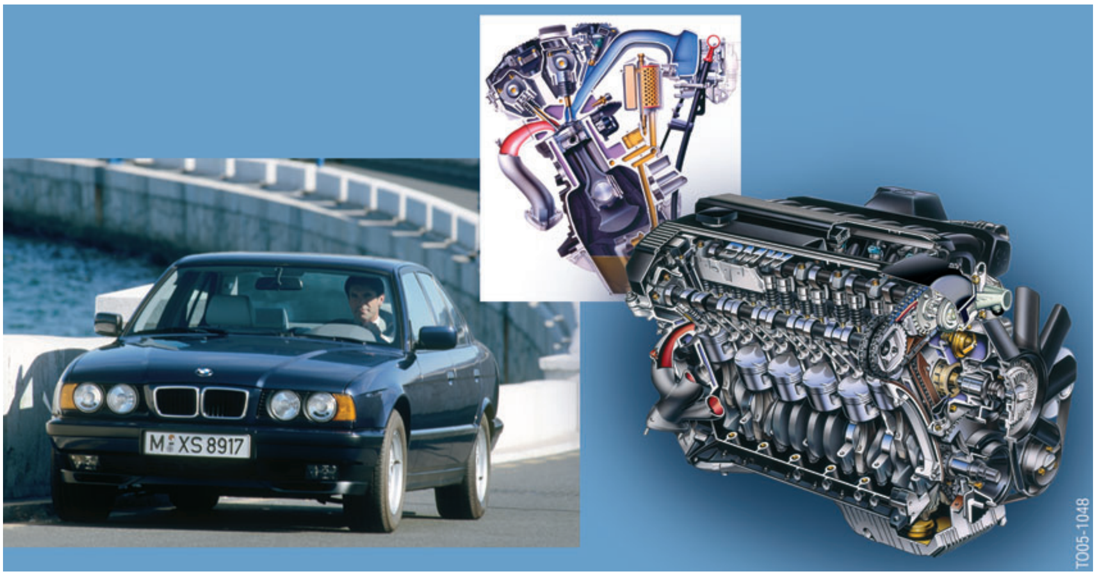
- BMW 520i with M50B20, 4 overhead valves per cylinder, double overhead camshaft (dohc)



5 - 1989: 520i with M50B20 engine

1992

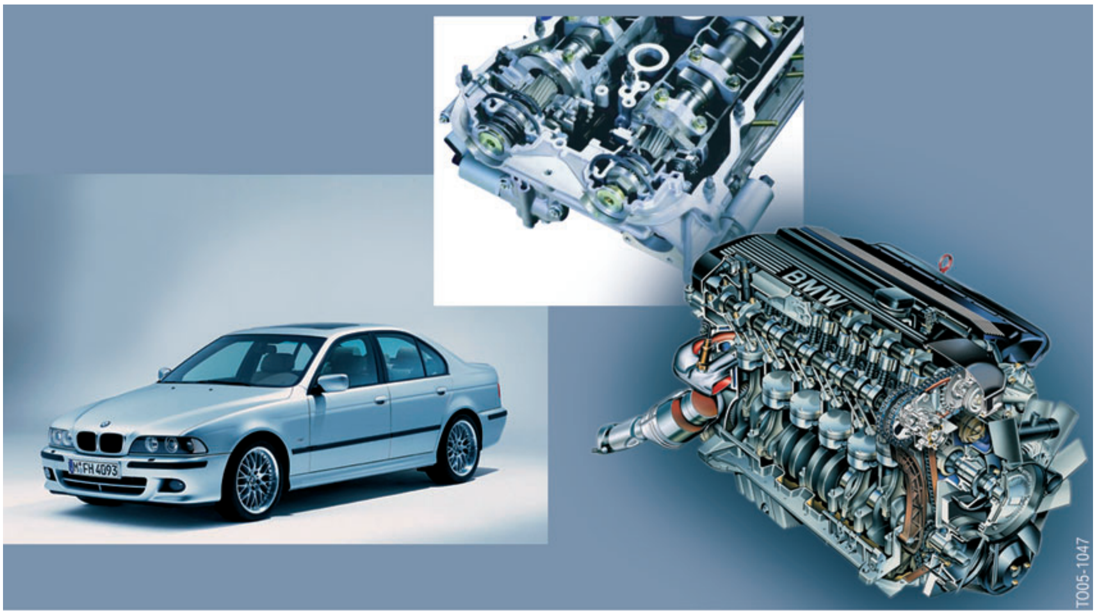
- BMW 520i with M50B20TU, 4 overhead valves per cylinder, double overhead camshaft (dohc), inlet VANOS



6 - 1992: 520i with M50B20TU engine

1997

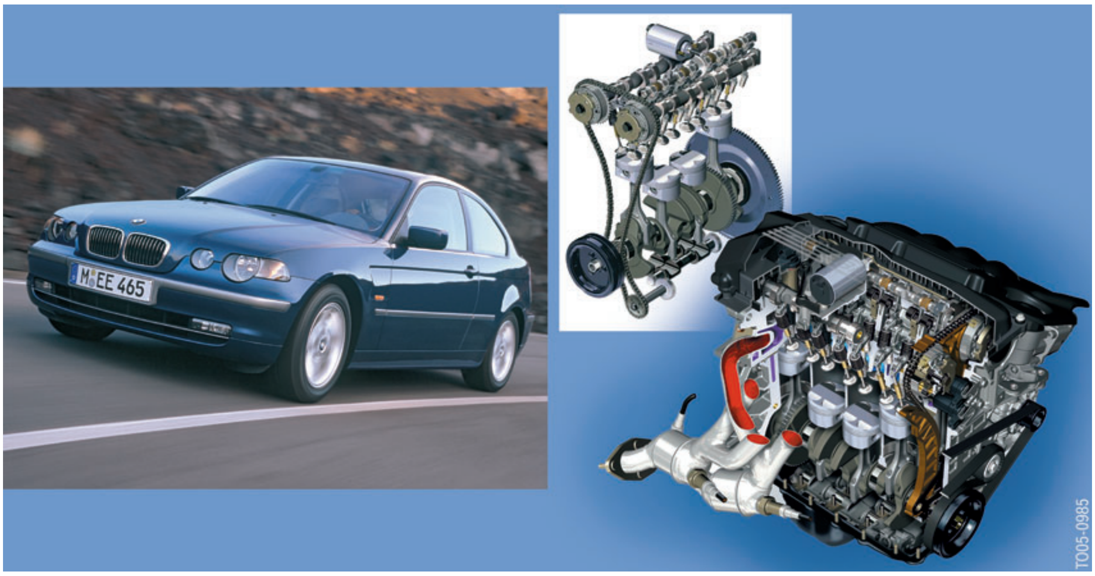
- BMW 528i with M52B28TU, 4 overhead valves per cylinder, double overhead camshaft (dohc), double VANOS



7 - 1997: 528i with M52B28TU engine

2001

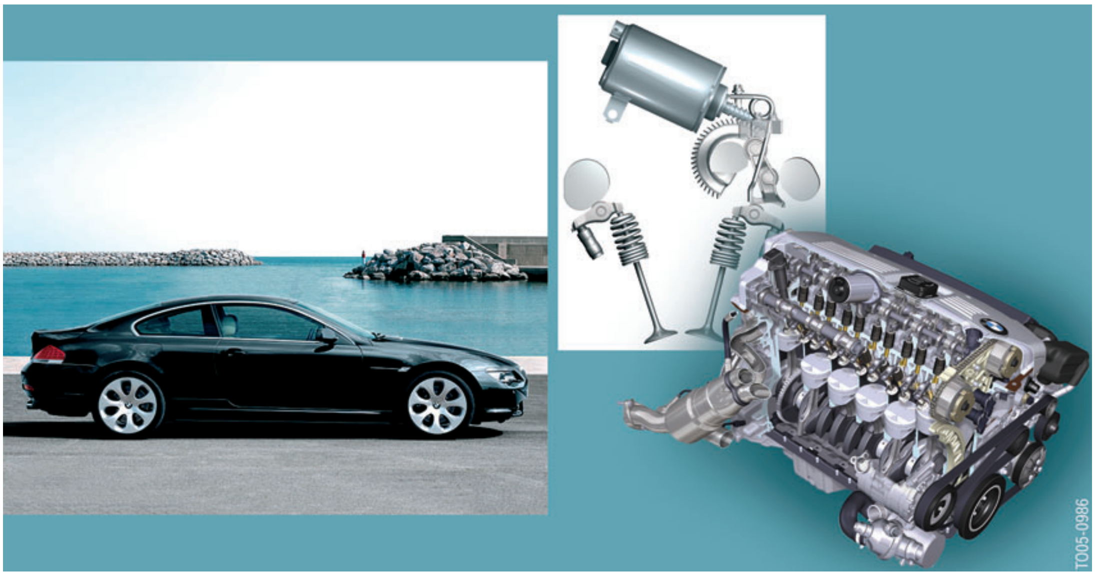
- BMW 316ti with N42B18, 4 overhead valves per cylinder, double overhead camshaft (dohc), VALVETRONIC (double VANOS + fully variable valve gear)



8 - 2001: 316ti with N42 engine

2005

- BMW 630ti with N52B30OL, 4 overhead valves per cylinder, double overhead camshaft (dohc), VALVETRONIC II (double VANOS + fully variable valve gear)



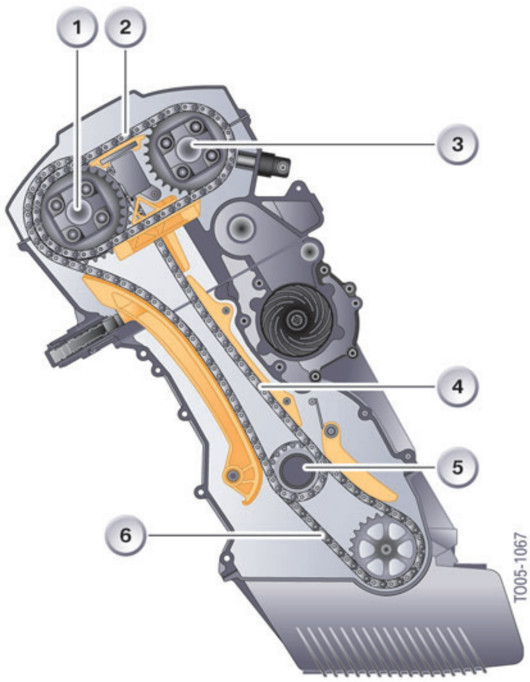
9 - 2005: 630i with N52 engine

System overview
VANOS

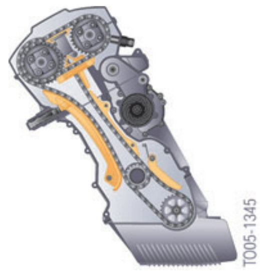
Valve gear function

On a conventional engine, the camshaft and the crankshaft are mechanically linked by a timing belt or chain (see diagram showing timing chains on M50 engine). In this case, the valve timing is fixed (see valve timing graph for M50 engine).

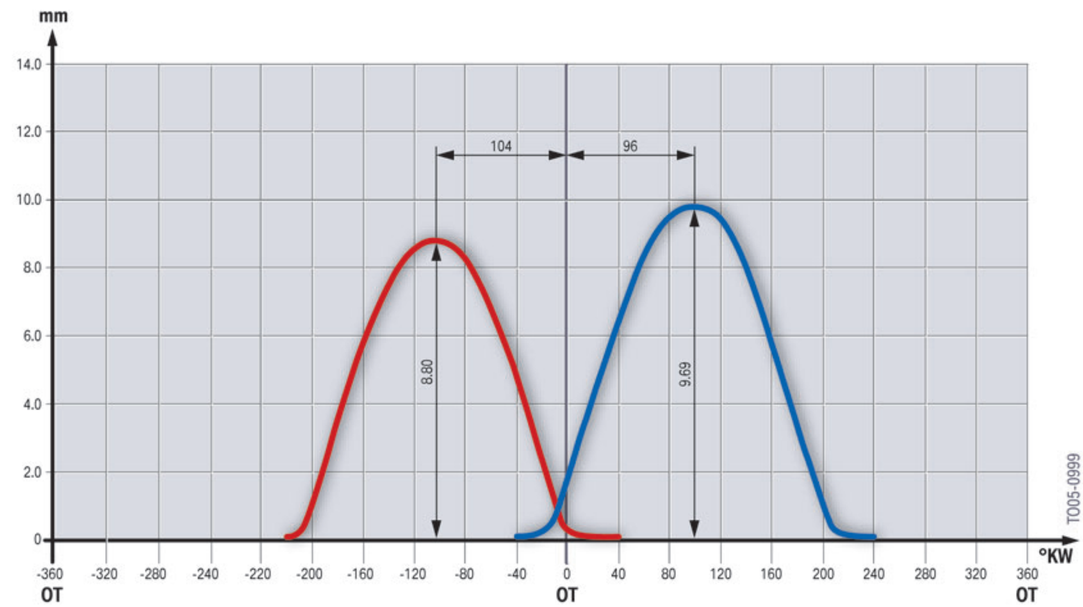
Index	Explanation
1	Exhaust camshaft
2	Secondary timing chain
3	Intake camshaft
4	Primary timing chain
5	Crankshaft
6	Oil pump drive chain



1 - Timing chains, M50 engine



The M50 engine was the starting point for introduction of the first VANOS system. It uses the familiar valve gear configuration with a timing chain connecting the crankshaft and camshafts.



2 - Valve timing graph, M50B20 engine

To date, five different VANOS systems have been developed by BMW. They are two-setting inlet VANOS, infinitely variable inlet VANOS, infinitely variable double VANOS, infinitely variable high-pressure VANOS and infinitely variable, high-pressure double VANOS

VANOS Systems on BMW Engines

General description

On engines with variable camshaft timing, the synchronization relative to the crankshaft of either the inlet camshaft on its own or, on later systems, the inlet and exhaust camshafts is varied. The adjustment is effected by means of oil pressure, which is controlled by electrically operated actuators. In order to optimize timing, the intelligence of the VANOS systems has developed and improved over the course of time. The pages that follow provide an introduction to the systems most commonly used by BMW and their effect on valve timing.

Systems:

- Two-setting inlet VANOS
  - M50TU
  - M52
- Infinitely variable inlet VANOS
  - M62TU
- Infinitely variable double VANOS
  - M52TU
  - M54
  - N40, N42, N45, N46, N52,
  - N62, N62TU, N73
- Infinitely variable high-pressure inlet VANOS
  - S50, S50TU
- Infinitely variable high-pressure double VANOS
  - S50B32, S52, S54
  - S62
  - S85

Main functions of VANOS

- Power enhancement
- Torque improvement
- Internal exhaust recirculation
- Reduction of emissions
- Reduction of fuel consumption

By adjusting camshaft timing on the inlet side, either the maximum torque or the maximum power output can be positively improved depending on the design of the cam profile.

The determining factor for maximum power output is the point at which the inlet valve closes. As engine speed increases, the timing of the point at which the inlet valve closes is "retarded". The timing is chosen so as to optimize cylinder charging and, therefore, to obtain high power output.

Back-flow of the cylinder charge out of the combustion chamber into the intake port can be prevented by adjusting the inlet valve closing point according to the engine speed.

With variable camshaft timing, the valve overlap can be varied in such a way that the residual exhaust levels in the cylinder can be controlled. Retaining a quantity of residual exhaust in the cylinder lowers the combustion temperature and consequently reduces NO_x emissions.

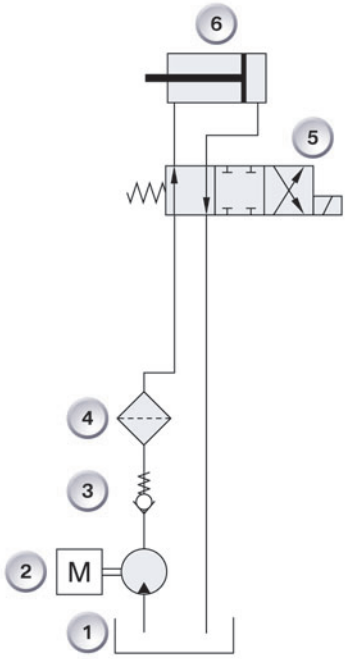
With infinitely variable VANOS, variation of the valve overlap is used to effect internal exhaust recirculation. This involves back-flow of the exhaust from the exhaust port into the inlet port during the overlap phase.

Thus adjustment of inlet camshaft timing at lower and medium engine speeds is used primarily to increase engine torque and to achieve internal exhaust recirculation. At higher engine speeds, power output is the prime objective.

Adjustment of exhaust camshaft timing is used to optimize engine idling smoothness or to achieve maximum exhaust recirculation rates.

The fuel-efficiency gain compared with engines without infinitely variable double VANOS can be as much as 10%.

Fundamental principle of a VANOS hydraulic system



3 - Hydraulic circuit diagram for M50TU and M52 engines

Index	Explanation	Index	Explanation
1	Sump	4	Oil filter
2	Oil pump	5	Solenoid valve
3	Non-return valve	6	VANOS control piston

The existing oil circulation system from the sump (1) via the oil pump (2), through a non-return valve (3) integrated in the oil filter to the oil filter (4) is used and extended by additional channels and components. The oil then passes through a port into a solenoid valve (5) in the form of a 4-port/3-way proportional control valve. The solenoid valve directs the flow of oil so as to apply pressure to either one side of the VANOS control piston (6) or the other.

Depending on the system design, adjustment of the camshaft position is effected either by a VANOS helical gear or a hydraulic oscillating or vane motor. The function of those positioners/actuators is described in more detail in the sections that follow.

Electrical operation

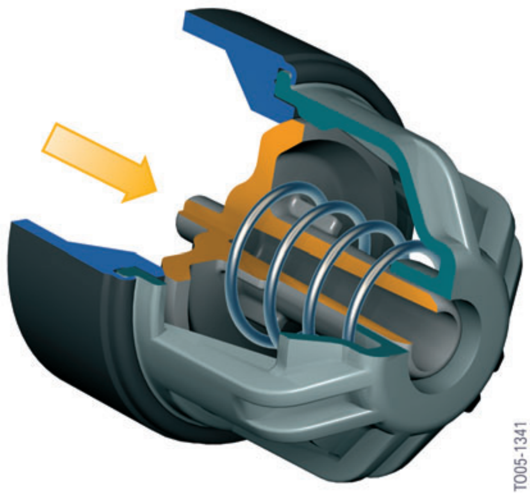
Operation and control of the VANOS components is performed by the digital electronic engine management system (DME). The DME knows the position of the crankshaft from the signals provided by the crankshaft sensor. From the information provided by the camshaft sensors, the relative positions of the camshafts to the crankshaft are identifiable. On that basis, therefore, the DME is able modulate the relative positions of the camshafts to the crankshaft by controlling the relevant solenoid valves.

The DME has stored data maps for the positions of the camshafts relative to the crankshaft. Those data maps essentially take account of the following parameters:

- Engine speed
- Throttle valve position (power demand)
- Coolant temperature

Non-return valve

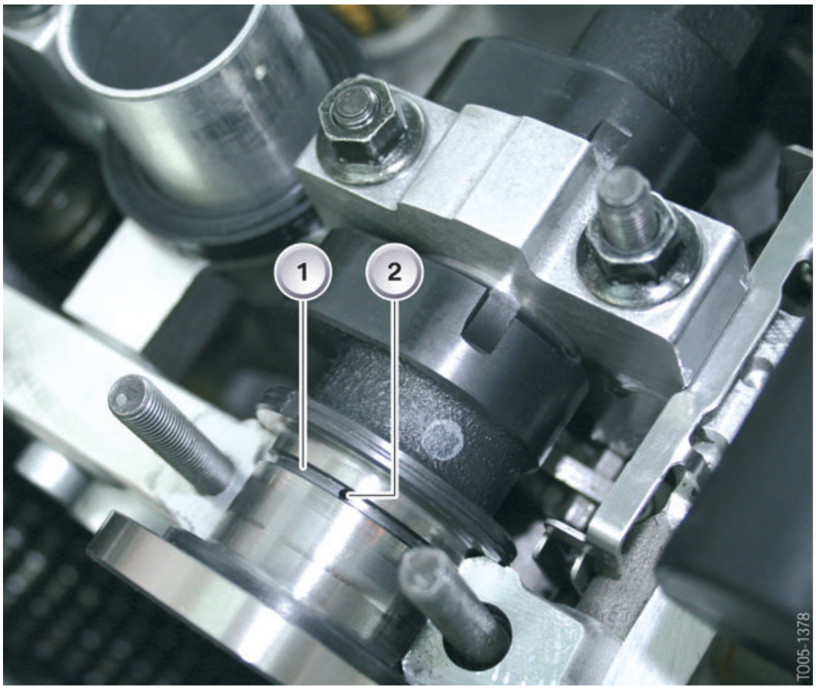
The non-return valve ensures that the oil channels do not empty when the engine is not running. It achieves that by allowing oil to flow in one direction only and blocking it in the other direction.



4 - Non-return valve

Lubrication of VANOS as illustrated by M52 engine

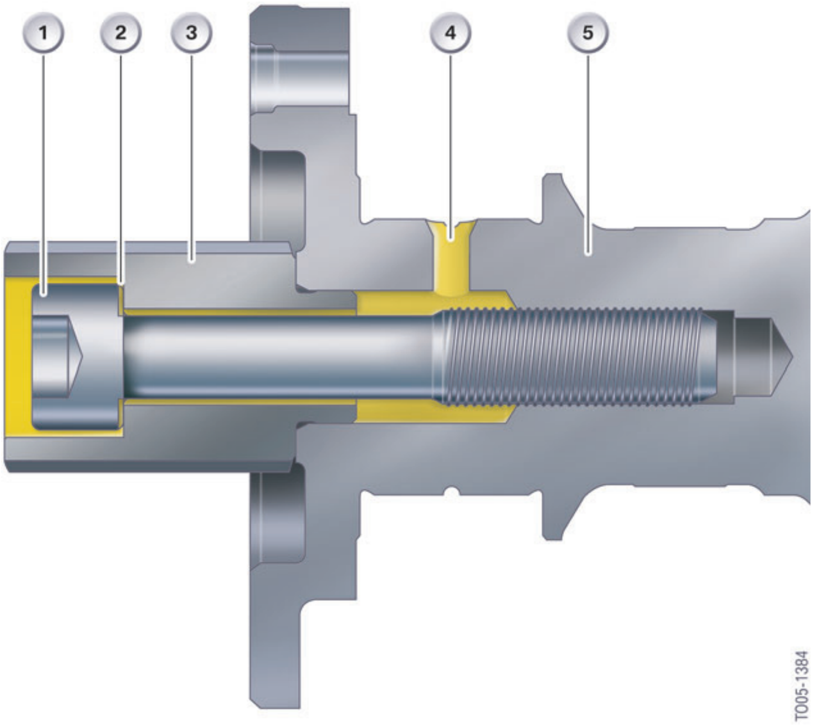
In order that the VANOS gear operates as quietly and with as little wear as possible, it is lubricated by oil from the oil circulation system. The oil passes from the oil supply to the first camshaft via a groove (1) in the camshaft into a bore hole (2) in the camshaft.



5 - Intake camshaft

Index	Explanation	Index	Explanation
1	Groove	2	Bore hole

From the bore hole (4) in the camshaft (5), the oil passes along between the Torx bolt (1) and the splined shaft (3) through two grooves (2) in the contact face of the Torx bolt (1) to the VANOS gear.



6 - Camshaft of M52 engine

Index	Explanation	Index	Explanation
1	Torx bolt	4	Bore hole
2	Groove	5	Camshaft
3	Splined shaft		

The two-setting inlet VANOS system was the first used on a BMW engine As the name implies, the system allowed only two possible settings for the inlet camshaft. The VANOS system produced improved idling, lower exhaust emissions and greater fuel-efficiency. Those benefits were utilized even more effectively by succeeding VANOS generations. Adjustment of the camshaft position was effected by a VANOS gear.

Two-setting inlet VANOS

M50TU engine

The two-setting inlet VANOS system allows the inlet camshaft to be set to either of two positions. Thus there is a choice between an advanced or a retarded setting.

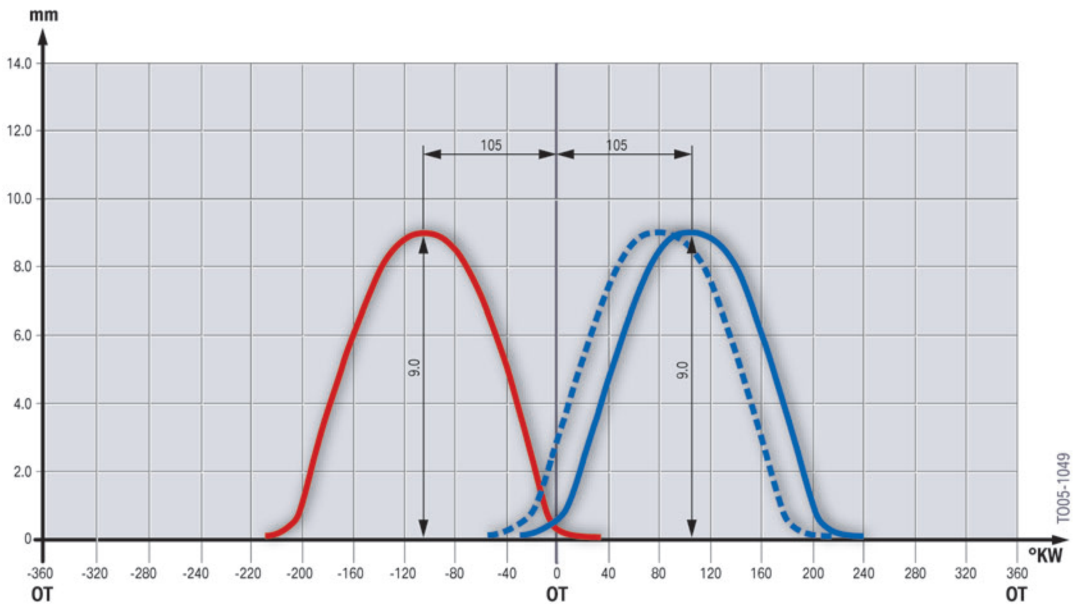
This type of valve timing adjustment was first used on the M50TU engine.

The valve timing graph overleaf shows the valve timing for the M50B20TU engine.

Two different engine management ECUs were used on the M50TU. The M50B20TU used the Siemens MS40.1 control unit while the Bosch ME3.3.1 was fitted to the M50B25TU engine.

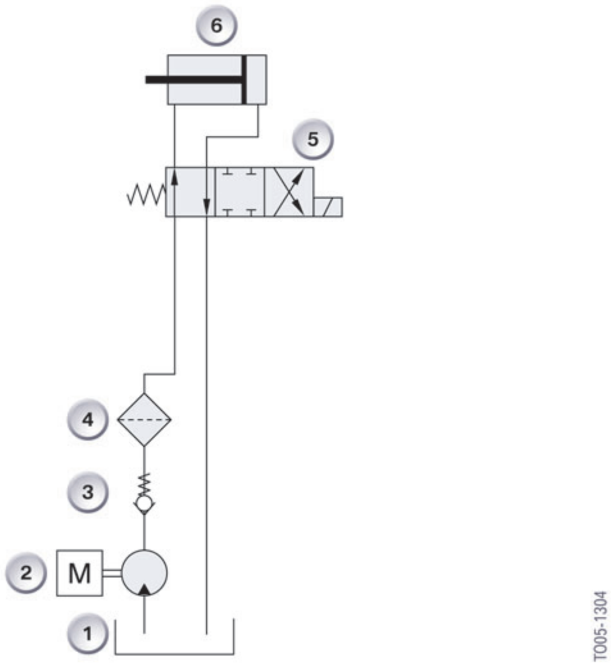
The MS40.1 and the ME3.3.1 have differing functions and technologies. Different types of camshaft sensor are employed. The MS40.1 has a Hall-effect sensor, whereas the ME3.3.1 uses a magnetoresistive angular-position sensor.

The control unit switches from one data map to the other according to the control parameters coolant temperature, engine load and engine speed. At the instant of camshaft adjustment, adjustments are also made to injection timing and ignition timing. As a result, the camshaft timing adjustment is indiscernible to the driver. To prevent repeated VANOS adjustments in rapid succession at the same engine speed (oscillating adjustment), the VANOS is activated (retarded) at a certain engine speed and switched back (advanced) at a different speed, e.g. 100 rpm lower. This prevents the possibility of oscillating adjustment at the same engine speed. This method of control is referred to as hysteresis.



7 - Valve timing graph, M50B20TU engine

Hydraulic circuit diagram



8 - Hydraulic circuit diagram for M50TU and M52 engines

Index	Explanation	Index	Explanation
1	Sump	4	Oil filter
2	Oil pump	5	Solenoid valve
3	Non-return valve	6	VANOS control piston

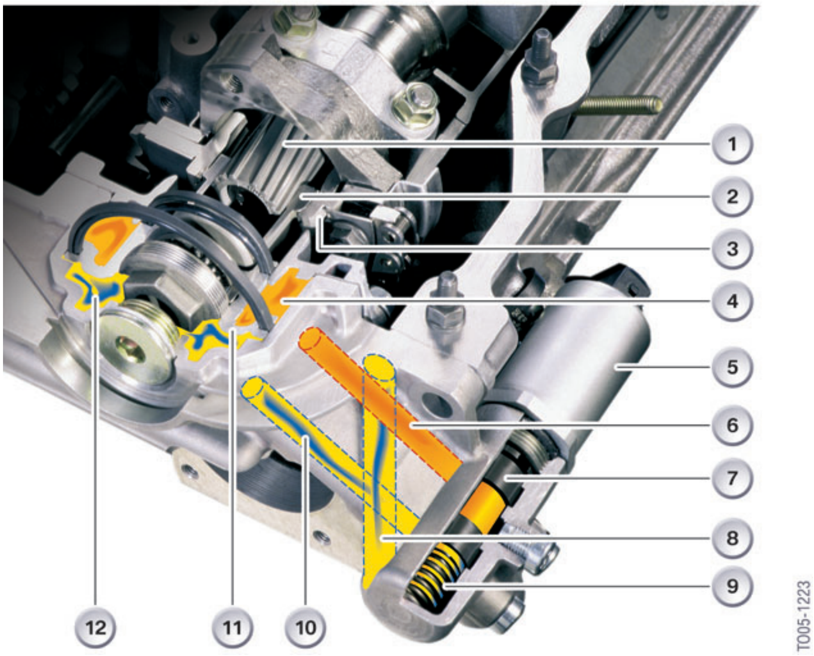
The existing oil circulation system from the sump (1) via the oil pump (2), through a non-return valve (3) integrated in the oil filter to the oil filter (4) is used and extended by additional channels and components. The oil then passes through a port into a solenoid valve (5) which is in the form of a 4-port/3-way proportional control valve. The solenoid valve directs the flow of oil so as to apply pressure to either one side of the VANOS control piston (6) or the other.

The camshaft position is adjusted by a VANOS helical gear.

Design and function

The camshaft is provided with a helical gear (1). The chain sprocket (3) is able to rotate relative to the camshaft and has an internal helical gear.

In engagement with those two helical gears there is a control sleeve (2) with helical gears machined on its inner and outer surfaces. If that control sleeve is moved along its axis, the chain sprocket (3) rotates relative to the camshaft.



9 - VANOS system design

Index	Explanation	Index	Explanation
1	Helical gear	7	Control piston
2	Control sleeve	8	Oil channel
3	Chain sprocket	9	Return spring
4	Pressure chamber for retarding	10	Oil channel
5	Solenoid valve	11	VANOS control piston
6	Oil channel	12	Pressure chamber for advancing

The position of the VANOS control piston (11) is altered by the oil pressure controlled by a solenoid valve (5). The solenoid valve (5) forces a control piston (7) against the action of a return spring (9). Depending on the position of the valve, the pressurized oil is allowed to pass into one or other of the oil channels (6 and 10). The other oil channel in each case (6 or 10) is short-circuited to another oil channel (8) which carries the oil returning from either the pressure chamber for retarding (4) or the pressure chamber for advancing (12) back into the cylinder-head oil chamber. Depending on whether the pressure chamber for retarding (4) or the pressure chamber for advancing (12) is pressurized, the VANOS retards or advances the camshaft setting.

A non-return valve (see hydraulic circuit diagram) prevents the VANOS system or the oil channels emptying.

The speed of adjustment depends on the engine oil pressure, the engine oil temperature and the engine speed.

⚠ The following faults are diagnosed by the MS40.1:

- Position feedback from inlet camshaft
- Output-stage fault
- Short circuit to positive or negative
- Circuit break ◄

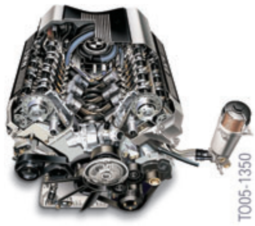
Infinitely variable inlet VANOS

M62TU engine

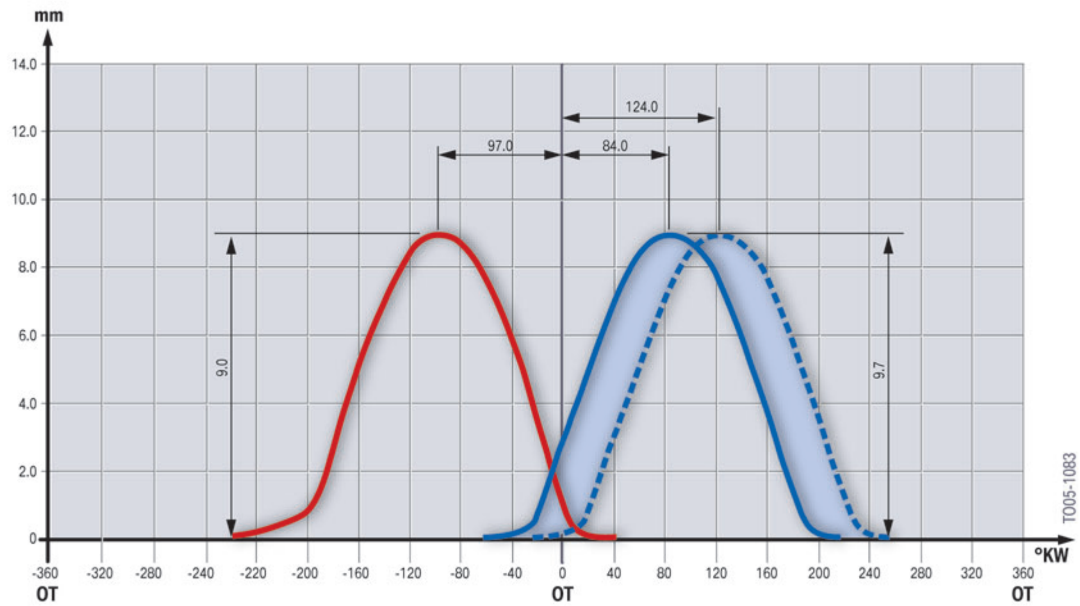
Infinitely variable inlet VANOS was a refinement of the two-setting inlet VANOS system. It was first introduced on the M62TU engine. It was the first VANOS system which allowed fully variable inlet valve timing.

The system allows for infinite variation of timing according to the control commands from the engine management ECU.

On the graph overleaf, the adjustment range of the infinitely variable inlet VANOS is clearly identifiable by area shaded in blue.

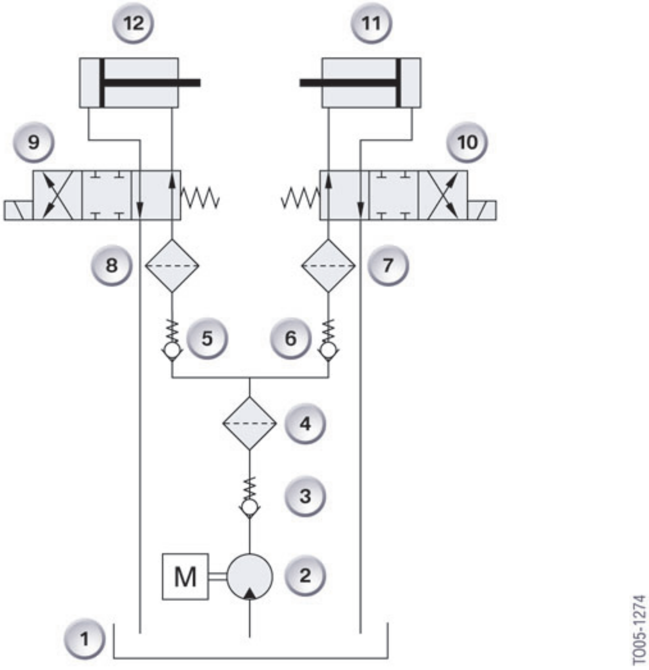


The arrival of infinitely variable inlet VANOS took the VANOS system a further step forward in terms of the degree of variability of inlet camshaft timing. Engine smoothness was further improved and the exhaust emissions brought well below the limits in force at the time. The system was easier to fit as a compact VANOS gear was introduced for the first time. The new VANOS gear could not be dismantled.



10 - Valve timing graph, M62TU engine

Hydraulic circuit diagram



11 - Hydraulic circuit diagram, M62TU engine

Index	Explanation	Index	Explanation
1	Sump	7	Filter
2	Oil pump	8	Filter
3	Non-return valve	9	Solenoid valve
4	Oil filter	10	Solenoid valve
5	Non-return valve	11	VANOS control piston
6	Non-return valve	12	VANOS control piston

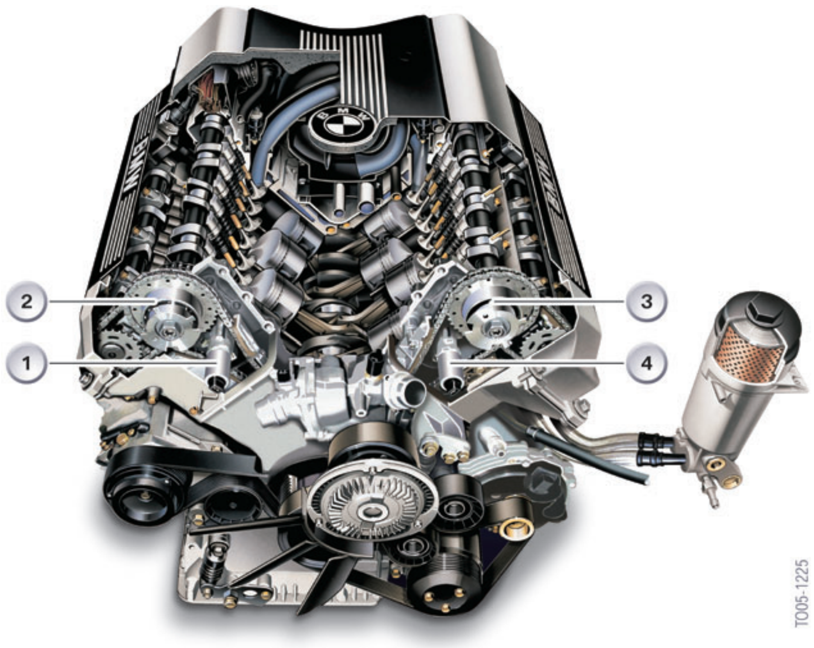
The oil circulation for the VANOS system passes from the sump (1) via the oil pump (2), through a non-return valve (3) integrated in the oil filter to the oil filter (4). It then passes separately in each cylinder head through a non-return valve (6), a fine filter (7) integrated in the solenoid valve, and into the solenoid valve (10). The solenoid valves take the form of 4-port/3-way proportional control valves. The solenoid valves direct the flow of oil so as to apply pressure to either one side or other of the relevant VANOS control piston (11 or 12).

The camshaft position is adjusted by a VANOS helical gear.

Design and function

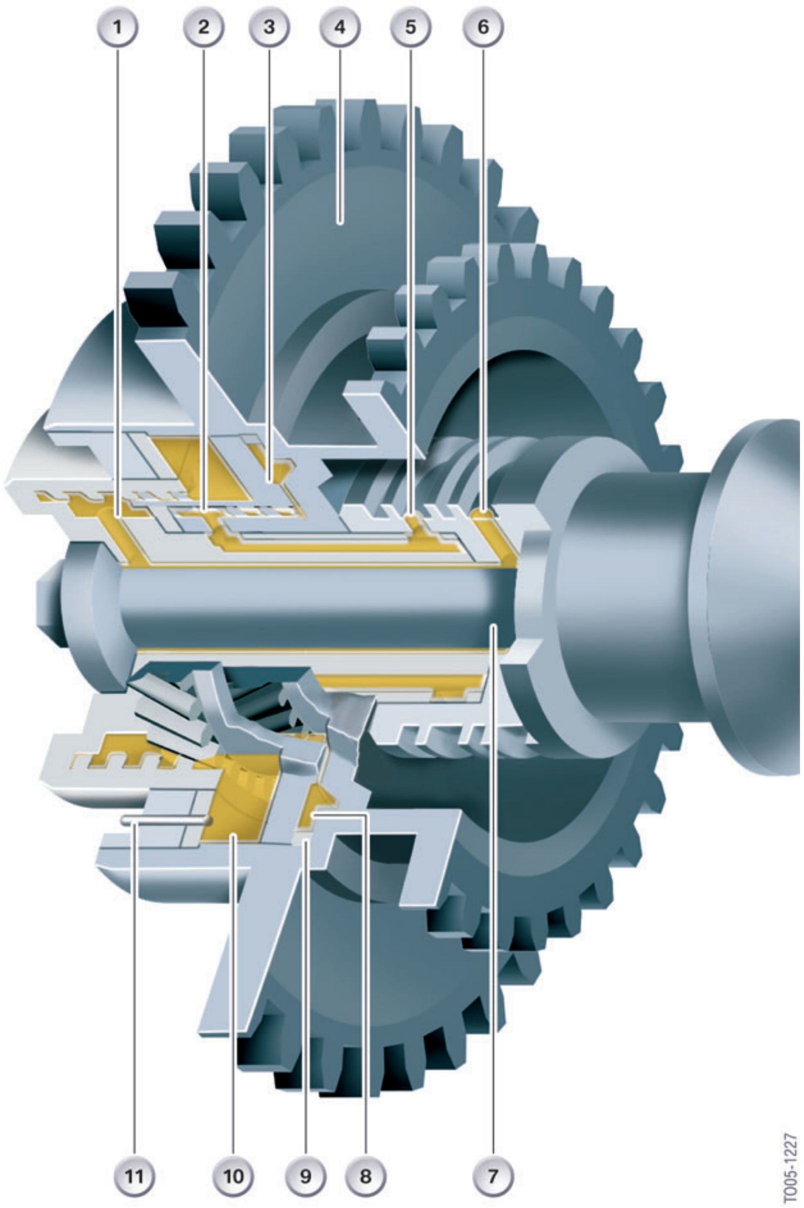
The VANOS unit was a new design in comparison with the two-setting inlet VANOS system. It became a self-contained unit screwed onto the camshaft. The VANOS unit consists of the VANOS gear and the two chain sprockets.

Once the optimum camshaft position for a particular set of conditions is obtained, the solenoid valves hold the oil volume in both chambers of the positioner constant so that the camshafts remain in the positions concerned.



12 - M62TU engine

Index	Explanation	Index	Explanation
1	Solenoid valve, cylinders 1-4	3	VANOS unit with sensor wheel, cylinders 5-8
2	VANOS unit with sensor wheel, cylinders 1-4	4	Solenoid valve, cylinders 5-8



13 - VANOS unit

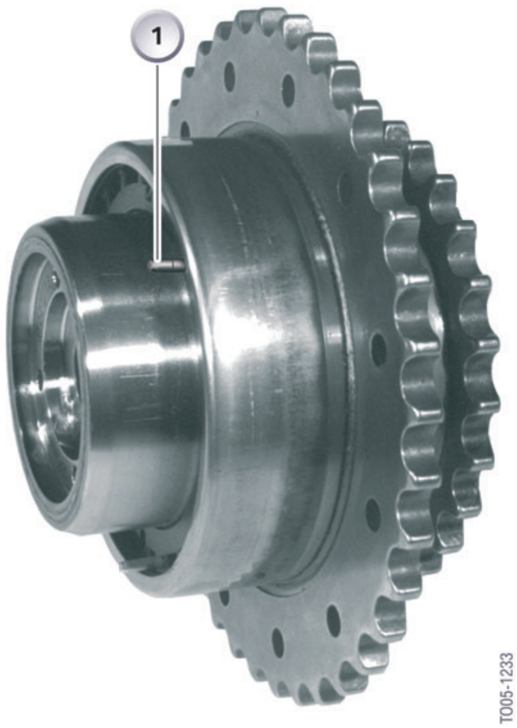
Index	Explanation	Index	Explanation
1	Oil channel	7	Mounting bolt
2	Piston helix collar	8	Pressure chamber for retarding
3	Piston	9	Stop ring
4	Chain sprocket and casing	10	Pressure chamber for advancing
5	Oil channel	11	Contact pin (x 3)
6	Oil channel		

In order that the adjustment limit of the VANOS unit can be detected, the unit is fitted with three contact pins. At the limit of camshaft adjustment (maximum retardation) those contact pins are in contact with the positioner piston. Using an ohmmeter, that position can be reliably detected (resistance measurement across pin and engine earth).

A non-return valve fitted upstream of the solenoid valve ensures that the oil channels of the VANOS system do not empty. That prevents the VANOS unit generating noises when the engine is started.

⚠ The central mounting bolt that fixes the VANOS unit to the camshaft has a left-hand thread.

In emergency mode, the solenoid valves are de-energized. The inlet camshafts are then in the retarded position. ◄



14 - VANOS unit

Index	Explanation
1	Contact pin (x 3)

The advent of infinitely variable double VANOS marked the arrival of variable inlet and exhaust camshaft timing, the system version in use today. The advantages such as higher torque, improved idling characteristics, lower exhaust emissions and greater fuel-efficiency were further enhanced.

Infinitely variable double VANOS

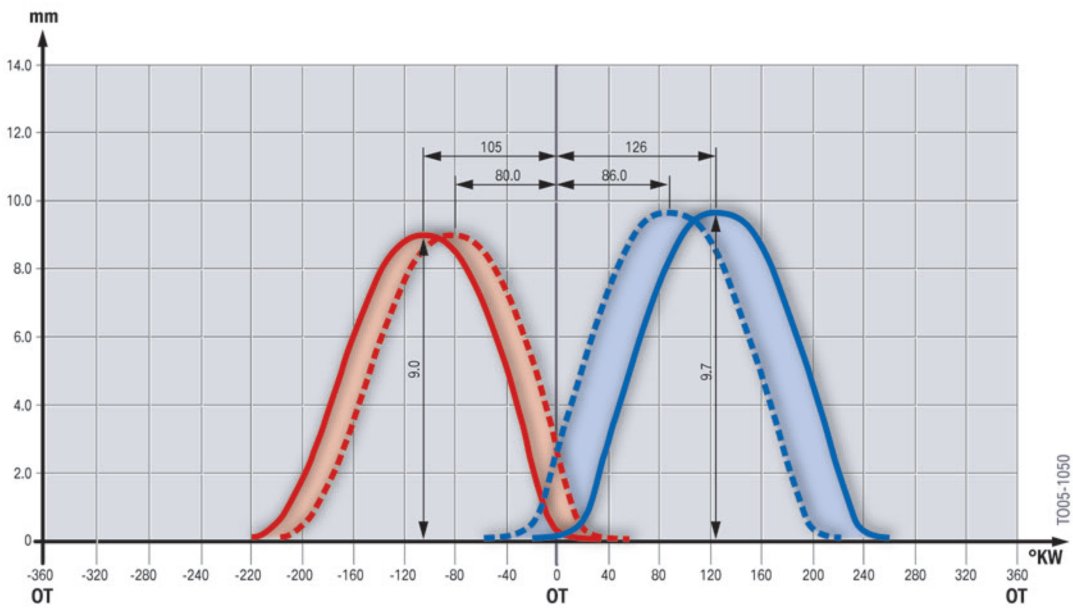
M52TU engine

Infinitely variable double VANOS was first introduced on the M52B20TU engine. The design is similar to that of two-setting inlet VANOS. The new feature is that in addition to the timing of the inlet camshaft, the timing of the exhaust camshaft can also be varied. The system allows for infinite variation of timing of both camshafts according to the control commands from the engine management ECU.

The advantages of infinitely variable double VANOS are:

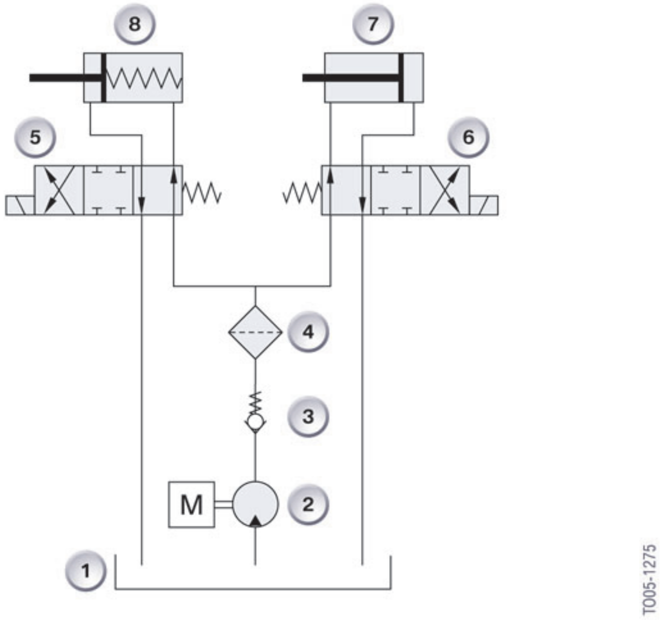
- Higher torque at low and medium engine speeds
- Smaller quantity of residual exhaust when idling due to smaller valve overlap resulting in improved idling
- Internal exhaust recirculation in the medium power band in order to reduce nitrogen oxide emissions
- Faster warm-up of catalytic converters and lower raw emission levels after a cold start
- Reduction of fuel consumption

The possible adjustment range of the double VANOS system is clearly identifiable by the blue/red shaded areas.



15 - Valve timing graph, M52B28TU engine

Hydraulic circuit diagram



16 - Hydraulic circuit diagram, M52TU and M54

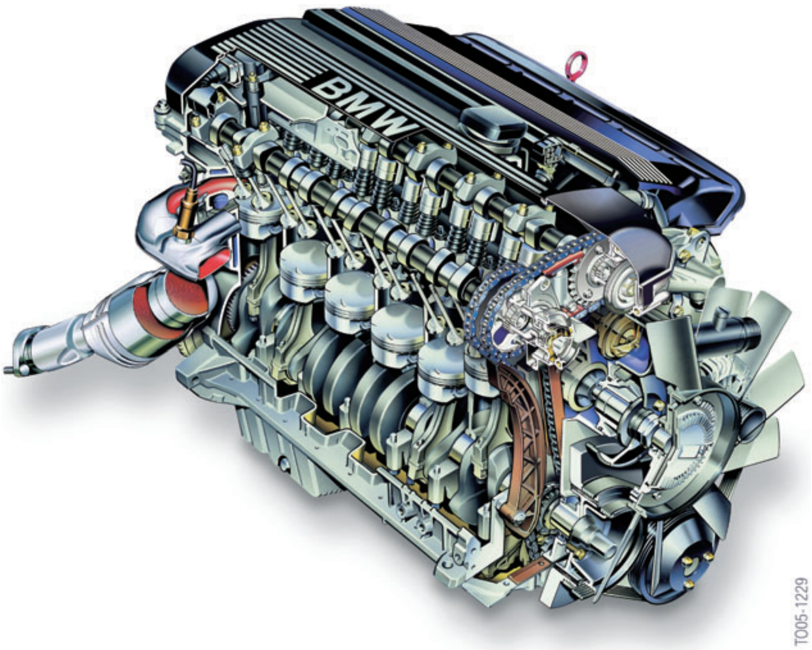
Index	Explanation	Index	Explanation
1	Sump	5	Solenoid valve
2	Oil pump	6	Solenoid valve
3	Non-return valve	7	VANOS control piston
4	Oil filter	8	VANOS control piston

The oil circulation for the VANOS system passes from the sump (1) via the oil pump (2), through a non-return valve (3) integrated in the oil filter to the oil filter (4). It then passes separately for each camshaft into a solenoid valve (6). The solenoid valves direct the flow of oil so as to apply pressure to either one side or other of the relevant VANOS control piston (7 or 8).

One of the VANOS control pistons (8) is spring loaded and thus when unpressurized is held in the retarded position when the engine is started. That VANOS control piston (8) is the one for the exhaust camshaft.

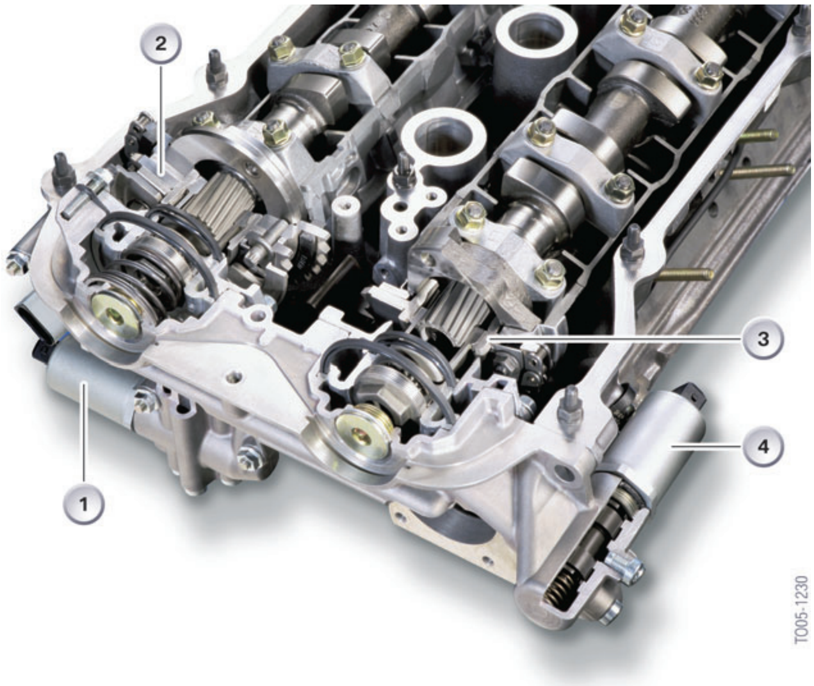
The camshaft position is adjusted by a VANOS helical gear.

Design and function



17 - M52TU engine

The VANOS units for the inlet and exhaust camshafts are very similar in design. The solenoid valve (1) for adjusting the timing of the exhaust camshaft is mounted on the exhaust side of the cylinder head (see illustration overleaf).



18 - VANOS units

Index	Explanation	Index	Explanation
1	Solenoid valve	3	VANOS unit
2	VANOS unit	4	Solenoid valve

When the engine is started, the inlet camshaft is in the fully retarded position. The exhaust camshaft is held in the advanced position because the solenoid valve is spring loaded. While the solenoid valves are de-energized, the camshafts are held at their limit positions by the oil pressure.

Approx. 50 revolutions or 2-5 seconds after the engine starts, the engine management ECU detects the current positions of the camshafts by means of the camshaft sensors.

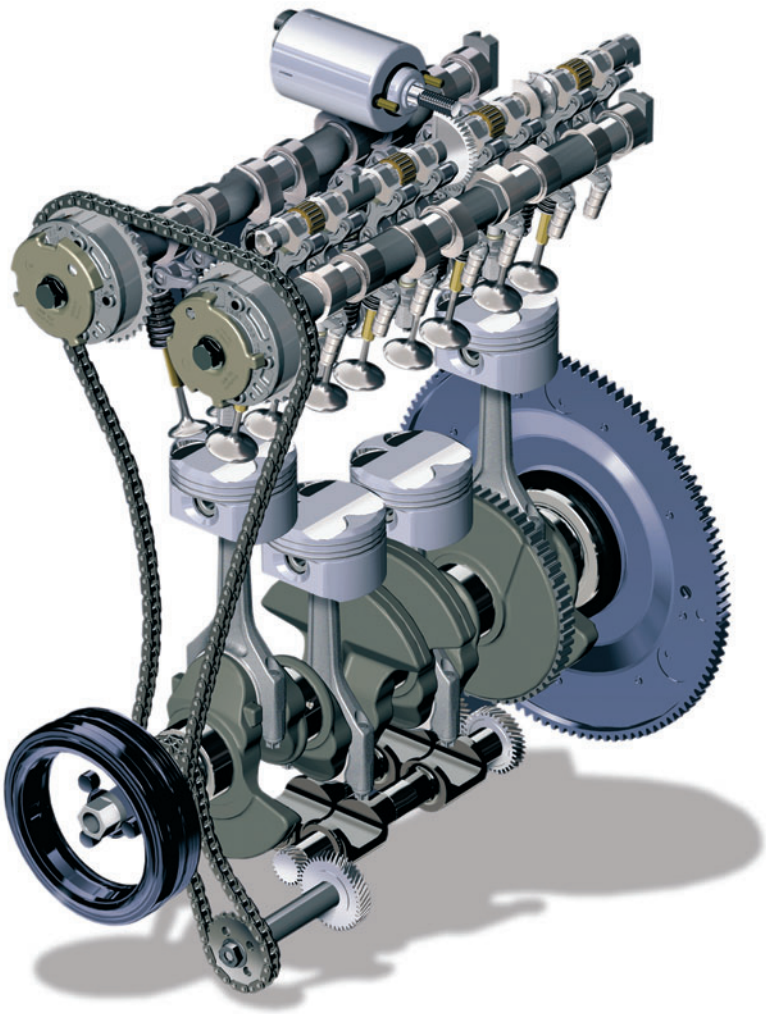
From the engine speed signal (crankshaft sensor) and the load signal, the required position of the inlet and exhaust camshafts is determined and set taking account of the temperature of the intake air and the engine coolant.

⚠ In emergency mode, the solenoid valves are de-energized. The inlet camshaft is then in the retarded position and the exhaust camshaft in the advanced position. ◄

N42/N52 engine

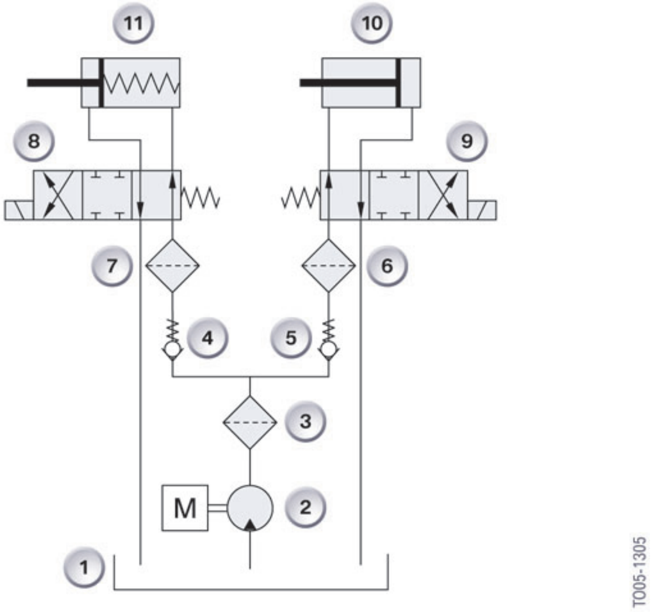
The N42 engine brought with it the introduction of a new, compact, infinitely variable vane-type VANOS unit. This VANOS unit is distinguished by straightforward fitting and removal characteristics.

It is designed as an integral component of the camshaft chain drive system and is secured to the relevant camshaft by a central bolt.



19 - Camshaft chain drive system of N42 engine

Hydraulic circuit diagram



20 - Hydraulic circuit diagram, N40, N42, N45 and N46 engines

Index	Explanation	Index	Explanation
1	Sump	7	Filter
2	Oil pump	8	Solenoid valve
3	Oil filter	9	Solenoid valve
4	Non-return valve	10	Hydraulic vane motor
5	Non-return valve	11	Hydraulic vane motor
6	Filter		

The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there separately for the inlet and exhaust camshafts through a non-return valve (5) fitted between the cylinder head and the crankcase, into a fine filter (6) on the solenoid valve, and into the solenoid valve (9). The solenoid valves direct the flow of oil so as to apply pressure to either one side or other of the pressure chamber in relevant hydraulic vane motor (10 or 11).

The position of the inlet and exhaust camshafts is adjusted by a hydraulic vane motor on each camshaft.

The two seals between camshaft and camshaft bearing are required to ensure a reliable supply of oil.

The solenoid valves are attached to the cylinder head by mounting brackets.

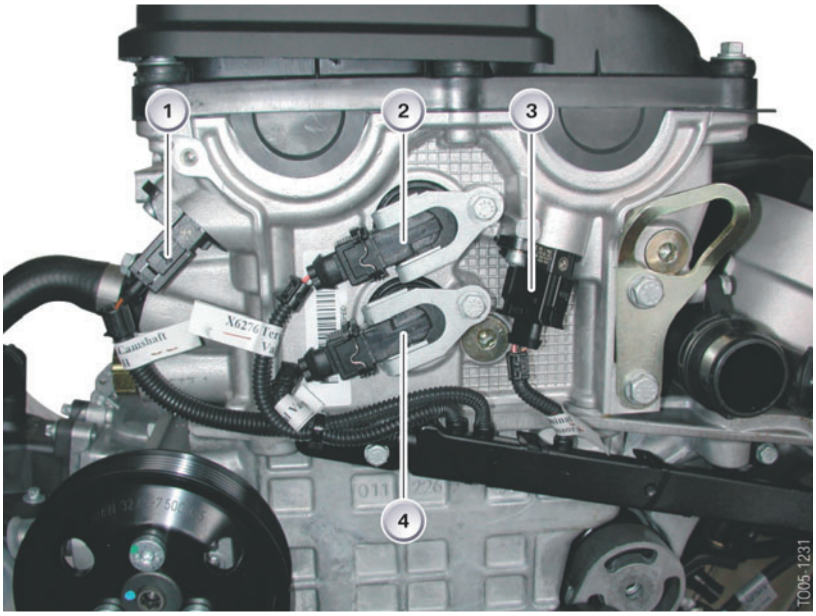
⚠ The mounting brackets must not be bent; observe repair instructions. ◄

The adjustment time for 60 ° of crankshaft rotation is approx. 300 ms.

That figure is true of all VANOS systems with hydraulic vane motor or oscillating motor.

Design and function

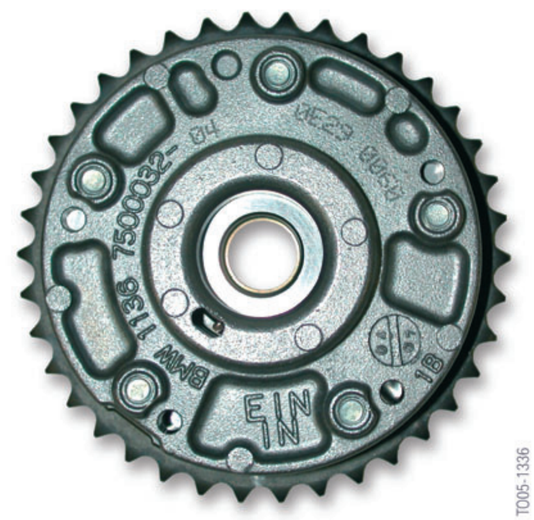
The illustration below shows the fitted locations of the solenoid valves and the camshaft sensors on the N42 engine.



21 - Locations of solenoid valves and camshaft sensors

Index	Explanation	Index	Explanation
1	Exhaust camshaft sensor	3	Solenoid valve
2	Solenoid valve	4	Inlet camshaft sensor

The illustration below shows a hydraulic vane motor/VANOS unit viewed end-on.

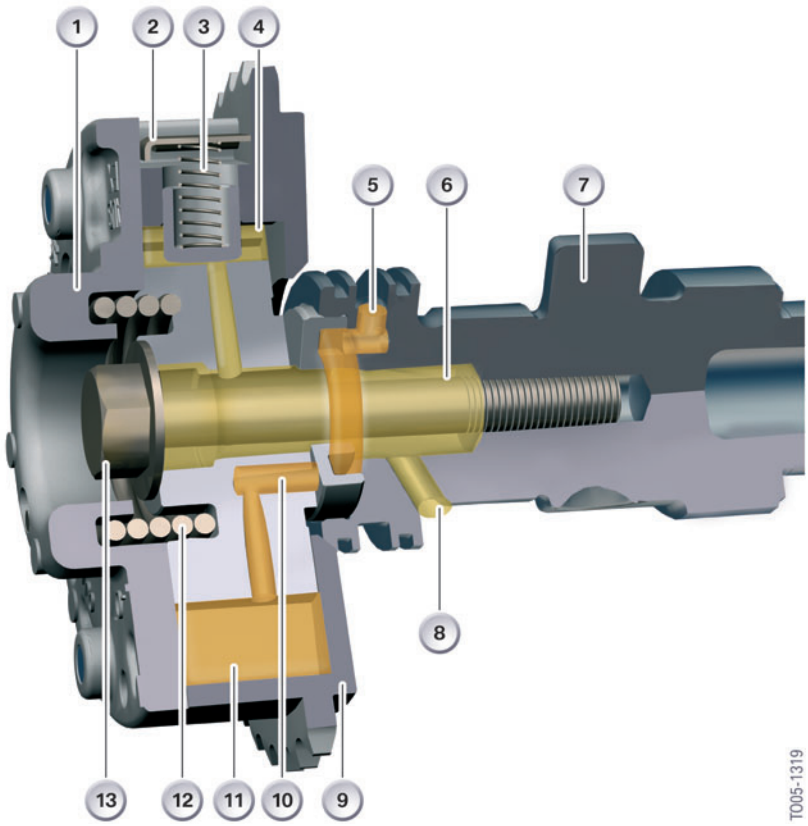


22 - VANOS unit

⚠ The identification "EIN IN" can clearly be seen stamped on the end face. The VANOS units for the inlet and exhaust camshafts are different and thus distinguished by such identification marks. The VANOS unit for the exhaust (outlet) camshaft bears the identification mark "AUS OUT".

A number of variations of that VANOS unit are used on different engines. Since those VANOS units are virtually indistinguishable visually, it is essential to check the part number.

Fitting the wrong unit can result in terminal engine damage ◄



23 - Hydraulic vane motor/ VANOS unit

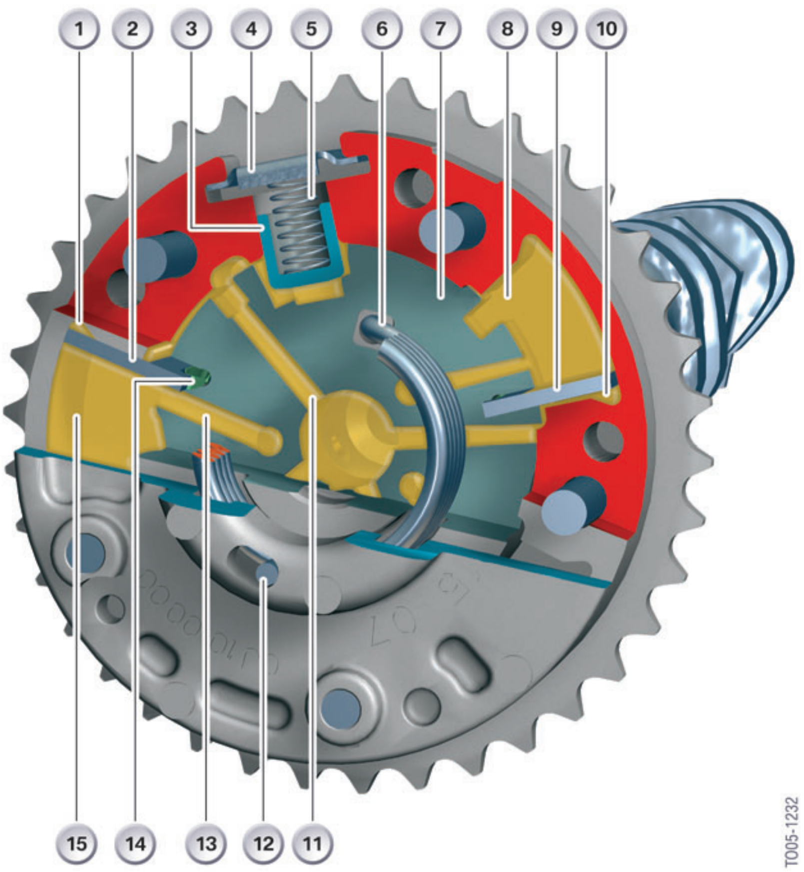
Index	Explanation	Index	Explanation
1	Front plate	8	Oil channel
2	Retaining plate	9	Casing with ring gear
3	Lock spring	10	Oil channel
4	Pressure chamber for advancing	11	Pressure chamber for retarding
5	Oil channel	12	Torsion spring
6	Oil channel	13	Mounting bolt
7	Camshaft		

A fundamental advantage of the vane motor is that it enables very simple adjustment of camshaft timing. The adjustment of camshaft timing is comparable with engines without VANOS.

This is made possible by the use of a locking pin (item 3 in the diagram overleaf) in the VANOS unit. That pin engages as soon as the VANOS unit is depressurized and forced into the locking position by the torsion spring (12).

The oil passes from the relevant solenoid valve through the cylinder head and the oil channel (5 or 8) in the camshaft into the VANOS unit.

There are special oil seals between the camshaft and the cylinder head which seal off the oil channels from one another and from the camshaft case.



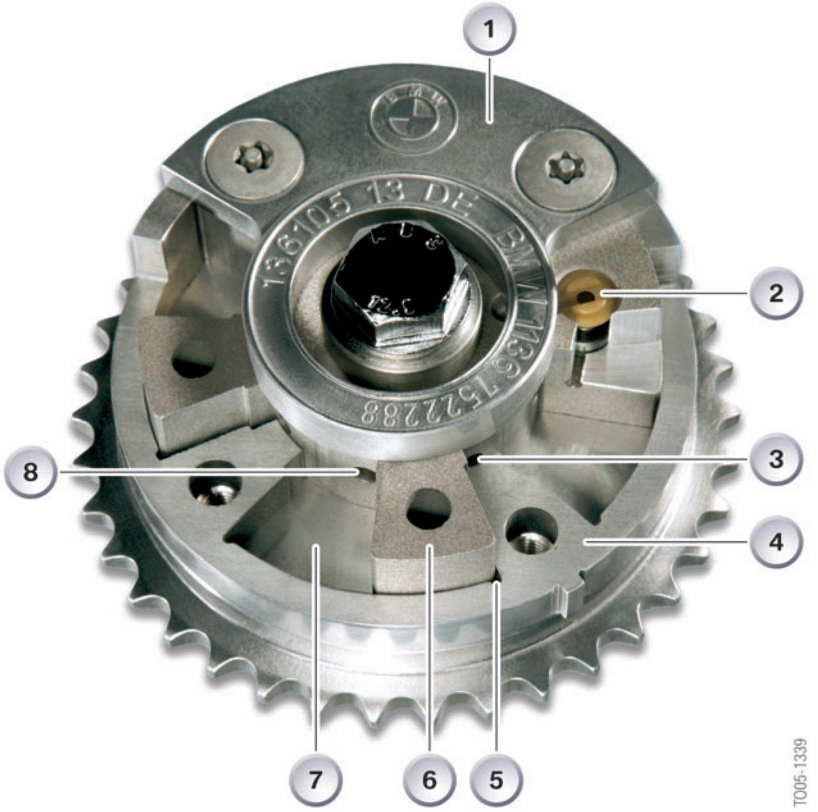
24 - Hydraulic vane motor/ VANOS unit

Index	Explanation	Index	Explanation
1	Pressure chamber for advancing	9	Vane
2	Vane	10	Pressure chamber for advancing
3	Locking pin	11	Oil channel
4	Retaining plate	12	Spring hook
5	Lock spring	13	Oil channel
6	Spring hook	14	Spring
7	Rotor	15	Pressure chamber for retarding
8	Pressure chamber for retarding		

To adjust the VANOS unit from its resting position, oil is forced through the oil channel (11) into the pressure chamber for advancing (1 and 10). The oil pressure forces the locking pin (3) outwards against the force of the lock spring (5). This releases the rotor (7) from the casing and integral ring gear so that the relative position of the rotor can be shifted by the oil pressure. The oil from the pressure chamber for retarding (8 and 15) passes through the oil channels (13), the camshaft and the solenoid valve into the cylinder-head camshaft case.

The oil is fed into the camshaft case because the oil channel is at the highest point of the VANOS oil system and the VANOS oil channels cannot empty.

Special features of N52 engine



25 - Hydraulic oscillating motor/VANOS unit

Index	Explanation	Index	Explanation
1	Front plate	5	Pressure chamber for advancing
2	Locking pin	6	Oscillating rotor
3	Oil channel	7	Pressure chamber for retarding
4	Casing with ring gear	8	Oil channel

As can be seen from the above illustration, the VANOS unit on the N52 engine is different from the one used on the N42 engine. The function is identical but some components have been omitted and the VANOS unit has been optimized.

The individual vanes of the N42 VANOS unit are replaced on the N52 VANOS unit by an oscillating rotor. The torsion spring integrated in the N42 VANOS unit becomes a coil spring accommodated on the rear of the N52 VANOS unit protected by a plastic cover.

⚠ The VANOS units for the inlet and exhaust camshafts have different adjustment ranges. Consequently, they must not be mixed up as engine damage due to the pistons striking the valves is likely to result. Therefore, the front plates of the VANOS units have the respective identifying marks "AUS/EX" and "EIN/IN" engraved on them. ◄

26 - Rear view of VANOS unit with cover removed

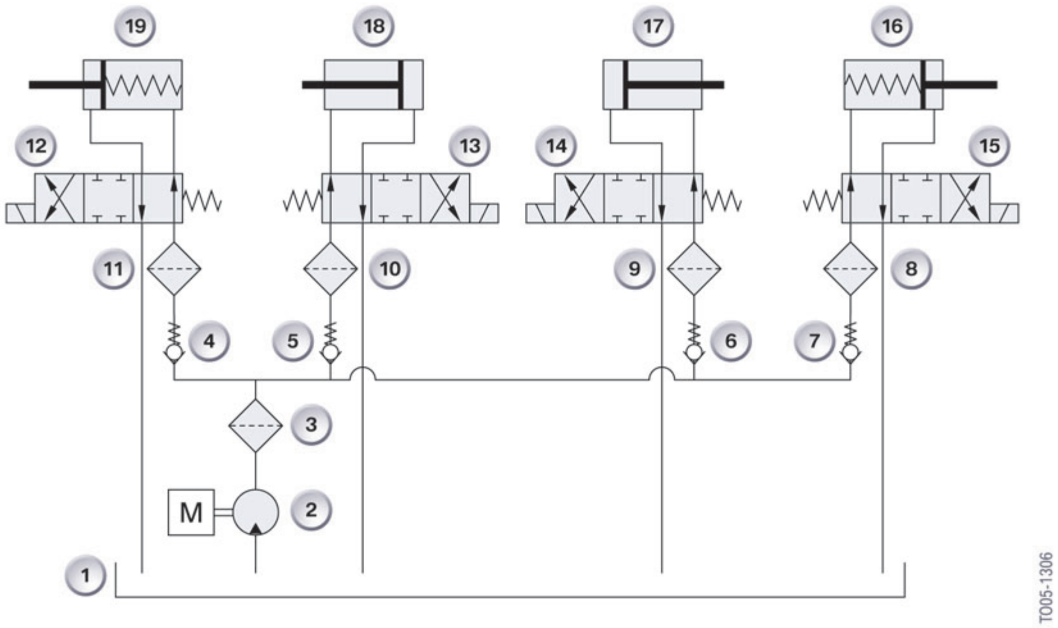
27 - Front view of VANOS unit for exhaust camshaft

N62/N73 engine

The N62 and N73 engines are also fitted with a vane motor-type VANOS unit. The design and function are identical with the unit used on the N42 engine.

To reduce wear, a spring plate is fitted between the VANOS unit and the vacuum pump drive.

Hydraulic circuit diagram



28 - Hydraulic circuit diagram, N62, N62TU and N73 engines

Index	Explanation	Index	Explanation
1	Sump	11	Filter
2	Oil pump	12	Solenoid valve
3	Oil filter	13	Solenoid valve
4	Non-return valve	14	Solenoid valve
5	Non-return valve	15	Solenoid valve
6	Non-return valve	16	Hydraulic vane motor
7	Non-return valve	17	Hydraulic vane motor
8	Filter	18	Hydraulic vane motor
9	Filter	19	Hydraulic vane motor
10	Filter		

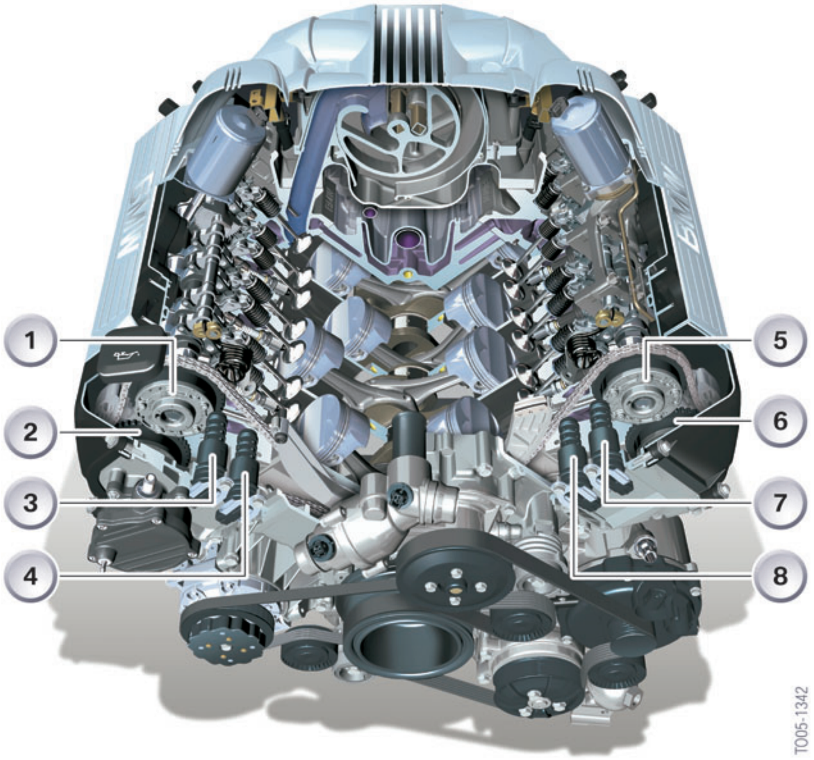
The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there separately for each cylinder head and for the inlet and exhaust camshafts through a non-return valve (6) screwed into the cylinder head, through a filter (9) on the solenoid valve, and into the solenoid valve (14).

The solenoid valves direct the flow of oil so as to apply pressure to either one side or other of the pressure chamber in relevant hydraulic vane motor (16/17/18/19/).

The position of the inlet and exhaust camshafts is adjusted by a hydraulic vane motor on each camshaft.

Design and function

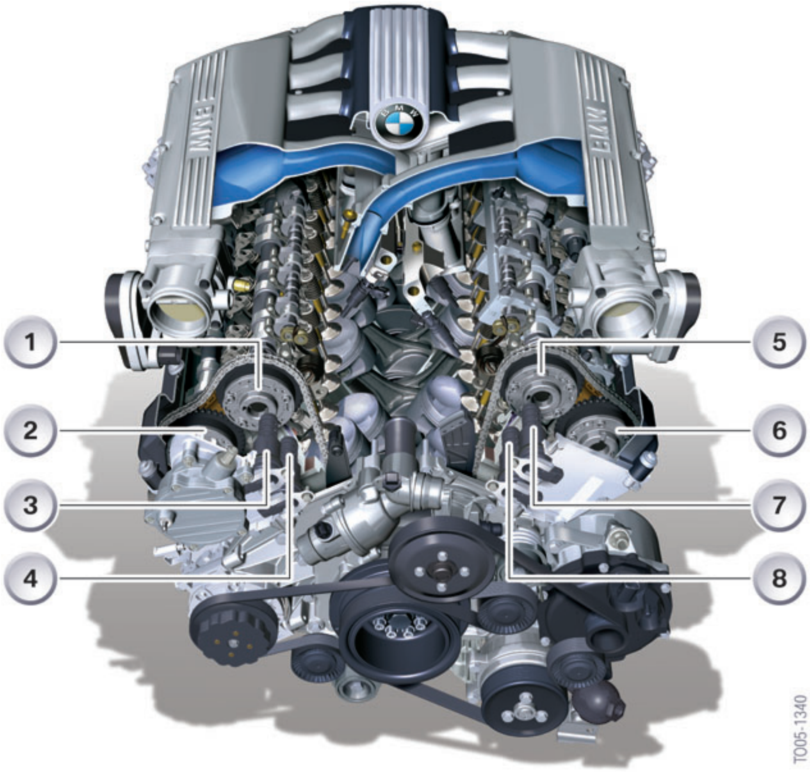
The design and function of the VANOS unit on the N62 engine is identical with the design and function of the VANOS unit on the N62TU and N73 engines.



29 - N62 Engine

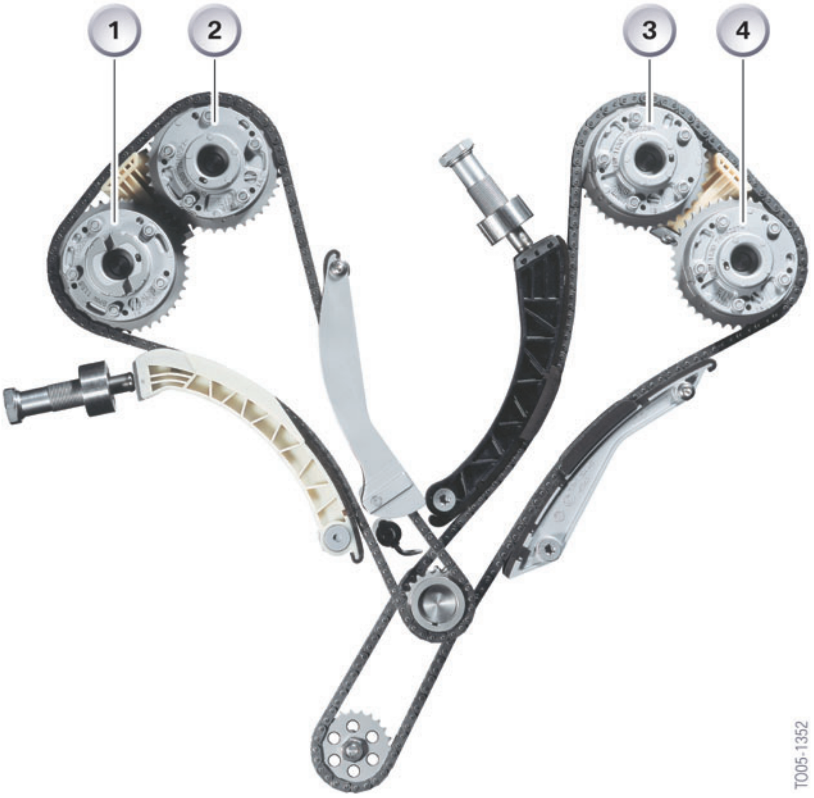
Index	Explanation	Index	Explanation
1	Hydraulic vane motor	5	Hydraulic vane motor
2	Hydraulic vane motor	6	Hydraulic vane motor
3	Solenoid valve	7	Solenoid valve
4	Solenoid valve	8	Solenoid valve

The timing chains on the N62 engine are silent chains.



30 - N73 Engine

Index	Explanation	Index	Explanation
1	Hydraulic vane motor	5	Hydraulic vane motor
2	Hydraulic vane motor	6	Hydraulic vane motor
3	Solenoid valve	7	Solenoid valve
4	Solenoid valve	8	Solenoid valve



31 - Timing chains, N73 engine

Index	Explanation	Index	Explanation
1	VANOS unit for exhaust camshaft, cylinder bank 1	3	VANOS unit for inlet camshaft, cylinder bank 2
2	VANOS unit for inlet camshaft, cylinder bank 1	4	VANOS unit for exhaust camshaft, cylinder bank 2

The VANOS unit for the inlet camshaft on cylinder bank 1 (1) is provided with a socket for driving the vacuum pump.

The timing chain drive system on the N73 engine is very similar to that on the N62 engine.

Around the time that two-setting inlet VANOS was introduced, the M engines were being fitted with infinitely variable high-pressure inlet VANOS. The advantage of high-pressure actuation is the extremely rapid adjustment time. That means that better and more precise control is possible compared to standard VANOS. With infinitely variable high-pressure inlet VANOS, the speed limiting function is performed by the VANOS system.

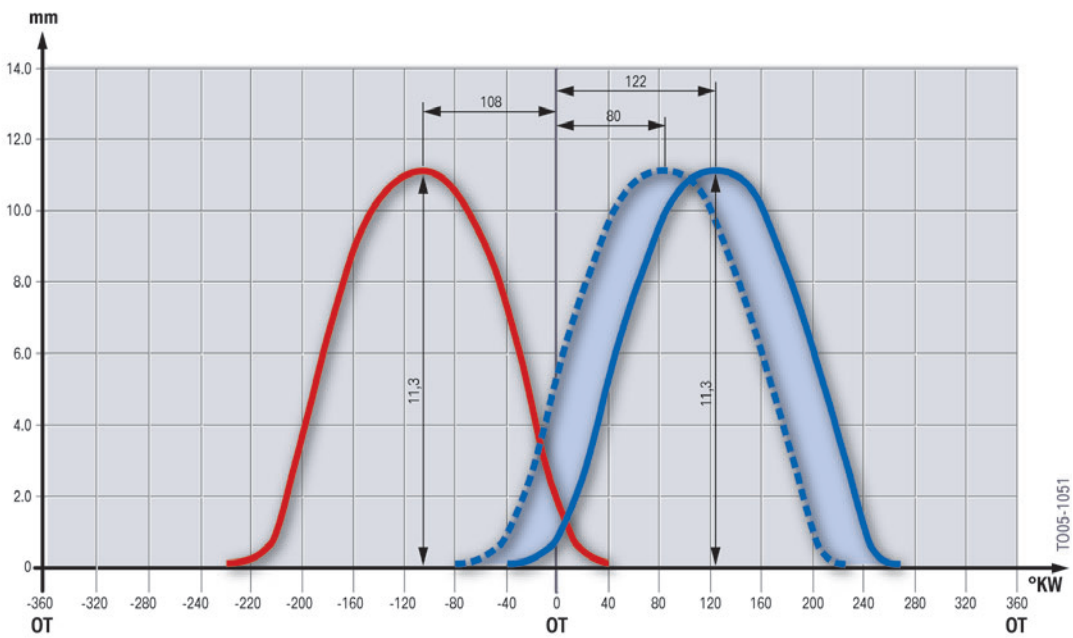
Infinitely variable high-pressure inlet VANOS

As illustrated by the S50B30 engine

With the introduction of the E63 M3 came a new generation of VANOS systems. The special feature of that new VANOS generation is that the application of the settings calculated by the engine management ECU takes place extremely rapidly. An important contributor to that speed of VANOS adjustment is the higher oil pressure of 100 bar. In addition, the vibrations in the intake manifold are utilized to achieve improved cylinder charging. The speed limiting function is also performed by the VANOS system.

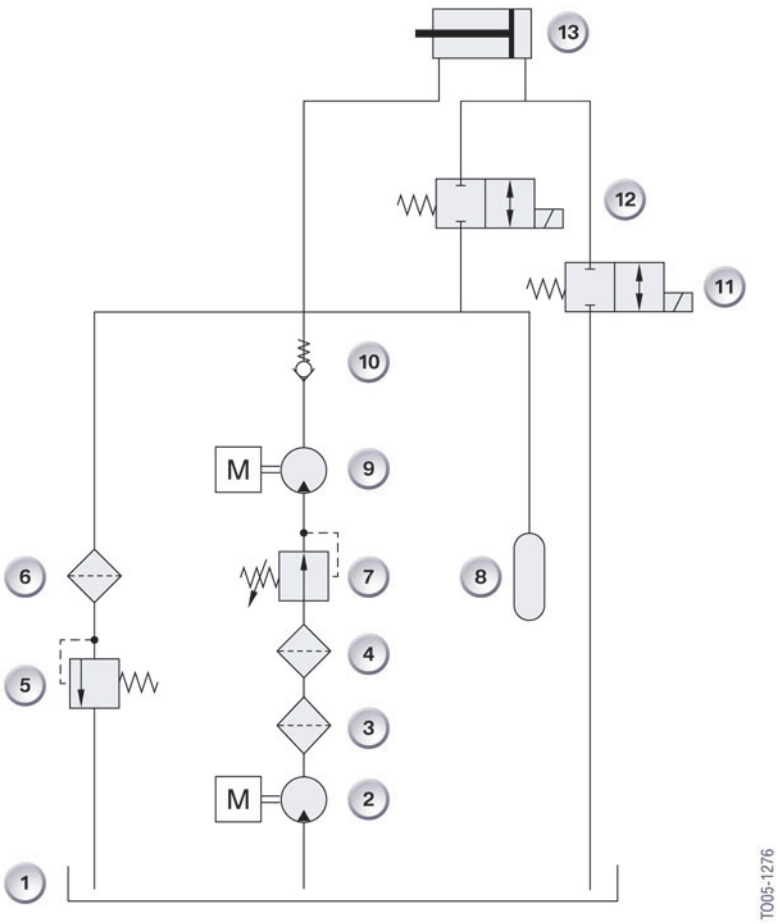
With a standard VANOS unit, the rate of adjustment is approx. 200 ° of crankshaft rotation per second. With the high-pressure VANOS system, that rate is around 1000 ° per second at an engine oil temperature of between 20 °C and 80 °C.

The graph shows the adjustment range of inlet VANOS. It is very similar to the graph for infinitely adjustable inlet VANOS as the advantage of the faster response time cannot be represented on this graph.



32 - Valve timing graph, S50B30 engine

Hydraulic circuit diagram



33 - Hydraulic circuit diagram, S50B30 engine

Index	Explanation	Index	Explanation
1	Sump	8	Pressure accumulator
2	Oil pump	9	High-pressure pump
3	Oil filter	10	Non-return valve
4	Filter	11	Solenoid valve
5	Pressure limiting valve	12	Solenoid valve
6	Filter	13	VANOS control piston
7	Infeed valve		

The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there through a filter (4) integrated in the infeed valve (7), to the high-pressure pump (9) and through the non-return valve (10).

Now at a pressure of approx. 100 bar, the oil passes into the pressure accumulator (8). Any surplus oil delivered passes through a filter (6) into a pressure limiting valve (5) which limits the oil pressure to approx. 100 bar and diverts the surplus oil back to the sump. The oil delivered by the high-pressure pump continues to the VANOS control piston (13) in the VANOS gear, as well as to two solenoid valves (12 and 11).

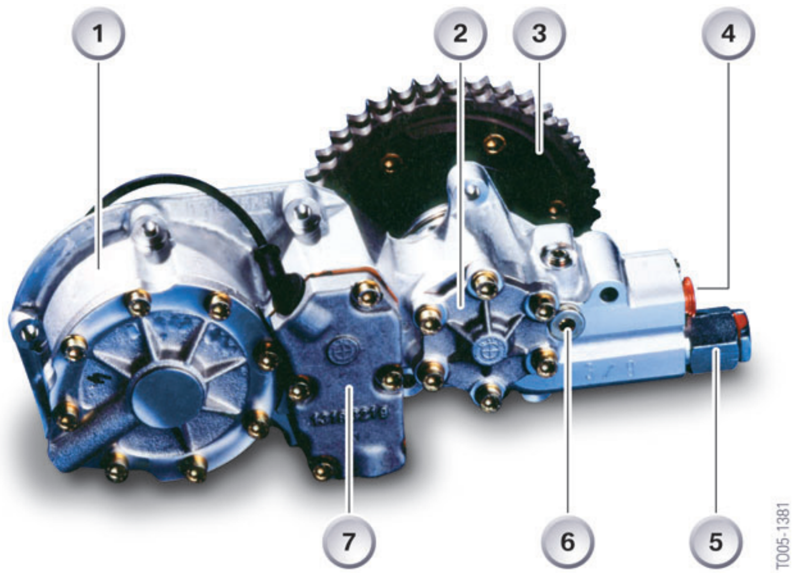
The VANOS control piston (13) moves out as soon as the first solenoid valve (12) is operated and connects the oil pressure of 100 bar through to the other side of the VANOS control piston (13).

Since, in that situation, the same oil pressure is applied to both sides of the VANOS control piston (13), the piston only moves because of the difference in surface area between the two sides. The oil from the smaller piston chamber is returned to the high-pressure circuit. A particular piston position is held by closing the first solenoid valve (12). To retract the piston, the second solenoid valve (11) is opened, thereby releasing the pressure and allowing the oil to run back into the sump.

Design and function

Fundamentally, infinitely variable high-pressure inlet VANOS has the same job as the other VANOS systems described earlier.

If, for example less power is called for, fuel consumption and exhaust take precedence, while in the warm-up phase the emphasis might be on catalytic converter heating, or on smooth running when idling.



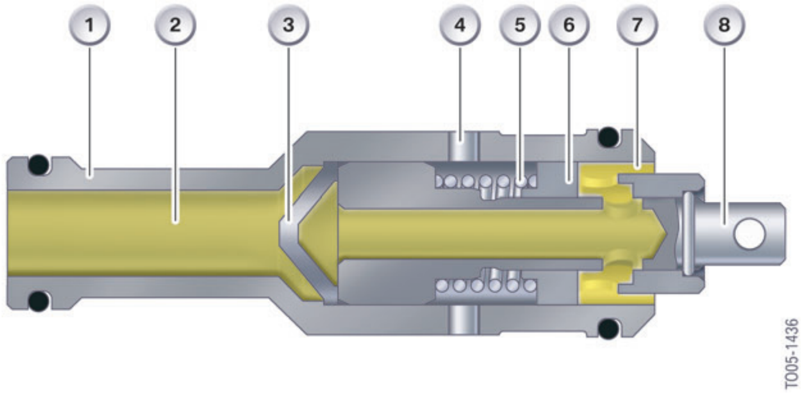
34 - VANOS unit on the S50B30 engine

Index	Explanation	Index	Explanation
1	High-pressure pump	5	Pressure limiting valve
2	VANOS gear	6	Filter
3	Chain sprocket for inlet camshaft	7	Solenoid valve block
4	Connection to pressure accumulator		

The high-pressure pump (1) for producing the high pressure of 100 bar is driven by the exhaust camshaft. The high-pressure pump is a radial piston pump.

A non-return valve connected downstream of the high-pressure pump prevents oil flowing back from the high-pressure chamber into the piston chamber while the piston chamber is not completely full. The malfunctioning or failure of that non-return valve would lead to heavy pressure pulsations and also have a negative effect on the required power of the high-pressure pump as a result of frictional losses.

The infeed valve ensures that the oil infeed rate and supply pressure remains constant over the full range of engine oil pressures, which is why it is referred to as the pressure reducing valve on earlier systems. On the S50 engine, the valve is fitted into the cylinder head from underneath. On the S54 engine, it is fitted between the VANOS unit and the cylinder head.

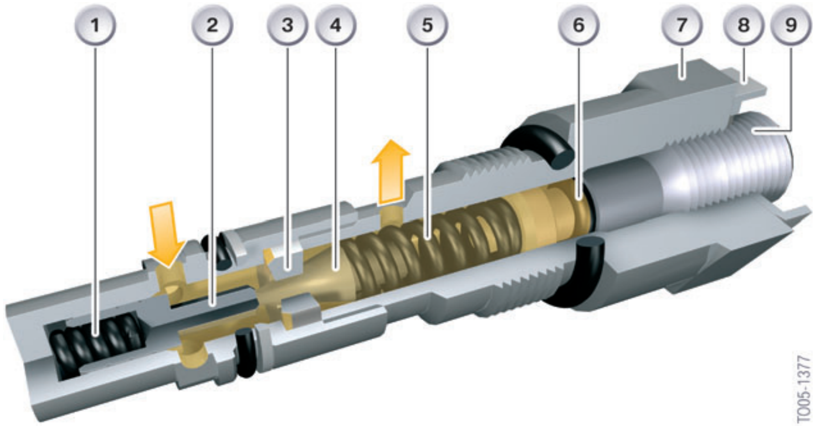


35 - Infeed valve, S54 engine

Index	Explanation	Index	Explanation
1	Valve socket	5	Compression spring
2	Oil from engine oil filter	6	Slider
3	Filter	7	Oil to high-pressure pump
4	Bore	8	Piston

The oil from the engine oil filter (2) passes through the valve socket (1) to the filter (3). The job of the filter (3) is to protect the infeed valve, the high-pressure pump and the VANOS unit from dirt particles larger than 80 µm. The left end of the infeed valve fits into the cylinder head and the right end into the VANOS unit. The piston (8) is in contact with the VANOS unit. If only a small quantity of oil is required, the pressure of the oil (7) between the valve and the high pressure pump increases so that the slider (6) is forced to the left against the compression spring (5), thereby reducing the gap between the piston (8) and the slider (6). Only a small quantity of oil can then flow through the infeed valve. The bore (4) for the ambient pressure is required to equalize the pressure from the movement of the slider (6).

The pressure limiting valve ensures that an oil pressure of approx. 100 bar is maintained within the system. At higher oil pressures, the surplus oil delivered is returned to the engine's normal oil system via the sump.



36 - Pressure limiting valve, S50B30 engine

Index	Explanation	Index	Explanation
1	Compression spring	6	O-ring
2	Damper piston	7	Holder
3	Seal plate	8	Lock nut
4	Seal cone	9	Adjuster piston
5	Compression spring		

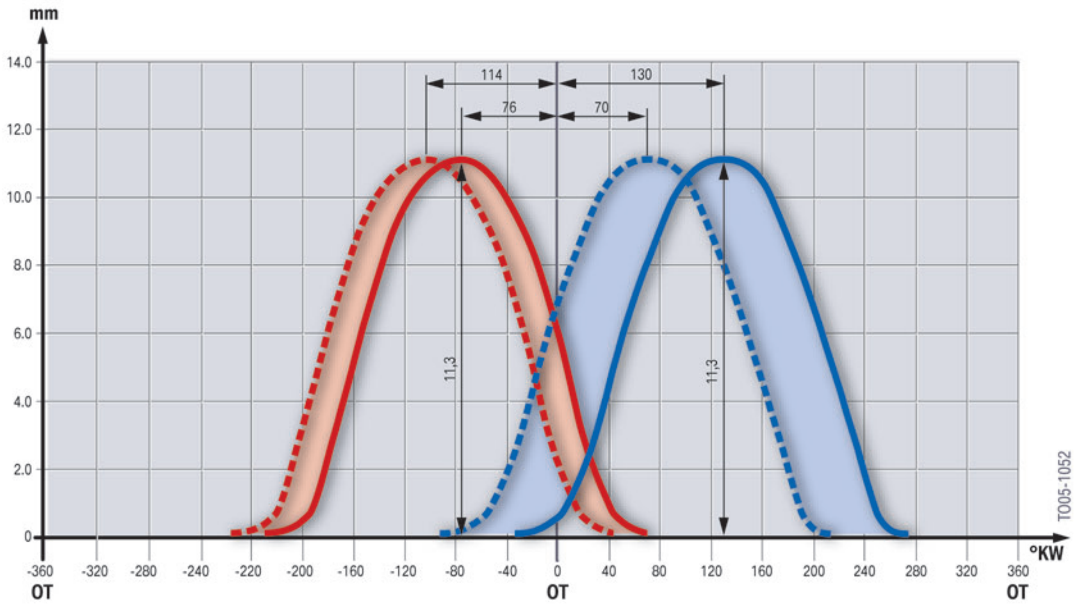
The oil delivered by the high-pressure pump passes through a filter into the pressure regulating valve. The pressure is applied below the seal plate (3) and the seal cone (4). If the pressure rises above the opening pressure of the seal cone (4), the seal cone (4) is lifted up against the pressure of the compression spring (5) and the oil can escape through the gap between seal plate (3) and seal cone (4) and through the bore in the holder (7) into the sump. The opening pressure is factory set using the adjuster piston (9) and fixed by means of the locking nut (8).

Infinitely variable high-pressure double VANOS

S50B32 engine

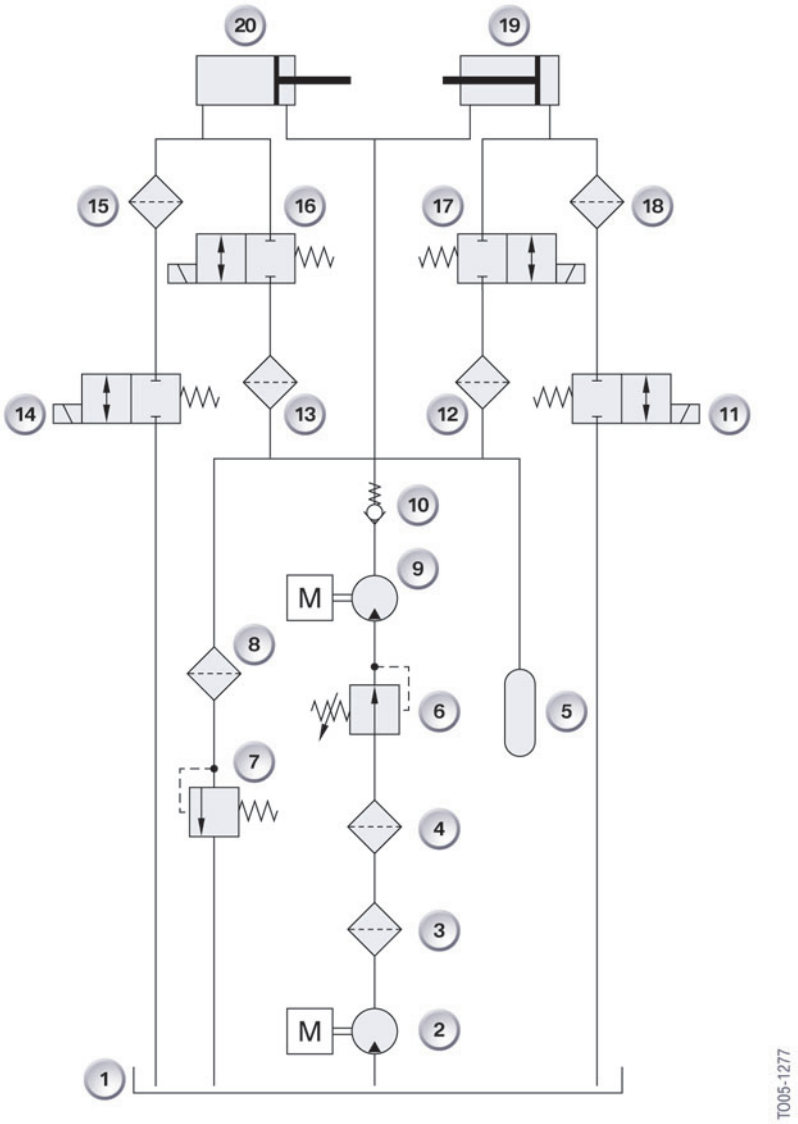
The arrival of the S50B32 engine saw the use of a double VANOS system on a BMW engine for the first time. That double VANOS system continues to be used on current M engines in a slightly modified form. As an infinitely variable, high-pressure double VANOS system, it extends the benefits of infinitely variable, high-pressure inlet VANOS to the exhaust camshaft as well.

The arrival of the S50B32 engine saw the use of an infinitely variable double VANOS system on a BMW engine for the first time. For the M engines, the concept of the high pressure VANOS was retained and has been consistently adopted up to the present. All current M engines are equipped with infinitely variable high-pressure double VANOS. The valve timing is adjusted as required with a bias towards fuel consumption and emissions or power output.



37 - Valve timing graph, S50B32 engine

Hydraulic circuit diagram



38 - Hydraulic circuit diagram, S50B32 engine

Index	Explanation	Index	Explanation
1	Sump	11	Solenoid valve
2	Oil pump	12	Filter
3	Oil filter	13	Filter
4	Filter	14	Solenoid valve
5	Pressure accumulator	15	Filter
6	Infeed valve	16	Solenoid valve
7	Pressure limiting valve	17	Solenoid valve
8	Filter	18	Filter
9	High-pressure pump	19	VANOS control piston
10	Non-return valve	20	VANOS control piston

The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there through a filter (4) integrated in the infeed valve (6), to the high-pressure pump (9) and through the non-return valve (10).

On the S50B32 engine, the infeed valve (6) is screwed into the cylinder head from underneath.

At a pressure of approx. 100 bar, the oil passes into the pressure accumulator (5). Any surplus oil delivered passes through a filter (8) into a pressure limiting valve (7) which limits the oil pressure to approx. 100 bar and diverts the surplus oil back to the sump. The oil delivered by the high-pressure pump continues to the VANOS control pistons (19 and 20) in the VANOS gears, as well as through the filters (12 and 13) and to the first solenoid valve (16 and 17) of each pair of valves.

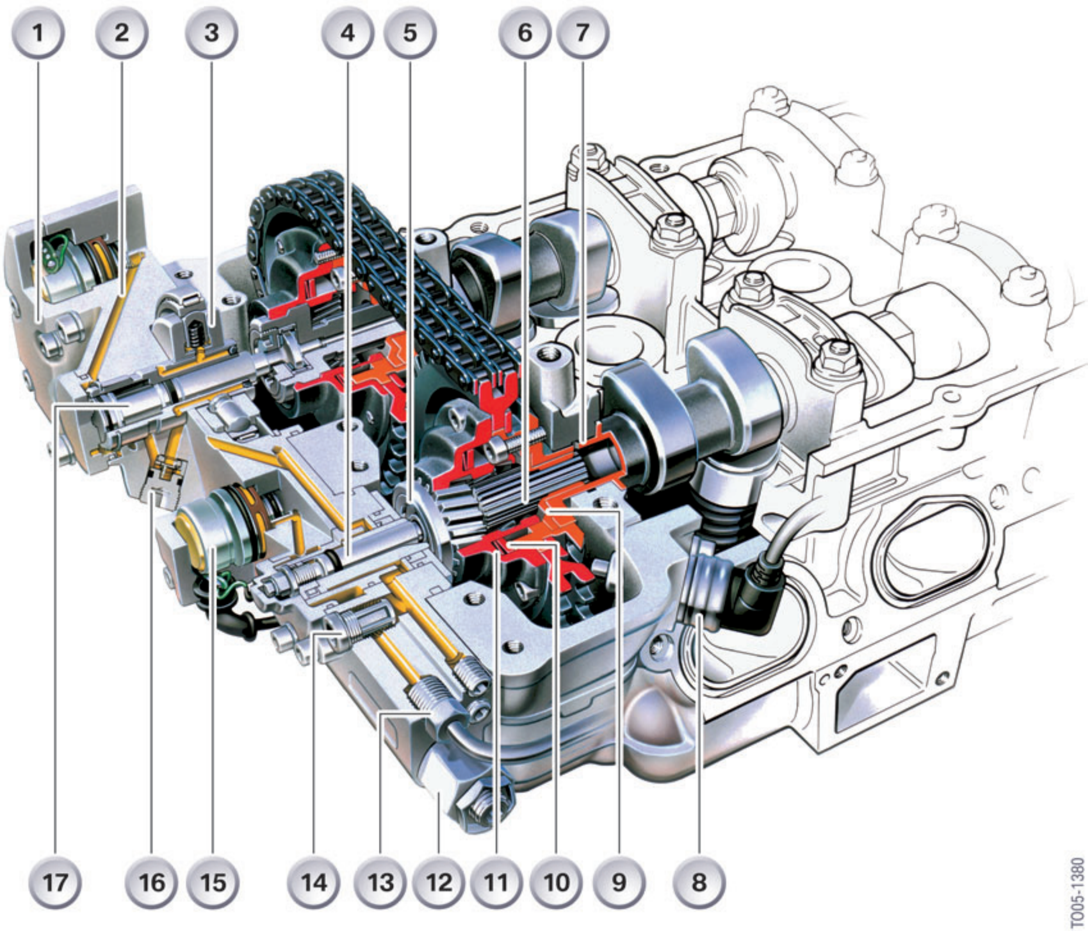
The VANOS control piston (19) for the one camshaft moves out as soon as its first solenoid valve (17) is operated and connects the oil pressure of 100 bar through to the other side of the VANOS control piston.

The VANOS control piston (20) for the other camshaft moves out as soon as its first solenoid valve (16) is operated and connects the oil pressure of 100 bar through to the other side of the VANOS control piston.

Since, in those situations, the same oil pressure is applied to both sides of the VANOS control pistons, the pistons only move because of the difference in surface area between their two sides. The oil from the smaller piston chamber is returned to the high-pressure circuit. A particular piston position is held by closing the first solenoid valve in each case (17 or 16). To retract the piston in each case, the oil is allowed to pass back into the sump through the filter (15 or 18) by opening the second solenoid valve (11 or 14).

The camshaft position is adjusted by a VANOS helical gear.

Design and function



39 - VANOS system, S50B32 engine

Index	Explanation	Index	Explanation
1	Solenoid valve block for exhaust VANOS	10	Buffer disc
2	Oil channel	11	Plate spring
3	High-pressure pump	12	Pressure limiting valve
4	Pressure chamber for retarding	13	Connection to pressure accumulator
5	VANOS control piston	14	Filter
6	Splined shaft	15	Solenoid valve
7	Bore	16	Pressure valve
8	Inlet camshaft sensor	17	VANOS control piston
9	Helix sleeve		

This infinitely variable, high-pressure double VANOS system is a refinement of the infinitely variable, high-pressure inlet VANOS system. The cut-away graphic clearly shows that the exhaust camshaft is fitted with a similar gear to the one on the inlet camshaft. The method of lubrication of the VANOS gear is identical to that used for the VANOS gear on the S54B32 engine and is explained in detail in the section on that engine.

⚠ The filter for the pressure limiting valve is fitted separately and has to be serviced according to the servicing instructions. ◄

S54 engine

The VANOS system on the M54 engine was further optimized. The solenoid valves are grouped together in a multi-valve block and manufactured as integral components of the valve block.

The electrical components of the solenoid valves are similarly grouped together in a single module and are attached to the valve block by four bolts.
The two units together form the solenoid valve block.

The solenoid valve block is in turn fixed to the positioner unit by four bolts.

The oil pressure for this high-pressure VANOS was raised from 100 bar to 115 bar.

Hydraulic circuit diagram

The hydraulic circuit diagram for the S54B32 engine is almost identical to the hydraulic circuit diagram for the S50B32 engine. The only difference is that the non-return valve downstream of the high-pressure pump is dispensed with.

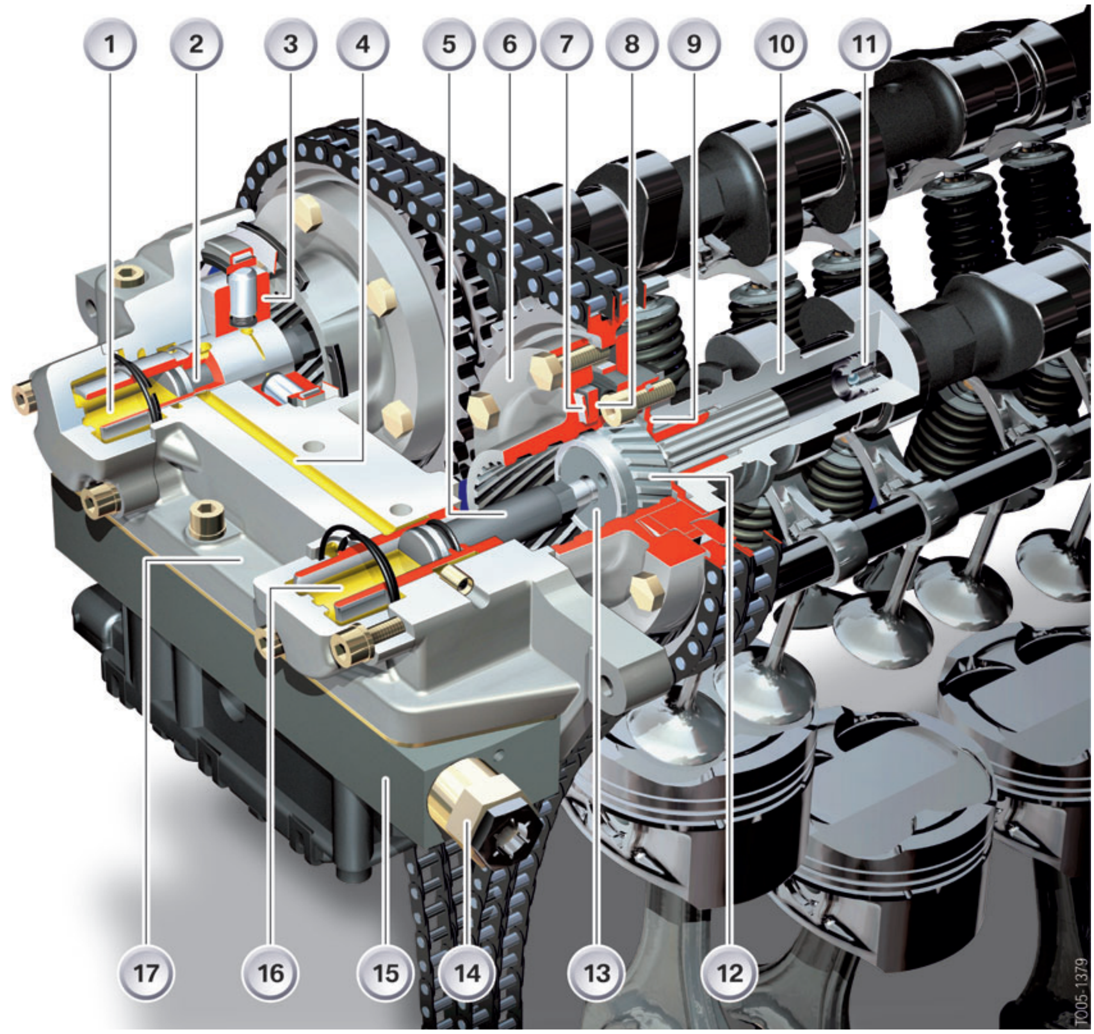
The filter for the pressure limiting valve in this system is fitted directly onto the pressure limiting valve and does not have to be changed.

The infeed valve on the S54B32 engine is fitted between the VANOS unit and the cylinder head. The infeed valve is combined with a filter to keep dirt out of the high-pressure circuit.

Lubrication of VANOS gear as illustrated by S54 engine

In order that the VANOS gear operates as quietly and with as little wear as possible, it is lubricated by oil from the oil circulation system. The oil passes through a bore hole in the first camshaft bearing into the camshaft and to the VANOS gear.

When the VANOS setting is adjusted by the high-pressure circuit, the lubricating oil in the camshaft is therefore potentially a hindrance to the movement of the piston. To prevent that happening, there is a pressure relief valve with an opening pressure of 4.5 bar fitted in the camshaft. That pressure relief valve opens at an oil pressure of 4.5 bar and allows the oil to escape into the rear section of the camshaft. The camshaft has an open end as well as open inspection holes. Thus the oil can return to the oil circulation system.



40 - VANOS system, S54B32 engine

Index	Explanation	Index	Explanation
1	Pressure chamber for retarding	10	Intake camshaft
2	VANOS control piston	11	Pressure relief valve
3	High-pressure pump	12	Splined shaft
4	Oil channel	13	Axial needle bearing
5	VANOS control piston	14	Pressure limiting valve
6	VANOS gear	15	Valve block
7	Plate spring	16	Pressure chamber for advancing
8	Buffer disc	17	Adjustment unit
9	Helix sleeve		

S62 engine

Because of its 'V' configuration, the S62 engine required two infinitely variable, high-pressure double VANOS units.

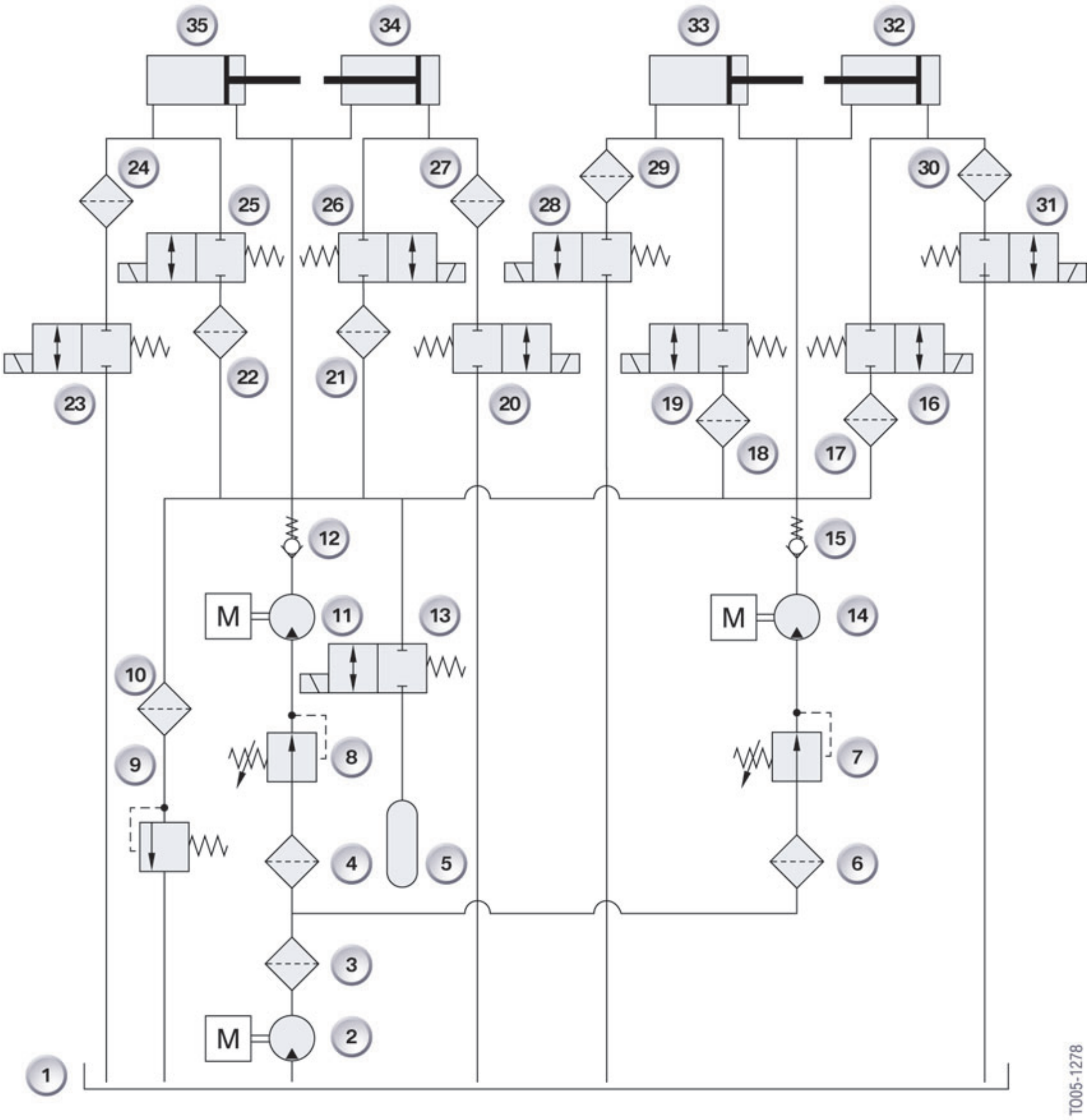
The method of operation of the S62 VANOS system is the same as the S50 VANOS. The VANOS units are very similar.

The VANOS hydraulic unit has been redesigned. It has a central valve unit with the four solenoid valves in the centre. The high-pressure pump on the S62 is driven by the inlet crankshaft. On the S50 engine, it is driven by the exhaust camshaft.

The speed limiting function is no longer performed by the VANOS system but by the throttle valves instead.

The oil pressure for this high-pressure VANOS system is approx. 115 bar.

Hydraulic circuit diagram



41 - Hydraulic circuit diagram, S62B50 engine

Index	Explanation	Index	Explanation
1	Sump	19	Solenoid valve
2	Oil pump	20	Solenoid valve
3	Oil filter	21	Filter
4	Filter	22	Filter
5	Pressure accumulator	23	Solenoid valve
6	Filter	24	Filter
7	Infeed valve	25	Solenoid valve
8	Infeed valve	26	Solenoid valve
9	Pressure limiting valve	27	Filter
10	Filter	28	Solenoid valve
11	High-pressure pump	29	Filter

Index	Explanation	Index	Explanation
12	Non-return valve	30	Filter
13	Pressure accumulator shut-off valve	31	Solenoid valve
14	High-pressure pump	32	VANOS control piston
15	Non-return valve	33	VANOS control piston
16	Solenoid valve	34	VANOS control piston
17	Filter	35	VANOS control piston
18	Filter		

The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there separately for each cylinder bank through a filter (4/6) fitted in the infeed valve, to the infeed valve (8/7). On the left cylinder bank, the pressurized oil passes from the high-pressure pump (11) through the non-return valve (12) and the accumulator shut-off valve (13) into the pressure accumulator (5), as well as directly to the two VANOS control pistons (35), and via the filters (22 and 21) to the first solenoid valve (25 and 26) in each pair of valves.

The surplus oil delivered is returned to the sump (1) via a filter (10) and the pressure limiting valve (9).

The VANOS control piston (35/34) for each camshaft moves out as soon as its first solenoid valve (25/26) is operated and connects the oil pressure of 115 bar through to the other side of the VANOS control piston.

Since, in those situations, the same oil pressure is applied to both sides of the VANOS control pistons, the pistons only move because of the difference in surface area between their two sides. The oil from the smaller piston chambers is returned to the high-pressure circuit. A particular piston position is held by closing the first solenoid valve in each case (25/26).

To retract the piston in each case, the oil is allowed to pass back into the sump through the filter (24 or 27) by opening the second solenoid valve (23 or 20).

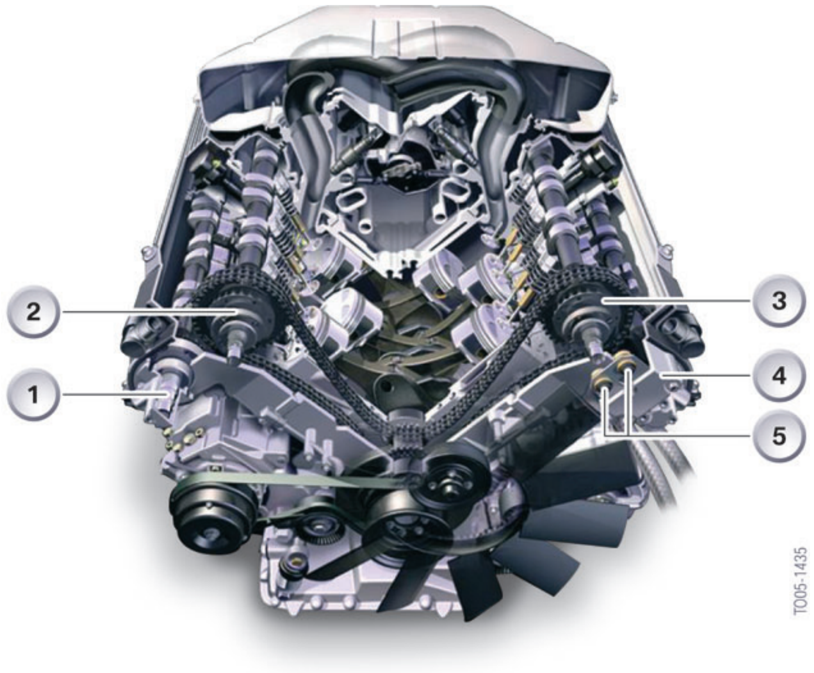
The position of each camshaft is adjusted by a VANOS helical gear.

Design and function

The purpose of the accumulator shut-off valve is to maintain the pressure in the accumulator when the engine is not running. That means that when the engine is started, the valve can be opened so that the pressure is available to the system.

Without the accumulator shut-off valve, the VANOS system would produce rattling noises for the first 3 to 7 seconds after the engine was started due to lack of system pressure.

The illustration below shows the layout of the VANOS system on the S62 engine.



42 - S62 engine

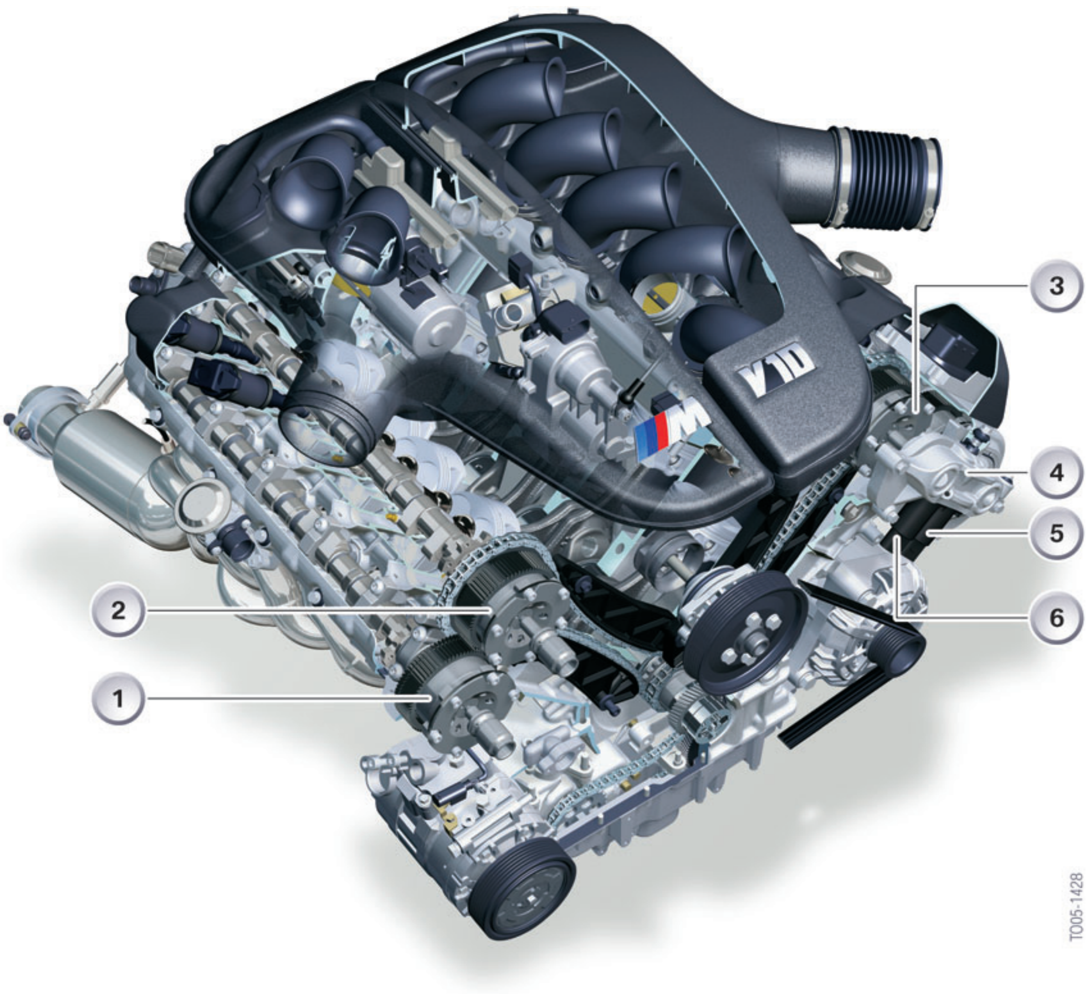
Index	Explanation	Index	Explanation
1	VANOS control piston	4	VANOS unit
2	VANOS gear	5	Solenoid valves
3	VANOS gear		

S85 engine

The VANOS system on the S85 engine has an operating oil pressure of 80 bar. Instead of 2-port/2-way solenoid valves, 3-port/2-way solenoid valves (proportional valves) are used. This means that only one solenoid valve per VANOS unit is required.

Compared with the 2-port/2-way solenoid valves, the proportional valves have faster actuation times and are more reliable in operation.

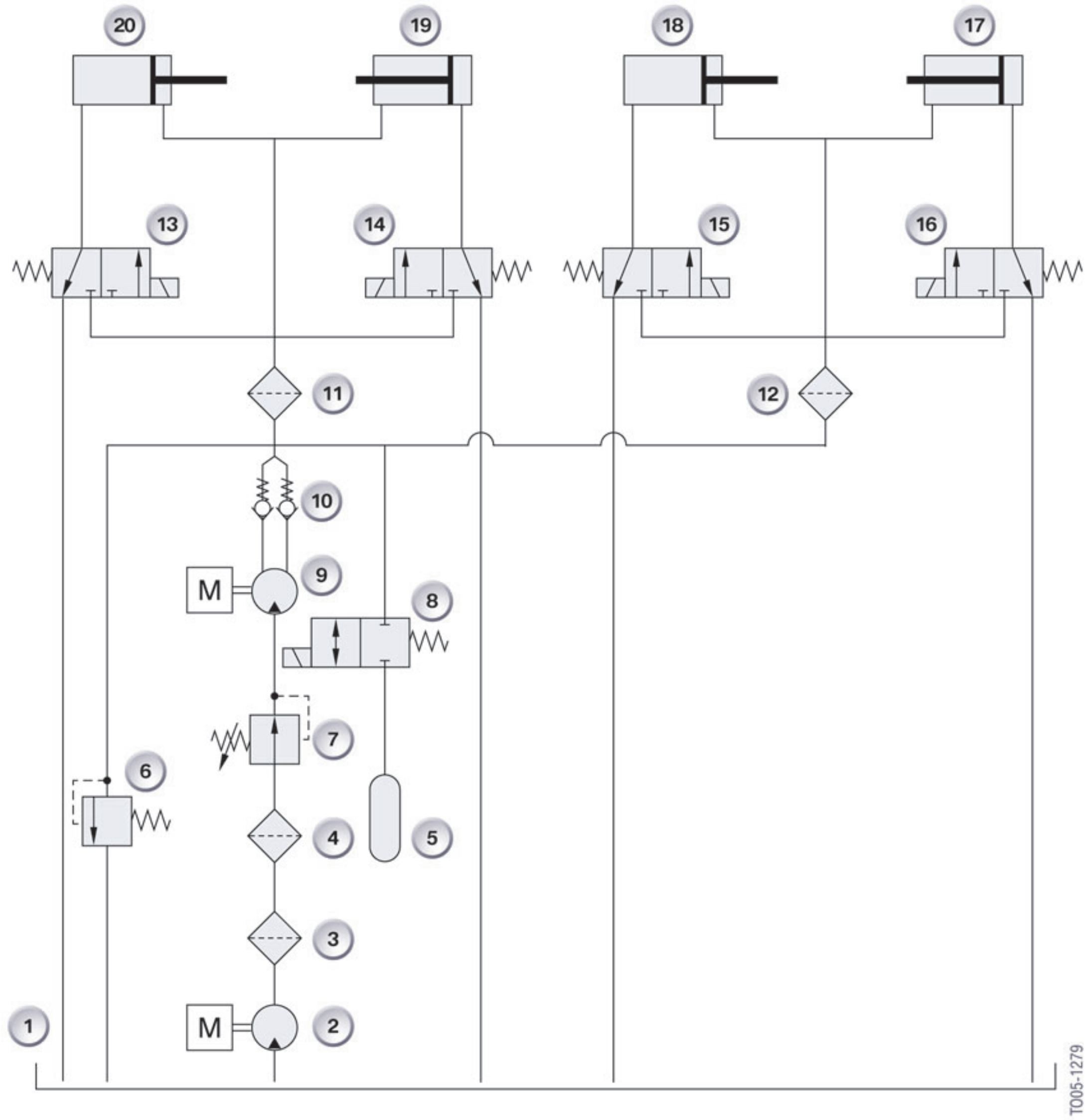
Only one high-pressure pump is fitted and is driven directly by the crankshaft. Two high-pressure lines carry the oil to the two VANOS positioner units and the pressure accumulator.



43 - S85 engine

Index	Explanation	Index	Explanation
1	VANOS gear	4	VANOS unit
2	VANOS gear	5	Solenoid valve
3	VANOS gear	6	Solenoid valve

Hydraulic circuit diagram



44 - Hydraulic circuit diagram, S85B50 engine

Index	Explanation	Index	Explanation
1	Sump	11	Filter
2	Oil pump	12	Filter
3	Oil filter	13	Solenoid valve
4	Filter	14	Solenoid valve
5	Pressure accumulator	15	Solenoid valve
6	Pressure limiting valve	16	Solenoid valve
7	Infeed valve	17	VANOS control piston
8	Pressure accumulator shut-off valve	18	VANOS control piston
9	High-pressure pump	19	VANOS control piston
10	Non-return valve (x 2)	20	VANOS control piston

The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there through a filter (4) that is fitted in the bedplate upstream of the high-pressure pump, into the infeed valve (7), to the high-pressure pump (9) and to the two non-return valves (10) which also separate the two pressure chambers from one another.

The pressurized oil passes through the accumulator shut-off valve (8) into the pressure accumulator (5), as well as separately for each cylinder bank via a filter (11/12) to the two VANOS control pistons (20 and 19 or 18 and 17), and to the two solenoid valves (13 and 14 or 15 and 16).

The surplus oil delivered is returned via the pressure limiting valve (6), which limits the oil pressure to approx. 80 bar, to the sump (1).

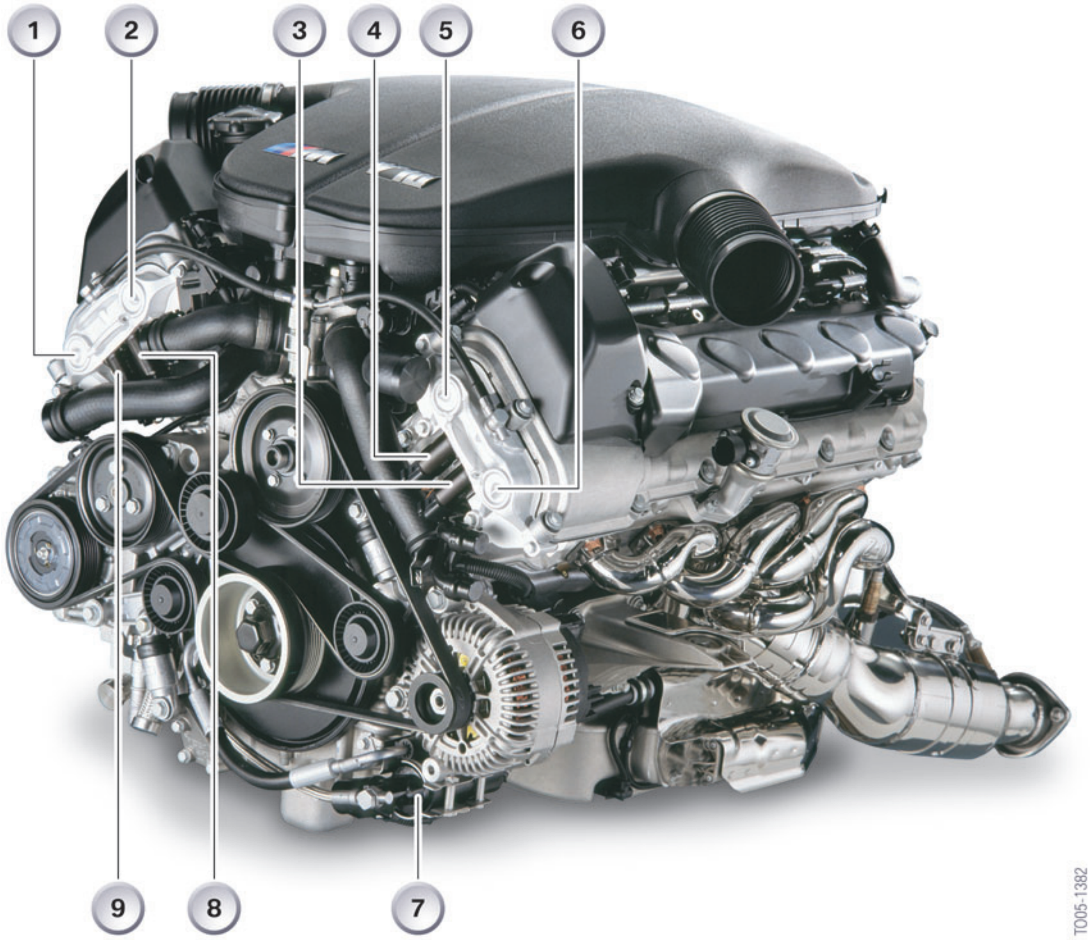
When the solenoid valve (13/14/15/16) is de-energized, pressure is only applied to the smaller piston chamber in each case so that the relevant VANOS control piston (20/19/18/17) retracts.

When the solenoid valve (13/14/15/16) is fully actuated, the relevant VANOS control piston (20/19/18/17) moves out because the oil pressure of 80 bar is acting on both sides of the piston and the two surface areas are different. The oil from the smaller piston chamber in each case is returned to the high-pressure circuit.

To hold a piston in a specific position, the relevant solenoid valve (13/14/15/16) is partially actuated allowing the desired partial pressure to be applied to the larger side of the VANOS control piston concerned. As a result, the pressure on the larger side of the VANOS control piston is lowered, altering the balance of forces between the two sides of the piston. The VANOS control piston is held in its position.

The position of each camshaft is adjusted by a VANOS helical gear.

Design and function

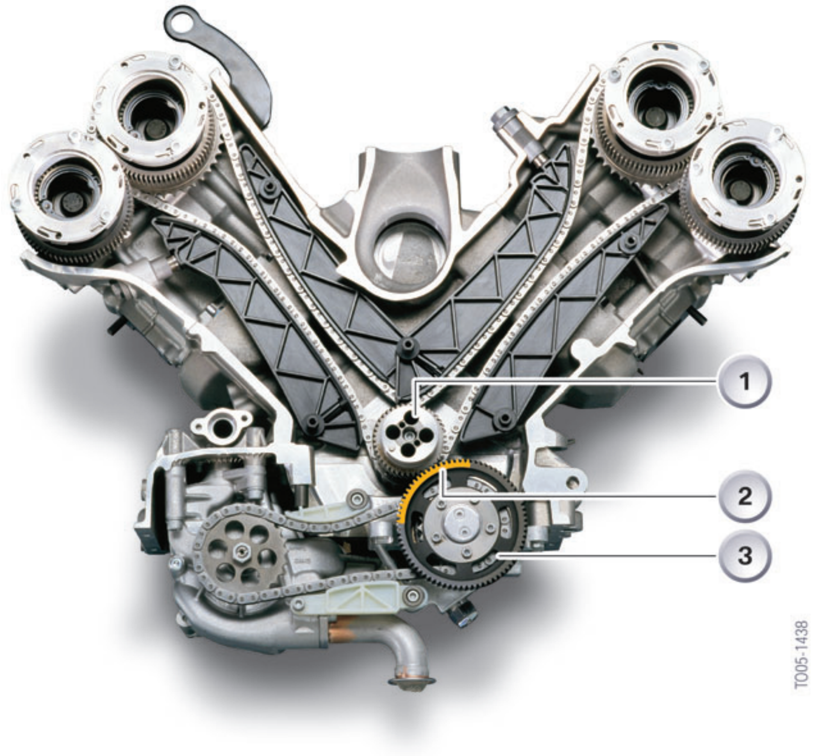


45 - S85B50 engine

Index	Explanation	Index	Explanation
1	Exhaust VANOS	6	Exhaust VANOS
2	Inlet VANOS	7	High-pressure accumulator
3	Solenoid valve	8	Solenoid valve
4	Solenoid valve	9	Solenoid valve
5	Inlet VANOS		

The oil supply to the high-pressure pump is provided by bore holes in the bedplate. There is a filter fitted in the connecting port which protects the high-pressure pump and the VANOS components from dirt particles larger than 80 µm.

The high-pressure pump is in the form of a radial piston pump with 5 pistons. It is gear-driven directly by the crankshaft.

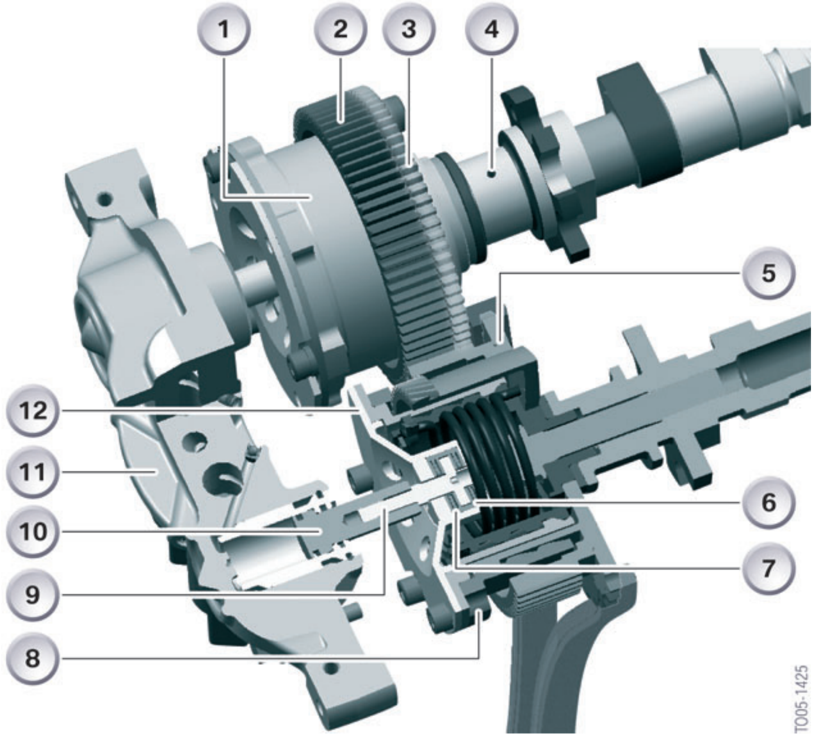


46 - Chain drive system and high-pressure pump

Index	Explanation	Index	Explanation
1	Crankshaft with drive gear	3	High-pressure pump sprocket
2	Coated section		

⚠ To prevent gear noise, the high-pressure pump sprocket (3) must be fitted with the coated section (2) facing the crankshaft (1) so that there is no play. The correct degree of play between the gears will then automatically be established by the coating wearing off in the course of operation. ◄

An infeed valve familiar from the high-pressure VANOS systems ensures that the oil infeed rate and supply pressure to the high-pressure pump remains constant over the full range of engine oil pressures.



47 - VANOS unit

Index	Explanation	Index	Explanation
1	VANOS gear	7	Axial needle bearing
2	Gear 1	8	Outer sleeve
3	Gear 2	9	Piston rod
4	Bore	10	VANOS control piston
5	Drive sprocket	11	VANOS unit
6	Axial needle bearing	12	Axial bearing housing

The VANOS units for the inlet camshafts are each driven by a separate timing chain running off the crankshaft. Directly interlocking gears on the inlet and exhaust VANOS units effect transmission of the drive to the exhaust-camshaft units.

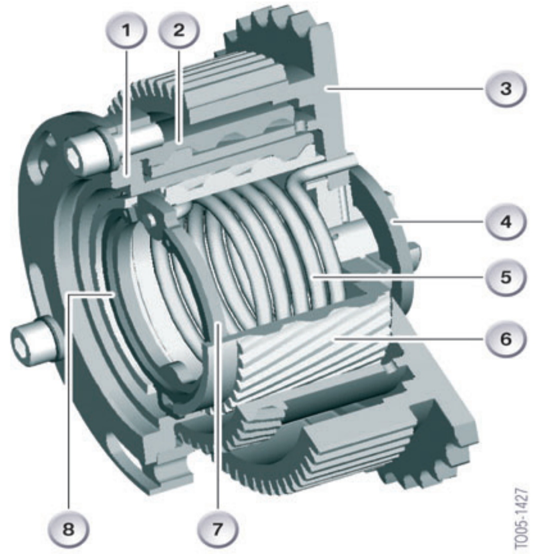
Since the fact that those gears mesh directly with one another means that they, and therefore the inlet and exhaust camshafts, rotate in opposite directions, the inlet unit retards timing when operated, whereas the exhaust unit advances timing.

In order to prevent gear noise from the VANOS units, the drive gear for the exhaust camshaft is split into two. The two gears (2 and 3) are twisted in opposite directions to one another by a spring so that they are always in contact with both sides of the teeth on the drive gear (5) on the inlet unit under any load conditions.

The movement of the VANOS control piston (10) is transmitted to the VANOS gear by a piston rod (9). The piston rod (9) runs on axial needle bearings (6 and 7) in the axial bearing housing (12) because the VANOS gear rotates during operation whereas the positioner unit and VANOS control piston (10) do not.

The illustration that follows shows the design of the VANOS gear for the inlet camshaft. The drive sprocket bearing (6) is screwed to the camshaft by a central bolt. The drive sprocket bearing (6) has an external helix. The drive sprocket (3) is driven by the timing chain and is able to rotate relative to the drive sprocket bearing (6). Oil ducts in the drive sprocket bearing provide lubrication between the drive sprocket bearing and the drive sprocket as well as for the entire VANOS gear. The drive sprocket is also integral with the gear for driving the exhaust camshaft drive gear. The drive sprocket (3) also has an internal helix. The internal helix of the drive sprocket engages with the helix of the outer sleeve (2). The external helix of the drive sprocket bearing (6) engages with the helix of the inner sleeve (1). The inner sleeve and outer sleeve are screwed to one another and are moved by the VANOS control piston. When the inner and outer sleeves are moved in or out, the drive sprocket is rotated relative to the drive sprocket bearing.

A torsion spring returns the VANOS gear to its basic setting (as shown in the illustration) when it is unpressurized. The torsion spring (5) is held in place by a fixing ring (7) and a circlip (8).



48 - Cross-section of VANOS gear, S85 engine

Index	Explanation
1	Inner sleeve
2	Outer sleeve
3	Drive sprocket
4	Disc
5	Torsion spring
6	Drive sprocket bearing
7	Fixing ring
8	Circlip

As on the other high-pressure VANOS systems, the control pistons are double-action cylinder designs.

System overview

Two-setting inlet VANOS

M50TU engine

⚠ The following faults are diagnosed by the MS40.1:

- Position feedback from inlet camshaft
- Output-stage fault
- Short circuit to positive or negative
- Circuit break ◄

Infinitely variable inlet VANOS

M62TU engine

⚠ The central mounting bolt that fixes the VANOS unit to the camshaft has a left-hand thread.

In emergency mode, the solenoid valves are de-energized. The inlet camshafts are then in the retarded position. ◄

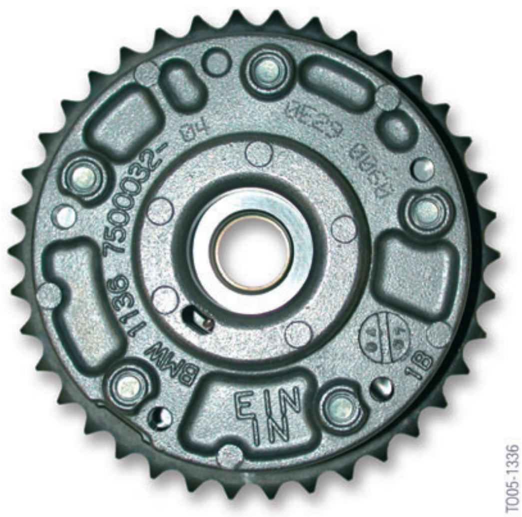
Infinitely variable double VANOS

M52TU engine

⚠ In emergency mode, the solenoid valves are de-energized. The inlet camshaft is then in the retarded position and the exhaust camshaft in the advanced position. ◄

N42/N52 engine

⚠ The mounting brackets must not be bent; observe repair instructions. ◄



1 - VANOS unit

⚠ The identification "EIN IN" can clearly be seen stamped on the end face. The VANOS units for the inlet and exhaust camshafts are different and thus distinguished by such identification marks. The VANOS unit for the exhaust (outlet) camshaft bears the identification mark "AUS OUT".

A number of variations of that VANOS unit are used on different engines. Since those VANOS units are virtually indistinguishable visually, it is essential to check the part number.

Fitting the wrong unit can result in terminal engine damage ◄

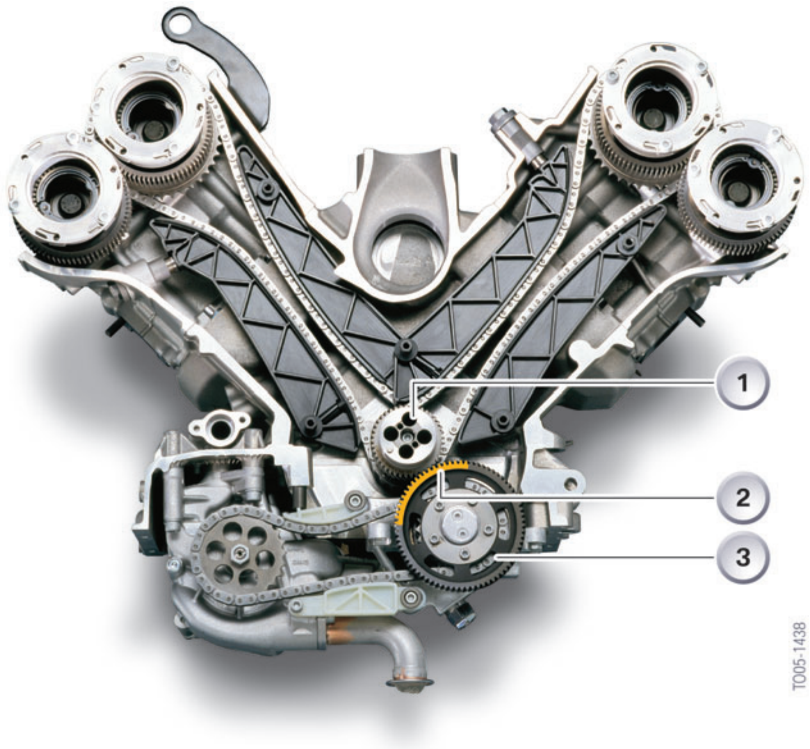
⚠ The VANOS units for the inlet and exhaust camshafts have different adjustment ranges. Consequently, they must not be mixed up as engine damage due to the pistons striking the valves is likely to result. Therefore, the front plates of the VANOS units have the respective identifying marks "AUS/EX" and "EIN/IN" engraved on them. ◄

Infinitely variable high-pressure double VANOS

S50B32 engine

⚠ The filter for the pressure limiting valve is fitted separately and has to be serviced according to the servicing instructions. ◄

S85 engine



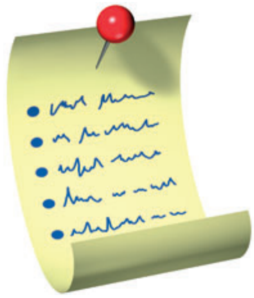
2 - Chain drive system and high-pressure pump

Index	Explanation	Index	Explanation
1	Crankshaft with drive gear	3	High-pressure pump sprocket
2	Coated section		

⚠ To prevent gear noise, the high-pressure pump sprocket (3) must be fitted with the coated section (2) facing the crankshaft (1) so that there is no play. The correct degree of play between the gears will then automatically be established by the coating wearing off in the course of operation. ◄

Summary
VANOS

Points to remember



Points to remember for everyday theoretical and practical applications.

The table below summarizes the most important information on the subject of Basic Engine Principles, VANOS Systems.

This list outlines the main points in concise form and provides the opportunity of rechecking the most important facts provided in this Product Information Manual.

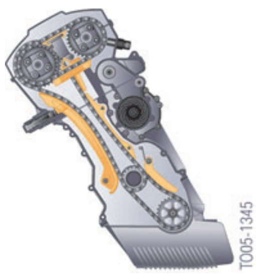
Models

VANOS has been used on BMW vehicles since 1992. Now, all petrol engines are equipped with double VANOS.

Introduction

Since the early days of the 3/15 and its DA1 engine in 1929, the average rated speed has increased from 3000 rpm to today's 6200 rpm. Now, infinitely variable double VANOS is standard on BMW petrol engines and is the most technically advanced system offered by the automotive technology market anywhere in the world.

Valve gear function



The M50 engine was the starting point for introduction of the first VANOS system. It uses the familiar valve gear configuration with a timing chain connecting the crankshaft and camshafts.

VANOS Systems on BMW Engines

To date, five different VANOS systems have been developed by BMW. They are two-setting inlet VANOS, infinitely variable inlet VANOS, infinitely variable double VANOS, infinitely variable high-pressure VANOS and infinitely variable, high-pressure double VANOS

Two-setting inlet VANOS

The two-setting inlet VANOS system was the first used on a BMW engine. As the name implies, the system allowed only two possible settings for the inlet camshaft. The VANOS system produced improved idling, lower exhaust emissions and greater fuel-efficiency. Those benefits were utilized even more effectively by succeeding VANOS generations. Adjustment of the camshaft position was effected by a VANOS gear.

Infinitely variable inlet VANOS

The arrival of infinitely variable inlet VANOS took the VANOS system a further step forward in terms of the degree of variability of inlet camshaft timing. Engine smoothness was further improved and the exhaust emissions brought well below the limits in force at the time. The system was easier to fit as a compact VANOS gear was introduced for the first time. The new VANOS gear could not be dismantled.

Infinitely variable double VANOS

The advent of infinitely variable double VANOS marked the arrival of variable inlet and exhaust camshaft timing, the system version in use today. The advantages such as higher torque, improved idling characteristics, lower exhaust emissions and greater fuel-efficiency were further enhanced.

Infinitely variable high-pressure inlet VANOS

Around the time that two-setting inlet VANOS was introduced, the M engines were being fitted with infinitely variable high-pressure inlet VANOS. The advantage of high-pressure actuation is the extremely rapid adjustment time. That means that better and more precise control is possible compared to standard VANOS. With infinitely variable high-pressure inlet VANOS, the speed limiting function is performed by the VANOS system.

Infinitely variable high-pressure double VANOS

The arrival of the S50B32 engine saw the use of an infinitely variable double VANOS system on a BMW engine for the first time. For the M engines, the concept of the high pressure VANOS was retained and has been consistently adopted up to the present. All current M engines are equipped with infinitely variable high-pressure double VANOS. The valve timing is adjusted as required with a bias towards fuel consumption and emissions or power output.

Test questions
VANOS

Questions

Consolidating and assessing what you have learned.

In this section you have the opportunity to assess what you have learned. It contains a series of questions on the subject of VANOS systems.

1. Which VANOS systems are you familiar with?

- ☐ Two-setting, high-pressure inlet VANOS
- ☐ Infinitely variable, high-pressure inlet VANOS
- ☐ Infinitely variable, high-pressure double VANOS
- ☐ Two-setting inlet VANOS
- ☐ Infinitely variable double VANOS
- ☐ Infinitely variable inlet VANOS
- ☐ Two-setting double VANOS

2. Why are VANOS systems used?

- ☐ It allows torque to be optimized.
- ☐ It allows power output to be increased.
- ☐ It allows engine speed to be increased.
- ☐ It allows exhaust emissions to be lowered.

3. When was the first VANOS system introduced on a BMW engine?

- ☐ 1992
- ☐ 1985
- ☐ 1998

4. Which types of VANOS units are used on BMW engines?

- ☐ Hydraulic vane motor
- ☐ Hydraulic oscillating motor
- ☐ VANOS unit with helical gear
- ☐ Variable roller tappet adjustment

Answers to questions

1. Which VANOS systems are you familiar with?

☐ Two-setting, high-pressure inlet VANOS
☑ Infinitely variable, high-pressure inlet VANOS
☑ Infinitely variable, high-pressure double VANOS
☑ Two-setting inlet VANOS
☑ Infinitely variable double VANOS
☑ Infinitely variable inlet VANOS
☐ Two-setting double VANOS

2. Why are VANOS systems used?

☑ It allows torque to be optimized.
☑ It allows power output to be increased.
☐ It allows engine speed to be increased.
☑ It allows exhaust emissions to be lowered.

3. When was the first VANOS system introduced on a BMW engine?

☐ 1992
☐ 1985
☑ 1998

4. Which types of VANOS unit are used on BMW engines?

☑ Hydraulic vane motor
☑ Hydraulic oscillating motor
☑ VANOS unit with helical gear
☐ Variable roller tappet adjustment

BMW Service
Aftersales Training
80788 München
Fax +49 89 382-34450