

---

# Table of Contents

## S85 Engine

Subject	Page
<b>Introduction</b> .....	<b>5</b>
Motorsport Engine History .....	6
S38 (M88) .....	6
S14 .....	7
S50 (US) .....	8
S52 .....	8
S54 .....	9
S62 .....	10
Formula One Engine .....	12
<b>Components</b> .....	<b>14</b>
Engine Block and Bedplate .....	14
Bedplate Sealing .....	16
Oil Pan .....	16
Crankshaft .....	17
Connecting Rods .....	17
Pistons .....	17
Cylinder Head and Valvetrain .....	18
Cylinder Head Cover .....	18
Valves .....	18
Valve Springs .....	18
Valve Keepers (Cotters) .....	19
Hydraulic Valve Actuators (HVA) .....	19
Camshaft .....	20
Camshaft Drive .....	20
VANOS .....	21
VANOS Hydraulic Schematic .....	22
VANOS Actuators .....	23
VANOS Gear Mechanism .....	25
VANOS High Pressure Pump .....	28
Intake Plenum (Manifold) .....	31
Intake Silencers .....	31
Throttle Valves .....	32
Idle Control .....	32
Secondary Air System .....	33
Exhaust System .....	33

---

<b>Subject</b>	<b>Page</b>
Lubrication System .....	.34
Oil Pumps .....	.35
Electric Oil Pumps .....	.37
Oil Spray Nozzles .....	.37
Oil Filter Housing .....	.37
Cooling System .....	.38
Radiator .....	.39
Thermostat .....	.39
Water Pump .....	.39

BLANK  
PAGE

---

# S85 Engine

Model: E60 M5 and E63/E64 M6

Production: All

# OBJECTIVES

After completion of this module you will be able to:

- Understand the construction of the S85 V-10 engine
- Identify and locate S85 engine components
- Perform basic engine services on the S85 engine

## Introduction

For the first time in a road-going BMW, a new Formula 1 inspired V-10 has been developed for the new M5 and M6. The new S85 engine benefits from the knowledge gained from F1 racing development.



The all aluminum V-10 produces in excess of 500 horsepower at 7750 RPM. One of the concepts adapted from F1 is the “High RPM Power Concept” which allows the S85 to achieve a maximum RPM of 8250.

Other features of the S85 include a light alloy, 2-piece crankcase which uses a bedplate design for additional reinforcement. The familiar High-Pressure Double VANOS is carried over from previous BMW Motorsport engine designs.

The S85 is naturally aspirated and “breathes” through 10 individual throttle assemblies which are actuated by two throttle motors (One per bank).

Together with all of the other engine concepts in this design, the S85 propels the new M5 and M6 to sub-5 second 0-60 mph times. The M5 offers the best power to weight ratio in comparison with the other vehicles in it’s class.

---

## Motorsport Engine History

Since 1972, BMW M GmbH, the “motorsport” division of BMW has been turning out some of the most powerful and legendary engine packages in the auto industry. The letter “M” has been referred to as “the most powerful letter in the world”. Customers who are familiar with the “M” badge know that when they buy an M-car, they have come to expect something special under the hood.

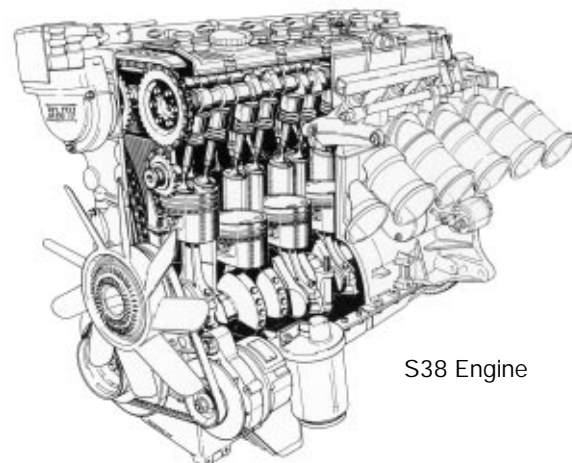


### S38 (M88)

The first BMW motorsport engine was the inline 6-cylinder known then as the M88. This engine was introduced with the legendary M1 in 1978. Since then, the M88 engine has been known as the S38 in production vehicles. In the M1, the M88 produced 277hp which was impressive for a 6-cylinder engine in 1978.



The S38 engine, which was a slightly “de-tuned” version of the M88, was first introduced into the US market in the E28 M5 in 1988. The 256 hp S38 featured some of the BMW motorsport philosophy which is still in use today. Innovations such as individual throttles, 4 valves per cylinder, lightweight valvetrain and steel crankshaft are still in use on current M engines.



S38 Engine

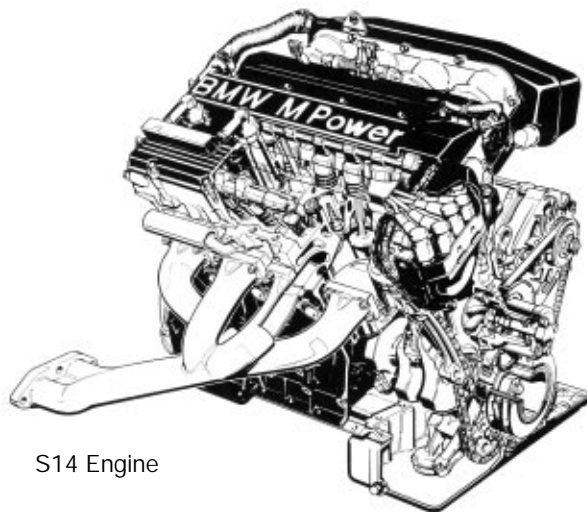
The E24 M6 also took advantage of the S38 engine technology through its production life. The M6 was available in the US in 1987 and 1988.

## S14

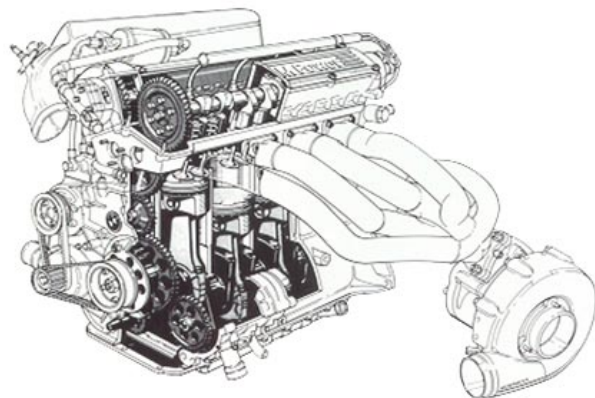
Introduced a year before the M5, BMW also produced a "Motorsport" version of the E30. The first M3 featured a Formula One derived race bred powerplant that came to be known as the S14. The S14 was a 2.3 liter, 4-cylinder engine capable of 192 hp at 6750 rpm. Considering that this is a "naturally aspired" engine, a 4-cylinder engine producing 192 horsepower was impressive especially in 1987.



The S14 engine was a further development of the 4-cylinder engine which was used to propel the BMW Brabham F1 car to the 1983 F1 World Championship. The Formula 1 engine (M12/M13) was derived from the "stock block" M10 engine. The M12/M13 F1 engine displaced 1.5 liters and was turbocharged and capable of producing in excess of 1100 bhp. This is an impressive feat for an engine which was developed from a stock powerplant. The extensive research and development of the Formula 1 engine led to the ultimate production of the S14.



S14 Engine



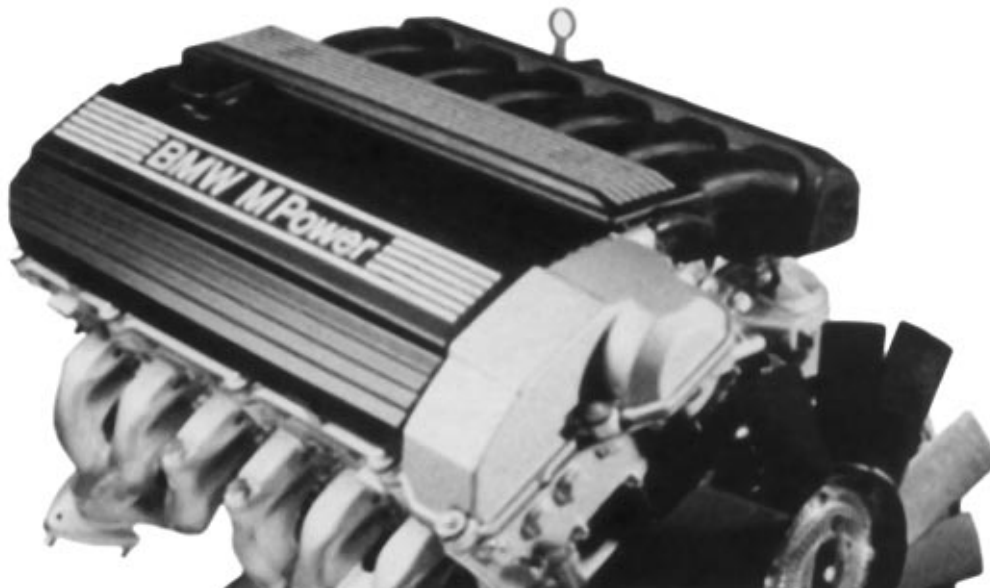
M12/M13 F1 Engine

---

### S50 (US)

The E30 M3 was discontinued in 1991. The next generation M3 would not be available until 1995. The E36 M3 was based on the new 3 series coupe introduced in 1991. This was the first time that a 6-cylinder was available in the M3.

The new S50 (US) engine was derived from the M50TU already in use at that time. The new M3 engine produced 240 hp and differed considerably from the European version. The S50 (US) engine was only available for one year (1995). In order to comply with OBD II regulations, the S50 was discontinued in favor of the S52 in 1996. The S52 was a 3.2 liter engine using Siemens engine management.



### S52

In 1996, the M3 received the new S52 3.2 liter engine which produced 240 hp. This was the first OBDII compliant "M" engine and also the first to use Siemens engine management instead of Bosch.

The engine was based on the M52 production engine and used much of the same technology as the previous (S50US) engine. The S52 was also used in the new "M" Roadster and Coupe. The S52 would be in use until 2001, when it was replaced by the S54





---

## S54

The S54 would be the powerplant of choice for the 3rd generation M3. The new in-line 6-cylinder "Motorsport" engine marked a major leap in engine technology for that time. For the first time in a production "M" car, the S54 achieved the elusive goal of 100 hp per liter. With 333 hp at 7900 RPM, S54 propelled the E46 M3 to 0-60 times of 4.8 seconds.



The S54 was the first Motorsport 6-cylinder to use the "High-Pressure Double VANOS" system. Some of the other engine highlights include:

- 11.5 to 1 compression
- 6 - individual throttle assemblies with electronic throttle control
- A unique lightweight valve actuating mechanism
- Forged steel crankshaft with "nitro-carburized" heat treatment
- "Semi-dry sump" lubrication system
- Light weight one-piece cylinder head
- High-strength cast iron engine block

Together with the Motorsport designed engine management system, the S54 also meets the required LEV emission standards as well.

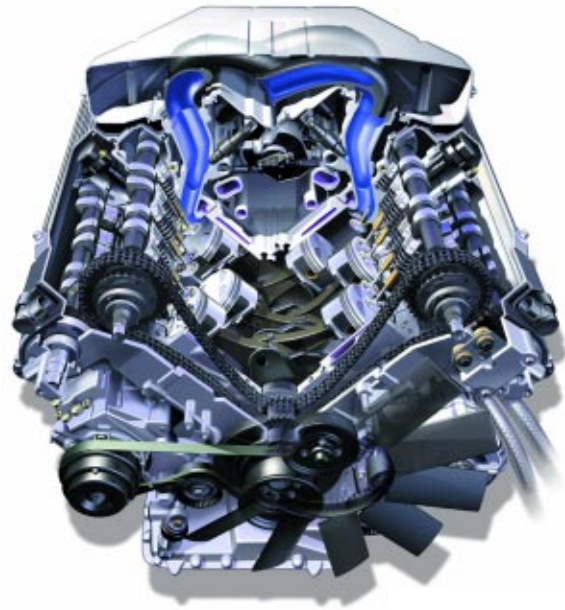
## S62

Another first time achievement for the Motorsport division, was the introduction of the first V-8 "M" engine. The 5 liter S62 was also the most powerful production "M" engine with an output of 394 hp.

The S62 was first used in the third generation M5, the E39. Also, the S62 was used in the Z8 which marks only the second time in which an "M" engine was used in a non-"M" vehicle. The first time being the S70 in the E31 850Csi.

Features of the S62 engine include:

- 8 individual throttle controlled electronically via two throttle motors
- Hi-pressure Double VANOS
- Lightweight aluminum block and cylinder heads
- Lightweight valvetrain
- "Semi-dry sump" oiling system



## BMW Motorsport Engine Summary

Designation	# of cyl.	Displacement (Liters)	Output (horsepower)	Vehicle (year)	Comments
<b>S14</b>	I-4	2.3	192 hp	E30 M3 (87-91)	First 4-cylinder Motorsport engine
<b>S38 (M88)</b>	I-6	3.5 (M1) 3.5 (E28/E24) 3.6 (E34)	277hp 256 hp 310hp	M1 (1978-81) E28 (88) E24 (87-88) E34 (91-93)	First production Motorsport engine.
<b>S50US</b>	I-6	3.0	240 hp	E36 M3 (95)	Used in 1995 only
<b>S52</b>	I-6	3.2	240 hp	E36 M3 (96-99) E36/7 M Roadster E36/7 M Coupe	OBD II compliant
<b>S54</b>	I-6	3.2	333 hp	E46 M3 (01-05)	Adjustable Valvetrain
<b>S62</b>	V-8	5.0	394 hp	E39 M5 (00-04) E52 Z8	First V-8 motorsport engine
<b>S85</b>	V-10	5.0	500 hp	E60 M5 (07- ) E63/E64 M6 (07- )	First V-10 motorsport engine
<b>S70</b>	V-12	5.6	375 hp	E31 850CSI (94-95)	Used in the 850Csi
<b>M12/M13</b>	I-4	1.5	over 1100 hp	Brabham BMW F1 BT53 1983	1983 Formula 1 championship winning engine
<b>P84/5</b>	V-10	3.0	over 900 hp	BMW Williams F1	Formula 1 V-10 engine

---

## Formula One Engine

The S85 engine has benefitted greatly from the lessons learned in Formula 1. The F1 counterpart of the S85 is known as the P84/5. This is a 3 liter V-10 which consists of approximately 5000 parts and requires around 100 hours of assembly time.

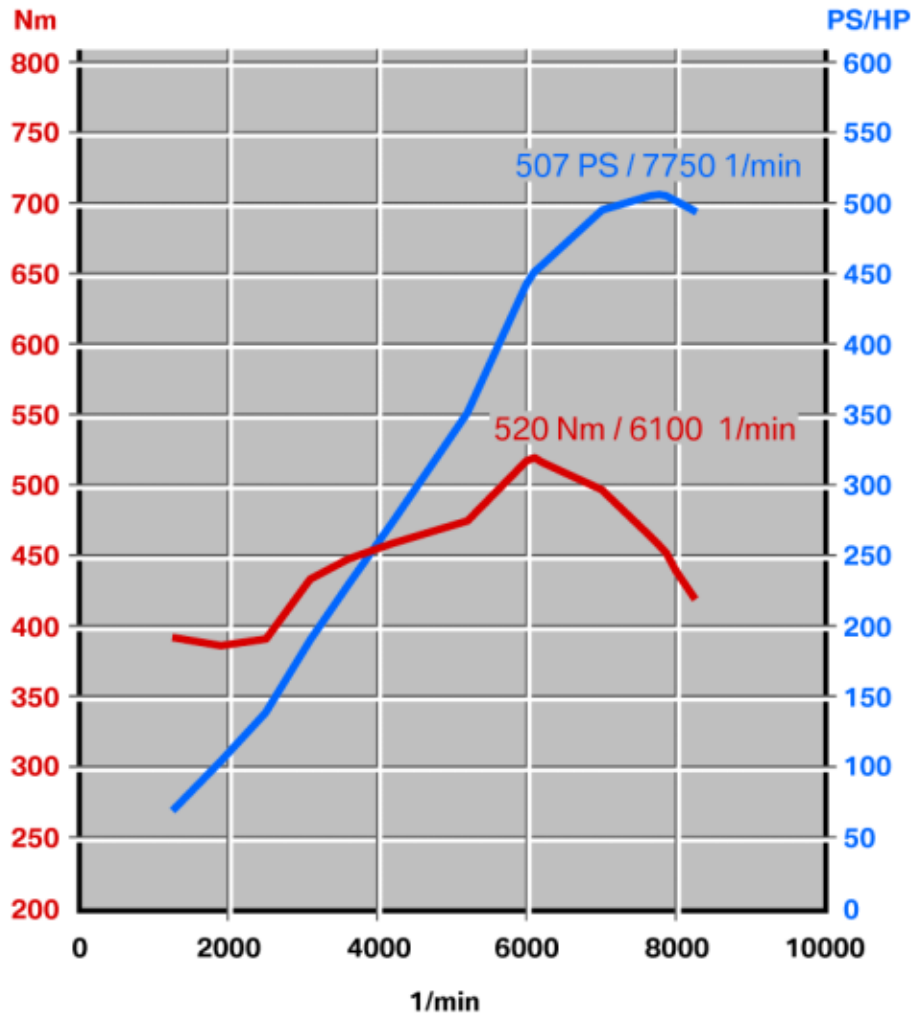


The engine block and cylinder heads are constructed of aluminum alloy and are designed to withstand the demands and stresses of an F1 race. The titanium connecting rods are just one example of components which allow the P84/5 to reach engine speeds of more than 19,000 RPM.

Some interesting facts of the F1 V-10:

- During the design of the F1 V-10 approximately 1000 technical drawing are created.
- The total engine weighs less than 195 pounds.
- The exhaust temperature can reach up to 16,200 degrees Fahrenheit
- The air temperature in the pneumatic valve system can reach 4,500 degrees F.
- Before the recent changes in F1 rules regarding engines, BMW produced about 200 engines per race season.
- The P84/5 engine propels the FW27 F1 car to 120mph in five seconds.
- At 19,000 RPM the following events occur in one second - The engine rotates 316.7 revolutions, the ignition system fires 1,583 times, 9,500 engine speed measurements are made, the pistons covers a distance of 75 yards and nearly 140 gallons of air are drawn into the engine.

## Engine Statistics



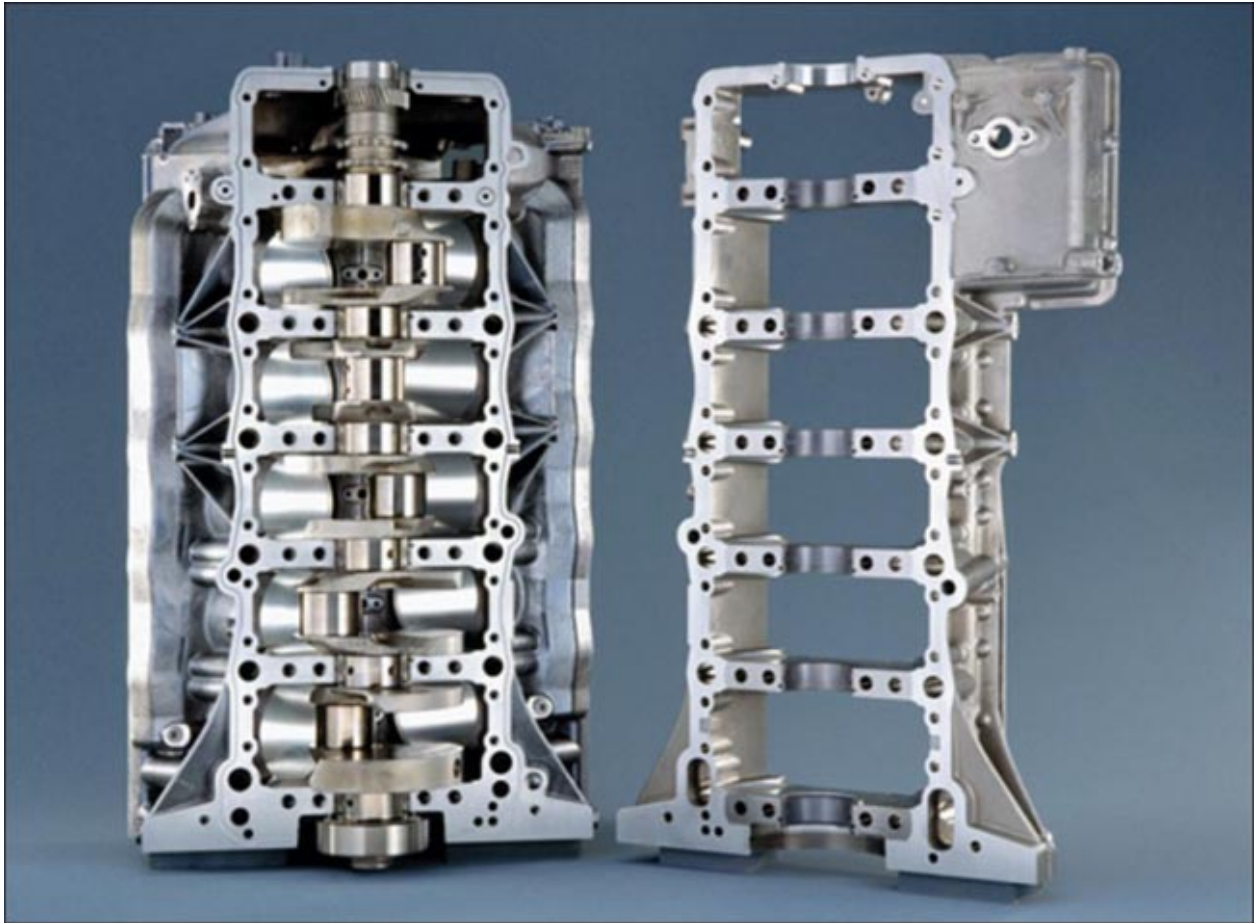
Description	S85 V-10	P84/5 F1 V-10
Engine Configuration	90 Degree V-10, 4 valves per cylinder	90 Degree V-10, 4 valves per cylinder
Displacement	4,999 cm <sup>3</sup> (5.0 Liter)	2,999 cm <sup>3</sup> (3.0 Liter)
Bore and Stroke	92mm X 75.2 mm	Unknown
Horsepower	373kW (500bhp) @7750	900 hp +
Torque	520Nm @ 6100RPM	Unknown
Maximum engine RPM	8250	19,200
Compression	12 to 1	Unknown

---

# Components

## Engine Block and Bedplate

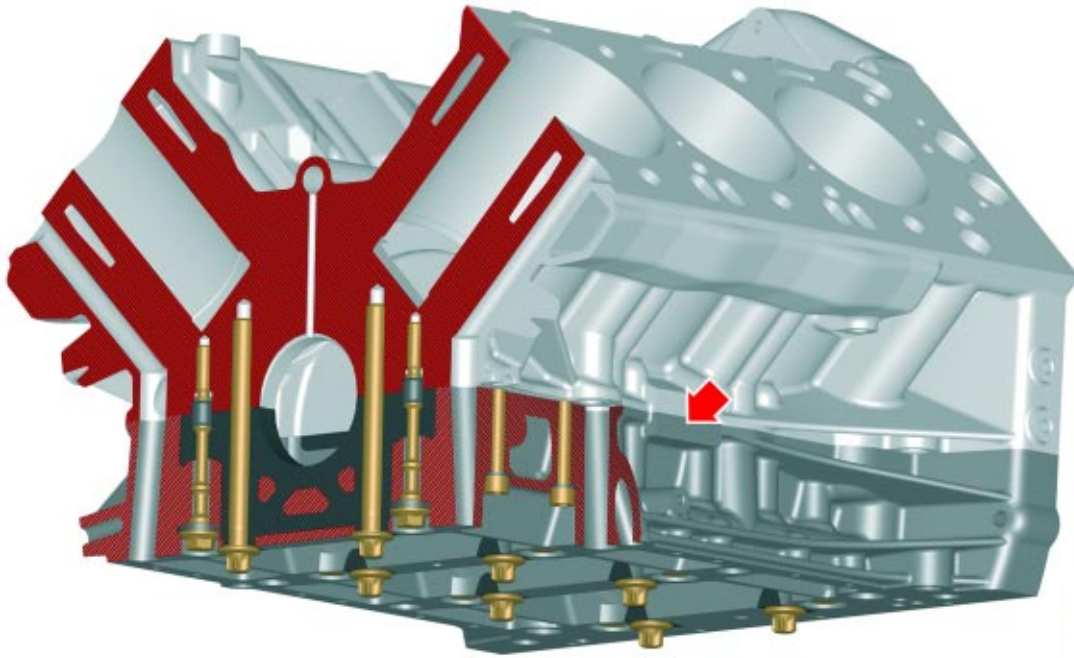
Similar in design to the N52 engine, the S85 takes advantage of the additional stiffening properties of the 2-piece crankcase.



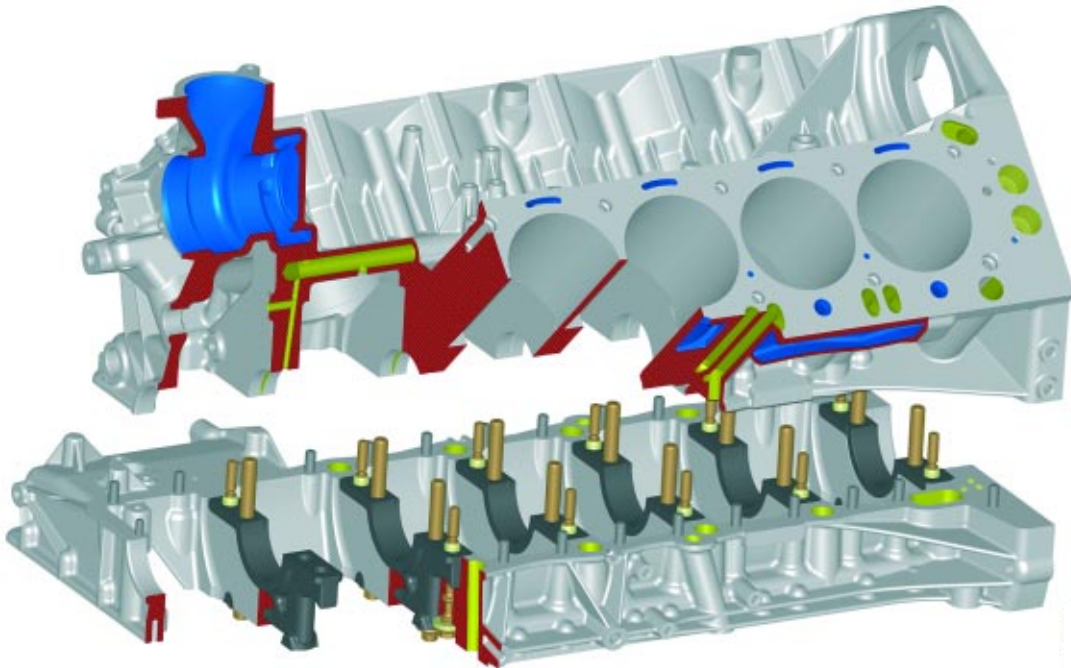
The 10 cylinder crankcase uses the familiar Alusil construction which is split at the crankshaft centerline. The bedplate is machined together with the crankcase and is mounted to the upper section of the crankcase when the engine is assembled. This design contributes to improved torsional stiffness. Better engine acoustics (NVH) are also attributed to the improved stiffness.

Some of the other benefits of the bedplate include the ability to accommodate additional assemblies and to facilitate the assembly of the crankshaft main bearings.

The bedplate assembly contains cast iron bearing bridges which take up additional forces from the pistons and connecting rods. The engine serial number is stamped on the bedplate assembly.

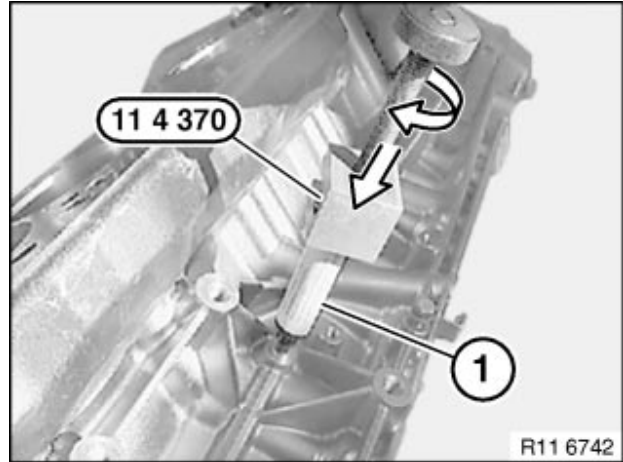
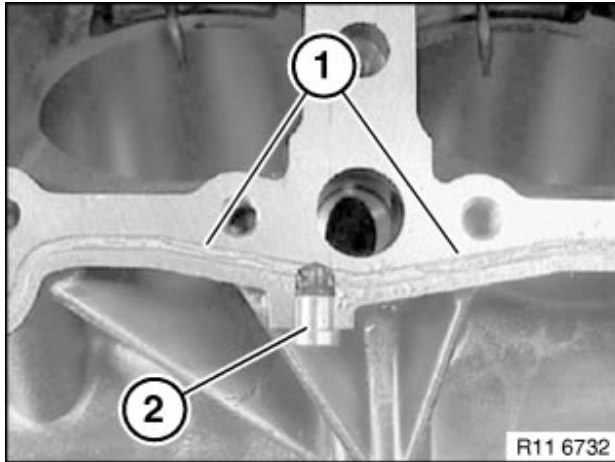


The bedplate is secured to the upper section of the crankcase with the main bearing bolts. The positions are fixed with fitted sleeves. Strict adherence to the bolt tightening procedure is necessary to prevent engine failure.



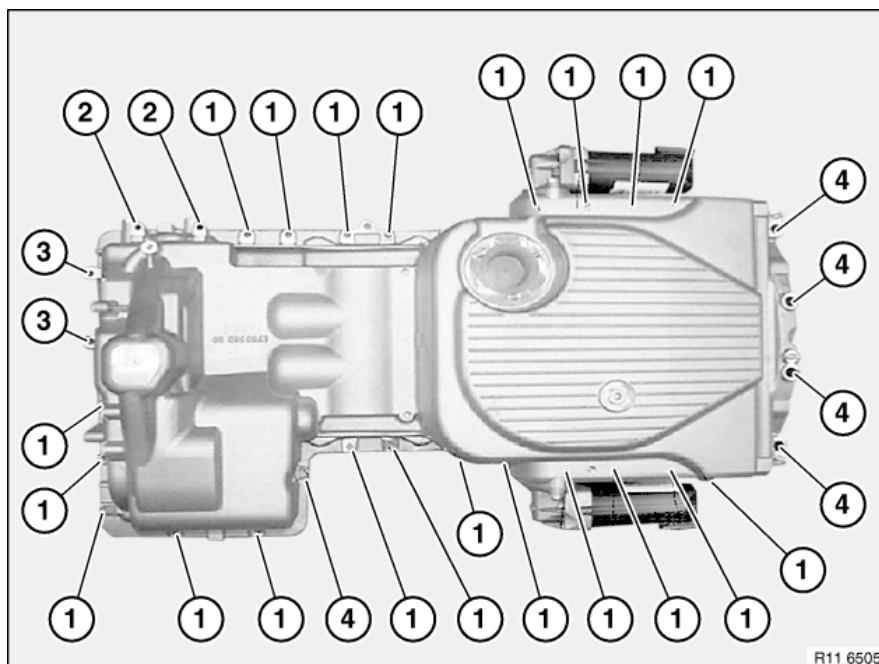
## Bedplate Sealing

As with the N52 engine, the S85 uses the same technique for bedplate sealing. There is a machined groove (1) in the upper part of the crankcase. A liquid sealant is injected into the groove through ports (2) on each side of the crankcase.



## Oil Pan

The oil pan is an all aluminum one-piece design. Due to the configuration of the front subframe crossmember, the pan has a front and rear sump. The oil pan provides the mounting for the electric oil pumps and the oil lines. When removing and installing the oil pan, note the location of the oil pan bolts. There are 4 different types of bolts, each requiring a specific installation location.



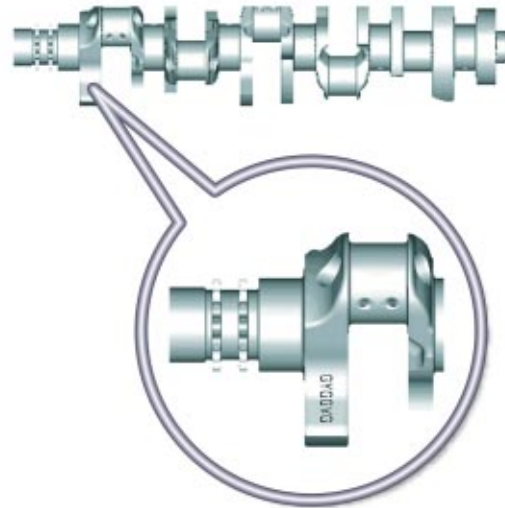


## Crankshaft

The S85 crankshaft is forged steel and has 5 crankpins (journal) each offset 72 degrees apart. The crankshaft is also "nitro-carburized" for increased surface hardness.

The sprocket for the primary chain drive is integrally cast as part of the crankshaft. Also, the drive sprocket for that VANOS high pressure pump is bolted to the crankshaft snout.

The color codes for the main bearing classification are stamped onto the crankshaft.



## Connecting Rods

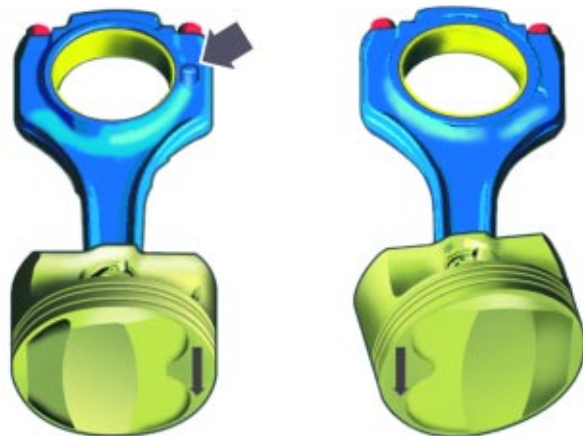
The connecting rods are forged steel and use the "cracked" configuration on the "big end". For weight reduction, the small end of the connecting rod is trapezoidal and uses a tapered piston pin.

The connecting rods weigh 582 grams +/- 2 grams. The rods are also of asymmetrical construction which allows for a narrower connecting rod. The narrower rods contribute to the overall reduction in engine length. The rods can only be installed one way. Refer to repair instructions during installation.



## Pistons

The pistons are cast from aluminum alloy. To promote the optimum friction partner with the cylinder bore, the piston skirt is coated. There is a galvanic ferrous layer at a thickness of approximately 10 microns. There is an additional tin layer of 2 microns that act as the run-in layer.

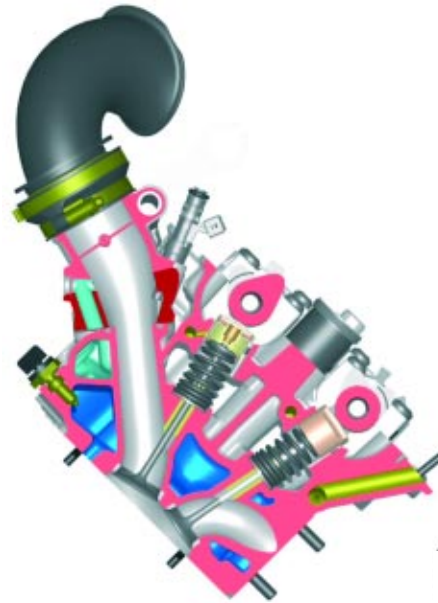


---

## Cylinder Head and Valvetrain

The cylinder head is an aluminum one-piece design to improve overall rigidity. The idle air port and secondary air channel are integrated into the head.

The familiar 4-valve per cylinder arrangement is used on the S85. However there are some additional refinements carried over from racing applications.



### Cylinder Head Cover

The cylinder head cover is cast aluminum with provisions for mounting the ionic current control units as well as the camshaft sensors and components for the crankcase ventilation system.

### Valves

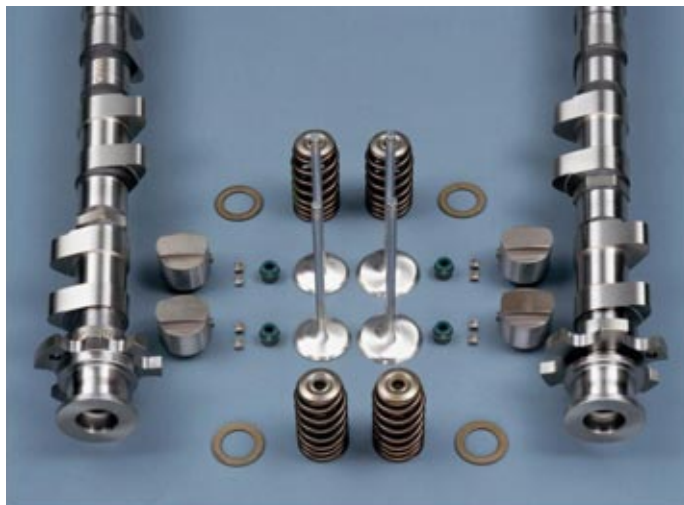
Both the intake and exhaust valves are designed as solid valves with a 5mm stem diameter. The reduced stem diameter not only reduces weight, but also improves airflow qualities.

The intake valve is a one-piece design made from a steel alloy (X45CrSi9-3). In contrast, the exhaust valve is a two piece design. The stem is made from the same steel alloy as the intake valve and is friction welded to the valve head, which is made from different alloy (NiCr20TiAl).

The valve guides are not replaceable. The cylinder head cannot be machined

### Valve Springs

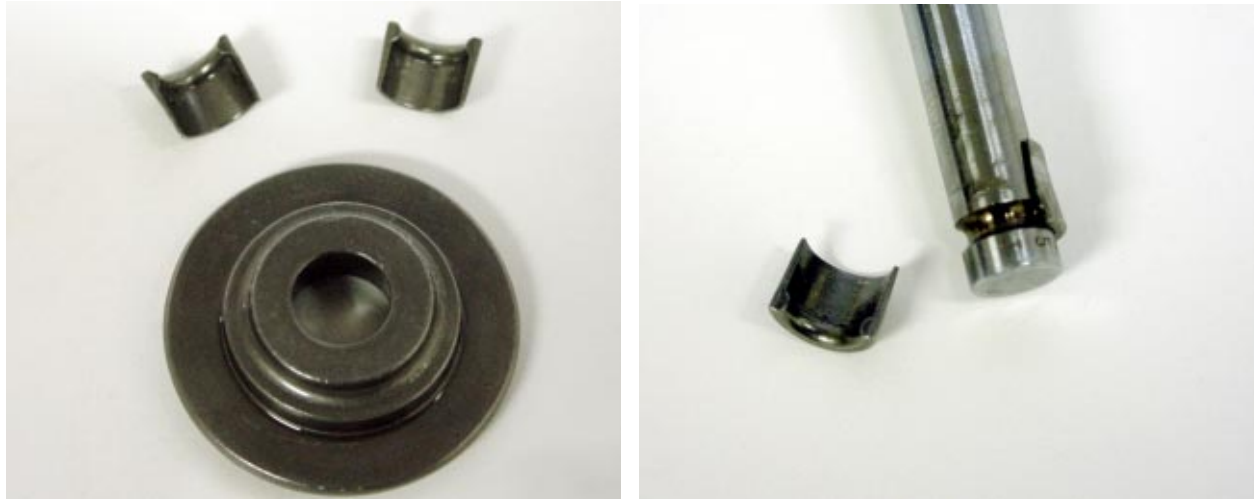
The valve springs are the conical design familiar from past engine designs.



### Valve Keepers (Cotters)

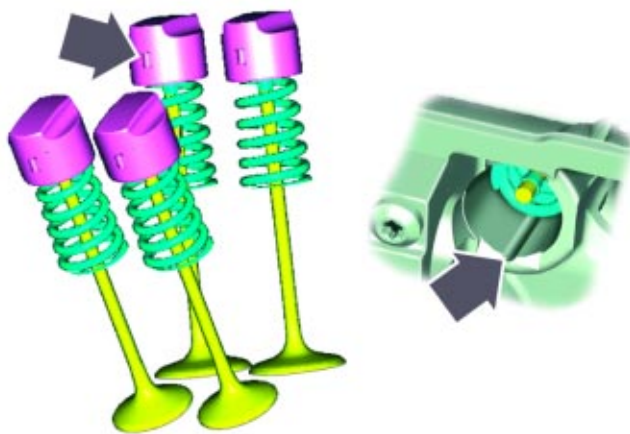
The valve keepers are a single row design rather than the three row design. The single row design is a "clamping type" which prevent the valve from turning during engine operation. The valve turning method is not needed due to the clean efficient combustion and close production tolerances.

The single row keeper is also 50% lighter than the three row design. In addition, the single row design provides less stress on the 5mm valve stems for increased reliability.



### Hydraulic Valve Actuators (HVA)

The HVA assemblies are differently configured from past designs to save weight and improve the frictional characteristics. The new tappet design is referred to as the "box" type tappet. This style of tappet has been used in racing applications. The box tappet does not rotate in the cylinder head, therefore a groove is milled to prevent rotation. A corresponding "anti-torsion" pin is part of the tappet.



---

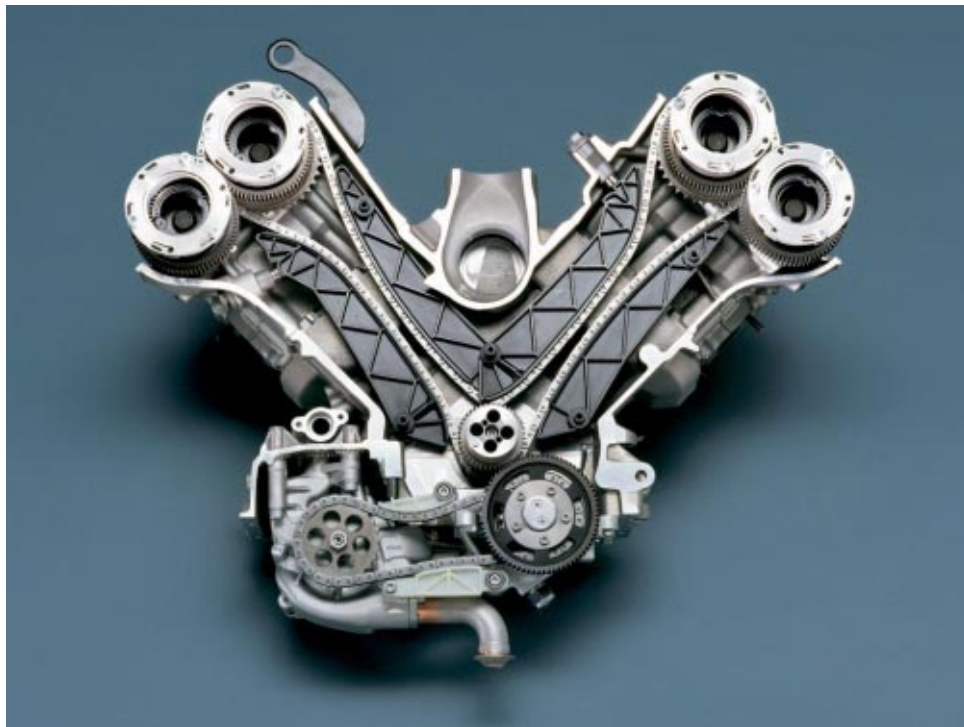
## Camshaft

The camshaft is a “hollow chill” casting (GGG60). In contrast to previous designs, the camshaft sensor trigger wheel is cast as one piece with the camshaft. An M12X1 thread is integrated into the camshaft for the VANOS gear mounting.



## Camshaft Drive

The primary camshaft drive is provided by two timing chains to drive the intake camshafts (one chain for each intake camshaft). The exhaust camshafts are driven by a “gear-to-gear” connection between the intake camshaft sprocket and the exhaust camshaft sprocket.



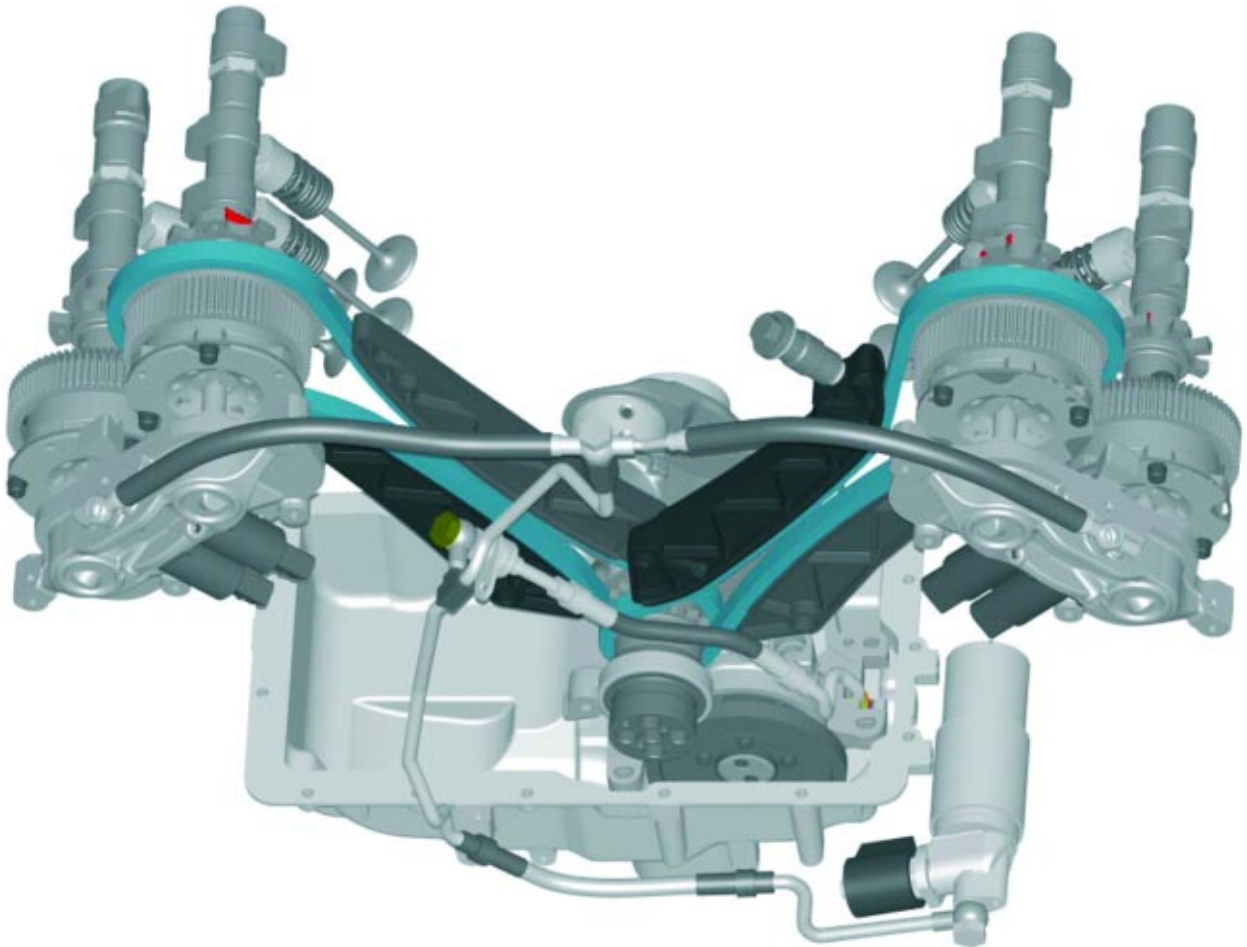
---

## VANOS

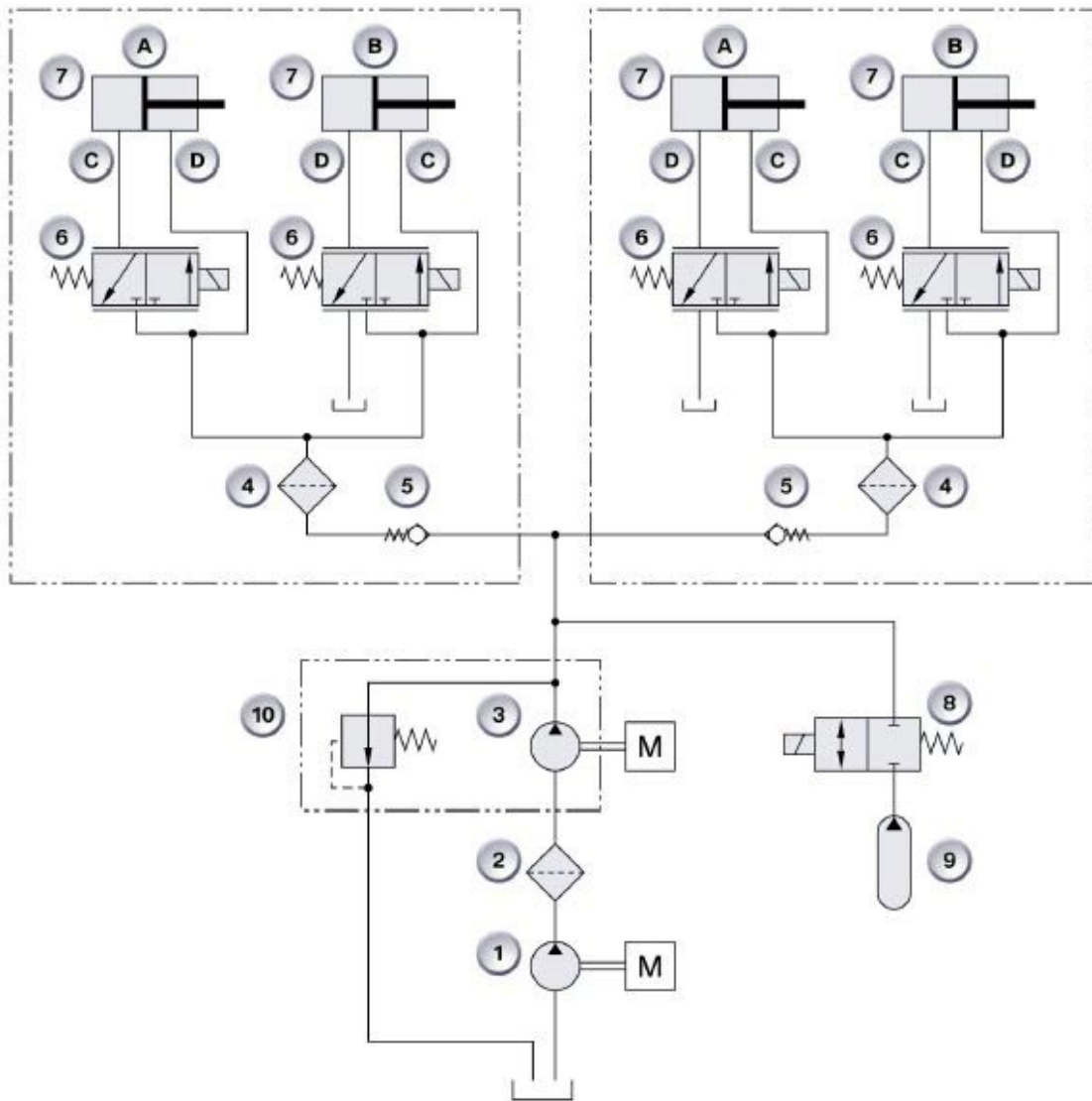
The VANOS system on the S85 is carried over from previous “M-engine” designs with some minor changes. The adjustment range of the intake camshafts is 60 degrees of crankshaft angle and the exhaust camshaft can be adjusted up to 37 degrees (crankshaft).

The S85 VANOS system is operated on the “high-pressure” concept which uses up to 115 bar for VANOS operation.

The VANOS high pressure pump is driven directly from the crankshaft via a gear-to-gear connection. The pressurized oil is routed from the pump via two delivery lines to the two VANOS units. A “T-connection” provides high pressure oil to the pressure accumulator.



## VANOS Hydraulic Schematic

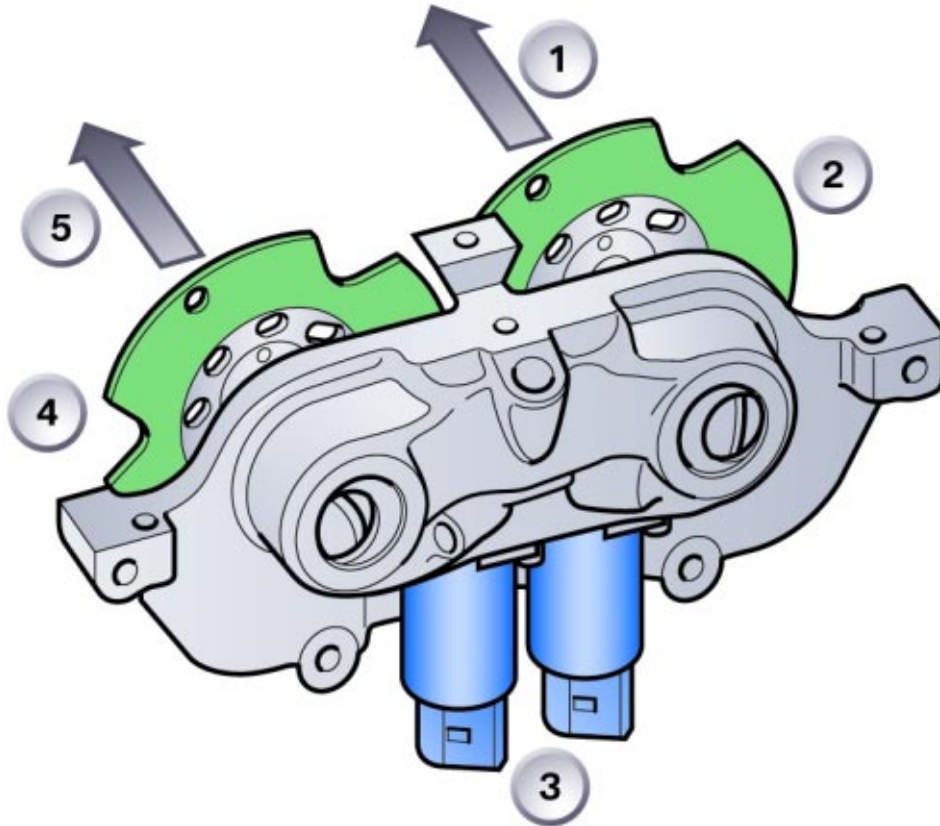


Index	Explanation	Index	Explanation
A	Exhaust	4	Filter (50 micron)
B	Intake	5	Check valve (optional)
C	Advance	6	Proportional valve (3/2-way)
D	Retard	7	Adjustment piston, pressure accumulator
1	Engine oil pump (1-5 bar)	8	Pressure accumulator shut-off valve
2	Filter (80 micron)	9	Pressure accumulator
3	High pressure pump (115 bar - HDP)	10	Pressure relief valve HDP VANOS hydraulic units

## VANOS Actuators

Separate adjustment units are provided for each cylinder bank for the purpose of adjusting the VANOS gear mechanism. These adjustment units are known as the actuators. The VANOS high pressure pump supplies them with oil under high pressure.

Since the exhaust camshaft is driven via a gear-to-gear connection, the intake and exhaust camshaft rotate in opposing directions, the intake is adjusted towards advance and the exhaust towards retard when the plunger extends.



Index	Explanation	Index	Explanation
1	Adjustment direction, advance	4	Exhaust
2	Intake	5	Adjustment direction, retard
3	Plug contacts for solenoid valves		

The adjustment pistons are designed as double-acting cylinders and differ with regard to the adjustment range for the intake and exhaust camshafts.

The stroke range on the exhaust side of maximum 14.25 mm corresponds to 18.5° camshaft angle (37° crankshaft angle). The stroke on the intake side of maximum 25.25 millimeter corresponds to 30° camshaft angle (60° crankshaft angle).

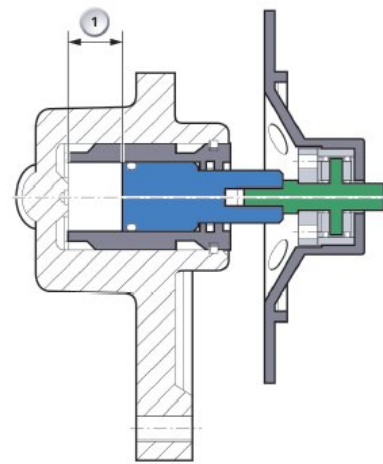
When extended into the two piston chambers, the adjustment pistons are subject to a system pressure of 115 bar. They therefore extend only due to the different piston surface areas.

The oil from the small piston chamber is transferred into the high pressure circuit. The proportional valve must be fully actuated in order to extend the adjustment piston.

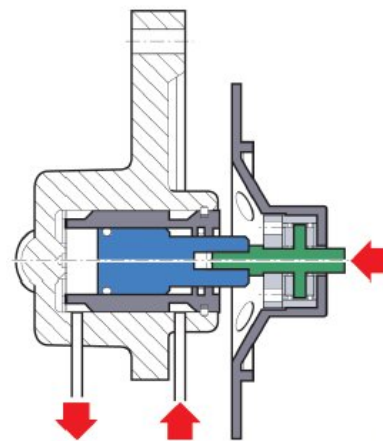
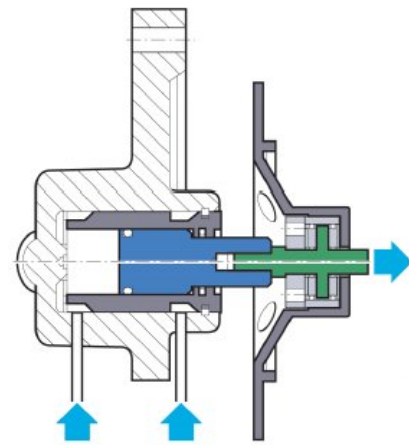
The holding function and piston retraction are achieved by reducing the oil feed on the side with the largest piston surface area by partly actuating the proportional valve.

The reduced oil feed decreases the oil pressure, thus initiating a change in the forces exerted on the adjustment pistons.

The retraction movement of the adjustment pistons is supported by the camshafts as they push back the spline shafts in the hydraulic units due to the helical gearing in the VANOS gear mechanism.



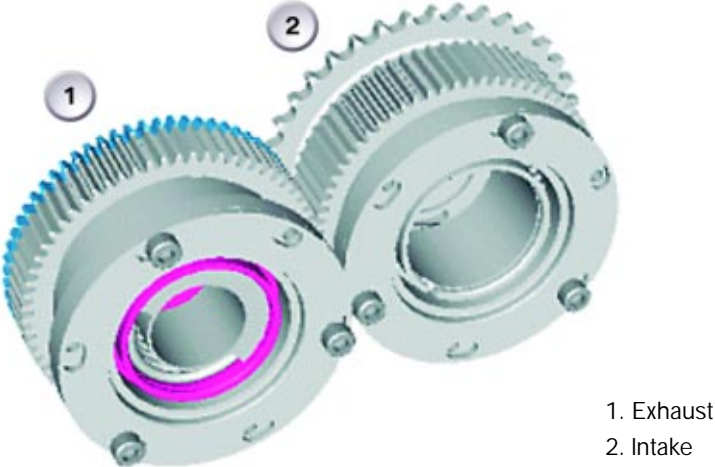
1. Stroke range of adjustment piston



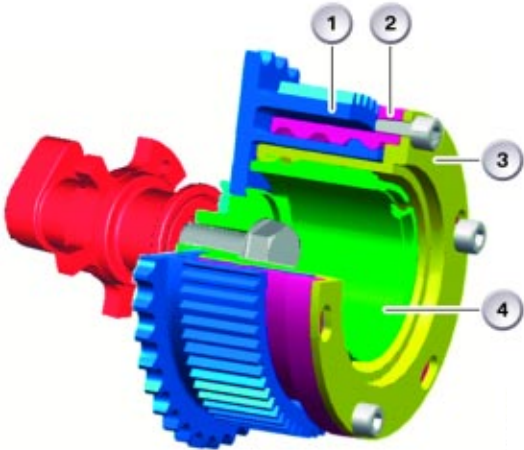


**VANOS Gear Mechanism**

The VANOS gear mechanism (transmission) connects the crankshaft with the intake camshafts via a chain sprocket. The intake VANOS gear mechanism also provides the drive mechanism for the exhaust camshaft via a gear-to-gear connection. The gear mechanism also permits "torsion" of the camshafts. The gear mechanisms for the intake and exhaust sides differ in terms of the exterior structure of the gear and chain drive while the adjustment mechanism on the inner side is identical.



The gear mechanism is driven by the drive gearwheel that interacts with the helical gearing on the inner sleeve. The threaded connections for the gearing connects the inner sleeve to the outer sleeve. With (wide) helical gearing, the inner sleeve acts on the bearing assembly for the drive gearwheel that is firmly secured to the camshaft with the central bolt.



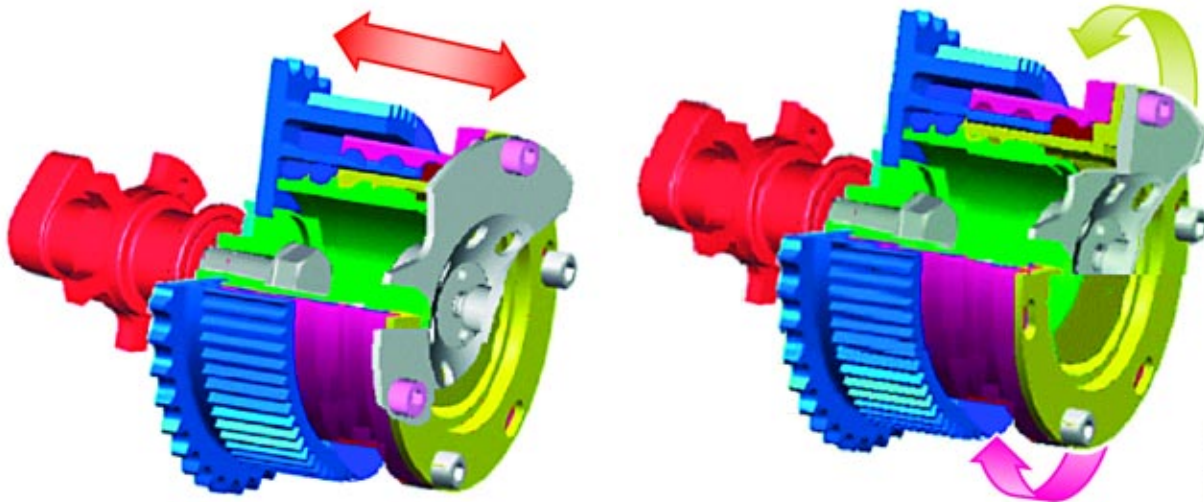
Index	Explanation	Index	Explanation
1	Drive gearwheel assembly	3	Outer sleeve
2	Inner sleeve	4	Bearing for drive gearwheel

---

The actuator (adjustment unit) is connected to the outer and inner sleeve by the screw connection of the gear mechanism. During adjustment, the inner sleeve and outer sleeve are pulled out of and pushed into the gear mechanism.

The inner sleeve is turned by the helical gearing on the "fixed" drive gearwheel (timing chain drive). Due to the non-positive screw connection of the outer sleeve, this sleeve also turns. In connection with a further helical gear, the outer sleeve now turns the bearing for the drive gearwheel and in turn the camshaft connected with the central bolt.

The gear units are mounted in their base position, i.e. pulled apart. The camshafts are adjusted when the gear units are pushed together. The drive gearwheel and bearing for the drive gearwheel are connected by a torsion spring to assist the return movement.

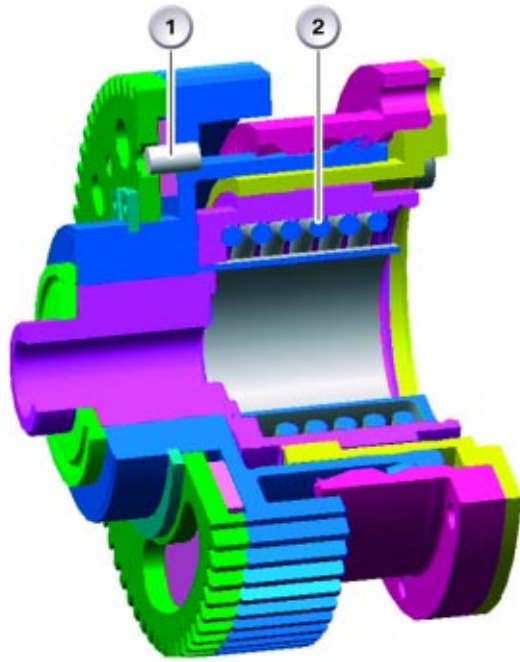


**Intake gear mechanism adjustment direction**

**Direction of rotation during adjustment**

The mounting screws for the gear mechanism are tightened only lightly when assembling the actuators. As a result, no force is transmitted from the outer sleeve to the inner sleeve when sliding the actuators onto the cylinder head (to facilitate the sliding movement of the gear unit). Due to the "fixed" drive gearwheel, the outer sleeve turns in the direction of engine rotation. At the same time the "fixed" bearing for the drive gearwheel turns the inner sleeve opposite the direction of engine rotation.

The exhaust camshaft is driven by the intake camshaft in connection with a gear drive mechanism. The drive gearwheel is split in two in order to avoid gearing noises caused by a change in the driving tooth profile in connection with a change in load. A disc spring turns the two halves of the gearwheel in opposing directions (functional principle similar to dual-mass flywheel) so that both tooth profiles of the exhaust gearwheel always rest on the intake gearwheel under all load conditions.

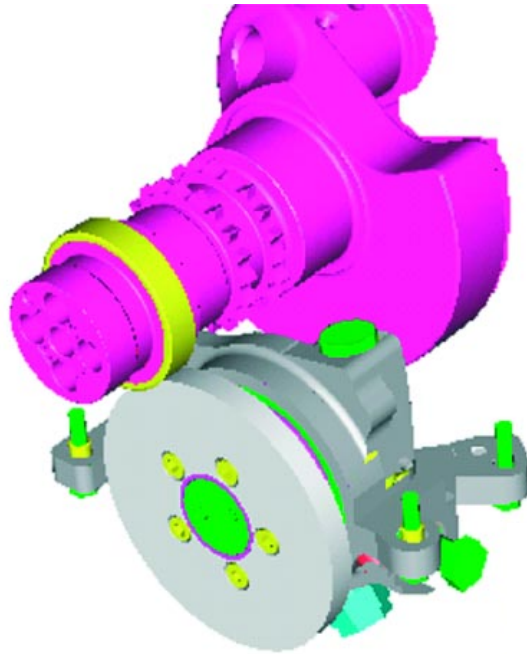


Index	Explanation	Index	Explanation
1	Annular spring	3	Lock screw
2	Torsion spring	4	

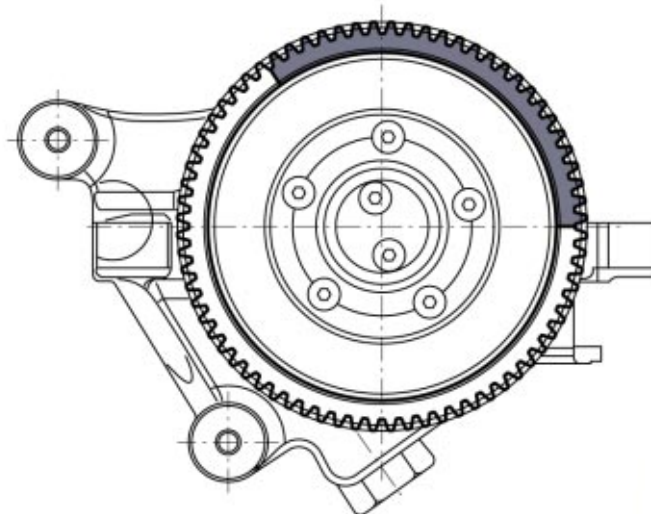
---

### **VANOS High Pressure Pump**

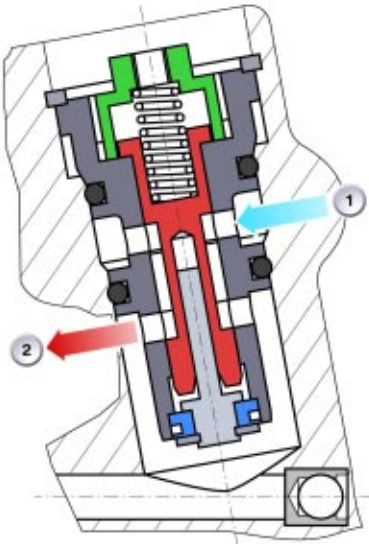
The high pressure pump is designed as a radial piston pump with five pump plungers. It is driven via a gear mechanism directly by the crankshaft. To avoid gearing noise, when mounting the sprocket of the high pressure pump, the coated part must face towards the crankshaft without any clearance. The correct gear clearance is then established automatically by the coating scraping off.



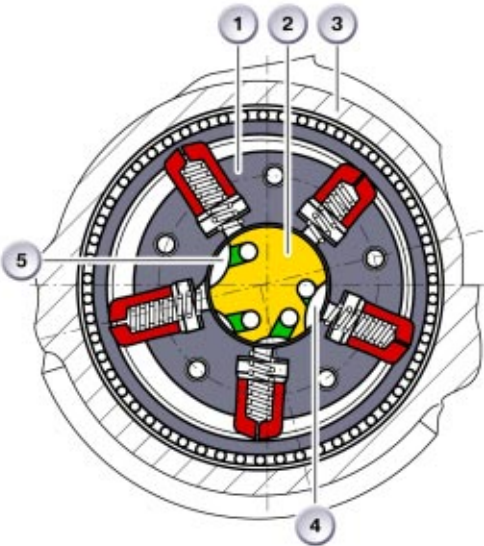
The high pressure pump receives its oil supply from the bedplate. An 80 micron fine filter is installed in the transition hole from the bedplate to the high pressure pump. This filter has the sole purpose of holding back any impurities that may accumulate during series production and is not replaced during vehicle operation.



A feed valve in the high pressure pump ensures a constant supply of oil over the entire pressurized engine oil range.



The high pressure pump consists of the fixed stator about which the rotor rotates. Five moving plungers are mounted in the rotor. The stator and rotor are installed off-center in the pump housing. The plungers are guided radially as the rotor rotates thus producing the pump stroke motion.

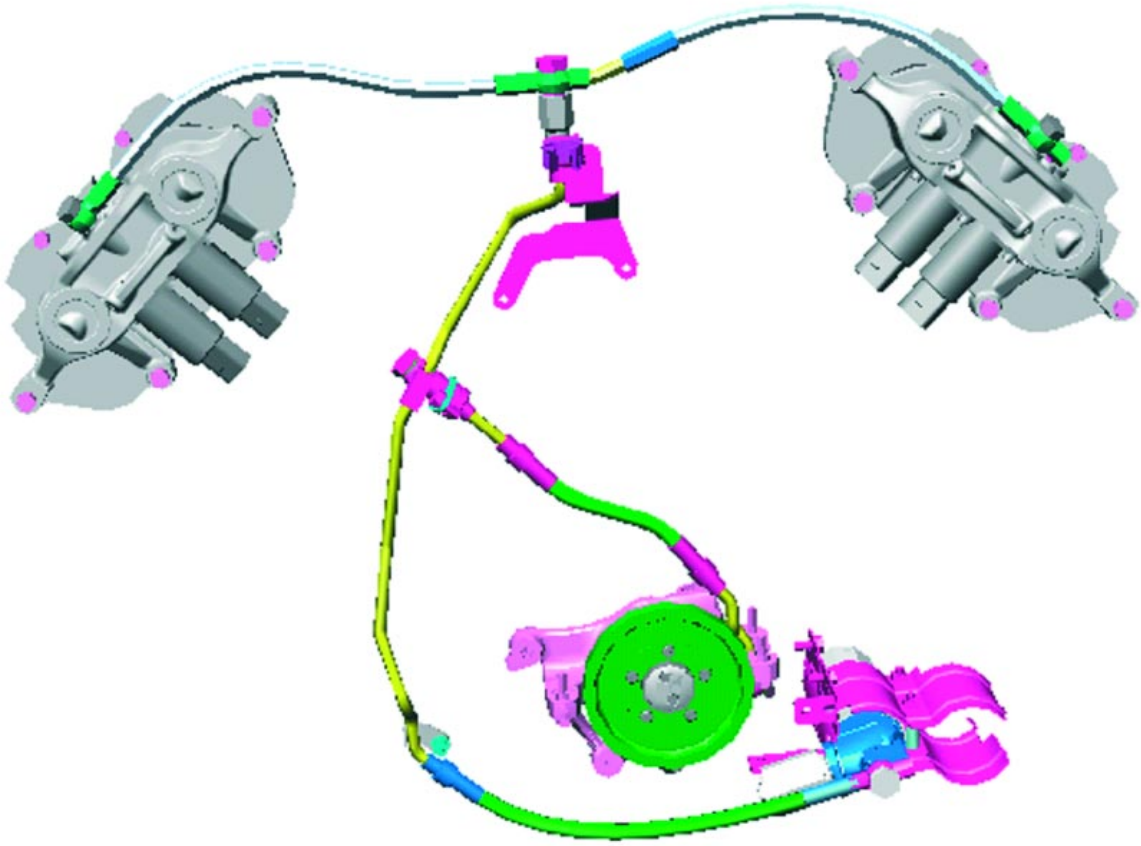


Index	Explanation	Index	Explanation
1	Rotor	4	Engine oil is supplied by the stator and taken up by the pistons
2	Stator	5	Engine oil is compressed and returned to the stator at 115 bar.
3	Pump housing		

---

The pressure relief valve integrated in the high pressure pump opens in response to pressure peaks in the high pressure system and opens up a bypass to the oil pan.

The oil pressurized at 115 bar is routed via three delivery lines to the two VANOS control units and to the pressure accumulator.



---

## Intake Plenum (Manifold)

The S85 features a separate intake air plenum for each cylinder bank that is mounted with hose clips on the throttle valve assemblies.



1. Cyclone separator

Cyclone separators are installed in the intake air plenums in the area of the fifth and tenth cylinder. The oil from the oil separators and the condensate from the manifolds merge in two channels in the crankcase behind the tenth cylinder and routed into the oil sump.

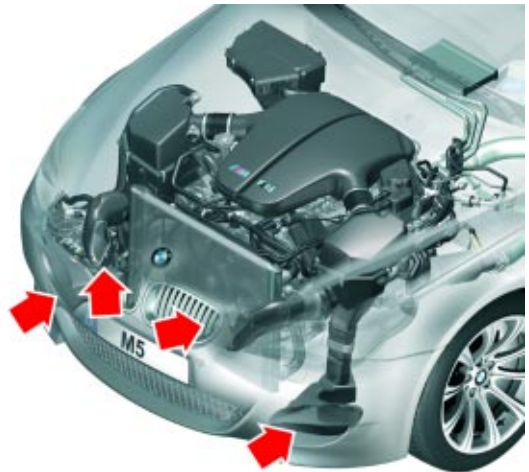
The design of the intake air manifold is similar to that mounted on the S54. The shells are also made from PA66 on the S85 but they are joined together by a butt-welding process.

### Intake Silencers

The air to the intake silencers is drawn in via two routes. One from the area behind the kidney grille and the other from the large air inlets in the bumper.

The S85 requires four air ducts in order to achieve maximum output. A large cross section is not possible due to space reasons.

In the US version, the air cleaner element is additionally equipped with an activated carbon filter. This filter serves the purpose of ensuring no vapors containing hydrocarbons can escape from the intake area into the environment when the vehicle is stationary.



---

## Throttle Valves

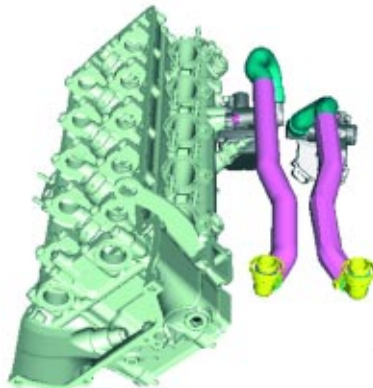
10 individual throttle valves control the air supply for the S85. The individual throttle valves of each cylinder bank are operated separately by an actuator unit and operating shaft. The actuator motors operate independently.

The throttle valves are set with respect to each other (as on S54). There are no facilities for the synchronization of the cylinder banks with respect to each other as well as for setting the full load stop. The necessary corrections are undertaken by the engine management (see section entitled Engine Management MS S65).



## Idle Control

The idle speed is controlled by two idle speed actuators that route the intake air from the intake air manifolds directly into the idle air port of the respective cylinder head. Each cylinder bank is controlled individually.

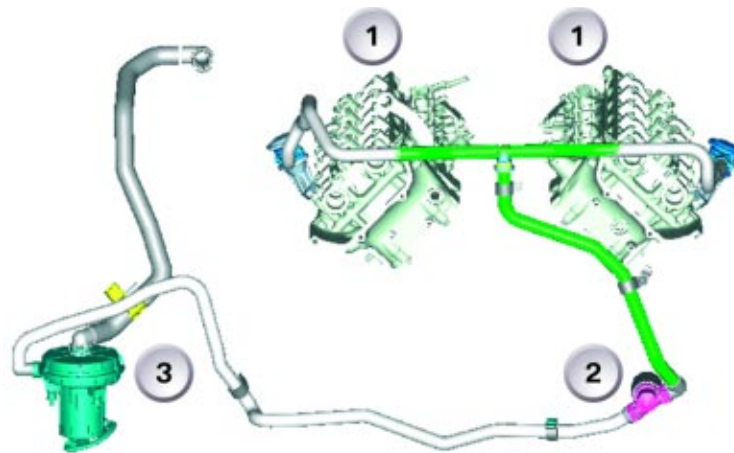




## Secondary Air System

In order to comply with LEV II standards, the S85 uses a secondary air system. The secondary air system helps reduce HC emissions during the cold start period. The catalyst warm-up time is also reduced.

The secondary air is injected into the exhaust ports via pressure controlled diaphragm valves on the cylinder heads. The air from the secondary air pump is routed through channels in the cylinder heads.



Index	Explanation	Index	Explanation
1	Diaphragm valve	3	Secondary air pump
2	Hose junction		

## Exhaust System

The S85 is equipped with stainless steel exhaust manifolds. The manifolds are “hydroformed” and feature equal length tubes with a wall thickness of 0.8 mm. The tubes are configured as a 5-into-1 design with one “near-engine” catalyst per cylinder bank.

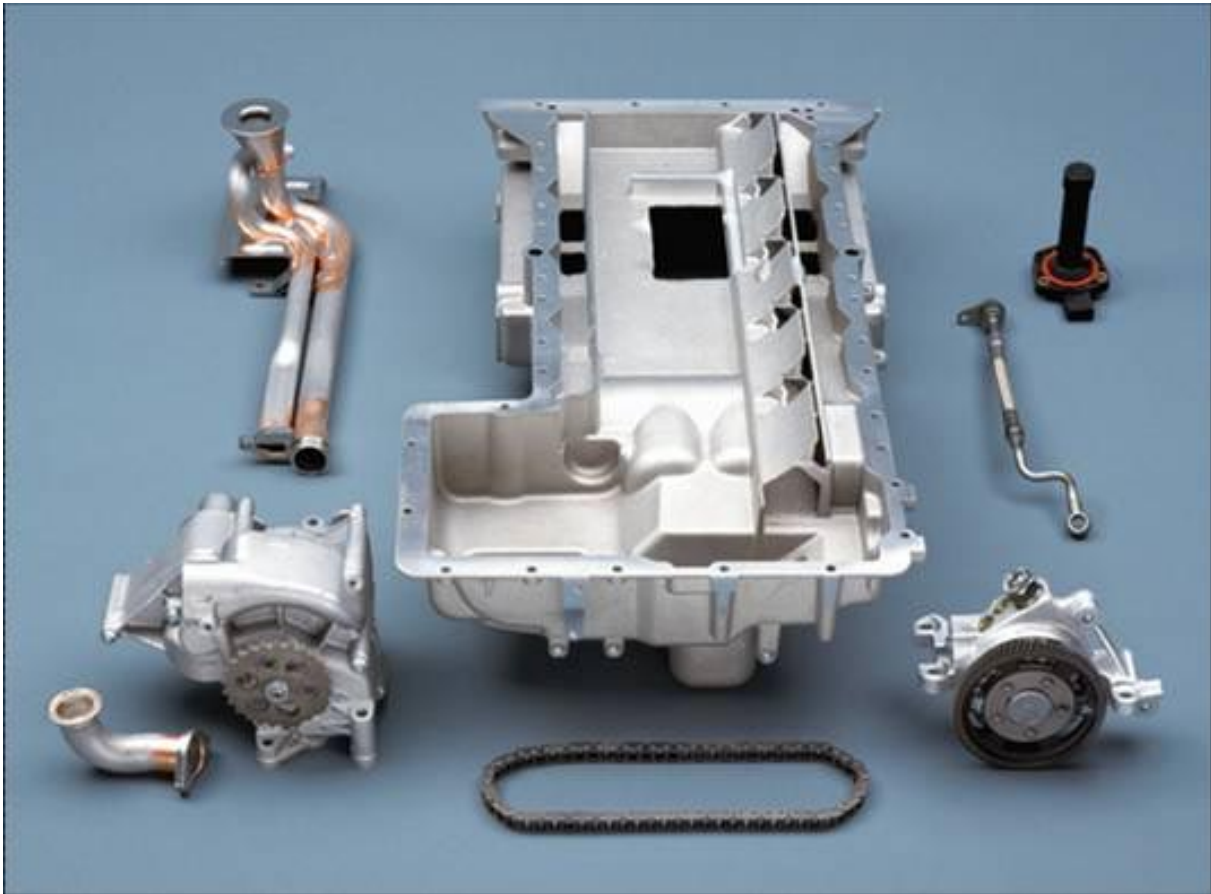
There are 2 pre-catalyst oxygen sensors for mixture control which are Bosch LSU 4.9. The two post-catalyst O<sub>2</sub> sensors are Bosch LSF25. In addition there are 2 exhaust gas temperature sensors (one for each bank) for catalyst protection.



---

## Lubrication System

The S85 is equipped with a quasi-dry sump. For this reason, a suction pump is used to pump the oil out of the oil pan in the area ahead of the rack and pinion power steering gear into the rear oil sump. From here, a controllable slide valve pump conveys the oil at a maximum pressure of 5 bar into the oil filter. A thermostat that enables the path to the engine cooler is additionally located in the oil filter head.



The oil is then routed from the oil filter into the engine. Here it is divided over three lines to the two cylinder heads and to the crankcase.

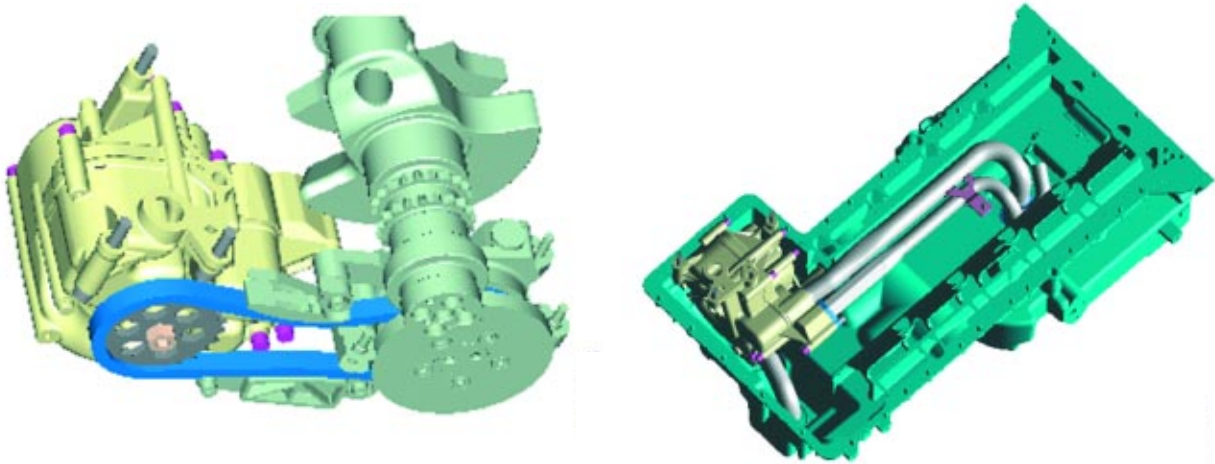
A special feature of this system are the two electrically driven oil pumps that are located on the left and right of the oil pan. The electric oil pumps start up at a transverse acceleration of 0.8 G and pump the oil from the cylinder heads which, under these centrifugal force conditions, would otherwise no longer flow back into the oil pan.

The crankcase is ventilated each with by a cyclone separator in the intake air manifold. The return flow line from the oil separator and the condensation return flow lines from the intake air manifolds are routed along the 6-10 cylinder bank of the crankcase into the oil sump.

## Oil Pumps

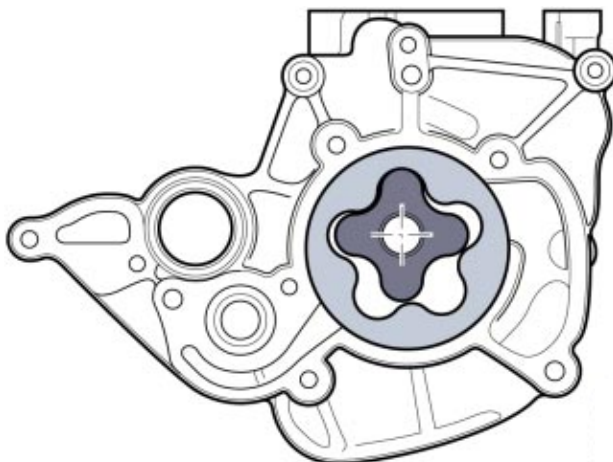
Due to the race-inspired design of the S85 engine, the lubrication system has been adapted to meet the oiling needs during all operating conditions.

The primary oil pump is driven from a chain connected to the high pressure VANOS pump (which is driven via the gear-to-gear connection with the crankshaft). The oil pump housing accommodates two oil pumps. One of the pumps is a duocentric design which pumps oil from the front oil sump to the rear oil sump. This ensures that oil is in the rear sump at all times especially during hard braking.

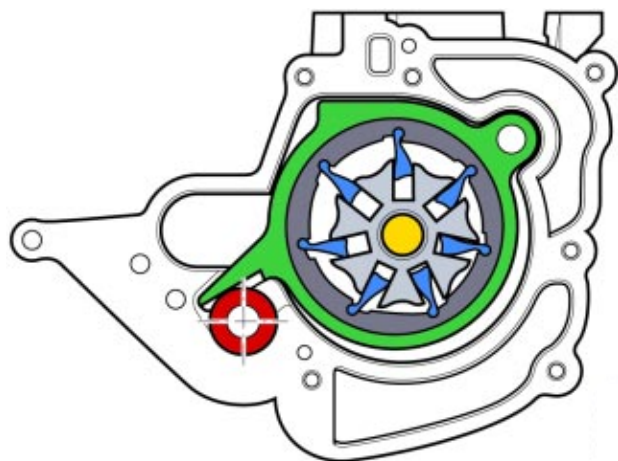


The other pump is a slide-valve design which has a variable displacement capability. The slide valve pump takes the oil from the rear sump and conveys it to the oil filter at a variable pressure of up to 5 bar.

Duocentric Oil Pump



Slide Valve Oil Pump

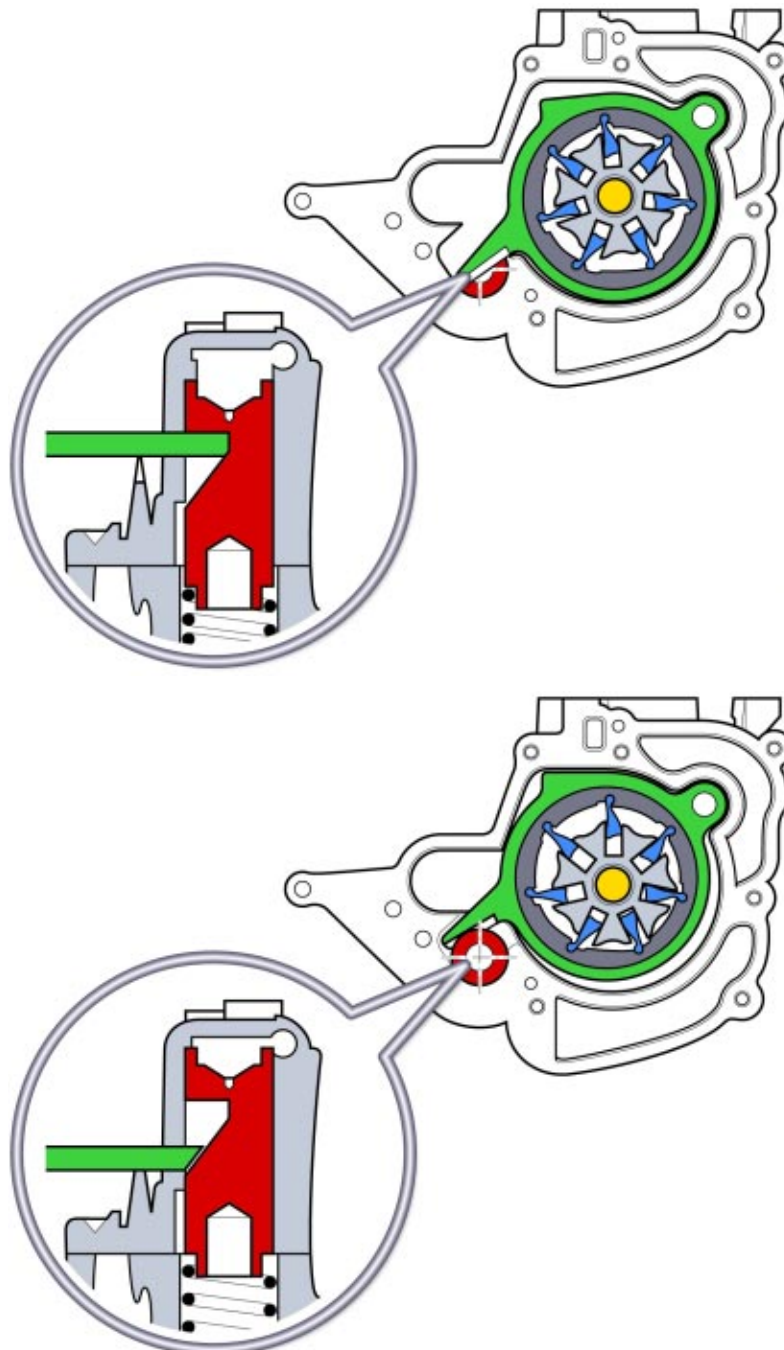


---

The pump outlet is determined by the eccentricity of the pendulum-type slide valve. No oil is delivered when the pump runs centrally with respect to the rotor as all pump chambers are the same size.

The slide valve is displaced by an inclined piston. This piston is in equilibrium between the piston spring and the engine oil pressure.

The greater the engine oil pressure, the more the piston is pressed against the spring and the more the slide valve turns in the direction of 0 delivery.



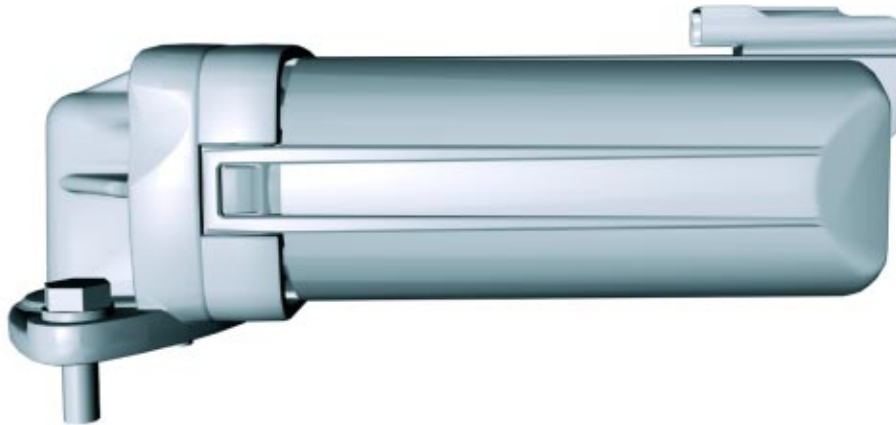
---

## Electric Oil Pumps

When cornering at high speeds, the centrifugal force forces the engine oil into the outer cylinder head so that it can no longer flow back into the oil pan of its own accord.

It must therefore be pumped off by the respective oil pump and returned to the oil sump. The electric oil pumps are activated by the engine control unit that determines the cornering speed with a yaw rate sensor.

The electric oil pumps are protected by heat shields from the heat radiated from the exhaust manifolds.



## Oil Spray Nozzles

Double-hook oil spray nozzles are used on the S85 for the purpose of cooling the piston crown. The oil spray nozzle is equipped with an integrated pressure control valve.

Opening pressure: 1.8 to 2.2 bar

Closing pressure: 1.3 to 1.9 bar

## Oil Filter Housing

A thermostat that opens the path to the engine oil cooler is mounted in the head of the oil filter housing.

The filter housing is located behind the front bumper on the right side, near the secondary air pump.

The underbody panels must be removed during an oil service to access the oil filter.



---

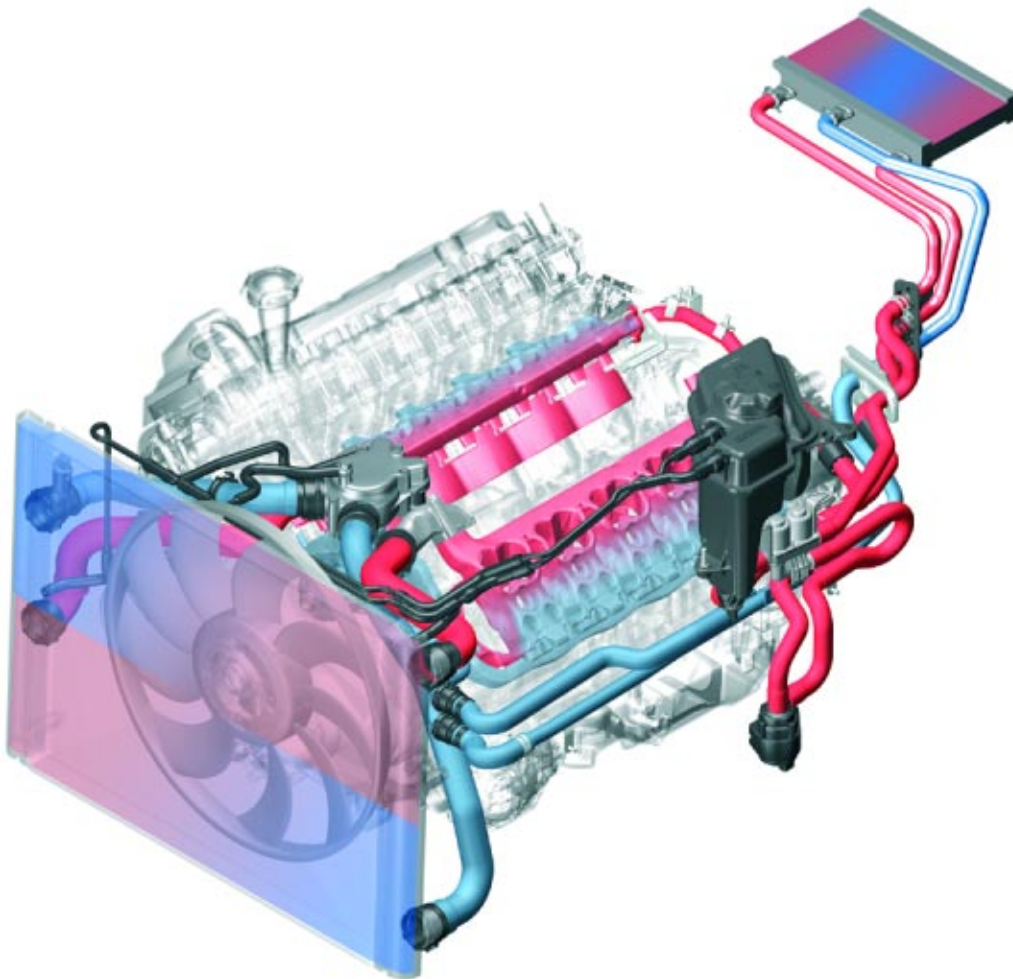
## Cooling System

The cooling system uses the cross-flow technique, however there are some changes over previous systems. For instance, each cylinder head has its own radiator feed and the coolant thermostat is located in the return flow line.

The radiator is divided into an upper and lower water tank. Coolant emerges from the Bank II (6-10) cylinder head through the upper water tank. Bank I (1-5) flows through the lower water tank.

The split cooler design makes it necessary to provide three bleeder opening and two bleeder lines to ensure adequate self-bleeding of the system.

The tap-off point for the heating system is located at the rear of the cylinder heads. The heating return line and the line to the expansion tank merge at a "T-connection" ahead of the water pump.

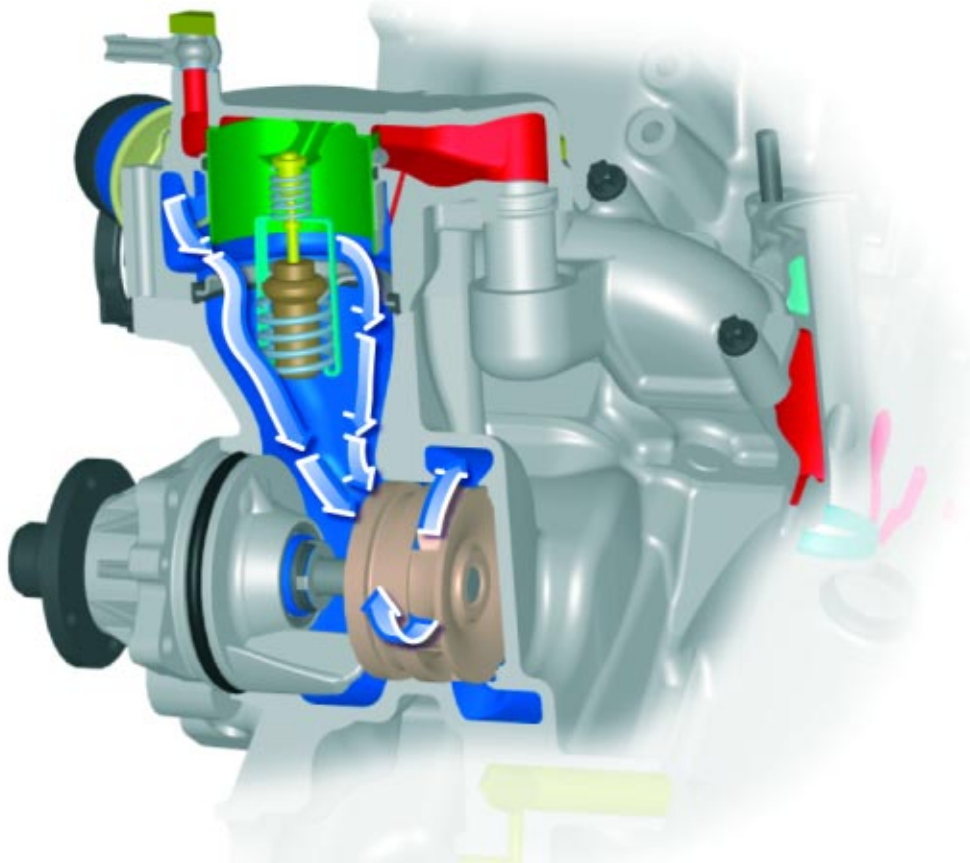


---

## Radiator

The radiator of the S85 is divided into an upper and a lower tank. The lower tank serves the purpose of cooling the coolant from Bank I (Cyl 1-5) while the upper water tank is responsible for cooling the cylinder Bank II (Cyl 6-10).

Due to the split design, it has been possible to reduce the pressure drop in the radiator from approximately 3 bar to approximately 1.4 bar.



## Thermostat

Due to the two-part cooling concept, the thermostat has been relocated to the return line. It is designed as a conventional thermostat that opens at a temperature of 79°C.

The coolant from the cylinder head enters the outlet for the radiator feed and from here it is routed both via the double o-ring carrier into the thermostat as well as into the coolant supply hoses.

## Water Pump

The water pump is belt driven and it is located directly below the thermostat housing.

---

## Classroom Exercise - Review Questions

1. Where are the color codes for the main bearing classification?

---

---

---

---

2. What is unique about the valve and valve keepers?

---

---

---

---

3. What are the advantages of a "box type" tappet?

---

---

---

---

4. What is unique about the camshaft drive mechanisms?

---

---

---

---

5. What drives the VANOS high pressure pump?

---

---

---

---



---

## Classroom Exercise - Review Questions

6. Describe the oiling system on the S85: (i.e. how many pumps, what are the functions of the oil pumps etc.)

---

---

---

---

7. Where is the oil filter located?

---

---

---

---

8. What is unique about the cooling system?

---

---

---

---

9. Describe the construction of the crankcase:

---

---

---

---

10. What is meant by an "asymmetrical" connecting rod?

---

---

---

---



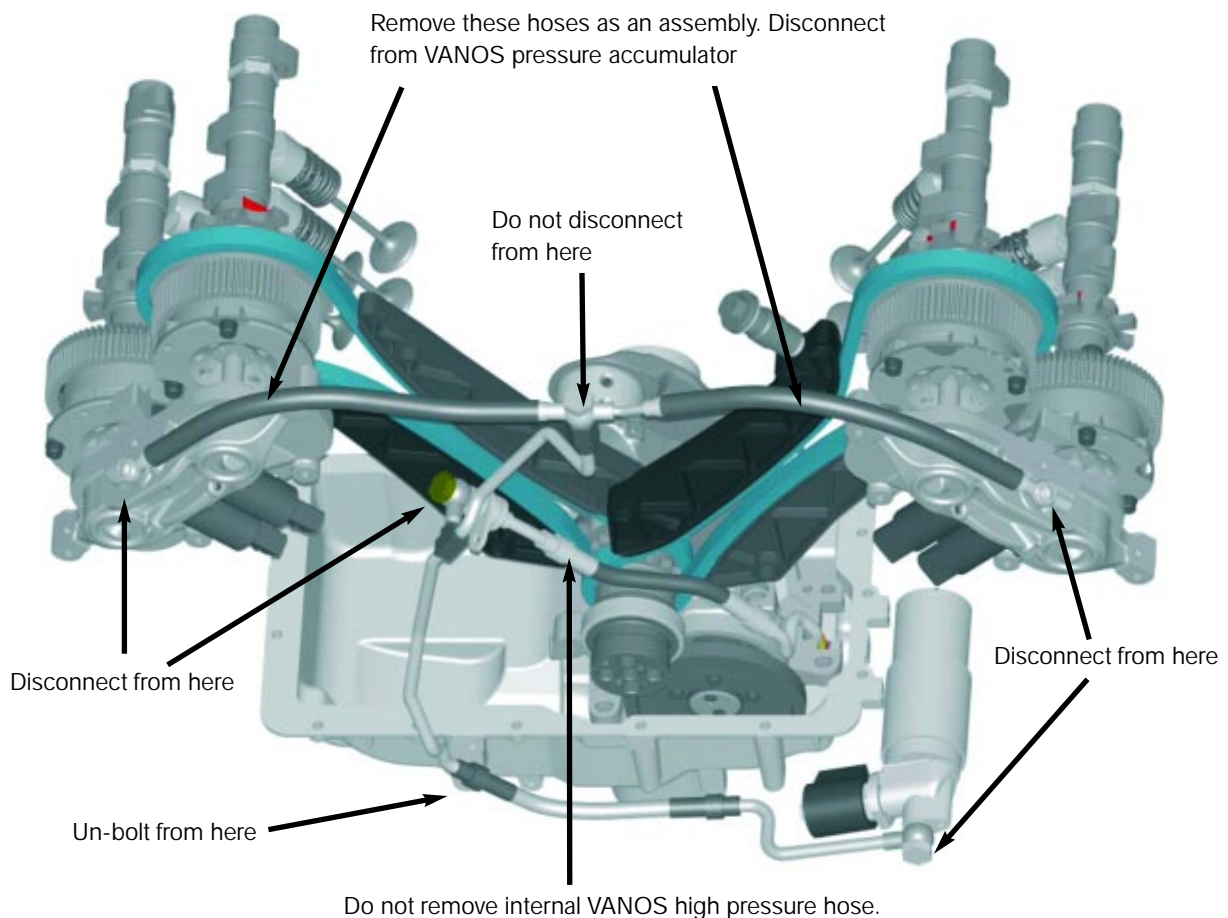
## Workshop Exercise - Engine Disassembly

Using the instructor designated S85 engine trainer, remove the left and right intake air manifolds (plenum). Remove plastic trim covers from the cylinder head covers. Remove ignition coils and ionic current control units. Then proceed to remove **both** cylinder head covers using proper repair procedures.

What should be noted regarding the spark plug tubes?

What is the purpose of the ground strap between the cylinder head cover and the engine block?

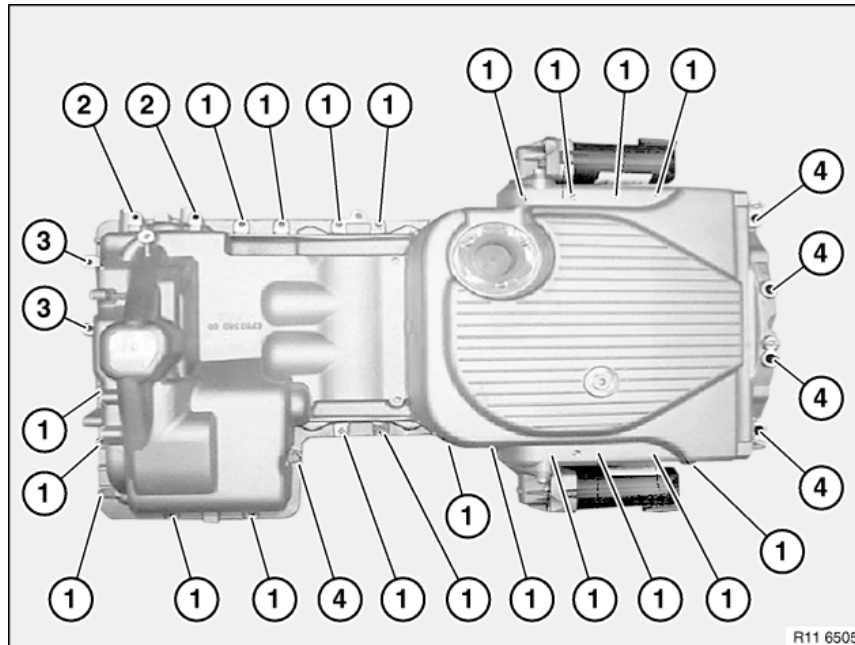
Proceed and remove VANOS high pressure hoses and the VANOS pressure accumulator. (Do not remove internal VANOS high pressure hose)





## Workshop Exercise - Engine Disassembly

*Invert engine on stand to remove oil pan. Pay close attention to bolt arrangement.*



*Complete chart below by filling in oil pan bolt descriptions:*

Bolt #	Bolt Description (type and amount)
1	
2	
3	
4	

*Once oil pan removal is complete, remove engine oil pump and VANOS high pressure pump.*

What is the purpose of the shims under the VANOS high pressure pump?

---



---



---

What is the specification for VANOS pump gear backlash?

---

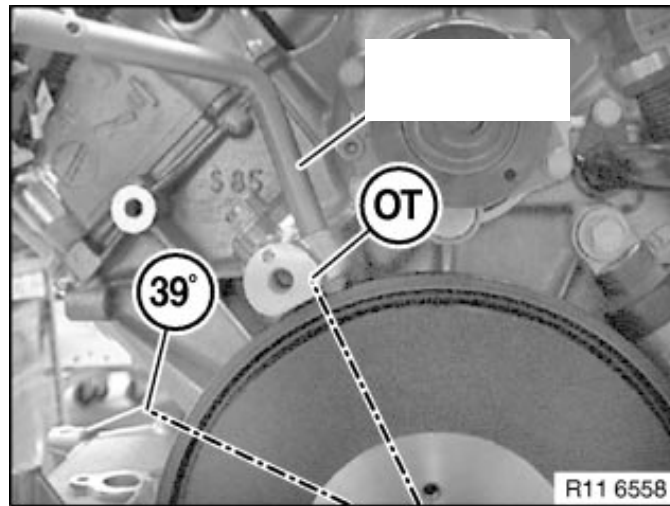


---



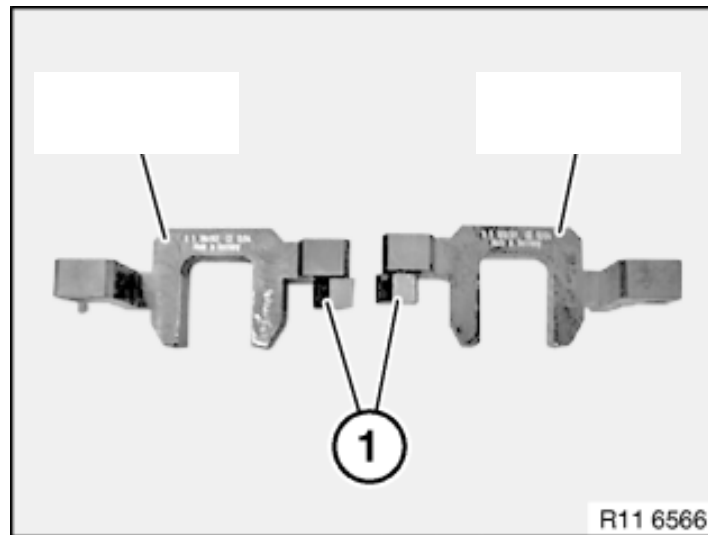
## Workshop Exercise - Engine Disassembly

*Invert engine to upright position and prepare to CHECK camshaft timing. Rotate engine to #1 cylinder at TDC (on compression stroke). Check to see if the numbers on the camshaft (dihedron) are facing upwards.*



*Lock engine in place at "OT" position using special tool. Fill in the special tool number in space provided above.*

*Proceed to check the INTAKE camshaft timing using special tools.*



*Write the part numbers in the spaces provided for the special tools shown above.*

*In the above illustration, what is the purpose of the spacers (1)?*

---

---

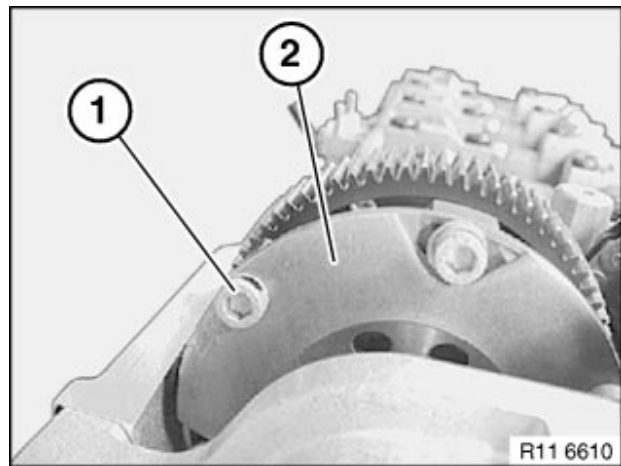
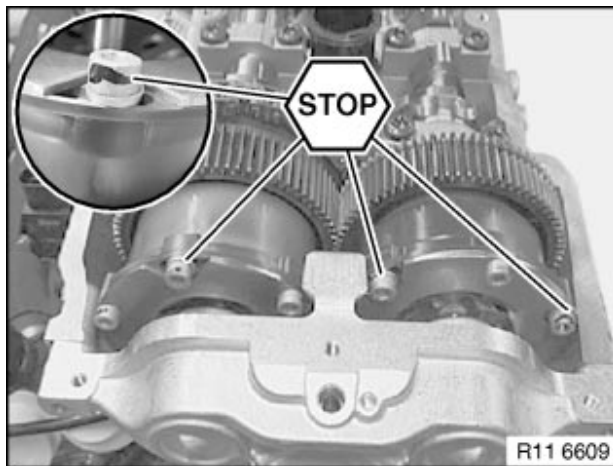


## Workshop Exercise - Engine Disassembly

*Rotate the engine to the 39 degree position and lock in place with special tool. Check the EXHAUST camshaft using the special tools.*

When checking the camshaft timing (intake and exhaust), what is the maximum allowable protrusion of the special tool?

*After checking the camshaft timing, proceed with removal of BOTH VANOS actuating units. Pay special attention to the removal procedure. **Do NOT loosen bolts with washers or the cam timing will be affected (if the engine is rotated).***



*Remove 6 bolts (reference #1 on graphic) on each VANOS adjusting unit, rotate engine to access all bolts on both banks. Proceed with removal of both VANOS adjusting units as per repair instructions.*

*Once complete, return the engine to the #1 TDC position and proceed with removal of the bank I cylinder head (cyl 1-5).*

*Are the VANOS adjusting units bank specific? (can they be swapped from bank to bank?) Why or why not?*

---

---

---

---

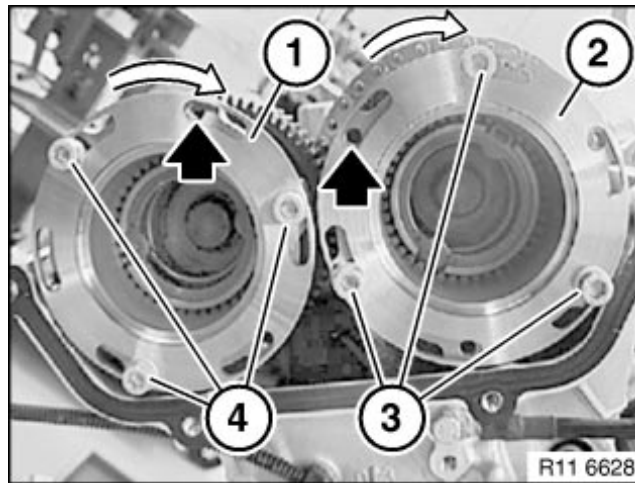
---



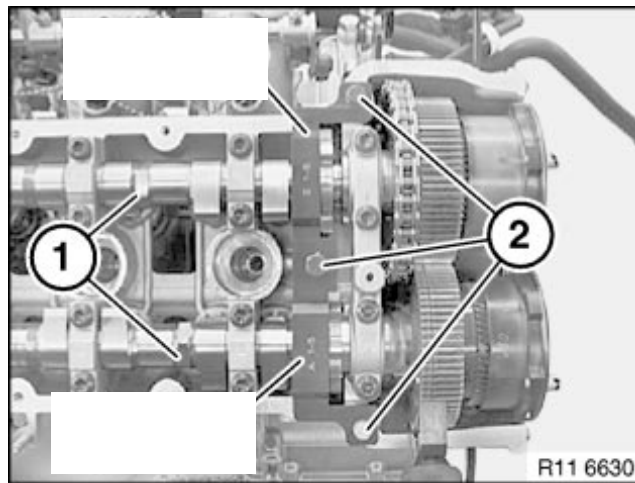
## Workshop Exercise - Engine Disassembly

Remove both intake and exhaust VANOS gear (transmission) and both camshafts to facilitate cylinder head removal.

Install all necessary special tools to remove both VANOS gears.



Loosen bolts (3 and 4) but do not remove. Rotate inner sleeve of VANOS gear to the left most stop (refer to graphic above - 1 and 2). Re-tighten bolts (3 and 4) to approximately 5 Nm.

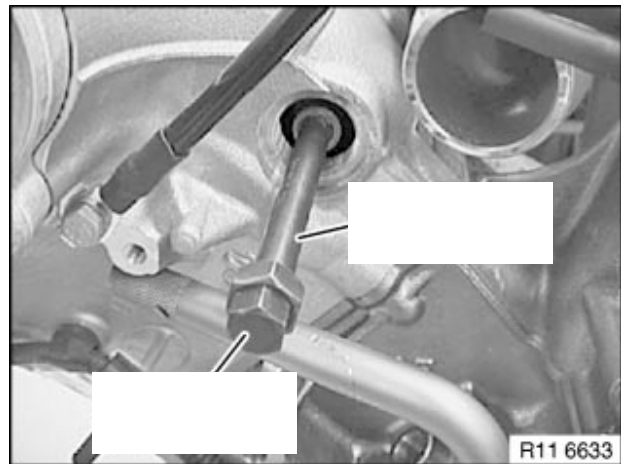
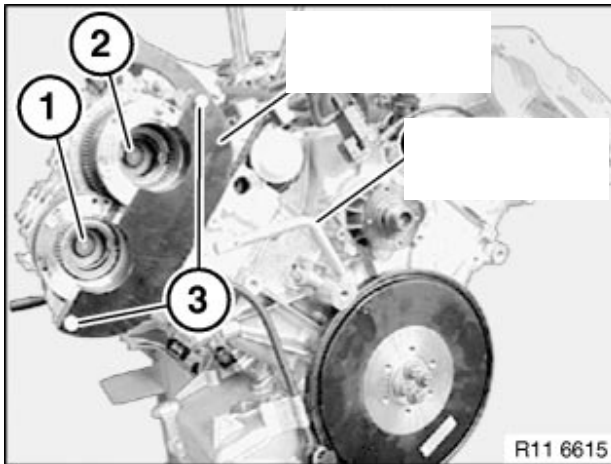


Install special tools as shown above, write correct tool numbers in spaces provided. Be sure to fully tighten all bolts (see 2 above).

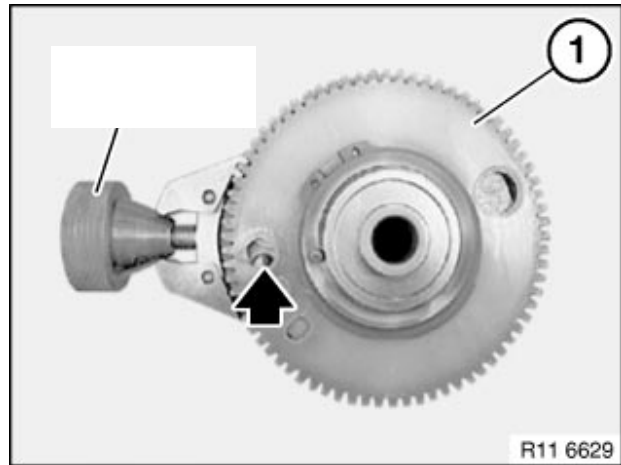
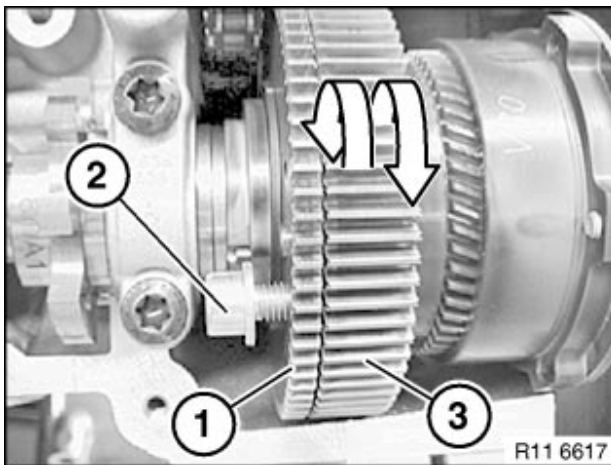


## Workshop Exercise - Engine Disassembly

Install special tools as shown. Remove the right side chain tensioner and the bolt for the chain rail (on the cylinder head only). Fill in special tool numbers in the spaces provided below.



Install M8 X18mm lock bolt (2) on the exhaust VANOS gear as shown below. Tighten fully to prevent slippage of split gear mechanism (1 and 3).



What is the purpose of the M8 x 18mm lock bolt?

---

---

What is the purpose of the special tool shown above (#1 on right)? Record the part number of the tool in the space provided.

---

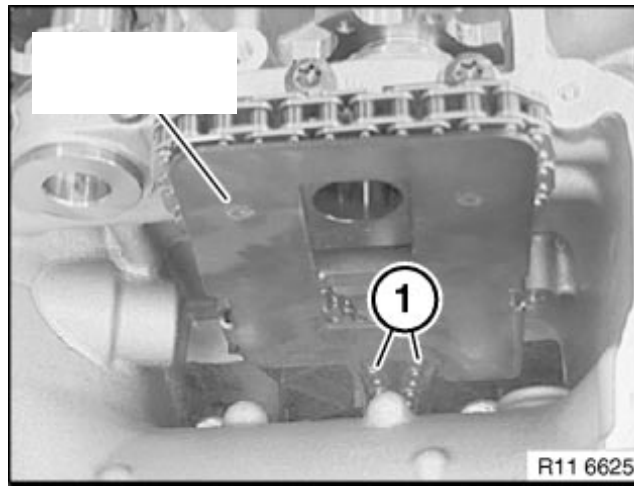
---



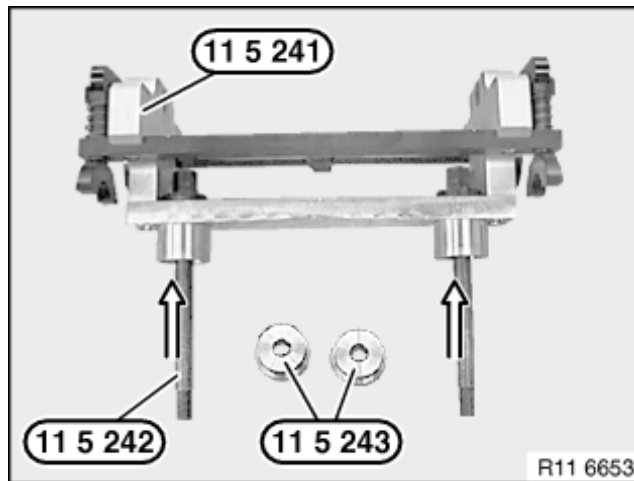
## Workshop Exercise - Engine Disassembly

Remove both central bolts on the intake and exhaust VANOS gears. Remove exhaust VANOS gear first and set aside. Remove intake VANOS gear without dropping the timing chain.

Install special tool as shown below. Write in the correct tool number in the spaces provided.



Proceed with removal of the intake and exhaust camshaft using special tools.



### **IMPORTANT!!!**

When removing the intake camshaft, there are special tool inserts (115243) which should be installed into the camshaft removal tool (115241).

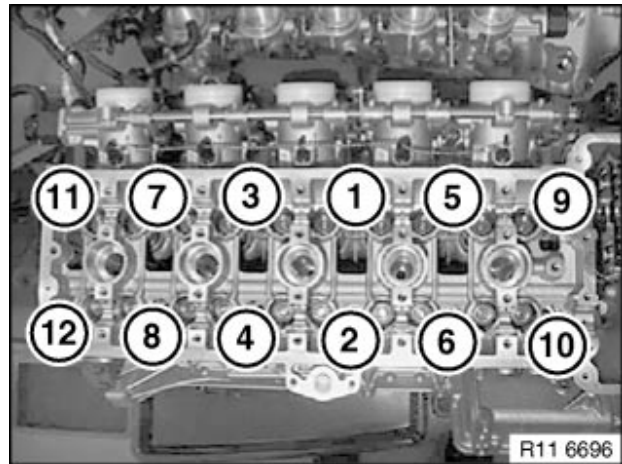
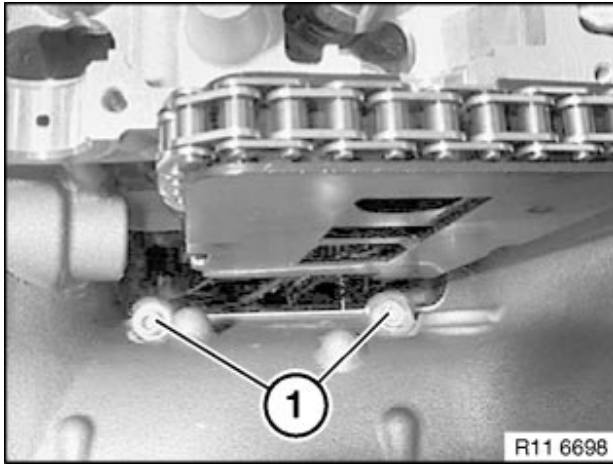
When removing the exhaust camshaft, the inserts (115243) should be removed from the tool.





## Workshop Exercise - Engine Disassembly

Once the intake and exhaust camshafts are removed, remove the tappets (HVA) and proceed with head bolt removal. Loosen bolts in proper sequence (from 12 to 1). Retrieve all cylinder head bolt washers when removing head bolts.



Remove cylinder head and inspect piston installation for reference. Note coolant and oil passages.

What is the minimum thickness of the cylinder head? \_\_\_\_\_

Is it possible to machine the cylinder head sealing surface? \_\_\_\_\_

Re-install the cylinder head and tighten the head bolts in proper sequence (1-12). Since this is a trainer engine, do not tighten head bolts to full torque.

Fill in the chart below with the proper head bolt torque specifications.

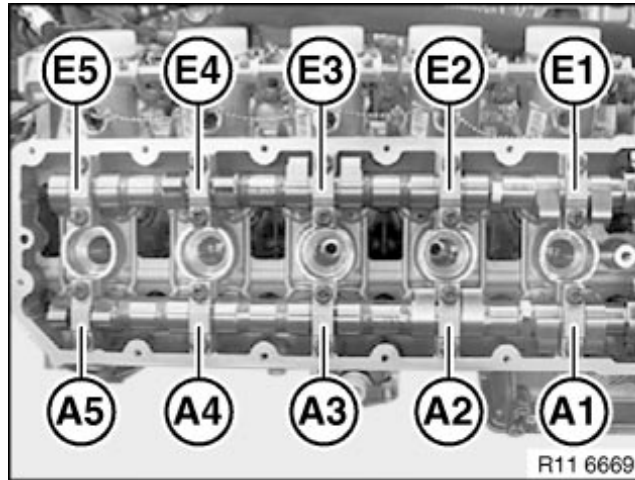
Torque Specification (M10 X1.5X110 bolt)	Measurement
Joining Torque >	
Torque Angle >	
Torque Angle >	
Torque Specification (M6 bolt on front of cyl head)	Measurement
Torque	



## Workshop Exercise - Engine Disassembly

Re-install tappets (HVA) noting the location of the “anti-torsion” pin. Proceed with installation of the intake and exhaust camshafts, starting with the exhaust camshaft.

Be sure to install camshafts with the numbers facing upwards and aligned to cam timing tools. Install camshaft bearing caps in proper order as shown below.



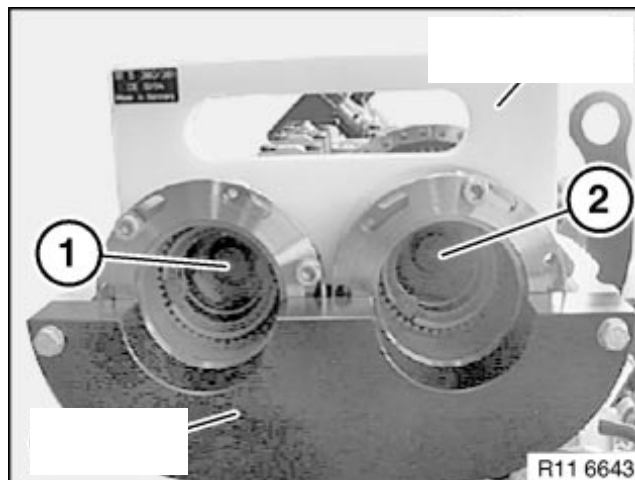
Depress camshafts with special tool and secure bearing caps. Do not tighten the camshaft bearing caps to full specification on the trainer engine.

Once the camshaft installation is complete, proceed with the installation of the intake and exhaust VANOS gears. Install intake VANOS gear first.

Ensure that the timing chain does not bind during installation.

Install special tools as shown below. Be sure that the camshaft locking tools are still in place before tightening the camshaft central bolts.

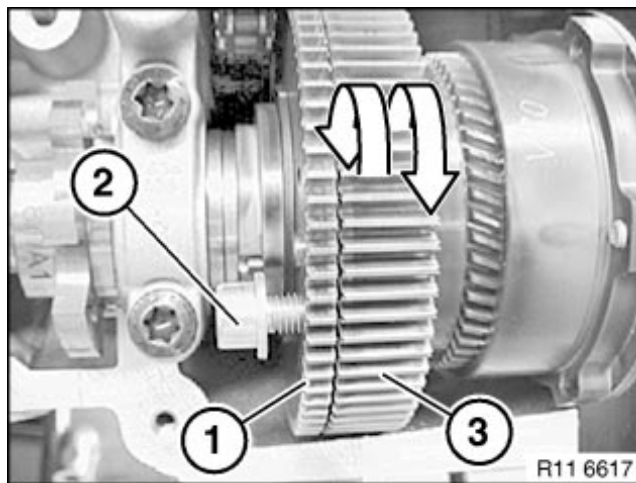
Tighten camshaft central bolts to the proper specification and remove special tools.



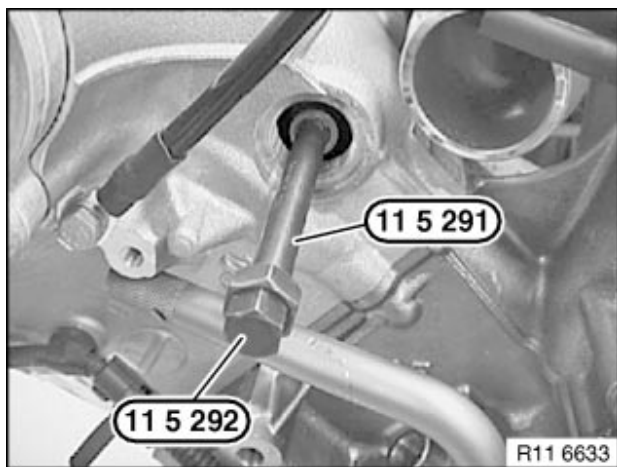


## Workshop Exercise - Engine Disassembly

Note: Before proceeding, remove M8 X 18mm lock bolt (2) as shown below.

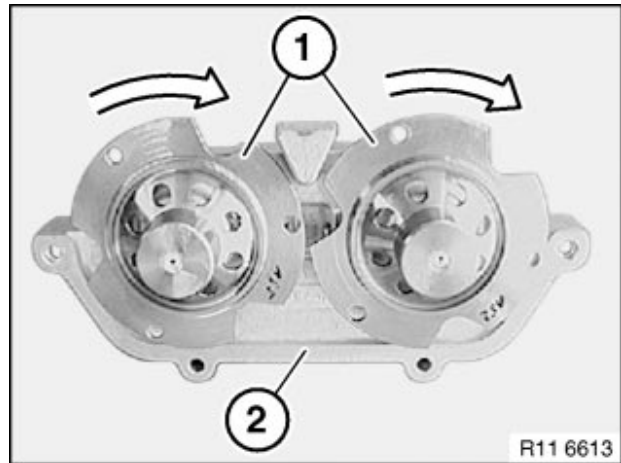
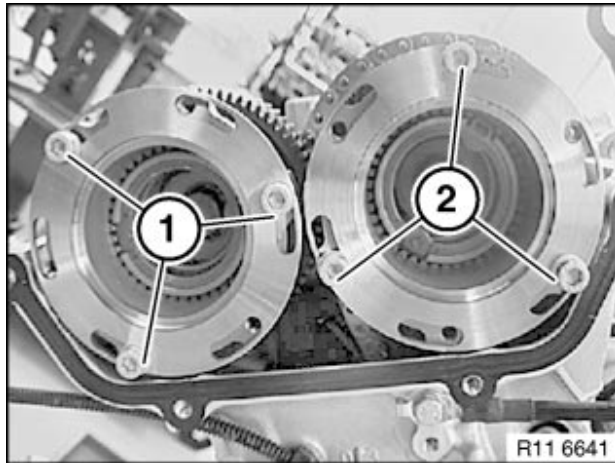


Re-install bolt for timing chain guide rail and install timing chain tensioner. Proceed with installation of the VANOS units.

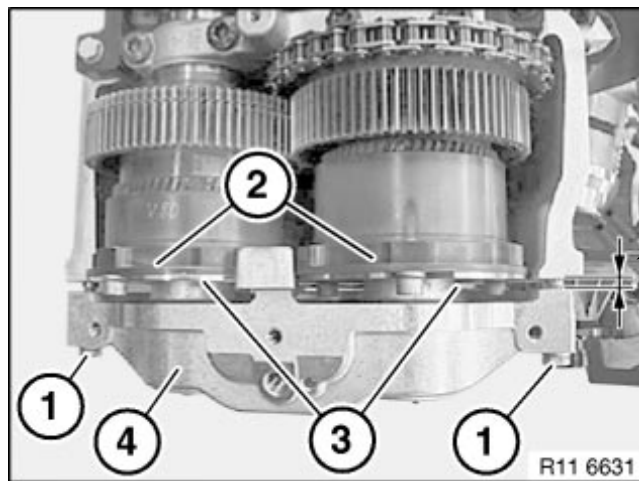




## Workshop Exercise - Engine Disassembly



Loosen bolts (see above left picture 1 and 2) 90 degrees. Before installing VANOS adjusting unit, ensure that the thrust plates (see above right - 1) are fully retracted and rotate freely without binding.



Note: There should be an gap of approximately 8mm at this point during installation.

Install VANOS adjusting unit (with gasket). Position the adjustment unit using the outer bolts (1), but **do not tighten** bolts. Ensure that the VANOS gears (2) are fully extended. Align thrust plates (3) and make sure that the thrust plates are flush with the VANOS gears. Install the (exposed) hex (Allen) bolts, tighten and then loosen 90 degrees.

Before tightening the bolts (1) for the VANOS unit, ensure that all of the hex (allen) bolts (with and without washers) are loose. Tighten bolts (1) in increments of 1/2 turn.

While tightening bolts (1) observe that the outer sleeves will rotate and retract 8mm.



## Workshop Exercise - Engine Disassembly

*Once the VANOS adjusting unit has been seated and all bolts tightened. Proceed with the final installation and tightening of the hex (allen) bolts.*

**Note: Do not rotate engine unless the hex (allen) bolts are tight. Before rotating the engine, tighten the exposed bolts. Failure to do so will alter camshaft timing.**

*Tighten all bolts (with and without washers) to 10Nm. Rotate the engine through 120 degree increments to access all bolts.*

*Continue with installation of the Bank II (6-10) VANOS unit by following the same steps.*

*At this point, CHECK the camshaft timing. If not correct, proceed with necessary steps to ADJUST camshaft timing.*



*Re-install cylinder head covers, ignition coils and the ionic current control units.*

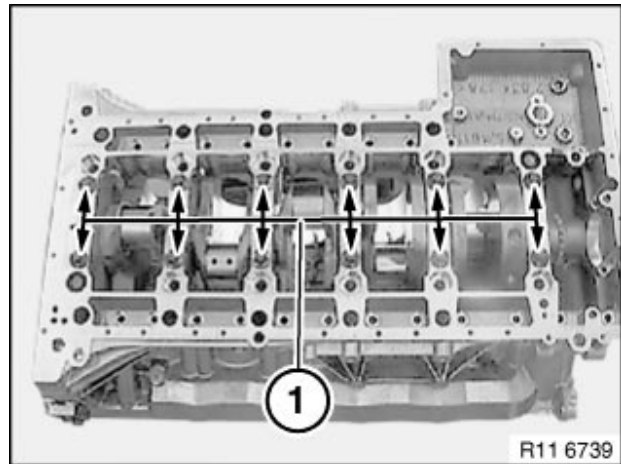
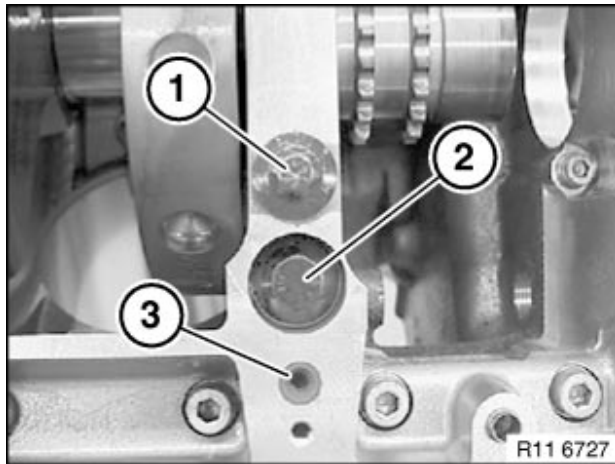
What is the correct torque specification for the cylinder head cover bolts?

What should be noted regarding the installation of the ionic current control units?



## Workshop Exercise - Engine Disassembly

*Invert engine for access to bedplate. Proceed with removal of bedplate assembly.*



*First remove all M8 fit bolts (#2 - above left) completely from engine. Next, remove the M11 main cap bolts (#1- above right). Then proceed by removing the remainder of the hex (allen) bolts.*

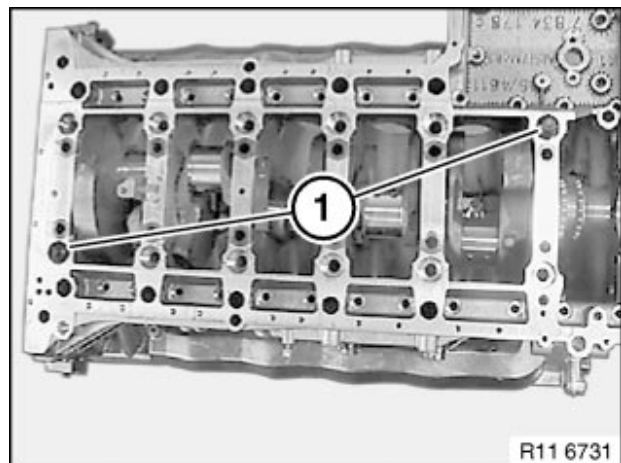
*Then remove the bedplate, paying close attention to the main bearing installation position. Take this opportunity to review engine construction, look over oil passages and bedplate sealing grooves etc.*

*Proceed with re-installation of bedplate.*

**Note:** Bedplate does not use locating dowels, the M8 "fit" bolts provide the locating reference for the bedplate. Therefore proper installation is critical to prevent engine damage.

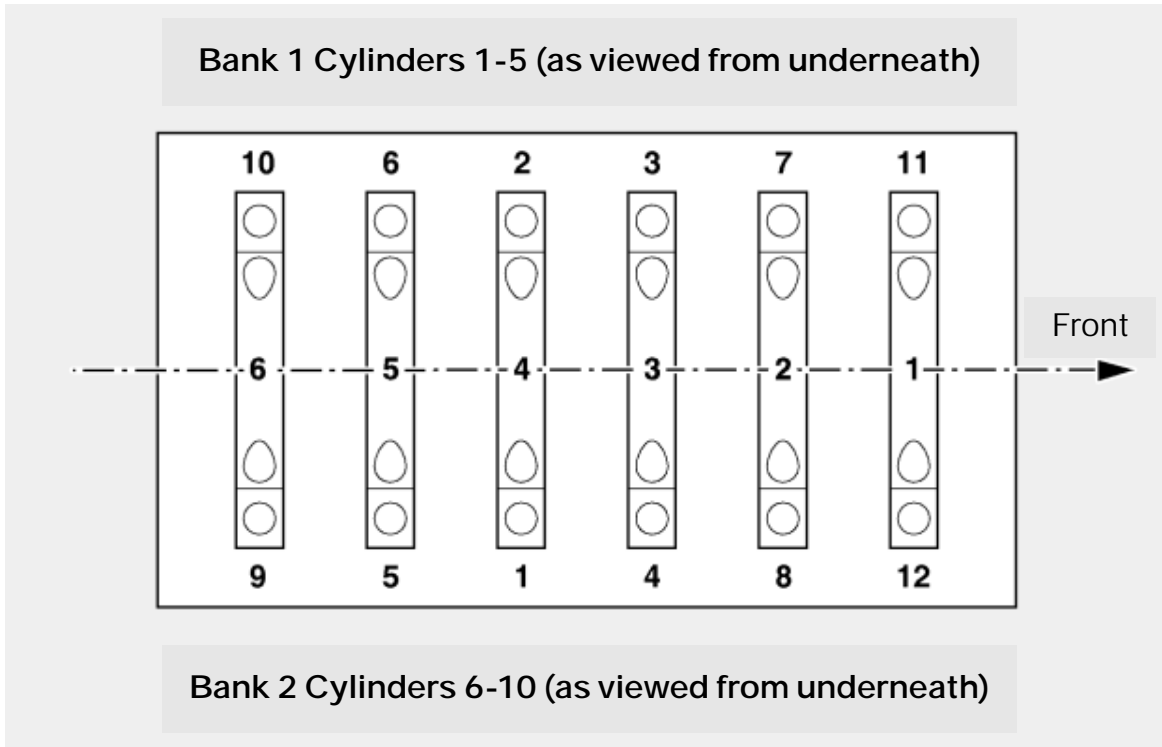
*Install bedplate as shown on right. Install two M8 fit bolts diagonally as shown on right.*

*Tighten only the two M8 bolts to 8 Nm.*





## Workshop Exercise - Engine Disassembly



*Proceed and install all, M11 main bearing cap bolts. And tighten in sequence (on the trainer engine only tighten to 30Nm).*

What is the difference in the tightening procedure between "old" main cap bolts and "new" main cap bolts?

---

---

---

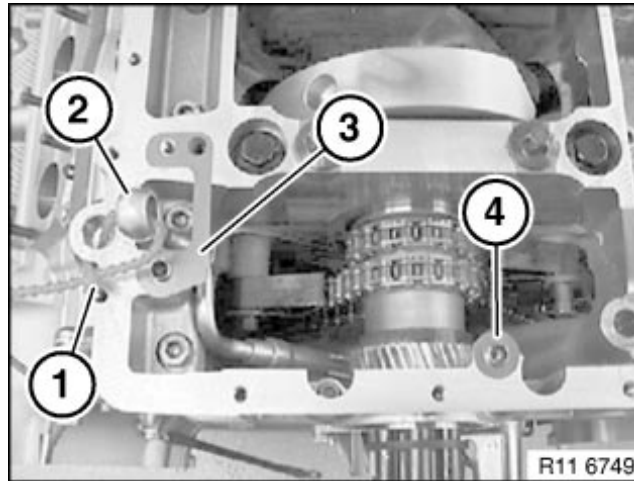
---

Install the M8 "fit" bolts and tighten in sequence (For trainer engine only tighten to 15Nm)  
Install remaining bolts, tighten in sequence. ( minimum torque).



## Workshop Exercise - Engine Disassembly

*After bedplate installation is complete, proceed with the installation of the engine oil pump and VANOS high pressure pump.*

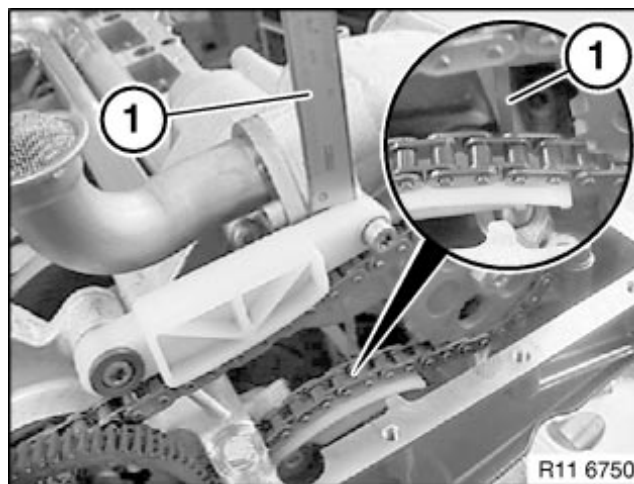


*Re-install VANOS pump, note installation position of the shims (3 and 4 above).*

What special tool is used to check the "backlash" of the VANOS pump gear? And, what is the backlash specification?

---

*Re-install engine oil pump as per repair instructions. Measure travel of chain tensioner piston as shown.*



What is the specification for the travel of the chain tensioner?

---





## Workshop Exercise - Engine Disassembly

What is the specification for the travel of the chain tensioner?

---

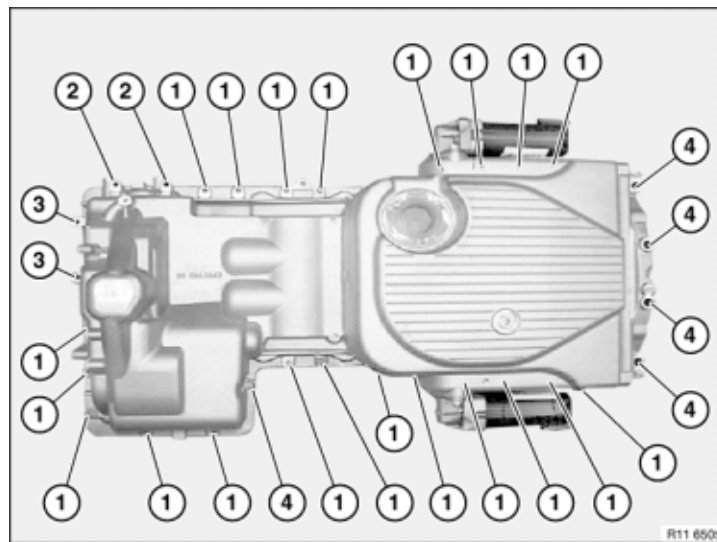
---

If the chain tensioner travel is out of specification, how is it adjusted?

---

---

*Re-install oil pan and observe proper bolt installation. Record bolt descriptions and bolt torque in the chart below.*



Bolt #	Bolt Description (type and amount)	Torque Specification
1	M6 X 22 Hex Bolt (10mm) 23 bolts total	
2	M6 X 40 Hex Bolt (10mm) 2 bolts total	
3	M6 X 75 Hex screw T30 Torx 2 bolt total	
4	M6 X 22 Hex Screw T30 Torx 5 bolts total	

*Re-attach VANOS high pressure hoses.*

*Re-install trim covers and intake plenum.*

*Check over engine and re-install any additional items such as harmonic balancer etc.*

---

## Classroom Exercise - Review Questions

1. Is it possible to remove the cylinder head without removing the camshafts?  
(Why or Why not?)

---

---

---

---

2. What is the difference between TDC and the "39 degree" position?

---

---

---

---

---

3. What is the purpose of the "split gear" on the exhaust VANOS gear?

---

---

---

---

---

4. When removing the exhaust camshaft, what should be done to the special tool 115 241 and why?

---

---

---

---

---

