ŠKODA

1.6 l TDI and 2.0 l TDI Engines

with the Common Rail Injection System

EA288 Design Series

Self-Study Programme

ŠKODA Service®

100

Contents

Instructions for assembly, disassembly, repairs, diagnosis and detailed user information can be found in VAS diagnostic testers and vehicle's onboard literature.

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This document is not subject to updating.

SP95_00

1. Introduction of the EA288 Series MDB Engines

1.1 1.6 l TDI and 2.0 l TDI Engines of the EA288 Series

In ŠKODA AUTO, the new MDB modular concept 1.6 and 2.0 liter engines are introduced for the first time in the ŠKODA Octavia III model. The 1.6 l drive unit is produced in three power versions - 66 kW, 77 kW and 81 kW. The higher displacement (2.0 l) engine also offers three power versions - 105 kW, 110 kW and the most powerful 135 kW version, which is reserved for the ŠKODA Octavia III RS model.

1.2 Modular Diesel Engines Design (MDB – Modularer Diesel-Baukasten)

The 1.6 l TDI and 2.0 l TDI engines have been designed in accordance with the new modular strategy of the VW Group. The dimensions, mounting and connecting points of these new engines are designed to enable their use as "global drive units". That way these engines are going to be used in vehicles of all the VW Group brands.

The modular design is applied both to basic structural sub-assemblies (engine block, cylinder head, crank mechanism) and to additionally mounted engine parts (redesigned exhaust manifold closer to the engine, intake manifold with integrated intake air cooler).

2 Technical Data of the Engines

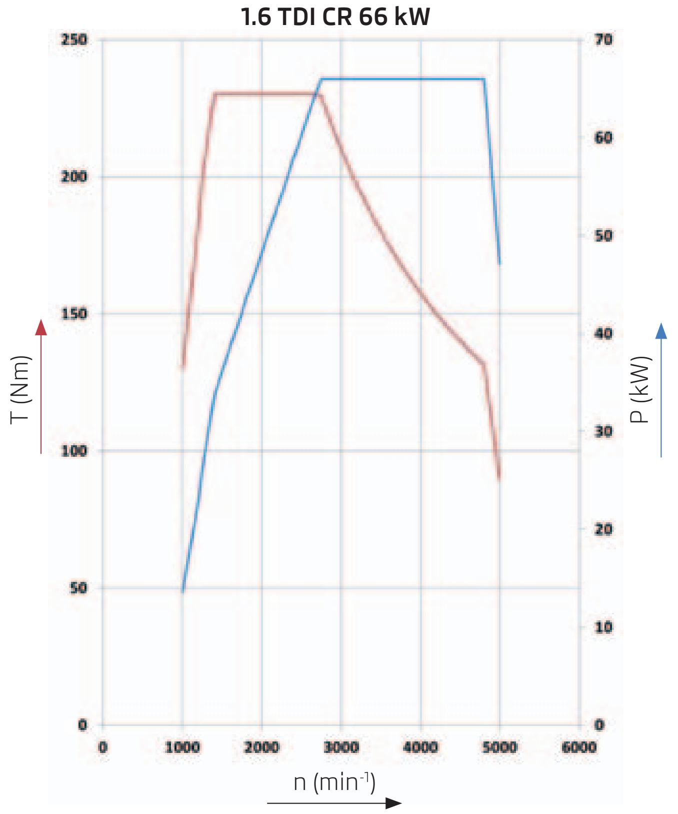
2.1 1.6 l TDI CR Engine Parameters

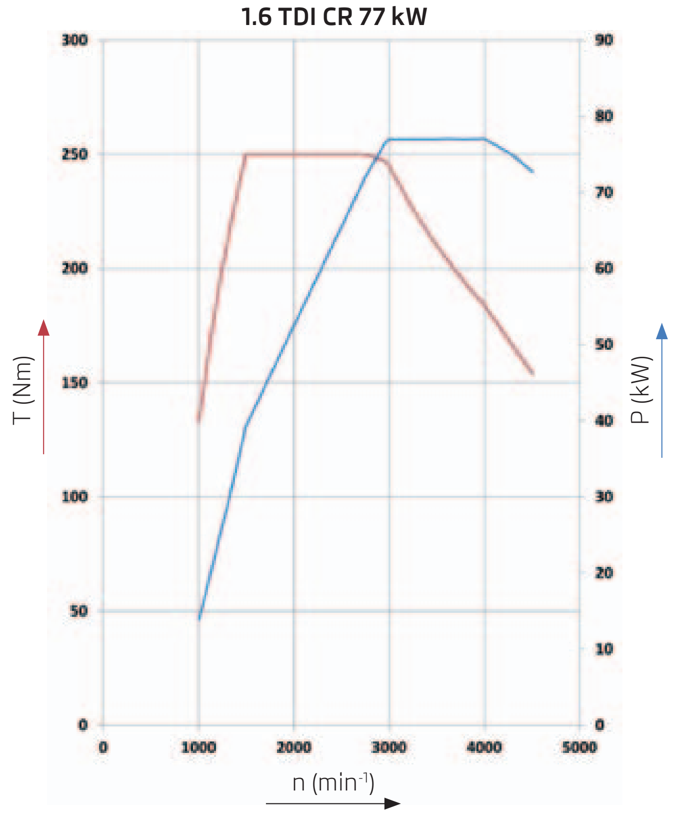
	Power versions of the 1.6 l TDI CR engine		
Engine Parameters	**66 kW (engine code: CLHB)**	**77 kW (engine code: CLHA)**	**81 kW (engine code: CRKB)**
Design	compression-ignition engine with direct high-pressure fuel injection, turbocharged by a turbocharger with variable blade geometry, liquid cooled, 2 x OHC, intended for front transverse mounting		
Number of Cylinders	4		
Displacement	1598 cm^3		
Bore	79.5 mm		
Stroke	80.5 mm		
Cylinder Pitch	88 mm		
Valves per Cylinder	4		
Max. Power	**66 kW at 2750-4800 min^{-1}**	**77 kW at 3000-4000 min^{-1}**	**81 kW at 3250-4000 min^{-1}**
Max. Torque	**230 Nm at 1400-2700 min^{-1}**	**250 Nm at 1500-2750 min^{-1}**	**250 Nm at 1500-3000 min^{-1}**
Compression Ratio	16.2 : 1		
Charging	electronically controlled high-pressure common-rail injection system		
Max. Injection Pressure	1800 bar		
Lubrication	circulatory pressure oil lubrication with 100% oil filtering		
Fuel	diesel		
Emission Standard	**EU 5**	**EU 5**	**EU 5, EU 6***
Balancing Shafts	NO		

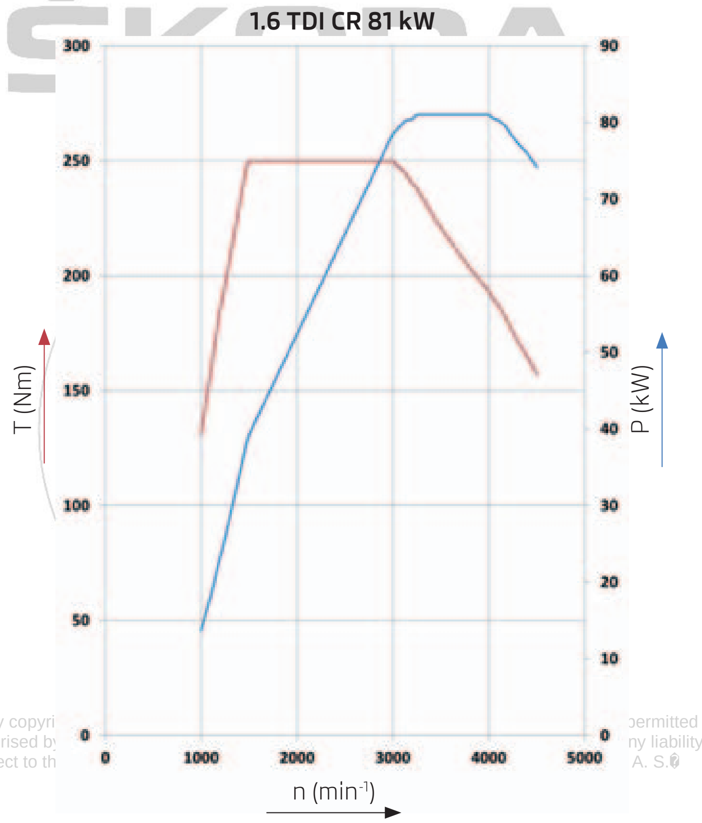
The 66 kW and 77 kW power versions of the 1.6 TDI engine differ by engine control unit software, the structural design of both the versions is identical. The 81 kW version, compliant with the EU 6 standard, involves a different exhaust gas recirculation duct, see chapter 10 of this SSP.

* The engine hardware is prepared to comply with the EU 6 standard, as of the date of publishing this SSP (11/2013), the engine is offered as compliant with the EU 5 standard.

2.2 Power and Torque Characteristics of the 1.6 TDI CR 66 kW, 77 kW and 81 kW Engines







P – power, T – torque, n – engine revolutions

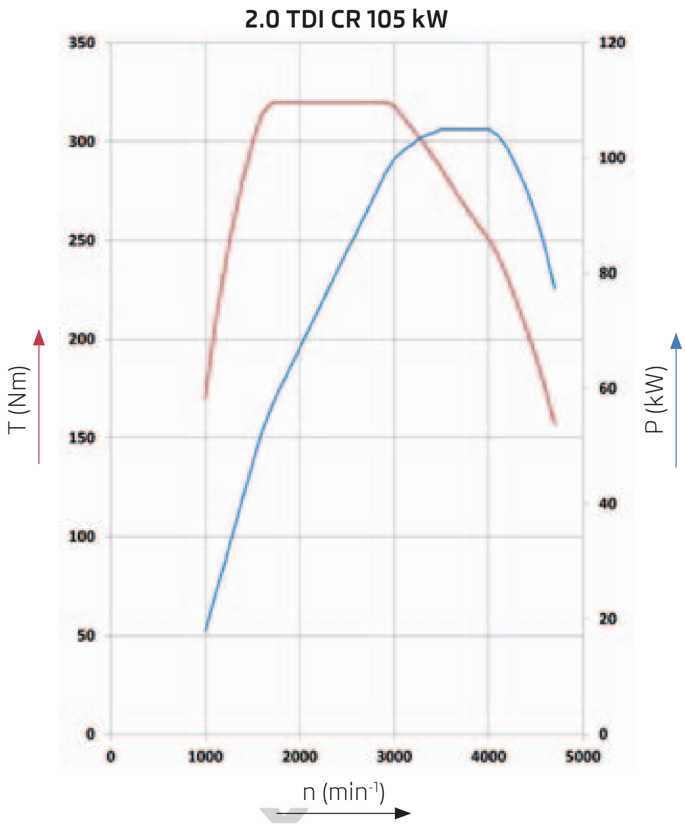
engine torque curve

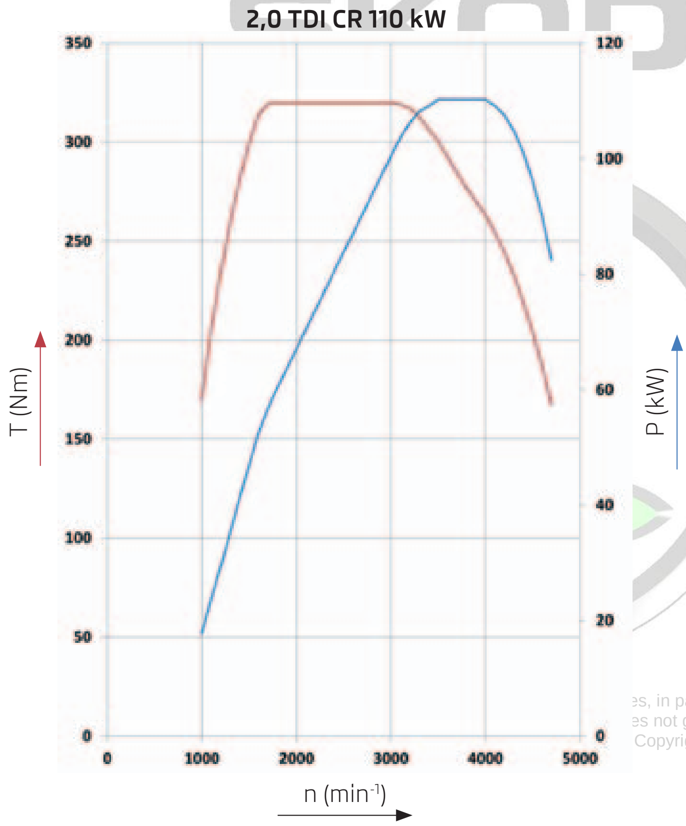
engine power curve

2.3 2.0 l TDI CR 105 kW, 110kW Engine Parameters

	Power versions of the 2.0 l TDI CR engine	
Engine Parameters	**105 kW (engine code: CRVC)**	**110 kW (engine code: CKFC)**
Design	compression-ignition engine with direct high-pressure fuel injection, turbocharged by a turbocharger with variable blade geometry, liquid cooled, 2 x OHC, intended for front transverse mounting	
Number of Cylinders	4	4
Displacement	1968 cm^3	1968 cm^3
Bore	81 mm	81 mm
Stroke	95.5 mm	95.5 mm
Cylinder Pitch	88 mm	88 mm
Valves per Cylinder	4	4
Max. Power	**105 kW at 3500–4000 min^{-1}**	**110 kW at 3500–4000 min^{-1}**
Max. Torque	**320 Nm at 1750-3000 min^{-1}**	**320 Nm at 1750-3000 min^{-1}**
Compression Ratio	16.2 : 1	16.2 : 1
Charging	electronically controlled high-pressure common-rail injection system	
Max. Injection Pressure	1800 bar	1800 bar
Lubrication	circulatory pressure oil lubrication with 100% oil filtering	
Fuel	diesel	
Emission Standard	EU 4	EU 5
Balancing Shafts	**NO**	**NO**

2.4 Power and Torque Characteristics of the 2.0 TDI CR 105 kW and 110 kW Engines





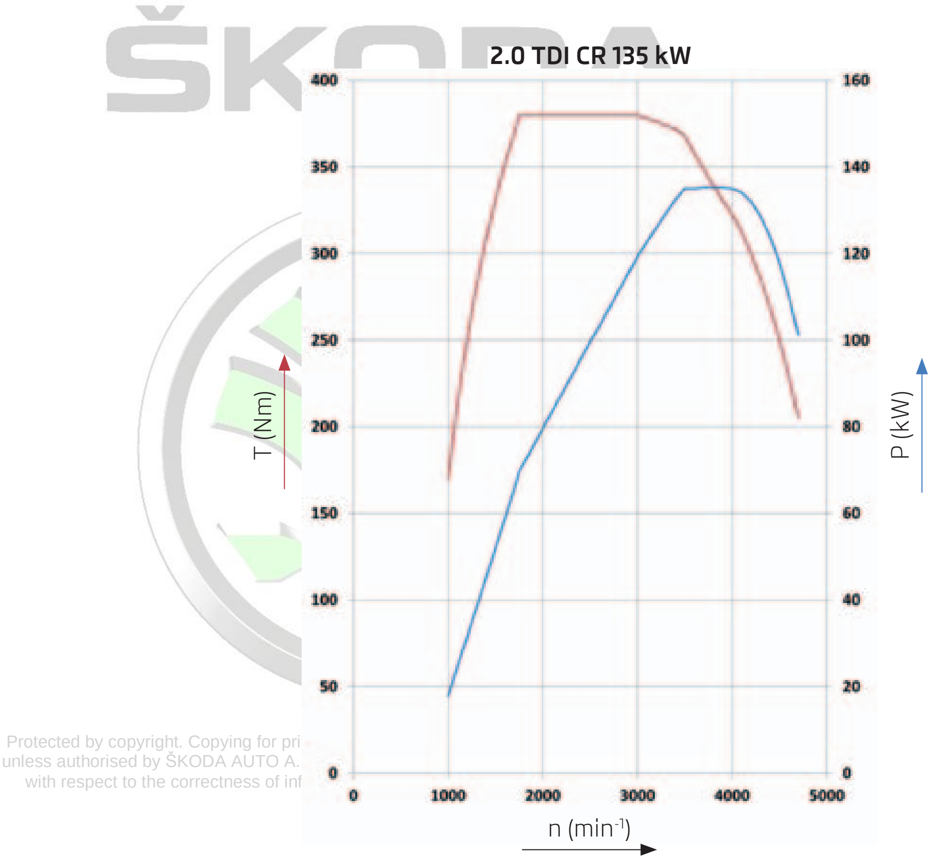
P – power, T – torque, n – engine revolutions

engine torque curve

engine power curve

Engine Parameters	Power version of the 2.0 l TDI CR engine 135 kW (engine code: CUPA)
Design	compression-ignition engine with direct high-pressure fuel injection, turbocharge by a turbocharger with variable blade geometry, liquid cooled, 2 x OHC, intended for front transverse mounting
Number of Cylinders	4
Displacement	1968 cm^3
Bore	81 mm
Stroke	95.5 mm
Cylinder Pitch	88 mm
Valves per Cylinder	4
Max. Power	**135 kW at 3500–4000 min^{-1}**
Max. Torque	**380 Nm at 1750-3000 min^{-1}**
Compression Ratio	15.8 : 1
Charging	electronically controlled high-pressure common-rail injection system
Max. Injection Pressure	2000 bar
Lubrication	circulatory pressure oil lubrication with 100% oil filtering
Fuel	diesel
Emission Standard	EU 5
Balancing Shafts	**YES**

2.4 Power and Torque Characteristics of the 2.0 TDI CR 135 kW Engine



P – power, T – torque, n – engine revolutions

- engine torque curve
- engine power curve

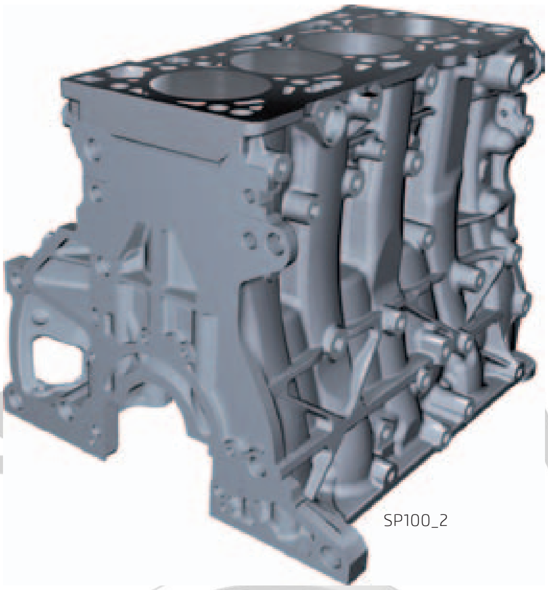
3. Engine Mechanics

3.1 Engine Blocks

The blocks of the 1,6/2,0 l TDI engines are made of GG-GJL-250 grey cast iron, which displays good combination of strength and hardness. The used material has good vibration damping properties.

3.1.1 Structural Differences of the 1.6 l and 2.0 l Engine Blocks

The concept of 1,6 l and 2,0 l engine blocks is uniform, having cylinder pitch of 88 mm. The diameter of cylinders on the 1,6 l and 2,0 l block differs.
The 2,0 l 135 kW engine is additionally equipped with balancing shafts and the engine block is modified to enable their embedding. See page. 13 of this SSP.



the 1.6 l engine block does not include the balancing shafts module

Engine	Code Engine	Emission standard.	Bore	Stroke	Pitch of cylinders	Balancing shafts
1,6 l 66 kW	CLHB	EU 5	79.5 mm	80.5 mm	88 mm	NO
1,6 l 77 kW	CLHA	EU 5	79.5 mm	80.5 mm	88 mm	NO
1,6 l 81 kW	CRKB	EU 5, EU 6*	79.5 mm	80.5 mm	88 mm	NO
2,0 l 105 kW	CRVC	EU 4	81 mm	95.5 mm	88 mm	NO
2,0 l 110 kW	CKFC	EU 5	81 mm	95.5 mm	88 mm	NO
2,0 l 135 kW	CUPA	EU 5	81 mm	95.5 mm	88 mm	YES

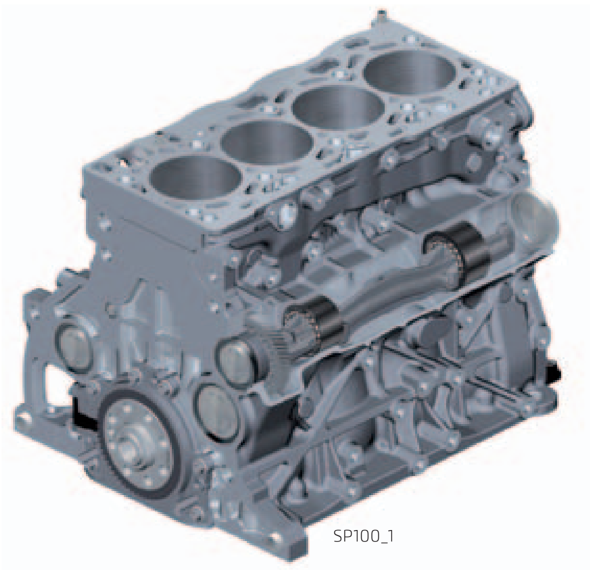
* The engine hardware is prepared to comply with the EU 6 standard, as of the date of publishing this SSP (11/2013), the engine is offered as compliant with the EU 5 standard.

3.2 Balancing Shafts of the 2.0 l 135 kW

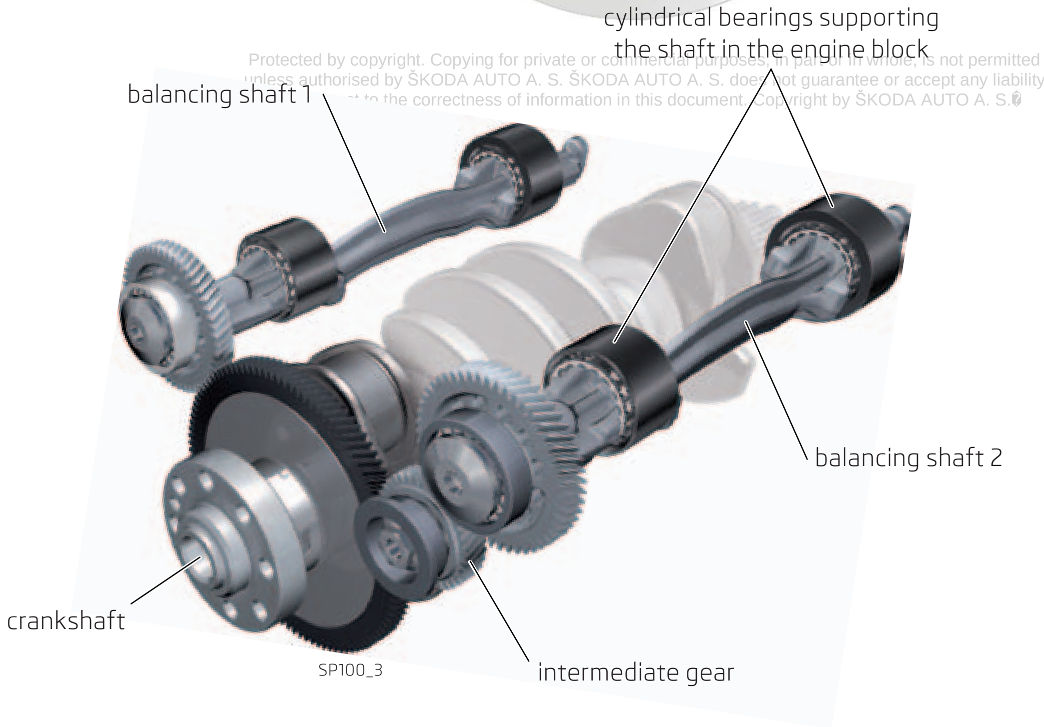
Two counter-rotating balancing shafts with counterweights are used to suppress 2nd order inertial forces generated by pistons moving in the cylinders..

The balancing shafts are rotating at double angular velocity of the crankshaft. The change in the direction of rotation of the second balancing shaft is executed by means of an intermediate gear.

Their drive is derived from the crank shaft via helical gears.
Shafts are supported in roller bearings. Bearings are lubricated by oil mist from the engine block.



supporting of the balancing shafts of the 2,0 l 135 kW engine

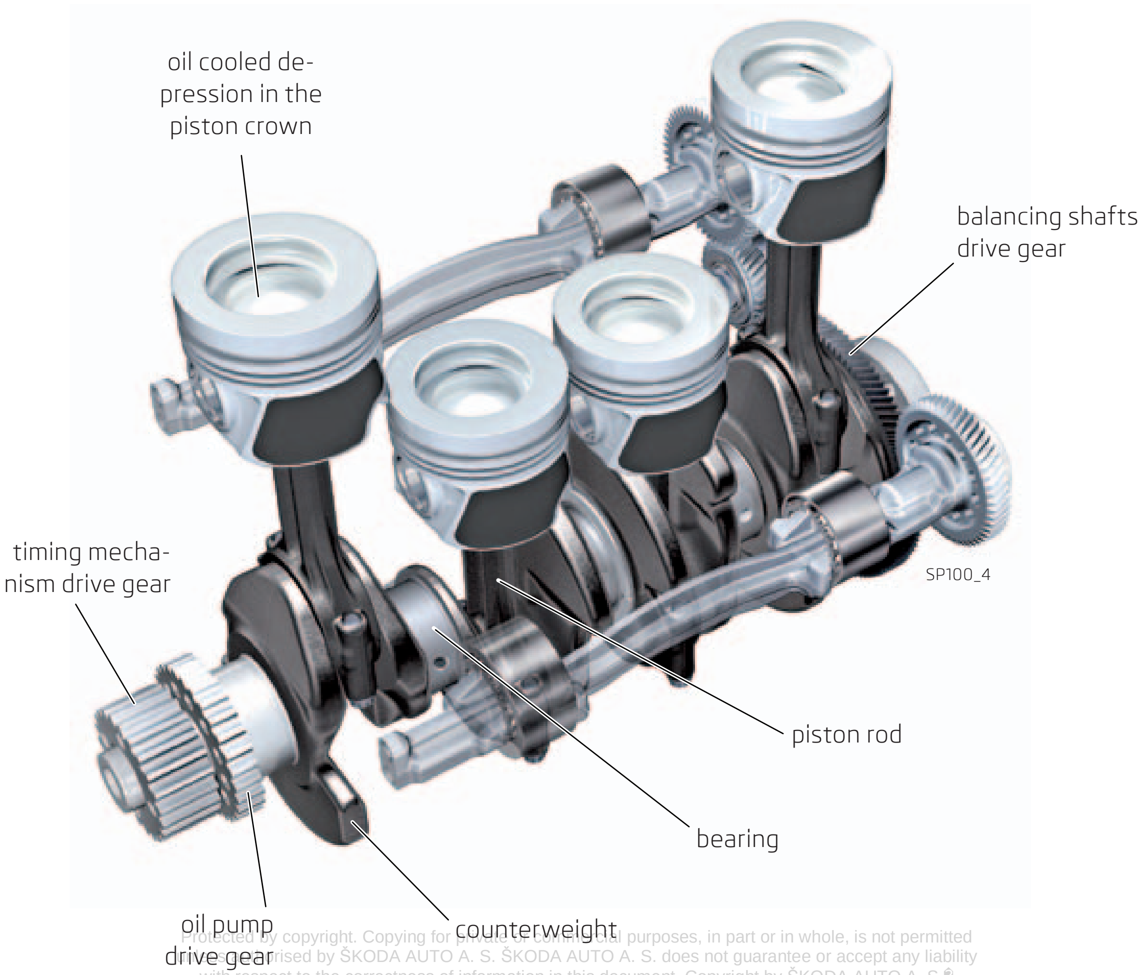


3.3 Crank Mechanism

The crankshaft, supported by five bearings, is balanced by four counterweights. Cracking has been used to achieve good connection of the head of the forged connecting rod bearing cap. Piston tops feature depressions, without recesses for pistons. These depressions are positioned off-center in order to correspond to the structural position of the valves in the cylinder head. The depression in the piston crown forms part of the combustion space, and therefore is significantly thermally loaded. The pistons are hollow and cooled by oil channels.
Oil is sprayed to the piston hollows by nozzles at the bottom dead center.

The crankshaft is fitted with three gears:

- spur gear for timing mechanism drive
- spur gear for oil pump drive
- helical gear for driving balancing shafts (of the 2,0 TDI 135 kW)



3.4 Timing Mechanism and Auxiliaries Drive

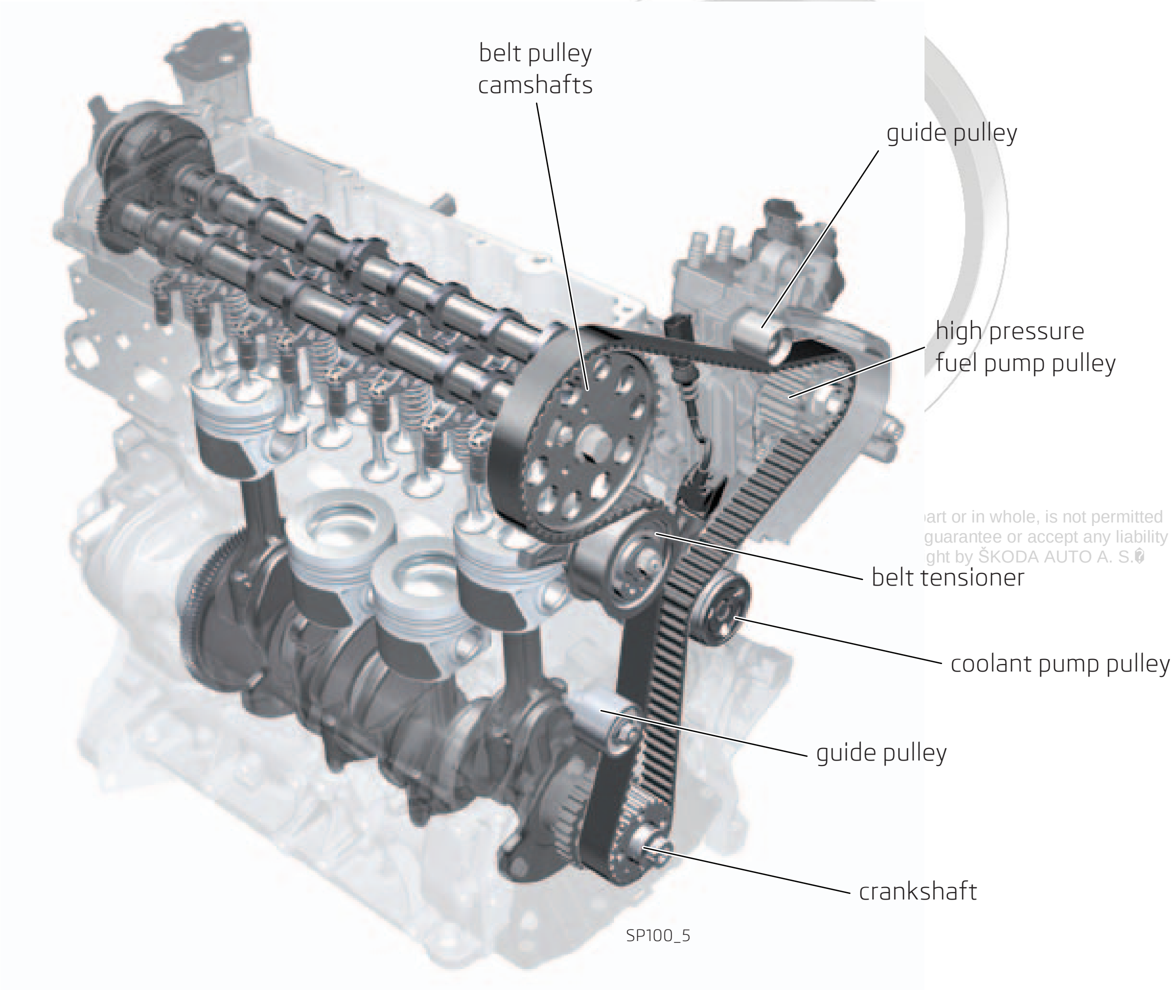
Drive of the timing mechanism and auxiliaries is executed by means of two belts.
One cogged and one ribbed belt.

3.4.1 Timing Mechanism Drive by a Cogged Belt

The cogged belt transfers rotary motion of the crankshaft to:

- camshafts
- high pressure fuel pump
- switchable coolant pump

Proper tensioning and routing of the cogged belt is assured by means of an automating tensioner assembly with a pair of guide pulleys.

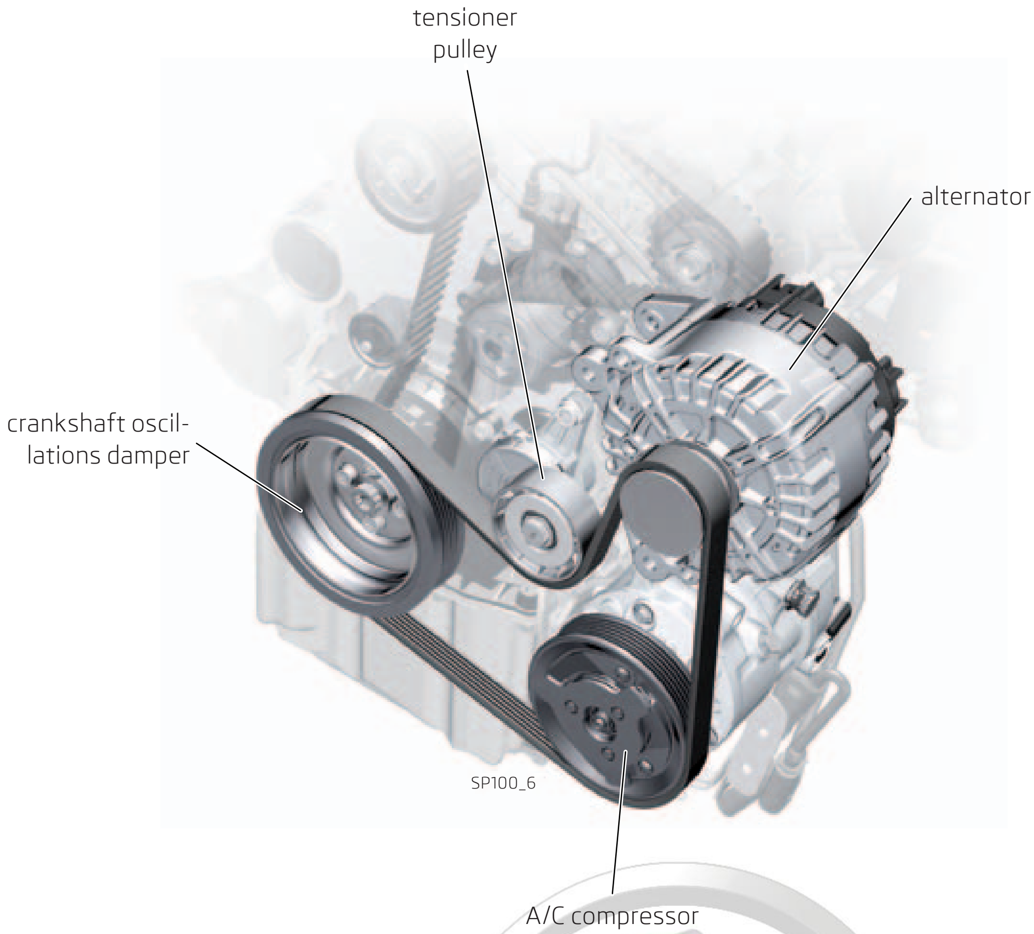


3.4.2 Auxiliaries Drive

The auxiliaries are driven by a ribbed belt, which is driven by the crankshaft via an oscillation damper. Proper tensioning of the ribbed belt is assured by means of a tensioner pulley.

The following auxiliaries are driven by the ribbed belt:

- alternator
- A/C compressor

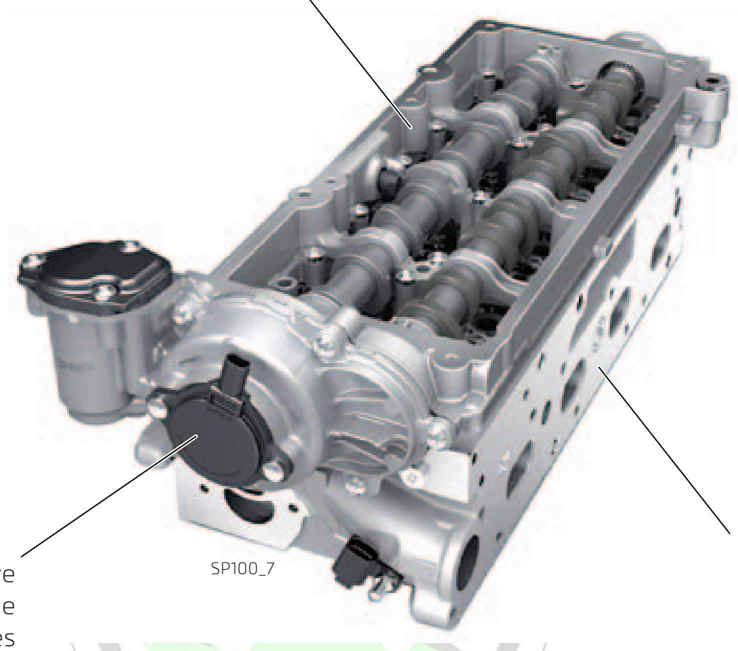


The used ribbed belt shall always be mounted in the same direction of rotation, otherwise it may get damaged.

3.5 Cylinder Head

The cylinder head module is composed of the following structural parts:

- camshaft housing (bearing frame with permanently integrated camshafts)
- cylinder head with valves and other fittings
- variable valve timing modules (on EU 6 compliant engines)

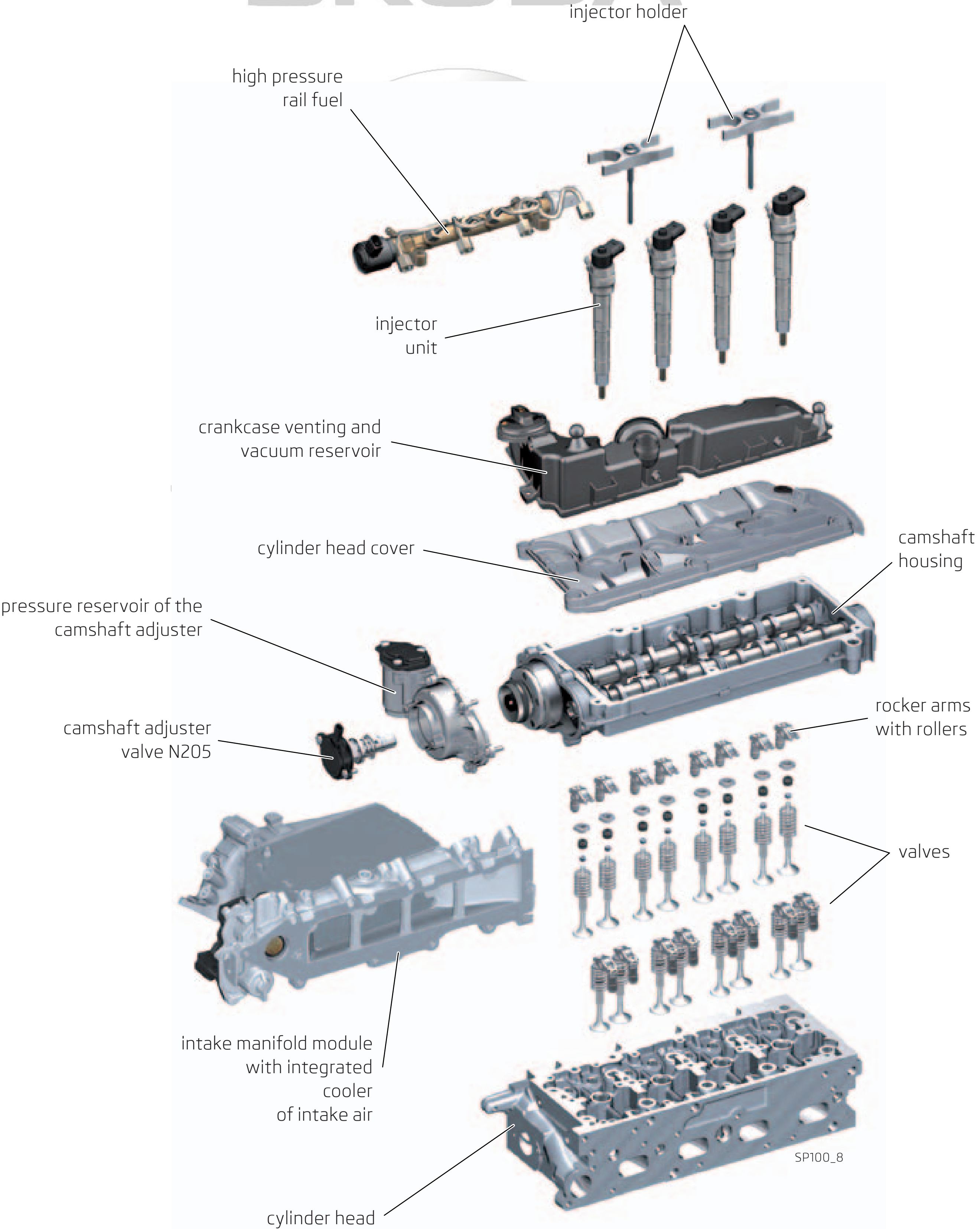


3.5.1 Camshaft Housing

The camshafts are supported in the camshaft frame using the method of thermal joining. The same method is used to mount the individual cams to the shafts. In the process of thermal joining, cams and the frame are placed in exact positions using a special auxiliary jig, and subsequently the cams are heated. Then cooled down shafts are inserted into the jig.
Once temperatures of the individual components equalize, a very strong connection of the whole module is achieved.

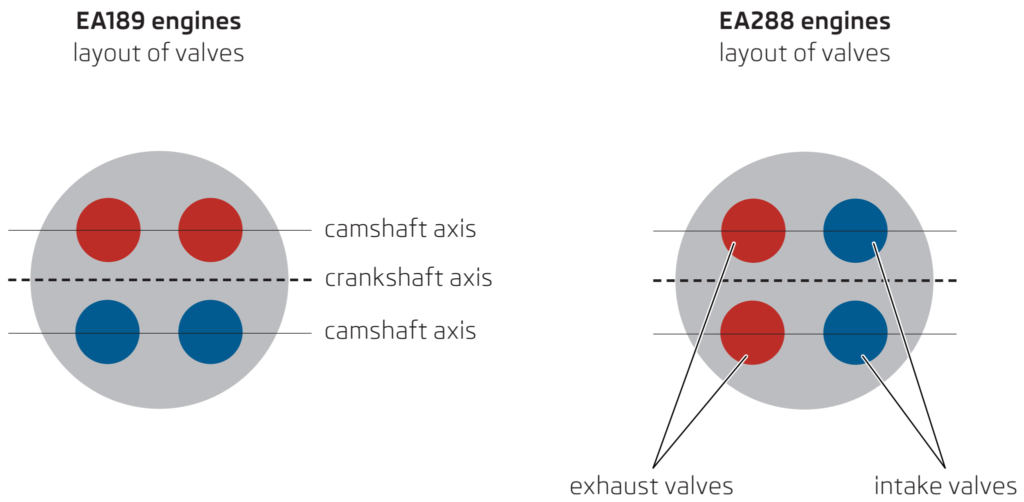
The MDB 1.6 l TDI and 2.0 l TDI engines are the first compression-ignition engines within the VW Group, where thermal joining replaced the previously used hydraulic pressing-on of shaft components.

3.5.2 Cylinder Head Design - Overview (EU 6 compliant design)

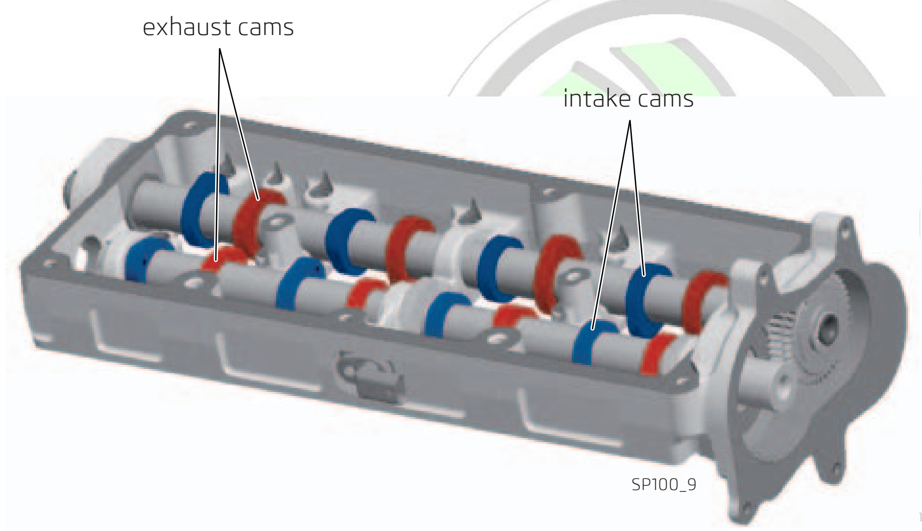


3.5.3 Intake and Exhaust Valves Layout

The previous generation of diesel engines had one camshaft dedicated for intake valves and the other for exhaust valves. The layout of valves on the new generation of MDB engines is modified, so now each of the camshafts actuates four intake and four exhaust valves.



The valves are now rotated by 90° in relation to the crankshaft axis. When viewed from the intake flange side, a pair of intake valves of the new EA288 engines is located behind each other. The same applies to the pairs of exhaust valves.

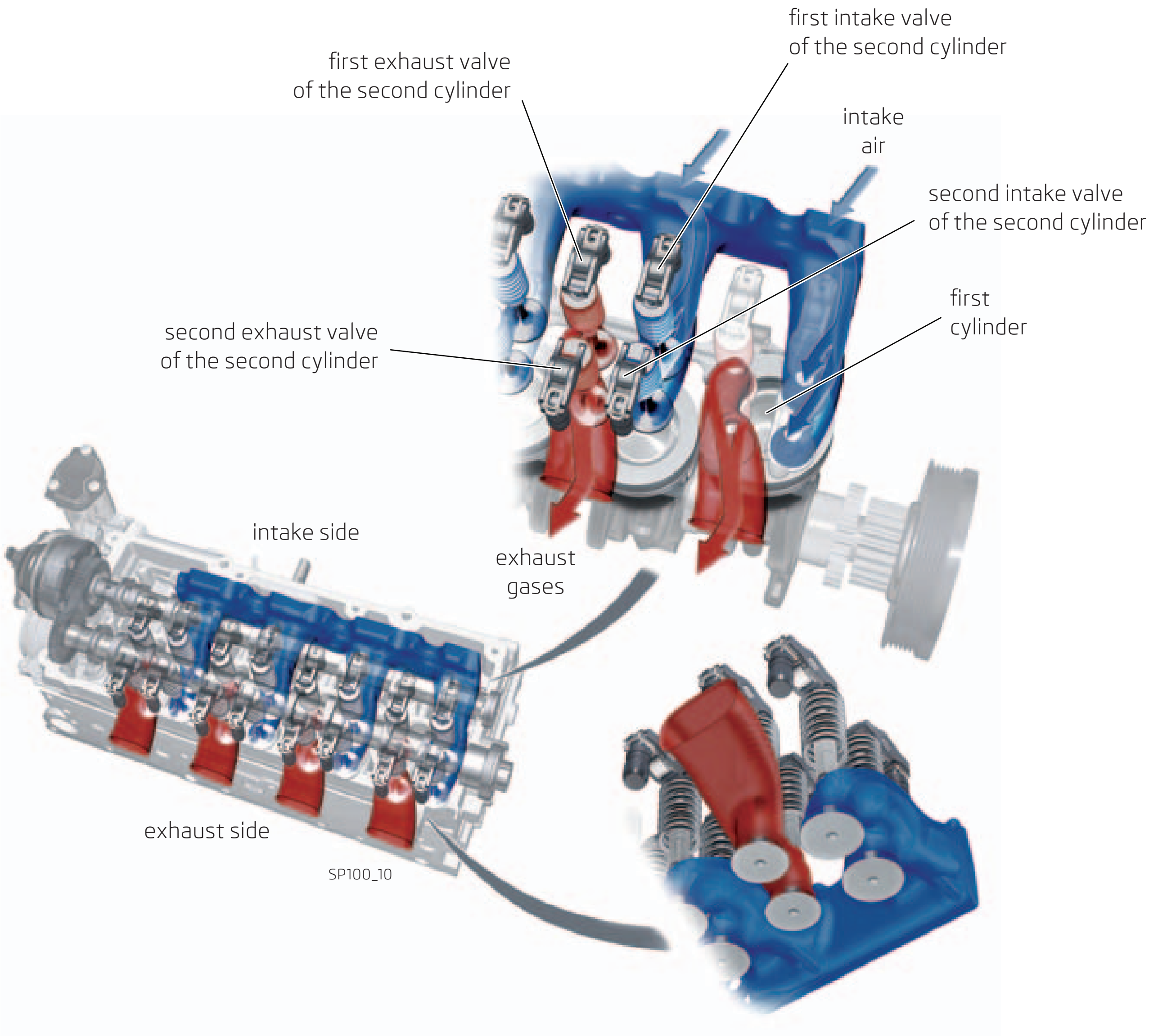


The reason to modify the layout of valves was the new system of their variable timing. This system will be introduced in the EA288 engines compliant with the EU 6 emission standard.
The newly oriented intake and exhaust valves enable modifications of intake port shape and using intake manifold without swirl flaps.

3.5.4 New Intake and Exhaust Ports Design

The shape of ports is also adapted to the new layout of valves. The intake ports feature tapered seats that deliver good swirl characteristics in the full range of valve lift. This design of intake ports enabled elimination of the swirl flaps.

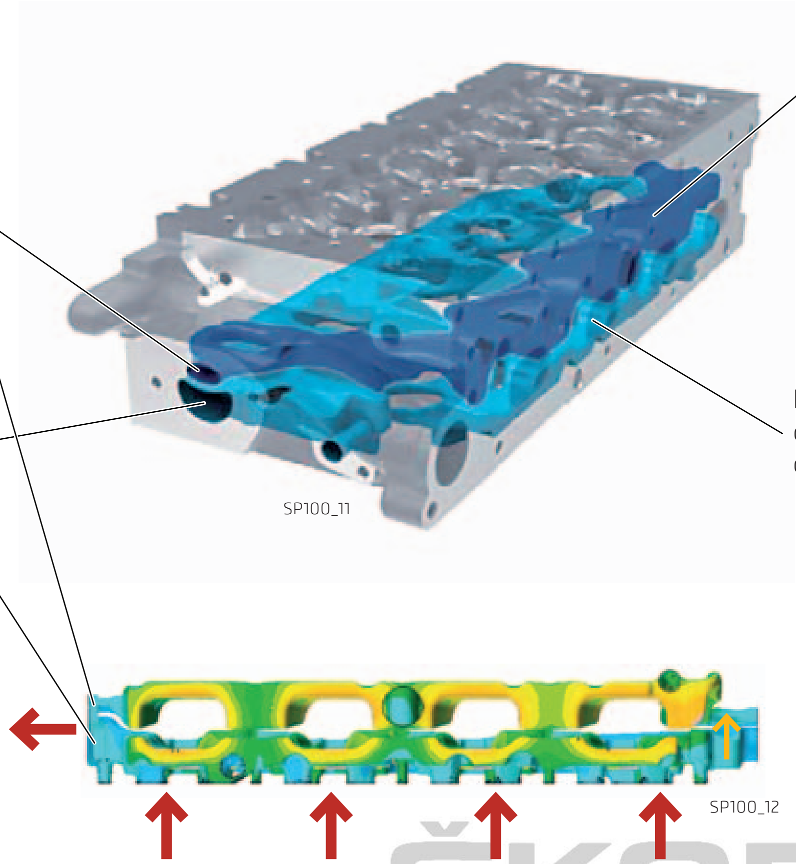
The newly designed intake ports project from the cylinder head in vertical direction. The exhaust ports are routed on the opposite side of the cylinder head. This vertical arrangement of the intake flange enables ergonomic connection of quite a big intake manifold module with integrated boost air cooler. Thanks to this design, the engine structure remained compact, without unnecessary increase in height.



3.5.5 Cylinder Head Cooling

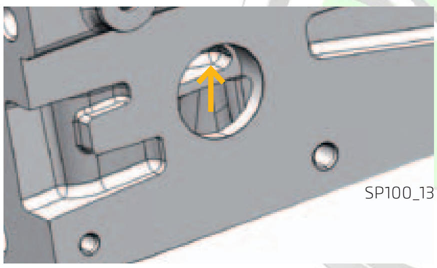
In order to achieve efficient cooling of the areas adjacent to the combustion space, two separate water channels have been integrated into the cylinder head, which are located on top of each other - the upper and lower cylinder head cooling channel.
The upper and lower coolant channel merge into a common outlet to the heat exchanger for interior heating in a heating flange, which is provided with an air bleeding collar.

When the engine is cold, the coolant in the upper and lower cooling channel is flowing throughs recirculated exhaust gas cooler and further to the heat exchanger.



the coolant flows to the lower cylinder head channel from the engine block cooling channels

The cooling channels are not connected on an unmachined cylinder head casting. The connection of the lower and upper cooling channel is created by milling a technological opening from the side of the cylinder head, the opening is then sealed by a plug. The connection created in this way then enables passage of the coolant from the lower to the upper cooling channel, see the yellow arrow on the picture.



4. Variable Valve Timing

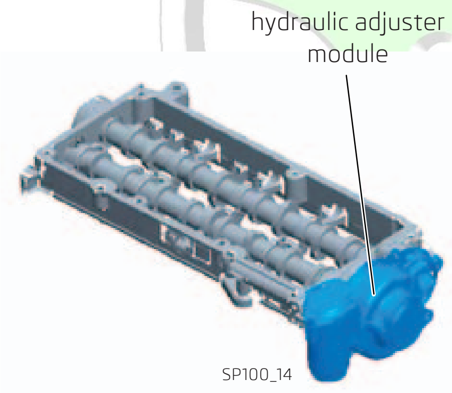
Variable valve timing will be used on MDB engines compliant with the new EU 6* emission standard.

The main reason to introduce variable valve timing on diesel engines is the need to comply with the new emission standards. Another justification is the trend of fuel consumption reduction.

Variable valve timing with earlier or later closing of intake valves enables decreasing the NO_x or CO_2 emissions. By variable timing of the intake valves, it is even possible to decrease the efficient compression ratio. This results in lower compression temperatures and consequently lower NO_x emissions.

4.1 Hydraulic Camshaft Adjuster Module

Variable valve timing is executed by means of a hydraulic camshaft adjuster. The new layout of valves, which combines intake and exhaust cams on each of the camshafts, also enables to vary timing of the exhaust valves.



EU 6 – camshaft module with the adjuster

EU 4, EU 5 - camshaft module without the adjuster

The variable valve timing enables:

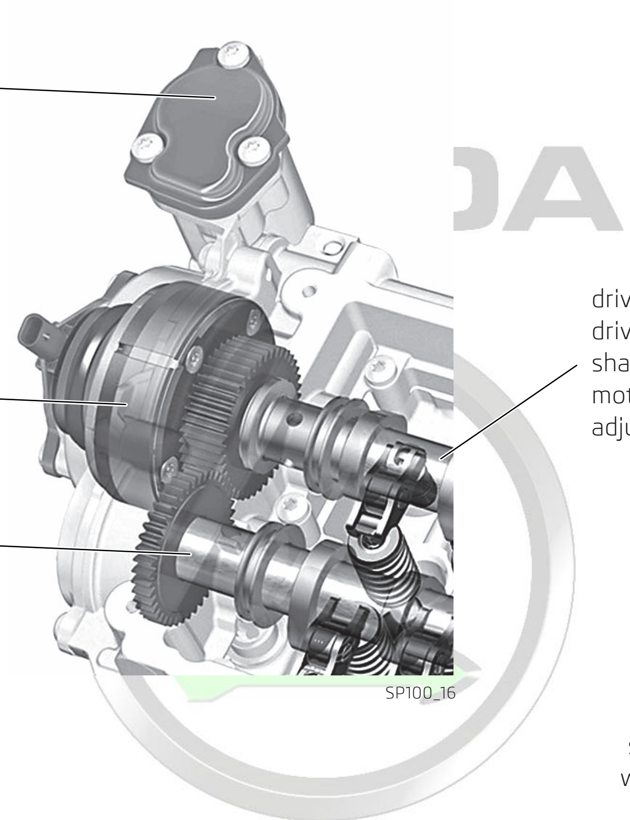
- optimized charging at full load
- operation at lower emission levels and reduced fuel consumption due to variable, which also means more efficient, compression ratio
- maximum utilization of the expansion stroke
- high compression ratio at cold starts

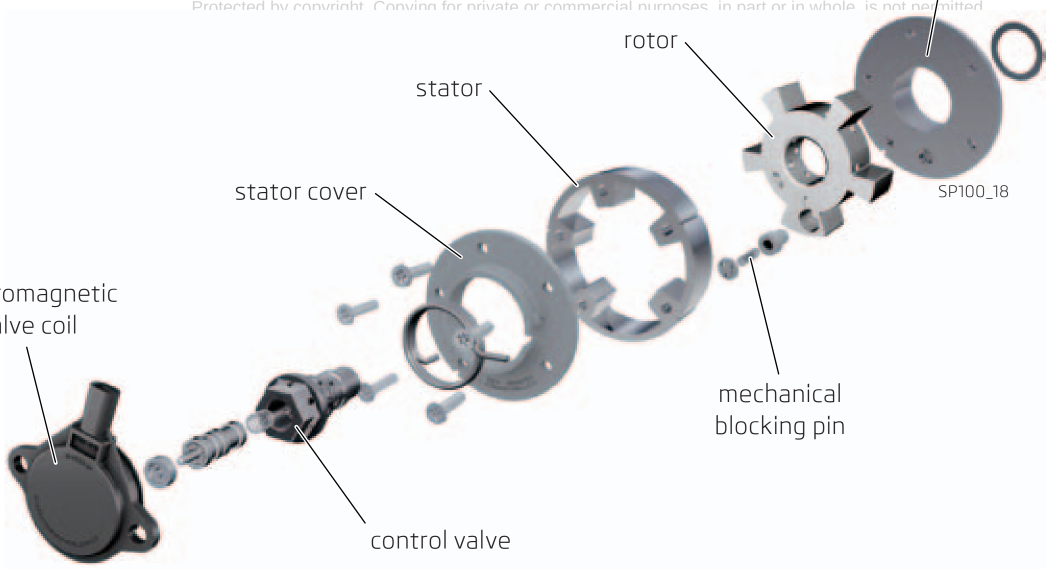
* On the closing date (11/2013) of this SSP, the 1.6 l TDI 81 kW engine was offered in the EU 5 version with variable valve timing, therefore its hardware is ready to comply with the EU 6 standard.

4.1.1 Hydraulic Camshaft Adjuster Functional Principle and Design

Torque transfer from the crankshaft to the driven camshaft

Crankshaft motion is transferred via the driving camshaft to the stator of the hydraulic camshaft adjuster motor by means of a pair of gears. The hydraulic camshaft adjuster is located in the axis of the driven camshaft. The stator of the hydraulic camshaft adjuster motor is permanently connected to the gear of the second camshaft. However, this gear is separated from the driven camshaft by a bearing. That way torque is only transferred from the stator to the rotor of the hydraulic motor. The rotor is permanently connected to the driven camshaft.

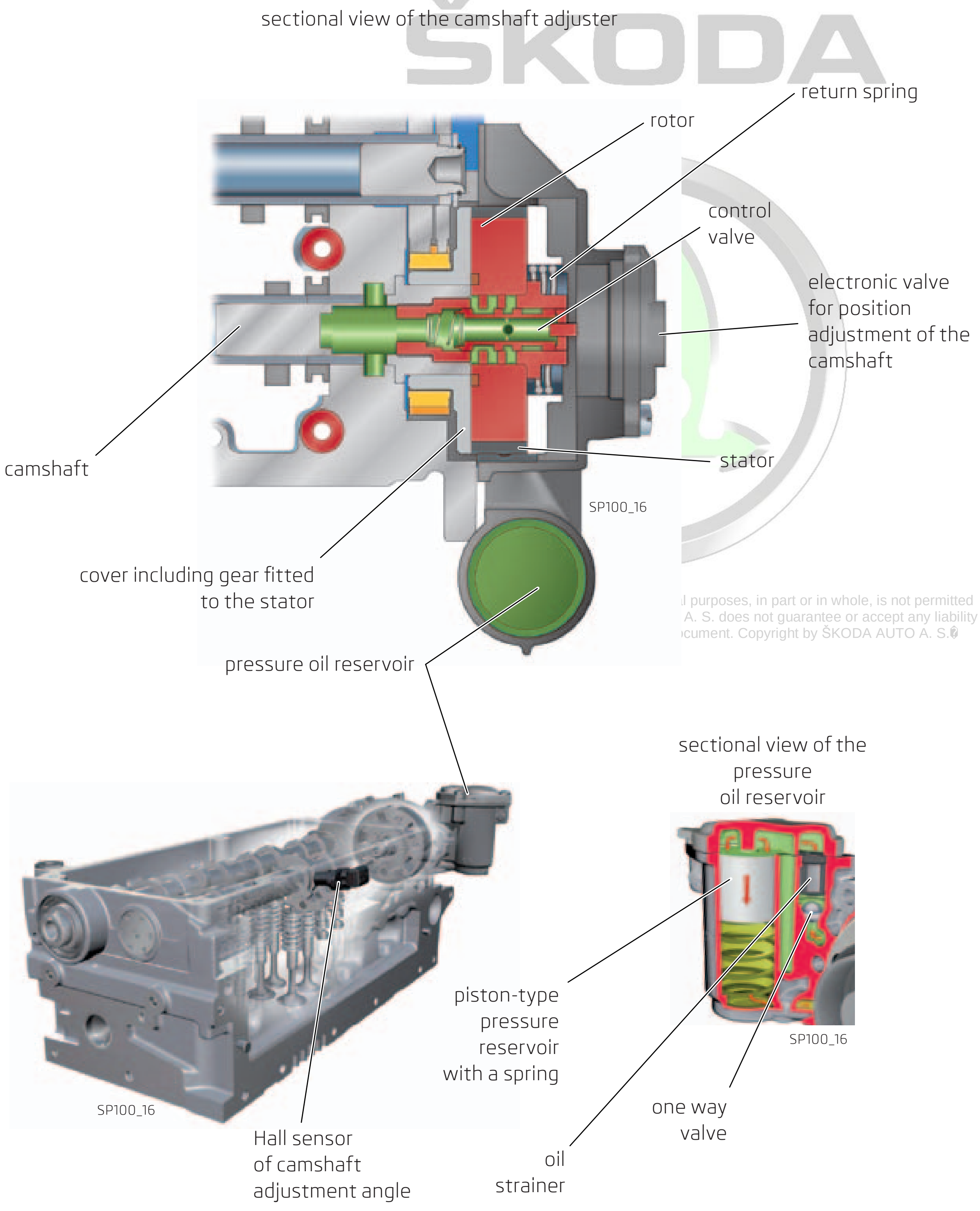




Operating Principle of the Camshaft Adjuster

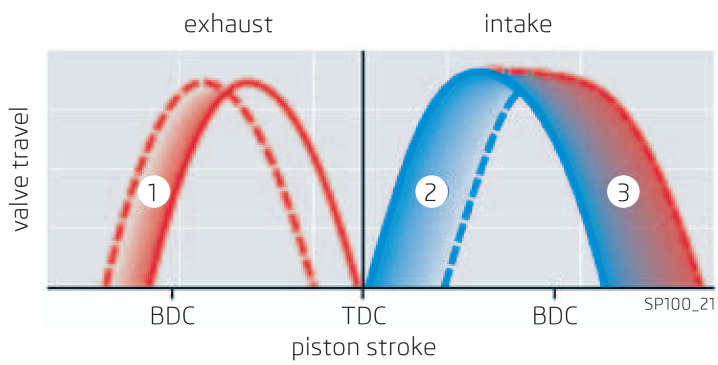
The hydraulic adjuster is supplied by pressure oil from the oil pump. The angle of camshaft adjustment is controlled by the engine control unit by means of a 4/2 way proportional control valve. The control valve is controlled by an electronic valve by means of pulse width modulation (PWM). The adjustment of the camshaft is achieved by the force of pressure oil acting in the chambers in between the rotor and the stator.

During engine starting, the adjuster motor is mechanically locked. Locking the motor is performed by means of a blocking pin, until the necessary oil pressure is built. In order to pressurize the hydraulic adjuster as quickly as possible, an auxiliary pressure reservoir with a one way valve is used.



4.1.2 Operating Ranges of the Hydraulic Camshaft Adjuster

Variable valve opening/closing chart



(BDC - bottom dead center, TDC - top dead center)

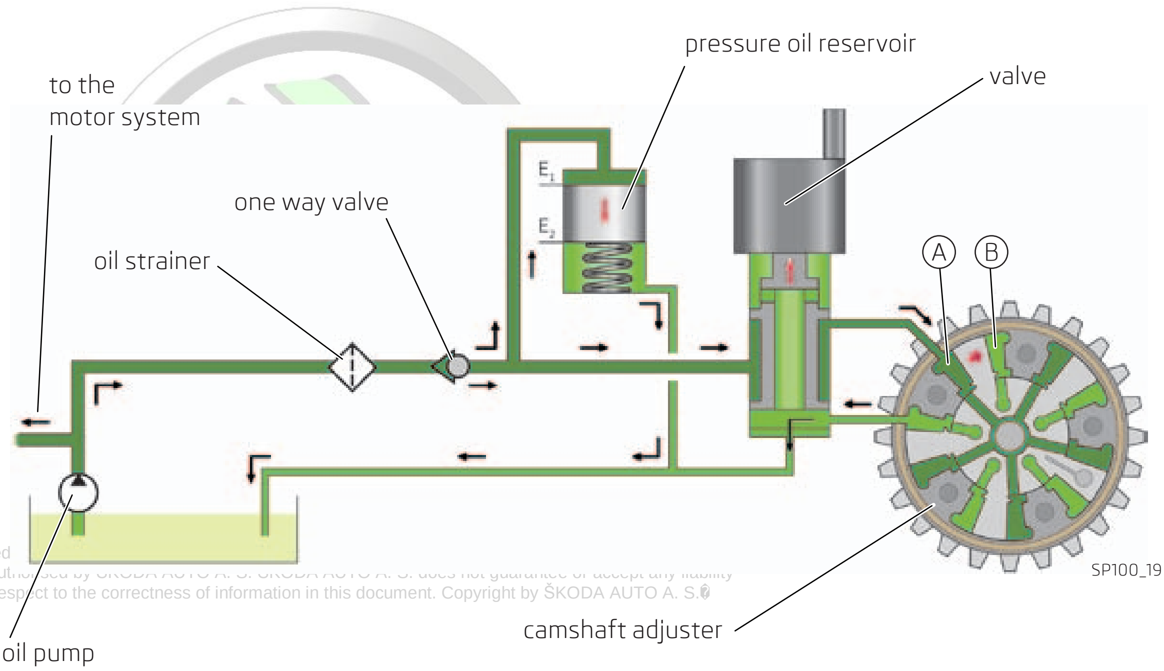
Key:

1 – exhaust: variable opening
2 – intake: variable opening
3 – intake: variable closing

The camshaft adjuster valve is controlled in a way that oil pressure acts in both the chambers of the hydraulic motor. The rotor, permanently connected to the camshaft, moves to the "advance" or "retard" direction based on the ratio of pressures in the pressure chambers between the rotor and the stator.
Once the engine is shut down, the hydraulic adjuster is set into the "advance" opening position by the spring and gets locked in this position by the locking pin.

Camshaft position adjustment to the "ADVANCE" position

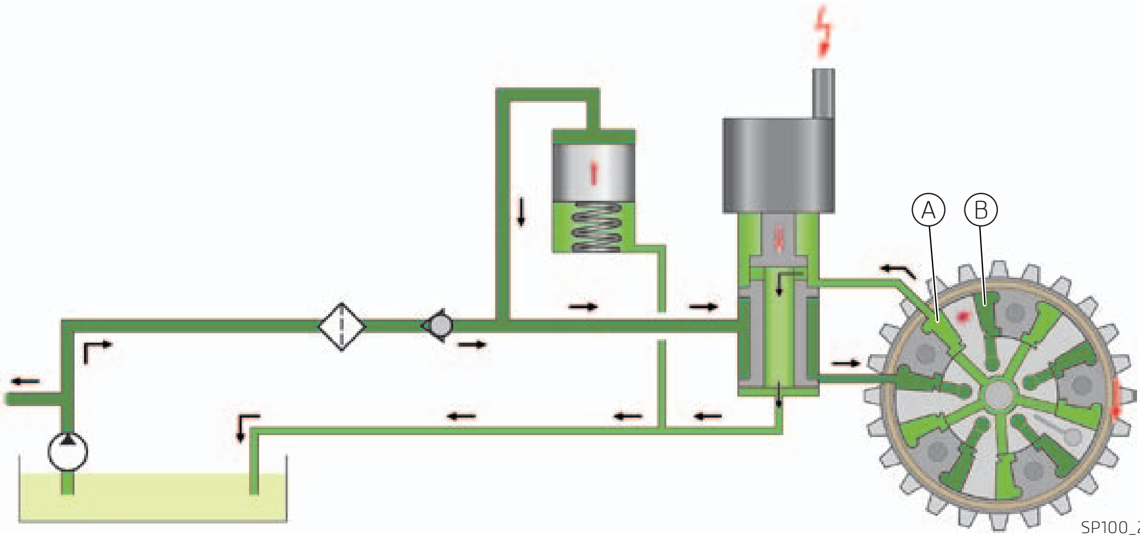
In case zero PWM signal is applied to the electronic valve, the oil pressure gets through the camshaft adjuster valve to the operating chamber "A" of the hydraulic motor. The rotor starts moving in the direction of the operating chamber "B" (towards the "advance" position). Finally the locking pin engages, which locks the camshaft in the "earlier" position.
In case, the camshaft is set to the "advance" position, both the intake valves are opened simultaneously.



Camshaft position adjustment to the "RETARD" position

In case active PWM signal is applied to the electronic valve, the oil pressure gets through the camshaft adjuster valve to the operating chamber "B" of the hydraulic motor. The pressure reservoir actively supports maintenance of pressure in the chamber "B". The hydraulic motor is thus turning the shaft to the "retard" position.
In case, the camshaft is set to the "retard" position, the rear intake valve is opened. (The valve on the driving camshaft.) The front valve on the camshaft with variable timing opens with offset.

Control by means of pulse width modulation - PWM - enables continuous variation of the camshaft position.



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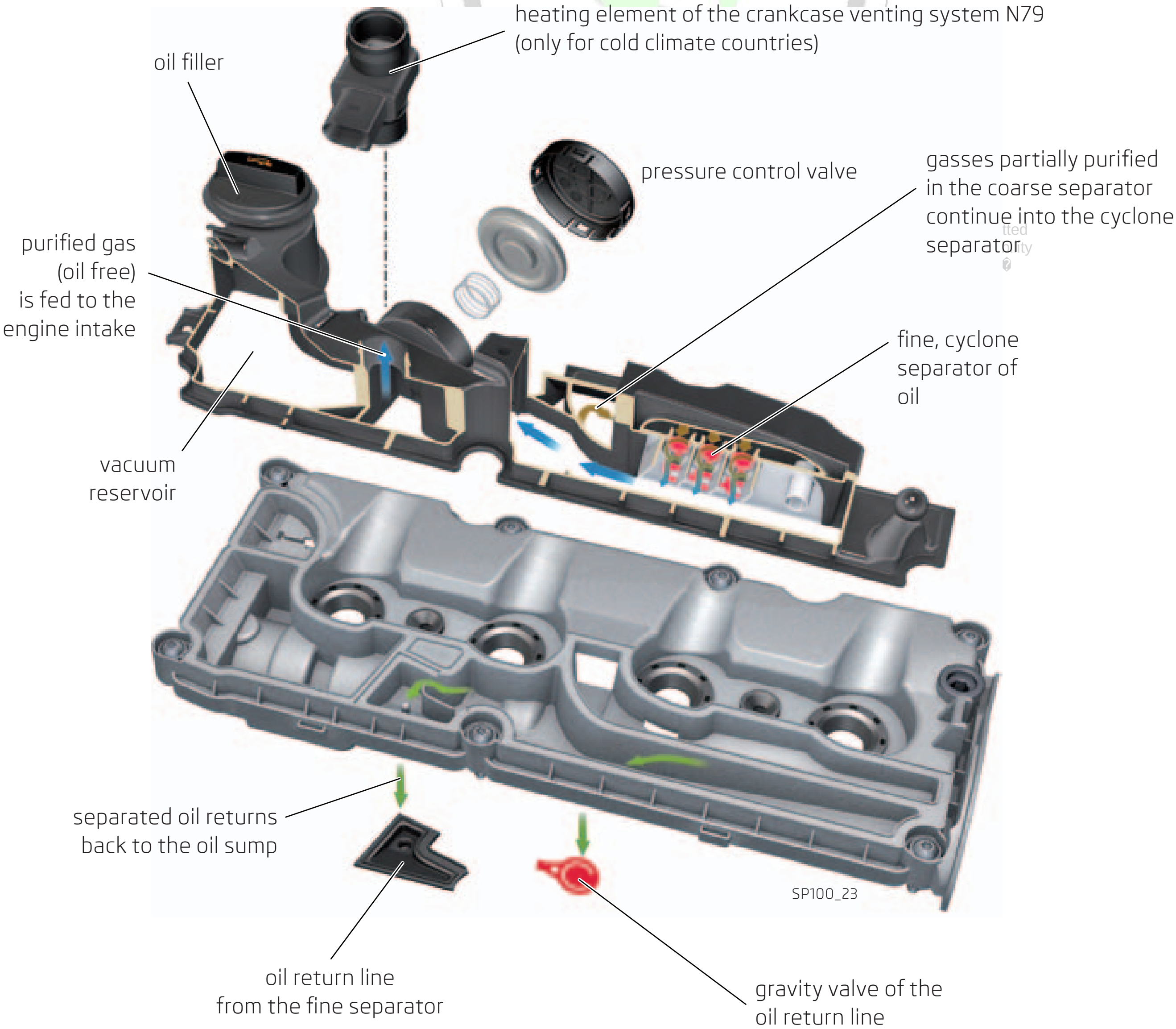
5. Crankcase Ventilation

Cylinder Head Cover

The cylinder head cover is made of plastic, its primary function is to seal the cylinder head. The cover integrates the following components: oil filler, vacuum system pressure reservoir and crankcase ventilation system.

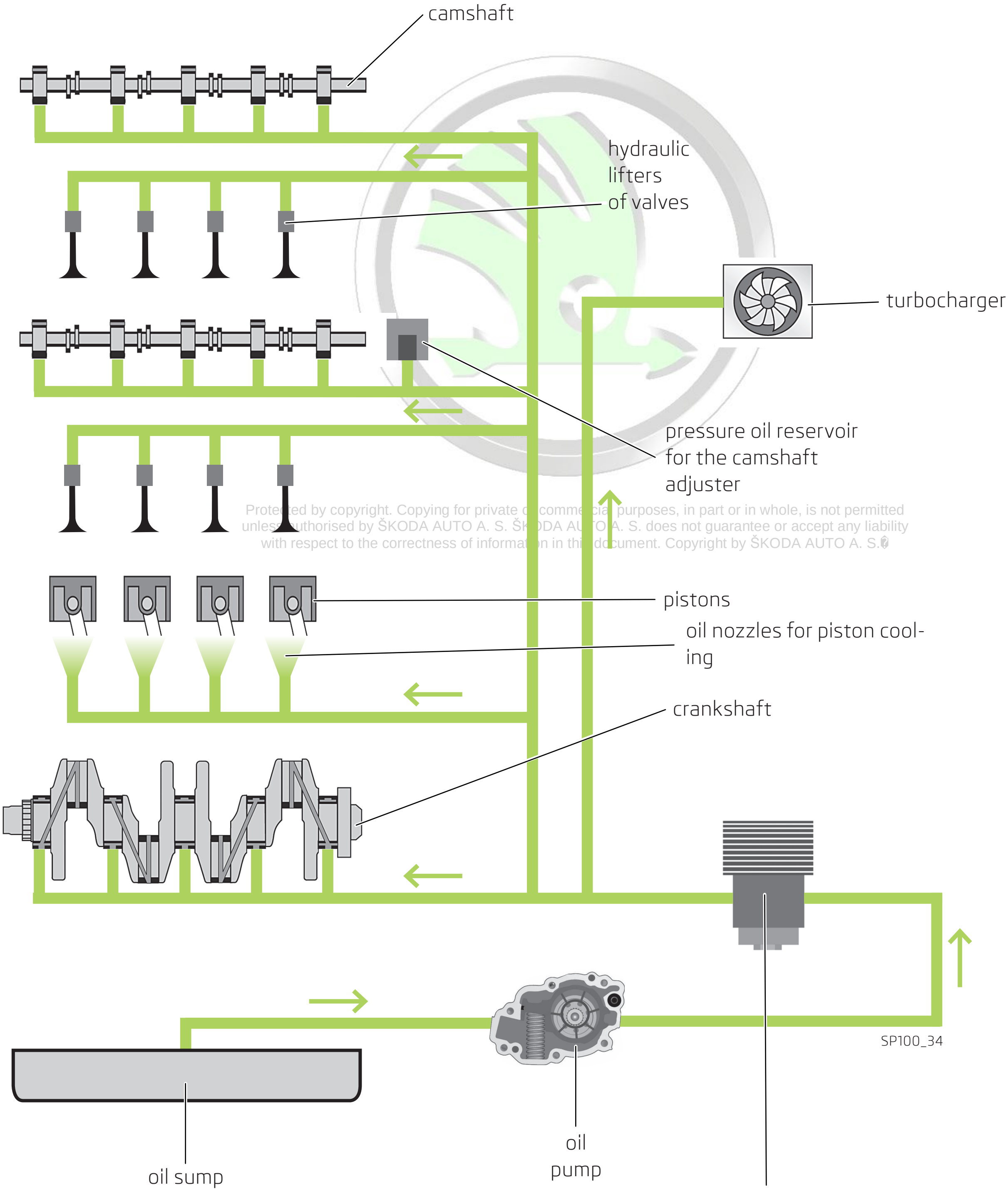
Oil Separation

Due to the pressure difference in between the combustion chambers of the engine and the crankcase, gas leakage takes place between the piston rings and cylinder slide surface into the crankcase. These gasses are referred to as "blow-by" gasses. Gases in the crankcase contain oil in the form of aerosol. Oil gets separated in the crankcase ventilation system. The gas first passes through a coarse oil separator and then a fine cyclone separator. The purified gas is routed via a pressure control valve into engine intake and combusted. Separated oil returns back to the oil sump.



6. Engine Lubrication

6.1 Oil Circuit

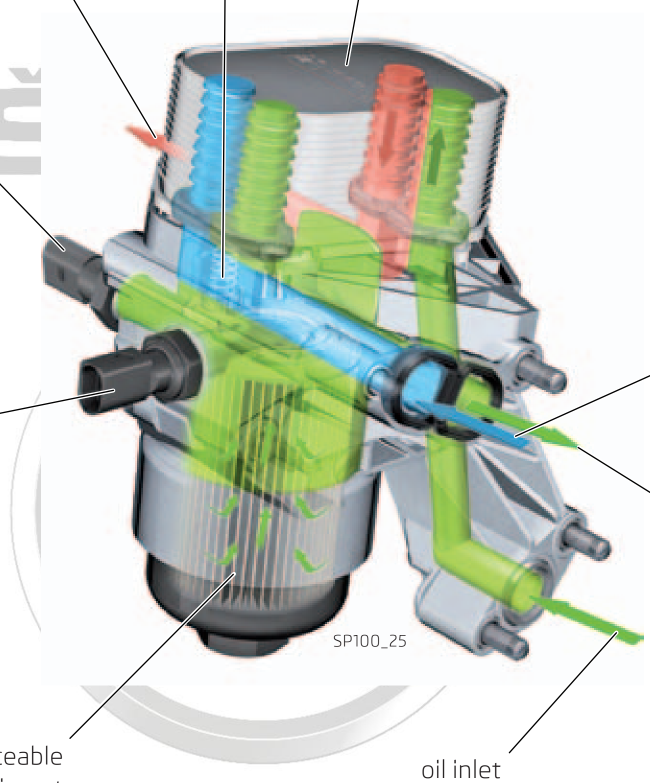


6.2 Oil Filter Module

Next to the oil filter, the oil filter module also contains engine oil cooler. The replaceable oil filter insert is placed in a casing with a by-pass valve. The by-pass valve opens in case the oil filter gets clogged, in order to provide for continued engine lubrication is such a case.

The oil filter module contains two pressure switches:

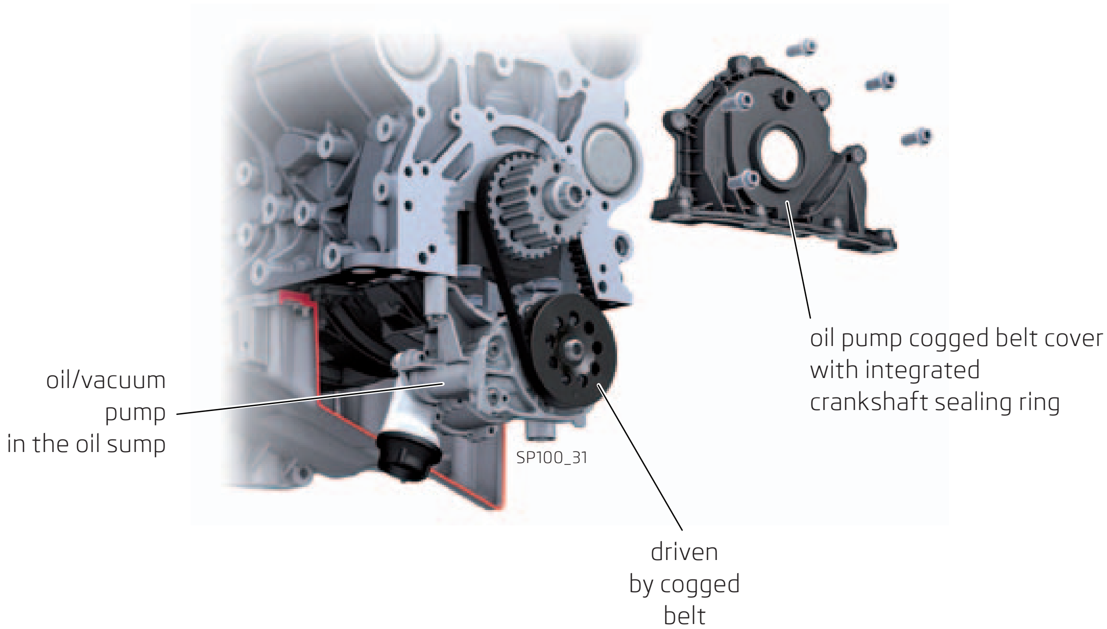
- F378 pressure switch for low, reduced oil pressure (0.3–0.6 bar – switching pressure)
- F378 pressure switch for high oil pressure(2.5-3.2 bar – switching pressure)



6.3 Oil Pump

The pump is doubled, next to oil pressure delivery, it also functions as a vacuum pump. The oil pump is located right in the oil sump and is bolted to the lower part of the engine block. The drive from the crankshaft is transferred to the pump by a cogged belt, which operates in the oil bath. The cogged belt has no tensioner pulley.

The oil pressure control valve is not directly integrated in the oil pump, but it is located in the lower part of the engine block, right above the oil pump.



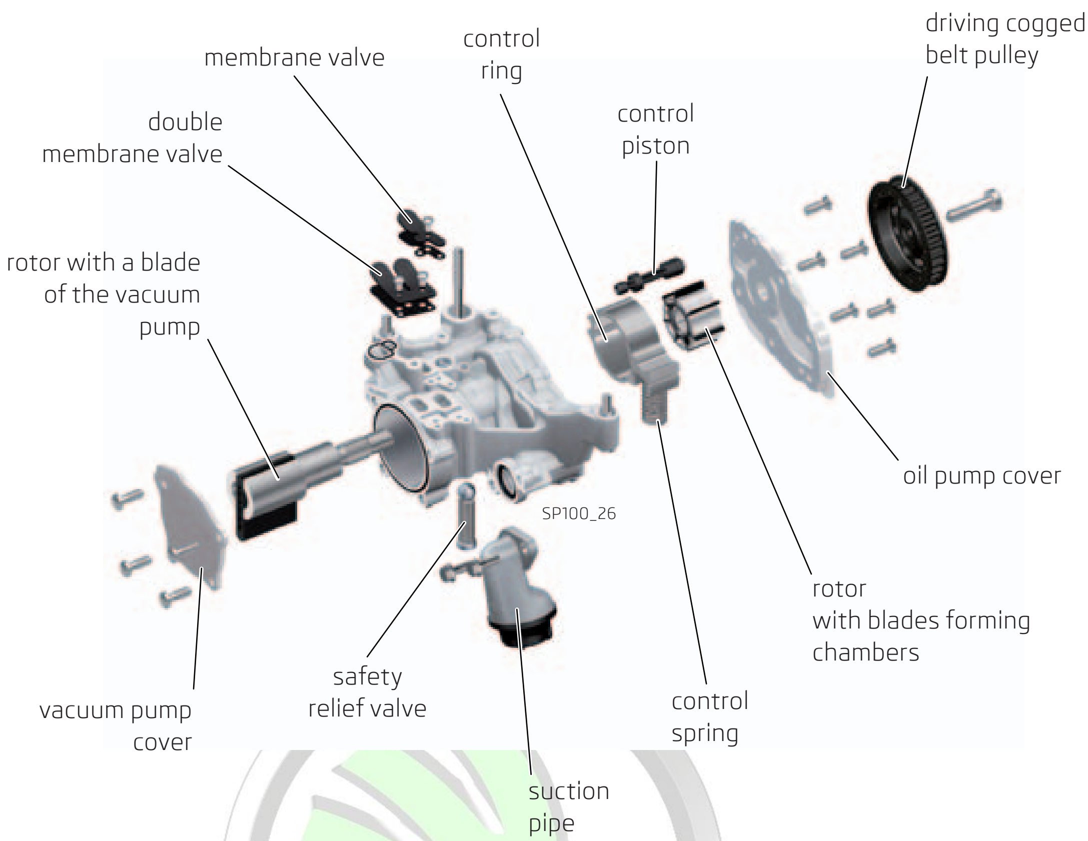
6.3.1 Oil Pump Design

Oil Pump

The oil pump varies the pressure in the lubricating system by varying the oil flow rate. From the design point of view, it is a blade-type chamber pump with eccentrically positioned control ring. The ring is used to vary the oil flow rate. The suction pipe is specially shaped in order to provide for reliable oil suction from the oil sump even at high transversal accelerations of the vehicle.

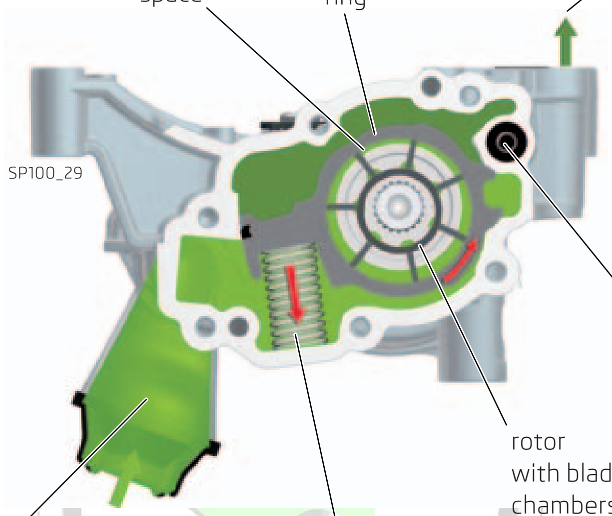
Vacuum Pump

The vacuum pump draws air from the brake booster. From there, air passes through membrane valves into the engine block, where it is used to equalize pressure in the crankcase. The double membrane valve has sufficient cross-section to drain oil from the vacuum pump.

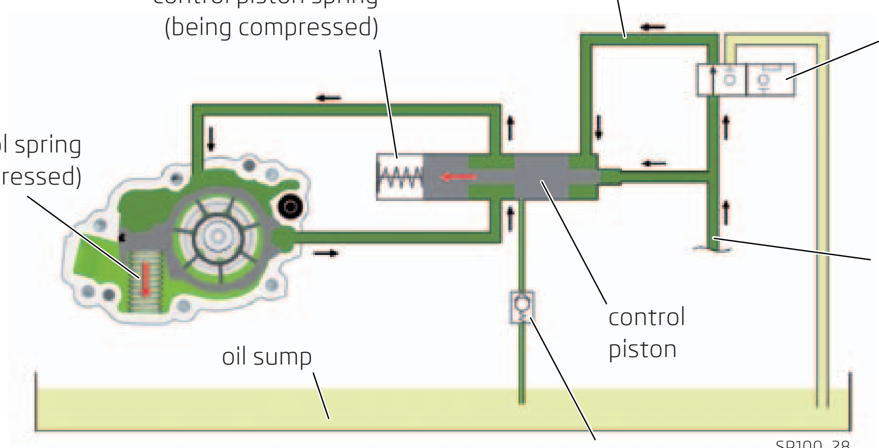


6.3.3 Oil Pump Operating Ranges

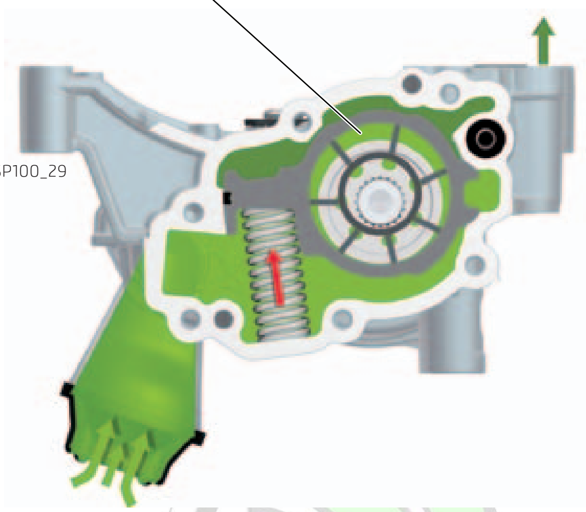
Low Flow Rate



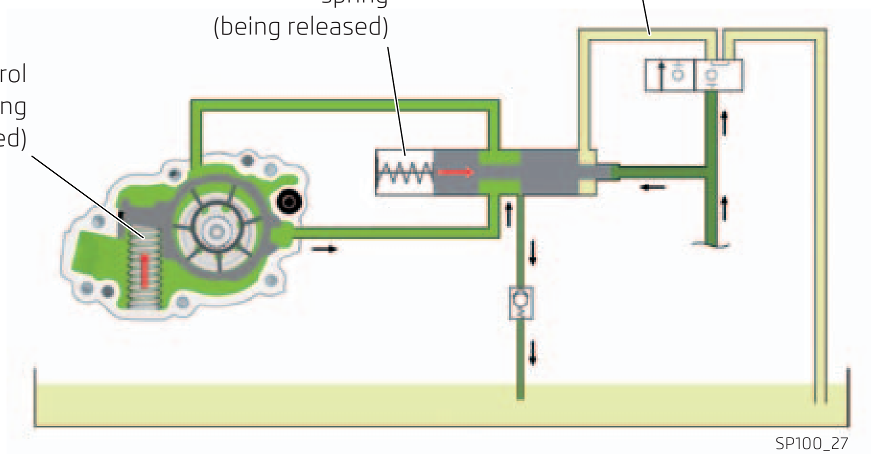
In the low flow rate mode (lower engine rpm range) the N428 valve is grounded (voltage free). That way the connecting oil channel, leading to the control piston, is open. Oil pressure starts acting on the surface of the control piston, shifts it again the force of the piston spring and opens the oil channel to the surface, which actuates the control ring. Oil pressure acts on the pump control spring and turns the control ring counter-clockwise, i.e. towards the center of the pump with blades forming pumping chambers. The size of pumping chambers in between the blades is decreased, which decreases the flow rate through the engine lubrication system.



High Flow Rate

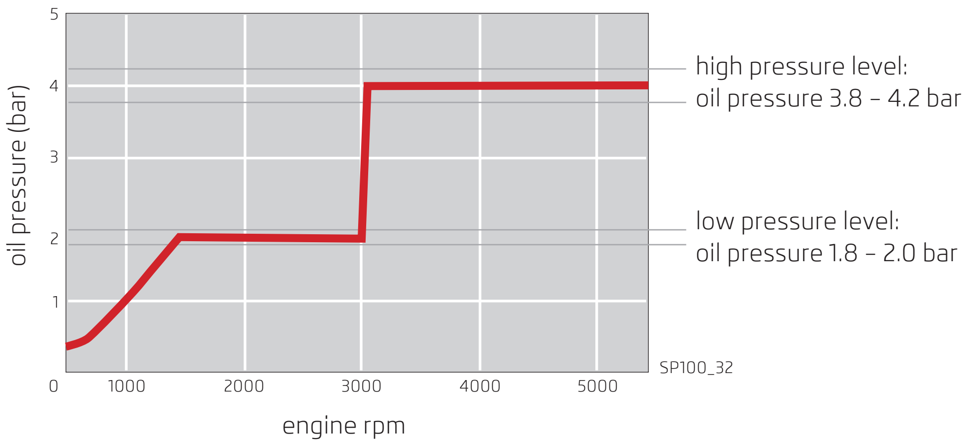


In the high flow rate mode (lower engine rpm range) the N428 valve is under voltage. The connecting oil channel is being emptied. The control piston spring closes the channel to the actuating surface of the control ring. The control ring is thus relieved of oil pressure and the oil pump control spring sets it to the upper position of the supporting bed by clockwise motion. The control ring can move out the center position and increase the pumping space in between blades. This increases the oil flow rate through the lubricating circuit.



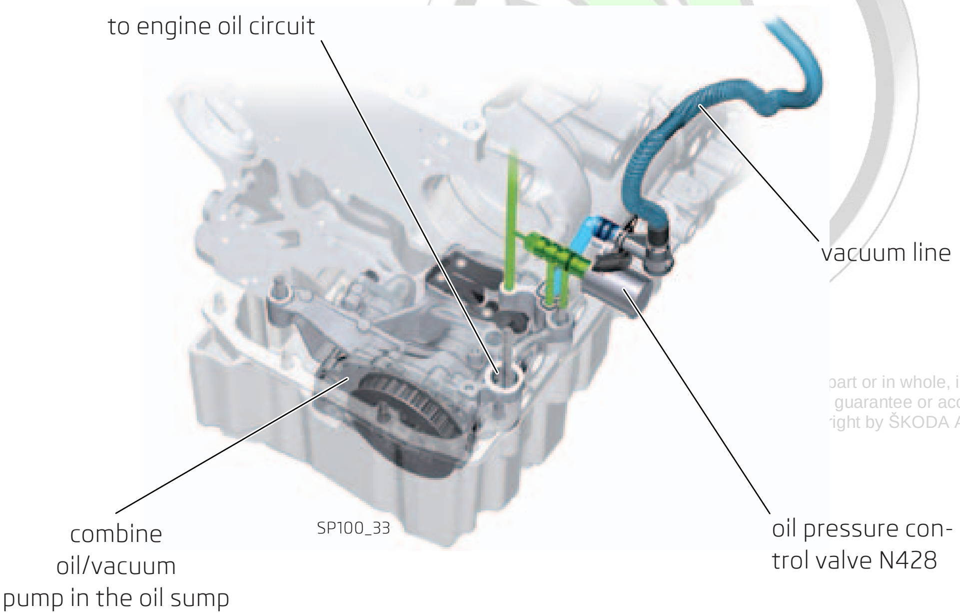
6.3.4 Oil Pressure Control Chart

The oil pump operates in two oil pressure modes depending on engine rpm.
The mechanism of the oil pump maintains reduced oil pressure in the range of 1.8 to 2 bar when the engine operates at up to 3000 rpm. This pressure is maintained by varying the oil flow rate.
For high engine rpm values - above 3000 rpm the oil pressure is increased to 3.8 to 4.2 bar.



6.3.5 Oil Pressure Control Valve Position

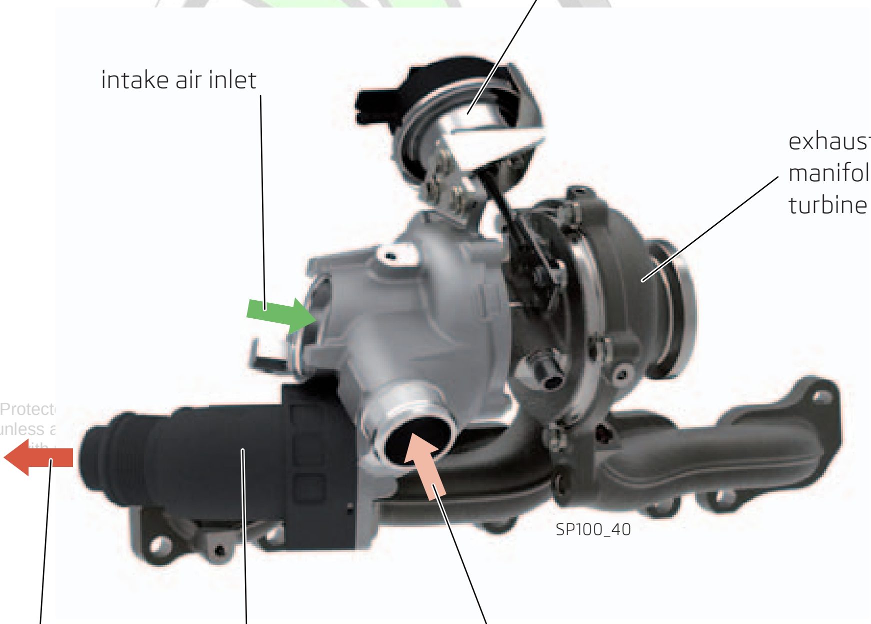
The oil pressure control valve N428 is not directly integrated in the oil pump, but it is located in the lower part of the engine block, right above the oil sump.



7. Turbocharger

The turbocharger module is composed of an exhaust gas collector, in which a turbine wheel with variable blade geometry (VGT) is integrated. The VGT technology enables to change the pitch of turbocharger blades based on current engine load in order to optimize charging of cylinders. The turbocharger is controlled by a vacuum boost pressure controller with a position sensor - G581.

The turbochargers for MDB engines are delivered by several suppliers.



The picture of the turbocharger corresponds to the EU 6 compliant version.

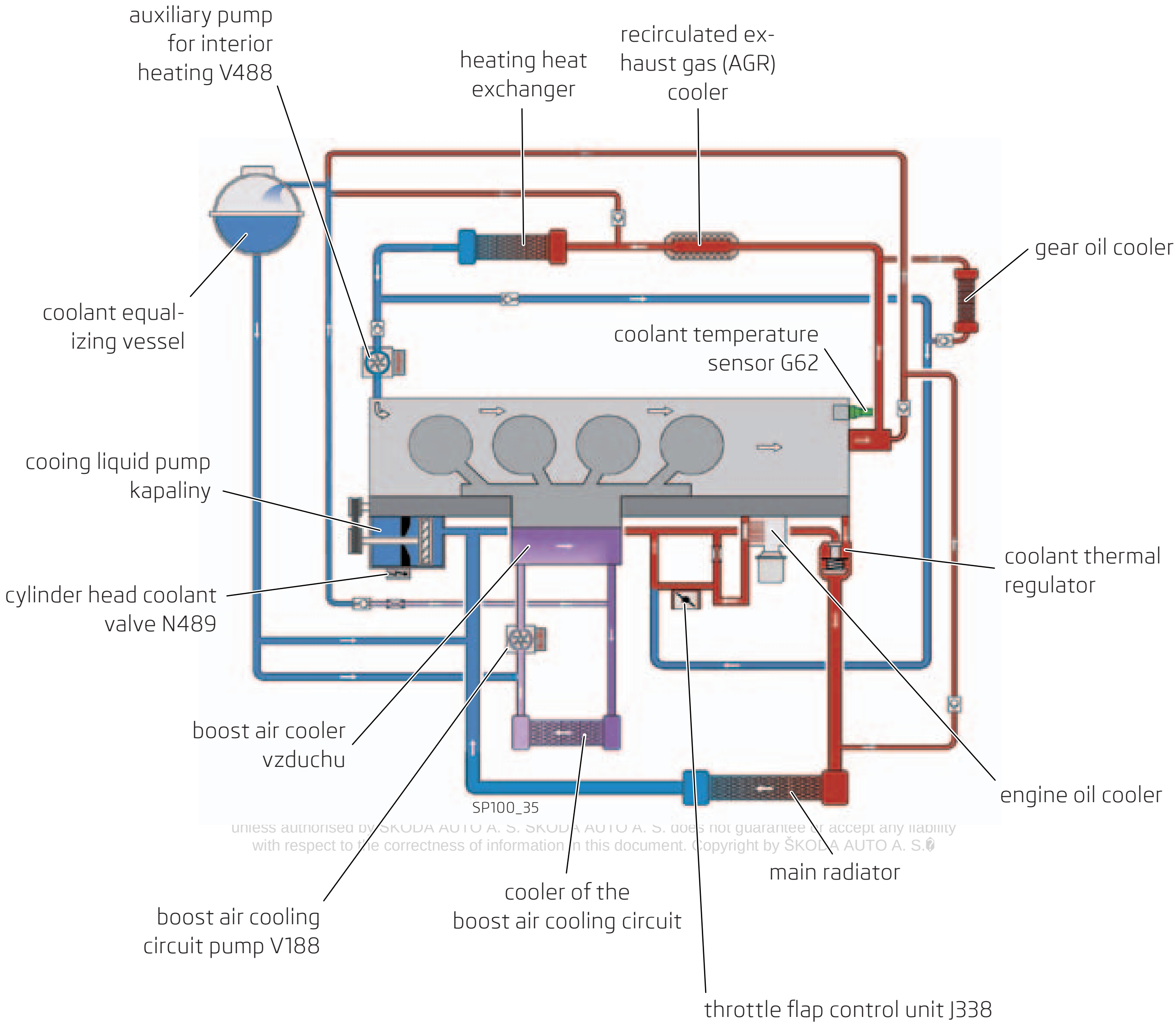
8. Cooling System

The EA288 series MDB engines are equipped with an intelligent multi-circuit system for engine temperature control. The core of the cooling system is formed by a switchable pump and a coolant temperature regulator. Based on the current engine temperature, its big cooling circuit is being blocked or opened.
The whole system is designed to maximally shorten the heat up phase after cold engine starts. Further tasks of the system are to quickly heat up the vehicle interior and to operate the engine in ideal operating temperature range in order to achieve minimum internal friction.

The cooling system is composed of three circuits:

- small cooling circuit (micro-circuit)
- big cooling circuit (high-temperature cooling circuit)
- boost air cooling circuit (low temperature circuit)

8.1 Cooling Liquid Overview



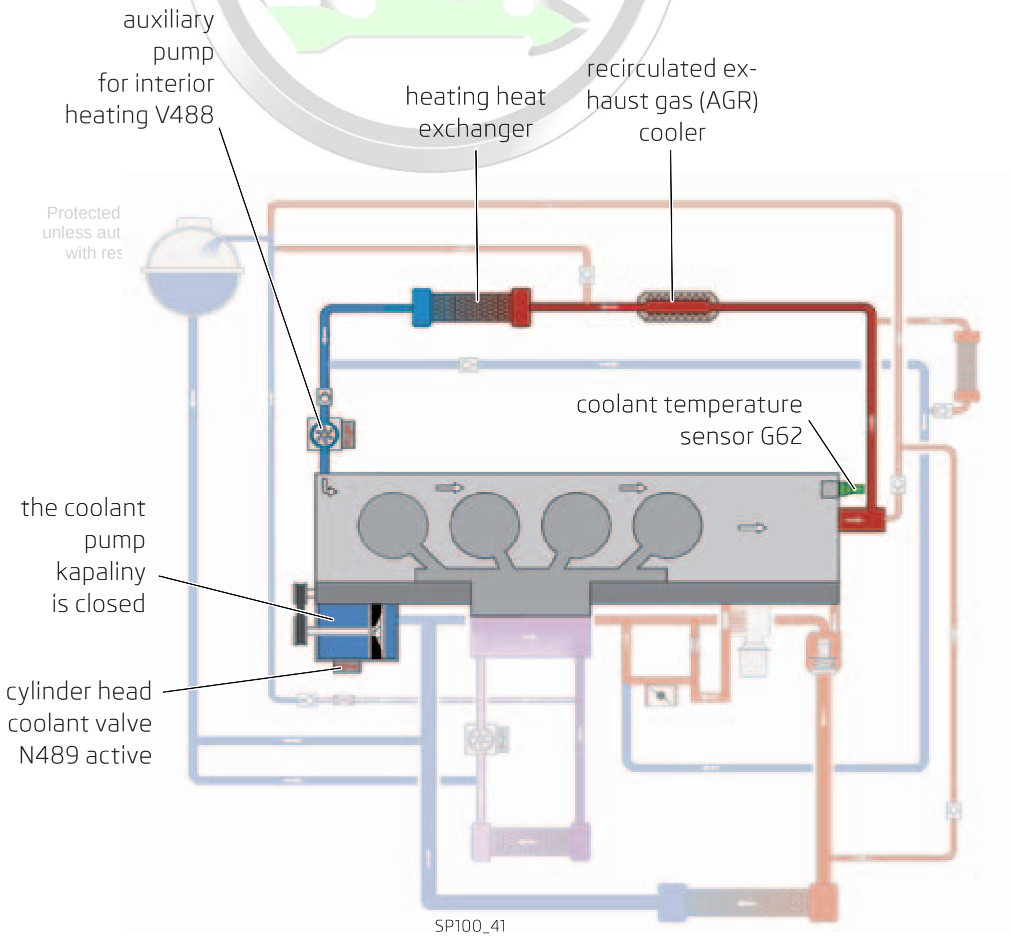
Note: The cooling system diagrams in Chapter 8 apply to the EU 5 compliant version of the engine.

8.2 Small Cooling Circuit

The small cooling circuit passes through:
Cylinder head - recirculated exhaust gas cooler (AGR) - heating heat exchanger - auxiliary electrical coolant pump.

At cold engine starts, only the small cooling circuit is active in order to enable quick engine heat up and interior heating in case of such requirement. The switchable coolant pump is powered, which means it is closed. The coolant circuit in the engine is thus disconnected and the coolant in it is not moving - this enables the cold engine to get very quickly heated up.

When it is required to quickly heat the interior (driver's requirement received by the air-condition control unit) the heating circuit pump V488 is activated. That way the coolant only circulateds in the small cooling circuit and heats the heat exchanger for interior heating.



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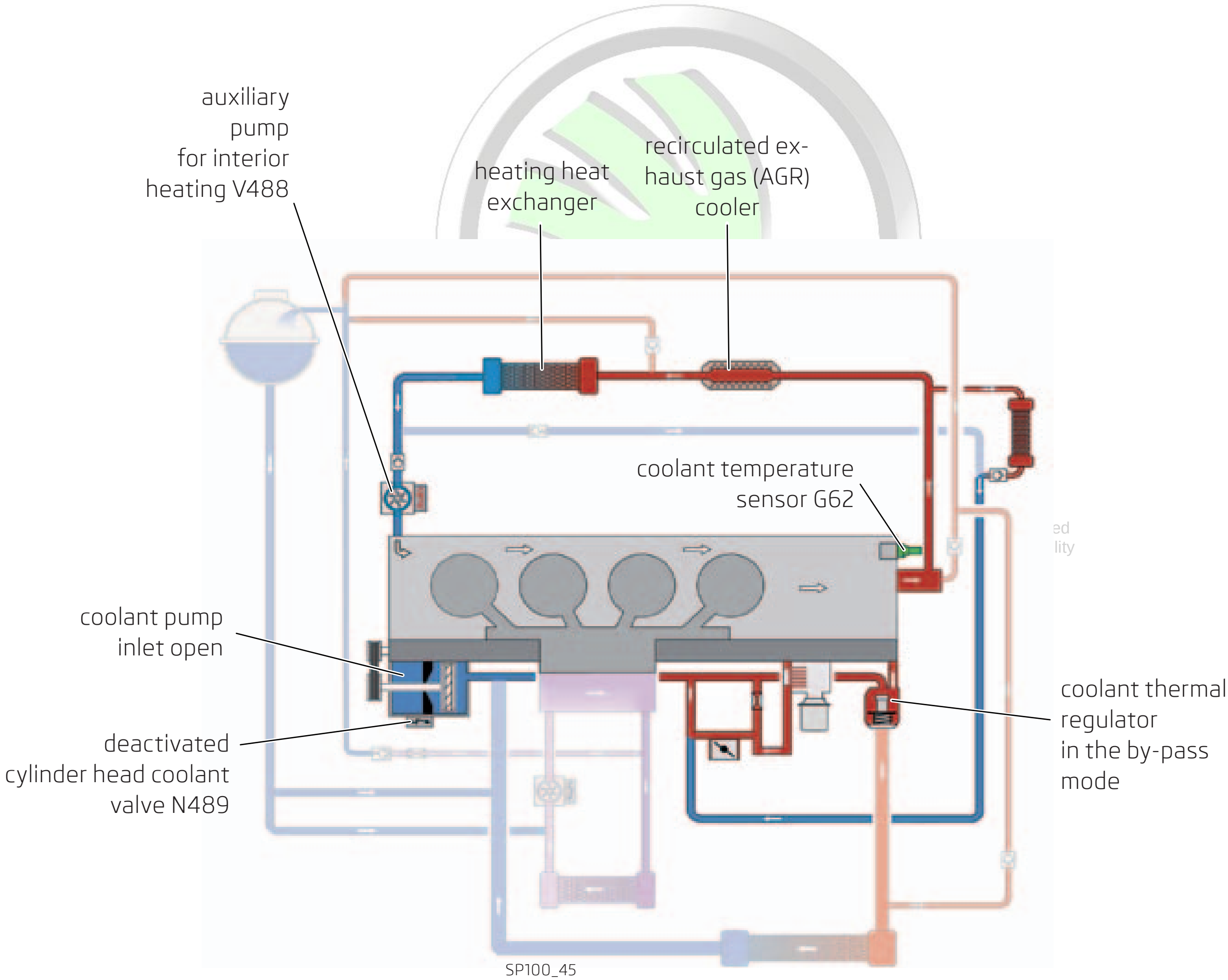
The switchable coolant pump
is controlled by the cylinder head coolant valve N489.

8.3 Small Cooling Circuit at High Engine Loads

As the engine load is increasing and speed rises over 3000 rom, the switchable coolant pump is activated and the coolant start flowing through the engine. Once engine speed drops below 2000 rpm, the switchable coolant pump stops. The engine is then again operated without coolant circulation.

The coolant pump is permanently active once coolant temperature in the cylinder head exceeds 60°C. This temperature correspond to a heated-up engine. As the coolant did not yet reach operating temperature, the thermal regulator is still in the by-pass mode and does not open the passage to the big cooling circuit.



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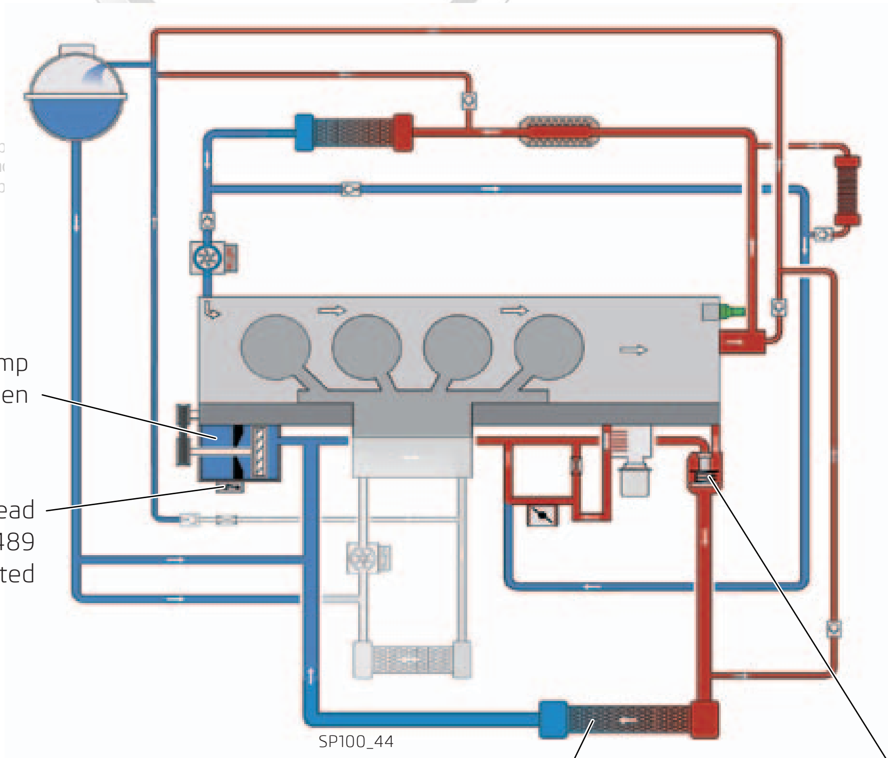
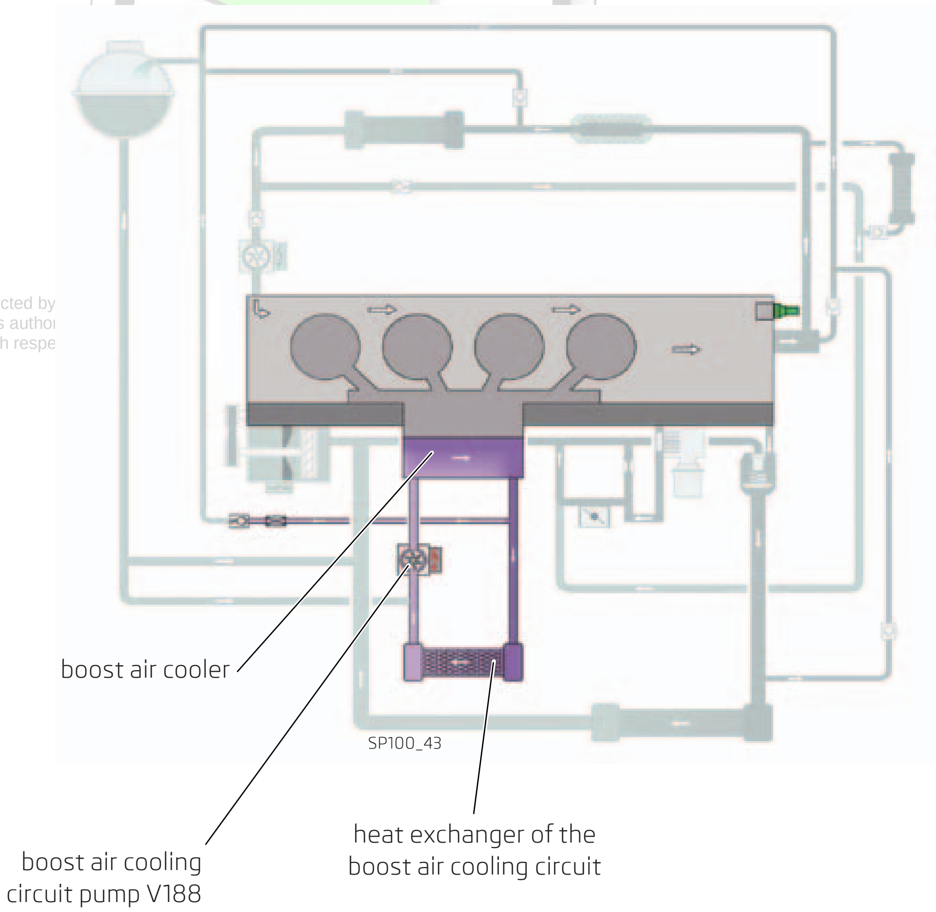
8.4 Big Cooling Circuit

Once the coolant is heated to the operating temperature, the thermal regulator opens and the coolant start flowing through the big cooling circuit. The thermal regulator further controls the coolant temperature.



8.5 Coolant Circuit for Boost Air Cooling

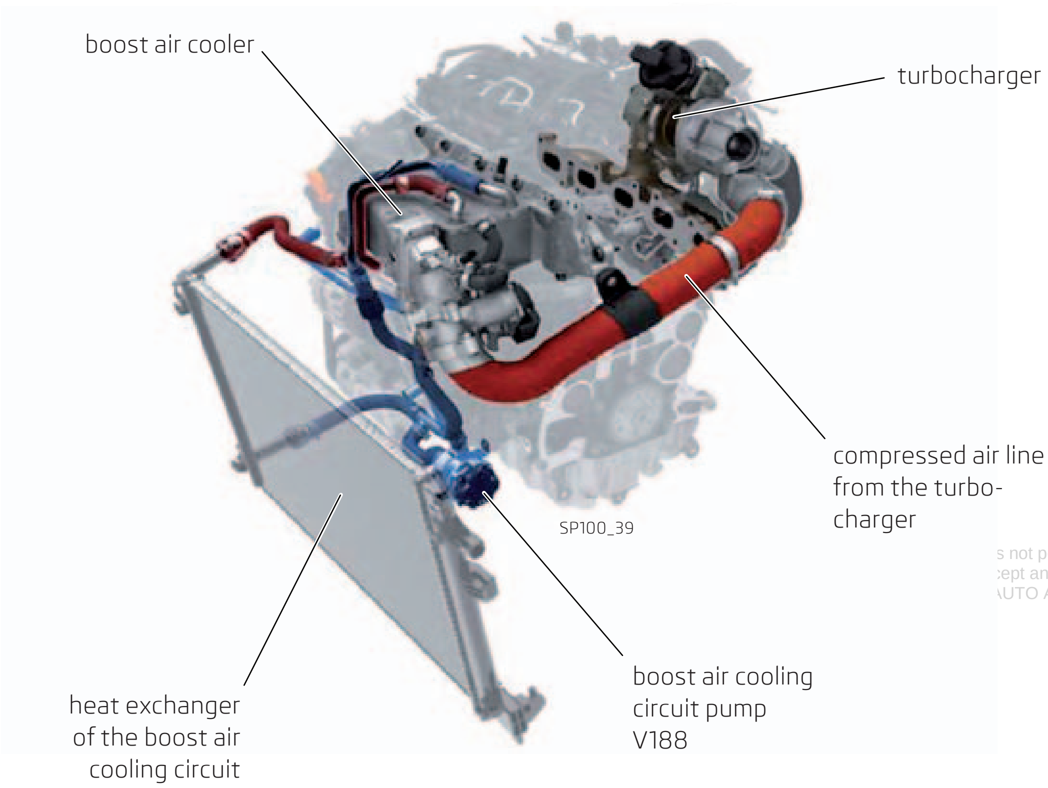
The coolant circuit for boost air cooling is fully independent. The V188 pump speed is controlled based on temperature in the intake manifold. The value is sensed by the boost air temperature sensor - G811.



8.5.1 Boost Air Cooling

Air compression in the turbocharger results in undesirable temperature increase. The intake gas temperature is further increased by exhaust gas recirculation upstream the turbocharger.

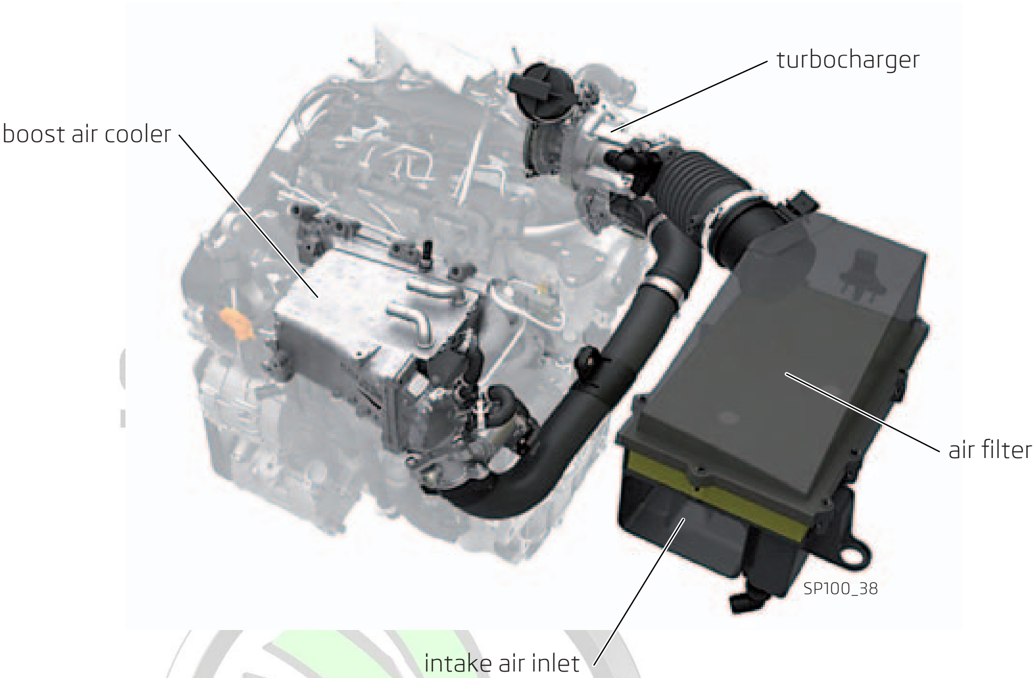
In diesel engines, in order to avoid the need to combust too rich mixture, it is necessary to combust the intake air. Boost air cooling on the EA288 series MDB engines is similar to the EA211 series petrol engines. A boost air cooler (air-to-coolant) is integrated in between the turbocharger and cylinder head.



Boost air cooling is executed by means of a separate low-temperature coolant circuit with coolant-to-air heat exchanger. An electrical coolant pump V188 with variable speed is used to circulate coolant in this circuit.

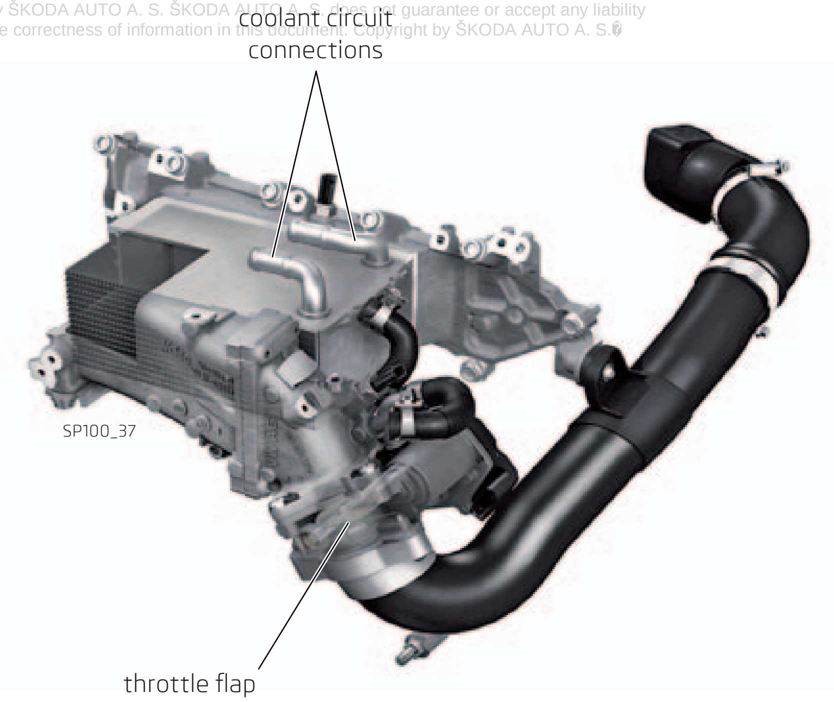
* The design of the heat exchanger of the boost air cooling circuit may differ based on the version used.

8.5.1.1 Boost Air Cooling Design



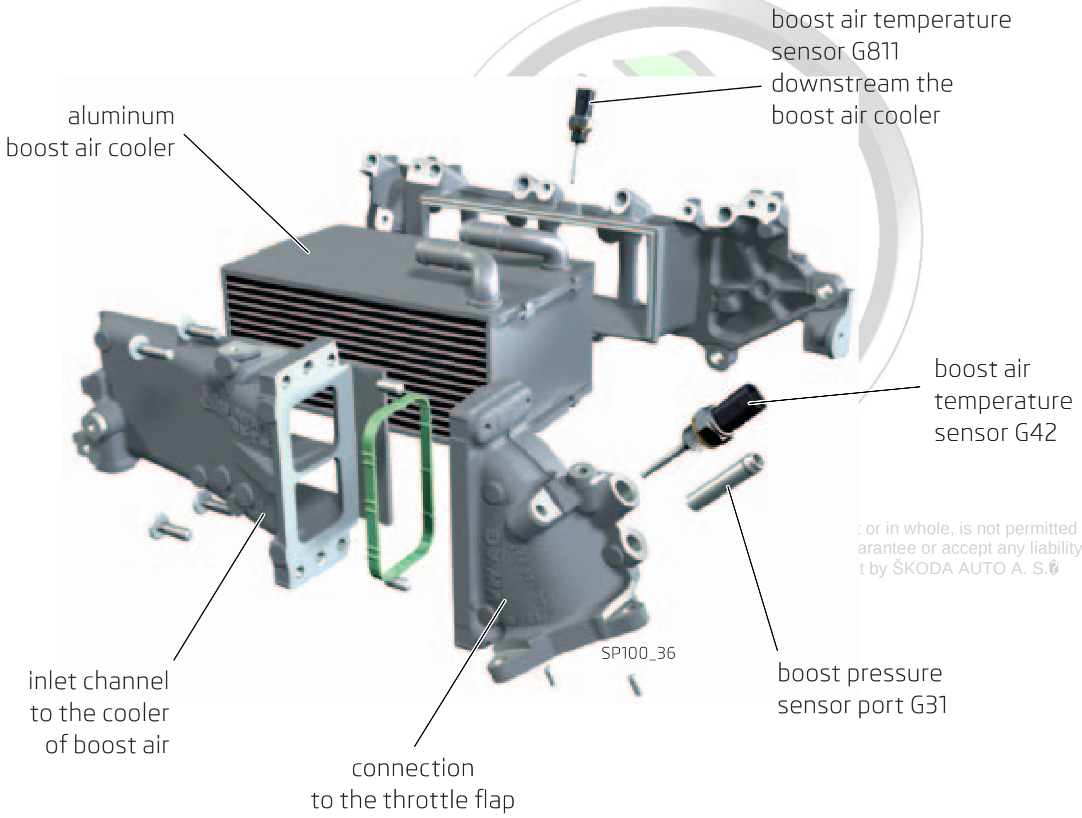
The compressed air cooler integrated in the intake manifold is completely made of aluminum. It is composed of cooling plates, lamellas, cover plates and coolant ports.

The coolant flows through the W -shaped cooling plates in counter-flow mode. The special shape of the cooling plates divides the flow along all the length of the flat tube and also inverts the flow. This enables good heat transfer from the aluminum sheet metal to the coolant.



8.5.1.2 Boost Air Cooling System Sensors

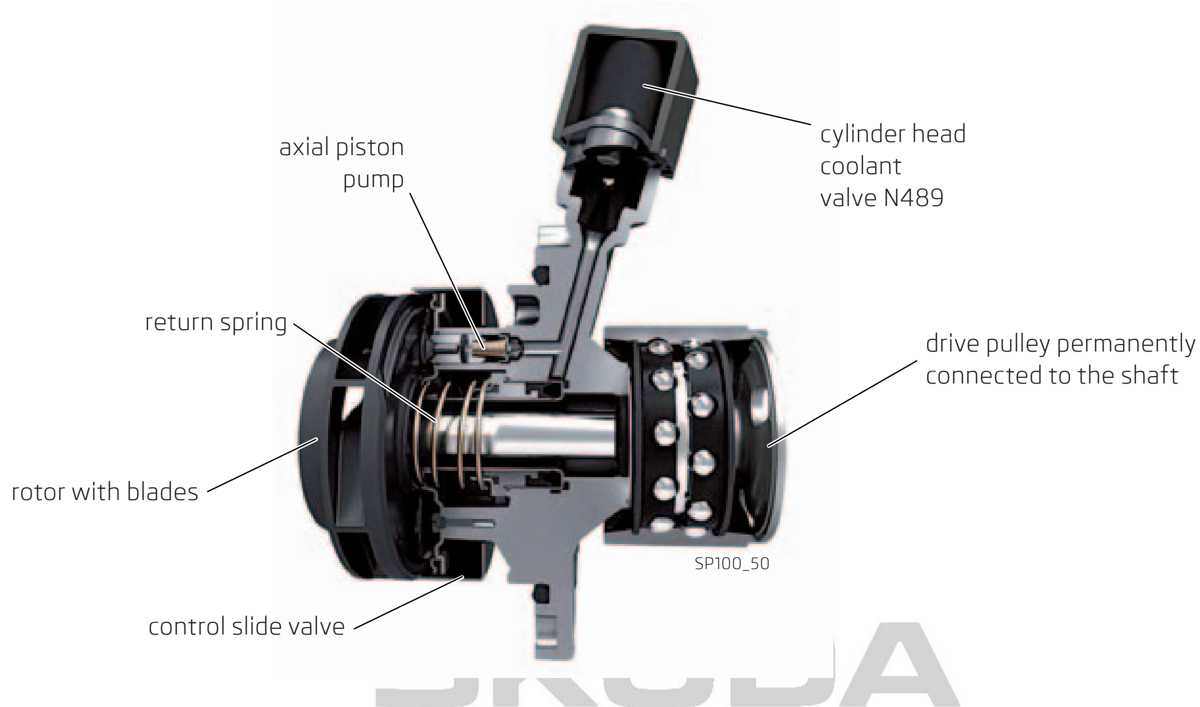
Sensor of the boost air cooler include input boost air temperature sensor G42 and boost air pressure sensor G31. Boost air temperature G811 is fitted on the cooler outlet.

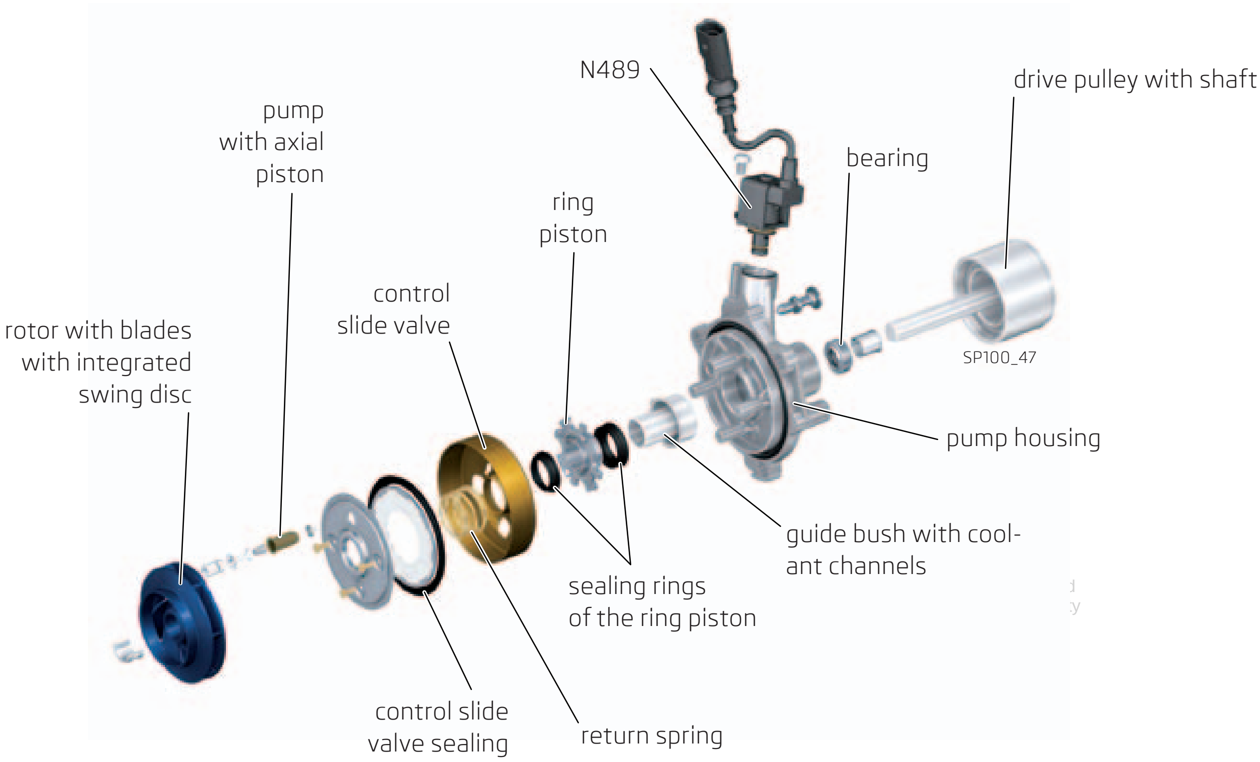


8.6 Coolant Pump

The cooling system of the EA288 series MDB engines features a switchable pump. When switched off, the rotor is covered by a control slide valve and thus the coolant is not pumped and circulating through the cooling circuit. Switching of the pump is controlled by means of a solenoid valve - N489.

The coolant pump is driven by the flat side of the clogged belt.





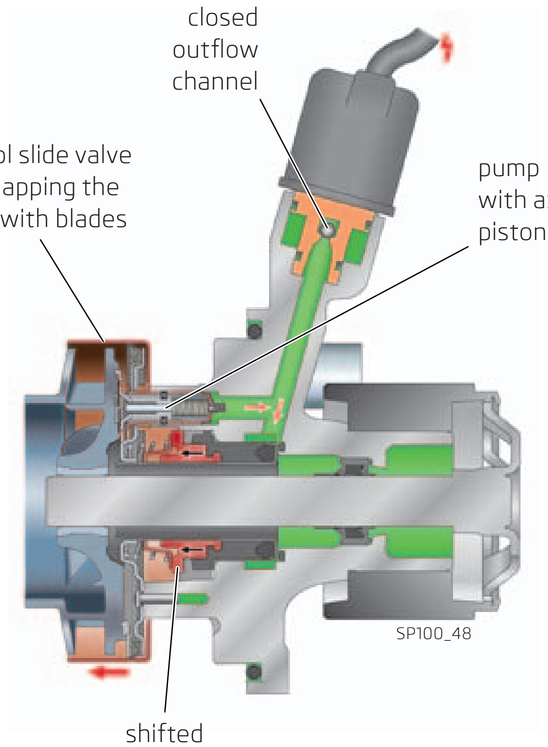
8.7 Coolant Pump Operating Ranges

Pump with Axial Piston

The housing of the coolant pump contains a miniature pump with an axial piston. This pump drives the swing disk located on the rear side of the rotor with blades. The miniature pump is not switchable and is permanently running once the engine is operating.

Standstill Coolant Mode

In this mode, the N489 valve is powered. Thus the outflow channel to the coolant circuit is closed. The miniature valve with the axial piston remains permanently operational and builds pressure in the enclosed system, which shifts the ring piston. The shifted piston moves the control slide valve against a spring, the slide valve thus overlaps the rotor with blades and interrupts coolant flow.



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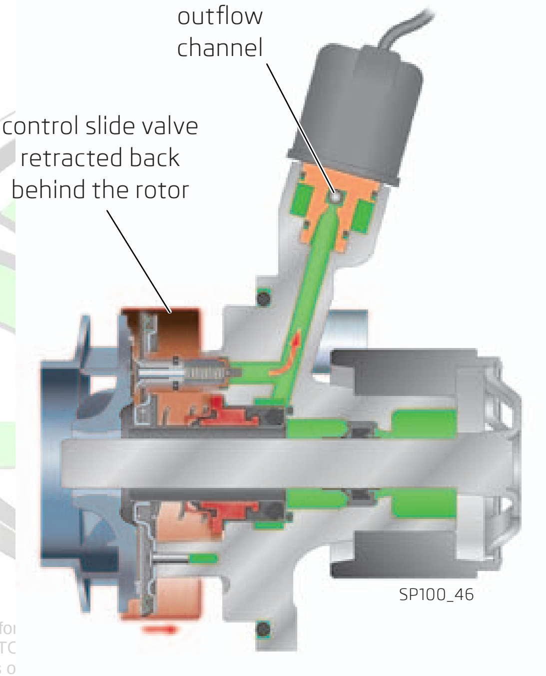
Circulating Coolant Mode

In this mode, the solenoid valve N489 is not powered. Thus the outflow channel to the coolant circuit is open. Hydraulic pressure drops in the pump control channel and the spring moves the ring piston and control slide valve back to the initial position. The rotor with blades is thus revealed again and pumps the coolant.



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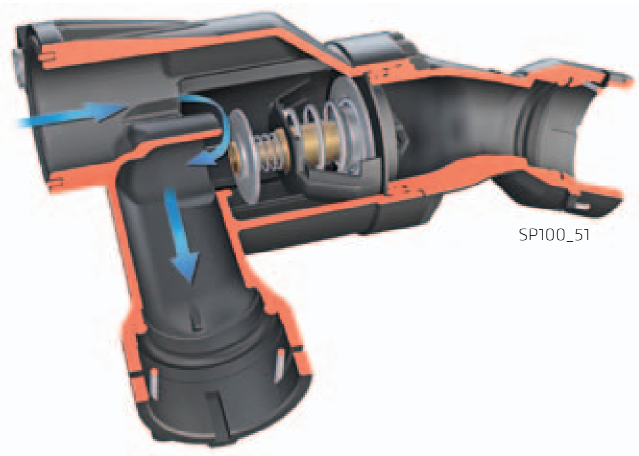
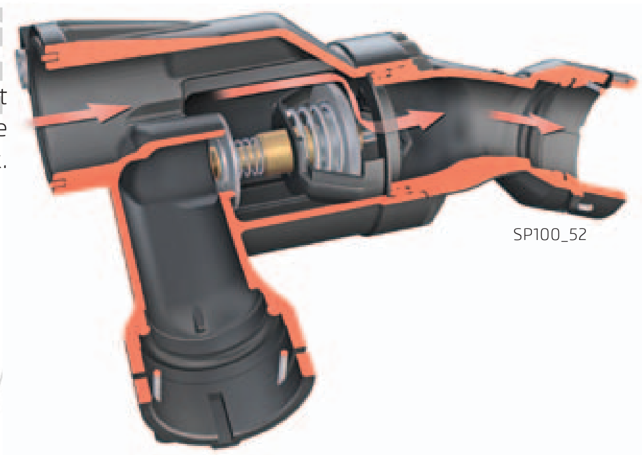
8.8 Coolant Thermal Regulator

Changes in coolant flow in the thermal regulator - a 3/2-way valve, are performed by a thermostat - an expansive sensor filled with wax. Once the coolant temperature reaches the standard operating level, the thermostat starts closing the small cooling circuit and simultaneously opens the big cooling circuit.

Small Cooling Circuit Mode



Big Cooling Circuit Mode



9. Fuel System

9.1 Common Rail Fuel Injection System

The 1:6 and 2.0 l common rail MDB engines are equipped with a well-proven common rail injection system by Bosch. For fuel injection, a high pressure fuel reservoir (called rail) is used, which is common for all the four injectors. High fuel pressure is achieved by means of a dedicated high pressure fuel pump.
The pressure built by this pump is accumulated in the high pressure fuel reservoir, from where it passes to the injectors. All the fuel injection system is controlled by the engine control unit.

Comparison with Previous Generation of the TDI CR Engines

The fuel system of the EA288 series engines went through the following modifications in comparison to the previous generation:

- the auxiliary electrical fuel pump and filtering sieve upstream the high pressure fuel pump were eliminated
- the fuel pump in the fuel tank is equipped by a dedicated control unit J538, which generates three-phase signal to supply the pump and provides its diagnostic functions
- the DC motor of the previous fuel pump generation was replaced by an asynchronous three-phase motor
- new fuel filter design without a preheater valve, only the return line from the high pressure fuel reservoir (rail) connects back to the fuel filter, the remaining return lines are connected directly to the fuel tank

Injectors

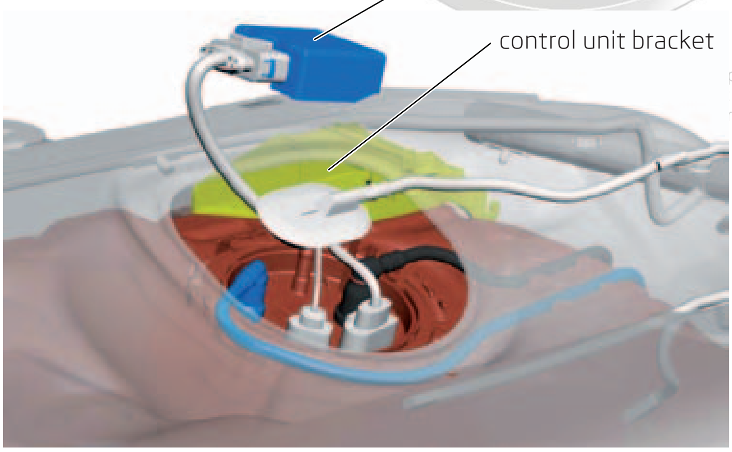
The EA288 series of MDB engines uses electromagnetic valves by Bosch.

Fuel Pump (for EA288 series MDB engines)

The fuel pump is equipped with a dedicated fuel pump control unit - J538.
Pressure relief valves of the fuel pump differ based on the emission standard, for which the engine is designed.

EU 4:
- The fuel pump contains a pressure relief valve set to 5.8 bar.

EU 5, EU 6:
- The fuel pump contains a pressure relief valve set to 6.6 bar.



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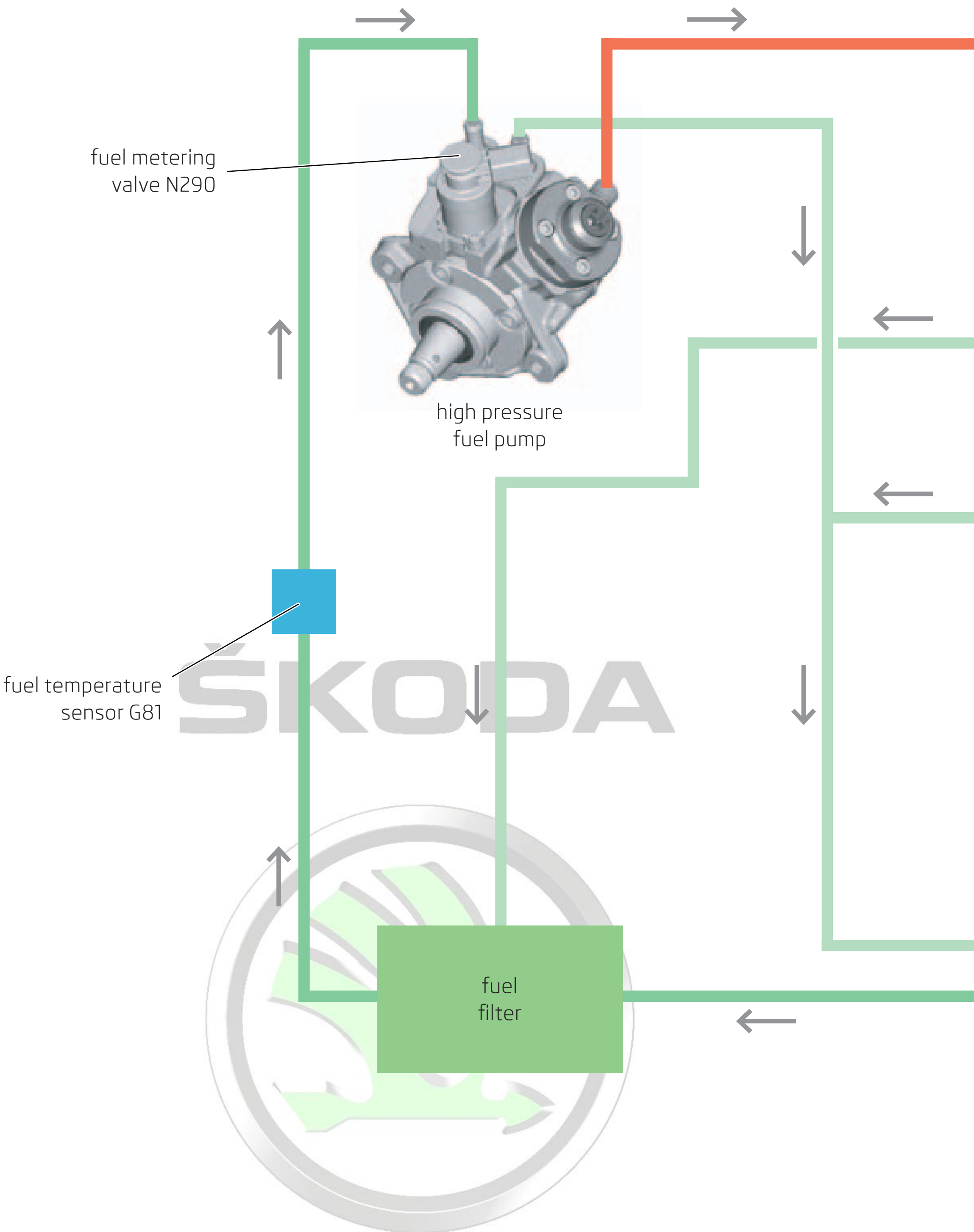
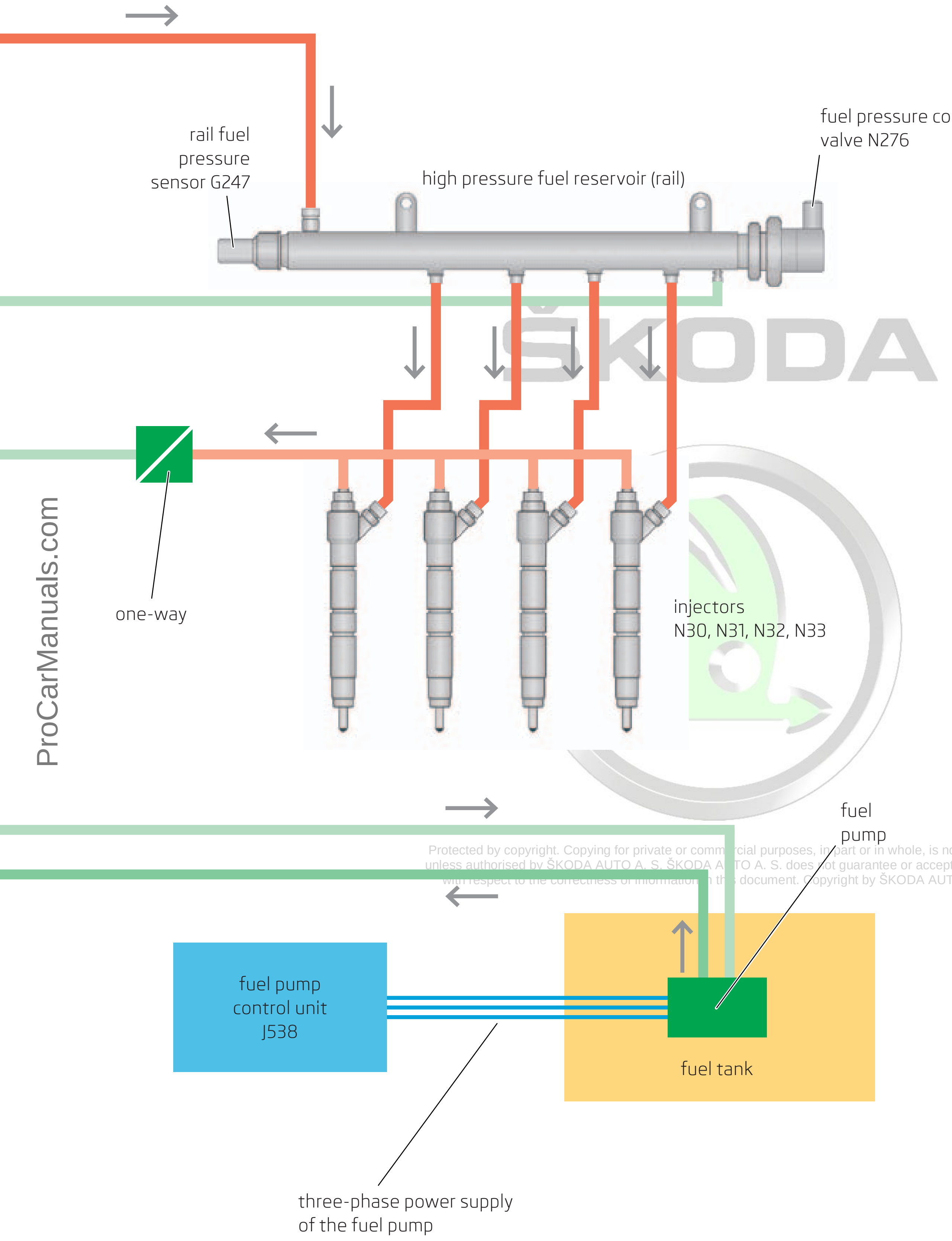
9.2 Fuel System Diagram



- high fuel pressure
- pressure in the return line from injectors
- controlled fuel delivery pressure
- fuel return line


rail fuel pressure sensor G247
high pressure fuel reservoir (rail)
fuel pressure control valve N276
one-way
injectors N30, N31, N32, N33
fuel pump
fuel pump control unit J538
fuel tank
three-phase power supply of the fuel pump

10. Exhaust Gas Recirculation

10.1 Emission Standards

The EA288 series MDB engines are using different exhaust gas recirculation systems depending on the emission standard that the engine complies with.

Engines will be produced in the following versions:

- engines compliant with **EU 4** (with high pressure exhaust gas recirculation)
- engines compliant with **EU 5** (with low pressure exhaust gas recirculation)
- engines compliant with **EU 6** (with low pressure exhaust gas recirculation)

Overview of exhaust gas recirculation installations for the different emission standards:

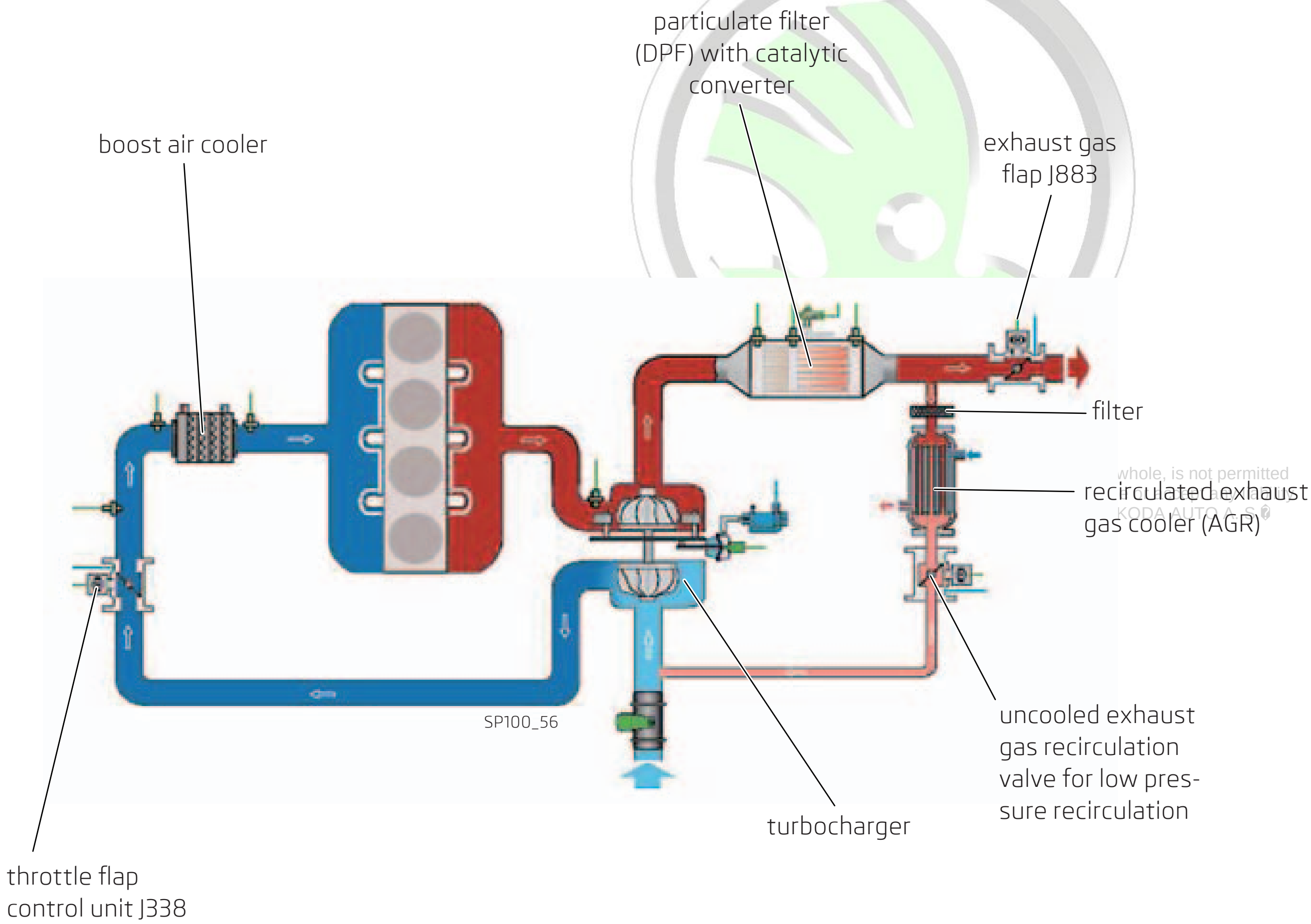
exhaust gas recirculation systems design	EU 4	EU 5	EU 6
recirculated exhaust gas cooler	●	●	●
high pressure exhaust gas recirculation with cooled exhaust gas recirculation valve	●	–	●
low pressure exhaust gas recirculation with uncooled exhaust gas recirculation valve	–	●	●
four-way catalytic converter	–	–	●

10.2 Low Pressure Exhaust Gas Recirculation – Engines Compliant with the EU 5 Emission Standard

The EA288 series MDB diesel engines compliant with the EU 5 emission standard are equipped with low pressure exhaust gas recirculation.

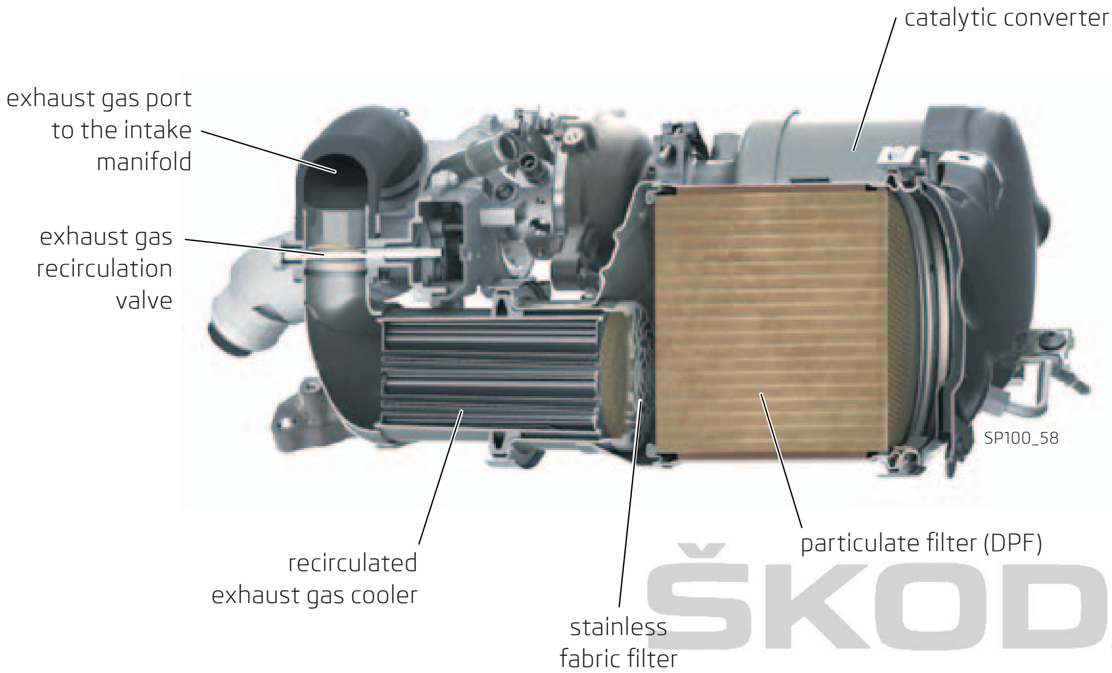
Downstream the particulate filter, exhaust gasses are routed back through the filter, the coolant-cooled recirculated exhaust gas cooler (AGR) and the uncooled exhaust gas recirculation valve to a point upstream the turbocharger, where they get mixed with boost air. The compressed mixture of exhaust gases and boost air is cooled in the boost air cooler.

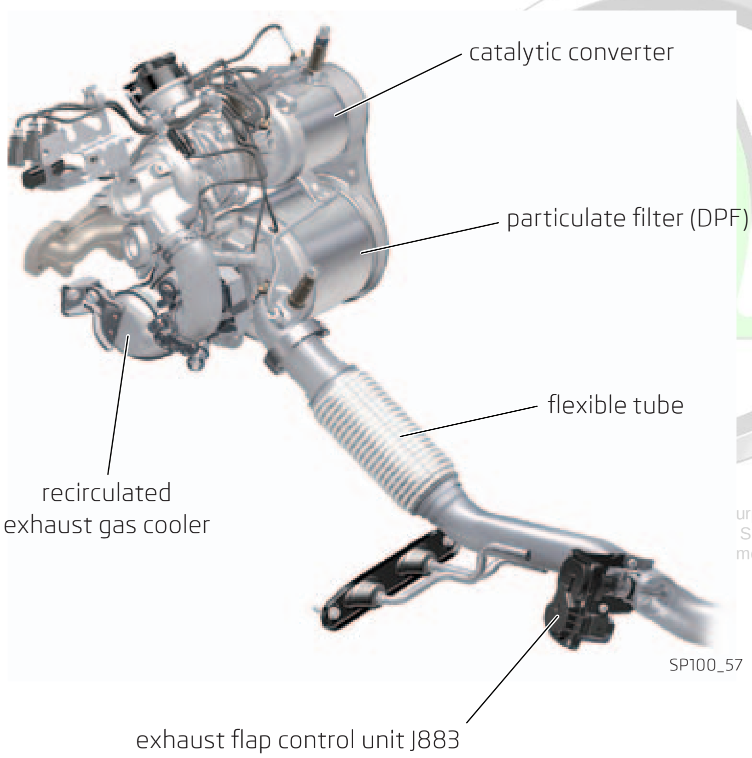
The main exhaust manifold also contains an exhaust gas flap, which has an integrated servomotor and a real position sensor. This flap is controlled by the engine CU. By partial closing, the flap enables achieving required pressure in the recirculated exhaust gas line. The flap generates overpressure downstream the particulate filter corresponding to about 30–40 mbar in relation to the exhaust gas downstream the exhaust flap.



10.2.1 Recirculated Exhaust Gas Cooler AGR with a Superposed Filter

All the recirculated exhaust gas is passing through a cooler. This protects other components of the recirculation system from high temperatures. The inlet side of the cooler includes a stainless fabric filter, which prevents ingress of impurities from the catalytic converter towards the turbocharger. The uncooled exhaust gas recirculation valve is located at the outlet of the recirculated exhaust gas cooler.

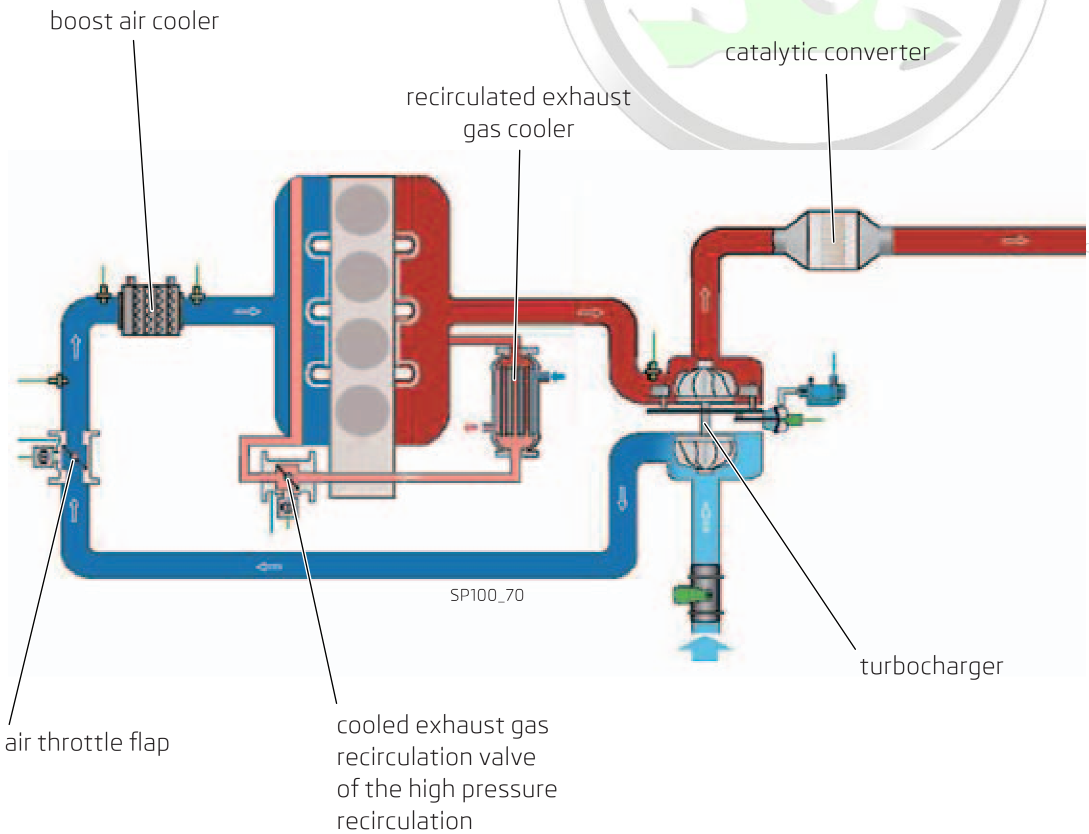




10.2 High Pressure Exhaust Gas Recirculation - Engines Compliant with the EU 4 Emission Standard

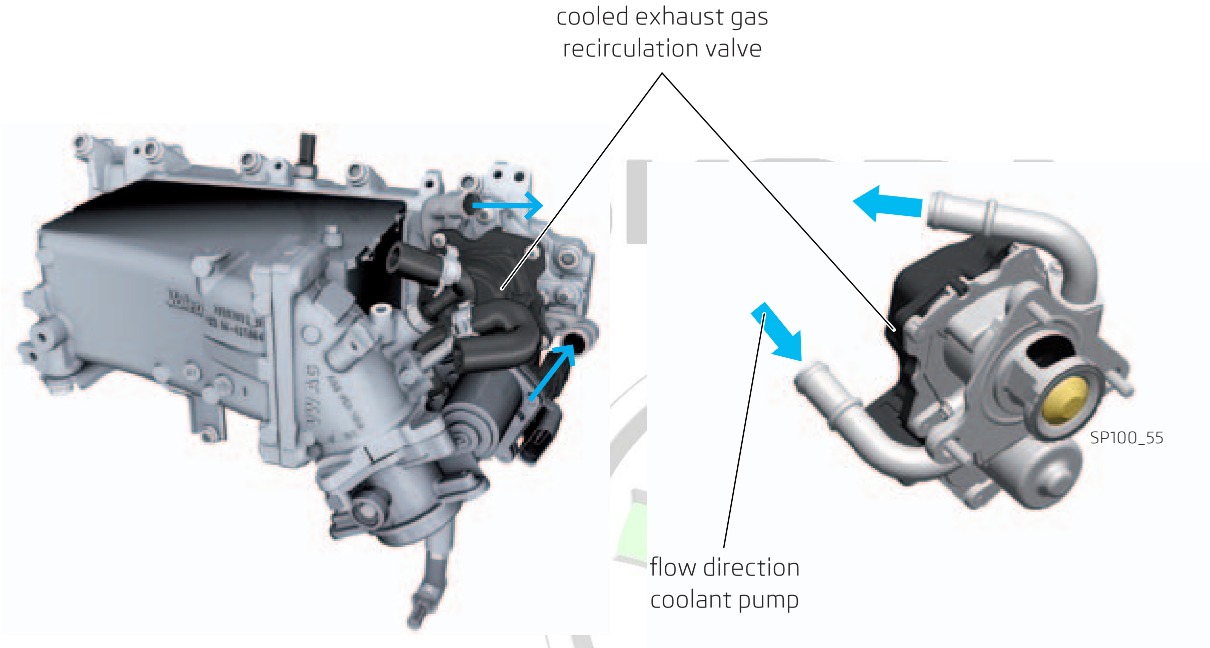
The EU 4 compliant version of engines uses high pressure exhaust gas recirculation with a cooled exhaust gas recirculation valve and a recirculated exhaust gas cooler. The engine is equipped with a catalytic converter, but no particulate filter.

The recirculated exhaust gas cooler is equipped with a by-pass valve, which is controlled by the engine control unit. Exhaust gasses are brought to the cooled exhaust gas recirculation valve through a channel in the cylinder head.



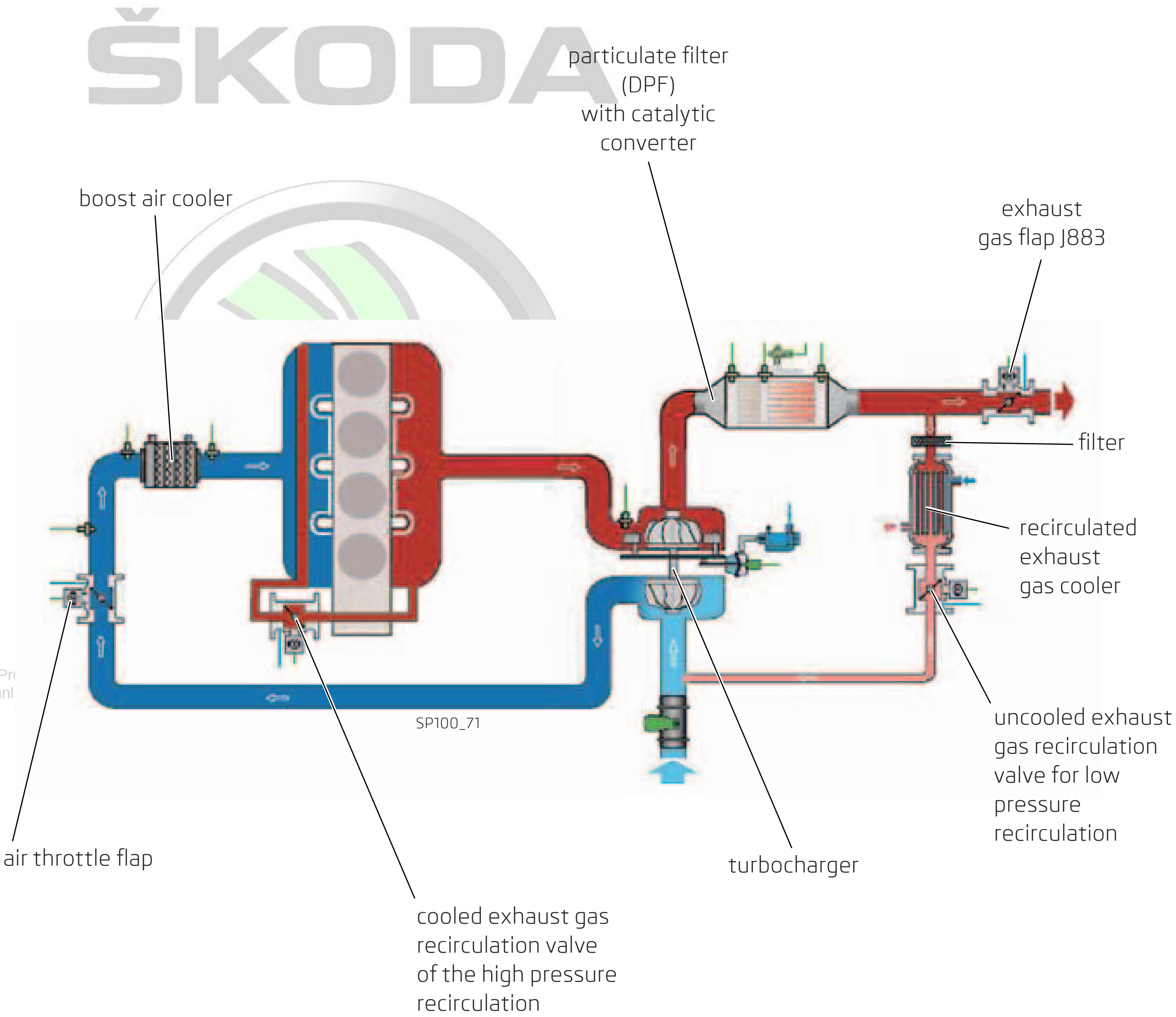
Cooled Exhaust Gas Recirculation Valve

The high pressure recirculation control valve is operated by the V338 servomotor.

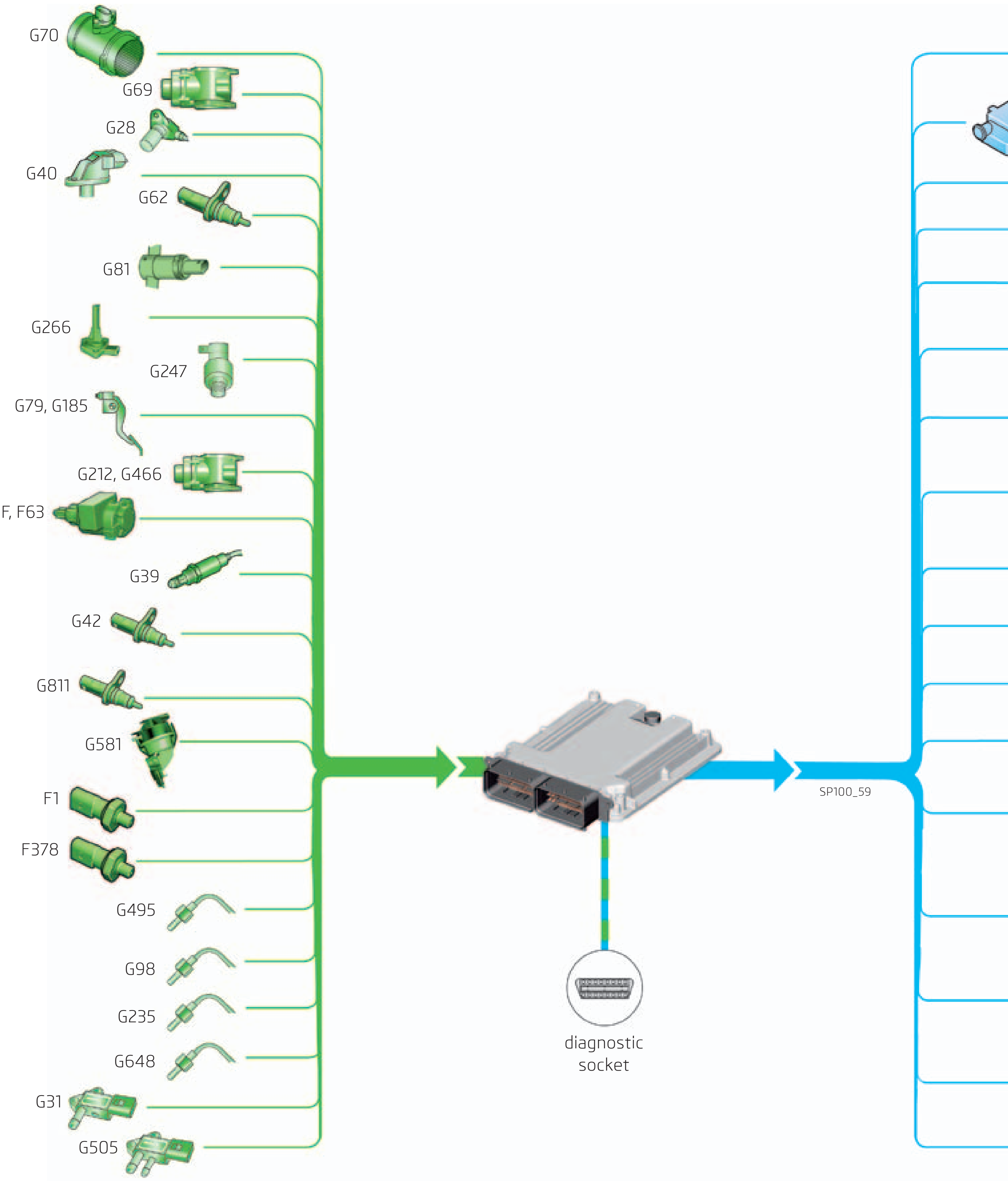


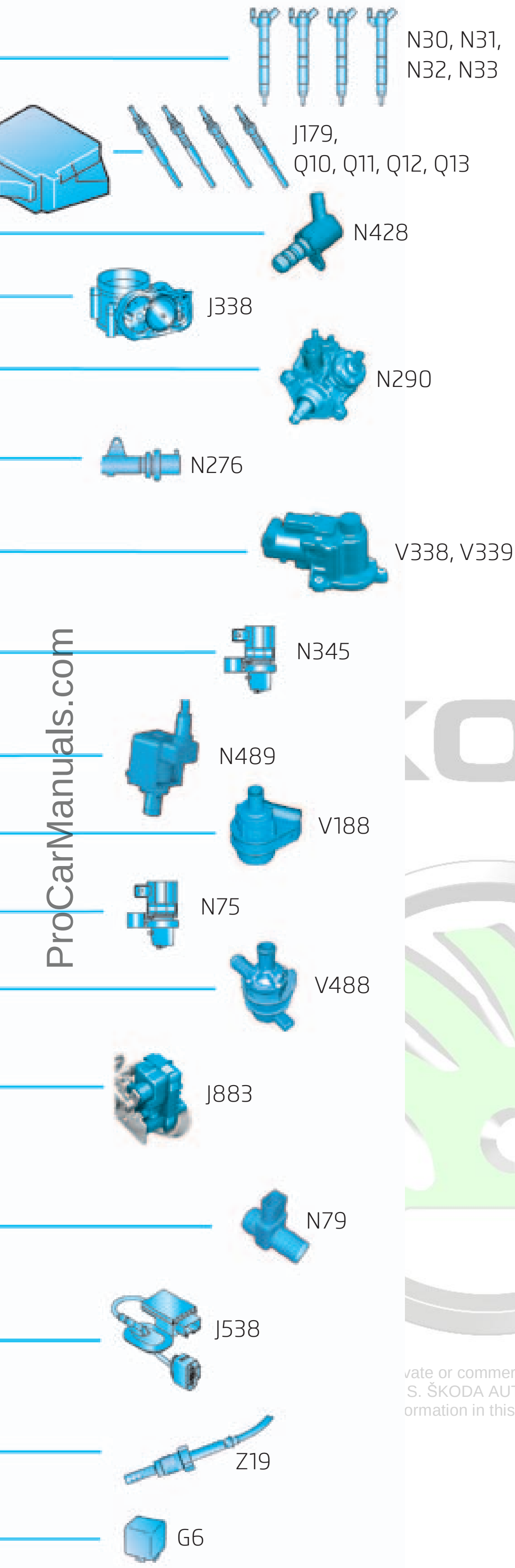
10.4 Combined Low and High Pressure Exhaust Gas Recirculation System – Engines Compliant with the EU 6 Standard

The EA288 series MDB engines compliant with the new EU 6 emission standard have two separate exhaust gas recirculation lines. A low pressure and a high pressure one. The principle of the low pressure line is identical with the EU 5 compliant engines. Compared to the EU 4 compliant engines, the high pressure line of the EU 6 compliant engines does not involve the exhaust gas cooler.



11. Engine Control System Overview





Sensors:

G70 – intake air mass sensor
G69 – throttle flap potentiometer
G28 – engine speed sensor
G40 – Hall sensor
G62 – cooling liquid temperature sensor
G81 – fuel temperature sensor
G266 – oil level and temperature sensor
G247 – fuel pressure sensor
G79 – accelerator pedal position sensor
G185 – accelerator pedal position 2nd sensor
G212 – exhaust gas recirculation potentiometer (high pressure exhaust gas recirculation)
G466 – exhaust gas recirculation potentiometer 2 (low pressure exhaust gas recirculation)
G581 – boost pressure controller position sensor
F – brake lights switch
F47 – brake pedal switch
G39 – lambda probe
G42 – intake air temperature sensor
G811 – boost air temperature sensor downstream the boost air cooler
G581 – charge pressure controller position sensor
F1 – oil pressure switch
F378 – oil pressure switch for lowered oil pressure
G495 – exhaust gas temperature sensor 3 (downstream the catalytic converter)
G98 – recirculated exhaust gas temperature sensor (CRVC engine; EU 4)
G235 – exhaust gas temperature sensor 1
G648 – exhaust gas temperature sensor 4
G31 – charge pressure sensor
G505 – differential pressure sensor

Actuators:

N30, N31, N32, N33 – injectors for cylinders 1–4
J179 – automatic glow time determination control unit
Q10, Q11, Q12, Q13 – glow plugs 1–4
N428 – oil pressure control valve
J338 – throttle flap control unit
N290 – fuel metering valve
N276 – fuel pressure control valve
V338 – exhaust gas recirculation servomotor (high pressure exhaust gas recirculation)
V339 – exhaust gas recirculation servomotor 2 (low pressure exhaust gas recirculation)
N345 – recirculated exhaust gas cooler selector valve (only for EU 4)
N489 – cylinder head cooling liquid valve
V188 – boost air cooling circuit pump
N75 – boost pressure limiting solenoid valve
V488 – heating circuit auxiliary pump
J883 – exhaust gas flap control unit
N79 – heating resistor of the crankshaft ventilation system (only for cold climate countries)
J538 – fuel pump control unit
Z19 – lambda probe heating
G6 – fuel pump

12. Special Workshop Tools and Equipment

T10490 – special tool for locking the crankshaft pulley

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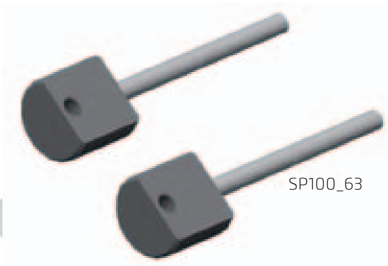
T10491 – adapter for dismounting the lambda probe

SP100_62

T10492 – locking pins for locking camshaft and high pressure fuel pump gears



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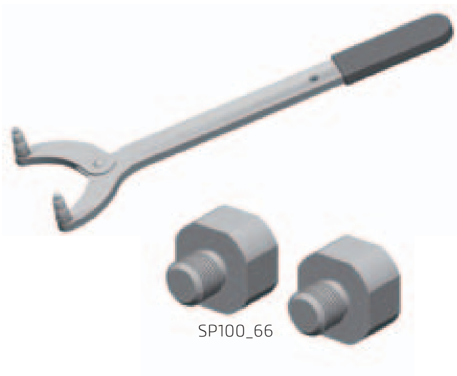
T10172 + T10172/11 – lever with adapters for dismounting the camshaft pulley



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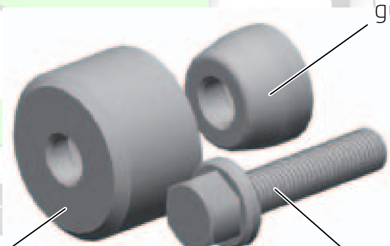
T10489 – puller for dismounting the pulley of the high pressure fuel pump

SP100_60

T10493 – tool kit for camshaft sealing ring replacement



SP100_64

T10501 – socket spanner XZN 10


SP100_67

T10512 – calibration tool for compensating elements (special nuts) for mounting the exhaust gas purification module)


SP100_68

T10511 – special tool for assembly and disassembly of the exhaust gas purification module


SP100_69

Overview of Hitherto Issued Workshop Teaching Aids

No.	Name
1	Mono-Motronic
2	Central Locking
3	Car Alarm Equipment
4	Work with Wiring Diagrams
5	ŠKODA FELICIA
6	ŠKODA Car Safety
7	ABS - Basics - not issued
8	ABS - FELICIA
9	Starting Protection Device with Transponder
10	Air Conditioning in Car
11	FELICIA Air Conditioning
12	1.6 - MPI 1AV Engine
13	Four-Cylinder Compression Ignition Engine
14	Power Steering
15	ŠKODA OCTAVIA
16	1.9 l TDI Compression Ignition Engine
17	ŠKODA OCTAVIA Comfort Electronics System
18	ŠKODA OCTAVIA 02K, 02J Mech. Gearbox
19	1.6 l and 1.8 l Gasoline Engines
20	Automatic Gearbox - Basics
21	01M Automatic Gearbox
22	1.9 l/50 kW SDI, 1.9 l/81 kW TDI Compression Ignition Engines
23	1.8 l/110 kW and 1.8 l/92 kW Gasoline Engines
24	OCTAVIA, CAN-BUS Data Bus
25	OCTAVIA - CLIMATRONIC
26	OCTAVIA - Vehicle Safety
27	OCTAVIA - 1.4 l/44 kW Engine and 002 Gearbox
28	OCTAVIA - ESP - Basics, Design, Function
29	OCTAVIA 4 x 4 - All-Wheel Drive
30	2.0 l 85 kW and 88 kW Gasoline Engines
31	Radio Navigation System - Design and Function
32	ŠKODA FABIA - Technical Information
33	ŠKODA FABIA - Electrical Devices
34	ŠKODA FABIA - Electrohydraulic Power Steering
35	1.4 l - 16 V 55/74 kW Gasoline Engines
36	ŠKODA FABIA - 1.9 l TDI Pump-Nozzle
37	02T and 002 Mechanical Gearbox
38	ŠKODAOctavia; Model 2001
39	Euro-On-Board-Diagnose
40	001 Automatic Gearbox
41	02M Six-Speed Gearbox
42	ŠKODAFabia - ESP
43	Emissions in Exhaust Gases
44	Extended Service Intervals
45	1.2 l Three-Cylinder Spark-Ignition Engines
46	ŠkodaSuperb; Presentation of the Vehicle, Part I
47	ŠKODASuperb; Presentation of the Vehicle, Part II
48	ŠKODASuperb; V6 2.8 l/142 kW Spark-Ignition Engine
49	ŠKODASuperb; V6 2.5 l/114 kW TDI Compression Ignition Engine
50	ŠKODASuperb; 01V Automatic Gearbox
51	2.0 l/85 kW Spark-Ignition Engine with Balancing Shafts and 2-Stage Intake Pipe
52	ŠKODAFabia; 1.4 l TDI Engine with Pump-Nozzle Injection System
53	ŠKODAOctavia; Presentation of the Vehicle
54	ŠKODAOctavia; Electrical Components
55	FSI Spark-Ignition Engines; 2.0 l/110 kW and 1.6 l/85 kW
56	DSG-02E Automatic Gearbox
57	Compression Ignition Engine; 2.0 l/103 kW TDI with Pump-Nozzle Units, 2.0 l/100 kW TDI with Pump-Nozzle Units
58	ŠKODAOctavia, Chassis and Electromechanical Power Steering
59	ŠKODAOctavia RS, Engine 2.0 l/147 kW FSI Turbo
60	2.0 l/103 kW 2V TDI Compression Ignition Engine; Diesel Particulate Filter with Additive
61	Radio Navigation Systems in ŠKODA Cars
62	ŠKODARoomster; Presentation of the Vehicle, Part I
63	ŠKODARoomster; Presentation of the Vehicle, Part II
64	ŠKODAFabia II; Presentation of the Vehicle
65	ŠKODASuperb II; Presentation of the Vehicle, Part I
66	ŠKODASuperb II; Presentation of the Vehicle, Part II
67	Compression Ignition Engine; 2.0 l/125 kW TDI with Common Rail Injection System
68	1.4 l/92 kW TSI Spark-Ignition Engine, Turbo Charged
69	3.6 l/191 kW FSI Spark-Ignition Engine
70	All-Wheel Drive with Generation IV Haldex Clutch
71	ŠKODAYeti; Presentation of the Vehicle, Part I
72	ŠKODAYeti; Presentation of the Vehicle, Part II
73	LPG System in ŠKODA Cars
74	1.2 l/77 kW TSI Spark-Ignition Engine, Turbo Charged
75	7-Speed Automatically Controlled Gearbox with 0AM Double Clutch
76	Green-Line Cars
77	Geometry
78	Passive Safety
79	Independent Heating
80	Compression Ignition Engines 2.0 l; 1.6 l; 1.2 l with Common Rail Fuel Injection System
81	Bluetooth in ŠKODA Cars
82	Motor Vehicle Sensors - Drivetrain
83	1.4 l/132 kW TSI Spark-Ignition Engine, Double Supercharged (Compressor, Turboblower)
84	ŠKODAFabia II RS; Presentation of the Vehicle
85	KESSY System in ŠKODA Cars
86	START-STOP System in ŠKODA Cars
87	Immobilizers in ŠKODA Cars
88	Brake and Stabilization Systems
89	Sensors in ŠKODA Cars – Safety and Comfort
90	Customer Satisfaction Enhancement through CSS Study
91	ŠKODA Car Wiring Repairs
92	ŠKODA Citigo – Presentation of the Vehicle
93	Five-Speed 0CF Mechanical Gearbox and ASG Automated Five-Speed Gearbox
94	0AM and 02E Automatic Gearbox Diagnostics
95	ŠKODA Rapid – Presentation of the Vehicle
96	ŠKODA Octavia III – Presentation of the Vehicle – Part I
97	ŠKODA Octavia III – Presentation of the Vehicle – Part II
98	ŠKODA Octavia III – Electronic systems
99	Engines 1.8 l TFSI 132 kW and 2.0 l TFSI 162 kW - EA888
100	1.6 l TDI and 2.0 l TDI; EA288 Design Series