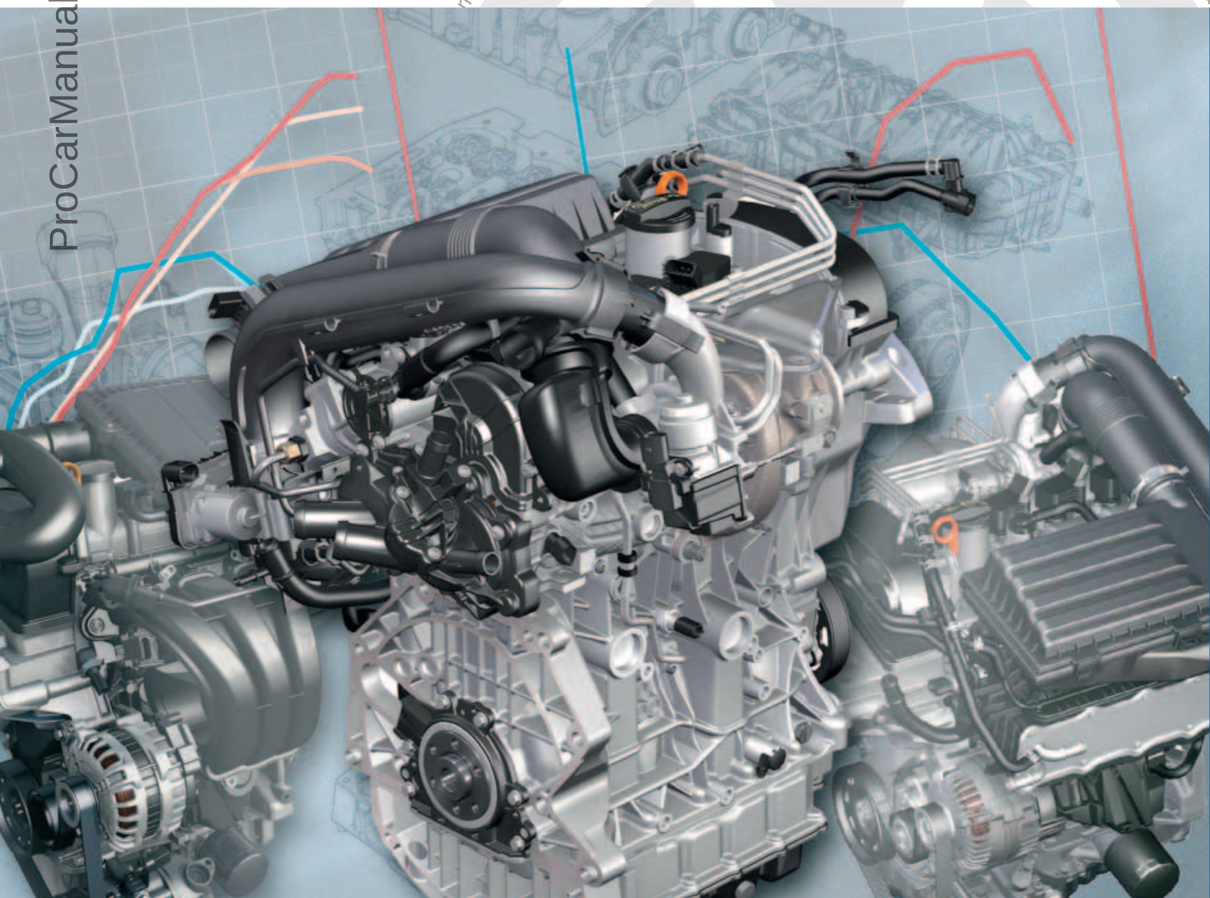
Service Training

Self-Study Programme 511

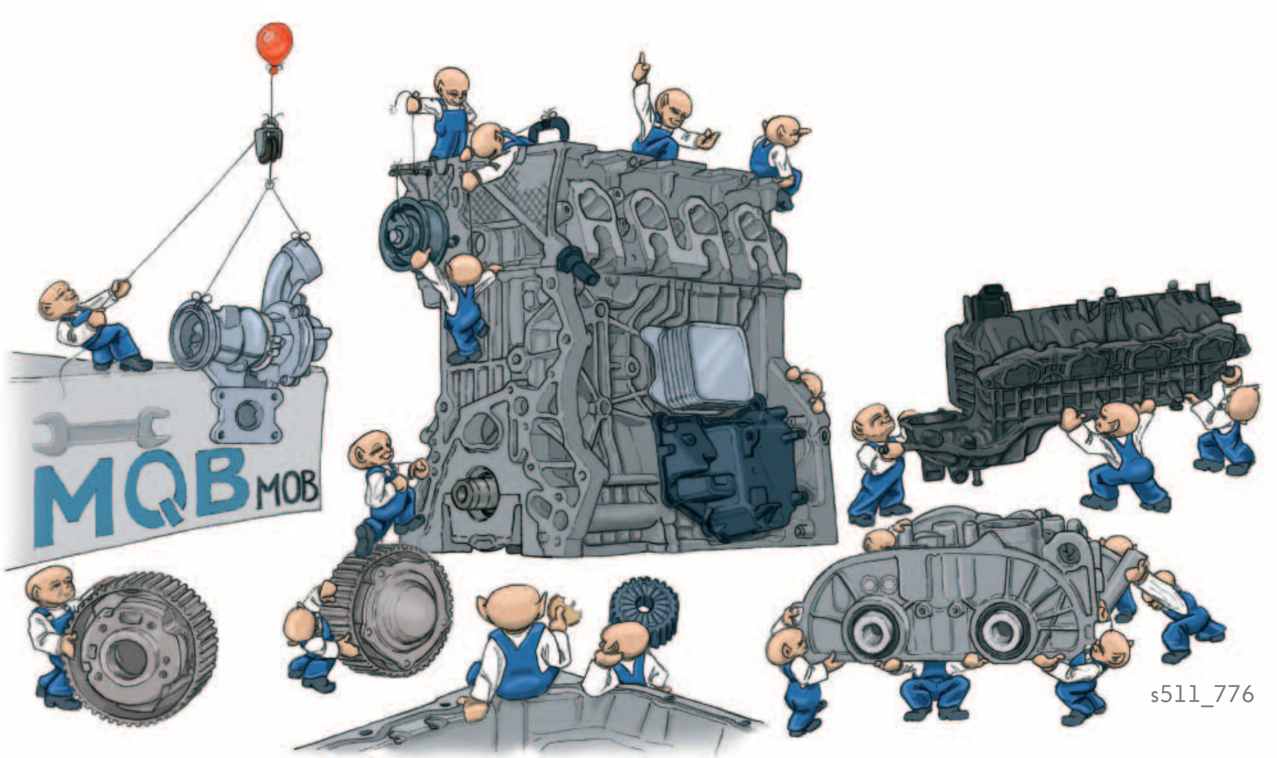
The New EA211 Petrol Engine Family

Design and function



A new modular strategy has been introduced at Volkswagen with the modular transverse matrix (**M**odularen **Q**uer **B**aukasten), or **MQB** for short. This allows all vehicle modules in the Polo, Golf and Passat classes to use standardised components and modules.

A similar modular strategy is now being launched for petrol engines with the new EA211 petrol engine family. This has been called the EA211 modular petrol engine matrix (**M**odulare **O**ttomotoren **B**aukasten). The engines have a capacity of 1.0 l to 1.6 l. The basic engine is a 1.4 l 103 kW TSI engine.



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The diagram shows a number of details of the new engines which you will become familiar with over the course of the Self-Study Programme and whose design and function are described.

You can find further information about the new engine family in Self-Study Programmes No. 508 “The 1.0 l 44/55 kW MPI Engine with Intake Manifold Injection” and No. 510 “The Active Cylinder Management ACT in the 1.4 l,103 kW TSI Engine”.

The self-study programme presents the design and function of new developments!
The content will not be updated.

Current testing, setting and repair instructions can be found in the provided service literature.

Important note

Contents

Introduction

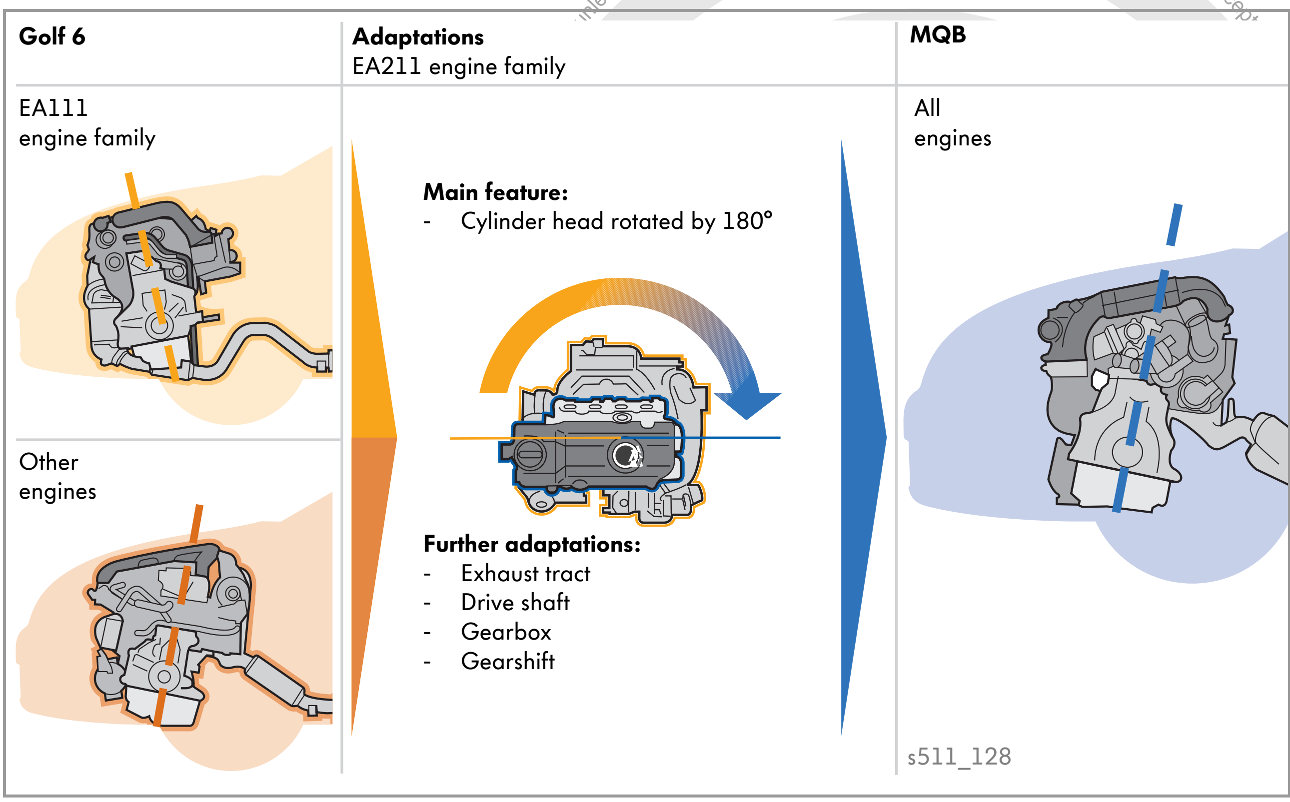
Modular Petrol Engine Matrix MOB

The engine installation positions in the vehicle

In the past, the installation position of the engines, for example in the Golf model year 2009, varied widely. While the previous engine family EA111 with its 1.4 l engines was tilted forwards and the exhaust system faced the front end radiator, the other petrol and diesel engines were installed tilting backwards. The exhaust system was installed facing the bulkhead.

In order to take advantage of the full savings potential, all engines using the modular transverse matrix will now have a uniform installation position.
The new installation position of the EA211 engines made an overhaul of the basic engine structure necessary. The engineers took full advantage of this opportunity, developing a new series of engines in line with the modular strategy.

Advantages of the new modular strategy:
- Uniform installation position
- Standardisation, e.g. of the gearbox connections, cooling system and exhaust system
- Compact engine dimensions
- Reduction of the engine depth by 50 mm by tilting the installation position back by 12°

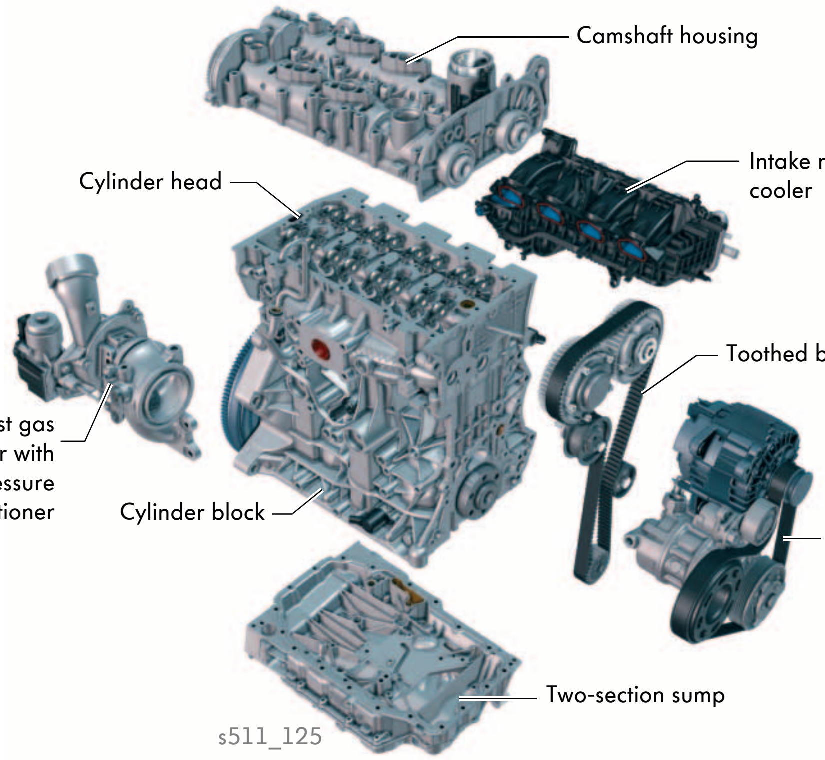


The newly developed EA211 petrol engine family

A multitude of requirements need to be implemented when developing new engines.
At the same time, this provides an opportunity to employ technologies which were too costly to utilise in existing engines.

The requirements which have been implemented are:
- Modular structure
- Rotated installation position of the engines
- Compact design
- Reduction in consumption and therefore CO_2 emissions by 10 - 20%
- Reduction in the engine weight by up to 30%
- Compliance with the future EU6 emission standard

Modular design of the 1.4 l 103 kW TSI engine with Active Cylinder Management



The attributes shared by all engines in the EA211 family are:

- Uniform installation position
- Installation of the air conditioner compressor and the alternator, bolted directly onto the sump or onto the engine block respectively without additional brackets
- Four-valve technology
- Aluminium cylinder block
- Exhaust manifold integrated into the cylinder head
- Camshaft driven via a toothed belt

Overview of the new EA211 petrol engine family

The 1.0 l 44 kW/50 kW/55 kW MPI engine with intake manifold injection

This engine was developed especially for the up!
It is available in three power versions, with 44 kW (CHYA), 50 kW (CPGA) and 55 kW (CHYB).
The 50 kW version is an engine with natural gas drive for the eco up!

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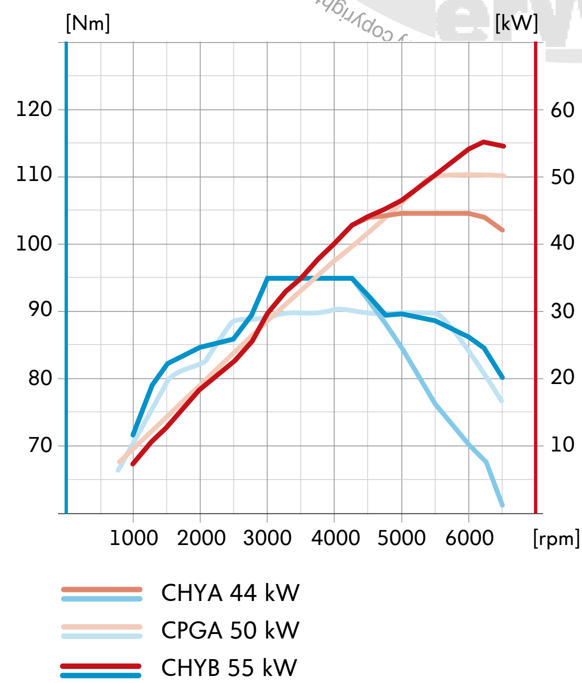
Technical features

- Cylinder head with integrated exhaust manifold
- Camshafts driven by a toothed belt
- Coolant pump integrated into the thermostat housing
- Coolant pump driven by a toothed belt from the exhaust camshaft
- Inlet camshaft adjustment
- Crankshaft oil pump
- Single-section aluminium sump
- Valves and valve seat inserts for the engine of the eco up! adapted for natural gas fuel

Torque and performance diagram



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Technical data

Engine code	CHYA	CPGA	CHYB
Design	3-cylinder inline engine		
Displacement	999 cm^3		
Bore	74.5 mm		
Stroke	76.4 mm		
Valves per cylinder	4		
Compression ratio	10.5:1	11.5:1	10.5:1
Max. output	44 kW at 5000 rpm	50 kW at 6200 rpm	55 kW at 6200 rpm
Max. torque	95 Nm at 3000 - 4250 rpm	90 Nm at 3000 - 4250 rpm	95 Nm at 3000 - 4250 rpm
Engine management	Bosch Motronic ME 17.5.20		
Fuel	Super unleaded with RON 95 (Normal unleaded at RON 91 with slight reduction in performance)		
Exhaust gas aftertreatment	Three-way catalytic converter, a step-type lambda probe (44/55 kW version), or a broadband lambda probe (50 kW version) before catalytic converter and a step-type lambda probe after the catalytic converter.		
Emissions standard	EU5		

1.2 l 63/77 kW TSI engine with turbocharger

The 1.2 l TSI engine from the new EA211 petrol engine family is available in two different power versions with 63 kW or 77 kW. The two different power versions is achieved via the software.


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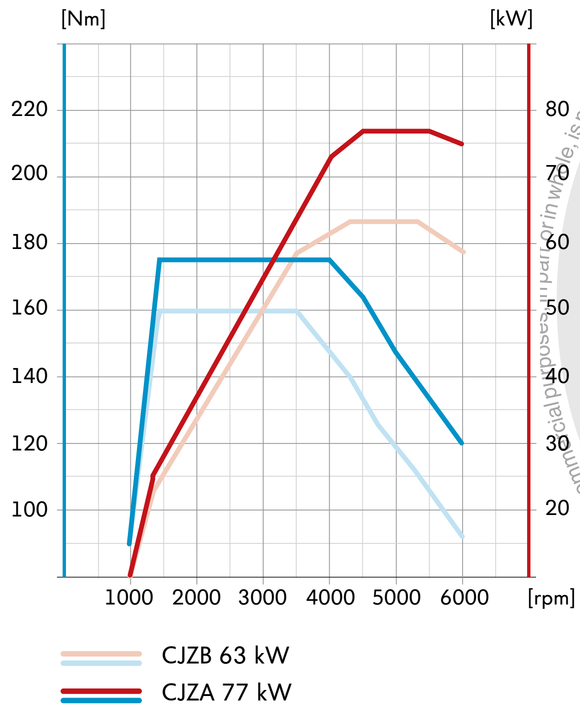
Technical features

- Cylinder head with integrated exhaust manifold
- Camshafts driven by a toothed belt
- The thermostat housing and the coolant pump form a single unit
- Coolant pump driven by a toothed belt from the exhaust camshaft
- Turbocharger with electric charge pressure positioner
- Inlet camshaft adjustment
- Crankshaft oil pump
- Two-section sump (upper and lower section made of aluminium)

Torque and performance diagram



Technical data

Engine code	CJZB	CJZA
Design	4-cylinder inline engine	
Displacement	1197 cm^3	
Bore	71 mm	
Stroke	75.6 mm	
Valves per cylinder	4	
Compression ratio	10.5:1	
Max. output	63 kW at 4300 - 5300 rpm	77 kW at 4500 - 5500 rpm
Max. torque	160 Nm at 1400 - 3500 rpm	175 Nm at 1400 - 4000 rpm
Engine management	Bosch Motronic MED 17.5.21	
Fuel	Super unleaded with RON 95	
Exhaust gas aftertreatment	Three-way catalytic converter with one step-type Lambda probe before and one after the catalytic converter	
Emissions standard	EU5	

1.4 l 90 kW TSI engine with turbocharger

The 1.4 l 90 kW TSI engine is hardly distinguishable from the 1.4 l 103 kW TSI engine on the outside. However, while both power versions feature inlet camshaft adjustment, the 103 kW version features additional exhaust camshaft adjustment.

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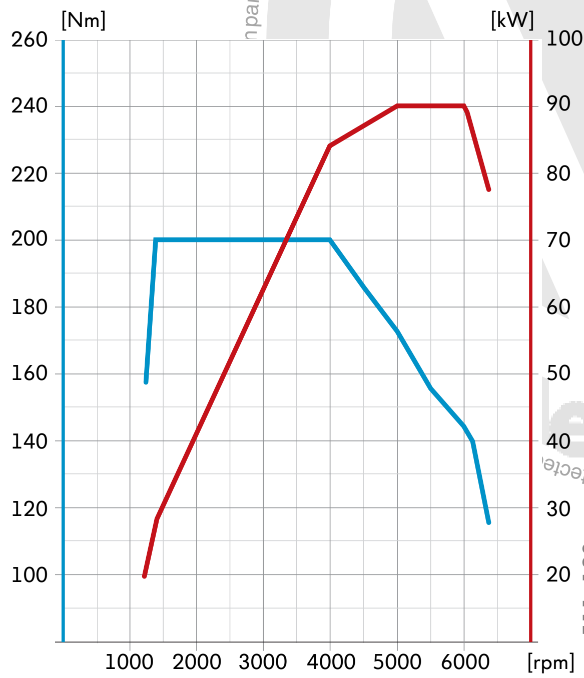
Technical features

- Cylinder head with integrated exhaust manifold
- Camshafts driven by a toothed belt
- The thermostat housing and the coolant pump form a single unit
- Coolant pump driven by a toothed belt from the exhaust camshaft
- Turbocharger with electric charge pressure positioner
- Inlet camshaft adjustment
- External gear wheel oil pump with two-stage oil pressure regulation
- Two-section sump (upper section made of aluminium, lower section made of sheet metal)

Torque and performance diagram



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Technical data

Engine code	CMBA
Design	4-cylinder inline engine
Displacement	1395 cm^3
Bore	74.5 mm
Stroke	80 mm
Valves per cylinder	4
Compression ratio	10.5:1
Max. output	90 kW at 5000 - 6000 rpm
Max. torque	200 Nm at 1400 - 4000 rpm
Engine management	Bosch Motronic MED 17.5.21
Fuel	Super unleaded with RON 95
Exhaust gas aftertreatment	Three-way catalytic converter with one step-type Lambda probe before and one after the catalytic converter
Emissions standard	EU5

1.4 l 103 kW TSI engine with turbocharger

The 1.4 l 103 kW TSI engine is the basic engine in the new EA211 petrol engine family. It is available in two versions, with and without Active Cylinder Management (ACT). The power and the torque are the same in both versions.

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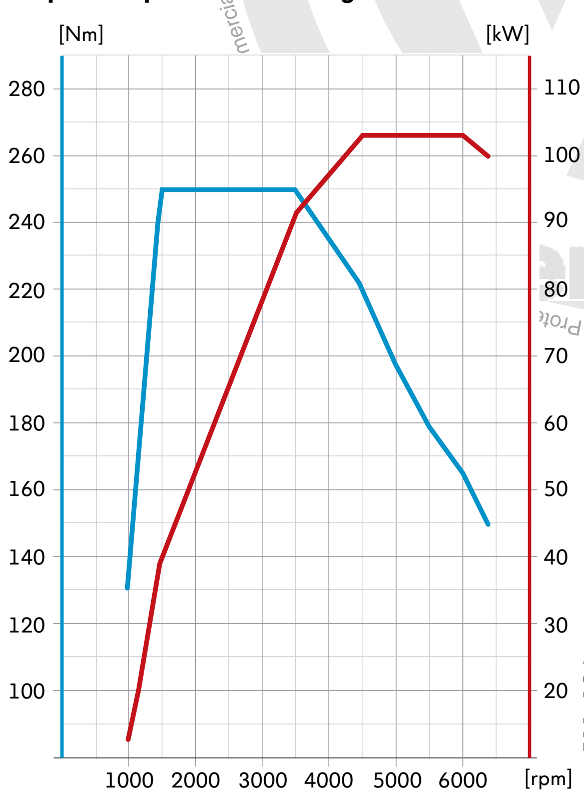
Technical features

- Cylinder head with integrated exhaust manifold
- Camshafts driven by a toothed belt
- The thermostat housing and the coolant pump form a single unit
- Coolant pump driven by a toothed belt from the exhaust camshaft
- Turbocharger with electric charge pressure positioner
- Inlet and exhaust camshaft adjustment
- External gear wheel oil pump with two-stage oil pressure regulation
- Two-section sump (upper section made of aluminium, lower section made of sheet metal)

Torque and performance diagram



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Technical data

Engine code	CHPA	CPTA with ACT
Design	4-cylinder inline engine	
Displacement	1395 cm^3	
Bore	74.5 mm	
Stroke	80 mm	
Valves per cylinder	4	
Compression ratio	10.0:1	
Max. output	103 kW at 4500 - 6000 rpm	
Max. torque	250 Nm at 1500 - 3500 rpm	
Engine management	Bosch Motronic MED 17.5.21	
Fuel	Super unleaded with RON 95	
Exhaust gas aftertreatment	Three-way catalytic converter with one upstream broadband Lambda probe and one step-type Lambda probe downstream of the catalytic converter	
Emissions standard	EU5	EU6

The EA211 engines with intake manifold injection or for alternative drive systems

1.4 l 66 kW / 1.6 l 81 kW MPI engine with intake manifold injection

These engines with the engine codes CKAA (66 kW) and CPDA (81 kW) were developed for the markets outside Europe.
The first use of the 1.6 l 81 kW MPI engine is in China.

Technical features

- Camshafts driven by a toothed belt
- Camshaft housing features a modular design
- Cylinder head with integrated exhaust manifold
- Coolant pump integrated into the thermostat housing
- Coolant pump driven by a toothed belt from the exhaust camshaft
- Inlet camshaft adjustment

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1.4 l 81 kW TGI engine (natural gas)

This engine with the engine code CPWA is being used in the Golf 2013. It features a bivalent natural gas drive. The only difference to the 1.4 l 90 kW TSI engine is the additional components for the natural gas drive.

Technical features

- One engine control unit for natural gas and petrol operation
- Electronic gas pressure regulator with a mechanical pressure reduction level
- Optimised gas injection valve, allowing a start from -10 °C in natural gas operation
- Valve seat inserts reinforced, hard-faced inlet valves, valve stem oil seals with a second sealing lip, resulting in forced lubrication of the valve stem in the valve guides

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1.4 l 90 kW TSI Multifuel engine

This engine, with the engine code CPVA, is being used in the Golf 2013 in Sweden and Finland.

Technical features
- Compatible with up to 85% bioethanol
- Fuel quality sender for identifying the proportion of bioethanol in the fuel
- Electric engine preheating element in the cooling system
- Valve seat inserts reinforced, hard-faced inlet valves, valve stem oil seals with a second sealing lip, resulting in forced lubrication of the valve stem in the valve guides

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1.4 l 110 kW TSI engine Hybrid

This engine is being used in the Jetta Hybrid with the engine codes CRJA (Europe) and CNLA (North American region, NAR). The basic engine is the 1.4 l 103 kW TSI engine.

Technical features
- Crankshaft with teeth for connecting to the three-phase current drive VX54 (electric drive motor)
- Vibration damper on crankshaft
- Cylinder block and sealing flange on gearbox side with leadthroughs for coolant for cooling the electric drive motor V141 as well as hydraulic fluid for activating the disengagement clutch K0
- Electric air conditioner compressor
- Alternator and starter functions are carried out by the electric drive motor V141
- Secondary air system (NAR)
- Performance increase to 110 kW with the aid of software modifications
- Changes to materials used for lines for the crankcase breather, as well as the fuel and activated charcoal receptacle system, due to emission regulations (NAR)

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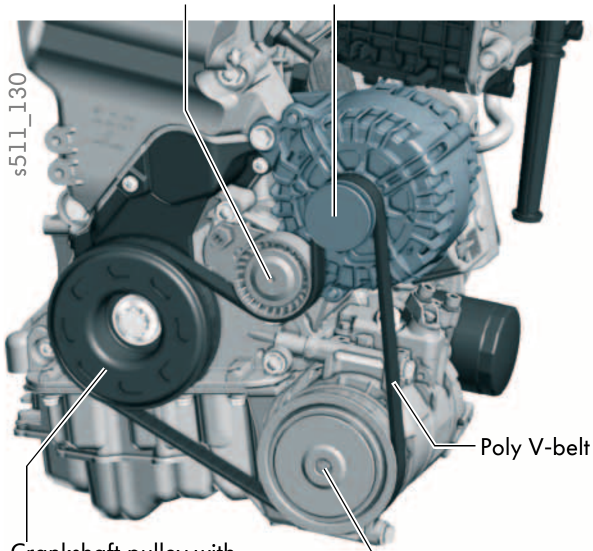
Poly V-belt drive

Depending on the engine and the equipment installed, there are three versions of the poly V-belt drive.
They are generally driven by a six-rib poly V-belt. In all engines, the belt pulley on the crankshaft is equipped with a vibration damper to ensure the engine runs quietly.

The ancillaries are bolted directly onto the cylinder block and the sump in order to save space.
No additional brackets are necessary.

The air conditioner compressor and the alternator are driven electrically in the 1.4 l 110 kW TSI engine in the Jetta Hybrid. There is no poly V-belt drive.



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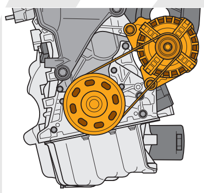
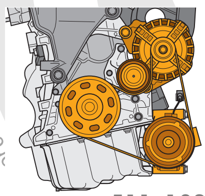
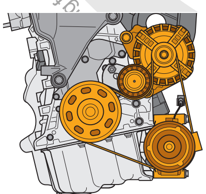
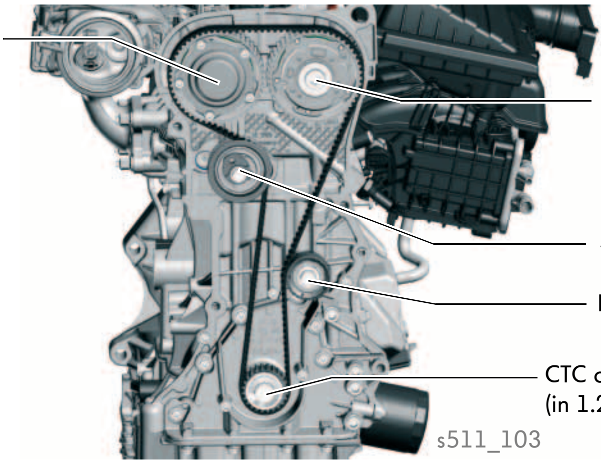
Versions of the poly V-belt drive

Tensioning of the poly V-belt drive by ...		**3-cylinder engine with intake manifold injection MPI**	**4-cylinder engine with direct injection TSI**
A flexible and tensile poly V-belt without tensioning roller	 s511_131	- without A/C compressor - without BlueMotion technology	----
A rigid tensioning roller	 s511_132	- with A/C compressor - without BlueMotion technology	----
An automatic tensioning roller	 s511_133	- with BlueMotion technology - independent of whether an air conditioner compressor is installed	- with BlueMotion technology - independent of whether an air conditioner compressor is installed

Toothed belt drive

The camshafts are driven by a maintenance-free toothed belt. It is tensioned using an automatic tensioning roller, which uses contact shoulders at the same time to guide the toothed belt.
An idler roller on the tension side and the special shape of the camshaft sprockets in the 3-cylinder engine, or camshaft gearwheel in the 4-cylinder engine respectively, ensure that the toothed belt runs smoothly.

1.4 l 103 kW TSI engine



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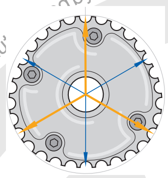
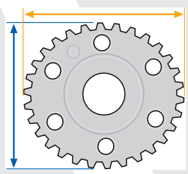
Engine versions	Gear wheel	Effects
3-cylinder engines	Tri-oval camshaft sprockets 	A certain amount of force is required to open the valves of a cylinder. This force also acts on the toothed belt drive every time the valve is opened, and at higher speeds will cause it to vibrate. To minimise the strong vibrations which are typical for 3-cylinder engines in particular, special camshaft gears have been employed. It has been designed with a larger radius, at intervals of 120° (tri-oval).
4-cylinder engines	Oval CTC crankshaft sprocket 	A so-called CTC crankshaft sprocket is installed in the 4-cylinder engines. CTC is an abbreviation which stands for Crankshaft Torsionals Cancellation, meaning the tensile forces and vibrations from the crankshaft are reduced. During the working stroke, the toothed belt is slackened slightly due to its smaller radius. This reduces the tensile forces and lowers the vibrations of the toothed belt drive.

Advantages

- The lower toothed belt forces allow the tension force of the tensioning roller to be reduced. This results in lower friction and mechanical stress on the entire toothed belt drive.
- The reduced level of vibrations allows the toothed belt drive to run even more quietly.

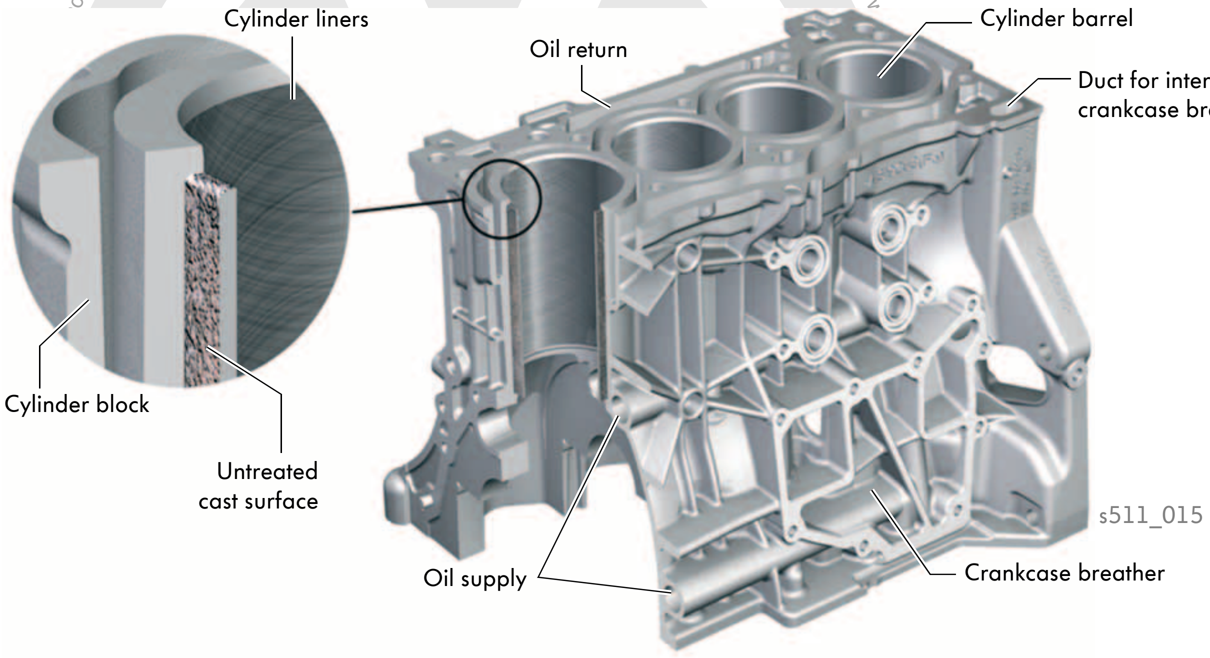
Cylinder block

The cylinder block consists of cast aluminium and has been designed as an open-deck version. Open deck means that it has no webs between the outer wall of the cylinder block and the cylinder liners.

The has the advantage of:

- not allowing air bubbles to form in this area, which would lead to ventilation and cooling problems
- cylinder deformation is kept low when the cylinder head is bolted to the cylinder block. The piston rings can easily compensate this low level of cylinder liner deformation, and the consumption of oil is reduced.

The galleries for the oil pressure supply, the oil return pipes and the crankcase breather have been cast into the cylinder block. This reduces the number of additional components as well as the amount of machining required.



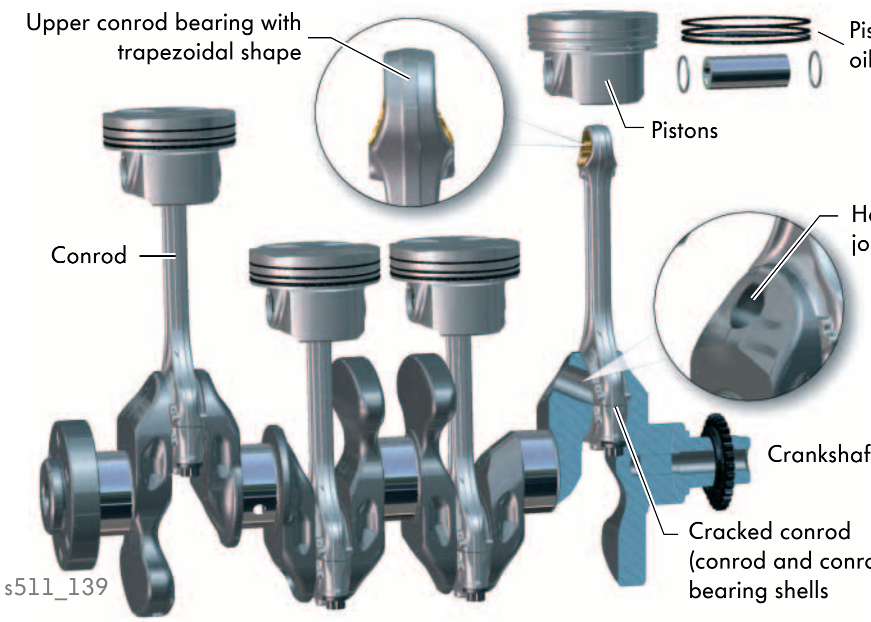
Grey cast iron cylinder liners

The grey cast iron cylinder liners are individually cast into the cylinder block. Their outer surface is very coarse, which increases the surface area and improves the transfer of heat to the cylinder block.

In addition, this ensures that there is a firm fit between the cylinder block and the cylinder liner.

Crankshaft group

The crankshaft group was designed for low, moving masses and low friction. The weight of the crankshafts, conrods and the pistons has been so well optimised that the balancer shaft, otherwise standard in three-cylinder engines, could be omitted.



Conrod
The conrods are fracture-split. In the area subject to a lower load, the upper conrod bearing has a trapezoidal design. This reduces the weight and the friction even further.

Pistons, piston rings, piston pins
The pistons are made from die-cast aluminium.
The piston crown features a flat design, because a wall guide for the inner mixture formation, normally standard in the EA111 engines, has been eliminated.
Along with reduced weight, the combustion heat is also distributed over the piston crown more evenly, and misfires are thus prevented.
The installation tolerance of the piston rings was increased, and friction therefore reduced.

Crankshafts
Cast crankshafts have been used in the MPI engines, which are subject to a lower load, and forged crankshafts have been used in the TSI engines.
Furthermore, they are distinguished by the number of bearing points, the counterweights and the diameters of the main mounting and conrod bearings.
In the 1.4 l 103 kW TSI engine, which is subject to a higher load, this is, a forged steel crankshaft. It features five bearings, four counterweights and a main bearing and conrod bearing diameter of 48 mm. To reduce the weight even further, the conrod journals are hollow-bored. Together, these measures reduce the inside forces on the crankshaft and therefore the load on the main bearings.

Cylinder head

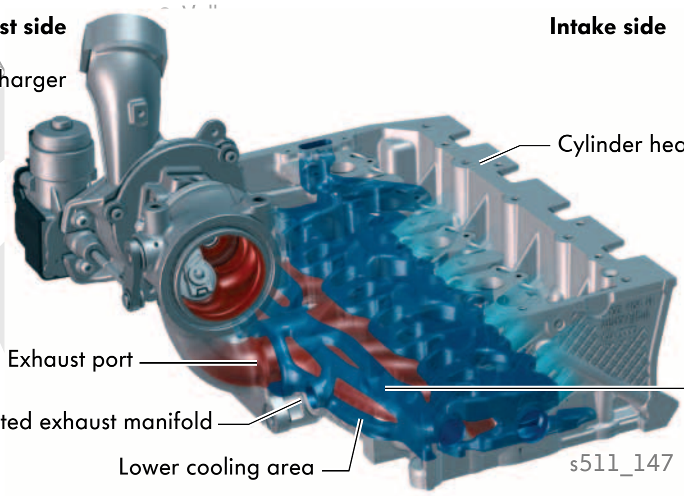
During development of the aluminium cylinder head, priority was given to enhanced use of the exhaust gas energy to ensure a fast engine warm-up phase.

Technical features

- 4-valve technology
- Cross-flow cooling
- Integrated exhaust manifold
- Designed for alternative fuels

Design

The cross-flow cylinder head allows the coolant to flow from the inlet side to the exhaust side via the combustion chambers. It is divided into two sections above and below the exhaust manifold. It flows through several ports, absorbing the heat. It flows from the cylinder head into the thermostat housing, mixing with the remaining coolant.



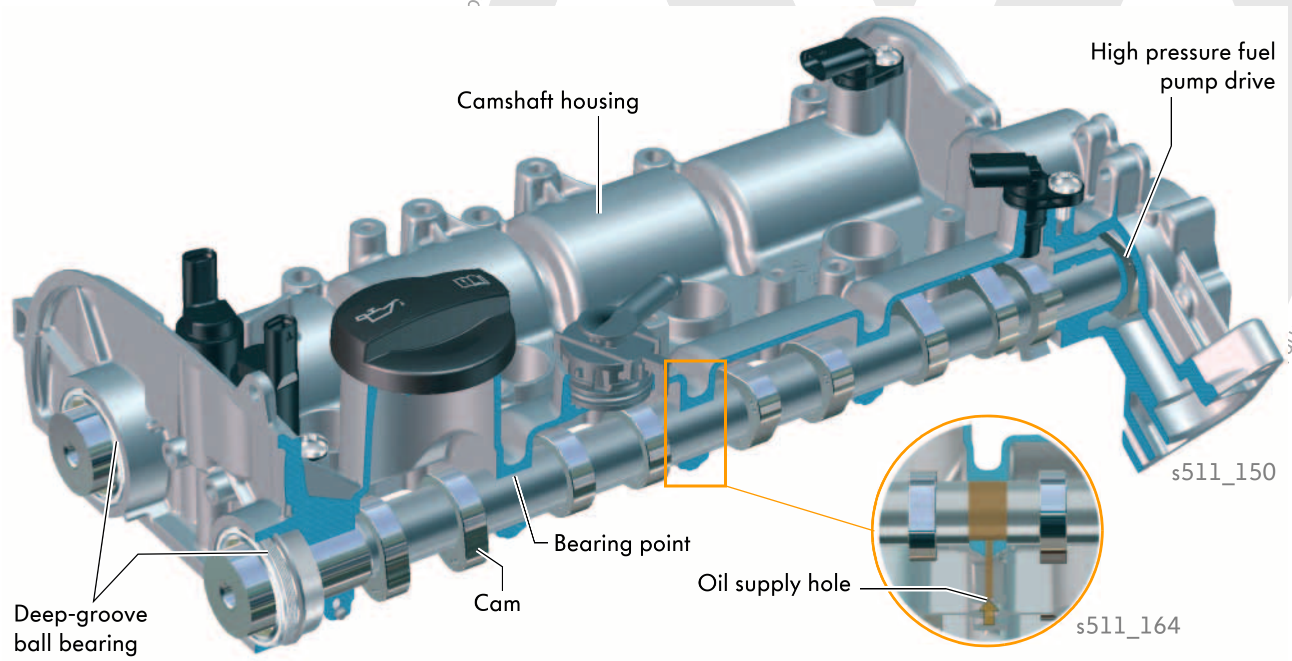
Integrated exhaust manifold
The four exhaust ports within the cylinder head have been combined into one central flange in the integrated exhaust manifold. The exhaust gas turbocharger is bolted directly onto this flange.

This design has several benefits:
- The coolant is warmed up by the exhaust gas while the engine is warming up. The engine reaches its operating temperature faster. This reduces fuel consumption, and the vehicle interior can be heated sooner.
- Due to the smaller exhaust-side wall surface extending to the catalytic converter, the exhaust gas looses little heat during the warm-up phase. This allows the catalytic converter to heat up to operating temperature faster, despite the cooling effect of the coolant.
- When the system is operating at full capacity, the exhaust manifold and the exhaust gas are cooled even more, and the engine can be operated in a larger consumption-optimised and exhaust-optimised lambda=1 range when operating at full capacity.

Camshaft housing

Design

The camshaft housing is made of cast aluminium and, together with the two camshafts, forms an integral module. The modular design involves assembling the camshafts directly into the camshaft housing. As the cams no longer have to fit through the bearing points, it is possible to design very small bearings.



Advantages of smaller bearing points

- lower friction in the bearings and
- higher rigidity.

Oil supply to the bearing points

The sleeve bearings are supplied with oil from oil supply holes.

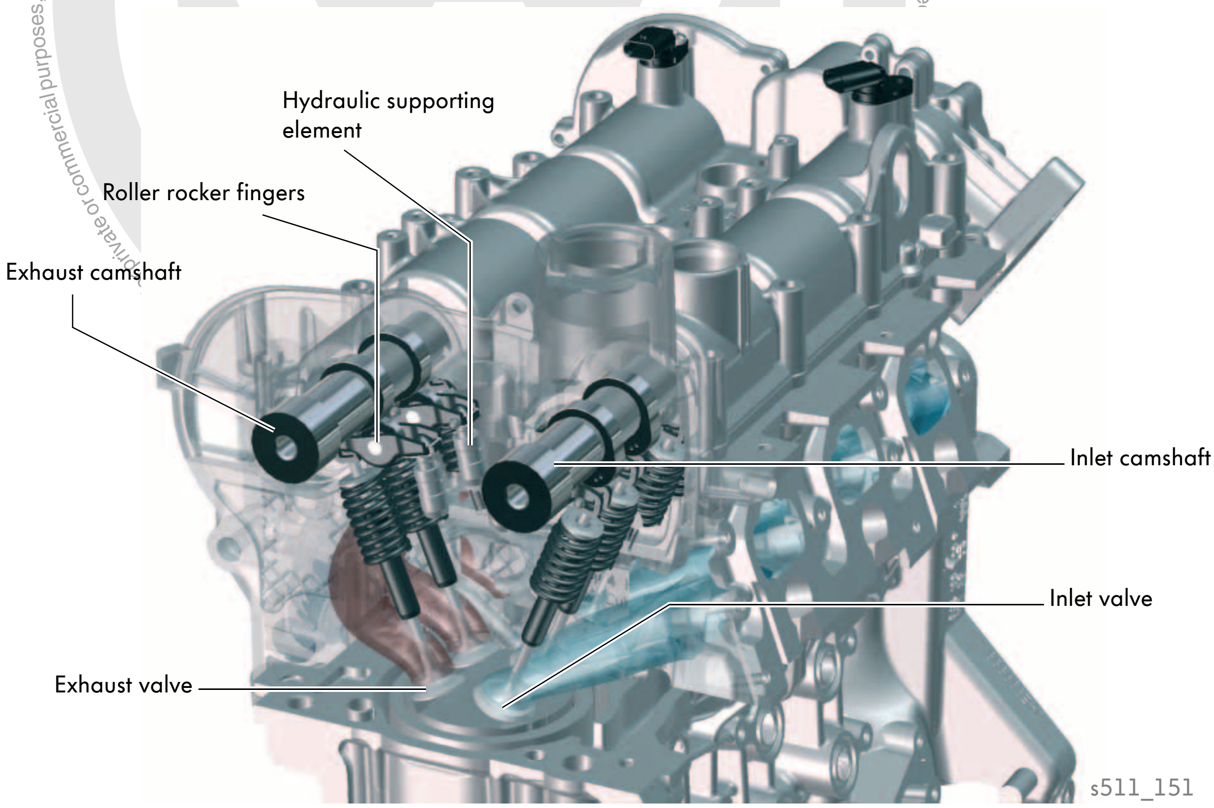
Grooved ball bearing

To reduce friction, the first bearing of that particular camshaft, which is subjected to the highest load from the toothed belt drive, is a grooved ball bearing.

In the event of a repair, the camshaft housing is replaced together with the camshafts.
The grooved ball bearings are secured by a snap ring, however they cannot be replaced.

Valve gear

The EA211 engine family is generally equipped with 4-valve technology.
In this family, the inlet valves are installed at an angle of 21°, and the exhaust valves at an angle of 22.4°, arranged overhead of the combustion chamber. The valves are actuated by roller rocker fingers with hydraulic supporting elements.



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Advantages of the 4-valve technology

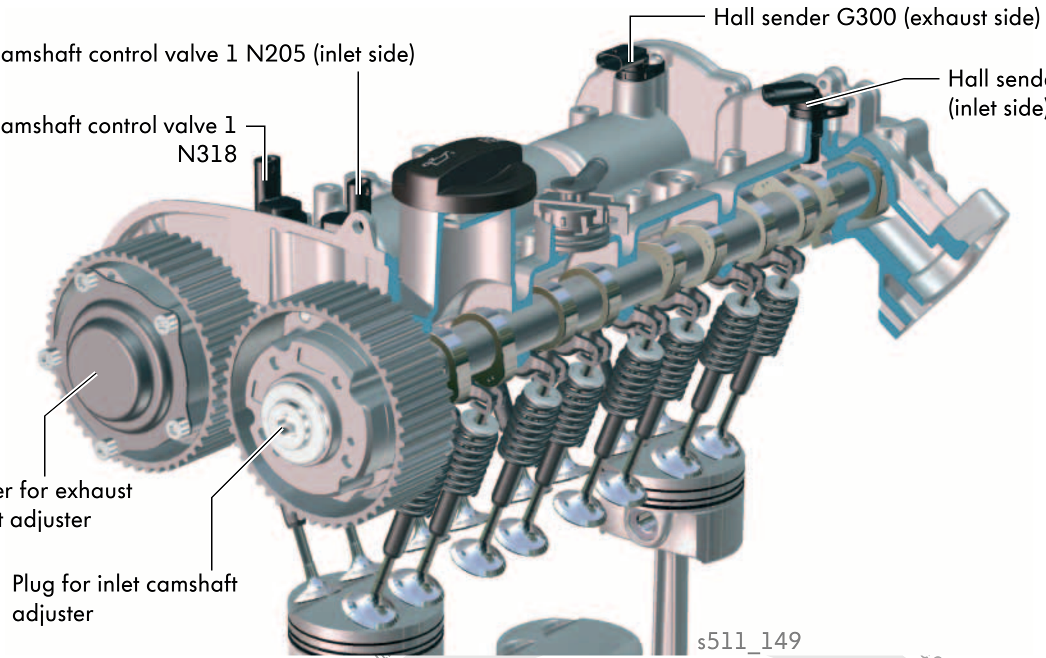
- Good cylinder charging and discharging
- High power yield with a small capacity
- Low fuel consumption due to high efficiency
- High torque and pulling power
- Quieter operation

Other features

- The valve stems have been reduced to a diameter of 5 mm. This results in fewer moving masses and fewer friction losses due to lower valve spring forces.
- The valve seat angle is 90° on the inlet side and 120° on the exhaust side, which contributes to an increase in the wear resistance for alternative fuels, e.g. natural gas.

Variable valve timing

All EA211 engines employ stepless inlet camshaft adjustment, engines with an output of 103 kW or more have stepless exhaust camshaft adjustment as well.
The camshaft adjuster directly on the camshafts carries out the adjustment according to the engine load and speed. They are adjusted by the valves for the camshaft adjustment, which are integrated directly in the oil circuit. The two Hall senders are used to identify the adjustment angle.



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Camshaft adjustment versions

Engine version	Inlet camshaft adjustment	Exhaust camshaft adjustment
1.0 l 44/50/55 kW MPI engine	Stepless up to a crank angle of 40°	–
1.2 l 63/77 kW TSI engine and 1.4 l 90 kW TSI engine	Stepless up to a crank angle of 50°	–
1.4 l 103 kW TSI engine with/without Active Cylinder Management	Stepless up to a crank angle of 50°	Stepless up to a crank angle of 40°

Camshaft adjuster seals and attachment

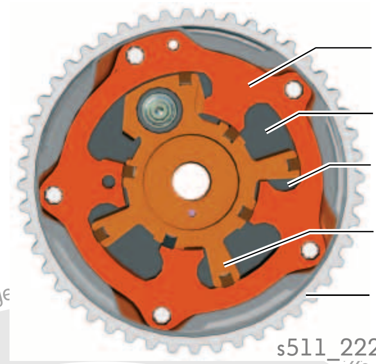
To ensure no engine oil finds its way onto the toothed belt, the camshaft adjusters are sealed. This is done by a rubber seal on the end cover of the exhaust camshaft adjuster and one on the plug for the inlet camshaft adjuster.
Both camshaft adjusters are attached using securing bolts on the camshafts.
Both bolts have a right-handed thread.

Inlet and exhaust camshaft adjustment

The basic design of both camshaft adjusters is identical.

Special features of the camshaft adjusters

Vane-type adjusters
The camshaft adjusters function according to the vane-type adjuster principle. Depending on which of the two chambers the oil is guided to, the rotor turns and the camshaft turns with it.
The adjustment is stepless.



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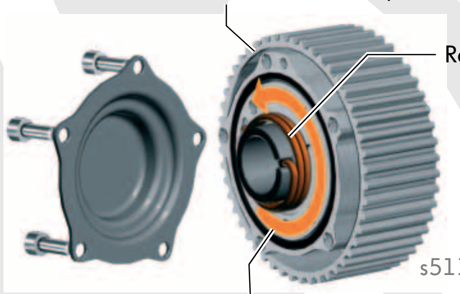
Exhaust camshaft adjuster return
If the engine is to start quickly, no residual gases may enter the cylinders. To ensure this happens, the exhaust camshaft adjuster is locked in the "early position" and the inlet camshaft adjuster is locked in the "late position" when the engine is switched off.
The exhaust camshaft adjuster is set to a position which is opposite to the direction of engine rotation. Due to the large adjustment angle up to a 40° crank angle, the oil pressure alone may not be sufficient enough for this.
A return spring on the exhaust camshaft adjuster assists the oil pressure when being set in the "early position".



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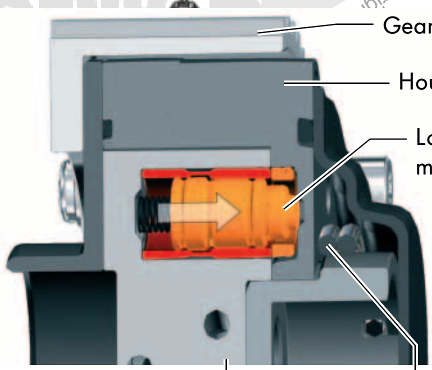
Locking
When the engine is switched off, the exhaust camshaft adjuster is locked in the early position and the inlet camshaft adjuster is locked in the late position. This prevents adjustment of the camshafts during the engine start, and the engine starts faster. Furthermore, it prevents noises when the engine is starting.



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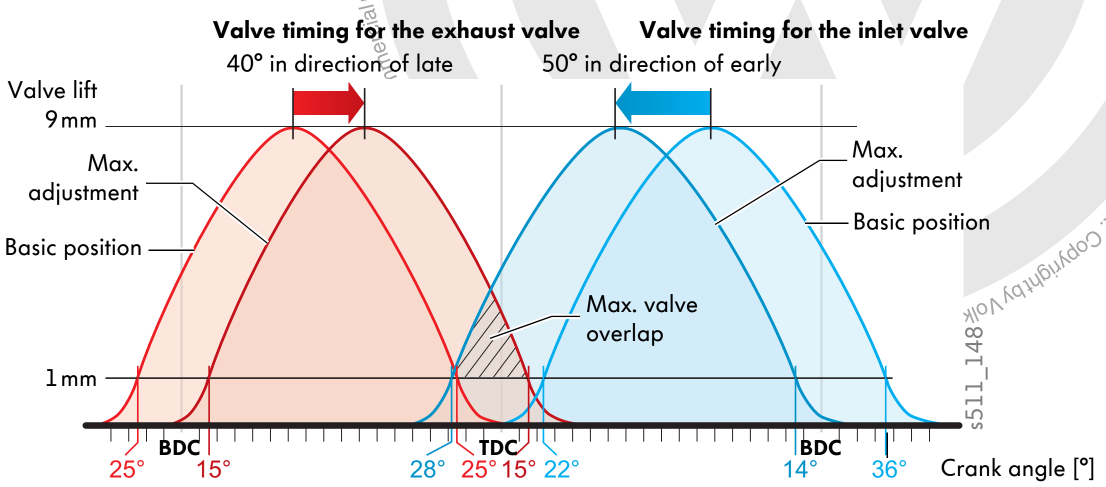
Valve timing

The use of an inlet and exhaust camshaft adjuster allows the valve timing to be optimized to the requirements of the engine. This is because, depending on the engine's operation, different opening and closing times provide important advantages.



Speed/ load range	**Pressure ratio intake manifold/ exhaust system**	**Valve overlap**	**Effects**
Idling	Intake manifold pressure lower than the exhaust back pressure	None	- Very few residual gases in the cylinder, producing quiet running.
Low speed/ low to medium load	Intake manifold pressure lower than the exhaust back pressure	High	- Residual gases are drawn out of the exhaust system into the cylinders. - The throttle valve is opened further to ensure there is an adequate supply of fresh air for the torque required. - The engine is dethrottled, the fuel consumption falls.
Low speed/ high load	Intake manifold pressure higher than the exhaust back pressure due to charge pressure	High	- Fresh air is forced into the cylinders, residual gases are forced out. - Due to a low proportion of residual gas, the rated torque is reached at a low engine speed. - Improved response by the exhaust gas turbocharger and reduced tendency to knock.
Medium engine speed/ medium load	Charge pressure approximately equal to exhaust back pressure	Low	- When pressure ratios are equal, a larger valve overlap has little benefit.
High speed/ high load	Charge pressure lower than the exhaust back pressure	Low	- No residual gases forced back despite high exhaust back pressure, preventing any disadvantageous mixture formation.

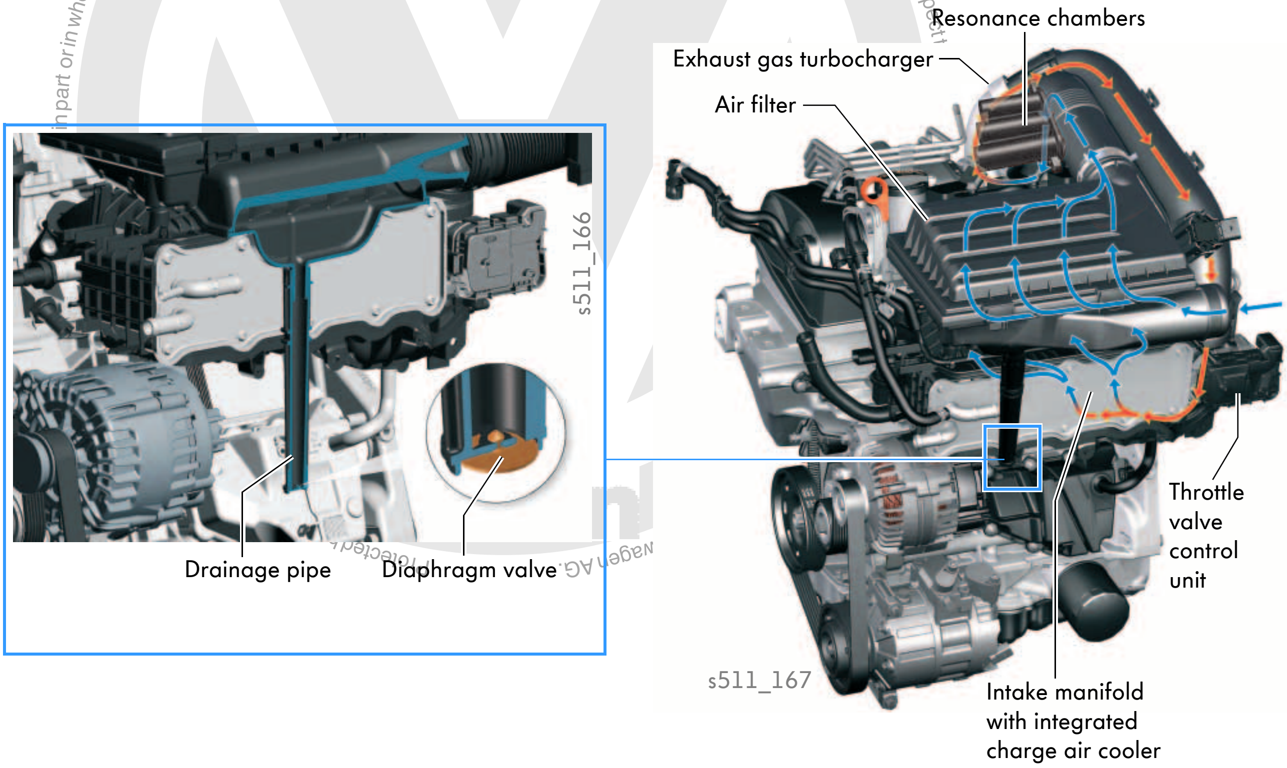
Engine mechanics

Air duct system

The fresh air is guided into the cylinders via the air filter directly on the engine, the exhaust gas turbocharger, the throttle valve module, the intake manifold with integrated charge air cooler, the inlet ports and the inlet valves.

Special features of the air duct system

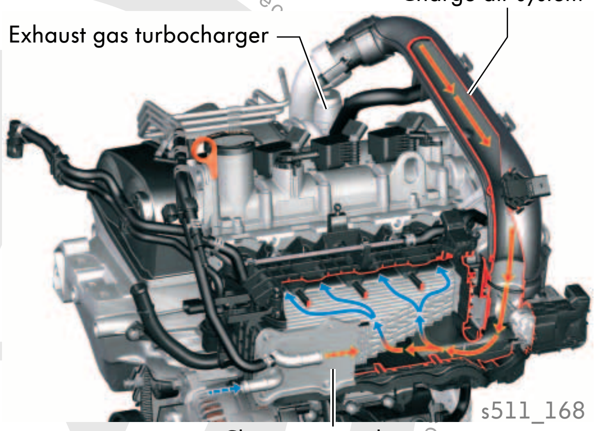
- The intake connecting pipe features resonance chambers which reduce the vibrations produced in the intake system during the intake process. Depending on their frequency, vibrations can lead to a variety of noises.
- The inlet ports have been designed to ensure good air flow control with low flow resistance.
- The charge air is cooled by a charge air cooler, through which coolant flows, located in the intake manifold.
- A nozzle is attached to the air filter in the 1.4 l 103 kW TSI engine with Active Cylinder Management in the Polo Blue GT, in which condensation collects and drips out via a membrane once a certain quantity has been reached.



Exhaust gas turbocharger

An exhaust gas turbocharger is used for charging in the TSI engines in the EA211 engine family. This was designed for a high torque at low engine speeds and a fast response. This allows the 1.4 l 103 kW TSI engine to reach its maximum torque of 250 Nm at just 1500 rpm.

A special feature of the charge air system is its compact design. This means the exhaust gas turbocharger has to compress a smaller volume and the required charge pressure is reached faster.



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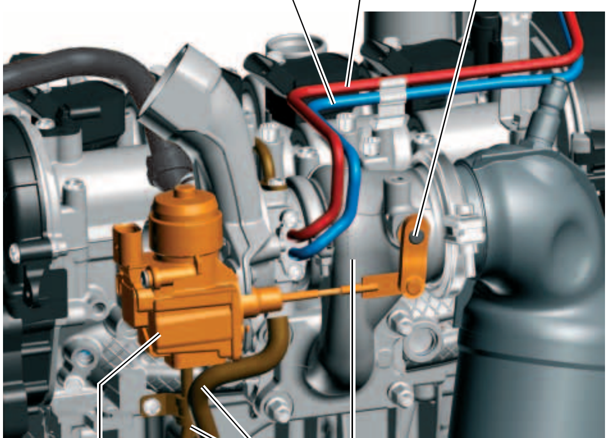
Exhaust gas turbocharger

Every exhaust gas turbocharger was newly developed for their respective engine and the corresponding power. While the basic design with the air duct system, the lubrication or the cooling is identical in all versions, they differ in the dimensions of the turbine and compressor wheels. Another difference between them is found in the charge pressure positioners. They can be replaced individually, however the attachment to the wastegate and the basic setting after replacement differ according to the engine.

Features of the exhaust gas turbocharger:

- Small turbine and compressor wheel diameter with correspondingly low moments of mass inertia.
- Material designed for a maximum exhaust gas temperature of 950°C.
- Integration into the coolant circuit of the charge air cooling to keep the temperature at the shaft bearings low once the engine has been switched off.
- Connection to the oil circuit for lubrication and for cooling the shaft bearings.
- Activation of the wastegate for charge pressure control by an electrical charge pressure positioner with integrated position sender.



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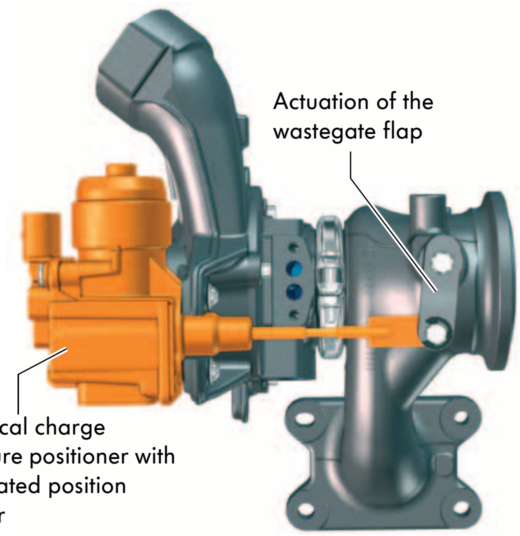
Charge pressure positioner V465

The advantages of the electric charge pressure positioner in comparison with the pneumatic charge pressure control solenoid valve are:

- A fast adjustment time and therefore faster charge pressure build-up.
- A high actuation force, as a result of which the wastegate remains firmly closed, even in the event of high exhaust gas mass flows, in order to achieve the specified charge pressure.
- The wastegate can be actuated independently of the charge pressure. This allows it to be opened in the lower engine load/speed range.
  The basic charge pressure drops and the engine has less charge cycle work to do.



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Further information on the electrical charge pressure positioner V465 can be found in Self-Study Programme No. 443 “The 1.2 l 77 kW TSI engine with turbocharger”.

Exhaust gas turbocharger versions

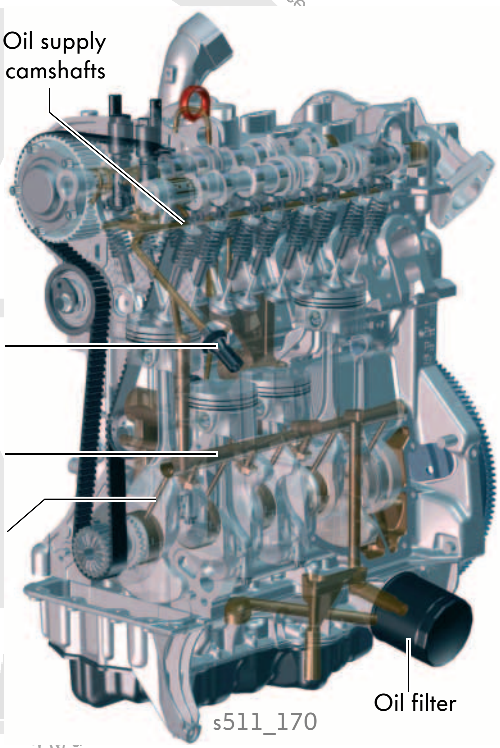
Engine version	Diameter turbine wheel	Diameter compressor wheel	Max. charge pressure according to map	Charge pressure positioner adaptation
1.2 l 63 kW/ 77 kW TSI	33.6mm	36mm	1.7 bar (63 kW) 1.0 bar (77 kW)	Fault reader
1.4 l 90 kW TSI	37mm	40mm	1.8 bar	Threaded rod preset, vehicle diagnostic tester
1.4 l 103 kW TSI with/without ACT	39.2mm	41mm	2.2 bar	Fault reader

Oil circuit

The oil circuit, which refers to the path taken by the oil when being guided to the engine, is very similar in all engines in the new EA211 engine family.

There are differences:

- according to oil pump type and drive,
- according to the oil pressure regulation type
- whether an oil cooler is installed and
- whether an exhaust gas turbocharger is installed.



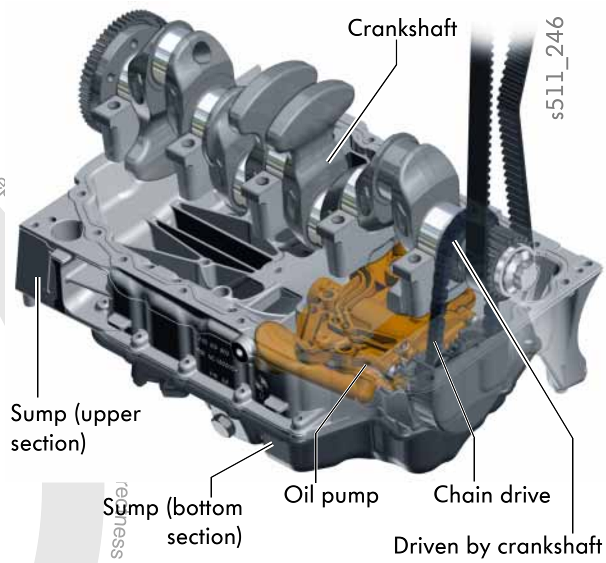
The table shows which oil pump has been used for which engine, how it is driven and how the pressure is regulated.

Engine version	Type of oil pump/drive	Type of regulation
1.0 l 44/50/55 kW MPI engine and 1.2 l 63 kW/77 kW TSI engine	Duocentric oil pump Driven directly by the crankshaft	A pressure regulating valve in the oil pump housing regulates the oil pressure to a constant pressure of approx. 3.5 bar. The oil quantity pumped depends on the engine speed.
1.4 l 90 kW/103 kW TSI engine	External gear oil pump Driven by the crankshaft via a chain drive	The quantity of oil being pumped is adapted by the oil pump according to the load and engine speed. This allows for two-level oil pressure regulation at 1.8 and 3.3 bar respectively.

Further information about the duocentric crankshaft oil pump can be found in Self-Study Programmes No. 508 “The 1.0 l 44/55 kW MPI engine with Intake Manifold Injection” and No. 196 “The 1.4 l 16 V 55 kW Engine”.

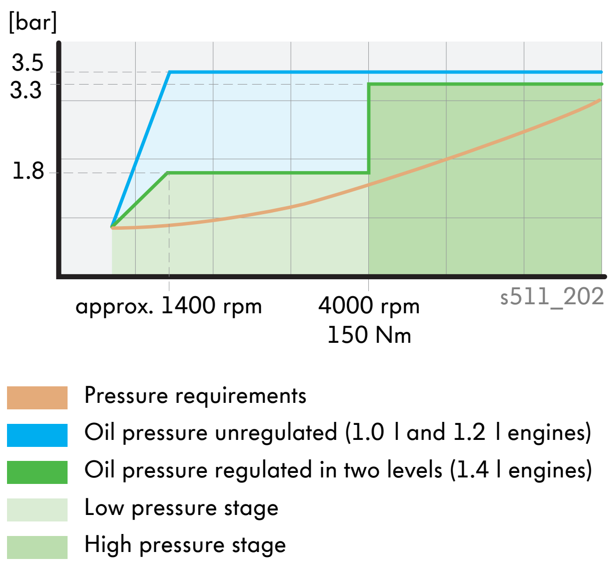
External gear oil pump

An external gear oil pump is being used in the 1.4 l TSI engines. It features very efficient operation and contributes to fuel savings and CO_2 reductions.
The oil pump is bolted onto the upper section of the sump and operates in two pressure stages of approx. 1.8 bar and 3.3 bar depending on the load and engine speed.
It is driven by the crankshaft via a maintenance-free chain drive without a chain tensioner.
The respective oil pressure is regulated by the oil quantity pumped.



Advantages of the two-level oil pressure and oil quantity regulation

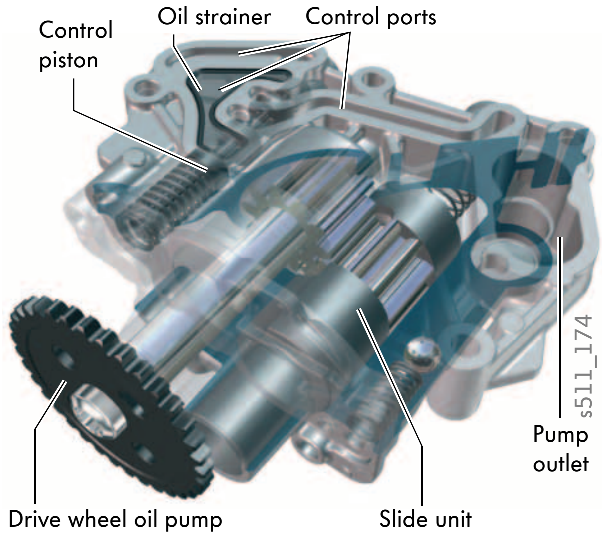
- The drive output of the oil pump is lowered because the oil pump only pumps as much oil as is required.
- Oil degradation is reduced, because less oil is being circulated.



The components in the two-level oil pressure regulation

External gear oil pump

The housing and the housing cover are made of aluminium and feature several control ports for oil pressure regulation. Depending on how the control piston and the slide unit are pressurised with oil from the oil circuit via the control ports, the quantity of oil being pumped and the oil pressure will change.

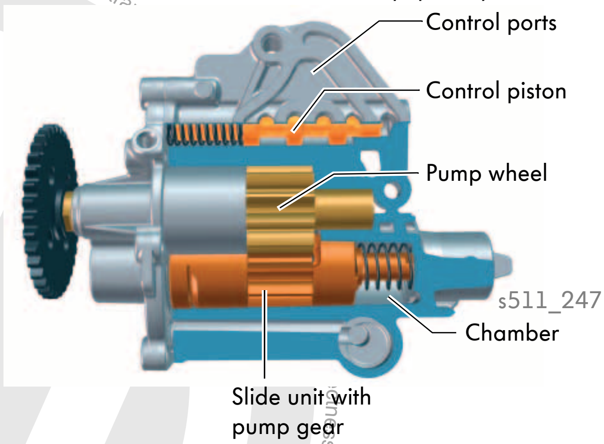


The control piston and the slide unit

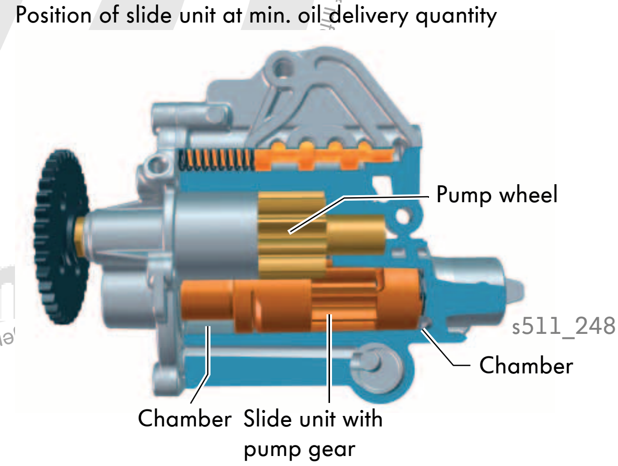
The oil is actually pumped by two intermeshed gear wheels (pump gears).
One pump gear is located on the drive shaft, which is driven by the crankshaft via a chain.
The second pump gear is located on a shaft which can be moved longitudinally. The pump gear and the shaft form the slide unit.

The slide unit allows an influence to be exerted on the delivery rate and the delivery pressure in the oil circuit.
The position of the slide unit is determined by the pressure ratio acting in the chambers to the left and right of the slide unit.
The pressure ratio depends, in turn, on the activation of the control piston.

Position of slide unit at max. oil delivery quantity



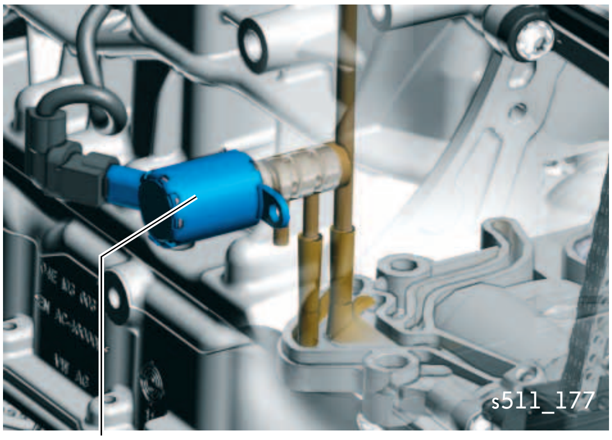
Position of slide unit at min. oil delivery quantity



Valve for oil pressure control N428

The valve for oil pressure control is actuated by an earth signal from the engine control unit in accordance with the load and engine speed. A valve is used to switch between the two oil pressure stages by alternately supplying the various control ports of the oil pump with oil.

The valve features the following switch states:
- If the valve is actuated, it opens the control port to the oil pump and pumps at the low oil pressure stage of 1.8 bar.
- If the valve is not actuated, the port is kept closed by spring pressure and the oil pump and pumps at the high oil pressure stage of 3.3 bar.

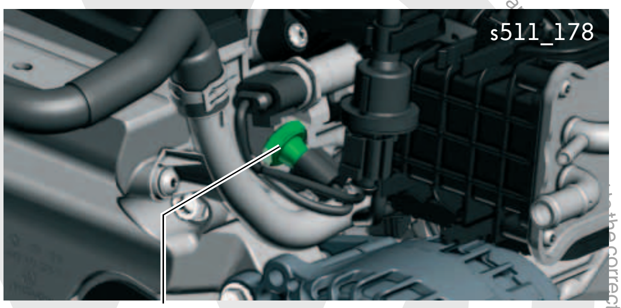


Valve for oil pressure control N428

Oil pressure switch for reduced oil pressure F378 and oil pressure switch F1

The two oil pressure switches allow the engine control unit to monitor the oil pressure at the respective oil pressure stage. If the oil pressure exceeds a certain threshold, the corresponding oil pressure switch opens and the engine control unit receives a signal. This then transmits a message on the CAN bus and the engine oil pressure warning lamp K3 in the dash panel insert is activated.

Oil pressure switch for reduced oil pressure F378
It is bolted on the intake side, near the toothed belt in the cylinder head. It is used to determine whether the minimum oil pressure is being achieved.



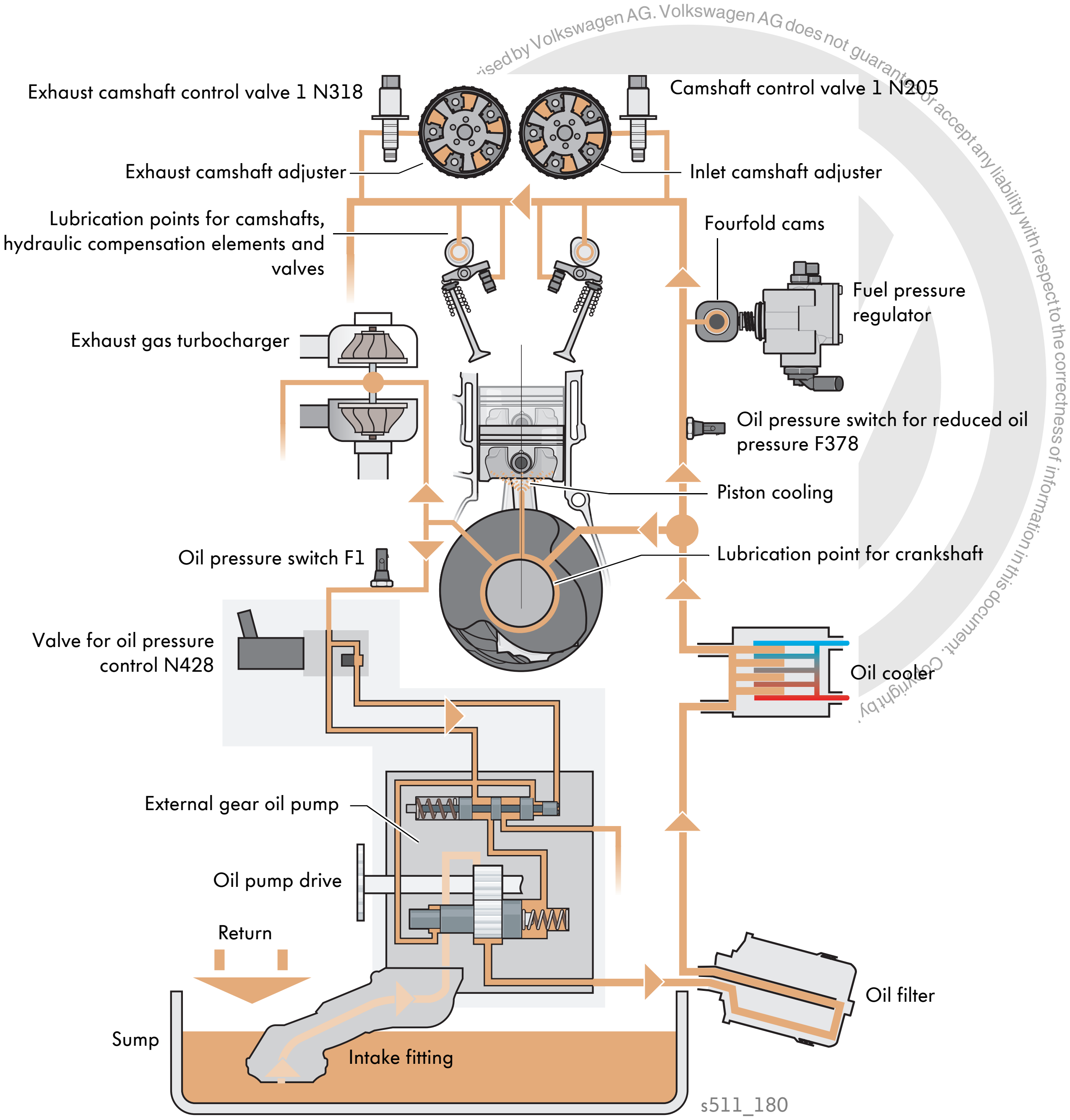
Oil pressure switch for reduced oil pressure F378

Oil pressure switch F1
It is bolted into the middle of the cylinder block on the exhaust side. If the engine control unit has switched over to the high oil pressure stage, then it is used to monitor the high oil pressure.

Oil pressure switch F1

The oil pressure control

Compared to an unregulated oil pump, the drive power had already been reduced considerably in the regulated ducocentric oil pumps in the EA111 petrol engine family. It only pumped as much oil over the entire engine speed range as was needed to keep the oil pressure at a constant 3.5 bar.
With the new oil pumps for the EA211 engine family, the oil pressure is regulated at two levels depending on the engine speed and load. Above all, in the lower to medium engine speed/load range, the drive power falls as the oil pressure is only approx. 1.8 bar in this case. Less oil therefore has to be pumped by the oil pump.



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Functional sequence of the oil pressure regulation

The oil pressure level is set by the oil quantity being pumped. The amount of oil being pumped depends on the position of the slide unit, how far the two pump gears are apart, and the engine speed.

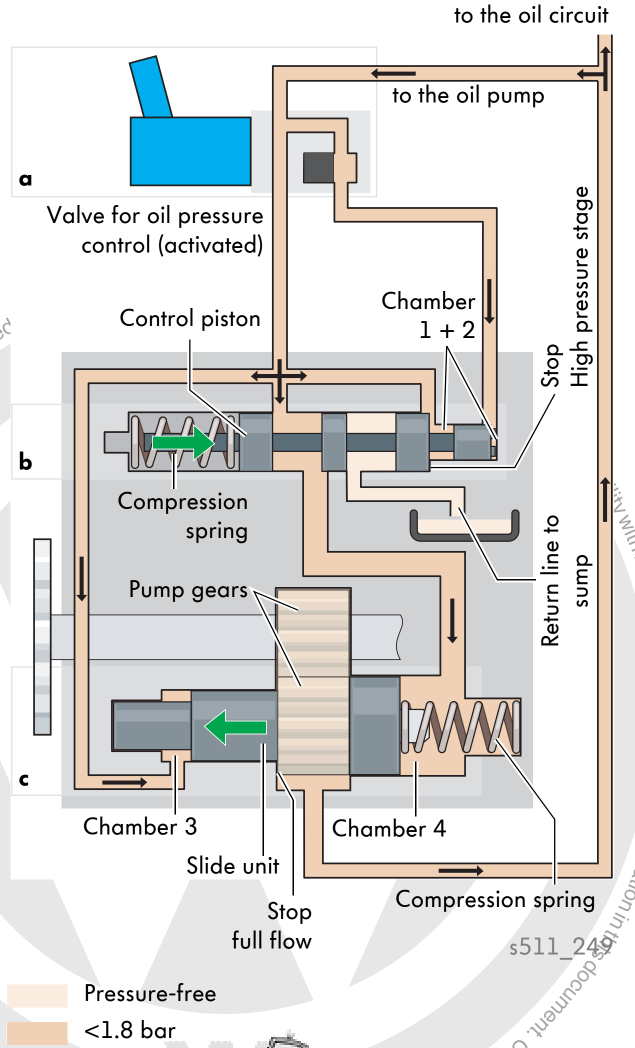
Pressure build-up from engine start to approx. 1.8 bar

Once the engine has started, the required oil pressure must be built up as quickly as possible. The two pump gears are exactly opposite each other and the maximum oil quantity at the engine speed is pumped into the oil circuit.

a) The valve for oil pressure control is activated by the engine control unit using the earth and opens the control port to chamber 2.

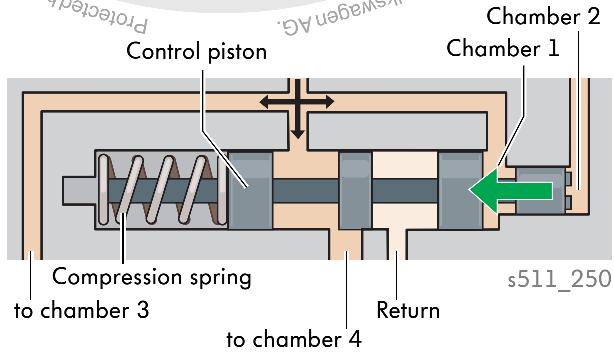
b) The control piston is pressed onto the stop of the high pressure stage by the compression spring.

c) The oil pressure in chambers 3 and 4 totals less than 1.8 bar and has no effect on the position of the slide unit. The compression spring presses the slide unit against the full flow stop.



Engine speed increases

When the engine speed increases, the oil pump pumps more oil and the oil pressure increases. At the same time, the pressure in chambers 1 and 2 of the control piston increases, and it is pushed to the left against the spring force. Because the pressure in chambers 3 and 4 of the slide unit still totals less than 1.8 bar, the slide unit remains at the full flow stop.



Low-pressure stage – approx. 1.8 bar

At approx. 1400 rpm, the oil pressure reaches the lower pressure stage of approx. 1.8 bar. This pressure is kept constant up to 400 rpm or 150 Nm respectively.

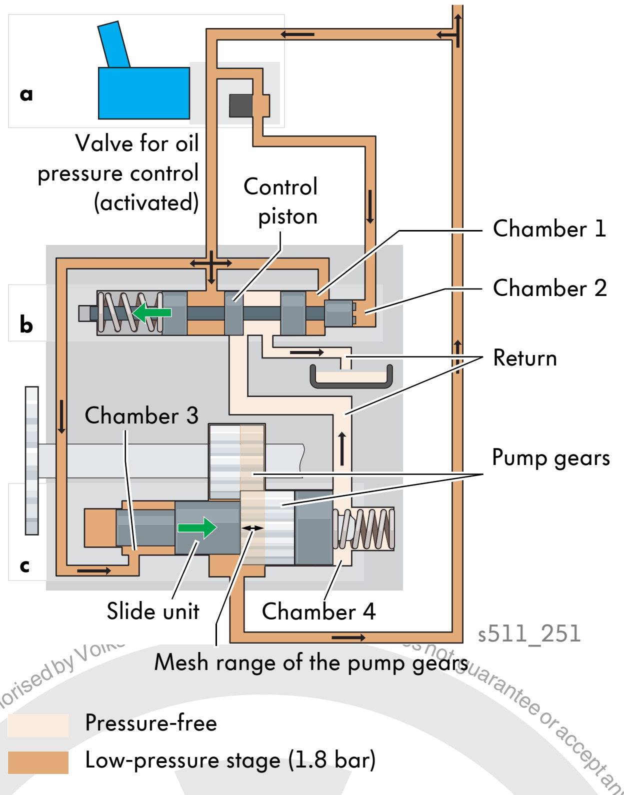
When the engine speed increases, the oil flow quantity and the oil pressure increase; they decrease when the engine speed falls.

Oil pressure regulation when the oil pressure increases to more than 1.8 bar

a) The valve for oil pressure control is activated by the engine control unit using the earth and opens the control port to chamber 2.

b) The increasing engine speed increases the pressure in chambers 1 and 2 to more than 1.8 bar and the control piston is pushed to the left against the spring force. The path from chamber 4 to the return to the sump is opened.

c) The pressure in chamber 3 increases to more than 1.8 bar and pushes the slide unit slightly to the right, against the spring force. The oil from chamber 4 is pressed back into the sump. The pump gears no longer intermesh as much, and the oil quantity being pumped, and therefore the oil pressure, decrease.

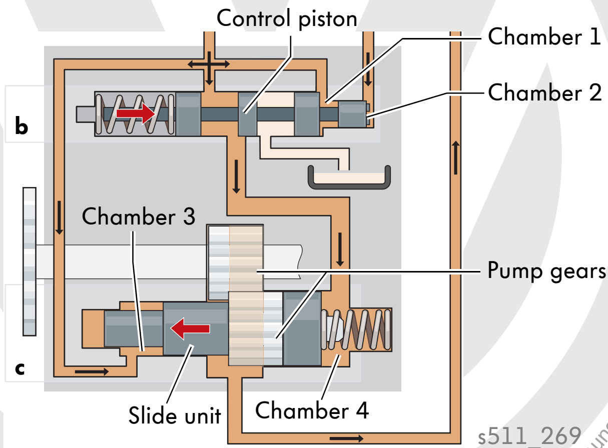


Oil pressure regulation when the oil pressure falls below 1.8 bar

a) The valve for oil pressure control remains open.

b) When the engine speed decreases, the pressure in chambers 1 and 2 falls below 1.8 bar and the control piston is pushed to the right by the spring force. The path from the oil circuit to chamber 4 of the slide unit is opened.

c) The pressure in chambers 3 and 4 is now equal again. Together with the spring force, the slide unit is pushed slightly to the left. The pump gears continue to intermesh, and the oil quantity being pumped, and therefore the oil pressure, increase.



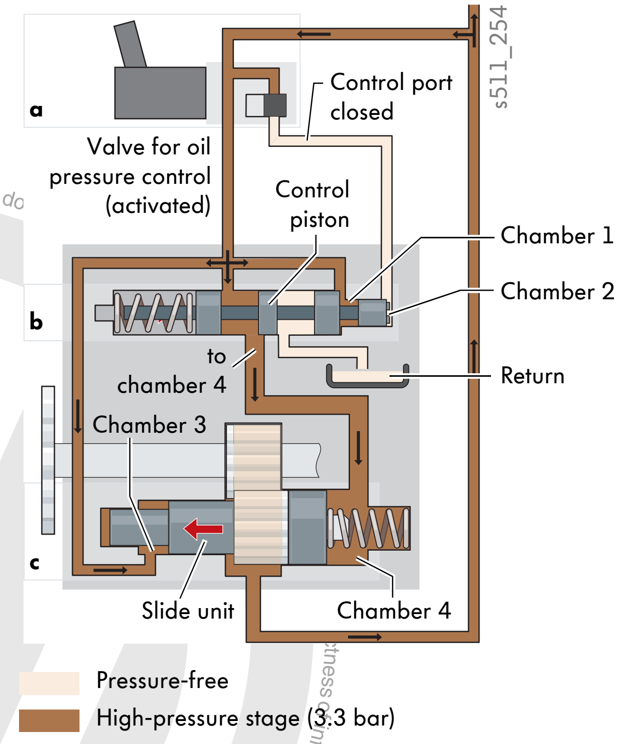
Switching over to the high pressure stage – approx. 3.3 bar
At an engine speed of 4000 rpm or an engine load of 150 Nm, a switchover to the high pressure stage of approx. 3.3 bar occurs. To reach the higher pressure, the quantity of oil pumped is increased.

Switchover position to the high pressure stage

a) The valve for oil pressure control is no longer activated by the engine control unit and closes the control port to chamber 2.

b) The lack of oil pressure in chamber 2 allows the compression spring to push the control piston far to the right, and opens a large cross section to chamber 4.

c) The oil pressure in chamber 4 of the slide unit increases and pushes this far to the left together with the compression spring. The two pump gears now intermesh deeply and pump more oil, and the oil pressure increases.



Switching back to the low pressure stage
To switch back to a low pressure stage, the valve for oil pressure control is activated again using the earth and it opens the control port to chamber 2. The oil pressure in chambers 1 and 2 pushes the control piston to the left against the spring force, closes the control port to chamber 4 and opens the return line to the sump. This causes the oil pressure in chamber 4 to fall, and the slide unit is pushed to the right by the higher oil pressure in chamber 3. The pump gears intermesh less, and the oil quantity being pumped, and therefore the oil pressure, decrease.

High-pressure stage – approx. 3.3 bar

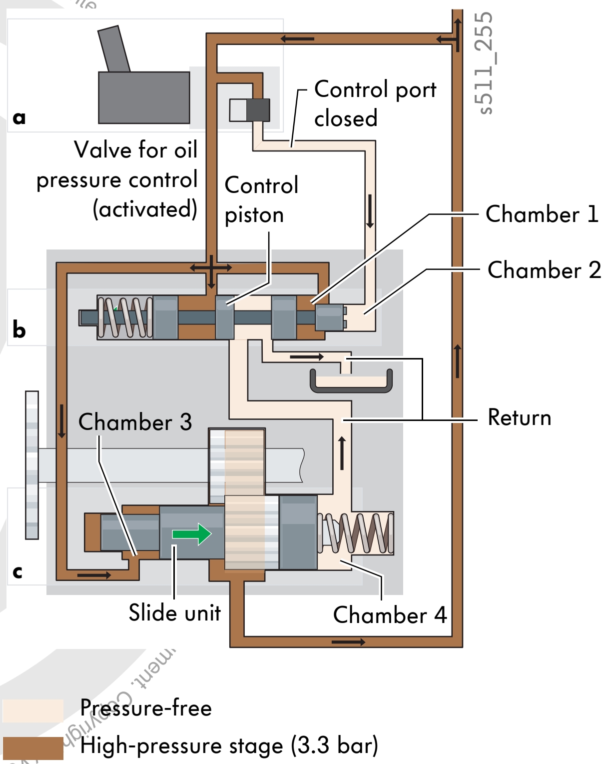
As with the low pressure stage, the oil pressure is also regulated at a constant 3.3 bar in the high pressure stage. When the engine speed increases, the oil quantity being pumped and the oil pressure also continue to increase. To keep the oil pressure at a constant 3.3 bar, the quantity of oil being pumped is adjusted. The regulation at a constant oil pressure is carried out the same way as it is for the low pressure stage.

Oil pressure regulation when the oil pressure increases to more than 3.3 bar

a) The valve for oil pressure control is not activated by the engine control unit and closes the control port to chamber 2.

b) The oil pressure in chamber 1 is now high enough that it pushes the control piston to the left against the force of the spring, and opens the return port from chamber 4 to the sump.

c) The pressure in chamber 4 falls, and the slide unit is pushed to the right against the compression spring by the high oil pressure in chamber 3. The pump gears no longer intermesh as deeply, pumping less oil, and the oil pressure falls to approx. 3.3 bar.



Oil pressure regulation when the oil pressure falls below 3.3 bar

If the oil pressure falls below 3.3 bar, for example because the engine speed is falling, then the same regulation is carried out as in the low pressure stage. The regulation at a constant pressure is a continual process in both pressure stages:

- If the oil pressure is too low, the control port from the oil circuit to chamber 4 opens at the slide unit. The oil flowing in pushes it so that the pump gears intermesh further, more oil is pumped and the oil pressure increases.
- If the oil pressure is too high, the return line from chamber 4 to the sump opens. The oil flowing back pushes the slide unit so that the pump gears do not intermesh as far, less oil is pumped and the oil pressure decreases.

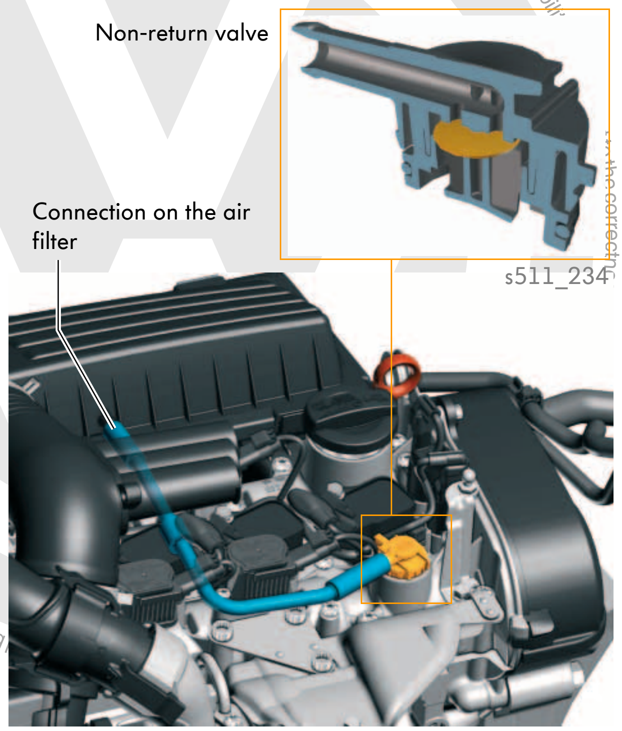
Crankcase breather and ventilation system

The crankcase breather and ventilation system must ensure that:

- The formation of condensation in the oil remains low on short trips and therefore prevents the crankcase breather from freezing, and
- oil vapour and uncombusted hydrocarbons are prevented from being emitted into the environment under all operating conditions.

Crankcase breather

The crankcase breather allows the crankcase to be flushed with fresh air, therefore reducing the formation of condensation in the oil. It is ventilated with fresh air using a hose leading from the air filter to the non-return valve on the camshaft housing. The non-return valve prevents oil or unfiltered blow-by gases from entering the air filter. If the pressure in the crankcase becomes too high, it opens the path to the air filter. This prevents any damage to seals due to excessive pressures.



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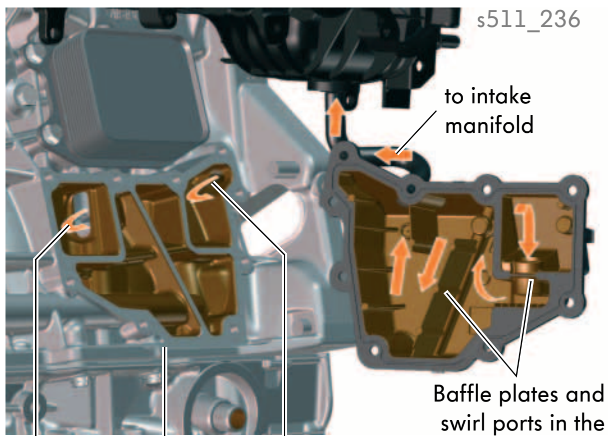
Crankcase ventilation

The gases flow from the crankcase into the oil separator. In the coarse oil separator, the large drops of oil are first separated from the gases by baffle plates and swirl ports, followed by the small drops of oil in the fine oil separator, which are separated by smaller swirl ports. A throttle bore in the housing of the oil separator to the intake manifold limits the throughput when the vacuum in the intake manifold is too high.
After the oil separator, the gases reach the inlet point to the intake manifold or to the exhaust gas turbocharger.



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Discharge of blow-by gases into fresh air

The EA211 engines features an internally guided crankcase breather which prevents any freezing. Internal means that the blow-by gases purified of oil in the oil separator are largely guided to the inlet points within the engine. They mix with fresh air there.

In the 1.0 l MPI engines, the gases are drawn into the intake manifold by a vacuum.
In the 1.2 l and 1.4 l TSI engines they go directly to the intake manifold or the intake side of the exhaust gas turbocharger, depending on the pressure ratio.

Vacuum in intake manifold
The suction effect of the engine makes the pressure in the valve in the intake manifold lower than that on the intake side of the turbocharger. This opens the valve in the intake manifold and the valve on the intake side of the turbocharger closes.
The blow-by gases are now sucked into the intake manifold via the hose.

Charge pressure in the intake manifold
The pressure on the intake side of the turbocharger is lower than in the intake manifold in this case. The valve on the intake side of the turbocharger opens. The valve in the intake manifold closes. The blow-by gases are drawn in directly by the turbocharger.

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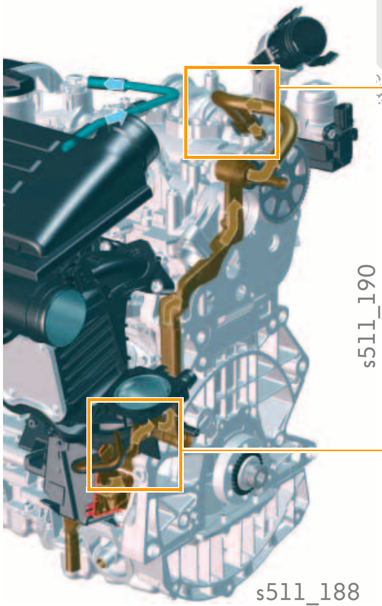
Non-return valve
intake side on the
exhaust gas turbocharger



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Non-return valve
on the intake manifold

Non-return valve in the intake manifold
This is attached to the lowest point of the intake manifold. When the engine is at a standstill, it is open and any oil there can flow back to the separator.

Cooling system

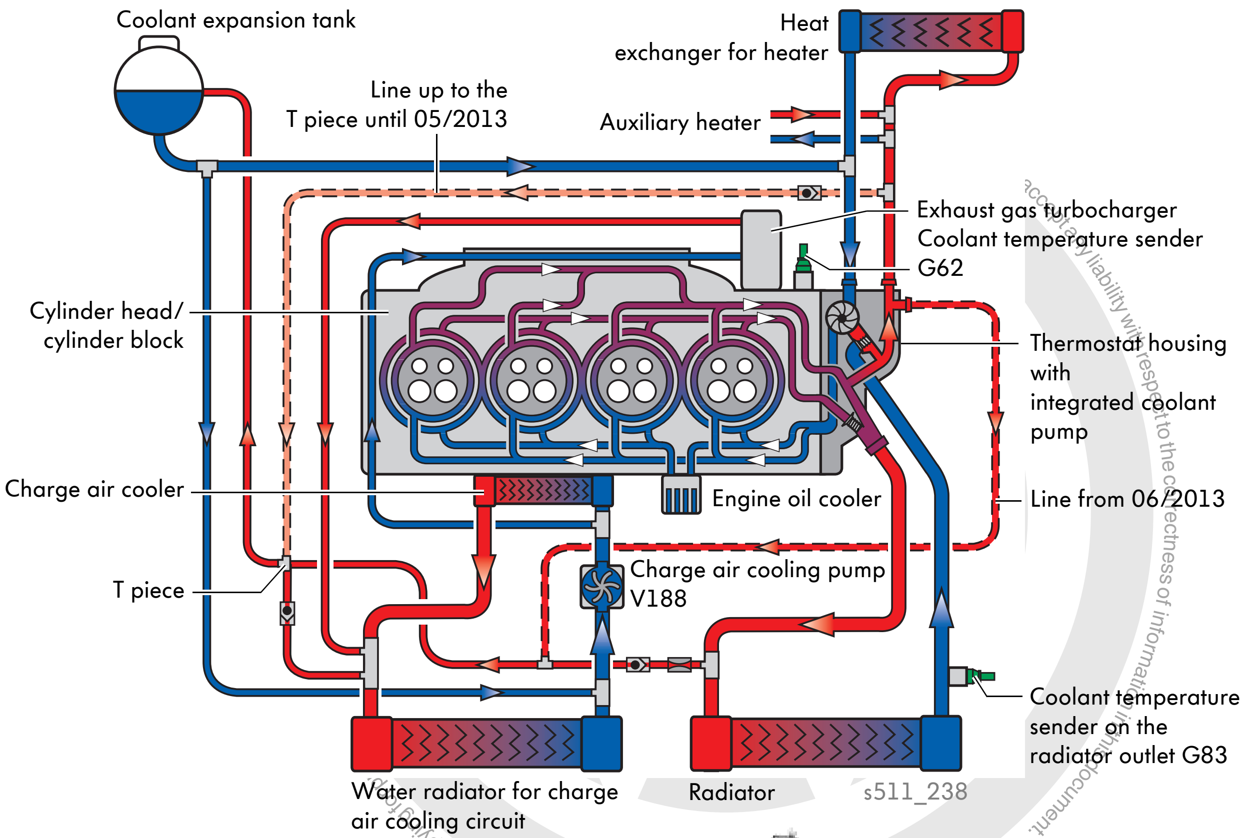
A dual-circuit cooling system is used for engine cooling in all EA211 engines. With this system, the coolant is channelled separately through the cylinder block and cylinder head at different temperatures. The temperature regulation is controlled by two thermostats in the thermostat housing. The respective coolant temperatures differ according to the engine.

Special features of the engine cooling system:

- Cross-flow cooling in the cylinder head for a more uniform temperature distribution
- Thermostat housing with integrated coolant pump
- Coolant pump driven by the exhaust camshaft using a toothed belt

Special features of the charge air cooling system:

- Cooling for the integrated exhaust manifold
- Charge air cooling pump V188
- Air-to-liquid charge air cooler in intake manifold
- Cooling of the exhaust gas turbocharger



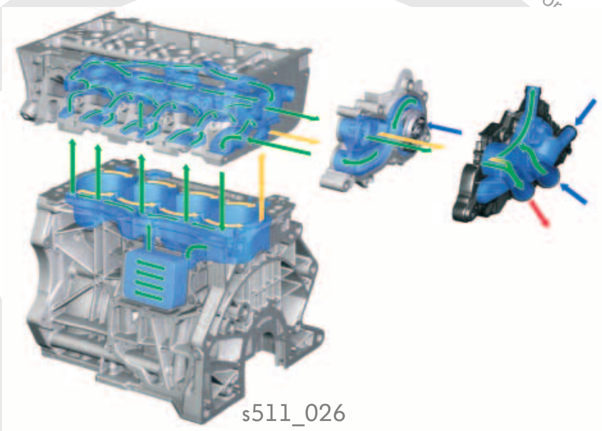
The charge-air cooling system needs to be bled after it is opened to ensure a correct cooling output. The system is bled either by using the cooling system charge unit VAS 6096 or by using the guided function “Filling and bleeding cooling system”. Please note the instructions in ELSA.

Engine cooling system

The dual-circuit cooling system for the engine pumps the coolant from a coolant pump integrated into the thermostat housing to the cylinder head and cylinder block.

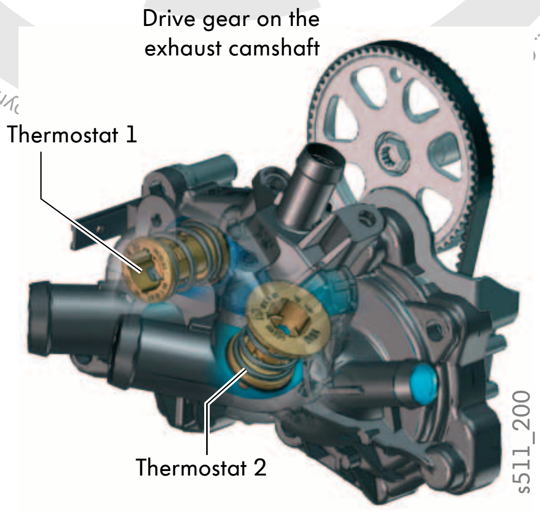
The dual-circuit cooling system has the following advantages:

- The cylinder block warms up faster because the coolant remains in the cylinder block until it reaches approx. 105 °C.
- Less friction in the crankshaft group due to the higher temperature level in the cylinder block.
- Better cooling of the combustion chambers due to the lower temperature level in the cylinder head. This ensures better filling with a lower knocking tendency.



Thermostat housing with integrated coolant pump

The thermostat housing is installed on the cylinder head on the gearbox side. The coolant pump has been integrated into the thermostat housing to produce the most compact cooling system design possible. The coolant pump is driven by the exhaust camshaft using a toothed belt.

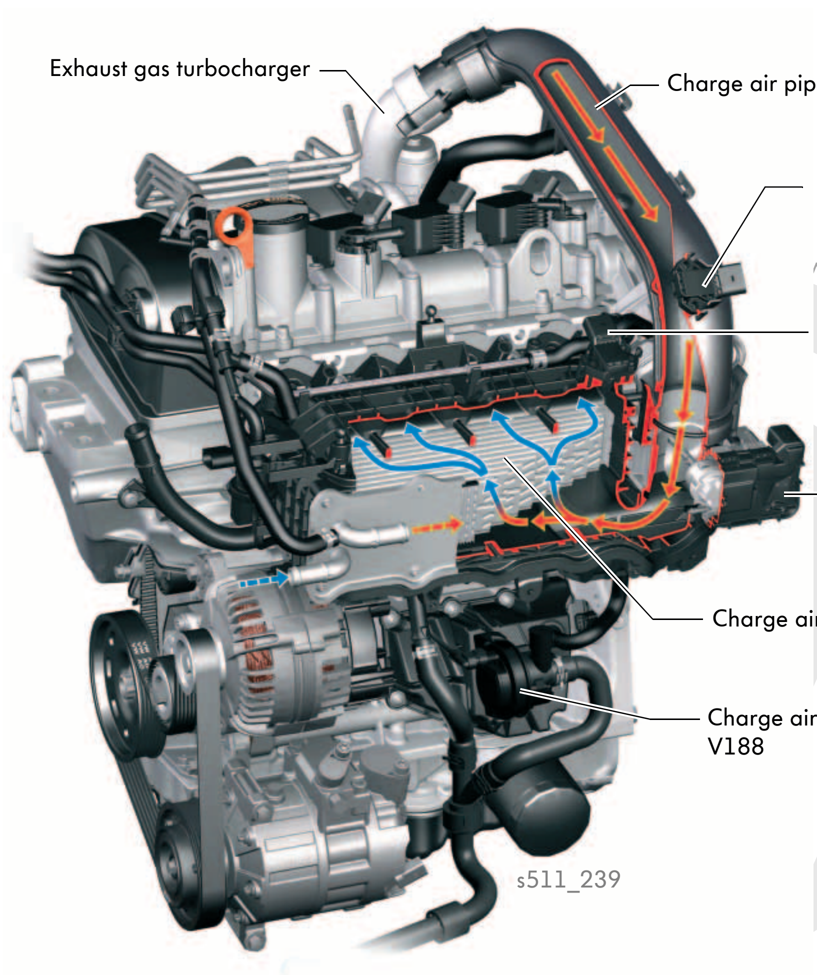


Thermostat 1 for cylinder head
It opens at a temperature of 87 °C or above, and opens the path from the radiator to the coolant pump.
It opens at a coolant temperature of 80 °C or above in the MPI engines.

Thermostat 2 for cylinder block
It opens at a temperature of 105 °C or above, and opens the path for the warm coolant from the cylinder block to the radiator.
The entire coolant circuit is open.

Charge air cooling system

When the intake air is compressed by the exhaust gas turbocharger, the pressure, and therefore the intake air temperature, increases significantly. Warm air has a lower density and less oxygen enters the cylinder. The charge air is cooled to ensure the filling is a good as possible. The engine knocking is also reduced. A charge air cooler through which coolant flows is installed in the intake manifold. The heated charge air flows through it and transfers the majority of its heat to the charge air cooler and the coolant.



Charge air cooling pump V188

The charge air cooling system is a self-contained cooling system in which the turbocharger is also integrated. The charge air cooling pump is a circulation pump which is activated according to requirements. It draws the coolant from the auxiliary radiator for charge air and conveys it to the charge air cooler in the intake manifold and to the exhaust gas turbocharger. From there it flows back to the charge air cooler at the front end.

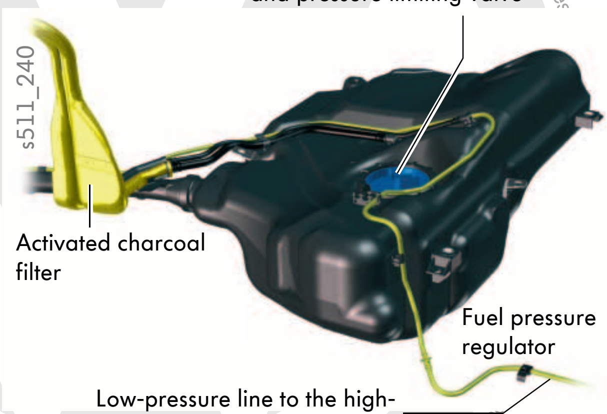
Fuel system

The fuel system used for the TSI engines is divided into a low-pressure and a high-pressure fuel system. In addition, the fuel is fed via the activated charcoal filter system for combustion.

Low-pressure fuel system

In the low-pressure fuel system, the fuel is delivered to the high-pressure fuel pump by the electric fuel pump in the fuel tank. The fuel pressure is between 2 and 6 bar depending on requirements.

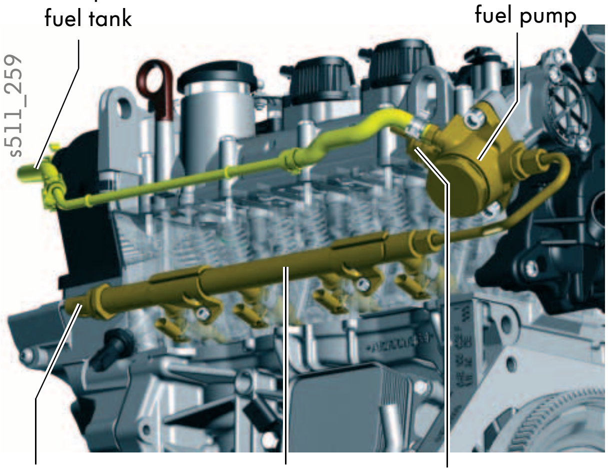
In normal operation, the fuel pressure is between 2 and 5 bar. When a cold or hot start is made, the pressure is briefly raised to 5 to 6 bar, depending on the engine temperature.



High-pressure fuel system

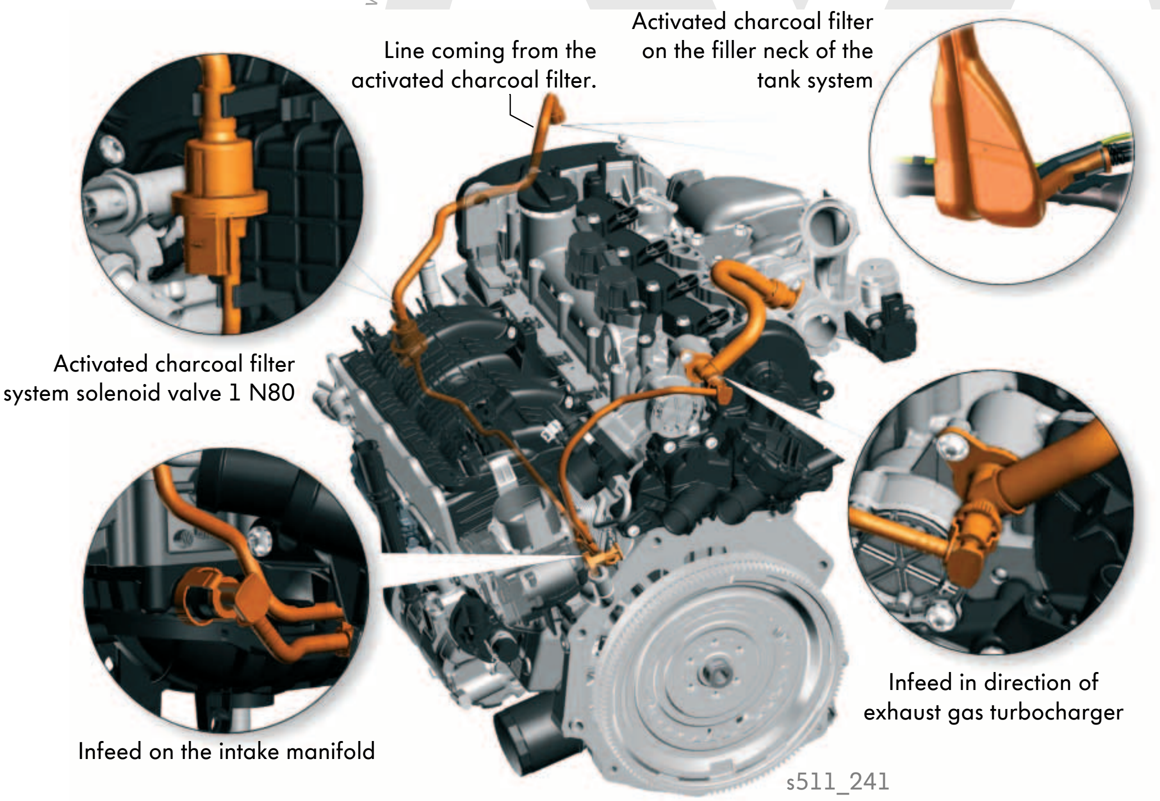
In the high pressure fuel system, fuel is pumped from the high pressure fuel pump into the fuel rail. The pressure is measured by the fuel pressure sender there and is regulated by the fuel pressure regulating valve from 120 up to 200 bar in the 1.2 l TSI engines and from 140 up to 200 bar in the 1.4 l TSI engines. The fuel is injected by the high pressure injectors.

The high pressure ensures a very good mixture formation and reduces the particle emissions.



Activated charcoal filter system

This is required to comply with the legal regulations governing the reduction of hydrocarbon emissions (HC). This prevents fuel vapours escaping from the fuel tank into the environment.
The fuel vapours are stored in an activated charcoal filter and are routinely used for combustion.
In the 1.0 l MPI engines, this is always done on the intake manifold and in the 1.2 l and 1.4 l TSI engines, this is done directly on the intake manifold or on the intake side of the exhaust gas turbocharger, depending on the pressure ratios.



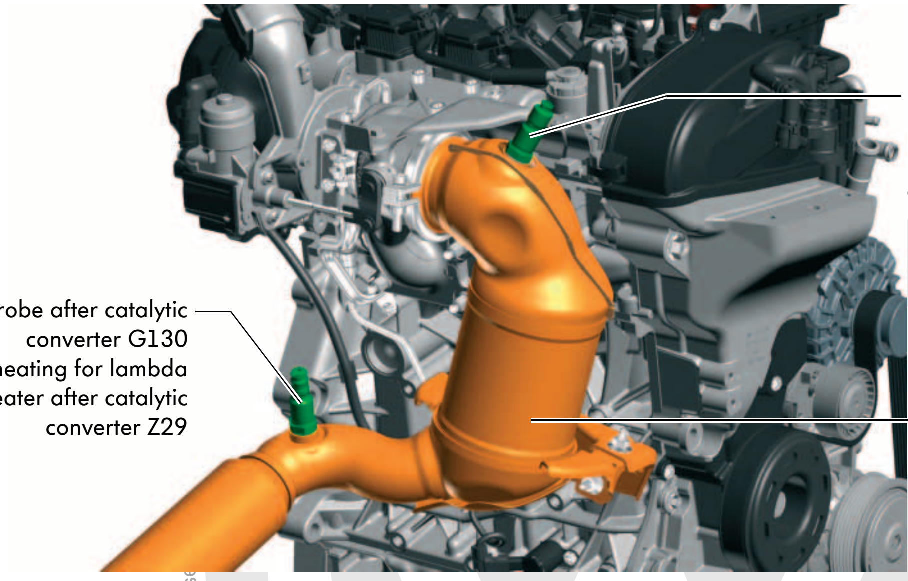
The engine control unit calculates how much fuel may be supplied from the activated charcoal filter system. The solenoid valve is then activated, the injection quantity is then adjusted and the throttle valve is set.

To do so, it requires the following information:
- the engine load from the intake manifold pressure sender G71
- the engine speed from the engine speed sender G28
- the intake air temperature from the intake air temperature sender 2 G299
- the load level of the activated charcoal filter via the lambda probe G39

Exhaust system

In all EA211 engines, the exhaust system consists of an exhaust manifold integrated into the cylinder head, a step-type or broadband lambda probe before the three-way catalytic converter (depending on the engine), a step-type lambda probe after the catalytic converter, a damper element and a main silencer.

Due to the rotation of the cylinder head compared to the EA111 engine family, the catalytic converter is located at the back of the engine.
The integrated exhaust manifold allows the lambda regulation to start even earlier.



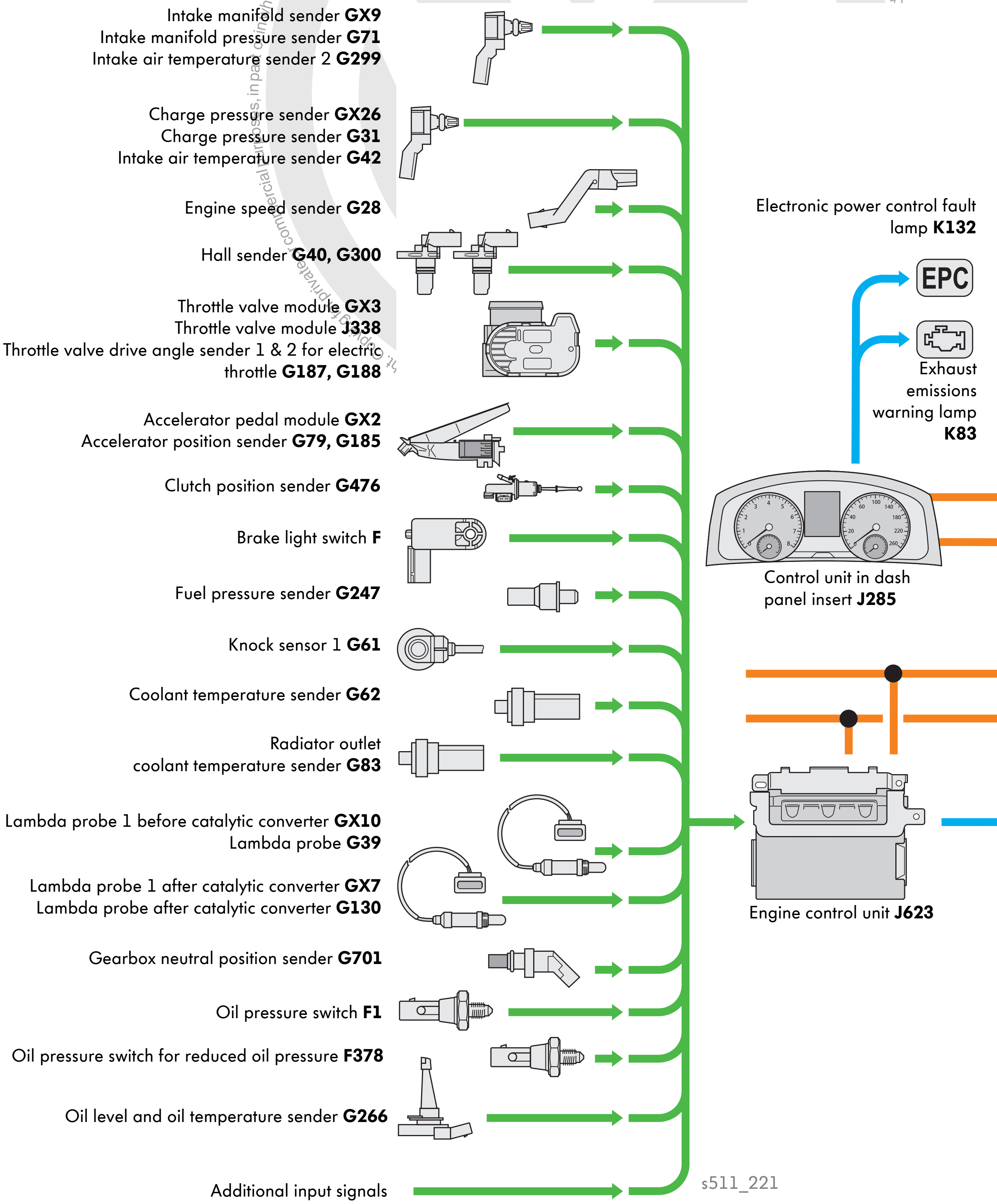
Mixture regulation and catalytic converter monitoring

Engine	Starter catalytic converter lambda probe	Post catalytic converter lambda probe
1.0 l 44/55 kW MPI engine	Step-type lambda probe	Step-type lambda probe
1.0 l 50 kW MPI engine (natural gas)	Broadband lambda probe	Step-type lambda probe
1.2 l 63/77 kW TSI engine and 1.4 l 90 kW TSI engine	Step-type lambda probe	Step-type lambda probe
1.4 l 103 kW TSI engine and 1.4 l 103 kW TSI engine with ACT	Broadband lambda probe	Step-type lambda probe

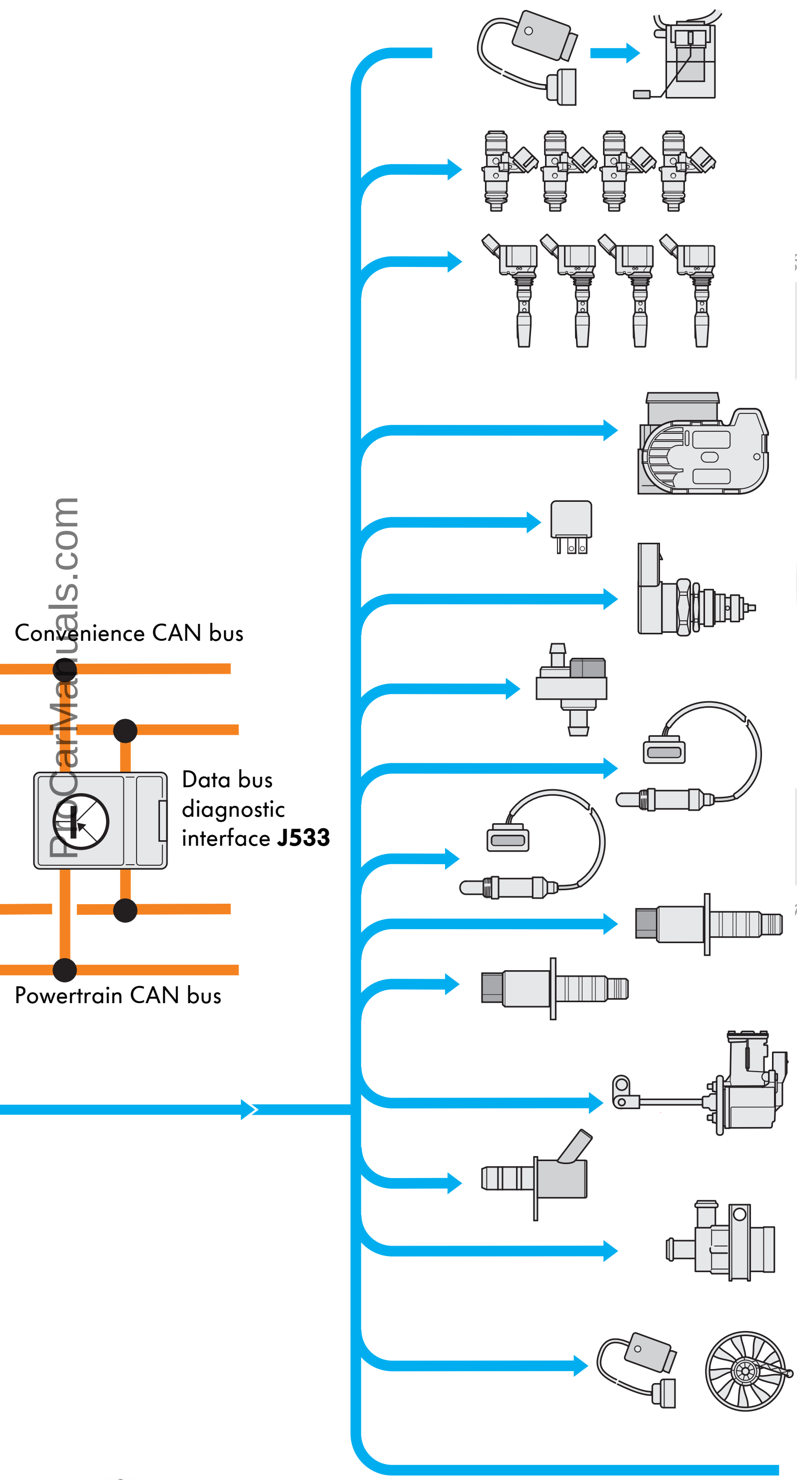
System overview

Using the 1.4 l 103 kW TSI engine as an example

Sensors



Actuators



Fuel pump control unit **J538**
Fuel delivery unit **GX1**
Fuel system pressurisation pump **G6**

Injectors, cylinders 1 - 4 **N30 - N33**

Ignition coils 1 - 4 with output stages
N70, N127, N291, N292

Throttle valve module **GX3**
Throttle valve module **J338**
Throttle valve drive for electric throttle **G186**

Main relay **J271**

Fuel pressure regulating valve **N276**

Activated charcoal filter system solenoid valve 1 **N80**

Lambda probe 1 before catalytic converter **GX10**
Lambda probe heater **Z19**

Lambda probe 1 after catalytic converter **GX7**
Lambda probe 1 heater after catalytic converter **Z29**

Camshaft control valve 1 **N205**

Exhaust camshaft control valve 1 **N318**

Charge pressure positioner **V465**

Valve for oil pressure control **N428**

Charge air cooling pump **V188**

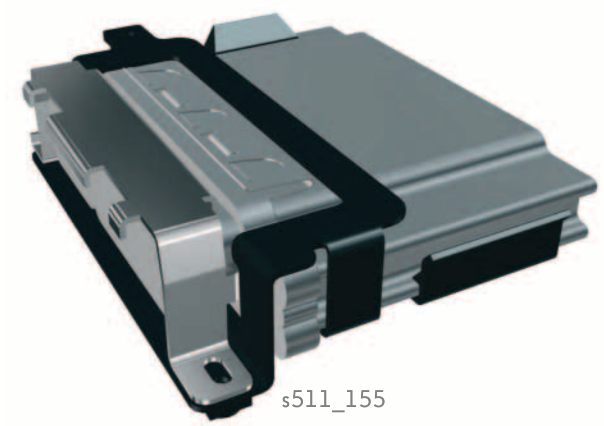
Radiator fan **VX57**
Radiator fan control unit **J293**
Radiator fan **V7**

Additional output signals

Components with an X in the short designation contain several sensors, actuators or switches in one housing, such as the intake manifold sender GX9 with the intake manifold pressure sender G71 and the intake manifold temperature sender 2 G299.

Engine control unit J623

Depending on the engine version, different engine control units with different control unit functions are used.
The engine management system in the 1.0 l engine in the up! is also responsible for activation of the air conditioning system while in the 1.4 l TSI engines, for example, it is responsible for the two-stage oil pressure regulation or, if installed, the Active Cylinder Management (ACT).
The fitting location depends on the vehicle model.



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Overview of the engine management system versions in the EA211 engine family

Engine version	Engine management system	Connector
1.0 l MPI engine	Bosch Motronic ME 17.5.20	2 x 56 pins
1.2 l / 1.4 l TSI engines	Bosch Motronic MED 17.5.21	1 x 60 pins and 1 x 94 pins

Engine management system diagnosis
The engine control unit also performs the sensor and actuator diagnosis. Exhaust gas-related faults are indicated by the exhaust emissions warning lamp K83 and functional errors in the system are indicated by the electronic power control fault lamp K132.

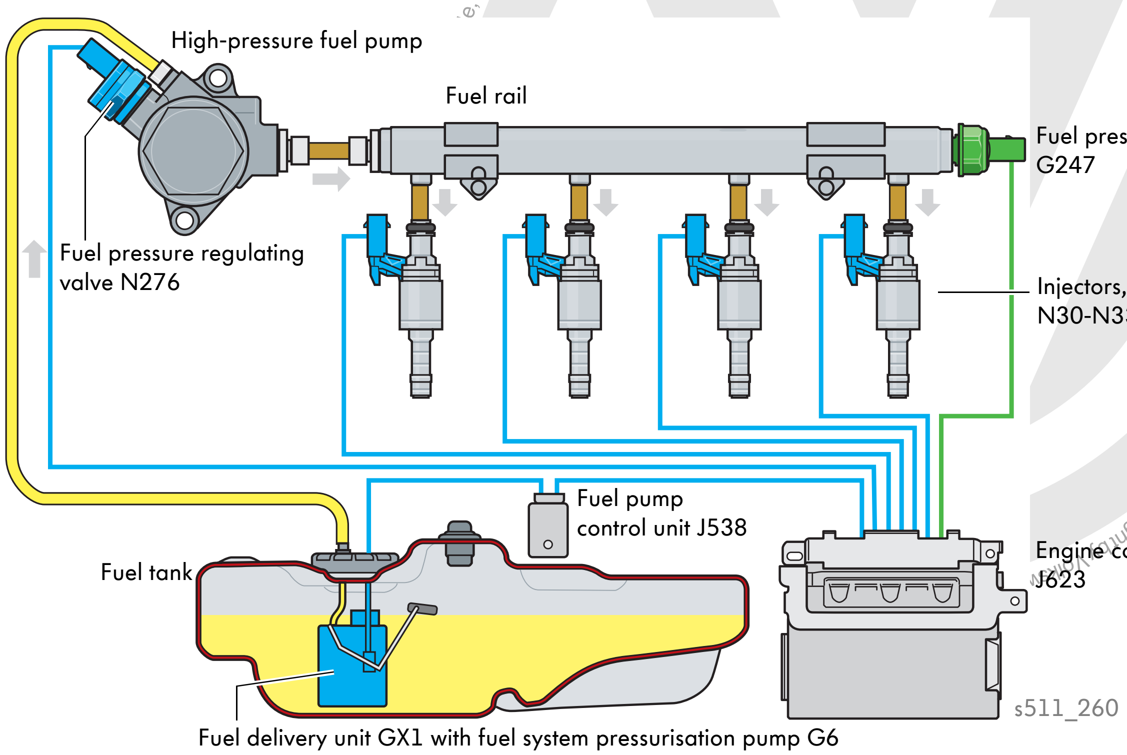
Examples of exhaust gas relevant and functional sensors and actuators respectively are the engine speed sender G28, the Hall senders G40 and G300, the charge pressure sender G31 with the intake air temperature sender G42, the intake manifold pressure sender G71 with the intake air temperature sender 2 G299 or the fuel pressure regulating valve N276.

In contrast, the electronic power control fault lamp K132 is switched on in the oil pressure switch F1 and the oil pressure warning lamp K3 is switched on in the oil pressure switch for reduced oil pressure F378.

If a fault is detected, an entry is made in the event memory.

Fuel system

The demand-based fuel system consists of the low-pressure and the high-pressure fuel system.
It has the advantage that both the electrical fuel pump and the high-pressure fuel pump only deliver the amount of fuel required by the engine at that moment. This reduces electrical and mechanical drive power of the fuel pumps and fuel is saved.



High-pressure system
Fuel system/low pressure system
Actuator/output signal
Sensor/input signal

Low-pressure fuel system
In the low-pressure fuel system, the pressure is between approx. 2 and 6 bar, depending on the engine map.

When making a cold start, higher pressure is used to start to build up fuel pressure as quickly as possible. When making a hot start, higher pressure is used to prevent steam bubbles from forming in the high-pressure fuel pump. The temperature in the high-pressure fuel pump as calculated by the engine control unit is the deciding factor.

High-pressure fuel system
In the high-pressure fuel system, the pressure in the 1.2 l TSI engines is between 120 and 200 bar, and in the 1.4 l TSI engines between 140 and 200 bar, depending on the load and engine speed. This high pressure results in improved vaporisation of the injected fuel and therefore an improved mixture formation with fewer exhaust emissions and less soot formation.
Furthermore, the spray pattern of the injectors has been optimised to ensure the fuel jet does not hit any components in the combustion chamber.

Injection strategies

Different injection strategies are used in all TSI engines. Depending on the coolant temperature, engine speed and engine load of the respective engine, different injection quantities are injected up to three times at different points in time.

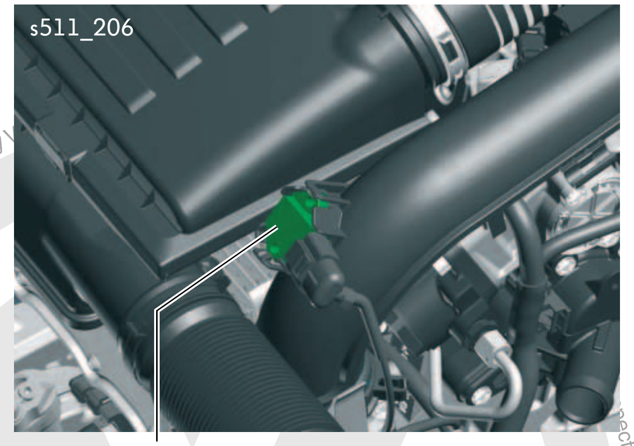
The injection strategies of the EA211 engine family can be found in the table.

Operating status	Number of injections	Measure
Multiple injection high-pressure engine start **Coolant temperature <18°C** **Coolant temperature >18°C**	 3 2	When the engine is started, there are 2 or 3 injections respectively per combustion cycle, depending on the coolant temperature. By dividing the fuel quantity for injection up over several injections, the injection time per injection is reduced and therefore the depth to which the fuel jet penetrates the combustion chamber. Less fuel hits the components in the combustion chamber, the mixture formation is improved and the engine reaches its idling speed faster.
Multiple injection catalytic converter heating	Engine map-dependent 2 to 3	The catalytic converter is heated quickly during catalyst heating with multiple injection. The multiple injection makes a stable engine run at late firing angles possible. Thanks to retarded combustion, higher exhaust gas temperatures and mass flows act on the catalytic converter. It is heated faster. All of these elements contribute towards reducing exhaust gas emissions and consumption. At the first injection, the majority of the total fuel quantity is injected during the intake cycle. This effectuates uniform processing of the fuel-air mixture.
Single/ multiple injection part load/full load up to 3000 rpm	Engine map-dependent 1 to 3	The single injection takes place in the lowest load range. Multiple injection from idle speed to full load at up to 3000 rpm ensures a more even mixture preparation. Initial injection takes place before ignition TDC during the intake cycle. Depending on the engine map, 50 - 80% of the total fuel to be injected is injected in this case. The remaining fuel quantity is injected during the second and possibly a third injection, . Less fuel is deposited on the cylinder wall as a result. The fuel evaporates almost completely and mixture formation is improved. In addition, the mixture which is produced in the area of the spark plug is slightly richer than that in the rest of the combustion chamber. This improves the combustion process and reduces knocking.

Sensors

Charge pressure sender G31 and intake air temperature sender G42

The charge pressure sender with intake air temperature sender is screwed into the pressure pipe just in front of the throttle valve module. It measures the pressure and temperature in this area.



Charge pressure sender G31 and intake air temperature sender G42

Signal use
The engine control unit regulates the turbocharger charge pressure using the signal from the charge pressure sender. It is regulated via the electrical charge pressure positioner.

The signal from the intake air temperature sender is required:

- to protect components. If the temperature of the charge air rises above a certain value, the charge pressure is reduced.

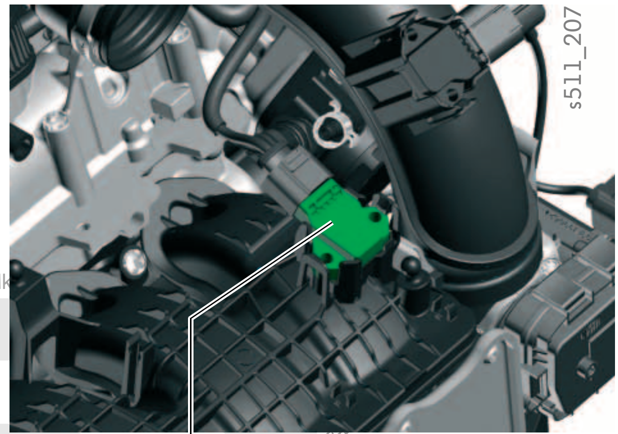
The signals from both intake air temperature senders G42 and G299 are required:

- to activate the charge air cooling pump. If the temperature difference of the charge air before and after the charge air cooler is less than 12 °C, the charge air cooling pump is activated. If it increases to more than 15 °C, the pump is deactivated again.
- for a plausibility test of the charge air cooling system. If, under certain conditions, the temperature difference between the charge air before and after the charge air cooler is too low despite activation of the charge air cooling pump, then it is assumed there is a fault in the charge air cooling system.

Effects upon signal failure
If one or both senders fail, the turbocharger operation is just regulated.
The charge pressure is lower and the power is reduced.

Intake manifold pressure sender G71 and intake air temperature sender 2 G299

The intake manifold pressure sender with intake air temperature sender is screwed into the intake manifold behind the charge air cooler.
It measures the pressure and temperature in this area.



Intake manifold pressure sender G71 and intake air temperature sender 2 G299

Signal use

The engine control unit uses the signals from both senders and the engine speed to calculate the air mass taken in.

The signal from the intake air temperature sender is required:

- to calculate a correction value for the charge pressure. The effect of the temperature on the density of the charge air is taken into consideration.

The signals from both intake air temperature senders G42 and G299 are required:

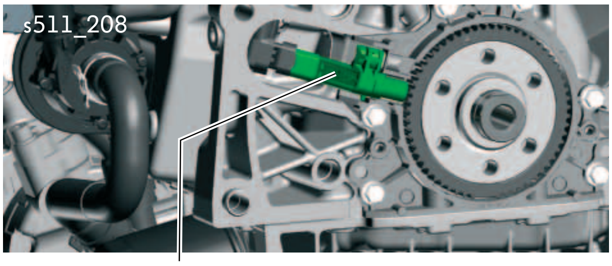
- to activate the charge air cooling pump. If the temperature difference of the charge air before and after the charge air cooler is less than 12 °C, the charge air cooling pump is activated. If it increases to more than 15 °C, the pump is deactivated again.
- for a plausibility test of the charge air cooling system. If, under certain conditions, the temperature difference between the charge air before and after the charge air cooler is too low despite activation of the charge air cooling pump, then it is assumed there is a fault in the charge air cooling system.

Effects upon signal failure

If one or both signals fail, the throttle valve position and the temperature from the intake air temperature sender G42 is used as a replacement signal.
The turbocharger is only operated with regulation.
The charge pressure is lower and the power is reduced.

Engine speed sender G28

The engine speed sender is integrated into the sealing flange on the gearbox side, with the flange being, in turn, bolted to the cylinder block. It scans a 60-2 sender wheel on the crankshaft. The engine control unit can identify the engine speed using these signals.



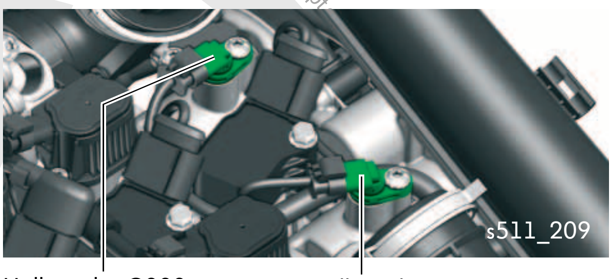
Engine speed sender G28

Signal use
The calculated injection time, the injection duration and the ignition timing are determined using the signals. It is also used together with the Hall senders to identify the position of the crankshaft to the camshaft and for the camshaft adjustment.

Effects upon signal failure
If the signal fails, the signal from the Hall sender G40 will be used as a replacement signal.
The next engine start will take longer, the engine speed will be limited to 3000 rpm and the torque will be reduced.

Hall sender G40 and Hall sender G300
(1.4 l 103 kW TSI engine)

The Hall sender is on the flywheel side on the camshaft housing above the inlet and exhaust camshaft. They scan a sender wheel with a special cam contour.
The signals are used to identify the positions of the two camshafts and the position of the individual cylinders in their work cycles.



Hall sender G300 Hall sender G40

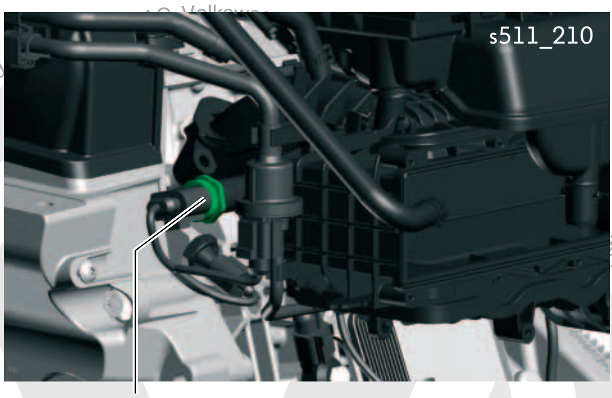
Signal use
Their signals and those from the engine speed sender allow the ignition TDC of the first cylinder and the position of the camshafts to be identified. They are used to determine the injection time, the ignition time and for adjusting the camshaft.

Effects upon signal failure
If one of the two senders fails, the signal from the other sender respectively will be used as a replacement signal.
If both senders fail, the next engine start will take considerably longer. In both cases, the engine speed will be limited to 3000 rpm and the camshaft adjustment will be deactivated.

The engine speed sender and the Hall sender examine the position of the crankshaft to the respective camshaft. If the values are outside the tolerance, for example due to unacceptable elongation of the toothed belt, or toothed belt slip, then an entry will be made in the event memory. If applicable, the camshaft adjustment will be deactivated to prevent any engine damage between the valves and pistons.

Fuel pressure sender G247

The sender is installed on the intake manifold (bottom section) on the same side as the toothed belt, and is screwed into the fuel rail. It measures the fuel pressure in the high-pressure fuel system and transmits the signal to the engine control unit.



Fuel pressure sender G247

Signal use

The engine control unit evaluates the signals and regulates the pressure in the fuel rail using the fuel pressure regulating valve. If the fuel pressure sender also identifies that the target pressure can no longer be adjusted, then it is limited to 125 bar and the low-pressure fuel pump is fully activated.

Effects upon signal failure

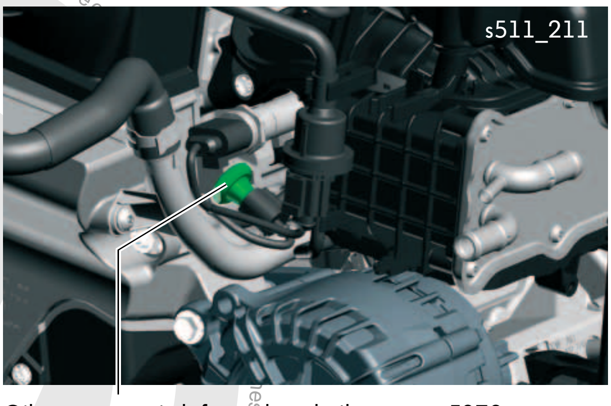
If the fuel pressure sender fails, the fuel pressure regulating valve is kept open so that no high pressure can be built up. At the same time, the electric fuel pump is fully activated, providing adequate fuel pressure for emergency operation of the engine. The engine torque and the power are reduced drastically.

Oil pressure switch for reduced oil pressure F378

It is screwed into the cylinder head next to the intake manifold on the same side as the toothed belt. It is used to check whether the minimum oil pressure is being applied.

Signal use

When there is no pressure, the oil pressure switch is open. If the pressure rises above a certain value, the switch closes. The engine control unit can identify that the oil pressure in the oil system is sufficient by its closed state. If the oil pressure falls below the required oil pressure, the oil pressure warning lamp K3 in the dash panel insert is switched on.



Oil pressure switch for reduced oil pressure F378

Effects upon signal failure

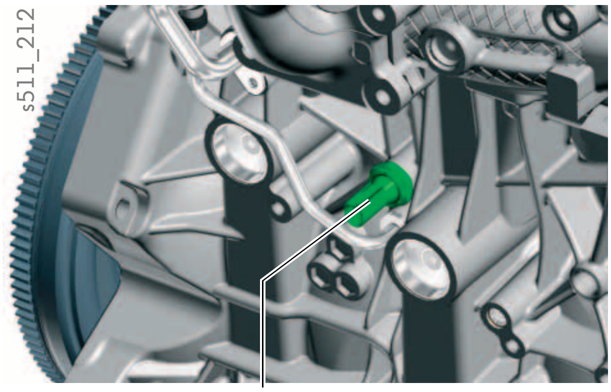
If the oil pressure switch fails, an entry is made in the event memory and the oil pressure warning lamp K3 is switched on.

Oil pressure switch F1

It is bolted into the middle of the cylinder block on the exhaust side. It is used to examine whether high oil pressure is being applied.

Signal use

Once a certain load and engine speed are reached, a switchover to the high oil pressure stage occurs. If high oil pressure is reached, the switch closes and the engine control unit identifies that high oil pressure is being applied. If it falls below a threshold for a certain period of time, the electronic power control fault lamp K132 is switched on.



Oil pressure switch F1

Effects upon signal failure

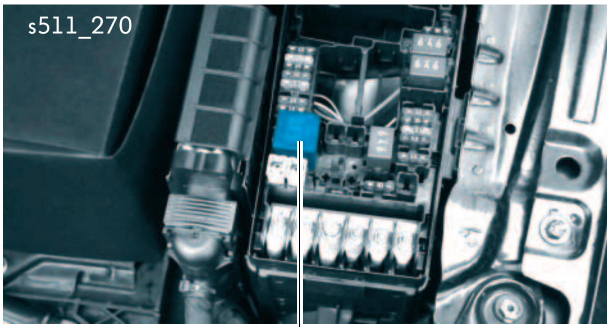
If the oil pressure switch fails, the engine speed is limited to 4000 rpm and the electronic power control fault lamp K132 is switched on.

If one of the two oil pressure switches is identified as being activated 60 seconds after the “engine is off”, the oil pressure warning lamp K3 will be activated for 15 seconds the next time the engine is started.

Actuators

Main relay J271

The main relay is installed on the left of the engine compartment in the electronics box.



Main relay J271

Task

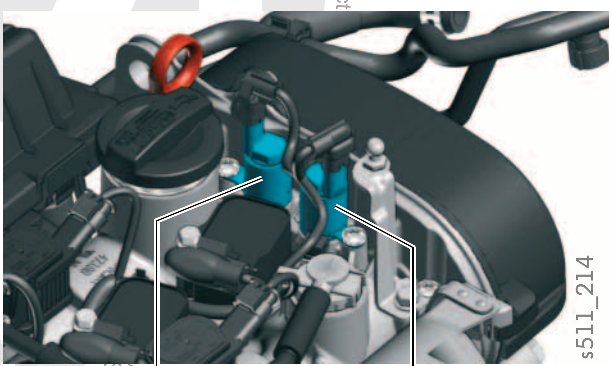
Using the current supply relay, the engine control unit can still perform certain functions and work in run-on mode even after the engine has been turned off (ignition OFF).
In this operating mode, the pressure senders, among other things, are compared and the radiator fan can be activated.

Effects upon failure

If the relay fails, the corresponding sensors and actuators are no longer triggered.
The engine is turned off and can no longer be started.

Camshaft control valve 1 N205, Exhaust camshaft control valve 1 N118

These valves are installed in the camshaft housing and are integrated into the engine oil circuit.



Camshaft control valve 1 N205

Exhaust camshaft control valve 1 N188

Task

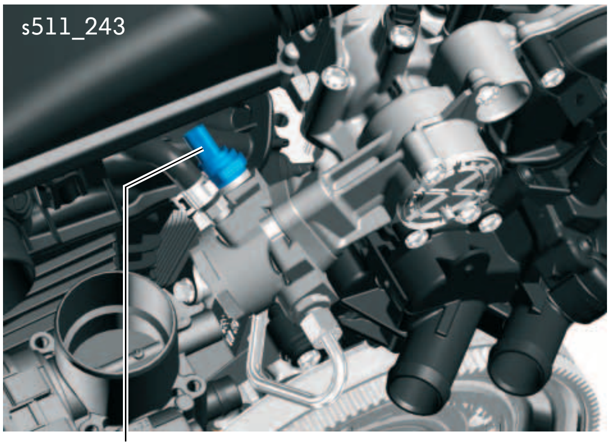
Activating the camshaft control valves distributes the oil in the vane-type adjuster. Depending on which oil channel is opened, the inner rotor is adjusted in the "early" or "late" direction or is kept in its position.
As the inner rotor is bolted to the inlet camshaft, it is also adjusted in the same way.

Effects upon failure

If one of the camshaft control valves fails, camshaft adjustment will no longer be possible.
The inlet camshaft remains in the "late" position and the exhaust camshaft in the "early" position.
A loss in torque results.

Fuel pressure regulating valve N276

The fuel pressure regulating valve is located on the side of the high-pressure fuel pump.



Fuel pressure regulating valve N276

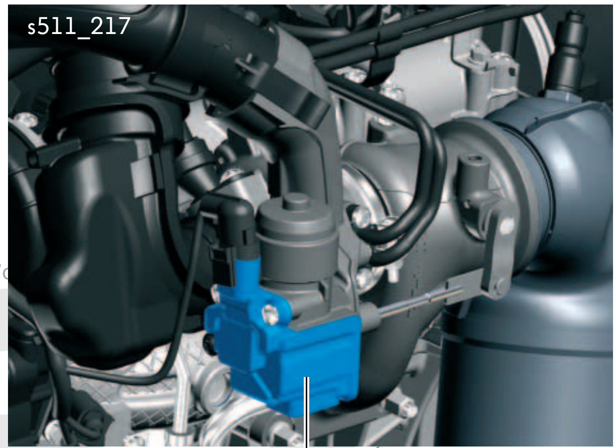
Task
It has the task of supplying the required quantity of fuel in the fuel rail.

Effects upon failure
The fuel pressure regulating valve is closed and without current. This means that the fuel pressure rises when the regulating valve fails until the pressure limiting valve in the high-pressure fuel pump opens at approx. 235 bar.
The engine management system adjusts the injection times to the high pressure and the engine speed is limited to 3000 rpm.

The fuel pressure needs to be reduced before the high-pressure fuel system is opened.
For this reason, the “reduce high fuel pressure” function is included in the “guided functions”.
It is used to open the regulating valve and reduce the pressure while the engine is running.
Please note that the fuel pressure rises again when the system heats up.
Please note the instructions in ELSA.

Charge pressure positioner V465

The charge pressure positioner is part of the exhaust gas turbocharger module.



Charge pressure positioner V465

Task

It controls the charge pressure.

The advantages of the electric charge pressure positioner in comparison with the pneumatic charge pressure control solenoid valve are:

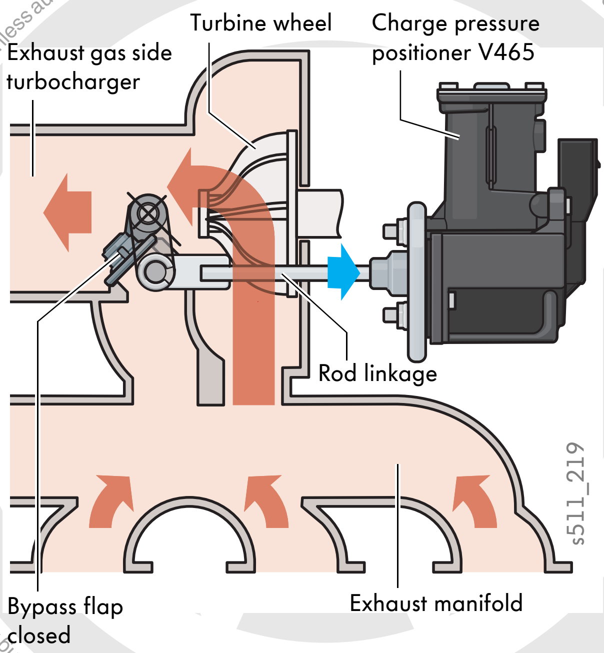
- A fast adjustment time and therefore faster charge pressure build-up.
- A high actuation force, as a result of which the wastegate remains firmly closed, even in the event of high exhaust gas mass flows, in order to achieve the specified charge pressure.
- The wastegate can be actuated independently of the charge pressure. This opens the wastegate in the lower engine load/speed range. The basic charge pressure drops and the engine has less charge cycle work to do.

Effects upon failure

In the event of an electrical failure, the wastegate is pushed open by the exhaust gas mass flow. In the event of a mechanical failure, the wastegate is opened by the electric charge pressure positioner or the throttle valve is closed accordingly. Charge pressure is not built up in either case.

How it works:
The engine control unit calculates the required target charge pressure depending on torque requirements in order to deliver the necessary air mass to the cylinders. The wastegate remains closed until this target charge pressure has been attained. The entire exhaust gas flow is therefore directed towards the turbine wheel and drives it.

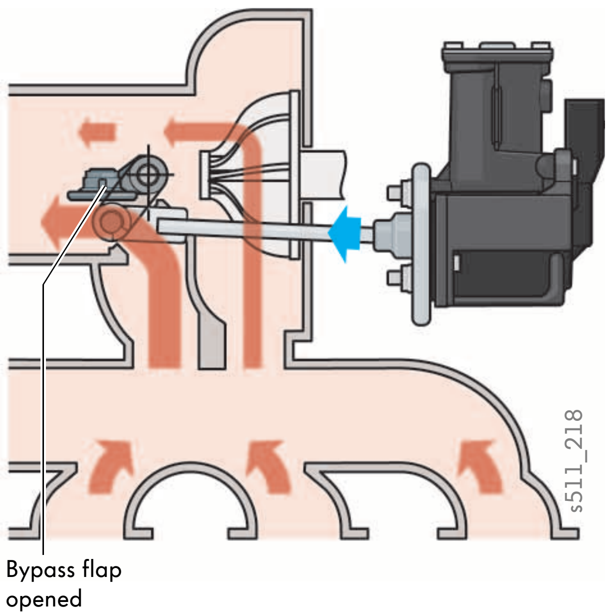
The turbine wheel is connected to the compressor wheel on the fresh air side via a common shaft. This compresses the intake air until the target charge pressure is achieved.



Once the target charge pressure has been reached, the wastegate is regulated to the position required for the target/actual charge pressure.

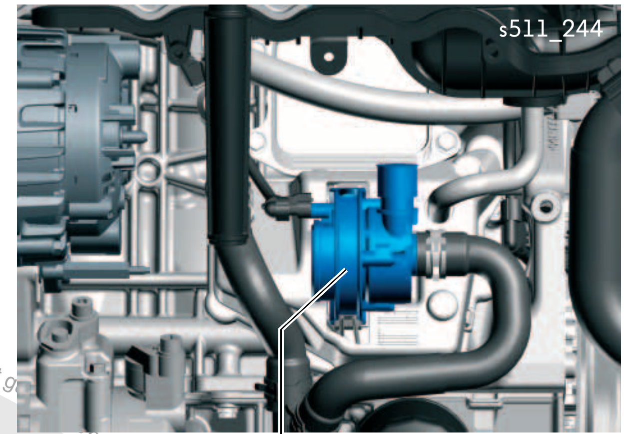
If the wastegate is opened further, for example, part of the exhaust gas flow flows past the turbine wheel. This reduces the rotational speed of the turbine and the compressor wheel. The intake air is no longer compressed as much, and the charge pressure is reduced.

The engine control unit calculates the necessary wastegate adjustment travel via the rod linkage using the actual and the target charge pressure. The charge pressure sender G31 measures the actual charge pressure.



Charge air cooling pump V188

The electronically control charge air cooling pump is bolted to the housing cover of the oil separator below the intake manifold. It is a component of a self-contained cooling system.



Charge air cooling pump V188

Task

The charge air cooling pump conveys coolant from the water radiator for charge air cooling circuit to the charge air cooler in the intake manifold and to the exhaust gas turbocharger. The pump is activated by a PWM signal by the engine control unit when required. It is always activated at maximum power.

It is activated under the following conditions:

- briefly after each time the engine is started
- constantly above a torque requirement of approx. 100 Nm
- constantly from a charge air temperature of 50 °C in the intake manifold
- at temperature differences of less than 12 °C in the charge air before and after the charge air cooler
- when the engine is running, every 120 seconds for 10 seconds to avoid heat accumulation, above all in the exhaust gas turbocharger and,
- depending on the engine map, for 0 - 480 seconds after the engine is turned off to avoid overheating with formation of steam bubbles in the exhaust gas turbocharger.

Effects upon failure

The different faults which can occur on the charge air cooling pump have the following effects:

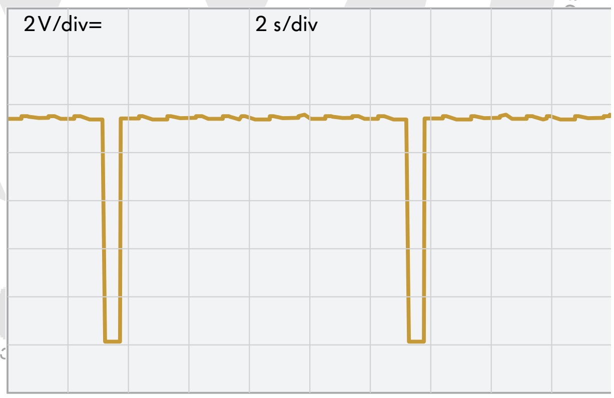
Cause of fault	Effect
Electrical fault or mechanical fault	- Entry in engine control unit event memory - Loss of power
Open circuit in signal line	- Entry in engine control unit event memory - Pump running at top speed
Open circuit in a pump voltage supply wire	- Entry in engine control unit event memory - The pump does not work - Loss of power

Please note that, for example, a highly soiled water radiator for charge air cooling circuit or an incorrectly filled cooling system can result in an entry in event memory, which will require an examination of the charge air cooling system.

Activating the charge air cooling pump

Control electronics are installed in the pump. They allow the electric motor to be activated, and they monitor the pump function. They transmit the actual state of the pump to the engine control unit by switching the PWM signal to earth at regular intervals.

Charge air cooling pump “OK”
During pump operation, the control electronics switch the PWM signal from the engine control unit to earth for 0.5 seconds in 10-second intervals. This tells the engine control unit that the pump is ready for operation.



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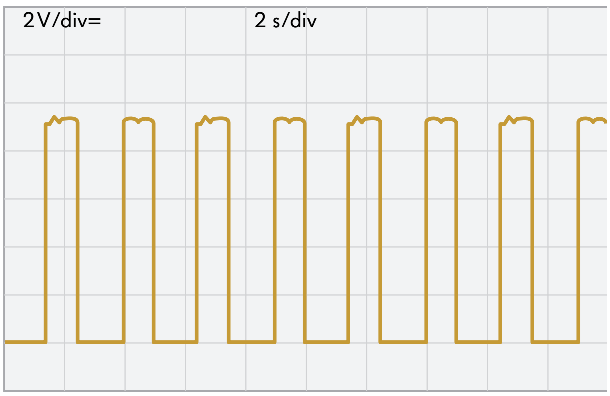
Charge air cooling pump “not OK”
If the self-diagnosis detects a fault, caused for example by a blocked pump or a dry-running pump, the control electronics change the duration of the earth switching of the PWM signal depending on the cause of the fault.



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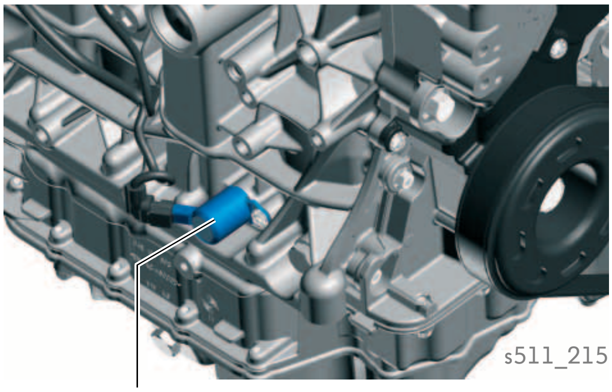
In the event of fault, attempts will be made at regular intervals to switch the charge air cooling pump back on. If this succeeds, the control electronics transmit the charge air cooling pump “OK” signal to the engine control unit again.

Valve for oil pressure control N428

The valve is screwed into the cylinder block on the exhaust side, near the toothed belt and sump (top section).

Task

The valve for oil pressure control N428 is a hydraulic 3/2-way valve. The electric activation by the engine control unit switches the value between the two oil pressure stages depending on the load and engine speed. When there is no current, it is closed, and the oil pump pumps at the high oil pressure stage. If it is activate, an oil port to the control piston opens and moves it within the oil pump. This switches it to the lower pressure stage.



Valve for oil pressure control N428

Effects upon failure

If the valve fails, it is closed.
The oil pump pumps at the high oil pressure stage.

Special tools

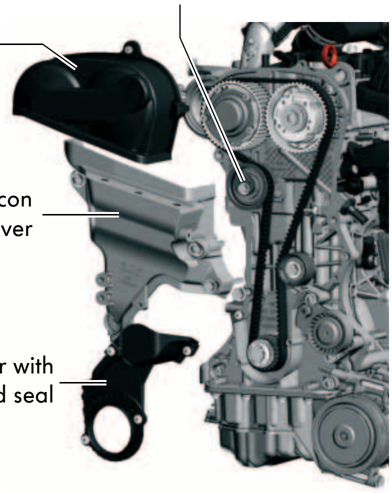
Description	Tool	Usage
T10487 Assembly tool	 s511_264	The toothed belt between the camshafts is pressed downwards using this assembly tool, in order to allow the camshaft clamp T10494 to be inserted into the camshafts under tension.
T10494 Camshaft clamp	 s511_267	For fixing the camshaft when checking and adjusting the valve timing.
T10499 Special wrench	 s511_266	The wrench is used to loosen and tighten the eccentric toothed belt tensioner
T10500 Insert tool	 s511_265	The insert is used to loosen and tighten to bolt on the eccentric toothed belt tensioner if an engine support is installed.
VAS 6583 Electronic torque wrench	 s511_263	The electronic torque wrench is used to tighten the bolt on the eccentric toothed belt tensioner and, when installing the thermostat housing, to tension the toothed belt for the coolant pump drive to an exact torque.

Technical data

Toothed belt cover

The toothed belt is protected against the ingress of dust and dirt by a three-part toothed belt cover. This extends the service life of the toothed belt.

The tensioning roller for the toothed belt can be released without having to remove the engine support. The insert T10500 and the electronic torque wrench VAS 6583 will be required for this, among other tools. The insert acts like an extension for a standard torque wrench. The tightening torque would normally be far too high on the bolted connection. To prevent this, actual dimensions are specified on the insert, which is entered into the electronic torque wrench. This input allows the bolt to the tightened to the correct torque.



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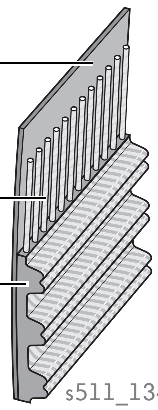
Toothed belt

The toothed belt must not, under any circumstances, be kinked when doing assembly work, when transporting or storing it. Otherwise the tension strands will be damaged, the toothed belt will tear and engine damage will result.



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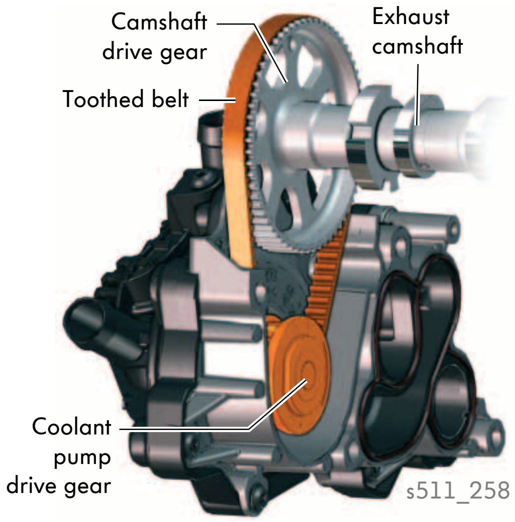
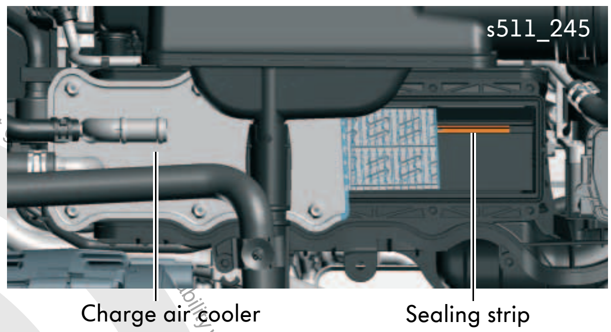
Toothed belt for the coolant pump

Before removing the drive wheel, and when tensioning the toothed belt, you must pay attention to the notes in ELSA. Only a correctly tensioned toothed belt will ensure the coolant pump functions long-term without fail.
To ensure the toothed belt for the coolant pump is correctly tensioned, it must be pretensioned to an exact torque via the thermostat housing using the electronic torque wrench VAS 6583.



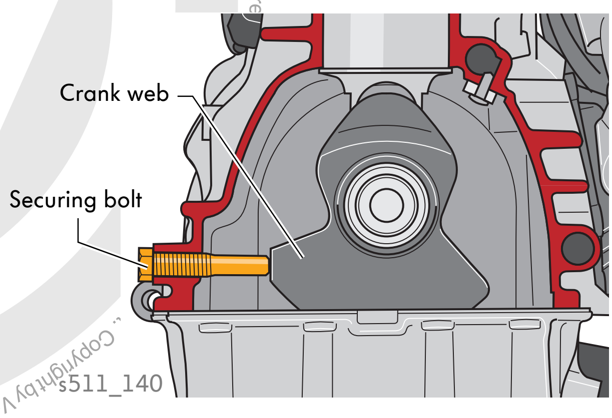
Charge air cooler sealing strip

When installing the charge air cooler, ensure that the sealing strip is correctly fitted. If it is not installed properly, vibrations will occur, the charge air cooler will crack and will no longer be airtight.



Crankshaft clamp

When adjusting the valve timing, the crank web is only touching the securing bolt.
The crankshaft is not fixed and can be rotated against the direction of engine rotation.



Test your knowledge

Which answers are correct?

One or several of the given answers may be correct.
All questions refer to the new EA211 petrol engine family.

1. Which technical features are the same on all EA211 engines?

❒ a) Camshaft driven via toothed belt

❒ b) 4-valve technology

❒ c) Exhaust manifold integrated into the cylinder head

2. What are the differences between the toothed belt drives?

❒ a) The 3-cylinder engines feature tri-oval camshaft gears.

❒ b) The toothed belt drives are identical in all EA211 engines.

❒ c) The 4-cylinder engines feature an oval CTC camshaft gear wheel.

3. Which statements about the oil pressure regulation are correct?

❒ a) The oil pressure regulation occurs in two oil pressure stages, of approx. 1.8 bar and 3.3 bar in the 1.4 l TSI engines.

❒ b) In the 1.0 l and 1.2 l engines, a pressure regulating valve in the oil pump housing regulates the oil pressure to approx. 3.5 bar.

❒ c) In all EA211 engines, the oil filter is installed on the sump.

4. Which statements about the cooling system are true?

❒ a) Engine cooling as a dual-circuit system with varying coolant temperatures in the cylinder head and cylinder block.

❒ b) The coolant pump is integrated into the thermostat housing.

❒ c) There are two coolant circuits, comprised of the engine cooling system and the charge air cooling system.

5. At which position in the TSI engines are the gases from the crankcase breather and the activated charcoal canister system added to fresh air?

❒ a) Directly into the intake manifold in all cases, as the highest vacuum is found there.

❒ b) The gases are generally directed to the intake side of the exhaust gas turbocharger.

❒ c) Depending on where the pressure is lower, either the intake manifold or the intake side of the exhaust gas turbocharger.

6. What advantages does the integrated exhaust manifold offer?

❒ a) The coolant is warmed up faster by the exhaust gas while the engine is warming up.

❒ b) Due to the smaller area of the exhaust gas-side wall surface extending to the catalytic converter, the exhaust gas does not emit as much heat during the warm-up phase, and the catalytic converter is more rapidly heated up to the operating temperature by the coolant, despite its cooling effect.

❒ c) When the system is operating at full capacity, the exhaust manifold and the exhaust gas are cooled even more, and the engine can be operated in a larger consumption-optimised and exhaust-optimised lambda=1 range when operating at full capacity.

7. In which range is the fuel high pressure found in the TSI engines for the Golf 2013?

❒ a) The fuel pressure totals 160 or 200 bar respectively depending on displacement.

❒ b) The fuel pressure in the 1.2 l TSI engines totals between 120 and 200 bar, and in the 1.4 l TSI engines between 140 and 200 bar.

❒ c) The fuel pressure is between 40 and 140 bar in all TSI engines.

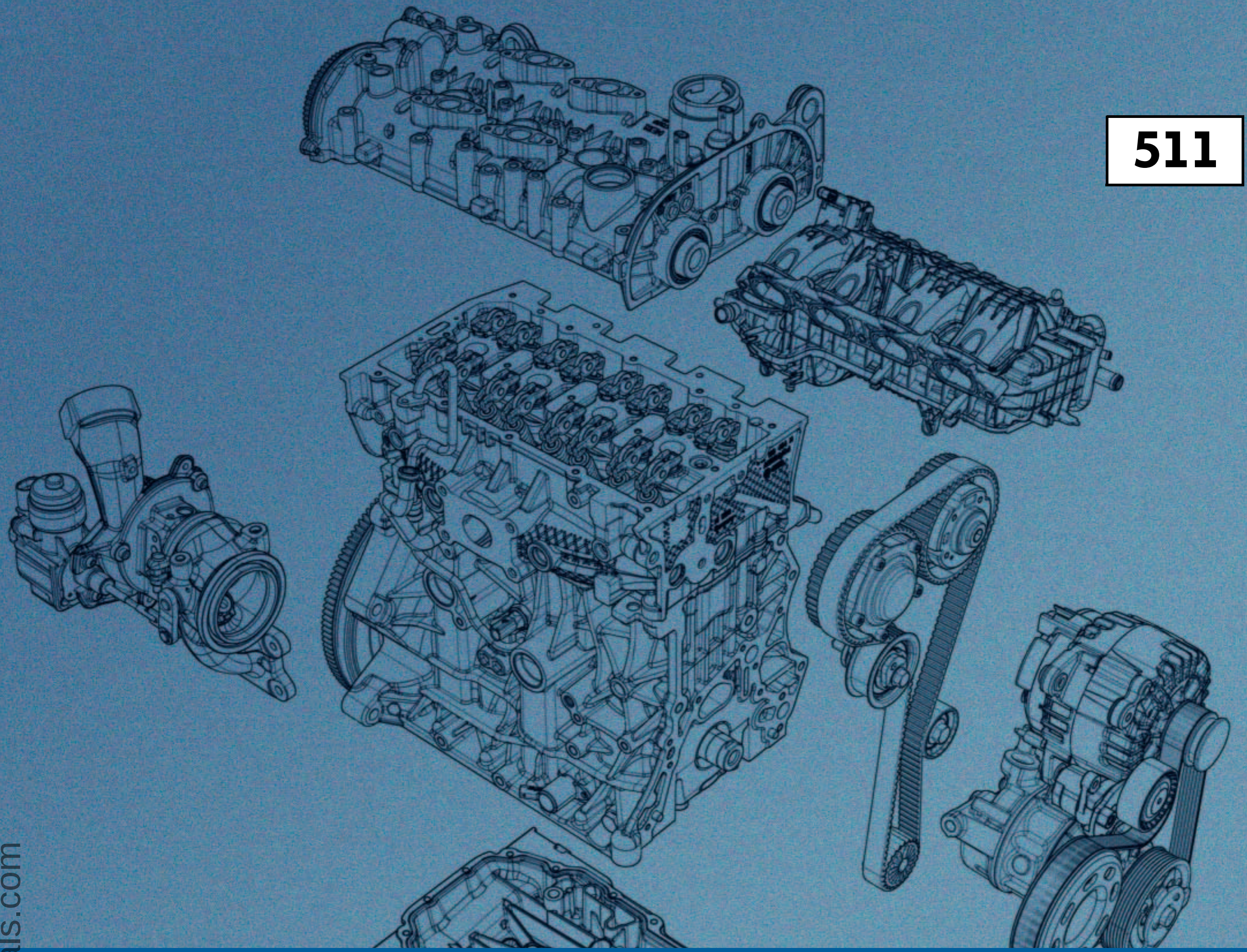
8. What needs to be observed when tightening the toothed belt tensioning roller when the engine support is installed?

❒ a) The electronic torque wrench VAS 6583 is required.

❒ b) The toothed belt tensioning roller is tightened using a standard torque wrench and an extension piece.

❒ c) Actual dimensions are specified on the insert T10500, which have to be entered in the electronic torque wrench.

Solution:
1. a), b), c); 2. a), c); 3. a), b), c); 4. a), b), c); 5. c); 6. a), b), c); 7. b); 8. a), c)



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