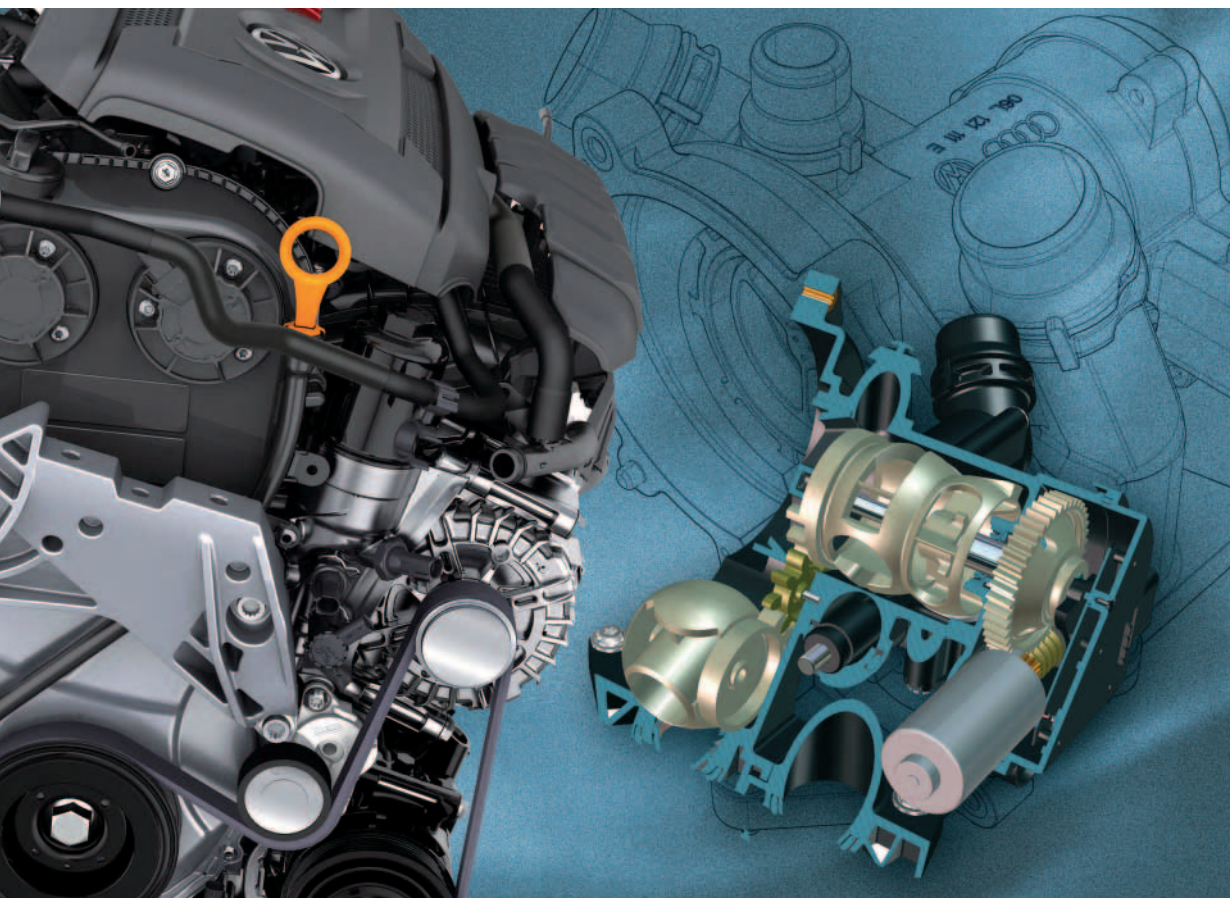


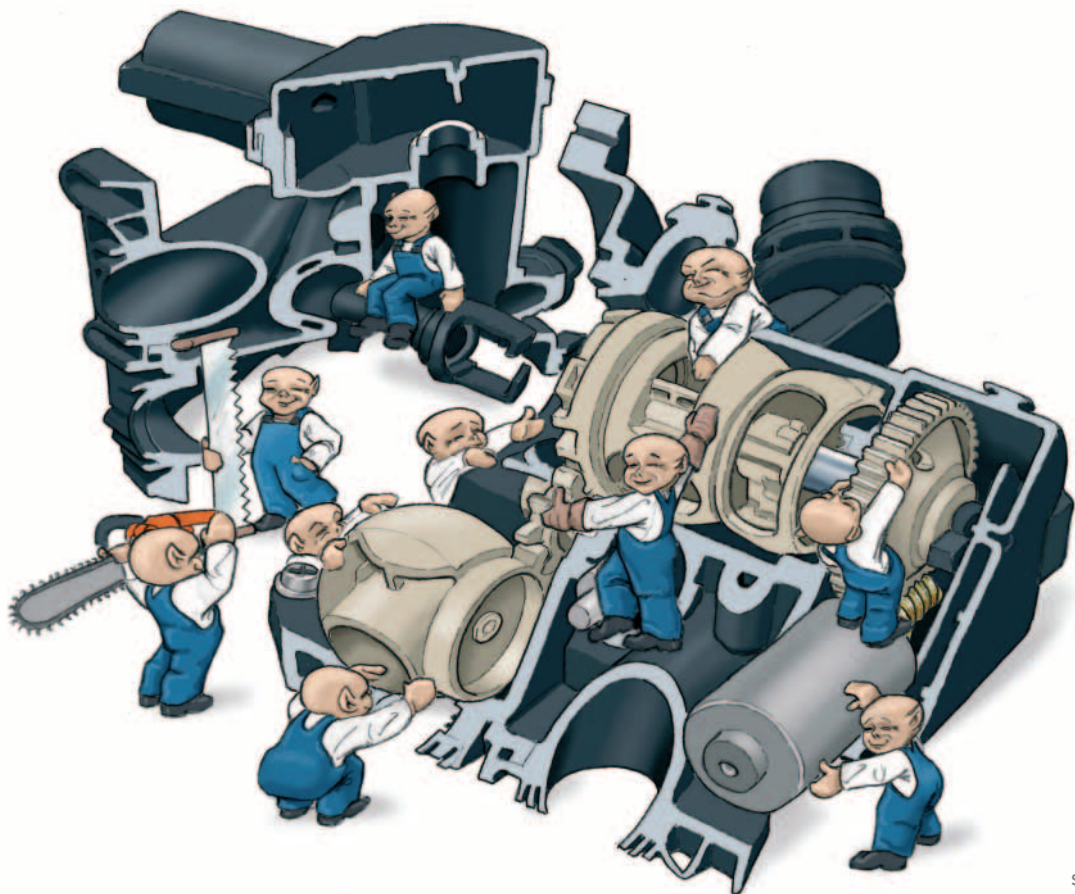


Self-study Programme 522

The 2.0 I 162 kW / 169 kW TSI engine
Design and Function



In this self-study programme we would like to introduce you to the 2.0 l 162kW / 169kW TSI engine of the EA888 engine family. It is the 3rd generation of this engine. The 2.0 l 162kW / 169kW TSI engine already complies with the future EU6 emission standard and is manufactured at the Győr factory in Hungary. This engine is designed for use in the MQB modular transverse matrix platform and can therefore be universally used within the Volkswagen Group.



s522_777



You will find further information on the 1.8 l and 2.0 l petrol engines in Self-study Programmes no. 337 „The 2.0 l FSI engine with turbocharger” and no. 401 „The 1.8 l / 118 kW TFSI engine with timing chain”.

The self-study programme describes the design and function of new developments. The contents will not be updated.

For current testing, adjustment and repair instructions, refer to the relevant service literature.



Important Note



Introduction	4
Overview of the technical features	4
Engine mechanics	6
Cylinder block	6
Crankshaft group	7
Chain drive	8
Cylinder head with valve-lift switching	11
Crankcase breather and ventilation system	19
Oil circuit	22
Overview of the oil supply	22
Two-stage external gear oil pump	23
Switchable piston cooling jets	25
Cooling system	29
Overview of the cooling system	29
Innovative Thermal Management	30
Air supply unit and forced induction	40
Overview of the charge air system	40
Turbocharger	41
Fuel system	44
Overview of the fuel system	44
Mixture formation	45
Engine management	48
Overview of the system	48
Service	50
Special tools	50
New component clusters	52
Test your knowledge	53



Introduction



During the further development of the well-known EA888 engine family, the two most important development objectives were, to meet the EU6 emission standard and to ensure the usability of the engines in the modular transverse matrix (MQB) platform. Further development objectives were:

- To lower the CO₂ emissions
- To reduce the engine weight
- To reduce the friction in the engine
- To optimise performance and torque in relationship to fuel consumption
- To reduce operational noise

Overview of the technical features



s522_123

Engine mechanics

The following features in the engine mechanics characterise the development of the 2.0 TSI engine family:

- Total weight savings of 7.8kg
- Cylinder head with integrated exhaust manifold
- Roller bearing balance shafts
- Smaller crankshaft main bearings with now only four counterweights
- Turbocharger with electrical wastegate flap actuation
- Reduced oil pressure level
- Separate sump top section in aluminium and sump bottom section in plastic
- Oil filter and oil cooler integrated in the ancillary unit carrier

Engine management

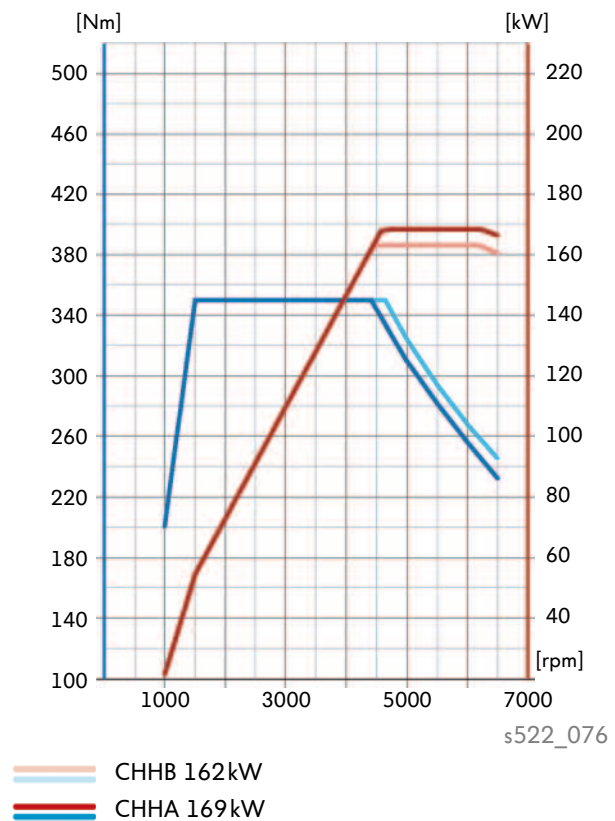
The engine management system of the 2.0 TSI engine family has the following features:

- Intake camshaft and exhaust camshaft adjustment
- Electronic valve-travel switching
- Dual injection system with TSI and SRE injectors (combined direct injection and intake manifold injection)
- Innovative thermal management with rotary valve regulation (actuator for engine temperature regulation N493)
- Selectable piston cooling jets
- Adaptive lambda control
- Map-controlled ignition with high-voltage distribution
- Intake manifold flaps
- Two-stage oil pressure regulation with external gear oil pump
- Fully electronic engine management SIMOS 18.1 with electric throttle
- Performance variants 162 kW and 169 kW is achieved via engine management

Technical data

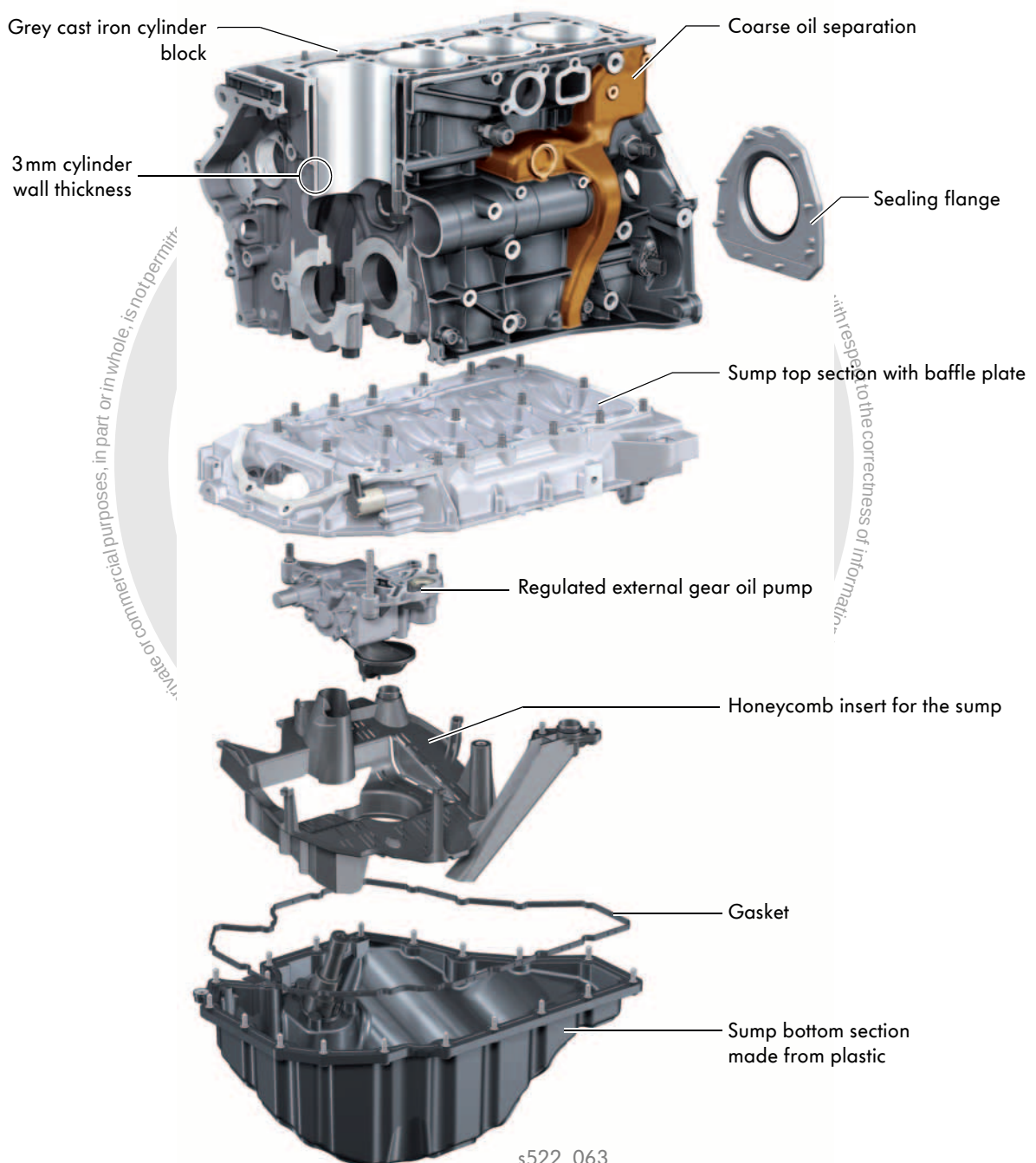
Engine code	CHHB	CHHA
Design	4-cylinder inline engine	
Displacement	1984 cm ³	
Bore	82.5 mm	
Stroke	92.8 mm	
Valves per cylinder	4	
Compression ratio	9.6:1	
Max. output	162 kW at 4,500 - 6,200 rpm	169 kW at 4,700 - 6,200 rpm
Max. torque	350 Nm at 1,500 - 4,400 rpm	350 Nm at 1,500 - 4,600 rpm
Engine management	SIMOS 18.1	
Fuel	Super unleaded with RON 98	
Exhaust gas aftertreatment	Three-way catalytic converter, one upstream broadband lambda probe of the turbo-charger and one step-type lambda probe downstream of the catalytic converter	
Emission standard	EU6	

Torque and performance diagram



Cylinder block

A systematic reworking of the cylinder block design has resulted in a 2.4kg weight saving in the cylinder block alone compared to the previous model. The cylinder wall thickness has been reduced from approx. 3.5mm to approx. 3mm. The housing for the coarse oil separator of the crankcase breather is fully integrated into the cylinder block.



Crankshaft group

The measures described below improved the inner friction and reduced the weight of the crankshaft group.

The crankshaft

The main bearing diameters were reduced from 52mm to 48mm. The number of counterweights were reduced from eight to four counterweights. The upper and lower main bearing shells are constructed in two layers and without lead additive. The crankshaft is 1.6kg lighter in weight.

Conrod

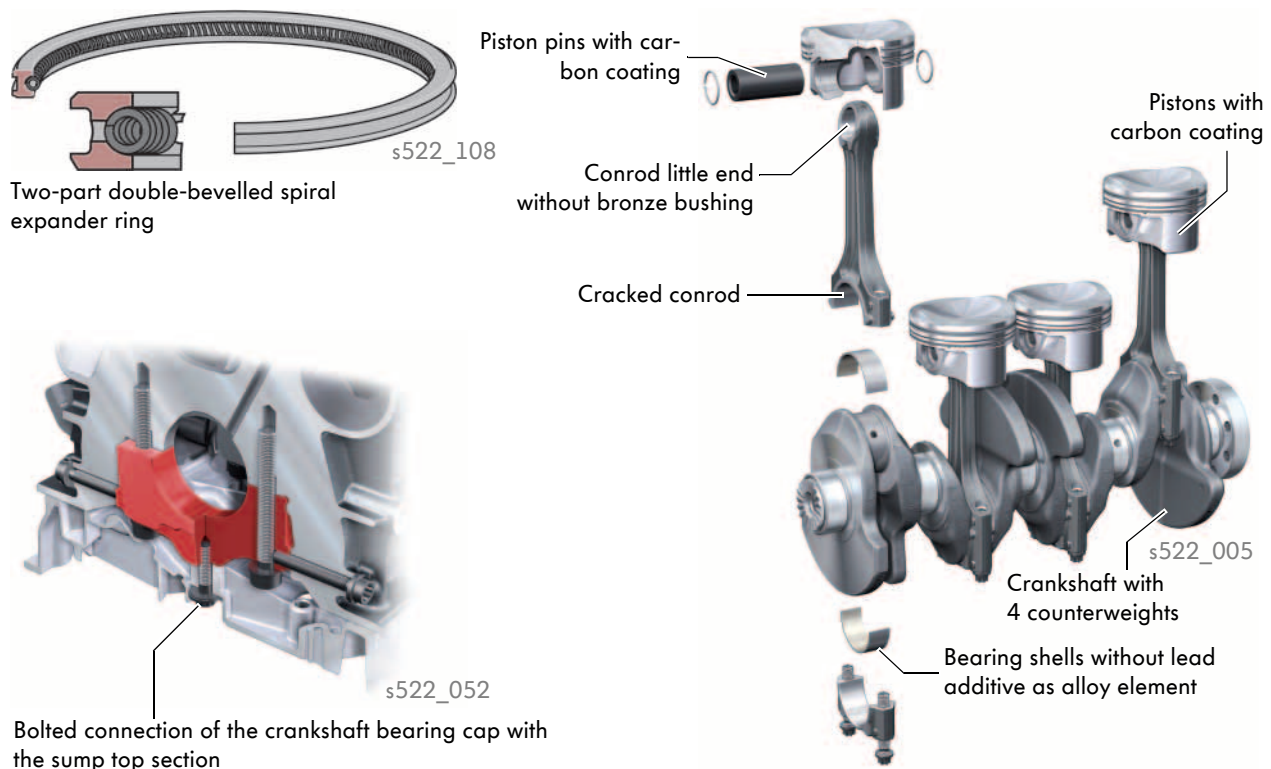
The conrods are manufactured as cracked conrods. Two-layer crankshaft bearing shells without lead additive are used in the lower conrod cap as in the main bearings. There are no bronze bushes in the conrod's little end. However, the piston pins have been given a special surface coating in carbon.

Pistons

The piston clearance has been increased to reduce the friction during the engine warm-up phase. A carbon coating is also used for minimising wear. The upper piston ring is designed as a rectangular ring, the middle piston ring is a taper-faced Napier ring, and the third piston ring is a two-part double-bevelled spiral expander ring for skimming off oil.

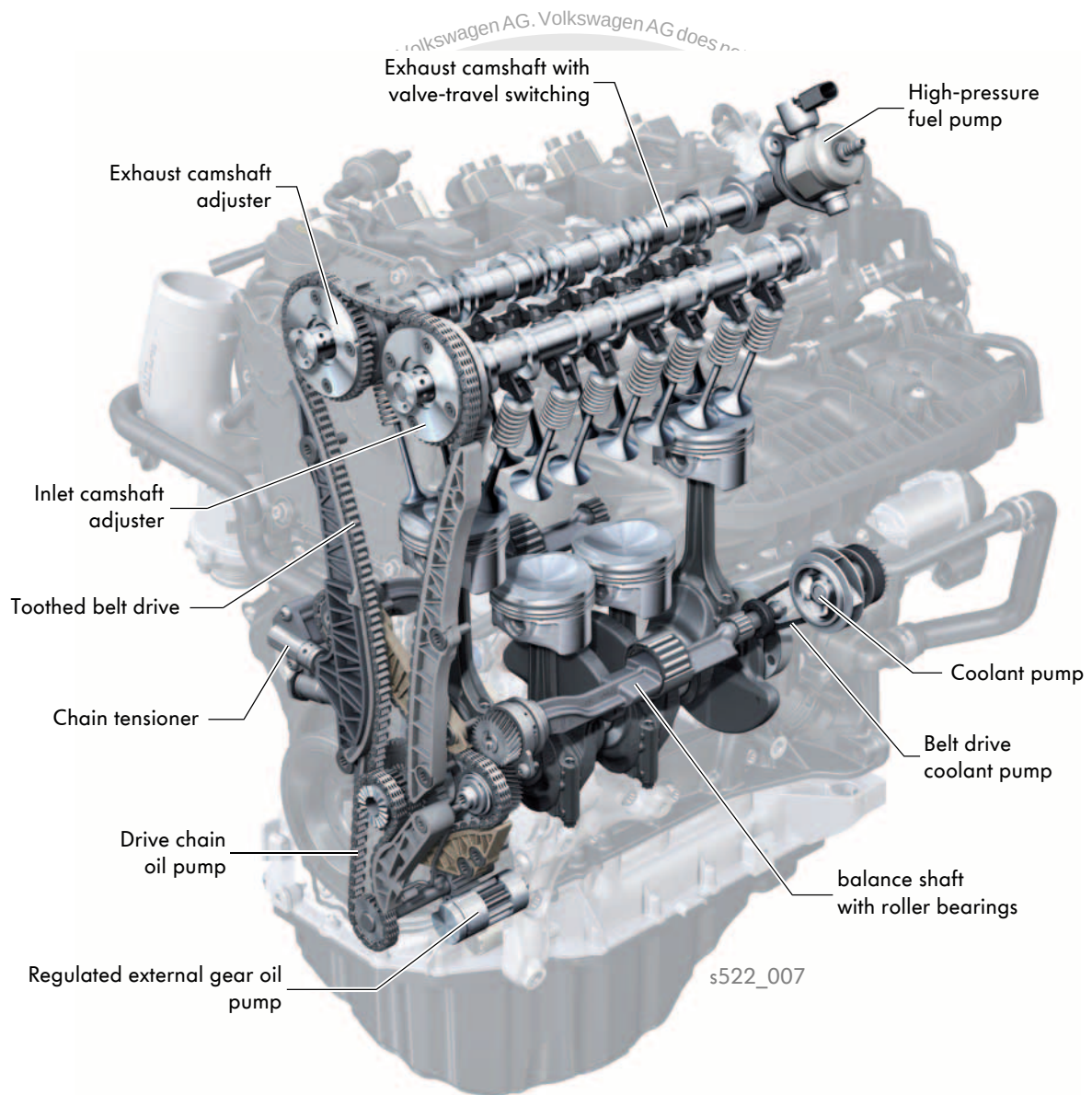
Bearing bracket

The crankshaft bearing caps are bolted to the sump top section. This improves the running properties of the engine concerning engine acoustics and vibration characteristics.



Chain drive

The basic design of the chain drive has been taken from the previous model and developed further. Due to the lower oil consumption of the engine, the drive power for the chain drive could be reduced. The chain tensioners have been modified to the reduced oil pressure accordingly.





A new feature in the engine is a testing programme for diagnosing chain elongation.

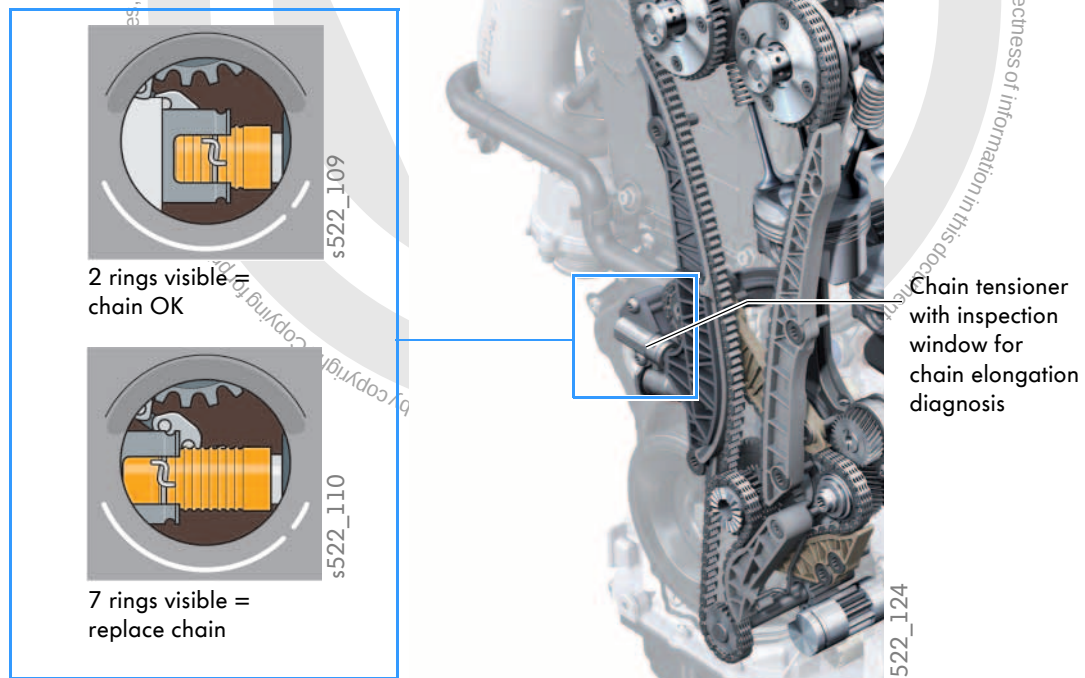
The chain elongation diagnosis detects an elongated timing chain in the engine. Chain elongation is detected by the camshaft sensors and the crankshaft sensor by means of the relative position of the camshafts compared to the crankshaft.

Following an entry in the event memory, chain elongation is checked by means of a visual inspection of the chain tensioner.

If the positions repeatedly exceed a camshaft-specific threshold, an entry is generated in the event memory.

For the diagnosis to function properly after a repair, it must be updated after the following work on the engine:

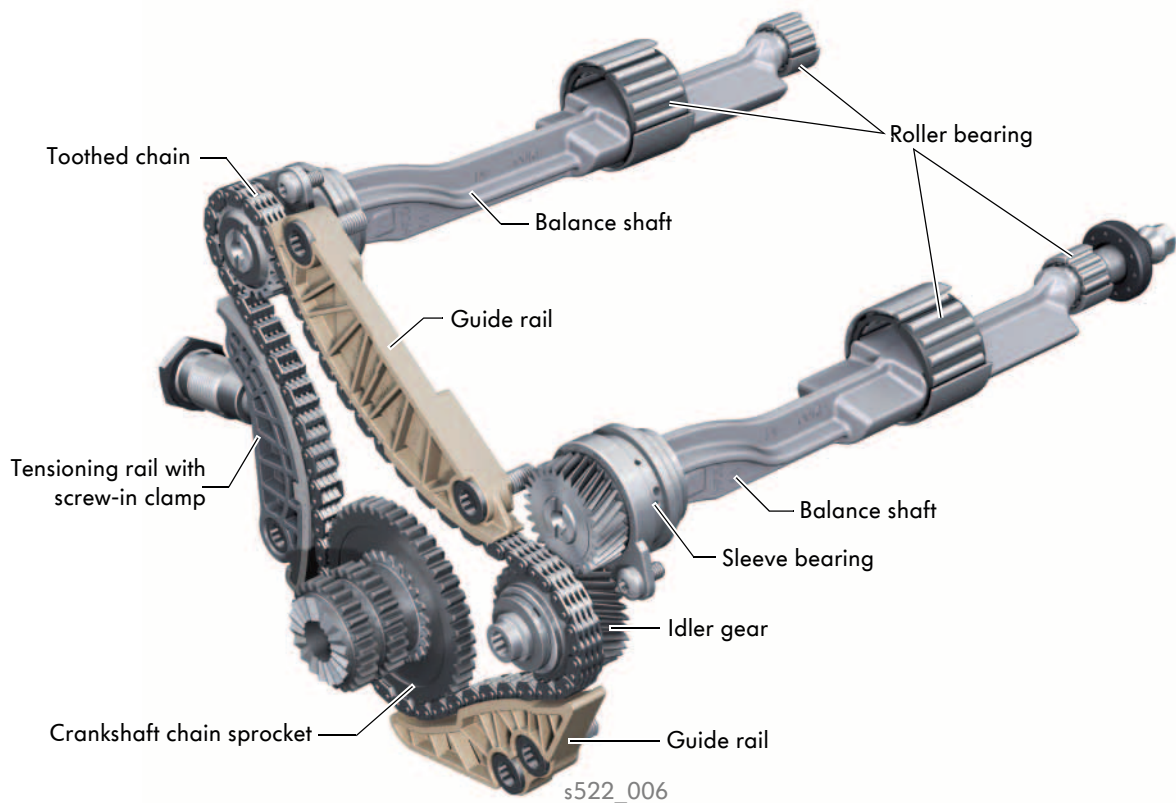
- Exchanging the engine control unit
- Exchanging engine components connected to the chain drive
- Exchanging the timing chain or the complete engine



Note that the work steps when mounting the chain are different than on the previous model. The chain length must be adjusted with the diagnostic tester after working on the chain drive. Follow the detailed instructions and information in ELSA when working on the chain drive.

Balance shafts

The weight was also able to be reduced on the balance shafts compared to the previous model. The balance shaft mounting is partially done via roller bearings. This feature reduces the friction of the balance shafts, particularly in the low operating temperature range and thus low oil temperature range.

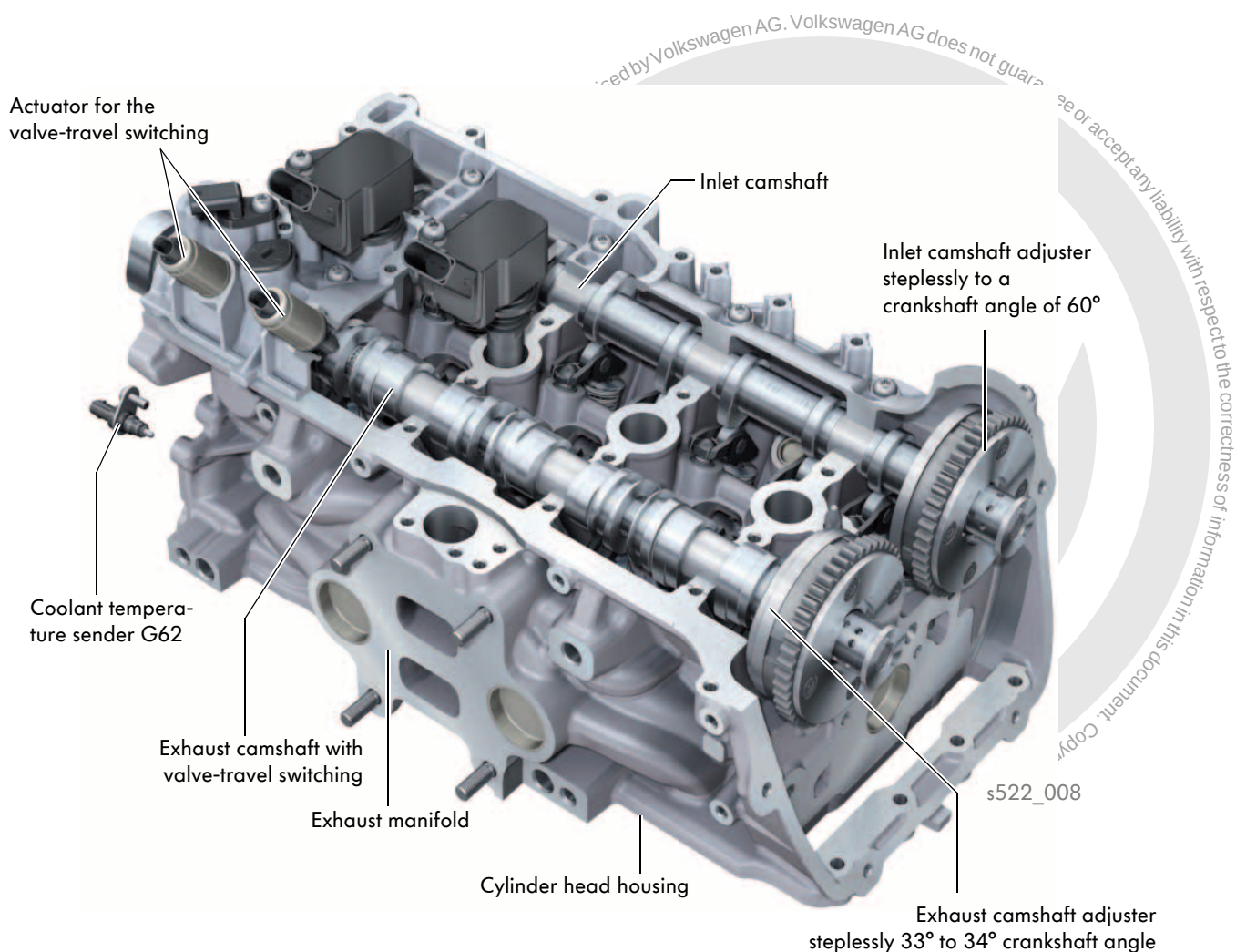


A repair kit is used to repair the balance shafts. It consists of the two balance shafts and their roller bearings. Only the middle, large roller bearings can be exchanged together with the balance shafts. The small, rear roller bearings are built into the cylinder block and cannot be separately exchanged.

Cylinder head with valve-lift switching

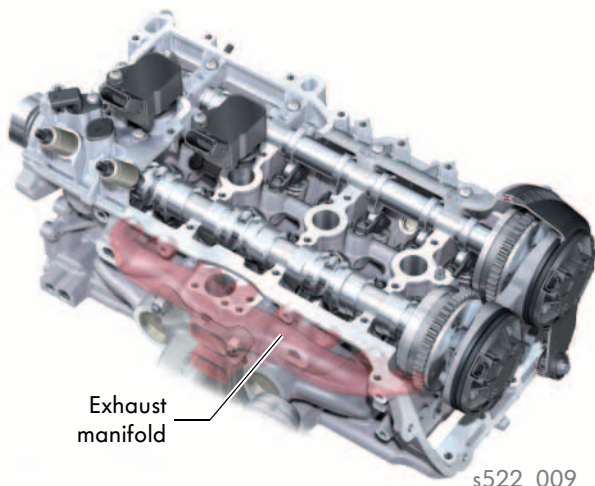
The cylinder head of the 2.0 I TSI engines has been completely redeveloped. The exhaust manifold is now integrated into the cylinder head so that the exhaust gas recirculation cooling and the exhaust gas flow takes place inside the cylinder head. Inlet and exhaust camshafts have variable valve timing. The exhaust camshaft also has valve-lift switching, which enables the valves to open and close on two different cam profiles.

Coolant temperature sender G62 is screwed into the cylinder on the gear box side. There, where it is mounted at the hottest spot in the cylinder head, it can precisely record the temperature changes and prevent the coolant from boiling.



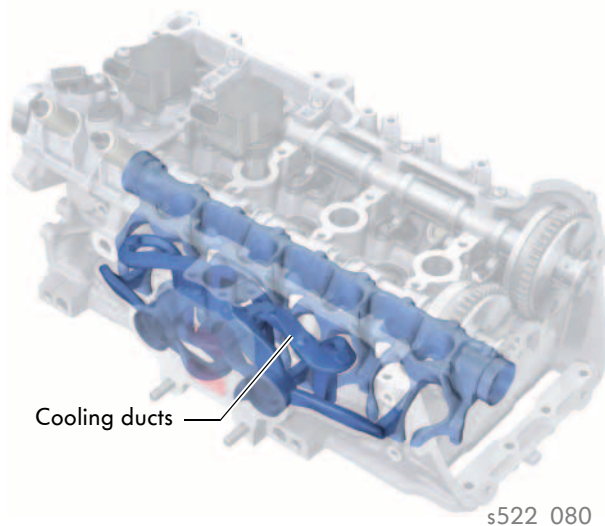
The actuators for the valve-lift switching are designated in the workshop documentation as follows: exhaust cam actuator A for cylinder 1 N580, exhaust cam actuator B for cylinder 1 N581, exhaust cam actuator A for cylinder 2 N588, exhaust cam actuator B for cylinder 2 N589, exhaust cam actuator A for cylinder 3 N596, exhaust cam actuator B for cylinder 3 N597, exhaust cam actuator A for cylinder 4 N604, exhaust cam actuator B for cylinder 4 N605.

Integrated exhaust manifold



The use of an integrated exhaust manifold significantly reduces the exhaust temperature before the turbine of the turbocharger. A full load enrichment for turbine protection can be largely eliminated owing to the combination with a high-temperature-proof turbocharger, especially at high revs. This reduces fuel consumption and CO₂ emissions.

The exhaust channels are arranged so that the exhaust gas flow of an emitting cylinder has no disruptive influence on the flushing action of another cylinder. Consequently, the entire streaming energy in the exhaust gas stream is available for driving the turbine of the turbocharger.



Another advantage of the integrated exhaust manifold is the faster heating up of the coolant in the warm-up phase of the engine. In this way it is possible to use the regulated cooling mode of the Innovative Thermal Management system after a very short warm-up phase.

Because the lambda probe is mounted directly behind the integrated exhaust manifold, it reaches the optimal operating temperature faster.

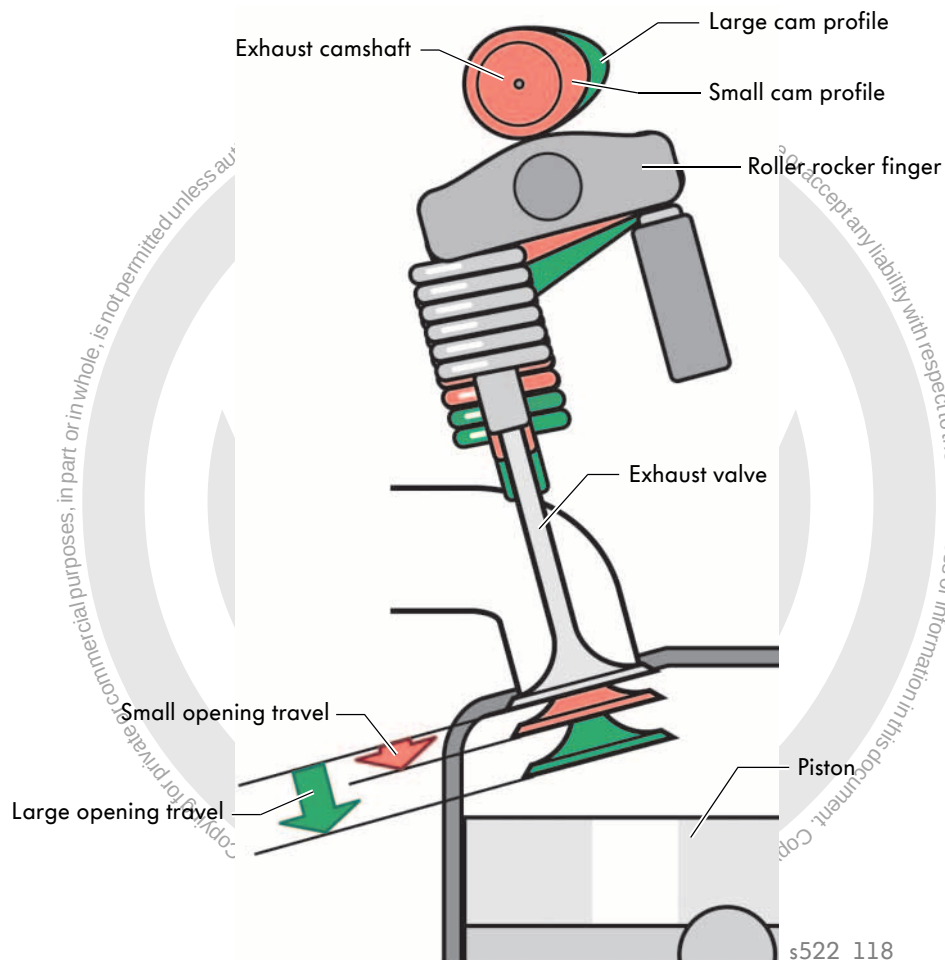
Electrical valve-lift switching

Optimised control of the gas exchange for each cylinder is made possible by the electrical valve-lift switching on the exhaust camshaft in conjunction with the variable valve timing on the inlet and exhaust camshafts. The smaller cam profile is only used for low revs.

When and which cam profile is used is stored in a map.

This measure does the following:

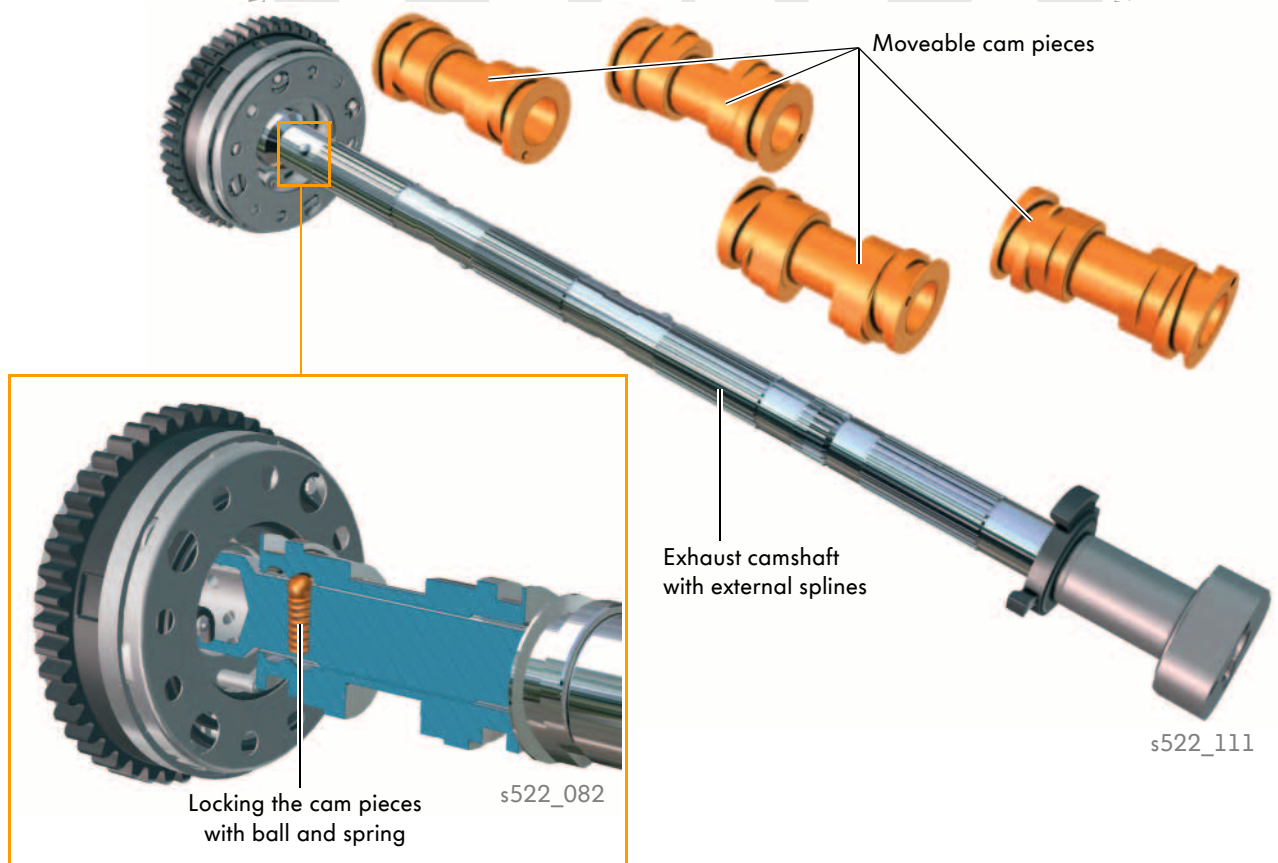
- Optimises the gas exchange
- Prevents exhaust gas from streaming back to the previously 180° emitting cylinder
- Enables higher degree of filling with earlier inlet opening time
- Reduces the residual gases through a positive difference in pressure in the combustion chamber
- Improves responsiveness
- Achieves a higher torque at lower revs and higher charge pressure



Design

To enable switching between two different valve lifts on the exhaust camshaft, this camshaft has four moveable cam pieces with internal splines. Each cam piece is fitted with two cam pairs whose cam lifts are different. Switching between the two lift levels is done by means of electrical actuators that engage a sliding groove on each cam piece and move the cam piece on the camshaft. This means that each cam piece has two actuators to switch back and forth between the two lift levels.

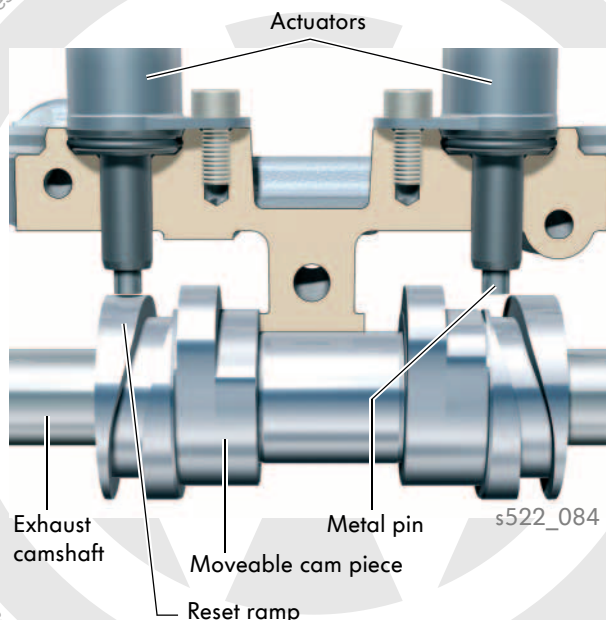
A spring-loaded ball in the camshaft locks the cam pieces in their respective end positions. The sliding grooves and the axial bearing of the camshaft limit the movement of the cam pieces. Because the design involves a pair of cams on the camshaft, the contact surface of the roller rocker fingers has to be narrower.



The construction and function of the electrical valve-lift switching is similar to that of the Active Cylinder Management (ACT). Please also see SSP 510 „Active Cylinder Management (ACT) in the 1.4 l 103kW TSI engine”. The ball and spring will be available as a spare part.

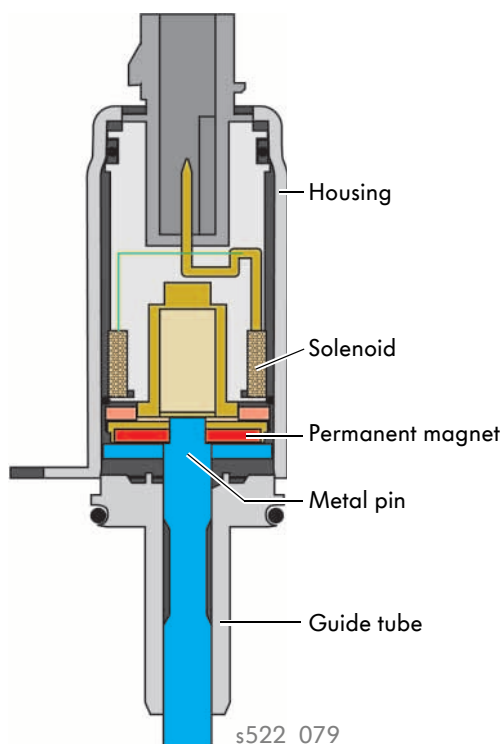
Actuators for valve-lift switching

With the help of its two electrical actuators (exhaust cam actuators A/B for cylinders 1–4) each cam piece is pushed back and forth on the exhaust camshaft between its two switching positions. One actuator per cylinder switches to the larger valve-lift; the second actuator switches to the smaller valve-lift. Each individual actuator is activated by an earth signal via engine control unit J623. The voltage supply is via main relay J271. The current consumption of the actuators is approx. 3 A.



Design

Each actuator (exhaust cam actuators A/B for cylinders 1–4) consists of a solenoid by means of which a metal pin is moved downward through a guide tube. In the retracted position and in the extended position the metal pin is held in position in the housing of the actuator by a permanent magnet.



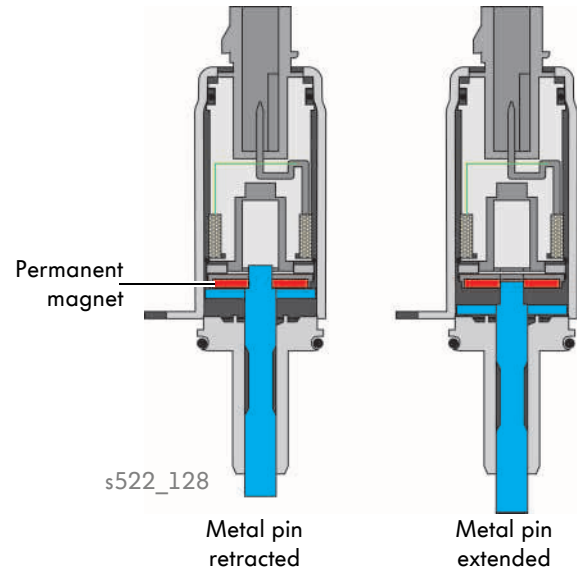
Engine mechanics

Function

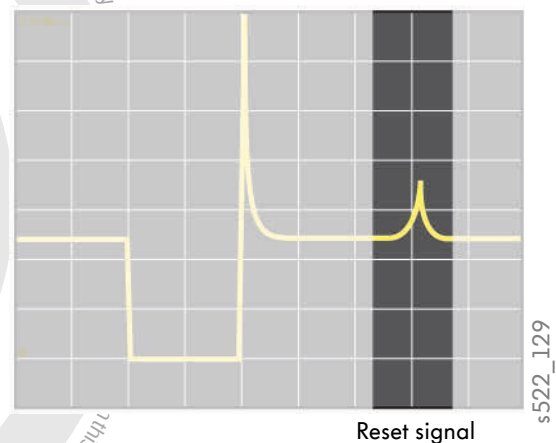
When current is applied to the solenoid of an actuator, the metal pin is moved in 18–22 milliseconds.

The extended metal pin engages the associated sliding groove of the cam piece on the exhaust camshaft and moves it through the rotation of the camshaft to the respective switching position. The pin is retracted mechanically by the sliding groove acting as a reset ramp.

Actuation of the two actuators of a cam piece is always such that on only one of the two actuators is the metal pin moved.



The engine control unit knows the current position of the metal pin based on reset signals. A reset signal occurs when the reset ramp pushes the metal pin of an actuator back into the guide tube of the element. The engine management system can determine the current position of the concerned slide unit based on which actuator delivers reset signals.



Effects of failure

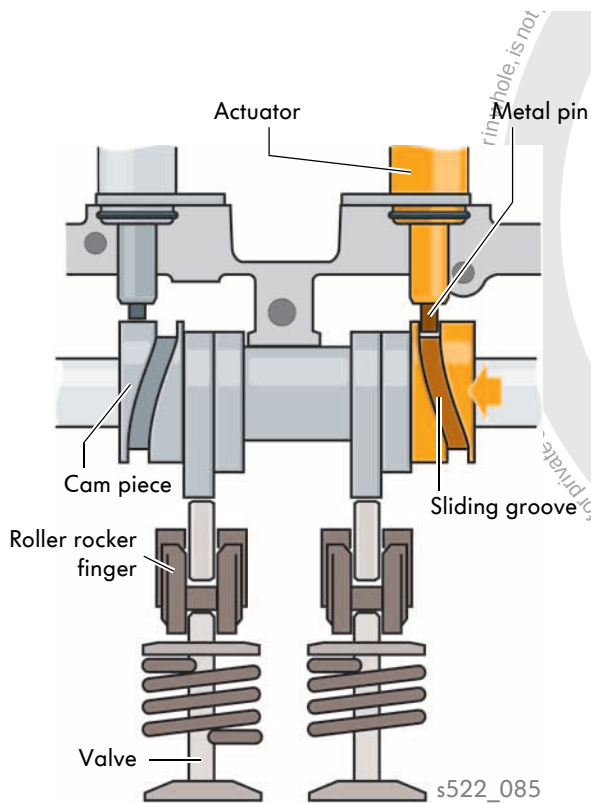
If an actuator fails, the valve-lift switching function can no longer be carried out. In this case, the engine management system attempts to switch all cylinders to the most recently successful valve-lift switching. If this is not successful, all cylinders are switched to the smaller valve-lift position.

The engine speed is then limited to 4,000 rpm and an entry is made in the event memory.

The EPC warning lamp is switched on.

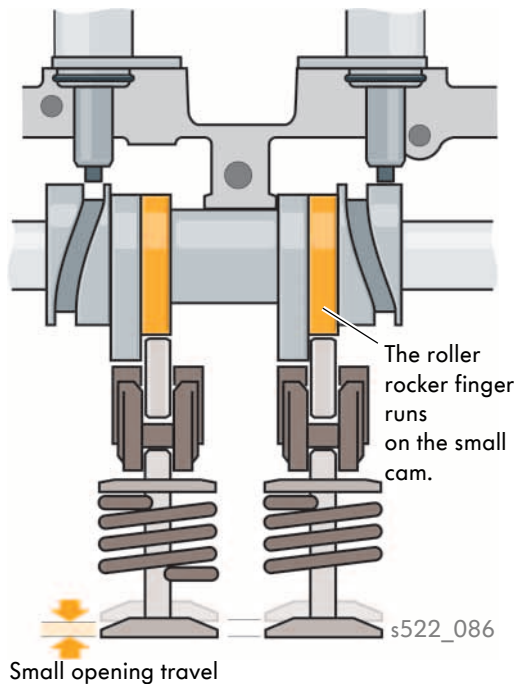
If switching to the larger valve-lift position is possible, an entry is also made in the event memory.

In this case, however, the engine speed is not limited and the EPC lamp is not switched on.



Camshaft position in the lower engine speed range

To improve the gas exchange for this load range, the inlet camshaft is advanced and the exhaust camshaft is retarded by the engine management system via the camshaft adjuster. Valve-lift switching to the smaller exhaust cam profile occurs and the right actuator moves the metal pin. It engages the sliding groove and moves the cam piece toward the small cam profile.

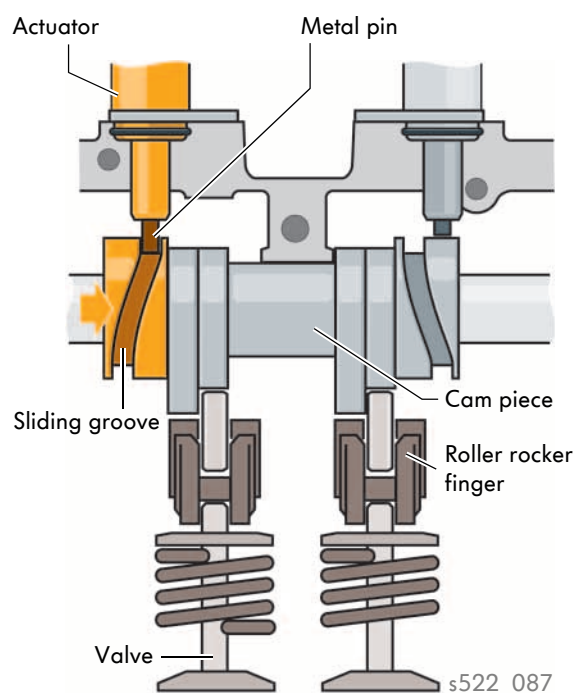


The valves now go up and down with the smaller valve profile. The somewhat twisted position of the two small cams against each other ensures that the opening time of the two exhaust valves of a cylinder are offset. These two measures result in a reduced pulsation of the exhaust gas stream when the exhaust gas is expelled from the piston into the turbocharger so that a higher charge pressure is achieved for the lower rpm range.

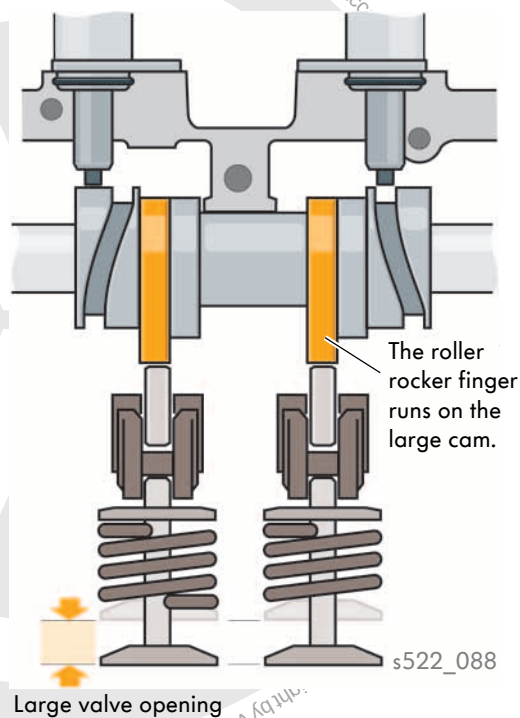
Camshaft position in the partial and full load range

The driver accelerates and changes from partial load to full load range. The gas exchange of the cylinder must now be adapted to the higher performance requirement.

The engine management system advances the inlet camshaft and retards the exhaust camshaft via the camshaft adjuster. To enable an optimal filling of the cylinder, the exhaust valves require the greatest possible valve lift. To achieve this, the left actuator is activated so that it moves its metal pin.



The metal pin moves the cam piece via the sliding groove towards the large cam. The exhaust valves now open and close with the maximum lift. The cam pieces are also held in this position by the spring-loaded ball in the camshaft.



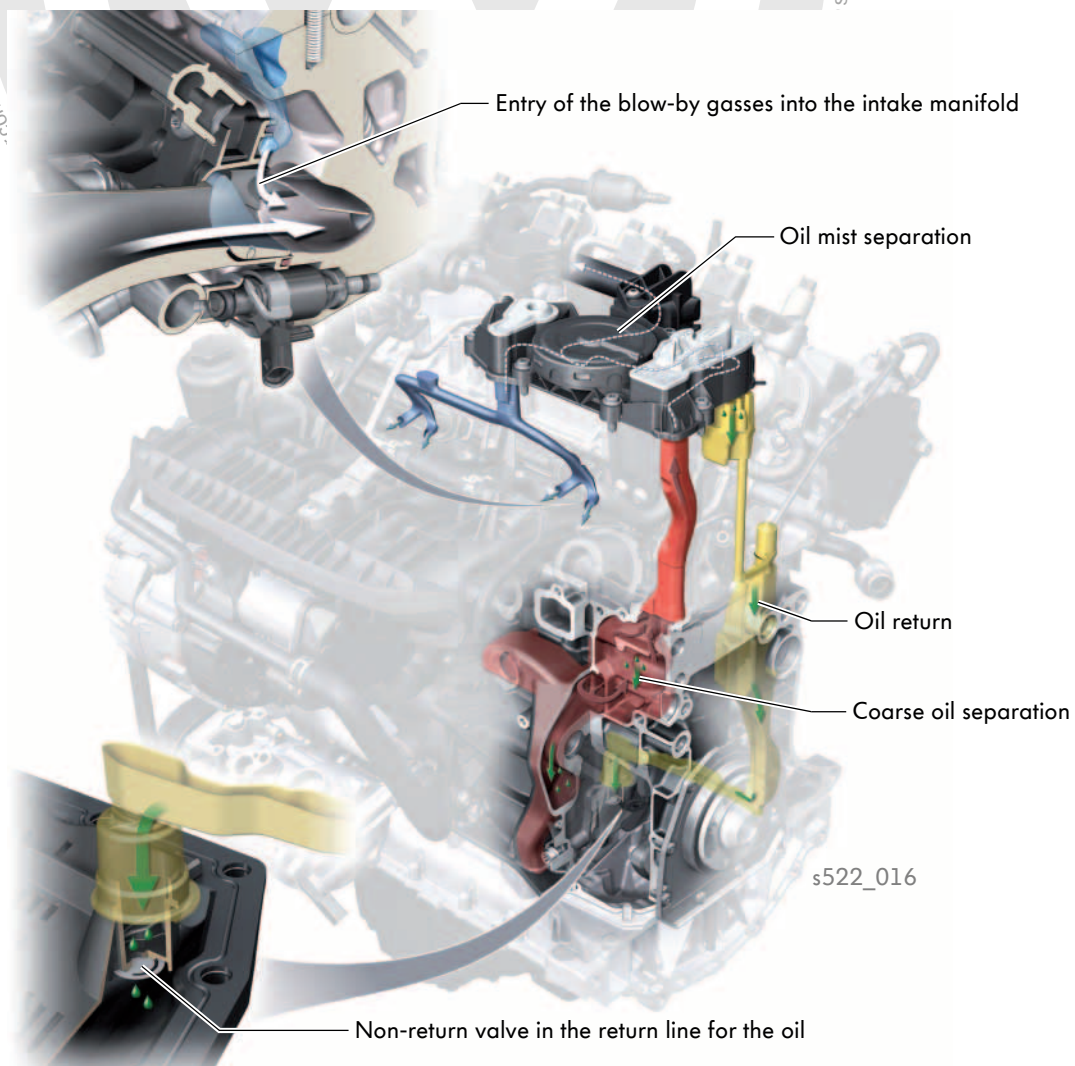
A final control diagnosis is not intended for the actuators.

Crankcase breather and ventilation system

The crankcase breather and ventilation system of the new 2.0 TSI engines is designed for a larger pressure difference. This measure has a positive effect on the oil consumption of the engine. During development particular attention was paid to channelling the blow-by gases inside the engine as much as possible to reduce the number of required components. Thus in this engine only one pipeline is necessary to divert the cleaned blow-by gasses in front of the turbine of the turbocharger.

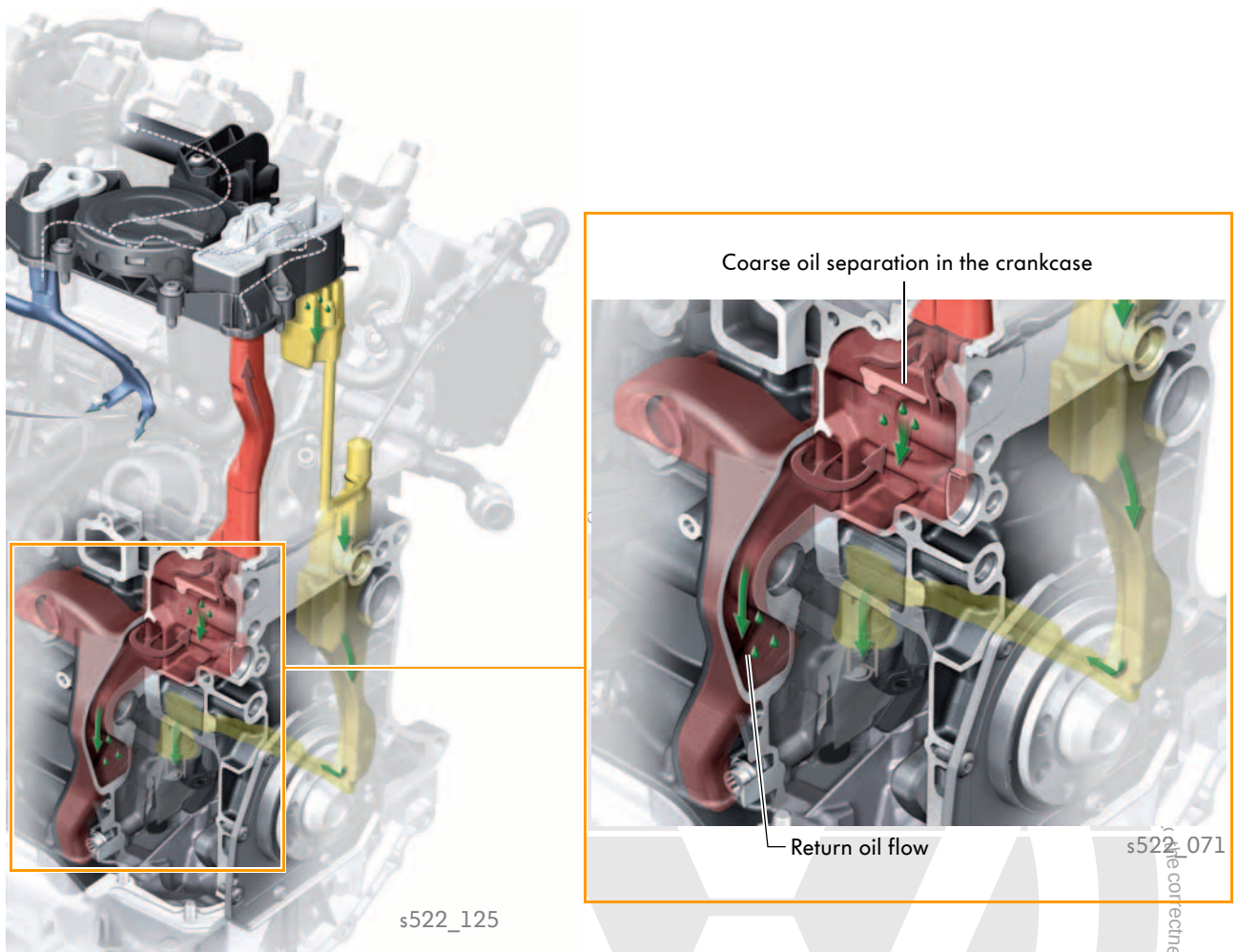
The crankcase breather and ventilation system consists of:

- The coarse oil separator in the cylinder block
- A fine oil separator bolted onto the cylinder head cover
- The hose connection for diverting the cleaned blow-by gasses only to the turbocharger
- The oil return in the cylinder block with non-return valve in the sump's honeycomb insert
- The pressure regulating valve designed for a difference in pressure to the outside air of minus 100 mbar
- The connection of the activated charcoal filter on the fine oil separator



The coarse oil separator

The coarse oil separator is part of the cylinder block. The blow-by gasses are conducted through the coarse oil separator with several directional changes. Large drops of oil are separated by baffle plates in the coarse oil separator and run back to the sump through a return channel. The roughly cleaned blow-by gasses are directed through channels in the cylinder block and cylinder head to the fine oil separator.

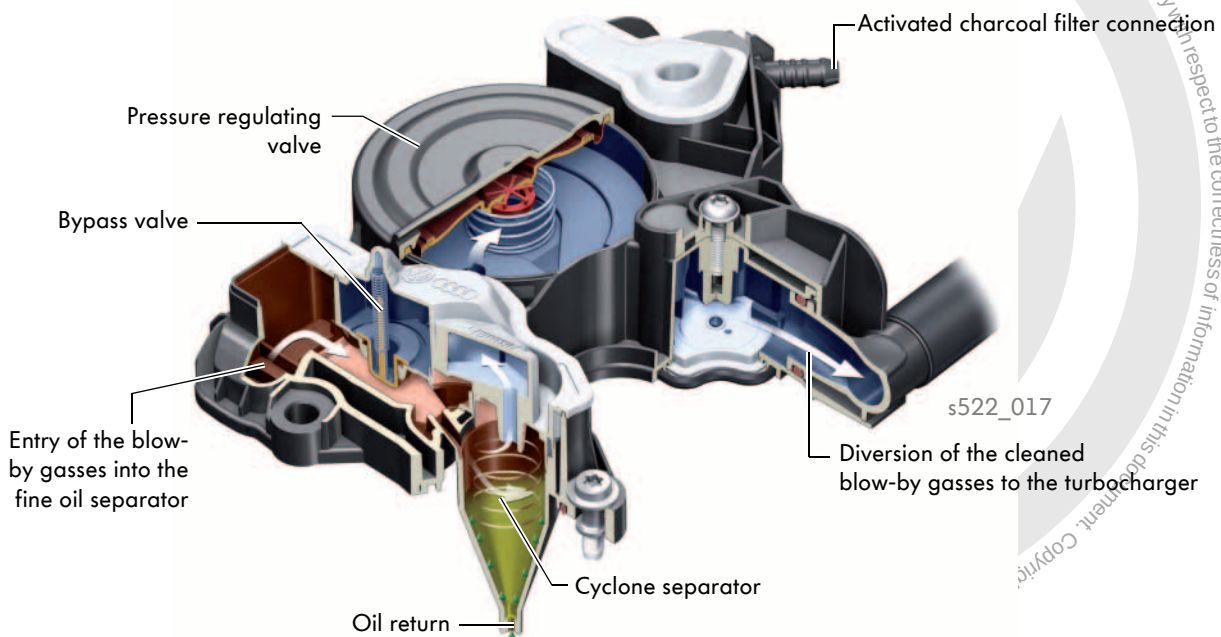


Fine oil separation

The gases travel via a channel in the crankcase to the fine oil separator on the cylinder head cover. Here they first pass through a bypass valve before they enter a cyclone separator. The bypass valve opens mechanically when the blow-by gas stream is too high and the engine speeds are very high to avoid damaging the seals.

The blow-by gasses rotate up to 16,000 rpm in the cyclone separator. This separates even the finest oil droplets. They are directed back to the oil pan through a return flow channel in the cylinder block. At the end of the return flow channel is a non-return valve in the sump. It prevents oil from being sucked back into the oil separator via the return flow channel in the event of unfavourable pressure conditions or strong lateral accelerations.

The cleaned blow-by gasses are sent behind the cyclone separator through a one-stage pressure regulating valve. The pressure regulating valve is designed for a pressure differential to the outside air of minus 100 mbar. Depending on the prevailing pressure conditions in the charge air system, the cleaned blow-by gasses enter the intake manifold (suction mode) or the turbocharger (charging operation).



Overview of the oil supply

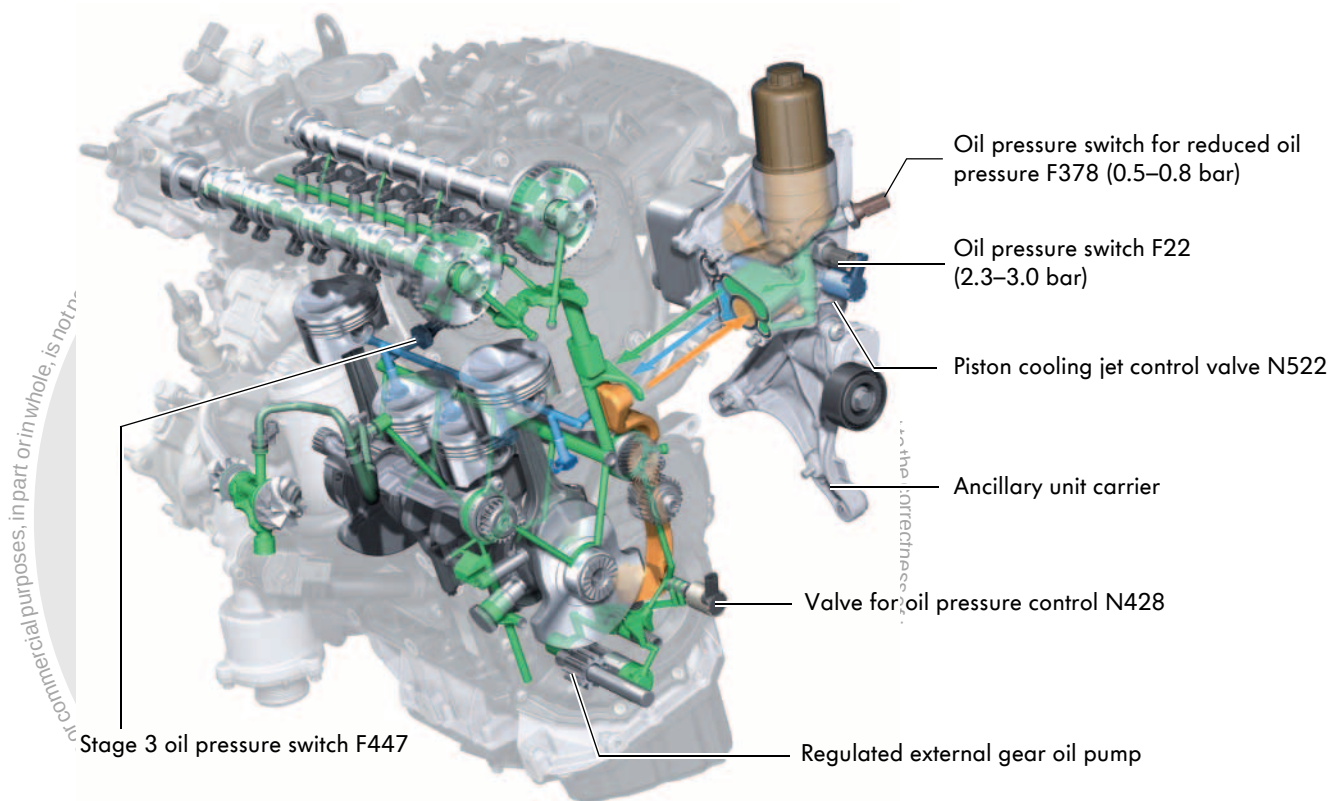
During the development of the oil supply system, the following objectives were key:

- To regulate the oil pressure with two pressure stages
- To reduce the ratio of the regulated oil pump
- To expand the rpm range in the low pressure stage
- To reduce the oil pressure in the low pressure stage
- To use electrically switching piston cooling jets
- To bolt oil filter and oil cooler onto the ancillary unit carrier

Ancillary unit carrier

Besides the oil cooler and oil filter, the following components are also located on the ancillary unit carrier:

- Oil pressure switch F22
- Oil pressure switch for reduced oil pressure F378
- Piston cooling jet control valve N522
- Automatic tensioning roller for the poly V-belt of the ancillary unit drive



Oil pressure switches F22, F378 and F447 must be replaced when they are removed.



Two-stage external gear oil pump

Compared to the oil pump on the previous engine, the ratio of the pump drive has been reduced so that the pump runs more slowly. It is still driven by the crankshaft via a separate chain.

The slide unit is inside the two-stage external gear oil pump. It enables the two pump gears to move longitudinally against each other for two-stage pump power control.

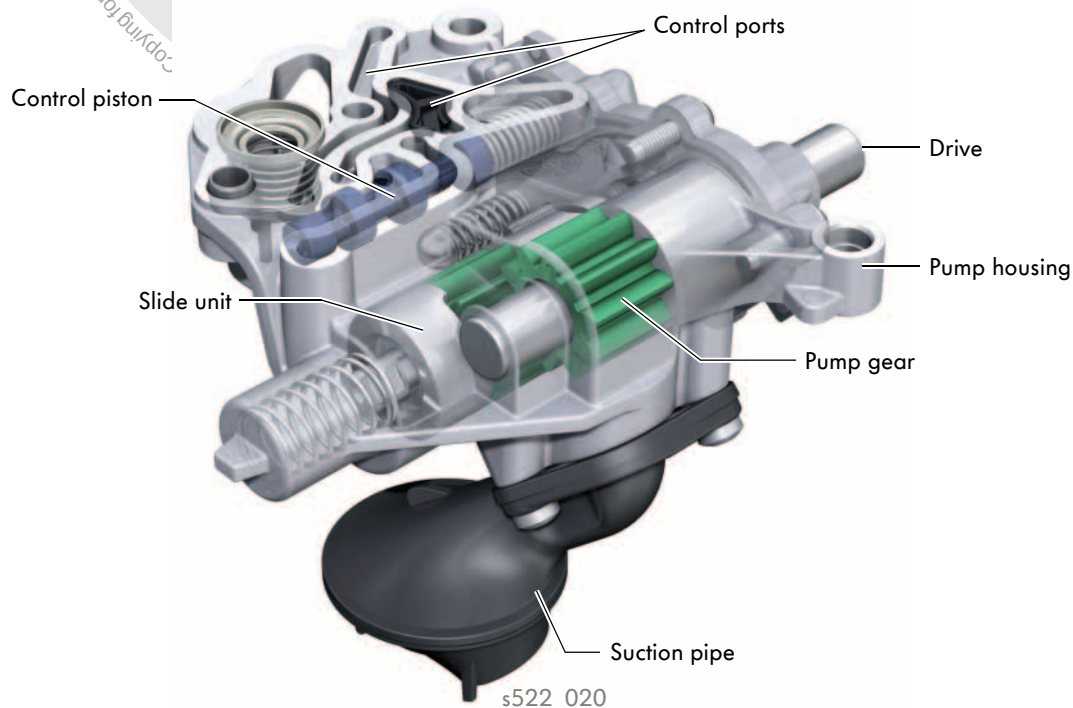
If the two gears are at exactly the same height, the pump works at maximum power; if the two gears are pushed together, the pump works with less power. The slide unit is moved by a control piston and control ports inside the oil pump.

The control piston directs the regulated oil flow to the left or right side of the slide unit, which then moves in the longitudinal direction according to the oil pressure.

The control piston is actuated by the valve for oil pressure control N428.

The switch from the low to the high supply stage is determined by the load and/or rpm. Below this threshold, the pump works at a pressure of 1.5 bar. When a speed of 4,500 rpm is reached, the pump produces 3.75 bar oil pressure.

The engine runs up to 1,000 rpm only in the high pressure stage.



The oil pump is essentially identical to the regulated oil pump of the EA211 engine family. A detailed description of the design and functionality of the two-stage external gear oil pump can be found in SSP no. 511 „The New EA211 Petrol Engine Family”.

Oil circuit

The electrical components of the oil pressure control

Oil pressure switch F22

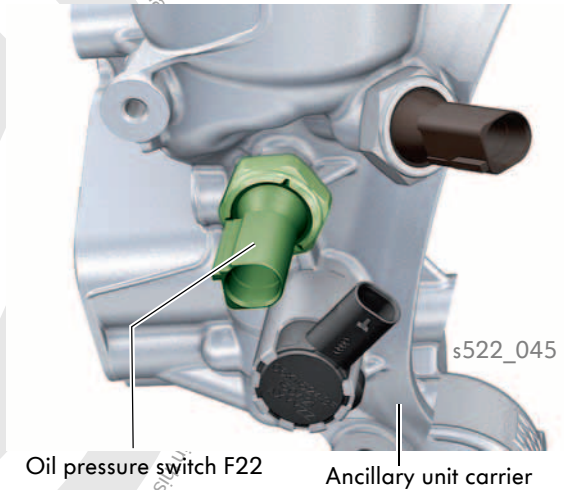
Oil pressure switch F22 is screwed into the ancillary unit carrier below the oil filter.

Signal use and task

With this sensor the engine management system checks, among other things, whether the oil pump is working in the high oil pressure stage.

Effects of failure

If the oil pressure switch fails, an entry is entered into the engine control unit's event memory and the oil warning lamp is switched on.



Valve for oil pressure control N428

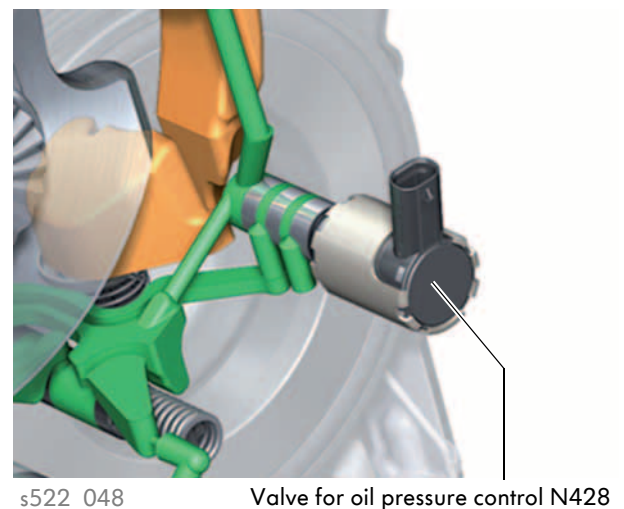
The solenoid valve is bolted into the front edge of the cylinder block and below the ancillary unit carrier.

Task and function

The solenoid valve is actuated by the engine control unit to switch the external gear oil pump back and forth between the two pressure stages. For this purpose the control piston in the oil pump applies oil pressure by the solenoid valve via the control ports depending on the switch state. The position of the control piston then produces the pressure switching.

Effects of failure

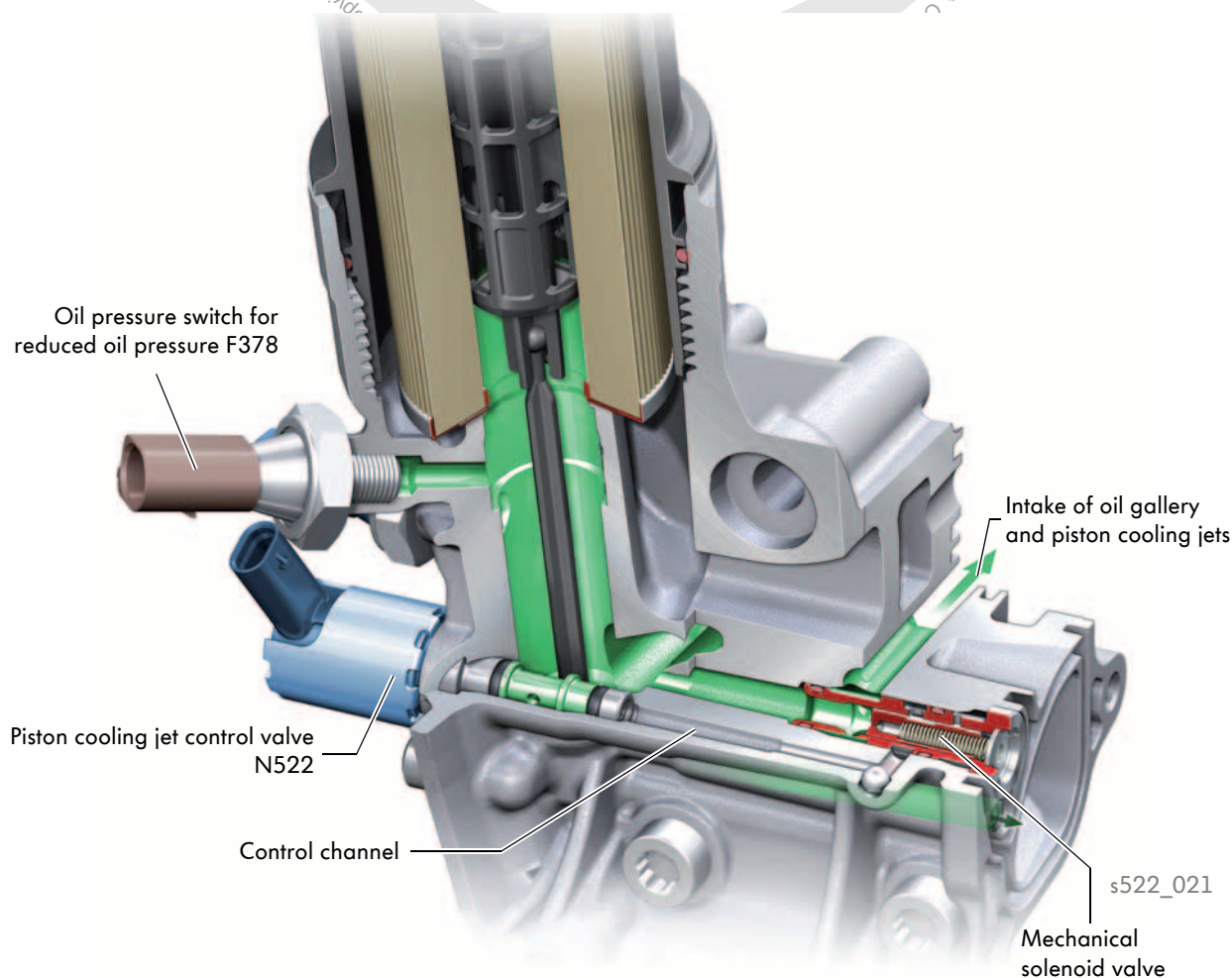
If the valve fails, it is closed. The oil pump works in the high pressure stage.



Switchable piston cooling jets

Cooling the piston crowns is not necessary in every operating range of the engine. This is why the 2.0 TSI engines of this family have switchable piston cooling jets. The piston cooling jet control valve N522 is actuated via a map. A mechanical solenoid valve opens when the oil pressure exceeds 0.9 bar. The control valve and the solenoid valve are built into the ancillary unit carrier and connected by a control port.

Switching of the piston cooling jets can occur in the high pressure stage of the oil circuit or in the low pressure stage. An additional oil pressure switch (stage 3 oil pressure switch F447) detects the oil pressure in the additional oil gallery and monitors the functioning of the piston cooling. The oil pressure switch closes at an oil pressure of 0.3–0.6 bar.

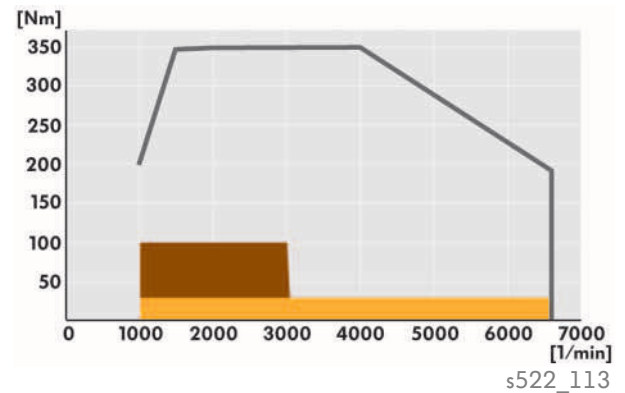


Actuation of the piston cooling jets

Control strategy

Actuation of the control valve is by means of the engine control unit with the help of a map. The engine control unit uses the engine torque, the engine speed and the oil temperature to calculate the map.

For an oil temperature below 50°C, the piston cooling jets remain switched off in a map range of 1,000–6,600 rpm and a load of approx. 30 Nm. For an oil temperature above 50°C, the piston cooling jets remain switched off in a speed range of 1,000–3,000 rpm and a load range of 30–100 Nm. The piston cooling jets are switched on in all other ranges of the map.



- Piston cooling temporarily switched off (oil temperature < 50°C)
- Piston cooling switched off (oil temperature > 50°C)

Function monitoring of the piston cooling jets

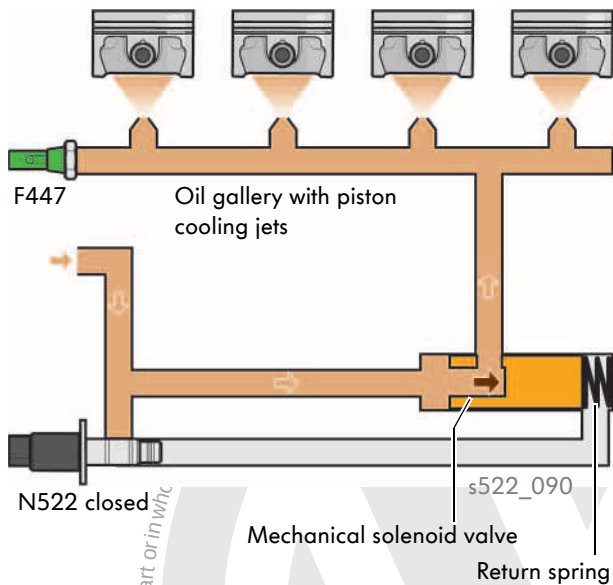
With the help of the stage 3 oil pressure switch F447 and the diagnostic capability of piston cooling jet control valve N522, the correct functioning of the piston cooling jets and thereby sufficient cooling of the pistons can be monitored.

It is possible to identify the following faults:

- No oil pressure on the piston cooling jets despite being required
- Stage 3 oil pressure switch F447 defective
- Oil pressure despite the piston cooling jets being switched off
- Disconnection = piston cooling jets always on
- Short circuit to earth = piston cooling jets off
- Short circuit to positive = piston cooling jets on

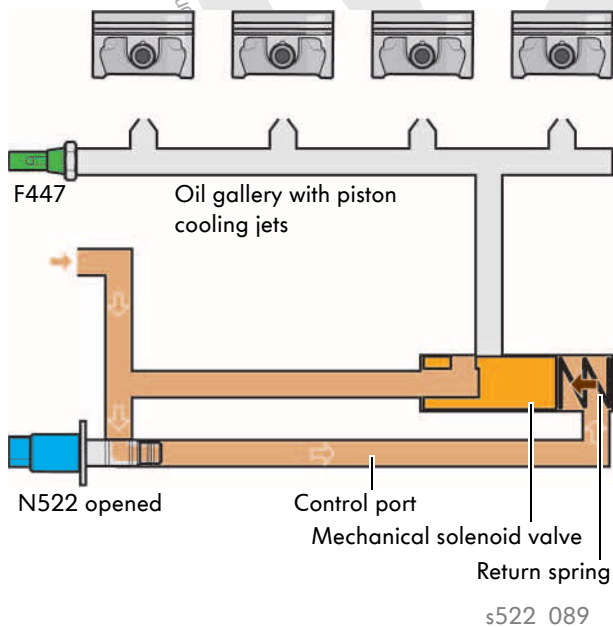
Effects without piston cooling:

- Torque and speed limitation
- No low oil pressure level
- EPC lamp in the instrument cluster on
- Message that engine speed is limited to 4,000 rpm



Piston cooling jets switched on

In the de-energised state the piston cooling jet N522 control valve is closed. This also closes the control port between control valve and solenoid valve. Thus the solenoid valve has oil pressure applied only on one side and continues to move against a return spring until the channel to the piston cooling jets is free. The oil flows from the solenoid valve to the additional oil gallery and from there to the piston cooling jets. This activates the jets. Based on the signal of the stage 3 oil pressure switch F447, the engine control unit determines that the piston cooling jets are activated.



Piston cooling jets switched off

The engine control unit actuates the piston cooling jet control valve N522 to switch off the piston cooling jets.

In the switched state, piston cooling jet control valve N522 opens the control port to the solenoid valve. The solenoid valve now has oil pressure applied from both sides. The force of the return spring is greater and the solenoid valve is pushed back. The connecting pipe to the oil gallery is interrupted and the piston cooling jets are switched off. Based on the signal of the stage 3 oil pressure switch F447, the engine control unit determines that the piston cooling jets are deactivated.



The electrical components for piston cooling

Stage 3 oil pressure switch F447

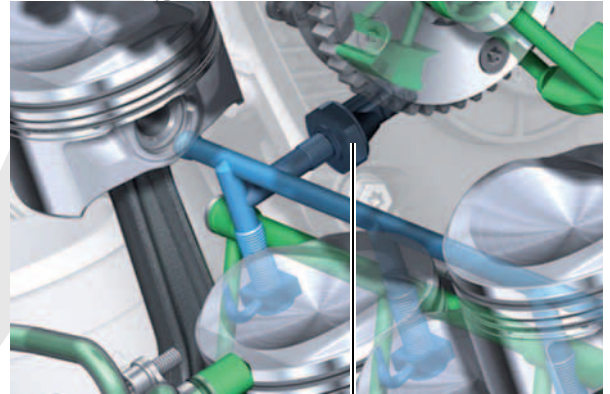
Stage 3 oil pressure switch F447 is screwed in below the intake manifold in the block.

Signal use and task

This oil pressure switch monitors the oil pressure in the oil gallery, which the piston cooling jets supply. With the help of the stage 3 oil pressure switch F447, the engine management system can determine a malfunction of the piston cooling jets, e.g. lack of oil pressure despite activated piston cooling, or oil pressure present despite deactivated piston cooling.

Effects of failure

Diagnostics can be run on the oil pressure switch. If the sensor signal fails, piston cooling remains activated.



Stage 3 oil pressure switch F447

s522_046

Oil pressure switch for reduced oil pressure F378

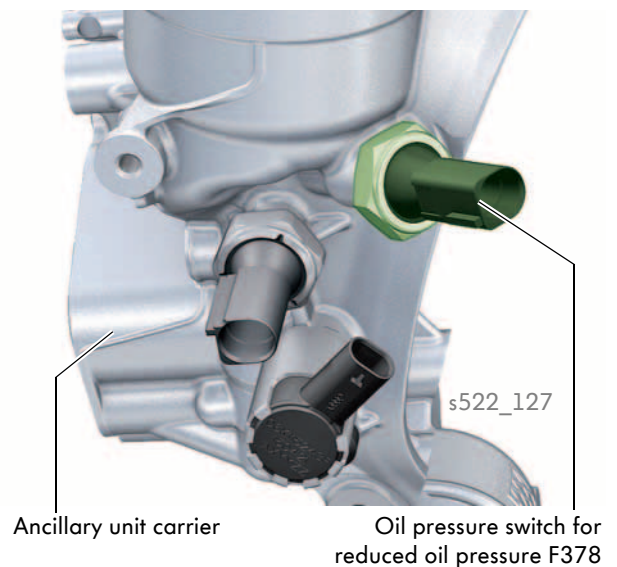
This oil pressure switch is also screwed into the ancillary unit carrier below the oil filter.

Signal use and task

Via the oil pressure switch for reduced oil pressure, the engine management system monitors the pressure control of the two-stage external gear oil pump.

Effects of failure

Without the signal of the oil pressure switch for reduced oil pressure F378, two-stage oil pressure control is not possible. If the oil pressure switch fails, an entry is made in the event memory and the oil warning lamp is switched on. The oil pump then runs only at the high pressure stage.



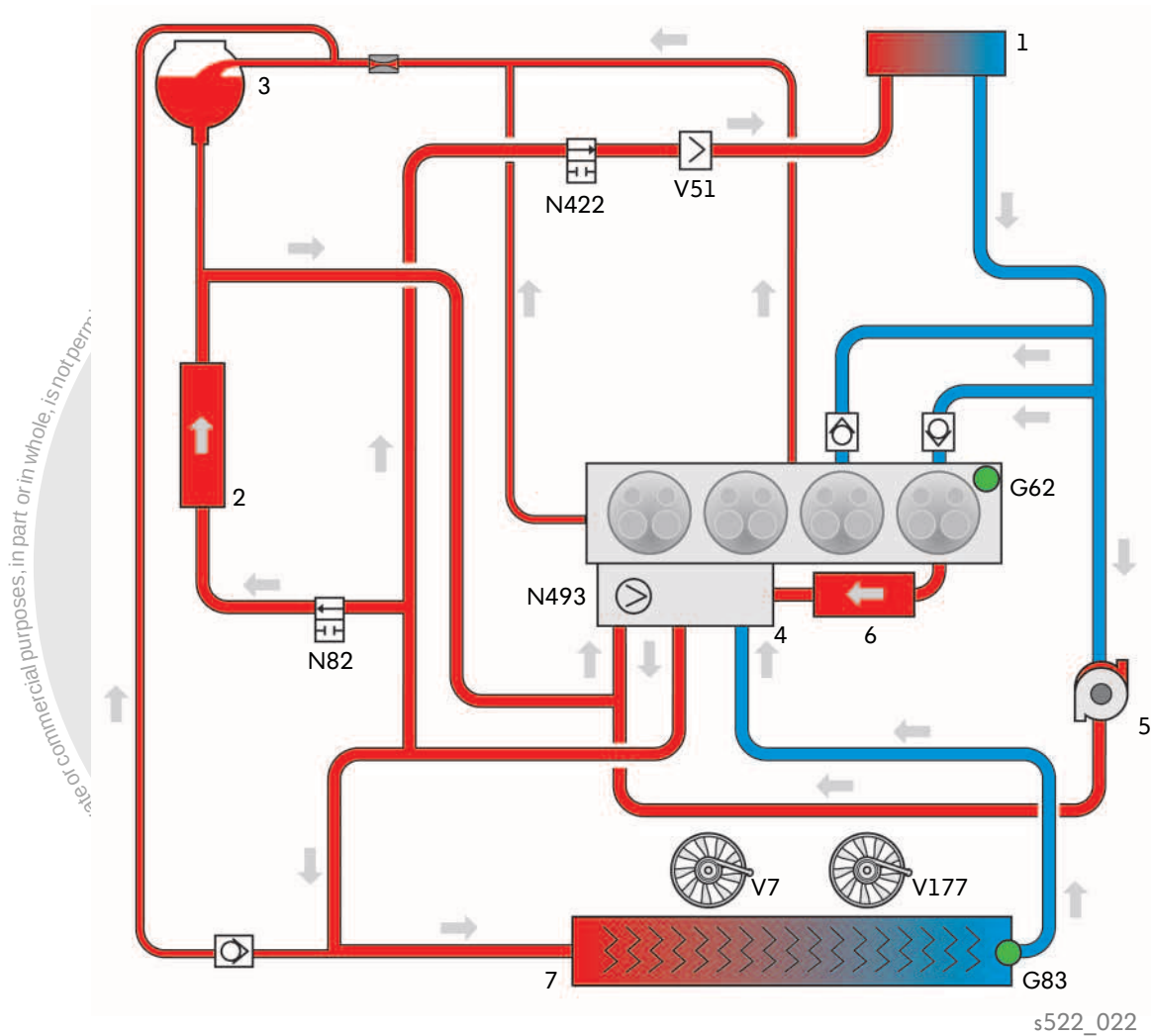
Ancillary unit carrier

Oil pressure switch for reduced oil pressure F378

s522_127

Overview of the cooling system

Cooling systems are designed for the engine power and equipment level of a vehicle. For this reason we mention only a simplified cooling circuit based on an example without a dual clutch gearbox to illustrate the basic design of the cooling system. Essential features of the coolant circuit, especially with reference to the innovative thermal management, include the exhaust manifold integrated in the cylinder head and a new rotary valve module.



Legend

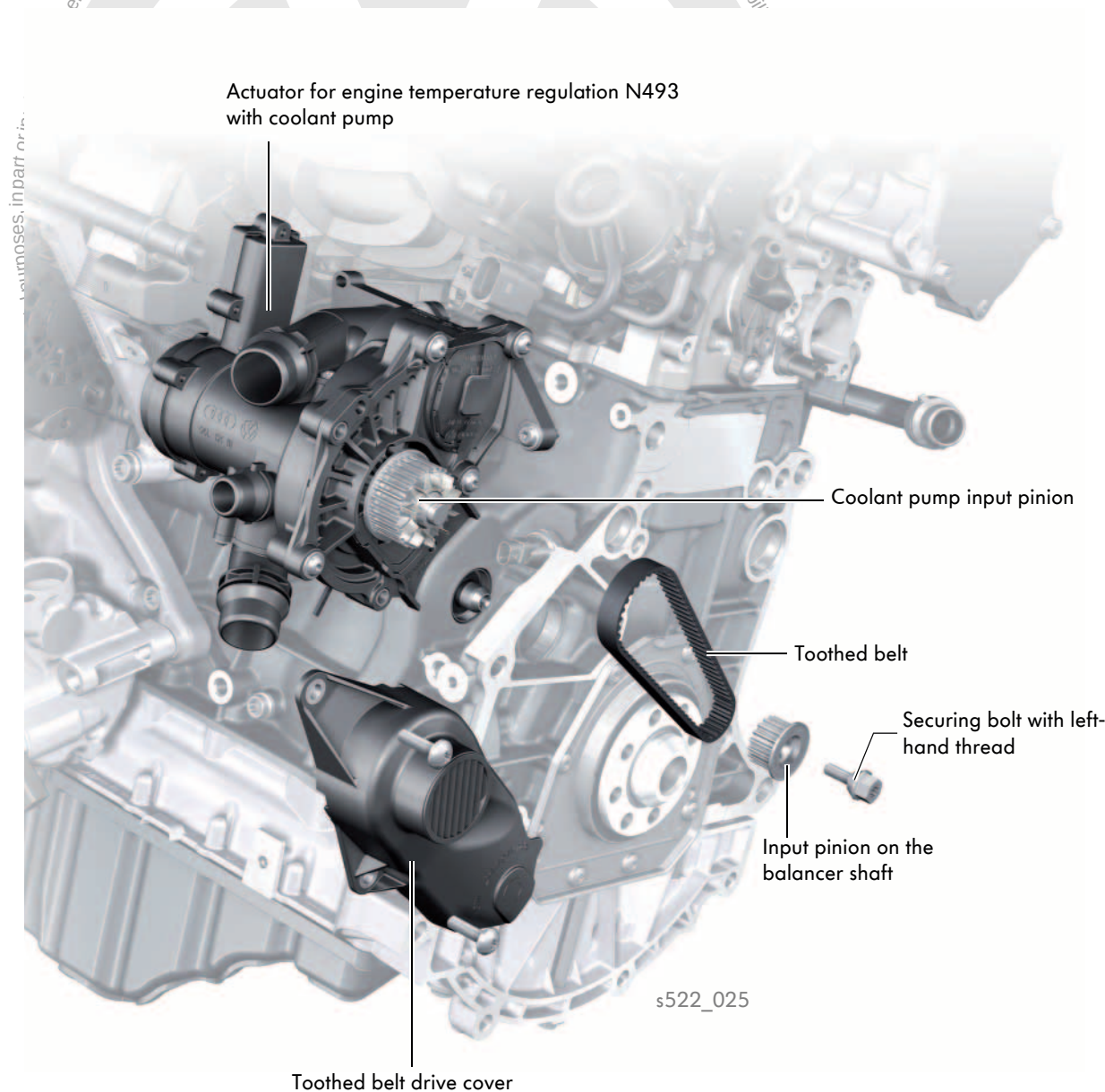
G62	Coolant temperature sender	1	Heat exchanger for heater
G83	Radiator outlet coolant temperature sender	2	Gear oil cooler (optional)
N82	Coolant shut-off valve	3	Coolant expansion tank
N422	Climatronic coolant shut-off valve	4	Rotary valve module with coolant pump
N493	Actuator for engine temperature regulation	5	Turbocharger
V7	Radiator fan	6	Engine oil cooler
V51	Continued coolant circulation pump	7	Main water cooler
V177	Radiator fan 2		



Cooling system

Innovative Thermal Management

The Innovative Thermal Management system (ITM) is an intelligent cold start and warm-up program for the engine and gearbox. It enables fully variable engine temperature regulation with targeted control of the coolant stream. The core element is the actuator for engine temperature regulation N493 (rotary valve module). It is screwed onto the crankcase on the intake side below the cylinder head.



When exchanging the rotary valve module or the water pump, please refer to the workshop manual.

Actuator for engine temperature regulation (rotary valve module)

Includes:

- Coolant pump
- Two rotary valves
- Thermostat
- Actuator for engine temperature regulation N493 for controlling the coolant streams
- Gear with turn angle sensor

Coolant pump driven by a toothed belt from the balance shaft

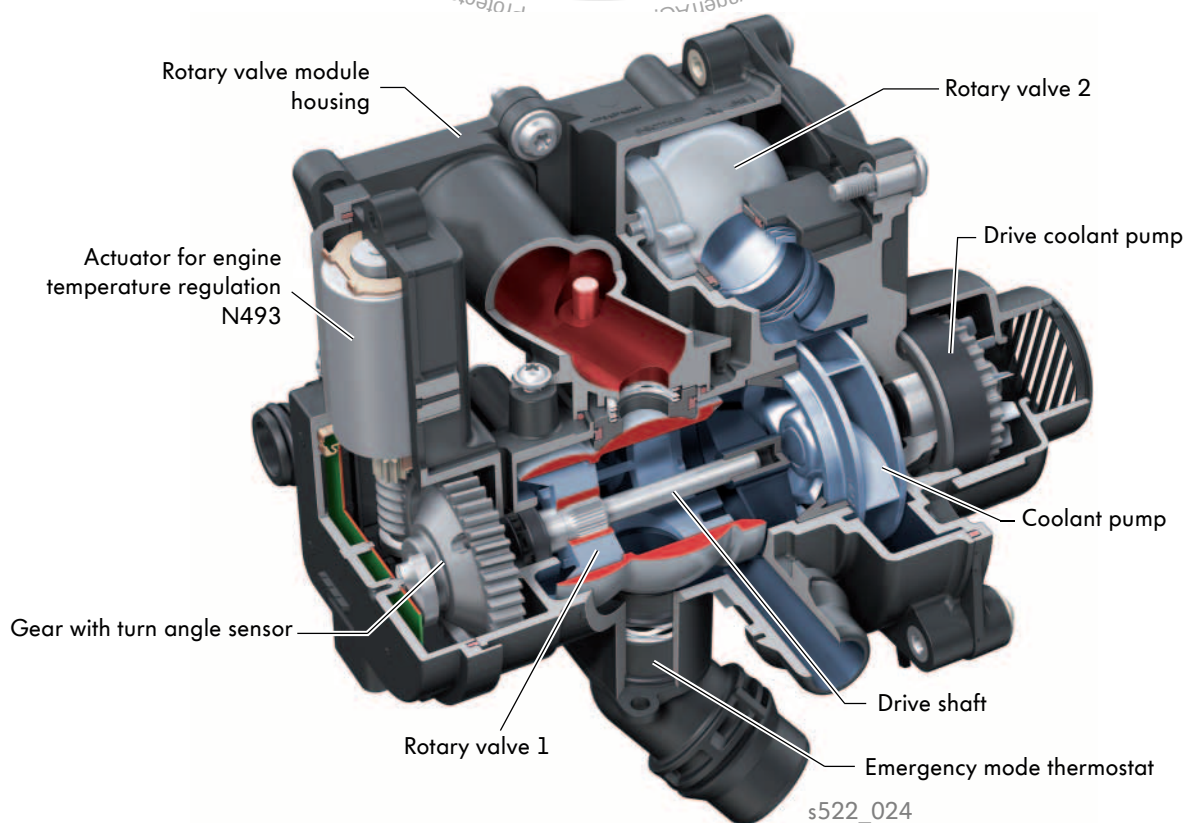
Design

The essential feature of the rotary valve module comprises the two rotary valve elements inside the module that are electrically actuated by the actuator for engine temperature regulation N493.

Rotary valve 1 is driven directly by the actuator for engine temperature regulation N493 via a shaft.

Rotary valve 2 is moved by a toothed gate on rotary valve 1 via an intermediate gear (pin wheel gear).

This means that rotary valves 1 and 2 are mechanically coupled and move in relationship to each other. An additional thermostat with expansion element serves as a safety device (emergency thermostat) and opens at 113°C in the event of a failure.



Cooling system

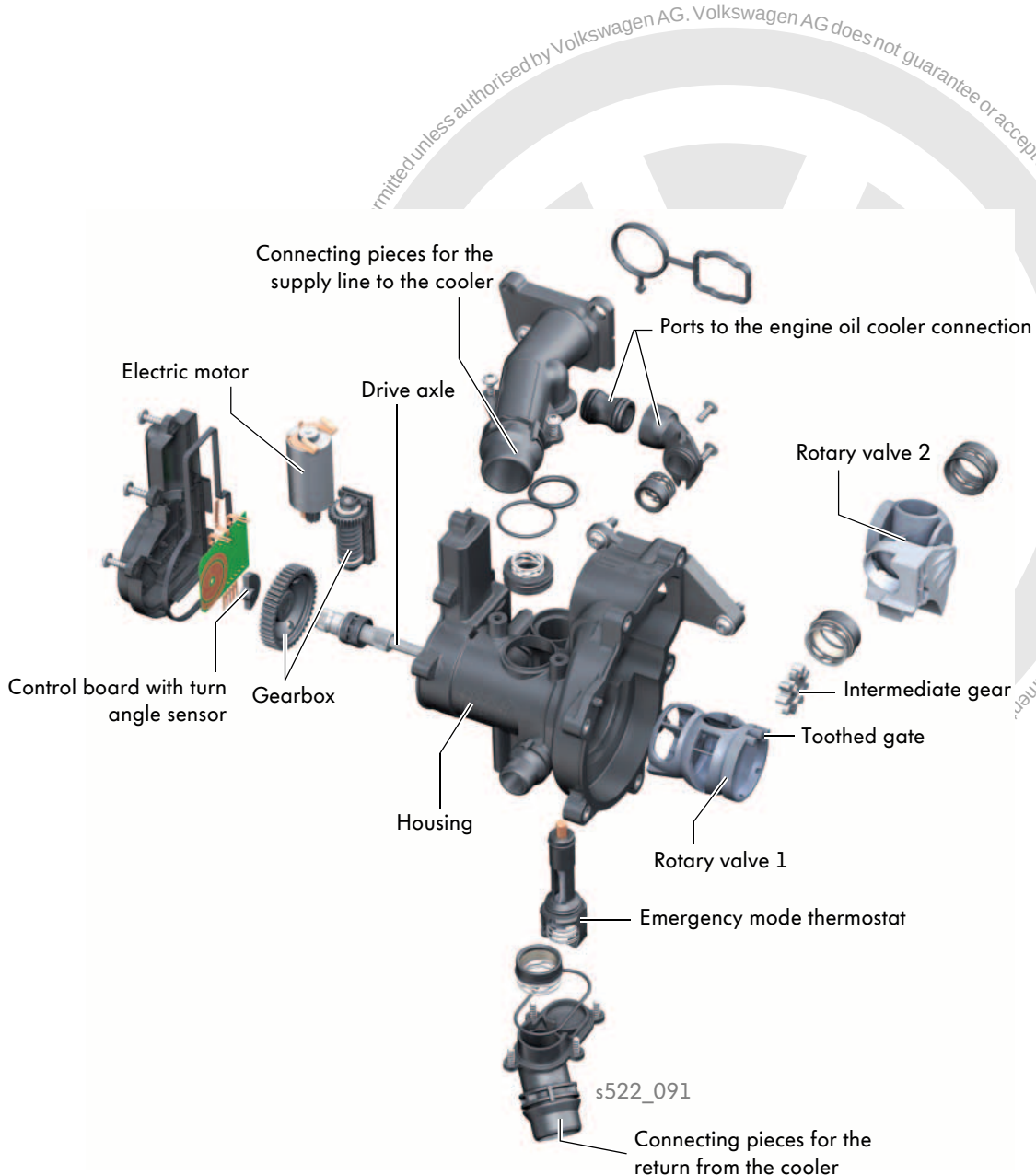
Functional principle of the rotary valve module

The electric motor of the actuator drives the rotary valve 1 via a gear.

It controls the coolant flow between oil cooler, engine and main water cooler. The hotter the engine, the more rotary valve 1 is rotated by the electric motor of the actuator.

Rotary valve 2 is driven by a toothed gate on rotary valve 1 via an intermediate gear.

A turn angle sensor (Hall sender) on the control board communicates the positions of the rotary valve to the engine control unit. After the engine is switched off and the run-on finishes, the rotary valve positions itself at a 40° angle. If there is a fault in the system, the engine can run in this angle range via the emergency thermostat. If there is no fault and the engine is started, the rotary valve is positioned at a 160° angle.

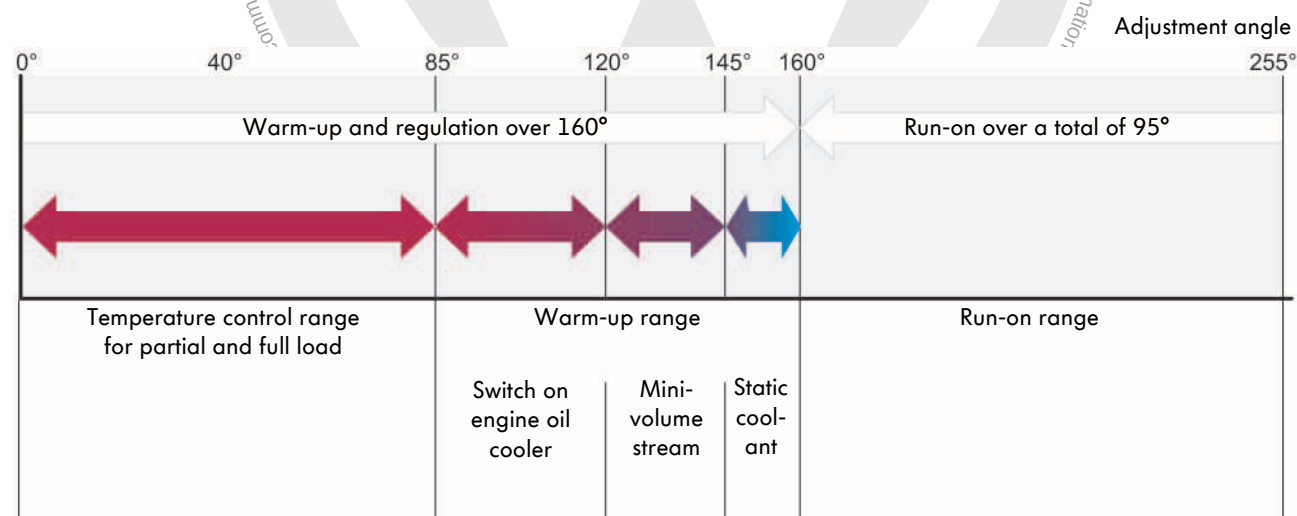


Actuation of the actuator is by means of the engine control unit via maps. By means of a corresponding actuation of the rotary valve, different switch positions are possible that enable running through a fast warm-up phase and keeping the engine temperature between 86°C and 107°C. There are three basic control ranges:

- Warm-up range
- Temperature control range
- Run-on range

The toothed gate on rotary valve 1 is designed so that it engages rotary valve 2 when it is at a 145° angle position. The coolant stream to the cylinder block is opened and rises with the rotation of rotary valve 2. At an angle of 85° on rotary valve 1, rotary valve 2 decouples after it has reached its maximum angle of rotation and the coolant stream to the cylinder block has fully opened.

The warm-up range is in turn divided into three phases of regulation.



s522_107

On the following pages the sequence for the regulation from the warm-up range to the temperature control range and finally to the run-on is described with examples. A highly simplified representation of the rotary valve module and the coolant circuit of the engine is provided.

The electrical drive of both rotary valves in the rotary valve module and the toothed belt drive of the coolant pump are not taken into account in this representation.



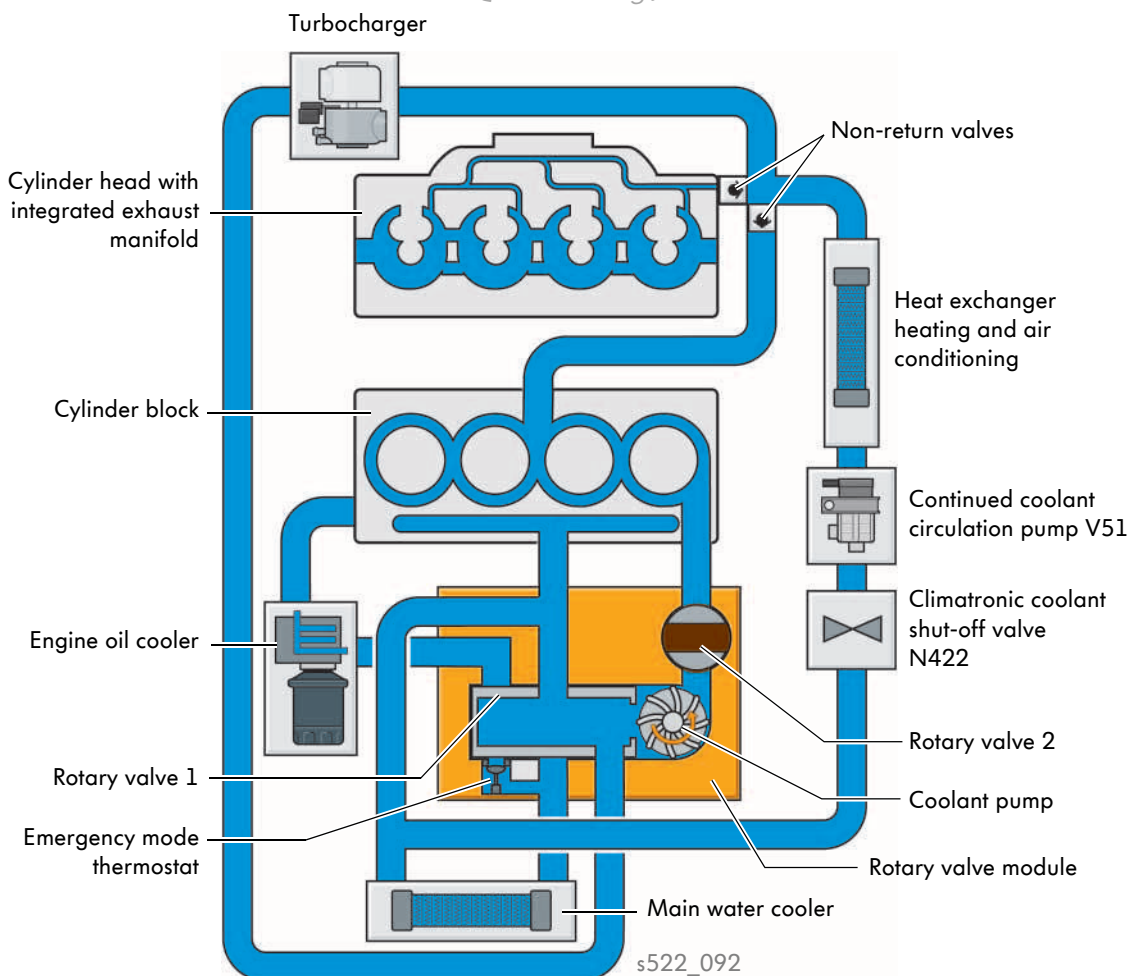
Cooling system

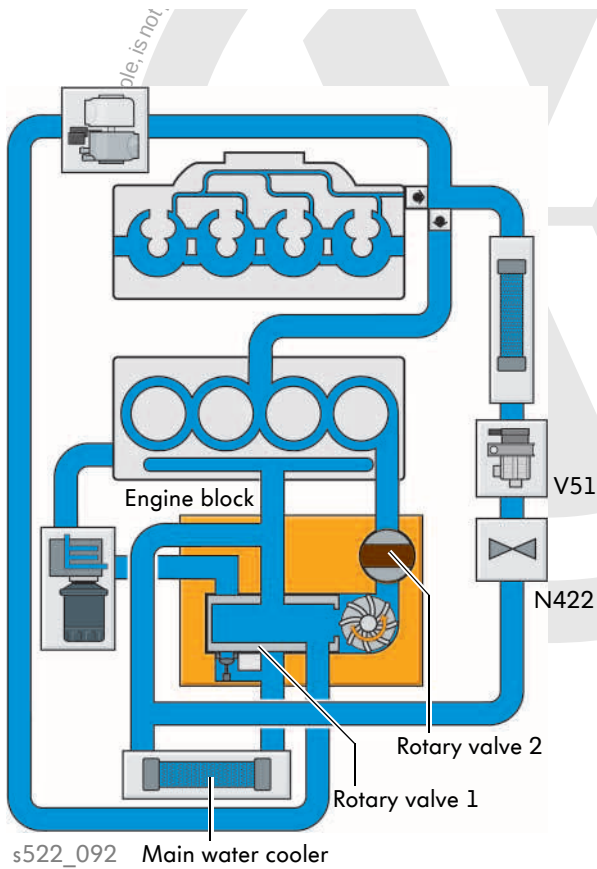
Regulation sequence

During warm-up, the engine runs through three phases:

- Static coolant
- Mini-volume stream
- Switch on engine oil cooler

The individual phases differ in the positions of the two rotary valves and merge seamlessly into each other. The objective is to use the heat resulting from the combustion of the fuel in the cylinders for heating the engine as much as possible. If, however, occupants of the vehicle want heating during the „static coolant” phase, heat energy is provided to the interior.

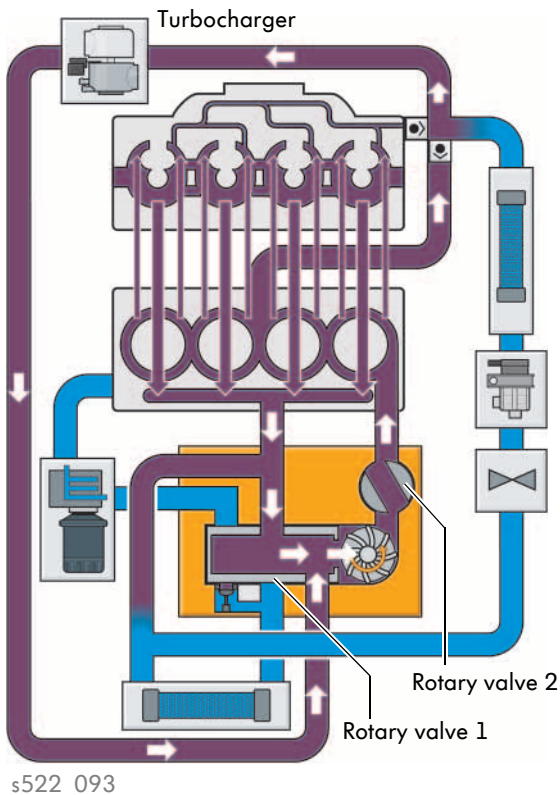




Warm-up with static coolant

To keep the heat resulting from the combustion in the engine, rotary valve 2 is closed. This interrupts the supply stream of the coolant pump to the engine block. Rotary valve 1 blocks the return from the engine oil cooler and the return from the main water cooler.

The climatronic coolant shut-off valve N422 interrupts the coolant stream to the heating and air conditioning system. The electric continued coolant circulation pump V51 is switched off.



Warm-up with mini-volume stream

This control phase in the warm-up range serves to protect the cylinder head and the turbocharger from overheating by the exhaust manifold with static coolant. At a rotary valve 1 angle position of 145°, rotary 2 engages and begins to open slightly the coolant stream to the cylinder block. Now a small coolant stream flows through the cylinder block, the cylinder head and turbocharger back to the rotary valve module and the coolant pump. This prevents an accumulation of heat and the cylinder head/turbocharger from overheating.



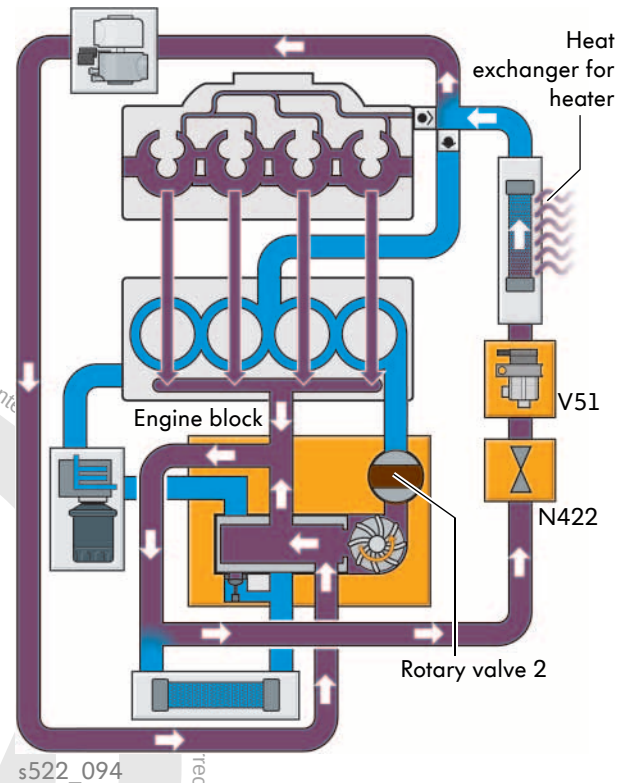
Cooling system

Warm-up with mini-volume stream and heating in the vehicle interior

If heating is required in the interior of the vehicle in this phase, the Climatronic coolant shut-off valve N422 opens and the continued coolant circulation pump V51 starts delivery. Rotary valve 2 temporarily interrupts the coolant flow to the cylinder block.

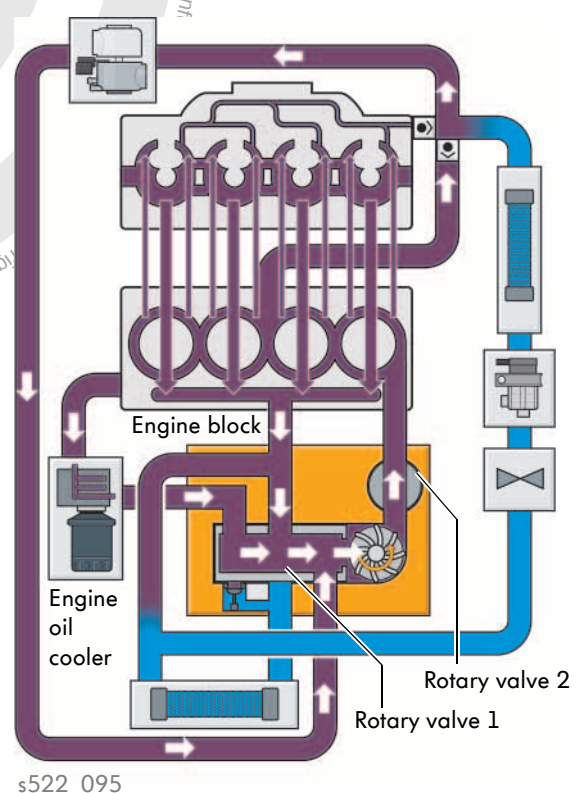
The coolant is directed in this way through the cylinder head, turbocharger and heat exchanger for the heater. This causes the warm-up phase of the engine to take longer.

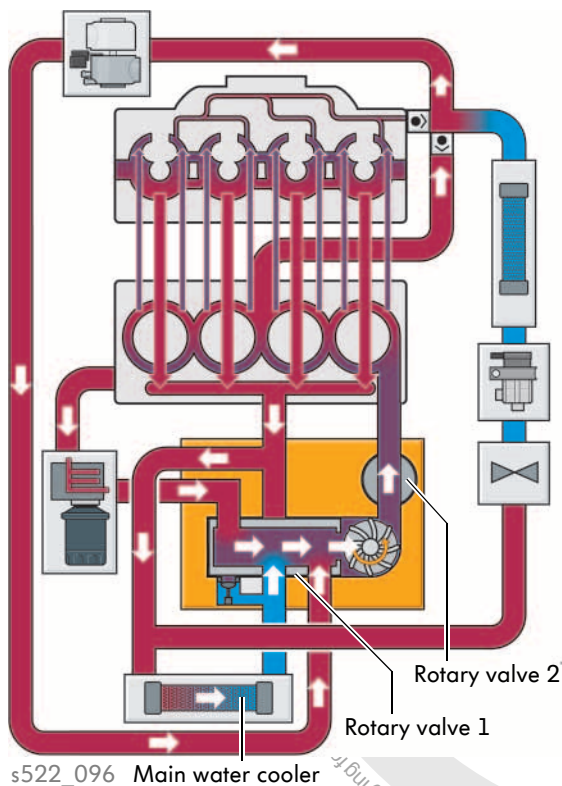
The Climatronic coolant shut-off valve N422 and the continued coolant circulation pump V51 are also always actuated to comply with the requirement in the subsequent control ranges. The coolant stream to the engine block is reduced or blocked by rotary valve 2 as required.



Warm-up with map-controlled engine cooling switched on

Next, the engine oil cooler is switched on during the warm-up phase of the engine. The rotary valve moves to a 120° angle position, opening the coolant connection to the oil cooler. Because rotary valve 2 is still engaged, it also turns more and thereby enlarges the coolant stream through the cylinder block. A large amount of heat distribution takes place in the engine block and excess heat is discharged via the oil cooler.

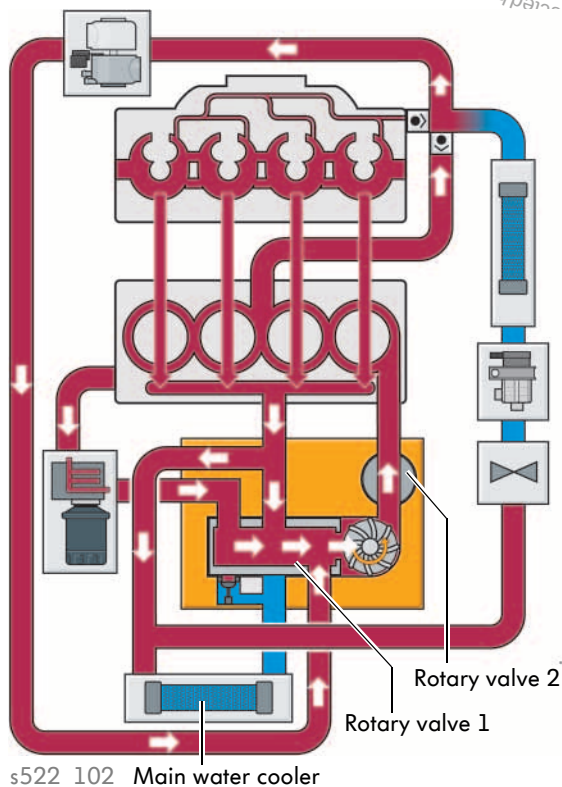




Temperature control range

The innovative thermal management moves seamlessly from the warm-up range to the temperature control range. Here, rotary valve module regulation is dynamic and depends on the engine load.

To conduct excess heat away, the connection to the main water cooler from the rotary valve module is opened. For this purpose, the actuator for engine temperature regulation N493 positions rotary valve 1 in an angle position of 0° and 85°, depending on how much heat has to be conducted away. For a rotary valve 1 angle position of 0° the connection to the main water cooler is fully opened.



If the engine is running at a lower load and speed (partial load range), the thermal management adjusts the coolant temperature to 107°C. Since the full cooling power is not required, rotary valve 1 temporarily closes the connection to the main water cooler. If the temperature rises above this threshold value, the connection to the main water cooler is opened again. Constant opening and closing is necessary to keep the temperature as much as possible at a constant 107°C.

When load and engine speed increase, coolant temperature is reduced to 85°C (full load range) by first completely opening the connection to the main water cooler.



Cooling system

Run-on range when switching off the engine

To prevent the coolant from boiling in the cylinder head and in the turbocharger when the engine is switched off, the engine control unit starts a run-on function via a map. It can be active for up to 15 minutes after the engine is switched off.

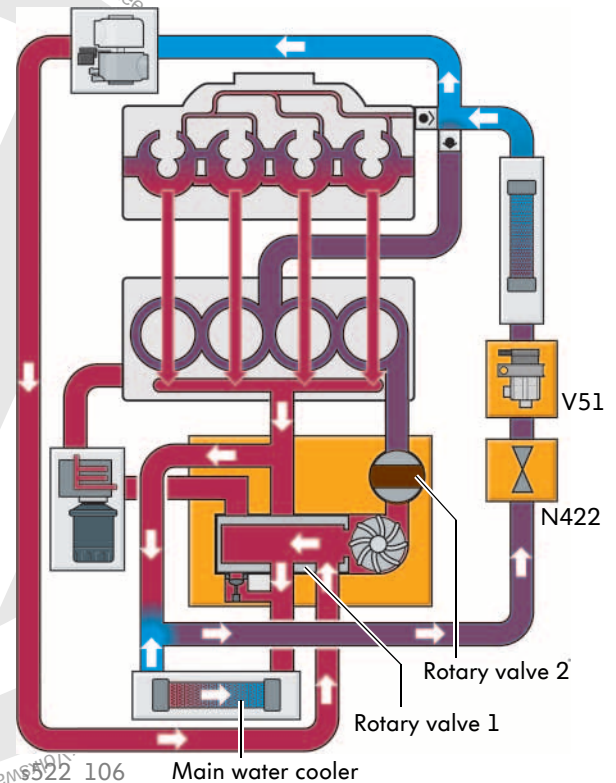
For the run-on function, rotary valve 1 of the actuator for engine temperature regulation N493 is positioned at an angle of between 160° and 255° .

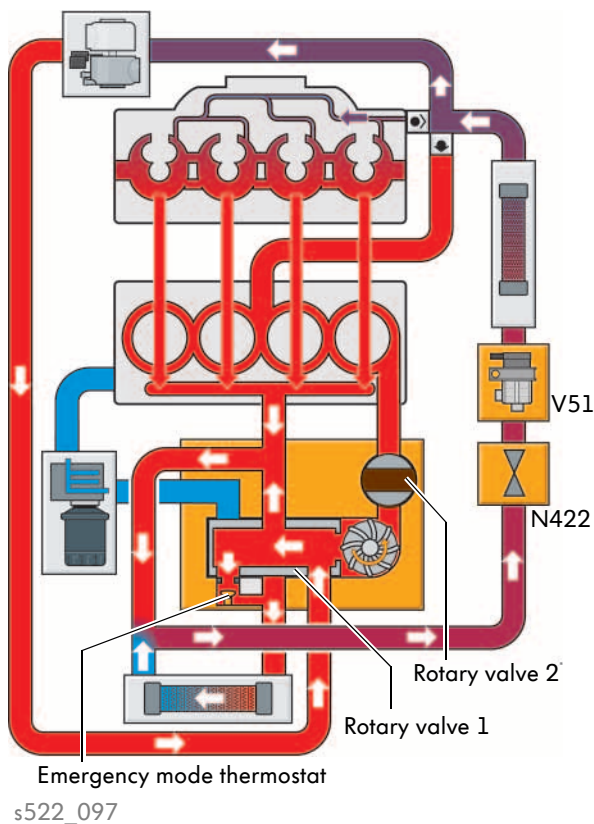
The greater the run-on cooling requirement, the higher the angle position. At 255° the connection to the return line of the main water cooler is fully open so that maximum heat is conveyed away.

Rotary valve 2 is in the run-on position and not engaged in rotary valve 1. Supplied by continued coolant circulation pump V51, the coolant now flows in two sub-streams in the coolant circuit.

One sub-stream flows over the cylinder head and back to the continued coolant circulation pump V51. A second sub-stream flows via the turbocharger through rotary valve 1 to the main water cooler and likewise back to the continued coolant circulation pump V51.

The cylinder block is not supplied with coolant in the run-on position.





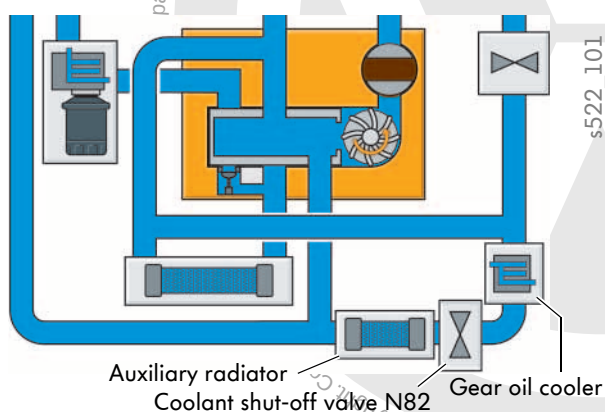
Emergency mode strategy

If the temperature in the rotary valve module exceeds 113°C, the emergency thermostat opens a bypass to the main water cooler. This design feature enables the vehicle to continue travelling to a limited extent if the rotary valve module is defective. If the engine control unit receives no position feedback from the actuator for engine temperature regulation N493, it actuates the rotary valve so that maximum engine cooling is guaranteed regardless of the current engine load and operating temperature.

In the event of a malfunction of the rotary valve module (e.g. if the electric motor fails or the rotary valve drive jams) further measures include:

- A fault message is displayed in the dash panel insert and, concurrently, engine speed is limited to 4,000 rpm. A warning tone and the switched on EPC lamp also make the driver aware of the situation.
- The actual coolant temperature in °C is digitally displayed in the dash panel insert.
- The coolant shut-off valve N422 is opened.
- The continued coolant circulation pump V51 is switched on to ensure cylinder head cooling.
- An entry is made in the event memory of the engine control unit.

If the position signal from the turn angle sensor fails, the engine control unit actuates the rotary valve to be on the safe side so that the maximum cooling function is achieved.



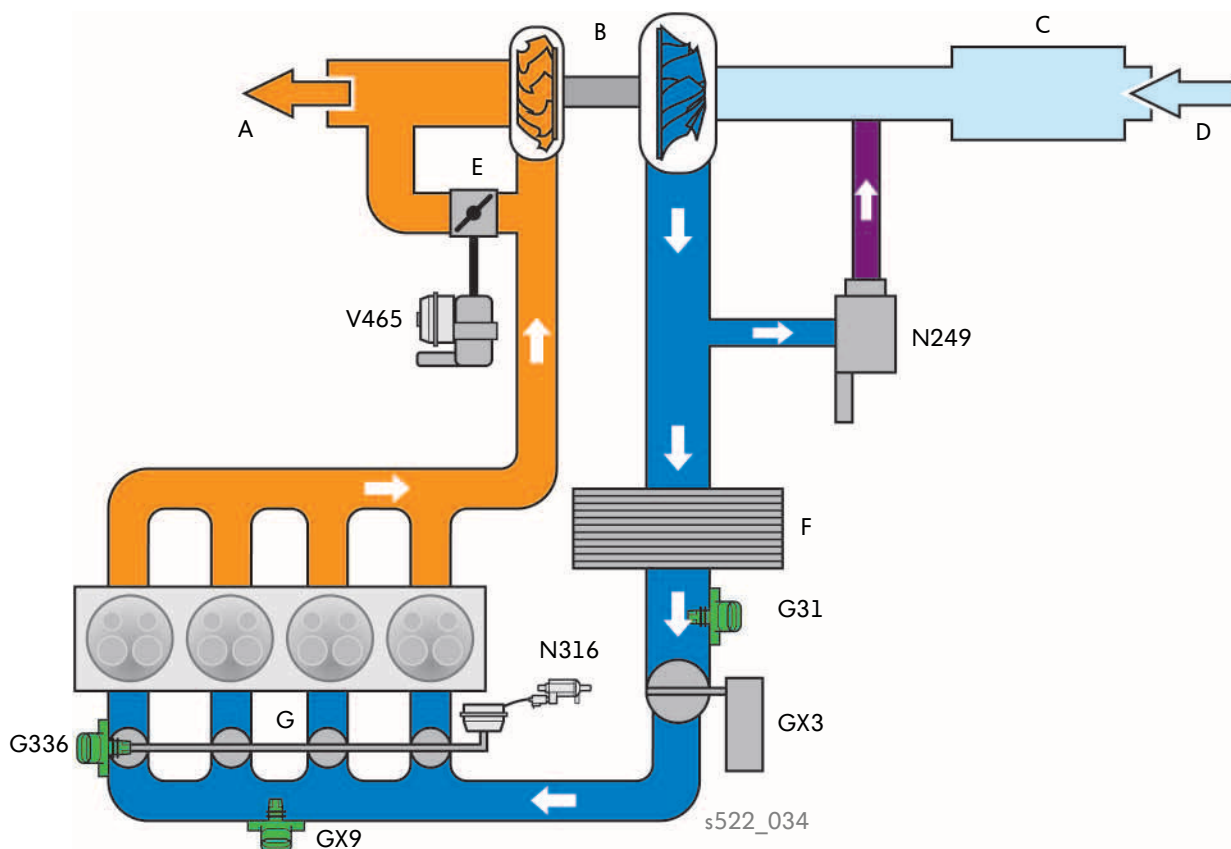
2.0 | 162 kW / 169kW TSI engines with dual clutch gearbox

If the engine has a dual clutch gearbox (DSG), the coolant circuit is expanded to include the gear oil cooler, coolant shut-off valve N82 and an auxiliary radiator. The individual regulation steps in the temperature management correspond to those of engines without DSG.



Air supply unit and forced induction

Overview of the charge air system



Legend

GX9 Intake manifold sender with:

- G31 Charge pressure sender
- G42 Intake air temperature sender
- G71 Intake manifold pressure sender

GX3 Throttle valve module with:

- G186 Throttle valve drive for electric throttle
- G187 Throttle valve drive angle sender 1 for electric throttle
- G188 Throttle valve drive angle sender 2 for electric throttle
- G336 Intake manifold flap potentiometer
- J338 Throttle valve module

N249 Turbocharger air recirculation valve

- N316 Intake manifold flap valve
- V465 Charge pressure positioner
- A Exhaust gas flow
- B Turbocharger
- C Air filter
- D Fresh air stream
- E Wastegate flap
- F Charge air cooler
- G Intake manifold flaps

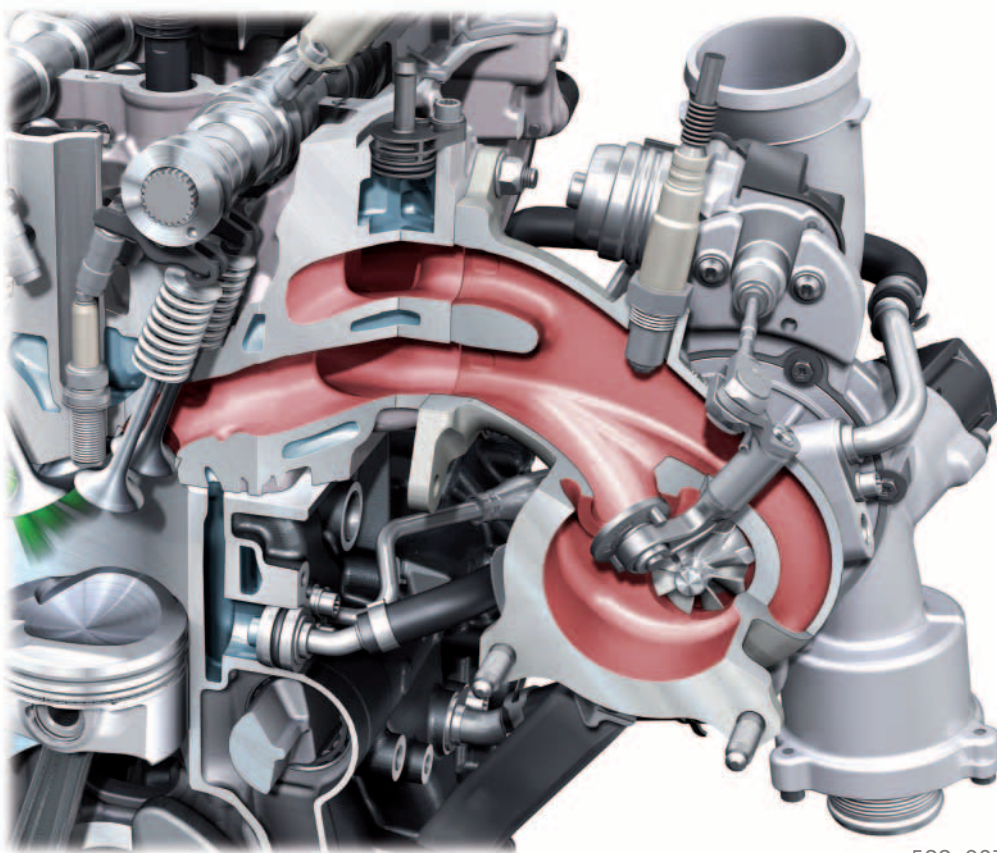
- Exhaust gas
- Intake air (negative pressure)
- Charge air (charge pressure)
- Overrun recirculation (charge pressure)

Turbocharger

The new 2.0 TSI engines use a newly developed turbocharger with an electric charge pressure positioner. It is bolted directly to the exhaust manifold integrated into the cylinder head.

Further features of the new turbocharger are:

- Electrical wastegate adjustment with charge pressure positioner V465 and the position sender for charge pressure positioner G581
- Lambda probe GX10 (with lambda probe G39 and lambda probe heater Z19) upstream of the turbocharger
- Compact cast-steel turbine housing with twin-track exhaust gas recirculation
- Compressor housing with integrated resonance silencer and electric turbocharger air recirculation valve N249
- Turbine wheel made of a special steel alloy with a temperature resistance of up to 980°C
- Bearing seat with uniform connections for oil and coolant



s522_037



Air supply unit and forced induction

Design

Turbine housing and turbine wheel

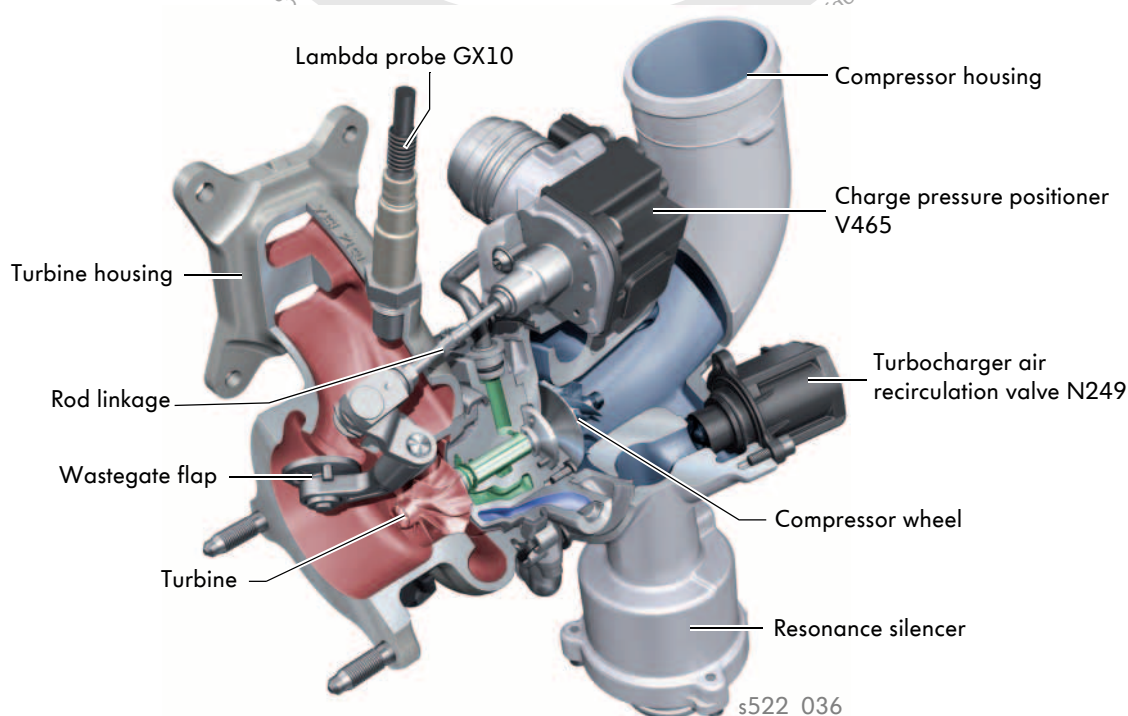
The turbine housing is produced with a new cast steel material to make it temperature resistant up to 980°C. The twin-track duct conduction of the exhaust gas from the exhaust manifold is maintained in the turbocharger until just before the turbine. This results in the best possible firing sequence separation. The load performance of the turbine has been particularly improved in the upper rpm range.

Compressor housing and compressor wheel

The compressor housing is made of cast aluminium. Due to high actuation forces by the charge pressure positioner, its construction has been reinforced. A resonance silencer is located directly on the compressor housing. The electric turbocharger air recirculation valve N249 regulates the air flow to the resonance silencer. The connecting flange to the entrance of the blow-by gasses from the crankcase breather is integrated into the compressor housing.

Lambda probe GX10

Lambda probe GX10 is a broadband lambda probe. It is bolted directly into the connecting flange of the turbocharger on the cylinder head. Because it is mounted close to the engine, the probe records the exhaust gas of each cylinder. This enables a significantly earlier dew point end and thereby an earlier enablement of the lambda regulation about 6 seconds after engine startup.

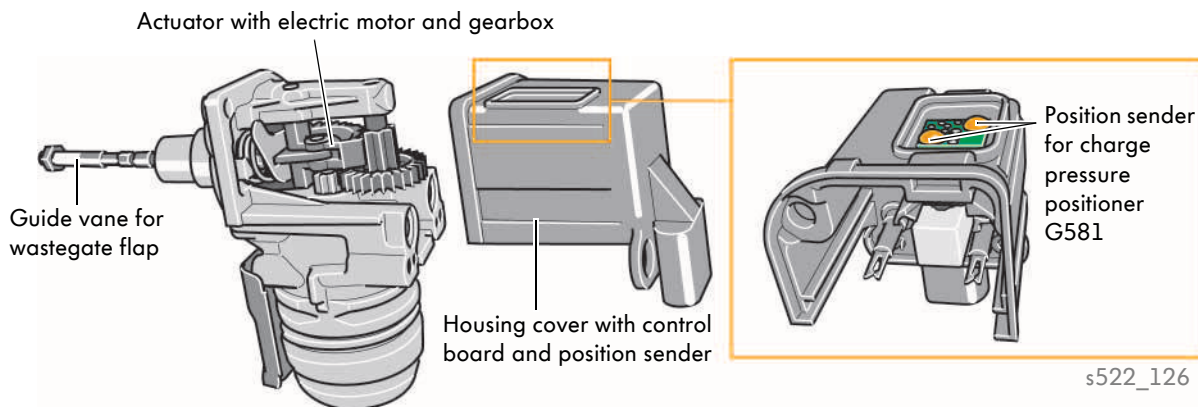


Charge pressure positioner V465

On charge pressure positioner V465, the wastegate flap of the turbocharger is actuated by means of an electric motor and a gearbox, which moves the wastegate flap push rod.

The electric motor drive permits fast and precise charge pressure control and also has the following advantages:

- Activation of the wastegate flap is possible regardless of the pending charge pressure.
- The high pressing force of the wastegate flap contributes to reaching the maximum torque of 350Nm beginning at an engine speed of 1500 rpm.
- Opening the wastegate flap in the partial load range lowers the basic charge pressure. This reduces CO₂ emissions by about 1.2g/km.
- Opening the wastegate flap during catalytic converter heating produces a 10°C higher exhaust gas temperature upstream of the catalytic converter. This means lower cold-start emissions.
- The high adjustment speed of the charge pressure positioner causes an immediate reduction in charge pressure during load changes and in overrun mode.



The position sender for charge pressure positioner G581

The position sender for charge pressure positioner G581 is a Hall sensor that is integrated in the housing of the charge pressure positioner. A solenoid holder with two connected permanent magnets is on the mechanical part of the gearbox. They perform the same longitudinal movement as the push rod. The Hall sensor detects the movement of the solenoid and sends the information to the engine control unit. In this way the engine control unit determines the position of the wastegate flap.

Charge pressure positioner V465 cannot be individually replaced.

You will find further information about the resonance silencer in Self-study Programme no. 401 „The 1.8l 118 kW TFSI engine with timing chain“.



Overview of the fuel system



Legend

G6	Fuel system pressurisation pump	A	Fuel filter
G247	Fuel pressure sender	B	Fuel tank
G410	Fuel pressure sender for low-pressure	C	High-pressure fuel pump
J538	Fuel pump control unit	D	Fuel low-pressure rail
N276	Fuel pressure regulating valve	E	Fuel high-pressure rail
N30- N33	Injectors, cylinders 1-4		High-pressure system
N532- N535	Injectors 2, cylinders 1-4		Fuel system / low pressure system
			Actuator / output signal
			Sensor / input signal

Mixture formation

The new 2.0 I TSI engines have a dual injection system. This means there are two fuel mixture methods.

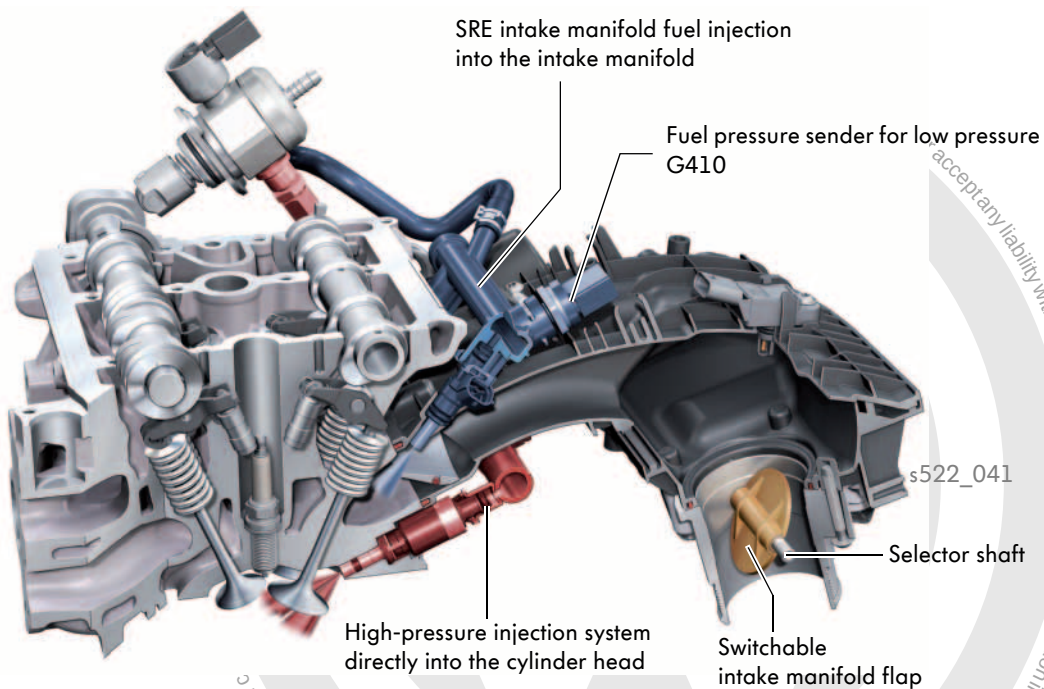
One method is direct injection in the cylinder with the TSI high-pressure injection system.

The second method uses the intake manifold fuel injection system (SRE).

Intake manifold fuel injection greatly reduces the emission of fine soot particulates.

Further development objectives of the dual injection system are:

- To increase pressure in the high-pressure fuel system to 150–200 bar
- To reach the particulate threshold values of the new EU6 emission standard concerning particulate mass and the number of particulates
- To reduce CO₂ exhaust emissions
- To lower consumption in the partial load range
- To include the intake manifold fuel injection
- To improve engine acoustics



Intake manifold

The stainless steel intake manifold flaps of the selector shafts are boat shaped. This shape prevents vibration excitation of the flaps caused by air flow. The flap position is monitored by intake manifold flap potentiometer G336.

Actuation of the selector shaft is via the intake manifold flap valve N316.

The torque and rpm dependent switch times are stored in a map.

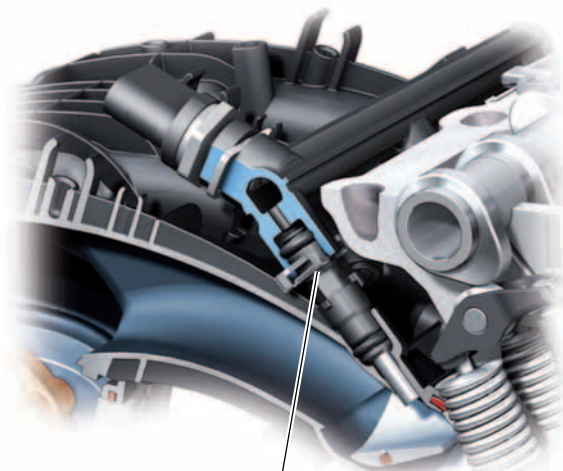


Fuel system

SRE fuel injection system

The SRE injection system is supplied by a divert connection on the high-pressure fuel pump. The divert connection is part of the fuel low-pressure system. Upstream of the divert connection, the fuel enters the fuel low-pressure rail and from there into the SRE injectors, which inject the fuel into the intake manifold. With fuel pressure sender for low-pressure G410 the SRE injection system has its own pressure sensor for monitoring the fuel supply system. Fuel supply is only via fuel system pressurisation pump G6 in the fuel tank and not via the high-pressure fuel pump.

The use of the divert connection of the high-pressure fuel pump for the fuel line means that the high-pressure fuel pump is diverted and thus cooled even in SRE mode. In SRE mode the high-pressure pump delivery via fuel pressure regulating valve N276 can be turned off.



SRE injector

s522_043

The intake manifold fuel injection is used mainly in the partial load range. There the fuel droplets have enough time to atomize and mix with the air. The mixture formation long before ignition results in:

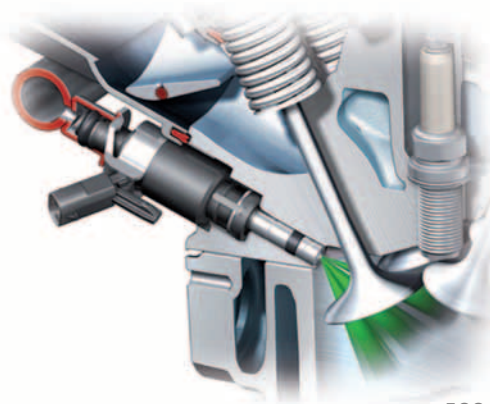
- Reduction of particulate mass and soot formation
- Lower CO₂ emissions
- Reduced fuel consumption

High-pressure injection system

The increased fuel pressure of up to 200 bar made it necessary to adapt the design of the high-pressure fuel system.

The high-pressure injectors were acoustically uncoupled from the cylinder head by using sealing rings. The position of the valves has been moved back slightly. This improves the mixture formation and reduces the temperatures of the valves.

The high-pressure fuel rail has been acoustically uncoupled from the intake manifold.



s522_042

Modes of operation

The regulation concept for executing modes of operation has been standardised in a map. The map defines whether and when the engine is driven in SRE and when in high-pressure mode. The following modes of operation are available:

- SRE single injection
- High-pressure single injection
- High-pressure dual injection
- High-pressure triple injection

Depending on the temperature, load and engine speed, the system changes between the individual modes of operation.

Engine start

When the engine is cold with a coolant temperature under 45°C and for each engine start, a triple direct fuel injection takes place via the high-pressure injection system in the compression cycle.

Engine running under full load

Due to the high performance requirement, the system switches into high-pressure mode. A dual direct fuel injection takes place in the intake and compression cycle.

Warm-up and catalytic converter heating

In this phase a dual direct fuel injection takes place in the intake and compression cycle. The firing point is somewhat retarded. The intake manifold flaps are closed.

Emergency running function

If one of the injection systems fails, the engine is driven only in the remaining system by the engine control unit. This guarantees that the vehicle remains ready to drive. The red engine indicator lamp in the instrument cluster lights up.

Engine runs in the partial load range

If the engine temperature is above 45°C and the engine is driven in the partial load range, it is switched over to SRE mode. The intake manifold flaps remain mostly closed.

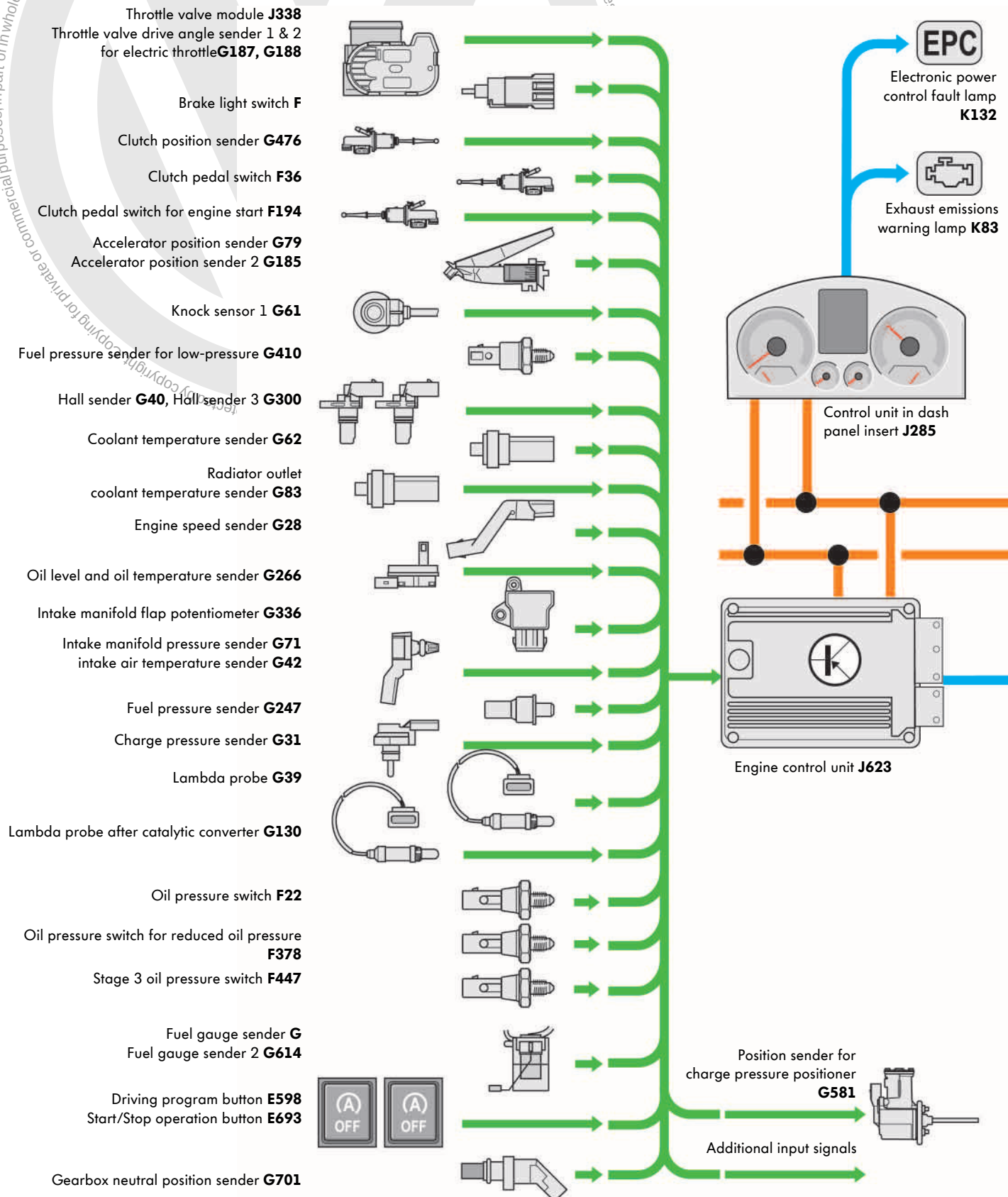


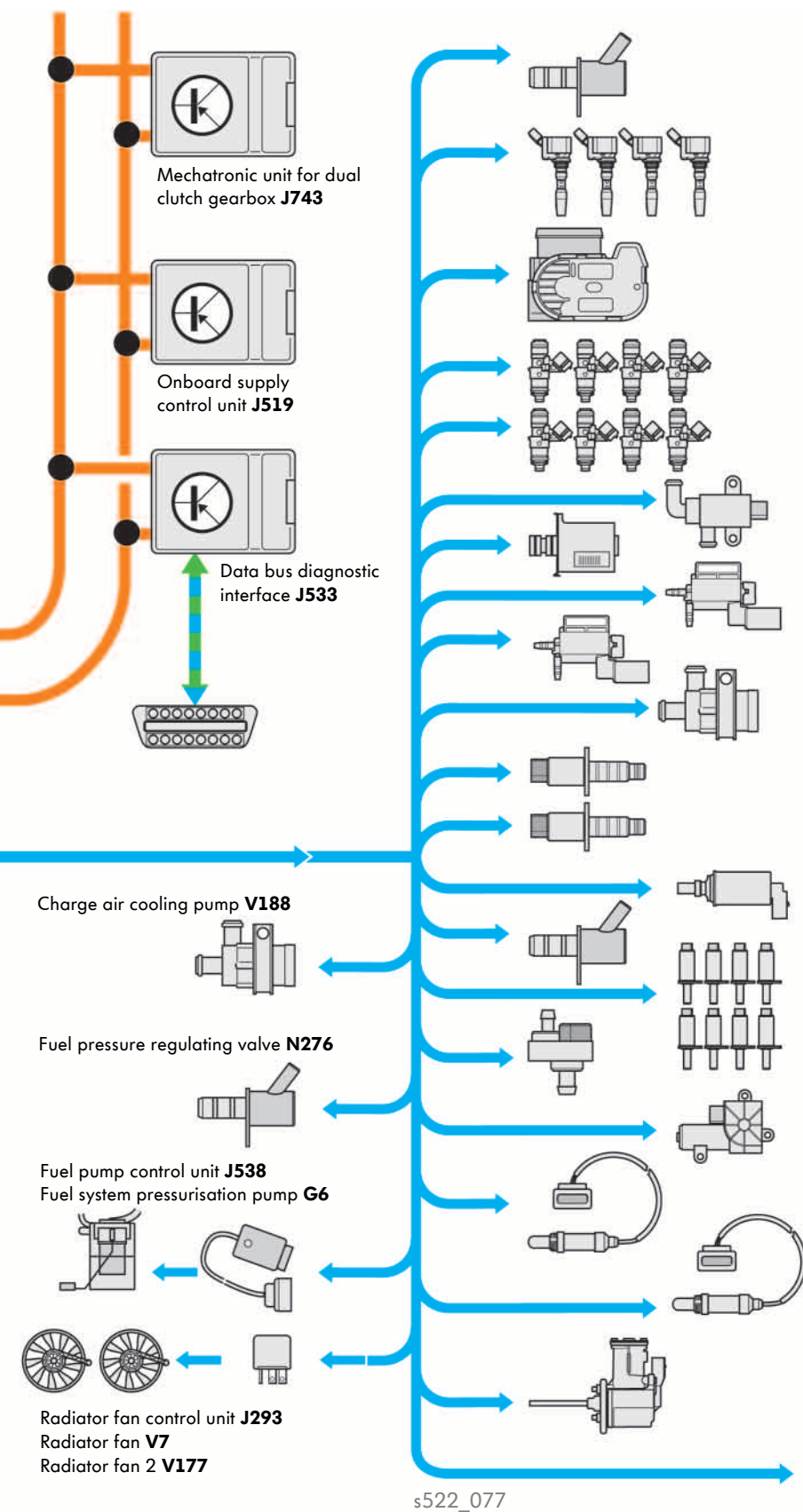
To depressurise the injection system, the engine must be running and the plug from the fuel pressure regulating valve N276 must be removed. A certain amount of residual pressure from the fuel system pressurisation pump G6 remains. It is very important to follow the instructions in ELSA!



Overview of the system

Sensors





s522_077

Actuators

Piston cooling jet control valve **N522**

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

Throttle valve drive for electric throttle **G186**

Injector 2, cylinders 1-4 **N532-535**

Injectors, cylinders 1-4 **N30-33**

Coolant shut-off valve **N82**

Turbocharger air recirculation valve **N249**

Intake manifold flap valve **N316**

Climatronic coolant shut-off valve **N422**

Continued coolant circulation pump **V51**

Camshaft control valve 1 **N205**

Exhaust camshaft control valve 1 **N318**

Fuel metering valve **N290**

Valve for oil pressure control **N428**

Exhaust cam actuator A/B for cylinders 1-4 **N580, N581, N588, N589, N596, N597, N604, N605**

Activated charcoal filter solenoid valve 1 **N80**

Actuator for engine temperature regulation **N493**

Lambda probe heater **Z19**

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

Charge pressure positioner **V465**

Additional output signals



Special tools

Designation	Tool	Usage
T10133/16A Disassembly tool	 s522_112	Removal of the high-pressure injectors. This tool replaces previous disassembly tool T10133/16.
T10133/18 Sleeve	 s522_056	Removal of the high-pressure injectors.
T401243 Lever	 s522_057	Tool for retracting the crankshaft tensioner.
T40267 Locking tool	 s522_058	Locking the crankshaft tensioner of the timing chain.
T40274 Extractor hook	 s522_059	Removal of the crankshaft O-ring.
T40270 Socket insert XZN 12	 s522_060	Removal and installation of the assembly mountings.



Designation	Tool	Usage
T40191/1 Spacers Instruction chart: W00-10704	 s522_117	For installation of the ball coupling on the exhaust camshaft with sliding pieces.
T40058 Adapter	 s522_073	For turning the camshafts.
T40271 Fastener	 s522_061	Fastening for the sprocket wheels on the camshafts.



New component clusters

Thanks to the further development of the electronic components, it is possible to group various sensors and actuators together in component clusters. The following table provides an overview of the new designation of the clusters and their constituent sensors and actuators.

Component cluster	Included sensors and actuators
Accelerator pedal module GX2	Accelerator pedal position sender G79 and sender 2 for accelerator pedal position G185
Throttle valve module GX3	Throttle valve control unit J338, throttle valve drive for electric throttle G186, throttle valve drive angle sender 1 for electric throttle G187, and throttle valve drive angle sender 2 for electric throttle G188
Lambda probe 1 after catalytic converter GX7	Lambda probe after catalytic converter G130 and lambda probe 1 heater after catalytic converter Z29
Intake manifold sender GX9	Intake manifold pressure sender G71 and intake air temperature sender G42
Lambda probe 1 before catalytic converter GX10	Lambda probe G39 and lambda probe heater Z19
Dash panel insert KX2	Control unit in dash panel insert J285
Radiator fan VX57	Control unit for radiator fan J293, radiator fan V7 and radiator fan 2 V177
Switch module in console EX23	Driving program button E598 and Start/Stop operation button E693



Which answers are correct?

One or several of the given answers may be correct.

1. The electric wastegate enables ...

- ☐ a) higher pressing forces.
- ☐ b) higher exhaust gas temperature for catalytic converter heating.
- ☐ c) reduction of charge pressure for load changes.

2. What are the important features of the rotary valve module?

- ☐ a) It regulates the coolant stream to the heat exchanger for the heater.
- ☐ b) The actuator for temperature regulation also contains a thermostat that can be opened in an emergency.
- ☐ c) The bolted connection of the input pinion on the balancer shaft has a left-hand thread.

3. The piston cooling jets are ...

- ☐ a) mechanically actuated at a high oil pressure level.
- ☐ b) actuated by the stage 3 oil pressure switch F447.
- ☐ c) actuated via a control valve on the ancillary unit carrier.

4. In suction mode of the engine, the blow-by gasses are ...

- ☐ a) directed before the turbocharger.
- ☐ b) directed into the intake manifold.
- ☐ c) returned back to the crankcase via the fine oil separator.



Test your knowledge

5. What is the advantage of valve-travel switching?

- ☐ a) At high speeds the gas exchange is optimised.
- ☐ b) Exhaust gas streams are prevented from returning to the emitting cylinder.
- ☐ c) The residual gases are reduced by means of a positive difference in pressure in the combustion chamber.

6. Which statements about the dual injection system are correct?

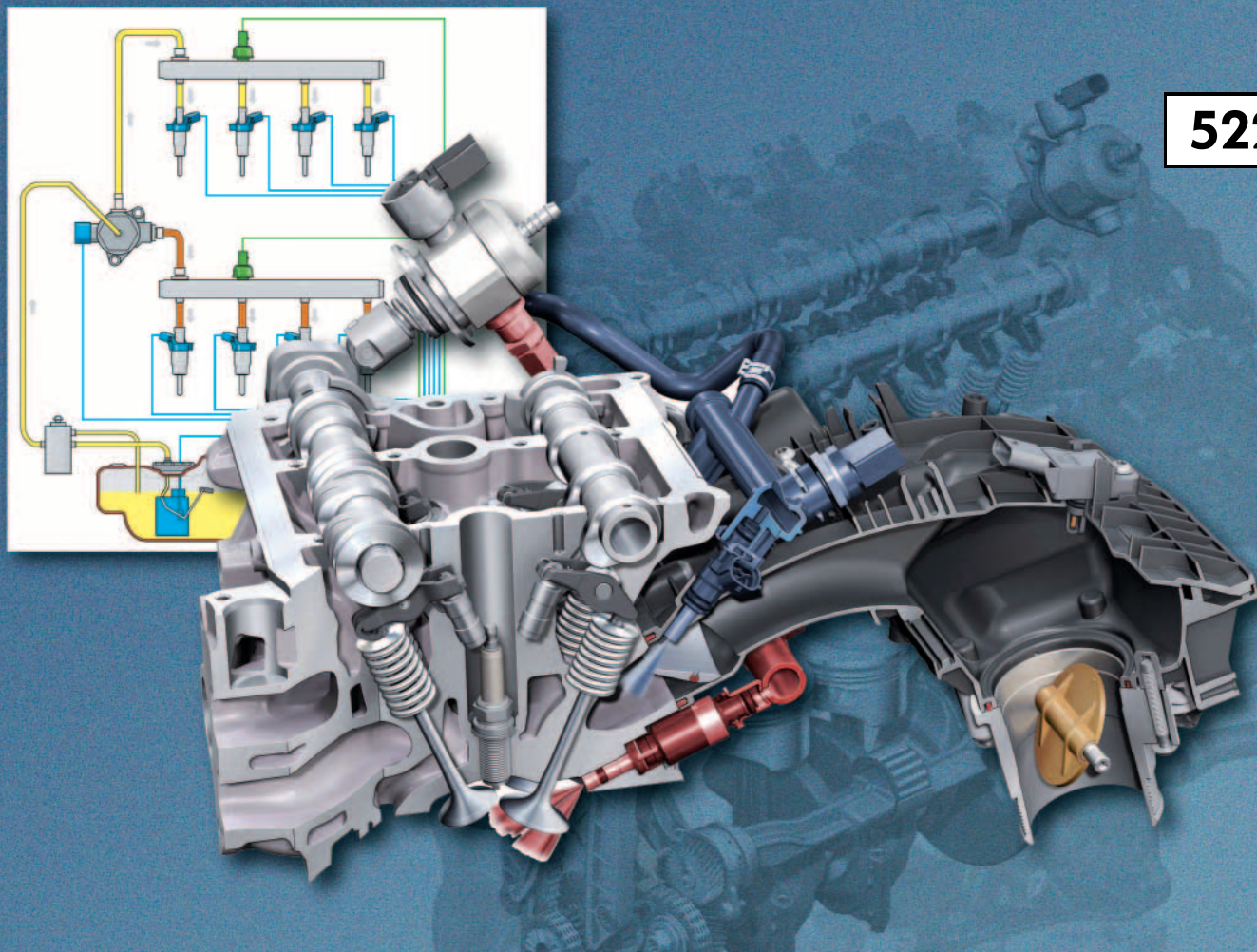
- ☐ a) Higher performance is available with intake manifold fuel injection and direct fuel injection.
- ☐ b) The fuel droplets have more time to gasify in the intake manifold mode.
- ☐ c) In the intake manifold mode, dual injection is also possible for reducing the particulate mass.

7. What is important to know about the chain drive?

- ☐ a) There is a chain elongation diagnosis.
- ☐ b) Chain elongation can be recognised on the chain tensioner via rings.
- ☐ c) After a cylinder head was removed and then mounted again, a chain elongation diagnosis must be performed.

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





© VOLKSWAGEN AG, Wolfsburg
All rights and rights to make technical alterations reserved.
000.2812.79.20 Technical status 08/2013

Volkswagen AG
After Sales Qualification
Service Training VSQ-2
Brieffach 1995
D-38436 Wolfsburg

♻️ This paper was manufactured from pulp that was bleached without the use of chlorine.