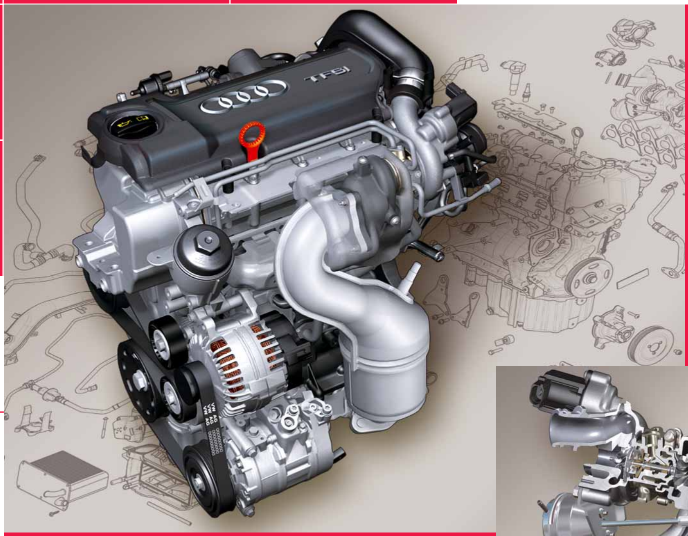
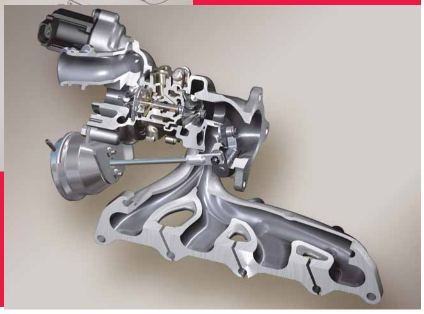
Service Training





The Audi 1.4l TFSI Engine

Self-Study Programme 432

432_072

With the 1.4l TFSI engine, Audi introduces a modern power plant for the entry-level segment. The new engine has been systematically developed according to the so-called "*downsizing** concept". It represents a major step towards the development of more fuel-efficient and cleaner engines. In specific terms, this means that non-charged engines will be replaced by smaller, turbocharged units. The aims of downsizing are, above all, to reduce overall weight, to minimise friction, to improve fuel efficiency, to achieve lower exhaust emissions and, of course, to create a more compact engine that requires less space. This, in turn, has further advantages in terms of the utilisation of space in the vehicle.

The 1.4l TFSI engine was developed by Volkswagen in association with Audi and will be used throughout the Group. The basis for the joint development project was the 1.4l TSI engine with dual charging by Volkswagen.

The new 1.4l TFSI engine will be used on the Audi A3 and A3 Sportback. It is positioned between the 1.6l MPI engine (75 kW) and 1.8l TFSI engine (118 kW). With a maximum power output of 92 kW (125 bhp), peak torque of 200 Nm and exceptional fuel efficiency for an engine of this size, customers can look forward to a powerplant that combines performance and economy. The 1.4l TFSI engine combines with a long-throw 6-speed manual gearbox or the 7-speed twin-clutch gearbox to create a compelling powertrain concept that offers driving enjoyment without any regrets.

432_071

The objectives of this Self-Study Programme

In this Self-Study Programme you will learn about the design and operation of the 1.4l TFSI engine. Once you have worked your way through this Self-Study Programme, you will be able to answer the following questions:

– How is the engine designed mechanically?
– How does the oil supply system work?
– What are the special features of the air supply system?
– How does the cooling system work, and to what should attention be paid during servicing?
– What are the special features of the improved fuel system?
– How is the exhaust gas turbocharger designed?
– What are the new features of the engine management system?
– What are the special points which have to be kept in mind during servicing?

Contents

Engine mechanicals

Oil circulation system

Cooling system

Fuel system

Intake and exhaust system

Engine management

Service

Annex

The Self-Study Programme teaches the design and function of new vehicle models, new automotive components or new technologies.

The Self-Study Programme is not a Repair Manual. The values given are for illustration purposes only and refer to the software version valid at the time of publication of the SSP.

For information about maintenance and repair work, always refer to the current technical literature. Terms written in italics or indicated by an asterisk (*) are explained in the glossary at the back of this Self-Study Programme.

Reference

Note

Brief technical description

- Four-cylinder petrol engine with four valves per cylinder and turbocharging

- Engine block
  Cast iron cylinder crankcase,
  steel crankshaft,
  in-sump oil pump chain driven by the crankshaft,
  timing gear chain at the front of the engine

- Cylinder head
  4-valve cylinder head,
  single intake camshaft adjuster

- Fuel supply
  Demand controlled on the low and high pressure sides,
  multi-connection high-pressure injectors

- Combustion process
  Direct injection, homogeneous

- Engine management
  Bosch MED 17.5.20 engine control unit,
  throttle valve with contactless sensor,
  map-controlled ignition with cylinder-selective,
  digital knock control, single-spark ignition coils

- Turbocharging
  Integral exhaust turbocharger,
  charge air cooler,
  boost pressure control with modulated charge pressure,
  electrical wastegate valve

- Exhaust system
  Single-chamber exhaust system with close-coupled catalytic converter,
  use of a nonlinear sensor upstream and downstream of the catalytic converter.

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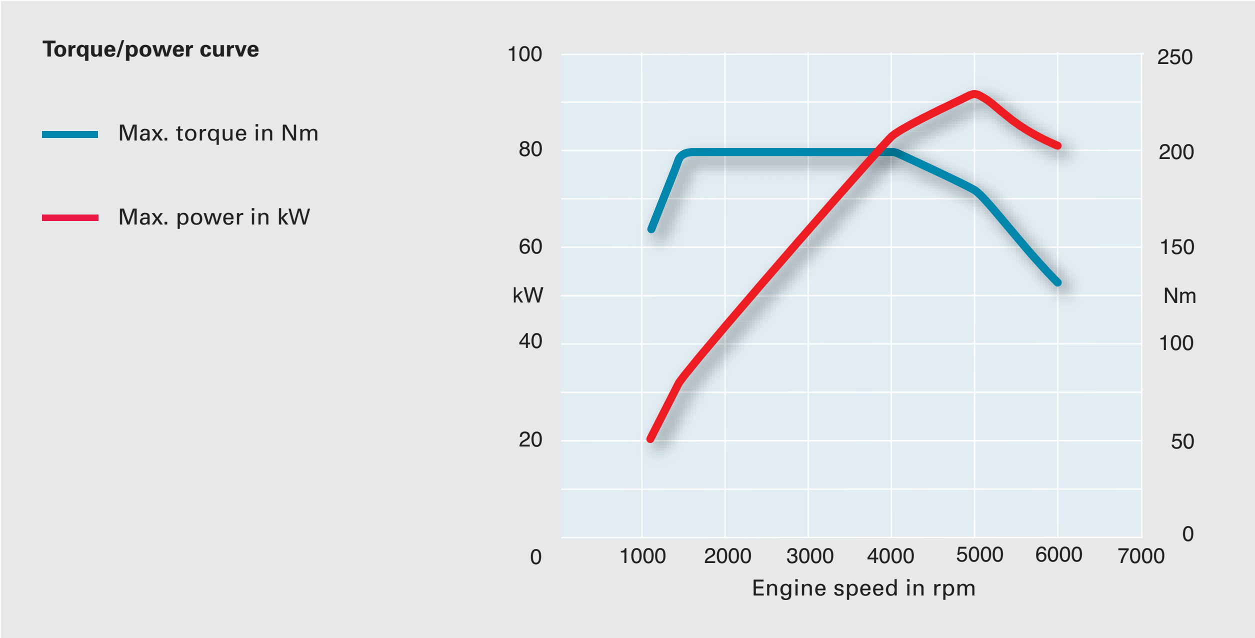
Fuel consumption

The engine is notable for its exceptional fuel economy of 6.2 l per 100 km (manual gearbox) at market launch.

When the annual model changeover takes place in 2009, that figure will be reduced again to 5.9 l per 100 km for the manual gearbox and 5.6 l per 100 km for the twin-clutch gearbox.



Specifications

Engine code	CAXC
Engine type	Four-cylinder inline engine
Displacement in cm^3	1390
Max. power in kW (bhp)	92 (125) at 5000 rpm
Max. torque in Nm	200 at 1500 – 4000 rpm
Valves per cylinder	4
Bore in mm	76.5
Stroke in mm	75.6
Compression ratio	10.0 : 1
Firing order	1–3–4–2
Engine weight in kg	approx. 129
Engine management	Bosch MED 17.5.20
Fuel grade	95 RON
Mixture formation	Direct injection/fully electronic with drive-by-wire throttle control, High-pressure fuel pump: HDP 3 (Hitachi)
Exhaust emission standard	EU 4
Exhaust aftertreatment	Exhaust system with close-coupled ceramic material catalytic converter and one nonlinear sensor upstream and downstream of the catalytic converter
CO_2 emissions in g/km	154

Cylinder block

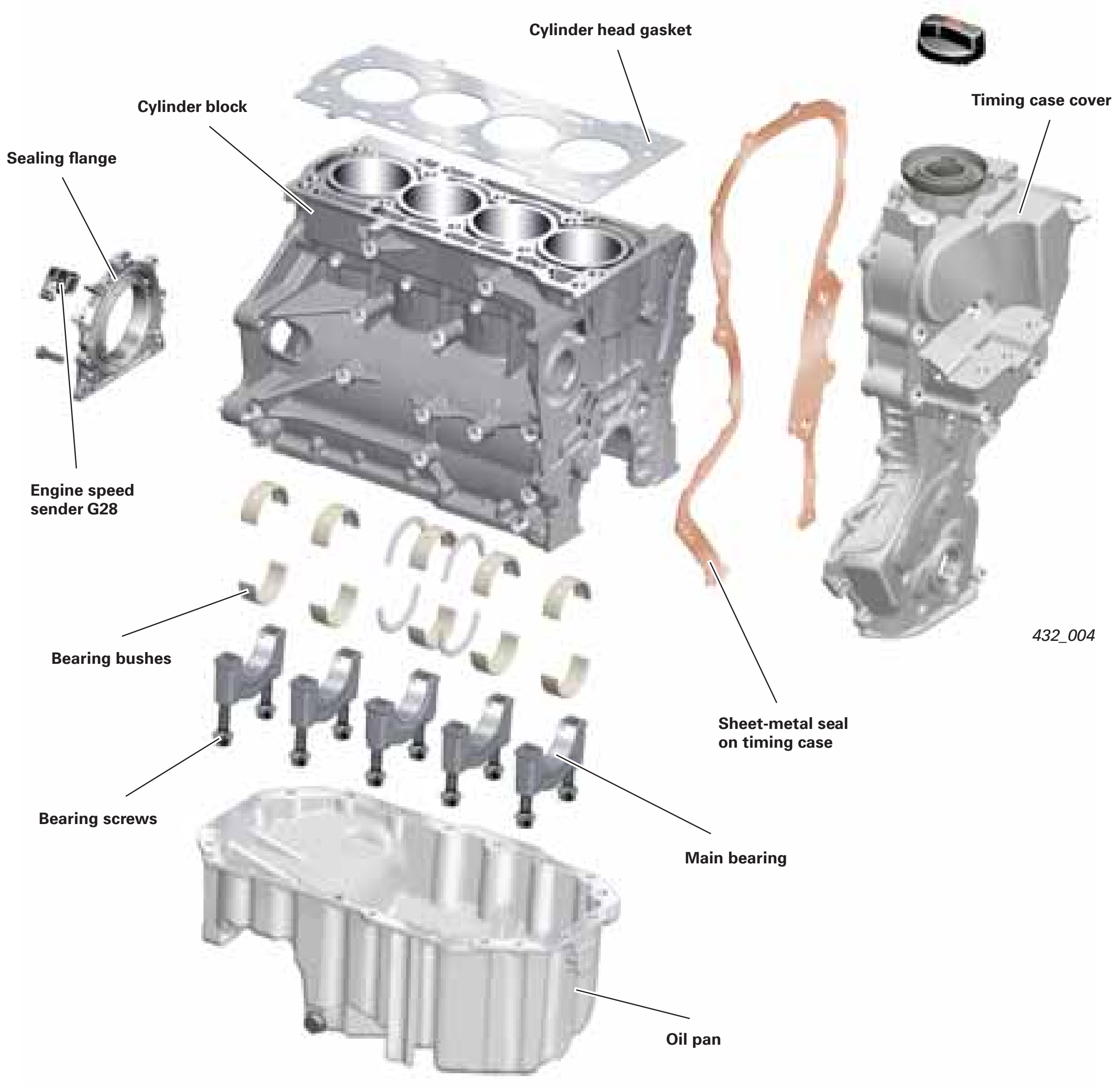
The cylinder block of the 1.4l TFSI engine is manufactured from cast iron containing lamellar graphite. It has an *open-deck design**.
With this design concept, the water jacket enveloping the cylinder is open facing upwards. This allows better cooling of the hot upper section of the cylinder.

The five crankshaft bearing caps are also manufactured from cast iron. The main bearing bushes are lead-free two-component composite bearings. They are designed to withstand the various stresses which occur. This means that the top and bottom bushes have different material properties.
The oil pan is made of cast aluminium. It houses the oil level/oil temperature sender G266, the oil drain screw and the oil pump (bolted to the cylinder block).

The underside of the oil pan is ribbed to improve engine oil cooling. The oil pan is sealed off from the cylinder block by means of liquid sealant. Sealing is provided on the power transmission side of the engine by a sealing flange mounted on the crankshaft. This flange also accommodates the engine speed sender G28. Sealing is provided on the timing side by the timing case, which is made of aluminium alloy.
An *elastomer** coated sheet-metal seal is used. The two inner O-rings must be replaced before fitting the timing case. The crankshaft oil seal can also be replaced.

Other functions of the timing case are:

– Crankcase breather with integrated oil separator
– Engine mount and oil filter housing

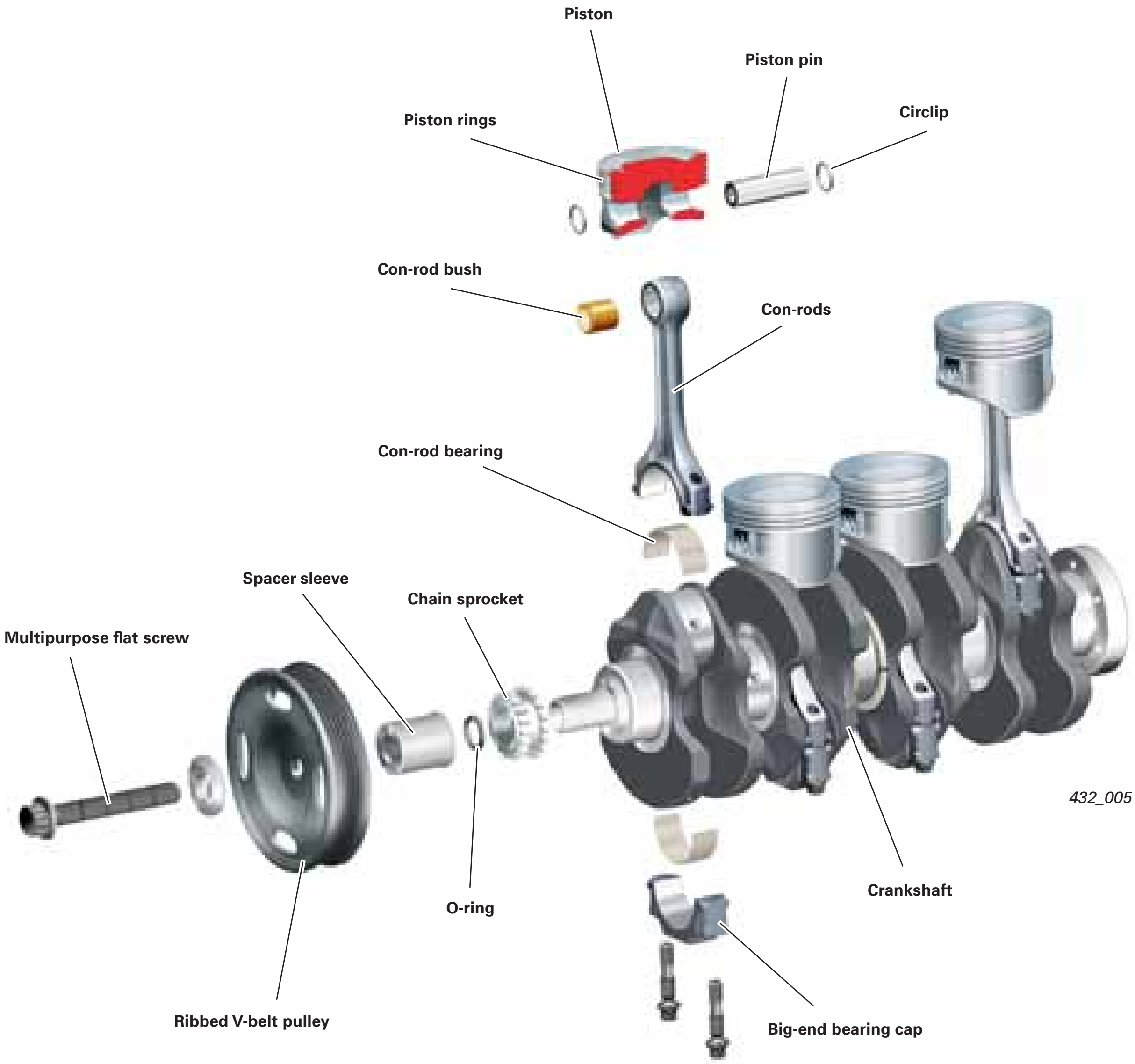


Crankshaft drive

Crankshaft

The forged steel crankshaft runs in five bearings. Main bearing 3 is designed as a thrust bearing and limits the axial play of the crankshaft. The chain sprocket is mounted on the timing side.

A spacer sleeve with an O-ring on the crankshaft journal establishes the connection between the chain sprocket and the ribbed V-belt pulley.
All components are interconnected by means of a multipurpose flat screw.



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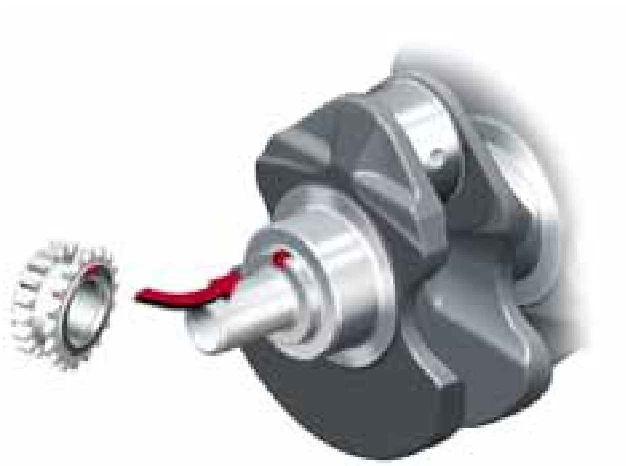
Chain sprocket

The chain sprocket is mounted on the crankshaft. It is fixed in the correct position by a lobe on the crankshaft and by a mating slot in the chain sprocket.



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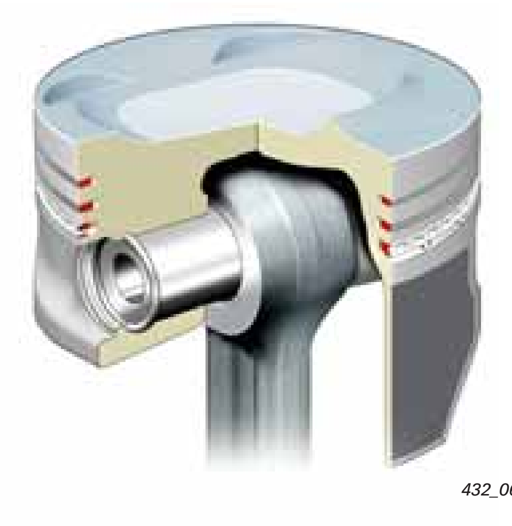
Piston

The pistons have an FSI-specific design and are made of die-cast aluminium.
To reduce thermal stress on the exhaust side, oil spray nozzles spray the piston crown from below with engine oil. The injectors open when an opening pressure of 2 bar is exceeded. The oil spray nozzles are attached to the oil gallery by screws.

To reduce friction, the piston skirts have a graphite coating. The design of the piston ring assembly has also been optimised to minimise friction.
The gudgeon pins are mounted in a floating position and secured by circlips.



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Con-rod

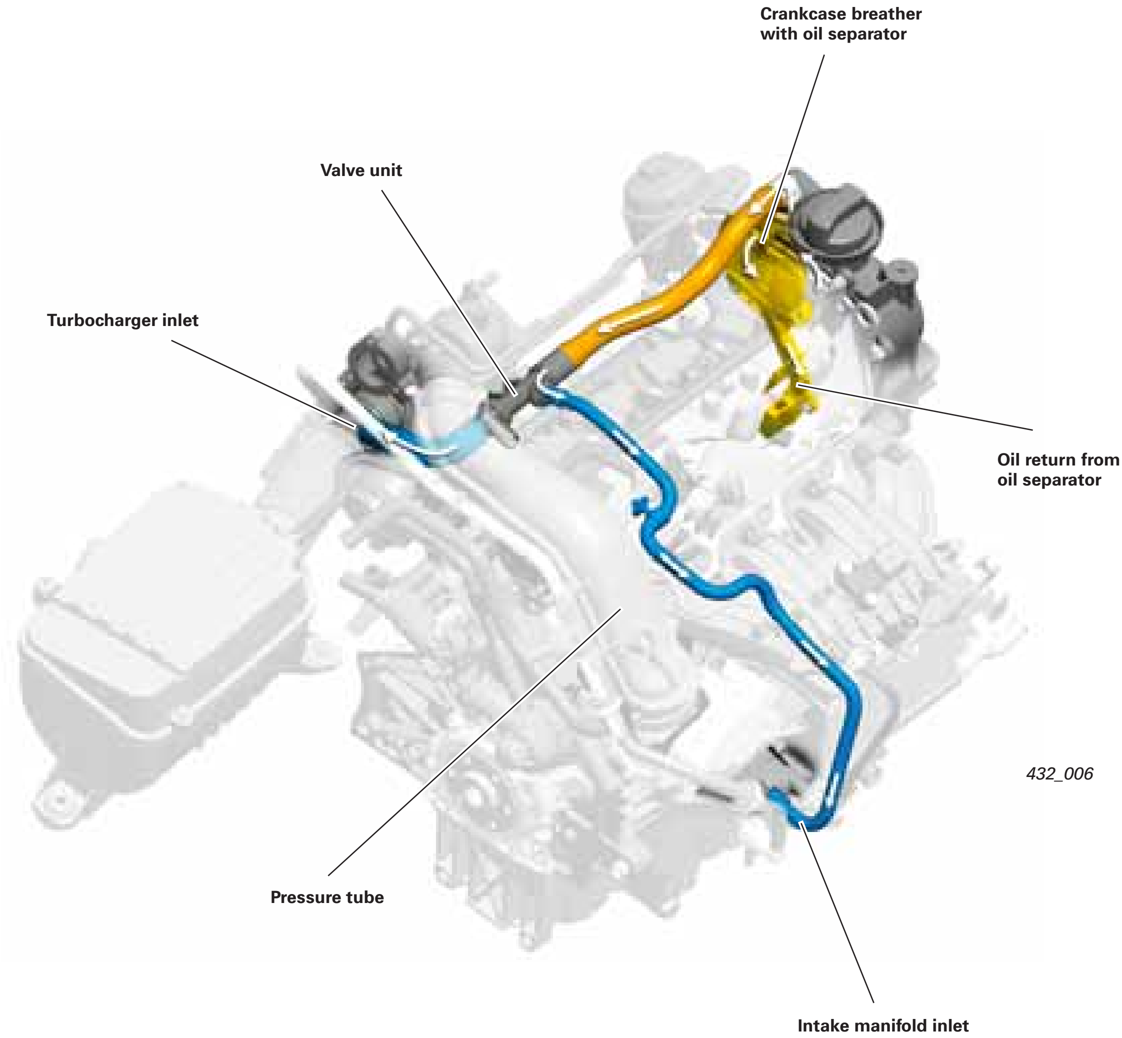
Cracked con-rods are used in the 1.4l TFSI engine. The big-end bearings are load-free two-component composite bearings.
The bottom and top bushes are identical. The small-end bush is made of bronze.
It is cross-ovalised to enhance oil supply and reduce the tendency to deform.

432_068

Crankcase breather

In the 1.4l TFSI engine, the crankcase breather together with the oil separator are integrated in the timing case. The *blow-by gases** flow through a vent line routed to the engine intake.
Since different pressure states exist in the intake air duct during engine operation, the blow-by gases must be conveyed to different intake air points depending on the engine's operating state.

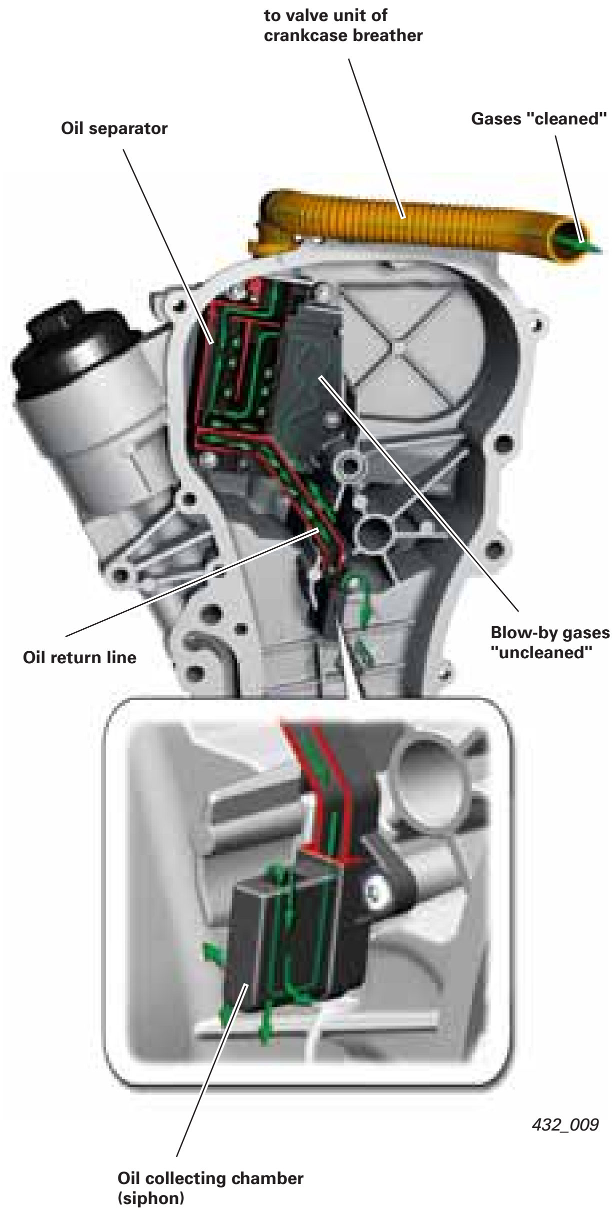
A valve unit integrated in the breather pipe controls the point at which blow-by gases are admitted.



Oil separation

Before the blow-by gases are introduced into the combustion cycle, the entrained oil must be extracted. This extraction process takes place inside the oil separator.

The oil separator is a module which is attached by screws to the timing case cover, where the gases flow through a labyrinth. In the process, the heavier oil droplets precipitate onto the walls and accumulate in the oil return line.



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Oil return line

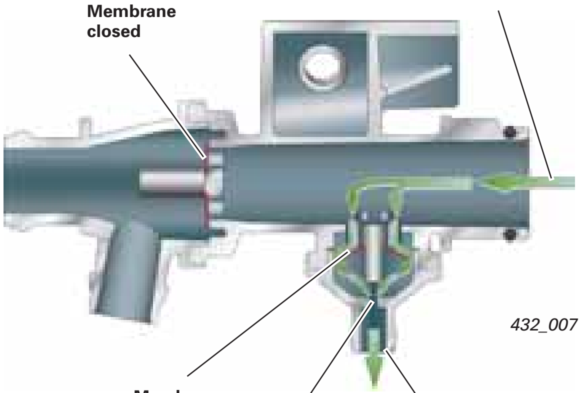
The oil return line is located at the bottom end of the oil separator, where it has a reservoir.
The reservoir is designed like a siphon and prevents "uncleaned" blow-by gases from entering the engine intake.

Valve unit

The blow-by gases are controlled by a valve unit which is integrated in the breather pipe.

Position at low engine speeds

At low engine speeds, there is mainly vacuum in the intake line.
In this state, the blow-by gases are admitted through a branch in the breather pipe downstream of the throttle valve because the pressure gradient is steeper here.
The gases flowing from the activated charcoal filter are not extracted in this operating condition.



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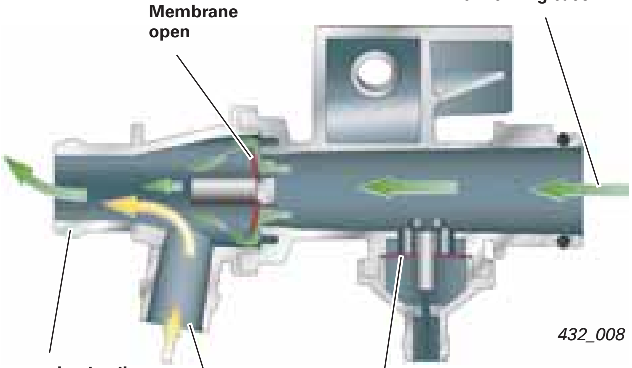
Position at medium and high engine speeds

When the exhaust gas turbocharger builds up pressure, the valve unit closes the line routed to the intake manifold. At the same time, the other branch opens admitting the blow-by upstream of the exhaust gas turbocharger intake.
The gases from the activated charcoal filter are extracted in this operating condition and likewise admixed with the intake air.



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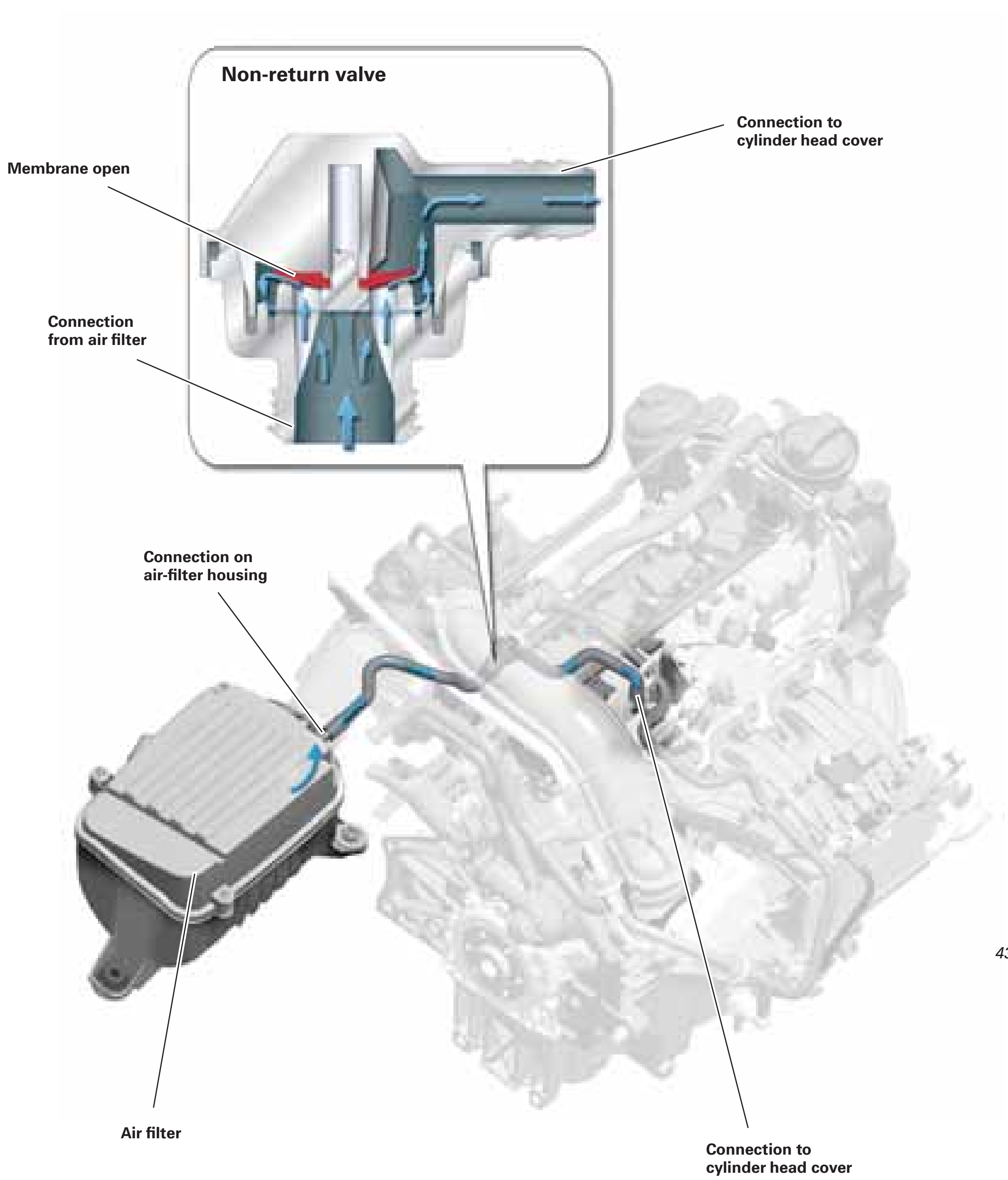
Pressure regulation

A flow restrictor built into the valve unit (see illustration above) prevents an excessively large vacuum from developing inside the crankcase. Because of this, there is no need for a separate pressure regulating valve.

Positive crankcase ventilation system

The crankcase is actively ventilated by means of a hose pipe with an integrated non-return valve.
For this purpose, fresh air is admitted directly from the air filter into the crankcase via the connection on the valve cover.
A non-return valve prevents blow-by gases from leaving the engine block "uncleaned".

The valve shuts off in the direction of the air filter. The purpose of positive crankcase ventilation is, above all, to promote the discharge of fuel and water condensate from the cylinder block and from the engine oil.



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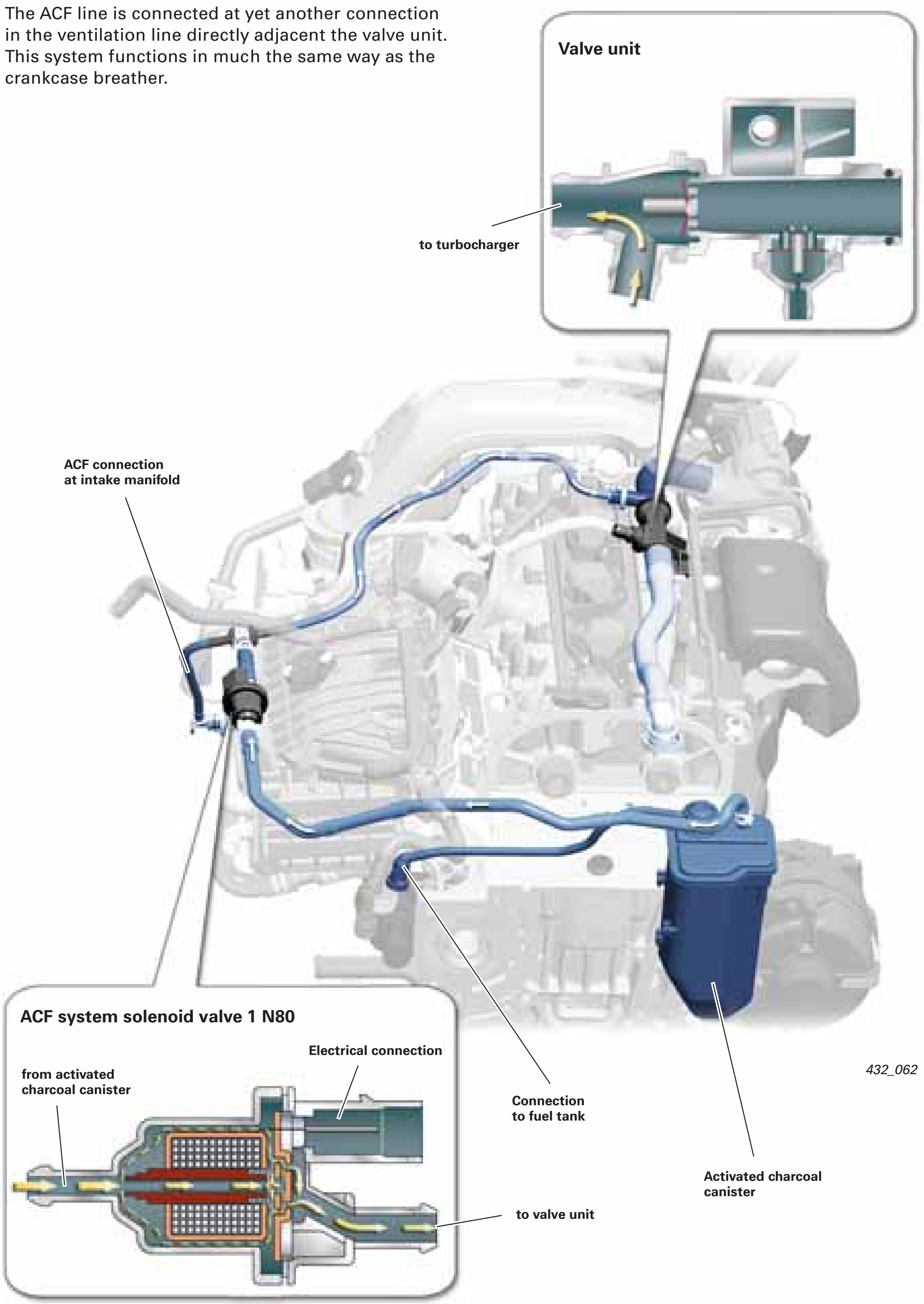
Activated charcoal filter system

The ACF line is connected at yet another connection in the ventilation line directly adjacent the valve unit. This system functions in much the same way as the crankcase breather.



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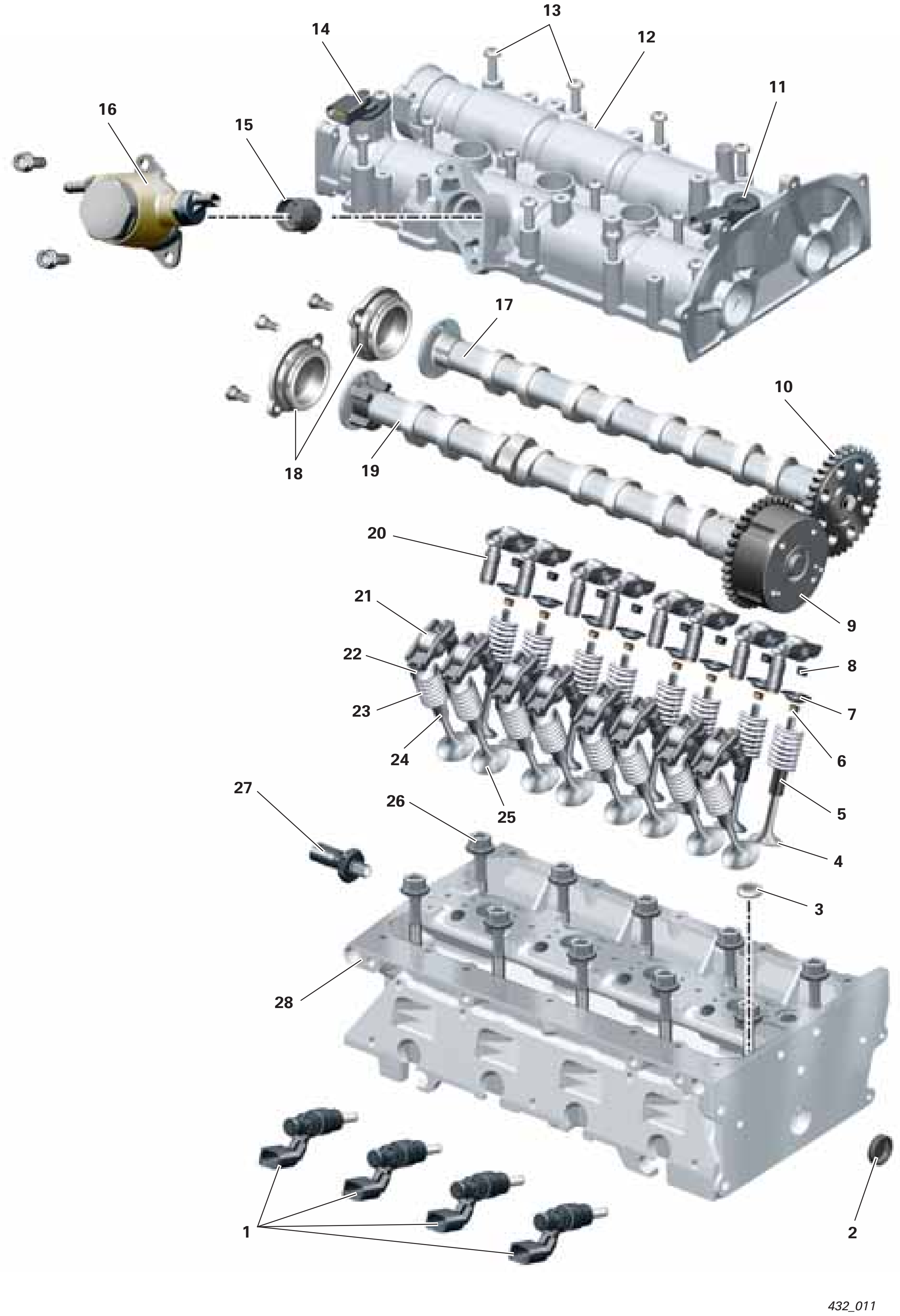
Cylinder head



Specifications:

- Aluminium cylinder head with twin assembled camshafts
- Four valves per cylinder
- Valve actuation via roller cam followers with static hydraulic valve clearance adjustment
- Intake valve: solid-stem valve with induction hardened seat
- Exhaust valve: solid-stem valve, solid stem with induction hardened seat
- Single valve springs
- Variable intake camshaft phasing is based on the same working principle as the vane cell adjuster, adjustment range 40° crank angle, arrested in retard position at engine shutoff by a locking bolt
- Inlet camshaft timing adjustment valve -1- N205 is attached to the cylinder head cover from above
- The Hall sender G40, which is bolted in the cylinder head cover from above, is responsible for checking the adjustment of the intake camshaft and 1st cylinder sensing
- Three-ply metal head gasket
- The high-pressure fuel pump is driven by the intake camshaft by means of four-lobe cams
- The high-pressure fuel pump is attached to the cylinder head cover
- Cylinder head cover made of cast aluminium
- Three camshaft bearings in the cylinder head cover (low-friction bearing); axial play is limited by the sealing covers and by the cylinder head cover
- The cylinder head cover is sealed off from the cylinder head by a liquid sealant

Legend

1 Injectors N30 – N33
2 Sealing cover
3 Oil screen
4 Exhaust valve
5 Exhaust valve guide
6 Valve stem seals
7 Valve spring retainer
8 Valve wedges
9 Variable valve timing
10 Camshaft chain sprocket
11 Inlet camshaft timing adjustment valve N205
12 Cylinder head cover
13 Cylinder flange screws
14 Hall sender G40
15 Cylindrical tappet
16 High-pressure fuel pump
17 Exhaust camshaft
18 Sealing cover
19 Intake camshaft
20 Support element
21 Roller cam follower
22 Valve spring retainer
23 Valve spring
24 Intake valve guide
25 Intake valve
26 Cylinder head bolt
27 Oil pressure switch F1
28 Cylinder head

Note

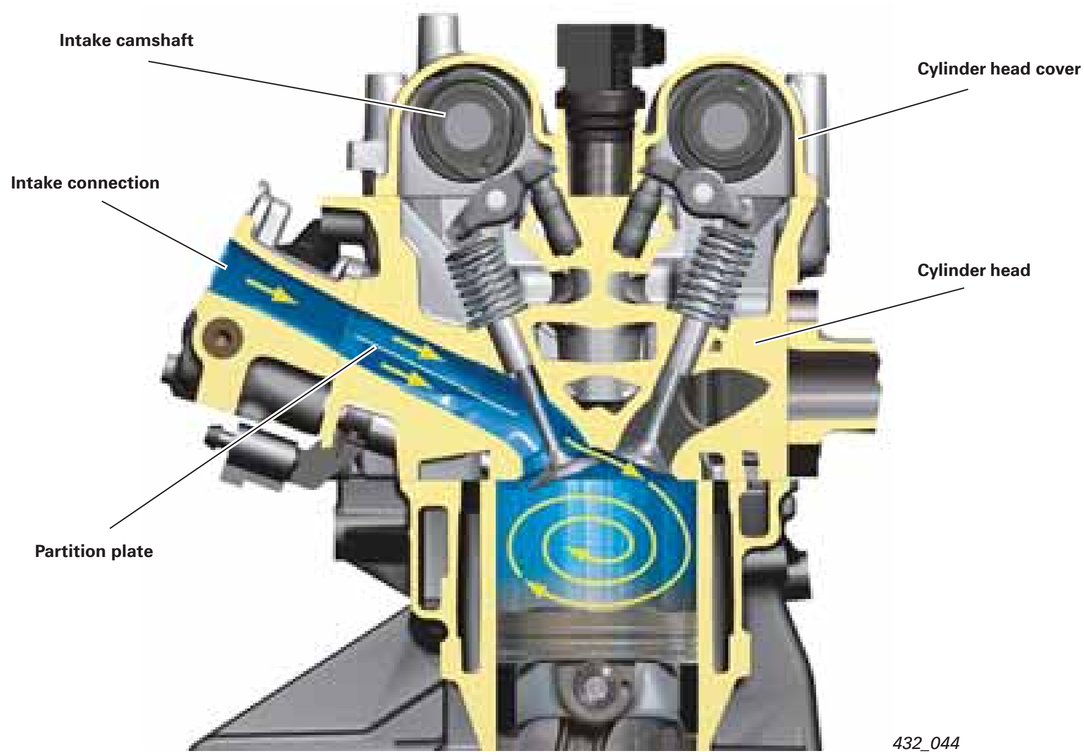
The axial play of the camshafts must be checked whenever work is done on the valve gear.
For a detailed description of the procedure, please refer to the Workshop Manual.

Intake ports

The intake ports have been kept flat in comparison with previous FSI engines.
They are divided by a tumble plate. The FSI-specific tumbling airflow inside the combustion chamber is produced by directing the flow over the upper edge of the valve discs and the outline edges at the base of the intake valves.

For this reason, it has been possible to dispense with additional intake manifold flaps.
Intake camshaft adjustment enhances the engine's torque characteristics.

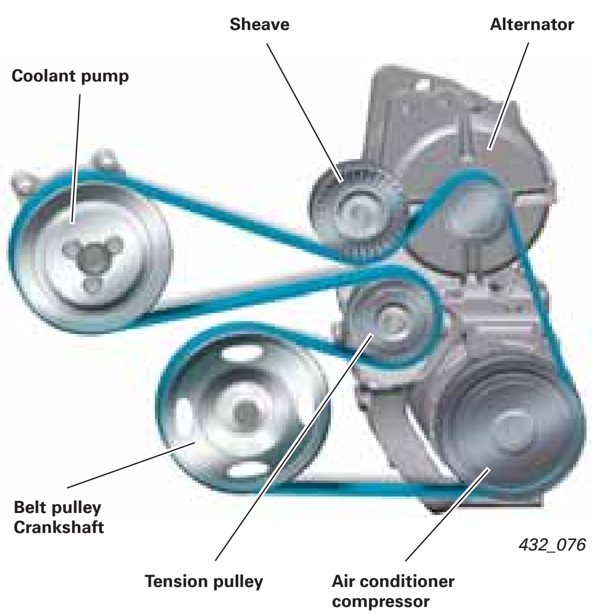
Airflow in the intake line



Ribbed V-belt drive

The coolant pump, the alternator and the air conditioning compressor are driven via the belt drive. A tension pulley, together with a sheave, produces the required belt tension.
A six-groove ribbed V-belt is used.

The illustration shows the belt track in an engine equipped with an optional air conditioning system.



Chain drive

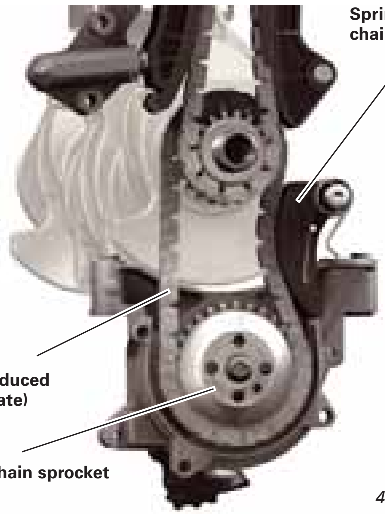
The 1.4l TFSI engine is driven via a maintenance-free chain drive. The chain drive is biplanar.
The oil pump drive is on the first plane.
The second and outer pinions drive the two camshafts. On account of its acoustic advantages, as well as its good power transmission and friction properties, a gear chain is used to drive the camshafts.

For chain drive of the camshafts, use is made of a chain tensioner which is pretensioned by a mechanical spring and additionally subjected to oil pressure from the engine oil circuit.
The camshaft chain is guided by a sliding rail which is securely bolted on one side. A tensioning rail acts as an additional guide. It is mounted rotatably at the top end. The chain tensioner acts at the bottom end.

432_045

Oil pump drive

The oil pump is attached to the cylinder housing and driven by a separate chain.
The roller chain fitted at SOP will be replaced by a gear chain at a later date.
The oil pump chain drive is tensioned by a spring-loaded chain tensioner.



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Lubrication system

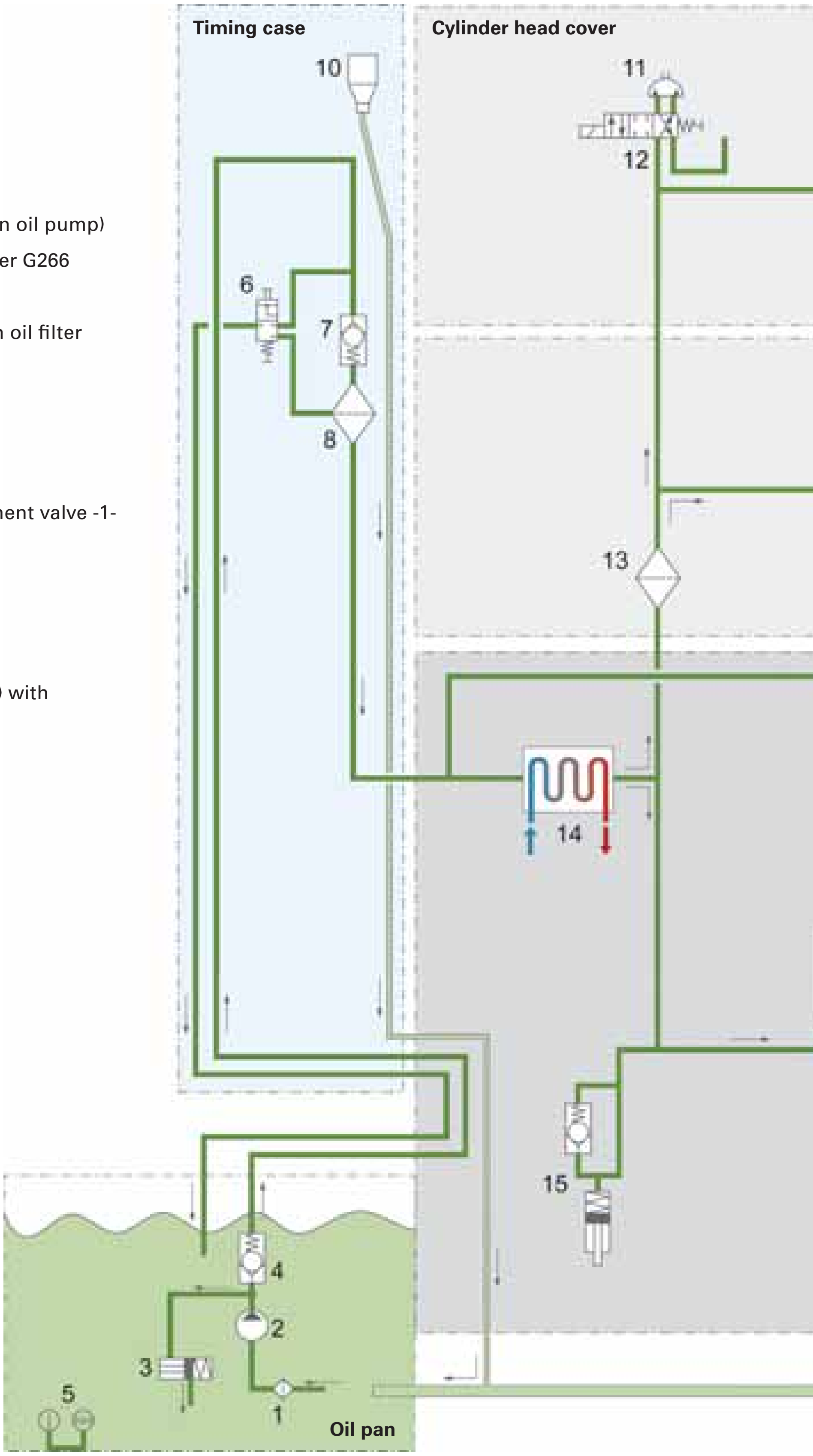
Legend

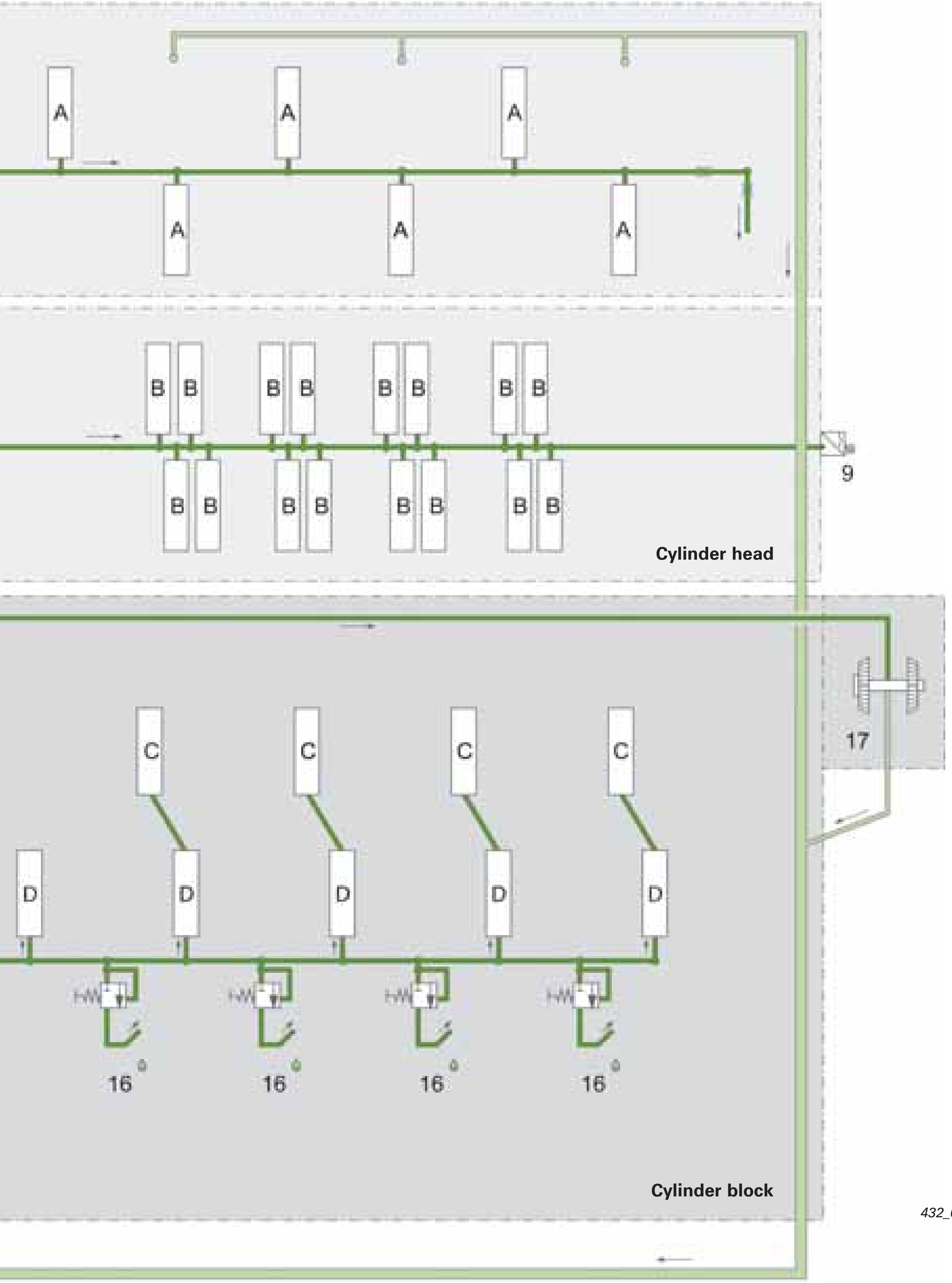
1 Screen
2 Oil pump
3 Cold start valve
4 Non-return valve (integrated in oil pump)
5 Oil level/oil temperature sender G266
6 Oil drain valve
7 Non-return valve integrated in oil filter
8 Oil filter
9 Oil pressure switch F1
10 Oil separator
11 Camshaft adjuster
12 Inlet camshaft timing adjustment valve -1- N205
13 Oil screen in cylinder head
14 Oil cooler
15 Chain tensioner
16 Spray nozzles (piston cooling) with integrated valves
17 Exhaust gas turbocharger

Low-pressure circuit

High-pressure circuit

A Camshaft bearing
B Support elements
C Big-end bearing
D Main bearing





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Note

For oil pressure values, please refer to the Workshop Manual.

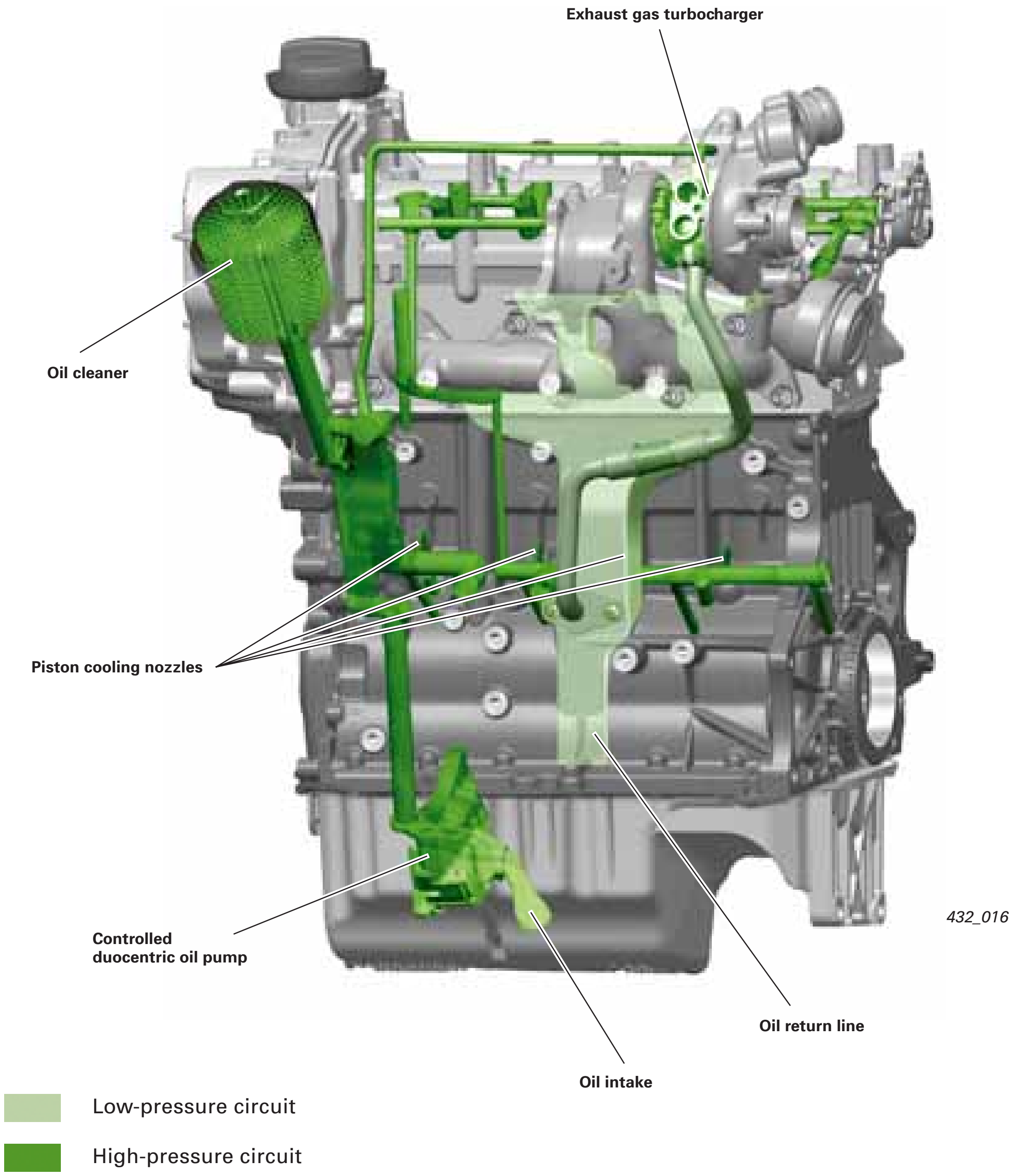
Oil supply

Internal friction in the engine was minimised during the development of the oil circulation system. To achieve this aim, a self-regulating *duocentric oil pump** is used.
The oil pump is driven by the crankshaft via a chain drive. The gear is configured for speed reduction (reduction ratio i = 0.6).

Another focus of development is ease of servicing. To achieve this, the oil filter was positioned for easy replacement from above.

An oil cooler is used for cooling the engine oil.
It is bolted to the crankcase and integrated in the cooling system.
An oil pressure switch F1 for checking the oil pressure is attached to the inside of the cylinder head.
The oil level/oil temperature sender G266 (*TOLS sensor**, TOLS = thermal oil level sender) is integrated in the oil pan.
The signals provided by this sensor are used to compute the oil change interval and the "min oil" warning.
The signals generated by F1 and G266 are evaluated by the control unit with display in dash panel insert J285.

Oil circulation system on engine



Modified oil filter

The oil filter module will be replaced by an oil filter cartridge at a later date, necessitating the use of an adapted timing case cover.

As with the previous oil filter module, the oil filter cartridge can be accessed from above for easy servicing. To ensure that no oil is spilt on the engine when replacing the oil filter, a return connection in the timing case cover is opened on removal of the filter cartridge. This allows the oil to flow directly back into the oil pan. In the screwed-on condition, this port is sealed by a spring-loaded seal.
When the filter cartridge is removed, the valves inside it are closed to prevent oil from escaping.

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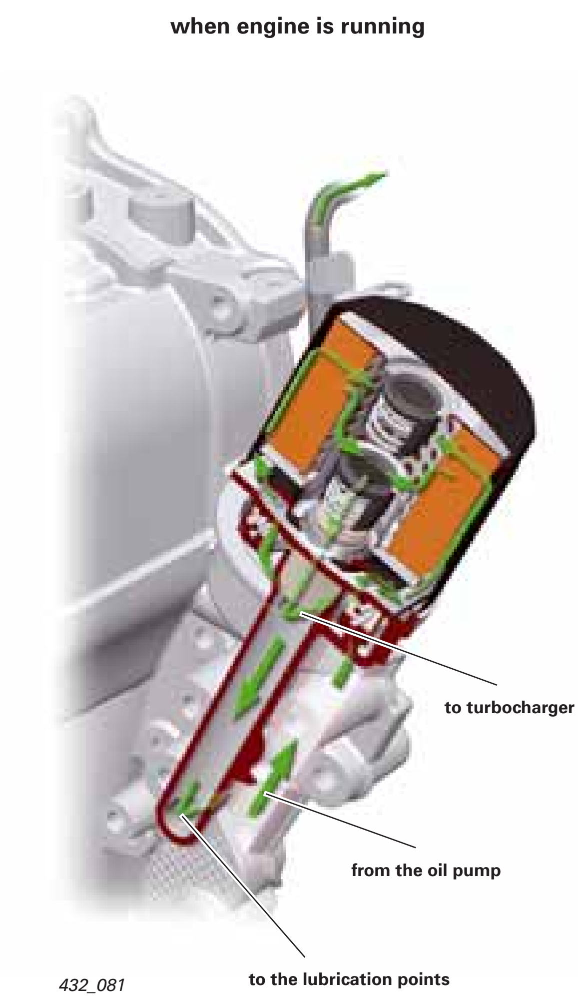
Design



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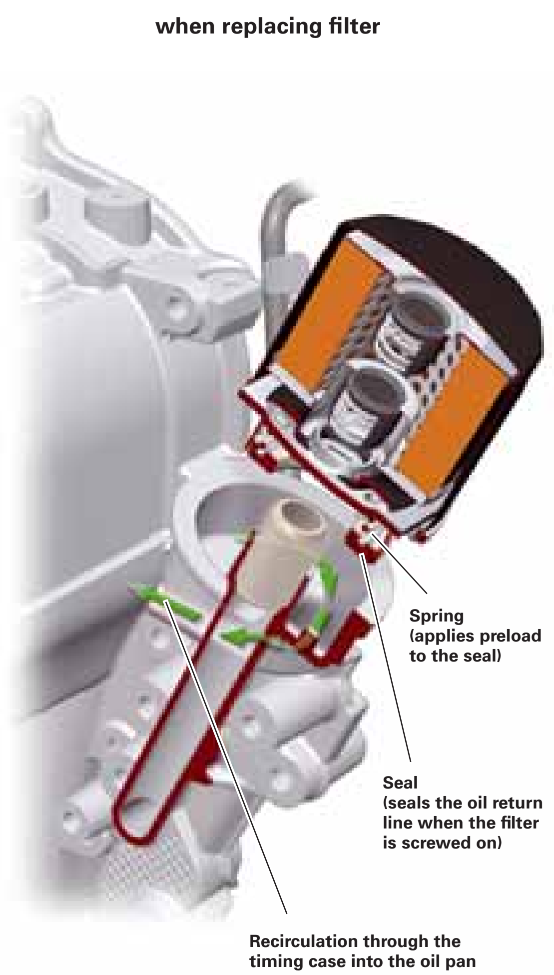

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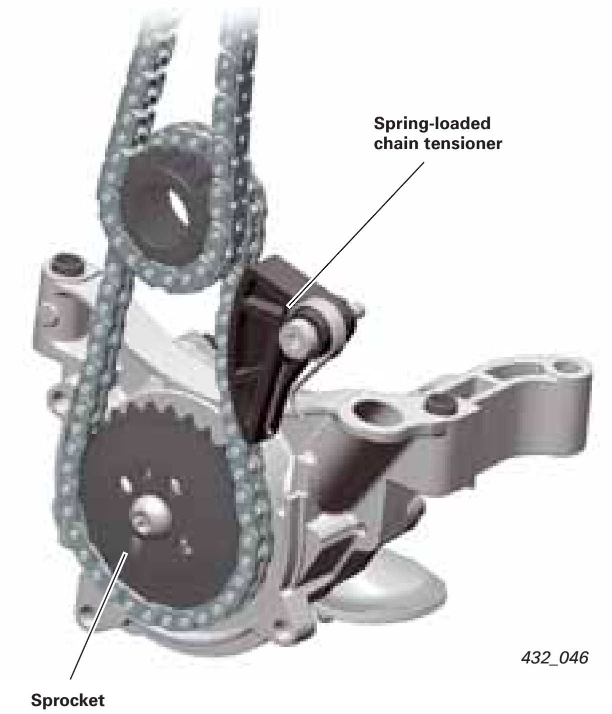
Self-regulating duocentric oil pump

A self-regulating duocentric pump is utilised as an oil pump. It has the following advantages over a non self-regulating pump:

- Oil pressure is volume flow regulated to a level of approx. 3.5 bar.
- As a result, the pump consumes up to 30 % less engine power than a conventional-type pump.
- There is less deterioration in oil quality due to the lower recirculation rate.
- Less oil foaming occurs because a constant oil pressure is maintained.

By being volume flow regulated, the pump only delivers as much as oil (at a pressure of approx. 3.5 bar) as the engine actually needs at any given moment.
In contrast, a non self-regulating pump discharges the excess oil which it has delivered via a pressure regulating valve.



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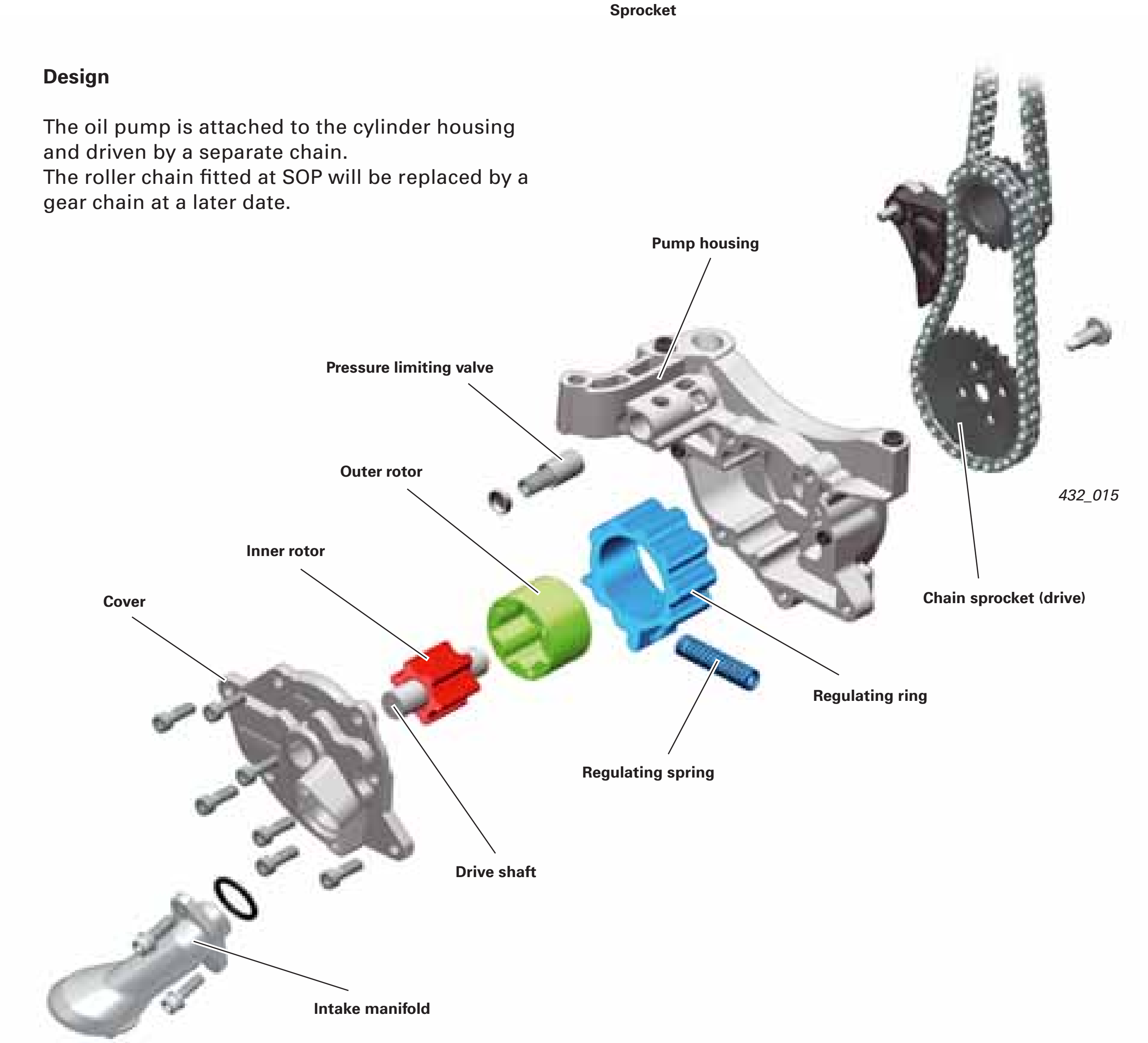
Design

The oil pump is attached to the cylinder housing and driven by a separate chain.
The roller chain fitted at SOP will be replaced by a gear chain at a later date.



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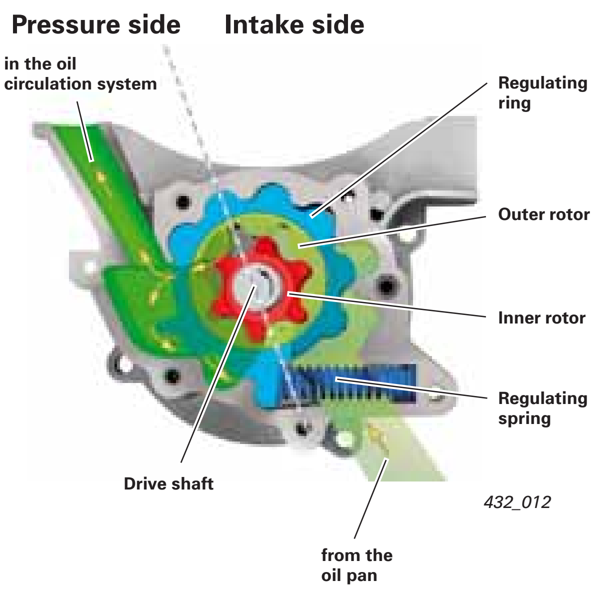
Function

The inner rotor is driven by the chain sprocket via the drive shaft, thereby driving the outer rotor.
The outer rotor rotates within the regulating ring.
The inner and outer rotors rotate on different axes. This creates an increase in volume at the intake end during the rotational movement. Oil is induced and delivered to the pressure side. On account of the reduction in volume on the pressure side, the oil is forced into the oil circulation system.
A pressure limiting valve (cold start valve) in the pressure side of the pump protects the engine from excessively high pressures. It opens at a pressure of approx. 6 bar. Pump regulation is a dynamic process that is directly dependent on the swept volume of the engine.

The increase in engine speed also creates a higher oil demand. To meet this demand while maintaining a constant pressure, the delivery rate of the oil pump must be adapted.
This is achieved by rotating the regulating ring in the pump. The constant pressure ensures that enough oil is circulated in all engine speed ranges. Due to the rotation of the regulating ring, the outer rotor is automatically adjusted, too. The rotational axes of the inner and outer rotors change as a result, thereby also altering the volume of the pump chamber.
The regulating ring rotates automatically when the pressure changes on the supply side of the pump, i.e. in the oil circulation system. This rotation is provided by the regulating spring, which rests on the regulating ring and is mounted in the pump housing.

Increase in delivery rate

If oil demand goes up due to increasing engine speed, the pressure in the oil circulation system decreases. As a result, the regulating spring exerts pressure on the regulating ring, thereby displacing the latter and increasing the capacity of the pump chamber. The delivery rate of the pump increases.



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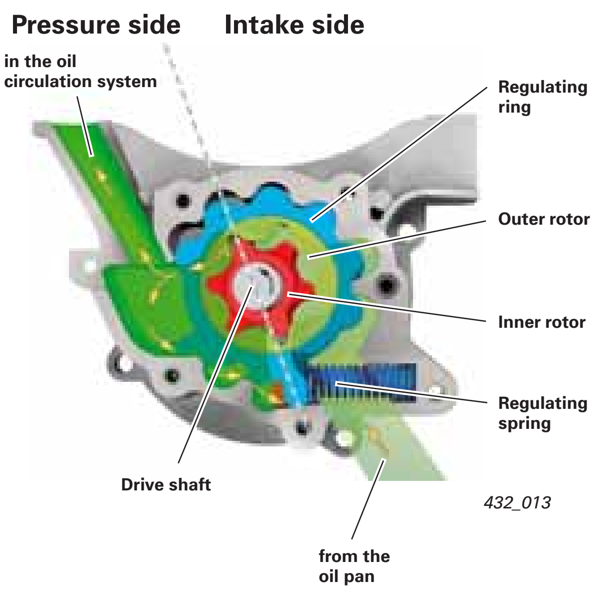
Reduction in delivery rate

When engine speed decreases, with the result that the engine requires less oil, the pressure in the oil circulation system increases. The regulating ring is thereby displaced, compressing the regulating spring. The rotation of the regulating ring decreases the capacity of the pump chamber. This, in turn, reduces the oil delivery rate.



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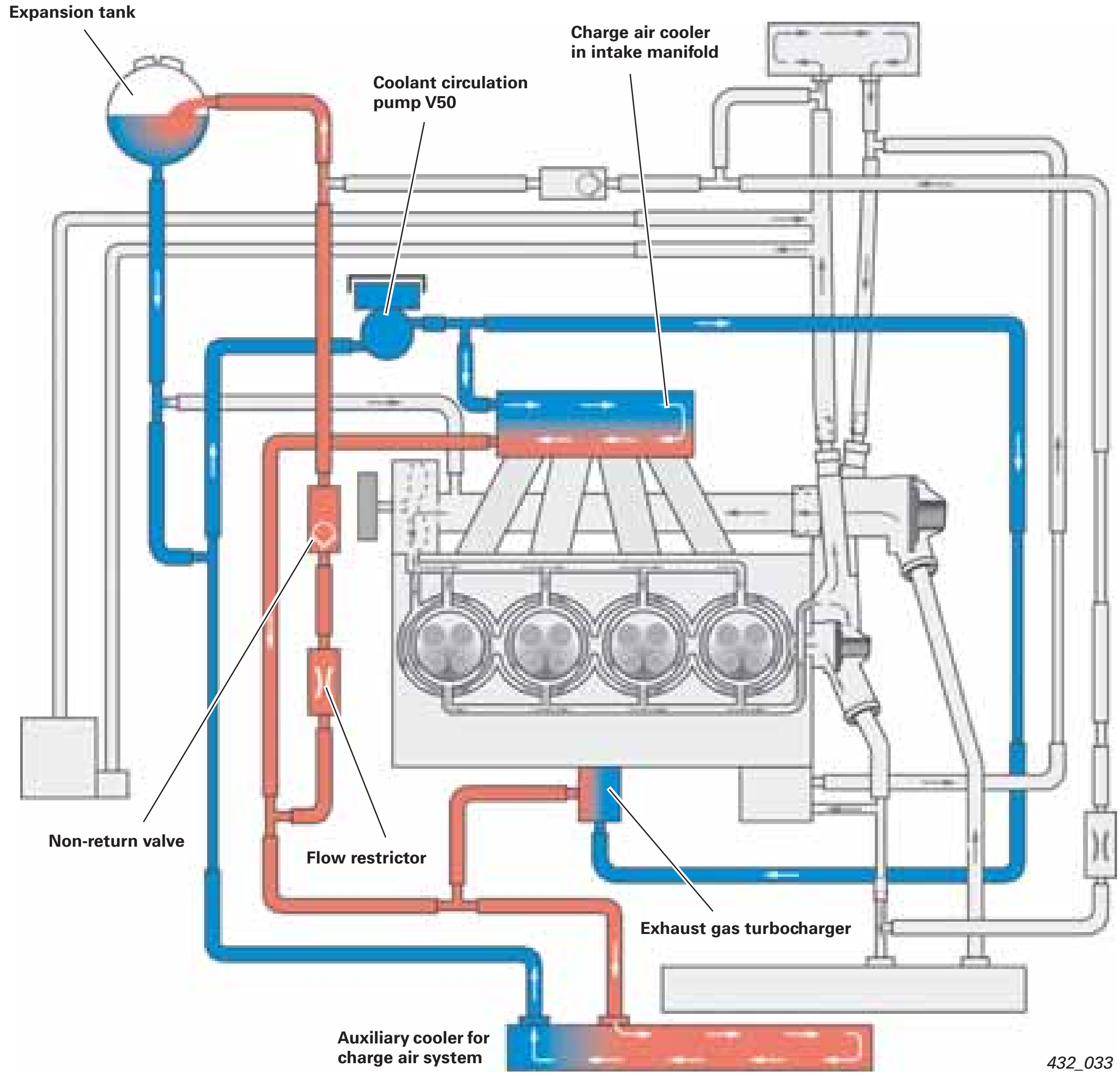
Dual-circuit cooling system

Charge air cooling system

The cooling system has been systematically developed with the aim of reducing friction in the engine and achieving cleaner emissions.
For this reason, the engine has two independent cooling circuits. The first circuit is responsible for cooling the exhaust gas turbocharger and the charge air. The other circuit is the main cooling circuit, which cools the engine. Both circuits are, however, interconnected by a flow restrictor and have a common expansion tank.

It is necessary to separate the two systems as they can have different temperatures and therefore different pressures. The temperature difference between the two cooling circuits can be as much as 100 °C.
A non-return valve shuts off when there is high pressure in the main cooling circuit. This prevents the hotter coolant in the main cooling circuit from entering the charge air cooling circuit.



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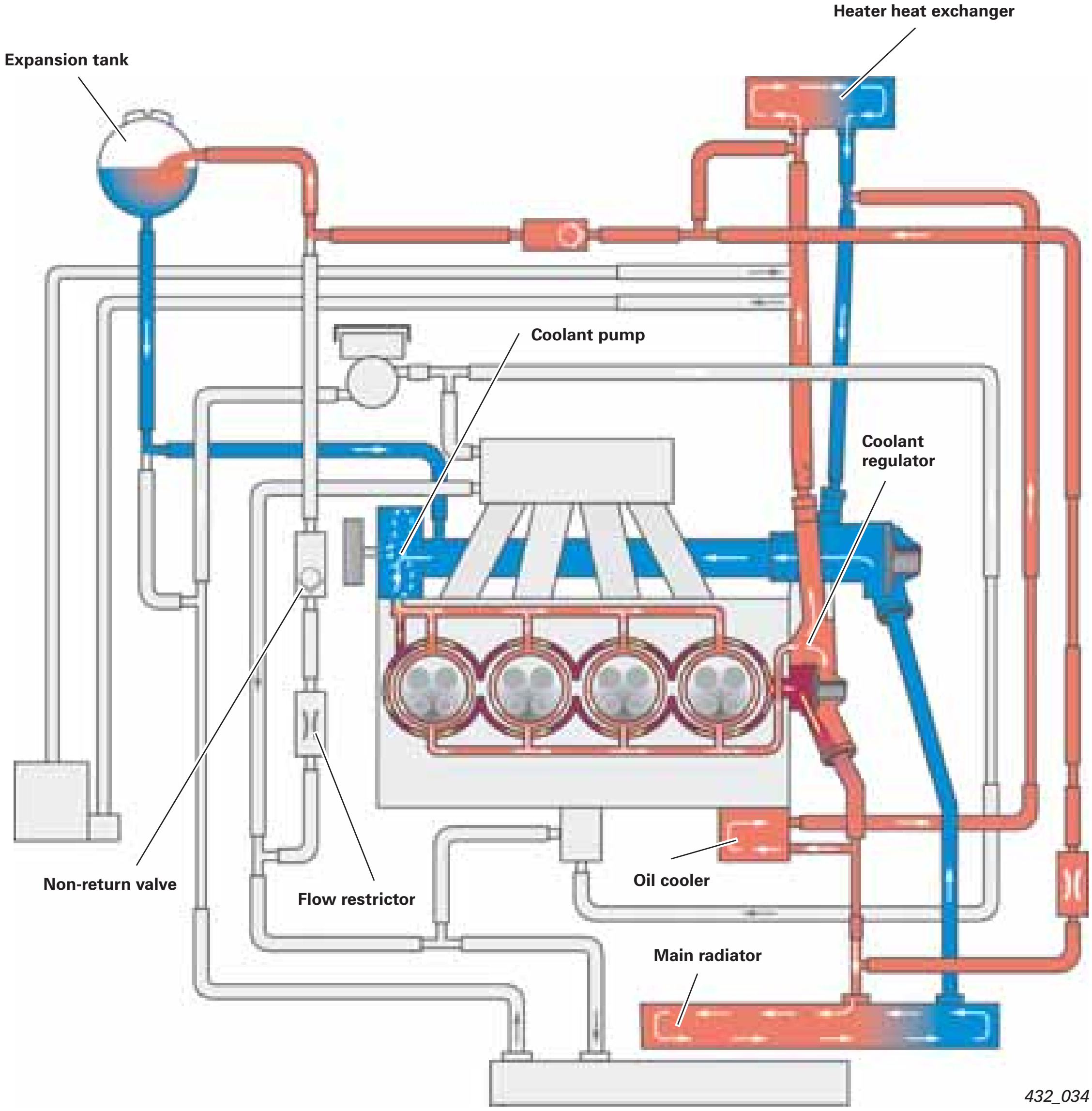
Legend

- Coolant in cylinder block
- Coolant in cylinder head and in remaining circuit
- Cooled coolant

Main cooling circuit

The special feature of the main cooling circuit is a further subdivision. A flow restrictor separates the charge air cooling circuit from the main cooling circuit.

The main cooling circuit is subdivided into two circuits. One circuit flows through the cylinder block. The second circuit cools the cylinder head.



432_034

Note

When filling and venting the cooling system, the instructions given in the Workshop Manual must be followed.The procedure for filling and venting the cooling system with the cooling system filling unit VAS 6096 is described herein.
There is also a second way of venting the cooling system, which involves running the "Filling and venting cooling system" test program on the diagnostic unit.

Temperature control

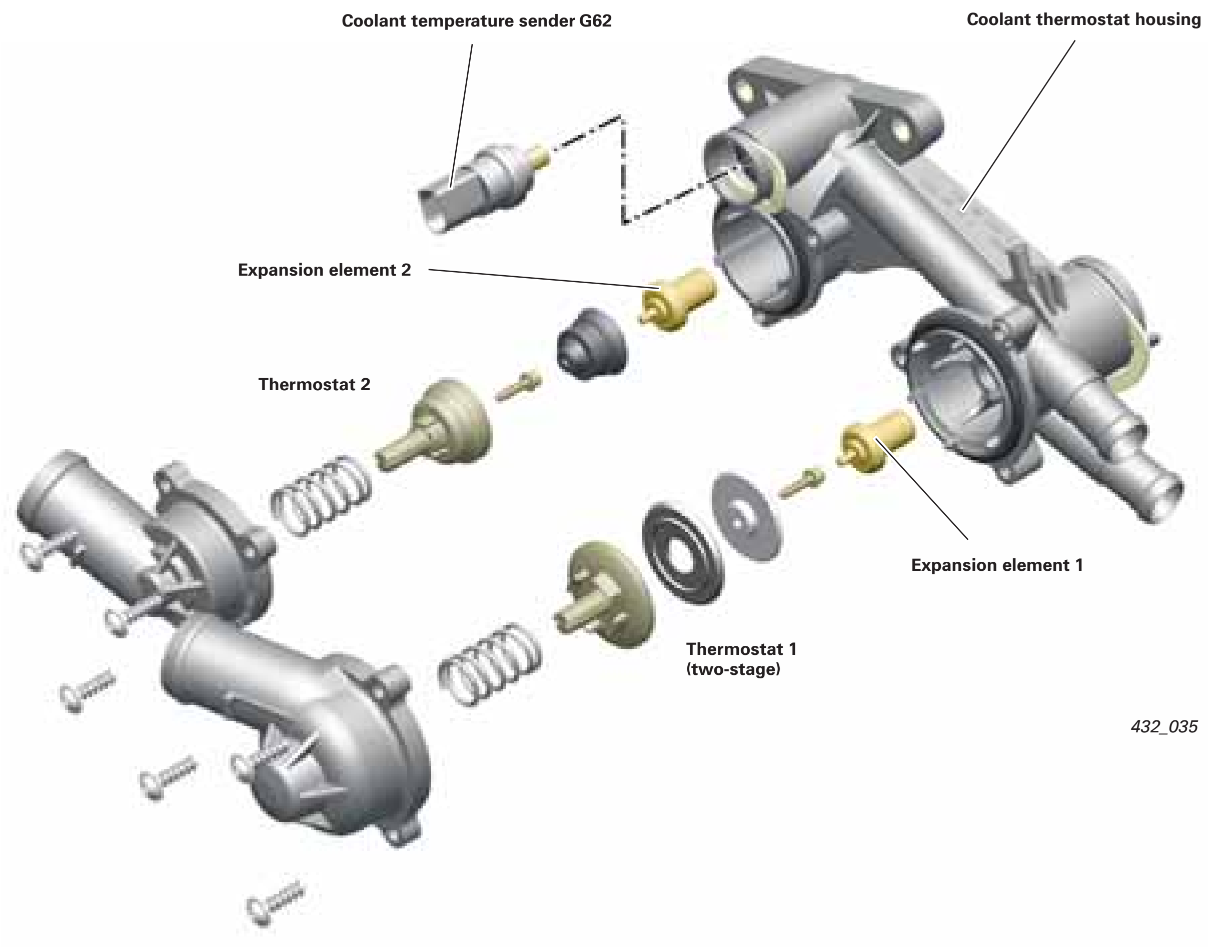
The cooling system is designed in such a way that the cylinder block can be heated quickly and that the temperature level in the cylinder block is generally higher than in the cylinder head.
To implement this function, there are two thermostats. They are built into a common housing, the coolant thermostat. The thermostats are actuated by *expansion elements**.

To monitor the coolant temperature, the coolant temperature sender G62 is integrated in the housing of thermostat 2. The temperature of the coolant flowing out of the cylinder head is measured here.

The advantages of subdividing the cooling system into two circuits are:

- Faster heating of the cylinder block because the coolant remains in the cylinder block until a temperature of 105 °C is attained in the cylinder block.
- Due to the higher temperature in the cylinder block, the friction inside the crank mechanism is reduced.
- Since cylinder head is cooled better, the temperature inside the combustion chamber is lower. The results are improved volumetric efficiency and reduced knock tendency.

Coolant thermostat



432_035

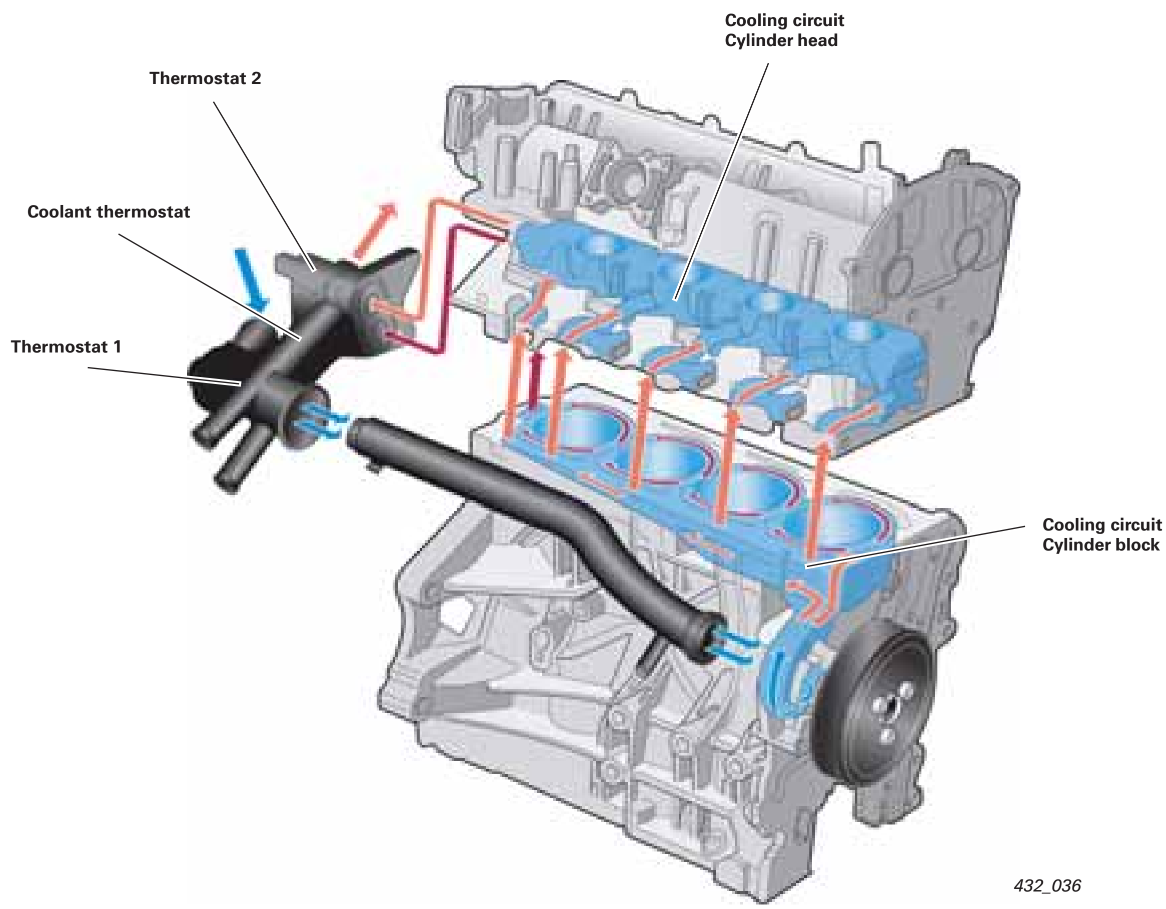
Subdivision of the coolant flow

For temperature control in the dual-circuit cooling system, the coolant quantity is subdivided. One third is used for cooling the cylinders, and therefore flows through the engine block. Two thirds flow through the cylinder head, where they cool the combustion chambers.
The flowrate, i.e. temperature, is controlled by using different thermostat cross-sections.

Due to the different temperatures in both circuits, different pressure conditions can also exist. In this case, too, both systems are separated by the two thermostats.

Because a higher pressure prevails in the cylinder block coolant circuit, a two-stage thermostat is used to provide exact temperature-controlled opening.
If a single-stage thermostat is used, a large thermostat plate would have to be opened against the high pressure. Due to the counter forces, however, the thermostat would only open at high temperatures.

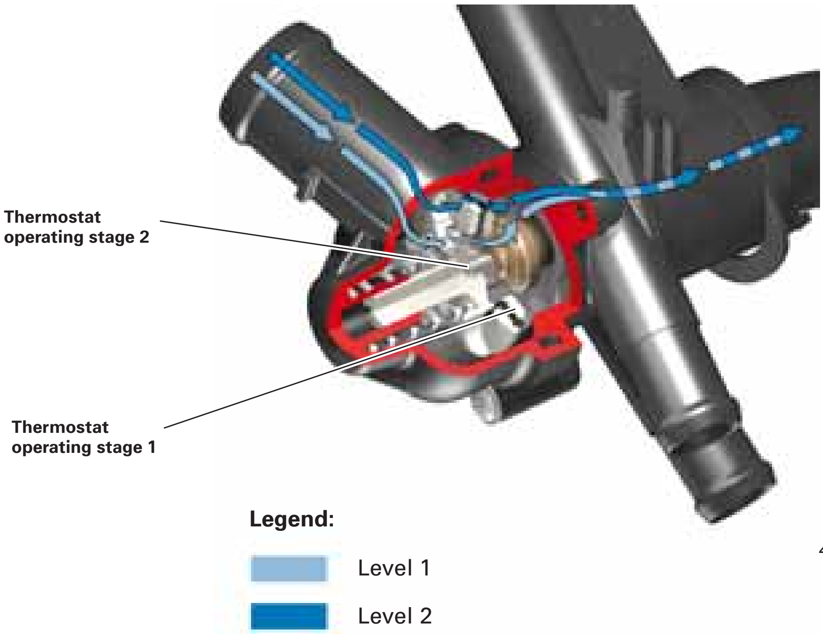
If a two-stage thermostat is used, only a small thermostat plate opens initially when the opening temperature is reached. Due to the smaller surface area, the counter forces are lower and the thermostat opens in an exact temperature-controlled manner.
After the plate has travelled a certain distance, the small thermostat plate drives a larger plate, opening the full cross-section of the thermostat.



432_036

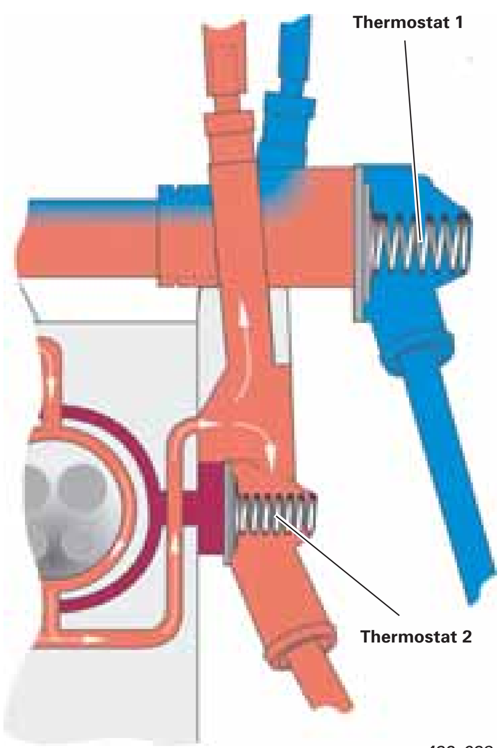
Thermostat

Design and function



432_037

Position at temperatures up to 87 °C



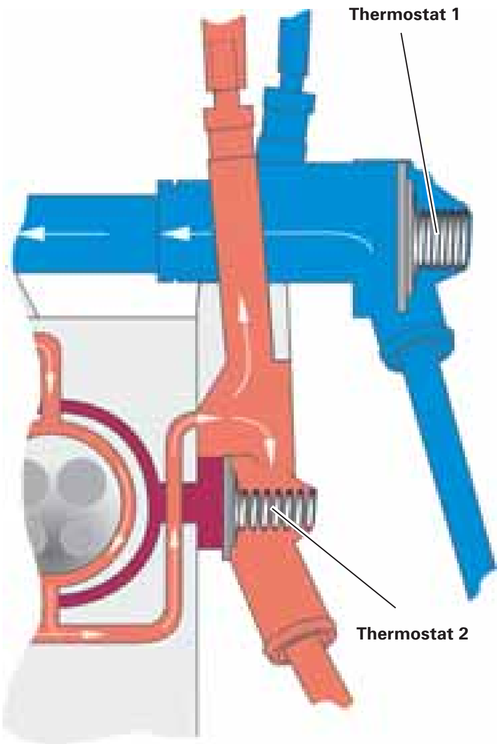
432_038

Both thermostats are closed. As a result, the engine heats up more quickly.

Coolant flows through the following components:

- Coolant pump
- Cylinder head
- Coolant thermostat housing
- Heater heat exchanger
- Oil cooler
- Expansion tank

Position at temperatures from 87 °C – 105 °C



432_039

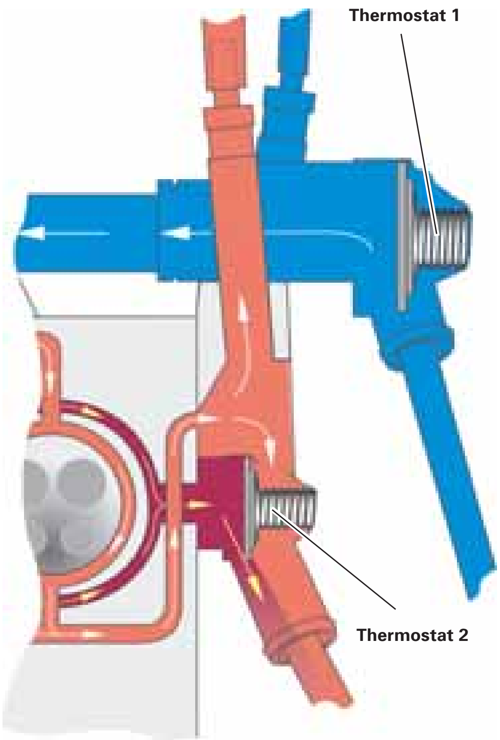
Thermostat 1 is open and thermostat 2 is closed.

Thus, the temperature in the cylinder head is set to 87 °C and further increased in the cylinder block.

Coolant flows through the following components:

- Coolant pump
- Cylinder head
- Coolant thermostat housing
- Heater heat exchanger
- Oil cooler
- Expansion tank
- Radiator

Position at temperatures over 105 °C



432_040

Both thermostats are open.

Thus, the temperature is set to 87 °C in the cylinder head and to 105 °C in the cylinder block.

The coolant flows through the following components:

- Coolant pump
- Cylinder head
- Coolant thermostat housing
- Heater heat exchanger
- Oil cooler
- Exhaust gas recirculation valve
- Expansion tank
- Radiator
- Cylinder block

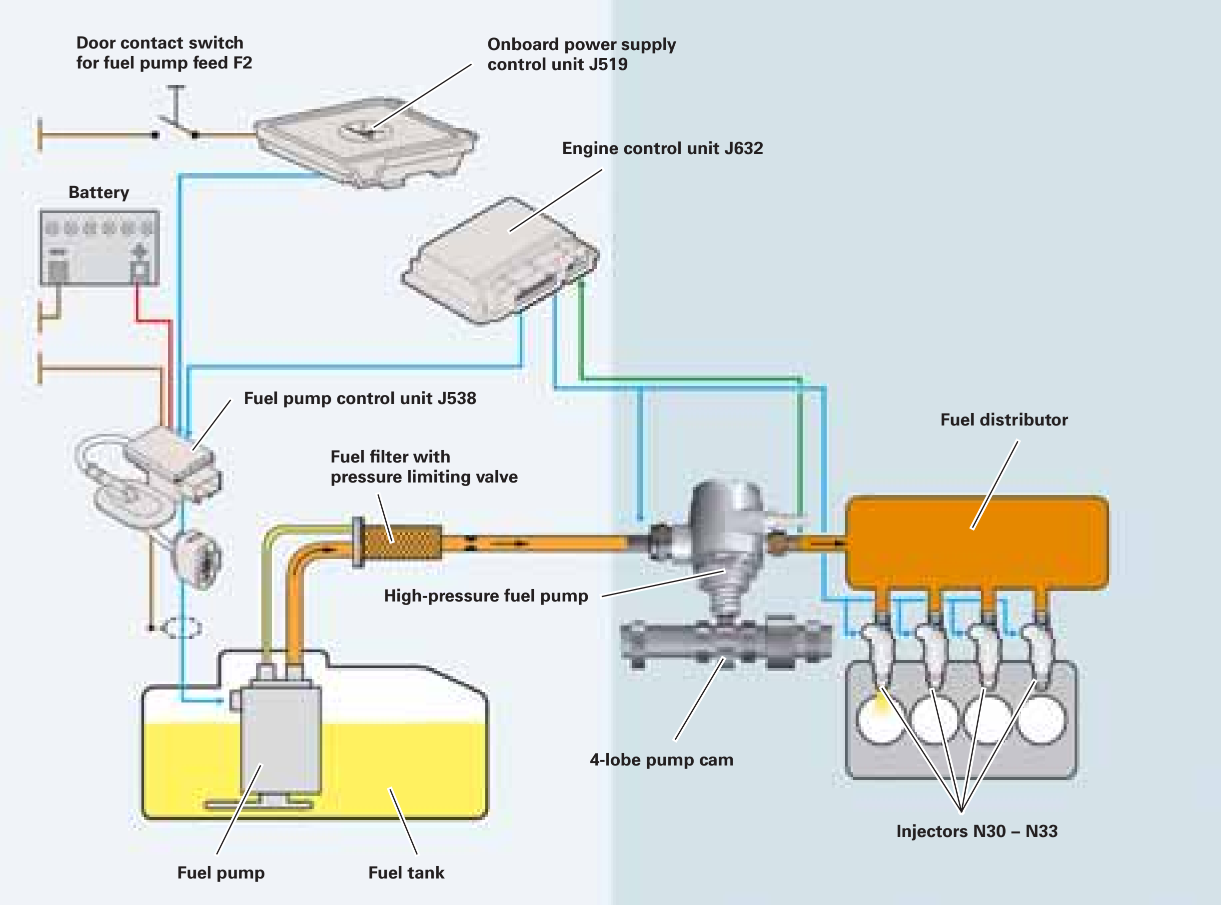
Fuel system (overview)

Supply-on-demand fuel system

In this system, the electric fuel pump in the fuel tank and the high-pressure fuel pump only deliver as much fuel as the engine actually needs at any given moment.

The electrical and mechanical power requirements of the fuel pumps are thus kept to a minimum. This saves fuel.

Low-pressure fuel system **High-pressure fuel system**



432_014

Legend

depressurised

4 bar

35 – 100 bar

Low-pressure fuel system

To adjust the delivery rate of the fuel pump, the supply voltage is modulated by the fuel pump control unit by means of a PWM signal.
In this way, the pump voltage is set to between 6V and battery voltage. The signal for the correct pump voltage is supplied by the engine control unit.

For this purpose, a PWM signal is transmitted from the engine control unit to the fuel pump control unit.
The delivery rate of the pump is defined by a characteristic map stored in the engine control unit. The delivery rate of the pump also varies as a function of pump voltage. A constant pressure of 4 bar is maintained within the fuel system.

Pump delivery rate diagram

Low pressure detection

The low-pressure system does not have a built-in pressure sensor. The delivery rate is checked by the engine control unit as follows:
In each driving cycle, the delivery rate of the electric fuel pump is reduced until a certain pressure can no longer be maintained in the high-pressure fuel system.

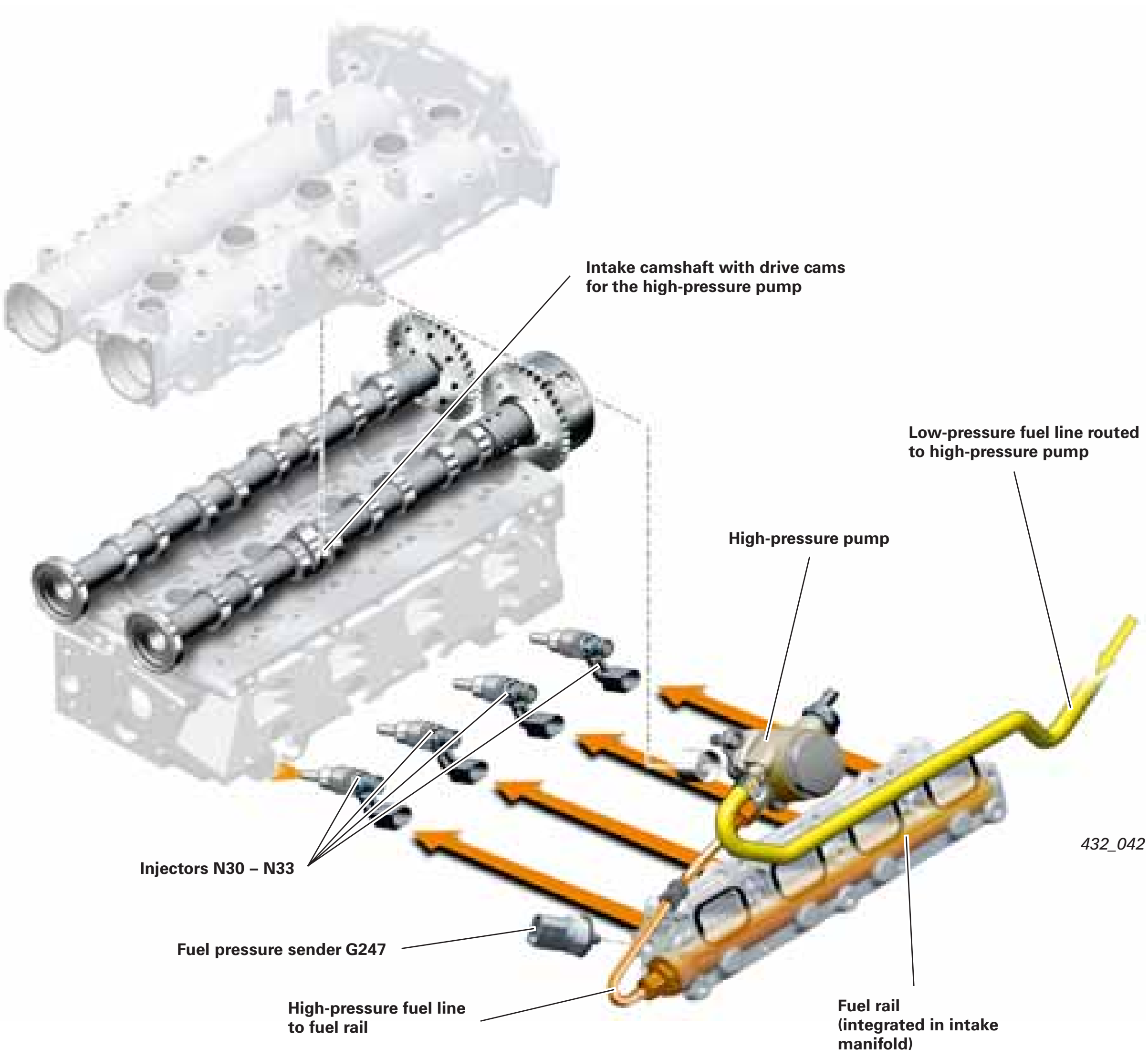
The engine control unit compares the PWM signal used for activating the electric fuel pump with the PWM signal stored in the engine control unit. In case of deviations, the signal stored in the engine control unit is adapted.

High-pressure fuel system

The pressure is the system is adjusted variably between 35 and 100 bar depending on engine load.

The following components are used:

– High-pressure fuel pump with fuel pressure regulating valve N276 and integrated pressure limiting valve
– High-pressure fuel line
– Fuel distributor pipe
– Fuel pressure sender G247
– Injectors N30 – N33



432_042

Note

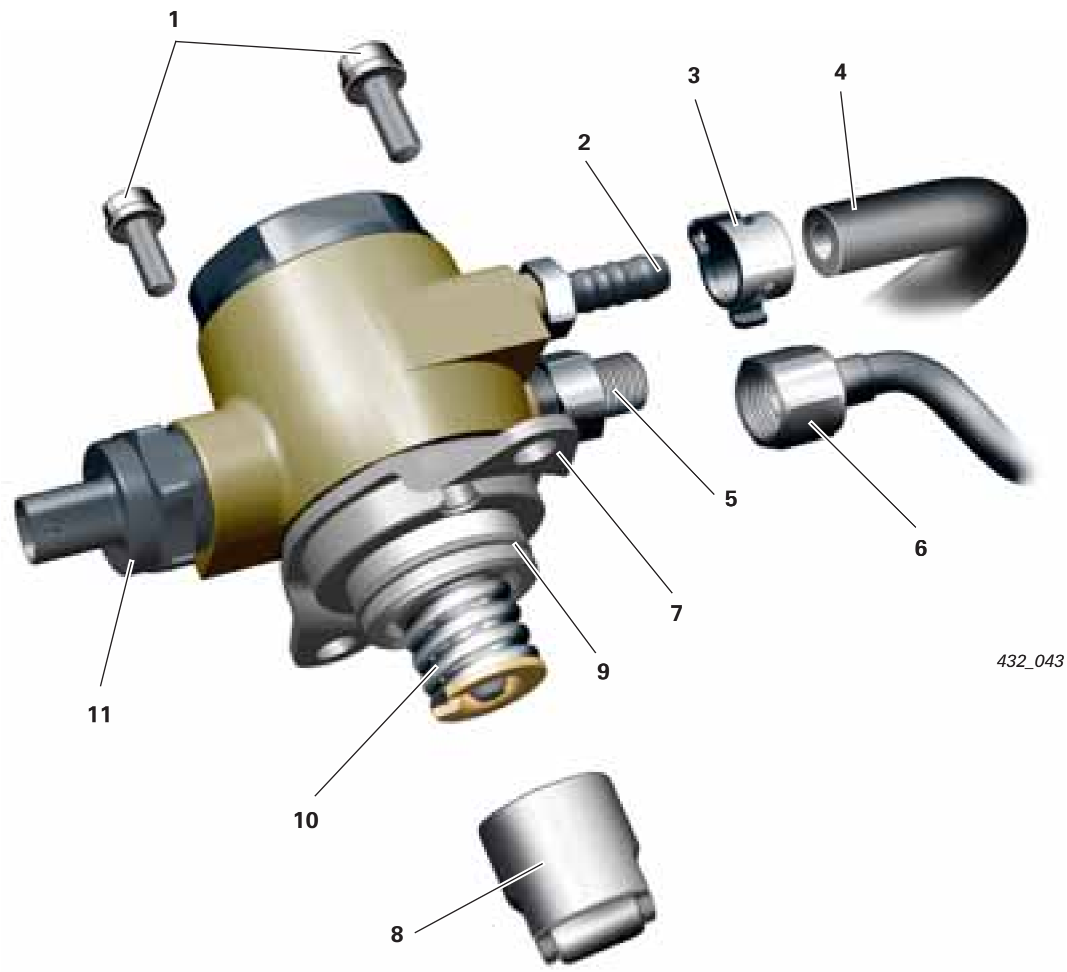
The fuel pressure must be reduced before opening the high-pressure fuel system. Previously, this could be done by disconnecting the connector from the regulating valve. The deenergised regulating valve was open, allowing the fuel pressure to bleed. In this engine, however, the regulating valve is closed when deenergised, which means that the fuel pressure can no longer be reduced by disconnecting the connector. Please note that fuel pressure increases again immediately, due to heating. Please refer to the relevant information stored in the ELSA system.

High-pressure fuel pump

A new 3rd generation high-pressure pump is used on 1.4l TFSI engine.
The pump is manufactured by Hitachi.

Key new features of the pump are:

- Smaller delivery stroke (3 mm),
- A pressure limiting valve integrated in the pump eliminates the need for a return line routed from the fuel distributor



Legend

1 Pump attaching screws
2 Low-pressure connection
3 Hose clamp
4 Return hose
5 High-pressure connection
6 Pressure line, high-pressure connection
7 Flange mount
8 Cylindrical tappet
9 Damper ring
10 Spring
11 Fuel pressure regulating valve N276

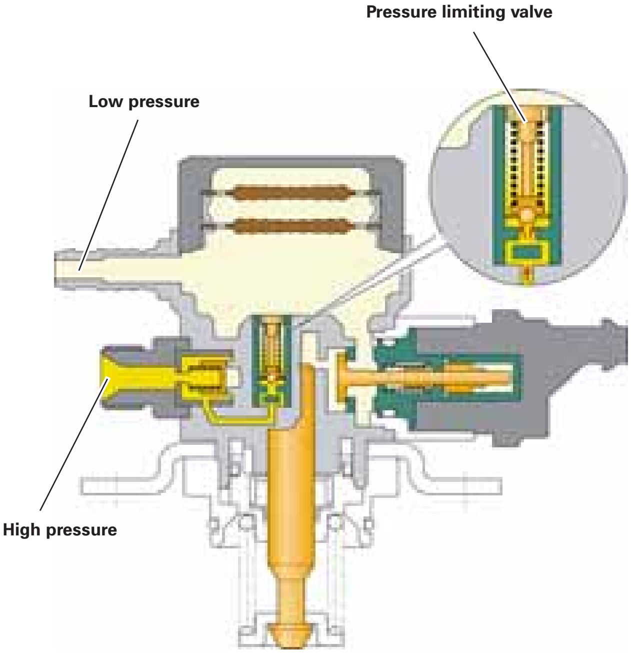
High-pressure pump regulating concept

Fuel regulation is demand-driven.
If the fuel pressure regulating valve N276 is not activated, the fuel is delivered into the high-pressure fuel system.
The high-pressure pump is driven by a four-lobe cam on the intake camshaft.

To minimise friction between the pump push rod and the camshaft, the movement of the push rod is transmitted by means of cylindrical tappets.
The pump is mounted at an angle in the cylinder head cover.

Pressure limiting valve

The pressure limiting valve is integrated in the high-pressure fuel pump and protects the components against excessively high fuel pressures caused by thermal expansion or malfunctioning.
It is a spring-loaded valve, opening at a fuel pressure of 140 bar. When the valve opens, the fuel flows from the high-pressure side of the pump into the low-pressure side.



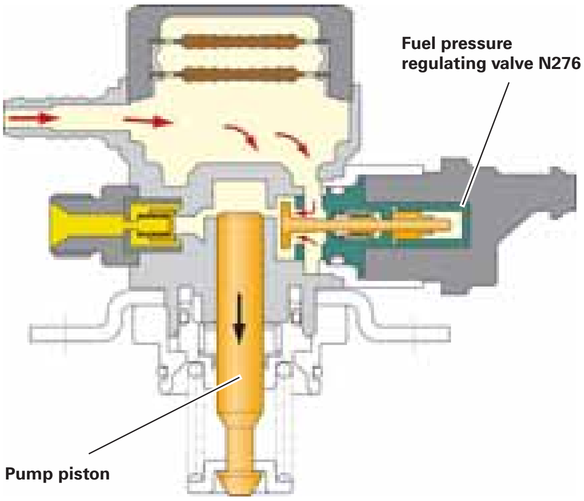
432_055

Function

Fuel intake stroke

The fuel pressure regulating valve N276 is energised by the engine control unit throughout the intake stroke. Due to the magnetic field thus produced, the intake valve opens against the pressure of the spring.

The pump piston moves downwards, creating a pressure gradient inside the pump chamber. As a result, the fuel flows from the low-pressure side into the pump chamber.

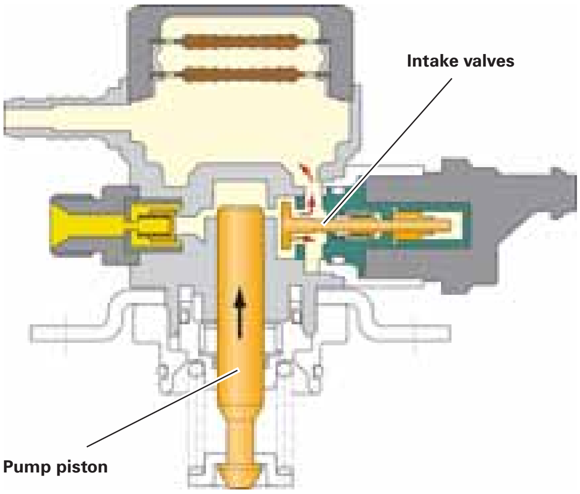


432_052

Fuel recirculation

To adapt the fuel feed rate to actual consumption, the intake valve remains open when the pump piston commences its upwards stroke.

The pump piston forces the excess fuel back into the low-pressure side. The resulting pulsation is equalised by the pressure reducer integrated in the pump and by a flow restrictor in the fuel supply line.

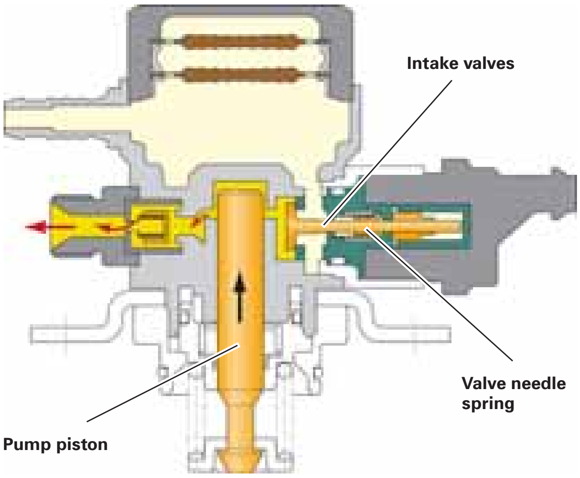


432_053

Fuel delivery stroke

The fuel pressure regulating valve is deenergised at the computed commencement point of the delivery stroke. The intake valve is closed by the rising pressure inside the pump and by the force of the valve needle spring.

The upward motion of the pump piston produces a pressure inside the pump chamber. If the pressure inside the pump chamber is greater than the pressure inside the fuel distributor, the exhaust valve opens. Fuel is pumped into the fuel distributor.



432_054

Effects of failure

The regulating valve is closed when it is deenergised. This means that in the event of failure of the regulating valve, the fuel pressure increases until the pressure limiting valve in the high-pressure fuel pump opens at approx. 140 bar.
The engine management system adapts the injection timing to the high pressure, and engine speed is limited to 3000 rpm.

System components

Fuel pressure sender G247

The sender is located at the bottom of the intake manifold on the flywheel side and is attached to the fuel rail by screws. It measures the fuel pressure in the high-pressure fuel system and transmits a signal containing this information to the engine control unit.

432_056

Fuel pressure sender G247

Signal utilisation

The engine control unit evaluates the signals and regulates the pressure in the fuel rail by means of the fuel pressure regulating valve.
If the fuel pressure sender also detects that the nominal pressure cannot be set, the fuel pressure regulating valve is activated continuously during the compression cycle and is open. Thus, the fuel pressure is reduced to 5 bar.

Effects of signal failure

If the fuel pressure sender fails, the fuel pressure regulating valve is activated continuously during the compression cycle, and is open. Thus, the fuel pressure is reduced to 5 bar. As a result, the engine has significantly less torque and power.

High-pressure injectors N30 – N33

The spray pattern of the 6-hole high-pressure injectors is designed to avoid wetting of the piston crown with fuel at full throttle or during the twin injection cycle in the warm-up phase of the catalytic converter.

Mixture formation is better. Hydrocarbon emissions are lower. Fuel entrainment into the engine oil is also reduced when the engine is cold.

432_058

The solenoid injectors are opened by the engine control unit with a voltage of 65V. Electrical current peaks of up to 12 amperes can occur. The holding current is approx. 2.6 amperes.
The injectors are attached to the base of the intake manifold, in which the fuel distributor is also integrated.

432_057

Note

To remove the injectors, the puller T10133/2 in tool set T10133 must be adapted accordingly and then labelled T10133/2A.
For a detailed description of the procedure, please refer to the Workshop Manual.

Control of mixture formation

Despite the fact that this engine meets the provisions of the EU IV exhaust emission standard, no secondary air injection system or exhaust gas recirculation are needed. The exhaust gases are treated in a three-way catalytic converter, which is located downstream of the exhaust gas turbocharger close to the engine.
Due to this configuration, the ceramic catalytic converter reaches its operating temperature very quickly.
Mixture formation is controlled by nonlinear lambda sensors. One sensor (G39) is located directly upstream of the catalytic converter and is responsible for mixture formation. The nonlinear lambda sensor G130 checks for proper functioning of the sensor upstream of the catalytic converter and the conversion rate of the catalytic converter. It is located directly downstream of the catalytic converter.

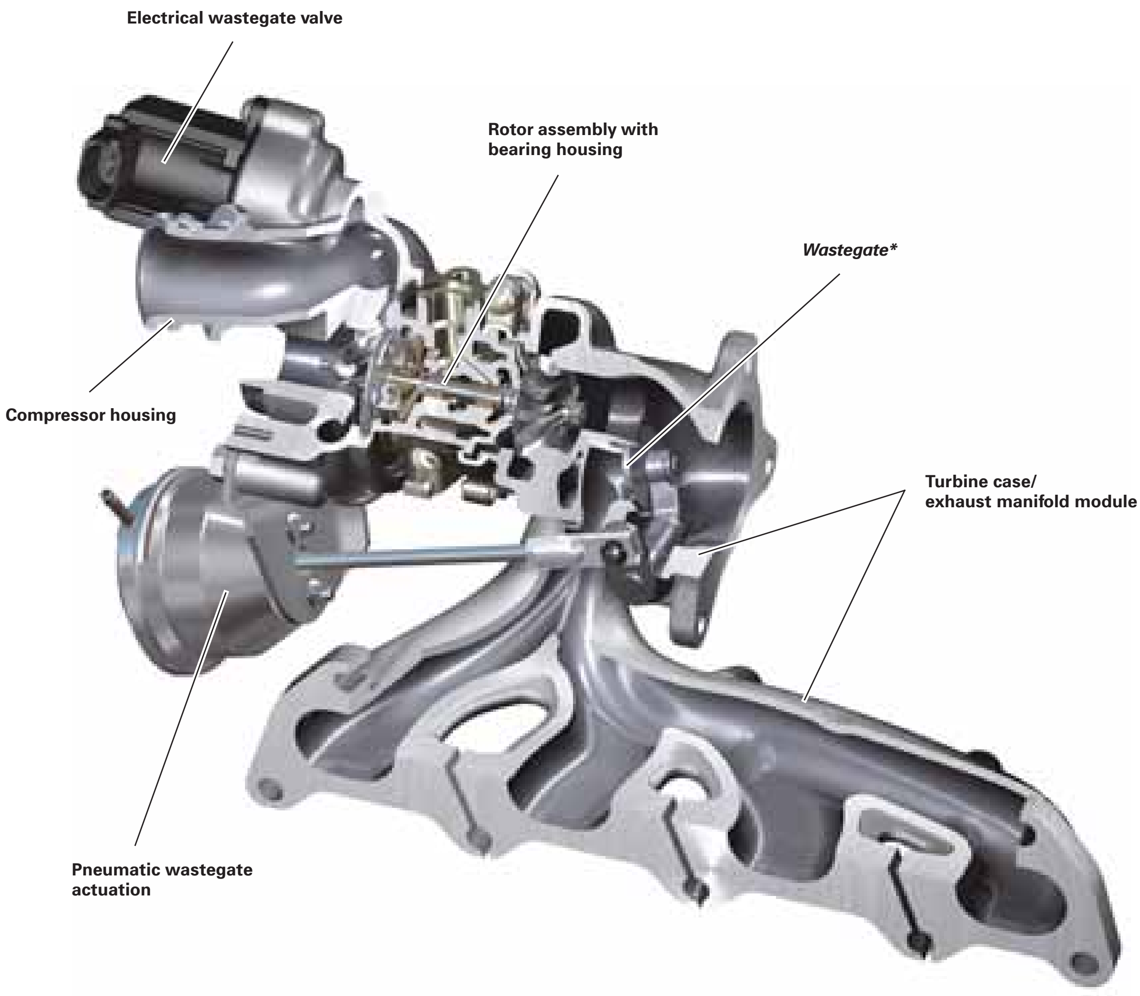
Exhaust gas turbocharger

The exhaust gas turbocharger and the exhaust manifold are integrated in a common module. The turbocharger divert air valve N249 and the vacuum actuator for charge air control are separately exchangeable parts.

During the development phase, special emphasis was placed on very good response at low engine speeds. For this reason, the turbine and compressor rotors were designed very compactly with diameters of 37 mm and 41 mm respectively.

As a result, the exhaust gas turbocharger responds at engine speeds just above idling level.
The wastegate port has a large diameter of 26 mm, which serves to reduce excessively high exhaust gas pressures.

Due to these design modifications, 80 % of the maximum torque is available at an engine speed of only 1250 rpm. A maximum torque of 200 Nm is available at engine speeds above 1500 rpm.
The maximum available charge pressure is 1.8 bar (absolute).



432_025

Note

For a description of the wastegate control system, refer to Self-Study Programme 332 "Audi A3 Sportback".

Cooling and lubrication of the exhaust gas turbocharger

To protect the exhaust gas turbocharger from overheating, it is integrated in the cooling circuit of the charge air cooling system (see overview of coolant system on page 27).
To prevent heat accumulation, the cooling system continues to circulate coolant after the engine shuts down for a set period of time preconfigured in a characteristic map.

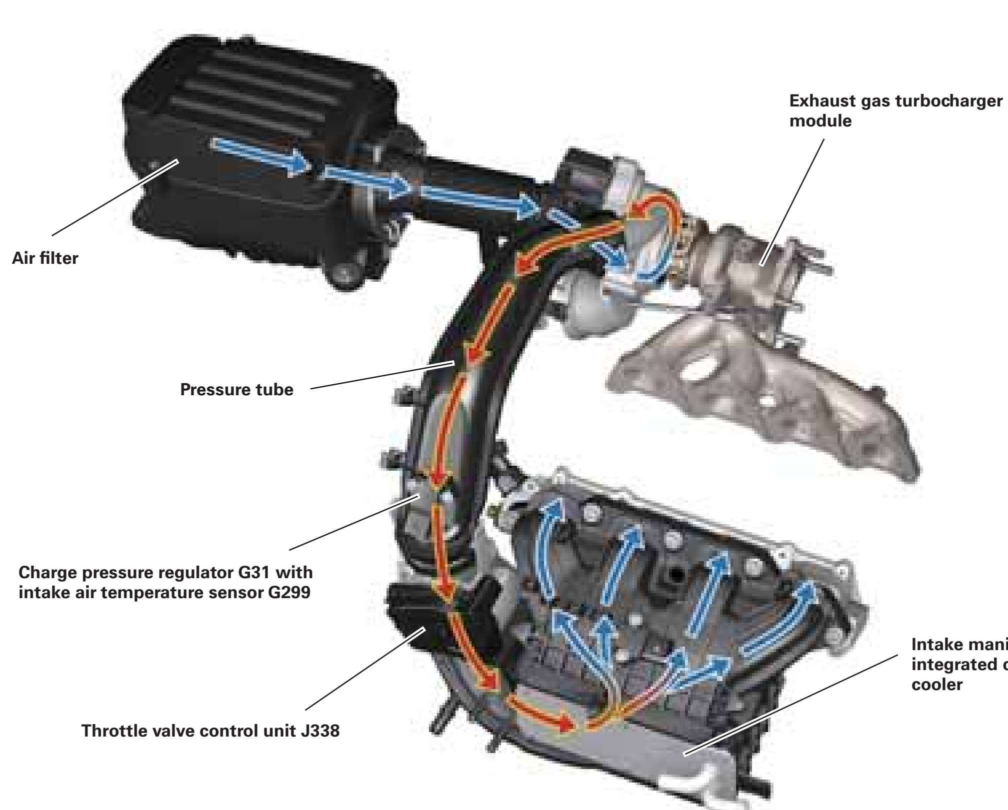
For this purpose, the coolant circulation pump V50 is integrated in the charge air cooling system.
It is activated by the engine control unit via the auxiliary coolant pump relay J496.
The exhaust gas turbocharger rotor assembly is coupled to the engine lubricating oil system for lubrication and cooling.

432_026

Intake system

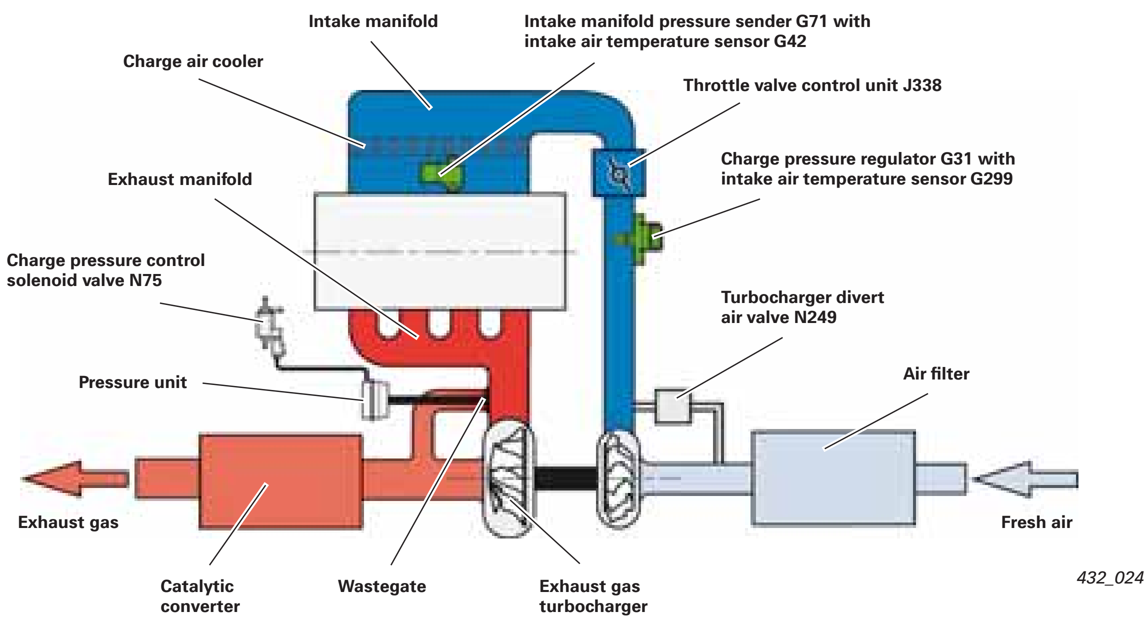
The entire air supply system of the 1.4l TFSI engine is designed very compactly.
The development goal was achieve the shortest possible flow paths. To this end, the system does without an air-to-air charge air cooler and accompanying charge air line. Instead, an air-to-water charge air cooler has been integrated directly into the intake manifold.

This enabled the air volume between the exhaust gas turbocharger and the intake valve to be more than halved, reducing pressure and flow losses and providing a marked improvement in the response of the charging system. As a result, the overall efficiency of the engine is higher.



432_023

System overview



432_024

Charge pressure control

Charge pressure is regulated by means of a wastegate (bypass valve). The wastegate is actuated by a vacuum actuator via a linkage, which, for this purpose, is subjected to a modulated charge pressure by the charge pressure control solenoid valve N75.

The air mass required by the engine is determined and regulated by the charge pressure control system. This p/n control system uses two pressure and temperature sensors.

Charge pressure sender G31 with intake air temperature sensor 2 G299

This sender is integrated in the pressure tube upstream of the throttle valve module, where the air pressure and temperature downstream of the turbocharger are metered. The signal from G31 is utilised by the engine control unit to regulate the charge pressure.

The signal from G299 is required:

– to calculate a correction value for charge pressure.
  Thus, allowance is made for the effect of temperature on charge air density.
– for component protection.
  If the temperature of the charge air exceeds a certain value, the charge pressure is reduced.
– to activate the coolant recirculating pump.
  If the temperature difference between the charge air upstream and downstream of the charge air cooler is less than 8 °C, the coolant circulation pump is activated.
– to check the plausibility of the signal from the coolant recirculating pump.
  If the temperature difference between the charge air upstream and downstream of the charge air cooler is less than 2 °C, it is assumed that the pump is faulty. The exhaust gas warning lamp K83 is activated.

Effects of signal failure

If the signal from both sensors fail, the turbo-charger is operated under open loop control only. Charge pressure, i.e. engine power, is reduced.

432_027

Intake manifold pressure sender G71 with intake air temperature sensor G42

This duosensor (identical to G31/G299) is integrated in the intake manifold downstream of the charge air cooler, where the air pressure and temperature downstream of the turbocharger are also metered.

The air mass is calculated from the signals from this sensor making allowance for engine speed. At this metering point downstream of the charge air cooler, the metered and computed air mass is identical to the air mass being used by the engine.

The signal from G42 is also required:

– to activate the coolant run-on pump.
  If the temperature difference between the charge air upstream and downstream of the charge air cooler is less than 8 °C, the coolant circulation pump is activated.

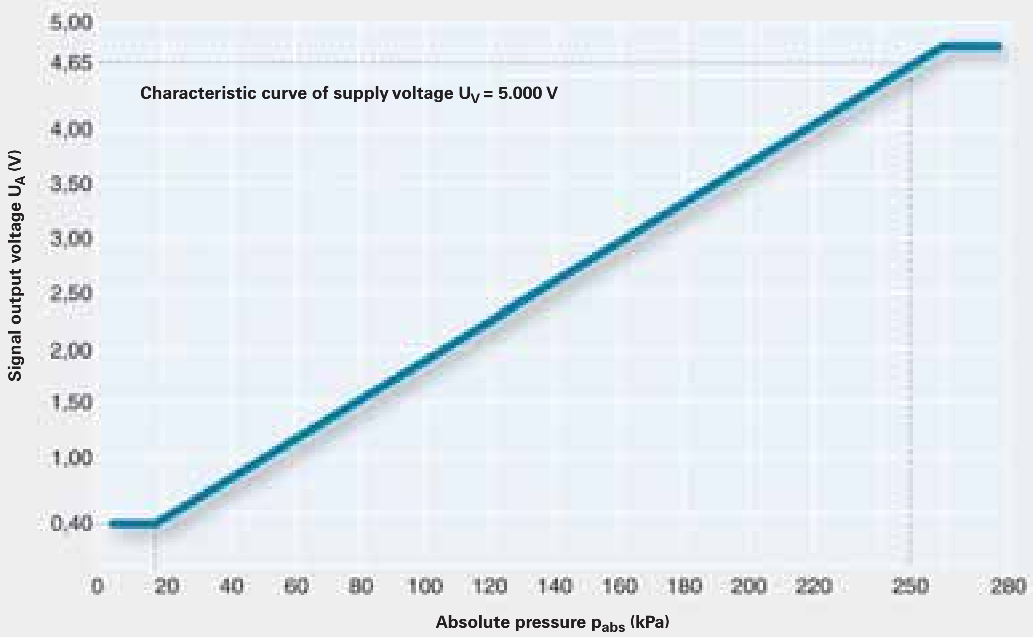
– to check the plausibility of the signal from the coolant recirculating pump.
  If the temperature difference between the charge air upstream and downstream of the charge air cooler is less than 2 °C, it is assumed that the pump is faulty. The exhaust emissions warning lamp K83 is activated.

432_028

Effects of signal failure

In the event of signal failure, the throttle valve position signal and the temperature signal from G299 are utilised as substitute signals. The turbo-charger is operated under open loop control only. Charge pressure, i.e. engine power, is reduced.

Signal pattern of intake manifold pressure sender

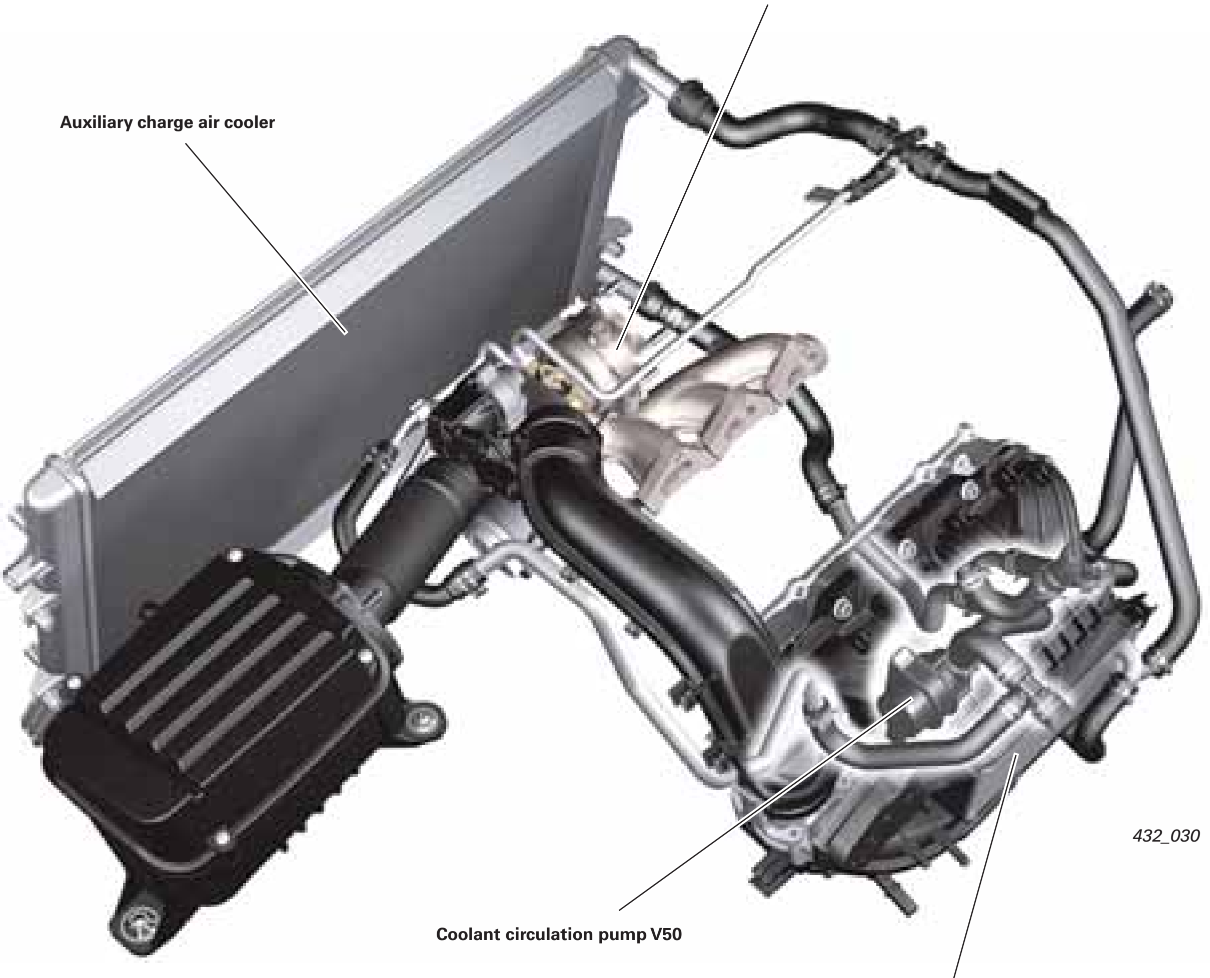


Charge air cooling

A liquid-cooled charge cooling system is used for the first time in this engine series. In this system, a charge air cooler with coolant flowing through it is located directly in the intake manifold.
The charge air cooler has its own circuit and is integrated in the engine cooling system.
The exhaust gas turbocharger is also an integral part of this circuit.

The existing coolant circulation pump V50 is used as a delivery pump for this low temperature system. It is controlled according to demand by the engine control unit via the auxiliary coolant pump relay.

The signals from intake air temperature sensors G42 and G299 are utilised to calculate the activation pulse.
When the pump is running, the cooled coolant from the charge-air system's auxiliary cooler is fed through the charge air cooler in the intake manifold and, at the same time, through the exhaust gas turbocharger.
From here the heated coolant recirculates to the charge air system's auxiliary cooler.
The temperature differential between the air downstream of the charge air cooler and the ambient temperature is approximately 20 °C in the worst case.

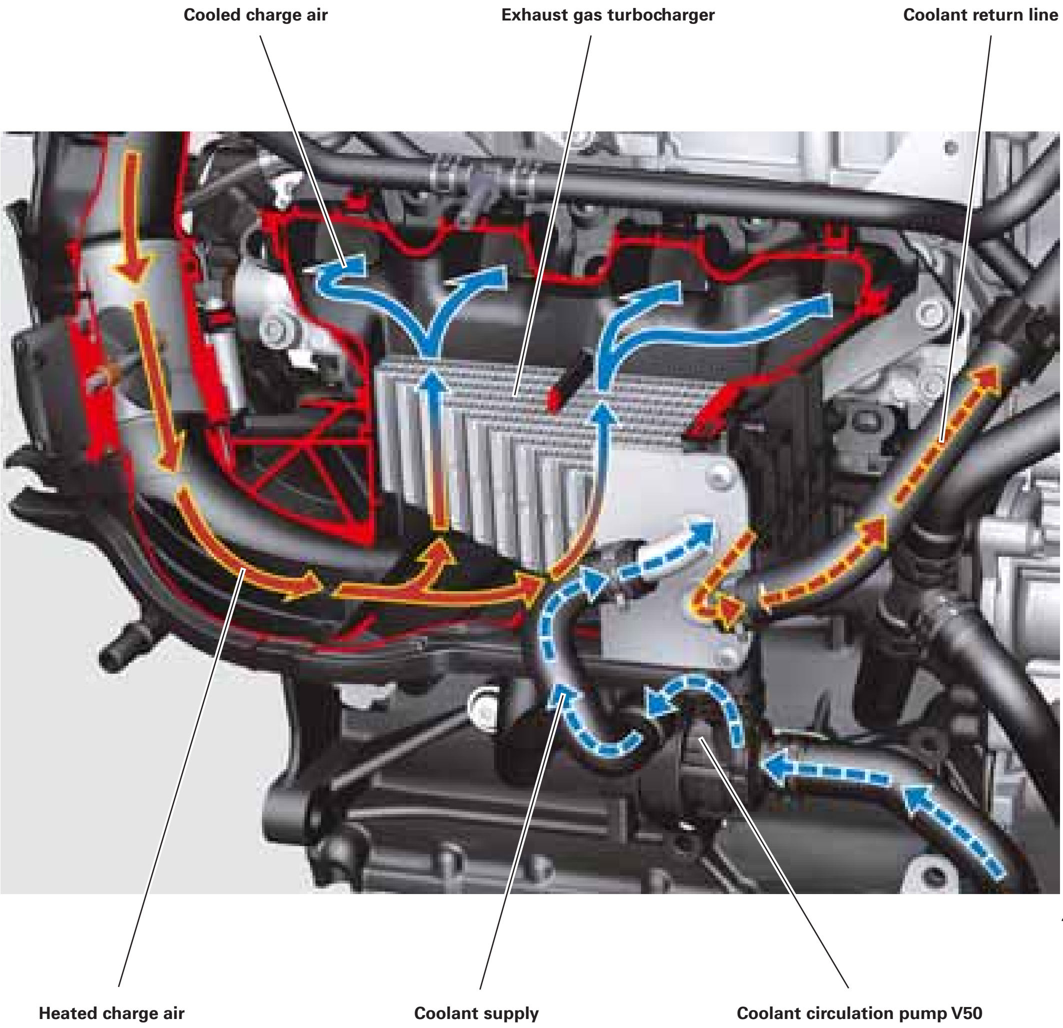


432_030

Charge air cooler

The charge air cooler has a similar design and function to a regular liquid cooler.
The coolant flows through a pipe integrated in an aluminium plate assembly.

The warm air flows past the plates and dissipates heat to the plates.
The plates, in turn, transfer the heat they have absorbed to the coolant. The heated coolant is fed to the auxiliary cooler of the charge air system, where it is cooled.



432_031

Legend

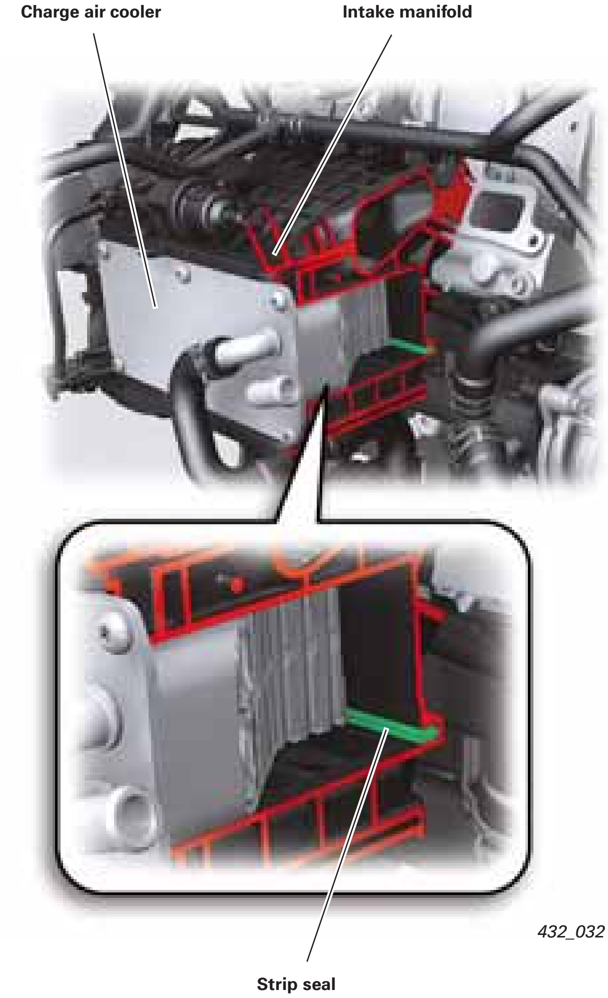
- Cooled charge air
- Warm charge air
- Cold coolant
- Warm coolant

Installing and removing

The charge air cooler is pushed into the intake manifold and fastened with six screws.
There is a strip seal on the back of the charge air cooler. It serves to seal the charge air cooler off from the intake manifold while simultaneously supporting the charge air cooler.

Note

When installing the charge air cooler, pay attention to correct fitting of the strip seal.
If the seal is not fitted correctly, vibration will occur, causing the seal to break and the charge air cooler to leak.



432_032

Coolant circulation pump V50

The coolant circulation pump V50 is attached by screws to the cylinder block below the intake manifold. It is an integral part of an independent cooling system.

Task

The coolant circulation pump delivers coolant from a front-end auxiliary cooler to the charge air cooler and to the exhaust gas turbocharger. It is activated under the following conditions:

- briefly after every engine start
- continuously at engine torque levels above approx. 100 Nm
- continuously at charge air temperatures higher than 50 °C in the intake manifold
- when the temperature difference between the charge air upstream and downstream of the charge air cooler is less than 8 °C
- for 10 seconds every 120 seconds when the engine is running in order to avoid heat build-up, particularly at the exhaust gas turbocharger
- in a map-dependent manner for 0 – 480 seconds after engine shut-off in order to prevent overheating and vapour bubble formation at the exhaust turbocharger

432_077

Effects of failure

Overheating can occur if the coolant run-on pump fails. The pump itself is not checked by the self-diagnostics. The cooling system is monitored by comparing the temperature upstream and downstream of the charge air cooler, and, in the event of a fault, the exhaust gas warning lamp K83 is activated.

System overview 1.4l TFSI engine

Sensors

Intake manifold pressure sender G71 (after throttle valve)
Intake air temperature sensor G42

Charge pressure sender G31 with intake air temperature sender 2 G299 (after throttle valve)

Engine speed sender G28

Hall sender G40

Throttle valve control unit J338
Throttle valve drive angle senders 1 and 2 G187, G188

Accelerator pedal position senders G79 and G185

Clutch position sender G476

Brake light switch F
Brake pedal switch F63

Fuel pressure sender G247

Knock sensor 1 G61

Coolant temperature sender G62

Radiator outlet coolant temperature sender G83

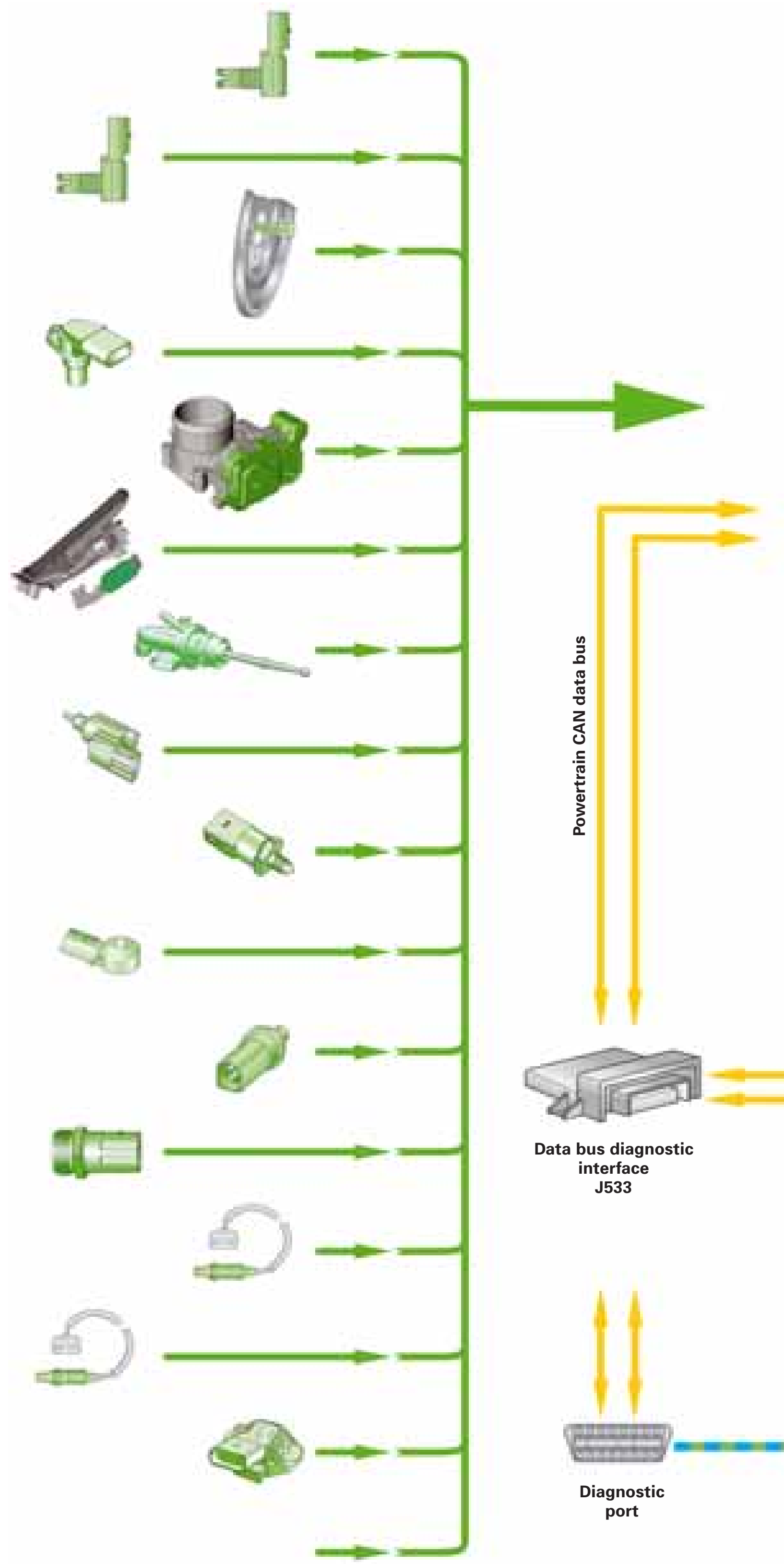
Lambda probe G39

Lambda probe after catalytic converter G130

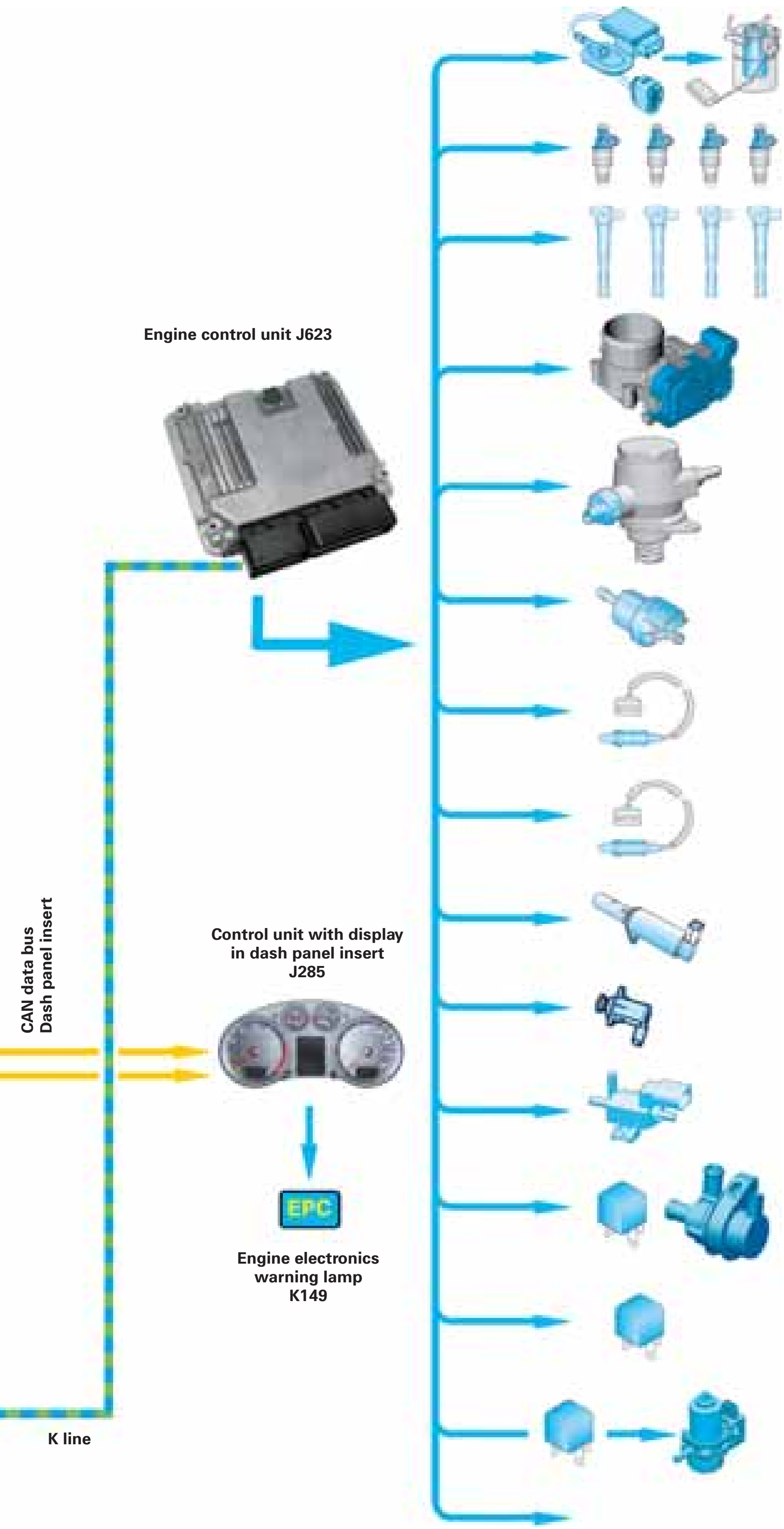
Brake servo pressure sensor G294*

Auxiliary input signals:
- **Cruise control system I/O via J527**
- **Alternator terminal DFM**
- **Radiator fan speed 1 (pulse width modulated signal)**

*** only relevant to vehicles with twin-clutch gearbox and ABS without ESP**



Actuators



432_022

Fuel pump control unit J538
Fuel pump (pre-supply pump) G6

Injector, cylinder 1 – 4
N30 – N33

Ignition coil 1 – 4 with output stage
N70, N127, N291, N292

Throttle valve control unit J338
Throttle valve with electric power control G186

Fuel pressure regulating valve N276

Activated charcoal filter solenoid valve 1 N80

Lambda probe heater Z19

Lambda probe 1 heating, after catalytic converter Z29

Inlet camshaft timing adjustment valve -1- N205

Turbocharger divert air valve N249

Charge pressure control solenoid valve N75

Auxiliary coolant pump relay J496
Coolant circulation pump V50

Motronic current supply relay J271

Vacuum pump relay J57
Vacuum pump for brakes V192
(for vehicles with automatic gearbox)

Auxiliary output signal:
– Brake light to onboard power supply control unit J519

Engine control unit

The Bosch Motronic MED 17.5.20 is an improved version of the MED 17.5 used on the Audi 1.8l TFSI engine (EA 888).

Apart from several modifications, the MED 17.2.20 is a typical Audi FSI engine management system for turbocharged engines principally designed for single injection with a fuel-air ratio of lambda = 1.

432_059

Modified functions of the MED 17.5.20

- At launch, the engine will feature a lambda control system with sensors upstream and downstream of the catalytic converter (both nonlinear sensors). This system is adequate because the engine is predominantly operated with a fuel-air ratio of lambda = 1 and the Euro IV exhaust emission standard can be met even without an expensive broadband sensor.
- As a further development, the sensor upstream of the catalytic converter will be replaced by a broadband sensor at a later date. This will keep exhaust emissions within the limits prescribed by the Euro V standard.
- Intake manifold flaps have been dispensed with. Therefore, to avoid adversely affecting exhaust emissions, performance and running refinement, the complete injection system has been redesigned.
- Control and diagnosis of the cooling system to regulate cooling output (due to the fact that the system has been separated into two circuits).
- The high-pressure fuel pump control concept has been modified by changing over to a 3rd generation pump.

Operating modes

- In the start phase, a high-pressure stratified start-up strategy is applied. A fuel pressure of approximately 60 bar is injected shortly before the ignition point.
- After the start phase, the Homogeneous Split (HOSP) mode is activated for up to 20 seconds. In this mode, the catalytic converter is heated to its operating temperature as quickly as possible.
- During normal engine operation, fuel is injected by a single injection pulse with open intake valve. An air-fuel mixture with a fuel-air ratio of lambda = 1 is implemented.
- Only in the upper engine load and speed ranges is the mixture slightly enriched.
- Enrichment is also used as a way of protecting components against overheating. The over-rich fuel-air mixture has a cooling effect because fuel precipitates onto the overheated components in the combustion chamber and evaporates.

Maintenance work

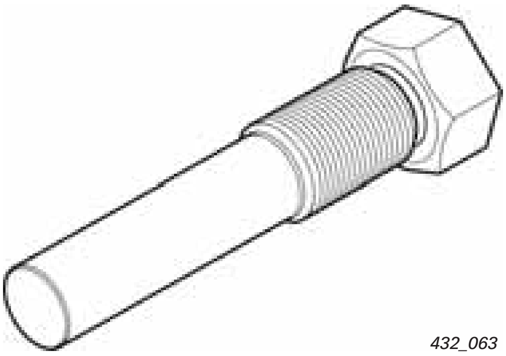
Maintenance work	Interval
Engine oil replacement interval with LongLife/24 months: with engine oil specifications:	up to a maximum of 30,000 km or a maximum of 24 months depending on SID [1] (change interval is dependent on driving style) Engine oil according to VW standard 504 00
Engine oil replacement interval without LongLife/12 months: with engine oil specifications:	Fixed interval of 15,000 km or 12 months (depending on comes first) Engine oil according to VW standard 504 00 or 502 00
Engine oil filter replacement interval:	at every oil change
Engine oil change quantity (inc. filter):	3.6 litres
Engine oil extraction/drainage:	both are possible
Air filter replacement interval:	90,000 km/6 years
Fuel filter replacement interval:	none
Spark plug replacement interval:	60,000 km

Timing and ancillary unit drive	
Ribbed V-belt replacement interval:	Lifetime
Ribbed V-belt tensioning system:	Lifetime
Timing belt replacement interval:	n.a. (engine is chain driven)
Timing gear chain replacement interval:	Lifetime
Timing gear chain tensioning system:	Lifetime

[1] *SID = Service Interval Display*

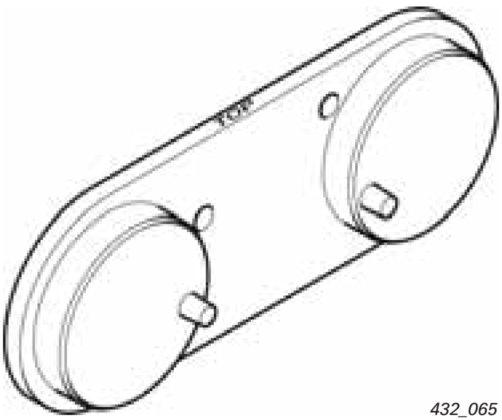
Special tools

Here are the special tools for the 1.4l TFSI engine.



432_063

T10340
Locating screw
For locating the crankshaft in order to set the valve timing



432_065

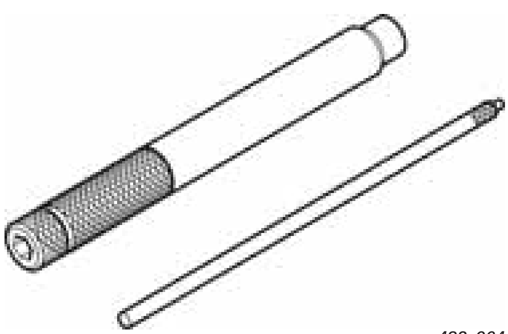
T10171 A
Camshaft locating tool
For locating the camshafts in position and checking and setting the valve timings

Note

This special tool is the special tool previously designated "camshaft locating fixture" T10171. Because a different attachment point is used for the special tool, you have to adapt the special tool accordingly. Follow the instructions given in ELSA.

432_061

VAS 6079
Dial gauge
For setting TDC of the 1st cylinder



432_064

T10170
Dial gauge adaptor
together with dial gauge For setting TDC of 1st cylinder

Glossary

This glossary explains to you all terms written in italics or indicated by an asterisk (*) in this Self-Study Programme.

Blow-by gases
Also referred to as leakage gases. When the engine running, blow-by gases flow from the combustion chamber into the crankcase bypassing the piston. This is caused by high pressure inside the combustion chamber and by the absolutely normal leakage which occurs around the piston rings. Blow-by gases are extracted from the crankcase by a crankcase breather and fed into the combustion chamber.

Cracked con-rods
The name "cracked con-rod" derives from the manufacturing process. The con-rod shaft and the con-rod cap are separated from each other by precision cracking. The advantage of this process is that the finished parts fit each other perfectly.

Expansion element (thermostat)
An expansion element is integrated in the cooling system thermostats, which contain a wax that expands on heating, thereby displacing a lifting pin. This pin moves the thermostat plate and thus opens the primary cooling circuit.

Downsizing
Increased efficiency through synergy effects.
This means that less hardware is needed to achieve the same level of performance.

Duocentric oil pump
This type of pump comprises an inner rotor and an outer rotor. The inner rotor has one tooth less than the outer rotor and is coupled to the input shaft. The centres of both rotors are slightly offset, hence the name "duocentric". The self-regulating version also has a regulating spring which allows a near-constant oil pressure to be maintained throughout the rev range.

Elastomers
Elastomers are plastics that are dimensionally stable, but elastically deformable. The plastics are deformable under tensile and compressive load, but subsequently return to their original shape. Elastomers are used, for example, in cylinder-head gaskets.

Open-deck design
Is a design used for cylinder blocks. The cooling ducts are completely open facing upwards. This provides very good exchange of coolant between the cylinder block and head. However, cylinder blocks of this type have less stability. Greater stability is achieved by using special cylinder-head gaskets.

TOLS sensor
The abbreviation TOLS stands for "thermal oil level sensor". The sensor is located directly inside the oil pan. For the purposes of measurement, the measuring element integrated in the sensor is briefly heated to above the current oil temperature and subsequently cools down again. This process takes place continuously. From the cooling times, an electronic device computes the current oil level and sends a signal containing this information to the control unit with display in dash panel insert.

Wastegate
To regulate the charge pressure on a turbocharger, a wastegate is installed in the exhaust gas flow.
If the charge pressure is too high, an actuator opens the wastegate. The exhaust gas bypasses the turbine and is routed directly into the exhaust system, thus preventing a further increase in turbine speed.

Test yourself

Which of the following answers is correct?
Sometimes only one answer can be chosen.
At other times, more than one answer may be correct – or all of them!

1. What are the characteristic features of the 1.4l TFSI engine?

☐ A Exhaust gas turbocharger with charge air cooler
☐ B Variable valve timing on the intake and exhaust
☐ C Lambda control with nonlinear sensor and broadband oxygen sensor

2. Which of the following statements applies to the engine crankcase breather?

☐ A The oil separator is located in the timing case cover.
☐ B The "cleaned" blow-by gases are admixed with the intake air through a value unit.
☐ C Depending on the operating state of the engine, the "cleaned" blow-by gases are admixed with intake air on the intake side of the turbocharger or directly at the intake manifold.

3. What are the advantages of the regulated duocentric oil pump?

☐ A The engine requires less oil than a conventional oil pump.
☐ B Less engine power is required, thus saving fuel.
☐ C Reduced oil quality deterioration due to lower oil recirculation rate.

4. When does the exhaust gas warning lamp K83 in the dash panel insert come on?

☐ A When faults are detected in the exhaust treatment system (oxygen sensors).
☐ B When faults are detected in the cooling system (e.g. coolant circulation pump).
☐ C When faults occur in the automatic gearbox.

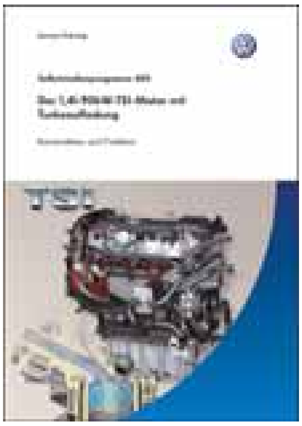
5. At which pressure do the injectors inject the fuel into the combustion chambers?

☐ A 5 bar
☐ B 1400 bar
☐ C 35 — 100 bar

Solutions:

1. A; 2. A, B, C; 3. B, C; 4. A, B; 5. C

Self-Study Programmes

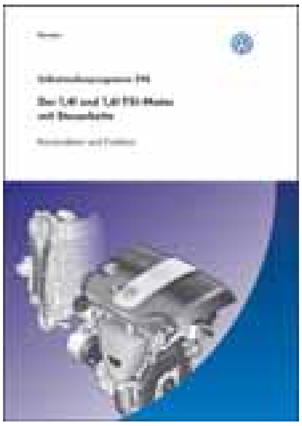


432_083

SSP 405
The 1.4l 90kW TSI Engine With Turbocharging

SSP 359
The 1.4l TSI Engine With Dual Charging

432_084



432_085

SSP 296
The 1.4l And 1.6l FSI Engines With Timing Chain

432

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