Self Study Programme 608

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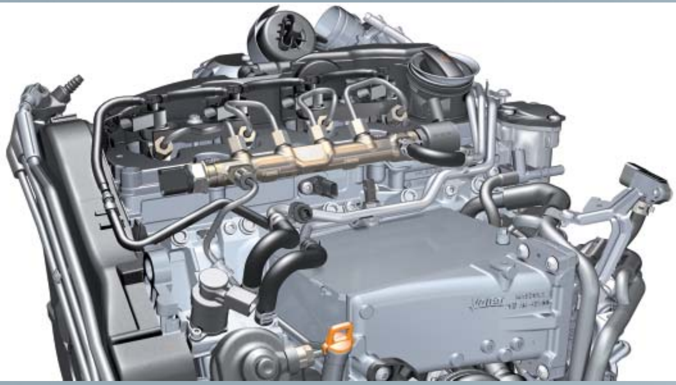
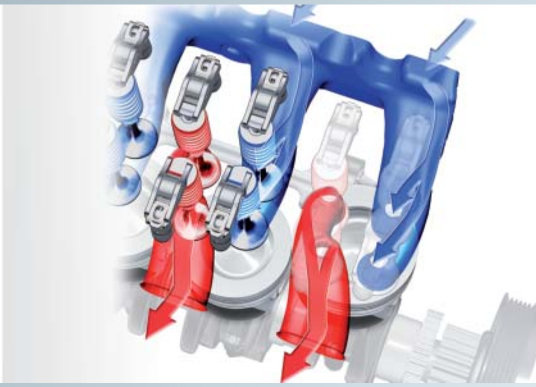




The Audi 1.6l and 2.0l 4-cylinder TDI engines

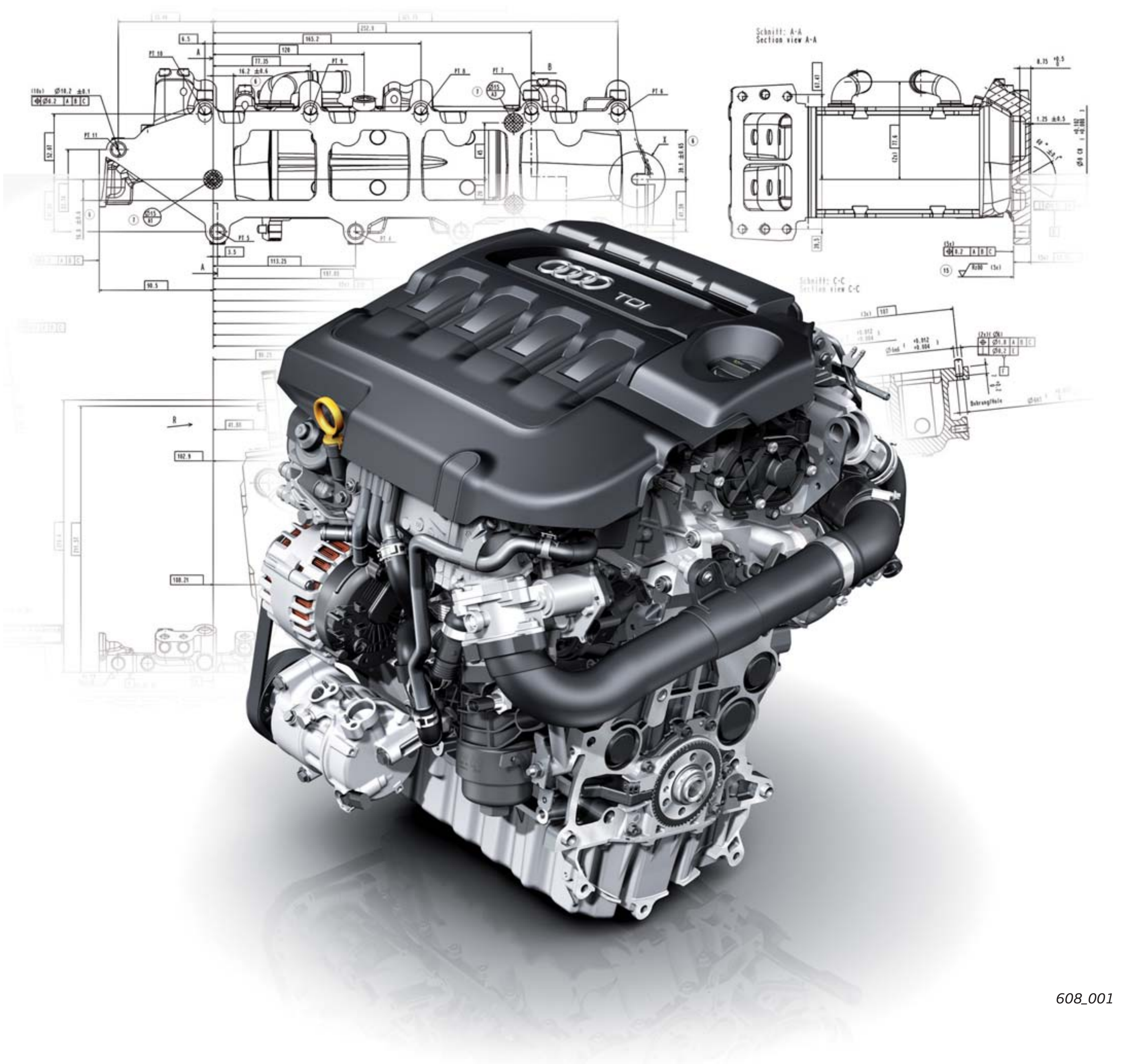
Audi
Service Training

The new modular TDI® generation provides a harmonised basis for future diesel engines. It comprises four cylinder engines with displacements from 1.6 l to 2.0 l and power outputs from 66 kW to 135 kW in the various exhaust emission versions.
Audi's engine development engineers have translated this strategy to the Modular Diesel Platform (MDP) in order that successive platforms in the mid-range, compact and subcompact classes can be supplied with identical or adapted engine assembly modules in future.
This will allow for standardised procedures during the development process and at production facilities within the Group, whilst also ensuring an economical flow of materials.

The modular design principle has been applied both to the core assemblies (basic engine assembly, cylinder head and valvegear) and to the attachments (close-coupled exhaust gas treatment system and intake manifold with integrated charge air cooler).

The Modular Diesel Platform (MDP) will:

- meet future exhaust emission regulations,
- reduce CO_2 emissions still further,
- cater to EU and NAR markets by providing an identical basic concept and
- eliminate the need for universal use of SCR (selective catalytic reduction) and accompanying engineering work in vehicle platforms.



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Learning objectives of this Self Study Programme:

This self study programme describes the design and function of the 1.6l/2.0l 4-cylinder TDI engine (MDP – Modular Diesel Platform). After you have worked your way through this Self Study Programme, you will be able to answer the following questions:

- How are the balancer shafts driven?
- What is the function of the exhaust flap in the exhaust system?
- What is the term used to describe the cooling system at cold start?
- What distinguishes the cylinder block of the 1.6l TDI from that of the 2.0l TDI engine?
- In what order are the cylinder head valves fitted?

Contents

- The Self Study Programme teaches a basic knowledge of the design and functions of new models, new automotive components or new technologies.

It is not a Repair Manual! Figures are given for explanatory purposes only and refer to the data valid at the time of preparation of the SSP.

For further information about maintenance and repair work, always refer to the current technical literature.

Note

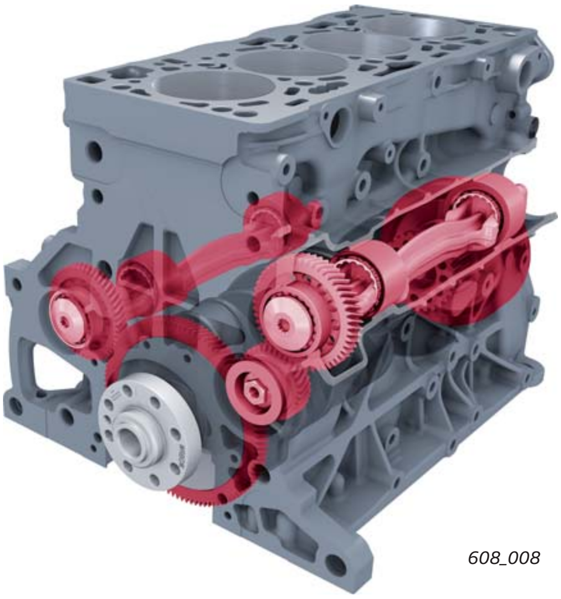
Reference

Introduction

Brief technical description

Technical features of the 1.6l/2.0l 4-cylinder TDI engine (MDP)

Cylinder block with integrated balancer shafts (2.0l TDI engine only)



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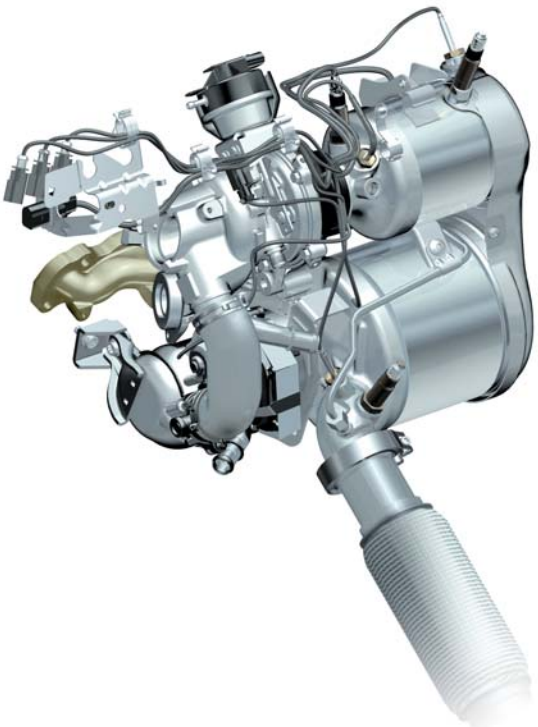
Oxidising catalytic converter and diesel particulate filter (transverse installation)



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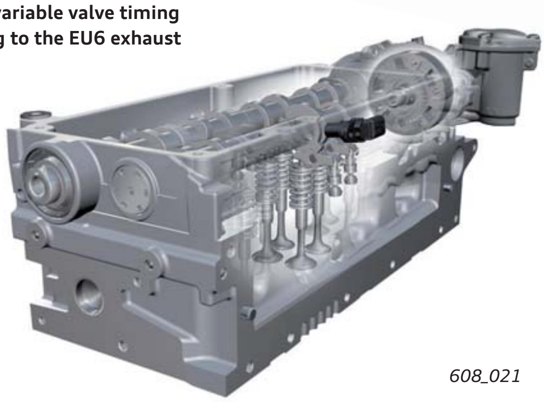
Cylinder head with variable valve timing (engines conforming to the EU6 exhaust emission standard)



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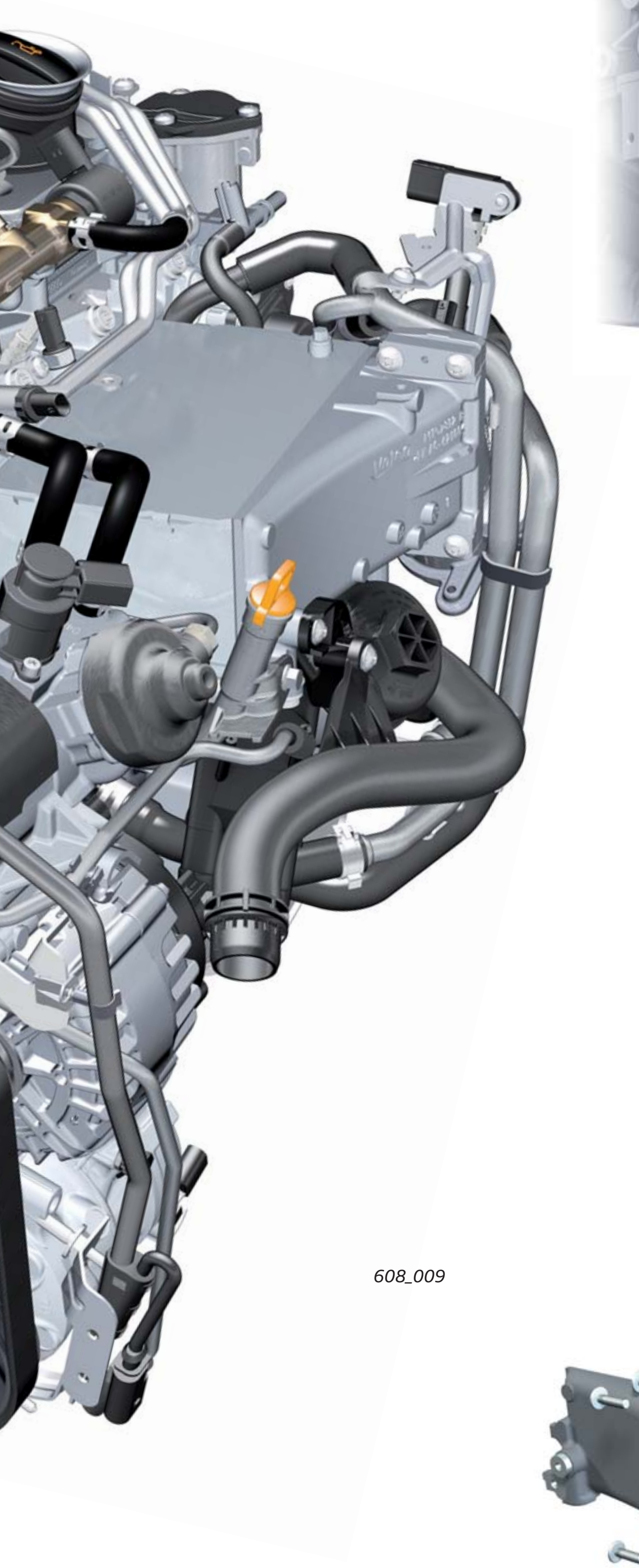

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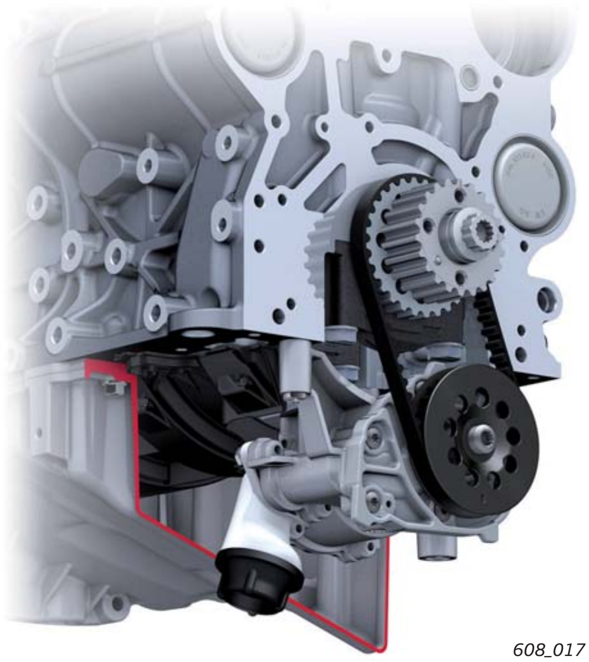
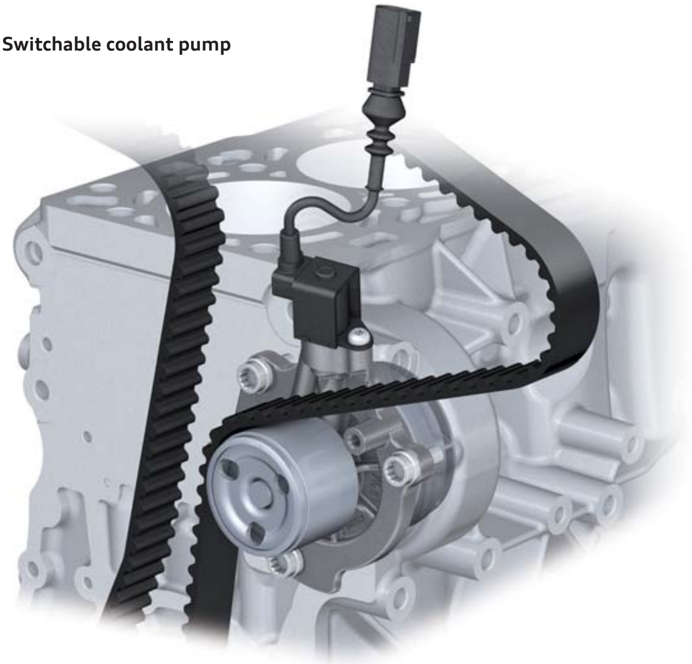
Oil pump with integral vacuum pump



608_017

Switchable coolant pump



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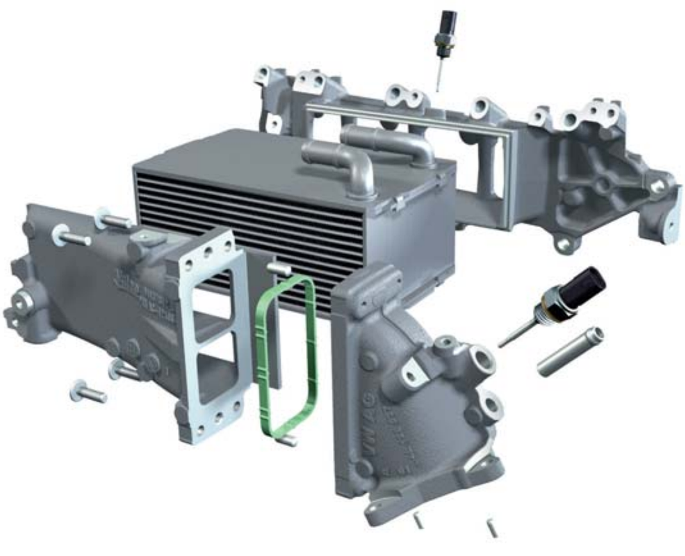
Intake manifold module with integrated charge air cooler



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Specifications

Torque/power curve of 1.6l TDI engine

Power output in kW

Torque in Nm

Engine number

608_059

608_002

Engine code	CLHA
Type	Four-cylinder inline engine
Displacement in cm^3	1598
Stroke in mm	80.5
Bore in mm	79.5
Cylinder spacing in mm	88.0
Number of valves per cylinder	4
Firing order	1–3–4–2
Compression ratio	16.2 : 1
Power output in kW at rpm	77 at 3000 – 4000
Torque in Nm at rpm	250 at 1500 – 2750
Fuel	Diesel to EN 590
Engine management system	Bosch EDC 17
Maximum injection pressure in bar	1800 with solenoid valve injector CRI2-18
Emissions standard	EU5
CO_2 emission in g/km	99

Torque/power curve of 2.0l TDI engine

Engine with engine codes CRLB and CRBC

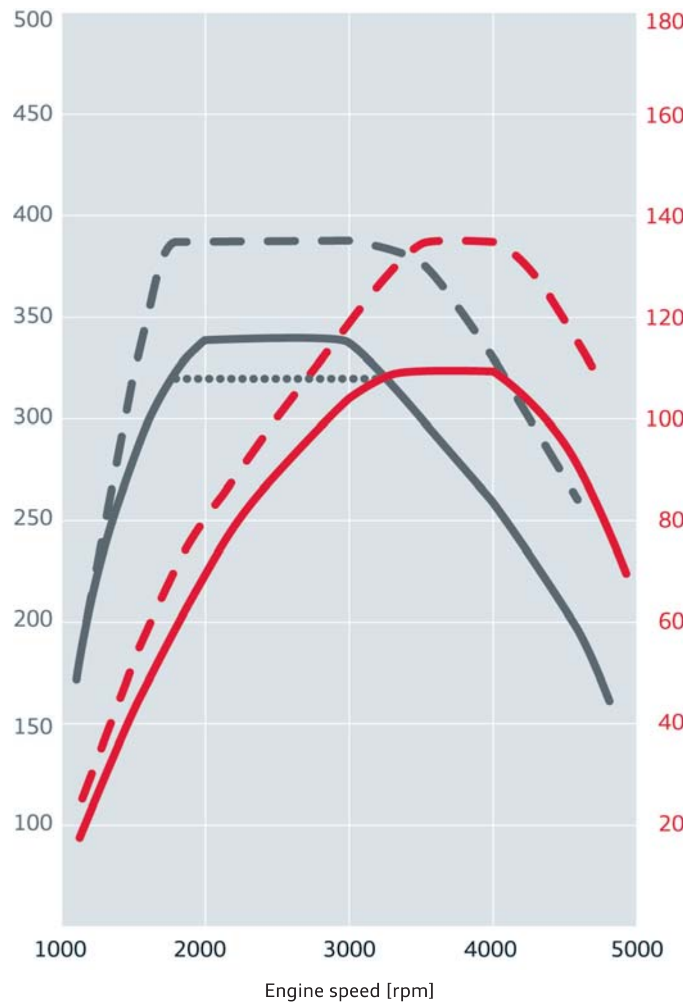
- Power output in kW (solid red line)
- Torque in Nm (CRLB) (solid grey line)
- Torque in Nm (deviation from CRBC) (dotted line)

Engine with engine code CUPA

- Power output in kW (dashed red line)
- Torque in Nm (dashed grey line)

Engine number

608_057



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Engine code	CRBC	CRLB	CUPA
Type	Four-cylinder inline engine	Four-cylinder inline engine	Four-cylinder inline engine
Displacement in cm^3	1968	1968	1968
Stroke in mm	95.5	95.5	95.5
Bore in mm	81.0	81.0	81.0
Cylinder spacing in mm	88.0	88.0	88.0
Number of valves per cylinder	4	4	4
Firing order	1–3–4–2	1–3–4–2	1–3–4–2
Compression ratio	16.2 : 1	16.2 : 1	15.8 : 1
Power output in kW at rpm	110 at 3500 – 4000	110 at 3500 — 4000	135 at 3500 — 4000
Torque in Nm at rpm	320 at 1750 – 3000	340 at 1750 – 3000	380 at 1750 – 3250
Fuel	Diesel to EN 590	Diesel to EN 590	Diesel to EN 590
Engine management system	Bosch EDC 17	Bosch EDC 17	Bosch EDC 17
Maximum injection pressure in bar	1800 with solenoid valve injector CRI2-18	2000 with solenoid valve injector CRI2-20	2000 with solenoid valve injector CRI2-20
Emissions standard	EU5	EU6	EU5
CO_2 emission in g/km	106	-[1)]	-[1)]

[1)] Data was unavailable at time of going to print.

Engine mechanicals

Cylinder block

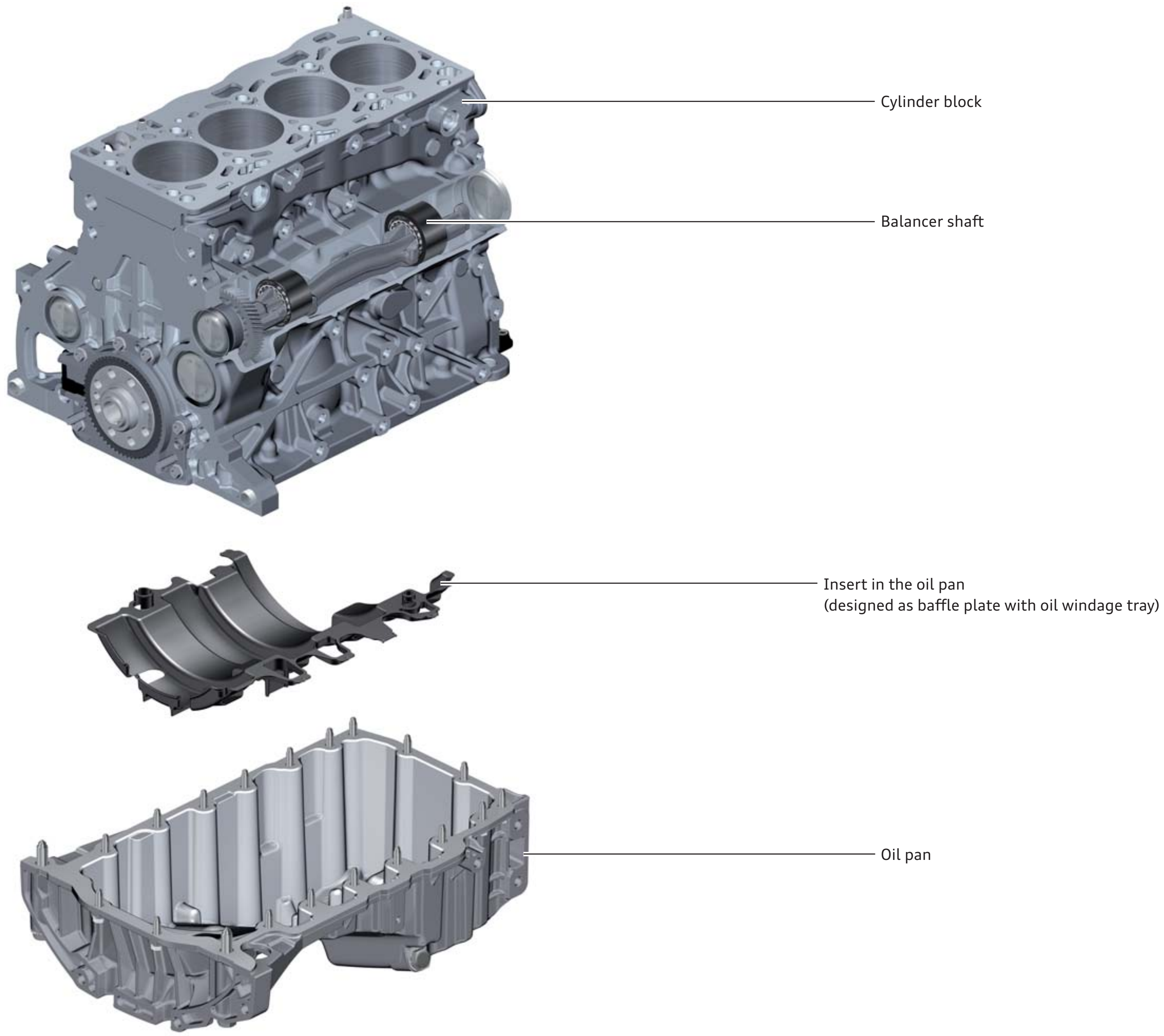
As with previous units, the cylinder block of the 1.6l / 2.0l TDI engine is made of cast iron. The material in question is an alloy of cast iron and nodular graphite (GG-GJL-250). In addition to having a high tensile strength of 250 – 300 Nm/mm², this material boasts a number of outstanding properties. The construction of the cylinder block was also revised. For instance, the influence of the threaded connections was shifted towards the bottom end of the cylinder block by using low-seated cylinder bolt threads.

The net effect is an optimised distribution of power flow within the engine block structure. This results in higher pre-compression of the combustion chamber stopper as well as providing a more homogeneous pressure distribution across the full circumference of the cylinder head gasket. In addition, the cylinders are finished by bolting a honing plate to the engine block. This allows the cylinder heads to be mounted without warping, thereby reducing prestress in the piston rings.

The cylinder block has the following technical features:

- Integrated balancer shafts above the crankshaft
- Short water jacket for rapid component heating
- Optimal cooling of the webs between the cylinders
- Integration of thermal management measures into the oil and water circuits

Overview



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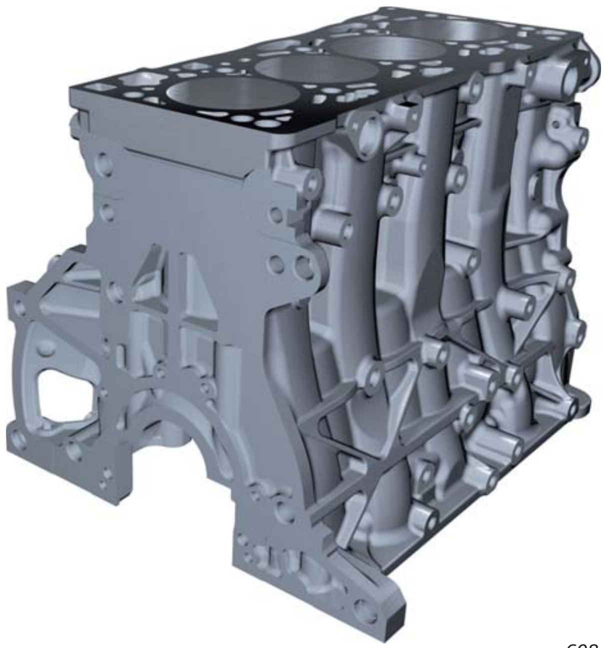
Differences between the 1.6l and 2.0l TDI engines

Unlike the 2.0l TDI engine, the lower-displacement engine version does not have balancer shafts. For this reason, the cylinder block was adapted in these areas.

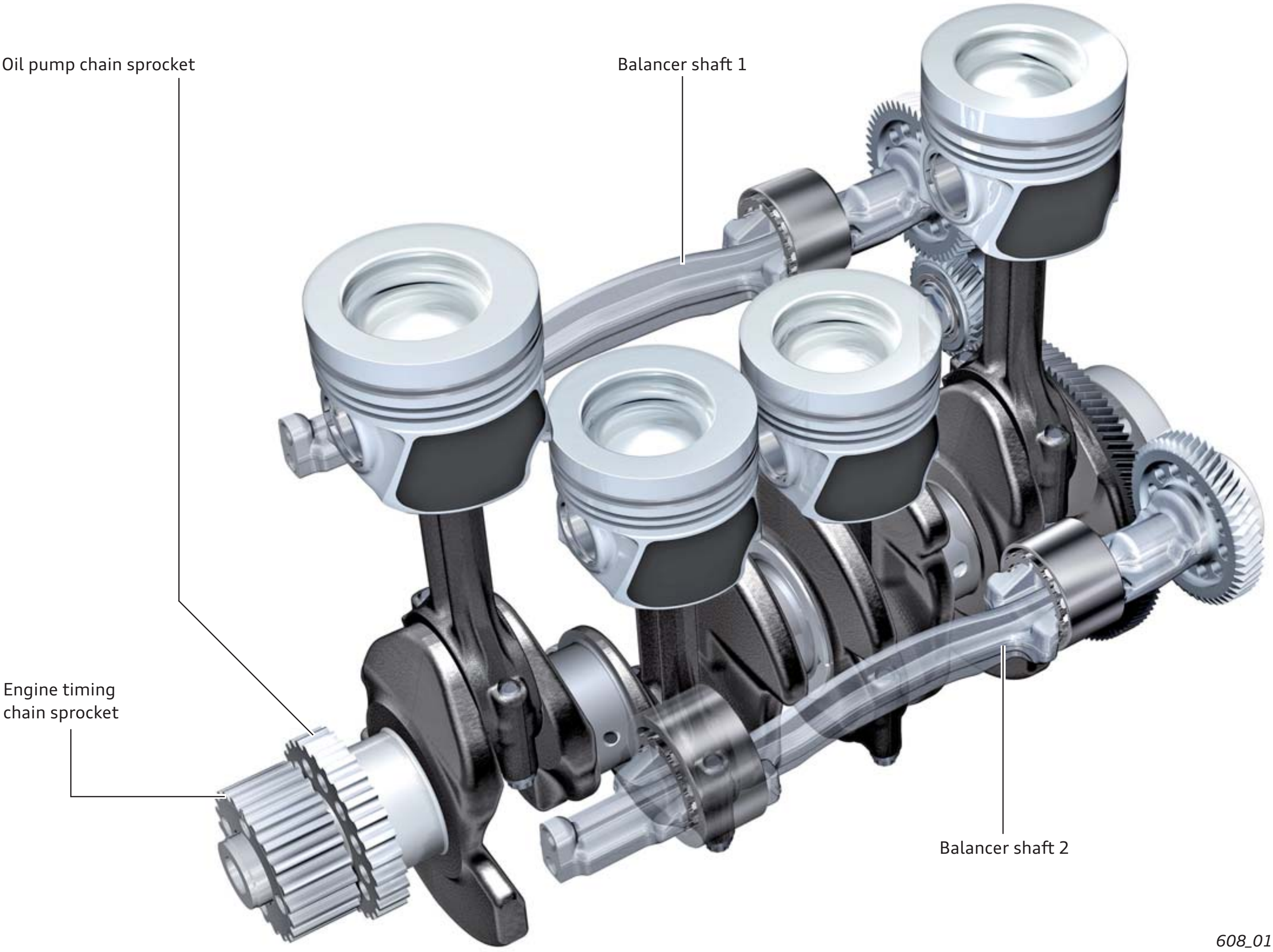


608_014

Crank mechanism

Components:

- Forged crankshaft mounted in five bearings
  - For weight reasons, only four counterweights are used
- Cracked trapezoidal conrods
- Bowl pistons without valve pockets
  - A single annular oilway
  - supplied with cooled oil for cooling the piston crown



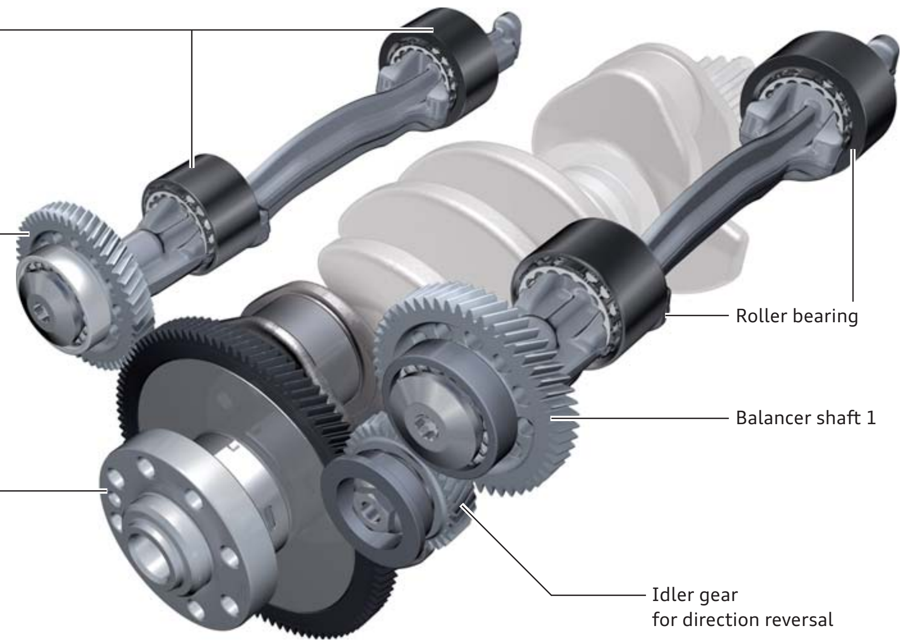
608_015

Balancer shafts

To neutralise second order free inertial forces, use is made of a balancer shaft system which is integrated in the cylinder block over the crankshaft.

Vibration is combatted by dual counter-rotating shafts with counterweights rotating at twice the speed of the engine. The direction of rotation of the second shaft is reversed by an idler gear.

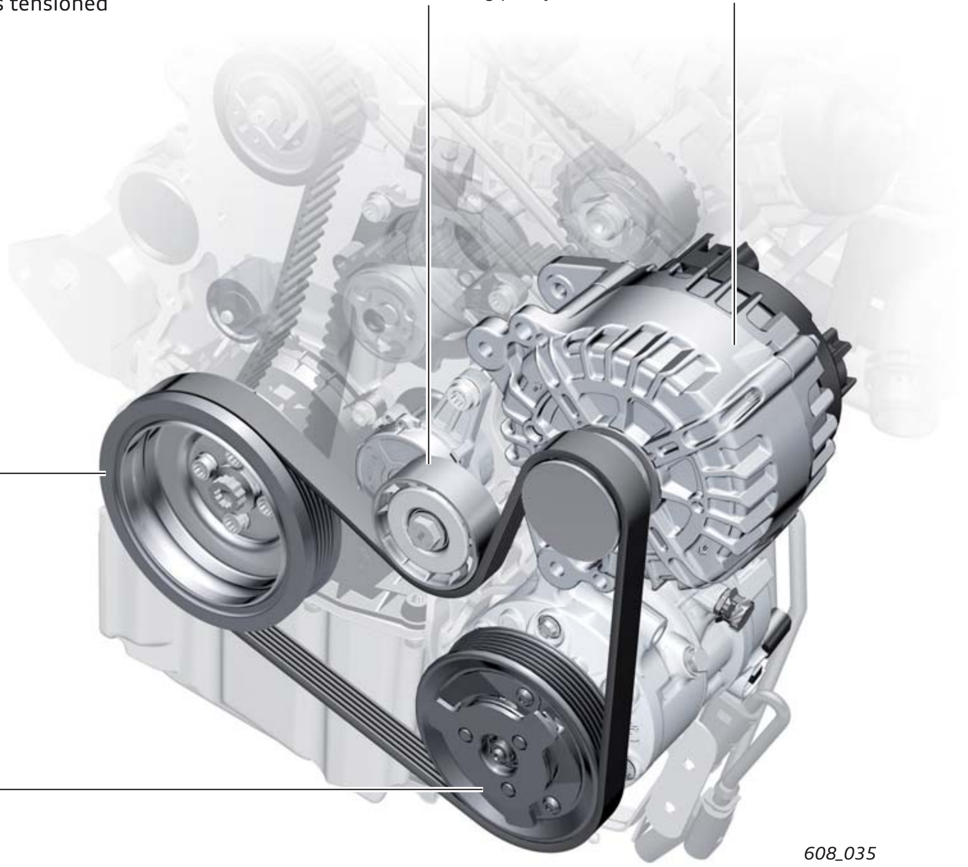
Drive is provided by the crankcase through helical-cut gears on the output side. The shafts and the idle gear are located radially and axially by a roller bearing. The bearings are lubricated with oil spray from the cylinder block. Roller bearings lubricated with oil spray have less of a drag effect at low temperatures and high engine speeds.



608_034

Drive mechanism for auxiliary units

The auxiliary unit mount supports the alternator and the A/C compressor. An automatic belt tensioner driven by the crankshaft via the vibration damper ensures that the poly V-belt is tensioned correctly.

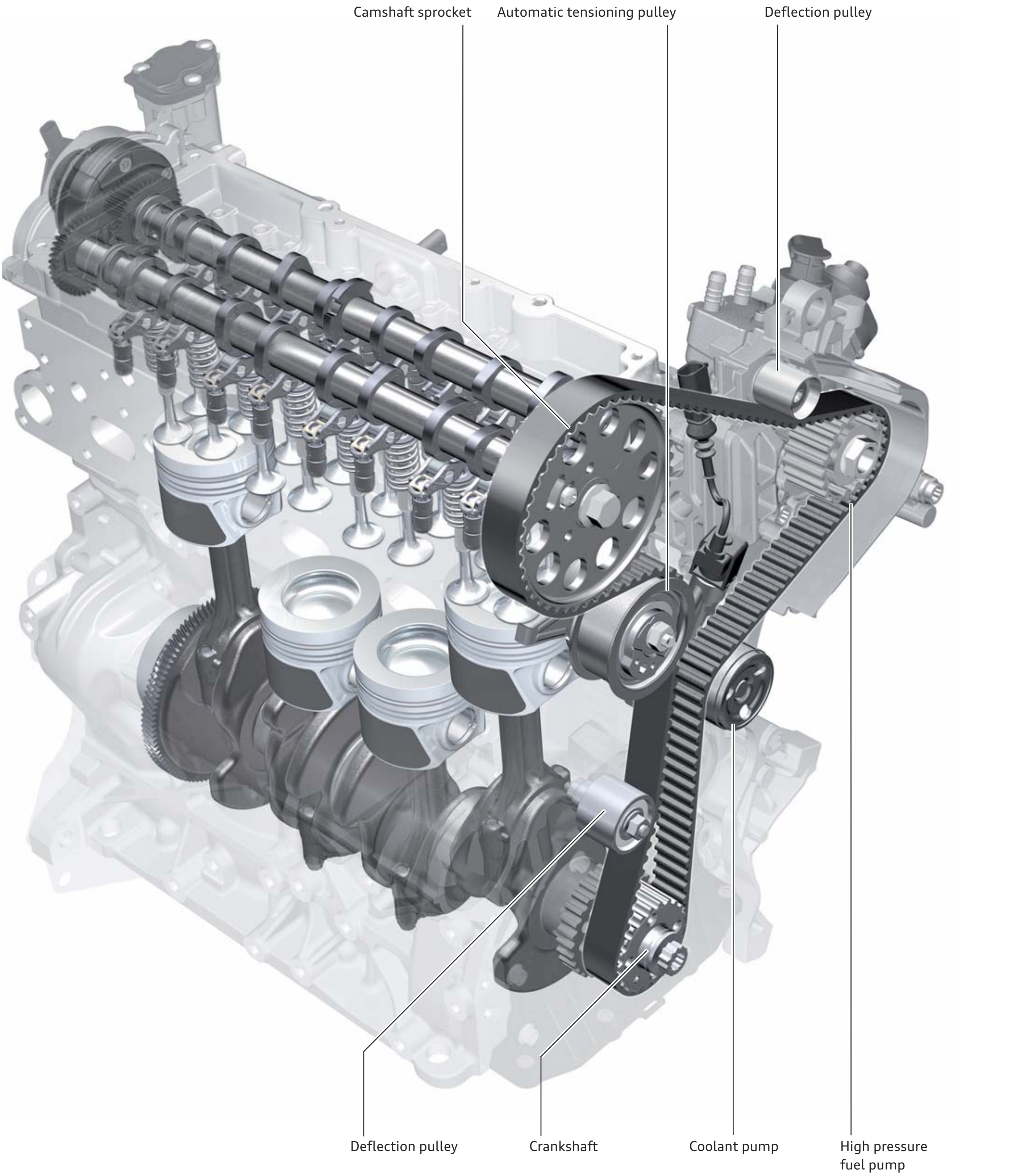


608_035

Toothed belt drive

The timing gear is fitted with a high-mileage toothed belt[1]. The toothed belt runs from the crankshaft to the tensioning pulley, and via the camshaft sprocket to the high pressure pump drive and the switchable coolant pump.

Interposed deflection pulleys provide increased wrap-around of the chain sprockets.



608_023

[1] For information on replacement of the toothed belt, please refer to the applicable version of "Strict Maintenance Operations".

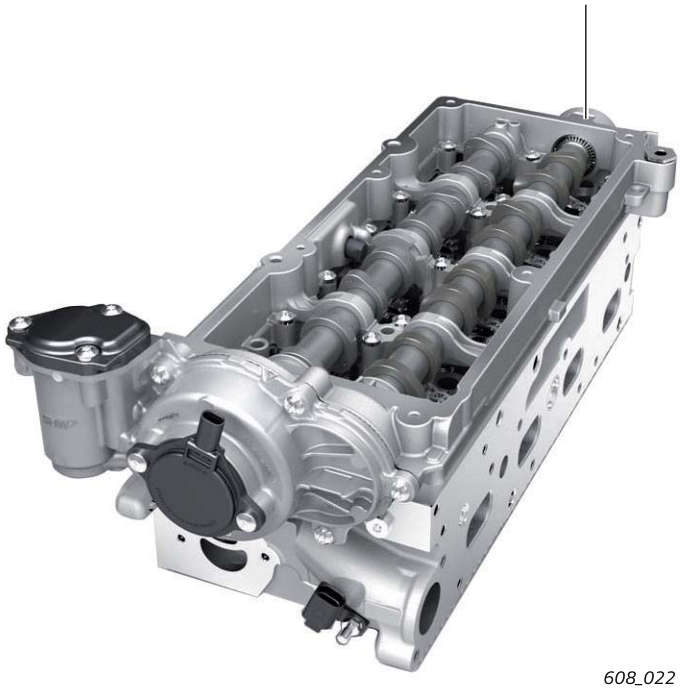
Cylinder head

Special features of the cylinder head[1)] are the "offset radial valve arrangement", a split coolant jacket and a vertical intake manifold flange.

The cylinder head comprises two components: firstly, the bearing frame with integral camshafts (integrated valvegear module) and, secondly, the cylinder head with fittings.

The camshaft tubes are inserted into the enclosed bearing frame to create the integrated valvegear module. With this method, the finish-machined bearing frame is mounted in a fixture, and the finish-ground, heated cam elements and the encoder wheel are held in the correct position in the bearing frame by a joining cassette.

Having been fitted with end pieces and supercooled, the camshaft tubes are then passed through the frame mounting points and the heated cams. When the temperatures of the components are equalised, both camshafts are mounted inseparably in the integrated valvegear module.
This method allows the camshaft mounting to be designed for high rigidity and low weight. To minimise friction, there is a needle bearing on the output side of the camshaft.
The thermal joining method described here is used for the first time in diesel engines of the Volkwagen Group. Previously, the components were press-fitted hydraulically.



608_022

[1)] The figure shows the EU6 version.

Legend of figure on page 13:

1 Fuel pressure regulating valve N276

2 High pressure fuel reservoir

3 Fuel pressure sensor G247

4 Clamping elements

5 Injectors

6 Positive crankcase ventilation and vacuum reservoir

7 Cylinder head cover

8 Pressure accumulator of the variable valve timing

9 Intake manifold module with integrated charge air cooler

10 Intake camshaft timing adjustment valve 1 N205

11 Needle bearing

12 Bearing frame with camshafts

13 Roller-type cam follower

14 Camshaft valves 1

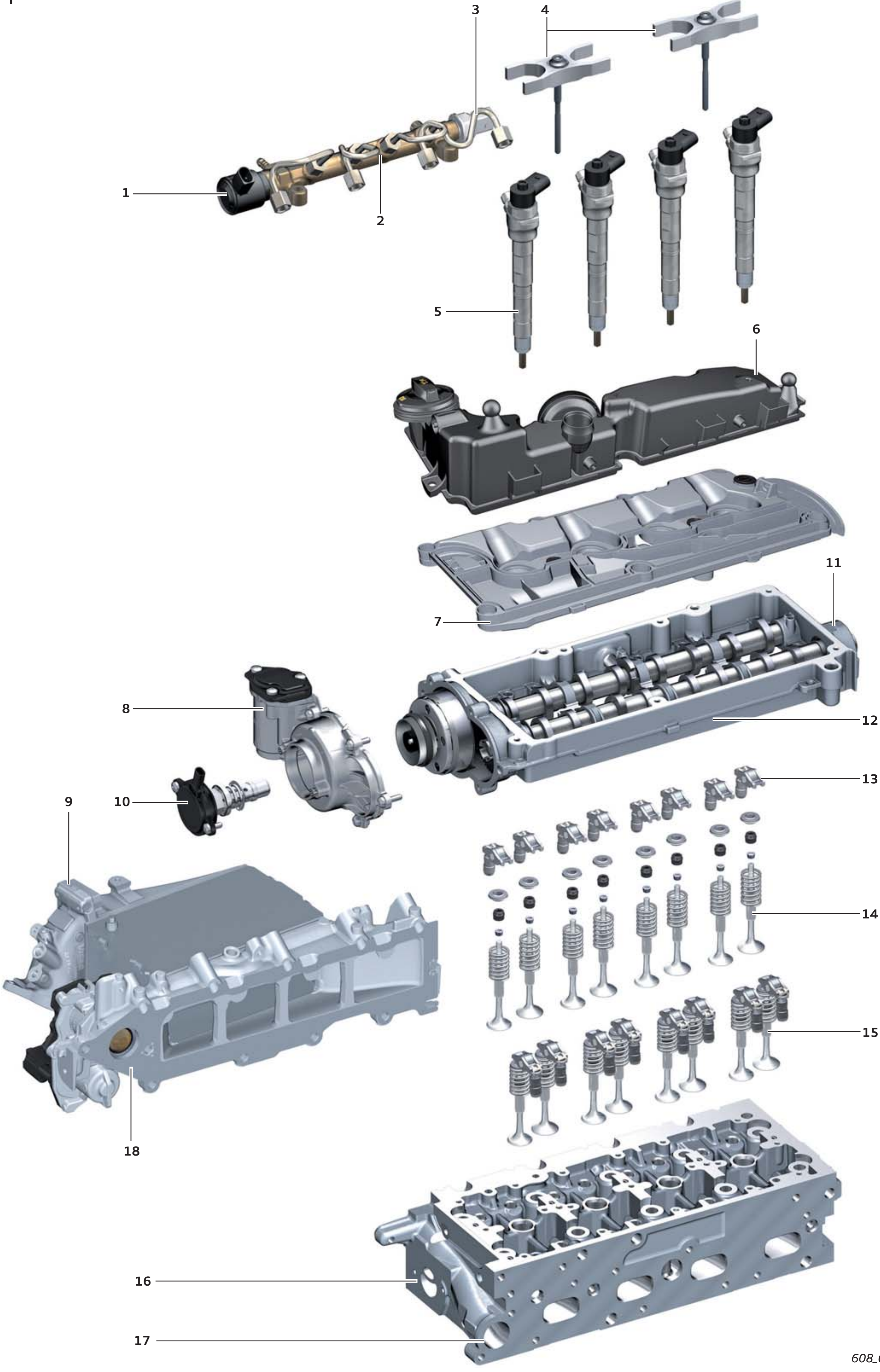
15 Camshaft valves 2

16 Cylinder head

17 High pressure exhaust recirculation duct

18 Distributor rail

Component overview



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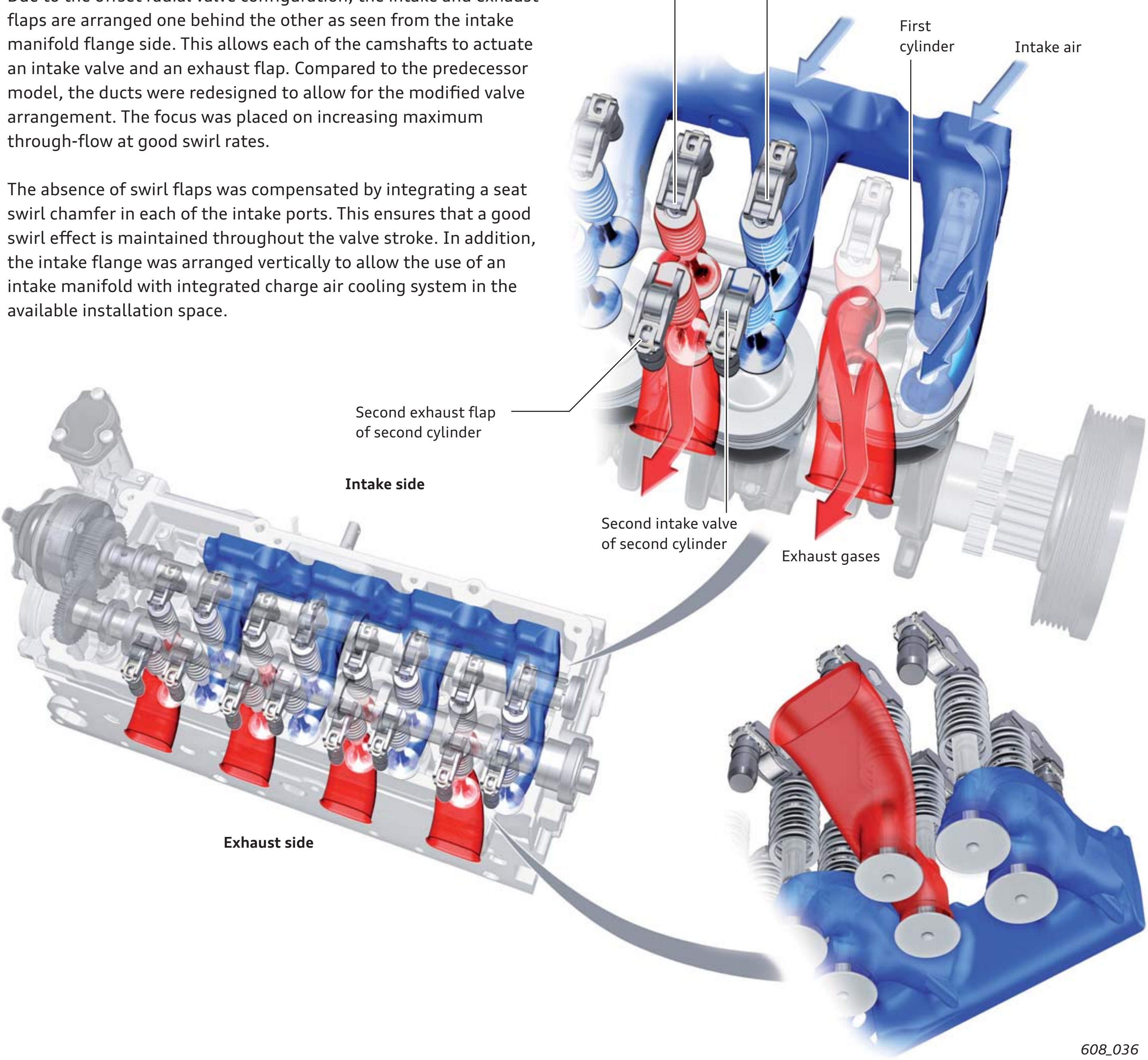
Arrangement of intake and exhaust flaps

Due to the offset radial valve configuration, the intake and exhaust flaps are arranged one behind the other as seen from the intake manifold flange side. This allows each of the camshafts to actuate an intake valve and an exhaust flap. Compared to the predecessor model, the ducts were redesigned to allow for the modified valve arrangement. The focus was placed on increasing maximum through-flow at good swirl rates.

The absence of swirl flaps was compensated by integrating a seat swirl chamfer in each of the intake ports. This ensures that a good swirl effect is maintained throughout the valve stroke. In addition, the intake flange was arranged vertically to allow the use of an intake manifold with integrated charge air cooling system in the available installation space.

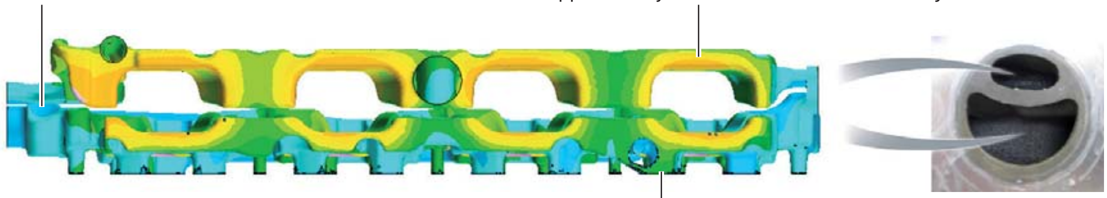


608_036

Coolant jacket in cylinder head

To increase heat dissipation in vicinity of the combustion chamber, the water jacket was split into lower and upper water jacket cores. Both cores are mounted independently of one another in the gravity die, and not conjoined in the casting. A defined cross section which limits the upper volumetric flow is produced on the control side by mechanical machining.

The heater flange with ventilation socket merges the coolant flows at the common outlet to the heater heat exchanger. When the engine is cold, the coolant in the lower and upper water jacket cores is diverted towards the heater heat exchanger via the EGR cooler.



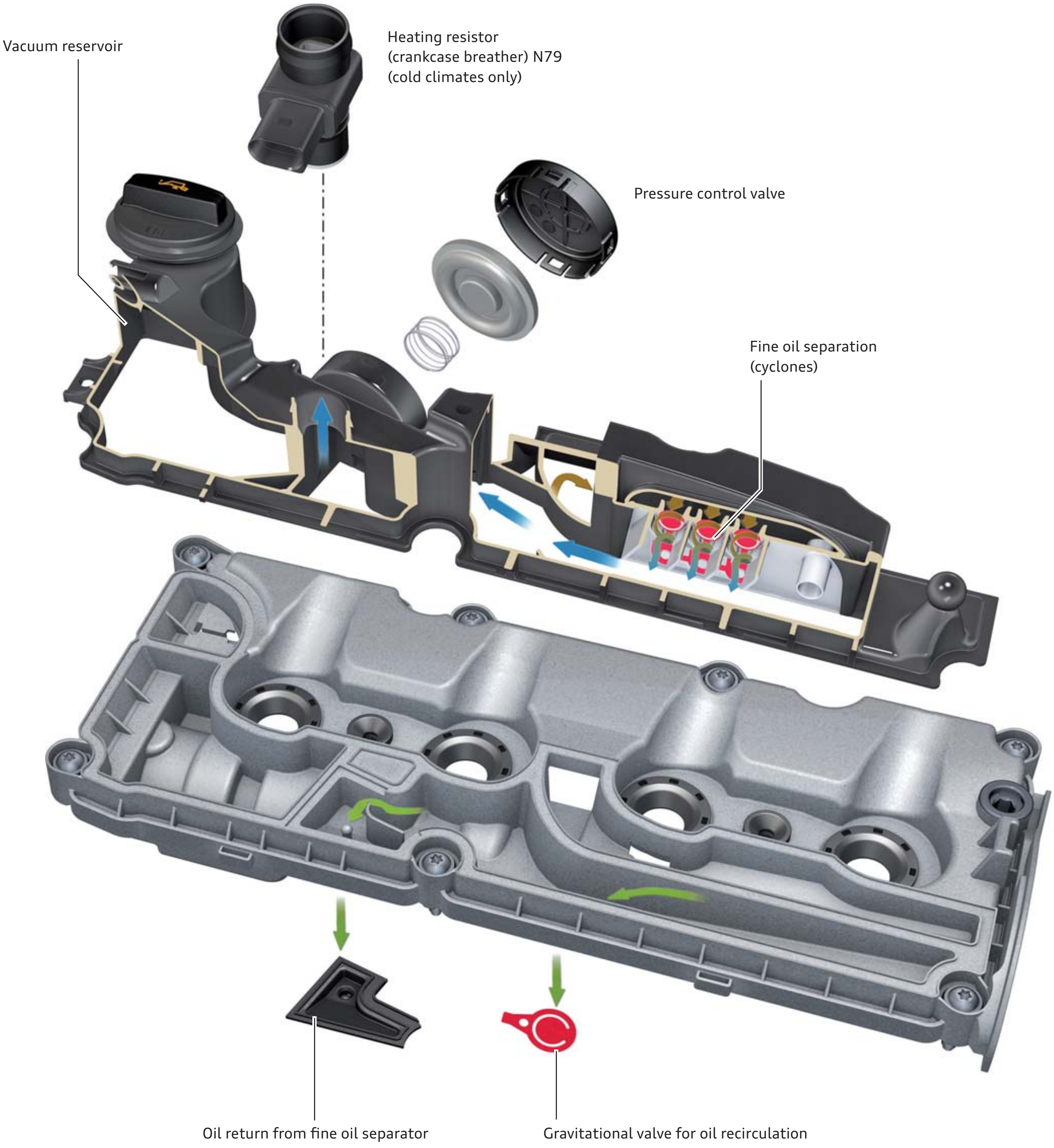
608_043

Positive crankcase ventilation

The cylinder head cover is made of polyamide. Its principal task is to seal the cylinder head and integrate the vacuum reservoir.

Additional functions, such as the separation of coarse and fine of the oil from the blow-by gases and pressure regulation in the cylinder crankcase, are also integrated. The blow-by gases flow from the crank chamber into the coarse oil separator through small ports and then from the crank chamber into the cyclones.

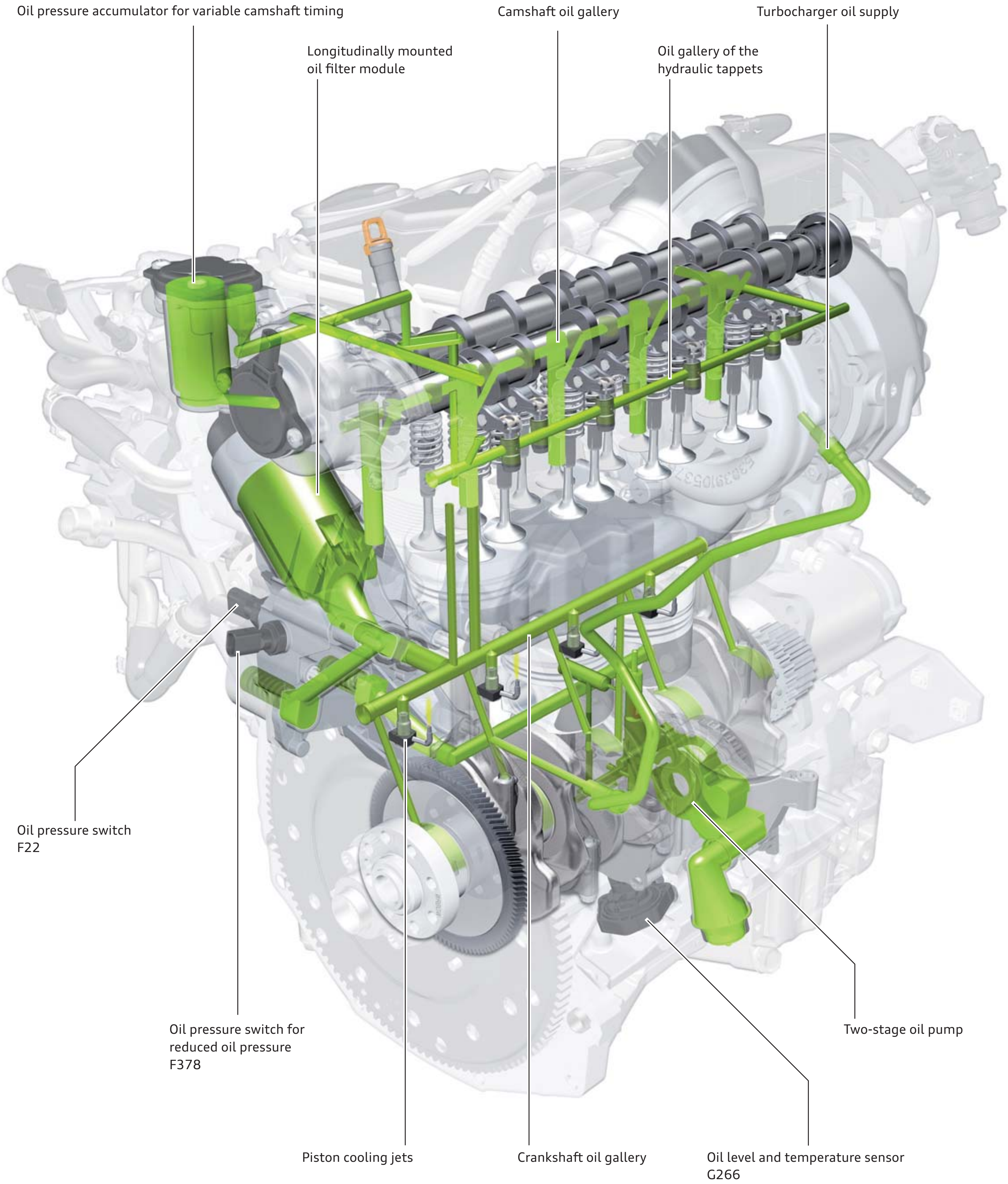
Fine oil separation takes place here. After passing through the cylones, the blow-by gases flow to the pressure control valve. In addition, they are fed into the combustion chamber through the intake manifold.



608_051

Oil supply

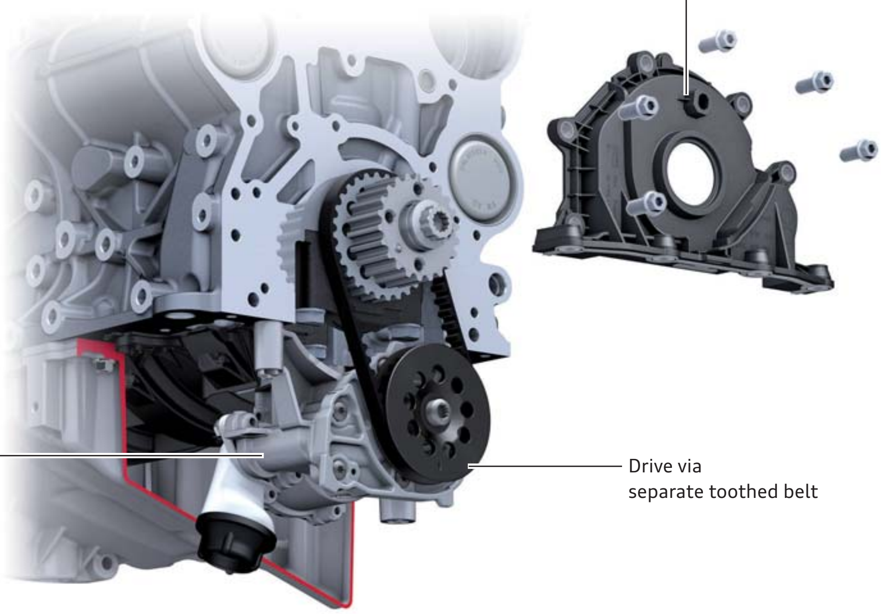
Oil circuit



608_024

Oil pump with integral vacuum pump

The combined oil/vacuum pump is located in the oil pan and bolted to the cylinder block from below. It is driven by the crankshaft via the toothed belt drive. The toothed belt is immersed in oil and has no belt tensioner; pretensioning is defined by the axial spacings between components. This ensures ideal friction conditions in the duopump drive.



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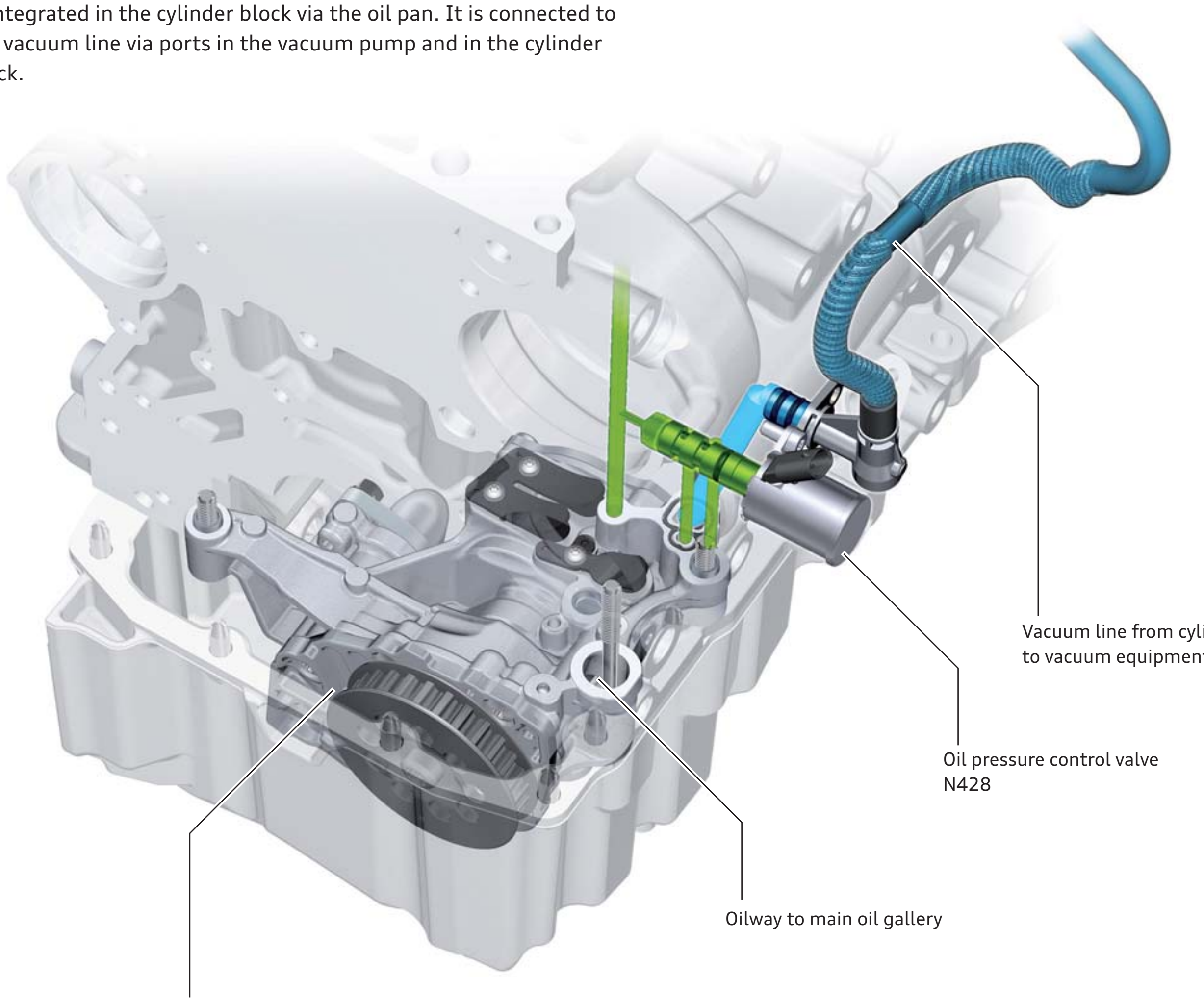
Connections to the vacuum supply and oil circuit

In addition to the vacuum line, the oil pressure control valve N428 is integrated in the cylinder block via the oil pan. It is connected to the vacuum line via ports in the vacuum pump and in the cylinder block.



608_038

Design

The pump is a vane cell pump with an excentrically mounted adjustment ring. To reduce the required drive output, the oil pump has a volumetric flow control mechanism.

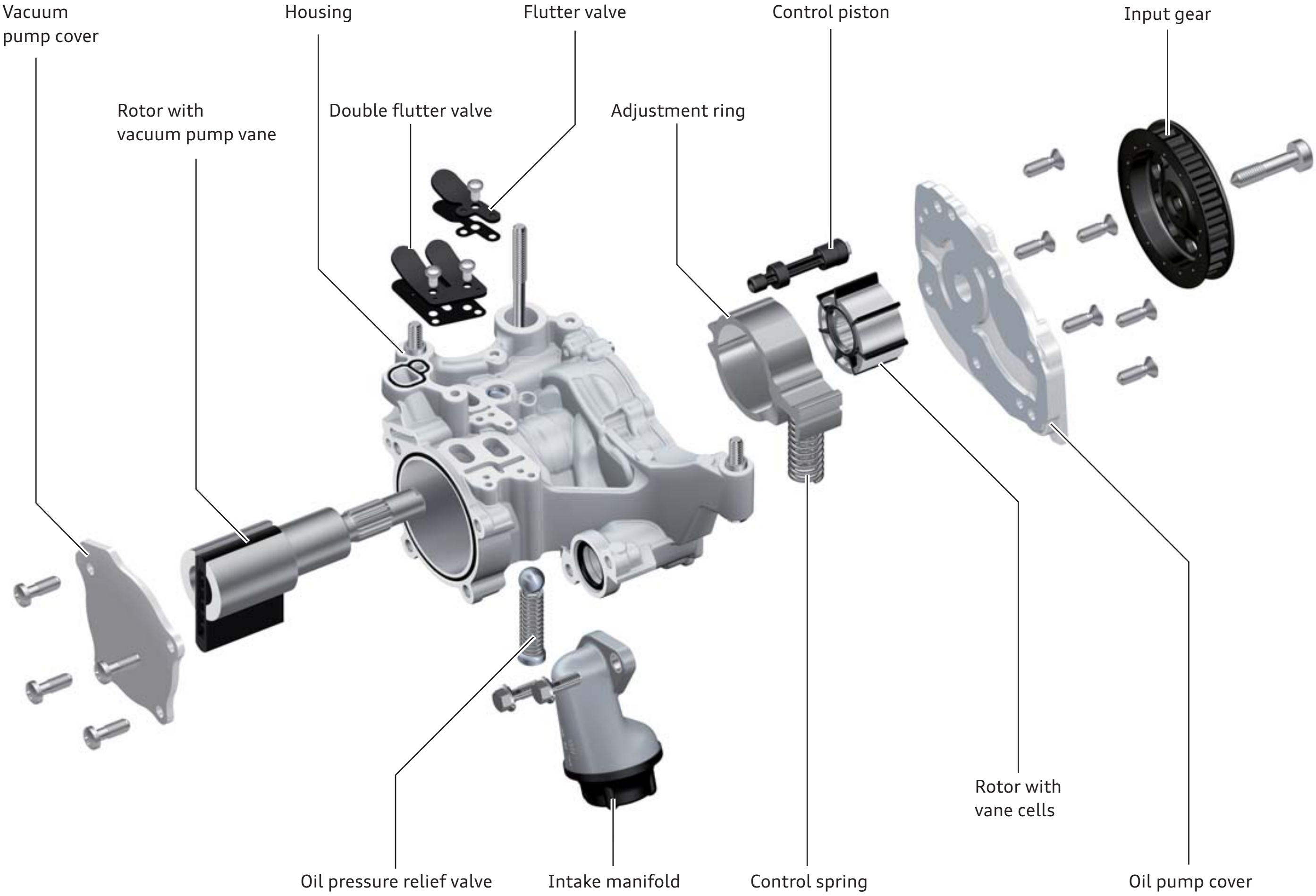
The delivery characteristic can be adjusted using a rotatably mounted adjustment ring. By applying oil pressure to the adjustment ring via a control surface, it can be swivelled against the force of the control spring.

A specially shaped intake manifold ensures reliable engine oil intake from the oil pan, even when the vehicle is subjected to high transverse acceleration.

The vacuum pump induces air from the brake servo through a vacuum line and ports in the cylinder block.

The extracted air flows through flutter valves into the cylinder block and ventilates its inner chamber. This air is then admitted into the combustion chamber via the engine breather as blow-by gas.
The double flutter valve provides a cross section which is large enough to expel the oil into the vacuum pump chamber. This helps to keep drive torque to a minimum, even at low temperatures.

Component overview



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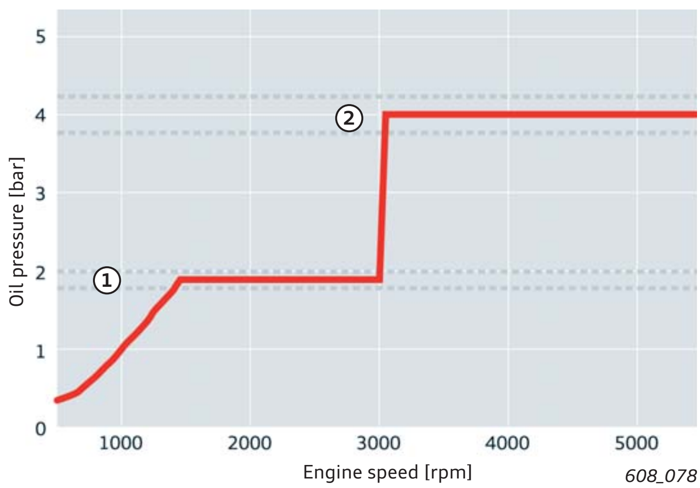
Oil pressure control

The oil pump operates in two pressure stages, which are activated in dependence on engine speed.

① Low pressure stage: oil pressure 1.8 – 2.0 bar

② High pressure stage: oil pressure 3.8 – 4.2 bar



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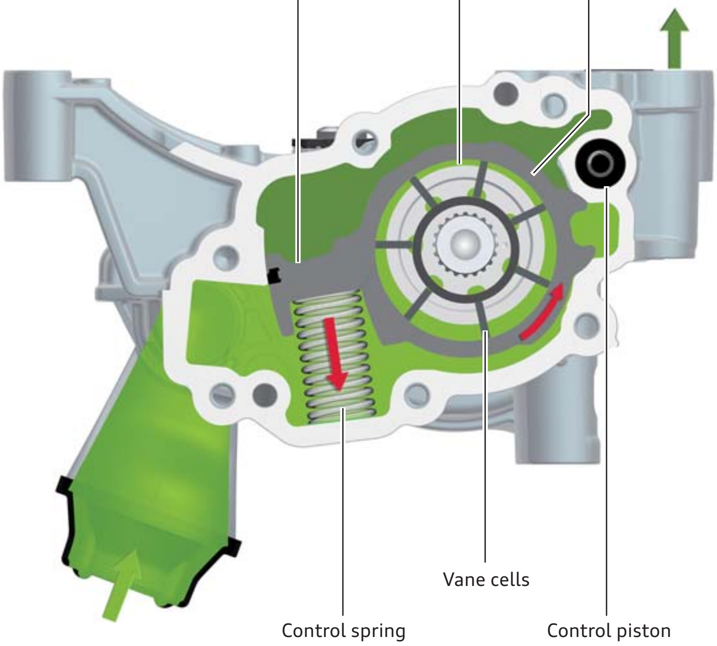
Function

Low delivery rate

At low engine speeds, the oil pressure control valve N428 energised by terminal 15 is connected to ground by the engine control unit and opens the active oilway to the control piston. The oil pressure now acts on both faces of the control piston, pushing the piston against the control piston spring and opening the oilway to the control surface of the adjustment ring.
The oil pressure acts on the control surface. The resultant force is greater than that of the control spring and swivels the adjustment ring counterclockwise into the centre of the vane cell pump, thereby reducing the delivery space between the vane cells.
The lower pressure stage is activated in dependence on engine load, engine speed, oil temperature and other operating parameters, reducing the drive output of the oil pump.



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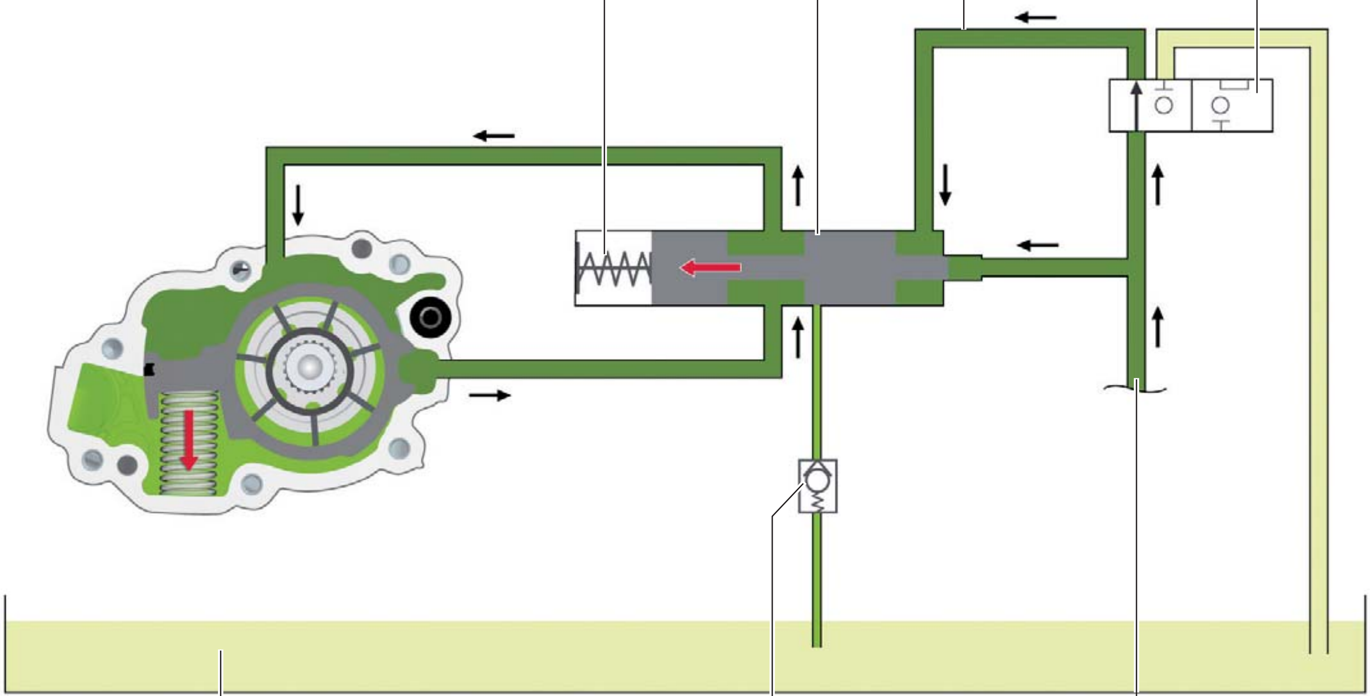

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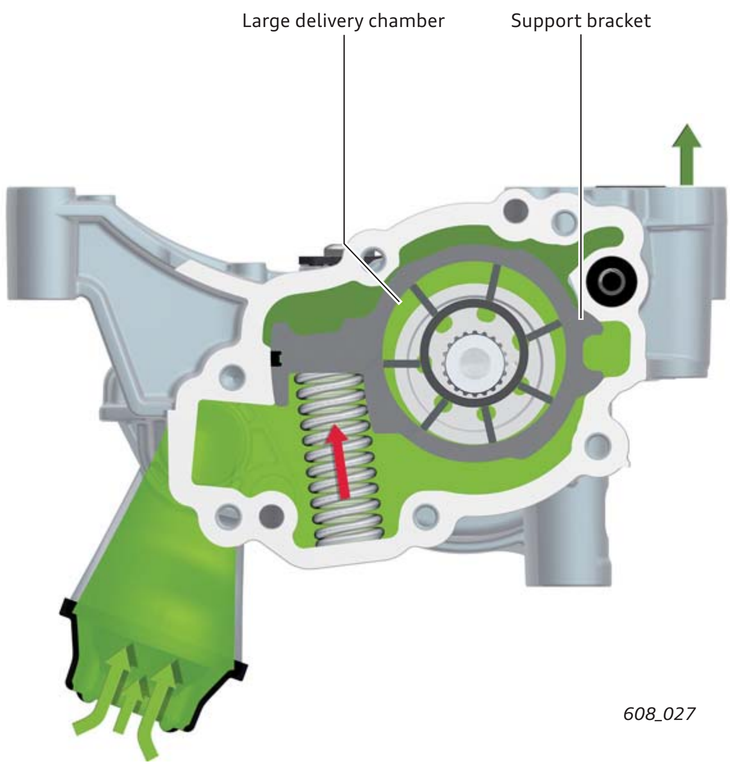
High delivery rate

In the upper engine speed range or at high engine load (full-throttle acceleration), the oil pressure control valve N428 is disconnected from ground by the engine control unit J623 in order to vent the active oilway. The force of the remaining surface under oil pressure is less than the force of the control piston spring and closes the oilway to the control surface of the adjustment ring. In the absence of oil pressure, the control spring swivels the adjustment ring clockwise about the counter-bearing. The adjustment ring now swivels out of its centre position and enlarges the delivery space between the individual vanes. Oil delivery is increased by enlarging the spaces between the vane cells.

The higher volumetric oil flow is countered by the oil ports and by crankshaft bearing play, causing the oil pressure to increase. This made it possible to realise a volume-controlled oil pump with two pressure stages.



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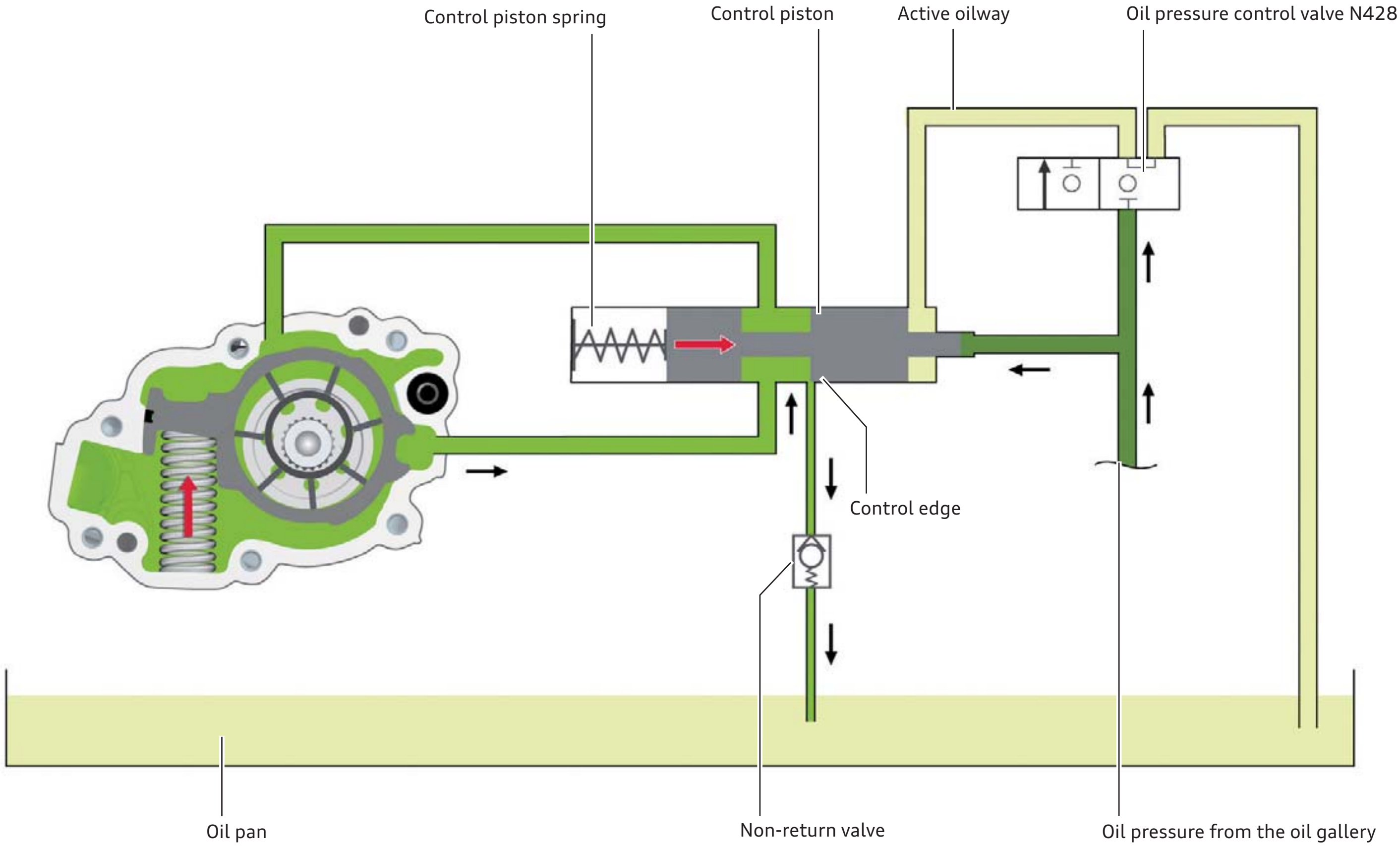

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Note
The maximum rate of delivery is always available when the solenoid valve is deenergised.

Oil filter module

Depending on the engine's installation position, there are two different oil filter modules.

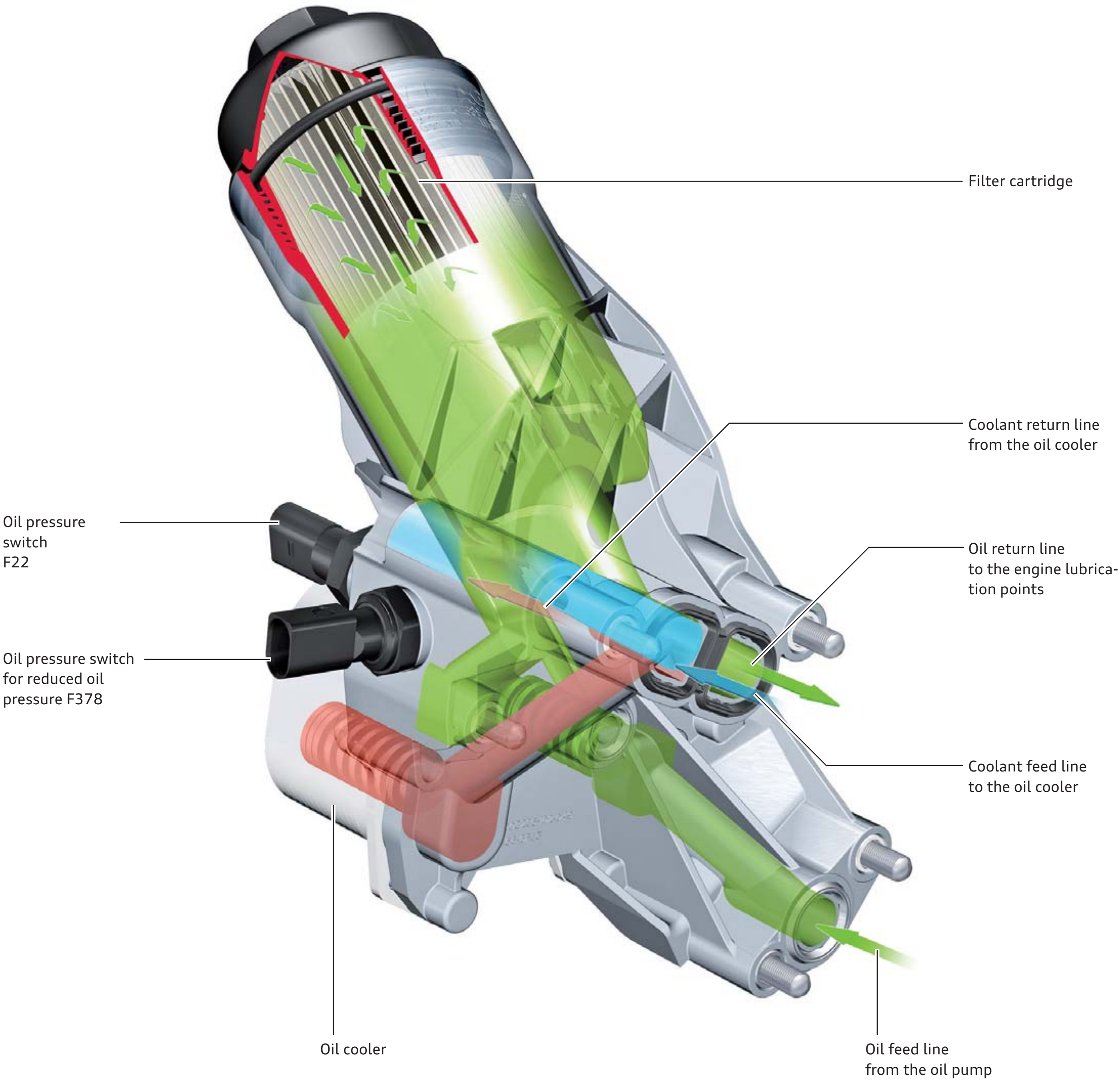
Longitudinally mounted engines

The oil filter module for longitudinal engine installation comprises the following components:

- Upright oil filter housing with oil drain valve
- Filter cartridge
- Oil pressure switch for reduced oil pressure F378 (0.3 – 0.6 bar)
- Oil pressure switch F22 (2.5 – 3.2 bar)

In addition, the oil filter module consists of the oil cooler, which is mounted to the side of the oil filter module, as well as the oil filter bypass valve and oil cooler bypass valve.

Longitudinally mounted engines



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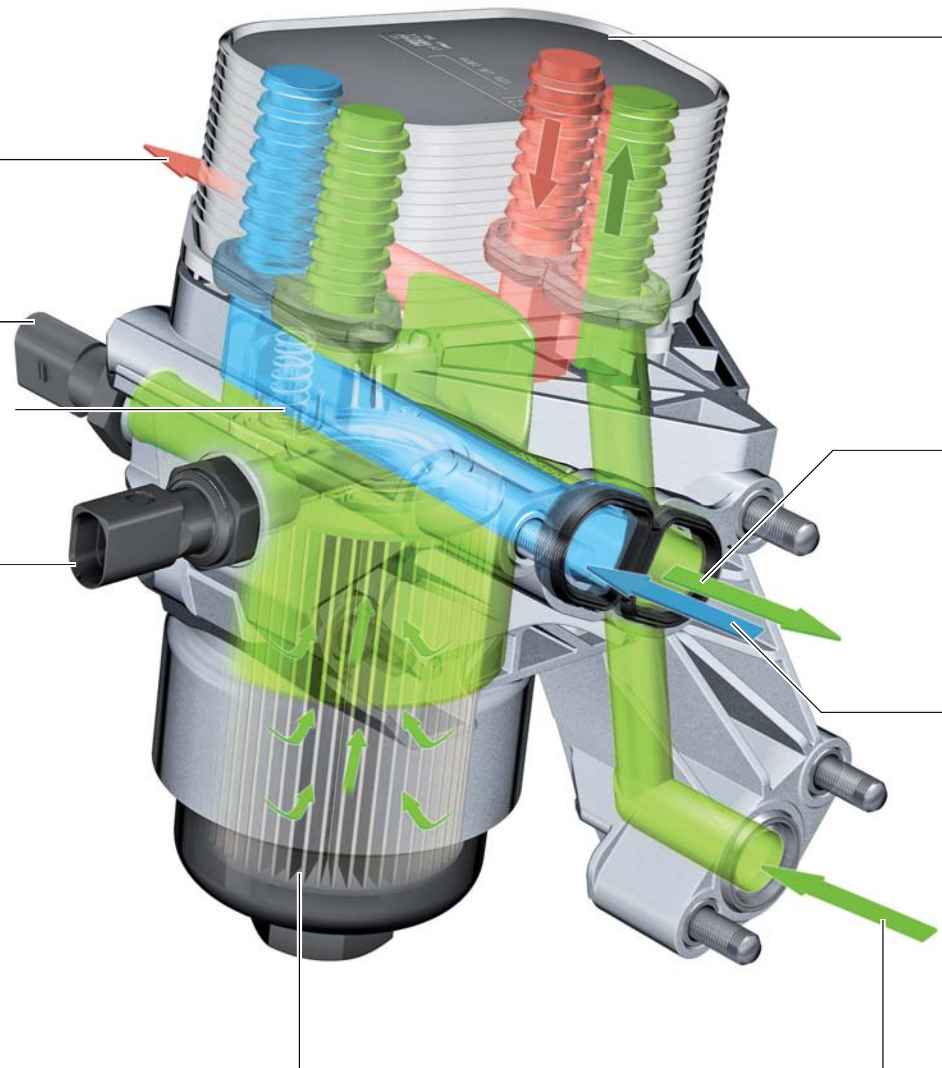
Transversely mounted engines

Components
- Upright oil filter housing with oil drain valve
- Filter cartridge
- Oil pressure switch for reduced oil pressure F378 (0.3 – 0.6 bar)
- Oil pressure switch F22 (2.5 – 3.2 bar)

In addition, the oil filter module comprises the oil cooler, which is mounted to the side of the oil filter module, as well as the oil filter bypass valve and the oil cooler bypass valve.



608_046

Variable camshaft timing

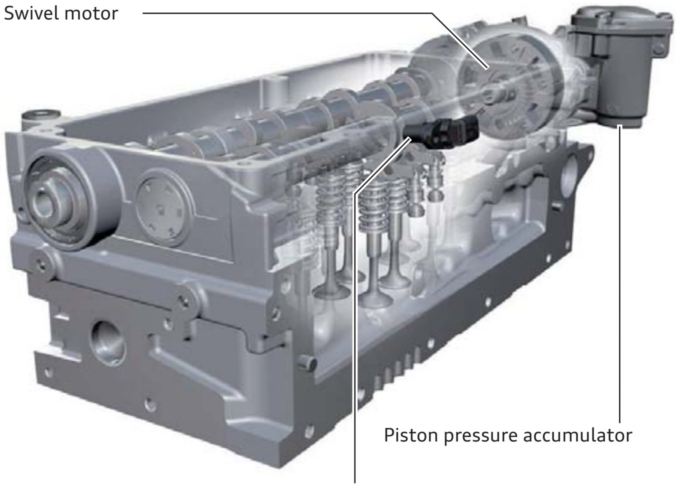
Introduction

In addition to reducing raw emissions, future technical development efforts will focus on cutting fuel consumption. A possible solution is to use a variable valvegear. A charge motion can be induced by using a variable intake, rendering a swirl flap superfluous. Another alternative is to adapt the intake valve timing for advanced or retarded closing, thereby allowing NO_x and CO_2 emissions to be reduced. Compression can also be effectively reduced by means of a variable intake valve timing mechanism. This would result in lower compression temperatures and, in turn, in reduced NO_x emissions.

Variable camshaft timing is only used in vehicles which meet the EU6 exhaust emission standard. Multiple valvegear variables can be controlled by using a phase adjuster in combination with a mixed intake and exhaust camshaft configuration.

This technical innovation allows:
- optimised volumetric efficiency at full throttle
- optimised emissions and fuel efficiency through variable (and thus more effective) compression
- maximum expansion loop utilisation
- high compression ratios at cold start

Variable valve timing is provided by means of a swivel motor. At engine start, the swivel motor is mechanically locked in the advance position by a locking bolt until the required oil pressure is achieved.
The active adjustment range for the intake and exhaust flaps is 50° of crank angle after retard.



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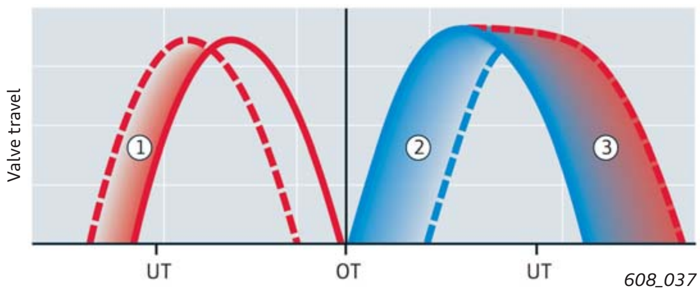


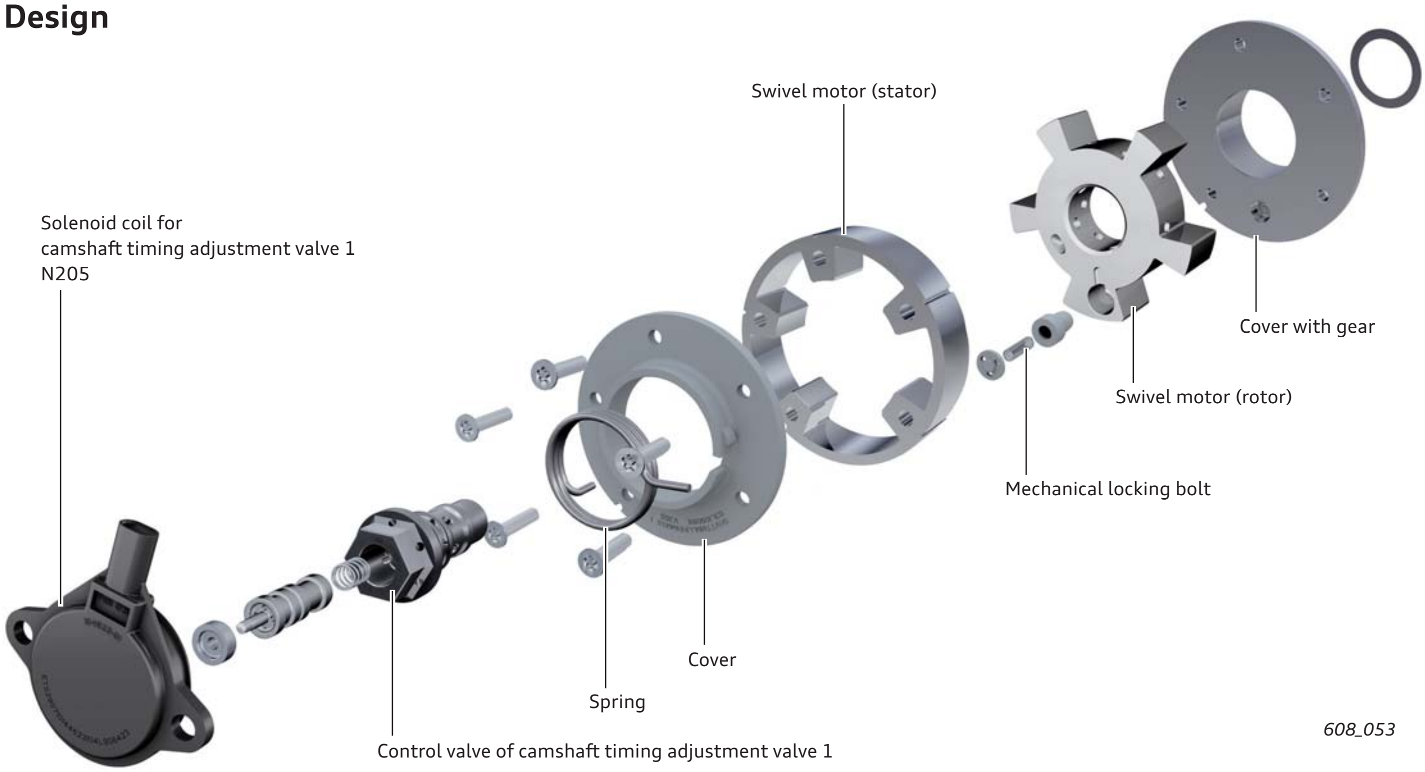
608_037

Key:

①	Exhaust:	variable opening
②	Intake:	variable opening
③	Intake:	variable closing

Advance: both intake valves open simultaneously
Retard: only the rear intake valve on the "exhaust side" opens; opening of the second intake valve is delayed

Design

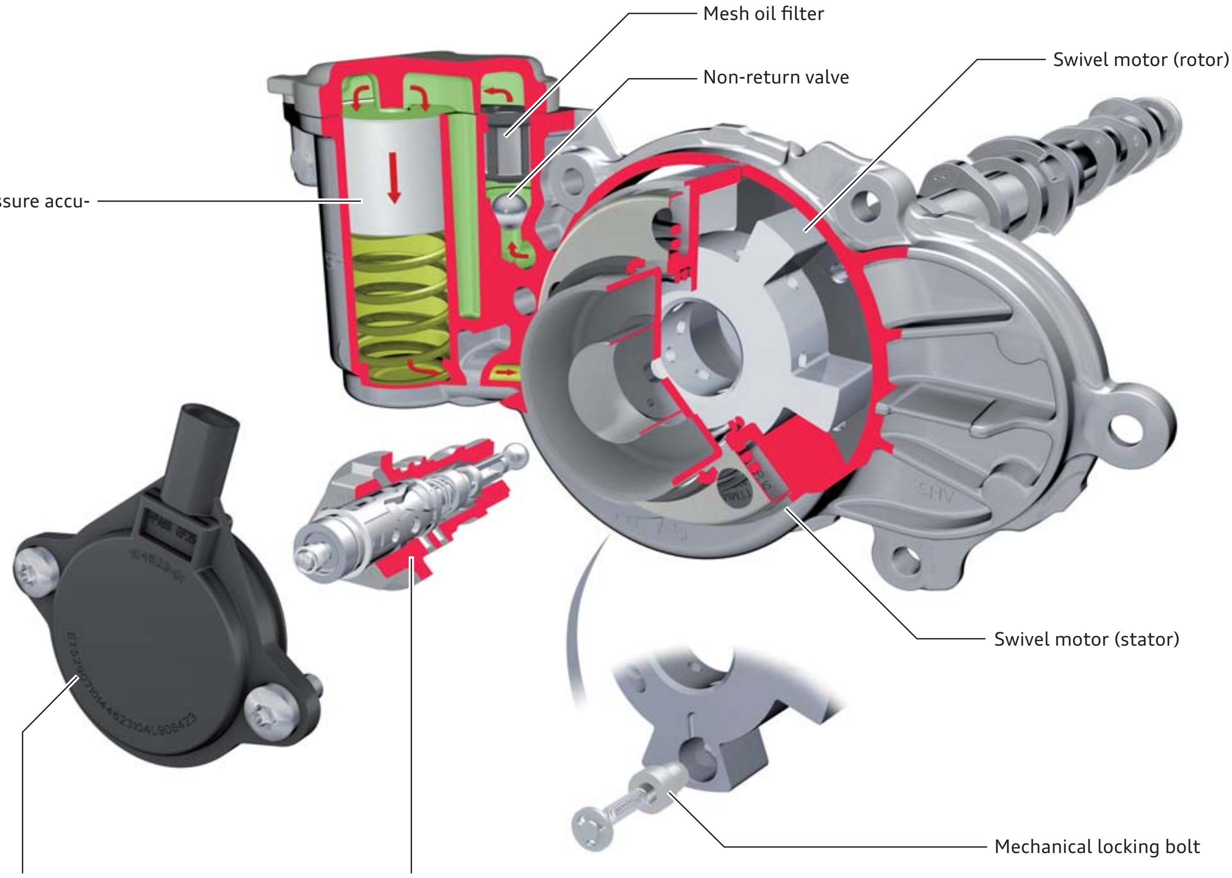


608_053

Function

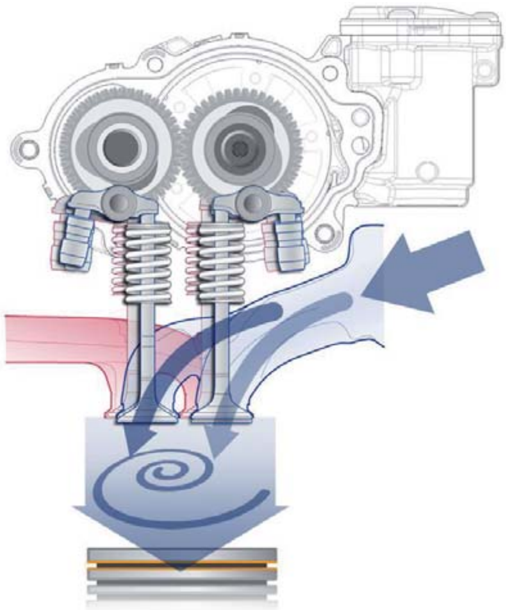
The swivel motor is supplied with pressurised oil by the volume-controlled oil pump via a separate pressure line in the cylinder head. The camshaft is adjusted by the engine control unit by means of a 4/2-way proportional valve, which is activated in a pulse-width-modulated manner. The inner vane ring (rotor) of the swivel motor is connected to the camshaft.

The outer ring (stator) is fixed to a gear which engages a gear on the driven camshaft. The camshaft is adjusted relative to the crankshaft by applying oil pressure to working chambers (A) and (B) between the rotor and stator.



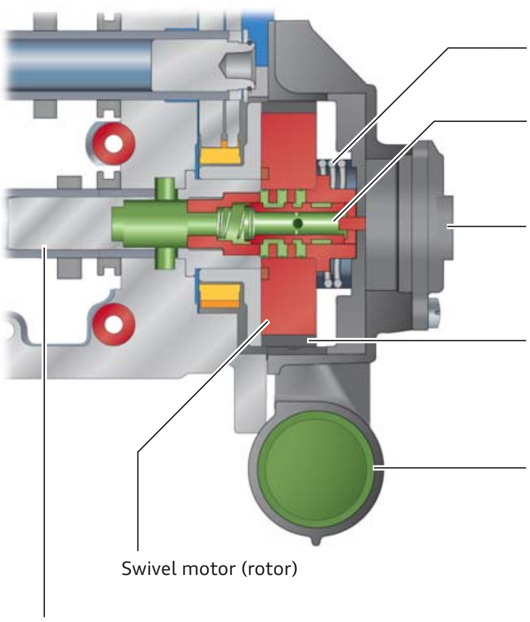
608_010

Airflow – at retarded ignition timing during the intake cycle



608_060

Sectional view of swivel motor



608_054

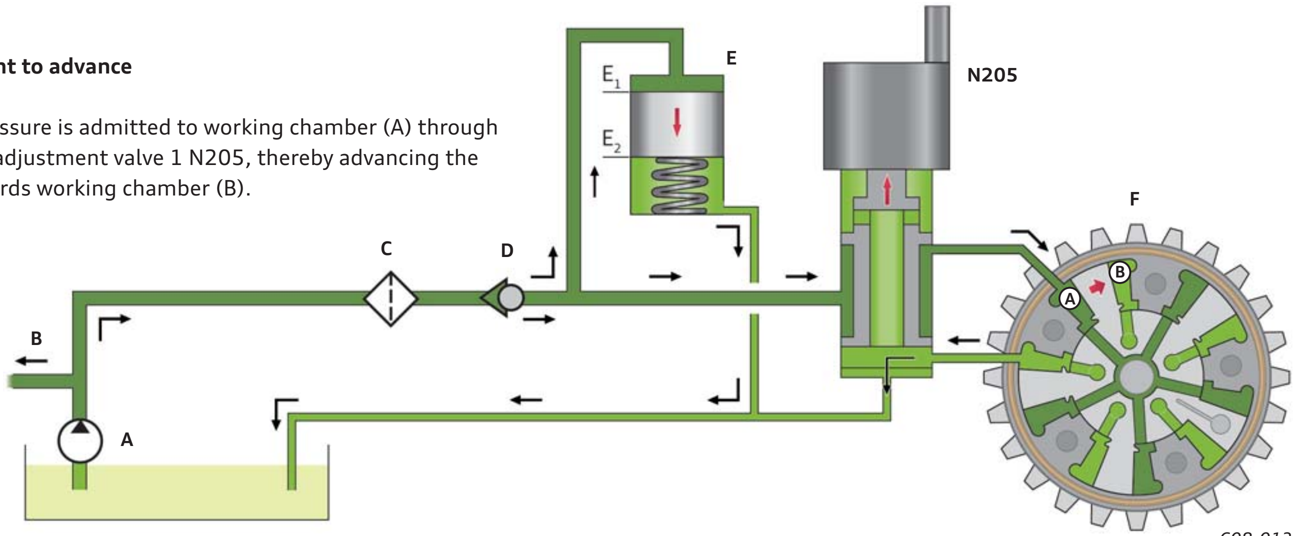
Operating ranges

A swivel motor of the camshaft adjustment system must be subjected to a high volumetric oil flow during the adjustment cycle in order to ensure rapid control response. The camshaft adjustment system is supplied with oil by a two-stage, volume-controlled oil pump. To ensure rapid camshaft adjustment in the first stage at a low pressure level, a pressure accumulator was integrated in the camshaft adjuster. This pressure accumulator ensures a sufficient supply of oil, whereby the holding pressure inside the pressure accumulator can be up to 1.8 bar. The camshaft timing adjustment valve 1 N205 dictates when the pressure accumulator releases its oil into the corresponding port on the swivel motor. The camshaft timing adjustment valve 1 is activated by the engine control unit J623 in a pulse-width-modulated manner.

In the unpressurised oil chamber, the oil is expelled from the swivel motor and forced into the return line. If the gallery pressure is less than the pressure inside the pressure accumulator during camshaft adjustment, the adjustment cycle is always assisted by the pressure accumulator. When the swivel motor reaches its end position, the oil pressure in the pressure accumulator is restored and the oil pressure in the feed line is at gallery pressure. The camshaft timing adjustment valve 1 N205 can be set in such a way that both working chambers are subjected to oil pressure. Depending on the oil pressure conditions in working chambers (A) and (B), both the rotor and the camshaft are adjusted to either "advance" or "retard". When the engine is shut off, the swivel motor is adjusted to the "advance" position with spring assistance and locked.

Adjustment to advance

The oil pressure is admitted to working chamber (A) through camshaft adjustment valve 1 N205, thereby advancing the rotor towards working chamber (B).

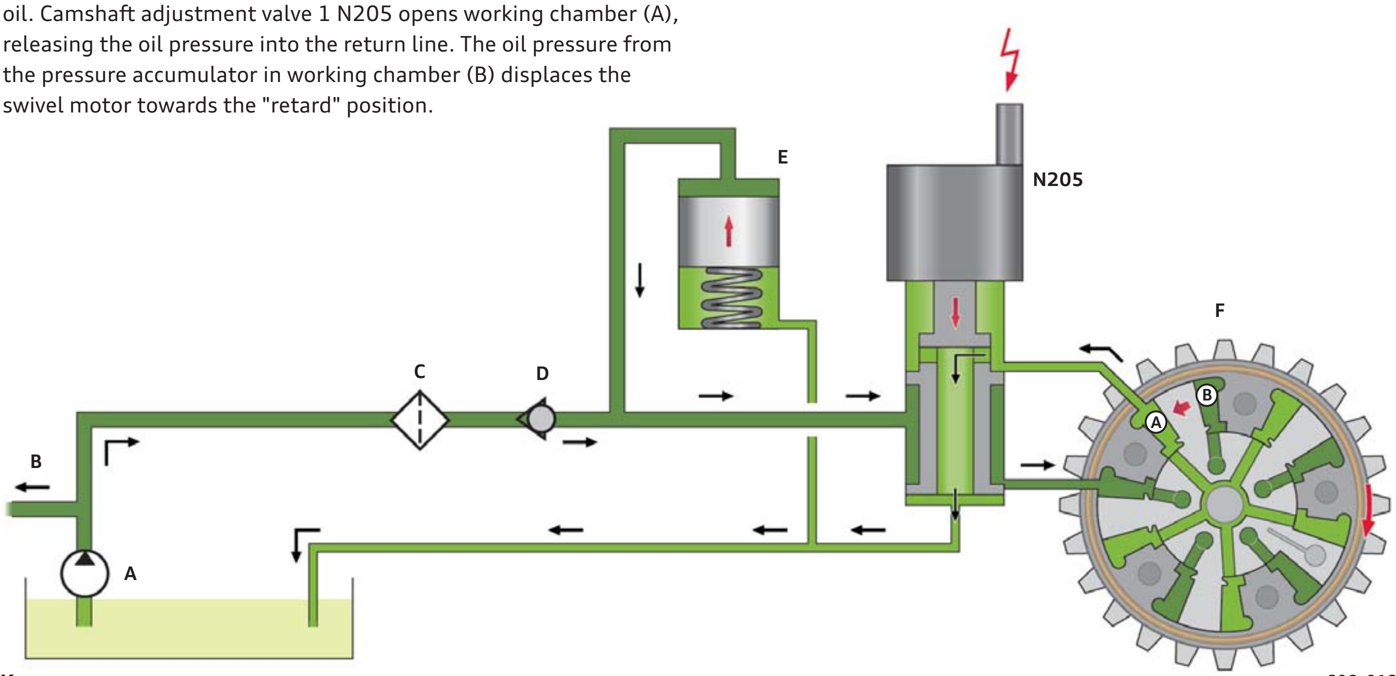


608_013

Adjustment to retard

The camshaft is locked in the "advance position". The spring-loaded differential pressure bolt is released by the pressure of the engine oil. Camshaft adjustment valve 1 N205 opens working chamber (A), releasing the oil pressure into the return line. The oil pressure from the pressure accumulator in working chamber (B) displaces the swivel motor towards the "retard" position.

Continuously variable valve timing is achieved by pulse-width-modulated activation.



608_012

Key:

Ⓐ Ⓑ Working chambers in the swivel motor
A Oil pump
B Engine lubrication system
C Mesh oil filter
D Nonreturn valve

E Piston pressure accumulator
E_1: Start of charging at approx. 0.6 bar
E_2: End of charging at approx. 1.8 bar
F Camshaft adjuster (swivel motor)
N205 Intake camshaft timing adjustment valve 1

Exhaust gas recirculation

Exhaust emission standards

The various versions of the exhaust gas recirculation system are subdivided according to the applicable EU exhaust emission standards.
A common feature of all versions is an intake manifold module with an integrated water-cooled charge air cooler with a flange or distributor rail.

The task of the intake manifold module is to direct the fresh air flow (including high and low pressure exhaust gas recirculation) into the cylinder head. Depending on driving cycle, the compressed air is cooled according to requirements by the integrated charge air cooler. This is achieved by variation of the coolant flow rate by the electrical coolant pump.

Overview of exhaust emission standards

The engine is manufactured in the following emission versions.

- EU4 with high pressure exhaust gas recirculation
- EU5 with low pressure exhaust gas recirculation
- EU6, EU6 heavy duty and BIN5 with low and high pressure exhaust gas recirculation.

In vehicles in EU6 heavy duty and BIN5 configurations, the SCR (selective catalytic reduction) system with cylinder pressure sensors in the glow plugs is additionally installed. In the BIN5 configuration, use is made of an additional coolant temperature sensor at radiator outlet G83.
Depending on exhaust emission standard, there are differences between components, both in terms of type and how the exhaust gases enter the intake system.

Installation list for exhaust gas recirculation system

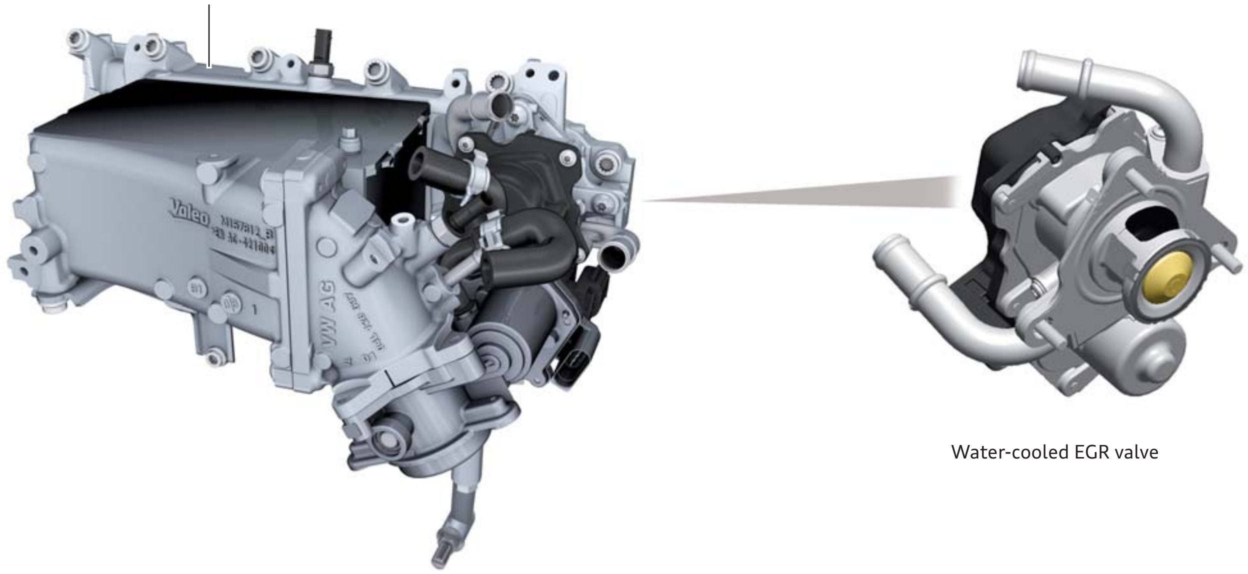
Features	EU4	EU5	EU6	EU6 heavy duty	BIN5[1]/ULEV
High pressure exhaust recirculation	x		x	x	x
Low pressure exhaust recirculation		x	x	x	x
Cooled exhaust recirculation valve	x		x	x	x
Uncooled exhaust recirculation valve		x	x	x	x
SCR system (AdBlue)				x	x
EGR cooler	x	x	x	x	x
Additional temperature sensor at radiator outlet					x
4-way catalytic converter (modified coating on the monoliths)			x		
Cylinder pressure sensor			1	1	4

[1] The term "BIN" stems from the word "bag". During exhaust emission tests, the exhaust gases are collected in bags and analysed. Exhaust emission standards are ranked from BIN10 to BIN5.

Engines in EU4 configuration (high pressure exhaust recirculation)

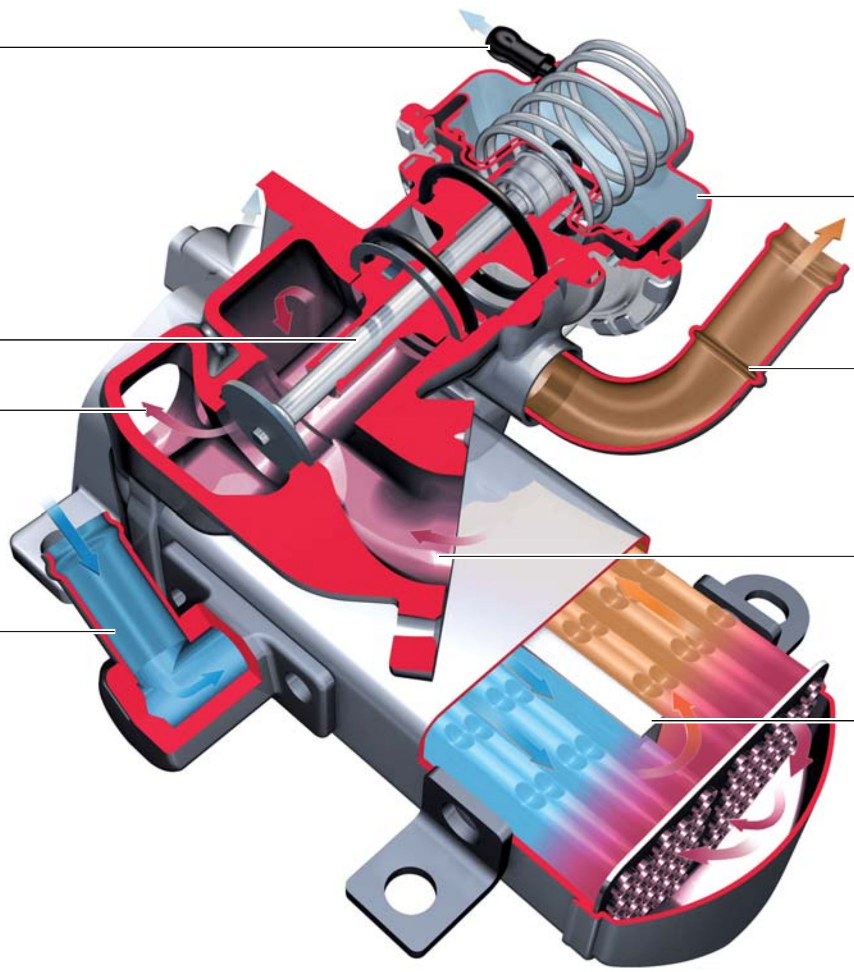
The EU4 version has a high pressure exhaust gas recirculation system with a cooled EGR valve and an EGR cooler. The EGR cooler has a vacuum-controlled bypass flap which is actuated by the engine control unit depending on operating temperature. Upstream of the exhaust turbocharger the recirculated exhaust gases flow through a port in the cylinder head and into a water-cooled exhaust gas recirculation valve mounted on the distributor rail.

The recirculated exhaust gases are divided among the compressed air and the cooled charge air via the distributor rail. This air mixture is channeled to the cylinder head intake port.



608_048

Design of the exhaust gas recirculation (EGR) cooler



608_041

Engines in EU5 configuration (low pressure exhaust recirculation)

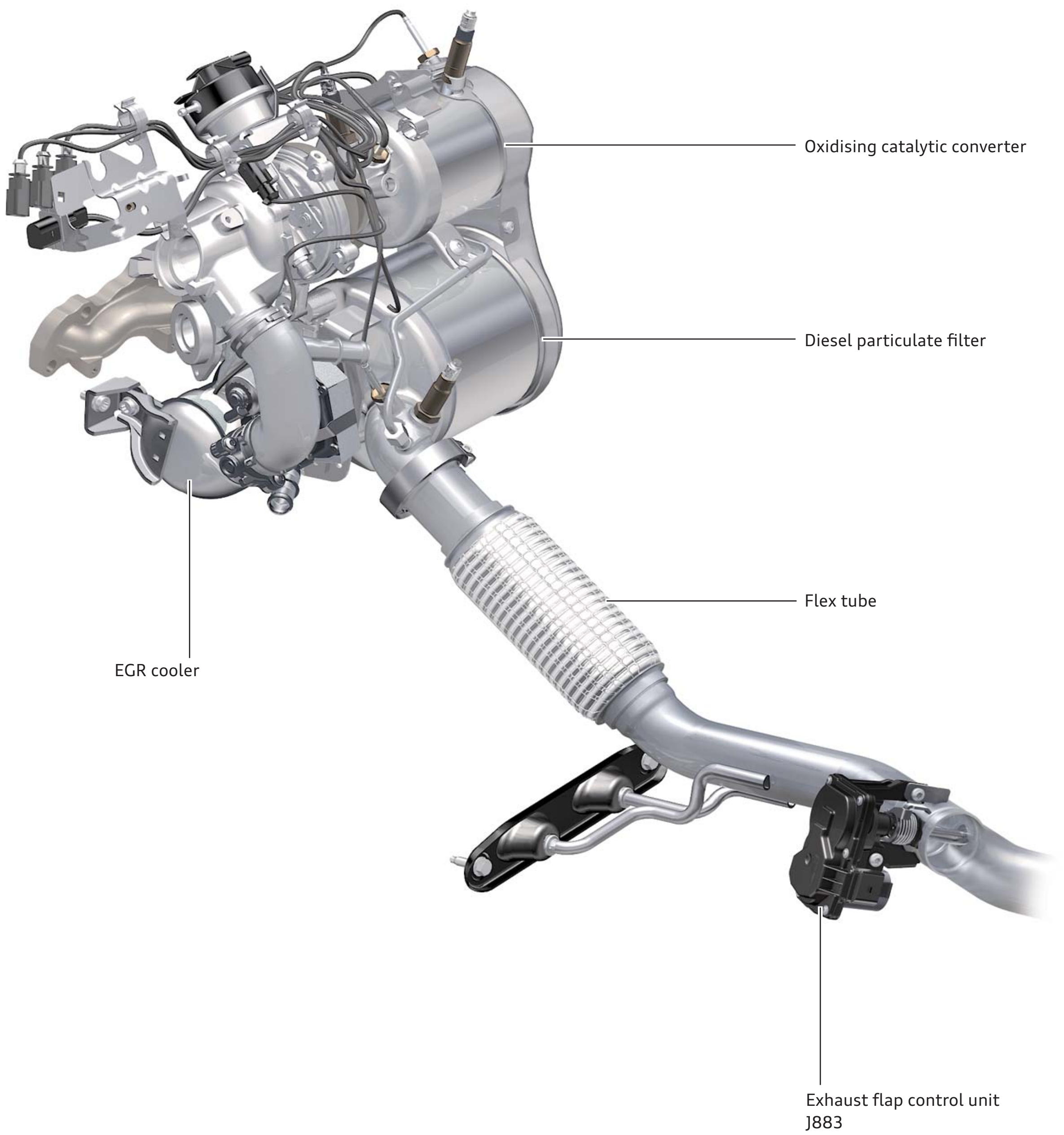
The EU5 version has a low pressure exhaust recirculation system with an uncooled EGR valve and an EGR cooler on the diesel particulate filter.

Downstream of the diesel particulate filter the recirculated exhaust gases flow through the water-cooled EGR cooler to the uncooled exhaust gas recirculation valve via a filter cartridge. From here, the cooled exhaust gases are channeled to the exhaust turbocharger compressor, optimally mixed with charge air and admitted to the intake manifold system with integrated charge air cooler.
To utilise the low pressure exhaust gas recirculation system across the full mapped range, the complete exhaust gas flow from the diesel particulate filter is shut off in a controlled manner by a motor-operated exhaust flap.

This produces an excess pressure of approx. 30 – 40 mbar downstream of the particulate filter relative to the exhaust pressure downstream of the exhaust flap. This excess pressure results in a positive flow gradient (purging rate) via the EGR cooler and the following EGR valve. The quantity of recirculated exhaust gas is controlled by the EGR valve.

The 73° operating range of the exhaust flap is defined by:
- exhaust pressure downstream of the exhaust flap
- nominal exhaust pressure upstream of the exhaust flap
- mass flow through the exhaust flap

System overview

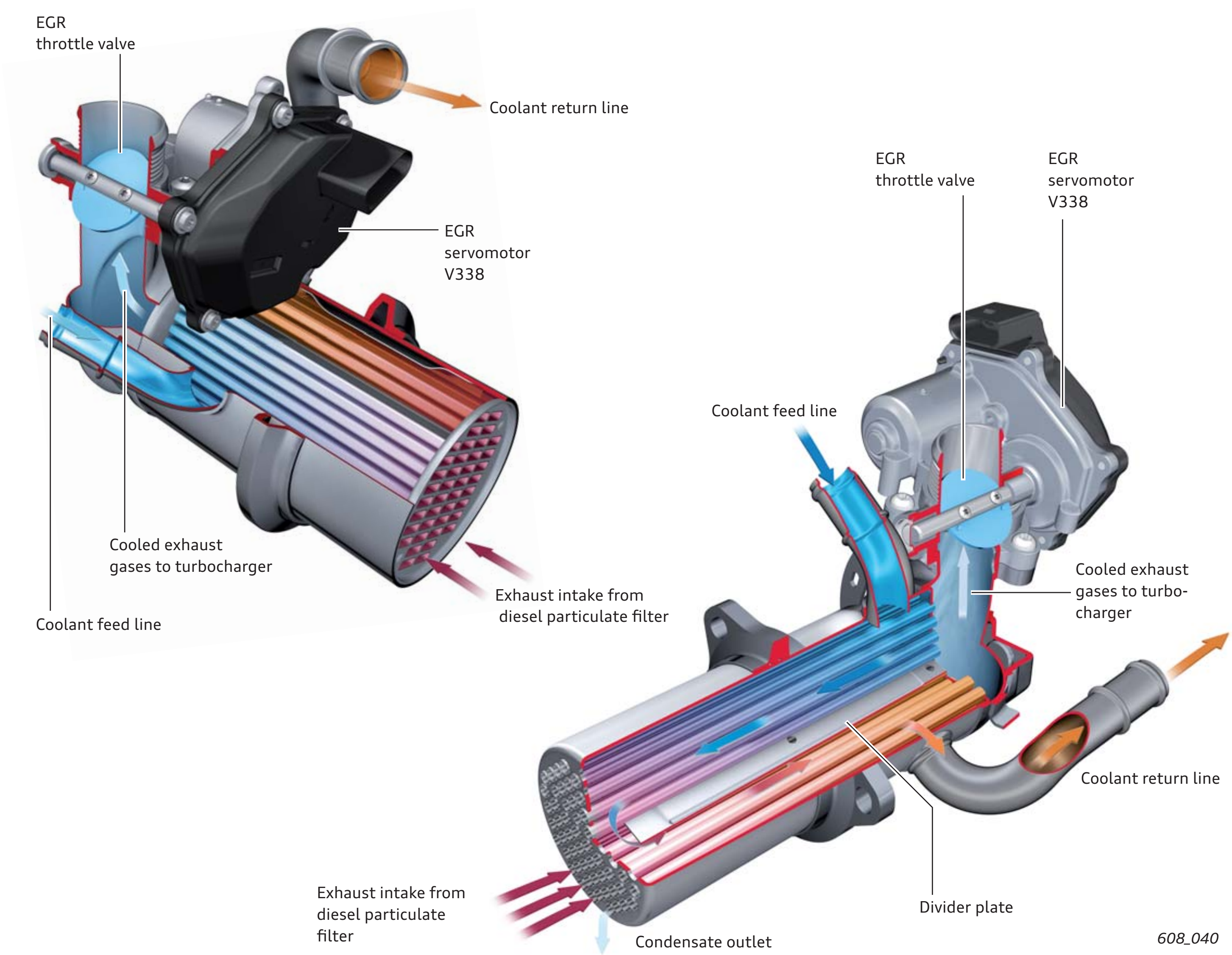


608_061

Design of the exhaust gas recirculation (EGR) cooler

Transversely mounted engines

Longitudinally mounted engines

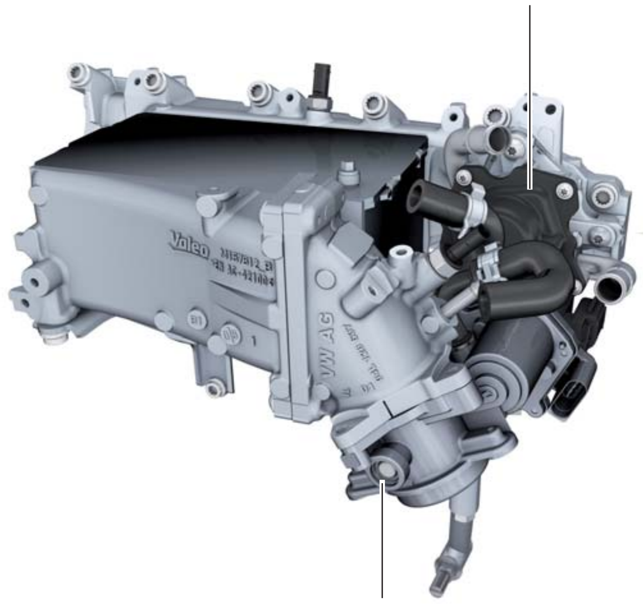


608_040

Engines in EU6, EU6 heavy duty and BIN5 configurations (low and high pressure exhaust gas recirculation)

The EU6 version has low and high pressure exhaust gas recirculation systems with cooled and uncooled EGR valves and an EGR cooler in the low pressure exhaust gas recirculation system.

The exhaust gases are recirculated in the same way as in EU5 engines. Uncooled exhaust gases from the high pressure exhaust gas recirculation system are fed in via a water-cooled EGR valve in the distributor rail at defined operating points.



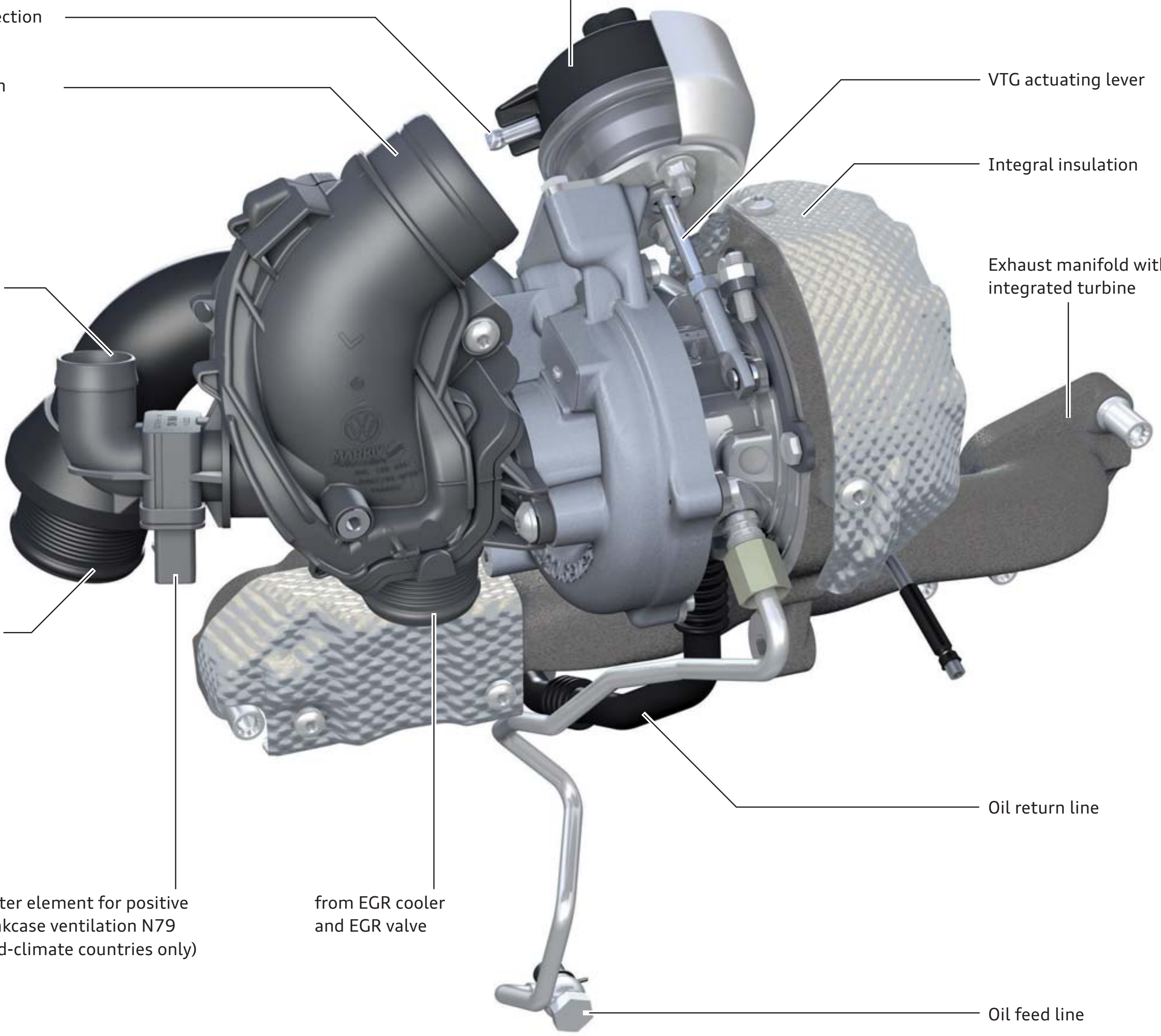
608_048

Exhaust manifold module

The exhaust manifold module consists of the exhaust manifold, the exhaust turbocharger integrated in the exhaust manifold, the low pressure exhaust gas recirculation intake and the baffled sound absorber. Use is made of an exhaust turbocharger with a pneumatically actuated Variable Turbine Geometry (VTG) and a position sensor.
The recirculated exhaust gases are not extracted at the turbine housing, rather at the diesel particulate filter outlet. In the EU5 version, the full mass flow is always channeled through the turbocharger compressor by extracting the recirculated exhaust gases downstream of the diesel particulate filter outlet.

The turbocharger can thus be operated with greater efficiency. This allows higher charge pressures and higher volumetric efficiency to be achieved at partial throttle in particular. A benefit of this is the higher cooling capacity of the exhaust gas recirculation system, which helps to reduce the mixing temperature of the fresh air and recirculated exhaust gases.
The overall system was designed in such a way that the versions with high and low pressure exhaust gas recirculation in EU4 and EU6 configurations can be implemented modularly by modifying the compressor housing and the exhaust manifold.
The acoustic characteristics of the exhaust turbocharger were improved by using modified damping chambers in the baffled sound absorber.

Exhaust turbocharger module for longitudinal installation



608_079

Charge air cooler

By way of improvement, the water-cooled charge air cooler for diesel engines is integrated in the intake manifold as in the 1.4l TFSI petrol engines. The heat sink comprises the coolant plates, fins; top, base and side plates; and coolant connections. A separate low temperature coolant circuit equipped with and air-to-water heat exchanger provides demand-oriented charge air cooling in combination with a variable-speed electrical coolant pump.

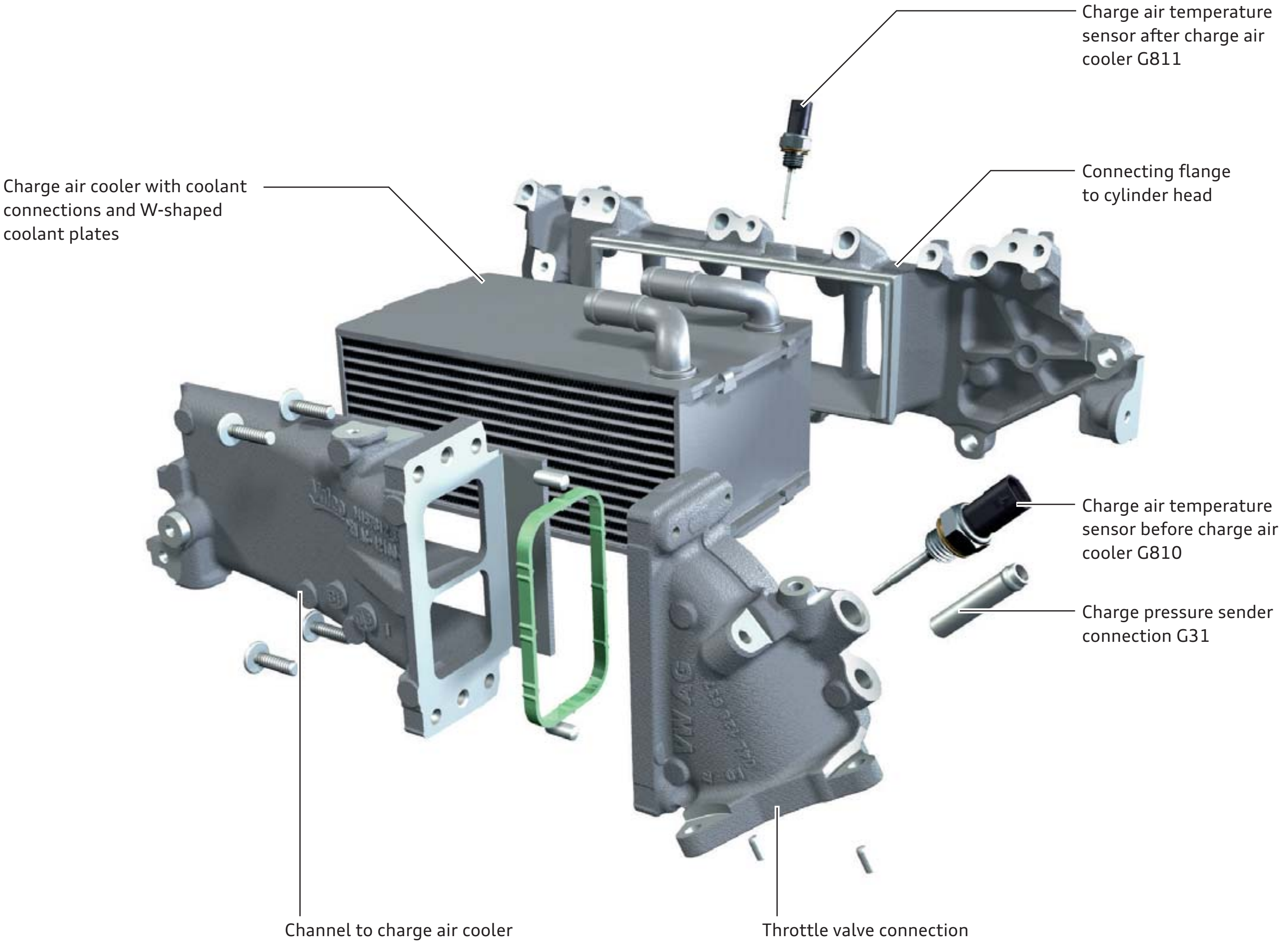
This has the following advantages:

- As the intake manifold temperatures are adjustable within defined limits, the system can operate independently of the intake air temperature and the recirculated exhaust gas.
- The result is a compact charge air circuit.
- Flow losses are reduced.
- Icing and condensation are avoided in the charge air cooler

- Synergy is achieved in particular by using the charge air cooler as a high-performance low pressure exhaust gas recirculation and cooler system

The charge air cooler integrated in the intake manifold is fully brazed and made of aluminium. The intake and exhaust boxes are subsequently welded to the heat sink.
Coolant flows through the coolant plates in a W configuration according to the counterflow principle. Due to the special geometry of the coolant plates, the coolant flow is distributed across the width of the flat tube and simultaneously diverted. This makes for effective heat transfer from the aluminium panel to the coolant.

Design



608_019

Note
For information on the functioning of the low temperature coolant circuit, refer to p. 38 of this booklet.

Cooling system

Thermal management

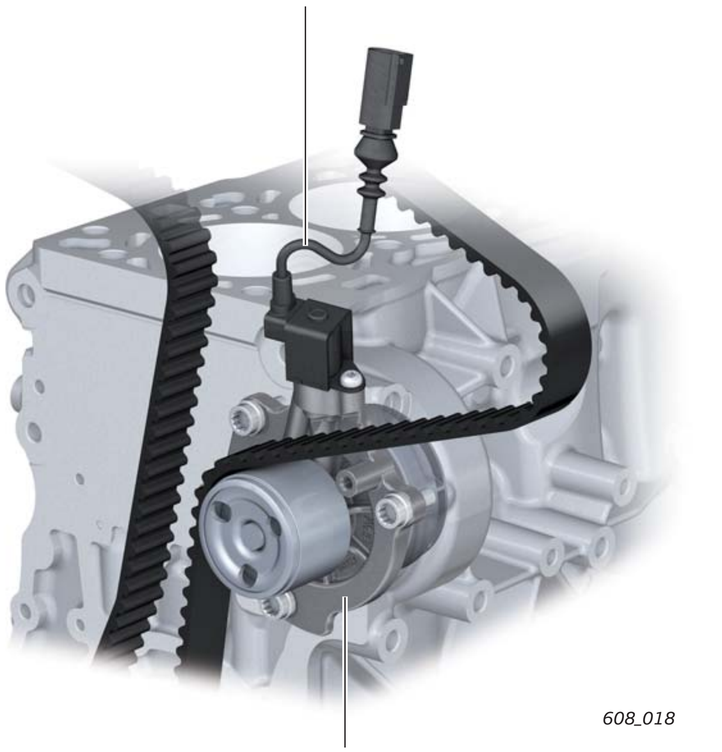
The 1.6l/2.0l TDI engine has a thermal management system which is designed to shorten the warm-up phase after a cold start and channel the heat produced by the engine to where it can be advantageously utilised to boost vehicle efficiency.
The focus here is on reducing intra-engine friction. Other goals are to ensure the early availability of emission reduction measures and to reduce the use of heating measures which impair fuel efficiency.

The overall cooling circuit comprises three sub-circuits:

- Secondary cooling circuit (micro circuit)
  - Cylinder head
  - EGR cooler of low pressure exhaust gas recirculation system
  - Heater heat exchanger
  - Electrical auxiliary coolant pump

- Primary cooling circuit (high temperature circuit)
  - Cylinder block
  - Engine and gear oil cooler
  - Coolant thermostat (3/2-way valve)
  - Main radiator
  - Switchable coolant pump

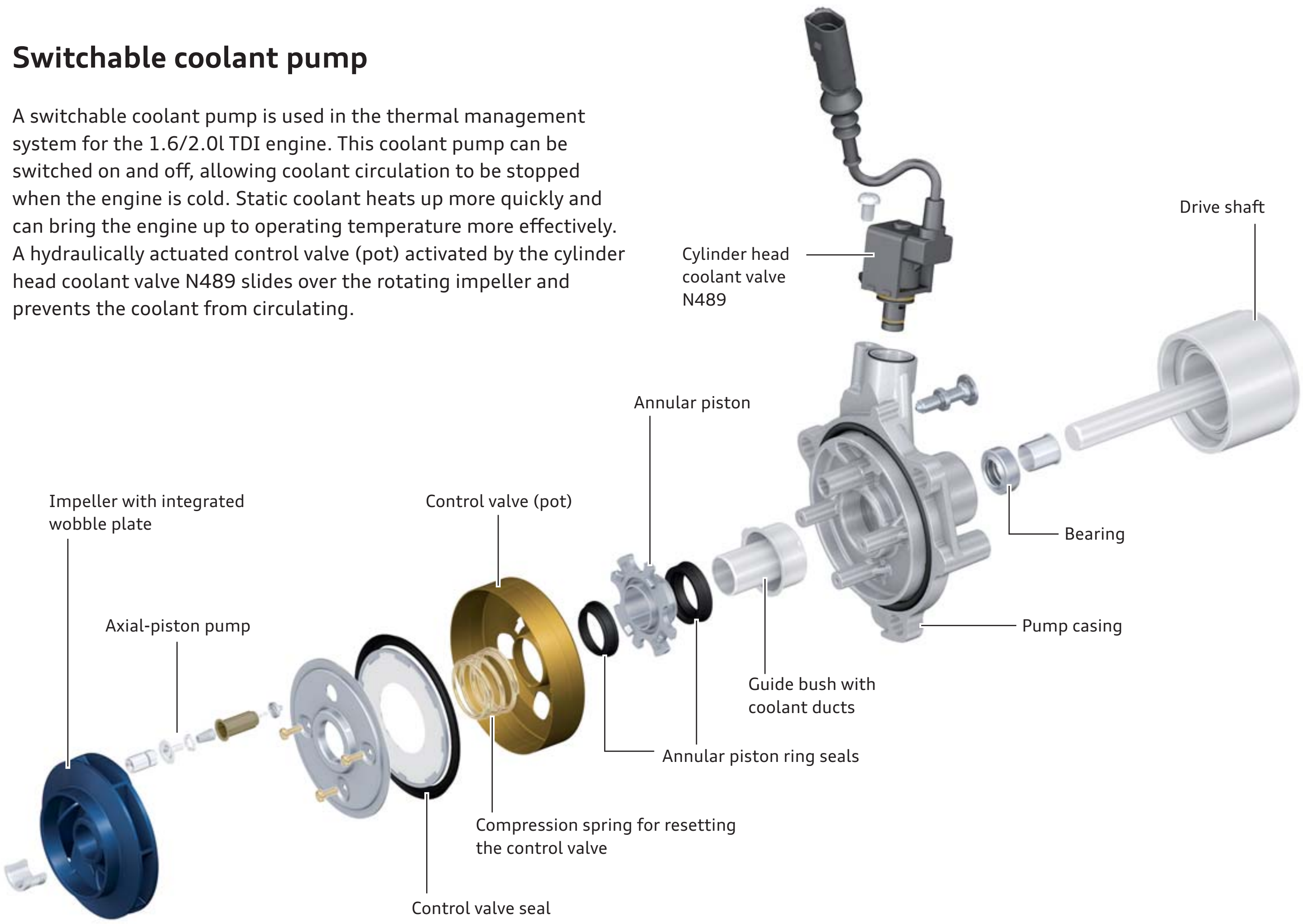
- Cooling circuit with charge air cooling (low temperature circuit)
  - Charge air cooler
  - Front radiator
  - Electrical auxiliary coolant pump



608_018

Switchable coolant pump

A switchable coolant pump is used in the thermal management system for the 1.6/2.0l TDI engine. This coolant pump can be switched on and off, allowing coolant circulation to be stopped when the engine is cold. Static coolant heats up more quickly and can bring the engine up to operating temperature more effectively.
A hydraulically actuated control valve (pot) activated by the cylinder head coolant valve N489 slides over the rotating impeller and prevents the coolant from circulating.



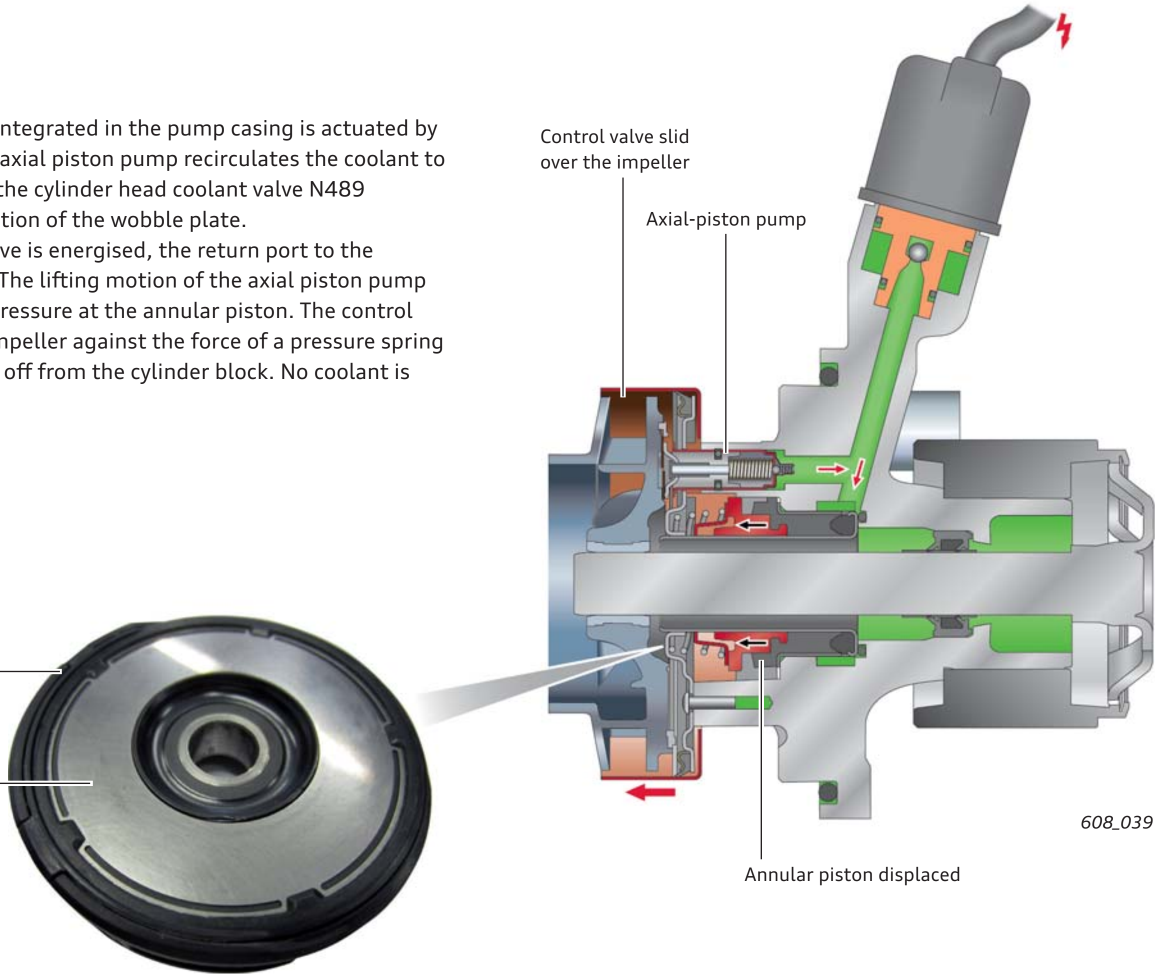
608_029

Coolant pump function

The control valve can slide hydraulically over the impeller, thus preventing coolant from being circulated. The impeller has an integral cast-in stainless steel plate which acts as a wobble plate.

Static coolant

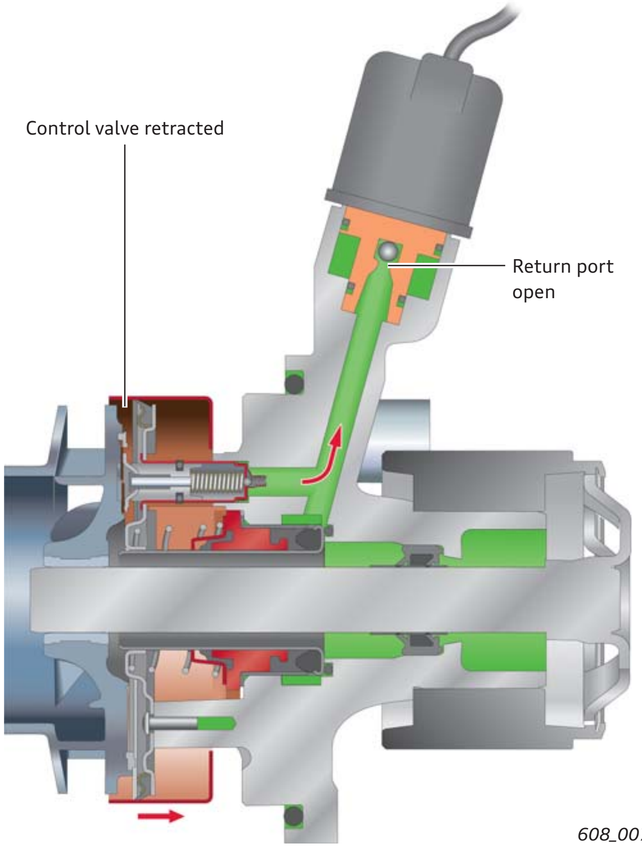
An axial piston pump integrated in the pump casing is actuated by the wobble plate. The axial piston pump recirculates the coolant to the cooling circuit via the cylinder head coolant valve N489 through the lifting motion of the wobble plate.
When the solenoid valve is energised, the return port to the coolant circuit closes. The lifting motion of the axial piston pump produces a hydraulic pressure at the annular piston. The control valve slides over the impeller against the force of a pressure spring and seals the impeller off from the cylinder block. No coolant is circulated.



608_039

Coolant is circulated

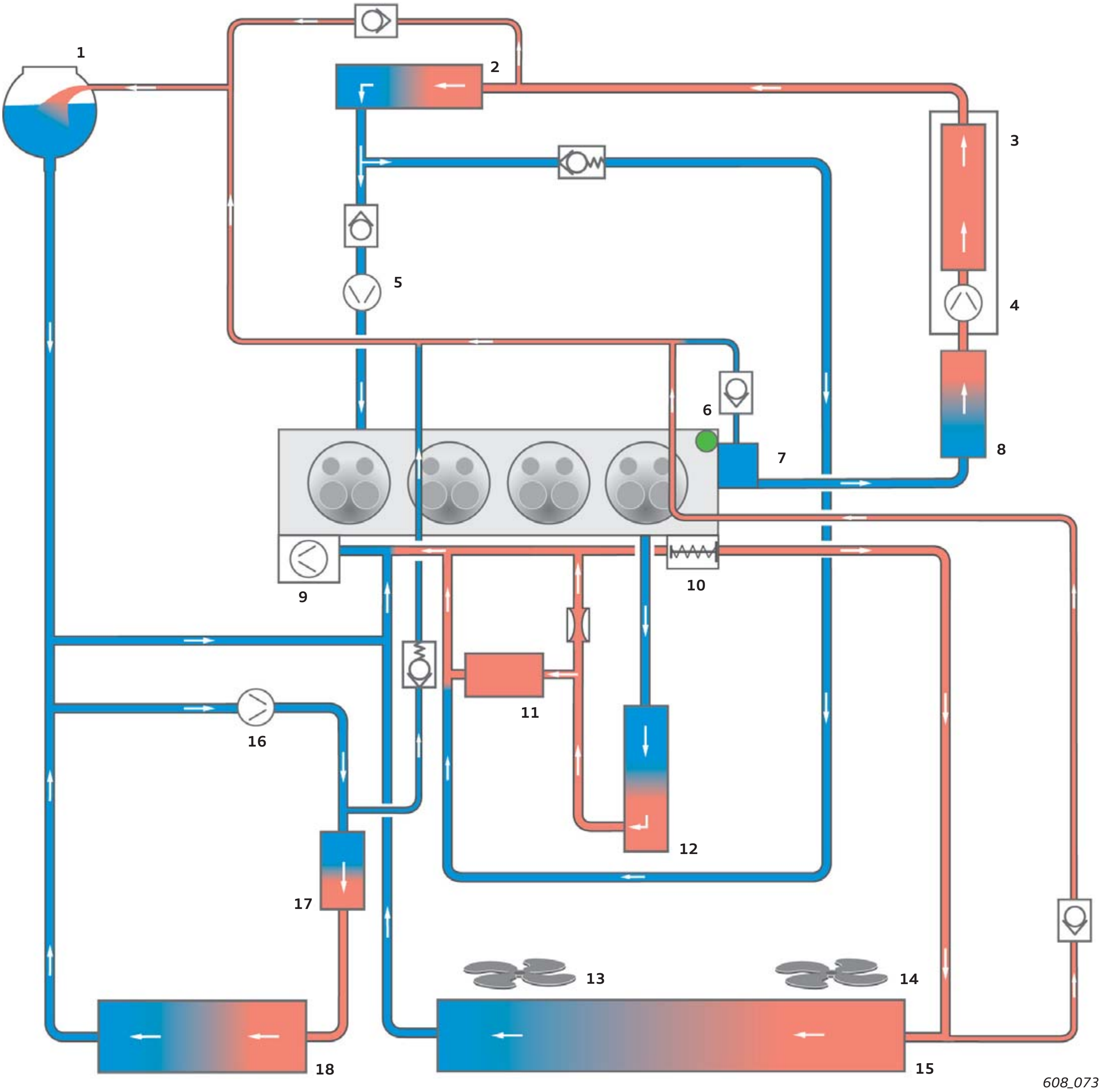
If the solenoid valve is deenergised, the return port to the coolant circuit opens, and the annular piston is pushed back by the compression spring and restores the control valve to its original position. The impeller is again free and the coolant begins to circulate. The axial piston pump operates whenever the engine is running.



608_007

System overview

The following diagrams show the cooling system in the engine version which meets the EU5 exhaust emission standard.



Key:

1 Coolant expansion tank
2 Heater heat exchanger
3 Auxiliary heater
4 Recirculation pump V55
5 Heating assistance pump V488
6 Coolant temperature sender G62
7 Coolant socket
8 EGR cooler
9 Cylinder head coolant valve N489
10 Coolant thermostat
11 Throttle valve
12 Engine oil cooler
13 Radiator fan V7
14 Radiator fan 2 V177
15 Radiator
16 Charge air cooling pump V188
17 Charge air cooler integrated in intake manifold
18 Radiator for charge air cooling

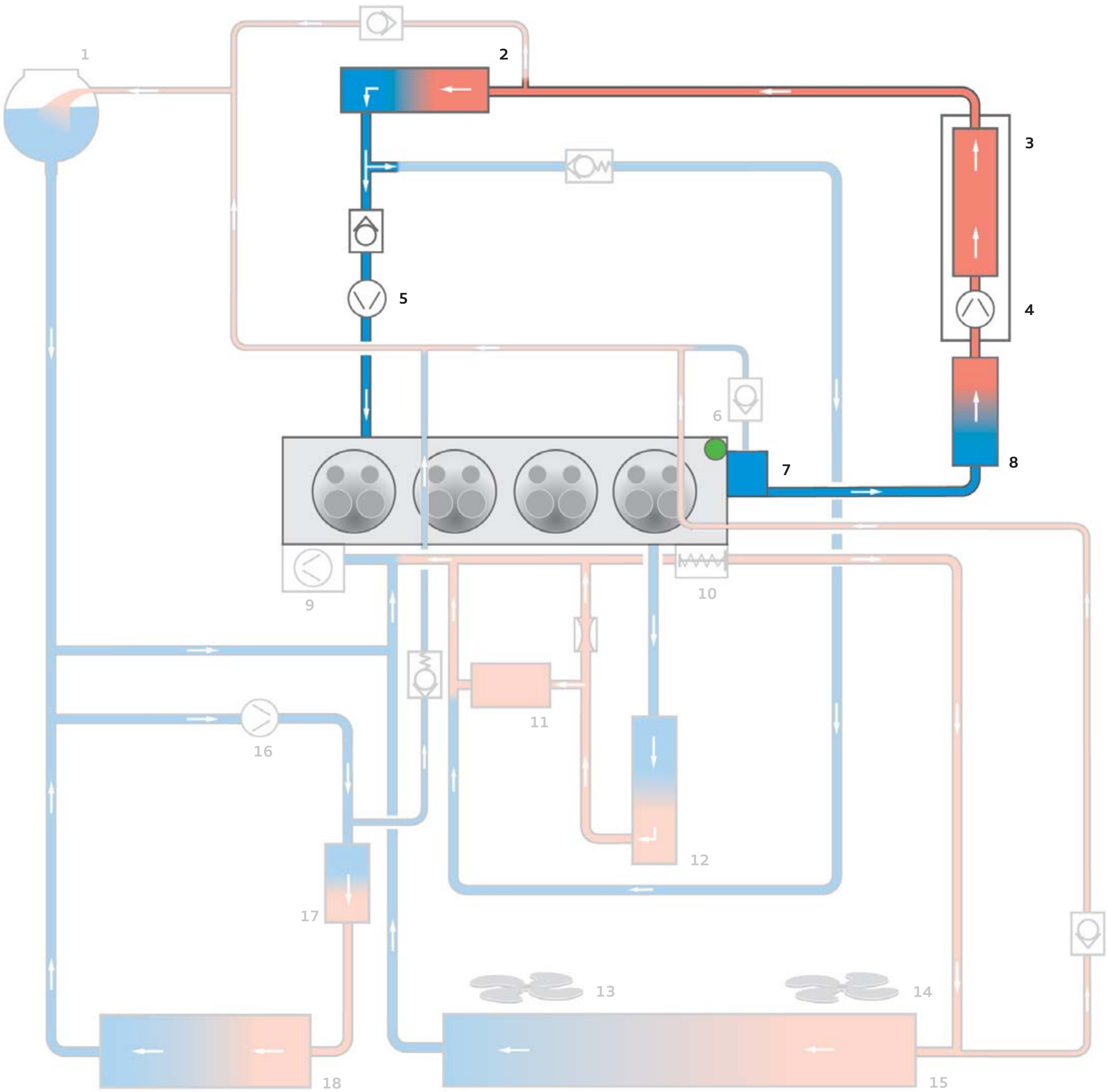
Cooled coolant
Heated coolant

Secondary cooling circuit (micro circuit, heating circuit)

If the engine is cold, the thermal management system is started in conjunction with the secondary cooling circuit, thereby ensuring that the engine and interior are heated quickly. The switchable coolant pump is activated via the cylinder head coolant valve N489.

This stops the coolant from circulating in the engine block. The electrical heating assistance pump V488 initiates the secondary cooling circuit in a controlled manner, depending on the coolant temperature in the cylinder head.

The driver's temperature preference is registered by the A/C control unit and taken into consideration when the coolant pump is activated.



608_074

Auxiliary heater operation

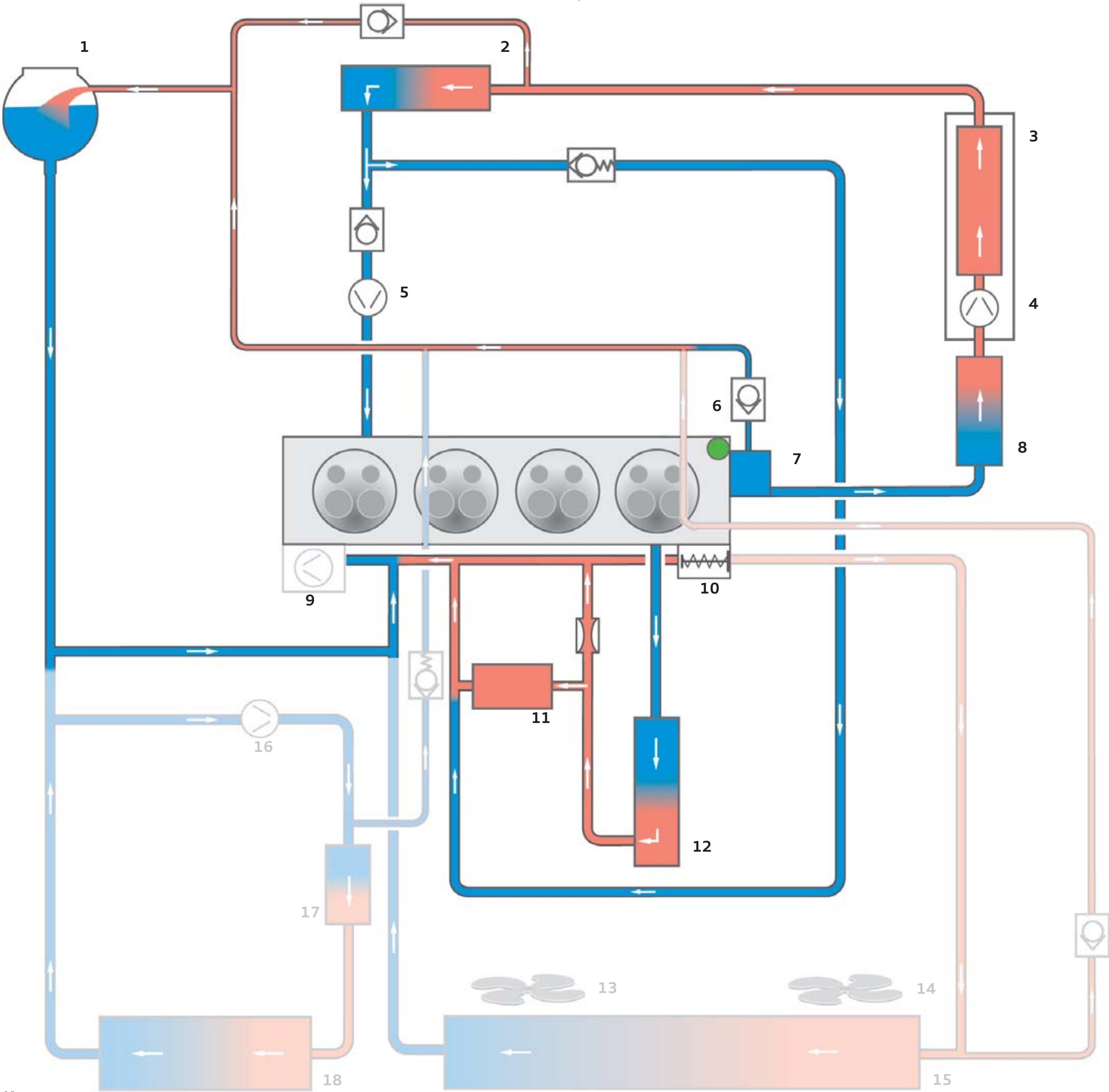
The auxiliary heater is integrated in-line with the heater heat exchanger without changeover valves. It has a separate circulation pump V55.

The heating assistance pump V488 provides back-up in cold ambient conditions in order to ensure that a minimum volumetric flow is achieved at high coolant viscosity.

Secondary cooling circuit – engine cooling requirements / high engine load

The switchable coolant pump is activated at increasing engine load and engine speed. This ensures that the engine is cooled. After the engine speed drops below a threshold level, the coolant pump is deactivated again and the engine is operated without coolant circulation until the required coolant temperature is achieved.

The coolant pump is continuously activated when the coolant temperature exceeds a threshold level at the cylinder head, indicating that the engine is at operating temperature. When the coolant pump is activated, it is ensured that a sufficient quantity of coolant flows through the cylinder head. For this purpose, the engine has a thermostat with an integrated short circuit (refer to p. 39).



608_075

Key:

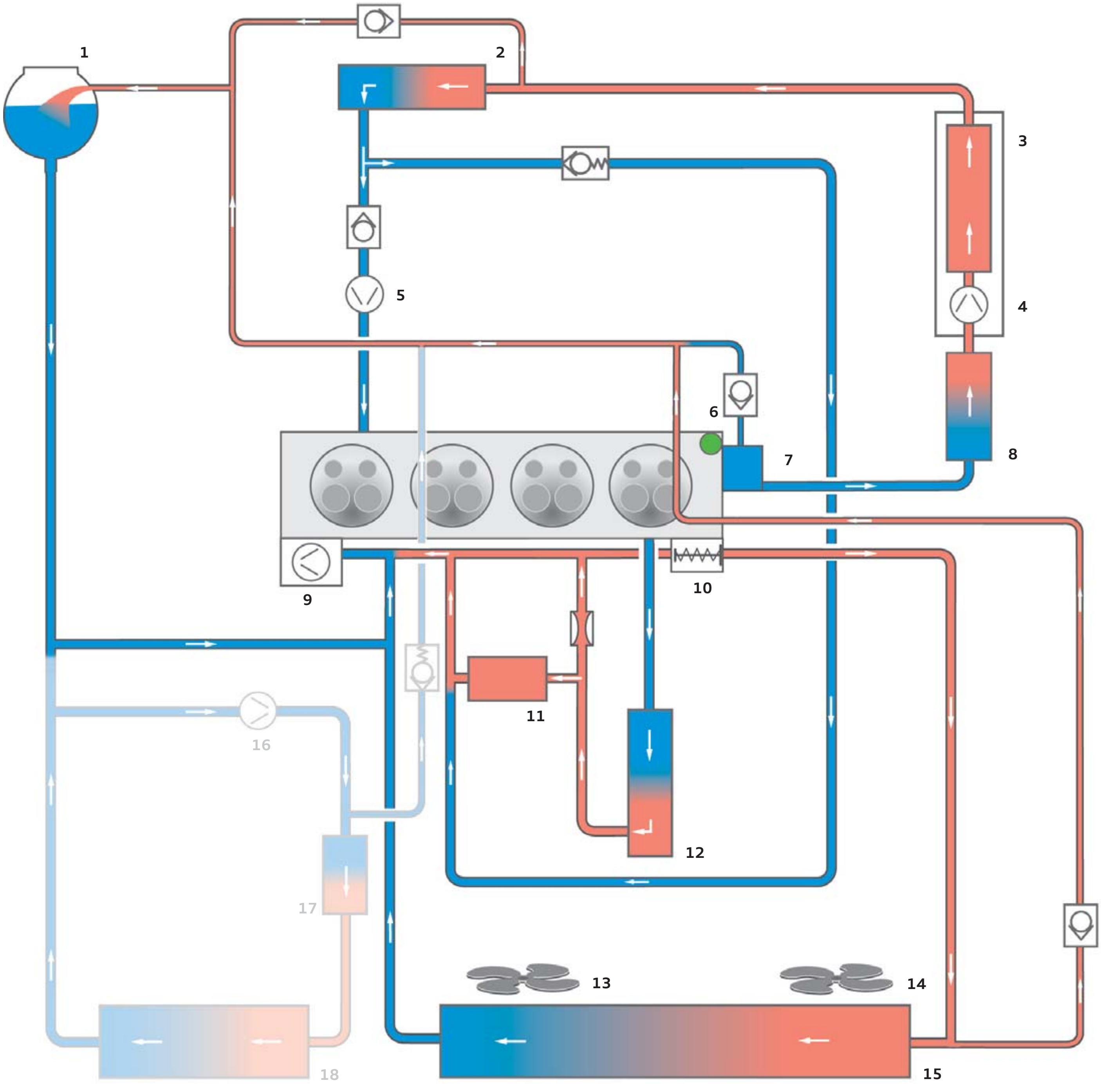
1	Coolant expansion tank
2	Heater heat exchanger
3	Auxiliary heater
4	Recirculation pump V55
5	Heating assistance pump V488
6	Coolant temperature sender G62
7	Coolant socket
8	EGR cooler
9	Cylinder head coolant valve N489
10	Coolant thermostat
11	Throttle valve
12	Engine oil cooler
13	Radiator fan V7
14	Radiator fan 2 V177
15	Radiator
16	Charge air cooling pump V188
17	Charge air cooler integrated in intake manifold
18	Radiator for charge air cooling

Cooled coolant
Heated coolant

Primary cooling circuit (high temperature circuit) – coolant at operating temperature

If the coolant is at operating temperature, the coolant thermostat opens and enters control mode. The radiator (main radiator) is integrated in the cooling circuit.

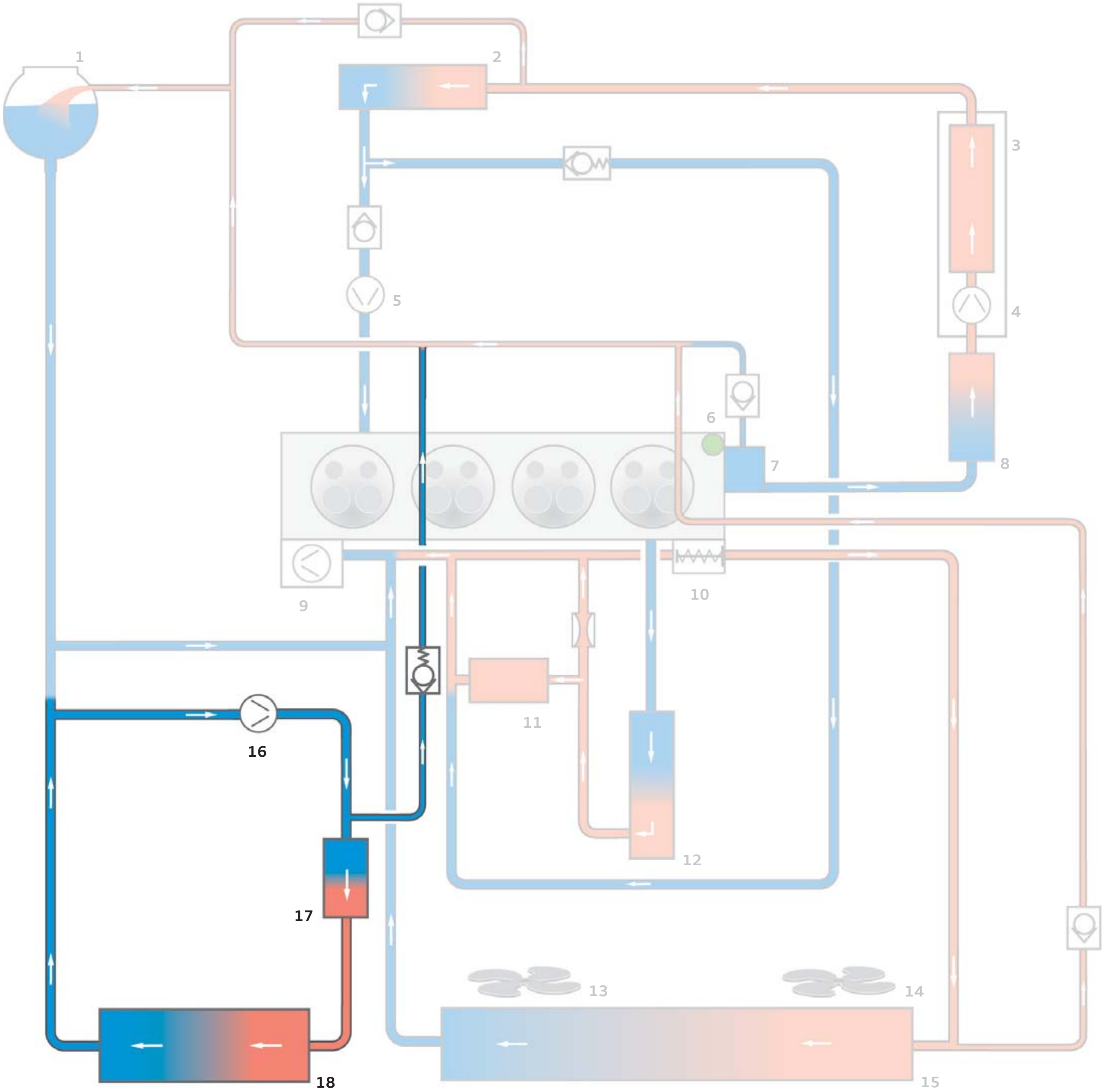
The coolant thermostat controls the engine outlet temperature and is located in the main radiator feed line.



608_076

Low temperature cooling circuit – coolant circuit for charge air cooling

The intake manifold temperature is used as a reference variable for activating the charge air cooling circuit. After this tagert temperature is achieved, the intake manifold temperature is regulated by activating the charge air cooling pump V188.



Key:

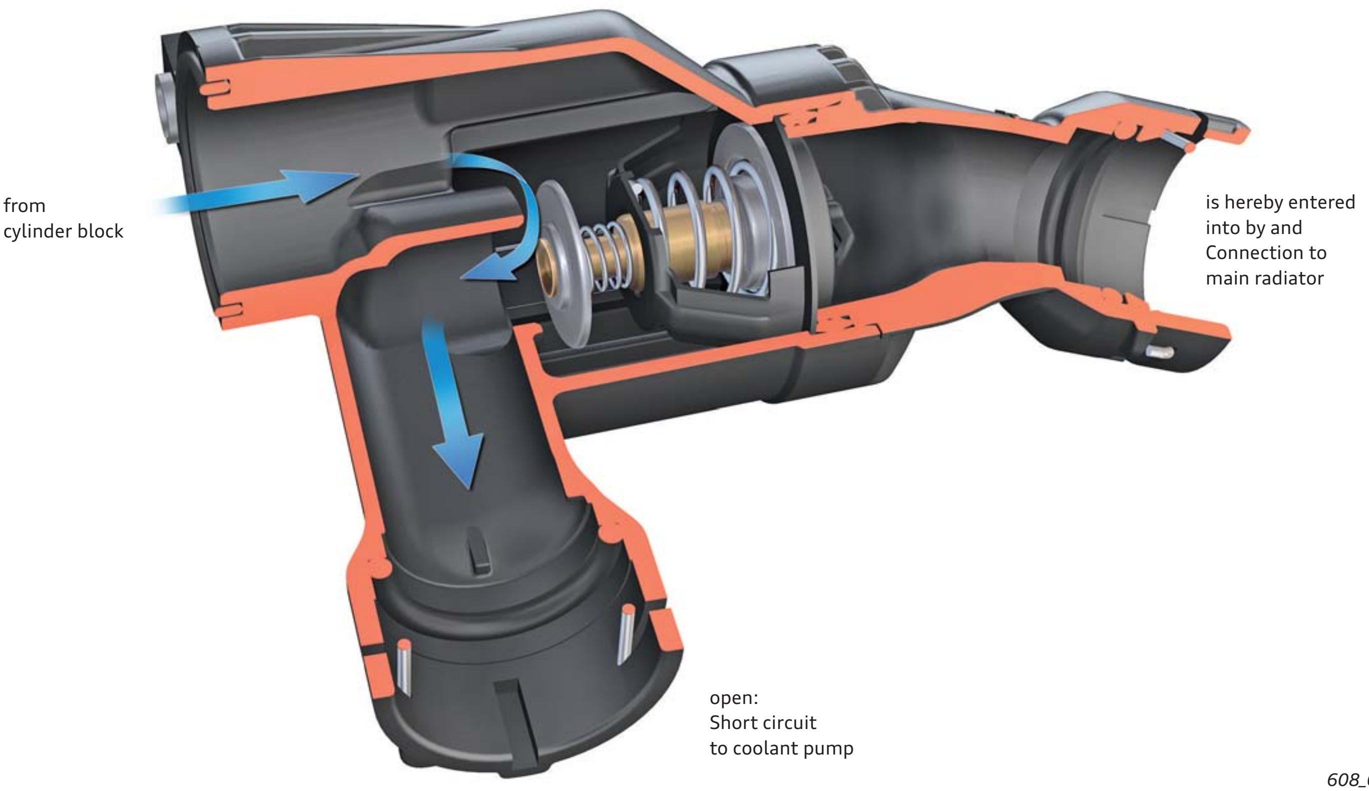
1 Coolant expansion tank
2 Heater heat exchanger
3 Auxiliary heater
4 Recirculation pump V55
5 Heating assistance pump V488
6 Coolant temperature sender G62
7 Coolant socket
8 EGR cooler
9 Cylinder head coolant valve N489
10 Coolant thermostat
11 Throttle valve
12 Engine oil cooler
13 Radiator fan V7
14 Radiator fan 2 V177
15 Radiator
16 Charge air cooling pump V188
17 Charge air cooler integrated in intake manifold
18 Radiator for charge air cooling

Cooled coolant
Heated coolant

Coolant thermostat as 3/2-way valve

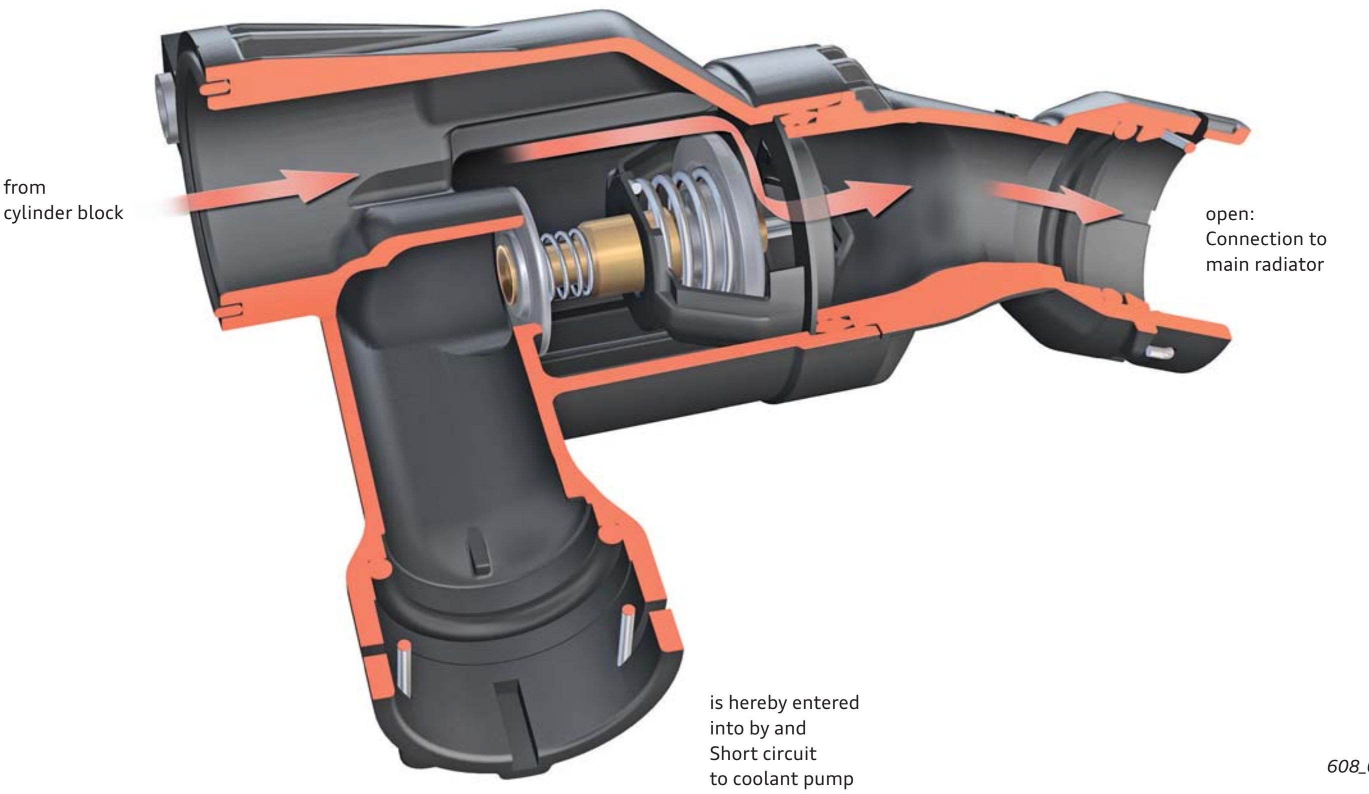
The coolant thermostat is activated by an expanding wax element, which begins to close the secondary cooling circuit when operating temperature is reached. The primary cooling circuit is closed at the same time.

Secondary cooling circuit (micro circuit)



608_005

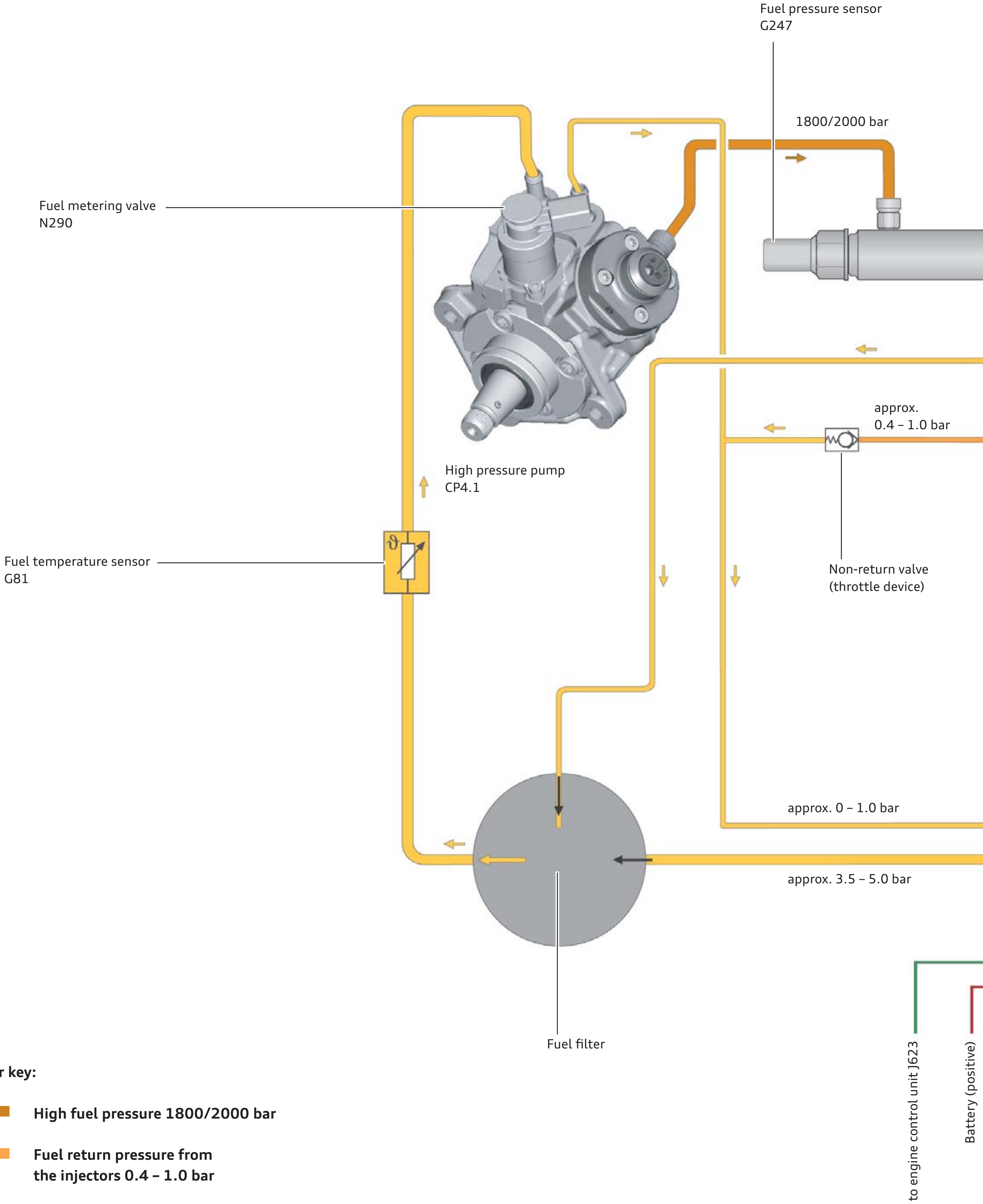
Primary cooling circuit (high temperature circuit, controlled)



608_006

Fuel system

Overview

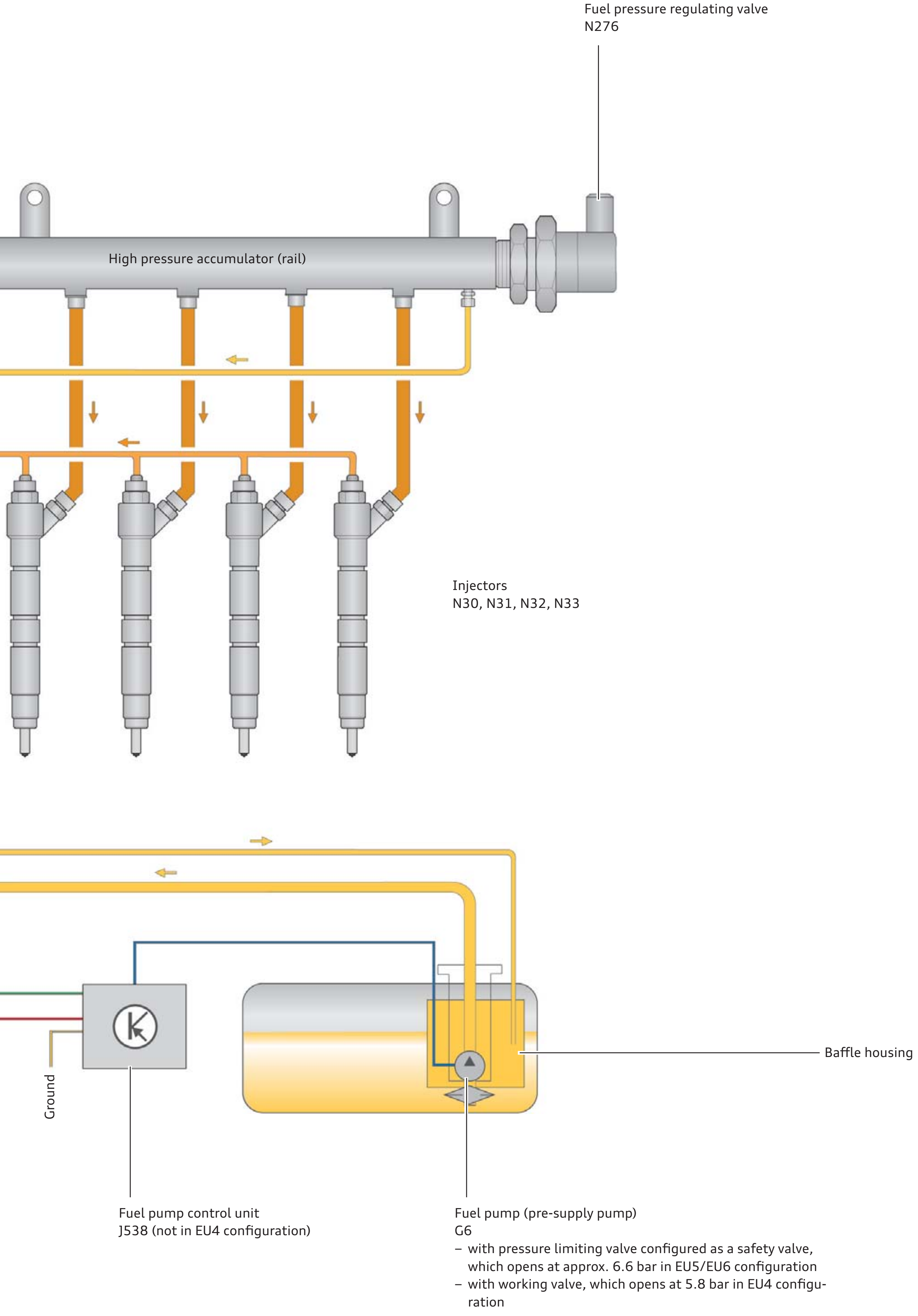


Colour key:

High fuel pressure 1800/2000 bar

Fuel return pressure from the injectors 0.4 – 1.0 bar

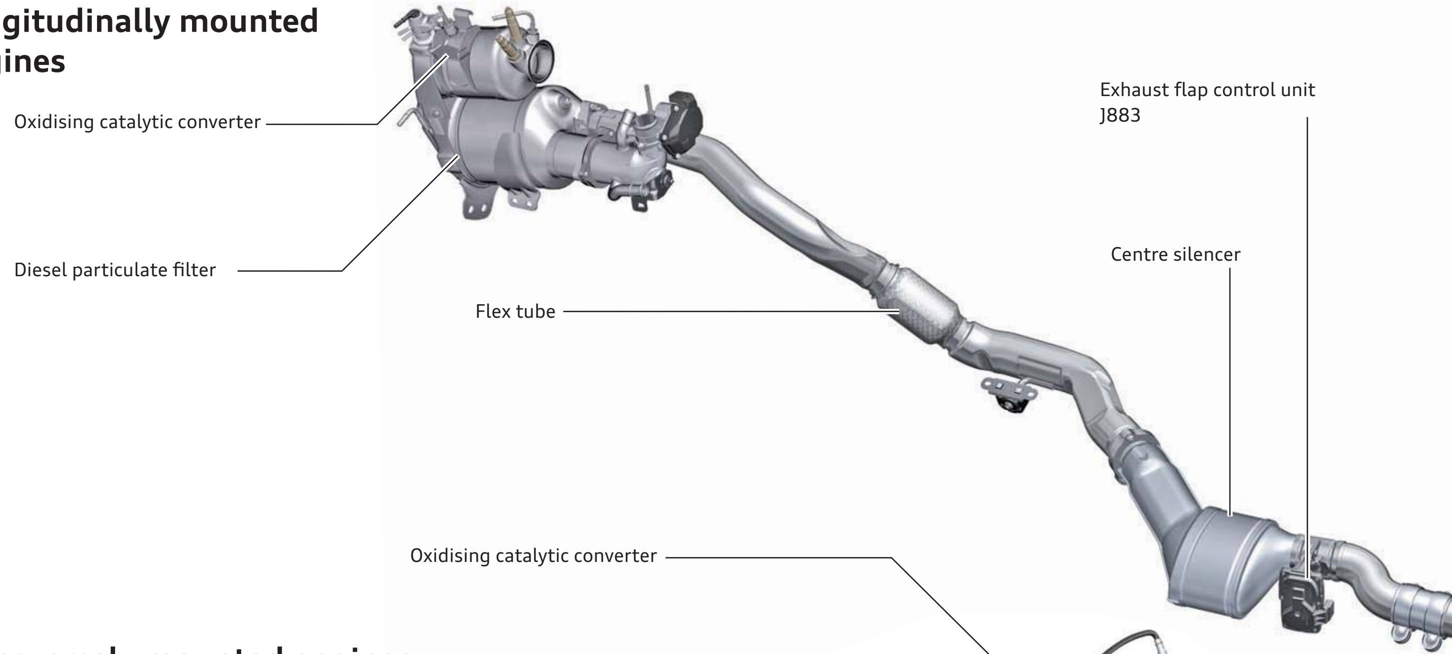
Fuel feed pressure (demand controlled) 3.5 – 5.0 bar


Fuel pressure regulating valve
N276
High pressure accumulator (rail)
Injectors
N30, N31, N32, N33
Ground
Baffle housing
Fuel pump control unit
J538 (not in EU4 configuration)
Fuel pump (pre-supply pump)
G6
– with pressure limiting valve configured as a safety valve, which opens at approx. 6.6 bar in EU5/EU6 configuration
– with working valve, which opens at 5.8 bar in EU4 configuration

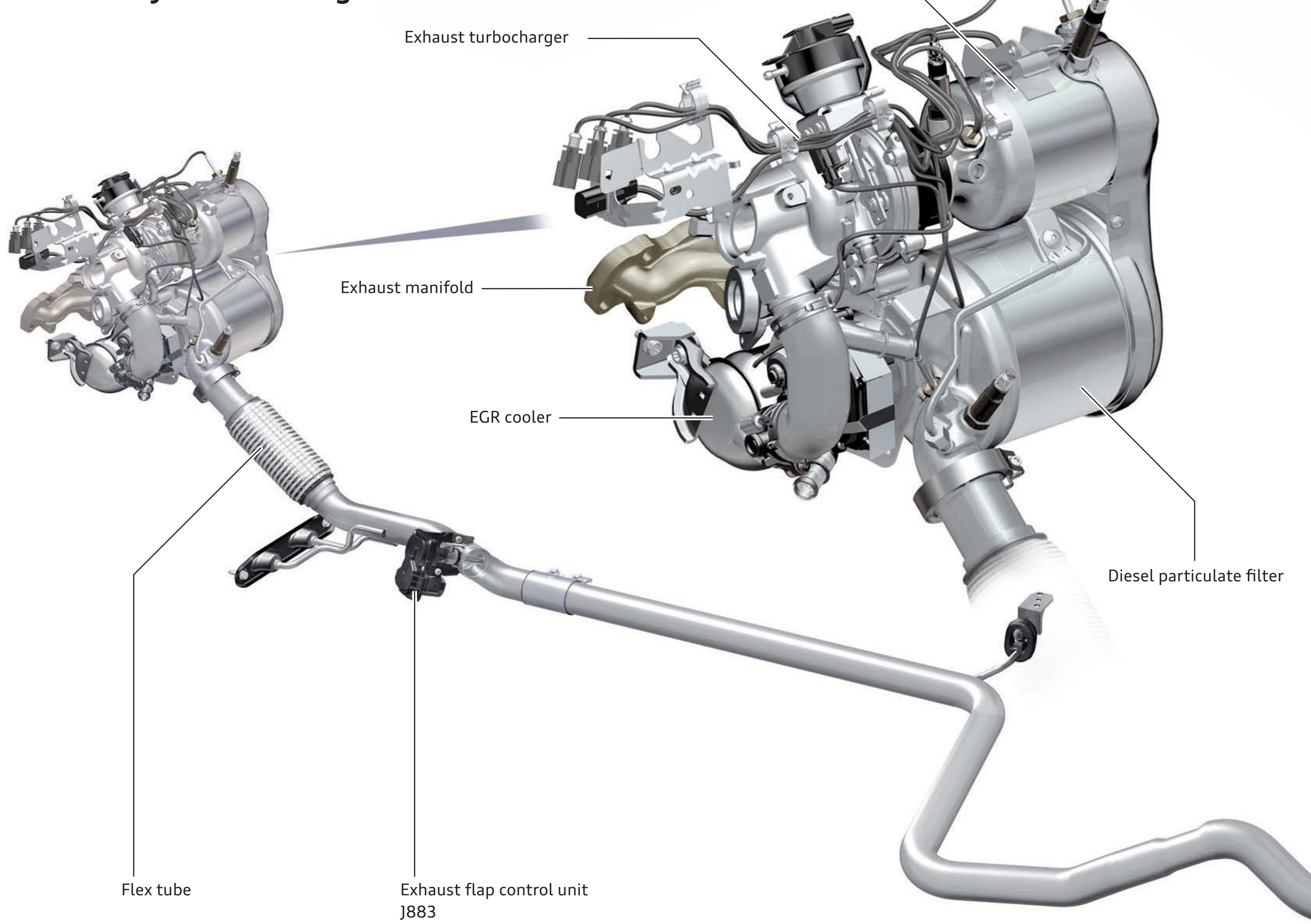
608_028

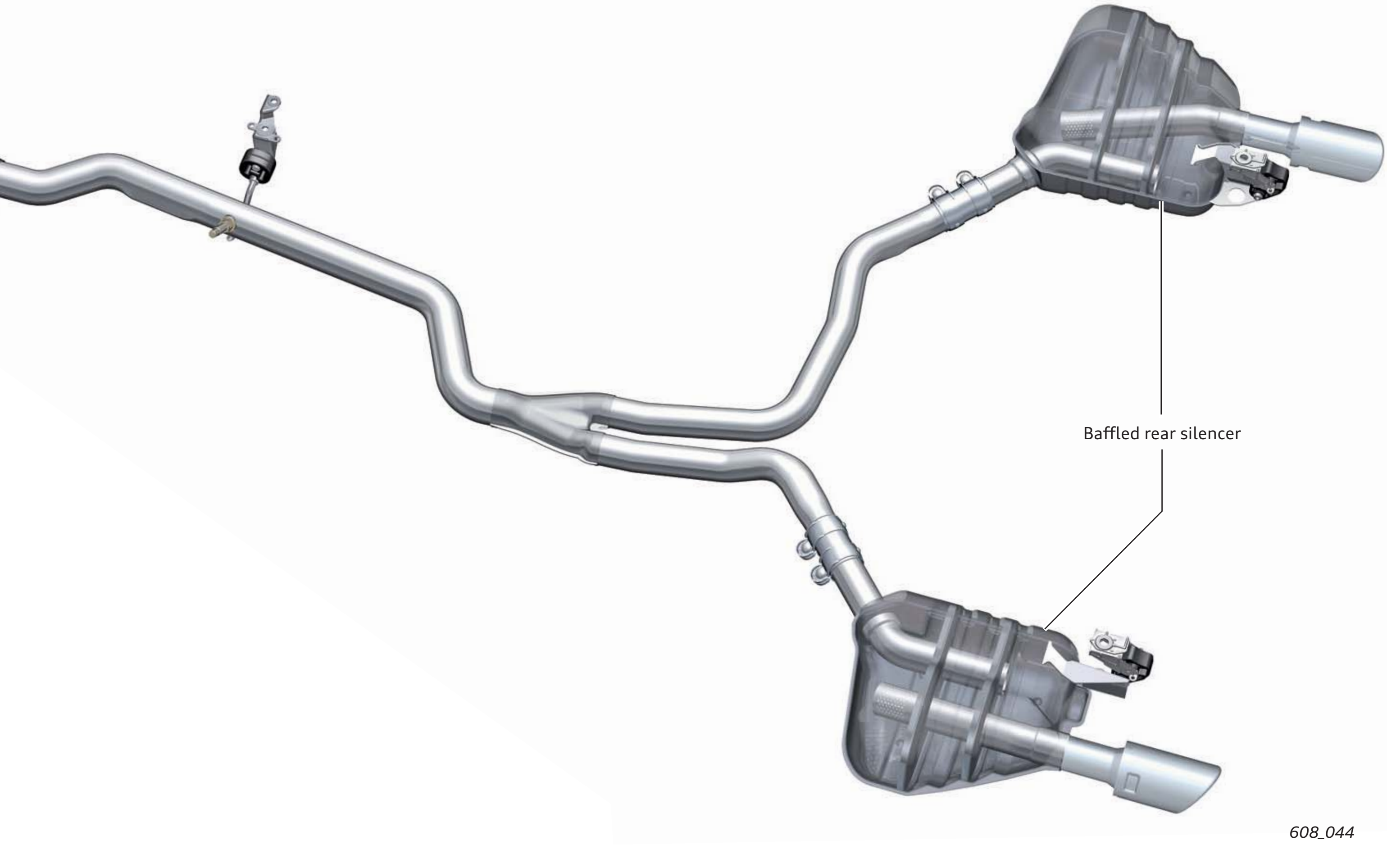
Exhaust system

Longitudinally mounted engines

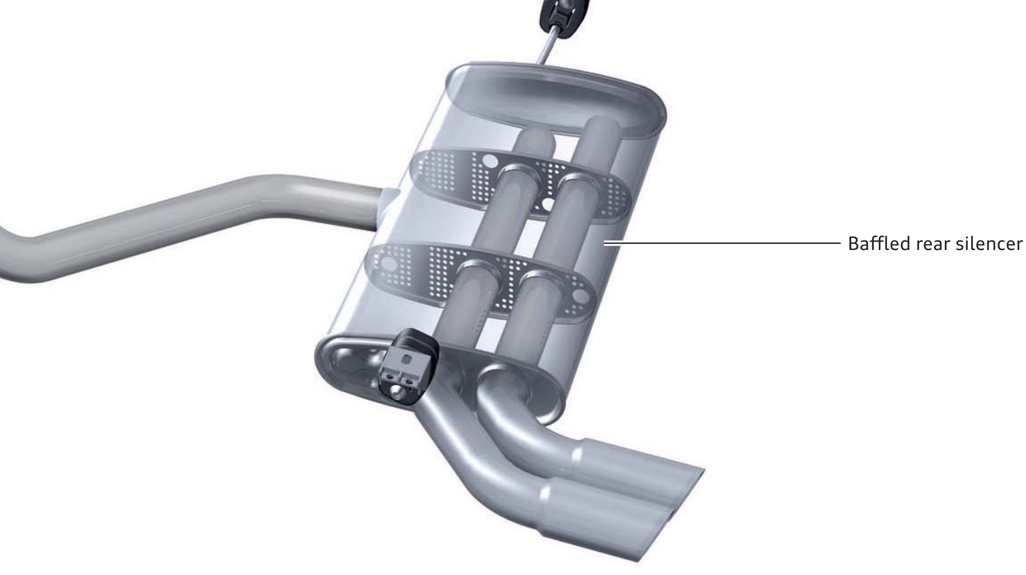


Transversely mounted engines





608_044



608_050

Engine management system

System overview

Sensors

Air mass meter G70

Throttle valve potentiometer G69

Engine speed sender G28

Hall sender G40

Coolant temperature sender G62

Fuel temperature sender G81

Coolant temperature sender at radiator outlet G83[1)]

Oil level/oil temperature sensor G266

Fuel pressure sensor G247

Accelerator pedal sender G79 and accelerator pedal position sender G185

Exhaust gas recirculation potentiometer 2 G466
Charge pressure actuator position sensor G581

Brake light switch F
brake pedal switch F63

Combustion chamber pressure sender for cylinder 3 G679[1)]

Oxygen sensor G39

Charge air temperature sensor before charge air cooler G810

Charge air temperature sensor after charge air cooler G811

Charge pressure actuator position sensor G581

Oil pressure switch F22

Oil pressure switch for reduced oil pressure F378

Exhaust gas temperature sender 3 (after cat) G495

EGR temperature sensor G98 (EU4)

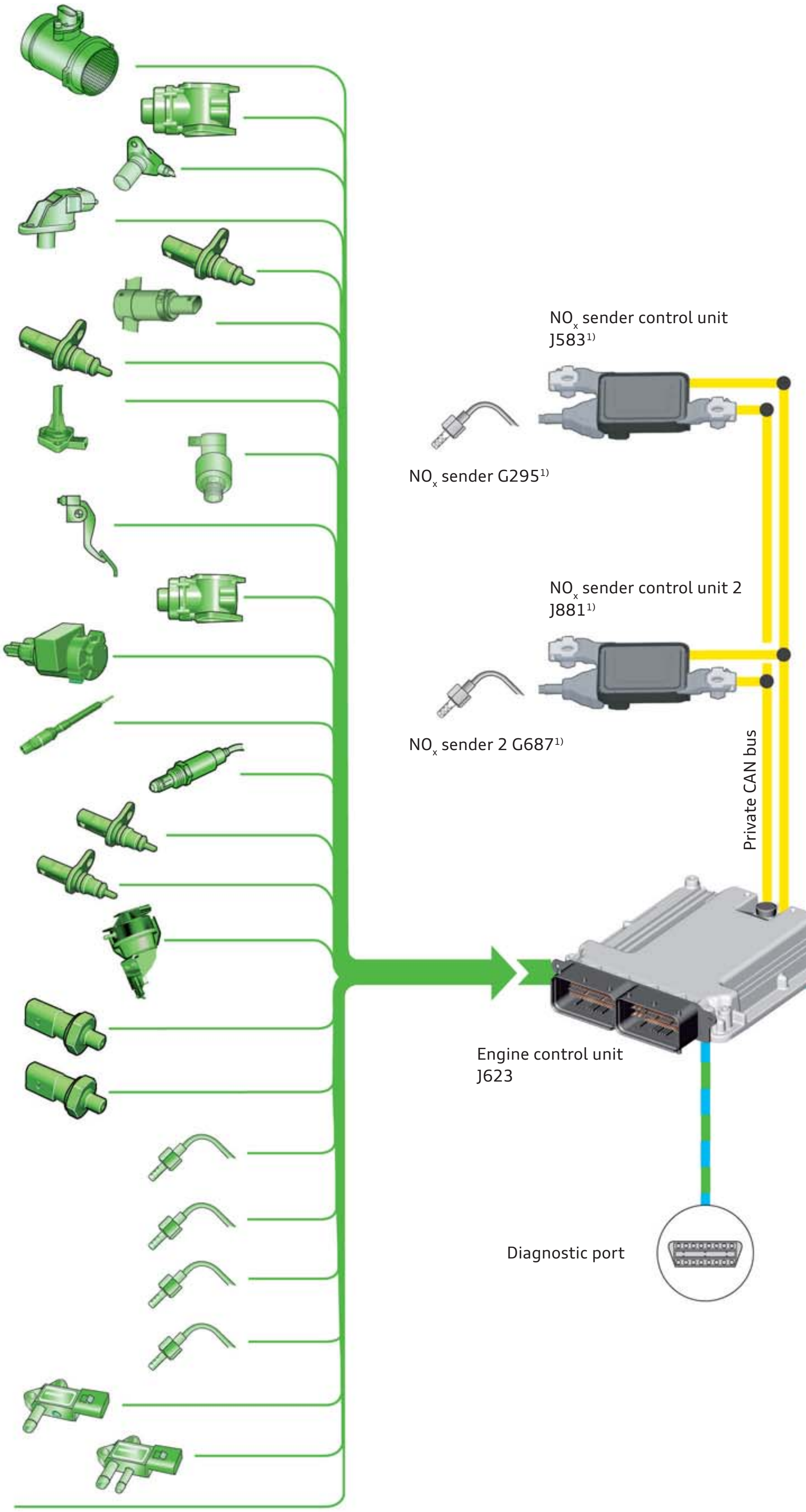
Exhaust gas temperature sender 1 G235

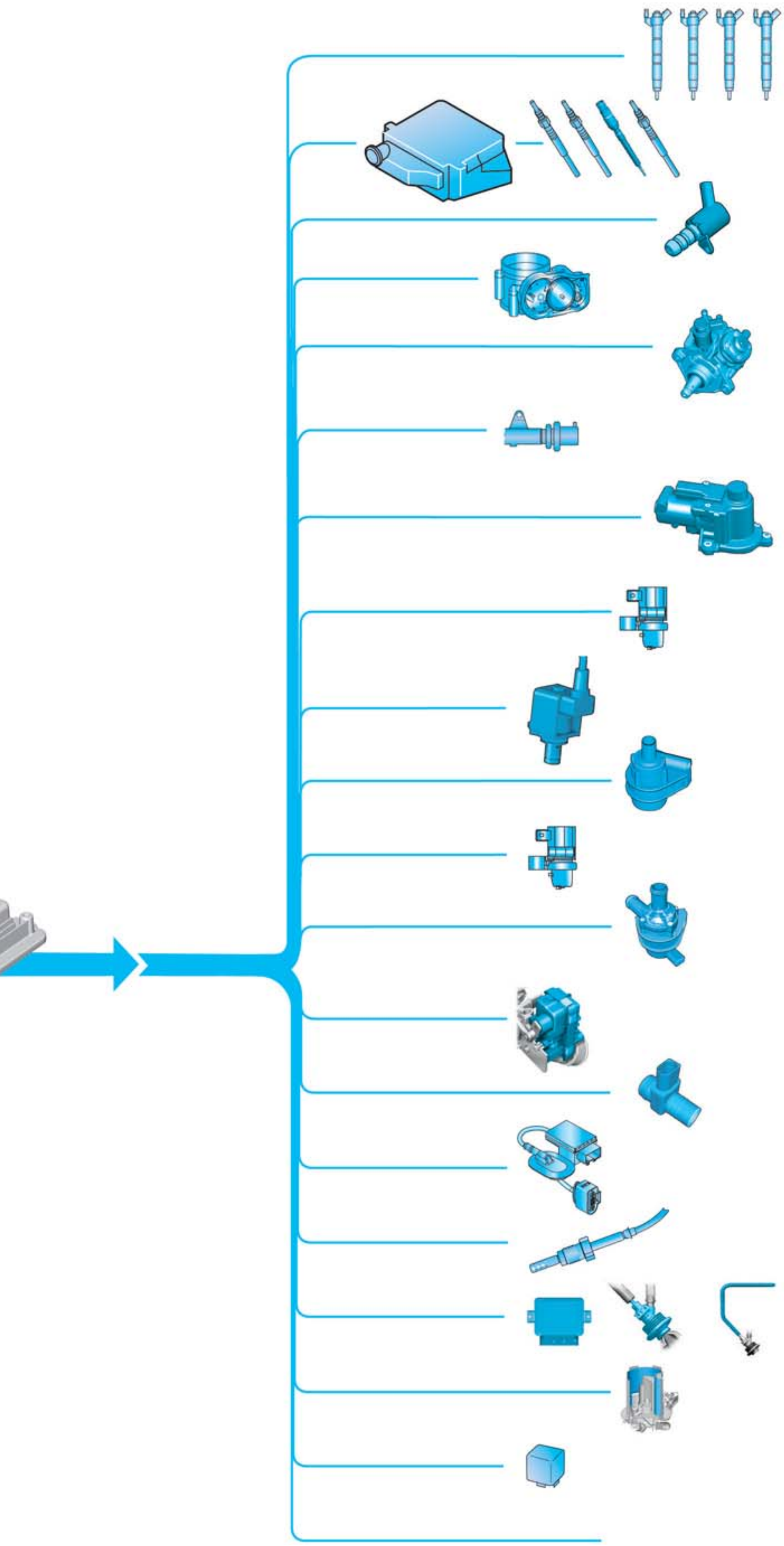
Exhaust gas temperature sender 4 G648

Charge pressure sensor G31

Differential pressure sender G505

Auxiliary signals:
- Cruise control system
- Speed signal
- Start request to engine control unit (Kessy 1 + 2)
- Terminal 50
- Crash signal from airbag control unit





Actuators

Injectors, cylinders 1 – 4
N30, N31, N32, N33

Automatic glow period control unit for J179
Glow plugs 1 – 4 Q10, Q11, Q12, Q13

Oil pressure control valve N428

Throttle valve control unit J338

Fuel metering valve N290

Fuel pressure regulating valve N276

Exhaust gas recirculation servomotor V338
(Low pressure exhaust gas recirculation)
Exhaust gas recirculation servomotor 2 V339
(High pressure exhaust gas recirculation)

Exhaust gas recirculation cooler change-over valve N345
(EU4)

Cylinder head coolant valve N489

Charge air cooling pump V188

Charge pressure limitation solenoid valve N75

Heating assistance pump V488

Exhaust flap control unit J883

Heater element for positive crankcase ventilation N79
(cold-climate countries only)

Fuel pump control unit J538

Oxygen sensor heater Z19

Reduction agent metering system control unit J880[1)]
Reduction agent injector N474[1)]
Reduction agent line heater Z104[1)]

Reduction agent pump V437
Reduction agent tank heater Z102

Fuel pump relay J17
Fuel predelivery pump G6

Auxiliary signals:
A/C compressor
Auxiliary coolant heater
Fan setting 1 + 2
Auxiliary air heater element Z35

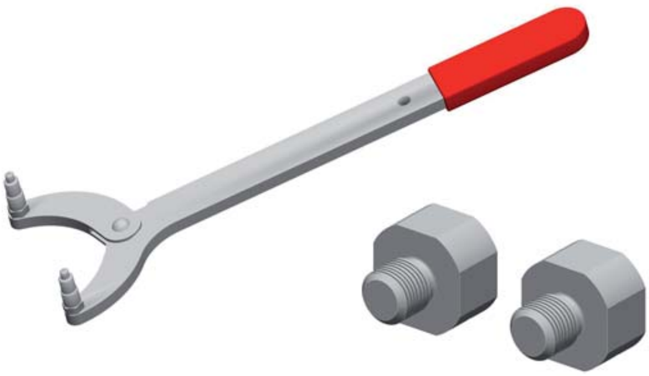
608_058

[1)] These components are for EU6 heavy duty and BIN5 configurations only

Service

Special tools and workshop equipment

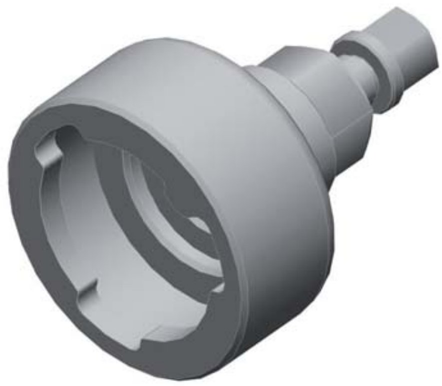
T10172 with T10172/11



608_071 *608_072*

Tensioning the timing belt

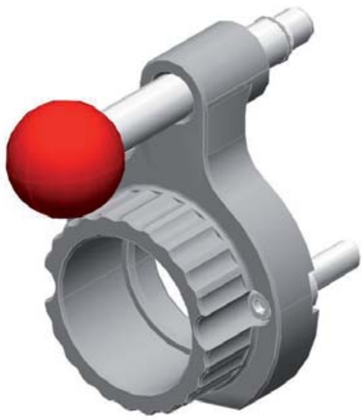
T10489



608_064

Removing the high pressure pump drive gear

T10490



608_066

Locking the crankshaft with round and oval chain sprockets

T10491

608_068

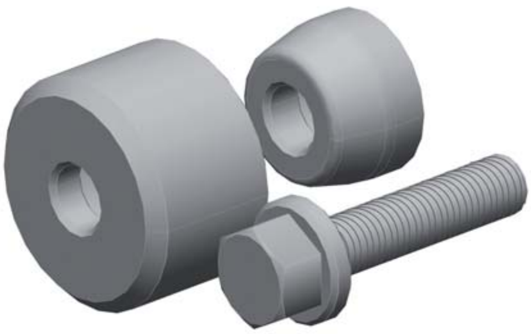
Removing and fitting the oxygen sensor

T10492

608_069

Locking the high pressure pump and camshaft

T10493



608_070

Fitting the camshaft seal

Self Study Programmes

You will find further information on the technology of the 1.6l/2.0l TDI engine in the following Self Study Programme.

608_081

SSP 420 Audi 2.0l TDI Engine with Common Rail Injection System, order number: A08.5S00.45.20

AUDI AG
D-85045 Ingolstadt
Technical status 04/12

Printed in Germany
A12.5S00.92.20