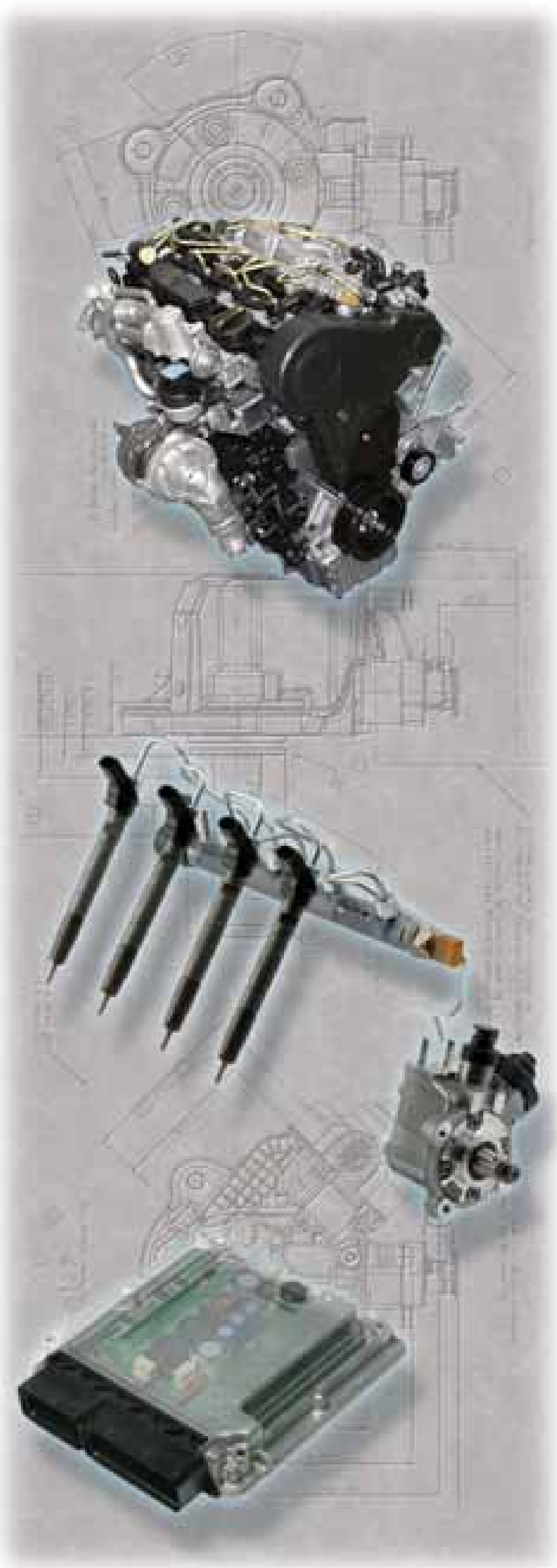
Service Training

Audi 2.0-litre TDI Engine with Common Rail Injection System

Self-Study Programme 420



The 105 kW (143 hp) 2.0-litre TDI engine featuring common rail (CR) injection technology marks the birth of a new generation of dynamic and efficient diesel engines. It reinterprets the qualities of the TDI concept while addressing the future challenges facing environmental protection in particular.

The 2.0-litre TDI CR engine is based on the successful 2.0-litre pump injector TDI engine, whereby the combination of the 2.0-litre TDI unit with common rail technology sets new standards.
The new 2.0-litre TDI CR engine built at Audi Hungaria Motor in Györ already meets the high standards of the Euro 5 exhaust emission standard due to come into effect in 2010.

Thanks to the use of common rail technology, the 2.0-litre TDI CR engine has major advantages with regard to exhaust emissions, acoustics, weight and overall build height.
The TDI engines deliver high torque at low revs.
The goal for the development of the 2.0-litre TDI CR engine was to enhance this character.

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Engine mechanicals

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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.
Values specified herein are intended for easier understanding only and refer to the software version valid at the time of preparation of the SSP.

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

Reference

Note

2.0-litre 105 kW TDI engine with common rail injection system

The 2.0-litre TDI engine with common rail injection system is based on the 1.9-litre/2.0-litre TDI engine with pump injection system.
The predecessor engine (base engine) is one of the world's biggest-selling diesel engines.
To meet the higher demands with regard to acoustics, fuel economy and exhaust emissions, a large number of engine components have been revised.

A major change was the adoption of the common rail technology for the injection system.
Equipped with a diesel particulate filter, the engine meets current Euro 4 emission standards.
In several markets the engine is also available without a diesel particulate filter. These engines meet the Euro 3 exhaust emission standard.

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2.0-litre TDI common rail engine

Technical features

- Common rail injection system with piezoelectric injectors
- Diesel particulate filter with upstream oxidising catalytic converter
- Intake manifold with swirl flap adjustment
- Electrical EGR valve
- Adjustable exhaust gas turbocharger with flow-path feedback
- Low-temperature EGR cooling system

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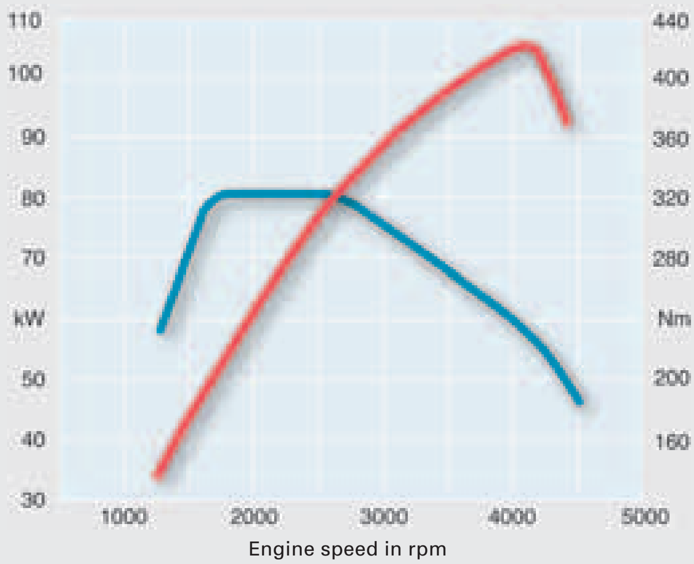
Torque/power curve

Max. torque in Nm

Max. power in kW



Specifications	
Engine code	CAGA
Type of engine	4-cylinder inline engine
Displacement in cm^3	1968
Max. power in kW (bhp)	105 (143) at 4200 rpm
Max. torque in Nm	320 at 1750 to 2500 RPM
No. of valves per cylinder	4
Bore in mm	81
Stroke in mm	95.5
Compression ratio	16,5 : 1
Engine management	Bosch EDC 17
Exhaust emission control	Oxidising catalytic converter, water-cooled exhaust gas recirculation, maintenance-free diesel particulate filter
Exhaust emission standard	Euro 4

New engine code system

To reduce engine code diversity, a new fourth digit has been added to the three-digit engine code.
The new fourth digit denotes the power level, e.g. A, B etc., whereby the base engine is identical.
Power and torque are adapted by means of the engine control unit software.
Engines with a modified exhaust emissions concept do not have a revised engine code.

The new generation of engine codes can be identified as follows:

- The first digit of the engine code begins with a "C".
- The three-digit engine codes are still used on the engine block.
- The four-digit engine codes can only be found on the vehicle data storage module, the control unit and the nameplate.

Adhesive labels on the engine control unit

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Adhesive label with engine code

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Nameplate

420_129

Vehicle data storage module

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Engine code on the engine block

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Cylinder block

The cylinder block of the 2.0-litre TDI engine with common rail injection system is made of cast iron with lamellar graphite. The cylinder-to-cylinder spacing is 88 mm.

The geometry of the cylinder block is based on that of the 2.0-litre TDI engine with pump injection system.

420_010

Crankshaft drive

Crankshaft

On account of the high mechanical load, the 2.0-litre TDI common rail engine uses a forged crankshaft. To reduce the load on the crankshaft bearings, the crankshaft has only four counterweights instead of the usual eight.
The result is enhanced engine vibrational behaviour and reduced noise emission.

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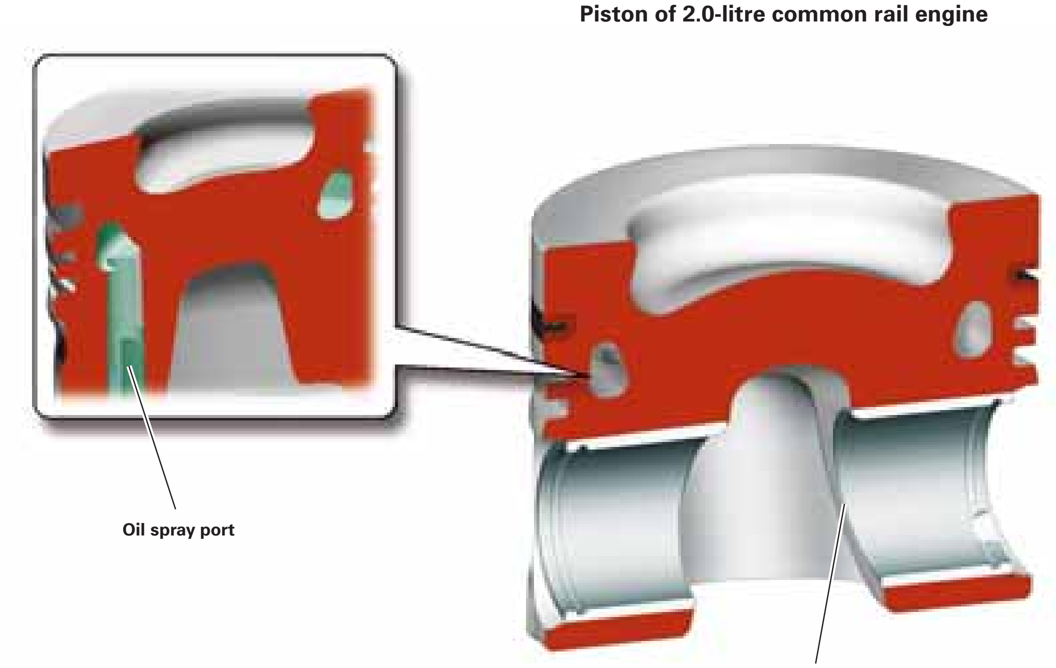
Pistons

Like on the 2.0-litre 125 kW TDI engine with pump injection system, the pistons have no valve pockets. This modification reduces crevice volume.
For purposes of cooling the piston ring zone, the piston has an annular cooling duct into which oil is injected through piston spray nozzles.

The piston recess where the injected fuel is swirled and mixed with the air is aligned with the discharge plane of the injectors and has a wider and flatter geometry than the piston on the pump injector engine. (This allows the formation of a homogeneous air-fuel mixture and reduces particulate matter formation).

Piston of 2.0-litre common rail engine



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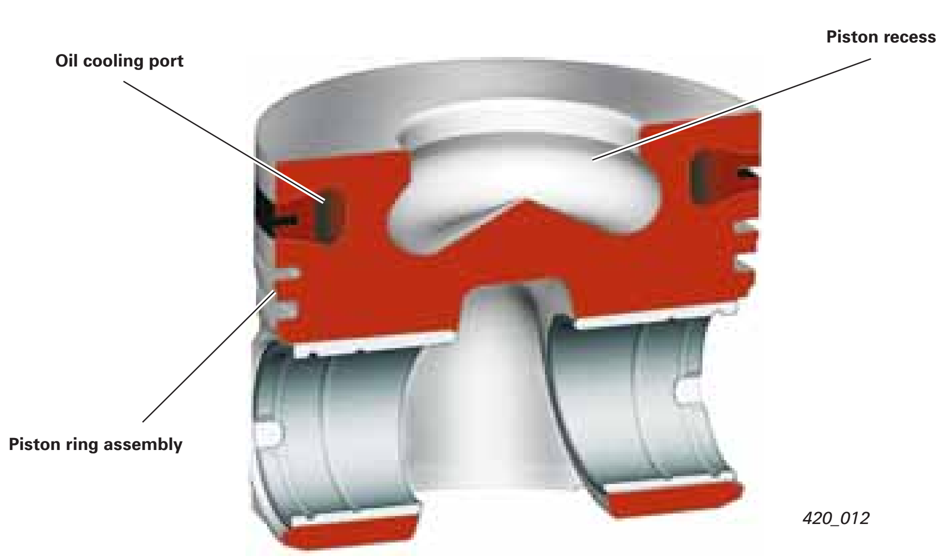
Piston - 2.0-litre pump injector engine



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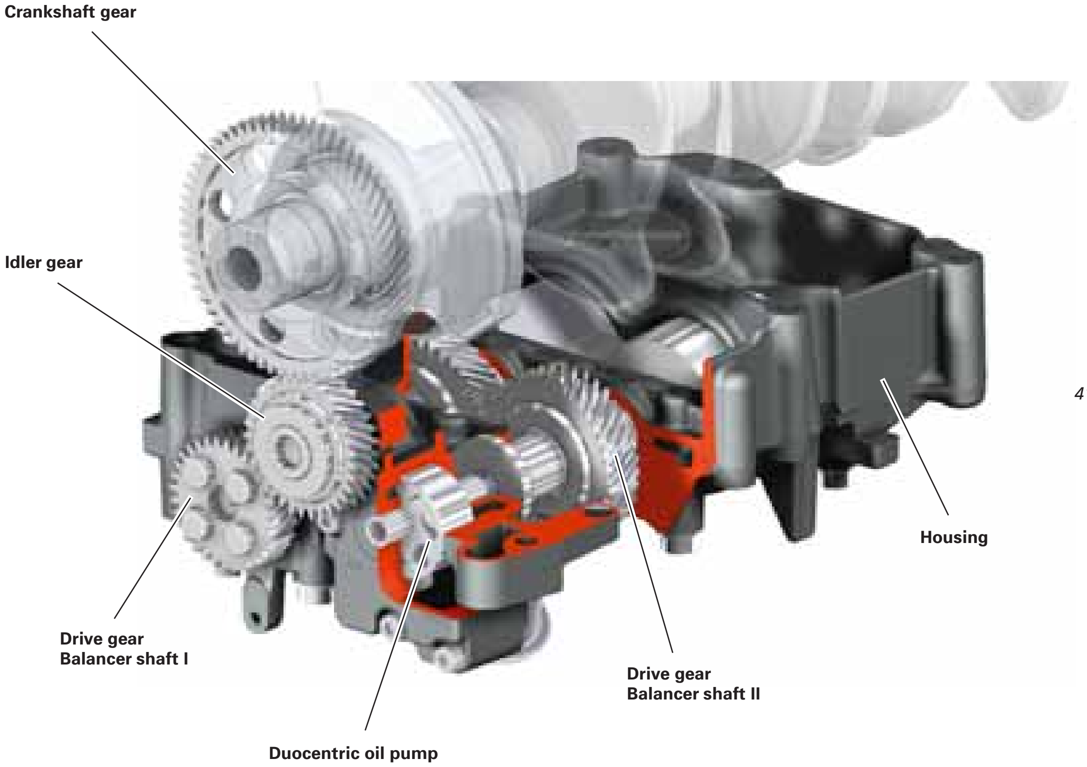
Balancer shaft module

The 2.0-litre 105 kW TDI common rail engine has a balancer shaft module accommodated in the oil pan under the crankshaft.

The balancer shaft module is driven by the crank-shaft through a gear drive.
The Duocentric oil pump is integrated in the balancer shaft module.



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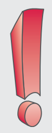
Design

The balancer shaft module consists of a cast iron housing, two counteropposed balancer shafts, the helical-cut gear drive and the integrated Duocentric oil pump.

The rotation of the crankshaft is transmitted to the intermediate gear on the outside of the housing.
The intermediate gear drives balancer shaft I.
The motion is then transmitted from this balancer shaft through a pair of gears inside the housing to balancer shaft II and the Duocentric oil pump.

The gear drive is configured in such a way that the balancer shafts rotate at twice the speed of the crankshaft.

The gear drive backlash is set by means of a coating on the idler gear. This coating wears off when the engine is put into operation, resulting in a defined backlash.



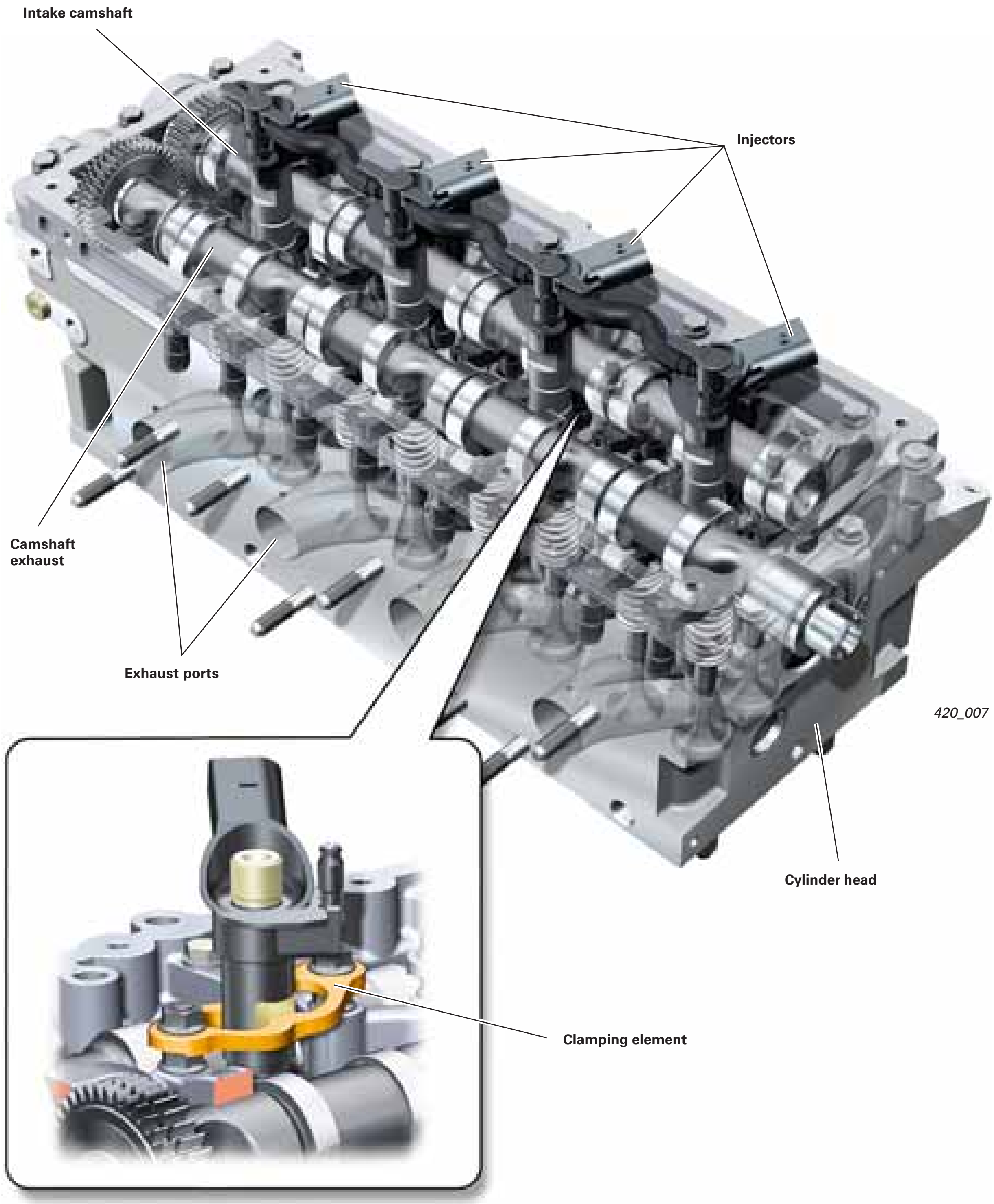
Note

The idler gear must be replaced whenever the idler gear or the drive gear of balancer shaft I are detached.

Cylinder head

The cylinder head of the 2.0-litre TDI engine with common rail injection system is a cross-flow aluminium cylinder head with two intake valves and two exhaust valves per cylinder. The injectors are arranged upright.
The overhead intake and exhaust camshafts are coupled via a spur gear assembly with integrated valve lifters.

They are driven by a crankshaft through a timing belt and by the camshaft sprocket of the exhaust camshaft.
The valves are actuated by low-friction roller cam followers with hydraulic valve lifters.
The injectors are held in place by clamps in the cylinder head and can removed through small caps on the valve cover hood.



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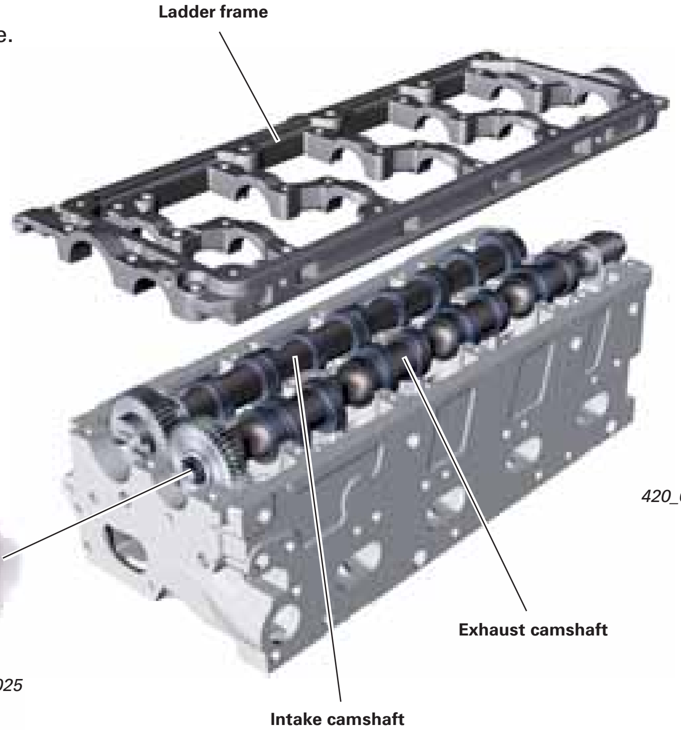
Camshaft drive

The intake and exhaust camshafts are coupled to the integrated tooth flank lifters through a spur gear assembly.
The spur gear of the intake camshaft is driven by the spur gear of the exhaust camshaft. Backlash compensation provides low-noise camshaft drive.



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Reference

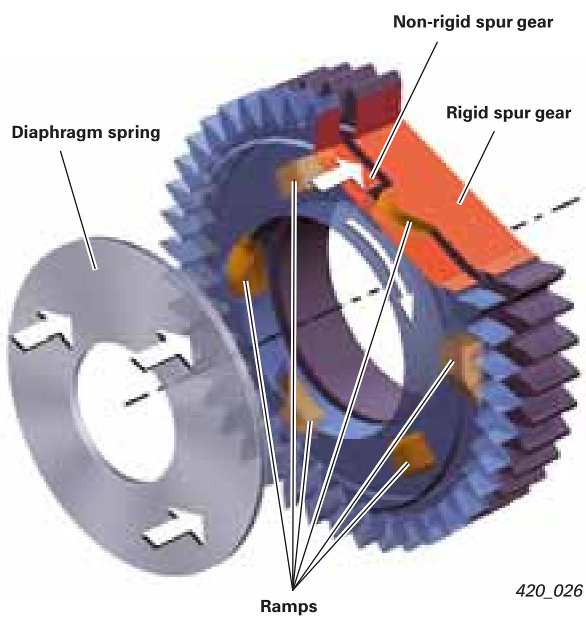
For information about the design and function of the valve lifters, please refer to SSP 325, Audi A6 ´05 Engines and Transmissions.

Design

The wider spur gear element (non-rigid spur gear) is positively connected to the exhaust camshaft. There are six ramps on the face.
The narrower spur gear element (non-rigid spur gear) is radially and axially movable. There are recesses for the six ramps on the back.

Function

Both spur gear elements are pressed together in an axial direction by the force of a diaphragm spring, while being made to rotate by the ramps.



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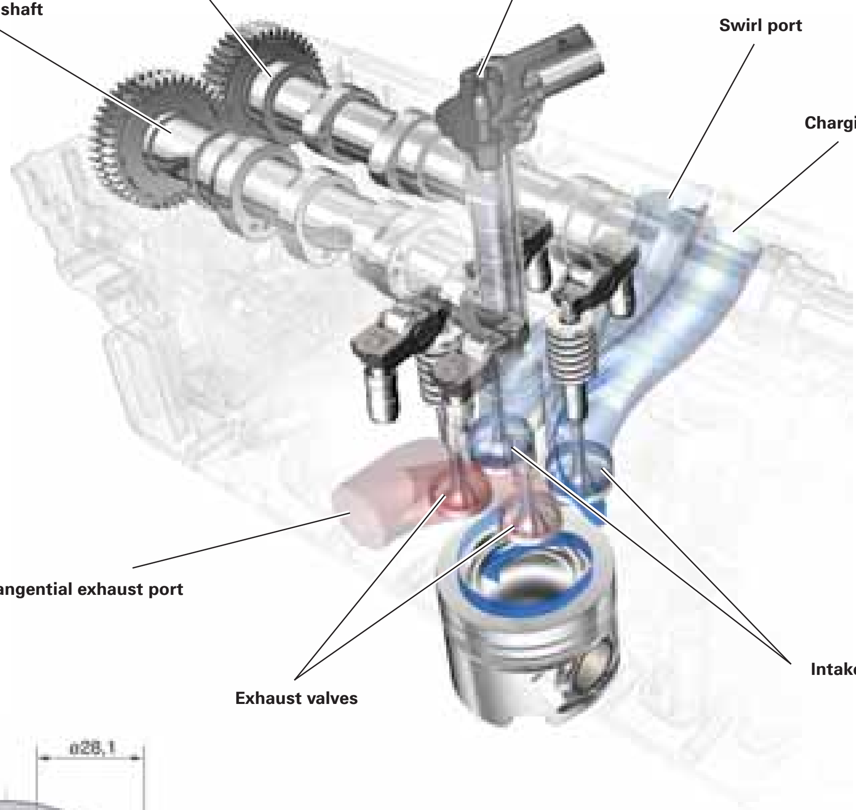
4 valve technology

Two intake valves and two exhaust valves per cylinder are arranged upright in the cylinder head.

The upright and centrally positioned injector is located above the centre of the piston recess.



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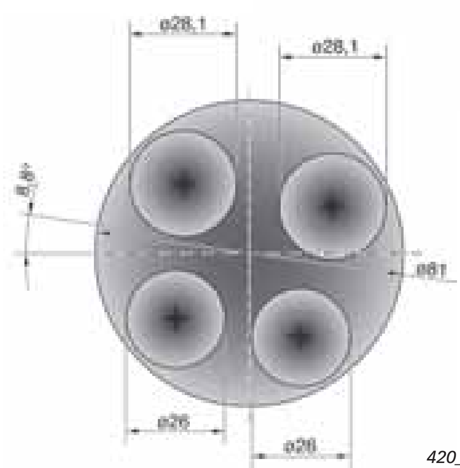
Rotated valve stem



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The shape, size and layout of the intake and exhaust ports are designed to ensure good volumetric efficiency and optimise the charge cycle inside the combustion chamber.

The intake ports are configured as swirl and charging ports. The swirl port produces the required swirling motion of the intake air.

The charging port provides good charging of the combustion chamber, particularly at high engine speeds.

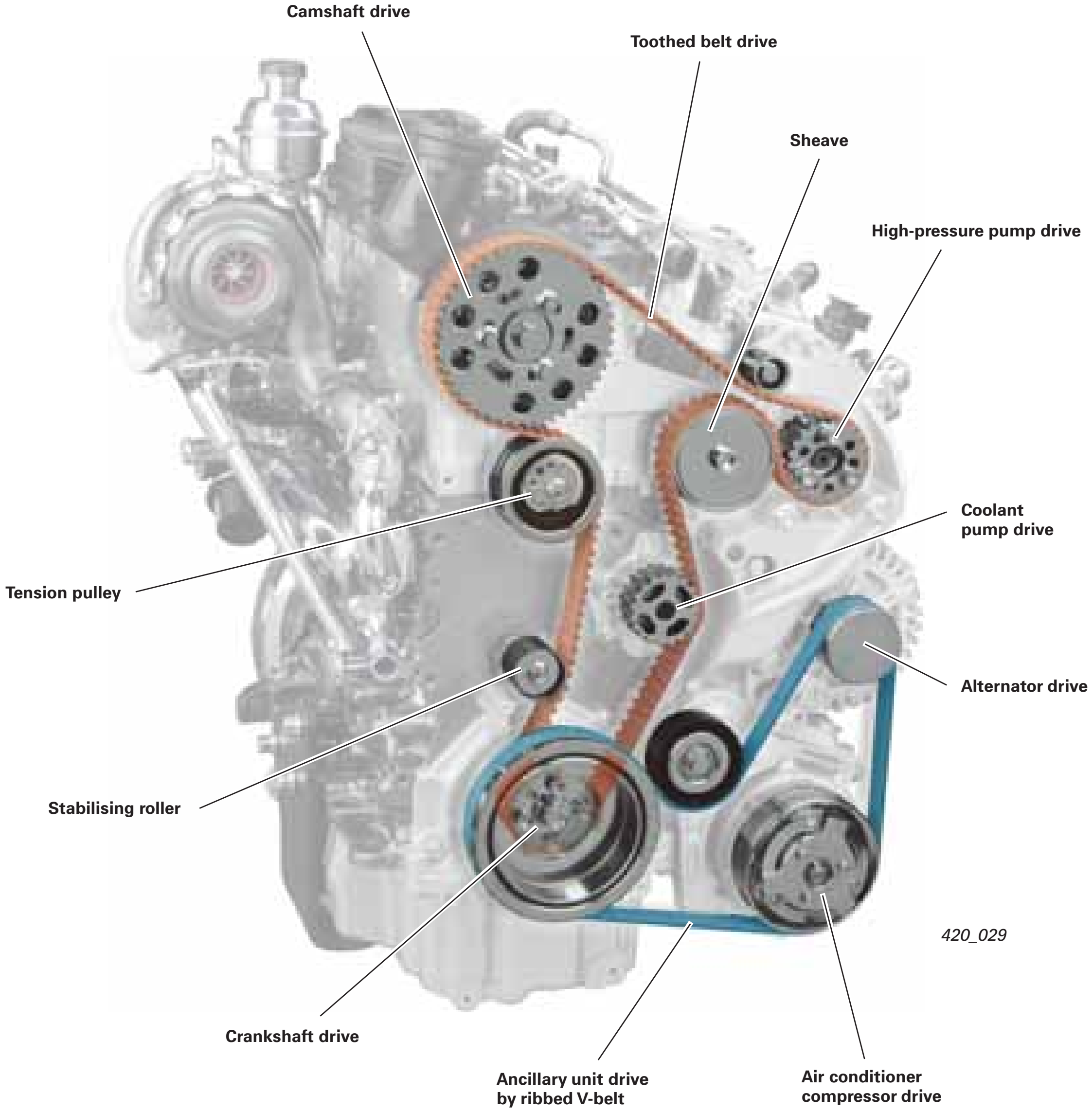
(To optimise the conditions of flow inside the intake and exhaust ports, the valve stem has been rotated 8.8° towards the engine's longitudinal axis.)

Toothed belt drive

The camshaft, the coolant pump and the high-pressure pump for the common rail injection system are driven through the timing belt.

Note

For information on the replacement interval of the timing belt, please refer to "Maintenance".



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Ancillary unit drive

The ancillary units (the alternator and the air conditioner compressor) are driven by the crankshaft through a ribbed V-belt.

The ribbed V-belt has a fibrous coating which enhances frictional behaviour and minimises noise in wet and cold weather.

Intake manifold with swirl flaps

Continuously variable swirl flaps are integrated in the intake manifold.

The swirl of the intake air is adjusted according to engine speed and load by the position of the swirl flaps.

The swirl flaps are actuated by the intake manifold flap motor V157 through a push rod.
For this purpose, the servomotor is activated by the engine control unit. The intake manifold flap potentiometer G336, which is integrated in the intake manifold flap motor, provides the engine control unit with feedback on the current position of the swirl flaps.

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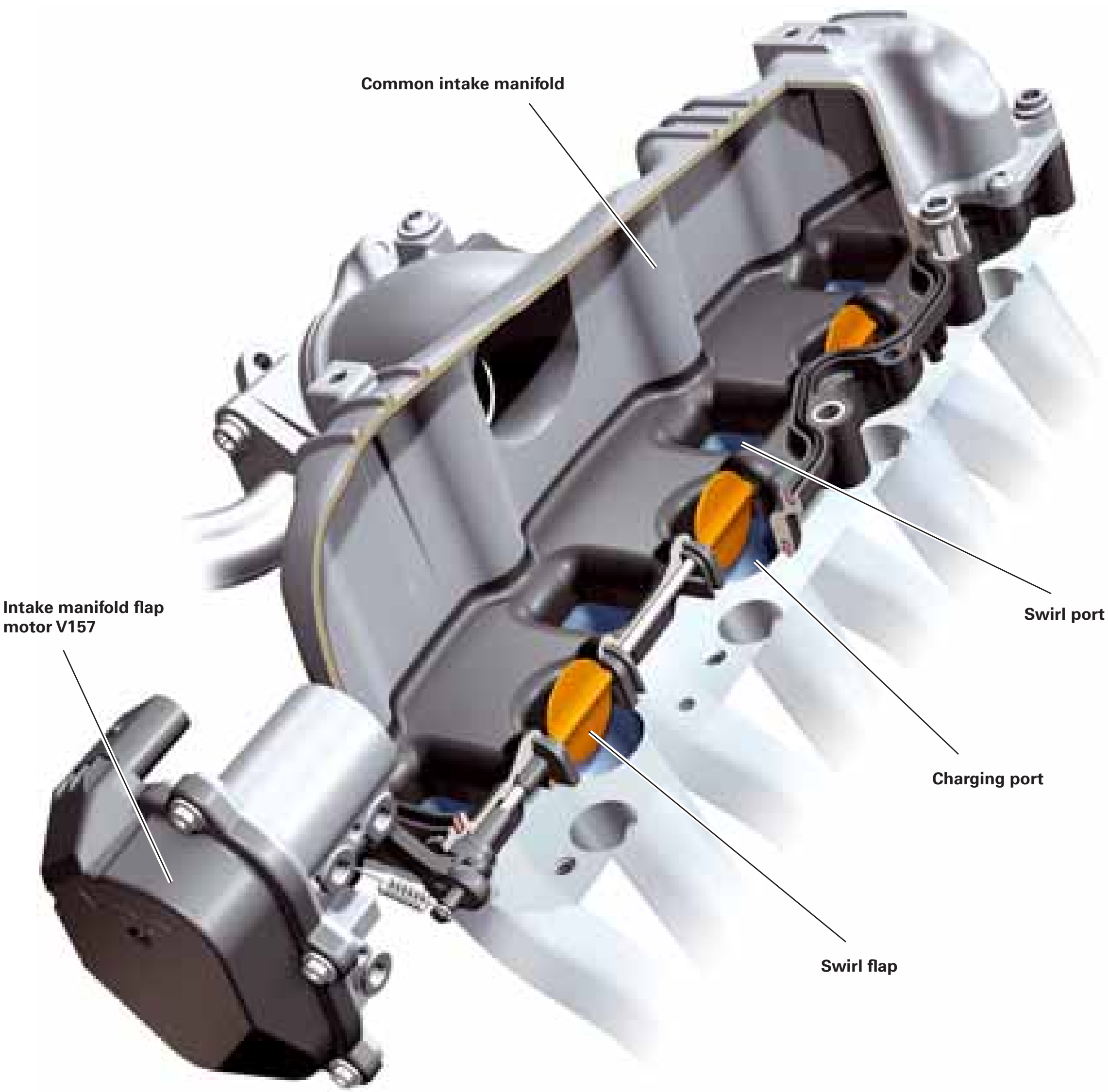

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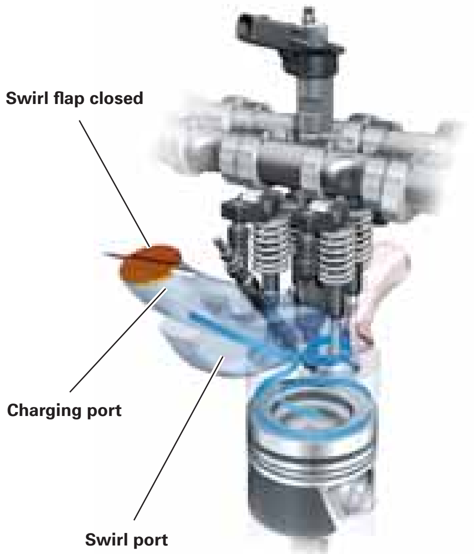
Function of the swirl flaps

The swirl flaps are closed when the engine is idling and running at low speed. This produces a strong swirl effect which optimises the mixture formation process.

The swirl flaps are opened when the engine is started, in limp-home mode and at full throttle.



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While driving, the swirl flaps are adjusted continuously according to engine load and speed. This ensures the optimum air flow inside the combustion chamber in every operating range.

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The swirl flaps are fully open at engine speeds of approx. 3000 rpm or higher. The increased air flow ensures optimum charging of the combustion chamber.

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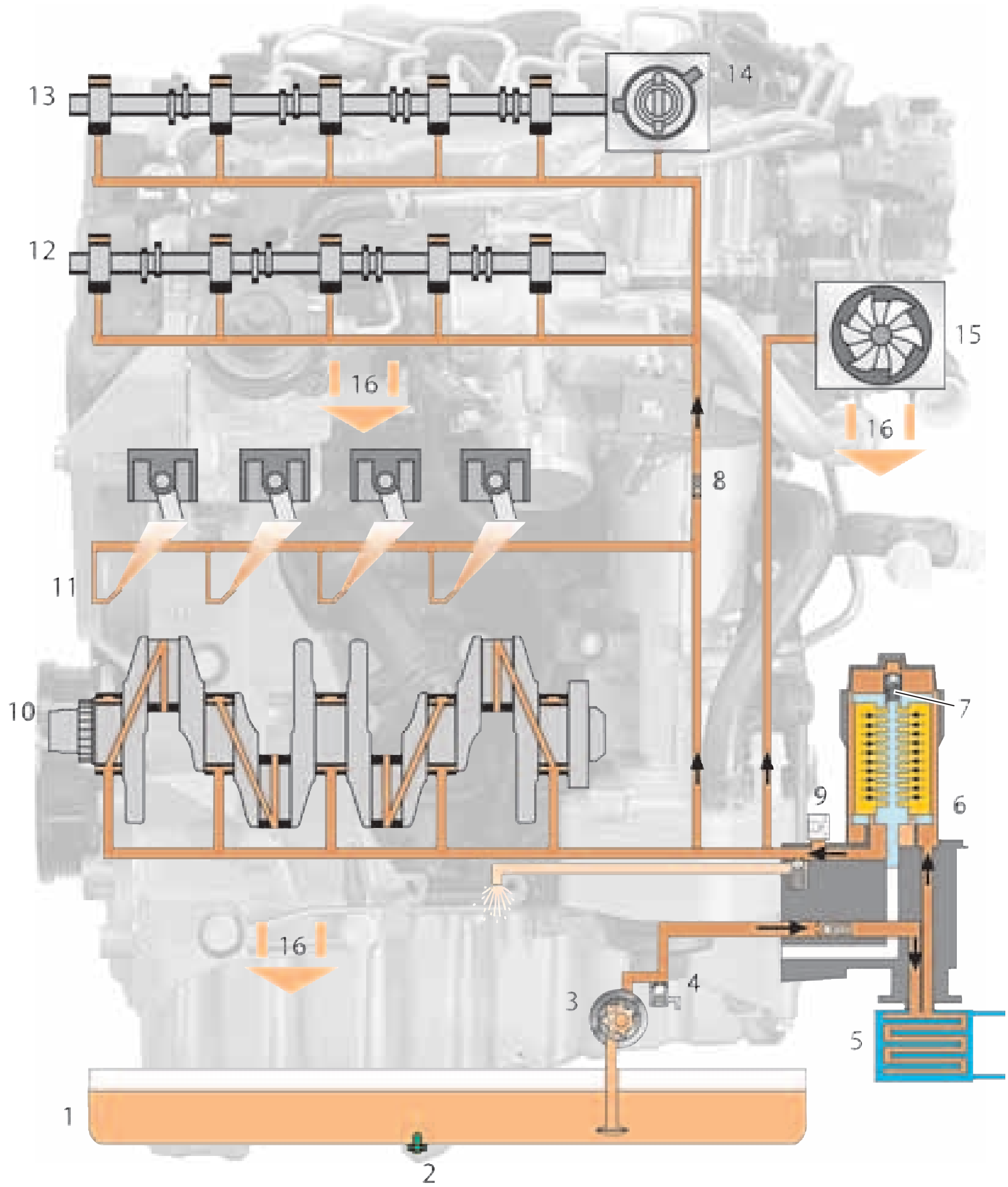
Oil circulation system



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Legend

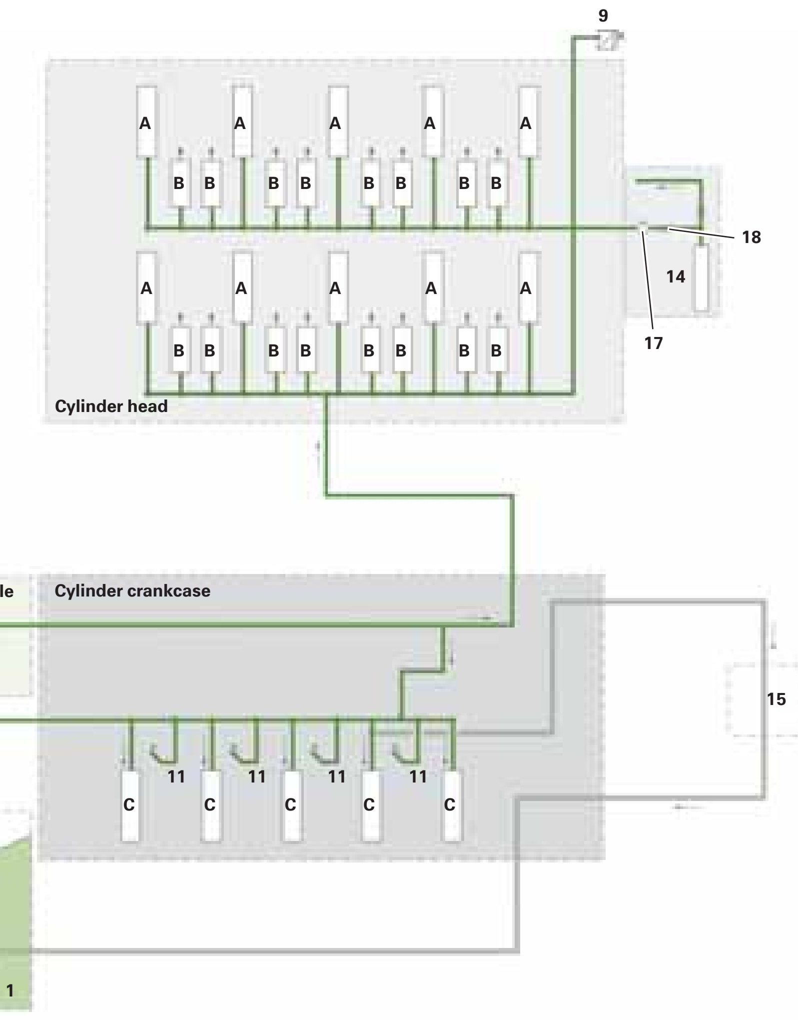
1 Oil pan
2 Oil level and temperature sender G266
3 Duocentric oil pump
4 Oil pressure regulator
5 Oil cooler
6 Oil filter
7 Short-circuit valve (filter bypass valve)
8 Oil pressure retaining valve
9 Oil pressure switch F1
10 Crankshaft
11 Oil spray nozzles for piston cooling
12 Exhaust camshaft
13 Intake camshaft
14 Vacuum pump
15 Turbocharger
16 Oil return line
17 Screen
18 Flow restrictor

Lubrication system

A Duocentric oil pump (3) produces the oil pressure required by the engine. It is integrated in the balancer shaft module and driven through the balancer drive shaft. The oil pressure regulator (4) is a safety valve.

It prevents engine component damage due to high oil pressure, e.g. at low ambient temperatures and at high engine speed.
The short-circuit valve (7) opens when the oil filter becomes clogged thereby ensuring that the engine is always lubricated.

A Camshaft bearing
B Hydraulic valve lifters
C Main bearing



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Crankcase ventilation system

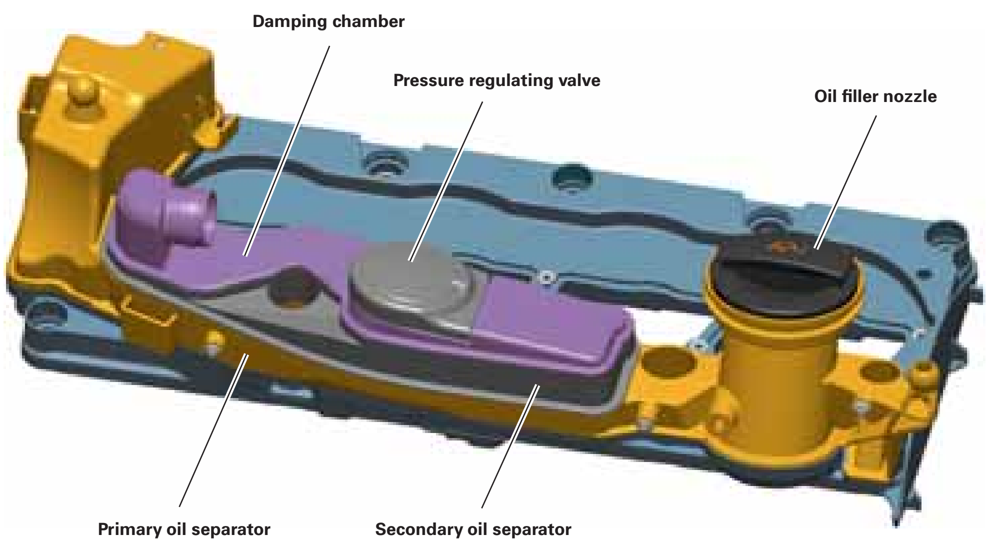
In internal combustion engines, pressure differences between the combustion chamber and the crankcase result in air currents between the piston rings and the cylinder liner, or what are known as blow-by gases. To protect the environment, these oil-containing gases are recirculated to the intake tract through the crankcase ventilation system.

The increasingly stringent environmental protection requirements are placing tough demands with regard to effective oil separation. The multistage separation process minimises ingress of oil into the intake air and thereby reduces particulate emissions.

Oil separation takes place in three stages:

– Coarse separation
– Fine separation
– Damping chamber

The crankcase ventilation system components are integrated in the cylinder head cover together with the oil filler and the pressure accumulator for the engine vacuum system.



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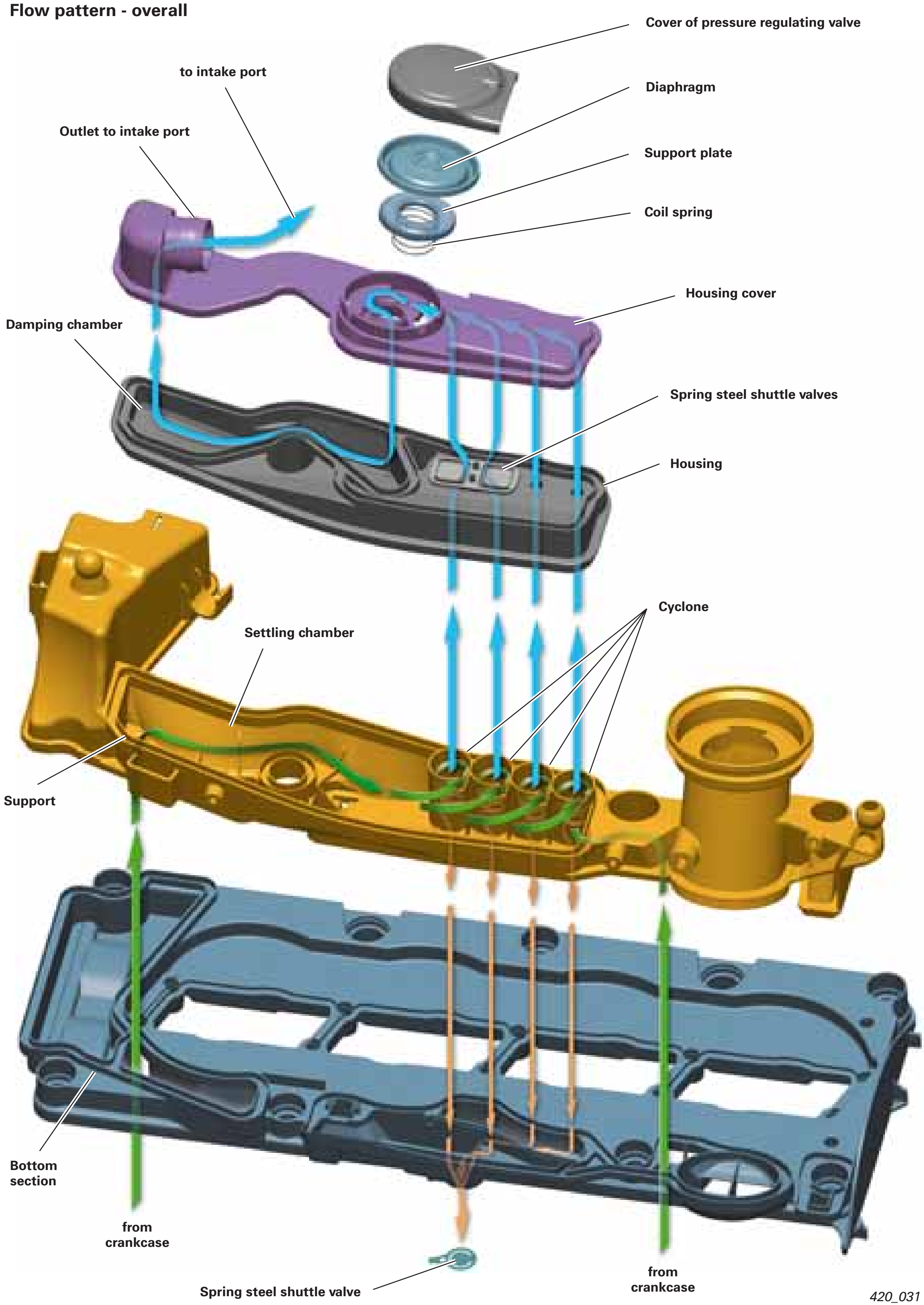
Primary oil separator

The blow-by gases flow from the crankshaft and camshaft space into a settling chamber. This chamber is integrated in the rocker cover. The larger oil droplets precipitate on the walls of the settling chamber and collect at the bottom of the settling chamber. The oil drips into the cylinder head through holes in the settling chamber.

Flow pattern - overall



Oil-containing blow-by gases from the crankcase

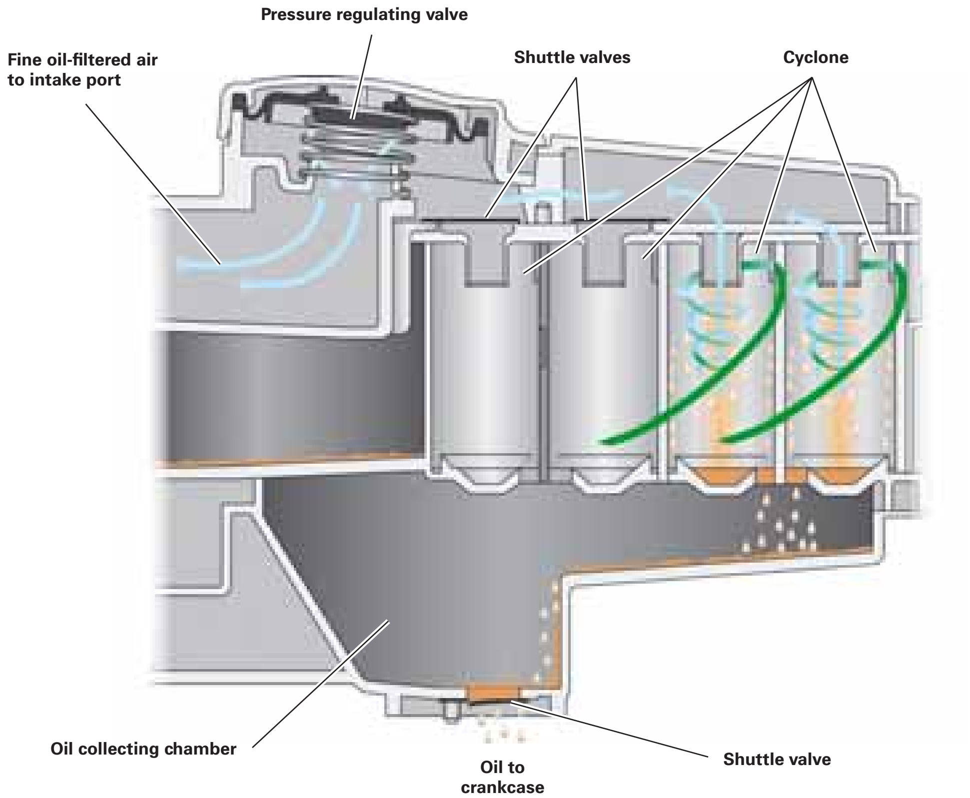
Oil-containing blow-by gases

Oil return line

Secondary oil separator

Fine separation is achieved by means of a cyclone oil separator consisting of a total of four cyclones. Depending on the pressure differential between the intake manifold and the crankcase, two or four cyclones are activated by spring-steel shuttle valves. Due to the shape of the cyclone, the air is made to rotate.

Fine separation, small pressure differential



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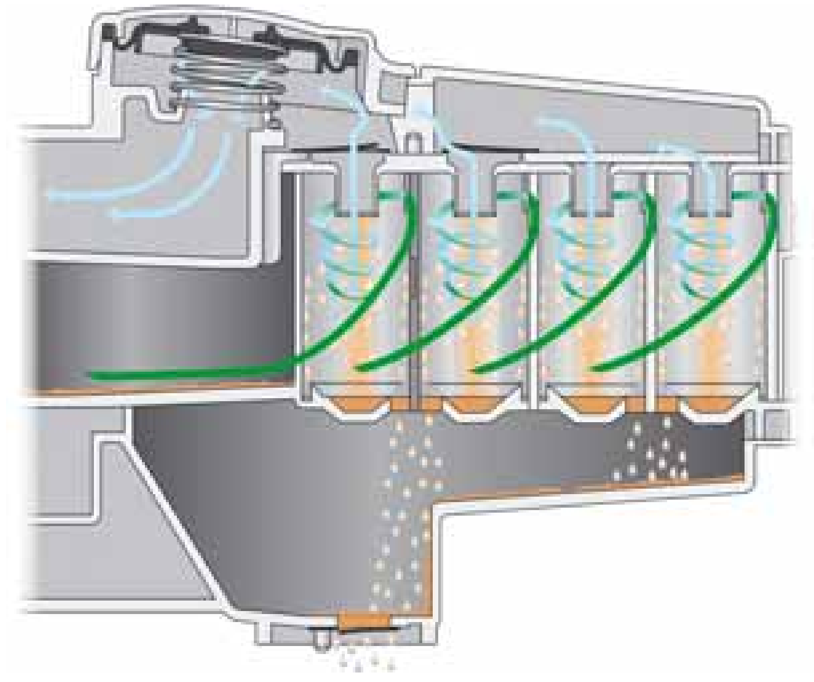
Fine separation, large pressure differential



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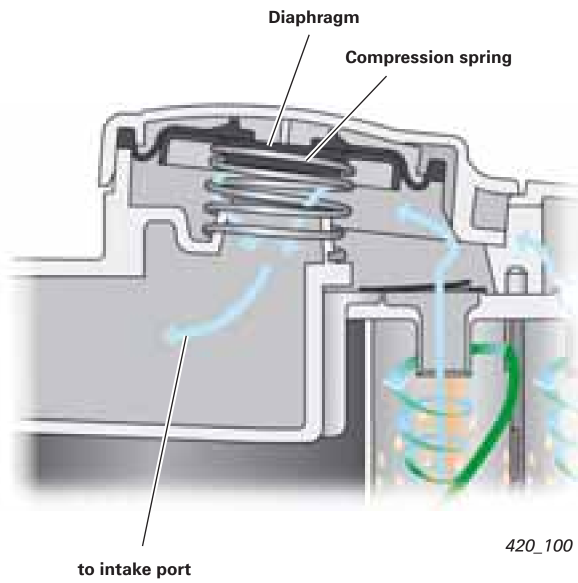
The pressure regulating valve regulates the pressure for ventilating the crankcase. It consists of a diaphragm and a compression spring. The pressure regulating valve limits the vacuum inside the crankcase when the blow-by gases are admitted. If the vacuum inside the crankcase is too high, the engine seals could become damaged.

Pressure regulating valve

If the vacuum inside the intake port is low, the valve opens due to the force of the compression spring.

If the vacuum inside the intake port is high, the pressure regulating valve closes.

Pressure regulating valve opens



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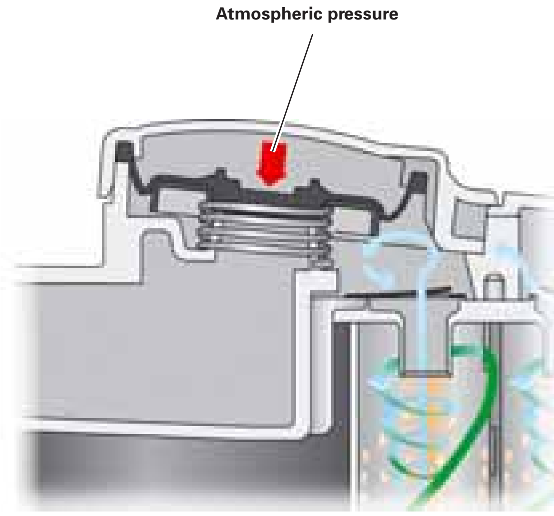

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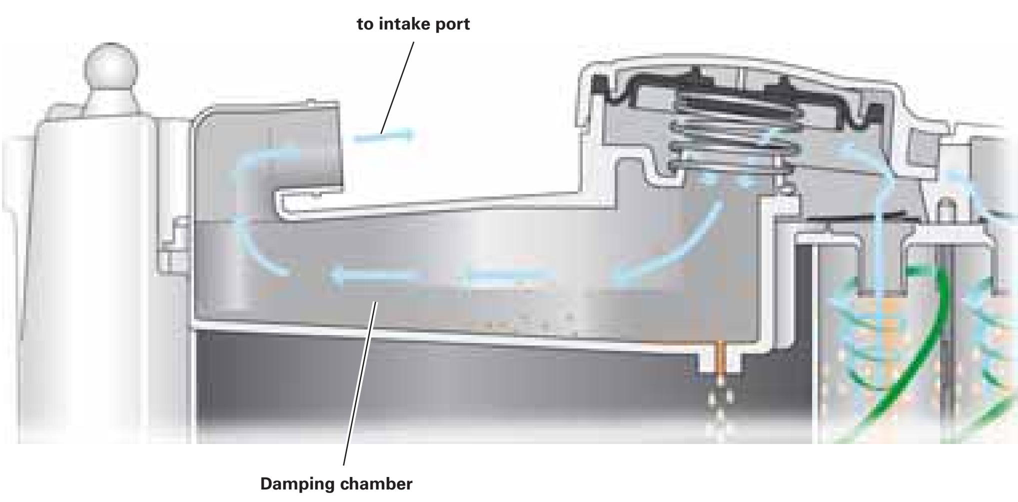
Damping chamber

To avoid unwanted eddy currents when the gases are admitted into the intake manifold, the gases enter a damping chamber after they leave cyclone oil separator. In this chamber the kinetic energy of the gases from the cyclone is reduced. A residual amount of oil again precipitates out in the damping chamber.



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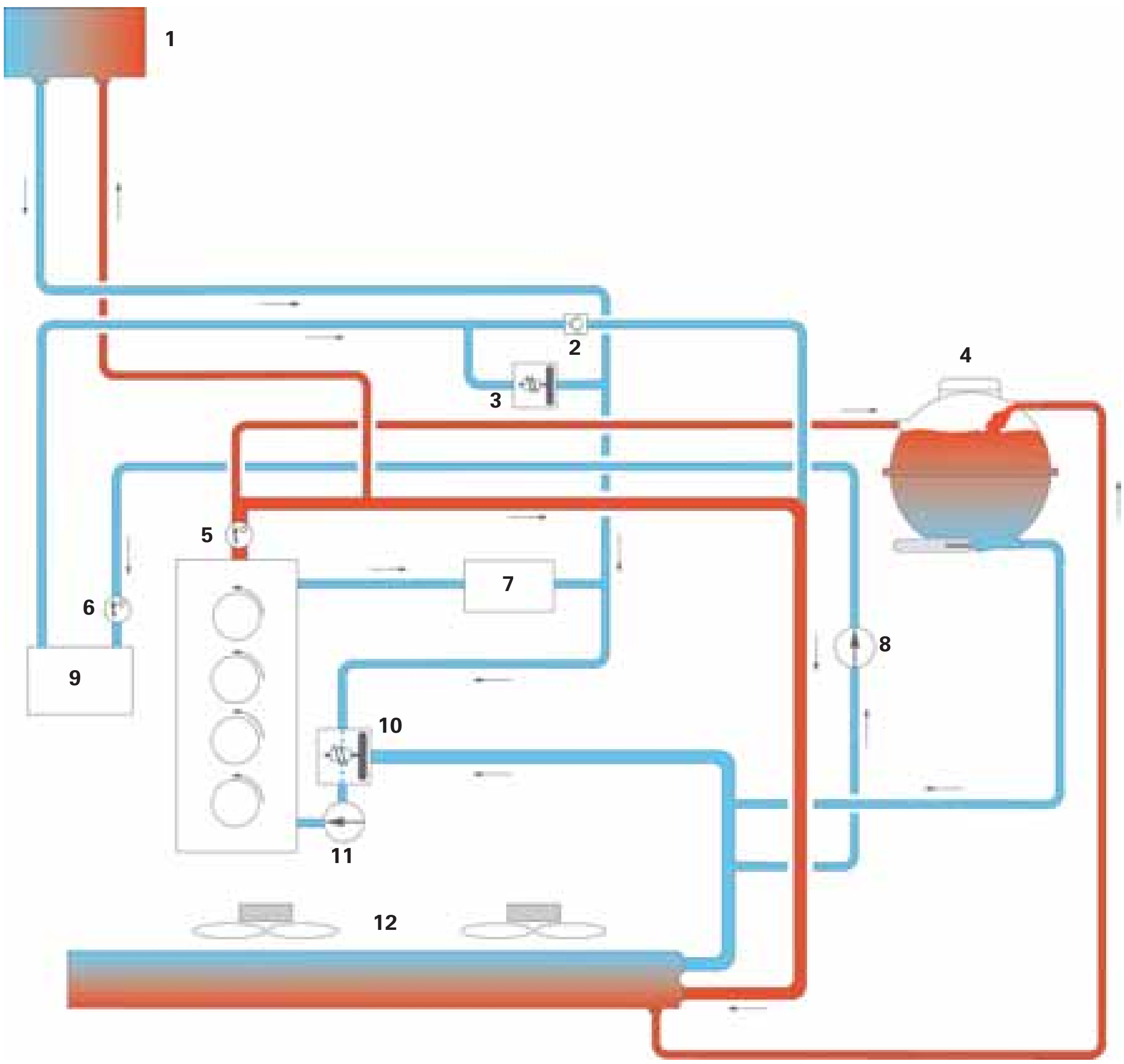
Coolant system

Schematic diagram

In the coolant system the coolant is circulated by a mechanical coolant pump. The pump is driven via the timing belt.

The circuit is divided into a small cooling circuit and a large cooling circuit by an expansion thermostat, the coolant thermostat.



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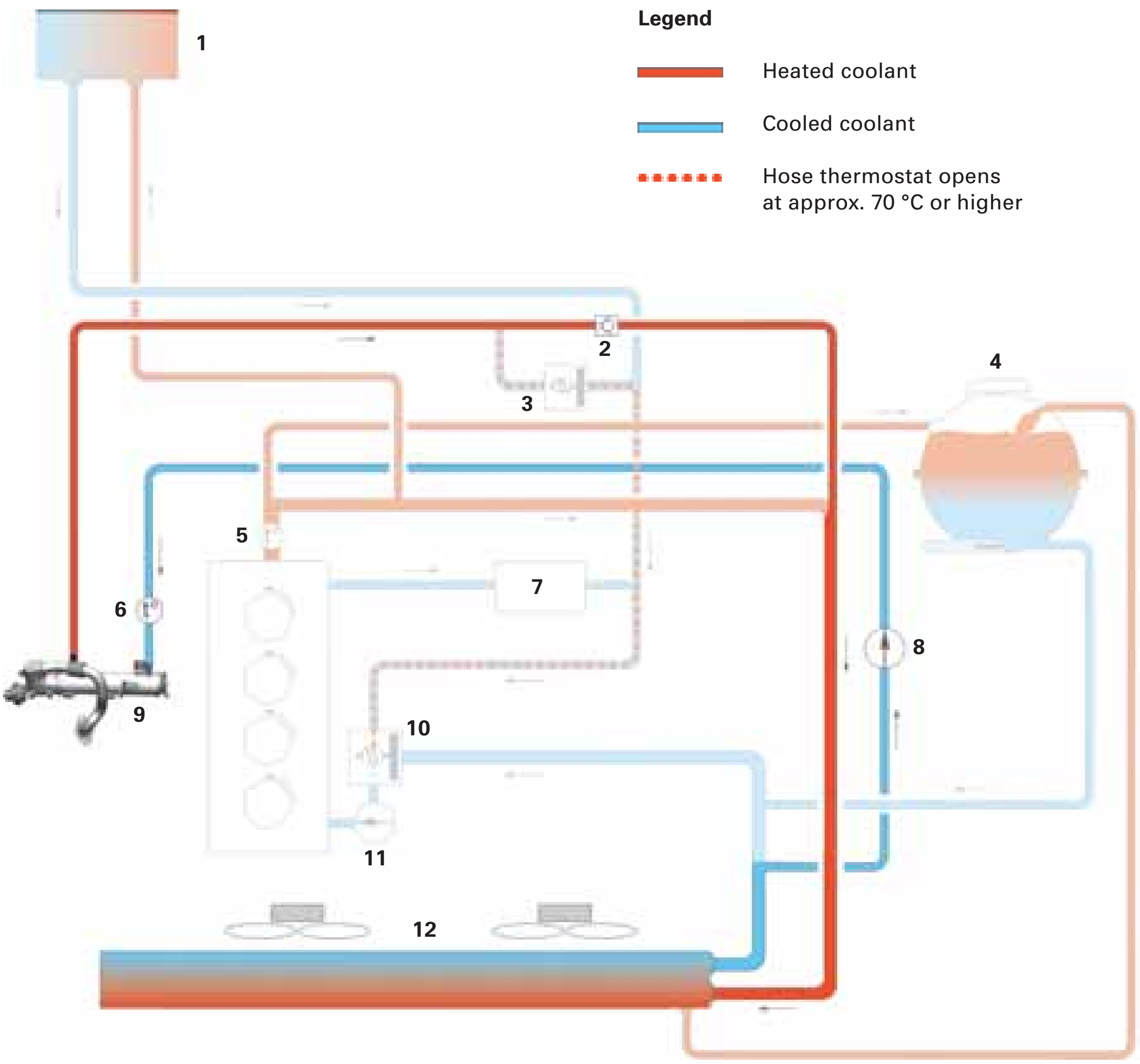
Legend

1 Heater heat exchanger
2 Non-return valve
3 Hose thermostat
4 Coolant expansion tank
5 Coolant temperature sender G62
6 Radiator outlet coolant temperature sender G83
7 Oil cooler
8 Exhaust gas recirculation cooler pump V400
9 Exhaust gas recirculation cooler
10 Coolant thermostat
11 Coolant pump
12 Cooler

Low-temperature exhaust gas recirculation system

To reduce NO_x emissions, the engine is equipped with a low-temperature exhaust gas recirculation system.

It is configured to operate as an independent circuit until the operating temperature is reached.



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Function

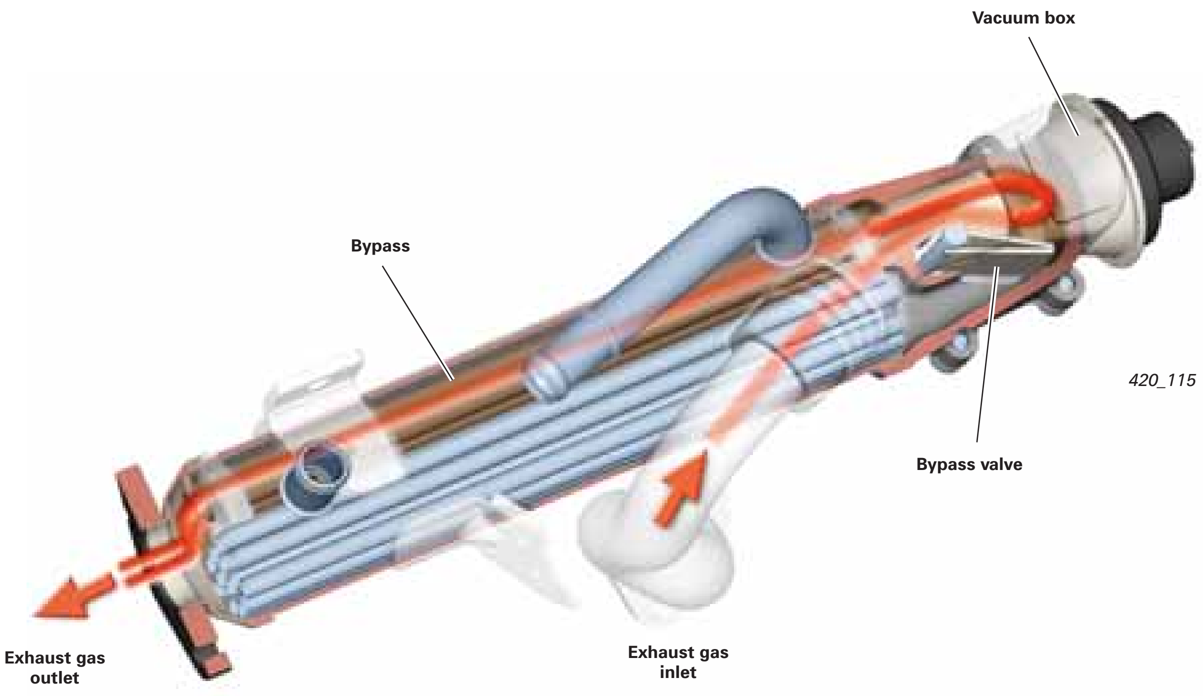
When the coolant thermostat is closed, the exhaust-gas recirculation cooler is supplied with cold coolant directly from the engine cooling system by the exhaust gas recirculation cooler pump V400.
Due to the lower exhaust gas temperature, a larger quantity of exhaust gas can be recirculated. This allows the combustion temperatures and, in turn, the nitrous oxide emissions to be reduced still further during the warm-up phase of the engine.

The electrical auxiliary water pump (exhaust gas recirculation cooler pump V400) is activated by the engine control unit and runs continuously after the engine has started.
When the temperature exceeds approx. 70 °C, the hose thermostat opens and the non-return valve closes. The non-return valve prevents counter-flow, which can lead to excessive heat build-up in the exhaust gas recirculation cooler.

Exhaust gas recirculation cooling system

Engine cold:

Bypass valve is open and allows gases to flow through the bypass.
The hot exhaust gases enable the catalytic converter to reach its operating temperature quickly.



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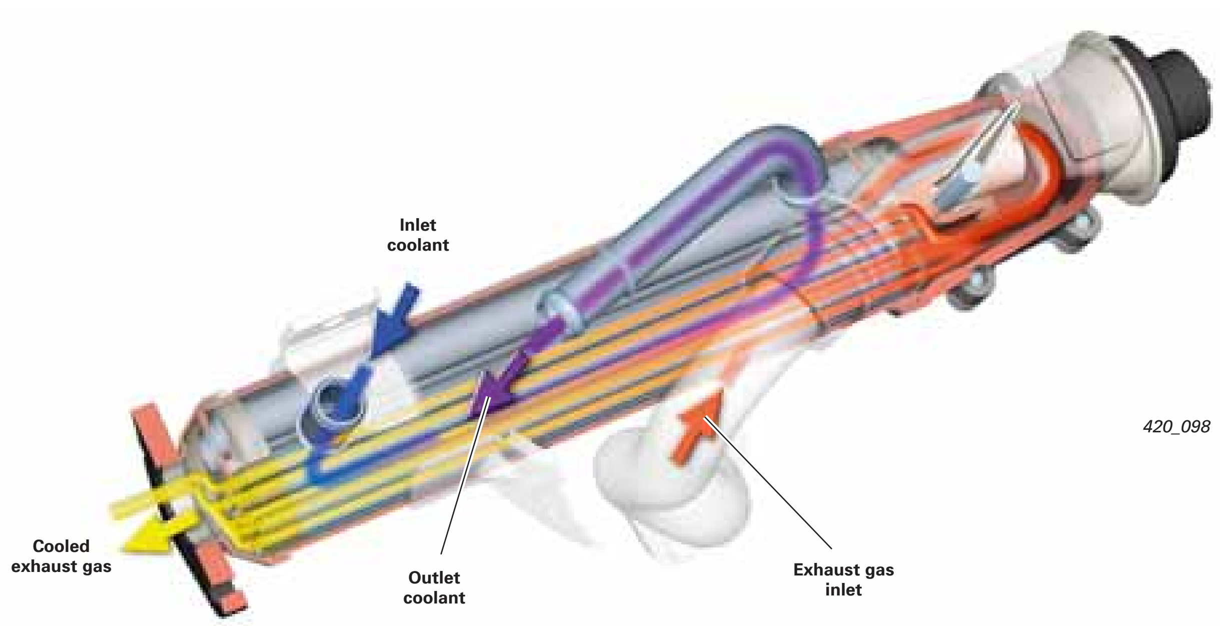
Engine in the warm-up phase:

Bypass valve is closed allows gases to flow through the cooling tubes upwards of a temperature of approx. 37 °C. Since the coolant in the exhaust-gas recirculation cooler comes directly from the radiator outlet, the exhaust gases are fed into the combustion chamber cooled. The cooler exhaust gases lower the combustion temperature, thereby reducing the emission of nitrous oxides (NO_x).



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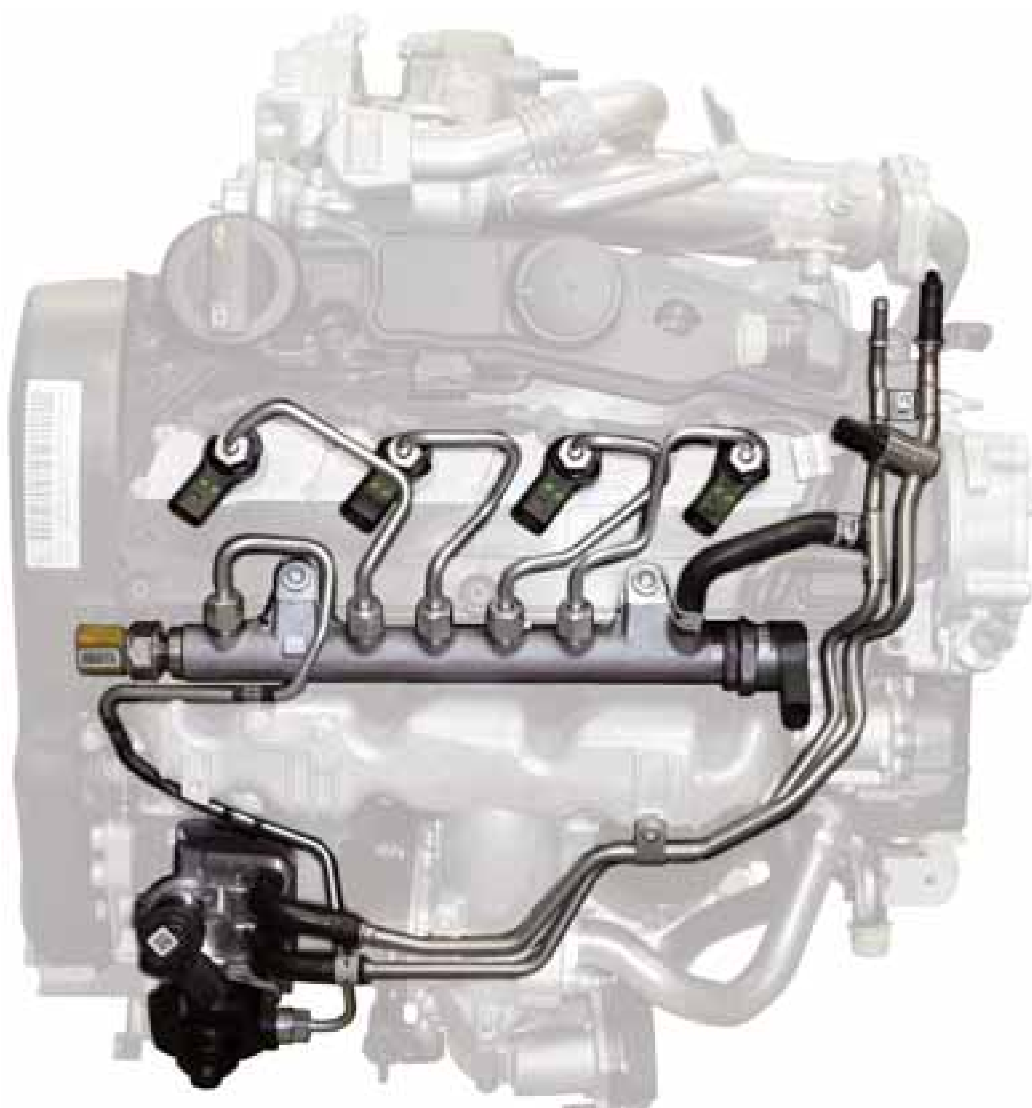
Introduction

The new 2.0-litre TDI engine has a common rail injection system for mixture preparation.
The common rail injection system is a high-pressure accumulator injection system for diesel engines.
The "common rail" is a common fuel high-pressure accumulator which serves all injectors.

Pressure generation and fuel injection are kept separate from one another in this injection system.
A separate high-pressure pump produces the high fuel pressure needed for injection.
This fuel pressure is stored in a high-pressure accumulator (rail) and made available to the injectors along short injection lines.
The common rail injection system is regulated by the Bosch EDC 17 engine management system.

Common rail injection system



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Fuel system

Schematic diagram

1 Fuel pump (pre-supply pump) G6
Delivers fuel continuously to the supply line.

2 Fuel preheating valve
Prevents clogging of the filter with paraffin crystals at low ambient temperatures.

3 Auxiliary fuel pump V393
Delivers the fuel from the supply line to the fuel pump.

4 Fuel filter

5 Fuel temperature sender G81
Determines the current fuel temperature.

6 High-pressure pump
Produces the high fuel pressure required for injection.

7 Fuel metering valve N290
Regulates the quantity of fuel to be compressed according to demand.

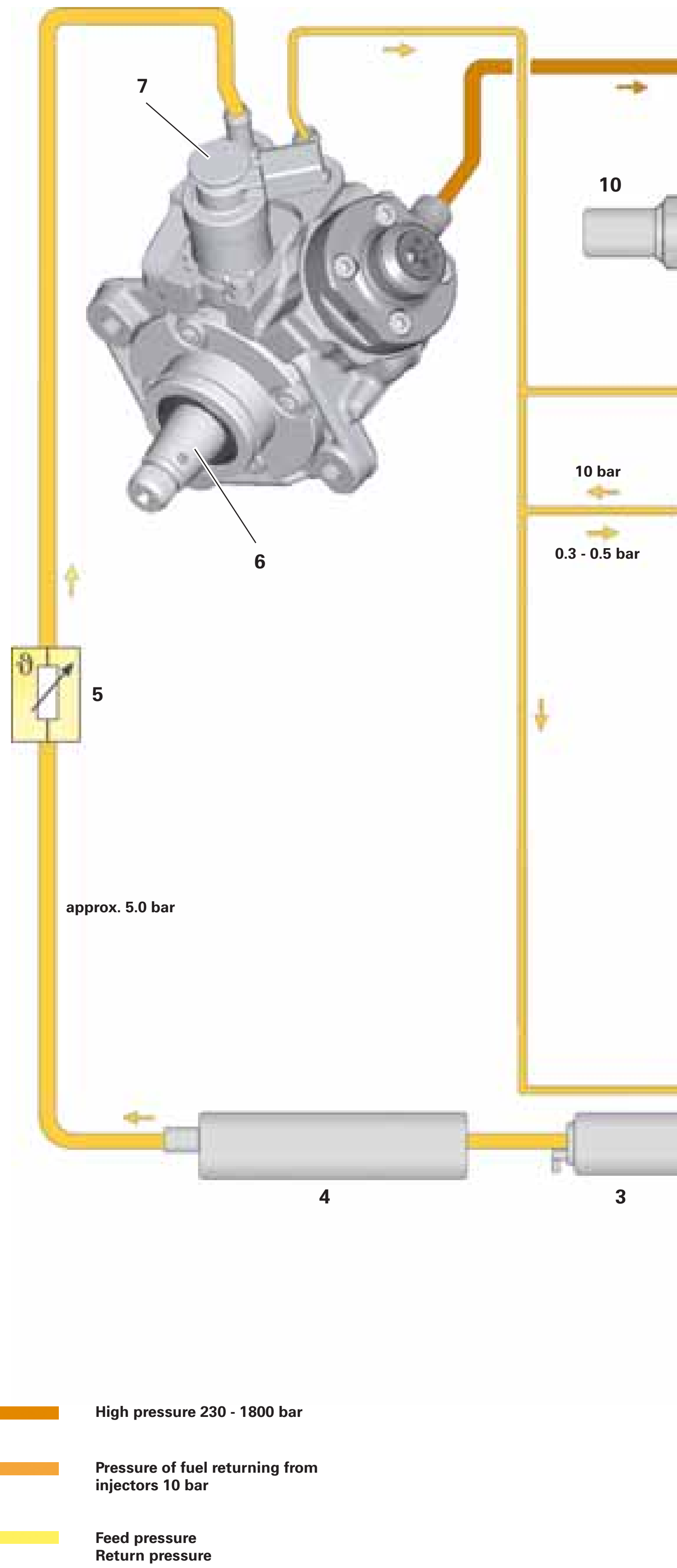
8 Fuel pressure regulating valve N276
Sets the fuel pressure on the high-pressure side.

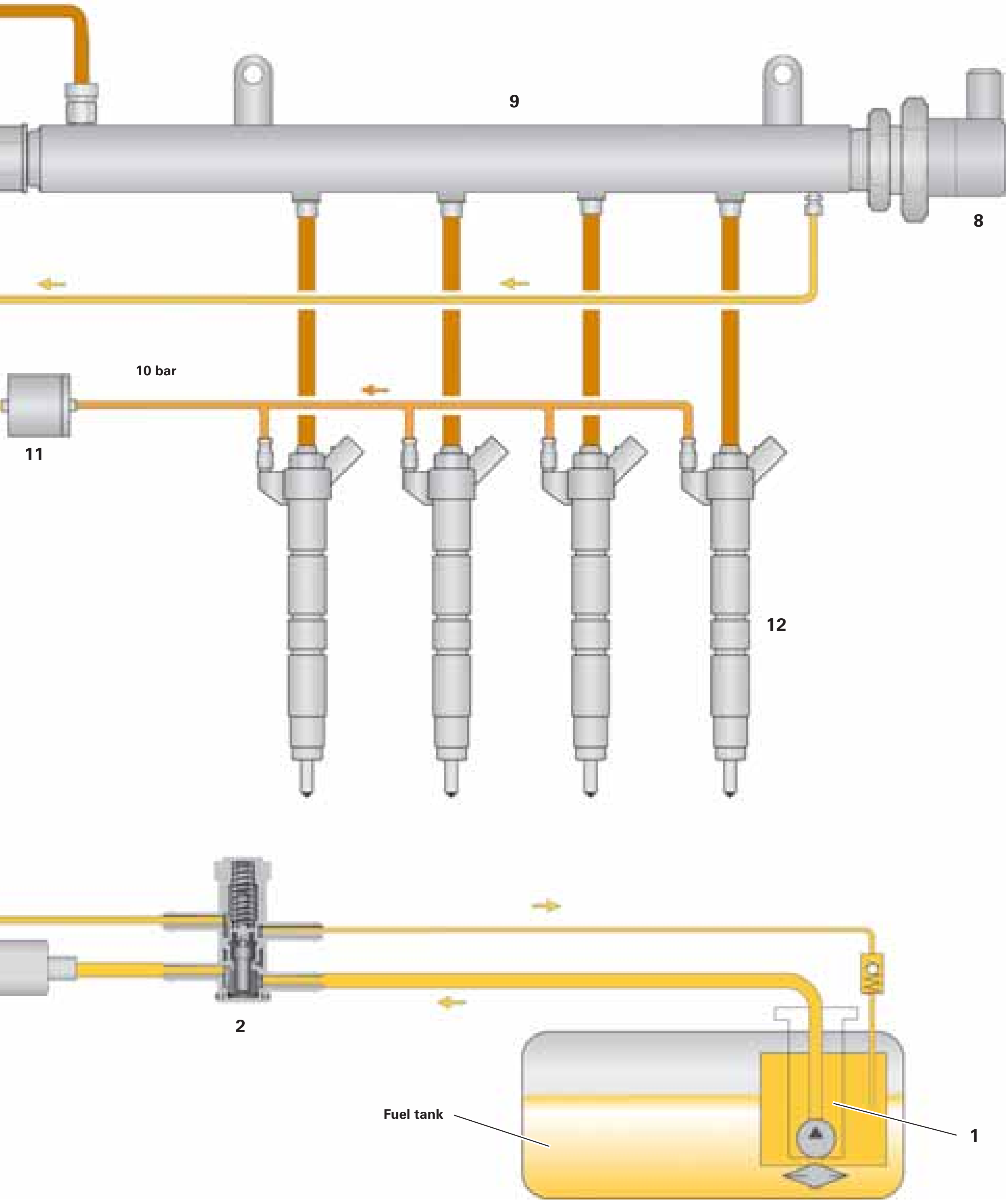
9 High-pressure accumulator (rail)
Accumulates under high pressure the fuel required for injection for all cylinders.

10 Fuel pressure sender G247
Determines the current fuel pressure on the high-pressure side.

11 Pressure retention valve
Maintains the pressure of the fuel returning from the injectors at approx. 10 bar.
This pressure is required for proper operation of the injectors.

12 Injectors N30, N31, N32, N33





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Note

With the 2.0-litre TDI CR engine, there is no fuel cooler fitted to the underbody. Exceptions apply to so-called 'hot climates'.

Auxiliary fuel pump

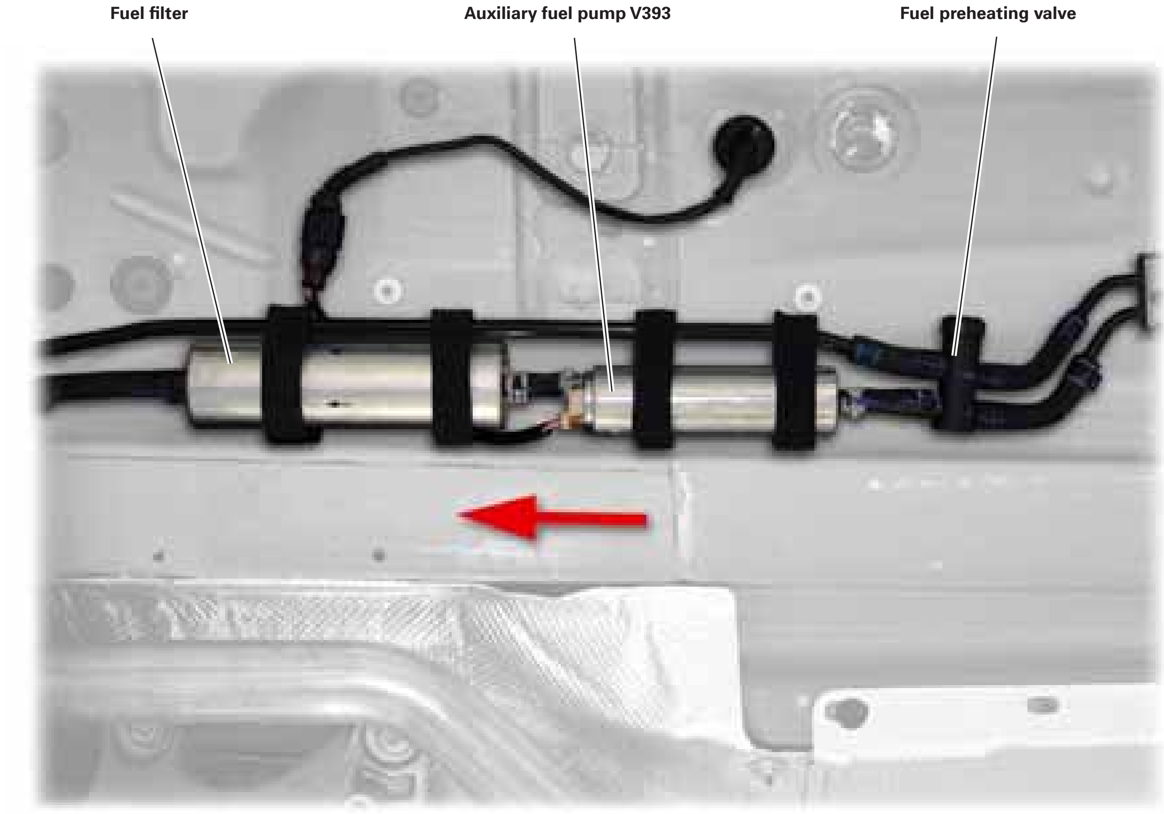
The auxiliary fuel pump is located in the underbody area at the front right. Its task is to deliver fuel from the fuel tank to the supply line leading to the high-pressure pump.

The auxiliary fuel pump is activated by the engine control unit through a relay, thereby increasing the fuel predelivery pressure in the fuel tank to approx. 5 bar.

This ensures a reliable supply of fuel to the high pressure pump in all operating states.

Effects of failure

If the auxiliary fuel pump fails, the engine will not run.



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Auxiliary fuel pump V393 and fuel filter

To protect the high-pressure pump against contamination with dirt particles, e.g. due to mechanical abrasion, a fuel filter is integrated in the fuel supply line upstream of the high-pressure pump.

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Fuel preheating valve

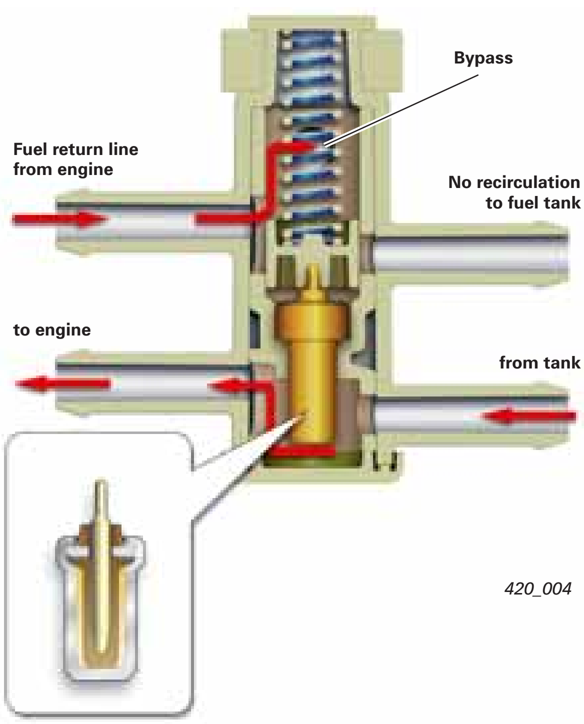
The fuel preheating valve was previously integrated in the fuel filter.
The fuel preheating valve is a control valve in the fuel line. When the engine is cold, an expansion element with a control piston closes off the return line to the fuel tank.

In the fuel preheating valve, the heated fuel diverted from the engine flows into the supply line to the engine through an internal bypass.
This heats up the cold fuel in the supply line running to the engine and thereby prevents clogging of the fuel filter at subzero temperatures due to paraffin precipitation.

Note

Please make sure the fuel preheating valve is fitted in the correct position.

Fuel cold



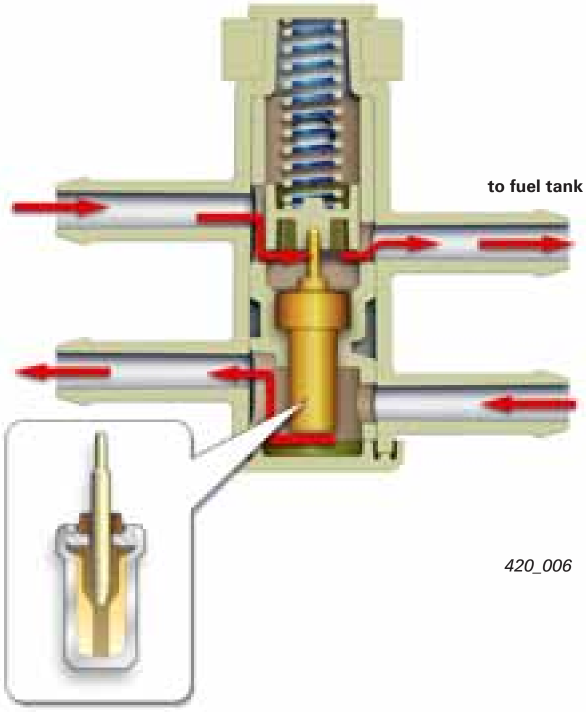
420_004

Expansion element

The expansion element is a pressure-resistant metal cell filled with a wax-like expanding material.
The increased fuel temperature causes the expanding material to melt, thereby considerably decreasing in volume. This pushes the inner pin connected to the control piston outwards and allows the fuel to flow unobstructed to the tank.

The opening temperature is approx. 15 °C and the adjustment range is approx. 2 mm.
When the fuel temperature decreases, the expanding material cools down and contracts again, whereupon the spring-loaded control piston re-closes the return line to the fuel tank.

Fuel warm



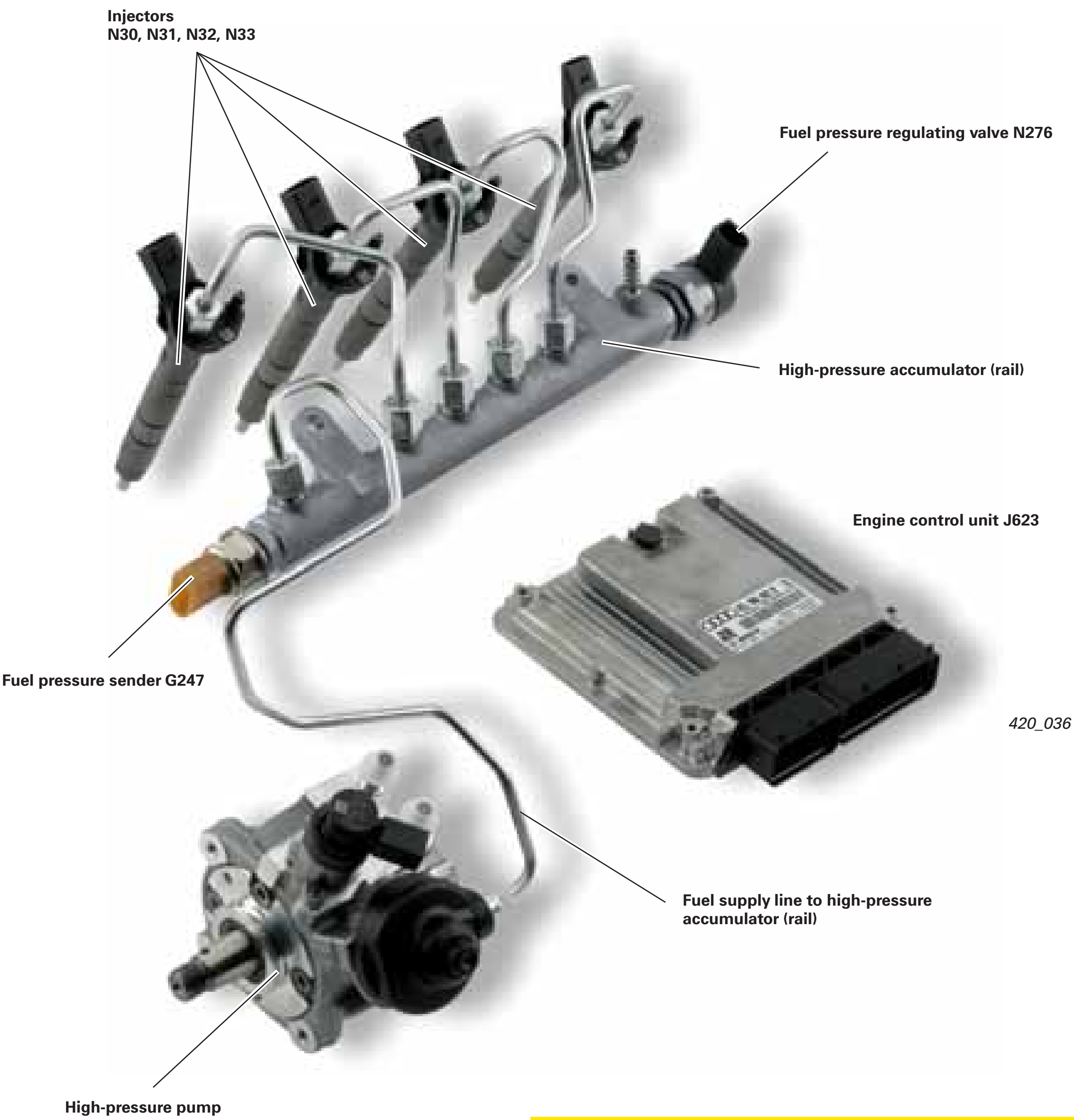
420_006

Common rail injection system

Characteristics of the injection system:

– The injection pressure is near-continuously variable and can be adapted to the operating state of the engine.
– A high injection pressure of up to 1800 bar allows fine atomisation of the fuel and ensures a good mixture formation.
– A flexible injection sequence with multiple pre and post injections.

The common rail injection system provides the flexibility to adapt the injection pressure and the injection sequence to the operating state of the engine.
As a result, the system has the capability to meet the ever-increasing requirements with regard to fuel efficiency, low emissions and smooth engine running.



420_036

Reference

The functional principle of the common rail injection system with piezoelectric injectors is described in SSP 325 Audi A6 ´05 Engines and Transmissions.

Injectors

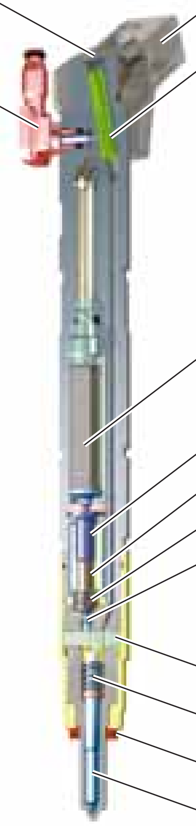
Piezo controlled injectors are used in the common rail system of the 2.0-litre engine.

The injectors are controlled by means of a piezo-electric actuator. The switching speed of a piezo-electric actuator is roughly four times that of a solenoid valve.

Furthermore, in comparison with solenoid-controlled injectors, the piezo technology has approx. 75 % less moving mass in the injector pintle.

This has the following advantages:

- Very short switching times
- Multiple partial injections (up to five) per working cycle
- Precisely controllable injection rates

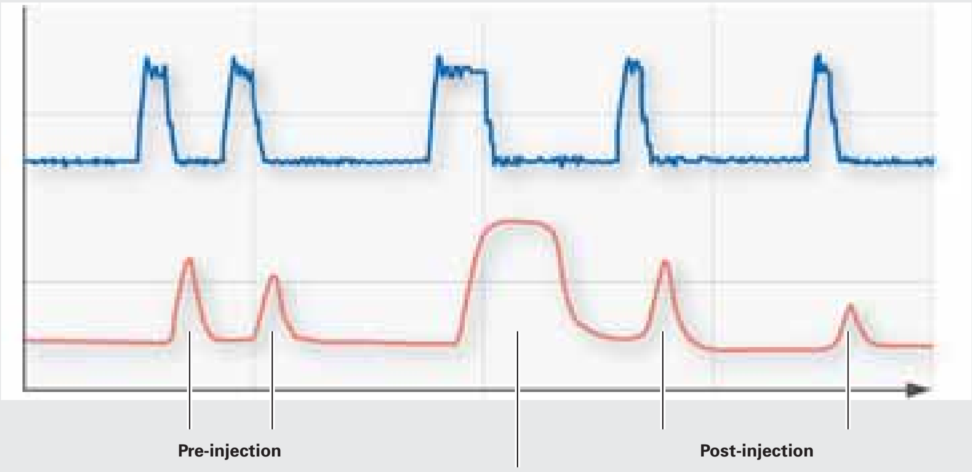


420_107

Reference

For information about the design and function of the injectors, refer to SSP 325 A6 ´05 Engines and Transmissions.

Injection curve

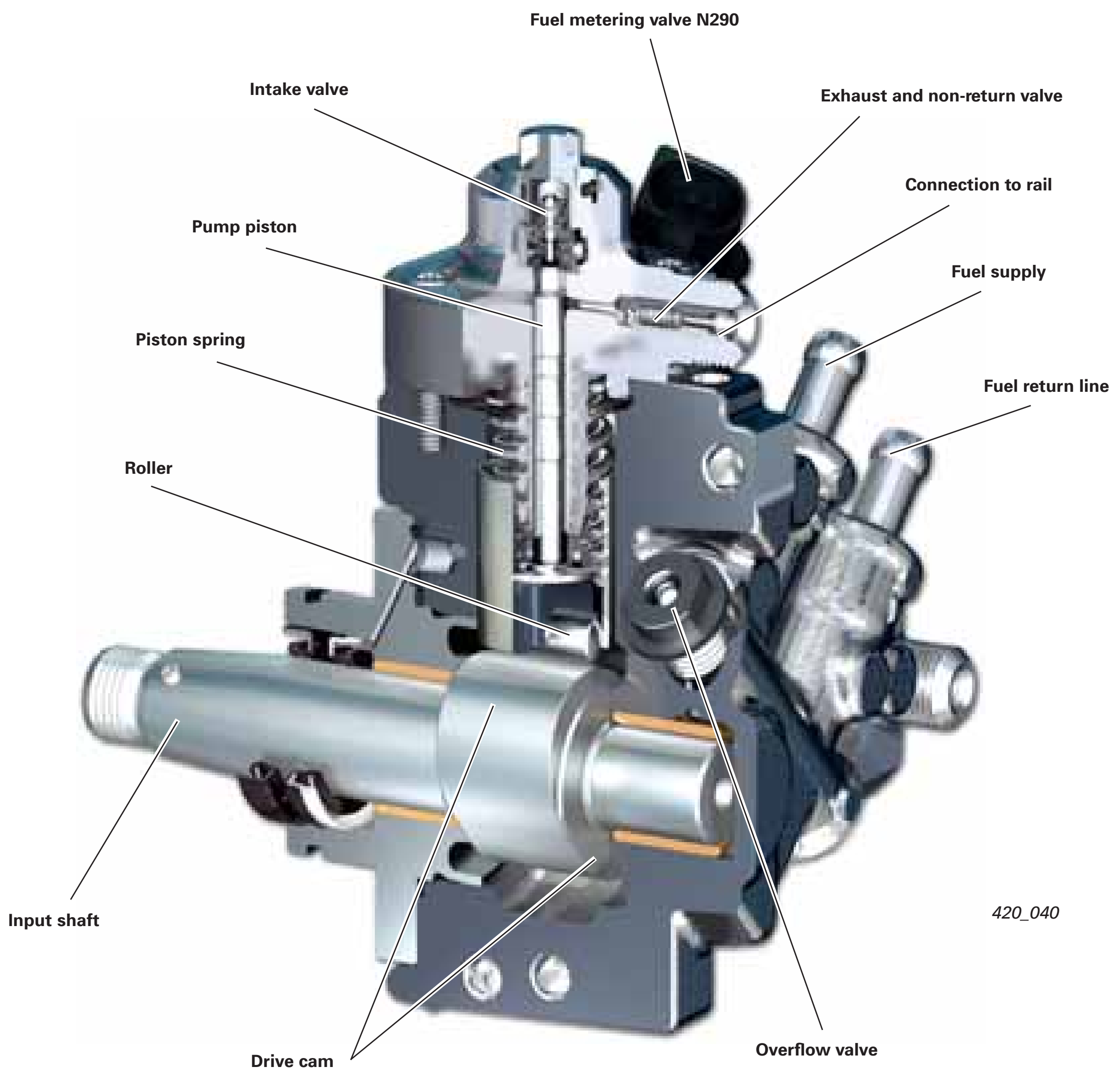


High-pressure pump CP 4.1

The high-pressure pump is a single-piston reciprocating pump. It is driven by the crankshaft at engine speed through the timing belt. The task of the high-pressure pump is to produce the high fuel pressures of up 1800 bar required for injection.

Pressure is produced by two cams offset 180° on the input shaft, with the result that the injection phase is always timed to take place during the compression stroke of each cylinder.
This means that the pump drive is loaded more evenly, and pressure fluctuations on the high-pressure side are kept to a minimum.

Design of the high-pressure pump

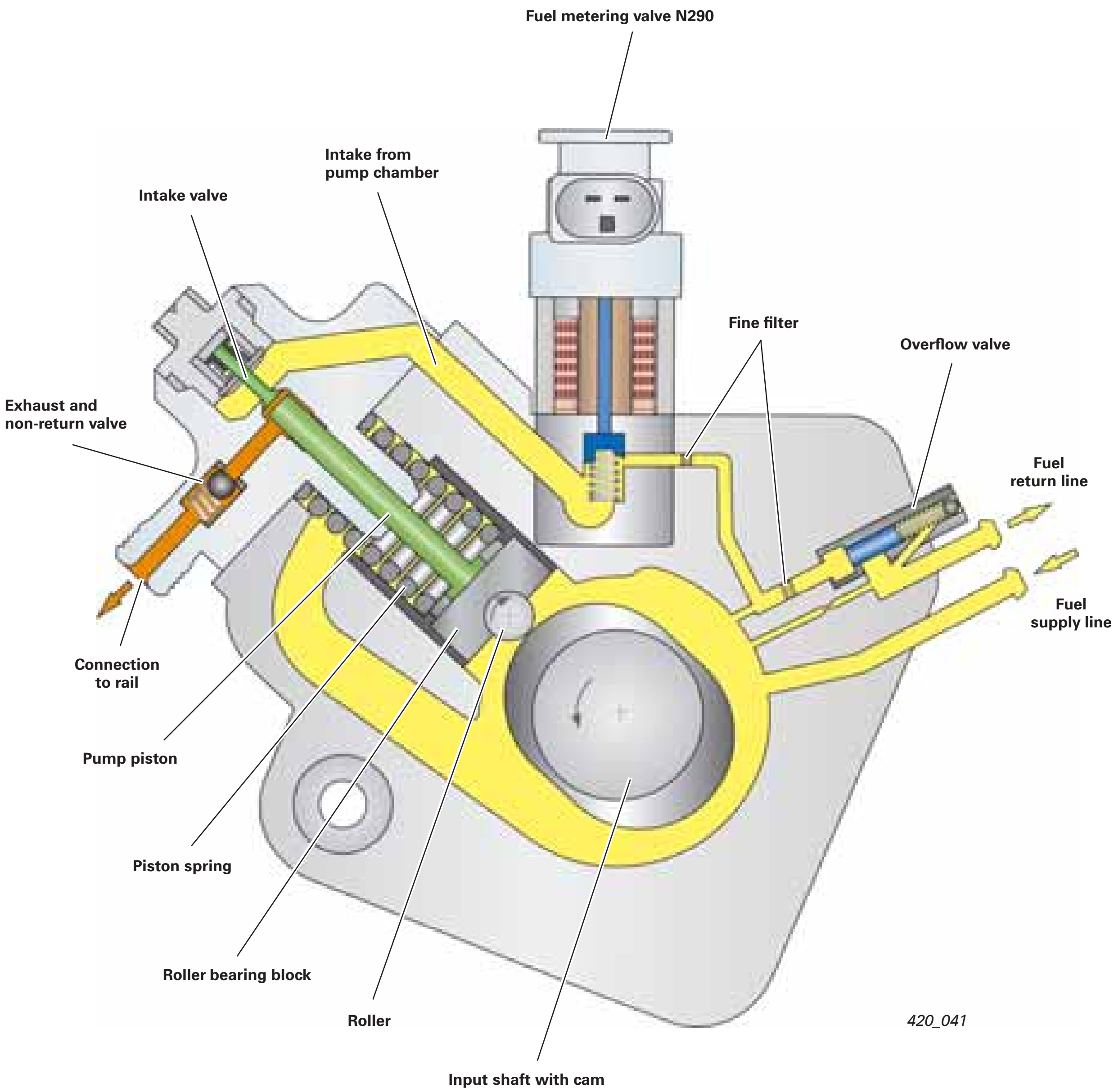


420_040

Note

When removing or replacing fuel-carrying components from the tank up to and including the high-pressure pump, always follow the procedure specified in the Workshop Manual.

Schematic design of the high-pressure pump



420_041

Note

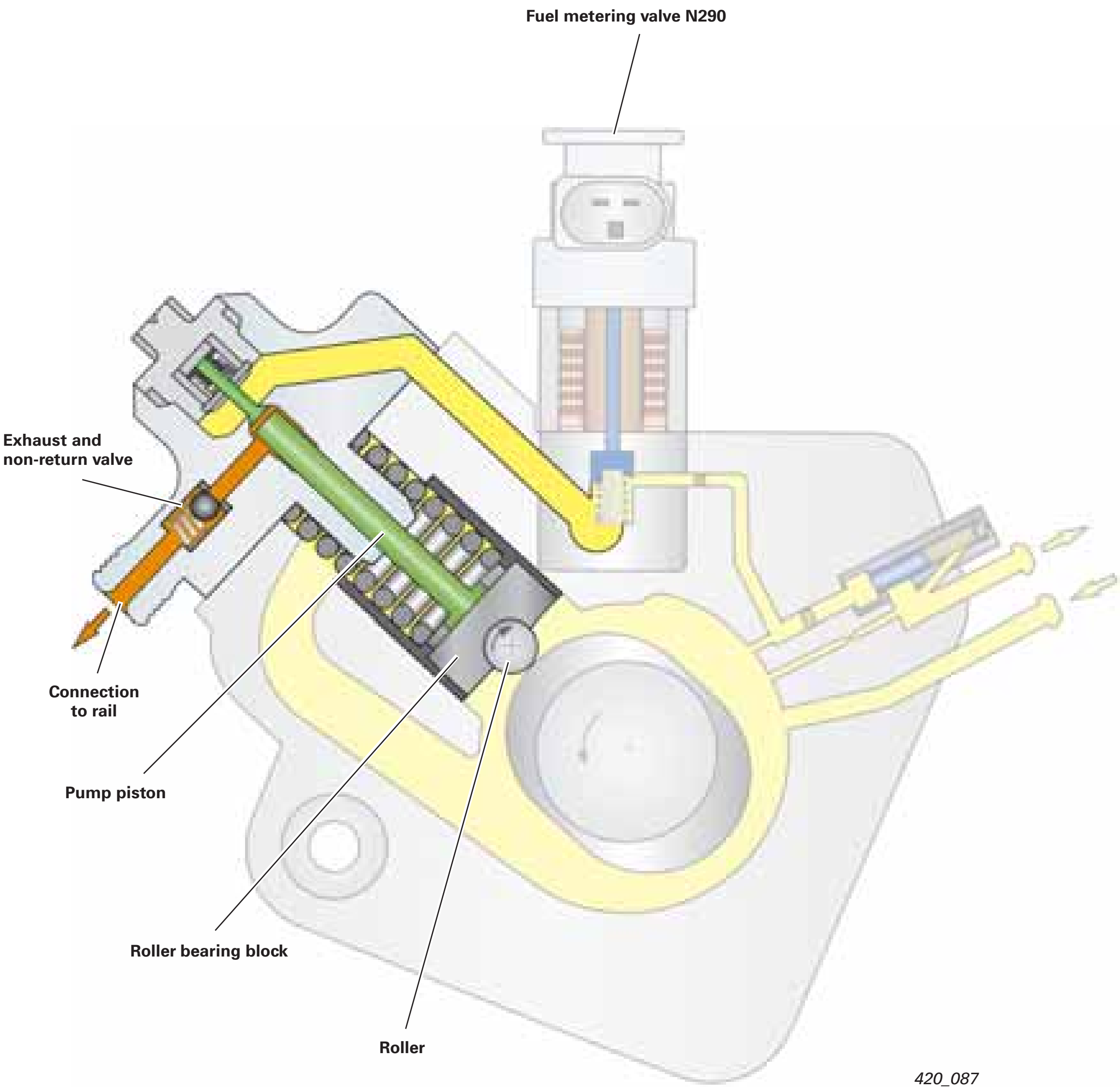
The moving parts in the high-pressure pump are lubricated by the fuel flowing through the pump.

High-pressure side

The auxiliary fuel pump supplies the high-pressure pump with sufficient fuel at a pressure of approx. 5 bar in every operating range of the engine.

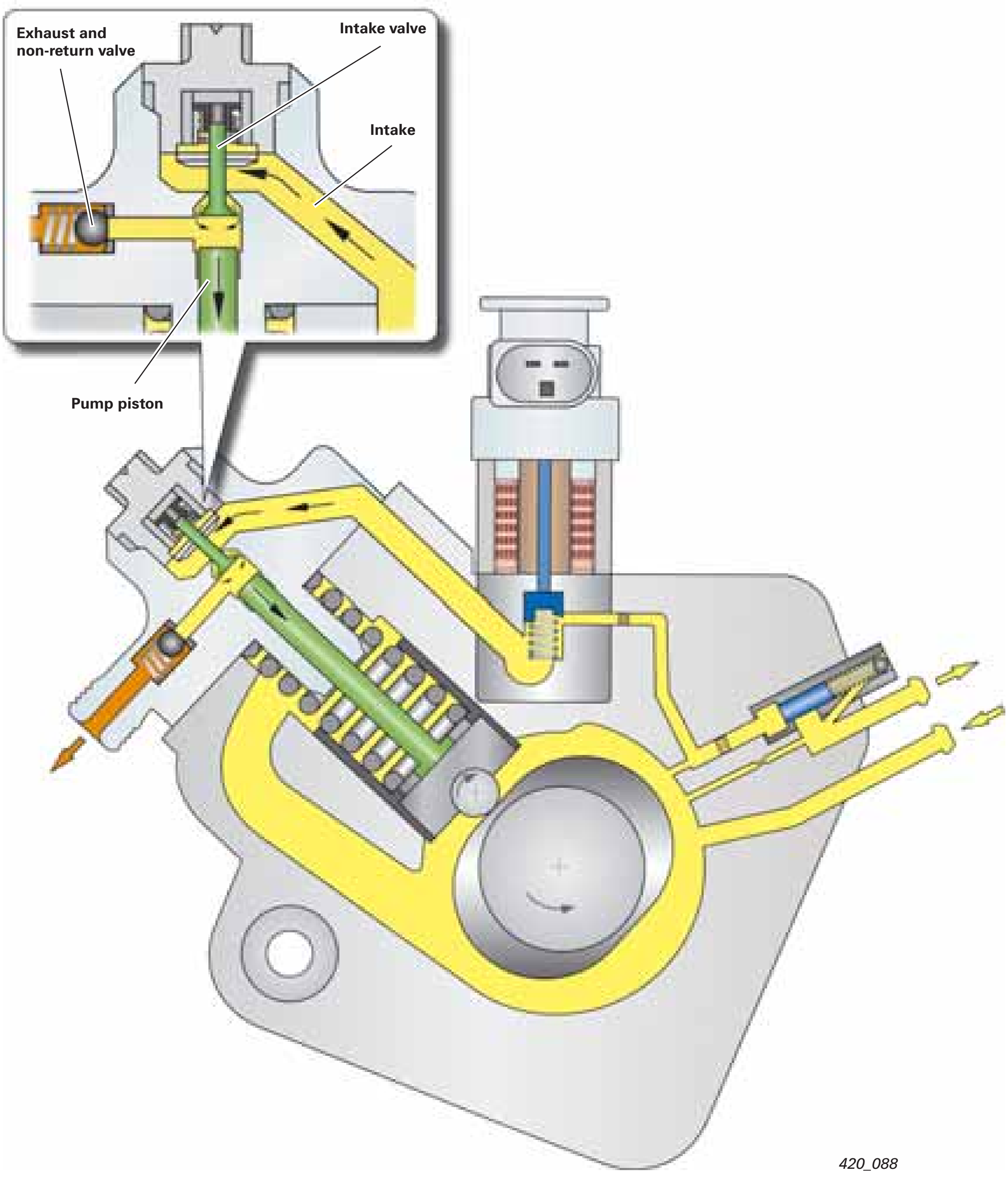
The fuel flows through the fuel metering valve N290 to the high-pressure side of the pump.

The pump piston is pushed upwards by the cams on the input shaft. To minimise internal friction, a roller runs in a roller bearing block at the end of the cam race.



Intake stroke

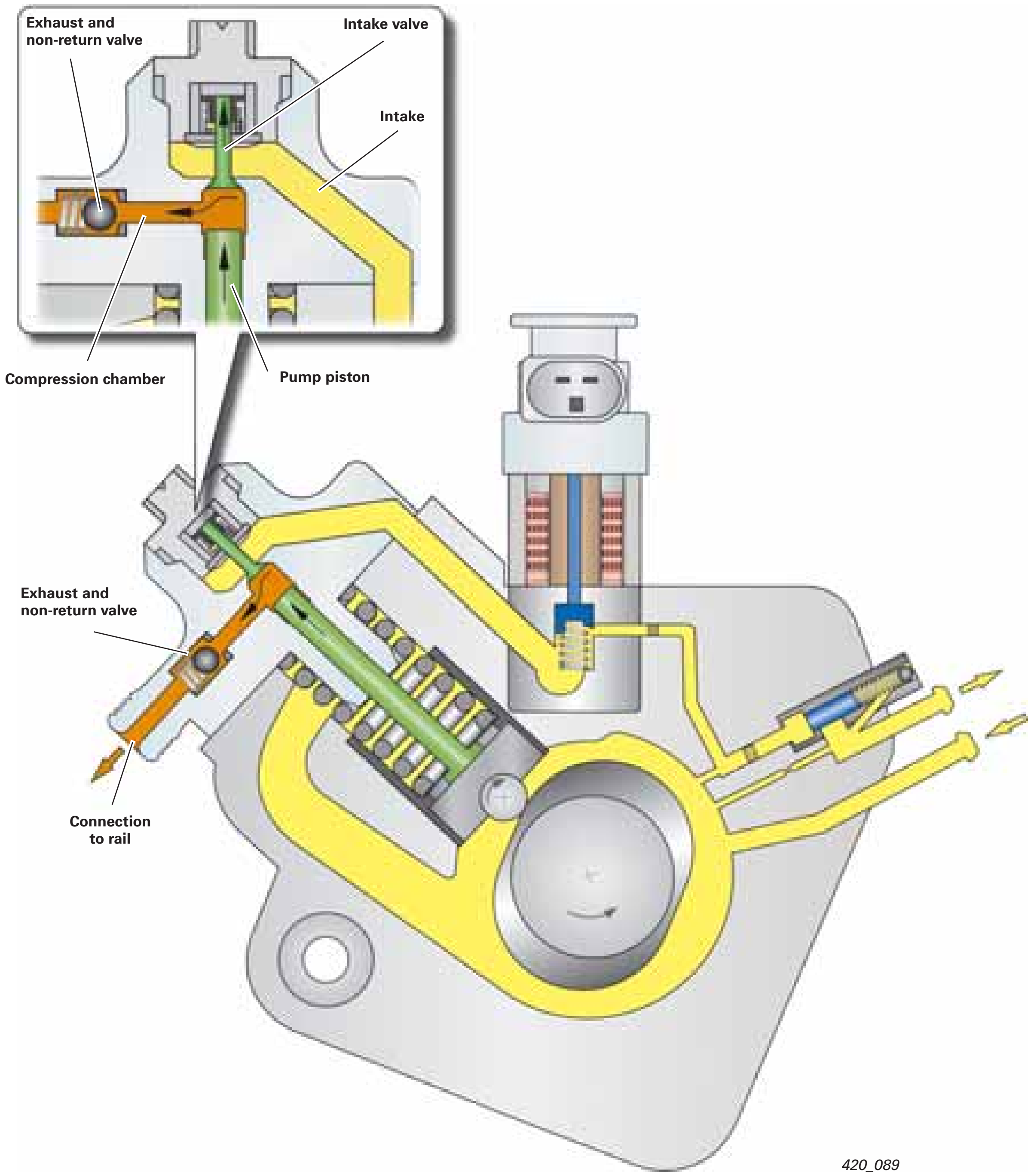
Due to the piston spring, the downward stroke of the pump piston causes an increase in the volume of the compression chamber. Due to the resulting pressure differential (vacuum) between the high-pressure pump intake and the compression chamber, the intake valve opens and fuel flows into the compression chamber.



420_088

Feed stroke

At the start of the pump piston's upward stroke, the pressure inside the compression chamber rises and the intake valve closes. As soon as the fuel pressure inside the compression chamber exceeds the pressure on the high-pressure side, the exhaust valve (non-return valve) opens and the fuel flows to the high-pressure accumulator (rail).



420_089

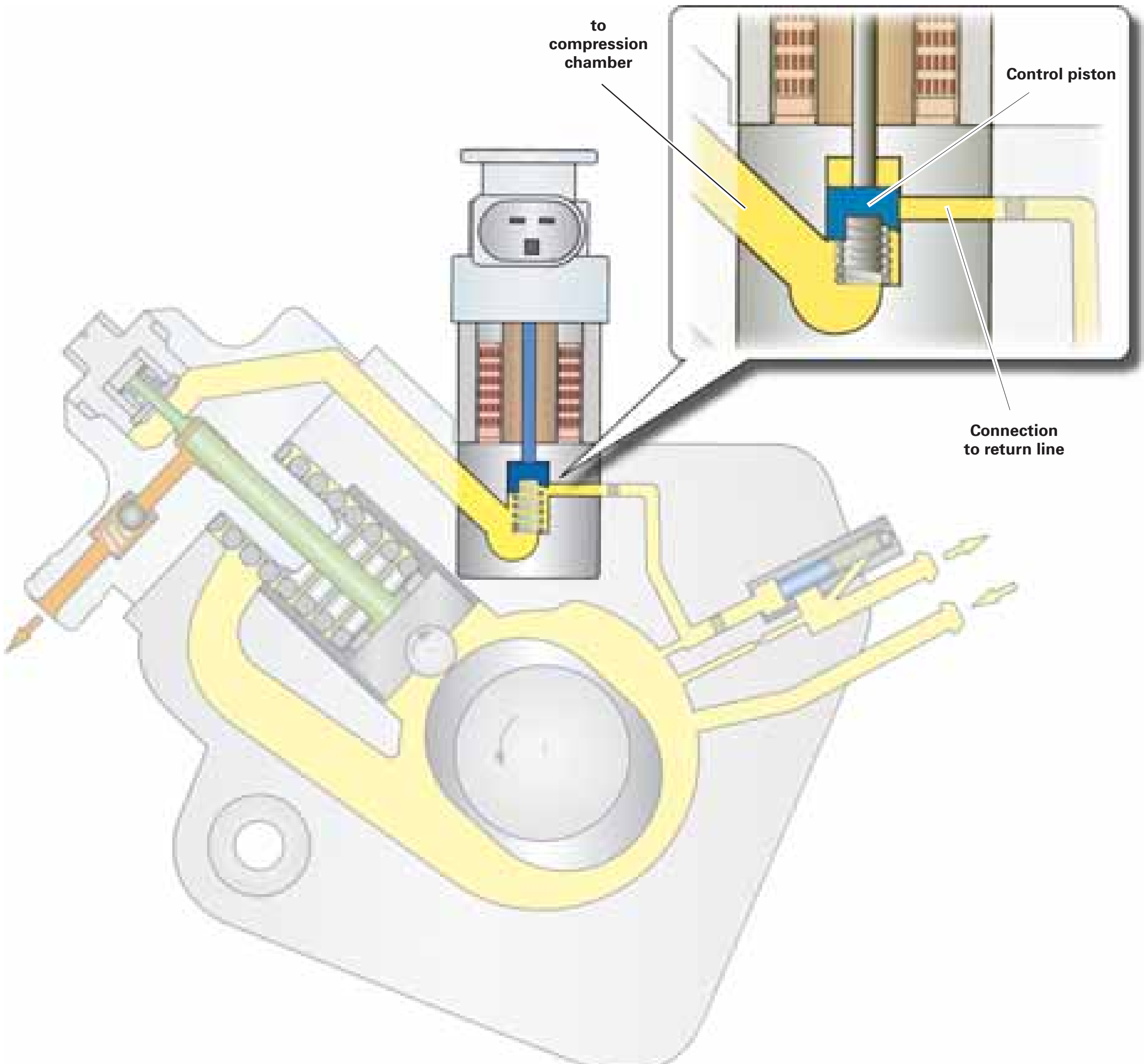
Fuel metering valve N290

The fuel metering valve N290 is integrated in the high-pressure pump. It allows fuel compression on the high-pressure side to be regulated according to demand. This has the advantage that the high-pressure pump only has to generate the pressure actually required to meet the operating requirements at any given moment. Thus, the high-pressure pump consumes less power and unnecessary heating of the fuel is avoided.

Function

In the deenergised condition, the fuel metering valve N290 is open. To reduce the inflow rate to the compression chamber, the valve from the engine control unit is activated by means of a pulse width modulated (PWM) signal.

The PWM signal closes the fuel metering valve N290 in a pulsed fashion. Depending on duty cycle variation, the position of the control piston changes, as does the rate of fuel inflow into the compression chamber of the high-pressure pump.



420_090

Effects of failure

Engine power is reduced. The engine management system runs in limp-home mode.

Low-pressure side

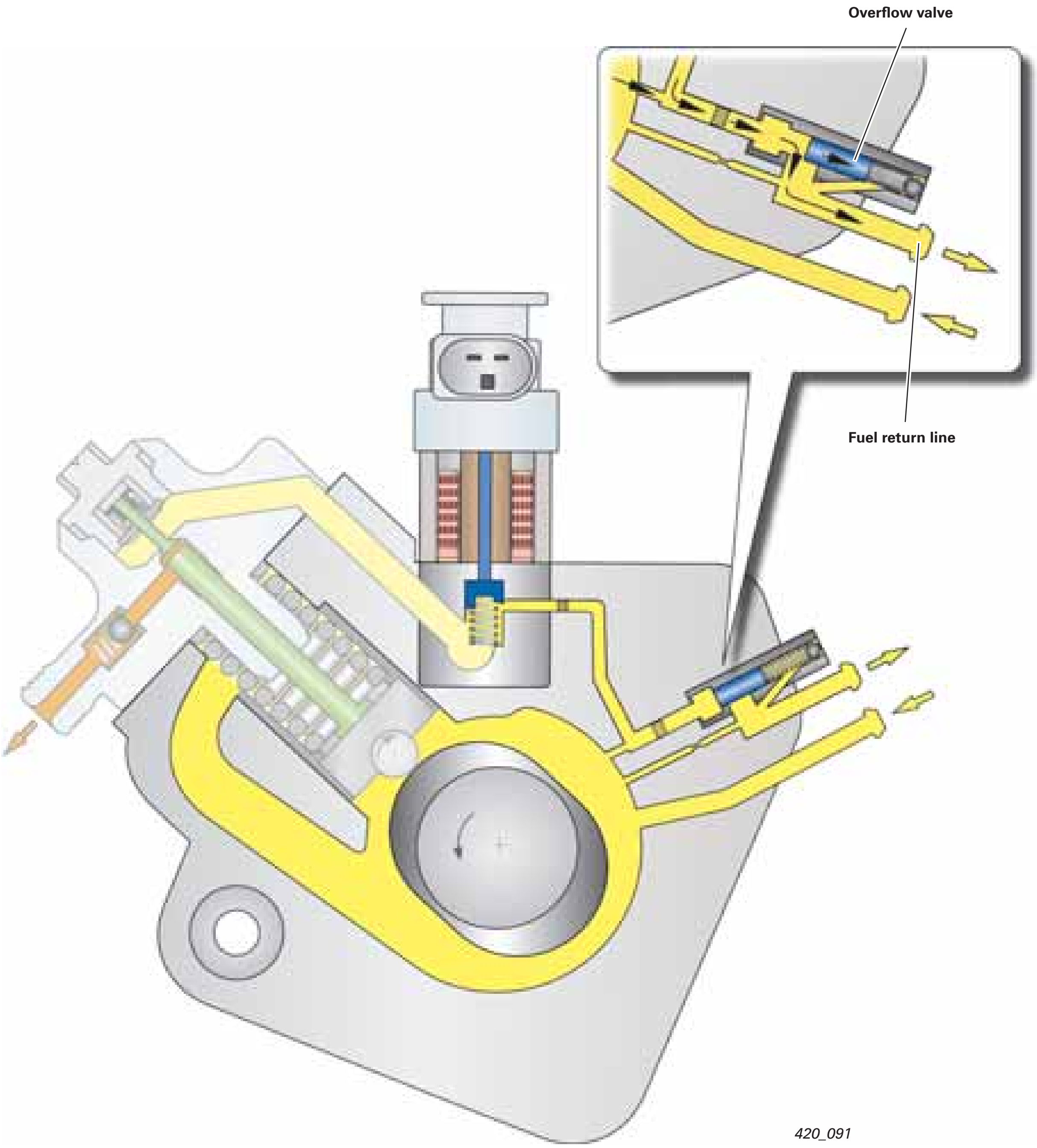
Overflow valve

The fuel pressure on the low-pressure side of the high-pressure pump is regulated by the overflow valve.

Function

The auxiliary fuel pump delivers fuel from the fuel tank into the high-pressure pump at a pressure of approx. 5 bar. This ensures a reliable supply of fuel to the high-pressure pump in all operating states. The overflow valve sets the internal fuel pressure in the high-pressure pump to approx. 4.3 bar.

The fuel delivered by the auxiliary fuel pump counteracts the pistons and the overflow valve piston spring. At a fuel pressure of over 4.3 bar, the overflow valve opens and allows fuel to flow into the return line. The excess fuel flows back into the fuel tank via the fuel return line.



420_091

High fuel pressure regulation

In the common rail injection system in the 2.0-litre TDI common rail engine, high fuel pressure is regulated by a so-called dual-regulator concept. Depending on the operating state of the engine, the high fuel pressure is regulated either by the fuel pressure regulating valve N276 on the rail or by the fuel metering valve N290 on the high pressure pump.

For this purpose, the valves are activated by the engine control unit by means of a pulse-width modulated signal (PWM signal).

Regulation by the fuel pressure regulating valve N276

When the engine is started and to heat up the fuel, the high fuel pressure is regulated by the fuel pressure regulating valve N276.
To heat up the fuel quickly, the high-pressure pump delivers and compresses more fuel than is needed. The excess fuel is redirected back to the fuel return line through the open fuel pressure regulating valve N276.

Regulation by the fuel metering valve N290

At high injection rates and rail pressures, the high fuel pressure is regulated by the fuel metering valve N290. In this way, high fuel pressure is controlled according to demand. This reduces the power consumption of the high-pressure pump and avoids unnecessary heating of the fuel.

Regulation by both valves

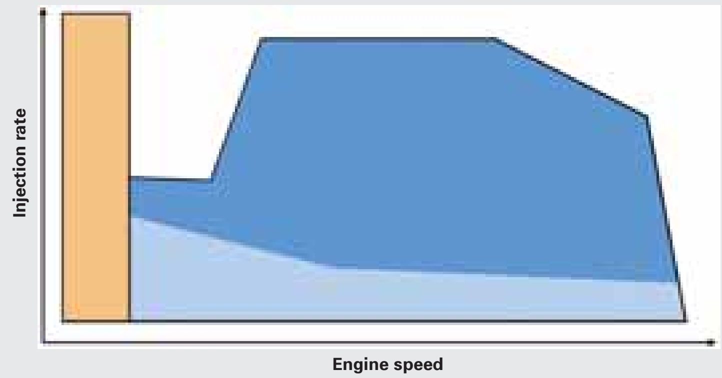
At idle, when coasting and at low injection rates, fuel pressure is regulated simultaneously by both valves.
This results in more exact regulation, which, in turn, improves idling quality, emissions and the transition to overrun.

Dual-regulator concept

N276 regulation at engine start and for fuel heating

N290 regulation at high injection rates and high rail pressures

Dual-regulator operation at idle, in overrun and at low injection rates



Fuel pressure regulating valve N276

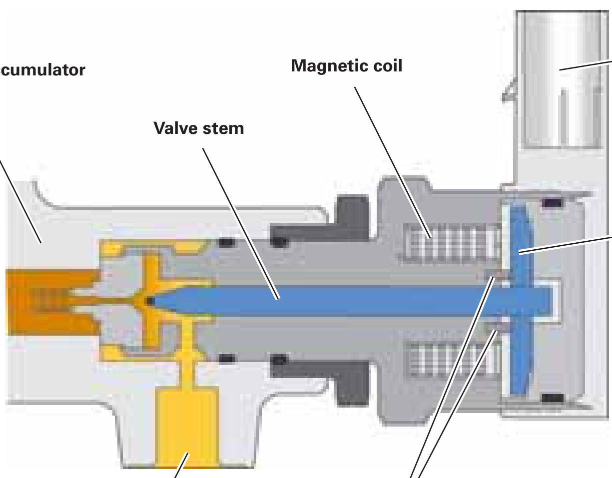
The fuel pressure regulating valve N276 is located on the high-pressure accumulator (rail).

Fuel pressure is adjusted on the high-pressure side by the opening and closing action of the regulating valve.

For this purpose, the fuel pressure regulating valve N276 is activated by the engine control unit by means of a pulse width modulated signal.

420_043

Design



420_044

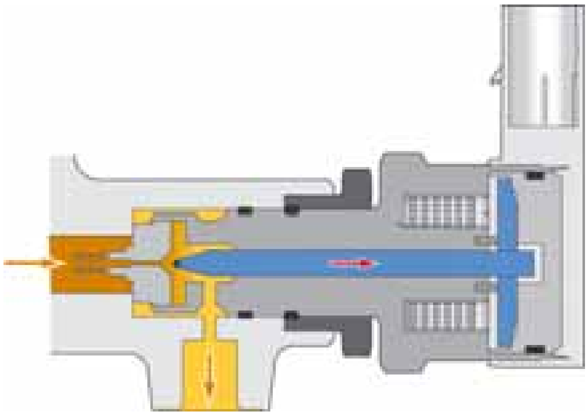
Note

The engine receives a start enabling signal through the engine control unit when the fuel pressure exceeds 120 bar and shuts off when the fuel pressure in the rail drops below 100 bar.

Regulating valve in rest position (engine "off")

If the regulating valve is not being driven, the pressure regulating valve is opened by the valve springs. The high-pressure side is connected to the fuel return line.

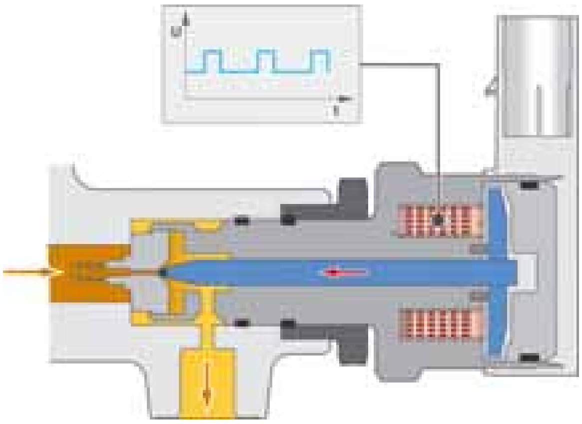
Volumetric equalisation between the high-pressure side and the low-pressure side is thereby ensured. This prevents vapour bubbles from occurring in the high-pressure accumulator (rail) while the engine is cooling down after shutoff and, in turn, enhances engine starting performance.



420_045

Regulating valve being driven (engine "on")

To set an operating pressure of 230 to 1800 bar in the high-pressure accumulator, the regulating valve is driven by the diesel direct injection system control unit J248 by means of a pulse-width modulated (PWM) signal.
A magnetic field is thereupon produced in the magnetic coil. The valve armature is energised and pushes the valve stem down into its seat.
The fuel pressure in the high-pressure accumulator is counteracted by a magnetic force.
Depending on the duty cycle of the drive circuit, the flow cross-section to the return line, i.e. the outflow rate, is modified. In this way, it is possible to compensate for pressure fluctuations in the high pressure accumulator.



420_046

Effects of failure

In the event of failure of the fuel pressure regulating valve N276, the engine will not run because the fuel pressure necessary for injection cannot be produced.

System overview

Sensors

Engine speed sender G28

Hall sender G40

Accelerator pedal position sender G79

Air mass meter G70

Coolant temperature sender G62

Charge pressure sender G31
Intake air temperature sensor G42

Radiator outlet coolant temperature sender G83

Fuel temperature sender G81

Fuel pressure sender G247

Exhaust gas recirculation potentiometer G212

Lambda probe G39

Exhaust gas pressure sensor 1 G450

Exhaust gas temperature sender -1- G235

Exhaust gas temperature sender -3- G495

Exhaust gas temperature sender -4- G648

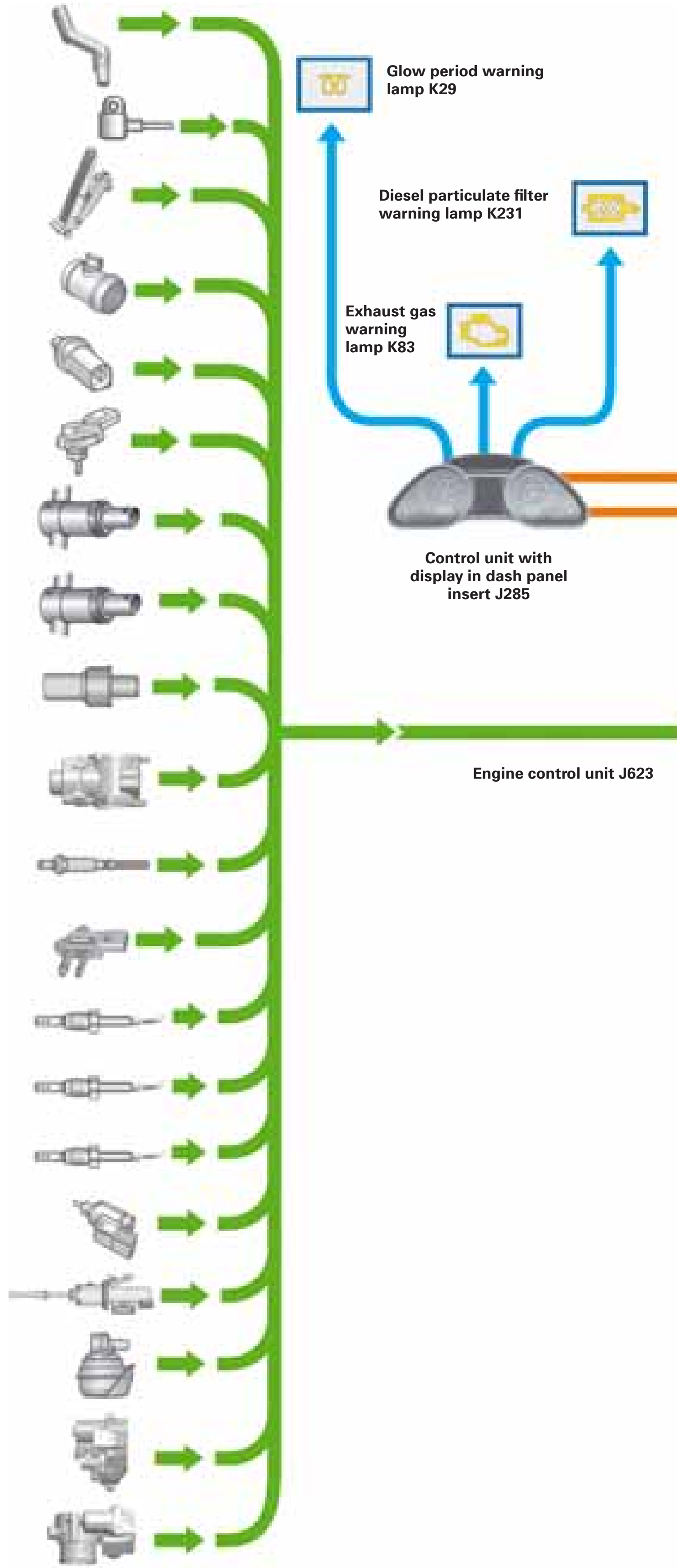
Brake light switch F

Clutch position sender G476

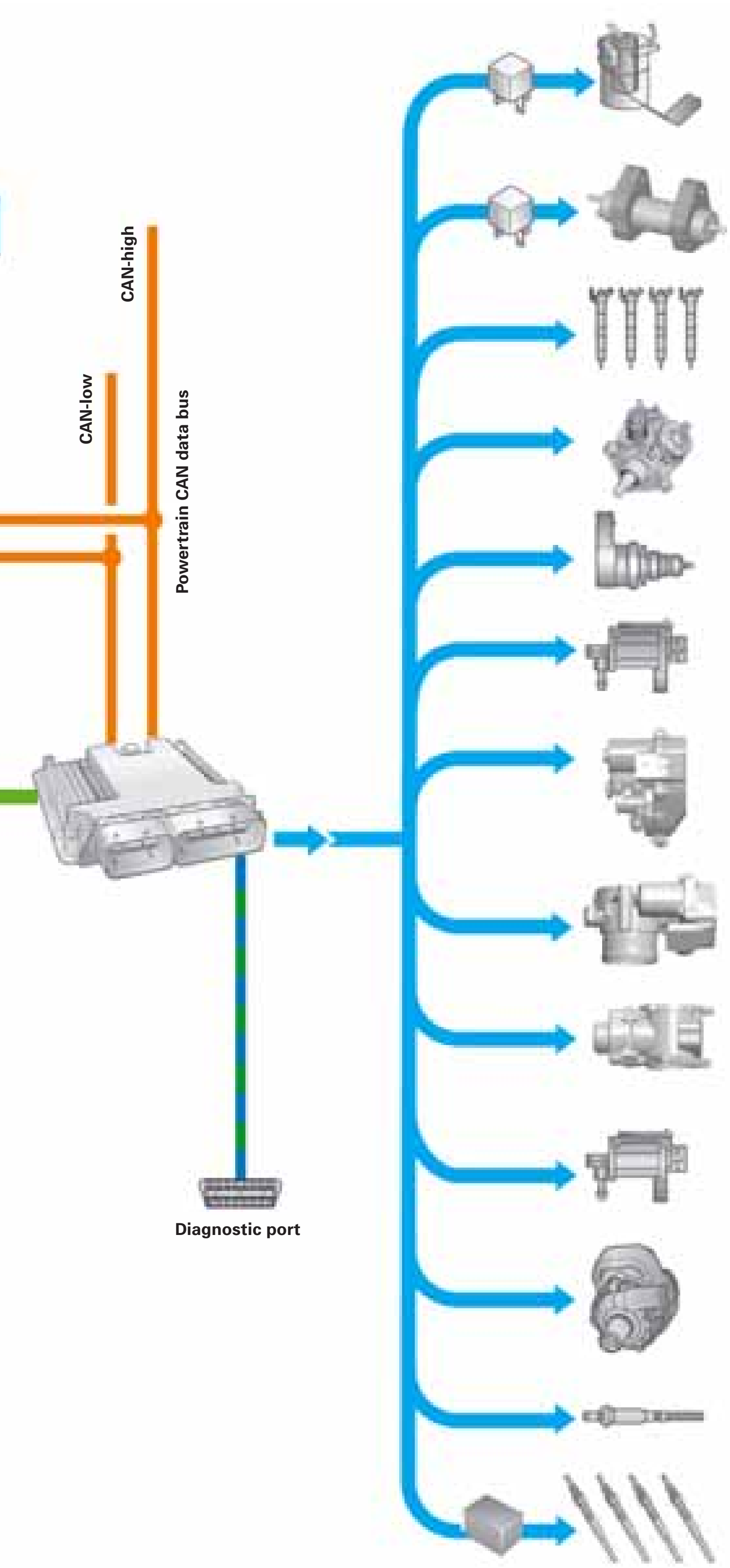
Charge-pressure actuator position sender G581

Intake manifold flap potentiometer G336

Throttle valve potentiometer G69



Actuators



Fuel pump relay J17
Fuel pump (pre-supply pump) G6

Auxiliary fuel pump relay J832
Auxiliary fuel pump V393

Injector, cylinder 1 N30
Injector, cylinder 2 N31
Injector, cylinder 3 N32
Injector, cylinder 4 N33

Fuel metering valve N290

Fuel pressure regulating valve N276

Charge pressure control solenoid valve N75

Intake manifold flap motor V157

Throttle valve control unit J338

Exhaust gas recirculation valve N18

Exhaust gas recirculation cooler changeover valve N345

Exhaust gas recirculation cooler pump V400

Lambda probe heater Z19

Automatic glow period control unit J179
Glow plug 1 Q10
Glow plug 2 Q11
Glow plug 3 Q12
Glow plug 4 Q13

420_047

Engine management

The engine management system of the 2.0-litre TDI engine with common rail injection system is the EDC 17 Electronic Diesel Control system by Bosch.
The EDC 17 engine management system is an improved version of the EDC 16.
It differs from the EDC 16 in that it has higher computing power and greater storage capacity.

420_048

CAN data bus interfaces (powertrain CAN data bus)

The messages list below are sent to the powertrain CAN data bus by the control units.
As there are numerous messages, only the most important ones are shown in the following overview.

Data bus diagnostic interface J533 (Gateway)
ACC information
Idle up
Mileage (km)
Date
Time
Brake light
Trailer detector
CCS information
Information on oil level and oil temperature
Alternator load
Audi drive select information
Lane departure warning system information
Electric parking brake

Automatic gearbox control unit J217
Shift mechanism activated/deactivated
Air conditioner compressor OFF
Lockup clutch status
Target gear
Selector lever position
NOMINAL engine torque
Motion resistance index (on downhill gradients)
Limp-home programs (information on self-diagnostics)
OBD2 status
Turbine speed
Nominal idling speed

CAN High

CAN Low

ABS control unit J104
TCS request
ABS request
EDL request
ESP intervention
Brake light switch ESP
Speed signal
EBC intervention torque
Lateral acceleration
Wheel speed
TCS intervention torque

Steering angle sensor G85
Steering wheel angle (is used for pilot control of idling speed and for calculating engine torque based on the power requirements of the power steering system)

Engine control unit J623
Idle information (EBC)
Kick-down information
Clutch pedal switch
Engine speed
ACTUAL engine torque
Coolant temperature
Brake light switch information
Brake pedal switch
CCS switch positions
CCS nominal speed
NOMINAL/ACTUAL idling speed
Preglow signal
Throttle-valve angle
Intake temperature
OBD2 lamp
"Hot" warning lamp
Coolant temperature
Fuel consumption
Radiator fan activation
Air conditioner compressor
Load shedding or power reduction
Particulate filter lamp
Start control
Interlock switch
Starter enable
Starter de-mesh
Oil temperature
Charge pressure control
Audi drive select information
Upshift or downshift recommendation
EMI information
Gearbox coding

Exhaust gas turbocharger

In the 2.0-litre TDI common rail engine, charge pressure is produced by a turbocharger with a variable turbine geometry.
It has adjustable guide vanes which can be used to control exhaust gas flow to the turbine wheel.

This has the advantage that an optimum charge (boost) pressure, i.e. good combustion, is achieved across the entire rev band. The adjustable guide vanes provide high torque at low revs and good acceleration from a standing start, as well as high fuel economy and low exhaust emissions at high revs. The guide vanes are adjusted by a vacuum-actuated linkage.

420_128

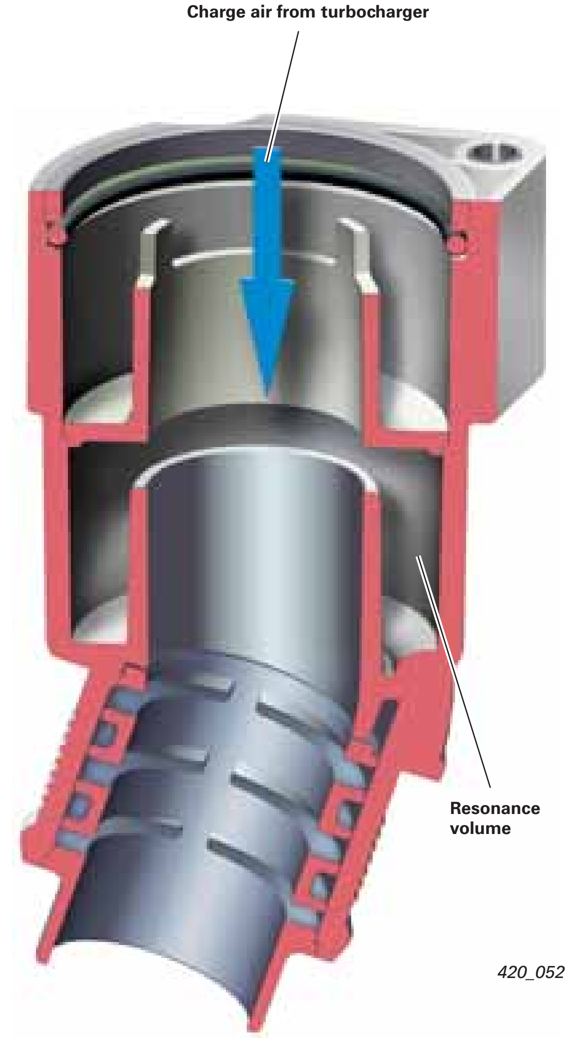
Flow restrictor

A stainless steel flow restrictor is installed downstream of the turbocharger outlet in the charge air tract. Its function is to minimise unwanted turbocharger noise.

Design and function

The turbocharger has to be able to develop charge pressure very quickly under full-throttle acceleration.
The turbine and compressor wheel are accelerated quickly and the turbocharger approaches its pumping limit. This can result in airflow breakaway producing unwanted noise in the charge air tract.

The charge air causes the air to oscillate inside the chambers of the flow restrictor.
These oscillations have roughly the same frequency as the noise produced by the charge air. Unwanted noise is minimised by superimposing the sound waves of the charge air and the air oscillation emanating from the chambers of the flow restrictor.



420_052

Charge pressure control system

The charge pressure control system controls the quantity of air compressed by the turbocharger.

Legend

1 Vacuum system

2 Engine control unit J623

3 Intake air

4 Charge-air cooler

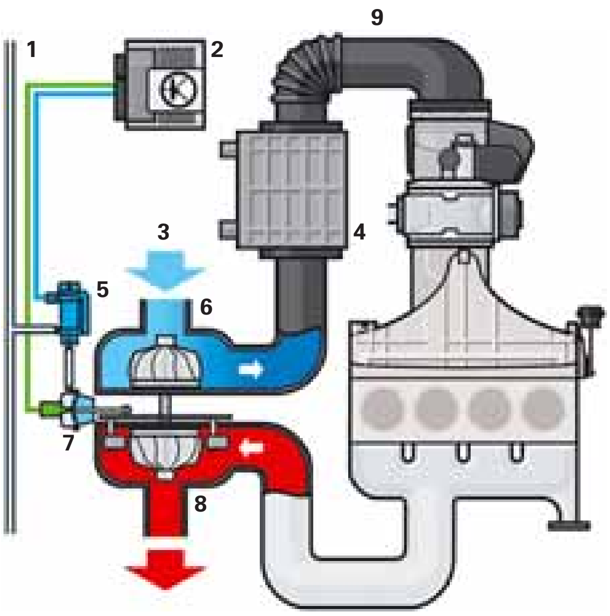
5 Charge pressure control solenoid valve N75

6 Turbocharger compressor

7 Vacuum cell

8 Exhaust gas turbine with vane adjustment

9 Charge pressure sender G31
Intake air temperature sensor G42



420_050

Charge pressure control solenoid valve N75

The charge pressure control solenoid valve N75 is an electro-pneumatic valve. The valve is used to control the vacuum required for adjustment of the guide vanes through the vacuum cell.

Effects of failure

In the event of valve failure, the vacuum cell will not be supplied with vacuum. A spring in the vacuum cell displaces the linkage of the adjustment mechanism in such a way that the guide vanes of the turbocharger are set to a steep angle of attack (limp-home position).
At low engine speeds, i.e. low exhaust gas pressures, the charge pressure is low. The engine has little power.

420_094

Charge pressure control solenoid valve N75

Charge pressure sender G31/ Intake air temperature sensor G42

The charge pressure sender G31 and the intake air temperature sender G42 are integrated in a single component and located in the boost pipe upstream of the throttle valve.

420_095

Charge pressure sender G31

Signal utilisation

The signal from the charge pressure sender G31 is used to determine the current air pressure in the intake manifold.
The engine control unit requires the signal to regulate the charge pressure.

Effects of failure

In the event of signal failure, no substitute function will be available.
The charge pressure control system is switched off and engine power decreases noticeably.

Intake air temperature sensor G42

The engine control unit utilises the signal from the intake air temperature sensor G42 to regulate the charge pressure. Since temperature affects the density of the charge air, the engine control unit utilises the signal as a correction valve.

Charge pressure actuator position sender G581

The charge pressure actuator position sender G581 is integrated in the vacuum cell of the turbocharger. It is a distance sensor which enables the engine control unit to determine the position of the turbo-charger guide vanes.

420_096

Signal utilisation

The signal from the sensor indicates to the engine control unit the current position of the turbocharger guide vanes. This signal can, therefore, be used together with the signal from the charge pressure sender G31 to determine the status of the charge pressure control system.

Effects of failure

In the event of sensor failure, the signal from the charge pressure sender G31 and the engine speed are utilised to determine the position of the guide vanes.
The exhaust emissions warning lamp K83 is activated.

Exhaust gas recirculation

The purpose of exhaust gas recirculation is to reduce nitrous oxide emissions. By recirculating the exhaust gases, a partial amount of the exhaust gases is returned to the combustion process. This reduces the oxygen content in the air-fuel mixture, thereby slowing down the combustion process. The result is a reduction in peak combustion temperature and lower nitrous oxide emissions.

Legend

1 Intake air

2 Throttle valve control unit J338 with throttle valve potentiometer G69

3 EGR valve with EGR potentiometer G212 and EGR valve N18

4 Engine control unit J623

5 Exhaust gas feed line

6 Coolant temperature sender G62

7 Oxygen sensor G39

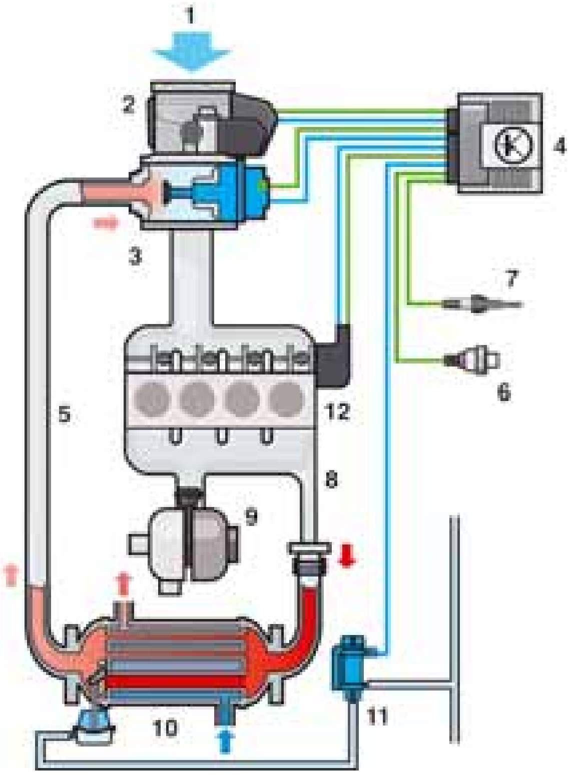
8 Exhaust manifold

9 Exhaust gas turbocharger

10 Exhaust gas cooler

11 Exhaust gas recirculation cooler changeover valve N345

12 Intake manifold flap motor V157 with intake manifold flap potentiometer G336



420_053

The exhaust-gas recirculation rate is controlled according to a characteristic map stored in the engine control unit. Allowance is made for engine speed, injection rate, intake air mass, intake air temperature and air pressure.

A broadband oxygen sensor is integrated in the exhaust line upstream of the particulate filter. The oxygen sensor enables the oxygen content in the exhaust gas to be measured over a wide range. The signal from the oxygen sensor is utilised as a correction valve for regulating the exhaust-gas recirculation rate in the exhaust gas recirculation system.

An exhaust gas recirculation cooler provides a further reduction in combustion temperature by cooling the recirculated exhaust gases, allowing a large quantity of exhaust gases to be recirculated.

This effect is intensified by the low-temperature exhaust gas recirculation system.

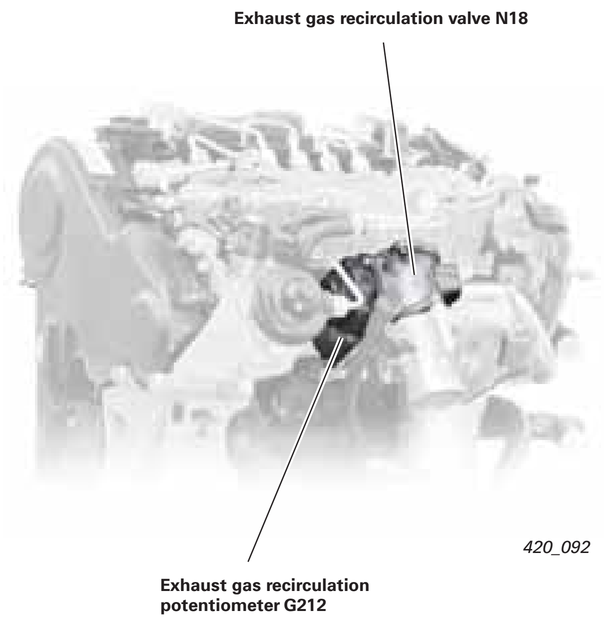
The function of the low-temperature exhaust gas recirculation system is explained in this booklet on page 23.

Exhaust gas recirculation valve N18

The EGR valve N18 is an electric-motor-actuated valve disc. It is driven by the engine control unit and can be adjusted continuously by an electric motor. The quantity of recirculated exhaust gas is controlled by the stroke of the valve disc.

Effects of failure

In the event of failure of EGR valve N18, the valve disc is closed by a valve spring. No exhaust gas can be recirculated.



420_092

Exhaust gas recirculation potentiometer G212

The exhaust gas recirculation potentiometer G212 determines the position of the valve disc in the exhaust gas recirculation valve.

Signal utilisation

The signal indicates to the engine control unit the current position of the valve disc. The quantity of recirculated exhaust gas, i.e. the nitrous oxide content in the exhaust gas, is regulated on the basis of this information.

Effects of failure

In the event of sensor failure, the exhaust gas recirculation system is switched off. The exhaust gas recirculation valve drive is deenergised and the valve disc closed by a valve spring.

Exhaust gas recirculation cooler changeover valve N345

The exhaust gas recirculation cooler is a switchable cooler. It enables the engine and the diesel particulate filter to reach their respective operating temperatures more quickly.
The exhaust-gas recirculation cooler switches over to cooling mode when the coolant temperature exceeds approx. 37 °C.

The exhaust gas circulation cooler changeover valve N345 is an electro-pneumatic valve.
It supplies the vacuum cell of the exhaust gas recirculation cooler with the amount of vacuum required to switch over the bypass valve.

420_102

Effects of failure

If the changeover valve fails, the bypass valve can no longer be actuated by the vacuum cell of the exhaust gas recirculation cooler.
The bypass valve closes the bypass and the exhaust gas cooling system remains active. As a result, the engine and diesel particulate filter take longer to reach their respective operating temperatures.

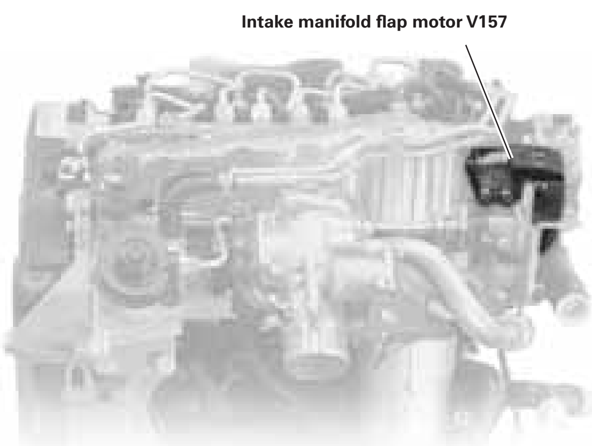
Exhaust-gas recirculation cooler

Function: refer to page 24

420_127

Intake manifold flap motor V157

Function: refer to page 14



420_120

Throttle valve control unit J338

The throttle valve control unit J338 is installed in the direction of flow upstream of the exhaust gas recirculation valve. An electric motor which actuates the throttle valve through a gear mechanism is integrated in the throttle valve control unit J338. The throttle valve is continuously adjustable according to engine load and speed.

The throttle valve control unit J338 has the following tasks:

In specific operating situation, the throttle valve produces a difference between the intake manifold pressure and the exhaust gas pressure.
The pressure difference ensures effective exhaust gas recirculation.
When the diesel particulate filter is in regeneration mode, the intake air flow rate is regulated with the throttle valve.
The throttle valve is closed when the engine is shut off. As a result, less air is induced and compressed, and the engine smoothly slows to a stop.

Effects of failure

In the event of failure of the throttle valve control unit, the exhaust gas recirculation rate cannot be regulated correctly. Active regeneration of the diesel particulate filter does not take place.

Throttle valve potentiometer G69

The throttle valve potentiometer G69 is integrated in the throttle valve drive. The sensor element determines the current position of the throttle valve.

Signal utilisation

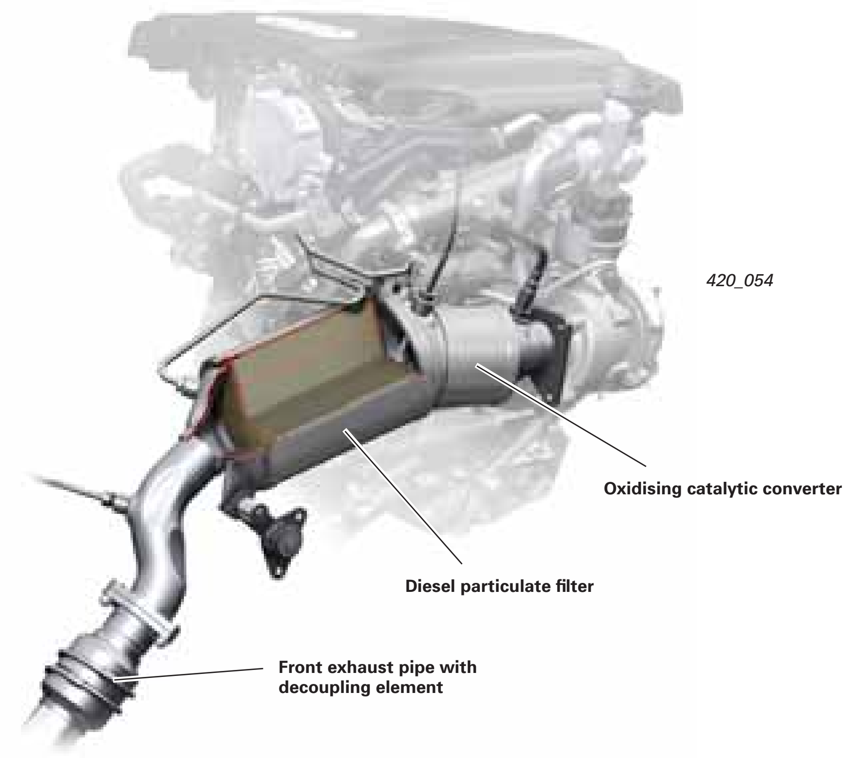
The signal indicates to the engine control unit the current position of the throttle valve.
This information is required for regulation of the exhaust gas recirculation system and particulate filter regeneration.

Effects of failure

In the event of failure of the throttle valve potentiometer, the exhaust gas recirculation system will be shut down and no active regeneration of the diesel particulate filter will take place.

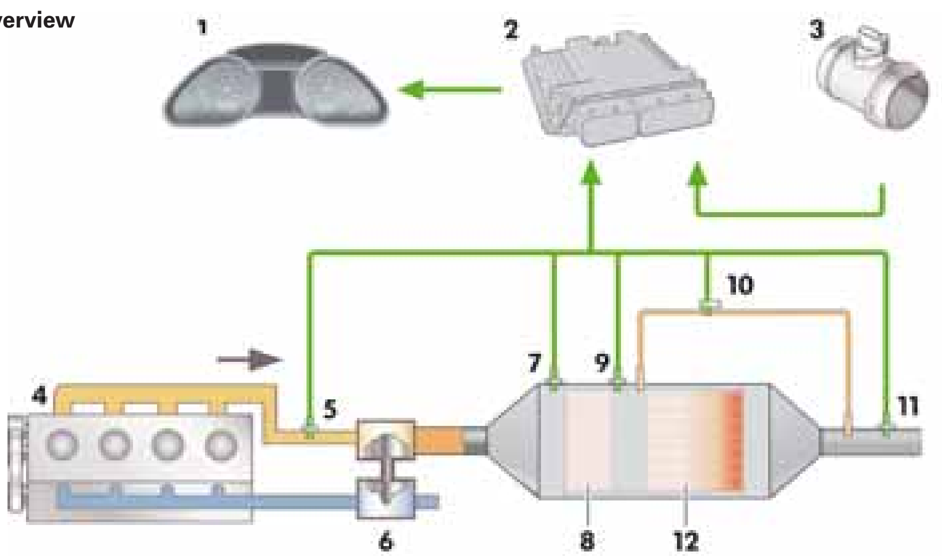
Diesel particulate filter

In the 2.0-litre TDI common rail engine, particulate emissions are reduced by a diesel particulate filter in addition to intra-engine modifications.
The diesel particulate filter is located downstream of the oxidising catalytic converter. Both components are integrated in a close-coupled housing so that the operating temperature is reached rapidly.



420_054

System overview



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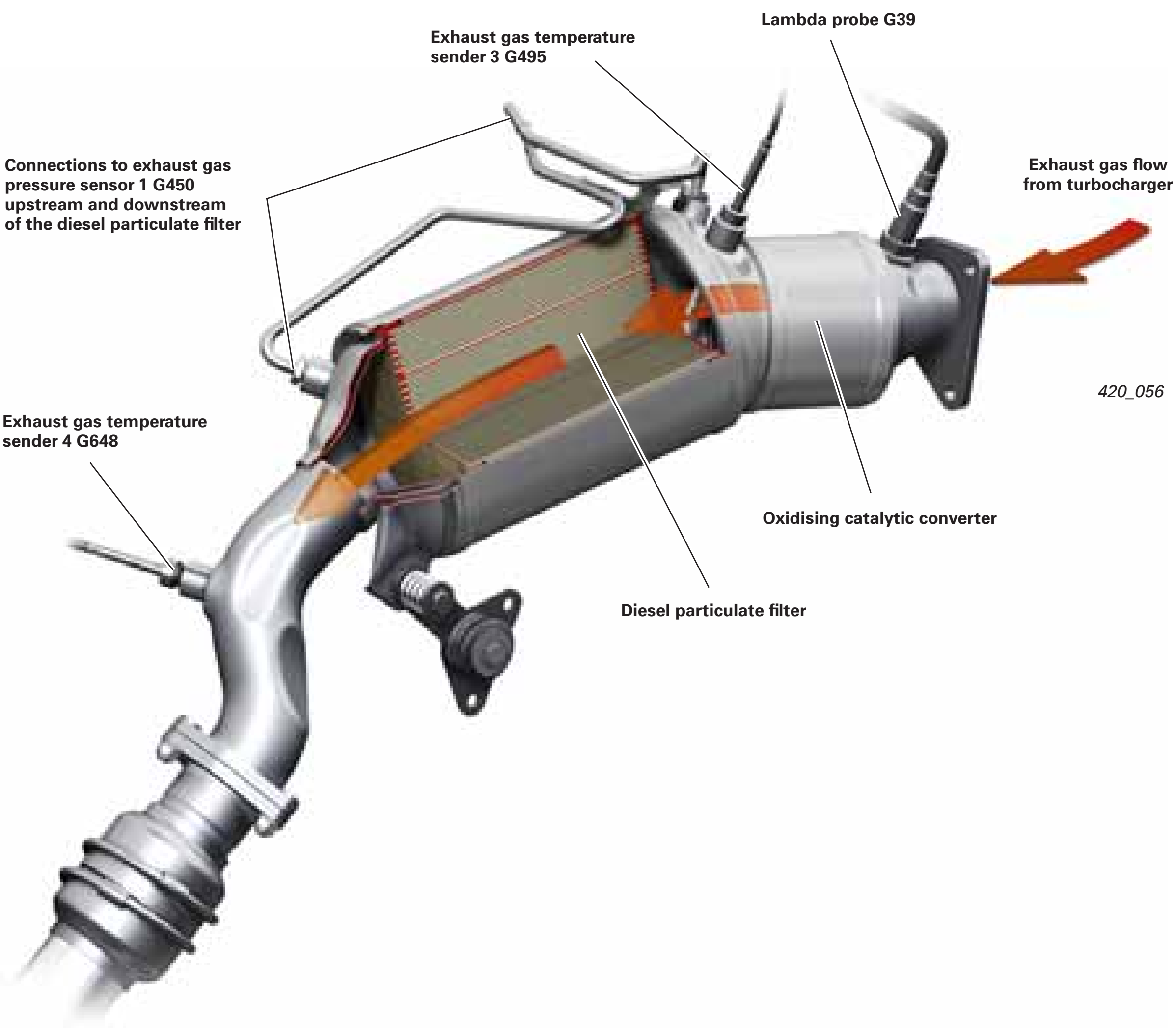
Legend

1 Control unit with display in dash panel insert J285
2 Engine control unit J623
3 Air mass meter G70
4 Diesel engine
5 Exhaust gas temperature sender -1- G235
6 Turbocharger
7 Oxygen sensor G39
8 Oxidising catalytic converter
9 Exhaust gas temperature sender 3 G495
10 Exhaust gas pressure sensor 1 G450
11 Exhaust gas temperature sender 4 G648
12 Diesel particulate filter

Design

The diesel particulate filter and the oxidising catalytic converter are installed separately in a common housing.

The oxidising catalytic converter is located in the direction of flow upstream of the particulate filter.



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The upstream oxidation catalytic converter configuration has the following advantages in combination with the common rail injection system:

– The temperature of the exhaust gas used for the regeneration cycle can be regulated more exactly (finely) in comparison with the catalysed soot diesel particulate filter. The heat level in the oxidising catalytic converter during the oxidation of hydrocarbons and carbon monoxide is measured directly upstream of the particulate filter by a temperature sensor. This information allows more exact determination of the fuel quantity post-injected to increase the exhaust gas temperature during the regeneration cycle.

– High level of safety in regeneration mode of the diesel particulate filter.

– When the vehicle is in overrun (coasting), excessive cooling of the diesel particulate filter by the induced cold air is avoided because the oxidation catalytic converter acts as a heat storage device in this situation.

Oxidising catalytic converter

The substrate of the oxidising catalytic converter is made of metal in order to reach the activation temperature quickly. This metal element is coated with an aluminium oxide substrate. Platinum is vapour deposited onto the substrate as a catalyst for the hydrocarbons (HC) and carbon monoxide (CO).

420_123

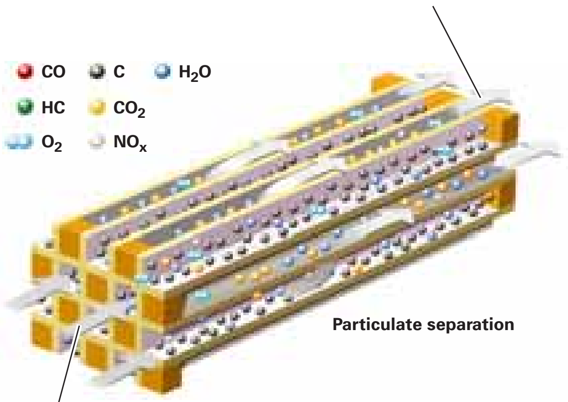
Function

The oxidising catalytic converter converts a large proportion of the hydrocarbons (HC) and carbon monoxide (CO) into water vapour and carbon dioxide.

Diesel particulate filter

The diesel particulate filter consists of a honeycomb-shaped silicone carbide ceramic substrate subdivided into a multiplicity of small channels which are alternately closed, resulting in intake and exhaust ports separated by filter walls.

The filter walls are porous and coated with an aluminium oxide (and ceroxide) substrate.
The precious metal platinum is vapour deposited onto this substrate as a catalyst.



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Function

The soot-containing exhaust gas passes through the porous filter walls of the intake ports. Unlike the gaseous constituents of the exhaust gas, the particulate matter remains behind in the intake ports.

Note

For general information regarding the diesel particulate filter system, refer to SSP 325 Audi A6 ´05 Engines and Transmissions.

Regeneration

The particulate filter must be regenerated regularly in order to prevent particulate matter from clogging the filter and impairing filter performance. The particulate matter which accumulates in the particulate filter is combusted (oxidised) during the regeneration process.

The particulate filter regeneration process comprises the following stages:

– Passive regeneration
– Heating-up phase
– Active regeneration
– Regeneration run by customer
– In-service regeneration

Heating-up phase

To heat a cold oxidising catalytic converter and particulate filter to operating temperature as quickly as possible, the engine management system performs a controlled post-injection after the main injection phase.

This fuel combusts inside the cylinder and increases the combustion temperature level. The resulting heat is transported by the air stream in the exhaust system to the oxidising catalytic converter and to the particulate filter, thus heating the latter.
The heating-up phase is complete as soon as the operating temperatures of the oxidising catalytic converter and the particulate filter have been maintained for a set period of time.

Passive regeneration

During the passive regeneration phase, the particulate matter is continuously combusted without intervention on the part of the engine management system. This usually occurs at high engine loads, e.g. during motorway operation at exhaust gas temperatures of 350 °C - 500 °C.
The particulate matter is converted to carbon dioxide by reaction with nitrogen dioxide.

Active regeneration

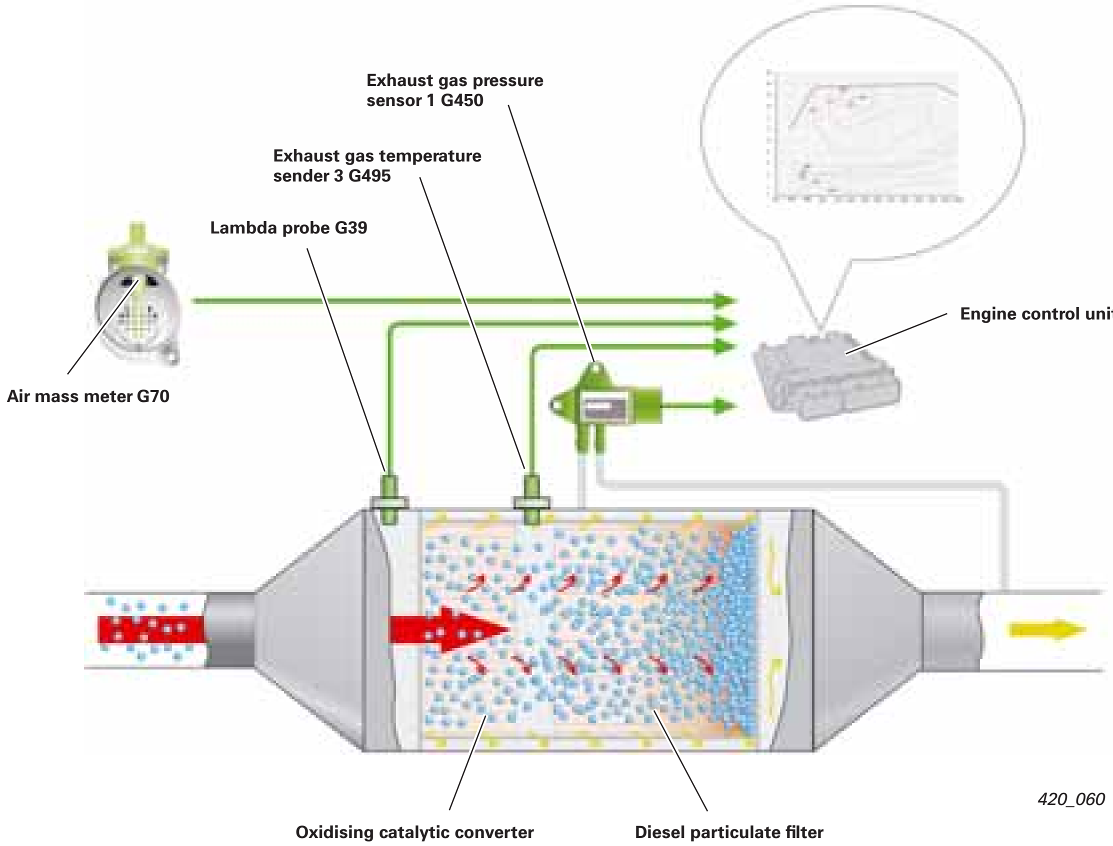
Over a large part of the operating range, the exhaust gas temperatures are too low for passive regeneration. Since the particulate matter can no longer be eliminated, it begins to accumulate in the filter.
When the particulate load in the filter reaches a set level, the engine control unit starts an active regeneration cycle. The particulate matter is combusted to carbon dioxide at an exhaust gas temperature of 600 - 650 °C.

The function of active regeneration

The particulate load of the particulate filter is calculated by two loading models preprogrammed in the engine control unit.

The first loading model is determined from the user's driving profile, as well as the signals from the exhaust gas temperature sensors and the oxygen sensor.

A further particulate loading model is the flow resistance of the particulate filter. It is calculated on the basis of the signals from exhaust gas pressure sensor 1 G450, the exhaust gas temperature sender 3 G495 upstream of the particulate filter and the air mass meter G70.



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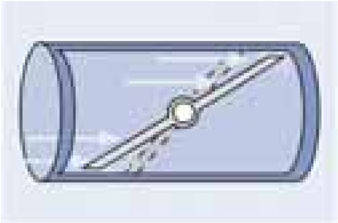
The following measures are taken by the engine control unit J623 during active regeneration in order to increase the exhaust gas temperature:

– Intake air feed is regulated by the throttle valve control unit J338.



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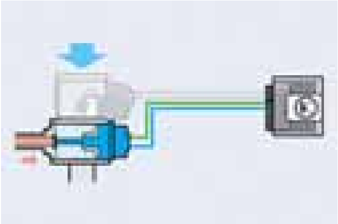
– Exhaust gas recirculation is shut off in order to increase the combustion temperature and the oxygen level inside the combustion chamber.



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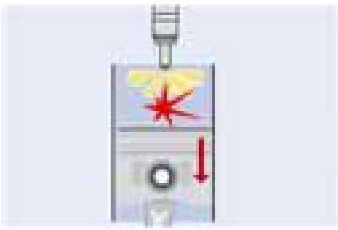
– Shortly after the main injection has been shifted to "retard", the first post-injection is initiated in order to increase the combustion temperature.



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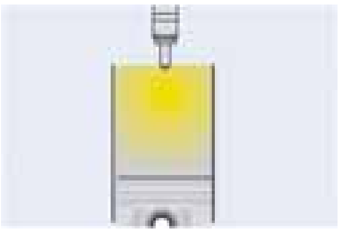
– A further post-injection phase is initiated after the main injection.
This fuel does not combust inside the cylinder, rather it evaporates in the combustion chamber.



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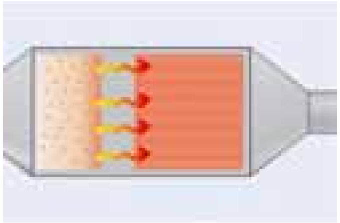
– The unburned hydrocarbons of these fuel vapours are oxidised in the oxidising catalytic converter. The resulting heat provides an increase in exhaust gas temperature upstream of the particulate filter to approx. 620 °C.



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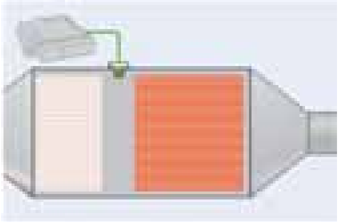
– The signal from the exhaust gas temperature sender 3 G495 upstream of the particulate filter is utilised by engine control unit J623 to calculate the quantity of fuel for the retarded post-injection phase.



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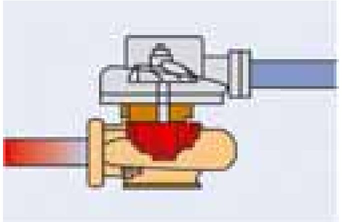
– The charge pressure is adapted so that the torque does not change noticeably for the driver during the regeneration process.



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Regeneration run by customer

In extreme short-distance traffic, the exhaust gas temperature will not be high enough to regenerate the filter. When the load state of the diesel particulate filter reaches a certain limit value, the diesel particulate filter warning lamp K231 in the dash panel insert comes on.

Based on this signal, the driver is requested to carry out a regeneration run. The vehicle must be driven at an increased speed for a short period of time to ensure a high enough exhaust gas temperature and the constant operating conditions required for successful regeneration.

Note

For detailed information about driving performance while the diesel particulate filter warning lamp K231 is on, please refer to the vehicle owner's manual.

In-service regeneration

If the regeneration run is not successful and the particulate load on the filter has reached 40 grammes, the glow period warning lamp K29 comes on in addition to the diesel particulate filter warning lamp K231.

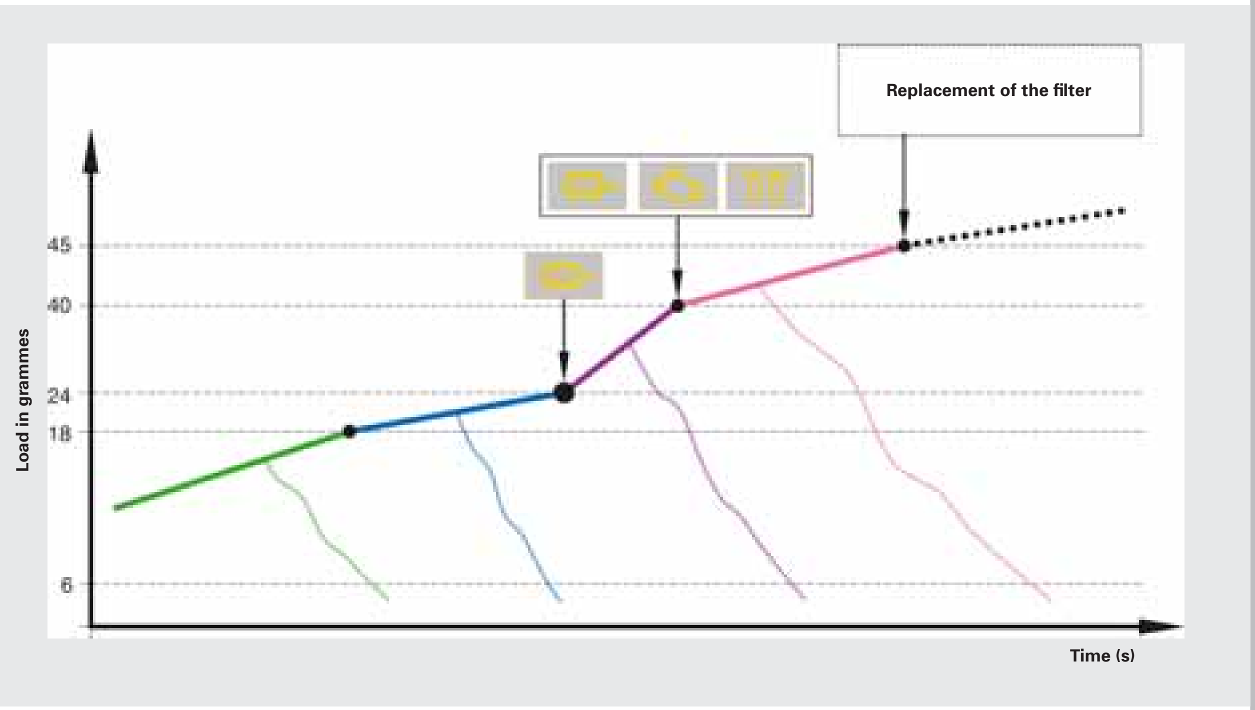
The text "Engine fault Workshop" appears on the dash panel insert display.
The driver is requested to take the vehicle to the nearest workshop. To avoid damaging the particulate filter, active regeneration of the diesel particulate filter is in this case disabled in the engine control unit.

The particulate filter can only be regenerated by an in-service regeneration at the workshop, which is carried out using the VAS 5051 A/B.

Note

In-service regeneration is not possible as of a particulate load of 45 grammes because the risk of causing irreparable damage to the filter is too high. In this case, the filter must be replaced.

Regeneration stages of the 2.0-litre TDI common rail engine



Example: Increase in particulate load

Example: Load characteristic after successful regeneration in each stage

Passive regeneration

Active regeneration

Regeneration run by the customer

In-service regeneration

Replacement of the filter

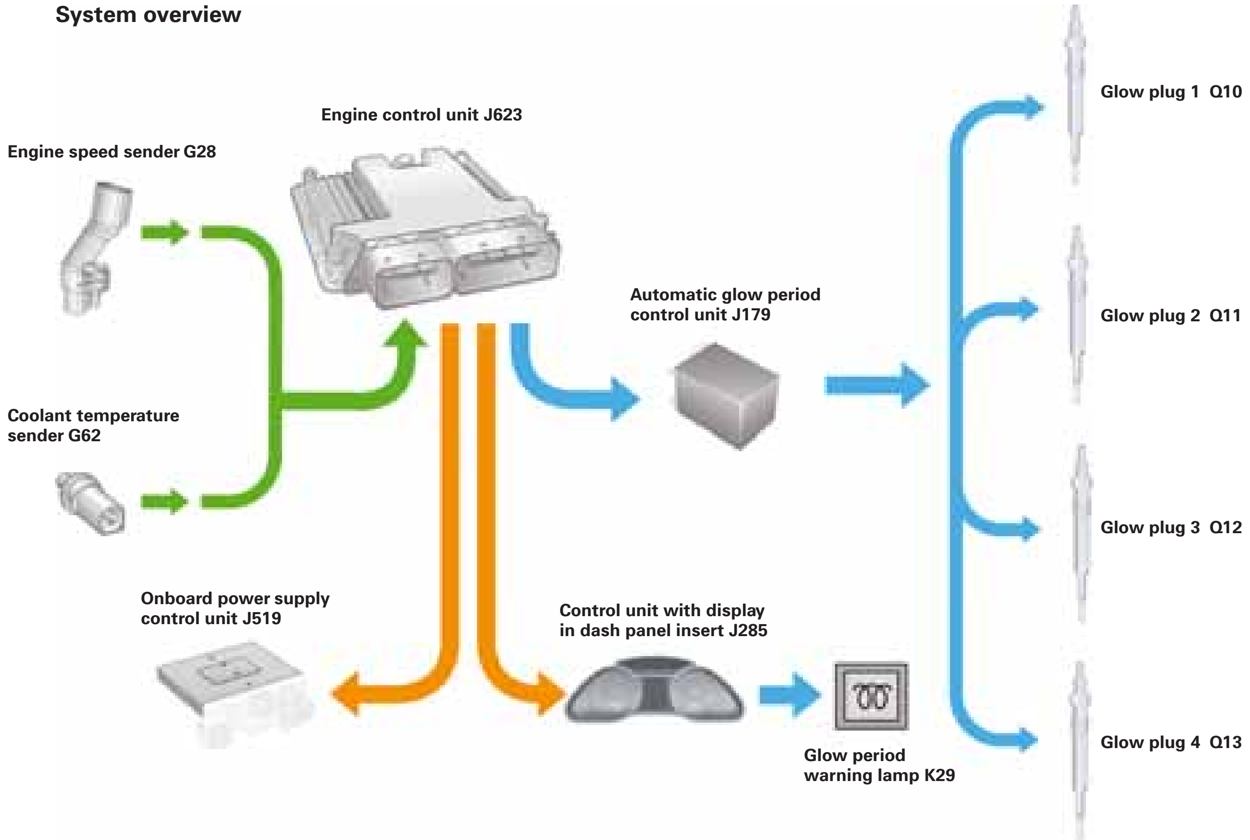
Glow plug system

The 2.0-litre TDI engine with common rail injection system has a diesel quick start glow plug system.
It allows the engine to be started immediately without a long glow period in practically all climatic conditions.

Advantages of the glow plug system:

- Petrol-engine-like starting at temperatures of up to -24 °C
- Extremely quick heating-up time - the glow plugs reach a temperature of 1000 °C within 2 seconds
- Controllable preheating and post-heating temperatures
- Self-diagnostic capability
- Part of Euro On-Board Diagnostic System - glow plug system

System overview



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Function

Preheating

The steel glow plugs are activated in a phase-offset manner by the engine control unit J623 through the automatic glow period control unit J179 by means of a pulse-width modulated signal (PWM).
The voltage at the individual glow plugs is set according to the frequency of the PWM pulses.
For quick starting at an ambient temperature of less than 25 °C, the maximum voltage of 11.5 V is applied during the preheating phase.
It ensures that the glow plug is heated to over 1000 °C within an extremely short period of time (max. 2 seconds). This reduces the preheating time of the engine.

Intermediate glow phase

To regenerate the particulate filter, an intermediate glow phase is initiated by the engine control unit J623. The intermediate glow phase serves to improve the combustion conditions during the regeneration process.

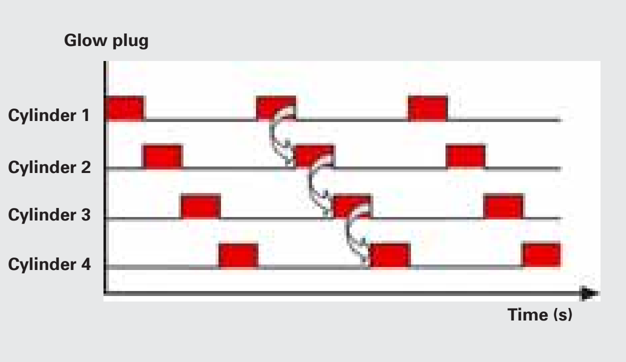
Post-glow phase

By continuously reducing the drive frequency of the PWM signal, the voltage for the post-glow phase is set to a rated voltage of 7 V depending on the operating point.

The post-glow phase continues until a coolant temperature of 25 °C is reached, or for up to 5 minutes after starting the engine. The post-glow phase serves to reduce hydrocarbon emissions and combustion noise during the warm-up phase of the engine.

Phase-offset activation of the glow plugs

To reduce the load on the vehicle electrical system during the glow phases, the glow plugs are activated in a phase-offset fashion.
The falling signal edge always activates the next glow plug.



Special tools

The special tools for the 2.0-litre 105 kW TDI engine with common rail injection system are shown below.

420_071

T10172 Plus adaptor

420_076

T10377 Assembly sleeve

420_072

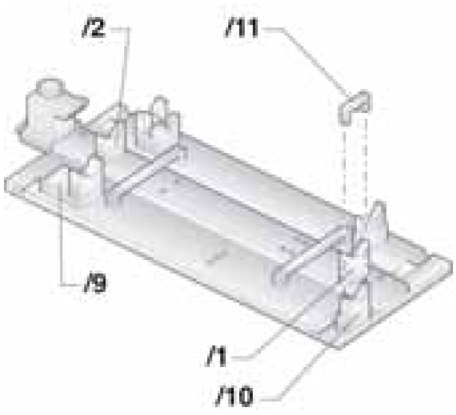
T3359 Rig pin

420_073

T10050 Crankshaft stop

420_074

T40064 **Puller** **T40064/1** **Press tool**



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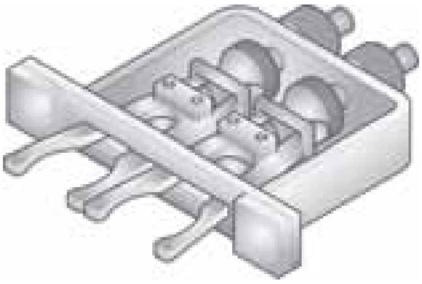
T40094 Camshaft fitting tool
T40094/1 Support
T40094/2 Support
T40094/9 Support
T40094/10 Support
T40094/11 Lock



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T40095 **Holder**

420_105

T40096/1 **Tensioner**

420_106

T40159 **Socket insert with ball head**

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I/VK-35
Service.training@audi.de
Fax +49-841/89-36367

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