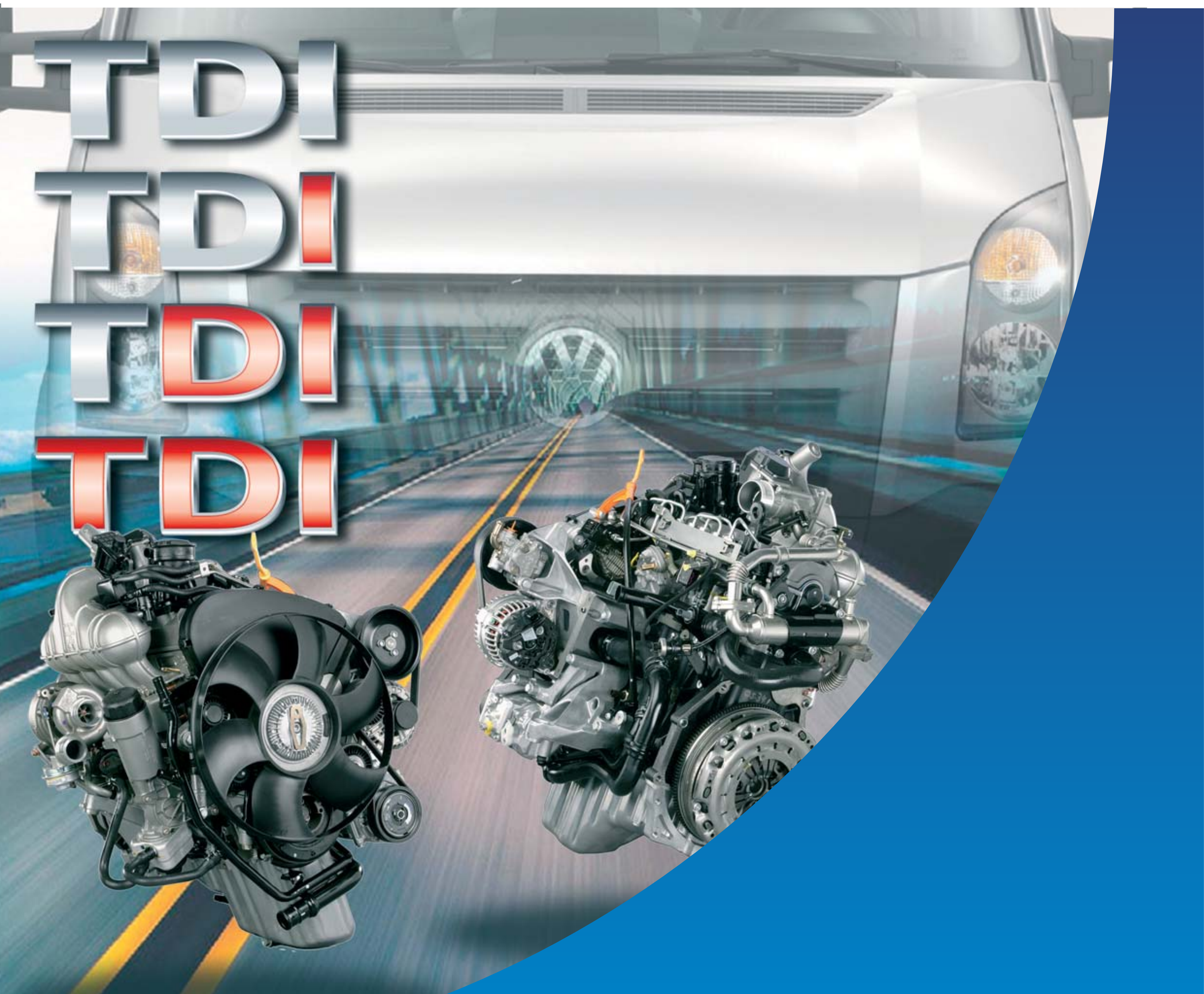
Service Training

Commercial Vehicles

Self-study programme 371

The 2.5l TDI engines in the Crafter

Design and function



For the Crafter from Volkswagen, a new 5-cylinder diesel engine generation with common rail injection system has been developed. This new engine generation is based on the tried and tested 2.5l TDI engine (with sales into the millions) with 5-cylinders and a distributor-type injection pump in the LT2 and Transporter T4.

The emphasis during development was placed on fulfilment of the exhaust emissions and improvement of the engine acoustics and also reduction in operating and repair costs.

In this self-study programme, you can find out about the design and features of this new engine generation.

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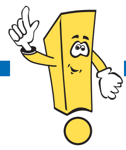
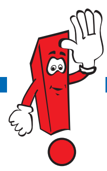
NEW



Caution
Note



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

For latest inspection, adjustment and repair instructions, please refer to the appropriate workshop literature.

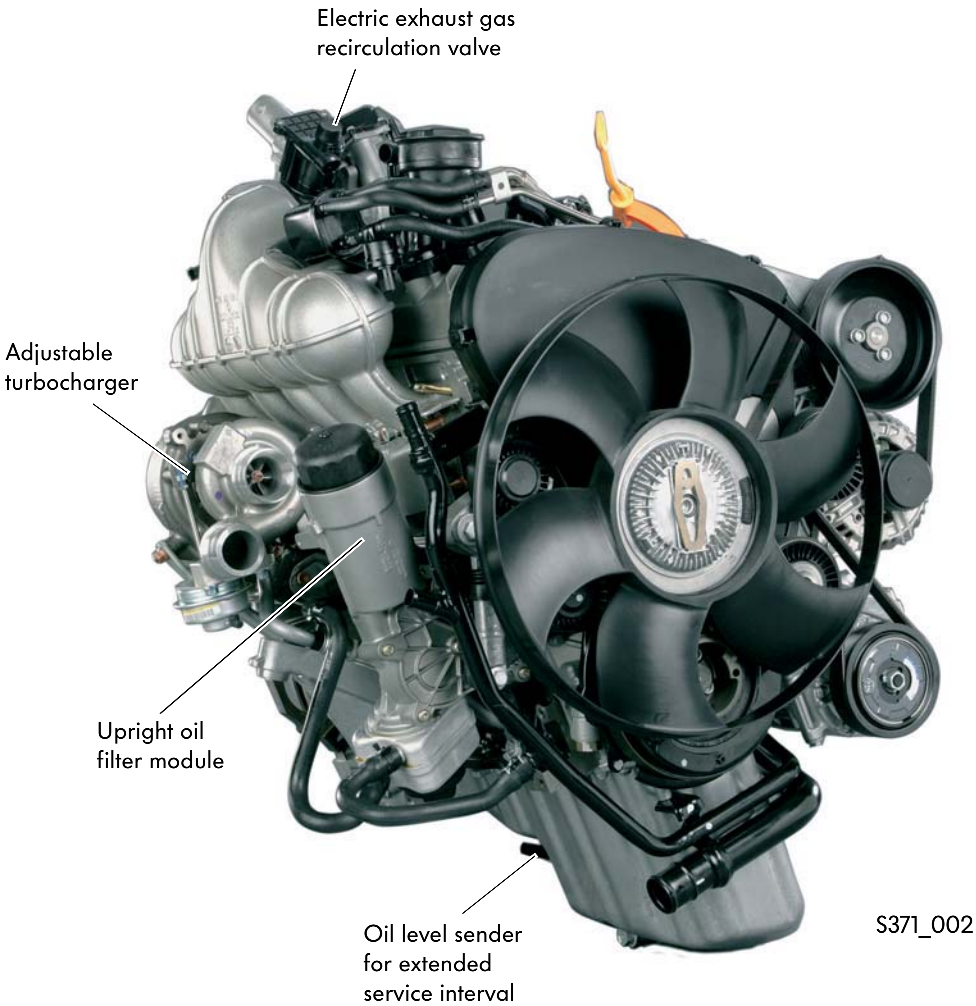
At a glance

Introduction

Installed in the Crafter is the 2.5 l TDI engine in four outputs from 65kW to 120kW. All engine variants are derived from a uniform foundation model, which is based in its geometrical basic dimensions on the tried and tested 5-cylinder TDI engine with distributor-type injection pump from the LT2 and Transporter T4. Depending on the output, they are adapted both in the mechanical configuration and also the engine management system.

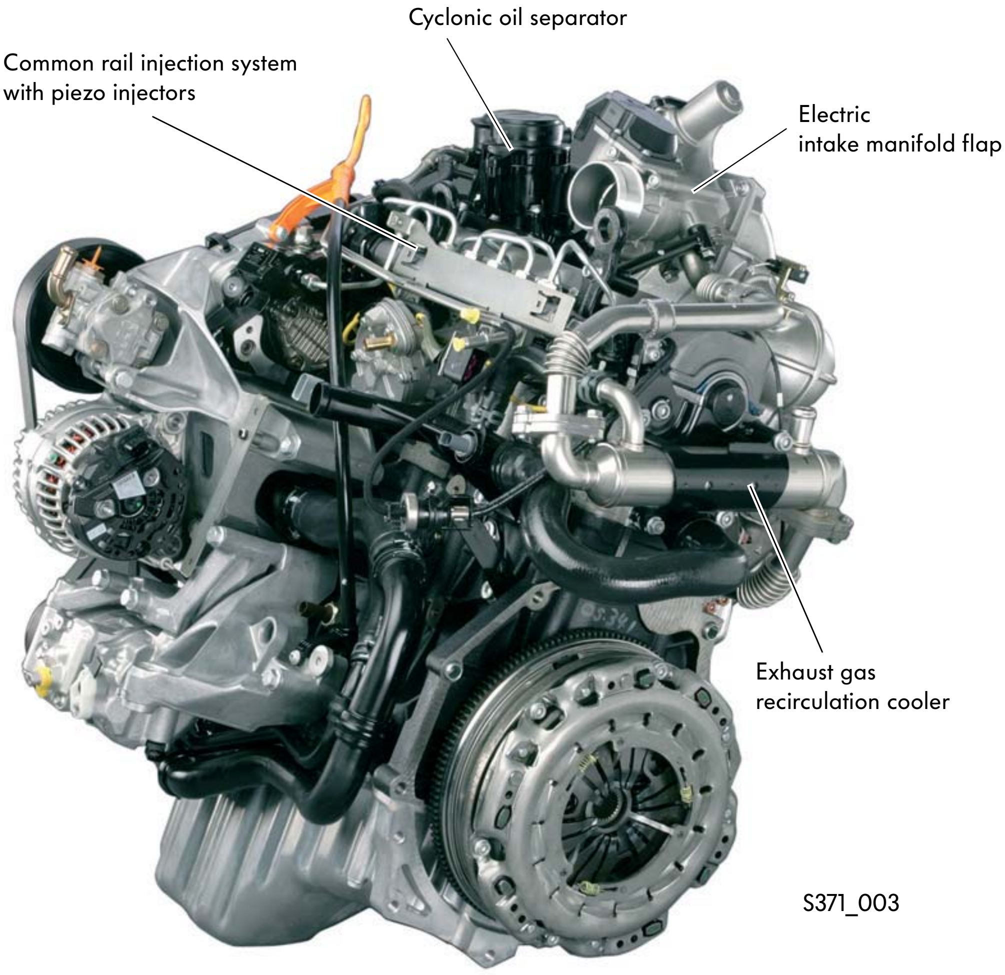
In order to meet the rising demands in output, acoustics, emissions, consumption and extended service intervals, a large number of engine components have been revised. Of particular importance here is the conversion of the engine to common rail injection technology.

Equipped with a catalytic coated diesel particulate filter, all engine variants fulfil the EURO 4/EU4 emissions standard. Engines with EURO 3/EU3 emissions standard have no diesel particulate filter.



Technical features

- Common rail injection system with piezo injectors
- Catalytic coated diesel particulate filter
- Electric intake manifold flap
- Electric exhaust gas recirculation valve
- Exhaust gas recirculation cooler
- Adjustable exhaust gas turbocharger
- Upright oil filter module
- Crankcase breather with cyclonic oil separator
- Oil level sender for extended service interval

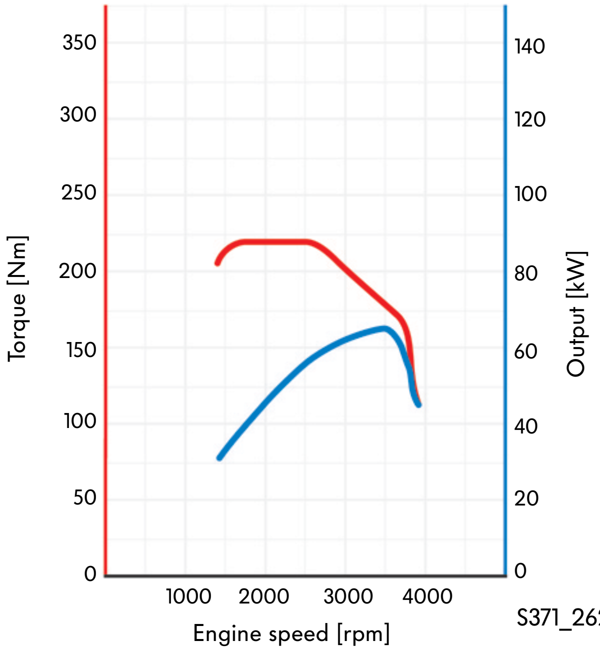


Technical data

The 2.5l 65kW TDI engine

Engine code	BJJ
Type	5-cylinder inline engine
Displacement	2461cm^3
Bore	81.0mm
Stroke	95.5mm
Valves per cylinder	2
Compression ratio	16.8 : 1
Max. output	65kW at 3500 rpm
Max. torque	220 Nm at 2000 rpm
Engine management	Bosch EDC 16 C
Fuel	Diesel with at least 51CN
Exhaust gas treatment	Exhaust gas recirculation with exhaust gas cooler; catalytic coated diesel particulate filter
Emissions standard	EU4/EURO 4

Performance and torque graph



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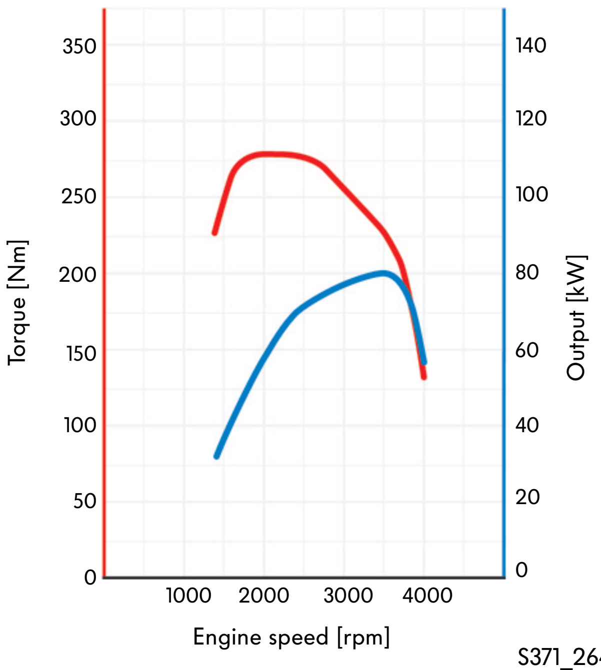
The 2.5l 80kW TDI engine

Engine code	BJK
Type	5-cylinder inline engine
Displacement	2461cm^3
Bore	81.0mm
Stroke	95.5mm
Valves per cylinder	2
Compression ratio	16.8 : 1
Max. output	80kW at 3500 rpm
Max. torque	280 Nm at 2000 rpm
Engine management	Bosch EDC 16 C
Fuel	Diesel with at least 51CN
Exhaust gas treatment	Exhaust gas recirculation with exhaust gas cooler; catalytic coated diesel particulate filter
Emissions standard	EU4/EURO 4 EURO 3/EU3 (without diesel particulate filter and exhaust gas cooler)

Performance and torque graph



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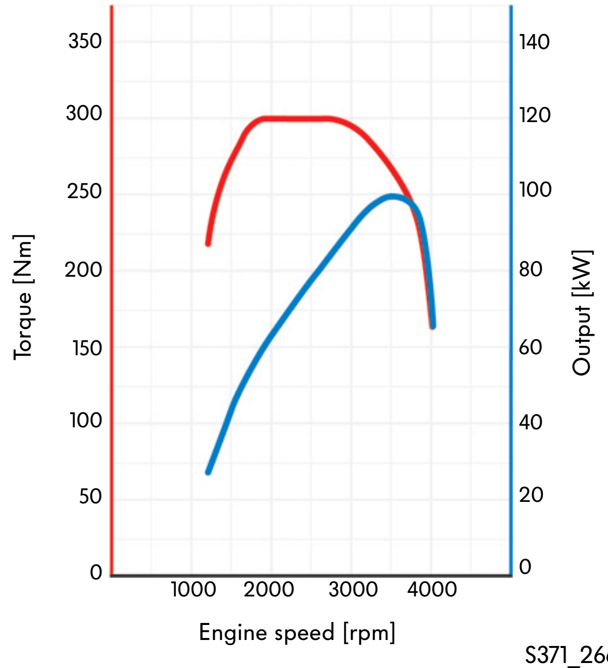
The 2.5l 100kW TDI engine

Engine code	BJL
Type	5-cylinder inline engine
Displacement	2461cm^3
Bore	81.0mm
Stroke	95.5mm
Valves per cylinder	2
Compression ratio	16.8 : 1
Max. output	100 kW at 3500 rpm
Max. torque	300 Nm at 2000 rpm
Engine management	Bosch EDC 16 C
Fuel	Diesel with at least 51CN
Exhaust gas treatment	Exhaust gas recirculation with exhaust gas cooling; catalytic coated diesel particulate filter
Emissions standard	EU4/EURO 4

Performance and torque graph



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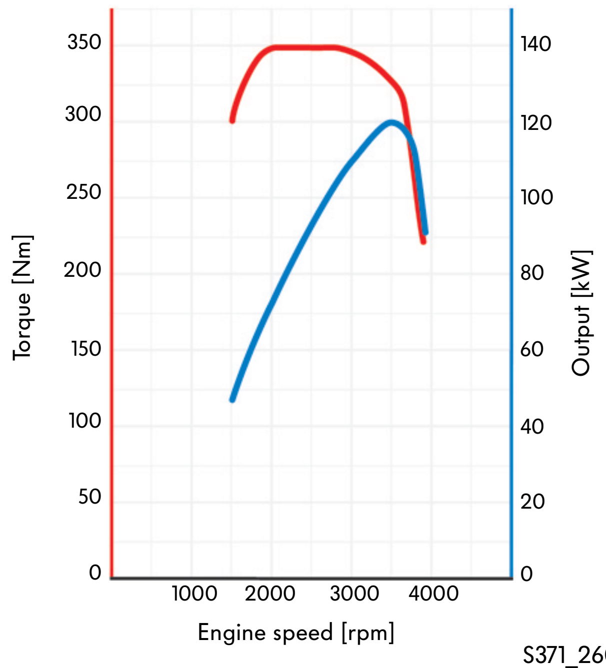
The 2.5l 120kW TDI engine

Engine code	BJM
Type	5-cylinder inline engine
Displacement	2461cm^3
Bore	81.0mm
Stroke	95.5mm
Valves per cylinder	2
Compression ratio	16.8 : 1
Max. output	120 kW at 3500 rpm
Max. torque	350 Nm at 2000 rpm
Engine management	Bosch EDC 16 C
Fuel	Diesel with at least 51CN
Exhaust gas treatment	Exhaust gas recirculation with exhaust gas cooling; catalytic coated diesel particulate filter
Emissions standard	EU4/EURO 4 EURO 3 (without diesel particulate filter)

Performance and torque graph



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The emissions standards

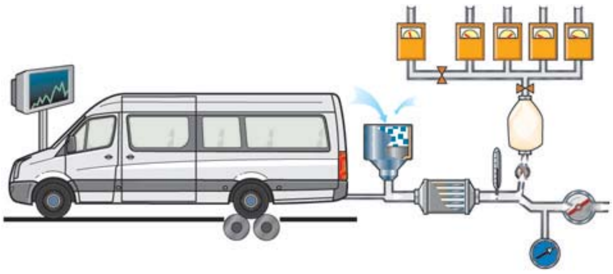
The diesel engine of the Crafter meets the European emissions standards EU4 and EURO 4.
To monitor the exhaust gas relevant components, all vehicles have European onboard diagnosis (EOBD).
EOBD is prescribed in the member states of the European Union for type approval as of 1st January 2006 even for commercial vehicles. In some countries, the 2.5l TDI engine is also offered as a variant with EU3/EURO 3 emissions standard. These engines are not fitted with a diesel particulate filter.

Crafter registered for passenger transportation (emissions standard EU4)

The emissions standard EU4 applies for all vehicles registered for the transportation of passengers, for example a Crafter with up to 9 seats to transport passengers.

For type approval, the exhaust emissions of the vehicles are determined on a test bed or rolling road with a fixed driving cycle and a prescribed method of measurement. The harmful emissions are calculated in grams per kilometre (g/km).

The emissions thresholds shown in the diagram refer to vehicles with a maximum permissible weight > 2.5 t and a kerb weight of > 1.76 t.



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Emissions thresholds for diesel vehicles

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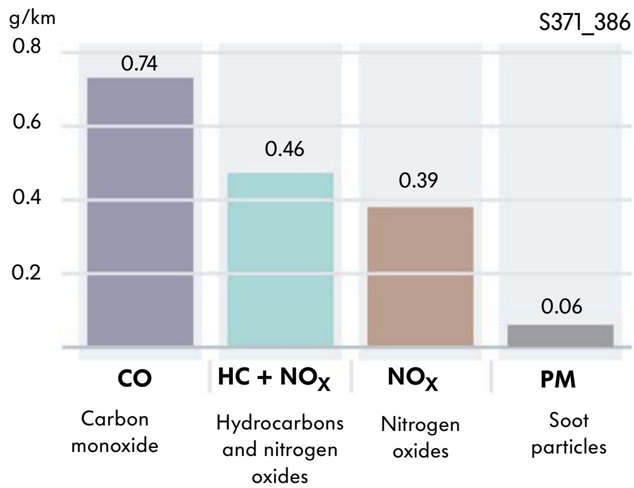
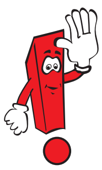
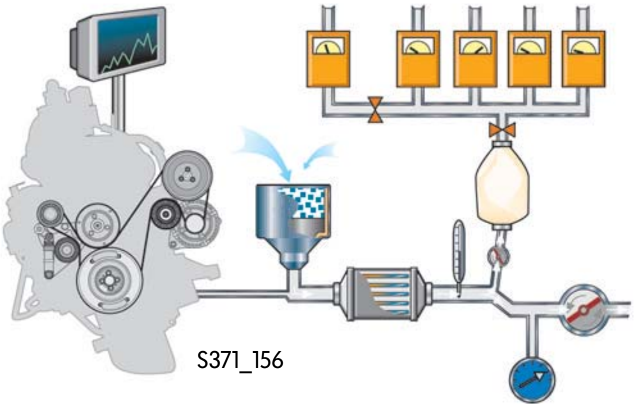




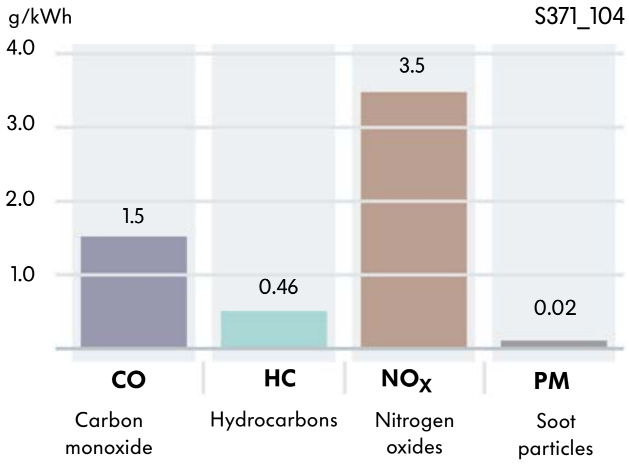
If you require further information about European onboard diagnosis on diesel vehicles, please refer to self-study programme SSP 315 “Euro onboard diagnosis for diesel engines”.

Crafter registered for commercial use (emissions standard EURO 4)



The emissions standard EURO 4 applies for all vehicles registered for commercial use (LCVs, HGVs). In order to restrict the amount of work necessary for type approval of these vehicles on a test bed or rolling road (e.g. for custom body manufacturers), the harmful emissions are determined on an engine performance test bed. This inspection is sub-divided into three test procedures. The harmful emissions are calculated in grams per kilowatt-hour (g/kWh).

Emissions thresholds for ESC test



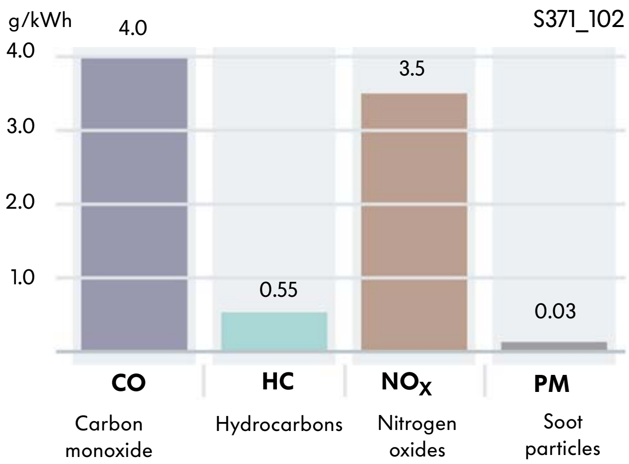
ESC test

The ESC test stands for European Steady Cycle. With this procedure, the gaseous harmful substances and particulate emissions are determined in 13 different operating conditions of the engine.

ELR test

ELR is the abbreviation for European Load Response. With this testing procedure, the smoke opacity is determined in a test cycle as a measurement for the soot particles suspended in the exhaust stream of a diesel engine. The permissible threshold for smoke opacity is 0.5 1tr./m.

Emissions thresholds for ETC test



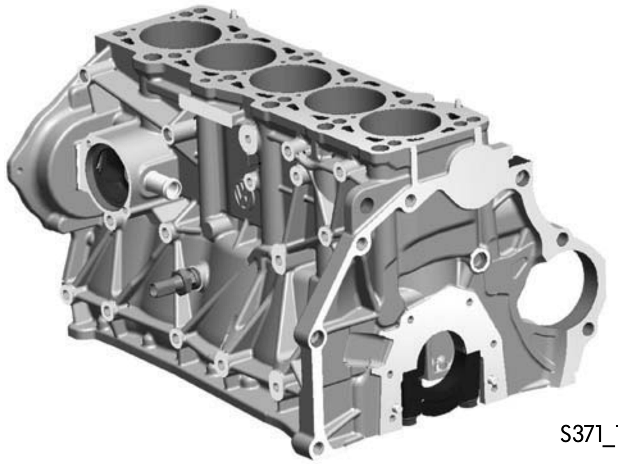
ETC test

ETC means European Transient Cycle.
This test is prescribed for engines equipped with exhaust gas treatment systems, for example a diesel particulate filter. During this test, the exhaust emissions are determined in a test cycle in which the load and speed are calculated for each second.
The test cycle lasts for 1800 seconds.

Engine mechanics

The cylinder block

The cylinder block of the 2.5l TDI engine is made from cast iron with flake graphite. In its basic geometric dimensions it is based on the 2.5 l TDI engine with distributor-type injection. The transmission connection was adapted to the new manual gearbox in the Crafter.



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The crankshaft drive

Crankshaft

Due to the high compression pressures and temperatures, the components of the crankshaft drive system have been altered in many areas compared with the previous engine with distributor-type pump.
The steel crankshaft is die cast and is mounted in six positions. The diameter of the conrod journals has been made larger by 3mm. The load capability of the crankshaft against torsional forces has thereby been improved.

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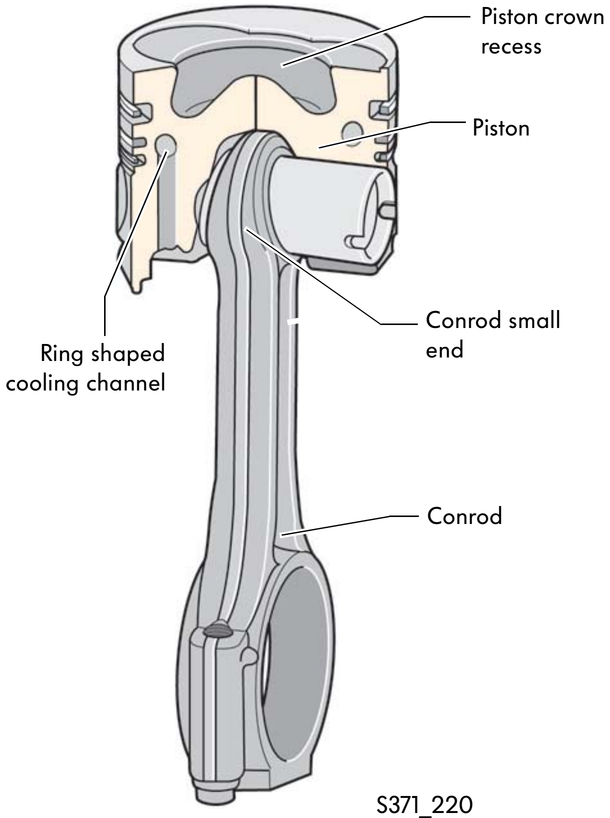
Piston



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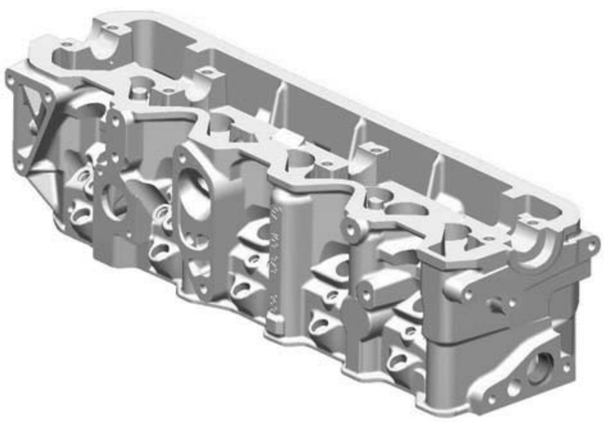
The pistons are manufactured from an aluminium alloy by gravity die casting. Due to the 25° angled fuel injectors, the piston crown recess is positioned asymmetrically in the piston.

The pistons of the engines with performances from 100kW and 120kW have a ring-shaped cooling channel. Oil is sprayed via the oil injectors in the cooling channel to improve cooling of the piston crown.

Connecting rod

The small conrod end has a trapezoidal shape. Thanks to this trapezoidal shape, the combustion pressures are distributed over a large surface area and the conrod and also gudgeon pin are placed under less strain.

The cylinder head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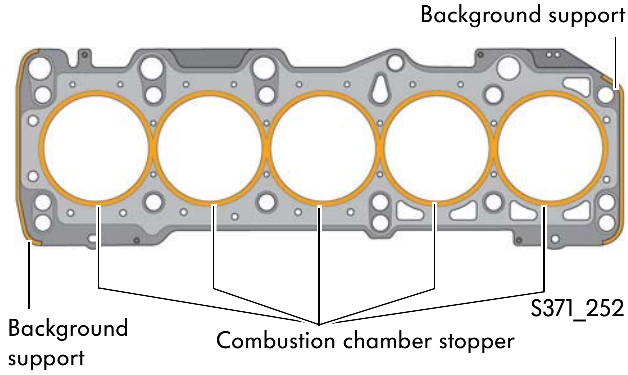
The cylinder head has been revised in some areas compared with the previous engine with distributor-type injection pump. The flow distribution of the coolant has been optimised. The inlet ports have been revised, resulting in improved swirl and flow of the incoming air. The position of the holes for the glow plugs has been adapted to the geometry of the new ceramic glow plugs.

Engine mechanics

Cylinder head gasket

A newly designed cylinder head gasket reduces the distortion of the cylinder head and the cylinder holes. In this way, sealing of the combustion chambers has been improved.
The cylinder head gasket has a 5-layer structure and features two special characteristics:

- Height-profiled combustion chamber stopper
- “Background support”



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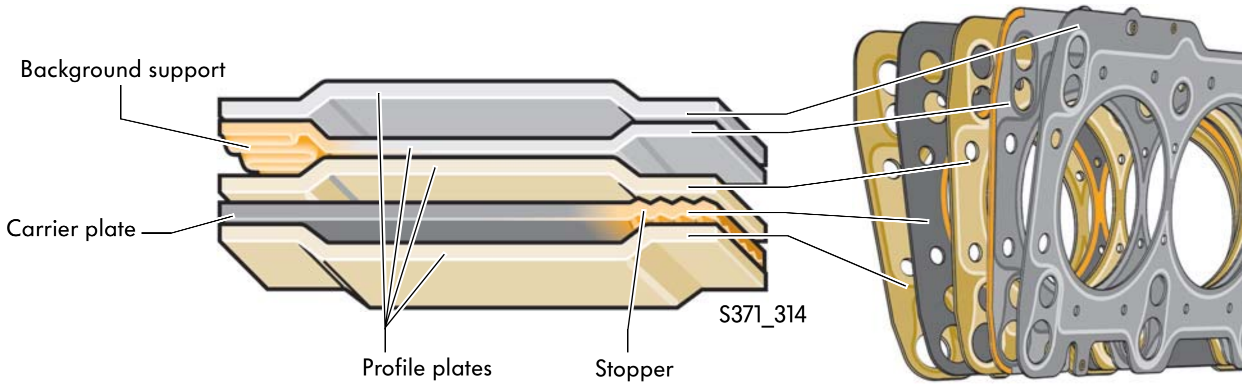
Schematic diagram of cylinder head gasket cross section



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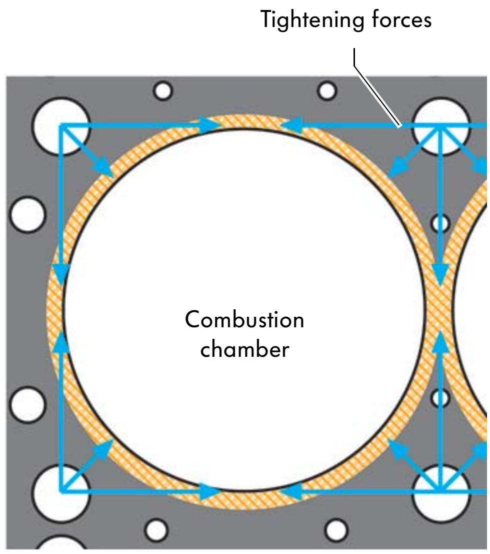
Height-sectioned combustion chamber stopper

Combustion chamber stopper refers to the sealing edge on the cylinder head bore. It has a height-profiled design. This means that the edge profile along the combustion chamber has different heights.
Thanks to this special forming, an equal distribution of the tightening forces is achieved on the combustion chambers. Distortions at the cylinder bores and any occurring vibrations in the sealing gaps are thereby reduced.



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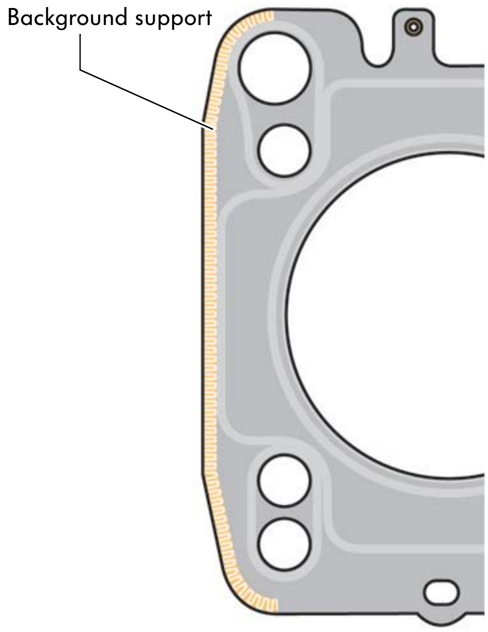
“Background support”



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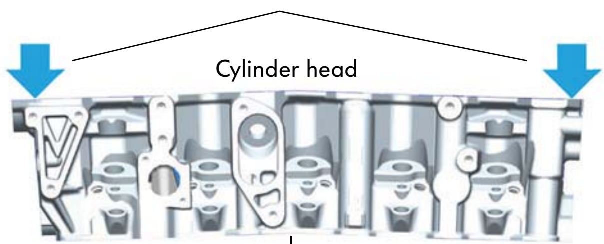
Background support refers to the profile in the area of both outer cylinders of the cylinder head gasket. The background support results in an equal distribution of the tightening forces in these areas. In this way, bending of the cylinder head and distortion of the outer cylinders is reduced.

Distribution of tightening forces without background support



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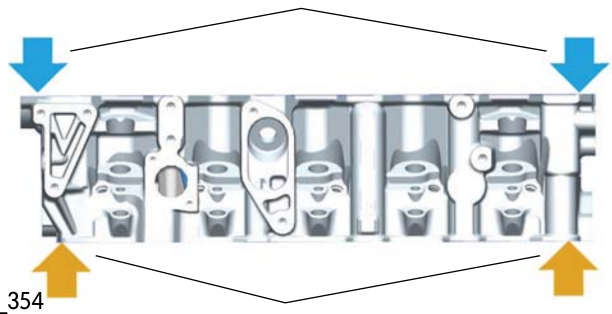
Distribution of tightening forces with background support



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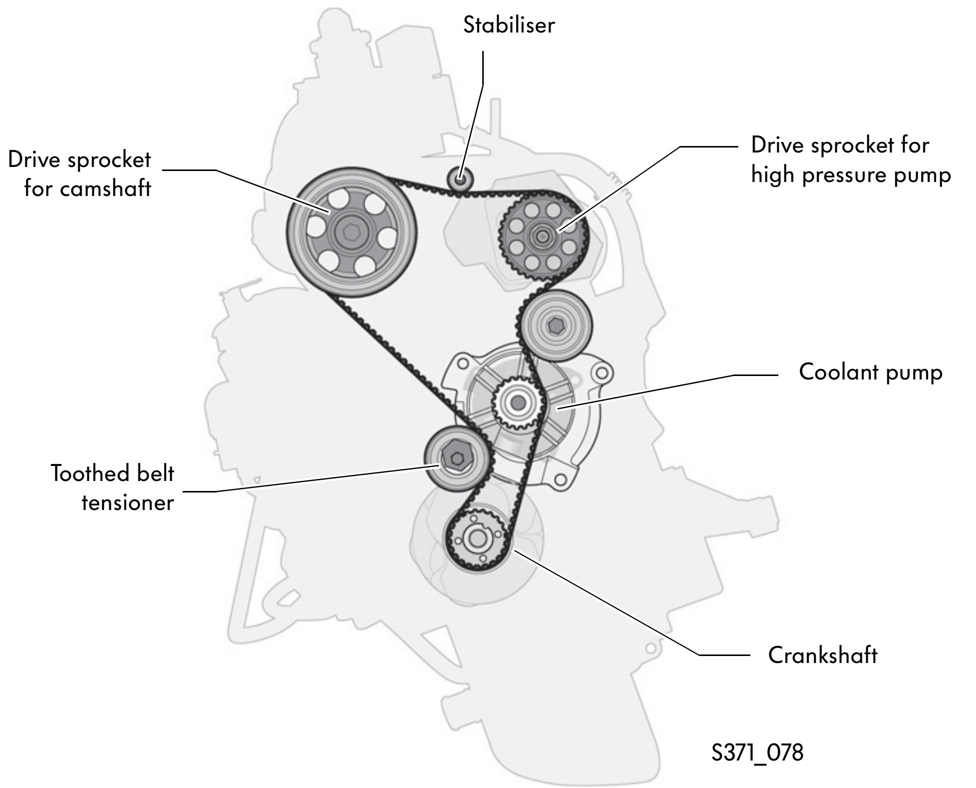
The outer cylinder head bolts generate higher tightening forces due to the smaller contact surface of the cylinder head. This leads to greater pressure of the cylinder head gasket and thereby bending of the cylinder head. This bending subsequently causes distortion at the outer cylinder holes.

With the background support, the greater edge pressure of the cylinder head gasket is brought under control so the cylinder head is bent less. Thanks to this improvement, the tightening force distribution at the outer combustion chamber stoppers has been optimised. In addition, overall movement of the cylinder head during engine operation has been reduced.

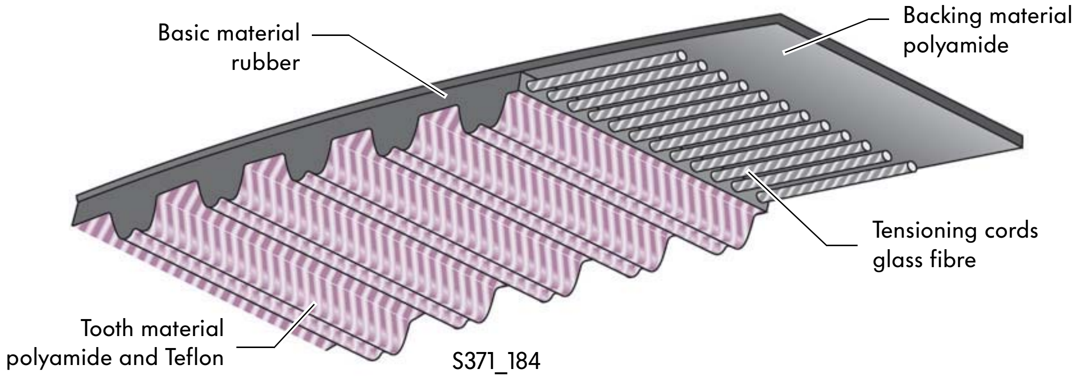
The toothed belt drive

Driven via the toothed belt are the camshaft, the coolant pump and the high pressure pump for the common rail injection system.



Toothed belt

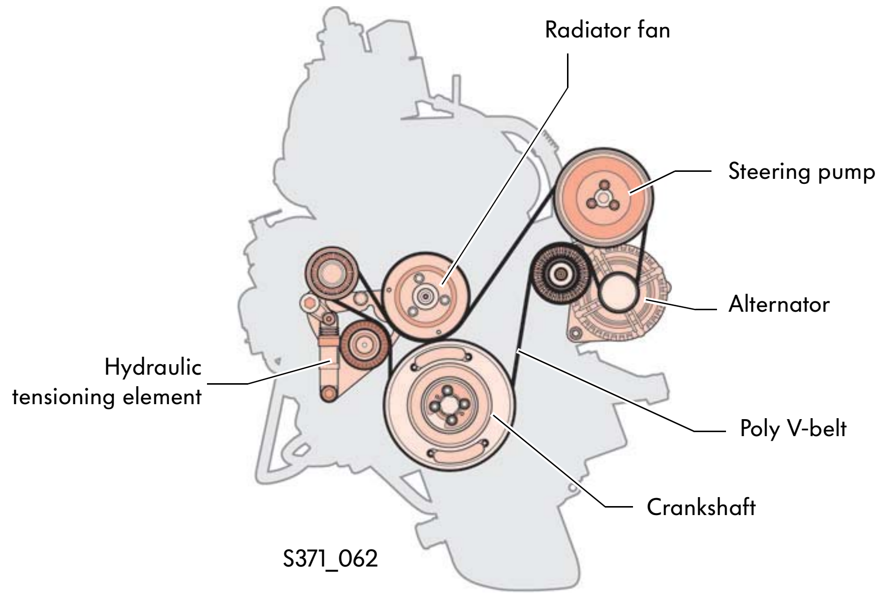
Compared with the previous engine with distributor-type injection pump, the resistance to wear of the toothed belt has been markedly improved. The 26mm broad toothed belt features a polyamide material backing, which reduces wear of the toothed belt edges. The tooth material is also polyamide with an added polytetrafluoroethylene (Teflon) wear guard.



Ancillary equipment drive

The ancillary equipment is driven by the crankshaft via a poly V-belt.
The poly V-belt is held under constant pretension by means of a hydraulic tensioning system and is maintenance-free. In the belt drive system, the radiator fan, the steering assistance pump and the alternator are driven via the poly V-belt. There is also an option for an air conditioning compressor or second alternator to be integrated in this belt drive system.

Belt drive



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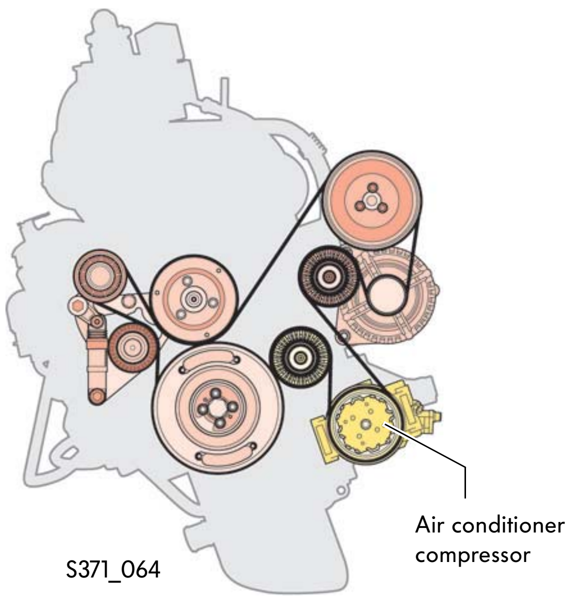
Belt drive with air conditioner compressor



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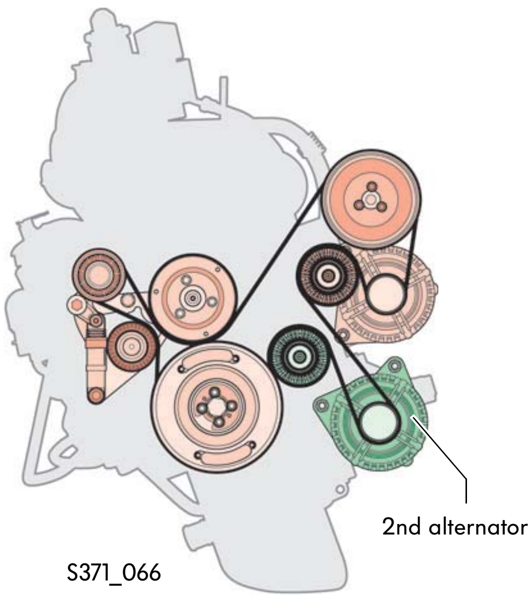
Belt drive with 2nd alternator



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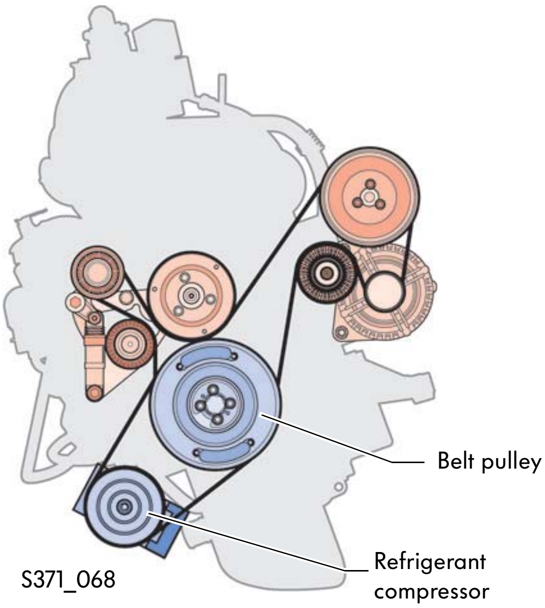
Engine mechanics

Additional ancillary equipment

As an option, drive of the ancillary equipment can also be extended by a further ancillary drive unit. If required, a refrigerant compressor for a body with cooling system or a hydraulic pump can be driven by the belt pulley of the vibration damper via an additional poly V-belt.

Belt drive with ancillary drive for refrigerant compressor



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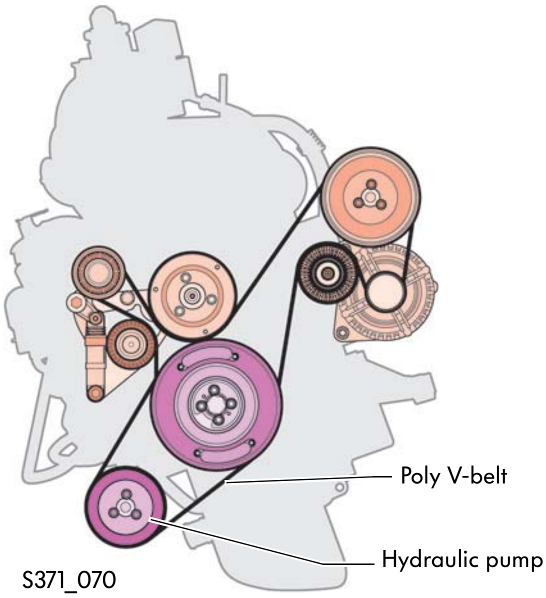
Belt drive with ancillary drive for hydraulic pump



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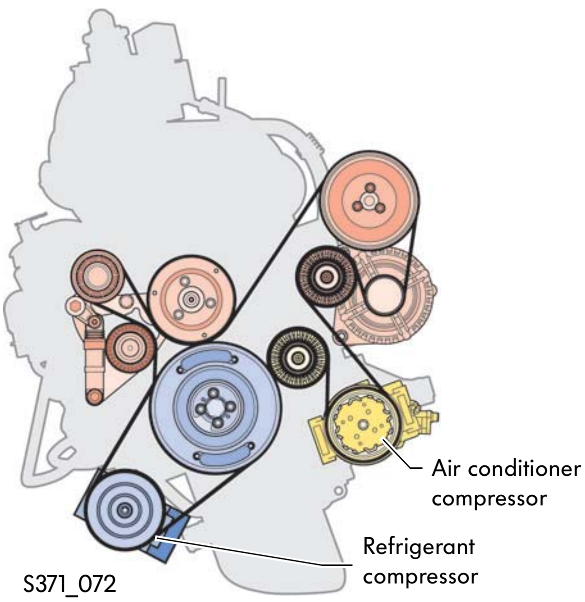
Belt drive with air conditioner compressor and ancillary drive for refrigerant compressor



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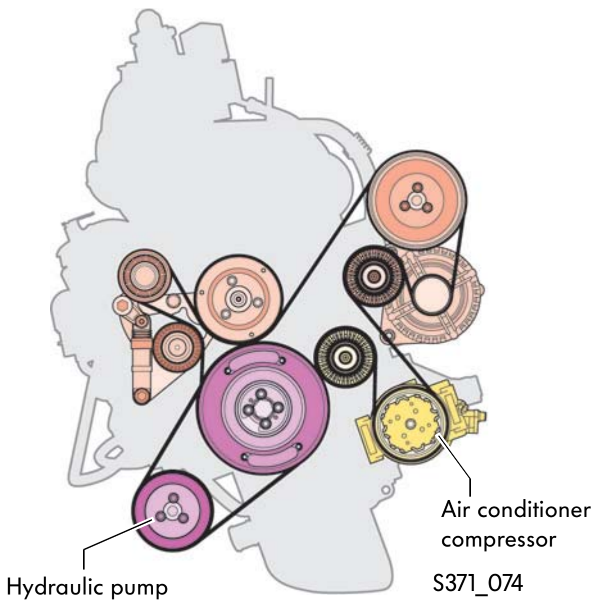
Belt drive with air conditioner compressor and ancillary drive for hydraulic pump



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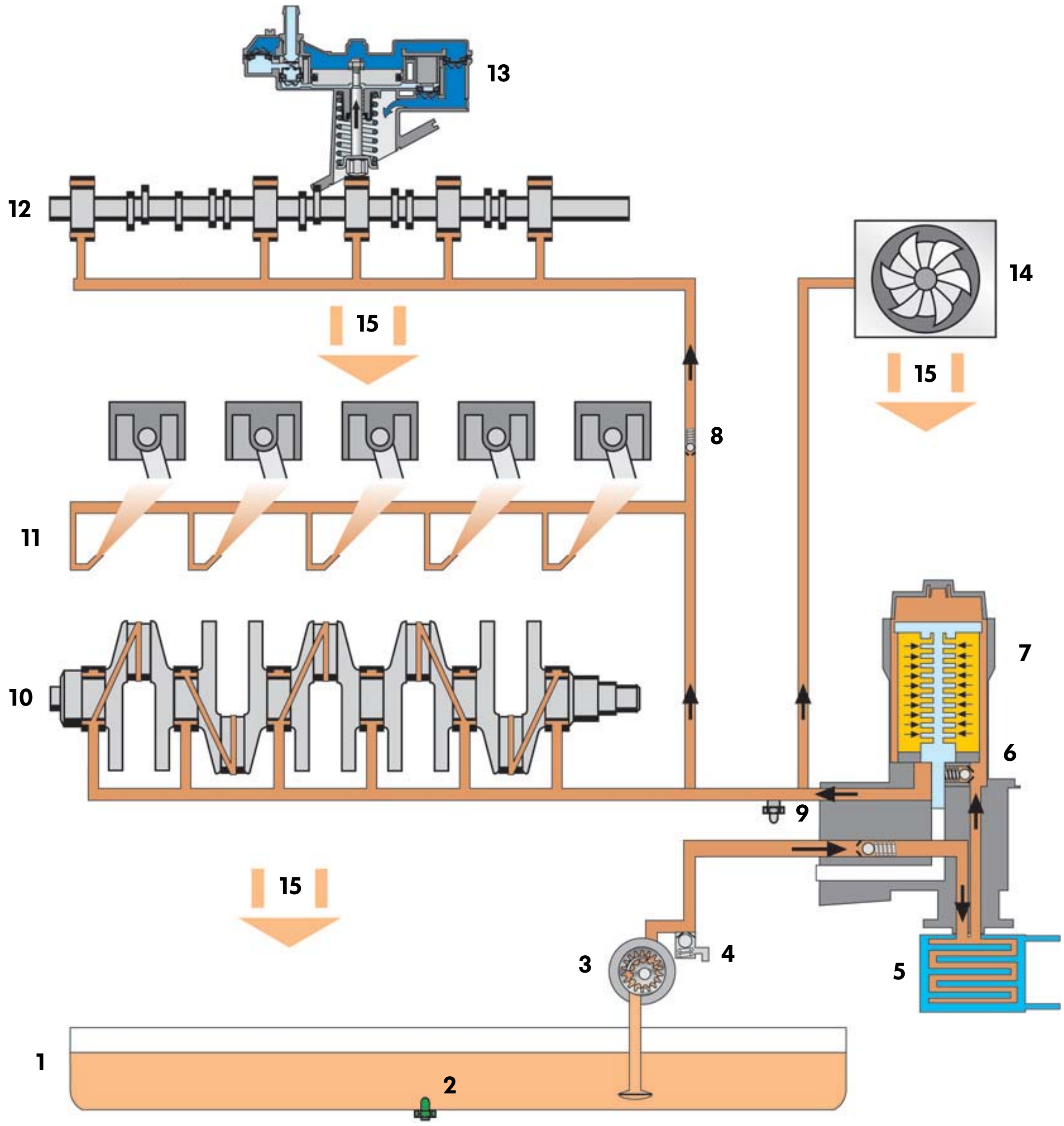
The oil circuit

Oil pressure is generated as on the previous engine by a self-priming crescent pump. It is bolted to the front of the cylinder block and is driven directly by the crankshaft. The pressure relief valve prevents components from becoming damaged as a result of excessive oil pressure. In the event of a blocked oil filter, the by-pass valve opens and thereby safeguards oil supply to the engine. The oil pressure retension valve assures lubrication of the valve drive.



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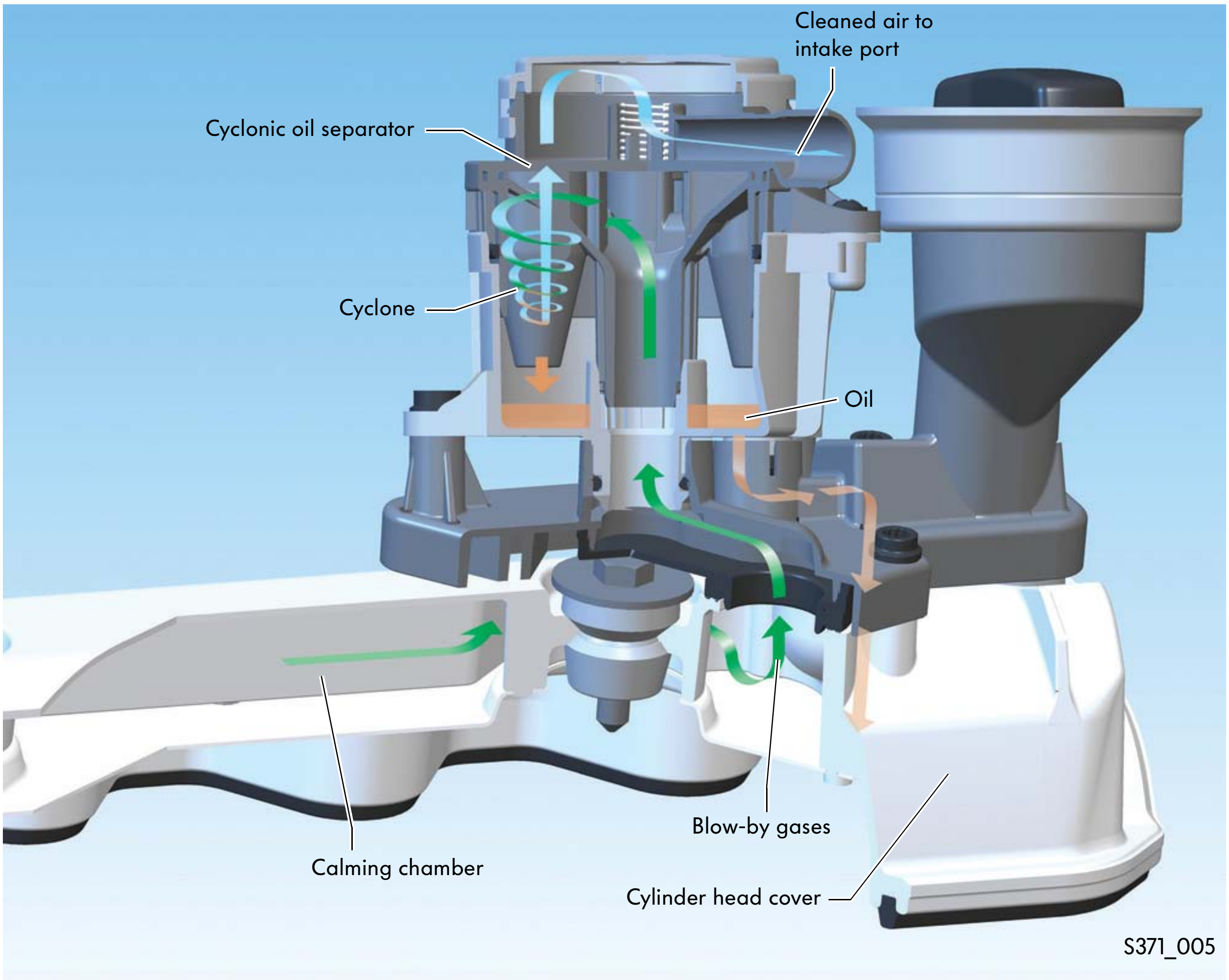
Key

1 - Oil sump
2 - Oil level and oil temperature sender G266
3 - Oil pump
4 - Oil pressure relief valve
5 - Oil cooler
6 - By-pass valve
7 - Oil filter
8 - Oil pressure retension valve
9 - Oil pressure switch F1
10 - Crankshaft
11 - Spray jets for piston cooling
12 - Camshaft
13 - Vacuum pump
14 - Turbocharger
15 - Oil return

The crankcase breather



On internal combustion engines, pressure differences between the combustion chamber and crankcase cause air to flow between the piston rings and the cylinder path, otherwise known as blow-by gases. To avoid placing undue strain on the environment, these oil-rich gases are recirculated back to the intake area via the crankcase breather.

On the cylinder head cover there is a cyclonic oil separator. It separates the oil contained in the gases from the air. The oil is fed back to the oil sump via a channel in the crankcase.

Coarse separation

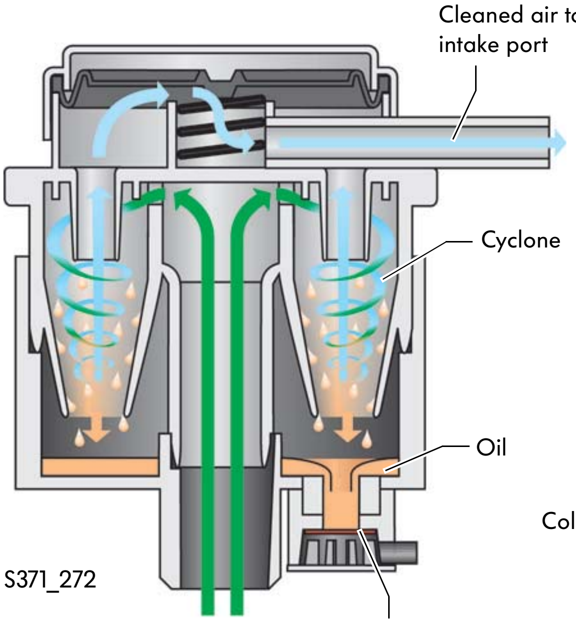
The blow-by gases make their way from the crankshaft and camshaft area into a calming chamber. This is integrated in the cylinder head cover. In the calming chamber, larger droplets of oil are separated onto the walls and then collect on the floor. The oil can then drop into the cylinder head via the openings of the calming chamber.

Fine separation

Fine separation is carried out via a cyclonic oil separator, which consists of three cyclones. Due to the shape of the cyclones, the air is caused to rotate. The centrifugal force that is caused as a result forces the atomised oil against the separator wall. The oil droplets are separated on the housing wall of the cyclonic oil separator and are collected in a collection chamber.

When the engine is stationary, a reed valve opens that is closed when the engine is running by higher pressure in the cylinder head.
The oil makes its way from the collection chamber back to the oil sump via the cylinder head.

Cyclonic oil separator during engine operation



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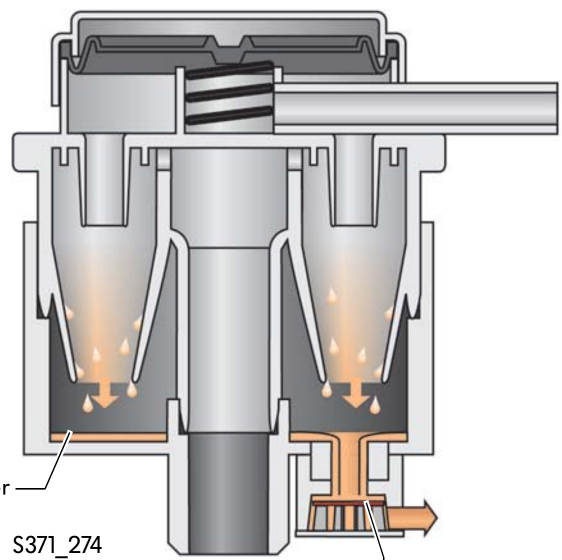
Cyclonic oil separator when engine is stationary



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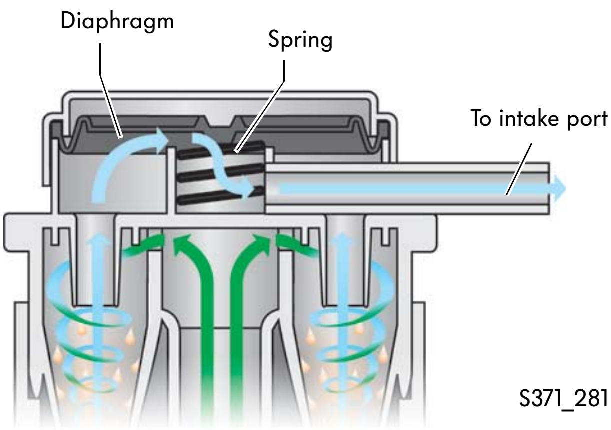
Pressure control valve

The pressure control valve can be found in the cover of the cyclonic oil separator. It comprises of a diaphragm and a spring and controls the pressure for ventilation of the crankcase.

On induction of blow-by gases, the pressure control valve restricts vacuum in the crankcase.
If vacuum pressure is too great in the crankcase, the engine gaskets and seals could become damaged.

Pressure control valve open



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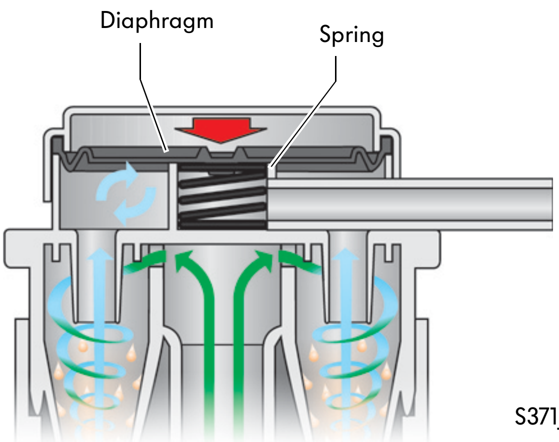
If vacuum pressure is low in the intake port the valve opens by spring pressure.

Pressure control valv closed



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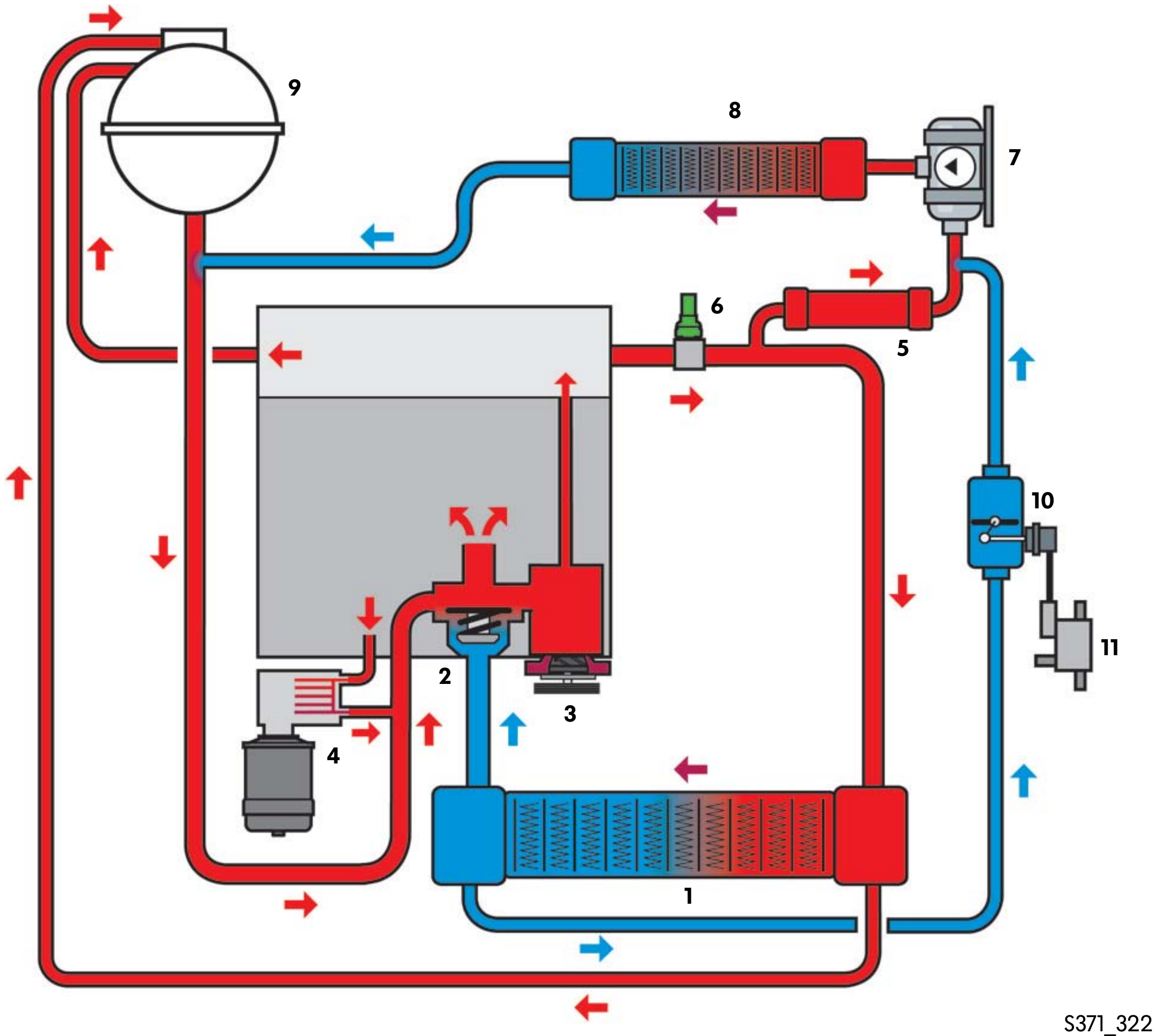
If vacuum pressure is great in the intake port the pressure control valve closes.

The coolant circuit

In the coolant circuit the coolant is circulated by a mechanical coolant pump. It is driven by the toothed belt. The circuit is controlled by an expansion thermostat. An electric pump, the pump for coolant run-on, serves to circulate the coolant for the enhanced features of residual heat utilisation and coolant run-on.



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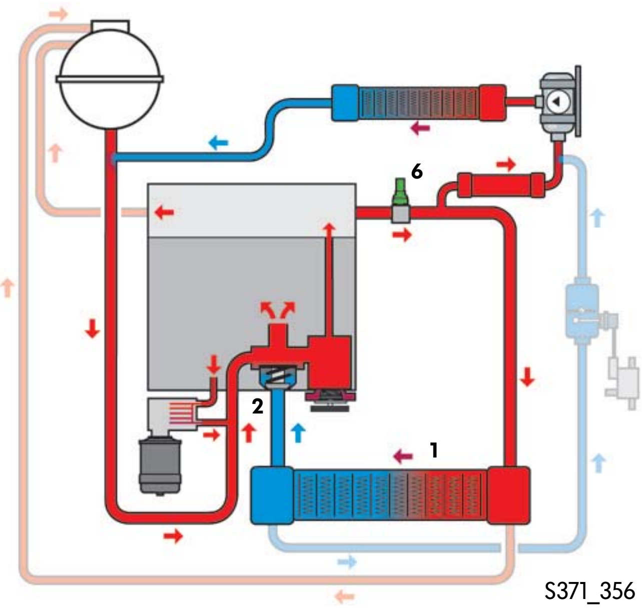
Key

1 - Radiator for engine coolant circuit
2 - Coolant regulator/thermostat
3 - Coolant pump
4 - Oil cooler
5 - Exhaust gas recirculation cooler
6 - Coolant temperature sender G62
7 - Coolant circulation pump V50
8 - Heat exchanger for heater
9 - Expansion tank
10 - Vacuum valve for coolant run-on
11 - Coolant circuit valve N214

Functions of coolant circuit

To warm up the engine quickly the thermostat [2] is closed and thereby seals return from the radiator [1]. At a coolant temperature from approx. 87°C the thermostat opens the large coolant circuit via the radiator. The coolant temperature is transmitted by the coolant temperature sender G62 [6] to the engine control unit.



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Enhanced features of coolant circuit

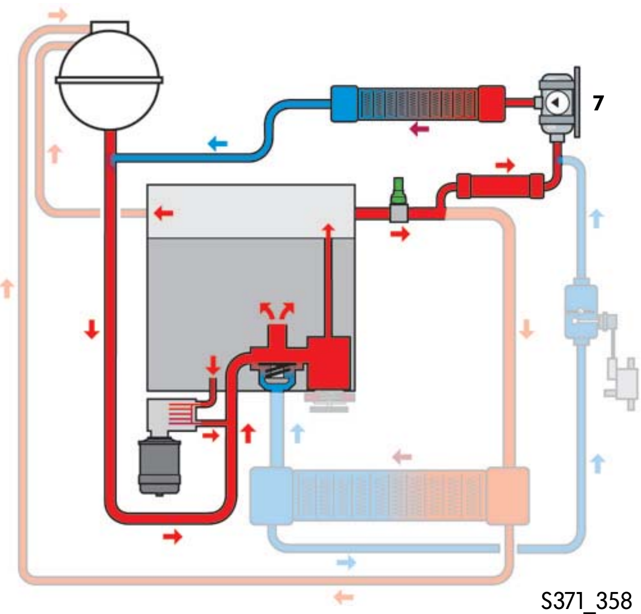
In addition to cooling the engine and the provision of heat for the vehicle heater, the cooling circuit has additional functions.

Residual heat utilisation

Residual heat utilisation makes it possible for the desired temperature in the passenger compartment to be maintained even when the engine is switched off. This is possible providing the coolant temperature is sufficiently high enough.

Function

For the residual heat function, the coolant circulation pump V50 [7] is actuated by the engine control unit in order to maintain the volumetric flow in the coolant circuit. If there is no longer enough residual heat, the air conditioning control unit switches the residual heat function off.



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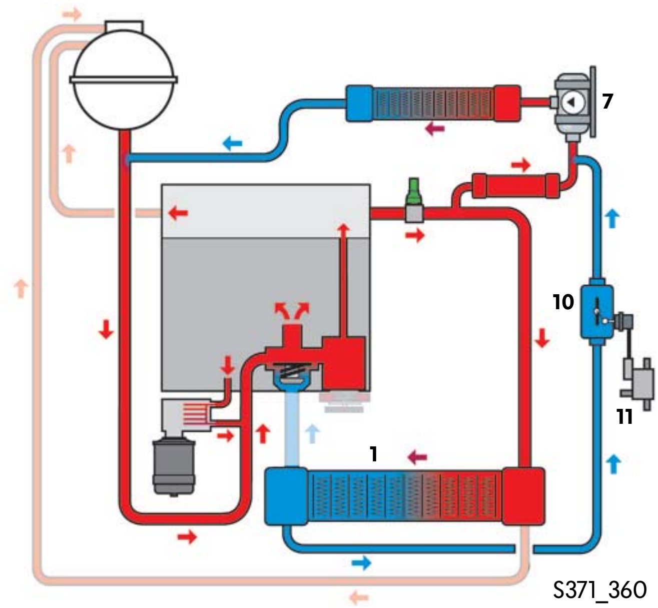
Coolant run-on



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The coolant run-on is a protective system for the engine. It prevents vapour locks forming in areas of the cylinder head when the engine is switched off. The function becomes active if the coolant temperature is more than 105°C after the engine has been switched off and the vehicle was driven in the previous driving cycle with a respectively high load.

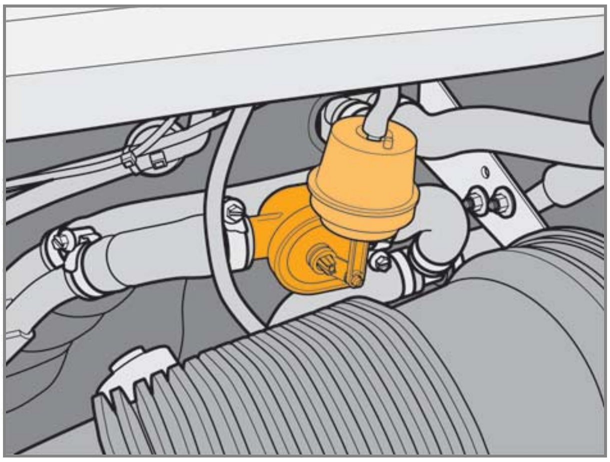
Function

For the function of the coolant run-on, the coolant circulation pump V50 [7] and the coolant circuit valve N214 [11] are actuated by the engine control unit. The coolant circuit valve N214 opens the coolant run-on vacuum valve [10]. In this way, cold water from the radiator [1] is added to the circuit. The cylinder head is thus cooled equally and quickly and vapour lock is avoided.

Coolant run-on vacuum valve

The coolant run-on vacuum valve is a mechanical-pneumatic valve. It is switched to the OPEN and CLOSED position by the coolant circuit valve N214 by vacuum pressure.

When unenergised, the vacuum valve is open.
When the engine is running, it is closed by the engine control unit via the coolant circuit valve N214.
To utilise the residual heat function when the engine is switched off, the vacuum valve is held closed by a non-return valve in the vacuum system.



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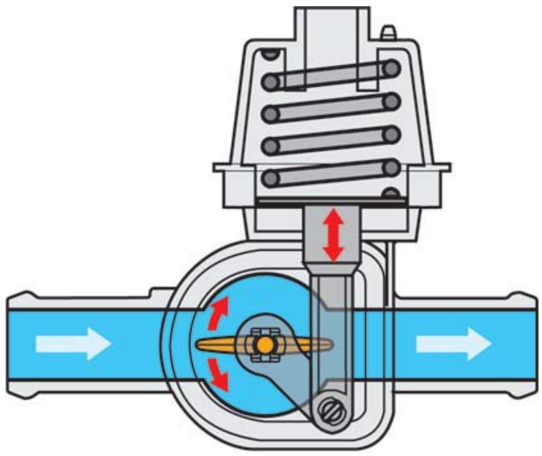

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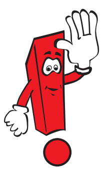
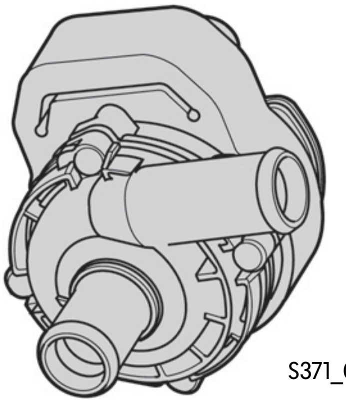


A defective vacuum valve or a defect in the associated vacuum system can lead to poor heater output and higher emissions of harmful substances during the starting and warm-up phase, particularly in winter. Because in this case cold water is still added to the heating circuit, despite the thermostat being closed, the engine has an insufficient warm-up phase.
Furthermore, a poor residual heat output can be an indication of a defect in the vacuum valve or the associated vacuum system.

Coolant circulation pump V50



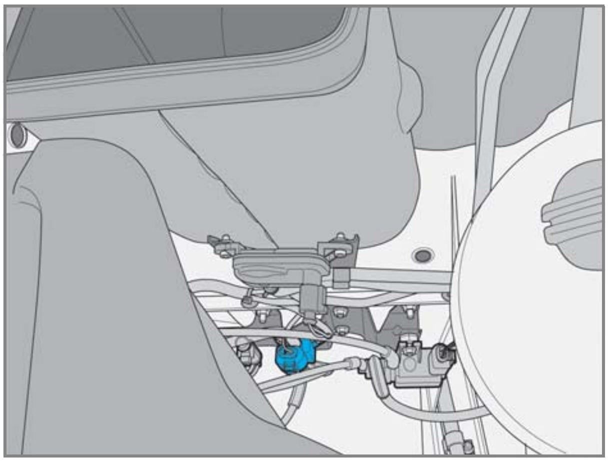
S371_026

The coolant circulation pump is an electrically driven pump that, when required, is actuated via the coolant run-on relay J151 by the engine control unit or the air conditioning control unit.

It fulfils the following roles:

- To support passenger compartment heating, the coolant circulation pump provides sufficient circulation of the coolant in the heating circuit.
- For the residual heat utilisation and coolant run-on functions, the pump assures recirculation of the coolant in the cooling circuit.

Coolant circuit valve N214



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The coolant circuit valve is an electro-pneumatic valve and can be found in the engine compartment above the right-hand vehicle side member.
It switches the vacuum to actuate the vacuum valve for coolant run-on.

Effects of failure

In the event of failure of the coolant circuit valve, the vacuum valve for coolant run-on cannot be closed after the engine has been started. This can lead to poor heater output during the start and warm-up phase and an increase in harmful emissions. Since in this case cold water is still added to the heater circuit despite the thermostat being closed, the engine has an insufficient warm-up phase.

The fuel system

Fuel supply pump G [2]
Continually delivers fuel to supply system.

Fuel filter heater Z57 [4]
Protects the filter from crystallising paraffins at low ambient temperatures.

Fuel temperature sender G81 [6]
Measutres the current fuel temperature.

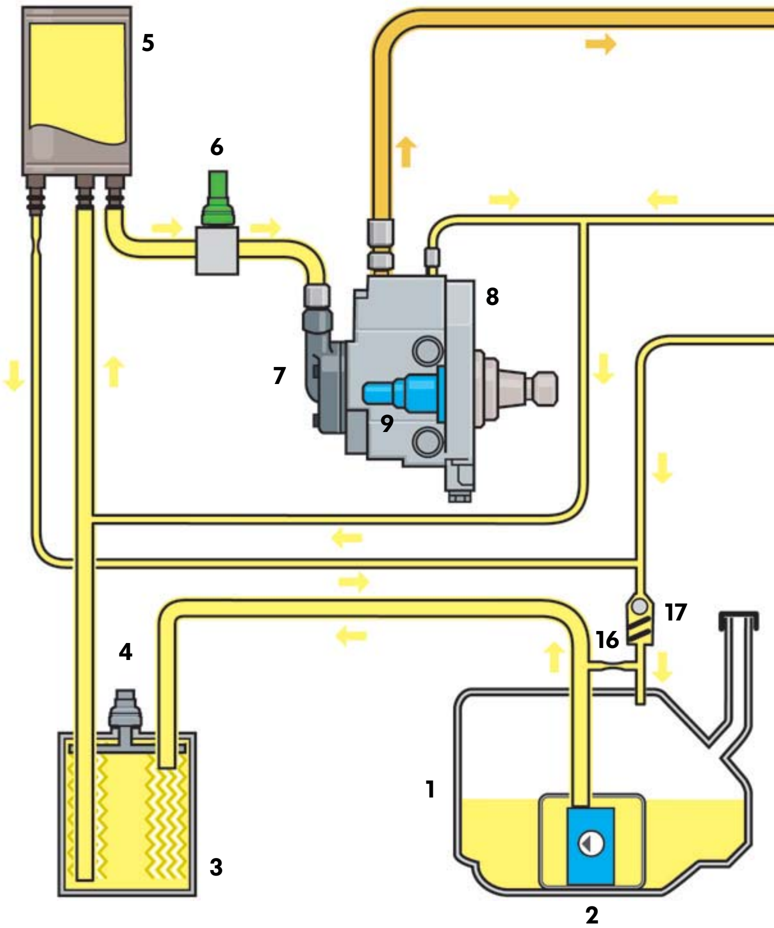
Mechanical gear-type pump [7]
Delivers fuel from supply system to the high pressure pump.

High pressure pump [8]
Generates high fuel pressure necessary for injection.

Fuel metering valve N290 [9]
Regulates the amount of fuel to be compressed based on requirement.

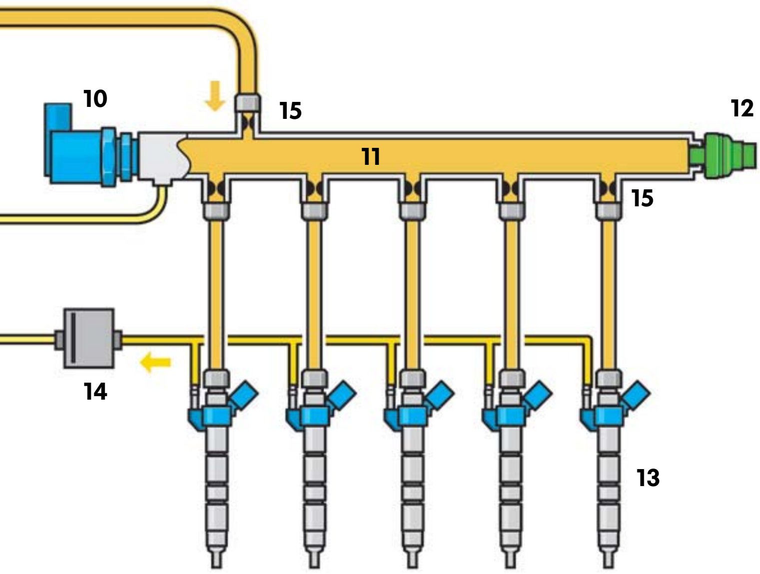
Fuel pressure control valve N276 [10]
Regulates the fuel pressure in the high pressure range.

High pressure accumulator (rail) [11]
Stores the fuel for all cylinders under high pressure as required for injection.



Key

1 - Fuel tank
2 - Electric fuel pump G6
3 - Fuel filter
4 - Fuel filter heater Z 57
5 - Fuel accumulator
6 - Fuel temperature sender G81
7 - Mechanical gear-type pump
8 - High pressure pump
9 - Fuel metering valve N290



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Colour coding/key

High pressure 230 – 1600 bar

Return pressure from injectors 10 bar

Supply pressure / return pressure

10 - Fuel pressure control valve N276
11 - High pressure accumulator (rail)
12 - Fuel pressure sender G247
13 - Injectors N30, N31, N32, N33, N83
14 - Pressure retension valve
15 - Restrictors
16 - Overflow
17 - Non-return valve

Fuel pressure sender G247 [12]
Measures the current fuel pressure in the high pressure range

Pressure retension valve [14]
Maintains the return pressure from the injectors at approx. 10 bar. This pressure is required for the injectors to function.

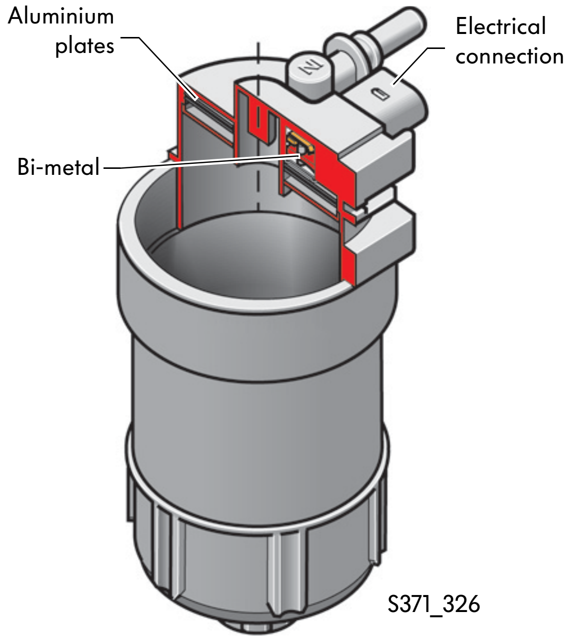
Restrictors [15]
Dampen pressure waves in the high pressure system that are caused during the injection sequence by opening and closing of the nozzles.

Overflow [16]
Thanks to the overflow from the fuel supply to the fuel return, the fuel pressure is regulated before the filter. When the delivery volume is high from the fuel supply pump G6, the fuel can flow back in the tank via the overflow.

Non-return valve [17]
Prevents fuel from entering the fuel system from the fuel supply pump G6 via the return, for example if the fuel filter is blocked.

Fuel filter

The fuel filter protects the injection system from contamination and wear from particles and water. Integrated in the fuel filter is an electric heater. This heats up the fuel in the filter at low ambient temperatures. In this way, action is taken to prevent crystallising paraffins building up in the fuel filter at low ambient temperatures.



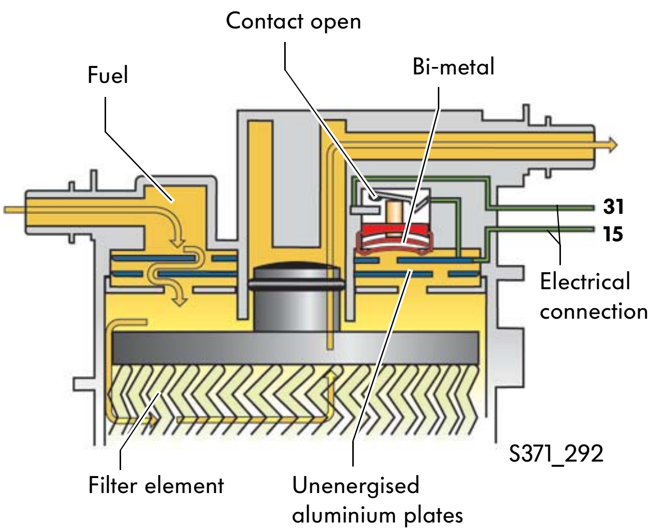
Fuel filter heater Z51

The fuel filter heater Z51 comprises of two aluminium plates and a bi-metal contact switch.

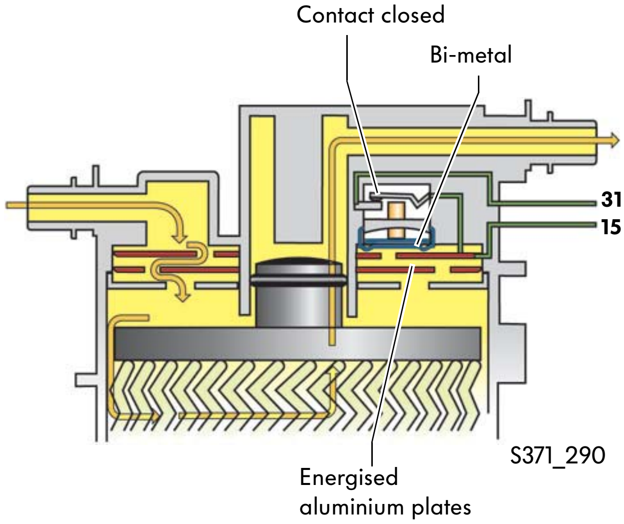
At warm temperatures, the bi-metal contact switch is in a state of rest. The electric contact is open. In this way, no current flows to activate the fuel filter heater.

At a temperature of approx. +3°C to +8°C the bi-metal contact closes. The fuel filter heater is energised and the fuel is heated up by the aluminium plates in the fuel filter.

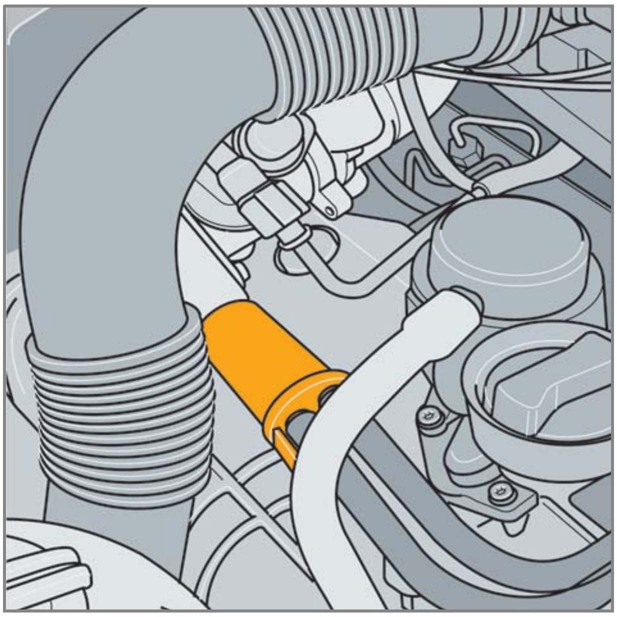
Heater off



Heater on



Fuel accumulator



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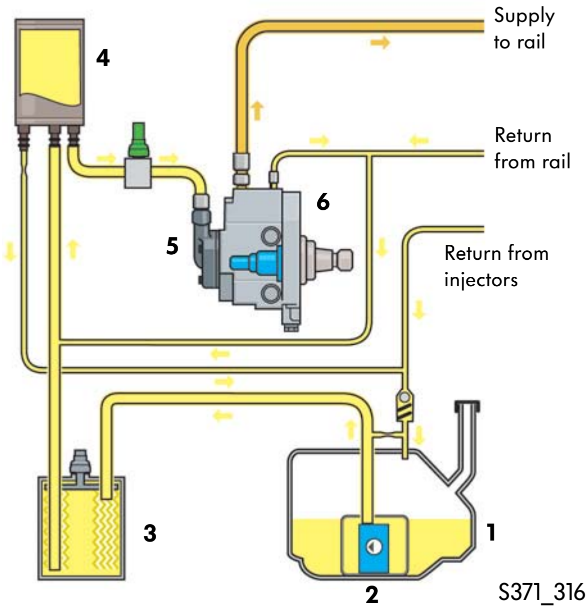

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Key

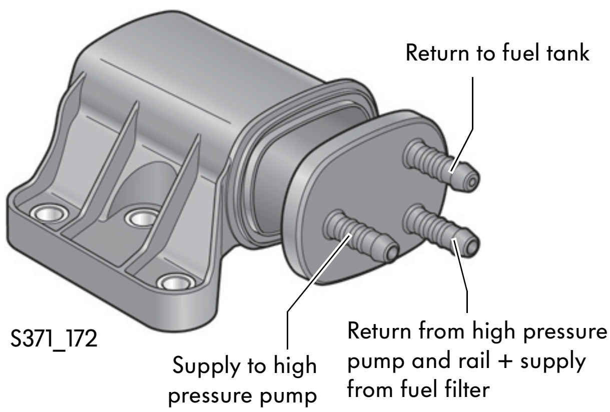
1 - Fuel tank
2 - Fuel supply pump G6
3 - Fuel filter
4 - Fuel accumulator
5 - Mechanical gear-type pump
6 - High pressure pump

The fuel accumulator is located on the engine above the exhaust manifold. It assures that the fuel pressure before the gear-type pump is near enough the same in all operating conditions.
The constant pressure level means that a good starting and idling response is achieved.

Function

The fuel delivered by the fuel supply pump G6 is fed to the fuel accumulator. From there is makes its way to the gear-type pump.
To balance out pressure deviations, the excess fuel in the fuel accumulator is fed back into the fuel return system.

The fuel return from the high pressure pump and the high pressure accumulator (rail) is fed in the fuel supply to the fuel accumulator. In the fuel accumulator, the warm fuel from the high pressure pump and the rail mixes with the cold fuel from the fuel supply. This results in the fuel heating up quickly in cold weather conditions and thereby for a good warm-up response of the engine.



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Engine mechanics

The common rail injection system

All 2.5 l TDI engines in the Crafter are equipped with a common rail injection system.
This is a high pressure accumulator injection system for diesel engines. The term “common rail” means that the high fuel pressure accumulator or rail is common for all the injectors of one cylinder bank.

Pressure generation and fuel injection are separated from each other on this injection system.
A separate high pressure pump generates the high pressure necessary for injection. It is stored or accumulated in a high pressure accumulator (rail) and makes its way via short injector lines to the injectors. The injection system is regulated by the Bosch EDC 16 C engine management system.

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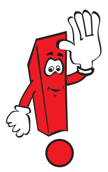
The properties of this injection system are:

- The injection pressure is able to be selected practically without restriction and can be adapted to the relevant operating status of the engine.
- A high injection pressure of up to maximum 1600 bar allows good mixture formation.
- A flexible injection pattern with several pilot and post injections
- Low fuel consumption
- Low harmful emissions
- Smooth engine running

The common rail injection system offers many means of configuration to adapt the injection pressure and the injection sequence to the operating status of the engine.

In this way, it is well setup to meet the rising demands on an injection system for low fuel consumption, low harmful emissions and smooth engine running.



The principle of operation of the common rail injection system with piezo injectors is described in self-study programme SSP 351 “The common rail injection system of the V6 TDI engine”.