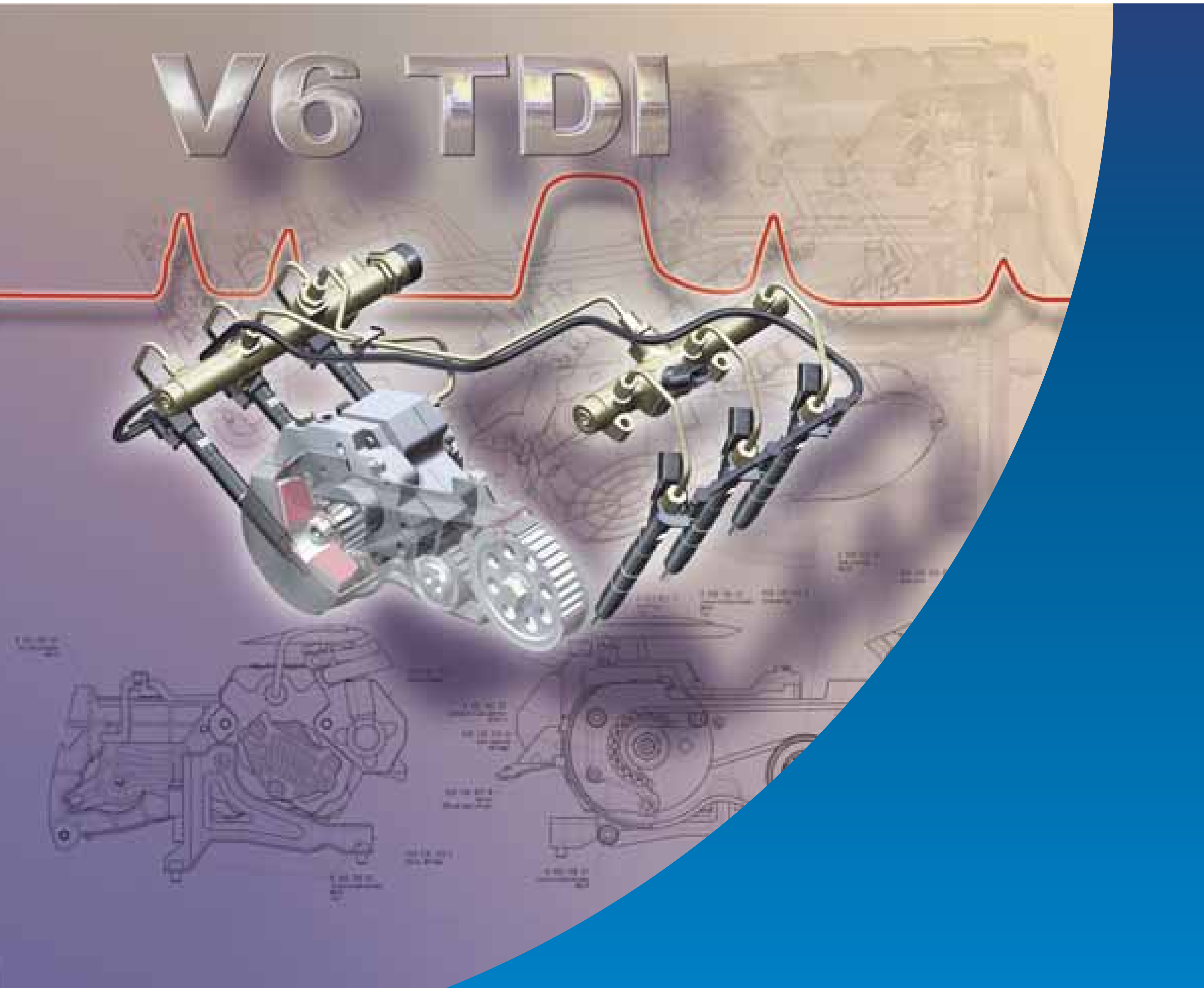
Service Training

Self-study Programme 351

The common rail fuel injection system fitted in the 3.0l V6 TDI engine

Design and Function

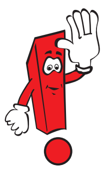


S351_003

The constant increase in requirements pertaining to low fuel consumption, low exhaust emissions and smooth running characteristics make extensive demands on a diesel engine fuel injection system.
These requirements can only be met by a fuel injection system which injects the fuel into the cylinders at high pressure, precisely controls injection and is able to structure the injection process by means of several pilot and secondary injection processes.

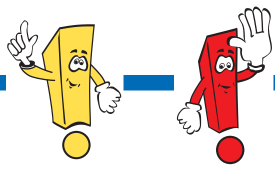
The technology implemented in the piezo-controlled common rail fuel injection system enables highly-flexible adaptation of the injection process to the engine's operating statuses.

This self-study programme provides information on the way in which the piezo-controlled common rail fuel injection system fitted in the 3.0l V6 TDI engine functions.



A description of the 3.0l V6 TDI engine can be found in self-study programme 350 "The 3.0l V6 TDI engine".

NEW



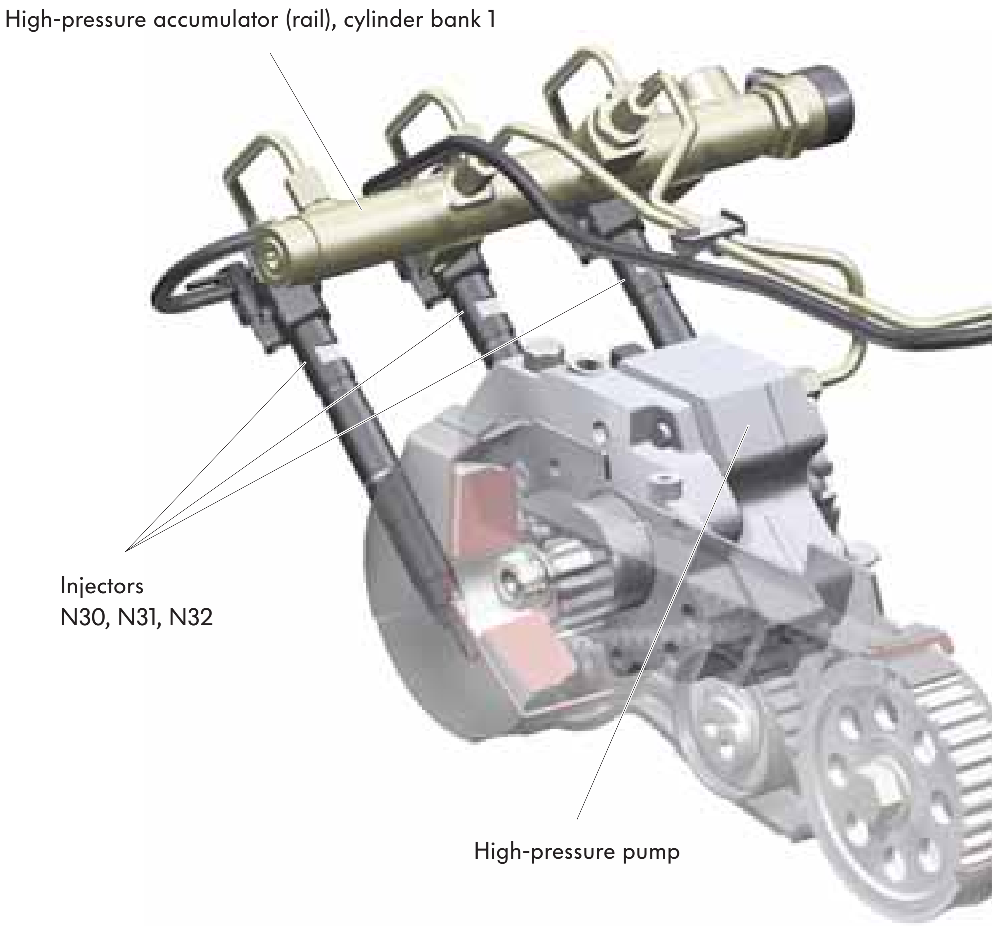
Important Note

Contents

Common rail fuel injection system

The 3.0l V6 TDI engine fitted in the Phaeton and Touareg is equipped with a common rail fuel injection system for mixture preparation.
The common rail fuel injection system is a high-pressure accumulator fuel injection system for diesel engines.
The term "common rail" means that all of one cylinder bank's injectors have a common, high-pressure fuel accumulator.

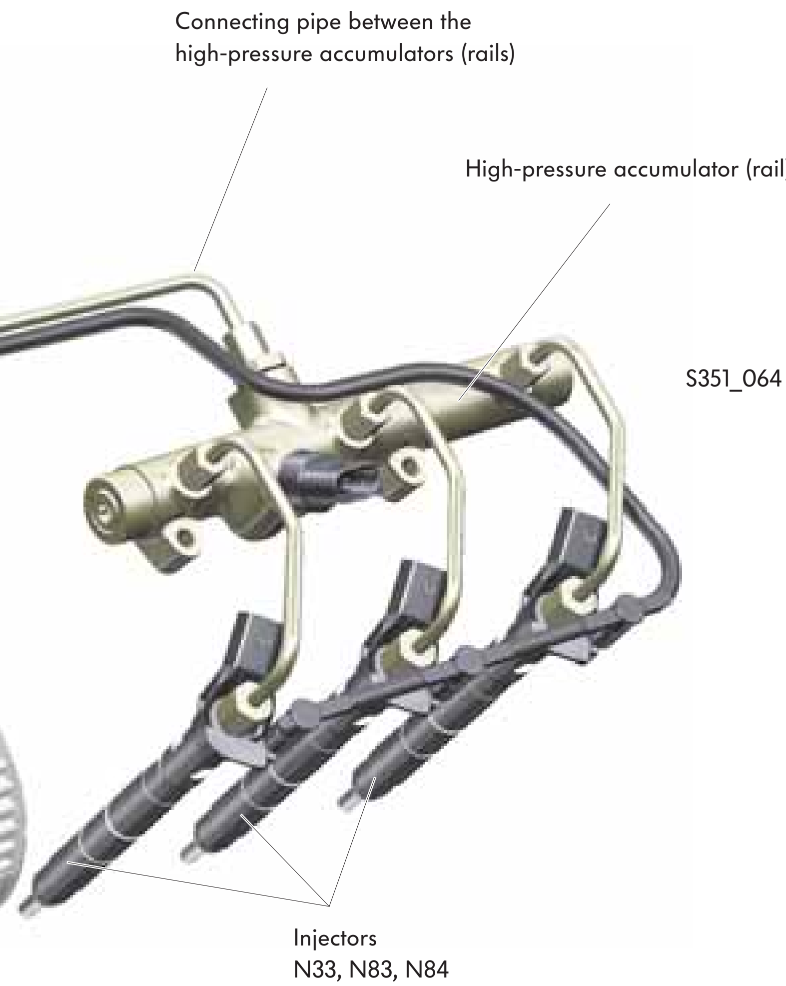
In this injection system, pressure generation and fuel injection are separate. The high pressure required for injection is generated by a separate high-pressure pump. This fuel pressure is stored in a high-pressure accumulator (rail) and is made available to the injectors via short injector pipes.
The common rail fuel injection system is controlled by the Bosch EDC 16 CP engine management system.



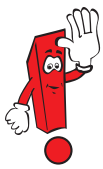
This fuel injection system's characteristics include:

- The injection pressure can be selected almost infinitely and can be adapted to the engine's relevant operating status.
- A high injection pressure up to a maximum of 1600 bar enables optimal mixture formation.
- A flexible fuel injection process, with several pilot and secondary injection processes.

The common rail fuel injection system offers many options for adapting the injection pressure and the injection process to the engine's operating status.
It therefore offers very good prerequisites for meeting the constant increase in requirements pertaining to low fuel consumption, low exhaust emissions and smooth running characteristics.



S351_064



Injectors are also referred to as injection valves in the specialist literature. Due to the electrical component designation in the repair literature, they are called injectors in the self-study programme.

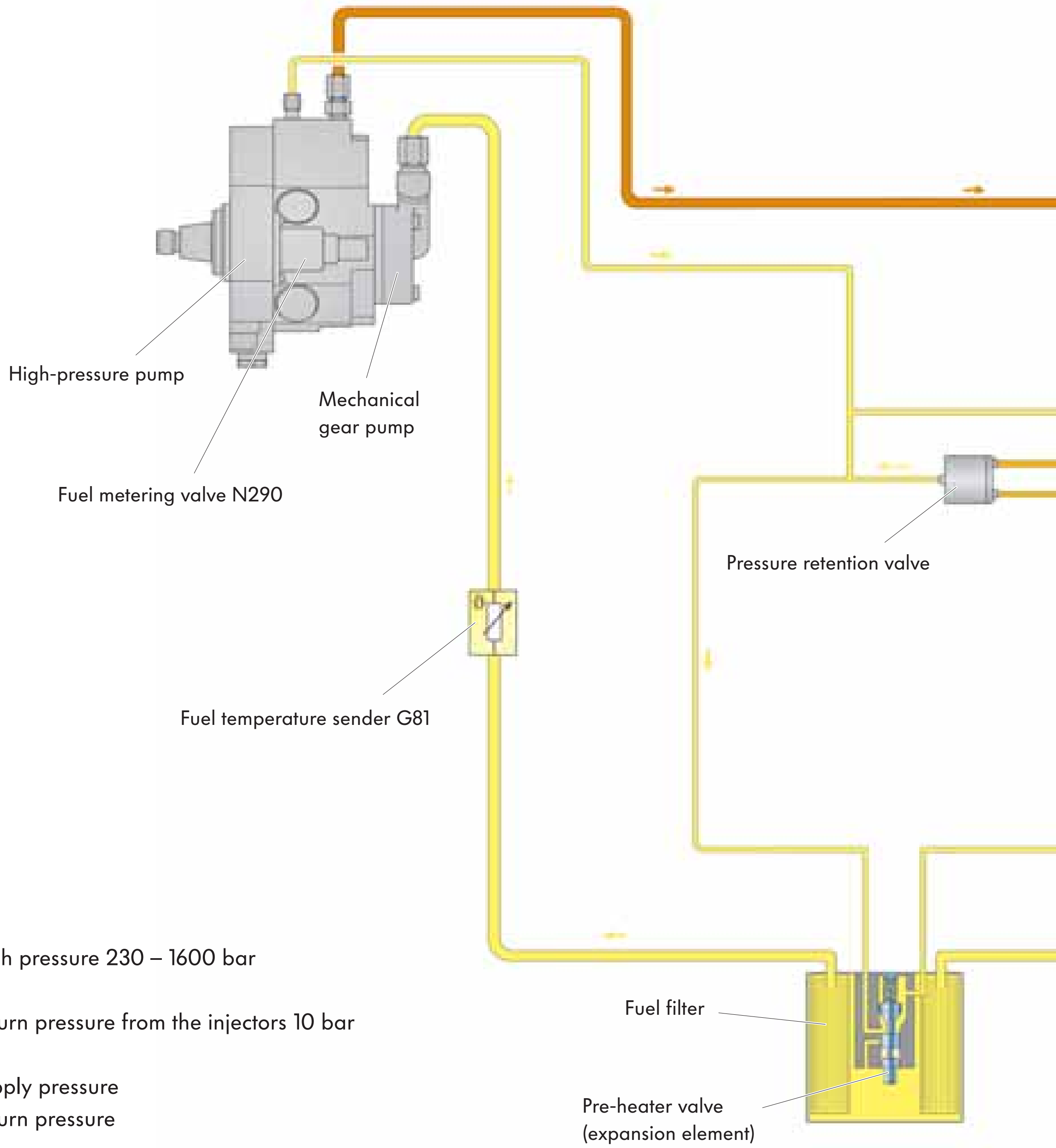
Fuel system

Overview of the system

The fuel system is sub-divided into three pressure ranges:

- High pressure 230 – 1600 bar
- Return pressure from the injectors 10 bar
- Supply pressure, return pressure

In the fuel supply system, the fuel is delivered to the high-pressure pump from the fuel tank via the fuel filter by the electric fuel pumps and the mechanical gear pump. The high fuel pressure required for injection is generated in the high-pressure pump and is fed into the high-pressure accumulator (rail).



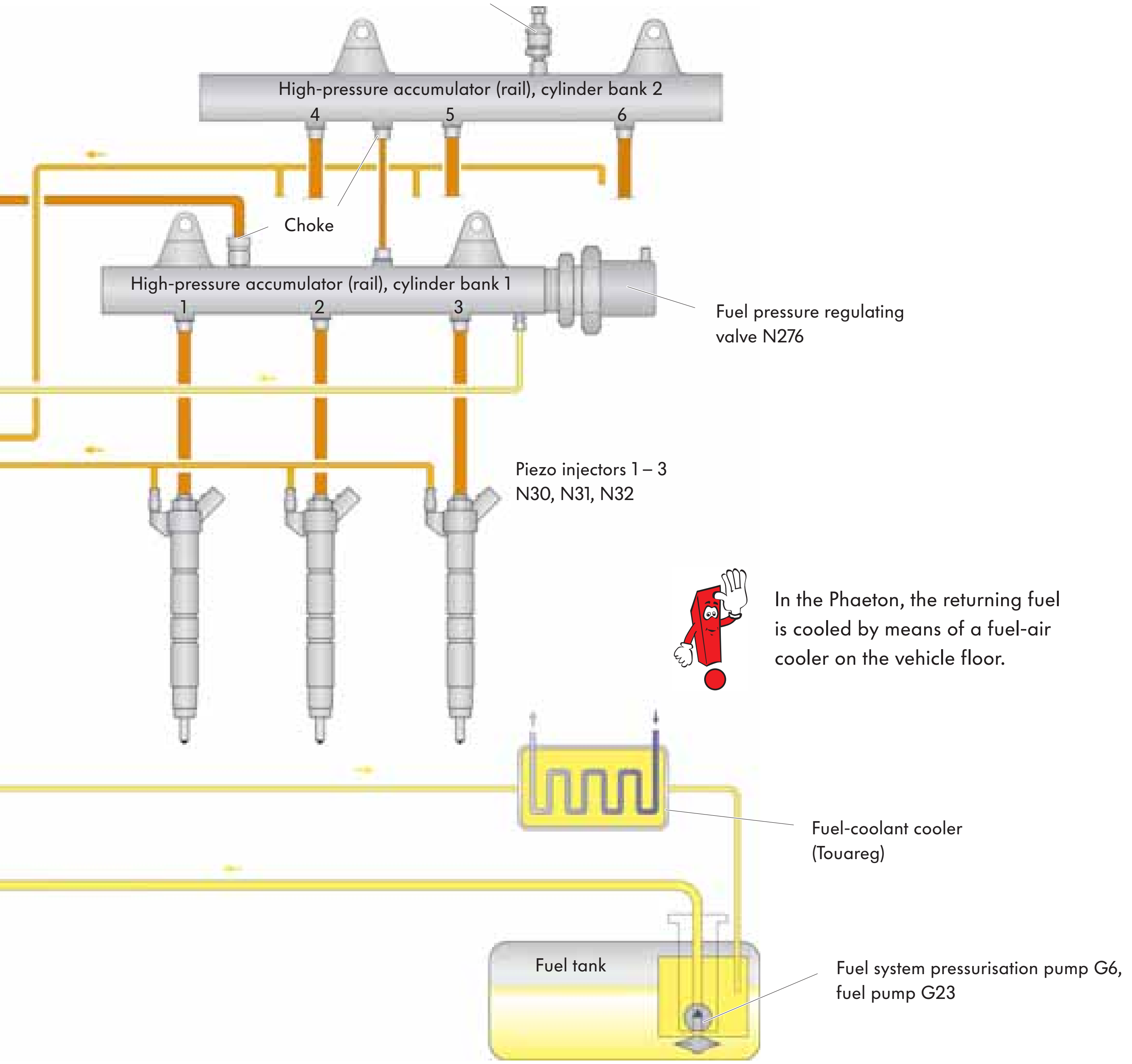
High pressure 230 – 1600 bar

Return pressure from the injectors 10 bar

Supply pressure
Return pressure

From the high-pressure accumulator, the fuel is forwarded to the injectors, which inject it into the combustion chambers.

The pressure retention valve maintains the injectors' return pressure at 10 bar. This pressure is required for the piezo injectors' function.



In the Phaeton, the returning fuel is cooled by means of a fuel-air cooler on the vehicle floor.

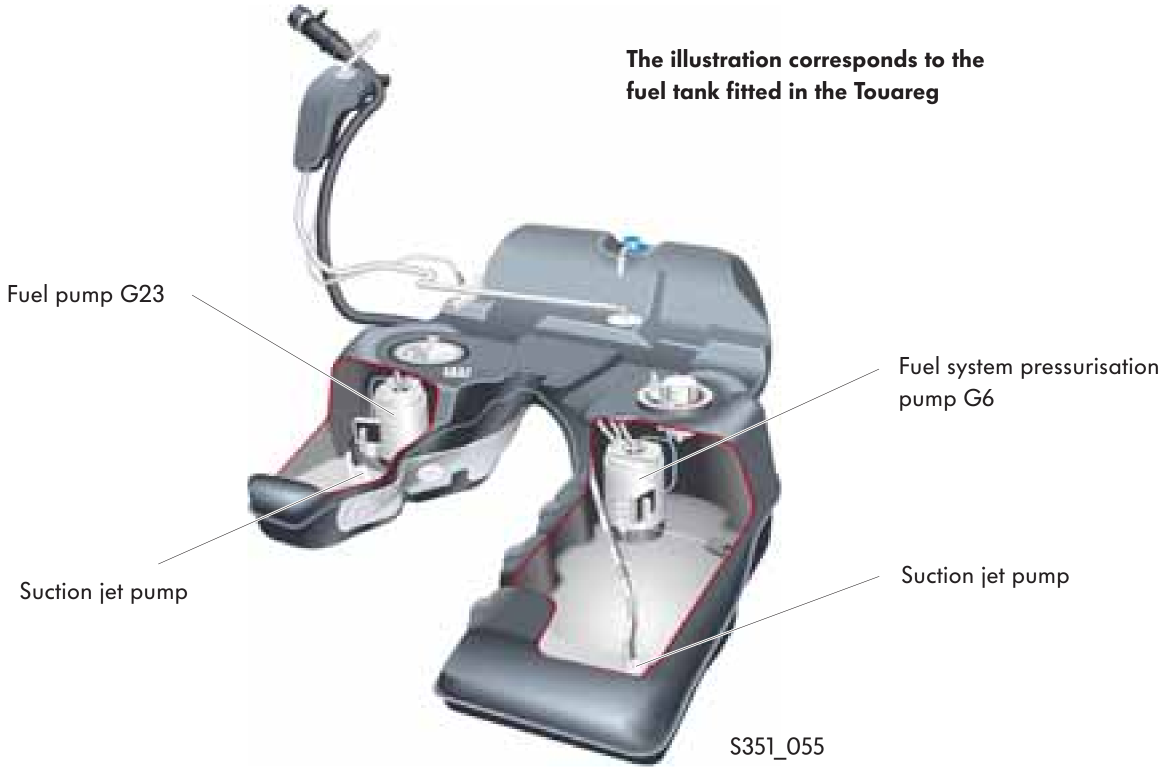
S351_005

Fuel system

Fuel system pressurisation pump G6 and fuel pump G23

The two fuel pumps, G6 and G23, are installed in the fuel tank. They operate as pre-supply pumps for the mechanical gear pump. The fuel tank fitted in the Touareg and the Phaeton is sub-divided into a left- and a right-hand chamber.

- The fuel system pressurisation pump G6 and a suction jet pump are installed in the left-hand chamber of the fuel tank.
- The fuel pump G23 and a suction jet pump are installed in the right-hand chamber.



When the ignition is switched on and the engine speed exceeds 40 rpm, the two electric fuel pumps are initialised by the diesel direct injection system control unit J248 via the fuel pump relay J17, and build up pilot pressure.
As soon as the engine is running, both pumps continuously pump fuel into the fuel supply system.
The right-hand chamber's suction jet pump pumps the fuel into the pre-delivery tank for the fuel system pressurisation pump G6, and the left-hand chamber's suction jet pump pumps fuel into the pre-delivery tank for the fuel pump G23. Both suction jet pumps are driven by the electric fuel pumps.

Effects in the event of failure

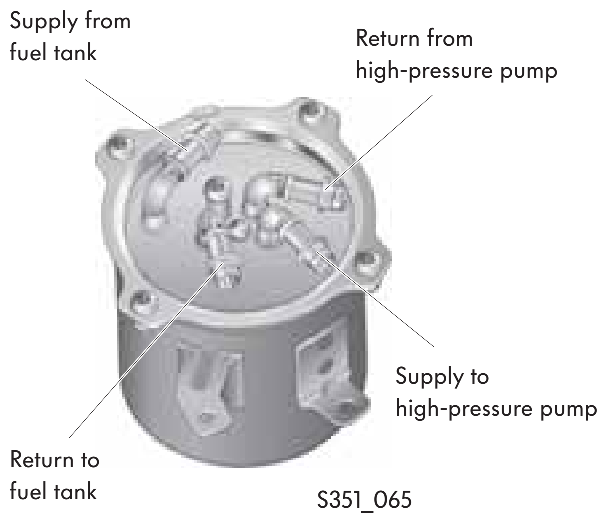
In the event of pump failure, a lack of fuel may lead to deviations in fuel pressure in the high-pressure accumulator (rail) in combination with a fault memory entry. The engine's output is reduced.

Fuel filter with pre-heater valve

The fuel filter protects the fuel injection system against contamination and wear caused by particles and water.

The centre fuel filter pipe contains a pre-heater valve, which is comprised of an expansion element and a spring-loaded plunger. Depending on the fuel temperature, the pre-heater valve conducts the fuel flowing back from the high-pressure pump, the high-pressure accumulators and the injectors into the fuel filter or to the fuel tank.

This prevents the fuel filter's becoming clogged via paraffin crystal formation at low ambient temperatures, thereby leading to malfunctions in engine operation.



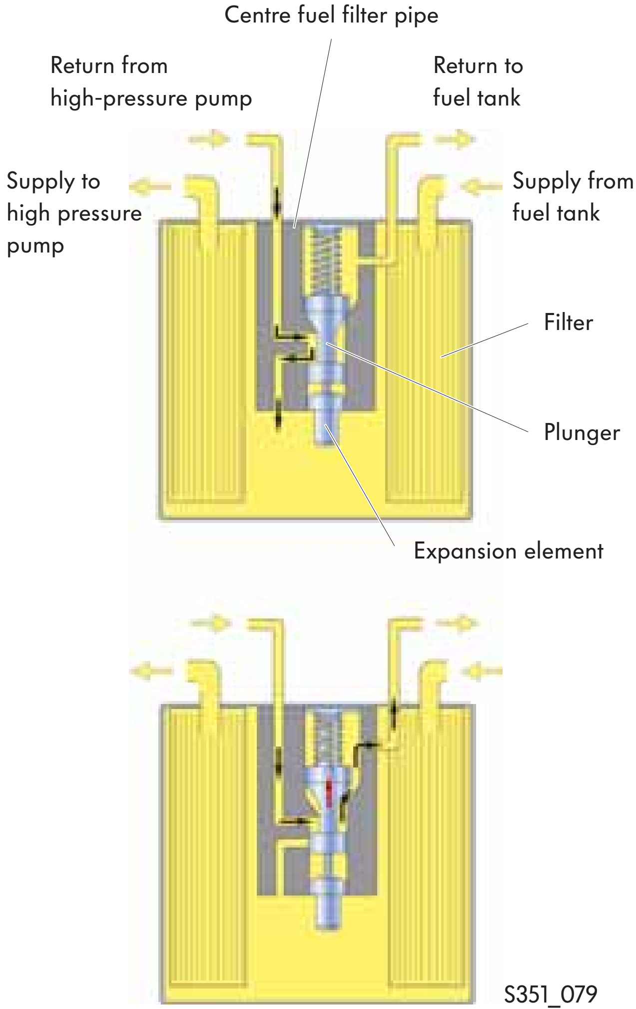
S351_065

Fuel temperature below 5 °C

At a fuel temperature of less than 5 °C, the expansion element is completely contracted, and the plunger seals the route back to the fuel tank with the aid of spring force. As a result of this, the hot fuel flowing back from the high-pressure pump, the high-pressure accumulators and the injectors is fed to the fuel filter, and the fuel located there is heated.

Fuel temperature over 35 °C

At a fuel temperature of more than 35 °C, the expansion element in the pre-heater valve is completely opened, releasing the route back to the fuel tank. The hot, returning fuel flows directly into the fuel tank.

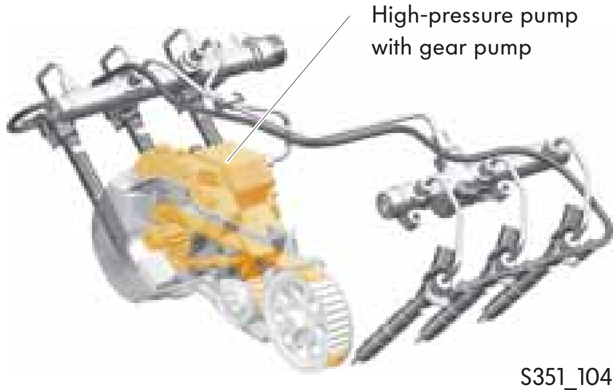


S351_079

High-pressure pump with gear pump

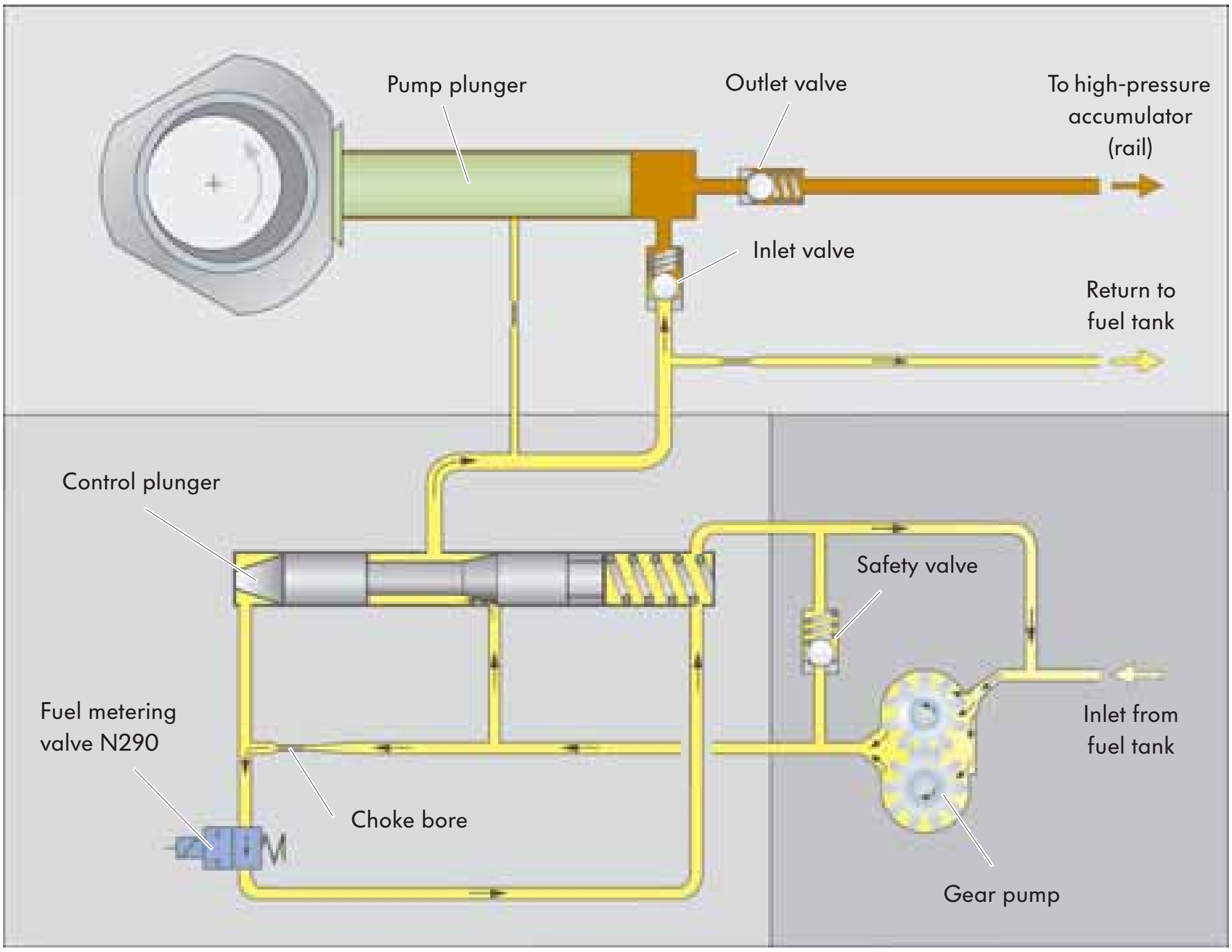
The high-pressure pump generates the high fuel pressure required for injection. A gear pump, which pumps the fuel into the high-pressure pump from the fuel supply system, is integrated into the high-pressure pump's housing.

Both pumps are driven by a common shaft. This shaft is driven by the cylinder bank 2 inlet camshaft via a toothed belt.



S351_104

Schematic overview of the path taken by the fuel in the high-pressure pump

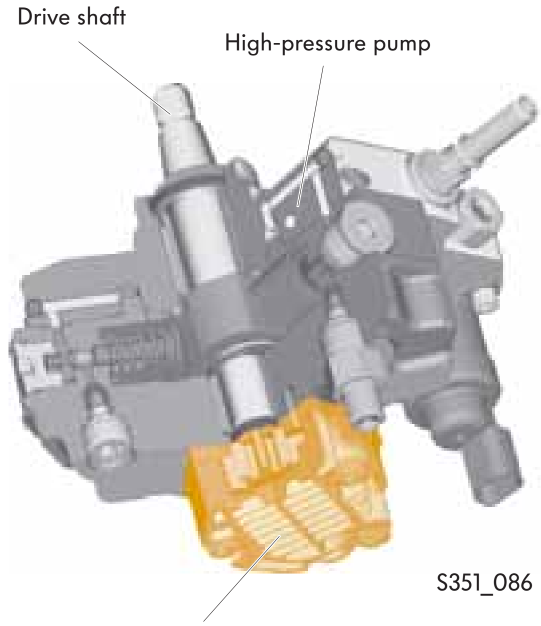


S351_105

Gear pump

The gear pump is a purely mechanical pre-supply pump. It is driven by the drive shaft together with the high-pressure pump.

The gear pump increases the fuel pressure pre-supplied by the two electric fuel pumps in the fuel tank. This ensures that the high-pressure pump is supplied with fuel in all operating statuses.



S351_086

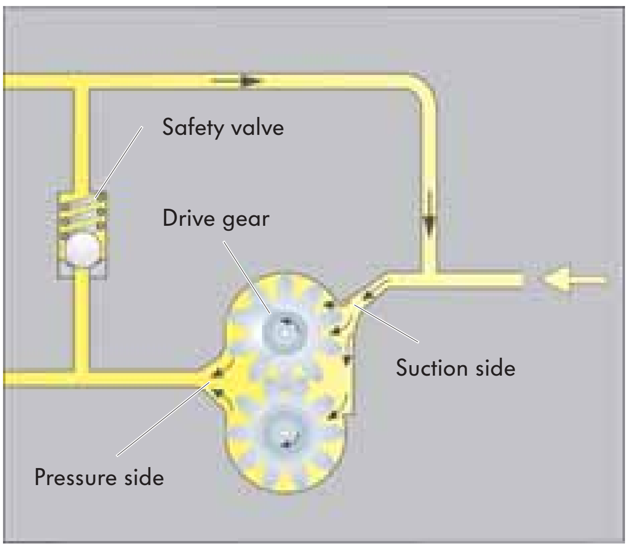
Design

Two counter-rotating gears are located in a housing, whereby one gear is driven by the continuous drive shaft.

Function

When the gears rotate, fuel is transported between the tooth gaps and is delivered to the pressure side along the inner wall of the pump.
From there, it is passed on to the high-pressure pump housing. Intermesh between both gears' teeth prevents the fuel from flowing back.

The safety valve opens when the fuel pressure on the gear pump's pressure side exceeds 5.5 bar. The fuel is then returned to the gear pump's suction side.



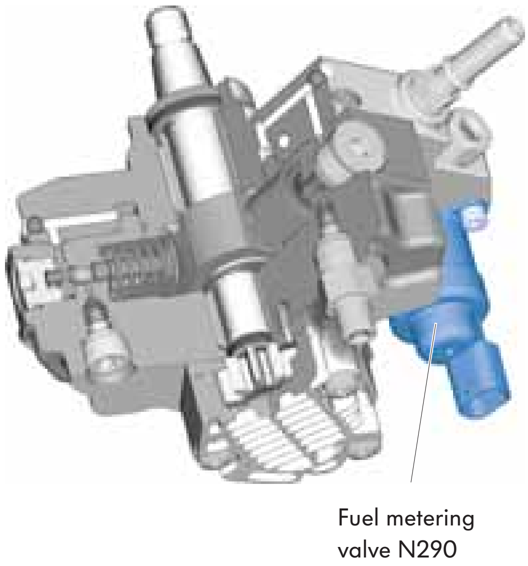
S351_007

Fuel system

Fuel metering valve N290

The fuel metering valve is integrated into the high-pressure pump. It ensures that the fuel pressure is regulated as required in the high-pressure area.

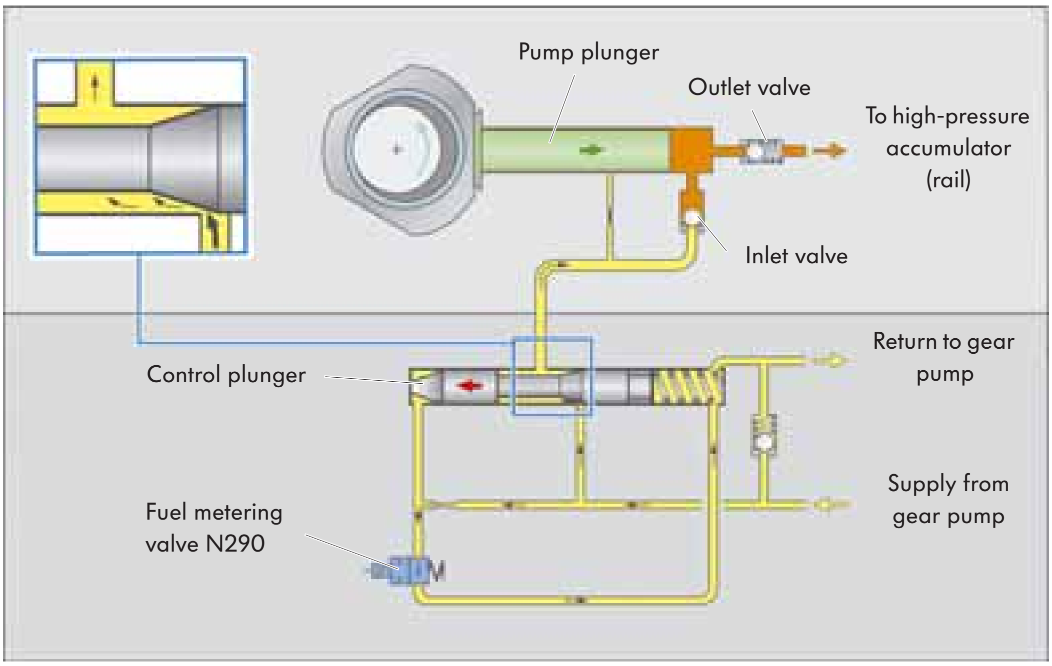
The fuel metering valve regulates the quantity of fuel which flows to the high-pressure pump.
The advantage of this is that the high-pressure pump only has to generate the pressure which is required for the current operating situation. This reduces the high-pressure pump's power consumption and avoids unnecessary fuel heating.



S351_011

Fuel metering valve N290 function – without current

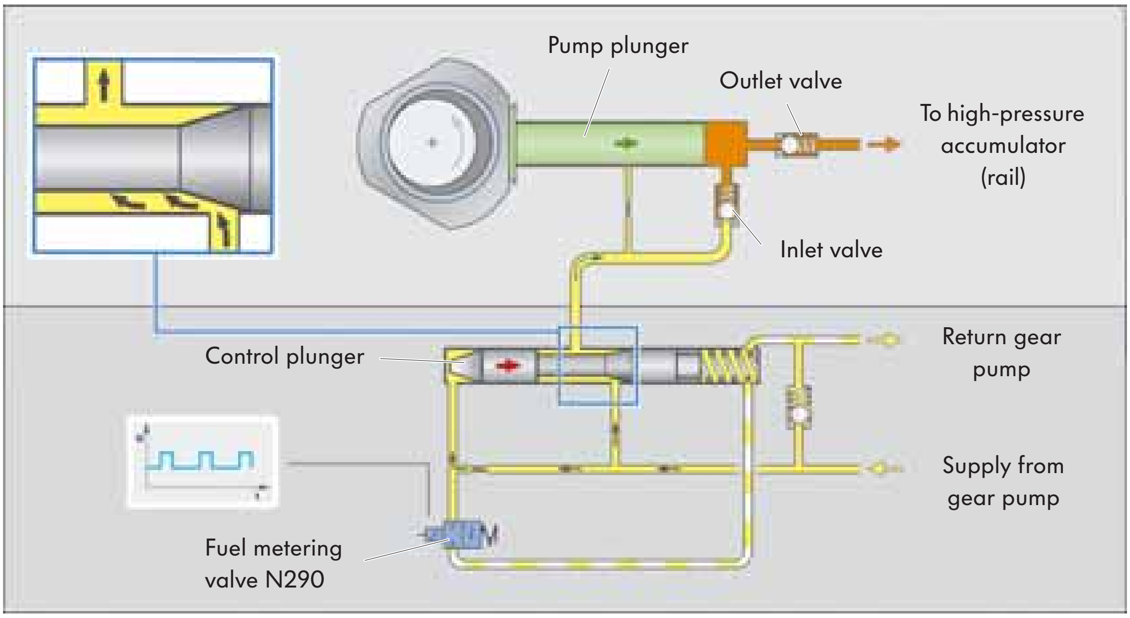
When no current is supplied, the fuel metering valve N290 is open. The control plunger is shifted to the left via the spring force, and releases the minimal cross-section to the high-pressure pump. As a result of this, only a small quantity of fuel enters the high-pressure pump's compression chamber.



S351_013

Fuel metering valve N290 function – initialised

To increase the quantity inlet to the high-pressure pump, the fuel metering valve N290 is initialised by the diesel direct injection system control unit J248 using a pulse width modulated (PWM) signal.
Due to the PWM signal, the fuel metering valve is pulsed closed. This results in a control pressure, which acts on the control plunger, downstream of the valve. Varying the on-off ratio changes the control pressure and therefore the position of the plunger. The control pressure decreases and the control plunger is shifted to the right. This increases the fuel inlet to the high-pressure pump.



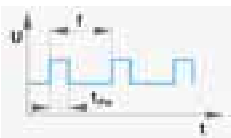
S351_088

Effects in the event of failure

The engine's output is reduced. The engine management system operates in emergency running mode.

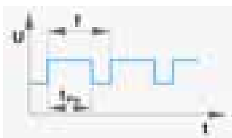
PWM signals

PWM signals are "pulse width modulated" signals. These are square-wave signals with a variable on-time and constant frequency. Changing the valve's on-time for fuel metering, for example, enables the control pressure and therefore the position of the control plunger to be changed.



S351_124

Short pulse width = small fuel inlet



S351_125

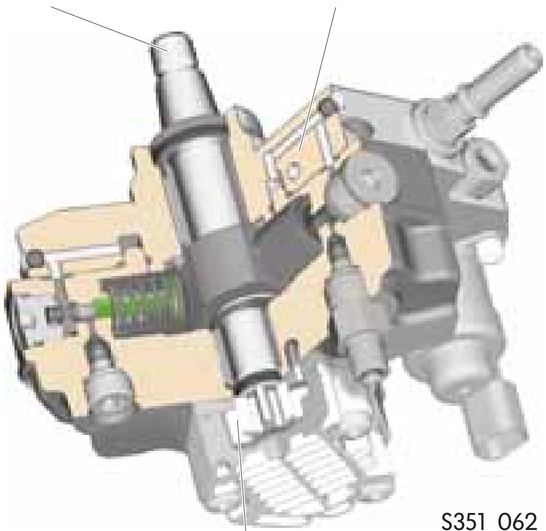
Large pulse width = large fuel inlet

U	Voltage
t	Time
f	Cycle duration (frequency)
t_{Pw}	Pulse width (on-time)

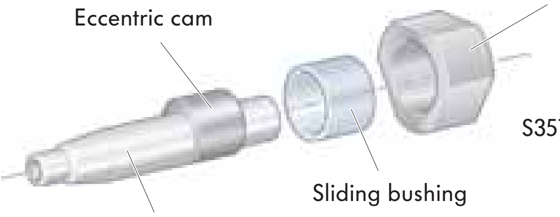
Fuel system

High-pressure pump

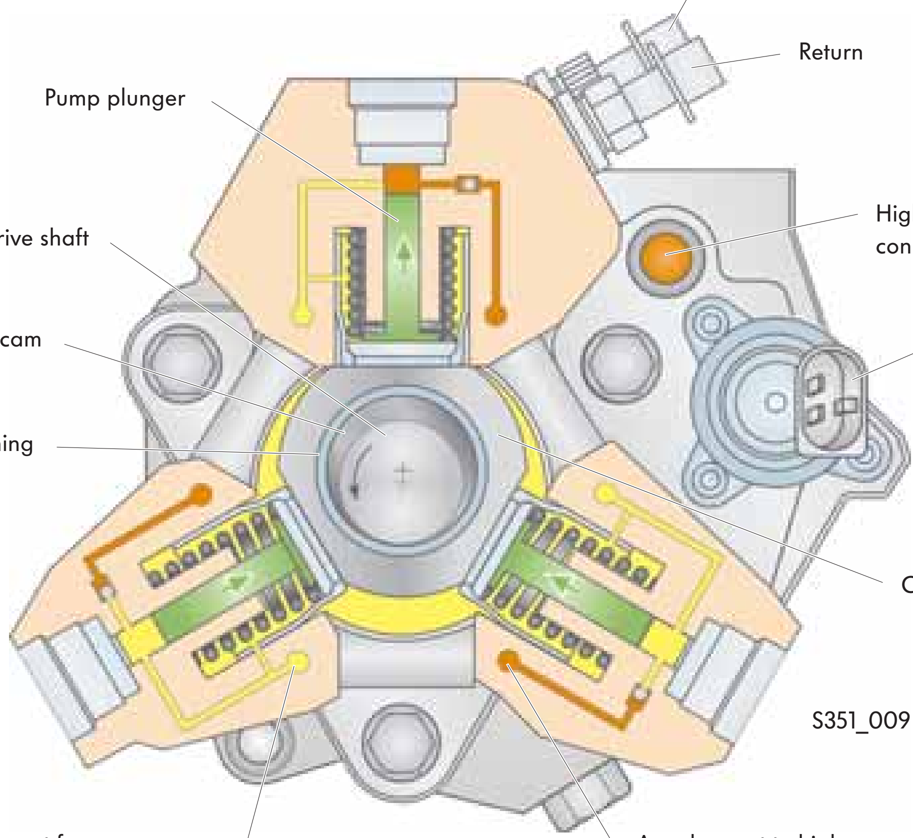
The high-pressure pump is 3-cylinder radial piston pump. It is driven by the drive shaft together with the gear pump.
The high-pressure pump has the task of generating the high fuel pressure of up to 1600 bar, which is required for fuel injection.
Due to the three pump plungers, which are arranged at intervals of 120°, the strain on the pump drive is even and pressure fluctuations in the high-pressure accumulator are minimised.



S351_062



S351_114



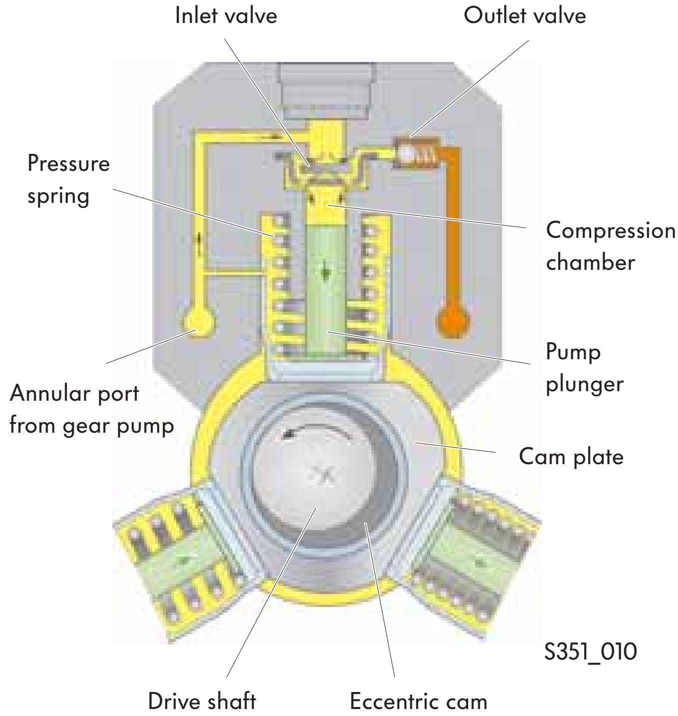
S351_009

Function

An eccentric cam is located on the high-pressure pump's drive shaft. Via a cam plate, this cam causes three pump plungers, which are arranged with radial offset of 120°, to move up and down.

Suction stroke

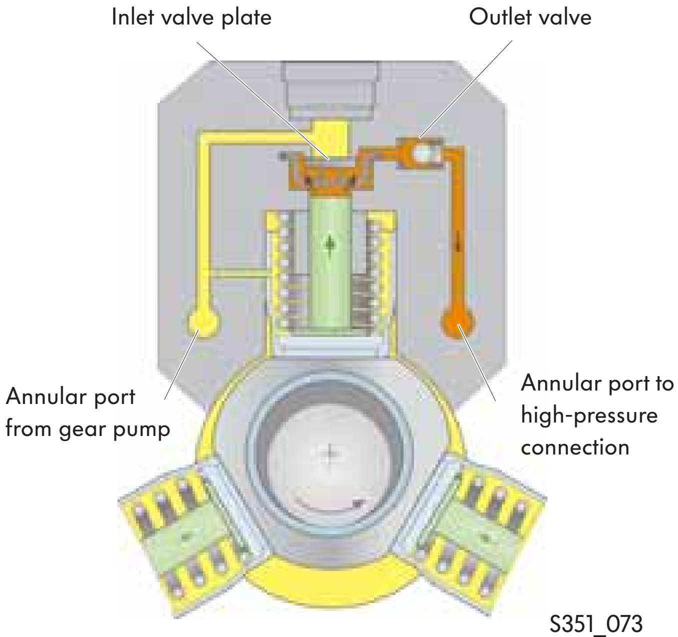
Downwards movement on the part of the pump plunger leads to an increase in the volume of the compression chamber. The fuel pressure within the compression chamber falls as a result of this. Due to the pressure exerted by the gear pump, fuel is now able to flow into the compression chamber via the inlet valve.



S351_010

Delivery stroke

The pressure in the compression chamber increases when the pump plunger begins to move upwards. As a result of this, the inlet valve plate is pushed upwards, sealing the compression chamber. Pressure continues to be built up due to the plunger's moving upwards. As soon as the fuel pressure in the compression chamber exceeds the pressure in the high-pressure area, the outlet valve opens and the fuel enters the high-pressure accumulator via the annular port.



S351_073

Fuel system

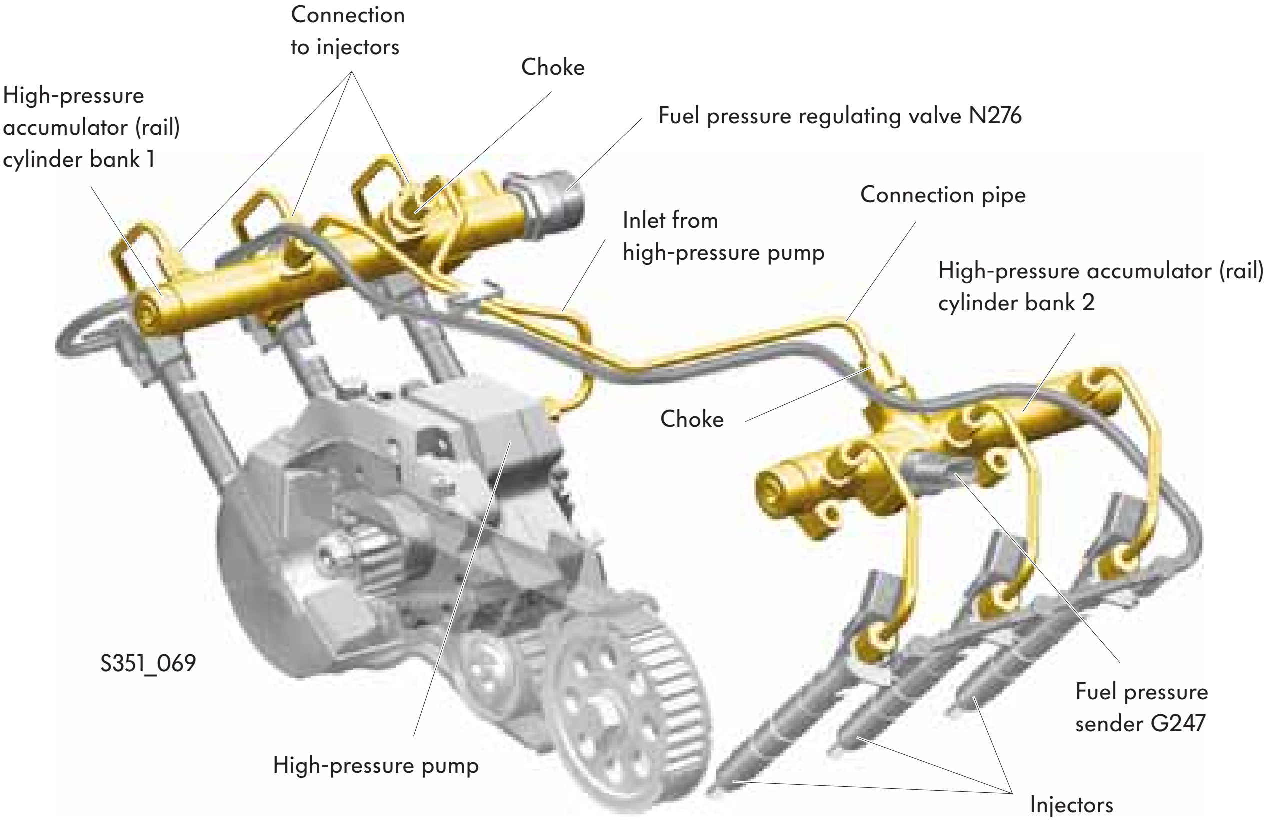
High-pressure accumulator (rail)

A high-pressure accumulator (rail) is fitted for each of the engine's cylinder banks. The high-pressure accumulator is a forged steel pipe. It has the task of storing the fuel required for injection for all of the cylinders at high pressure.

Design

Both high-pressure accumulators are spatially separated. They are connected to each other by a pipe. The fuel inlet connection from the high-pressure pump, the connections to the injectors and the fuel pressure regulating valve N276 are located on the cylinder bank 1 high-pressure accumulator.

The fuel inlet connections from the connection pipe, the connections to the injectors and the fuel pressure sender G247 are located on the cylinder bank 2 high-pressure accumulator.



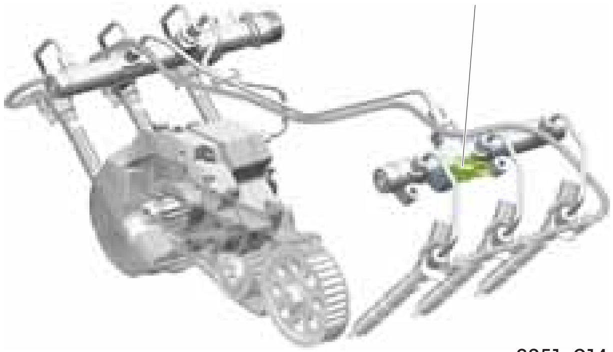
Function

The fuel in the high-pressure accumulator is constantly at a high pressure. If fuel is drawn from the high-pressure accumulator for injection, the pressure within the high-pressure accumulator remains virtually constant thanks to its large storage volume.

Pressure fluctuations, which arise due to the pulsating fuel supply to the high-pressure accumulator via the high-pressure pump, are compensated by the high-pressure accumulator's large storage volume and a choke in the fuel inlet from the high-pressure pump.

Fuel pressure sender G247

The fuel pressure sender is located on the cylinder bank 2 high-pressure accumulator (rail). It determines the current fuel pressure in the high-pressure area.



S351_014

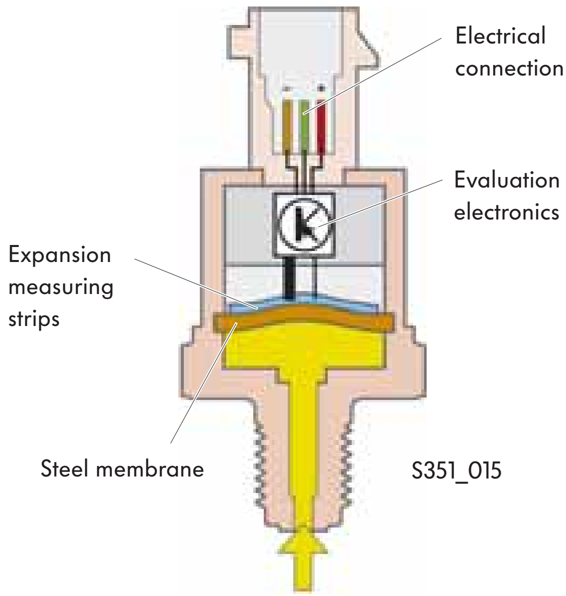
Function

The fuel pressure sender contains a sensor element, which is comprised of a steel membrane with expansion measuring strips.

The fuel pressure reaches the sensor element via the high-pressure connection.

In the event of a change in pressure, the steel membrane's deflection changes, as does the resistance value of the expansion measuring strips.

The evaluation electronics calculate a voltage from the resistance value and transmit this to the diesel direct injection system control unit J248.
A characteristic curve stored in the control unit J248 is used to calculate the current fuel pressure.



S351_015

Effects in the event of signal failure

In the event of fuel pressure sender failure, the diesel direct injection system control unit J248 employs a fixed, substitute value for calculation purposes. The engine's output is reduced.

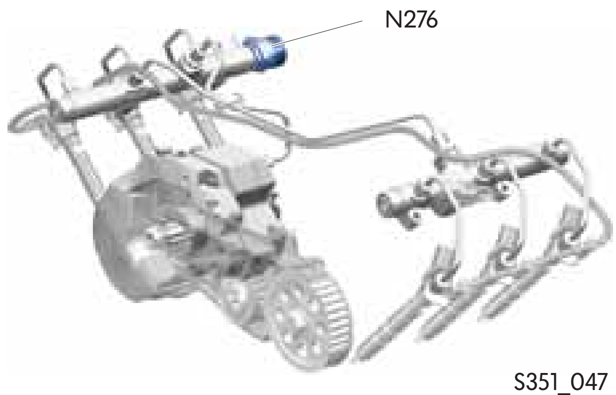
Fuel pressure regulating valve N276

The fuel pressure regulating valve is located on the cylinder bank 1 high-pressure accumulator (rail).

The regulating valve is used to adjust the fuel pressure in the high-pressure area. To do this, it is initialised by the diesel direct injection system control unit J248. Depending on the engine's operating status, the pressure is between 230 and 1600 bar.

If the fuel pressure in the high-pressure area is too high, the regulating valve opens, with the result that some of the fuel in the high-pressure accumulator enters the fuel tank via the fuel return.

If the fuel pressure in the high-pressure area is too low, the regulating valve closes, thereby sealing the high-pressure area at the fuel return.

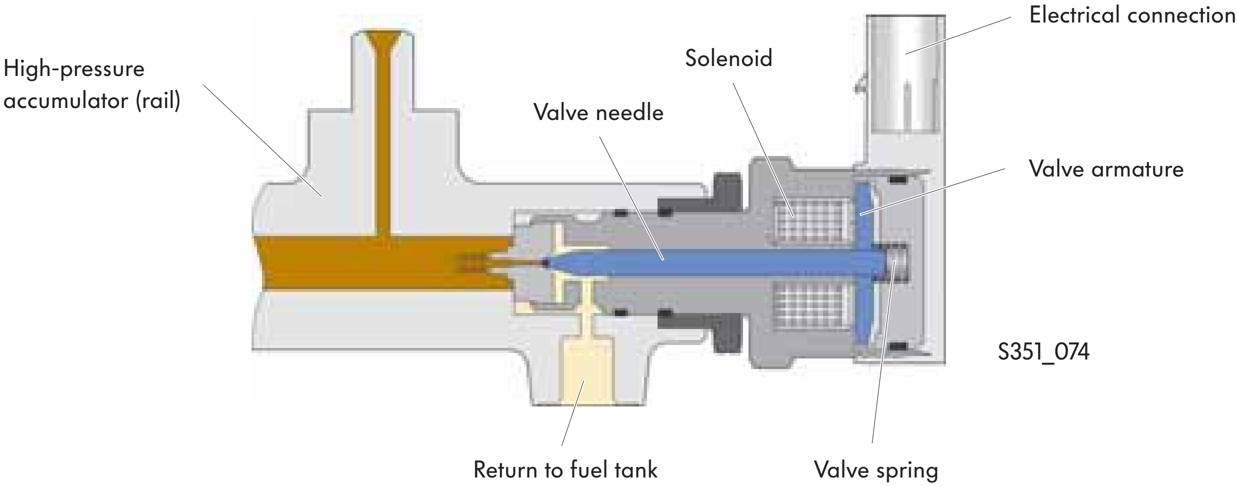


S351_047

Function

Regulating valve in resting position (engine "off")

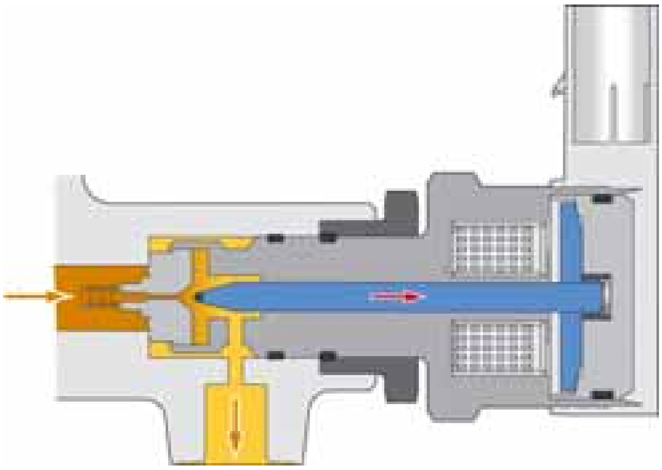
If the regulating valve is not initialised, the valve needle is exclusively pressed into its seat via the force exerted by the valve spring. The high-pressure area is separated from the fuel return in this case.
The valve spring is designed in such a way that a fuel pressure of approx. 80 bar is attained in the high-pressure accumulator.



S351_074

Regulating valve opened mechanically

If the fuel pressure in the high-pressure accumulator is greater than the valve spring force, the regulating valve opens and the fuel flows into the fuel tank via the fuel return.



S351_087

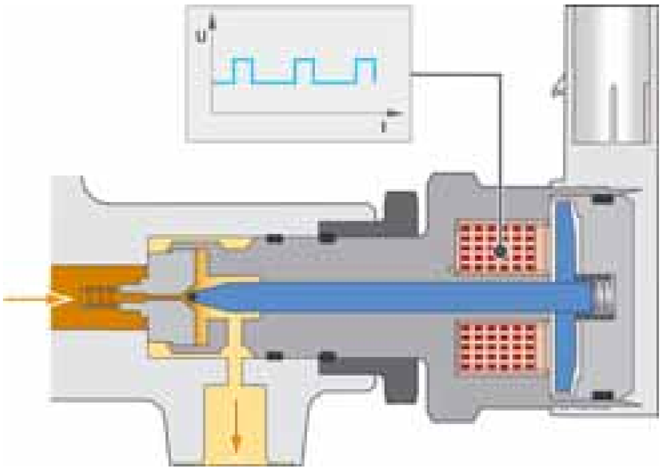
Regulating valve initialised (engine "on")

To attain an operating pressure of 230 to 1600 bar in the high-pressure accumulator, the regulating valve is initialised by the diesel direct injection system control unit J248 using a pulse width modulated (PWM) signal. This leads to a magnetic field in the solenoid. The valve armature is picked up and presses the valve needle into its seat.

The fuel pressure in the high-pressure accumulator is therefore opposed by a magnetic force in addition to the valve spring's force.

Depending on the on-off ratio of initialisation, the flow cross-section to the return pipe and therefore the quantity flowing off are varied.

This also enables pressure fluctuations in the high-pressure accumulator to be compensated.



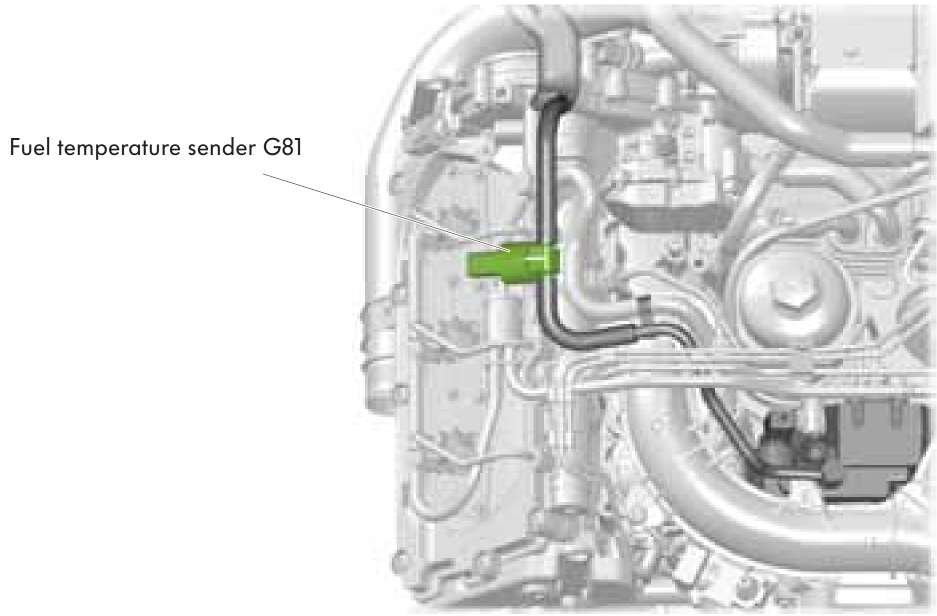
S351_106

Effects in the event of failure

Engine operation is impossible in the event of fuel pressure regulating valve failure, as no fuel pressure which is sufficiently high for fuel injection can be built-up.

Fuel temperature sender G81

The fuel temperature sender is located in the fuel supply pipe to the high-pressure pump. The fuel temperature sender is used to determine the current fuel temperature.



S351_031

Signal usage

The diesel direct injection system control unit J248 uses the fuel temperature sender's signal to calculate the fuel density. This serves as a correction variable to calculate the injection quantity, to regulate the fuel pressure in the high-pressure accumulator and to regulate the quantity inlet to the high-pressure pump.

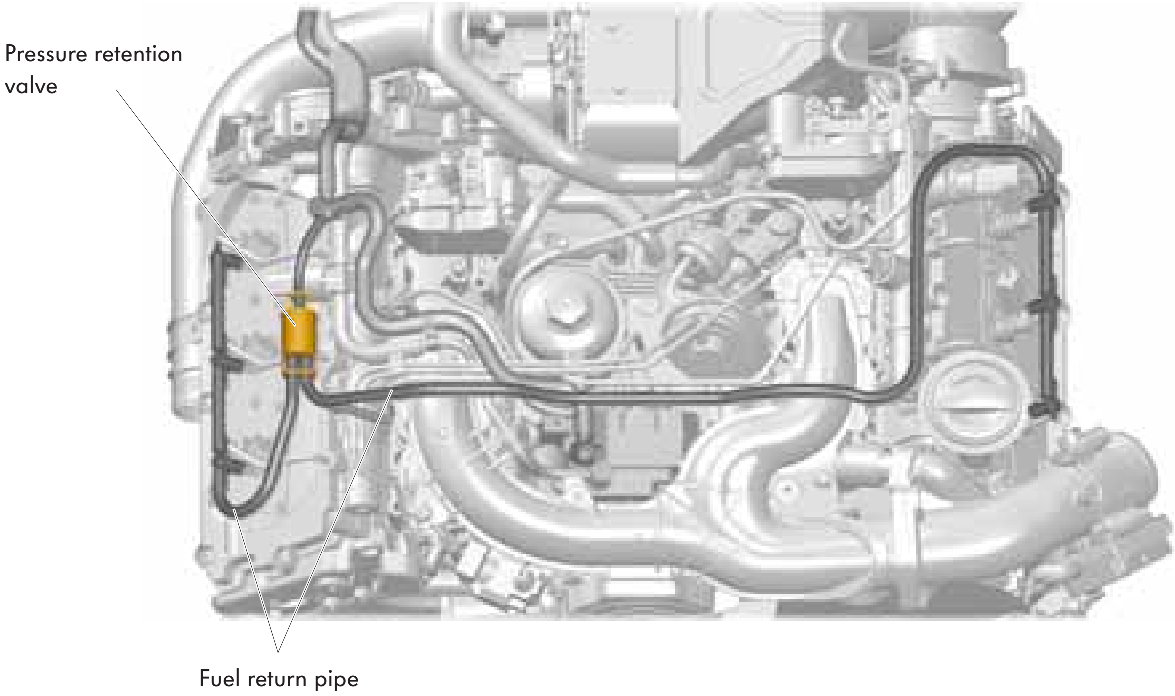
To protect the high-pressure pump against excessively high fuel temperatures, the fuel temperature sender is located in the fuel supply system. In the event of excessively high temperatures in the fuel supply system, the engine's output is limited in order to protect the high-pressure pump. As a result of this, the quantity of fuel to be compressed in the high pressure pump is also indirectly reduced and the fuel temperature is therefore lowered.

Effects in the event of signal failure

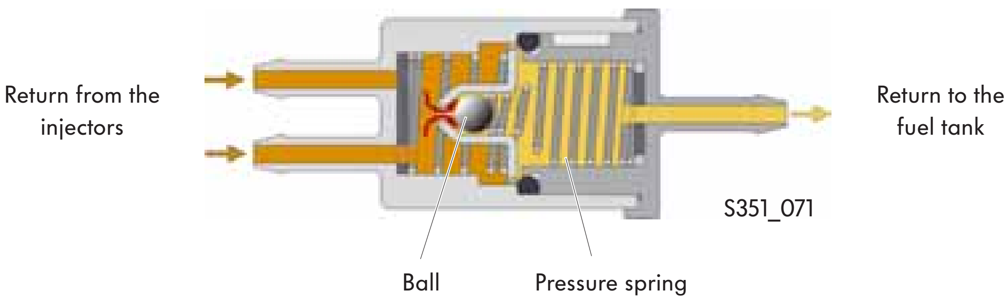
In the event of temperature sender failure, the diesel direct injection system control unit J248 employs a fixed, substitute value for calculation purposes.

Pressure retention valve

The pressure retention valve is a purely mechanical valve. It is located between the return pipes from the injectors and the fuel system's fuel return.



S351_090



S351_071

Task

The pressure retention valve maintains a fuel pressure of approx. 10 bar in the injectors' fuel return. This fuel pressure is required for the injectors' function.

Function

During engine operation, fuel flows from the injectors to the pressure retention valve via the return pipes.
At a fuel pressure in excess of 10 bar, the ball is lifted from its seat counter to the pressure spring's force.
The fuel flows through the open valve into the fuel return to the fuel tank.

Injectors (injection valves)

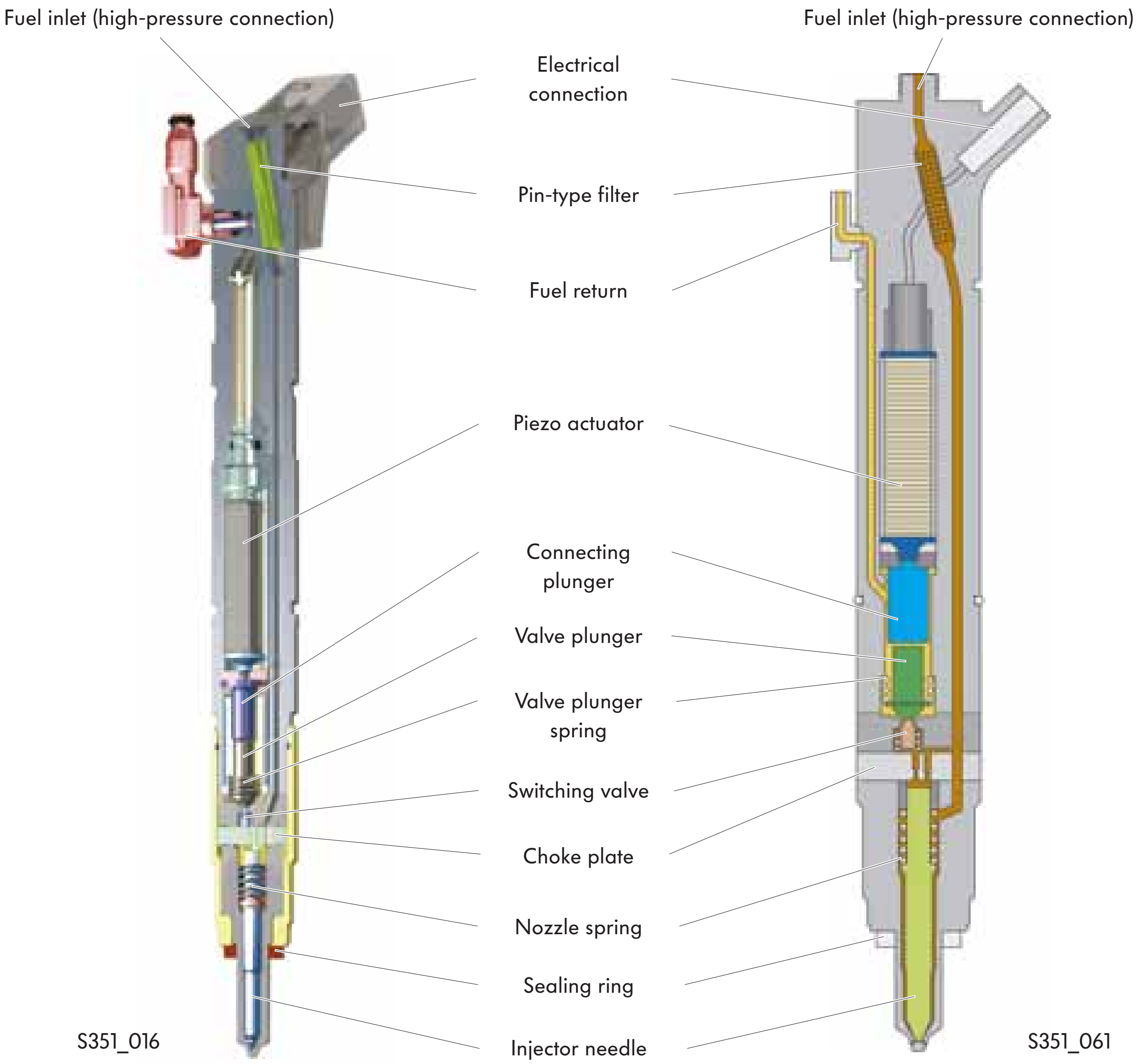
The injectors are installed in the cylinder head. They have the task of injecting the correct quantity of fuel into the combustion chambers at the correct time. The 3.0l V6 TDI engine is fitted with piezo-controlled injectors. In this case, the injectors are controlled via a piezo actuator. A piezo actuator's switching speed is approximately four times faster than that of a solenoid valve.

In comparison with solenoid valve-controlled injectors, piezo technology has approximately 75 % less moved mass at the injector needle.

This results in the following advantages:

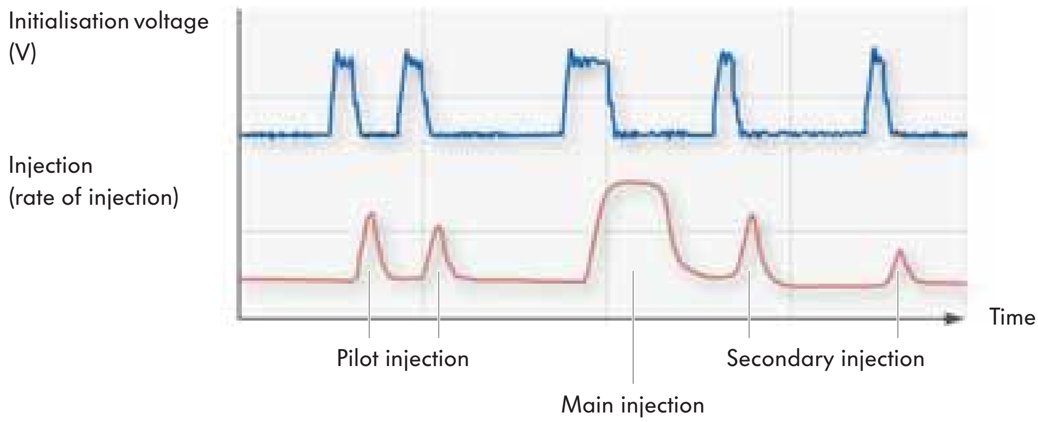
- Very short switching times
- Several injections per working cycle are possible
- Precisely apportionable injection quantities

Structure of an injector



Injection process

The piezo-controlled injectors' very short switching times enable flexible and precise control of the injection phases and injection quantities. As a result of this, the injection process can be adapted to the engine's relevant operating requirements. Up to five partial injections can be carried out per injection process.



S351_118

Pilot injection

A small quantity of fuel is injected into the combustion chamber prior to main injection. This leads to a rise in temperature and pressure in the combustion chamber. The main injection ignition time lag is therefore shortened, thereby reducing the rise in pressure and pressure peaks in the combustion chamber. This leads to low combustion noise and low exhaust emissions.
The number, time and injection quantities of the pilot injection processes are dependent on the engine's operating status.
When the engine is cold and at low engine speeds, two pilot injections are carried out due to acoustic reasons.
At higher loads and engine speeds, only one pilot injection is carried out, in order to reduce exhaust emissions.
No pilot injection is carried out at full throttle and high engine speeds, because a large quantity of fuel has to be injected to achieve a high level of efficiency.

Main injection

Following pilot injection, the main injection quantity is injected into the combustion chamber following a brief injection pause.
The injection pressure level remains virtually identical throughout the entire injection process.

Secondary injection

Two secondary injection processes are carried out to regenerate a diesel particulate filter. These secondary injections increase the exhaust gas temperature, which is necessary to combust the soot particles in the diesel particulate filter.

Piezo actuator

A piezo actuator is used to control the injectors. This is located in the injector housing, and is initialised via the diesel direct injection system control unit J248 electrical connection. The piezo actuator has a high switching speed, switching in less than one ten-thousandth of a second. The inverse piezo-electric effect is used to control the piezo actuator.

Piezo effect

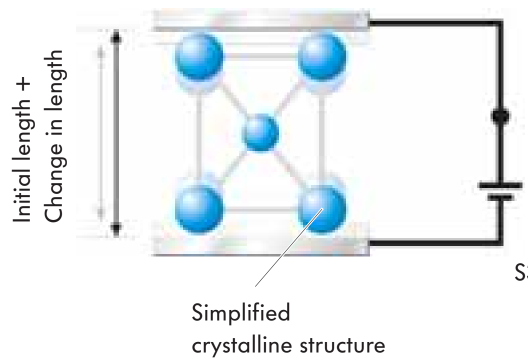
Piezo (Greek) = pressure

Piezo elements are frequently used in sensor systems. In this case, pressure is applied to a piezo element, leading to a measurable voltage. This behaviour on the part of a crystalline structure is called the piezo-electric effect.

Inverse piezo-electric effect

The piezo-electric effect is employed in reverse form to use a piezo-controlled actuator. In this case, a voltage is applied to the piezo element, and the crystalline structure reacts by changing length.

Piezo element with voltage U

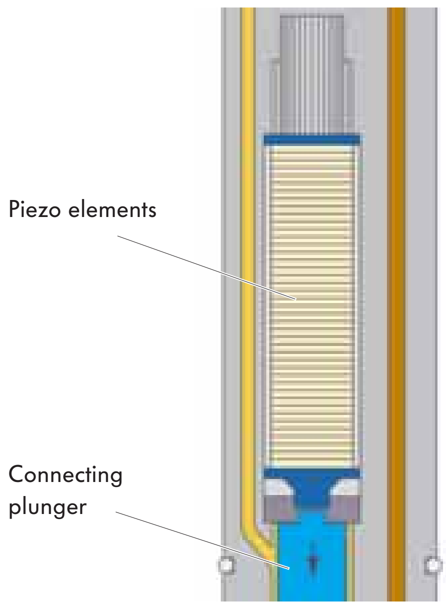


S351_096

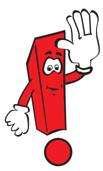
Piezo actuator

The piezo actuator is comprised of a multitude of piezo elements, so that sufficiently extensive switching travel for controlling the injector is achieved.

On application of a voltage, the piezo actuator expands by up to 0.03 mm. (For comparison purposes: A human hair has a diameter of approximately 0.06 mm).



S351_017



The piezo actuators are initialised with a voltage of 110 – 148 V. Note the safety instructions in the workshop manual.

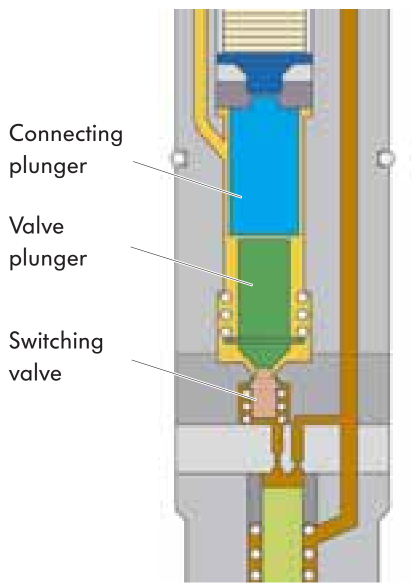
Connecting module

The connecting module is comprised of the connecting plunger and the valve plunger. The connecting module acts in the same manner as a hydraulic cylinder. It hydraulically converts the piezo actuator's very rapid longitudinal change and actuates the switching valve. Thanks to hydraulic force transmission, switching valve opening is dampened, and injection is therefore precisely controlled.

Advantages of hydraulic force transmission

- Low friction forces
- Damping of moving components
- Compensation of component longitudinal changes caused by thermal expansion
- No mechanical forces acting on the injector needles

Connecting module in resting position



S351_018

Hydraulic principle

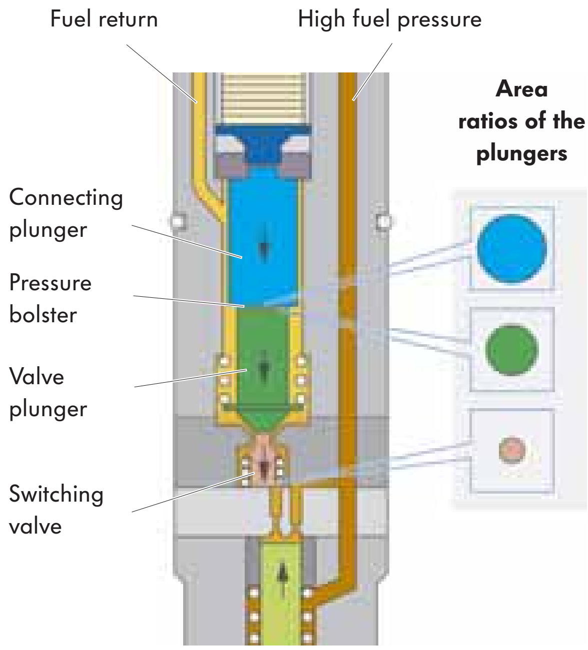
The connecting module is a hydraulic system, in which both the forces and the plunger areas behave in relation to each other.

In the connecting module, the area of the connecting plunger is greater than the area of the valve plunger. The valve plunger is therefore actuated by the connecting plunger's force.

The area ratio of the connecting plunger to the switching valve is several times higher. As a result of this, the switching valve can be actuated by the connecting module counter to the rail pressure.

The pressure retention valve in the fuel return maintains a fuel pressure of approx. 10 bar in the connecting module. This fuel pressure serves as a pressure bolster for hydraulic force transmission between the connecting plunger and valve plunger.

Connecting module actuated



S351_108

Fuel system

Injector in resting position

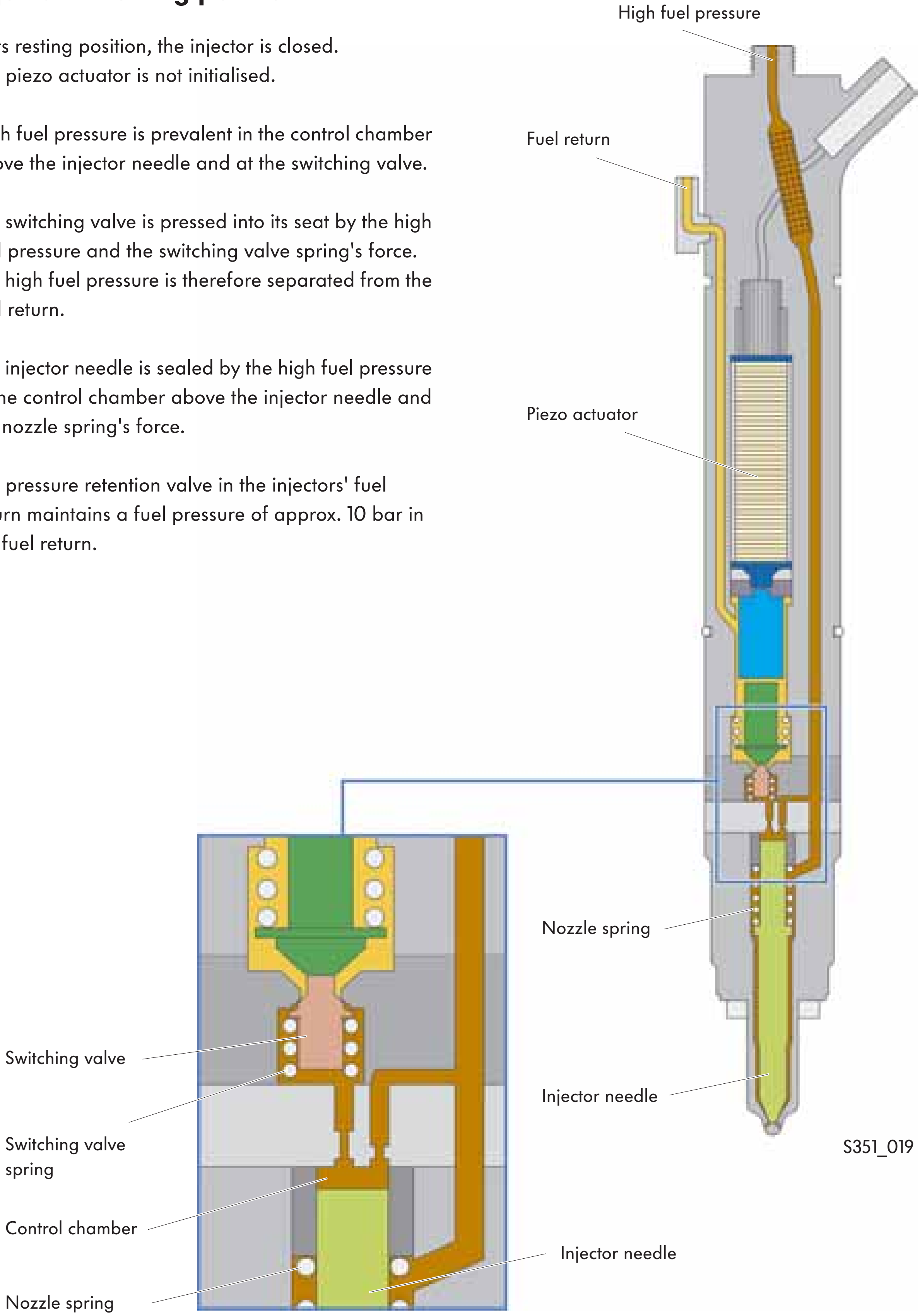
In its resting position, the injector is closed.
The piezo actuator is not initialised.

High fuel pressure is prevalent in the control chamber above the injector needle and at the switching valve.

The switching valve is pressed into its seat by the high fuel pressure and the switching valve spring's force. The high fuel pressure is therefore separated from the fuel return.

The injector needle is sealed by the high fuel pressure in the control chamber above the injector needle and the nozzle spring's force.

The pressure retention valve in the injectors' fuel return maintains a fuel pressure of approx. 10 bar in the fuel return.



S351_019

Start of injection

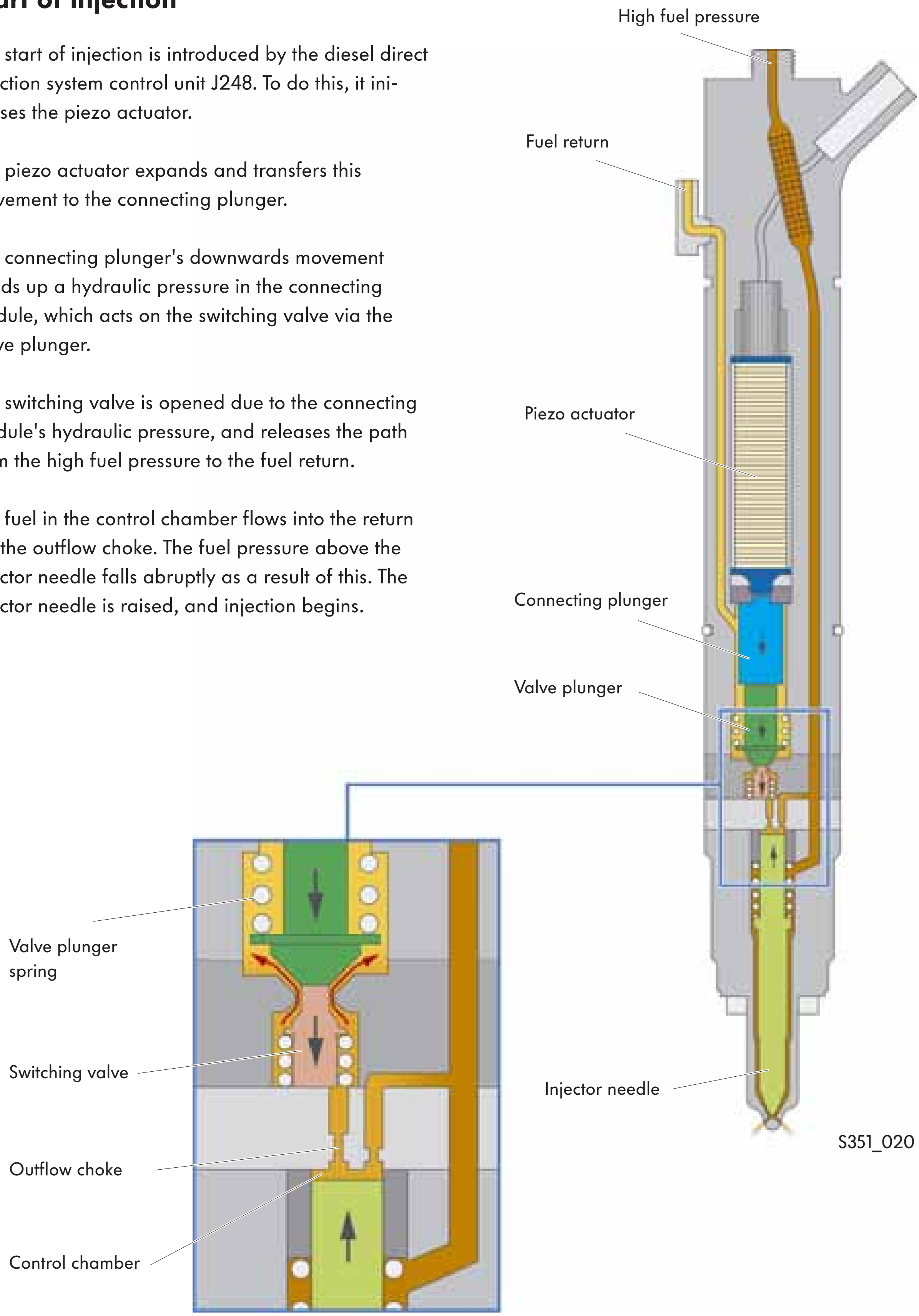
The start of injection is introduced by the diesel direct injection system control unit J248. To do this, it initialises the piezo actuator.

The piezo actuator expands and transfers this movement to the connecting plunger.

The connecting plunger's downwards movement builds up a hydraulic pressure in the connecting module, which acts on the switching valve via the valve plunger.

The switching valve is opened due to the connecting module's hydraulic pressure, and releases the path from the high fuel pressure to the fuel return.

The fuel in the control chamber flows into the return via the outflow choke. The fuel pressure above the injector needle falls abruptly as a result of this. The injector needle is raised, and injection begins.



S351_020

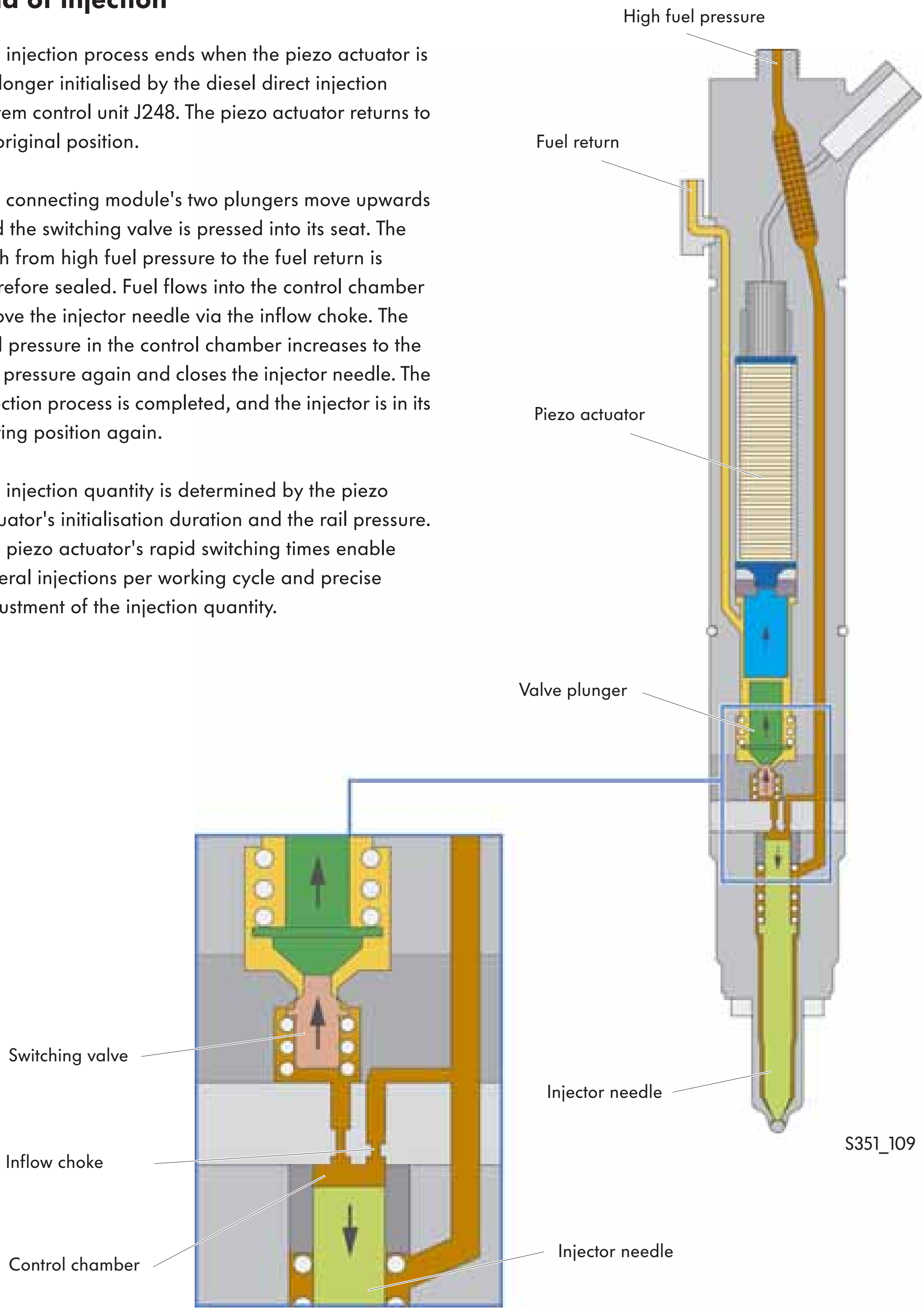
Fuel system

End of injection

The injection process ends when the piezo actuator is no longer initialised by the diesel direct injection system control unit J248. The piezo actuator returns to its original position.

The connecting module's two plungers move upwards and the switching valve is pressed into its seat. The path from high fuel pressure to the fuel return is therefore sealed. Fuel flows into the control chamber above the injector needle via the inflow choke. The fuel pressure in the control chamber increases to the rail pressure again and closes the injector needle. The injection process is completed, and the injector is in its resting position again.

The injection quantity is determined by the piezo actuator's initialisation duration and the rail pressure. The piezo actuator's rapid switching times enable several injections per working cycle and precise adjustment of the injection quantity.



S351_109

Injector Delivery Calibration (IDC)

Injector delivery calibration (IDC) is a software function in the diesel direct injection system control unit J248 for initialising the injectors.

This function is used to individually correct the injection quantity for each common rail fuel injection system injector throughout the entire performance map range. The precision of the fuel injection system is improved as a result of this.

Thanks to injector delivery calibration, differences in the injector's injection behaviour, which are caused by production tolerances, are balanced out.

The objectives of this injection quantity correction are:

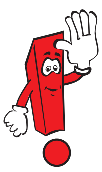
- Reducing fuel consumption
- Reducing the quantity of exhaust gas
- Smooth running characteristics

IDC value

A 7-digit calibration value is printed on each injector. This calibration value may be comprised of letters and/or numbers.

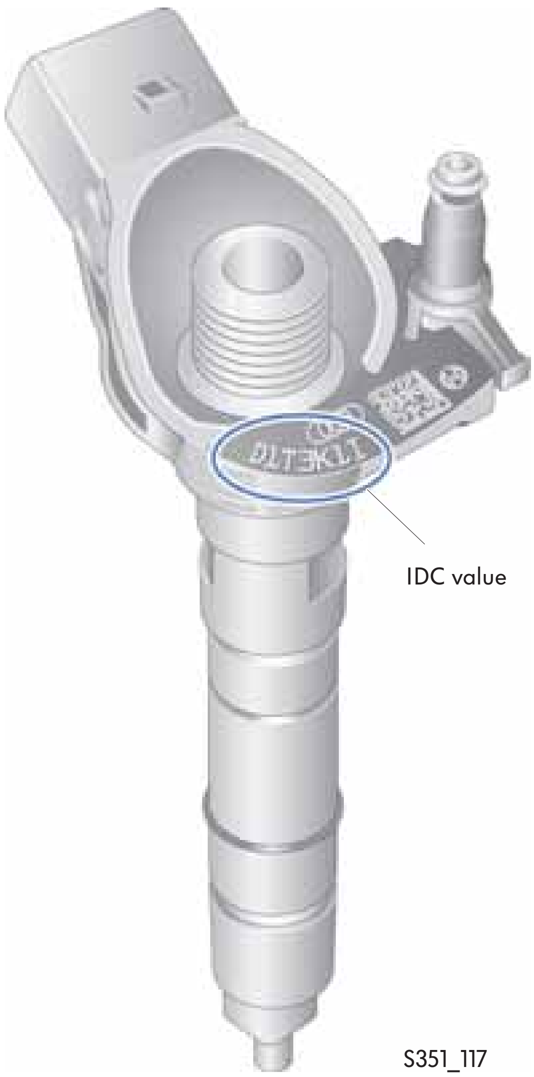
The IDC value is determined on a test rig during injector production. It portrays the difference from the nominal value, and therefore describes an injector's fuel injection behaviour.

The IDC value enables the diesel direct injection system control unit J248 to precisely calculate the initialisation times required for injection for each individual injector.



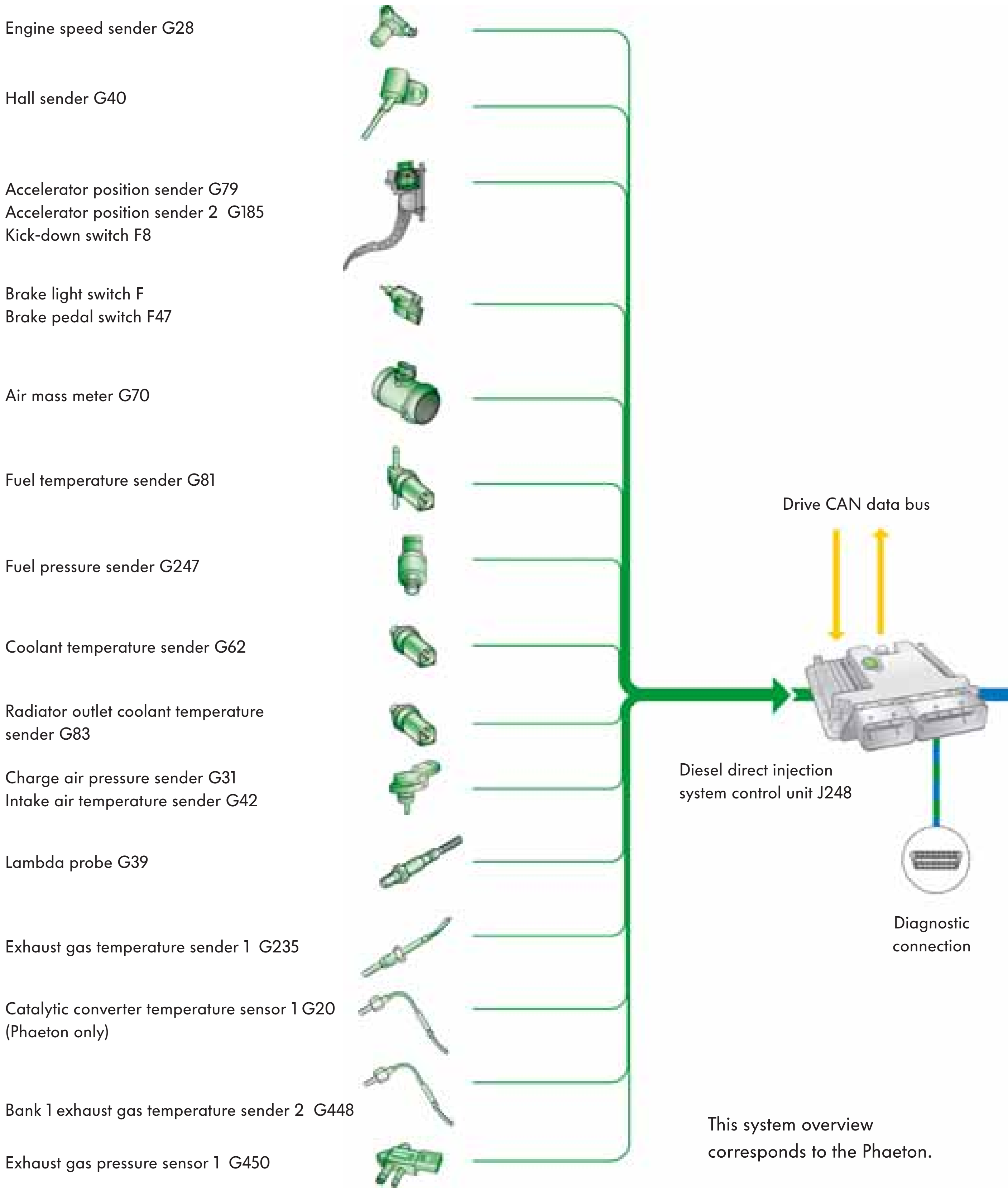
If an injector (injection valve) is renewed, it must be matched to the fuel injection system. Injector delivery calibration must be carried out.
Please carry injector delivery calibration out with the aid of guided fault finding!

Example of an IDC code on the injector



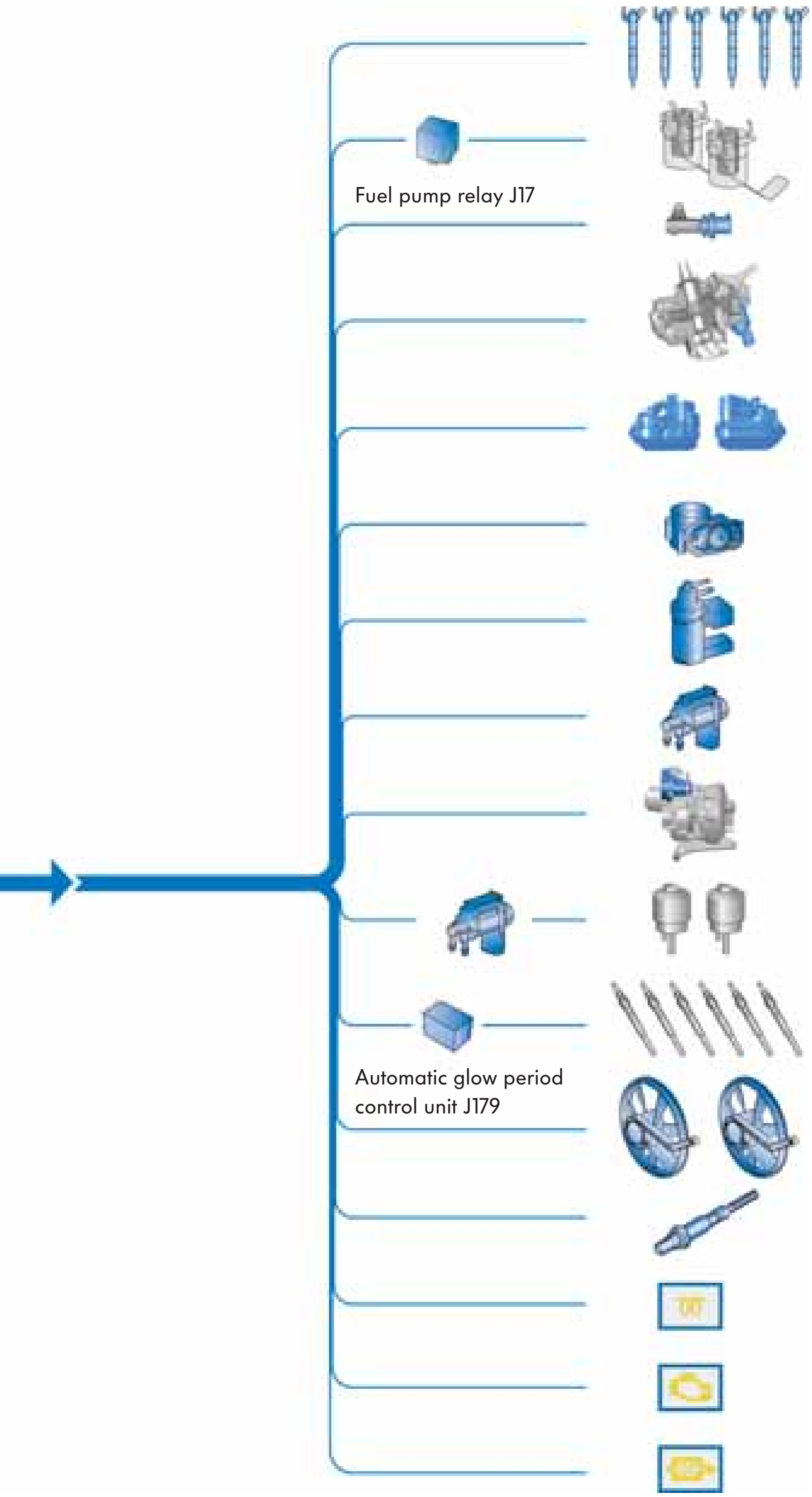
Overview of the system

Sensors



This system overview corresponds to the Phaeton.

Actuators



Injectors for cylinders 1 – 6
N30, N31, N32, N33, N83 and N84

Fuel system pressurisation pump G6
Fuel pump G23

Fuel pressure regulating valve N276

Fuel metering valve N290

Intake manifold flap motor V157
Intake manifold flap 2 motor V275

Throttle valve module J338

Exhaust gas recirculation valve N18

Exhaust gas recirculation cooler change-over valve N345

Turbocharger 1 control unit J724

Left electrohydraulic engine mounting solenoid valve N144

Glow plugs 1 – 6
Q10, Q11, Q12, Q13, Q14 and Q15

Radiator fan control unit J293
Radiator fan control unit 2 J671
Radiator fan V7
Radiator fan 2 V177

Lambda probe heater Z19

Glow period warning lamp K29

Exhaust emissions warning lamp K83

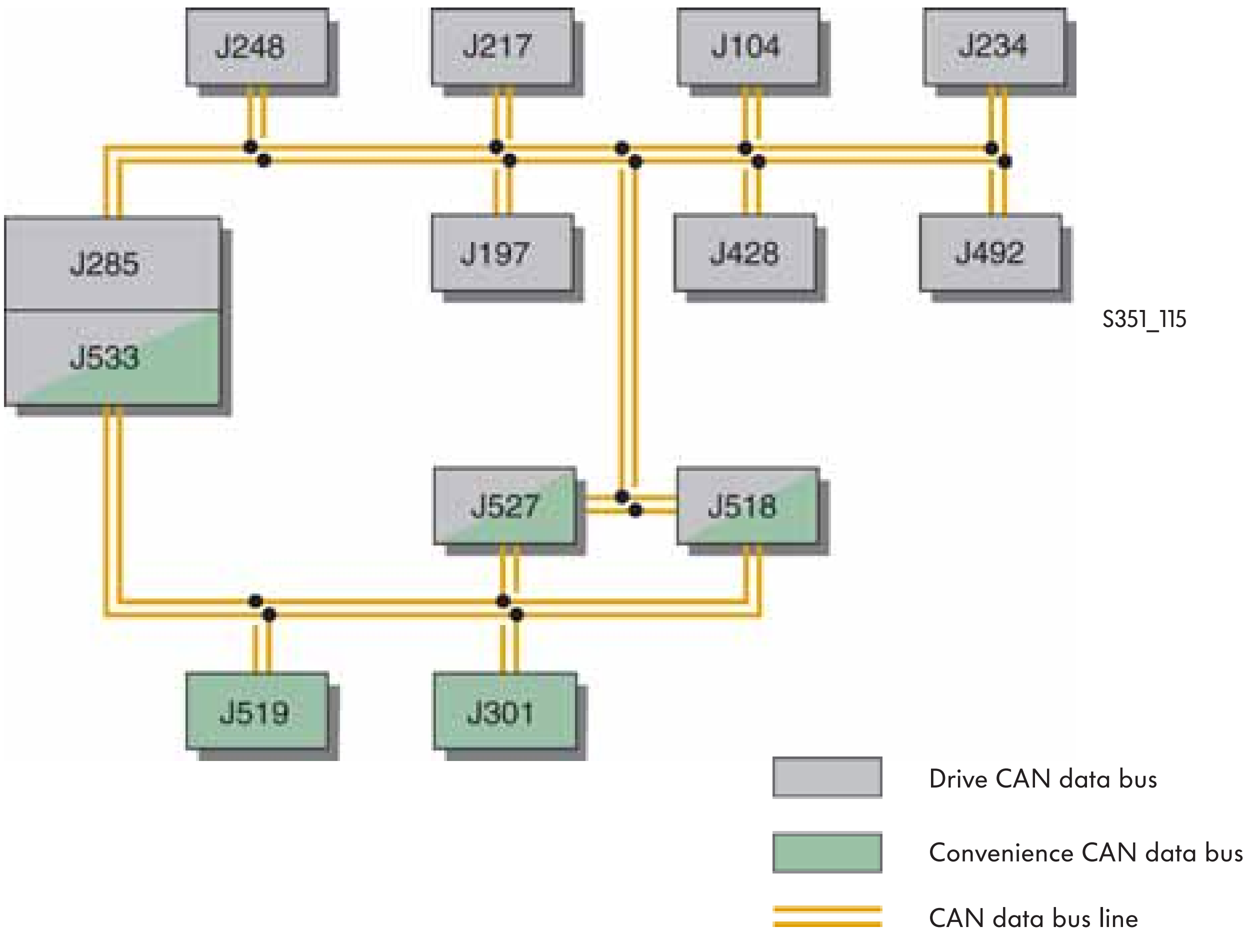
Diesel particulate filter warning lamp K231

S351_053

Engine management system

Control units in the CAN data bus

The schematic shown below shows the integration of the diesel direct injection system control unit J248 into the vehicle's CAN data bus structure.
Information is transmitted between the control units via the CAN data bus. For example, the diesel direct injection system control unit J248 receives the speed signal via the ABS control unit.



S351_115

Drive CAN data bus

- J248 Diesel direct injection system control unit
- J217 Automatic gearbox control unit
- J104 ABS control unit
- J234 Airbag control unit
- J197 Adaptive suspension control unit
- J428 Adaptive cruise control unit
- J492 Four-wheel drive control unit

Convenience CAN data bus

- J285 Control unit with display in dash panel insert
- J527 Steering column electronics control unit
- J518 Entry and start authorisation control unit
- J519 Onboard supply control unit
- J301 Air conditioning system control unit
- J533 Data bus diagnostic interface

Sensors

Engine speed sender G28

The engine speed sender is secured to the gearbox housing. It is an inductive sender, which samples a 60-2 sender wheel, which is secured to the drive plate. A segment gap on the sender wheel serves the engine speed sender as a reference mark.

Signal usage

The engine speed and the precise position of the crankshaft are recorded via the sender's signal. This information is used by the diesel direct injection system control unit J248 to calculate the injection point and the injection quantity.

Effects in the event of signal failure

In the event of signal failure, the engine is shut off and can no longer be started.

S351_021

Hall sender G40

The hall sender is secured in the retaining frame of the cylinder bank 1 cylinder head. It scans the sender wheel on the camshaft, with which the position of the camshaft is detected.

Signal usage

The sender signal is required by the diesel direct injection system control unit J248 to detect the first cylinder on starting the engine.

Effects in the event of signal failure

Starting the engine is impossible in the event of signal failure.

S351_022

Accelerator position sender G79 and accelerator position sender 2 G185

The accelerator position sender G79 and accelerator position sender 2 G185 are comprised in one component and integrated into the accelerator pedal module.

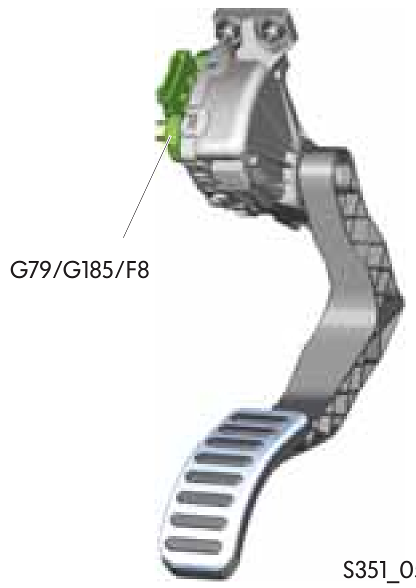
Signal usage

The accelerator position sender G79 and acceleration position sender 2 G185 are used to detect the position of the accelerator throughout the entire adjustment range. These signals are used by the diesel direct injection system control unit J248 to calculate the injection quantity.

Effects in the event of signal failure

In the event that one of the two senders, G79 and G185, fails, the system first switches to idle speed. If the second sender is detected within a defined period of time, vehicle operation becomes possible again. However, the engine speed only increases slowly at the desired full throttle.
In the event that both senders fail, the engine only runs at increased idle speed, and no longer responds to the accelerator.

Accelerator pedal module



S351_056

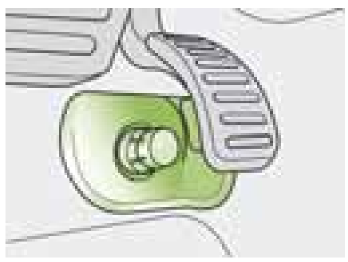
Kick-down switch F8

In the Phaeton, the kick-down switch is fitted as an autonomous component on the floor panel beneath the accelerator pedal module. In the Touareg, the kick-down switch function is integrated into the accelerator pedal module.

Signal usage

In addition to the accelerator position sender signals, the kick-down switch signal serves the engine control unit to detect the kick-down position. This information is transmitted to the automatic gearbox control unit via the drive CAN data bus, and the kick-down function is carried out.

Kick-down switch F8 in Phaeton



S351_068

Effects in the event of signal failure

In the event of kick-down switch failure, the engine control unit uses the accelerator position sender values.

Brake light switch F and brake pedal switch F47

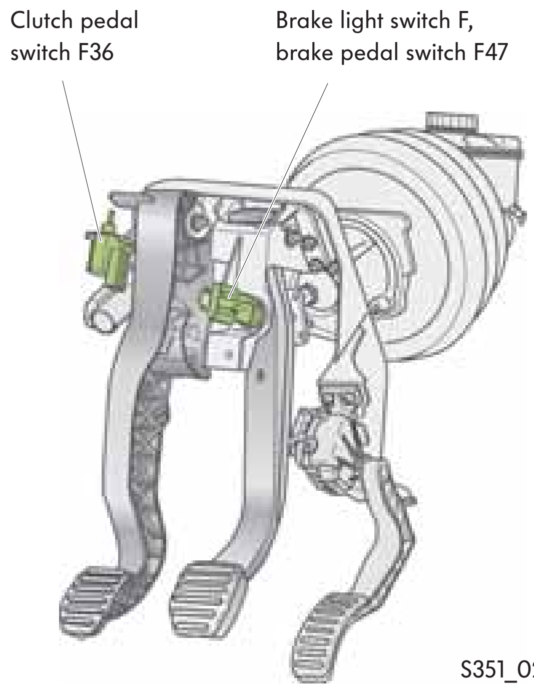
The brake light switch F and the brake pedal switch F47 are located together in one component on the pedal cluster. Both switches help the engine control unit to detect whether the brake is actuated.

Signal usage

When the brake is actuated, the cruise control system is shut off, and the engine no longer responds to the accelerator pedal.

Effects in the event of signal failure

If a sender's signal fails, the injection quantity is reduced and the engine has less output. The cruise control system is additionally shut off.



S351_025

Air mass meter G70

The air mass meter is located in the intake manifold. It works according to the hot film principle, and determines the mass of air which is actually intaken.

Signal usage

The injection quantity and the exhaust gas recirculation quantity are calculated by the diesel direct injection system control unit J248 on the basis of this signal. In connection with the diesel particulate filter system, the signal is used to determine the diesel particulate filter's soiling status.

Effects in the event of signal failure

In the event of signal failure, the diesel direct injection system control unit J248 employs a substitute value comprised of the charge air pressure and engine speed for calculation purposes.

S351_100

Coolant temperature sender G62

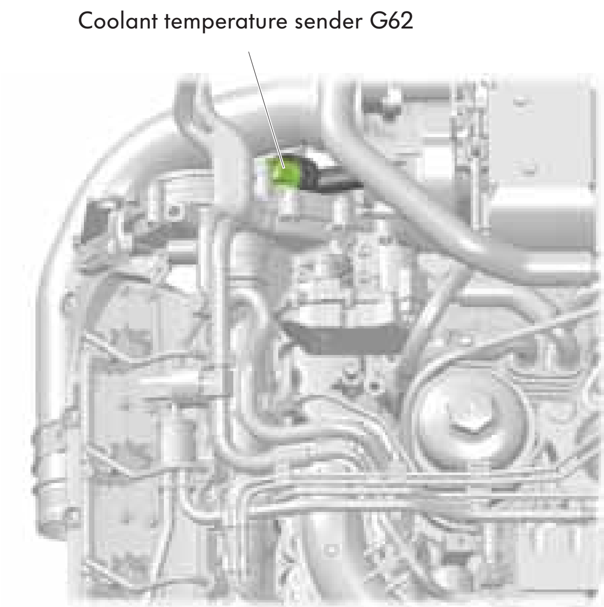
The coolant temperature sender is located on the right cylinder head's coolant connection.
The sender provides the diesel direct injection system control unit J248 with information on the current coolant temperature.

Signal usage

The coolant temperature is used by the diesel direct injection system control unit J248 as a correction value for calculating the injection quantity, the charge air pressure, the injection point and the exhaust gas recirculation quantity.

Effects in the event of signal failure

If the sender signal fails, the diesel direct injection system control unit J248 uses the signal from the radiator outlet coolant temperature sender G83 and a fixed, substitute value for calculation purposes.



S351_029

Radiator outlet coolant temperature sender G83

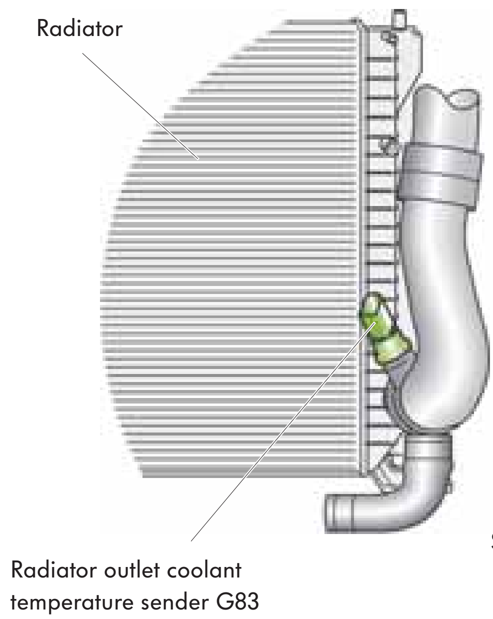
The coolant temperature sender is located in the line at the radiator outlet, where it measures the outlet temperature.

Signal usage

Radiator fan initialisation is carried out by comparing the signals from the two senders, G62 and G83.

Effects in the event of signal failure

If the signal from the radiator outlet coolant temperature sender G83 fails, radiator fan stage 1 is continuously initialised.

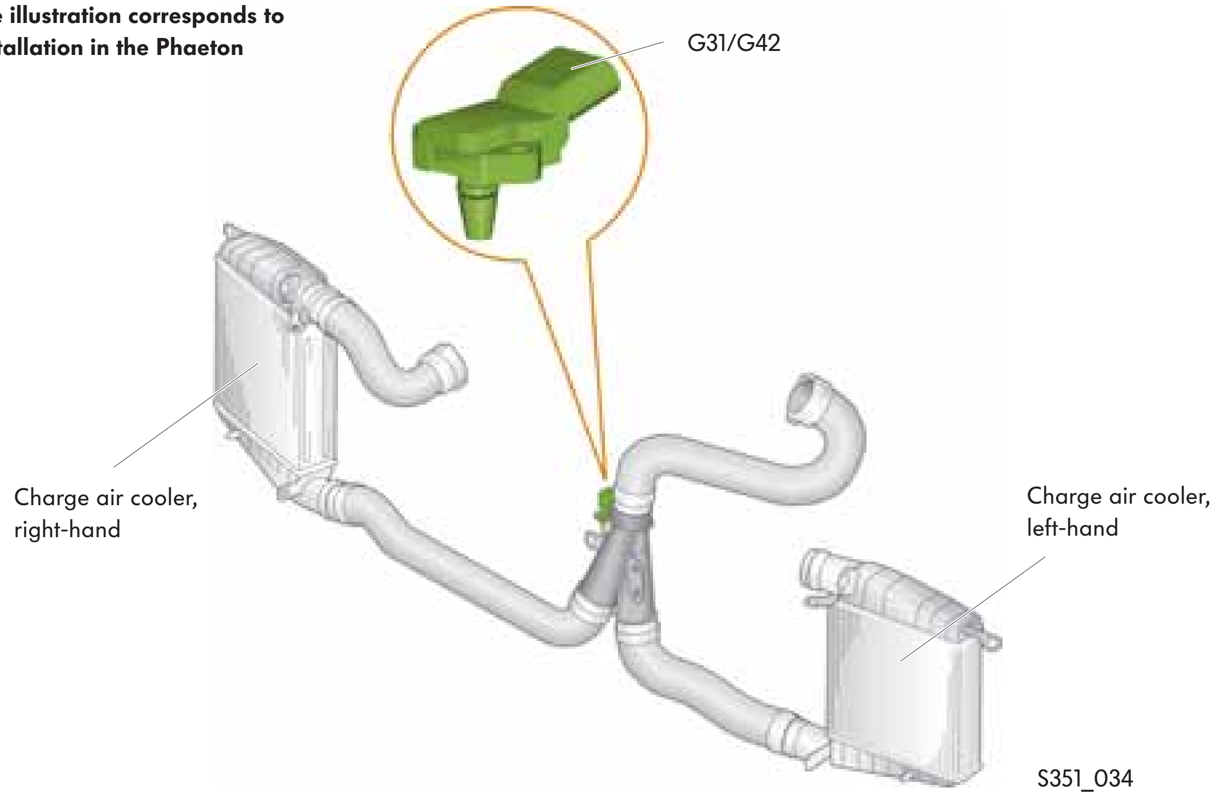


S351_089

Charge air pressure sender G31 and intake air temperature sender G42

The charge air pressure sender G31 and intake air temperature sender G42 are integrated into one component and are located in the intake manifold.

The illustration corresponds to installation in the Phaeton



S351_034

Charge air pressure sender G31

Signal usage

The diesel direct injection system control unit J248 uses the sender's signal to regulate the charge air pressure.

Effects in the event of signal failure

There is no substitute function in the event of signal failure. Charge air pressure regulation is shut off, leading to a significant reduction in engine output.

Intake air temperature sender G42

Signal usage

The diesel direct injection system control unit J248 uses the sender's signal to calculate a correction value for the charge air pressure. Evaluation of the signal gives consideration to the influence of temperature on the density of the charge air.

Effects in the event of signal failure

In the event of signal failure, the diesel direct injection system control unit J248 employs a fixed, substitute value for calculation purposes. This may lead to reduced engine output.

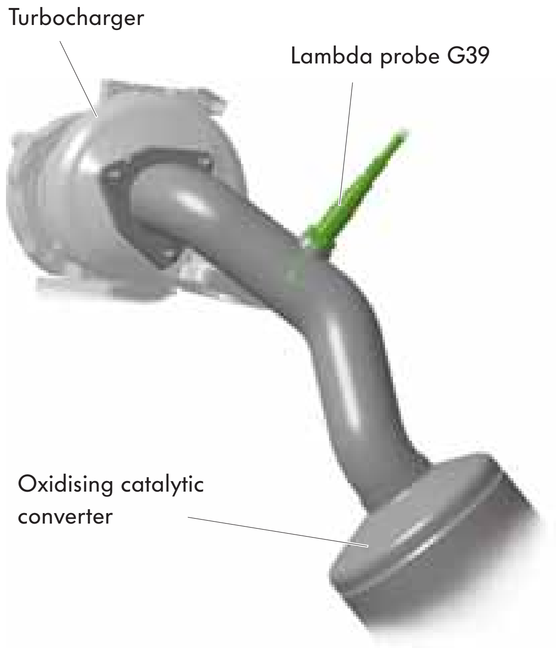
Lambda probe G39

A broadband lambda probe is located upstream of the oxidising catalytic converter in the exhaust system. The lambda probe enables determination of the oxygen content in the exhaust gas over a wide measuring range.

Signal usage

The lambda probe's signal is used to correct the exhaust gas recirculation quantity.

The signal also serves to determine the diesel particulate filter's soiling status. In this calculation model, the lambda probe signal is used to measure the engine's carbon emissions. If the exhaust gas oxygen content is excessively low in comparison with the nominal value, increased carbon emissions are concluded.

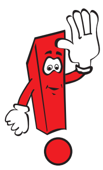


S351_101

Effects in the event of signal failure

If the signal fails, the exhaust gas recirculation quantity is determined using the air mass meter signal. As this regulation is not so precise, nitrogen oxide emissions may increase.

Calculation of the diesel particulate filter's soiling status is less accurate. However, regeneration of the diesel particulate filter remains reliable.



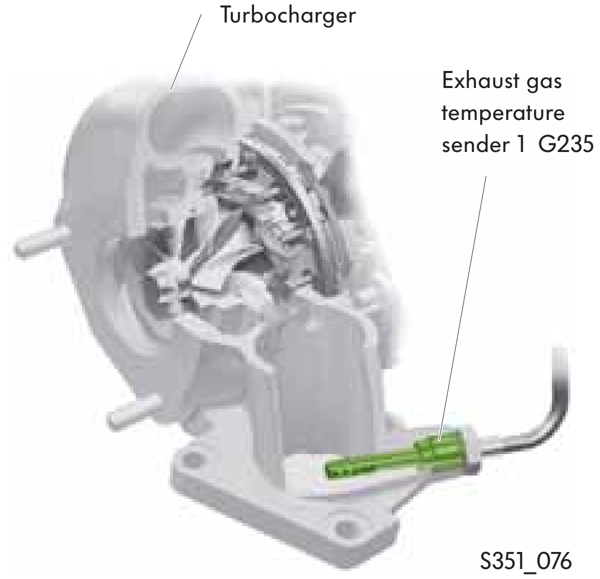
Information on the structure and function of a broadband lambda probe is available in self-study programme 231.

Exhaust gas temperature sender 1 G235

Exhaust gas temperature sender 1 is a PTC sensor. It is located in the exhaust system upstream of the turbocharger, where it measures the temperature of the exhaust gas.

Signal usage

The diesel direct injection system control unit J248 uses the exhaust gas temperature sender's signal to protect the turbocharger from impermissibly high exhaust gas temperatures.



S351_076

Effects in the event of signal failure

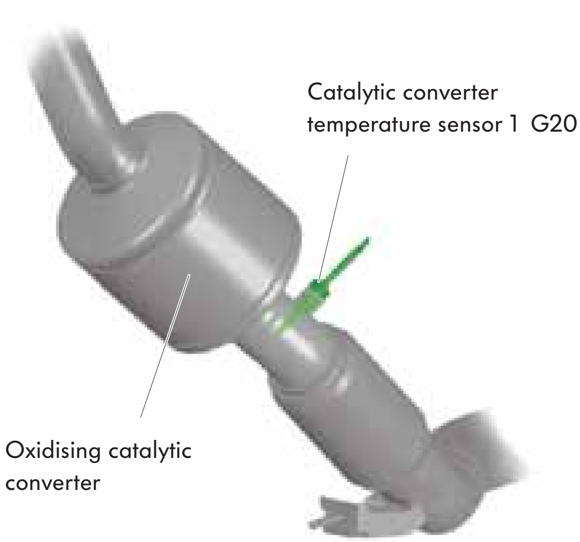
If the exhaust gas temperature sender signal fails, the diesel direct injection system control unit J248 employs a fixed, substitute value for calculation purposes, and engine output is reduced.

Catalytic converter temperature sensor 1 G20 (Phaeton only)

Catalytic converter temperature sensor 1 is a PTC sensor. It is located in the exhaust system directly downstream of the oxidising catalytic converter, where it measures the temperature of the exhaust gas. Due to the long distance between the catalytic converter and the diesel particulate filter, this sensor is only installed in the Phaeton.

Signal usage

This signal is evaluated by the diesel direct injection system control unit J248, and serves as a control variable for secondary injection during the regeneration phase.
The signal also serves as component protection, in order to protect the catalytic converter from excessively high exhaust gas temperatures.
In addition, the temperature information is used for the calculation model to determine the diesel particulate filter's soiling status.



S351_091

Effects in the event of signal failure

If the temperature sensor signal fails, diesel particulate filter regeneration takes place according to the mileage covered or hours of operation. The exhaust emissions warning lamp K83 is activated after three driving cycles.

Bank 1 exhaust gas temperature sender 2 G448

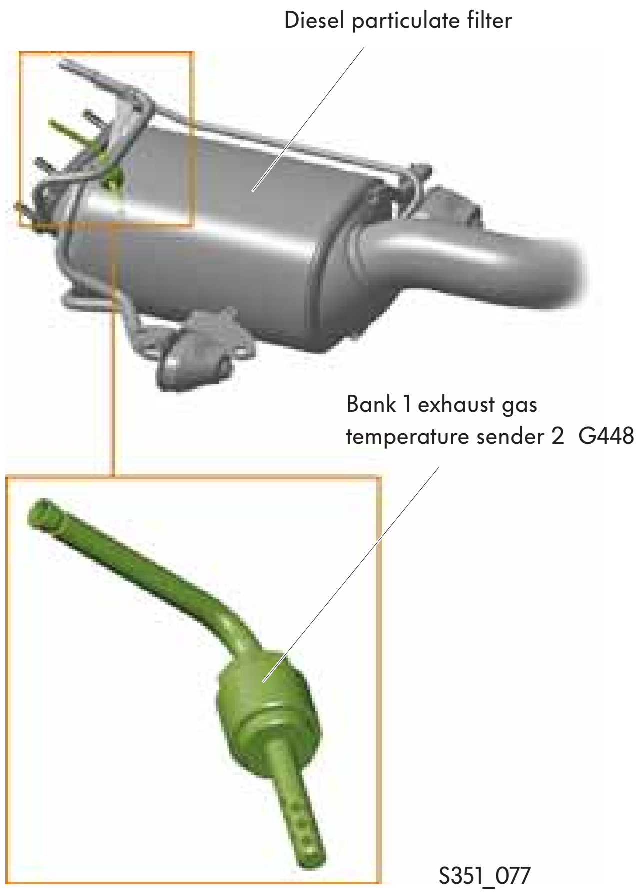
Bank 1 exhaust gas temperature sender 2 is a PTC sensor. It is located in the exhaust system upstream of the diesel particulate filter, where it measures the temperature of the exhaust gas.

Signal usage

The diesel direct injection system control unit J248 uses the signal from bank 1 exhaust gas temperature sender 2 to calculate the diesel particulate filter's soiling status.

The diesel particulate filter's soiling status is calculated using the signal from the bank 1 exhaust gas temperature sender 2, together with the signals from the exhaust gas pressure sensor, the air mass meter and the lambda probe.

The signal also serves as component protection, in order to protect the diesel particulate filter from excessively high exhaust gas temperatures.



Effects in the event of signal failure

If the bank 1 exhaust gas temperature sender 2 signal fails, diesel particulate filter regeneration takes place according to the mileage covered or hours of operation. The exhaust emissions warning lamp K83 is activated after three driving cycles.

Engine management system

Exhaust gas pressure sensor 1 G450

Exhaust gas pressure sensor 1 measures the difference in pressure in the flow of exhaust gas upstream and downstream of the diesel particulate filter. It is secured to a bracket on the gearbox.

Signal usage

The diesel direct injection system control unit J248 uses the pressure sensor's signal to calculate the diesel particulate filter's soiling status.

The diesel particulate filter's soiling status is calculated using the exhaust gas pressure sensor signal, together with the signals from the bank 1 exhaust gas temperature sender 2, the air mass meter and the lambda probe.

S351_032

Effects in the event of signal failure

If the pressure sensor signal fails, diesel particulate filter regeneration takes place according to the mileage covered or hours of operation. Glow period warning lamp K29 flashes at the same time. The exhaust emissions warning lamp K83 is activated after three driving cycles.

Information on the structure and function of the pressure sensor can be found in self-study programme 336 "The catalytic coated diesel particulate filter".

Actuators

Intake manifold flap motor V157 and intake manifold flap 2 motor V275

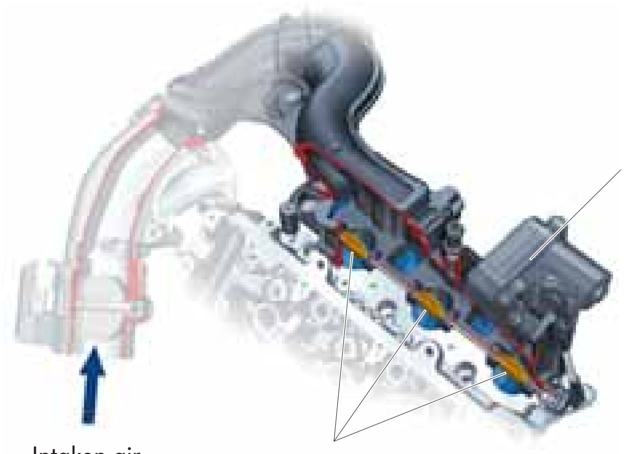
The 3.0l V6 TDI engine has one intake manifold flap motor per cylinder bank. They are located on the lower section of the intake manifold on the relevant cylinder bank.

Task

Continuously variable swirl flaps are located in the lower sections of the intake manifolds of both cylinder banks. The intaken air's swirl is adjusted via the position of the swirl flaps, depending on the engine speed and load.

The intake manifold flap motors have the task of varying the position of the swirl flaps in the intake ports by means of a push rod.
To do this, the intake manifold flap motors are initialised by the diesel direct injection system control unit J248.

S351_037



S351_122

Effects in the event of failure

If the intake manifold flap motors fail, the swirl flaps remain open.

The function of the intake manifold flap motors is described in self-study programme 350.

Throttle valve module J338

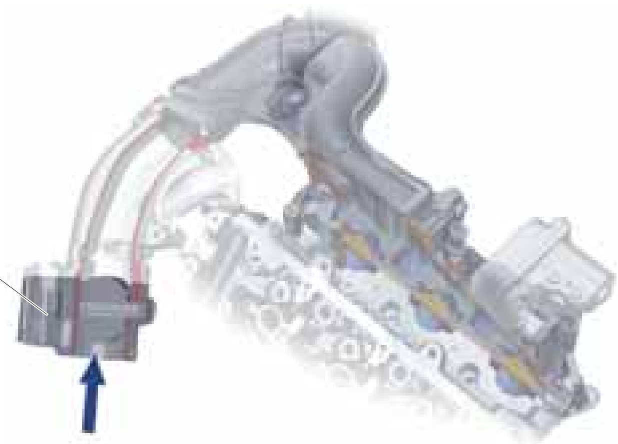
The throttle valve module is located in the intake port upstream of the upper section of the intake manifold. The throttle valve in the throttle valve module is initialised via a positioning motor by the diesel direct injection system control unit J248.

Task

The continuously variable throttle valve is used, in specific operating statuses, to generate a vacuum specified by the diesel direct injection system control unit J248 in the intake manifold. Effective exhaust gas recirculation is achieved as a result of this.

When the engine is switched off, the throttle valve is closed and the air supply is interrupted. Less air is therefore intaken and compressed, as a result of which engine coasting is gentle.

S351_036



S351_123

Effects in the event of failure

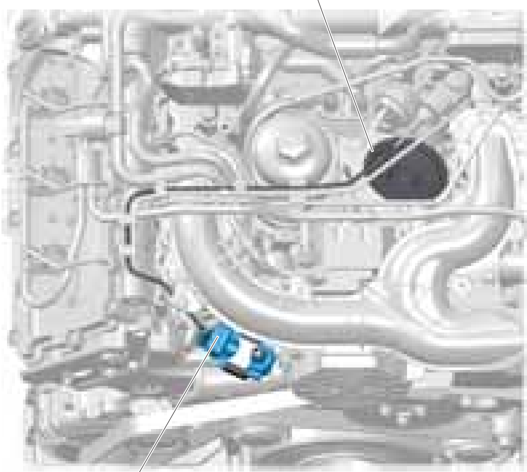
The throttle valve remains open. Correct regulation of the rate of exhaust gas recirculation is impossible.

Exhaust gas recirculation valve N18

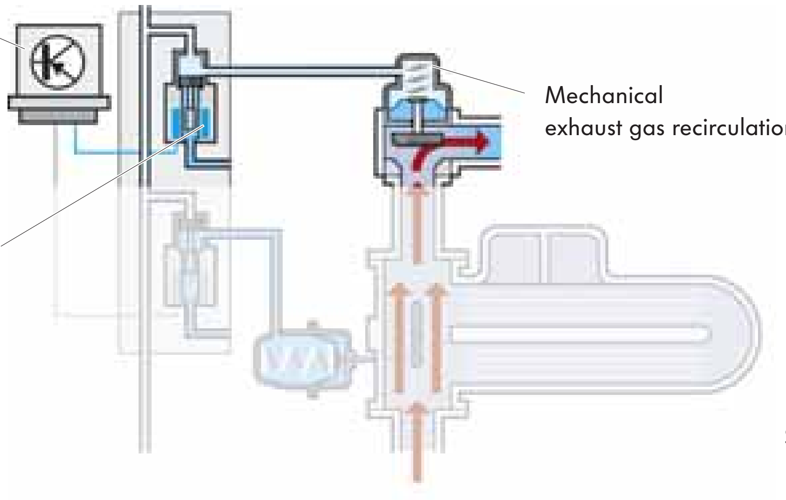
The exhaust gas recirculation valve N18 is an electropneumatic valve. It switches the control pressure to actuate the mechanical exhaust gas recirculation valve.

Task

The exhaust gas recirculation rate is determined by means of a performance map in the diesel direct injection system control unit J248. For control purposes, the exhaust gas recirculation valve N18 is initialised by the diesel direct injection system control unit J248. The control pressure, with which the mechanical exhaust gas recirculation valve is opened, is determined depending on the signal on-off ratio.



S351_099



S351_040

Effects in the event of failure

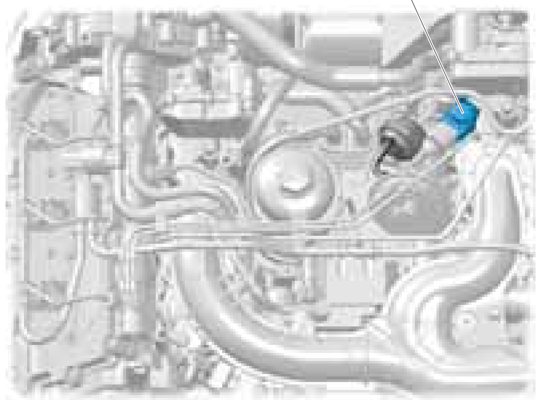
If the signal fails, the exhaust gas recirculation function is not guaranteed.

Exhaust gas recirculation cooler change-over valve N345

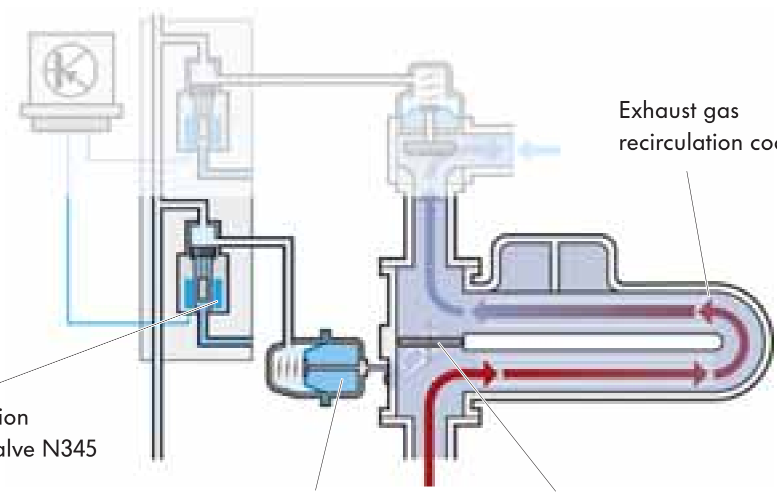
The exhaust gas recirculation cooler change-over valve is an electropneumatic valve. It switches the vacuum unit's control pressure to actuate the bypass valve in the exhaust gas recirculation cooler.

Task

In order to reduce nitrogen oxide emissions even more effectively, the recirculated exhaust gases are conducted through the exhaust gas recirculation cooler when the engine is at operating temperature. The bypass valve in the exhaust gas recirculation cooler is actuated to achieve this. The change-over valve is initialised by the diesel direct injection system control unit J248 depending on the temperature. This then switches the vacuum unit's control pressure to actuate the bypass valve in the exhaust gas recirculation cooler.



S351_049



S351_103

Effects in the event of failure

If the changeover valve fails, the exhaust gas recirculation cooler bypass valve remains closed. The exhaust gas is always cooled, and both the engine and the oxidising catalytic converter take longer to reach their operating temperature.

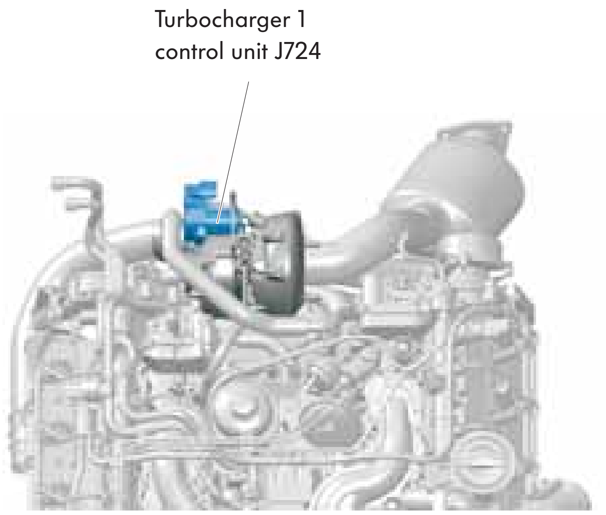
Turbocharger 1 control unit J724

The turbocharger 1 control unit is located on the turbocharger.

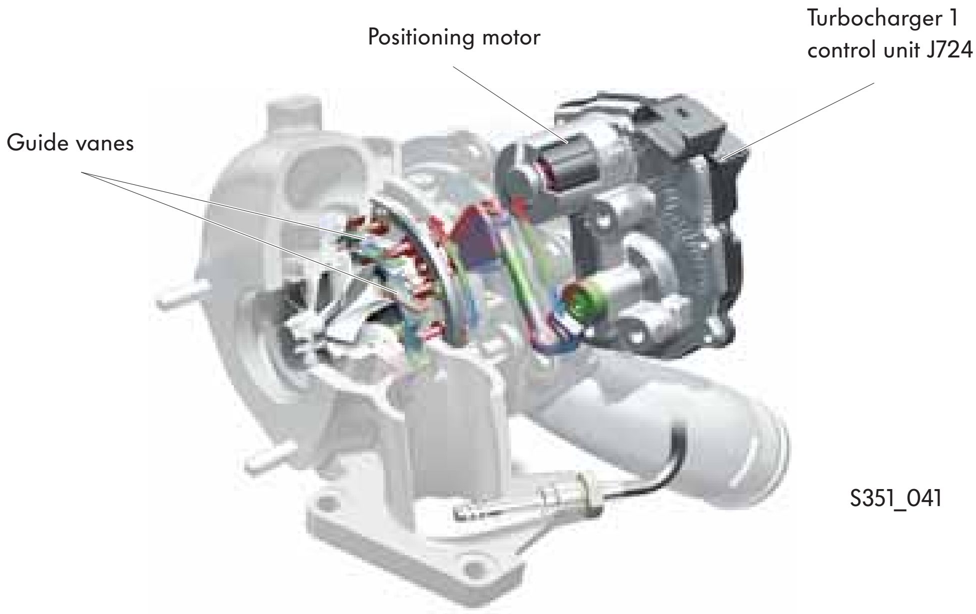
Task

The turbocharger 1 control unit controls guide vane adjustment in the turbocharger via an electric positioning motor. Electric initialisation makes fast turbocharger response behaviour and precise regulation possible.

To adjust the guide vanes, the turbocharger 1 control unit is initialised by the diesel direct injection system control unit J248 using a pulse width modulated (PWM) signal.



S351_092



S351_041

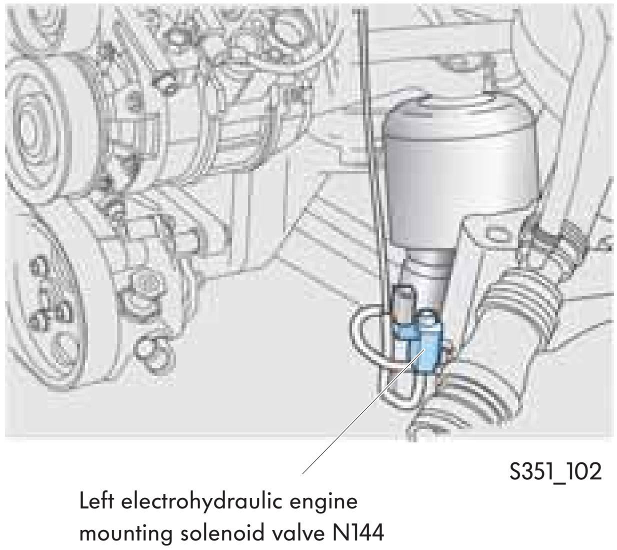
Effects in the event of failure

No further charge air pressure control is possible in the event of turbocharger 1 control unit failure. The injection quantity is limited and engine output is reduced.

Engine management system

Left electrohydraulic engine mounting solenoid valve N144

The left electrohydraulic engine mounting solenoid valve is an electropneumatic valve. It is located on the engine bracket on the left-hand side of the engine compartment.

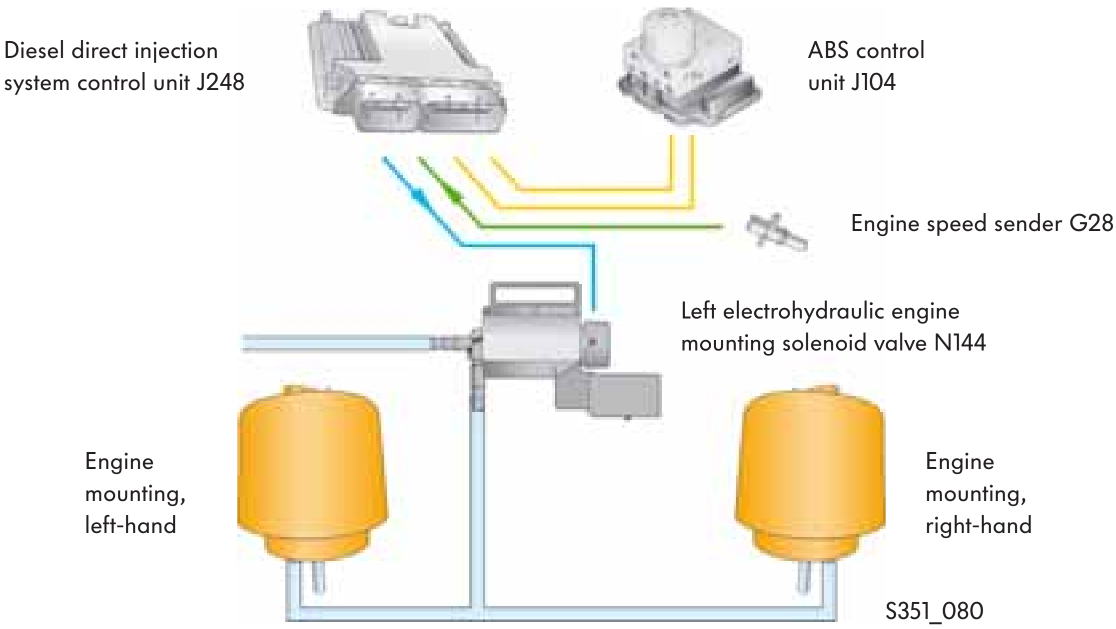


Task

The 3.0l V6 TDI engine fitted in the Phaeton is equipped with hydraulically damped engine mountings. These engine mountings reduce the transmission of engine vibrations to the body, and thereby ensure a high level of ride comfort.
The electrohydraulic engine mounting solenoid valve is used to switch the control pressure for both engine mountings.

Function

The left electrohydraulic engine mounting solenoid valve N144 is initialised by the diesel direct injection system control unit J248 in order to change the engine mountings' damping characteristics. The solenoid valve then switches the control pressure for both engine mountings. The vehicle speed and the engine speed are used as input signals by the diesel direct injection system control unit J248.

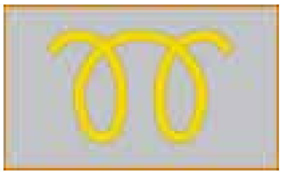


Detailed information on the electrohydraulic engine mounting can be found in self-study programme 249 "The W8 engine management system in the Passat".

Glow period warning lamp K29

The glow period warning lamp has two functions:

- It lights up to indicate the glow period to the driver prior to starting the engine.
- It flashes to notify the driver of an engine malfunction.

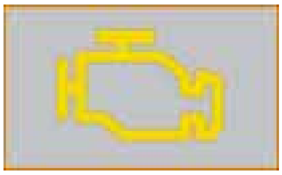


S351_113

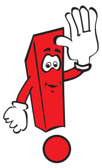
Exhaust emissions warning lamp K83 (MIL)

Those engine management system components relevant to exhaust emissions are checked as regards failure and malfunctions within the framework of European On-Board Diagnosis (EOBD).

The exhaust emissions warning lamp (MIL = Malfunction Indicator Lamp) indicates faults detected by the EOBD system.



S351_111

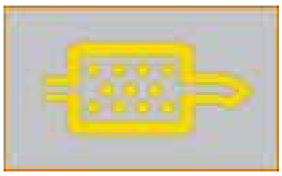


Detailed information on the exhaust emissions warning lamp and the EOBD system can be found in self-study programme 315 "European On-Board Diagnosis for diesel engines".

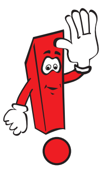
Diesel particulate filter warning lamp K231

The diesel particulate filter warning lamp lights up if the diesel particulate filter can no longer be regenerated as a result of operation over extremely short distances.

Via this signal, the driver is requested to drive as evenly as possible at increased speed for a short period of time, so that the diesel particulate filter can be regenerated.



S351_112



For precise information on driving behaviour when the diesel particulate filter warning lamp lights up, please refer to the vehicle owner's manual.

Glow plug system

The 3.0l V6 TDI engine is fitted with a diesel quick-start glow plug system.

This enables immediate starting, like that of a petrol engine, without a long glow period under practically all climatic conditions.

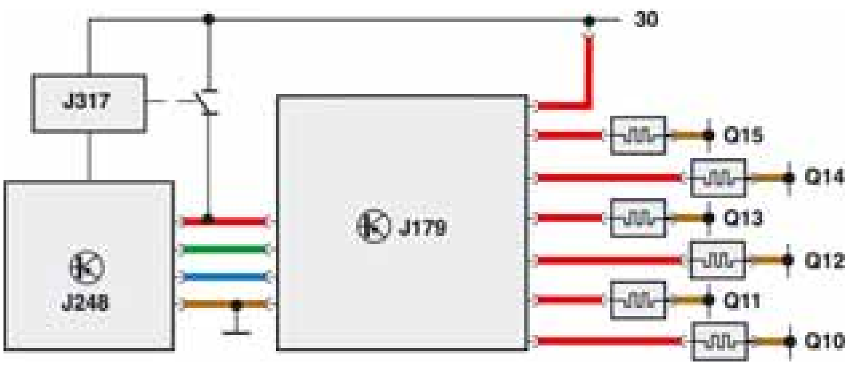
Advantages of this glow plug system

- Reliable starting at temperatures down to –24 °C
- Extremely rapid heating time – within two seconds, a temperature of 1000 °C is reached at the glow plug
- Controllable glow and post-start glow temperature
- Self-diagnosis-capable
- European On-Board Diagnosis

The automatic glow period control unit is provided with information by the diesel direct injection system control unit J248 for the glow function. The glow period, the glow duration, the initialisation frequency and the on-off ratio are therefore determined by the engine control unit.

Automatic glow period control unit functions

- Switching the glow plugs with a PWM signal
- Integrated overvoltage and overtemperature shut-off
- Individual plug monitoring
  - Detection of overcurrent and short-circuit in the glow circuit
  - Glow circuit overcurrent shut-off
  - Glow electronics diagnosis
  - Detection of an open glow circuit in the event of glow plug failure



S351_098

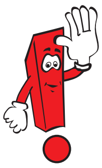
J179	Automatic glow period control unit
J248	Diesel direct injection system control unit
J317	Terminal 30 voltage supply relay
Q10–Q15	Glow plugs

Red: Supply voltage
Brown: Earth
Green: Control signal from J248
Blue: Diagnostic signal to J248

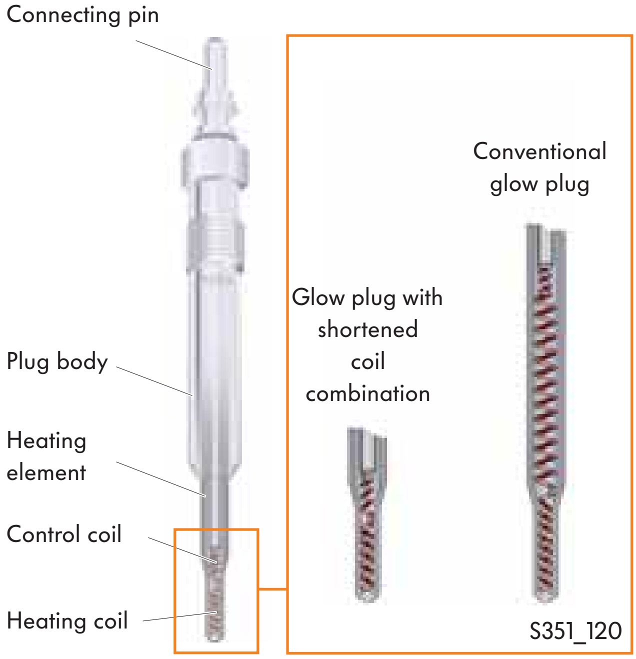
Glow plugs

The glow plugs are made up of the plug body, the connecting pin and the heating element with heating and control coil.
In comparison with conventional, self-regulating glow plugs, the coil combination, comprised of the control coil and the heating coil, is approximately one-third shorter. This has enabled the glow period to be reduced to two seconds.

The glow plugs have a rated voltage of 4.4 V.



Never check the function of the glow plugs with 12 V, as the glow plugs otherwise melt!



S351_120

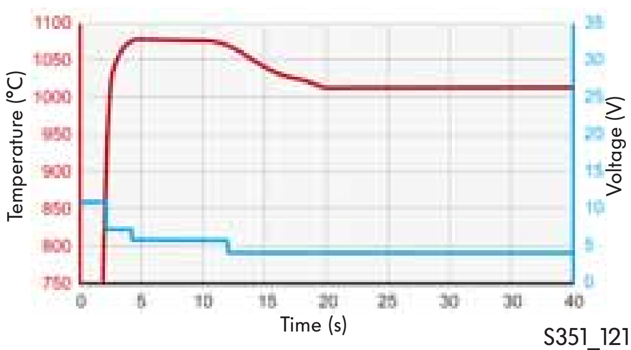
S351_119

Glowing

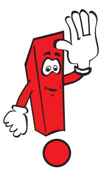
After switching on the ignition, the glow plugs are switched on via the automatic glow period control unit by the diesel direct injection system control unit J248 at a temperature of less than 20 °C. During the initial glowing phase, the glow plugs are operated at a voltage of approx. 11 V for a maximum of two seconds. The glow plugs are then supplied with the voltage required for the relevant operating status by the automatic glow period control unit.
To relieve the onboard supply, glow plug initialisation is phase-offset.

Post-start glowing

Post-start glowing is carried out each time after the engine has been started, in order to minimise combustion noise and reduce hydrocarbon emissions. Glow plug initialisation is corrected by the diesel direct injection system control unit J248 depending on load and engine speed.

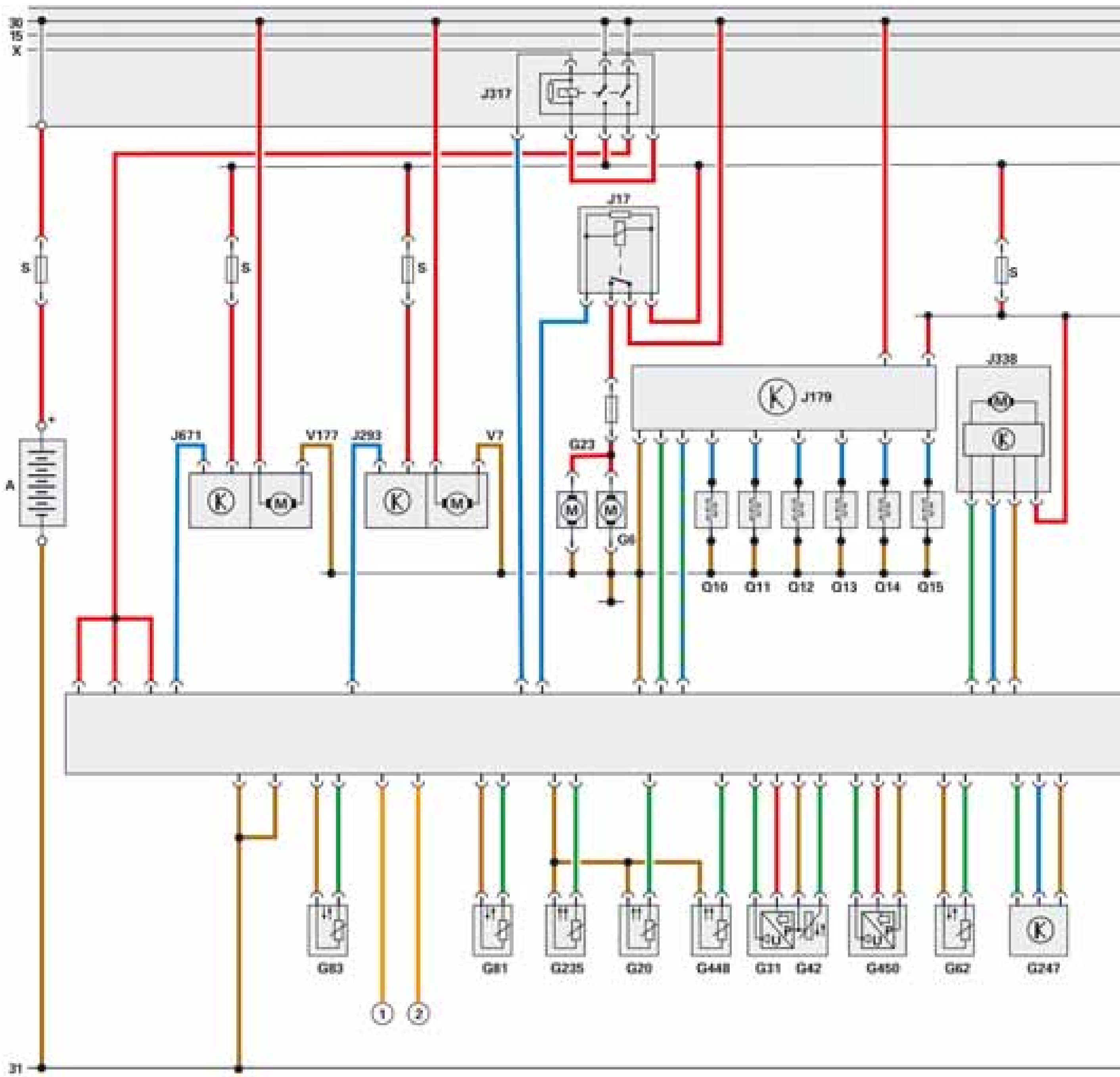


S351_121

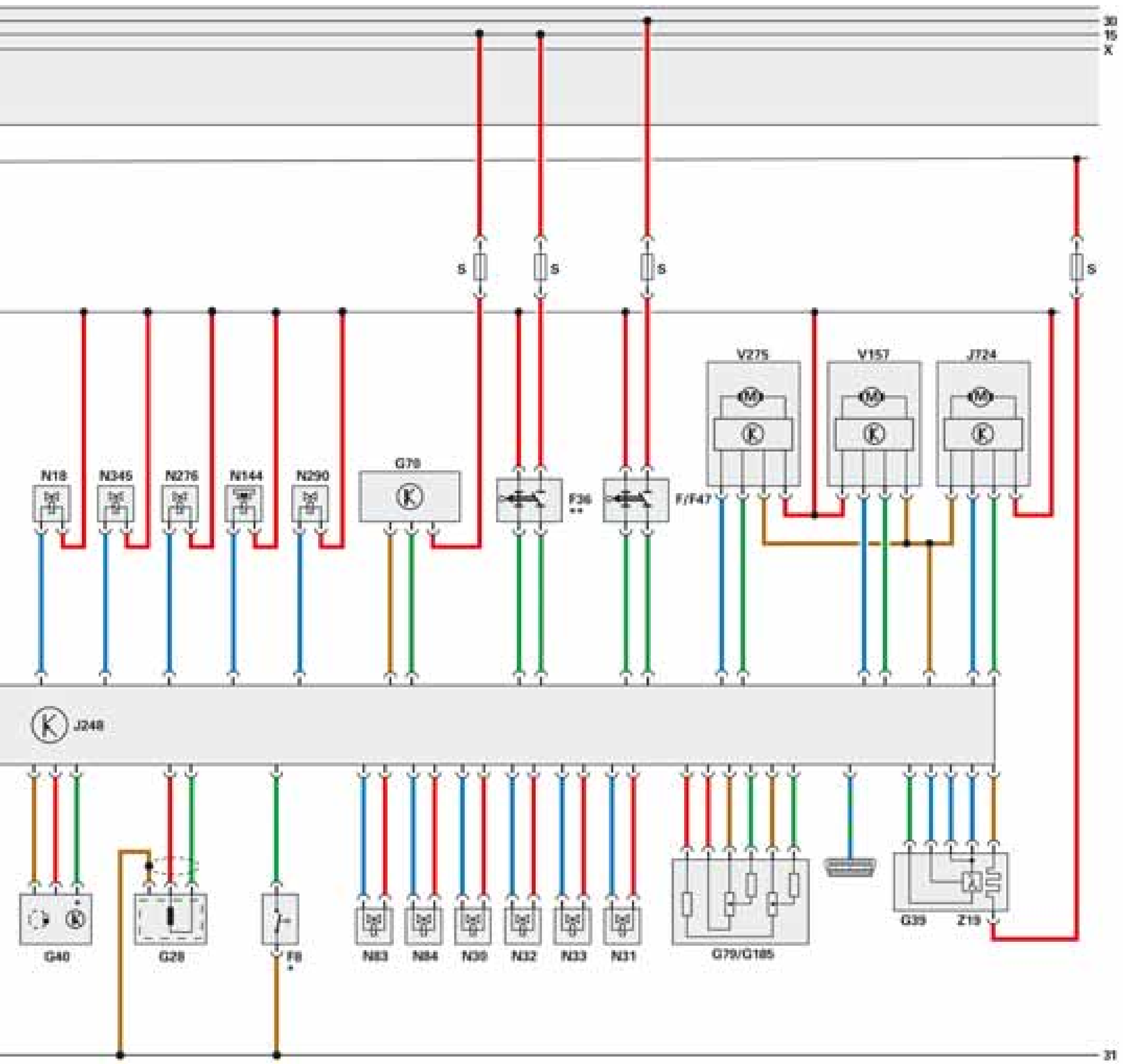


Post-start glowing is no longer carried out as of a coolant temperature of 35 °C. Post-start glowing is interrupted after a maximum of three minutes.

Engine management system



A	Battery
F	Brake light switch
F8	Kick-down switch (Phaeton only)*
F36	Clutch pedal switch (Touareg with manual gearbox only)**
F47	Brake pedal switch
G6	Fuel system pressurisation pump
G20	Catalytic converter temperature sensor 1 (Phaeton only)
G23	Fuel pump
G28	Engine speed sender
G31	Charge air pressure sender
G39	Lambda probe
G40	Hall sender
G42	Intake air temperature sender
G62	Coolant temperature sender
G70	Air mass meter
G79	Accelerator position sender
G81	Fuel temperature sender
G83	Radiator outlet coolant temperature sender
G185	Accelerator position sender 2
G235	Exhaust gas temperature sender 1
G247	Fuel pressure sender
G448	Bank 1 exhaust gas temperature sender 2
G450	Exhaust gas pressure sensor 1
J17	Fuel pump relay
J179	Automatic glow period control unit
J248	Diesel direct injection system control unit
J293	Radiator fan control unit
J317	Terminal 30 voltage supply relay
J338	Throttle valve module
J671	Radiator fan control unit 2
J724	Turbocharger 1 control unit
N18	Exhaust gas recirculation valve



S351_052

N30	Injector, cylinder 1
N31	Injector, cylinder 2
N32	Injector, cylinder 3
N33	Injector, cylinder 4
N83	Injector, cylinder 5
N84	Injector, cylinder 6
N144	Left electrohydraulic engine mounting solenoid valve (Phaeton)
N276	Fuel pressure regulating valve
N290	Fuel metering valve
N345	Exhaust gas recirculation cooler change-over valve
Q10-15	Glow plugs 1 – 6
S	Fuse
V7	Radiator fan
V157	Intake manifold flap motor
V177	Radiator fan 2
V275	Intake manifold flap 2 motor
Z19	Lambda probe heater

① CAN-BUS L
② CAN-BUS H

Diagnostic connection

= Input signal
= Output signal
= Positive
= Earth
= CAN BUS
= Bi-directional

Test your knowledge

1. **What are the advantages of injectors which are initialised via a piezo actuator versus injectors controlled by solenoid valves?**

☐ a) More injections per working cycle are possible.

☐ b) The injection quantities can be metered more precisely.

☐ c) The fuel is injected into the combustion chamber in more finely atomised form.

☐ d) The injector is able to generate higher fuel pressure.

2. **Which statement on the piezo actuator is correct?**

☐ a) A piezo actuator's switching speed corresponds to that of a solenoid valve.

☐ b) The inverse piezo-electric effect is used to control the piezo actuator.

☐ c) The piezo actuator acts like a hydraulic cylinder and serves to transmit force to the switching valve.

3. **Which statement applies to Injector Delivery Calibration (IDC)?**

☐ a) Injector delivery calibration is a software function in the diesel direct injection system control unit for initialising the injectors.

☐ b) If an injector is renewed, it must be matched to the fuel injection system by means of injector delivery calibration.

☐ c) Injector delivery calibration ensures that all injectors can be manufactured without production tolerances.

4. **What is the task of the fuel metering valve N290?**

☐ a) It maintains a fuel pressure of approx. 10 bar in the injectors' fuel return.

☐ b) It regulates the quantity of fuel which flows to the high-pressure pump.

☐ c) It regulates the quantity of fuel which is injected into the combustion chambers.

☐ d) Depending on the fuel temperature, it conducts the fuel returning from the high-pressure pump, the high-pressure accumulators and the injectors back into the fuel filter or to the fuel tank.

5. **Which statement on the fuel pressure regulating valve N276 is correct?**

☐ a) Engine operation is not possible in the event of fuel pressure regulating valve failure.

☐ b) The engine continues to operate in emergency running mode in the event of fuel pressure regulating valve failure.

☐ c) The fuel pressure regulating valve is used to adjust the fuel pressure in the high-pressure accumulator.

☐ d) The fuel pressure regulating valve is used to adjust the fuel pressure in the injectors' fuel return.

6. **The pressure retention valve maintains a fuel pressure of approx. 10 bar in the injectors' fuel return. What is this fuel pressure required for?**

☐ a) For the injectors' function.

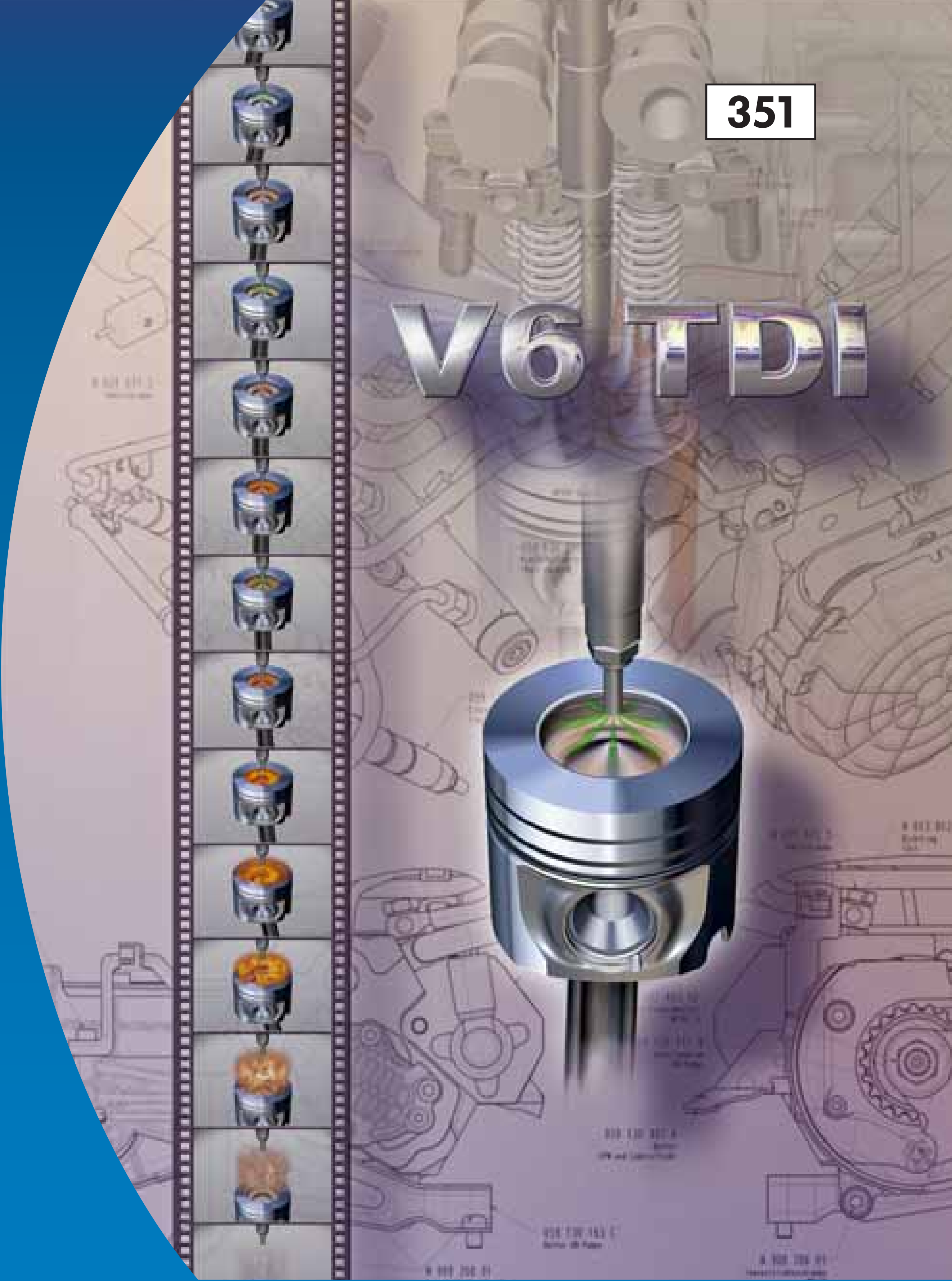
☐ b) For the high-pressure pump's function.

☐ c) For faster fuel heating.

☐ d) For compensating pressure fluctuations in the high-pressure accumulator.

Answers

1. a), b)
2. b)
3. a), b)
4. b)
5. a), c)
6. a)



000.2811.65.20 Technical status 07.2005

Volkswagen AG
Service Training VK-21
Brieffach 1995
38436 Wolfsburg