

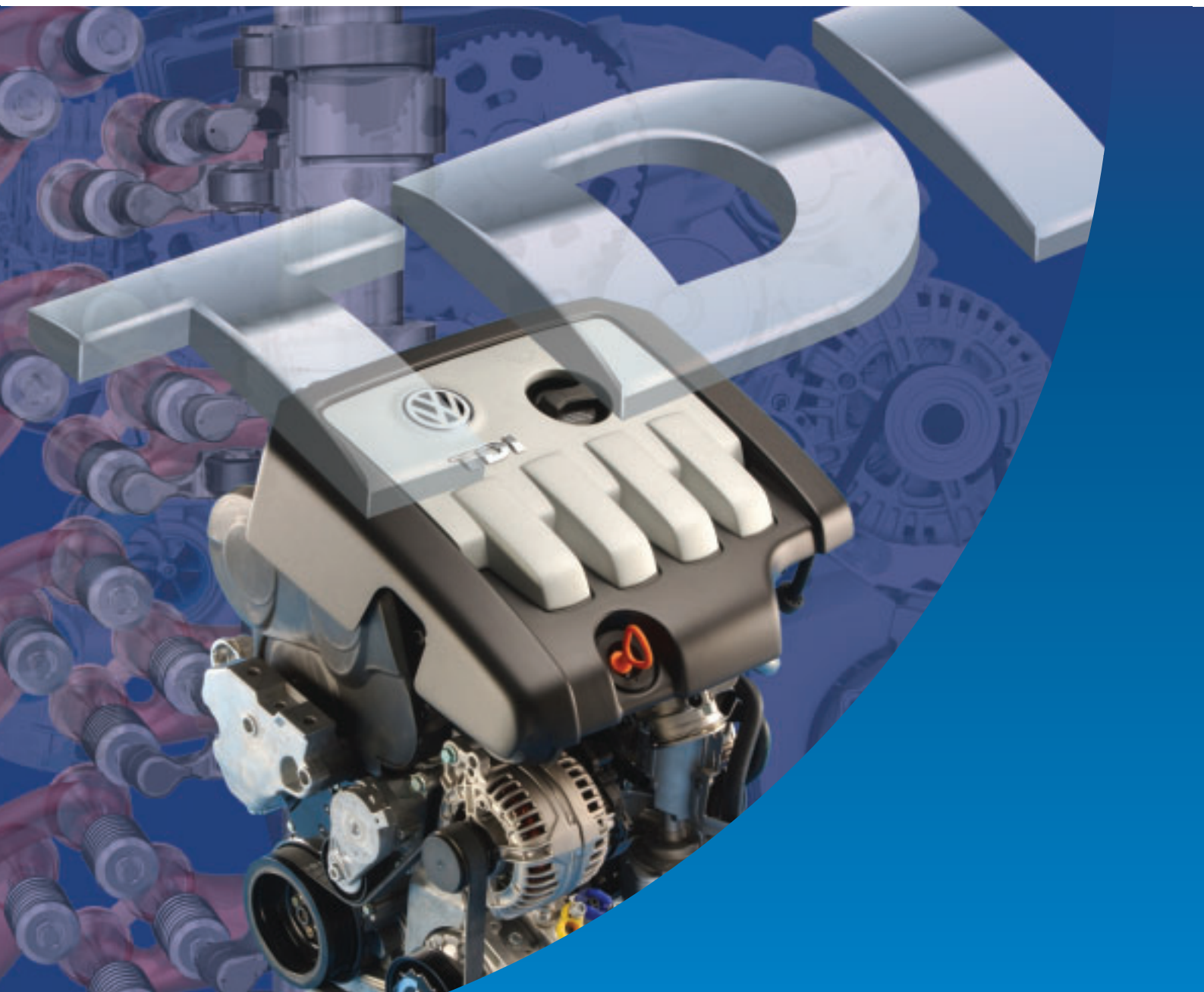
Service Training



Self-study programme 316

# The 2.0 ltr. TDI engine

Design and function



The days of sluggish and noisy diesel engines that, when started, startled the whole neighbourhood out of bed and left a trail of black smoke when full throttle was applied are long gone.

Driving performance, driving dynamics, driving comfort, economy and emissions have been markedly improved due to the consistent further development of all the engine components, the combustion procedure, the materials and processes and also the injection pressures.

In order to meet the stricter emissions regulations and to further reduce fuel consumption with greater power output, Volkswagen uses the TDI engine generation with 4 valve technology.

The 2.0 ltr. TDI engine was developed as the first four cylinder diesel engine with four valve technology in the Volkswagen Group for use in the Touran, in the Golf 2004 and also in other vehicles yet to be introduced.



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**NEW**



**Important Note**



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

For current inspection, adjustment and repair instructions, please refer to the relevant service literature.



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# Introduction



## The 2.0 ltr./103 kW TDI engine with 4-valve technology



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The 2.0 ltr./103 kW TDI engine is the first in a line of new TDI engine generations with 4 valve technology from VOLKSWAGEN.

A 100 kW version of the engine has already been introduced in the Volkswagen Touran.

It is a further development of the 1.9 ltr./96 kW TDI engine. The increase in engine size compared with the standard engine was achieved by resizing the bore.

The new 2.0 ltr./103 kW TDI engine features a newly developed cross-flow aluminium cylinder head with two inlet and two exhaust valves per cylinder.

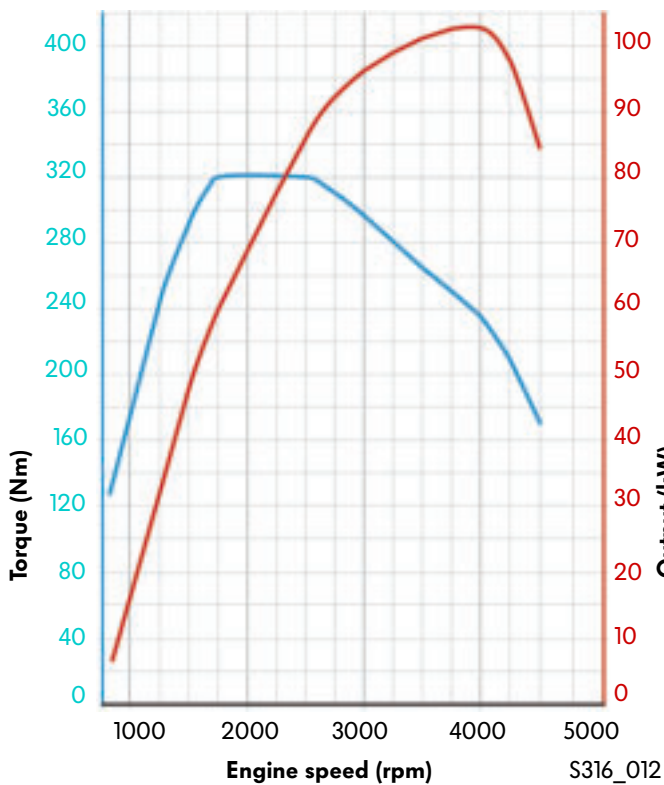
Further technical highlights are a switchable cooler for exhaust gas recirculation, a crankshaft sealing flange with integrated engine speed sender wheel and a new preglow system.

## Technical data



Engine code	BKD
Type	4-cylinder in-line engine
Displacement	1968 cm <sup>3</sup>
Bore	81 mm
Stroke	95.5 mm
Valves per cylinder	4
Compression ratio	18:1
Max. output	103 kW at 4000 rpm
Max. torque	320 Nm at 1750 rpm to 2500 rpm
Engine management	EDC 16 with unit injector system
Fuel	Diesel, at least 49 CN
Exhaust gas treatment	Exhaust gas recirculation and oxidising catalytic converter
Emissions standard	EU4

### Torque and power development diagram

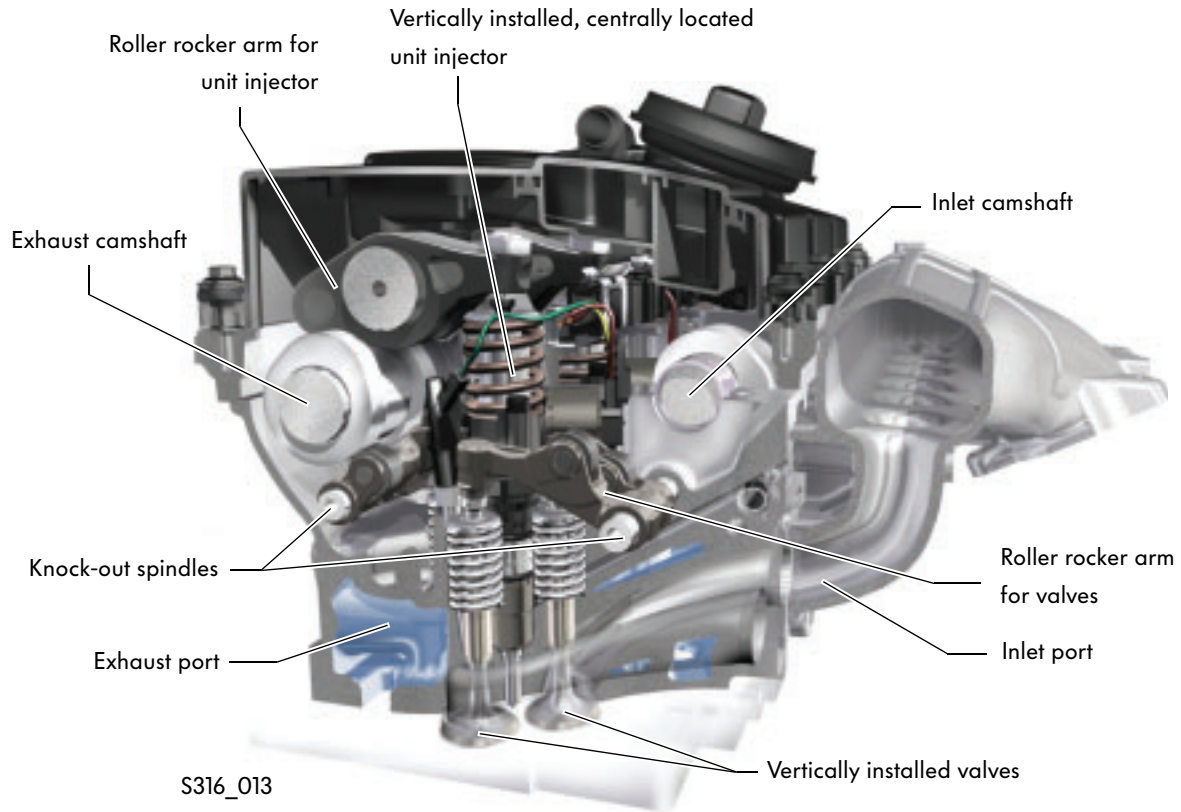


At an engine speed of between 1750 rpm and 2500 rpm, the 2.0 ltr./103 kW TDI engine develops 320 Nm of torque.

Its maximum output of 103 kW is reached at a speed of 4000 rpm.

# Engine mechanics

## The cylinder head



The cylinder head of the 2.0 ltr. TDI engine is of the cross-flow type made from aluminium with two inlet and two exhaust valves per cylinder. The valves are installed vertically.

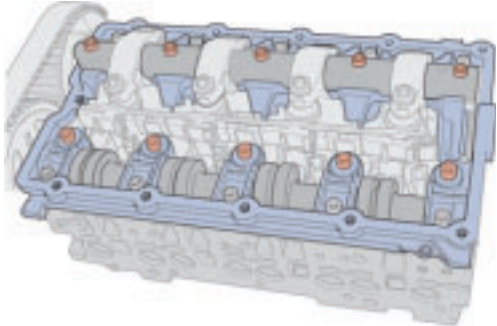
The two overhead camshafts are driven together by a toothed belt.

In addition to exhaust valve timing, the exhaust camshaft is responsible for providing drive to the unit injectors.

In addition to inlet valve timing, the inlet camshaft is responsible for providing drive to the tandem pump.

Valve actuation is via roller rocker arms, which are mounted on knock-out spindles.

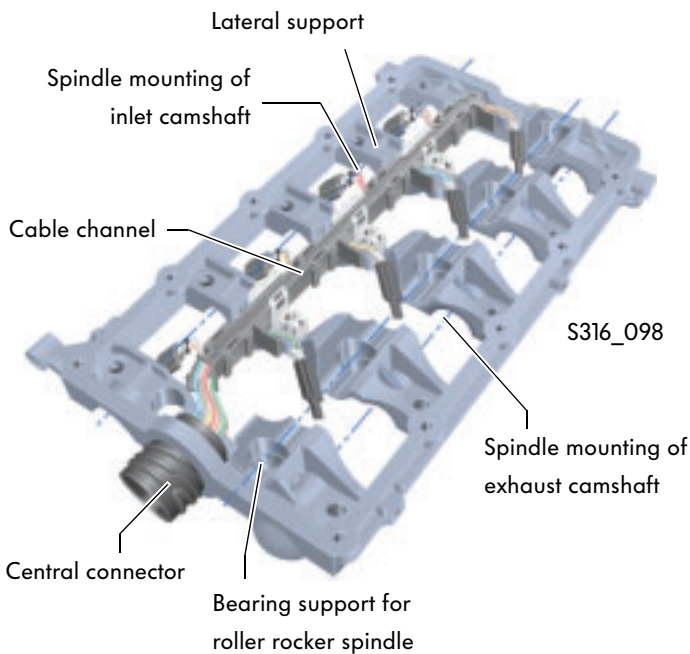
## The bearing frame



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The bearing frame is a compact component, pressure cast from aluminium. It is responsible for the following functions:

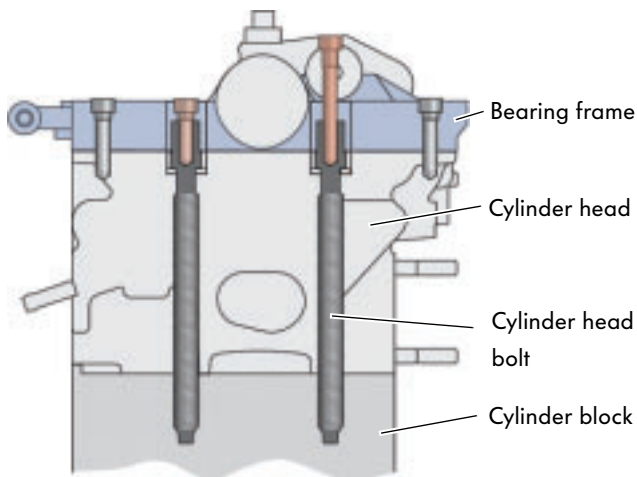
- Mounting of the camshafts
- Spindle mounting and guide for roller rockers to drive unit injectors
- Mounting of central connector for power supply
- Mounting of cable channel for unit injectors and glow plugs.



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Thanks to the overall design of the bearing frame, which features five strong lateral supports, not only has rigidity in the cylinder head been achieved but the acoustics of the engine have also been markedly improved.

## Fixture concept "bolt in bolt"



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The bearing frame is bolted directly in the bolt heads of the cylinder head bolts at both inner rows by means of a "bolt in bolt" bonding concept.

This space saving concept of joining bearing frame and cylinder head to the engine block is a prerequisite for the low cylinder clearance.

# Engine mechanics

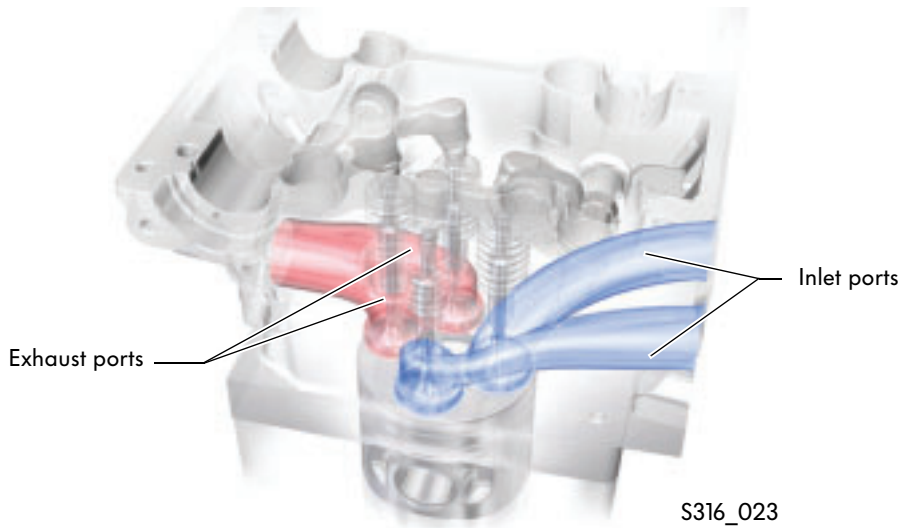
## The 4 valve technology

Each cylinder is allocated two inlet and two exhaust valves, which are installed vertically.

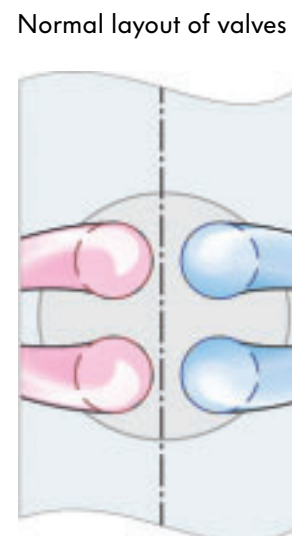
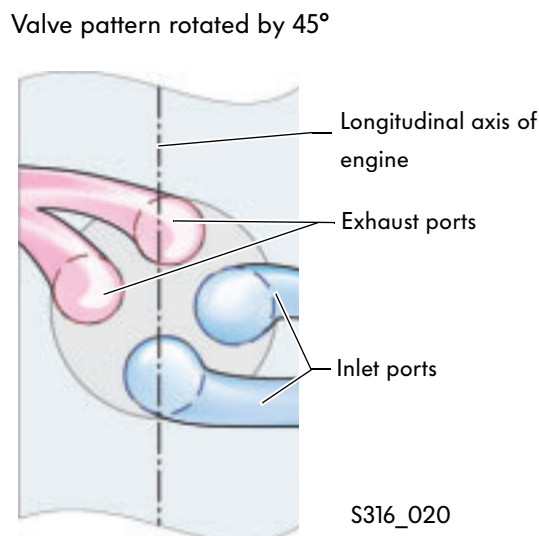
Shape, size and layout of the inlet and exhaust valves are contributory factors for improved volumetric efficiency and better air/fuel mixture flow.

The vertically installed, centrally located unit injectors can be found directly above the central piston crowns.

This design positively affects the mixture formation. The result is a reduction in fuel consumption and lower exhaust emissions.



For optimal flow properties through the inlet and exhaust ports, the valve pattern is rotated by 45° to the longitudinal axis of the engine.

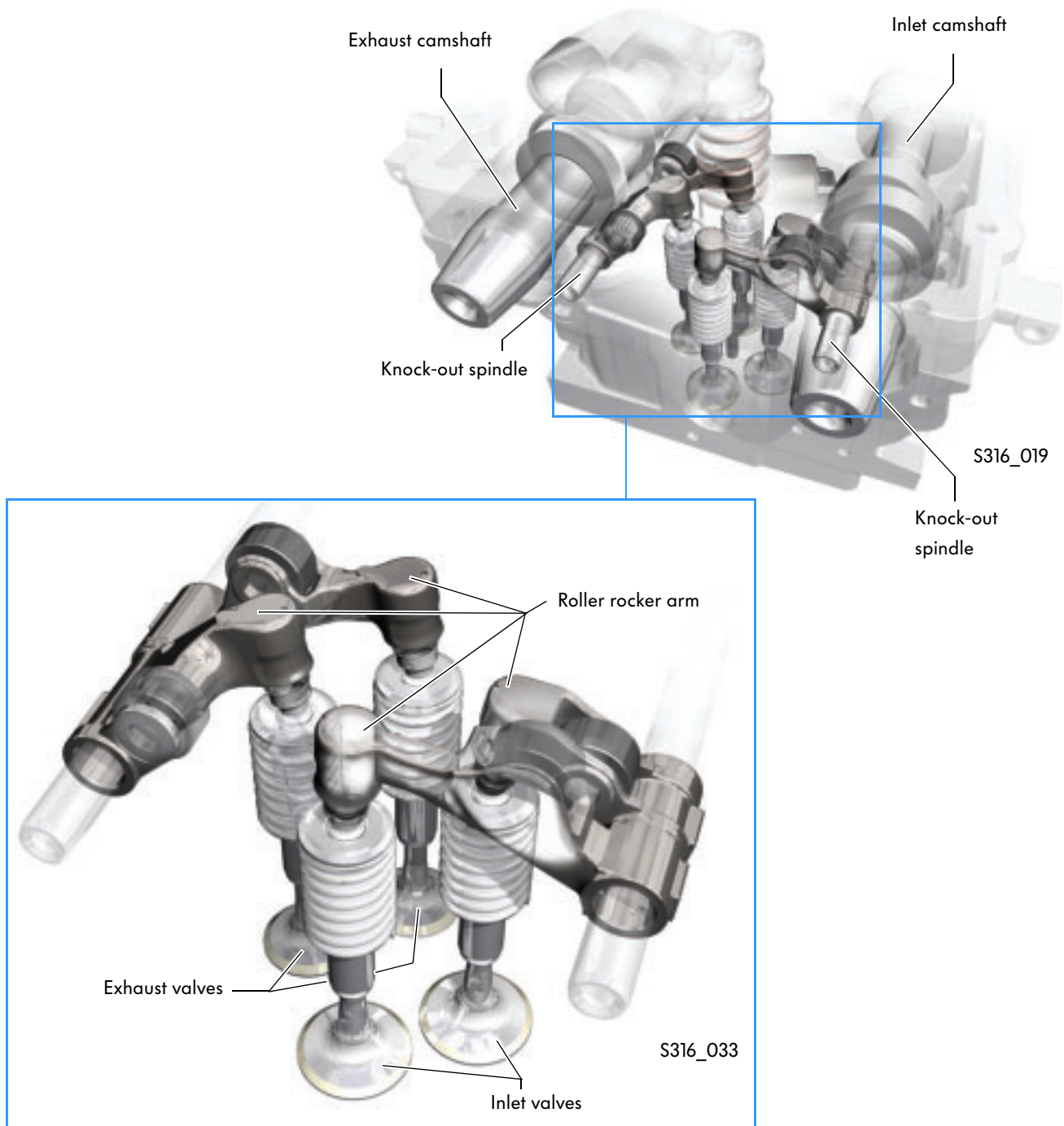




## Drive for inlet and exhaust valves

Both camshafts for control of the inlet and exhaust valves are driven by a toothed belt. Valve actuation is via roller rocker arms, which are mounted on a knock-out spindle.

Due to dimensional requirements in component assembly, the four roller rocker arms differ in size and shape.

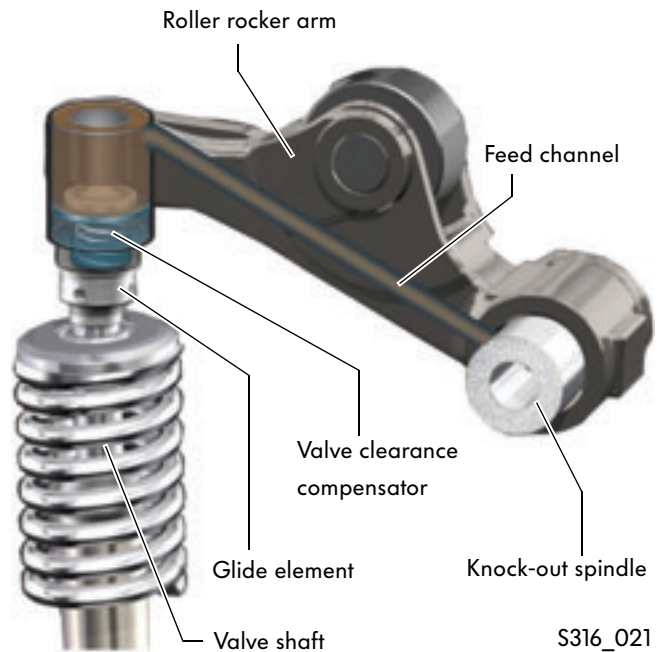


# Engine mechanics

## The roller rocker arms

These are mounted, to allow freedom of movement, on a knock-out spindle. The valve clearance compensator can be found directly above the valve shaft.

Oil is supplied to the valve clearance compensator from the knock-out spindle via a feed channel in the roller rocker arm. A floating glide element installed between valve clearance compensator and valve shaft, ensures an equal and balanced distribution of force.

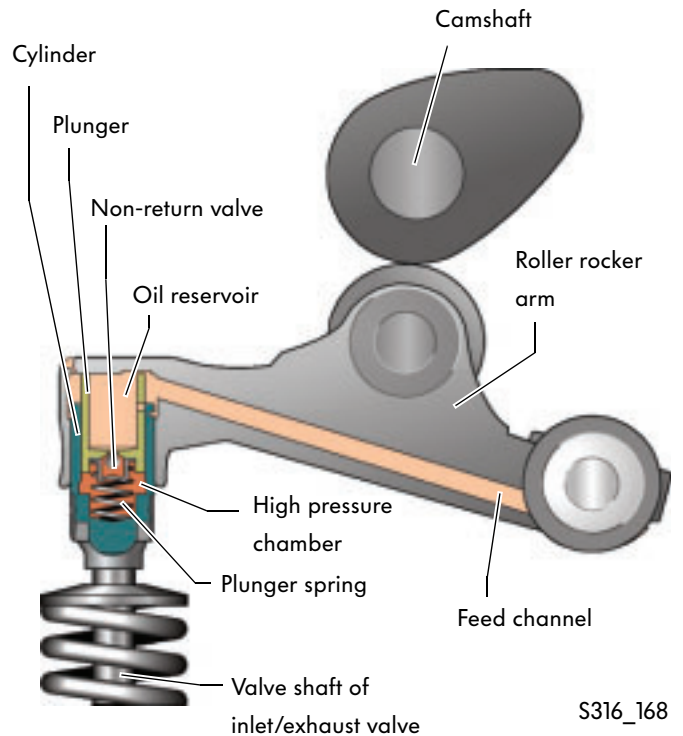


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## Design and function of valve clearance compensator

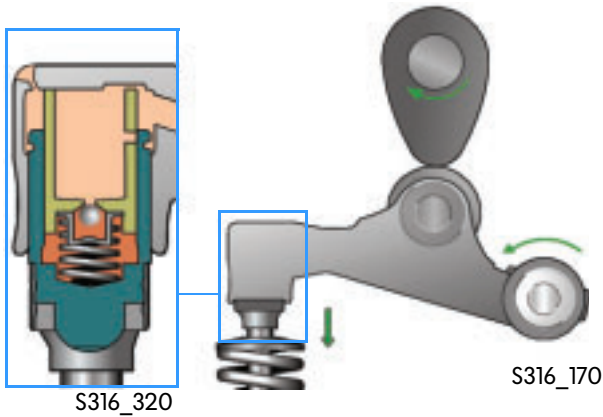
The valve clearance compensator comprises, among other things, of two parts: Plunger and cylinder. These are subjected to opposing forces.

A plunger spring forces both parts apart so that the clearance is taken up between roller rocker arm and camshaft. The non-return valve serves as a means of filling and sealing the high pressure chamber.



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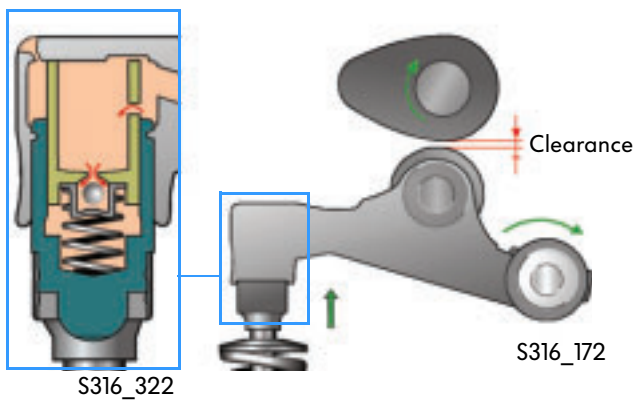
## Valve stroke



When pressure is exerted on the roller rocker arm from the cam, the non-return valve closes and pressure is built up in the high pressure chamber.

The valve clearance compensator acts as a solid element when the valve opens, as the oil cannot be compressed in the high pressure chamber.

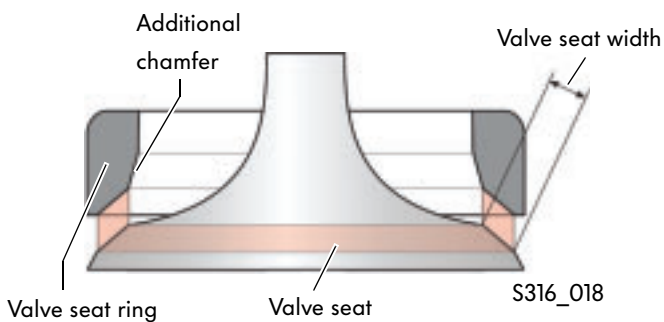
## Compensation of valve clearance



The cam no longer exerts pressure on the roller rocker arm and the inlet or exhaust valve is closed. Pressure in the high pressure chamber drops. The plunger spring forces the cylinder and plunger apart so that clearance is taken up between roller rocker arm and camshaft.

The non-return valve opens to let oil flow into the high pressure chamber.

## The valve seat rings



The valve seat forms the seal from the combustion chamber.

To permit a greater degree of sealing pressure, and thereby a tighter seal in the contact area between valve seat and valve seat ring, the width of the valve seat is reduced by an additional chamfer.

This additional chamfer also ensures good swirl properties of the intake air.



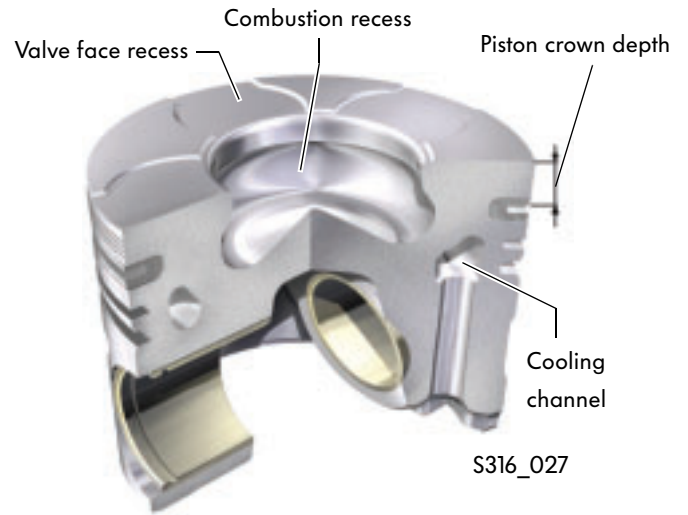
Valve seat rings should not be reworked, otherwise the swirl effect of the intake air, and thereby the mixture formation, would be affected considerably. Only grinding in to match surfaces is permissible.

# Engine mechanics

## The piston

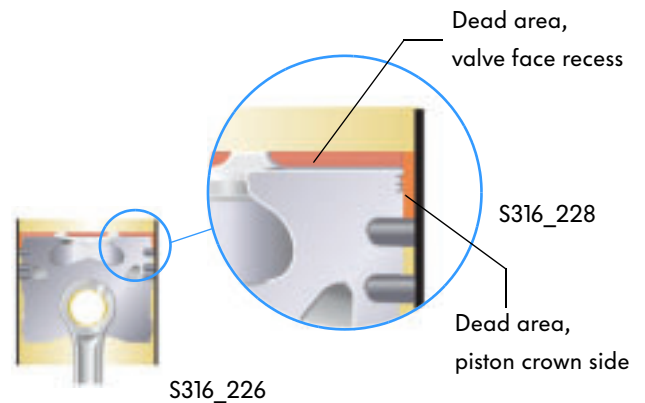
The pistons of the 2.0 ltr. TDI engine have a centrally located combustion recess. Thanks to this recess, a good swirl effect of the intake air is achieved, also resulting in an optimal mixture formation.

A reduction in the valve face recess and a piston crown depth of just 9 mm made it possible to reduce the dead area above the piston crown, and thus also the level of harmful emissions.



## Dead area

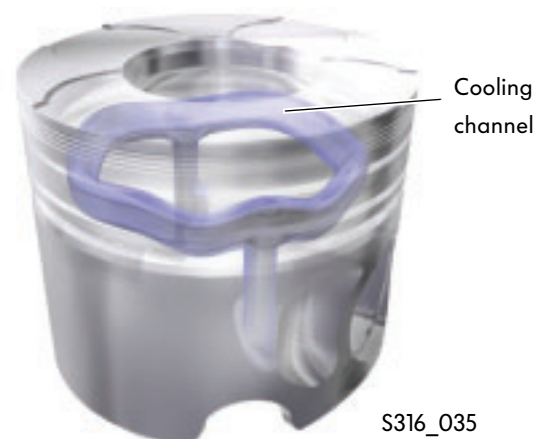
The dead area is the space above the piston crown in the combustion chamber where access to the air and fuel mixture is poor. In this area, the air and fuel mixture does not burn fully.



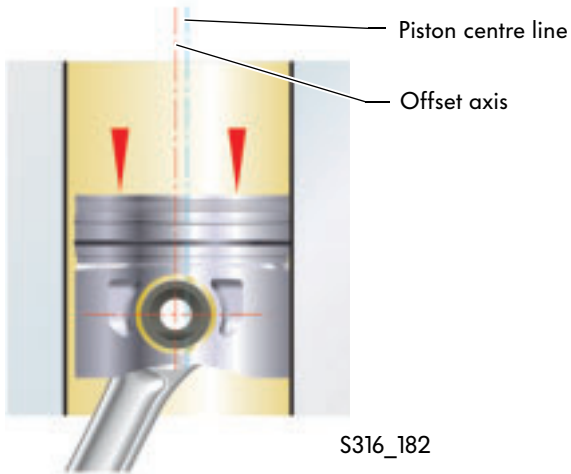
## Cooling channel

The piston has an undulating cooling channel. Thanks to this cooling channel, the temperature is reduced in the area of the piston rings and piston crown.

The undulating shape allows a greater surface area of the cooling channel, thus increasing transfer of heat from the piston to the oil. In this way, cooling efficiency is improved.



## Offset piston pin axis



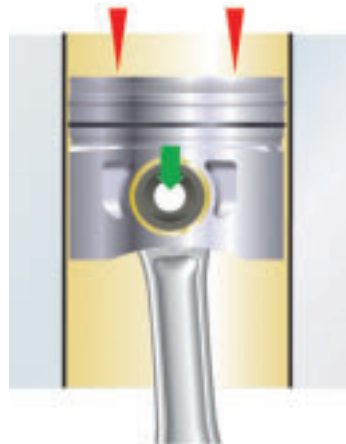
Offset piston pin axis means that the bearing point of the piston is not central. This measure serves as a means of noise reduction, as rocking of the piston at top dead centre is reduced.



When the conrod is at an angle, pressure is exerted on both sides of the piston from the reciprocating motion of the crankshaft, which pushes the piston against the cylinder walls.



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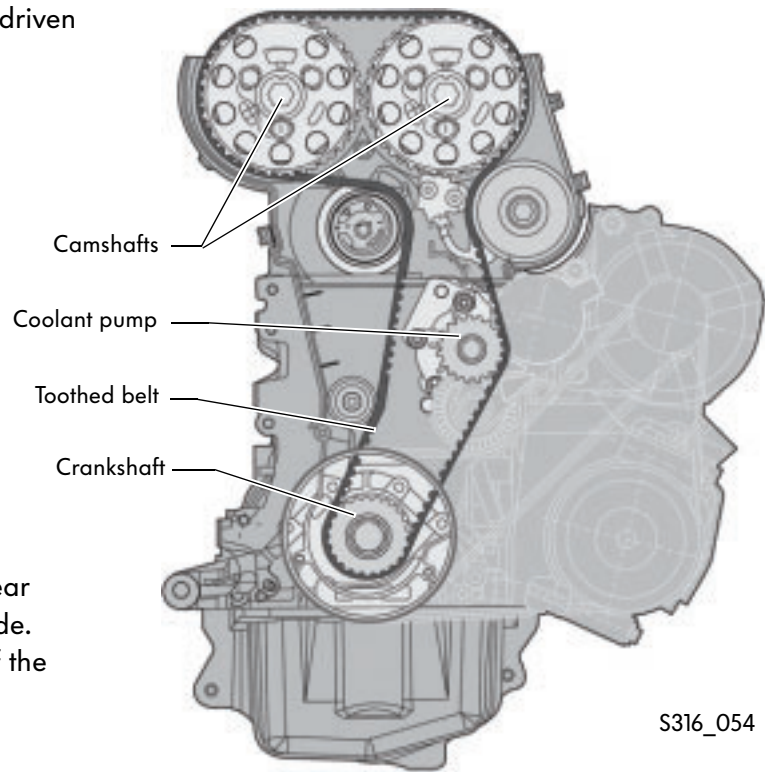
At top dead centre, the pressure on the piston changes sides. Here, the piston is pushed against the opposite cylinder wall in a rocking motion, which causes the noise. As a measure to reduce this noise, the piston pin axis is moved from the centre line.

Thanks to the offset, the piston changes sides before top dead centre, thereby preventing pressure from being exerted, and it supports itself against the opposite cylinder wall.

# Engine mechanics

## The toothed belt drive

Both camshafts and the coolant pump are driven by the crankshaft via a toothed belt.



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### Toothed belt

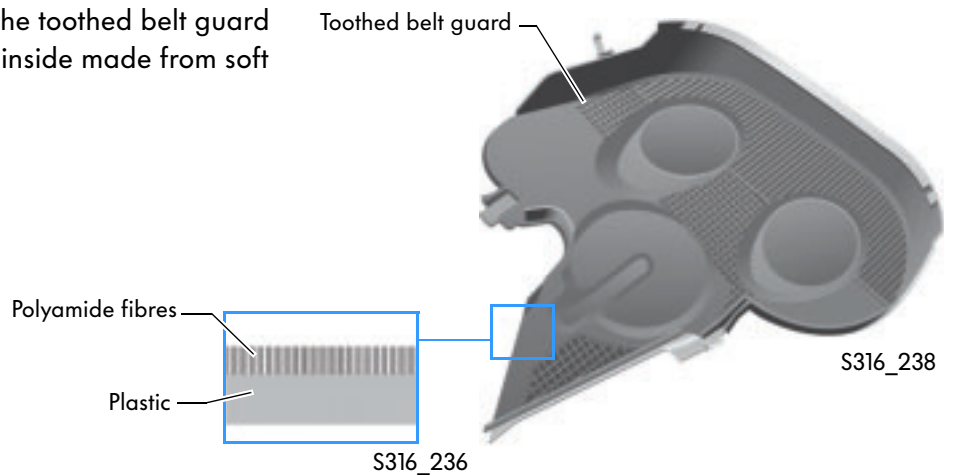
The 30 mm wide toothed belt features a rear cord support backing made from polyamide. The cord support backing reduces wear of the belt edges.



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### Toothed belt guard

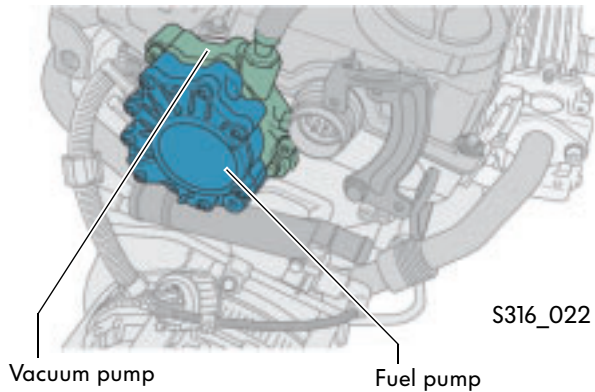
To insulate against noise, the toothed belt guard has a woven lining on the inside made from soft polyamide fibres.



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## The tandem pump

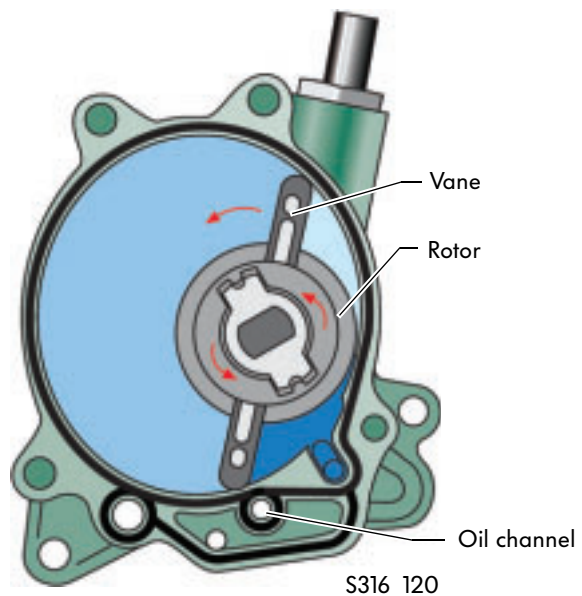
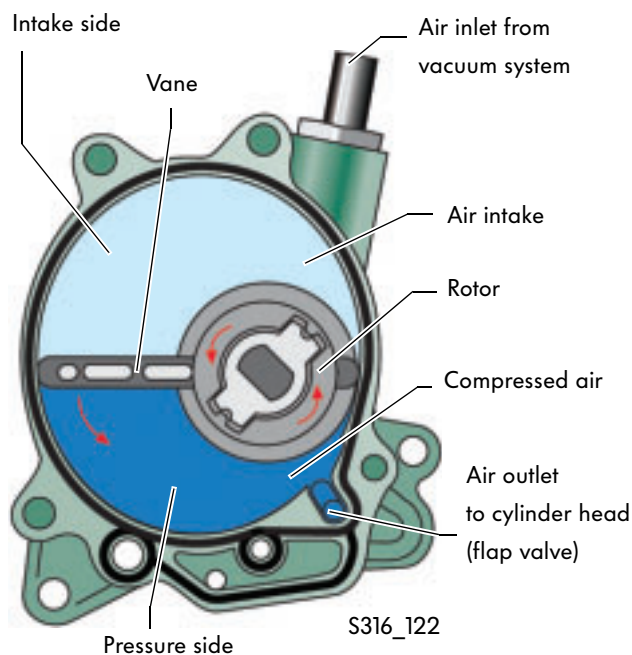


Due to the new cylinder head design, there is a new type of tandem pump.

The tandem pump comprises of vacuum pump and fuel pump. It is driven by the inlet camshaft.



### Vacuum pump



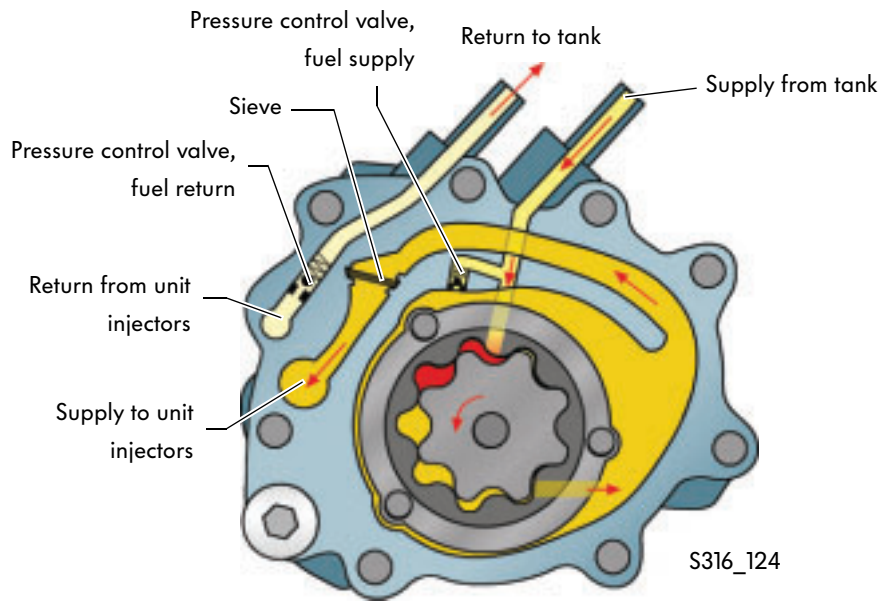
The vacuum pump consists of a rotor (offset from the middle) and a moving vane made from plastic, which separates the vacuum pump into two compartments.

The vane continually changes its position due to the rotation of the rotor. In this way, one compartment becomes bigger and the other becomes smaller.

On the intake side, air is drawn from the vacuum system, which is pumped in the cylinder head via a flap valve. The vacuum pump is supplied with oil via a channel to the cylinder head. The oil serves as a means of lubricating the rotor and as a fine seal between vane and pump housing.

# Engine mechanics

## Fuel pump

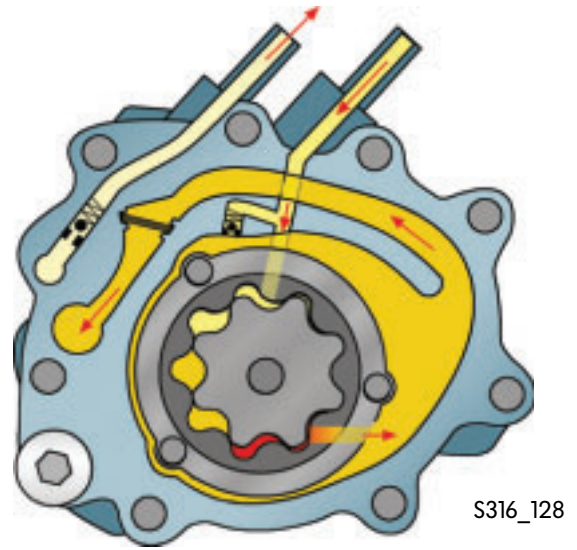
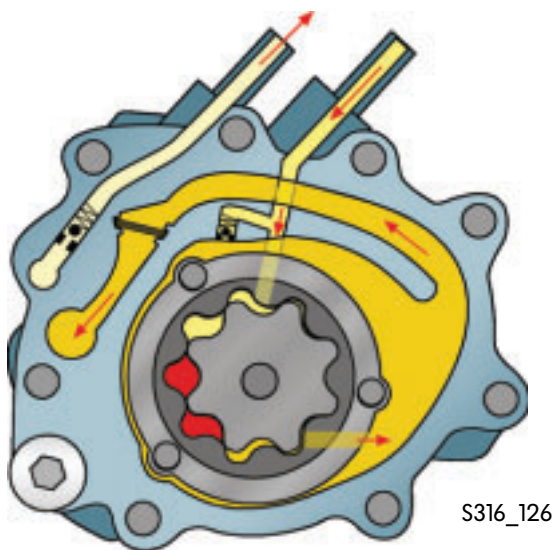


The fuel pump works in the same way as an interior gear pump. The principle of fuel induction and supply is shown by the movement of fuel marked red within the pump in the individual illustrations.

Fuel pressure is regulated by a pressure control valve in the fuel supply path.

It reaches a maximum of 11.5 bar at an engine speed of 4000 rpm.

The pressure control valve in the fuel supply path maintains fuel return pressure at approx. 1 bar. In this way, an equal and balanced distribution of pressure is assured at the solenoid valves of the unit injectors.



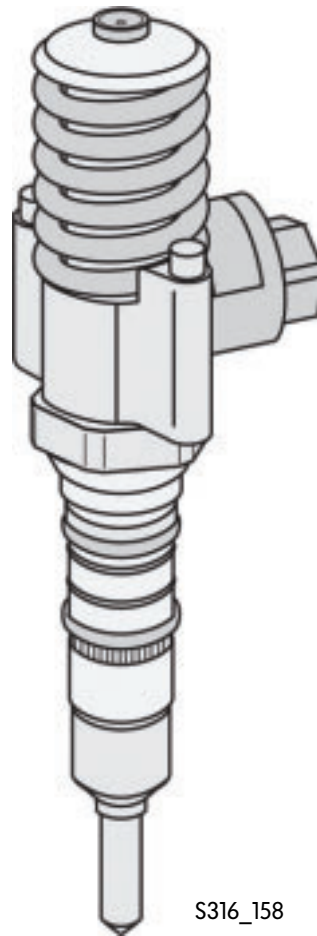


## The unit injector

For the 2.0 ltr. TDI engine with 4 valve technology, the unit injector was further developed.

Characteristics of the unit injector:

- More streamline and compact design
- Fixed in cylinder head by means of two bolts
- Increase in injection pressure at part throttle
- Retraction plunger brake to reduce injection noise
- Redesigned, tapered unit injector seat in cylinder head.

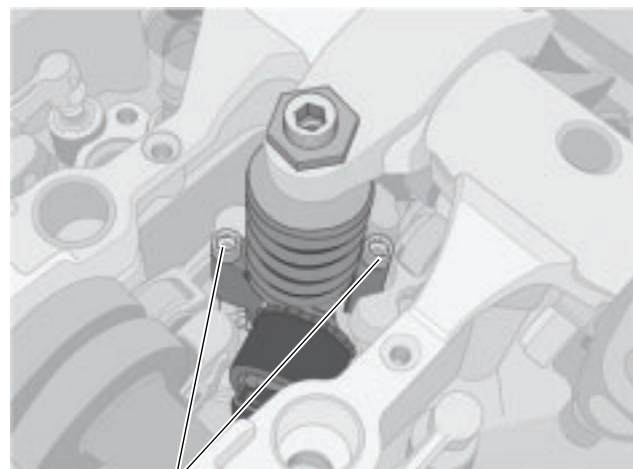


### Fitting location

The unit injector can be found in the cylinder head. It is in the vertical position and located directly above the centre of the piston crown.

### Attachment

Attachment of the unit injector is via two bolts. This choice of bolted connection, practically free of lateral stress, reduces the transfer of structural noise from the unit injector to the cylinder head.



Securing bolts

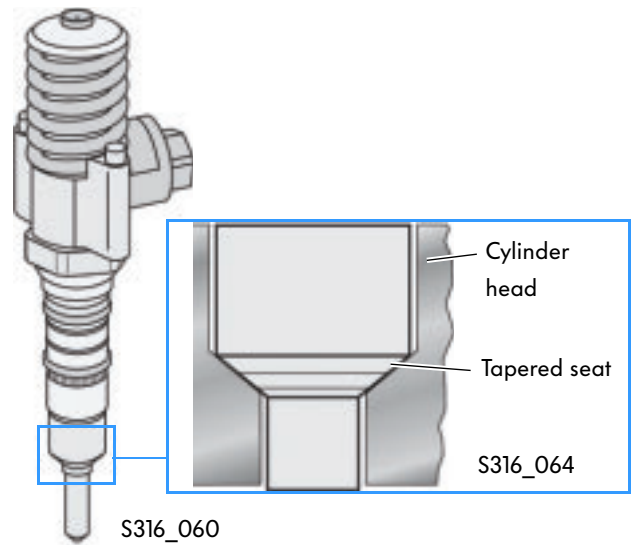


# Engine mechanics

## Tapered seat

The redesigned tapered seat of the unit injector in the cylinder head allows the unit injector to be centred optimally. The new sealing concept between injector and cylinder head has been modified from a ground surface with washer to a tapered seat.

As a result, the heat insulating seal and lower O-ring are no longer fitted.

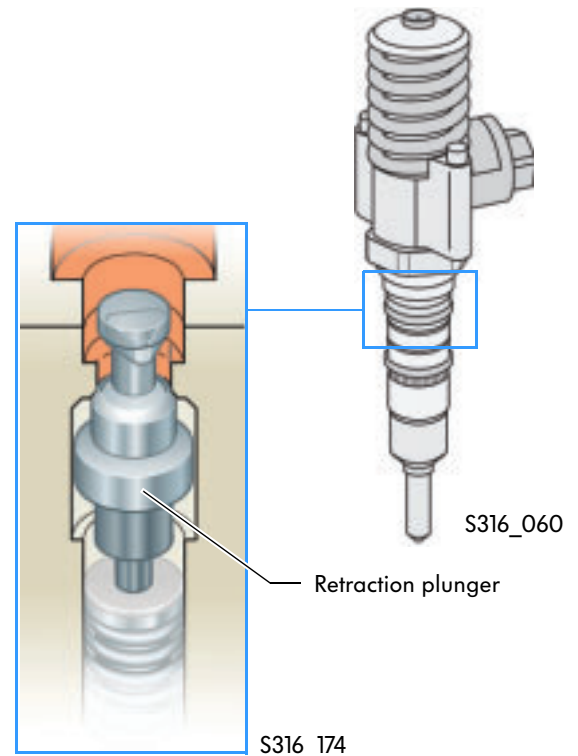


## Retraction plunger brake

The retraction plunger can be found between pump and injector and controls the quantity and period of pilot injection.

To reduce injection noise, the unit injector is equipped with a retraction plunger brake. On the unit injector system, injection noise is generated by:

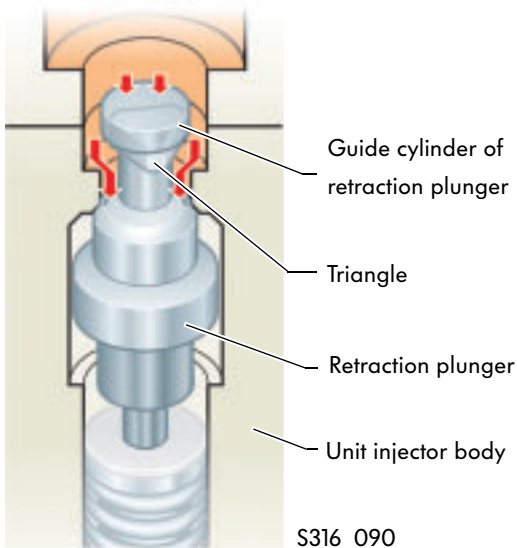
- Rapid pressure increase and release in the high pressure chamber
- Cavity caused as a result of pressure release (cavitation)
- Mechanical impact from:
  - Retraction plunger
  - Valve pin
  - Injector pin.



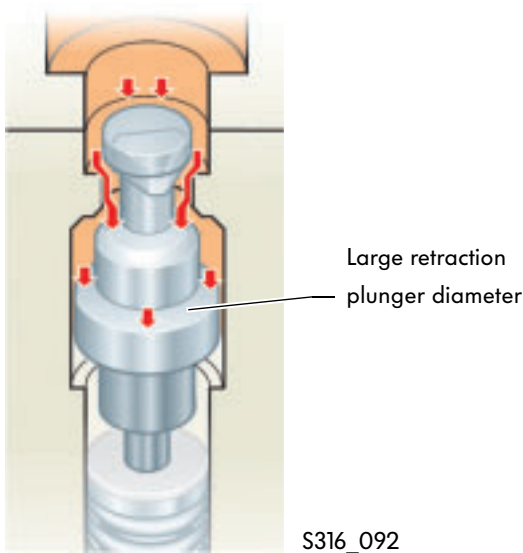
An efficient and realistic aid towards noise reduction is a measure to brake the retraction plunger before it reaches its mechanical stop, i.e. the retraction plunger brake.

With the retraction plunger brake, the hydraulic pressure above the retraction plunger is reduced before the retraction plunger hits its mechanical stop.

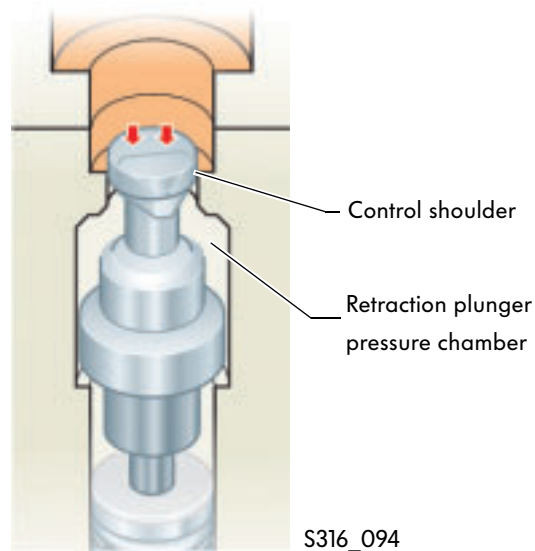
## Function



On the retraction plunger brake, the guide cylinder of the retraction plunger features three level surfaces (triangle) and a control shoulder. Before retraction begins, the retraction plunger is in the closed position.



As soon as the plunger moves downwards, high pressure is applied to the large retraction plunger diameter, thus allowing rapid shutoff of pilot injection.



As soon as the guide cylinder reaches the control shoulder above the three flat surfaces, supply to the retraction plunger compression chamber is stopped. This reduces pressure at the large retraction plunger diameter abruptly. In this way, the retraction plunger makes contact more smoothly and impact noise is reduced.

# Engine management

## System overview

### Sensors



G28 Engine speed sender

G40 Hall sender

G79 Accelerator pedal position sender 1  
G185 Accelerator pedal position sender 2

G70 Air mass meter

G62 Coolant temperature sender

G83 Coolant temperature sender  
radiator outlet

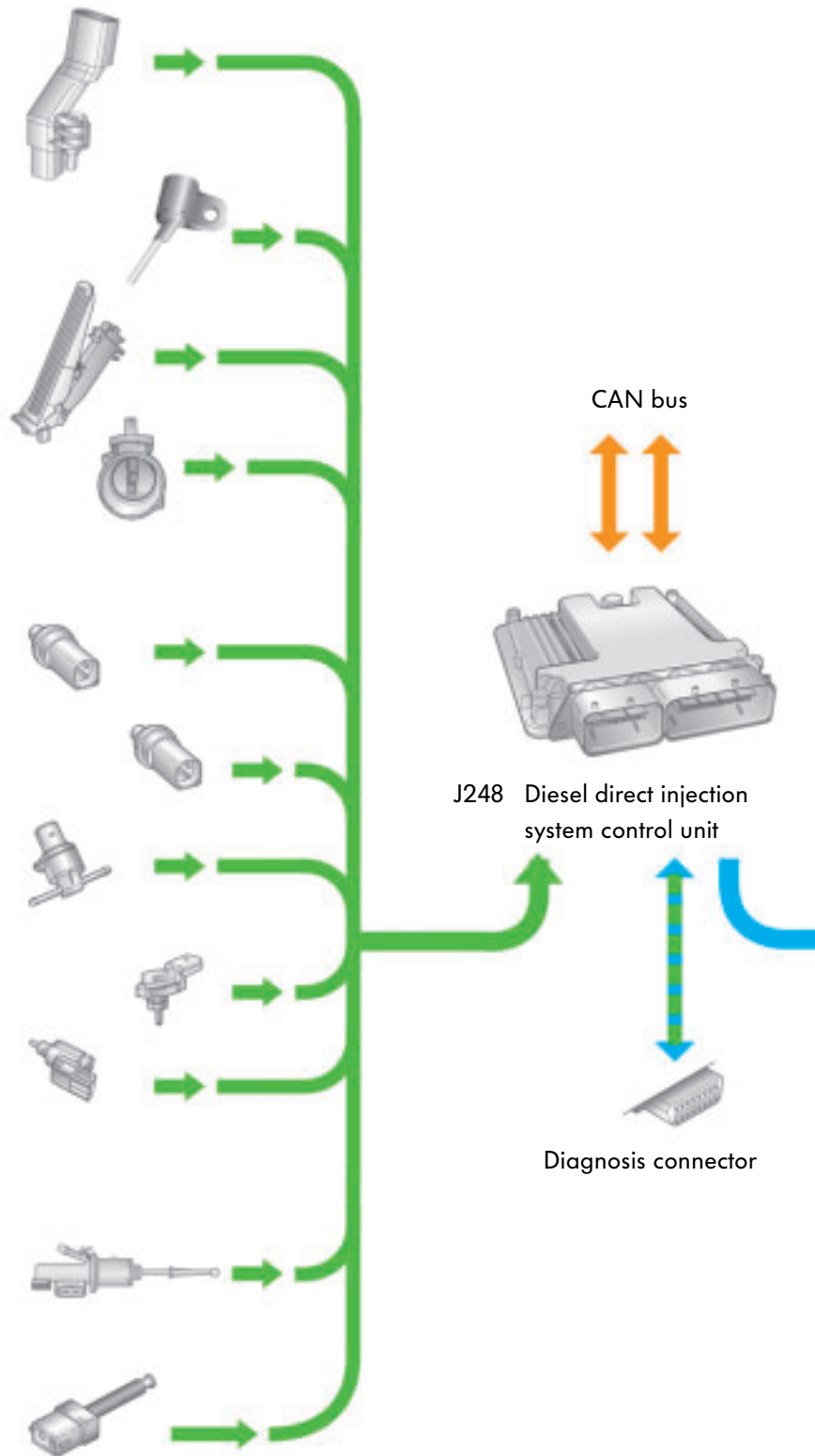
G81 Fuel temperature sender

G42 Intake air temperature sender

F Brake light switch  
F47 Brake pedal switch for CCS

G476 Clutch position sender

G31 Charge air pressure sender



## Actuators

- N240 Unit injector valve, no. 1 cylinder
- N241 Unit injector valve, no. 2 cylinder
- N242 Unit injector valve, no. 3 cylinder
- N243 Unit injector valve, no. 4 cylinder

Solenoid valve block with:

- N18 Exhaust gas recirculation valve
- N345 EGR cooler changeover valve
- N75 Charge pressure control solenoid valve

V157 Intake manifold flap motor

- J17 Fuel pump relay
- G6 Fuel pump

- J293 Radiator fan control unit
- V7 Radiator fan
- V35 Radiator fan, right

- J370 Glow plug control unit
- Q10 Glow plug 1
- Q11 Glow plug 2
- Q12 Glow plug 3
- Q13 Glow plug 4



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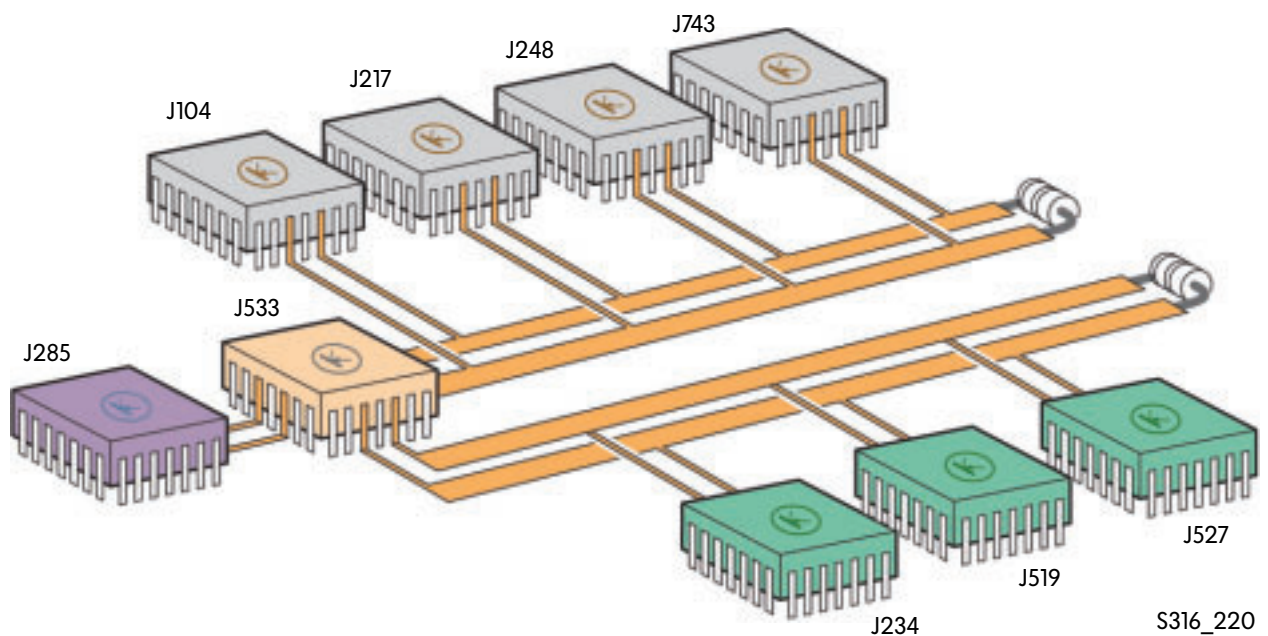
# Engine management

## The control units in the CAN data bus

The schematic diagram below shows the way the diesel direct injection control unit J248 is included in the CAN data bus structure of the vehicle.

Information is sent between control units via the CAN data bus.

For example, the diesel direct injection control unit receives the speed signal from a speed sensor via the ABS control unit.

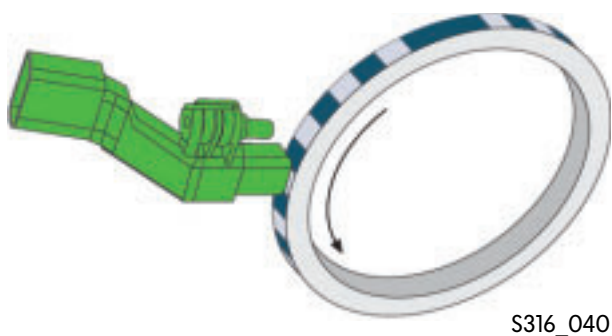
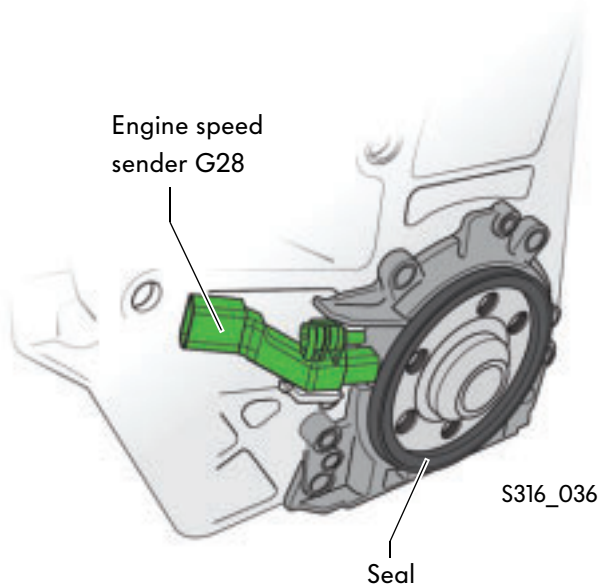


- J104 ABS with EDL control unit
- J217 Automatic gearbox control unit
- J234 Airbag control unit
- J248 Diesel direct injection system control unit
- J285 Control unit with display unit in dash panel insert
- J519 Onboard power supply control unit
- J527 Steering column electronics control unit
- J533 Data bus diagnosis interface
- J743 Direct shift gearbox mechatronics

### Colour codes/key

- = "Drive train" CAN data bus
- = "Convenience" CAN data bus
- = "Infotainment" CAN data bus

## The engine speed sender G28



### Signal application

The signal from the engine speed sender allows the engine control unit to determine the speed of the engine and the exact position of the crankshaft. With this information, the quantity of injection and start of injection are calculated.

The crankshaft sealing flange on the flywheel side is combined with the engine speed sender wheel. The seal in the sealing flange is made of polytetrafluorethylene (PTFE).

The engine speed sender is a Hall sender. It is bolted to the crankshaft sealing flange housing. The sender wheel is pressed into exactly the right position on the crankshaft flange.

The sender wheel consists of a steel ring, onto which a rubber composite material is sprayed. In this rubber composite material is a large quantity of metal shavings, which are magnetised alternately to north and south. As a reference mark for the engine speed sender there are two wider areas on the sender wheel that are magnetised to north. This results in a 60-2-2 sender wheel.

### Effects of signal failure

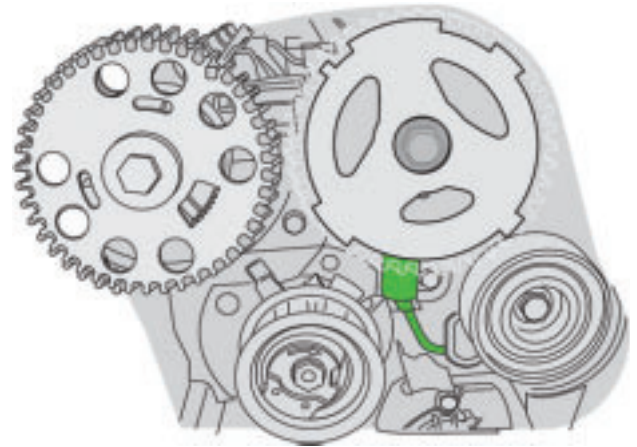
In the event of engine speed sender failure, the engine will continue to operate in emergency running mode. The speed of the engine is thereby limited to between 3200 rpm and 3500 rpm.



# Engine management

## The Hall sender G40

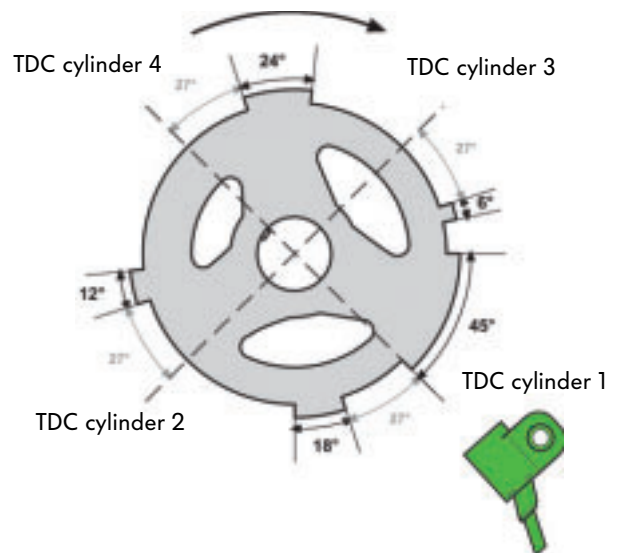
The Hall sender is attached to the cylinder head below the inlet camshaft. It picks up the position of the camshaft via a quick start sender wheel.



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The sender wheel on the camshaft is a new design. In conjunction with the Hall sender G 40 (camshaft), an emergency running mode is made possible in which the engine can continue to run even in the event of engine speed sender failure.

Around the circumference of the sender wheel are 4 segments split into 6°, 12°, 18° and 24° camshaft angles for cylinder assignment. A further segment with a 45° camshaft angle serves as a means of cylinder assignment for emergency running mode.



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### Signal application

With the signal from the Hall sender, the exact position of the camshaft in relation to the crankshaft is determined when the engine is started. Together with the signal from the engine speed sender G28, the system determines which cylinder is at TDC of the ignition stroke.

### Effects of signal failure

In the event of signal failure, the engine speed sender signal is used. Starting of the engine could take a little longer in this instance because the camshaft position, and thereby also the crankshaft position, is not immediately detectable.



## Emergency running mode

Unlike previous TDI engines, this engine will continue to run in the event of signal failure or implausible signals from the engine speed sender.

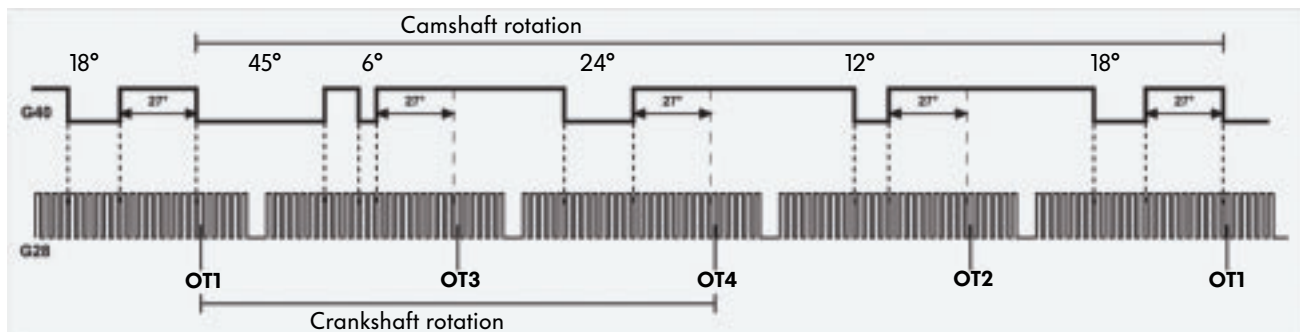
For emergency running mode, the engine control unit will evaluate only the rising flanks from the segments of the Hall sender signal, as vibrations from starting cause the engine control unit to detect too many segment flanks, which are difficult to allocate. To pick up TDC of cylinder 3, the 45° segment acts as a reference marking.

In emergency running mode:

- Engine speed is limited to between 3200 rpm and 3500 rpm
- Quantity of injection is restricted
- Starting takes slightly longer.

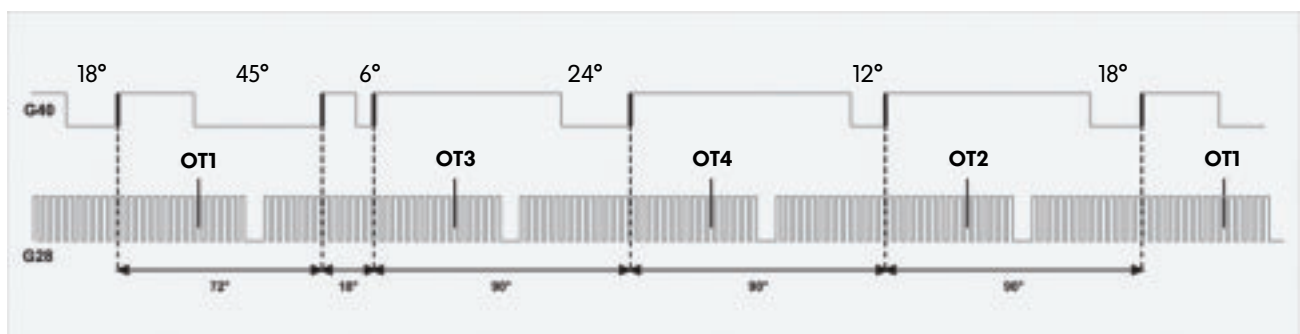


Signal pattern of Hall sender G40 (camshaft) and engine speed sender G28 during normal operation



S316\_048

Signal pattern of Hall sender G40 (camshaft) and engine speed sender G28 during emergency running



S316\_050

# Engine management

## The clutch position sender G476

The clutch position sender is clipped to the master cylinder. With this sender, the system can detect when the clutch is actuated.



### Signal application

With the clutch actuated, the

- cruise control system is switched off and
- the quantity of injection is reduced briefly, thus preventing engine surge during gear change.



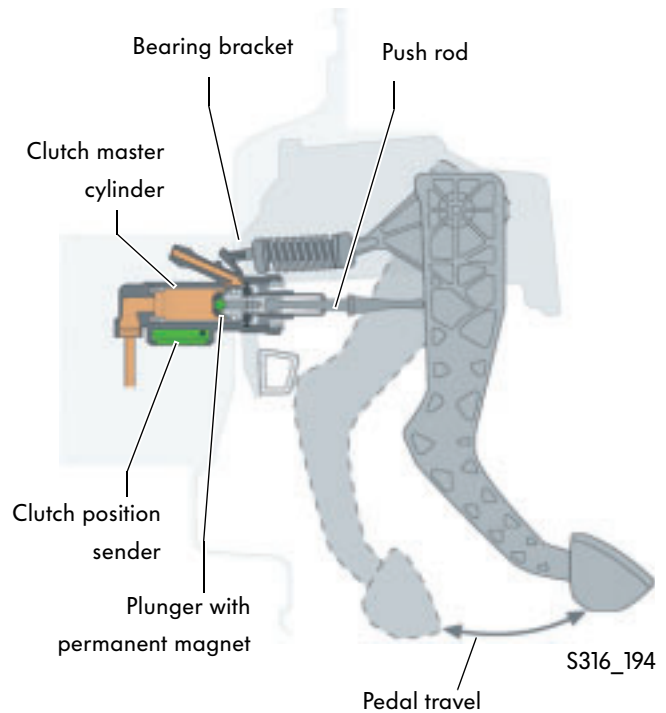
Clutch pedal with clutch position sender

S316\_191

### Construction

The master cylinder is attached to the bearing bracket by means of a bayonet connection.

When the clutch pedal is pressed, the push rod actuates a piston in the master cylinder.



S316\_194

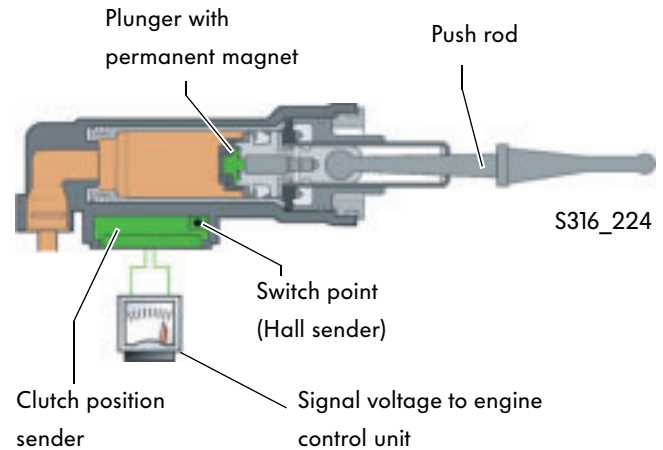
## How it works

### Clutch pedal not pressed

When the clutch is not pressed, the push rod and plunger are in the rest position.

From the evaluation electronics in the clutch position sender, a signal voltage is transmitted to the engine control unit, which is at 2 volts below supply voltage (battery voltage).

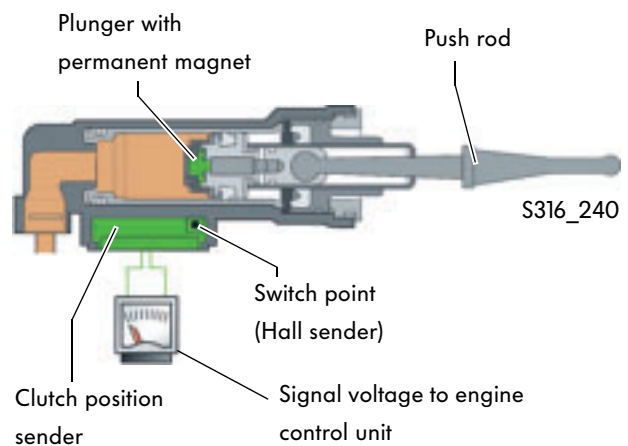
The engine control unit thereby detects that the clutch is not pressed.



### Clutch pedal pressed

When the clutch pedal is pressed, the push rod and plunger are pushed in direction of the clutch position sender. At the front end of the plunger is a permanent magnet.

As soon as the permanent magnet passes over the switch point of the Hall sender, a signal voltage is sent from the evaluation electronics of just 0 to 2 volts to the engine control unit. It detects in this way that the clutch pedal is pressed.



### Effects of signal failure

In the event of clutch position sender failure, the cruise control system cannot be used and the engine may surge during gear changes.



# Engine management

## The accelerator pedal position senders G79 and G185

Both accelerator pedal position senders are part of the accelerator pedal module and work without contact as inductive senders.

### Advantages

- No wear because senders work without contact
- No basic setting for kick-down necessary as this is part of the accelerator pedal module, therefore there are no tolerances between the accelerator pedal and the vehicle body

### Signal application

The engine control unit uses the signals from the accelerator pedal position sender to calculate the quantity of injection.



S316\_193

Accelerator pedal with accelerator pedal position senders

### Effects of signal failure

In the event of failure of both senders, an entry is made in the fault memory and the electric accelerator actuator warning lamp will light up.

The convenience functions, for example the cruise control system or engine braking control, will be switched off.

### Failure of one sender

will result in the system switching to idle. If the second sender is detected at idle within a specified test period, normal operation is permitted.

If the driver requests full power, speed is increased only gradually.

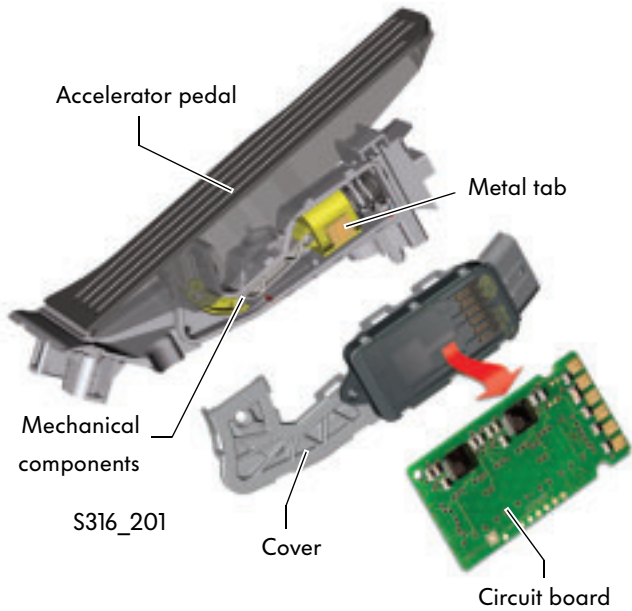
### Failure of both senders

will result in the engine running at increased idling speed (maximum 1500 rpm) with no response to accelerator pedal input.

## Construction

The accelerator pedal module comprises of accelerator pedal, pedal limit stop, the mechanical components for converting direction of movement and both accelerator pedal position senders G79 and G185.

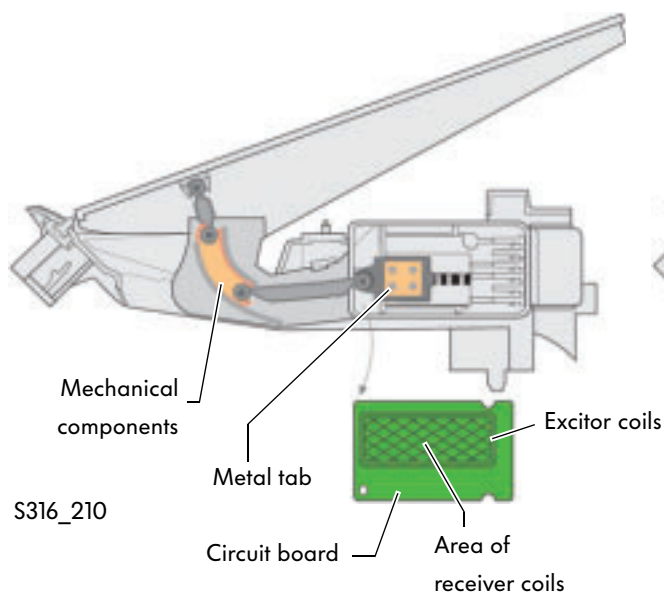
The senders are part of a circuit board and each comprise of an excitor coil, three receiver coils and electronics for control and evaluation. For reasons of safety, both senders operate independently of each other.



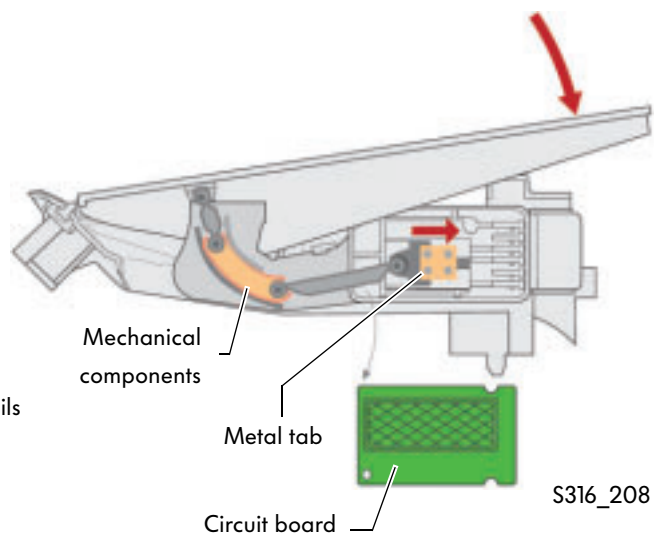
The mechanical components of the accelerator pedal module convert lever action of the accelerator pedal into straight movement.

A metal tab is attached in such a way that it moves with minimal resistance along a straight line to the circuit board when the accelerator pedal is pressed.

### Accelerator pedal not pressed



### Accelerator pedal pressed



# Engine management

## How it works

The pedal electronics are supplied with 5 volts and generate a high frequency alternating voltage, which creates an electromagnetic alternating field around the excitor coil. This electromagnetic alternating field influences a moving metal tab. In this way, a further electromagnetic alternating field is generated around the tab.

This alternating field, that becomes active in a particular position, has an effect on the receiver coils and thereby induces an alternating signal.

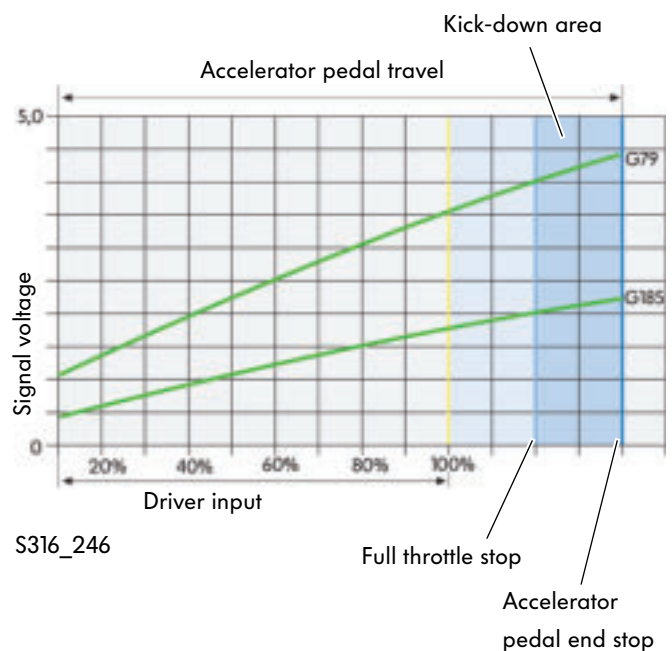
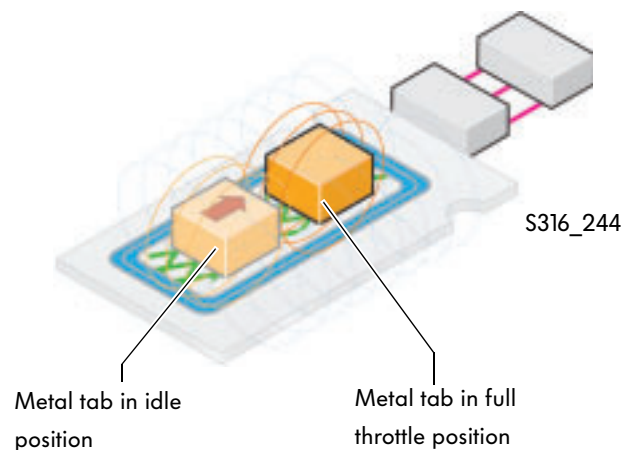
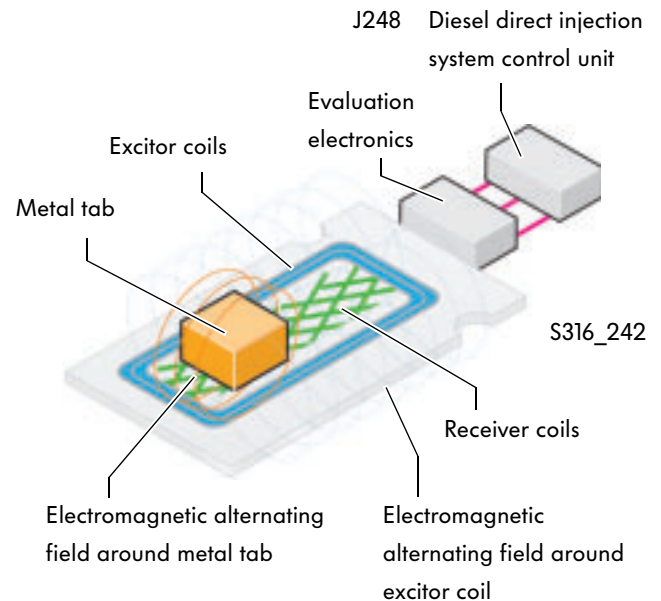
The strength of the induced alternating voltage depends wholly on the position of the metal tab. Depending on the position, the metal tab covers the receiver coils at different levels.

In the idle position, coverage is at the lowest level and, therefore, so is the induced alternating voltage.

In the full throttle position, i.e. kick-down on an automatic gearbox, coverage is at the highest level and, therefore, so is the induced alternating voltage.

## Evaluation

The evaluation electronics rectify the alternating voltages of the three receiver coils, these are boosted and the output voltages of the three receiver coils are positioned in relation to each other. After evaluation of the voltage, the result is converted to a linear voltage signal and sent to the engine control unit.

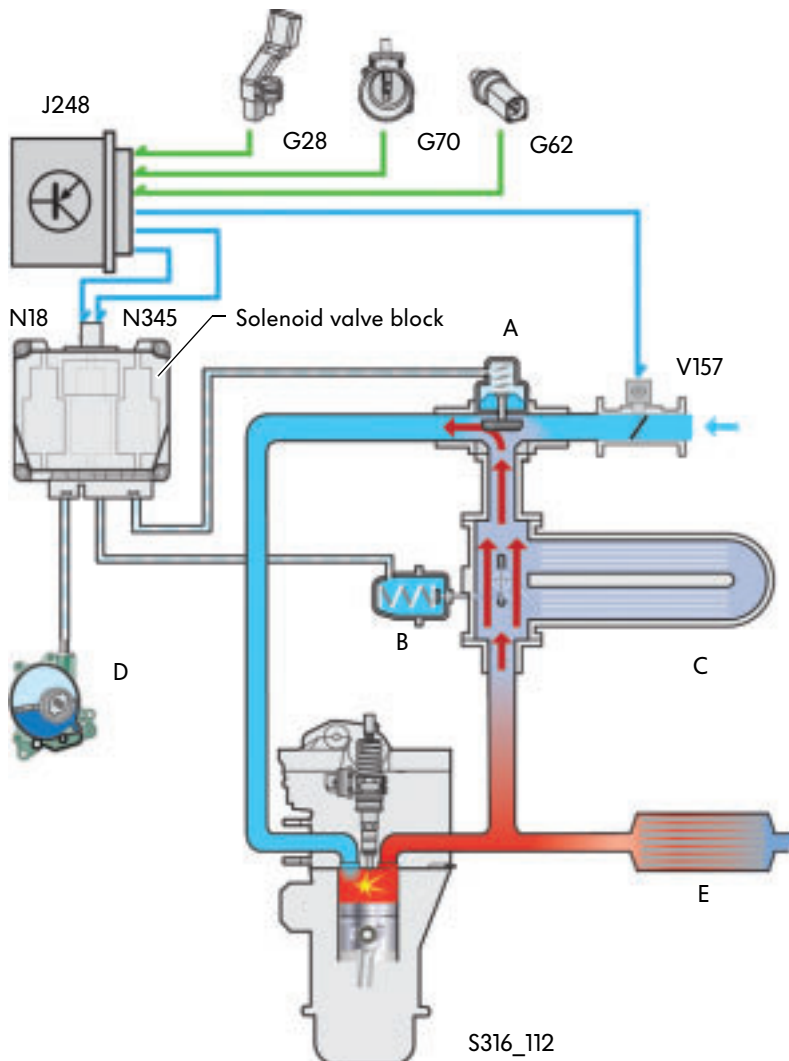


## The exhaust gas recirculation system

On the exhaust gas recirculation system, part of the exhaust gases are recirculated into the intake system and fed back into the combustion chamber. Since the exhaust gases are very weak in oxygen, the peak combustion temperature, and thereby also the peak combustion pressure, is reduced. This has the effect of reducing nitrogen oxide emissions.

The volume of recirculated exhaust gases depends on:

- Engine speed
- Quantity of injection
- Amount of air intake
- Intake air temperature
- Air pressure.



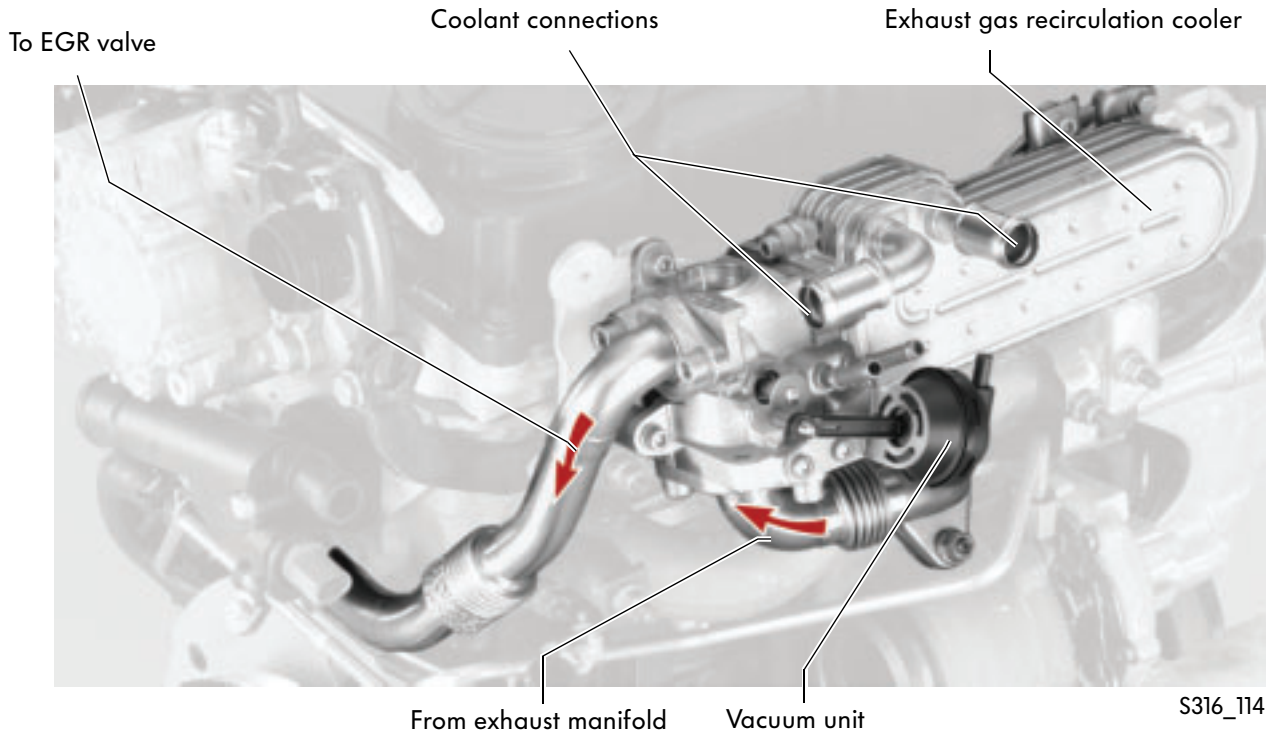
- G28 Engine speed sender
- G62 Coolant temperature sender
- G70 Air mass meter
- J248 Diesel direct injection system control unit
- N18 Exhaust gas recirculation valve
- N345 Exhaust gas recirculation cooler changeover valve
- V157 Intake manifold flap motor
- A EGR valve
- B Vacuum unit
- C EGR cooler
- D Vacuum pump
- E Catalytic converter

The recirculated exhaust gas is influenced by a map in the engine control unit.

# Engine management

## Switchable EGR cooler

The 2.0 ltr./103 kW TDI engine features a switchable EGR cooler.



## Functional principle of exhaust gas cooling

Cooling of the recirculated gases has the effect of reducing combustion temperature and a greater mass of exhaust gases can thus be recirculated. There are less nitrogen oxides as a result.

Installed in this system is a switchable EGR cooler to allow the engine and catalytic converter to reach their operating temperature quickly. Not until operating temperature is reached is the recirculated exhaust gas cooled.

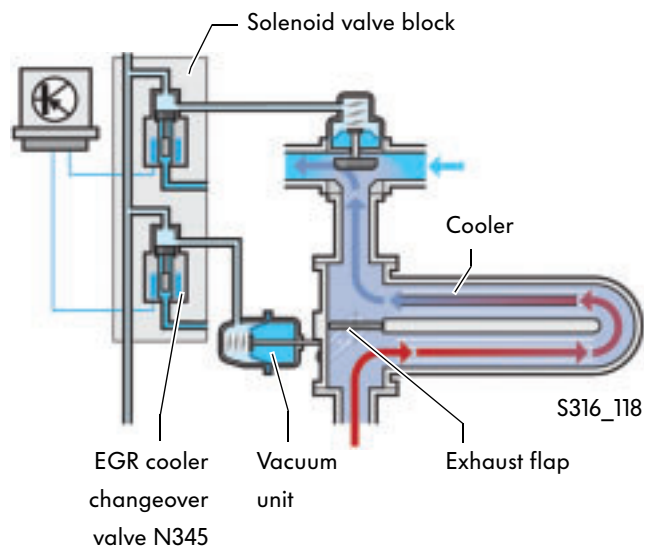
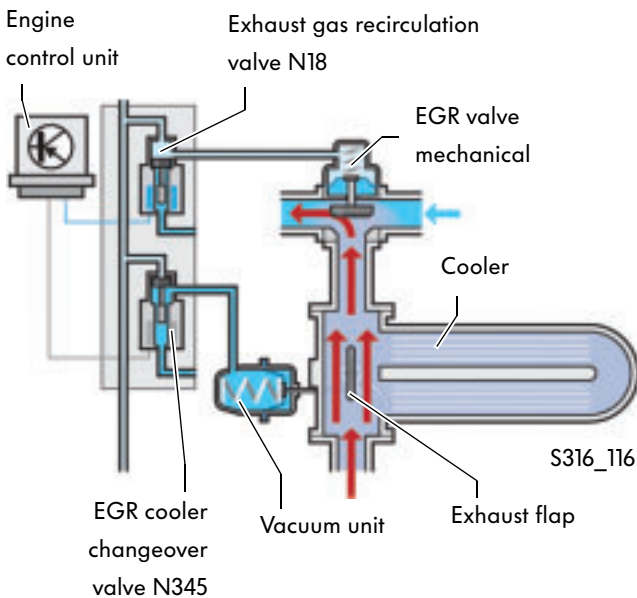


## Exhaust gas cooling switched off

The exhaust flap remains in the open position up to a coolant temperature of 50 °C and exhaust gas does not pass through the cooler. In this way, the catalytic converter and the engine reach their operating temperatures within a short space of time. The hydrocarbon, carbon monoxide and particulate emissions are reduced as a result.

## Exhaust gas cooling switched on

From a coolant temperature of 50 °C, the exhaust flap is closed by the changeover valve. The recirculated exhaust gas now flows through the cooler. This helps to further reduce nitrogen oxides.



# Engine management

## The preglow system

Installed in the 2.0 ltr./103kW TDI engine is a new glow plug system.

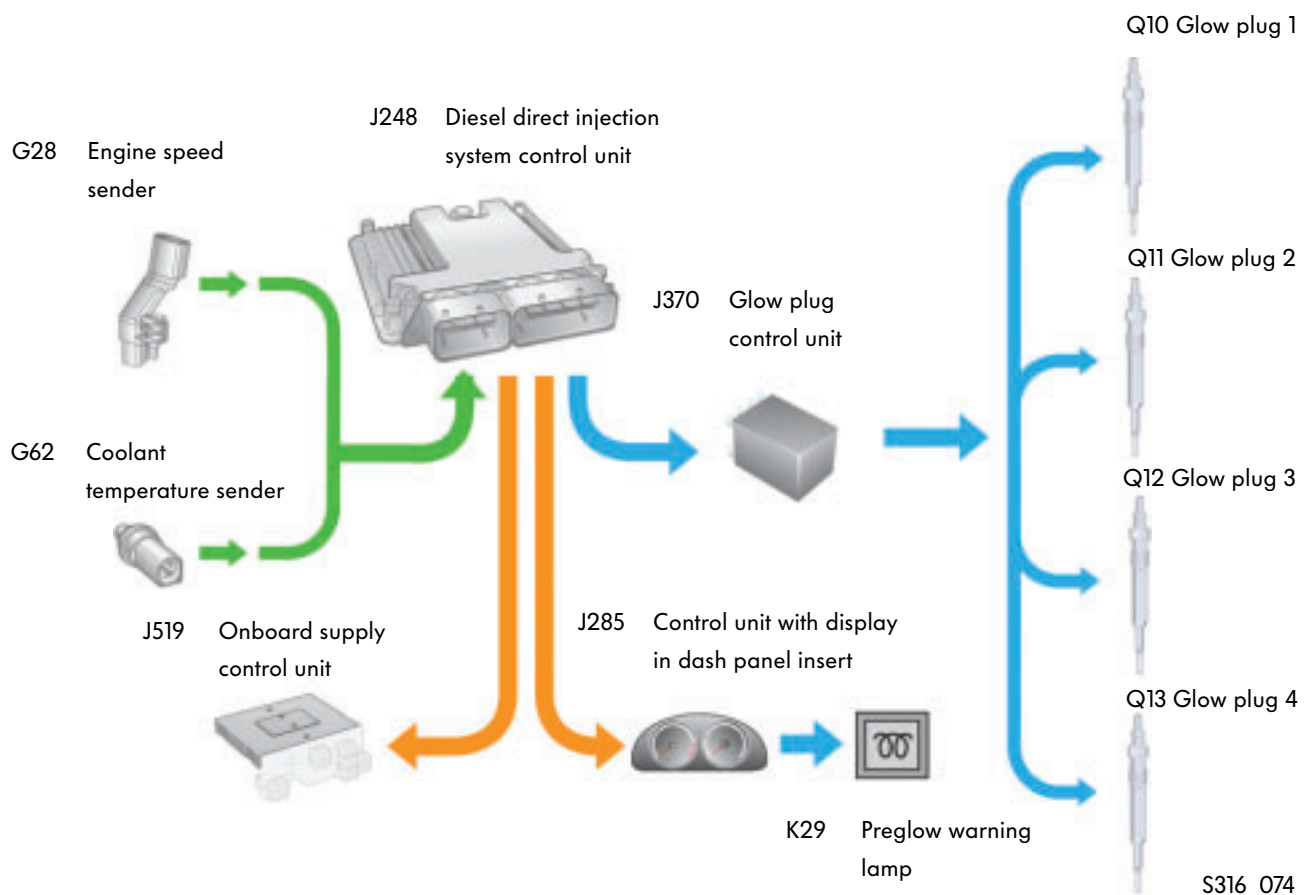
The new glow plug system is of the diesel quick start type. In practically all weather conditions, it allows immediate start, like on a petrol engine, without long periods of preglowing.

In conjunction with 6-hole injectors, which have a special "ignition" spray pattern, the new glow plug system offers excellent cold starting and cold running properties.

The advantages of the new glow plug system are:

- Safe start procedure at temperatures up to minus 24°C.
- Extremely quick preheating. In a matter of 2 seconds, 1000°C is reached at the glow plug.
- Controllable temperature for preglow and extended glow periods.
- Capable of self-diagnosis.
- Capable of European OBD

## System overview



## Glow plug control unit J370



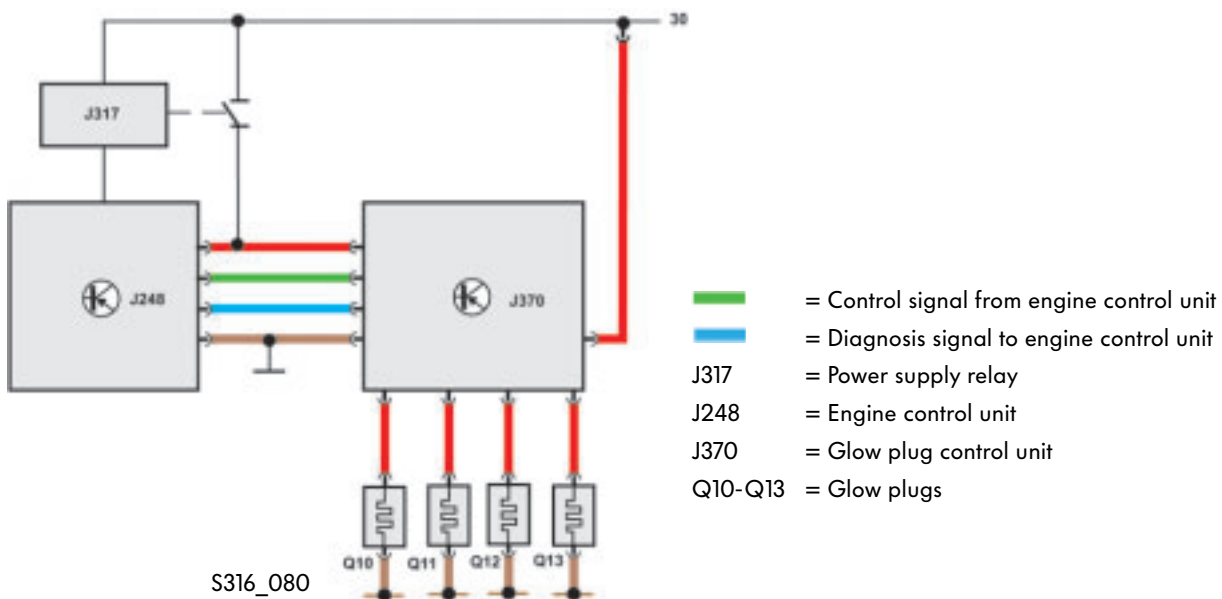
S316\_218

The glow plug control unit receives information about the glow function from the engine control unit. The start of glow plug operation, the period of glow plug operation, the actuation frequency and the pulse duty factor are therefore determined by the engine control unit.



The automatic glow period control unit functions as follows:

1. Switching of glow plugs with pulse width modulated signal
  - PWM low level = Glow plug energised
  - PWM high level = Glow plug at rest
2. Integrated protection against overload and overheating
3. Individual glow plug monitoring
  - Detection of voltage overload and short circuit in glow plug system
  - Voltage overload protection in glow plug system
  - Diagnosis of glow plug electronics
  - Detection of open circuit in glow plug system caused by glow plug failure



S316\_080

# Engine management

## Glow plugs

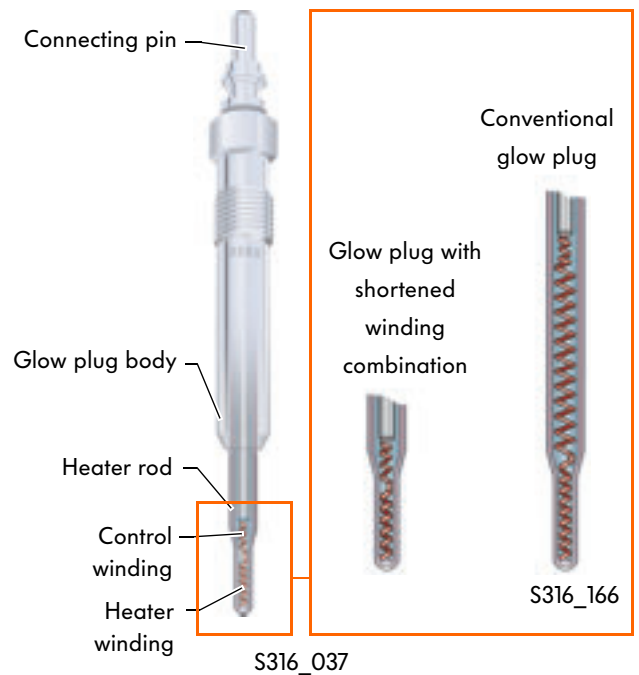
The glow plug is designed to support cold starting. Electronically generated heat energy that is fed into the combustion chamber creates the ideal conditions for ignition of the injected fuel.

Due to 4 valve technology, installation dimensions for the glow plugs are very restricted. Therefore, the glow plugs are streamline in design.



The glow plug consists of glow plug body, heater rod with heater and control windings and connecting pin.

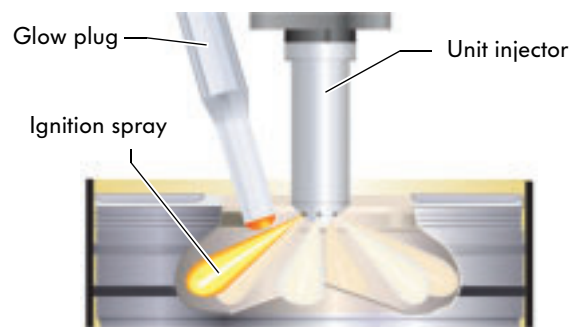
The glow plugs have a nominal voltage of 4.4 volts. Compared with conventional self-regulating metal glow plugs, the combination of control and heater windings is reduced by about a third. In this way, it was possible to reduce the glow period down to 2 seconds.



The glow plugs should never be checked for operation using 12 volts, as otherwise they will melt.

## Functional principle of "ignition spray pattern"

The 2.0 ltr. TDI engine has a 6-hole injector. One of the injection holes is designed to create an "ignition spray pattern" with optimal clearance to the glow plug. Thanks to this "ignition spray pattern", the cold start and cold running properties of the engine are improved.



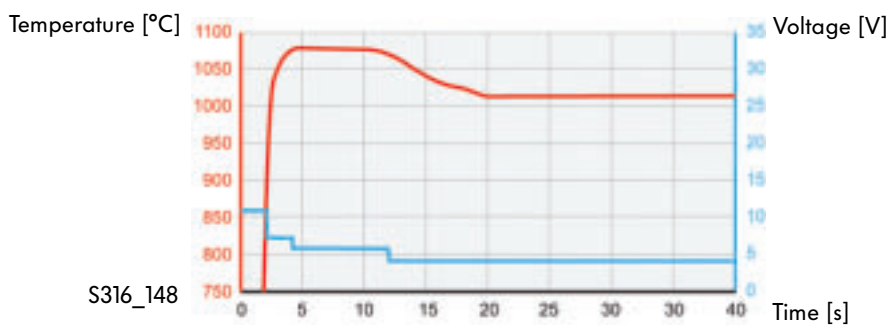
S316\_190

## Preglow

When the ignition is switched on and temperature is below 14°C, the preglow system is activated.

To do this, the engine control unit sends a PWM signal to the glow plug control unit. The glow plugs will then also be activated by the glow plug control unit by means of a PWM signal.

In the first stage of preglowing, the glow plugs are energised for a maximum of 2 seconds with approx. 11 volts. Thereafter, the glow plugs are supplied with voltage by the glow plug control unit, depending on the relevant operating conditions.



## Extended glow period

Each time the engine is started, an extended glow period is activated to reduce the combustion noise and amount of hydrocarbon emissions.

Actuation of the glow plugs is adjusted by the engine control unit depending on engine load and speed.

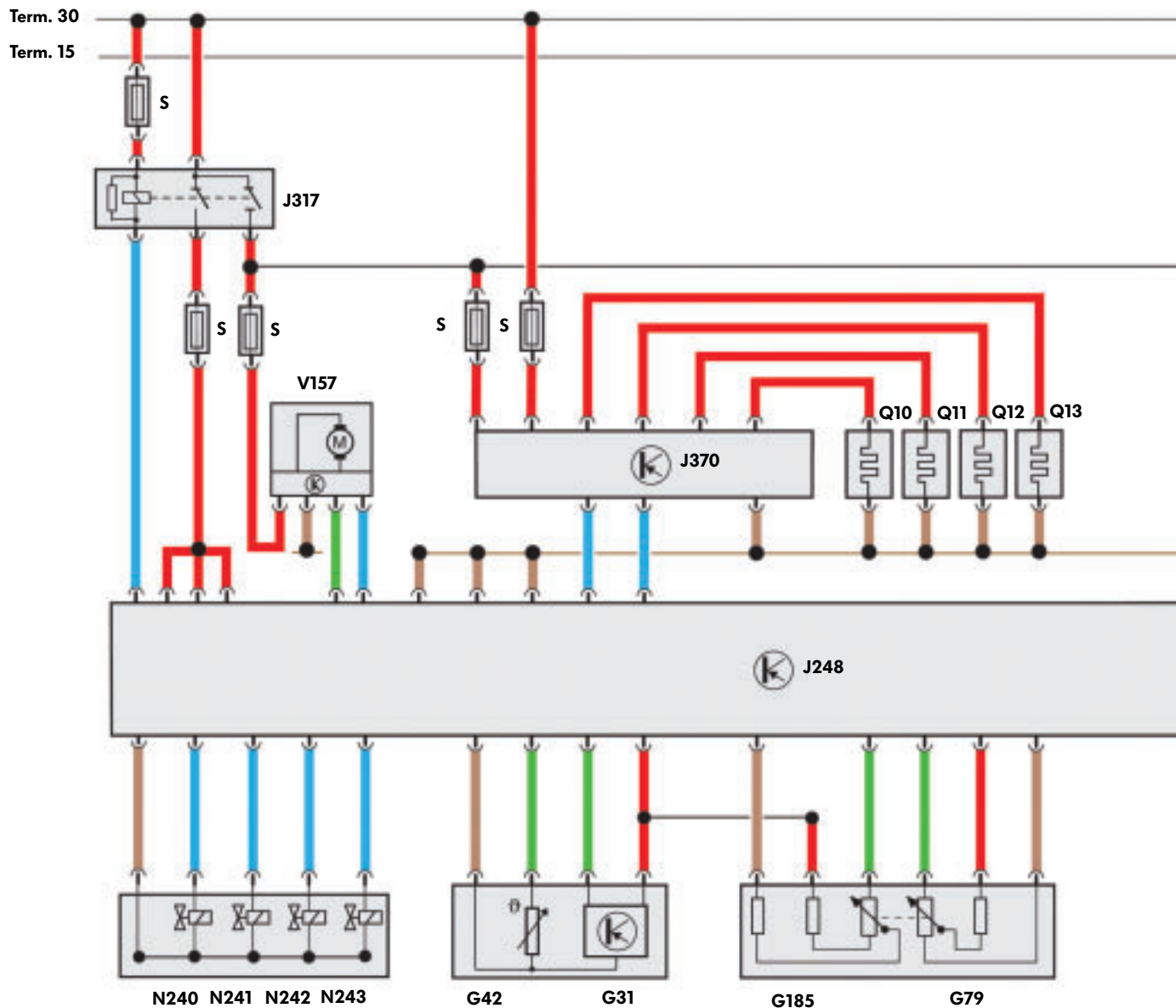
When the engine is running, the glow plug is cooled by the flow of air at load changes. Furthermore, glow plug temperature drops as engine speed increases if glow plug voltage remains constant.

To compensate for this cooling effect, the voltage is increased using a map in the engine control unit based on load and engine speed.



From a coolant temperature of 20° C, there is no extended glow period. After a maximum of 3 minutes, the extended glow period is cancelled.

# Functional diagram

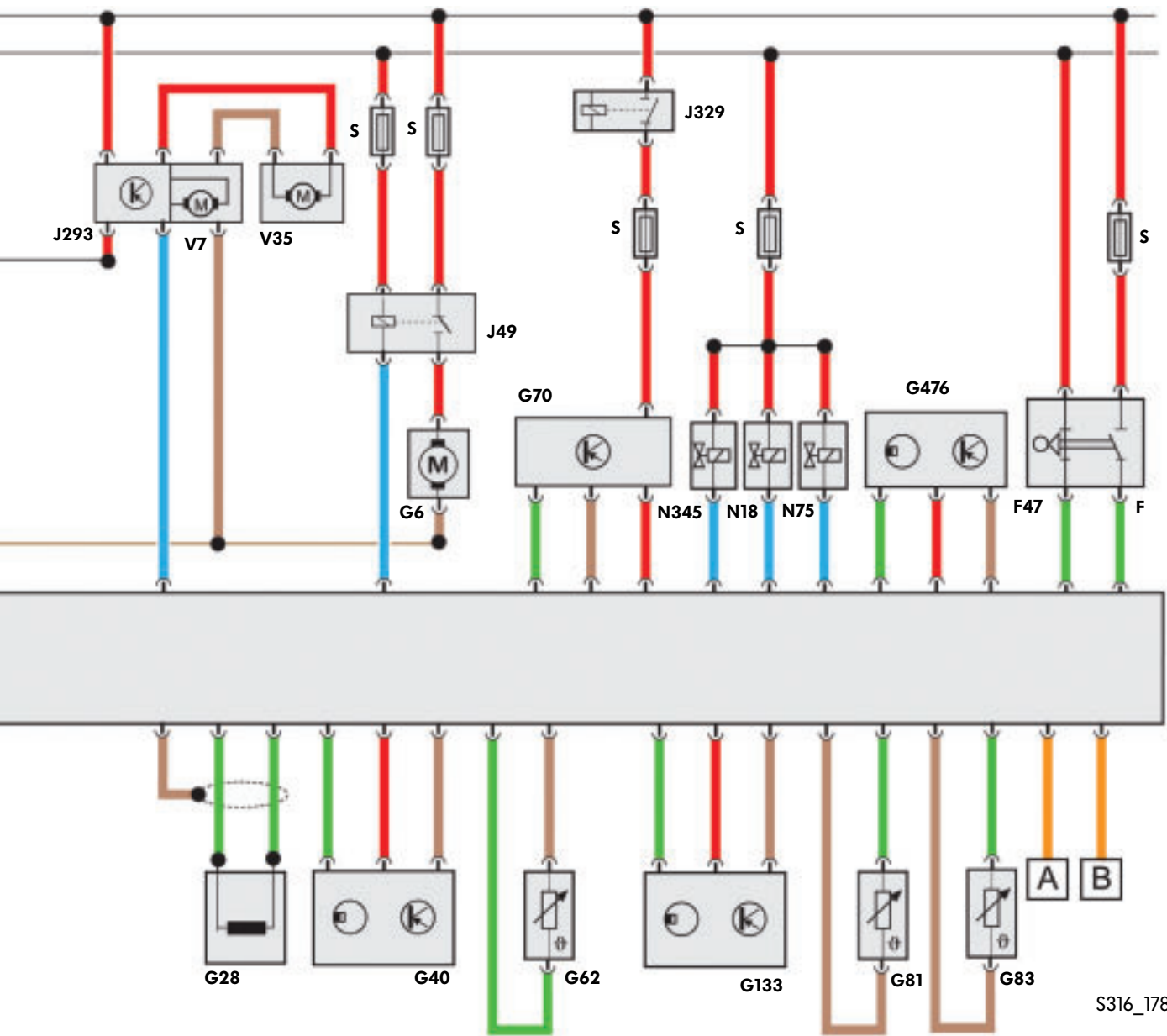


- G31 Charge air pressure sender
- G42 Intake air temperature sender
- G79 Accelerator pedal position sender
- G185 Accelerator pedal position sender -2-
- J370 Glow plug control unit
- J248 Diesel direct injection system control unit
- J317 Power supply relay term.30
- N240 Unit injector valve, no. 1 cylinder
- N241 Unit injector valve, no. 2 cylinder
- N242 Unit injector valve, no. 3 cylinder
- N243 Unit injector valve, no. 4 cylinder

- Q10 Glow plug 1
- Q11 Glow plug 2
- Q12 Glow plug 3
- Q13 Glow plug 4
- S Fuse
- V157 Intake manifold flap motor

## Colour codes/key

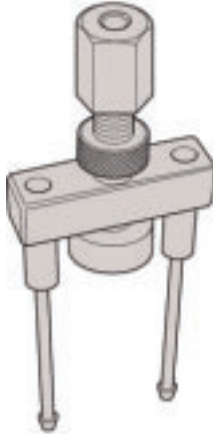



- █ = Input signal
- █ = Output signal
- █ = Positive
- █ = Earth
- █ = CAN data bus



S316\_178

- |      |   |      |  |
|------|---|------|--|
| A    | - CAN data bus low                          | G476 | Clutch position sender                 |
| B    | - CAN data bus high                         | J49  | Electric fuel pump relay II            |
| F    | Brake light switch                          | J293 | Radiator fan control unit              |
| F47  | Brake pedal switch for CCS                  | J329 | Power supply relay term.15             |
| G6   | Fuel pump                                   | N18  | Exhaust gas recirculation valve        |
| G28  | Engine speed sender                         | N75  | Charge pressure control solenoid valve |
| G40  | Hall sender                                 | N345 | EGR cooler changeover valve            |
| G62  | Coolant temperature sender                  | V7   | Radiator fan                           |
| G81  | Fuel temperature sender                     | V35  | Radiator fan, right                    |
| G83  | Coolant temperature sender, radiator outlet |      |  |
| G133 | Fuel composition sender                     |      |  |

## New special tools

Designation	Tool	Application
T10163 Puller	 <p>S316_066</p>	For removal and assembly of unit injector elements in conjunction with slide hammer T10133/3
T10164/1 Assembly sleeve	 <p>S316_068</p>	For removal and assembly of O-rings
T10164/2 Assembly sleeve	 <p>S316_070</p>	For removal and assembly of O-rings
T10134 Assembly device	 <p>S316_102</p>	For removal and assembly of sealing flange with sender wheel





## 1. The bearing frame of the 2.0 ltr. TDI engine

- a) comprises of two parts: Bearing frame upper part and lower part. Both parts are made from an aluminium and silicium alloy.
- b) is a compact component, pressure cast from aluminium.
- c) is made from high quality steel using a drop forge process.

## 2. Which constructive properties of the cylinder head influence optimal mixture formation in the cylinder?

- a) The symmetrical layout of two inlet and two exhaust valves and vertically installed unit injectors, located in the centre directly above the central piston crown recess, result in a good mixture formation.
- b) The valve pattern of the gas exchange ports was offset by 45° in the longitudinal axis of the engine. In this way, optimal flow conditions and good mixture formation is achieved.
- c) The combination of both the injector, which protrudes at an angle into the combustion chamber, and the three valve technology (two inlet valves and one exhaust valve, the former shaped for positive swirl effect) promote intensive mixing of the air and injected fuel.



## 3. Attachment of the unit injector is via:

- a) two bolts.
- b) clamping elements.
- c) a "bolt in bolt" bonding concept.
- d) a clamping element and a bolt.

# Test yourself

---

**4. The 2.0 ltr./103 kW TDI engine has a switchable EGR cooler. Which of the following statements is correct?**

- a) From a coolant temperature of 50°C, recirculated exhaust gas is fed through the switchable EGR cooler. The combustion temperature is lowered and a greater amount of exhaust gas can be recirculated. This helps to reduce nitrogen oxides.
- b) The flow of recirculated exhaust gas is fed by two thirds to the outer and by one third to the inner of the EGR cooler. This principle allows particularly equal and balanced cooling of the exhaust gas.
- c) Up to a coolant temperature of 50°C, the exhaust gas is fed passed the cooler. In this way, the catalytic converter and the engine can reach their operating temperatures within a short space of time. The hydrocarbon, carbon monoxide and particulate emissions are reduced as a result.

**5. Which injectors are installed in the 2.0 ltr./103 kW TDI engine?**

- a) 7-hole injectors.
- b) 5-hole injectors.
- c) 6-hole injectors.

**6. What are the properties of the preglow system in the 2.0 ltr. / 100 kW TDI engine?**

- a) Extremely quick preheating. In a matter of 2 seconds, 1000°C is reached at the glow plug.
- b) There is a preglow period every time the engine is started.
- c) The glow plugs also function as spark plugs.



6.) a

5.) c

4.) a, c

3.) a

2.) a, b

1.) b

**Answers**



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