

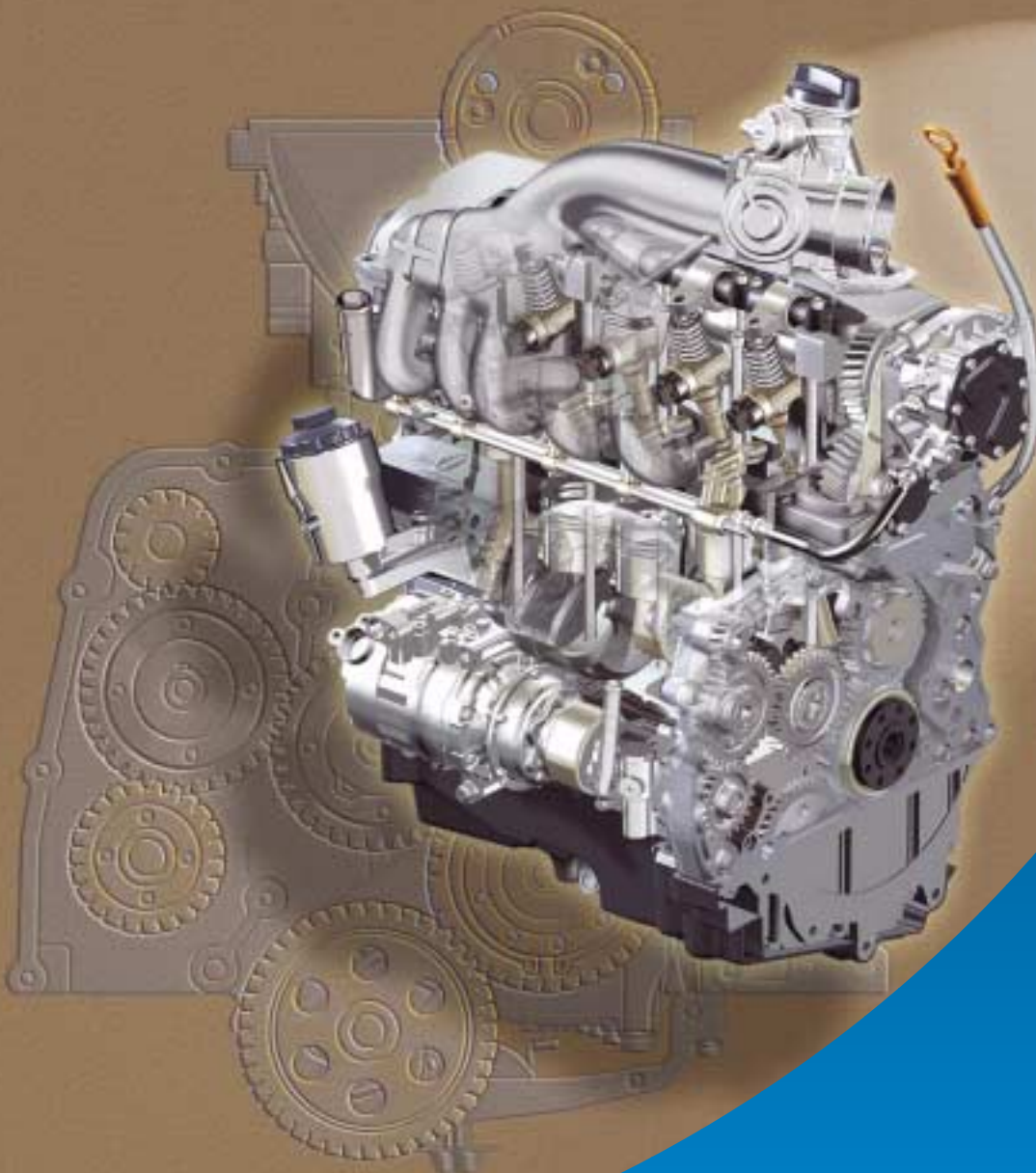
**Service.**



**Self-study programme 305**

# **The 2.5 l R5 TDI engine**

Design and function



The 2.5 l 5-cylinder in-line TDI engine with pump injection system represents a new generation of 5-cylinder diesel engines.

The primary development goal was to use the engine in various models (transverse and longitudinal mounting) with a high power density.

The engine is used in the Transporter 2004 with an output of 96 kW and 128 kW, and in the Touareg with an output of 128 kW.

The engines in the Transporter 2004 and in the Touareg differ particularly in respect to their adaptations for transverse and longitudinal mounting.



305\_018

**Transporter 2004 – transverse mounting**



305\_038

**Touareg – longitudinal mounting**

We will present to you the design and function of the new 2.5 l R5 TDI engine on the following pages.

**NEW**



**Important Note**



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

For the latest testing, adjustment and repair instructions, please refer to the relevant service literature.



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# Introduction



## Technical features

The engine is a new development.

The development goals were:

- compact design to allow longitudinal and transverse mounting
- performance gain to 128 kW
- low weight, for example by using an aluminium cylinder block
- low maintenance requirements, for example by using a maintenance free gear train
- soiling resistant ancillary units drive
- low number of sealing faces, for example by using a modular design
- Crossflow cylinder head with pump injection system



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### Technical features - engine mechanics

- Cylinder block with plasma-coated cylinder faces
- Single plane gear train with short installation length
- Crossflow cylinder head
- Crankshaft with integral vibration damper
- Upright oil filter module with paper filter element and integrated oil cooler
- The 3-phase AC alternator and the air conditioner compressor are driven by elastic drive couplings
- Exhaust gas recirculation

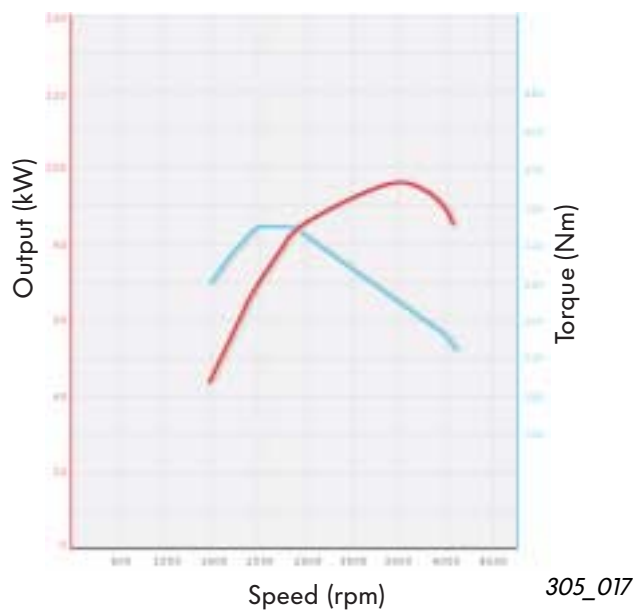
### Technical features - engine management

- Torque-oriented Bosch EDC 16 engine management system
- Pump injection system
- Variable geometry turbocharger (electro-pneumatic)

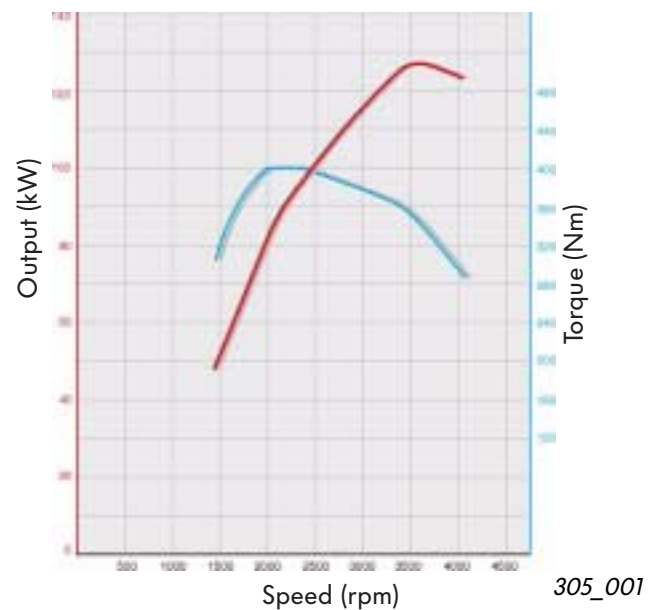
## Technical data

### Power/torque graph

2.5 l/96 kW – AXD



2.5 l/128 kW – AXE and BAC



Engine codes	AXD Transporter 2004	AXE Transporter 2004 BAC Touareg - longitudinal mounting
Type	5-cylinder in-line engine	
Displacement	2460 cm <sup>3</sup>	
Bore	81 mm	
Stroke	95.5 mm	
Compression ratio	18.0 : 1	
Valves per cylinder	2	
Firing order	1 - 2 - 4 - 5 - 3	
Max. output	96 kW at 3500 rpm	128 kW at 3500 rpm
Max. torque	340 Nm at 2000 rpm	400 Nm at 2000 rpm
Engine management	Bosch EDC 16	
Idling speed	800 rpm	
Fuel	Diesel (minimum 49 CN)	
Exhaust gas aftertreatment	Exhaust gas recirculation, main catalyst	
Exhaust emission standard	EU 3	



The performance difference between the 96 kW variant and the 128 kW variant is due to software modifications to the engine control unit and differences in the design of the exhaust gas turbocharger.

# Engine mechanics

## Cylinder block

The cylinder block is made from a high-strength aluminium alloy using the low pressure permanent mould casting method.

The cylinder blocks for the Transporter 2004 and the Touareg differ in particular in respect to their starter configuration.

- Where the engine is transversely mounted (Transporter 2004), the starter is mounted on the gearbox side.
- Where the engine is longitudinally mounted (Touareg), the starter is mounted on the engine side - which is why a starter mounting is cast on here.



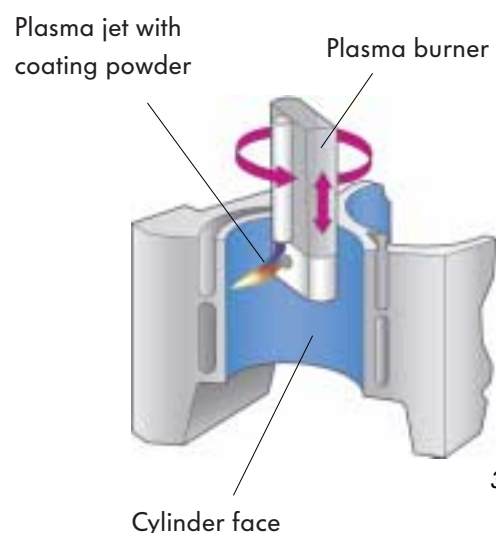
305\_007

## Plasma-coated cylinder faces

The cylinder faces of the 2.5 l R5 TDI engine are plasma-coated. This means that a coating powder is applied to the cylinder wall with a plasma burner. As a result, there is no need for cylinder liners in the aluminium cylinder block.

This has the following advantages:

- weight reduction compared to press-fitted cylinder liner made from grey cast iron
- more compact dimensions due to a smaller distance between the cylinder bores than in the previous production engine with grey cast iron cylinder block
- reduced wear through use of the plasma-coated cylinder face



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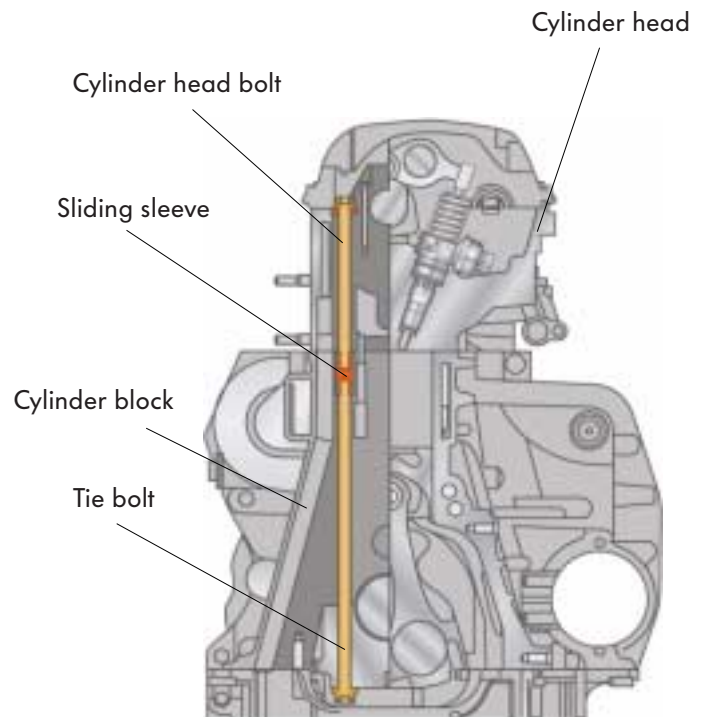


## Warp anchor principle

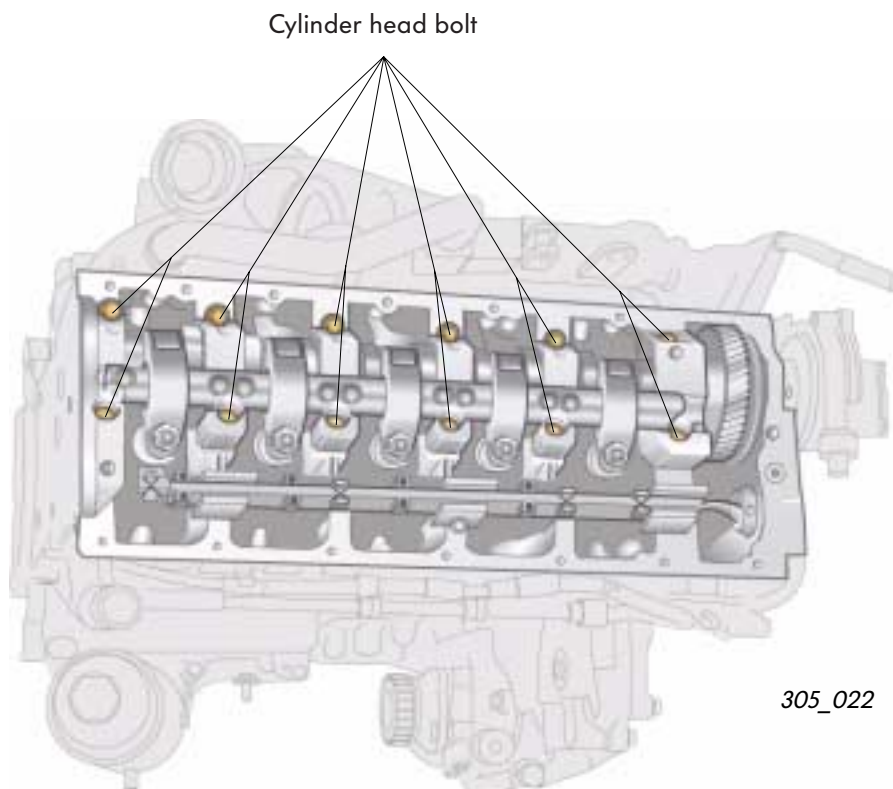
To avoid stresses and to ensure an optimal cylinder shape, the cylinder head and the cylinder block are bolted together by tie bolts.

The connection is made by means of sliding sleeves in the cylinder block. The sliding sleeves are placed in the cylinder block and locked against rotation.

The sliding sleeve accepts the cylinder head bolt from one side and the tie bolt from the other side.



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305\_022



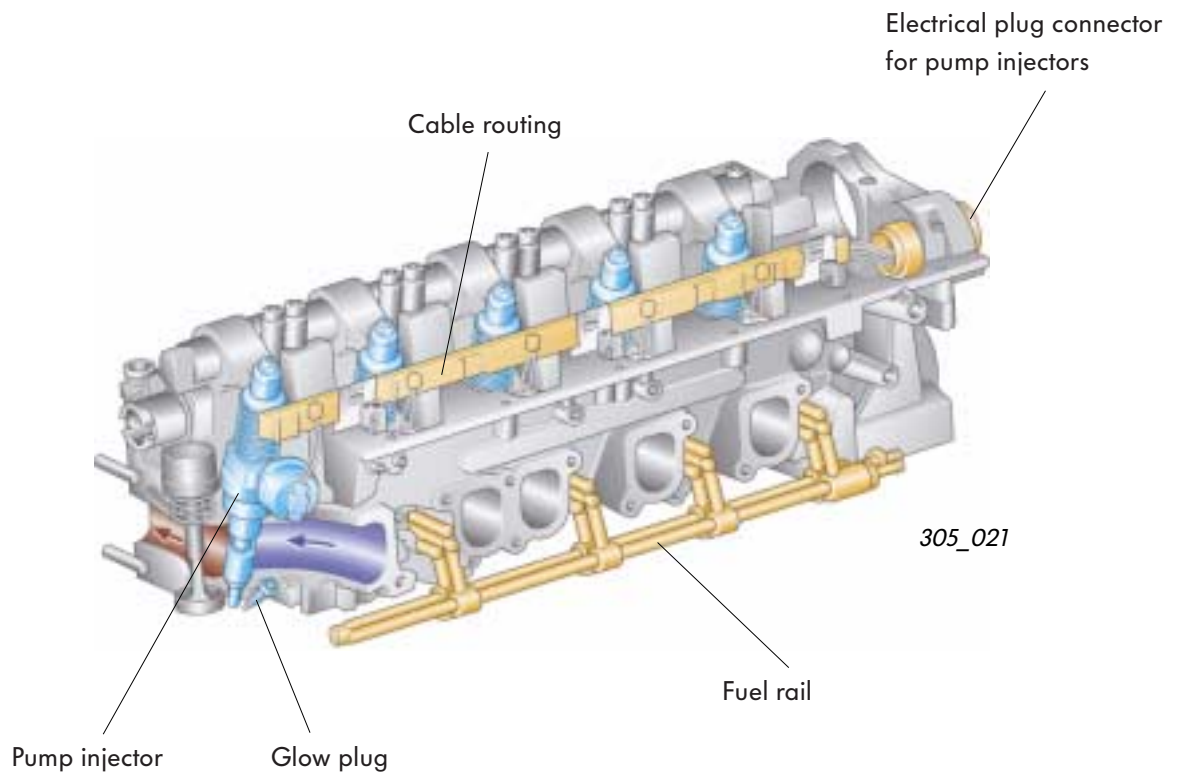
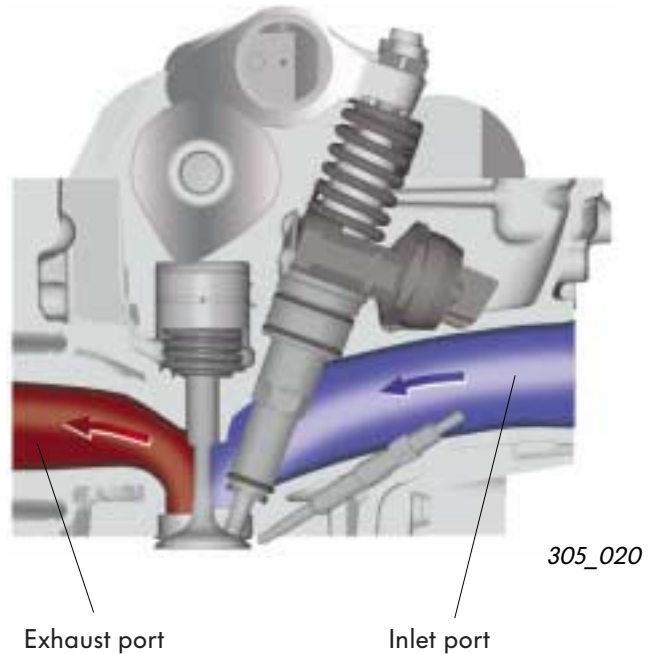
The removal and installation procedures, as well as the tightening sequence of the warp anchors and cylinder head bolts, are described in the workshop manual.

# Engine mechanics

## Cylinder head

The aluminium cylinder head has been developed as a crossflow cylinder head. This means that the intake port and exhaust ports are arranged opposite each other in the cylinder head. This ensures an efficient charge cycle, and therefore improved cylinder charging.

All control elements, such as the valves, tappets and rocker levers, have been adopted from other pump injector engines.





## Pump injectors

The second generation pump injectors used previously in the 1.9 l TDI engine are installed in the 2.5 l R5 TDI engine. They have been adapted in respect to jet position and flow.

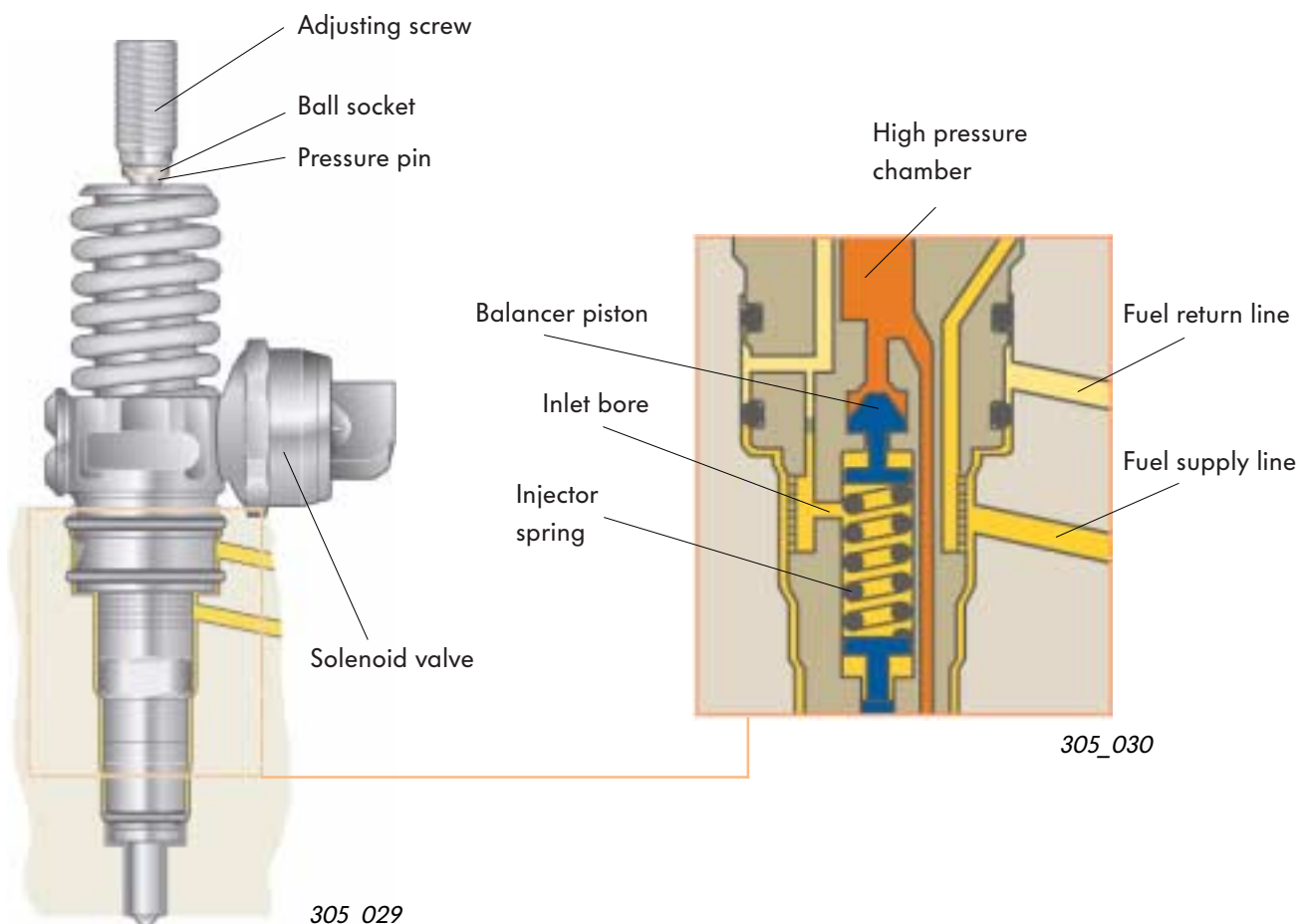
They have the following notable features:

- a low-friction drive
- an elevated injection pressure in the part-throttle range
- a compact solenoid valve

To keep drive friction to a minimum, the adjusting screw has a rounded end and the pressure pin has a ball socket. The large radii ensure a low surface pressure. In addition, the engine oil collects in the ball socket and thus provides good lubrication between the adjusting screw and the pressure pin.

The injection pressure in the part-throttle range has been increased by using a balancer piston with a longer stroke.

The pressure in the injector spring chamber rises due to the long stroke of the balancer piston and the flow-restricting action of the inlet bore between the injector spring chamber and the fuel duct. The injector spring is preloaded still further and the injection pressure increases.



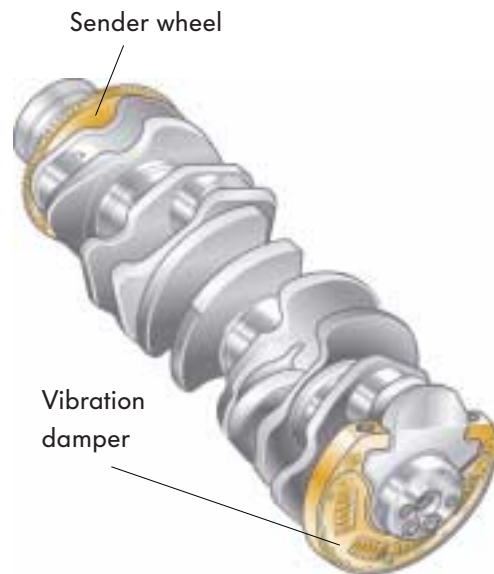
# Engine mechanics

## Crankshaft

To achieve a short installation length, the vibration damper is integrated in the crankshaft.



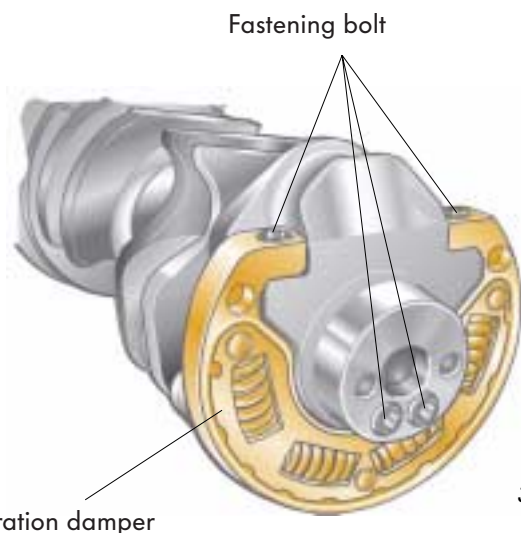
If the crankshaft is removed, the cylinder head must also be dismantled and the cylinder head gasket replaced. Please refer to the workshop manual.



305\_023

## Vibration damper

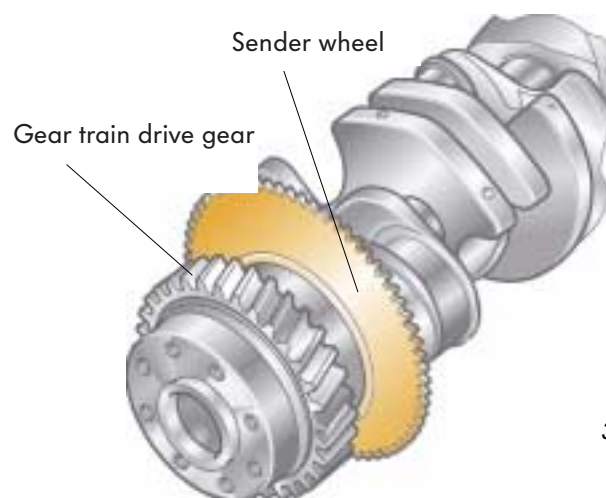
The vibration damper is mounted to crankshaft by four bolts in lieu of the first counterweight. Vibrations are damped over the full engine load and engine speed range by plastic friction elements.



305\_025

## Engine speed sender wheel

The gear for driving the gear train is pressed fitted onto the output end of the crankshaft. The sender wheel is machined as part of the crankshaft assembly. This eliminates additional assembly tolerances in the sender wheel and enhances the accuracy of the signal for engine speed measurement.



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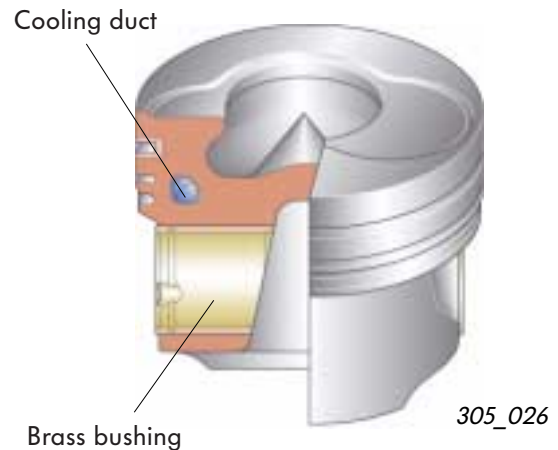


The vibration damper can be replaced without having to remove the crankshaft by detaching the first conrod bearing cap.

## Conrods and pistons

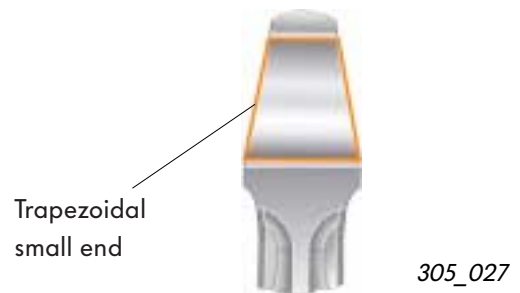
### Pistons

The piston bosses and the small end have a trapezoidal shape in order to minimise the stresses in the pistons and conrods under high combustion pressures. As a result, the combustion forces are distributed over a larger area. To provide good antifrictional properties, the piston bosses have brass bushings. A cooling duct has been cast into the piston in order to cool the piston ring zone. The oil spray nozzles inject oil into this cooling duct as soon as the piston is located at bottom dead center.



### Conrod

The single-piece conrod is made by forging. The connecting rod cap is made by cracking.

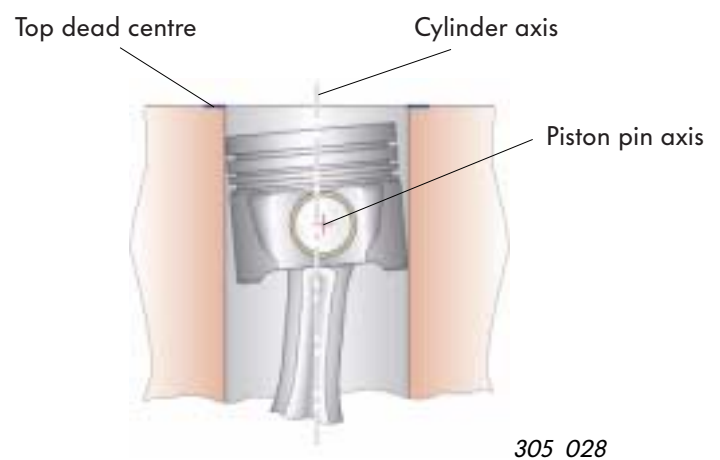


### Piston pin axis offset

The piston pin axis is arranged excentrically in order to eliminate noises caused by tilting of the piston at top dead centre.

Whenever the connecting rod is inclined, lateral piston forces which alternately press the piston against the cylinder wall are produced. The lateral piston force changes direction at top dead centre. Here the piston is tilted towards the opposed cylinder wall and produces noises. To prevent tilting of the piston and the resulting noises, the piston pin axis is arranged excentrically.

By offsetting the piston pin axis, the piston changes sides before it reaches top dead centre and rests against the opposite cylinder wall.

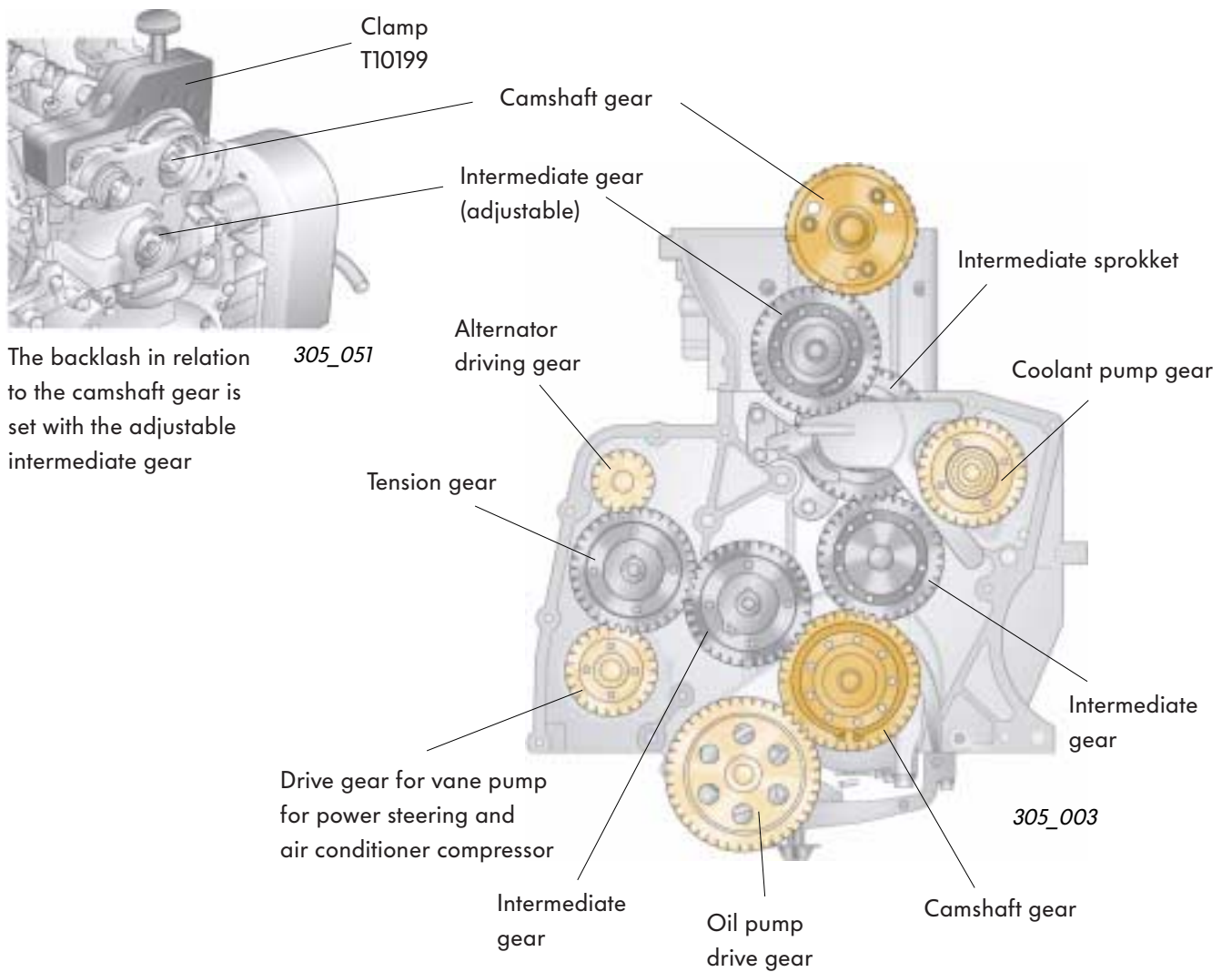


# Engine mechanics

## Gear train

Due to the constraints on space, particularly in vehicles with transversely mounted engines, a helical gear train is used. The gear train transmits the high drive forces in a space-saving manner. A 15° helical toothing increases the load-bearing tooth flank width and reduces the gear dimensions to a minimum.

The gear train is arranged on the flywheel end. The camshaft and the ancillary units are driven by the crankshaft via the gear train.



The gear train is maintenance free.  
Provision is not made for replacement of gears by after-sales service.

## Ancillary units drive

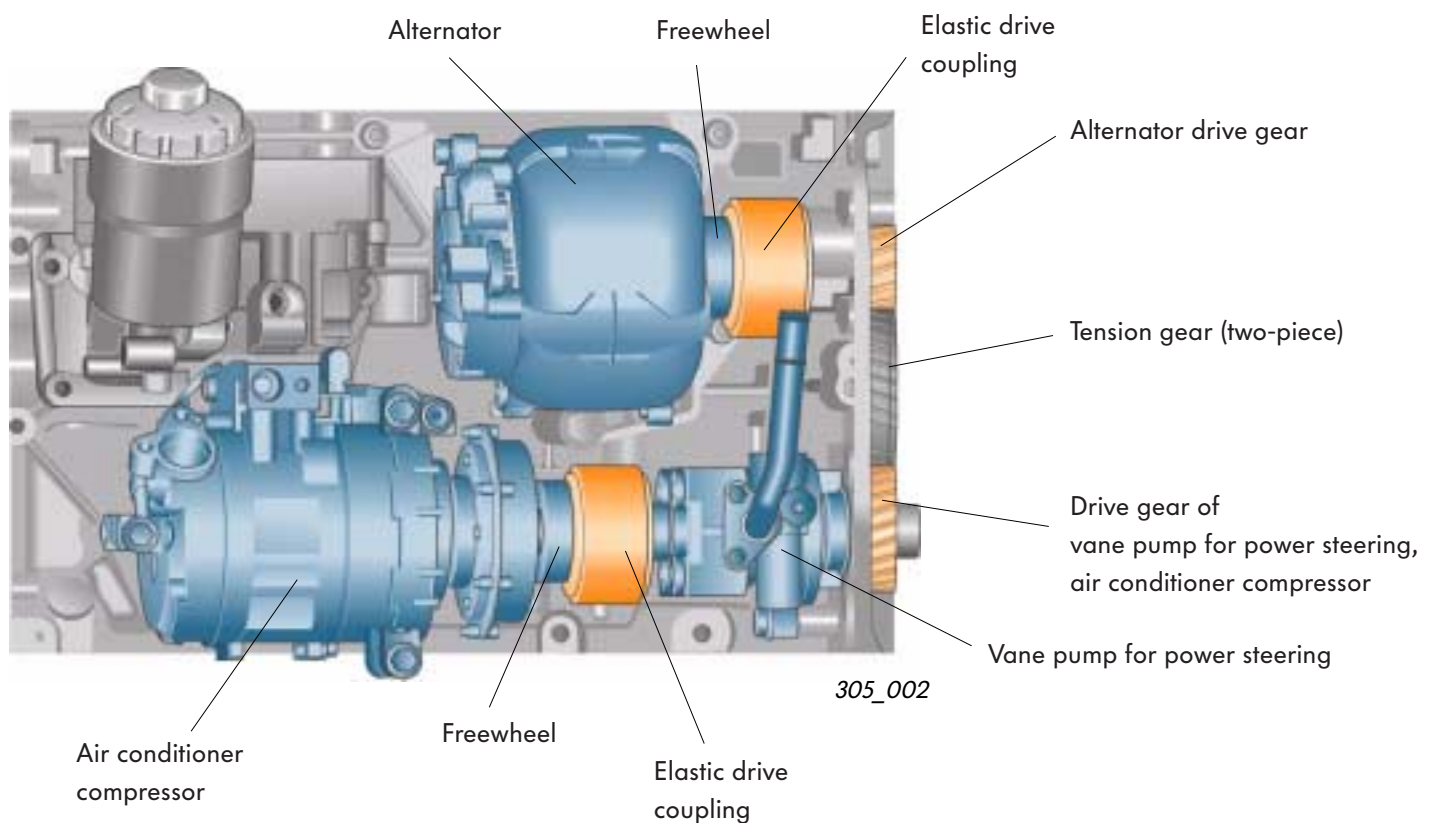
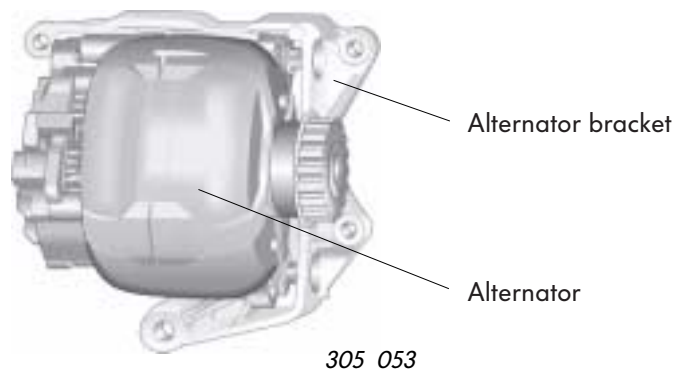
The ancillary units are driven directly by the gear train.

In the alternator and air conditioner compressor, the axis offset tolerances as well as the running irregularities in the longitudinal direction of the drive axis are equalised and damped by an elastic drive coupling.

A further advantage is that this coupling is not as prone to soiling. This is particularly important for off-road driving and in dusty countries.



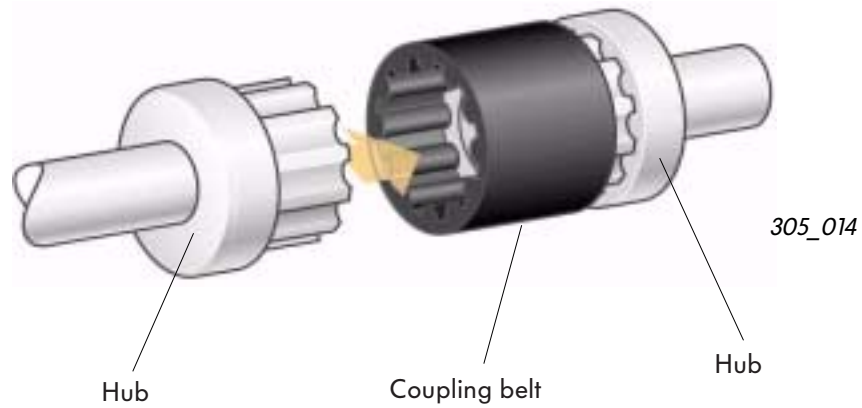
When removing the alternator, do not take apart the bracket and the alternator.



# Engine mechanics

## Elastic drive coupling

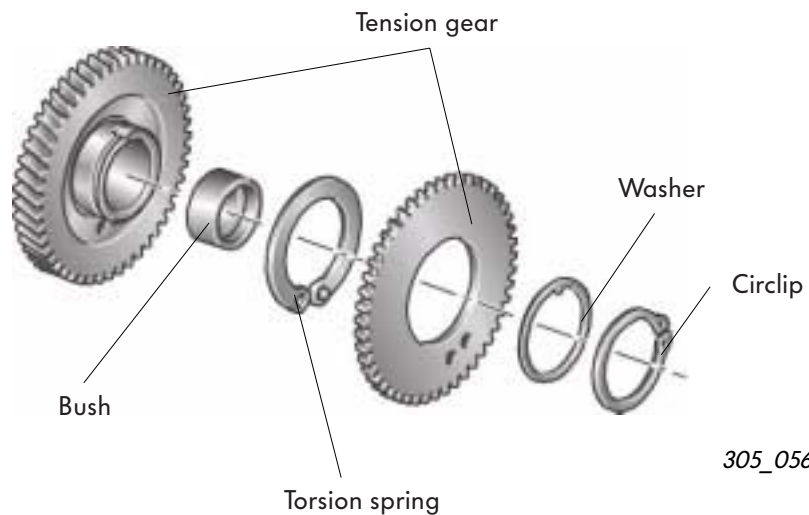
The elastic drive coupling comprises two geared metal hubs which are mechanically connected via a coupling belt.



## Tension gear

The task of the tension gear is to reduce the backlash of the gears which drive the ancillary units. The tension gear is a two-part construction. Both parts are connected by a torsion spring located between the two parts of the gear.

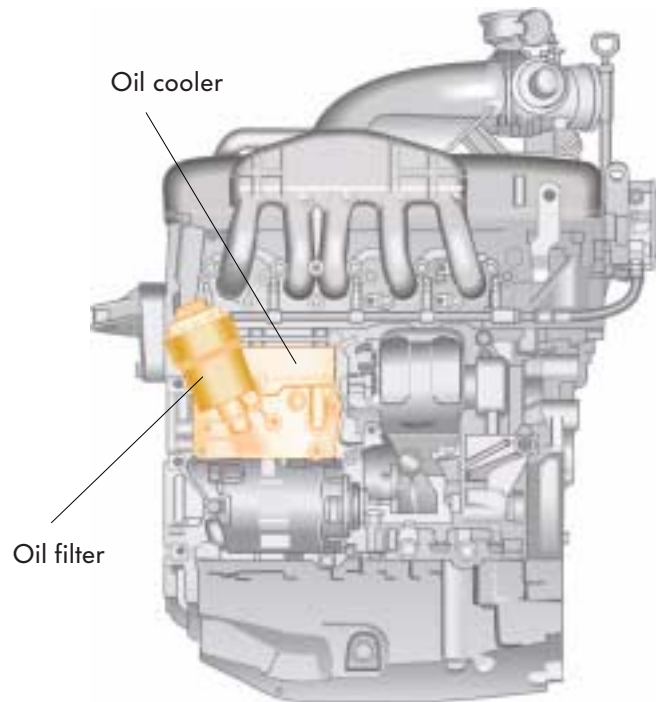
Preloading the torsion springs causes the parts of the gear to counterrotate. The backlash of the tension gear and meshing gears is thereby reduced.





## Oil filter module

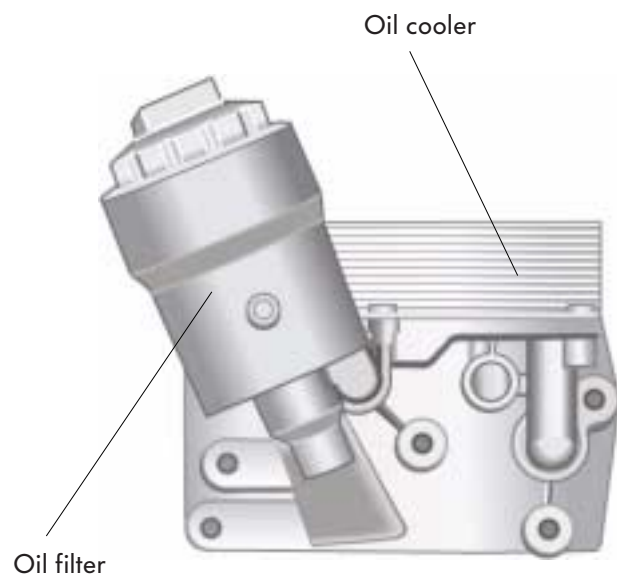
The oil filter module is mounted to the cylinder block by five bolts. It comprises an upright oil filter and an integrated oil cooler. The oil filter element is replaced in the upward direction.



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### Advantages of the oil filter module

- Sealing face with 5-point threaded connection
- Eco-friendly upright oil filter with paper element
- Integrated oil cooler



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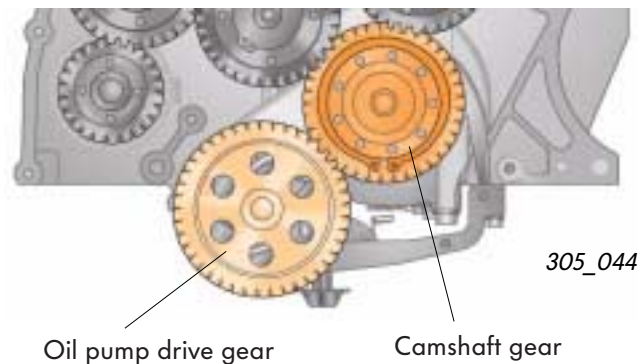
# Engine mechanics

## Oil pump

The Duocentric oil pump is bolted to the base of the cylinder block and driven by the crankshaft via gears.

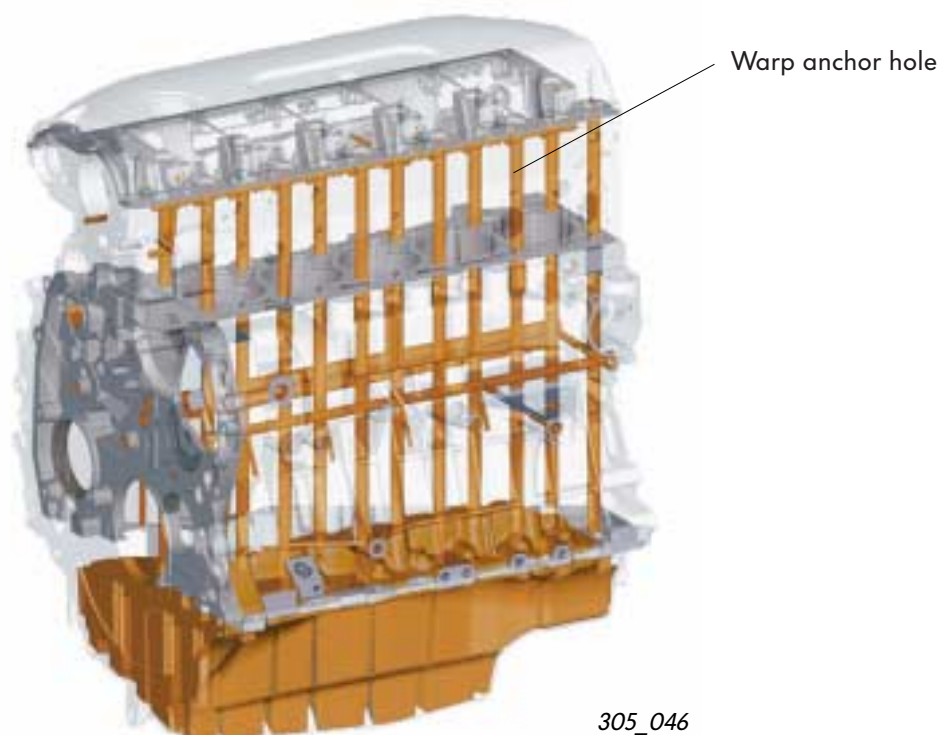


The oil pump is located by two fitted sleeves in the cylinder block. Please refer to the workshop manual.



## Oil circuit supply line

A special feature of the oil circuit is that the warp anchor holes are integrated in the oil supply line. Various bearing points and the gear train are supplied with oil through the warp anchor holes.

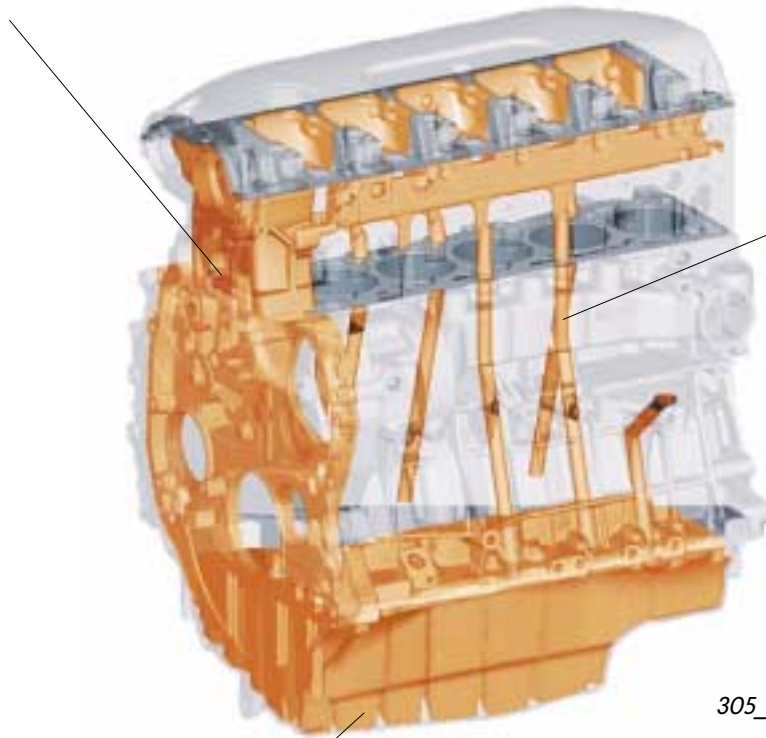


## Oil circuit return line

The oil mainly flows back from the cylinder head in the area of the gear train. A further portion of the oil flows back into the oil sump through return bores on both side walls of the engine.



Oil return in the area of  
gear train



Return bore

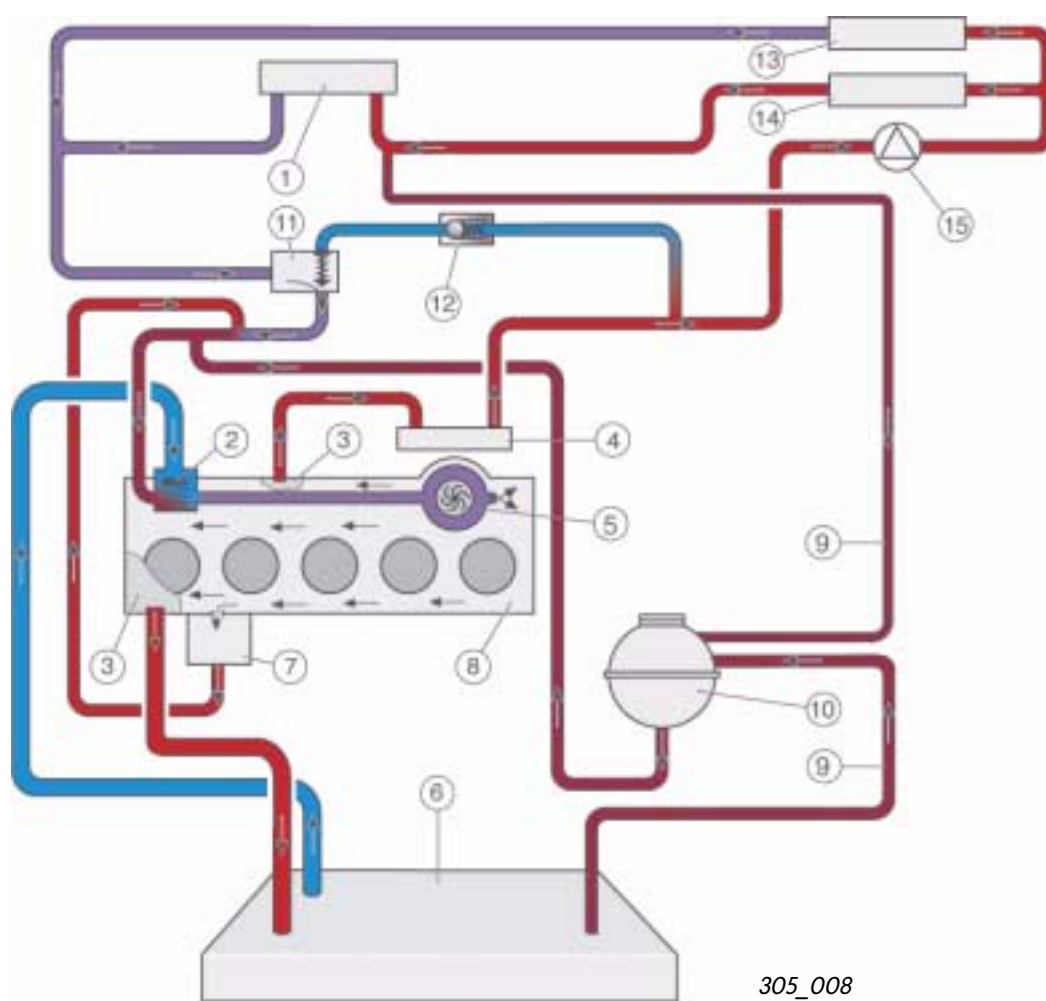
305\_045

Oil sump

# Engine mechanics

## Coolant circuit

The figure shows the coolant circuit of the Transporter 2004 with an supplementary coolant heater. Various variants are used depending on specification.



### Key

- |   |  |
|---|--|
| ① First heat exchanger  | ⑧ Cylinder block   |
| ② Coolant thermostat (opens when coolant temperature exceeds 80 °C) | ⑨ Vent pipe  |
| ③ Cylinder head   | ⑩ Expansion tank   |
| ④ Exhaust gas recirculation cooler                                  | ⑪ Heater coolant shut-off valve N279                     |
| ⑤ Coolant pump  | ⑫ Non-return valve                                       |
| ⑥ Cooler  | ⑬ Second heat exchanger (for rear passenger compartment) |
| ⑦ Oil cooler  | ⑭ Supplementary coolant heater                           |
|   | ⑮ Recirculation pump                                     |

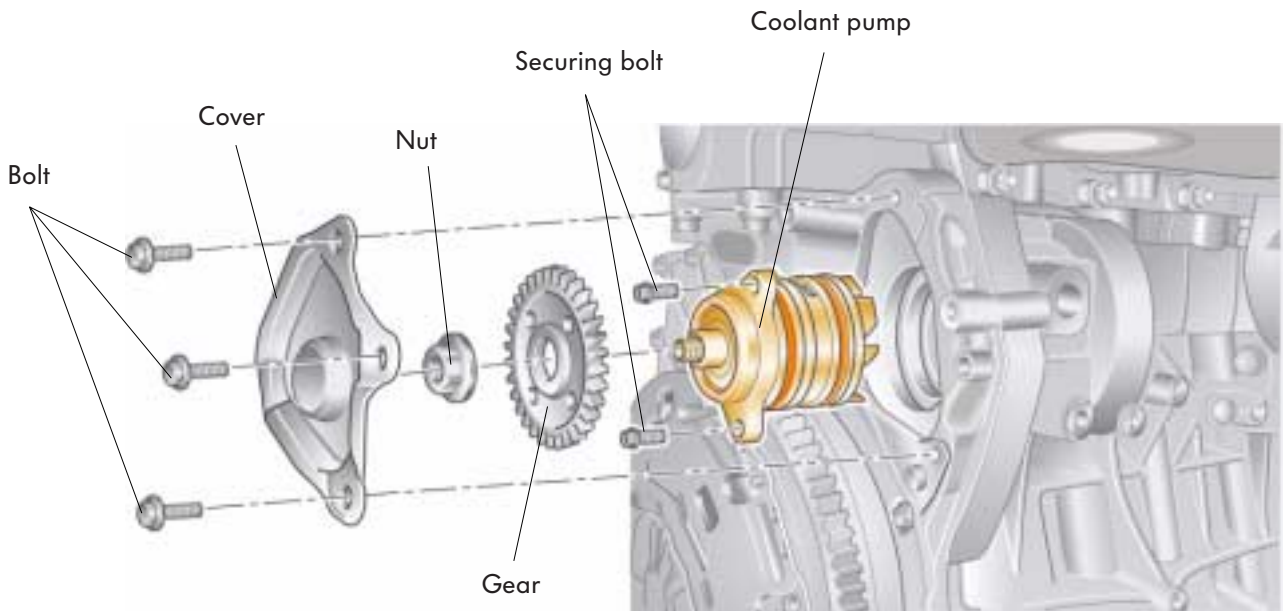
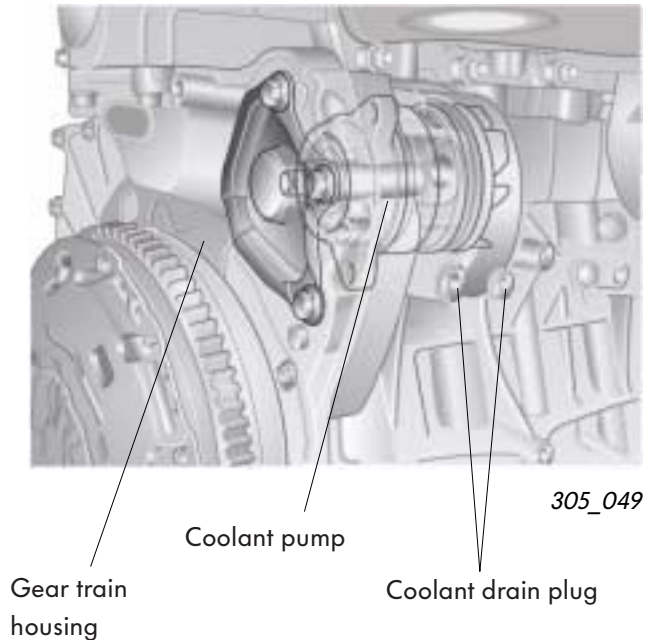
## Coolant pump

The coolant pump is designed as a vane pump and is inserted into the cylinder block on the spur gear side. It is driven via gears of the gear train.

The coolant pump can be removed without dismantling the gear train housing.



Before removing the coolant pump, the coolant must be drained at the coolant drain plugs. This prevents coolant from flowing into the gear train housing and oil sump and mixing with the engine oil.



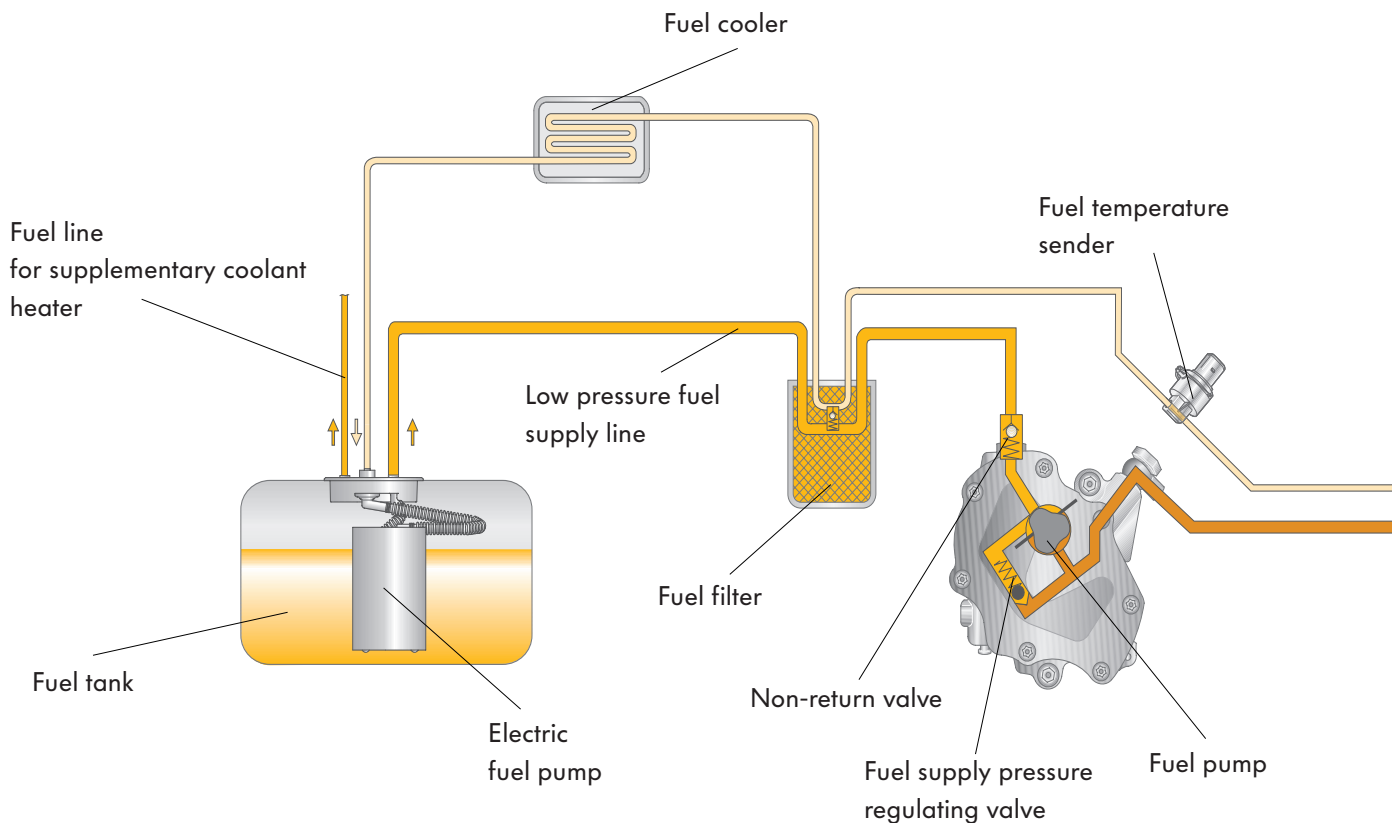
Special tools are used for removing the coolant pump: coolant pump spur gear puller T10221 and coolant pump puller T10222.



# Engine mechanics

## Fuel system

The overview shows the fuel system of the Transporter 2004.



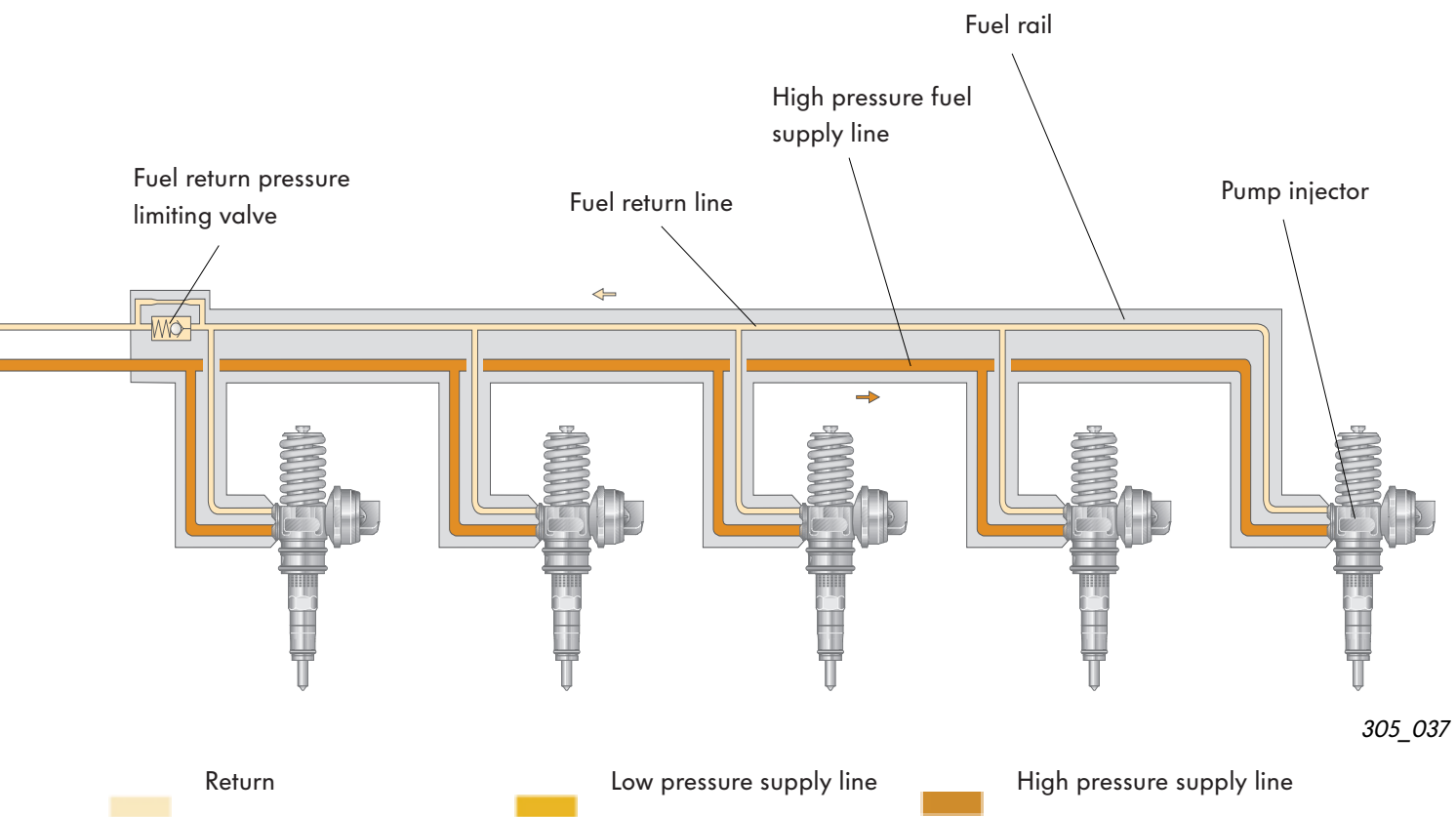
The **electrical fuel pump** in the tank serves as a pre-supply pump, and pumps fuel to the fuel filter.

The **non-return valve** prevents fuel from flowing back from the fuel rail and supply line into the fuel tank when the engine is stopped.

The **fuel filter** protects the injection system against soiling and wear by particles and water.

The **fuel pump** pumps the fuel out of the fuel filter and into the fuel supply line under high pressure.





The **pressure regulating valve** sets the fuel pressure in the fuel supply line to approximately 8.5 bar.

The **pressure limiting valve** limits the fuel pressure in the fuel return line to approximately 1 bar. The pressure conditions in the fuel system are thus balanced.

The **fuel cooler** cools the flowing back fuel in order to protect the fuel tank against excessively hot fuel.

The **fuel temperature sender** measures the fuel temperature for the engine control unit.

The **pump injectors** are solenoid valves that are activated by the engine control unit. They are used to control the commencement of injection and injection quantity.

# Engine mechanics

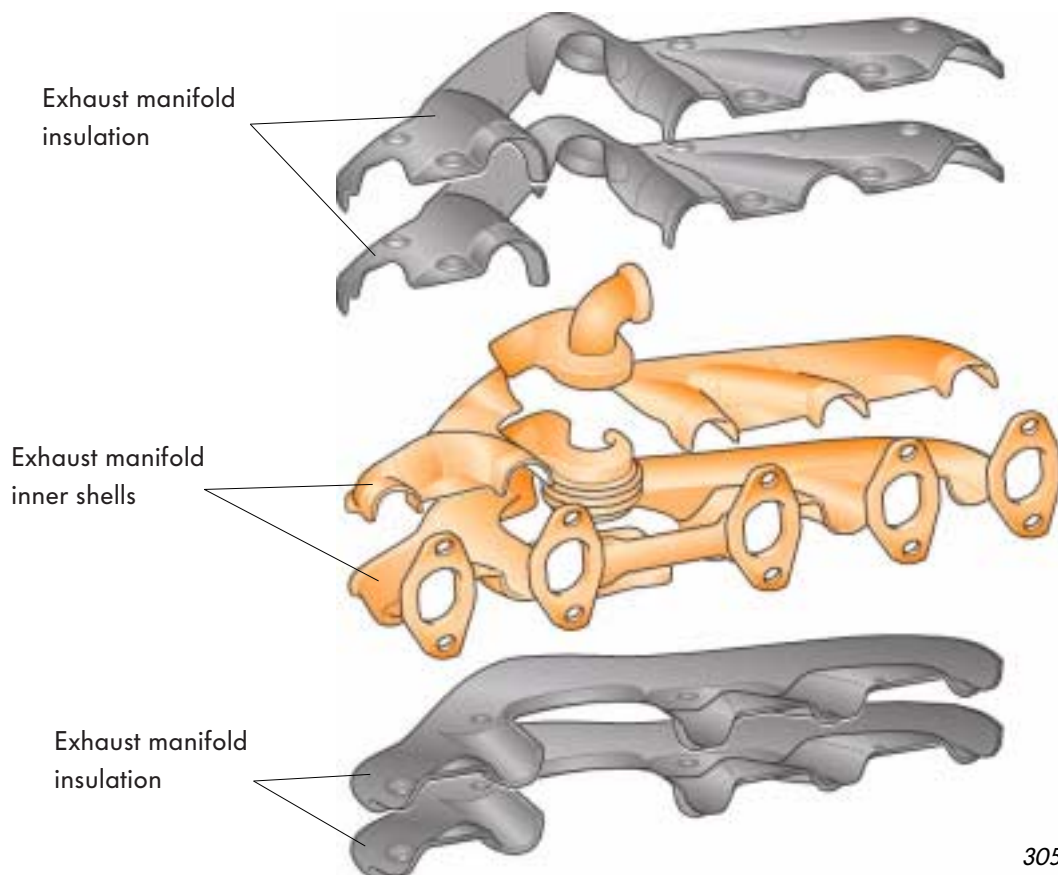
## Exhaust system

The exhaust system comprises an exhaust manifold, a main catalyst, a front silencer and a rear silencer.



### Exhaust manifold

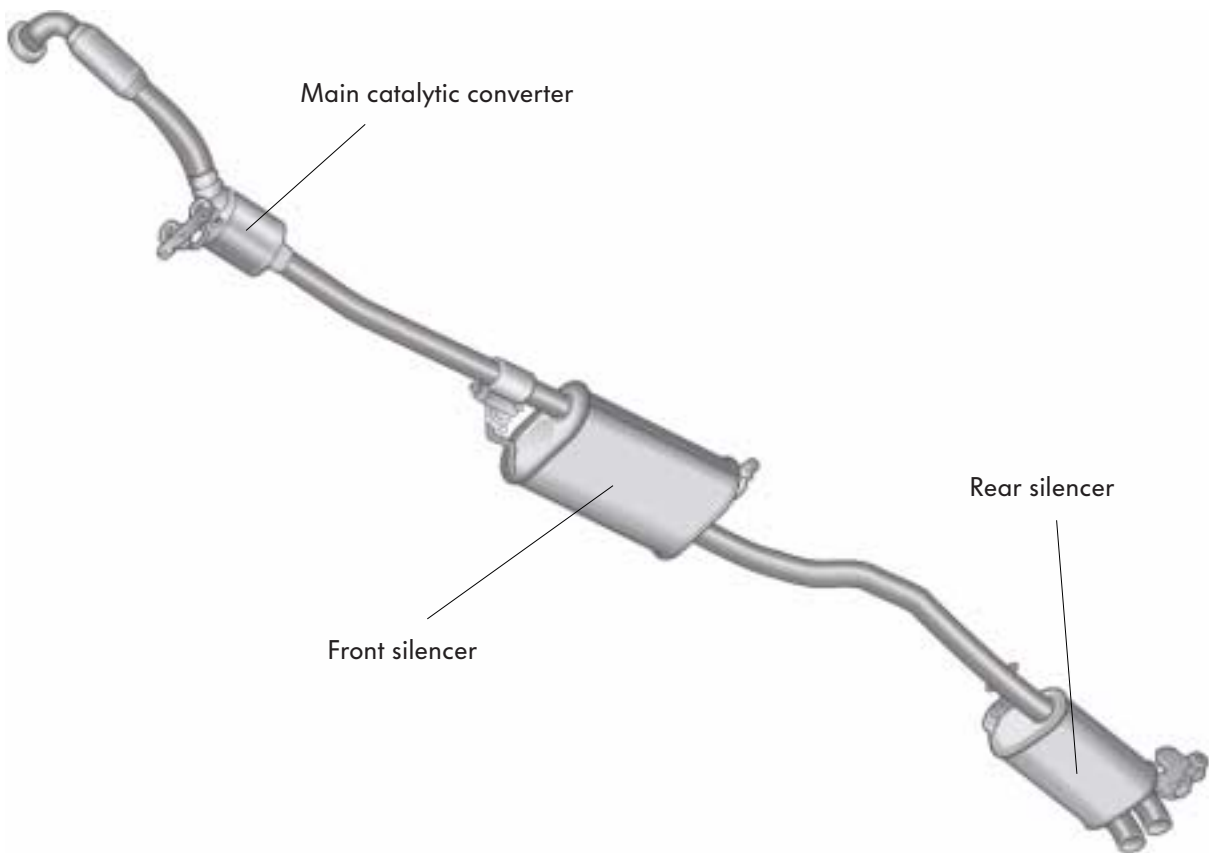
The exhaust manifold is an insulated sheet metal manifold with a gas-tight inner shell. This highly compact design ensures a high rate of heating. Additional heat shielding is not required.



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## Overview of the exhaust system

The overview shows the components of the exhaust system in the Transporter 2004.

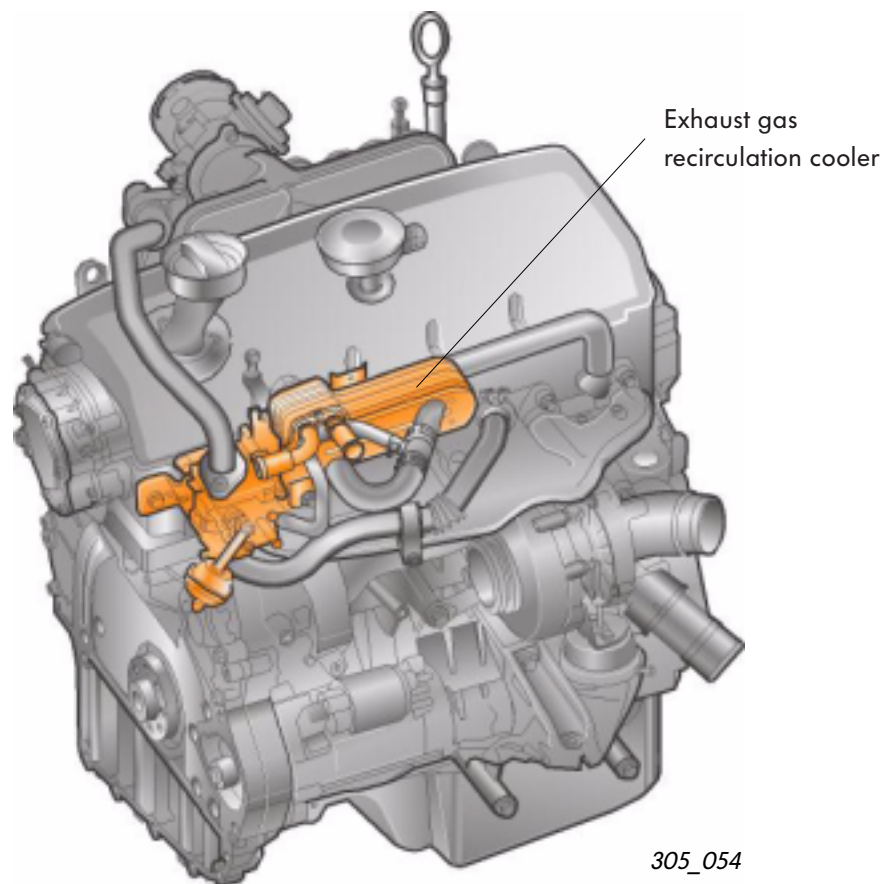


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# Engine mechanics

## Exhaust gas recirculation cooler

An exhaust gas recirculation cooler is used in several variants in order to lower the combustion temperature, and thus reduce nitrogen oxide emissions and soot formation.



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Variants:

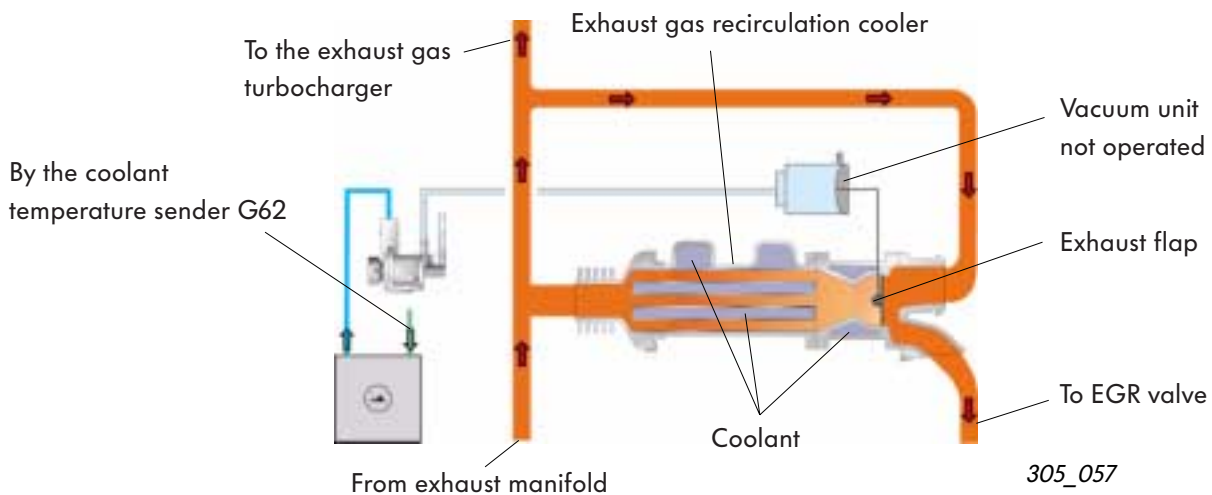
- An exhaust gas recirculation cooler, which continuously cools the exhaust gas, is used in the Transporter 2004 with automatic transmission and in the Touareg with manual gearbox.
- A switchable exhaust gas recirculation cooler, which cools the exhaust gas at a coolant temperature upwards of approximately 50 °C, is used in the Touareg with automatic transmission.

## How the switchable exhaust gas recirculation cooler works

A switchable exhaust gas recirculation cooler is used, because continuous cooling of the recirculated exhaust gases results in higher hydrocarbon and carbon monoxide emissions. The exhaust gas is ducted either through the cooler or past the cooler to the exhaust gas recirculation valve.

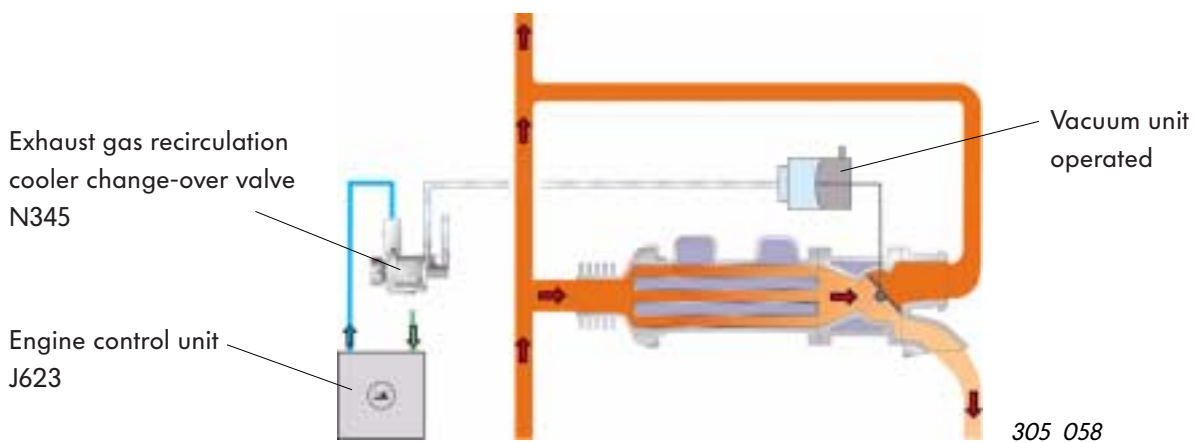
### Without exhaust gas cooling

The exhaust flap remains closed up to a coolant temperature of approximately 50 °C, and the exhaust gas bypasses the cooler.



### With exhaust gas cooling

The exhaust flap is opened by the exhaust gas recirculation cooler change-over valve at a coolant temperature of approximately 50 °C. The recirculated exhaust gas now flows through the cooler. The cooling capacity depends on the coolant temperature and the exhaust gas recirculation rate.

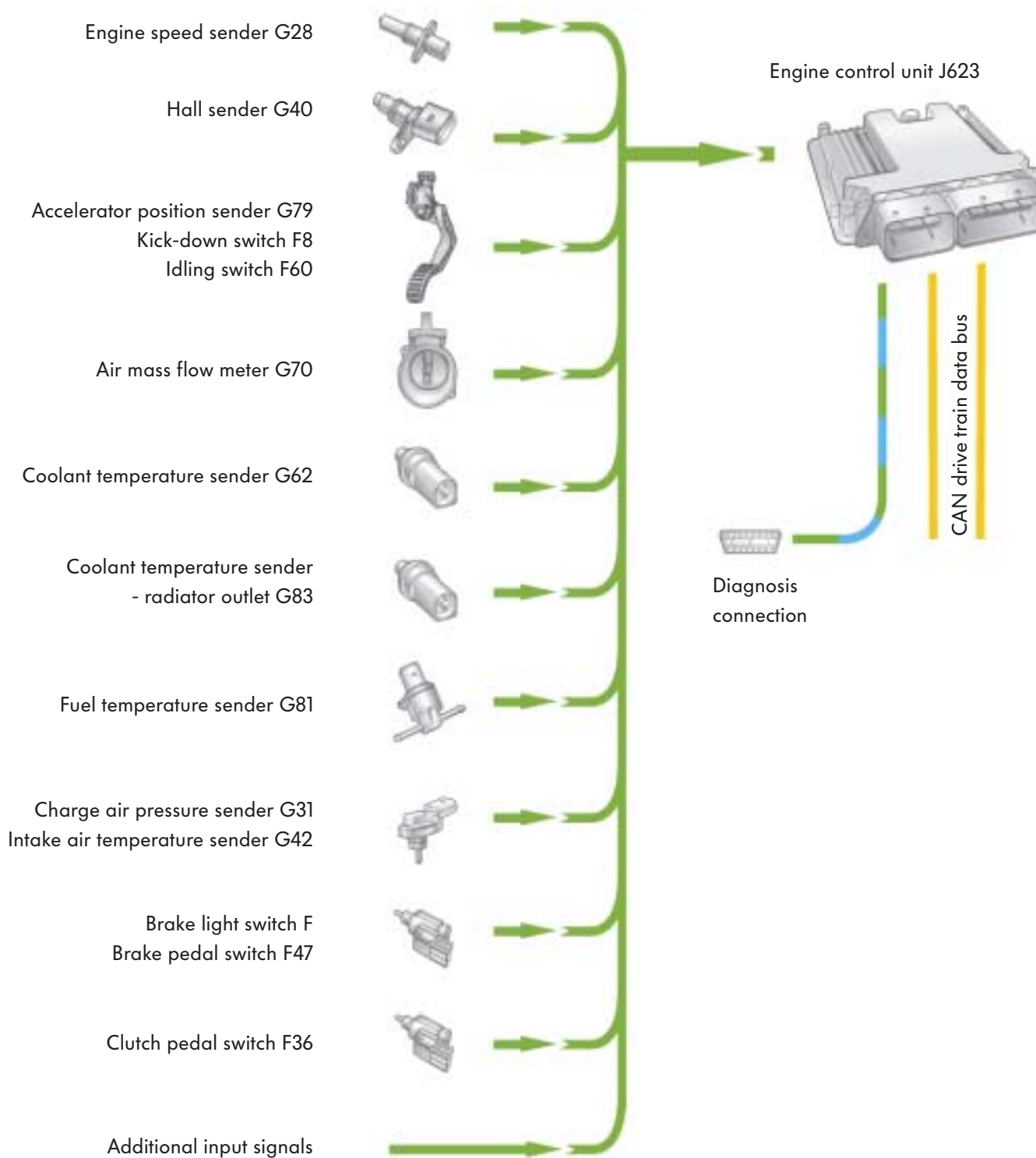


# Engine management

## System overview

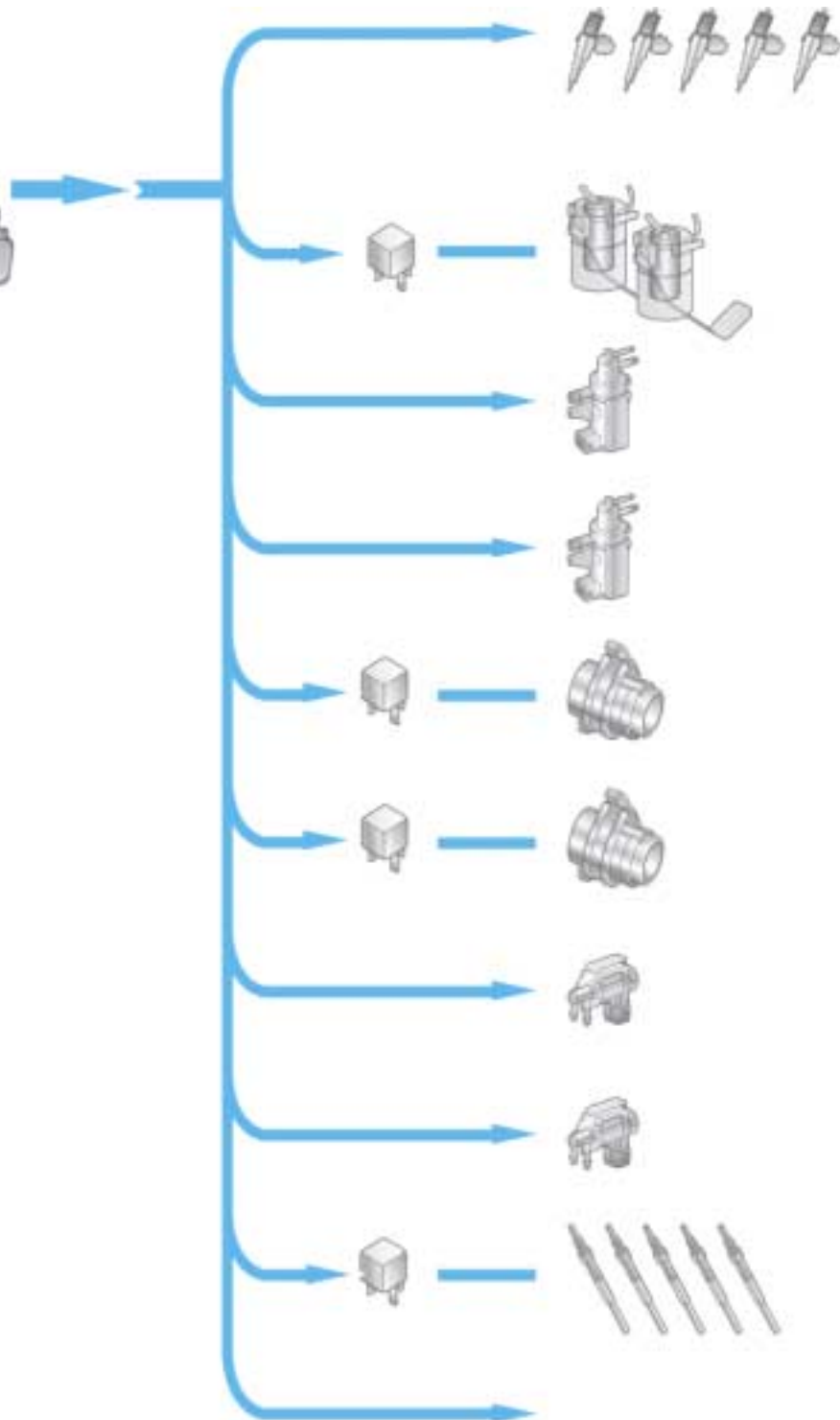
The Bosch EDC 16 Electronic Diesel Control is used in combination with a torque-oriented engine management system in the 2.5 l R5 TDI engine in the Transporter 2004 and in the Touareg.

### Sensors





You will find a detailed description of the engine management system in Self-Study Programme 304 "The EDC 16 Electronic Diesel Control".



### Actuators

Pump injector valves N240 ... N244

Fuel pump relay J17  
 Fuel pump (pre-supply pump) G6  
 Fuel pump G23 \*

Exhaust gas recirculation valve N18

Charge pressure control solenoid valve N75

Coolant pump run-on relay J151  
 Recirculation pump V55

Fuel cooling pump relay J445 \*  
 Fuel cooling pump V166 \*

Intake manifold flap change-over valve N239

Exhaust gas recirculation cooler change-over valve N345 \*\*

Glow plug relay J52  
 Glow plugs Q10 ... Q14

Additional output signals



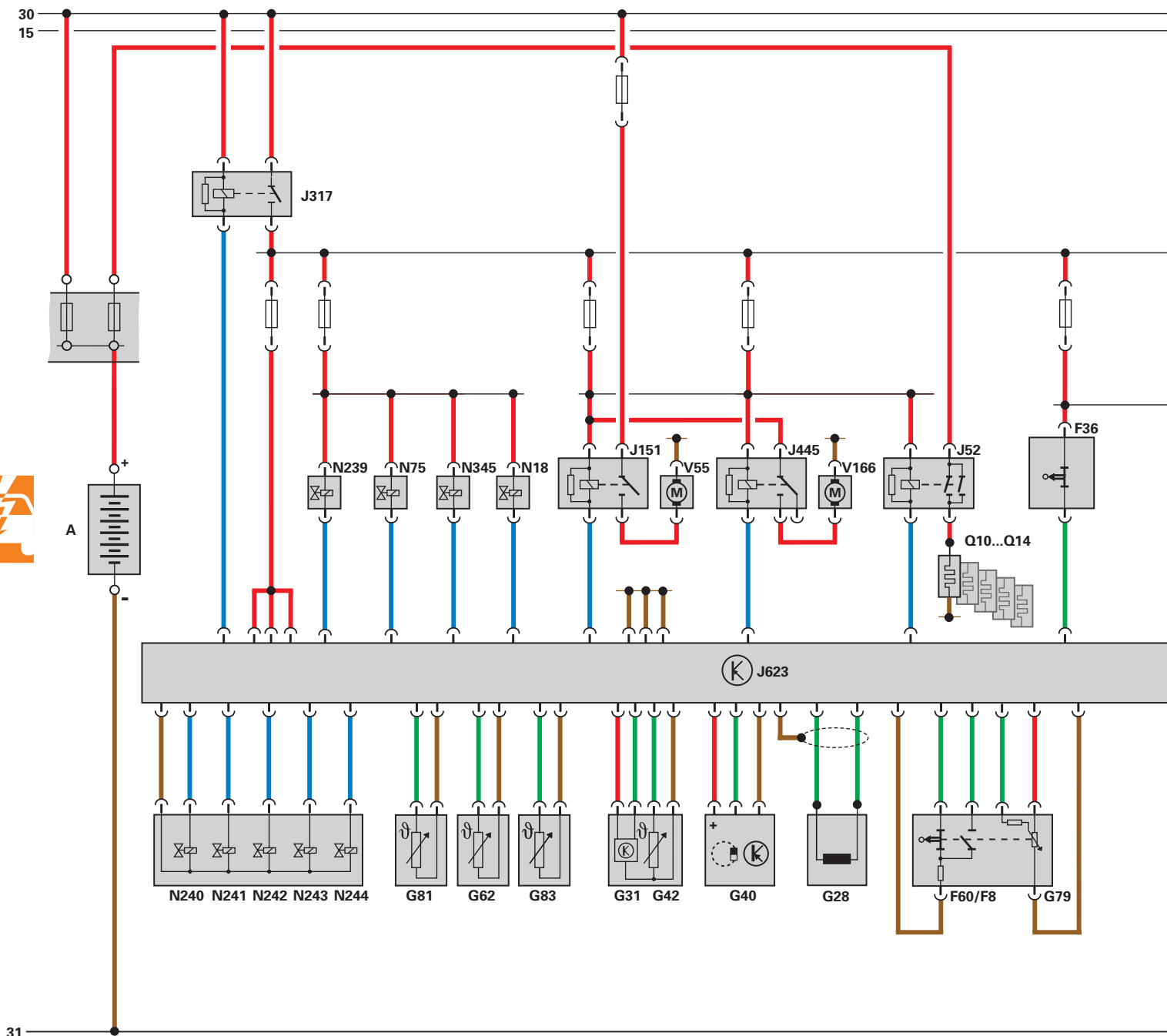
\* Used in the Touareg

\*\* Used in the Touareg with automatic transmission

# Engine management

## Functional diagram

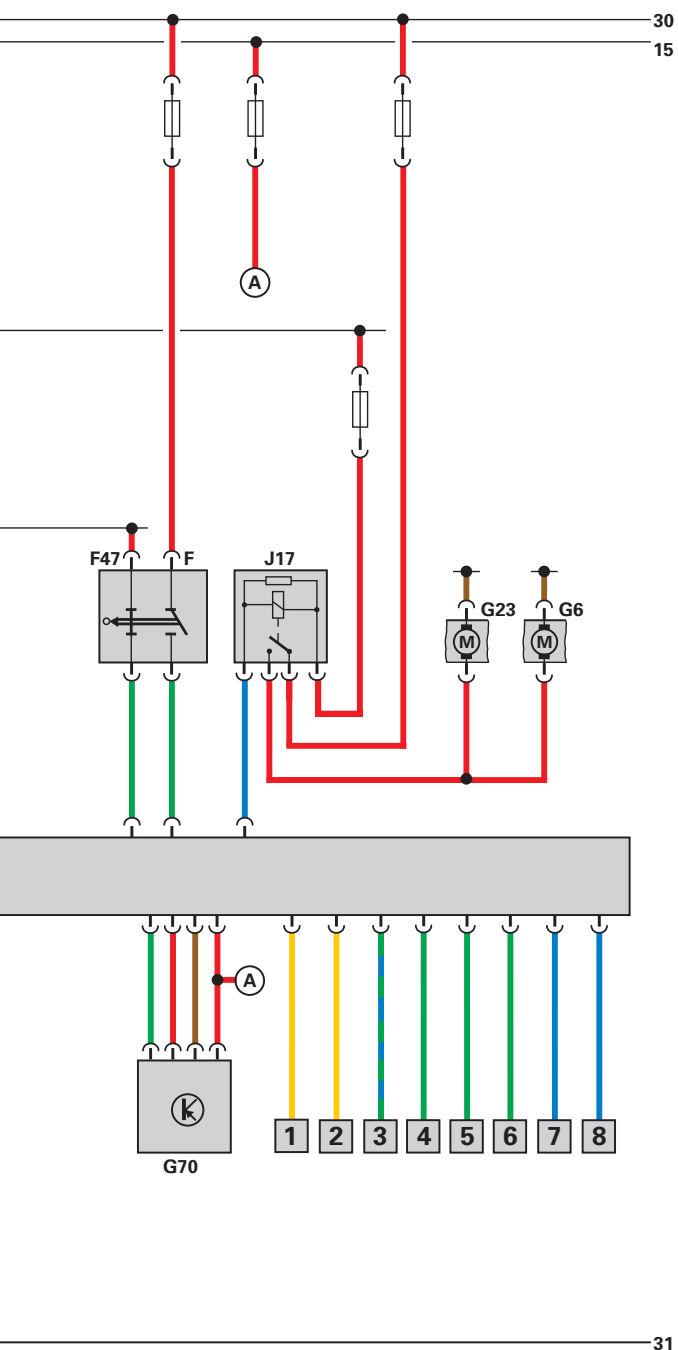
2.5 I R5 TDI engine with the EDC 16 in the Transporter 2004 and Touareg



### Additional signals

- |   |   |
|---|---|
| 1 | Drive train CAN data bus                    |
| 2 | Drive train CAN data bus                    |
| 3 | Communications line (diagnostic connection) |
| 4 | Road speed signal                           |

- |   |                                       |
|---|---------------------------------------|
| 5 | Alternator terminal DFM               |
| 6 | Cruise control system switch (ON/OFF) |
| 7 | Radiator fan - 1st speed              |
| 8 | Radiator fan - 2nd speed              |



## Key

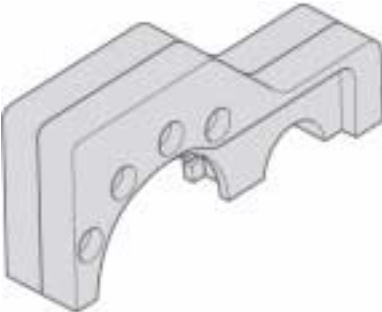



A	Battery
F	Brake light switch
F8	Kick-down switch
F36	Clutch pedal switch
F47	Brake pedal switch
F60	Idling switch
G6	Fuel pump (pre-supply pump)
G23	Fuel pump *
G28	Engine speed sender
G31	Charge air pressure sender
G40	Hall sender
G42	Intake air temperature sender
G62	Coolant temperature sender
G70	Air mass meter
G79	Accelerator position sender
G81	Fuel temperature sender
G83	Coolant temperature sender - radiator outlet
J17	Fuel pump relay
J52	Glow plug relay
J151	Coolant pump run-on relay
J317	Voltage supply relay - Term. 30
J445	Fuel cooling pump relay *
J623	Engine control unit
N18	Exhaust gas recirculation valve
N75	Charge pressure control solenoid valve
N239	Intake manifold flap change-over valve
N240	Injector solenoid valve, No. 1 cyl.
N241	Injector solenoid valve, No. 2 cyl.
N242	injector solenoid valve, No. 3 cyl.
N243	injector solenoid valve, No. 4 cyl.
N244	Injector solenoid valve, No. 5 cyl.
N345	Exhaust gas recirculation cooler change-over valve **
Q10	Glow plug -1-
Q11	Glow plug -2-
Q12	Glow plug -3-
Q13	Glow plug -4-
Q14	Glow plug -5-
V55	Recirculation pump
V166	Fuel cooling pump *

(A) Connection within the function diagram



\* Used in the Touareg  
 \*\* Used in the Touareg with automatic transmission



31  
305\_012

Designation	Special tool
Clamp T10199	 <p data-bbox="1310 792 1406 824">305_052</p>
Engine holder for assembly stand T10220	 <p data-bbox="1310 1169 1406 1200">305_042</p>
Coolant pump spur gear puller T10221	 <p data-bbox="1310 1554 1406 1585">305_039</p>
Coolant pump puller T10222	 <p data-bbox="1310 1924 1406 1955">305_041</p>



Designation	Special tool
Clutch centring mandrel T10223	Graphic unavailable at time of going to press
Engine holder for engine and gearbox lifter (removal and installation) T10224	Graphic unavailable at time of going to press
Key for turning the engine T10225	 <p style="text-align: right;">305_043</p>
Crankshaft locating tool T10226	 <p style="text-align: right;">305_040</p>



# Test your knowledge

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**Which of the following answers is correct?**

One or more, or even all, answers may be correct.

**1. What were the prescribed development goals for the 2.5 l R5 TDI engine?**

- a) A low weight, for example by using an aluminium cylinder block.
- b) A compact design to allow transverse and longitudinal mounting.
- c) Low maintenance requirements, for example by using a maintenance free gear train.

**2. What are the special features of the crankshaft?**

- a) The engine speed sender wheel is bolted on.
- b) The vibration damper is integrated in the crankshaft.
- c) The vibration damper can be replaced without removing the crankshaft.

**3. Which of the following statements on the gear train is true?**

- a) The backlash of the camshaft gear is adjustable.
- b) The gear train is designed to save weight.
- c) High drive forces can be transmitted in a space-saving manner by using gears.



**4. Which of the following statements on the ancillary units is true?**

- a) The ancillary units are driven by the gear train.
- b) In the alternator and air conditioner compressor, the axle offset tolerances and the running irregularities in the longitudinal direction are equalised and damped by an elastic drive coupling.
- c) The alternator and the bracket may only be removed completely, and must not be taken apart.

**5. What are the points which must be observed before removing the coolant pump?**

- a) The coolant must be drained at the coolant drain plugs before removing the coolant pump.
- b) The coolant pump can be removed without dismantling the gear train housing.
- c) The gear train housing must be removed before removing the coolant pump.

**6. Which engine management system is used?**

- a) The EDC 15 Electronic Diesel Control.
- b) The EDC 16 Electronic Diesel Control with torque-oriented engine management.
- c) The EDC 16 Electronic Diesel Control without torque-oriented engine management.



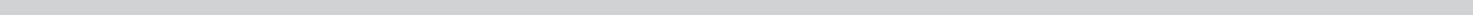


# Notes

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## Answers

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





# R5 TDI

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000.2811.25.20 Technical status 03/03

⚙️ This paper was manufactured from pulp that was bleached without the use of chlorine.