

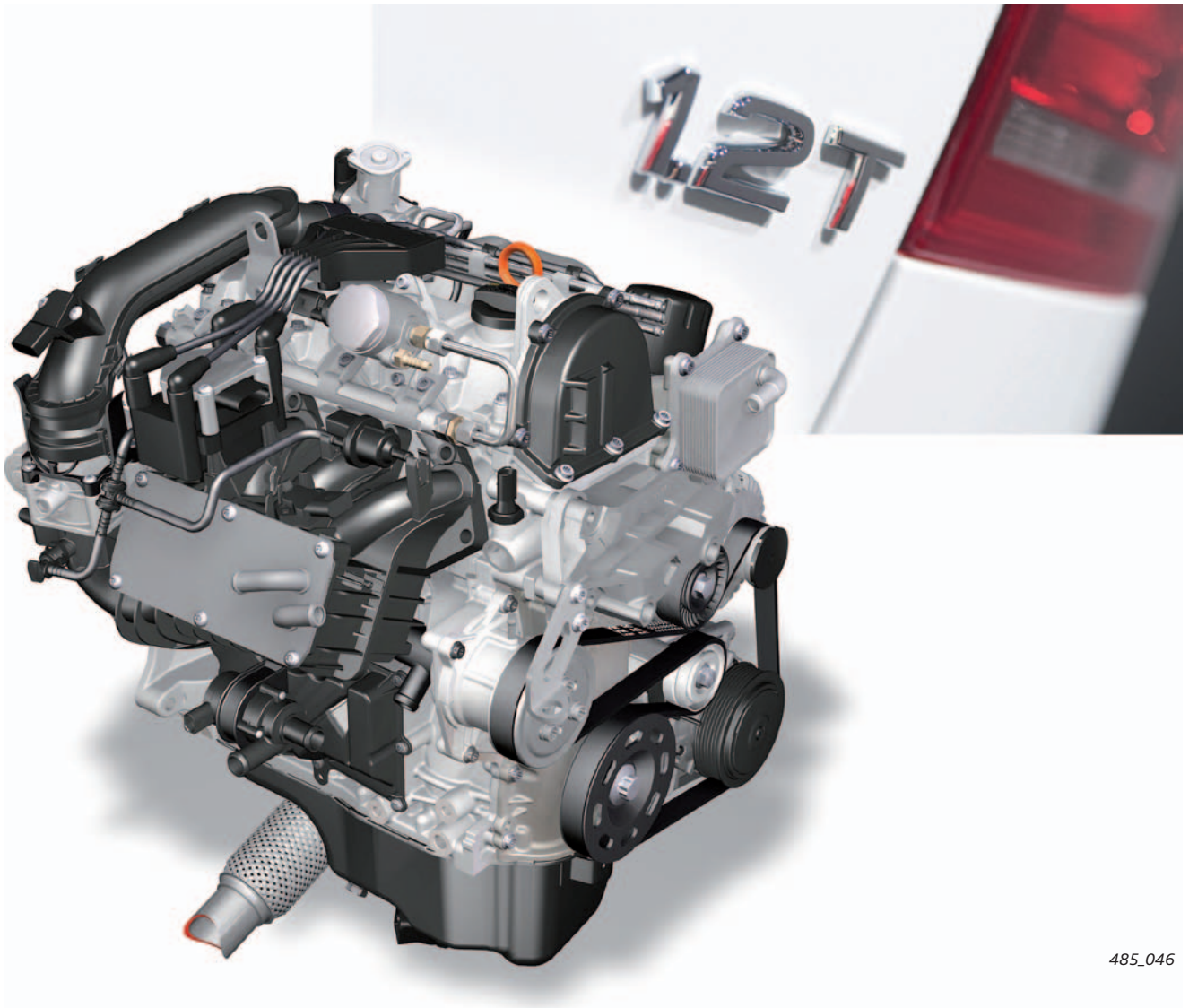
# Audi 1.2L TFSI engine

Following on from the A3 with its 92 kW 1.4l TFSI engine which paved the way for small petrol engines with superior torque and high fuel economy by combining turbocharging with direct fuel injection, Audi presents the 1.2l TFSI - yet another engine with TFSI technology for the entry-level segment. Economy and pulling power are still the key success factors, especially in the light of the on-going heated debate on CO<sub>2</sub> emissions.

For this reason, Audi has systematically extended its *TFSI*\* strategy, and with the new 63 and 77 kW 1.2l TFSI engines it continues its successful efforts in *downsizing*\* the volume engines for the A1 and A3. Audi has further improved the engine technology of the small but powerful EA 111 engine series by maintaining a sharp focus on optimising friction and lightweight design. Featuring a new weight-optimised aluminium cylinder block and an entirely new combustion process, this engine offers an ideal combination of performance, fuel economy and cost for entry-level Audi models.

The radically redesigned 1.2l TFSI engine, which in the A3 delivers a specific power output of 87.7 HP from a displacement of 1197 cm<sup>3</sup>, utilises the same technology as its renowned siblings with displacements of 1.8 and 2.0 litres. Turbocharging and direct petrol injection make a perfect combination in the A3 too, and together they provide a high compression ratio of 10.0 : 1 which not only benefits thermodynamic efficiency but also enhances performance and economy.

Typically of a turbo, the small four cylinder operates at low speeds. In the A3 the engine delivers an impressive 175 Nm of torque between 1550 and 4100 rpm and a maximum power output of 77 kW (105 hp) at 5000 rpm. This allows the engine to run smoothly and efficiently. The three-door Audi A3 with 1.2l TFSI engine accelerates in 11.1 seconds from zero to 100 kph (A3 Sportback 11.3 seconds). The A3 and the A3 Sportback consume on average only 5.5 litres of fuel per 100 km. At the same time, the engine produces CO<sub>2</sub> emissions of only 127 g/km. Fuel consumption is reduced by 1 litre per 100 km compared to the 75 kW (102 HP) predecessor engine (1.6l MPI).



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**Learning objectives of this Self Study Programme are:**

In this Self Study Programme you will learn the technology of the 1.2l TFSI engine.

When you have worked your way through this Self Study Programme you will be able to answer the following questions:

- ▶ How is the basic engine designed?
- ▶ What are the differences between the 1.2l TFSI engine and the TFSI engines previously used by Audi?
- ▶ Which modifications have been made to the fuel system?
- ▶ What are the special features of the engine management system?
- ▶ What must be observed when servicing the vehicle?

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► The Self Study Programme explains the basics of the design and function of new models, new automotive components or new technologies.

**It is not a Repair Manual! Figures given are for explanatory purposes only and refer to the software version valid at the time of preparation of the SSP.**

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

Terms shown in italics and marked by an asterisk (\*) are explained in the glossary at the back of this Self Study Programme.



**Note**



**Reference**

# Introduction

## Brief technical description

- ▶ Newly developed aluminium cylinder block with innovative cast iron cylinder liners
- ▶ Two-valve cylinder head with inclined overhead valves
- ▶ Steel crankshaft with reduced conrod and main bearing diameters of 42 mm
- ▶ Low-friction lightweight crank drive
- ▶ Positive crankcase ventilation system with oil separator integrated in the cylinder block and cylinder head
- ▶ Active coolant pump
- ▶ Easy-to-service split lightweight timing case with plastic and magnesium alloy covers
- ▶ Exhaust turbocharger module with electrical charge pressure actuator
- ▶ Ignition transformer
- ▶ Single-chamber exhaust system with close-coupled pre-catalyst
- ▶ Combustion process: Homogeneous direct injection



485\_014



### Reference

You can find basic information about the TFSI technology in Self Study Programmes 432 "Audi 1.4l TFSI engine" and 384 "Audi chain-driven 1.8l 4V TFSI engine".



# Specifications

## Torque/power curves

### 1.2l TFSI engine CBZA

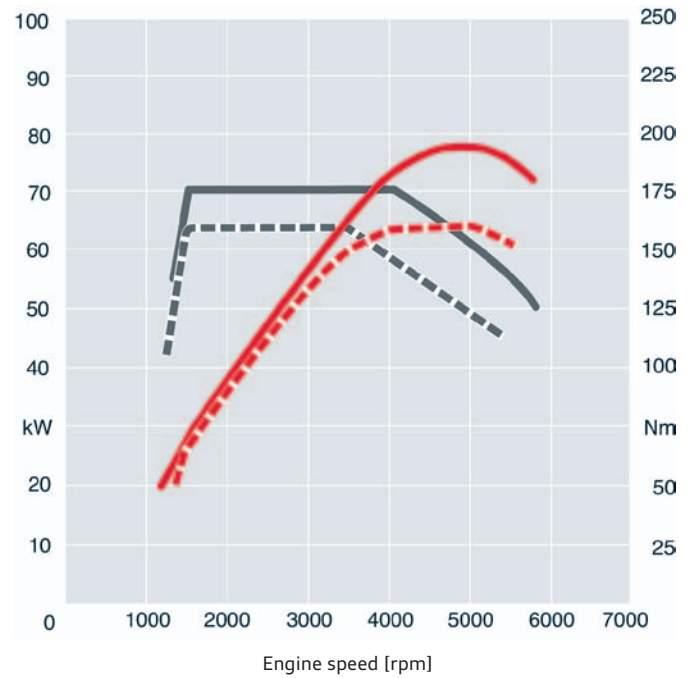
--- Power in kW

--- Torque in Nm

### 1.2l TFSI engine CBZB

— Power in kW

— Torque in Nm



485\_019

Engine code	CBZA	CBZB
Type	4-cylinder inline engine	4-cylinder inline engine
Displacement in cm <sup>3</sup>	1197	1197
Stroke in mm	75.6	75.6
Bore in mm	71	71
Number of valves per cylinder	2	2
Firing order	1-3-4-2	1-3-4-2
Compression ratio	10:1	10:1
Power output in kW at rpm	63/5000	77/5000
Torque in Nm at rpm	160/1500 – 3500	175/1550 – 4100
Fuel	Prem. unleaded 95 RON <sup>1)</sup>	Premium unleaded 95 RON <sup>1)</sup>
Engine weight in kg	89.5	89.5
Engine management	Continental Simos 10	Continental Simos 10
Emissions standard	EU 5	EU 5
CO <sub>2</sub> emission in g/km	118	127
Exhaust gas aftertreatment	3-way catalytic conv. with lambda control	3-way catalytic converter with lambda control
Vehicle use	A1	A3

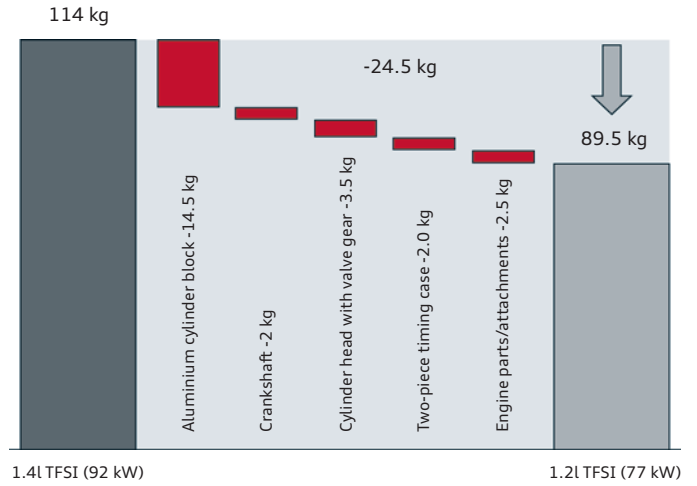
<sup>1)</sup> Unleaded regular 91 RON petrol can also be used, but will result in slight loss of power.

# Engine mechanicals

## Weight reduction measures

The 1.2l TFSI engine was developed on the basis of the 1.4l TFSI engine (EA 111). Compared to the 1.4l engine, the 1.2l engine has been reduced in weight by 24.5 kg by adopting various measures (see illustration).

A number of other measures have also been taken in order to reduce friction and improve the combustion process and, in turn, to optimise the general economic balance of the engine.



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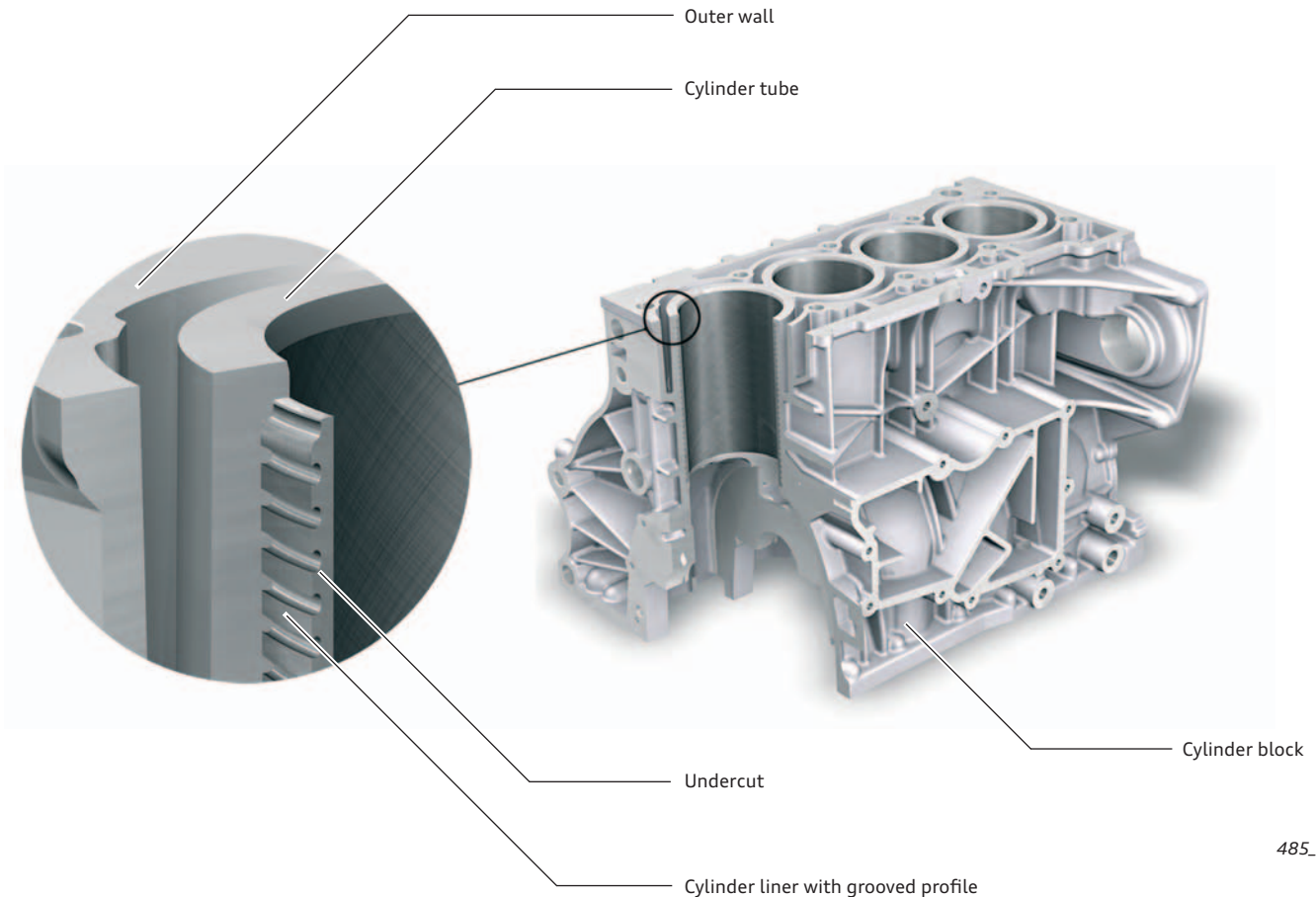
## Cylinder block

The cylinder block is made of die cast aluminium. As a result, it weighs 14.5 kg less than the lamellar graphite cast iron cylinder block used on the 1.4l 92 kW TFSI engine.

As was previously the case with the 1.4l 92 kW TFSI engine, the cylinder block has an *open-deck design*\*. This means that there are no cross-members between the outer wall and the cylinder tubes.

The integral cast iron cylinder liners have an undercut grooved profile on the side facing the cylinder block. This profile creates a permanent non-detachable connection (engagement) between the cylinder block and the cylinder liners.

This reduces the warping of the cylinder block. This also avoids uneven distribution of heat, which occurs due to gap formation in cast iron cylinder liners without an undercut.

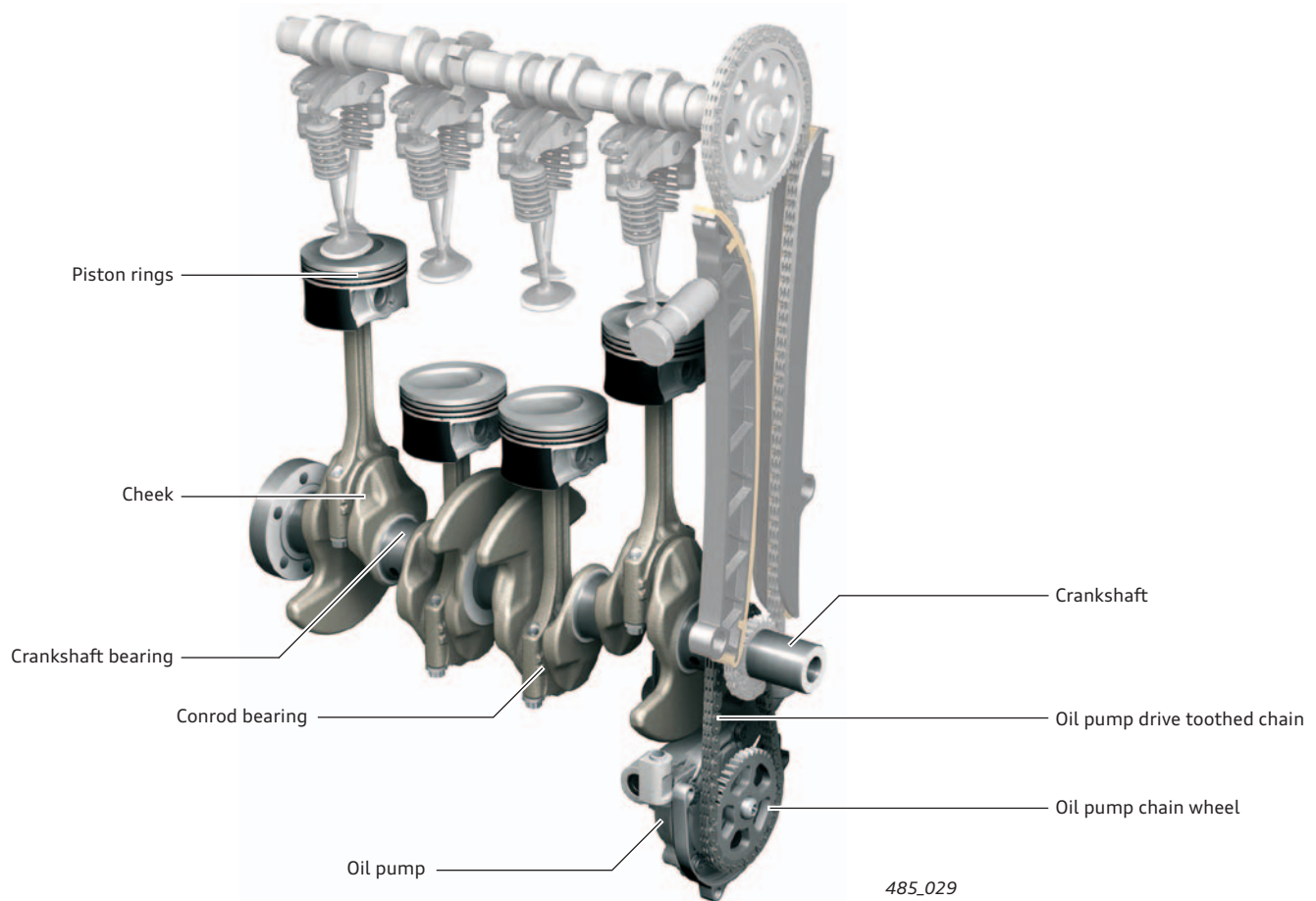


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## Cranktrain

The following modifications have been made compared to the 1.4l TFSI engine (92 kW):

- ▶ The crankshaft and conrod bearings have been reduced in diameter
- ▶ The crankshaft and conrod bearings have been reduced in width in order to increase the rigidity of the crankshaft
- ▶ Wider cheeks in the flexurally critical area of the crankshaft
- ▶ Piston rings are subject to less tangential stress

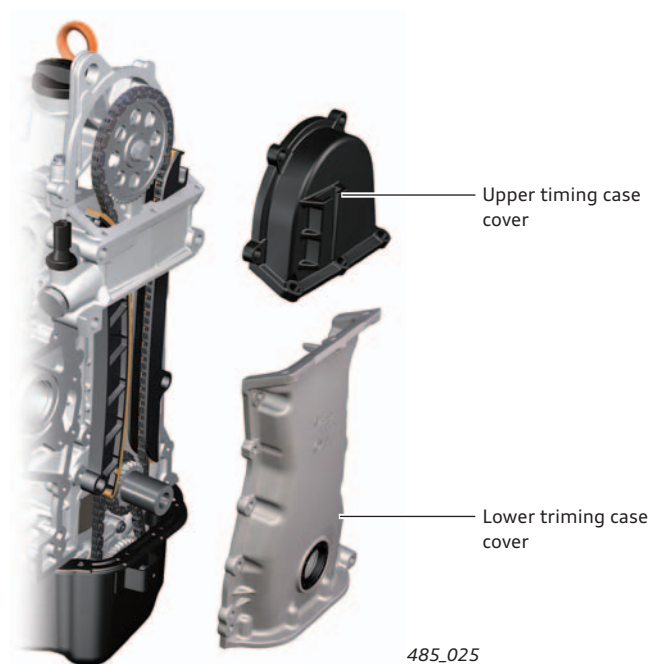


## Two-piece timing case

The timing case consists of two individual parts. The upper cover is made of plastic and can be removed individually.

The lower cover is made of die cast magnesium. This cover is fastened by special aluminium alloy screws and can be removed without having to take off the cylinder head.

Both timing case covers are sealed off from the cylinder block and cylinder head by means of liquid sealant (see ETKA).



### Note

The screws for fastening both covers must be replaced after installation work. This should be done as instructed in the Workshop Manual and using the proper tools, e.g. torque wrench VAS 6583.

## Chain drive

The camshaft is driven by a maintenance-free chain mechanism. The chain is tensioned by a hydraulic chain tensioner. This presses the tensioning rail against the chain below the camshaft gear. The chain tensioner is bolted into the cylinder head from the outside (see Fig. 485\_025).

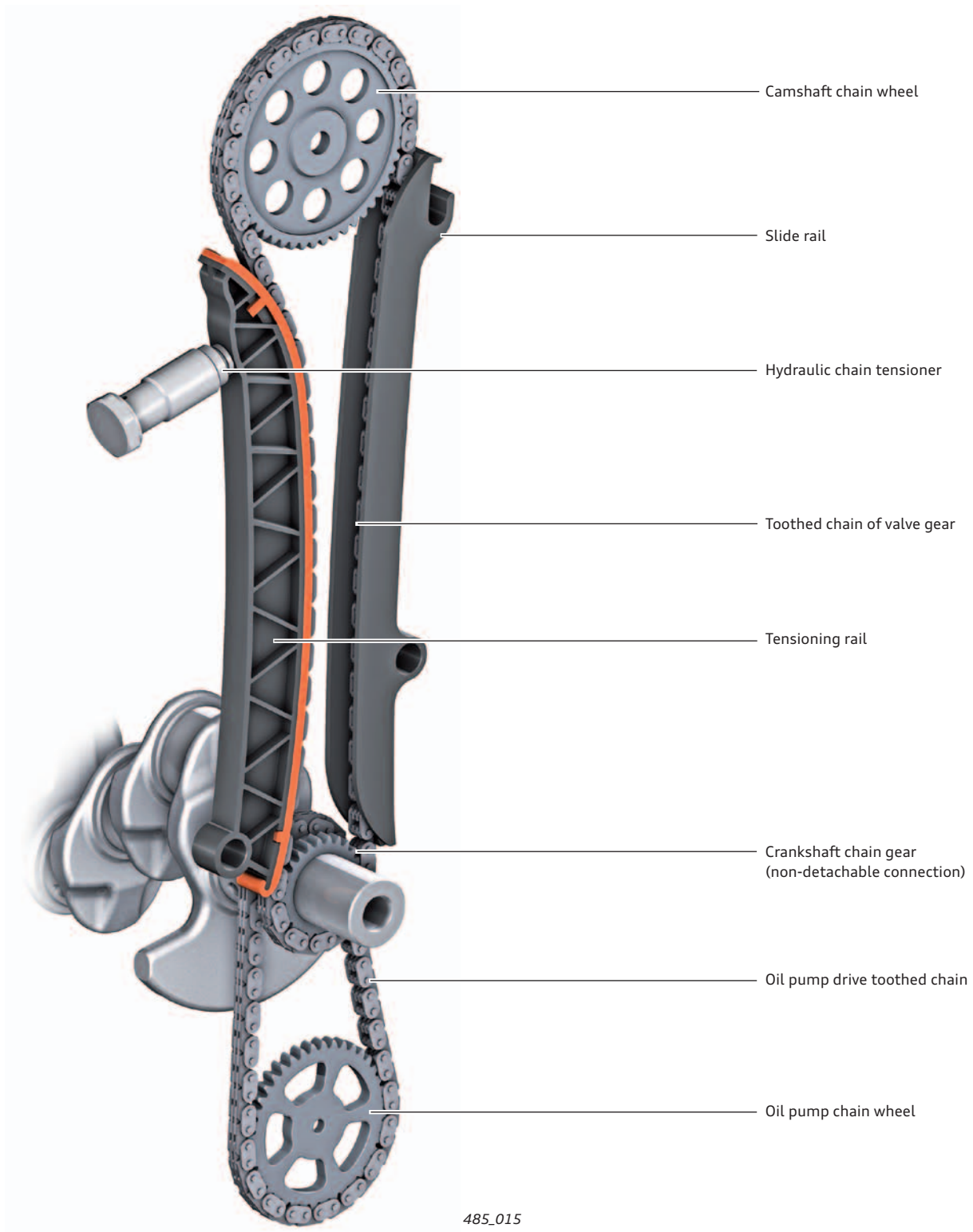
The sliding rail on the side opposite the tensioning rail prevents excessive oscillation of the chain. Two-valve technology has made it possible to design the tensioning and sliding rails with large radii that minimise friction.

The oil pump is also driven by a maintenance-free toothed chain. No chain tensioner is fitted here.

Features of the oil pump drive:

- ▶ Ratio = 0.6
- ▶ Control valve operates at  $3.8 \pm 0.3$  bar
- ▶ Safety valve  $11 \pm 2$  bar

The crankshaft chain wheel is permanently connected to the crankshaft and cannot be removed.



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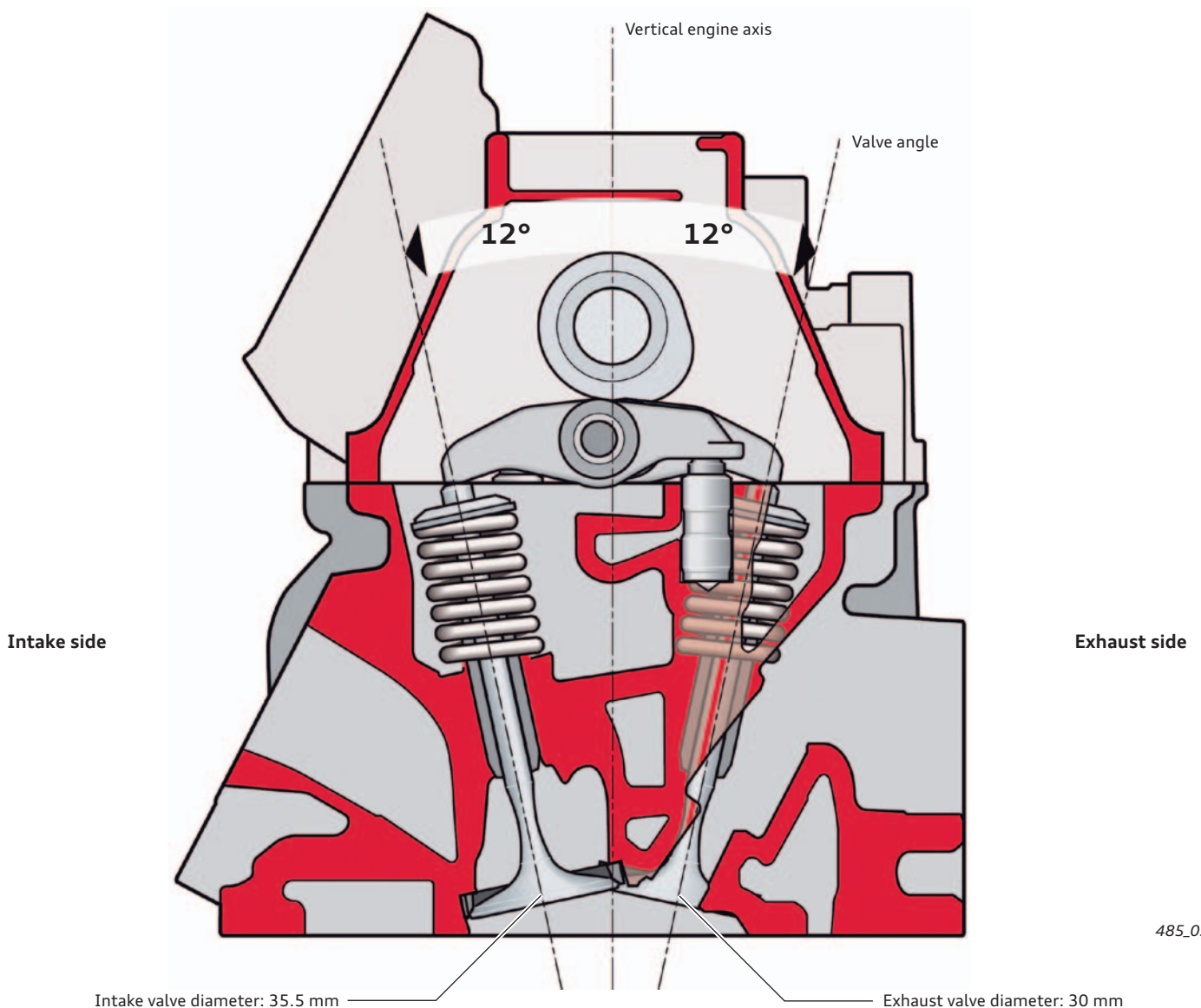
## Cylinder head

The change from four valves per cylinder to two-valve technology has reduced friction and saves weight. This has made it necessary, however, to rearrange the injectors and the spark plugs.

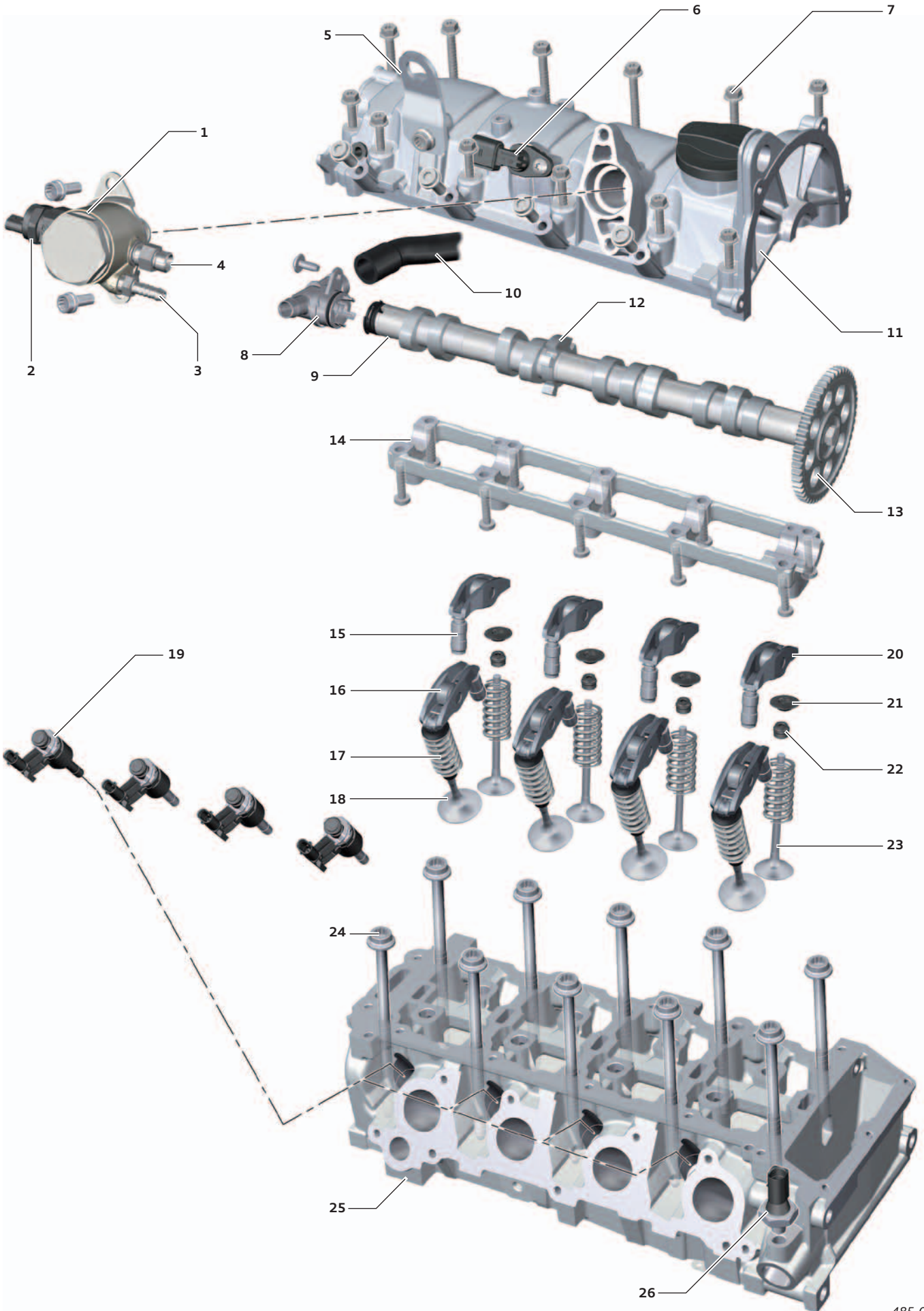
Based on its experience with the direct injection systems of the TFSI engine family, Audi has taken the specifications for this engine with respect to carburetion, charging motion and combustion rate and transferred them to a two-valve combustion process with non-variable *valve timings*\*

### Modifications compared to the 1.4l TFSI engine (92 kW):

- ▶ Two valves per cylinder (single camshaft), 12° valve angle
- ▶ The spark plugs are positioned on the exhaust side
- ▶ The fuel injectors are positioned on the intake side
- ▶ No camshaft adjustment
- ▶ The valves are actuated by roller cam followers
- ▶ Valves can be replaced or ground, but rework is not permitted.
- ▶ Valve guides cannot be replaced.



# Components on the cylinder head



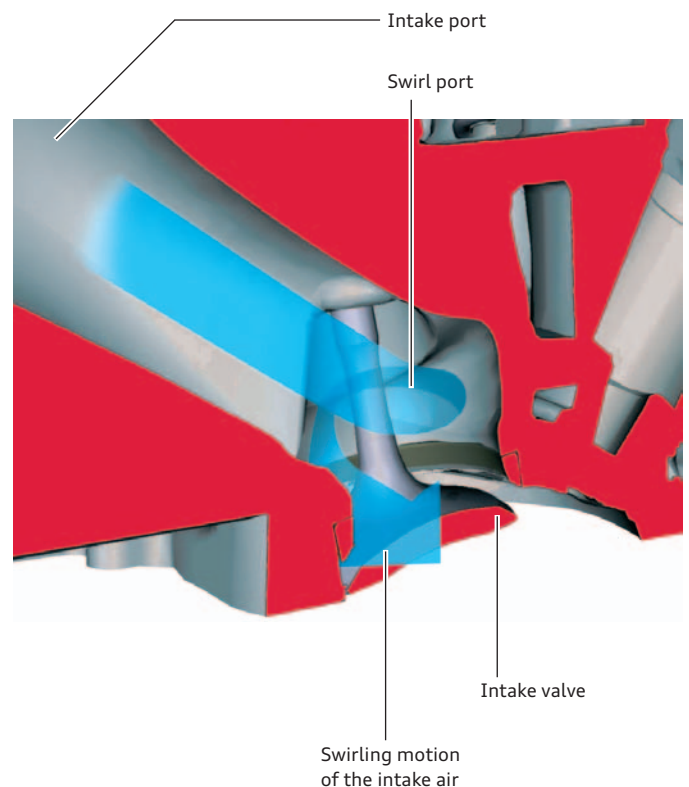
## Legend:

- |    |  |    |                                 |
|----|--|----|---------------------------------|
| 1  | High-pressure fuel pump                                      | 14 | Ladder frame (camshaft bearing) |
| 2  | Fuel pressure regulating valve N276                          | 15 | Support element (intake)        |
| 3  | Low pressure connection (supply)                             | 16 | Roller cam follower (intake)    |
| 4  | High pressure connection                                     | 17 | Valve spring (intake)           |
| 5  | Suspension eye   | 18 | Intake valve                    |
| 6  | Hall sender G40  | 19 | Injectors N30 – N33             |
| 7  | Cylinder flange screws                                       | 20 | Roller cam follower (exhaust)   |
| 8  | Sealing cover  | 21 | Valve spring plate (exhaust)    |
| 9  | Camshaft   | 22 | Valve steam seal (exhaust)      |
| 10 | Connecting line of the positive crankcase ventilation system | 23 | Exhaust valve with spring       |
| 11 | Cylinder head cover  | 24 | Cylinder head bolt              |
| 12 | Hall sender encoder disc G40                                 | 25 | Cylinder head                   |
| 13 | Camshaft chain wheel   | 26 | Oil pressure switch F1          |

## Swirl port

A new swirl combustion method providing excellent carburetion has been developed on the basis of the two-valve technology. The intake port is designed such that the fresh air rotates as it flows into the cylinder. This, together with valve masking, induces a pronounced swirling motion in the intake air throughout the entire combustion chamber between the piston recess and the roof of the combustion chamber.

This results in efficient carburetion and mixture propagation inside the combustion chamber, a short ignition delay, a high combustion rate and high knock resistance. These modifications mean there are no *intake manifold flaps*\* in the 1.2l TFSI engine.

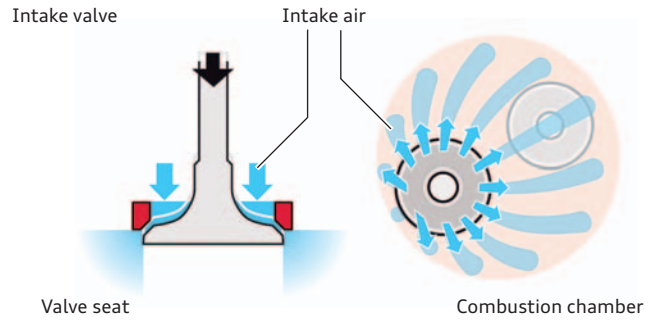


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## Intake valves

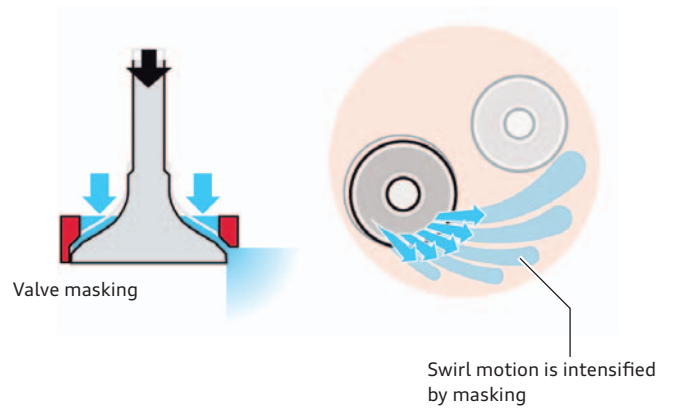
The intake valve seats have a special shape (valve masking). This ensures that the air can only flow in a certain area inside the cylinders during short valve strokes. In the process, the air is directed towards the cylinder wall, resulting in more intensive swirl and a higher flow rate. This promotes formation of a homogeneous air-fuel mixture inside the combustion chamber.

### Flow behaviour without masking



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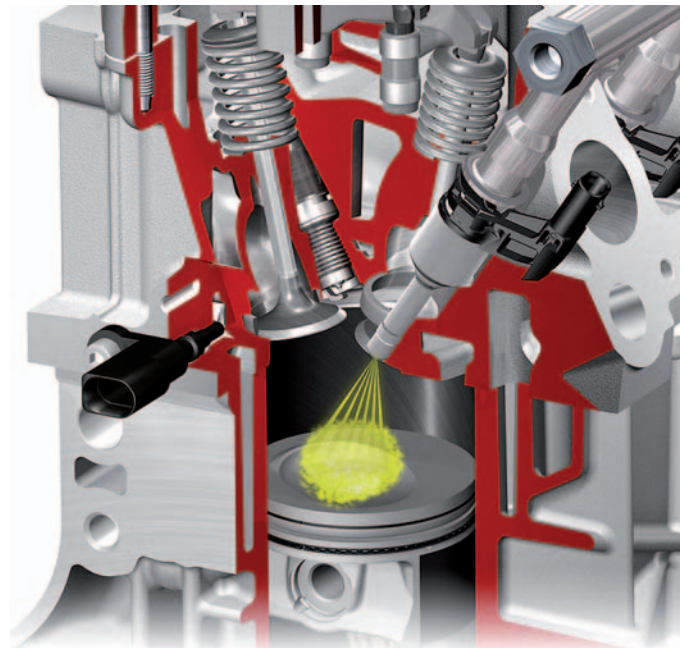
### Flow behaviour with masking



485\_033

## Injectors

The six individual jets of each individual injector are arranged in such a way as to provide an optimal spatial alignment. This ensures quicker and more efficient mixing of the intake air from the swirl port. The injection pressure is between 40 bar and 125 bar.



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## Positive crankcase ventilation

Unlike with the 1.4l 92 kW TFSI engine, an internally controlled positive crankcase ventilation system is employed.

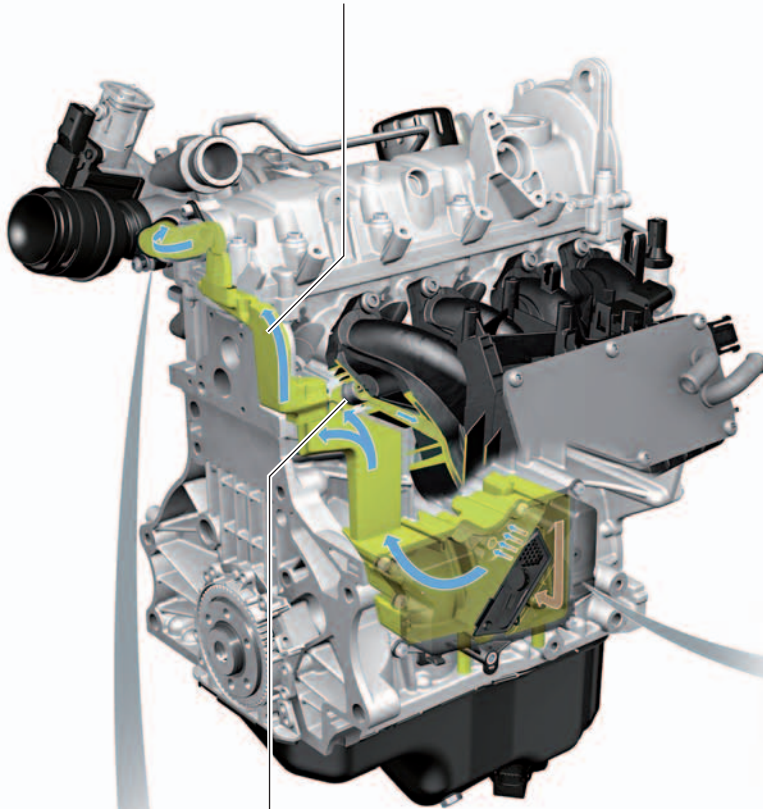
A plastic oil separator is bolted to the cylinder block. The oil is separated off from the *blow-by gases\** in the oil separator and drips into an oil collecting chamber. An oil drain valve prevents the oil from running into the oil pan. This valve is kept closed by the pressure present inside the crankcase. It opens automatically after the engine stops (gravity valve).

The oil returns to the oil pan. The gases now flow from the cylinder block to the cylinder head. Depending on where the greatest pressure gradient is in relation to the intake air, the gases are admitted directly into the intake manifold or continue to flow to the cylinder head cover until they reach the exhaust turbocharger compressor wheel.

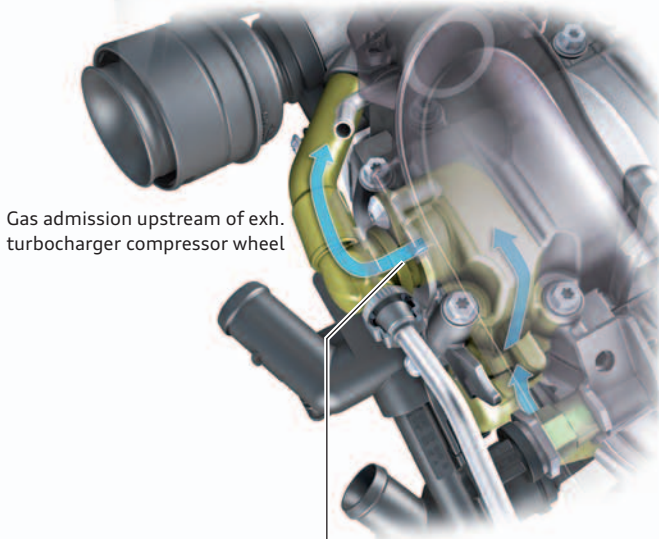
The internal gas ducting system prevents the positive crankcase ventilation system from freezing.

### Function

Internal ducting of gases through the cylinder block, cylinder head and cylinder head cover

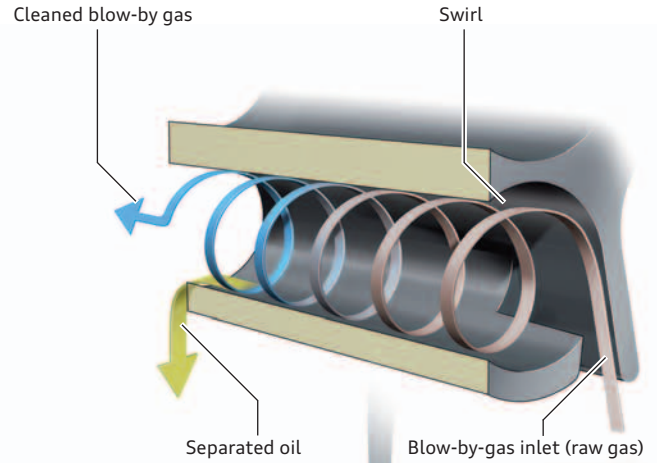


Gas admission into intake manif. with nonreturn valve

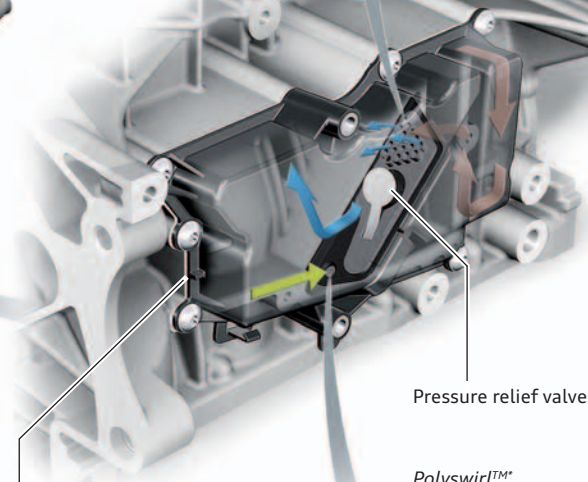


Gas admission upstream of exh. turbocharger compressor wheel

Non-return valve

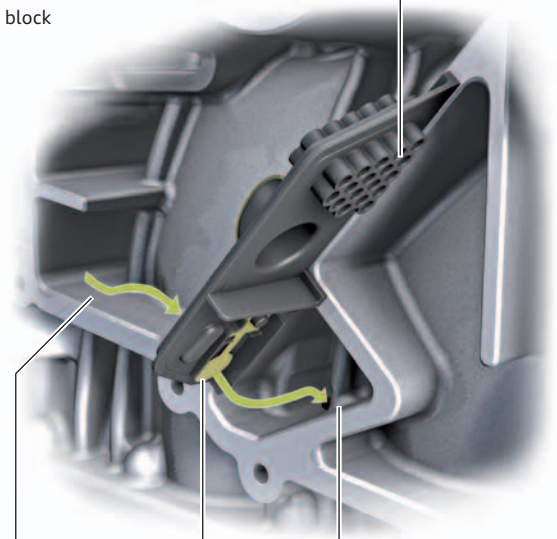


Oil separator in cylinder block



Pressure relief valve

Polyswirl™



Oil collection chamber

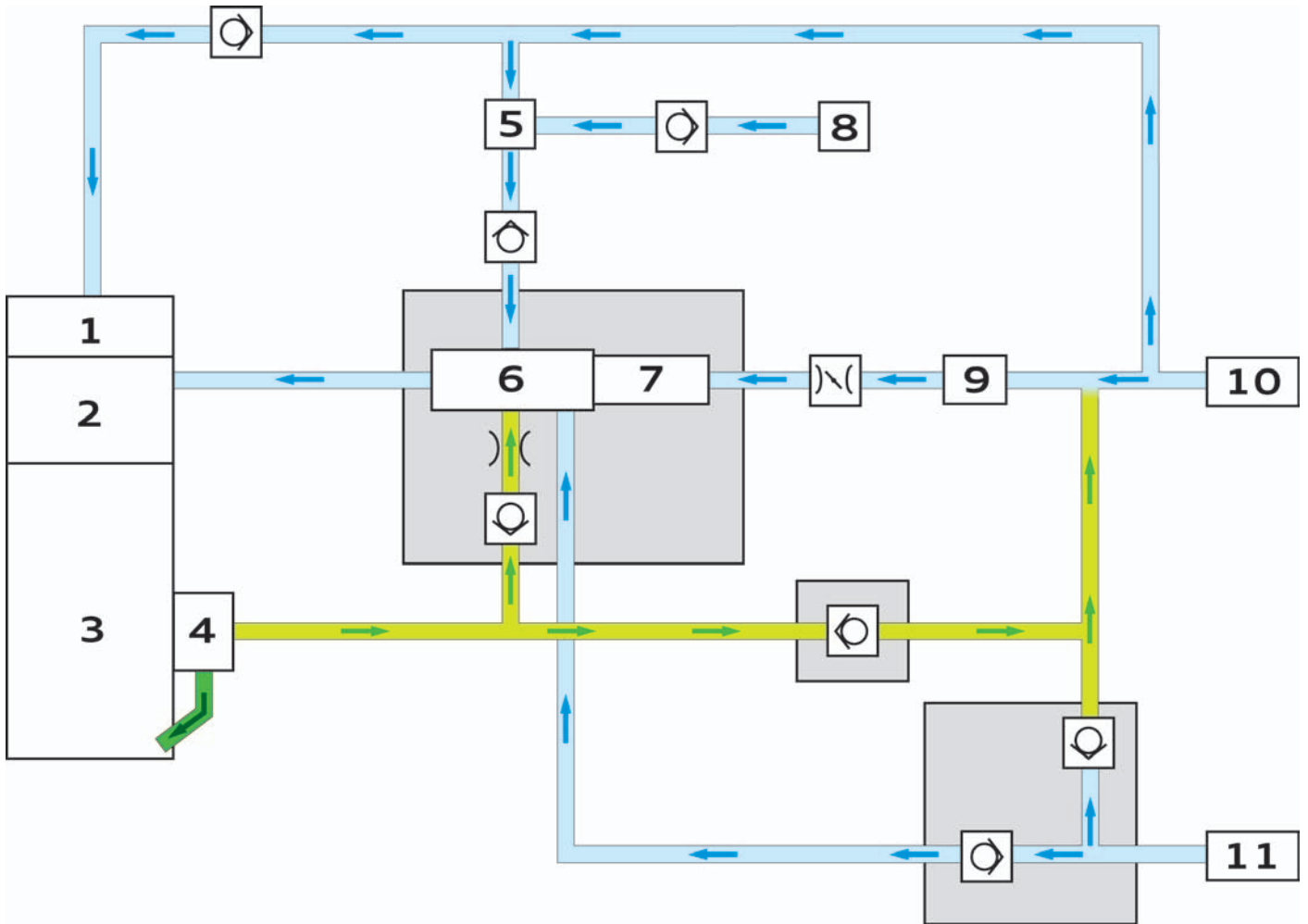
Oil drain valve

Oil return line to oil pan

## System overview

This schematic diagram includes the crankcase ventilation systems, the vacuum supply and the tank ventilation system.

The schematic diagram shows by way of example the system of a vehicle driven by a seven-speed dual clutch gearbox OAM (S tronic) with a suction jet pump.



485\_002

### Legend:

- |   |                                |    |                          |
|---|--------------------------------|----|--------------------------|
| 1 | Cylinder head cover            | 7  | Charge air cooler        |
| 2 | Cylinder head                  | 8  | Brake servo              |
| 3 | Cylinder block                 | 9  | Exhaust turbocharger     |
| 4 | Positive crankcase ventilation | 10 | Air filter               |
| 5 | Suction jet pump               | 11 | Fuel tank breather valve |
| 6 | Intake manifold                |    |                          |

## Vacuum supply

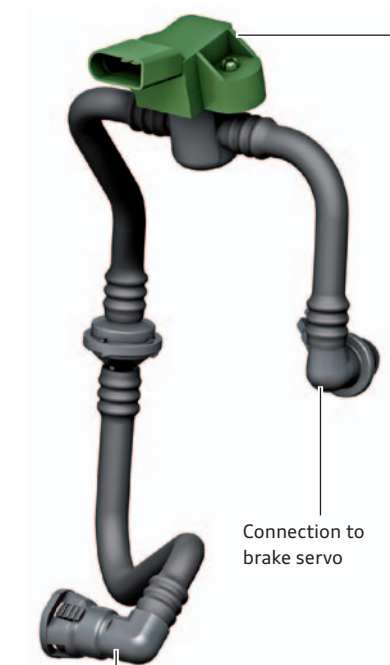
The lack of brake boost due to the vacuum being too low is compensated by the ESP hydraulics through active brake pressure build-up.

This necessitates gauging the pneumatic pressure in the brake servo. The difference between the pneumatic pressure and the ambient pressure is a direct measure for the maximum achievable brake boost. A pressure difference of zero means that the brake servo has reached its *saturation point*\*. In this case, the brake pressure can only be increased without additional brake boost by increasing the foot pressure on the brake pedal.

The design characteristic of the brake pressure curve is stored in dependence on the pressure differential in the ABS control unit J104. If the available intake manifold pressure is too low, the saturation point will be reached at brake pressures below the nominal level.

If this is the case, a controlled build-up of brake pressure will be initiated by the ESP hydraulics. The driver will not notice any difference over the conventional brake servo in terms of how much pressure has to be applied to the brake pedal.

### Audi A1 with manual gearbox

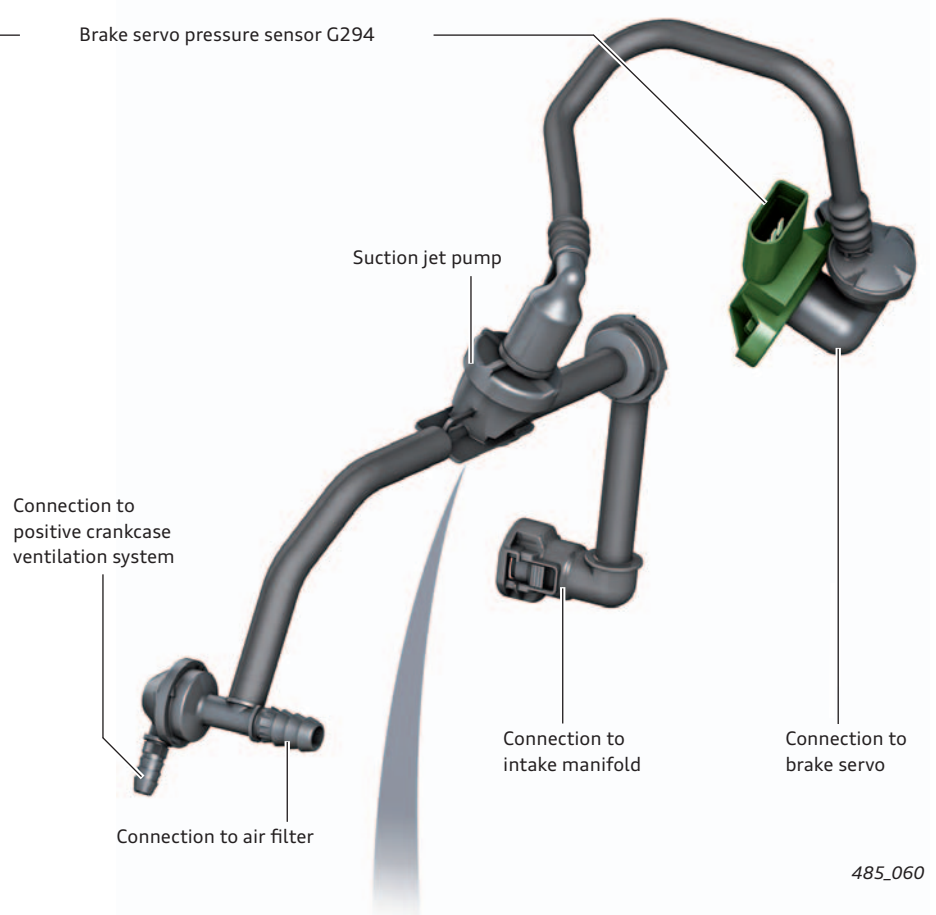


Intake manifold connection

Connection to brake servo

485\_035

### Audi A3 with S tronic seven-speed dual clutch gearbox



Brake servo pressure sensor G294

Suction jet pump

Connection to positive crankcase ventilation system

Connection to air filter

Connection to intake manifold

Connection to brake servo

485\_060

## Suction jet pump

The suction jet pump boosts the vacuum for the brake servo on models with seven-speed dual clutch gearbox OAM (S tronic). The functional principle corresponds to that of a venturi jet.



485\_018



# Oil supply

## Oil circuit

The smaller main and conrod bearing dimensions and the two-valve drive train with only a single camshaft significantly reduce engine oil requirements.

This allows a smaller oil pump to be installed and the average work output to be reduced by approx. 50 % compared to the closed-loop pump.

The pressure is controlled by a pressure control valve integrated in the oil pump. This ensures that sufficient oil pressure is always present in the engine irrespective of the oil filter load.

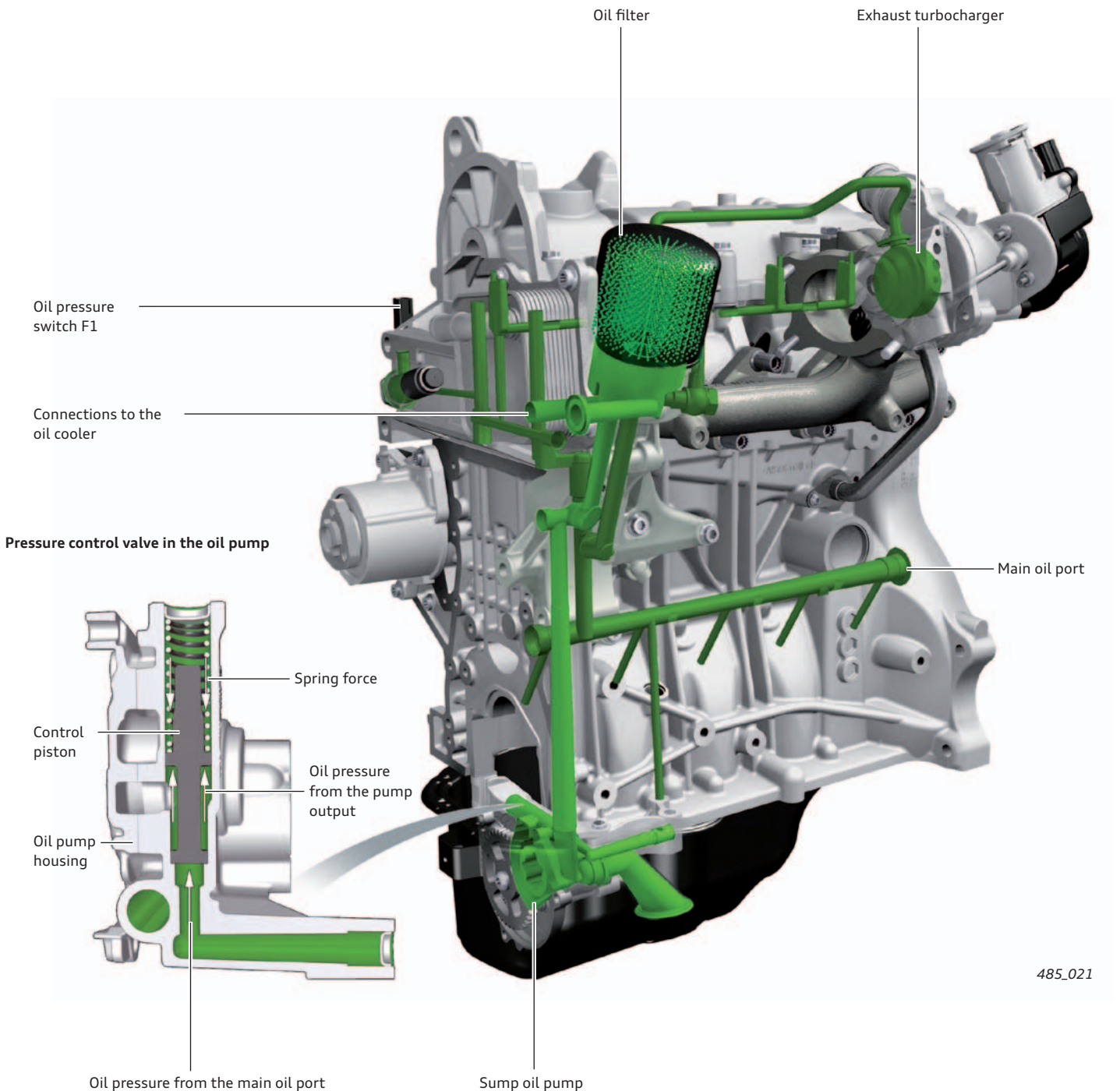
## Oil pump

The Duocentric oil pump is mounted at the bottom of the cylinder block and driven by the crankshaft via a maintenance-free toothed chain drive.

To minimise friction, the Duocentric pump is configured as a sump oil pump and runs at a low speed (ratio = 0.6).

A safety valve (cold start valve) in the pump opens at a pressure of approx. 11 bar.

## Overview



485\_021



## Oil filter

As with the 1.4l TFSI engine, a filter module with oil filter cartridge is employed in the 1.2l TFSI engine.

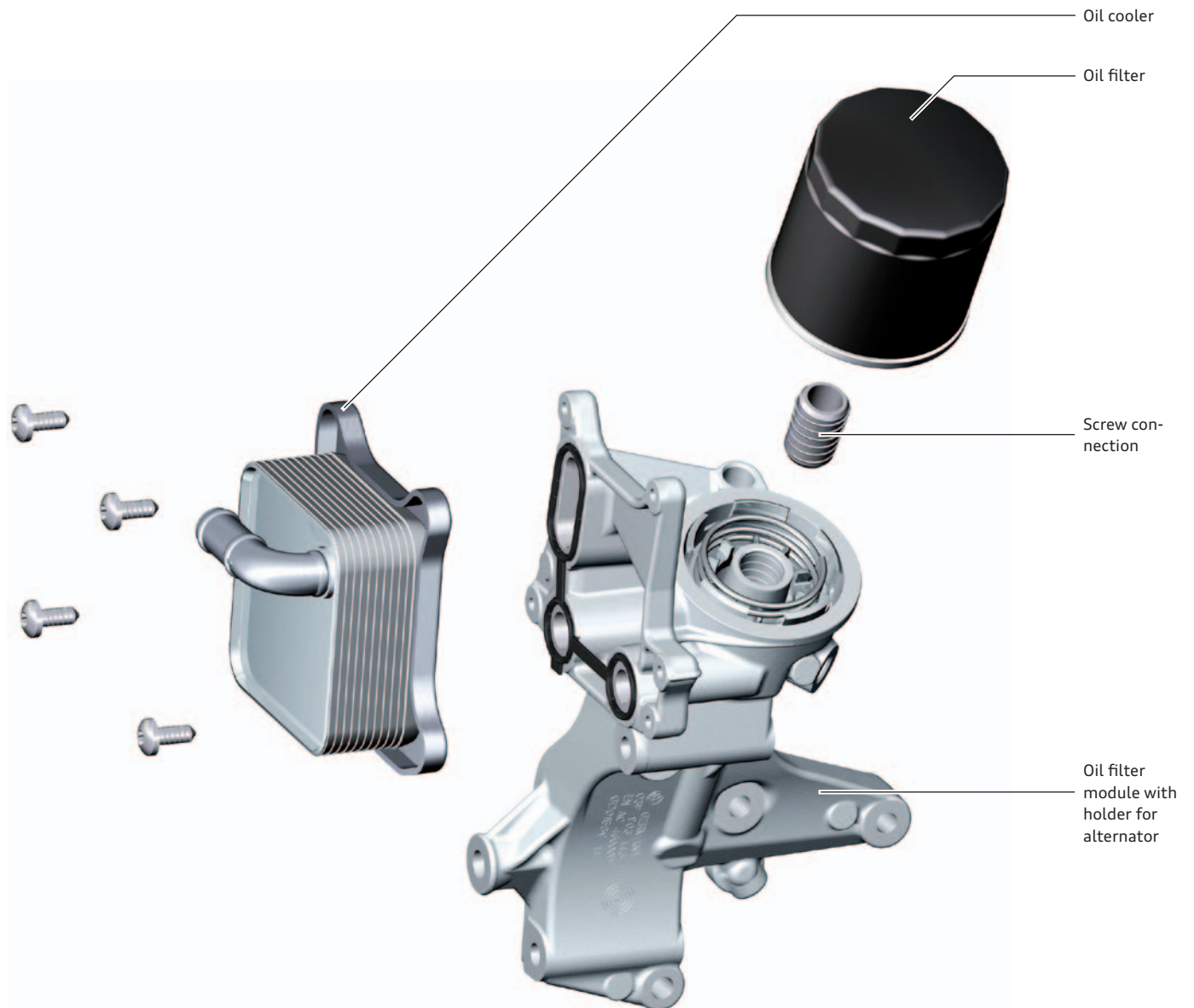
The oil filter cartridge is accessible from above to allow easy servicing. To ensure that no oil runs down the engine when replacing the oil filter, a return channel in the timing case cover opens when the filter cartridge is released. This allows the oil to flow directly into the oil pan.

This channel is sealed by a spring-loaded seal when fastened. The valves inside the filter cartridge are sealed in such a way that no oil can escape after the cartridge has been removed.

### Notes on filter changing:

- ▶ First unscrew the oil filter cartridge approx. 2 – 3 turns.
- ▶ Allow the contents of the filter to drain off (wait approx. 2 – 3 minutes).
- ▶ As a safety precaution, place a cleaning cloth below the filter module.

## Overview of the oil filter module



485\_007



### Reference

For further information about the design and function of the Duocentric oil pump and the oil filter module, please refer to Self Study Programme 432 "Audi TFSI engine".

# Air supply

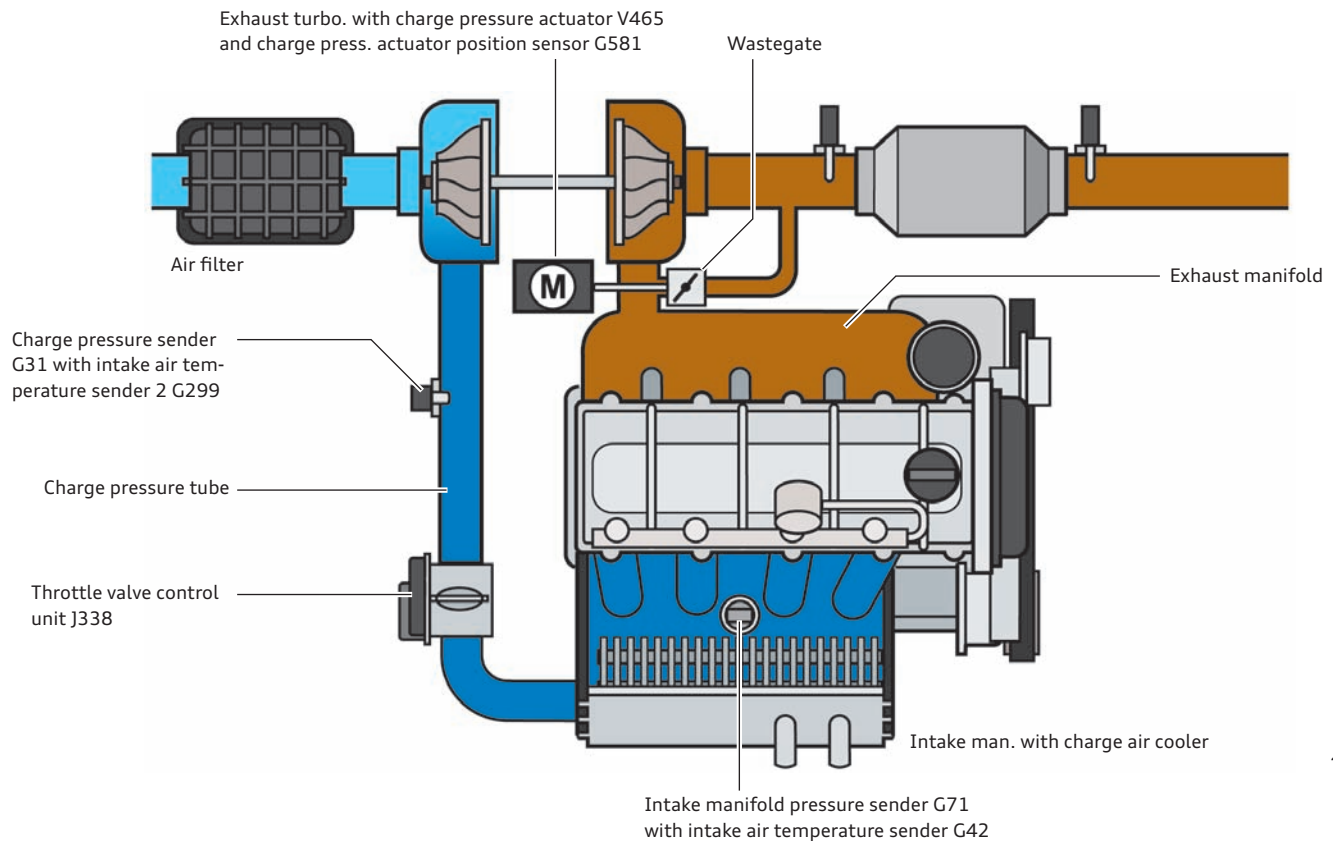
Intake manifold volume has been kept to a minimum for rapid exhaust turbocharger response. Charge pressure is controlled by the charge pressure actuator V465.

The rapid response of the electrical charge pressure actuator ensures that the wastegate opens quickly in overrun mode, thereby reducing the pumping effort of the turbocharger.

This eliminates the need for otherwise standard components such as:

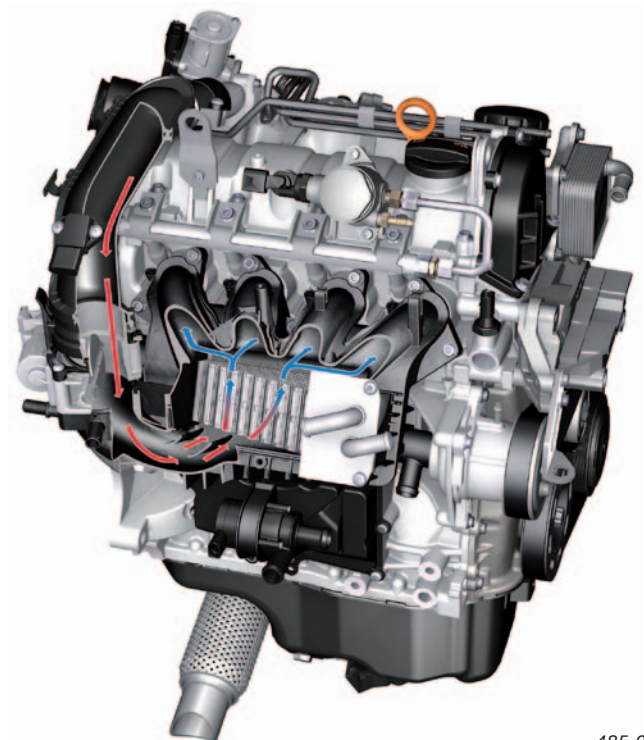
- ▶ Charge pressure limitation solenoid valve N75
- ▶ Pressure cell
- ▶ Turbocharger divert air valve N249

## Overview



## Charge air circuit

The charge air cooling principle essentially corresponds to that of the 92 kW 1.4l TFSI engine, compared to which the inner air volume has been reduced still further. This allows charge pressure to be built up more quickly.



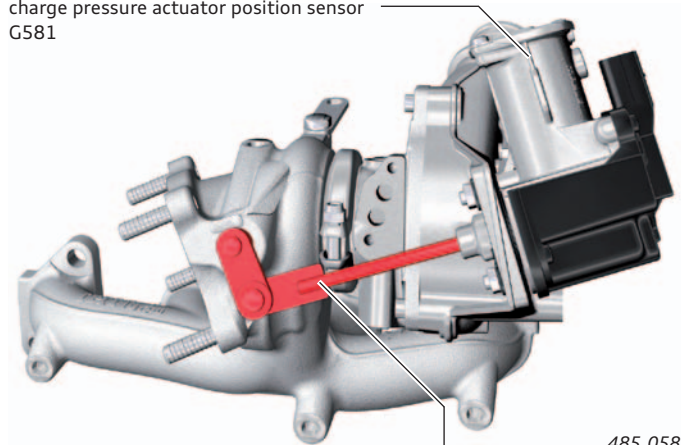
# Charge pressure actuator V465 with charge pressure actuator position sensor G581

The charge pressure actuator is an integral part of the exhaust turbocharger. Its purpose is to regulate the charge pressure.

The advantages of the electrical charge pressure actuator over the pneumatic charge pressure control solenoid valve are as follows:

- ▶ Fast adjustment times and, in turn, faster charge pressure build-up
- ▶ The high actuating force ensures that the wastegate remains securely closed even at high exhaust mass flow rates in order to achieve the nominal charge pressure
- ▶ The wastegate can be operated independently of the charge pressure with the result that the wastegate can open at lower engine loads and speeds; the basic charge pressure is reduced and the engine has less load-changing work to perform

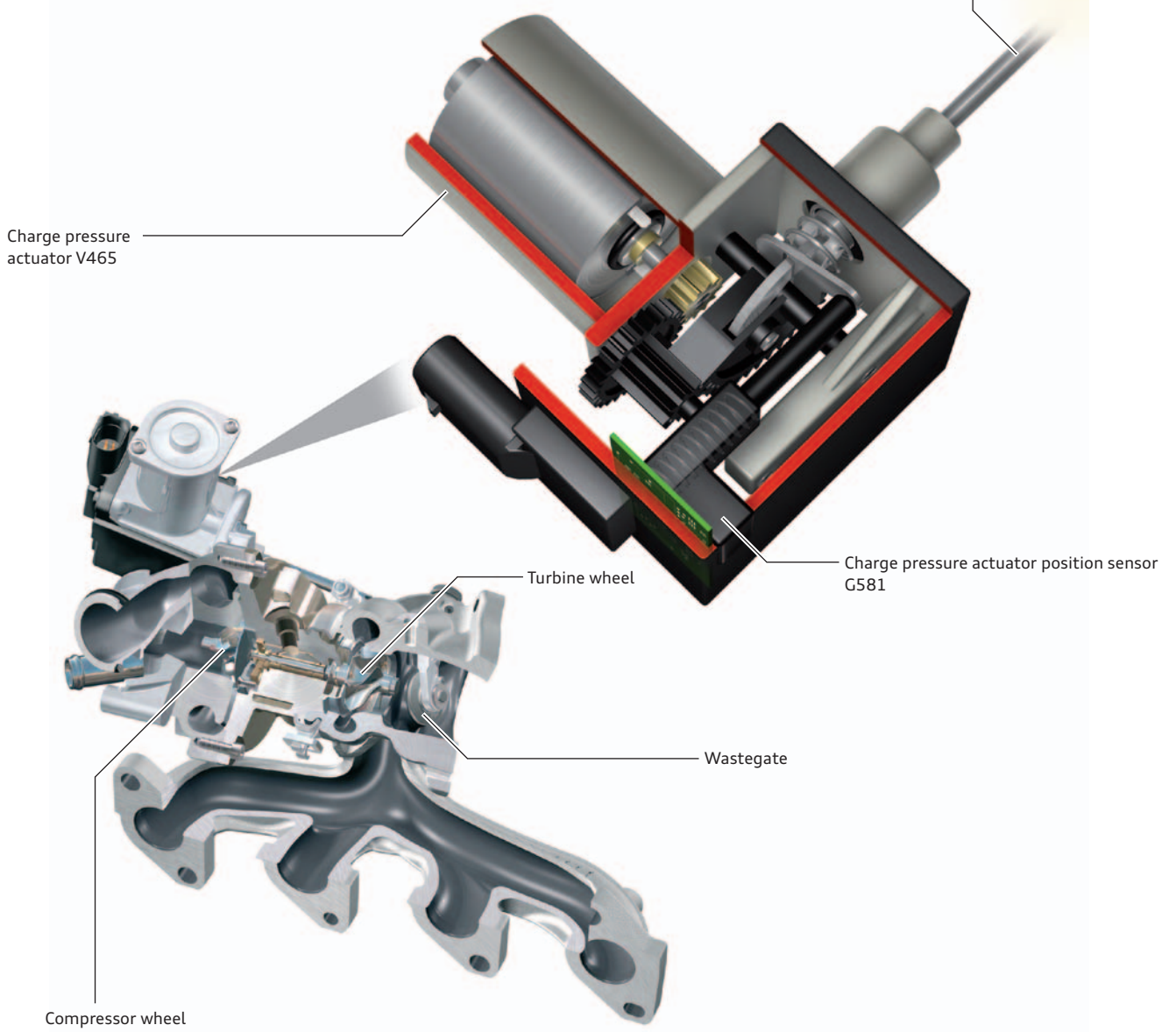
Charge pressure actuator V465 with charge pressure actuator position sensor G581



485\_058

Wastegate actuating lever

## Position on exhaust turbocharger



485\_037



### Note

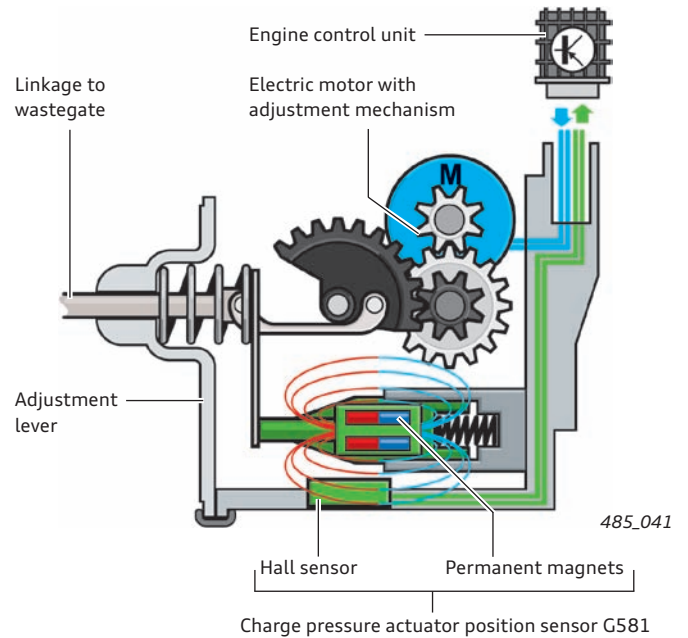
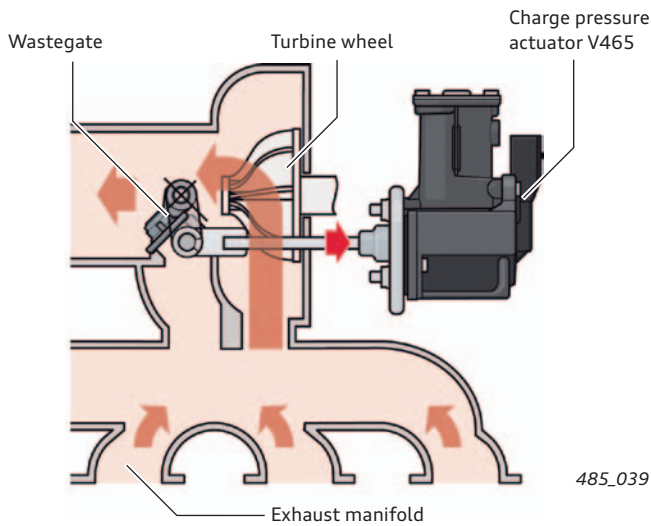
The charge pressure actuator can only be replaced complete with all attachments. After replacing the module, the new module must be programmed via Guided Fault Finding / Guided Functions.

## Charge pressure control function

The charge pressure control determines the air mass which is compressed by the exhaust turbocharger and pumped into the cylinders. Exact charge pressure control is provided by two pressure sensors each fitted with an intake air temperature sender.

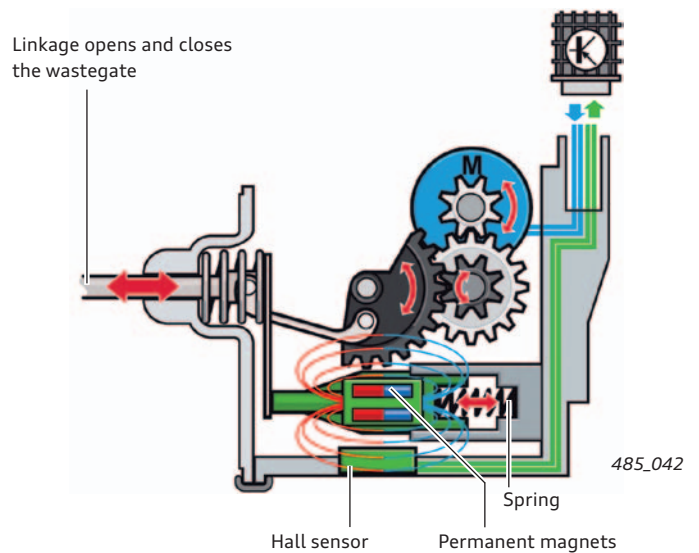
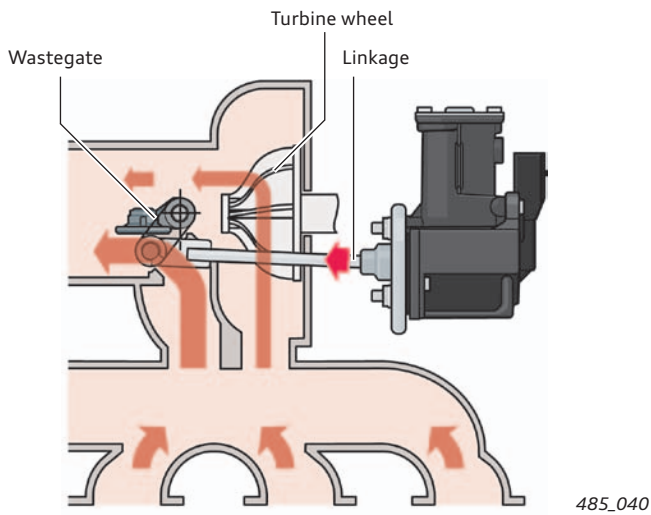
### Wastegate closed

The *wastegate\** remains closed until the nominal charge pressure is reached.



### Wastegate open

If the nominal charge pressure has been reached, the wastegate is adjusted to the position required to produce the nominal/actual charge pressure.



### Wastegate position detection

To be able to set the required wastegate position, and thus the nominal charge pressure, the charge pressure actuator position sensor G581 is integrated in the charge pressure actuator. This *Hall sensor\** is connected to the adjustment mechanism by a lever. The permanent magnets are pressed against a lever by a spring which moves in unison with the linkage. As a result, both magnets glide past the Hall sensor upon each adjustment of the wastegate.

From the magnetic field strength, the sensor electronics and/or the engine control unit detect the position of the adjustment mechanism and, in turn, the position of the wastegate. The signal which is output to the engine control unit is a voltage signal that changes as a function of the distance travelled by the adjuster (0 - 5 volts). The travel time of the charge pressure actuator from stop to stop is only 80 ms. The wastegate can be adjusted to any position at any time.



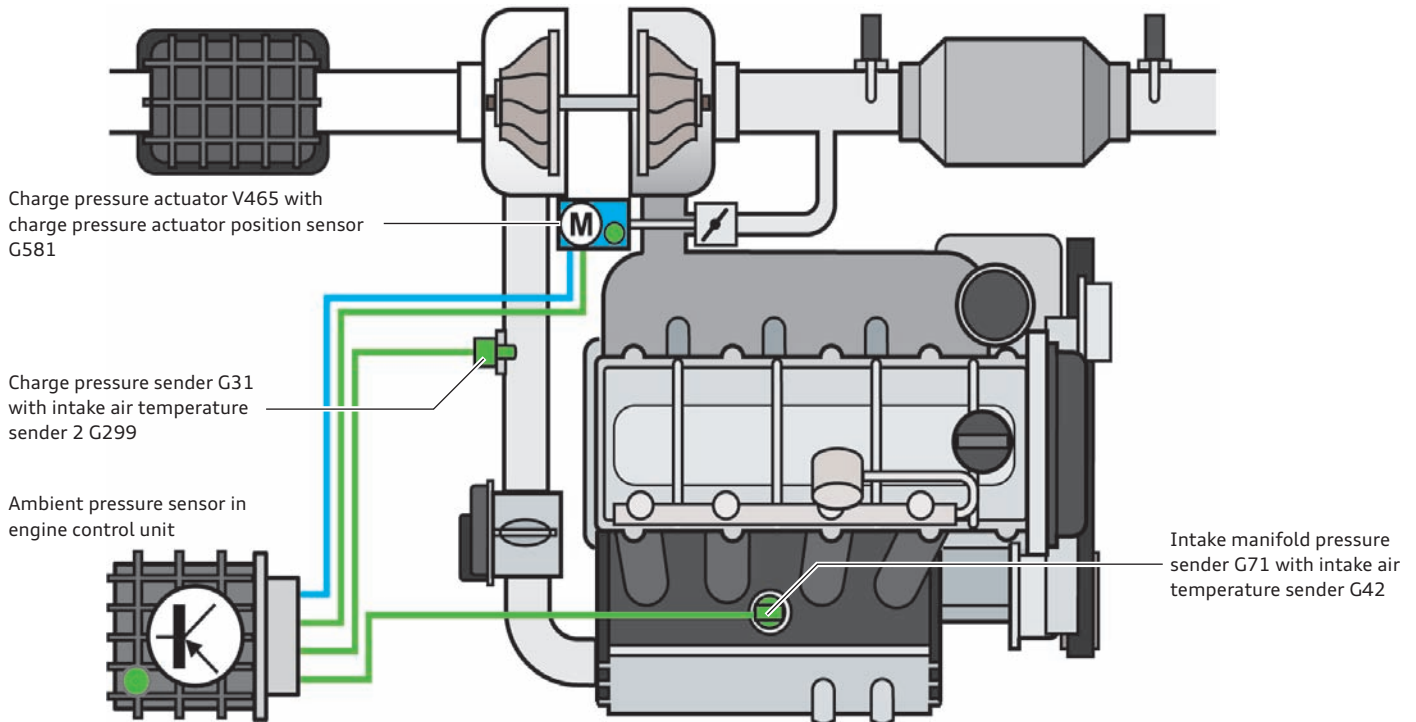
## Calculating the charge pressure

The charge pressure is calculated in the engine control unit using the signals from:

- ▶ charge pressure sender G31 with intake air temperature sender 2 G299
- ▶ intake manifold pressure sender G71 with intake air temperature sender G42

The signal from the ambient pressure sender in the engine control unit is used as a correction variable.

## Overview



485\_044

### Charge pressure sender G31 with intake air temperature sender 2 G299

The signal from the charge pressure sender is utilised to control and monitor the charge pressure. The signal from the intake air temperature sender is used for reducing the charge pressure if the temperature is too high in order to protect the components.

### Ambient pressure sender

The ambient pressure sender in the control unit gauges the ambient air pressure. This value is used as a correction factor for charge pressure control since the density of the intake air decreases with increasing altitude.

### Charge pressure control

The engine control unit J623 computes the nominal charge pressure from the requested torque. If the actual charge pressure deviates from the nominal charge pressure, the *wastegate\** is opened further by the charge pressure actuator V465 (charge pressure decreases) or closed further (charge pressure increases).

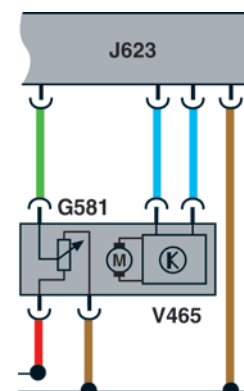
The wastegate is closed in the start position. The V465 is activated by the PWM signal, and the charge pressure actuator position encoder G581 provides position feedback. The wastegate is opened and closed variably depending on requirements.

### Intake manifold pressure sender G71 with intake air temperature sender G42

The engine control unit utilises the signals from the intake manifold sender and the intake air temperature sender to compute the air mass in the intake manifold downstream of the charge air cooler.

Depending on the calculated air mass, the charge pressure is adapted according to the characteristic map and boosted up to a maximum of 2.1 bar (absolute).

The signal from the intake air temperature sender is used as a correction factor for the charge pressure since the temperature influences the density of the charge air.



485\_043

# Cooling system

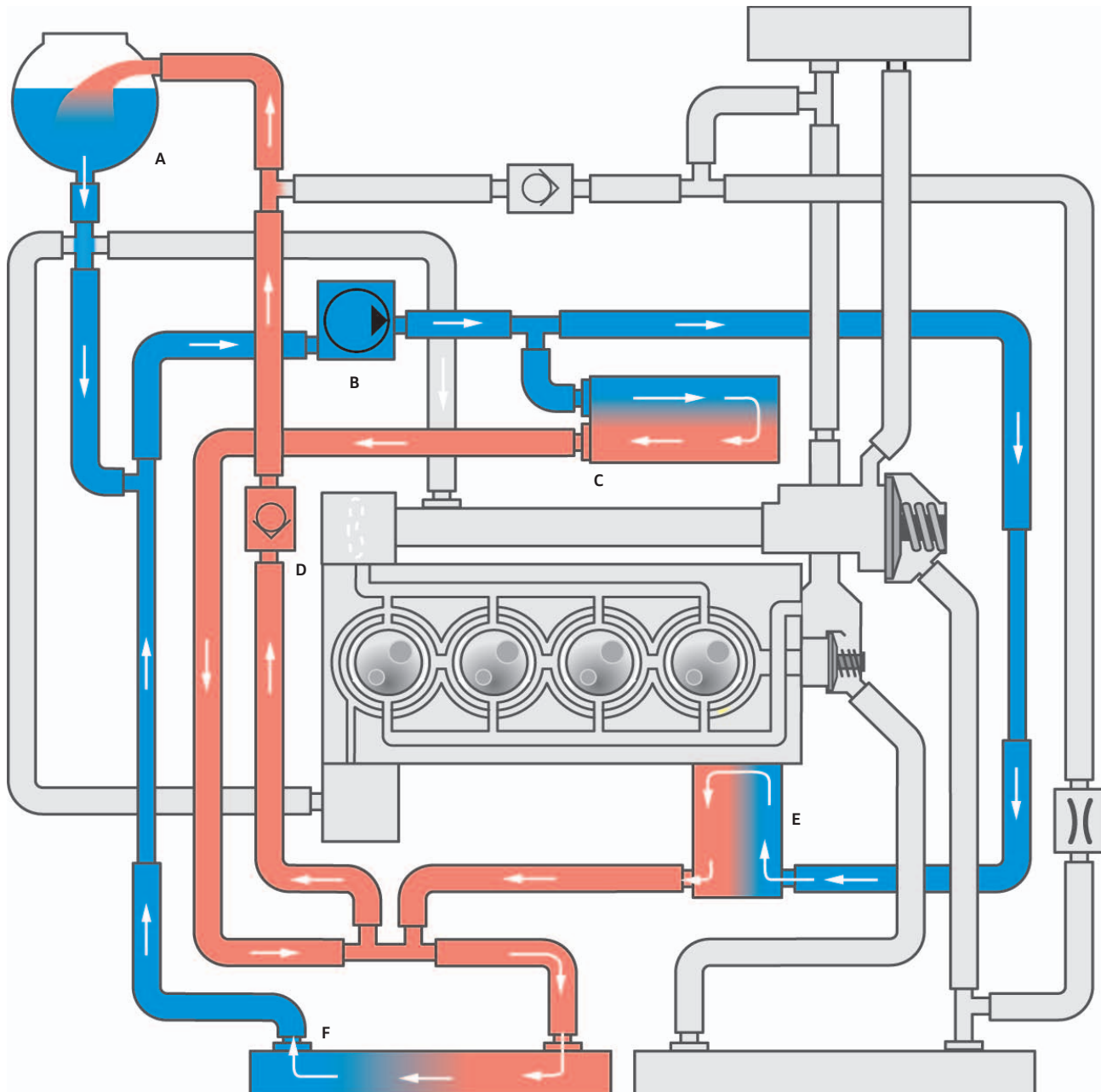
## Overview

The 1.2l TFSI engine has two independent cooling systems which are connected and disconnected by nonreturn valves and a flow restrictor:

- ▶ the charge air cooling system
- ▶ the engine cooling system which, in turn, is subdivided into two circuits.

Due to the presence of the flow restrictor and nonreturn valves, it is necessary to vent the entire system using VAS 6096 or using the "test program" on a vehicle diagnostic tester after carrying out work on the cooling system.

## Charge air cooling system



485\_013

### Legend:

- Hot coolant
- Cooled coolant

- A Expansion vessel
- B Coolant circulation pump V50
- C Charge air cooler in intake manifold
- D Nonreturn valve
- E Exhaust turbocharger
- F Charge air system auxiliary cooler

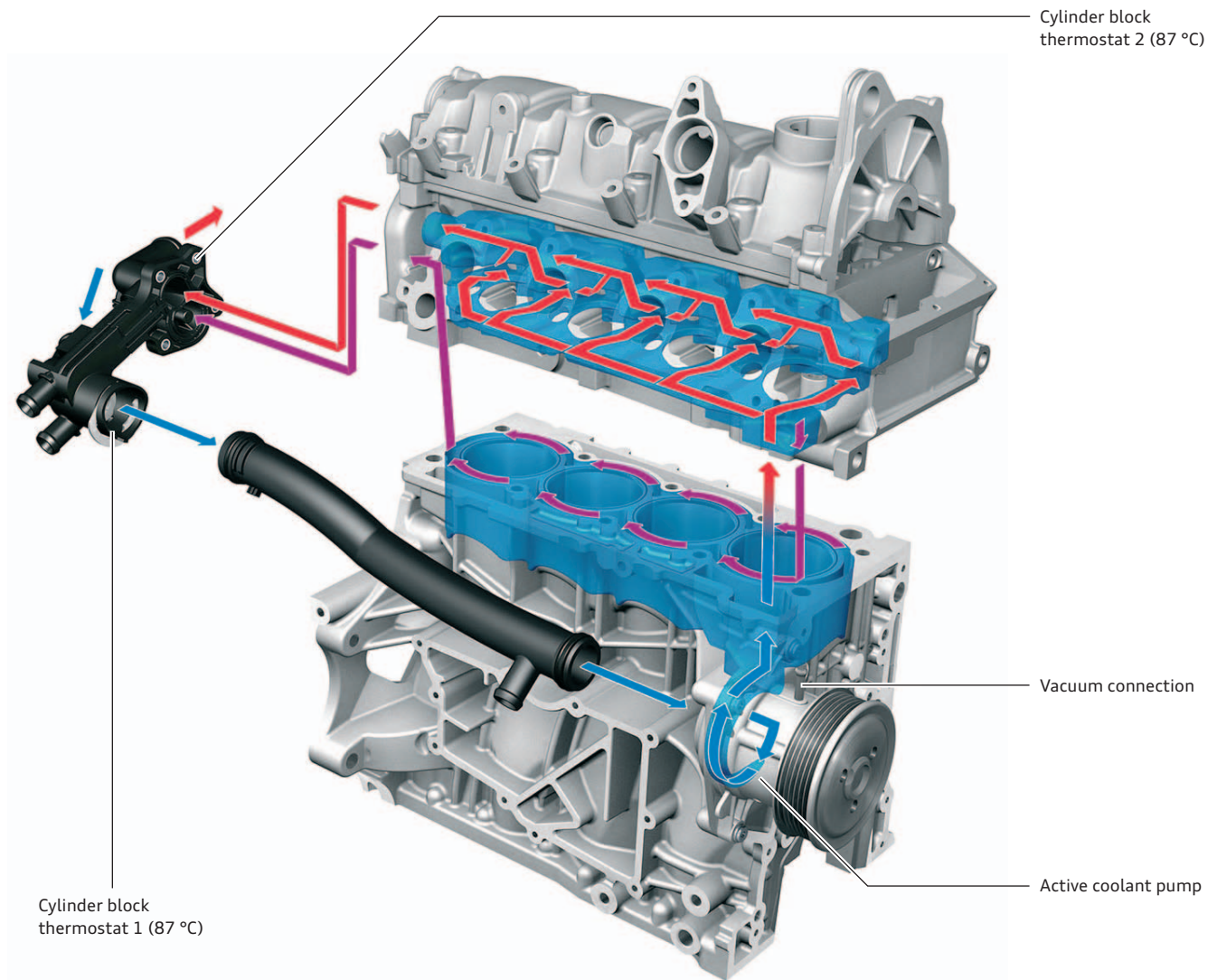
## Engine cooling system

The separate coolant flows inside the cylinder head and inside the engine block allow different temperatures to be achieved in both of these components by using a thermostatic housing with dual thermostats.

The cylinder head thermostat begins to open when the coolant temperature reaches approx. 80 °C. It achieves its maximum opening cross-section at a temperature of 135 °C.

On the other hand, the thermostat for the cylinder block begins to open at 87 °C. In this case, too, the thermostat achieves its maximum opening cross-section at a temperature of 135 °C. With this configuration, the circulation of coolant through the cylinder block is suppressed during the engine warm-up phase by the closed cylinder block thermostat. The cylinder linings can therefore heat up more quickly, and the friction of the piston assembly can be significantly reduced while the cylinder head is cooled more intensively in order to provide better knock resistance.

## Thermostats



485\_026

## Advantages of separate coolant flows

- ▶ The lower cylinder head temperature reduces NO<sub>x</sub> emissions.
- ▶ The cylinder walls heat up more quickly, thereby reducing raw HC emissions.



### Reference

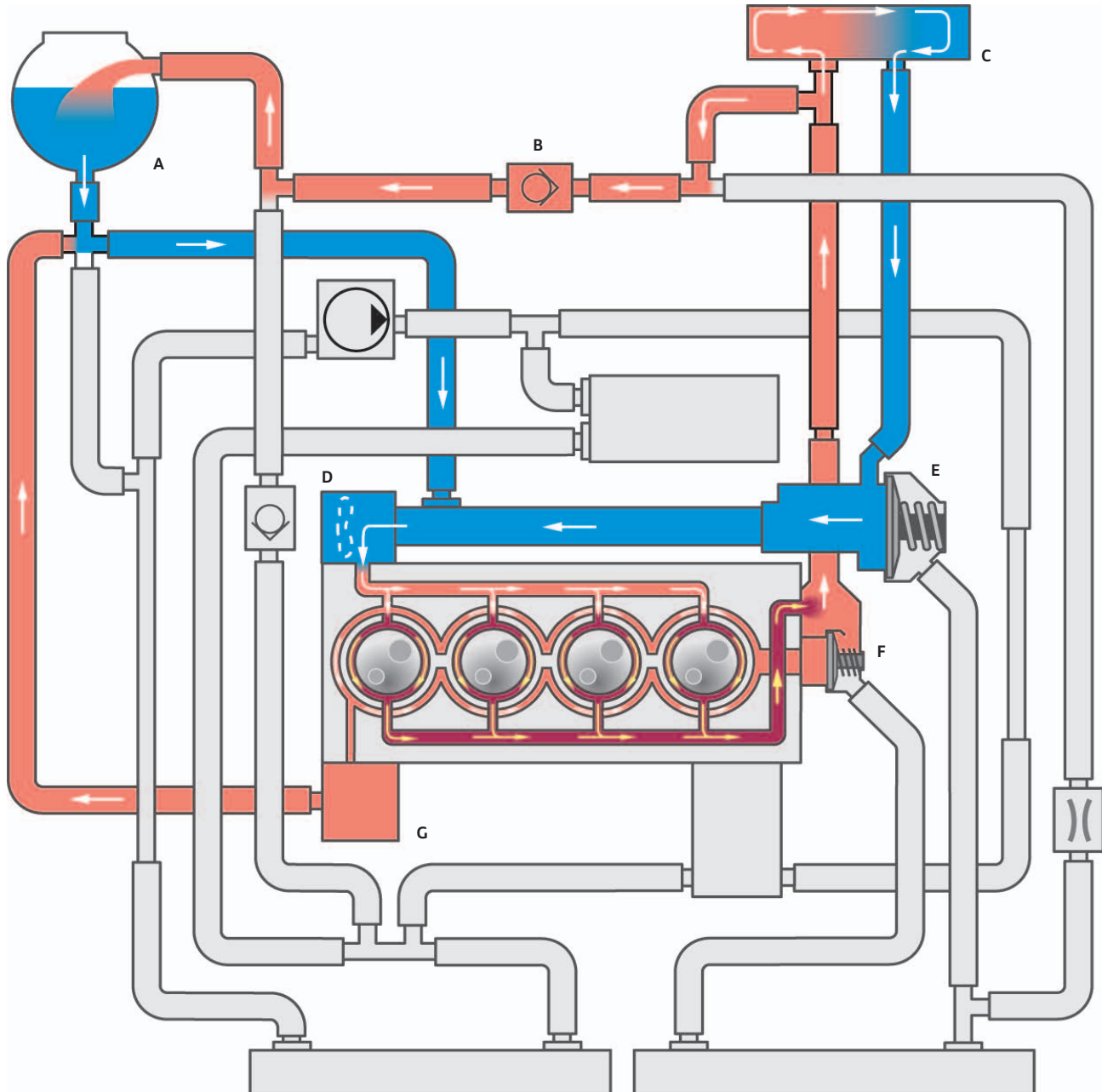
For further information about the design and function of the engine cooling system, refer to Self-Study Programme 432 "Audi 1.4l TFSI Engine".

## Engine cold

After cold-starting the engine, the active coolant pump is activated, thus stopping the coolant flow.

If no heating is requested, the engine heats up very quickly. If heating is requested, coolant circulation is stopped for approx. two minutes. Both thermostats are closed.

The coolant flows through the coolant pump, the cylinder block and the heater heat exchanger, and then back to the coolant pump. Parallel to this, the coolant flows through the oil cooler.



485\_010

### Legend:

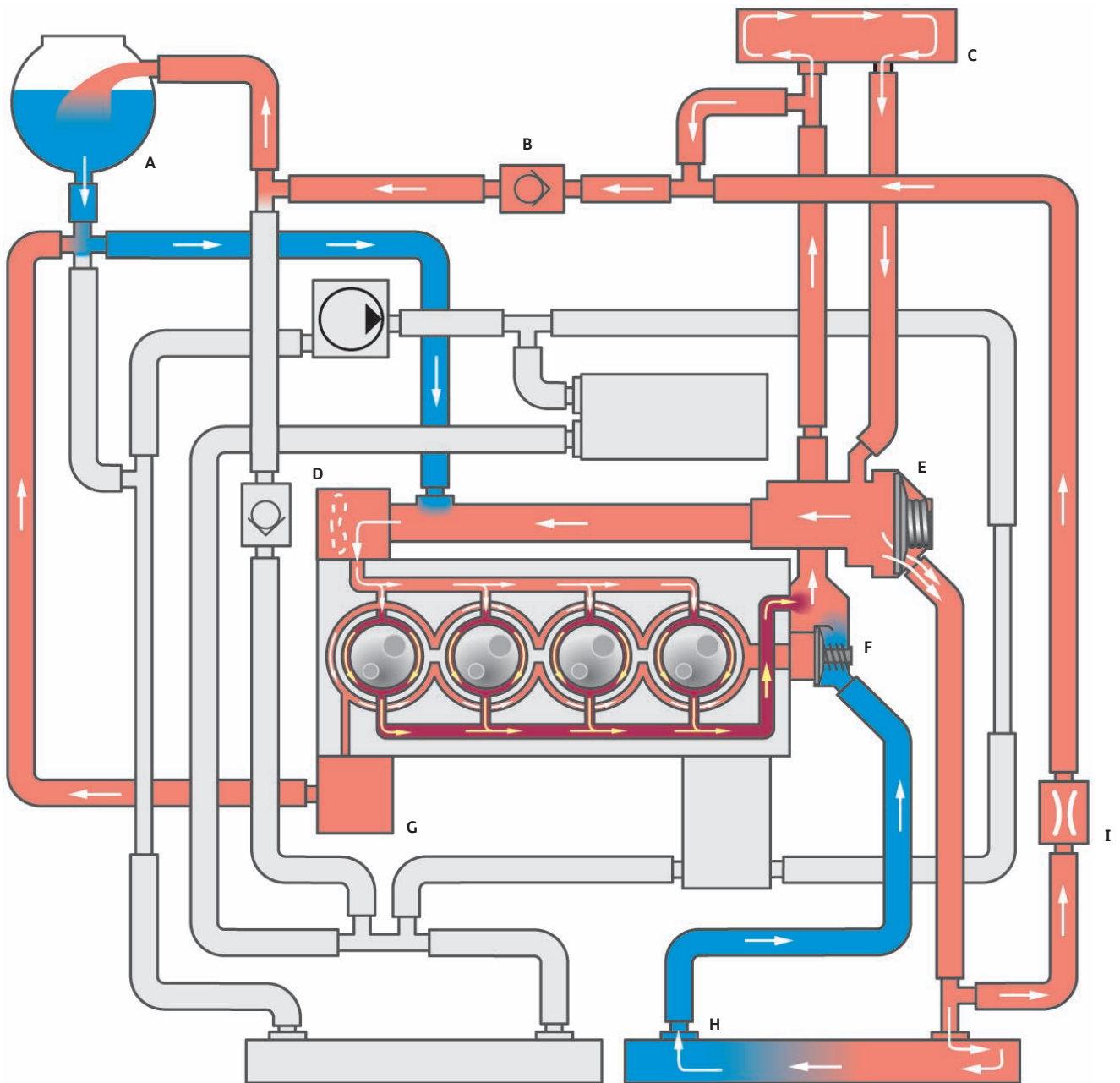
- Coolant in cylinder block
- Coolant in the cylinder head and in the remainder of the cooling system
- Cooled coolant

- A** Expansion vessel
- B** Nonreturn valve
- C** Heater heat exchanger
- D** Active mechanical coolant pump
- E** Cylinder head thermostat 1
- F** Cylinder block thermostat 2
- G** Oil cooler



## Engine warm, a thermostat opens

If the coolant has reached a temperature of 80 °C, the cylinder head thermostat opens. The main radiator is now integrated in the coolant flow.



485\_011

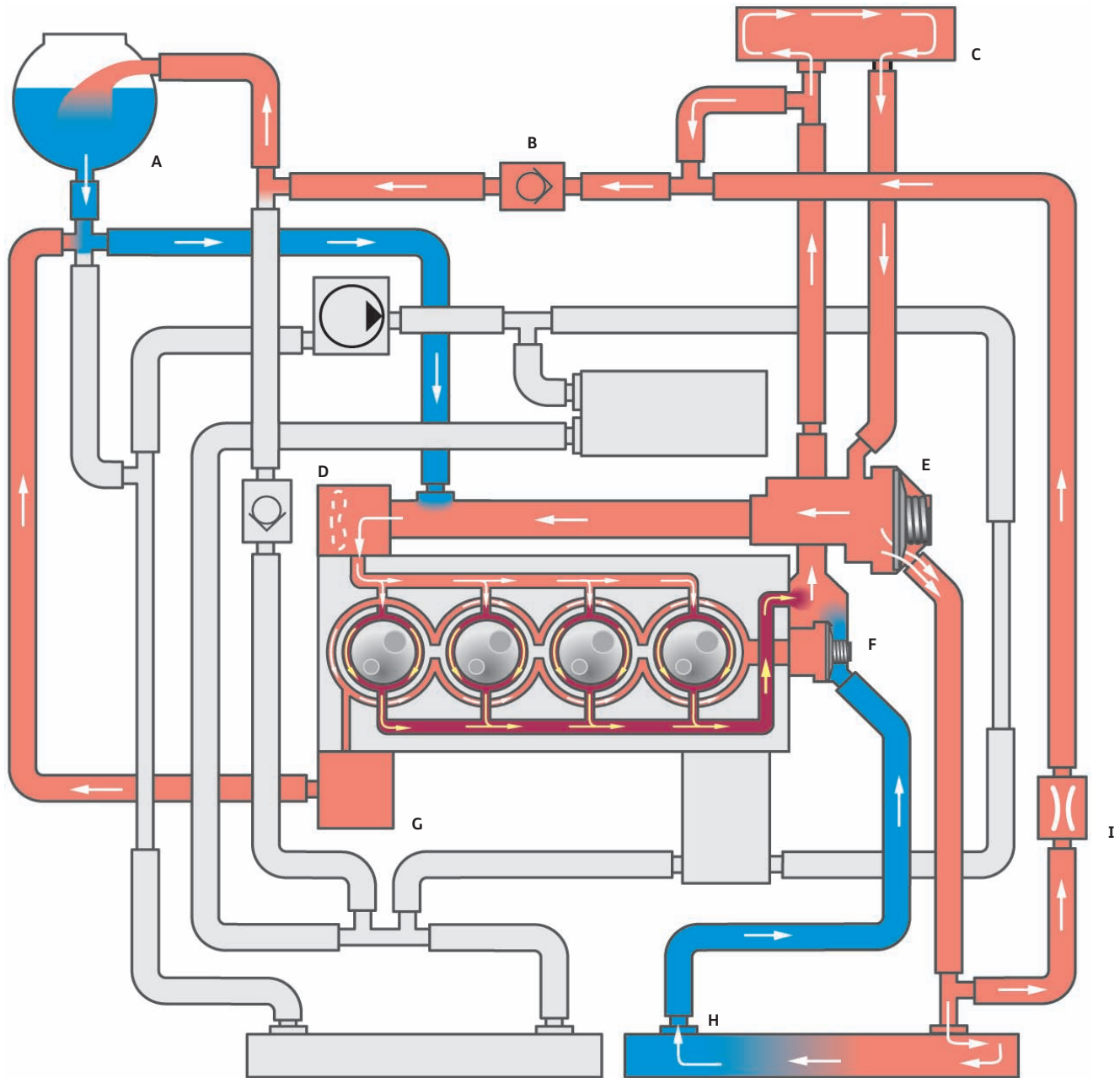
### Legend:

- Coolant in cylinder block
- Coolant in the cylinder head and in the remainder of the cooling system
- Cooled coolant

- A Expansion vessel
- B Nonreturn valve
- C Heater heat exchanger
- D Active mechanical coolant pump
- E Cylinder head thermostat 1
- F Cylinder block thermostat 2
- G Oil cooler
- H Radiator
- I Restrictor

## Engine warm, both thermostats open

When the coolant in the cylinder block reaches a temperature of 87 °C, the thermostat for this circuit opens with the result that the cylinder is now incorporated into the coolant circulation system.



485\_012

### Legend:

- █ Coolant in cylinder block
- █ Coolant in the cylinder head and remainder of the cooling system
- █ Cooled coolant

- A Expansion vessel
- B Nonreturn valve
- C Heater heat exchanger
- D Active mechanical coolant pump
- E Cylinder head thermostat 1
- F Cylinder block thermostat 2
- G Oil cooler
- H Radiator
- I Restrictor

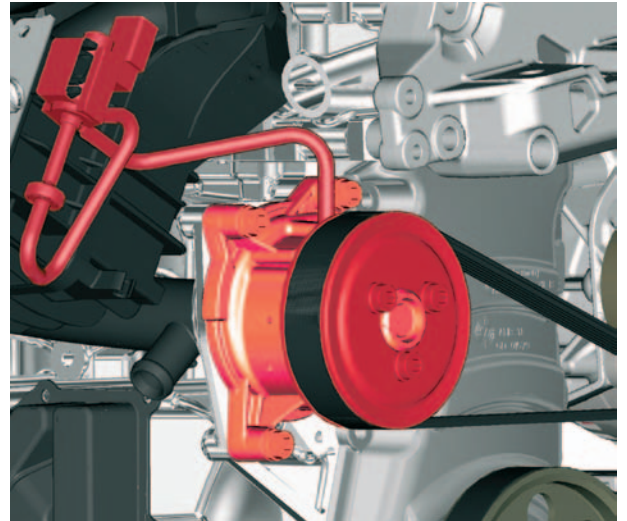
## Thermal management

The task of the thermal management system is to enable the engine to attain its operating temperature quickly since this improves fuel economy and reduces exhaust emissions.

Thermal management is implemented by stopping the circulation of coolant during the warm-up phase:

- ▶ up to a coolant temperature of 90 °C at "heater off"
- ▶ up to 2 minutes at "heater on"

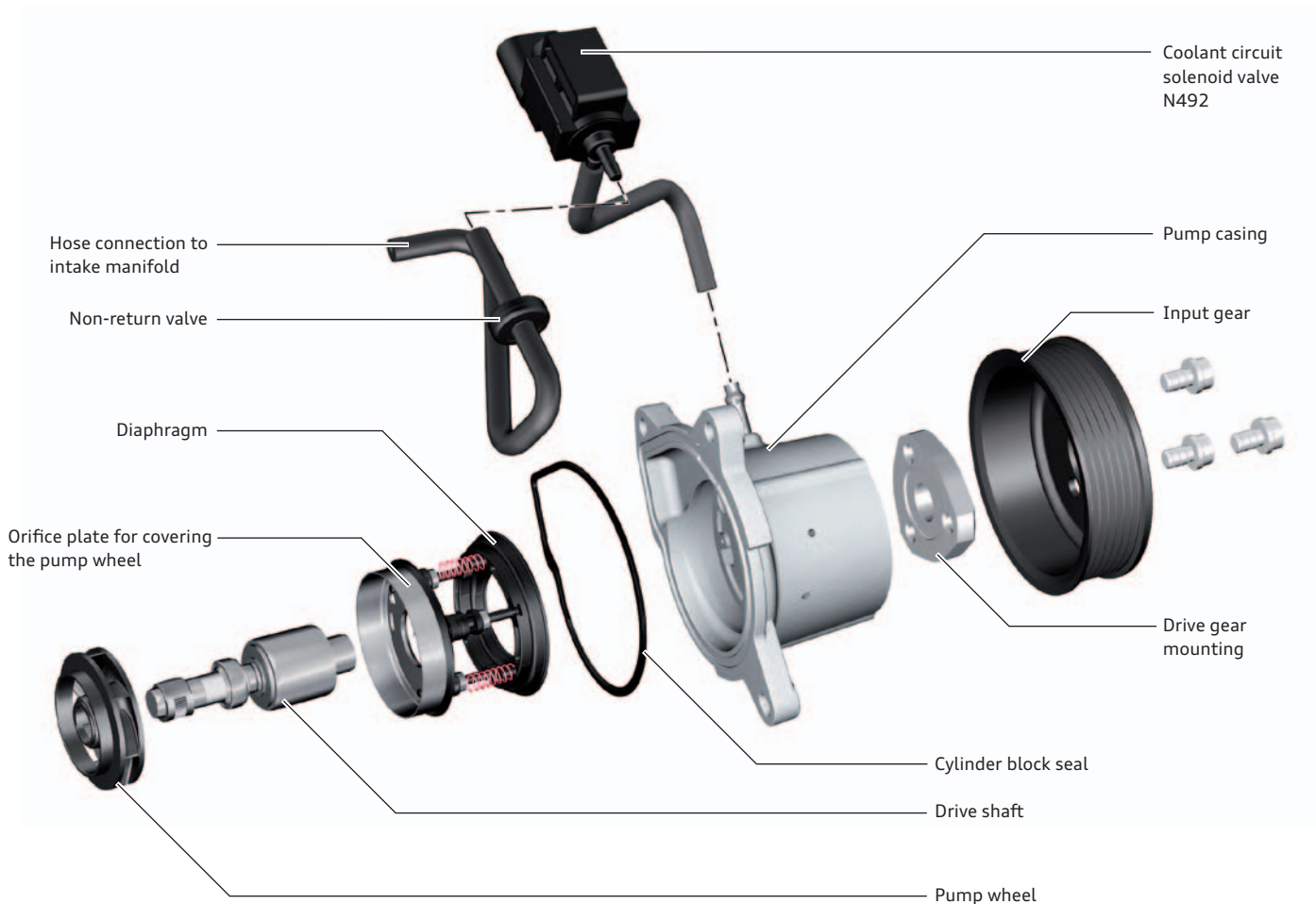
This is implemented technically by using an active coolant pump.



485\_024

## Active coolant pump

### Design



485\_006

## Function

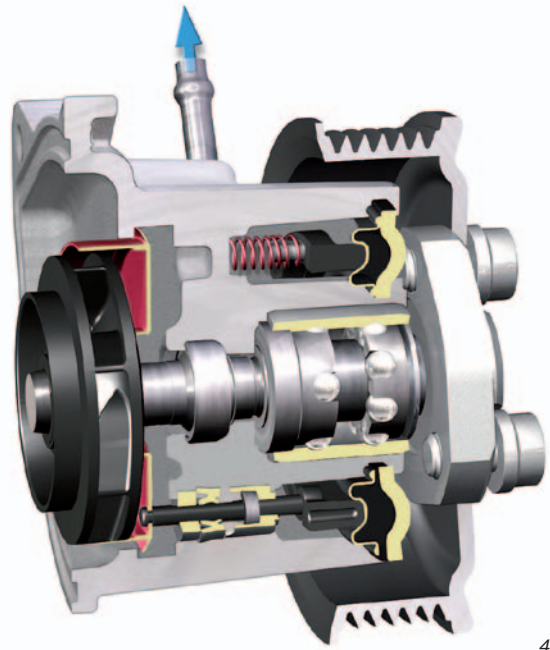
Basically, the active coolant pump works in much the same way as a conventionally driven coolant pump, i.e. with permanent mechanical drive.

### No coolant flow

The coolant flow is interrupted by sliding an orifice plate over the pump vane. The orifice plate is actuated by vacuum and spring pressure.

When the adjustment mechanism is activated (vacuum), the orifice plate counteracts the spring pressure and covers the pump vane. Coolant circulation is now interrupted.

The condition for this operating state is a coolant temperature of less than 30 °C.



485\_004

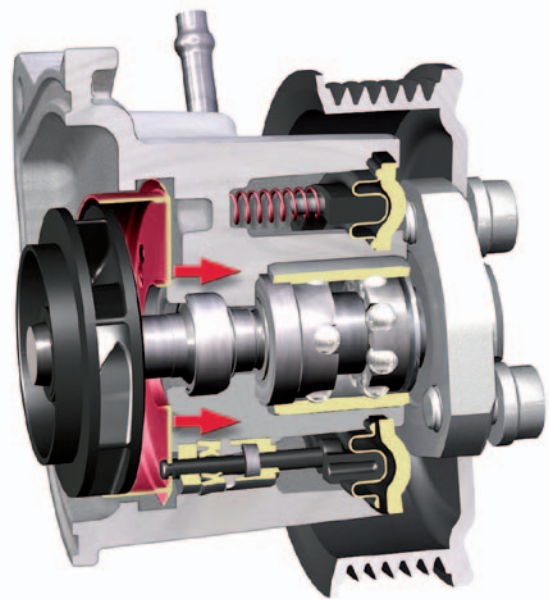
### Coolant is pumped

The vacuum supply is shut off to activate the coolant flow. The orifice plate is retracted by spring pressure.

Special restarting characteristics:

- ▶ switches on and off for the duration of one second
- ▶ this cycle is repeated several times in succession
- ▶ the interval between cycles is approx. 7 seconds

Thus, the warm coolant from the engine mixes slowly with the cold coolant. When heating is requested, the pump is switched on immediately.



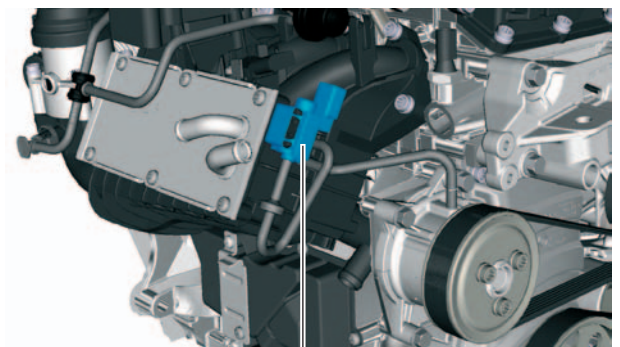
485\_005

### Vacuum activation

The coolant pump is activated by the coolant circuit solenoid valve N492. It is operated by the engine control unit (this is computed by a map). The pump is activated by means of a *PWM signal\**. However, the orifice plate is not actuated variably. It is only switched on or off.

If the valve is deenergised or fails, the coolant flow cannot be controlled since the orifice plate is kept retracted by the spring pressure (maximum coolant flow).

- ▶ Failure in off-state: the engine reaches its operating temperature more slowly.
- ▶ Failure in on-state: the coolant temperature increases to an unacceptably high level since the coolant pump is unable to feed in fresh coolant. The exhaust warning lamp K83 comes on.

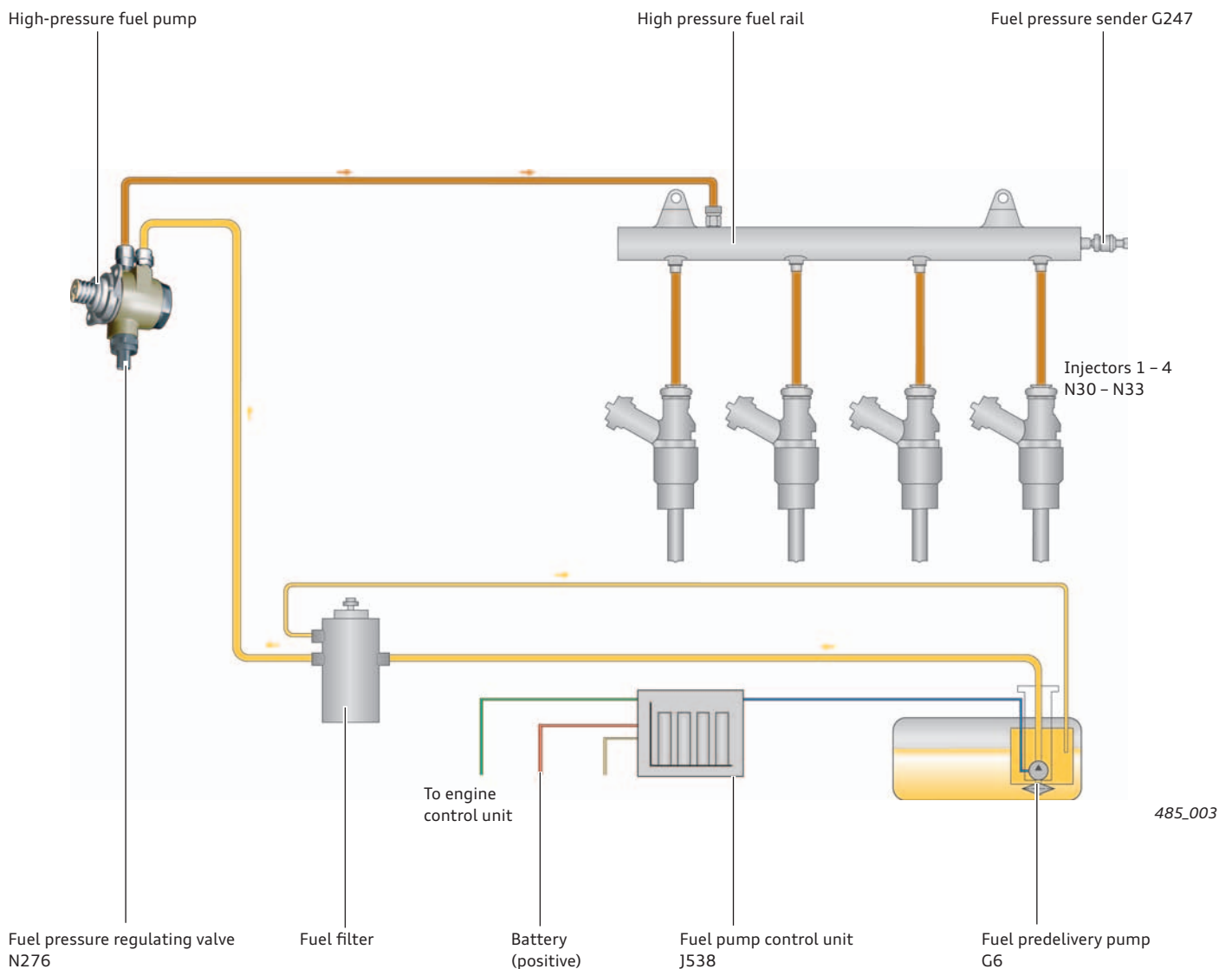


Coolant circuit solenoid valve N492

485\_027



## System overview



## Injectors N30 - N33

The configuration of the injectors, and in particular the orientation of the six individual jets, has been adapted to the engine. This ensures that the intake air from the swirl port mixes quickly with the fuel. The injectors are activated by the engine control unit, which applies a voltage of 65 volts.

The injectors are serviced in the same way as the previous systems (use of the seal set, use of special tools, etc.).



# Engine management

## Overview of the Simos 10 system on the Audi A3

### Sensors

Charge pressure sender G31  
Intake air temperature sender 2 G299

Intake manifold pressure sender G71  
intake air temperature sender G42

Engine speed sender G28

Hall sender G40

Throttle valve control unit J338  
Throttle valve drive angle sender with electronic power control G187, G188

Accelerator pedal position sensor G79  
Accelerator pedal position sensor 2 G185

Charge pressure actuator position sensor G581

Clutch position sensor G476

Brake pedal position sensor G100

Fuel pressure sender G247

Knock sensor 1 G61

Coolant temperature sender G62

Coolant temperature sender at radiator outlet G83

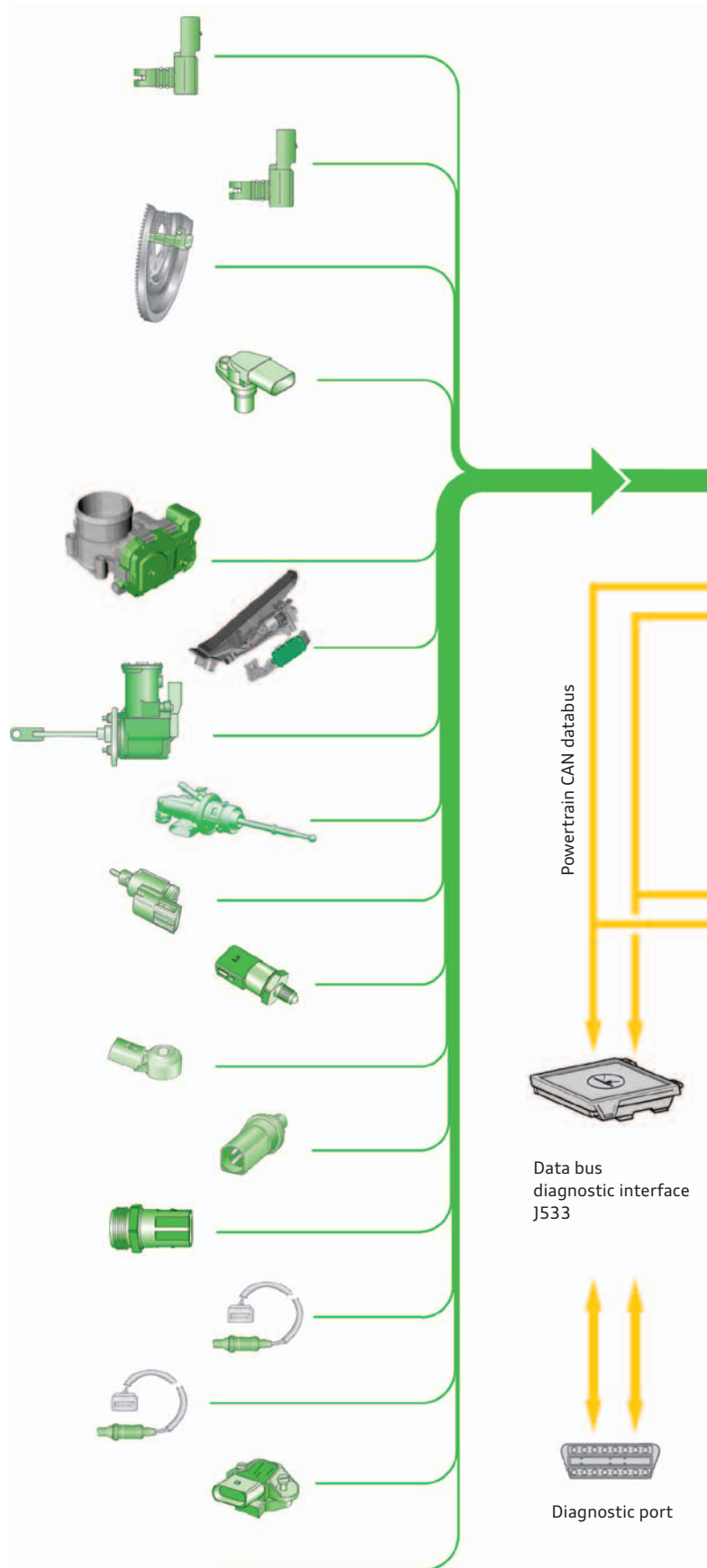
Oxygen sensor before catalytic converter G39

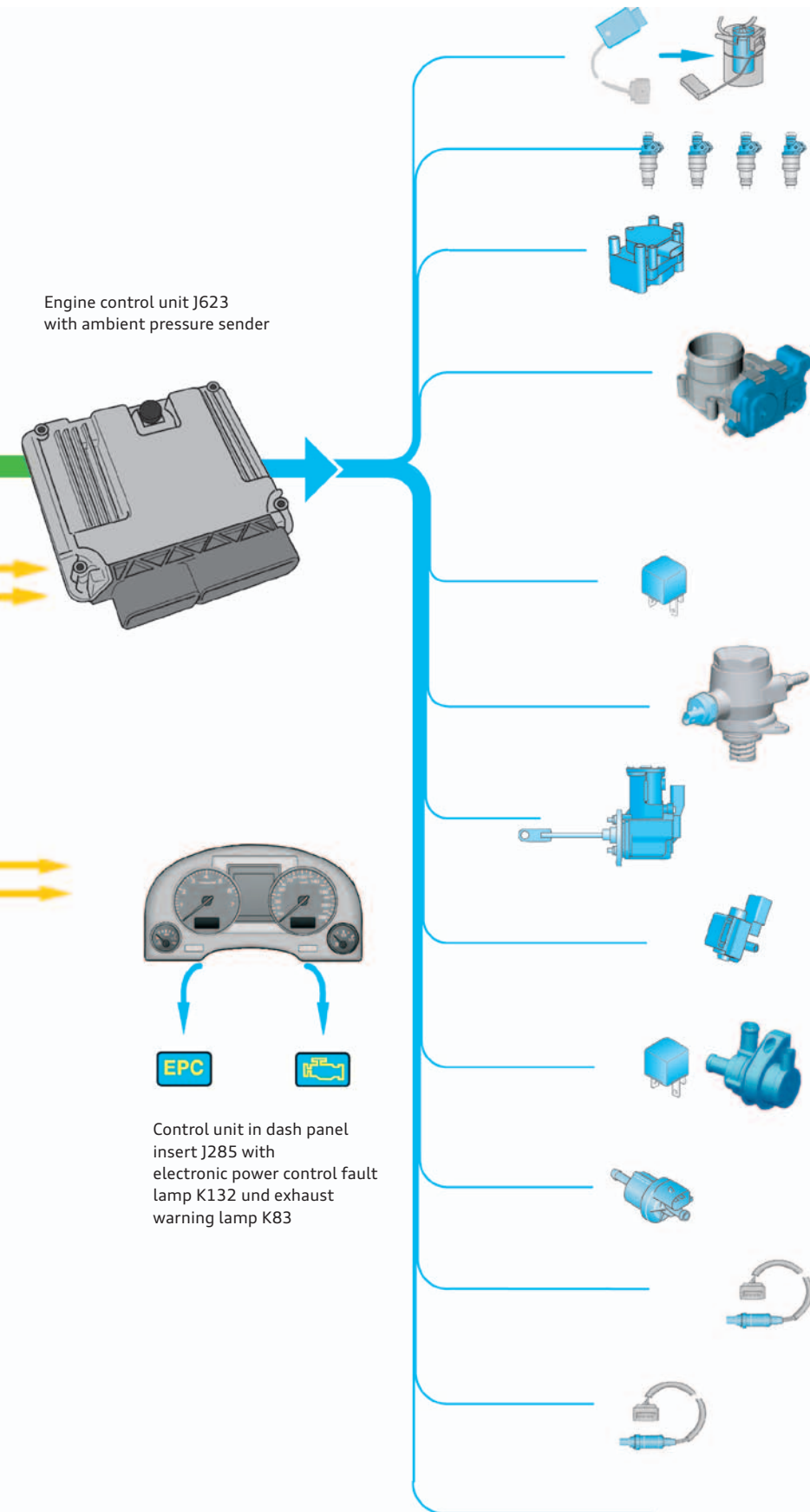
Oxygen sensor after catalytic converter G130

Brake servo pressure sensor G294

Auxiliary signals:

- Heating requested
- Cruise control system (CCS)
- DF signal (alternator)
- Terminal 50 on starter
- Starter relay output 1, terminal 85
- Starter relay output 2, terminal 85



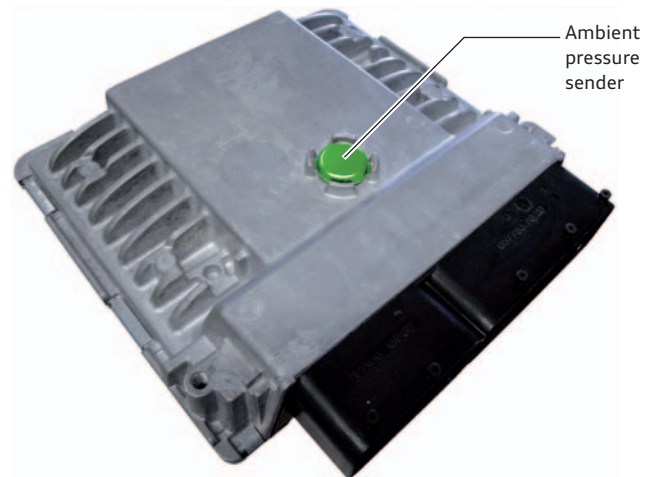


## Actuators

- Fuel pump control unit J538  
Fuel predelivery pump G6
- Injectors for cylinders 1 – 4 N30 – N33
- Ignition transformer N152
- Throttle valve control unit J338  
Throttle valve drive for electronic power control G186
- Motronic power supply relay J271
- Fuel pressure regulating valve N276
- Charge pressure actuator V465
- Coolant circuit solenoid valve N492
- Additional coolant pump relay J496  
Coolant circulation pump V50
- Activated charcoal filter system solenoid valve 1 N80
- Oxygen sensor heater Z19
- Lambda probe 1 heater, after catalytic converter Z29
- Auxiliary signals:  
– Radiator fan setting 1 (PWM)

## Engine control unit J623

The engine control unit J623 uses the Simos 10 system. It supports the UDS (UDS = universal diagnostic component) diagnostic data protocol. The ambient pressure sensor is also integrated in the engine control unit. All components can be tested electrically using the V.A.G 1598/39 adaptor cable and the V.A.G 1598/42 test box.



485\_022

## Operating modes

### Twin injection with catalytic converter heating

In the operating mode "twin injection with catalytic converter heating", the catalytic converter heats up more quickly than with a single injection.

Twin injection enables the engine to run smoothly at retarded ignition angles. Retarded ignition subjects the catalytic converter to higher exhaust temperatures and mass flows.

On the whole, this helps to reduce exhaust emissions and improve fuel economy.

In the first part of the injection cycle, 80 % of the total amount of fuel is injected during the intake stroke. This results in the formation of a homogeneous air-fuel mixture. In the second part of the injection cycle, a small amount of fuel is injected before ignition TDC.

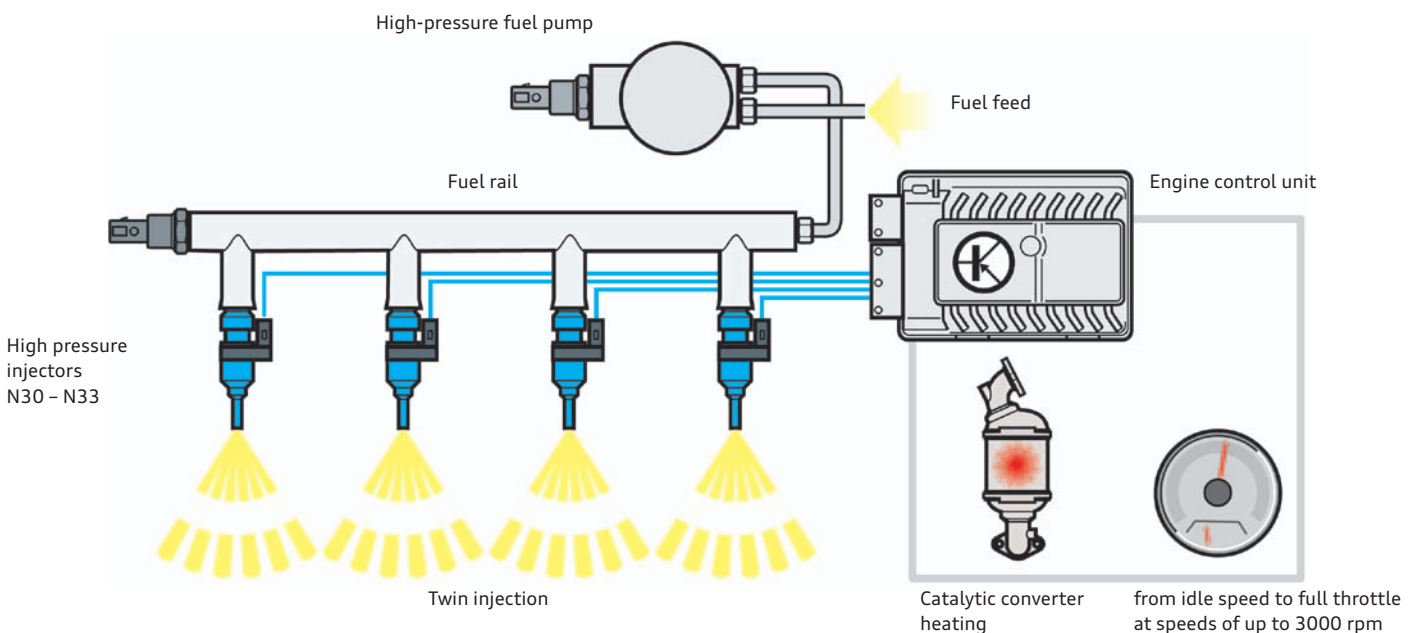
### Twin injection

The twin injection from idle speed up to full throttle at engine speeds of up to 3000 rpm allows a homogeneous air-fuel mixture to form.

The first injection takes place before ignition RDC during the intake stroke. In the process, 50 – 80 % of the total injectable amount of fuel is injected, depending on the fuel map.

During the second injection, the remainder of the fuel is injected at the start of the compression stroke. As a result, less fuel is deposited on the cylinder wall. The fuel evaporates almost entirely and carburetion is improved.

In addition, a slightly richer fuel-air mixture is produced in close proximity to the spark plug. This improves combustion and reduces engine knock.



485\_045



## Ignition system

The ignition system is simple in design and has a very favourable cost-benefit ratio. It is already used on a number of models within the VW Group. It is a mapped ignition system with static high-voltage distribution and cylinder-selective adaptive knock control.

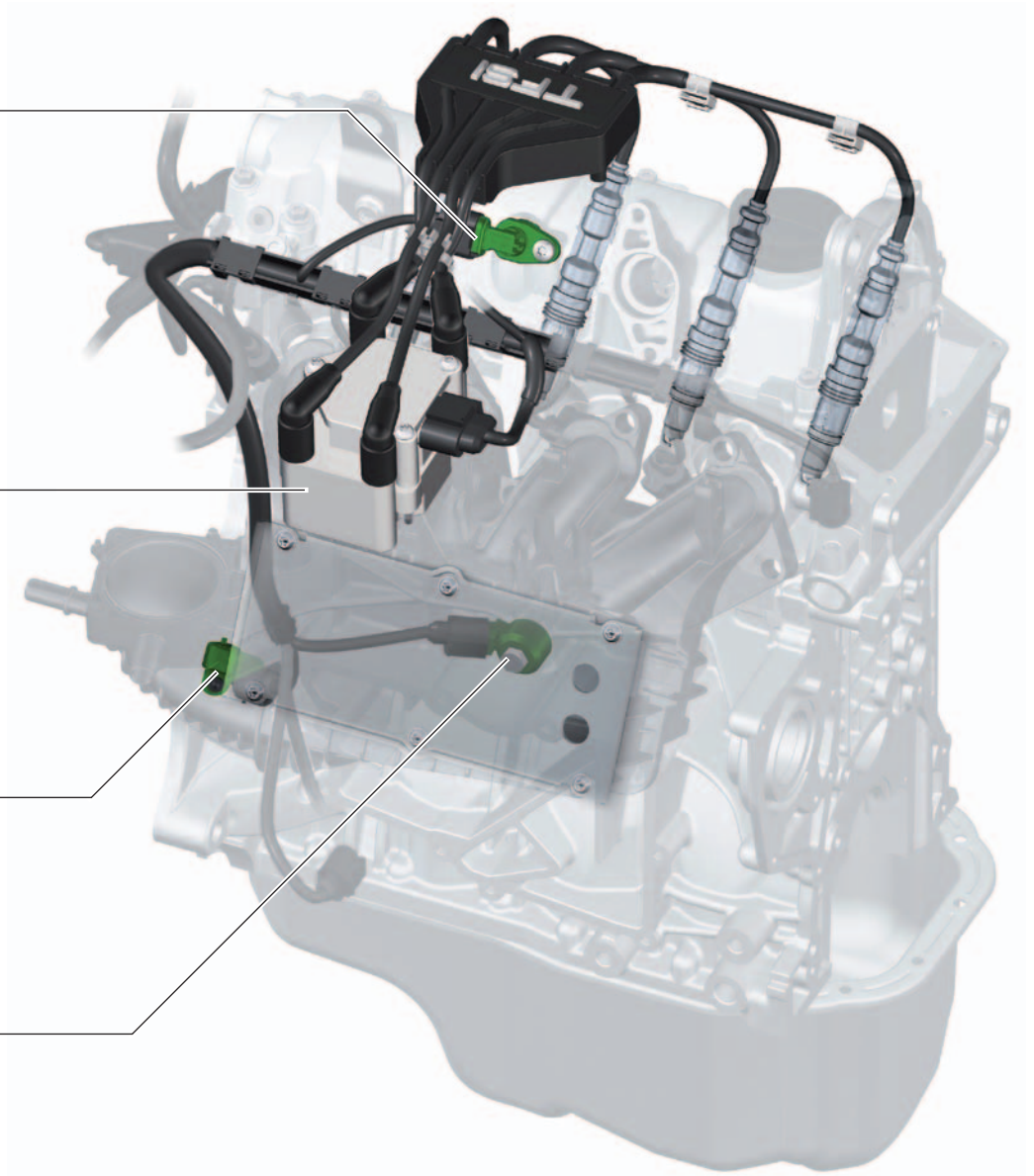
The engine control unit monitors the ignition process and sends a signal to the power output modules. These modules open and close the primary current of both ignition coils. One ignition coil always produces an ignition spark simultaneously for two spark plugs. The cylinders are selected in such a way that the second cylinder is in its exhaust stroke while the other cylinder is in its compression stroke.

Hall sender G40  
(in the cylinder head cover)

Ignition transformer N152  
(on the intake manifold)

Engine speed sender G28  
(on the gearbox)

Knock sensor 1 G61  
(on the cylinder block  
below the intake manifold)



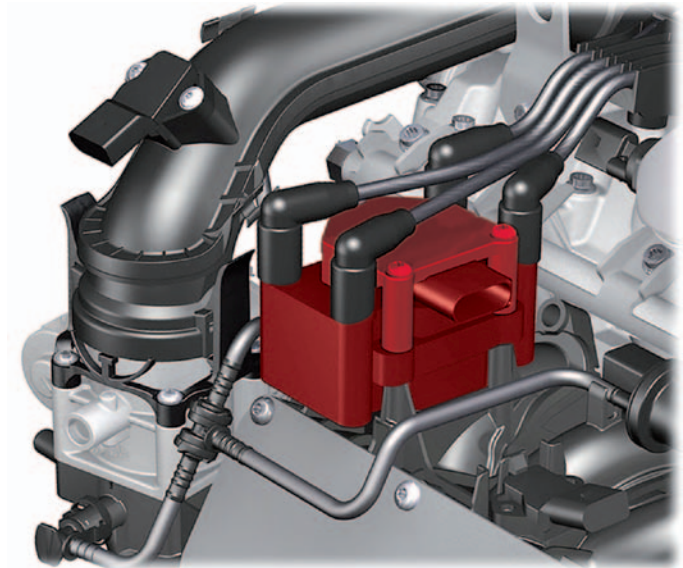
485\_008

## Ignition transformer N152

The ignition transformer for static voltage distribution is bolted on the intake manifold. Its task is to simultaneously ignite the air-fuel mixture via the spark plugs. The ignition angle is set individually for each cylinder.

### Effect of failure

If the ignition transformer fails, the engine will be shut down. There is no substitute function for the ignition transformer. A diagnostic trouble code is stored in the ECU fault memory and the exhaust warning lamp K83 is activated.



485\_023

### Design and function

The power output module and ignition coils are combined in a single component in the ignition transformer. Cylinders 1 and 4 as well as cylinders 2 and 3 respectively share a common ignition coil. Each ignition coil has two outputs for both spark plug cables.

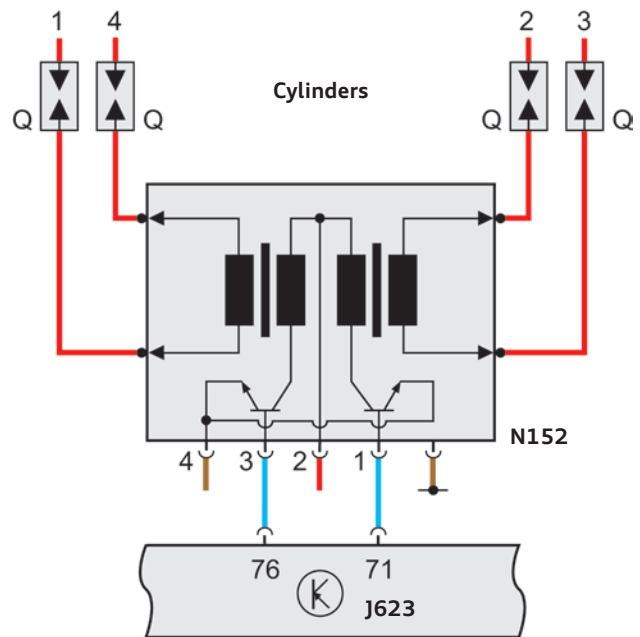
### Activation mechanism

The engine control unit activates the ignition coils via the power output modules independently of one another by applying ground. Activation timing and duration are dependent on the ignition angle and on the charging time of the coils.

The power output modules are activated via two cables:

- ▶ one cable for generating the spark in the ignition coil for cylinders 1 and 4
- ▶ one cable for the ignition coil of cylinders 2 and 3

### Circuit diagram



485\_059

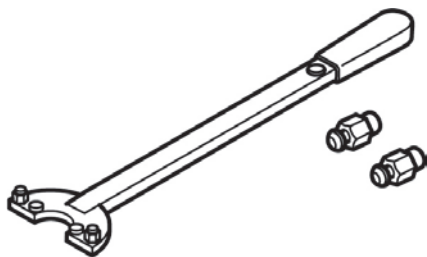
### Legend:

- 1 Input A/D from engine control unit
- 2 Terminal 15
- 3 Input B/C from engine control unit
- 4 Ground, terminal 31

- J623 Engine control unit
- N152 Ignition transformer
- Q Spark plug

## Special tools

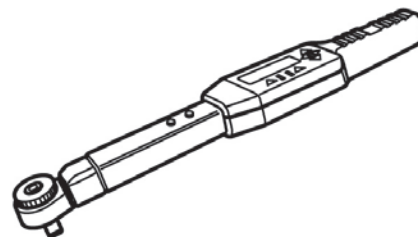
Counter-hold tool 3415 with adaptor 3415/2



485\_048

The counter-hold tool and the adaptor can be used to hold the belt pulley securely in place and to slacken or tighten the belt pulley fastening screw.

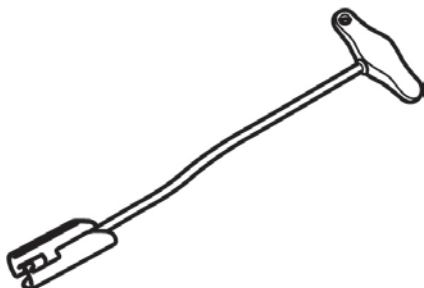
Torque wrench VAS 6583



485\_049

The electronic torque wrench can be used, for example, for tightening the screws of the lower and upper timing cases.

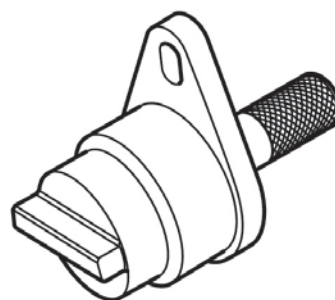
Extractor T10112A



485\_050

The extractor can be used to remove the spark plug connectors from the spark plugs.

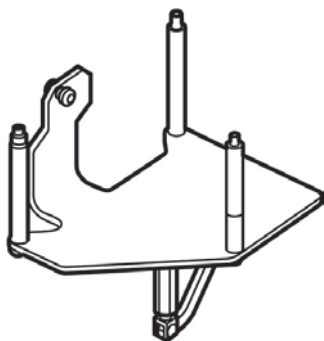
Locking pin T10414



485\_051

The locking pin is for locking the camshaft in place.

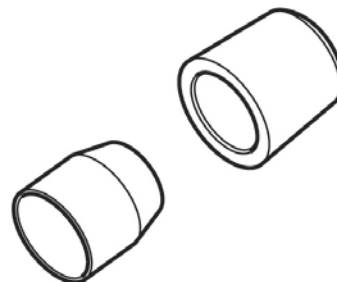
Engine support T10416



485\_052

The engine support is for lowering the engine and the gearbox.

Assembly device T10417



485\_053

The assembly device is for fitting the oil seal on the belt pulley side of the crankshaft.

## Scope of maintenance

Maintenance work	Interval
Engine oil change interval with LongLife oil	up to 30,000 km or 24 months depending on SID <sup>1)</sup> (change interval is dependent on driving style) Engine oil to VW standard 50400
Engine oil change interval without LongLife oil	Fixed interval of 15,000 km or 12 months (depending on which occurs first) Engine oil to VW standard 50400 or 50200
Engine oil filter change interval	during every oil change
Engine oil change quantity (for customer service)	3.7 litres (including oil filter)
Extract / drain engine oil	not permitted / yes
Air filter change interval	90,000 km
Fuel filter change interval	Lifetime
Spark plug replacement interval	60,000 km

<sup>1)</sup> SIA = Service Interval Display

## Timing and auxiliary drives

Maintenance work	Interval
Ribbed V belt replacement interval	Lifetime
Ribbed V belt tensioning system	Lifetime (automatic tensioner pulley)
Timing gear chain replacement interval	Lifetime
Timing gear chain tensioning system	Lifetime



### Note

The specifications contained in the current service literature always apply.



## Glossary

All terms shown in italics or by an asterisk (\*) in this Self-Study Programme are explained here.

### **Blow-by gases**

These are also referred to as leakage gases. When the engine is running, the blow-by gases flow from the combustion chamber and into the crankcase, bypassing the piston. They are produced by the high pressures which occur in the combustion chamber and constitute absolutely normal leakage around the piston rings. The blow-by gases are extracted from the crankcase by the positive crankcase ventilation system and combusted.

### **Downsizing**

Increasing efficiency by taking advantage of synergies. This means reducing the scope or size of materials and equipment while maintaining the same level of performance.

### **Hall sensor**

A Hall sensor, also known as Hall effect sensor or Hall probe, utilises the Hall effect to measure magnetic fields and electrical currents or for position sensing. If a Hall sensor is energised by an electrical current and passes through a vertical magnetic field, it will deliver an output voltage that is proportional to the product of the magnetic field strength and current.

### **Intake manifold flaps**

The position of the intake manifold flaps influences the carburetion process and, in turn, exhaust emissions. The intake manifold flap control system is one of the systems relevant to exhaust emissions and is monitored by the EOBD. As there are no intake manifold flaps in the 1.2l TFSI engine, their tasks are performed by specially shaped swirl channels.

### **Open-deck design**

Is a cylinder block type. Upwards, the cooling channels are absolutely open. This allows for excellent coolant exchange between the cylinder block and cylinder head. However, cylinder blocks of this type exhibit less stability. Additional stability is provided by specially designed cylinder head gaskets.

### **Polyswirl™**

The Polytec Group has developed a passive separation system which significantly reduces the amount of residual oil in the blow-by gases while taking up a minimum of space.

### **PWM signal**

The abbreviation PWM stands for pulse width modulated signal. This is a digital signal of which one variable (e.g. electrical current) alternates between two values. The intervals between these changes vary according to activation. As a result, digital signals can be transmitted.

### **Saturation point**

The vacuum provided by the internal combustion engine or a vacuum pump increases the pressure applied to the brake pedal by the driver. Depending on how much vacuum is available, at certain pedal pressures there occurs a state in which the pressure acting upon the actuator unit can only be increased by applying more pedal pressure since the vacuum brake servo has reached maximum power assistance. This state is referred to as the “saturation point” of the vacuum brake servo.

### **TFSI**

Abbreviation for Turbo Fuel Stratified Injection, a technology used by Audi for direct fuel injection into the combustion chamber on turbocharged petrol engines. The fuel is injected at pressures upwards of 100 bar.

### **Valve timing**

The periods during which the valves of an engine are open or closed. Plotting the angular ranges of the valves on a circle diagram results in the timing diagram of an engine.

### **Wastegate**

The wastegate, or bypass, channels waste exhaust gases past the turbocharger drive. This allows the turbocharger to shut down or reduce its power output.

## Test your knowledge

### 1. Which of the following statements regarding the mechanical coolant pump is correct?

- a) The mechanical coolant pump has been deleted. The electrical coolant circulation pump V50 performs the task of the mechanical coolant pump.
- b) The mechanical coolant pump is shut down when the engine is cold-started, thus allowing the engine to heat up more quickly.
- c) The mechanical coolant pump has been replaced by an electrical coolant pump which is not switched on when the engine is started, thus allowing the cold engine to heat up more quickly.

### 2. Which of the following statements regarding the positive crankcase ventilation system is correct?

- a) The crankcase is ventilated from the cylinder block via a tube running into the intake manifold.
- b) The crankcase is ventilated internally via the cylinder block where the gases are admitted into the intake manifold.
- c) The crankcase is ventilated internally and the gases are admitted into the intake manifold or upstream of the exhaust turbocharger compressor wheel depending on the pressure conditions in the air supply.

### 3. How is charge pressure controlled?

- a) Charge pressure is controlled via charge pressure control solenoid valve N75 and a pressure cell.
- b) Charge pressure is controlled via the electrical charge pressure actuator V465 and the charge pressure actuator position sensor G581.
- c) Charge pressure is controlled via the control flap control unit J808.

### 4. Which of the following statements regarding the timing case is correct?

- a) The timing case has a one-piece design.
- b) The timing case has a two-piece design; the lower and upper parts of the timing case are made of plastic.
- c) The timing case has a two-piece design; the upper part of the timing case is made of plastic and the lower part is made of magnesium and fastened with special aluminium screws.

### 5. What are the advantages of the electrical charge pressure actuator?

- a) Fast adjustment times and, in turn, faster pressure build-up.
- b) The high actuating force ensures that the wastegate remains securely closed even in conditions of high pressure fluctuation.
- c) The wastegate can be actuated at any time with the result that the wastegate can open at lower engine loads/speeds; the basic charge pressure is reduced and the engine has less load-changing work to perform.

## Summary

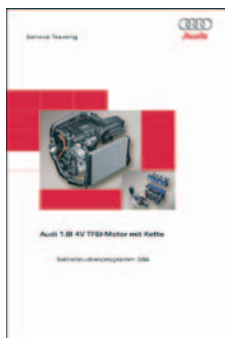
With the 1.2l TFSI engine, Audi offers an engine developed within the Volkswagen Group in the 100 kW class. It is a small and, therefore, economical unit. Nevertheless, it is a performance engine and, above all, it meets the required emission standards. All development objectives were achieved:

- ▶ reduced fuel consumption and CO<sub>2</sub> emissions
- ▶ reduced unit costs in production
- ▶ weight optimisation
- ▶ performance and driving pleasure

The engine was first employed on the VW Golf and subsequently on all A0 and A class Group models. Compared to the competition, the 1.2l TFSI engine is one of the front runners. It is, therefore, another key stepping stone towards reducing the CO<sub>2</sub> fleet emissions of the Volkswagen model range.

## Self Study Programmes

This Self-Study Programme summarises all you need to know about the 1.2l TFSI engine. You will find further information about the sub-systems mentioned in this document in our other Self-Study Programmes.



485\_054



485\_055



485\_056

**SSP 384** SSP 384 Audi chain-driven 1.8l 4V TFSI engine, order number: A06.5S00.29.20

**SSP 432** The Audi 1.4l TFSI engine, order number: A08.5S00.48.20

**SSP 436** SSP 436 Modifications to the chain-driven 4-cylinder TFSI engine, order number: A08.5S00.52.20

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