ŠKODA

Spark-ignition three-cylinder engine 1.0l TSI 85 kW series EA211

Self-study programme

ŠKODA Service®

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Contents

See VAS diagnostic tools and on-board literature for instructions for assembly and disassembly, repairs and diagnostics, and for detailed user instructions.

SP110_00

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1. Introduction

1.1 Spark-ignition three-cylinder engine 1.0l TSI 85 kW

The new modern turbocharged three-cylinder **1.0l TSI 85 kW** engine will replace the older four-cylinder **1.2l TSI 81 kW** engine in ŠKODA models.

With a displacement of 999 cm^3, the new 1.0l TSI engine has a power output of 85 kW at 2,000 to 3,500 rpm and a torque output of 200 Nm. The engine is very refined and its performance characteristics surpass its four-cylinder predecessor.

The **1.0l TSI 85 kW** engine is the first-ever three-cylinder engine deployed in the ŠKODA Octavia model range.

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Thanks to the compact design of its aluminium block, the engine weighs only 78 kg. Great care goes into the correct balancing of the aluminium pistons and forged connecting rods, and the engine is therefore very refined even without a balancing shaft. The crankshaft is very light and the created friction losses are very low.

The crankcase and the cylinder head have two independent cooling circuits.

The integrated exhaust manifold in the cylinder head plays an important part in engine heat management.

2. Engine technical data

2.1 1.0l TSI 85 kW engine parameters

Engine parameters:	1.0l TSI 85kW (engine code CHZD) CHZD)
Design	Transverse spark-ignition three-cylinder engine located in the front, with direct fuel injection, turbocharging, cooling by liquid, with two camshafts (DOHC) located in a cylinder head cover, and with toothed belt valvetrain drive.
Number of cylinders:	3
Displacement:	999 cm^3
Bore:	74.5 mm
Stroke:	76.4 mm
Number of valves per cylinder:	4
Maximum power:	**85 kW at 5,000–5,500 rpm**
Maximum torque:	**200 Nm at 2,000–3,500 rpm**
Compression ratio:	10.5: 1
Intake camshaft adjustment:	yes
Exhaust camshaft adjustment:	yes
Fuel preparation:	Electronically controlled direct fuel injection
Lubrication:	Circulating pressure circuit with full-flow oil filter
Fuel:	Unleaded gasoline with min. 95 octane rating
Emission standard:	EU 6

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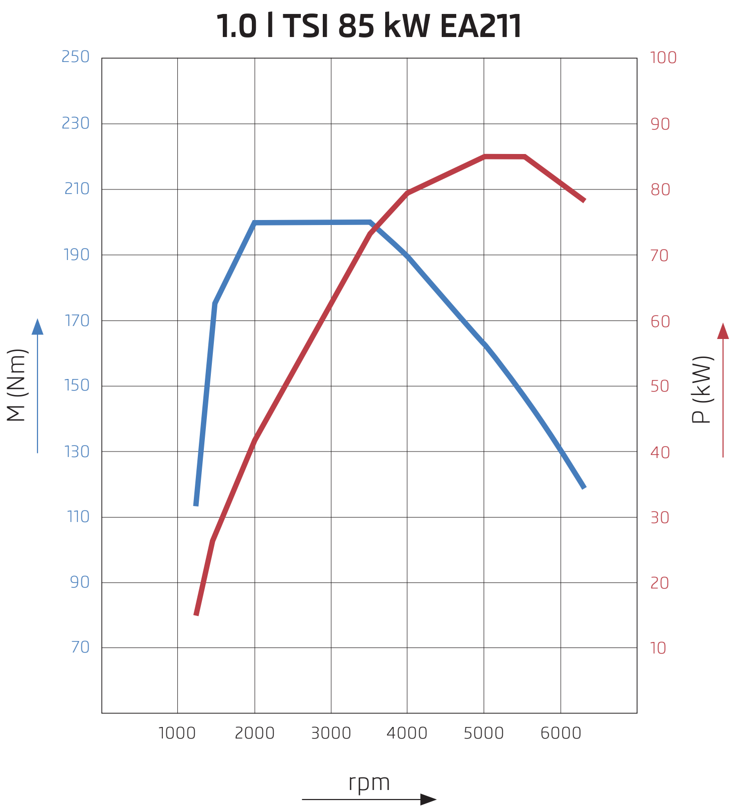
2.2 Power and torque characteristics of the three-cylinder 1.0l TSI 85 kW engine



P – power, M – torque, n – rpm

torque curve
power curve

2.3 Characteristic technical features of the 1.0l TSI 85 kW engine

1.0l TSI 85 kW engine design
Direct fuel injection
Exhaust turbocharger with an electric waste gate
Camshafts driven by a toothed belt
Cylinder head with an integrated exhaust manifold
Cooling regulator case with an integrated coolant pump
Coolant pump driven by a toothed belt off of the exhaust camshaft
Intake camshaft adjustment (50° of the crankshaft)
Exhaust camshaft adjustment (40° of the crankshaft)
Rotary vane oil pump with continuous oil pressure regulation

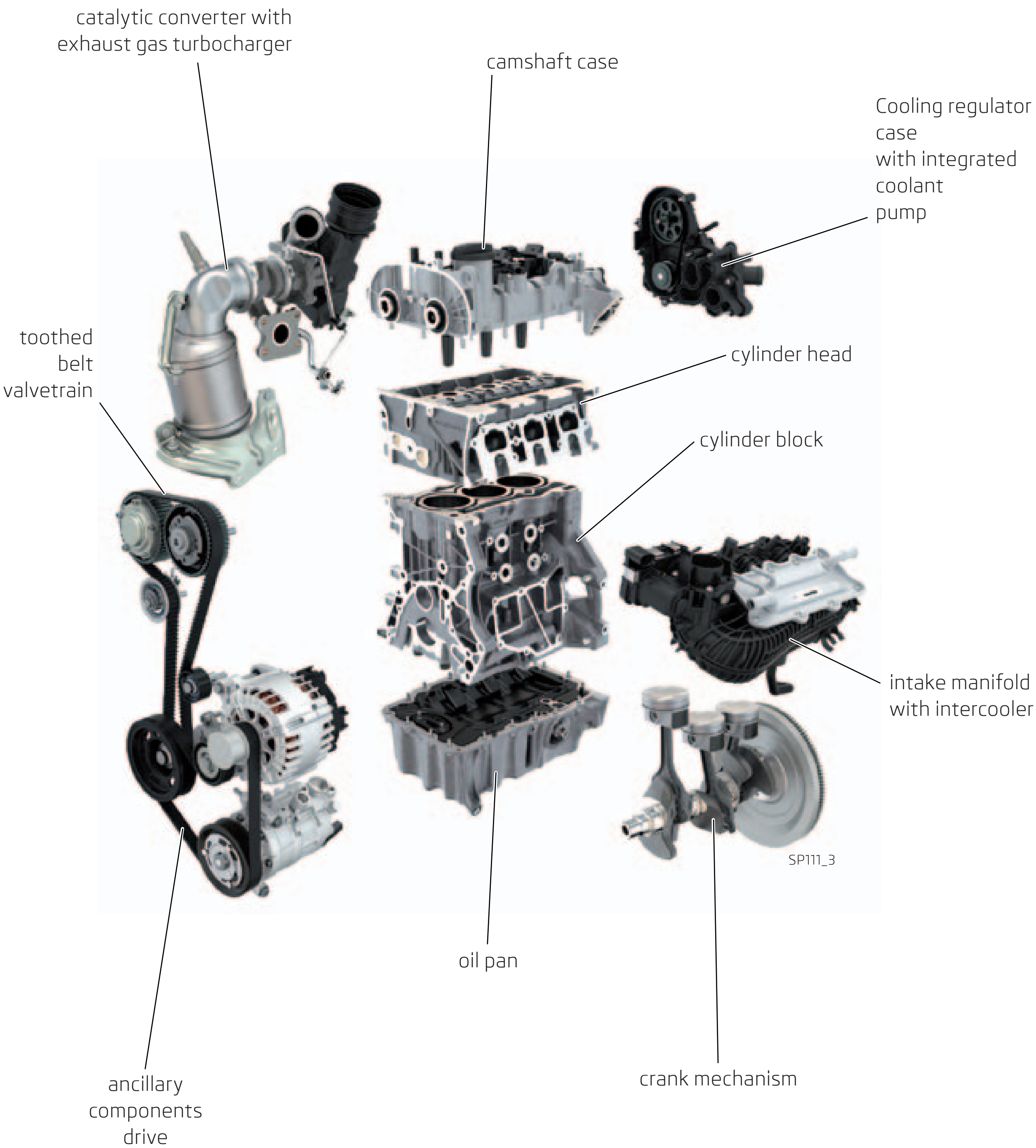
2.4 Modular engine construction

As is typical of the current EA211 engine range, this engine also uses a modular method of construction.

2.4.1 Common technical features of the EA211 engine range

Modular MOB features:
Fixed engine installation position
The air-condition compressor and alternator are mounted directly to the oil pan, cylinder block and oil pump housing without the use of an additional bracket.
Four-valve technology
Aluminium cylinder block
Cylinder head with an integrated exhaust manifold
Camshafts driven by a toothed belt
Cooling pump driven by a toothed belt

2.4.2 Modular construction of the three-cylinder 1.0l TSI 85 kW engine

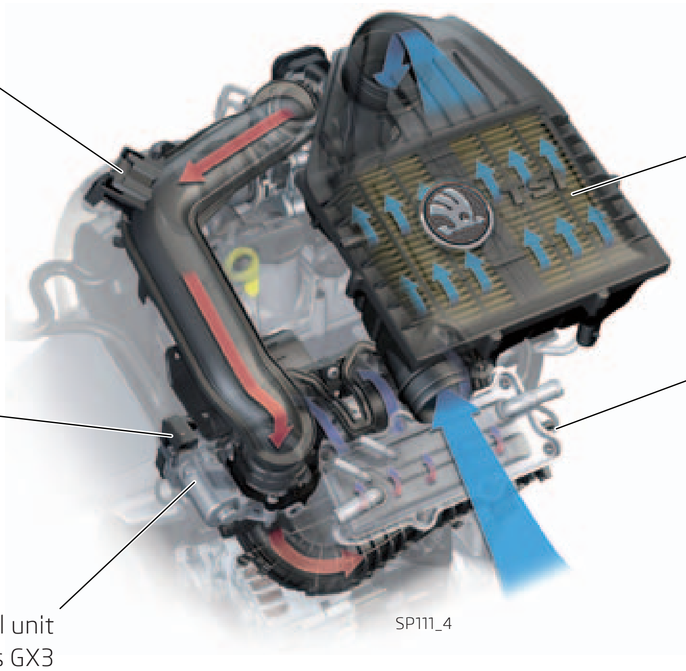


3. Engine mechanics

3.1 Characteristic features of the engine mechanics

3.1.1 Compact intake system

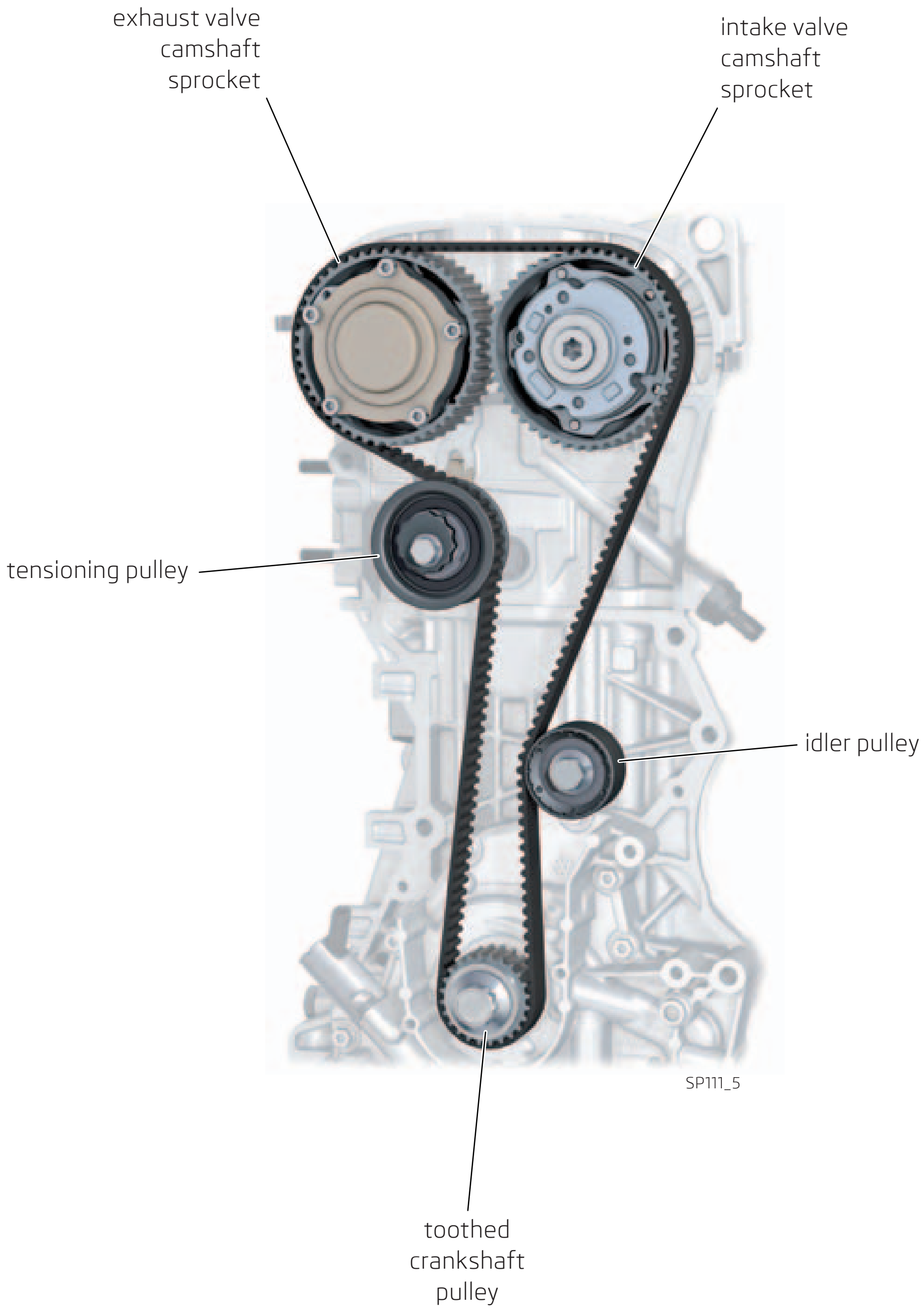
The intake system contains the air filter, turbocharger, throttle valve control unit GX3, intake manifold, and intake valves. It was designed to be as compact as possible in order to achieve fast reaction times for the turbocharger even at low engine speeds. There are two pressure senders in the intake system containing intake air temperature senders. These senders are located upstream of the throttle valve control unit and on the intake manifold downstream of the intercooler .



The intake manifold sender GX9 contains two senders. Intake air temperature sender 2 G299 and intake manifold pressure sender G71.
The intake pressure sender GX26 contains two senders. Intake pressure sender G31 and intake air temperature sender G42.

3.1.2 Toothed belt drive

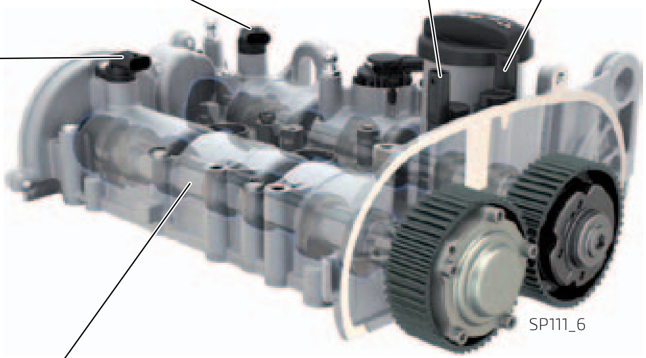
The camshafts are driven by a toothed belt. The belt is tensioned by an automatic tensioning pulley which is also equipped with a supportive lip to correctly guide the toothed belt. The combination of the idler pulley on the leading side and the camshaft sprockets ensures the steady operation of the belt.



3.1.3 Camshaft case

The camshaft case is an aluminium pressure casting which contains both camshafts and forms a single integrated module. This means that the camshafts, which are located in four bearings, cannot be disassembled.

The camshaft case also serves to hold the camshaft adjustment valves for the intake side (N205) and the exhaust side (N318), and also holds Hall senders G40 and G300.



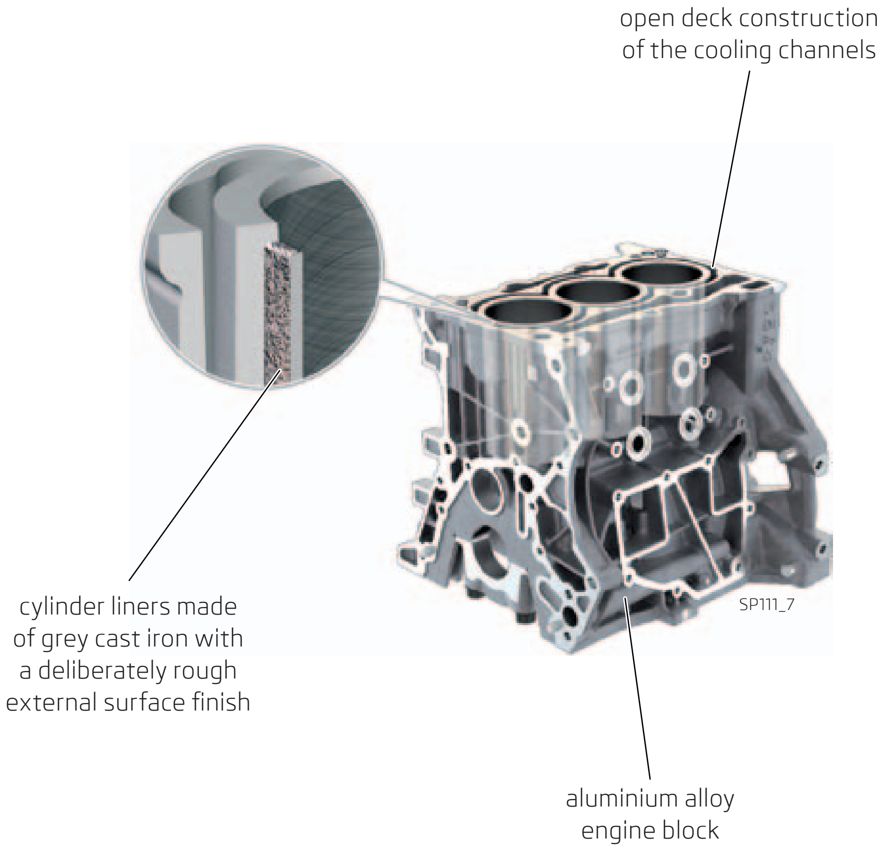
3.1.4 Aluminium cylinder block

The cylinder block is an aluminium pressure casting utilising an **open deck** cooling jacket design. The open deck design used for the cylinder block brings the following advantages:

- easier and less-costly production of the aluminium alloy cylinder block; (the engine block is manufactured by pressure casting without the necessity of using a sand core)
- compared to a closed deck design, the engine has better cooling in the upper section of the cylinder which is under the greatest temperature load (heat is conducted very quickly from the piston ring area)
- the cylinder liner shows minimal deformation after the cylinder head is attached and torqued to the engine block; (the piston rings can optimally adapt to the minor deformation of the cylinder liner)

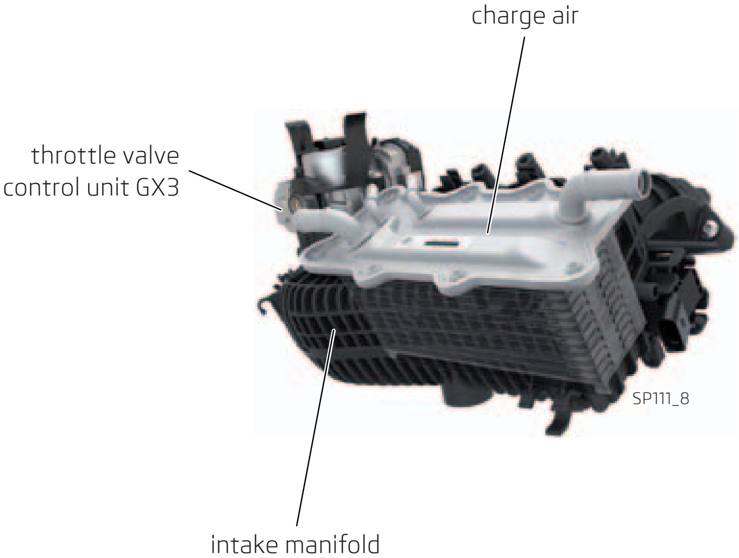
The cylinder liners are made of grey cast iron with a rough external surface finish. The purpose is to increase the contact area between the liner and the material of the engine block.

The individually integrated cylinder liners with a deliberately rough surface finish ensure a high level of rigidity in the cylinder block. The cylinder liners are honed in a honing machine to reduce cylinder deformation. This has made it possible to reduce piston ring pre-tension.



3.1.5 Charge air cooling

When the turbocharger compresses inlet air, it is heated up undesirably. It is necessary to cool the air. The intake air is routed through the intercooler which is integrated in the intake manifold module. The intercooler is an air-water heat exchanger and it is also connected to the engine cooling circuit.



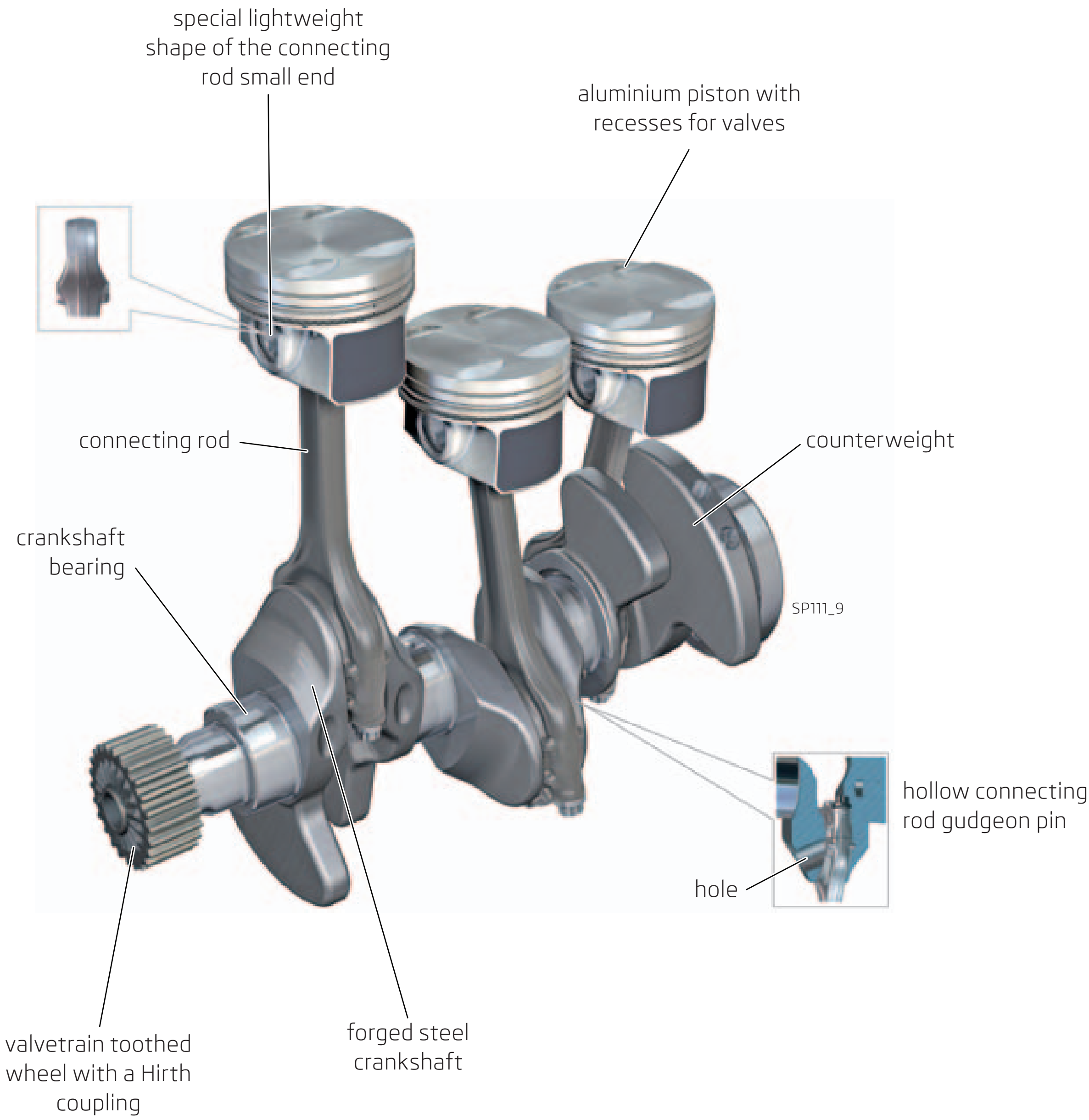
The intercooler is a part of the independent intake air cooling system. When the intake air is compressed, it heats up to a considerable temperature and is then passed through an intercooler. Most of the heat is then dissipated into the intercooler and the coolant.

Intercooler location

In the EA211 engine series, the intercooler is integrated into the plastic intake manifold. The advantage of this design is that the volume of air in the system is relatively low throughout the whole circuit, and it is therefore possible to compress it quickly. The result is a very fast rise in the charging pressure and spontaneous reactions of the engine. The intake air line through the plastic pipe from the turbocharger to the intake pipe module is also very short.

3.2 Crank mechanism

The crankshaft mechanism was designed with an emphasis on low inertia and friction. The weight of the forged connecting rods and aluminium pistons has been optimised in a way to forego the use of a balancing shaft. Together with the small crankshaft bearings (diameter 45 mm) and connecting rod bearings (diameter 47.8 mm), the weight of the engine and the friction of the crank mechanism has been further reduced.



Crankshaft

The steel crankshaft is located in four main bearings and has four counterweights to reduce internal forces in the crankshaft and the loads on the main bearings.
As an additional weight saving measure, the connecting rod gudgeon pins are hollow.

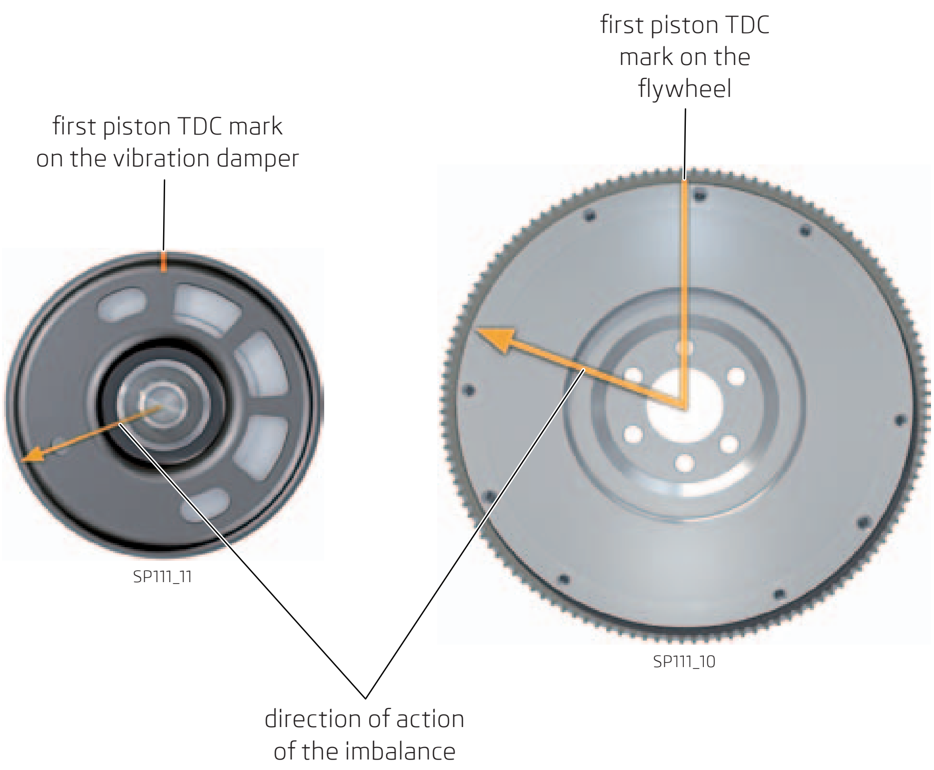
3.2.1 Technical features of the crank mechanism

Characteristic features of the pistons, piston rings, piston pins, connecting rods and bearings:
The pistons feature shallow recesses in the piston crown. This has the effect of reducing weight and evenly distributing the temperature across the piston crown.
The installation clearance for the pistons has been increased to reduce friction.
The piston pins carry a special hard carbon coating which is highly resistant to wear. The small end connecting rod bearing surfaces have also been hardened by so-called rolling. As a result of both measures, it is possible to forego the use of gudgeon pins for the connecting rod small ends.
The big ends of the connecting rods are manufactured by so-called fracture splitting. The small end of the connecting rod has a special lightweight design in the area which is under less load. Weight and friction has therefore been reduced.
The first crankshaft bearing wears a polymer coating for additional wear resistance due to the operation of the Start-Stop system.

3.2.2 Vibration damper and flywheel

Generally favourable vibration characteristics of the engine have already been achieved due to the basic design of the engine utilising rigid construction, a light crank mechanism and transverse location.

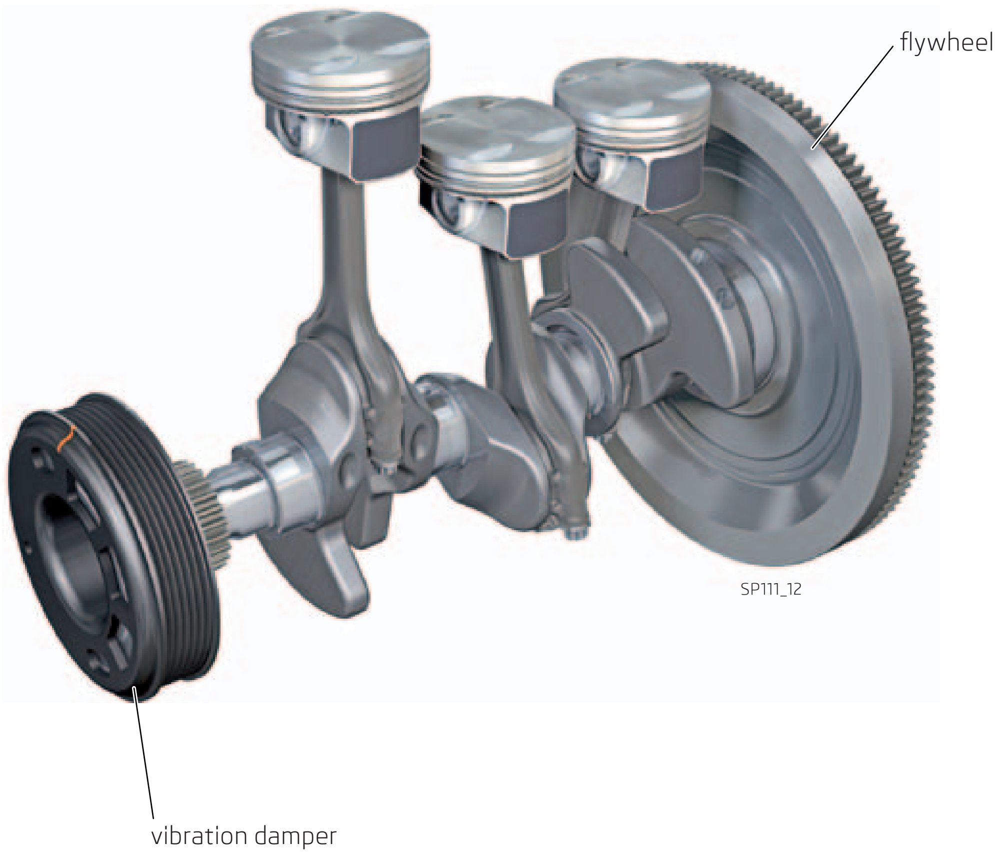
In order to refine engine operation even further, the vibration damper and the flywheel use deliberate material allowances and holes, respectively, to feature imbalances specific for the vehicle. This means that these imbalances have been adapted to the specific vehicle model.



When fitted correctly, the directions of action of both imbalances are approximately aligned against each other. Together with the optimised engine mounts, the vibration characteristics of the engine are improved and less noise is transmitted to the interior of the vehicle.

It is necessary to always fit the vibration damper to the toothed crankshaft pulley in the correct position. Attention, the position is not locked in place. **Follow the instructions in the Workshop Manual.** The vibration damper is a part of the V-belt pulley. See the fitting instructions for the vibration damper on page 18 of this workbook.

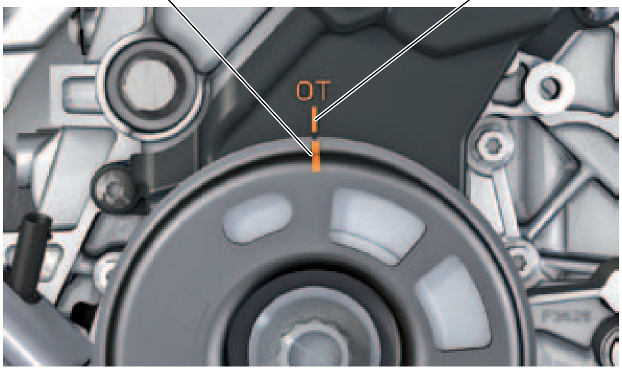
The correct fitting position of the flywheel to the crankshaft is ensured by the irregular position of one of the mounting holes. It is therefore impossible to misjudge the correct position.



3.2.3 Vibration damper fitting instructions

Due to an inherent imbalance in the vibration damper, it is necessary to use the correct fitting position for installing the damper:

- The engine must be at TDC for cylinder 1.
- The TDC marks on the vibration damper (groove) and the toothed belt cover (indentation) must be aligned in relation to each other.



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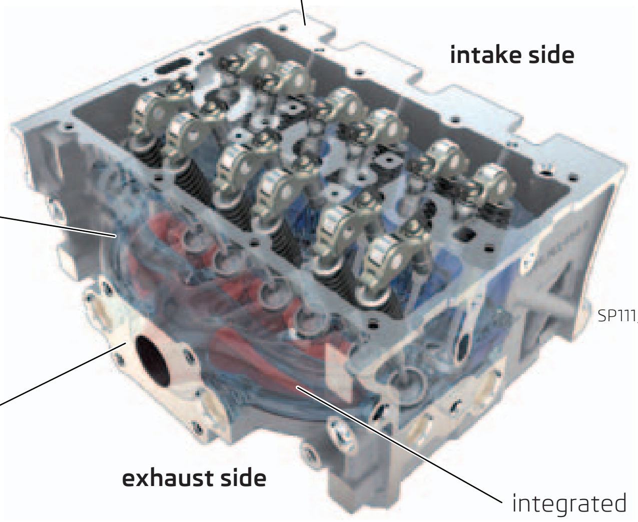
Alignment of TDC marks

The Hirth coupling on the vibration damper and the toothed crankshaft pulley are not equipped with any kind of mechanical coding. This means that it is possible to fit the vibration damper coupling to the toothed crankshaft pulley coupling in any position. For this reason, it is necessary to check that the TDC marks are aligned before the vibration damper is fitted (with using the prescribed torque).

3.3 Cylinder head

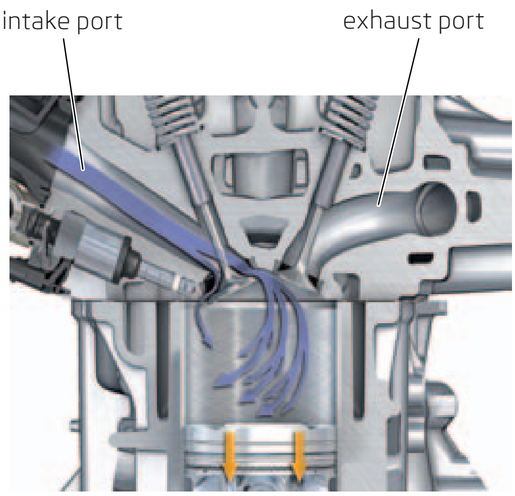
The integrated exhaust manifold in the aluminium cylinder head makes it possible to quickly utilise exhaust gas energy and rapidly warm up the engine. In the newest design evolution of the cylinder head, the main focus is on optimising fuel mixture preparation.



Characteristic design features of the cylinder head:
Four-valve technology with roller finger cam followers and backlash compensation
Cross-flow cooling
Integrated exhaust manifold
Suitable for the use of alternative fuels

3.3.1 Mixture preparation

The intake port is designed to allow high fuel mixture flow speeds without limiting the flow volume. The cylindrical shape of the inlet air intake port ensures high flow speeds with very good fuel mixture preparation.



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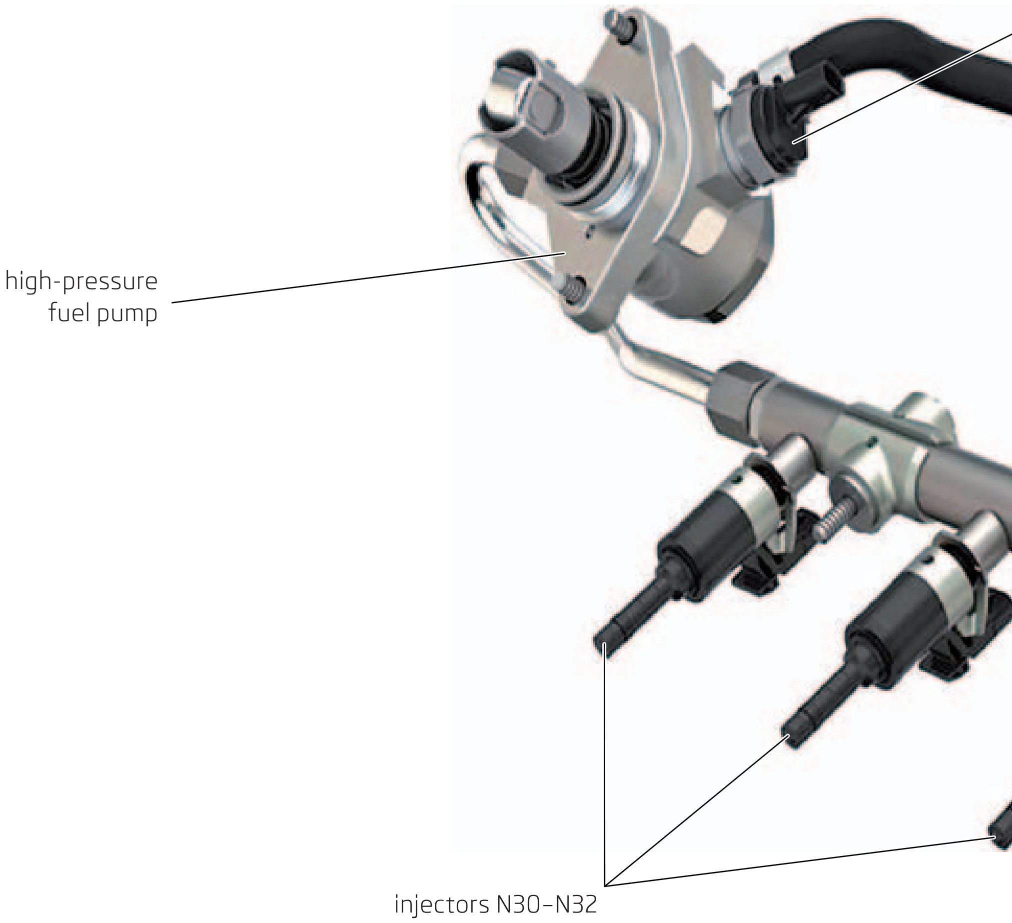
Notes:

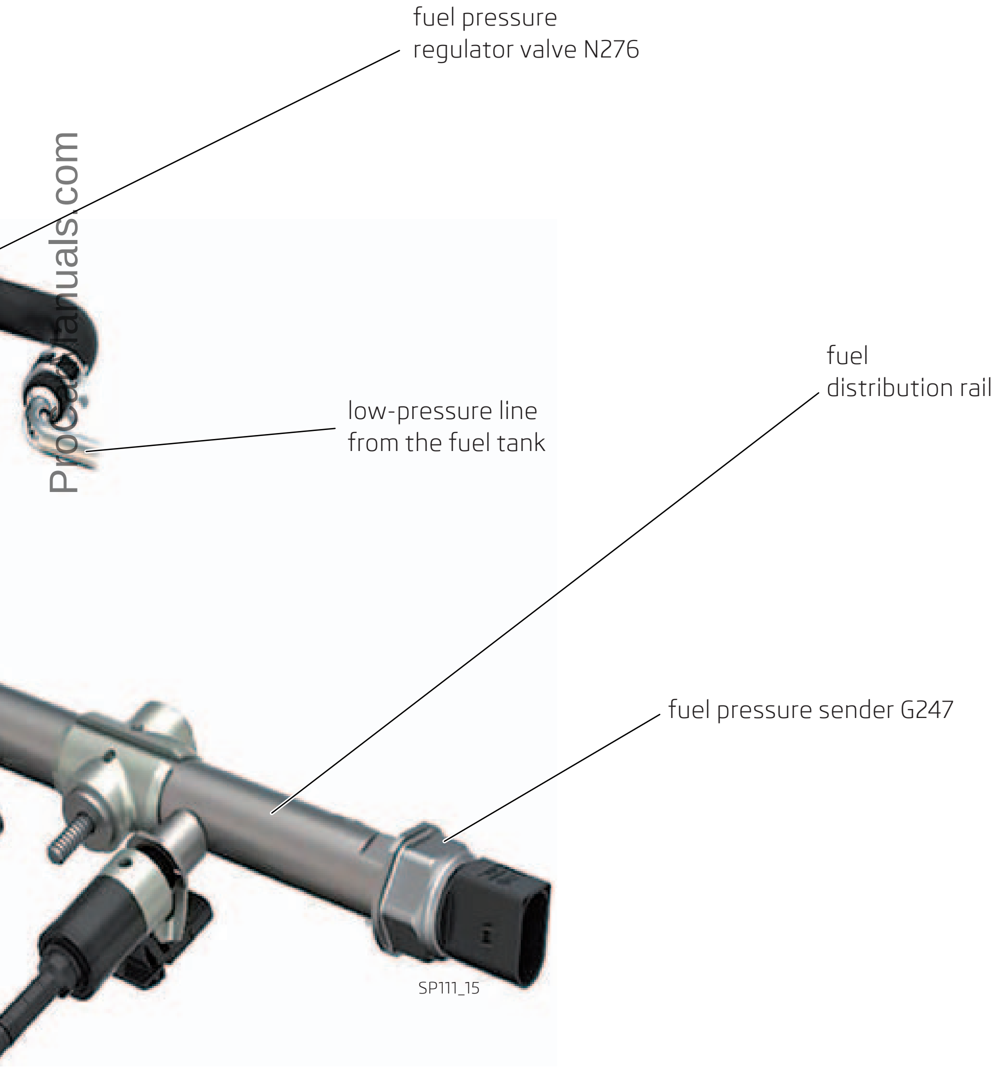
3.4 High-pressure fuel system

The basic design of the high-pressure fuel system corresponds with the design of the TSI EA211 engine series.

For the first time, however, fuel injection pressures of up to 250 bar are achieved. Together with the optimised stream shape of the injected fuel, very good mixture preparation is ensured throughout all loads and engine speeds. This has the effect of reducing fuel consumption, exhaust emissions and the adulteration of engine oil by fuel.

Characteristic features of the high-pressure fuel system:
High-pressure fuel pump with fuel pressure regulator valve N276
Injection pressure ranging from 120 to 250 bar
Fuel distribution rail made of stainless steel
5-hole injectors N30–N32
Fuel pressure sender G247
Multiple injections (up to three injections on engine start-up, catalytic converter warm-up and under full load up to 3,000 rpm)




fuel pressure
regulator valve N276
low-pressure line
from the fuel tank
fuel
distribution rail
fuel pressure sender G247
SP111_15

3.5 Turbocharger

The demands placed on the exhaust gas turbocharger are related to the performance characteristics of TSI engines. These include fast reaction times and high torque output at low engine speeds.

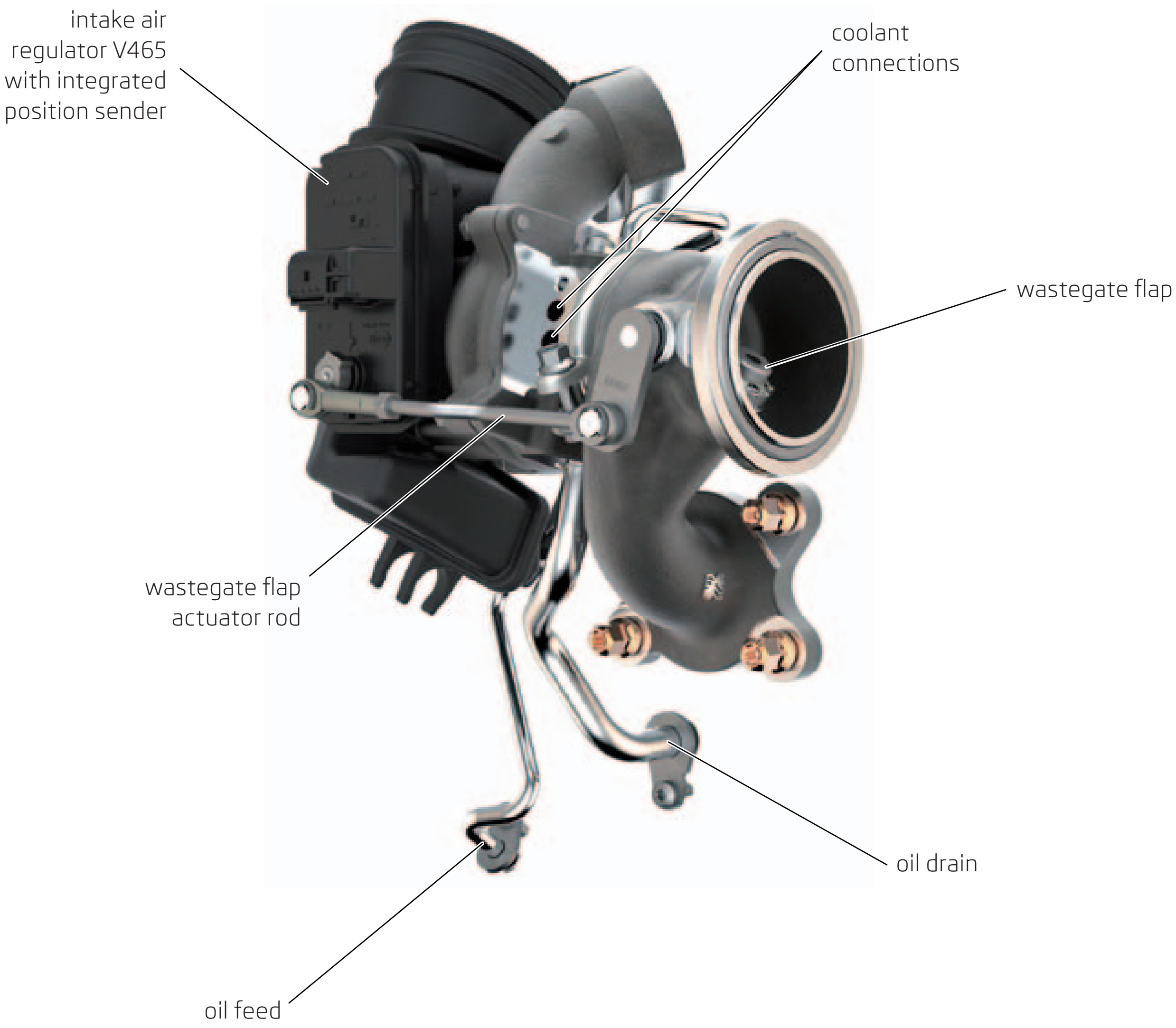
In order to achieve the required performance, the intake manifold was designed to be as compact as possible, and other modifications were made to the exhaust gas turbocharger:

- The angle of the exhaust gas flow over the turbine wheel is designed to easily overcome its moment of inertia. The turbine wheel can therefore quickly accelerate to high speeds.
- The wastegate flap is adjusted by the electronic charging pressure regulator which has very fast reaction times and high control forces.

Characteristic features of the high-pressure fuel system:
Charging pressure of up to 1.6 bar (relative)
Electronic charging pressure regulator with revolving outlet
High-temperature resistant cast steel housing for exhaust gas temperatures of up to 1,050° C

If a mechanical defect is found on the turbocharger (e.g. a damaged turbine wheel), the replacement of the turbocharger alone is not a sufficient repair. In order to prevent any future damage, it is necessary to carry out the following tasks:

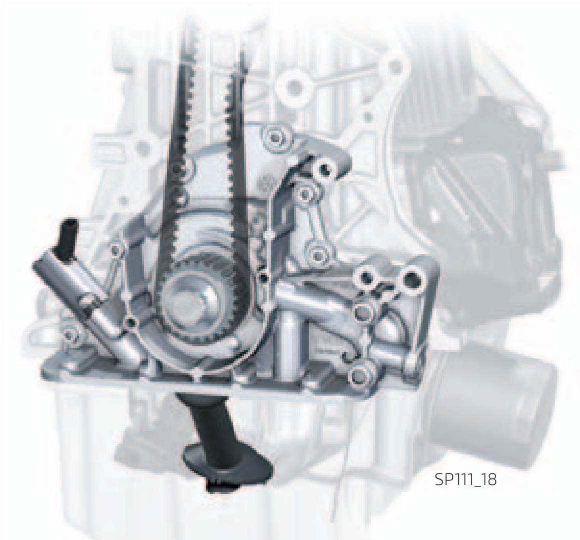
- Check for dirtiness in the air filter box, the air filter element and the intake air pipes.
- Check the complete length of the inlet air line and the intercooler for the presence of foreign objects.
- If foreign objects are found in the intake air system, clean the intake air line and replace the intercooler, if necessary.


intake air regulator V465 with integrated position sender
coolant connections
wastegate flap
wastegate flap actuator rod
oil drain
oil feed

3.6 Continuous oil pressure regulation

3.6.1 Rotary vane oil pump

The three-cylinder 1.0l TSI engine uses a continuous oil pressure regulation system. The oil pressure is regulated depending on the engine load, engine speed and oil temperature by a rotary vane oil pump. The pump is driven directly off of the crankshaft.



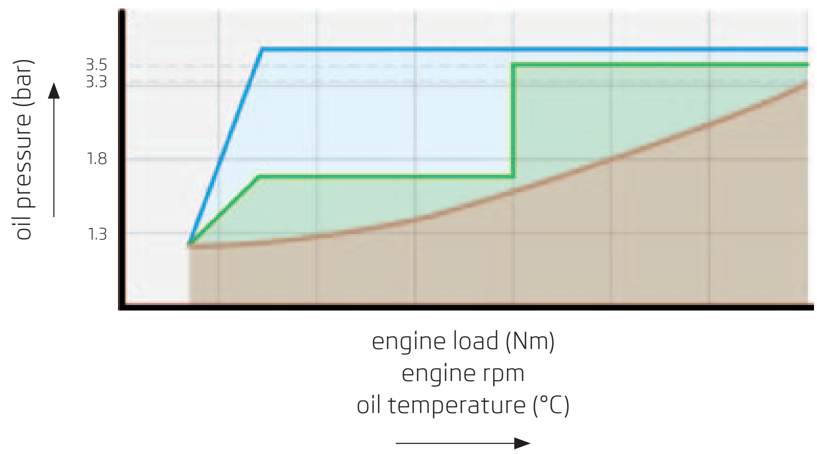
rotary vane oil pump

3.6.2 Advantages of continuous oil pressure regulation

Although four-cylinder 1.4l TSI engines switch between two pressure values, the oil pressure in this engine is regulated continuously in the pressure range from 1.3 to 3.3 bar (overpressure).

The input power of the pump is thereby even better adapted to the operating conditions of the engine.
The input power of the oil pump is significantly reduced mainly under the typical loads exerted by the customer, such as urban and extra-urban driving.

3.6.3 Comparison graph for continuous and two-stage oil pressure regulation



- continuously regulated oil pressure (1.0l TSI engines)
- two-stage oil pressure regulation (1.4l TSI engines)
- non-regulated oil pressure (1.0l and 1.2l engines)

Benefits compared to two-stage oil pressure regulation:
Additional reduction of internal friction in the engine
Additional reduction of the input power of the oil pump; the oil pump only pumps the necessary quantity of oil.
Additional reduction of oil deterioration in the oil circuit due to a lesser quantity of circulated oil

3.6.4 Construction design of the vane oil pump

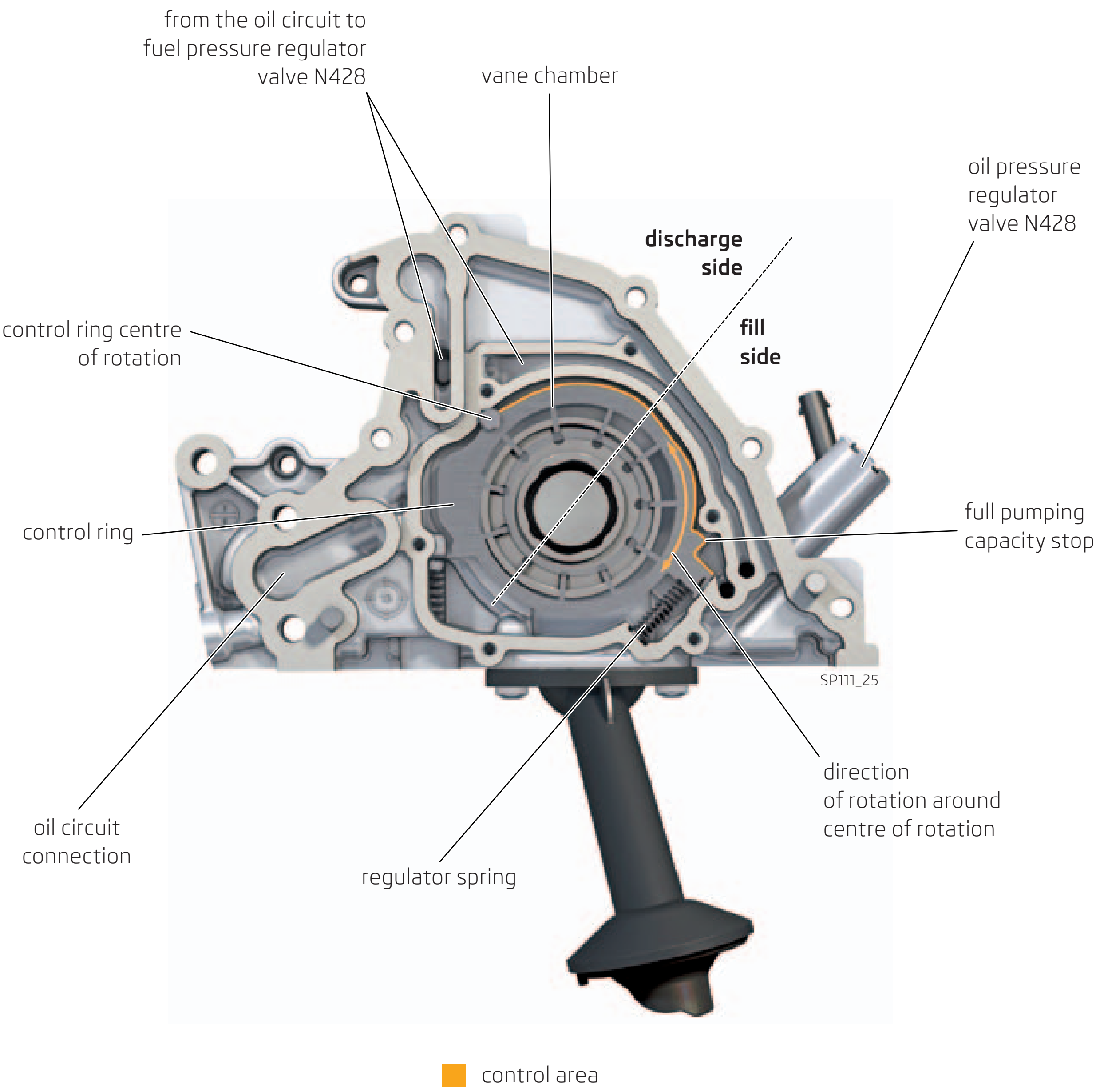
The rotary vane oil pump is equipped with an eccentrically mounted control ring. By rotating the control ring, the volume between the vane chambers on the fill and discharge side is either enlarged or reduced. This changes the quantity of the pumped oil.

Control mechanism

The control ring is rotated and the quantity of the pumped oil changes under the following conditions:

- The oil pressure regulator valve is actuated and oil from the oil circuit is directed to the control area. The force exerted by the oil on the control ring rotates the control ring clockwise against the force of the regulator spring.
- The volume between the vane chambers is decreased and the oil pressure is lowered.
- The oil pressure regulator valve is actuated by less oil being directed from the oil circuit to the control area. The force exerted by the oil decreases and the force of the spring rotates the control ring counter-clockwise. The volume between the vane chambers is larger and the oil pressure is increased.

The rate of rotation of the control ring depends on the actuation of the oil pressure regulator valve.



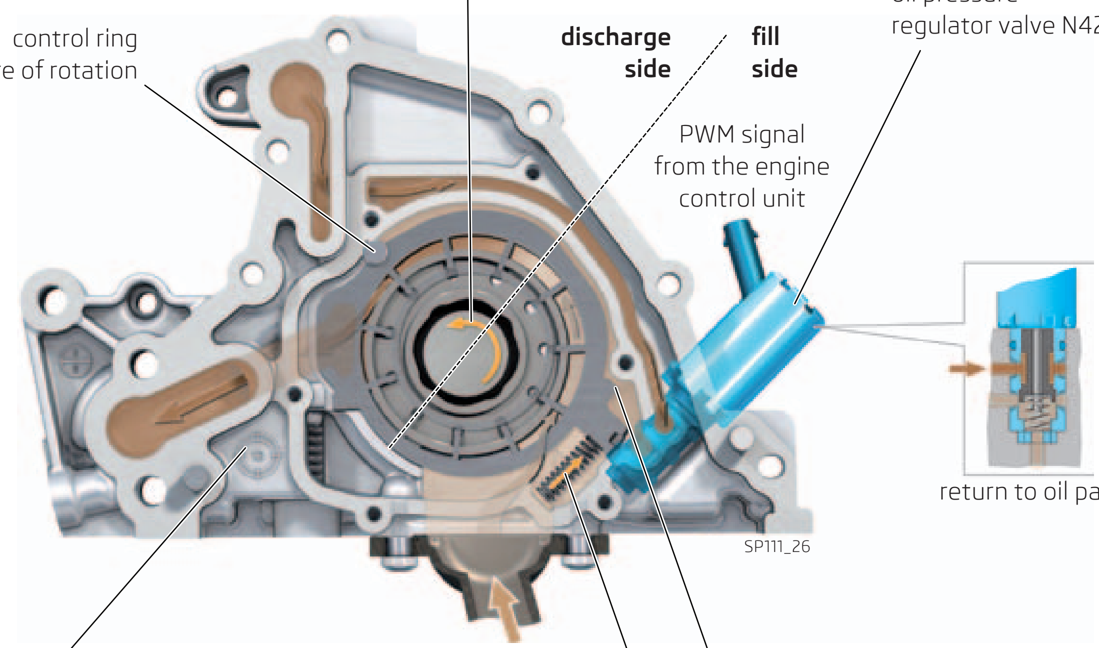
from the oil circuit to
fuel pressure regulator
valve N428
vane chamber
oil pressure
regulator
valve N428
discharge
side
fill
side
control ring centre
of rotation
control ring
full pumping
capacity stop
SP111_25
direction
of rotation around
centre of rotation
oil circuit
connection
regulator spring
control area

Function

Engine start-up

When starting the engine, it is necessary to generate oil pressure as quickly as possible:

- The oil pressure regulator valve N428 is actuated by the engine control unit via a pulse width modulation signal.
- Since there is still no oil pressure exerted on the control area, the regulator spring compresses the control rings counter-clockwise against the full pumping capacity stop.
- The chambers between the vanes on the fill and discharge side are open to the maximum setting.
- The oil pump delivers the maximum quantity of oil into the oil circuit for the applicable engine speed.



vacuum

oil pressure (up to 3.3 bar)

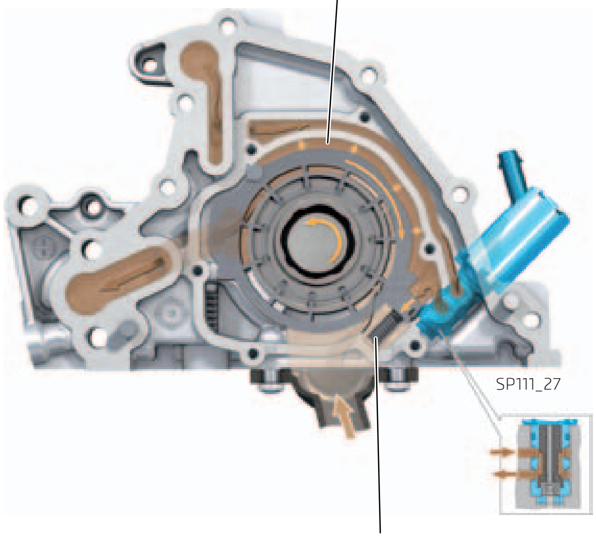
The oil return to the oil pan is open only if the oil pressure regulator valve is not actuated.

Engine running

When the engine is running, the oil pressure is always regulated continuously based on the characteristic fields for the engine load and speed and the temperature of the oil. The oil pressure regulator valve is actuated via a pulse width modulation signal (PWM) and ensures the applicable cross-section of the flow on the fill side of the oil circuit. The oil is introduced to the control area, rotates the control ring and thereby adjusts the actual oil pressure.

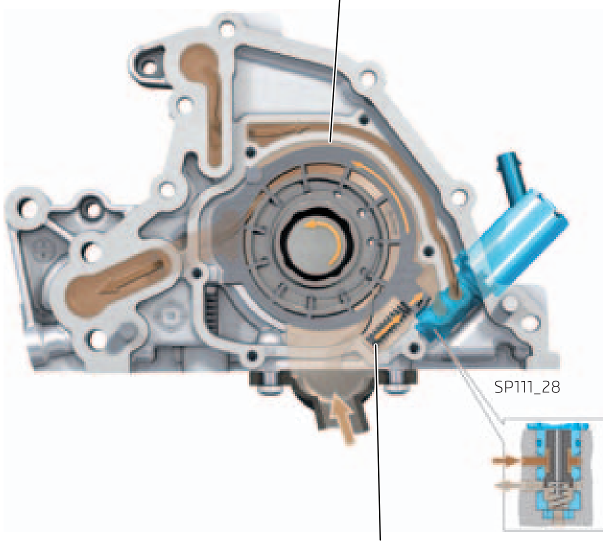
Decreasing the quantity and pressure of pumped oil

- The oil pressure regulator valve N428 is actuated by the engine control unit via a pulse width modulation signal (PWM) with a large impulse width.
- The cross-section to the control area of the control ring expands greatly. The oil pressure is exerted on the control area.
- The resulting force is higher than the force of the control spring, which rotates the control ring clockwise in the direction of the centre of the rotary vane oil pump. The pumping area of the fill and discharge side decreases and a lower quantity of oil is pumped into the oil circuit.



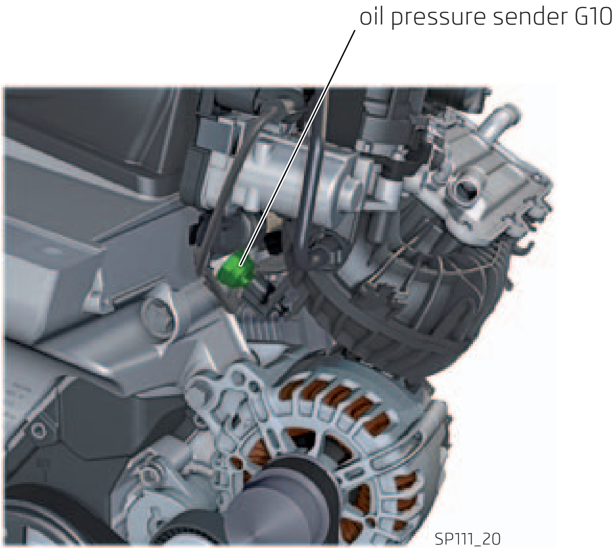
Increasing the quantity and pressure of pumped oil

- The oil pressure regulator valve N428 is actuated by the engine control unit via a pulse width modulation signal (PWM) with a narrow impulse width. The cross-section to the control area of the control ring is reduced.
- There is less oil pressure exerted on the control area.
- The resulting force is lower than the force of the control spring, which rotates the control ring counter-clockwise in the direction of the full pumping capacity stop. The pumping area of the fill and discharge side increases and a higher quantity of oil is pumped into the oil circuit.



3.6.5 Oil pressure sender G10

The oil pressure sender continuously measures oil pressure and transmits the data to the engine control unit via a data protocol.
Based on this signal, the engine control unit actuates the oil pressure valve and adjusts the quantity of the pumped oil. The oil pressure rises or falls, respectively.



Oil pressure sender G10 is screwed into the cylinder head under the toothed belt side under the intake manifold. It continuously measures oil pressure and transmits the data to the engine control unit via a data protocol.

Benefits of oil pressure sender G10:
Oil pressure is generated and correspondingly adjusted in short time intervals.
The signals are immune to electromagnetic interference.

Use of the signal from oil pressure sender G10

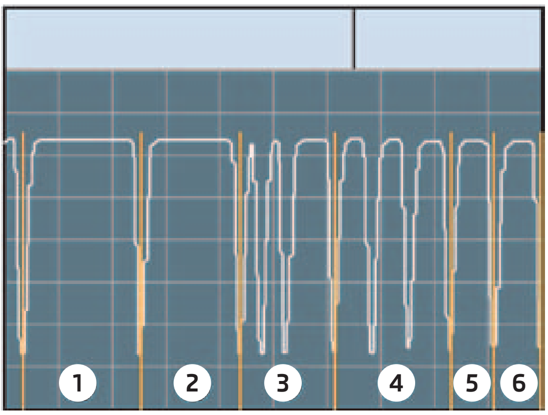
Depending on the characteristic field, the oil pressure sender signal is used for regulating the oil pressure to values from 1.3 to 3.3 bar. The signal is also used to check if the minimal oil pressure is available.

Consequences of signal loss from oil pressure sender G10

In the event of a signal loss from the oil pressure sender, the engine control unit calculates a substitute pulse width modulation signal (PWM) to constantly maintain oil pressure at approx. 3.3 bar. In such case, a record will be made in the event memory.

Oil pressure sender signal graph

The oil pressure sender sends a SENT data protocol to the engine control unit at short time intervals on the current oil pressure. The SENT data protocol consists of six information units.



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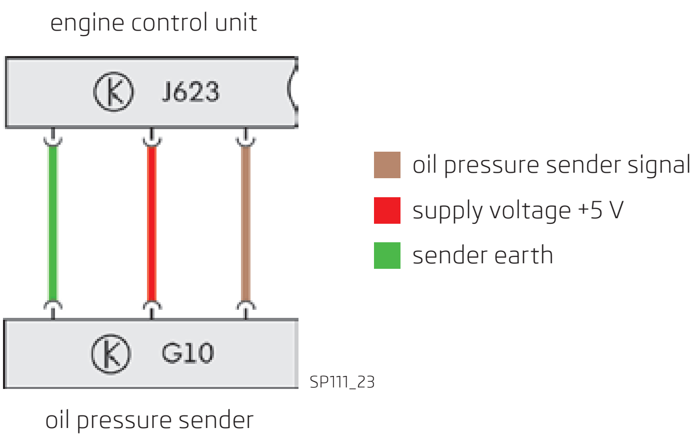
Meaning of SENT data protocol information units:	
1	Data transmission start; transmission of oil pressure sender information
2	Start of data transmission
3	Signal 1 (oil pressure)
4	Signal 2 (currently not utilised)
5	Check of validity of the transmitted data
6	Pause until the next data transmission

Signal evaluation

The evaluation electronic circuit of the oil pressure sender transforms the measured voltage corresponding to the oil pressure to a SENT data protocol and sends it to the engine control unit. The engine control unit evaluates the elapsed time between two dropping impulse slopes to identify the content of various information units, including the oil pressure value.

Electrical connection



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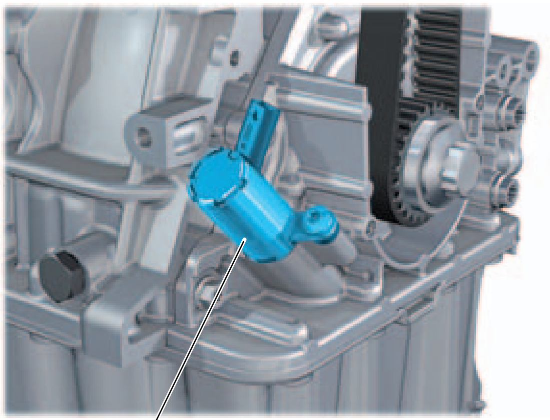
3.6.6 Oil pressure regulator valve N428

The oil pressure regulator valve N428 is actuated by the engine control unit on the basis of a characteristic field via a pulse width modulation signal (PWM) to values ranging from 20 % to 80 %. Depending on the actuation, the valve continuously controls the cross-section of the flow to the control area channel. The oil pressure is increased or decreased depending on the quantity of the oil directed to the control area.



oil pressure regulator valve N428

Function

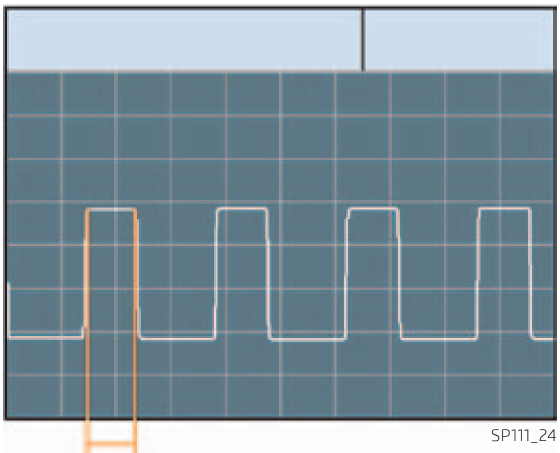
The oil pressure regulator valve N428 is a hydraulic 3/2-way valve. It is actuated by the engine control unit by pulse width modulation (PWM signal) depending on a characteristic field. The valve is actuated to ensure a given cross-section flow to the control channel in the rotary vane oil pump. Oil is introduced directly to the control area of the control ring. The oil readjusts the control ring and thereby affects the actual quantity of the pumped oil.

Consequences of signal loss

If there is no voltage introduced to the valve, the cross-section of the flow to the oil pump control channel either remains mechanically open or closed depending on the actual oil pressure.
In such case, the approximate oil pressure at a temperature of 120 °C is approx. 4.5 bar.
With the help of mechanical regulation, the necessary oil pressure is always ensured.
If the oil pressure rises to more than 4.5 bar, for example during acceleration, the cross-section of the flow to the control channel fully opens.
The oil flows to the control area and rotates the control ring in a way to lower the quantity of the pumped oil and thereby to lower the oil pressure to approx. 4.5 bar.

Activation of oil pressure regulator valve N428

The engine control unit actuates the fuel pressure regulator valve via a pulse width modulation signal (PWM). The impulse width varies between 20 % to 80 %, which makes it possible to continuously regulate the valve. The larger the impulse width, the greater the cross-section of the flow to the control channel.



impulse width

4. System overview

1.1 Spark-ignition three-cylinder engine 1.0l TSI 85 kW

Sensors

intake manifold sender GX9
intake manifold pressure sender G71
intake air temperature sender 2 G299

intake pressure sender GX26
intake pressure sender G31
intake air temperature sender G42

engine speed sender G28

Hall senders G40, G300

throttle valve control unit GX3
throttle valve control unit J338
angle senders 1 and 2 for throttle valve drive for electric accelerator pedal control G187, G188

accelerator pedal module GX2
accelerator pedal position senders G79
sender 2 of accelerator pedal position G185

clutch pedal position sender G476

brake light switch F

fuel pressure sender G247

knock sensor 1 G61

coolant temperature sender G62

coolant temperature sender in radiator outlet G83

lambda probe 1 before catalyst GX10
lambda probe G39

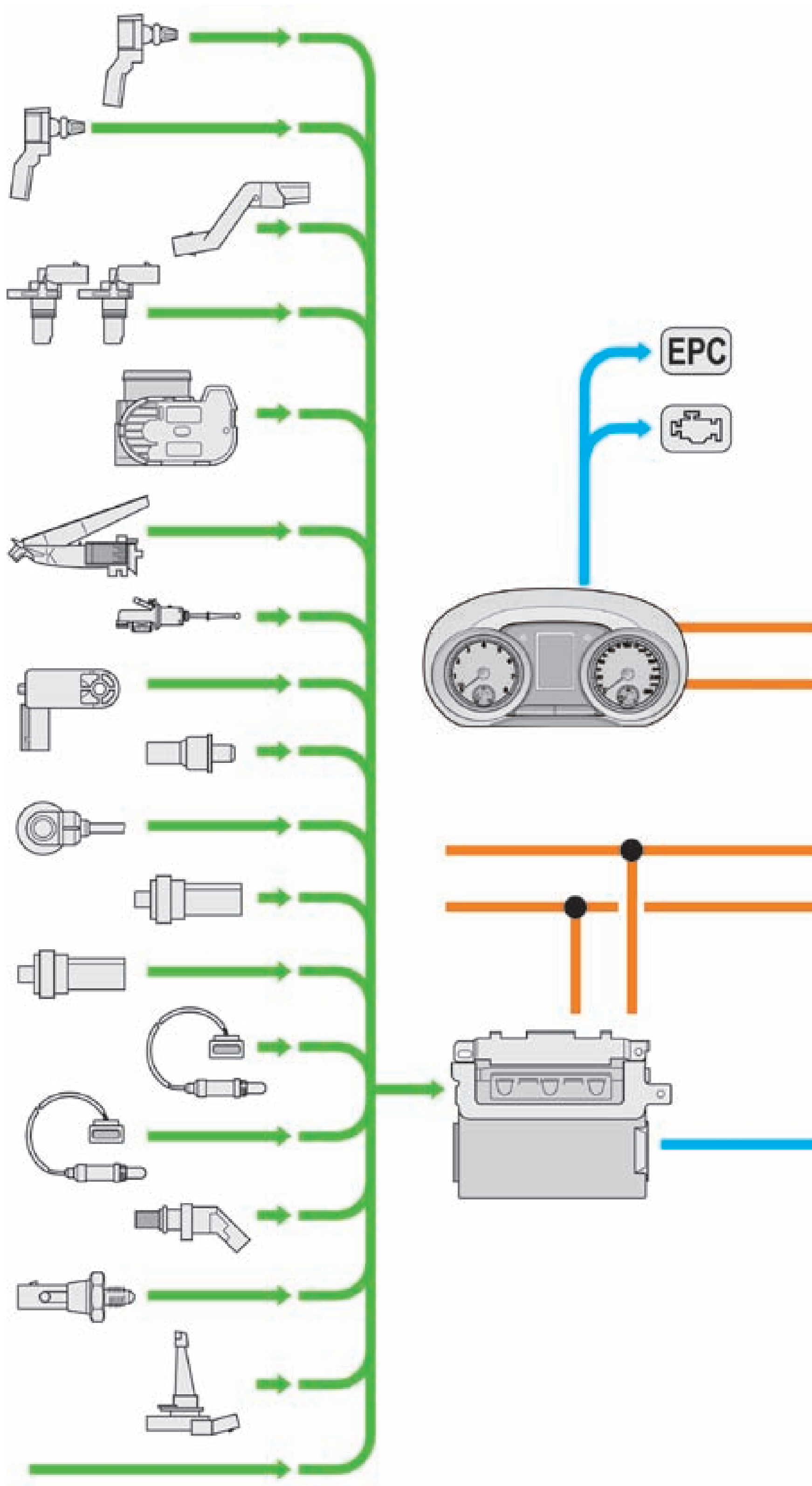
lambda probe 1 after catalyst GX7
lambda probe 1 after catalyst G130

gearbox neutral position sender G701

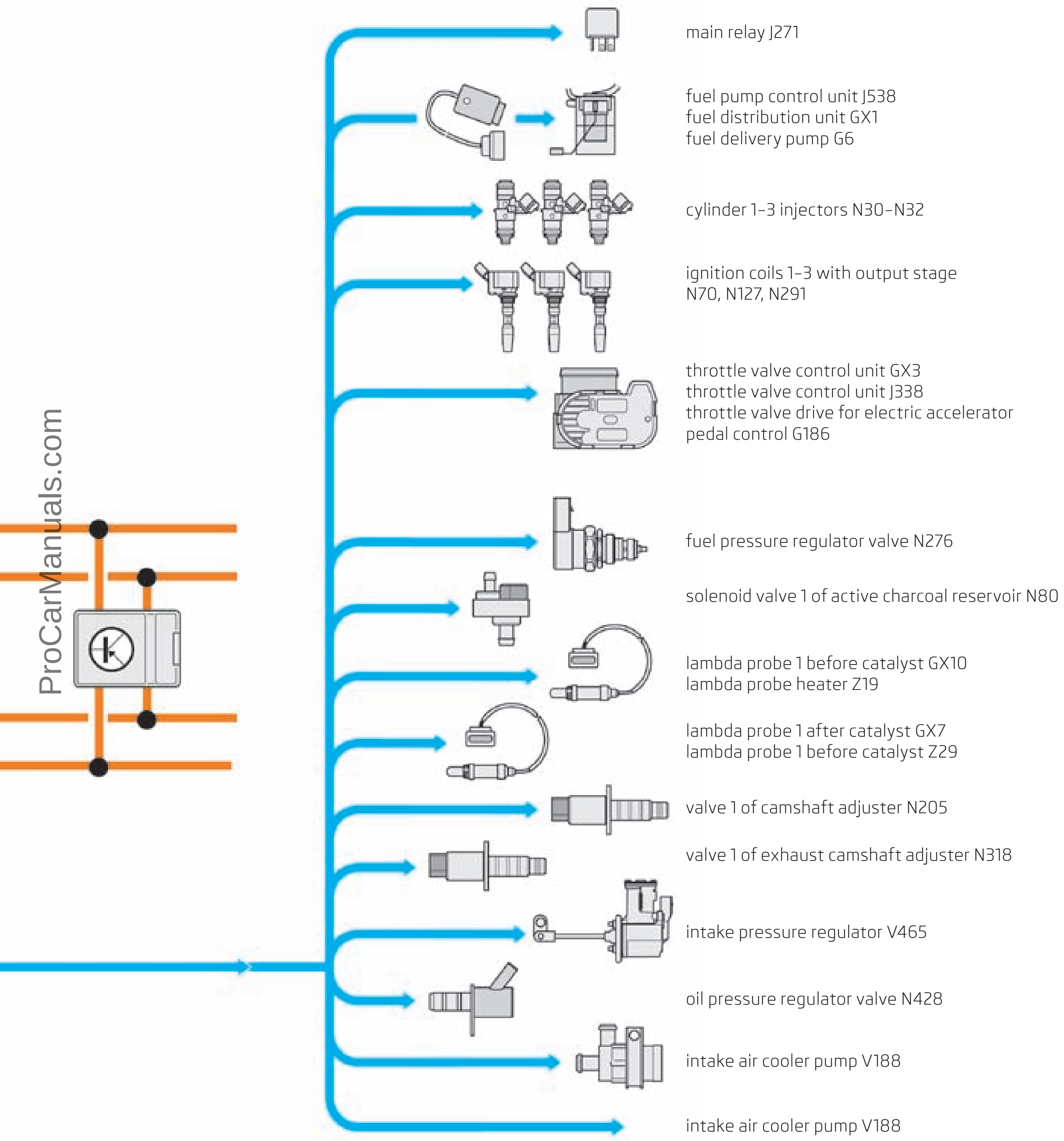
oil pressure sender G10

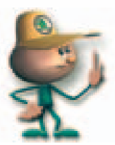
oil level and temperature sender G266

additional input signals



Actuators





Construction parts containing the letter X in the abbreviation include multiple sensors, actuators or switches within a single casing, such as sender GX9 in the intake manifold with intake manifold pressure sender G71 and intake air temperature sender 2 G299.

Notes: