

Audi 4.2 I V8 TDI with Common Rail Injection System

Self-Study Programme 365

In 1999, the 3.3 l A8 (1994) was installed for the first time with a V8 TDI engine, followed in the new A8 by an improved 4.0 l chain-driven engine.
With the 4.2 l V8 TDI engine, the vee engine family with its 90° cylinder angle, 90 mm cylinder spacing and output-end chain drive has undergone a complete overhaul.
The 4.2 l powerplant represents a logical evolution of the V8 TDI with 240 kW of power and 650 Nm of torque.

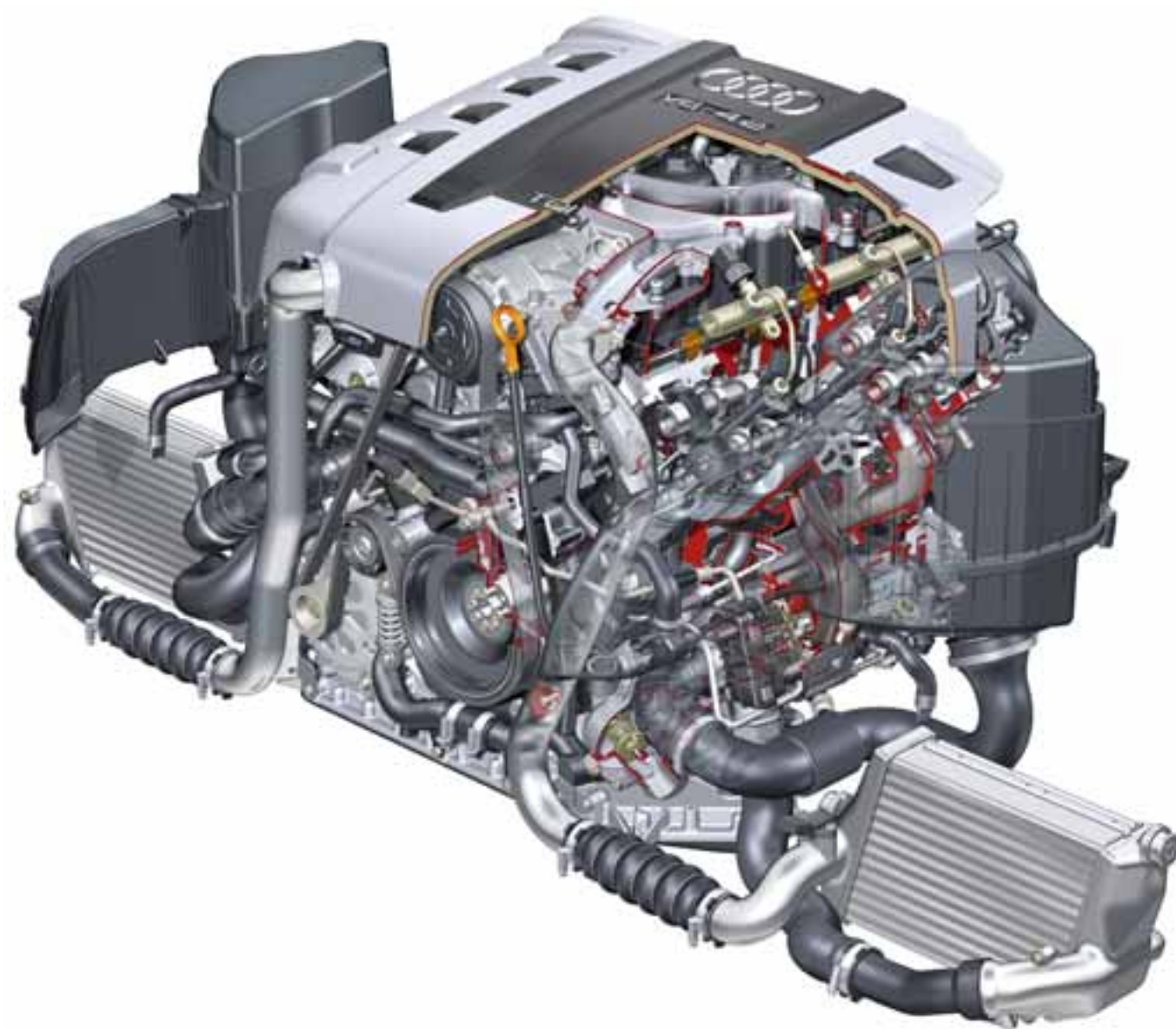


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The Self-Study Programme contains information on the design and function of new models, new automotive components or new technologies.


The self-study programme is not intended as a workshop manual!
All values given are only intended to help explain the subject matter and relate to the software version applicable when the SSP was compiled.

Use should always be made of the latest technical literature when performing maintenance and repair work.

Reference

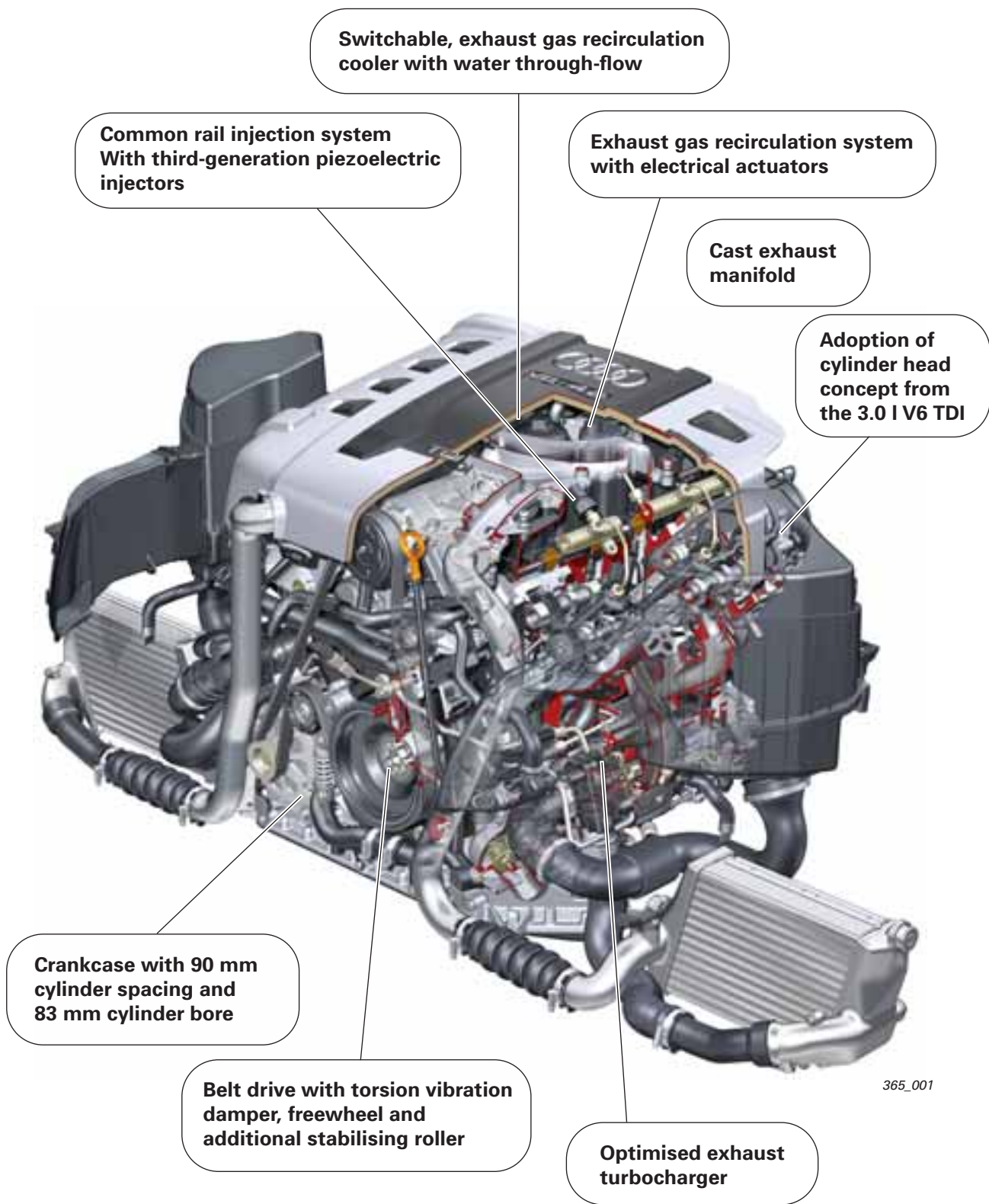


Note



4.2 I V8 TDI engine with common rail injection system

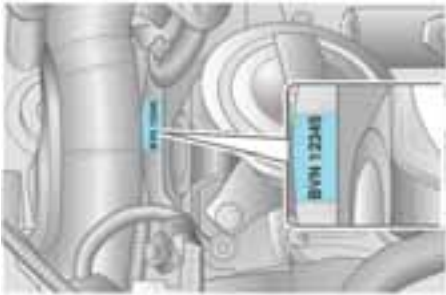
Differences between the 4.0 I and 4.2 I V8 TDI engines



Performance features

Engine code, torque and power output

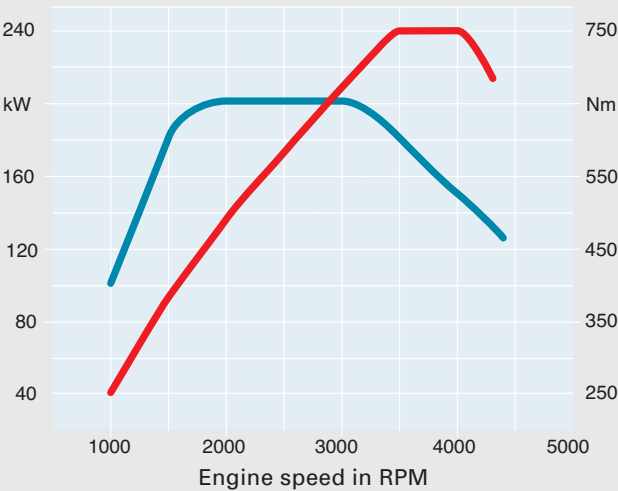
The engine number is located on the end face of cylinder bank II, left.



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Torque/power curve

- Max. torque in Nm
- Max. power output in kW



Specifications

Engine code	BVN
Type of engine	V8 diesel engine 90° vee angle
Displacement in cm ³	4134
Max. power output in kW (bhp)	240 (326)
Max. torque in Nm	650 at 1600 to 3500 RPM
Bore in mm	83
Stroke in mm	95.5
Compression ratio	16,4 : 1
Cylinder spacing in mm	90
Firing order	1-5-4-8-6-3-7-2
Engine weight in kg	255
Engine management	Bosch EDC-16CP+ common rail injection system up to 1600 bar with 8-port piezoelectric injectors
Exhaust gas recirculation system	Water-cooled EGR
Exhaust emission control	Two oxidising catalytic converters, Two maintenance-free diesel particulate filters
Exhaust emission standard	EU IV

4.2 I V8 TDI engine with common rail injection system

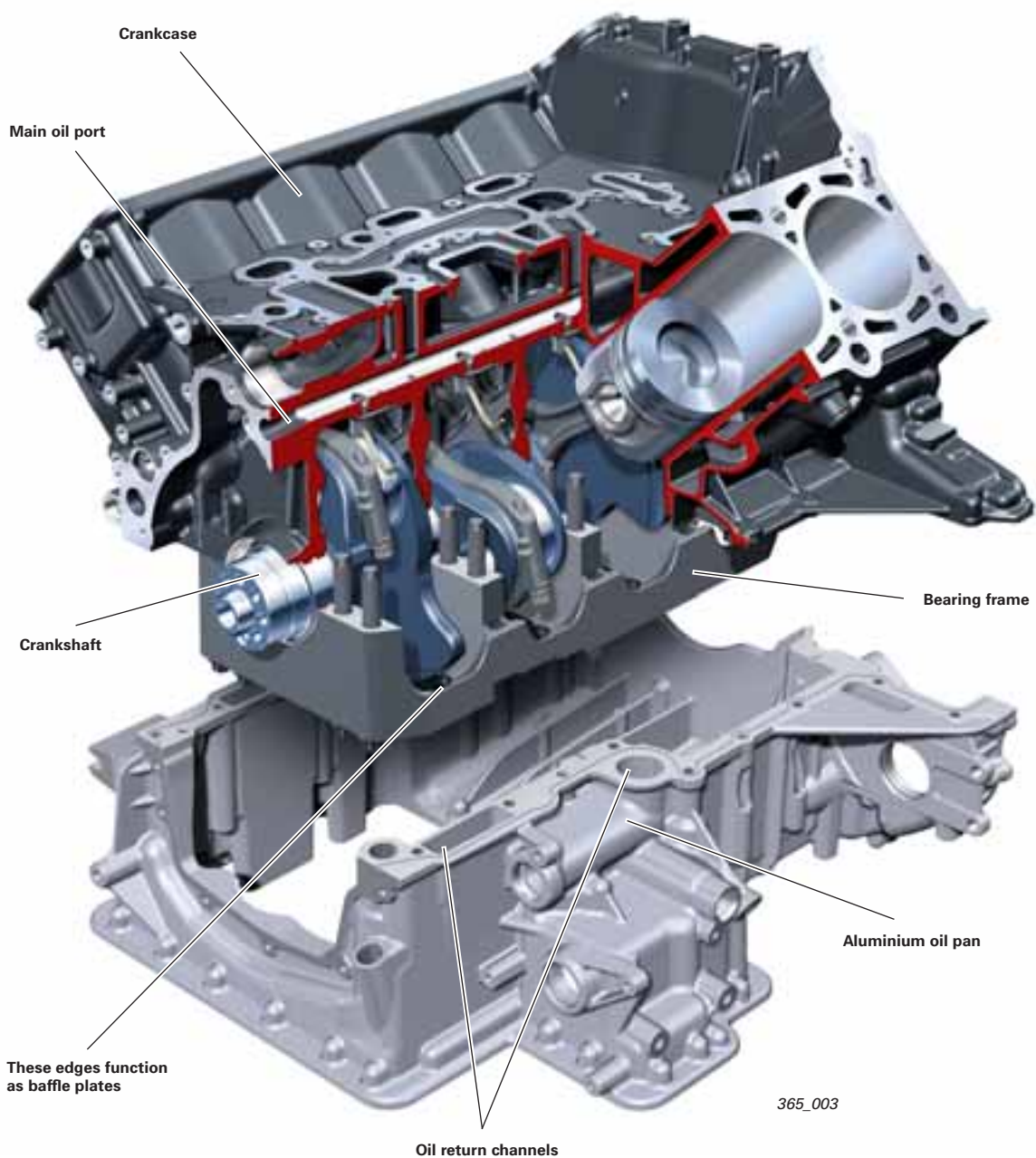
Crankshaft drive

The crankcase with 90 mm cylinder spacing is made of vernicular graphite (GJV 450) and, like the 4.0 I V8 TDI engine, is split at the centre of the crankshaft and bolted to a sturdy crankshaft bearing frame. The weight of the engine block was reduced by approximately 10 kg by utilising the material's special properties.

The forged steel crankshaft is made of 42 Cr Mo S4 and cranked in such a way that free first and second order moments are avoided. The crankshaft is runs in five bearings in the crankcase, and the radii of the con-rod bearing journals are rolled for strength reasons.

By using a compact design it was possible to achieve torque-free balancing of the cranktrain using the crankshaft's counterweights alone. An optimum balance was achieved with the help of additional weights, which are attached to the vibration damper and the driver plate. The deep aluminium oil pan is to a great extent isolated from crankshaft drive vibration, which has a positive effect on acoustic quality.

The main bearing frame contour serves an additional function. It acts as a "baffle plate" in the crankshaft counterweight and con-rod areas. Thus, draining oil is not distributed throughout the engine block, but is collected directly and drained off.



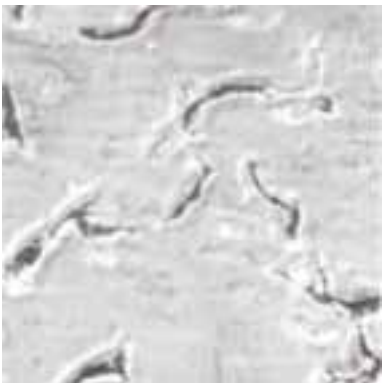
The UV laser imaging honing process used to manufacture the 3.0 I V6 TDI engine has also been used for this engine.

This process helps to reduce oil consumption. The antifriction properties of the cylinder liners were significantly improved in this way.



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without laser imaging



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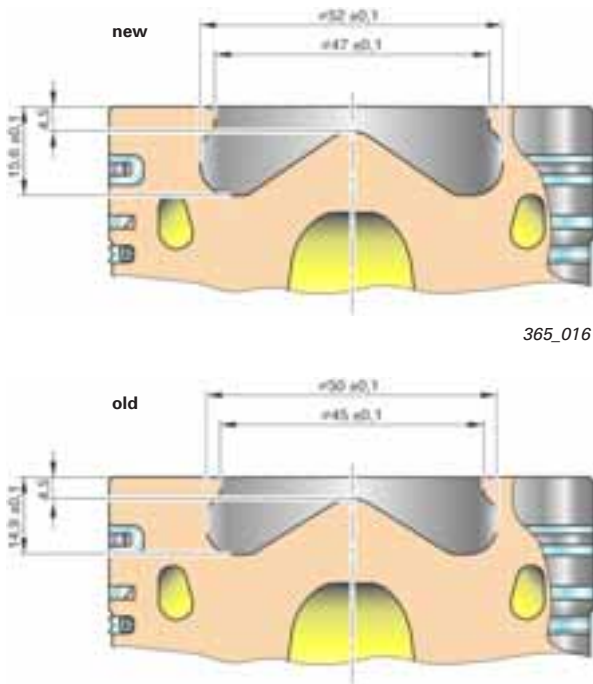
with laser imaging

Piston

Designed as a recessed-head type piston, the piston has a higher recessed head with a larger diameter which reduces the engine's compression ratio from 17.3 : 1 to 16.4 : 1.

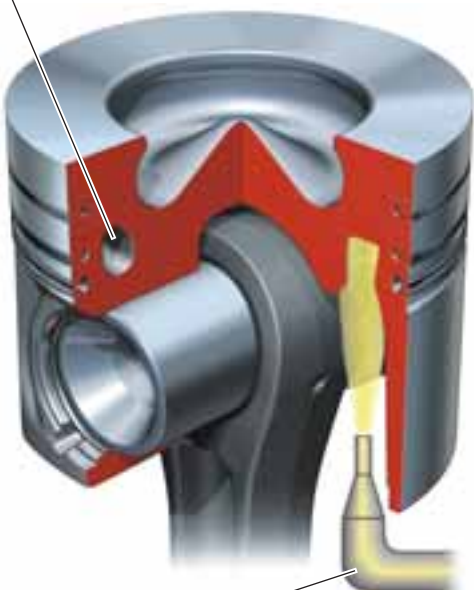
The piston has an annular cooling duct to reduce the temperature of the piston ring zone and the recess rim. An oil spray nozzle continuously sprays the oil into the annular oil cooling duct in order to cool the piston crown.

Comparison of piston crowns



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Annular oil cooling duct



Oil spray nozzle

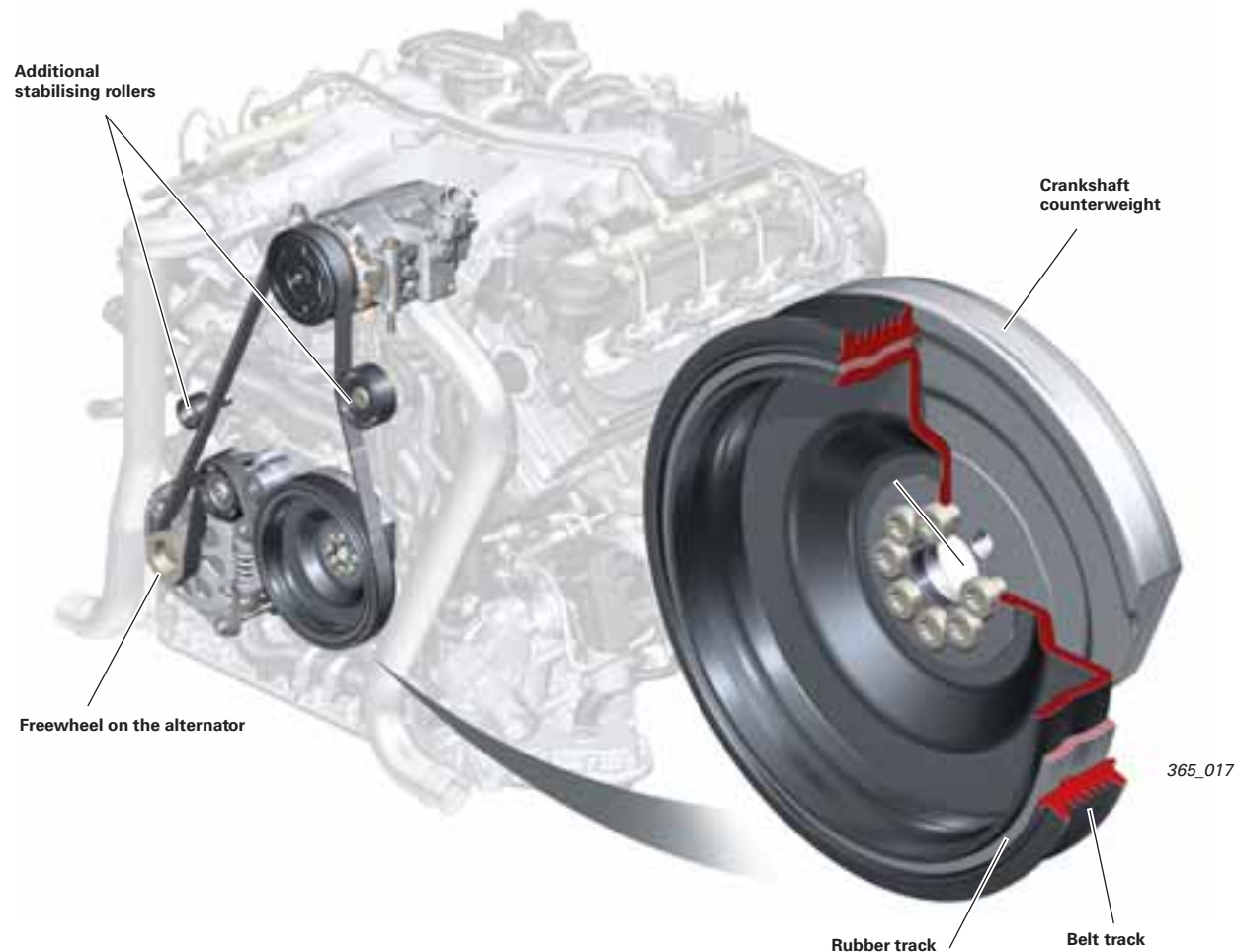
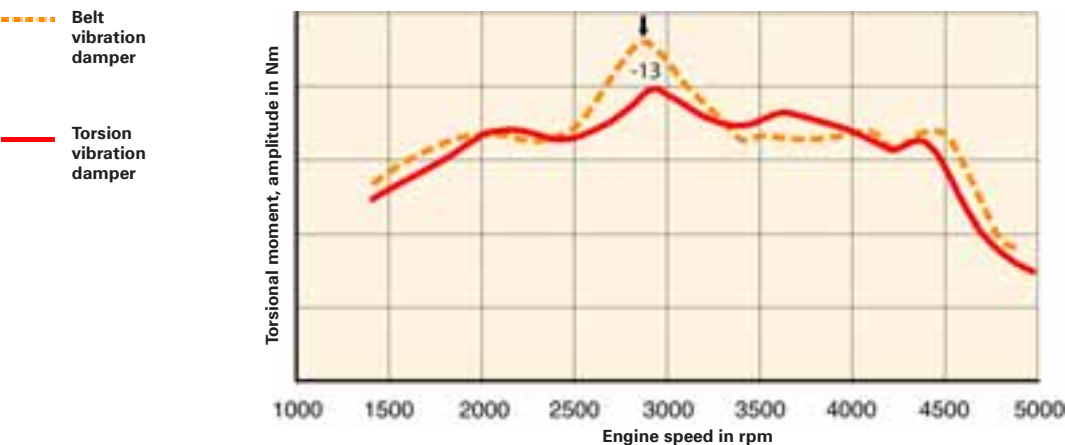
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4.2 | V8 TDI engine with common rail injection system

Crankshaft vibration damper

The 4.2 | V8 TDI engine is equipped with a torsion vibration damper (old version with a belt vibration damper with isolation of the poly vee belt track). To dampen oly vee belt vibrations, which occur at the different rates of acceleration of the piston during the combustion process, a freewheel was installed in the alternator and an additional stabilising roller was fitted.

The torsion vibration damper was designed to reduce the torsional moments which occur in the medium engine speed range by approximately 13 % compared to a belt vibration damper. The result is less load on the crankshaft and improved engine acoustics. The new belt drive drives the alternator and the air conditioner compressor.

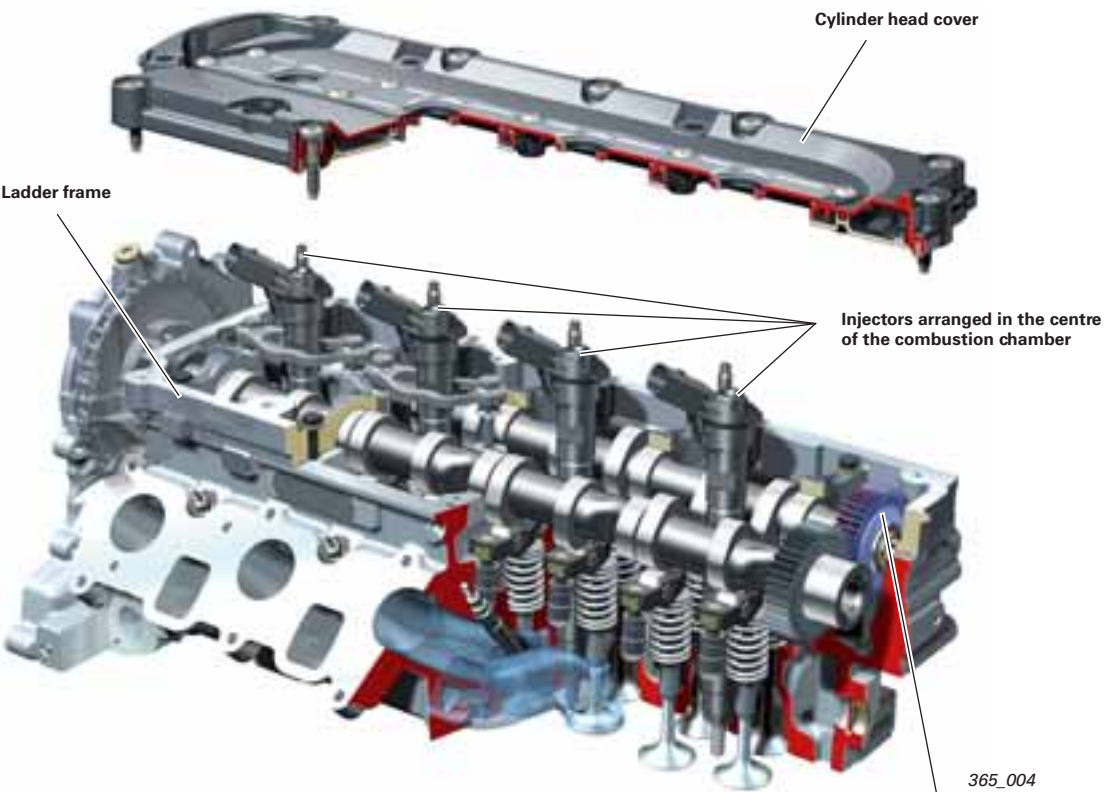


Cylinder head and valve gear

Derived from the 3.0 I V6 TDI engine, the cylinder head is installed in combination with the following components:

- four valves per cylinder,
- assembled camshafts,
- hydraulic valve lifters,
- roller cam followers and
- straight-cut/tensioned gears

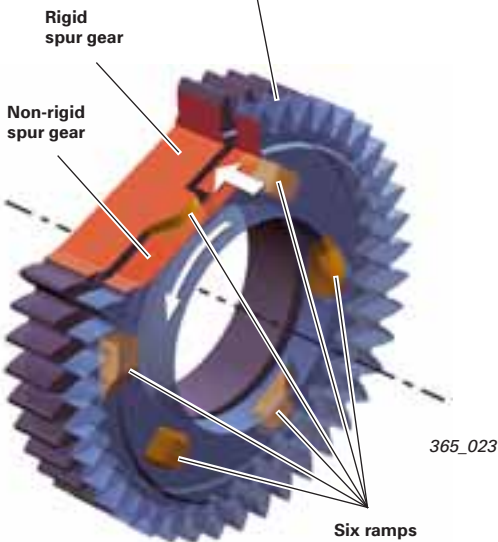
The camshafts are held in place in the cylinder head by a ladder frame with a flat sealing face. An acoustically isolated plastic cylinder head cover seals the cylinder head off from the exterior.



Design

The spur gear of the exhaust camshaft is split into two pieces in the cylinder head, left. The spur gear of the intake camshaft gear is split into two pieces in the cylinder head, right.

The wider part of the spur gear (rigid spur gear) is attached securely to the camshaft. There are six ramps on the front side of the spur gear. The narrower part of the spur gear (moving spur gear) moves in radial and axial directions. Recesses for the six ramps are located on the back of the spur gear.

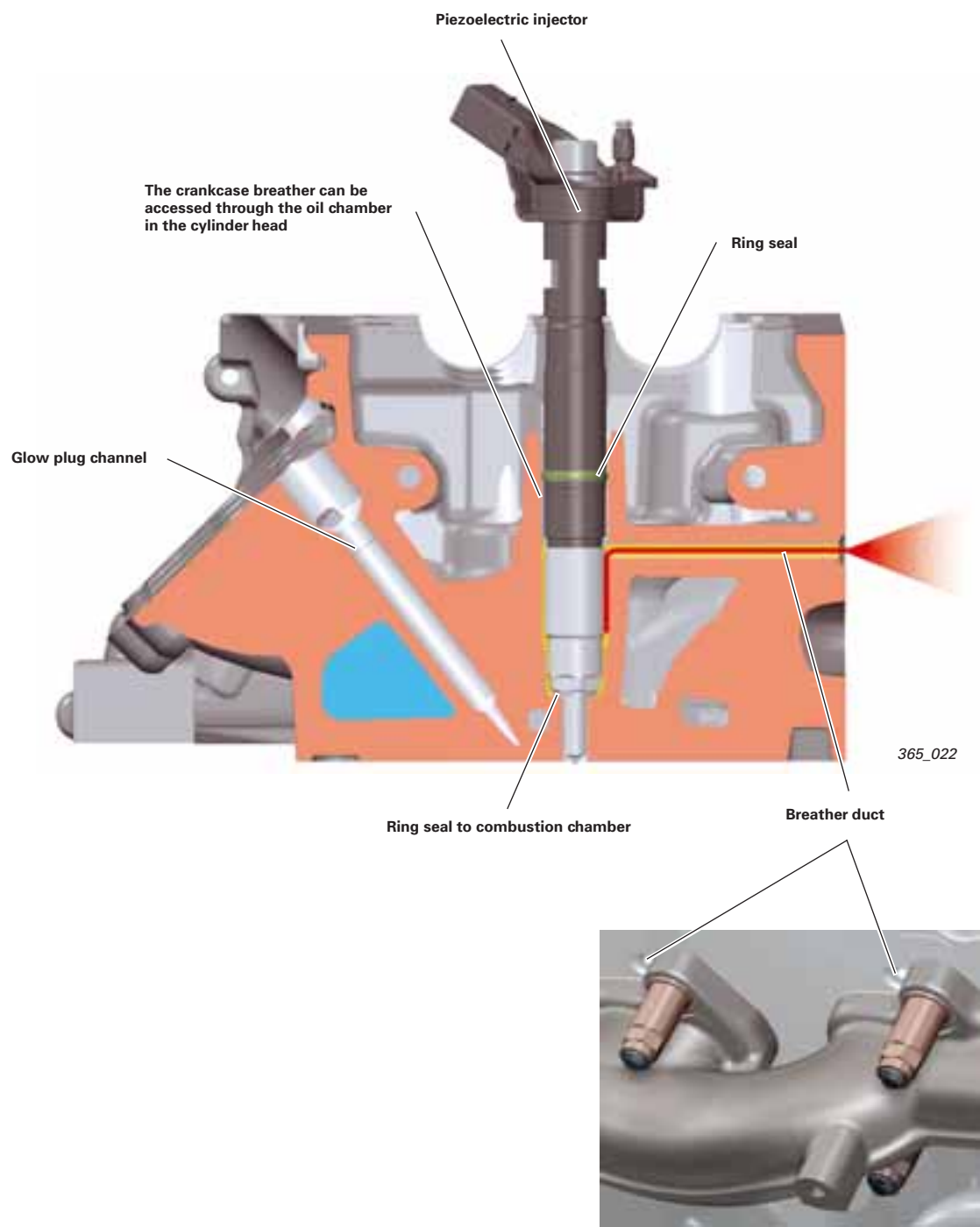


4.2 | V8 TDI engine with common rail injection system

Breather duct in the cylinder head

If a leak occurs in the area of the copper injector ring seal, the air is able to escape from the combustion chamber through a duct due to the combustion pressure of 165 bar. The breather duct is located above the exhaust manifold in the cylinder head.

It prevents the excess pressure from travelling from the combustion chamber via the crankcase breather to the compressor side of the exhaust turbocharger and possibly causing malfunctioning or damaging the ring seals.

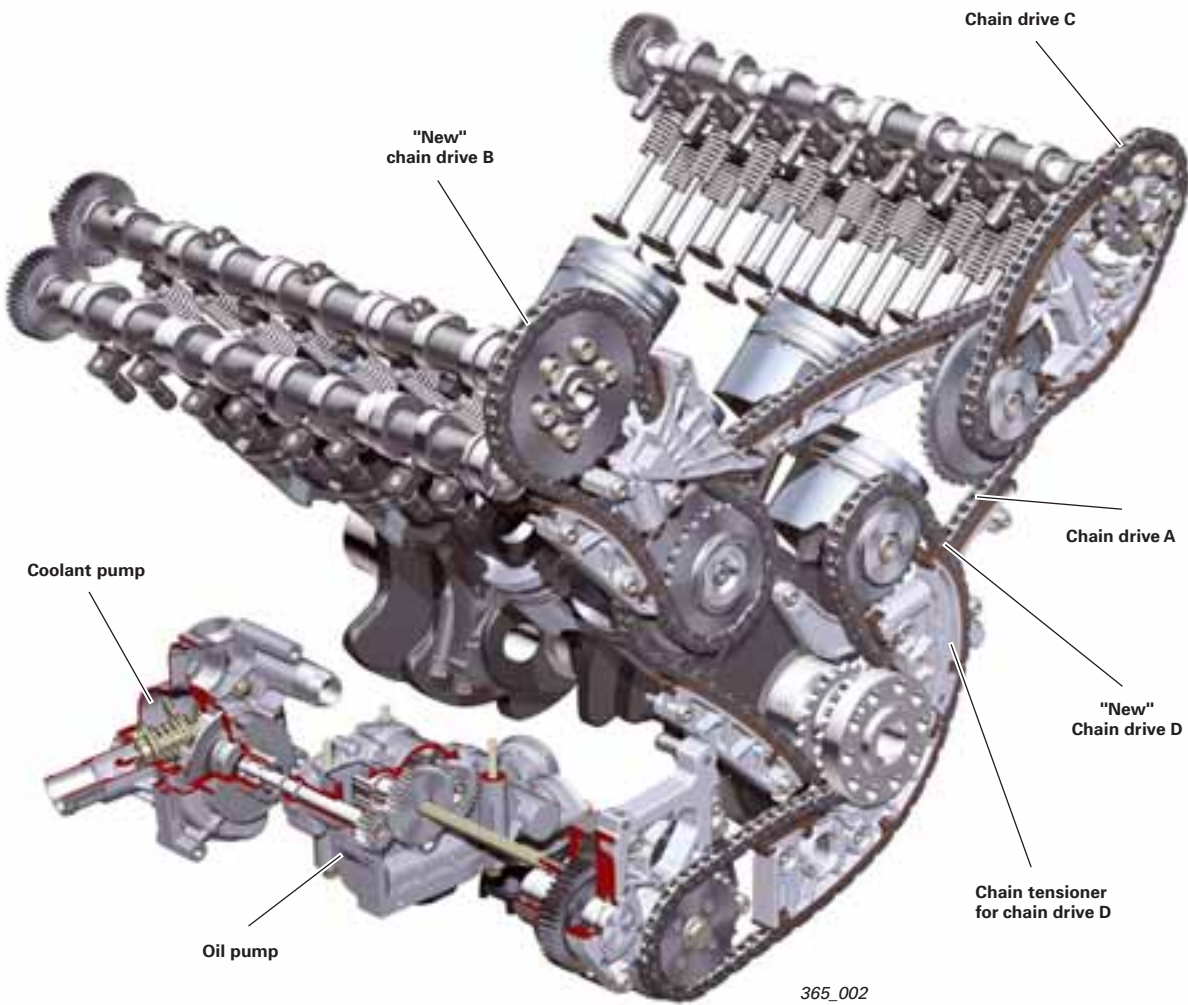
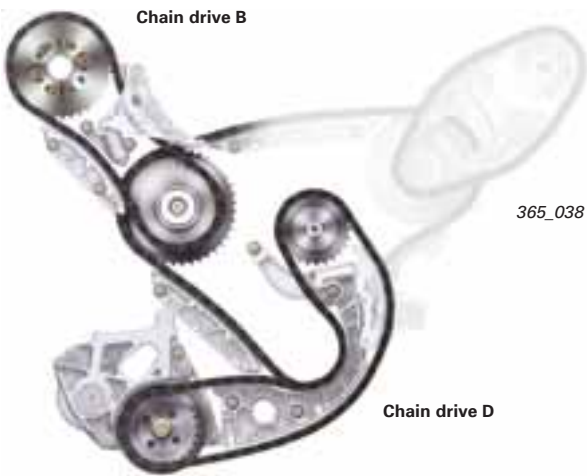


Chain drive

The chain drive adopted from the 4.0 I V8 TDI engine has been optimised with regard to friction and rotary oscillation. Part of the sliding rails in chain drive D has been replaced by a new chain tensioner, allowing the chain to be routed directly around the intermediate shaft, thus shortening the length of the chain.

Chain drive B has also been optimised, whereby the number of teeth and the belt gear contact angle has been increased and the chain guide has been tapered.

Ancillary units such as the oil pump, hydraulic pump and coolant pump are driven by chain drive D via a gear module.



Reference



For further information, please refer to SSP 325 - Audi A6 '05 Engines and Transmissions.

4.2 | V8 TDI engine with common rail injection system

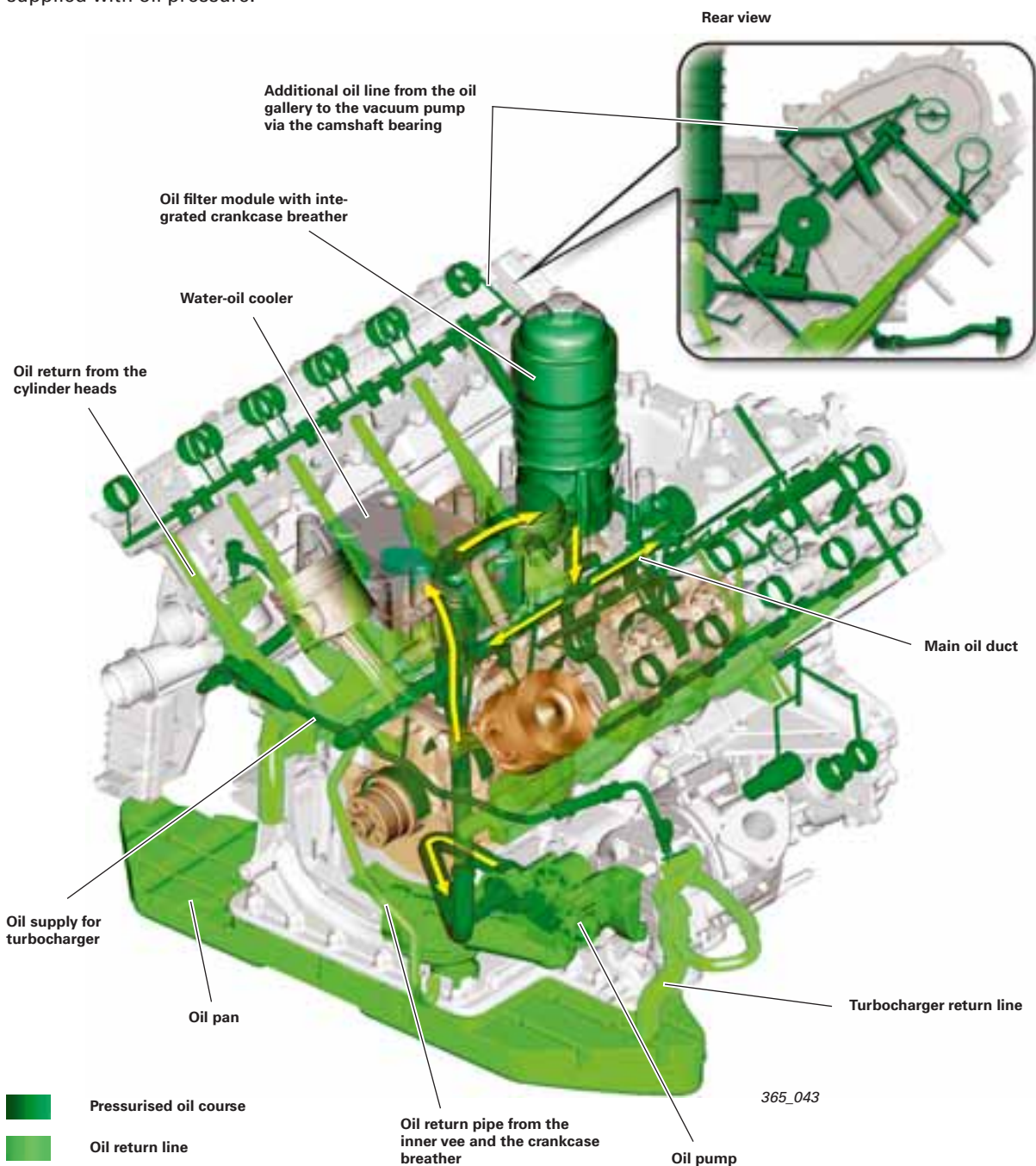
Oil circulation system

The oil circulation system, which is initially filled with 11.5 l oil, begins in the gear oil pump. The oil pressure relief valve is integrated in the oil pump. From here, the oil flows to the water-oil cooler installed in the engine's inner vee. The oil flows to the oil filter along internal ducts in the oil filter module. The oil filter module has a replaceable paper filter for ease of servicing. When the paper filter is removed, the oil remaining in the housing flows back into the oil pan through a drain valve.

After leaving the oil cleaner, the pressurised oil is channelled into the main oil duct located in the inner vee of the engine block. Here, the lubrication points of the crankshaft, the crankshaft bearings and the oil spray nozzle are supplied with oil pressure.

Both turbochargers are supplied with pressurised oil through additional outer oil lines from the main oilway. The oil pressure flows into the cylinder heads through risers with integrated restrictors, and from here to the camshafts, the cam followers and the hydraulic valve lifters.

A special feature is the vacuum pump lubrication system, which is driven and supplied with oil by the intake camshaft in the cylinder head, right. The lubrication system is also supplied with pressurised oil via its own oilway from the main oil duct.

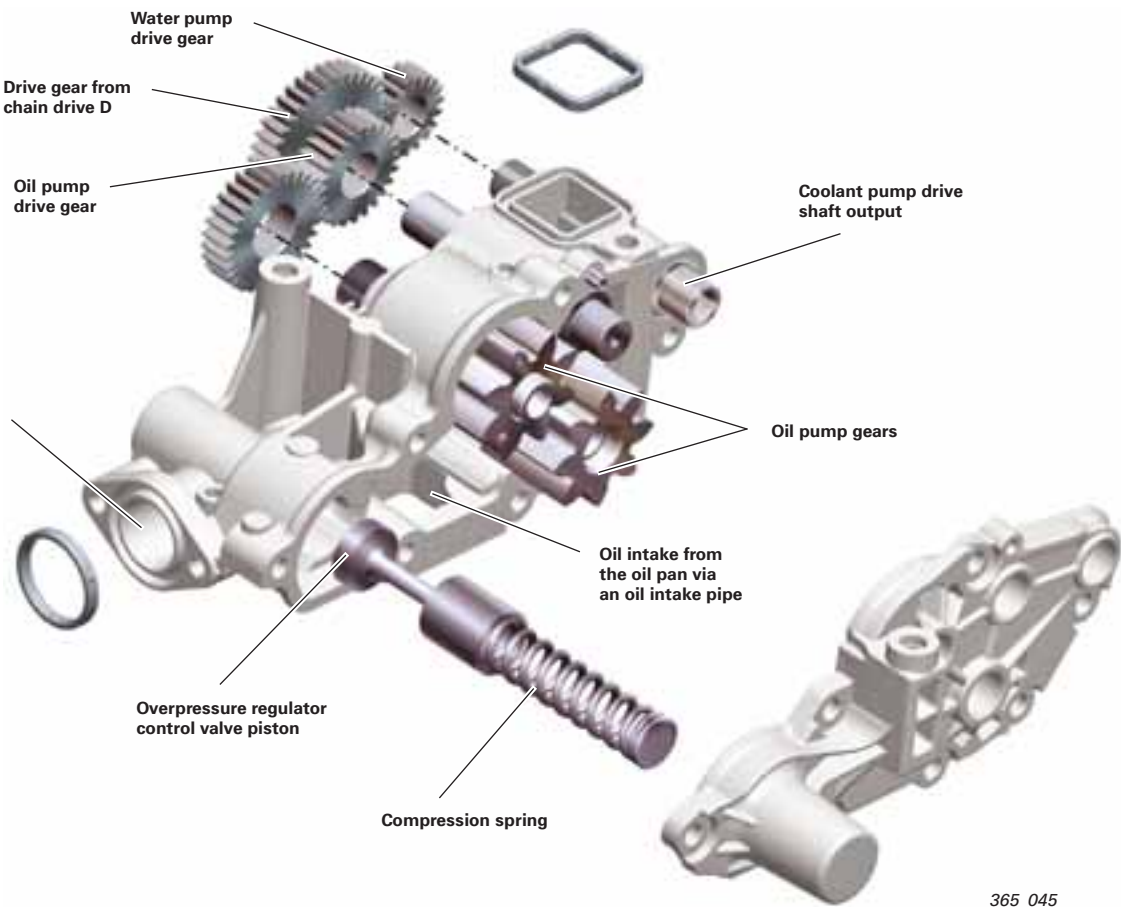


Oil pump

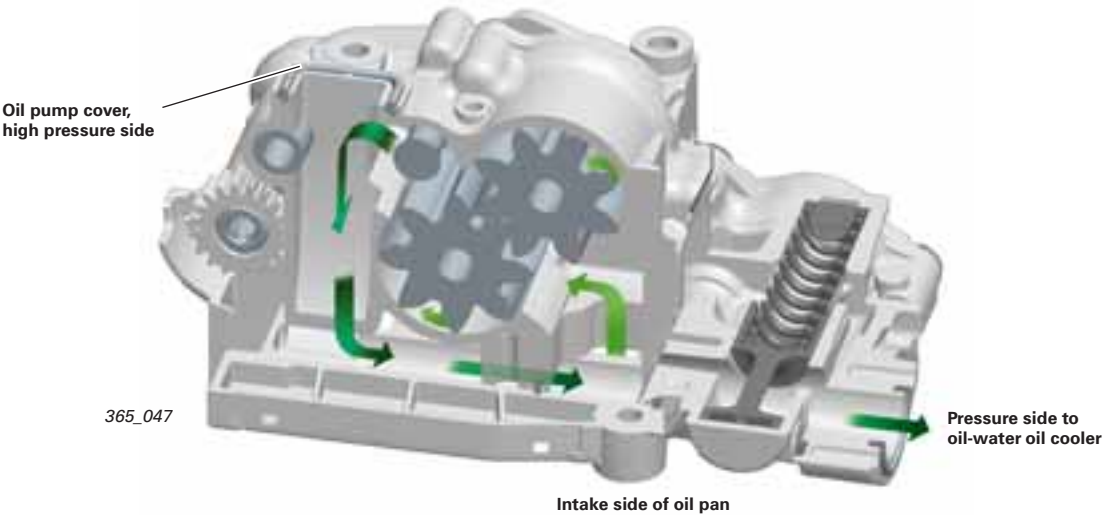
The gear oil pump is driven by a hexagonal shaft connected to chain drive D via a gear module. The oil pressure relief valve which the re-routes the excess oil pressure (exceeding approx. 5.1 bar) to the suction side of the oil pump. An additional gear module on the oil pump drives the coolant pump and the oil pump.



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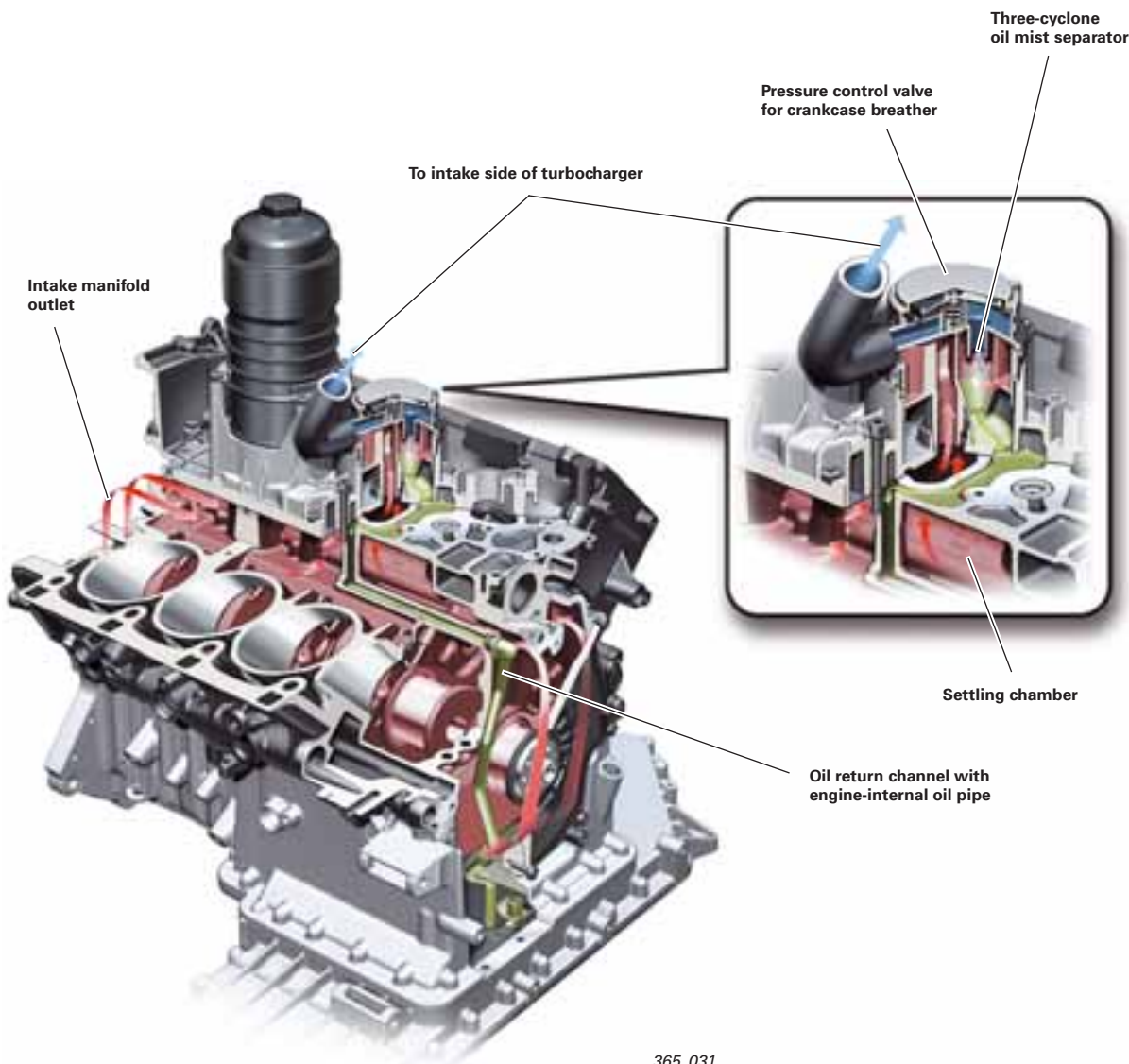
4.2 | V8 TDI engine with common rail injection system

Crankcase breather system

An oil filter module in the inner vee of the engine block accommodates the oil filter cartridge, the oil-water heat exchanger and the oil separator of the crankcase breather. The oil-water heat exchanger is designed in such a way that the maximum oil temperature remains well below the 150 °C max. limit even in extreme conditions.

On the chain and belt sides of the engine, the incoming blow-by gases flow through the settling chamber in the inner vee to the three-cyclone oil mist separator. The blow-by gases flow through the settling chamber into the three-cyclone oil mist separator in which the existing fine oil particles are separated.

Almost all oil-free blow-by gases flow through the pressure control valve to the intake side of both turbochargers. The separated oil is channelled into an oilway in the crankcase and an oil drain pipe with integrated non-return valve below the oil level.



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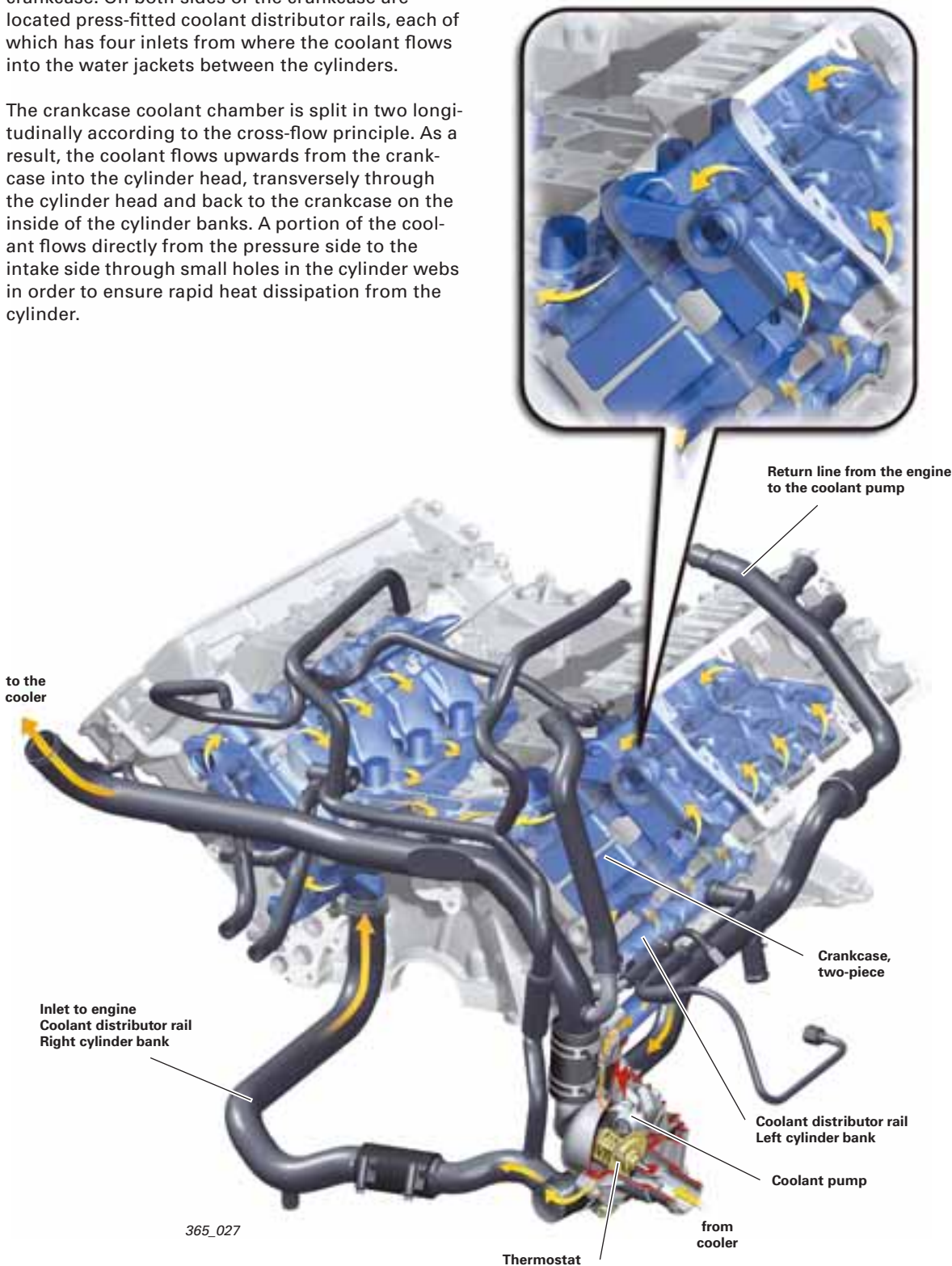
Cooling system

The coolant pump and the thermostat are housed in a shared pump housing outside the engine. The water pump is driven the oil pump gear module which is attached to the chain drive D via two stub shafts.

The pump housing has two outputs to the pressure side, each of which is routed to the outer side of the crankcase. On both sides of the crankcase are located press-fitted coolant distributor rails, each of which has four inlets from where the coolant flows into the water jackets between the cylinders.

The crankcase coolant chamber is split in two longitudinally according to the cross-flow principle. As a result, the coolant flows upwards from the crankcase into the cylinder head, transversely through the cylinder head and back to the crankcase on the inside of the cylinder banks. A portion of the coolant flows directly from the pressure side to the intake side through small holes in the cylinder webs in order to ensure rapid heat dissipation from the cylinder.

The coolant which is channelled through the engine collects in the inner vee of the crankcase, from where it flows to the cooler or back into the engine via the water pump depending on the thermostat setting.



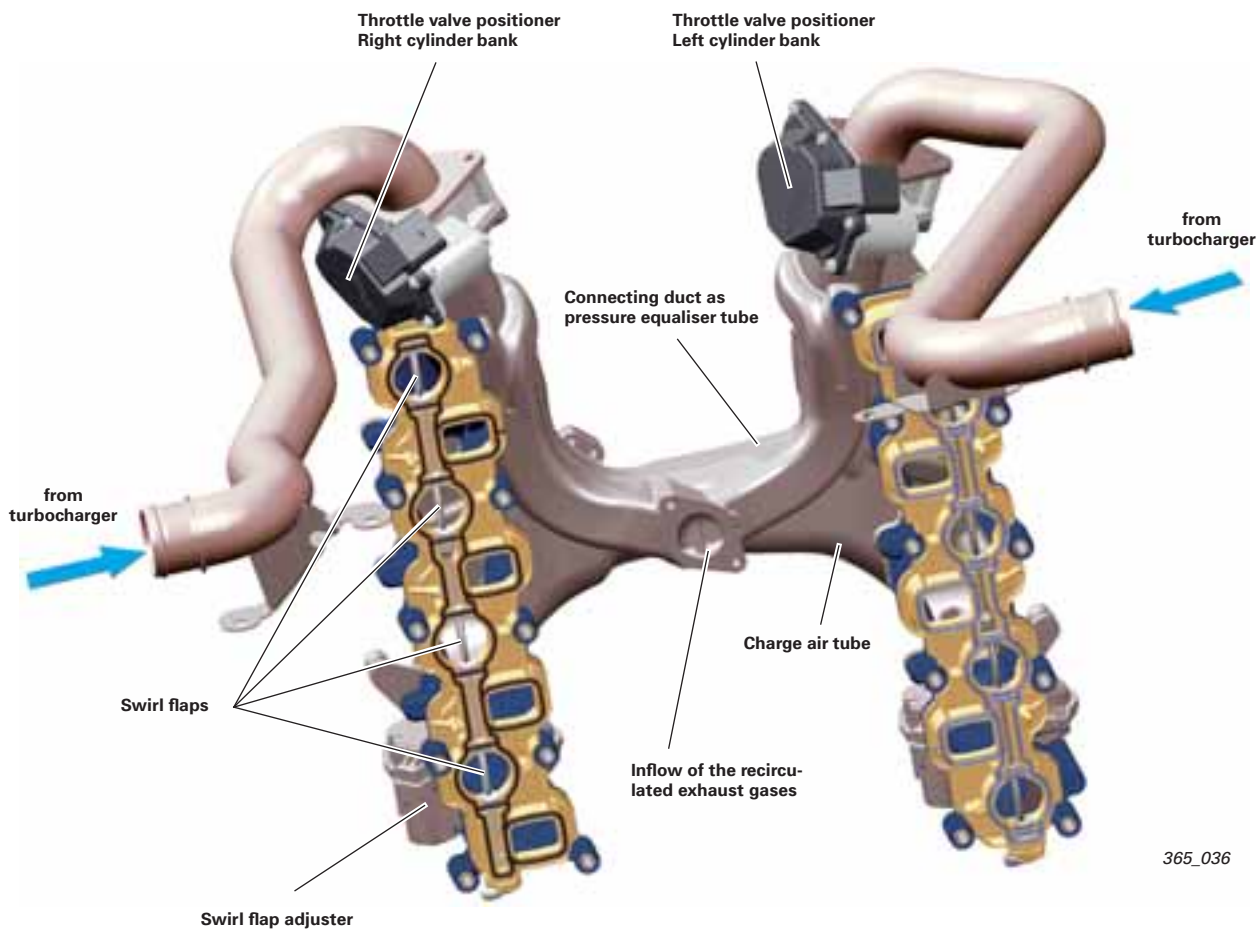
4.2 | V8 TDI engine with common rail injection system

Air intake

The design of the double-chambered air intake system, with two air filters, two air mass meters and two air-air charge-air intercoolers, was adopted from the 4.0 l V8 TDI engine.

Air is drawn in through the two electrically adjustable throttle valves. A connection between the two cylinder banks in the charge air tube, the so-called pressure equaliser tube, provides an even air distribution and equalises the pressure between the cylinder banks and the exhaust-gas return line.

The intake plenum, which is designed as a pressure equaliser tube, is subjected to higher temperatures due to the inflow of exhaust gases, and, therefore, is made of aluminium. The actual intake manifold is made of plastic and accommodates the intake manifold flaps. These flaps control the flow rate in the spiral duct and are used for adjusting the swirl depending on thermodynamic requirements. Each cylinder bank has a bidirectional electric motor which actuates the flaps by means of a linkage. Depending on operating state, there are open, closed and intermediate positions.



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Combustion process

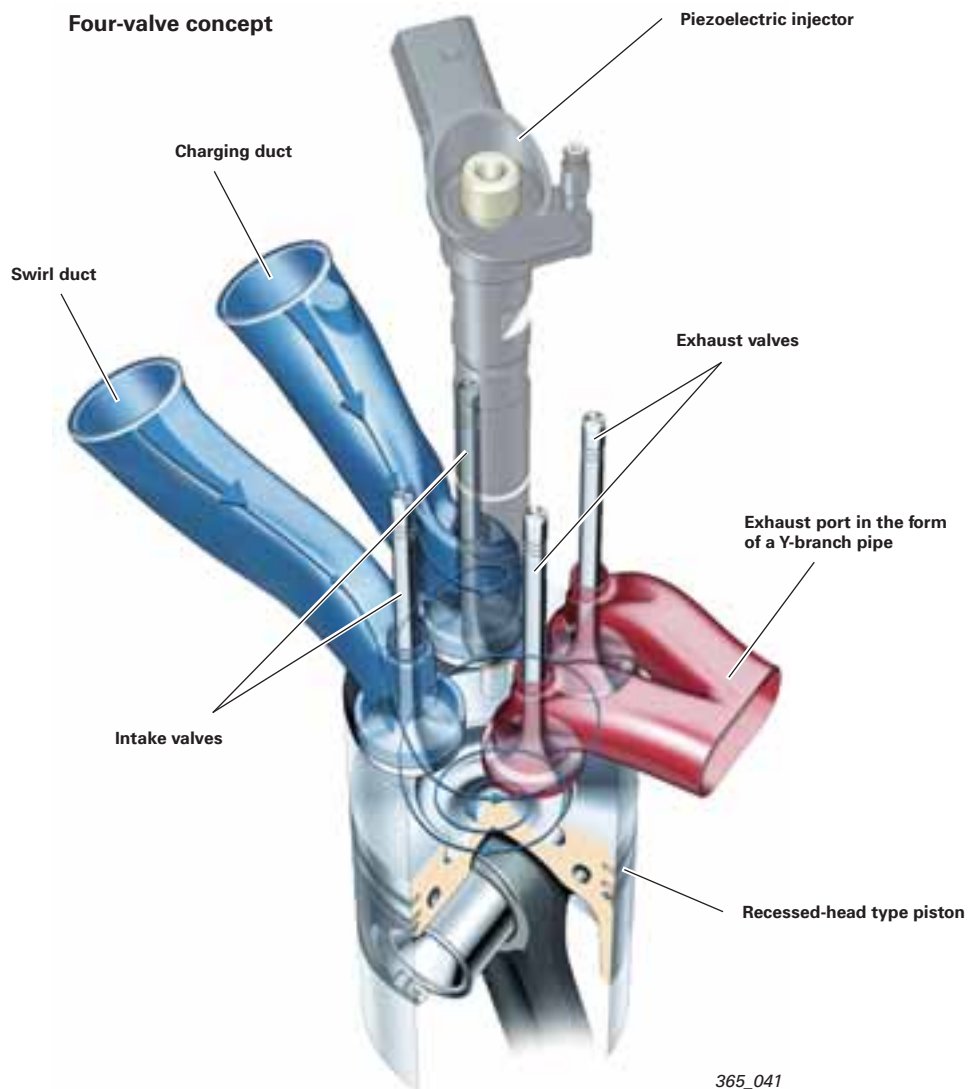
The main factors influencing the combustion process in charged diesel engines are:

- Combustion chamber shape
- Compression ratio
- Injection hydraulics
- Swirl formation
- Turbocharging

They are in mutual interaction with one another. The process was, therefore, optimised in iterative steps by utilising, in particular, the flexibility provided by the common rail system.

To achieve these ambitious development goals, the combustion system with the new four-valve concept used successfully in the 3.0 l V6 TDI engine was taken as the basis and adapted for the eight cylinder.

The duct geometry in combination with variably activated swirl flaps allows a broad propagation of the cylinder swirl. The switchable EGR cooling system significantly reduces untreated emissions, since hot or cooled exhaust gas can be added depending on the operating point and engine temperature.



4.2 | V8 TDI engine with common rail injection system

Swirl flaps

Swirl flap open:

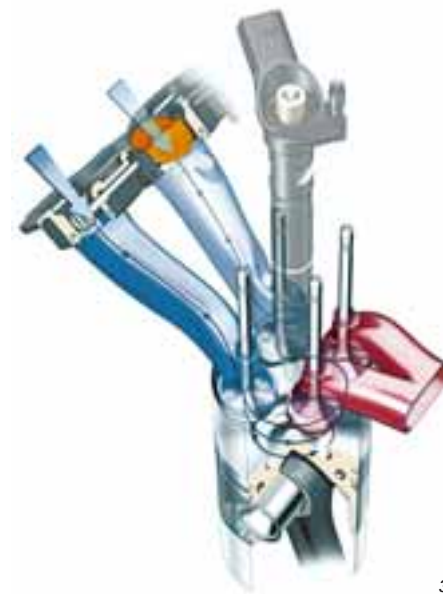
The intake air can flow in large volumes through the open intake ports and into the combustion chamber, thereby ensuring optimal charging.



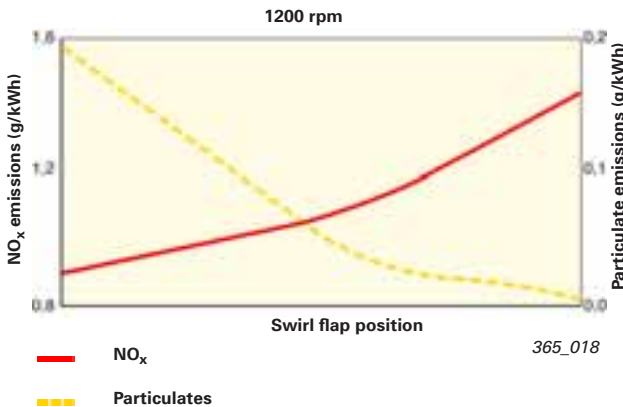
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Variable swirl flap:

To minimise untreated emissions, it is necessary to precisely adapt the cylinder swirl and hence the combustion process in dependence on the operating point. Requirement: continuous swirl flap adjustment.



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Swirl flap closed:

The strong swirl effect at low engine load optimises the combustion process within the combustion chamber and therefore results in fewer emissions.



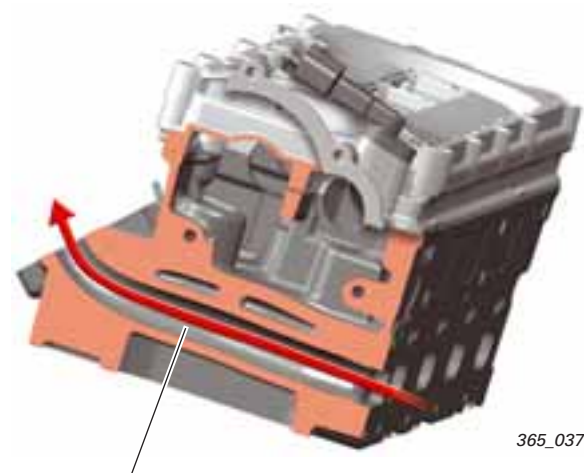
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Exhaust gas recirculation system

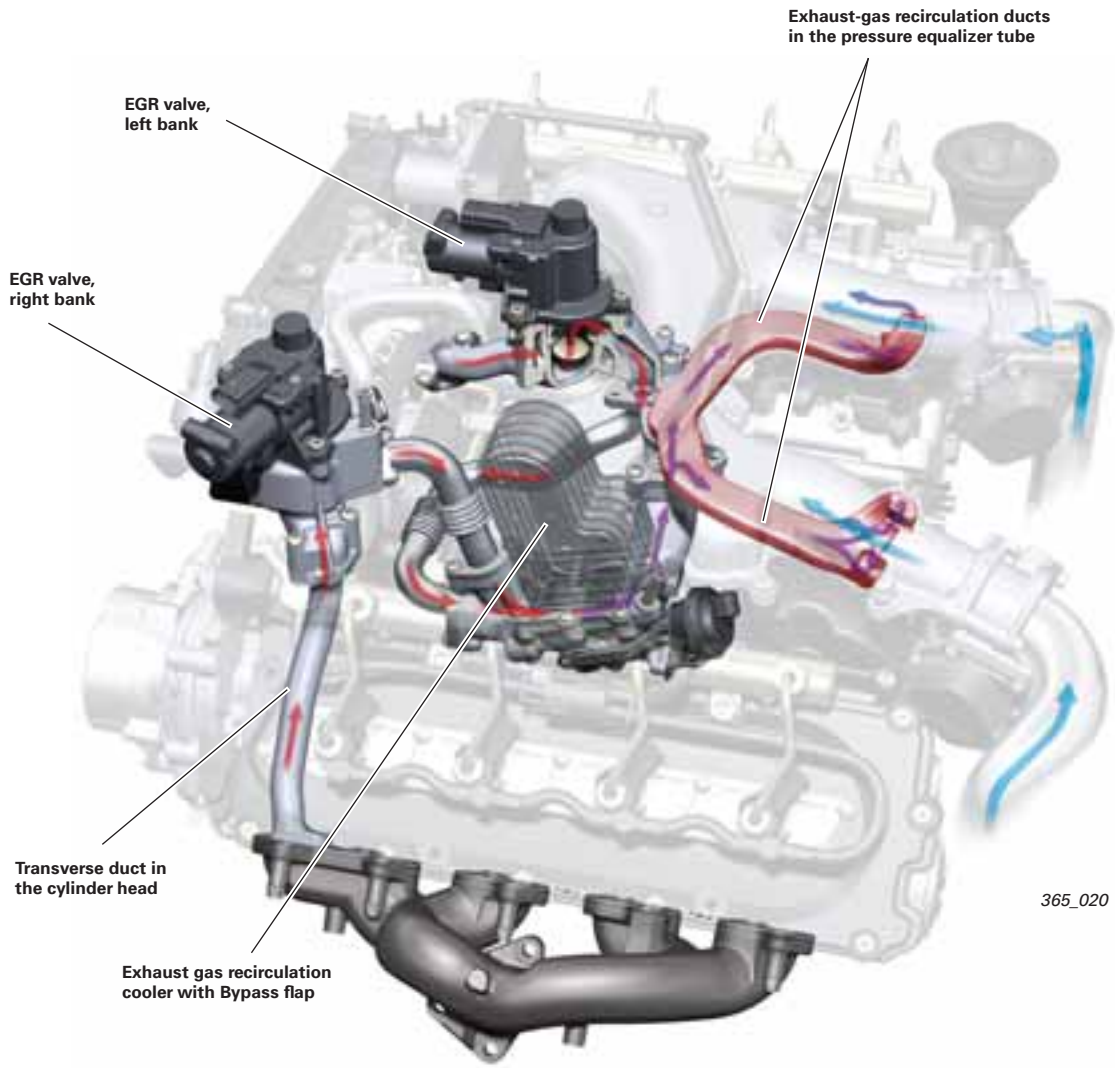
The exhaust gas flows from the exhaust manifolds through ducts cast into the cylinder heads to the EGR valves in the inner vee of the engine block. The exhaust gas is precooled via the auxiliary exhaust-gas recirculation duct by the cylinder head water cooling system. The EGR valves were modified for electrical - rather than pneumatic - actuation, including position feedback, and protected against excessively high temperatures by means of a water cooling system.

The precooled exhaust gases are subsequently cooled by a pneumatically operated exhaust gas recirculation cooler which enables cooling of the exhaust gases to be adapted depending on the operating point.

After passing through the exhaust gas recirculation cooler, the exhaust gases flow up into a branching duct within the pressure equalizer tube and mix with the induced air flow directly downstream of the throttle valves. When designing the ducts and inlet points, special attention was paid to optimal mixing of the dual gas flows.



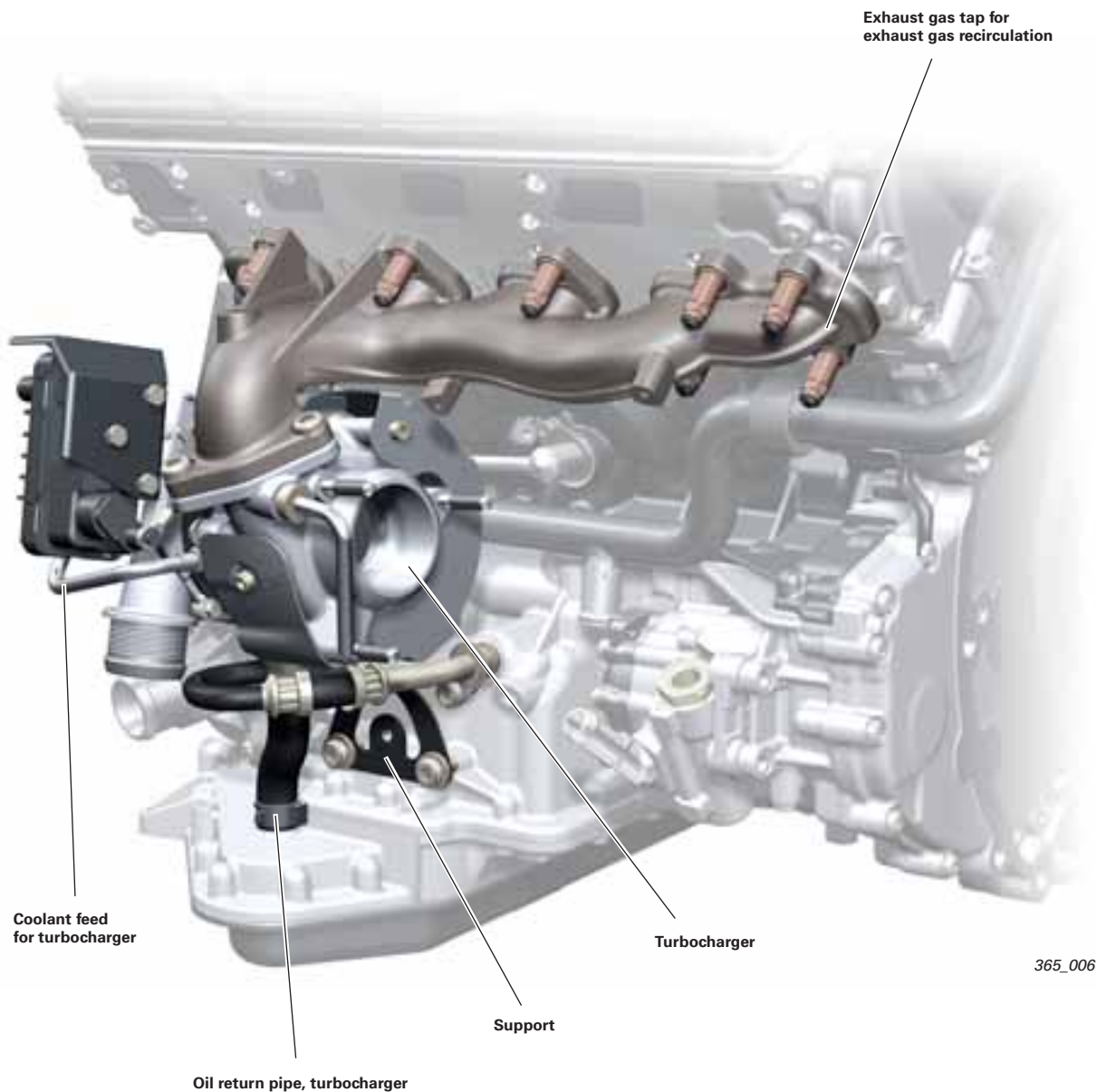
Exhaust port from four-cylinder exhaust manifold through the cylinder head to the EGR valve



4.2 | V8 TDI engine with common rail injection system

Exhaust manifold

The short gas paths between the cylinder head and the turbocharger made it possible to change over from an air-gap insulated exhaust manifold to a pure cast manifold. This did not result in any additional heat loss for the oxidising catalytic converter. Due to the higher rigidity of the cast manifold (reduced oscillation), the design of the turbocharger support has been simplified, thus influencing positively the natural oscillation of the components.



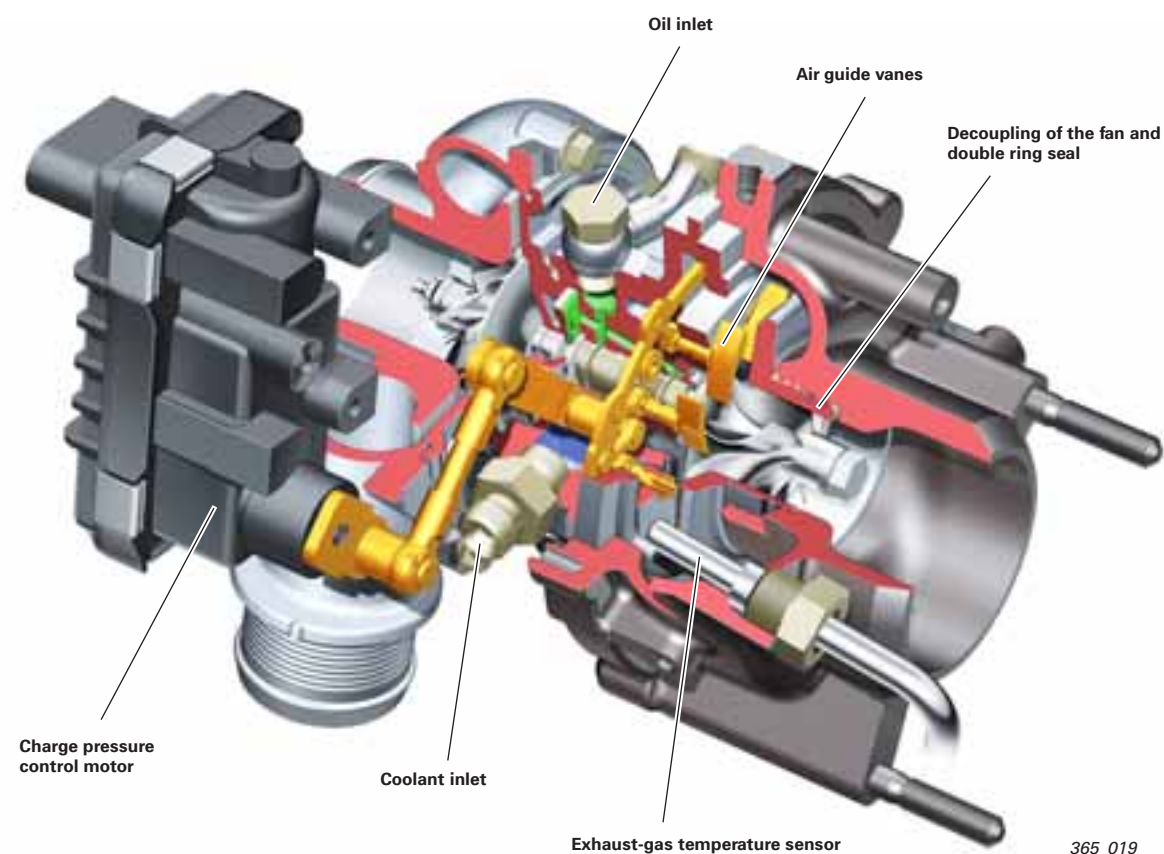
Turbocharger

Two Garrett GT17 chargers of the latest generation with electrical actuators are used for charging.

The compressor wheel and the guide vanes were optimised and the turbine-side fan was decoupled from the turbine in order to increase turbocharger speed (up to 226,000 rpm), exhaust gas temperature (approx. 860 °C) and charge pressure (approx. 2.5 bar absolute) in order to enhance engine performance.

The turbine side is now sealed by a double ring seal instead of a single ring seal. This ensures a good level of gas tightness, even at temporarily elevated exhaust back pressures due to loaded particulate filters.

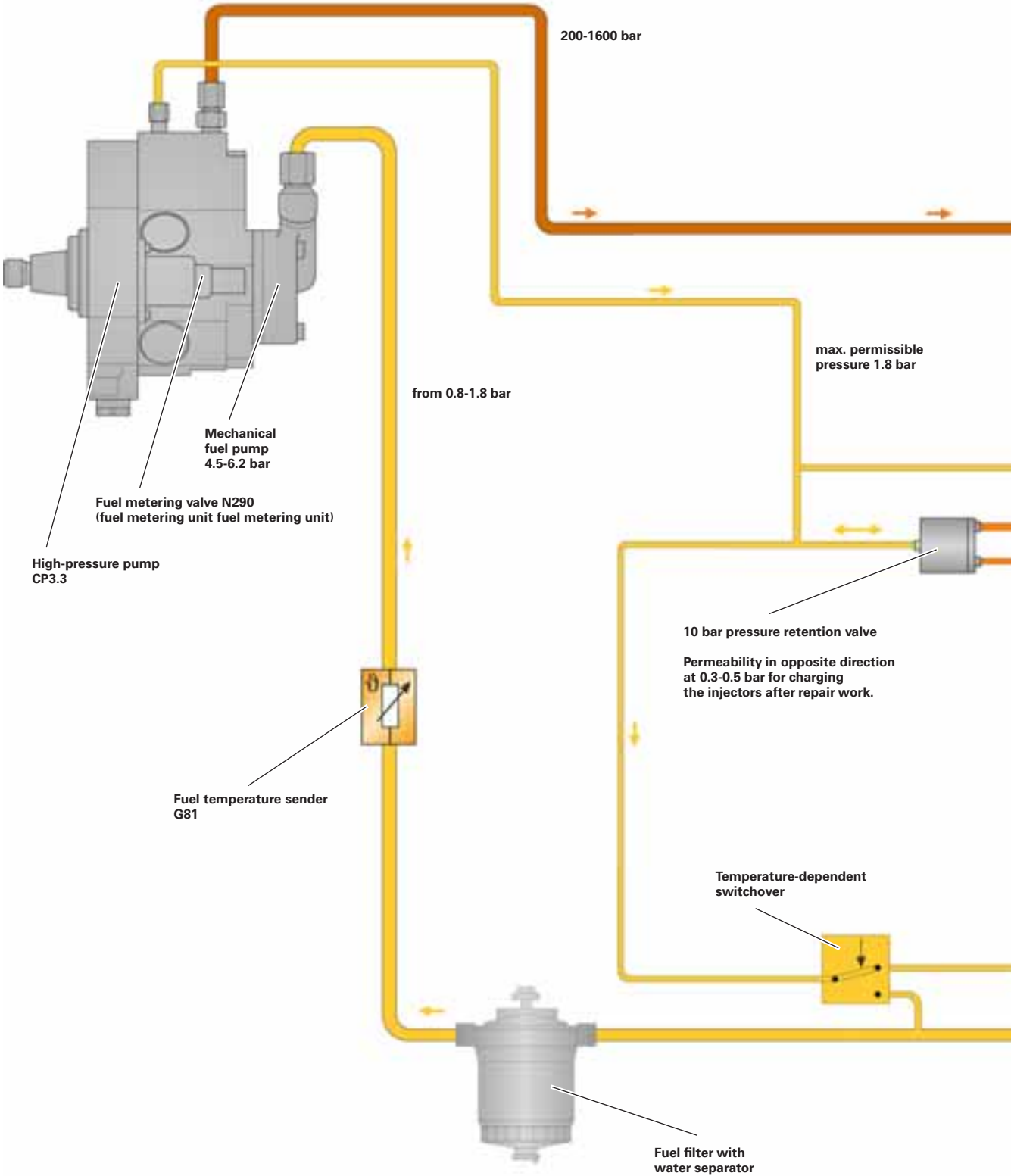
The engine management system has dual air mass meters which ensure that both chargers run at the same speed, and therefore have the same delivery rate.



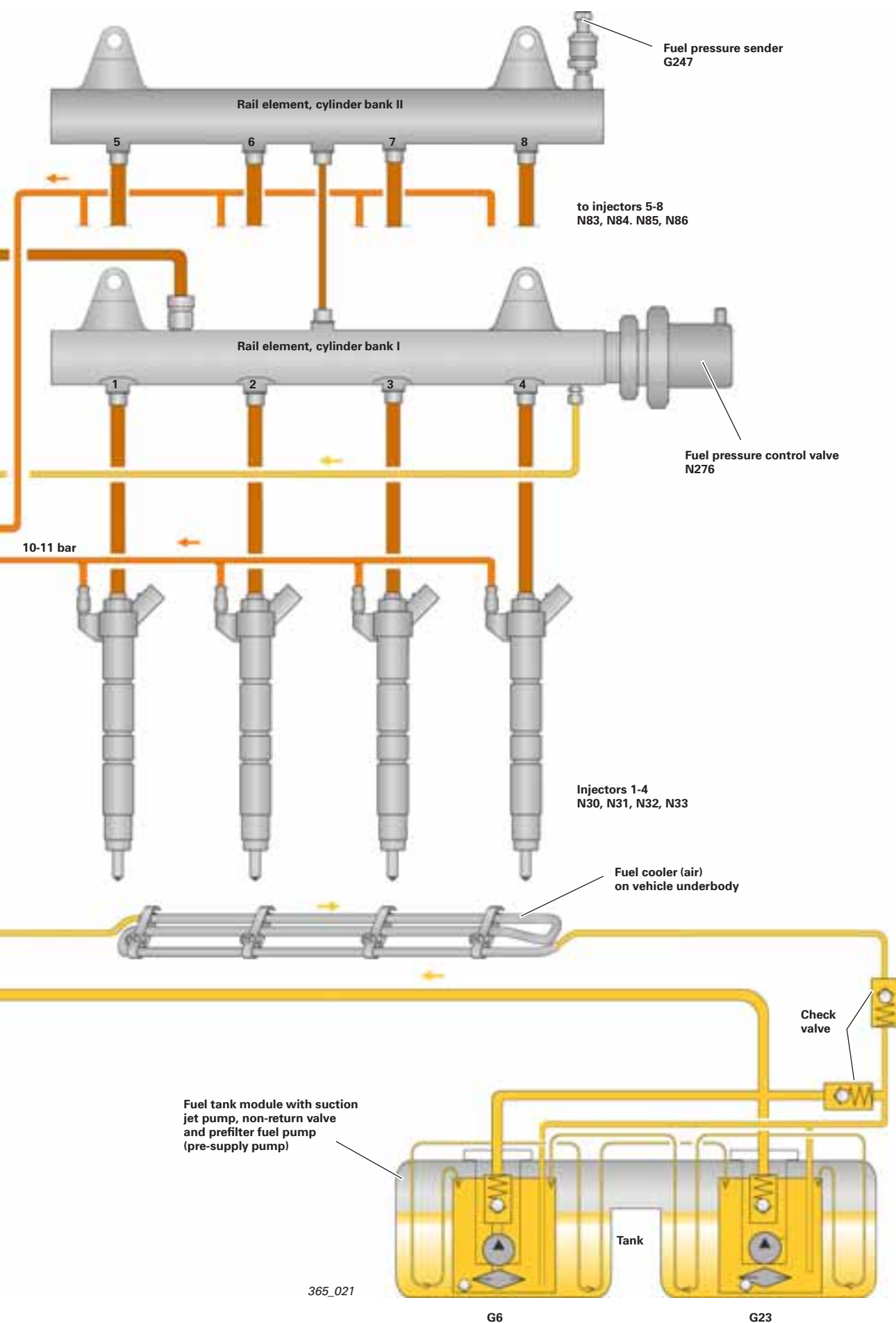
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4.2 | V8 TDI engine with common rail injection system

Fuel system



- High-pressure 200-1600 bar
- Return pressure from injector 10 -11 bar
- Supply pressure max. 1.8 bar
Return pressure max. 1.8 bar



365_021

G6

G23

4.2 | V8 TDI engine with common rail injection system

High-pressure fuel circuit

The three-piston high-pressure pump is located in the inner vee of the engine, and is driven by the intake camshaft of cylinder bank II via a toothed belt.

The high-pressure circuit consists of the following components:

- High-pressure pump with fuel metering valve (fuel metering unit) N290.
- Rail element I with fuel pressure regulating valve N276 and
- Rail element II with rail pressure sensor G247 and 8-port piezoelectric injectors.

It was possible to dispense with the distributor block in the CR system, as used in the 4.0 I V8 TDI engine.

This fuel pressure regulator and the fuel pressure sensor were distributed along both rails.

The rails themselves are now of welded construction, and no longer of forged construction. The rails are based on a seamlessly extruded steel tube, the open ends of which are sealed with threaded plugs. The connecting fittings for the high-pressure line and the rail pressure sensor were attached by capacitor discharge welding*.

*Notes

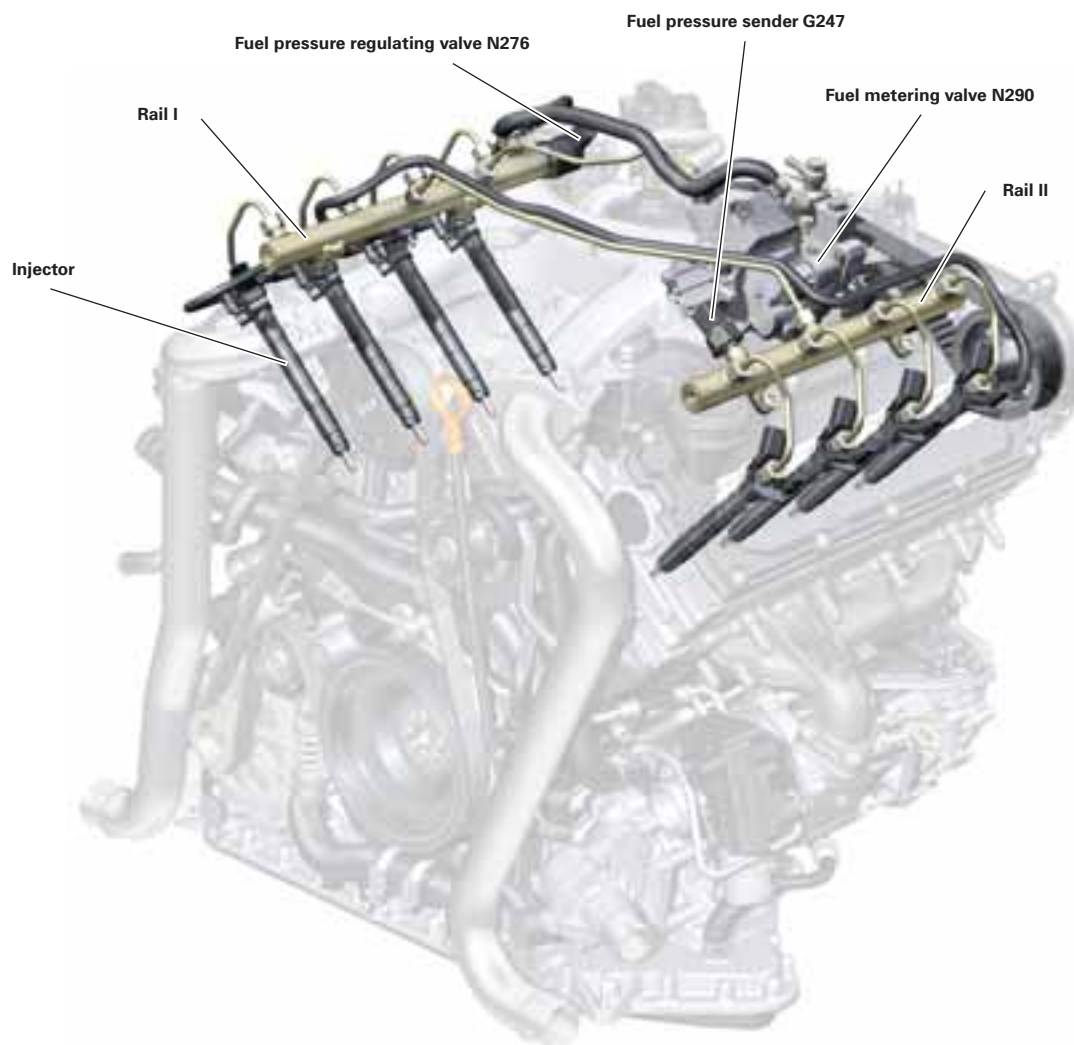
on capacitor discharge welding:

The advantage of this method lies in the very limited heat affected zone around the weld seam. Thus, the basic structure of the raw material remains unaltered.

Reference



For further information on design and function, please refer to SSP 325 - Audi A6 '05 Engines and Transmissions.



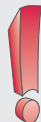
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Restrictors in the rail

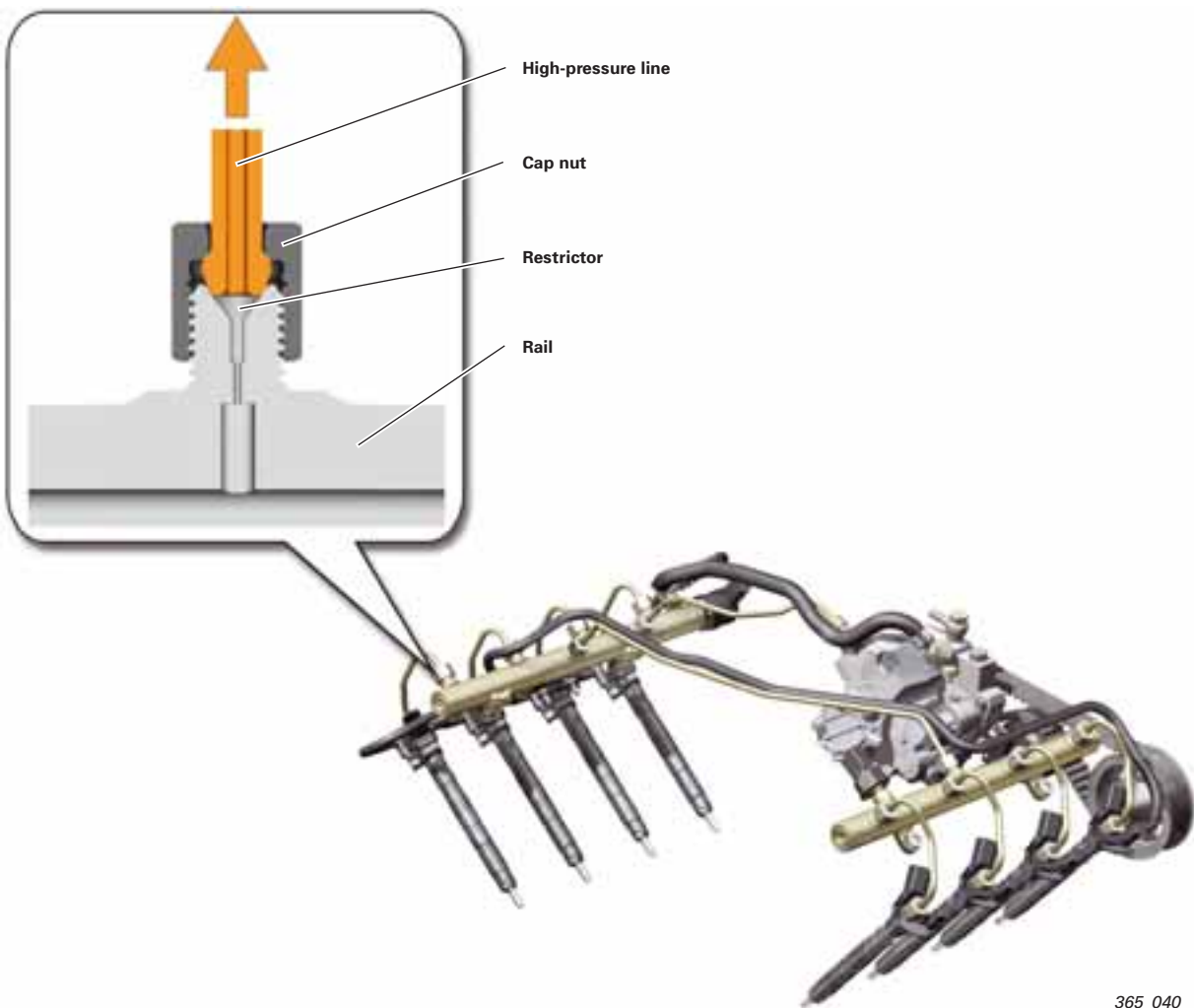
When the injector closes and during subsequent injection cycles, a pressure wave forms at the injector outlet. This pressure wave propagates to the rail, where it is reflected.

To dampen the pressure waves, flow restrictors are integrated in the rail in the supply line, in the high-pressure pump rail, in the left and right rails and upstream of each injector. These restrictors are produced by machining the outer surface of the rail.

Note



Make sure that the injector fuel line and the connecting line between the rails is tightened to the correct torque. Deformed or damaged high-pressure lines must not be reused, and must be replaced.



365_040

4.2 | V8 TDI engine with common rail injection system

Fuel pressure regulating valve N276

A new fuel pressure regulating valve is used for the common rail system of the 4.2 l V8 TDI engine. When the valve is in a deenergised state, it ensures a "short circuit" between the high-pressure end and the low-pressure end.

Function:

When the engine is running, the poppet valve is in force equilibrium with the spring and the magnetic circuit. The valve is open in the deenergised state whereby the spring relieves the load on the ball in the seat.

Unlike the previous version (which had a short-time retention pressure of approx. 100 bar), the pressure in the rail is reduced immediately, thus preventing the fuel from draining into the cylinder if an injector is open.

Reference



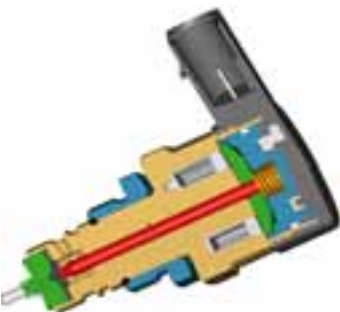
For further information on design and function, please refer to SSP 227 - 3.3 l V8 TDI Common Rail Injection System.

Note

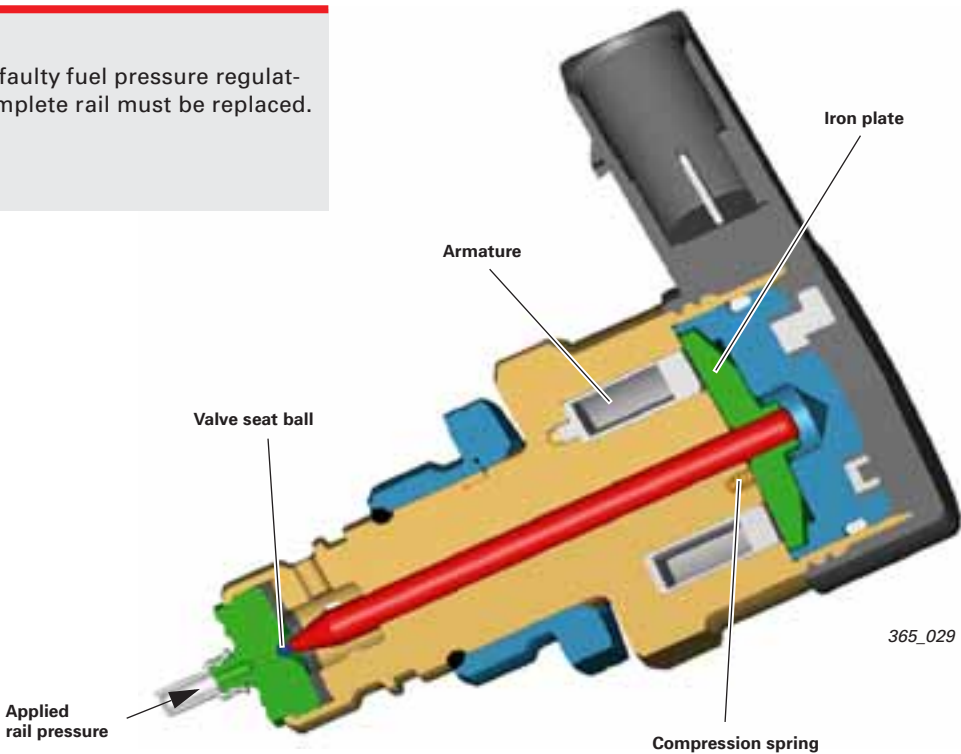


In the event of a faulty fuel pressure regulating valve, the complete rail must be replaced.

Previous version



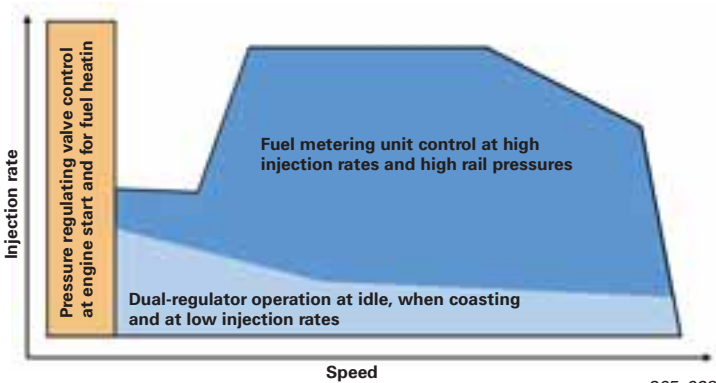
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365_029

Dual-regulator concept

The 3.0 l V6 TDI engine with common rail used a dual-regulator concept which activated the fuel pressure regulating valve N276 or the fuel metering valve (fuel metering unit) N290. With this concept, the pressure can be controlled simultaneously via the fuel pressure regulating valve and the fuel metering unit.



365_028

Piezoelectric injectors

By using piezoelectric injectors, it is possible to achieve:

- multiple electrical activation periods per working cycle,
- very short switching times for up to five injection cycles,
- large forces counter to the current rail pressure,
- high stroke precision for rapid rail pressure reduction

Depending on the rail pressure, piezoelectric injectors require a drive voltage of between 110 and 148 V through capacitors in the control unit.

Note

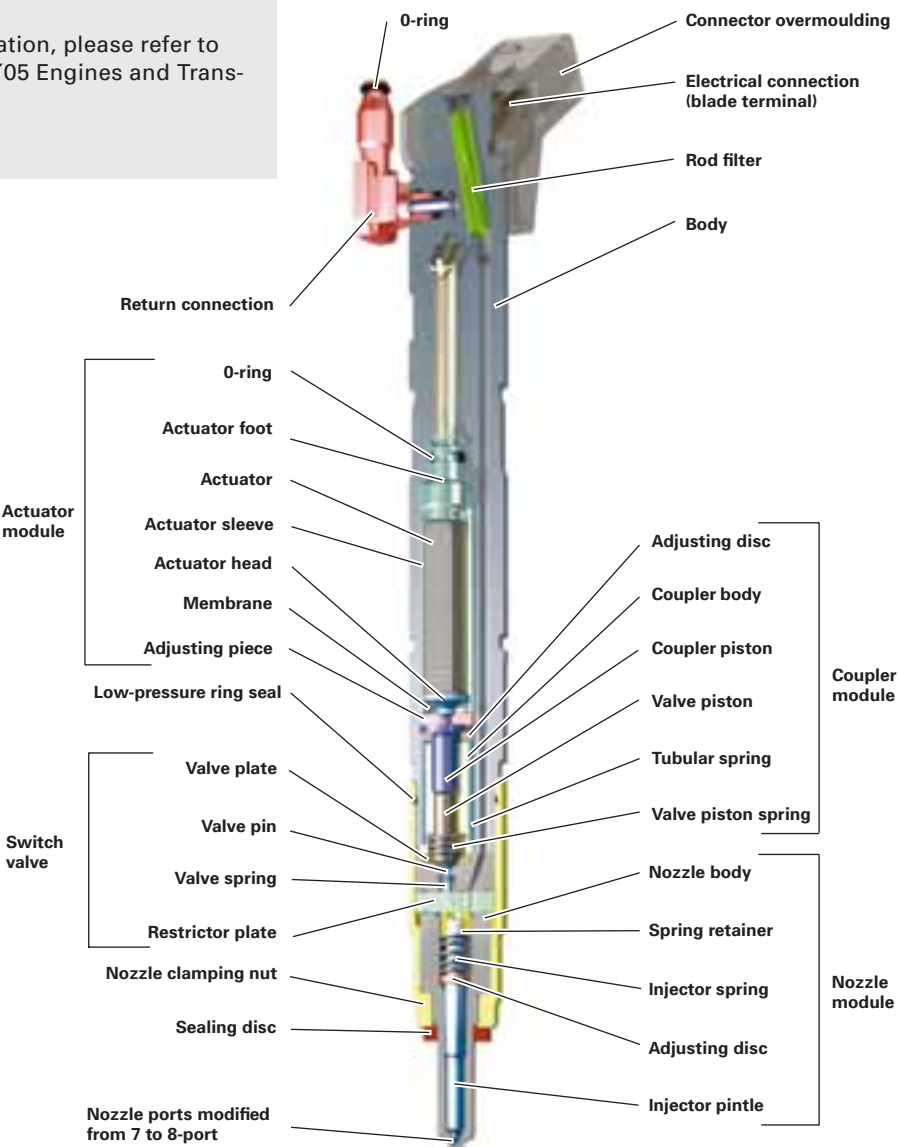


When an injector is replaced, the adaptation value for the new injector must be written to the engine control unit. When the engine control unit is replaced, the injector rate matching values and the injector voltage matching valve must be transferred to the new engine control unit.

Reference



For further information, please refer to SSP 325 - Audi A6 '05 Engines and Transmissions.



4.2 | V8 TDI engine with common rail injection system

System overview

Sensors

Air mass meter G70

Charge pressure sender G31
Intake air temperature sensor G42

Engine speed sender G28

Coolant temperature sender G62

Oil temperature sender G8

Fuel temperature sender G81

Fuel pressure sender G247

Coolant temperature sender
at radiator outlet G83

Hall sender G40

Accelerator pedal position sender G79
Accelerator pedal position sender -2- G185

Exhaust gas pressure sensor 1 G450

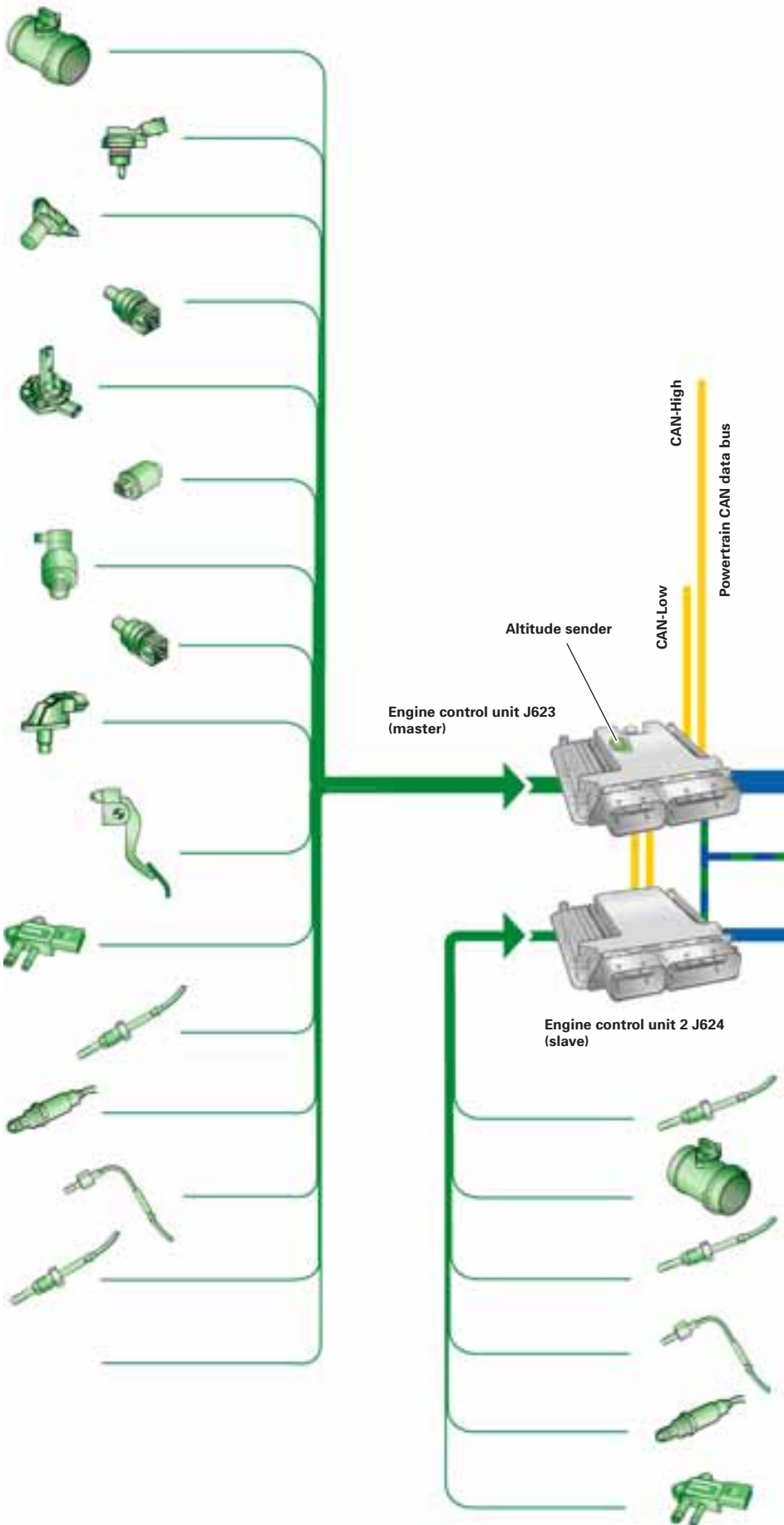
Exhaust gas temperature sender -1- G235

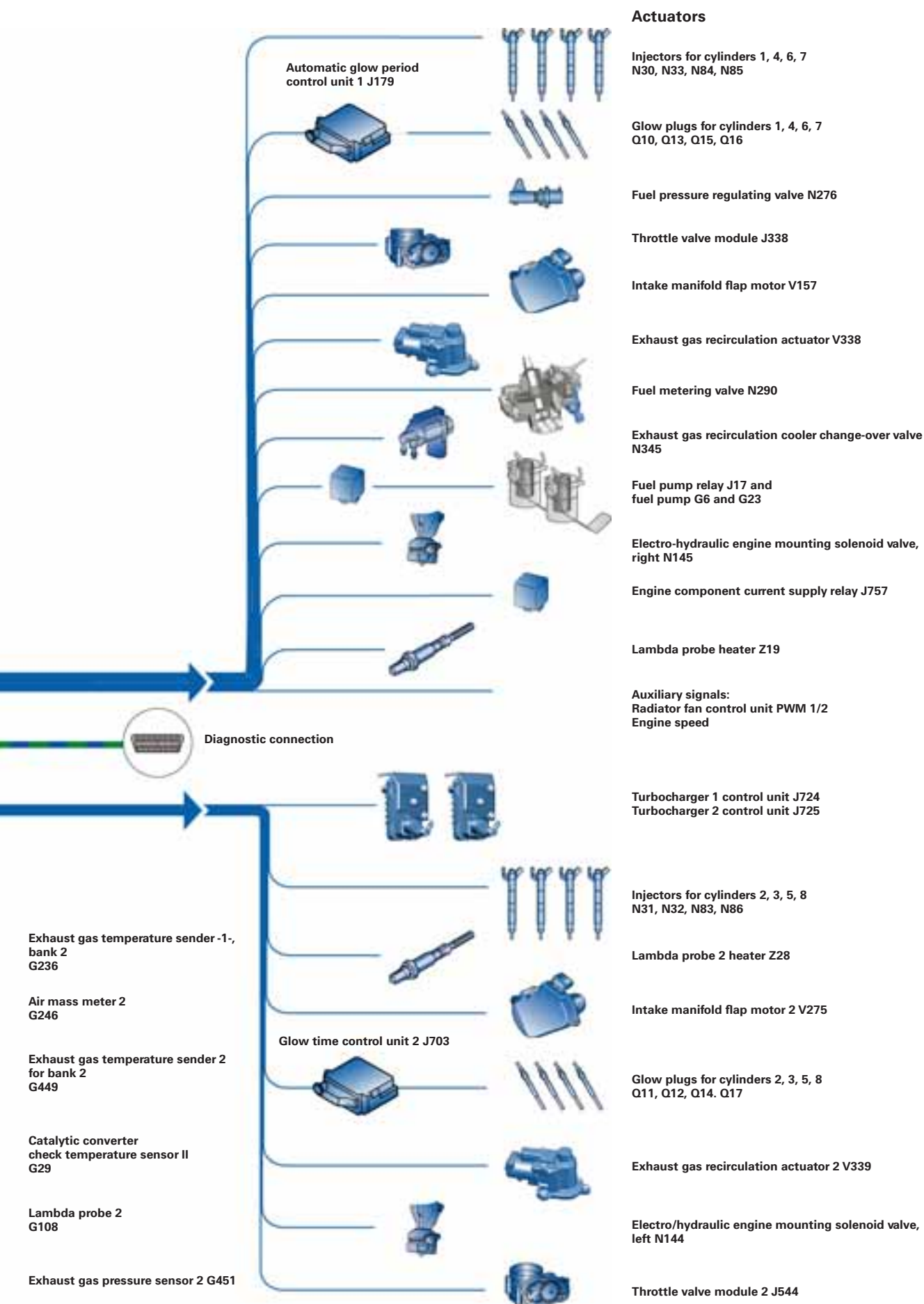
Lambda probe 1 G39

Catalytic converter temperature sensor I G20

Exhaust gas temperature sender 2 for bank 1
G448

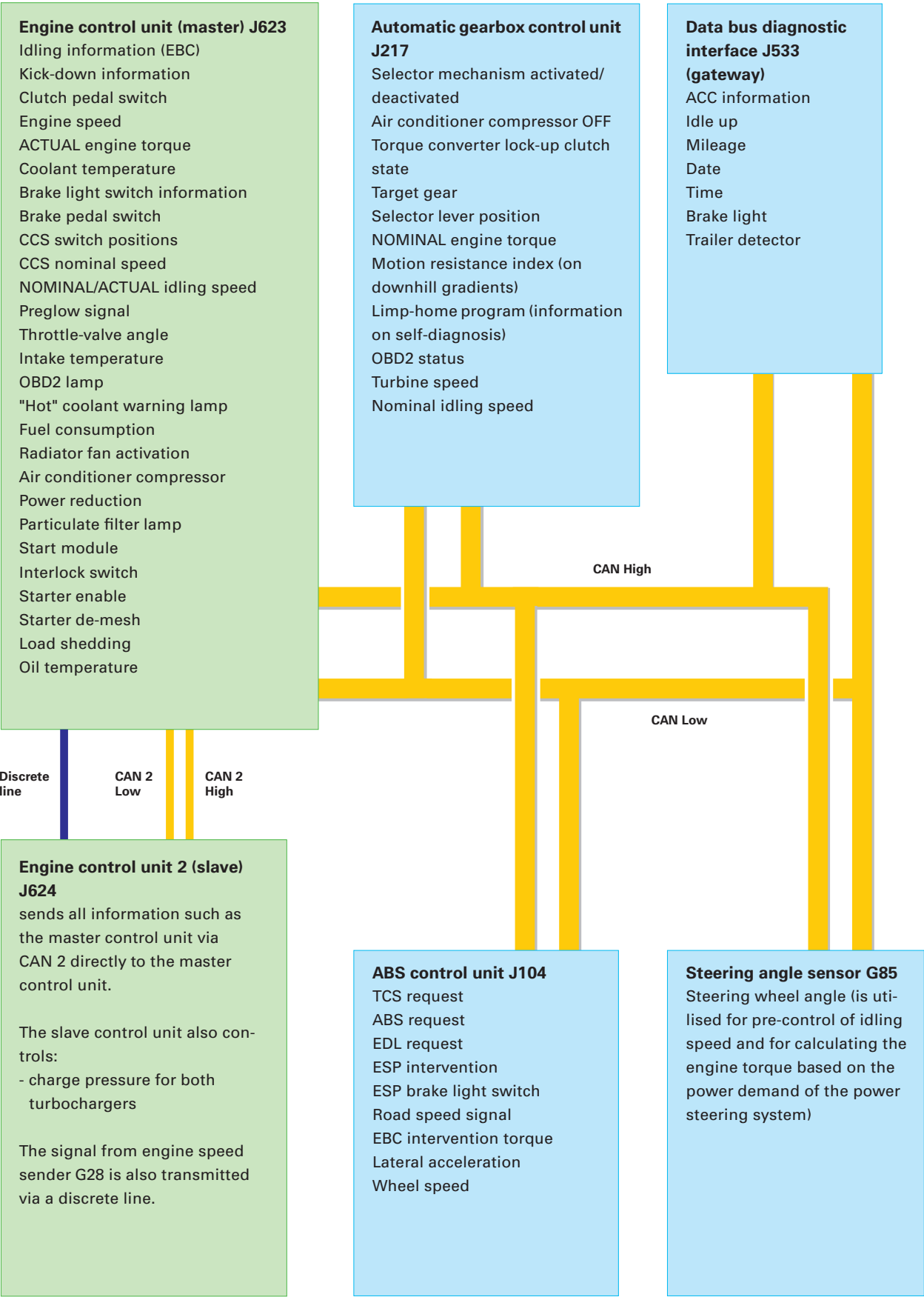
Auxiliary signals:
P/N signal
Term. 50 at starter
Start relay, term. 50 stage 1/2
Request start
Cruise control system
Auxiliary water pump (relay to control)





4.2 | V8 TDI engine with common rail injection system

CAN data bus interfaces (powertrain CAN data bus)



Exhaust system with diesel particulate filter

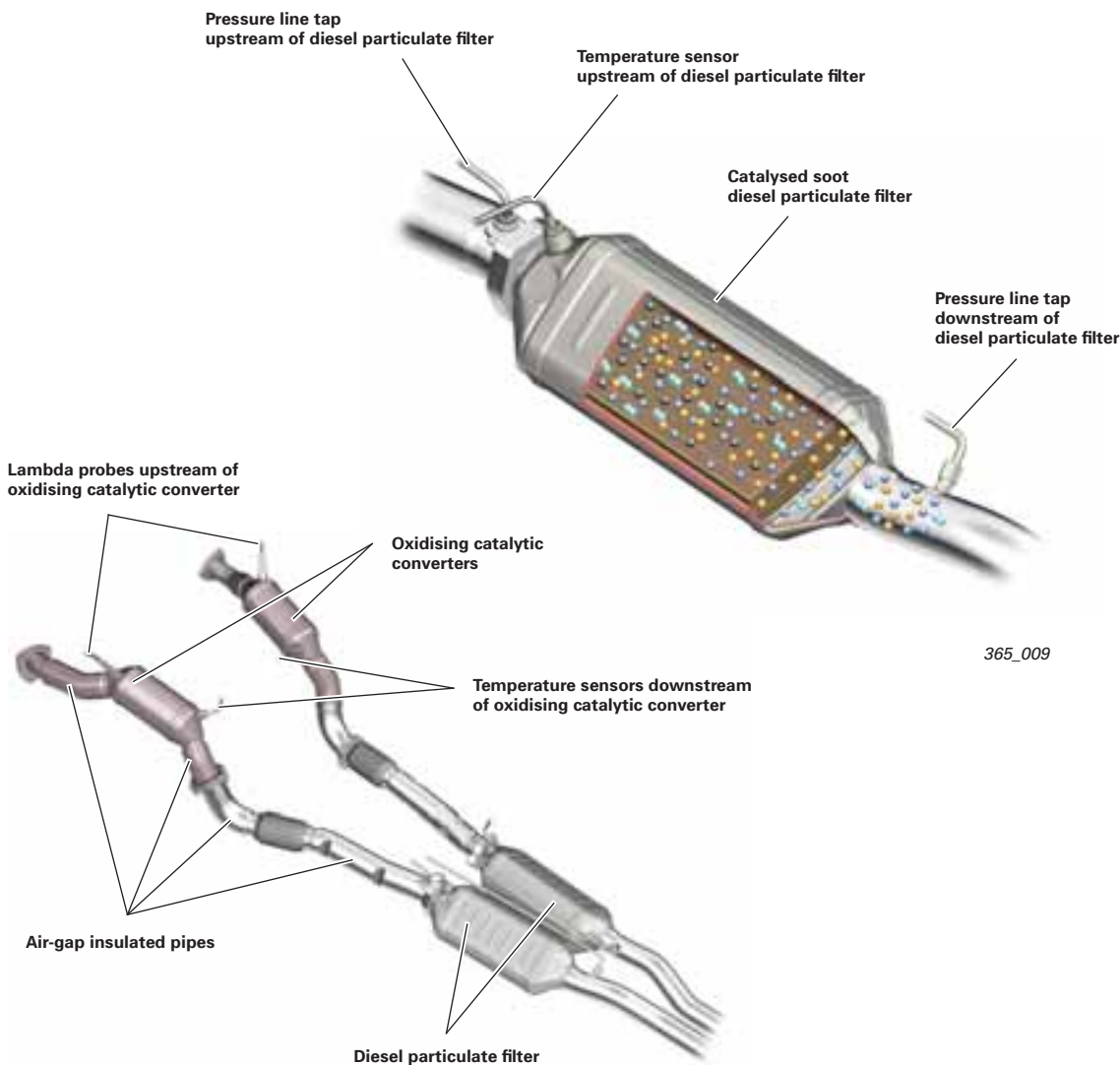
A double-chambered exhaust system with particulate filter is used in combination the 4.2 I V8 TDI engine. Each channel of the exhaust system comprises a close-coupled oxidising catalytic converter and a catalysed soot diesel particulate filter located in the under-body area. To minimise heat loss, the pipes from the turbochargers to the diesel particulate filters are air-gap insulated.

As in the 3.0 I V6 TDI engine, a diesel particulate filter consisting of a thin-wall silicon carbide substrate is used. Wall thickness has been reduced by 37 % to increase cellularity and thus enlarge the active surface area between the catalytic coating and the particulate layer. This helps to reduce the exhaust back-pressure and ensure faster filter regeneration times. The combination of a thin-wall substrate and a catalytic coating allows controlled filter regeneration at temperatures between 580 and 600 °C in addition to low exhaust back-pressures.

Reference



For further information on filter regeneration, please refer to SSP 325 - Audi A6 '05 Engines and transmissions.



365_009

4.2 I V8 TDI engine with common rail injection system

Special tools



Here you can see the special tools
for the 4.2 I V8 TDI engine with common rail.



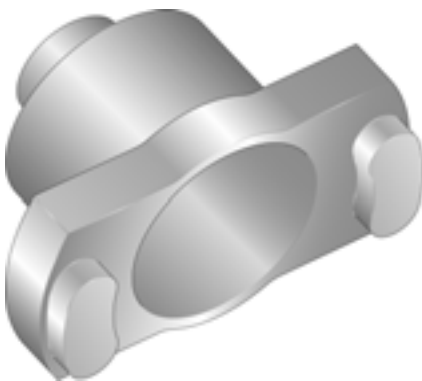
365_048

T40069
Locating pin



T40094
Camshaft insertion tool

365_049



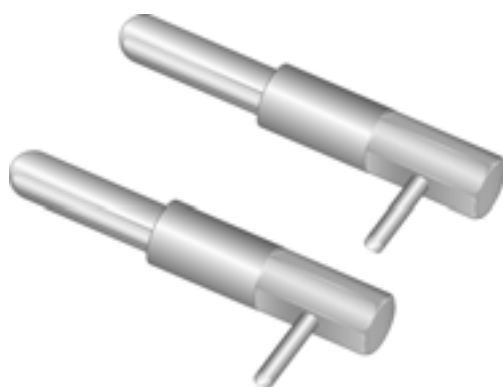
365_050

T40062
Adaptor
Sprocket wheel



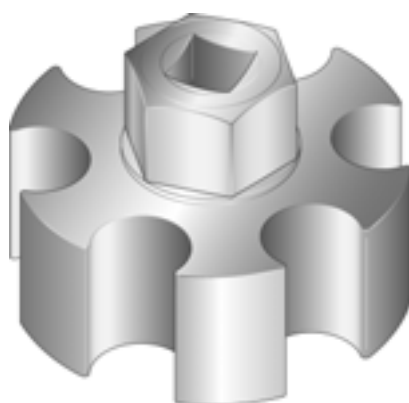
365_051

T40049
Adaptor



365_052

T40060
Timing pins



365_053

T40061
Adaptor
Camshaft

To broaden your knowledge of the common rail injection system, the following self-study programmes and CBTs have been prepared:



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