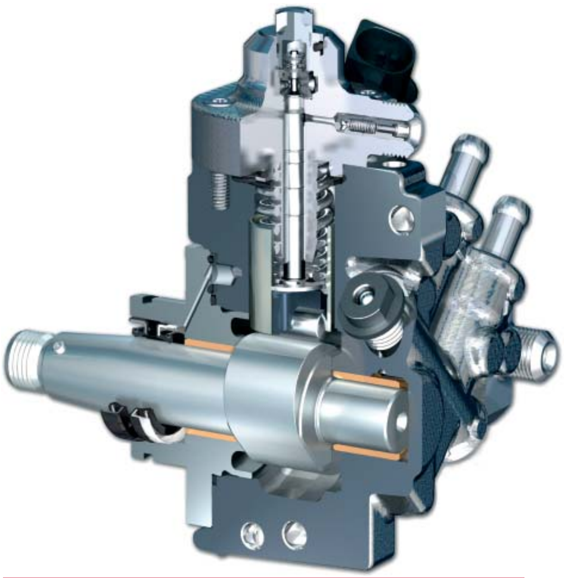
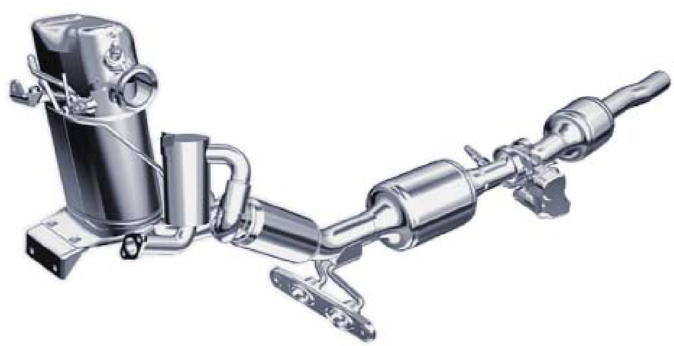
Service Training





2.0 Liter TDI Common Rail Engine
with Clean Diesel System

Self-Study Program 920193

Audi of America, LLC.

Service Training

Printed in U.S.A.

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Course Number 920193

Always check Technical Bulletins and the latest electronic repair literature for information that may supersede any information included in this booklet.

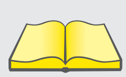
Table of Contents

The Self-Study Program teaches the design and function of new vehicle models, automotive components and technologies.

The Self-Study Program is not a Repair Manual!
The values given are only intended as a guideline. Refer to the software version valid at the time of publication of the SSP.

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

Reference



Note

Notes

Engines from Audi

The lead taken by Audi in 1989 with the introduction of the first turbocharged direct injection (TDI) diesel engine in the Audi 100 continues with a new generation of dynamic and efficient diesel engines. The 2.0 liter common rail TDI engine confirms the role of Audi as a pioneer in diesel technology.

By combining the successful and proven 2.0 Liter TDI engine with common rail technology, Audi is setting new standards in terms of such characteristic TDI attributes as dynamics, driving enjoyment, economy, and reliability. The superior qualities of the 2.0 Liter TDI engine with common rail injection system are oriented towards future challenges in acoustics, comfort, and exhaust gas after-treatment.

This engine offers the potential for future improvements in exhaust gas emission standards and the associated technologies.

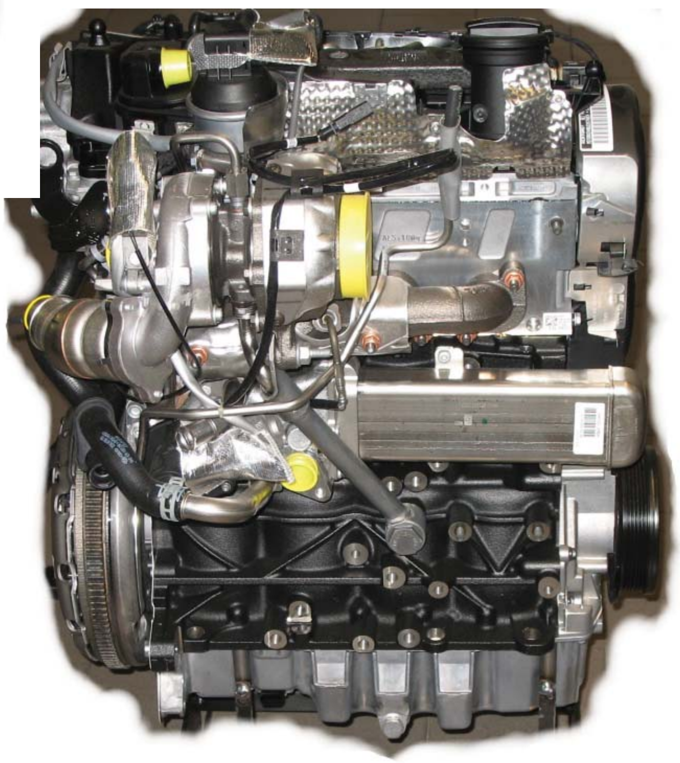
S 403_ 051

Notes

Heritage

The 2.0 Liter TDI engine with common rail injection system is based on the 1.9 Liter TDI engine with the Unit Injector System (UIS) also known as the “pumpe düse”. This predecessor engine is one of the most frequently built diesel engines in the world and has seen heavy use within the Audi Group.

To accommodate the increasing demand for improvements in acoustics, fuel consumption, and exhaust gas emissions, a large number of engine components were redesigned. The conversion of the injection system to a common rail design is one of the major changes to this engine. Equipped with a special exhaust gas after-treatment system, this engine meets stringent emissions standards.



Technical Characteristics

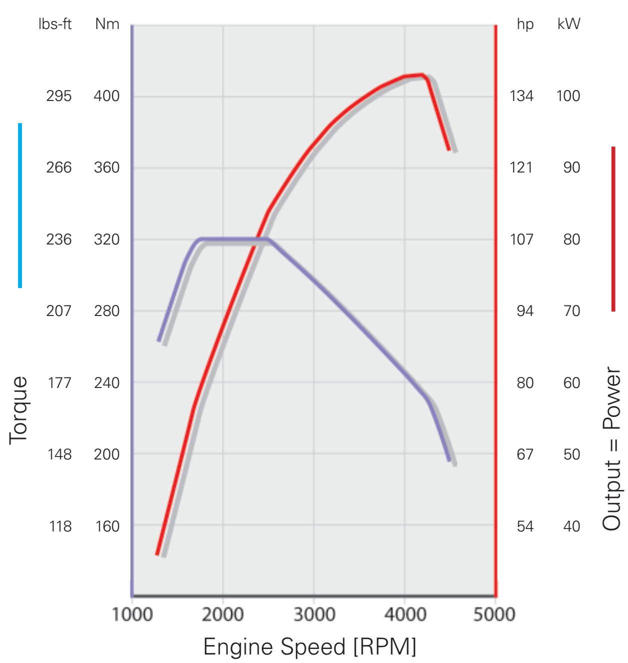
- Common rail injection system with Piezo fuel injectors
- Diesel particulate filter with upstream oxidation catalyst
- Intake manifold with flap valve control
- Electric exhaust gas return valve
- Adjustable exhaust gas turbocharger with displacement feedback
- Low and high pressure Exhaust Gas Recirculation (EGR) system

Engine

2.0 Liter TDI Technical Data

Design	4-Cylinder In-Line Engine
Displacement	120 in³ (1968 cm³)
Bore	3.189 in. (81 mm)
Stroke	3.760 in. (95.5 mm)
Valves per Cylinder	4
Compression Ratio	16.5:1
Maximum Output	140 hp (103 kW) at 4000 rpm
Maximum Torque	236 lb-ft (320 Nm) at 1750 rpm up to 2500 rpm
Engine Management	Bosch EDC 17 (Common Rail Control Unit)
Fuel	ULSD / ASTM D975-06b 2-D-S<15 (Ultra-Low Sulfur Diesel, under 15 ppm)
Exhaust Gas Treatment	High and Low Pressure Exhaust Gas Return, Oxidation Catalytic Converter, Diesel Particulate Filter, NOx Reduction Catalytic Converter

2.0L TDI Torque and Power



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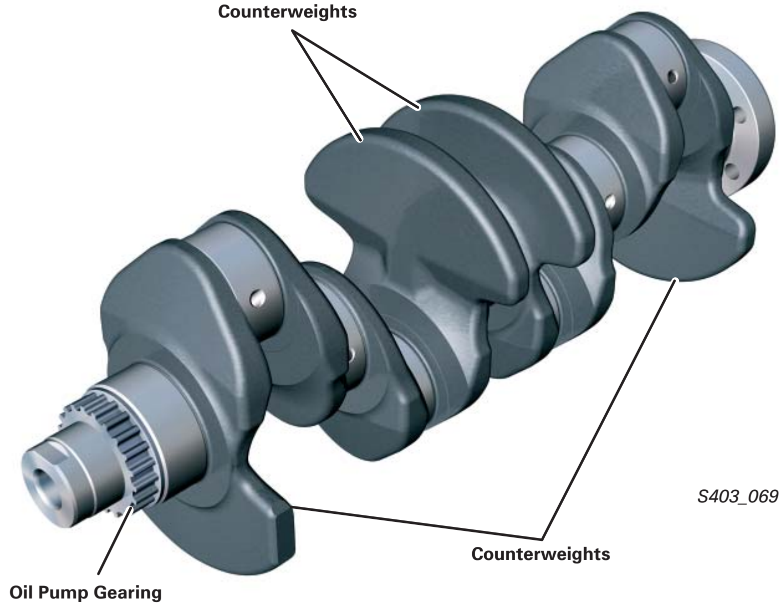
Crankshaft

The 2.0 Liter TDI common rail engine uses a forged crankshaft to accommodate high mechanical loads.

Instead of the customary eight counterweights, this crankshaft has only four. Using four counterweights reduces the load on the crankshaft bearings, as well as noise emissions that can occur due to the intrinsic motion and vibrations of the engine.



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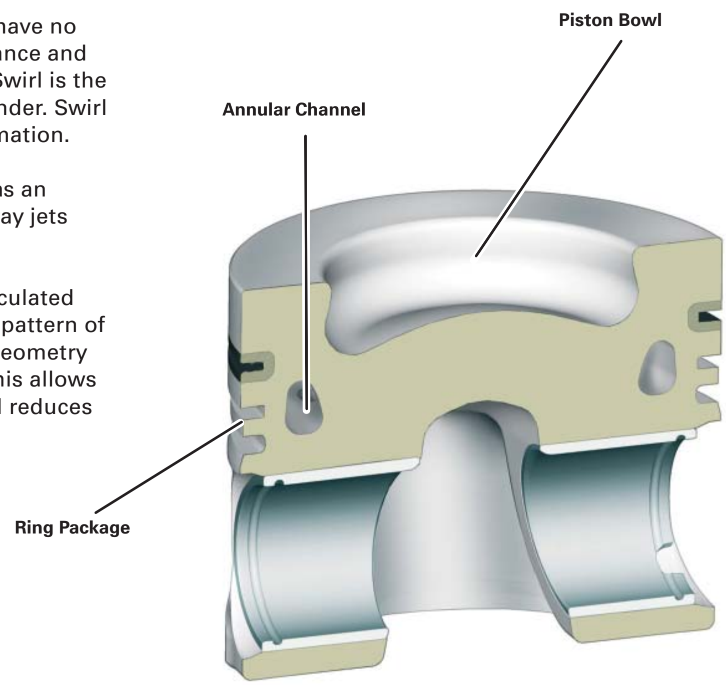
Pistons

The 2.0 Liter TDI common rail engine pistons have no valve pockets. This reduces the cylinder clearance and improves the swirl formation in the cylinder. Swirl is the circular flow about the vertical axis of the cylinder. Swirl has a significant influence on the mixture formation.

For cooling the piston ring zone, the piston has an annular cooling channel into which piston spray jets inject oil.

The piston bowl, where the injected fuel is circulated and mixed with air, is matched with the spray pattern of the injection jets and has a wider and flatter geometry than the piston in a pump-injection engine. This allows for a more homogeneous air/fuel mixture, and reduces formation of soot.



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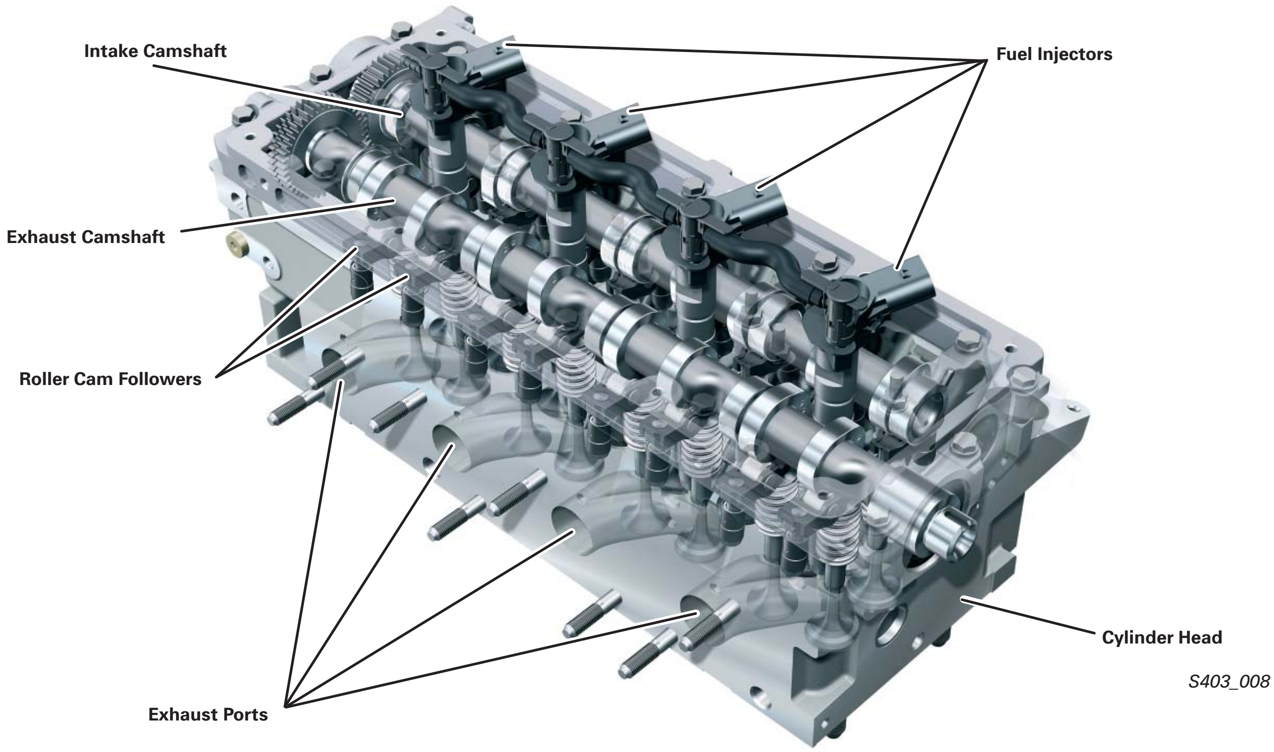
Cylinder Head

The 2.0 Liter TDI common rail engine has a crossflow aluminum cylinder head with two intake and two exhaust valves per cylinder. The valves are arranged vertically upright.

The two overhead camshafts are linked by spur gears with an integrated backlash adjuster. They are driven by the crankshaft with a toothed belt and the exhaust camshaft timing gear. The valves are actuated by low friction roller cam followers with hydraulic valve lash adjusters.



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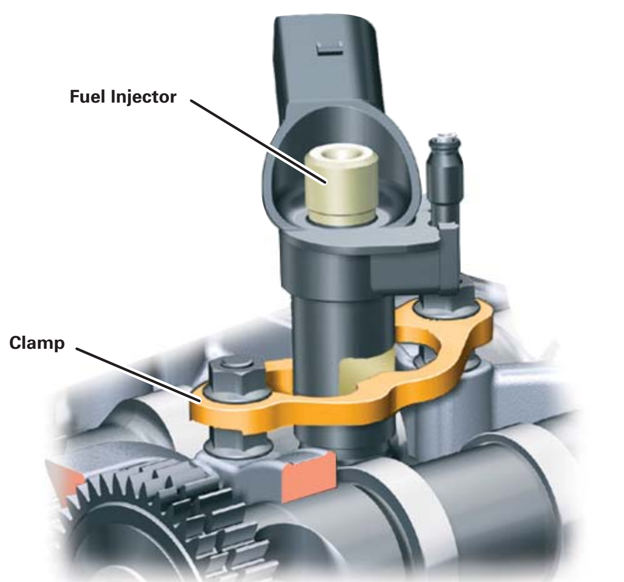
The fuel injectors are fixed in the cylinder head with clamps. They can be removed through small caps in the valve cover.

An additional feature of the cylinder head are pressure sensors that are integrated into the glow plugs.



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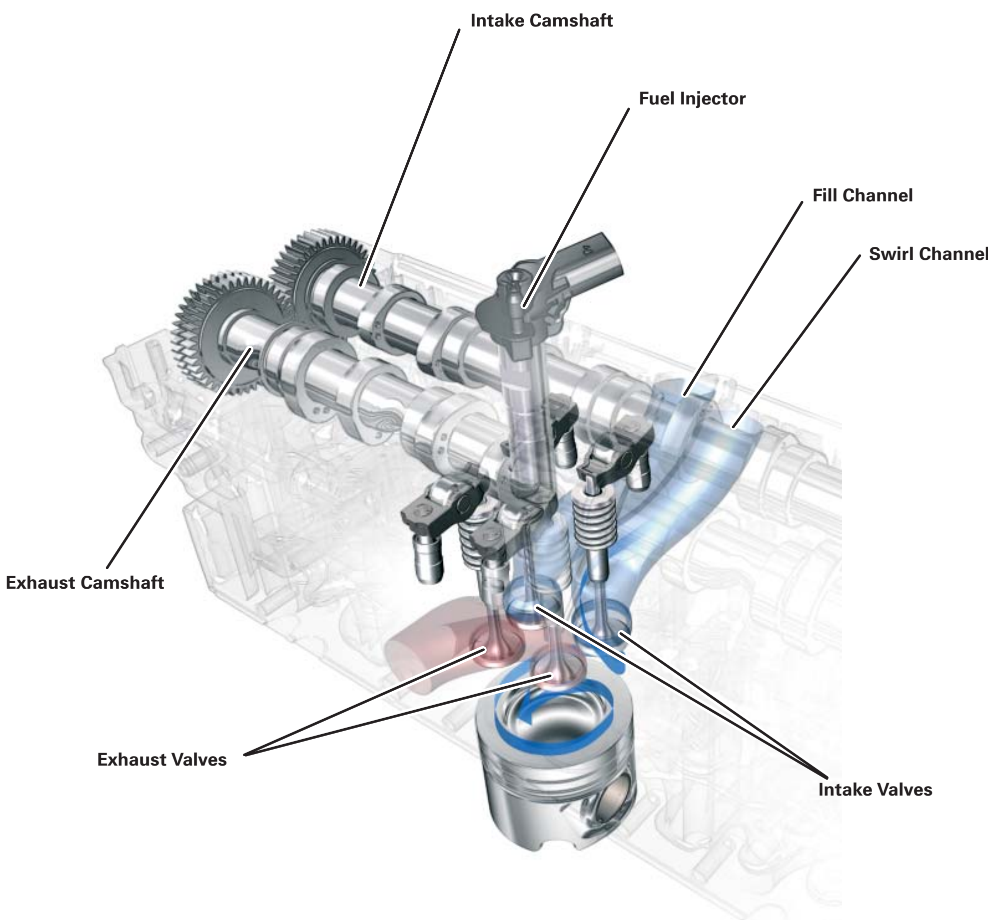
Four-Valve Technology

Two intake and two exhaust valves per cylinder are vertically suspended in the cylinder head. The vertically suspended and centrally situated fuel injector is arranged directly over the center of the piston bowl.

Shape, size, and arrangement of the intake and exhaust channels ensure a good degree of fill and a favorable charge cycle in the combustion chamber. The intake ports are designed as swirl and fill channels. The air flowing in through the fill channel produces the desired high level of charge motion.

The swirl channel ensures good filling of the combustion chamber, particularly at high engine speeds.



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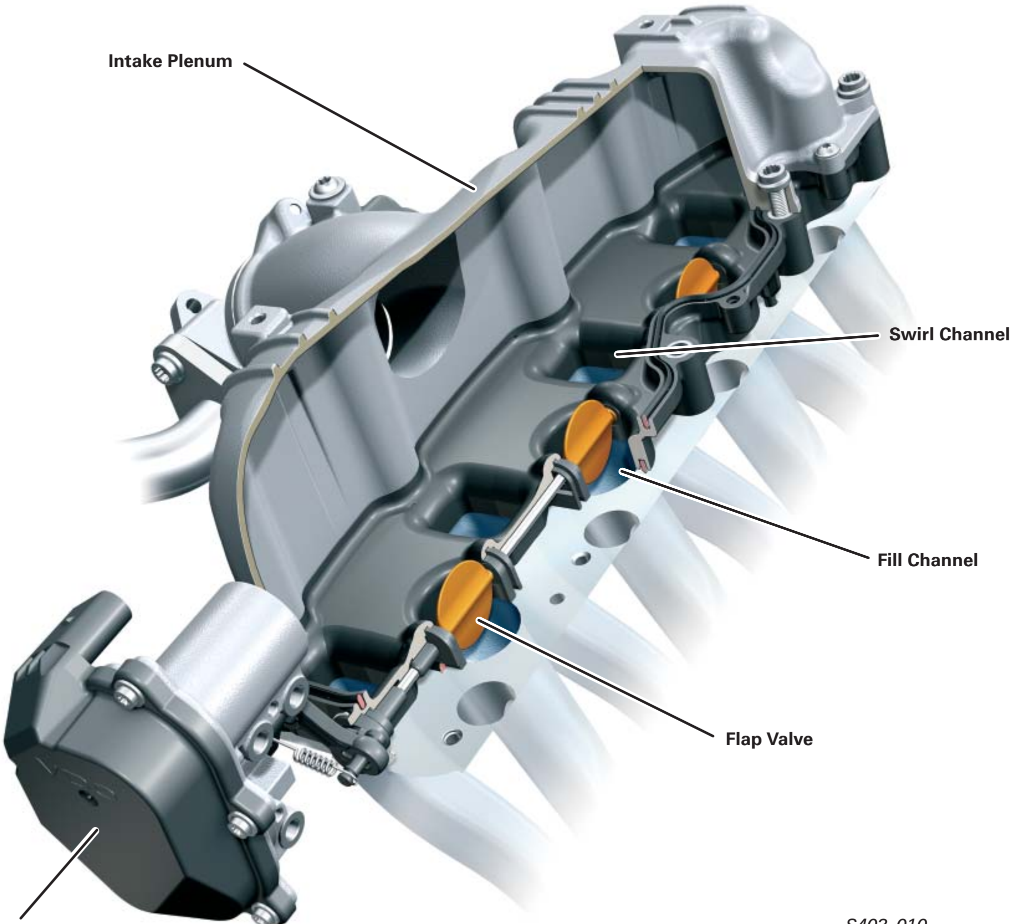
Intake Manifold with Flap Valves

Infinitely variable flap valves are located in the intake manifold. Through the positioning of the flap valves, the swirl of the intake air is adjusted based on the engine speed and load.

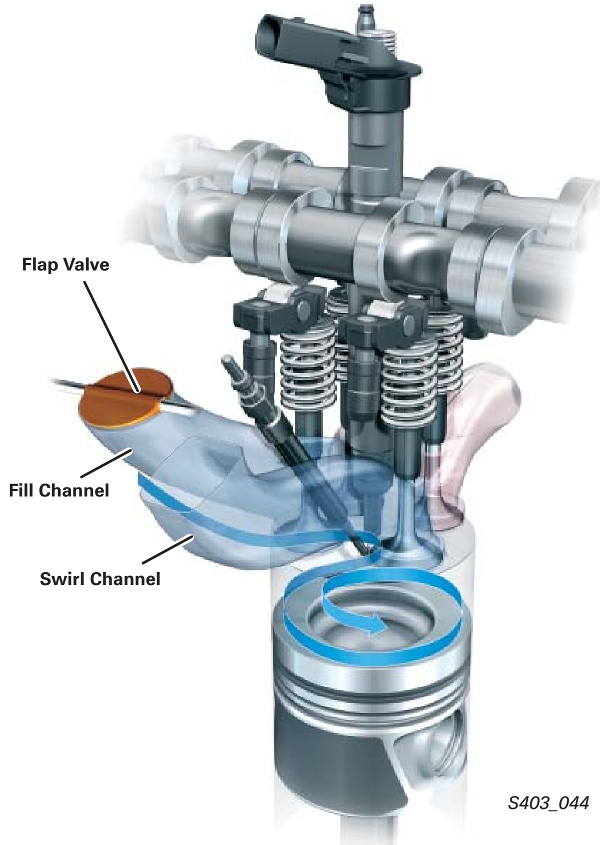
The flap valves are moved by a pushrod connected to the Intake Flap Motor V157. This step motor is activated by the Engine Control Module (ECM) J623. The Intake Manifold Runner Position Sensor G336 is integrated in the Intake Flap Motor V157 and electronically regulates its movement. It also provides the Engine Control Module (ECM) J623 with feedback of the current position of the flap valves.

Design



Flap Valve Function

During idling and at low engine speeds, the flap valves are closed. This leads to high swirl formation and good mixture formation.



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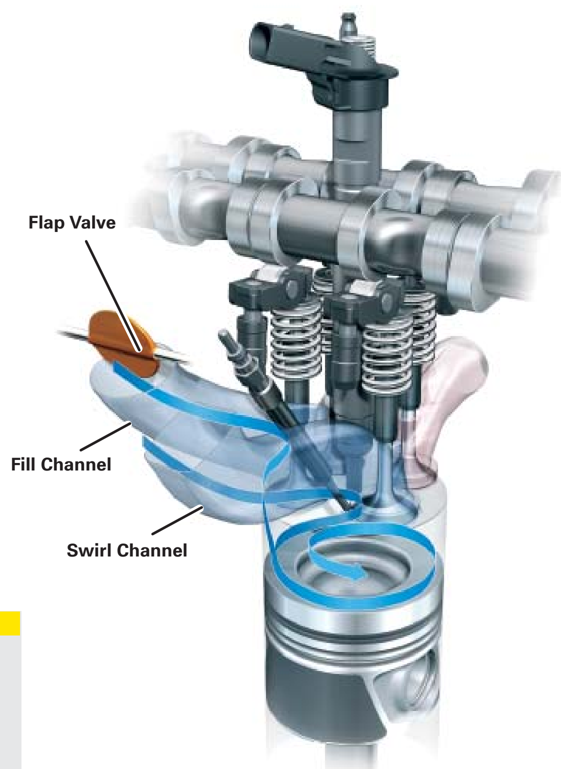
During driving, the flap valves are adjusted continuously based on the load and engine speed. Thus for each operating range the optimum air movement is available.

Starting at an engine speed of approximately 3000 rpm, the flap valves are completely open. The increased throughput of air insures good filling of the combustion chamber.



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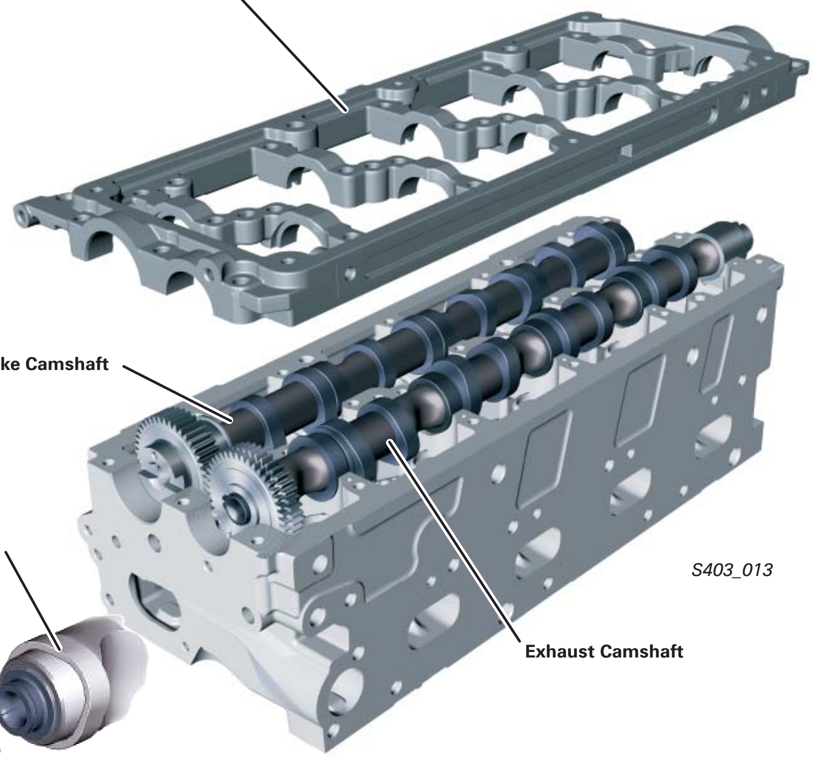
Reference

The flap valves are opened at startup and during emergency operation.

Camshaft Operation

The intake and exhaust camshafts are linked by spur gearing with an integrated backlash adjuster. The spur gear on the exhaust camshaft drives the spur gear on the intake camshaft.

Backlash compensation ensures quiet camshaft operation.



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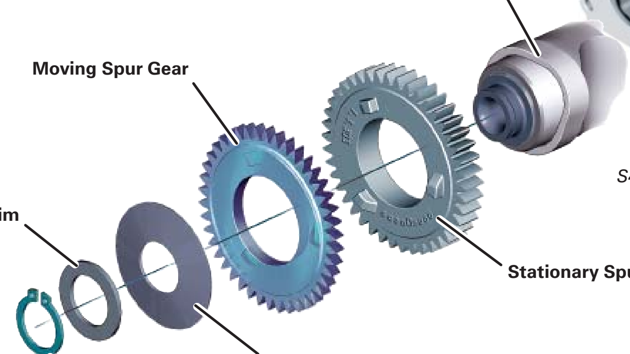
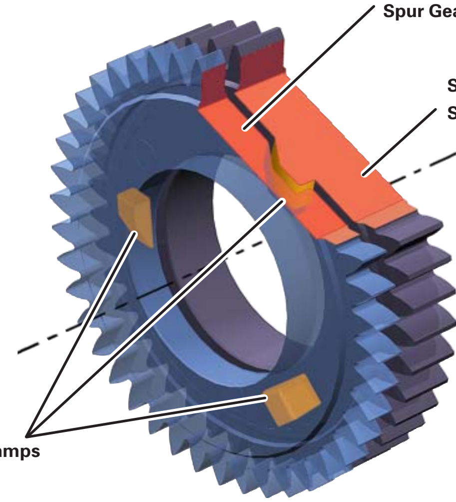


S403_012

Design

The wider part of the spur gear (stationary spur gear) is a press-fit on the exhaust camshaft. There are ramps on the front face of the stationary spur gear.

The narrower part of the spur gear (the moving spur gear) can move in both radial and axial directions. There are recesses for the stationary spur gear ramps in the rear face of the moving spur gear.



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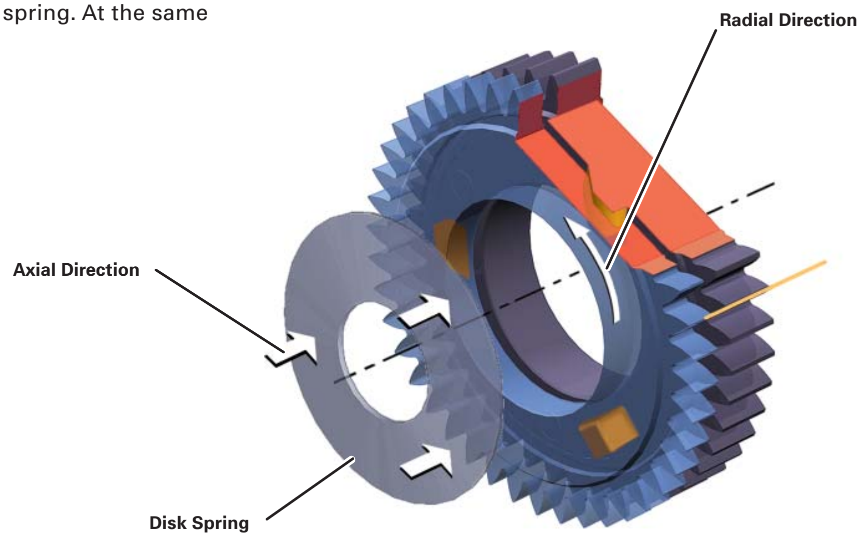
How it Works

Both parts of the spur gear are pushed together in an axial direction by the force of a disk spring. At the same time, they are rotated by the ramps.



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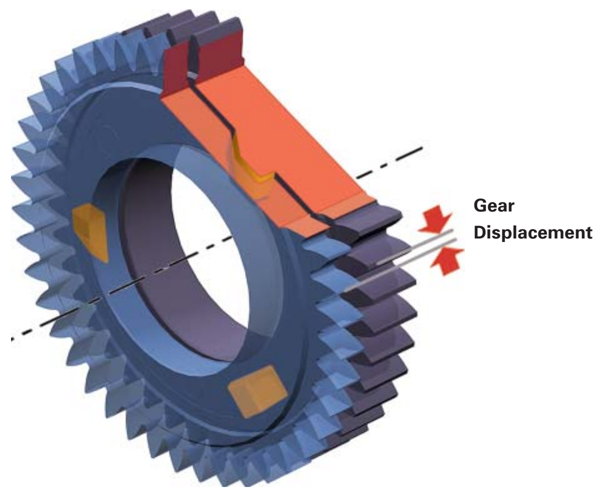
Lash Adjustment

The rotation leads to a gear displacement of the two spur gear parts and effects the lash adjustment between the intake and exhaust camshaft gears.



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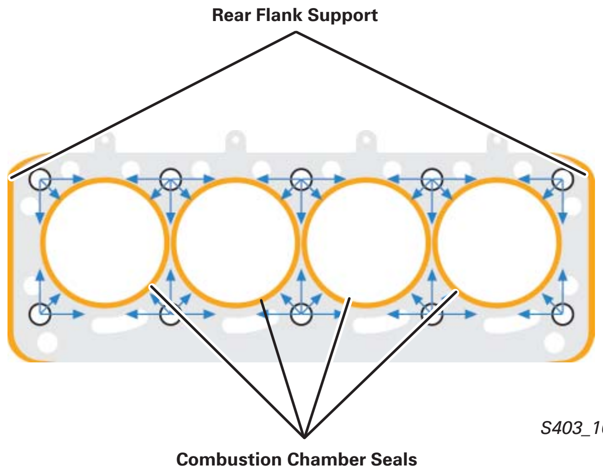
Cylinder Head Gasket

The cylinder head gasket is a four-layer design and has two special attributes that improve the sealing of the combustion chambers.

– Vertically profiled combustion chamber seals
– Rear flank support



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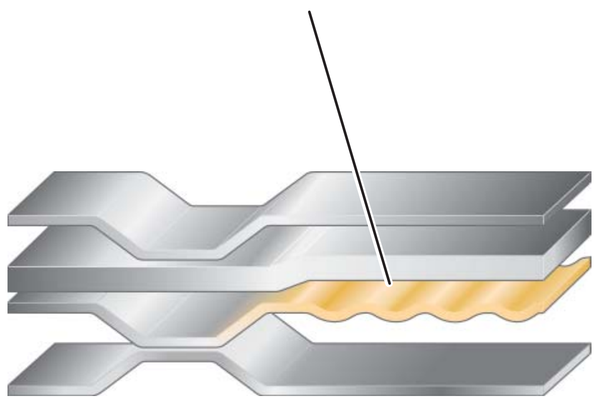
Vertically Profiled Combustion Chamber Seals

The sealing edge at the cylinder bore is called the combustion chamber seal. It is vertically profiled, which means that the edge profile has varying heights around the perimeter of the combustion chamber. This special geometry provides for the uniform distribution of cylinder head gasket sealing forces around the combustion chambers. This prevents deformation at the cylinder bores and fluctuations in the sealing gap.



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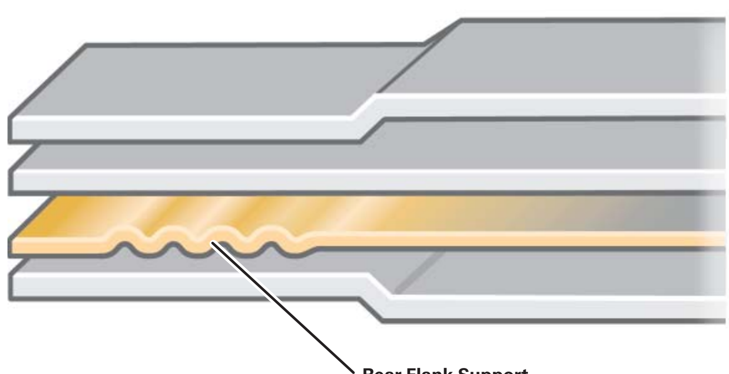
Rear Flank Support

The profile in the area of the two outer cylinders of the cylinder head gasket are called the “rear flank support.” The rear flank support effects a uniform distribution of the gasket sealing forces in these areas. This reduces flexing of the cylinder head and deformation of the outer cylinders.



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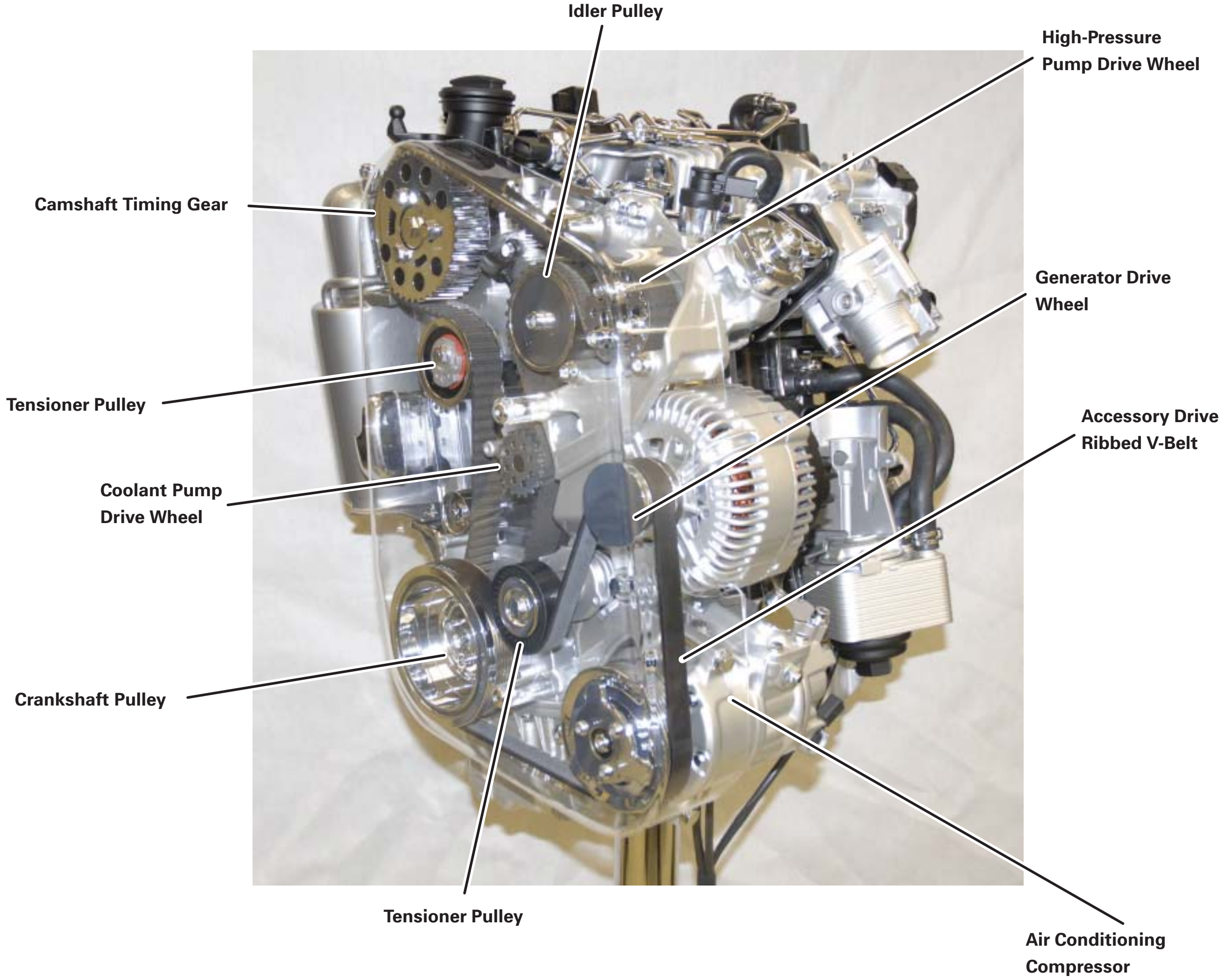
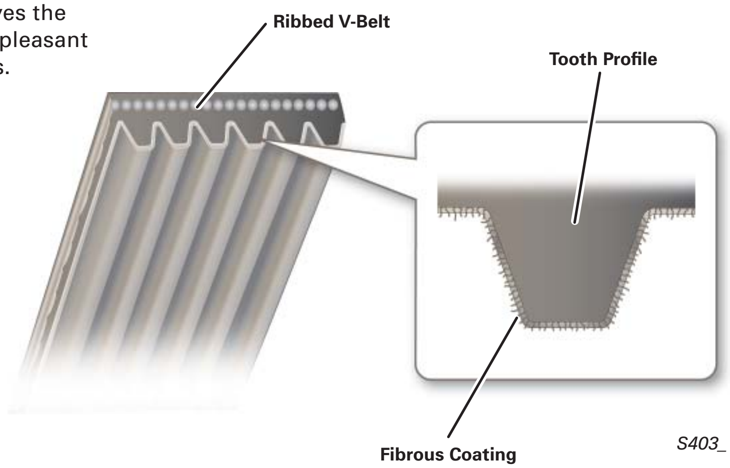
Toothed Belt Drive

The camshaft, coolant pump, and high pressure pump for the common rail injection system are driven by a toothed belt.



Accessory Drive

The generator and air conditioning compressor are driven by a ribbed V-belt. The profile surface of the ribbed V-belt has a fibrous coating. This improves the frictional properties of the belt and reduces unpleasant noise that can occur in wet and cold conditions.



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Balance Shaft Module

The balance shaft module is installed below the crankshaft in the oil pan. The balance shaft module is driven by the crankshaft by a gear drive. The duocentric oil pump is integrated into the balance shaft module.

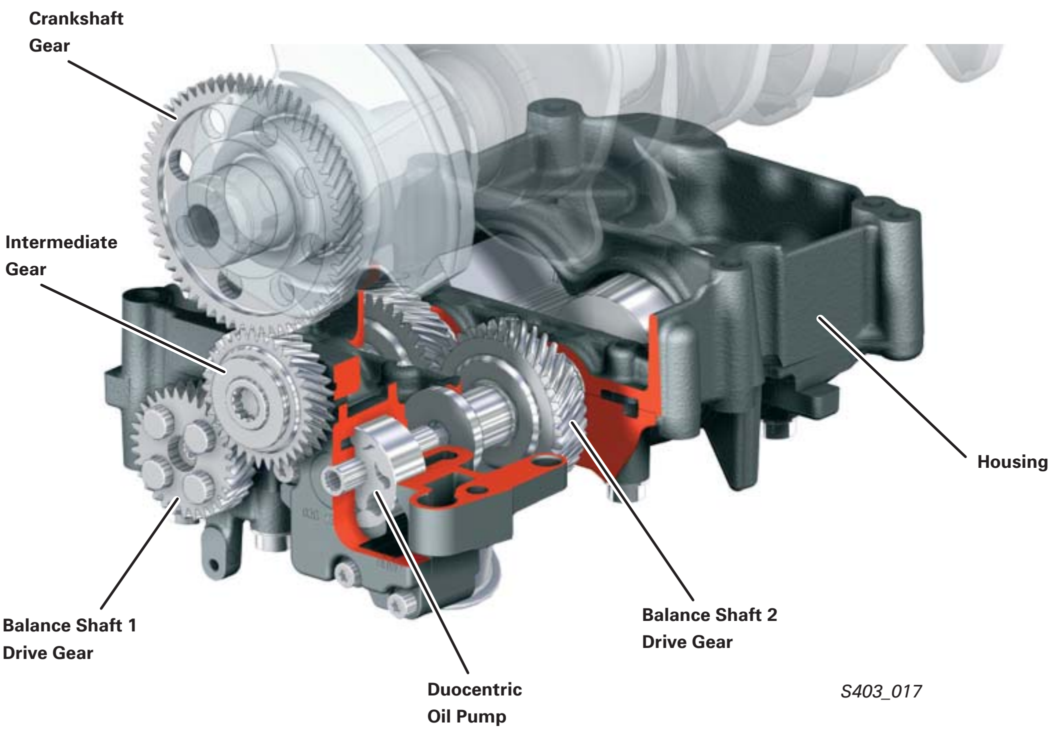
Design

The balance shaft module consists of a gray cast iron housing, two counter-rotating balance shafts, a helical-toothed gear drive, and an integrated duocentric oil pump. The rotation of the crankshaft is transferred to the intermediate gear on the outside of the housing. This drives the first balance shaft. From this balance shaft, the motion is then transferred inside the housing to the second balance shaft and to the duocentric oil pump.

The gear drive is designed so that the balance shafts rotate at double the crankshaft speed. The tooth backlash of the gear drive is adjusted with the help of a coating on the intermediate gear. This coating wears off during startup of the engine and results in excellent mating of the teeth on the two gears.

Note

The intermediate gear must always be replaced if the intermediate gear or the drive gear of the first balance shaft have been loosened.
Please refer to the instructions in the Repair Manual.



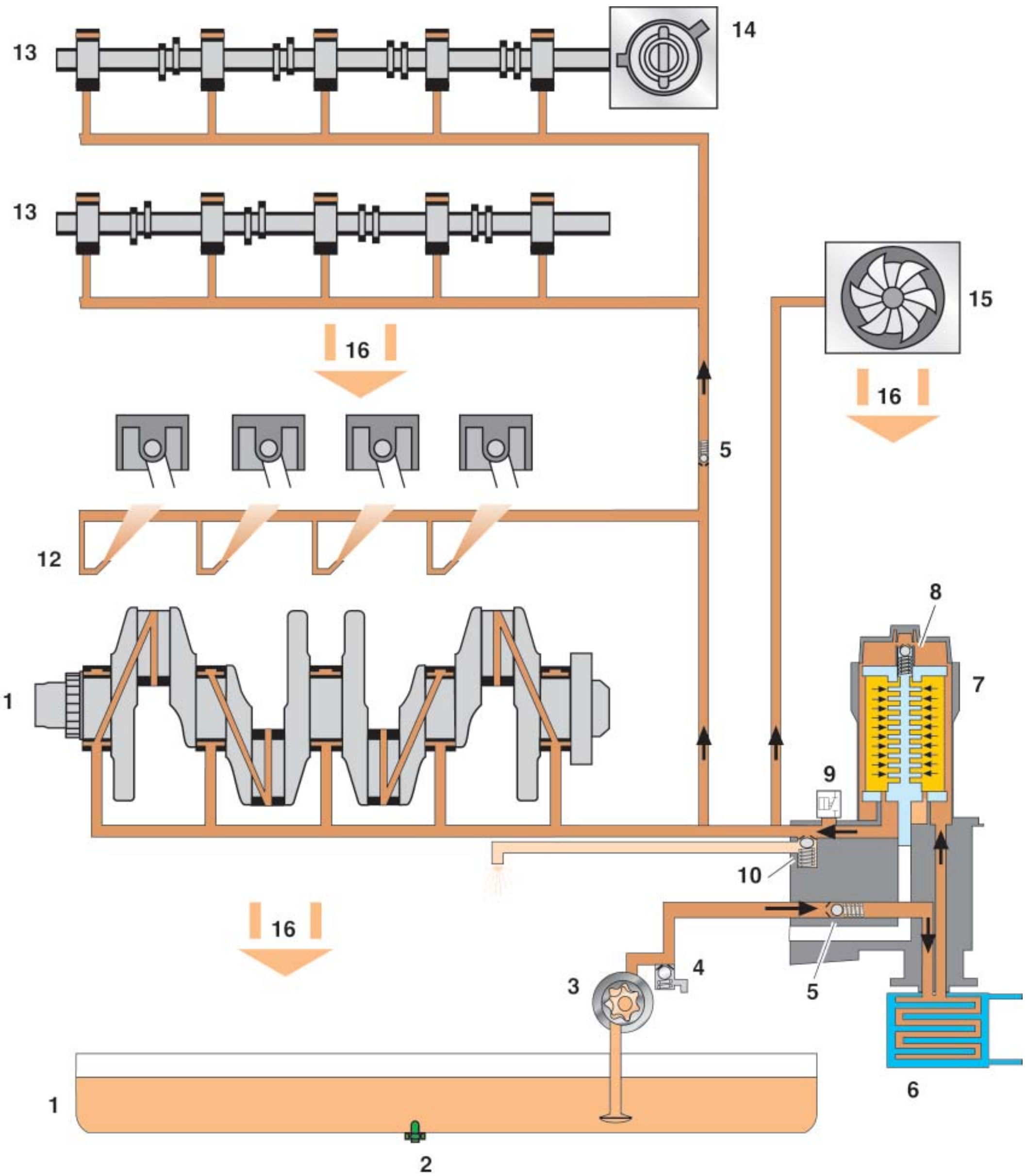
S403_017

Oil Circuit

A duocentric oil pump generates the oil pressure required for the engine. It is integrated into the balance shaft module and is driven by a balance shaft drive shaft.

The pressure relief valve is a safety valve. It prevents damage to engine components from excessive oil pressure, such as at high speeds and low ambient temperatures.

The oil pressure control valve regulates the oil pressure in the engine. It opens as soon as the oil pressure reaches the maximum allowable value. The bypass valve opens when the oil filter is clogged to safeguard the lubrication of the engine.



Legend

1 – Oil Pan
2 – Oil Level and Temperature Transmitter
3 – Oil Pump
4 – Oil Pressure Relief Valve
5 – Oil Return Block
6 – Oil Cooler
7 – Oil Filter
8 – Bypass Valve
9 – Oil Pressure Switch F1
10 – Oil Pressure Control Valve
11 – Crankshaft
12 – Spraying Nozzles for Piston Cooling
13 – Camshaft
14 – Vacuum Pump
15 – Turbocharger
16 – Oil Return

Crankcase Ventilation

In combustion engines, pressure differentials between the combustion chamber and the crankcase generate air flow between piston rings and cylinder bore that are called blow-by gases. These oily gases are returned to the intake area through the crankcase ventilation system to prevent pollution.

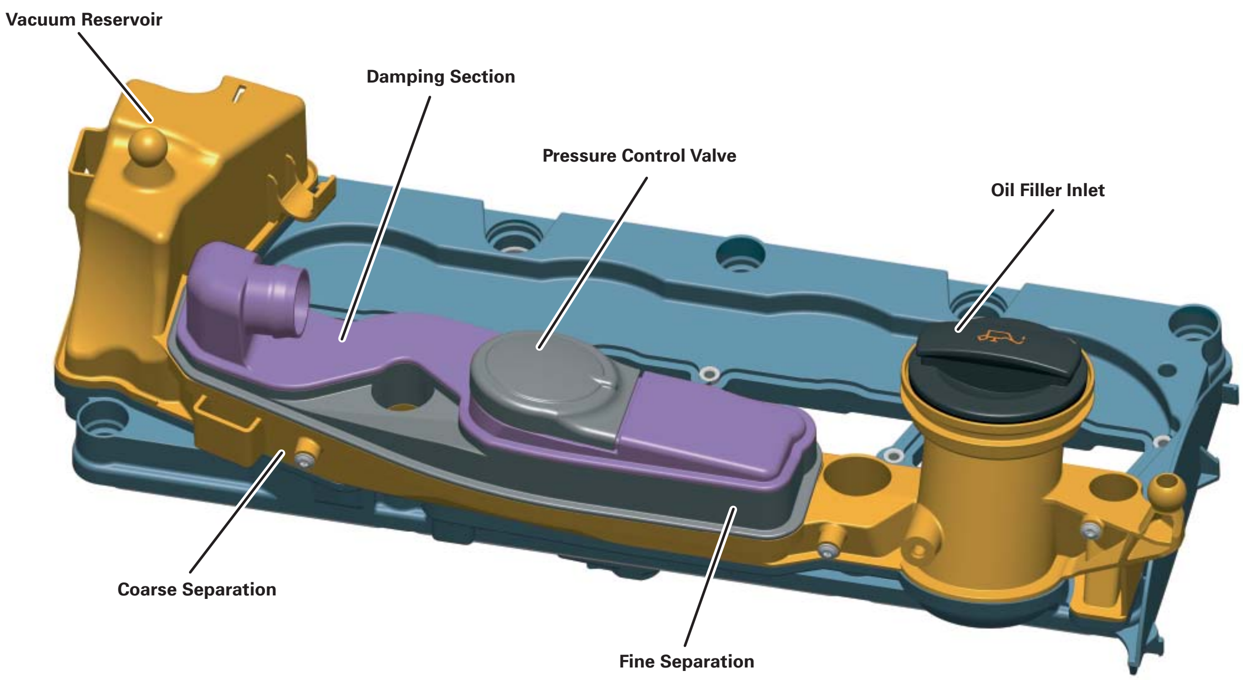
Effective oil separation keeps engine oil in the crankcase and prevents it from entering the intake manifold. This multi-stage system separates more oil than a single-stage system. The oil separation occurs in three stages:

– Coarse separation
– Fine separation
– Damping section

The crankcase ventilation components, oil filler inlet, and pressure reservoir for the vacuum system are all integrated in the cylinder head cover.

Coarse Separation

The blow-by gases move from the crankshaft and camshaft chamber into a stabilizing section that is integrated in the cylinder head cover. In this section, the larger oil droplets are separated onto the walls and collect on the floor. The oil drips into the cylinder head through the openings in the stabilizing section.



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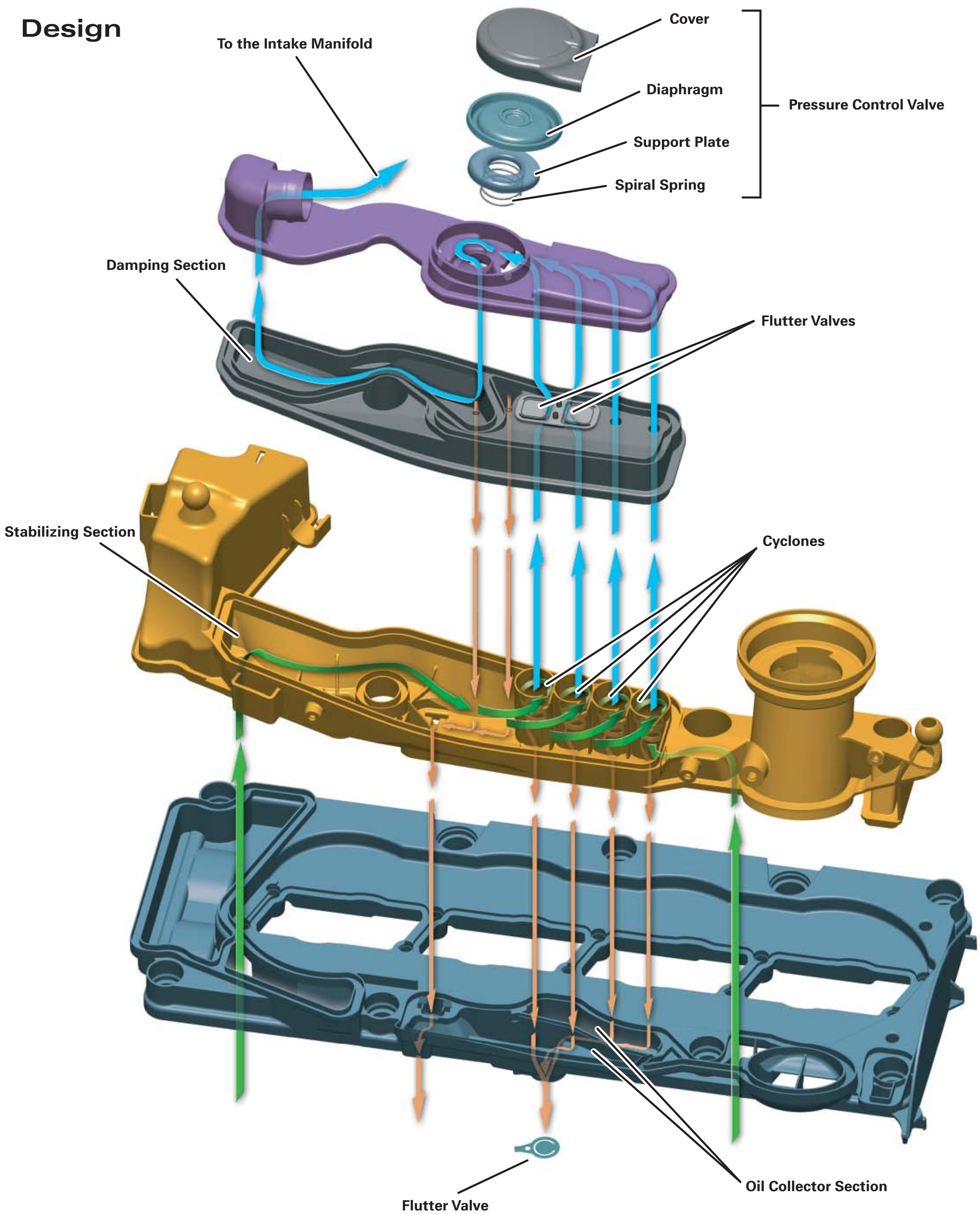
Design



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Legend

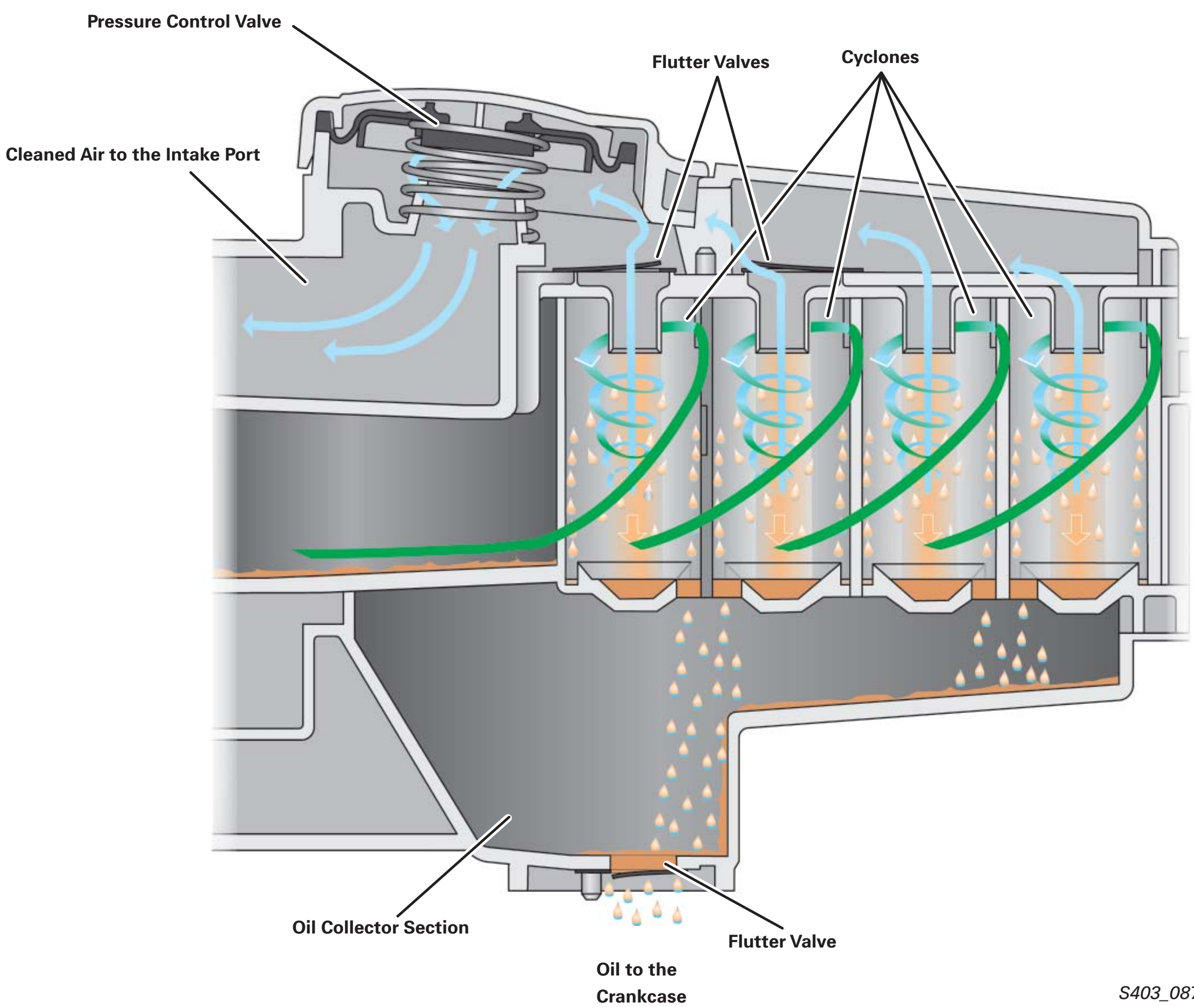
- Oily Air from the Crankcase
- Air Cleaned of Oil
- Oil Return

Fine Separation

The fine separation takes place over a four-cyclone separator. Depending on the amount of the pressure differential between the intake manifold and the crankcase, two or four cyclones are activated by spring steel flutter valves.

Due to the geometry of the cyclones, the air is set into a rotating motion. The resulting centrifugal force slings the oil mist onto the separator wall. The oil droplets are deposited on the wall of the cyclone and are captured in a collector section.

When the engine is OFF, a flutter valve opens. This valve closes during engine operation due to the increased pressure in the cylinder head. The only purpose of this valve is to let oil drain back into the engine sump when the engine is OFF.



S403_087

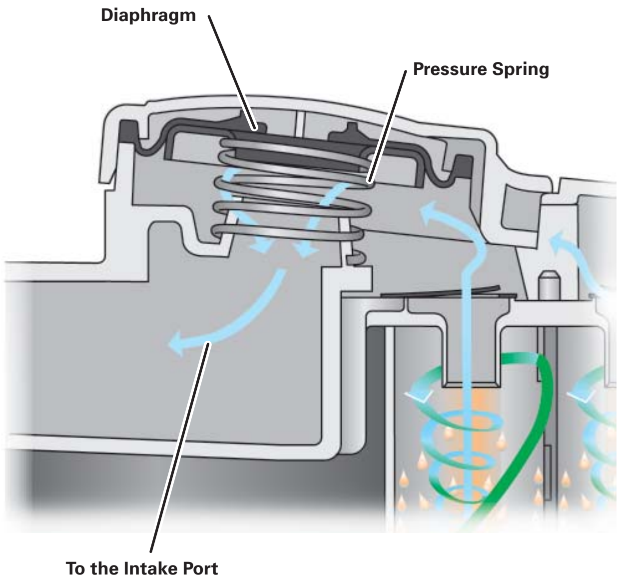
Pressure Control Valve

The pressure control valve regulates the pressure for ventilation of the crankcase. It consists of a diaphragm and a pressure spring.

When blow-by gases are present, the pressure control valve limits the vacuum in the crankcase. Excessive vacuum in the crankcase could result in damage to the engine seals.

When vacuum in the intake port is low, the valve opens through the force of the pressure spring.

Pressure Control Valve Opened



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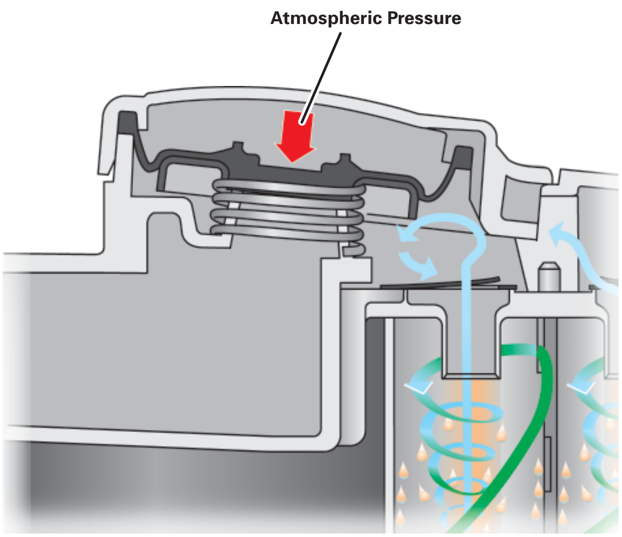
When vacuum in the intake port is high, the pressure control valve closes.

Pressure Control Valve Closed



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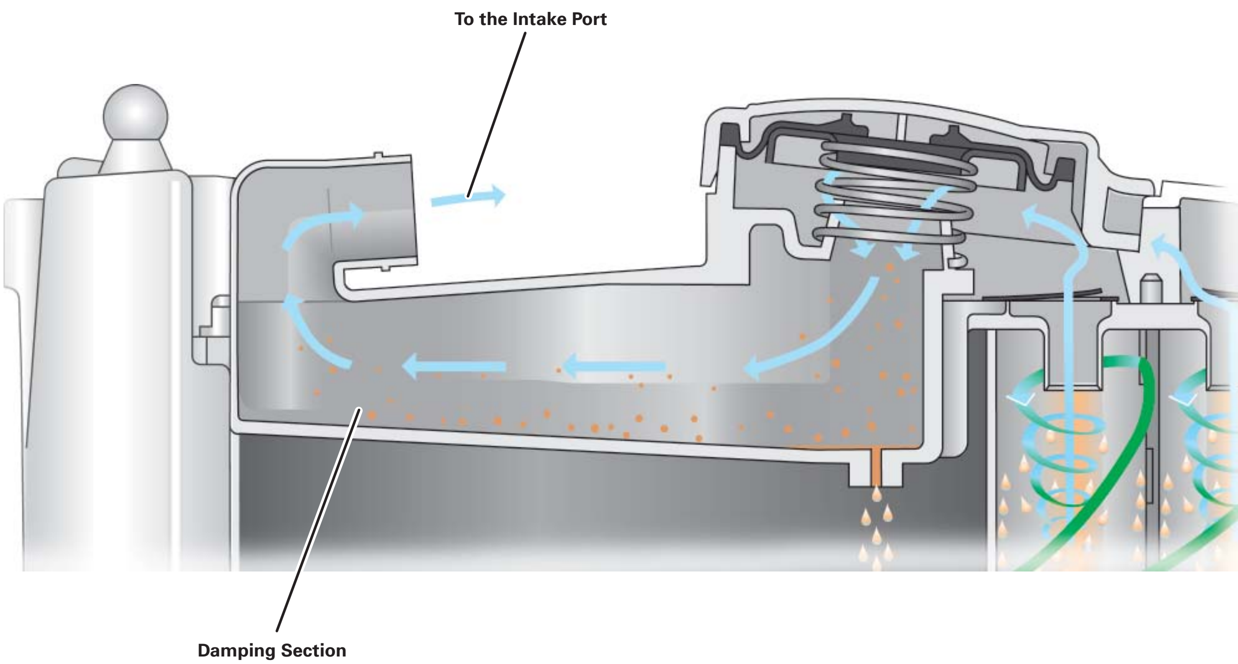
Damping Section

To prevent disruptive swirl when the gases enter the intake manifold, a damping section is connected to the cyclone oil separator. In this section the motion energy of the gases from the cyclone is reduced, and a residual quantity of oil is again separated out.



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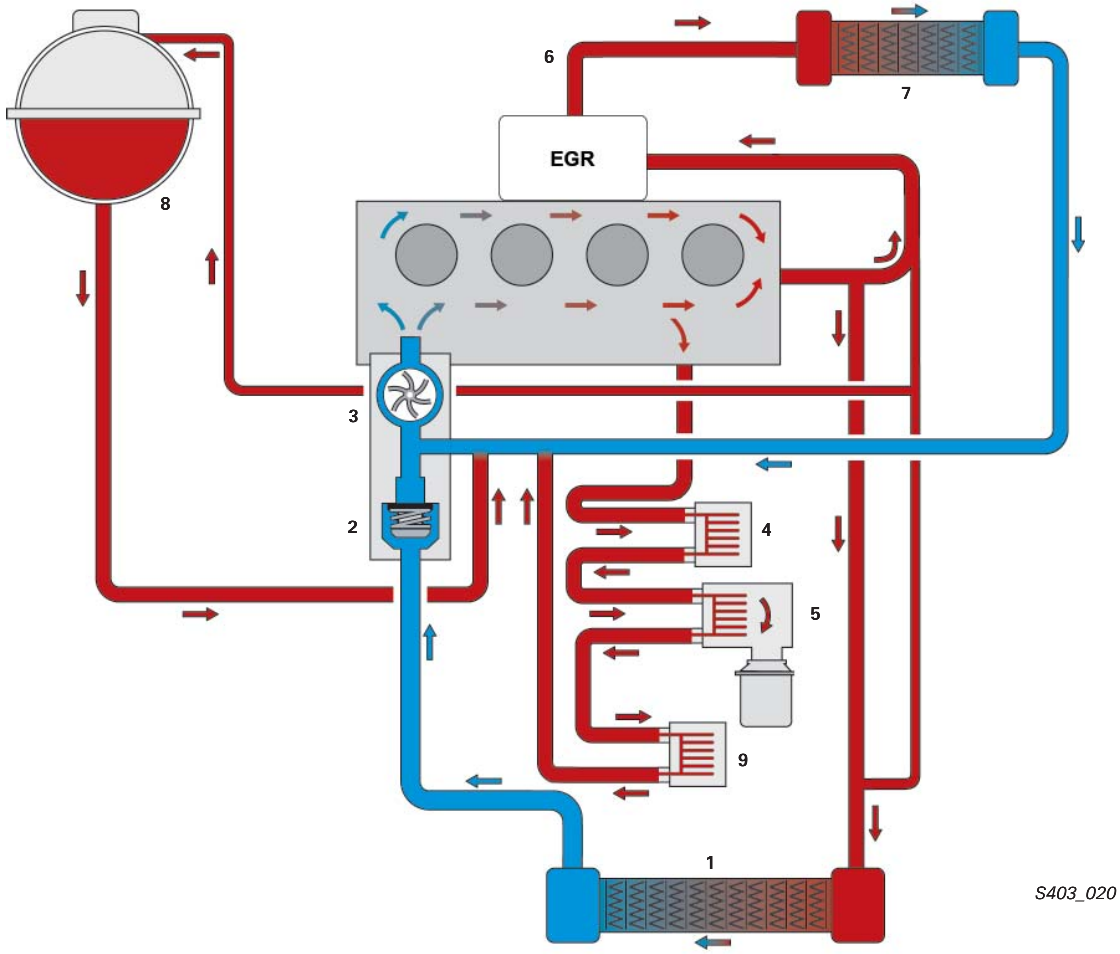
Coolant Circuit

In the coolant circuit, the coolant is circulated by a mechanical coolant pump. It is driven by the toothed belt. The circuit is controlled by an expansion-element thermostat, the Coolant Control Unit.



Legend

1 – Radiator
2 – Coolant Control Unit (Expansion Element Thermostat)
3 – Coolant Pump
4 – Transmission Cooler (if applicable)
5 – Oil Cooler
6 – Cooler for Exhaust Gas Return
7 – Heat Exchanger for Heater
8 – Equalizing Reservoir
9 – Engine Block Heater (optional)

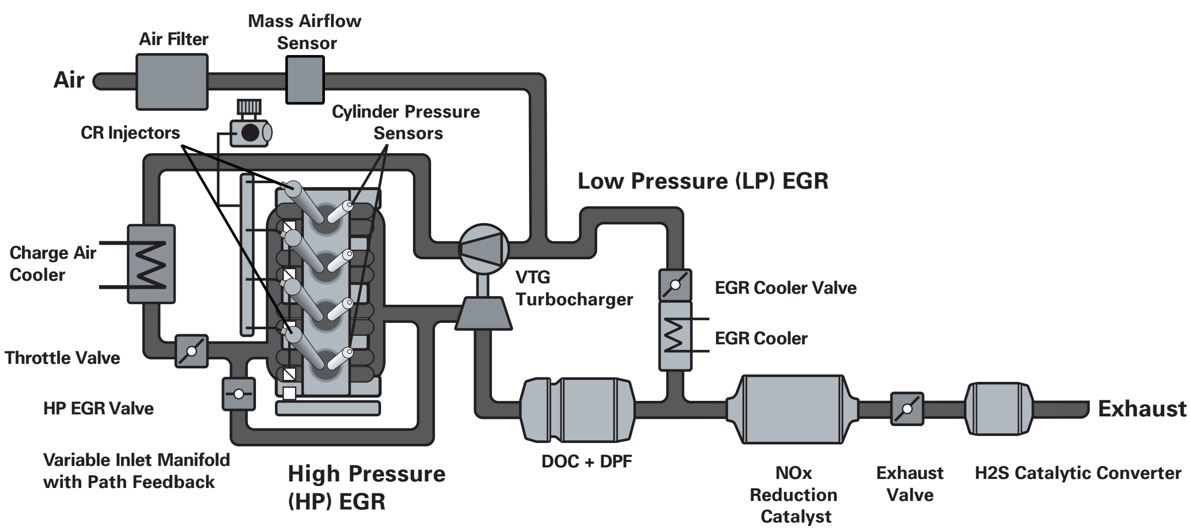
Reference

The engine block heater may not be available until later in production and will be a dealer-installed item.

High and Low Pressure Exhaust Gas Recirculation (EGR) System

The most effective way to reduce Oxides of Nitrogen (NOx) in an internal combustion engine is to recirculate exhaust gases back into the combustion chamber. When the exhaust gas is introduced at very low temperatures, NOx is decreased even more effectively.

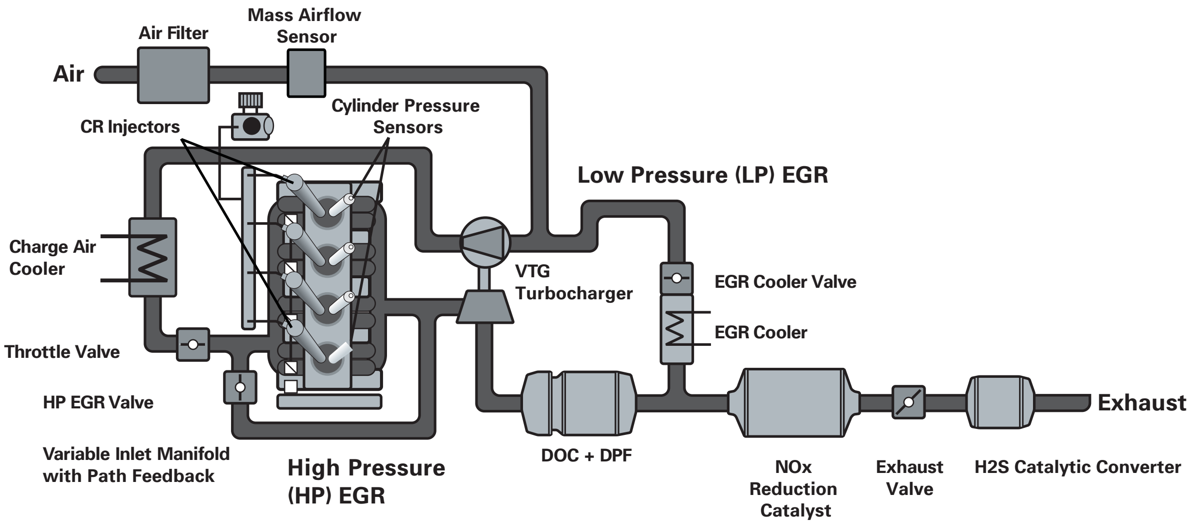
To meet BIN 5 emission standards, the EGR needed to be operational from idle to the full load of the engine. This required two separate systems; a high pressure system and low pressure system.



The air mass regulation of the High-Pressure EGR is regulated by the EGR Vacuum Regulator Solenoid Valve N18 and servo, and by the turbocharger vane position. The short path of the High-Pressure EGR is used to reach the desired EGR rate while driving at lower engine speeds and loads.

Depending on engine operating conditions and revolutions-per-minute (RPM), the combined EGR operation is continuously adjusted. Thus, no-load engine operation results in high amounts of High Pressure EGR application.

With rising engine load and engine RPM, the recirculation of exhaust gases is shifted to the Low Pressure EGR system to increase the recirculation rate. This happens to obtain optimal NO_x reduction at middle and high engine loads. Particularly in the high engine loads, the cooled Low Pressure EGR is a very large advantage over the High Pressure EGR system.



Uncooled EGR001

The Fuel System

Schematic Overview

1 – Transfer Fuel Pump (FP) G6
Feeds fuel continuously from the fuel tank.

2 – Fuel Filter with Preheating Valve
The preheating valve prevents the filter from becoming clogged due to crystallization of paraffin in low ambient temperatures.

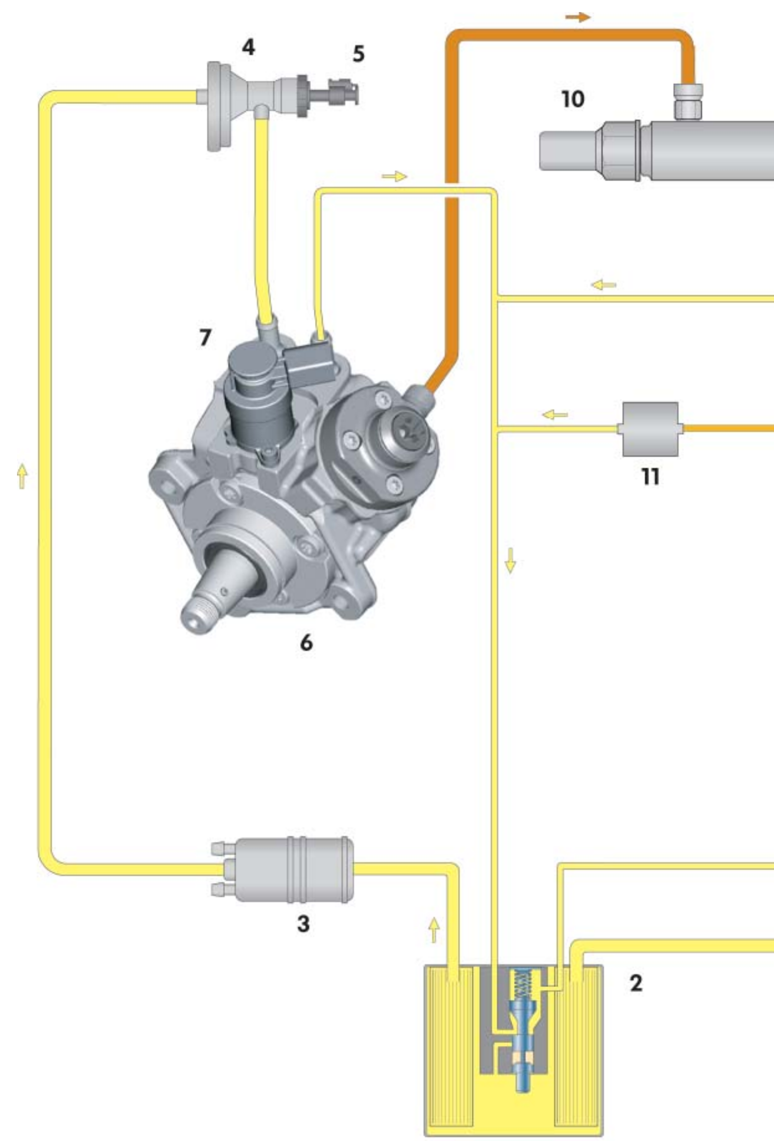
3 – Auxiliary Fuel Pump V393
Feeds fuel to the high pressure fuel pump.

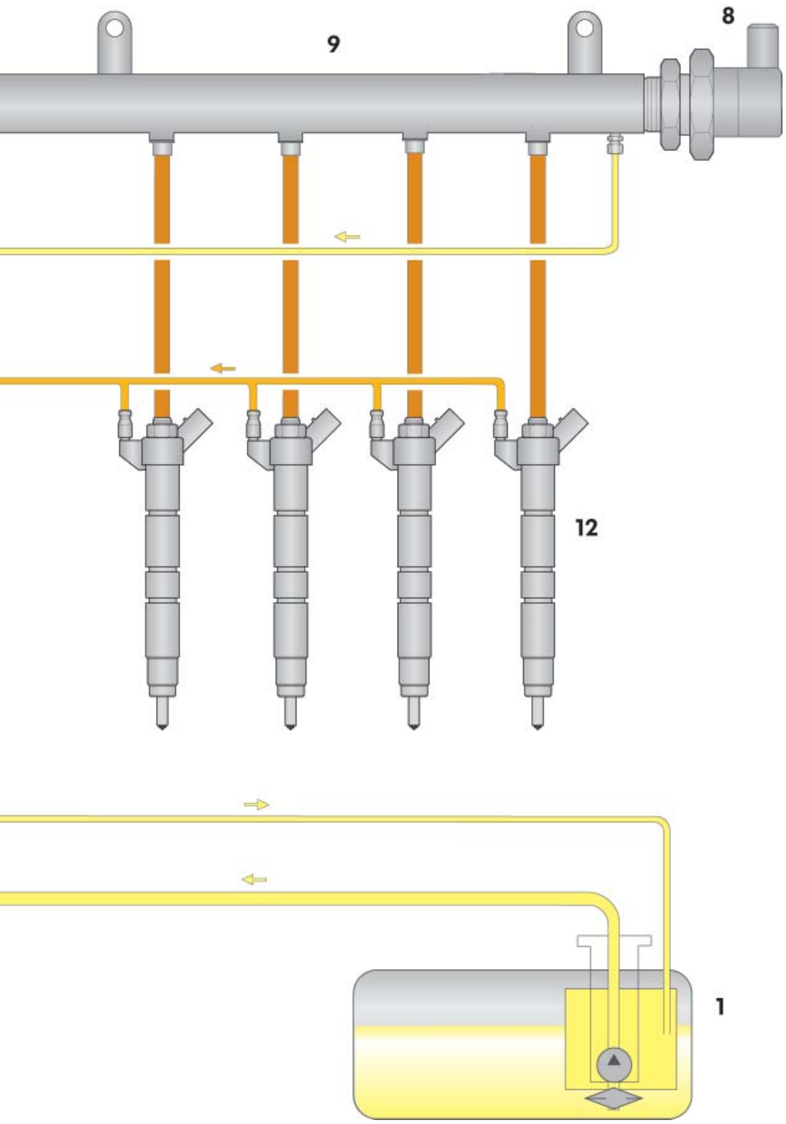
4 – Filter Screen
Protects the high-pressure pump from dirt particles.

5 – Fuel Temperature Sensor G81
Determines the current fuel temperature.

6 – High-Pressure Pump
Generates the high fuel pressure needed for injection.

7 – Fuel Metering Valve N290
Regulates the quantity of fuel to be compressed based on demand.





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8 – Fuel Pressure Regulator Valve N276
Adjusts the fuel pressure in the high-pressure area.

9 – High-Pressure Accumulator (Rail)
Stores the fuel needed for injection under high pressure for all cylinders.

10 – Fuel Pressure Sensor G247
Determines the current fuel pressure in the high pressure area.

11 – Pressure Retention Valve
Retains the return pressure of the fuel injectors at approximately 10 bar (145 psi). This pressure is needed for the function of the fuel injectors.

12 – Cylinder 1 through 4 Fuel Injectors N30, N31, N32, N33

High Pressure 3,336 – 26,107 psi (230 – 1800 bar)

Return Pressure of the Fuel Injectors 145 psi (10 bar)

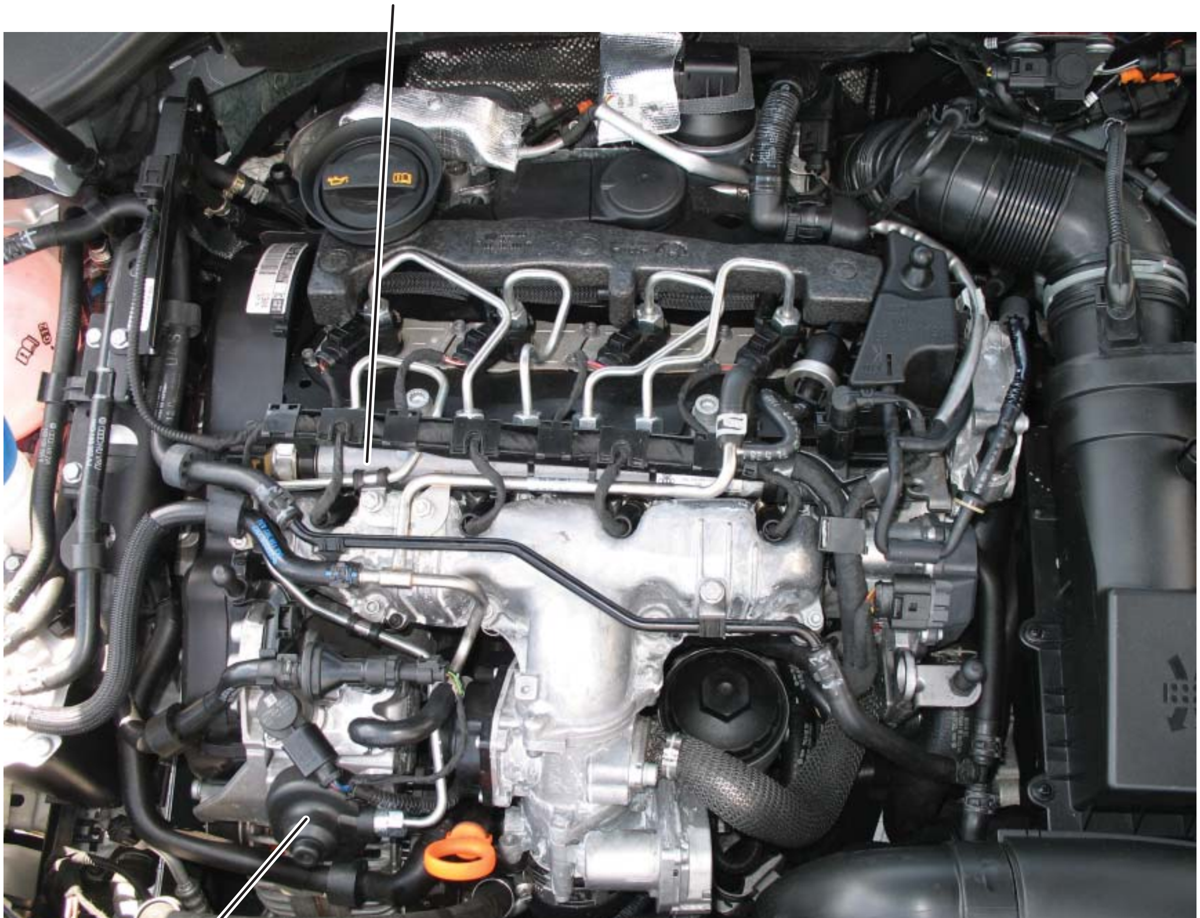
Supply Pressure
Return Pressure

Common Rail Injection System

The common rail injection system is a high-pressure accumulator injection system for diesel engines. The term “common rail” refers to the shared fuel high-pressure accumulator for all fuel injectors in a cylinder bank.

In this type of injection system, pressure generation and fuel injection are performed separately. A separate high-pressure pump generates the high fuel pressure required for injection. This fuel pressure is stored in a high-pressure accumulator (rail) and supplied to the fuel injectors over short injection lines.

The common rail injection system is controlled by the Bosch EDC 17 engine management system.



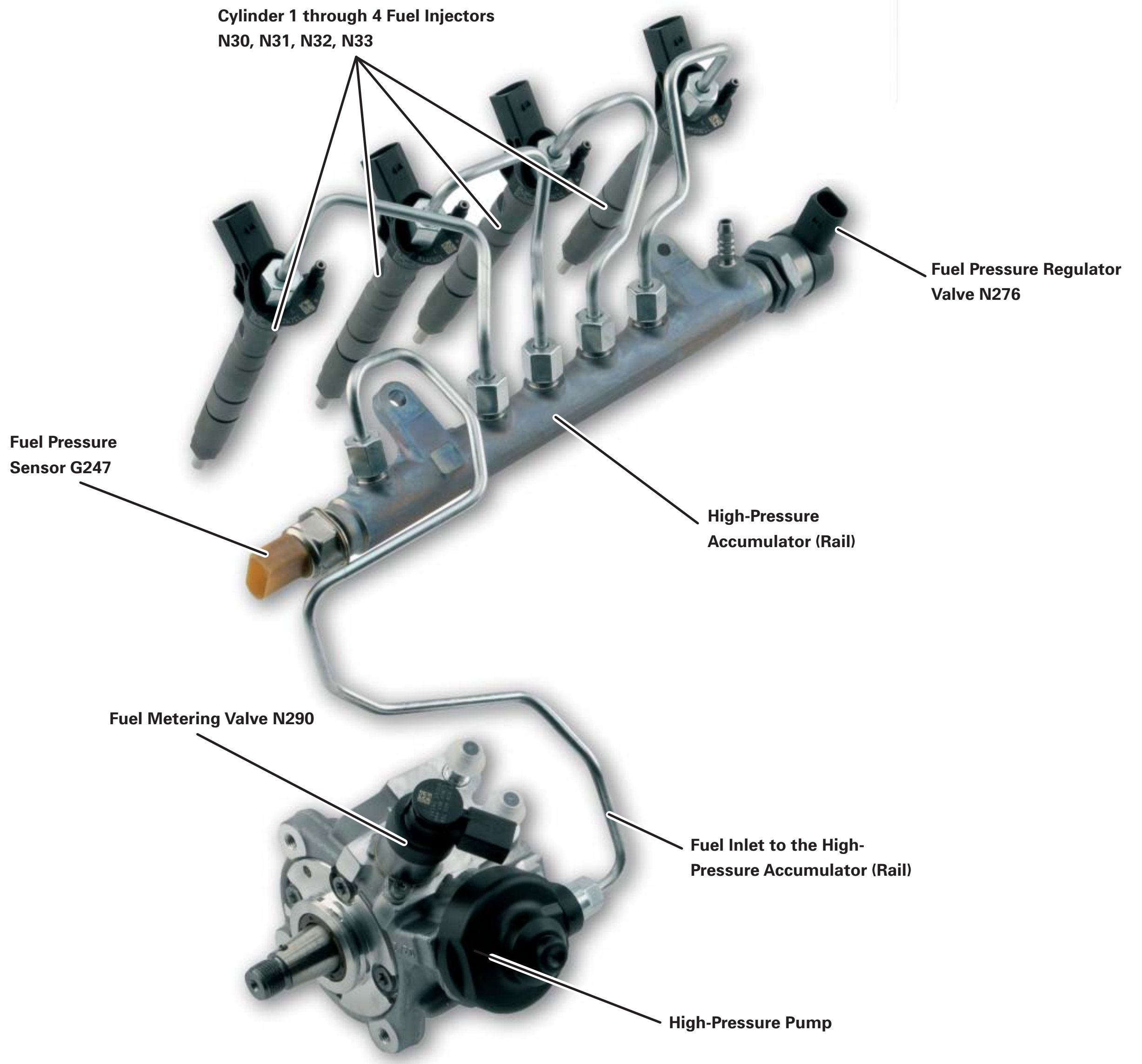
S403_036

The following are characteristics of this injection system:

- The injection pressure is selectable and can be adapted to the operating conditions of the engine.
- A high injection pressure up to a maximum of 1800 bar (26,107 psi) enables good mixture formation.
- A flexible course of injection with multiple pre-and post-injections.

The common rail injection system can adapt the injection pressure and the timing of the injection to the operating conditions of the engine.

This system is well suited to fulfill the constantly increasing requirements for an injection system to provide greater fuel economy, lower emissions, and quiet operation.



S403_055

Fuel Injectors N30, N31, N32, N33

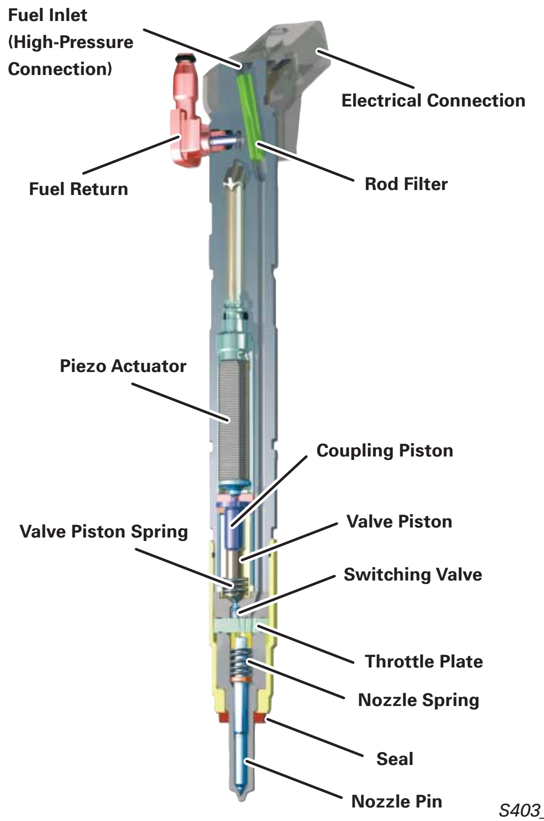
In the common rail system of the 2.0 Liter TDI engine, piezo-controlled Fuel Injectors N30, N31, N32, and N33 are used.

The fuel injectors are operated by a piezo actuator. The switching speed of a piezo actuator is approximately four times faster than a solenoid valve.

Compared to solenoid actuated fuel injectors, piezo technology also involves approximately 75% less moving mass at the nozzle pin.

This results in the following advantages:

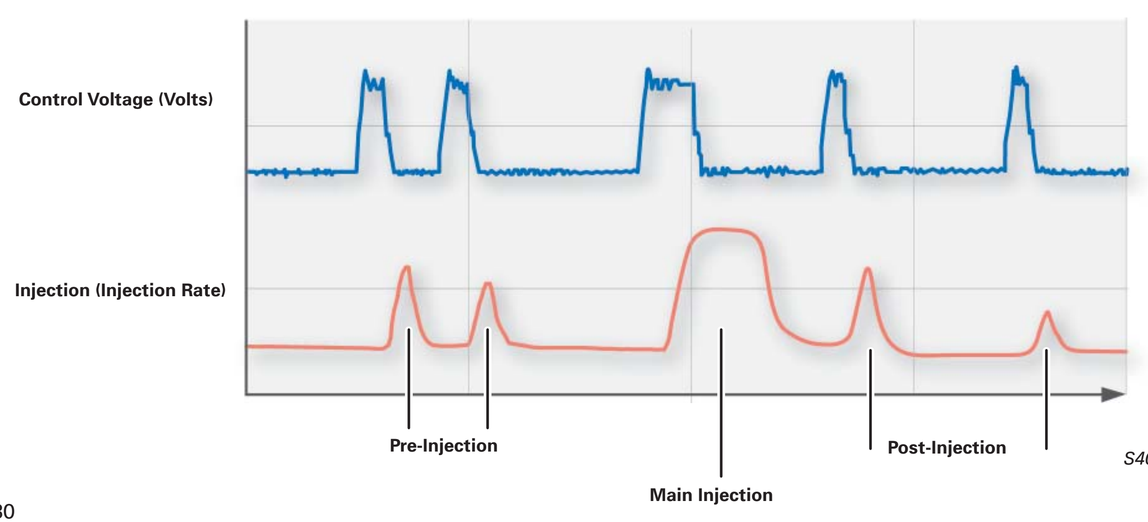
- Very short switching times
- Multiple injections possible per work cycle
- Precise metering of injection quantities



S403_024

Course of Injection

Due to the very short switching times of the piezo controlled fuel injectors, it is possible to control the injection phases and quantities flexibly and precisely. This enables the course of injection to be adapted to the operating conditions of the engine. Up to five partial injections can be performed per course of injection.



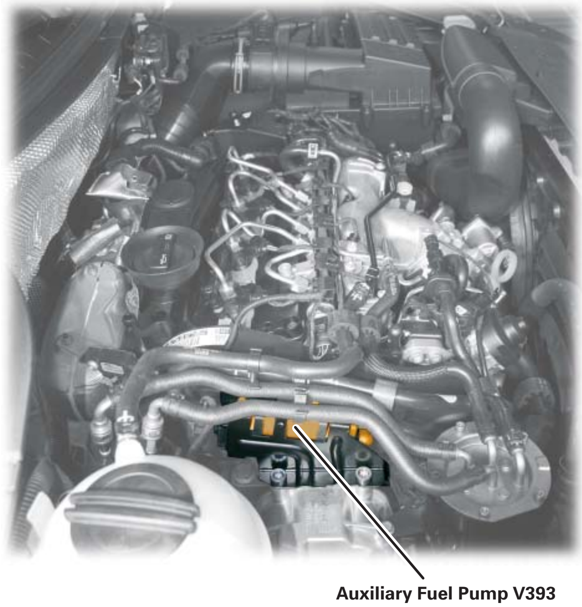
S403_025

Auxiliary Fuel Pump V393

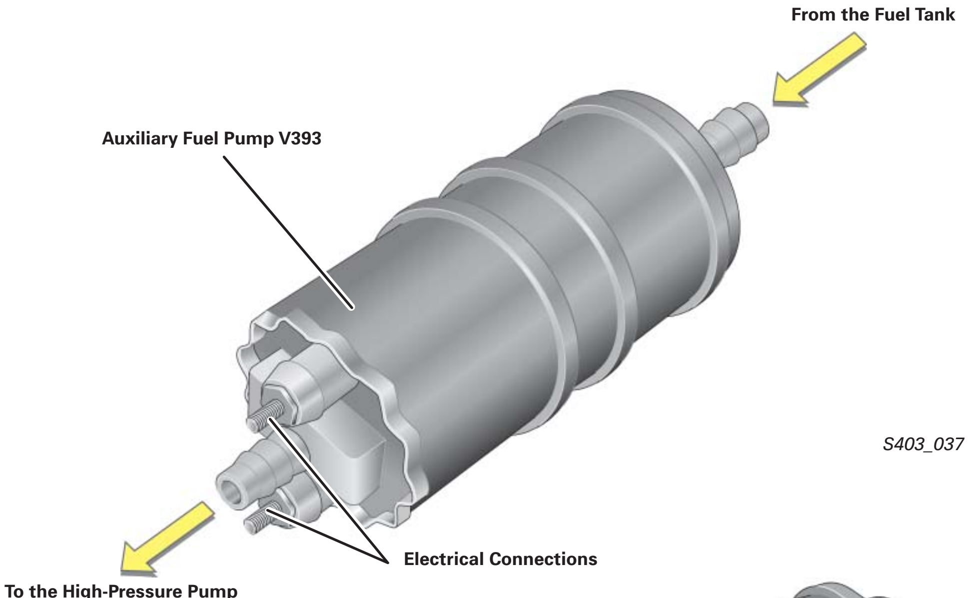
The Auxiliary Fuel Pump V393 is a roller-cell pump. It is located in the engine compartment and delivers fuel from the fuel tank to the high-pressure pump. The Auxiliary Fuel Pump V393 is actuated by the Engine Control Module (ECM) J623 through a relay and increases the fuel pressure presupplied by the Transfer Fuel Pump (FP) G6 in the fuel tank to approximately 5 bar (73 psi).

Effects of Failure

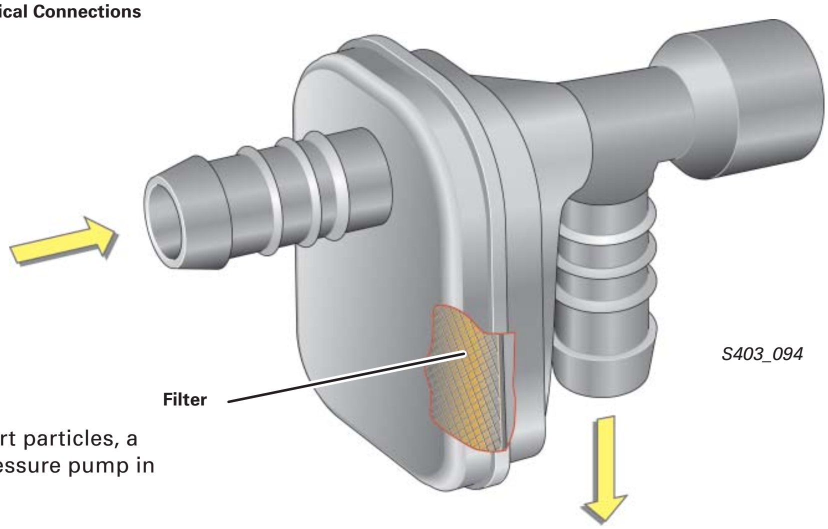
If the Auxiliary Fuel pump V393 fails, the engine will run with reduced power; engine startup will not be possible.



S403_058



S403_037



S403_094

Filter Screen

To protect the high-pressure pump from dirt particles, a filter screen is installed before the high-pressure pump in the fuel inlet.

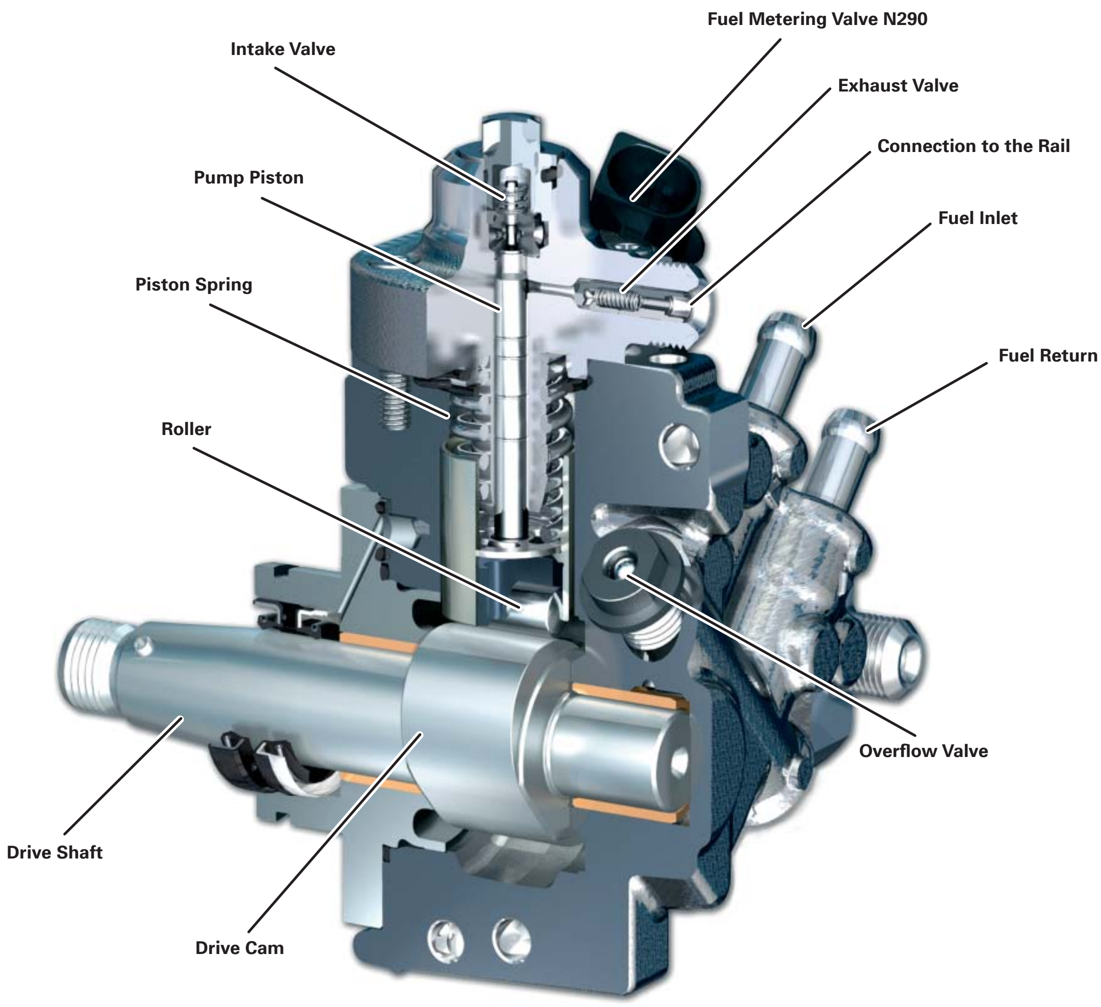
High-Pressure Pump

The high-pressure pump is a single-piston pump. It is driven via the toothed belt by the crankshaft at engine speed.

The high-pressure pump generates fuel pressure of up to 1800 bar (26,107 psi) as needed for injection.

Pressure is generated by the rotation of two cams offset by 180 degrees on the pump drive shaft. The injection is always in the operating cycle of the respective cylinder. This keeps the pump drive evenly loaded and pressure fluctuations in the high-pressure area are minimized.

Design of the High-Pressure Pump

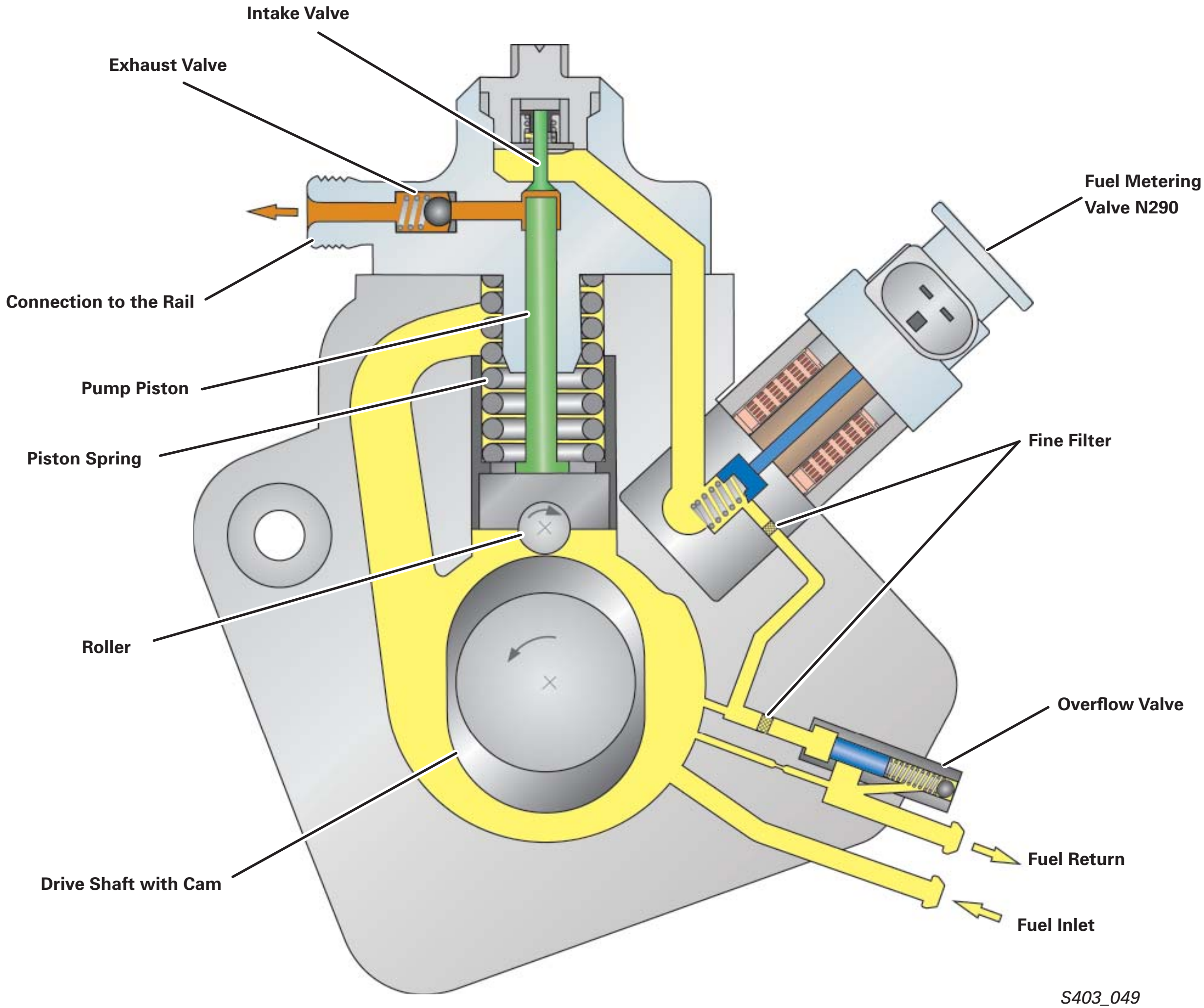


S403_027

Note

When timing the engine, the position of the high-pressure pump drive shaft must be set properly.
Please refer to the instructions in the Repair Manual.

High-Pressure Pump Schematic



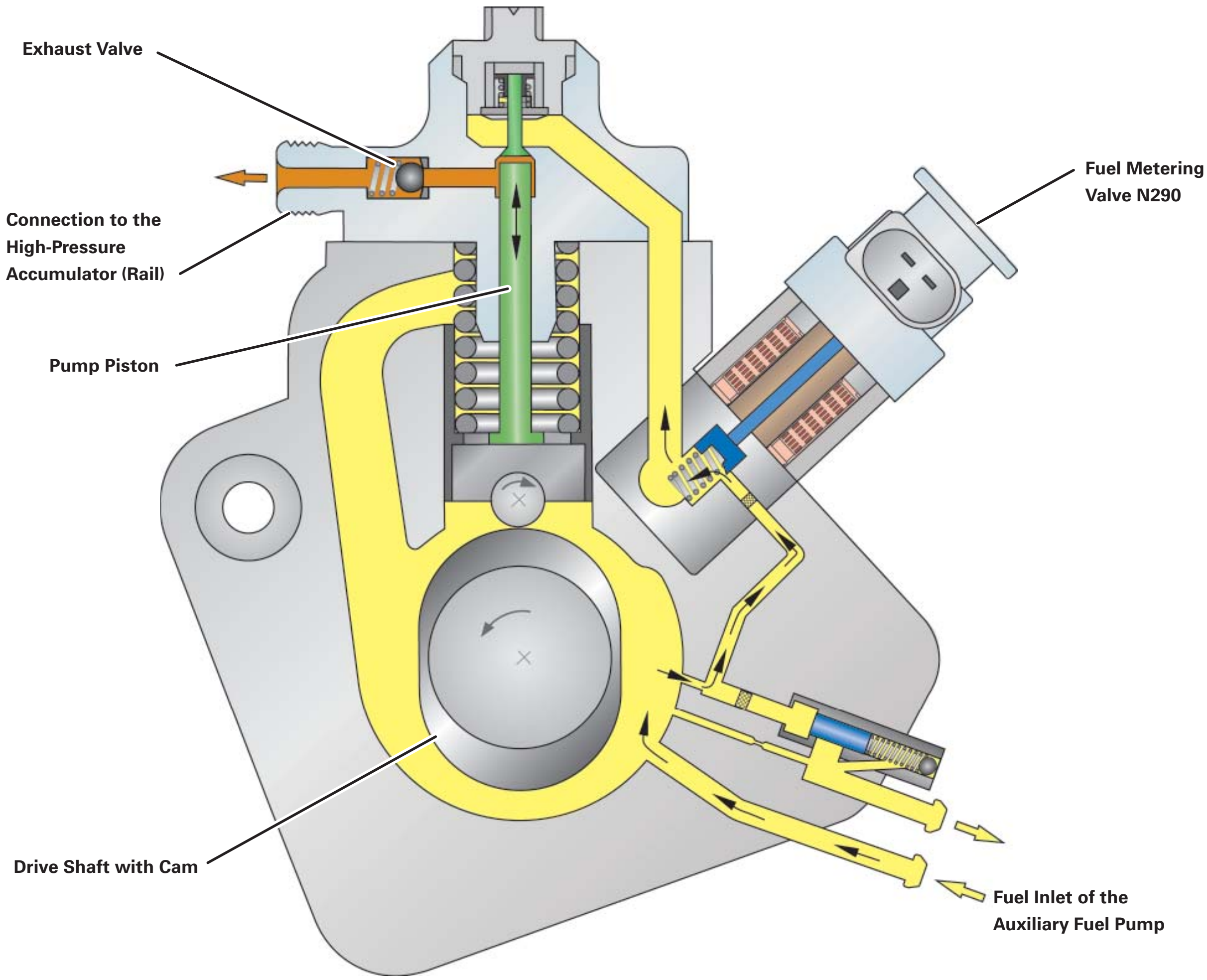
S403_049

High-Pressure Area

The high-pressure pump is supplied with adequate fuel by the Auxiliary Fuel Pump V393 in each operating range of the engine.

The fuel enters the high-pressure area of the engine through the Fuel Metering Valve N290.

The pump piston is moved up and down by the cams on the pump drive shaft.



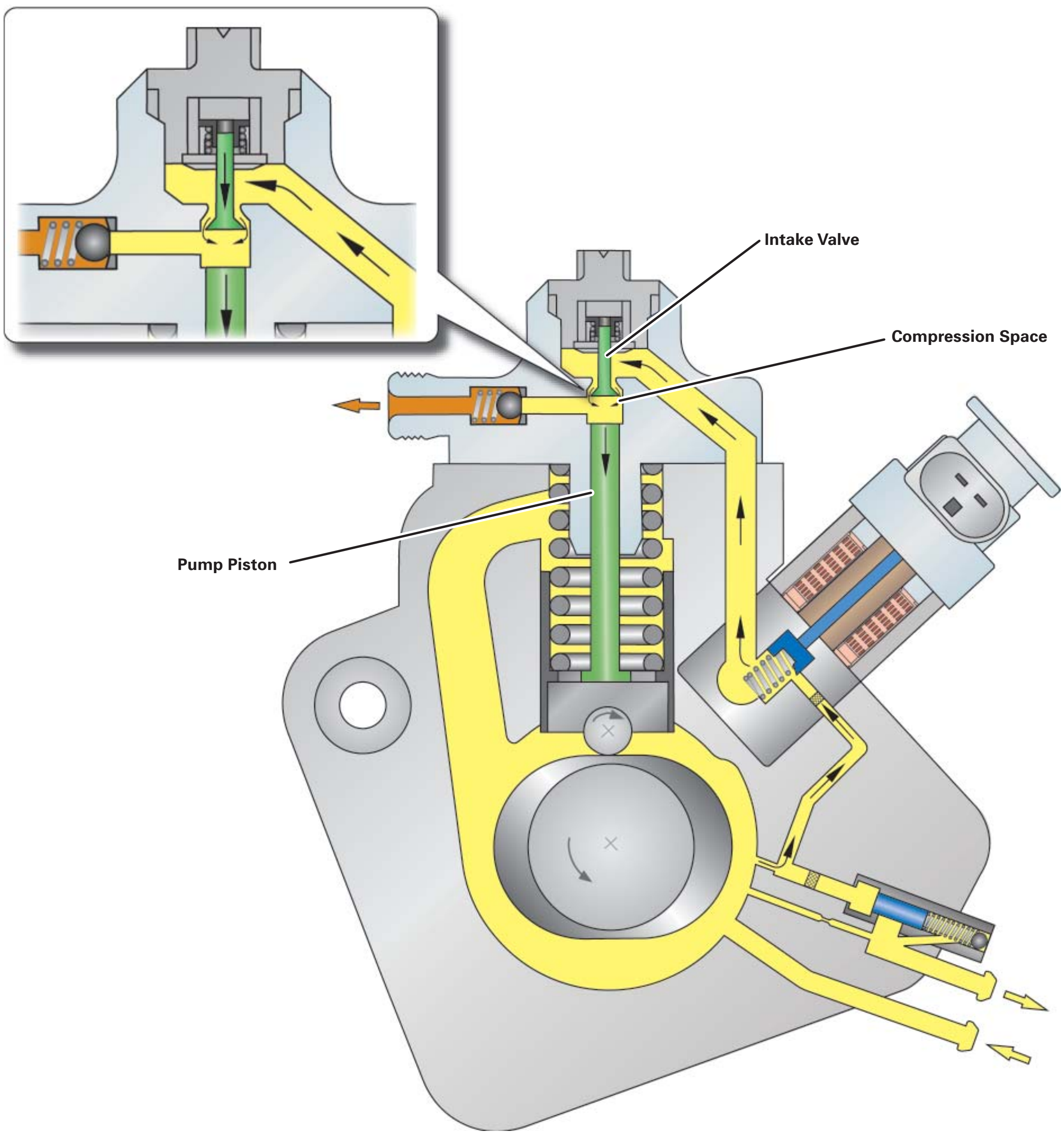
S403_107

Intake Stroke

The downward motion of the pump piston increases the volume of the compression space.

This results in a pressure differential between the fuel in the high-pressure pump and the compression space.

The intake valve opens and fuel flows into the compression space.

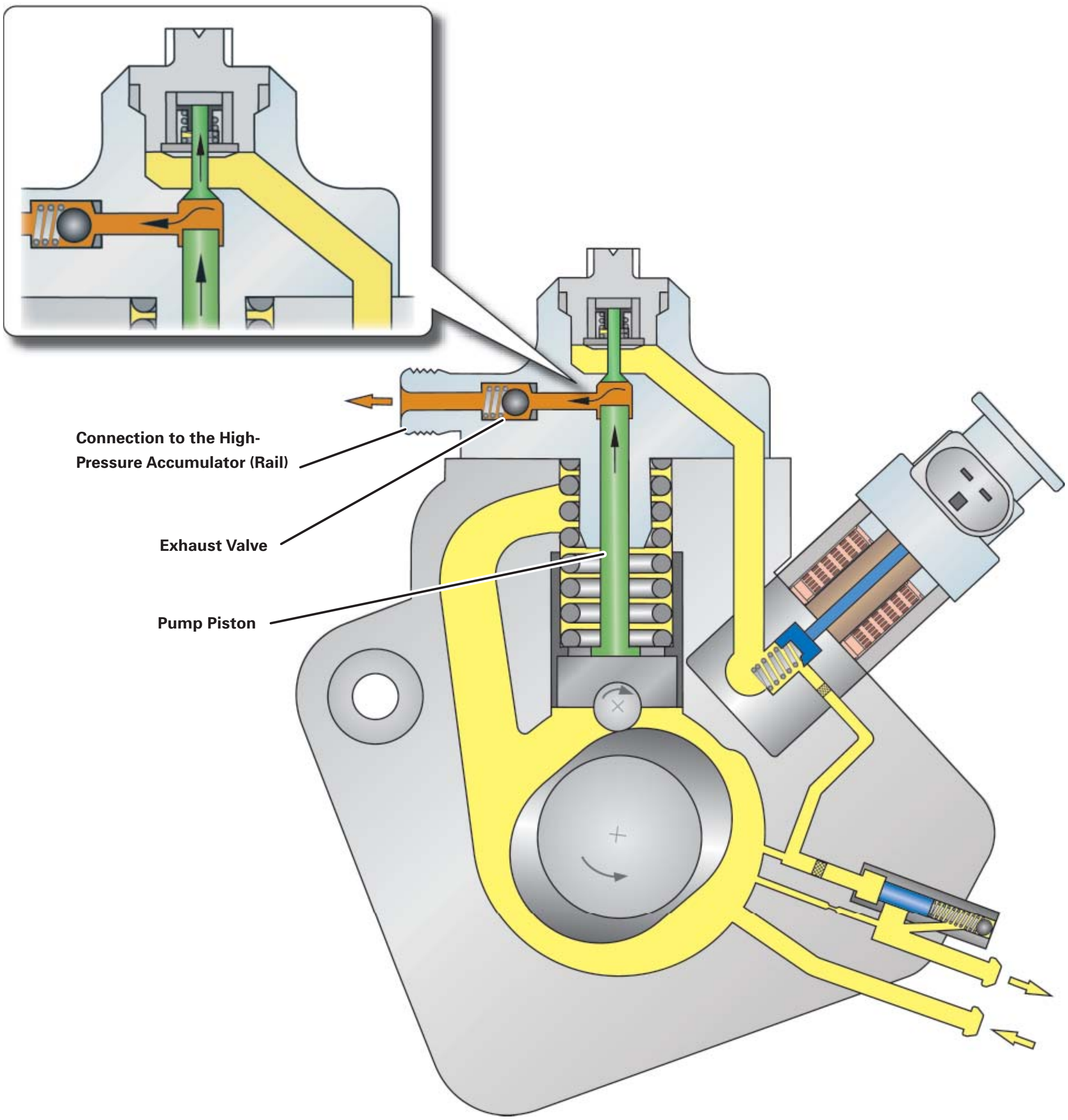


S403_108

Delivery Stroke

With the beginning of the upward motion of the pump piston, the pressure in the compression space increases and the intake valve closes.

As soon as the fuel pressure in the compression space exceeds the pressure in the high-pressure area, the exhaust valve (check valve) opens and fuel enters the high-pressure accumulator (rail).



S403_109

Fuel Metering Valve N290

Fuel Metering Valve N290 is integrated in the high pressure pump. It ensures demand-based control of the fuel pressure in the high-pressure area. The Fuel Metering Valve N290 controls the quantity of fuel needed for high-pressure generation. This represents an advantage, in that the high-pressure pump must generate only the pressure needed for the momentary operating situation. The power consumption of the high-pressure pump is reduced and unnecessary warming up of the fuel is avoided.

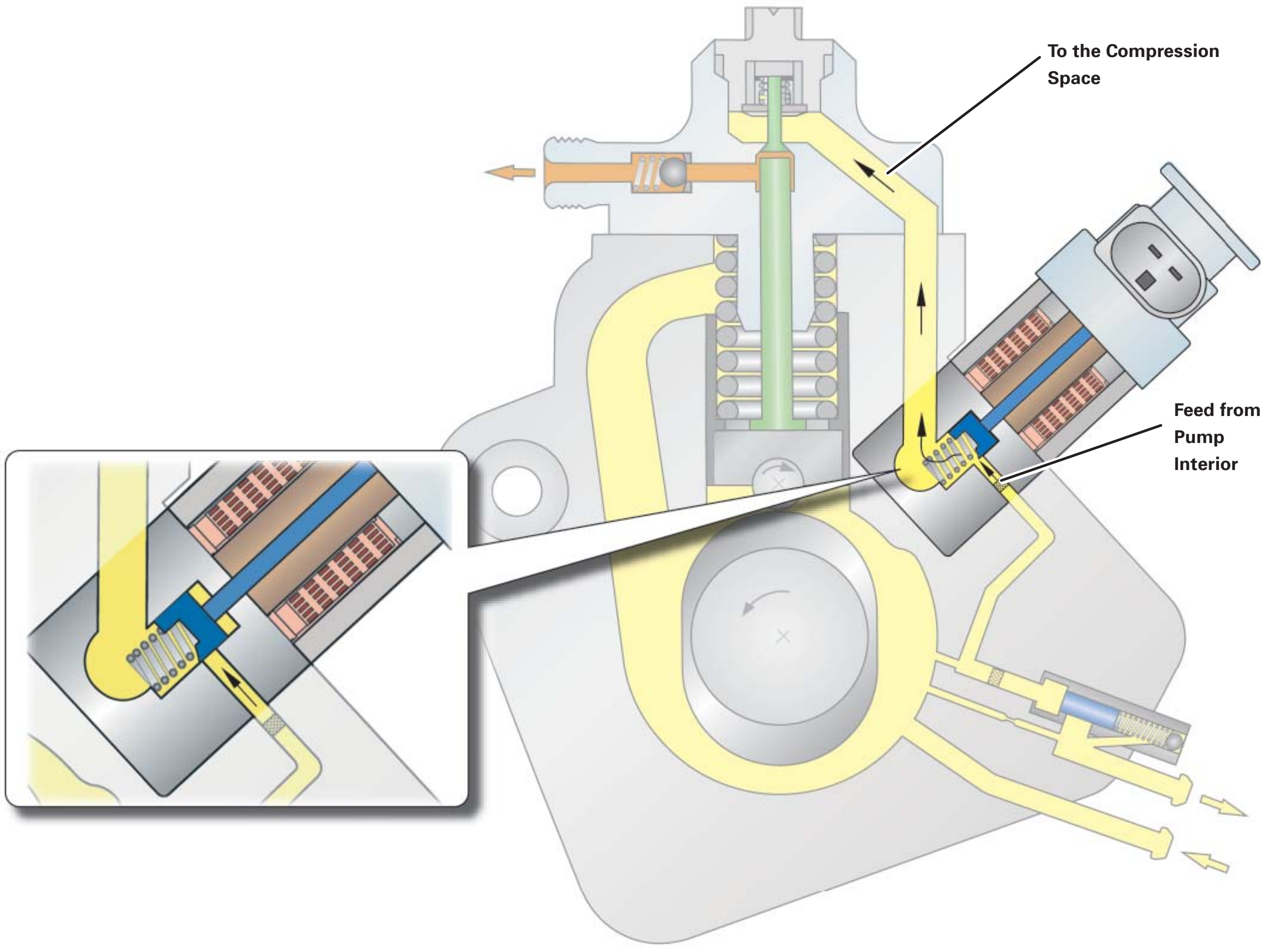
Function

The non-energized state the Fuel Metering Valve N290 is open. To reduce the feed quantity to the compression space, the valve is actuated by the Engine Control Module (ECM) J623 with a Pulse-Width Modulated (PWM) signal.

Through the PWM signal the Fuel Metering Valve N290 is closed cyclically. Depending on the duty cycle, the position of the locking piston changes as does the amount of fuel into the compression space of the high-pressure pump.

Effects of Failure

Engine power is reduced and the engine management system operates in emergency mode.



S403_110

Low-Pressure Area

Overflow Valve

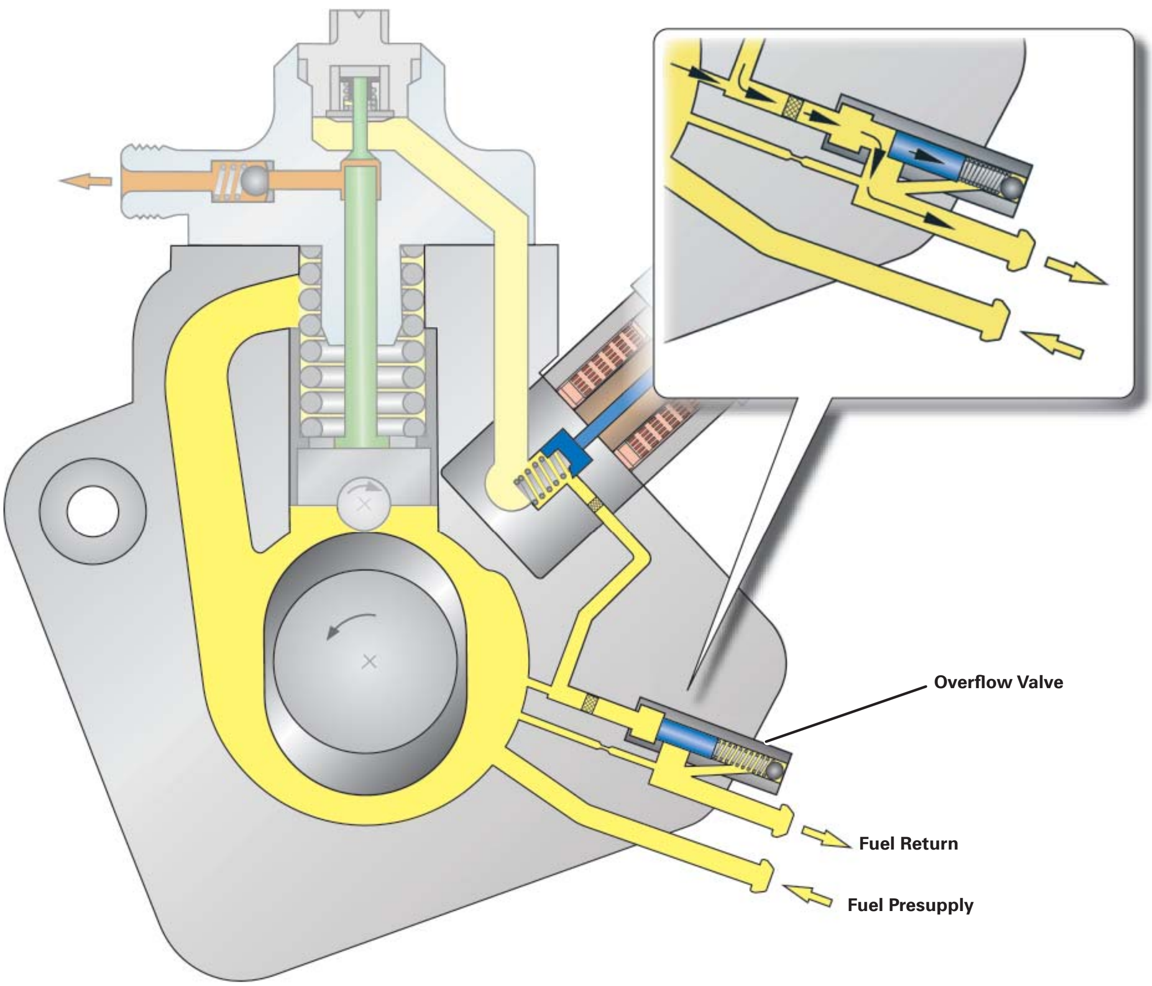
The fuel pressure in the low-pressure area of the high-pressure pump is controlled by the overflow valve.

Function

The Auxiliary Fuel Pump V393 delivers fuel from the fuel tank with a pressure of approximately 5 bar (73 psi) into the high-pressure pump. Thus the fuel supply to the high-pressure pump is ensured in all operating conditions.

The overflow valve regulates the fuel pressure in the high-pressure pump to approximately 4.3 bar (62 psi).

The fuel delivered by the Auxiliary Fuel Pump V393 acts in opposition to the piston and the piston spring of the overflow valve. With a fuel pressure over 4.3 bar (62 psi), the overflow valve opens and clears the way to the fuel return. The excess fuel flows through the fuel return into the fuel tank.



S403_111

High Pressure Fuel Control

In the common rail injection system, high pressure fuel is controlled by a so-called two-controller concept.

Depending on the operating conditions, the high pressure fuel is regulated either by the Fuel Pressure Regulator Valve N276 or the Fuel Metering Valve N290. The valves are actuated by the Engine Control Module (ECM) J623 with a Pulse-Width Modulated (PWM) signal.

Fuel Pressure Regulator Valve N276 Control

At engine start and for preheating of the fuel, the high pressure fuel is controlled by the Fuel Pressure Regulator Valve N276. To heat up the fuel quickly, the high-pressure pump delivers and compresses more fuel than is needed. The excess fuel is discharged by the Fuel Pressure Regulator Valve N276 into the fuel return.

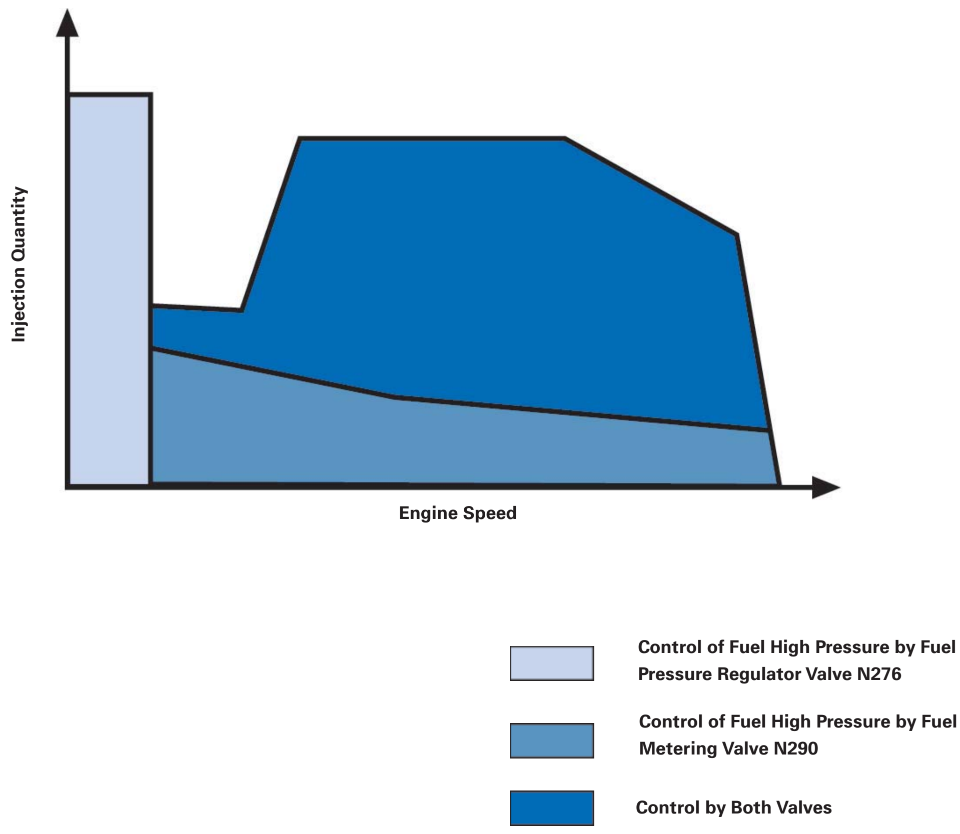
Fuel Metering Valve N290 Control

With large injection quantities and high rail pressures, the high pressure fuel is controlled by the Fuel Metering Valve N290. This effects a demand-based regulation of the high fuel pressure. The power consumption of the high-pressure pump is reduced and unnecessary heating of the fuel is avoided.

Control by Both Valves

During idle, trailing throttle conditions, and small injection quantities, the fuel pressure is controlled by both valves simultaneously. This enables precise control, improving idling quality and the transition into trailing throttle condition.

Two-Controller Concept



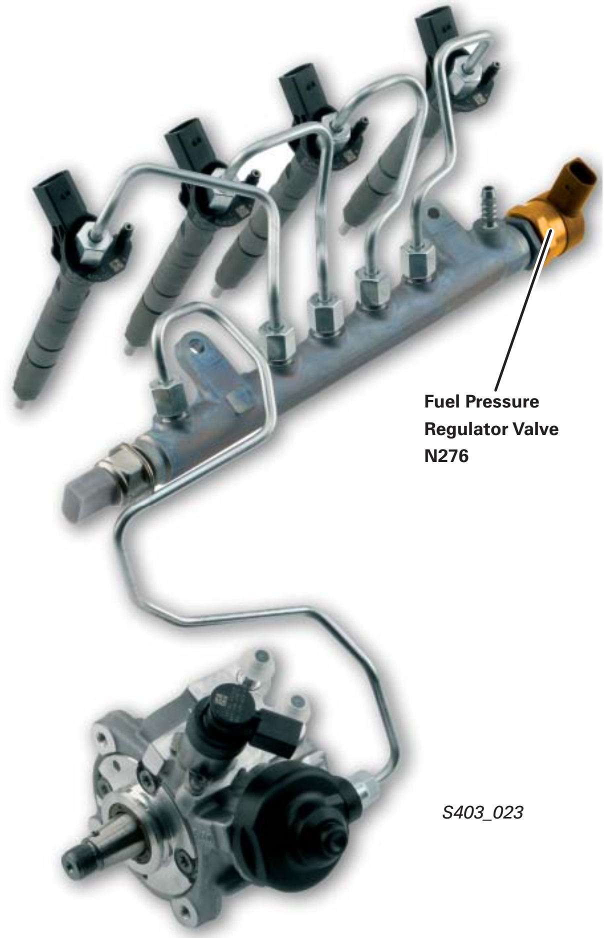
S403_030

Fuel Pressure Regulator Valve N276

The Fuel Pressure Regulator Valve N276 is located on the high-pressure accumulator (rail).

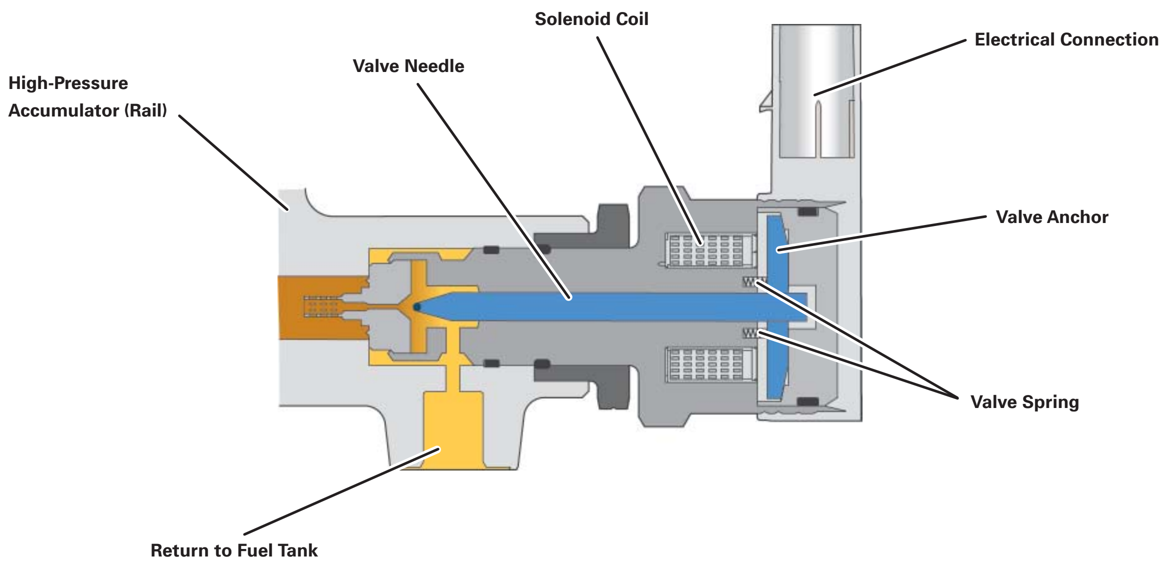
Opening and closing of the Fuel Pressure Regulator Valve N276 adjusts the pressure of the fuel in the high-pressure area.

This is actuated by the Engine Control Module (ECM) J623 by a Pulse-Width Modulated (PWM) signal.



S403_023

Design



S403_032

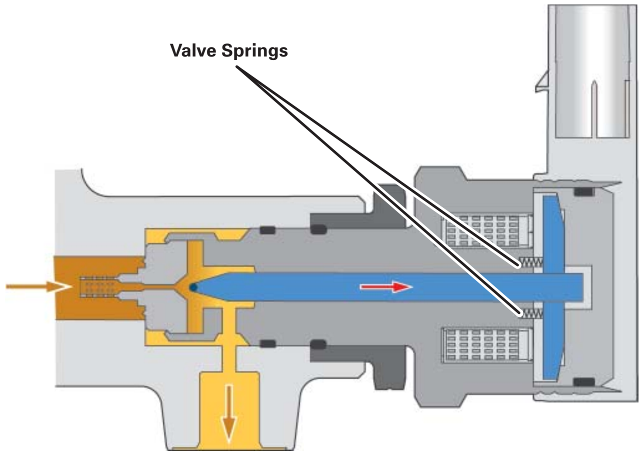
How it Works

In contrast to conventional control valves in common rail injection systems, the Fuel Pressure Regulator Valve N276 is open in the non-energized state.

Fuel Pressure Regulator Valve N276 in Rest Position (Engine OFF)

If the Fuel Pressure Regulator Valve N276 is not activated, the pressure regulator valve is opened by the valve springs. The high-pressure area is connected to the fuel return.

This ensures volume compensation between the high-pressure and low-pressure areas. Fuel vapor lock, which can occur during the cool-down with engine standstill in the high-pressure accumulator (rail), is avoided and the startup properties of the engine are improved.



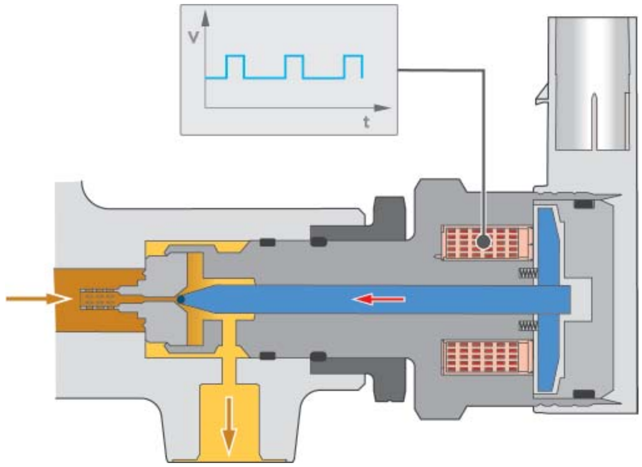
S403_033

Fuel Pressure Regulator Valve N276 Activated (Engine ON)

To set an operating pressure of 230 to 1800 bar (3,336 to 26,107 psi) in the high-pressure accumulator, the Fuel Pressure Regulator Valve N276 is actuated by the Engine Control Module (ECM) J623 with a PWM signal. Upon actuation a magnetic field is generated in the solenoid coil. The valve anchor is tightened and presses the valve needle into its seat. A magnetic force opposes the fuel pressure in the high-pressure accumulator. Depending on the duty cycle of the actuation, the flow cross-section to the return line and the exhaust quantity is changed. This also compensates for fluctuations in the high pressure accumulator.

Effects of Failure

If the Fuel Pressure Regulator Valve N276 fails, the engine cannot run because adequate high fuel pressure cannot be developed for injection.



S403_034

System Overview

Sensors

Engine Speed (RPM) Sensor G28

Camshaft Position (CMP) Sensor G40

Throttle Position (TP) Sensor G79 / Accelerator Pedal Position Sensor 2 G185

Mass Air Flow (MAF) Sensor G70

Engine Coolant Temperature (ECT) Sensor G62

Charge Air Pressure Sensor G31

Intake Air Temperature (IAT) Sensor G42

Fuel Temperature Sensor G81

Fuel Pressure Sensor G247

EGR Potentiometer G212

Heated Oxygen Sensor (HO2S) G39

Exhaust Pressure Sensor 1 G450

Low Pressure Exhaust Gas Recirculation (EGR) Pressure Sensor

Exhaust Gas Temperature (EGT) Sensor 1 G235

Exhaust Gas Temperature (EGT) Sensor 2 G448

Exhaust Gas Temperature (EGT) Sensor 3 G495

Exhaust Gas Temperature (EGT) Sensor 4 G648

Exhaust Gas Recirculation (EGR) Temperature Sensor G98

Engine Coolant Temperature (ECT) Sensor (on Radiator) G83

Oxygen Sensor (O2S) Behind Three Way Catalytic Converter (TWC) G130

Brake Light Switch F

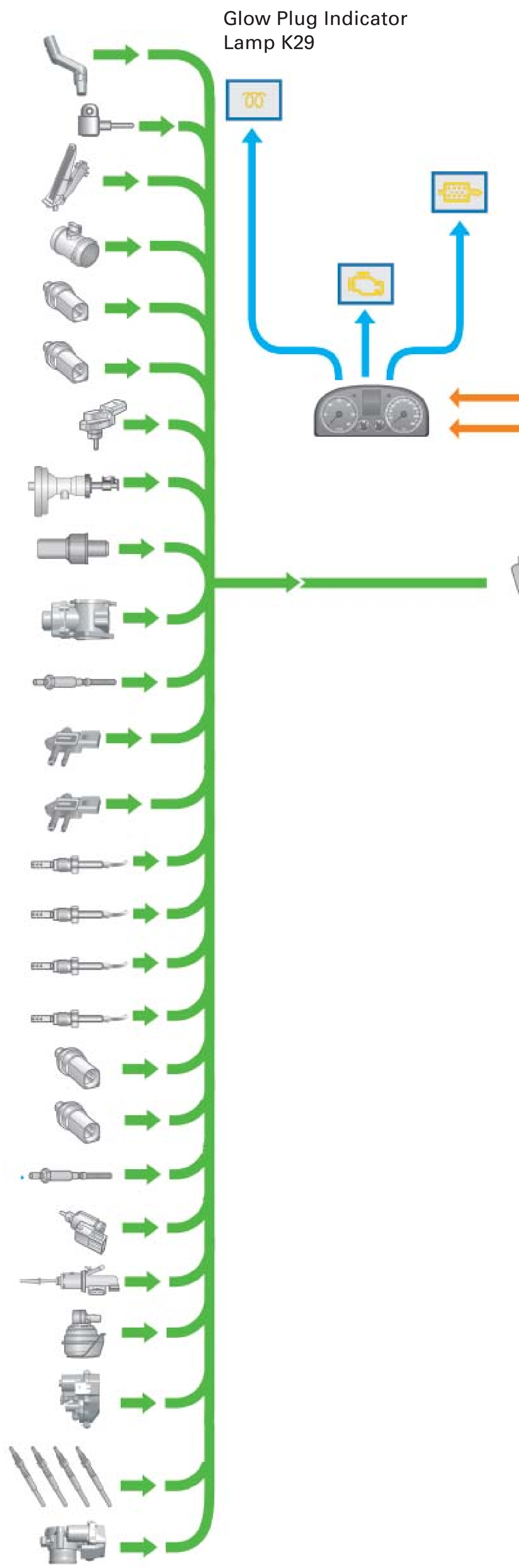
Clutch Position Sensor G476

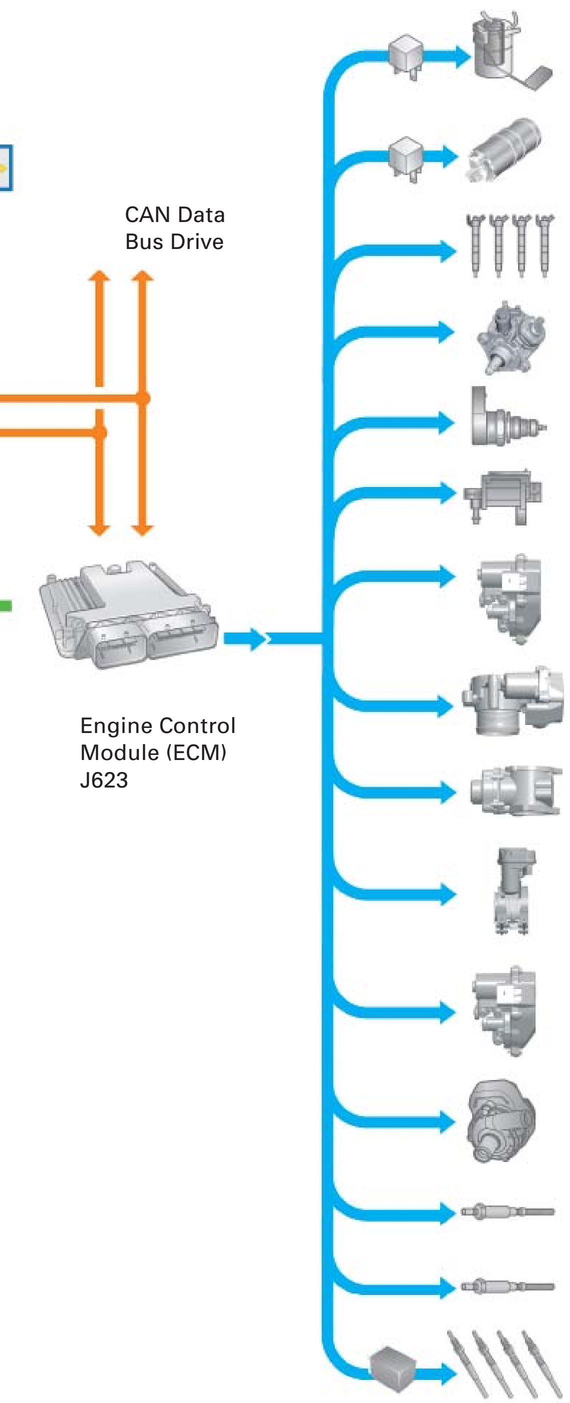
Charge Pressure Actuator Position Sensor G581

Intake Manifold Runner Position Sensor G336

Cylinder Pressure Sensors G620 - G623

Throttle Position (TP) Sensor G69





Actuators

Fuel Pump (FP) Relay J17
Transfer Fuel Pump (FP) G6

Auxiliary Fuel Pump Relay J832
Auxiliary Fuel Pump V393

Cylinder 1 Fuel Injector N30
Cylinder 2 Fuel Injector N31
Cylinder 3 Fuel Injector N32
Cylinder 4 Fuel Injector N33

Fuel Metering Valve N290

Fuel Pressure Regulator Valve N276

Wastegate Bypass Regulator Valve N75
(uses variable turbine geometry)

Intake Flap Motor V157

Throttle Valve Control Module J338

Exhaust Flap Control Module J883
With Position Sensor

EGR Vacuum Regulator Solenoid Valve N18

EGR Valve 2 N213

Engine Coolant (EC) Circulation Pump 2 V178

Oxygen Sensor (O2S) Heater Z19

Oxygen Sensor (O2S) Heater Z28

Automatic Glow Time Control Module J179
Glow Plug 1 Q10
Glow Plug 2 Q11
Glow Plug 3 Q12
Glow Plug 4 Q13

S403_028

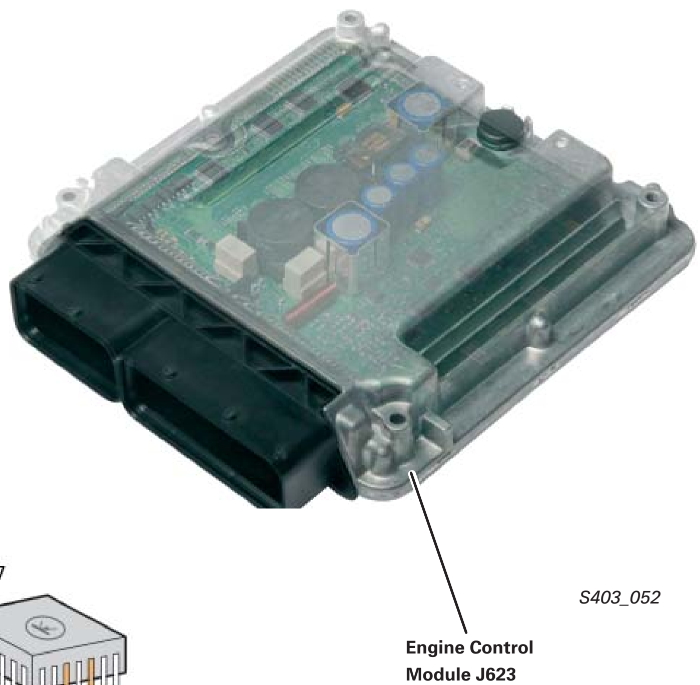
Electronic Diesel Control (EDC) Engine Management

The engine management system of the 2.0 Liter TDI engine with common rail injection system is the Bosch Electronic Diesel Control EDC 17.

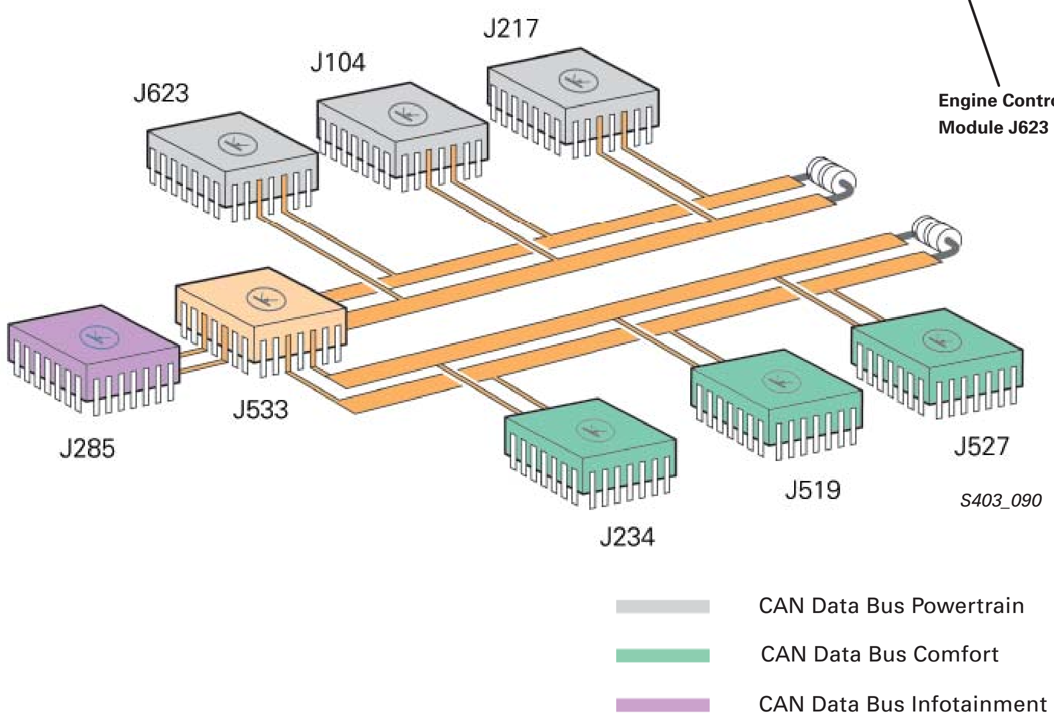
The EDC 17 engine management system has fast processing capability, large storage and offers the option of integrating control functions for future technologies.

Control Devices in the CAN DataBus

The schematic below shows the integration of the Engine Control Module J623 into the CAN data bus structure of the vehicle. Information is transmitted between control devices over the CAN data bus.



S403_052



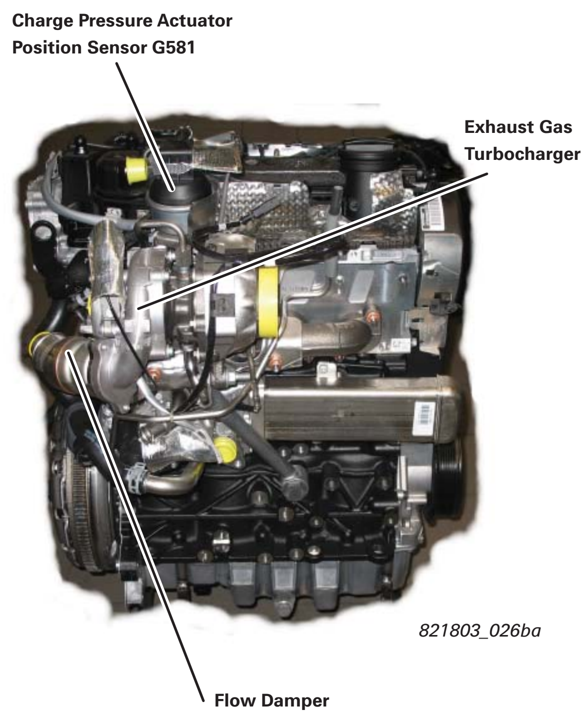
S403_090

Legend

J104 ABS Control Module
J217 Transmission Control Module (TCM)
J234 Airbag Control Module
J285 Instrument Cluster Control Module
J519 Vehicle Electrical System Control Module
J527 Steering Column Electronic Systems Control Module
J533 Data Bus On Board Diagnostic Interface
J623 Engine Control Module (ECM)

Exhaust Gas Turbocharger

The boost pressure in the 2.0 Liter TDI engine is generated by an adjustable turbocharger with adjustable guide vanes that can be used to influence the flow of exhaust gas onto the turbine wheel. The advantage is that optimum boost pressure and good combustion are achieved over the entire engine speed range. The adjustable guide vanes ensure high torque and good starting behavior in the lower speed range, as well as low fuel consumption and low exhaust gas emissions in the upper speed range. A linkage controlled by vacuum is used to adjust the guide vanes.



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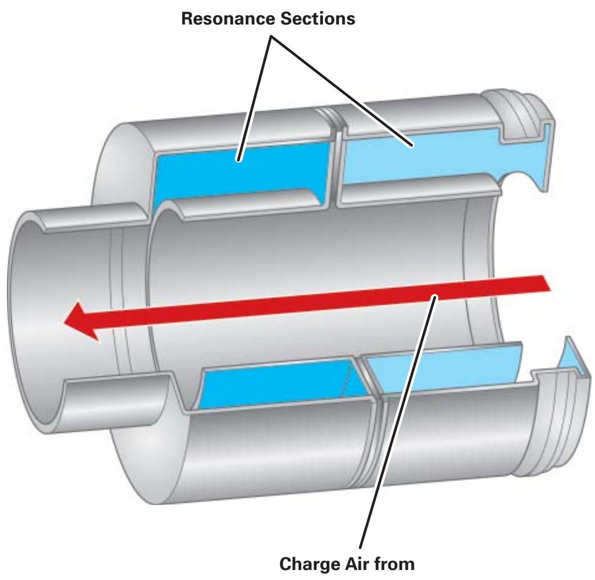
Flow Damper

A flow damper is located behind the outlet of the turbocharger in the charge air section. It reduces disagreeable turbocharger noise, such as whistling.

Design and Function

During full-load acceleration the turbocharger must build up boost pressure very quickly. The turbine and compressor wheel are accelerated quickly and the turbocharger approaches its pump limit. This can lead to burbling in the air flow, which causes disturbing noise that radiates into the charge air section.

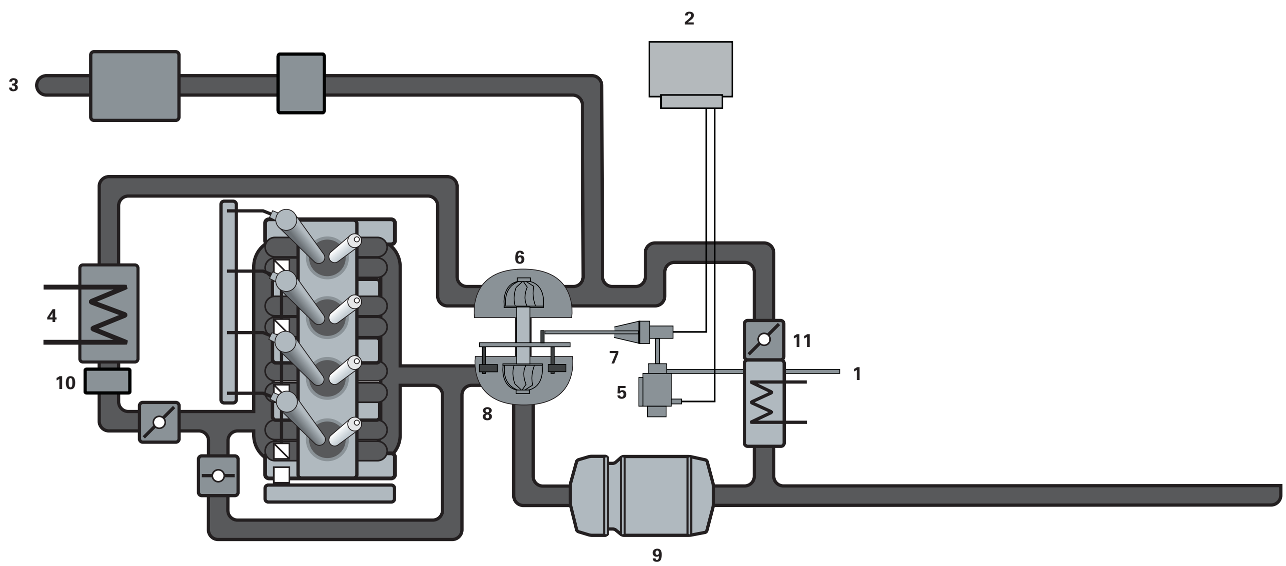
The charge air causes the air in the resonance sections of the flow damper to vibrate. The vibration has approximately the same frequency as the noise in the charge air. Unpleasant noise is minimized by superimposition of the charge air sound waves with the vibration of the air in the resonance sections of the flow damper.



S403_098

Boost Pressure Control

The boost pressure control manages the volume of air that is compressed by the turbocharger.



Legend

1 – Vacuum Supply
2 – Engine Control Module (ECM) J623
3 – Intake Air
4 – Charge Air Cooler
5 – Wastegate Bypass Regulator Valve N75
6 – Turbocharger Compressor
7 – Charge Pressure Actuator Position Sensor G581
8 – Exhaust Gas Turbine with Guide Vane Adjuster
9 – Diesel Particulate Filter / Oxidation Catalyst
10 – Charge Air Pressure Sensor G31 and Intake Air Temperature (IAT) Sensor G42
11 – EGR Valve 2 N213

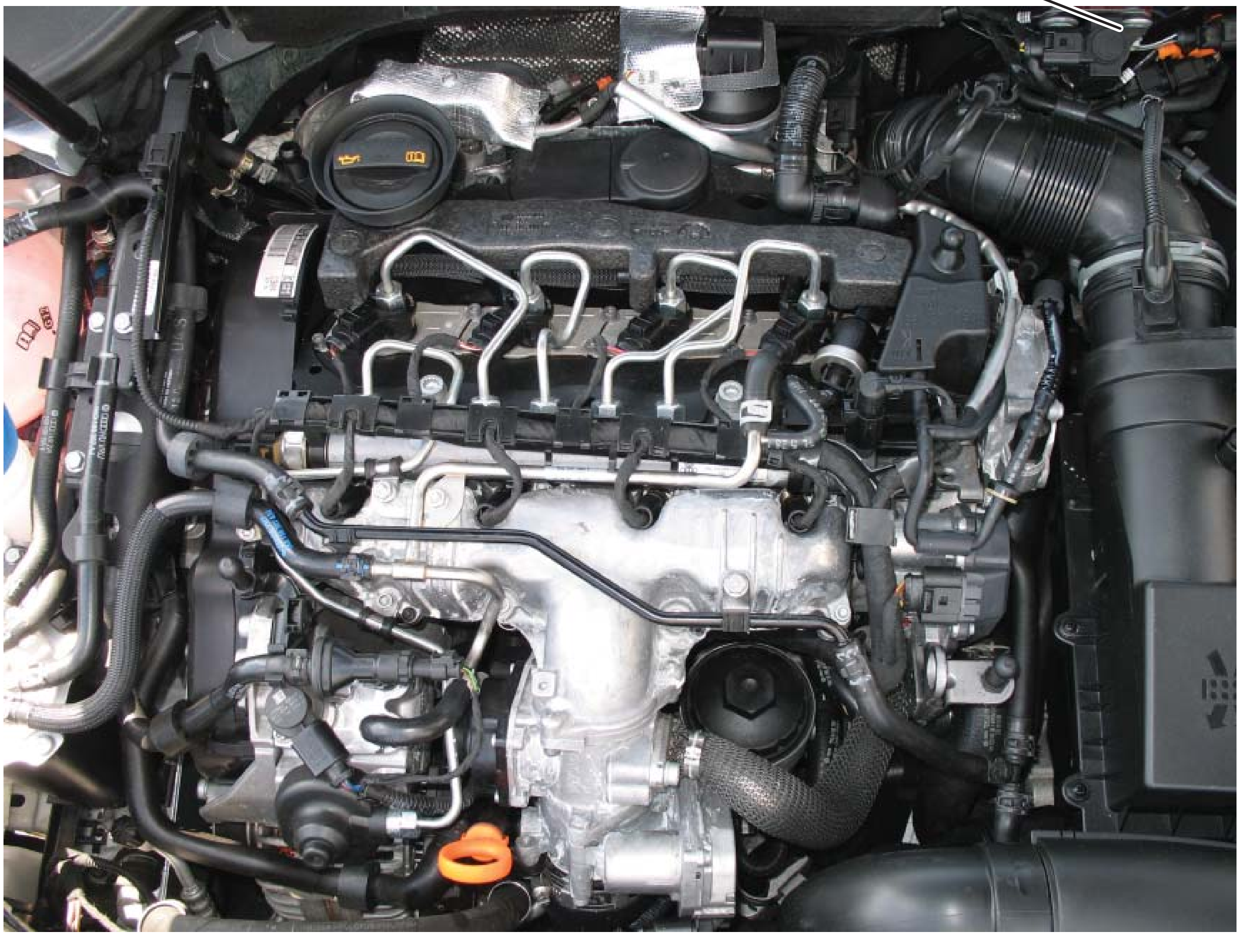
Wastegate Bypass Regulator Valve N75

The Wastegate Bypass Regulator Valve N75 is an electro-pneumatic valve. This valve is used to control the vacuum needed by the vacuum cell to adjust the guide vanes.

Effects of Failure

If the Wastegate Bypass Regulator Valve N75 fails, the vacuum cell is not supplied with vacuum. A spring in the vacuum cell pushes the linkage of the adjusting mechanism so that the guide vanes of the turbocharger are brought into a steep approach angle (emergency mode position). With lower engine speed and thus lower exhaust gas pressure, only a low boost pressure is available. The engine has less power, and an active regeneration of the particulate filter is not possible.

Wastegate Bypass Regulator Valve N75



Cylinder Pressure Sensors G620, G621, G622, G623

A cylinder pressure sensor is integrated into each Glow Plug. The glow element is attached to an extension, which can apply pressure to a diaphragm. The diaphragm has strain gauges that change resistance by deformation. The integrated electronics calculate tension which is proportional to the combustion chamber pressure.

Signal Use

The pressure sensor collects cylinder burn-data such as the burn moment and the conditions of the burn in relation to the crankshaft. This can result in an increase or decrease of the injection amount, because the pressure is indirectly related to the injection amount.

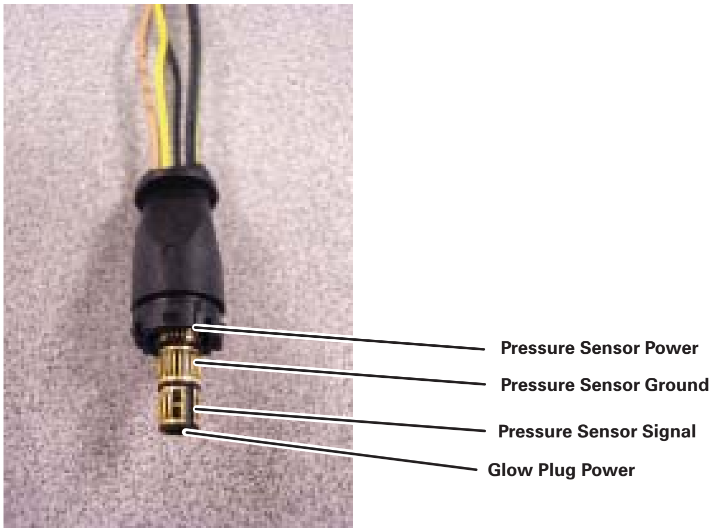
Correcting the injection using pressure sensor information balances the injection for all cylinders. This also compensates for manufacturing tolerances and engine aging.

As a direct result of the pressure sensors, emission tolerances are significantly reduced over the life span of the engine.

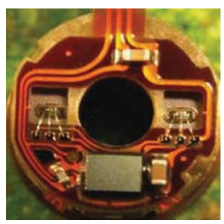
The regulation of the burn is accomplished by shifting the start of injection. The burn stabilizes during times of very large exhaust recirculation rates and during misfires so that other driveability issues can be avoided. In addition, the pressures can help to balance the time delays caused by bad fuel (low Cetane).

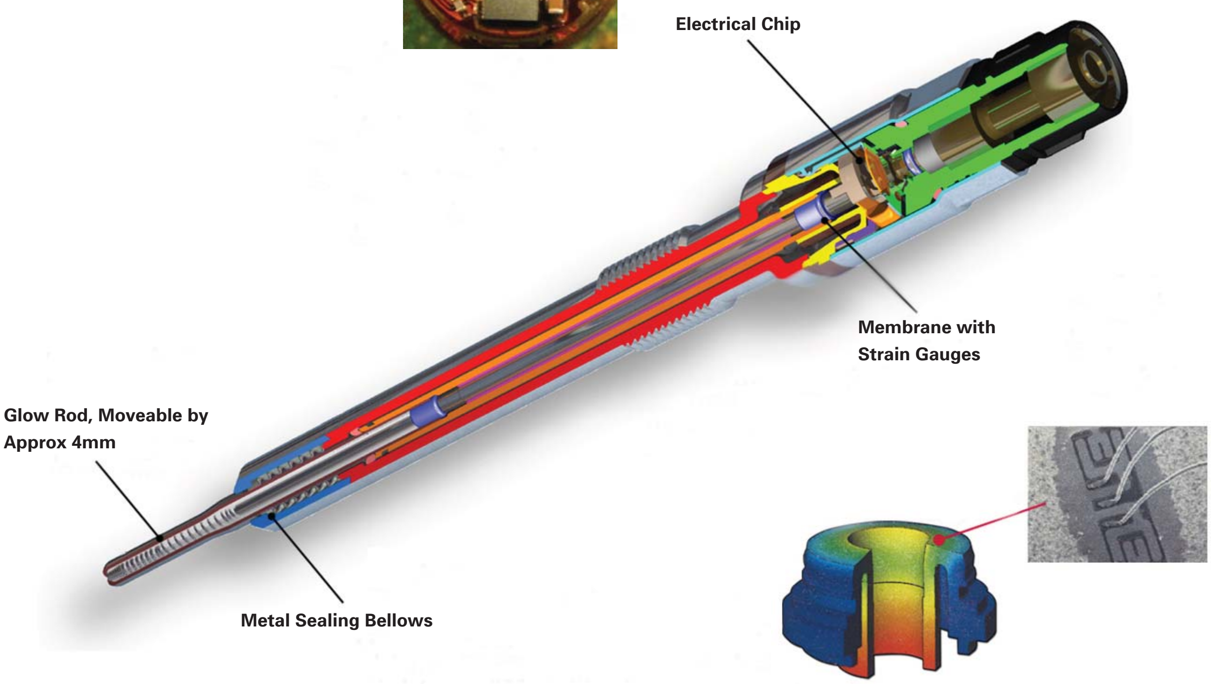
Effect of Failure

If one of the pressure sensors fail, a substitute value from the other pressure sensors is used.



Glow Plug / Pressure Sensor Connector



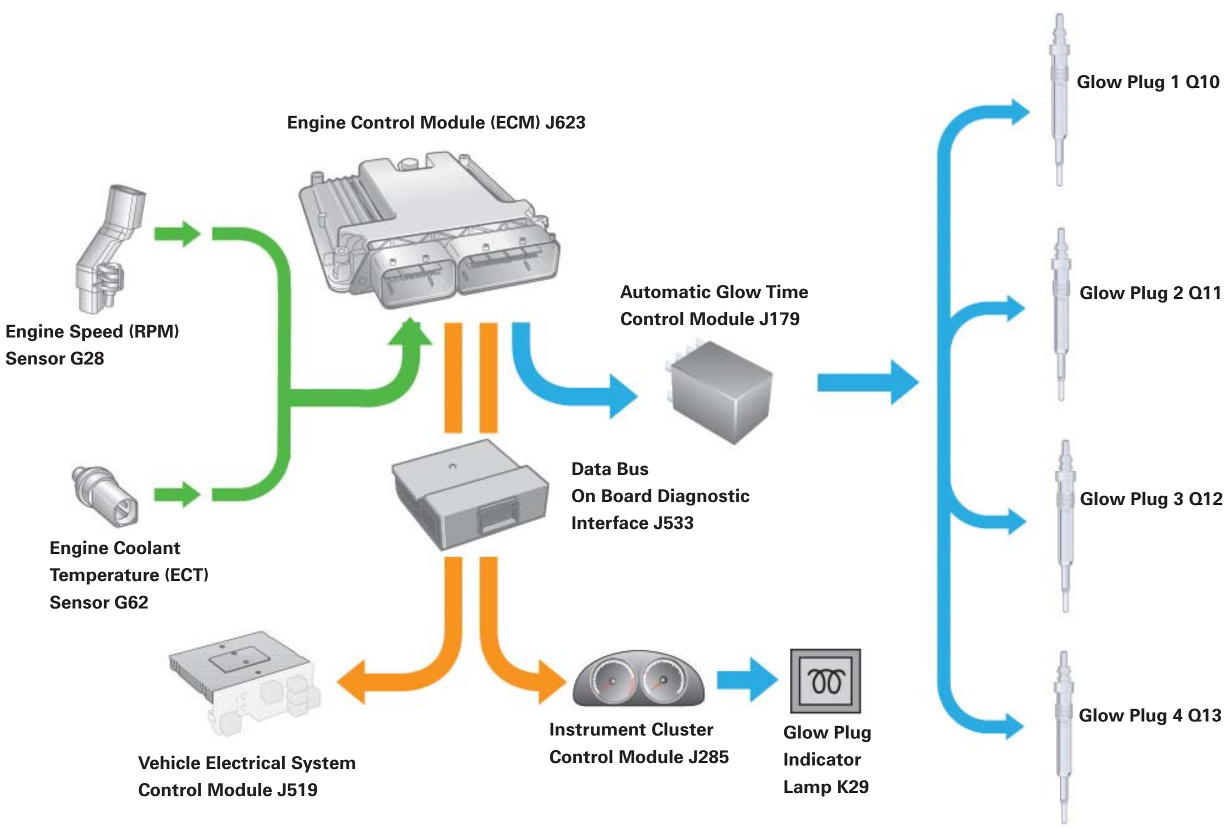


Glow Plugs Q10, Q11, Q12, Q13

The 2.0 Liter TDI engine with common rail injection system has a diesel quick-start glow plug system. This system allows immediate starting in virtually any climate condition, similar to a gasoline engine.

Advantages of the preheating system:

- Improved starting at temperatures to –24°C (–11.2°F).
- Extremely quick preheating time. Within two seconds a temperature of up to 1000°C (1832°F) is reached on the glow-plug.
- Controllable temperatures for preheating and postheating.
- Self-diagnostic capability.
- Part of the On-Board Diagnosis Preheating System.



S403_057

Function

Preheating

The steel glow plugs are activated by the Engine Control Module (ECM) J623 over the Automatic Glow Time Control Module J179 in phase displacement with a Pulse-Width Modulated (PWM) signal. The voltage on the individual glow plugs is adjusted over the frequency of the PWM impulses.

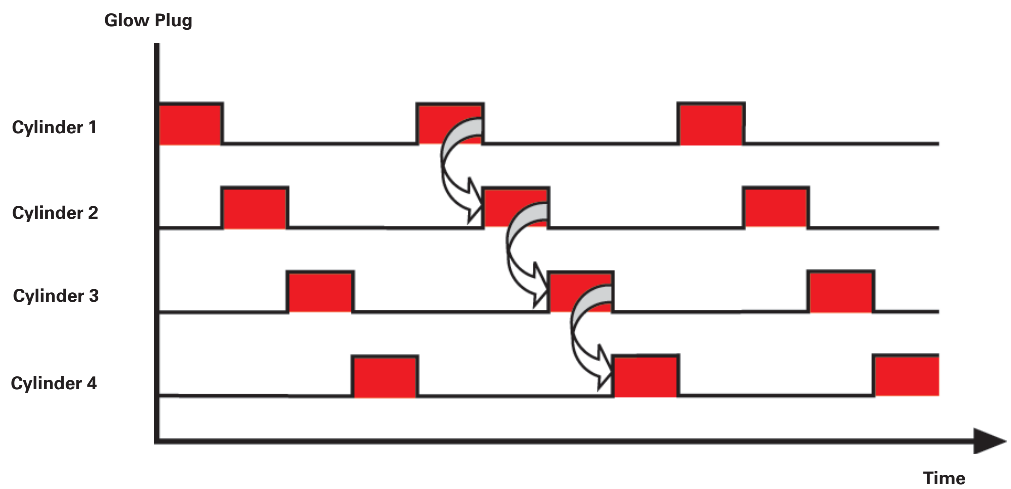
For quick start with an ambient temperature of less than 18°C (64°F), a maximum voltage of 11.5 volts is present during preheating. This ensures that the glow plug heats as quickly as possible (maximum two seconds) to over 1000°C (1832°F), thus reduces the preheating time of the engine.

Post-Heating

The PWM signal is reduced to 4.4 volts for post heating. Post-heating is performed up to a coolant temperature of 18°C (64°F) after the engine start for a maximum of five minutes. Post-heating helps reduce hydrocarbon emissions and combustion noise during the engine warm-up phase.

Phase-Displaced Activation of the Glow Plugs

To relieve the vehicle electrical system voltage during the preheating phases, the glow plugs are activated in phase displacement. The falling signal flank always controls the next glow plug.



S403_056

Charge Air Pressure Sensor G31and Intake Air Temperature (IAT) Sensor G42

The Charge Air Pressure Sensor G31 and Intake Air Temperature (IAT) Sensor G42 are integrated in one component. It is located in the induction pipe between the charge air cooler and the Throttle Valve Control Module J338.

Charge Air Pressure Sensor G31

Signal Use

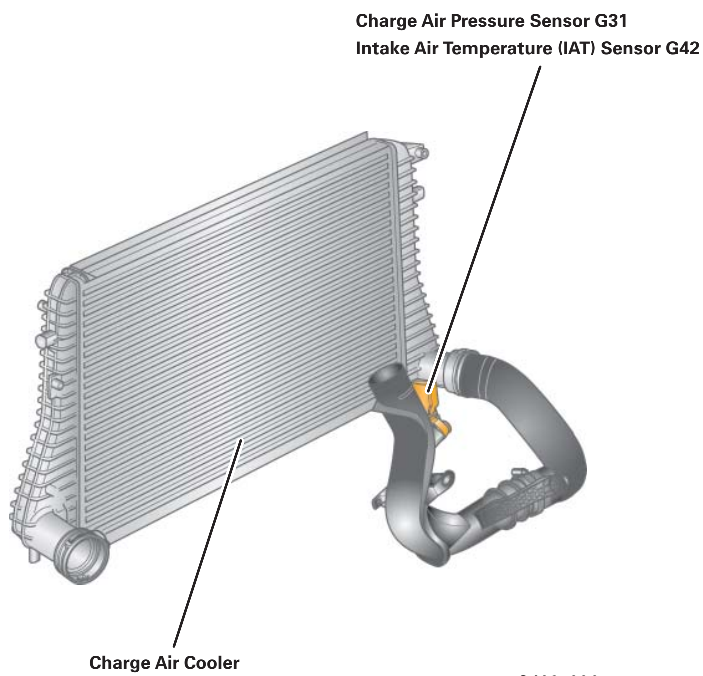
The air pressure in the intake manifold is determined from the Charge Air Pressure Sensor G31 signal. Engine Control Module (ECM) J623 needs the signal to control the boost pressure.

Effect of Failure

If the Charge Air Pressure Sensor G31 signal fails, there is no substitute function. The boost pressure control is disengaged and the engine power decreases significantly. The particulate filter cannot be actively regenerated.

Intake Air Temperature (IAT) Sensor G42

Engine Control Module (ECM) J623 uses the signal of Intake Air Temperature (IAT) Sensor G42 to control the boost pressure. Because the temperature influences the density of the charge air, the signal is used by Engine Control Module (ECM) J623 as a correction value.



S403_096

Charge Pressure Actuator Position Sensor G581

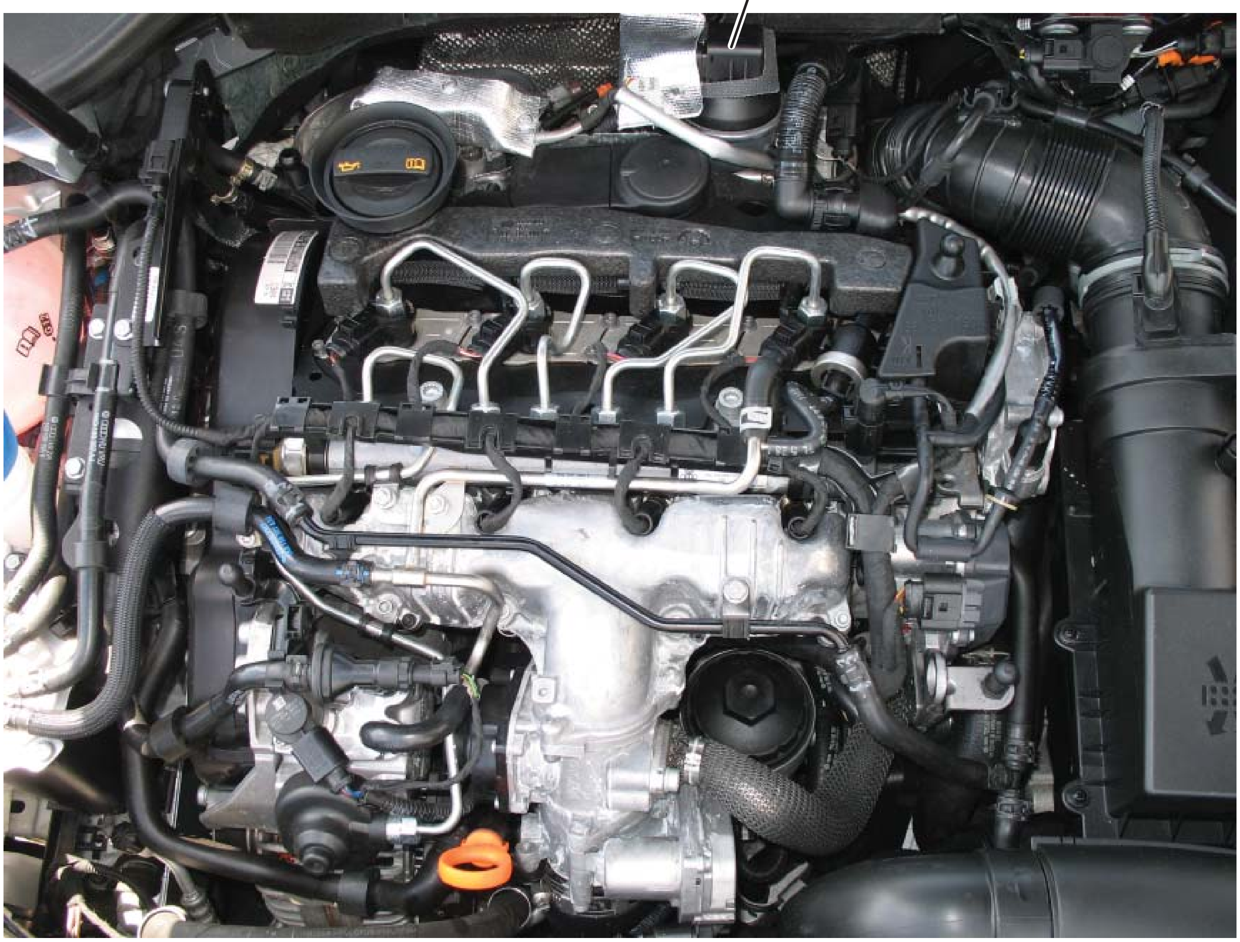
Charge Pressure Actuator Position Sensor G581 is integrated in the vacuum cell of the turbocharger. It is a displacement sensor that enables Engine Control Module (ECM) J623 to determine the position of the guide vanes in the turbocharger.

Signal Use

The signal of Charge Pressure Actuator Position Sensor G581 delivers the position of the guide vanes of the turbocharger to Engine Control Module (ECM) J623. Together with the signal of Charge Air Pressure Sensor G31, this allows conclusions about the state of boost pressure control.

Effects of Failure

If Charge Pressure Actuator Position Sensor G581 fails, the signal from Charge Air Pressure Sensor G31 and the engine speed are used to determine the position of the guide vanes. Malfunction Indicator Lamp (MIL) K83 is actuated.



S403_095

EGR Vacuum Regulator Solenoid Valve N18

The EGR Vacuum Regulator Solenoid Valve N18 is an electrically controlled valve plate. It is actuated by the Engine Control Module (ECM) J623 and can be infinitely adjusted by the electric motor. The angle of the valve plate controls the quantity of returned exhaust gas.

Effect of Failure

If the EGR Vacuum Regulator Solenoid Valve N18 fails, the valve plate is closed by a valve spring. No exhaust gas can be returned.

EGR Potentiometer G212

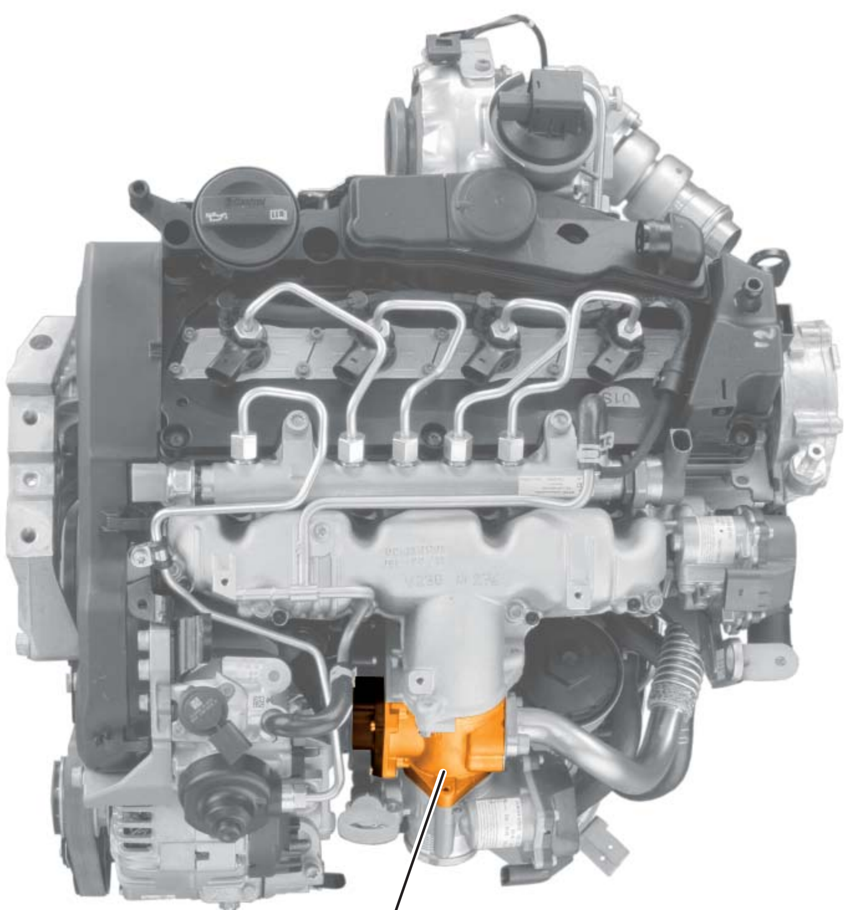
The EGR Potentiometer G212 captures the position of the valve plate in the exhaust gas return valve.

Signal Use

Based on the signal, the Engine Control Module (ECM) J623 recognizes the position of the valve plate. This enables control of returned exhaust gas volume and thus the oxides of nitrogen content in the exhaust gas.

Effect of Failure

If the EGR Potentiometer G212 fails, the exhaust gas return is deactivated. The EGR Vacuum Regulator Solenoid Valve N18 drive is switched to the non-energized state and the valve plate is closed by a valve spring.



Exhaust Gas Return Valve with EGR Potentiometer G212 and EGR Vacuum Regulator Solenoid Valve N18

S403_093

EGR Valve N213

EGR Valve N213 is an electrically-controlled valve plate. It is actuated by the Engine Control Module (ECM) J623 and can be infinitely adjusted by the electric motor. The position of the valve plate controls the quantity of the returned exhaust gas.

Effect of Failure

If EGR Valve N213 fails, the valve plate is closed by a spring. No exhaust gas can be returned.

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EGR Valve N213

EGR Potentiometer

The EGR Potentiometer captures the position of the valve plate in the Low Pressure exhaust gas recirculation valve.

Signal Use

Based on the signal, the Engine Control Module (ECM) J623 recognizes the position of the valve plate. This enables control of the returned exhaust gas volume and thus the oxides of nitrogen content in the exhaust gas.

Effect of Failure

If the EGR potentiometer fails, the Low Pressure recirculation is deactivated. EGR Valve N213 drive is switched to the non-energized state and the valve plate is closed by the valve spring.

Throttle Valve Control Module J338

In the direction of flow, Throttle Valve Control Module J338 is mounted before EGR Vacuum Regulator Solenoid Valve N18.

An electric motor in Throttle Valve Control Module J338 moves the throttle plate with a gear. Adjustment of the throttle is infinite and can be adapted to the respective load and speed of the engine.

The Throttle Valve Control Module J338 has the following tasks:

In certain operating situations, a difference between intake manifold pressure and exhaust gas pressure is generated through the throttle. This pressure difference facilitates exhaust gas return.

In the regeneration mode of the diesel particulate filter, the intake air volume is regulated with the throttle.

When the Throttle Valve Control Module J338 motor is switched off, the throttle is closed. Less air is taken in and compressed and the engine shuts down smoothly.

Effect of Failure

If Throttle Valve Control Module J338 fails, there is no regulation of the exhaust gas return rate. Active regeneration of the diesel particulate filter does not take place.

Throttle Valve Control Module J338 with Throttle Position (TP) Sensor G69

S403_101

Throttle Position (TP) Sensor G69

The Throttle Position (TP) Sensor G69 is integrated in the throttle drive. The sensor element captures the position of the throttle.

Signal Use

Based on the signal, Engine Control Module (ECM) J623 recognizes the position of the throttle. This information is needed to control exhaust gas return and particulate filter regeneration.

Effect of Failure

If the Throttle Position (TP) Sensor G69 fails, the exhaust gas return is deactivated and active regeneration of the diesel particulate filter does not take place.

Exhaust Flap Control Module J883

The exhaust throttle valve is a new component and is located behind the NO_x Reduction catalytic converter.

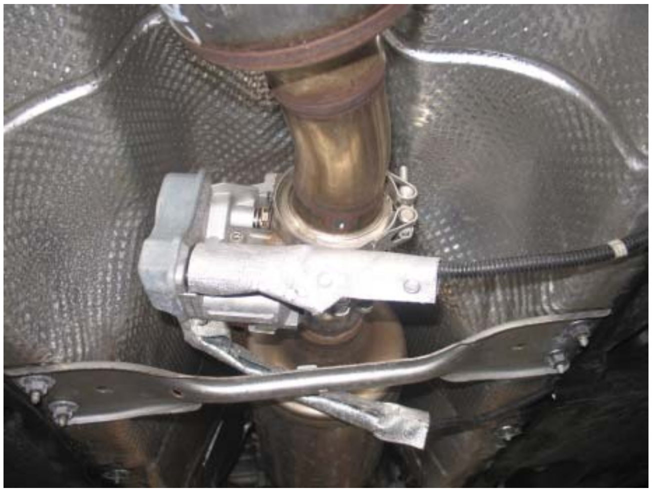
An electric motor inside the Exhaust Flap Control Module J883 moves the throttle plate with a gear. Adjustment of the throttle plate is infinite and can be adapted to respective load and speed of the engine.

The Exhaust Flap Control Module J883 has the following tasks:

– In certain operating conditions, a differential pressure is generated between the NO_x Reduction catalyst and the turbocharger.
– This increase in pressure helps with Low Pressure EGR return.

Effect of Failure

If the Exhaust Flap Control Module J883 fails, the correct regulation of exhaust gas recirculation rate is not possible. Exhaust gas recirculation is deactivated, and regeneration of the NO_x Reduction catalyst does not take place.



Exhaust Flap Control Module Position Sensor

The Throttle Position Sensor is integrated into the throttle valve drive. The purpose of this sensor is to capture the position of the throttle valve.

Signal Use

Based on the signal, the Engine Control Module (ECM) J623 recognizes the position of the throttle. This information is needed for control of exhaust gas recirculation.

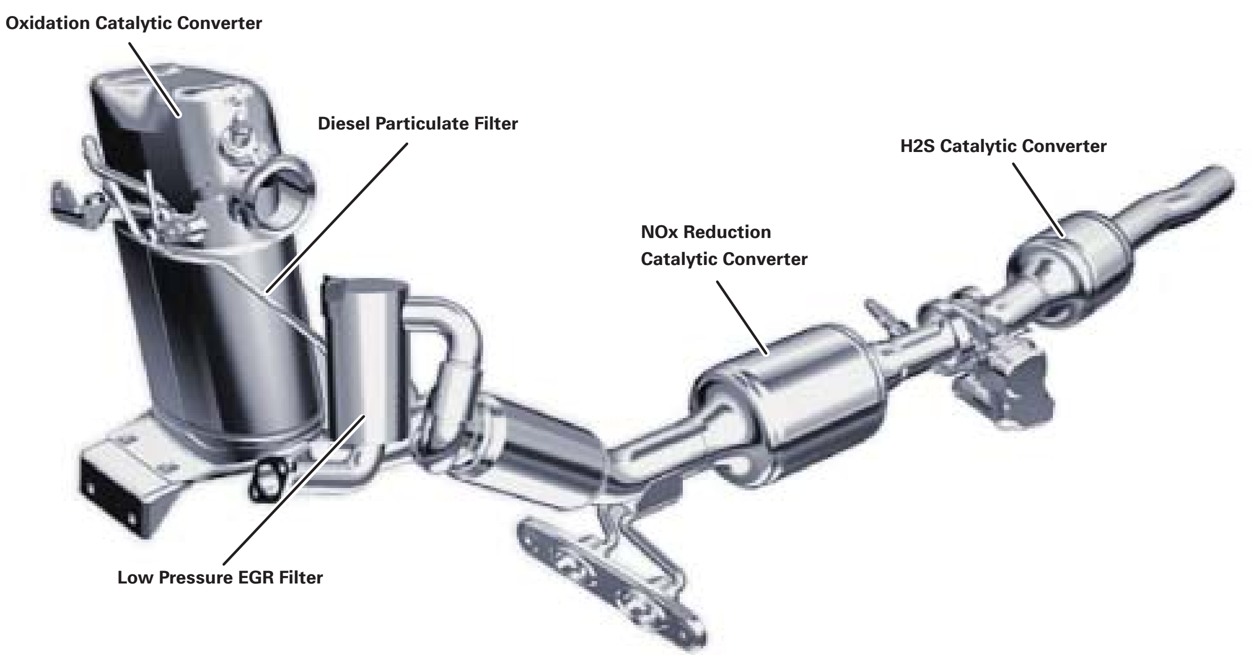
Effect of Failure

If Throttle Position (TP) Sensor fails, the exhaust gas recirculation is deactivated.

Exhaust System

The exhaust system of the 2.0L Common-Rail is very different from previous engines. The exhaust system consists of the following main components:

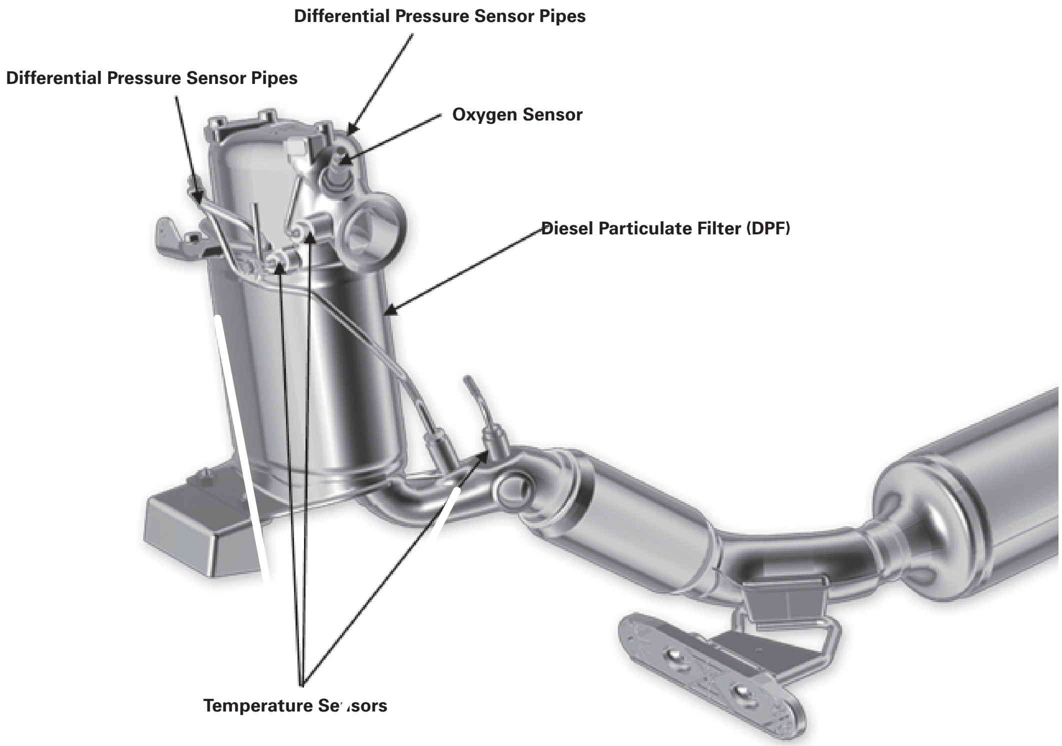
- Oxidation Catalytic Converter
- Particulate Filter
- NOx Reduction Catalytic Converter
- H2S Catalytic Converter
- Low Pressure EGR Filter



Diesel Particulate Filter System

In addition to internal engine measures in the 2.0 Liter TDI engine with common rail injection system, soot particle emissions are further reduced through a diesel particulate filter.

The diesel particulate filter and oxidation catalyst are in a single housing. It is located close to the engine so that it will reach operating temperature quickly.



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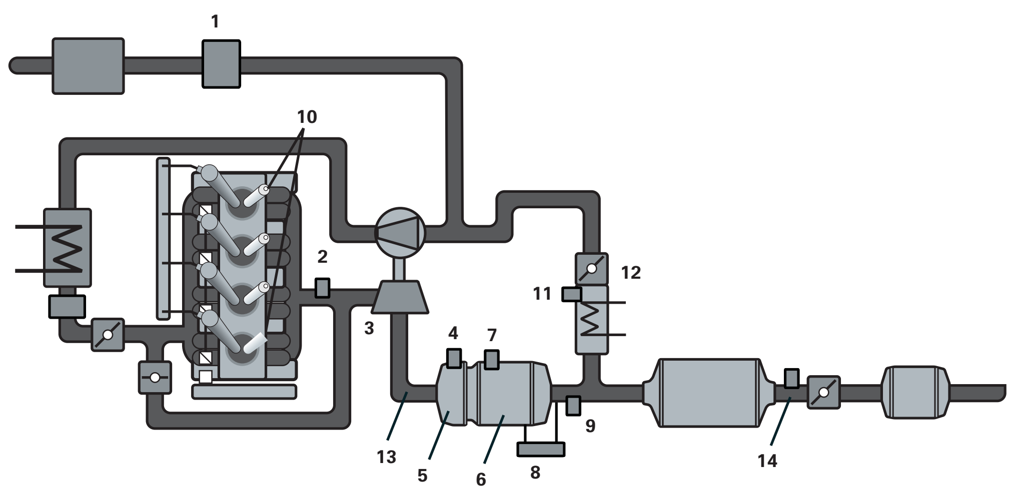
Diesel Particulate Filter and NOx Reduction Catalytic Converter System Overview



Legend

1 – Mass Air Flow (MAF) Sensor G70
2 – Exhaust Gas Temperature (EGT) Sensor 1 G235
3 – Turbocharger
4 – Heated Oxygen Sensor (HO2S) G39
5 – Oxidation Catalyst
6 – Particulate Filter
7 – Exhaust Gas Temperature (EGT) Sensor 3 G495
8 – Exhaust Pressure Sensor 1 G450
9 – Exhaust Gas Temperature (EGT) Sensor 4 G648

10 – Cylinder Pressure Sensors 1,2,3,4
11 – Low Pressure EGR Temperature Sensor
12 – Low Pressure EGR Potentiometer
13 - Exhaust Gas Temperature (EGT) Sensor 2
14 - Heated Oxygen Sensor ($H0_2S$) G130

Additional Components not Pictured:
- Low Pressure EGR Differential Pressure Sensor
- Wastegate Bypass Regulator Valve N75

Diesel Particulate Filter System Design

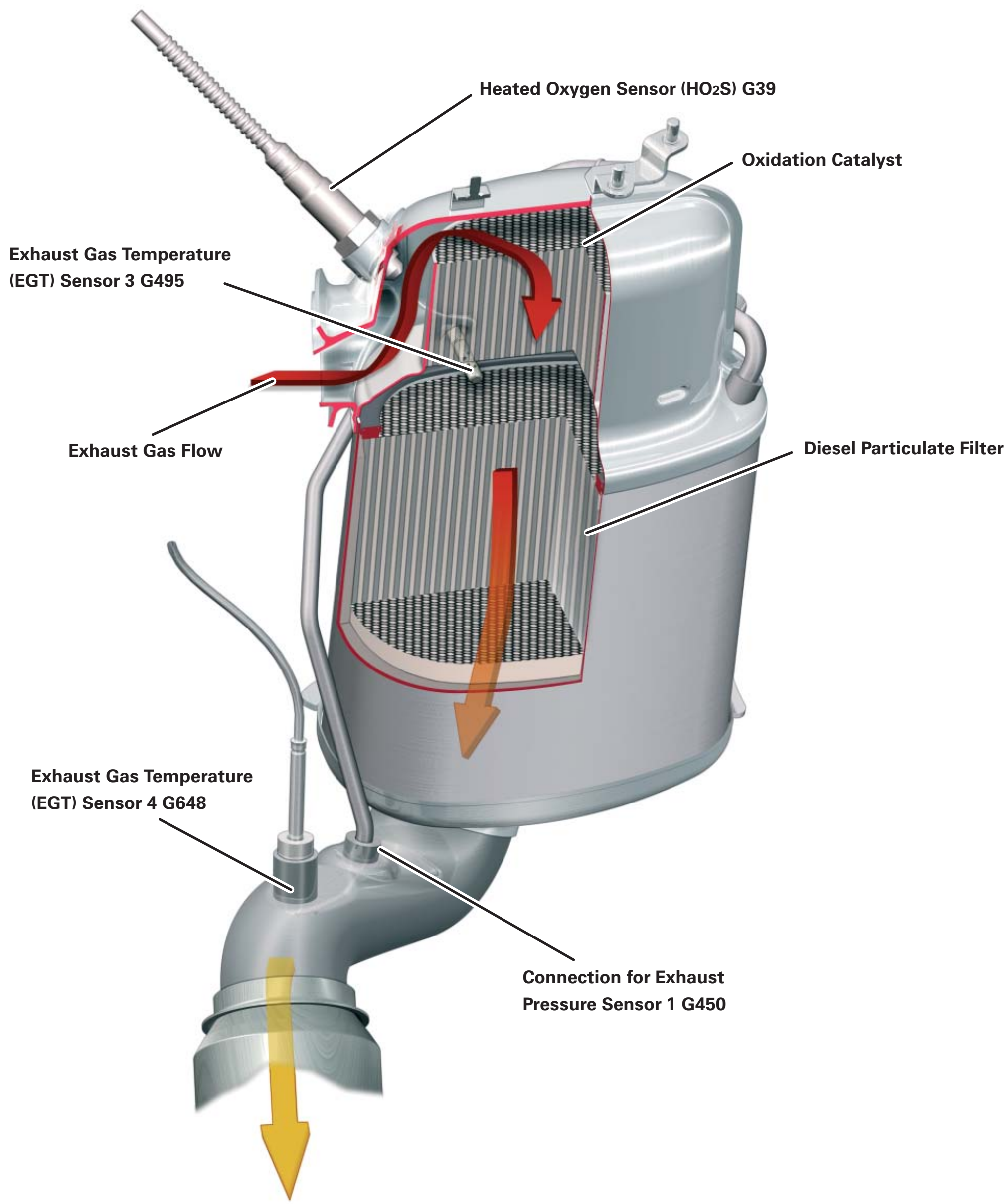
The diesel particulate filter and the oxidation catalyst are installed separately in a shared housing. The oxidation catalyst is located before the particulate filter in the direction of exhaust flow.

This design with the oxidation catalyst upstream offers the following advantages in connection with the common rail injection system.

– Because of the upstream placement of the oxidation catalyst, the temperature of the exhaust gas is increased before it enters the diesel particulate filter. As a result, the operating temperature of the diesel particulate filter is reached quickly.

– In trailing throttle condition, over cooling of the diesel particulate filter by the cold intake air is prevented. In this case, the oxidation catalyst acts as a heat exchanger, from which the warmth is routed through the exhaust gas flow to the particulate filter.

– In the regeneration operation, the temperature of the exhaust gas is accurately controlled. The Exhaust Gas Temperature (EGT) Sensor 3 G495 determines the temperature of the exhaust gas directly before the particulate filter. As a result, the fuel quantity of the post-injection is precisely calculated to increase the exhaust gas temperature in the regeneration operation.



S403_091

Oxidation Catalyst

The carrier material of the oxidation catalyst is metal, so the light-off temperature is reached quickly. This metal body has an aluminum oxide carrier coating, onto which platinum and palladium are vapor deposited as catalyst for the Hydrocarbons (HC) and the Carbon Monoxide (CO).

Function

The oxidation catalyst converts a large portion of the Hydrocarbons (HC) and the Carbon Monoxide (CO) into water vapor and Carbon Dioxide.

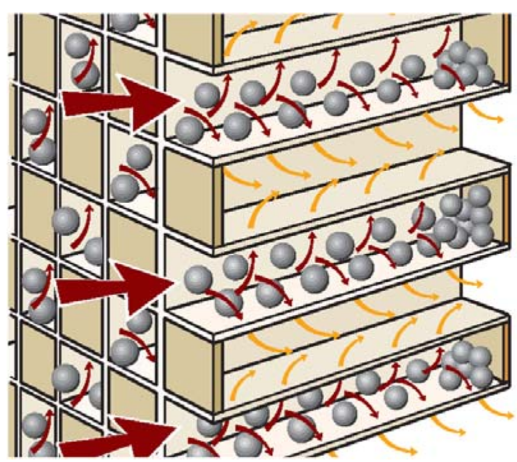
Diesel Particulate Filter

The diesel particulate filter consists of a honeycomb shaped ceramic body made of aluminum titanide. The ceramic body is partitioned into a large number of small channels, which are alternately open and closed at the ends. This results in inlet and outlet channels that are separated by filter walls.

The filter walls are porous and coated with a carrier coating of aluminum oxide. Vapor-deposited onto this carrier layer is the precious metal platinum, which acts as catalyst.

Function

As the soot-containing exhaust gas flows through the porous filter walls of the inlet channels, the soot particles are captured in the inlet channels.



S403_072

Regeneration

The particulate filter must be regenerated regularly so that it does not become clogged with soot particles and its function impaired. During regeneration, the soot particles collected in the particulate filter are burned off (oxidized).

The regeneration of the particulate filter is performed in the following stages:

– Warm-Up Phase
– Passive Regeneration
– Active Regeneration
– Customer-Initiated Regeneration Drive
– Service Regeneration

Warm-Up Phase

To heat a cold oxidation catalyst and particulate filter as quickly as possible to operating temperature, the engine management system introduces a post-injection after the main injection.

This fuel burns in the cylinder and increases the combustion temperature. Through the air flow in the exhaust gas tract, the resulting heat reaches the oxidation catalyst and the particulate filter and heats them.

The warm-up phase is complete when the operating temperature of the oxidation catalyst and the particulate filter has been reached for a specific period of time.

Passive Regeneration

During passive regeneration the soot particles are continuously burned without the intervention of the Engine Control Module (ECM) J623.

This occurs primarily at higher engine load, such as in highway driving, when exhaust gas temperatures range from 350°C to 500°C (662°F to 932°F).

At these temperatures the soot particles are converted into carbon dioxide through a combustion reaction with nitrogen dioxide.

Active Regeneration

In a large portion of the operating range, the exhaust gas temperatures are too low for a passive regeneration. Because soot particles can no longer be eliminated passively, soot accumulates in the filter. As soon as a specific soot load has been reached in the filter, the Engine Control Module (ECM) J623 initiates an active regeneration.

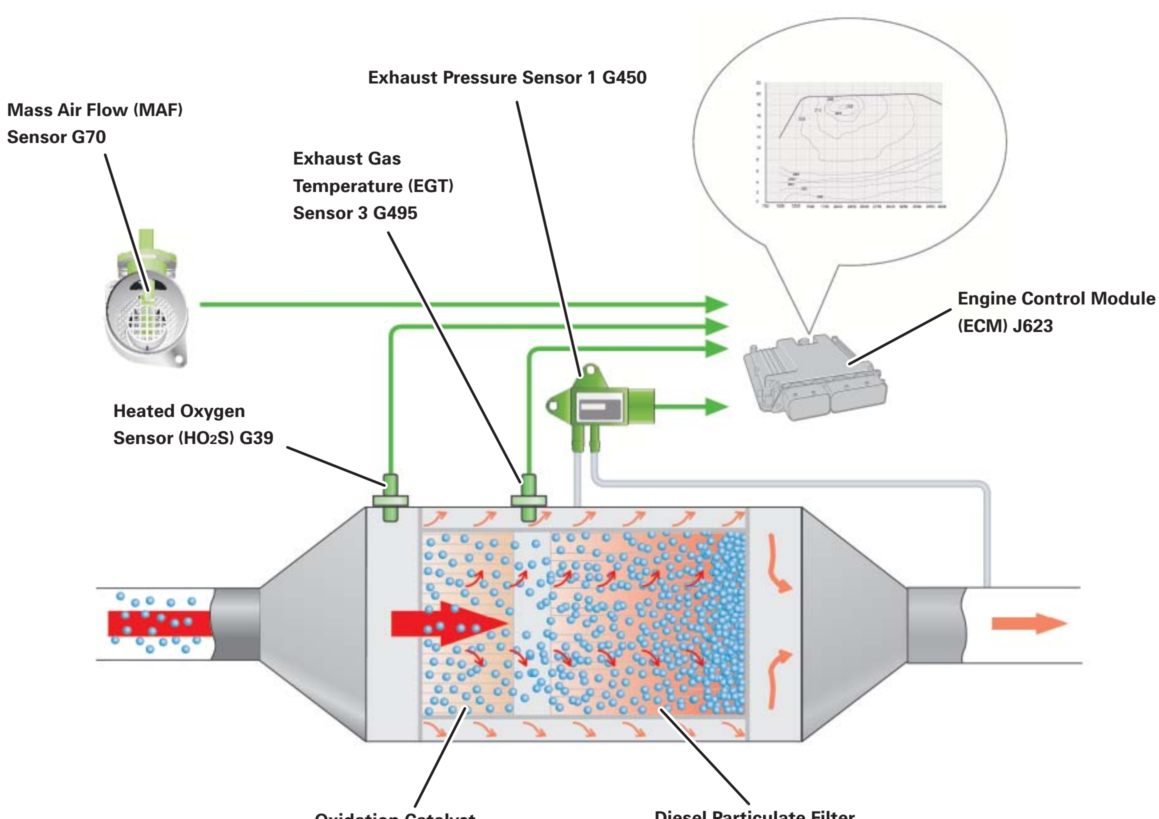
The soot particles are burned off at an exhaust gas temperature of 550°C to 650°C (1022°F to 1202°F).

Active Regeneration Function

The soot load of the particulate filter is calculated by two pre-programmed load models in the Engine Control Module (ECM) J623.

One of the load models is determined from the driving profile of the user and the signals from the exhaust gas temperature sensors and Heated Oxygen Sensor (HO2S) G39.

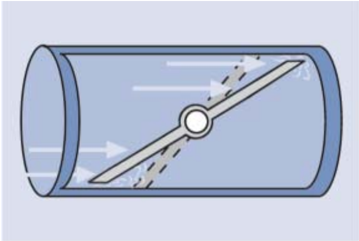
Another soot load model is the flow resistance of the particulate filter. It is calculated from the signals of Exhaust Pressure Sensor 1 G450, Exhaust Gas Temperature (EGT) Sensor 3 G495, and Mass Air Flow (MAF) Sensor G70.



S403_070

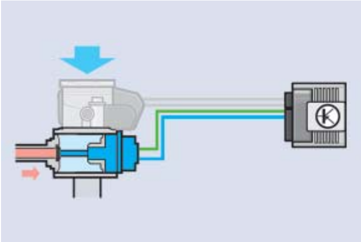
The Engine Control Module (ECM) J623 has several ways to control the increase of exhaust gas temperatures during active regeneration:

– The intake air supply is regulated by Throttle Valve Control Module J338.



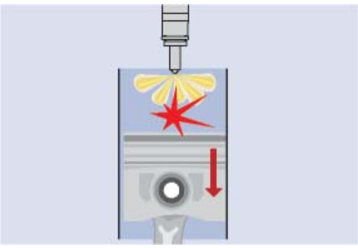
S403_074

– The exhaust gas return is deactivated to increase the combustion temperature and the oxygen content in the combustion chamber.



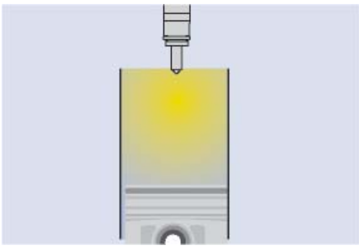
S403_075

– Shortly after a delayed “late” main injection, the first post-injection is initiated to increase the combustion temperature



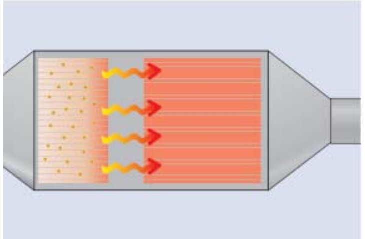
S403_076

– Late after the main injection, an additional post injection is initiated. This fuel does not combust in the cylinder, but instead vaporizes in the combustion chamber.



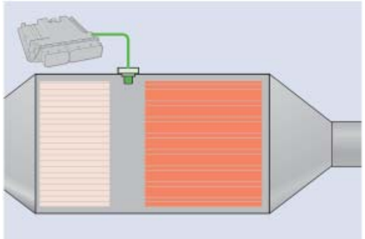
S403_077

– The unburned hydrocarbons of this fuel vapor are oxidized in the oxidation catalyst. This ensures an increase in the exhaust gas temperature to approximately 650°C (1202°F) as it reaches the particulate filter.



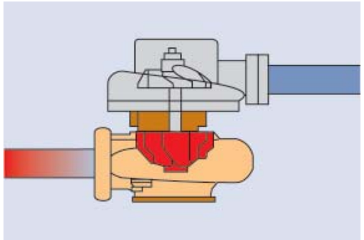
S403_078

– To calculate the injection quantity for the late post-injection, the Engine Control Module (ECM) J623 uses the signal of Exhaust Gas Temperature (EGT) Sensor 3 G495 located before the particulate filter.



S403_080

– The boost pressure is adjusted so that the torque during the regeneration operation does not change noticeably for the driver.



S403_079

Customer-Initiated Regeneration Drive

An exhaust gas temperature high enough for particulate filter regeneration is not reached when the vehicle is only driven for short-distances. If the soot load of the diesel particulate filter reaches a threshold value, Diesel Particle Filter Indicator Lamp K231 in the instrument panel illuminates.

This signal prompts the driver to perform a regeneration drive. The vehicle must be driven for a short period of time at increased speed to ensure an adequately high exhaust gas temperature is reached. The operating conditions must remain constant over the period for a successful regeneration.

Reference

Details of the driving behavior required when the Diesel Particle Filter Indicator Lamp K231 is illuminated are found in the Owner's Manual.

Note

When the soot load reaches 45 grams (1.59 ounces), service regeneration is no longer possible. Because the danger of destroying the filter is too great with this load, the filter must be replaced.

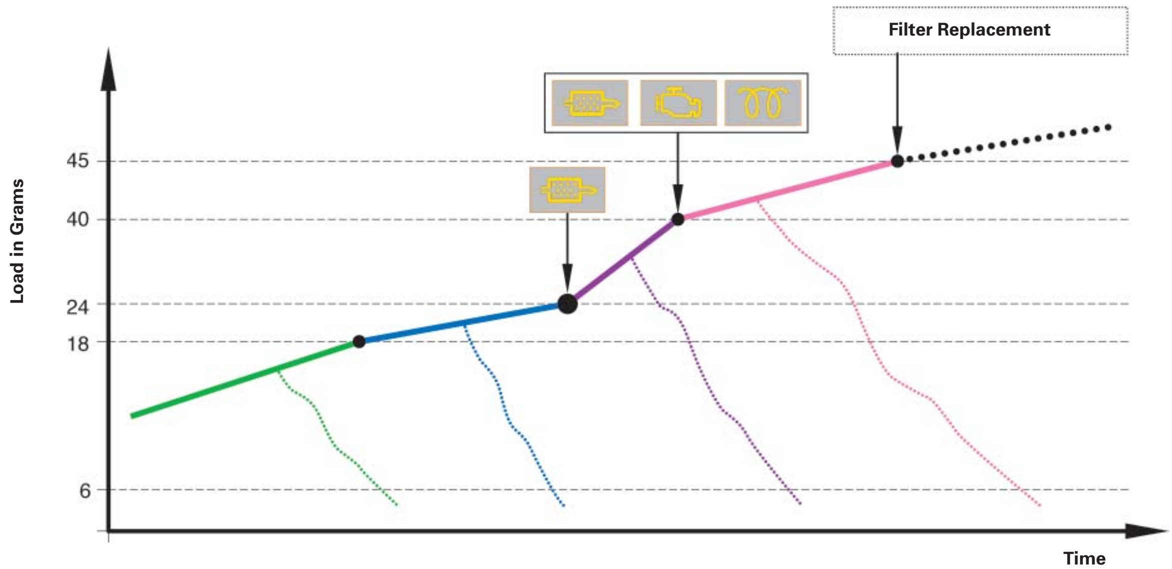
Service Regeneration

If the regeneration drive is not successfully completed and the soot load of the diesel particulate filter has reached 40 grams (1.41 ounces), Diesel Particle Filter Indicator Lamp K231 and Glow Plug Indicator Lamp K29 will light up simultaneously.

The text "Check Engine – Service Shop" will appear in the instrument panel display.

This prompts the driver to visit the nearest Audi dealership. In this case, the Engine Control Module (ECM) J623 blocks active regeneration of the diesel particulate filter to prevent damage to the filter. The particulate filter can only be regenerated by service regeneration using the VAS scan tool.

Regeneration of the 2.0 Liter TDI Particulate Filter



Example: Increase in soot load

Example: Profile with successful regeneration in the respective stage

Passive Regeneration

Active Regeneration

Customer-Initiated Regeneration Drive

Service Generation

Filter Replacement

S403_105

Distance Regeneration

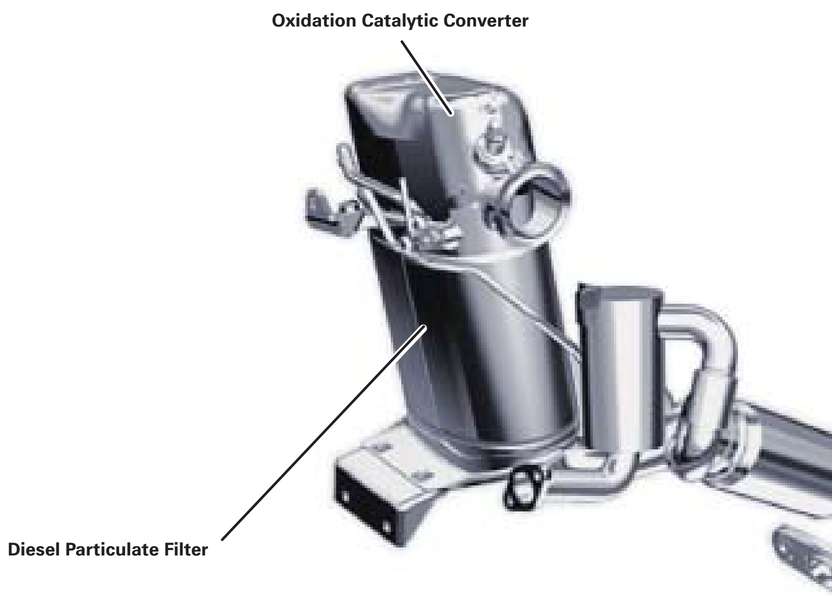
“Distance Regeneration” is a distance-dependent regeneration of the particulate filter. The Engine Control Module (ECM) J623 initiates an active regeneration automatically if during the last 750 to 1000 km (466 to 621 miles) of travel, no successful regeneration has taken place, regardless of the load condition in the diesel particulate filter.

Distance regeneration is an additional safeguard to minimize the load condition of the diesel particulate filter.

NOx Reduction Catalytic Converter

To reach the BIN5/LEV2 emission level, an efficient system for exhaust gas after-treatment is required. The NOx Reduction catalyst is used to supplement the particulate filter system.

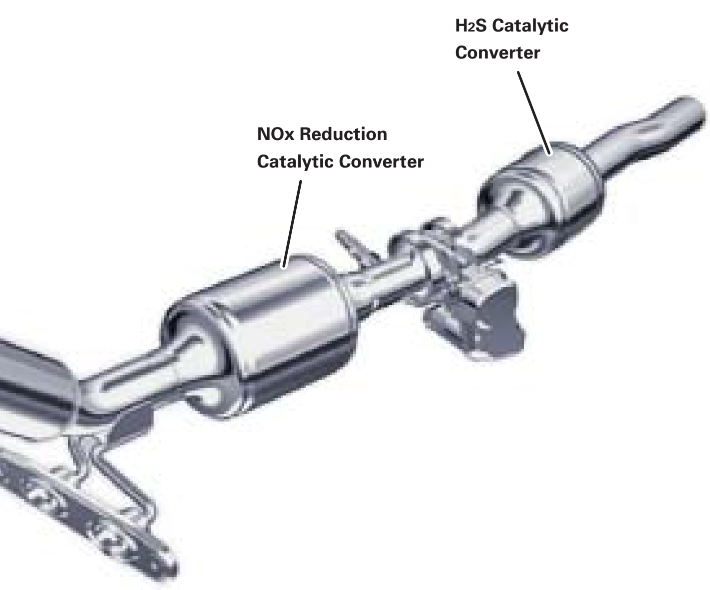
By placing the NOx Reduction catalytic converter away from the engine in the vehicle underbody, the thermal aging is considerably reduced. This also takes advantage that the CO and HC that have already been oxidized by the particulate filter. This allows an optimum NO_x conversion in the NO_x Reduction catalytic converter.



The exhaust system has two lambda sensors. The upstream lambda sensor of the oxidation catalytic converter regulates the air-reduced operating modes for the NO_x catalytic converter. It is also used for the initial value for the air model stored in the ECM. This model is used to calculate the NOx and soot emission reduction strategy of the Engine Control Module J623.

The second lambda sensor, which is placed downstream of the NO_x catalytic converter, detects an excess of reduction medium in the regeneration phase. This is used to determine loading and the aging condition of the NO_x catalytic converter.

The three temperature sensors integrated into the exhaust system enable the OBD functions for the catalytic components and are used as initial values in the regulation of the regeneration operating modes of the exhaust temperature model.



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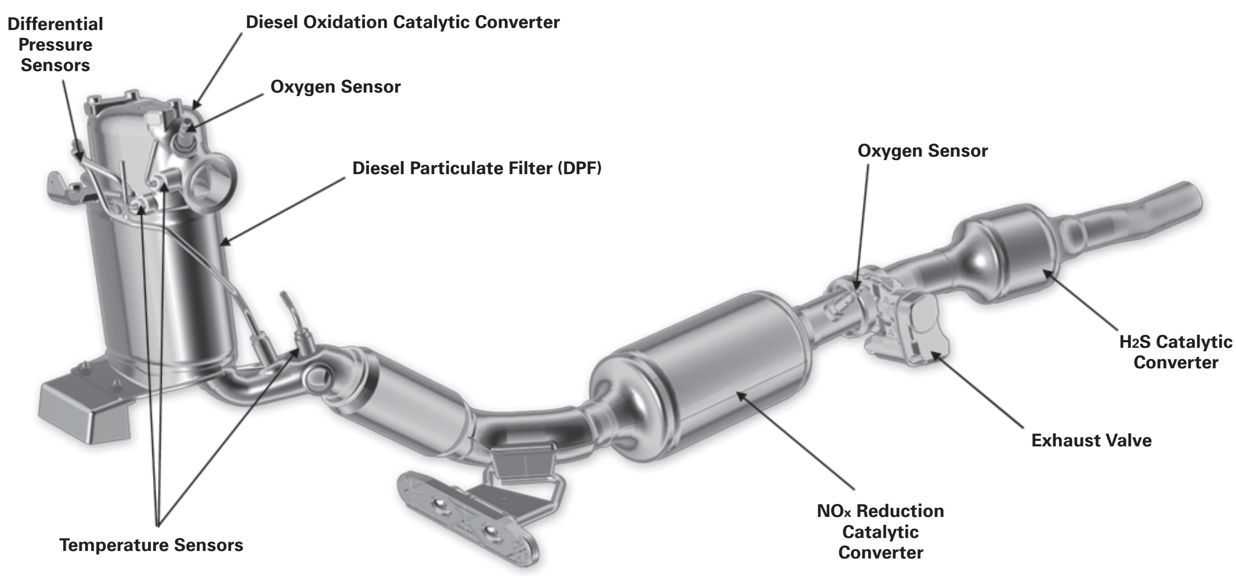
Additional Engine Operating Modes for Exhaust After-Treatment

DeNox Mode

The enhancement of the exhaust after-treatment system with a NOx Reduction catalytic converter requires the introduction of new regeneration modes to ensure NO_x conversion throughout the service life of the unit.

Unlike particulate filter regeneration, a sub-stoichiometric rich exhaust gas composition is necessary for the regeneration of the NOx Reduction catalytic converter. In sub-stoichiometric operation, the oxides of nitrogen stored during the lean operation are reduced by the exhaust enriched reduction media consisting of HC, CO and H_2.



DeSOx Mode

A further regeneration mode is provided by the sulphur removal of the NOx Reduction catalytic converter (DeSOx Mode). This is necessary because the sulphur contained in the fuel causes sulfate formation which slowly deactivates the NOx Reduction catalytic converter.

The de-sulphurization procedure is designed for a sulfur content of 15 ppm (parts per million).

Due to the high thermal stability of the sulfates, significant levels of sulphur reduction are only possible at temperatures above 620°C (1150°F).

The sulphur reduction procedure has been designed so that the storage capacity of the catalytic converter can mostly be restored without irreversible damage to the storage material.

The sub-stoichiometric mode is very demanding in terms of engine management. To be able to set air mass and exhaust gas recirculation independently of each other, two separate control circuits are used. The air mass is set using the intake manifold throttle valve. The exhaust recirculation rate is set using a new, model-based regulation concept.

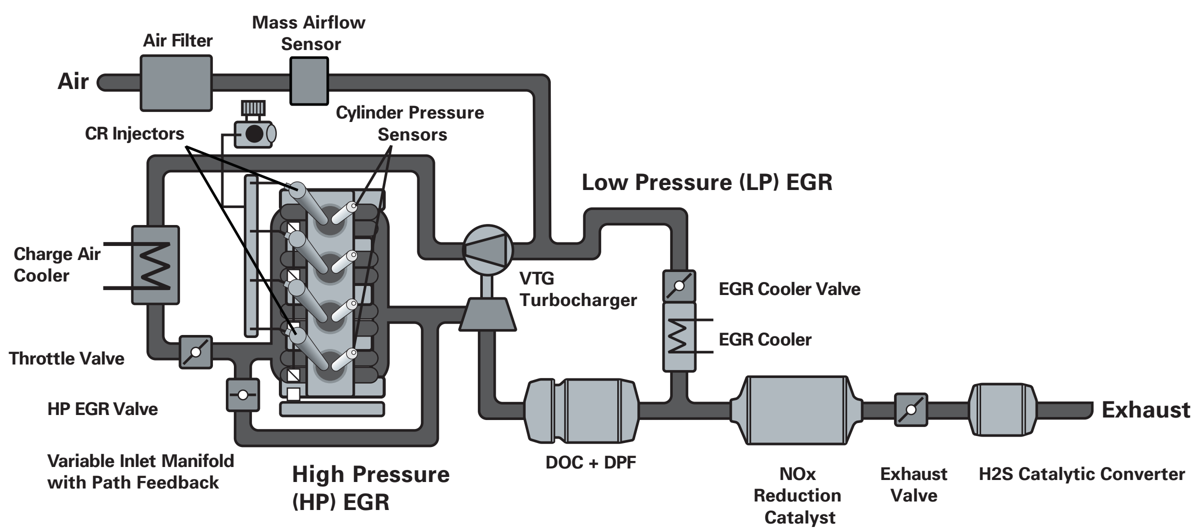


Figure 18

A suitable combination of high pressure and low pressure EGR with corresponding compression temperatures enable stable rich operation, even in the low load range.

In addition, the injection strategy for the rich mode is changed. Up to six injections are used depending on characteristic values to attain a stable and low-soot combustion. This is particularly important in the sulphur reduction process to prevent soot accumulation in the particulate filter.

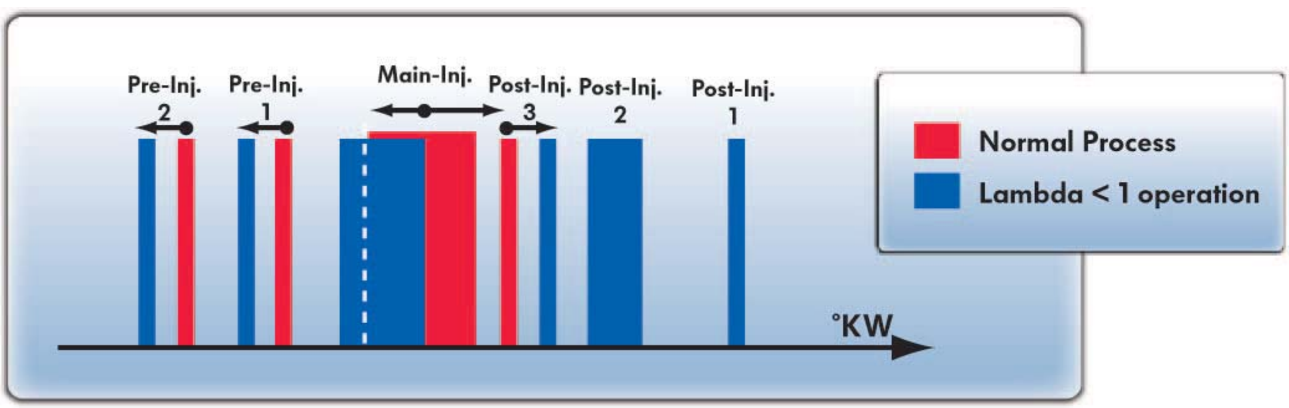


Figure 19

To reach the necessary exhaust gas temperatures in DeSOx operation, the conflict of interests between the component protection of the turbocharger and the higher sulfur-reduction performance was resolved using very late, non-combustion post-injection. The fuel partially reacts at the oxidation catalytic converter with the residual oxygen contained in the exhaust gas and therefore creates residual heat for the sulfur reduction of the NO_x Reduction catalytic converter.

These interventions in engine management are regulated to a neutral torque, meaning that the process has no noticeable effect on driving characteristics. As shown in the figure below, the regeneration intervals depend on the corresponding load conditions of the NO_x Reduction catalytic converter with sulfur, oxides of nitrogen or the soot load of the particulate filter. The maximum load conditions were adjusted to the allowable operating thresholds of the components.

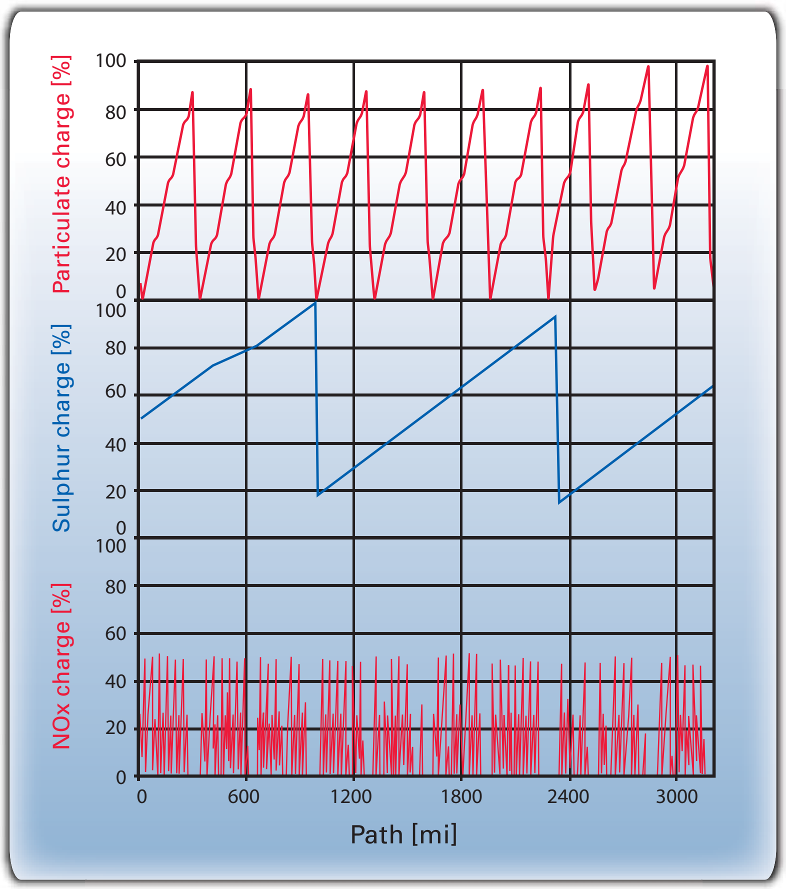


Figure 20

DeNOx Concept

Taking into consideration the necessary engine operation and regeneration conditions as well as the catalytic converter properties, the corresponding regeneration mode is prioritized by a coordination program in the ECM.

DeNOx regeneration is given a higher priority than other regenerations to prevent thermal NO_x desorption.

A loading and discharging model is stored in the ECM for DeNOx regeneration. This maps the characteristics of the NOx Reduction catalytic converter. The load condition of the catalytic converter is modeled during engine operation that is dependent on the exhaust temperature and volume velocity as well as the calculated raw NO_x emissions.

If the NO_x load value exceeds a threshold value that represents the optimum conversion rate for the catalytic converter, the regeneration is conducted when the operating condition of the engine allows a regeneration mode to be activated.

Two criteria, which relate to the lambda signal or a NO_x discharge model, are available for determining the end of regeneration.

As soon as the lambda sensor detects a rise in the reduction medium after the NO_x Reduction catalytic converter, it is free of nitrogen oxide and regeneration has ended.

Due to cross-sensitivity of the lambda probe, this criteria is not allowed during a certain threshold temperature. For this reason, the discharge of the NO_x Reduction catalytic converter is also modeled on the basis of the requirement and provision of reduction medium to reduce the stored NO_x.

Sulfur Reduction Concept

The requirement for a DeSOx mode depends on the sulfur load of the NOx Reduction catalytic converter and is calculated from fuel consumption and the sulfur content of the fuel.

To shorten the heating cycle of the exhaust system, sulfur reduction in the NOx Reduction catalytic converter is only conducted at the end of a particulate filter regeneration cycle.

After reaching the de-sulphurization temperature, the engine begins to use a long time-limited rich phase to enable an efficient desulphurization. The rich mode will be periodically interrupted to prevent excessive soot accumulation in the particulate filter. It is also interrupted when reaching a high exhaust gas temperature threshold. Likewise, this process is interrupted at very low and very high engine loads.

The sulfur discharge is calculated in the ECM. It depends on the sulfur load, the lambda value and the exhaust gas temperature. The de-sulfurization process will be ended by reaching the lower sulfur load threshold of the maximum time period.

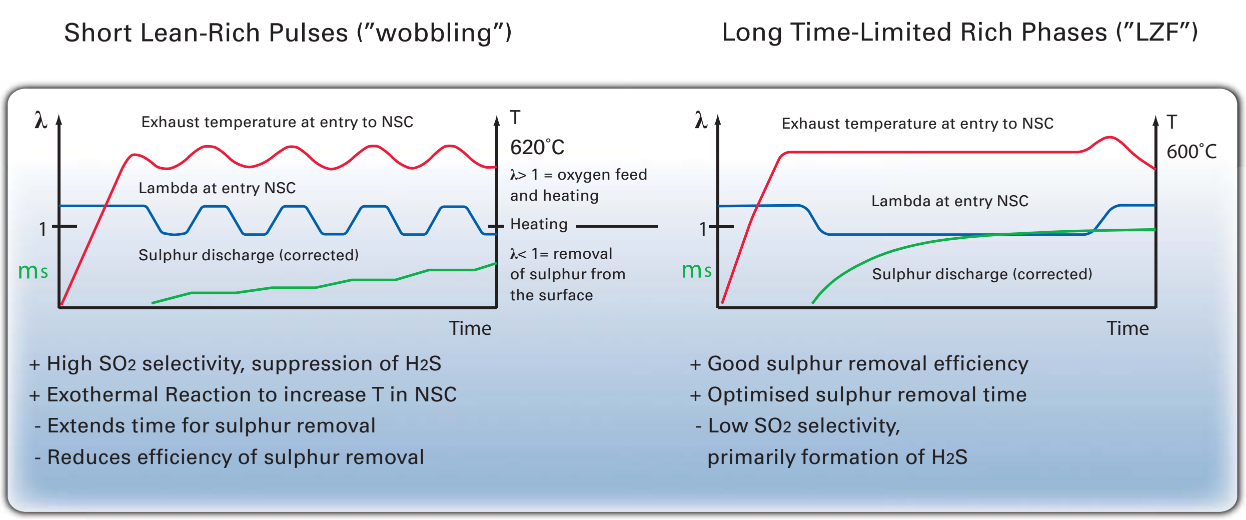


Figure 22

H_2S (Sulfur) Catalytic Converter

The H_2S catalytic converter, which was specially developed for this application, is placed downstream of the NO_x Reduction catalytic converter and converts the H_2S, which is created during the $DeSO_x$ regeneration mode, completely into SO_2.

The duration of the sulfur reduction process depends on the speed of sulfur reduction that is calculated for the NO_x Reduction catalytic converter. This in turn, depends on the lambda ratio and the temperature as it is calculated by the ECM.

The sulfur discharge is calculated in the ECM. It depends on the sulfur load, the lambda value and the exhaust temperature.

The de-sulfurization process is ended by reaching the sulfur load threshold or the maximum duration.

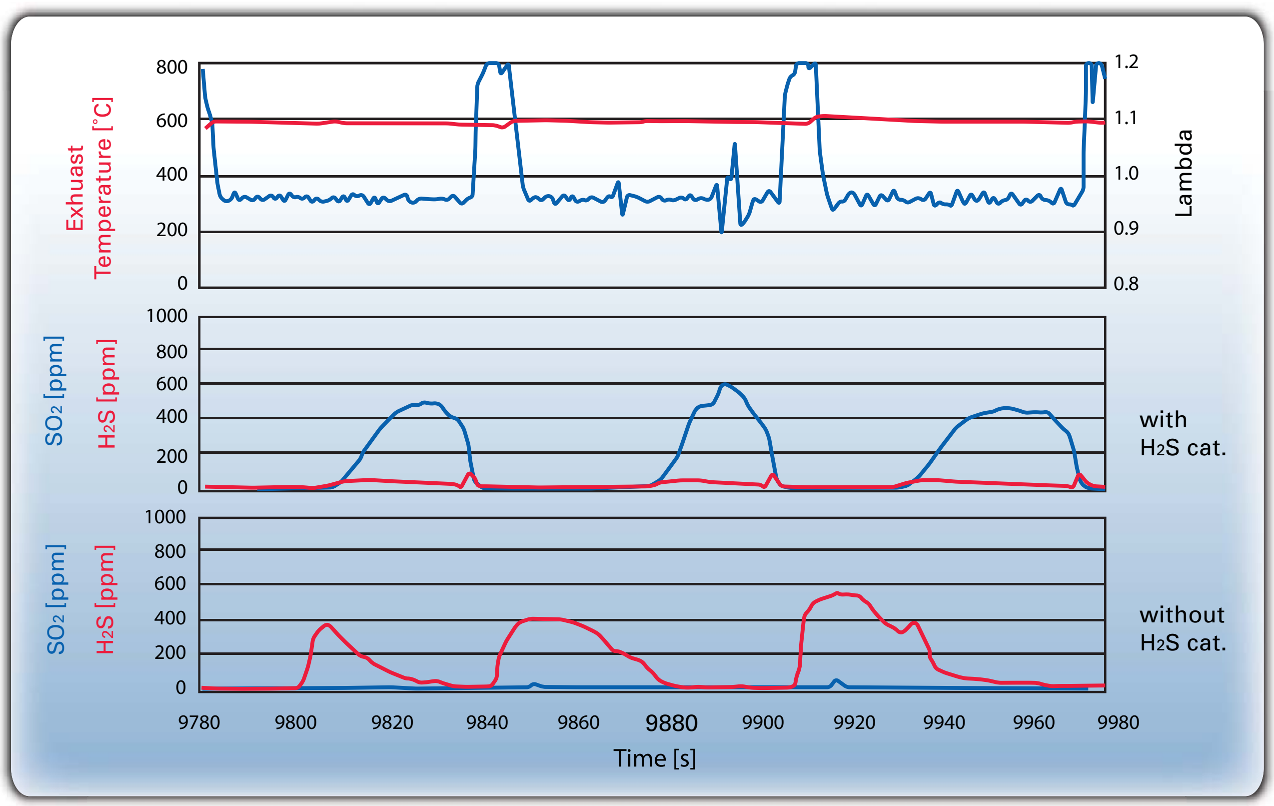
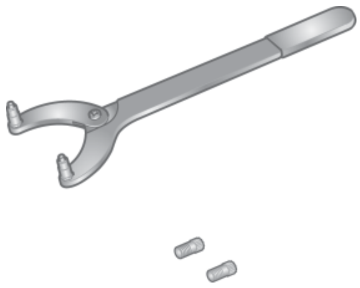
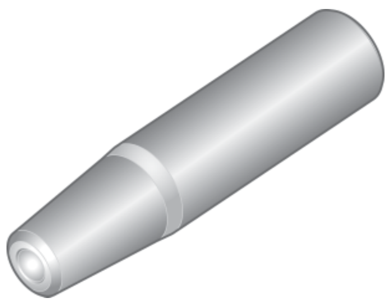
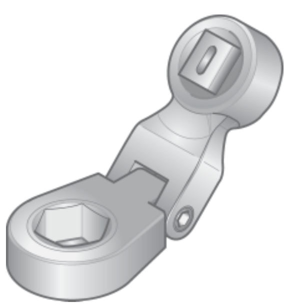
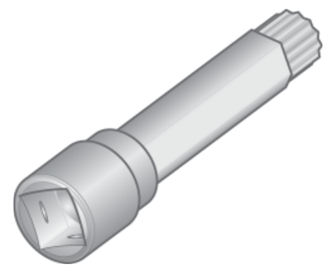
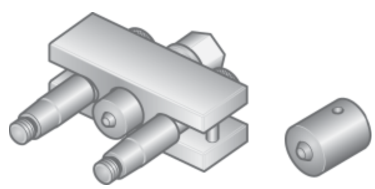
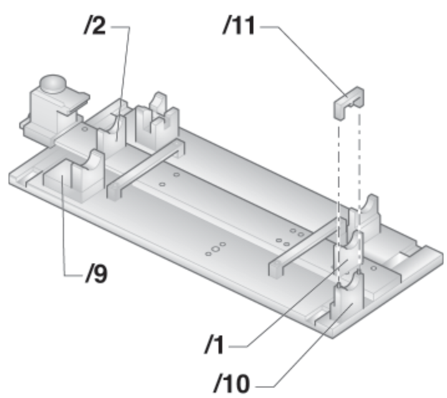
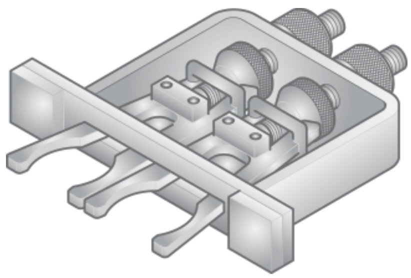
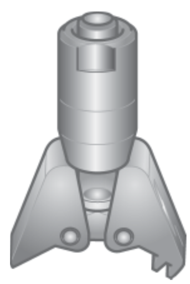
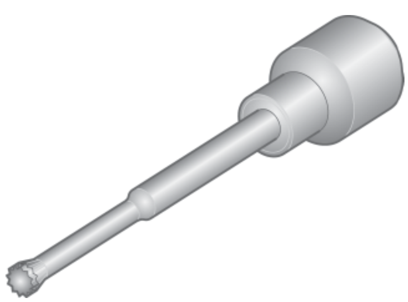


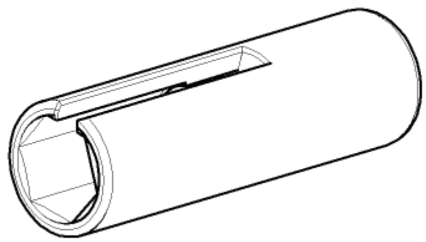
Figure 23

Special Tools

Designation	Tool	Use
T10172/9 Adapter	 S403_113	Adapter for work piece holder T10172
T10377 Assembly Sleeve	 S403_068	For assembly of the O-ring on the injection nozzle
T10384 Ratchet Ring Wrench	 S403_114	For removal and installation of the diesel particulate filter

Designation	Tool	Use
T10385 Insert Tool	 S403_112	For removal and installation of the exhaust gas return pipe
T40064/1 Pressure Piece	 S403_066	Pressure piece for extractor T40064 for removal of the toothed-belt wheel for the high-pressure pump
T40094 Camshaft Insert Tool T40094/1 Fixture T40094/2 Fixture T40094/9 Fixture T40094/10 Fixture T40094/11 Cover	 S403_063	For removal and installation of the camshaft

Designation	Tool	Use
T40095 Clamp	 S403_064	For removal and installation of the camshaft
T40096/1 Chuck	 S403_065	For securing the divided camshaft wheel during installation and removal of the camshaft
T40159 Insert Tool with Ball Head	 S403_067	For assembly work on the intake manifold

Designation	Tool	Use
T10401 Socket	 10723	For removal and installation of the EGR Cooler temperature sensor

Knowledge Assessment

An on-line Knowledge Assessment (exam) is available for this Self-Study Program.
The Knowledge Assessment may or may not be required for Certification.
You can find this Knowledge Assessment at:
www.accessaudi.com

From the accessaudi.com Homepage:
– Click on the “ACADEMY” Tab.
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– Click on the “CRC Certification” Link.
– Click on Course Catalog and select 920193 - 2.0 Liter TDI Common Rail Engine with Clean Diesel System

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Audi of America, LLC
2200 Ferdinand Porsche Drive
Herndon, VA 20171