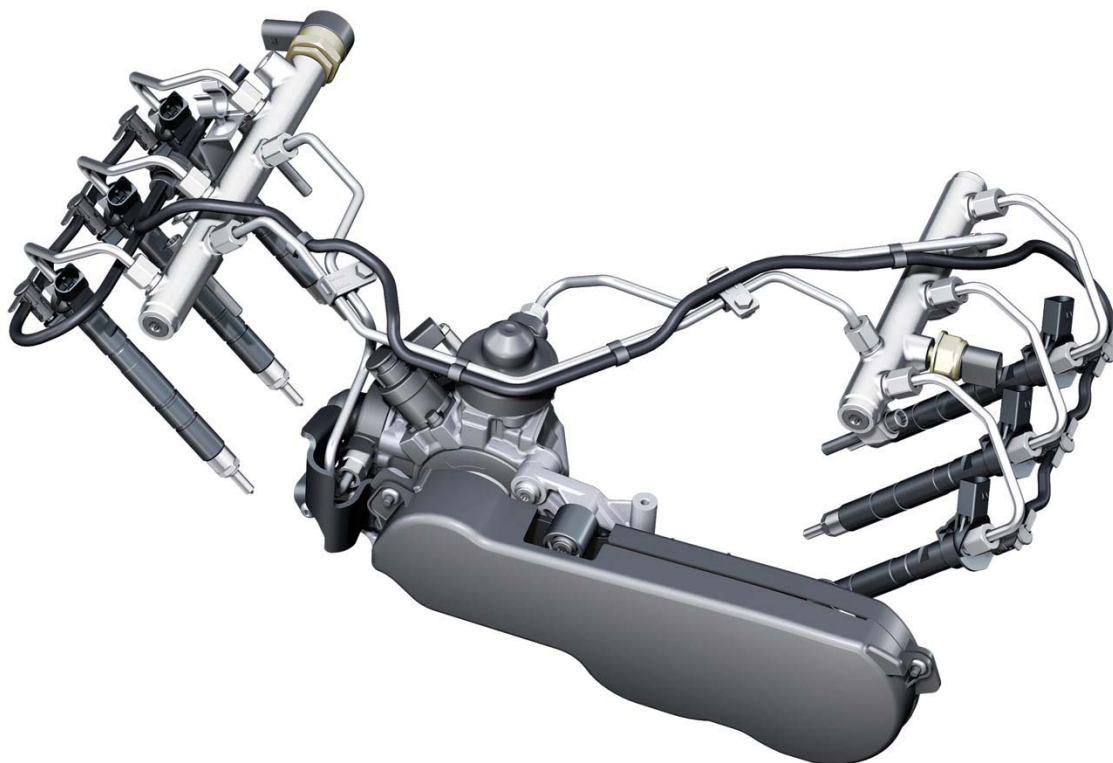




Self Study Program 840193

3.0-liter V6 TDI Clean Diesel Engine

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Volkswagen of America, Inc.
Volkswagen Academy
Printed in U.S.A.
Printed 04/2009

Course Number 840193

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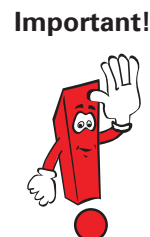
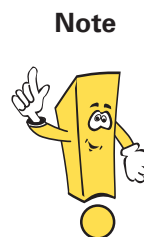
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This Self-Study Program provides information regarding the design and function of new models.
This Self-Study Program is not a Repair Manual.

This information will not be updated.
For maintenance and repair procedures, always refer to the latest electronic service information.



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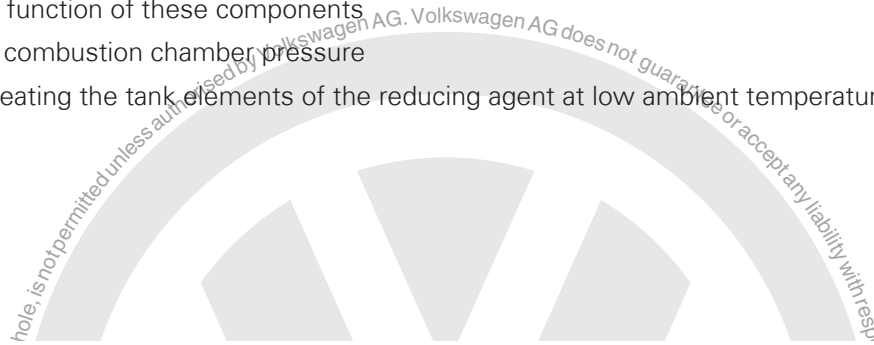


Introduction

This Self-Study Program (SSP) describes the design and function of the 3.0 liter Clean Diesel TDI Engine and exhaust gas aftertreatment system.

When you have completed this SSP, you will know the following:

- Design and function of the 3.0 liter TDI engine
- The limits established by the emission standards for diesel engines in various countries throughout the world
- Which components are used in the exhaust gas aftertreatment system
- The location and function of these components
- The influence of combustion chamber pressure
- The reason for heating the tank elements of the reducing agent at low ambient temperatures



428 -076

Introduction

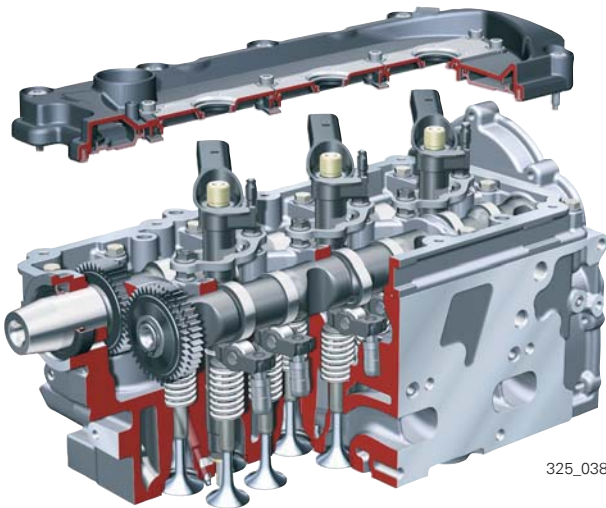
Volkswagen Introduces the Cleanest Diesel Technology World Wide into Standard Production

The systematic evolution of the TDI resulted with the development of the world's cleanest diesels. The core components of this current TDI combustion system development include:

- The fuel injection system
 - 29,000 psi (2000 bar) maximum injection pressure
- Comprehensively improved exhaust gas recirculation system
- Optimized turbocharging
- Integrated cylinder pressure control system

As a first step, improvements to these systems help to significantly reduce the engine's untreated emissions. In the second step, an active exhaust gas after-treatment system reduces the nitrogen oxides emissions to a minimum. Thus, by combining engine modifications with a new exhaust gas after-treatment system, the Clean Diesel system makes it possible to efficiently minimize emissions while at the same time reducing fuel consumption.

The objective is the further development of TDI technology to achieve emissions below the future EU6 limits, as well as below the most stringent Tier 2 BIN5/ULEV II limits, and to be ready for world-wide use.

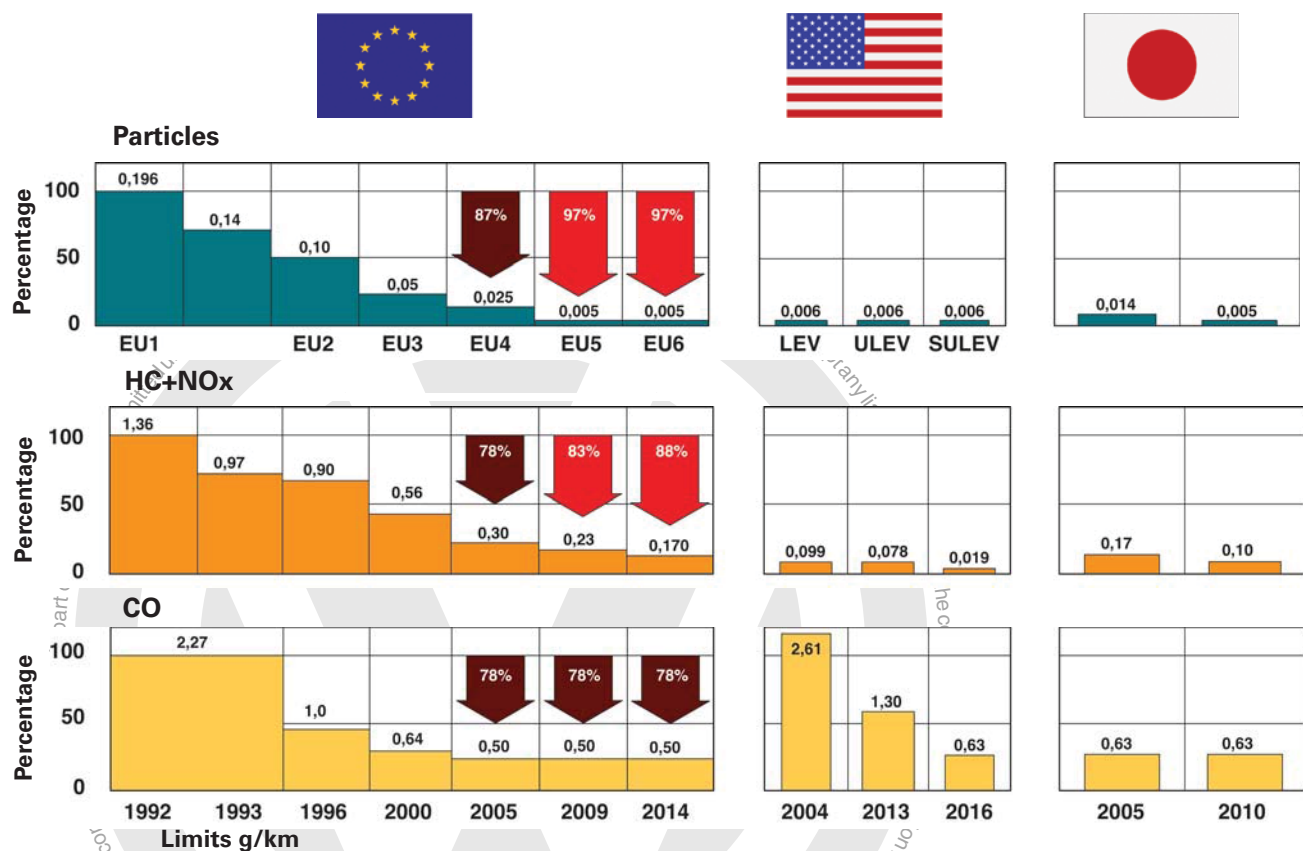


Emission Standards

The guidelines specify the following emission limits for gasoline and diesel engines:

- Diesel engine particles
- Unburned hydrocarbons (HC)
- Oxides of nitrogen* (NO_x)
- Carbon monoxide (CO)

Emission Limits



- LEV = Low Emission Vehicle
 ULEV = Ultra Low Emission Vehicle
 SULEV = Super Ultra Low Emission Vehicle
 BIN5 = Exhaust standard for California and other US states

The term "BIN" comes from the fact that the exhaust gases are collected and analyzed in bags during the exhaust tests. Depending on the specified emission standard, calculations go from BIN10 down to BIN5.

Engine Mechanical

Engine-Related Measures

The 3.0 liter V6-TDI was based on and developed from the EU5 (European) engine. It is a modular extension of an existing engine with the following changes:

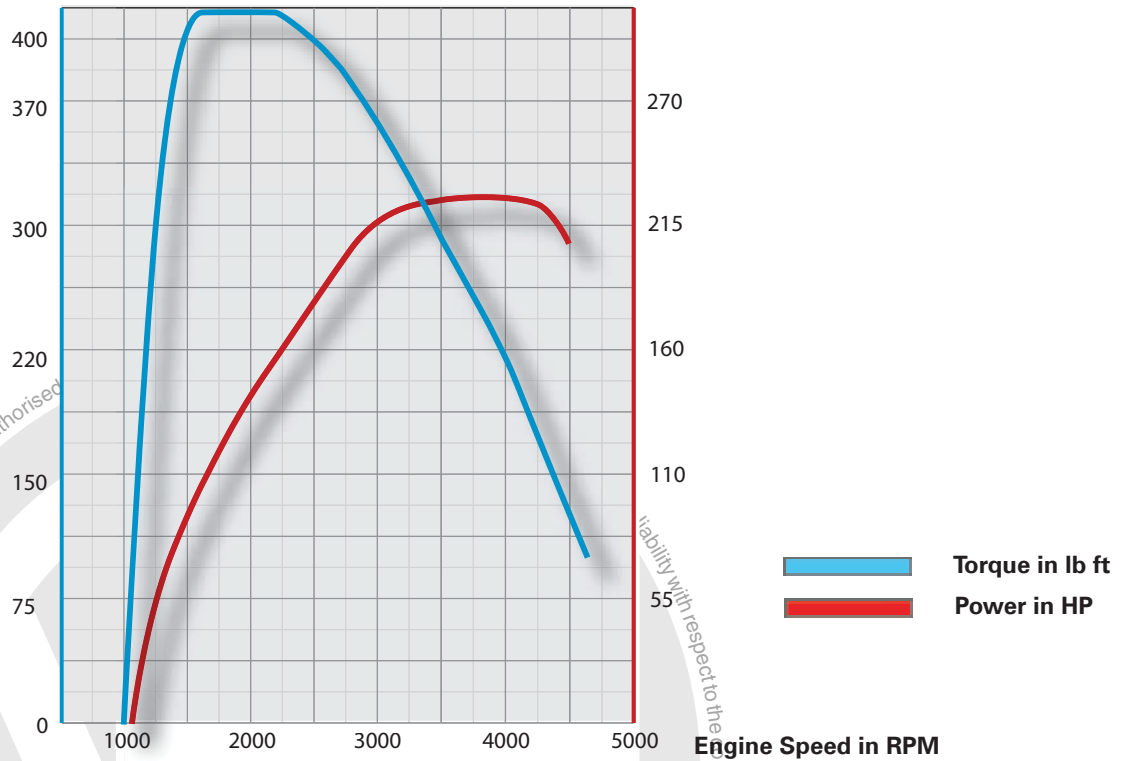
- An optimized two-stage chain drive that lowers the chain forces and thus reduces the frictional losses.
- An oil pump with flow rate-control and two pressure stages to reduce drive output required for lubrication

High exhaust gas recirculation cooling performance is achieved by using a new EGR system with aluminum module technology. This measure also reduces the pressure loss in the exhaust gas recirculation path, which has a positive effect on the charge cycle and on fuel consumption.

The injector system with a maximum injection pressure of 29,000 psi (2000 bar), optimized turbocharging, as well as a charge-air path with an integrated charge-air cooler bypass permits the optimized temperature management of the air path. The combustion chamber pressure sensor for cylinder pressure-based combustion is a new feature.



Power Curves

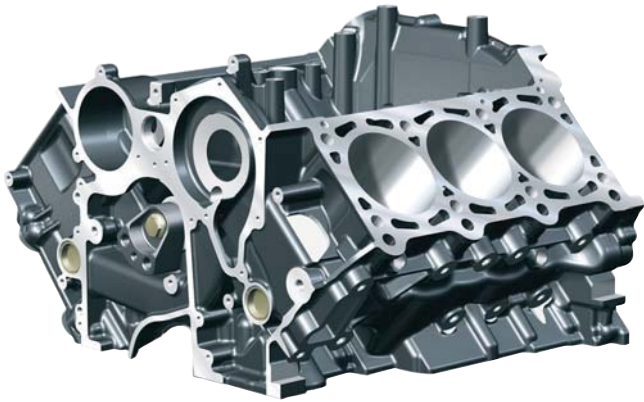


Specifications

Engine Code Letters	CATA
Design	6-cylinder V Engine
Displacement cu in (cm3)	181 (2967)
Output HP (kW)	225 (165) @ 3500 – 4000 rpm
Torque lb ft (Nm)	406 (550) @ 1750 – 2250 rpm
Valves per Cylinder	4
Bore in (mm)	3.27 (83)
Stroke in (mm)	3.6 (91.4)
Compression Ratio	16.8 : 1
Firing Order	1–4–3–6–2–5
Engine Management	Bosch EDC 17 CP 24
Fuel	Ultra-low sulfur diesel
Exhaust Standard	ULEV II/BIN5

Engine Mechanical

Mechanics

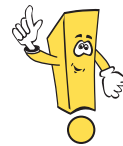


325_005

Crankcase

The engine block is made of GGV-40 (vermicular graphite cast iron) with a cylinder gap of 90 mm.

The cylinder bores undergo UV-photon honing for friction optimization and to minimize initial oil consumption.



Note:

UV photon honing involves using a laser beam to smooth the cylinder bores following honing.

The laser beam, which is applied at high force, melts down the remaining metal nibs in the one-billionth range. A smooth cylinder bore is achieved immediately in this way rather than through the break-in process.

Crankshaft

The crankshaft is forged from temper-hardened steel and is supported by 4 main bearings.

The upper end of the connecting rods are a trapezoidal design. The lower end of the connecting rods are cracked to ensure a precision fit and reduce movement of the bearing cap under load.

The upper and lower bearing shells are not identical in composition. The upper bearing shell is a two-component composite while the lower shell is a three-component composite bearing.



325_030



325_032

Pistons

Cast pistons with a centrally arranged piston trough are used. They are cooled by injected engine oil via a ring channel. The pistons do not have valve pockets.



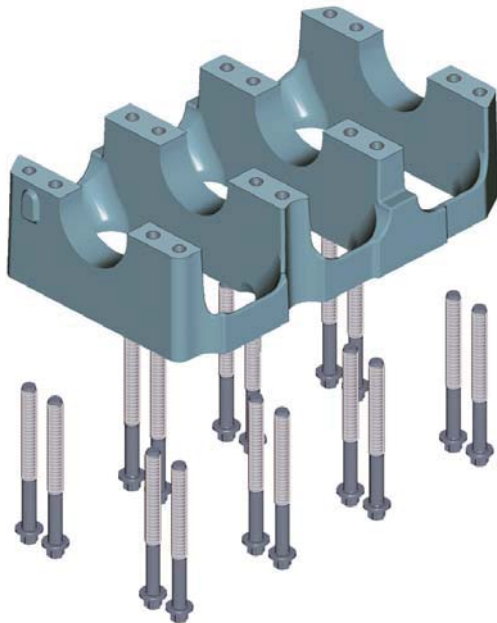
Balance Shaft

The balance shaft is located in the inner V of the engine block. The shaft goes through the engine and the balancing weights are secured at the ends.

Driven by chain drive D, the balancer shaft turns at crankshaft speed opposite the direction of engine rotation.



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325_010

Retaining Frame

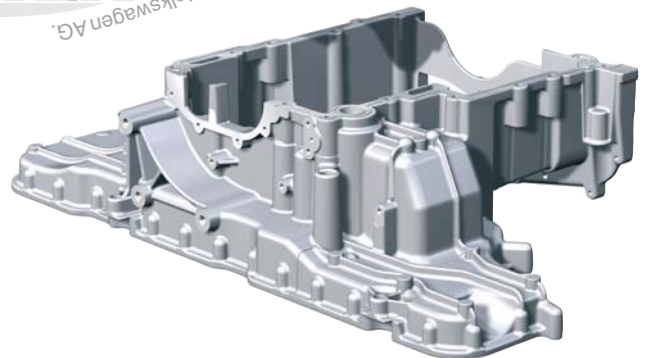
A retaining frame made of GGG 60 (spheroidal graphite cast iron) supports the crankshaft and serves to reinforce the crankcase.

Bolts/Main Bearing Assembly

Top Section of Oil Pan

The division between the crankcase and the oil pan is at the middle of the crankshaft.

The two-section oil pan is made up of an aluminum pressure-cast top section and a bottom section made of steel plate.



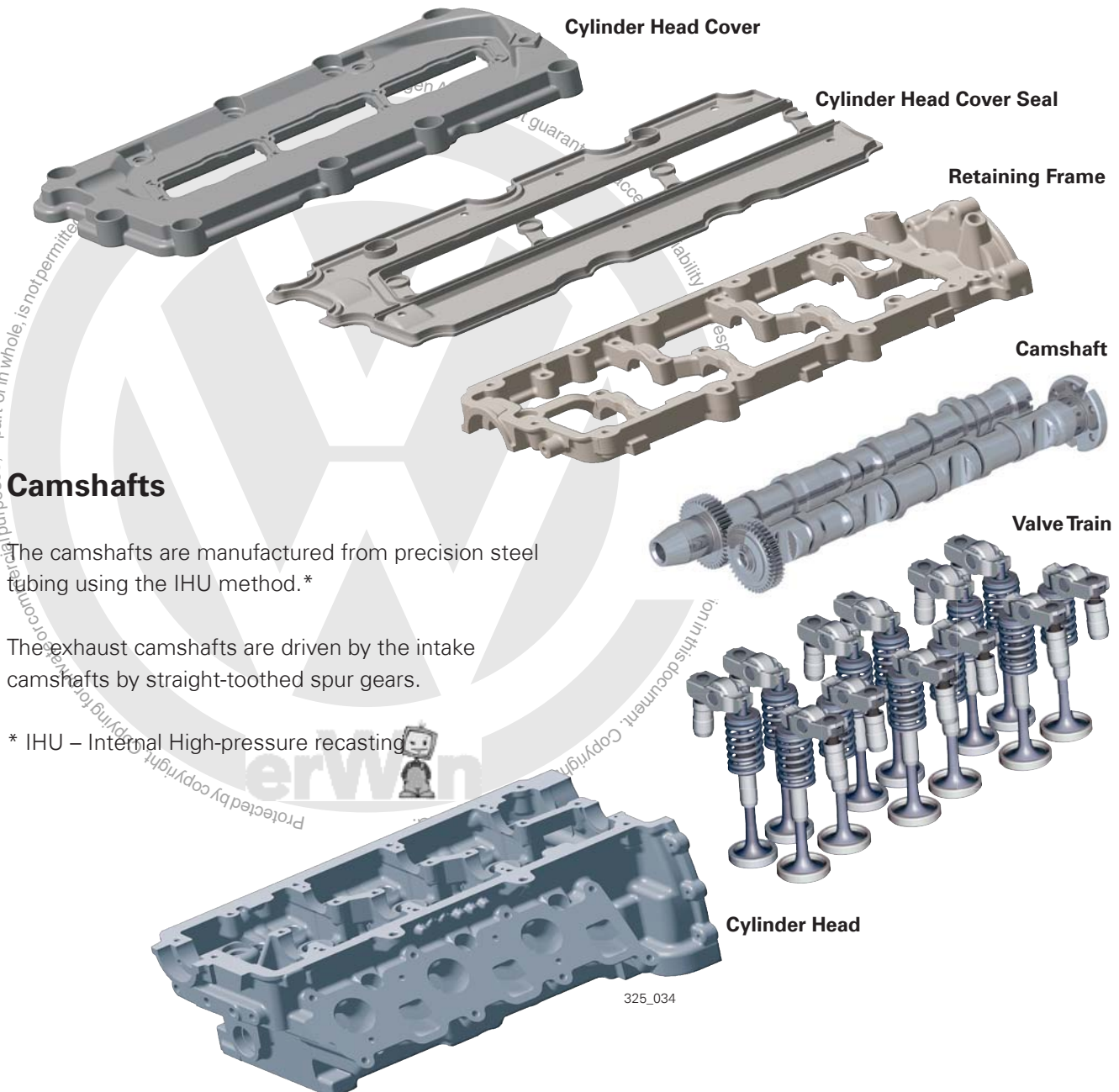
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Engine Mechanical

Cylinder Head

Four valves per cylinder ensure optimum charging of the combustion chamber. In the V6 TDI, the valves are actuated by roller-type cam followers with hydraulic valve clearance compensation.

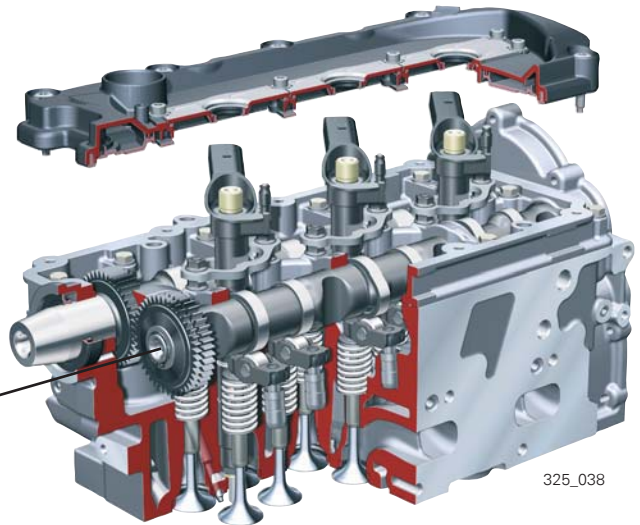
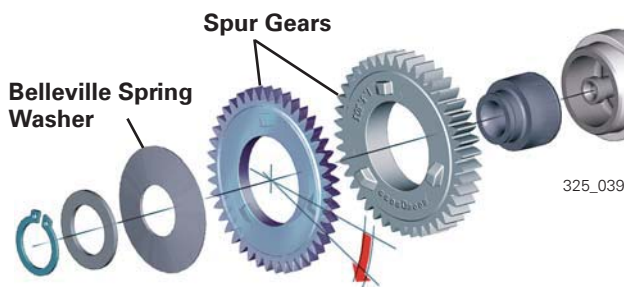
The acoustics of the unit benefits from the use of the roller-type cam followers. These, together with the tensioned and play-compensated camshaft drive gears, reduce the mechanical noise of the valve train.



Tooth Profile Clearance Compensation

The spur gear of the exhaust camshaft (driven spur gear) comes in two parts. The wide spur gear is held on the camshaft through spring actuation and has three ramps at the front.

The narrow spur gear has the corresponding grooves and is capable of both radial and axial movement. This is done to eliminate backlash between the gears.

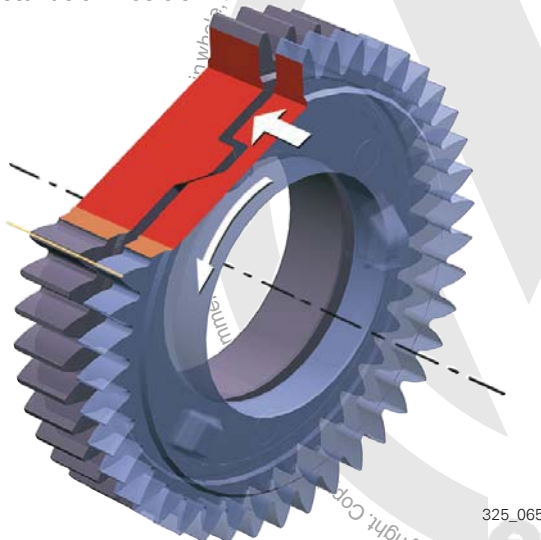


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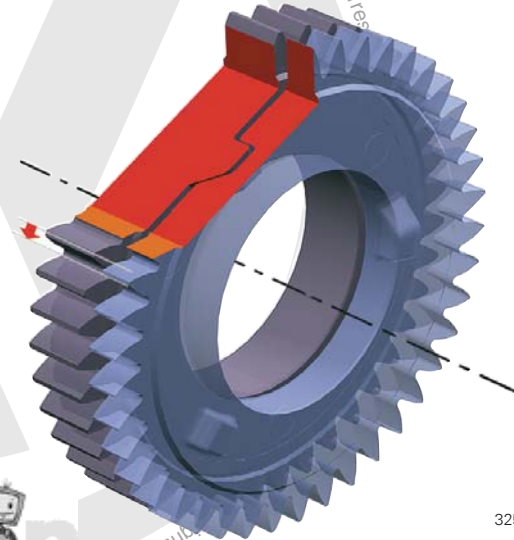
Please refer to the current service literature for assembly instructions.

A defined axial force is produced via a Belleville spring washer, where the axial movement is converted at the same time into a rotary movement with the help of the ramps. This offsets the teeth of the two driven spur gears, which in turn affects tooth clearance compensation.

Installation Position



Clearance Compensation



Engine Mechanical

Chain Drive Valve Train Assembly

The chain drive has been designed to minimize the loss to inner friction. Chain Drive B on the camshaft drive of Cylinder Bank 1 has been reshaped to increase the contact ratio of the camshaft gear that is now larger. At the same time, the gear ratio of the drive is modified making it possible to reduce the effort required for operation.

Chain Drive D is modified in the balance shaft area making it possible to enlarge the engagement of the chain on the gear wheel. Chain Drive D drives the balance shaft at crankshaft speed against the normal rotation of the engine.

New Camshaft Drive B

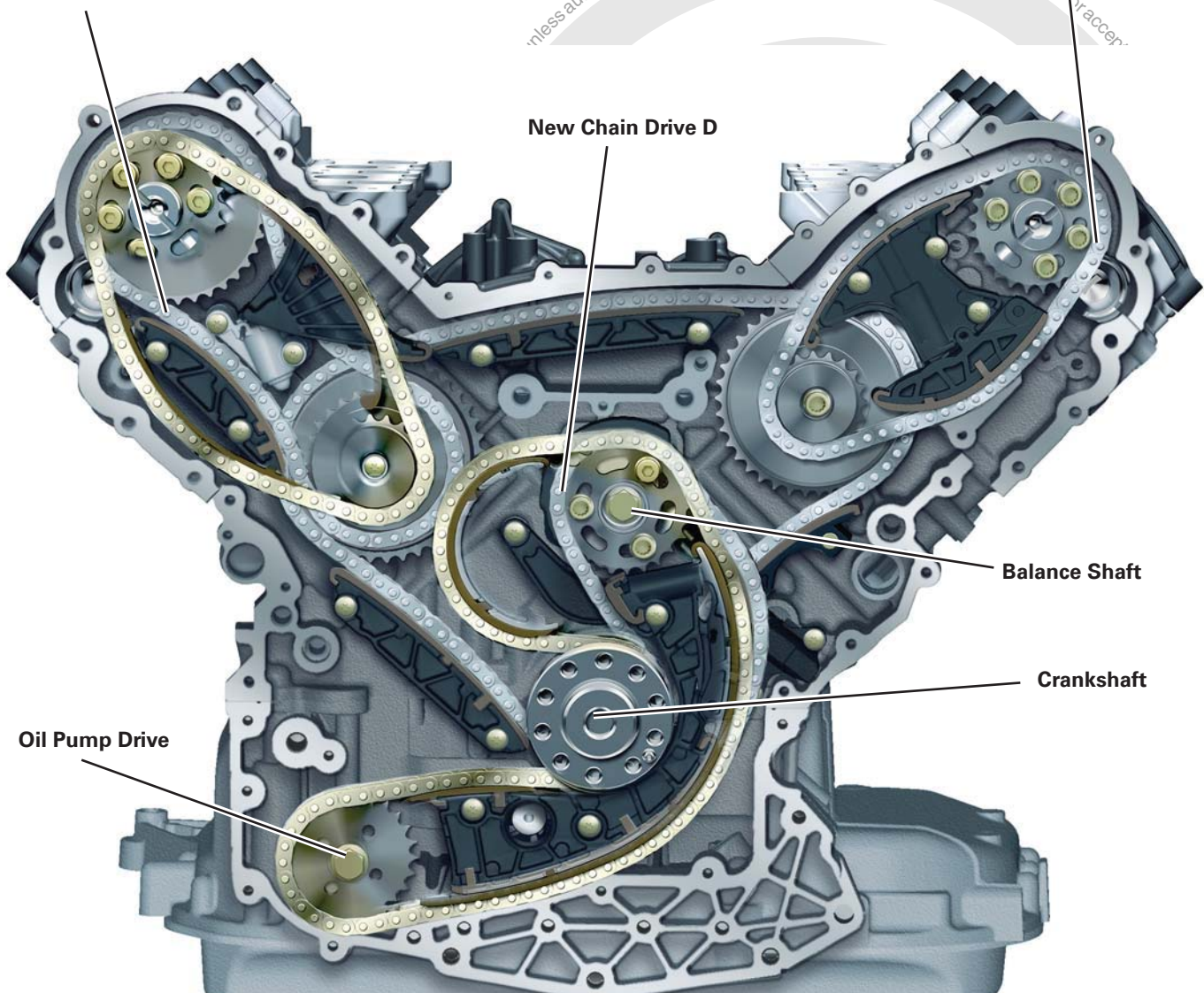
Camshaft Drive C

New Chain Drive D

Balance Shaft

Crankshaft

Oil Pump Drive



Gold Chain = Old Chain Drive from previous EU5 Engine
Silver Chain = Current Chain Drive

428_004

Flow Rate-Controlled Oil Pump

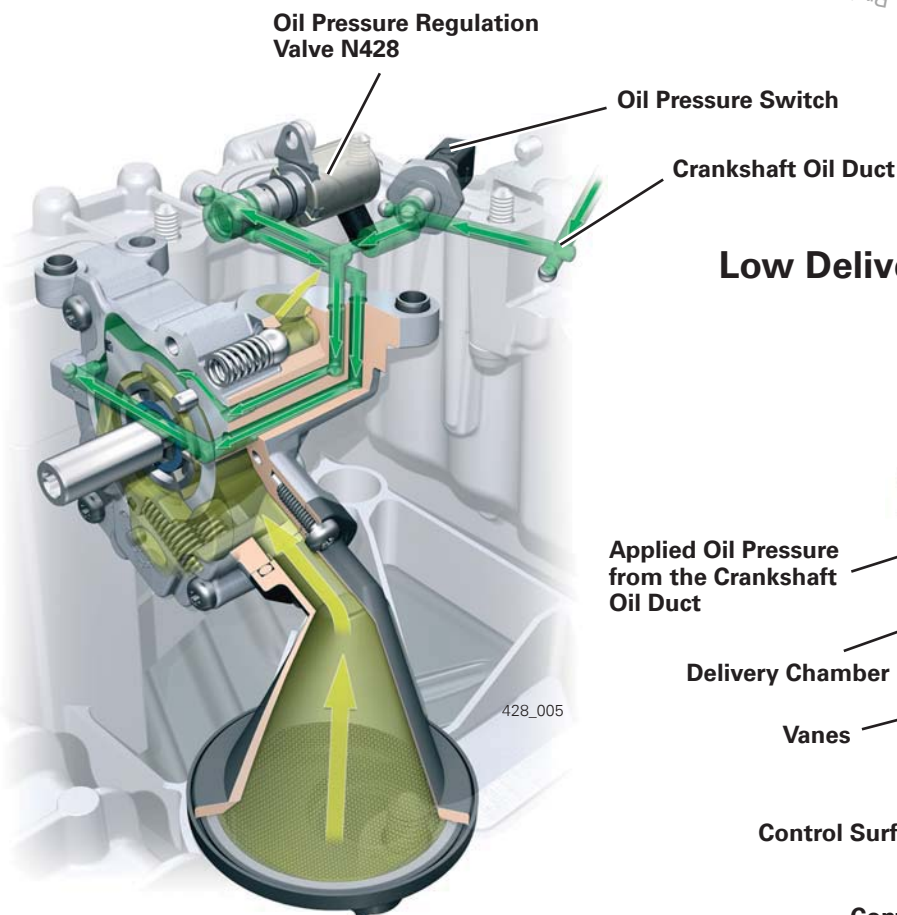
The use of a flow rate-control system reduces the required drive output of the oil pump.

A vane pump is used in the new 3.0 liter V6-TDI engine; its delivery characteristics can be changed via a pivoted adjustment ring. This adjustment ring can be loaded with oil pressure via Control Surfaces 1 and 2 and swiveled against the force of the control spring. The ECM connects ground to the energized Oil Pressure Regulation Valve N428 in the lower RPM range, and the solenoid valve opens the oil duct leading to the second control surface of the adjustment ring.

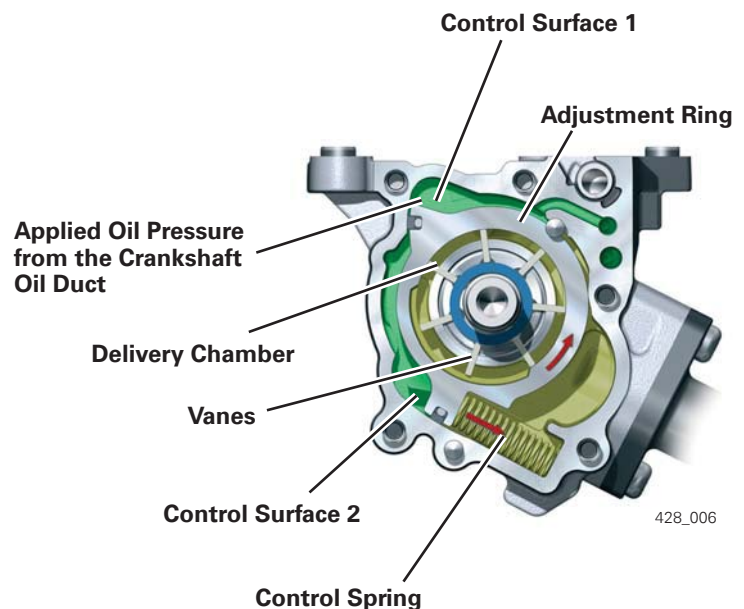
Both oil flows are now acting with identical pressure upon both control surfaces.

The forces resulting from this are higher than those of the control spring and they cause the adjustment ring to swivel counterclockwise.

The adjustment ring turns into the center of the vane pump and reduces the supply space between the vanes. The lower pressure level is switched depending on the engine load, engine speed, oil temperature, and other operating parameters, reducing the drive output of the oil pump.



Low Delivery Rate



Engine Mechanical

High Delivery Rate

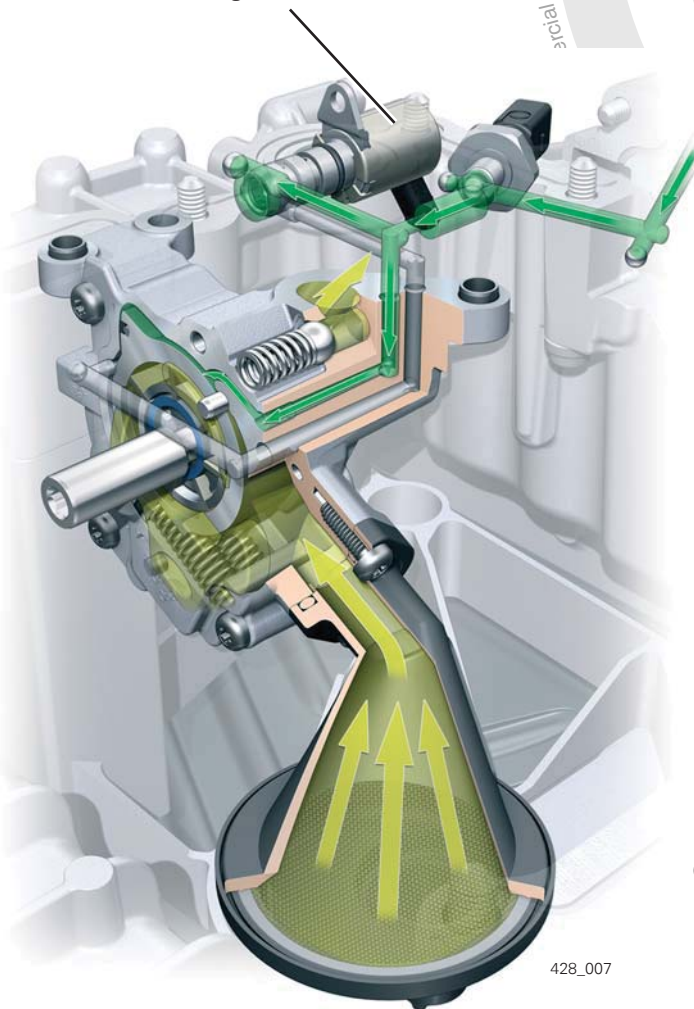
Starting at an engine speed of 2500 RPM or a torque of 300 Nm (wide open throttle acceleration), Engine Control Module J623 disconnects Oil Pressure Regulation Valve N428 from the ground connection thus closing the oil duct to Control Surface 2.

The applied oil pressure is now acting on Control Surface 1 only and acts with a lower pressure against the force of the control spring.

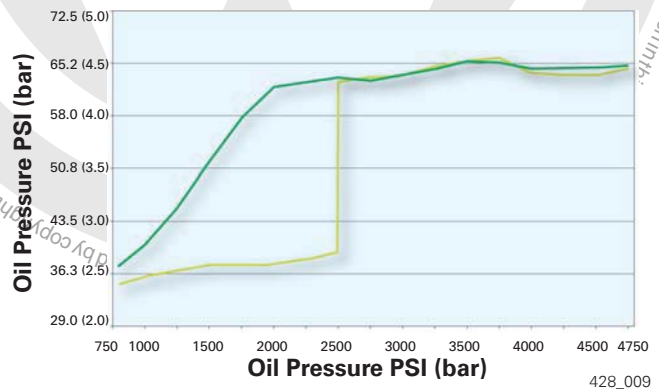
The control spring swivels the adjustment ring clockwise around the mounting flange. The adjustment ring now swivels out of the center position and increases the delivery space between the individual vanes.

More oil is delivered by increasing the spaces between the vanes. A resistance builds up against the higher oil volume flow due to the oil bores and the bearing clearance of the crankshaft, which lets the oil pressure increase. This makes it possible to implement a flow rate controlled oil pump with two pressure stages.

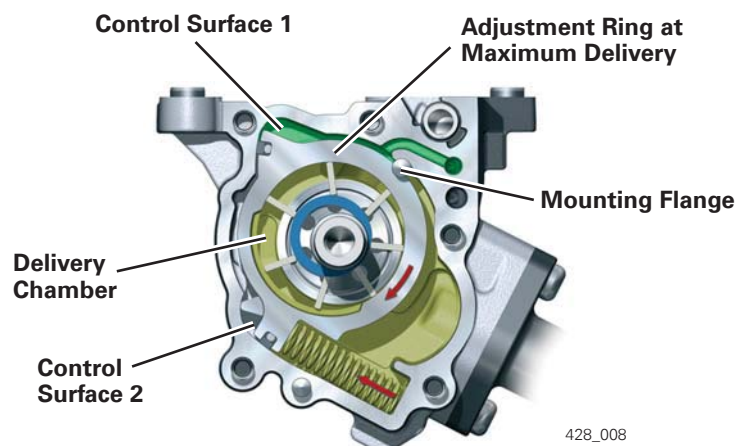
De-energized Solenoid



Oil Pressure Curve @ 212°F (100°C)



— Solenoid Valve Closed
— Solenoid Valve Open (current applied)

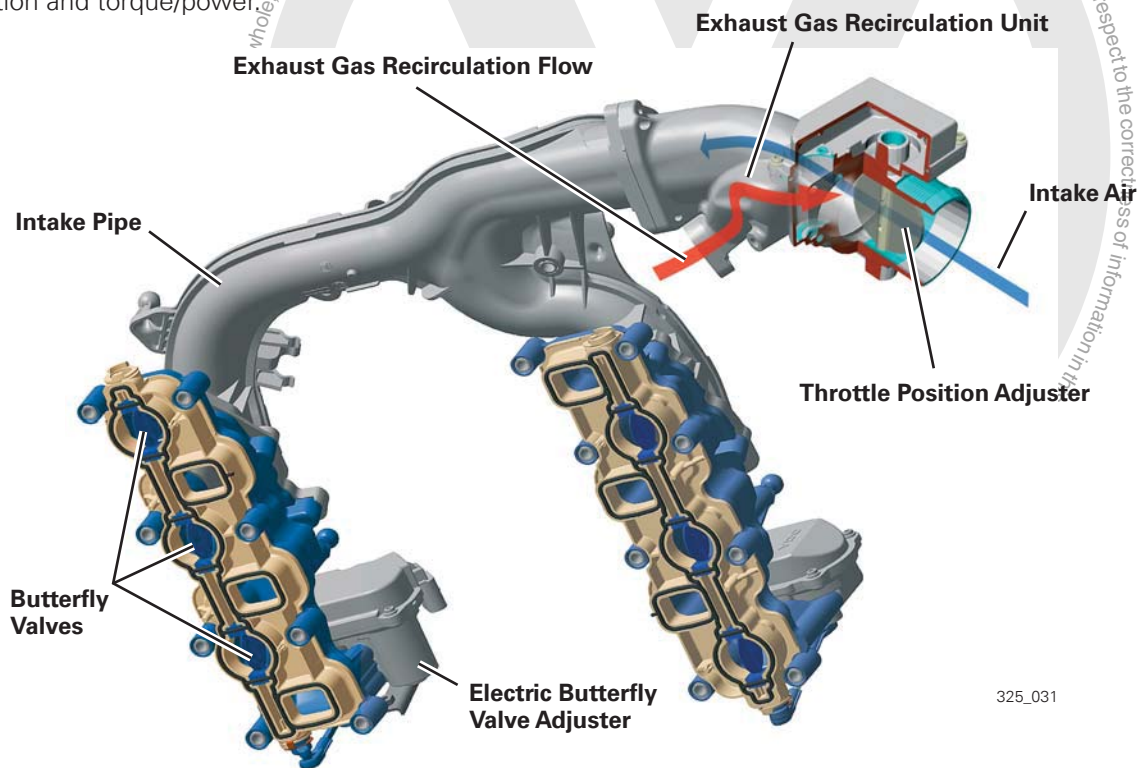


Air Intake

Intake Manifold with Butterfly Valves

Butterfly valves that can be regulated smoothly are integrated into the intake tract. These can be used to adapt the air movement according to the current engine speed and load with regard to emissions, consumption and torque/power.

The butterfly valve adjuster with potentiometer reports the current position of the butterfly valve back to the ECM.



Exhaust Gas Recirculation:

This involves high-pressure exhaust gas recirculation.

The entry of exhaust gasses into the intake tract counters the intake air flow, resulting in a constant mixture of fresh air and exhaust gas.



Note:

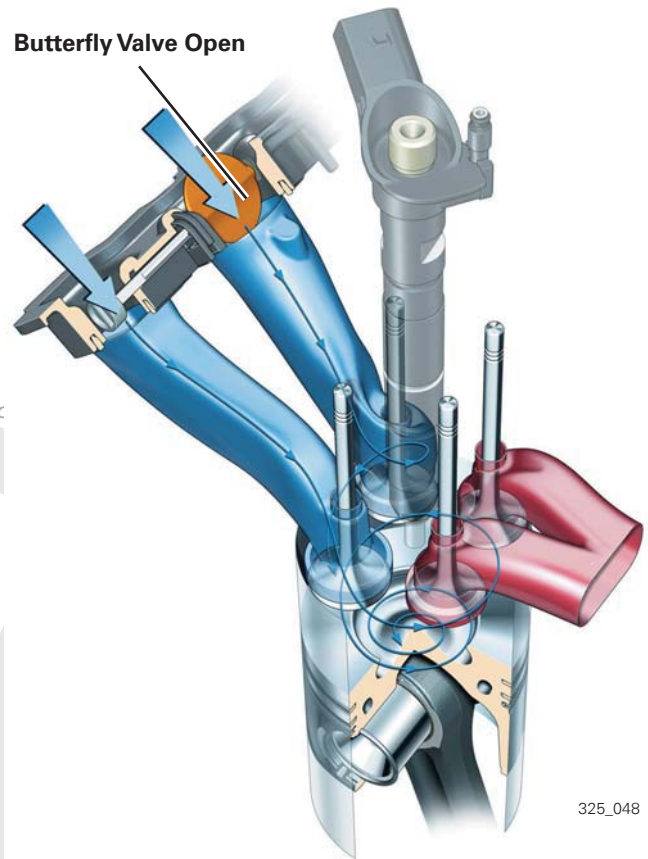
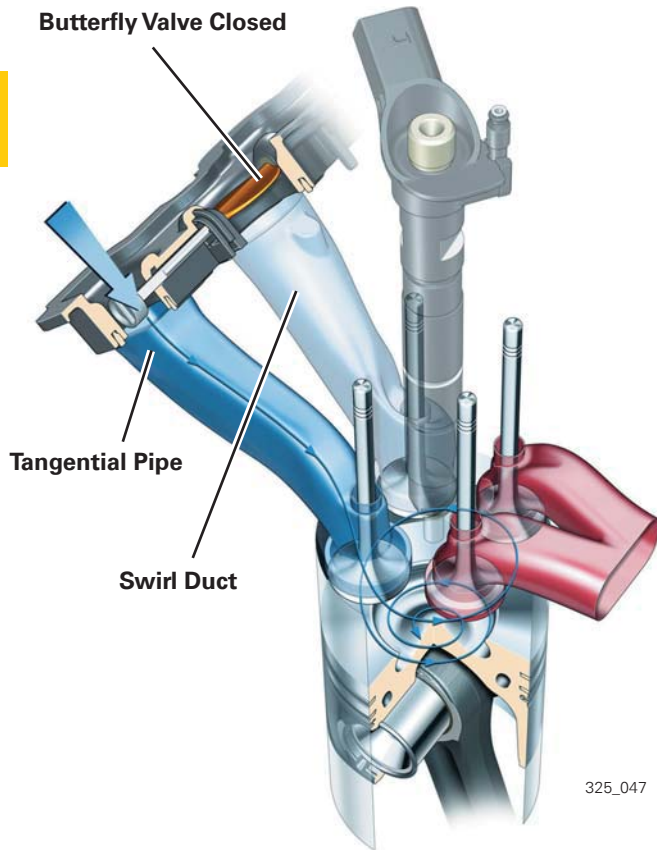
The throttle and butterfly valves are opened in coasting mode to check the air flow sensor and balance the oxygen sensor.

Throttle Position Adjuster:

The throttle is closed in order to stop the engine. This reduces the compression effect and achieves softer engine coasting.

In addition, the exhaust gas recirculation rate can be increased through targeted, map-controlled closure.

Engine Mechanical



To optimize the torque and combustion, a closed swirl duct increases the swirl at low loads.

When the engine is started, the butterfly valves are open and are only closed again at idle speed (duty cycle: approximately 80%).

Continuous opening is performed from idle speed to approximately 2,750 RPM (duty cycle: approximately 20%).

To optimize performance and combustion, an open swirl duct allows a high level of cylinder charging at high loads.

The butterfly valves are always completely open at a speed of approximately 2,750 RPM or higher.

The butterfly valve is also open both at idle speed and during coasting.



Note:

A replacement adjuster must be adapted with the Scan Tool to synchronize it with the butterfly valves.

Exhaust Gas Recirculation (EGR)

The EGR system combines the EGR coolers, EGR valve, and EGR bypass in a single component.

Due to the higher exhaust temperatures in the upper partial load range, increased EGR cooling performance becomes necessary.

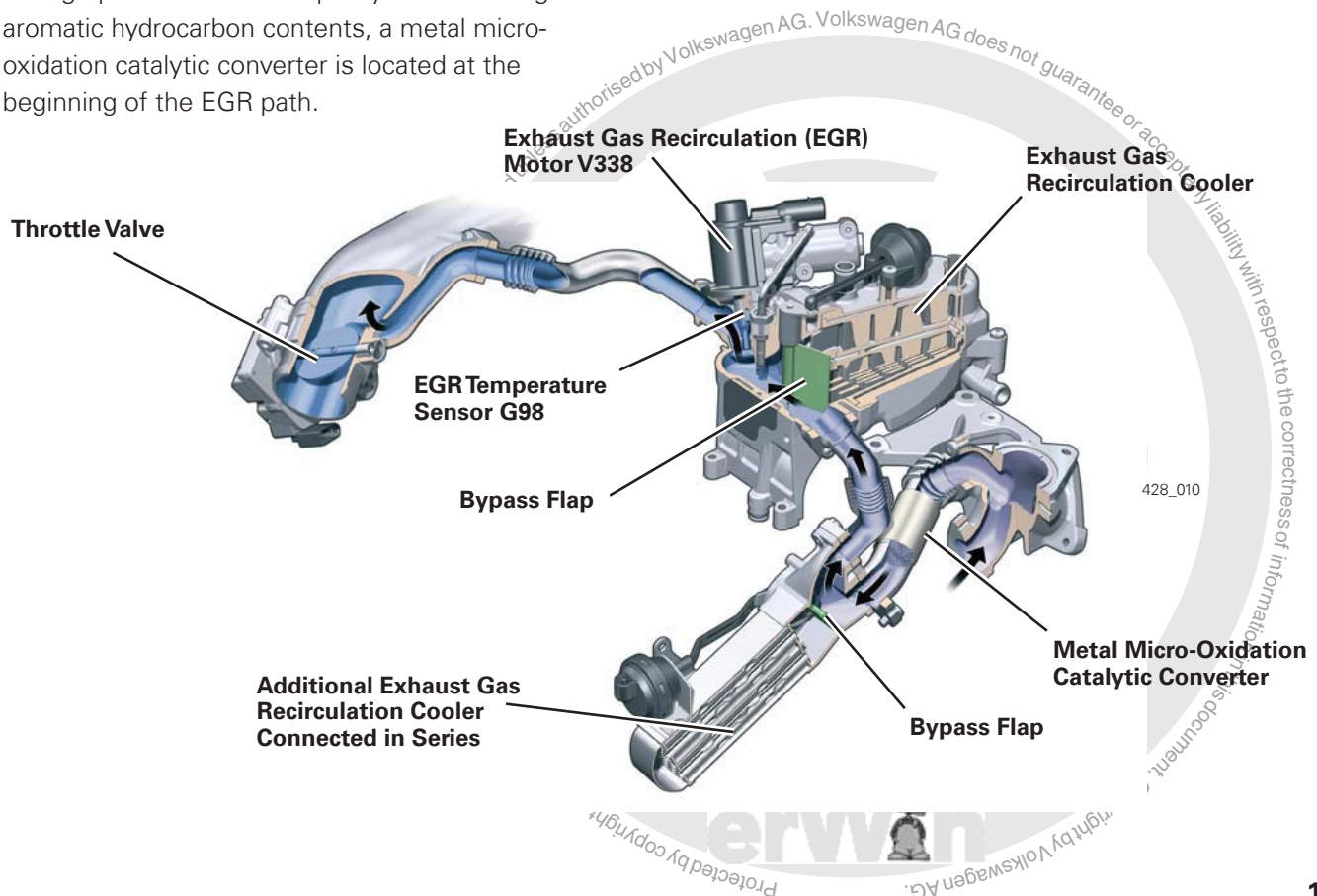
The exhaust gas recirculation path consists of the following: micro-catalytic converter, additional cooler, and cooler for exhaust gas recirculation temperature sensor, and electric water-cooled exhaust gas recirculation valve.

A separate cooling channel is integrated into the housing on the valve side to cool down the bypass flap and the EGR valve.

To prevent deposits in the EGR path, especially during operation with low-quality fuels with high aromatic hydrocarbon contents, a metal micro-oxidation catalytic converter is located at the beginning of the EGR path.

To obtain the lowest possible temperatures for the recirculated exhaust, the exhaust gas recirculation cooler is connected to a separate low temperature coolant circuit (described on the following pages). The coolant is extracted directly at the radiator outlet and delivered to the exhaust gas recirculation cooler by an electric pump. The additional cooler is connected to the engine cooling circuit and makes it possible to nearly double the cooling performance.

Both the EGR Cooler and the additional EGR Cooler connected in series have bypass flaps. This allows the demand controlled adjustment of the EGR cooling performance at specific load points. To reduce the carbon monoxide and hydrocarbon emissions, the flaps are set to bypass position (the exhaust gas does not go through either cooler) during the engine warm-up phase.



Engine Mechanical

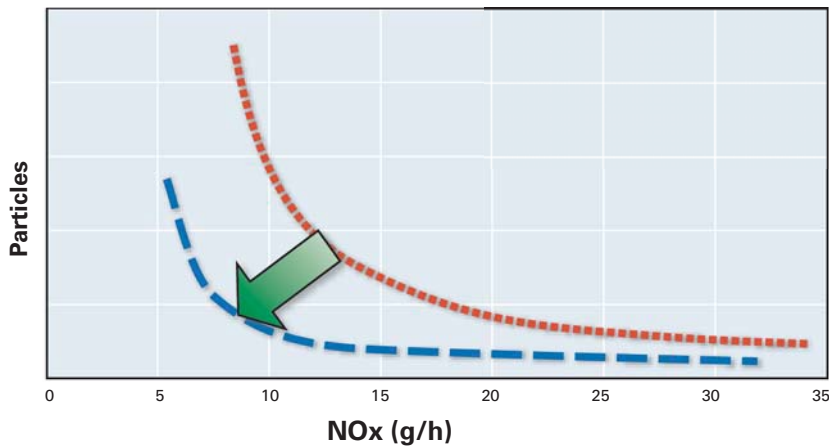
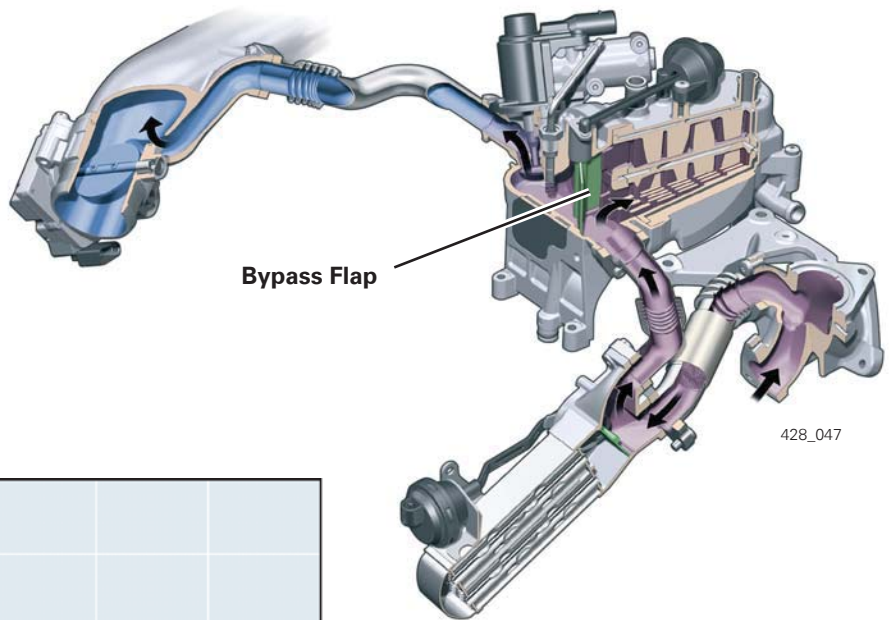
Switchable Exhaust Gas Recirculation Actuator

The cooling performance of the exhaust gas recirculation cooler leads to a clear reduction in particle and nitrogen emissions. The diagrams below and on the next page show the efficiency of the exhaust recirculation system in two selected partial load points.

Flow Through Exhaust Gas Recirculation Cooler – Additional EGR Cooler Bypassed

When the engine is in partial load operation, the bypass of the additional EGR cooler is open (exhaust gas does not flow through it). The bypass of the EGR cooler is closed and exhaust gas is directed through the cooler.

The bypass flap for the EGR cooler is opened at approximately 1750 RPM. It is controlled by the ECM, based on mapped values.

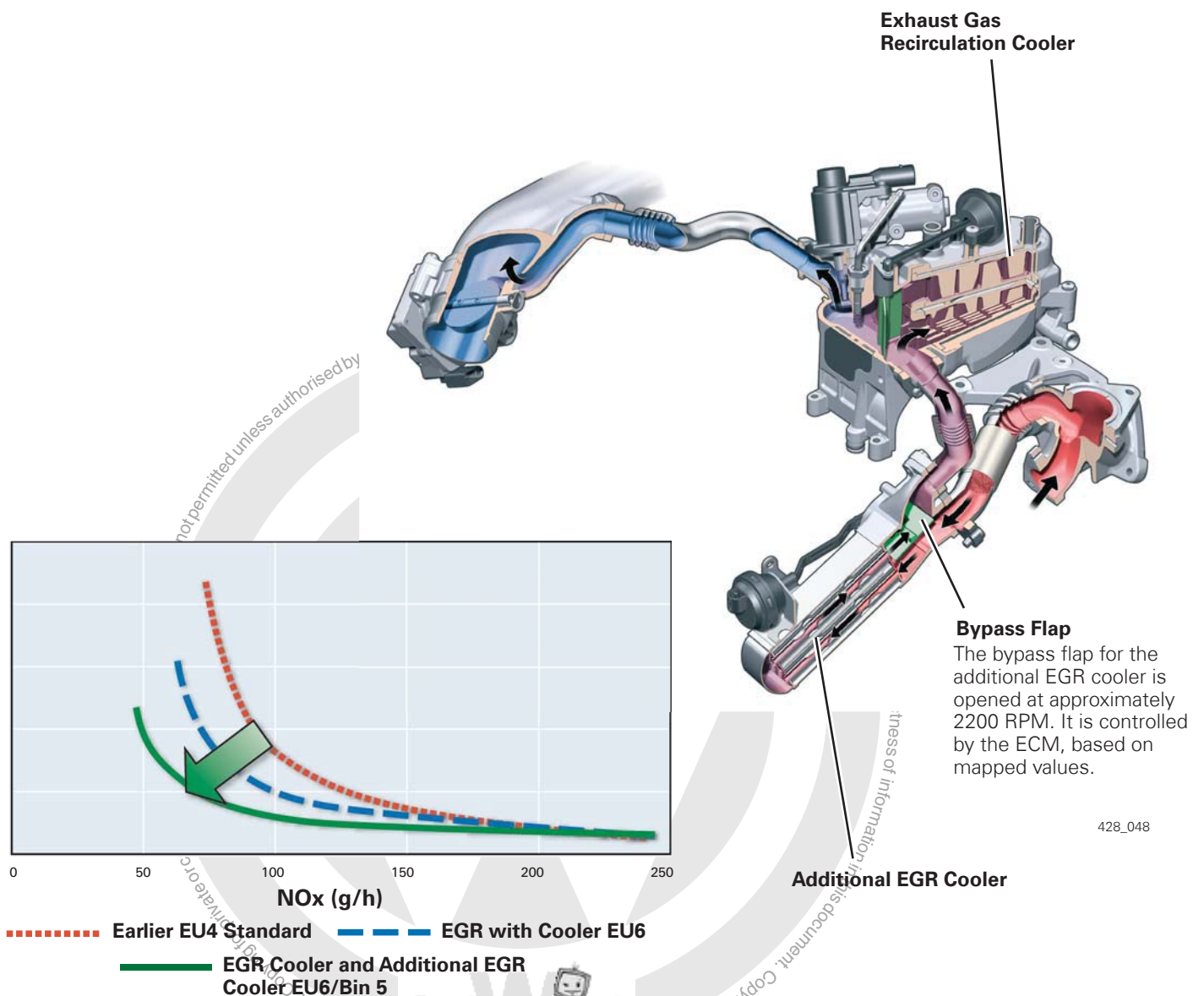


..... Earlier EU4 Standard

--- EGR with Cooler EU6/Bin 5

Flow Through Additional EGR Cooler – Flow Through EGR Cooler

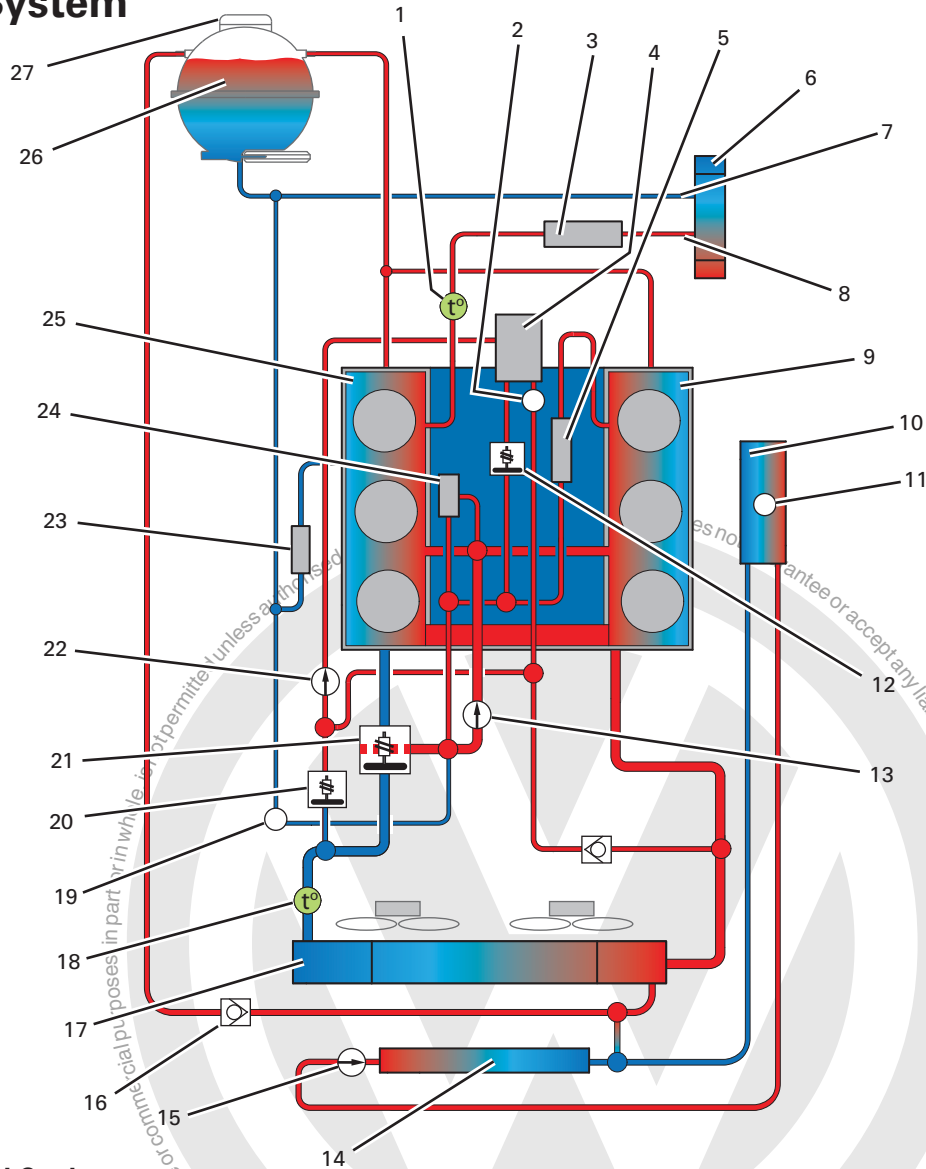
The additional cooler is opened with increasing load and resulting higher exhaust temperatures; thus both EGR coolers are in cooling mode. This allows an increase of the EGR rate. The exhaust gas temperatures are lower and nitrogen oxide emissions are further reduced.



428_048

Engine Mechanical

Cooling System



Legend

— Heated Coolant

— Cooled Coolant

1. Engine Coolant Temperature (ECT) Sensor G62
2. Bleeder Screw
3. Additional Exhaust Gas Recirculation Cooler
4. Exhaust Gas Recirculation Cooler
5. Change-Over Flap For Exhaust Gas Recirculation
6. Heater Core
7. From The Heater Core
8. To The Heater Core
9. Cylinder Head Bank 2 (Left)
10. Fuel Cooler (Fuel/Water)
11. Bleeder Screw
12. Coolant Regulator For Exhaust Gas Recirculation
13. Water Pump
14. Cooler For Fuel Cooling (Water/Air)

15. Fuel Cooler Pump V166
16. Check Valve
17. Radiator
18. Engine Coolant Temperature (ECT) Sensor (on Radiator) G83
19. Bleeder Screw
20. Coolant Regulator For Exhaust Gas Recirculation
21. Coolant Thermostat
22. Exhaust Gas Recirculation (EGR) Cooler Pump V400
23. Alternator
24. Engine Oil Cooler
25. Cylinder Head Bank 1 (right)
26. Coolant Expansion Tank
27. Cap For Coolant Expansion Tank

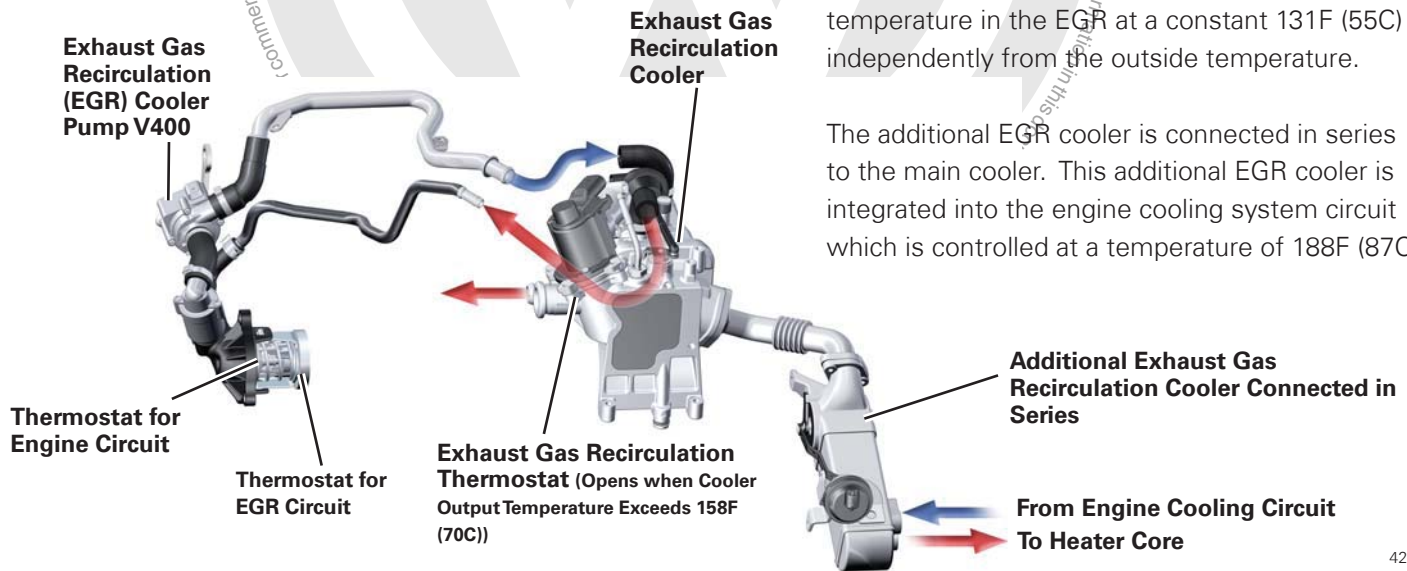
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Exhaust Gas Recirculation Cooling

The exhaust gas recirculation radiator has its own low-temperature cycle in the cooling system.

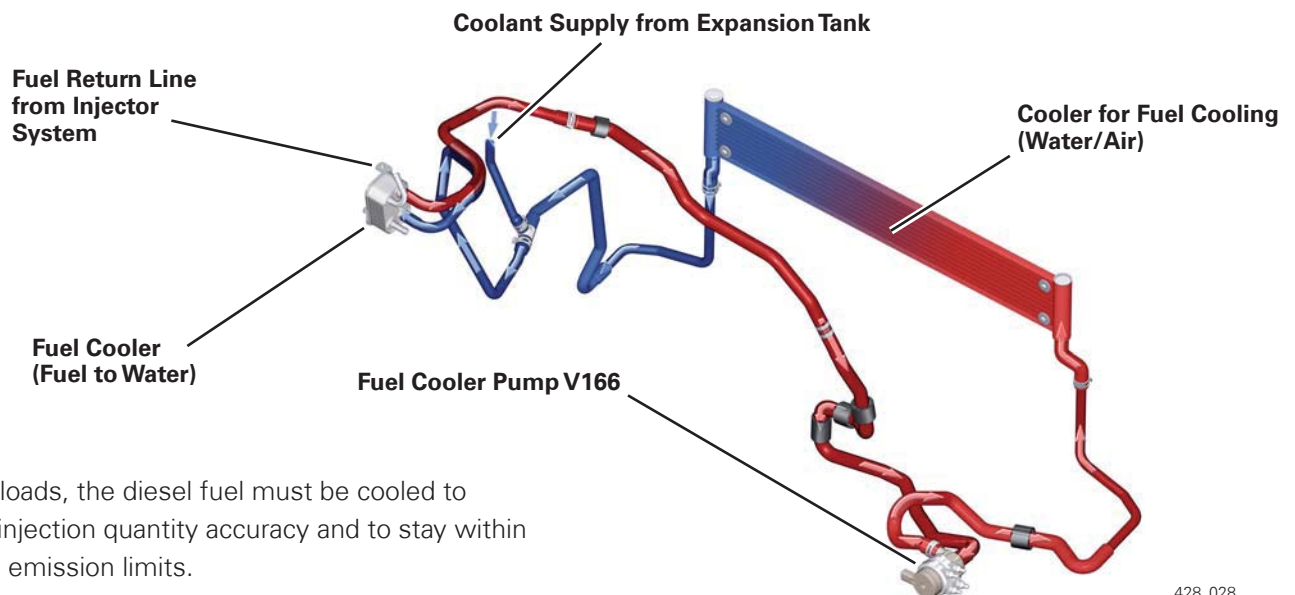
Exhaust Gas Recirculation Cooler Pump V400 activates after engine start and supplies the EGR with cold water directly from the radiator. The coolant regulator for the EGR controls the temperature in the EGR at a constant 131F (55C) independently from the outside temperature.

The additional EGR cooler is connected in series to the main cooler. This additional EGR cooler is integrated into the engine cooling system circuit which is controlled at a temperature of 188F (87C).



428_062

Fuel Cooling



428_028

At high loads, the diesel fuel must be cooled to ensure injection quantity accuracy and to stay within exhaust emission limits.

The fuel pump cooling runs at engine start.

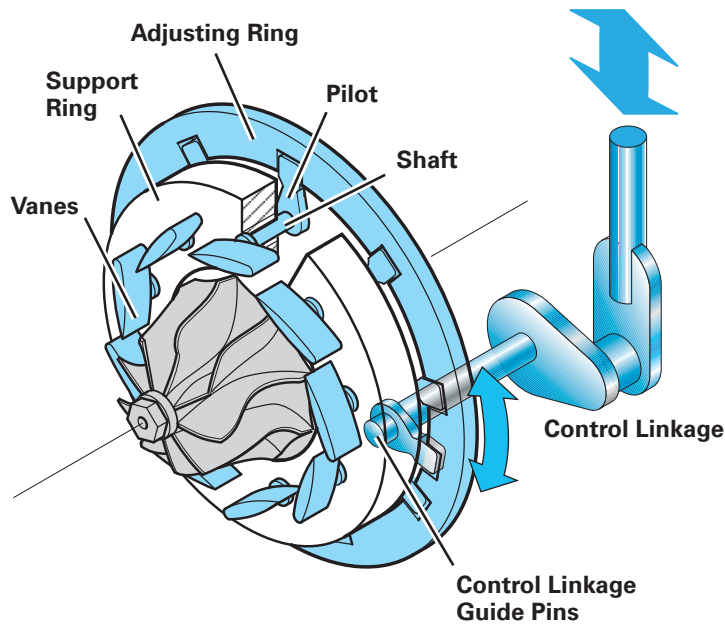
Engine Mechanical

Variable Vane Turbocharger

The 3.0L V6 TDI in the Touareg uses the well-known variable-vane turbocharger.

Advantages

- High engine output is available at the bottom end of the speed range since the exhaust gas flow is regulated by the adjustable vanes.
- The lower exhaust gas back-pressure in the turbine reduces fuel consumption at the top end of the speed range and also improves bottom-end power output.
- Exhaust gas emissions decrease because an optimum charge pressure and improved combustion is attained across the full speed range.



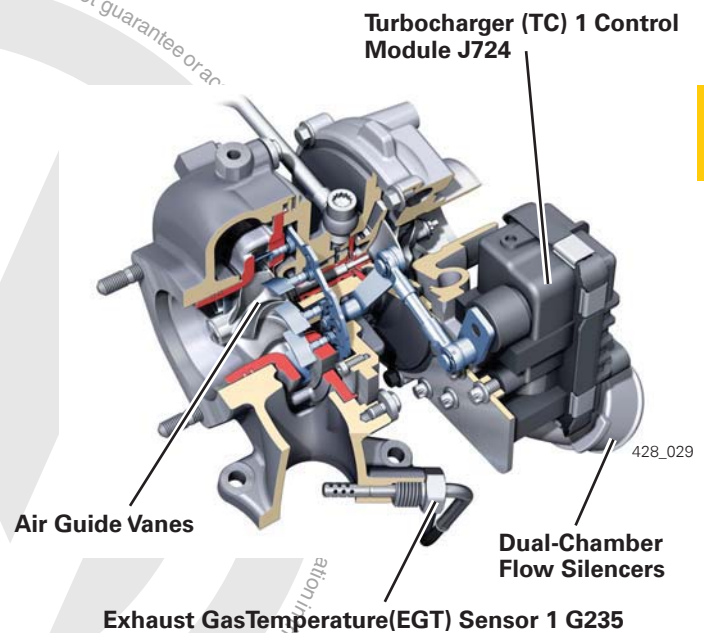
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Turbocharging with Charge-air Path

The small size of the compressor and turbine allows a high level of response with only a slightly reduced maximum output.

Optimized mounting of the turbine shaft reduces frictional losses with cold engine oil during the warm up phase and causes, especially at high elevations and at cold ambient conditions, a more spontaneous response behavior.

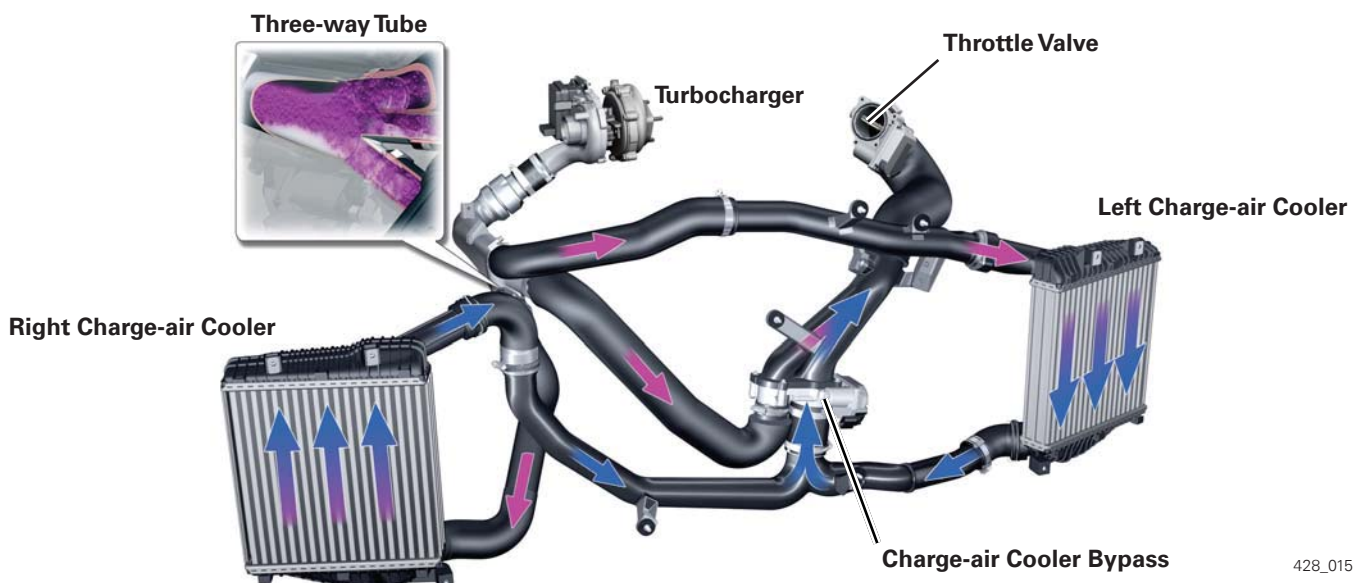
A flow silencer on the suction side and a dual-chamber flow silencer on the compressor outlet prevent flow noise associated with high supercharging pressures.



Charge-air Cooling with Integrated Charge-air Cooler Bypass

Controlling the charge-air temperature contributes to ensuring consistently low emissions at varying ambient temperatures.

Since the charge-air coolers are highly efficient and they cool the compressed charge-air to near ambient temperatures (at low outside temperatures), a bypass is integrated into the air path for bypassing the charge-air cooler.



Engine Mechanical

The bypass flap element consists of the flap housing and two flaps that are mounted at 90° angles on a common shaft. They permit continuous mixing of cooled air from the two charge-air coolers and heated air from the turbocharger. In the final positions of the flap, either only the heated air from the turbocharger or the cooled down air from the charge-air coolers is delivered into the intake manifold.

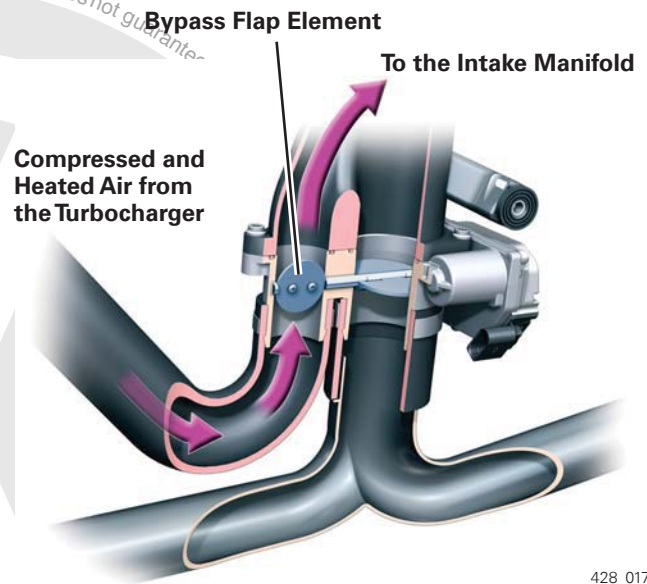
The advantage of variable charge-air mixing is that the intake air temperature can be regulated to the desired specified value depending on the characteristic map through a variable mixture ratio. This permits constant thermodynamic boundary conditions for low-emission and low-consumption combustion.

The Charge-air Pressure Sensor G31 with integrated Intake Air Temperature (IAT) Sensor G42 senses the charge-air temperature. It is installed just upstream of the throttle valve in the pressure hose.

Cold Engine, Low Outside Temperature

The heated charge-air, coming from the turbocharger over the three-way tube, is delivered directly through the bypass flap to the intake manifold.

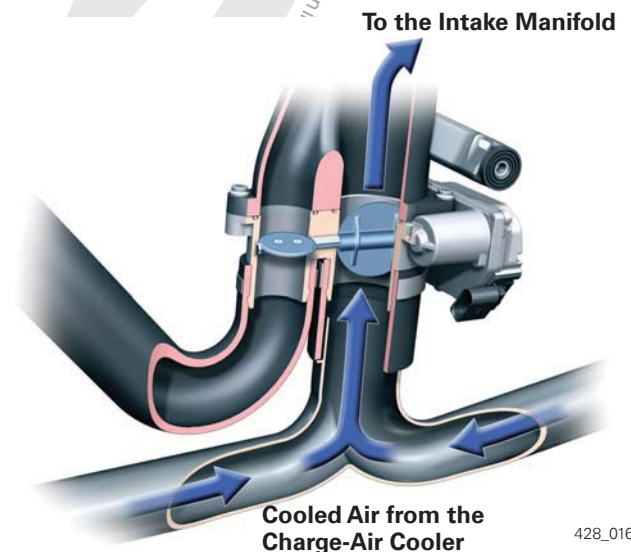
This allows the oxidation catalyst, the particle filter, and the exhaust cleaning systems to activate quickly.



Engine Under Load, High Outside Temperature

Starting at approximately 1750 RPM, depending on the characteristic map, the amount of cooled charge-air is delivered to the intake manifold through a defined position of the bypass flaps.

By closing the bypass flap, the direct path of the charge-air to the intake manifold is closed. The charge-air is directed to the intake manifold through the charge-air cooler.



Common Rail Fuel Injection System

The common rail fuel injection system is a high-pressure accumulator fuel injection system for diesel engines.

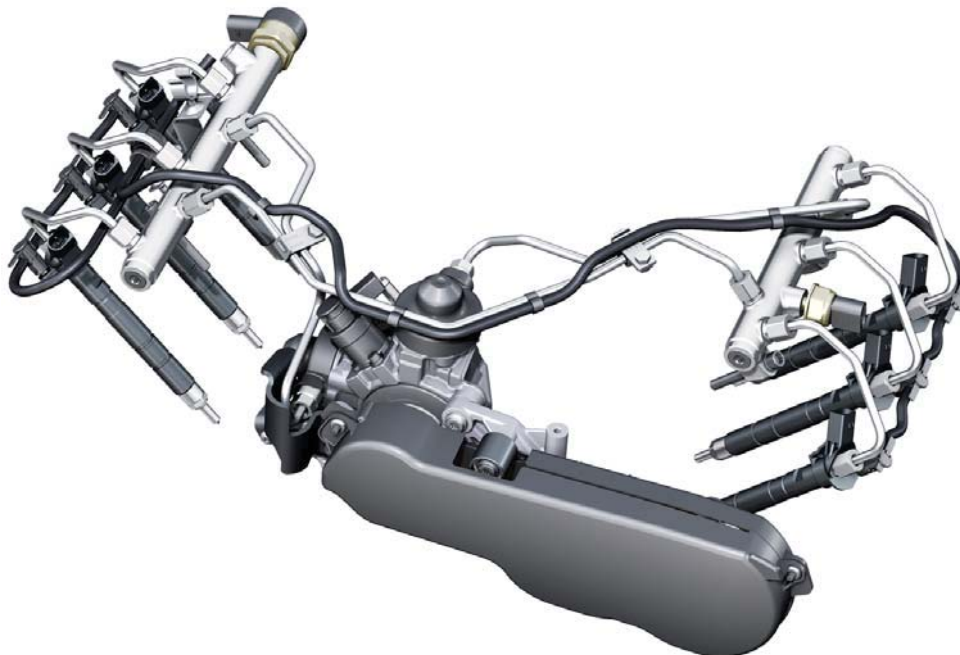
The term “common rail” means that all of one cylinder bank’s injectors have a common, high-pressure fuel accumulator or rail.

In this injection system, pressure generation and fuel injection are separate. The high pressure required for injection is generated by a separate high-pressure pump. This fuel pressure is stored in a high-pressure accumulator (rail) and is made available to the injectors via short injector pipes.

This fuel injection system’s characteristics include:

- The injection pressure can be selected almost infinitely and can be adapted to the engine’s operating status
- A high injection pressure up to a maximum of 29,000 PSI (2000 bar) enables optimal mixture formation
- A flexible fuel injection process, with several pilot and secondary injection processes

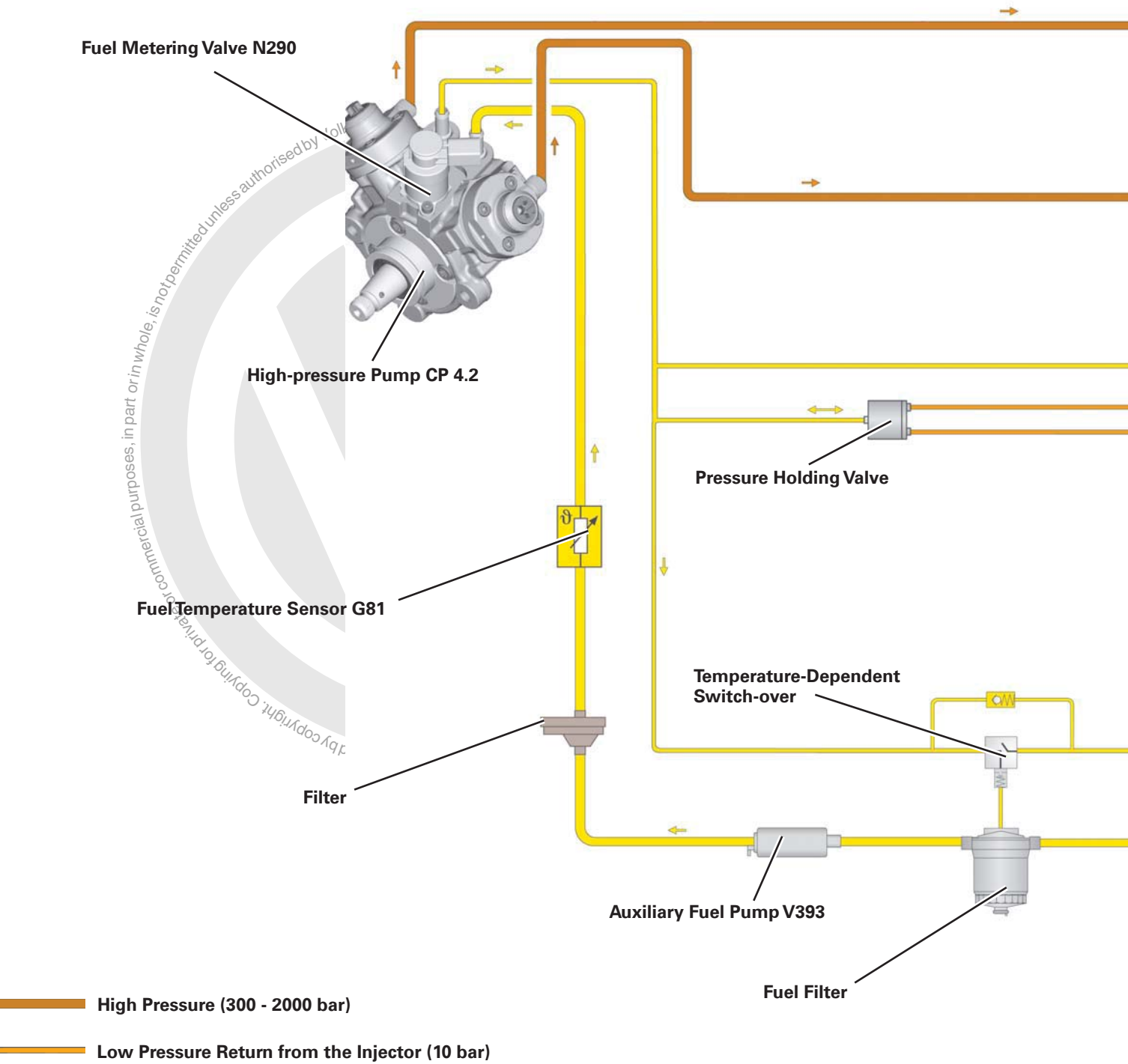
The common rail fuel injection system offers many options for adapting the injection pressure and the injection process to the engine’s operating status. It is designed to meet the ever increasing requirements for low fuel consumption, low exhaust emissions, and smooth running characteristics.



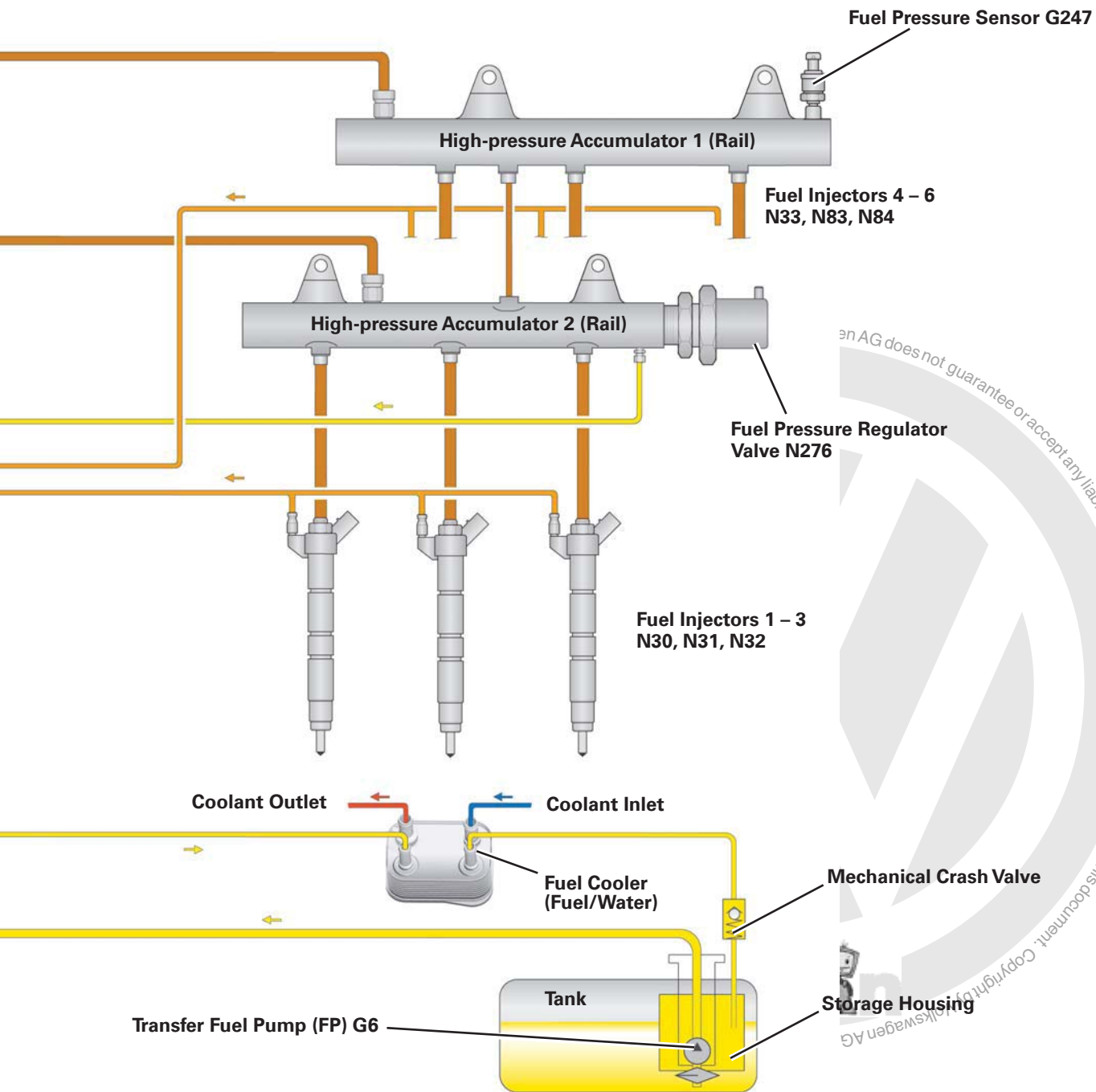
428_022

Fuel System

Fuel System



Fuel System



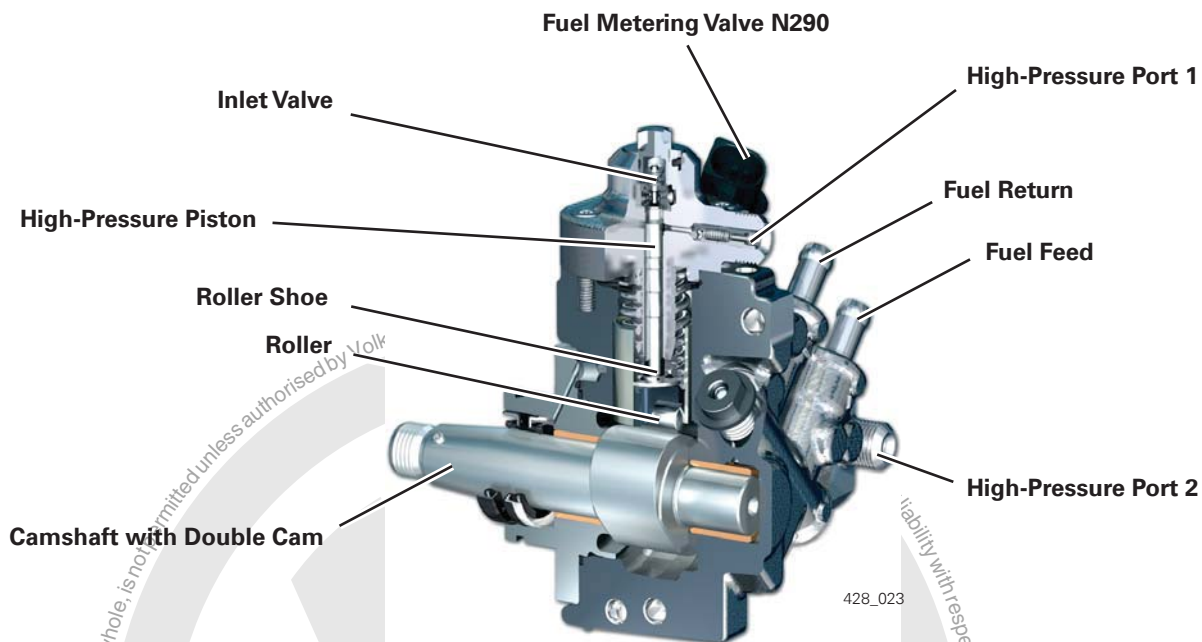
428_026

Fuel System

High-pressure Pump CP4.2

The new high-pressure pump CP4.2 operates with an injection pressure of approximately 29,000 psi (2000 bar).

The pump is supplied with fuel by the Auxiliary Fuel Pump V393 downstream of the Transfer Fuel Pump (FP) G6. Two pump pistons are actuated alternately by the camshaft (two lobes).



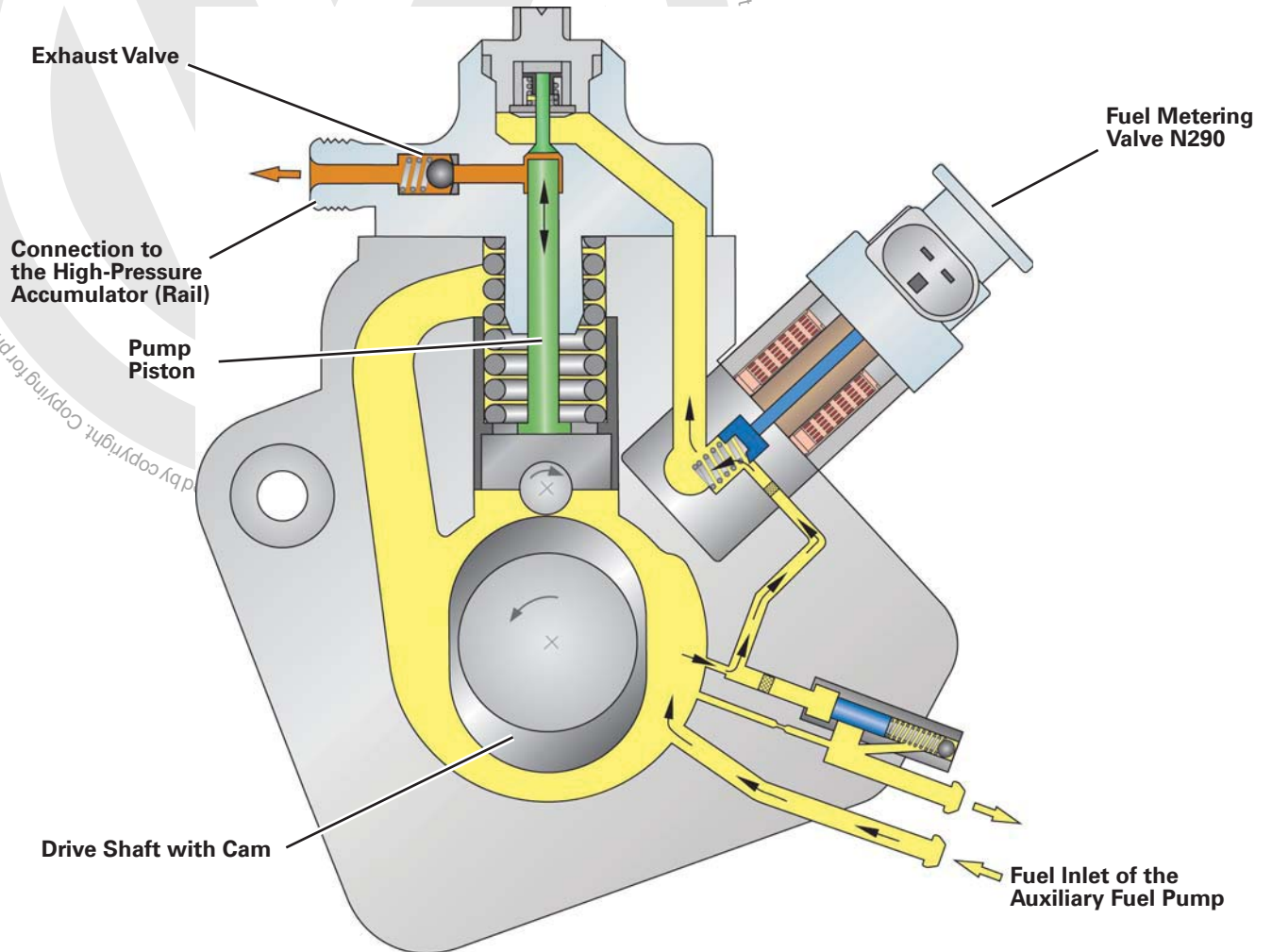
The benefits of the new high-pressure pump are:

- Produces rail pressures of up to 29,000 PSI (2000 bar)
- Has been adapted to deal with fuel quality issues
- Less force for pressure generation thanks to roller plunger
- Uniform stress on the pump toothed drive belt
- Greater efficiency thanks to volume control on the suction side via N290
- Self-lubricating

High-Pressure Area

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

The pump piston is moved upward and downward by the cams on the pump drive shaft.



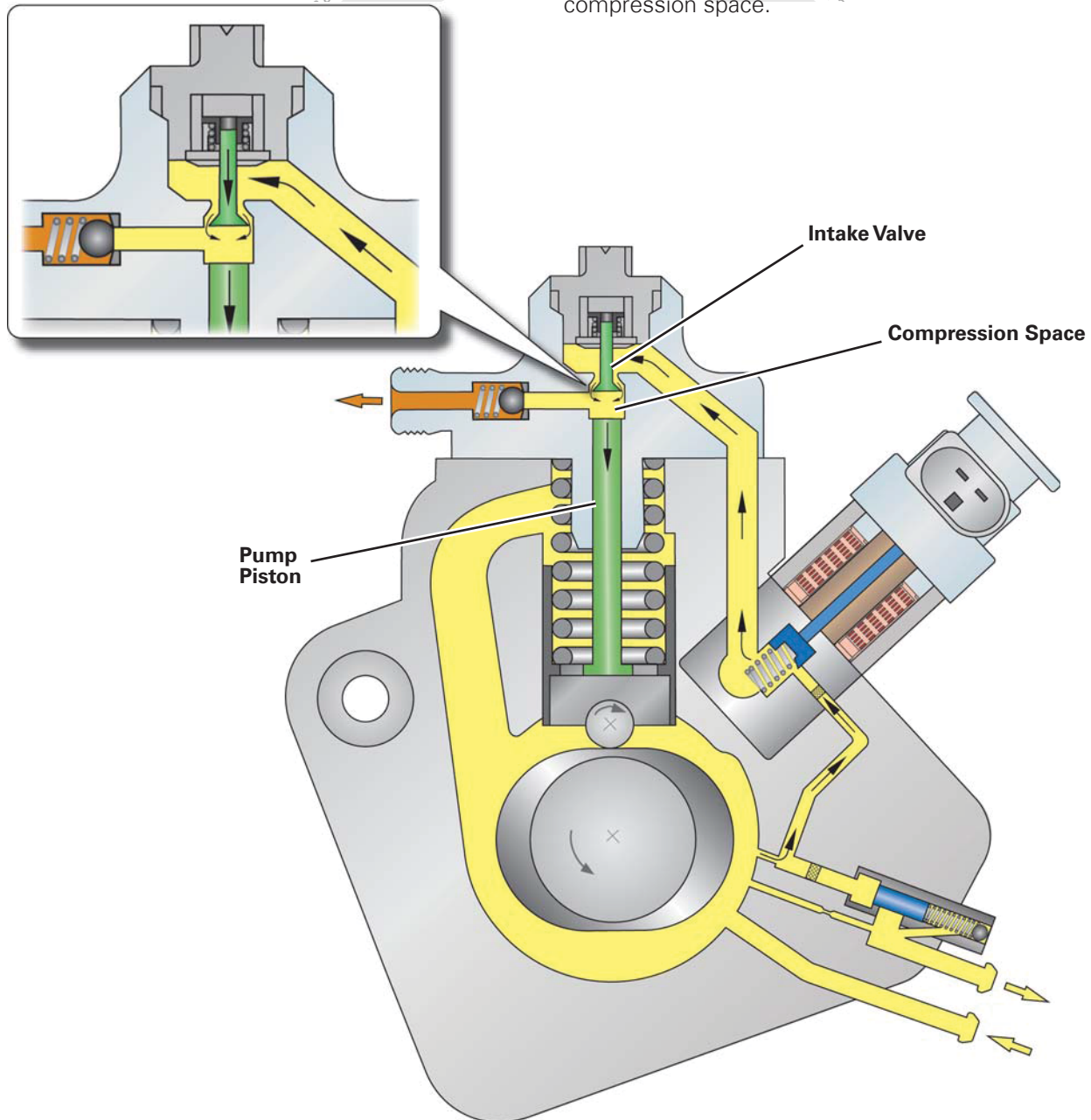
Fuel System

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.

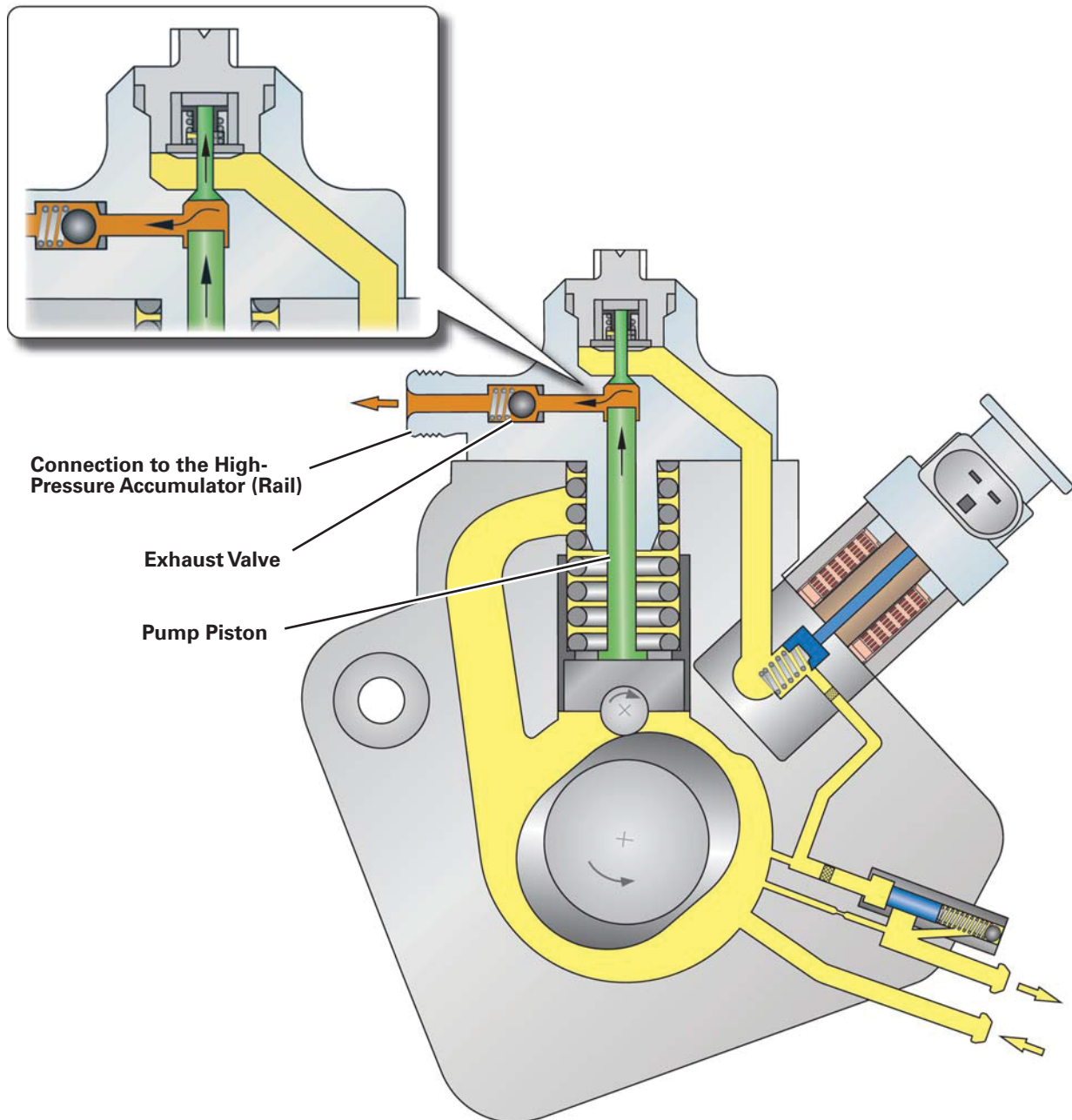


S403_108

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.

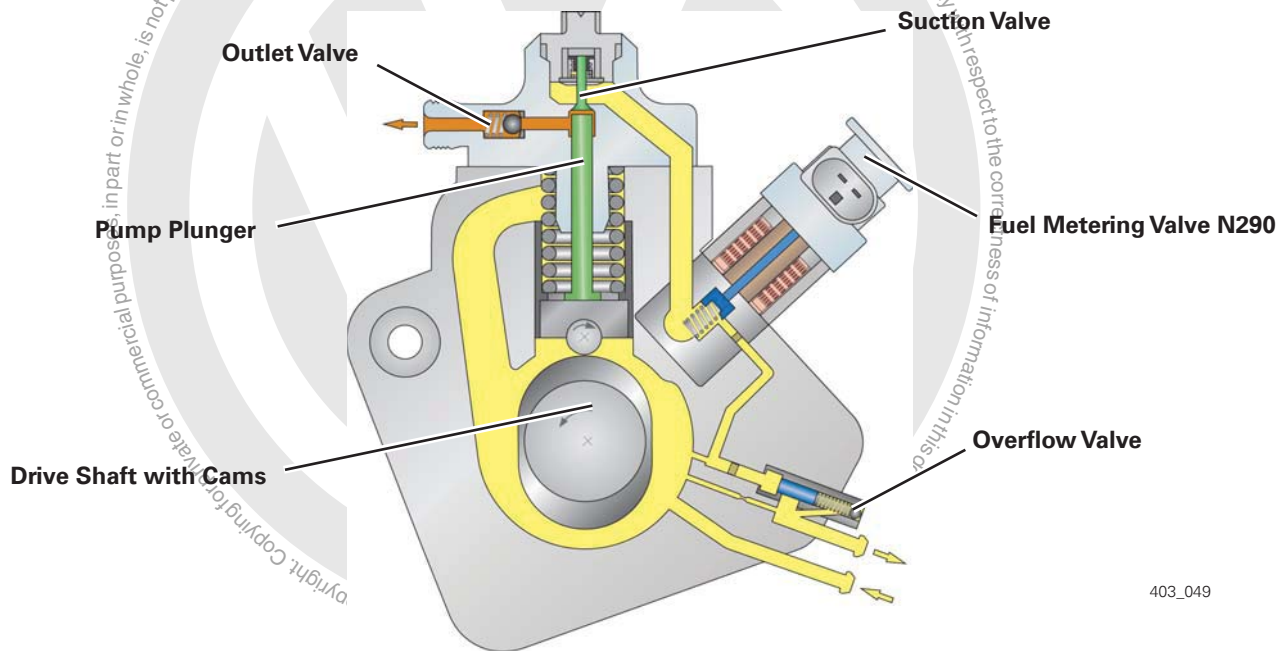
As soon as the fuel pressure in the compression space exceeds the pressure in the high-pressure area, the exhaust valve (check valve) opens and fuel enters the high-pressure accumulator (rail).



S403_109

Fuel System

Excess Pressure



The high-pressure pump is supplied fuel by Auxiliary Fuel Pump V393. At high engine speeds, the pump can deliver more fuel than the injectors can deliver. Fuel Metering Valve N290 helps reduce power consumption and unnecessary fuel heating. N290 is open when not powered. It works in conjunction with Fuel Pressure Regulator Valve N276 to regulate delivery and pressure.

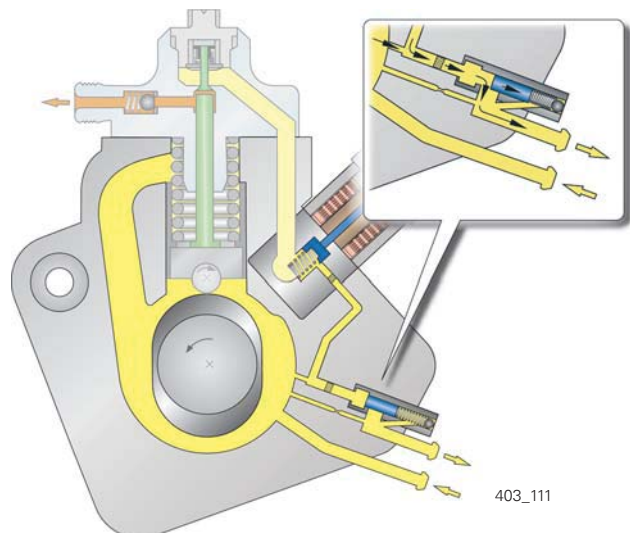
Overflow Valve

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

V393 delivers fuel from the tank at approximately 73 PSI (5 bar) to the high-pressure pump. The overflow valve regulates the intake fuel pressure in the high-pressure pump at approximately 62 PSI (4.3 bar).

The fuel delivered by the additional fuel pump works against the piston and the piston spring of the overflow valve. At a fuel pressure above 62 PSI (4.3 bar,) the overflow valve opens and allowing for return of the fuel.

The excess fuel flows via the fuel return line into the fuel filter.



Fuel Pressure Sensor G247

The Fuel Pressure Sensor G247 is located on the cylinder bank 2 high-pressure accumulator (rail). It determines the current fuel pressure in the high-pressure area.

Function

The Fuel Pressure Sensor G247 contains a sensor element, which is comprised of a steel membrane with expansion measuring strips.

The fuel pressure reaches the sensor element via the high-pressure connection.

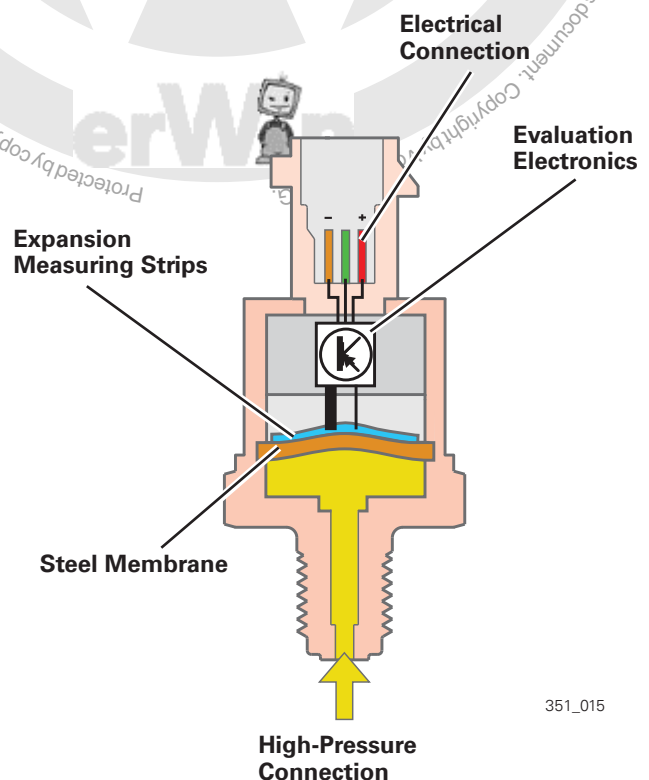
In the event of a change in pressure, the steel membrane deflection changes, as does the resistance value of the expansion measuring strips.

The evaluation electronics calculate a voltage from the resistance value and transmit this to the Engine Control Module.

A characteristic curve stored in the Diesel Direct Fuel Injector (DFI) Engine Control Module (ECM) J248 is used to calculate the current fuel pressure.

Effects of Failure

In the event of Fuel Pressure Sensor G247 failure, the ECM employs a fixed, substitute value for calculation purposes. The engine output is reduced.



351_015

Fuel System

High-Pressure Accumulator (Rail)

A high-pressure accumulator (rail) is installed for each engine cylinder bank. The high-pressure accumulators are forged steel pipes. They have the task of storing the fuel required for injection for all of the cylinders at high pressure.

Design

The high-pressure accumulators are connected to each other by a pipe. The fuel inlet connection from the high pressure pump, the connections to the injectors and the Fuel Pressure Regulator Valve N276 are located on the cylinder bank 1 high-pressure accumulator.

The fuel inlet connections from the connection pipe, the connections to the injectors, and the Fuel Pressure Sensor G247 are located on the cylinder bank 2 high pressure accumulator.

Function

The fuel in the high-pressure accumulators is constantly at a high pressure. When fuel is drawn from the high pressure accumulators for injection, the pressure within the high-pressure accumulators remains virtually constant due to their large storage volume.

The pressure fluctuations that arise due to the pulsating fuel supply to the high-pressure accumulator from the high-pressure pump are minimized by the high-pressure accumulator's large storage volume.

Fuel Rails



428_022

Fuel Temperature Sensor G81

The Fuel Temperature Sensor G81 is located in the fuel supply pipe to the high-pressure pump. G81 is used to determine the current fuel temperature.

Signal Usage

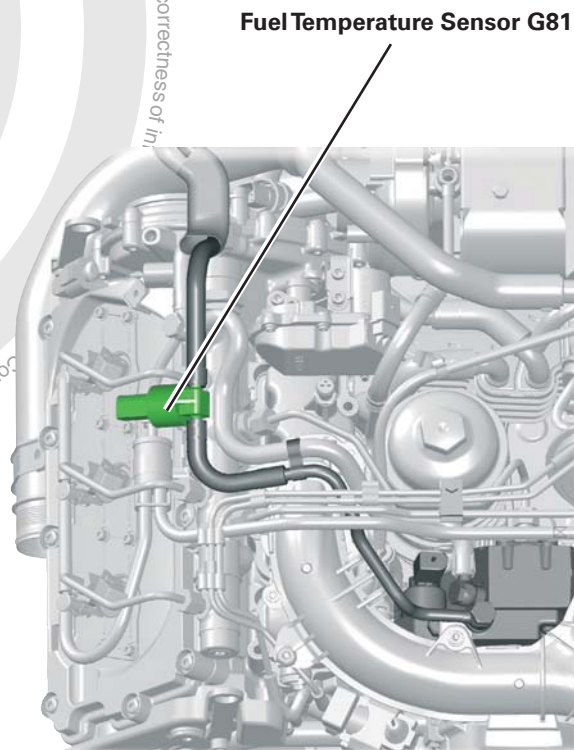
The ECM uses the Fuel Temperature Sensor G81 signal to calculate the fuel density.

This serves as a correction variable to calculate the injection quantity, to regulate the fuel pressure in the high-pressure accumulator, and to regulate the quantity inlet to the high-pressure pump.

To protect the high-pressure pump against excessively high fuel temperatures, the Fuel Temperature Sensor G81 is located in the fuel supply system. In the event of excessively high temperatures in the fuel supply system, the engine's output is limited in order to protect the high-pressure pump. As a result of this, the quantity of fuel to be compressed in the high-pressure pump is also indirectly reduced and the fuel temperature is lowered.

Effects of Failure

In the event of Fuel Temperature Sensor G81 failure, the ECM employs a fixed substitute value for calculation purposes.

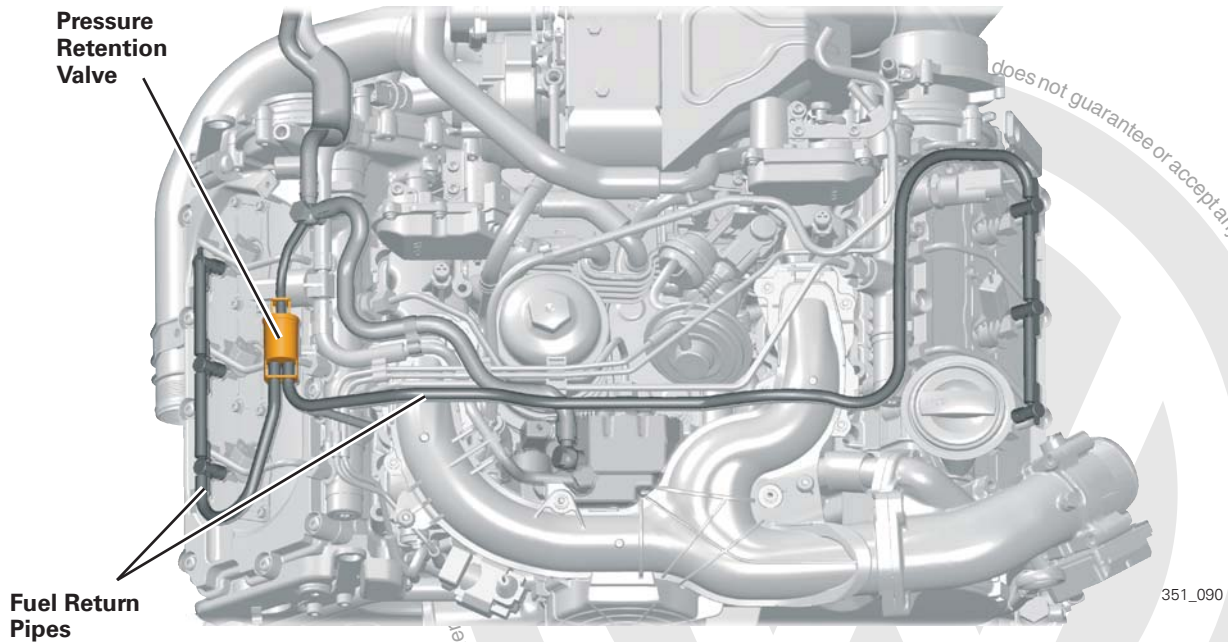


351_031

Fuel System

Pressure Retention Valve

The pressure retention valve is a purely mechanical valve. It is located between the return pipes from the fuel injectors and the fuel system fuel return.

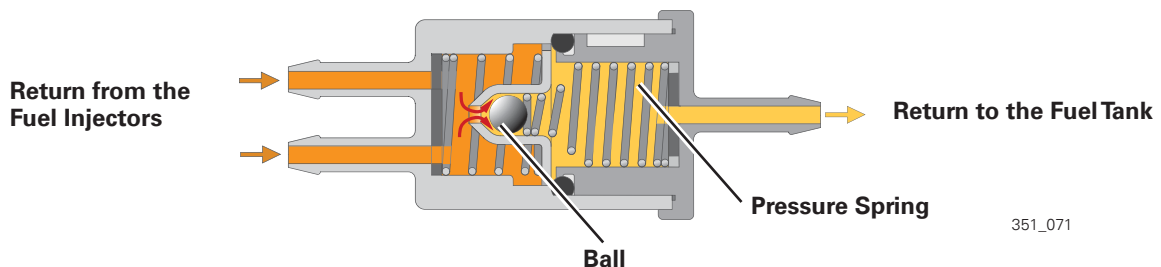


Task

The pressure retention valve maintains a fuel pressure of approximately 145 psi (10 bar) in the injector fuel return. This fuel pressure is required for fuel injector function.

Function

During engine operation, fuel flows from the fuel injectors to the pressure retention valve through the return pipes. At a fuel pressure in excess of 145 psi (10 bar), the ball is lifted from its seat counter to the pressure spring force. The fuel flows through the open valve into the fuel return to the fuel tank.



Control of the Fuel High Pressure

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

Depending on the operating conditions, the high fuel pressure 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.

Control by the Fuel Pressure Regulator Valve N276

At engine start and for preheating of the fuel, the high fuel pressure 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.

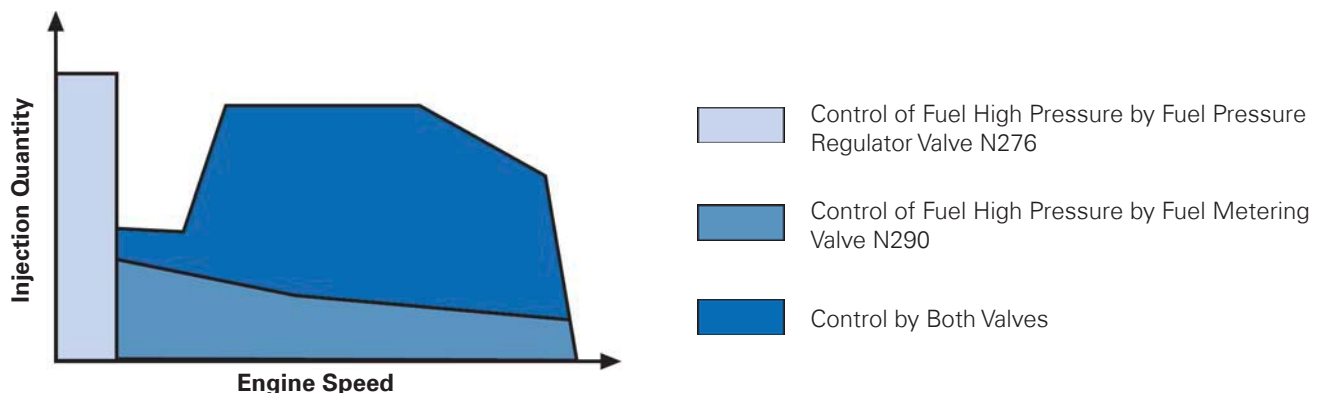
Control by the Fuel Metering Valve N290

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

Control by Both Valves

In idling, in trailing throttle condition and with small injection quantities, the fuel pressure is controlled by both valves simultaneously. This enables precise control, which improves idling quality and the transition into trailing throttle condition.

Two-Controller Concept



Fuel System

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 fuel quantity that is 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.

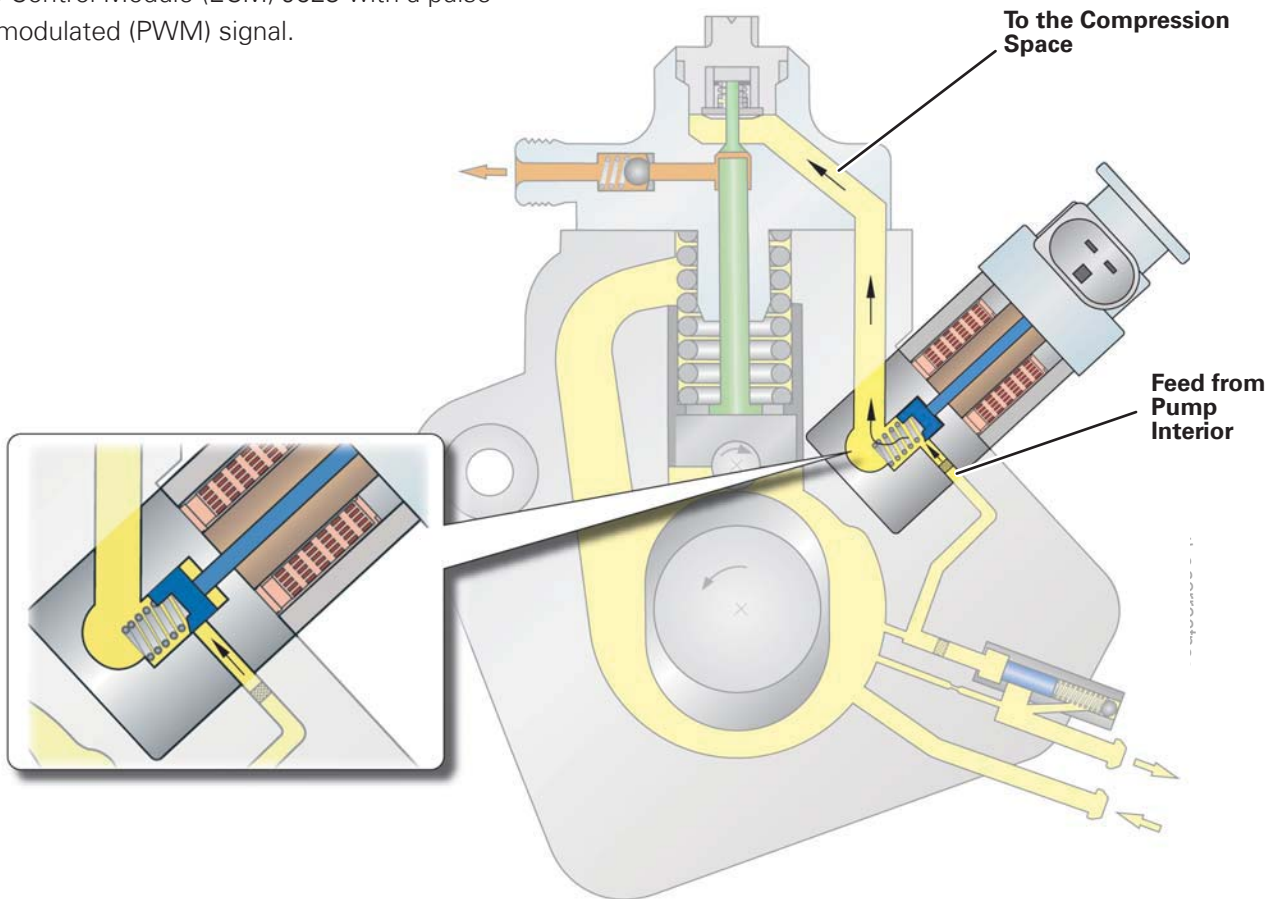
Function

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. Engine management operates in emergency mode.



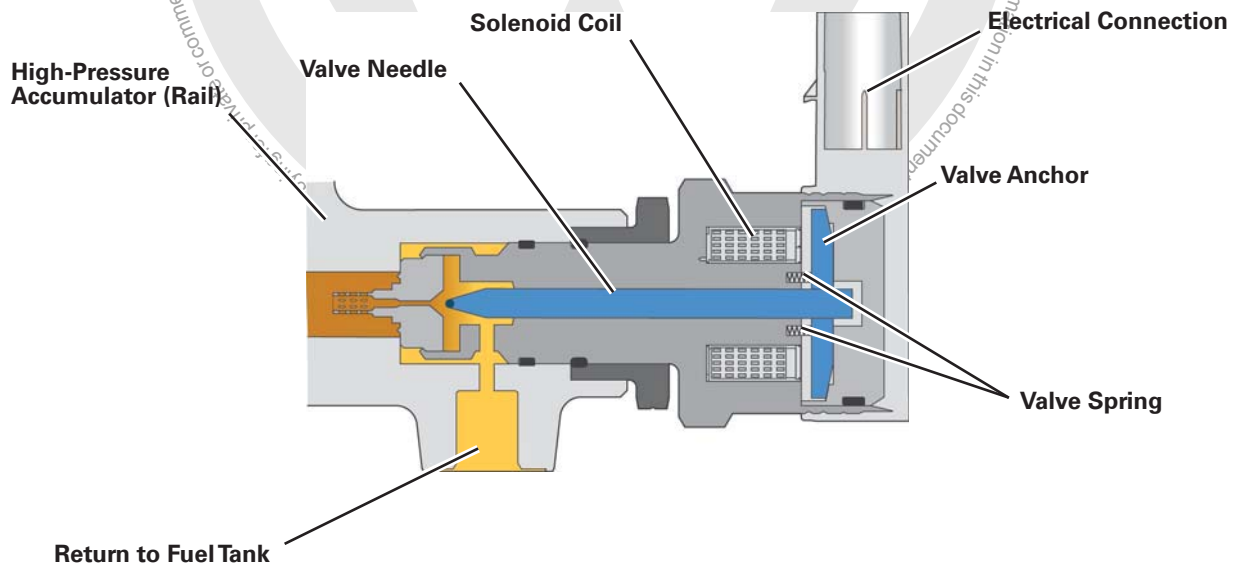
Fuel Pressure Regulator Valve N276

The Fuel Pressure Regulator Valve N276 is located on the cylinder bank 1 high-pressure accumulator (rail).

The regulator valve is used to adjust the fuel pressure in the high-pressure area. To do this, it is initialized by the ECM. Depending on the engine's operating status, the pressure is between 3,336 and 29,007 PSI (230 and 2000 bar).

If the fuel pressure in the high-pressure area is too high, the regulator valve opens, causing some of the fuel in the high-pressure accumulator to enter the fuel tank via the fuel return.

If the fuel pressure in the high-pressure area is too low, the regulator valve closes, thereby sealing the high pressure area at the fuel return.



Fuel System

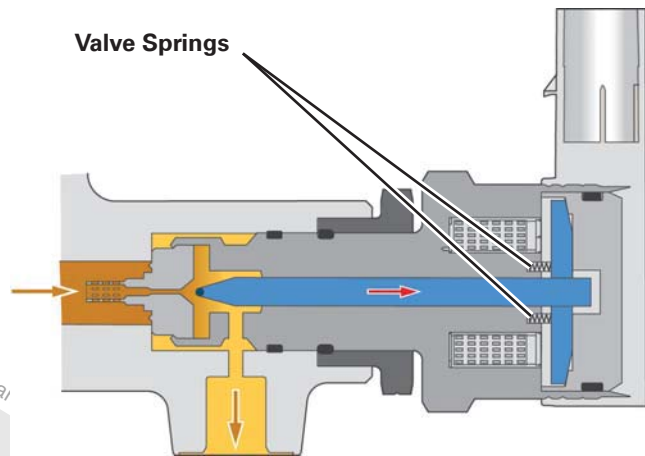
How it Works

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.

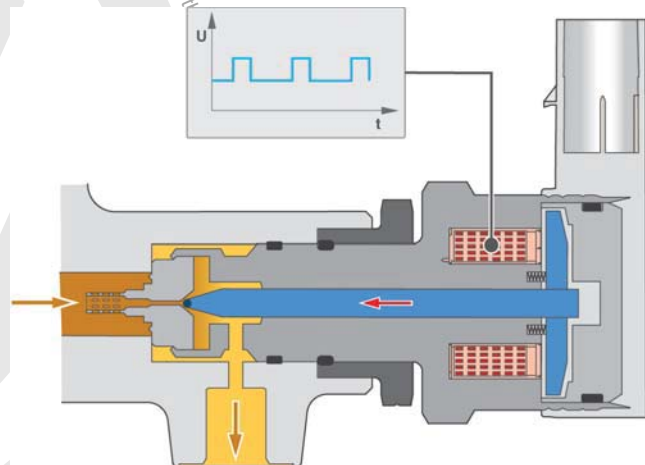
This ensures volume compensation between the high-pressure and low-pressure areas. Fuel vapor lock, which can occur during the cool-down with engine standstill in the high-pressure accumulator (rail), is avoided and the startup properties of the engine are improved.



S403_033

Fuel Pressure Regulator Valve N276 Activated (Engine "On")

To set an operating pressure of 3,336 to 26,107 psi (230 to 1800 bar) in the high-pressure accumulator, the Fuel Pressure Regulator Valve N276 is actuated by the Engine Control Module (ECM) J623 with a pulse-width modulated (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 allows fluctuations in the pressure in the high-pressure accumulator to be compensated.



S403_034

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.

Fuel Injectors (Injection Valves)

The fuel injectors are installed in the cylinder head. They have the task of injecting the correct quantity of fuel into the combustion chambers at the correct time.

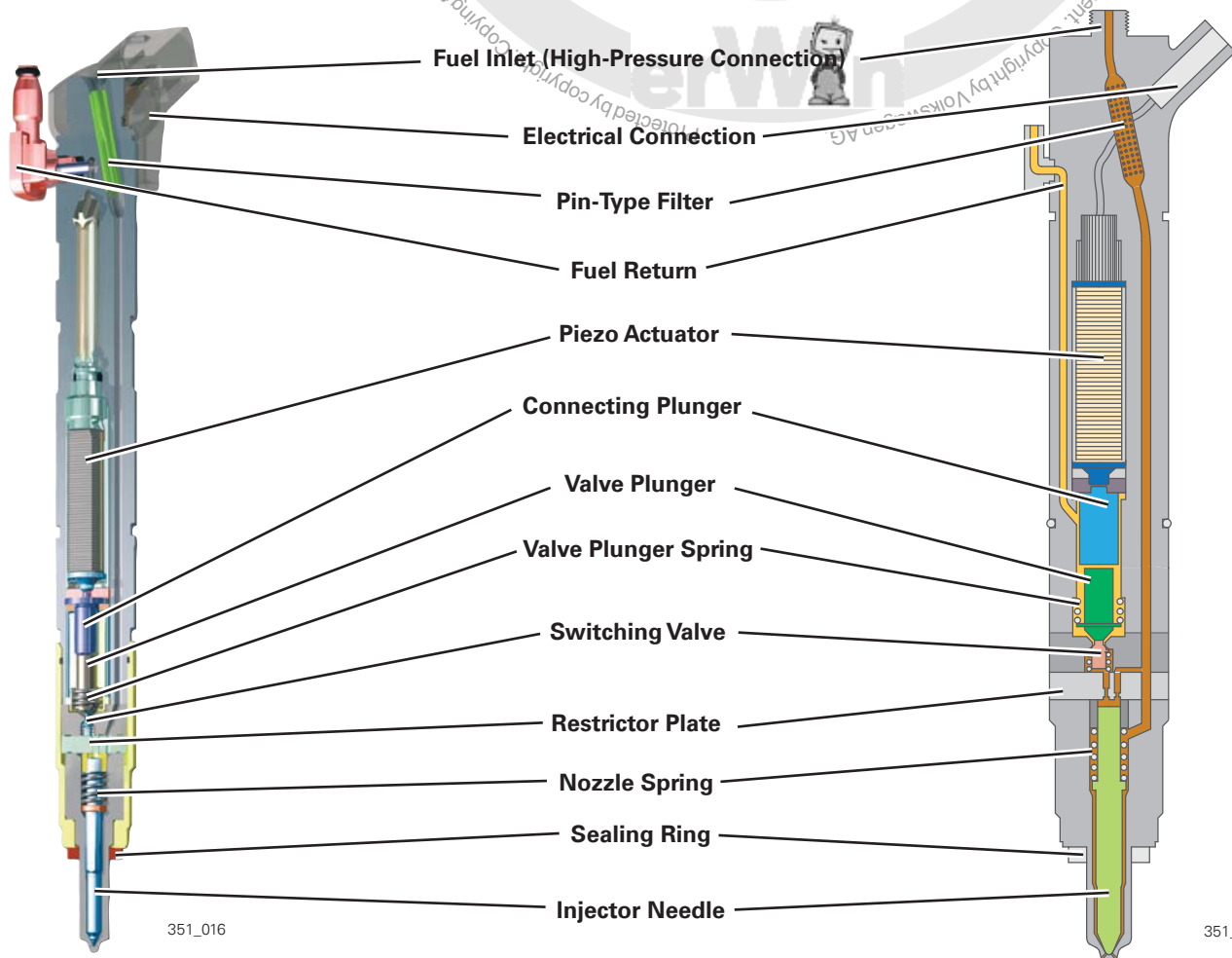
The 3.0L V6 TDI engine has piezo-controlled fuel injectors. Piezo injector switching speed is approximately four times faster than that of a solenoid valve.

In comparison with solenoid valve-controlled injectors, piezo technology has approximately 75% less moving mass at the injector needle.

This results in the following advantages:

- Very short switching times
- Several injections per working cycle are possible
- Precise injection quantities

Structure of an Injector



Fuel System

Injection Process

The very short switching times of the piezo-controlled fuel injectors enable flexible and precise control of the injection phases and injection quantities. As a result, the injection process can be adapted to engine operating requirements. Up to five partial injections can be carried out in a single injection process.

Pilot Injection

A small quantity of fuel is injected into the combustion chamber prior to main injection. This leads to a rise in temperature and pressure in the combustion chamber. The main injection ignition time lag is therefore shortened, reducing the rise in pressure and pressure peaks in the combustion chamber. This leads to low combustion noise and low exhaust emissions. The number, time, and injection quantities of the pilot injection processes are dependent on the engine operating status.

When the engine is cold and at low engine speeds two pilot injections are triggered for acoustic reasons.

At higher loads and engine speeds only one pilot injection is triggered in order to reduce exhaust emissions.

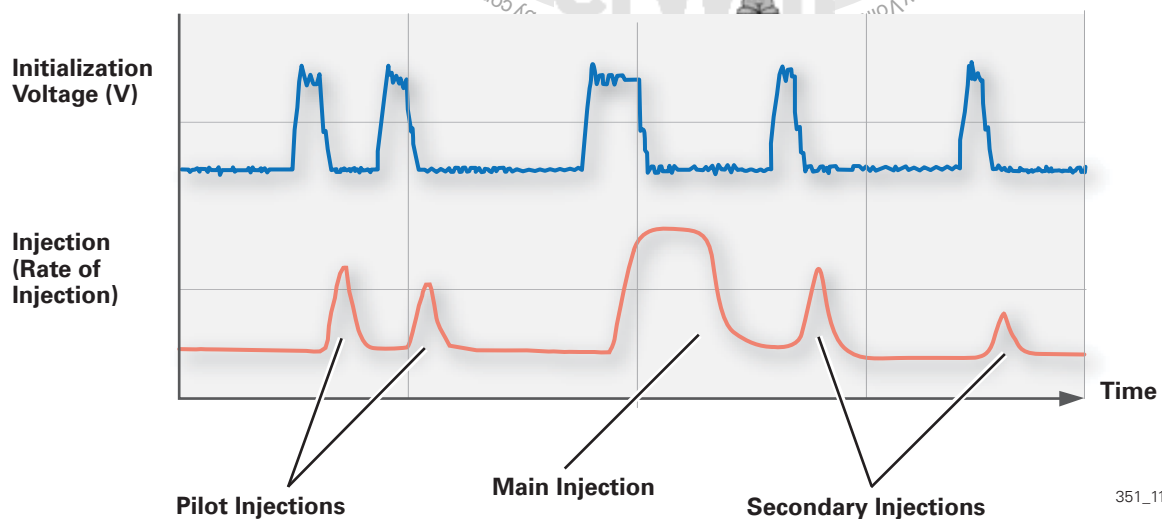
No pilot injection takes place at full throttle and high engine speeds, because a large quantity of fuel has to be injected to achieve a high level of efficiency.

Main Injection

Following pilot injection, the main injection quantity is injected into the combustion chamber following a brief injection pause. The injection pressure level remains virtually identical throughout the entire injection process.

Secondary Injection

Two secondary injections are used to regenerate the diesel particulate filter. These secondary injections increase the exhaust gas temperature, which is necessary to burn the soot particles in the diesel particulate filter.



351_118

Piezo Actuator

A piezo actuator is used to control the injectors. This is located in the injector housing, and is initialized through the ECM. The piezo actuator has a high switching speed, switching in less than one ten-thousandth of a second. The inverse piezo-electric effect is used to control the piezo actuator.

Piezo Effect

“Piezo” is a Greek word meaning “pressure.”

Piezo elements are frequently used in sensor systems. Pressure applied to a piezo element produces a measurable voltage. This behavior on the part of a crystalline structure is called the piezo-electric effect.

Inverse Piezo-Electric Effect

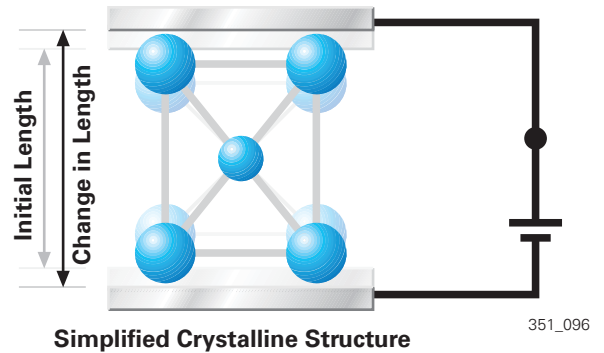
The piezo-electric effect is employed in reverse form in a piezo-controlled actuator. When a voltage is applied to the piezo element the crystalline structure reacts by changing length.

Piezo Actuator

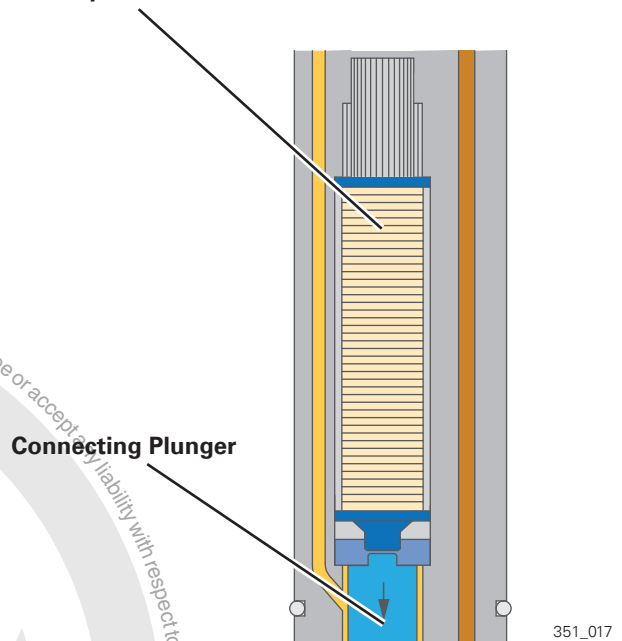
The piezo actuator is comprised of many piezo elements, so that switching travel is sufficient to control the fuel injector.

With the application of a voltage, the piezo actuator expands by up to 0.0012 inch (0.03 mm). For comparison purposes, a human hair has a diameter of approximately 0.0024 inch (0.06 mm).

Piezo Element with Voltage V Applied



Multiple Piezo Elements



Note:

The piezo actuators are initialized with a voltage of 110 – 148 V.
Note the safety precautions in the current service information.

Fuel System

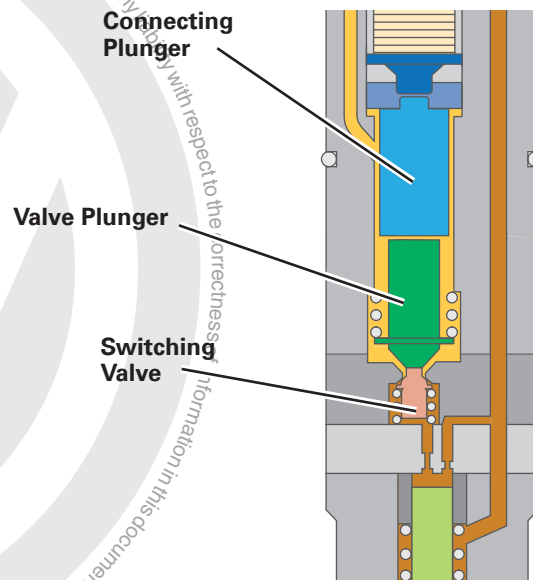
Connecting Module

The connecting module is comprised of the connecting plunger and the valve plunger. The connecting module acts in the same manner as a hydraulic cylinder. It hydraulically converts the piezo actuator's very rapid longitudinal change and actuates the switching valve. Due to hydraulic force transmission, switching valve opening is dampened, and injection is therefore precisely controlled.

Advantages of hydraulic force transmission:

- Low friction forces
- Damping of moving components
- Compensation of component longitudinal changes caused by thermal expansion
- No mechanical forces acting on the fuel injector needles

Connecting Module in Resting Position



351_018

Hydraulic Principle

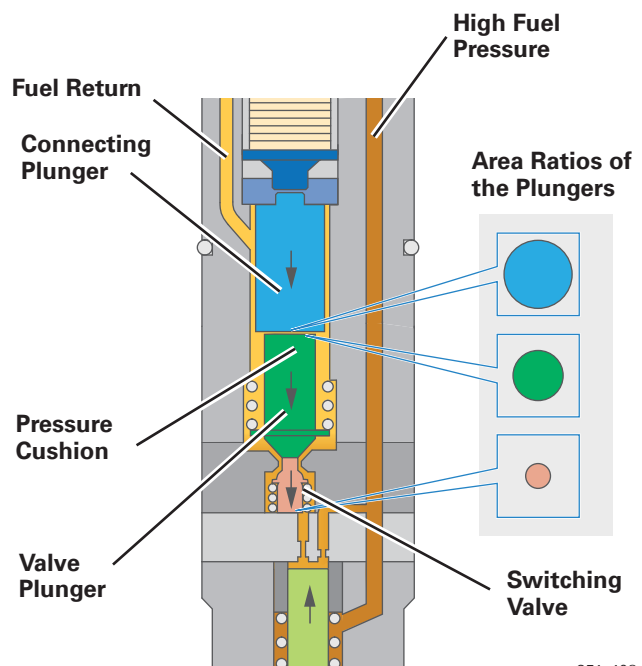
The connecting module is a hydraulic system in which both the forces and the plunger areas behave in relation to each other.

In the connecting module, the area of the connecting plunger is greater than the area of the valve plunger. The valve plunger is therefore actuated by the connecting plunger's force.

The area ratio of the connecting plunger to the switching valve is several times higher. As a result, the switching valve can be actuated by the connecting module counter to the rail pressure.

The pressure retention valve in the fuel return maintains a fuel pressure of approximately 145 psi (10 bar) in the connecting module. This fuel pressure serves as a pressure cushion for hydraulic force transmission between the connecting plunger and valve plunger.

Connecting Module Actuated



351_108

Fuel Injector in Resting Position

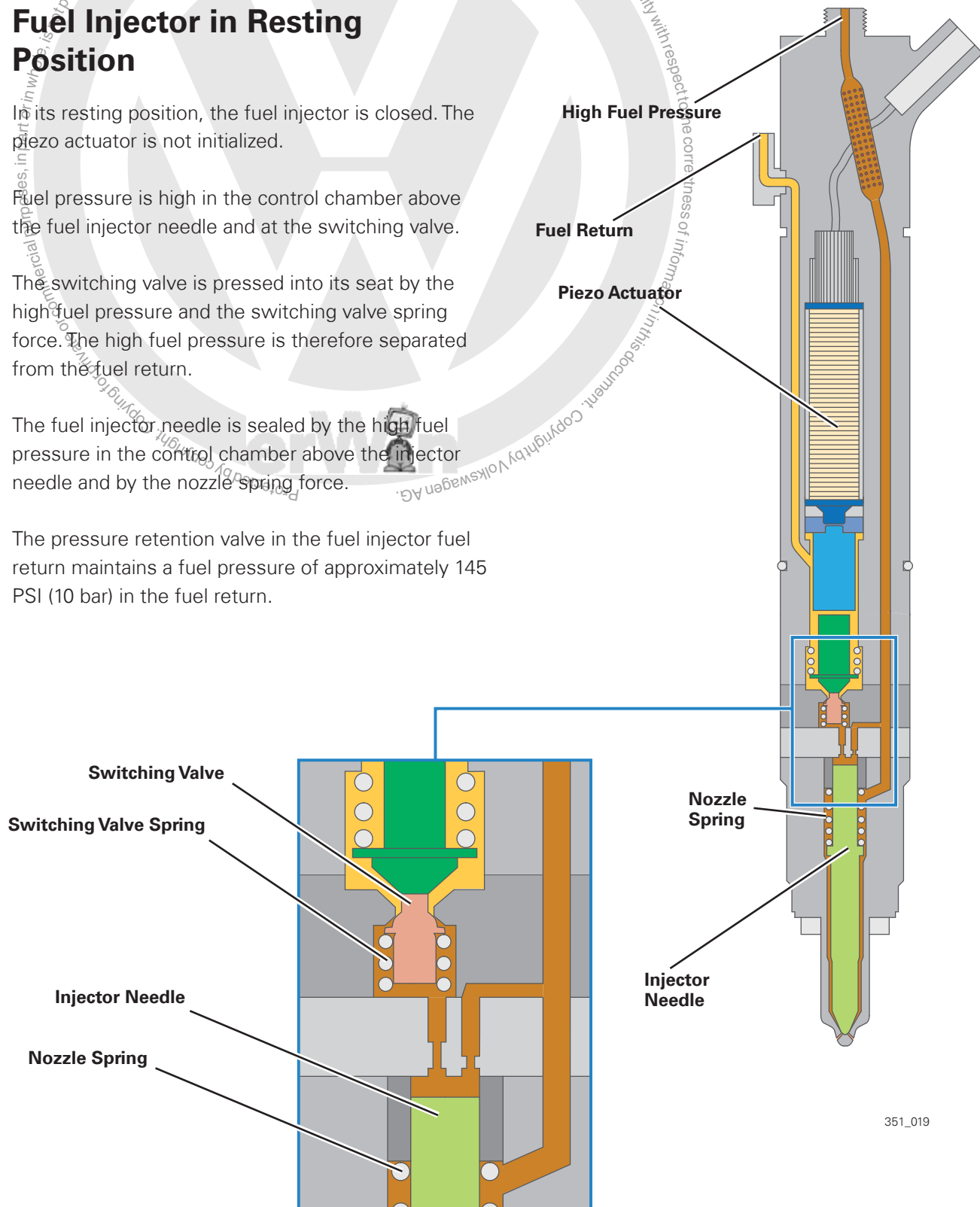
In its resting position, the fuel injector is closed. The piezo actuator is not initialized.

Fuel pressure is high in the control chamber above the fuel injector needle and at the switching valve.

The switching valve is pressed into its seat by the high fuel pressure and the switching valve spring force. The high fuel pressure is therefore separated from the fuel return.

The fuel injector needle is sealed by the high fuel pressure in the control chamber above the injector needle and by the nozzle spring force.

The pressure retention valve in the fuel injector fuel return maintains a fuel pressure of approximately 145 PSI (10 bar) in the fuel return.



351_019

Fuel System

Start of Injection

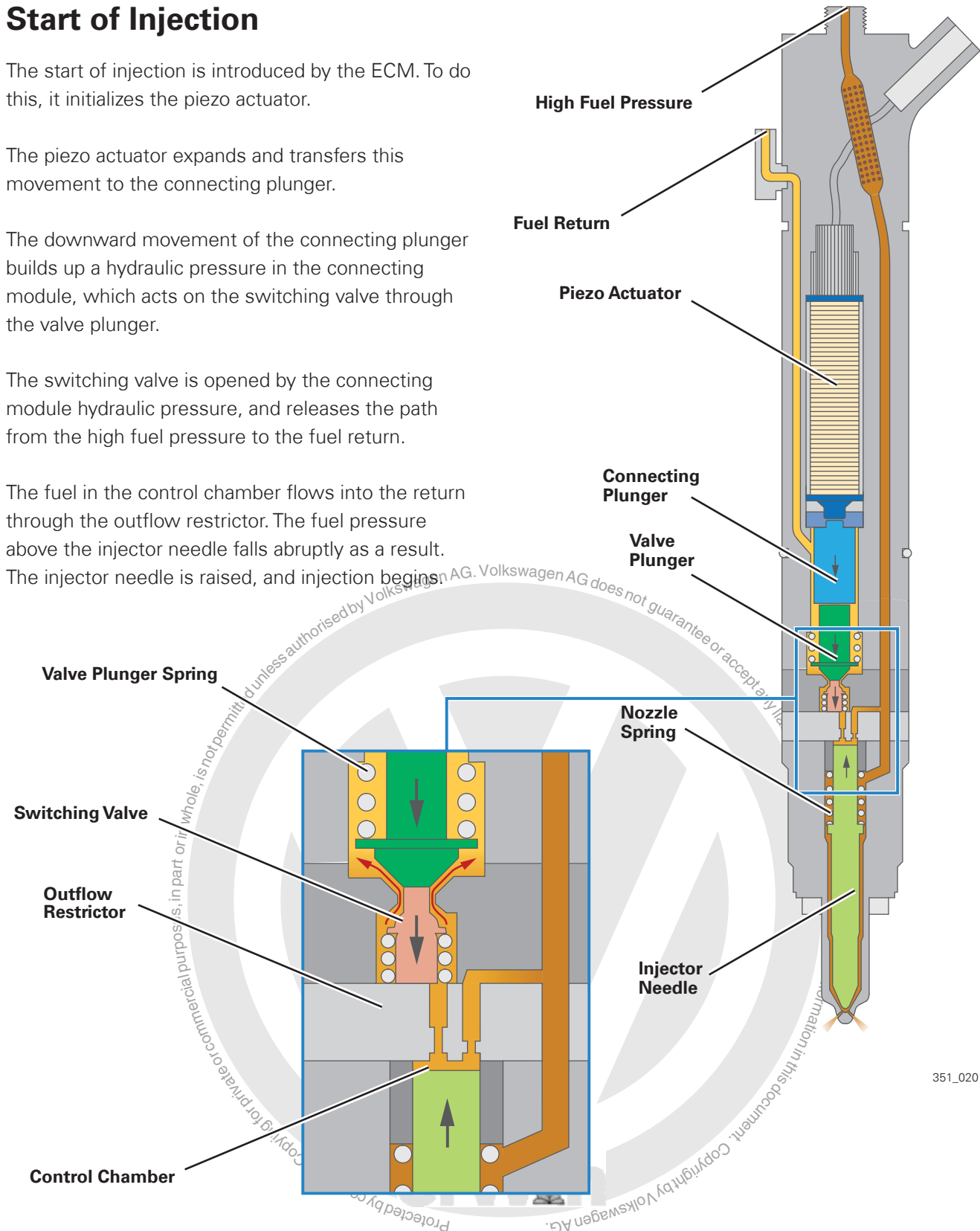
The start of injection is introduced by the ECM. To do this, it initializes the piezo actuator.

The piezo actuator expands and transfers this movement to the connecting plunger.

The downward movement of the connecting plunger builds up a hydraulic pressure in the connecting module, which acts on the switching valve through the valve plunger.

The switching valve is opened by the connecting module hydraulic pressure, and releases the path from the high fuel pressure to the fuel return.

The fuel in the control chamber flows into the return through the outflow restrictor. The fuel pressure above the injector needle falls abruptly as a result. The injector needle is raised, and injection begins.



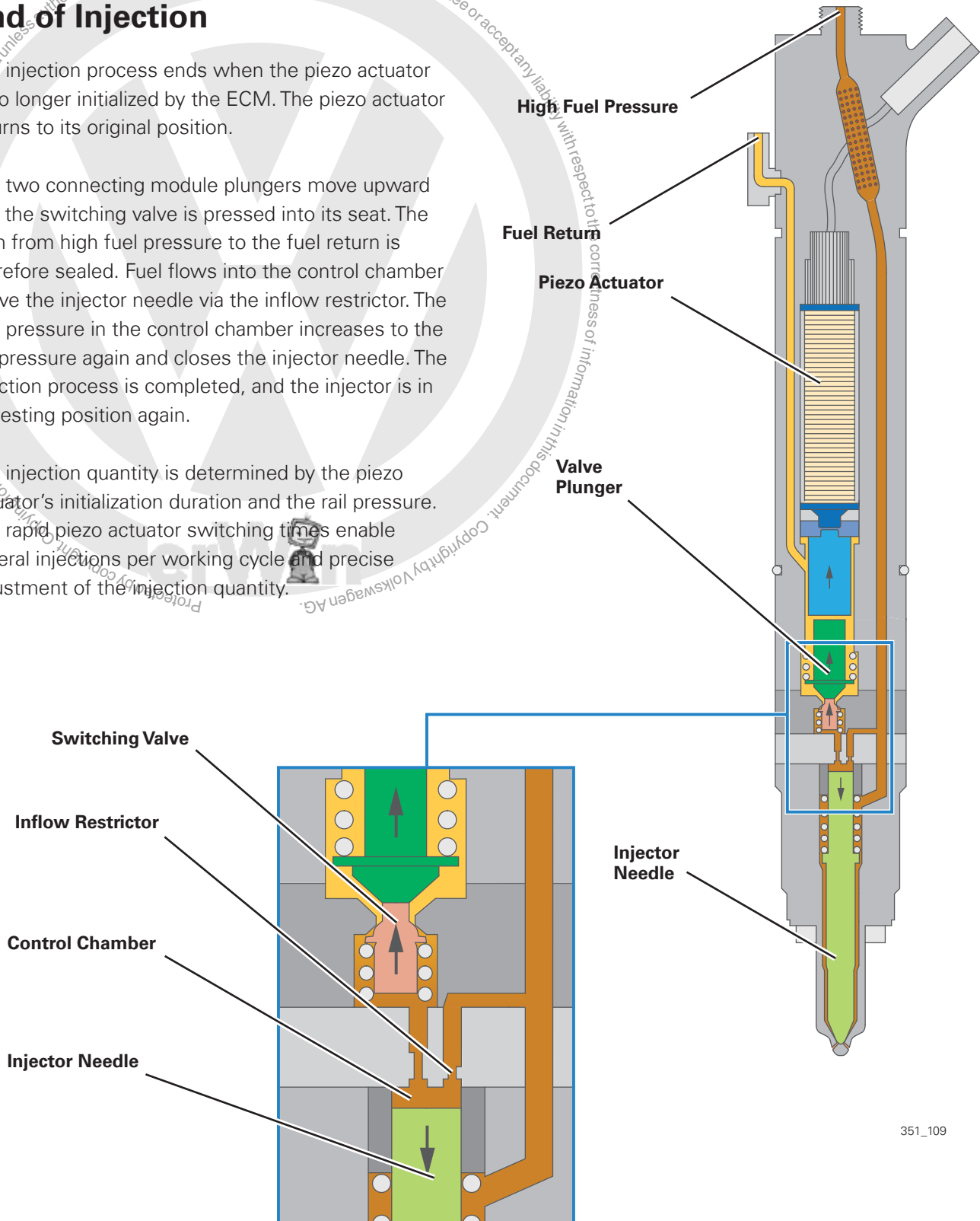
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End of Injection

The injection process ends when the piezo actuator is no longer initialized by the ECM. The piezo actuator returns to its original position.

The two connecting module plungers move upward and the switching valve is pressed into its seat. The path from high fuel pressure to the fuel return is therefore sealed. Fuel flows into the control chamber above the injector needle via the inflow restrictor. The fuel pressure in the control chamber increases to the rail pressure again and closes the injector needle. The injection process is completed, and the injector is in its resting position again.

The injection quantity is determined by the piezo actuator's initialization duration and the rail pressure. The rapid piezo actuator switching times enable several injections per working cycle and precise adjustment of the injection quantity.



351_109

Fuel System

Fuel Injector Delivery Calibration

Fuel Injector Delivery Calibration (IDC) is a software function in the ECM for initializing the fuel injectors.

This function is used to individually correct the injection quantity for each common rail fuel injection system fuel injector throughout the entire performance map range. The precision of the fuel injection system is improved as a result.

Fuel injector delivery compensation balances out production differences.

The objectives of this injection quantity correction are:

- Reducing fuel consumption
- Reducing the quantity of exhaust gas
- Smooth running characteristics

IVA/IQA Value

The Injector Voltage Adjustment (IVA) and Injector Quantity Adjustment (IQA) are adjusted for each injector using a calibration. A seven-digit calibration value is printed on each fuel injector. This calibration value may be comprised of letters and/or numbers.

The IVA/IQA value is determined on a test rig during fuel injector production. It denotes the difference from the nominal value, and therefore describes an injector's fuel injection behavior.

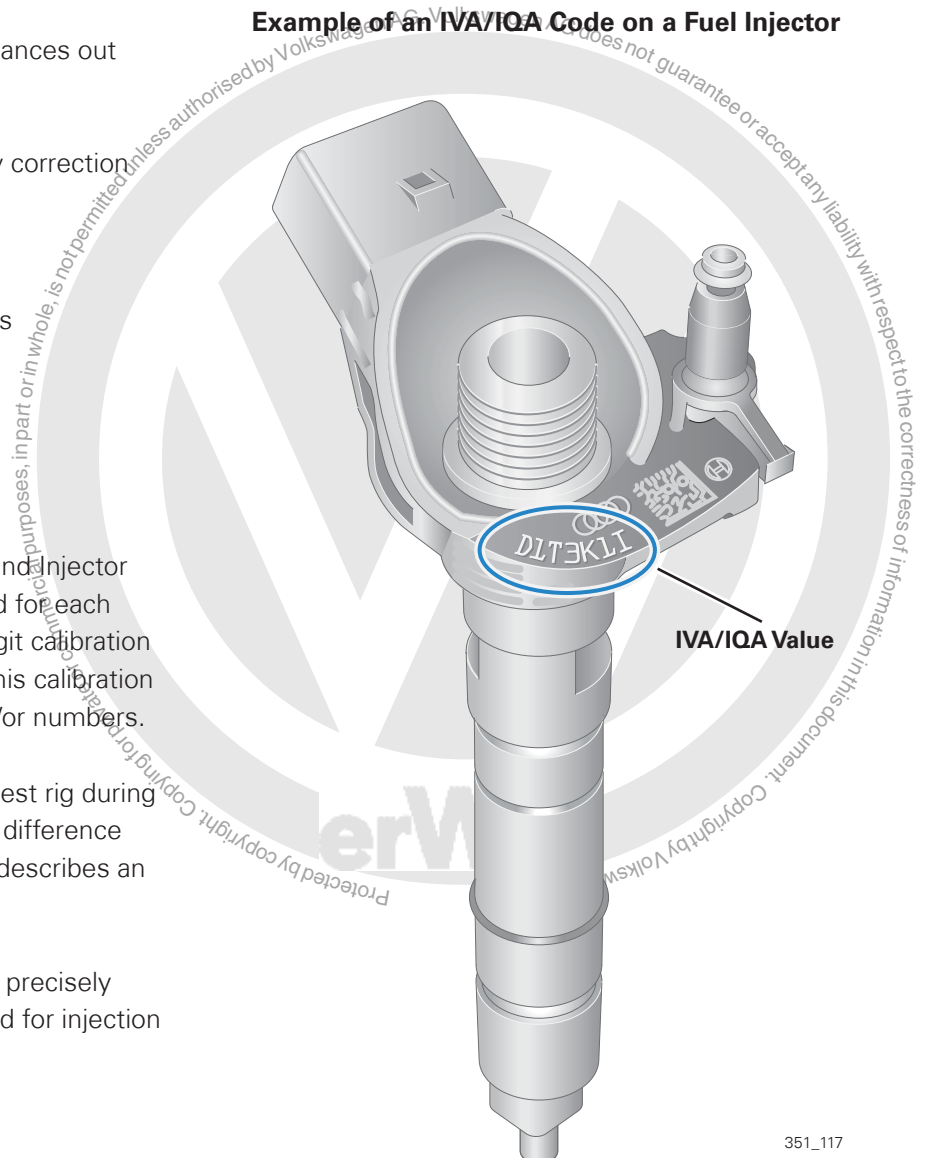
The IVA/IQA value enables the ECM to precisely calculate the initialization times required for injection for each individual fuel injector.



Note:

If a fuel injector (injection valve) is replaced, it must be matched to the fuel injection system. Fuel injector delivery calibration must be performed using Guided Fault Finding.

Example of an IVA/IQA Code on a Fuel Injector



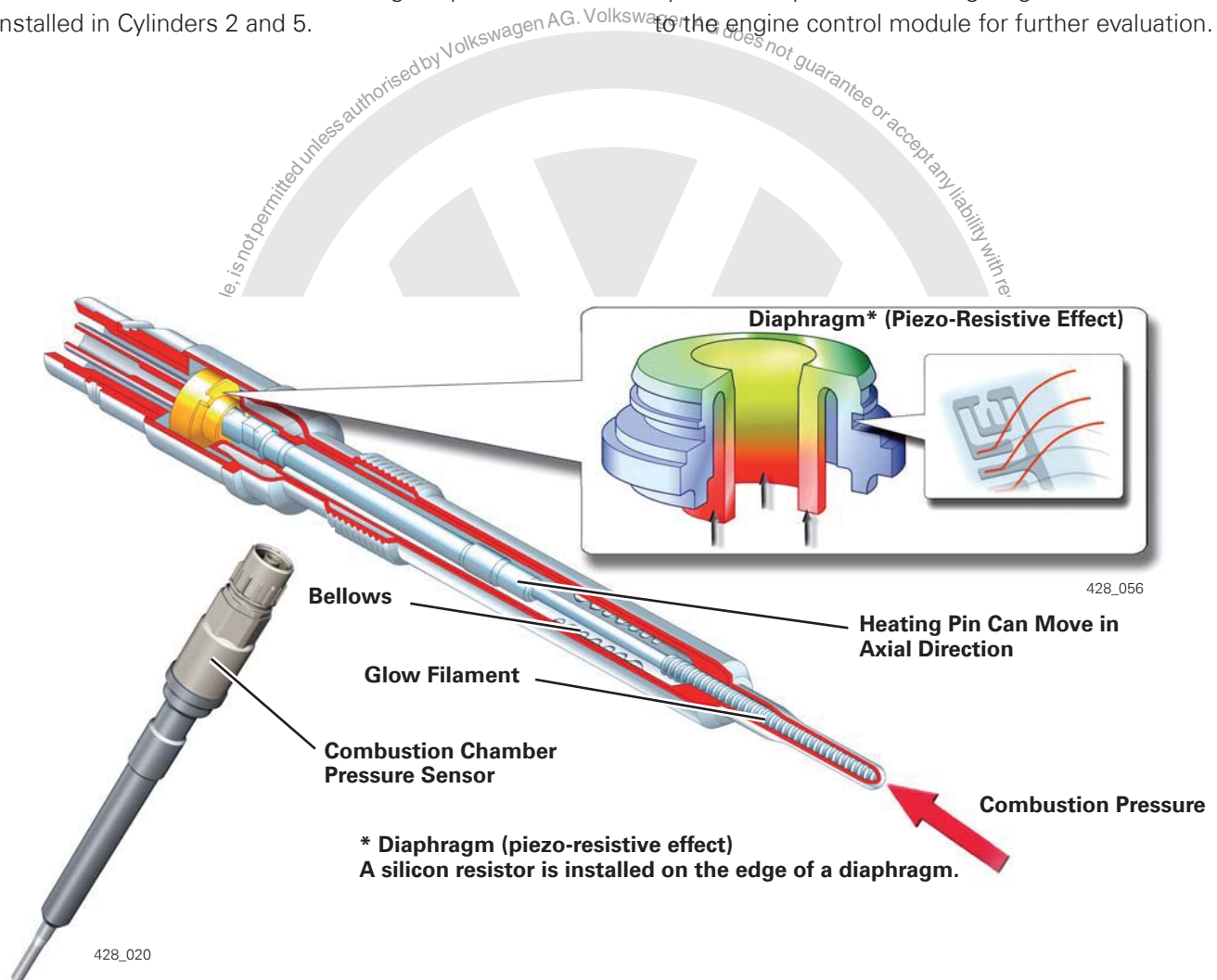
351_117

Cylinder Pressure-Based Combustion Control

Cylinder pressure-based combustion is another component used to achieve low emissions and at the same time achieve high fuel economy.

The combustion chamber pressure sensor used in the 3.0 liter V6-TDI engine is a product by Beru, available under the designation PSG (Pressure Sensor Glow Plug). It adds the combustion chamber pressure sensor function to a metal glow pin and is installed in Cylinders 2 and 5.

This provides the option of integrating this new functionality in the existing space of the cylinder head. The heating pin is supported in such a way that it can move in an axial direction within the glow pin housing. It transmits the cylinder pressure to a diaphragm via a push rod. The deformation of the diaphragm is registered through the change in resistance and processed in an integrated electronic system. The processed voltage signal is transmitted to the engine control module for further evaluation.



Fuel System

Cylinder pressure-based combustion permits the optimum adjustment of the injection point, and thus the pressure profile during combustion, to different fuel qualities and exhaust gas recirculation rates.

The course of combustion is determined from the pressure signal of the combustion chamber sensor and the engine speed signal.

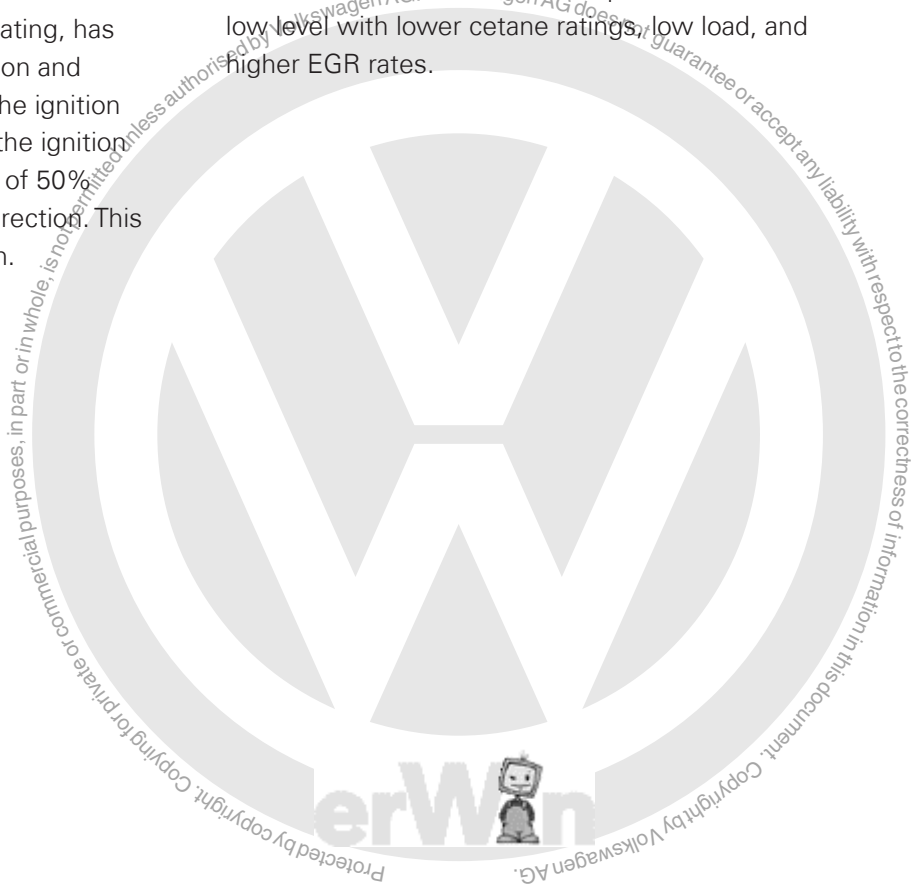
Based on the deviation from the target/performance comparison, a correction value is determined with regard to the target combustion development, which causes an intervention in both the injection and the air system.

The fuel quality, in particular the cetane rating, has a major effect on the course of combustion and the burn rate. With a low cetane rating, the ignition property of the fuel is reduced and thus the ignition delay is significantly increased. The point of 50% energy conversion moves in the "late" direction. This leads to incomplete or partial combustion.

In engines without cylinder pressure-based control, combustion cannot be fully completed at very high EGR rates due to the high displacement towards late and retardation. This causes combustion conditions similar to misfiring. As a result, the HC and CO emissions rise drastically.

The course of combustion is kept constant with the help of the cylinder pressure-based combustion control system and thus combustion is stabilized.

To counteract the higher ignition delay, the start of injection is moved to an earlier time. In this way the HC and CO emissions can be kept at a near constant low level with lower cetane ratings, low load, and higher EGR rates.



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Engine Management

Sensors

Mass Air Flow (MAF) Sensor G70

Engine Speed (RPM) Sensor G28

Camshaft Position (CMP) Sensor G40

Engine Coolant Temperature (ECT) Sensor G62

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

Fuel Temperature Sensor G81

Cylinder 2 Combustion Chamber
Pressure Sensor G678

Cylinder 5 Combustion Chamber
Pressure Sensor G681

Fuel Pressure Sensor G247

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

EGR Potentiometer G212

Brake Light Switch F and Brake Pedal Switch F47

Charge-air Pressure Sensor G31 and
Intake Air Temperature (IAT) Sensor G42

Heated Oxygen Sensor (HO2S) G39

Reducing Agent Tank Sensor G684

Reducing Agent Metering System Pressure Sensor G686

Reducing Agent Temperature Sensor G685

Exhaust Gas Temperature (EGT) Sensor 3 G495

Catalyst Temperature Sensor 1 G20

EGR Temperature Sensor G98

Exhaust Gas Temperature (EGT) Sensor 1 G235

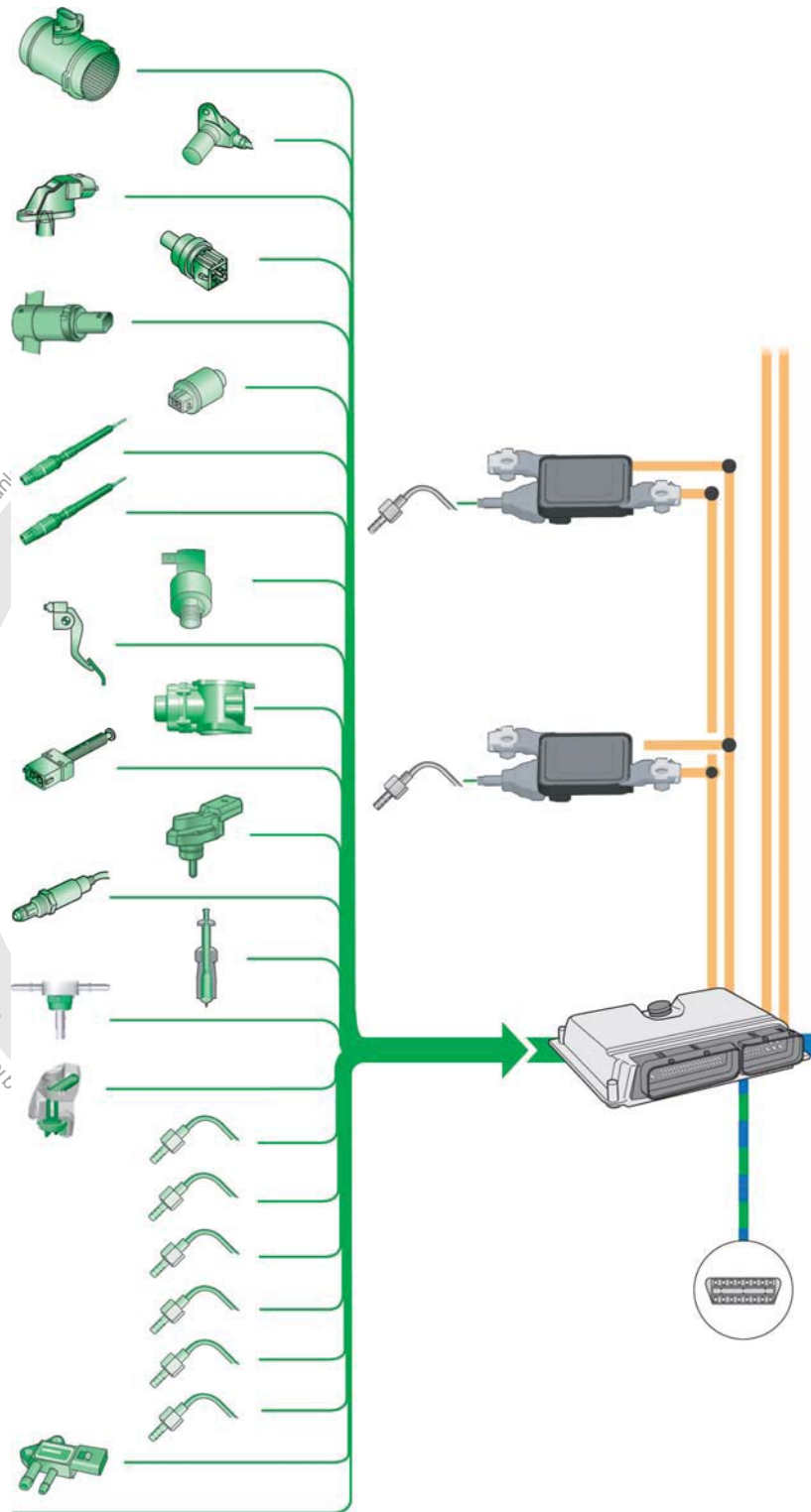
Exhaust Gas Temperature (EGT) Sensor 4 G648

Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448

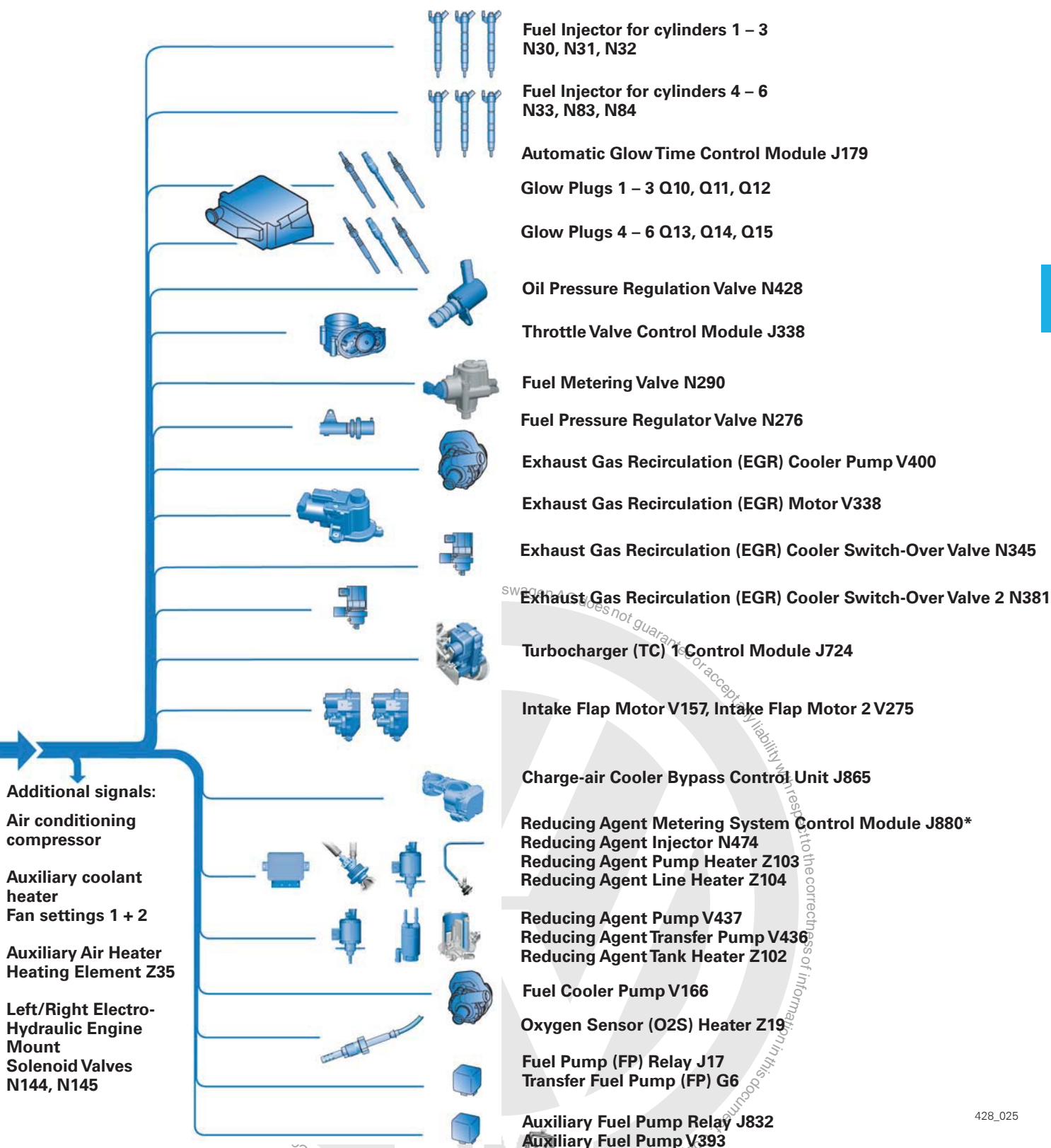
Differential Pressure Sensor G505

Additional signals:

Cruise control system, Terminal post 50, Speed signal,
Crash signal from the airbag control unit,
Requirement start on engine control module (Keyless E



Actuators

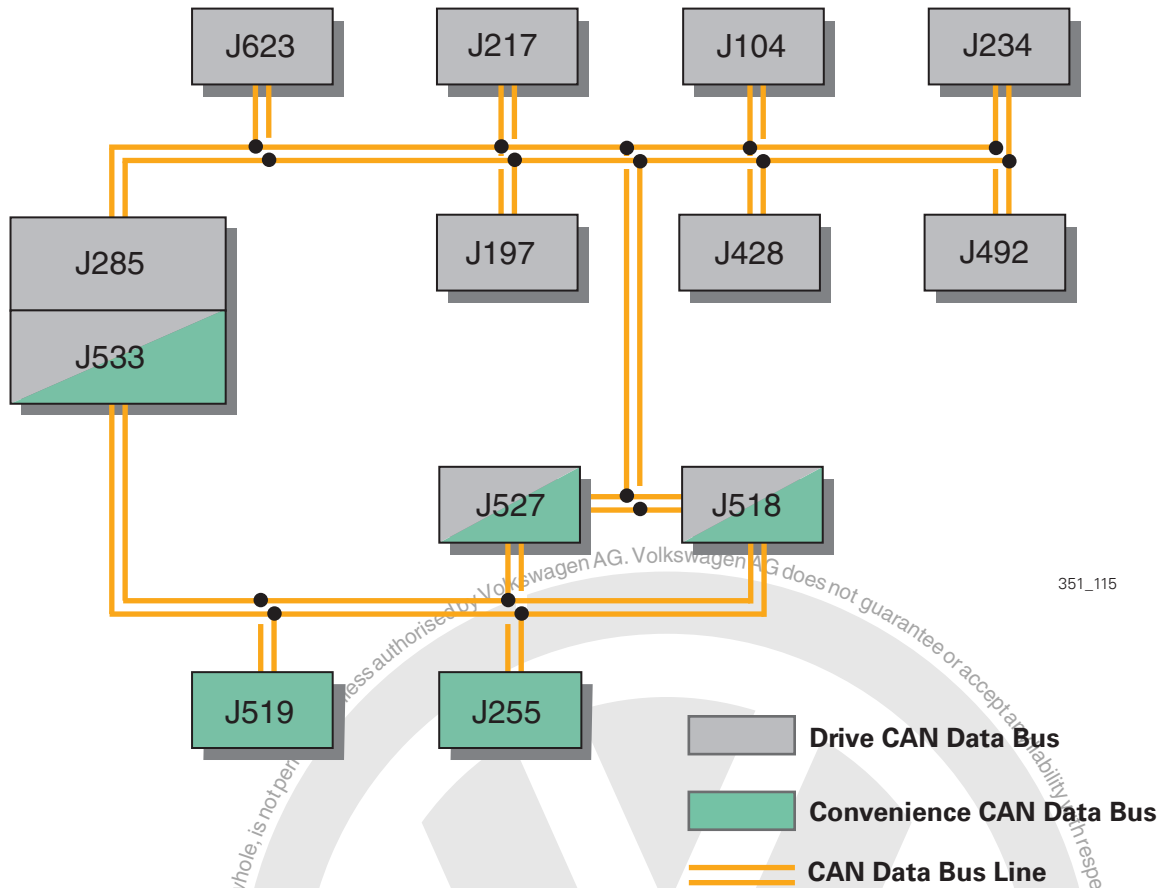


428_025

Engine Management

Control Modules in the CAN Data Bus

The schematic shown below shows the integration of the Engine Control Module (ECM) J623 into the vehicle's CAN data bus structure.



Drive CAN Data Bus:

J623 Engine Control Module (ECM)
J217 Transmission Control Module (TCM)
J104 ABS Control Module
J234 Airbag Control Module
J197 Level Control System Control Module
J428 Distance Regulation Control Module
J492 All Wheel Drive Control Module

Convenience CAN Data Bus:

J285 Instrument Cluster Control Module
J527 Steering Column Electronic Systems Control Module
J518 Access/Start Authorization Control Module
J519 Vehicle Electrical System Control Module
J255 Climatronic Control Module
J533 Data Bus On Board Diagnostic Interface

Sensors

Engine Speed (RPM) Sensor G28

The Engine Speed (RPM) Sensor G28 is secured to the gearbox housing. It is an inductive sensor, which samples a 60-2 sensor wheel, which is secured to the drive plate. A segment gap on the sensor wheel serves the Engine Speed (RPM) Sensor G28 as a reference mark.

Signal Usage

The engine speed and the precise position of the crankshaft are recorded via the sensor's signal. This information is used by the ECM to calculate the injection point and the injection quantity.

Effects of Failure

In the event of signal failure, the engine is shut off and can no longer be started.

Camshaft Position (CMP) Sensor G40

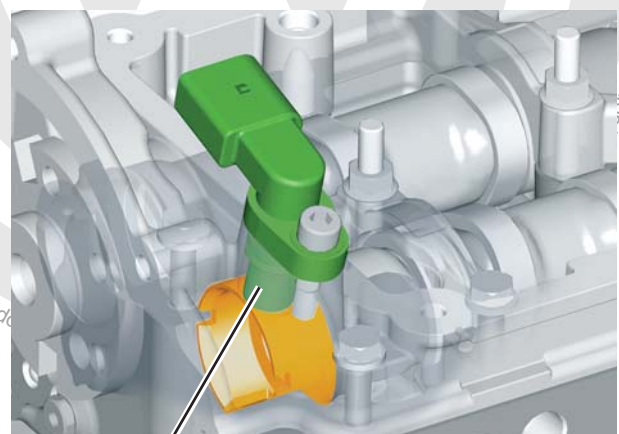
The Camshaft Position (CMP) Sensor G40 is secured in the retaining frame of the cylinder bank 1 cylinder head. It scans the sensor wheel on the camshaft, with which the position of the camshaft is detected.

Signal Usage

The sensor signal is required by the ECM to detect the first cylinder when starting the engine.

Effects of Failure

Starting the engine is impossible in the event of signal failure.



351_022

351_022

Engine Management

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

The Throttle Position (TP) Sensor G79 and Accelerator Pedal Position Sensor 2 G185 are combined in one component and integrated into the accelerator pedal module.

Signal Usage

The Throttle Position (TP) Sensor G79 and Accelerator Pedal Position Sensor 2 G185 are used to detect the position of the accelerator throughout the entire adjustment range. These signals are used by the ECM to calculate the injection quantity.

Effects of Failure

In the event that one of the two sensors (G79 or G185) fail, the system switches to idle speed. If the second sensor is detected within a defined period of time, vehicle operation becomes possible again. However, the engine speed only increases slowly to the desired throttle. In the event of both sensors failing, the engine only runs at increased idle speed, and no longer responds to the accelerator.

Kick Down Switch F8

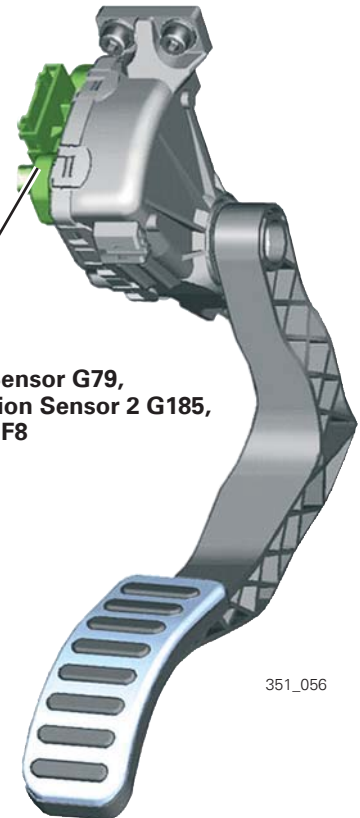
The Kick Down Switch F8 function is integrated into the accelerator pedal module.

Signal Usage

In addition to the accelerator position sensor signals, the Kick Down Switch F8 signal allows the ECM to detect the kick-down position. This information is transmitted to the Transmission Control Module (TCM) J217 via the drive CAN data bus, and the kick-down function is carried out.

Accelerator Pedal Module

Throttle Position (TP) Sensor G79, Accelerator Pedal Position Sensor 2 G185, and Kick Down Switch F8



351_056

Effects of Failure

In the event of Kick Down Switch F8 failure, the ECM uses the accelerator position sensor values.

Brake Light Switch F and Brake Pedal Switch F47

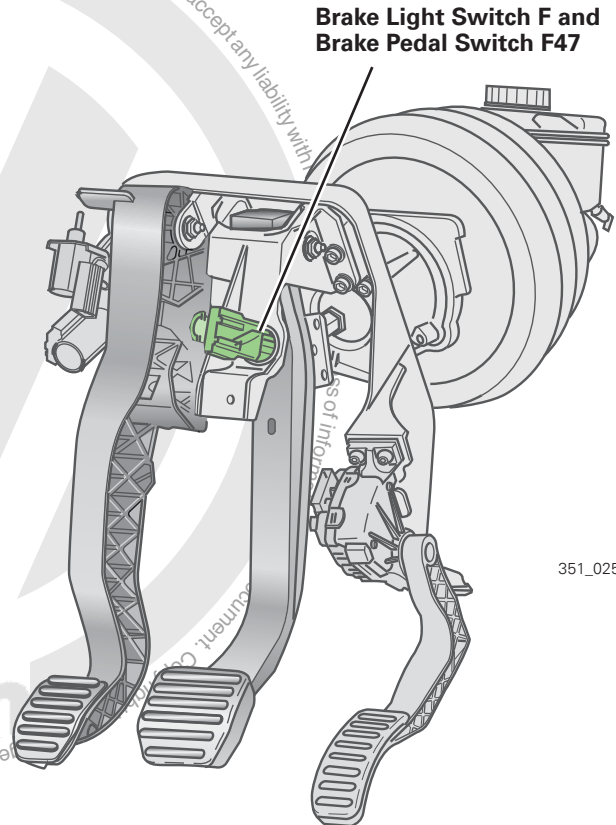
The Brake Light Switch F and Brake Pedal Switch F47 are located together in one component on the pedal cluster. Both switches help the ECM to detect whether the brake is actuated.

Signal Usage

When the brake is actuated, the cruise control system is shut off, and the engine no longer responds to the accelerator pedal.

Effects of Failure

If a sensor's signal fails, the injection quantity is reduced and the engine has less output. The cruise control system is also shut off.



351_025

Mass Air Flow (MAF) Sensor G70

The Mass Air Flow (MAF) Sensor G70 is located in the intake manifold. It works according to the hot film principle, and determines the amount of air which is actually taken in.

Signal Usage

The injection quantity and the exhaust gas recirculation quantity are calculated by the ECM on the basis of this signal. The signal is also used to determine the amount of diesel particulate filter contamination.

Effects of Failure

In the event of signal failure, the ECM employs a substitute value comprised of the charge air pressure and engine speed for calculation purposes.

Mass Air Flow (MAF) Sensor G70



351_100

Engine Management

Engine Coolant Temperature (ECT) Sensor G62

The Engine Coolant Temperature (ECT) Sensor G62 is located on the right cylinder head's coolant connection. The sensor provides the ECM with information on the current coolant temperature.

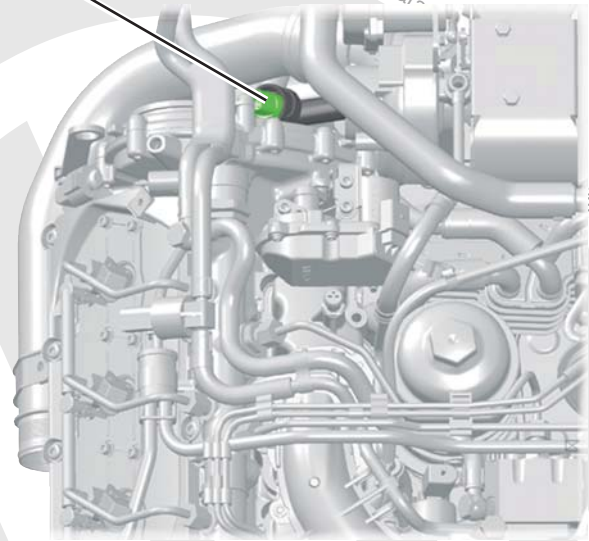
Signal Usage

The coolant temperature is used by the ECM as a correction value for calculating the injection quantity, the charge air pressure, the injection point, and the exhaust gas recirculation quantity.

Effects of Failure

If the sensor signal fails, the ECM uses the signal from the Engine Coolant Temperature (ECT) Sensor (on Radiator) G83 and a fixed, substitute value for calculation purposes.

Engine Coolant Temperature (ECT) Sensor G62



351_029

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

The Engine Coolant Temperature (ECT) Sensor (on Radiator) G83 is located in the line at the radiator outlet, where it measures the outlet temperature.

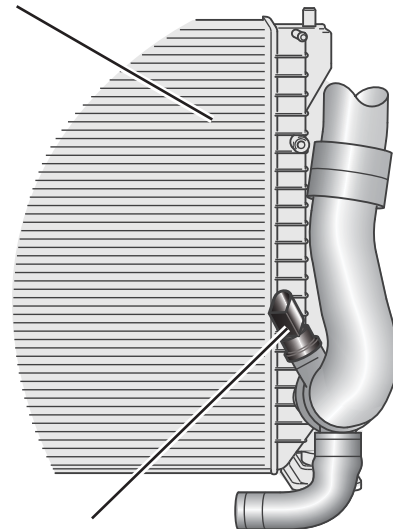
Signal Usage

Radiator fan initialization is carried out by comparing the signals from the two sensors, G62 and G83.

Effects of Failure

If the signal from the Engine Coolant Temperature (ECT) Sensor (on Radiator) G83 fails, radiator fan stage 1 is continuously initialized.

Radiator



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

351_089

Charge Air Pressure Sensor G31 and Intake Air Temperature (IAT) Sensor G42

The Charge Air Pressure Sensor G31 and Intake Air Temperature (IAT) Sensor G42 are integrated into one component and are located in the intake manifold.

Charge Air Pressure Sensor G31 Signal Usage

The ECM uses the sensor's signal to regulate the charge air pressure.

Effects of Charge Air Pressure Sensor G31 Failure

There is no substitute function in the event of signal failure. Charge air pressure regulation is shut off, leading to a significant reduction in engine output.

Intake Air Temperature (IAT) Sensor G42 Signal Usage

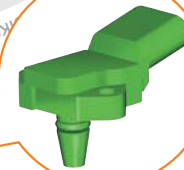
The ECM uses the sensor's signal to calculate a correction value for the charge air pressure. Evaluation of the signal gives consideration to the influence of temperature on the density of the charge air.

Effects of Intake Air Temperature (IAT) Sensor G42 Failure

In the event of signal failure, the ECM employs a fixed, substitute value for calculation purposes. This may lead to reduced engine output.



Front of Vehicle



Charge Air Pressure Sensor G31 and Intake Air Temperature (IAT) Sensor G42

Engine Management

Heated Oxygen Sensor (HO2S) G39

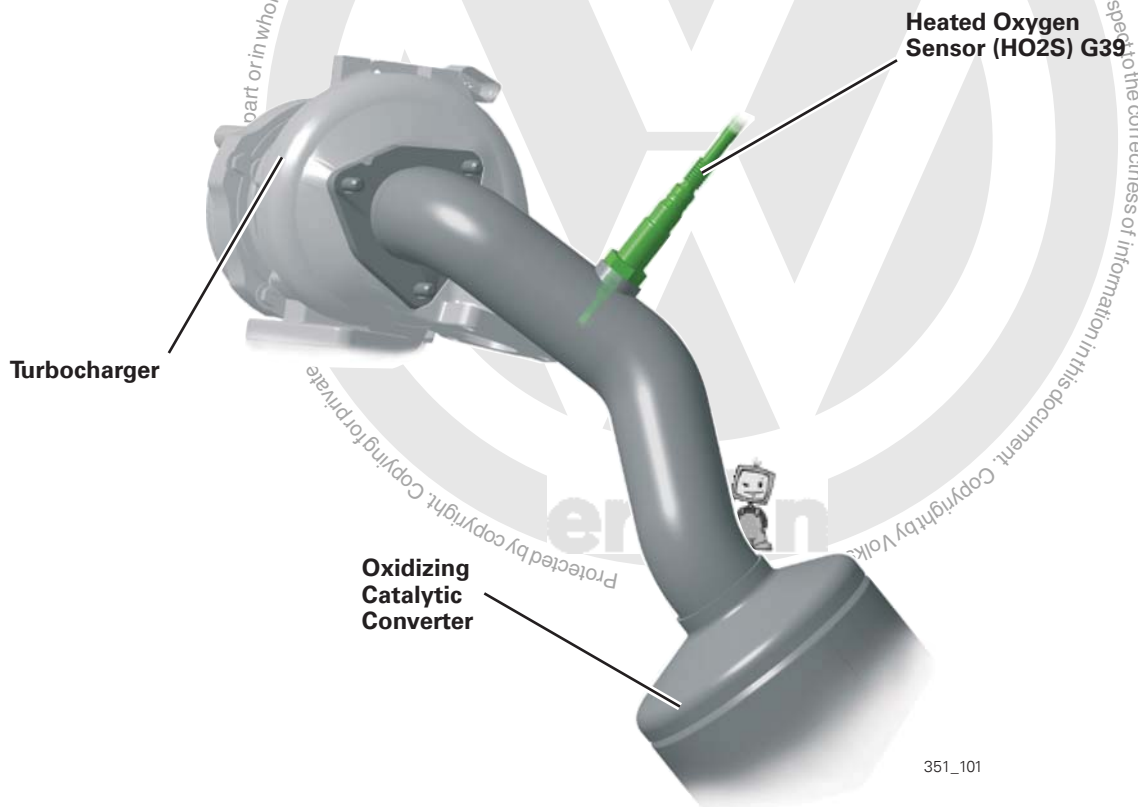
The Heated Oxygen Sensor (HO2S) G39 is a broadband type sensor. The sensor is located upstream of the oxidizing catalytic converter in the exhaust system. It enables determination of the oxygen content in the exhaust gas over a wide measuring range.

Signal Usage

The Heated Oxygen Sensor (HO2S) G39 signal is used to correct the exhaust gas recirculation quantity. The signal also serves to determine the amount of contamination of the diesel particulate filter. In this calculation model, the sensor signal is used to measure the engine's carbon emissions. If the exhaust gas oxygen content is excessively low in comparison with the nominal value, increased carbon emissions are concluded.

Effects of Failure

If the signal fails, the exhaust gas recirculation quantity is determined using the Mass Air Flow (MAF) Sensor G70 signal. As this regulation is not very precise, nitrogen oxide emissions may increase. Calculation of diesel particulate filter contamination is less accurate. However, regeneration of the diesel particulate filter remains reliable.



351_101

Exhaust Gas Temperature (EGT) Sensor 1 G235

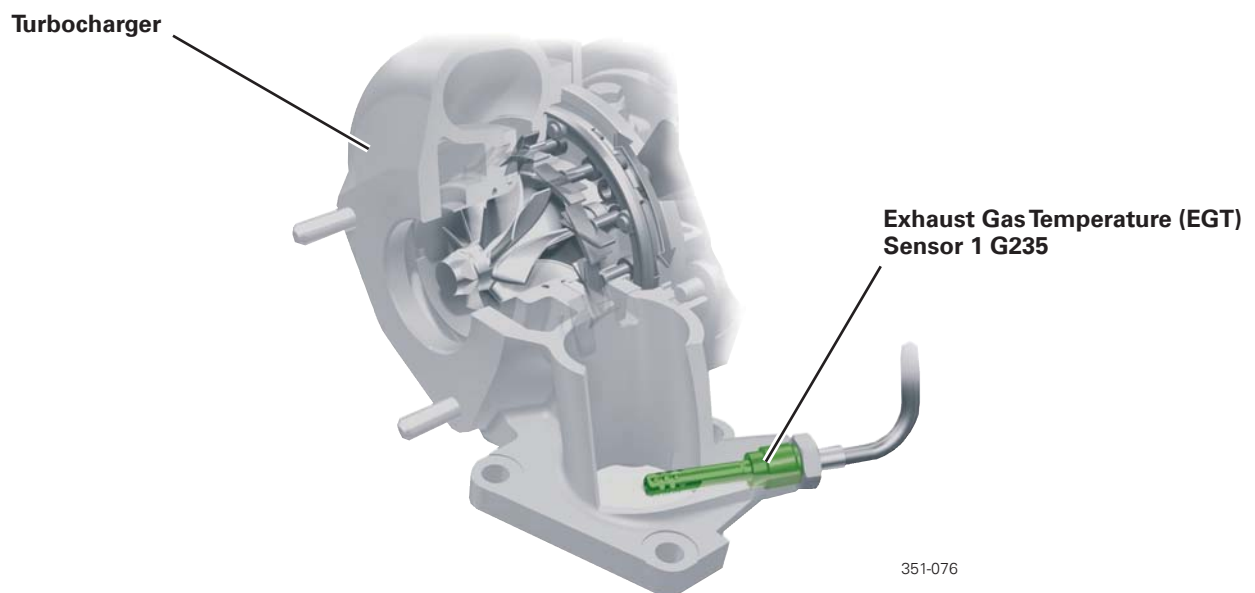
Exhaust Gas Temperature (EGT) Sensor 1 G235 is a PTC sensor. It is located in the exhaust system upstream of the turbocharger, where it measures the temperature of the exhaust gas.

Signal Usage

The ECM uses the Exhaust Gas Temperature (EGT) Sensor 1 G235 signal to protect the turbocharger from unacceptably high exhaust gas temperatures.

Effects of Failure

If the Exhaust Gas Temperature (EGT) Sensor 1 G235 signal fails, the ECM uses a fixed substitute value for calculation purposes and engine output is reduced.



Engine Management

Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448

Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448 is a PTC sensor. It is located in the exhaust system upstream of the diesel particulate filter, where it measures the temperature of the exhaust gas.

Signal Usage

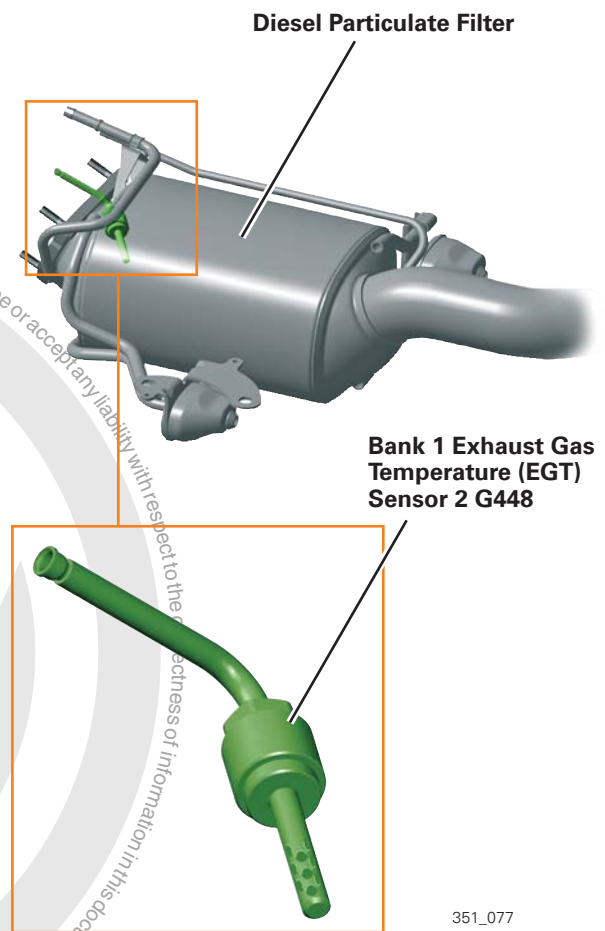
The ECM uses the signal from Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448 to calculate the amount of contamination in the diesel particulate filter.

The diesel particulate filter contamination status is calculated using the signal from the Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448, together with the signals from the Exhaust Pressure Sensor 1 G450, the Mass Air Flow (MAF) Sensor G70, and the Heated Oxygen Sensor (HO2S) G39.

The signal also serves as component protection in order to protect the diesel particulate filter from excessively high exhaust gas temperatures.

Effects of Failure

If the Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448 signal fails, diesel particulate filter regeneration takes place according to the mileage covered or hours of operation. The Malfunction Indicator Lamp (MIL) K83 is activated after three driving cycles.



351_077

Exhaust Pressure Sensor 1 G450

The Exhaust Pressure Sensor 1 G450 measures the difference in pressure in the flow of exhaust gas upstream and downstream of the diesel particulate filter. It is secured to a bracket on the transmission.

Signal Usage

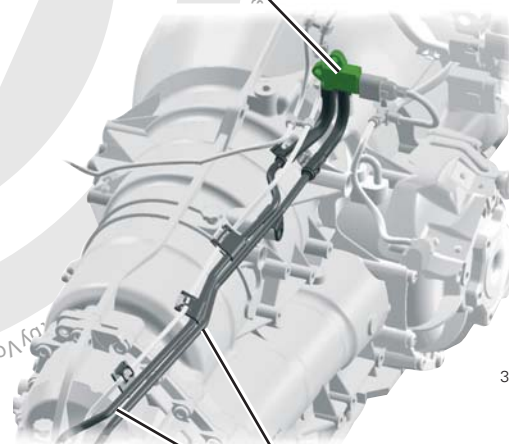
The ECM uses the Exhaust Pressure Sensor 1 G450 signal to calculate the amount of contamination in the diesel particulate filter.

The diesel particulate filter contamination status is calculated using the Exhaust Pressure Sensor 1 G450, together with the signals from the Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448, the Mass Air Flow (MAF) Sensor G70, and the Heated Oxygen Sensor (HO2S) G39.

Effects of Failure

If the Exhaust Pressure Sensor 1 G450 signal fails, diesel particulate filter regeneration takes place according to the mileage covered or hours of operation. Glow Plug Indicator Lamp K29 flashes at the same time. The Malfunction Indicator Lamp (MIL) K83 is activated after three driving cycles.

Exhaust Pressure Sensor 1 G450



351_032

Connections from the Diesel Particulate Filter

Engine Management

Actuators

Intake Flap Motor V157 and Intake Flap Motor 2 V275

The 3.0L V6 TDI engine has one intake manifold flap motor per cylinder bank. They are located on the lower section of the intake manifold on the relevant cylinder bank.

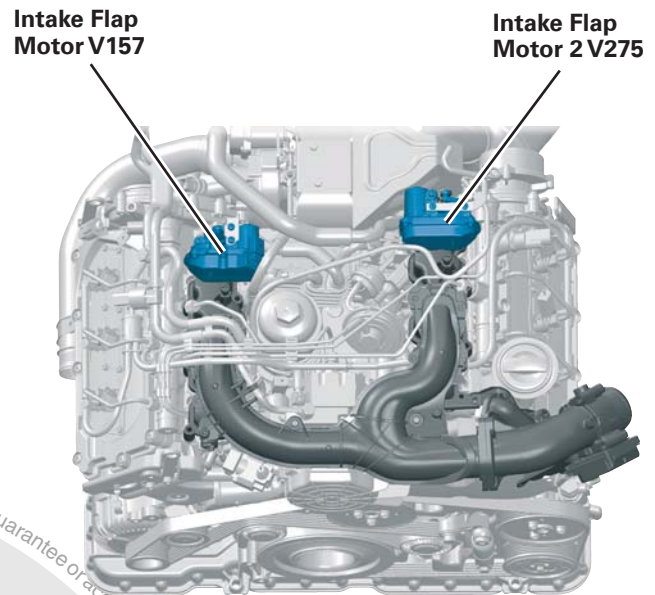
Task

Continuously variable swirl flaps are located in the lower sections of the intake manifolds of both cylinder banks. The swirl of intake air is adjusted by the position of the swirl flaps, depending on the engine speed and load.

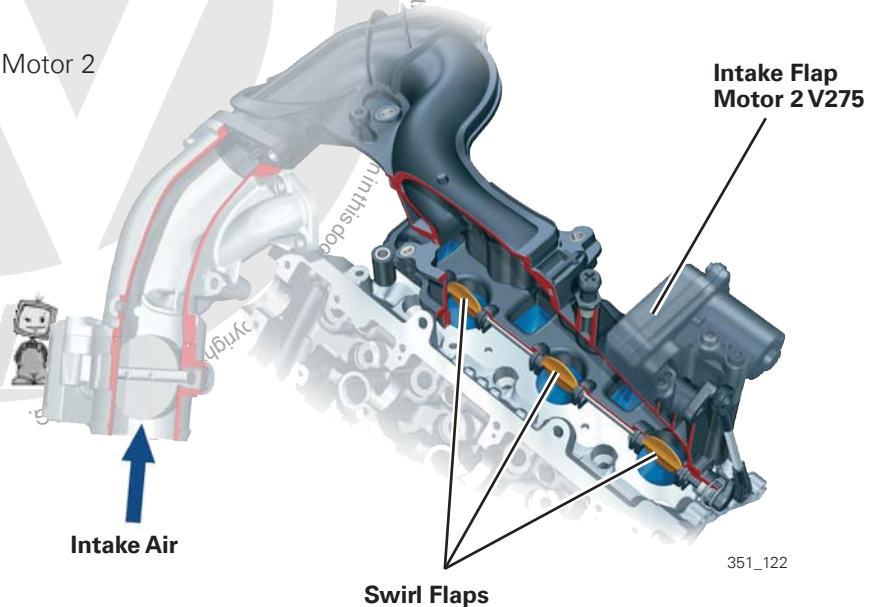
The Intake Flap Motor V157 and Intake Flap Motor 2 V275 have the task of varying the position of the swirl flaps in the intake ports by means of a push rod. To do this, the intake flap motors are initialized by the ECM.

Effects of Failure

If the Intake Flap Motor V157 or Intake Flap Motor 2 V275 fails, the swirl flap remains open.



351_037



351_122

Throttle Valve Control Module J338

The Throttle Valve Control Module J338 is located in the intake port upstream of the upper section of the intake manifold. The throttle valve in J338 is operated by a positioning motor and it is controlled by the ECM.

Task

The continuously variable throttle valve is used in specific operating conditions to generate a vacuum (determined by the ECM) in the intake manifold. This results in more effective exhaust gas recirculation.

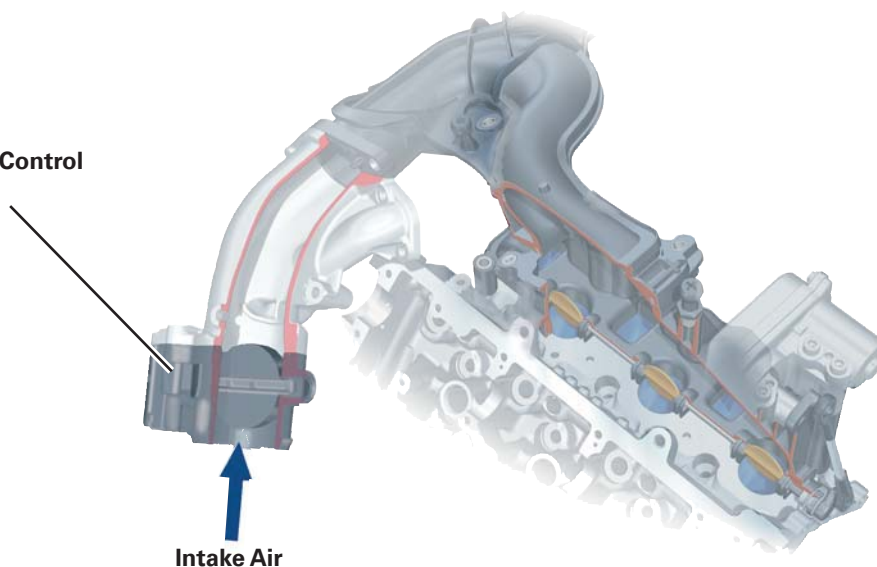
When the engine is switched off, the throttle valve is closed and the air supply is interrupted. Less air is taken in and compressed, and engine shutdown is smooth.

Effects of Failure

The throttle valve remains open. Correct regulation of the rate of exhaust gas recirculation is impossible.



Throttle Valve Control Module J338



Engine Management

Exhaust Gas Recirculation (EGR) Motor V338

The Exhaust Gas Recirculation (EGR) Motor V338 is a positioning motor used to actuate the exhaust recirculation valve.

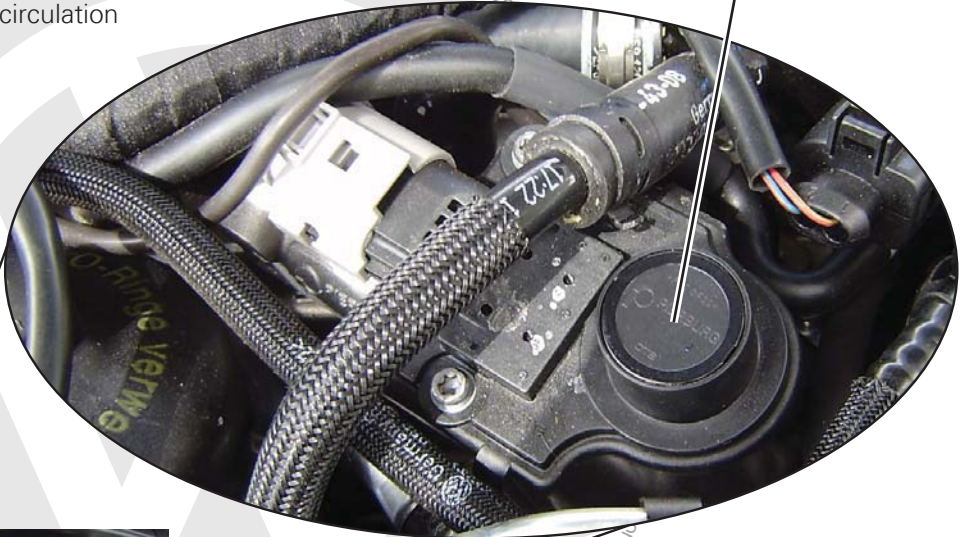
Task

The exhaust gas recirculation rate is determined by means of a performance map in the ECM. Exhaust Gas Recirculation (EGR) Motor V338 receives a pulse-width modulated signal to control the flow of exhaust gas into the intake manifold.

Effects of Failure

If the signal fails, the exhaust gas recirculation function is not reliable.

Exhaust Gas Recirculation (EGR) Motor V338

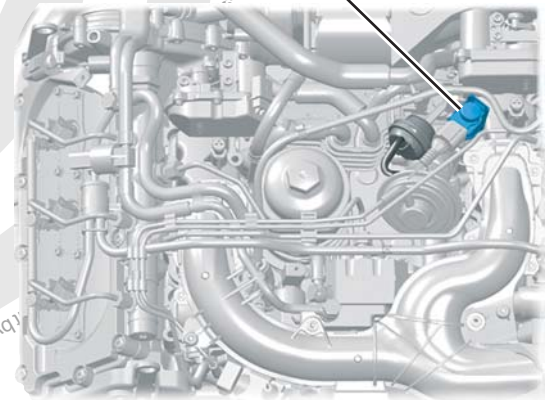


90024150

Exhaust Gas Recirculation (EGR) Cooler Switch Over Valve N345 Exhaust Gas Recirculation (EGR) Cooler Switch-Over Valve 2 N381

The Exhaust Gas Recirculation (EGR) Cooler Switch-Over Valve N345 and Exhaust Gas Recirculation (EGR) Cooler Switch-Over Valve 2 N381 are electropneumatic valves. They switch the vacuum unit's control pressure to actuate the exhaust gas coolers' bypass valves. N345 controls the main cooler bypass, and N381 controls the auxiliary cooler bypass.

Exhaust Gas Recirculation (EGR)
Cooler Switch-Over Valve N345



351_049

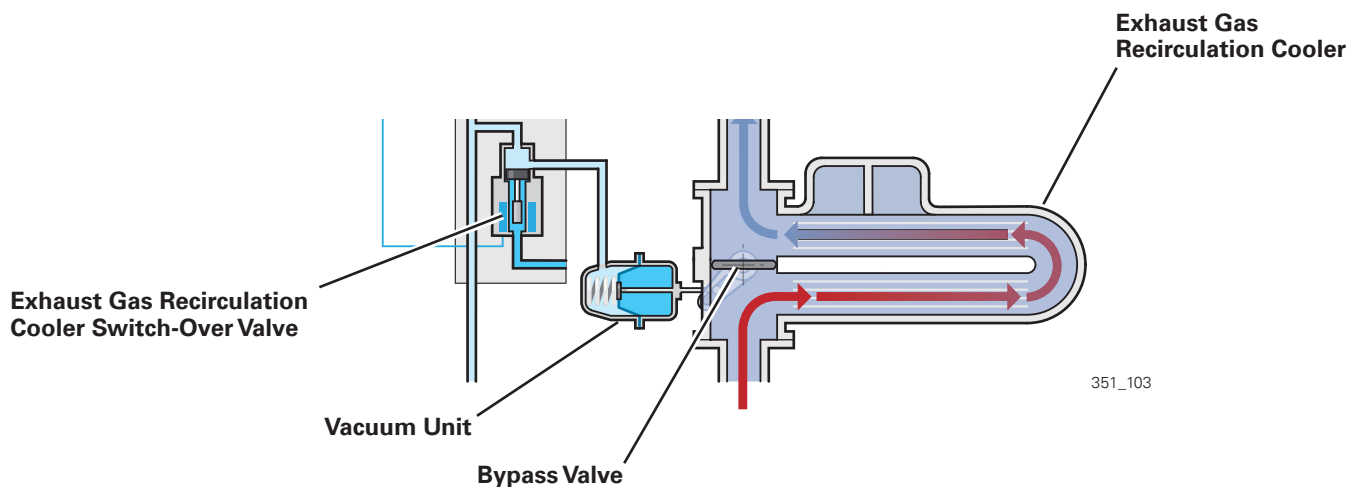
Task

In order to reduce nitrogen oxide emissions even more effectively, the recirculated exhaust gases pass through the exhaust gas recirculation cooler when the engine is at operating temperature.

The bypass valves in the exhaust gas recirculation cooler are actuated to achieve this. The valves are initialized by the ECM depending on the temperature. This then switches the vacuum unit's control pressure to actuate the specific bypass valve.

Effects of Failure

If either valve fails, the controlled exhaust gas recirculation cooler bypass valve remains closed. The exhaust gas is always cooled, and both the engine and the oxidizing catalytic converter take longer to reach their operating temperature.



351_103

Engine Management

Turbocharger (TC) 1 Control Module J724

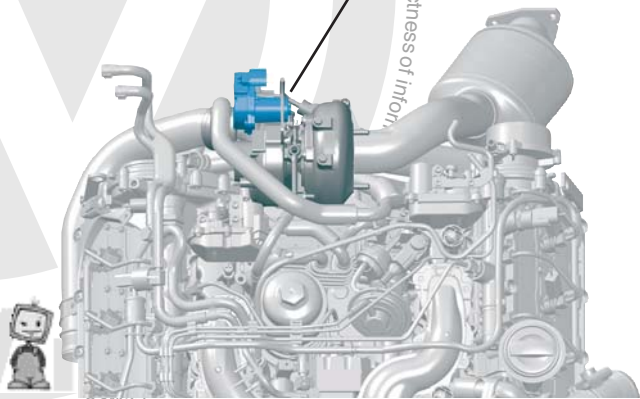
The Turbocharger (TC) 1 Control Module J724 is located on the turbocharger.

Task

The Turbocharger (TC) 1 Control Module J724 controls guide vane adjustment in the turbocharger with an electric positioning motor. Electric initialization makes quick turbocharger response and precise regulation possible.

To adjust the guide vanes, the Turbocharger (TC) 1 Control Module J724 is initialized by the ECM using a pulse-width-modulated (PWM) signal.

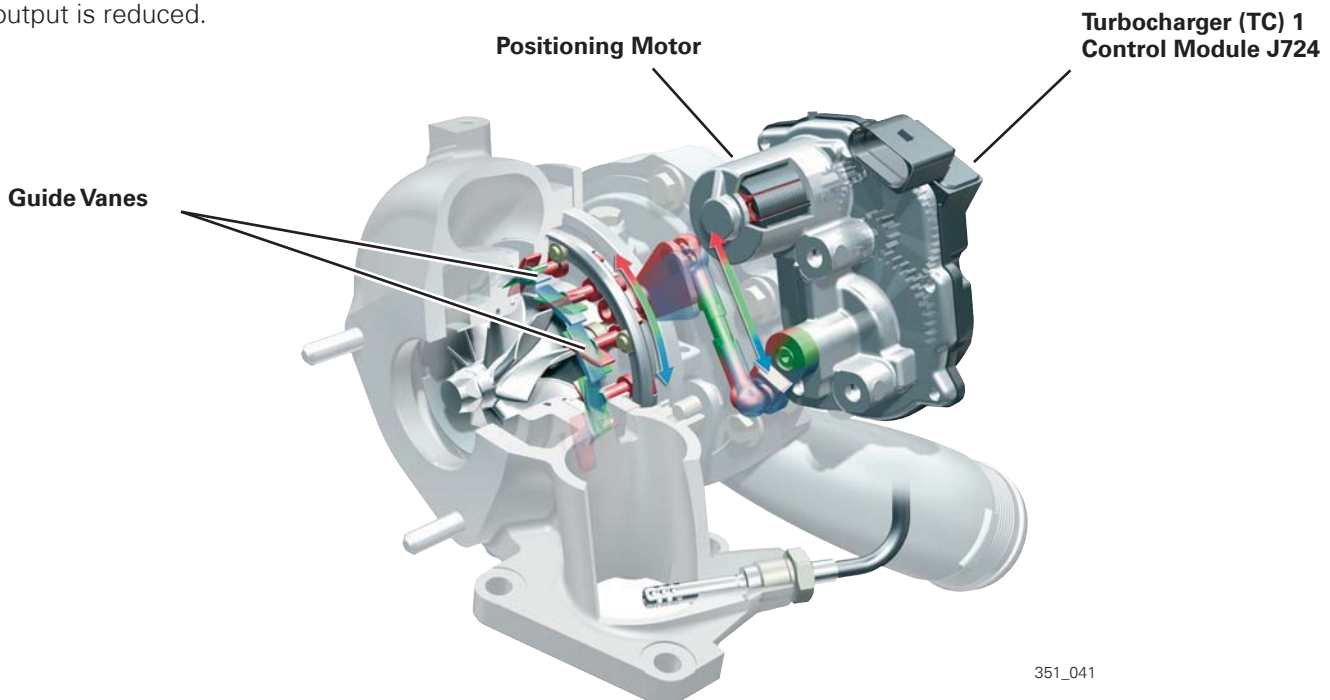
Turbocharger (TC) 1 Control Module J724



351_092

Effects of Failure

No further charge air pressure control is possible in the event of Turbocharger (TC) 1 Control Module J724 failure. The injection quantity is limited and engine output is reduced.

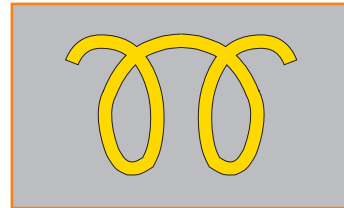


351_041

Glow Plug Indicator Lamp K29

The Glow Plug Indicator Lamp K29 has two functions:

- It illuminates to indicate the glow period to the driver prior to starting the engine
- It flashes to notify the driver of an engine malfunction

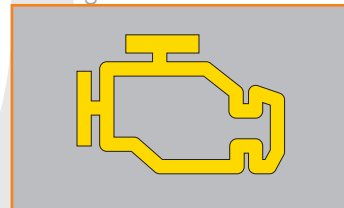


351_113

Malfunction Indicator Lamp (MIL) K83

Those engine management system components relevant to exhaust emissions are checked for failure and malfunctions within the framework of On-Board Diagnosis Second Generation (OBD II).

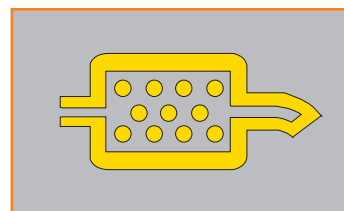
The Malfunction Indicator Lamp (MIL) K83 indicates faults detected by the OBD II system.



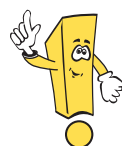
351_113

Diesel Particle Filter Indicator Lamp K231

The Diesel Particle Filter Indicator Lamp K231 illuminates if the diesel particulate filter can no longer be regenerated as a result of operation over extremely short distances. Via this signal, the driver is requested to drive as evenly as possible at increased speed for a short period of time, so that the diesel particulate filter can be regenerated.



351_112



Reference:

For information on driving instructions when the Diesel Particle Filter Indicator Lamp K231 lights up, refer to the vehicle owner's manual.

Engine Management

Glow Plug System

The 3.0L V6 TDI engine has a diesel quick start glow plug system.

This enables immediate starting, like that of a gasoline engine, without a long glow period under practically all climatic conditions.

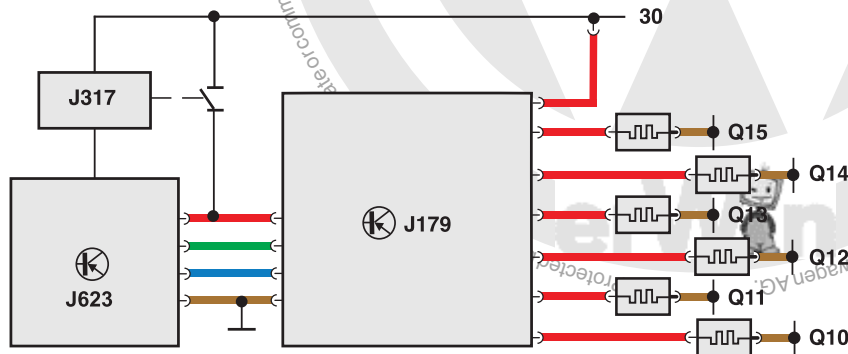
Advantages of this glow plug system include:

- Reliable starting at temperatures down to -11°F (-24°C)
- Extremely rapid heating time:
 - Within two seconds, a temperature of 1832°F (1000°C) is reached at the glow plug
- Controllable glow and post-start glow temperature
- Self-diagnosis-capable
- On-Board Diagnosis Second Generation (OBD II)

The Automatic Glow Time Control Module J179 is provided with information by the ECM for the glow function. The glow period, the glow duration, the initialization frequency and the on-off ratio are therefore determined by the ECM.

Automatic Glow Time Control Module J179 functions include:

- Switching the glow plugs with a PWM signal
- Integrated over-voltage and over-temperature shutoff
- Individual plug monitoring:
 - Detection of over-current and short-circuit in the glow circuit
 - Glow circuit over-current shut-off
 - Glow electronics diagnosis
 - Detection of an open glow circuit in the event of glow plug failure



J179 Automatic Glow Time Control Module
J623 Engine Control Module (ECM)
J317 Power Supply Relay (terminal 30, B+)
Q10–Q15 Glow Plugs

Supply Voltage
Ground
Control Signal from J623
Diagnostic Signal to J623

Glow Plugs Q10 – Q15

The Glow Plugs Q10 – Q15 are made up of the plug body, the connecting pin, and the heating element with heating and control coil.

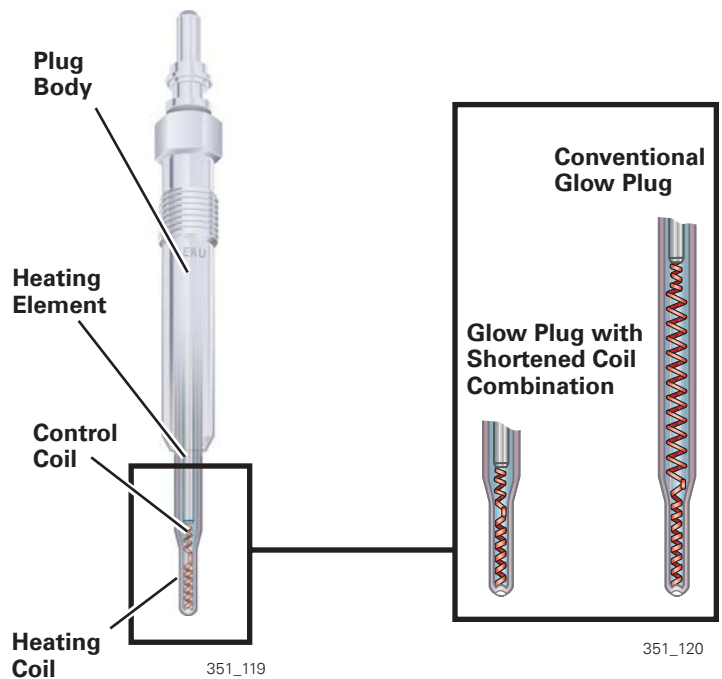
In comparison with conventional, self-regulating glow plugs, the coil combination, comprised of the control coil and the heating coil, is approximately one-third shorter. This has enabled the glow period to be reduced to two seconds.

The glow plugs have a rated voltage of 4.4 V.



Note:

Never apply 12 volts to the glow plugs to check function. Refer to Guided Fault Finding or the Repair Manual for correct glow plug testing procedures.



Glowing

After switching on the ignition, the Glow Plugs Q10 – Q15 are switched on via the Automatic Glow Time Control Module J179 by the ECM at a temperature of less than 68°F (20°C). During the initial glowing phase, the Glow Plugs Q10 – Q15 are operated at a voltage of approximately 11 V for a maximum of two seconds. They are then supplied with the voltage required for the relevant operating status by the Automatic Glow Time Control Module J179. To relieve the onboard power supply, glow plug initialization is phase-offset.

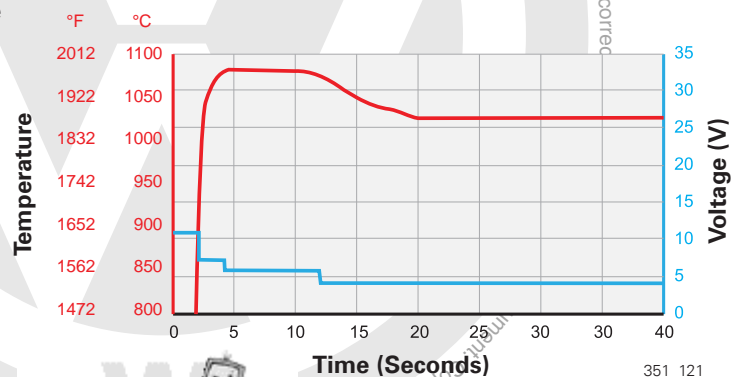
Post-Start Glowing

Post-start glowing is carried out each time after the engine has been started, in order to minimize combustion noise and reduce hydrocarbon emissions. Glow plug initialization is corrected by the ECM depending on load and engine speed.



Note:

Post-start glowing stops when engine coolant temperature reaches 95°F (35°C). Post-start glowing is interrupted after a maximum of three minutes.



Exhaust Treatment

System Overview

Substantial emission and fuel consumption reductions have been made through engine design modifications. Greater reductions in emissions are done through after-treatment of the exhaust gases.

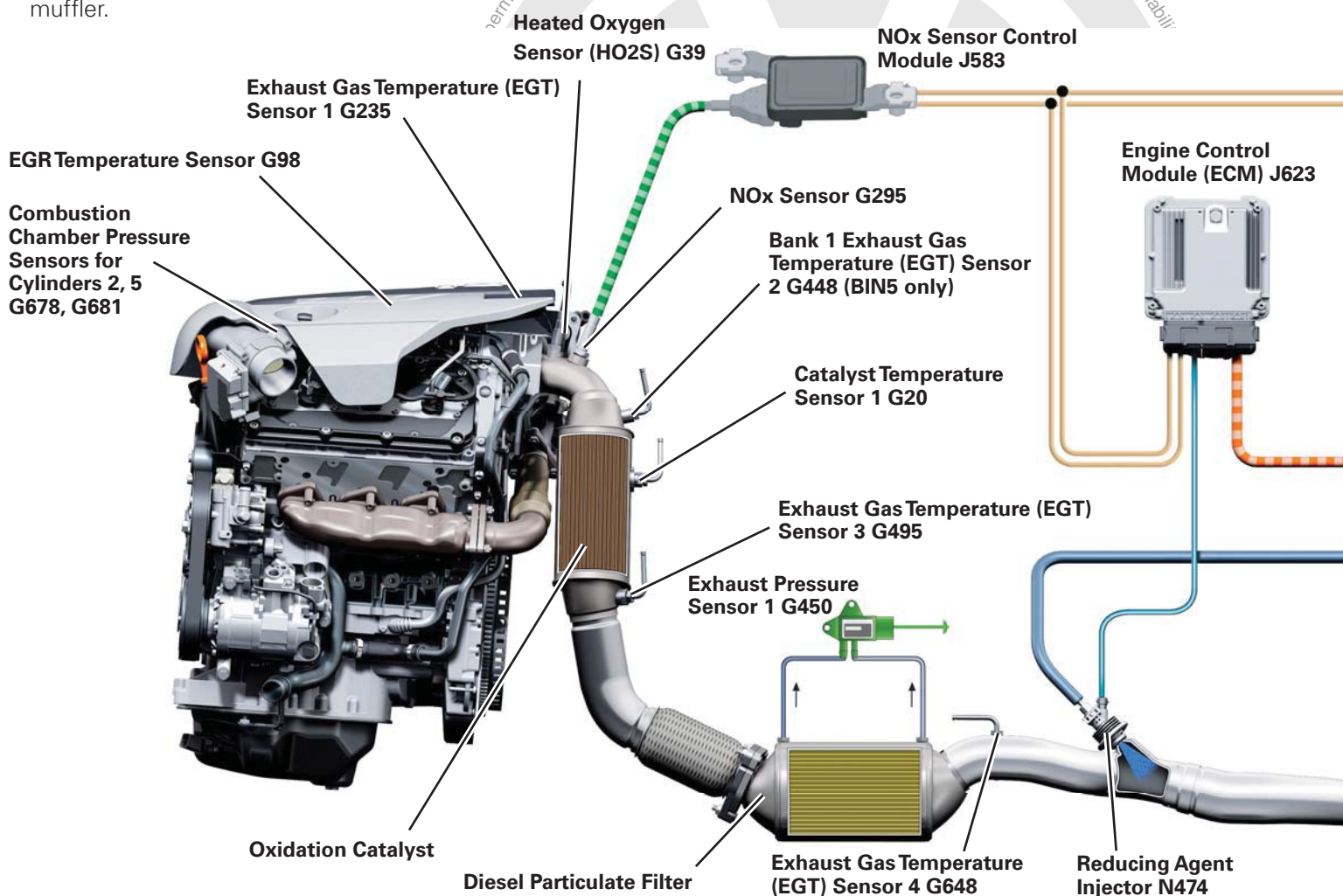
In addition to the known components such as the oxidation catalyst and diesel particulate filter, new components are used to minimize nitrogen oxide emissions.

The exhaust system consists of a close coupled oxidation catalyst, the coated particle filter, the active exhaust gas after-treatment system, as well as the muffler.

The following sensors are integrated into the exhaust system:

- Sensors for temperature measurement upstream and downstream of the oxidation catalyst, downstream of the diesel particulate filter
- Differential pressure sensor for detecting the soot level
- NOx sensors upstream of the oxidation catalyst and downstream of the DeNox catalytic converter

The exhaust gas after-treatment is checked with the help of these sensors.



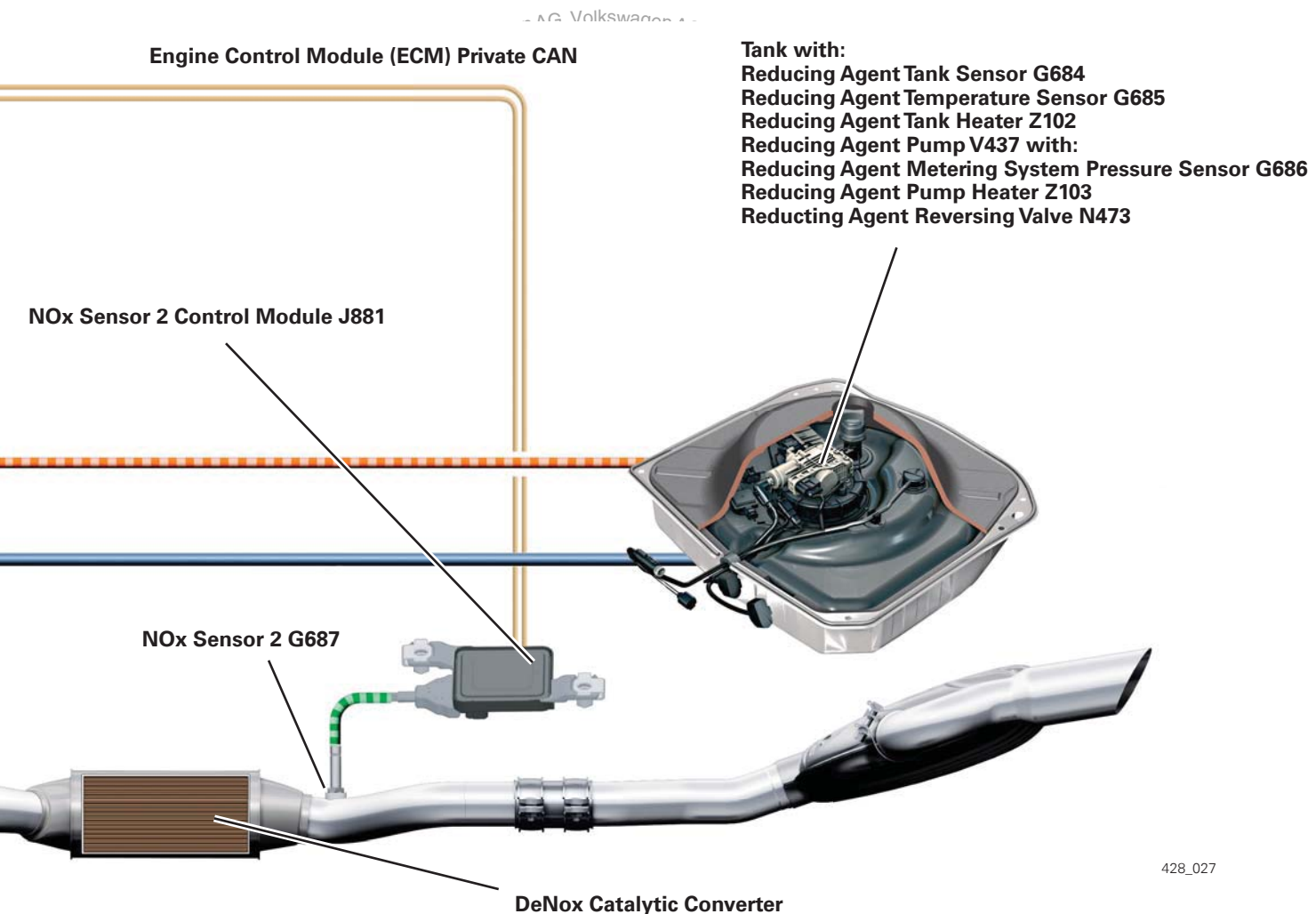
Exhaust Treatment

The exhaust gas after-treatment system consists of the DeNox catalytic converter, the injector for the reducing agent, as well as a tank system for the supply of the reducing agent together with a reducing agent supply unit and reducing agent lines.

Due to the additional DeNox catalytic converter located downstream of the oxidation catalyst and the diesel particulate filter, nitrogen oxide emissions can be nearly eliminated.

DeNox catalytic converter = catalytic converter that reduces nitrogen oxide

For this purpose, a 32.5% urea/water solution is used as a reducing agent (the reducing agent is referred to as Diesel Exhaust Fluid.), which is injected into the exhaust system in small quantities.



Exhaust Treatment

Diesel Particulate Filter

Design

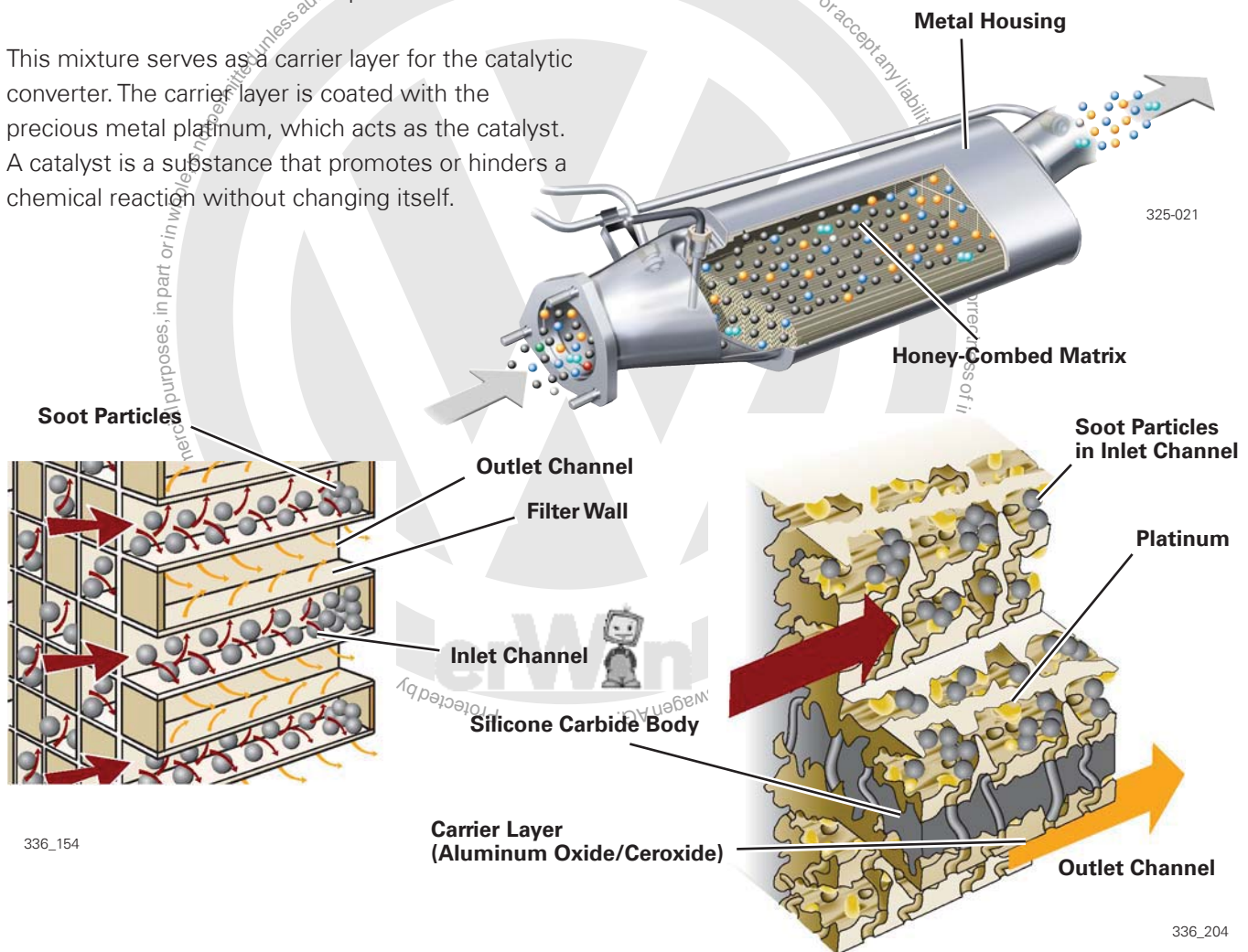
The diesel particulate filter is comprised of a honeycomb ceramic matrix made from silicon carbide placed in a metal housing. The ceramic matrix itself has many small channels that run parallel to each other and are alternately connected. In this way, inlet and outlet channels are created that are separated by filter walls.

The filter walls, made from silicon carbide, are porous. The silicon carbide body is coated with a mixture of aluminum oxide and peroxide.

This mixture serves as a carrier layer for the catalytic converter. The carrier layer is coated with the precious metal platinum, which acts as the catalyst. A catalyst is a substance that promotes or hinders a chemical reaction without changing itself.

Function

Since the channels are sealed alternately in the direction of flow from the inlet and outlet side, the carbon soot contaminated exhaust gas must flow through the porous filter walls made from silicon carbide. When this happens, the carbon soot particles and not the gaseous components are retained in the inlet channels.



Coated Zones

The diesel particulate filter must be long enough to provide sufficient storage volume for the carbon soot. In addition, it must be coated with a certain amount of platinum in order to attain the desired catalytic effect. The catalytic coating of the diesel particulate filter is separated into zones across the length of the filter.

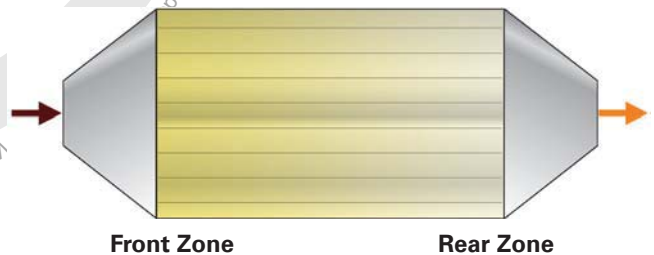
In the front zone, there is a large quantity of platinum and in the rear zone there is less platinum. The following are advantages from the zone-like coating:

- In normal operating modes of the engine, the diesel particulate filter heats up quickly in the front area. Due to the high concentration of platinum in this front zone of the catalyst, the filter has a very fast catalytic effect. The diesel particulate filter responds quickly.
- In regeneration mode, the rear area of the diesel particulate filter becomes very hot as the carbon soot is burned off. Due to these high temperatures, the platinum gets broken down over a period of time. Therefore, expensive raw material is not used as intensively at the rear zone.
- Another reason for reduced use of platinum in the rear zone is the aging of the diesel particulate filter. During operation, more and more ash particulates from regeneration stay in the filter. These impair the catalytic effectiveness of the platinum.

Regeneration

The diesel particulate filter must be cleaned of carbon soot particles regularly to prevent it from becoming blocked, inhibiting its function. During the regeneration phase, the particulates that have accumulated in the particulate filter are burnt off (oxidized).

With regeneration of the catalytic coated particulate filter, passive regeneration and active regeneration are separated. There are no signs to the driver that regeneration is occurring.



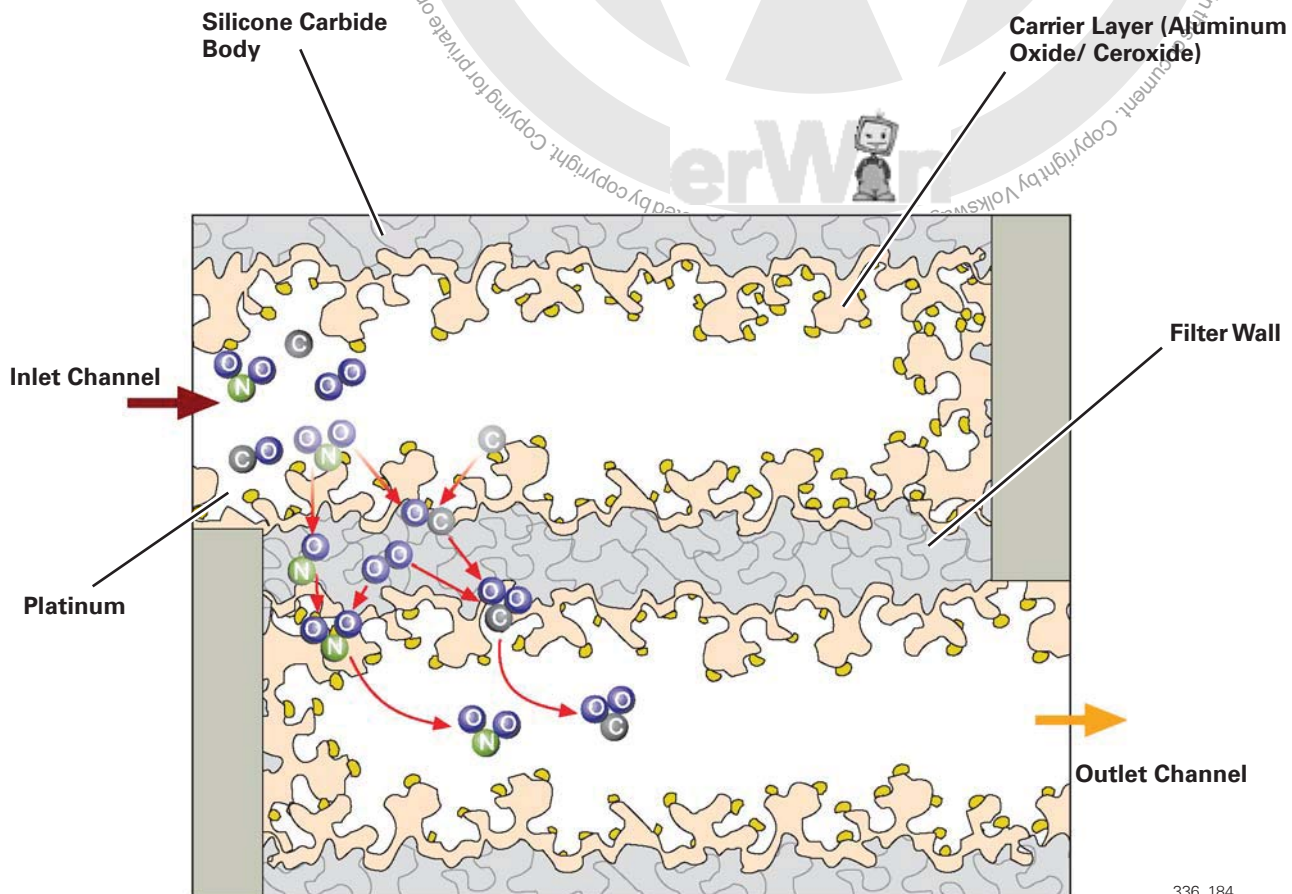
336_010

Exhaust Treatment

Passive Regeneration

With passive regeneration, the carbon soot particles are burned off continually without intervention from the engine management system. The particulate filter is positioned in close proximity to the engine. This assures that exhaust gas temperatures of 660–932°F (350–500°C) are reached during highway driving. The carbon soot particles are converted into carbon dioxide by a reaction with nitrogen oxide. This gradual process occurs slowly and continually through the platinum coating, which works as a catalyst.

From the oxides of nitrogen present in the exhaust gas (NOX) and oxygen (O₂), nitrogen dioxide (NO₂) is produced via the platinum coating. NOX + O₂ reacts to NO₂. The nitrogen dioxide (NO₂) reacts with the carbon (C) of the carbon soot particles. As a result, carbon monoxide (CO) and nitrogen monoxide (NO) are formed. NO₂ + C reacts to CO + NO. The carbon monoxide (CO) and nitrogen monoxide (NO) combine with oxygen (O₂) and form nitrogen dioxide (NO₂) and carbon dioxide (CO₂). CO + NO + O₂ reacts to NO₂ + CO₂.

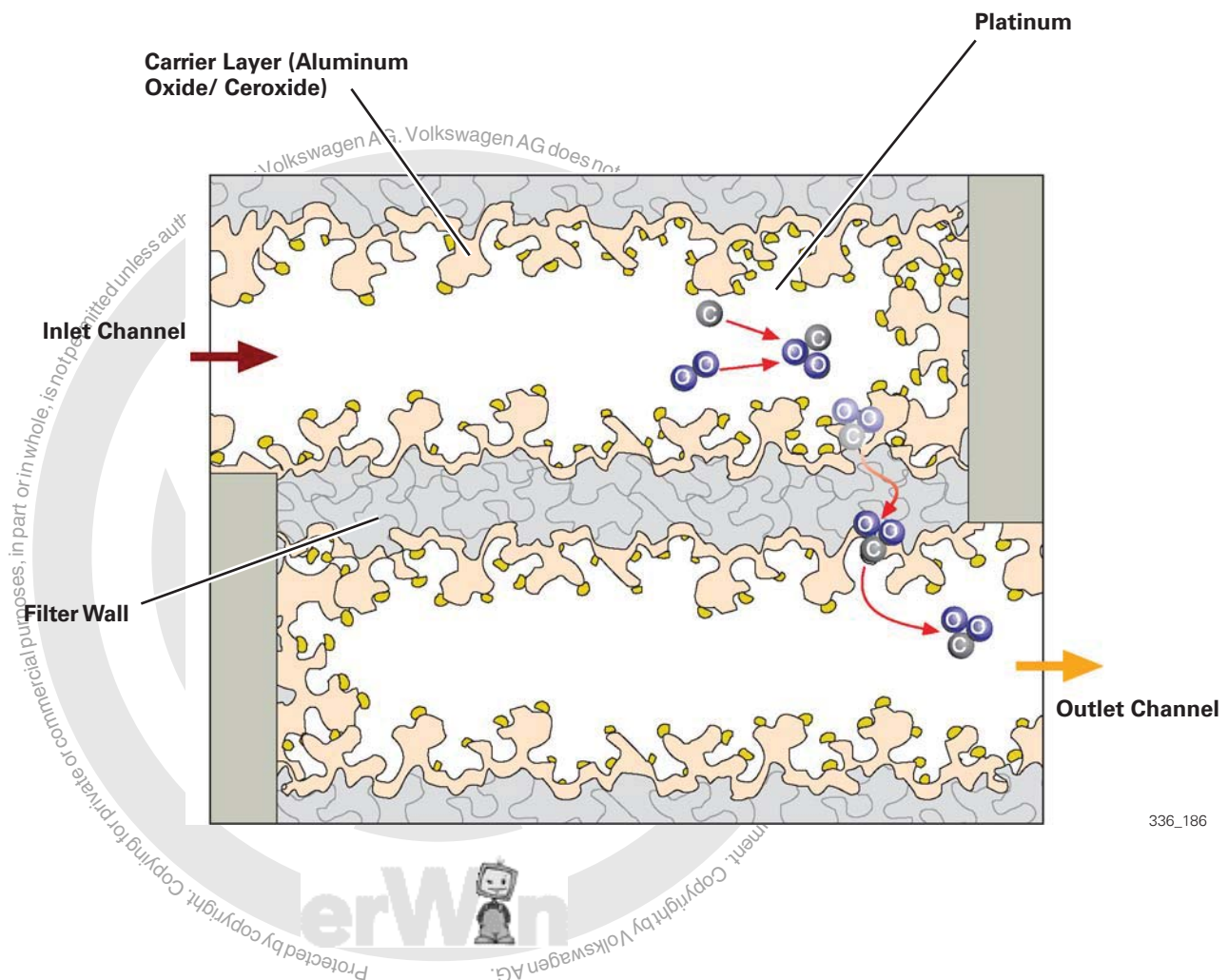


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Active Regeneration

With active regeneration, the carbon soot particles are burned off through a targeted increase in the exhaust gas temperature by the engine management system. In city traffic, which produces low loads on the engine, the exhaust gas temperatures for passive regeneration of the particulate filter are too low. Since the carbon soot particles cannot be broken down, deposits build up in the filter. As soon as a certain level of carbon soot deposits is reached in the filter, active regeneration is initiated by the engine management system. This process lasts for approximately 10 minutes. The carbon soot particles are burned off to carbon dioxide at an exhaust gas temperature of 1110–1200°F (600–650°C).

With active regeneration, the carbon soot particles are burned off by high exhaust gas temperatures. When this happens, the carbon from the soot particles oxidizes with oxygen and forms carbon dioxide. $C + O_2$ reacts to CO_2 .



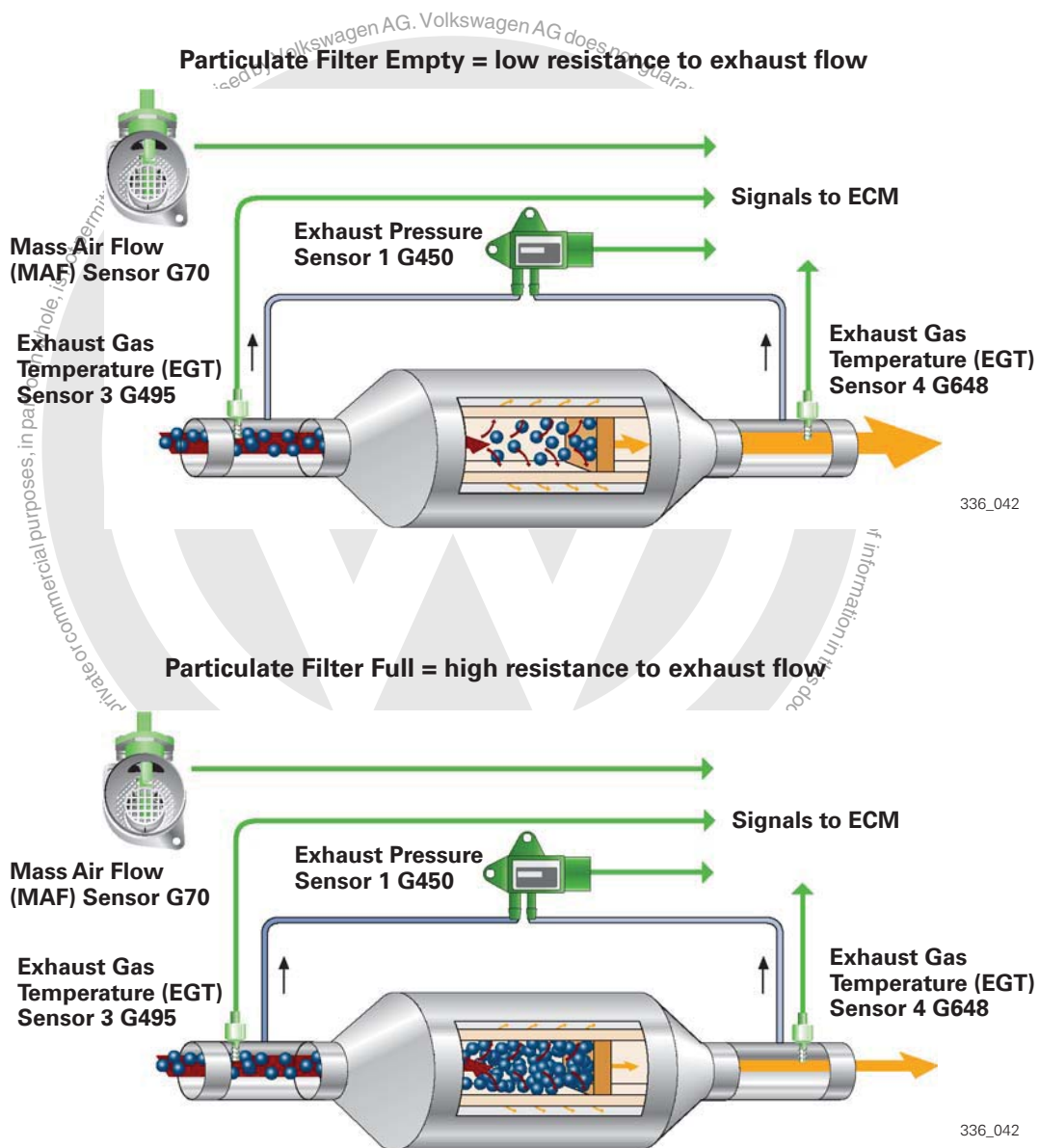
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Exhaust Treatment

Function of Active Regeneration

The carbon soot particles are retained in the inlet channels. The engine control module can detect the level of carbon soot in the particulate filter by evaluating the signals from the mass air flow sensors, the temperature senders before and after the particulate filter, and the exhaust pressure sensors.

When the carbon soot level reaches a predetermined limit, the engine management system initiates active regeneration.

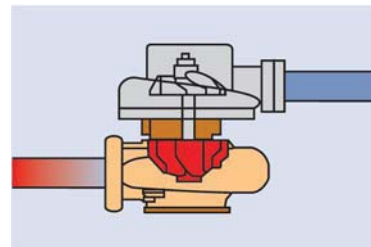
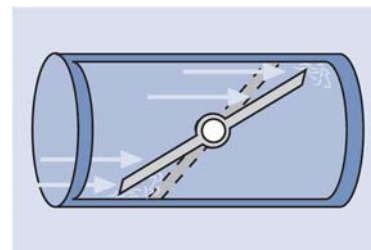
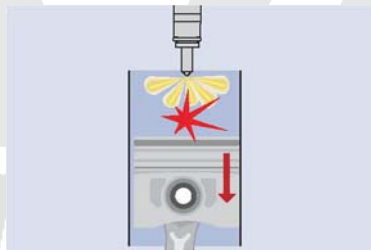
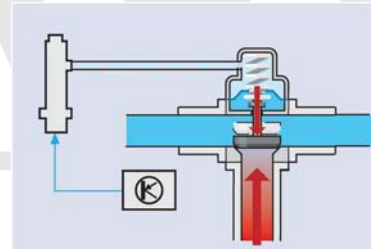


Engine Management During Initiation of Active Regeneration

From the flow resistance of the particulate filter, the engine control module can detect the level of carbon soot deposit in the filter. A high flow resistance indicates that the filter is in danger of becoming blocked. The engine control module initiates an active regeneration process. To do this:

- Exhaust gas recirculation is switched off to raise the combustion temperature
- An extended injection period is initiated after a period of main injection with reduced quantity at 35° crankshaft angle after TDC, in order to increase the exhaust gas temperature
- The intake air supply is regulated by the throttle valve
- The charge air pressure is adapted so that the torque during regeneration does not change noticeably by the driver

These measures lead to a targeted, brief increase in the exhaust gas temperature to approximately 1150°F – 1200°F (600°C – 650°C). In this temperature range, the collective carbon soot oxidizes to carbon dioxide. After this active regeneration period, the particulate filter is ready for operation again and can begin filtering carbon soot out of the exhaust gas.

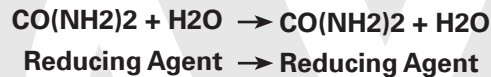


Exhaust Treatment

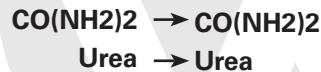
DeNox Catalytic Converter System Operating Principle

The DeNox catalytic converter reaches its 356°F (180°C) operating temperature a few minutes after engine start. When the Exhaust Gas Temperature (EGT) Sensor 4 G648, upstream of the DeNox catalytic converter, transmits this temperature information to Engine Control Module (ECM) J623, the reducing agent can be injected (metered in) by the Reducing Agent Injector N474. Different chemical processes take place as the reducing agent travels to and through the DeNox catalytic converter.

First, if the reducing agent is injected into a hot gas flow, the water evaporates.



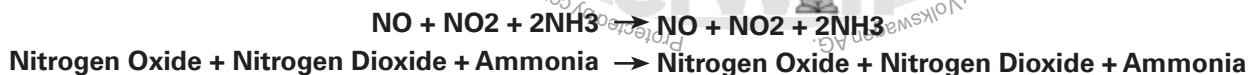
This is followed by thermolysis, during which urea decomposes into ammonia and isocyanic acid.



If hot surfaces are available, the isocyanic acid can be converted into carbon dioxide and another ammonia molecule through hydrolysis**.



Ammonia is stored in the DeNox catalytic converter and reacts with the nitrogen oxide (NO) and nitrogen dioxide (NO₂) from the exhaust flow to form nitrogen (N₂) and water (H₂O).



The water needed for the reaction is available in the exhaust flow as a product of the engine combustion processes. Thus, two ammonia molecules can be gained from one urea molecule and used for reactions on the reduction converter.



* Thermolysis = A chemical reaction where a chemical substance breaks up into several chemical substances when heated.

** Hydrolysis = Splitting a chemical compound using water.

Diesel Exhaust Fluid (Reducing Agent)

An extremely pure, transparent 32.5% urea/water solution is used as reducing agent, which is marketed in Europe under the brand name AdBlue® and in the U.S. under the designation Diesel Exhaust Fluid.

The reducing agent is non-hazardous, non-combustible, biodegradable, and categorized in the lowest water hazard class. It is not a hazardous substance or hazardous material.

Properties:

- It freezes at 12°F (-11°C)
- At temperatures of approximately 158 – 176°F (70 – 80°C), the reducing agent decomposes and there can be objectionable odors due to the development of ammonia
- Because of its unpleasant odor, aged reducing agent can be distinguished from the fresh solution, which is nearly odorless
- Aged reducing agent or other foreign material added to the tank is recognized by the NOx sensors in the exhaust system
- Escaping reducing agent crystallizes forming white salts
- The reducing agent has a high penetration ability and reaches the narrowest spaces due to the capillary effect

Handling:

- Use the Diesel Exhaust Fluid (reducing agent) released by Volkswagen/Audi according to Volkswagen standard and DIN 70070. Foreign media can damage the DeNox system.
- Do not reuse drained reducing agent to prevent impurities.
- The reducing agent should be added to the tank using only the released tools and containers specified by the from the tool kit.



Diesel Exhaust Fluid Refill Bottle 0.5 gallon (1.89 liter)

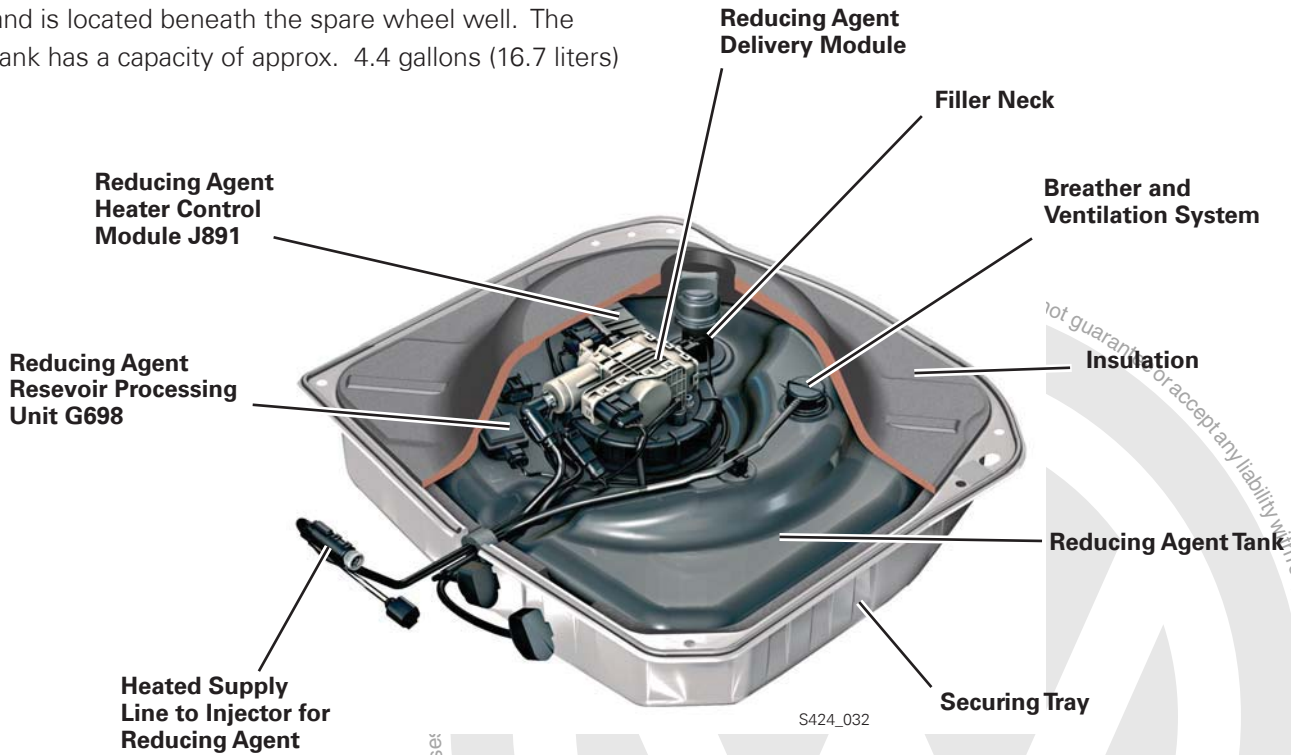


**Diesel Exhaust Fluid
2.6 gallon (10 liter) Containers**

Exhaust Treatment

Reducing Agent Tank System

The reducing agent tank is manufactured from plastic and is located beneath the spare wheel well. The tank has a capacity of approx. 4.4 gallons (16.7 liters)



- Reducing agent delivery module – the delivery module contains the sensors and actuators for delivering the reducing agent through the system.
- Reducing agent level evaluation unit – the evaluation unit measures the fluid level in the reducing agent tank.
- Control module for reducing agent heater – the control module actuates the reducing agent tank system heaters.
- Polypropylene foam insulation – the insulation

serves to protect the reducing agent from high and low ambient temperatures.

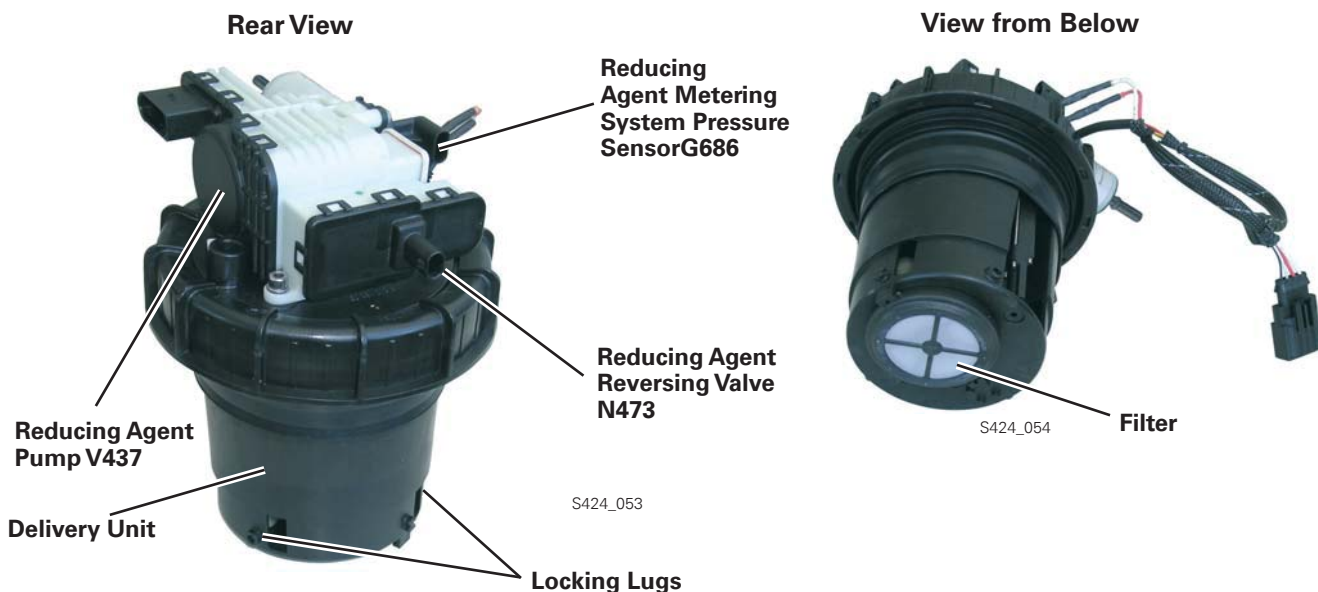
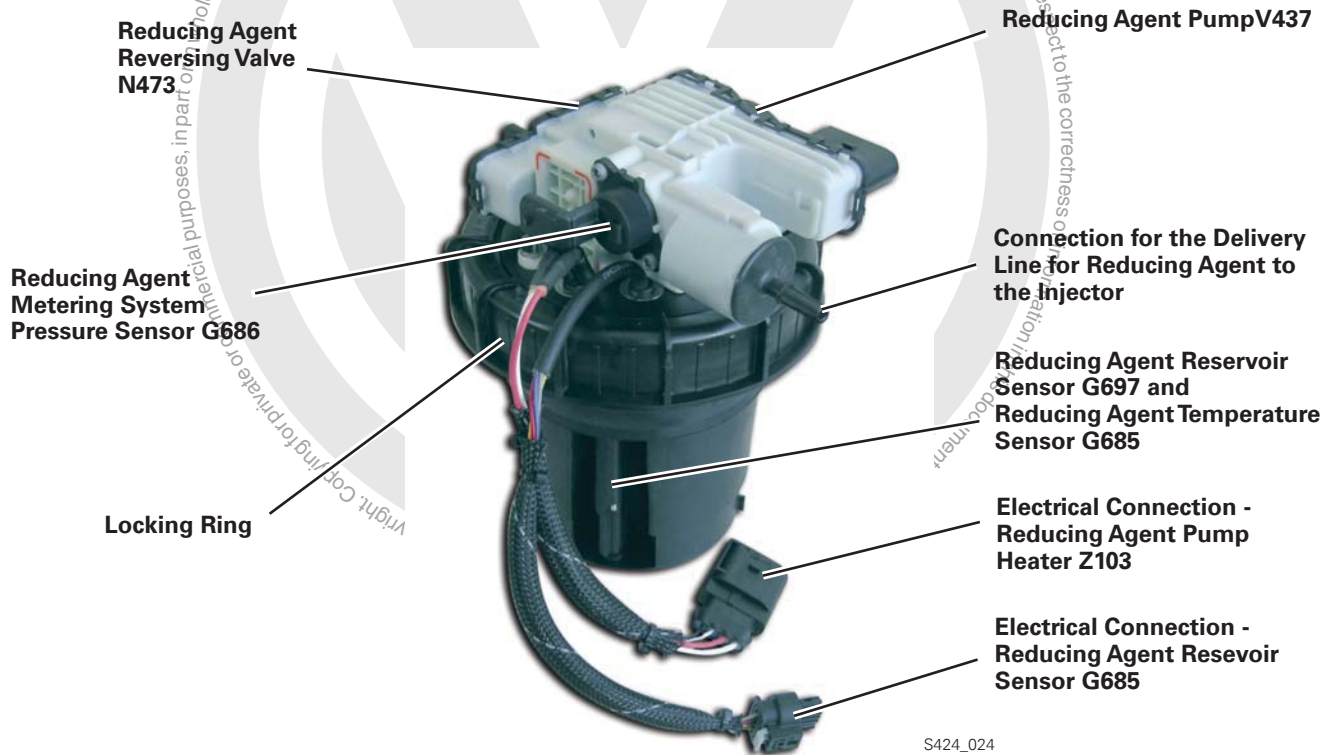
- Breather and ventilation system – the reducing agent tank system is virtually sealed from the outside using breather and ventilation system connections. Reducing agent tank pressure compensation takes place over a long period of

When filling the reducing agent tank, a sufficiently large expansion volume is necessary for the reducing agent in the tank. Only the intended containers and filling systems guarantee the correct filling speed and prevent overfilling the tank. These containers ensure that all gases from the tank are trapped in the containers and do not enter the atmosphere.

Always use the VAS 6542 bottle to ensure correct filling of the tank.

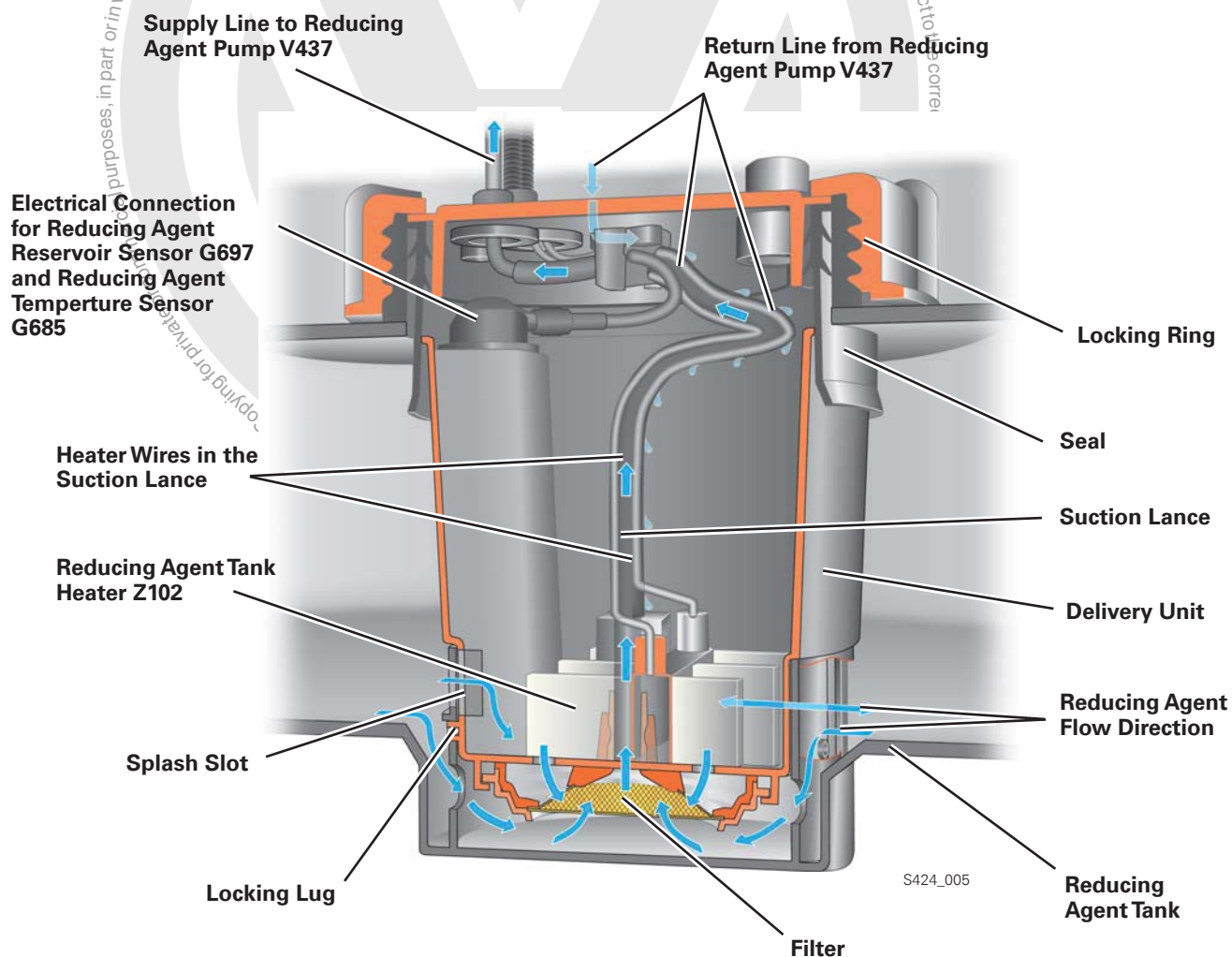
Reducing Agent Delivery Module

The reducing agent delivery module is secured with locking lugs in the tank and a locking ring on the upper side of the tank. The following components are integrated into the delivery module:



Exhaust Treatment

Delivery Unit

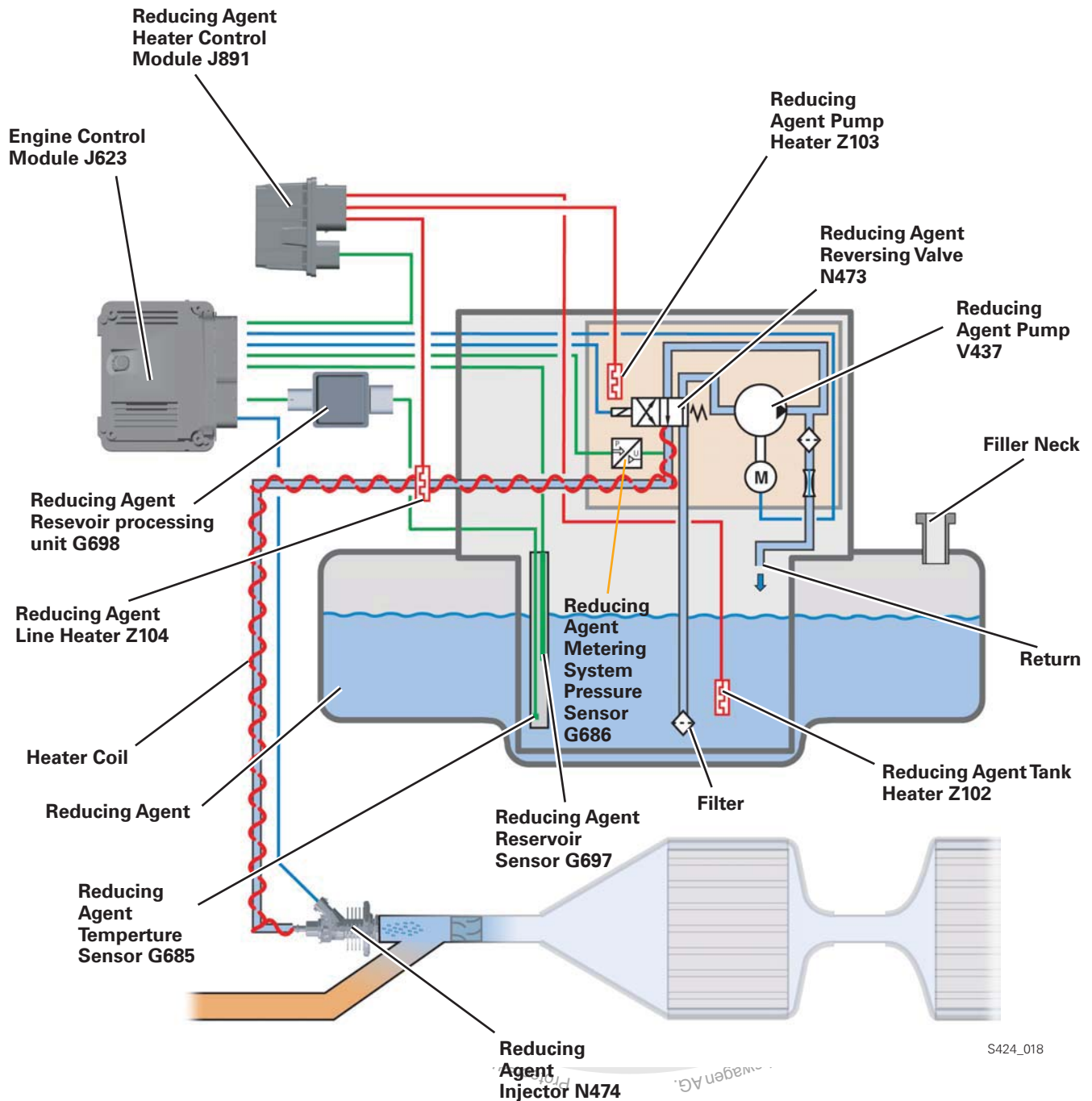


The reducing agent is sucked out of what is called the delivery unit via a suction lance and a filter by the reducing agent pump. The filter is intended to avoid damage to the SCR system caused by particles of dirt in the reducing agent. A heater in the delivery unit ensures that SCR operation is possible even at low exterior temperatures. Any reducing agent flowing back from the pump drips back into the delivery unit on the outer side of the suction lance.

The reducing agent enters the delivery unit from the tank via splash slots. At low temperatures, the splashing motion of the reducing agent from the delivery unit thaws out the frozen reducing agent in the tank.

Exhaust Treatment

Schematic Structure of the Reducing Agent Tank System



Exhaust Treatment

Reducing Agent Pump V437

The pump for reducing agent is a diaphragm pump. It is driven by a brushless direct current motor.

The pump for reducing agent is integrated into the delivery module housing and is actuated by the engine control module.

Tasks

The pump for reducing agent's tasks differ depending on the position of the reversing valve:

- When the ignition is switched on and the operating conditions for the SCR system are met, the pump delivers the reducing agent from the tank to the injector at a pressure of approx. 5 bar.
- When the diesel engine is switched off, it pumps the reducing agent out of the delivery line from the injector and back into the tank.

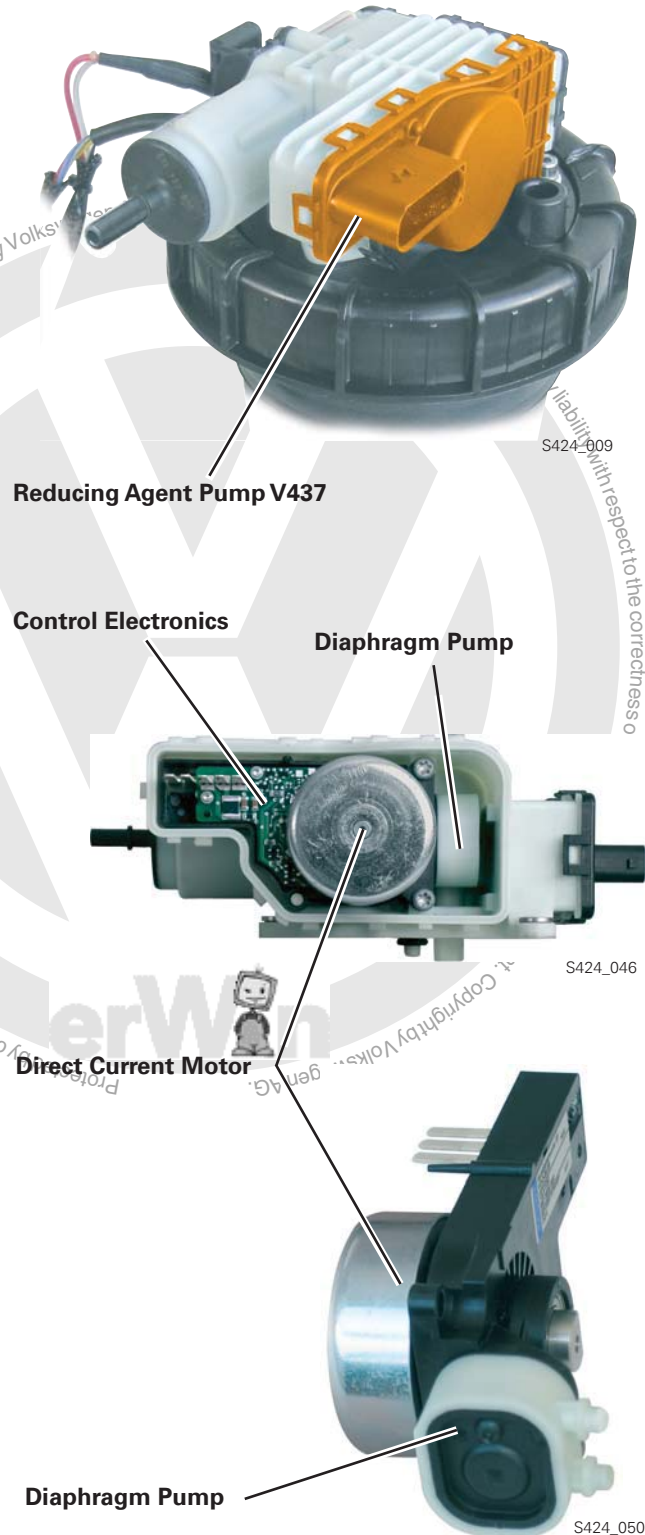
How it works

The engine control module actuates the motor with a pulse-width-modulated signal. The motor drives the diaphragm pump via a connecting rod. When the SCR system is active, the reducing agent is sucked out of the tank via the diaphragm pump and is pumped into the delivery line.

Effects in the event of failure

If the pump for reducing agent fails, the SCR system is unable to function.

The exhaust malfunction indicator lamp K83 (MIL) and the diesel exhaust fluid® warning display for system faults in the dash panel insert display are switched on.



Reducing Agent Metering System Pressure Sensor G686

The pressure sender for reducing agent metering system is attached to the delivery module. It determines the current for the reducing agent delivery pressure and transmits a voltage signal to the engine control module.

Reducing Agent Metering System Pressure Sensor G686



S424_065

Signal Use

Based on the signals, the engine control module calculates the reducing agent pressure in the line to the injector. This enables the engine control module to regulate the pump motor's speed and adapt the pump's required delivery rate.



S424_065

Effects in the event of failure

If the signal from the pressure sender for reducing agent metering system fails, reducing agent metering is switched off. The SCR system is unable to function. The exhaust emissions warning lamp K83 (MIL) and the diesel exhaust fluid warning display for system faults in the dash panel insert display are switched on.

Voltage-pressure chart (transmission function)



S424_022

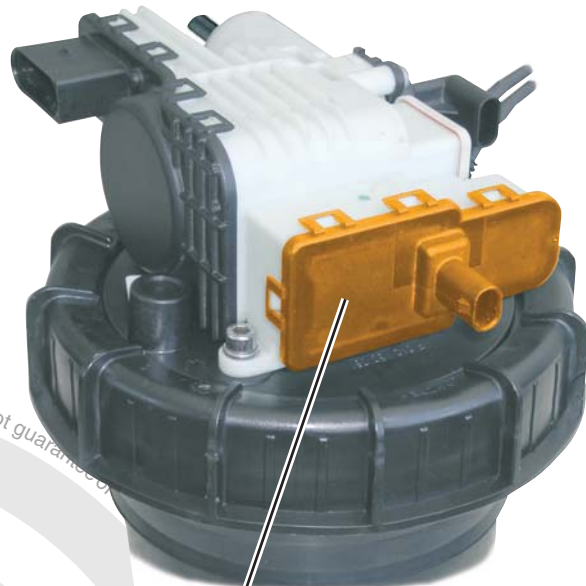
Exhaust Treatment

Reducing Agent Reversing Valve N473

The reversing valve for reducing agent is a 4/2-way directional control valve. It is integrated into the reducing agent delivery module.

Task

When the diesel engine is switched off, the reversing valve for reducing agent reverses the direction of reducing agent delivery. As a result, the reducing agent is returned from the delivery line to the reducing agent tank. This precautionary measure prevents the reducing agent from freezing in the delivery line and in the injector at low exterior temperatures.



S424_010

Reducing Agent Reversing Valve N473



S424_039

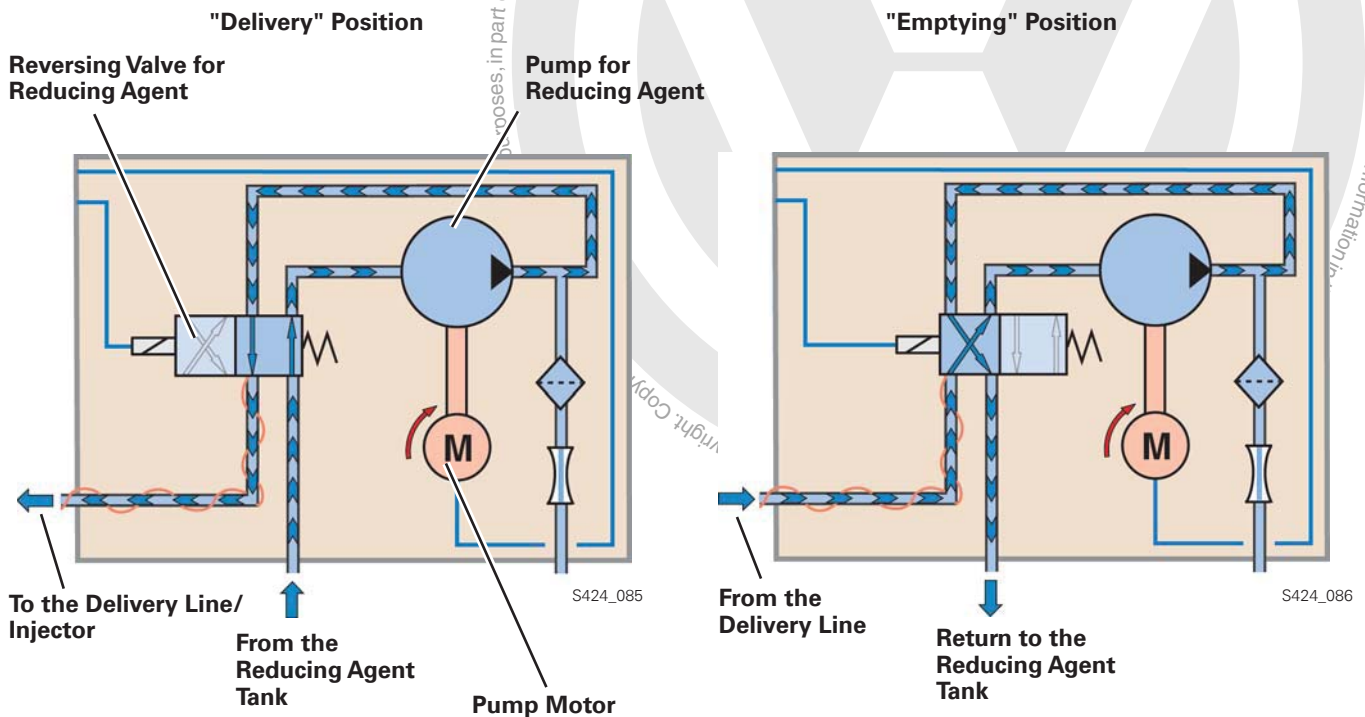
Reducing Agent Reversing Valve N473

Exhaust Treatment

How it Works

When the diesel engine is switched off, the reversing valve for reducing agent reverses the direction of reducing agent flow. To achieve this, the lifting magnet is actuated via a coil. The coil is actuated by the engine control module. Via a guide plate, the lifting magnet then switches the valve to the "emptying" position.

The pump motor, which only rotates in one direction, pumps the reducing agent from the delivery line back into the reducing agent tank.



Effects in the event of failure

In the event that the reversing valve for reducing agent fails, the reducing agent may possibly freeze in the delivery line and in the injector at low exterior temperatures.

If the valve remains in the "emptying" position, pressure build-up in the system is not possible. The exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are actuated.



The process for emptying the delivery line takes approx. 60 seconds. The vehicle battery must not be disconnected during this time, as the risk of reducing agent freezing in the delivery line at low exterior temperatures may occur.

Exhaust Treatment

Reducing Agent Reservoir Processing Unit G698

The reducing agent level sender is a sensor with four stainless steel level sensors. It is located directly in the delivery unit.

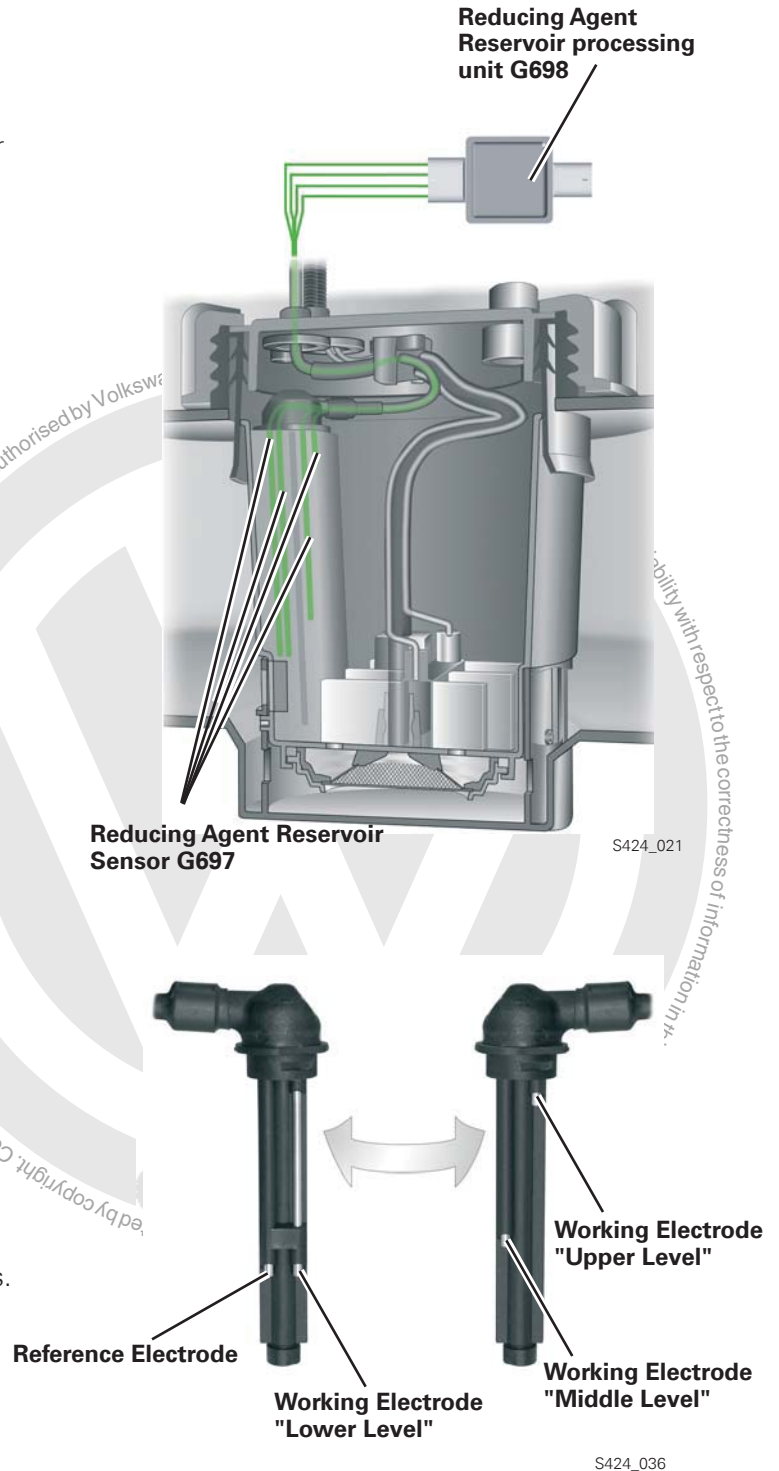
The evaluation unit evaluates the signals from the reducing agent tank sender and transmits a pulse width-modulated signal (PWM signal) to the engine control module. It is secured externally, to the top of the tank.

Task

The evaluation unit uses the signals from the reducing agent tank sender to determine three different reducing agent tank levels. The three different measured level values are required for different display warning stages for refilling the reducing agent.

Design

The four stainless steel level sensors serve the evaluation unit as operating and reference electrodes.



Exhaust Treatment

How it Works

The electrical conductivity of the reducing agent between the fluid level sensors (working electrodes) and the reference electrode is used to determine the tank's fluid level.

At short intervals, the evaluation unit applies an alternating voltage to the working electrodes and the reference electrode.

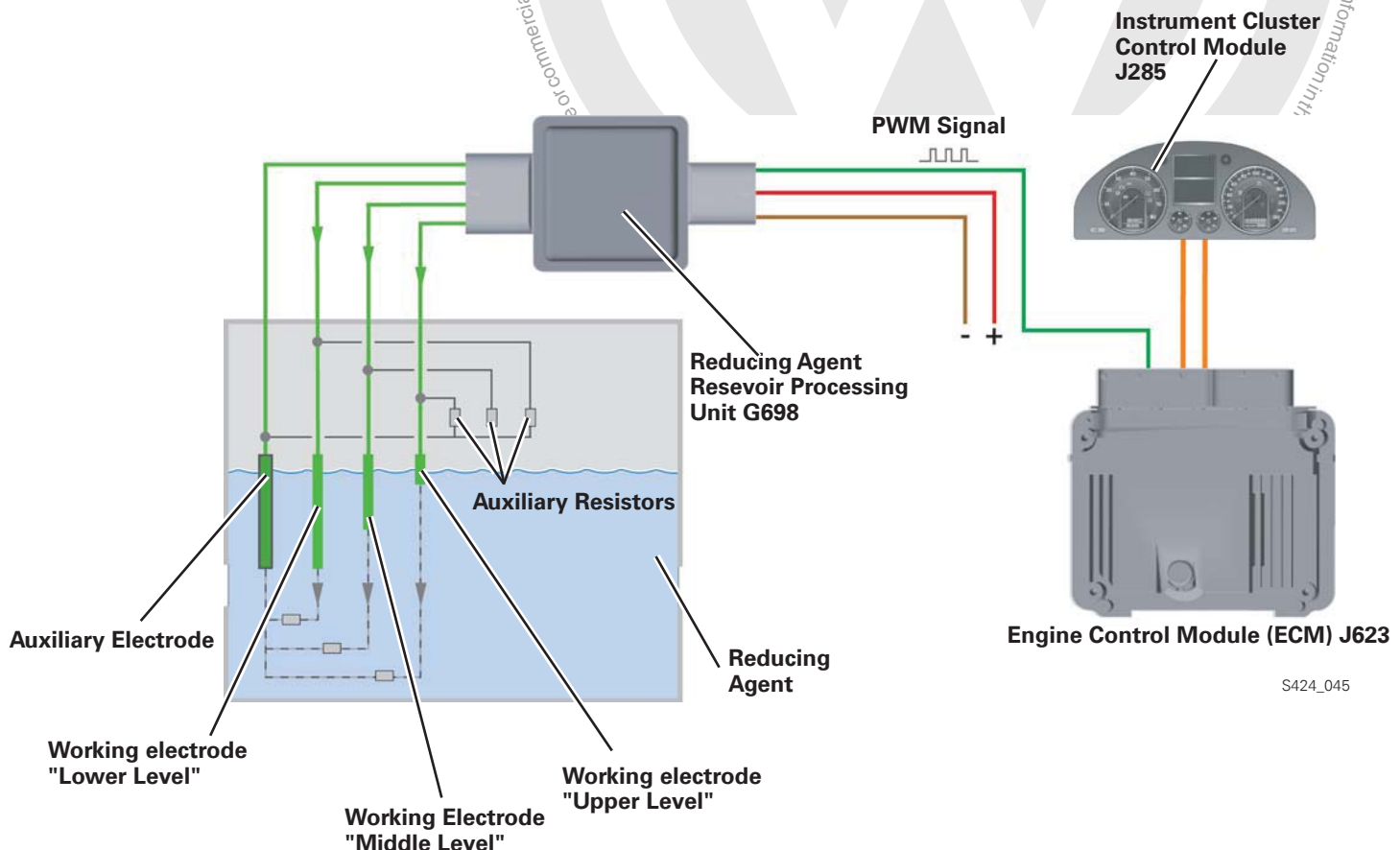
An electrical current is able to flow between two fluid level sensors (working electrode and reference electrode) when both are immersed in the reducing agent.

Based on the electrical conductivity, the evaluation unit determines whether the fluid level is above or below the relevant measuring sensor.

The resistance between the two measuring sensors changes due to the presence and absence of the reducing agent. This change in resistance is registered by the evaluation unit and is processed as a signal for the engine control module. "Splash conditions" are electronically "damped" by the evaluation unit.

Refilling is detected by the system after a delay due to the "electronic damping".

In order to point out to the driver that reducing agent should be replenished in the event of low fluid levels, the engine control module transmits a signal to the control module in Instrument Cluster Control Module J285.



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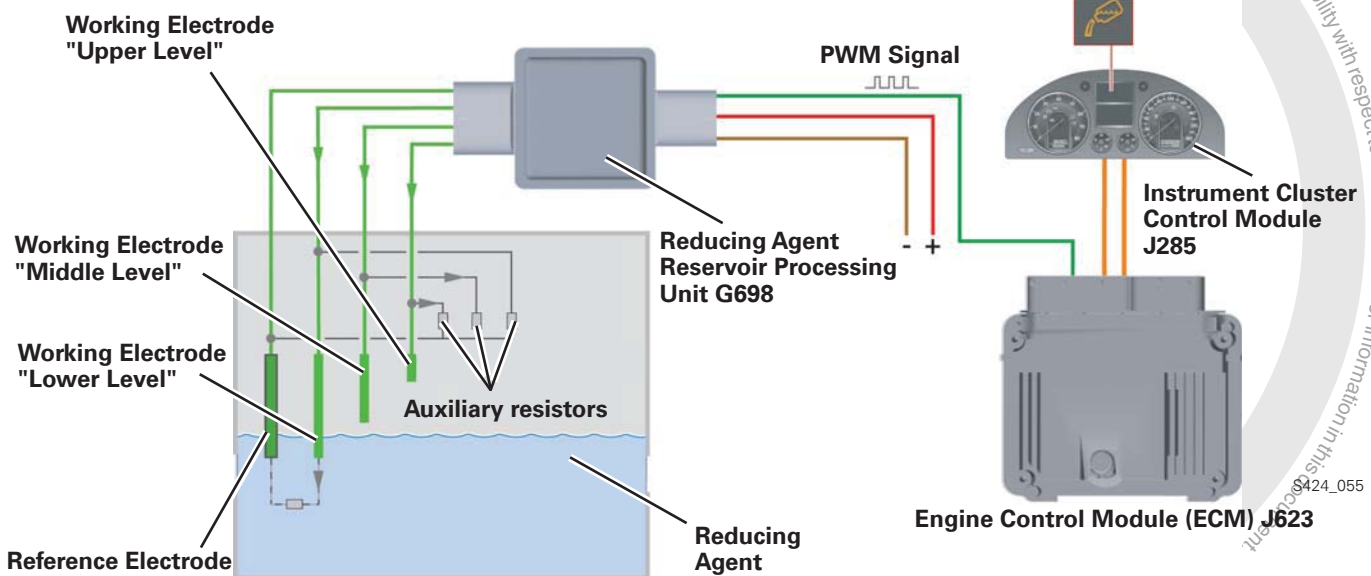
Exhaust Treatment

Warning Example for Declining Fluid Level

If the fluid level falls below the "middle level" measuring sensor, the evaluation current between the "middle level" working electrode and the reference electrode no longer flows via the reducing agent medium but via the auxiliary resistor belonging to the "middle level" working electrode. The current also flows via the relevant auxiliary resistor in the case of the "upper level" working electrode. The current flows via the reducing agent in the case of the "lower level" working electrode. The auxiliary resistor's resistance is many times higher than that of the reducing agent. From this changed resistance value, the evaluation unit recognises that the fluid level has fallen below this level. This signal is processed by the evaluation unit and transmitted to the engine control module.

In order to point out to the driver that reducing agent should be replenished in the case of this level, the engine control module transmits a signal to the control unit in dash panel insert. In the dash panel insert display, the driver is requested to fill up with fluid via a warning lamp, and the remaining range which can still be covered is displayed. The remaining range is calculated by the engine control module.

The auxiliary resistors also serve to diagnose open circuits and to check plausibility. The measuring principle does not function in the case of frozen reducing agent, as no reliable resistance value can then be determined.



Effects of Signal Failure

If the tank sender signal fails, the reducing agent tank's fluid level cannot be registered. However, the SCR system remains active. The diesel exhaust fluid warning display for a system fault lights up in the display and the exhaust Malfunction Indicator Lamp (MIL) K83 is switched on.

Reducing Agent Heater System

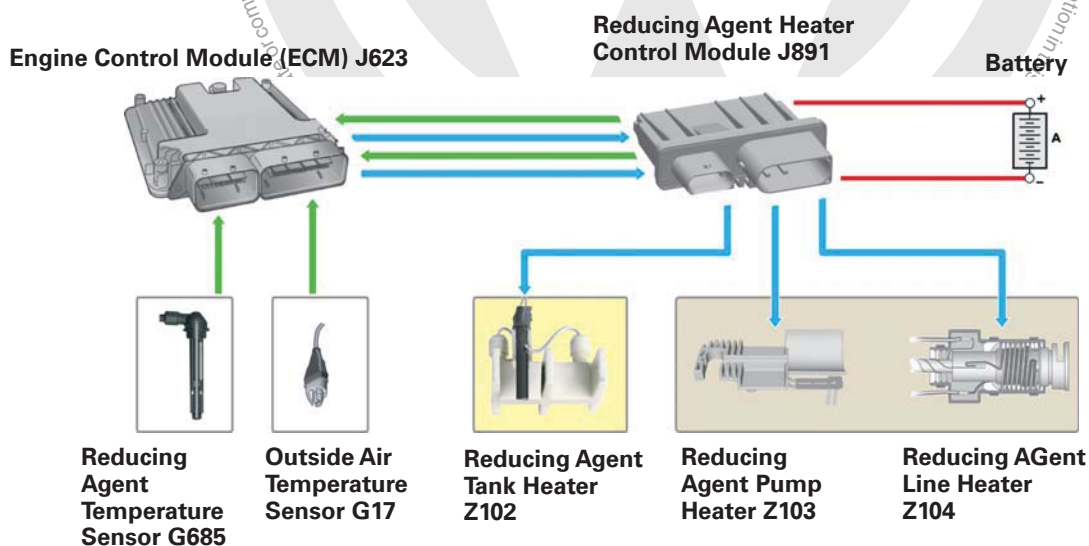
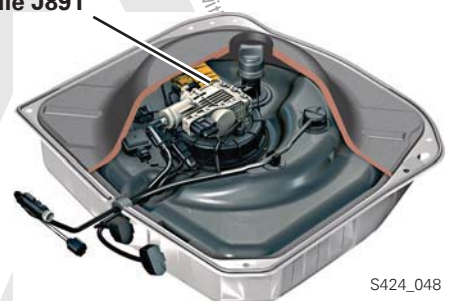
Due to the possibility of the reducing agent's freezing at low exterior temperatures, the reducing agent tank, the pump for reducing agent and the line to the injector are each equipped with a heater.

The heater system enables rapid SCR system operational readiness in the event of frozen reducing agent and ensures an adequate quantity of thawed reducing agent at all operating points..

Reducing Agent Heater Control Module J891

The control unit for reducing agent heater controls the electrical power supply for the SCR system's heaters. It is located on the upper side of the reducing agent tank and is actuated by the engine control module.

Reducing Agent Heater Control Module J891



Design

The engine control module recognizes the reducing agent's heating requirements from the Outside Air Temperature Sensor G17 and the Reducing Agent Temperature Sensor G685.

It then actuates the Reducing Agent Heater Control Module J891, which activates the electrical power supply for the heaters. The engine control module receives feedback regarding the electrical heater current actually flowing from the Reducing Agent Heater Control Module J891.

Exhaust Treatment

The control unit for reducing agent heater activates the SCR system's heaters.
The heater control system is sub-divided into two heater circuits.

	Heater Circuit 1	Heater Circuit 2
Activation	If the temperatures in the tank or in the ambient air are less than -7°C (19°F), the heater for reducing agent tank is activated via the control unit for reducing agent heater by the engine control unit.	If the temperatures in the ambient air are less than -5°C (23°F), the heater for pump for reducing agent and the heater for reducing agent line are activated via the control unit for reducing agent heater by
Heating Period for Thawing	At temperatures from -7°C to -13°C (19 to 9°F), the heating period is approx. 20 minutes. At temperatures of -25°C (-13°F) and below, the heating period may increase up to 45 minutes. In this case, the reducing agent is actively thawed in order to attain	At temperatures below -5°C (23°F), the heating period is approx. 100 seconds, increasing to 21 minutes at temperatures of -25°C (-13°F).
Readiness Heating	At temperatures below -7°C (19°F), the heating period for thawing is always followed by readiness heating. This takes approx. 5 minutes. Readiness heating serves to ensure that an adequate quantity of thawed reducing agent is provided at all operating points.	

Effects of Signal Failure

If the control unit for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures. The exhaust emissions warning lamp K83 (MIL) is switched on.

Reducing Agent Tank Heater Z102

The heater for reducing agent tank is a heater element with a PTC resistor. PTC resistors have their highest conductivity when cold. They have a positive temperature coefficient (PTC). This means that their resistance increases as the temperature rises, leading to a reduction in the flow of current.

The heater element is cast in plastic and is located directly in the reducing agent tank's delivery unit. The heater is actuated by the engine control module via the final output stage.

Task

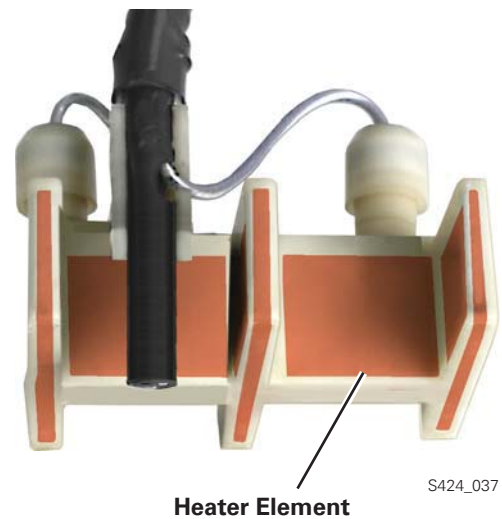
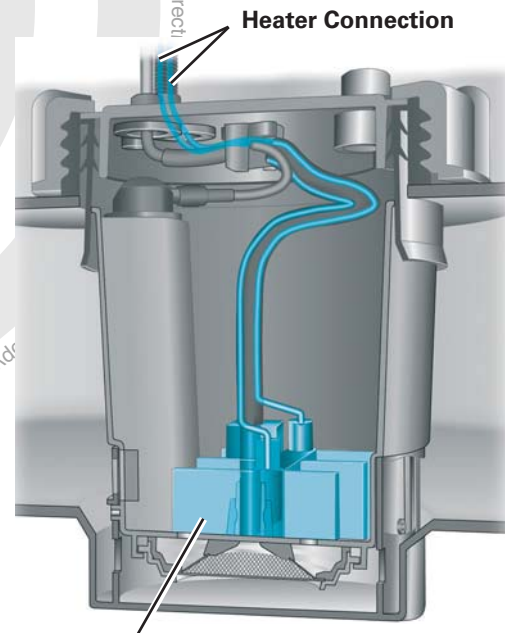
The heater for reducing agent tank has the task of heating the reducing agent in the delivery unit in the case of low exterior temperatures or low temperatures in the reducing agent tank, in order to enable metering readiness for the SCR system in a short space of time.

How it Works

If the temperatures in the tank or in the ambient air are less than -7°C (19°F), the heater for reducing agent tank is activated via the final output stage by the engine control module.

Effects of Signal Failure

If the control unit for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures. The exhaust malfunction indicator lamp K83 (MIL) is switched on.



Exhaust Treatment

Reducing Agent Pump Heater Z103

The reducing agent pump heater is also a heater element with a PTC resistor. PTC resistors reveal their highest conductivity when cold. They have a positive temperature coefficient (PTC). This means that their resistance increases as the temperature rises, leading to a reduction in the flow of current.

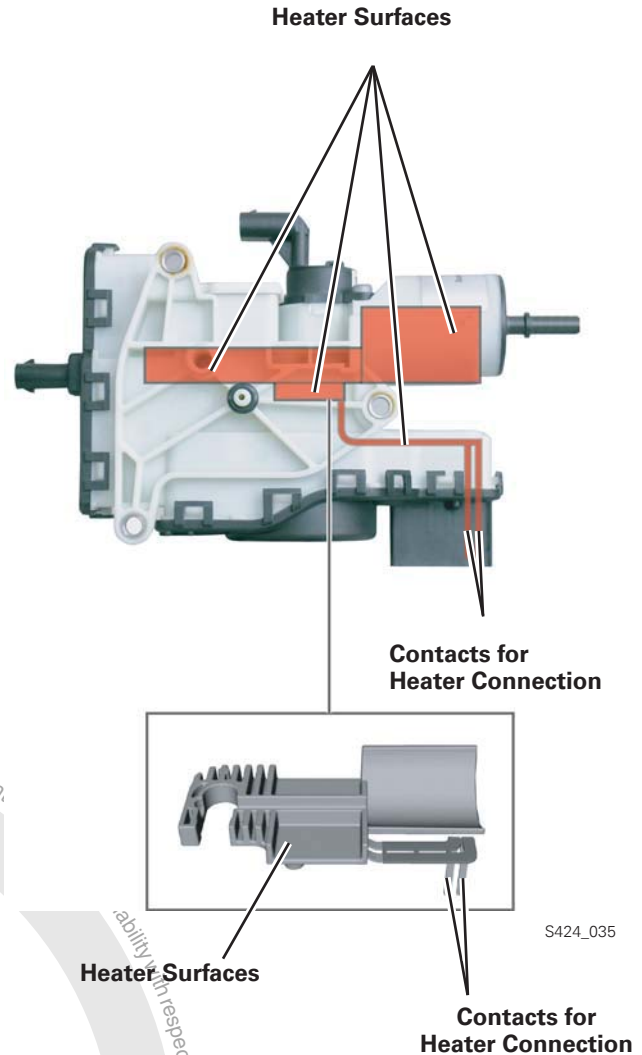
The heater element is cast into the delivery module and is located in the area of the pump for reducing agent, the reversing valve and the connection to the delivery line. The heater for pump for reducing agent is actuated by the engine control module via the final output stage.

Task

The heater for pump for reducing agent has the task of heating the reducing agent in the area of the pump for reducing agent, the reversing valve and the connection to the delivery line in the event of low exterior temperatures. This ensures reliable SCR system operation even at low exterior temperatures.

How it Works

If the temperature of the ambient air is less than -5°C (23°F) the heater for pump for reducing agent is activated via the final output stage by the engine control module.

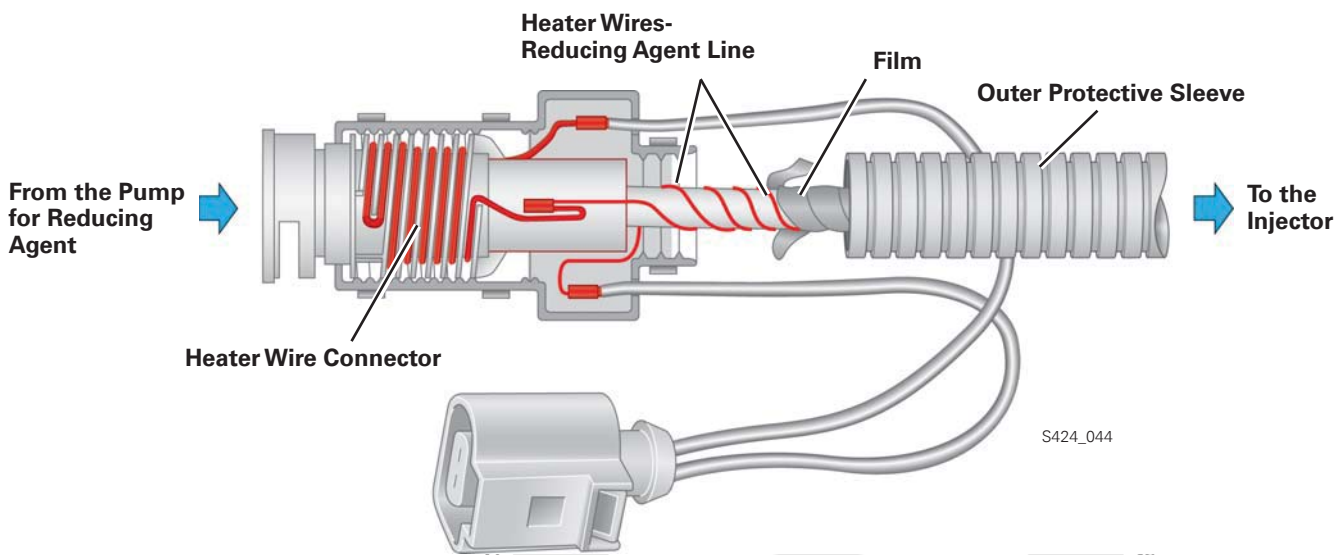


Effects of Signal Failure

If the control unit for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures. The exhaust malfunction indicator lamp K83 (MIL) is switched on.

Reducing Agent Line Heater Z104

The heater for the reducing agent line is a stainless steel resistor wire. The resistor wire is wound in the form of a spiral around the delivery line and is protected from the outside by a plastic tube. The heater for reducing agent line is actuated by the engine control module via the control unit for reducing agent heater.



Task

The heater for reducing agent line has the task of heating the reducing agent in the delivery line to the injector in the event of low exterior temperatures. This ensures reliable SCR system operation even at low exterior temperatures.

Effects in the event of failure

If the control module for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures. The exhaust malfunction indicator lamp K83 (MIL) is switched on.

How it works

If the temperature of the ambient air is less than -5°C (23°F), the heater current for the heater for reducing agent line is activated via the control unit for reducing agent heater.

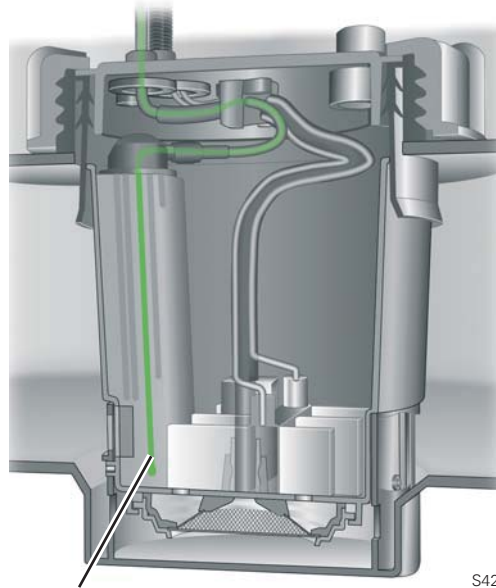
Exhaust Treatment

Reducing Agent Temperature Sensor G685

The temperature sender for the reducing agent is a sensor with a negative temperature coefficient (NTC). It is located in the housing of the reducing agent tank sender and measures the temperature of the reducing agent in the delivery unit.

Signal use

The engine control module uses the signal from the reducing agent temperature sensor to switch on the heater for the reducing agent tank and the heater for pump for reducing agent.



S424_056

**Reducing Agent
Temperature Sensor G685**

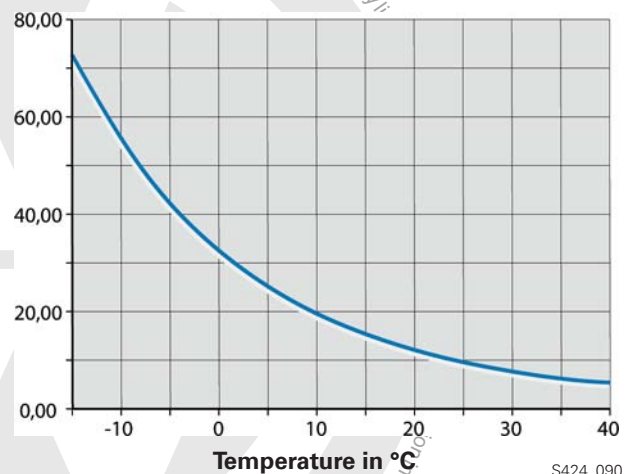
How it works

The temperature sender is a resistor wire with a negative temperature coefficient (NTC). This means that the sensor's electrical resistance decreases as the temperature of the reducing agent increases. The engine control module uses the resistance signal to calculate the current temperature of the reducing agent.

Effects of signal failure

The exhaust emissions warning lamp K83 (MIL) and the diesel exhaust fluid warning display for system faults in the dash panel insert display are switched on.

Resistance in k Ω



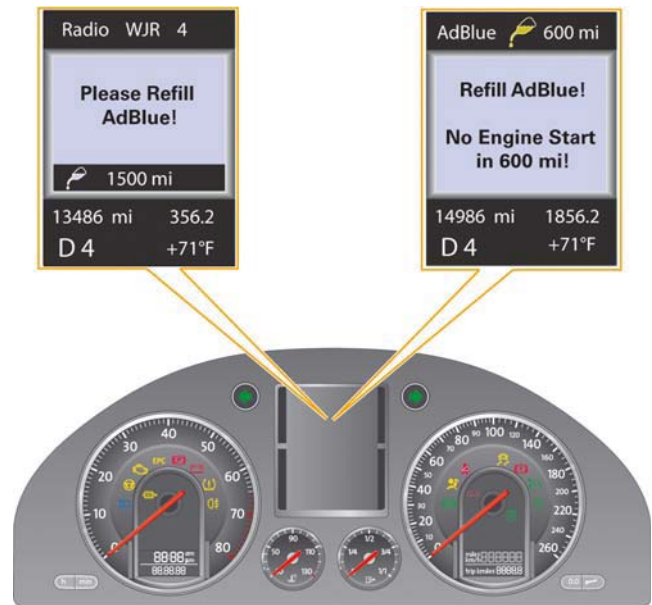
S424_090

Reducing Agent System Instrument Cluster Display

The display for the reducing agent system is located in the instrument cluster display. It illuminates to prompt the driver to add reducing agent or provide warning when problems develop in the system.

Federal standards require that the vehicle not start under the following conditions:

- There is not enough reducing agent in the tank
- Reducing agent metering (injection) is not possible due to system errors
- The reducing agent quality is inadequate
- There are deviations in the reducing agent consumption (leaks)



S424_028 edit

Exhaust Gas After-Treatment Display Strategy

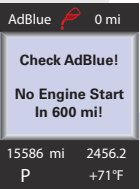
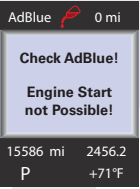
If the reducing agent quantity in the tank drops below a certain fill level, the driver is prompted to add reducing agent by three warning stages.

Remaining Range	Acoustic Warning	Dash Display	Driver Instructions
< 1500 mi (2400 km)	1 x gong		These instructions with the white filling bottle appear when the reducing agent quantity is only sufficient to drive for the remaining range specified in the text. The driver is prompted to refill reducing agent. An acoustic warning signal sounds as an additional alert.
< 600 mi (1000 km)	1 x warning buzzer		These instructions with the yellow filling bottle appear when the reducing agent quantity is only sufficient to drive for the remaining range specified in the text. The driver is prompted to refill reducing agent. Additionally, the driver is notified that, after the remaining driving range, it will no longer be possible to start the vehicle once the engine is turned off. An acoustic warning signal sounds as an additional alert.
0 mi (km)	3 x warning buzzer		These instructions with the red filling bottle appear when there is no more reducing agent left in the tank. The driver is notified that engine start is not possible and prompted to refill reducing agent. Three successive warning signals sound as an additional alert.

Exhaust Treatment

The Use of Incorrect Reducing Agent

If the reducing agent tank is filled up with a medium other than reducing agent diesel exhaust fluid, the NOx sensor can detect a reduced DeNox catalytic converter efficiency. In this case, the driver is notified as follows in the instrument cluster display.

Remaining Range	Acoustic Warning	Dash Display	Driver Instructions
< 600 mi (1000 km)	1 x warning buzzer		These instructions with the red filling bottle appear when it is only possible to drive for the remaining range specified in the text. The driver is notified that, after the remaining driving range, it will no longer be possible to start the vehicle once the engine is turned off.
0 mi (km)	3 x warning buzzer		The driver is prompted to visit the nearest qualified workshop. An acoustic warning signal sounds as an additional alert. These instructions with the red filling bottle appear when incorrect filling has been detected. The driver is notified that it will no longer be possible to start the vehicle once the engine is turned off and prompted to visit the nearest qualified workshop. Three successive warning signals sound as an additional alert.

Note:



When this information appears in the Touareg instrument cluster display, at least two 0.5 gal. (1.89 liter) diesel exhaust fluid refill bottles must be added to the tank. With this reducing agent quantity and after a waiting time of approximately two minutes, the system recognizes refilling and the engine can be started again. The graphical representations of the displays and filling quantities refer to Touareg. In other models, the displays and filling quantities can differ.

Dealing with Reducing Agents

... For the Customer

When driving a lot under load (mountain driving, trailer operation), the reducing agent consumption can rise. Therefore, the low reducing agent display in the instrument cluster may come on earlier. In this case, provisions are made that allow the customer to refill the diesel exhaust fluid independently by pouring in two diesel exhaust fluid refill bottles (0.5 gal [1.89 liters]).

The diesel exhaust fluid is available at a Volkswagen dealer and at some designated gas stations. For refilling purposes, an adapter must be screwed onto the diesel exhaust fluid refill bottle. After opening the diesel exhaust fluid refill bottle, the bottle can be screwed onto the filler neck of the reducing agent tank.

The valve in the adapter opens as a result of the pressure acting on the bottle and the reducing agent can flow into the active tank. The displaced gases in the reducing agent tank enter the ventilation system of the reducing agent tank. At the beginning of the cold season, the tank should always be filled with reducing agent. This ensures that the contents of the tank last throughout the cold part of the year.



Note:

Please observe the current operating instructions when handling the diesel exhaust fluid refill bottle as well as the vehicle labels indicating its use.



Aspect to the correctness of information in this document

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Exhaust Treatment

... for the Workshop

The reducing agent tanks must be refilled either when the customer is prompted or at regular scheduled service intervals. To determine the correct service interval, please refer to the owner's literature for the vehicle.

To refill the system, the reducing agent filling equipment VAS 6542 is screwed onto the filler neck of the reducing agent tank and the reducing agent container. A ventilation line is integrated in the filling line, which ensures the ventilation of the reducing agent tank and the container.

Please note that the container must hang at least 28 in. (700 mm) above the filler neck of the reducing agent to ensure reliable filling.



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Glossary

Glossary

Diesel Exhaust Fluid (Reducing Agent)

Diesel Exhaust Fluid describes a reducing agent that is mixed to the exhaust gas to reduce certain exhaust emissions. It is a non-hazardous solution.

May be sold under the brand name AdBlue®

Diesel Exhaust Fluid Refill Bottle

It is a refill bottle for the reducing agent diesel exhaust fluid, which has a special cap.

DeNox Catalytic Converter

The description DeNox stands for "nitrogen oxide reducing." During this chemical reaction, not all of the exhaust gas components, but only the oxides of nitrogen are reduced.

Piezo

Piezo is derived from Greek and means to "squeeze." A special crystal is used that generates a measurable voltage in response to pressure. Alternately, when a voltage is applied, the length of the crystal changes. This effect is utilized in common rail injection elements.

PSG

This abbreviation stands for "Pressure Sensor Glow Plug." It refers to a glow plug that is also able to sense the pressure on the inside of a cylinder.

Reed Contact

It is a special switch that operates contact-free. The contact is operated by a magnetic field acting from the outside, which is electrically generated by a permanent magnet (reed contact) positioned nearby or in an associated solenoid coil.

Reducing Agent Metering System Control Module J880

It is wired discretely and responsible for the heater of the diesel exhaust fluid systems, which we also refer to as power output stage for the tank heating system.

Oxides of Nitrogen

The general chemical term stands for nitrogen and oxygen compounds. (NO, NO₂) They are formed in the engine during the combustion processes and are partly responsible for causing harm to the environment.

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.vwwebsource.com

For Assistance, please call:

Volkswagen Academy

Certification Program Headquarters

1-877-491-4838

(8:00 a.m. to 8:00 p.m. EST)

Or, E-Mail:

concierge@volkswagenacademy.com



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Cautions & Warnings

Please read these WARNINGS and CAUTIONS before proceeding with maintenance and repair work. You must answer that you have read and you understand these WARNINGS and CAUTIONS before you will be allowed to view this information.

- If you lack the skills, tools and equipment, or a suitable workshop for any procedure described in this manual, we suggest you leave such repairs to an authorized Volkswagen retailer or other qualified shop. We especially urge you to consult an authorized Volkswagen retailer before beginning repairs on any vehicle that may still be covered wholly or in part by any of the extensive warranties issued by Volkswagen.
- Disconnect the battery negative terminal (ground strap) whenever you work on the fuel system or the electrical system. Do not smoke or work near heaters or other fire hazards. Keep an approved fire extinguisher handy.
- Volkswagen is constantly improving its vehicles and sometimes these changes, both in parts and specifications, are made applicable to earlier models. Therefore, part numbers listed in this manual are for reference only. Always check with your authorized Volkswagen retailer parts department for the latest information.
- Any time the battery has been disconnected on an automatic transmission vehicle, it will be necessary to reestablish Transmission Control Module (TCM) basic settings using the VAG 1551 Scan Tool (ST).
- Never work under a lifted vehicle unless it is solidly supported on stands designed for the purpose. Do not support a vehicle on cinder blocks, hollow tiles or other props that may crumble under continuous load. Never work under a vehicle that is supported solely by a jack. Never work under the vehicle while the engine is running.
- For vehicles equipped with an anti-theft radio, be sure of the correct radio activation code before disconnecting the battery or removing the radio. If the wrong code is entered when the power is restored, the radio may lock up and become inoperable, even if the correct code is used in a later attempt.
- If you are going to work under a vehicle on the ground, make sure that the ground is level. Block the wheels to keep the vehicle from rolling. Disconnect the battery negative terminal (ground strap) to prevent others from starting the vehicle while you are under it.
- Do not attempt to work on your vehicle if you do not feel well. You increase the danger of injury to yourself and others if you are tired, upset or have taken medicine or any other substances that may impair you or keep you from being fully alert.
- Never run the engine unless the work area is well ventilated. Carbon monoxide (CO) kills.
- Always observe good workshop practices. Wear goggles when you operate machine tools or work with acid. Wear goggles, gloves and other protective clothing whenever the job requires working with harmful substances.
- Tie long hair behind your head. Do not wear a necktie, a scarf, loose clothing, or a necklace when you work near machine tools or running engines. If your hair, clothing, or jewelry were to get caught in the machinery, severe injury could result.
- Do not re-use any fasteners that are worn or deformed in normal use. Some fasteners are designed to be used only once and are unreliable and may fail if used a second time. This includes, but is not limited to, nuts, bolts, washers, circlips and cotter pins. Always follow the recommendations in this manual - replace these fasteners with new parts where indicated, and any other time it is deemed necessary by inspection.

Cautions & Warnings

- Illuminate the work area adequately but safely. Use a portable safety light for working inside or under the vehicle. Make sure the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite spilled fuel or oil.
- Friction materials such as brake pads and clutch discs may contain asbestos fibers. Do not create dust by grinding, sanding, or by cleaning with compressed air. Avoid breathing asbestos fibers and asbestos dust. Breathing asbestos can cause serious diseases such as asbestosis or cancer, and may result in death.
- Finger rings should be removed so that they cannot cause electrical shorts, get caught in running machinery, or be crushed by heavy parts.
- Before starting a job, make certain that you have all the necessary tools and parts on hand. Read all the instructions thoroughly; do not attempt shortcuts. Use tools that are appropriate to the work and use only replacement parts meeting Volkswagen specifications. Makeshift tools, parts and procedures will not make good repairs.
- Catch draining fuel, oil or brake fluid in suitable containers. Do not use empty food or beverage containers that might mislead someone into drinking from them. Store flammable fluids away from fire hazards. Wipe up spills at once, but do not store the oily rags, which can ignite and burn spontaneously.
- Use pneumatic and electric tools only to loosen threaded parts and fasteners. Never use these tools to tighten fasteners, especially on light alloy parts. Always use a torque wrench to tighten fasteners to the tightening torque listed.
- Keep sparks, lighted matches, and open flame away from the top of the battery. If escaping hydrogen gas is ignited, it will ignite gas trapped in the cells and cause the battery to explode.
- Be mindful of the environment and ecology. Before you drain the crankcase, find out the proper way to dispose of the oil. Do not pour oil onto the ground, down a drain, or into a stream, pond, or lake. Consult local ordinances that govern the disposal of wastes.
- The air-conditioning (A/C) system is filled with a chemical refrigerant that is hazardous. The A/C system should be serviced only by trained automotive service technicians using approved refrigerant recovery/recycling equipment, trained in related safety precautions, and familiar with regulations governing the discharging and disposal of automotive chemical refrigerants.
- Before doing any electrical welding on vehicles equipped with anti-lock brakes (ABS), disconnect the battery negative terminal (ground strap) and the ABS control module connector.
- Do not expose any part of the A/C system to high temperatures such as open flame. Excessive heat will increase system pressure and may cause the system to burst.
- When boost-charging the battery, first remove the fuses for the Engine Control Module (ECM), the Transmission Control Module (TCM), the ABS control module, and the trip computer. In cases where one or more of these components is not separately fused, disconnect the control module connector(s).
- Some of the vehicles covered by this manual are equipped with a supplemental restraint system (SRS), that automatically deploys an airbag in the event of a frontal impact. The airbag is operated by an explosive device. Handled improperly or without adequate safeguards, it can be accidentally activated and cause serious personal injury. To guard against personal injury or airbag system failure, only trained Volkswagen Service technicians should test, disassemble or service the airbag system.

Cautions & Warnings

- Do not quick-charge the battery (for boost starting) for longer than one minute, and do not exceed 16.5 volts at the battery with the boosting cables attached. Wait at least one minute before boosting the battery a second time.
- Never use a test light to conduct electrical tests of the airbag system. The system must only be tested by trained Volkswagen Service technicians using the VAG 1551 Scan Tool (ST) or an approved equivalent. The airbag unit must never be electrically tested while it is not installed in the vehicle.
- Some aerosol tire inflators are highly flammable. Be extremely cautious when repairing a tire that may have been inflated using an aerosol tire inflator. Keep sparks, open flame or other sources of ignition away from the tire repair area. Inflate and deflate the tire at least four times before breaking the bead from the rim. Completely remove the tire from the rim before attempting any repair.
- When driving or riding in an airbag-equipped vehicle, never hold test equipment in your hands or lap while the vehicle is in motion. Objects between you and the airbag can increase the risk of injury in an accident.

I have read and I understand these Cautions and Warnings.