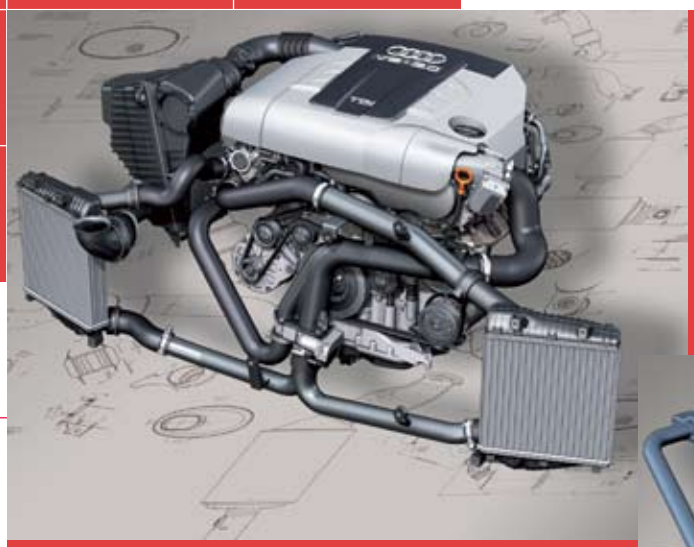
Service Training





Audi 3.0-liter V6 TDI

With Clean Diesel System

Self-Study Program 941803

Audi of America, LLC
Service Training
Printed in U.S.A.
Printed 03/2009
Course Number 941803

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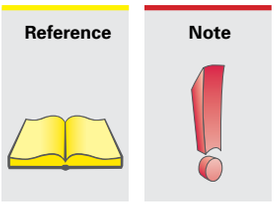
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Knowledge Assessment 99

The Self-Study Program provides introductory information regarding the design and function of new models, automotive components or technologies.

The Self-Study Program (SSP) is not a Repair Manual!
All values given are intended as guidelines only and refer to the software version valid at the time of publication of the SSP.

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



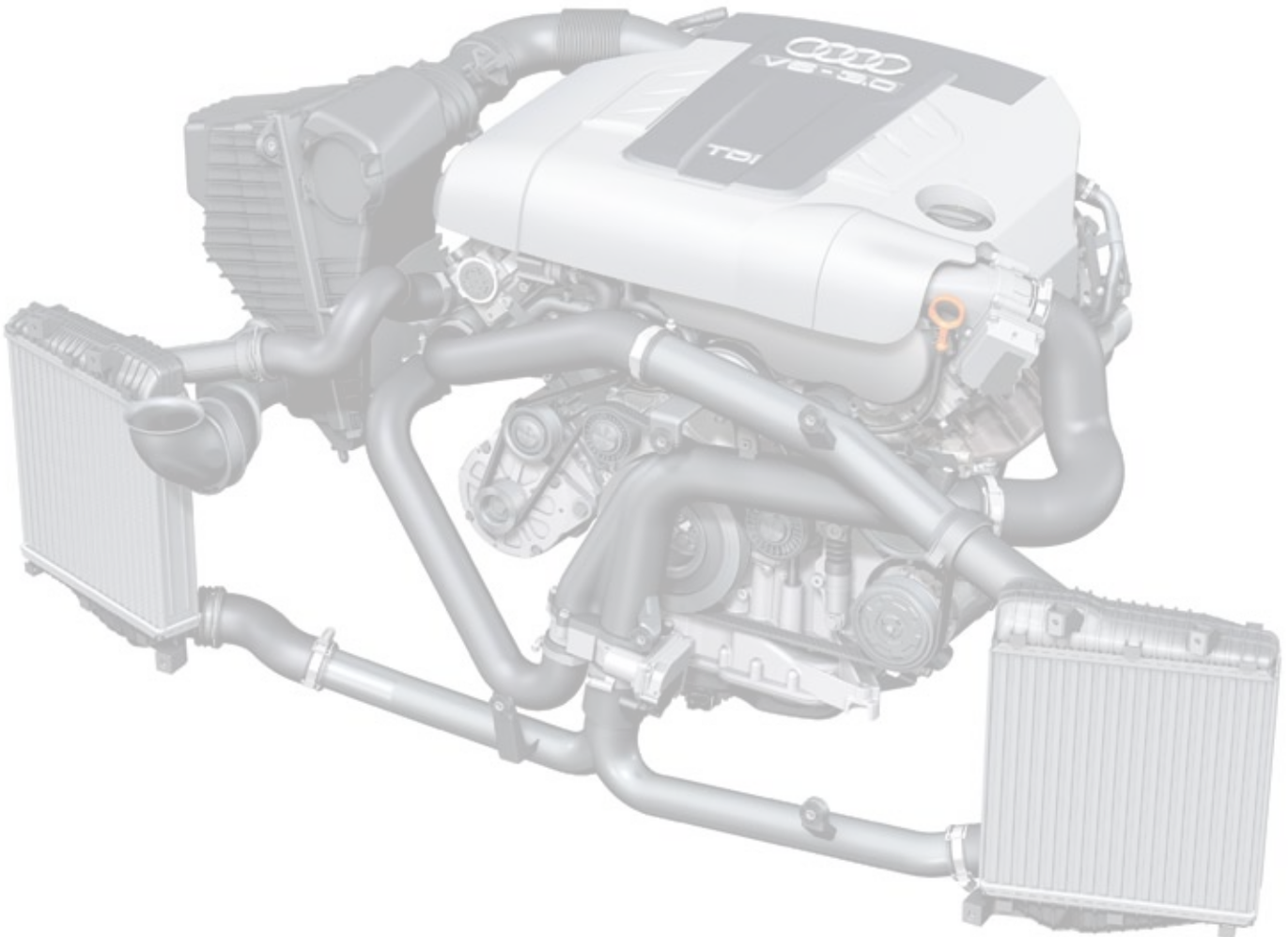
Notes

Introduction

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



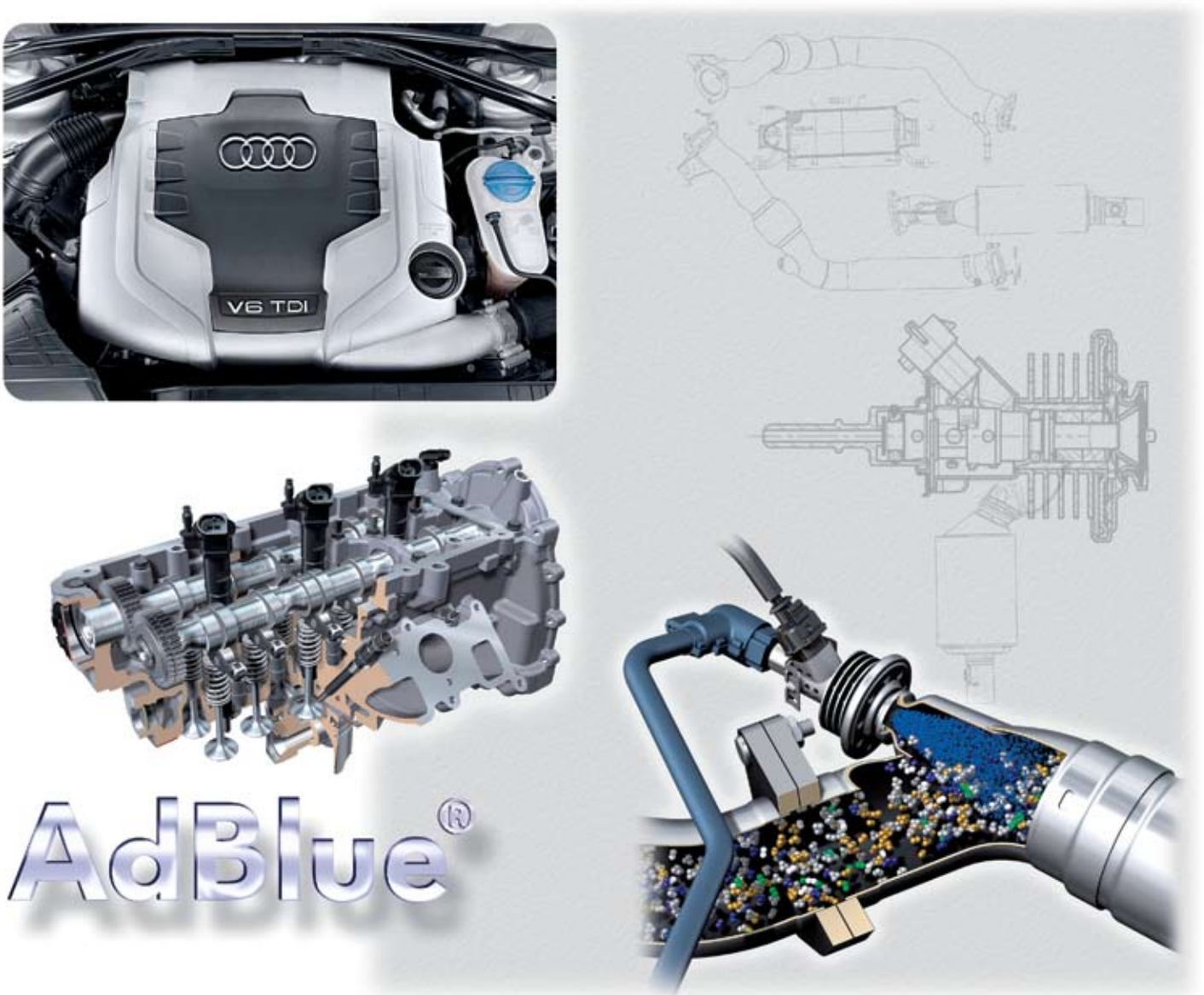
Audi Introduces the Cleanest Diesel Technology World Wide into Standard Production

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
- 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 oxides of nitrogen 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 LEV II/BIN5 limits, and to be ready for world-wide use.



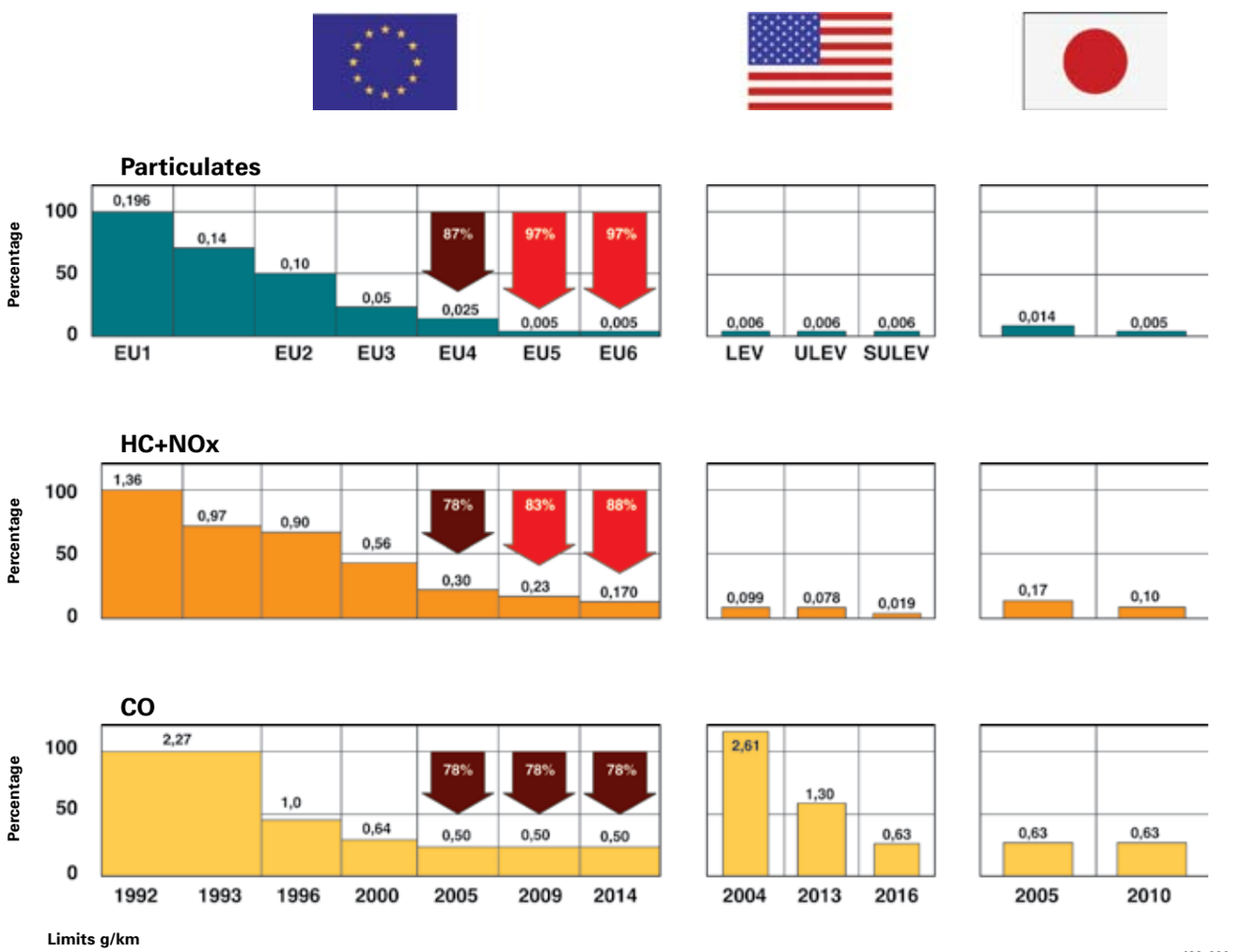
AdBlue® is a registered trademark of the Verbands der Automobilindustrie e. V. (VDA)

Emission Standards

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

- Diesel engine particulates
- Unburned hydrocarbons (HC)
- Oxides of nitrogen (NOx)
- 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 to BIN5.

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:

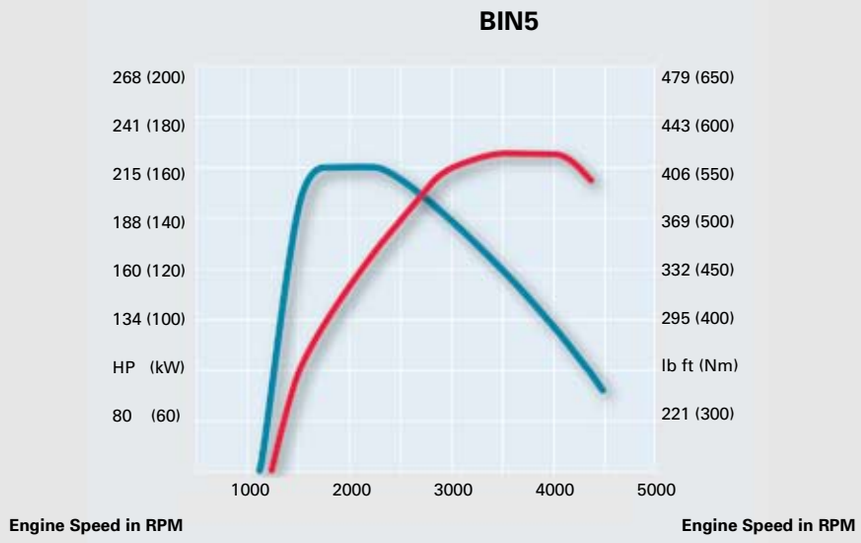
– An optimized two-stage chain drive that lowers the chain forces, reducing frictional losses
– An oil pump with flow rate-control and two pressure stages to reduce drive output required for lubrication

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 also a new feature.



Torque Curves



428_002-3

Specifications

	BIN5
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	US Diesel
Exhaust Standard	ULEV II/BIN5

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.

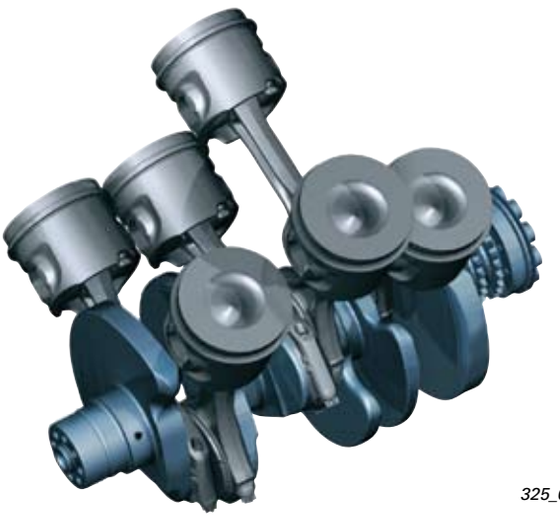
The laser beam, which is applied at high force, melts down the remaining metal nibs in the one-billionth range. A smooth cylinder bore is achieved immediately in this way rather than through the break-in process.

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

Bolts/Main Bearing Assembly

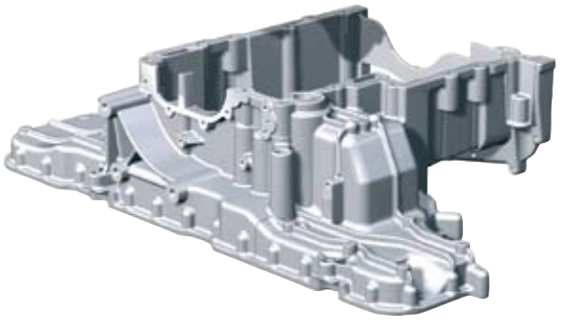
Retaining Frame

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

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 aluminium pressure-cast top section and a bottom section made of steel plate.

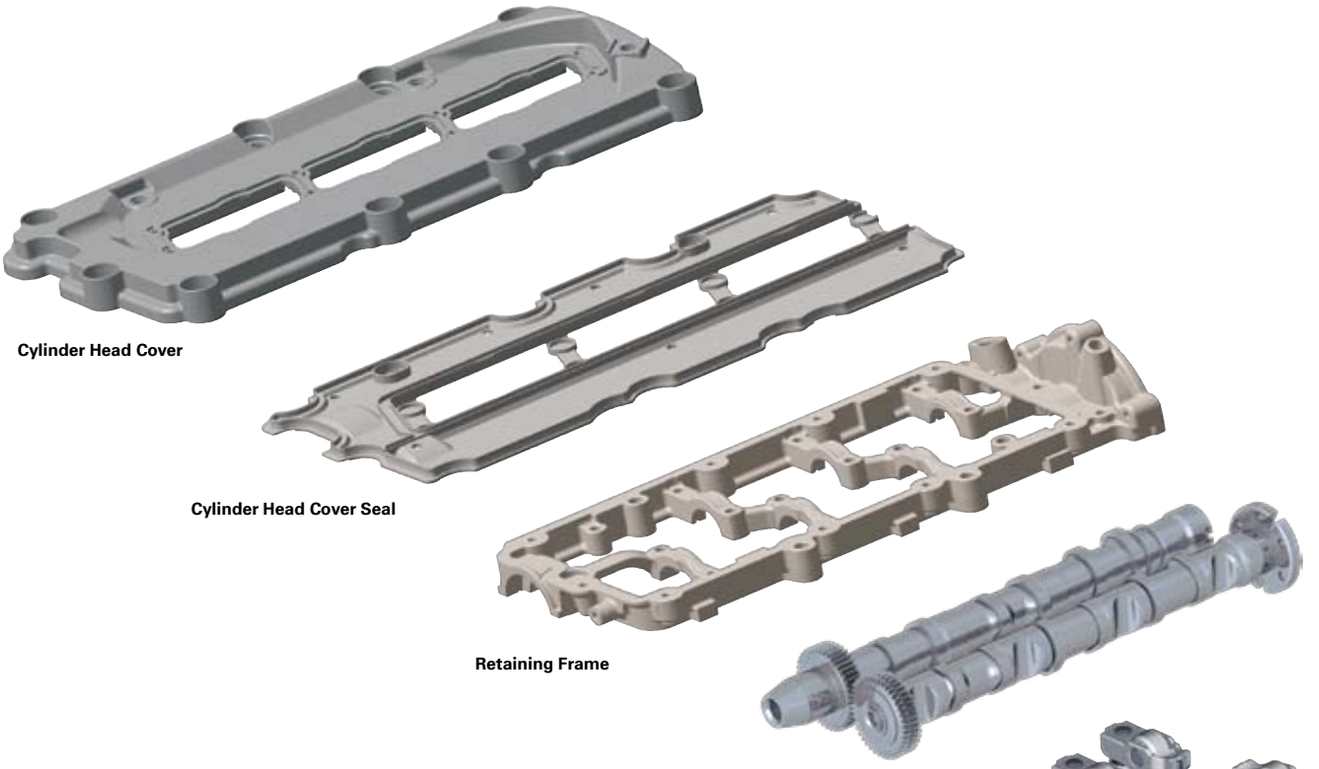


325_011

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.



Cylinder Head Cover

Cylinder Head Cover Seal

Retaining Frame

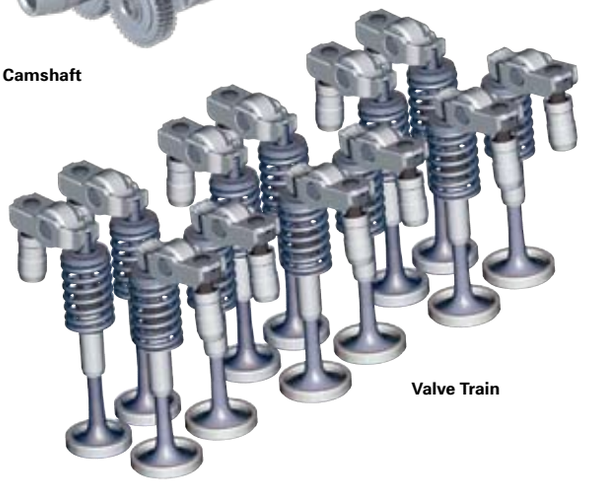
Camshaft

Camshafts

The camshafts are manufactured from precision steel tubing using the IHU method.*

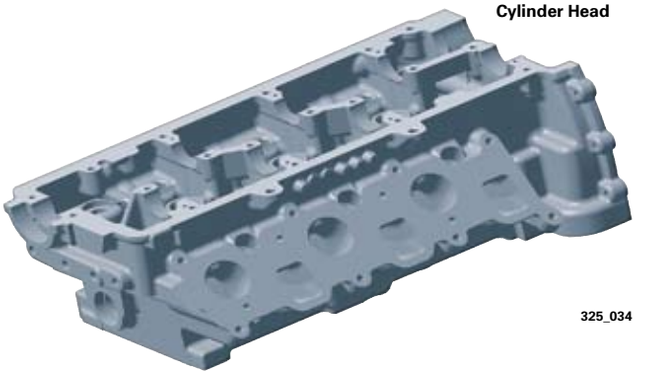
The exhaust camshafts are driven by the intake camshafts by straight-toothed spur gears.

* IHU – Internal High-pressure recasting



Valve Train

Cylinder Head

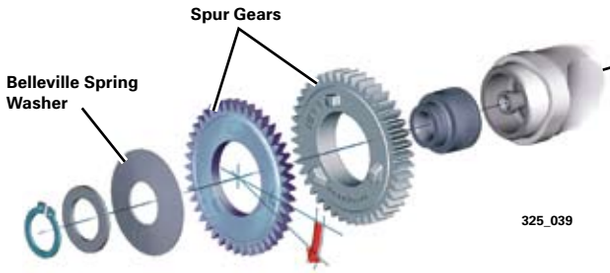


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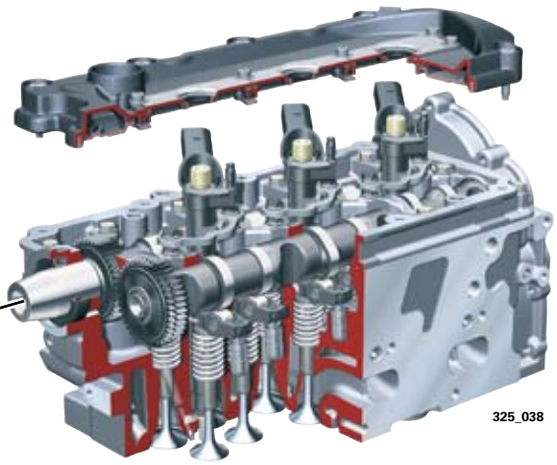
Tooth Profile Clearance Compensation

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.



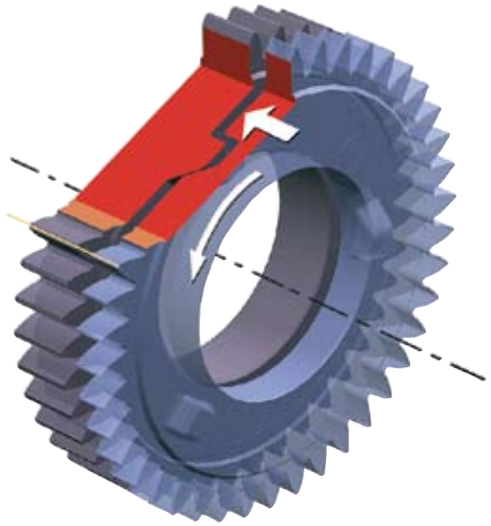
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325_038

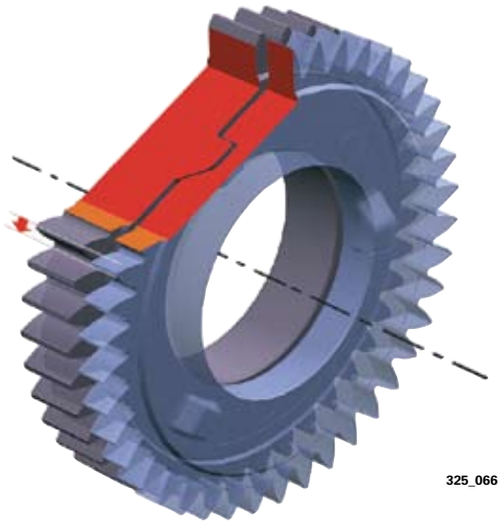
Note:
Please refer to the current service literature for assembly instructions.

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


325_065

Clearance Compensation

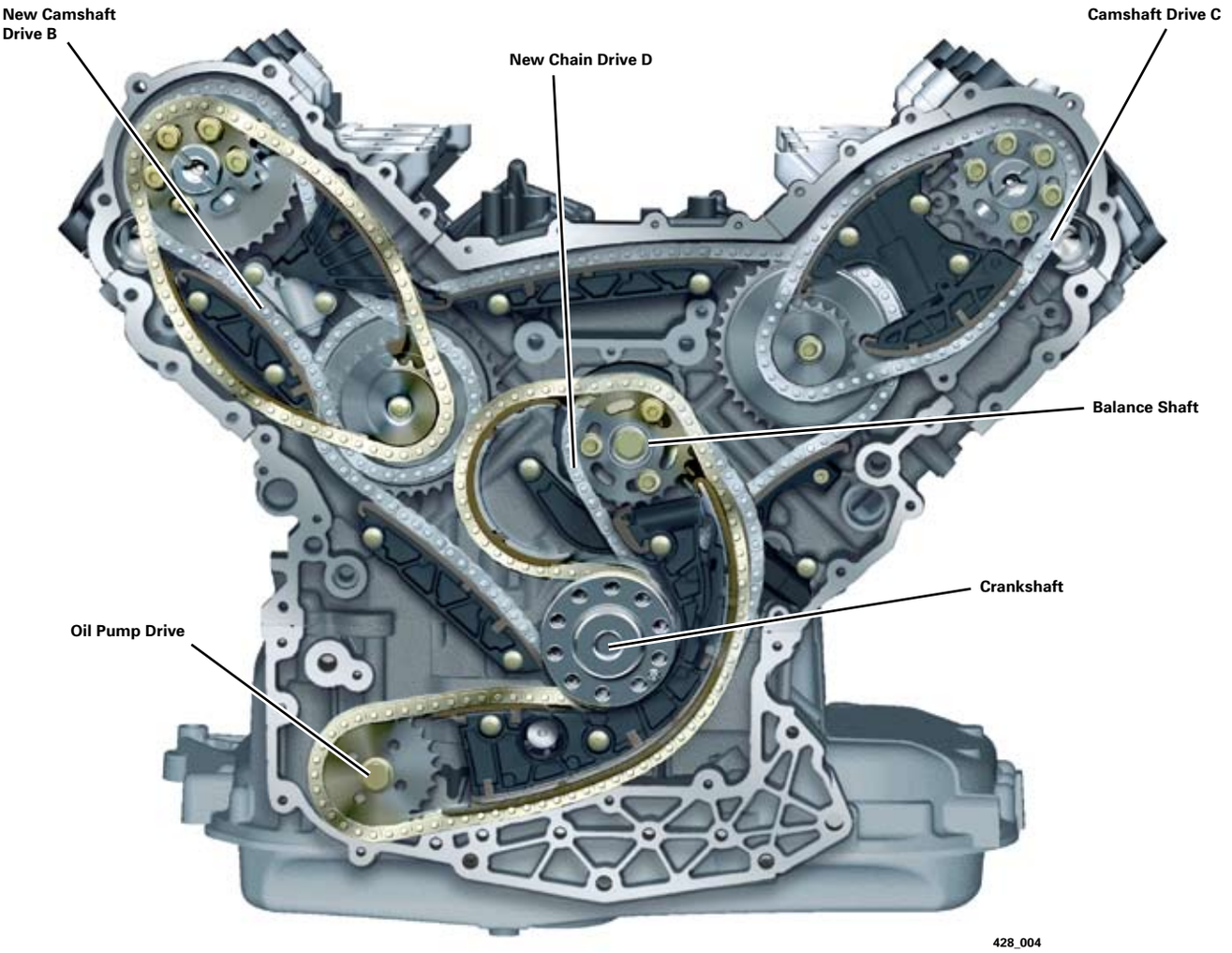

325_066

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.



Gold Chain = Old Chain Drive from previous EU5 Engine

Silver Chain = Current Chain Drive

Notes

Flow Rate-Controlled Oil Pump

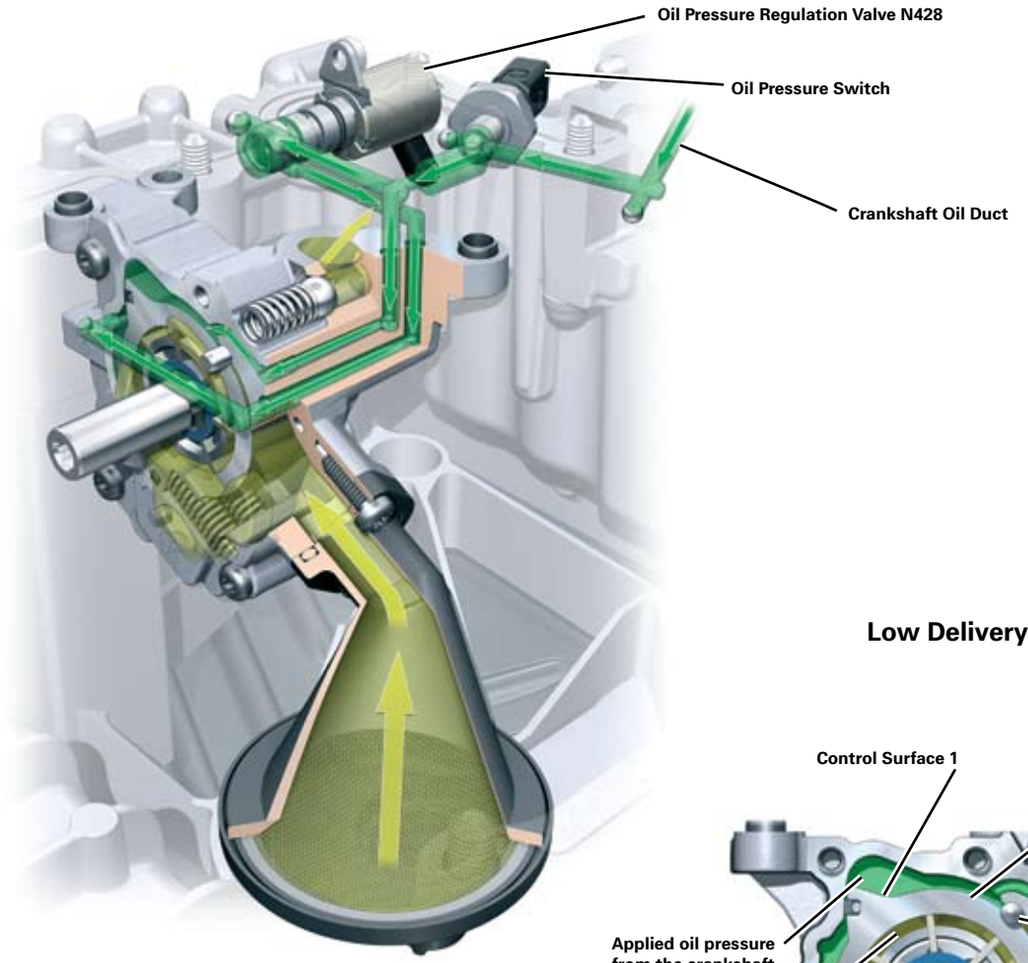
The use of a flow rate-control system reduces the required drive output of the oil pump.

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.

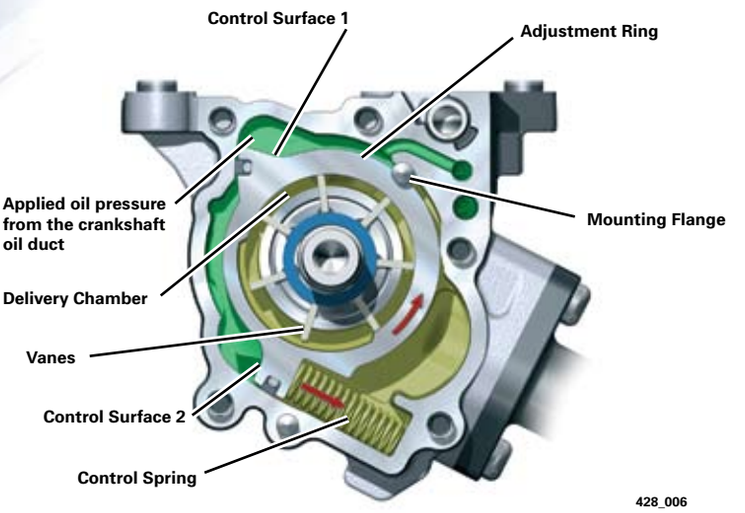
The forces resulting from this are higher than those of the control spring and they cause the adjustment ring to swivel counterclockwise.

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.



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Low Delivery Rate

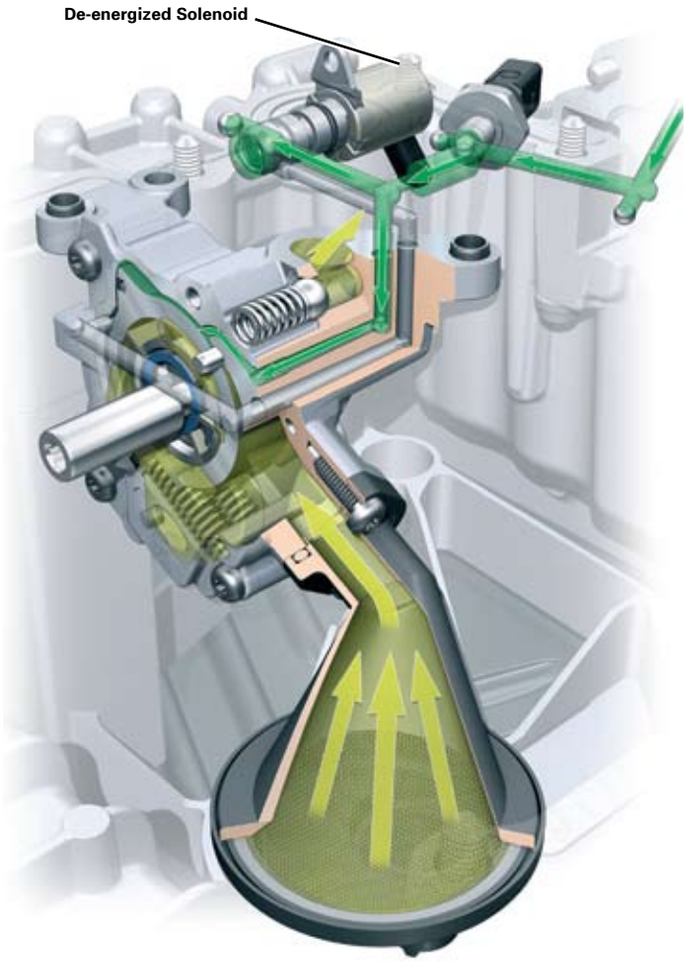


428_006

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.

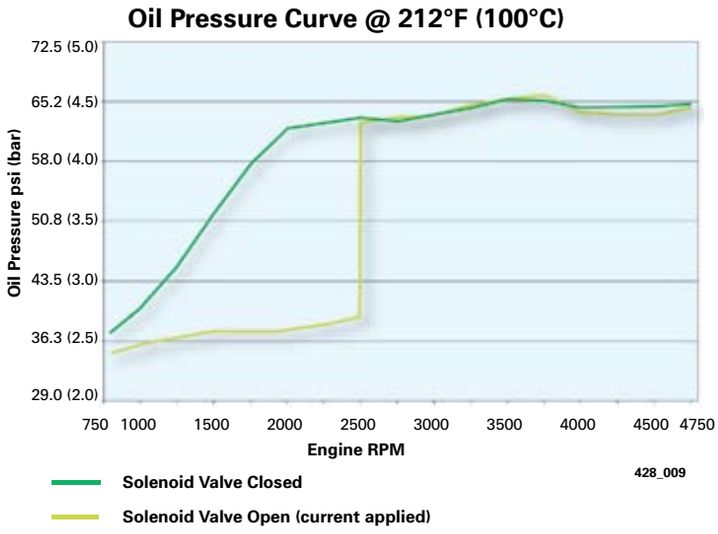
The applied oil pressure is now acting on Control Surface 1 only and acts with a lower pressure against the force of the control spring.



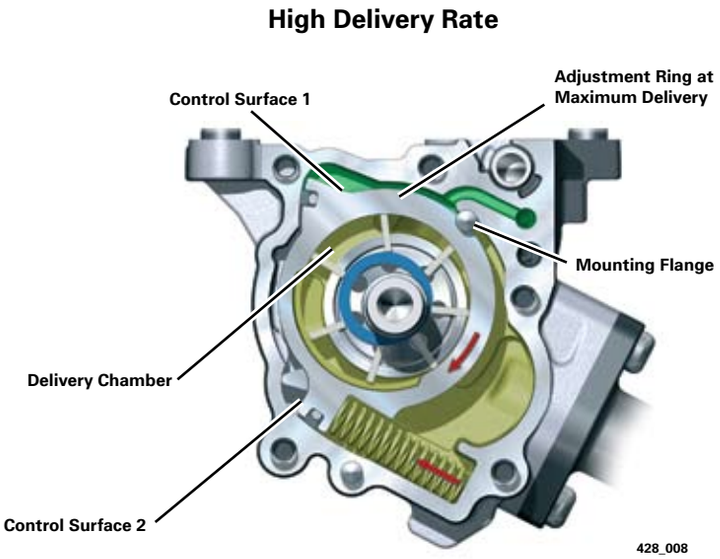
428_007

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.



428_009



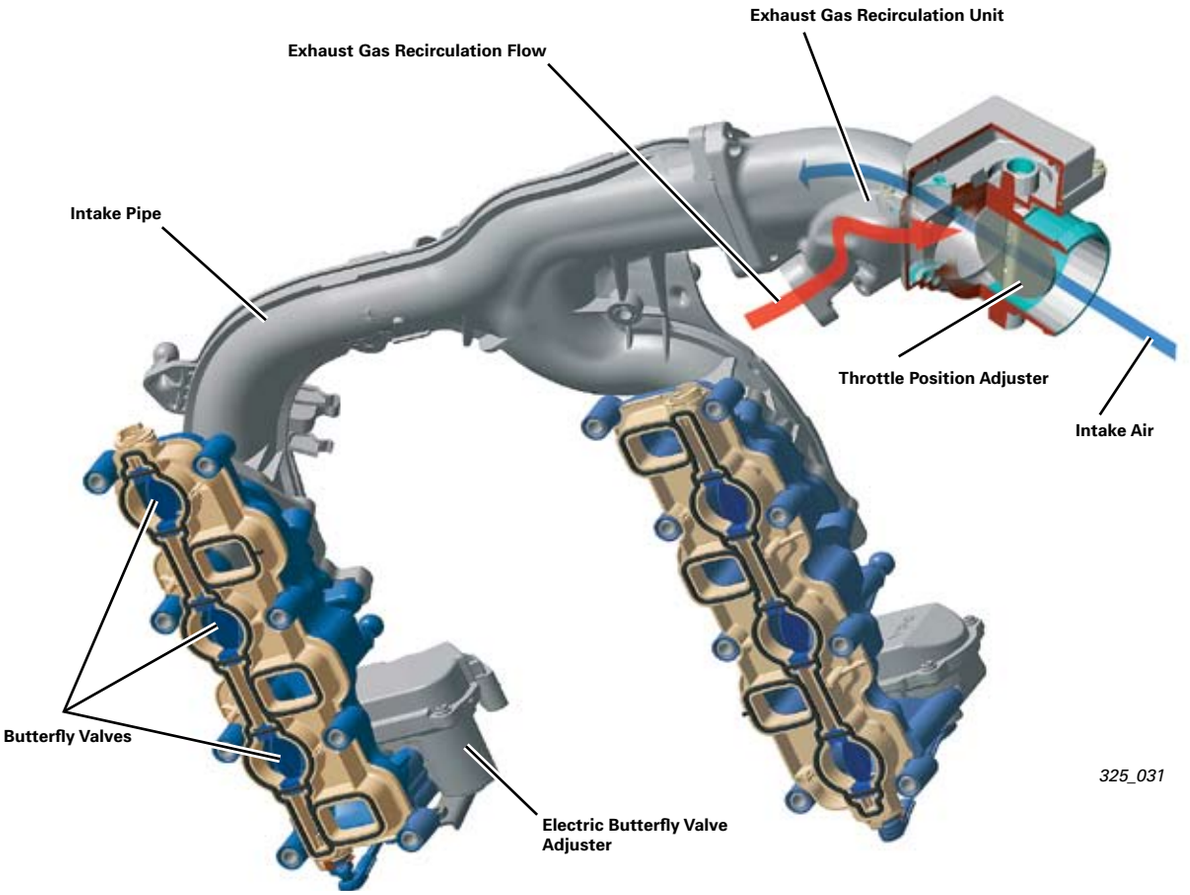
428_008

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.

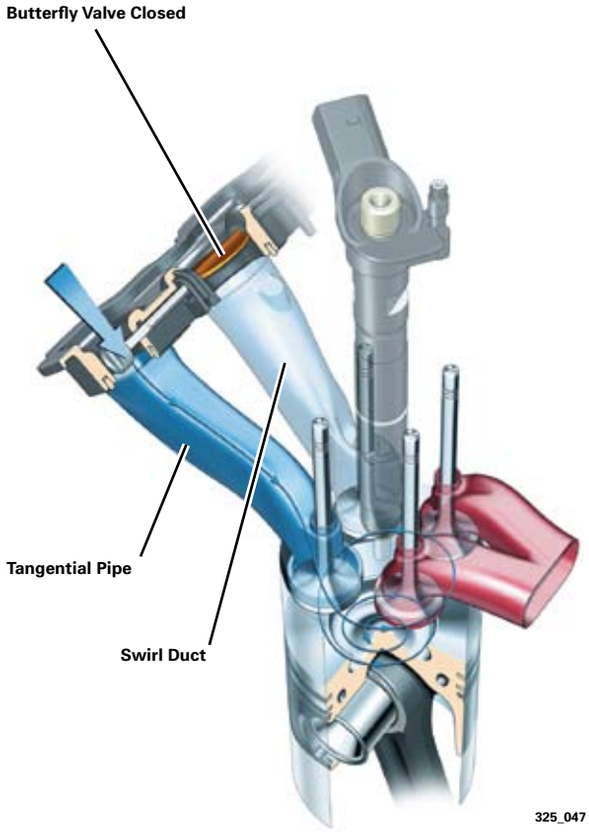
The entry of exhaust gasses into the intake tract counters the intake air flow, resulting in a constant mixture of fresh air and exhaust gas.

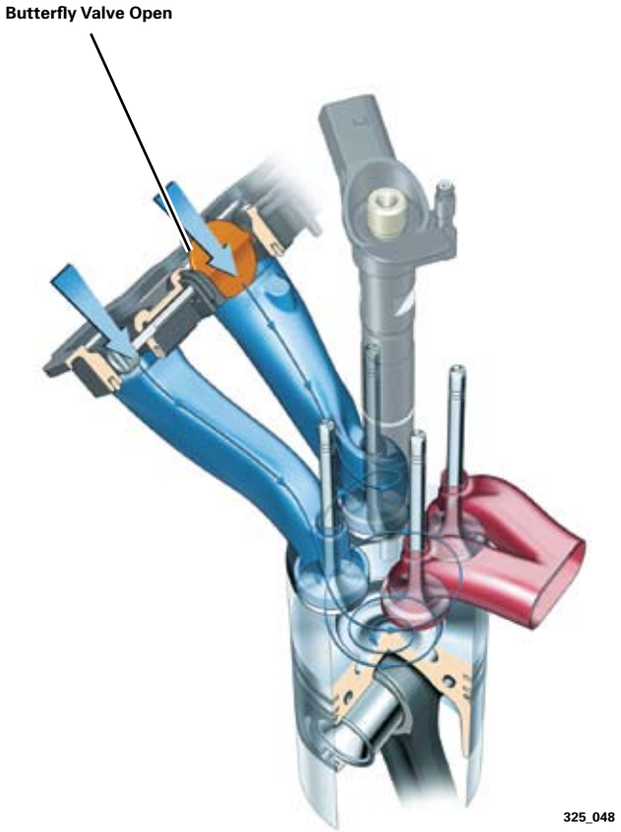
Throttle Position Adjuster:

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.

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





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.

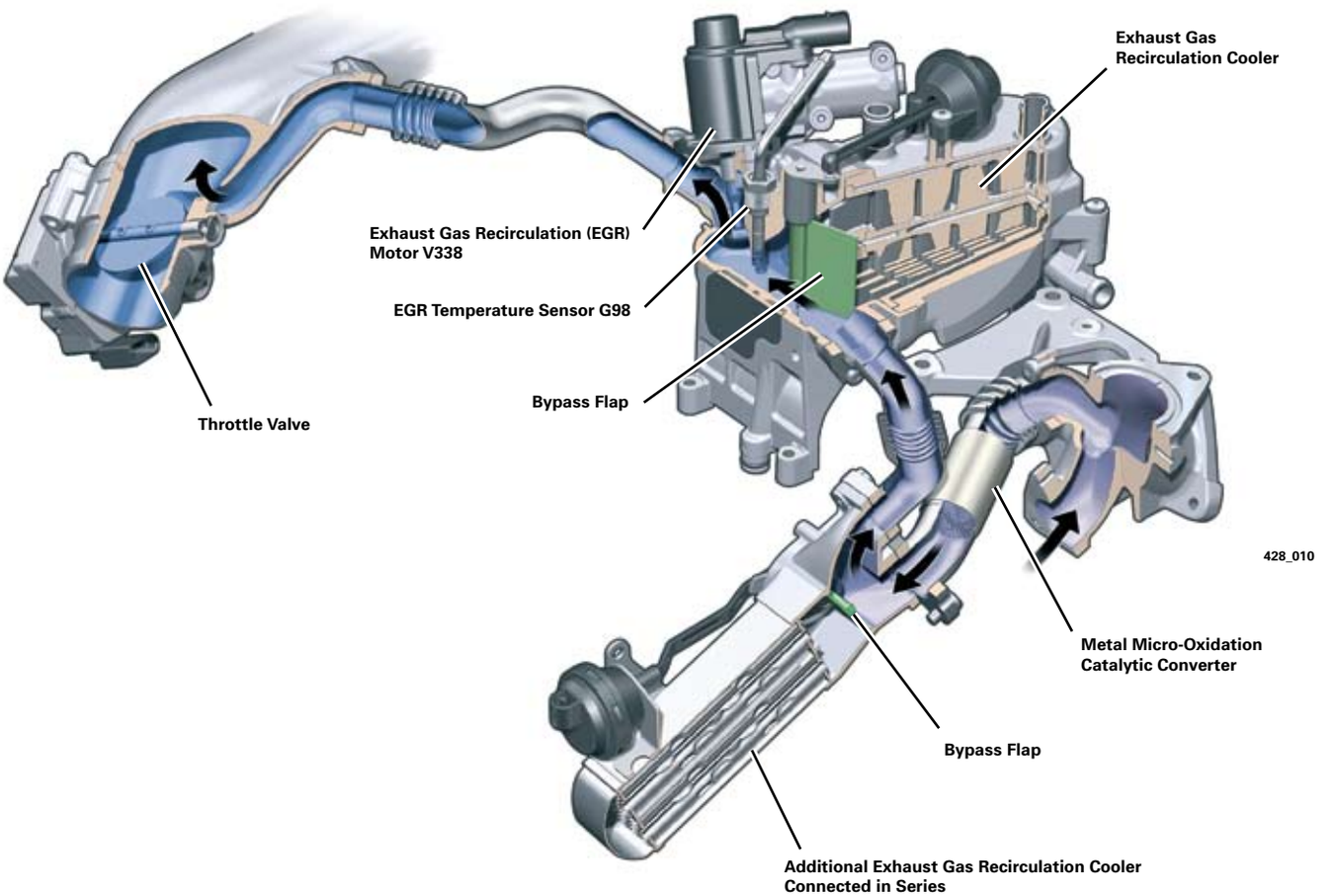
The exhaust gas recirculation path consists of the following: micro-catalytic converter, additional cooler, and cooler for exhaust gas recirculation temperature sensor, and electric water-cooled exhaust gas recirculation valve.

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.



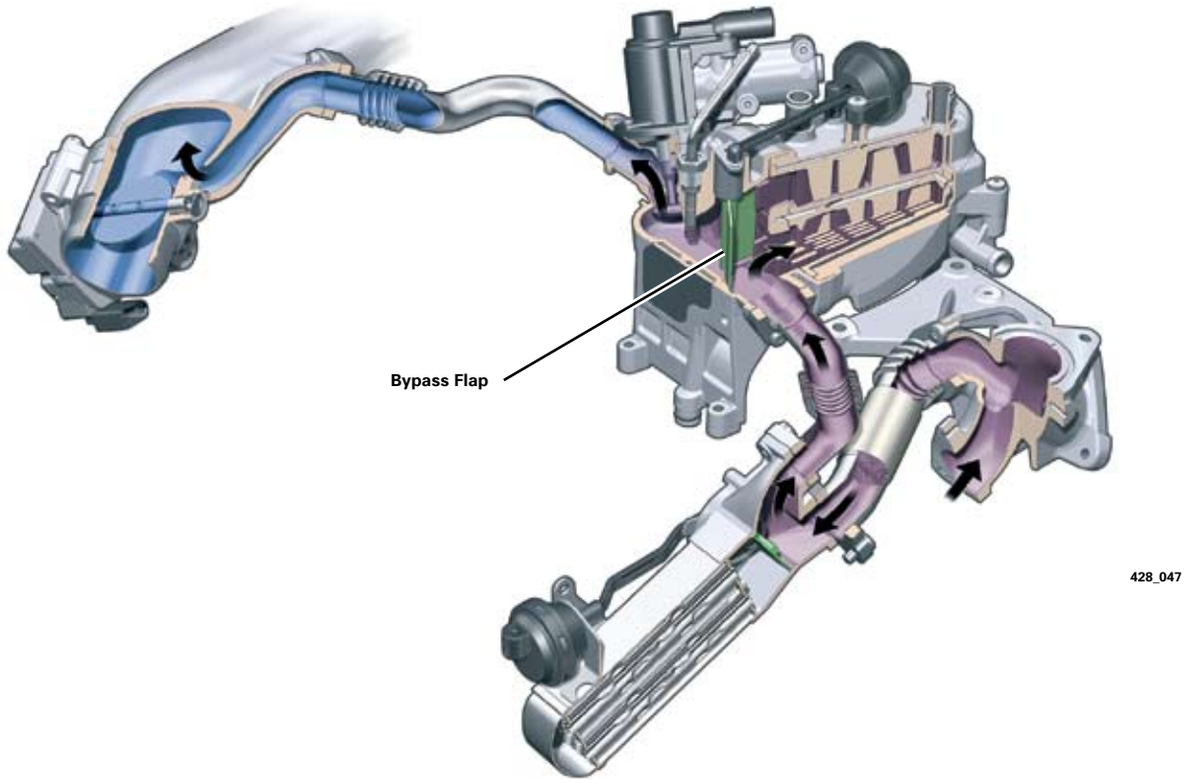
Switchable Exhaust Gas Recirculation Actuator

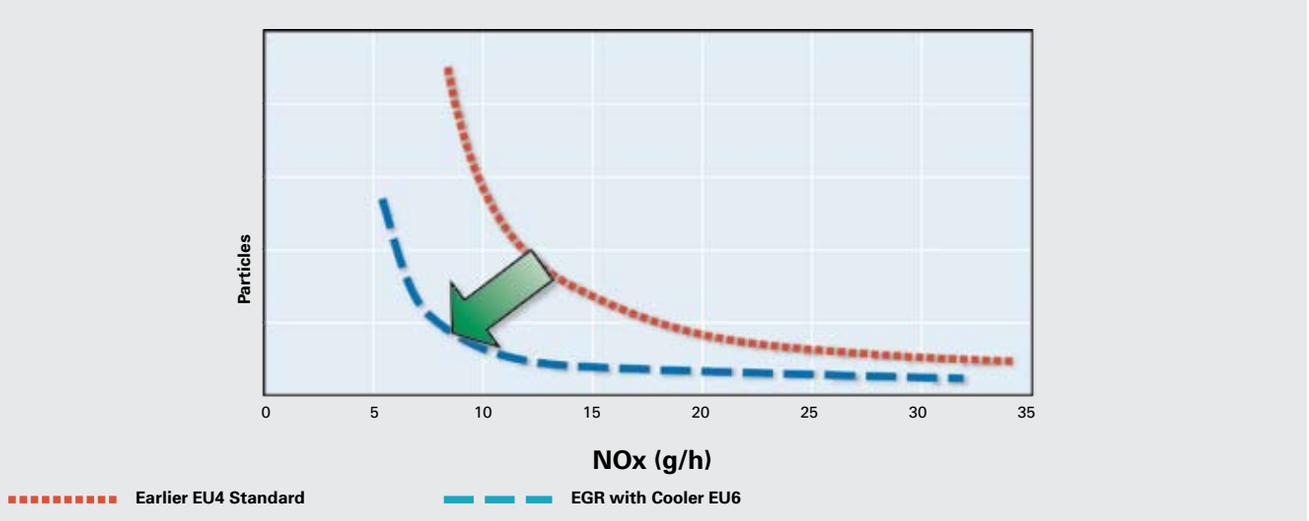
The cooling performance of the exhaust gas recirculation cooler leads to a clear reduction in particle and nitrogen emissions. The diagrams below and on the next page show the efficiency of the exhaust recirculation system in two selected partial load points.

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.

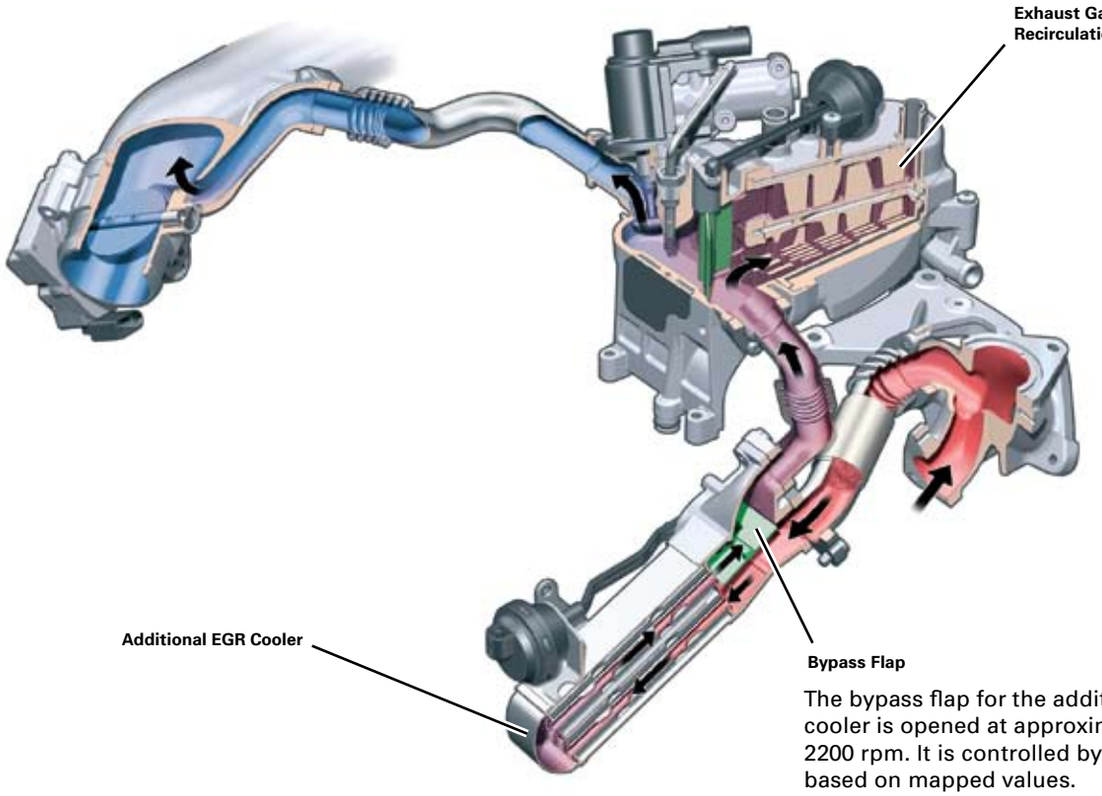
The bypass flap for the EGR cooler is opened at approximately 1750 rpm. It is controlled by the ECM, based on mapped values.



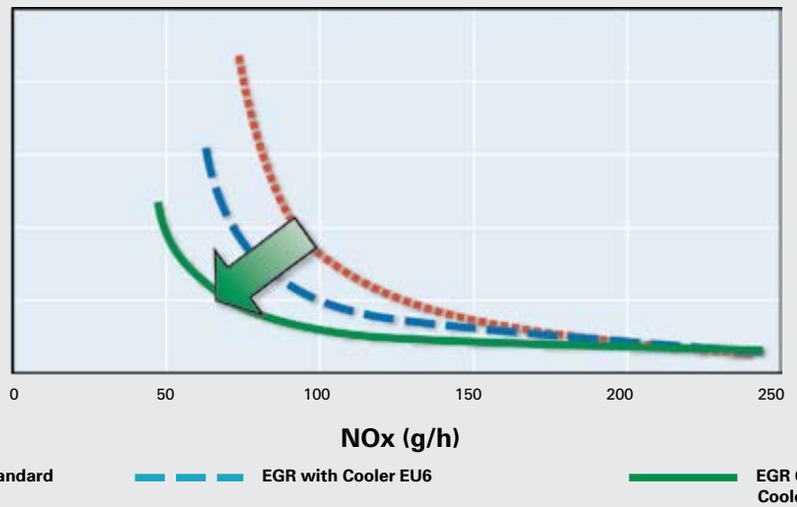


Flow Through Additional EGR Cooler – Flow Through EGR Cooler

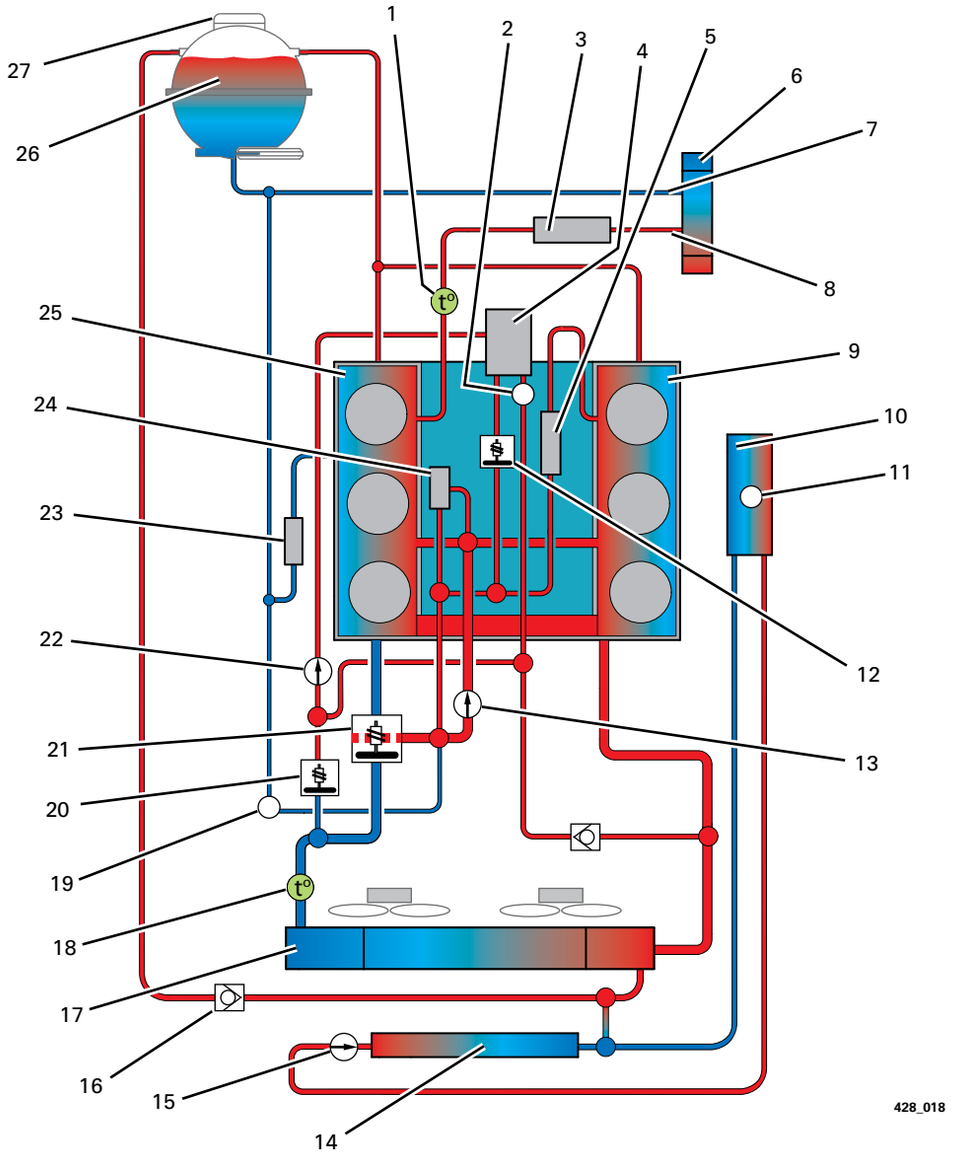
The additional cooler is opened with increasing load and resulting higher exhaust temperatures; thus both EGR coolers are in cooling mode. This allows an increase of the EGR rate. The exhaust gas temperatures are lower and nitrogen oxide emissions are further reduced.



The bypass flap for the additional EGR cooler is opened at approximately 2200 rpm. It is controlled by the ECM, based on mapped values.



Cooling System



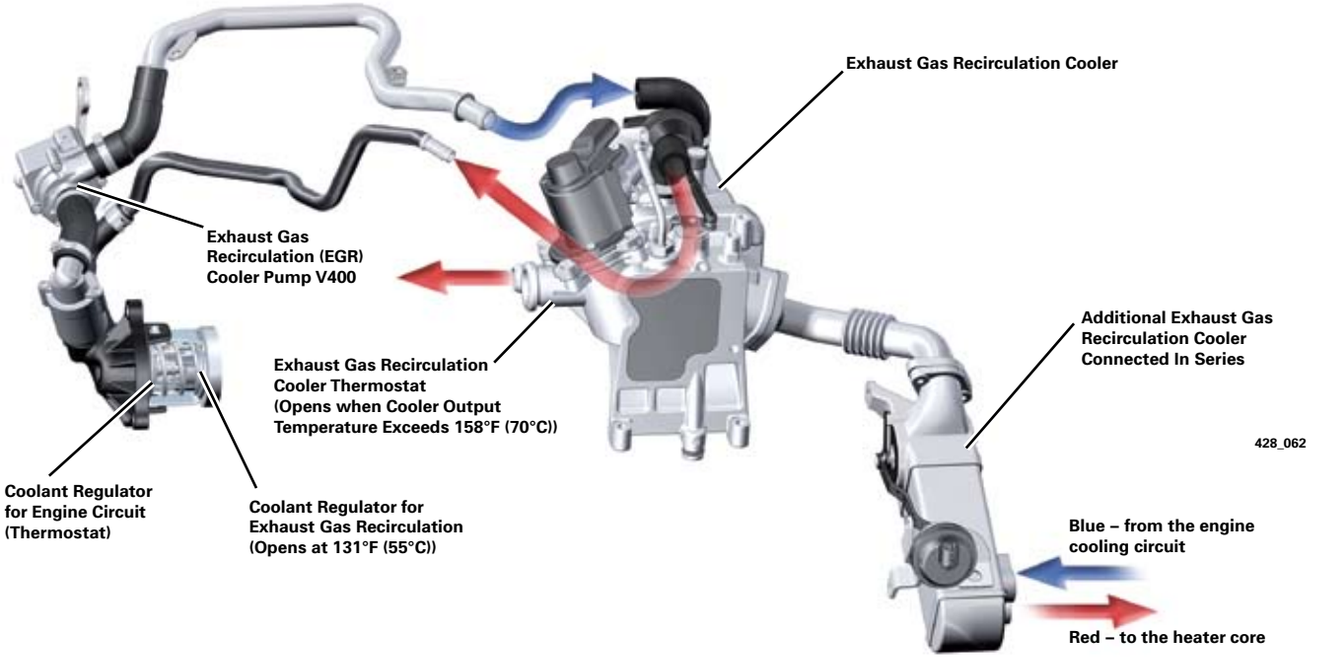
Legend

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

Exhaust Gas Recirculation Cooling

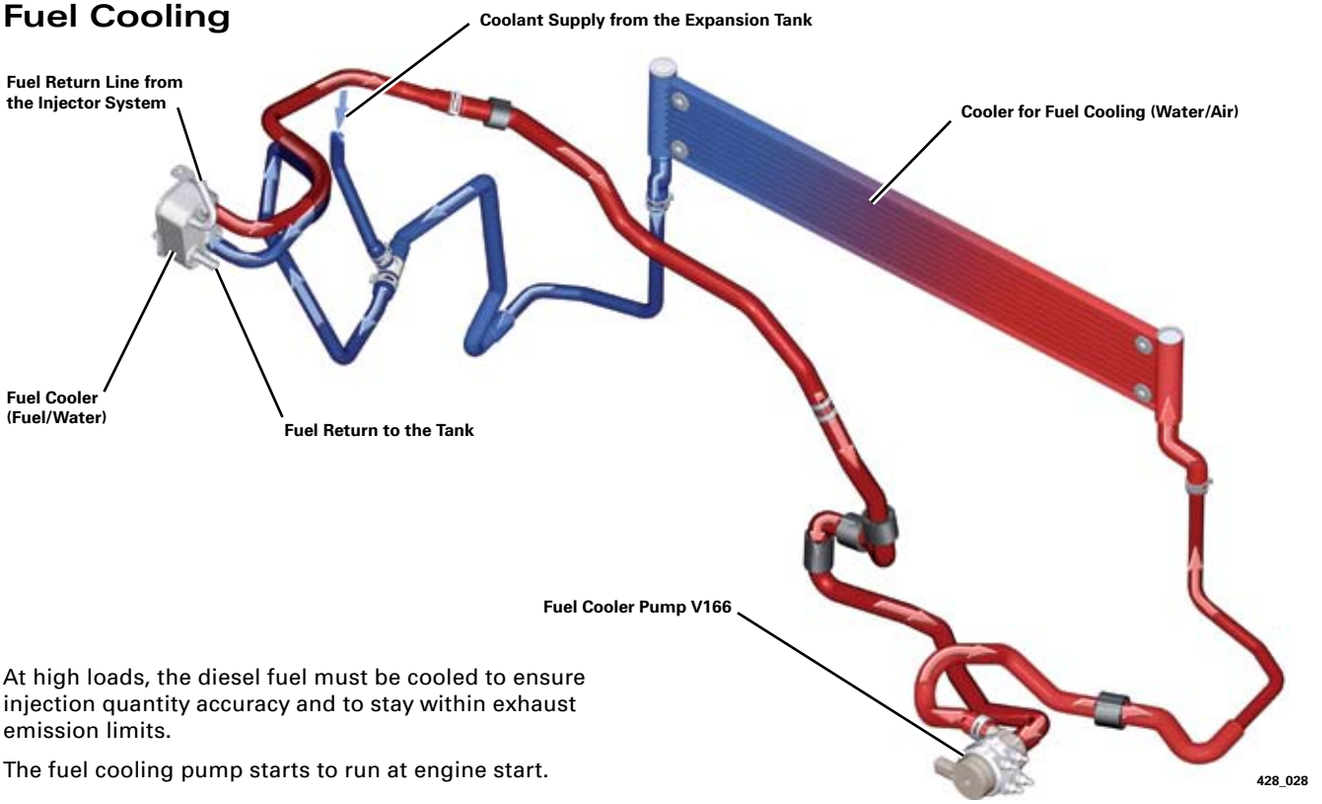


The high efficiency of the radiator for exhaust gas recirculation is reached through its own low-temperature cycle in the cooling system.

Exhaust Gas Recirculation Cooler Pump V400 activates after engine start up and supplies the EGR cooler with cold water directly from the main radiator. The coolant regulator for the EGR controls the temperature in the EGR cooler at a constant 131°F (55°C) 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 188°F (87°C).

Fuel Cooling



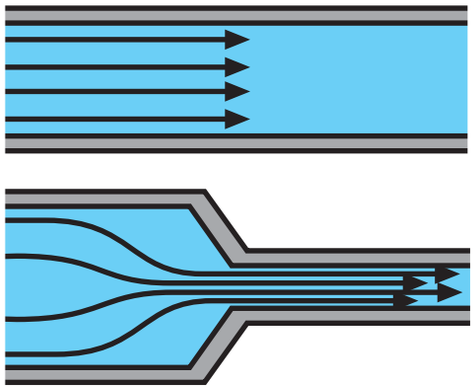
At high loads, the diesel fuel must be cooled to ensure injection quantity accuracy and to stay within exhaust emission limits.

The fuel cooling pump starts to run at engine start.

Variable Vane Turbocharger Operation

The adjustable turbocharger uses air guide vanes to regulate the flow of exhaust gas into the turbine. In contrast to the exhaust gas turbocharger fitted with a wastegate bypass, the adjustable turbocharger produces pressure not only at the top end of the speed range but also across the full speed range.

The fundamental principle here is that a gas will flow through a narrowed pipe more quickly than through a pipe without a restriction, provided that the pressure in the two pipes is equal.



190_007

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.

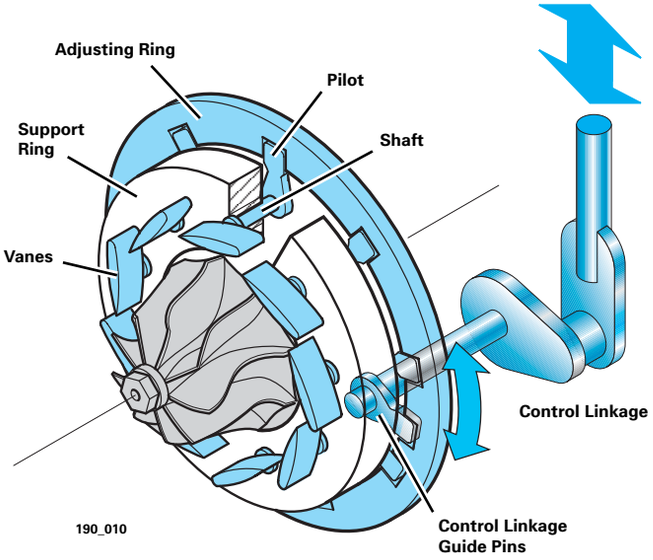
Low Engine Speed and High Charge Pressure are Required

The cross-section of the exhaust gas flow is narrowed upstream of the turbine wheel by means of vanes. Since the exhaust gas is forced to pass through the restricted cross-section more quickly, the turbine wheel rotates faster. The high turbine speed at low engine speed generates the required charge pressure. The exhaust gas back-pressure is high.

High Engine Speed

The turbocharger cross-section is adapted to the exhaust gas flow. In contrast to the wastegate bypass, the entire exhaust gas flow can be fed through the turbine in this way. The vanes free a larger inlet cross-section, thereby ensuring that the required charge pressure is not exceeded. The exhaust gas back-pressure drops.

The vanes are fitted together with their shafts onto a supporting ring. The pilot pins of each vane are engaged in an adjusting ring, which moves all vanes simultaneously. The adjusting ring is controlled by Turbocharger (TC) 1 Control Module J724 via a guide pin.



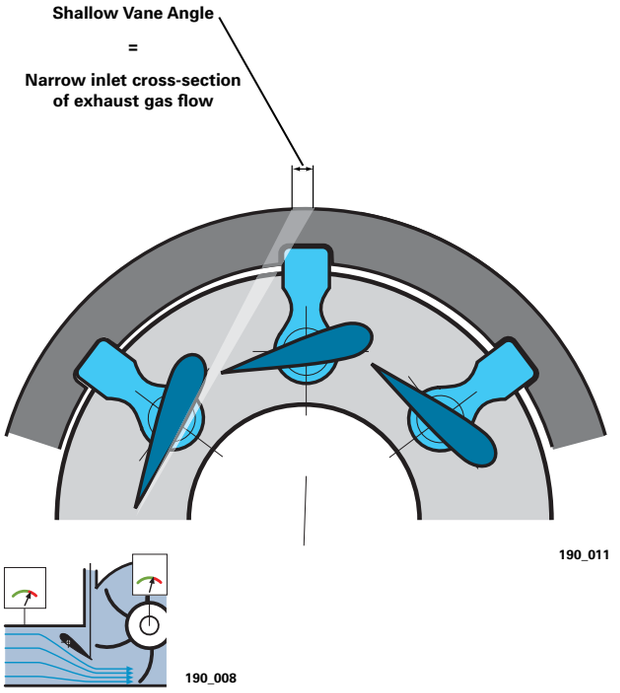
190_010

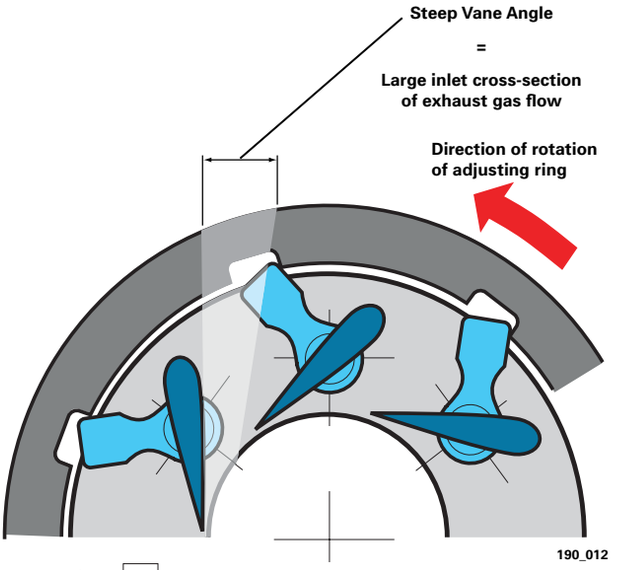
To allow a quick build-up of charge pressure at low speed and under full load, the vanes are set to a narrow inlet cross-section. The effect of the restriction is to speed up the exhaust gas flow, thus increasing turbine speed.

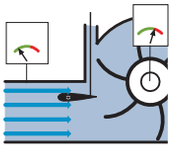
The vanes are set at a steeper angle with increasing exhaust gas flow rate or if a lower charge pressure is required.

When the inlet cross-section is enlarged, the charge pressure and the turbine output remain virtually constant.

In emergency operation, the vanes are at their maximum angle, providing the largest possible inlet cross-section.



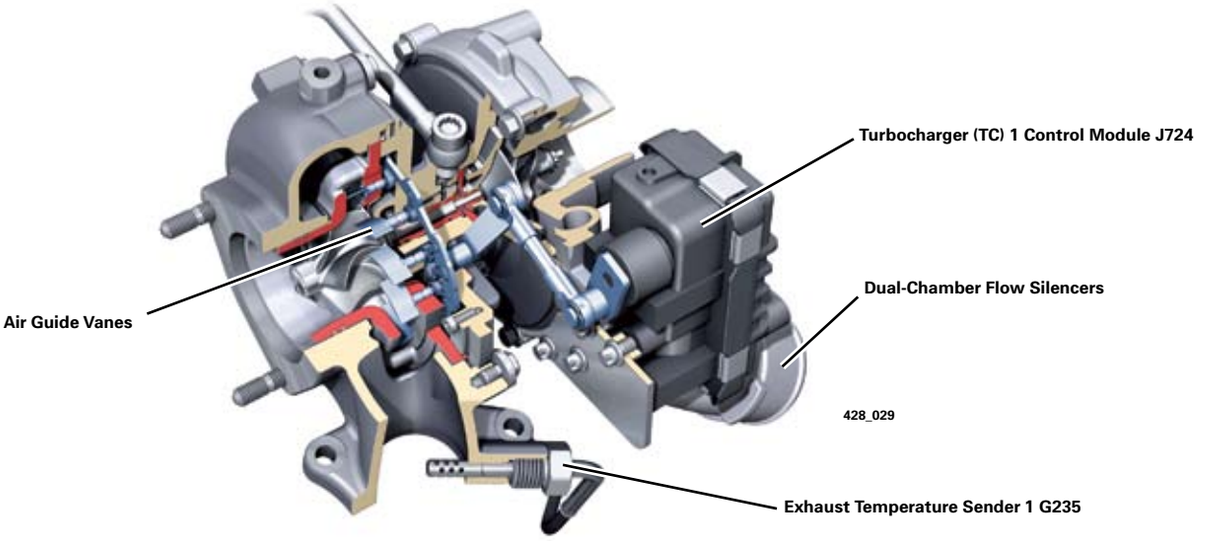




The small size of the compressor and turbine allows a high level of response with only a slightly reduced maximum output.

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.

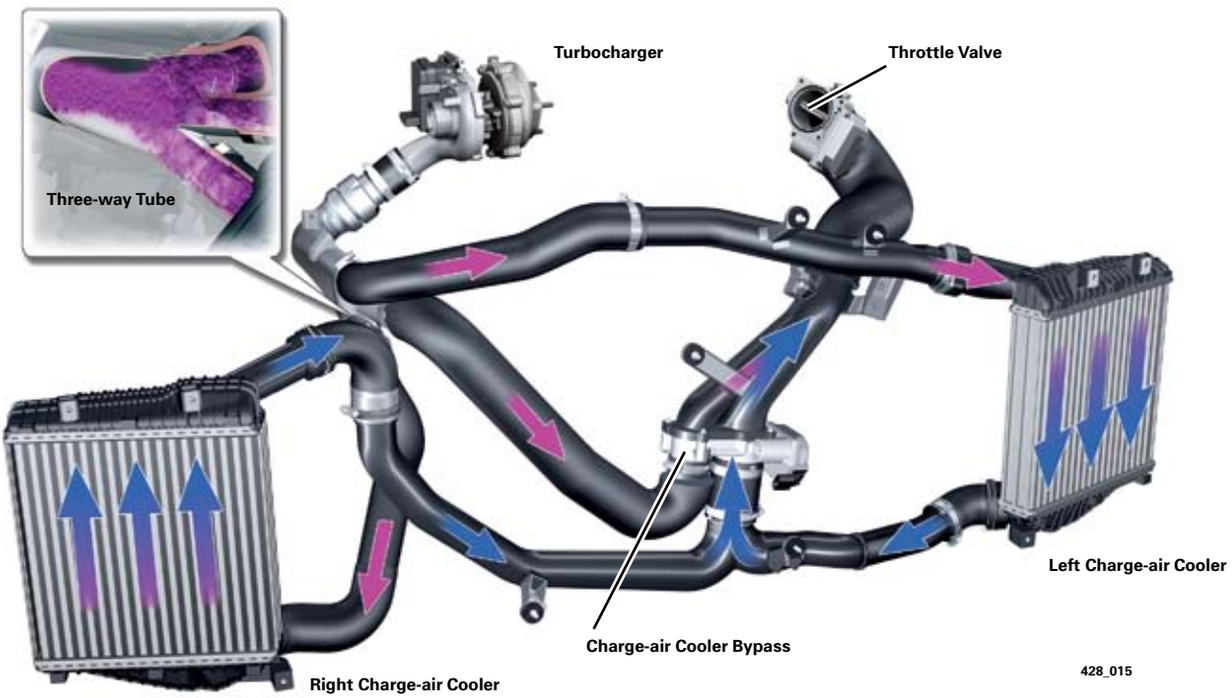
A flow silencer on the suction side and a dual-chamber flow silencer on the compressor outlet prevent flow noise associated with high supercharging pressures.



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.



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.

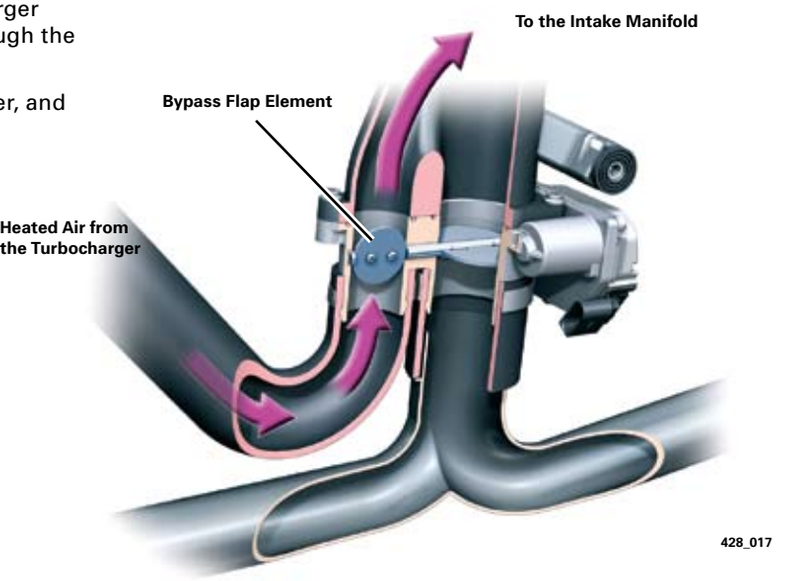
This permits constant thermodynamic boundary conditions for low-emission and low-consumption combustion.

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.

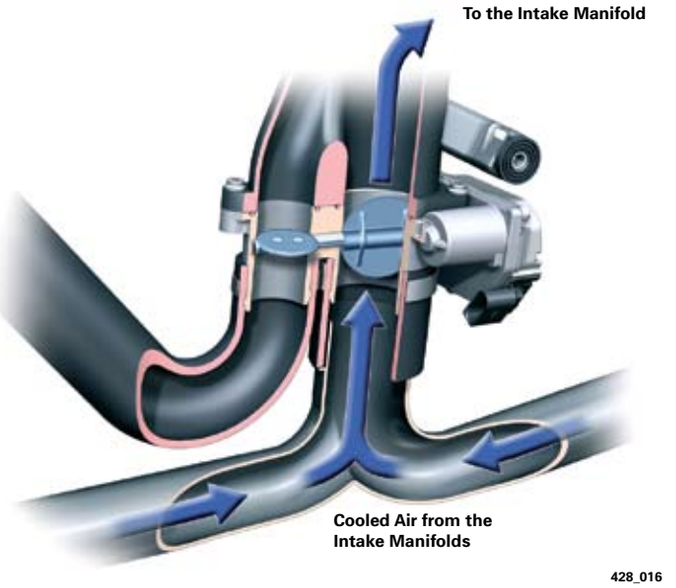
This allows the oxidation catalyst, the particle filter, and the exhaust cleaning systems to activate quickly.



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.

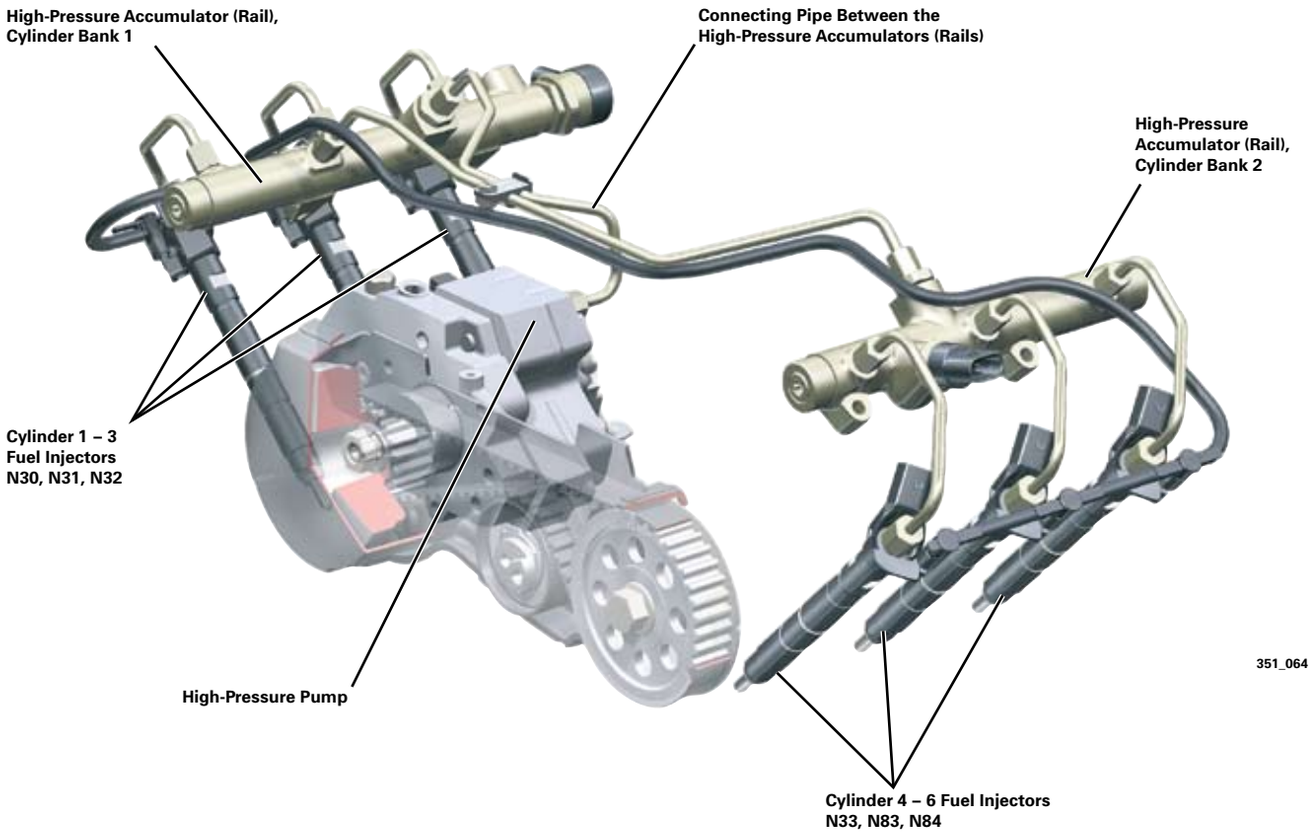
The term “common rail” means that all of one cylinder bank’s injectors have a common, high-pressure fuel accumulator or rail.

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.

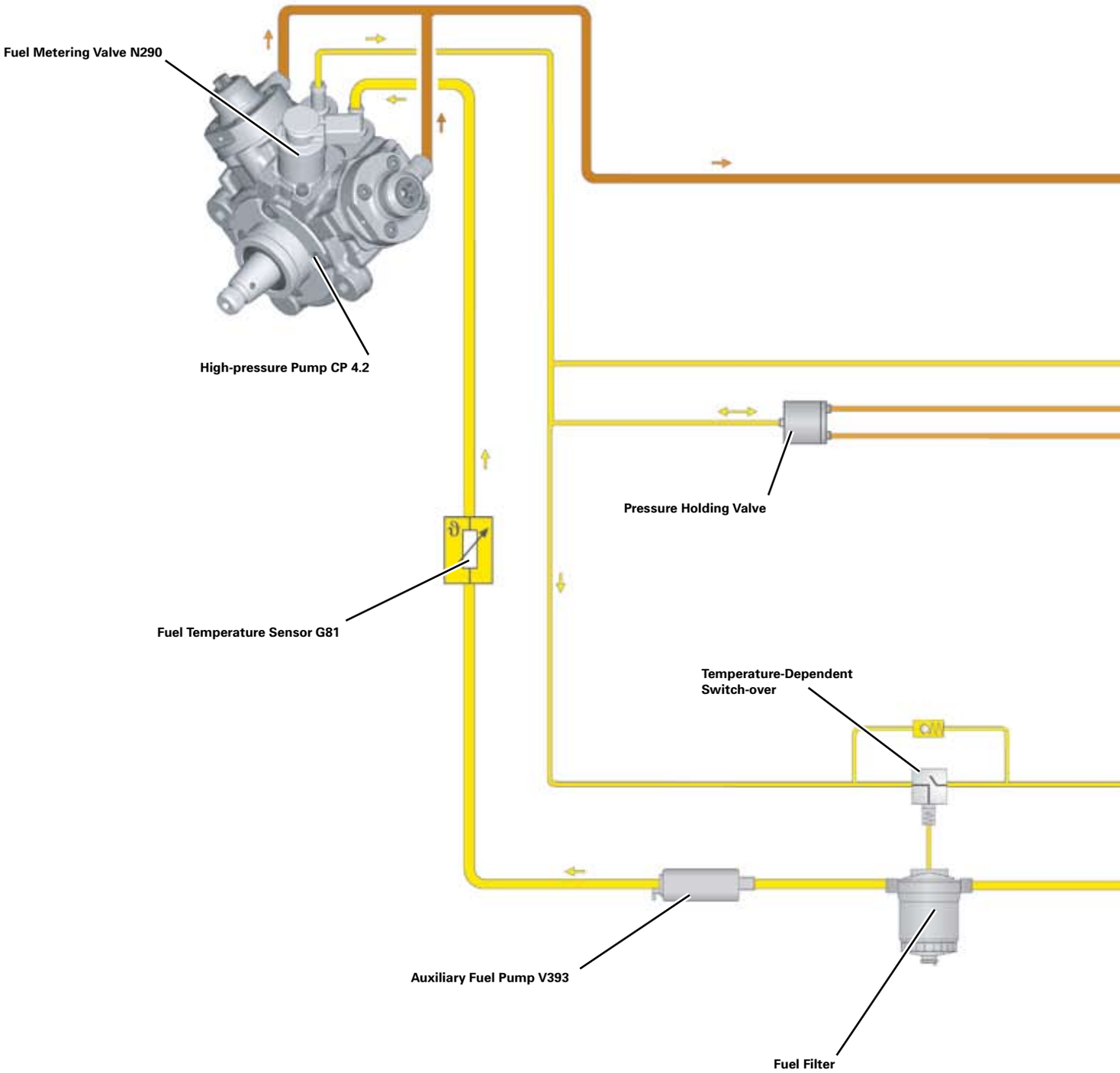
This fuel injection system’s characteristics include:

- 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.

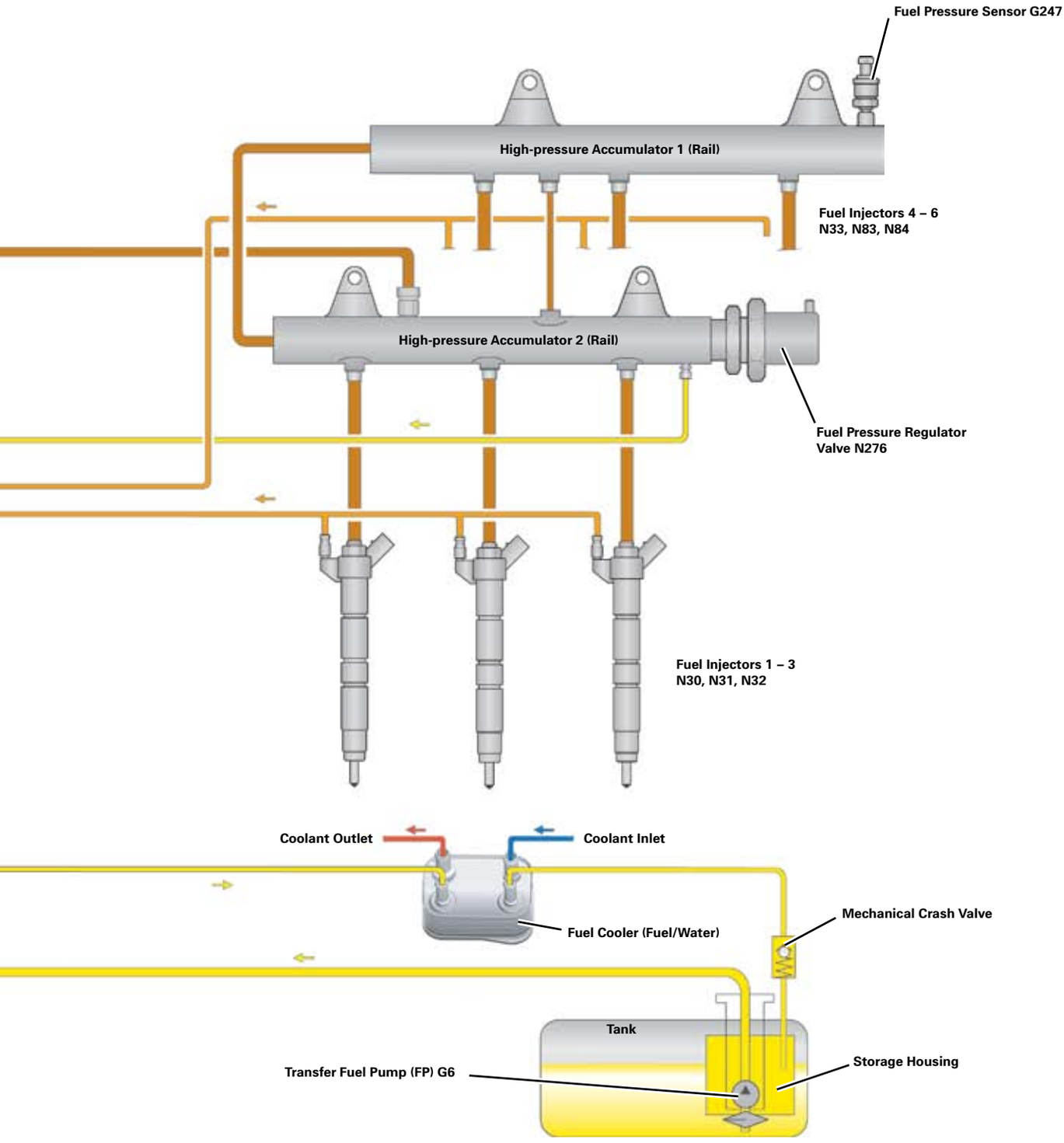


Fuel System



High Pressure (300 - 2000 bar)

Low Pressure Return from the Injector (10 bar)

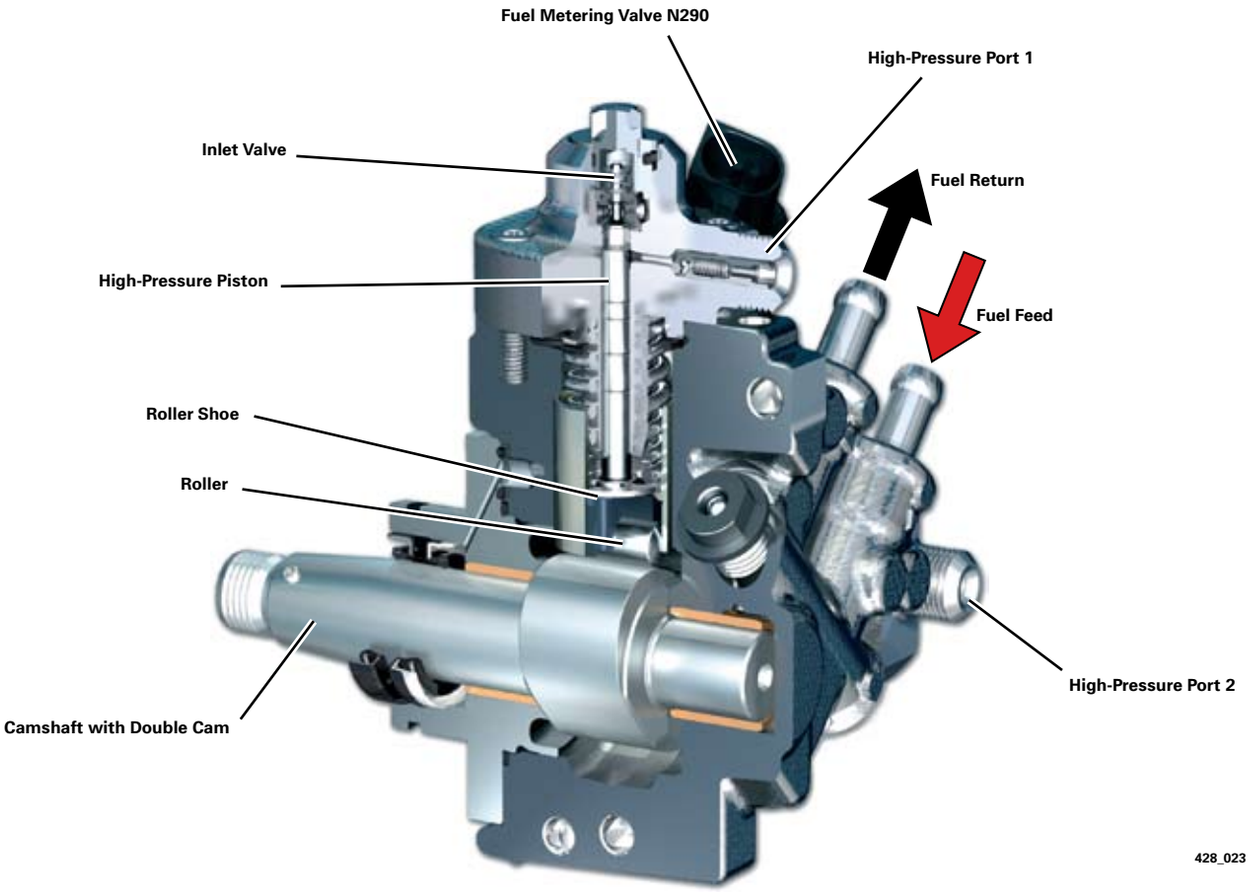

Fuel Pressure Sensor G247
High-pressure Accumulator 1 (Rail)
Fuel Injectors 4 – 6
N33, N83, N84
High-pressure Accumulator 2 (Rail)
Fuel Pressure Regulator
Valve N276
Fuel Injectors 1 – 3
N30, N31, N32
Coolant Outlet
Coolant Inlet
Fuel Cooler (Fuel/Water)
Mechanical Crash Valve
Tank
Transfer Fuel Pump (FP) G6
Storage Housing

428_026

High-pressure Pump CP4.2

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

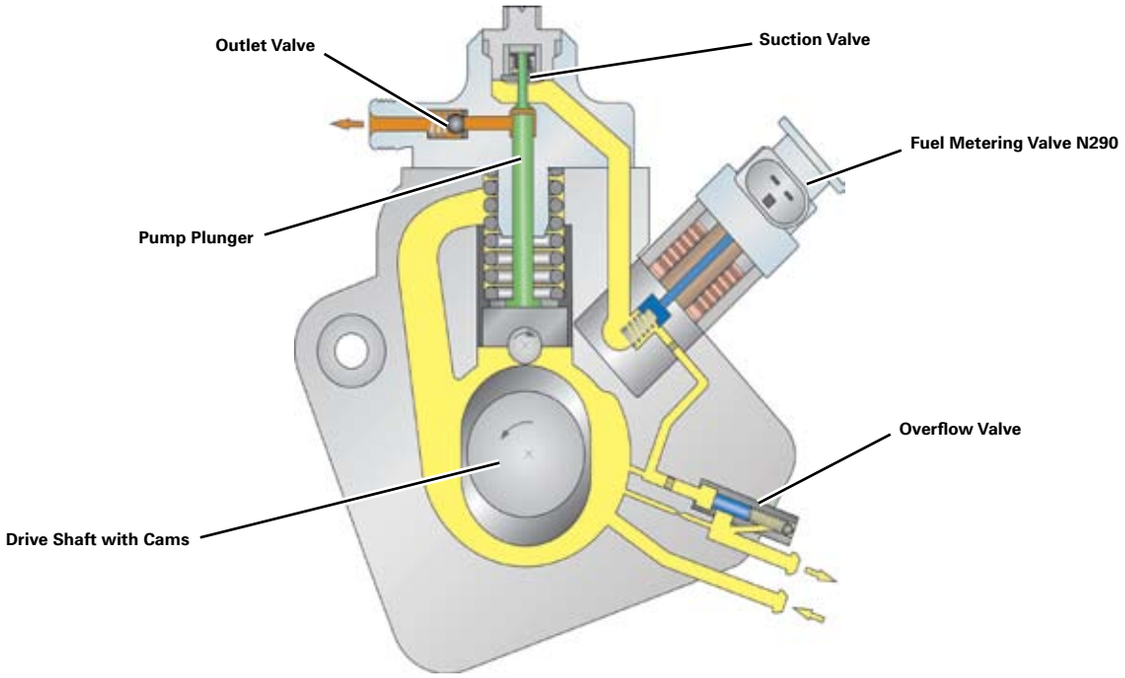
The pump is supplied with fuel by the Auxiliary Fuel Pump V393 downstream of the Transfer Fuel Pump (FP) G6. Two pump pistons are actuated alternately by the camshaft (two lobes).



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 Pump Internal Components



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.

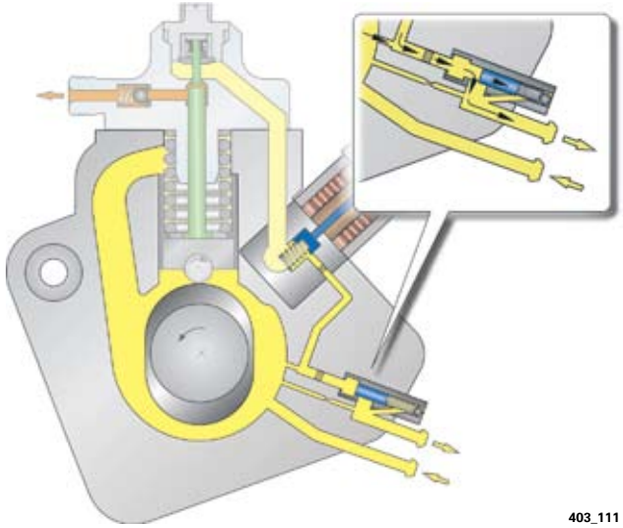
Overflow Valve

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.

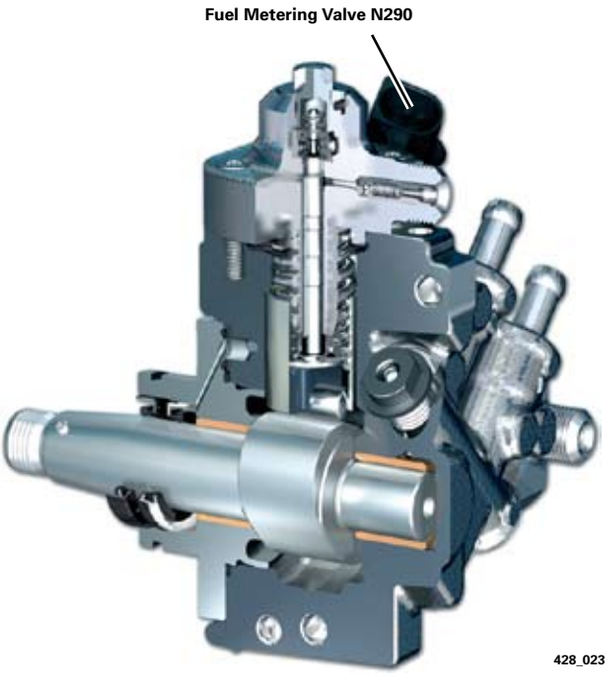
The excess fuel flows via the fuel return line into the fuel filter



Fuel Metering Valve N290

The Fuel Metering Valve N290 is integrated into the high-pressure pump. It ensures that the fuel pressure is regulated as required in the high-pressure area.

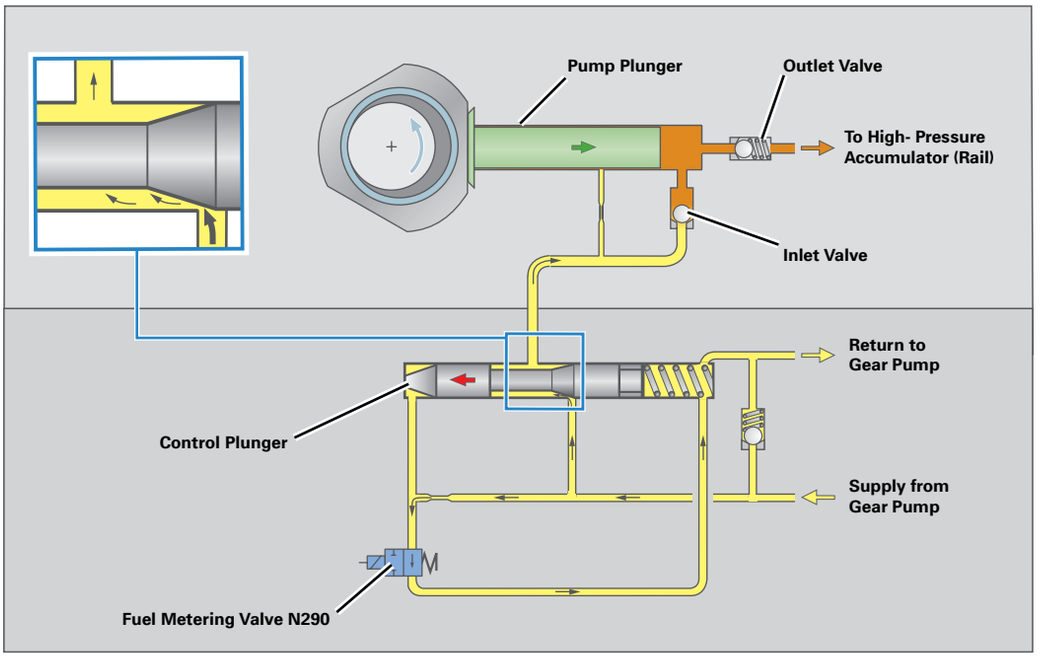
The Fuel Metering Valve N290 regulates the quantity of fuel which flows to the high-pressure pump. The advantage of this is that the high-pressure pump only has to generate the pressure which is required for the current operating situation. This reduces the high-pressure pump power consumption and avoids unnecessary fuel heating.



428_023

Fuel Metering Valve N290 Function – Without Current

When no current is supplied, the Fuel Metering Valve N290 is open. The control plunger is shifted to the left by the spring force, and releases the minimal cross-section to the high-pressure pump. As a result of this, only a small quantity of fuel enters the high-pressure pump compression chamber.

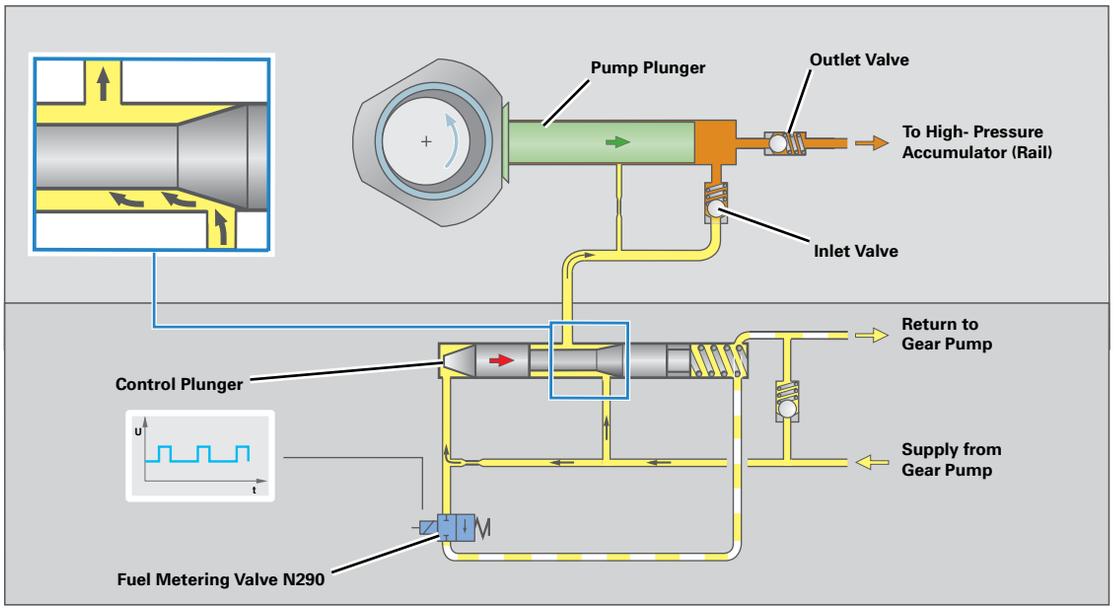


351_013

Fuel Metering Valve N290 Function – Initialized

To increase the quantity inlet to the high-pressure pump, Fuel Metering Valve N290 is initialized by the Engine Control Module through a Pulse-Width-Modulated (PWM) signal.

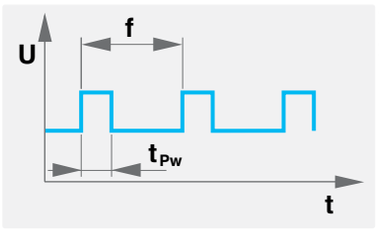
Due to the PWM signal, the Fuel Metering Valve N290 is pulsed closed. This results in a control pressure, which acts on the control plunger, downstream of the valve. Varying the on-off ratio changes the control pressure and therefore the position of the plunger. The control pressure decreases and the control plunger is shifted to the right. This increases the fuel inlet to the high-pressure pump.



351_088

Effects of Failure

The engine output is reduced. The engine management system operates in emergency running mode.

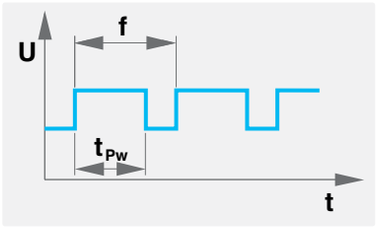


Short Pulse Width = Small Fuel Inlet

351_124

PWM Signals

PWM signals are “pulse-width-modulated” signals. These are square-wave signals with a variable on-time and constant frequency. Changing the valve on-time for fuel metering, for example, enables the control pressure and therefore the position of the control plunger to be changed.



Large Pulse Width = Large Fuel Inlet

351_125

U = Voltage

t = Time

f = Cycle Duration (Frequency)

t_{Pw} = Pulse Width (On-Time)

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

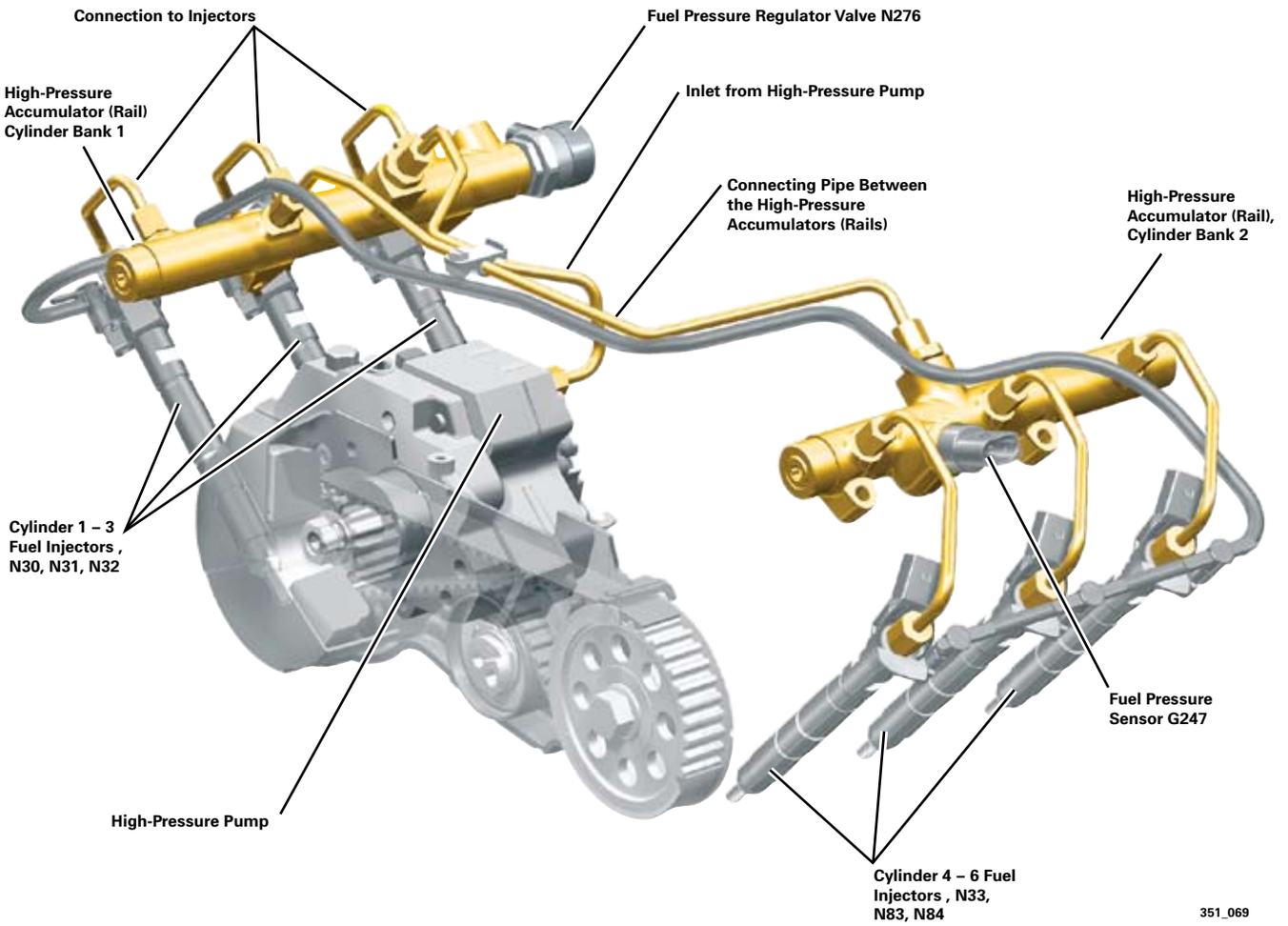
The high-pressure accumulators are connected to each other by a pipe. The fuel inlet connection from the high-pressure pump, the connections to the injectors and the Fuel Pressure Regulator Valve N276 are located on the cylinder bank 1 high-pressure accumulator.

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

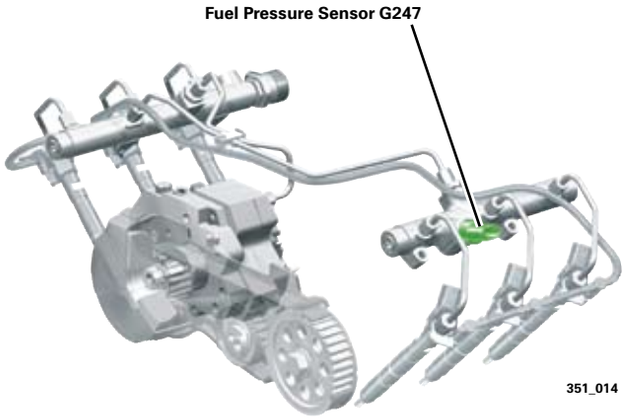
The fuel in the high-pressure accumulators is constantly at a high pressure. When fuel is drawn from the high-pressure accumulators for injection, the pressure within the high-pressure accumulators remains virtually constant due to their large storage volume.

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 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.

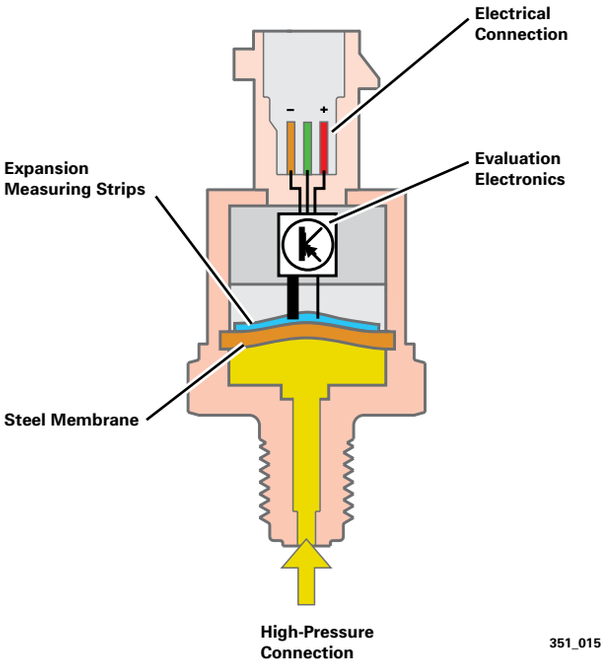
In the event of a change in pressure, the steel membrane deflection changes, as does the resistance value of the expansion measuring strips.

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

A characteristic curve stored in 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.



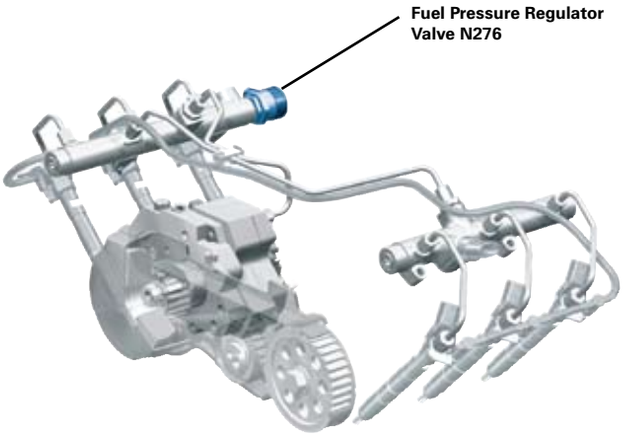
Fuel Pressure Regulator Valve N276

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.

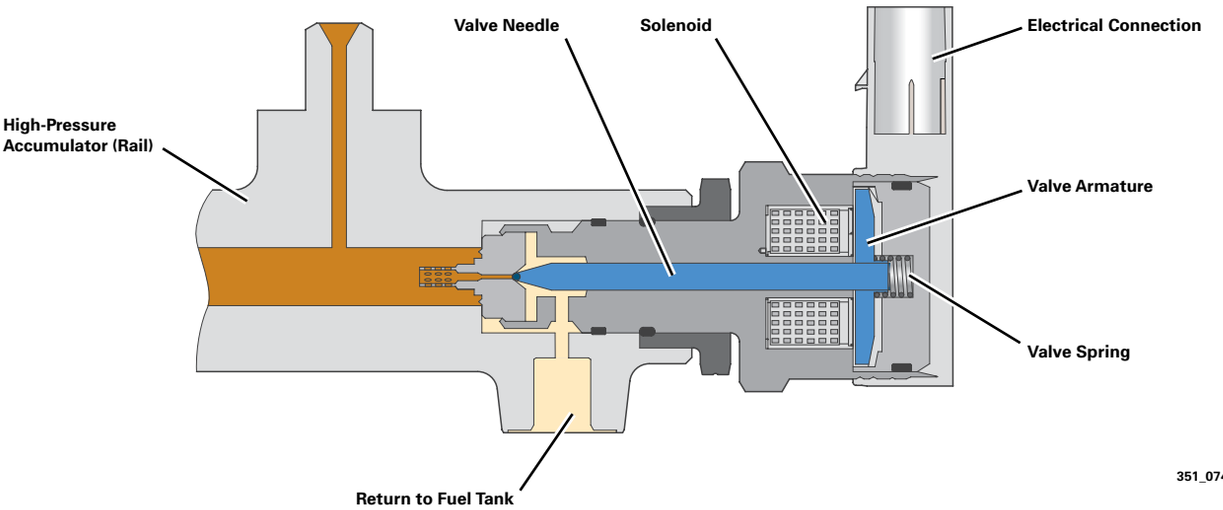


351_047

Function

The illustration below shows the regulator valve in the resting position (engine "off"). If the regulator valve is not initialized, the valve needle is exclusively pressed into its seat by the force exerted by the valve spring. The high-pressure area is separated from the fuel return in this case.

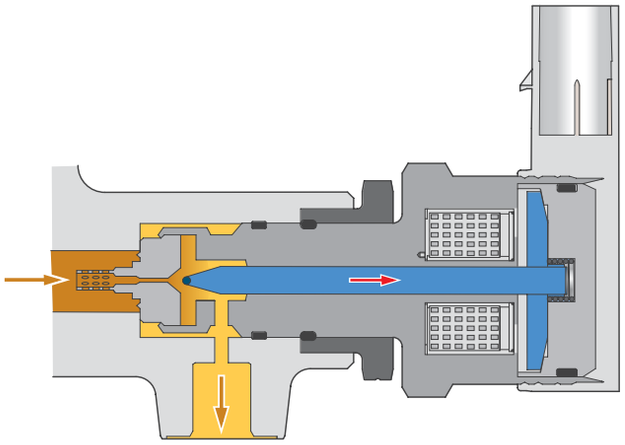
The valve spring is designed in such a way that a fuel pressure of approximately 1160 psi (80 bar) is attained in the high-pressure accumulator (rail).



351_074

Regulator Valve Opened Mechanically

If the fuel pressure in the high-pressure accumulator is greater than the valve spring force, the regulator valve opens and the fuel flows into the fuel tank via the fuel return.



351_087

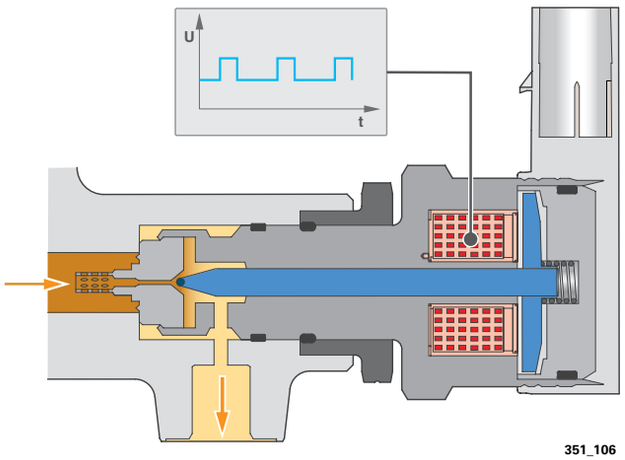
Regulator Valve Initialized (Engine “On”)

To attain an operating pressure of 3,336 and 29,007 psi (230 and 2000 bar) in the high-pressure accumulator, the regulator valve is initialized by the ECM using a PWM signal. This leads to a magnetic field in the solenoid. The valve armature is picked up and presses the valve needle into its seat.

The fuel pressure in the high-pressure accumulator is therefore opposed by a magnetic force in addition to the valve spring force.

Depending on the on-off ratio of initialization, the flow cross-section to the return pipe and therefore the flow is varied.

This also enables compensation for pressure fluctuations in the high-pressure accumulator.



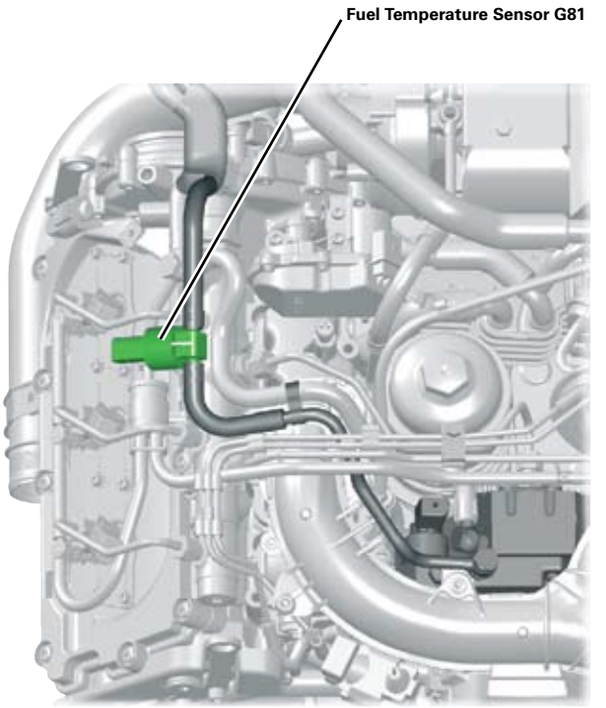
351_106

Effects of Failure

Engine operation is impossible in the event of Fuel Pressure Regulator Valve N276 failure, because sufficiently high fuel pressure for fuel injection cannot be built-up.

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.



S351_031

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.

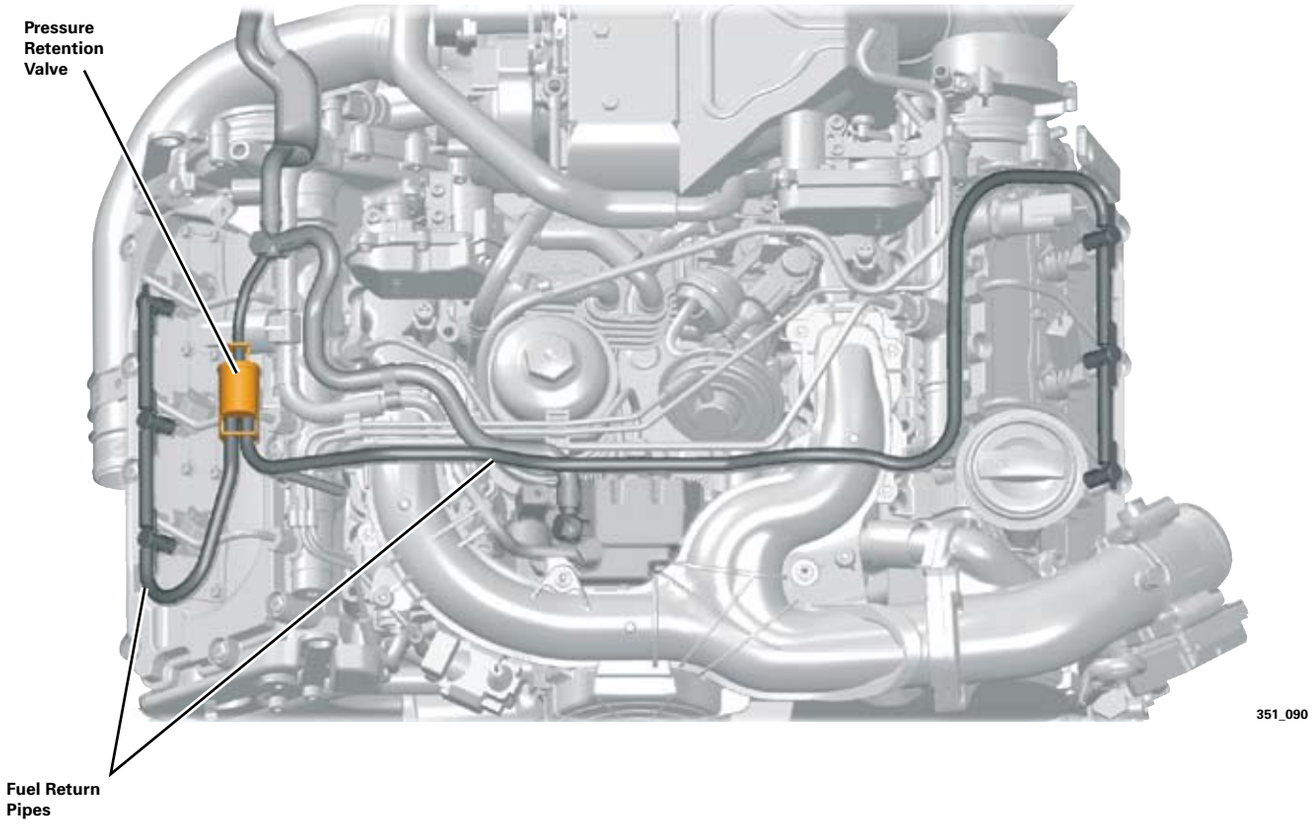
To protect the high-pressure pump against excessively high fuel temperatures, the Fuel Temperature Sensor G81 is located in the fuel supply system. In the event of excessively high temperatures in the fuel supply system, the engine's output is limited in order to protect the high-pressure pump. As a 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.

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.

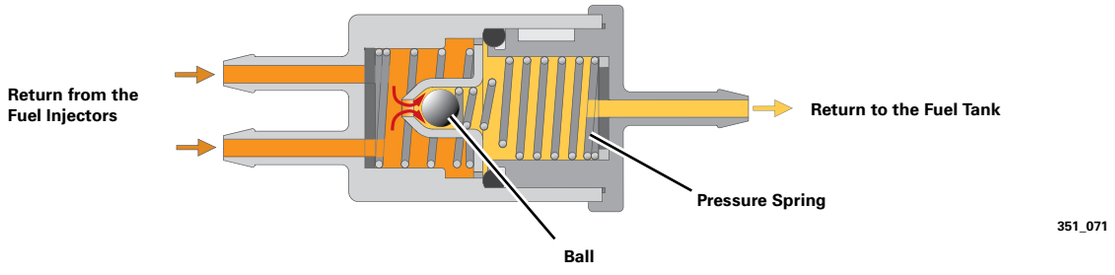


Task

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.



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.

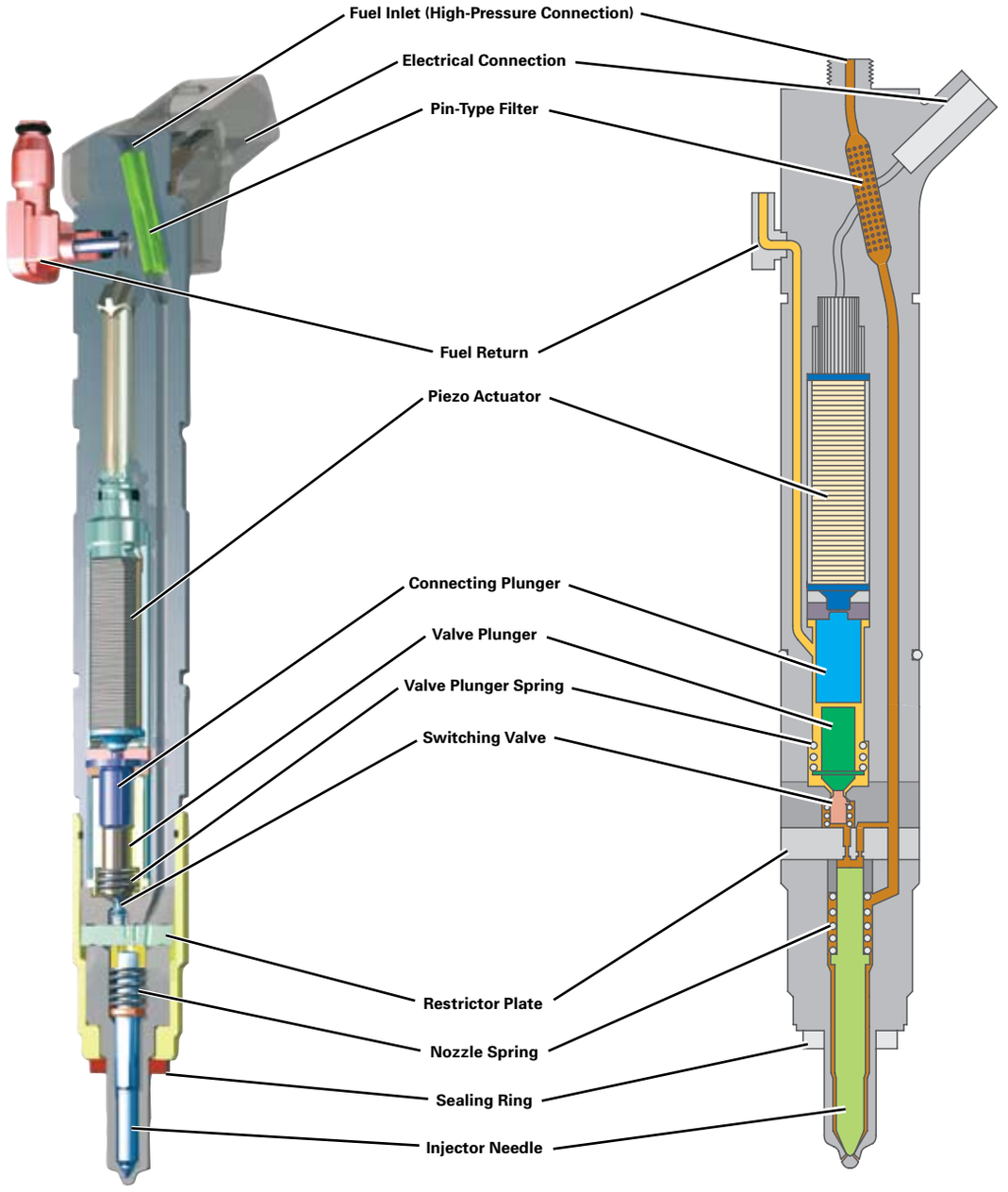
The 3.0L V6 TDI engine has piezo-controlled fuel injectors. Piezo injector switching speed is approximately four times faster than that of a solenoid valve.

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



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.

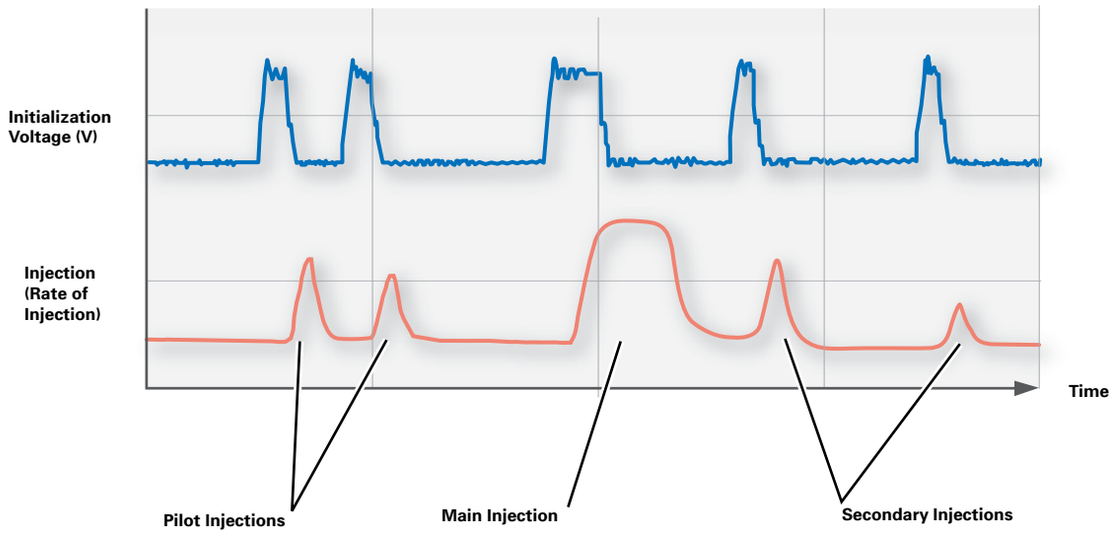
No pilot injection takes place at full throttle and high engine speeds, because a large quantity of fuel has to be injected to achieve a high level of efficiency.

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 piezoelectric effect.

Inverse Piezo-Electric Effect

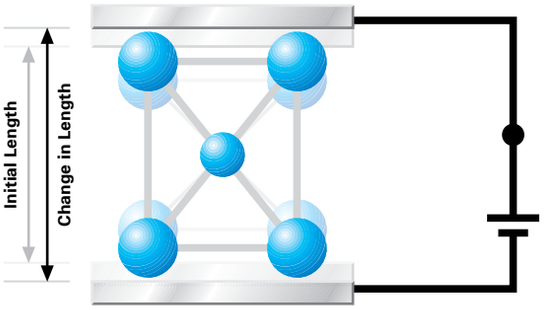
The piezo-electric effect is employed in reverse form in a piezo-controlled actuator. When a voltage is applied to the piezo element the crystalline structure reacts by changing length.

Piezo Actuator

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

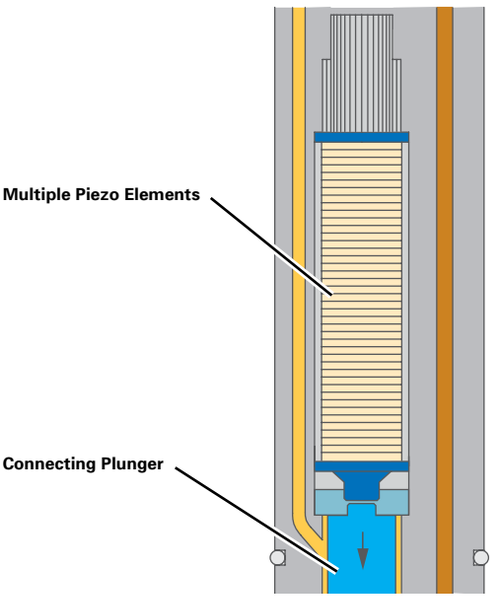
With the application of a voltage, the piezo actuator expands by up to 0.0012 inch (0.03 mm). For comparison purposes, a human hair has a diameter of approximately 0.0024 inch (0.06 mm).

Piezo Element with Voltage V Applied



Simplified Crystalline Structure

351_096



351_017

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

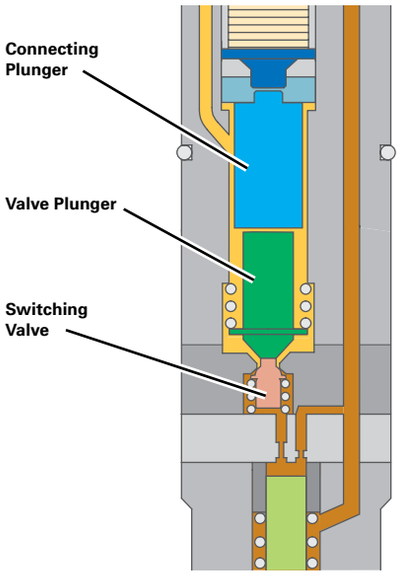
Connecting Module

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

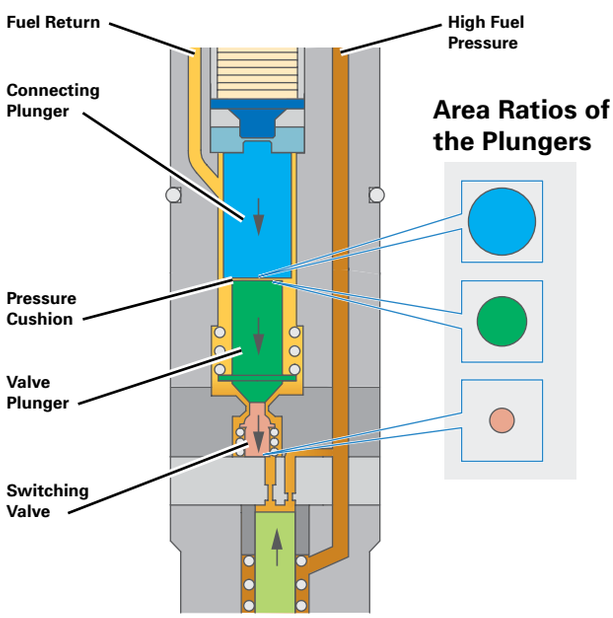
The connecting module is a hydraulic system in which both the forces and the plunger areas behave in relation to each other.

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

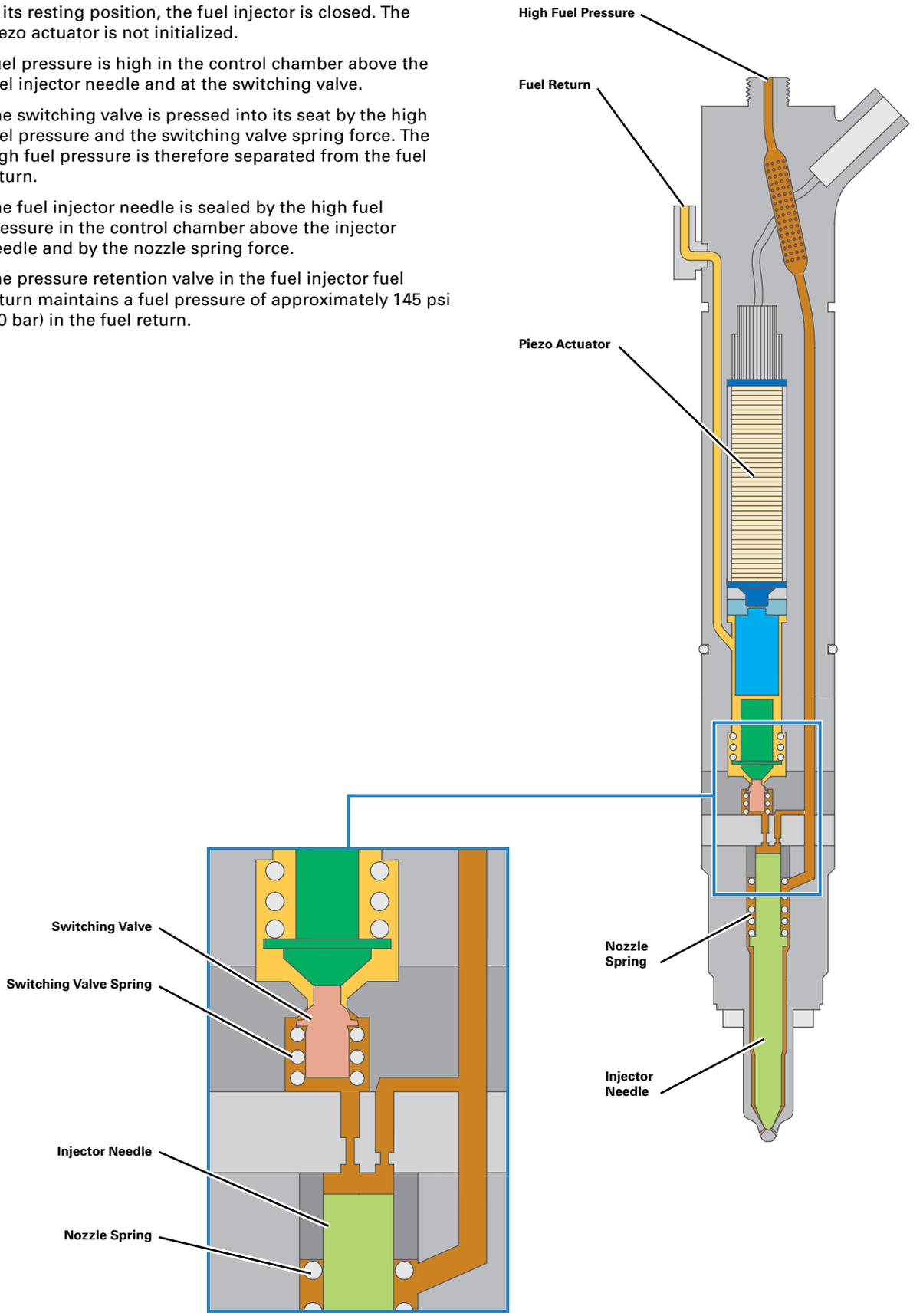
In its resting position, the fuel injector is closed. The piezo actuator is not initialized.

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.



Start of Injection

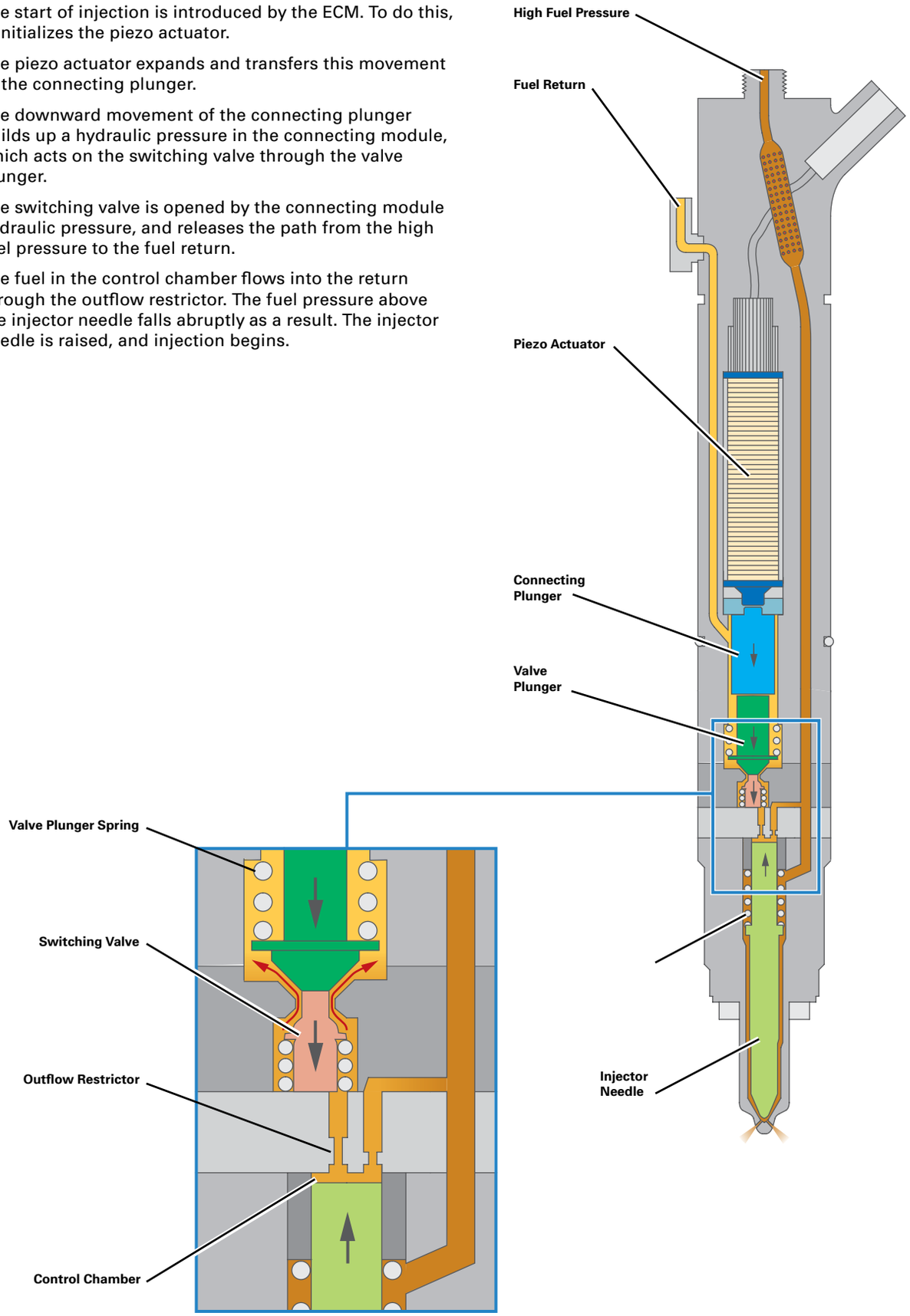
The start of injection is introduced by the ECM. To do this, it initializes the piezo actuator.

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.



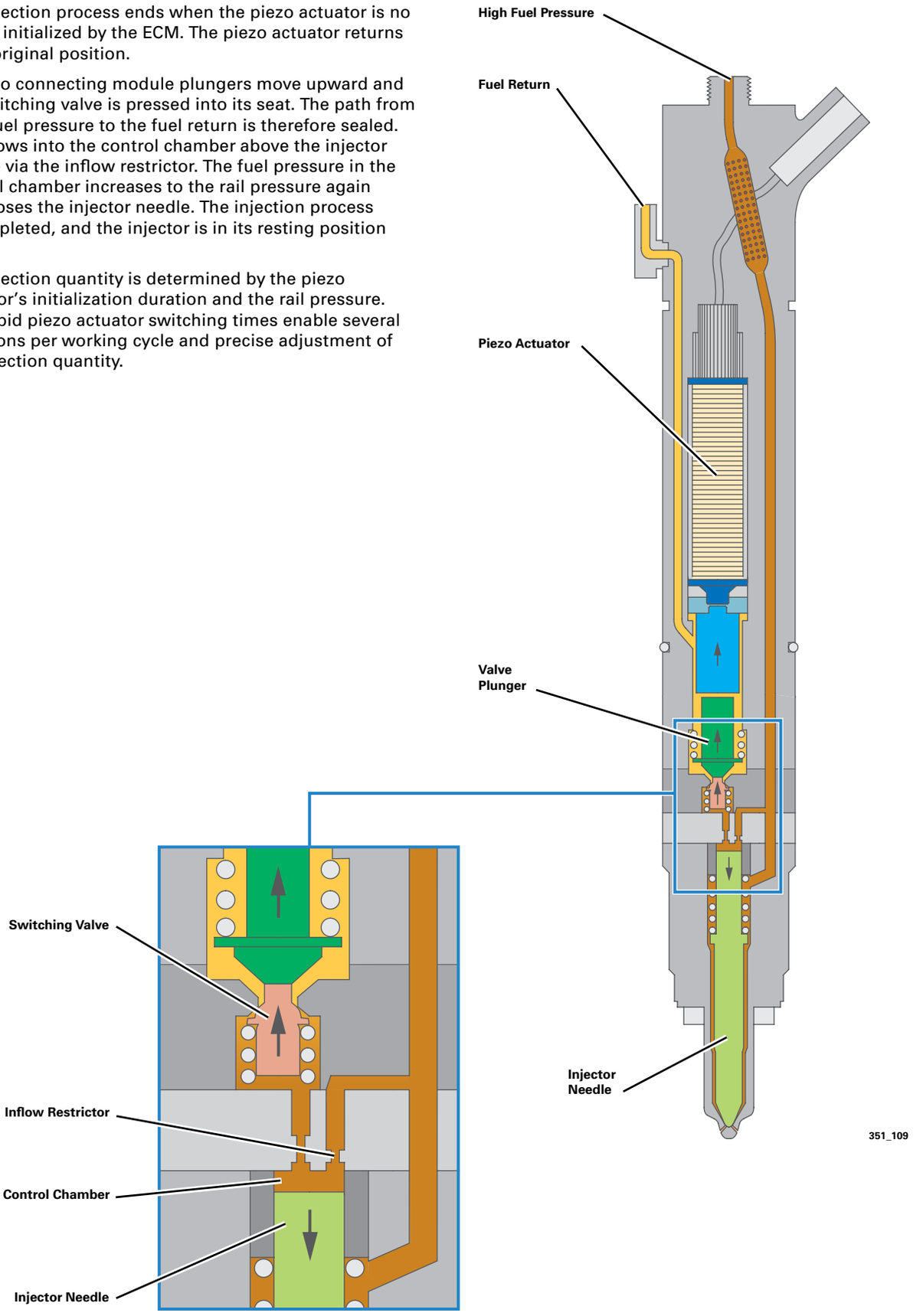
351_020

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.



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

IDC Value

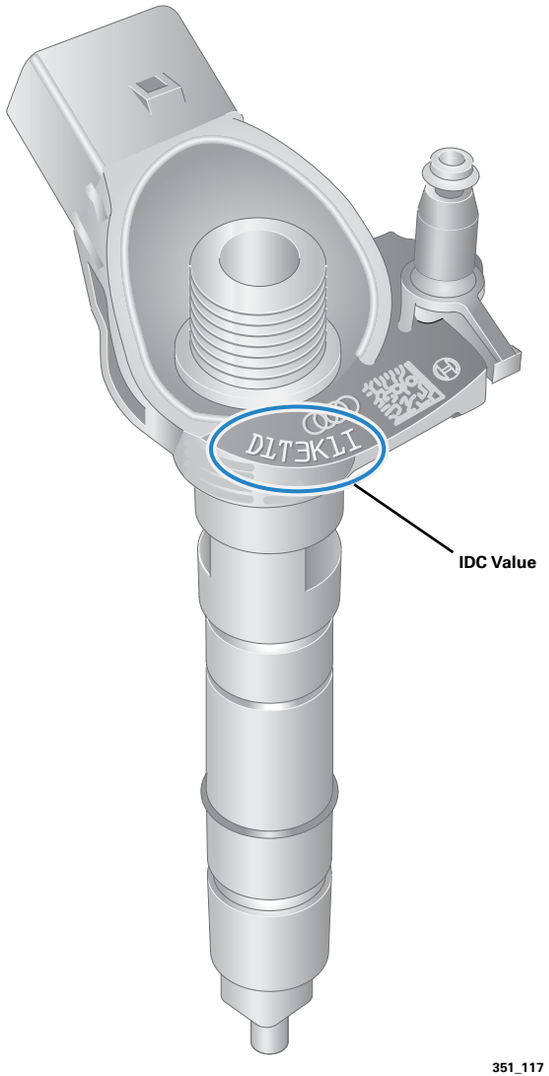
A seven-digit calibration value is printed on each fuel injector. This calibration value may be comprised of letters and/or numbers.

The IDC 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 IDC 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 IDC Code on a Fuel Injector



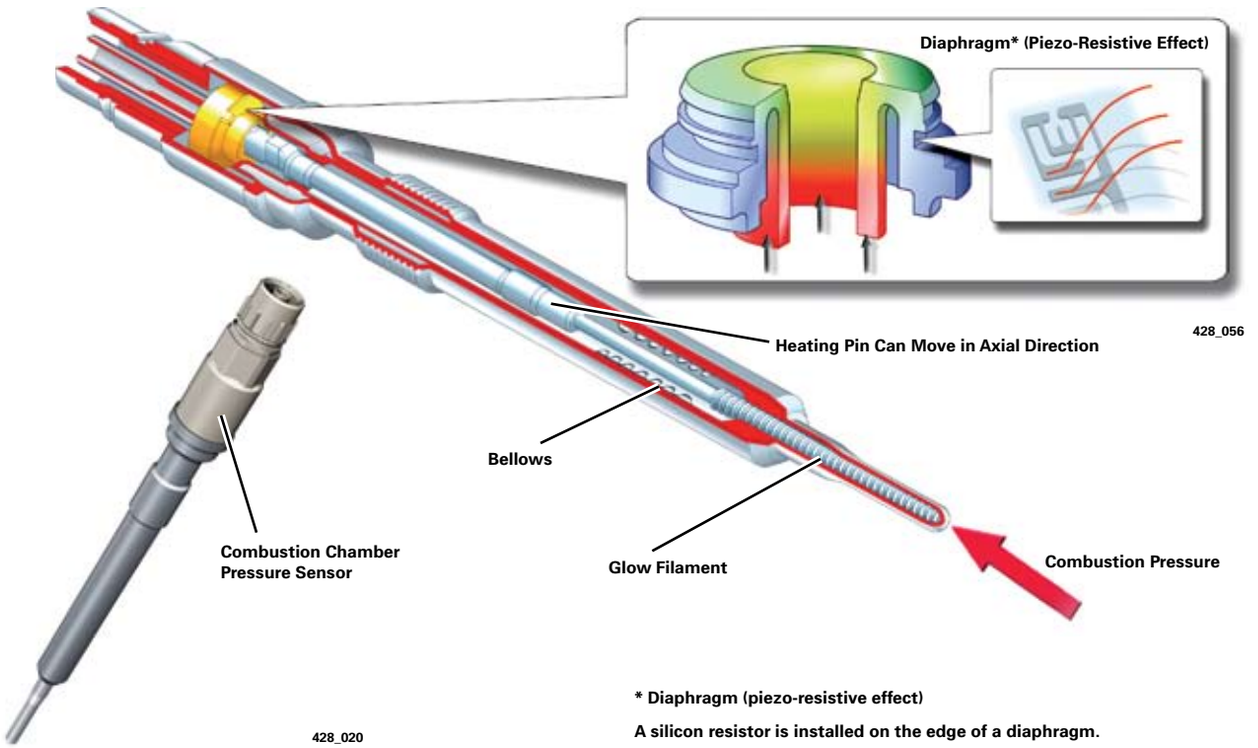
351_117

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 unit for further evaluation.



*** Diaphragm (piezo-resistive effect)**

A silicon resistor is installed on the edge of a diaphragm.

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.

Notes

System Overview

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

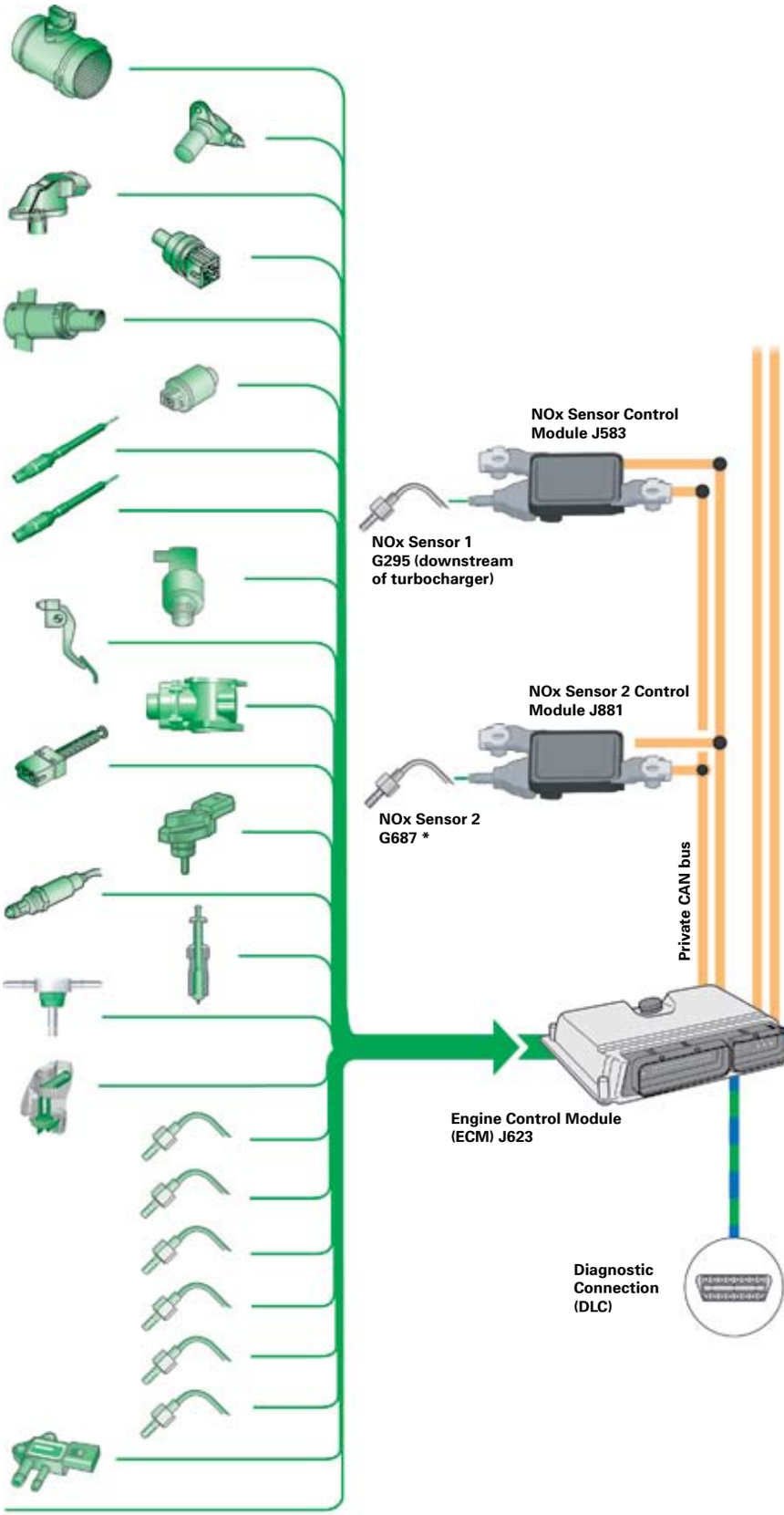
EGR Temperature Sensor G98

Exhaust Gas Temperature (EGT) Sensor 1 G235

Exhaust Gas Temperature (EGT) Sensor 4 G648

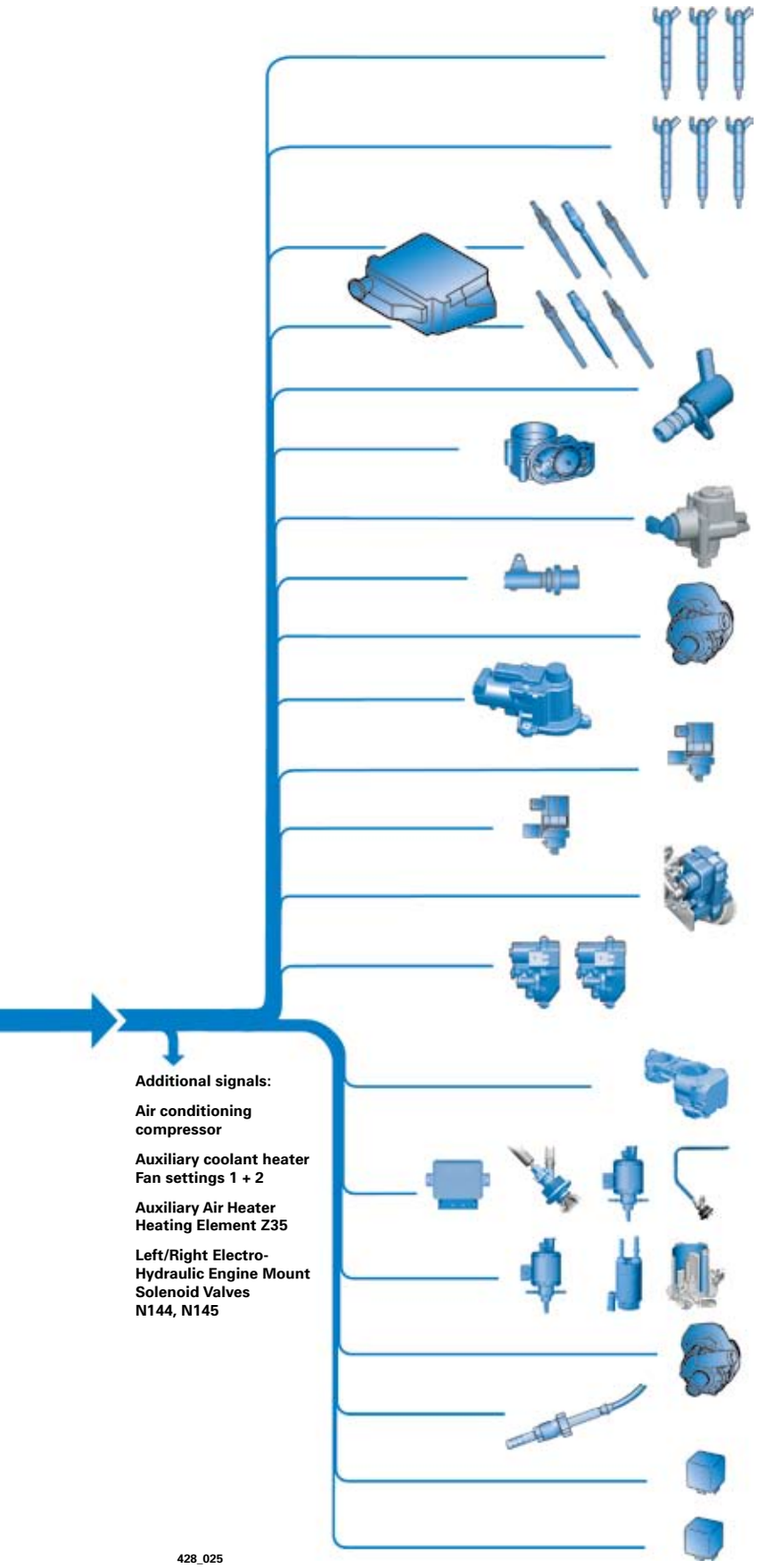
Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448

Differential Pressure Sensor G505



Additional signals:

- Cruise control system
- Speed signal
- Requirement start on engine control unit (Keyless Entry Start/Stop Systems 1 + 2)
- Terminal post 50
- Crash signal from the airbag control unit



Actuators

Fuel Injector for cylinders 1 – 3
N30, N31, N32

Fuel Injector for cylinders 4 – 6
N33, N83, N84

Automatic Glow Time Control Module J179

Glow Plugs 1 – 3
Q10, Q11, Q12

Glow Plugs 4 – 6
Q13, Q14, Q15

Oil Pressure Regulation Valve N428

Throttle Valve Control Module J338

Fuel Metering Valve N290

Fuel Pressure Regulator Valve N276

Exhaust Gas Recirculation (EGR) Cooler Pump V400

Exhaust Gas Recirculation (EGR) Motor V338

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

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

Turbocharger (TC) 1 Control Module J724

Intake Flap Motor 1 V157, Intake Flap Motor 2 V275

Charge-air Cooler Bypass Control Unit J865

Reducing Agent Metering System Control Module J880*
Reducing Agent Injector N474
Reducing Agent Pump Heater Z103
Reducing Agent Line Heater Z104

Reducing Agent Pump V437
Reducing Agent Transfer Pump V436
Reducing Agent Tank Heater Z102

Fuel Cooler Pump V166

Oxygen Sensor (O2S) Heater Z19

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

Auxiliary Fuel Pump Relay J832
Auxiliary Fuel Pump V393

Additional signals:

Air conditioning compressor

Auxiliary coolant heater Fan settings 1 + 2

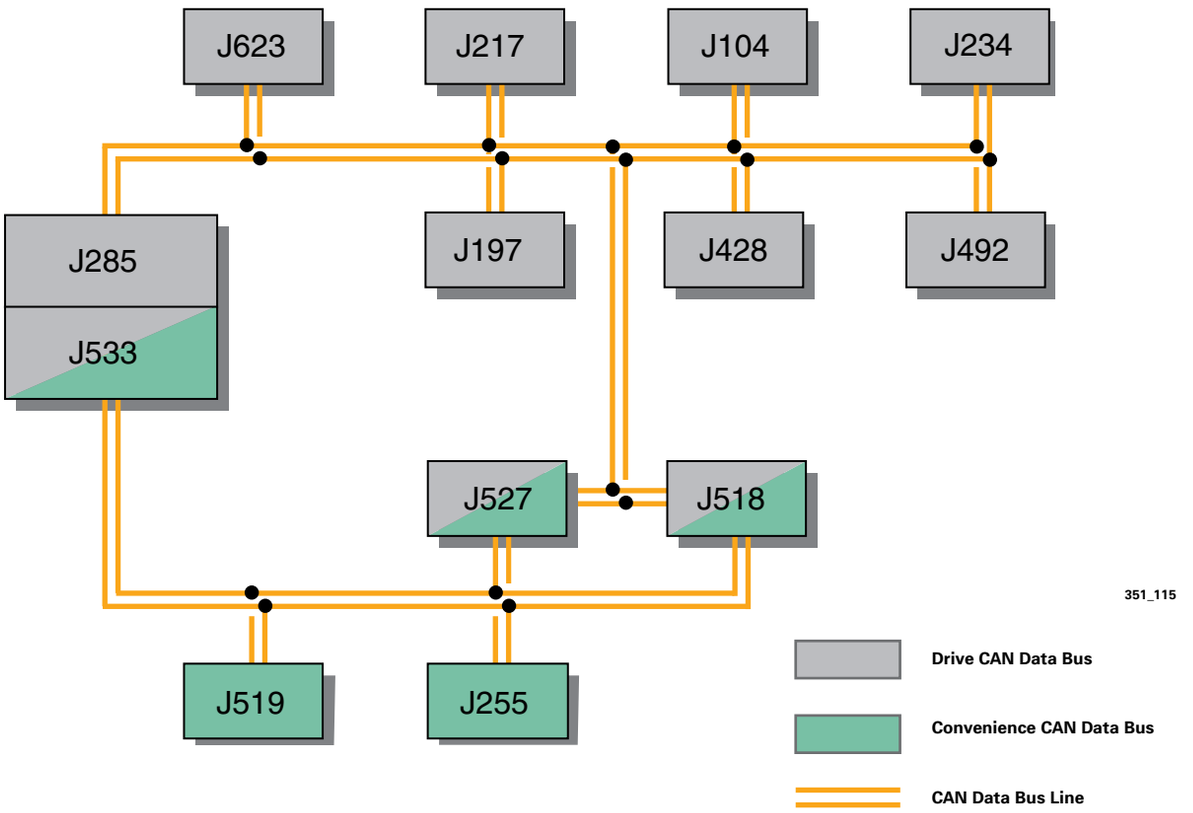
Auxiliary Air Heater Heating Element Z35

Left/Right Electro-Hydraulic Engine Mount Solenoid Valves N144, N145

428_025

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 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

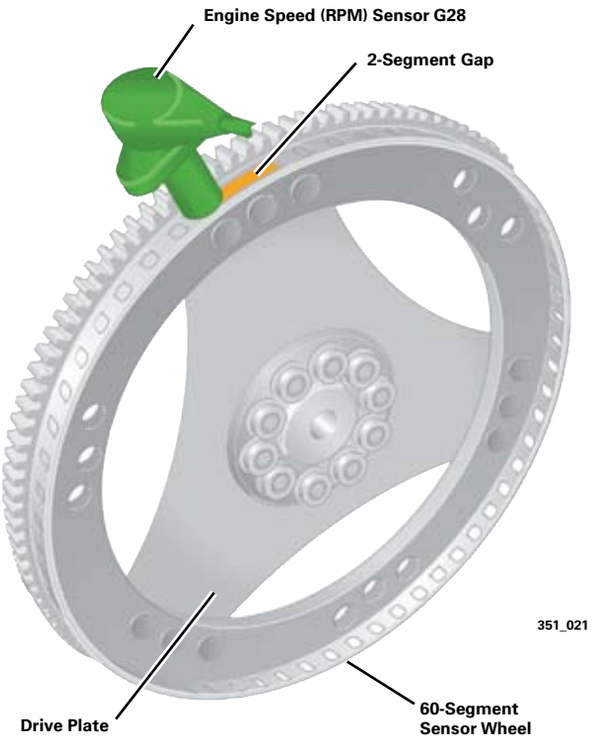
The Engine Speed (RPM) Sensor G28 is secured to the gearbox housing. It is an inductive sensor, which samples a 60-2 sensor wheel, which is secured to the drive plate. A segment gap on the sensor wheel serves the Engine Speed (RPM) Sensor G28 as a reference mark.

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

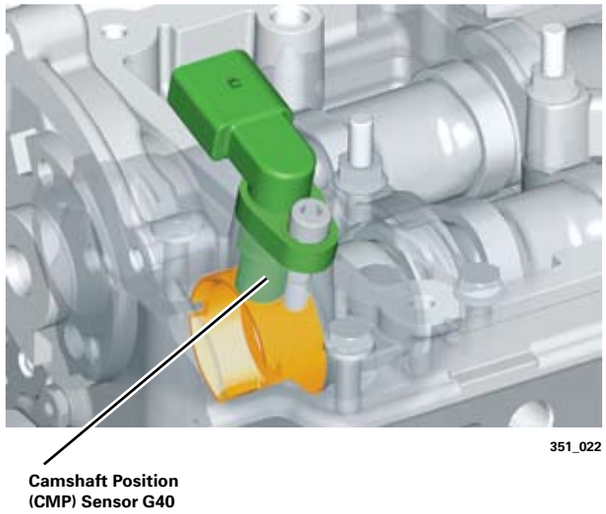
The Camshaft Position (CMP) Sensor G40 is secured in the retaining frame of the cylinder bank 1 cylinder head. It scans the sensor wheel on the camshaft, with which the position of the camshaft is detected.

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.



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.

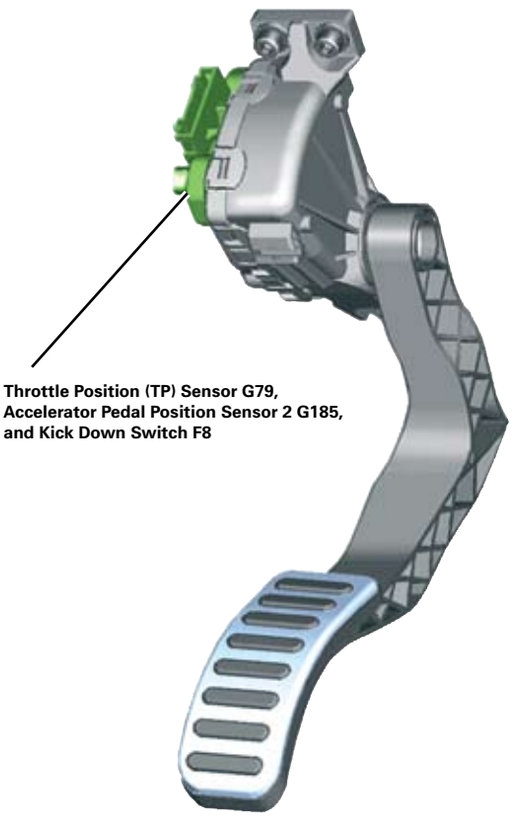
Signal Usage

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.

Effects of Failure

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

Accelerator Pedal Module



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

351_056

Brake Light Switch F and Brake Pedal Switch F47

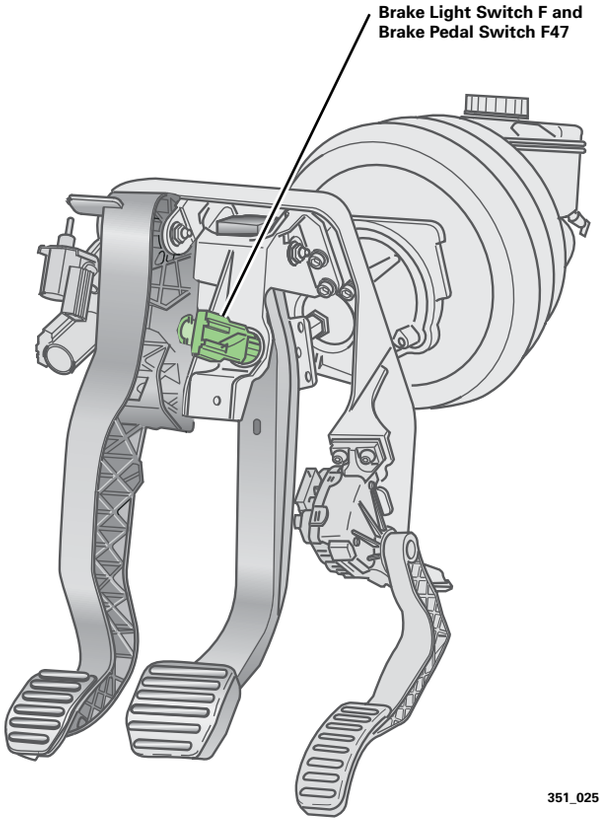
The Brake Light Switch F and Brake Pedal Switch F47 are located together in one component on the pedal cluster. Both switches help the ECM to detect whether the brake is actuated.

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.



351_100

Engine Coolant Temperature (ECT) Sensor G62

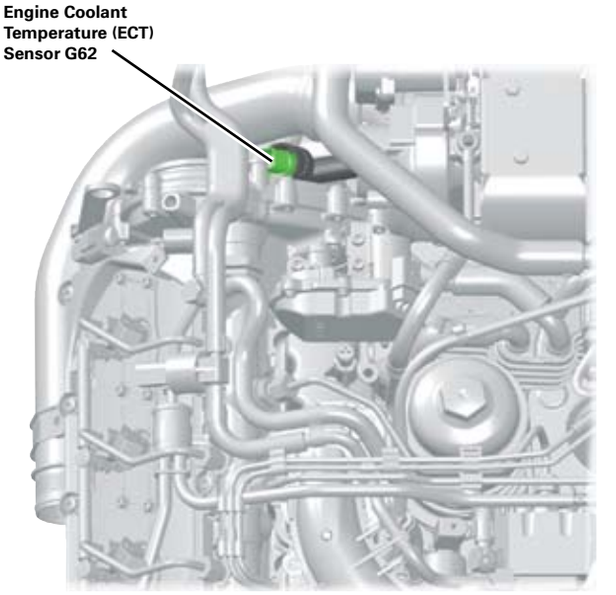
The Engine Coolant Temperature (ECT) Sensor G62 is located on the right cylinder head's coolant connection. The sensor provides the ECM with information on the current coolant temperature.

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.



351_029

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

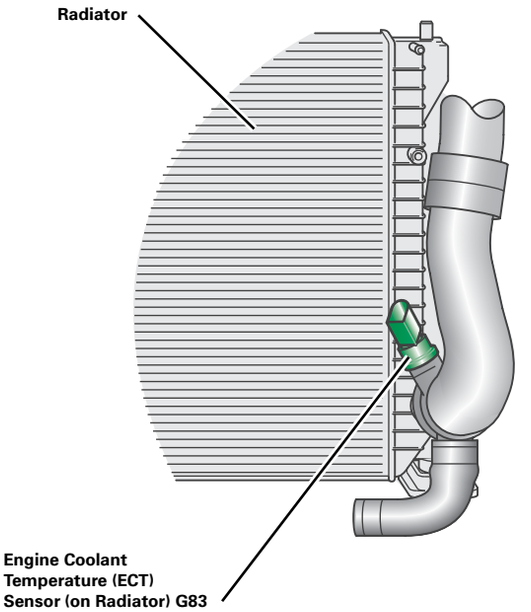
The Engine Coolant Temperature (ECT) Sensor (on Radiator) G83 is located in the line at the radiator outlet, where it measures the outlet temperature.

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.



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

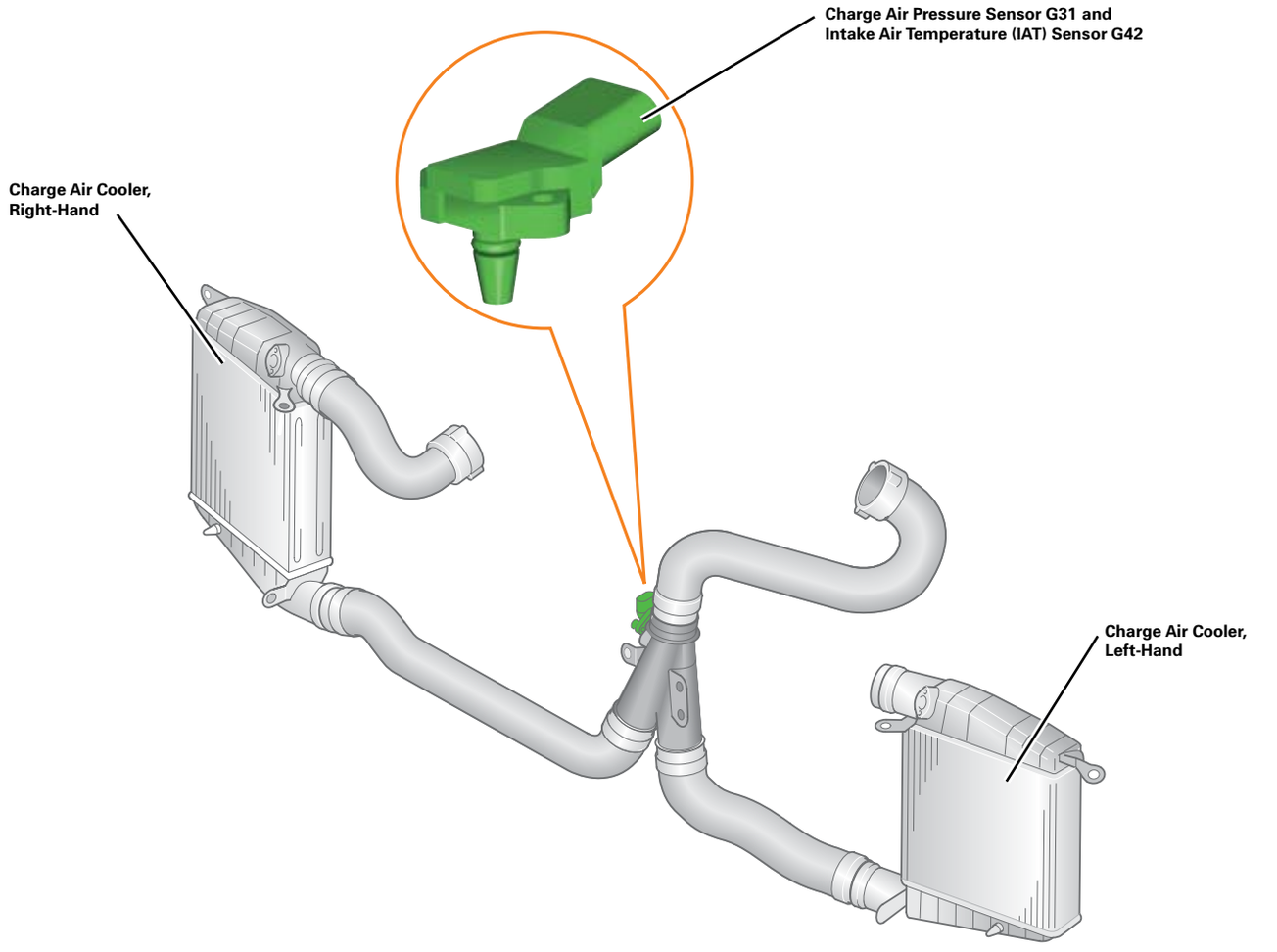
There is no substitute function in the event of signal failure. Charge air pressure regulation is shut off, leading to a significant reduction in engine output

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.



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.

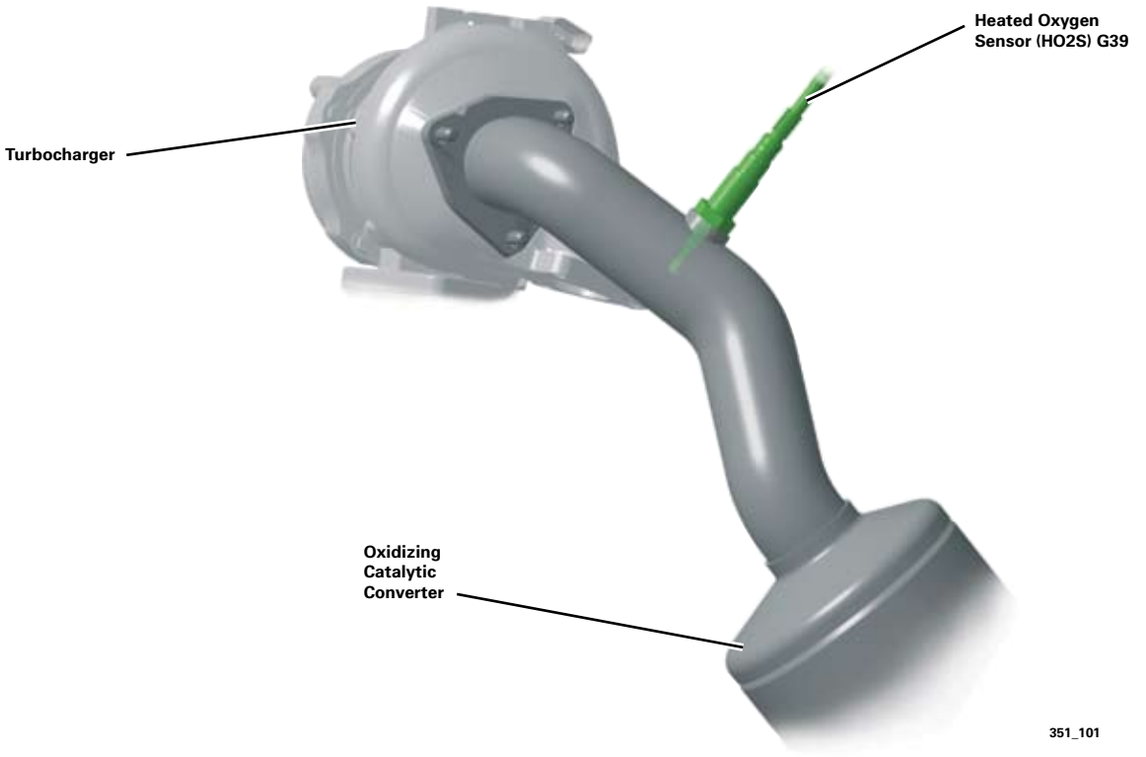
Signal Usage

The Heated Oxygen Sensor (HO2S) G39 signal is used to correct the exhaust gas recirculation quantity. The signal also serves to determine 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.



Exhaust Gas Temperature (EGT) Sensor 1 G235

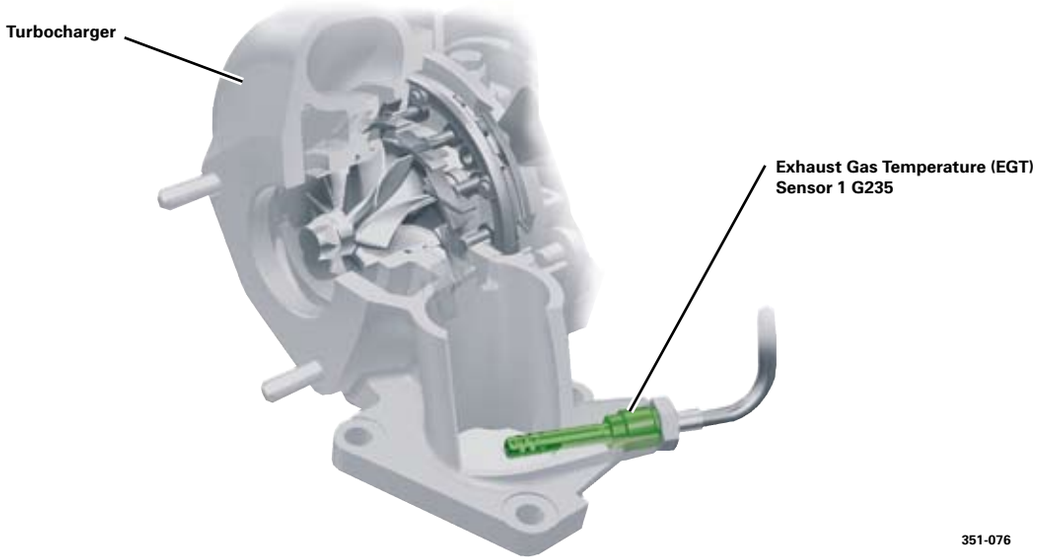
Exhaust Gas Temperature (EGT) Sensor 1 G235 is a PTC sensor. It is located in the exhaust system upstream of the turbocharger, where it measures the temperature of the exhaust gas.

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.



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

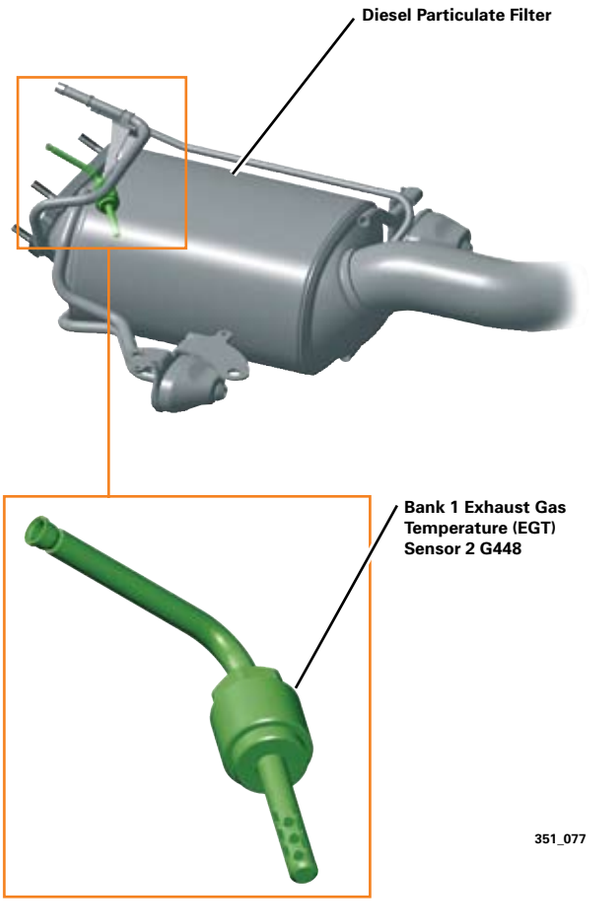
The ECM uses the signal from Bank 1 Exhaust Gas Temperature (EGT) Sensor 2 G448 to calculate the amount of contamination in the diesel particulate filter.

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.



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.

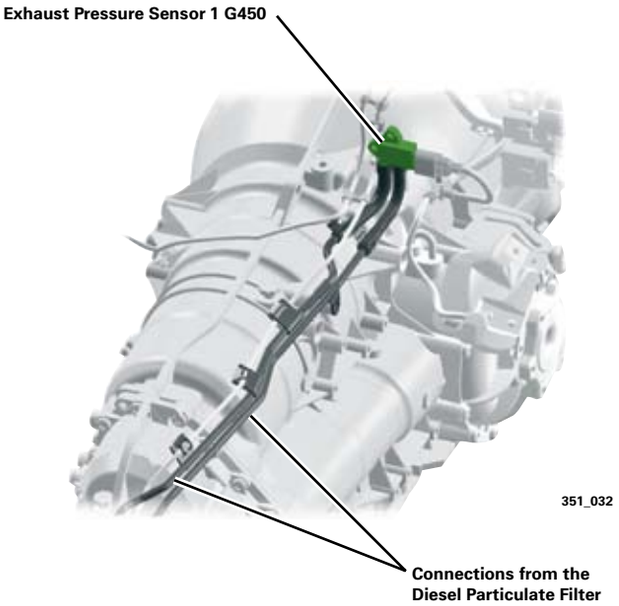
Signal Usage

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

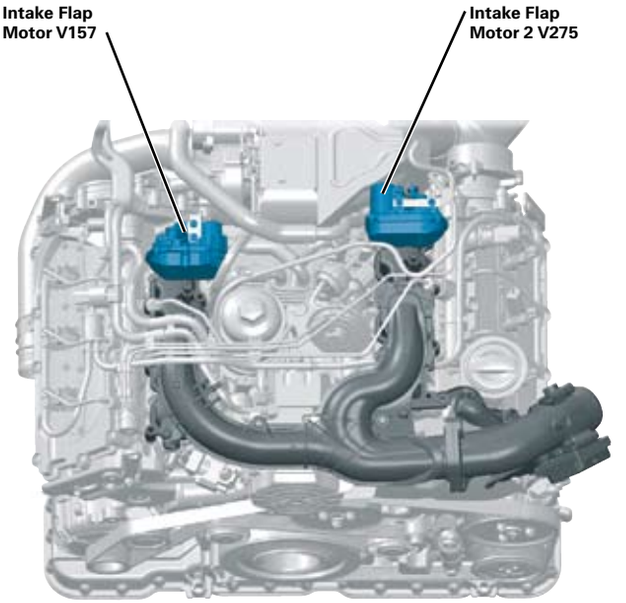
If the Exhaust Pressure Sensor 1 G450 signal fails, diesel particulate filter regeneration takes place according to the mileage covered or hours of operation. Glow Plug Indicator Lamp K29 flashes at the same time. The Malfunction Indicator Lamp (MIL) K83 is activated after three driving cycles.



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.



351_037

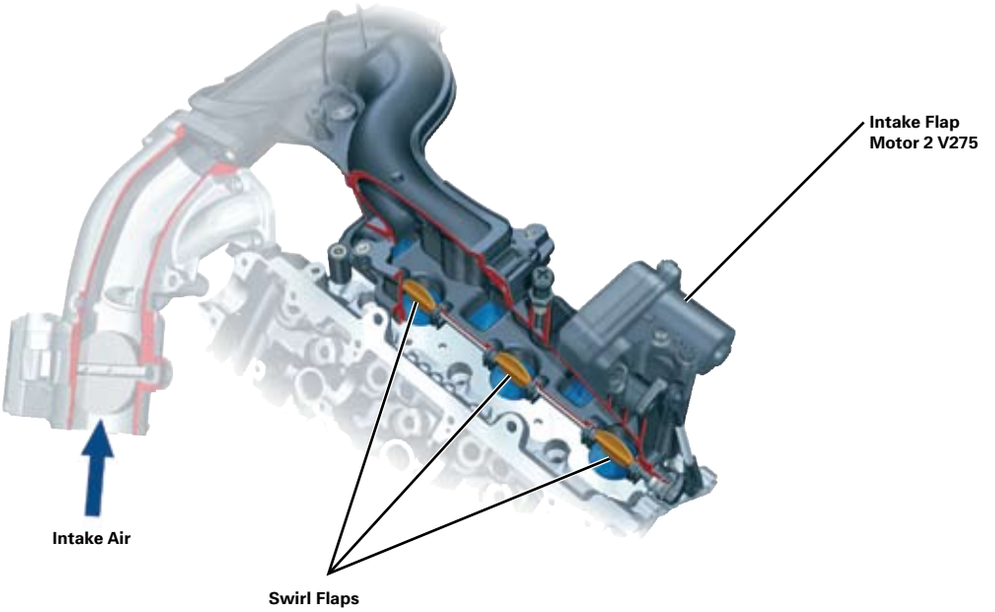
Task

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_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.

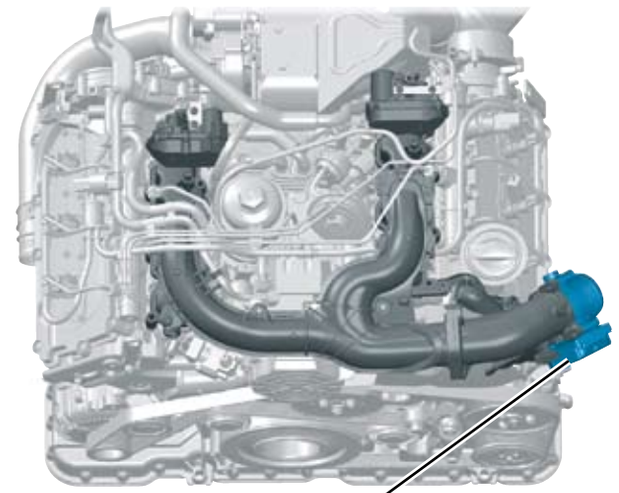
Task

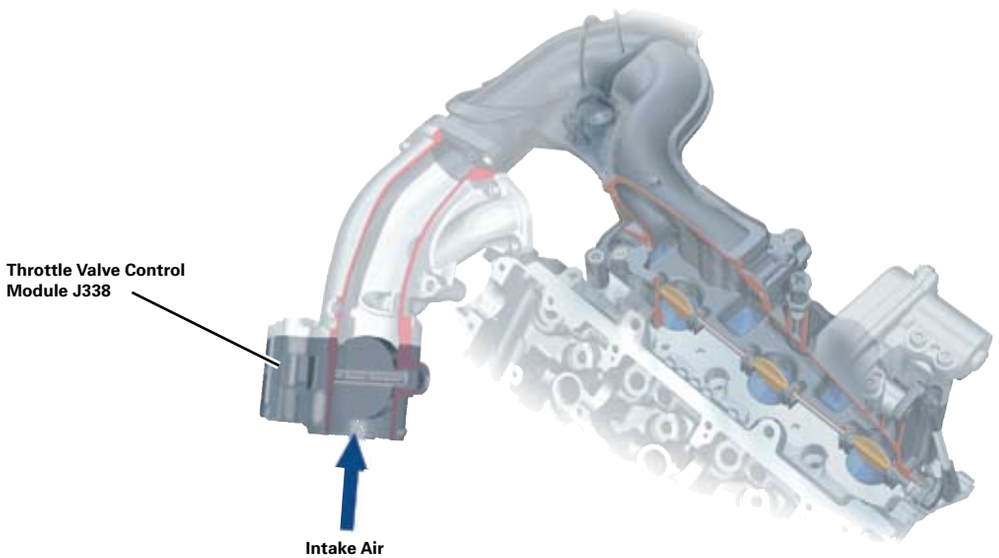
The continuously variable throttle valve is used in specific operating conditions to generate a vacuum (determined by the ECM) in the intake manifold. This results in more effective exhaust gas recirculation.

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.





Exhaust Gas Recirculation (EGR) Motor V338

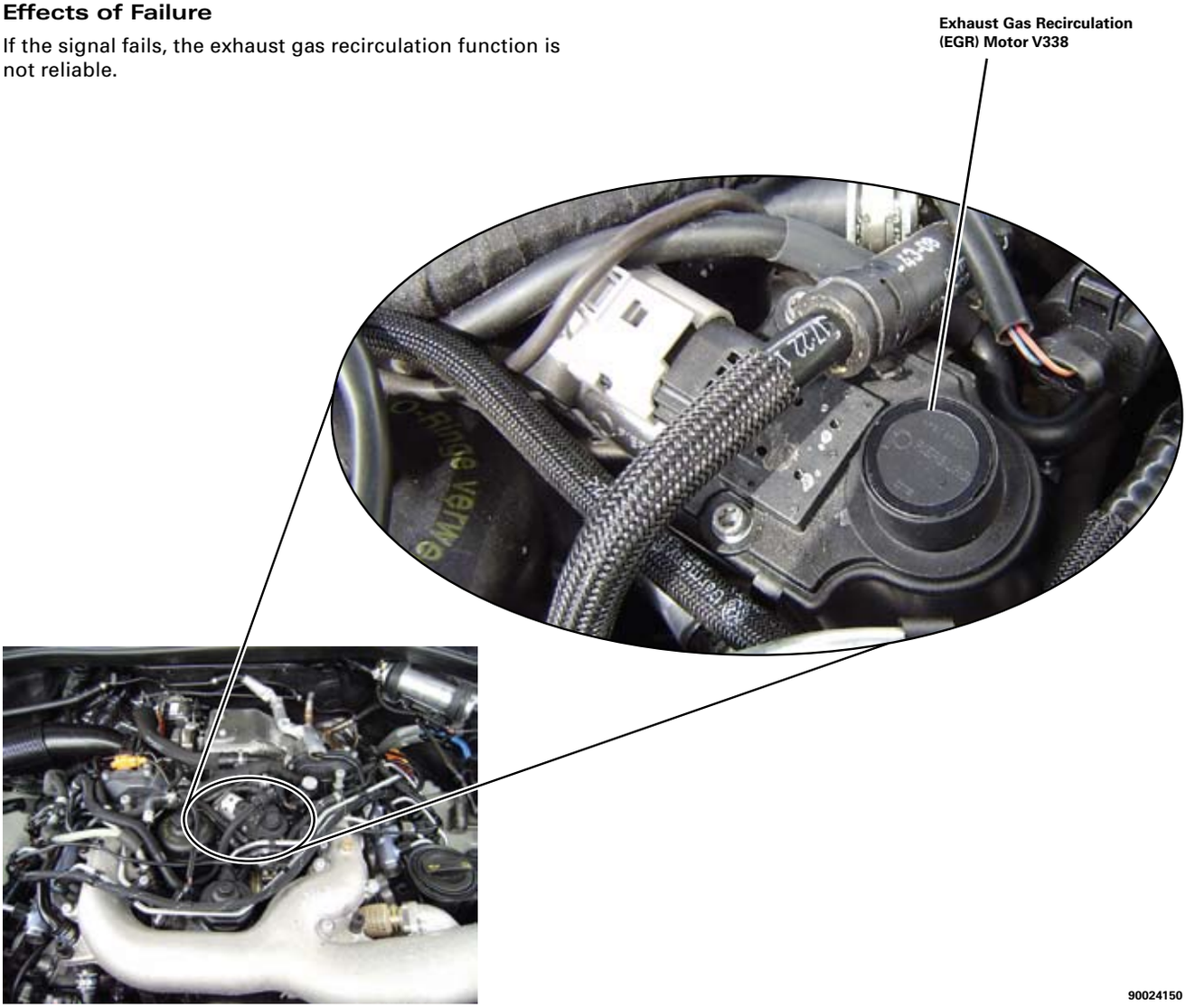
The Exhaust Gas Recirculation (EGR) Motor V338 is a positioning motor used to actuate the exhaust recirculation valve.

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.



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.

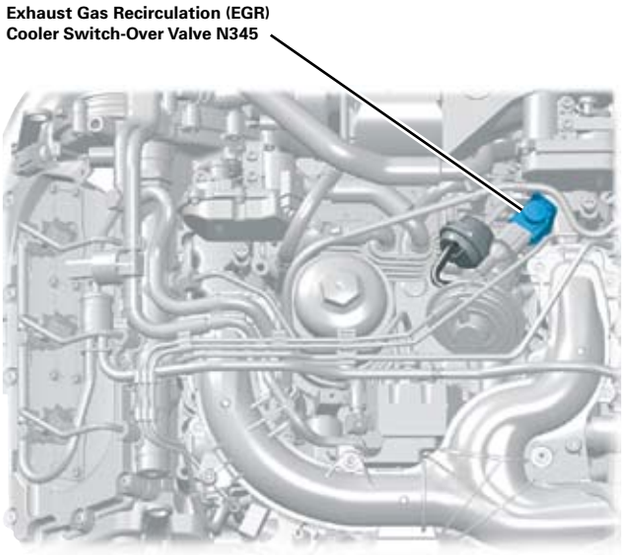
Task

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.

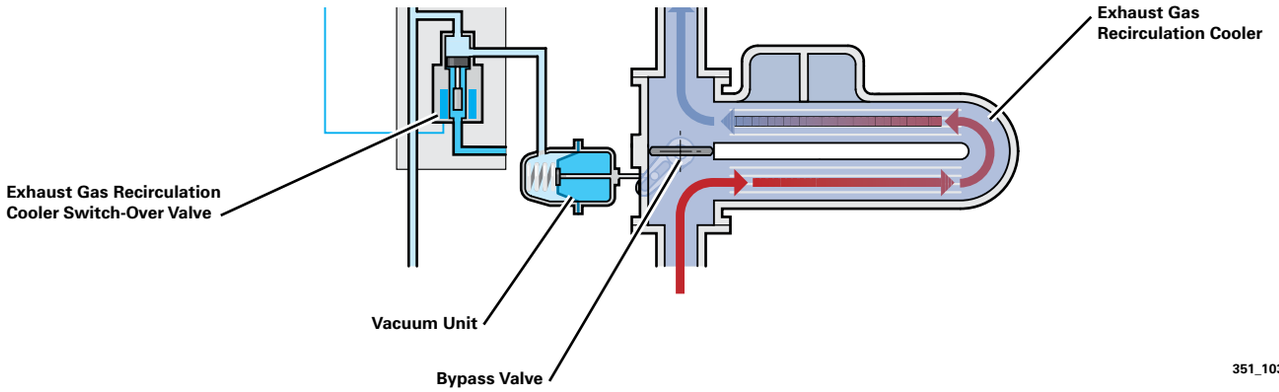
The bypass valves in the exhaust gas recirculation cooler are actuated to achieve this. The valves are initialized by the ECM depending on the temperature. This then switches the vacuum unit's control pressure to actuate the specific bypass valve.

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.



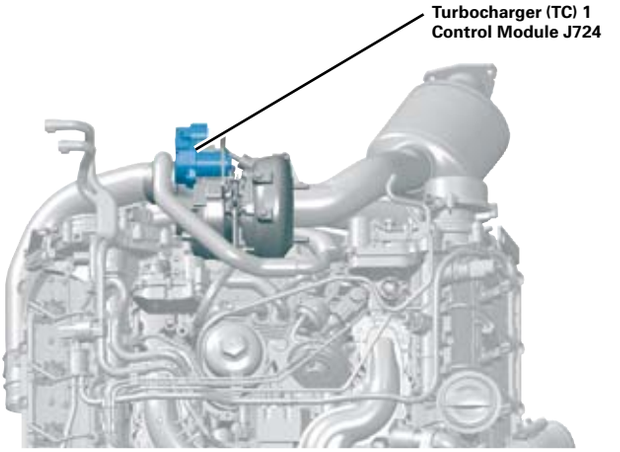
351_049



351_103

Turbocharger (TC) 1 Control Module J724

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



351_092

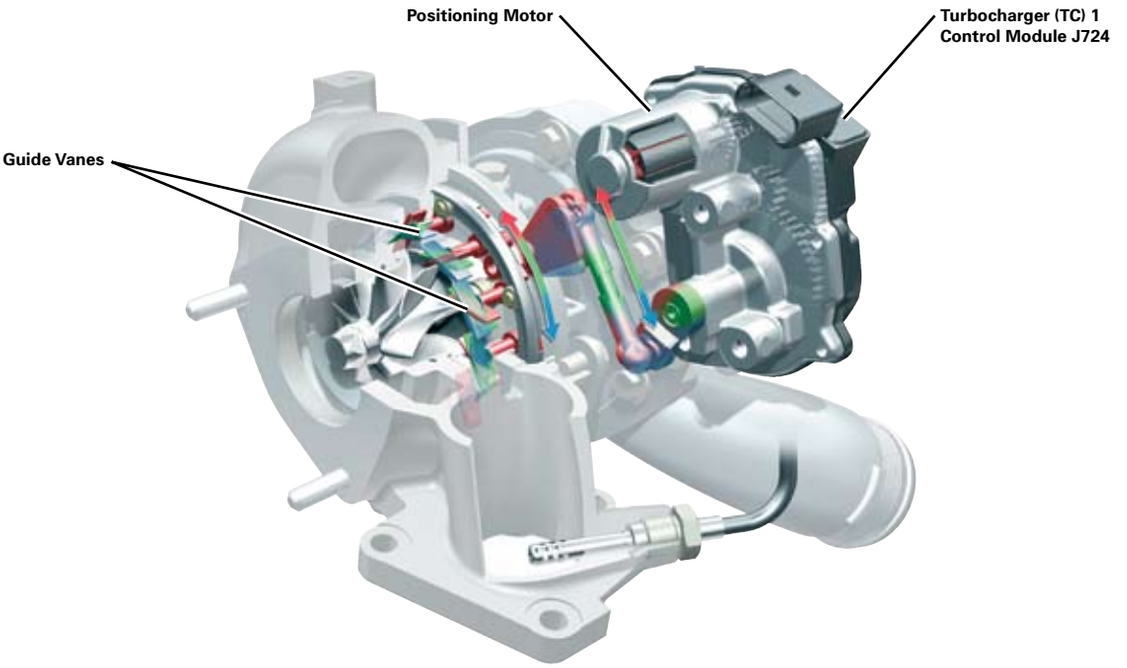
Task

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.

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.

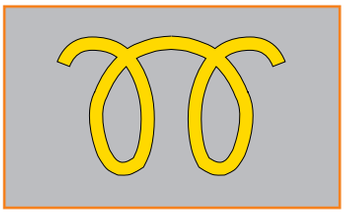


351_041

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

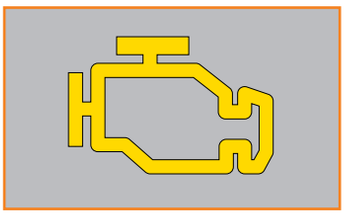


351_113

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).

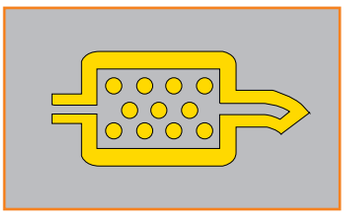
The Malfunction Indicator Lamp (MIL) K83 indicates faults detected by the OBD II system.



351_111

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.

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.

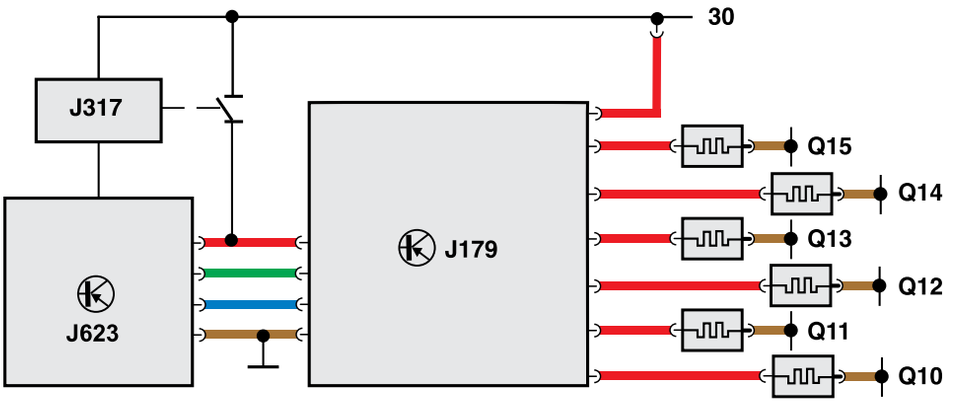
Advantages of this glow plug system include:

- 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

351_098

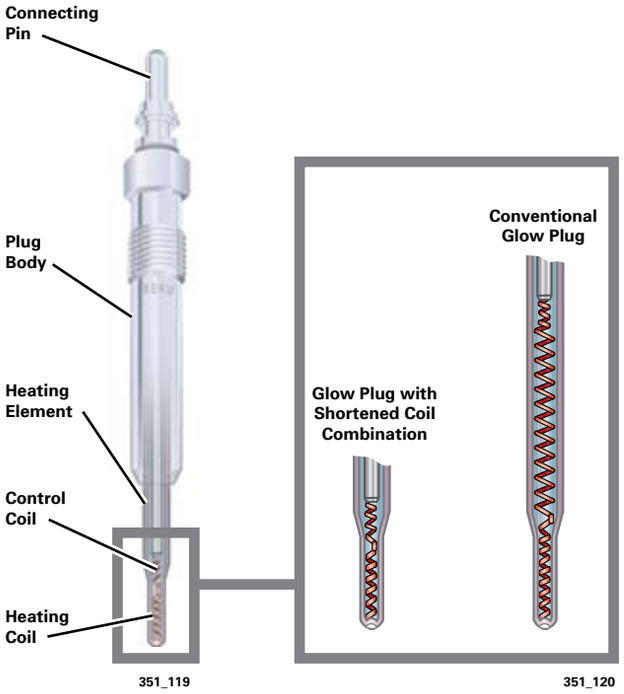
Glow Plugs Q10 – Q15

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.



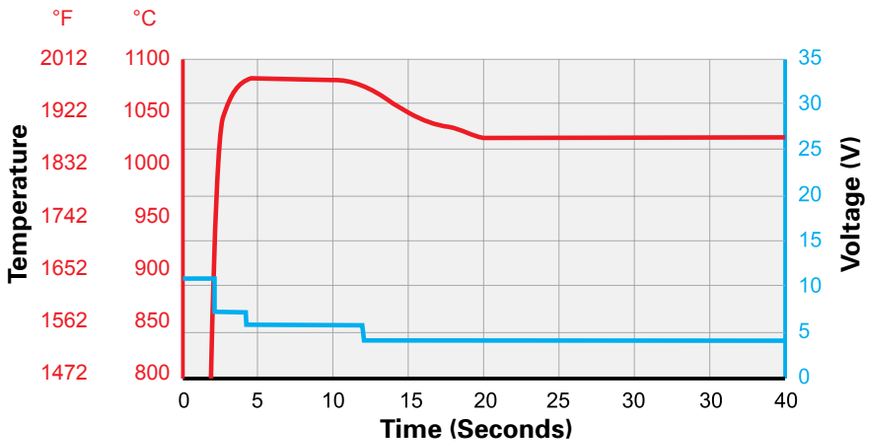
Glowing

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.



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.

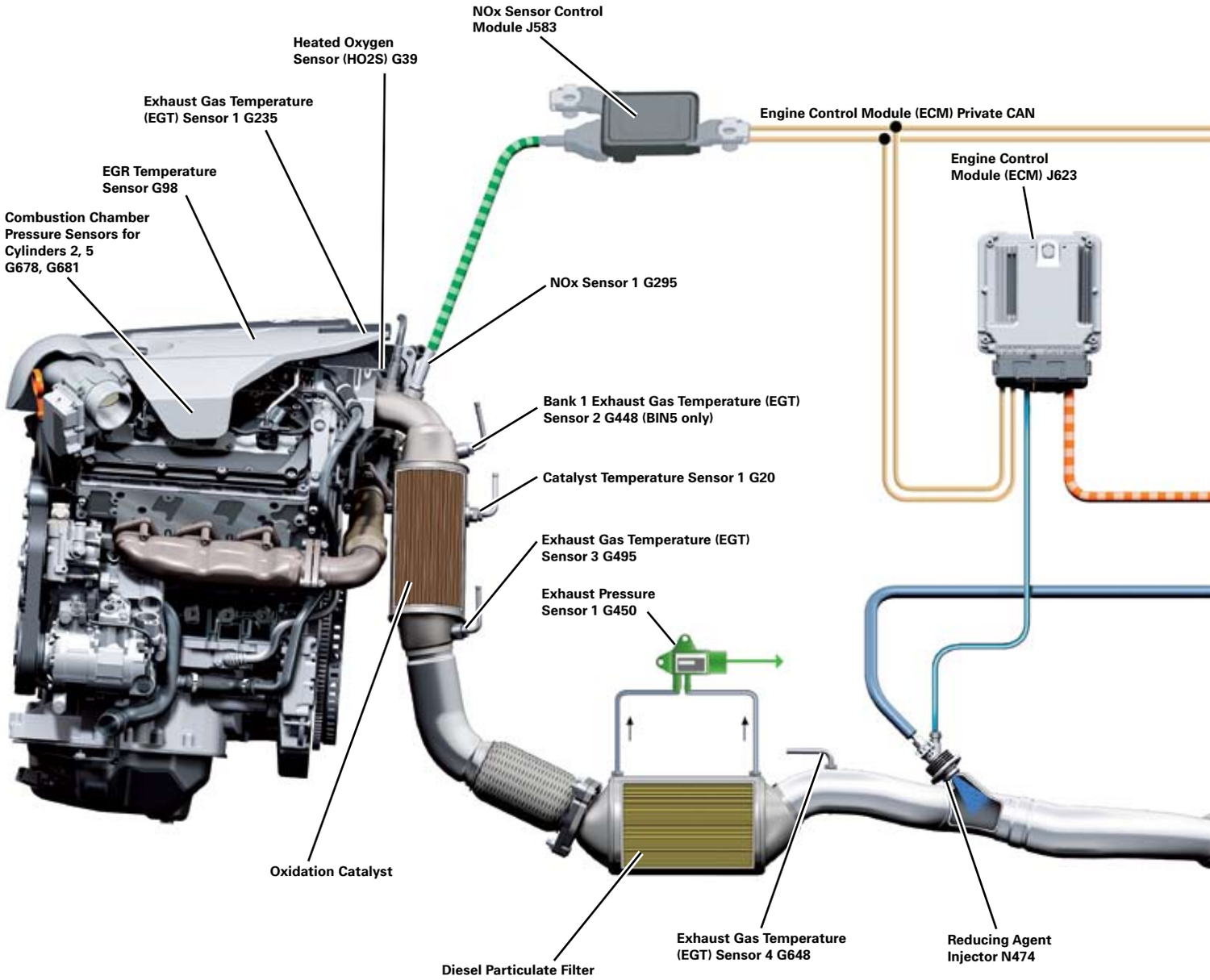
In addition to the known components such as the oxidation catalyst and diesel particulate filter, new components are used to minimize nitrogen oxide emissions.

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.

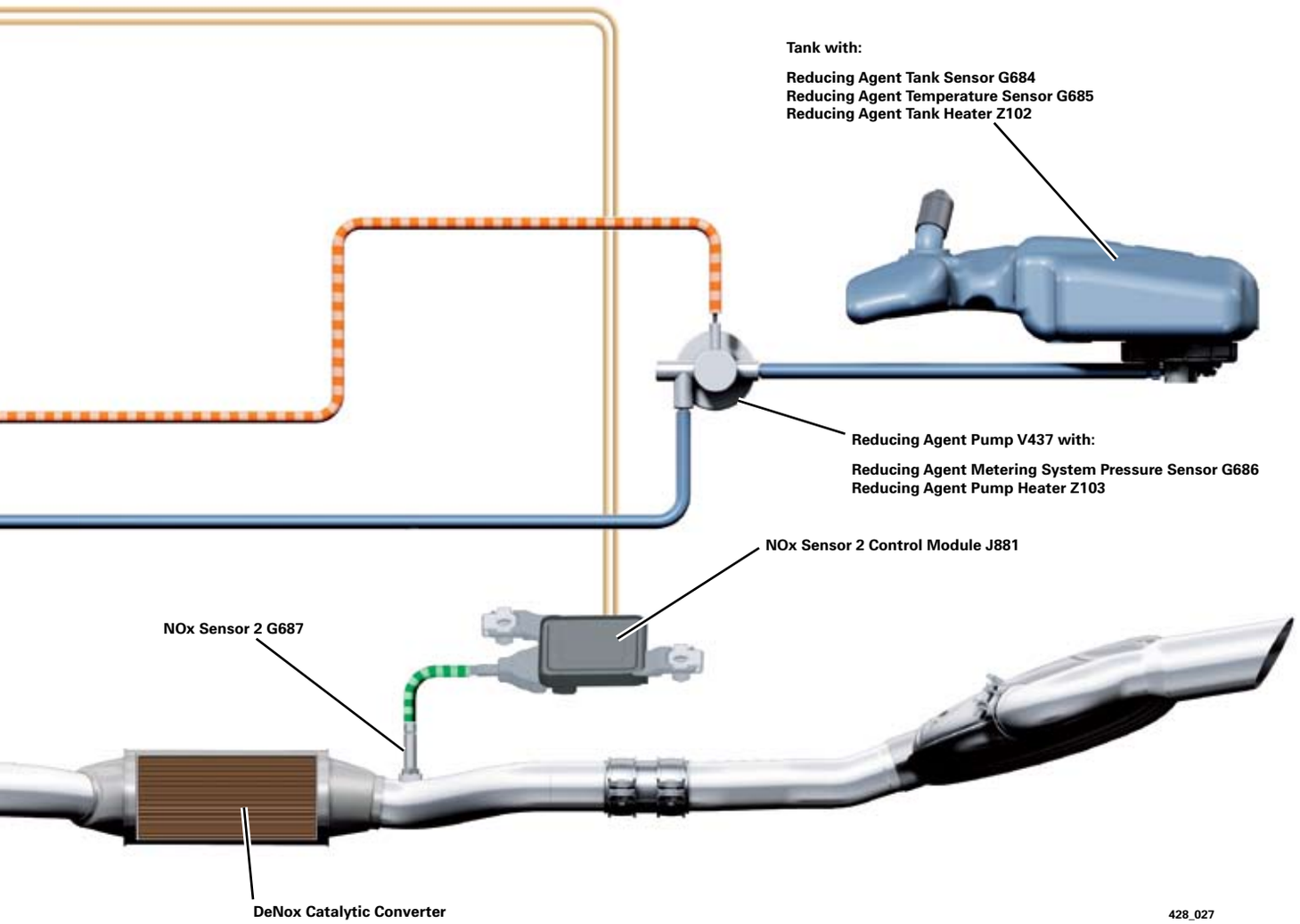


The exhaust gas after-treatment system consists of the DeNox catalytic converter, the injector for the reducing agent, as well as a tank system for the supply of the reducing agent together with a reducing agent supply unit and reducing agent lines.

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.

For this purpose, a 32.5% urea/water solution is used as a reducing agent (the reducing agent is sold under the name AdBlue®), which is injected into the exhaust system in small quantities.

DeNox catalytic converter = catalytic converter that reduces nitrogen oxide



Diesel Particulate Filter

Design

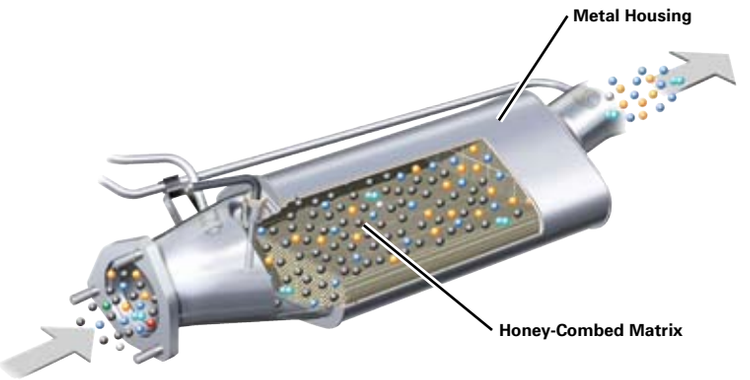
The diesel particulate filter is comprised of a honeycomb ceramic matrix made from silicon carbide placed in a metal housing. The ceramic matrix itself has many small channels that run parallel to each other and are alternately connected. In this way, inlet and outlet channels are created that are separated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

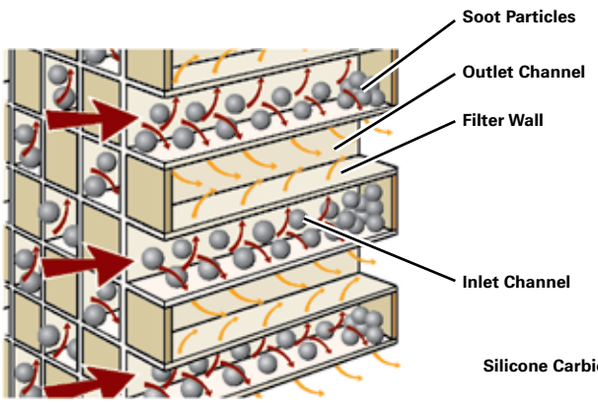
This mixture serves as a carrier layer for the catalytic converter. The carrier layer is coated with the precious metal platinum, which acts as the catalyst. A catalyst is a substance that promotes or hinders a chemical reaction without changing itself.

Function

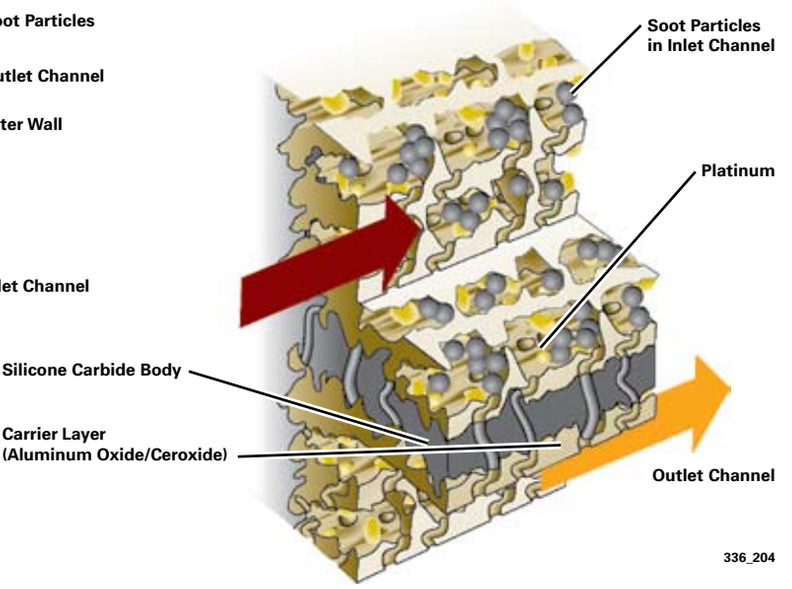
Since the channels are sealed alternately in the direction of flow from the inlet and outlet side, the carbon soot contaminated exhaust gas must flow through the porous filter walls made from silicon carbide. When this happens, the carbon soot particles and not the gaseous components are retained in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



325-021



336_154



336_204

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.

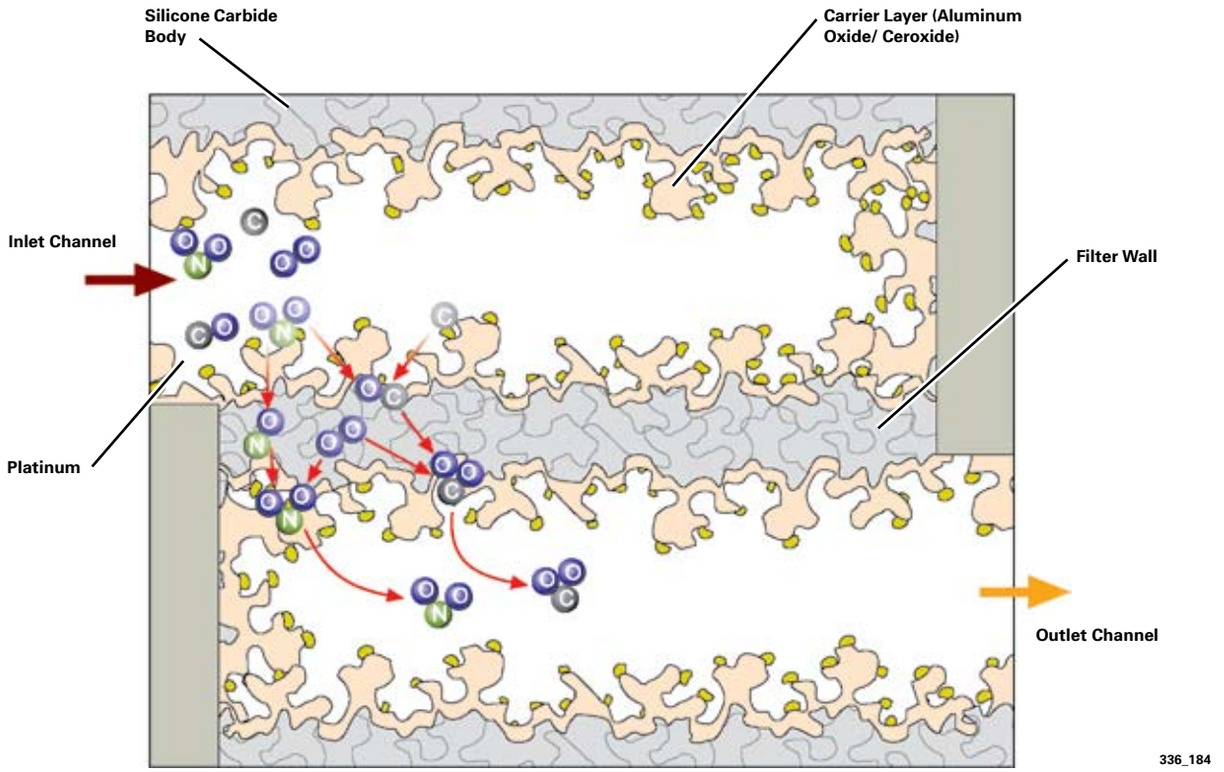


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Passive Regeneration

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.

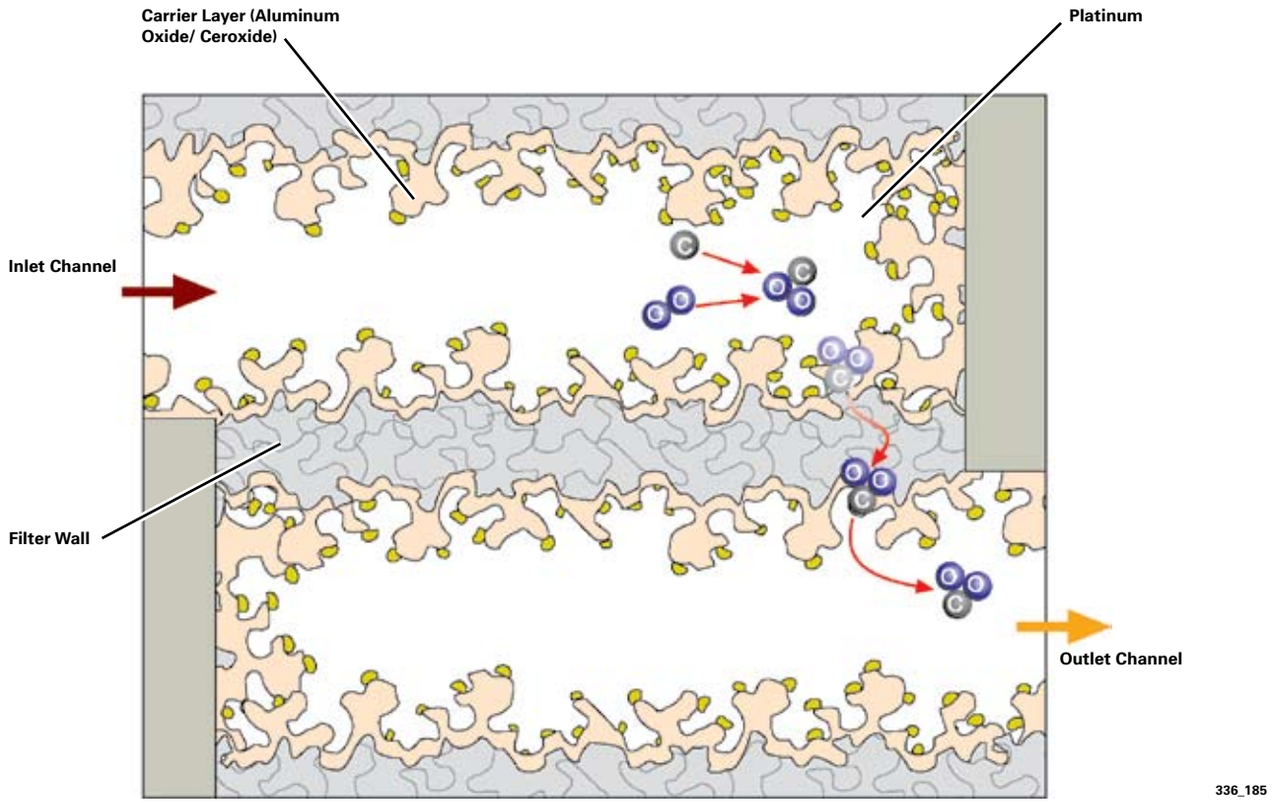
From the oxides of nitrogen present in the exhaust gas (NOX) and oxygen (O2), nitrogen dioxide (NO2) is produced via the platinum coating. NOX + O2 reacts to NO2. The nitrogen dioxide (NO2) reacts with the carbon (C) of the carbon soot particles. As a result, carbon monoxide (CO) and nitrogen monoxide (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.



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 + O2 reacts to CO2.

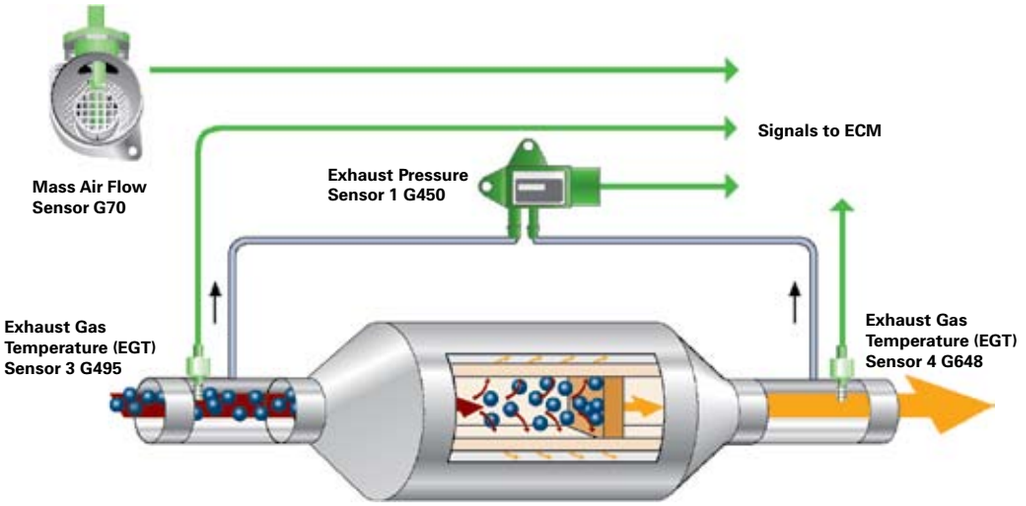


Function of Active Regeneration

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.

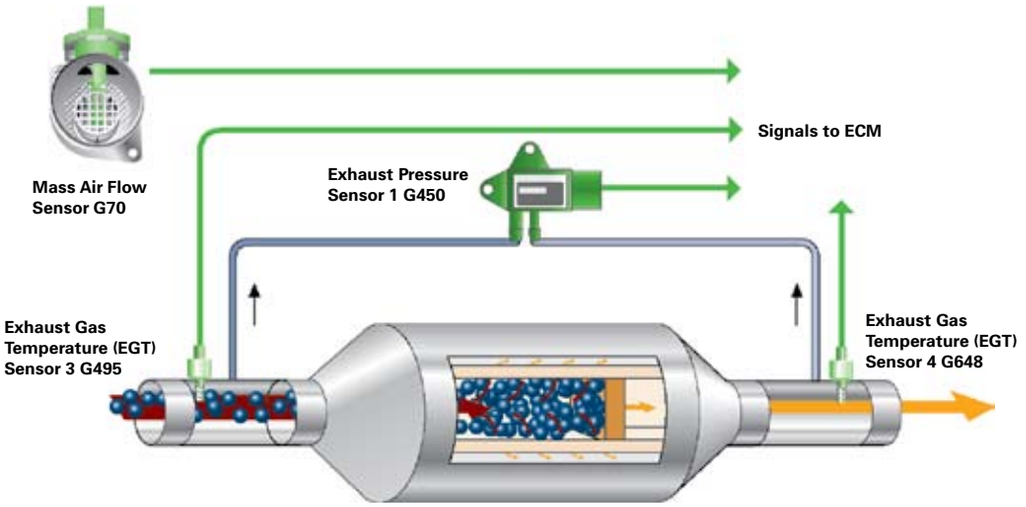
When the carbon soot level reaches a predetermined limit, the engine management system initiates active regeneration.

Particulate Filter Empty = low resistance to exhaust flow



336_042

Particulate Filter Full = high resistance to exhaust gas flow

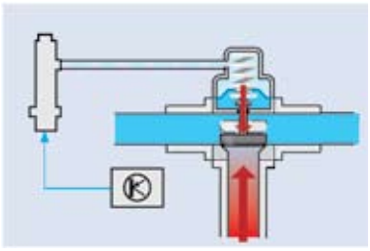


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Engine Management During Initiation of Active Regeneration

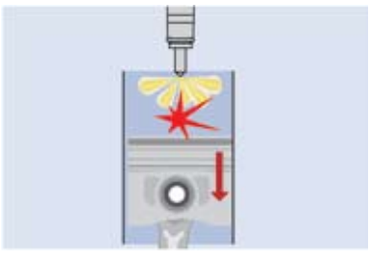
From the flow resistance of the particulate filter, the engine control module can detect the level of carbon soot deposit in the filter. A high flow resistance indicates that the filter is in danger of becoming blocked. The engine control module initiates an active regeneration process. To do this:

– Exhaust gas recirculation is switched off to raise the combustion temperature



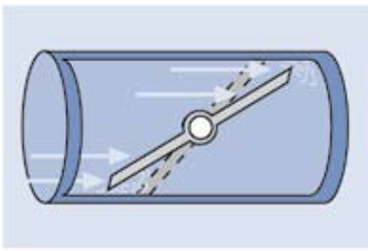
336_124

– 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



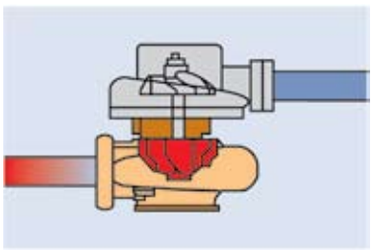
336_126

– The intake air supply is regulated by the throttle valve



336_120

– The charge air pressure is adapted so that the torque during regeneration does not change noticeably by the driver



336_122

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.

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 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.

$CO(NH_2)_2 + H_2O \rightarrow CO(NH_2)_2$
Reducing Agent → Urea

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

$CO(NH_2)_2 \rightarrow NH_3 + HNCO$
Urea → Ammonia + Isocyanic Acid

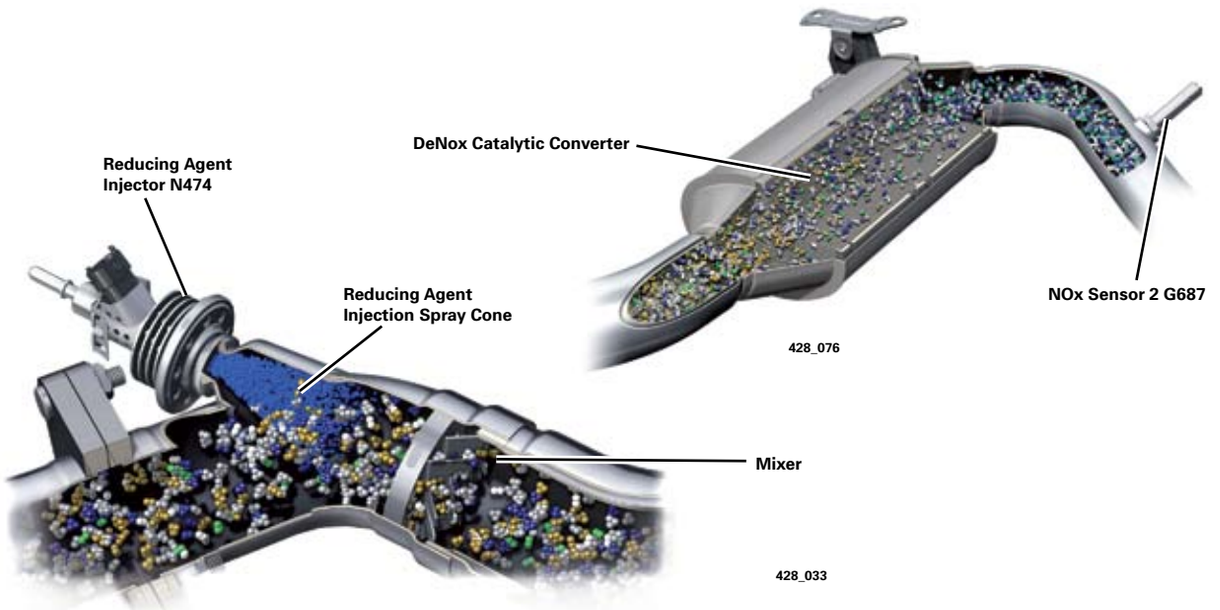
If hot surfaces are available, the isocyanic acid can be converted into carbon dioxide and another ammonia molecule through hydrolysis**.

$HNCO + H_2O \rightarrow NH_3 + CO_2$
Isocyanic Acid + Water → Carbon Dioxide + Ammonia

Ammonia is stored in the DeNox catalytic converter and reacts with the nitrogen oxide (NO) and nitrogen dioxide (NO_2) from the exhaust flow to form nitrogen nitrogen (N_2) and water (H_2O).

$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$
Nitrogen Oxide + Nitrogen Dioxide + Ammonia → Nitrogen + Water

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.

Reducing Agent AdBlue®

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 AdBlue®.

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

Reducing Agent 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

Reducing Agent AdBlue® Handling

- Use the reducing agent AdBlue® 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 manufacturer. The tank cap of the AdBlue® active tank can be opened using the lug wrench from the tool kit.

AdBlue® Refill Bottle
0.5 gallon (1.89 liter)



428_058

AdBlue® Reducing Agent
2.6 Gallon (10 liter) Containers



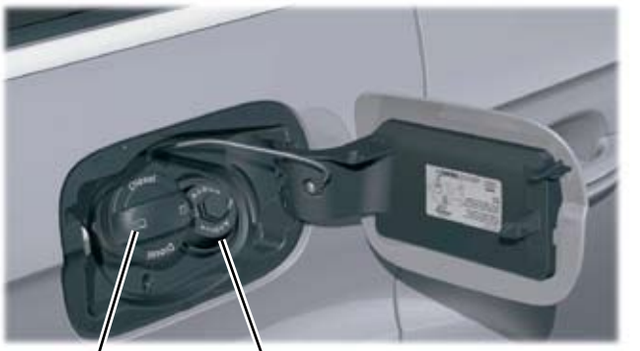
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Fuel and Reducing Agent Tanks

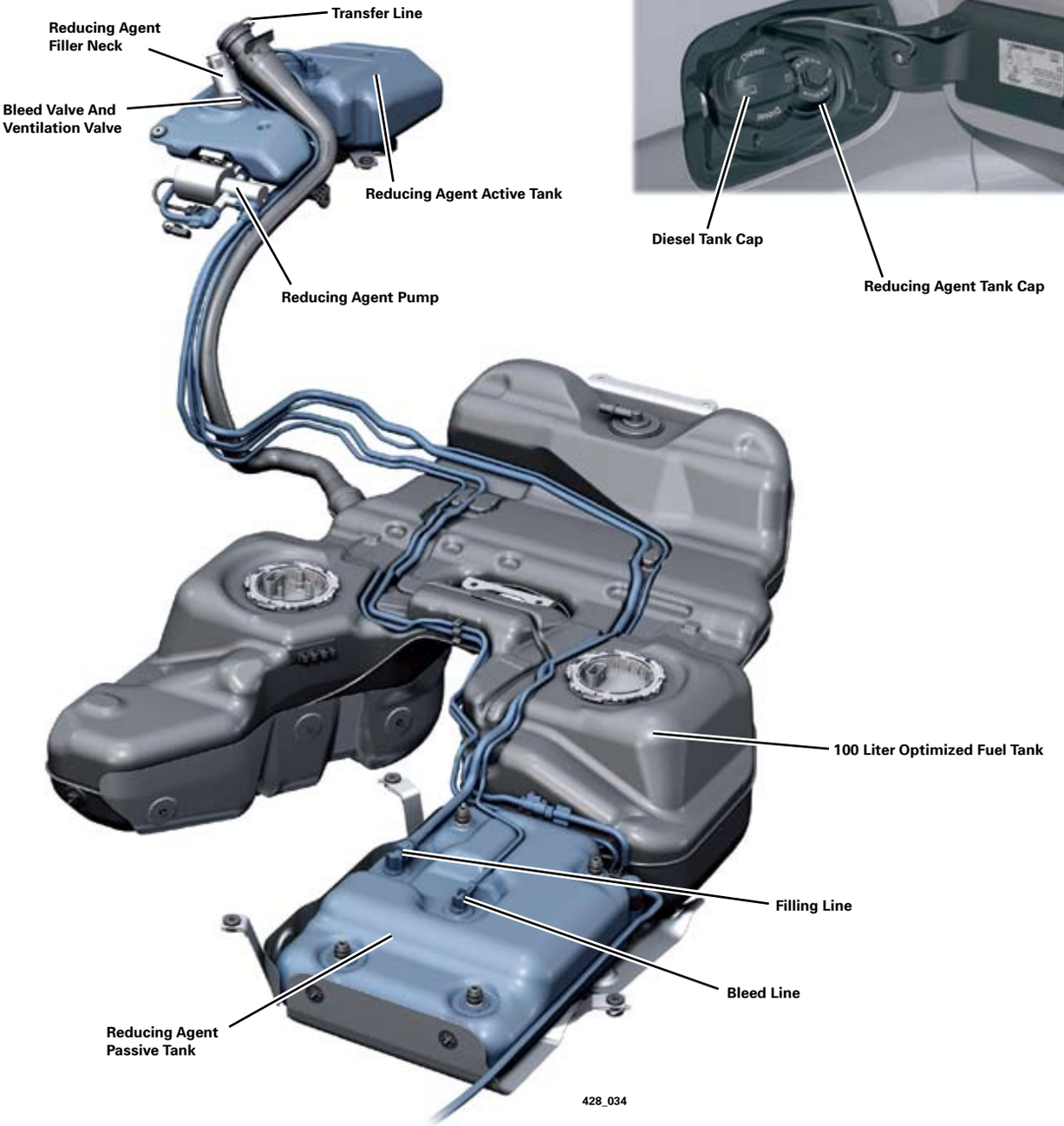
In addition to the conventional diesel fuel tank, two reducing agent reservoirs are added, the active and the passive tank. Through optimum utilization of the existing packaging spaces in the underbody area, it is possible to retain the 26.4 gallon (100 liter) diesel tank filling volume. The reducing agent tank system is designed as a closed pressure tank system.

A pressure relief valve is located in close proximity to the filler neck to prevent a vacuum or over-pressure. It opens at pressures below -0.5 psi (-40 mbar) and above 2.2 psi (150 mbar) and thereby protects the fuel system from excessive mechanical loads. Both tanks are connected to the pressure relief valve through breather lines.

The reducing agent reservoir volume of approximately 6 gal. (23 l) is distributed to the active tank in the area directly below the filler neck that holds 2 gal. (7.5 l), and to the passive tank in the underbody area that holds 4.1 gal. (15.5 l). Diesel fuel is filled up as usual through the fuel filler neck. The reducing agent reservoir is filled through an additional filler neck. Both are accessible through the fuel filler door.



428_031

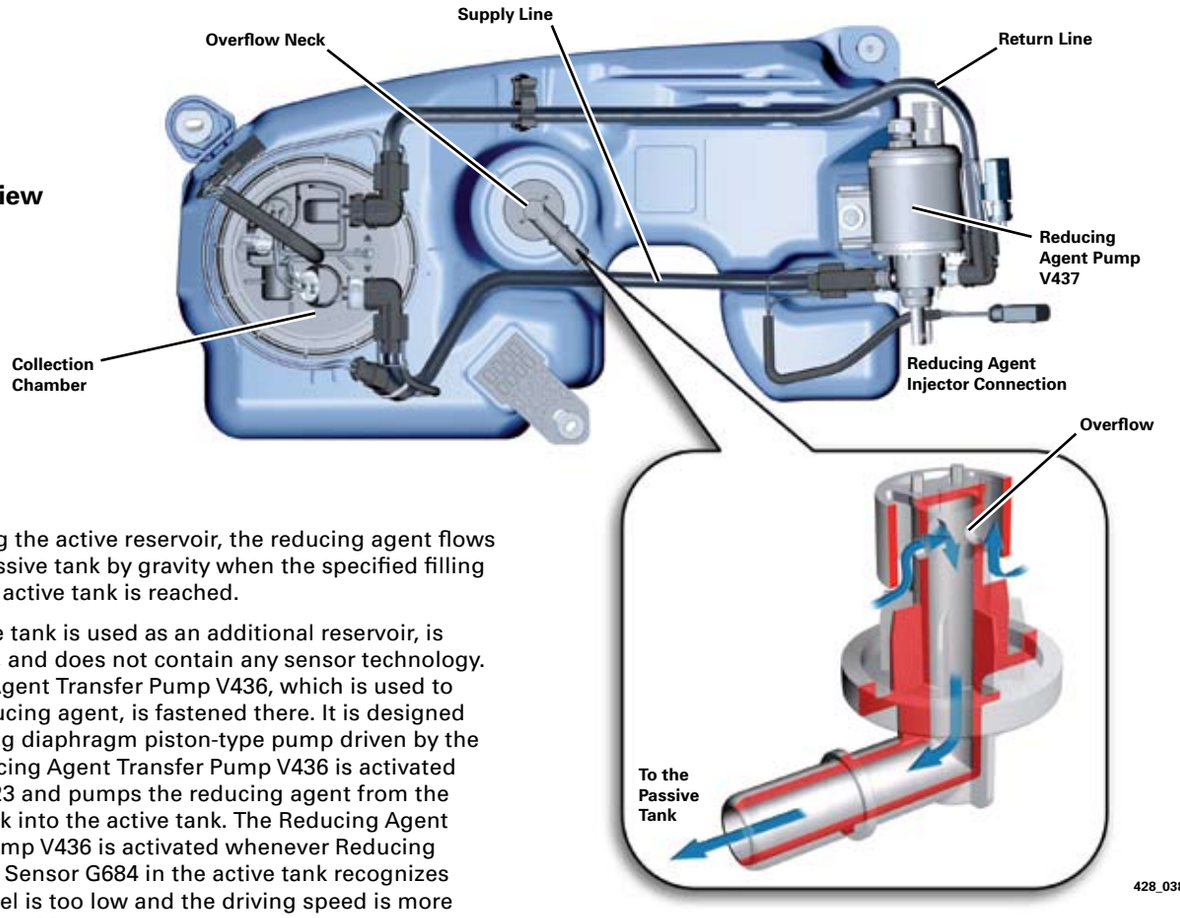


428_034

Active Tank

The Reducing Agent Pump V437, the overflow neck for filling the passive tank, the pipe unions for filling the passive tank, and the heated line for supply and return lines are installed on the active tank. The active tank is heated and contains sensor technology.

Bottom View



When filling the active reservoir, the reducing agent flows into the passive tank by gravity when the specified filling level in the active tank is reached.

The passive tank is used as an additional reservoir, is not heated, and does not contain any sensor technology. Reducing Agent Transfer Pump V436, which is used to supply reducing agent, is fastened there. It is designed as an analog diaphragm piston-type pump driven by the ECM. Reducing Agent Transfer Pump V436 is activated by ECM J623 and pumps the reducing agent from the passive tank into the active tank. The Reducing Agent Transfer Pump V436 is activated whenever Reducing Agent Tank Sensor G684 in the active tank recognizes that the level is too low and the driving speed is more than 6.2 mph (10 km/h).

Furthermore, the level sensor can leave the upper level for some time due to sloshing reducing agent on roads with numerous curves. ECM J623 recognizes this and also activates the Reducing Agent Transfer Pump V436.

Note:
The reducing agent tanks are large enough to maintain adequate supply between two service intervals.

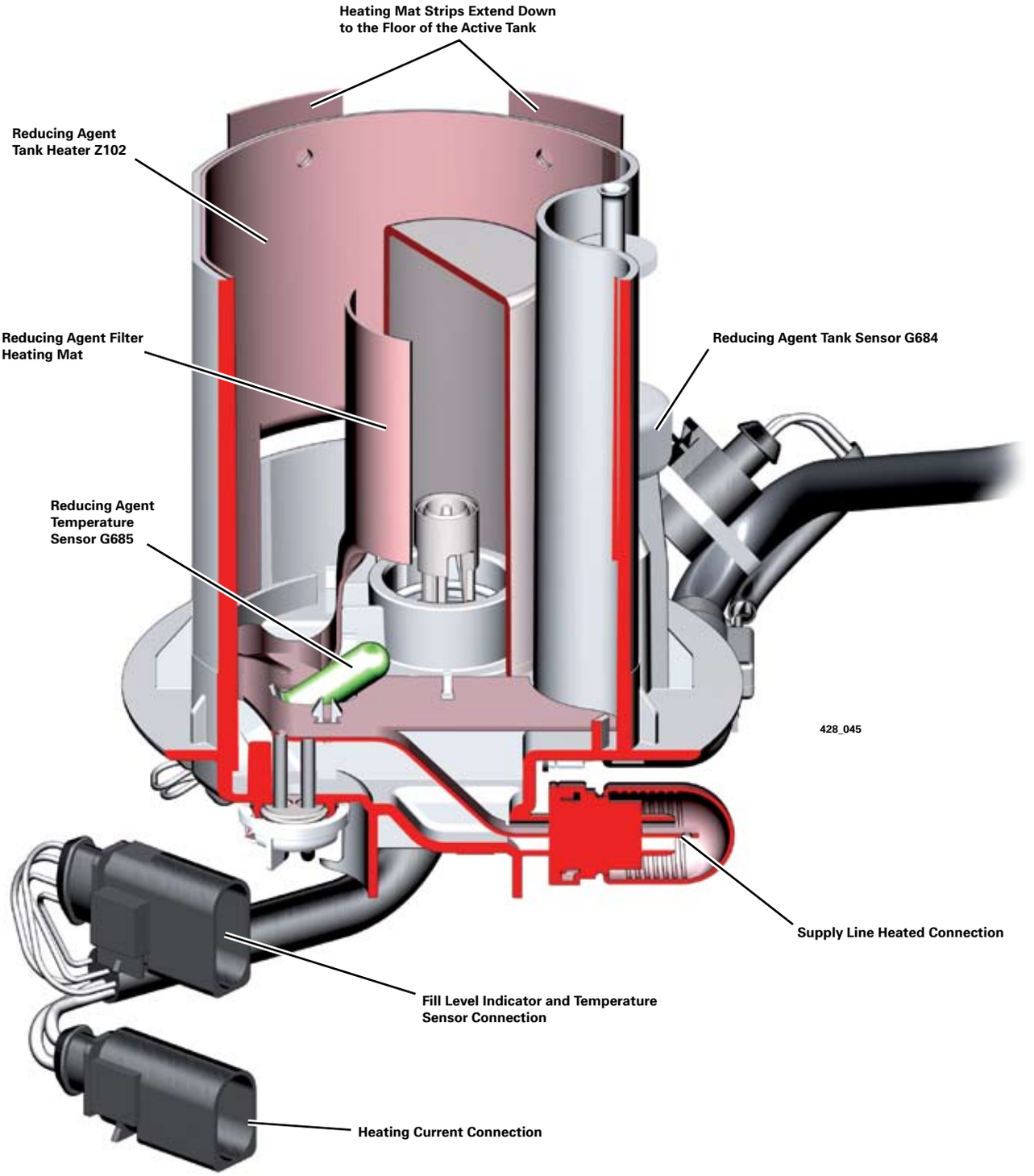
Passive Tank



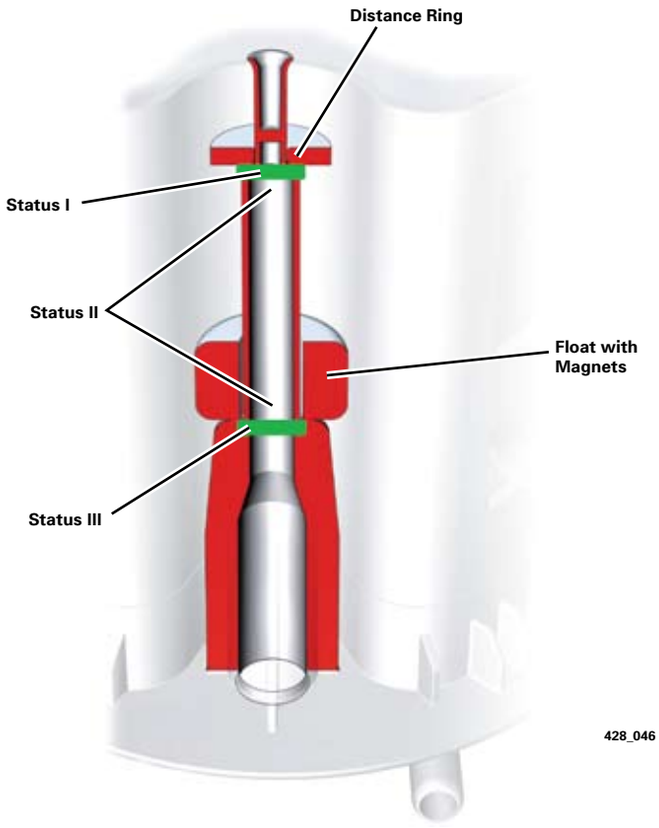
If there is no more reducing agent in the passive tank, the ECM recognizes through current flow that the pump resistance is decreased and switches off the pump.

Active Tank Collection Chamber

The collection chamber is installed into the active tank from below and contains a resistance mat as a heater, a reducing agent filter (designed to last the vehicle's service life), a level sensor, and a temperature sensor for the reducing agent.

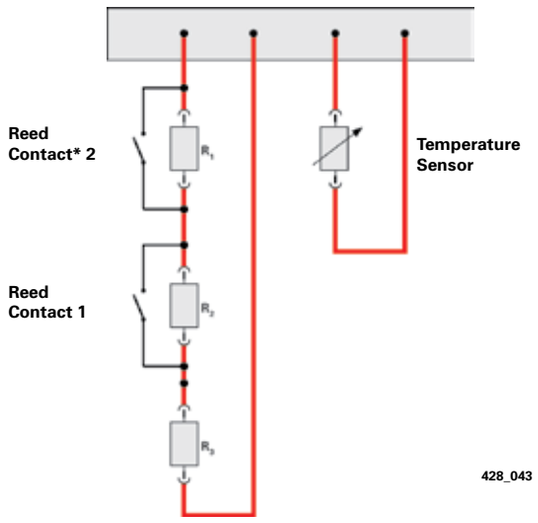


Reducing Agent Tank Sensor G684



428_046

Fill Level Indicator Schematic



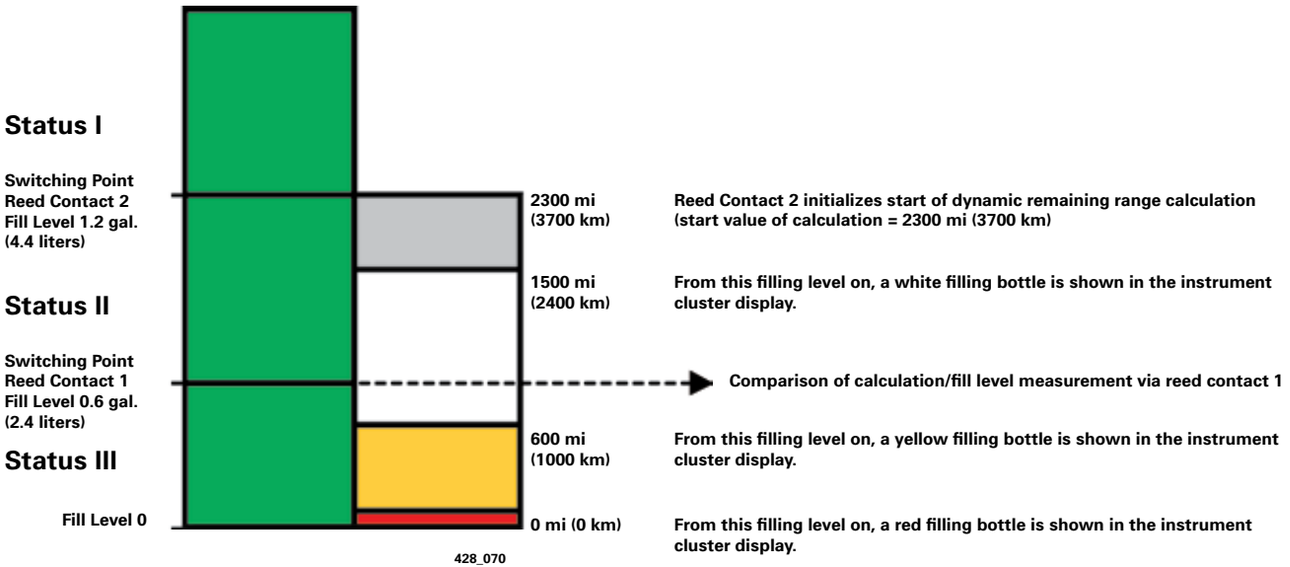
428_043

BIN5



428_069

Function

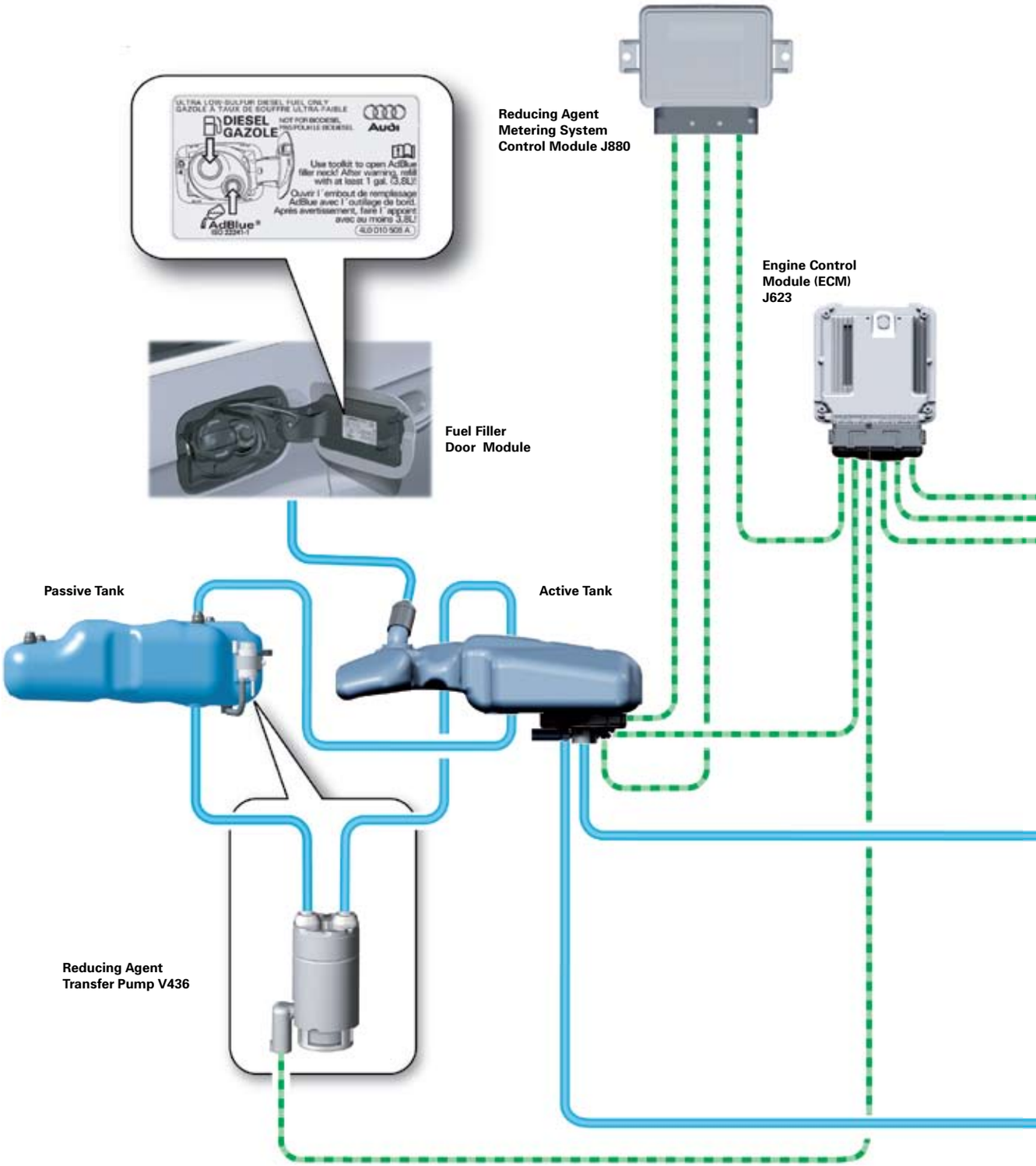


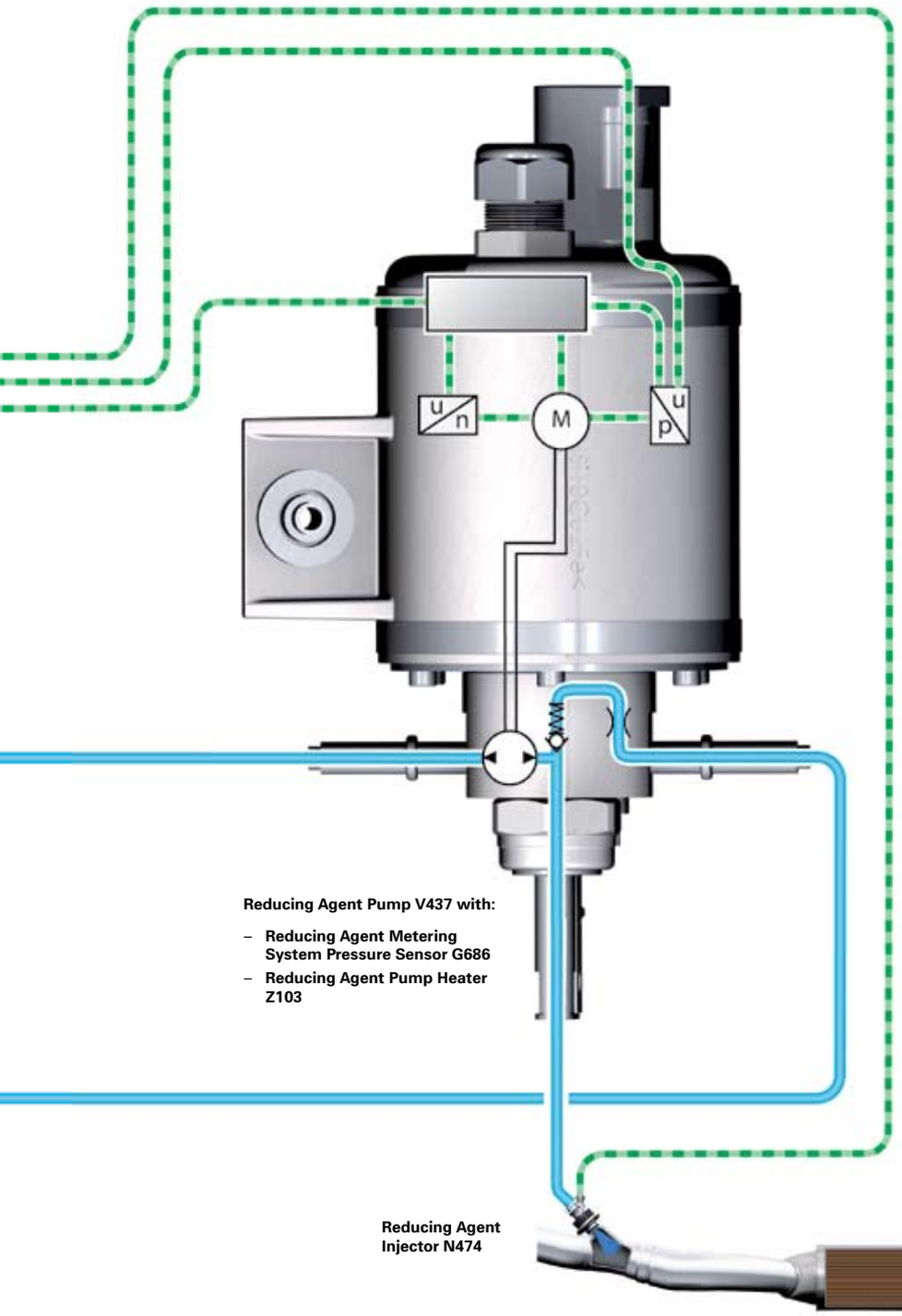
428_070

Refilling Procedure

During refilling, at least 1 gal. (3.8 liters) must be added. This resets the sensor system to Status I. (Refer to the information sticker on the inside of the fuel filler door).

DeNox System Overview





Reducing Agent Pump V437 with:

- **Reducing Agent Metering System Pressure Sensor G686**
- **Reducing Agent Pump Heater Z103**

Reducing Agent Injector N474

DeNox Catalytic Converter

428_040

Reducing Agent Pump V437

The reducing agent pump is installed on the active tank. This heated, electronically controlled gear pump is activated via a Pulse Width Modulated (PWM) signal by the ECM.

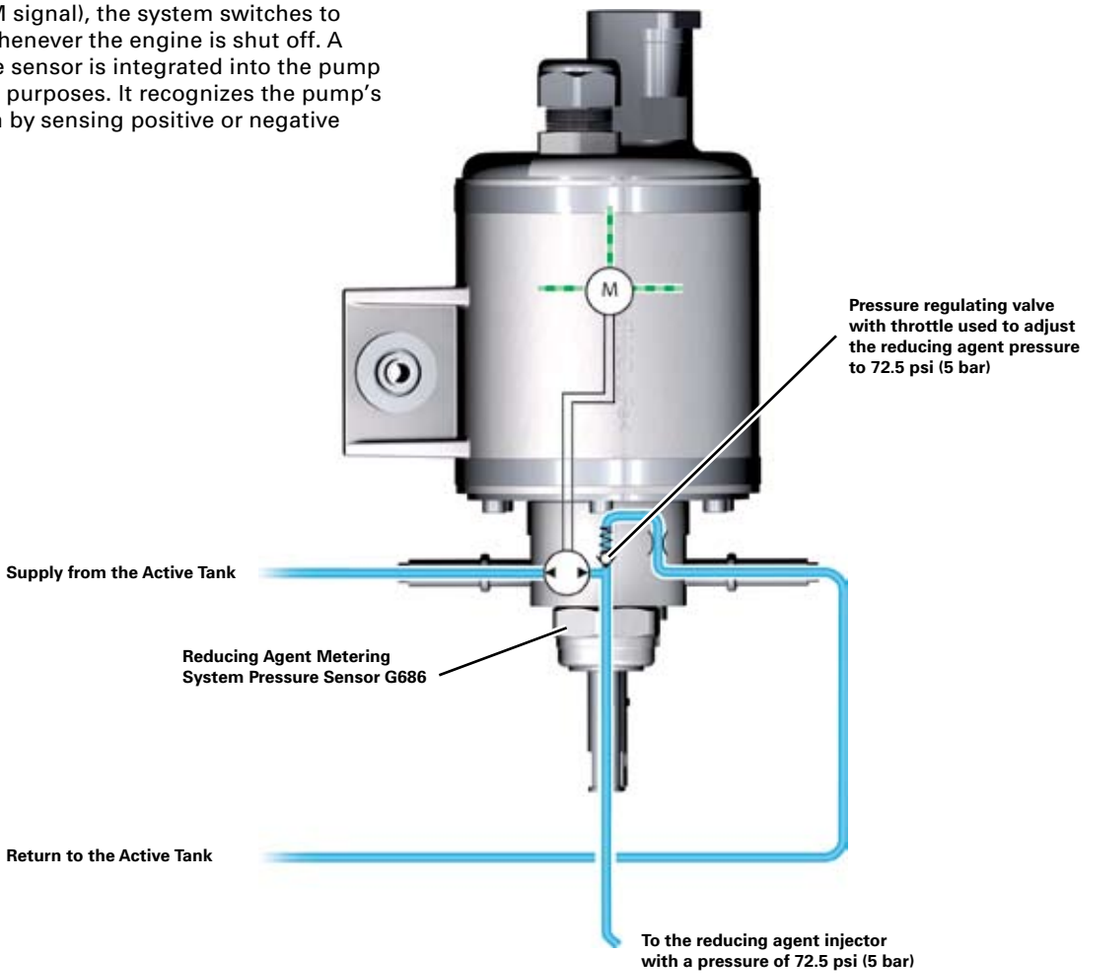
The reducing agent pump is the core of the tank system; it must make the reducing agent available with the specified inlet pressure of 72.5 psi (5 bar) on the reducing agent injector.

The reducing agent pump is able to evacuate the supply line to the reducing agent injector after the engine is shut off. This measure prevents the reducing agent from freezing in this area when the engine is not running.

By reversing the reducing agent pump's direction of rotation (via PWM signal), the system switches to evacuation mode whenever the engine is shut off. A differential pressure sensor is integrated into the pump for pressure control purposes. It recognizes the pump's direction of rotation by sensing positive or negative pressure.

To prevent hot exhaust gas from being evacuated, the injector is opened with a time delay (depending on the temperature in the exhaust system, maximum waiting time 60 seconds) and the reducing agent is suctioned back in.

The reducing agent pump is connected to the active tank via the supply and return line and via the heated supply line to the reducing agent injector.



Performance Characteristics of the Reducing Agent Metering System Pump

- Positive displacement gear pump
- Rotational speed of the pump Nmax = supply 2400 rpm, evacuation 3500 rpm
- Supply pressure Pmax = 87 psi (6 bar) (electronically controlled) pressure sensor always available
- Current draw = 25 W, nominal 12 W
- Flow rate Vmax = 1.3 – 2.6 gal/h @ 72.5 psi throttle valve difference (target:1.6 gal)
  (5 – 10 l/h at 5 bar throttle valve difference (target: 6 liters))

Reducing Agent Injector N474

Reducing agent AdBlue is supplied to the DeNox catalytic converter by Reducing Agent Injector N474.

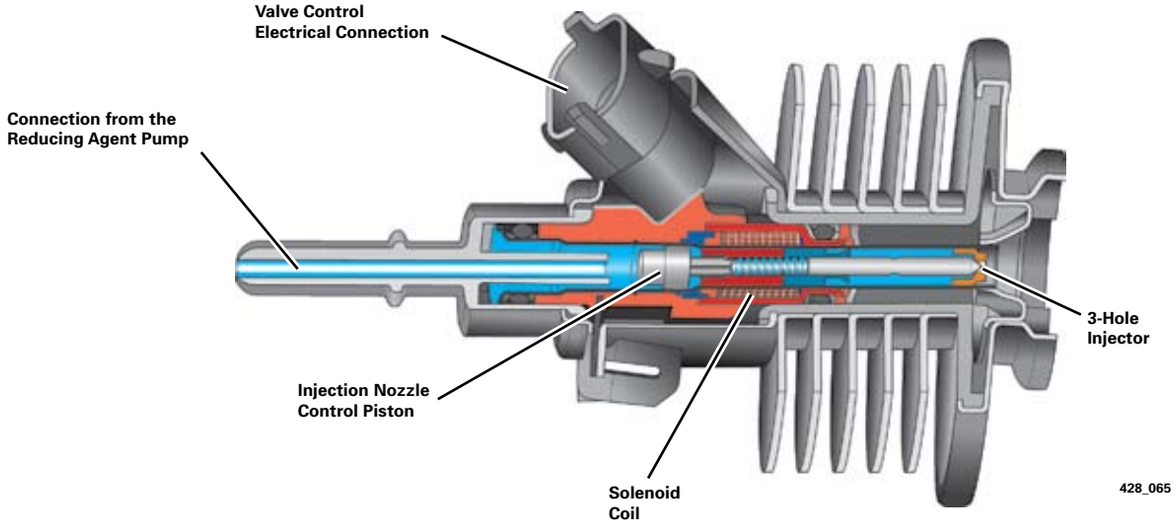
N474 is actuated by through a PWM signal from the ECM. The opening length of the injector depends partially on the amount of ammonia stored in the DeNox catalytic converter.

The function of the injector and the DeNox catalytic converter is monitored by NOx Sensor 2 G687, downstream of the DeNox catalytic converter.

Even distribution of ammonia in the DeNox catalytic converter is very important for a high conversion rate.

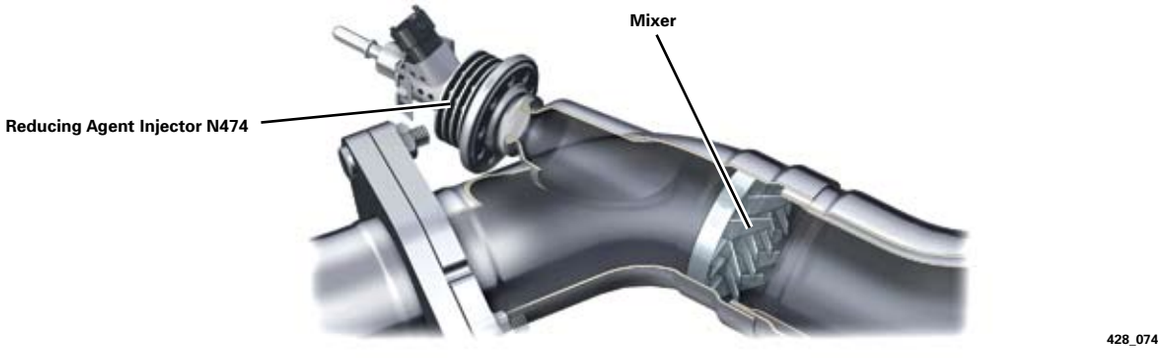
To achieve this, the injection spray geometry and the mixer located downstream in the exhaust path are optimized extensively.

This mixer is located directly downstream of the reducing agent injector. It is responsible for optimum mixing of the reducing agent and the exhaust gases. The mixer causes a turbulent stream of exhaust flow and reducing agent, whereby the mixer is also acting as an evaporator because its surface is heated, and the reducing agent can assume gaseous form in part.



Starting at temperatures of approximately 356°F (180°C), the urea in the exhaust gas is converted into ammonia (NH3).

The injection of the reducing agent is also conditional on this temperature threshold.



Reducing Agent System Heating

Since the reducing agent freezes at 12°F (-11°C), the metering system must be fitted with a heating system.

An integrated heating mat is located in the collection chamber.

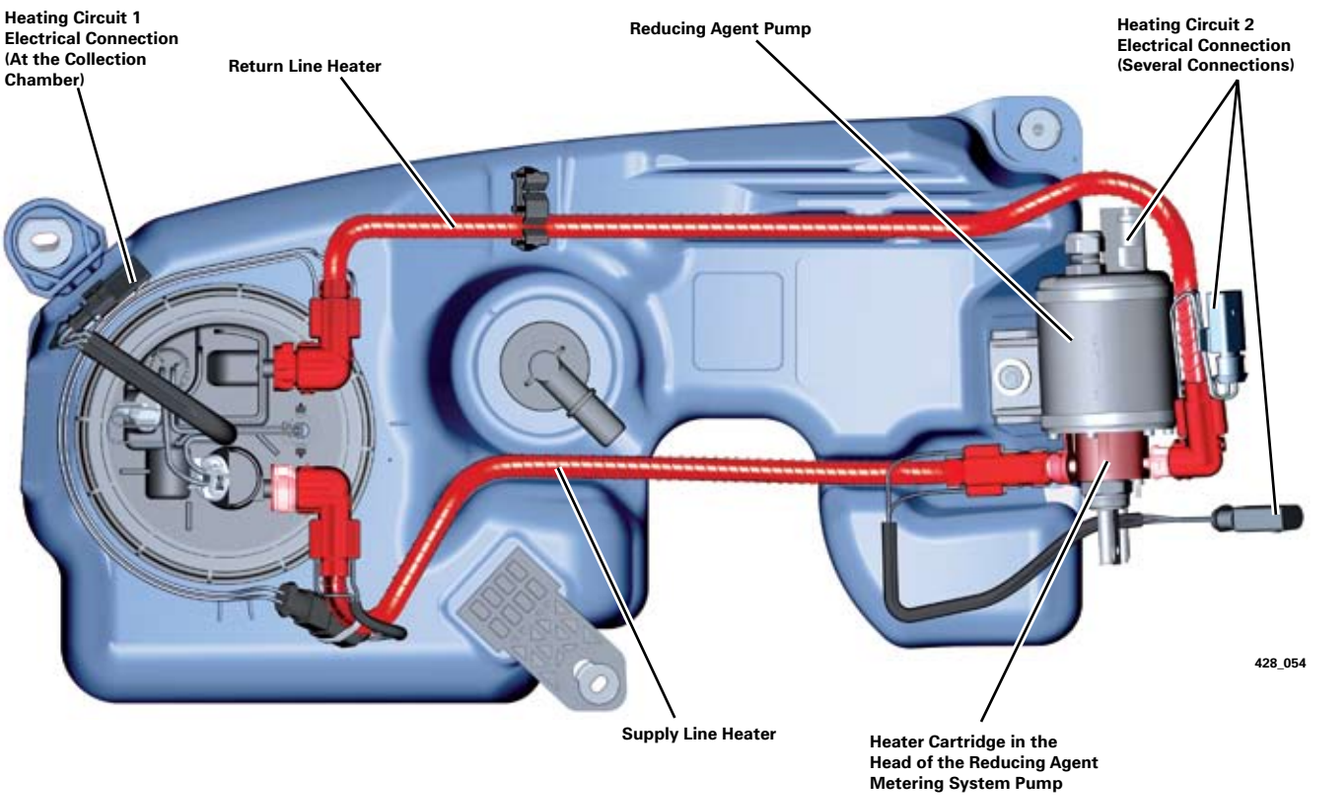
This heating mat heats up both the actual collection chamber (over the entire height) as well as the filter and the line connections.

Elongated heating mat sections reach into the tank. In addition, a heater cartridge in the head of the reducing agent pump heats the tank. To keep the reducing agent flowing to the reducing agent injector free from ice, the supply line is also heated electrically. This is done by a resistance wire wound around the lines.

Note:

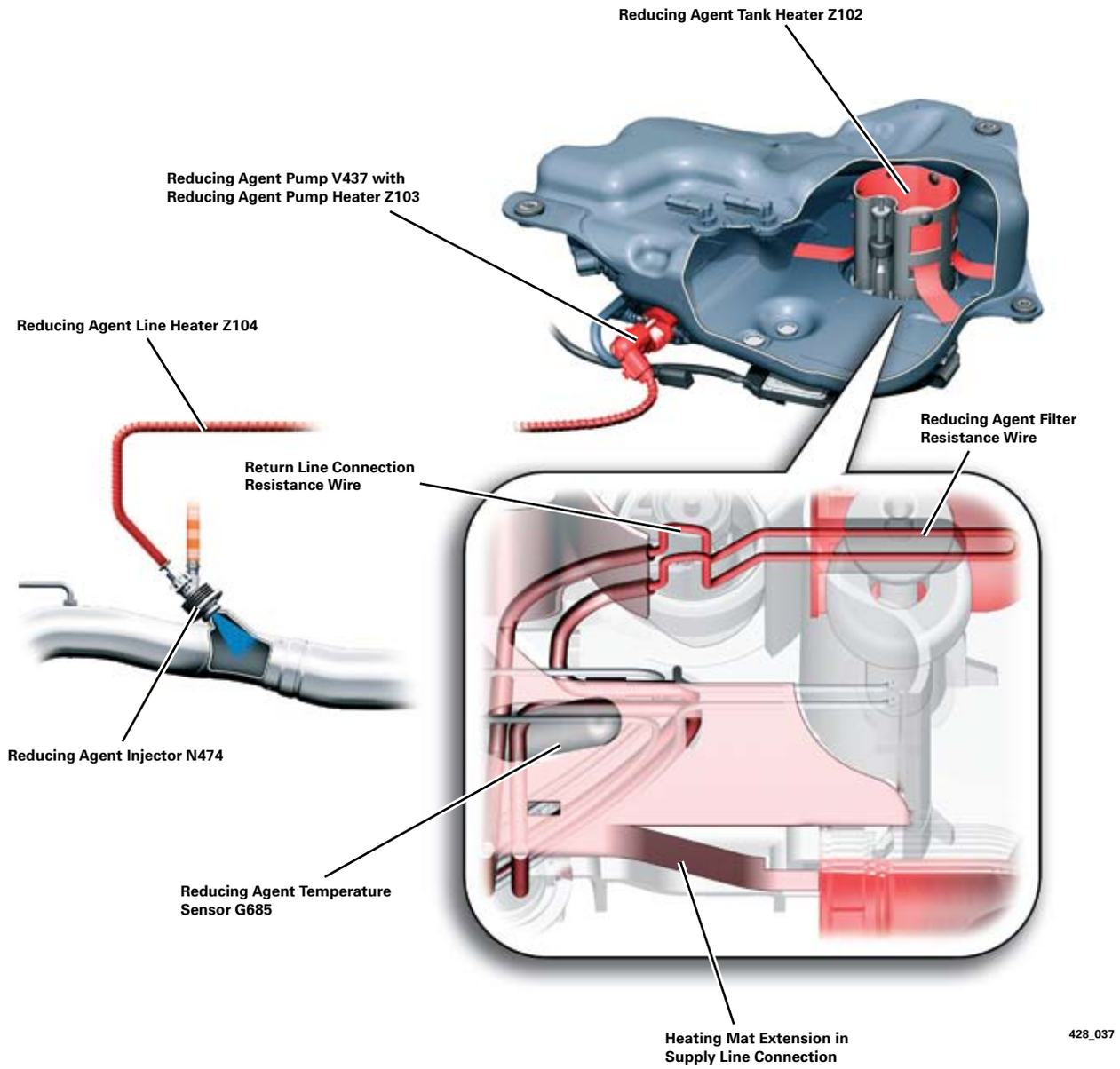
Heating circuit 1 – Tank heating

Heating circuit 2 – Reducing agent pump and heated lines



The heating devices are activated by the Reducing Agent Metering System Control Module J880 and are thus easy to control in either melting or warming mode via the ECM.

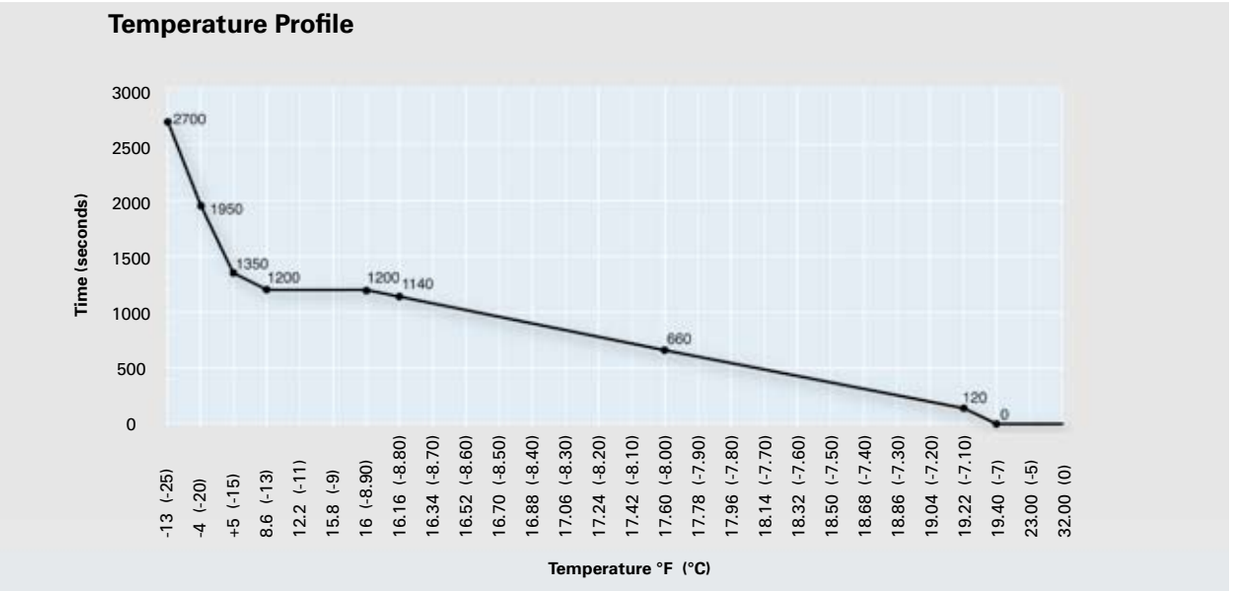
Reducing Agent Temperature Sensor G685 provides the temperature information on the reducing agent.



Note:

If all or part of the heating system for the reducing agent metering systems fails during vehicle operation, the reducing agent can freeze. No reducing agent can be injected. Malfunction Indicator Lamp (MIL) K83 is illuminated and a fault is stored in the ECM.

Reducing Agent Heating Temperature Profile



The characteristic curve of the temperature profile is required by law in the North America Region (NAR).

	Heating Circuit 1	Heating Circuit 2
Activation	If the temperatures in the tank or in the ambient air are below 19.4°F (-7°C), the reducing agent heating system is activated via the Reducing Agent Heating System Control Module J880 by the ECM.	If the temperatures in the ambient air are below 23°F (-5°C), the reducing agent pump heating system and the reducing agent line heating system are activated by the ECM via the Reducing Agent Heating System Control Module J880.
Heating Period	The heating period at temperatures of19.4°F (-7°C) to 8.6°F (-13°C) is approximately 20 minutes. At temperatures up to -13°F (-25°C), the heating period can increase to up to 45 minutes. The reducing agent is melted actively here to establish the metering properties for the system.	The heating period at temperatures below 23°F (-5°C) is approximately 100 seconds. This time increases to 21 minutes at temperatures of -13°F (-25°C).
Post-heating	At temperatures below 19.4°F (-7°C), the heating period is always followed by post-heating. This takes approximately five minutes. Post-heating is for safety purposes to provide an adequate amount of melted reducing agent in all operating points.	

Reducing Agent System Instrument Cluster Display

The display for the DeNox 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)

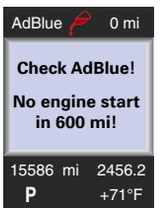
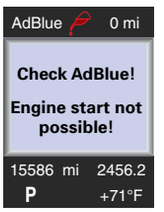
Exhaust Gas After-Treatment Display Strategy

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	Radio WJR 4 **Please Refill AdBlue!** 1500 mi 13486 mi 356.2 D 4 +71°F	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	AdBlue 600 mi **Refill AdBlue!** **No Engine Start in 600 mi!** 14986 mi 1856.2 D 4 +71°F	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	AdBlue 0 mi **Refill AdBlue!** **Engine Start Not Possible!** 15586 mi 2456.2 P +71°F	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.

The Use of Incorrect Reducing Agent

If the reducing agent tank is filled up with a medium other than reducing agent AdBlue®, 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.

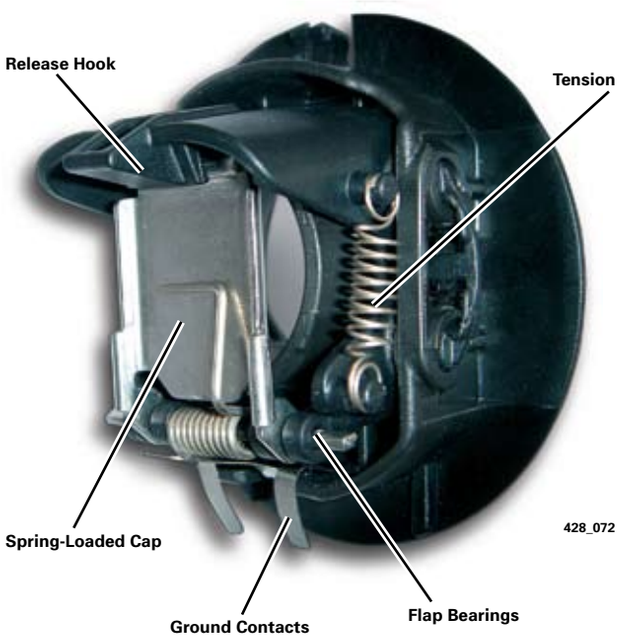
Remaining Range	Acoustic Warning	Dash Display	Driver Instructions
< 600 mi (1000 km)	1 x warning buzzer		These instructions with the red filling bottle appear when it is only possible to drive for the remaining range specified in the text. The driver is notified that, after the remaining driving range, 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 Audi Q7 instrument cluster display, at least two 0.5 gal. (1.89 liter) AdBlue® 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 Audi Q7. In other models, the displays and filling quantities can differ.

Protection Against Filling the Tank with Incorrect Fuel



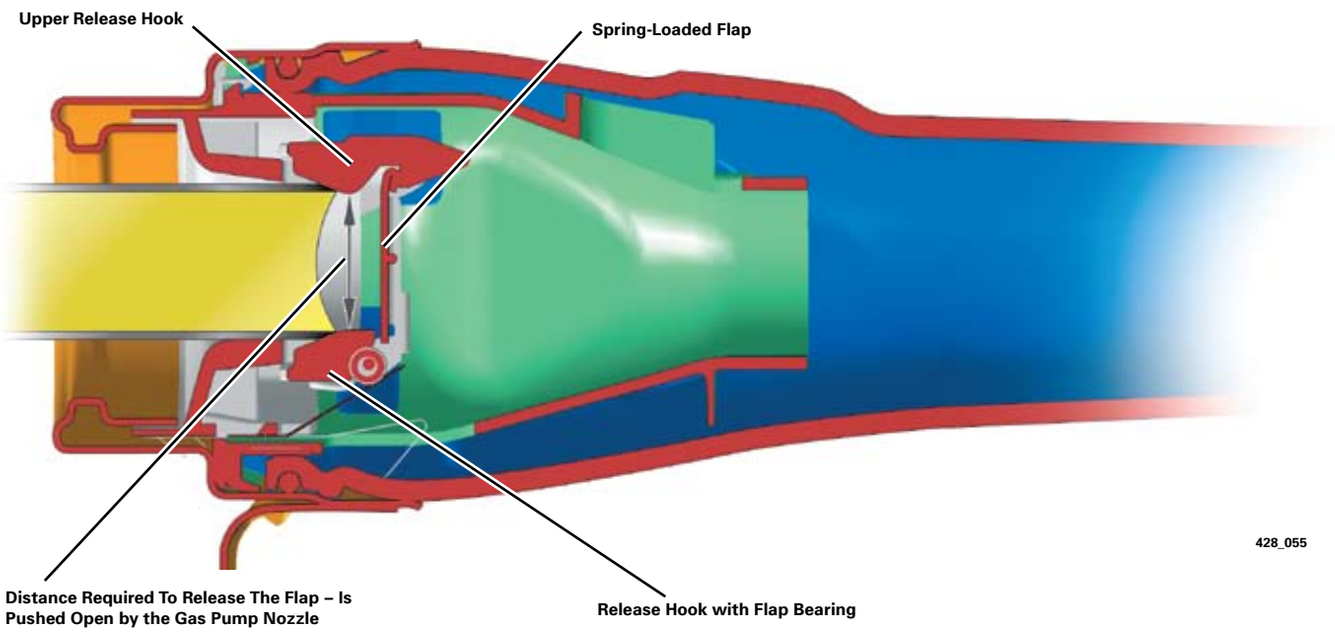


To ensure that only diesel fuel is filled into the diesel fuel tank, a cap is located in the fuel filler neck. This cap can only be unlocked using a pump nozzle with the diameter specific to a diesel pump nozzle. For this purpose, the diesel pump nozzle must push the two release hooks towards the outside at the same time to push the cap open. If only one release hook is operated due to a worn diesel pump nozzle, the entire mechanism moves away to the unlocked side because of the tension spring, and the cap remains closed.

Emergency slots on the sides make it possible to use an auxiliary filling can.

Note:

At some filling stations, a worn, damaged, or out of specification diesel pump nozzle may prevent the customer from being able to refuel his/her vehicle. Attempting to fill the vehicle with an incorrectly sized nozzle may result in refueling difficulties.



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 reducing agent (AdBlue®) independently be pouring in two AdBlue® refill bottles (0.5 gal [1.89 liters]).

The reducing agent AdBlue® is available at an Audi dealer and at some designated gas stations.

For refilling purposes, an adapter must be screwed onto the AdBlue® refill bottle. After opening the AdBlue® 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 gas in the reducing agent tank enters the ventilation system of the reducing agent tanks.

At the beginning of the cold season, the active tank should always be filled with reducing agent, since the volume of the passive tank is not available when frozen, and no heating elements are installed in the passive tank. This ensures that the contents of the active tank last throughout the cold part of the year.

Note:

Please observe the current operating instructions when handling the AdBlue® refill bottle as well as the labels in the fuel filler door.



428_066

Adblue® Refill Bottle 0.5 gal.(1.89 liters)

Bottle Adapter with Open/Close Function

428_058



428_059



Push down on the AdBlue® bottle to open, pull out to close.

428_060

... for the Workshop

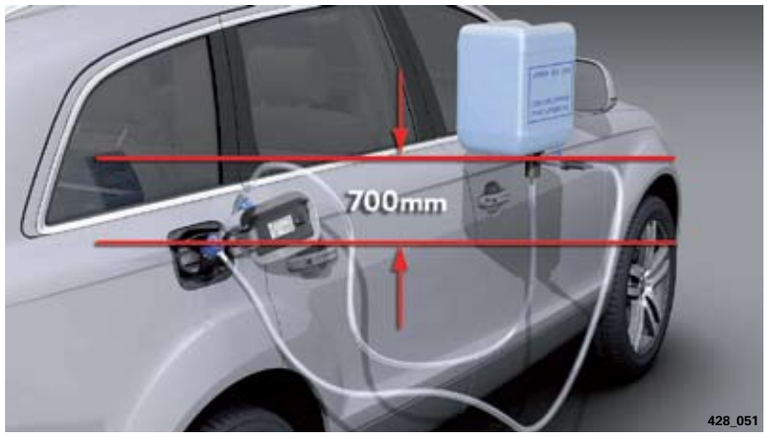
The reducing agent tanks must be refilled during Pre-Delivery Inspection (PDI), again at 5000 miles (8000 km), and every 10,000 miles (16,000 km) thereafter with the aid of the reducing agent filling equipment VAS 6542.



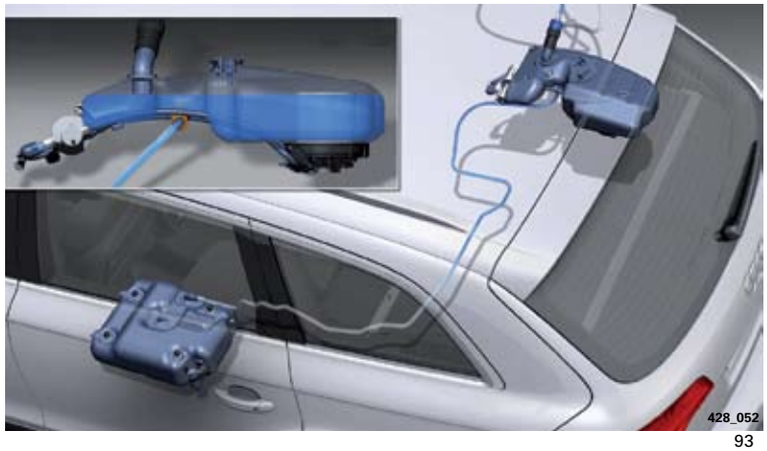
To do this, the reducing agent filling equipment VAS 6542 is screwed onto the filler neck of the reducing agent tank and the reducing agent container. A ventilation line is integrated in the filling line, which ensures the ventilation of the reducing agent tanks and the container.



Please note that the container must hang at least 28 in. (700 mm) above the filler neck of the active tank to ensure that the passive tank is reliably filled.



When the specified filling level in the active tank is reached, the passive tank is filled through the overflow neck in the active tank.



Appendix

Glossary

AdBlue®

AdBlue® is a registered trademark of the German Association of the Automotive Industry (VDA). It describes a reducing agent that is mixed to the exhaust gas to reduce certain exhaust emissions. It is a non-hazardous synthetic solution. It is made up of one-third urea and two-thirds water.

AdBlue® Refill Bottle

It is a refill bottle for the reducing agent AdBlue®, 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 AdBlue® 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.

Summary

The Audi Clean Diesel System is the best exhaust gas after-treatment technology currently available in series production.

This means that vehicles with the Clean Diesel System reach limits that are below the stringent U.S. BIN5 standards for all states including California – and also below the future EU6 limits for 2014 which are currently being discussed.

The TDI can then be used world wide. Due to a package full of new technologies, the 3.0 TDI achieves lower fuel consumption and thus CO2 reductions. The customer can enjoy the sporty and high-torque aspects knowing he is driving an ecologically-friendly vehicle.

The TDI is also fit for the future from a different perspective: It can be operated with alternative fuels. All forecasts predict a considerable increase in the percentage of diesel in the global market. With the TDI and the Clean Diesel System, Audi is well prepared for the future.

Notes

Notes

Notes

Knowledge Assessment

An on-line Knowledge Assessment (exam) is available for this SSP.

The Knowledge Assessment may or may not be required for Certification.

You can find this Knowledge Assessment at:

www.accessaudi.com

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