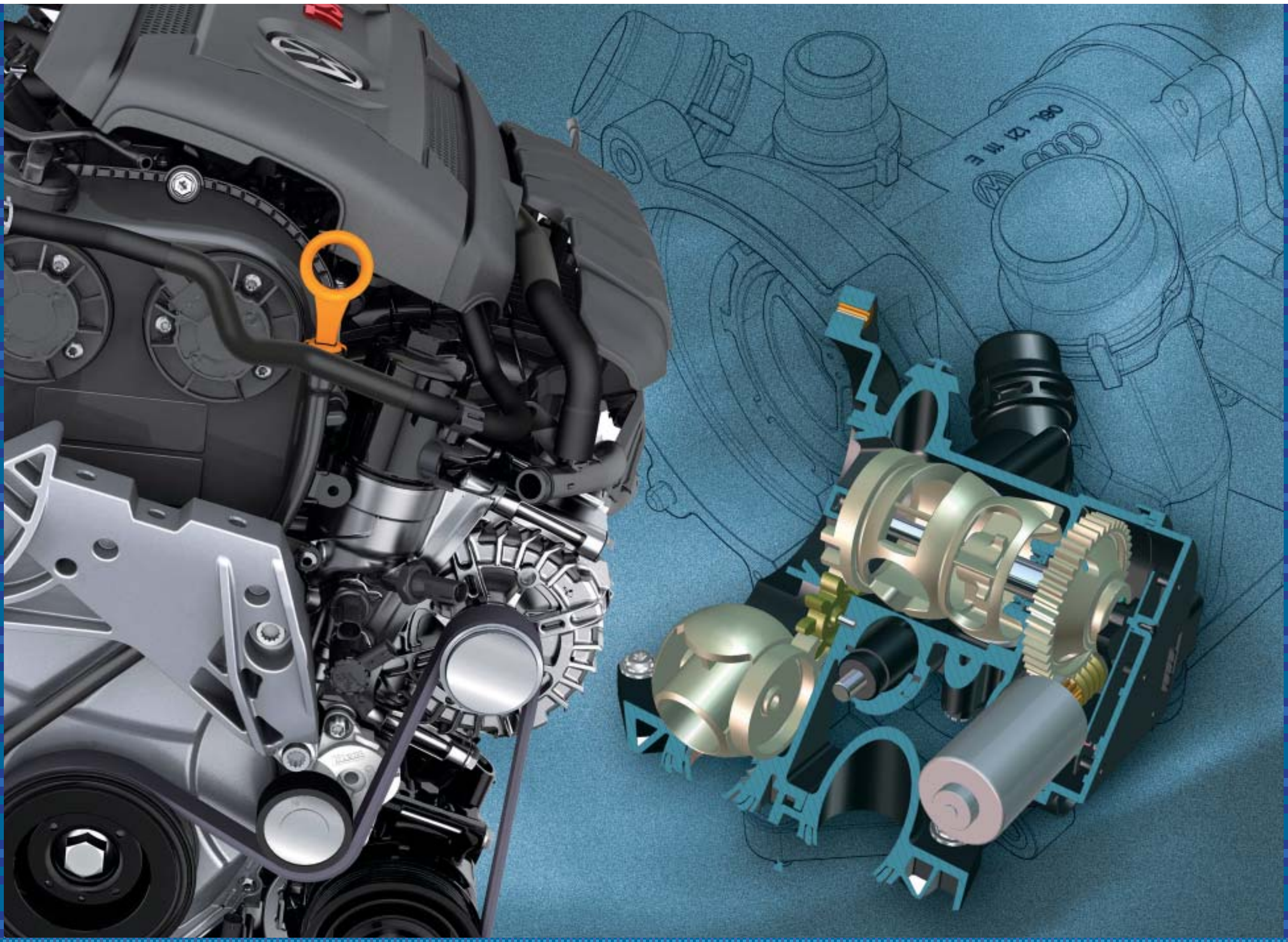
Service Training

Self Study Program 820533

The 1.8L and 2.0L TSI

3rd Generation EA888 Gasoline Engines

Design and Function



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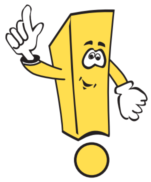
Always check Technical Bulletins and the latest electronic repair information for information that may supersede any information included in this booklet.

Contents

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

For maintenance and repair procedures, always refer to the latest electronic service information.

Note



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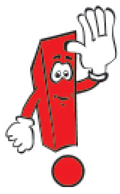

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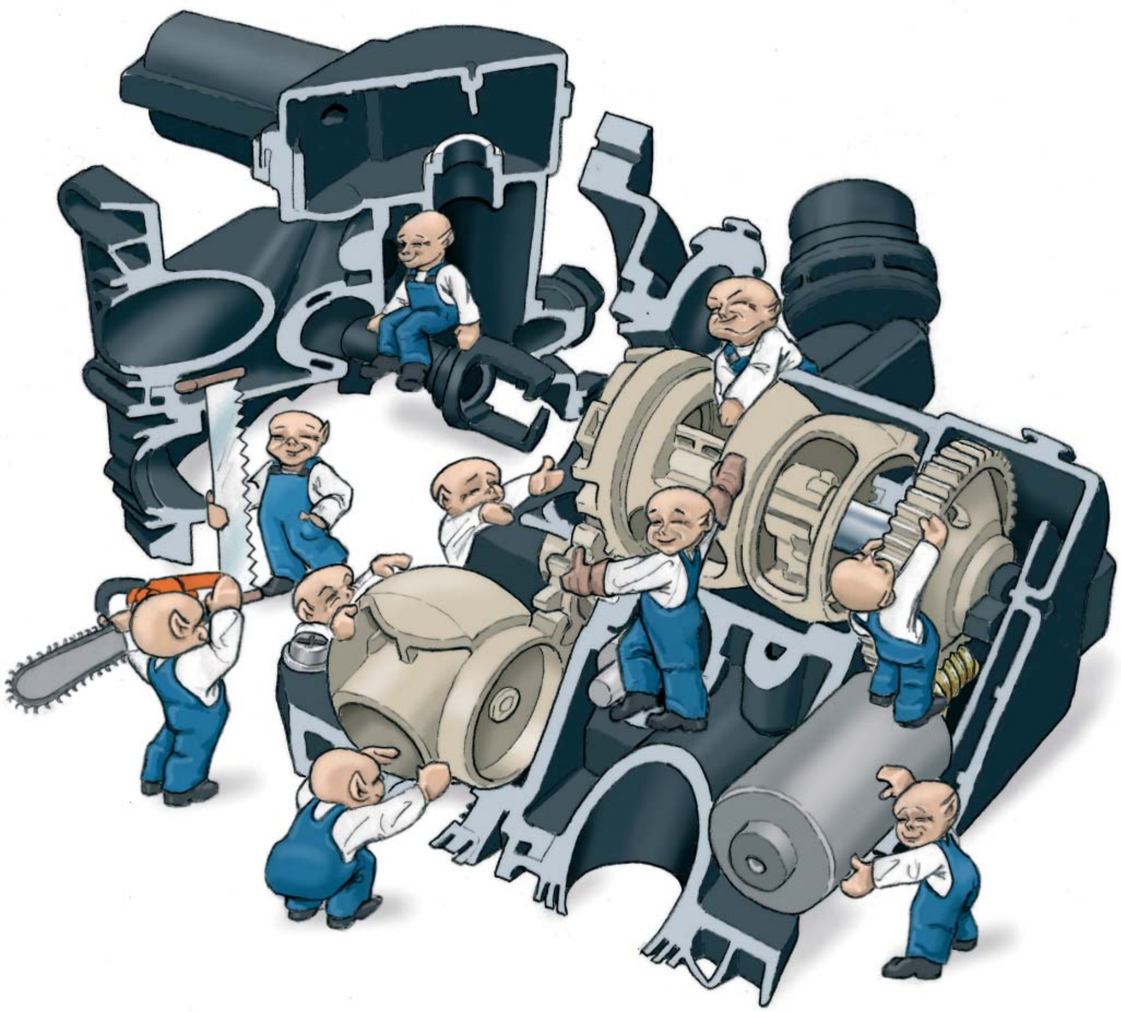
The 1.8L and 2.0L 3rd Generation EA888 Engines

This SSP covers the 3rd generation EA888 engine family. These engines are designed for use in the modular transverse matrix platform (MQB), allowing for universal use within the Volkswagen Group.



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Introduction

Technical Features

During the development of the EA888 engine, the two most important development objectives were to meet low emission standards and adapt the engine for use in the MQB platform. The main development goals were to:

- Lower the CO_2 emissions
- Reduce the engine weight
- Reduce the friction in the engine
- Match performance and torque
- Reduce fuel consumption
- Reduce operational noise

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Mechanical Highlights

- Cylinder head with integrated exhaust manifold
- Roller bearing balance shafts
- Smaller crankshaft main bearings with only four counterweights
- Turbocharger with electrical wastegate flap actuation
- Reduced oil pressure
- Sump with upper aluminum section and lower plastic section
- Accessory bracket with integrated oil filter and oil cooler
- Total weight savings of 7.8 kg (17.2 lb)

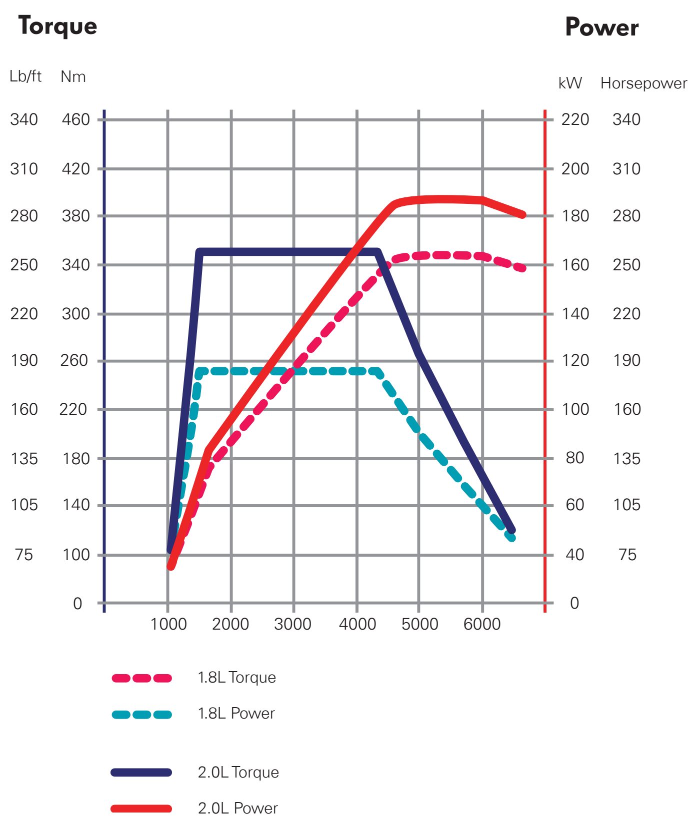
Engine Management

The engine management system has the capability for the following features. Not all features are available on all engines:

- Intake camshaft and exhaust camshaft adjustment (Some versions do not have both)
- Electronic valve lift
- Direct injection system
- Innovative thermal management with rotary valve regulation
- On/off piston cooling jets
- Adaptive lambda control
- Intake manifold flaps
- Two-stage oil pressure regulation with externally driven oil pump
- Fully electronic engine management SIMOS 18.1 with electric throttle

Technical Data

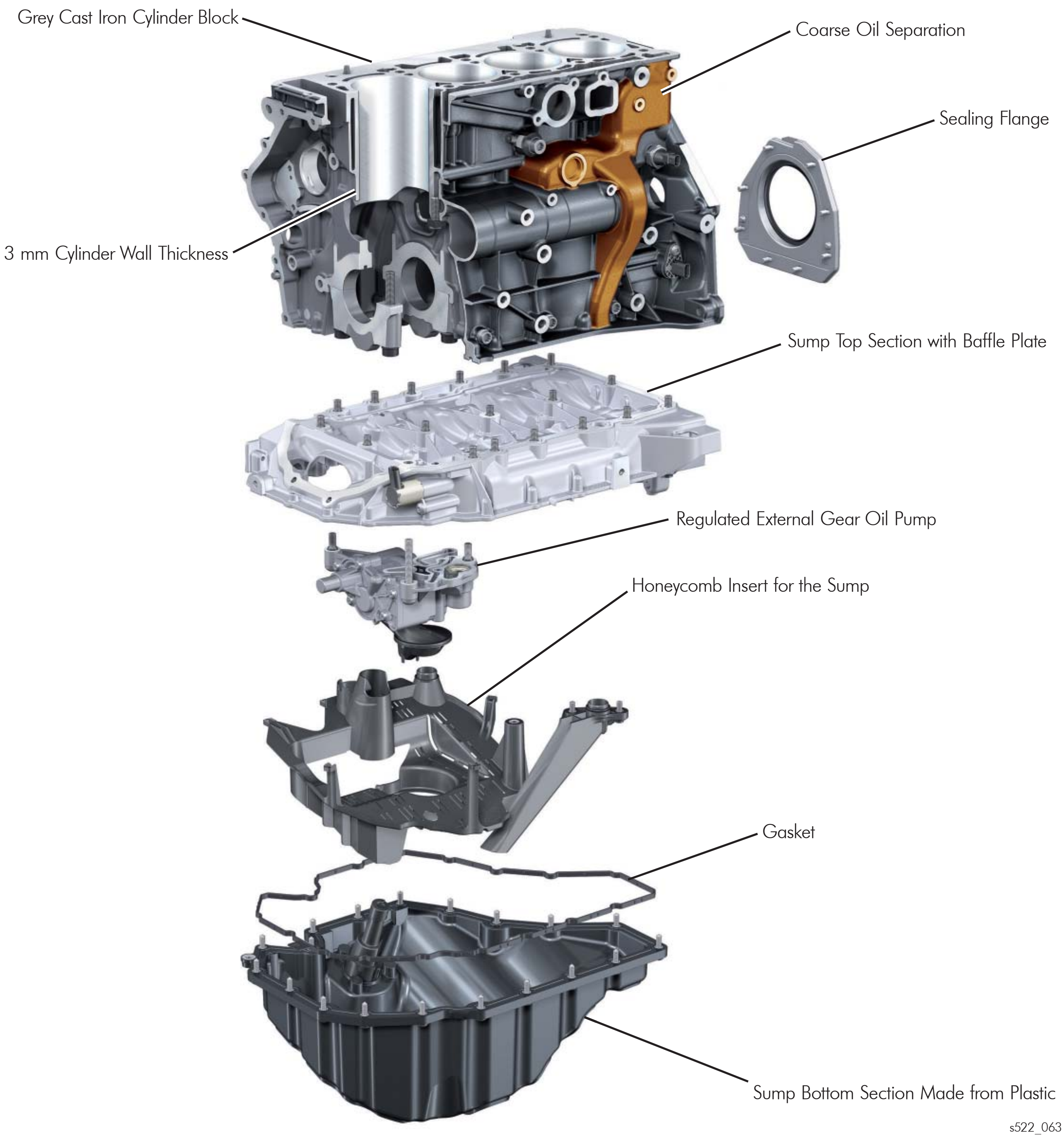
Engine Code	CNSA, CXBA	CNSB, CXBB	CNTA
Displacement	1798 cm^3	1798 cm^3	1984 cm^3
Bore	82.5 mm	82.5 mm	82.5 mm
Stroke	84.1 mm	84.1 mm	92.8 mm
Valves Per Cylinder	4		
Compression Ratio	9.6:1		
Horsepower	125 kW (170 hp) from 4,800 to 6,200 rpm	125 kW (170 hp) from 4,500 to 6,200 rpm	169 kW (220 hp) from 4,700 to 6,200 rpm
Torque	250 Nm (184 lb/ft) from 1,500 to 4,700 rpm	270 Nm (200 lb/ft) from 1,600 to 4,400 rpm	350 Nm (260 lb/ft) from 1,500 to 4,600 rpm
Engine Management	SIMOS 18.1		
Fuel	Premium		
Emission Treatment	Three-way catalytic converter, one upstream broadband lambda probe of the turbocharger and one step-type lambda probe downstream of the catalytic converter		
Emission Standard	PZEV/SULEV		



Engine Mechanics

Cylinder Block

Reworking the cylinder block reduced weight by 2.4 kg (5.3 lb) compared to the previous model. The cylinder wall thickness has been reduced from approximately 3.5 mm to approximately 3 mm. The crankcase coarse oil separator housing has been integrated into the cylinder block.



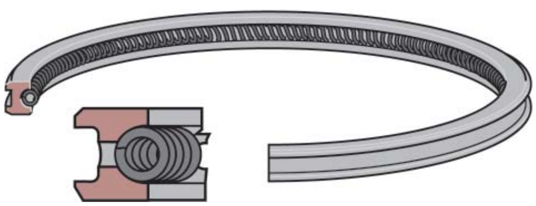
Crankshaft Group

Crankshaft

The main bearing diameters were reduced from 52 mm to 48 mm. The number of counterweights were reduced from eight to four counterweights. The upper and lower main bearing shells are constructed in two layers and without lead additive. The crankshaft is 1.6 kg (3.5 lb) lighter in weight.

Conrod

The conrods are manufactured as cracked conrods. Two-layer crankshaft bearing shells without lead additive are used in the lower conrod cap and in the main bearings. There are no bronze bushes in the conrod's small end. The piston pins have been given a special carbon surface coating.



Two-Part Double-Bevelled Spiral Expander Ring

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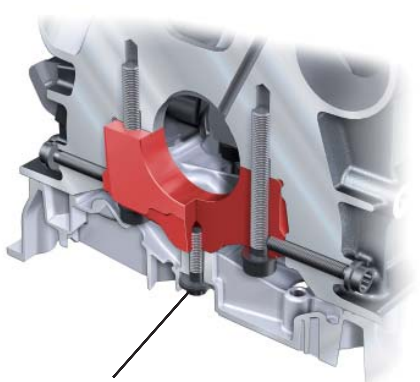

Bolted Connection of the Crankshaft Bearing Cap with the Sump Top Section

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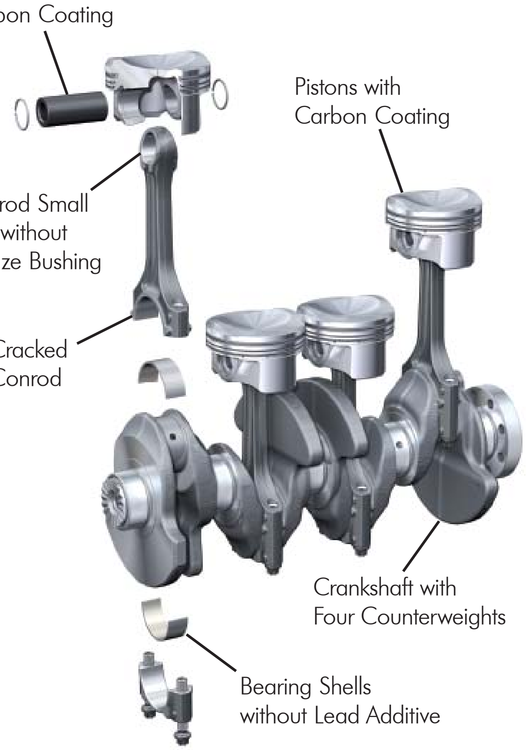
Pistons

The piston clearance has been increased to reduce the friction during the engine warm-up phase. A carbon coating has been added to minimize wear.

The upper piston ring is designed as a rectangular ring, the middle piston ring is a taper-faced Napier ring, and the third piston ring is a two-part double bevelled spiral expander ring for skimming off oil.

Bearing Bracket

The crankshaft bearing caps are bolted to the top of the sump which reduces engine noise and vibration.



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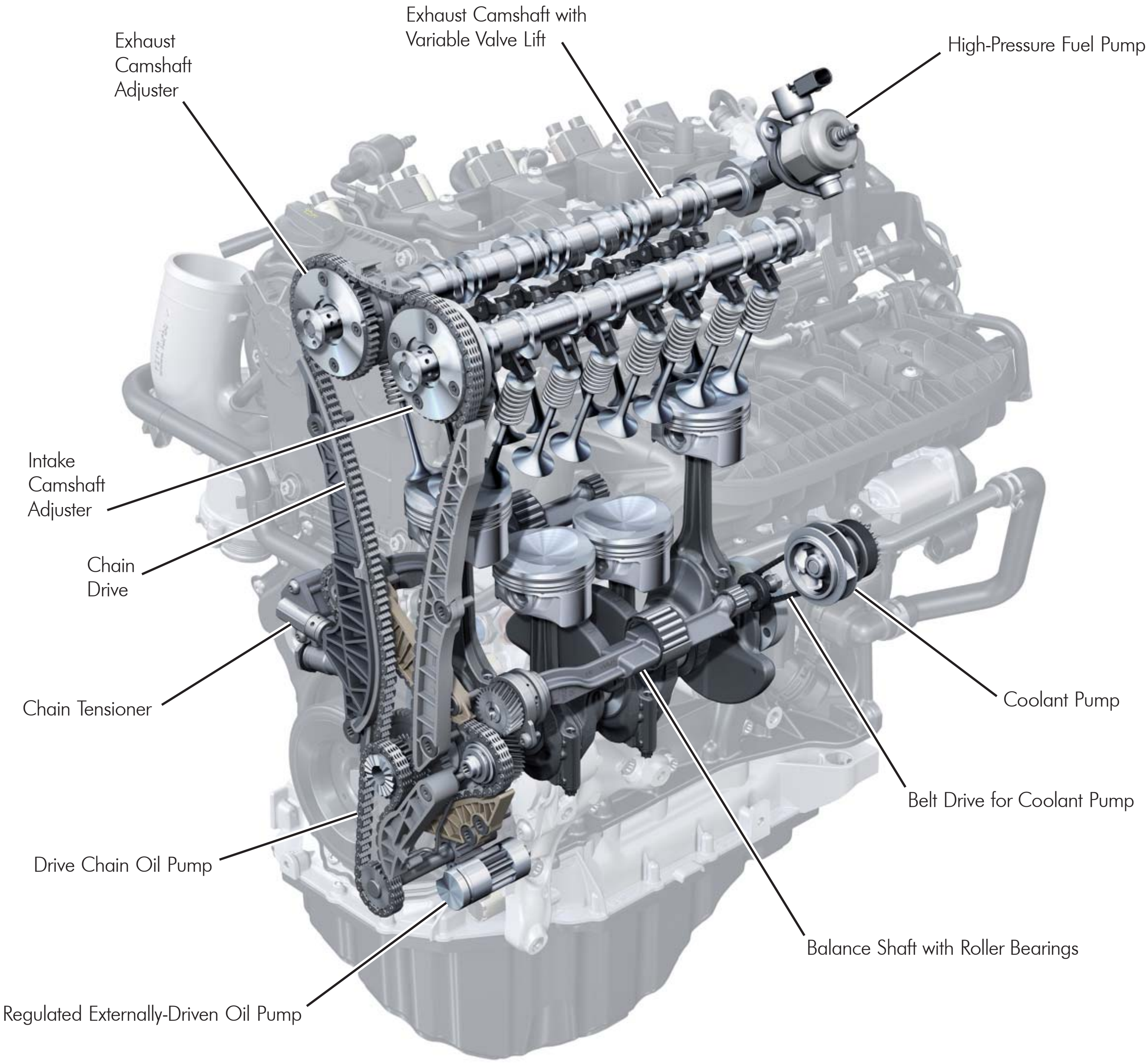
Engine Mechanics

Timing Chain

The timing chain has reduced tension, and the chain tensioners have been modified for this reduced tension.



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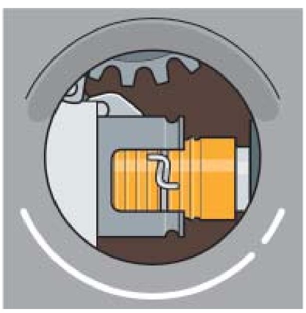
The ECM software for determining timing chain stretch. This software compares the signals between the crankshaft position sensor and the camshaft position sensors. If this comparison regularly exceeds a preset threshold, a DTC is set and a visual inspection of the timing chain must be performed.

For the timing chain diagnostic function to work properly, an adaptation must be performed after:

- Replacing the ECM
- Replacing engine components connected to the timing chain
- Replacing the timing chain or the complete engine



2 Rings Visible = Chain OK

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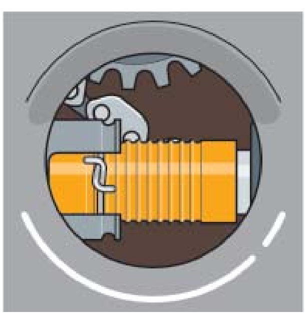

7 Rings Visible = Replace Chain

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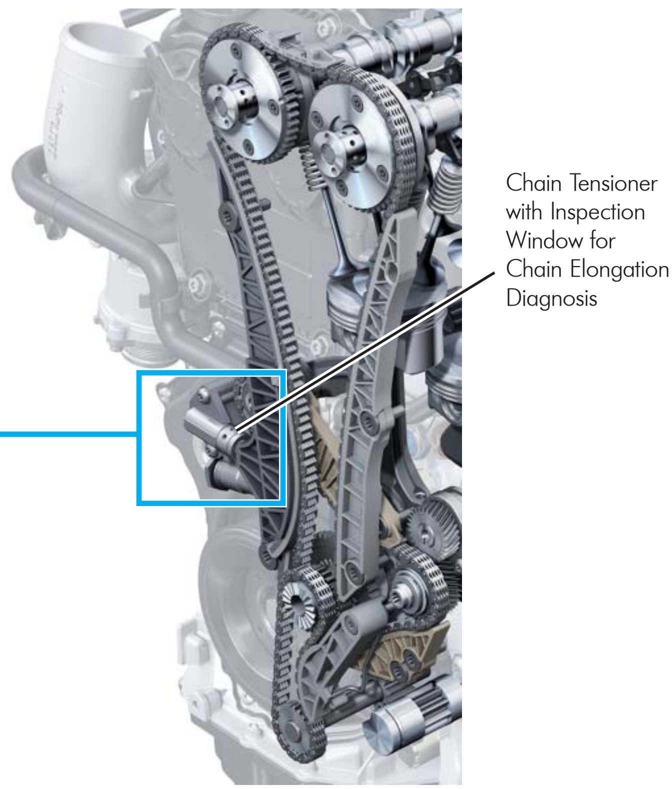

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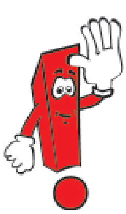


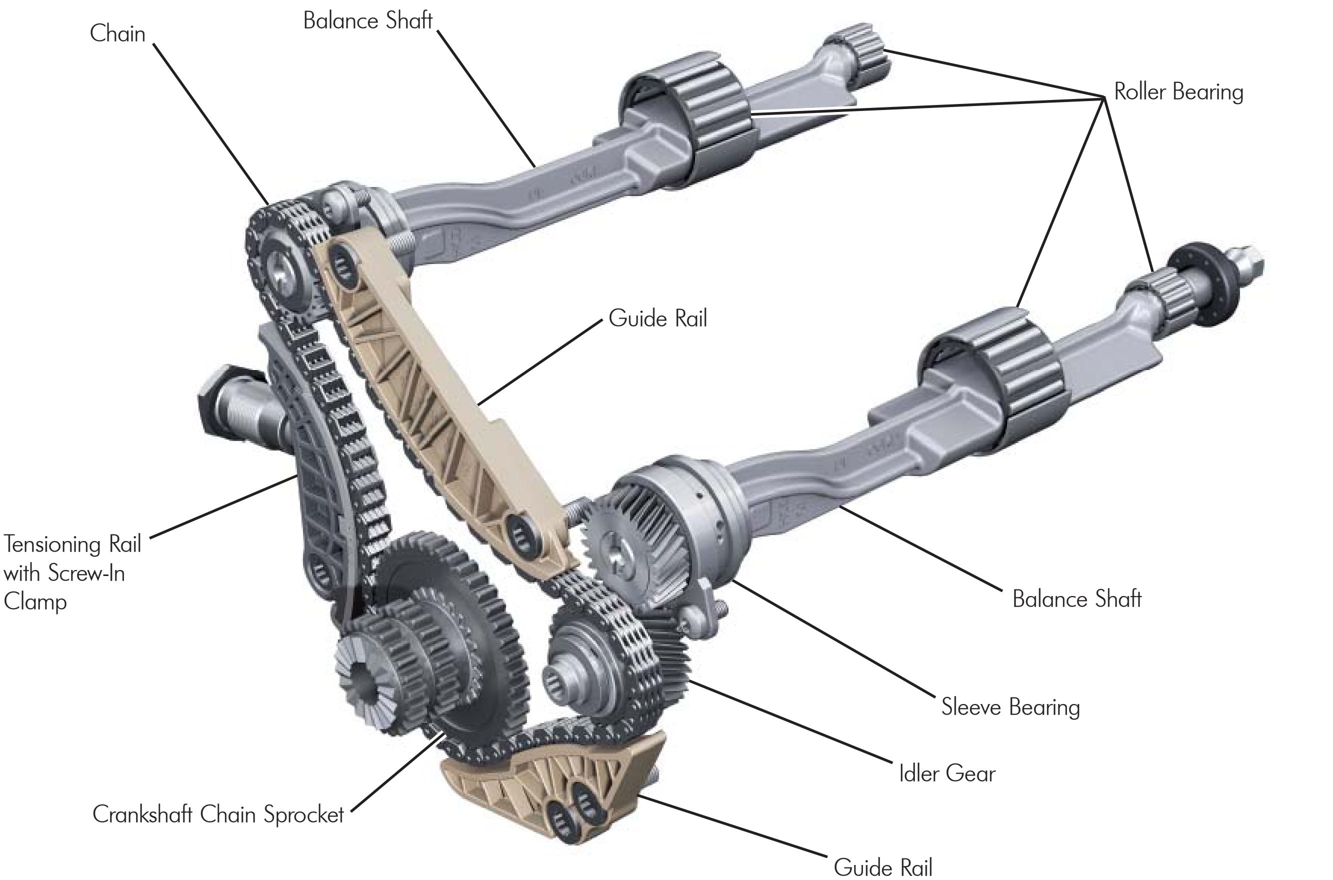
Note: The procedure to install the timing chain is different than on other engines. After the timing chain is installed, a test plan must be run in Guided Fault Finding to reset the chain length in the ECM.

Engine Mechanics

Balance Shafts

Compared to the previous model, the weight of the balance shafts has also been reduced.

The balance shafts use roller bearings. This reduces the friction of the balance shafts, particularly when the engine is cold.



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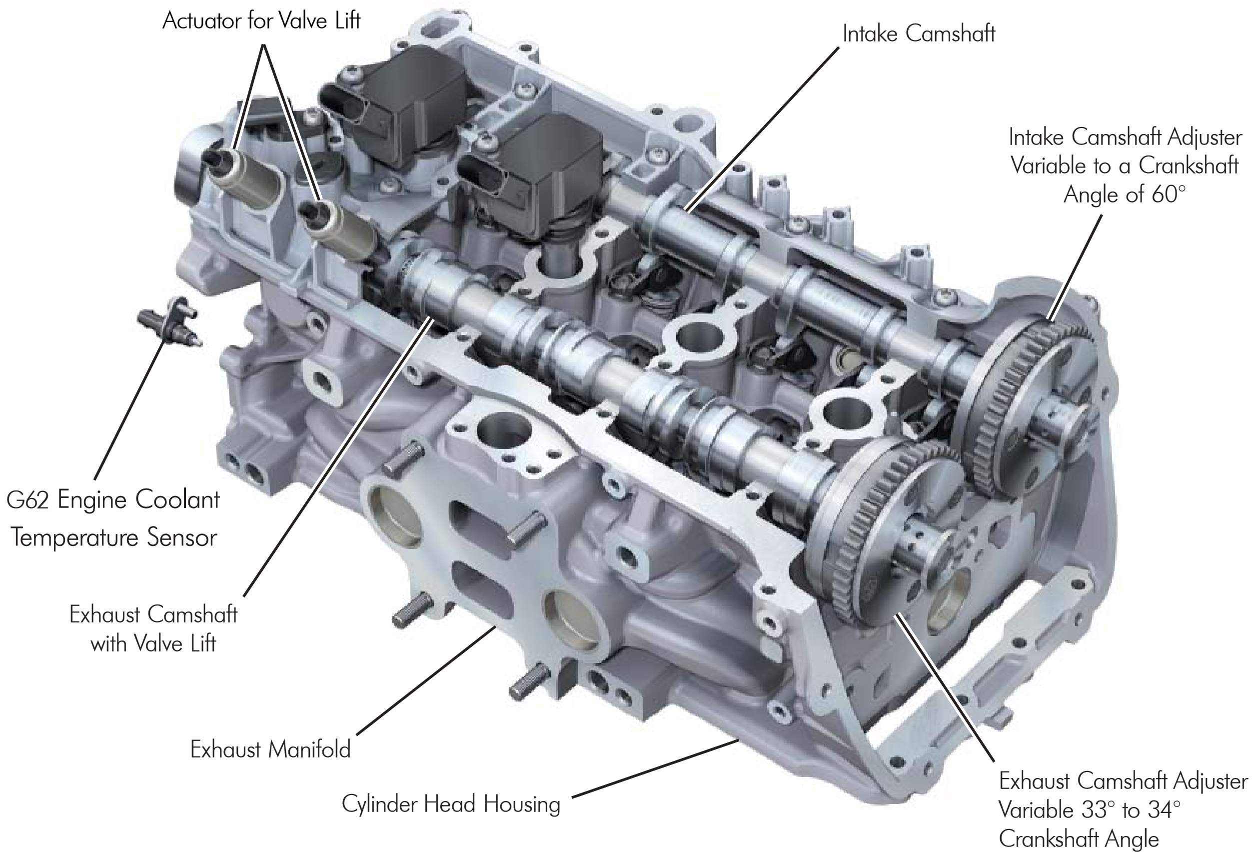
Cylinder Head

The cylinder head for the EA888 engines has been completely redesigned. The exhaust manifold is now integrated into the cylinder head so that the exhaust gas recirculation cooling and the exhaust gas flow takes place inside the cylinder head.

Intake and/or exhaust camshafts may have variable valve timing, depending on the engine version. The exhaust camshaft may also have variable valve lift, which allows the valves to switch between two different camshaft profiles which alter opening and closing height and timing.

G62 Engine Coolant Temperature Sensor is threaded into the cylinder head on the transmission side. This is the hottest spot in the cylinder head, so the sensor can precisely send temperature changes to the ECM and prevent the coolant from boiling.



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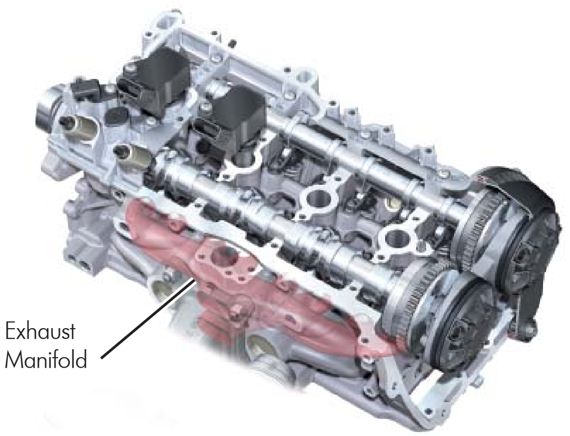
Engine Mechanics

Integrated Exhaust Manifold



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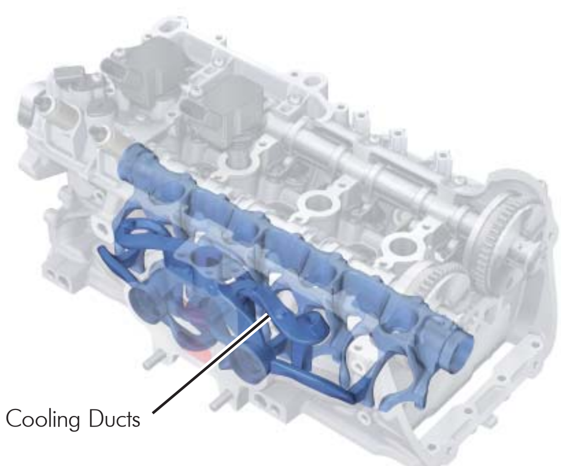
An integrated exhaust manifold significantly reduces the exhaust temperature before it reaches the turbocharger. It also reduces the need to enrich fuel for turbine protection, especially at high RPM. This reduces fuel consumption and CO_2 emissions.

The exhaust channels are arranged so that the exhaust gas flow of one cylinder has no disruptive influence on another cylinder. As a result, all exhaust gas energy can act on the turbine of the turbocharger.



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Another advantage of the integrated exhaust manifold is the faster coolant heating when the engine is cold. This allows the Innovative Thermal Management system to begin operating after a very short warm-up phase.

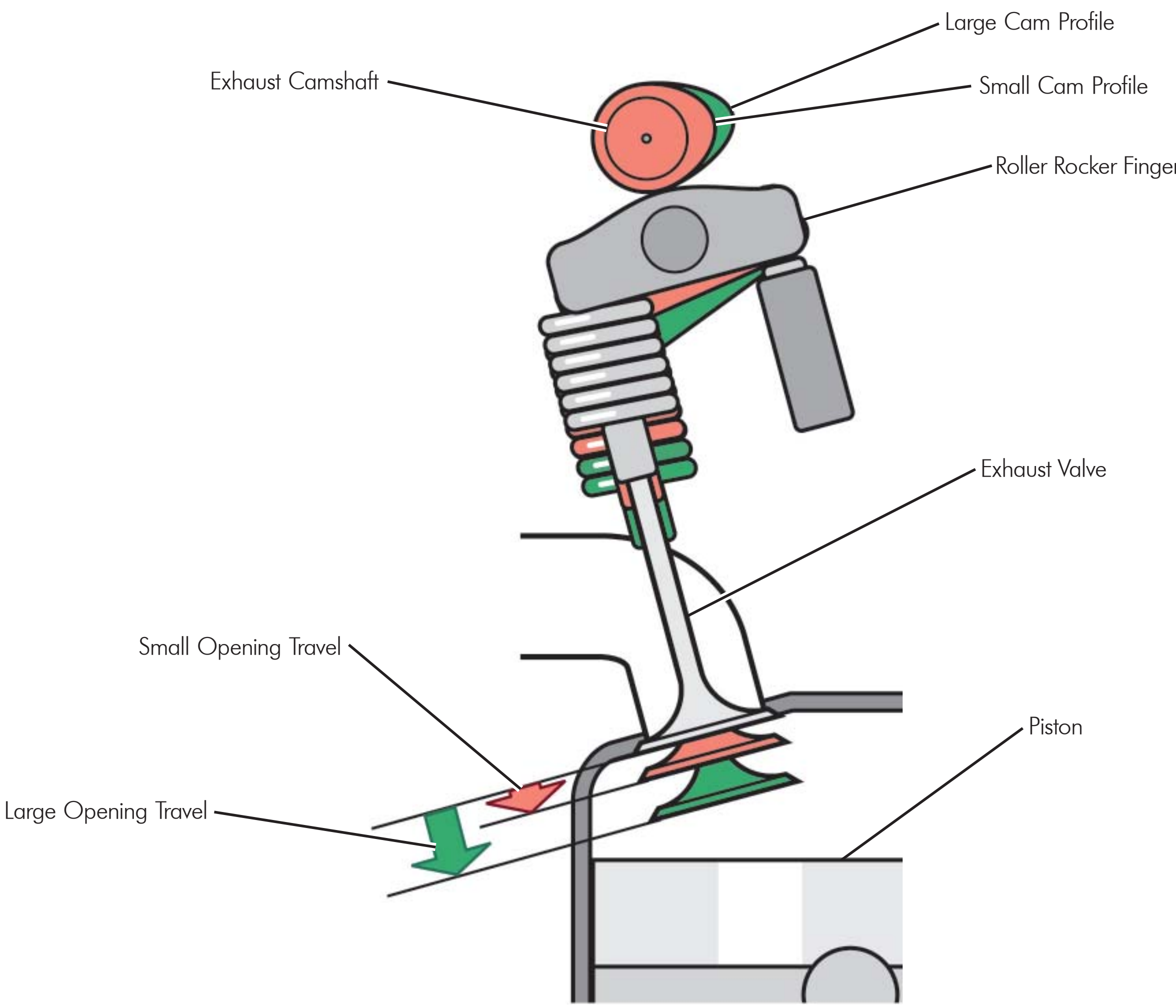
Because the lambda probe is mounted directly behind the integrated exhaust manifold, it reaches the optimal operating temperature faster.

Electrical Valve Lift

Electrical variable valve lift is not used on all EA888 engines. It allows for better exhaust control and is used with the variable valve timing on the intake and exhaust camshafts. The smaller cam profile is only used for low rpm. The switching between camshaft profiles is determined by a map in the ECM.

Variable valve lift:

- Allows for better exhaust gas control
- Prevents exhaust gas pulses from interfering with each other
- Enables better cylinder filling due to earlier intake opening time
- Reduces the residual gases by creating positive pressures in the combustion chamber
- Improves responsiveness
- Achieves a higher torque at lower rpm
- Allows for a higher charge pressure



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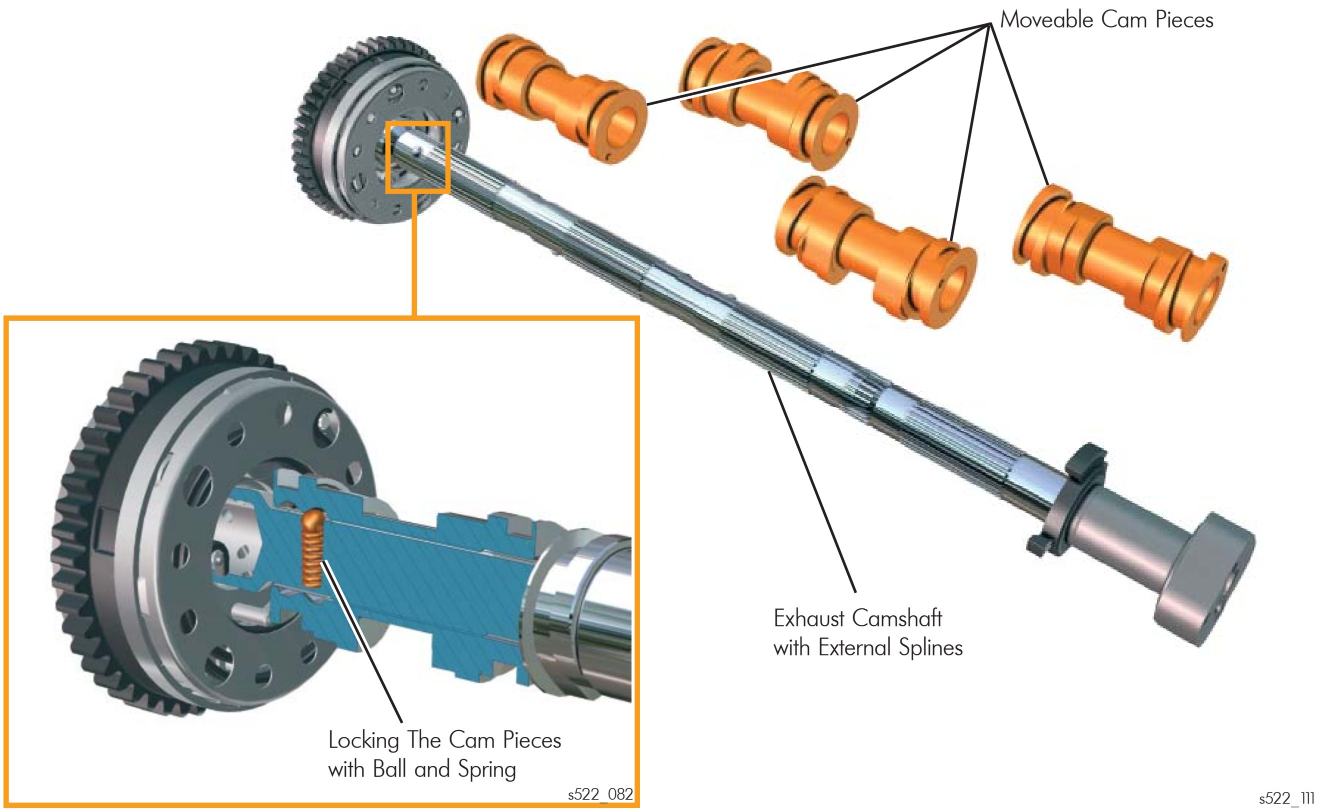
Engine Mechanics

Design

The exhaust camshaft has four moveable cam pieces with internal splines that allow switching between two different valve lifts. Each cam piece has two cam pairs with different lift profiles. Electrical actuators extend a pin into a sliding groove to move the camshaft piece and switch between two levels. There is an actuator to switch to each level for each cylinder.

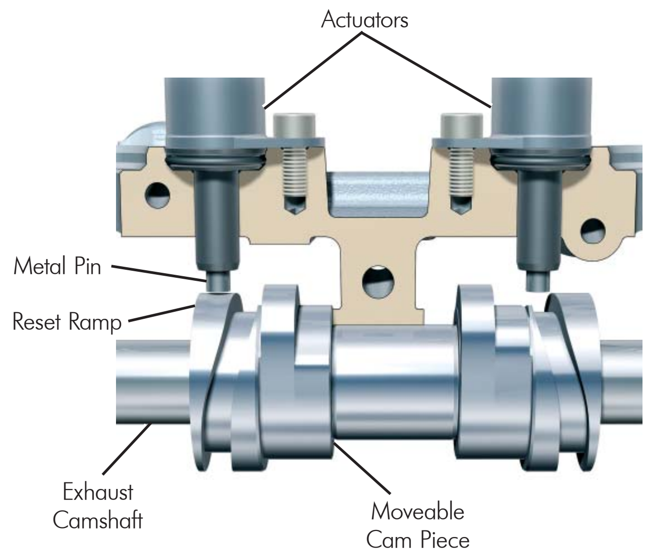
A spring-loaded ball in the camshaft locks the cam pieces in either end position. The sliding of the camshaft pieces is limited by the sliding grooves and the axial bearing. This design also has a narrower camshaft lobe contact surface, requiring the roller rocker fingers to be narrower.



Actuators for Valve Lift Switching

With the help of its two electrical actuators (exhaust cam actuators A/B for cylinders 1–4), each cam piece is pushed back and forth on the exhaust camshaft between its two positions. One actuator per cylinder switches to the larger valve lift; the second actuator switches to the smaller valve lift.

The actuators are activated using switched ground and are controlled by the ECM. The current consumption of the actuators is approximately. 3A.



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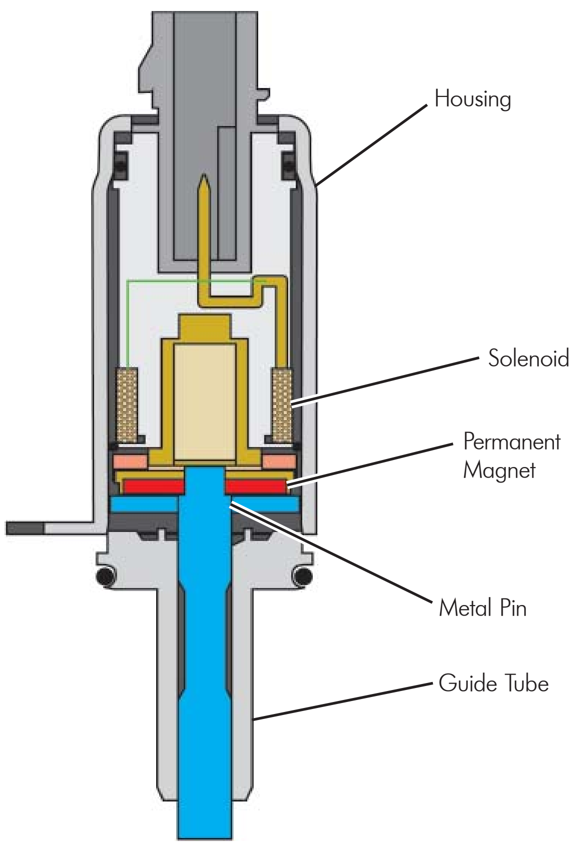
Design

Each actuator (exhaust cam actuators A/B for cylinders 1–4) is a solenoid with a metal pin that moves up and down through a guide tube. The metal pin is held in the extended or retracted position by a permanent magnet.



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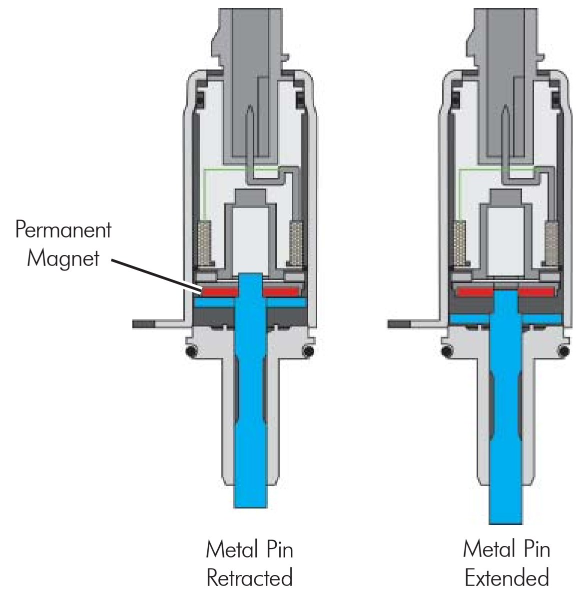
Function

When current is applied to the solenoid of the actuator, the metal pin is moved in 18–22 milliseconds.

The extended metal pin engages the sliding groove of the cam piece on the exhaust camshaft. As the camshaft rotates, the cam piece is moved to the requested position. A sliding groove acts as a reset ramp to mechanically push the pin back into the solenoid.

Only one actuator can operate at a time for a cylinder.



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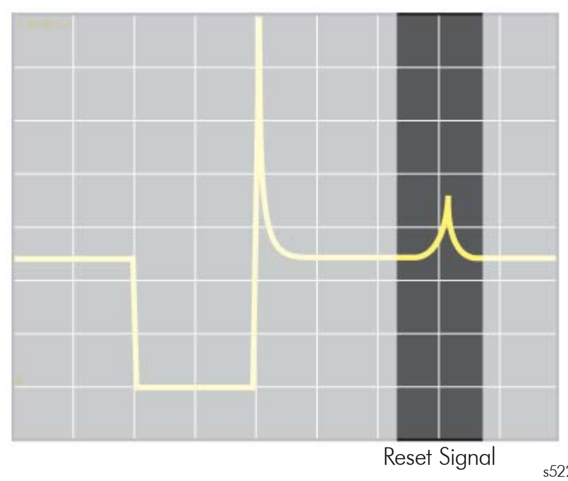
The ECM knows the position of the metal pin based on reset signals. A reset signal occurs when the reset ramp pushes the metal pin of the actuator back into the guide tube of the element.

The ECM can determine the current position of the slide unit based on which actuator delivers reset signals.



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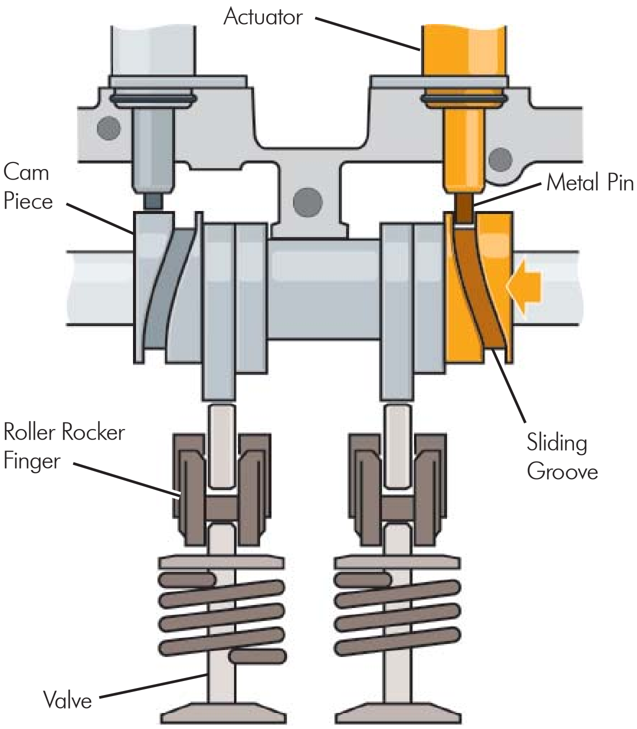
Effects of Failure

If an actuator fails, the valve lift switching function does not operate. In this case, the ECM attempts to switch all cylinders to the most recently successful valve lift position. If this is not successful, all cylinders are switched to the smaller valve lift position. The engine speed is limited to 4,000 rpm and a DTC is set. The EPC warning lamp is illuminated.

If switching to the larger valve lift position is possible, a DTC is still set. The engine speed is not limited and the EPC lamp is not illuminated.



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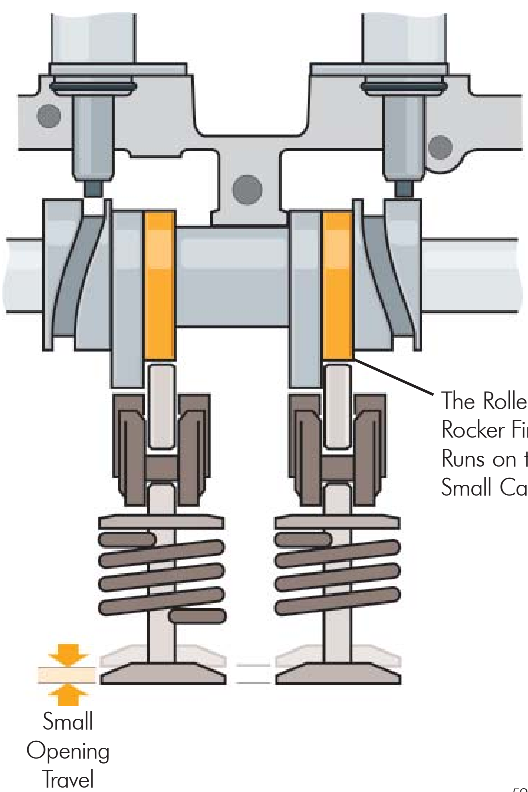
Camshaft Position in the Lower Engine Speed Range

To improve the gas exchange for this load range, the intake camshaft is advanced and the exhaust camshaft is retarded by the ECM using the camshaft adjuster. The Variable Valve Lift uses the right actuator to move to the smaller exhaust cam. The pin engages the sliding groove and moves the cam piece toward the small cam profile.



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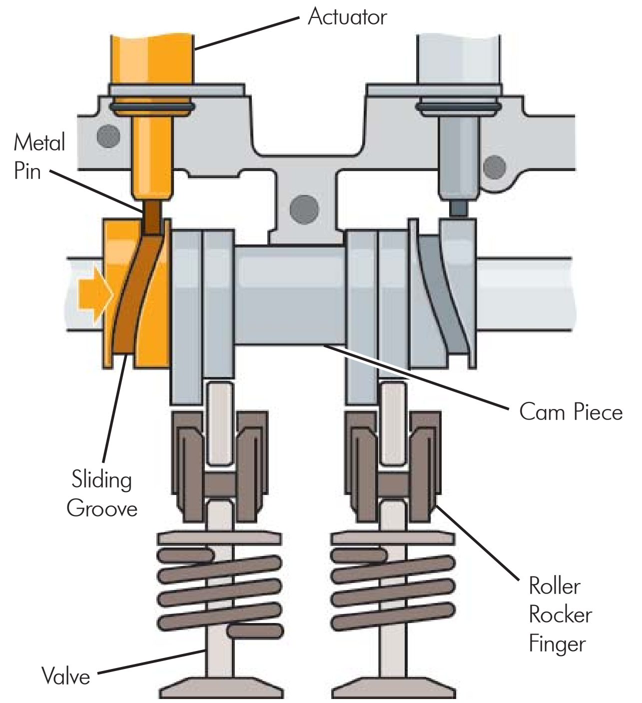
The valves now open and close with the smaller valve profile. The cams are slightly offset to that the opening time of the two exhaust valves of a cylinder are offset. This results in reduced pulsation of the exhaust gas stream, allowing for a higher turbocharger charge pressure.

Camshaft Position in the Partial and Full Load Range

When the driver accelerates from the partial to full load range, the cylinder gas exchange changes for higher performance requirements.

The ECM advances the intake camshaft and retards the exhaust camshaft using the camshaft adjuster.



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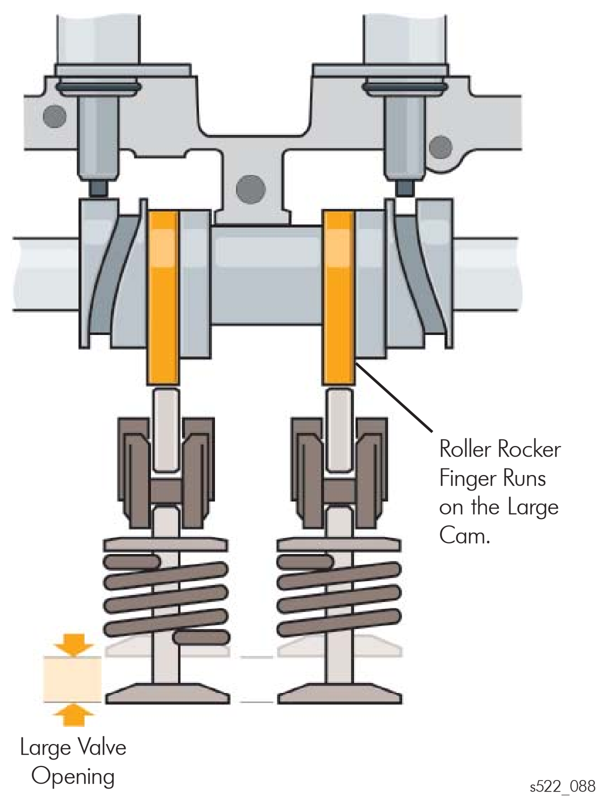
The left actuator is activated. The metal pin engages into the sliding groove to move the cam piece towards the large cam. The exhaust valves open and close with the maximum lift.

The cam pieces are held in this position by a spring-loaded ball in the camshaft.



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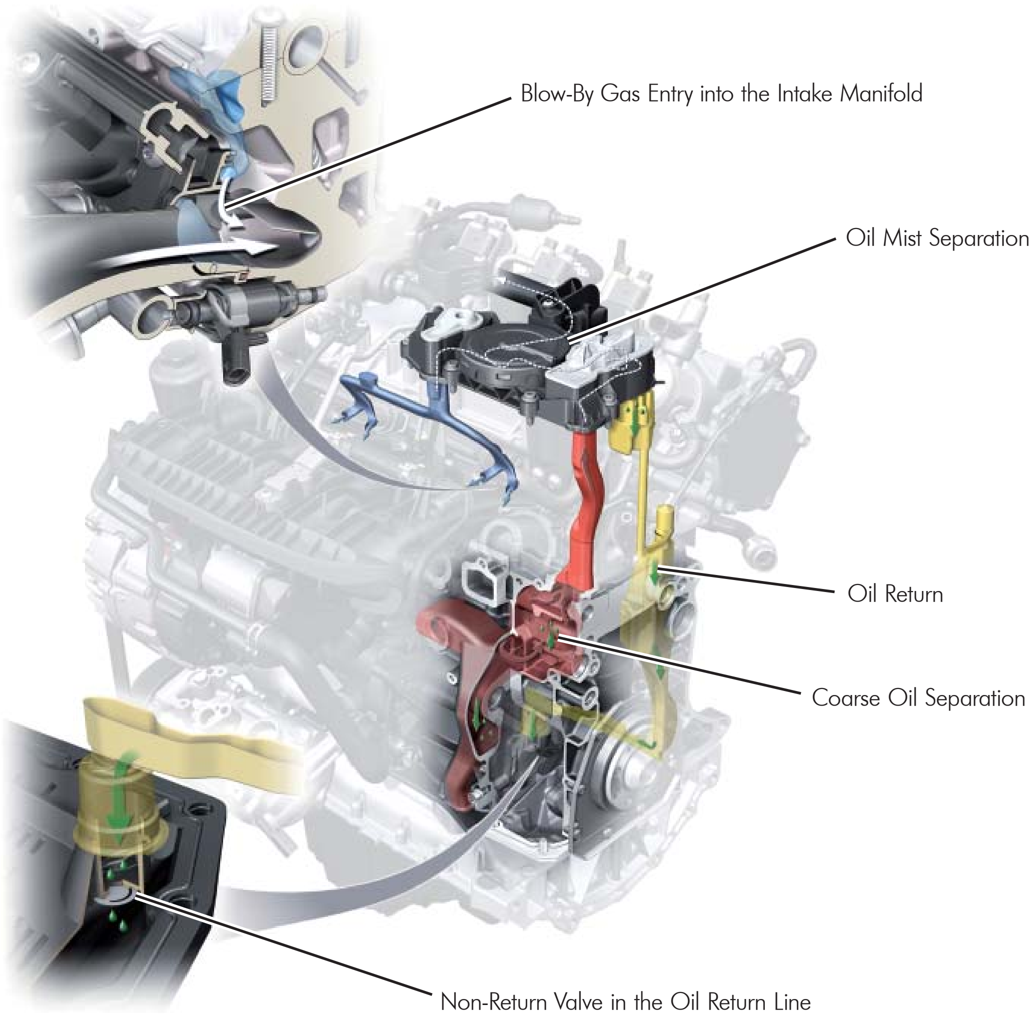
Crankcase Breather and Ventilation System

The crankcase breather and ventilation system of the new EA888 engines has a larger pressure difference that reduces engine oil consumption.

During the engine design, the number of components was reduced by channelling blow-by gases inside the engine as much as possible. Now only one path is used to divert the cleaned blow-by gasses in to the turbocharger.

The crankcase breather and ventilation system consists of:

- The coarse oil separator in the cylinder block
- A fine oil separator attached to the cylinder head cover
- The hose to route cleaned blow-by gasses only to the turbocharger
- The oil return in the cylinder block with non-return valve in the sump's honeycomb insert
- The pressure regulating valve designed for a difference in pressure to the outside air of minus 100 mbar
- The connection of the activated charcoal filter to the fine oil separator



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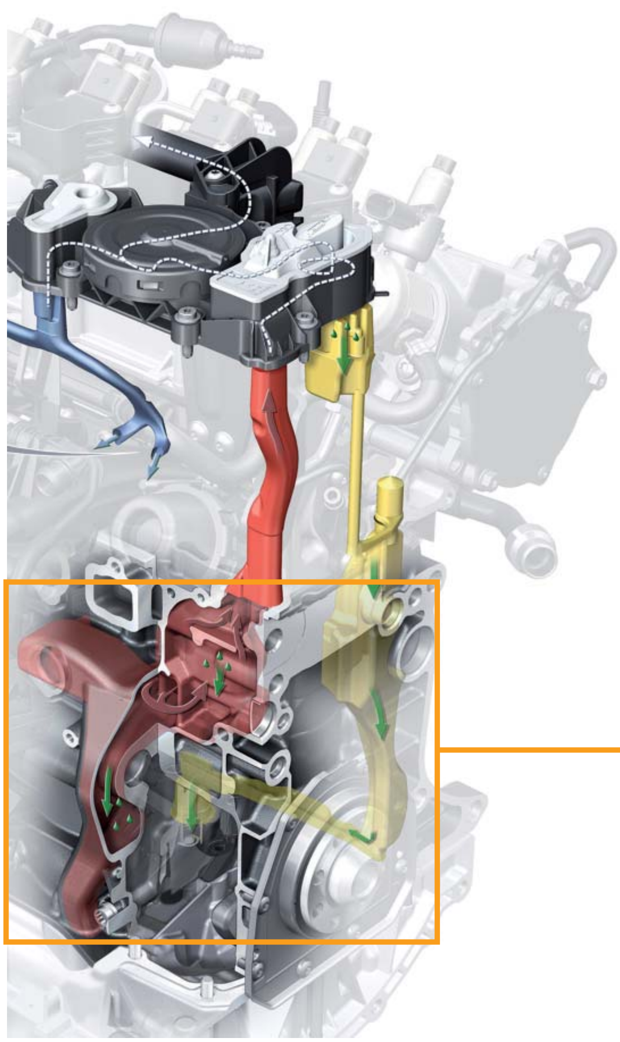
Coarse Oil Separator

The coarse oil separator is part of the cylinder block. The blow-by gasses are routed through the coarse oil separator with several directional changes. Large drops of oil are separated by baffle plates in the coarse oil separator and move back to the sump through a return channel. The roughly cleaned blow-by gasses are directed through cylinder block and cylinder head passages to the fine oil separator.



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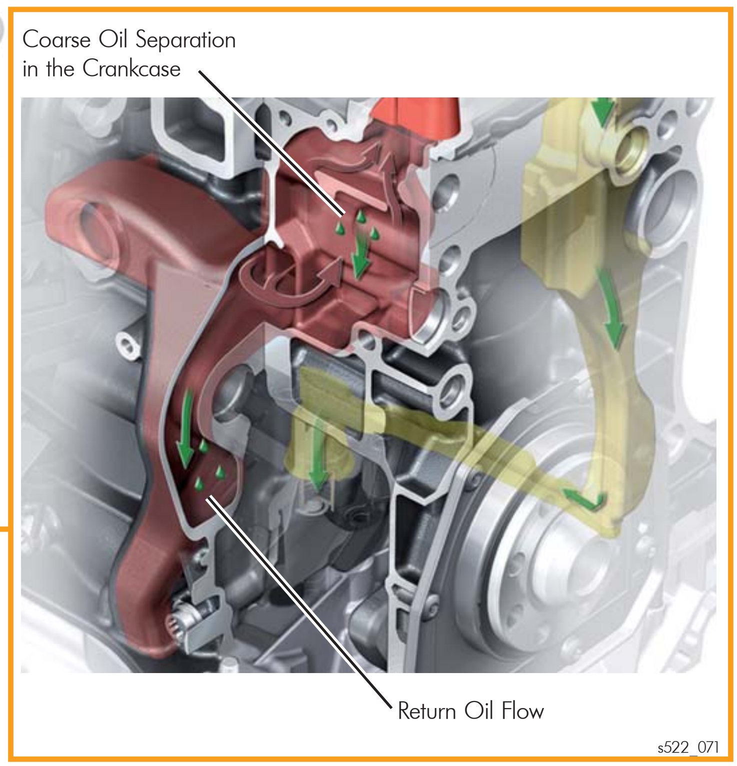

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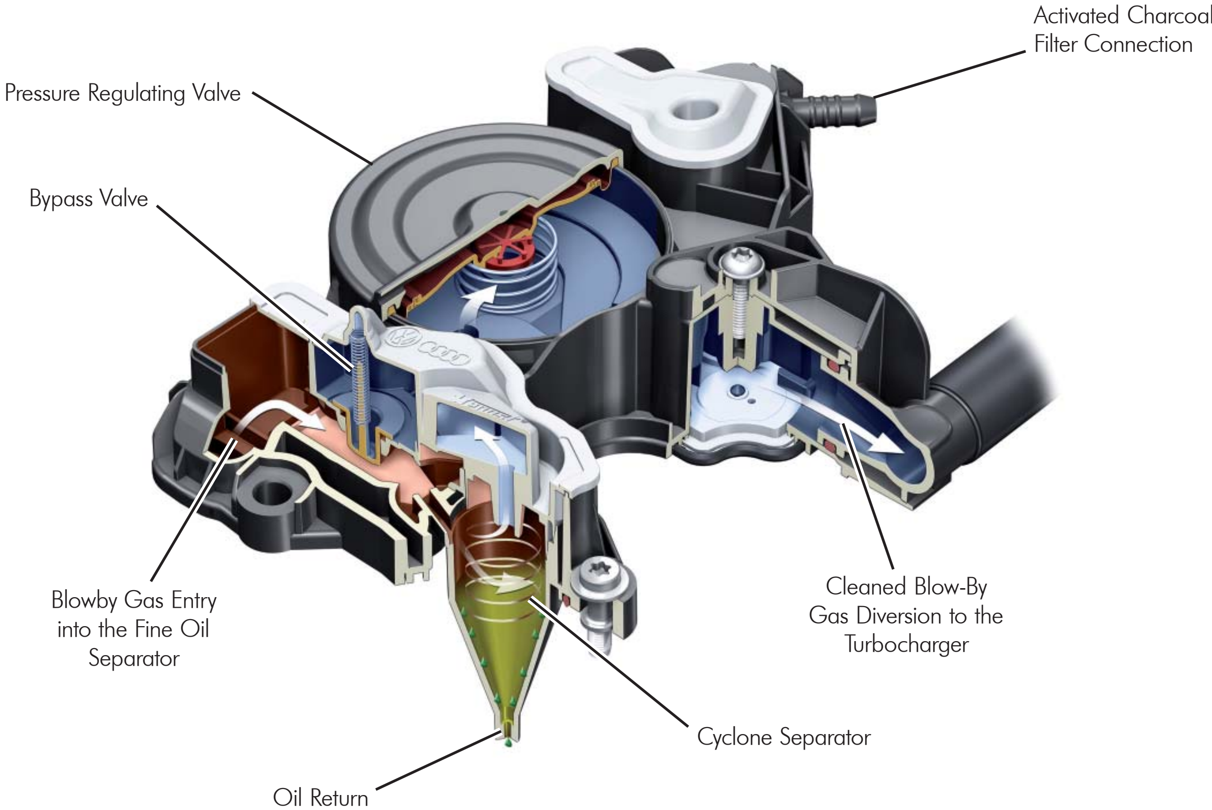
Fine Oil Separation

The gases are routed through passages to the fine oil separator on the cylinder head cover. The first stage of the fine oil separator is a bypass valve. If either the engine speeds are high or the blow-by gas stream has too high of a pressure, the bypass valve opens mechanically to prevent seal damage.

The blow-by gasses rotate at up to 16,000 rpm in the cyclone separator. This removes even the smallest oil droplets. The oil is routed back to the oil pan through a return flow channel in the cylinder block. A non-return valve is located at the end of the return flow channel. It prevents oil from being sucked back into the oil separator during unfavorable pressure conditions, rapid acceleration or strong lateral acceleration.

The cleaned blow-by gasses are directed through a one-stage pressure regulating valve. The pressure regulating valve is designed for a pressure differential to the outside air of minus 100 mbar. Depending on the prevailing pressure conditions in the charge air system, the cleaned blow-by gasses enter the intake manifold (suction mode) or the turbocharger (charging operation).



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Oil Circuit

Oil Supply

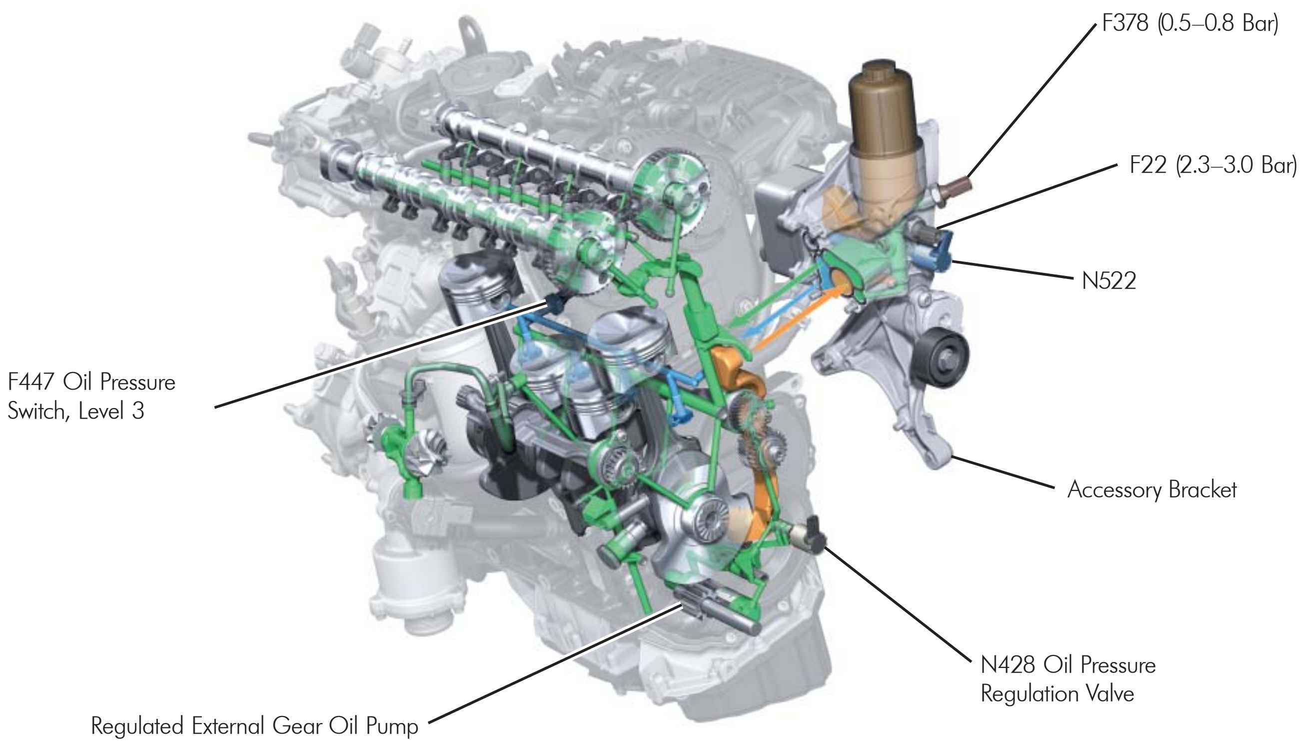
The oil system was designed to:

- Have two stage oil pressure control
- Reduce the oil pump speed
- Expand the rpm range in the low pressure stage
- Reduce the oil pressure in the low pressure stage
- Use electrically switching piston cooling jets
- Integrate the oil filter and cooler into the accessory bracket

Accessory Bracket

In addition to the oil cooler and oil filter, the following components are located on the accessory bracket:

- F22 Oil Pressure Switch
- F378 Reduced Oil Pressure Switch
- N522 Piston Cooling Nozzle Control Valve
- Automatic tensioning roller for the accessory poly V-belt



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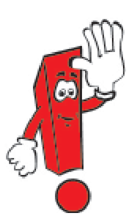


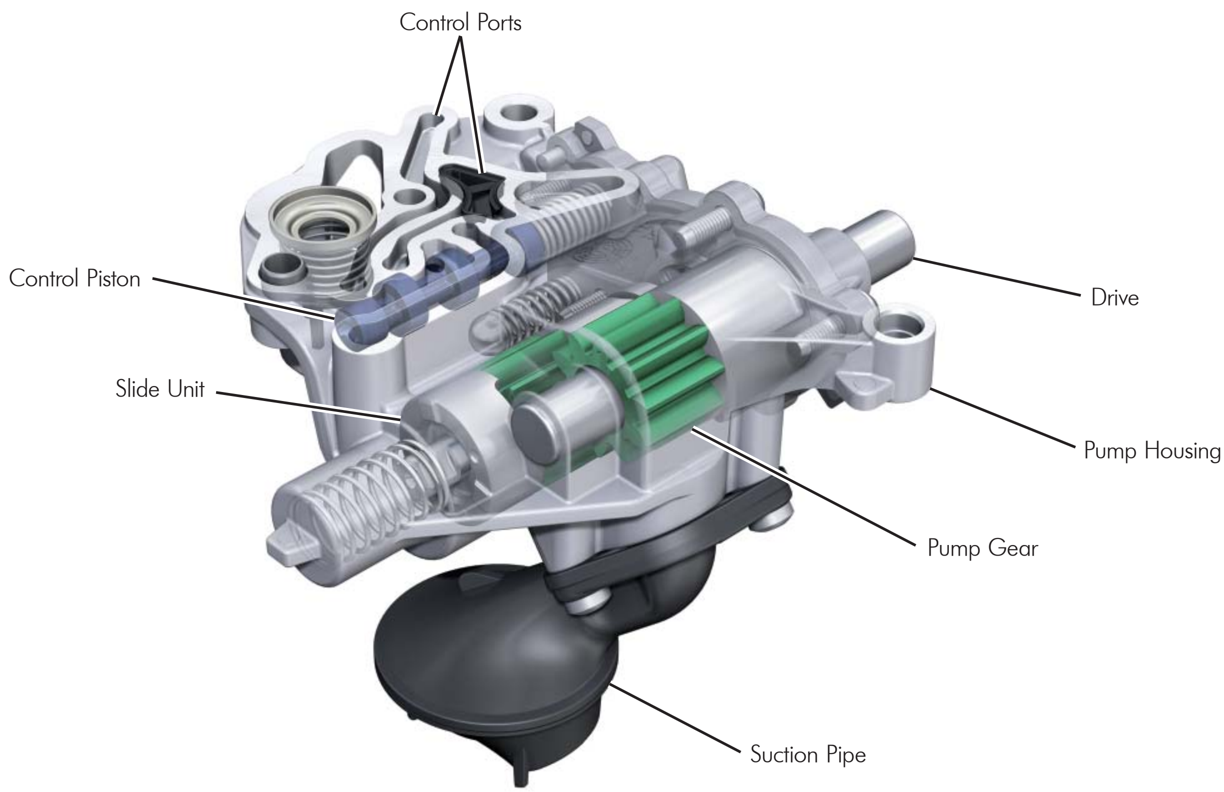
Oil pressure switches F22, F378 and F447 must be replaced when they are removed.

Two-Stage Oil Pump

Compared to the oil pump on the previous engine, the ratio of the pump drive has been reduced so that the pump runs slower. It is still driven by a chain connected to the crankshaft.

A slide unit inside the two-stage external gear oil pump enables two pump gears to move longitudinally against each other for two-stage pump power control. If the two gears are completely meshed, the pump works at maximum power. If the two gears are not completely meshed, the pump works with less power. The slide unit is moved by a control piston and control ports inside the oil pump.

The control piston directs the regulated oil flow to the left or right side of the slide unit, which then moves sideways according to the oil pressure. The control piston is actuated by the N428 Oil Pressure Regulation Valve. The switch from the low to the high supply stage is determined by the load and/or rpm. Below this threshold, the pump works at a pressure of 1.5 bar. When a speed of 4,500 rpm is reached, the pump produces 3.75 bar oil pressure.



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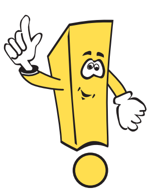


The oil pump is almost identical to the oil pump of the EA211 engine family. A detailed description of the design and functionality of the two-stage oil pump is found in SSP 820333, "The 1.4L EA211."

The two-stage oil pump is not used on all versions of the EA888 engines.

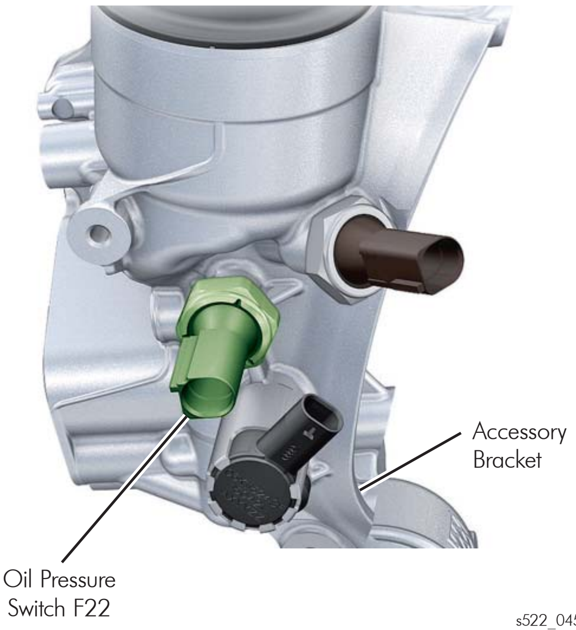
Electrical Components for Oil Pressure Control

F22 Oil Pressure Switch

F22 Oil Pressure Switch is screwed into the accessory bracket below the oil filter.

Signal Use and Task
The ECM uses this sensor to determine if oil pump is working in the high oil pressure stage.

Effects of Failure
If the oil pressure switch fails, the ECM creates a DTC and the oil warning lamp illuminates.



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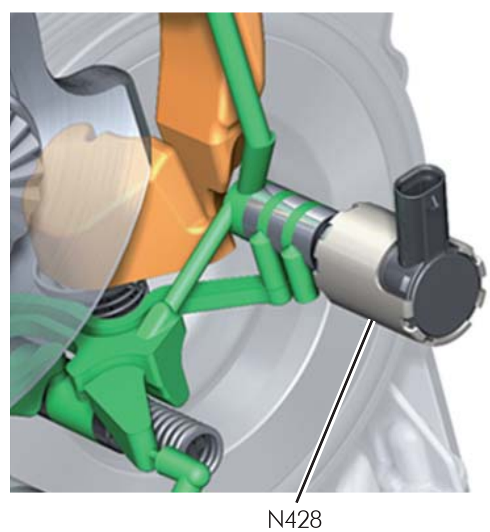
N428 Oil Pressure Regulation Valve

The solenoid valve is bolted into the front edge of the cylinder block and below the accessory bracket.

Task and Function
The ECM engages the solenoid valve to switch between low and high oil pressure stages. When activated, the solenoid valve moves and oil flows through the control valve ports. This oil acts on the control piston, moving the slide unit and changing the pump pressure characteristics.

Effects of Failure
The de-energized position of the valve is closed. The oil pump delivers high pressure.



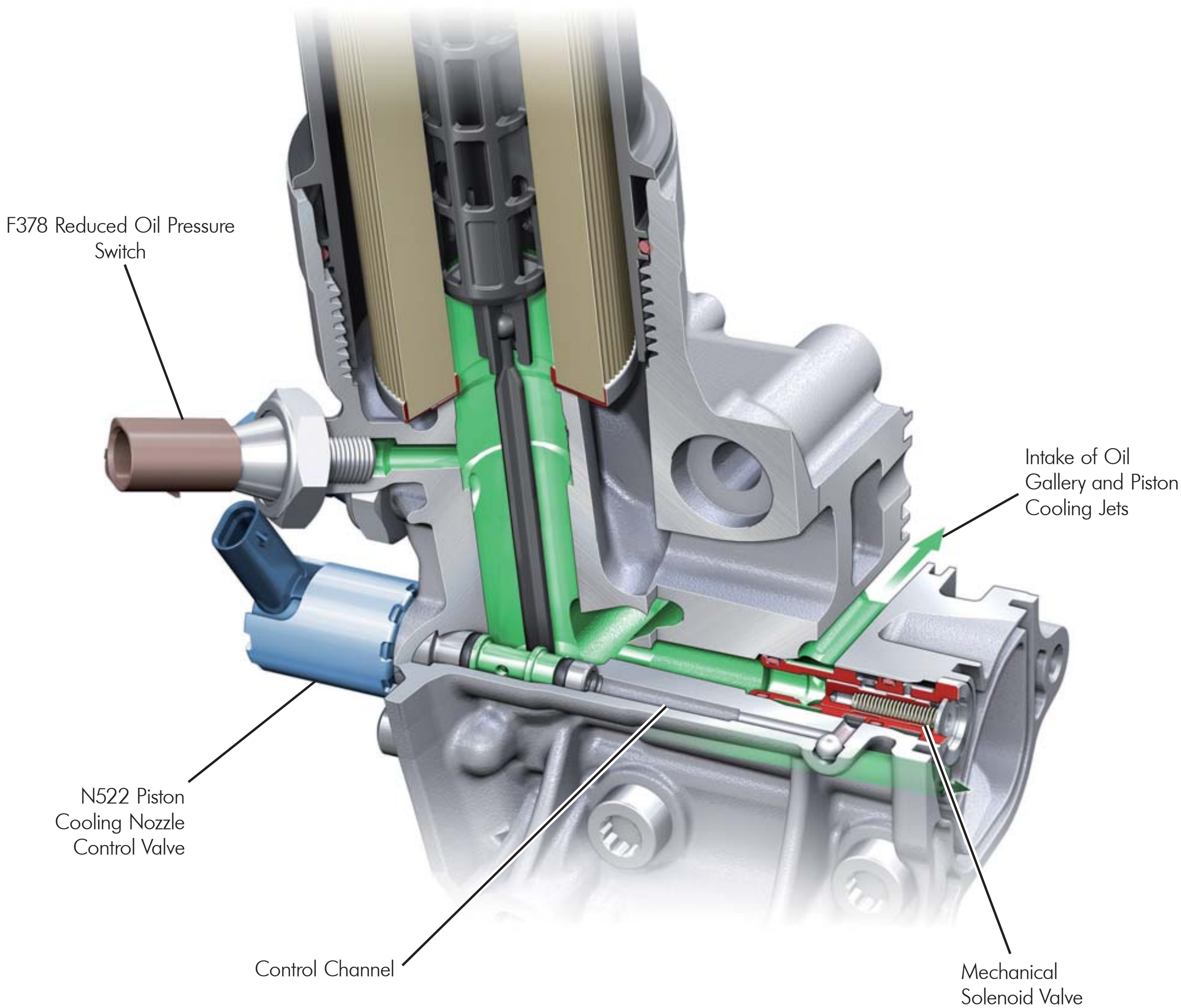
s522_048

Switchable Piston Cooling Jets

Cooling the piston crowns is not necessary during every operating range of the engine, so the piston cooling jets are now switchable. The control valve and the solenoid valve are built into the accessory bracket and are connected by a control port. The N522 Piston Cooling Nozzle Control Valve is actuated by a map. A mechanical solenoid valve opens when the oil pressure exceeds 0.9 bar.

The piston cooling jets can be activated in either the high or low pressure stage of the oil circuit. An additional oil pressure switch (F447 Oil Pressure Switch, Level 3) detects the oil pressure in the additional oil gallery and monitors the functioning of the piston cooling. The oil pressure switch closes at an oil pressure of 0.3–0.6 bar.

The switchable piston cooling jets are not used on all versions of the EA888 engine.



s522_021

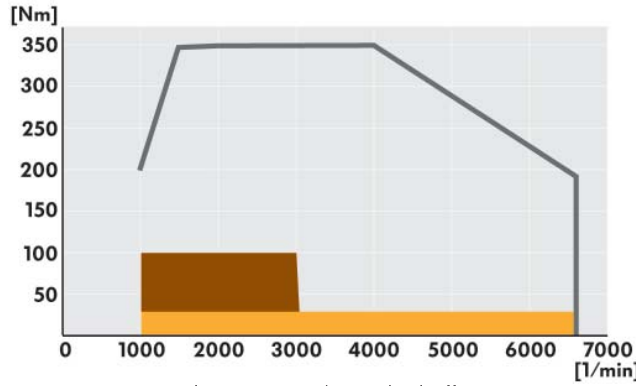
Oil Circuit

Control Strategy

The ECM uses a map to determine when to actuate the control valve. This map uses the variables of engine torque, the engine speed and the oil temperature.

- For an oil temperature below 50°C, the piston cooling jets remain off in a map range of 1,000–6,600 rpm and a load of approx. 30Nm.
- For an oil temperature above 50°C, the piston cooling jets remain off in a speed range of 1,000–3,000 rpm and a load range of 30–100Nm.

The piston cooling jets are on during all other ranges of the map.



s522_113

Function Monitoring

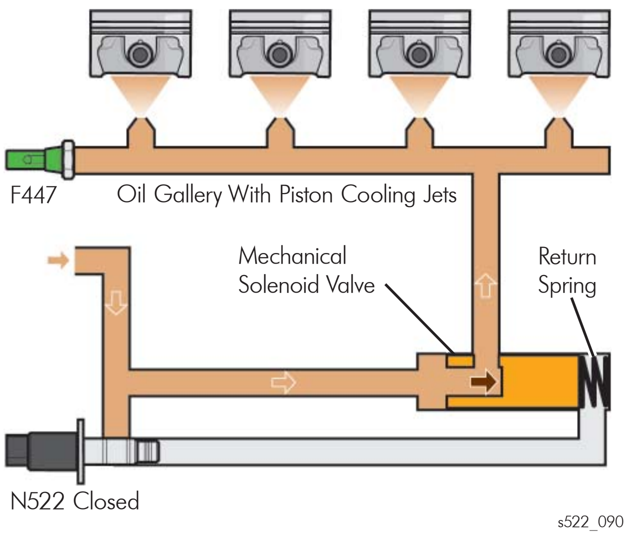
The cooling of the pistons can be monitored using the F447 Oil Pressure Switch, Level 3 and the diagnostic capability of N522 Piston Cooling Nozzle Control Valve.

The following faults can be identified:

- No oil pressure on the piston cooling jets when requested to activate
- F447 defective
- Oil pressure present despite the piston cooling jets being deactivated
- Disconnected = piston cooling jets always on
- Short circuit to ground = piston cooling jets off
- Short circuit to positive = piston cooling jets on

If piston cooling is not present:

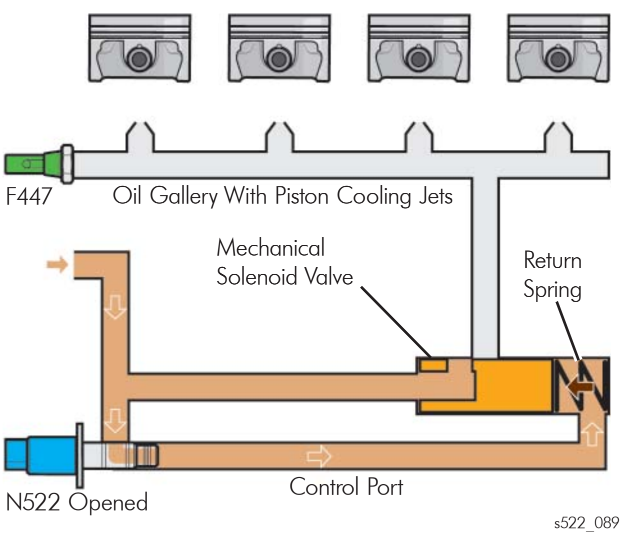
- Torque and speed is limited
- The oil system remains at high pressure
- The EPC lamp in the instrument cluster illuminates
- The MFD displays a message that engine speed is limited to 4,000 rpm



Piston Cooling Jets On

N522 Piston Cooling Nozzle Control Valve control valve is closed in its de-energized state which also closes the control port between control valve and solenoid valve. As a result, the solenoid valve has oil pressure applied only on one side and continues to move against a return spring until the channel to the piston cooling jets is open. The oil flows from the solenoid valve to the additional oil gallery and from there to the piston cooling jets. This activates the jets.

Based on the signal from F447 Oil Pressure Switch, Level 3, the ECM determines that the piston cooling jets are activated.



Piston Cooling Jets Off

The ECM actuates N522 to turn off the piston cooling jets.

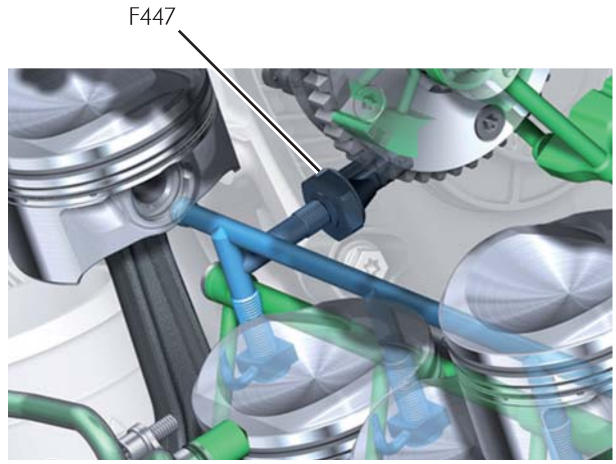
When activated, N522 opens the control port to the solenoid valve. The solenoid valve now has oil pressure applied from both sides. The force of the return spring is greater and the solenoid valve is pushed back. The connecting pipe to the oil gallery is blocked and the piston cooling jets are turned off.

Based on the signal from F447, the ECM determines that the piston cooling jets are deactivated.

Electrical Components for Piston Cooling

F447 Oil Pressure Switch, Level 3

F447 is screwed into the engine block below the intake manifold.



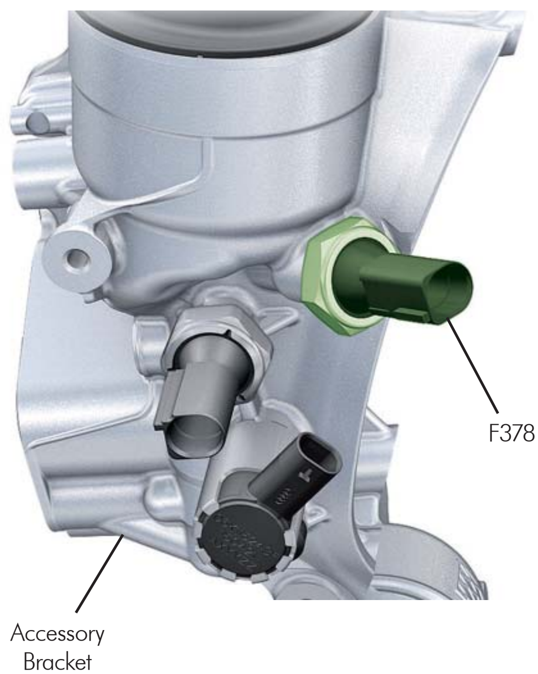
s522_046

Signal Use and Task
This oil pressure switch monitors the oil pressure in the oil gallery. If piston cooling is active and F447 does not detect pressure, the ECM sets a DTC.

Effects of Failure
The ECM can run diagnostics on the oil pressure switch. If no signal is present, piston cooling remains activated.

F378 Reduced Oil Pressure Switch

This oil pressure switch is screwed into the accessory bracket below the oil filter.



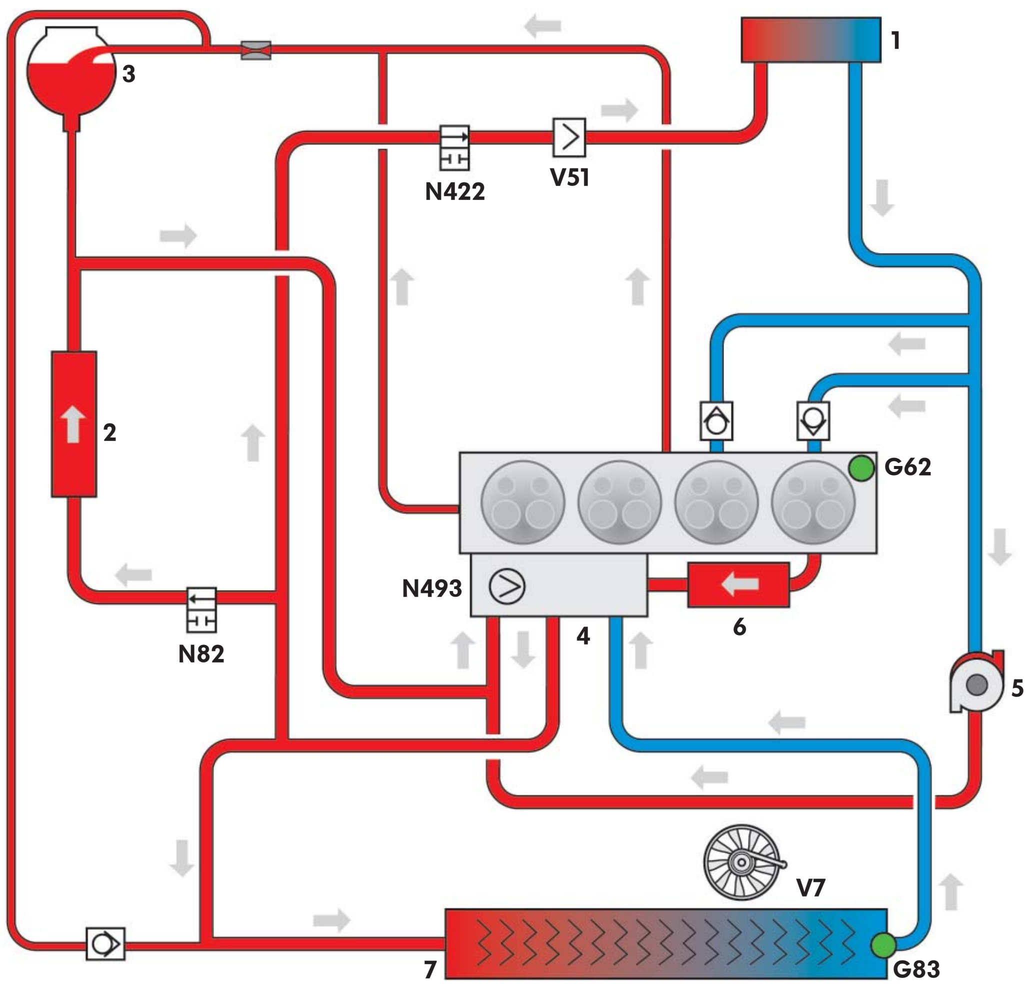
s522_127

Signal Use and Task
The ECM monitors the switch for reduced oil pressure to determine if the two-stage oil pump is operating correctly.

Effects of Failure
If the oil pressure switch fails, the ECM sets a DTC and the oil warning lamp illuminates. The oil pump runs only in the high pressure stage.

Cooling System

This is a basic illustration of an innovative thermal management system and may not display all available features. However, the cylinder head exhaust manifold and new rotary valve module are included.



s522_022

Legend

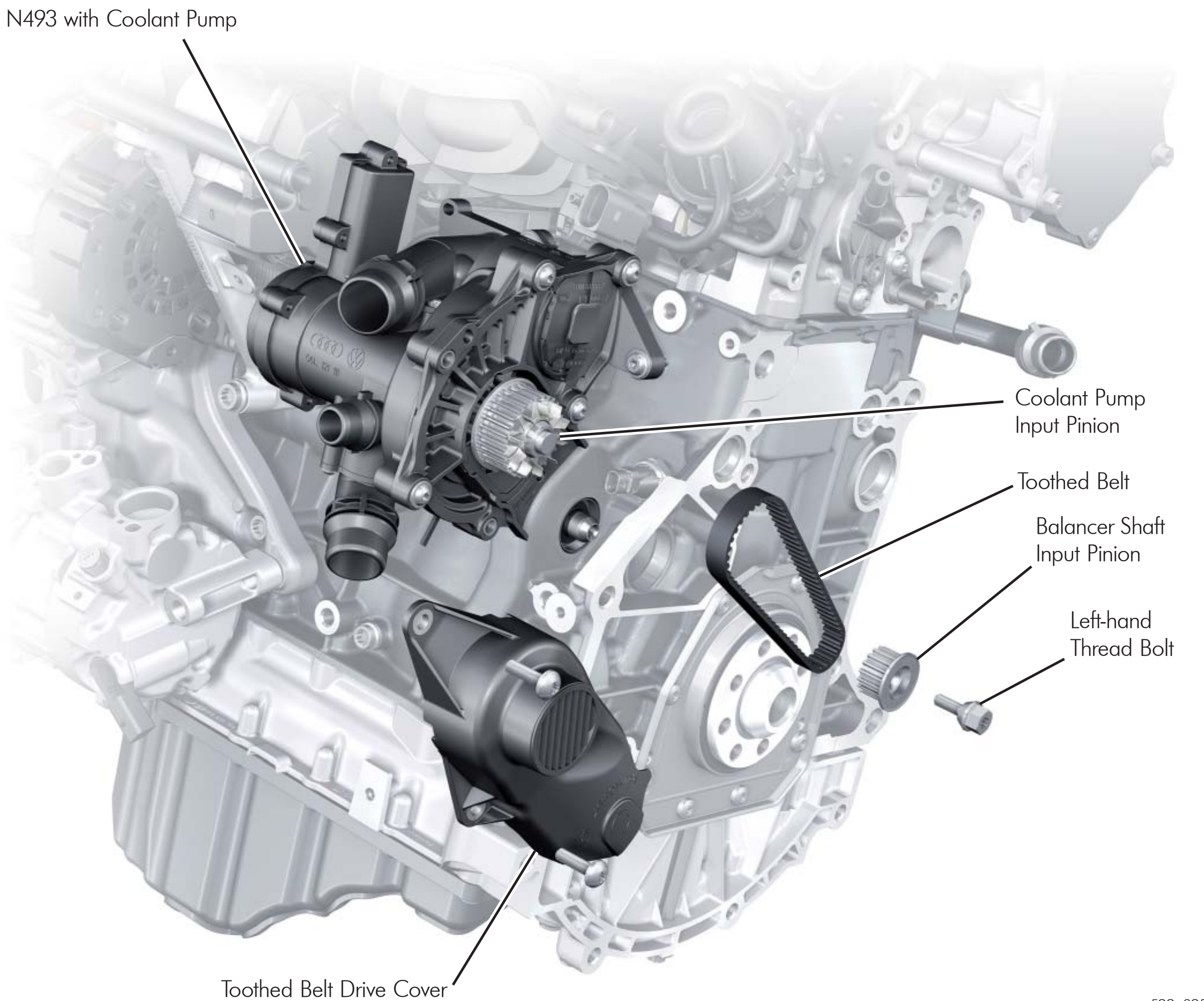
G62 Engine Coolant Temperature Sensor
G83 Engine Coolant Temperature Sensor on Radiator Outlet
N82 Coolant Shut-Off Valve
N422 Climatronic Refrigerant Shut-Off Valve
N493 Engine Temperature Control Actuator
V7 Coolant Fan
V51 After-Run Coolant Pump

1 Heat Exchanger for Heater
2 Gear Oil Cooler (Optional)
3 Coolant Expansion Tank
4 Rotary Valve Module with Coolant Pump
5 Turbocharger
6 Engine Oil Cooler
7 Main Water Cooler

Cooling System

Innovative Thermal Management

The Innovative Thermal Management system (ITM) is an intelligent cold start and warm-up program for the engine and transmission. It provides targeted control of the coolant stream. The main control element is the N493 Engine Temperature Control Actuator (rotary valve module). It is attached to the engine block on the intake side below the cylinder head.



s522_025

Engine Temperature Regulation Actuator (Rotary Valve Module)

Includes:

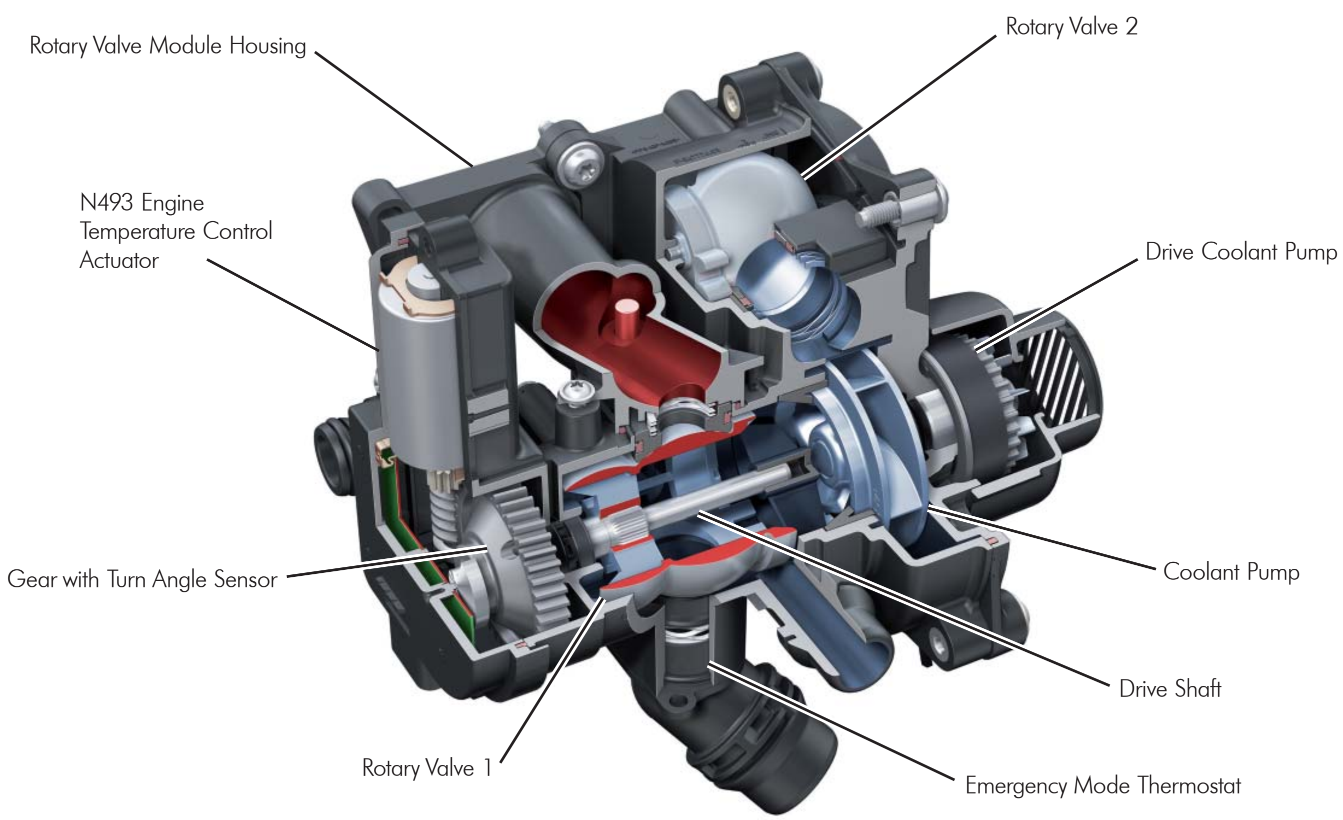
- Coolant pump
- Two rotary valves
- Thermostat
- N493 Engine Temperature Control Actuator for controlling the coolant streams
- Gear with angle sensor
- Coolant pump driven by a toothed belt from the balance shaft

Design

The two internal rotary elements are electrically actuated by N493. Rotary valve 1 is directly driven by N493 by a shaft. Rotary valve 2 is moved by a toothed gate on rotary valve 1 through an intermediate gear. Rotary valves 1 and 2 are mechanically coupled and move relative to each other.

An additional thermostat with expansion element serves as a safety device (emergency thermostat) and opens at 113°C in the event of a failure.

Not all versions of the EA888 engine have the rotary valve module.



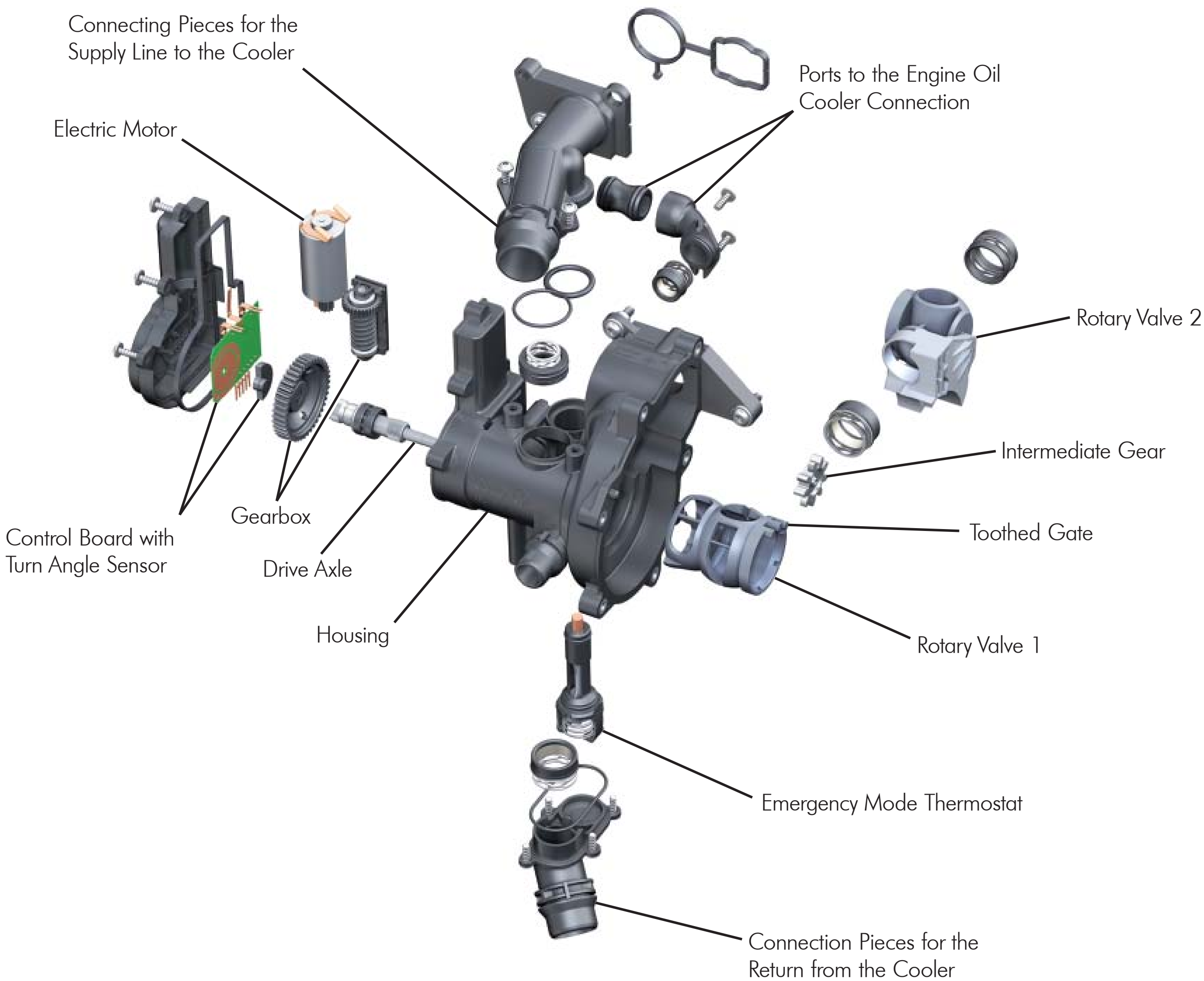
s522_024

Functional Principle

Rotary valve 1 is driven from the electric motor by a gear. It controls the coolant flow between oil cooler, engine and main water cooler. As the engine temperature increases, rotary valve 1 rotates farther.

Rotary valve 1 drives rotary valve 2 using a toothed gate and an intermediate gear.

A Hall sensor on the control board sends the rotary valve positions to the ECM. After the engine is turned off and the run-on finishes, the rotary valve positions itself at a 40° angle. If there is a fault in the system, the engine can run using this angle and the emergency thermostat. If there is no fault and the engine is started, the rotary valve is moved to a 160° angle.



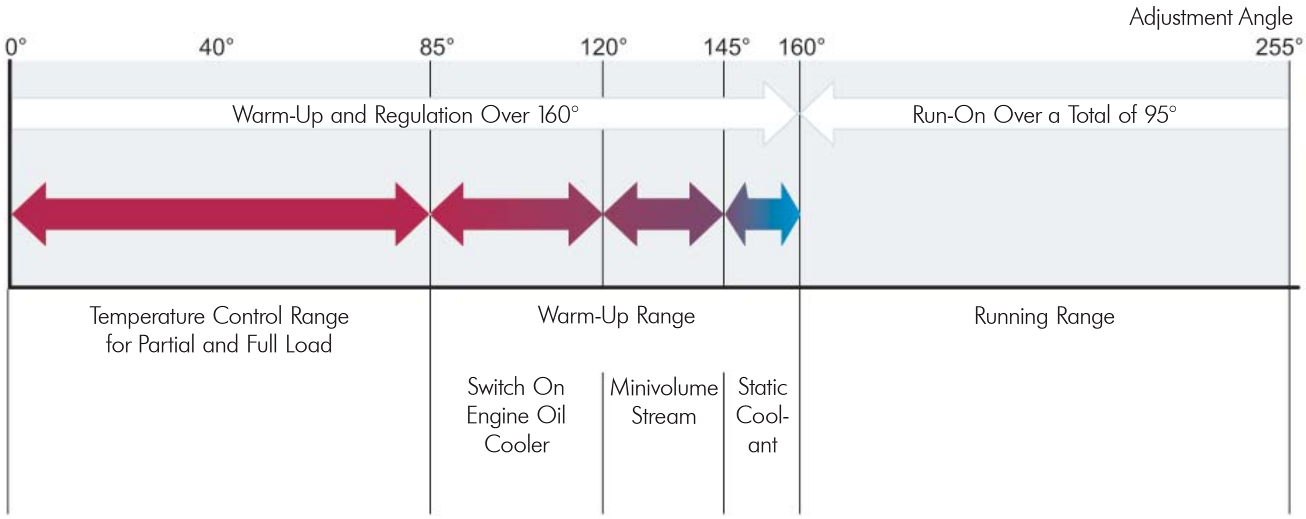
s522_091

The ECM moves the actuator using maps. Different positions are possible that enable either a fast warm-up phase or keeping the engine temperature between 86°C and 107°C. There are three basic control ranges:

1. Warm-up range
2. Temperature control range
3. Running range

The toothed gate on rotary valve 1 engages rotary valve 2 when it is at a 145° angle. This opens the coolant stream to the cylinder block. This stream increases as rotary valve 2 rotates.

When rotary valve 1 reaches an angle of 85°, rotary valve 2 has reached its maximum angle of rotation and decouples. At this point, the coolant stream to the cylinder block is fully opened.



s522_107

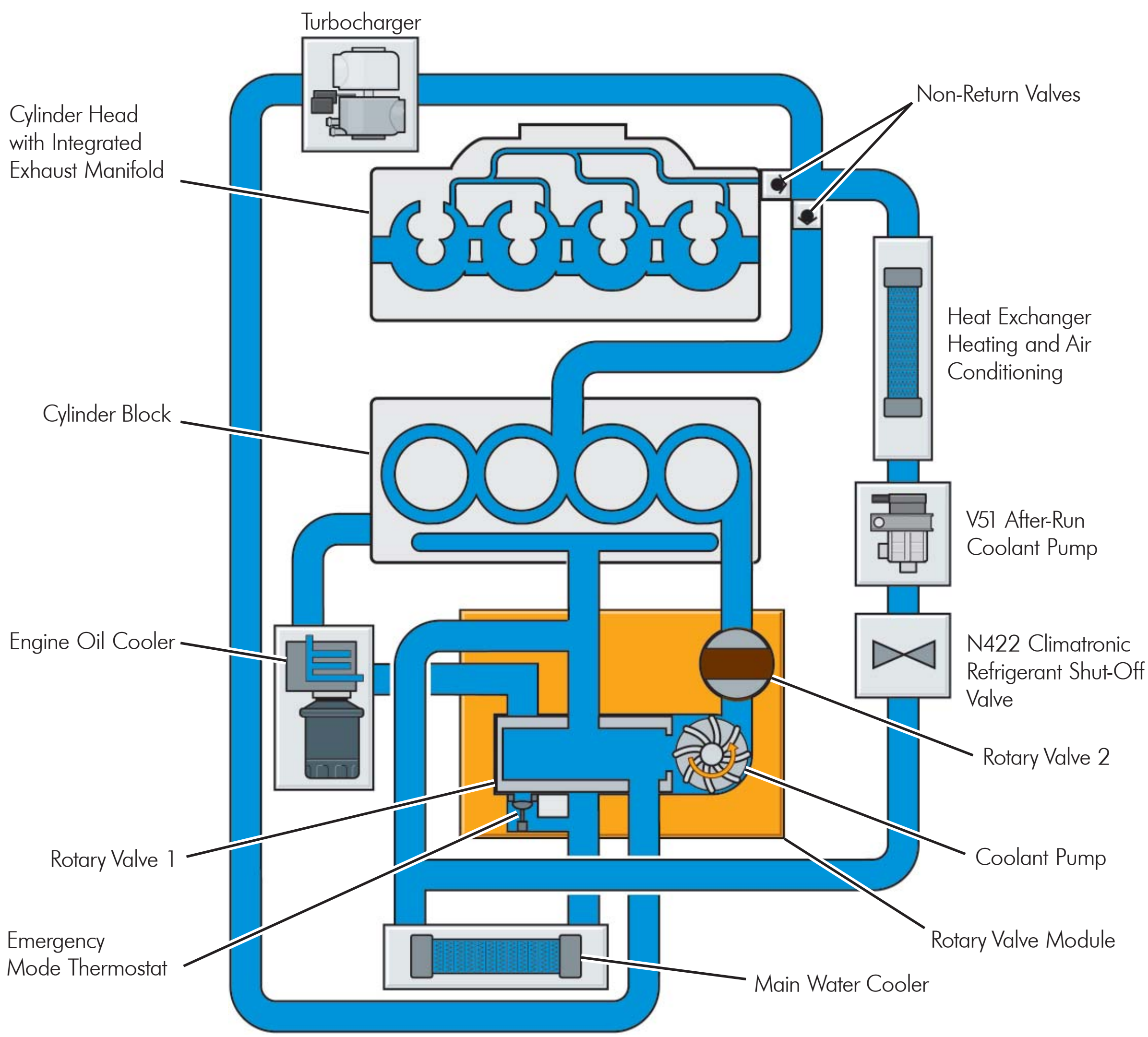
The following pages provide simplified operation for the different stages of regulation. A highly simplified representation of the rotary valve module and the coolant circuit is used.

Regulation Sequence

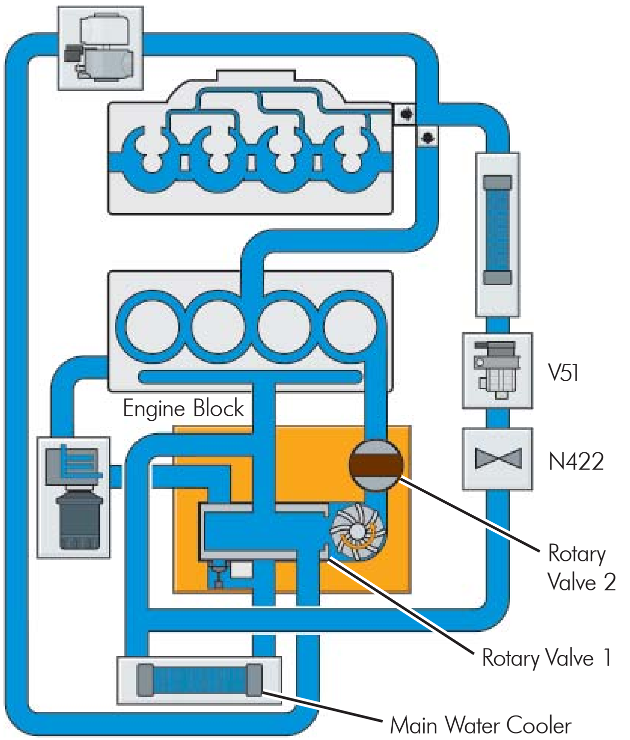
During warm-up, the engine runs through three phases:

1. Static coolant
2. Mini-volume stream
3. Turn on engine oil cooler

The phases have different rotary valve positions, but merge seamlessly into each other. The design is to heat the engine as quickly as possible. However, heat is routed to the vehicle interior during the "static coolant" phase if requested.



s522_092



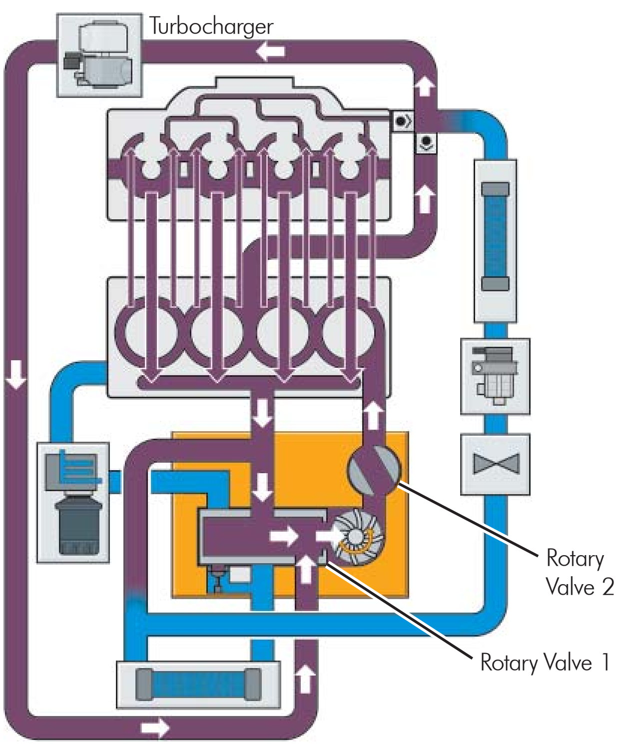
s522_092

Warm-Up with Static Coolant

Rotary valve 2 is closed to keep the combustion heat in the engine. This stops coolant from flowing into the engine block. Rotary valve 1 blocks the return from the engine oil cooler and the return from the main water cooler.

N422 Climatronic Refrigerant Shut-Off Valve stops flow to the heating and air conditioning system.

The electric V51 After-Run Coolant Pump is off.



s522_093

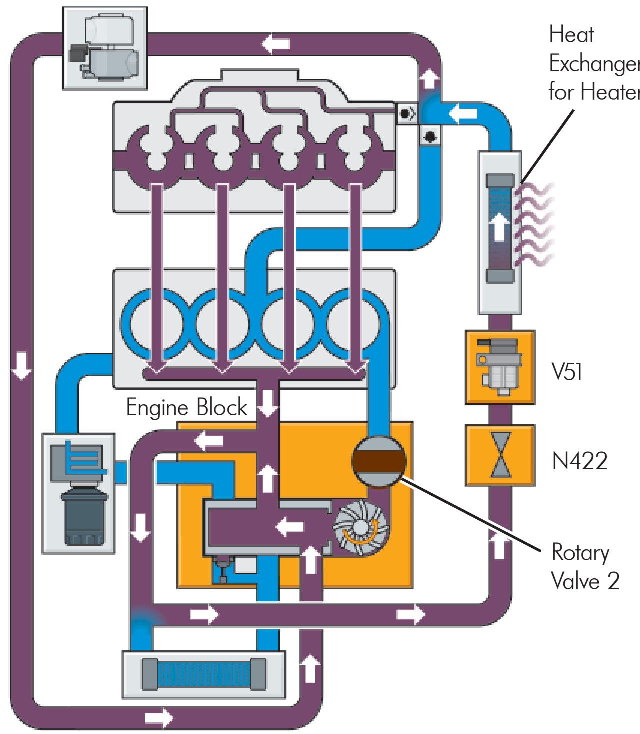
Warm-Up with Mini-Volume Stream

This control phase in the warm-up range prevents the cylinder head and the turbocharger from overheating. When rotary valve 1 reaches 145°, rotary valve 2 engages and slightly opens the coolant stream to the cylinder block. A small coolant stream flows through the cylinder block, the cylinder head and turbocharger back to the rotary valve module and the coolant pump.

Warm-Up with Mini-Volume Stream and Heating in the Vehicle Interior

If interior heat is requested in this phase, N422 Climatronic Refrigerant Shut-Off Valve opens and V51 After-Run Coolant Pump starts operating. Rotary valve 2 temporarily interrupts the coolant flow to the cylinder block. The coolant is directed through the cylinder head, turbocharger and heat exchanger. Engine warmup takes longer when this occurs.

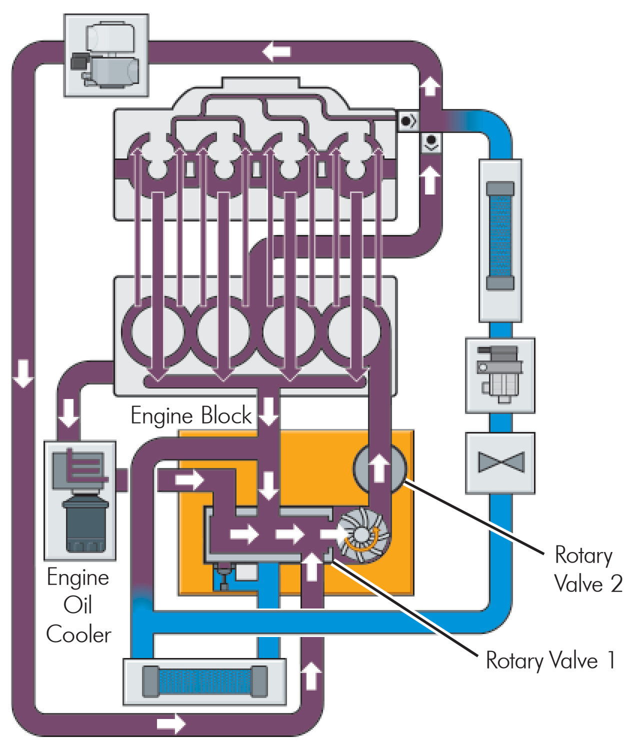
N422 and V51 are always used to control heat requests in all control phases. Rotary valve 2 reduces or stops coolant flow to the engine block.



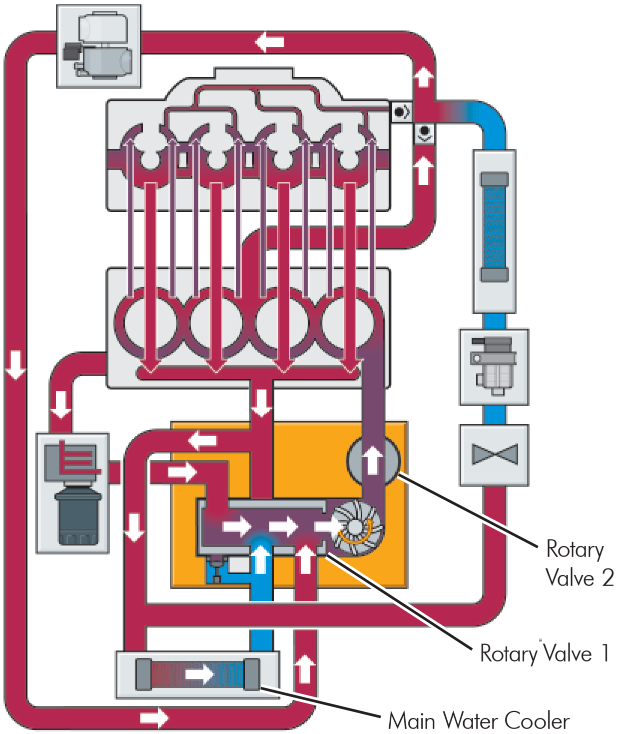
s522_094

Warm-Up with Map-Controlled Engine Cooling Switched On

The engine oil cooler is switched on during the warm-up phase of the engine. The rotary valve moves to 120°, opening the coolant connection to the oil cooler. Because rotary valve 2 is still engaged, it turns and increases the coolant stream through the cylinder block. A large amount of heat distribution takes place in the engine block and excess heat is discharged via the oil cooler.



s522_095

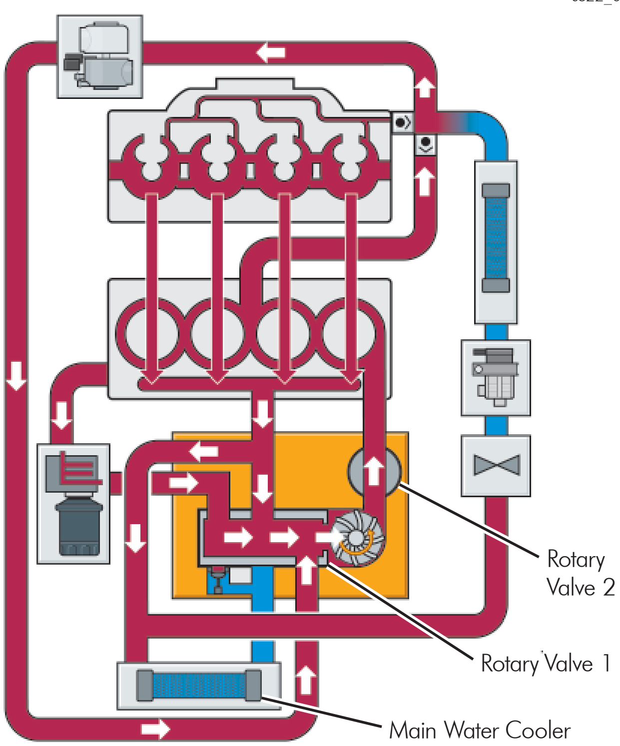


s522_096

Temperature Control Range

The innovative thermal management moves smoothly from the warm-up range to the temperature control range. Here, rotary valve regulation is dynamic and depends on the engine load.

To conduct away excess heat, the radiator connection from the rotary valve module is opened. The actuator for N493 Engine Temperature Control Actuator positions rotary valve 1 between 0° and 85°, depending on how much heat has to be removed. For a rotary valve 1 angle position of 0° the radiator connection is fully opened.



s522_102

If the engine is running at a lower load and speed (partial load range), the thermal management adjusts the coolant temperature to 107°C. Since the full cooling power is not required, rotary valve 1 temporarily closes the connection to the radiator. If the temperature rises above this value, the connection to the radiator is opened again. Constant opening and closing is necessary to keep the temperature as close to 107°C as possible.

When load and engine speed increase, coolant temperature is reduced to 85°C (full load range) by first completely opening the connection to the radiator.

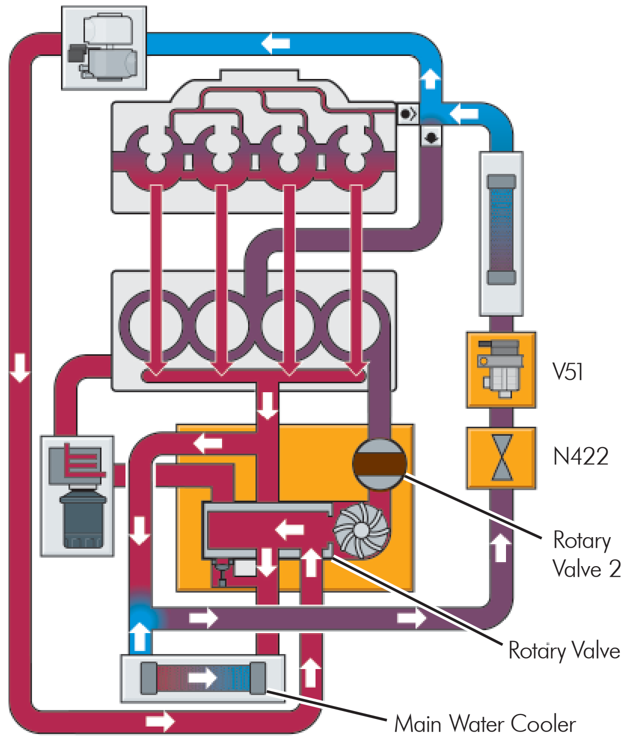
Run-On Range when Switching Off the Engine

When the engine is turned off, the ECM applies a map to prevent the coolant from boiling in the cylinder head and turbocharger. It can run for up to 15 minutes after the engine is off.

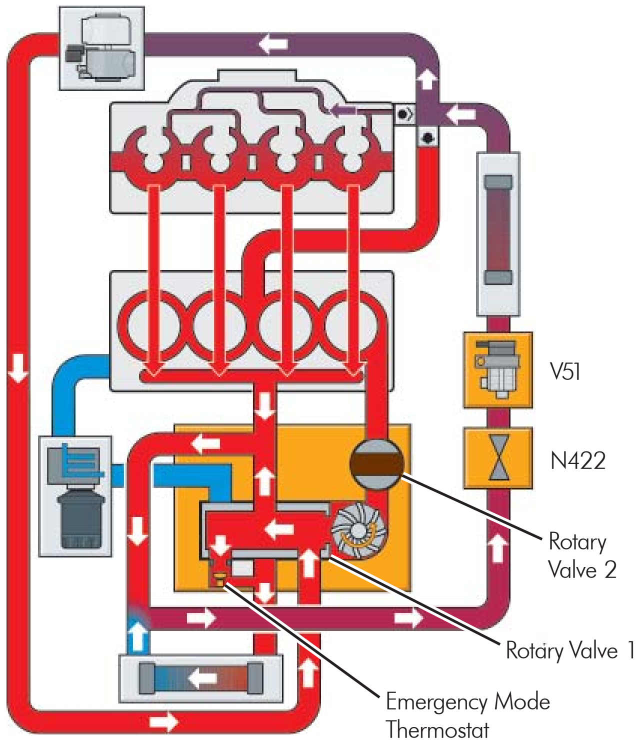
For the run-on function, rotary valve 1 is between 160° and 255°. At 255° the connection to the return line of the radiator is fully open so that maximum heat is dissipated.

Rotary valve 2 is in the run-on position and not engaged by rotary valve 1. The coolant now flows in two streams through the coolant circuit, as a result of V51 After-Run Coolant Pump. One stream flows through the cylinder head and back to the V51. A second stream flows through the turbocharger, through rotary valve 1, to the radiator and back to V51.

The cylinder block is not included in the coolant circulation circuit in the run-on position.



s522_106



s522_097

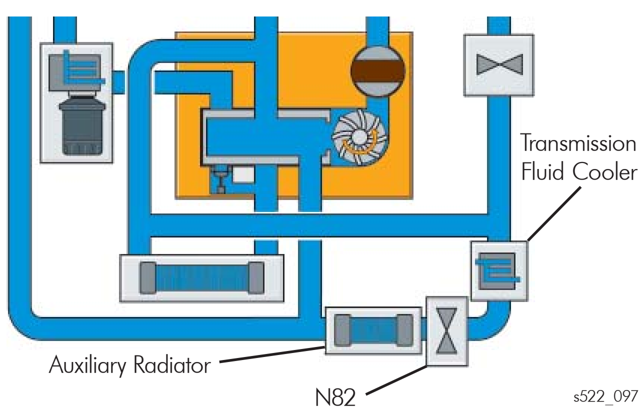
Emergency Mode Strategy

If the temperature in the rotary valve module exceeds 113°C, the emergency thermostat opens a bypass to the radiator. This enables the limited engine running if the rotary valve module is defective. If the ECM receives no position feedback from the N493, the rotary valve is actuated for maximum engine cooling regardless of the current engine load and operating temperature.

In the event of a malfunction of the rotary valve module (if the electric motor fails or the rotary valve drive jams) the following may take place:

- A fault message is displayed in the instrument cluster and engine speed is limited to 4,000 rpm. A warning tone sounds and the EPC lamp illuminates to make the driver aware of the situation
- The actual coolant temperature in °C is digitally displayed in the instrument cluster
- The N422 Climatronic Refrigerant Shut-Off Valve is opened
- The V51 is activated for cylinder head cooling
- A DTC is set in the ECM

If the position signal from the turn angle sensor fails, the ECM actuates the rotary valve to be on the safe side so that the maximum cooling function is achieved.

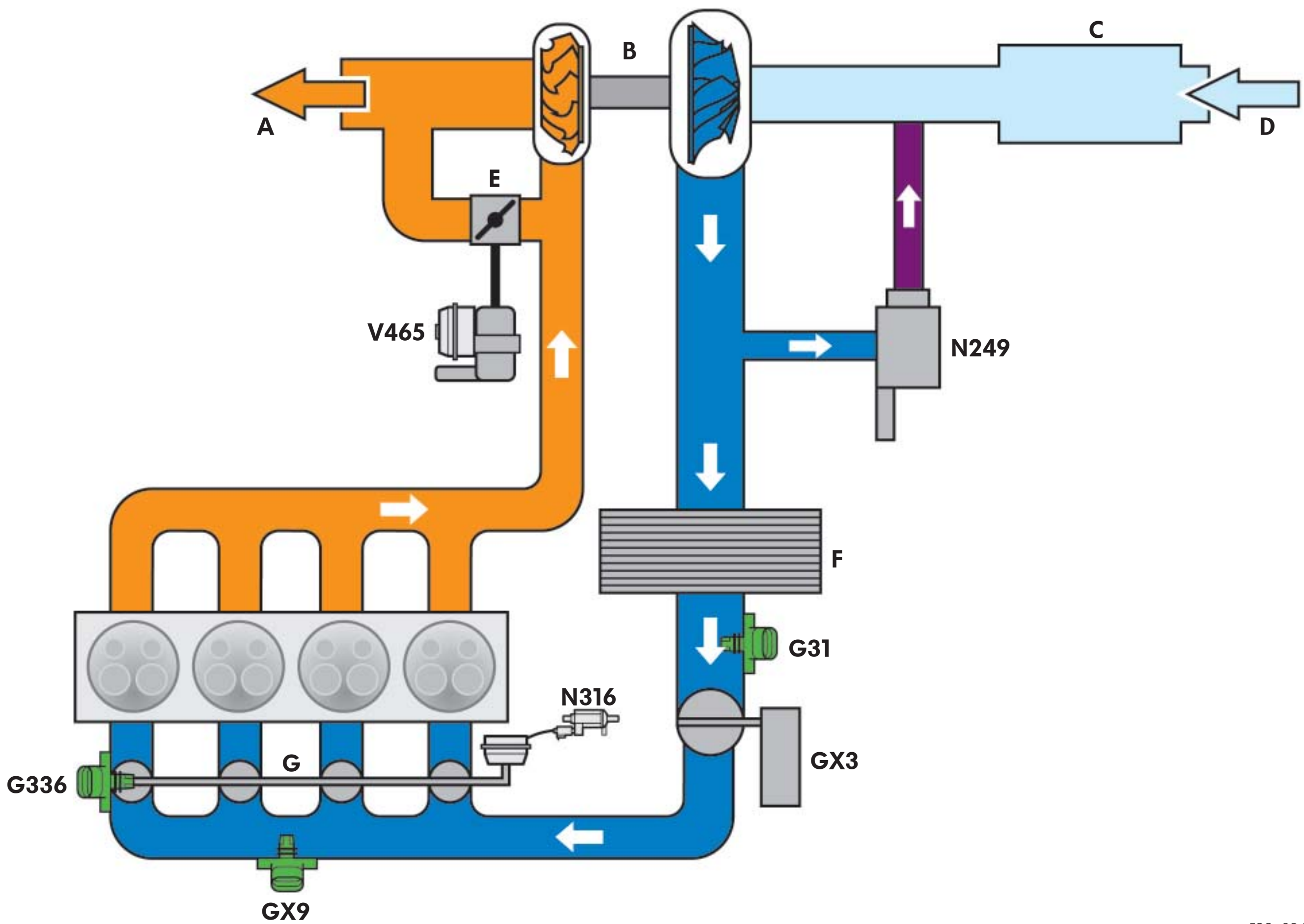


s522_097

Engines with Dual Clutch Gearbox

If the engine has a dual clutch gearbox (DSG), the coolant circuit is expanded to include the transmission fluid cooler, N82 Coolant Shut-Off Valve and an auxiliary radiator. The steps in the temperature management are similar to those without DSG.

Charge Air System



Legend

GX9 Intake Manifold Sensor with:
- G42 Intake Air Temperature Sender
- G71 Manifold Absolute Pressure Sensor

GX3 Throttle Valve Control Module with:
- G186 EPC Throttle Drive
- G187 EPC Throttle Drive Angle Sensor 1
- G188 EPC Throttle Drive Angle Sensor 2

G31 Charge Air Pressure Sensor
G336 Intake Manifold Runner Position Sensor
N249 Turbocharger Recirculation Valve
N316 Intake Manifold Runner Control Valve
V465 Charge Pressure Actuator

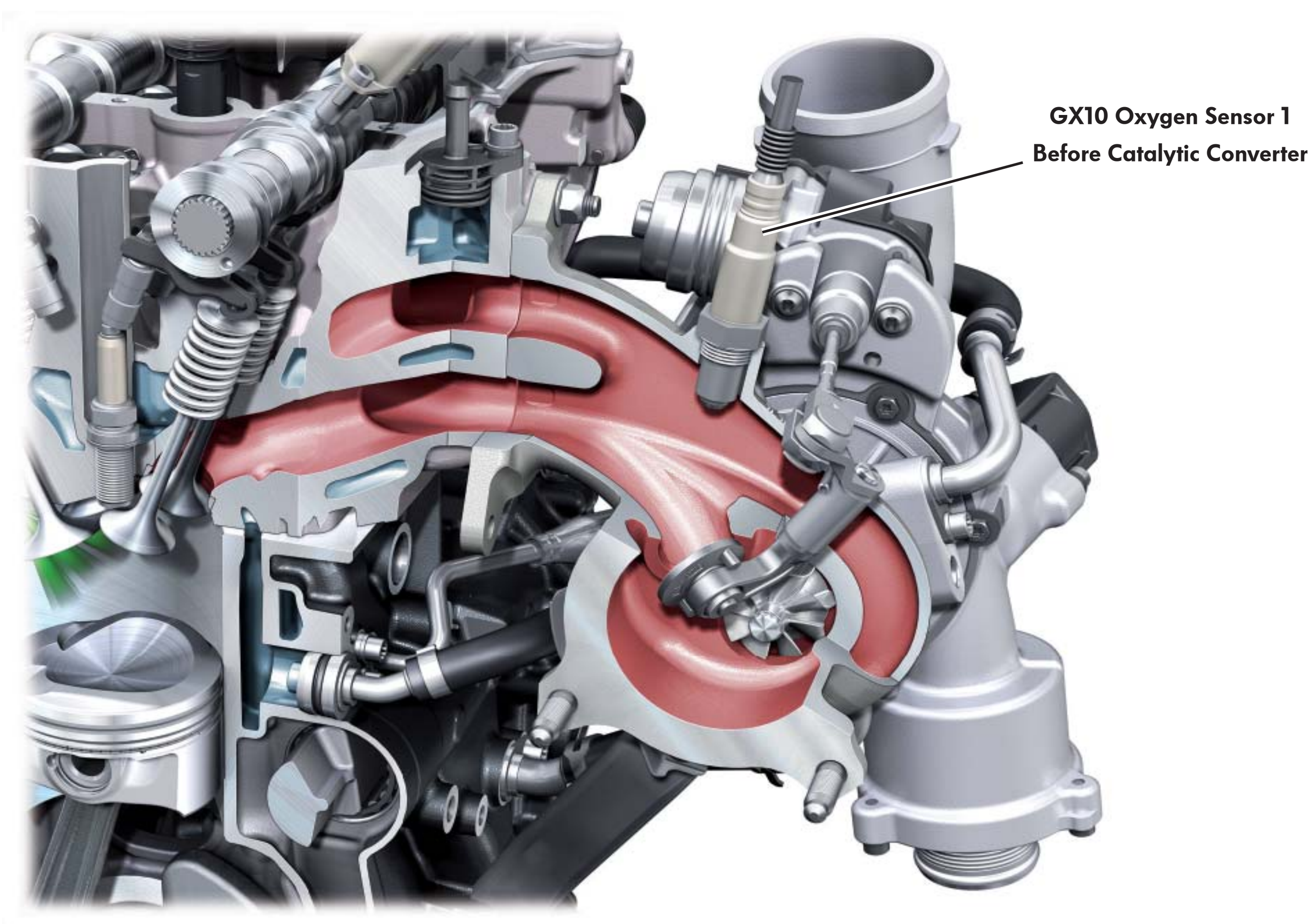
A Exhaust Gas Flow
B Turbocharger
C Air Filter
D Fresh Air Stream
E Wastegate Flap
F Charge Air Cooler
G Intake Manifold Flaps
Exhaust Gas
Intake Air (Negative Pressure)
Charge Air (Charge Pressure)
Overrun Recirculation (Charge Pressure)

Turbocharger

The new engines use a new turbocharger with an electric charge pressure positioner. It is bolted directly to the cylinder head exhaust manifold.

The turbocharger has:

- Electrical wastegate adjustment with V465 Charge Pressure Actuator and the G581 Charge Pressure Actuator Position Sensor
- GX10 Oxygen Sensor 1 before Catalytic Converter (with G39 Heated Oxygen Sensor and Z19 Oxygen Sensor Heater) upstream of the turbocharger
- Compact cast-steel turbine housing with twin-track exhaust gas recirculation
- Compressor housing with integrated resonance silencer and N249 Turbocharger Recirculation Valve
- Turbine wheel made of a special steel alloy with a temperature resistance of up to 980°C
- Bearing seat with uniform connections for oil and coolant



s522_037

Design

Turbine Housing and Turbine Wheel

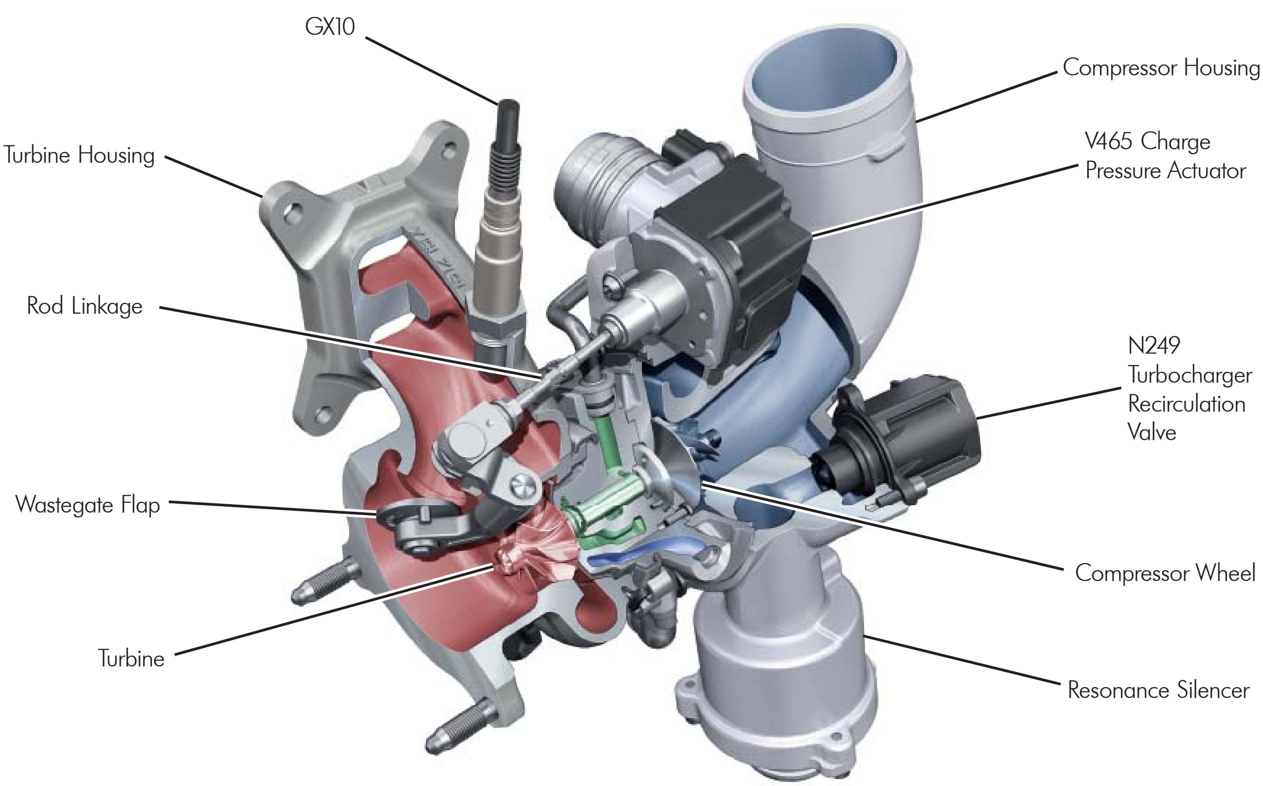
- The turbine housing is made of a new cast steel material for temperature resistance up to 980°C.
- The twin-track exhaust gas ducts in the exhaust manifold are maintained in the turbocharger until just before the turbine. This results in the best possible firing sequence separation.
- The load performance of the turbine has been particularly improved in the upper rpm range.

Compressor Housing and Compressor Wheel

- The compressor housing is made of cast aluminium. It has been reinforced because of high actuation forces by the charge pressure positioner. A resonance silencer is located directly on the compressor housing.
- The N249 Turbocharger Recirculation Valve regulates the air flow to the resonance silencer.
- The crankcase breather port is integrated into the compressor housing.

GX10 Oxygen Sensor 1 before Catalytic Converter

GX10 is a broadband lambda probe. It is bolted directly into the turbocharger housing. Because it is mounted close to the engine, the probe can record the exhaust gas of each cylinder. This improves accuracy and earlier lambda regulation - approximately 6 seconds after engine start.



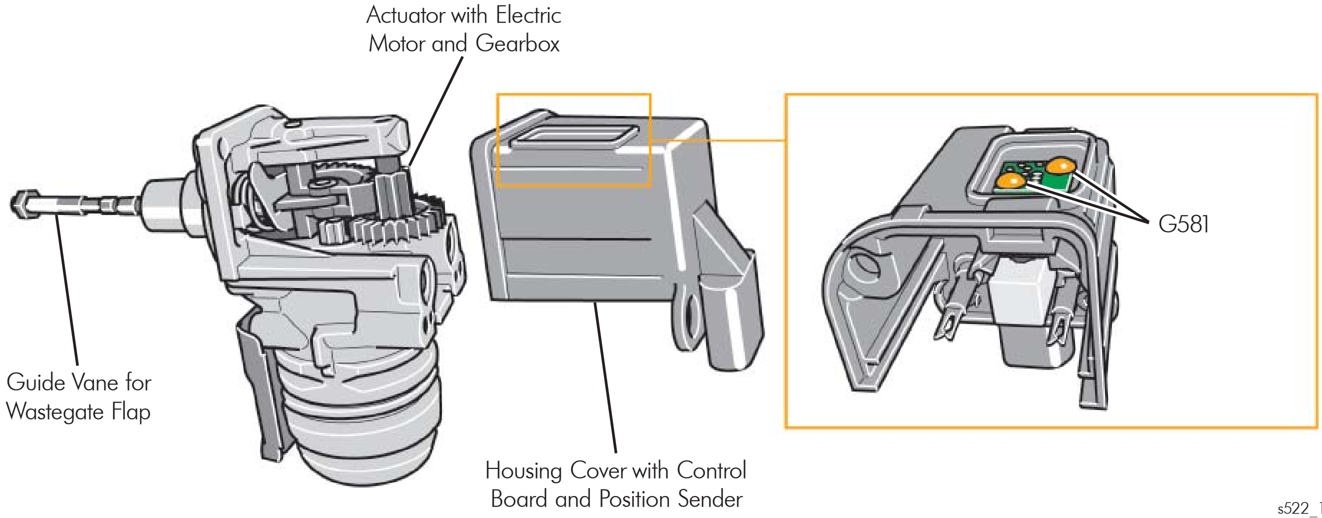
s522_036

V465 Charge Pressure Actuator

V465 actuates the wastegate flap with an electric motor that moves the wastegate flap push rod.

The electric motor provides fast and precise charge pressure control and has the following advantages:

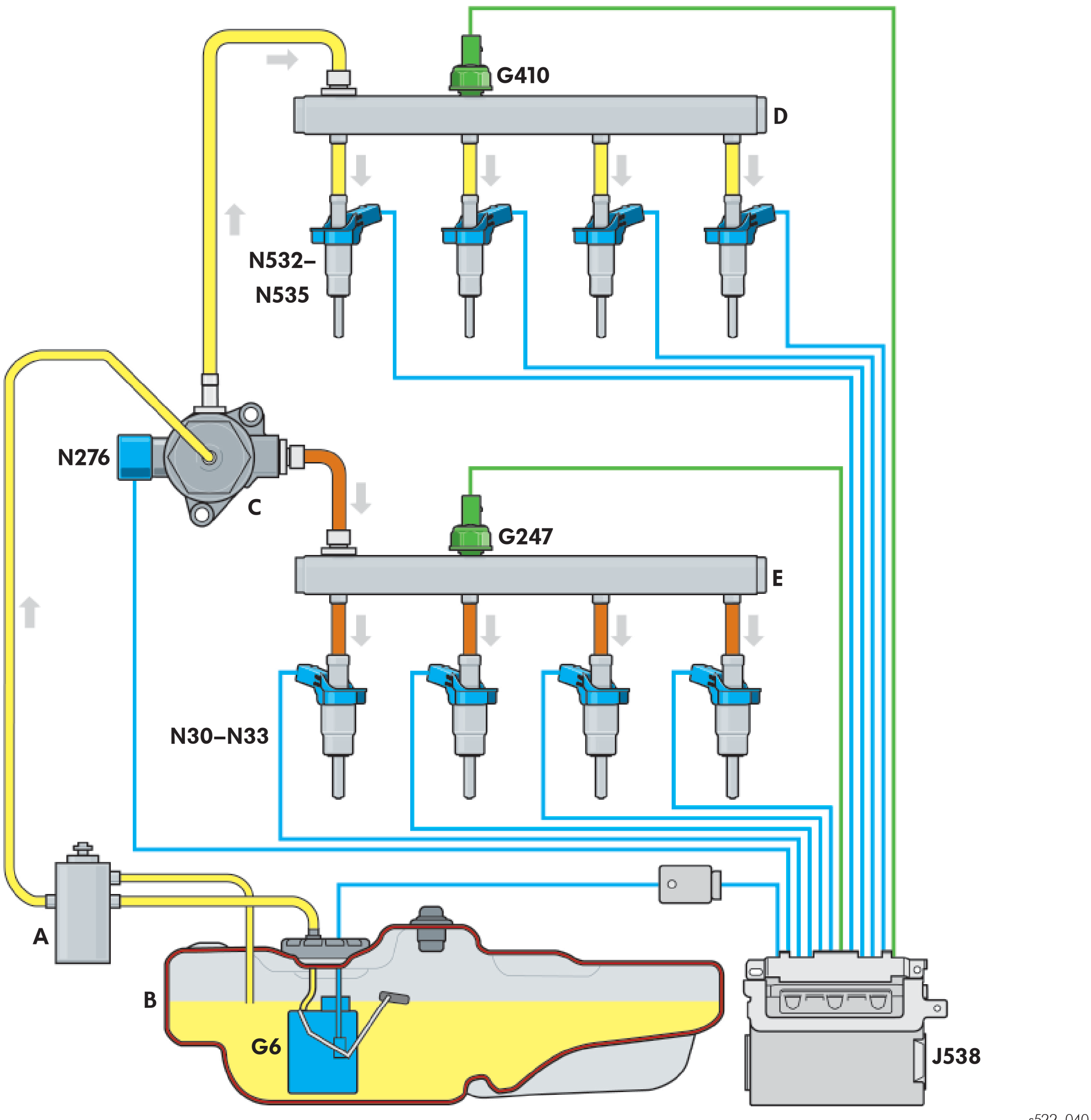
- Activates the wastegate flap regardless of the charge pressure.
- Allows the maximum engine torque to be reached as low as 1500 rpm.
- Opens the wastegate flap in the partial load range which lowers the basic charge pressure, reducing CO_2 emissions by about 1.2g/km.
- Opens the wastegate flap during catalytic converter heating to produce a 10°C higher exhaust gas temperature upstream of the catalytic converter for lower cold-start emissions.
- Fast charge pressure positioner speed causes an immediate reduction in charge pressure during load changes and in overrun mode.



G581 Charge Pressure Actuator Position Sensor

The G581 is a Hall sensor that is integrated in the housing of the charge pressure positioner. A solenoid with two permanent magnets is located on the mechanical part of the gearbox. They perform the same longitudinal movement as the push rod. The Hall sensor detects the movement of the solenoid and sends the information to the ECM which determines the position of the wastegate flap.

Fuel System



Legend

G6	Transfer Fuel Pump
G247	Fuel Pressure Sensor
G410	Low Fuel Pressure Sensor
J538	Fuel Pump Control Module
N276	Fuel Pressure Regulator Valve
N30–N33	Cylinder 1-4 Fuel Injector
N532–N535	Cylinder 1-4 fuel injector 2

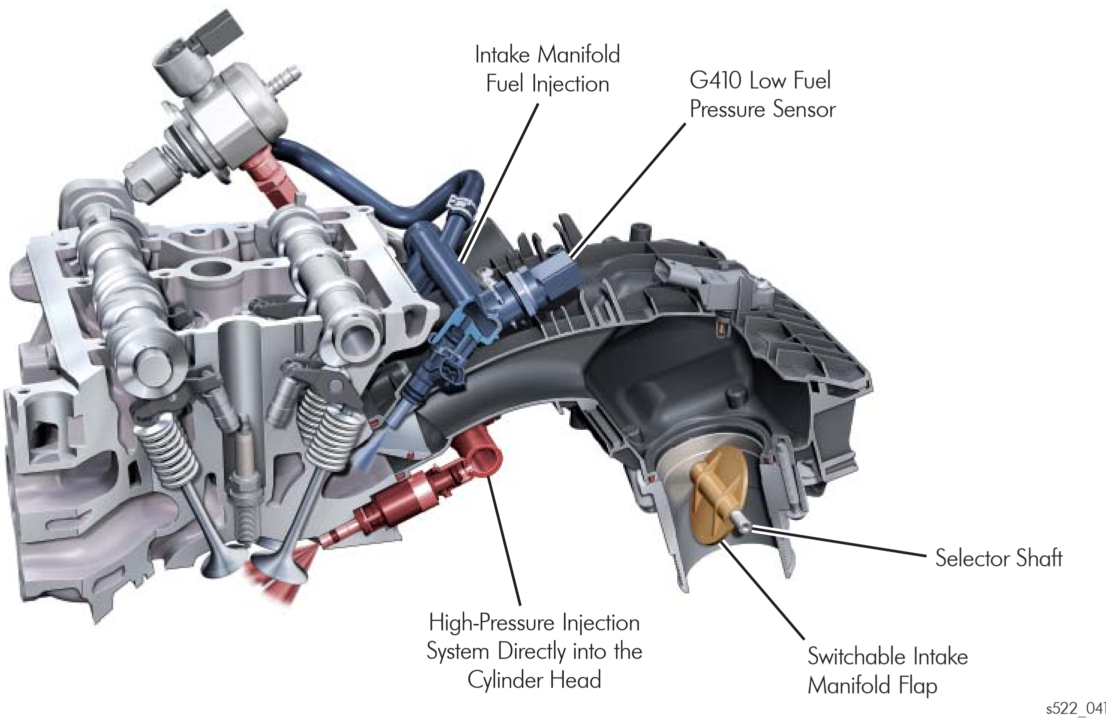
A	Fuel Filter
B	Fuel Tank
C	High-Pressure Fuel Pump
D	Fuel Low-Pressure Rail
E	Fuel High-Pressure Rail
(orange)	High-Pressure System
(yellow)	Fuel System / Low Pressure System
(blue)	Actuator / Output Signal
(green)	Sensor / Input Signal

Mixture Formation

Some upcoming EA888 engines have a dual injection system. One injection system is the direct injection TSI high-pressure injection system. The other system uses the intake manifold fuel injection system (SRE) which greatly reduces fine soot particulate emissions.

The dual injection system:

- Increases pressure in the high-pressure fuel system to 150–200 bar
- Reduces particulate mass and the number of particulates
- Reduces CO_2 exhaust emissions
- Lowers fuel consumption in the partial load range
- Include the intake manifold fuel injection
- Improves engine acoustics



Intake Manifold

The stainless steel intake manifold flaps are boat shaped to prevent air flow cavitation. The flap position is monitored by G336 Intake Manifold Runner Position Sensor.

The N316 Intake Manifold Runner Control Valve moves the selector shaft. The movement of the shaft depends on torque and RPM. The ECM uses a map to determine the position of the flaps.

Fuel System

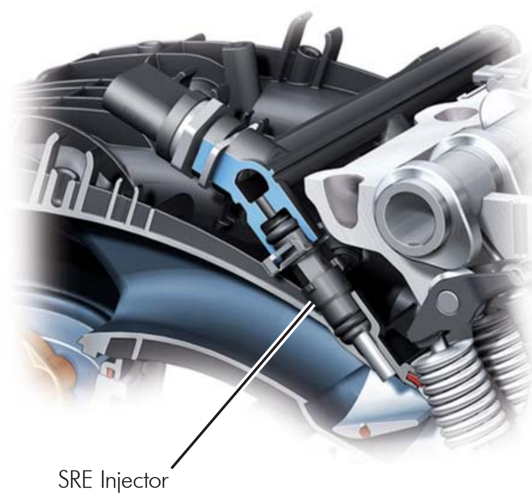
SRE Fuel Injection System

The SRE injection system is supplied by a separate connection on the high-pressure fuel pump. This connection is part of the fuel low-pressure system. After fuel has passed through this connection, fuel enters the fuel low-pressure rail and is directed to the SRE injectors which inject the fuel into the intake manifold. The G410 Low Fuel Pressure Sensor monitors the fuel pressure in the SRE injection system. Fuel supply pressure is provided from the G6 Transfer Fuel Pump in the fuel tank.

Using a high pressure fuel pump for the low pressure fuel supply allows for the high pressure fuel pump to be cooled even in SRE mode. In SRE mode, the high-pressure pump delivery N276 Fuel Pressure Regulator Valve can be turned off.

The SRE mode is primarily used in the partial load range. This range allows for the fuel droplets to atomize and mix with the air. Mixture formation long before ignition results in:

- Reduced particulate mass and soot formation
- Lower CO_2 emissions
- Reduced fuel consumption

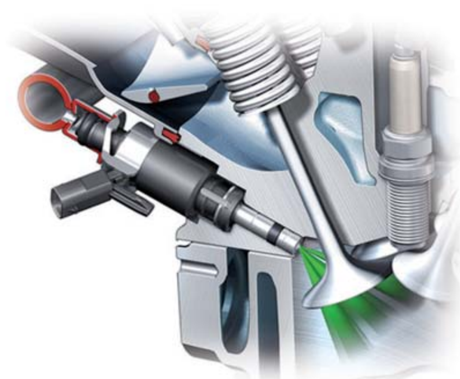


s522_043

High-Pressure Injection System

The fuel system was upgraded to allow for pressures up to 200 bar.

- Sealing rings to acoustically isolate the injectors from the cylinder head
- The valve position has been moved back slightly, improving mixture formation and lowering valve temperatures
- The high-pressure fuel rail acoustically isolated from the intake manifold



s522_042

Modes of Operation

The ECM uses a map to determine the operational modes. The map defines when the engine uses SRE and high-pressure injectors. The following modes of operation are:

- SRE single injection
- High-pressure single injection
- High-pressure dual injection
- High-pressure triple injection

The system switches between these modes of operation depending on the temperature, load and engine speed.

Engine Start

For each engine start when the engine is cold and coolant temperature is lower than 45°C, a high pressure triple direct fuel injection takes place during the compression stroke.

Warm-up and Catalytic Converter Heating

A dual direct fuel injection takes place during the intake and compression strokes. The ignition is somewhat retarded. The intake manifold flaps are closed.

Engine Runs in the Partial Load Range

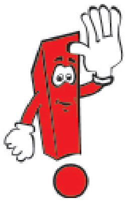
If the engine temperature is above 45°C and the engine is driven in the partial load range, SRE mode is used. The intake manifold flaps remain mostly closed.

Engine Running under Full Load

Due to the high performance requirement, the system switches into high-pressure mode. A dual direct fuel injection takes place during the intake and compression strokes.

Emergency Running Function

If one of the injection systems fails, the ECM uses the other system to keep the engine running. The red engine MIL in the instrument cluster illuminates.



There are special procedures to depressurize the fuel system. Follow all Repair Information and scan tool test plan instructions!

System Overview

Sensors

J338 Throttle Valve Control Module
G187, G188 EPC Throttle Drive Angle Sensor 1 and 2
F Brake Lamp Switch

G476 Clutch Position Sensor

F36 Clutch Pedal Switch

F194 Clutch Pedal Starter Interlock Switch

G79 Accelerator Pedal Position Sensor
G185 Accelerator Pedal Position Sensor 2

G61 Knock Sensor 1

G410 Low Fuel Pressure Sensor

G40 Camshaft Position Sensor,

G300 Camshaft Position Sensor 3

G62 Engine Coolant Temperature Sensor

G83 Engine Coolant Temperature Sensor on Radiator Outlet

G28 Engine Speed Sensor

G266 Oil Level Thermal Sensor

G336 Intake Manifold Runner Position Sensor

G71 Manifold Absolute Pressure Sensor
G42 Intake Air Temperature Sensor
G247 Fuel Pressure Sensor

G31 Charge Air Pressure Sensor

G39 Heated Oxygen Sensor

G130 Oxygen Sensor after Three-Way Catalytic Converter

F22 Oil Pressure Switch

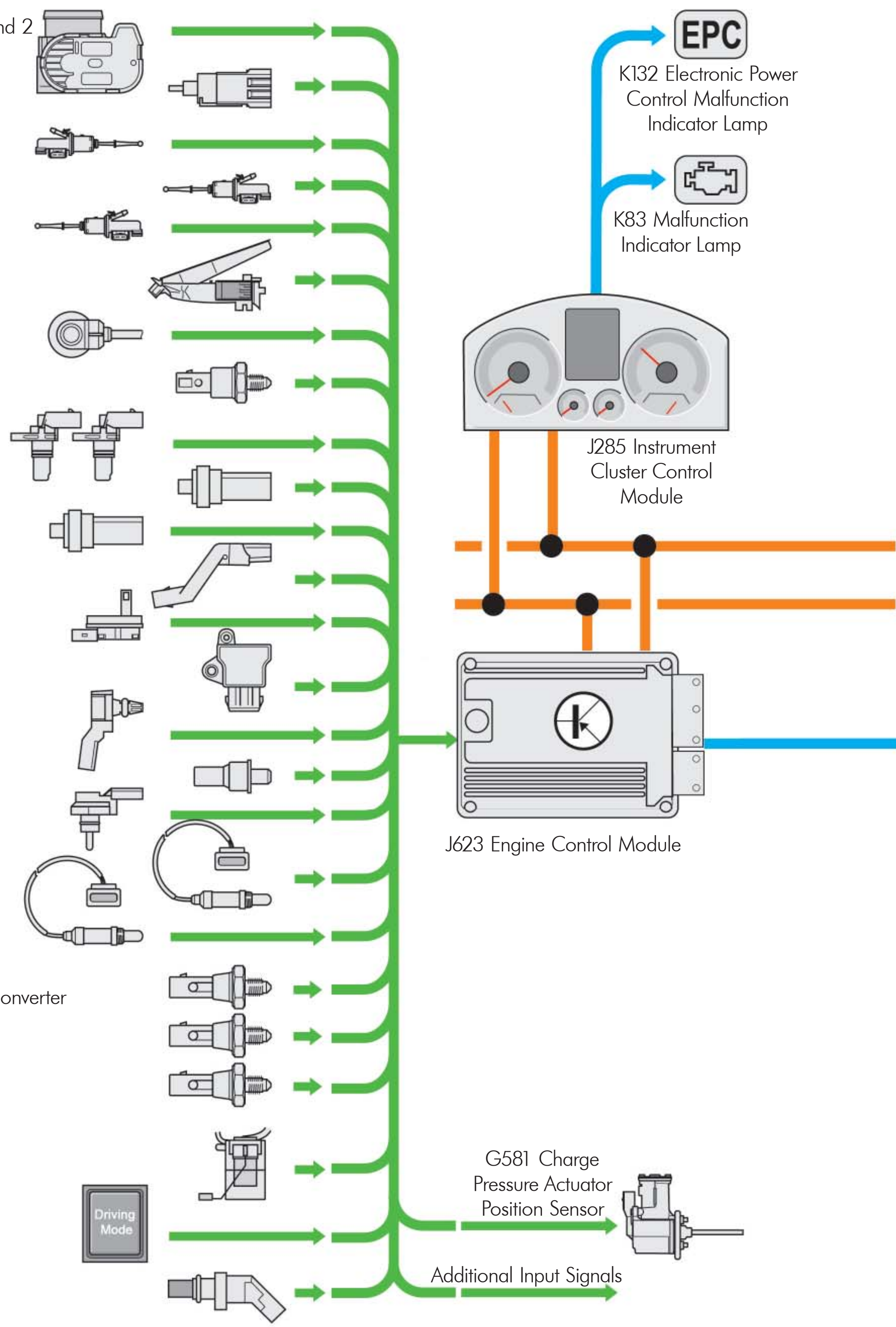
F378 Reduced Oil Pressure Switch

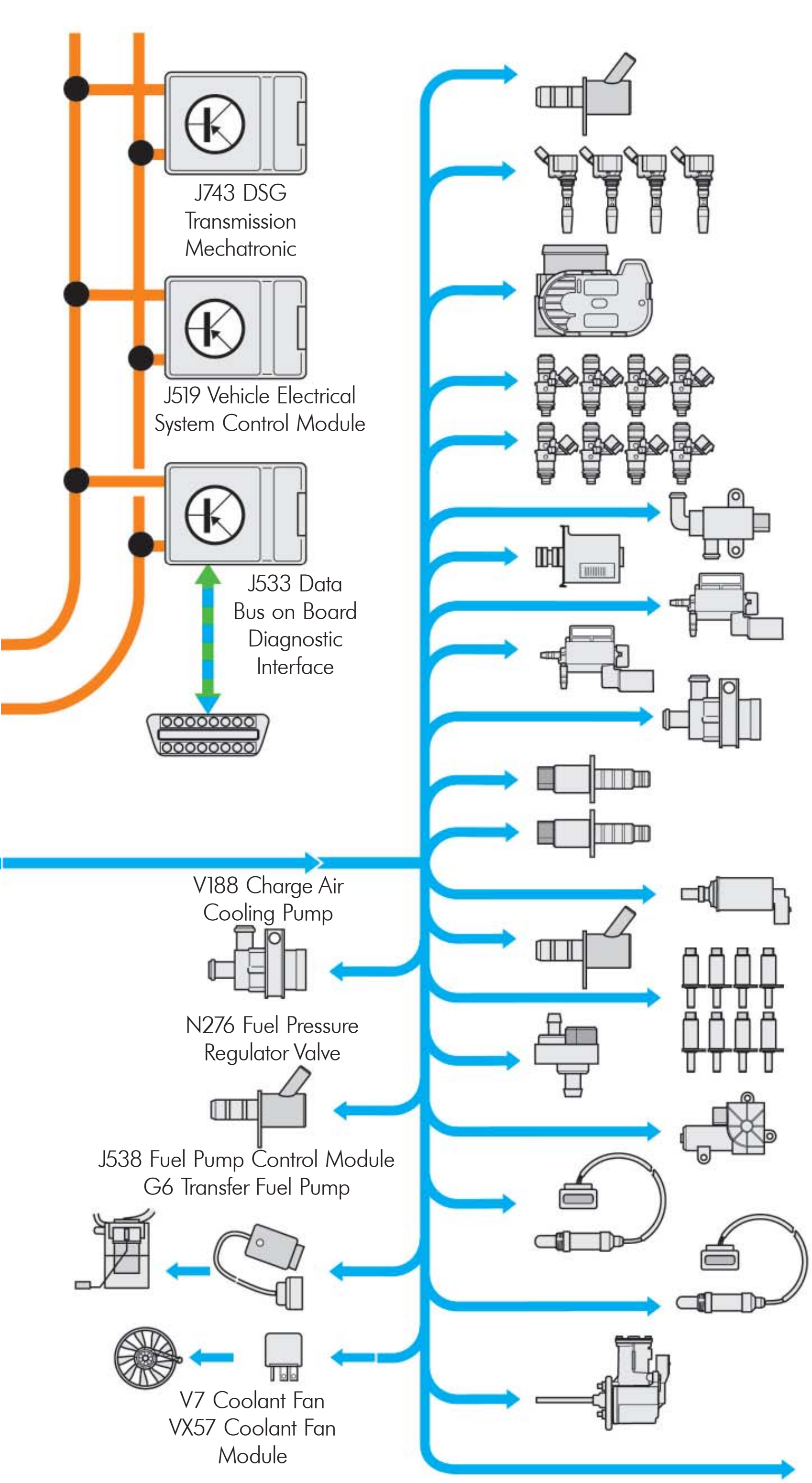
F447 Oil Pressure Switch, Level 3

G1 Fuel Gauge
G614 Fuel Gauge Sensor 2

E598 Driving Program Button

G701 Transmission Neutral Position Sensor

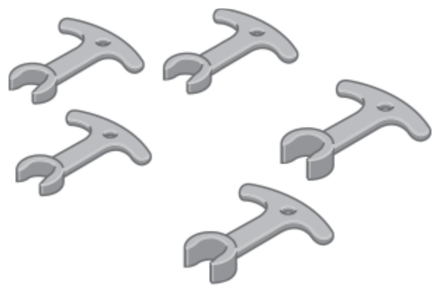
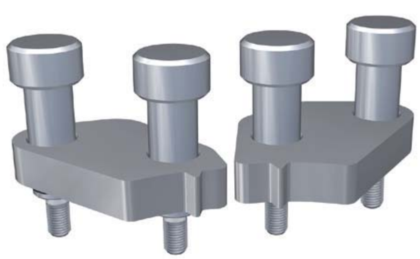



J743 DSG Transmission Mechatronic
J519 Vehicle Electrical System Control Module
J533 Data Bus on Board Diagnostic Interface
V188 Charge Air Cooling Pump
N276 Fuel Pressure Regulator Valve
J538 Fuel Pump Control Module G6 Transfer Fuel Pump
V7 Coolant Fan VX57 Coolant Fan Module
Actuators
N522 Piston Cooling Nozzle Control Valve
N70, N127, N291, N292 Ignition Coil 1 with Power Output Stage
G186 EPC Throttle Drive
N532–535 Cylinder 1 - 4 Fuel Injector 2
N30–33 Cylinder 1 - 4 Fuel Injector
N82 Coolant Shut-Off Valve
N249 Turbocharger Recirculation Valve
N316 Intake Manifold Runner Control Valve
N422 Climatronic Refrigerant Shut-Off Valve
V51 After-Run Coolant Pump
N205 Camshaft Adjustment Valve 1
N318 Exhaust Camshaft Adjustment Valve 1
N290 Fuel Metering Valve
N428 Oil Pressure Regulation Valve
N580, N581, N588, N589, N596, N597, N604, N605 Cylinder 1-4 Exhaust Camshaft Adjuster A/B
N80 EVAP Canister Purge Regulator Valve 1
N493 Engine Temperature Control Actuator
Z19 Oxygen Sensor Heater
Z29 Heater for Oxygen Sensor 1 after Catalytic Converter
V465 Charge Pressure Actuator
Additional Output Signals

s522_077

Special Tools

Description	Tool	Usage
T10133/16A Disassembly Tool	 s522_112	Removes the high-pressure injectors. Replaces previous disassembly tool T10133/16.
T10133/18 Sleeve	 s522_056	Removes the high-pressure injectors.
T401243 Lever	 s522_057	Retracts the crankshaft tensioner.
T40267 Locking Tool	 s522_058	Locks the timing chain crankshaft tensioner.
T40274 Extractor Hook	 s522_059	Removes the crankshaft O-ring.

Description	Tool	Usage
T40270 Socket Insert XZN 12	 s522_060	Removes and installs the assembly mountings.
T40191/1 Spacers Instruction Chart: W00-10704	 s522_117	Installs the ball coupling on the exhaust camshaft with sliding pieces.
T40058 Adapter	 s522_073	Turns the camshafts.
T40271 Fastener	 s522_061	Fastens the sprocket wheels on the camshafts.
T40196		Inserted when the variable valvelift actuator has been removed

New Component Clusters

Some sensors and actuators have been integrated into Component Clusters. The following table provides an overview of these clusters.

Component Clusters	Included Sensors and Actuators
GX2 Accelerator Pedal Module	G79 Accelerator Pedal Position Sensor and G185 Accelerator Pedal Position Sensor 2
GX3 Throttle Valve Control Module	J338 Throttle Valve Control Module, G186 EPC Throttle Drive, G187 EPC Throttle Drive Angle Sensor 1, and G188 EPC Throttle Drive Angle Sensor 2
GX7 Oxygen Sensor 1 after Catalytic Converter	G130 Oxygen Sensor after Three-Way Catalytic Converter and Z29 Heater for Oxygen Sensor 1 after Catalytic Converter
GX9 Intake Manifold Sensor	G71 Manifold Absolute Pressure Sensor and G42 Intake Air Temperature Sensor
GX10 Oxygen Sensor 1 Before Catalytic Converter	G39 Heated Oxygen Sensor and Z19 Oxygen Sensor Heater
KX2 Instrument Cluster	J285 Instrument Cluster Control Module
VX57 Coolant Fan	J293 Coolant Fan Control Module, V7 Coolant Fan and V177 Coolant Fan 2
EX23 Center Console Switch Module 1	E598 Driving Program Button and E693 Start/Stop Mode Button

Knowledge Assessment

An on-line Knowledge Assessment (exam) is available for this Self-Study Program.

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

You can find this Knowledge Assessment at:

www.vwwebsource.com

For Assistance, please call:

Volkswagen Academy

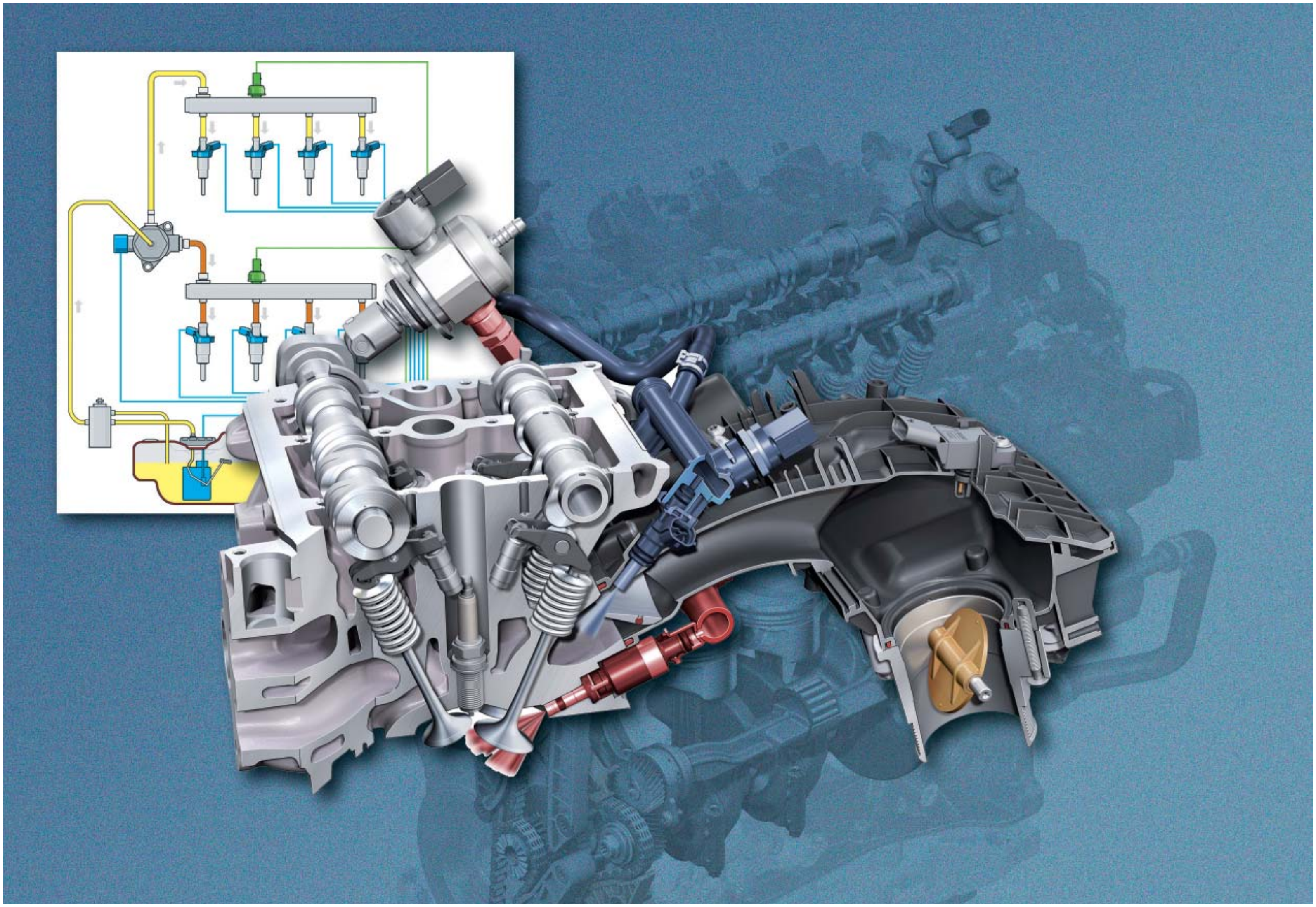
Certification Program Headquarters

1-877-791-4838

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

Or, E-mail:

concierge@volkswagenacademy.com



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