



## The Audi 2.0L Third Generation TDI Engine

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## eMedia



This eSSP contains video links which you can use to access interactive media.

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This eSelf Study Program provides a basic knowledge of the design and functions of new models, new automotive components or technologies.

It is not a Repair Manual! All values given are intended as a guideline only.

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



**Note**



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# Introduction

A new family of diesel engines has been developed with the designation EA288. EA is for Entwicklungsauftrag which means “development order.” It is based on the existing EA189 engine family.

Audi engineers have translated this development to the Modular Diesel Platform (MDP) so successive platforms in the mid-range, compact and subcompact classes can be supplied with identical or adapted engine modules.

The modular design principle has been applied both to the core assemblies (basic engine assembly, cylinder head and valve train) and to the ancillary components (close-coupled exhaust gas treatment system and intake manifold with integrated charge air cooler). Numerous sub-assemblies have already been redesigned and re-developed for the new 4-cylinder diesel engines in the EA288 family.



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Core assemblies	
1	Camshaft housing
2	Cylinder head
3	Cylinder block
4	Switchable coolant pump
5	Oil/vacuum pump
6	Timing drive and drive for auxiliary units

Ancillary components	
7	Exhaust manifold module with turbocharger
8	Intake manifold with water-cooled charge air cooler
9	Exhaust purification module
10	Exhaust gas recirculation module

**eMedia**

EA288 Engine

# Brief technical description

## 2.0l 4-cylinder TDI for the North American Region

Cylinder block with integrated balancer shafts



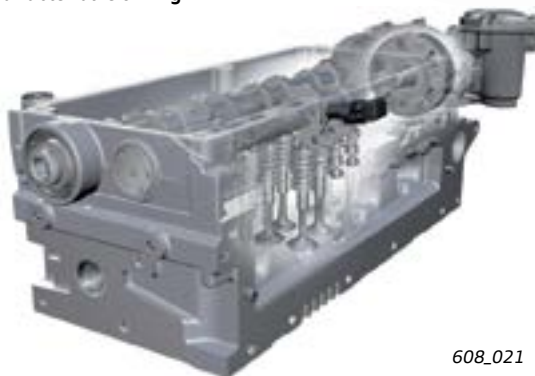
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Oxidizing catalytic converter and diesel particulate filter (shown here in a transverse engine configuration.)



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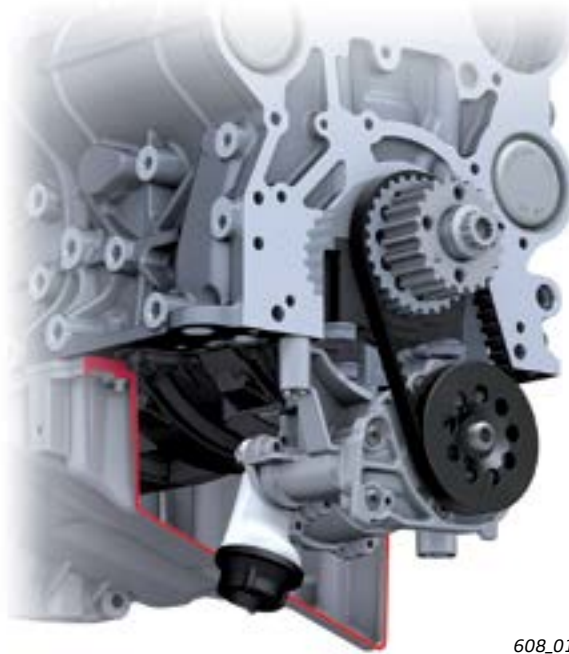
Cylinder head with variable valve timing



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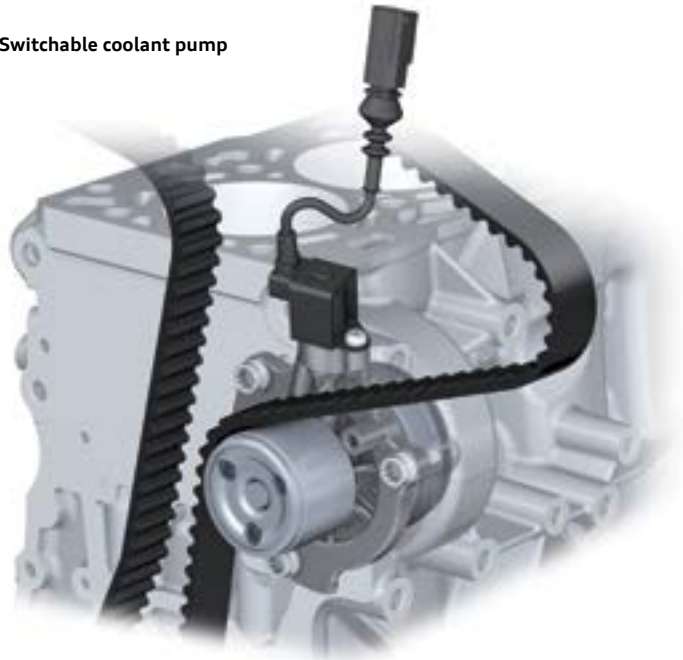


Oil pump with integrated vacuum pump



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Switchable coolant pump



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Intake manifold with integrated charge air cooler



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# Specifications of 2.0l TDI engine

## Torque-power curve

Engine with engine code CRUA (USA)

— Power output in kW (hp)

— Torque in Nm (lb ft)



625\_082



625\_023

Engine code	CRUA
Type	Four-cylinder in-line engine
Displacement in cm <sup>3</sup>	1968
Stroke in mm	95.5
Bore in mm	81.0
Cylinder spacing in mm	88.0
Number of valves per cylinder	4
Firing order	1-3-4-2
Compression ratio	16.2 : 1
Power output at rpm	110 at 3500 – 4000 (147.5 hp at 3500 - 4000)
Torque at rpm	320 at 1750 – 3000 (236.0 lb ft at 1750 - 3000)
Fuel	ULSD (Ultra Low Sulfur Diesel) with a sulfur content of 15 ppm or less; must meet ASTM D975 Grade 2 S15 specifications
Engine management system	Bosch EDC 17
Maximum injection pressure in bar	2000
Emission standard	BIN 5 – Tier 2
CO <sub>2</sub> emission in g/km	106



# Engine mechanicals

## Cylinder block

The cylinder block is made from an alloy of cast iron and nodular graphite (GG GJL 250).

The threads for the cylinder head bolts have been relocated to a position lower in the block.

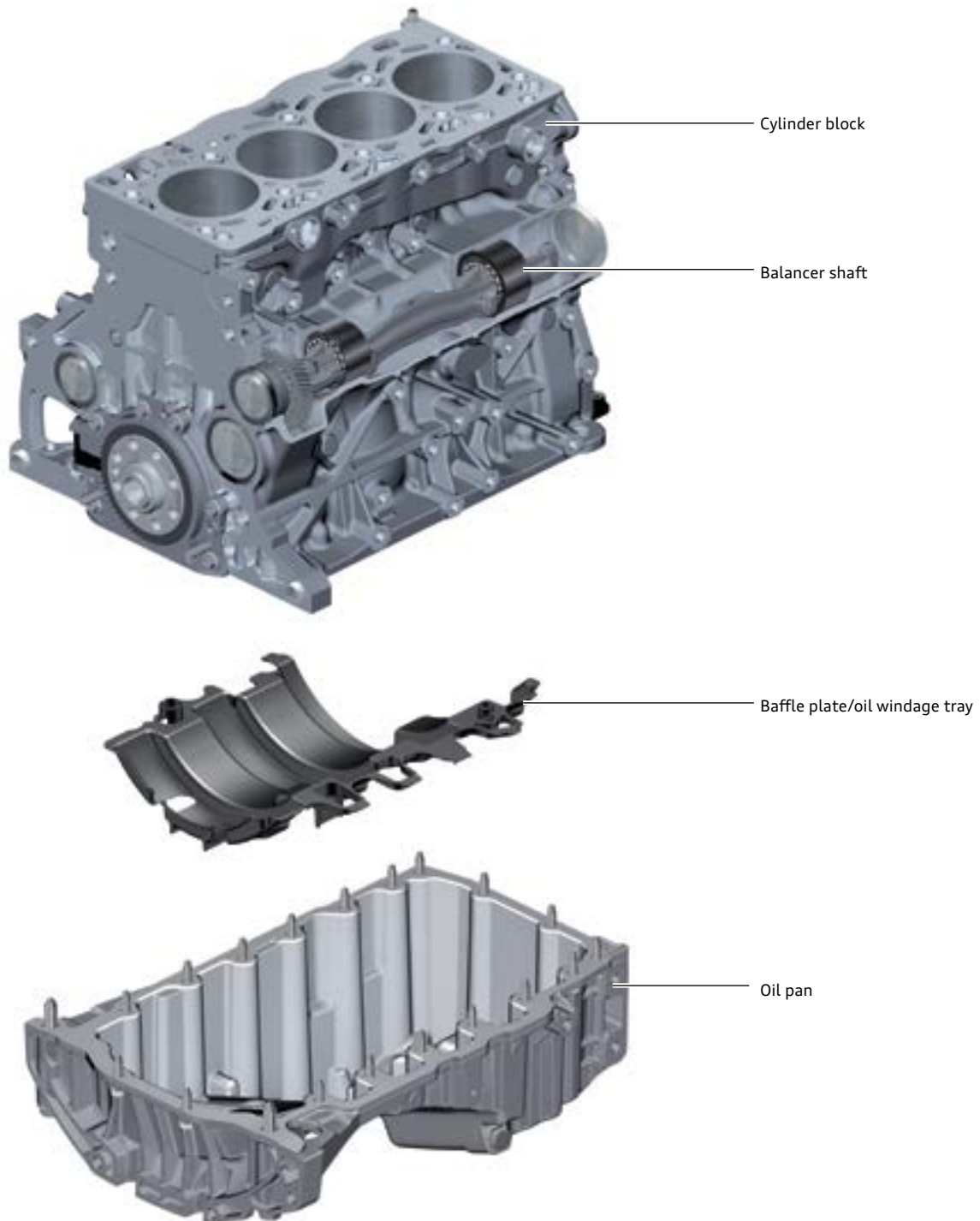
The net effect of lowering the threads is to ensure an even distribution of forces produced by the engine throughout the cylinder block. It also helps ensure an equal pressure distribution over the entire surface area of the cylinder head gasket.

The cylinders are surfaced honed after a torque plate has been bolted to the cylinder block. The use of the plate

ensures that there will be no bore distortion in the cylinder block once the cylinder head has been mounted and tightened to the proper torque specification. This also reduces the stress on the piston rings which in turn reduces friction. This process also leads to less blow-by gas and oil consumption.

The cylinder block has the following technical features:

- ▶ Integrated balancer shafts above the crankshaft
- ▶ Short-path water jacket for rapid component heating
- ▶ Optimal cooling of the webs between the cylinders
- ▶ Optimized oil and water circuits to facilitate ITM



## Crankshaft assembly

A forged crankshaft with five bearings is used in the EA288 engine. To reduce weight, the crankshaft only has four counterweights to counteract the rotating forces of inertia. The load on the crankshaft bearings is also reduced by this measure.

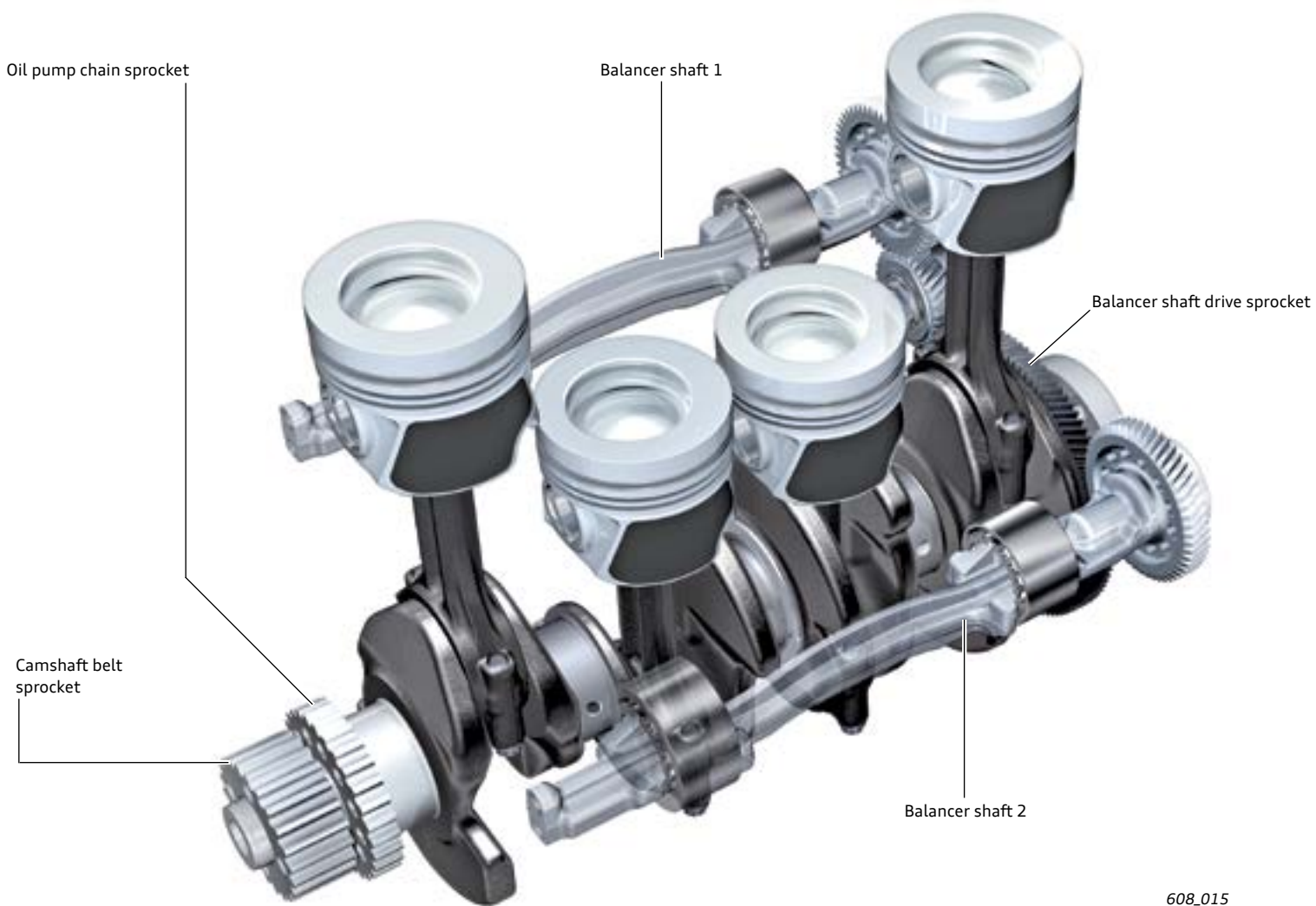
Noise emissions, which may be caused by the engine's inherent movement and vibrations, have also been reduced.

The toothed belt sprocket for the camshaft drive belt and the sprocket for the oil pump drive have been press-fit to the crankshaft.

The trapezoidal connecting rods are cracked at the lower end as on previous engines.

The pistons have no valve pockets. This design of the piston crown reduces the dead space and improves the swirl formation of the intake air in the cylinder.

The piston ring zones are cooled by engine oil via spray jets fed from a piston cooling gallery in the cylinder block. (See page 23).



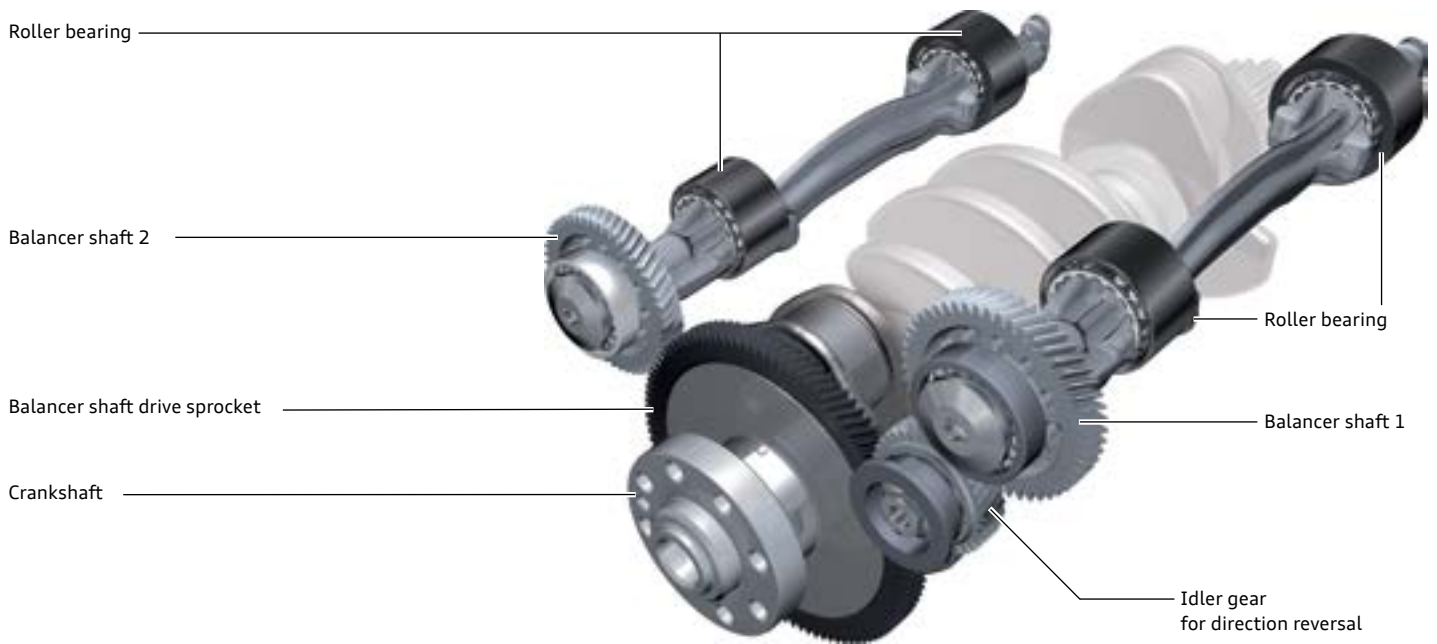
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## Balancer shafts

The movement of the pistons and connecting rods as well as the reciprocal movement of the crankshaft produce forces that cause vibrations. To counteract these vibrations, two balancer shafts rotate in opposite directions at twice the engine speed.

The balancer shafts are driven by a helical-cut gear mounted on the crankshaft. The direction of Balancer shaft 1 is reversed through the use of an idler gear.

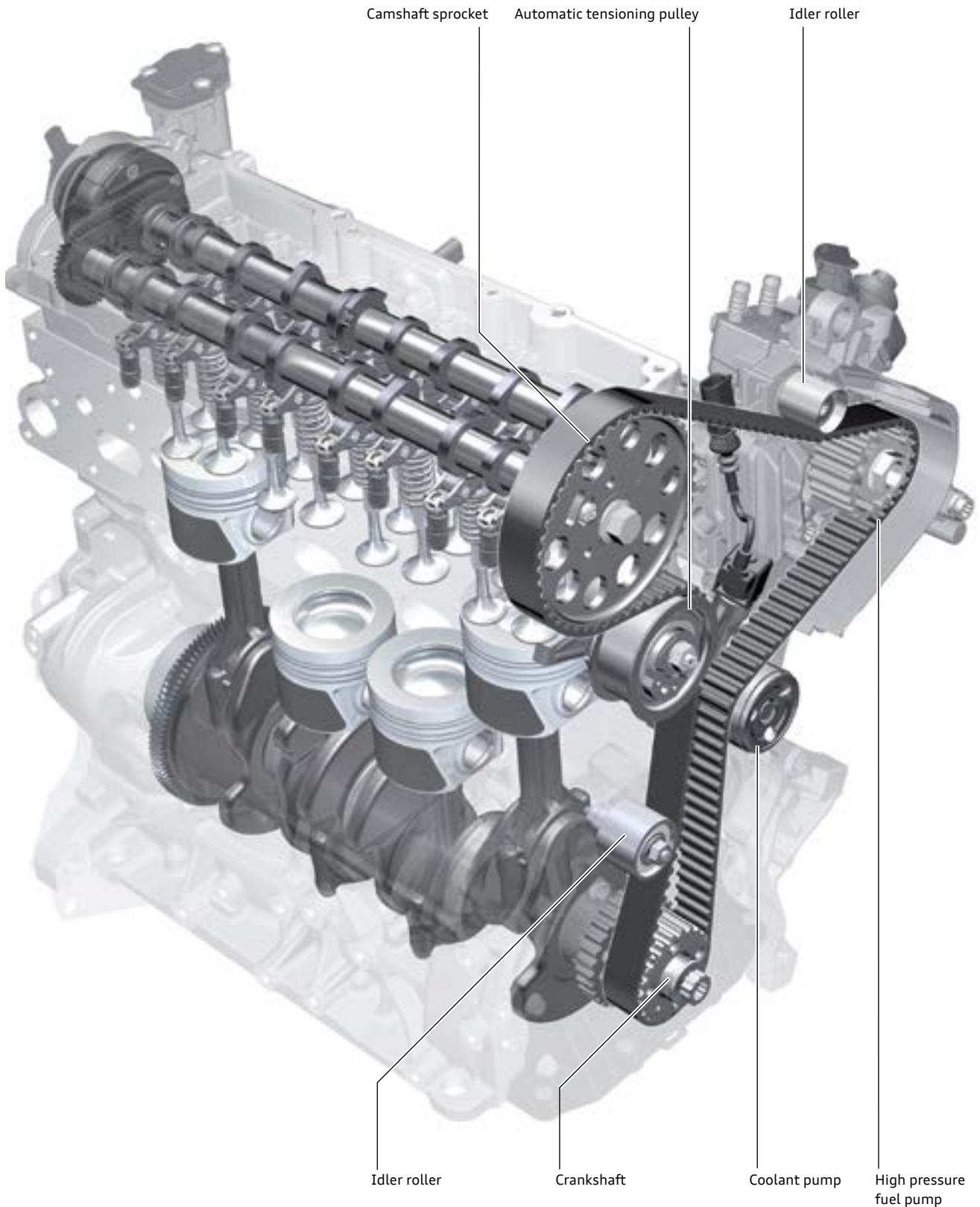
The shafts and idler gear are fixed in position radially and axially by roller bearings. The bearings are lubricated with oil spray from the cylinder block. Lubricating the roller bearings in this manner reduces the drag effect at low engine temperatures and high engine speeds.



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## Toothed belt drive

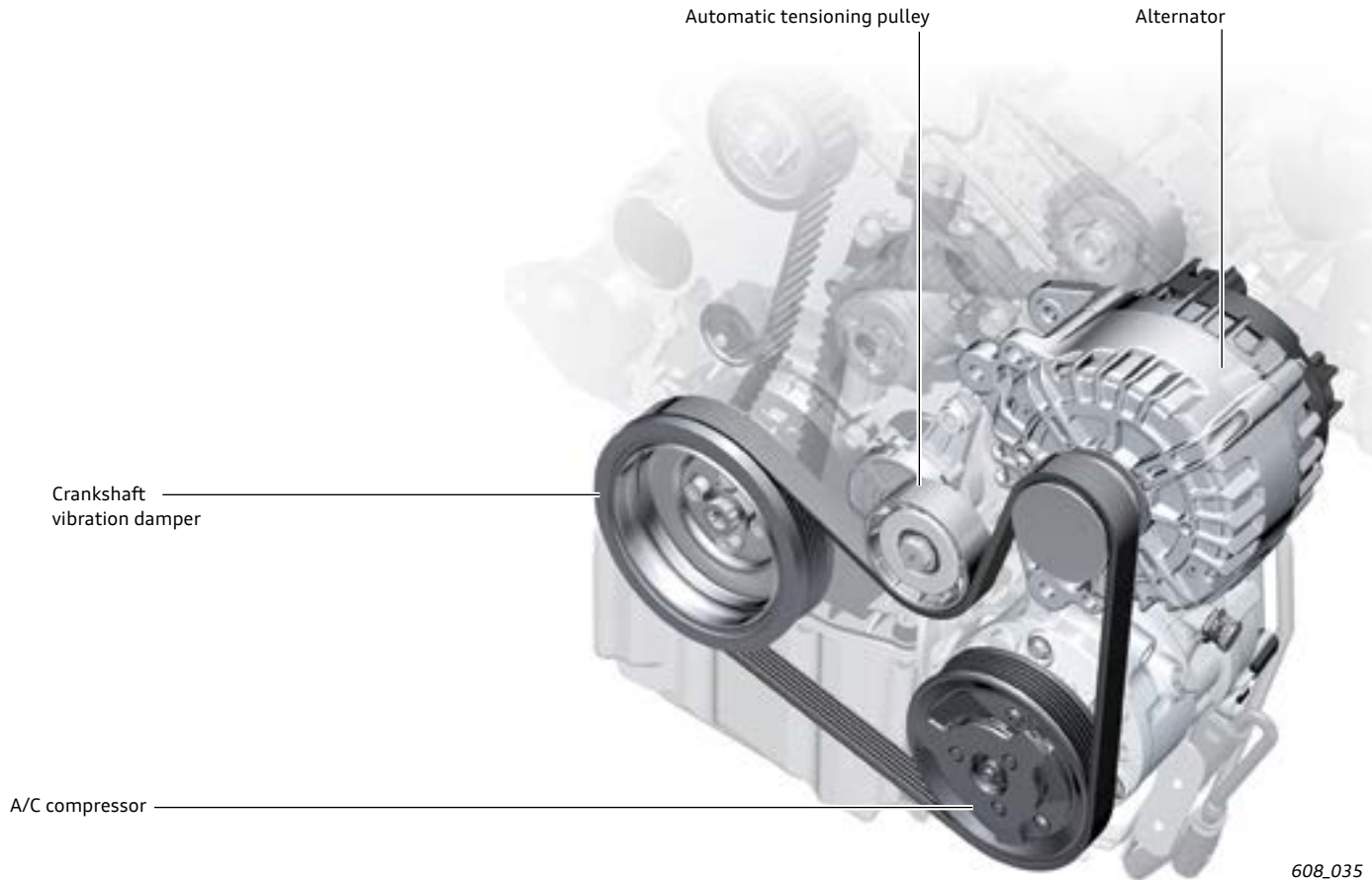
The camshafts, high pressure fuel pump and engine coolant pump are all driven by the crankshaft via a toothed belt. The toothed belt is tensioned by a spring operated automatic belt tensioner. Two idler rollers ensure better meshing of the toothed belt to the drive sprockets.



## Auxiliary component drive

Two auxiliary components - the alternator and the air conditioning compressor - are driven by the crankshaft with a poly V-belt. The pulley on the crankshaft also serves as a vibration damper.

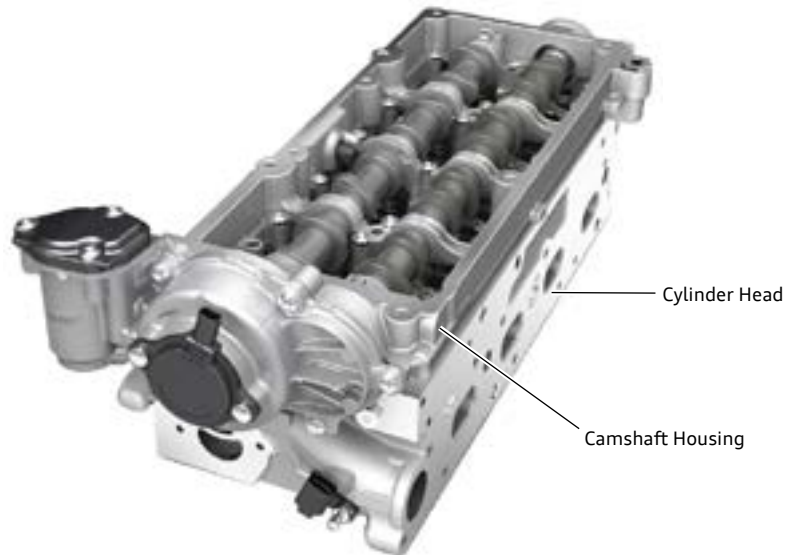
The poly V-belt is tensioned by a spring-loaded belt tensioner.



## Cylinder Head

The cylinder head of the engine is a cross-flow design made of aluminum alloy. The valves are operated by two overhead camshafts integrated into a separate housing module. One camshaft is driven by the toothed drive belt. The second camshaft is driven by a spur gear attached to the first.

Because of the valve layout for the cylinders, each camshaft controls both intake and exhaust valves.

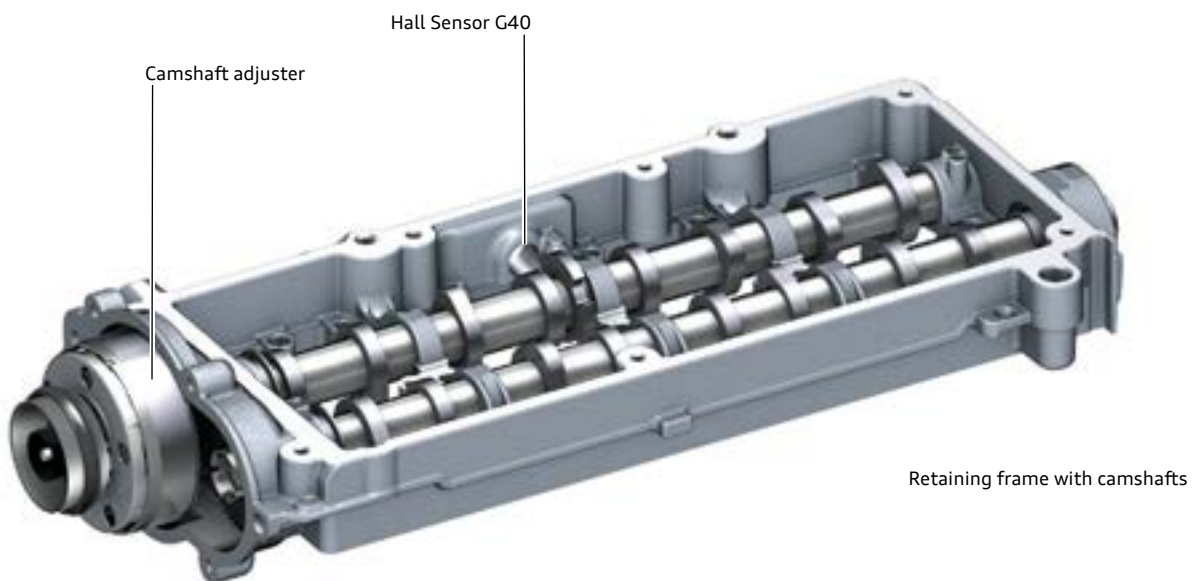


## Camshaft housing

The camshafts are integrated into a closed retaining frame using a thermal joining process and cannot be separated from the frame. This design ensures a rigid support for the camshaft bearings while keeping weight low.

To reduce friction, the first bearing (which is subjected to the highest load forces of the toothed drive belt) is a needle bearing.

The sender wheel for Camshaft Position Sensor G40 is located on one camshaft. It provides the ECM the current position of both camshafts.



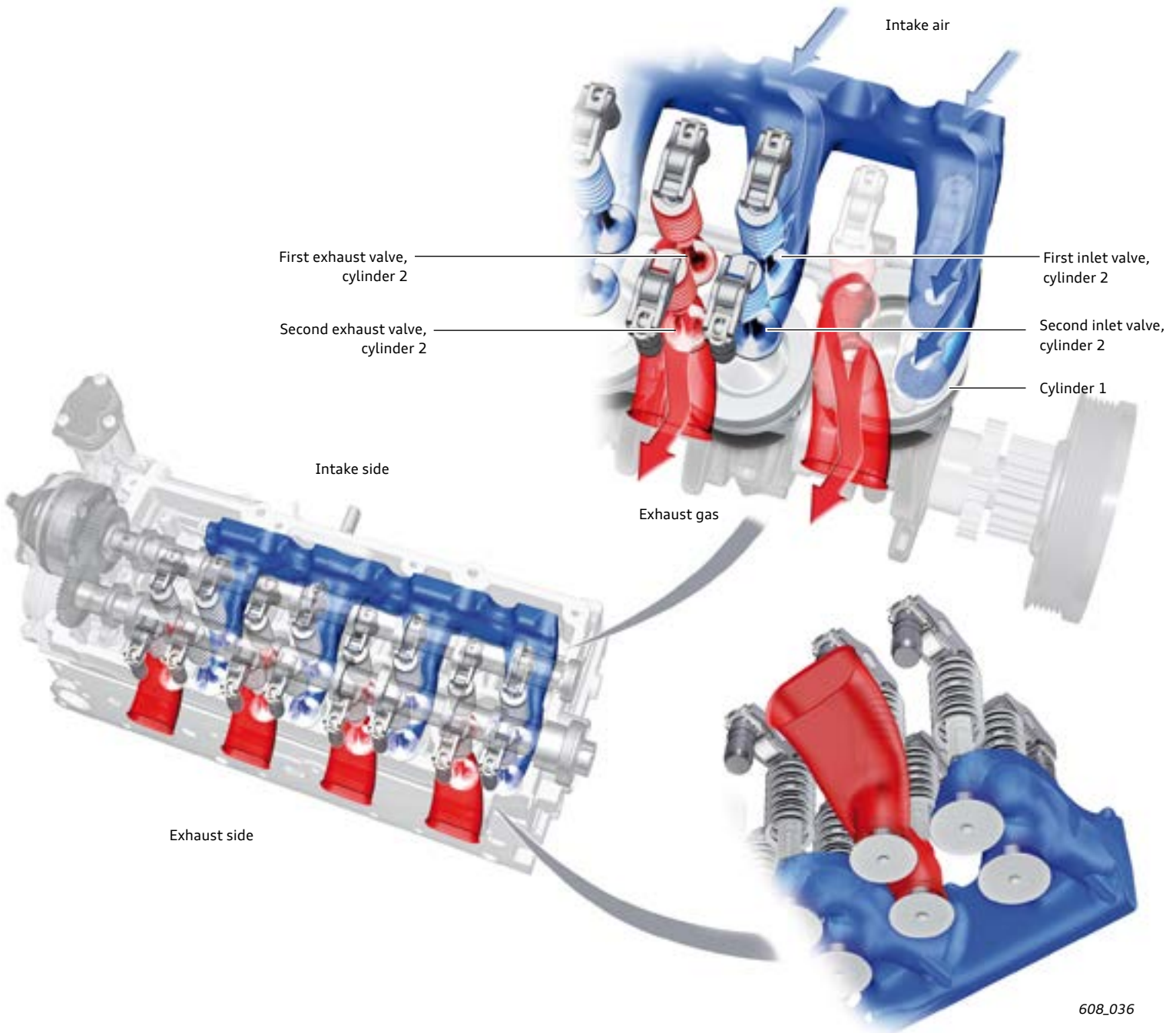
### Note

The camshafts can only be replaced together with the housing if repairs are necessary.

## Layout of the valves

The layout of the valves in the cylinder has been changed when compared to the previous generation diesel engine. The position of the valves (sometimes referred to as the 'valve star') has been rotated to the longitudinal axis of the engine. This means that the intake and exhaust ports for each cylinder are positioned one behind the other in the direction of flow.

It also means that each camshaft actuates one intake and one exhaust valve per cylinder. The valve layout was re-designed to allow maximum air delivery and enhance the swirl effect. It also helps ensure compliance to current and future exhaust emission standards.

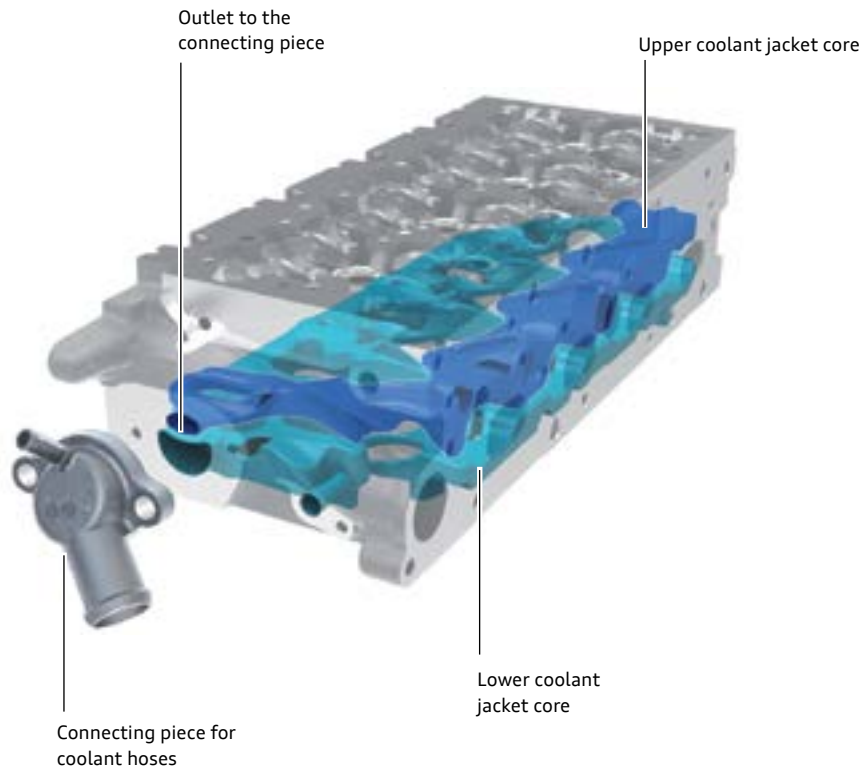


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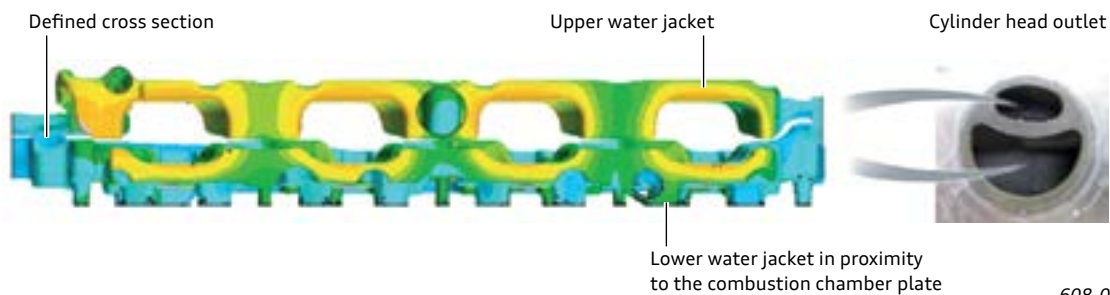
## Cylinder head coolant jacket

The coolant jacket in the cylinder head is divided into upper and lower sections. The lower coolant jacket core has a larger volume, ensuring there is a high level of heat dissipation in the part of the cylinder head close to the combustion chamber. The two cores in the cast part of the cylinder head are separate.

When the engine is cold, the coolant is channelled out of the upper and lower core, through the connecting piece and towards the heat exchanger for the heater.



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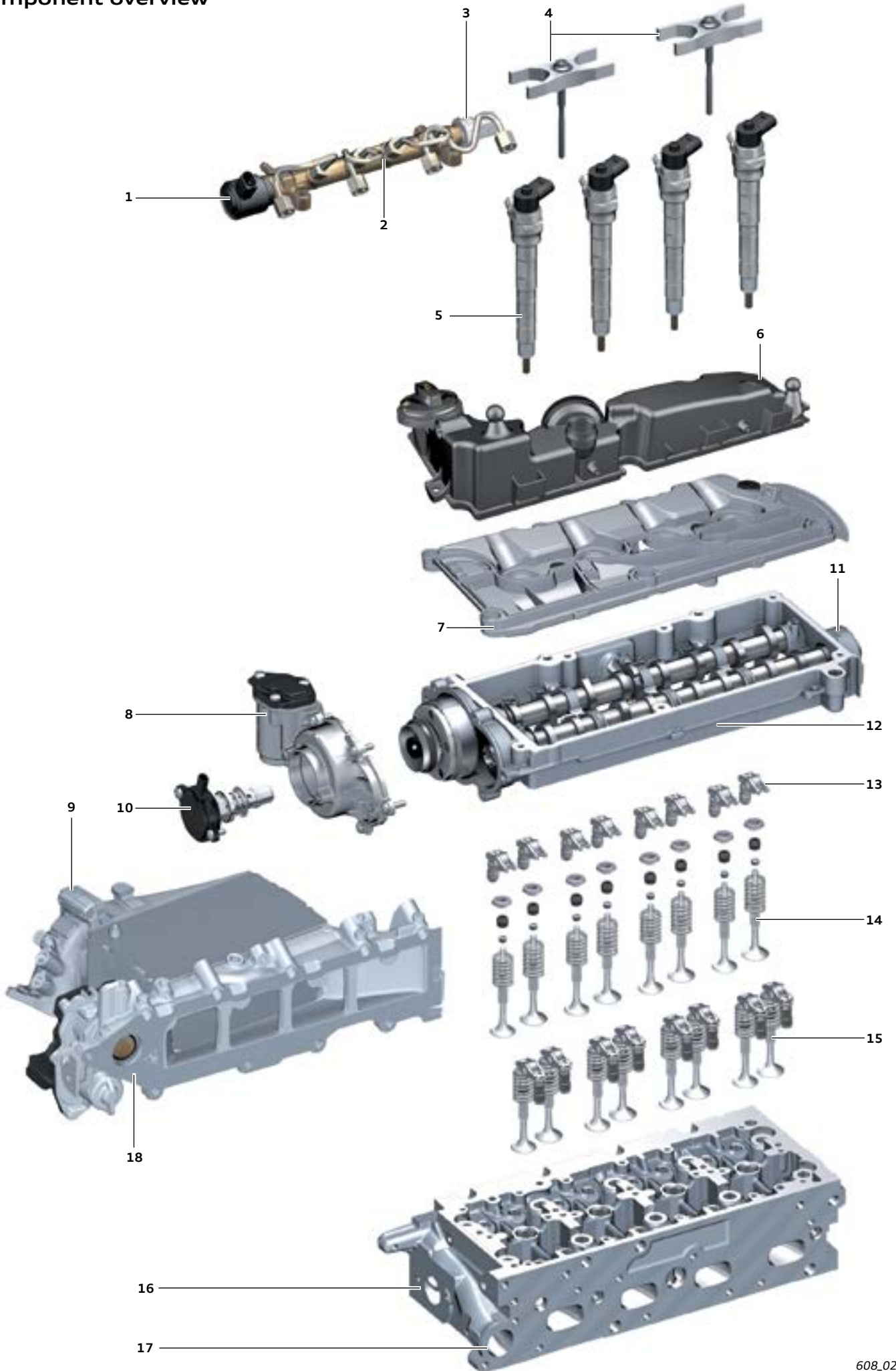
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### Legend for illustration on page 18:

- |   |  |    |  |
|---|--|----|--|
| 1 | Fuel Pressure Regulator Valve N276                       | 10 | Camshaft Adjustment Valve 1 N205                   |
| 2 | High pressure fuel reservoir                             | 11 | Needle bearing                                     |
| 3 | Fuel Pressure Sensor G247                                | 12 | Bearing frame with camshafts                       |
| 4 | Fuel injector clamps                                     | 13 | Roller-type cam follower                           |
| 5 | Fuel injectors   | 14 | Camshaft 1 valves                                  |
| 6 | Positive crankcase ventilation and vacuum reservoir      | 15 | Camshaft 2 valves                                  |
| 7 | Cylinder head cover                                      | 16 | Cylinder head                                      |
| 8 | Pressure accumulator for the variable valve timing       | 17 | High pressure EGR duct                             |
| 9 | Intake manifold module with integrated charge air cooler | 18 | Fuel distributor rail with high pressure EGR valve |



# Component overview



# Variable camshaft timing

## Introduction

Variable camshaft timing is currently only used on engines that must meet the EU6 or BIN5 Tier 2 emission standard. Multiple variables can be controlled through camshaft timing adjustments.

For example, a swirl charge motion can be induced by using variable intake openings which make the use of a separate swirl flap unnecessary. Another alternative is to adapt the intake valve timing for advanced and/or retarded closing which allows NO<sub>x</sub> and CO<sub>2</sub> emissions to be reduced. Compression can also be effectively reduced by means of a variable intake timing mechanism. This would result in lower compression temperatures and in turn, reduce NO<sub>x</sub> emissions.

In addition to reducing emissions, future technical developments will focus on reducing fuel consumption.

The current technical innovations allow

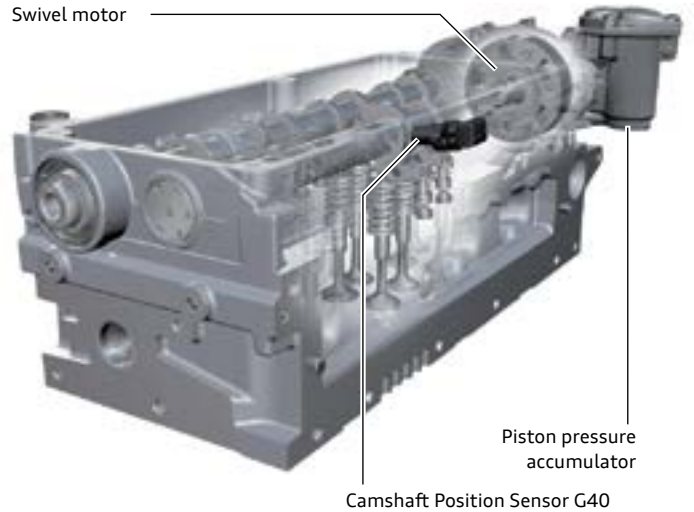
- ▶ Optimized volumetric efficiency at full throttle
- ▶ Optimized emission reduction and fuel efficiency through variable (and thus more effective) compression
- ▶ Maximum combustion pressure expansion utilization
- ▶ High compression ratios at cold start

Variable valve timing is done by a hydraulically moving (engine oil pressure) a swivel motor in the camshaft adjuster.

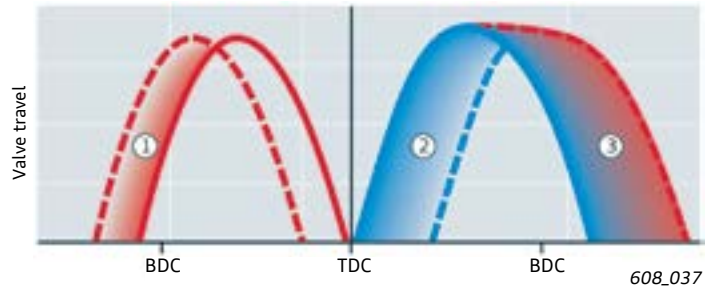
When the engine is started, the swivel motor is held in the advanced timing position by a locking element until the required oil pressure is reached.

The active adjustment range for the intake and exhaust valves is 50 degrees of crankshaft angle after retard.

## Design



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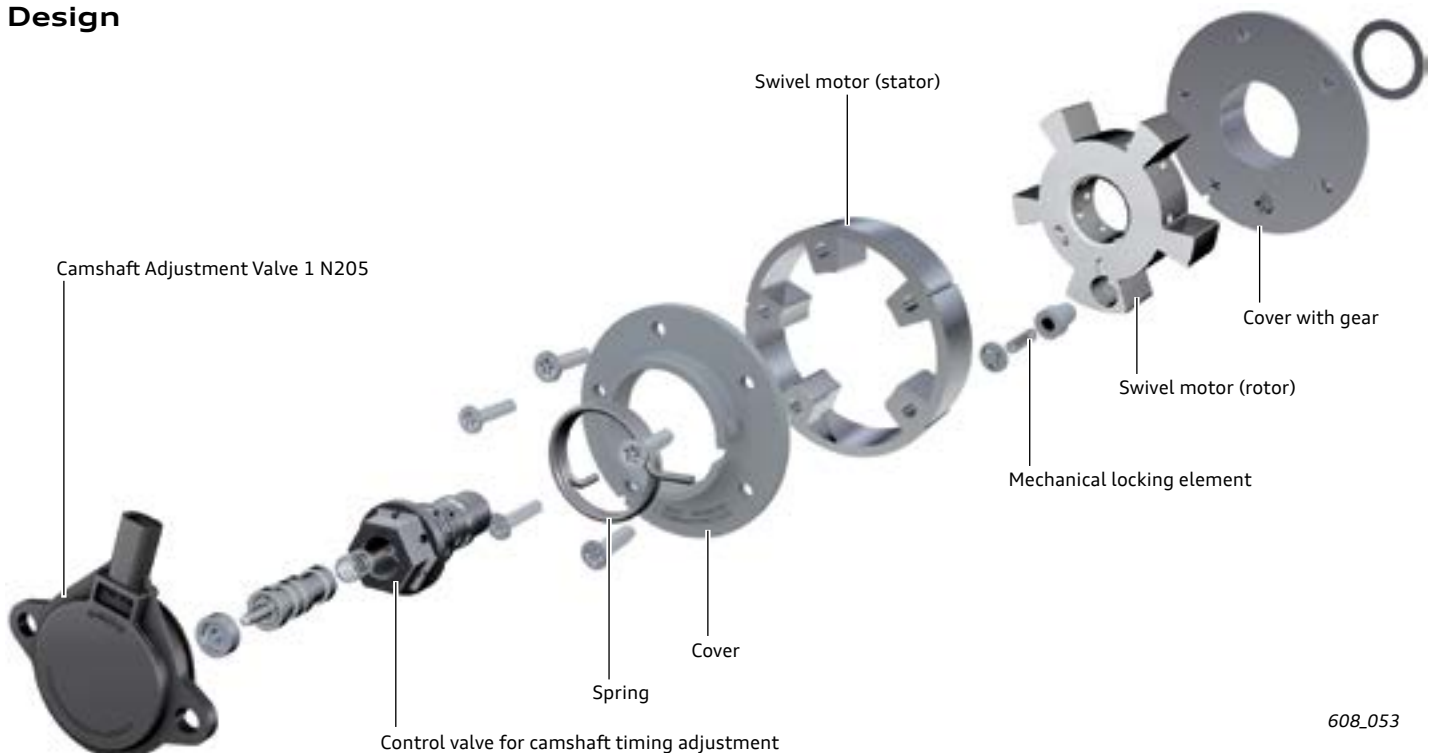
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### Key:

- ① Exhaust: variable opening
- ② Intake: variable opening
- ③ Intake: variable closing

**Advance:** both intake valves open simultaneously

**Retard:** only the rear intake valve on the "exhaust side" opens; opening of the second intake valve is delayed

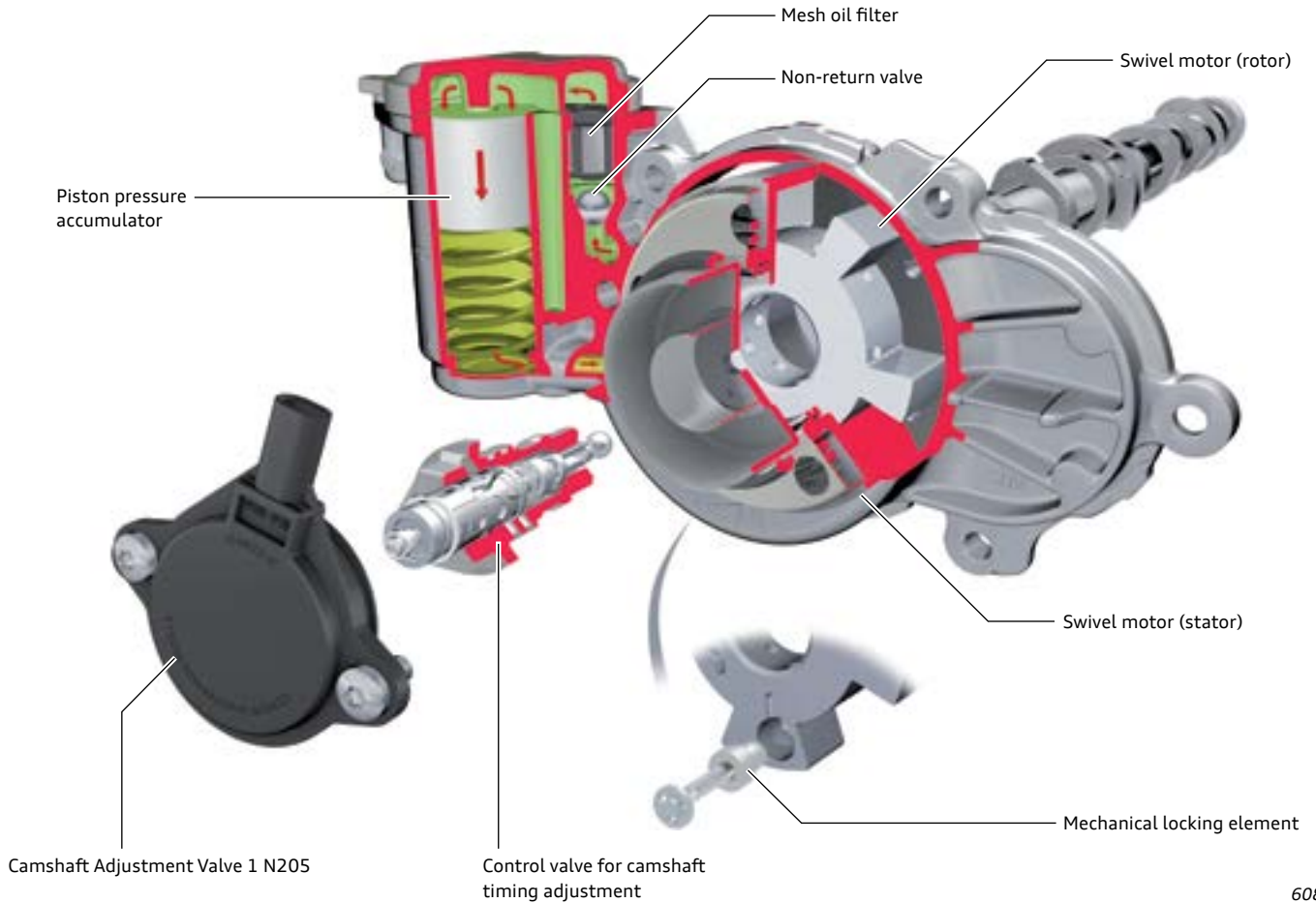


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## Function

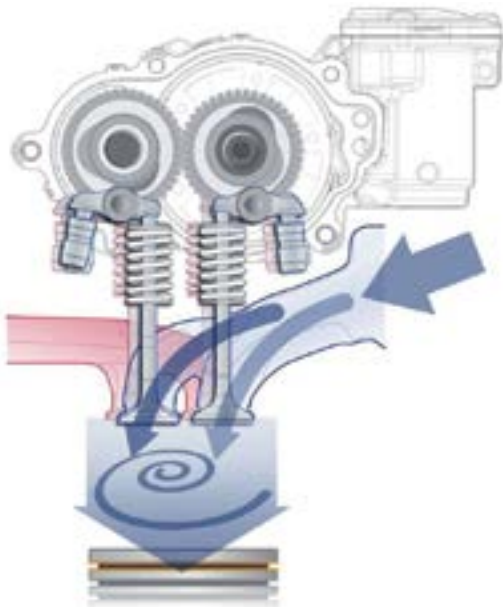
The inner vane ring (rotor) of the swivel motor is connected to the camshaft. The outer ring (stator) is attached to a gear which in turn engages a gear of the belt driven camshaft. The camshaft is adjusted relative to the crankshaft by applying oil pressure to working chambers between the rotor and stator.

The engine oil pump supplies the swivel motor with pressurized oil via a separate oil gallery in the cylinder head. Adjustment is controlled by the ECM through a 4/2-way proportioning valve. The ECM provides a pulse-width-modulated signal to activate the valve.



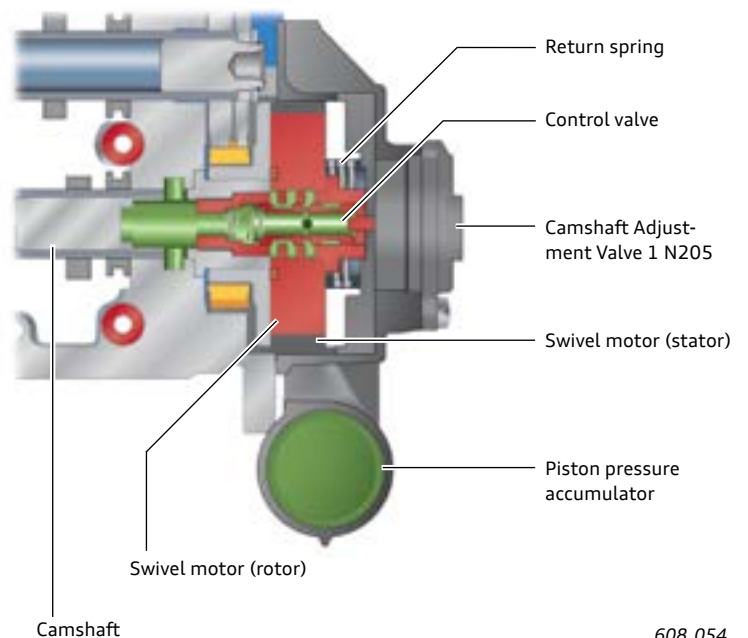
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## Airflow – at retarded ignition timing during the intake cycle



608\_060

## Cross-section view of swivel motor



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## Operating ranges

A swivel motor must be subjected to a high volumetric oil flow during the adjustment cycle to make a rapid control response. To ensure a rapid response in the first stage at a low pressure level, a pressure accumulator is integrated with the adjuster. The holding pressure inside the accumulator can be up to 1.8 bar. N205 determines when the pressure accumulator releases oil into the corresponding port on the swivel motor based on information from the ECM.

In the un-pressurized oil chamber, oil is expelled from the swivel motor and forced into the return line. If the oil gallery supply pressure is less than the pressure inside the accumulator during camshaft adjustment, the adjustment is assisted by the accumulator.

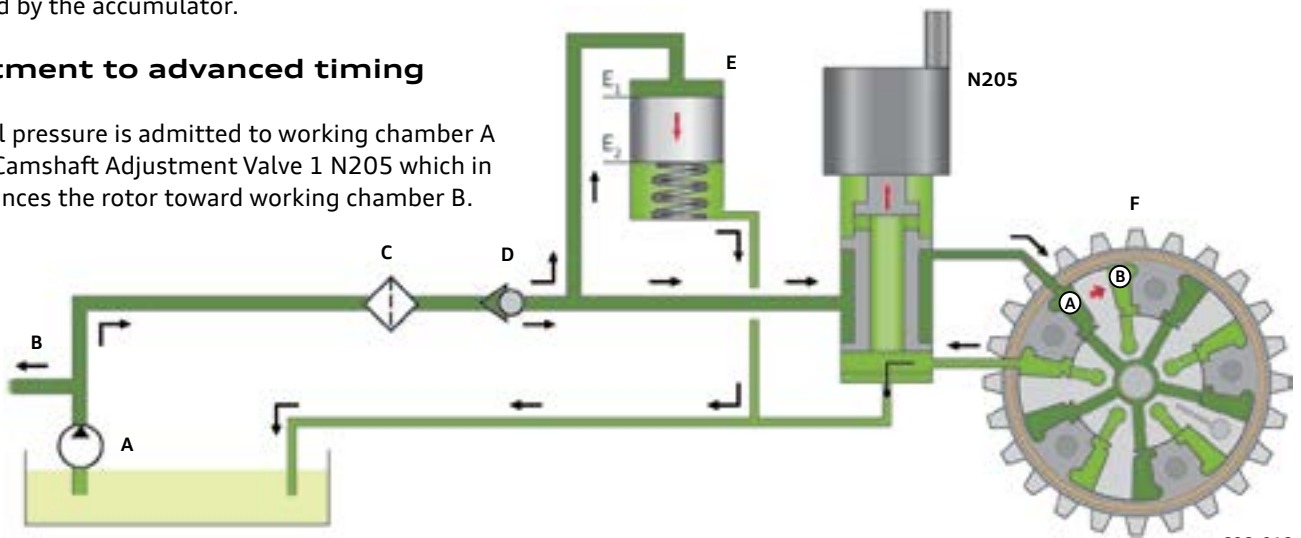
When the swivel motor reaches its end position, the oil pressure in the accumulator is restored and the pressure in the feed line is at gallery pressure.

N205 can adjust in such a way that both working chambers are subjected to oil pressure. Depending on the oil pressure conditions in the working chambers, both the rotor and the camshaft are adjusted to either “advance” or “retard”.

When the engine is switched off, the swivel motor is adjusted to the “advanced” position by the return spring and locked into its position.

### Adjustment to advanced timing

Engine oil pressure is admitted to working chamber A through Camshaft Adjustment Valve 1 N205 which in turn advances the rotor toward working chamber B.

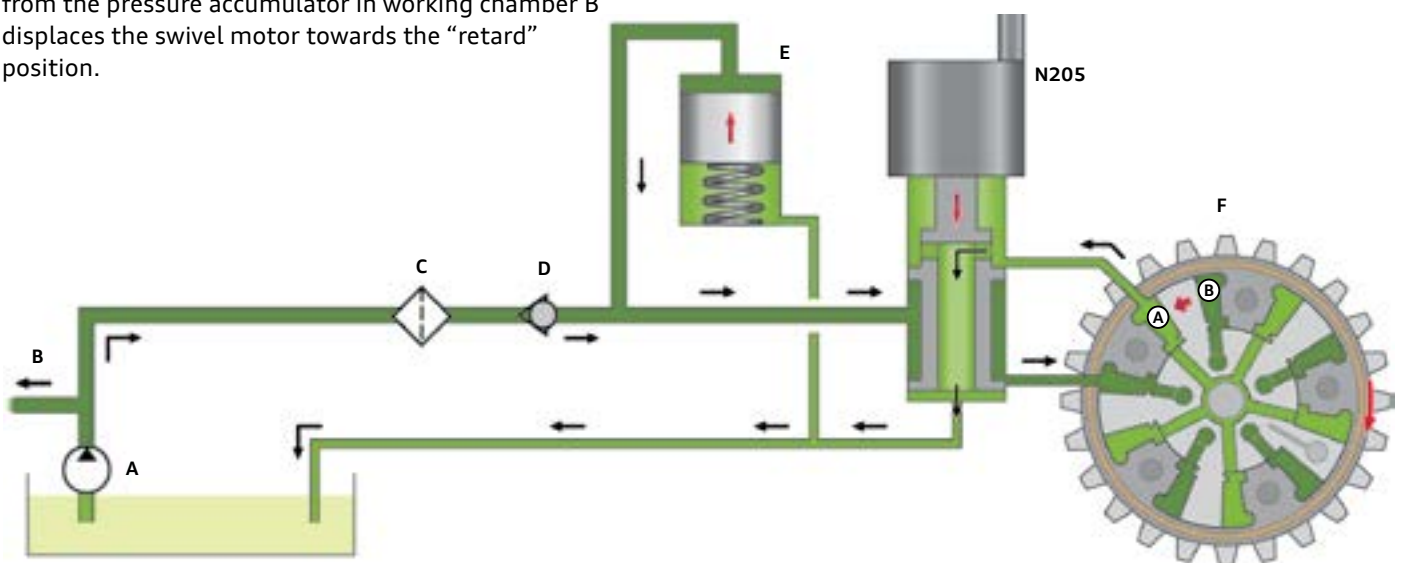


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### Adjustment to retarded timing

The camshaft is locked in the “advanced” position. The spring-loaded locking element is released when the oil pressure is sufficient. N205 opens working chamber A releasing the oil pressure into the return line. Oil pressure from the pressure accumulator in working chamber B displaces the swivel motor towards the “retard” position.

Continuously variable valve timing is achieved by pulse-width-modulated activation.



608\_012

- Key:**
- Ⓐ Ⓑ Working chambers in the swivel motor
  - A Oil pump
  - B Engine lubrication system
  - C Mesh oil filter
  - D Non-return valve
  - E Piston pressure accumulator
  - E<sub>1</sub>: Start of charging at approx. 0.6 bar
  - E<sub>2</sub>: End of charging at approx. 1.8 bar
  - F Camshaft adjuster (swivel motor)
  - N205 Intake camshaft timing adjustment valve 1

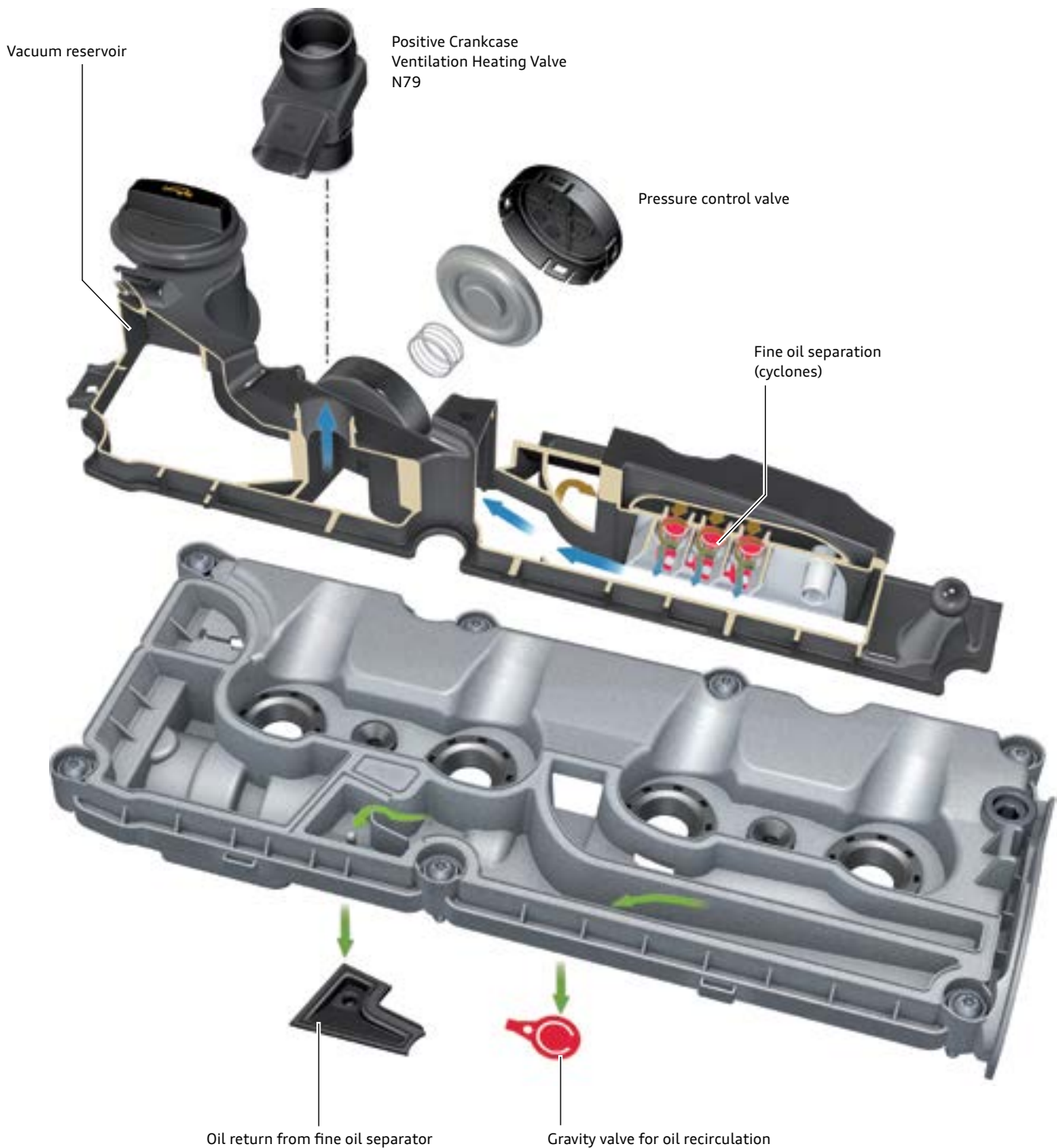
# Positive crankcase ventilation

The components of the crankcase breather are integrated into the polyamide cylinder head cover, together with the oil filler neck and the pressure accumulator for the vacuum system of the engine.

Separation of the coarse and fine oil from the blow-by gases as well as the pressure regulation of the crankcase also occurs in the cylinder head cover. The blow-by gases from the crankcase flow to the coarse oil separator through small ports and then into the cyclone-type fine oil separation section.

After passing through the cyclones, the blow-by gases flow to the pressure control valve; additionally, they are then fed into the combustion chamber through the intake manifold.

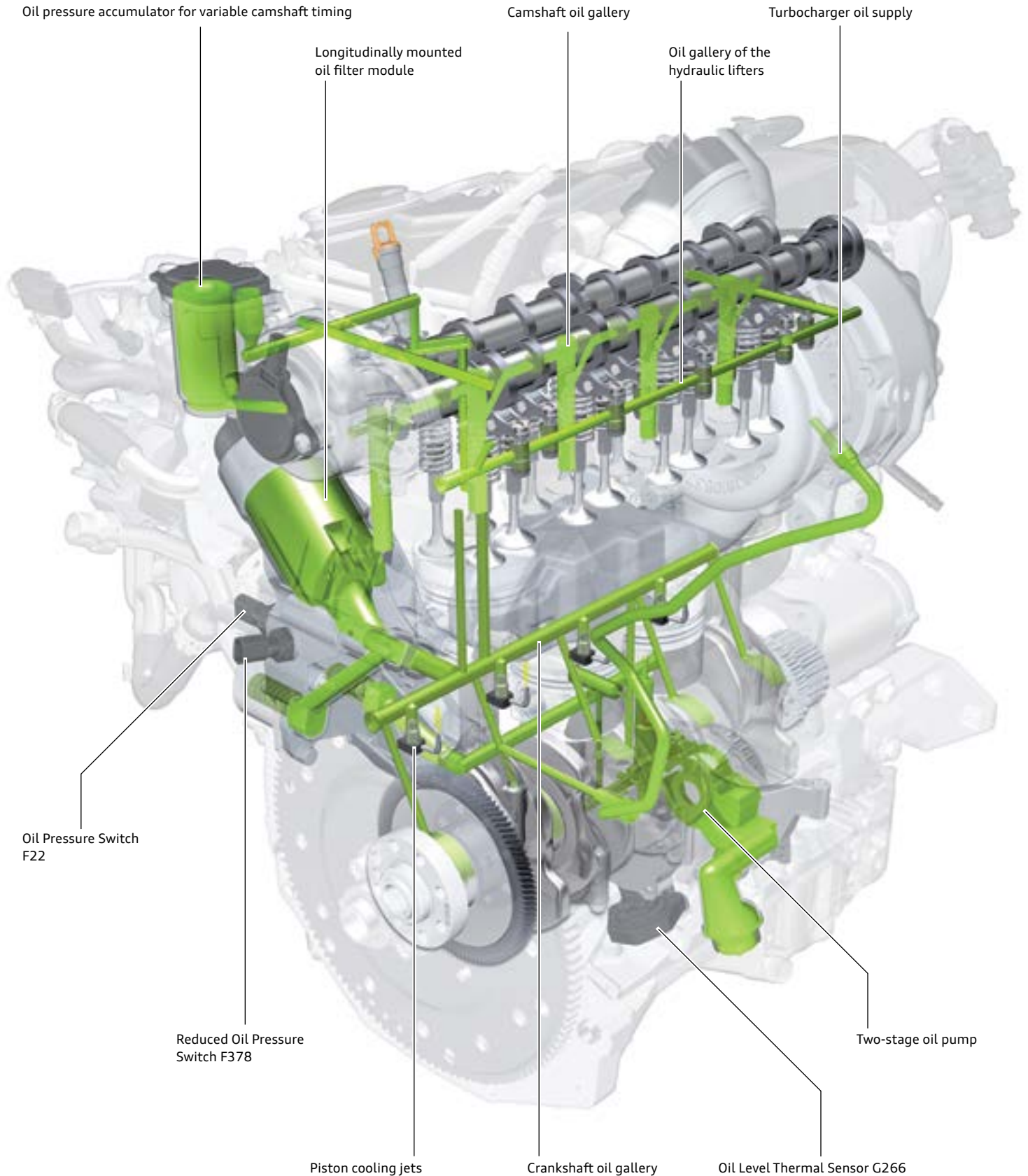
Positive Crankcase Ventilation Heating Valve N79 is used to prevent the freezing of the residual moisture of the blow-by gases during cold weather operation.



# Oil supply

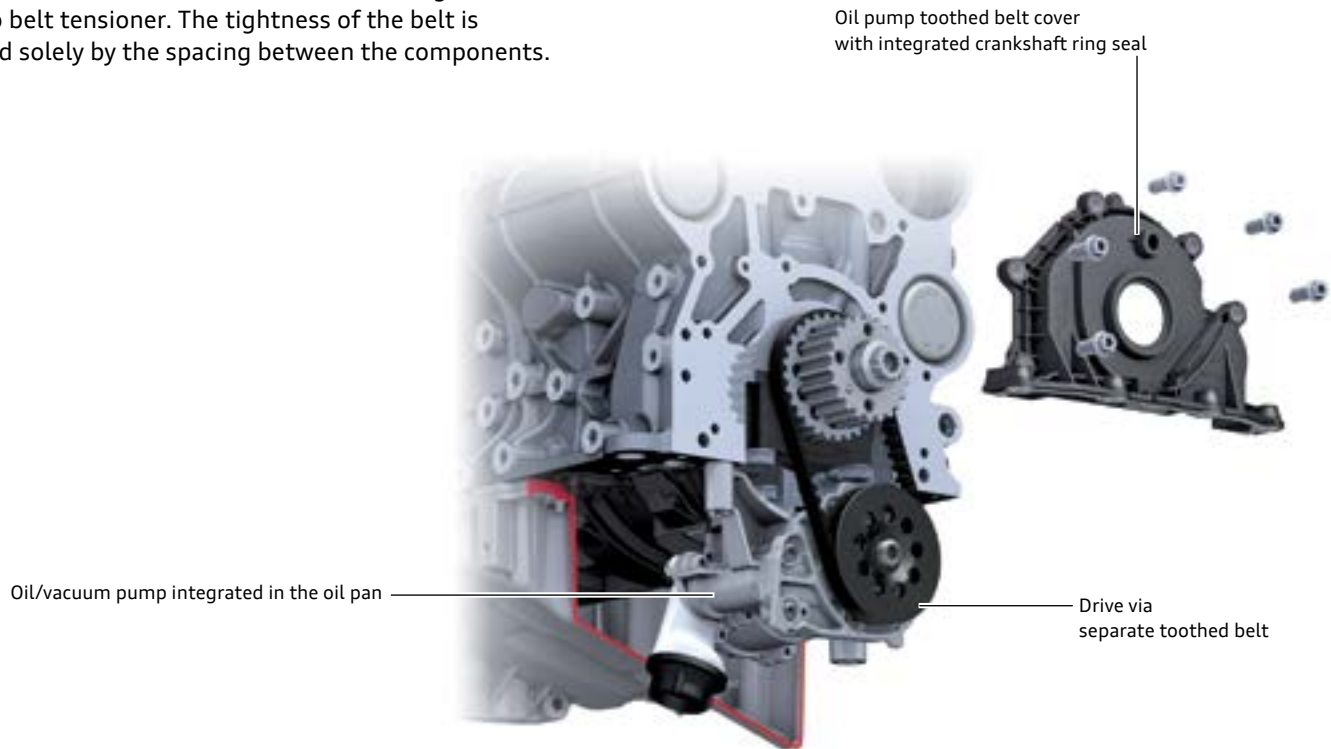
## Oil circuit

Engine oil pressure is generated by a flow-rate controlled oil pump. It is driven by the crankshaft via a separate toothed belt. The oil pressure can be switched to a high or a low pressure stage via the pump.



## Oil pump with integral vacuum pump

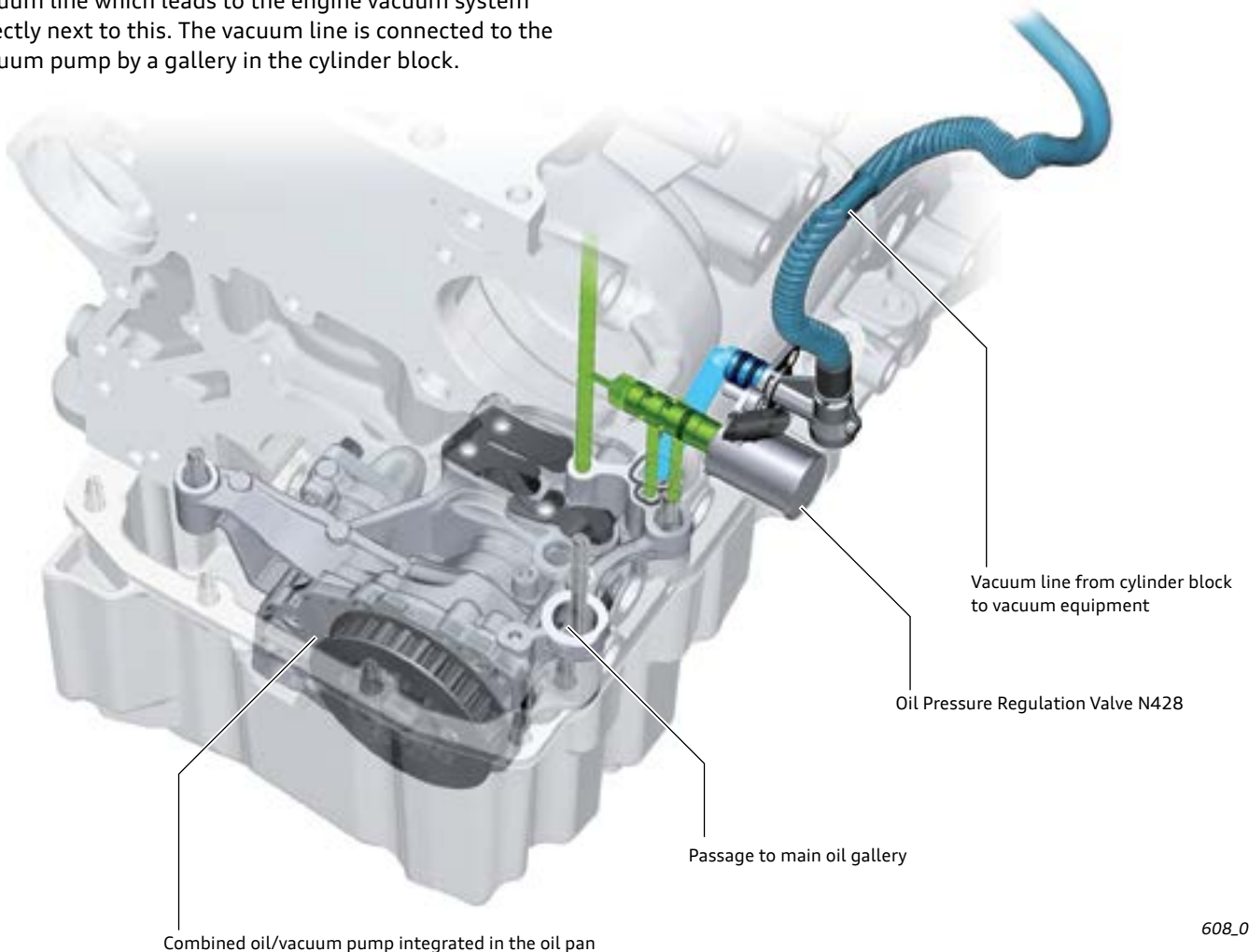
A combined oil/vacuum pump is located in the oil pan and bolted directly to the cylinder block. It is driven by a toothed belt. The toothed belt is immersed in engine oil and has no belt tensioner. The tightness of the belt is determined solely by the spacing between the components.



## Connections to the vacuum supply and oil circuit

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Oil Pressure Regulation Valve N428 is installed above the sump in the cylinder block. There is a connection for the vacuum line which leads to the engine vacuum system directly next to this. The vacuum line is connected to the vacuum pump by a gallery in the cylinder block.



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## Design

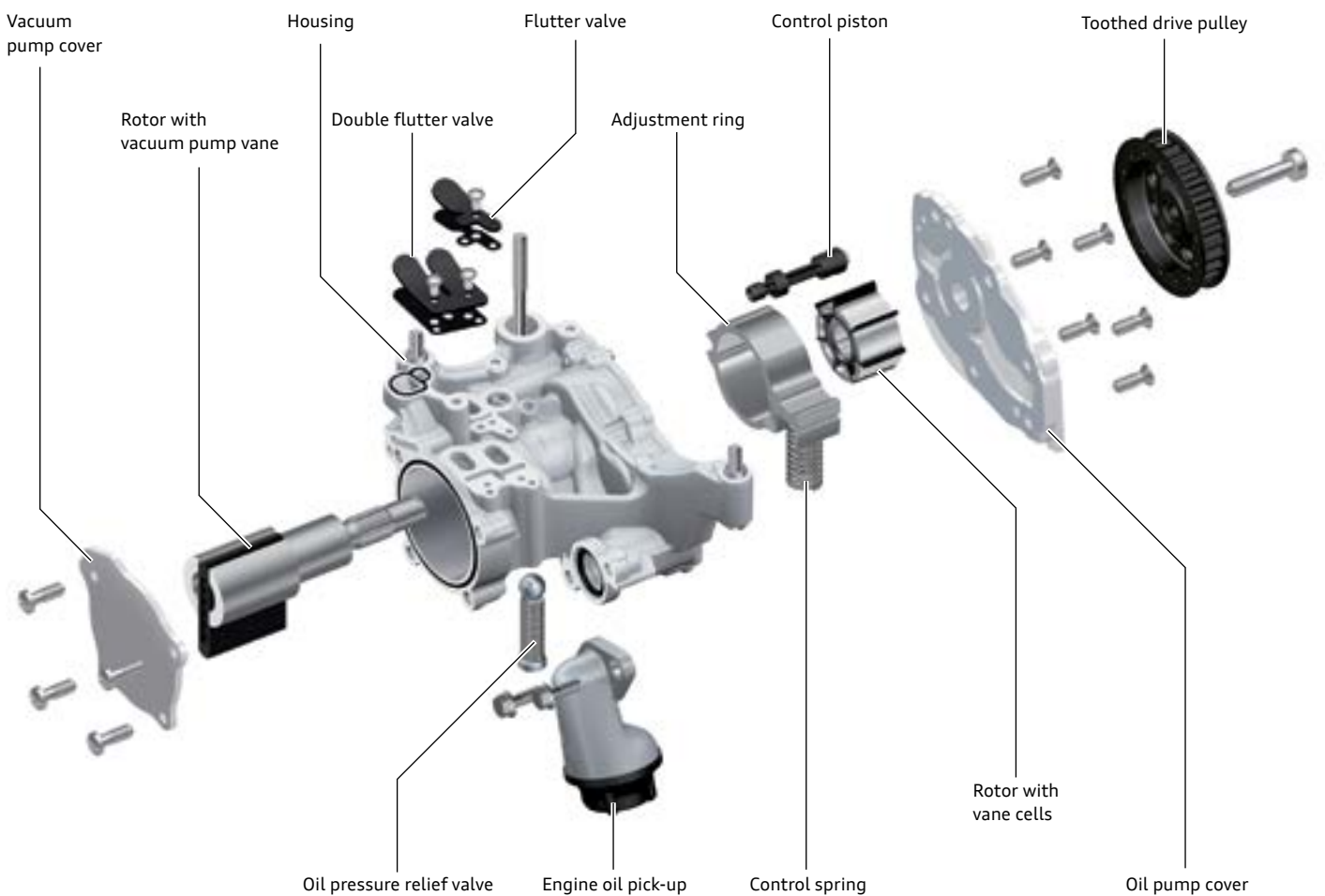
The oil pump is a flow-rate controlled vane pump on which the eccentrically mounted adjustment ring allows the delivery characteristics of the pump to be regulated. The position of the rotating adjustment ring changes the flow rate of the pump, and therefore allows the drive output of the pump to be adapted to the engine's operating conditions.

By applying oil pressure to the adjustment ring via a control surface, it can be swivelled against the force of the control spring.

A specially shaped engine oil pick-up ensures reliable oil intake from the oil pan even when the vehicle is subjected to high transverse acceleration in high speed turns and banking.

The vacuum pump inducts air from the brake servo through a vacuum line and ports in the cylinder block.

The air is drawn through flutter valves into the cylinder block and ventilates its inner chamber. This air is then admitted into the combustion chamber via the engine breather as blow-by gas.

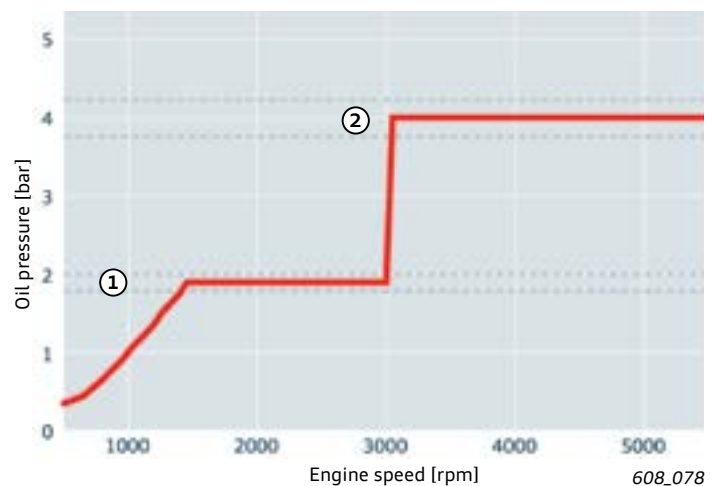


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## Oil pressure control

The oil pump operates in two pressure stages, which are activated depending on engine speed.

- ① Low pressure stage: oil pressure 1.8 – 2.0 bar
- ② High pressure stage: oil pressure 3.8 – 4.2 bar



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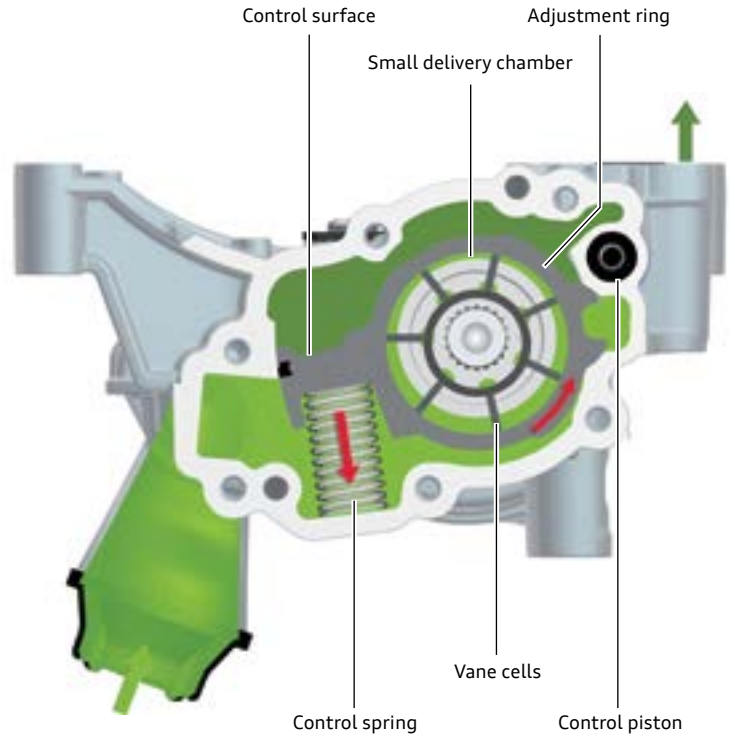
## Function

### Low delivery rate

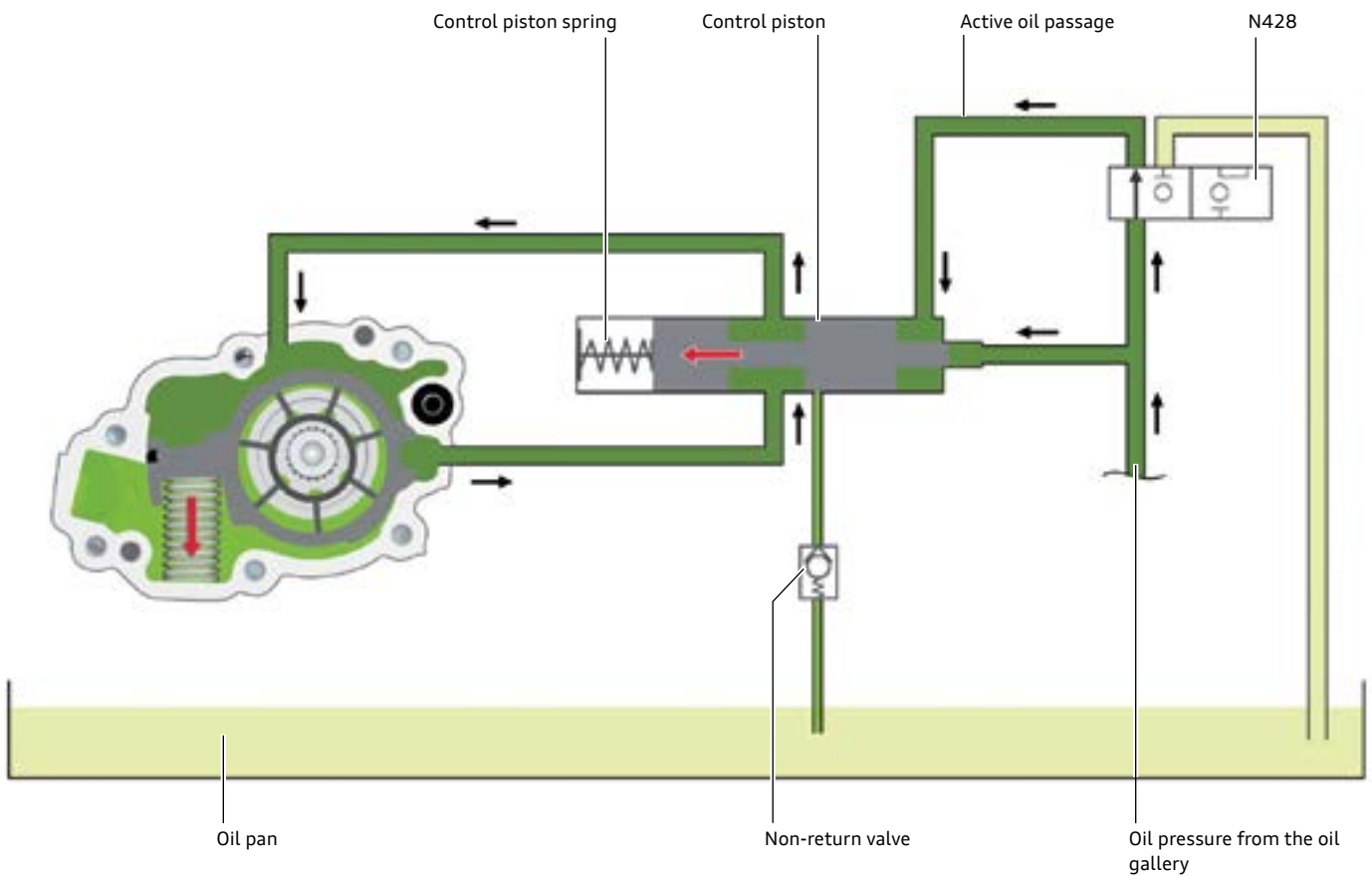
At low engine speeds, Oil Pressure Regulation Valve N428 is energized when the ECM connects it to ground. This opens the active passage to the control piston. The oil pressure now acts on both faces of the control piston, pushing the piston against its spring and opening the passage to the control surface of the adjustment ring.

The oil pressure now acts on the control surface of the pump. The force is greater than the control spring and swivels the adjustment ring counter-clockwise into the center of the vane cell pump which reduces the delivery space between the vane cells.

This lower pressure stage is activated dependent on engine load, engine speed, oil temperature and other operating parameters which in turn reduces the drive output requirement of the pump.



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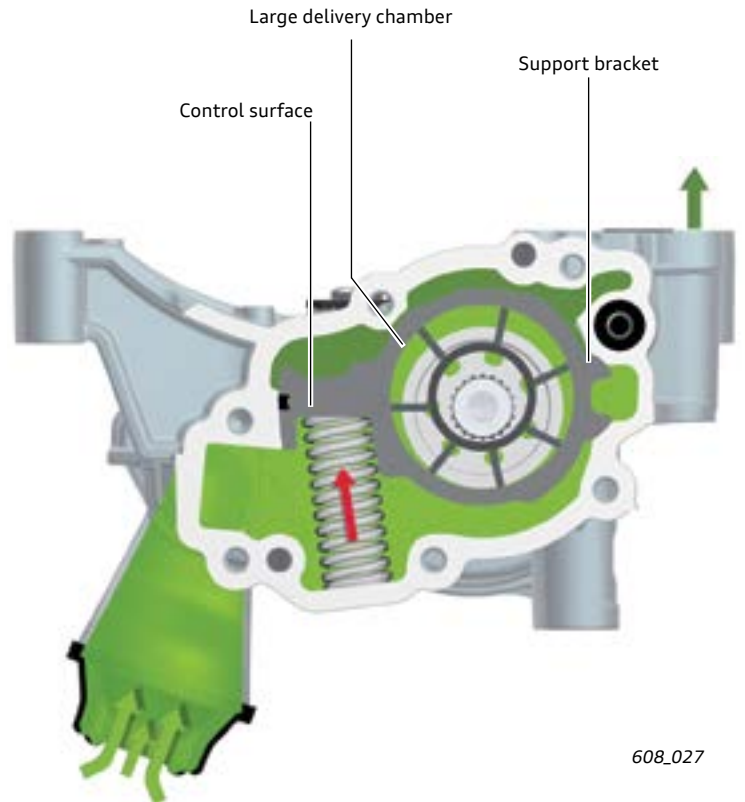
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## High delivery rate

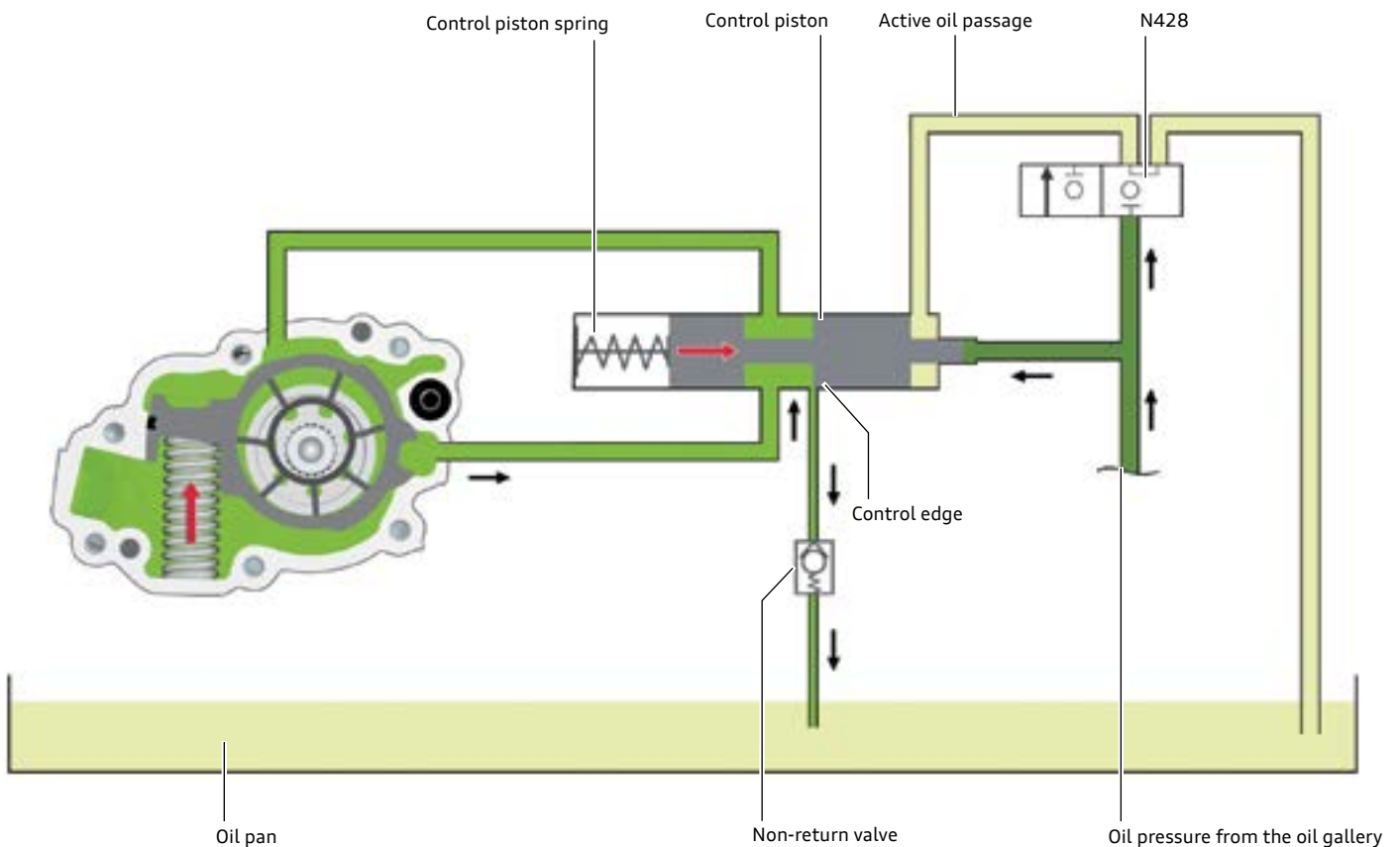
At high engine speed or load (for example, full throttle acceleration), Oil Pressure Regulation Valve N428 is de-energized by the ECM which in turn vents the active oil passage. The force of the remaining surface under oil pressure is less than the force of the control piston spring and closes the oil passage to the control surface of the adjustment ring.

Without oil pressure, the control spring swivels the adjustment ring clockwise around the center bearing. The adjustment ring now swivels out of its center position and increases the delivery space between the individual vanes which increases oil delivery. The higher volumetric oil flow is countered by the size of the oil galleries and crankshaft bearing play causing the oil pressure to increase.

If communication with the ECM is lost, spring force will move the control surface to the high delivery position. This ensures that the engine components are protected.



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### Note

The maximum rate of delivery is always available when the solenoid valve is de-energized.

## Oil filter module

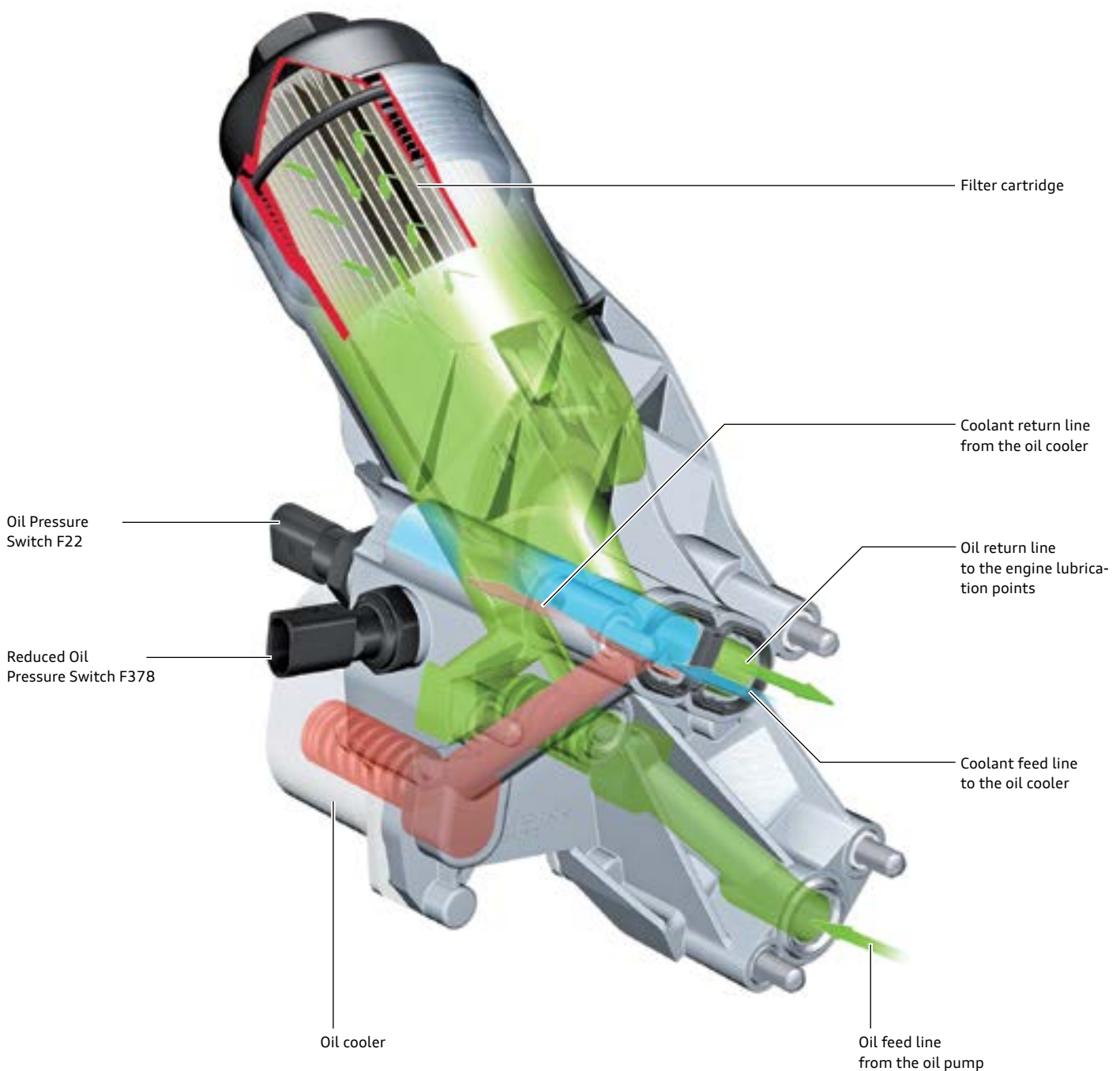
The oil filter module consists of the oil cooler, which is mounted to the side of the oil filter module, as well as the oil filter bypass valve and oil cooler bypass valve.

Depending on the engine's installation position, there are two different oil filter modules.

### Longitudinally mounted engines

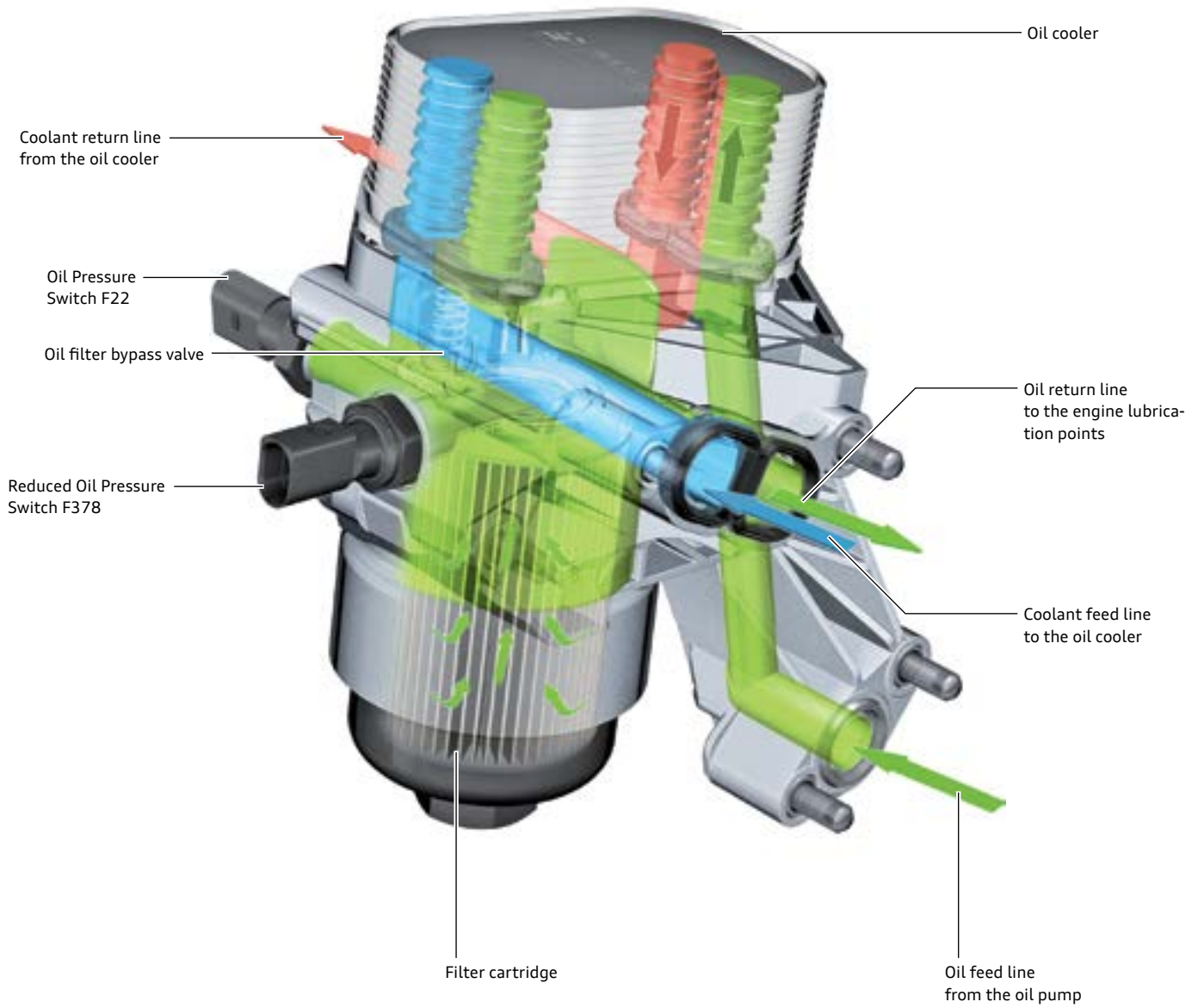
Components:

- ▶ Upright oil filter housing with oil drain valve
- ▶ Filter cartridge
- ▶ Reduced Oil Pressure Switch F378 (0.3 – 0.6 bar)
- ▶ Oil Pressure Switch F22 (2.5 – 3.2 bar)



## Transversely mounted engines

- ▶ Upright oil filter housing with oil drain valve
- ▶ Filter cartridge
- ▶ Reduced Oil Pressure Switch F378 (0.3 – 0.6 bar)
- ▶ Oil Pressure Switch F22 (2.5 – 3.2 bar)



608\_046

# Cooling system

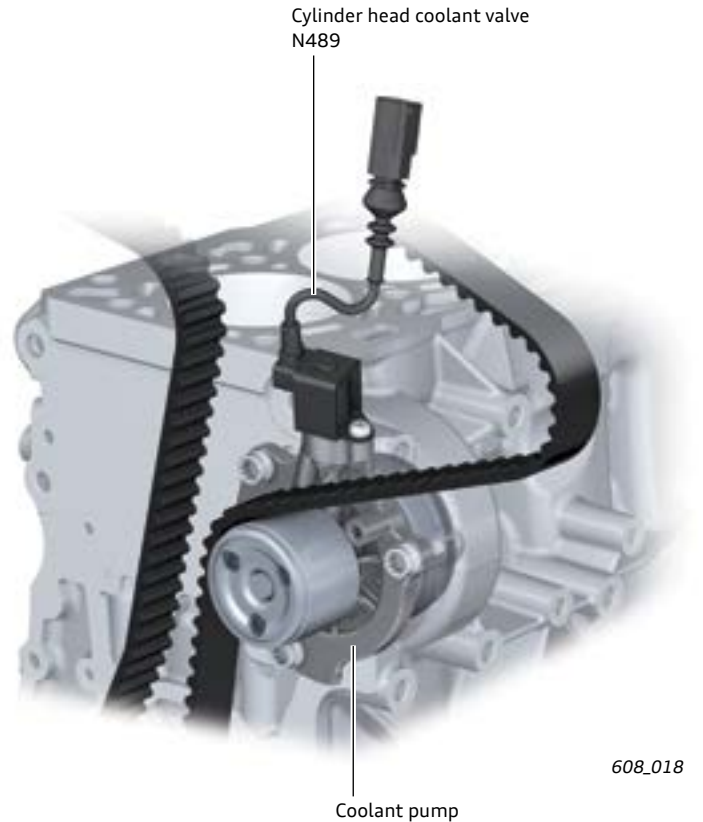
## Thermal management

The EA288 diesel engine uses a thermal management strategy designed to shorten the warm-up phase after a cold start and implement emission reduction measures quickly.

The thermal management system also directs the heat produced by the engine during normal operation to where it can be advantageously used to boost vehicle efficiency. A main focus is to reduce intra-engine friction.

The overall cooling circuit has three sub-circuits:

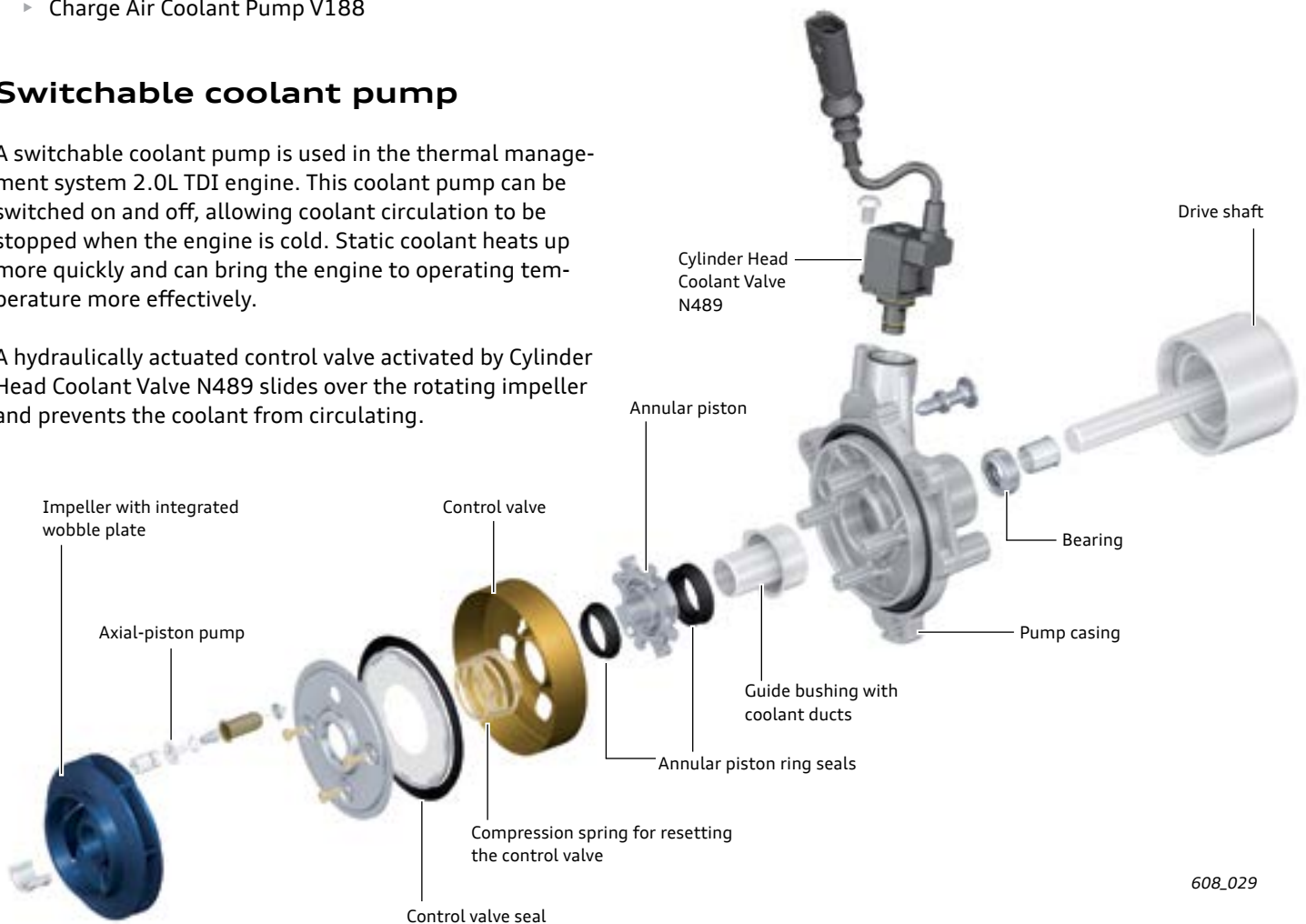
- ▶ Secondary cooling circuit (micro circuit)
  - ▶ Cylinder head
  - ▶ EGR cooler of low pressure exhaust gas recirculation system
  - ▶ Passenger compartment heat exchanger
  - ▶ Electrical auxiliary coolant pump
- ▶ Primary cooling circuit (high temperature circuit)
  - ▶ Cylinder block and intake manifold
  - ▶ Engine and transmission oil cooler
  - ▶ Coolant thermostat (3/2-way valve)
  - ▶ Main vehicle radiator
  - ▶ Switchable coolant pump
- ▶ Cooling circuit with charge air cooler (low temperature circuit)
  - ▶ Charge air cooler
  - ▶ Charge air cooler (in front of vehicle) radiator
  - ▶ Charge Air Coolant Pump V188



## Switchable coolant pump

A switchable coolant pump is used in the thermal management system 2.0L TDI engine. This coolant pump can be switched on and off, allowing coolant circulation to be stopped when the engine is cold. Static coolant heats up more quickly and can bring the engine to operating temperature more effectively.

A hydraulically actuated control valve activated by Cylinder Head Coolant Valve N489 slides over the rotating impeller and prevents the coolant from circulating.

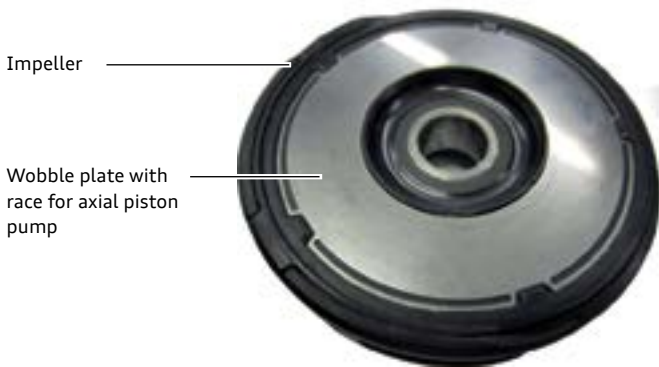


## Coolant pump function

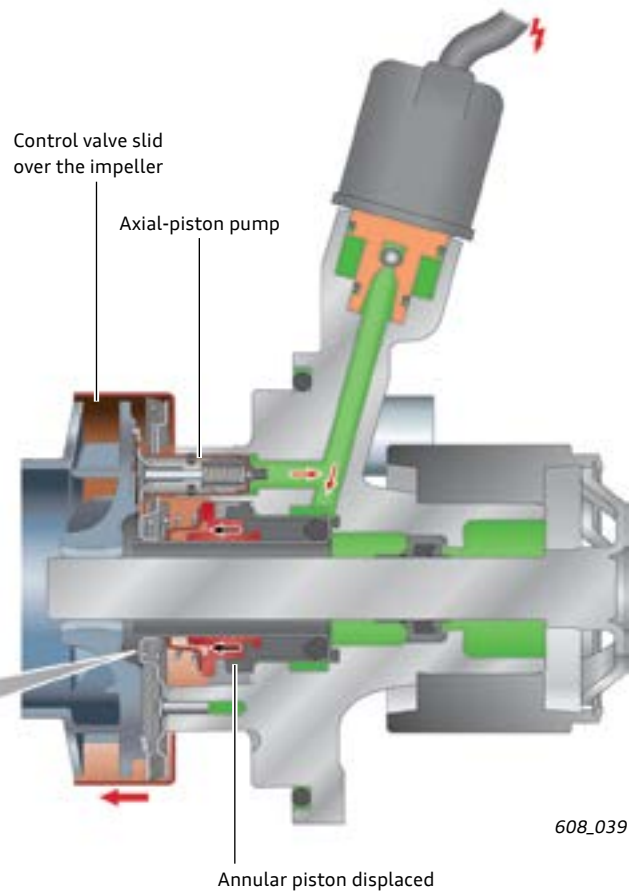
The control valve can slide over the impeller which will prevent coolant from being circulated. The impeller has an integral cast stainless steel plate that functions as a wobble plate. An axial piston pump integrated in the pump housing is actuated by the wobble plate. The pump recirculates the coolant to the coolant circuit via Cylinder Head Coolant Valve N489.

### Static coolant

When N489 is energized, the return port to the coolant circuit closes. This happens because the lifting motion of the axial piston pump produces a hydraulic pressure at the annular piston. The control valve slides over the impeller against spring tension and seals the impeller off from the cylinder block. No coolant is circulated.



Cylinder Head Coolant Valve N489  
ON

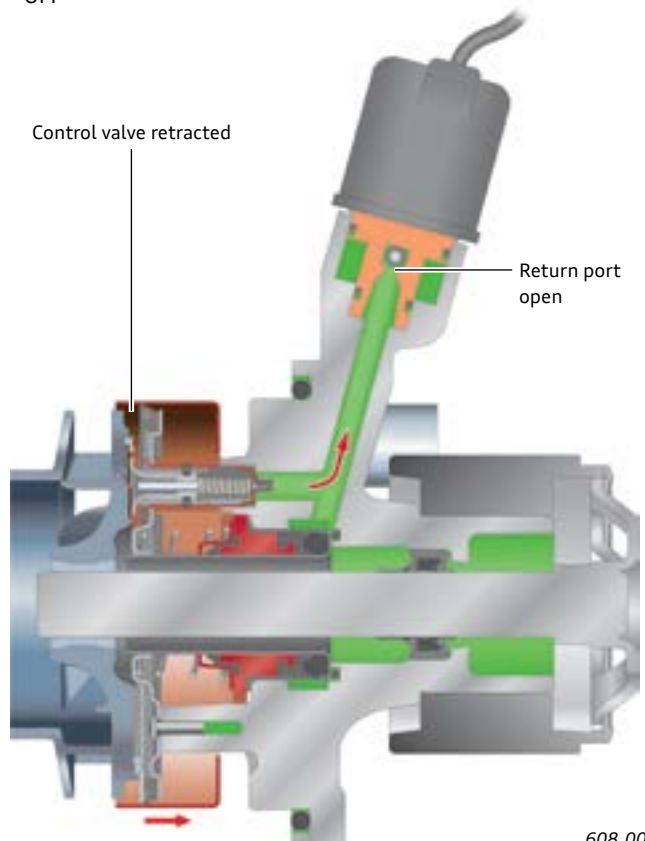


### Coolant is circulated

If N489 is de-energized, the return port to the coolant circuit opens, the ring-shaped piston is pushed back by the compression spring and restores the control valve to its original position.

The impeller is uncovered and the coolant begins to circulate. The axial piston pump operates whenever the engine is running.

Cylinder Head Coolant Valve N489  
OFF



eMedia



Coolant Pump Operation 1

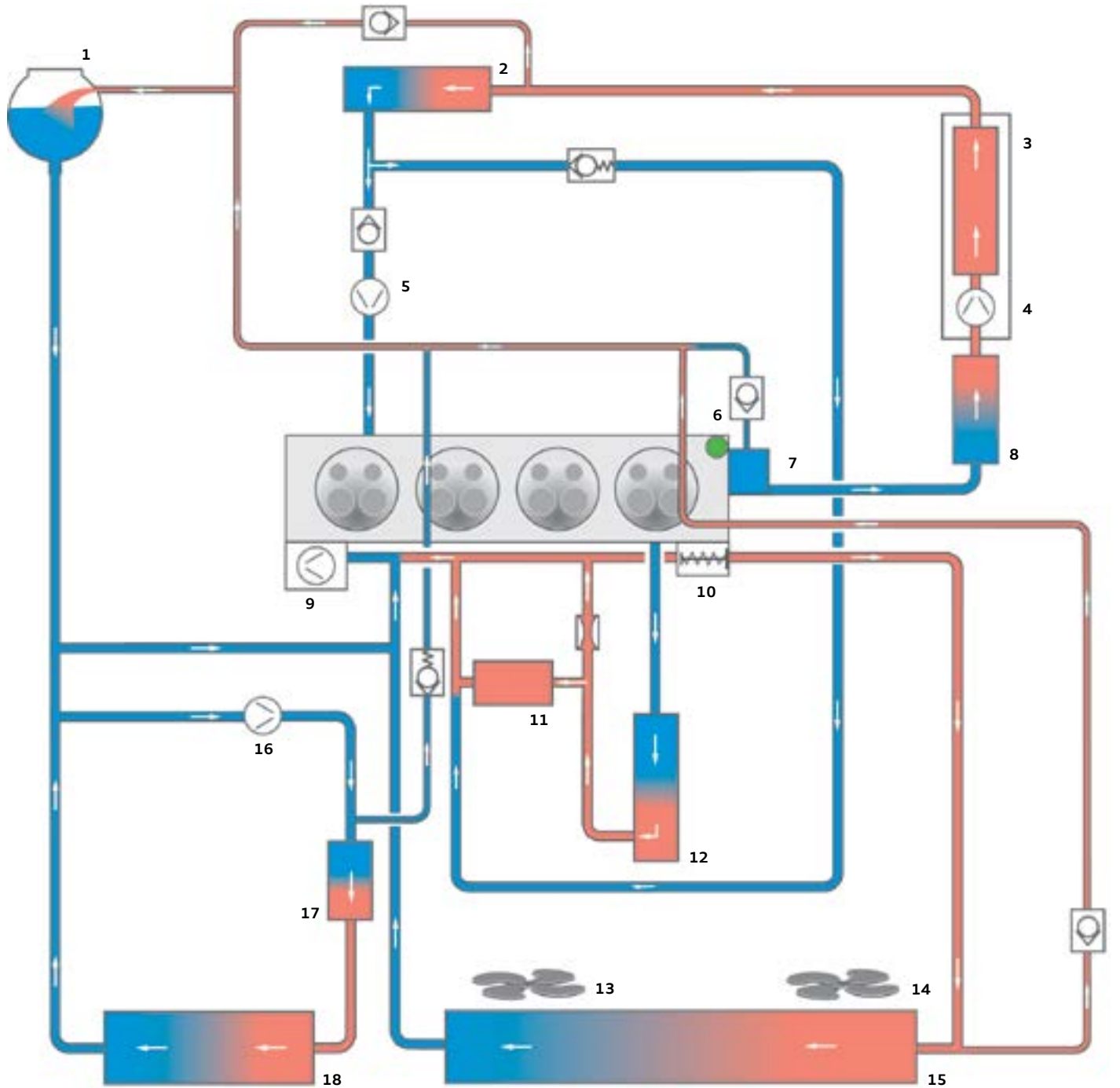
eMedia



Coolant Pump Operation 2

## System overview

The following diagrams show the cooling system in the engine version which meets the EU5 exhaust emission standard.



608\_073

### Key:

- |          |  |           |   |
|----------|--|-----------|---|
| <b>1</b> | Coolant expansion tank                                   | <b>10</b> | Coolant thermostat                              |
| <b>2</b> | Passenger compartment heat exchanger                     | <b>11</b> | Throttle valve                                  |
| <b>3</b> | Auxiliary heater (not for the North American market)     | <b>12</b> | Engine oil cooler                               |
| <b>4</b> | Recirculation Pump V55                                   | <b>13</b> | Coolant Fan V7                                  |
| <b>5</b> | Heater Support Pump V488                                 | <b>14</b> | Coolant Fan 2 V177                              |
| <b>6</b> | Engine Coolant Temperature Sensor G62                    | <b>15</b> | Radiator  |
| <b>7</b> | Coolant connection                                       | <b>16</b> | Charge Air Cooling Pump V188                    |
| <b>8</b> | EGR cooler   | <b>17</b> | Charge air cooler integrated in intake manifold |
| <b>9</b> | Cylinder Head Coolant Valve N489 (mounted on water pump) | <b>18</b> | Heat exchanger for charge air cooling           |

- █ Cooled coolant
- █ Heated coolant

## Secondary cooling circuit (micro circuit, heating circuit)

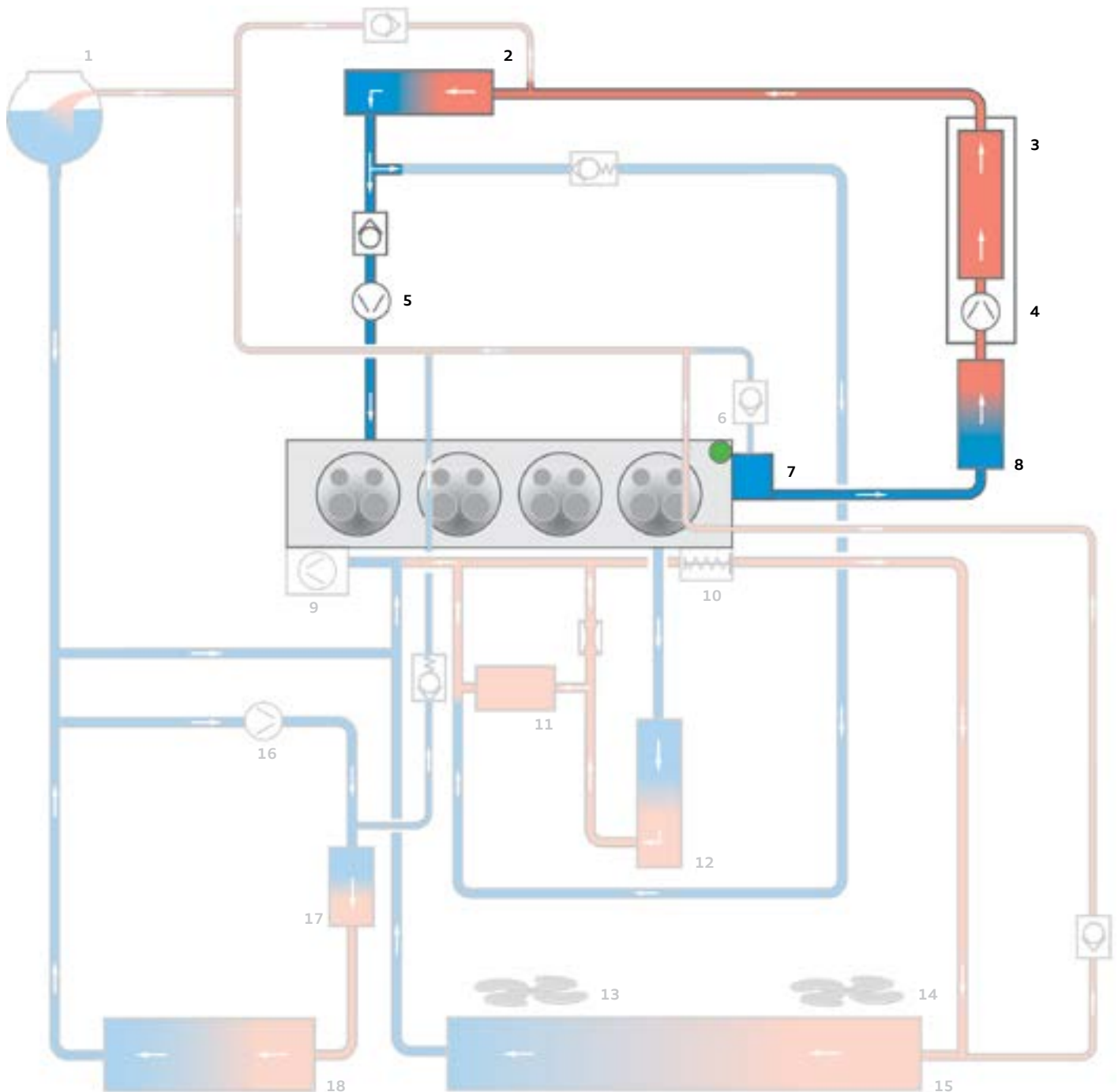
When the engine is cold, the thermal management system operates the cooling system in the secondary cooling circuit mode. This ensures the engine and passenger compartment are heated quickly.

Cylinder Head Coolant Valve N489 is energized and the water pump control valve is moved to cover the impeller to prevent coolant flow in the engine block.

At the same time, Heater Support Pump V488 operates. Coolant flows in the secondary cooling circuit in a controlled manner depending on the coolant temperature in the cylinder head.

V488 provides back-up in cold ambient conditions to ensure that a minimum volumetric flow is achieved at high coolant viscosity.

The driver's temperature preference is registered by the A/C control module when V488 is activated.



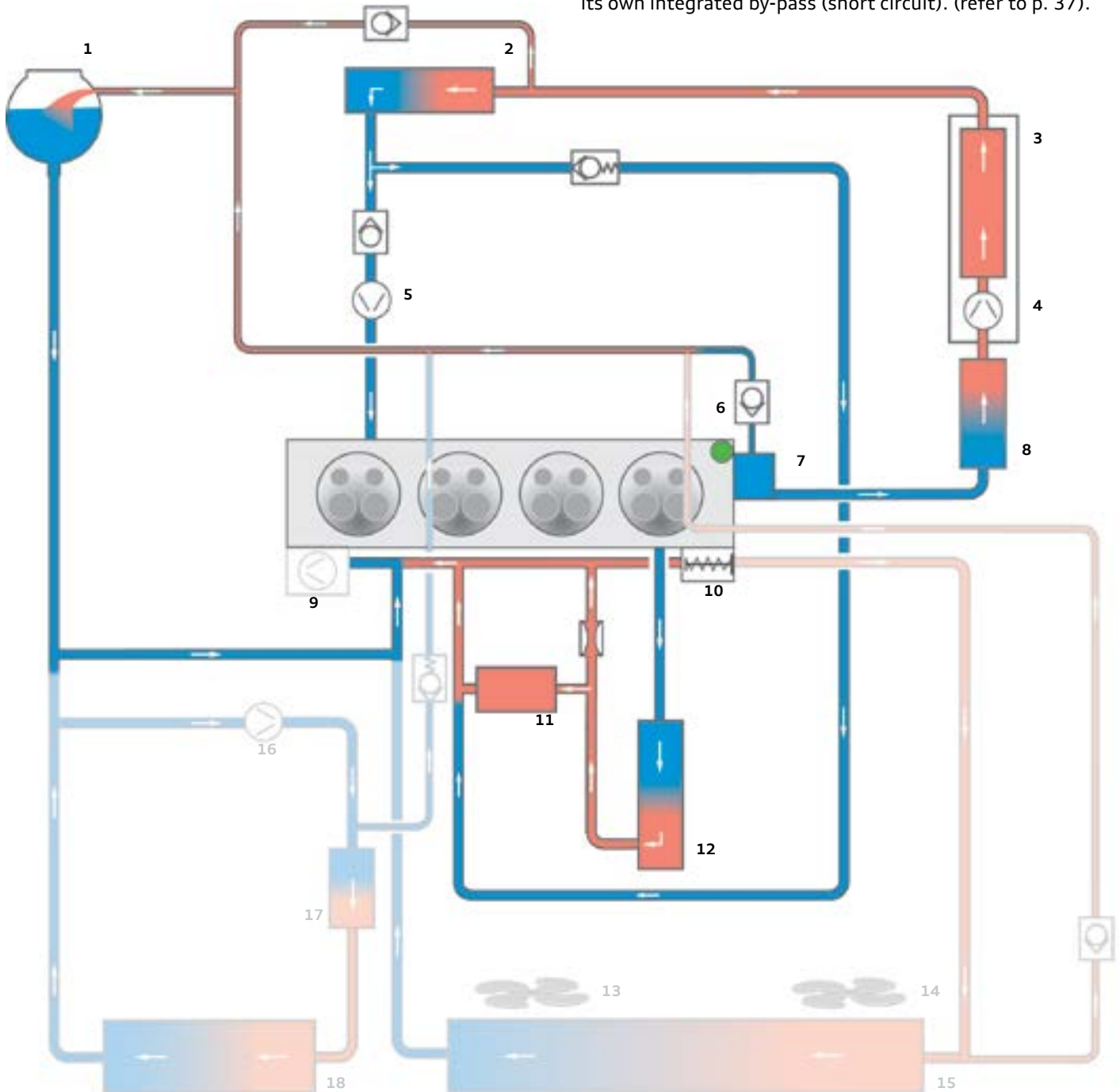
608\_074



## Secondary cooling circuit – engine cooling requirements / high engine load

The switchable coolant pump is activated (N489 de-energized) at increasing engine load and engine speed. This ensures the engine is cooled. After the engine speed drops below a threshold level, the coolant pump is de-activated again (N489 energized) and the engine is operated without coolant circulation until a required temperature is achieved.

The coolant pump is continuously activated when the coolant temperature exceeds a threshold level at the cylinder head, indicating that the engine is at operating temperature. When the coolant pump is activated, it is ensured that a sufficient quantity of coolant flows through the cylinder head. For this purpose, the engine thermostat has its own integrated by-pass (short circuit). (refer to p. 37).



### Key:

- |          |  |           |   |
|----------|--|-----------|---|
| <b>1</b> | Coolant expansion tank                                   | <b>10</b> | Coolant thermostat                              |
| <b>2</b> | Passenger compartment heat exchanger                     | <b>11</b> | Throttle valve                                  |
| <b>3</b> | Auxiliary heater (not for the North American market)     | <b>12</b> | Engine oil cooler                               |
| <b>4</b> | Recirculation Pump V55                                   | <b>13</b> | Coolant Fan V7                                  |
| <b>5</b> | Heater Support Pump V488                                 | <b>14</b> | Coolant Fan 2 V177                              |
| <b>6</b> | Engine Coolant Temperature Sensor G62                    | <b>15</b> | Radiator  |
| <b>7</b> | Coolant connection                                       | <b>16</b> | Charge Air Cooling Pump V188                    |
| <b>8</b> | EGR cooler   | <b>17</b> | Charge air cooler integrated in intake manifold |
| <b>9</b> | Cylinder Head Coolant Valve N489 (mounted on water pump) | <b>18</b> | Heat exchanger for charge air cooling           |

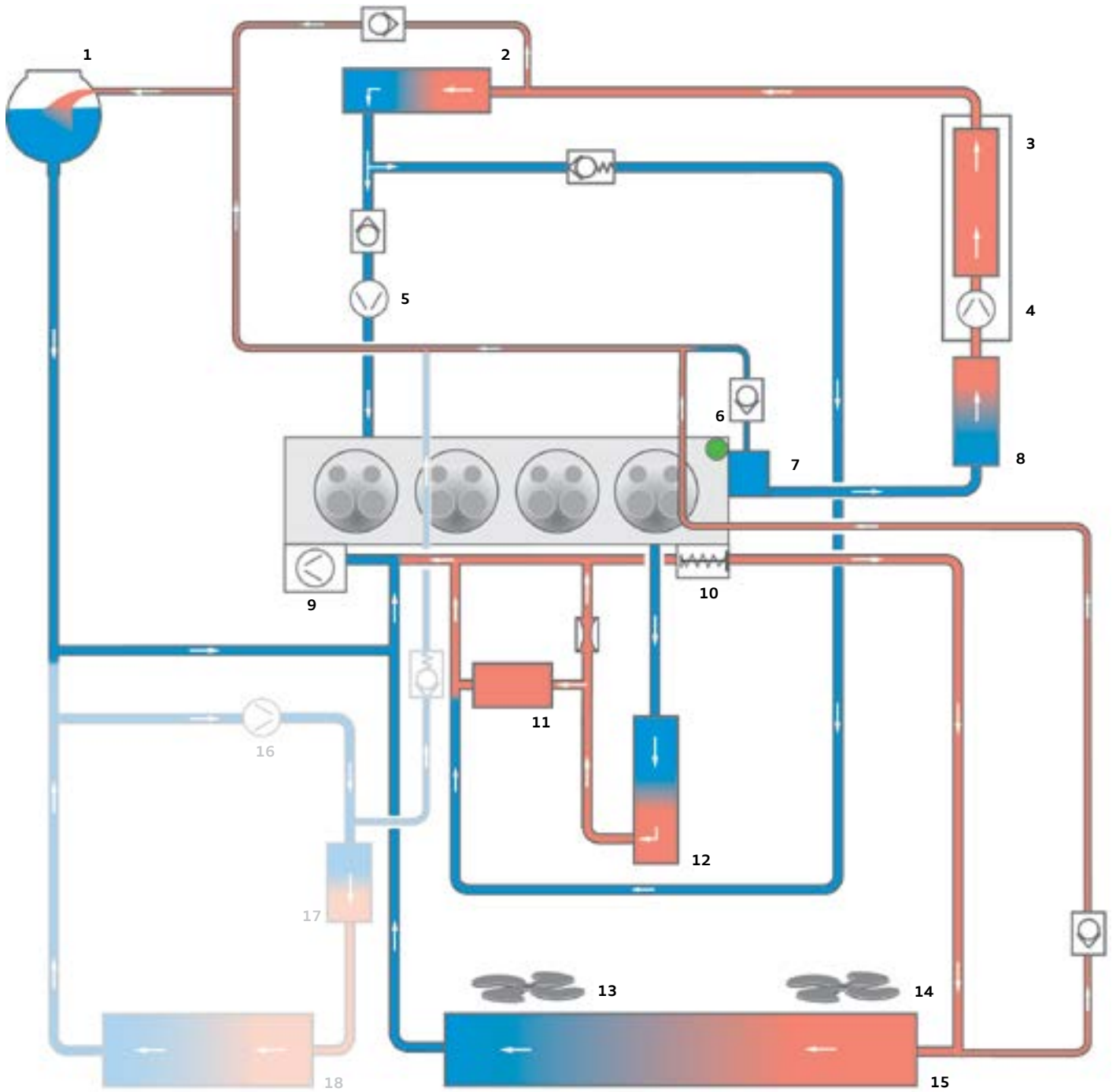
- █ Cooled coolant
- █ Heated coolant

608\_075

## Primary cooling circuit (high temperature circuit) – coolant at operating temperature

If the coolant is at operating temperature, the coolant thermostat opens and enters control mode. The radiator (main radiator) is integrated in the cooling circuit.

The coolant thermostat controls the engine outlet temperature and is located in the main radiator feed line.

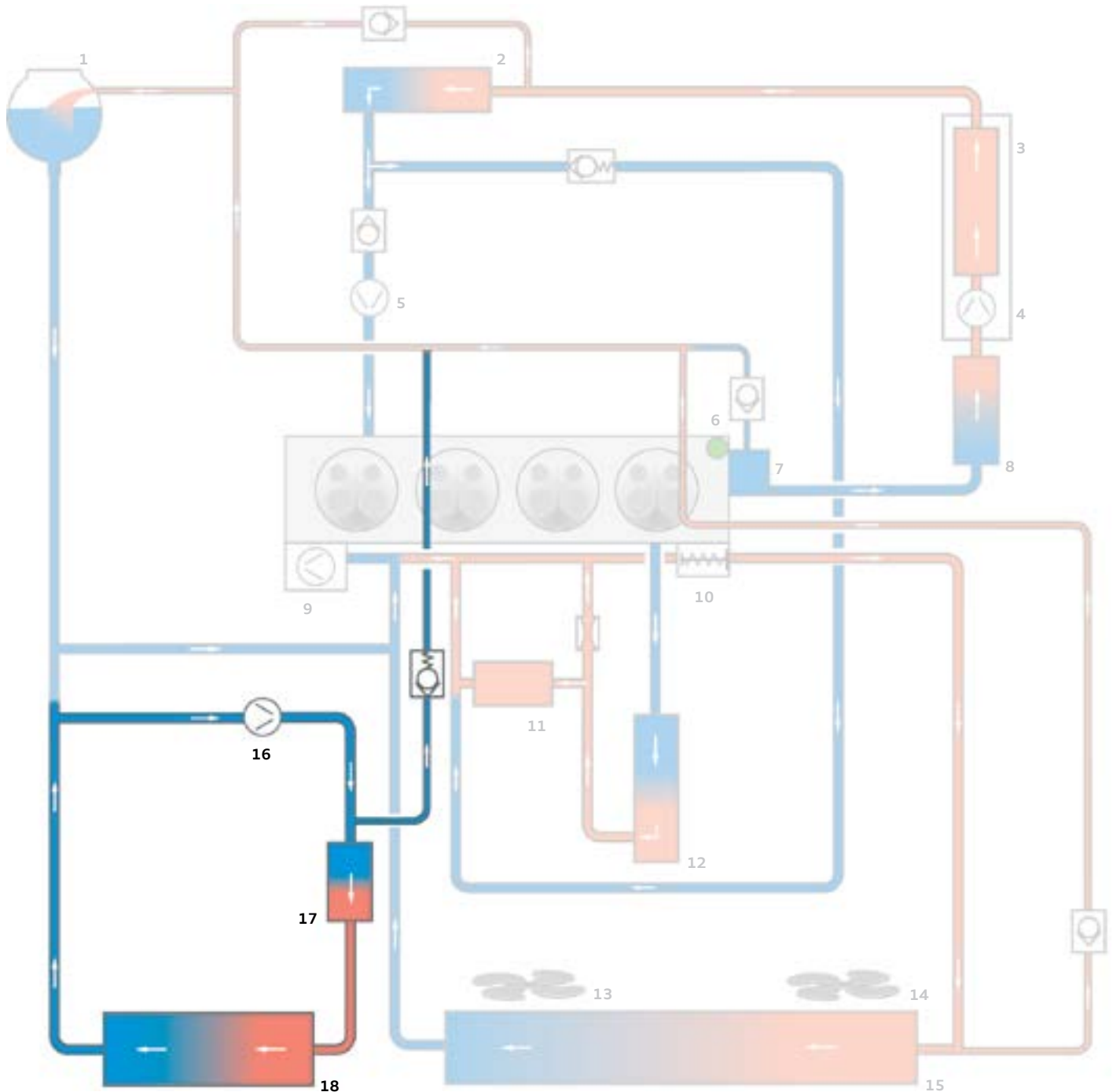


608\_076

## Low temperature cooling circuit – coolant circuit for charge air cooling

The intake manifold temperature is used as a reference variable for activating the charge air cooling circuit. After this target temperature is achieved, the intake manifold

temperature is regulated by activating Charge Air Cooling Pump V188.



608\_077

### Key:

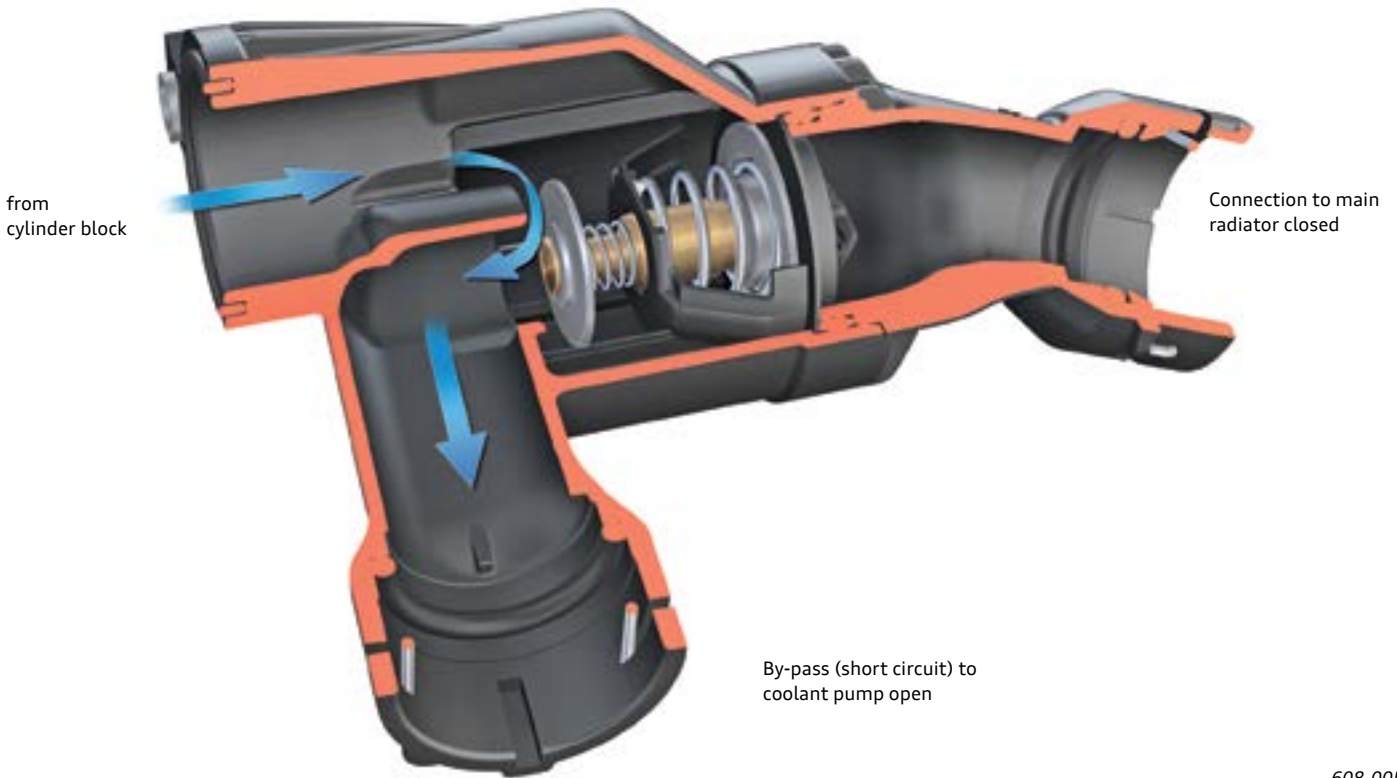
- |          |  |           |   |
|----------|--|-----------|---|
| <b>1</b> | Coolant expansion tank                                   | <b>10</b> | Coolant thermostat                              |
| <b>2</b> | Passenger compartment heat exchanger                     | <b>11</b> | Throttle valve                                  |
| <b>3</b> | Auxiliary heater (not for the North American market)     | <b>12</b> | Engine oil cooler                               |
| <b>4</b> | Recirculation Pump V55                                   | <b>13</b> | Coolant Fan V7                                  |
| <b>5</b> | Heater Support Pump V488                                 | <b>14</b> | Coolant Fan 2 V177                              |
| <b>6</b> | Engine Coolant Temperature Sensor G62                    | <b>15</b> | Radiator  |
| <b>7</b> | Coolant connection                                       | <b>16</b> | Charge Air Cooling Pump V188                    |
| <b>8</b> | EGR cooler   | <b>17</b> | Charge air cooler integrated in intake manifold |
| <b>9</b> | Cylinder Head Coolant Valve N489 (mounted on water pump) | <b>18</b> | Heat exchanger for charge air cooling           |

- Cooled coolant
- Heated coolant

## Coolant thermostat

The coolant thermostat (3/2-way valve) is activated by an expanding wax element, which begins to close the secondary cooling circuit when operating temperature is reached. The primary cooling circuit is closed at the same time.

### Secondary cooling circuit (micro circuit)



608\_005

### Primary cooling circuit (high temperature circuit, controlled)

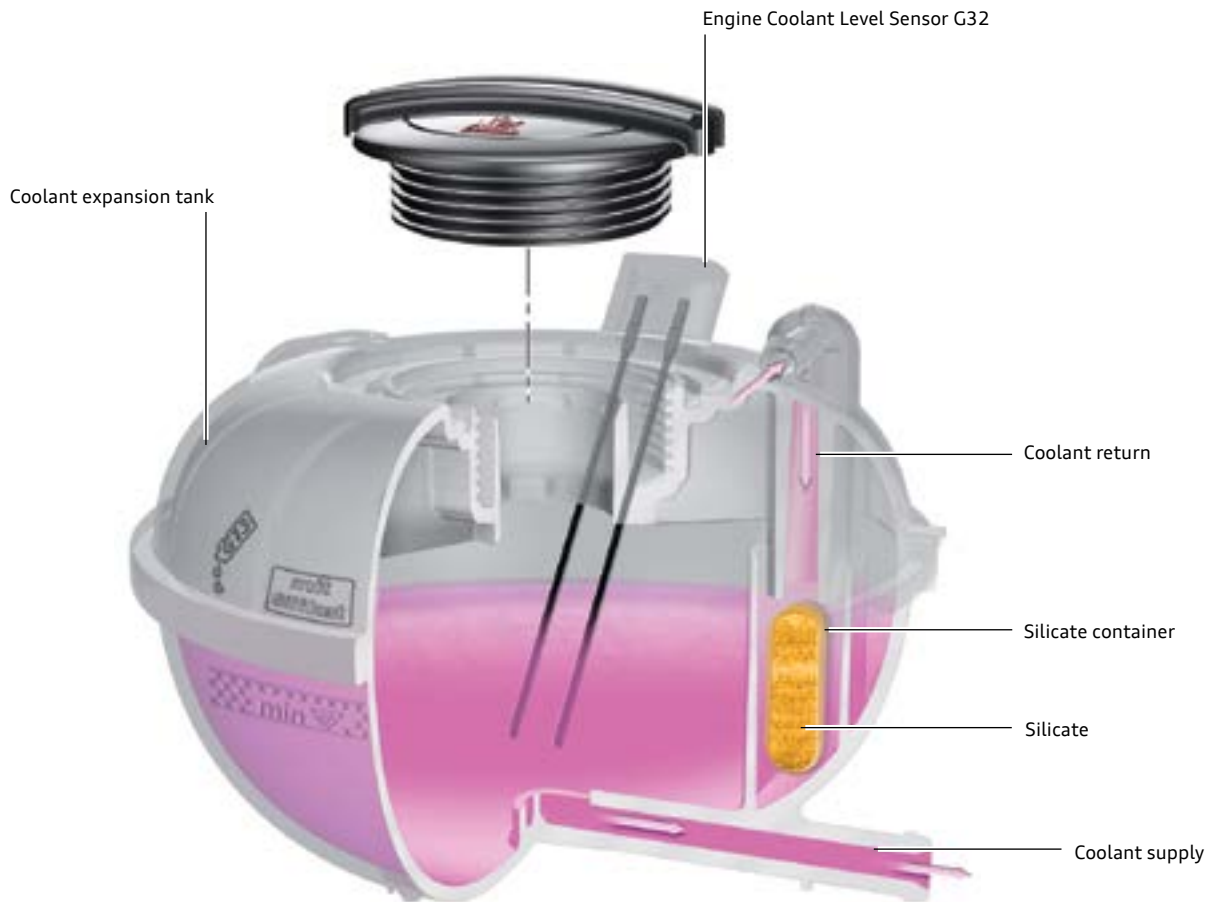


608\_006

## Coolant expansion tank with silicate repository

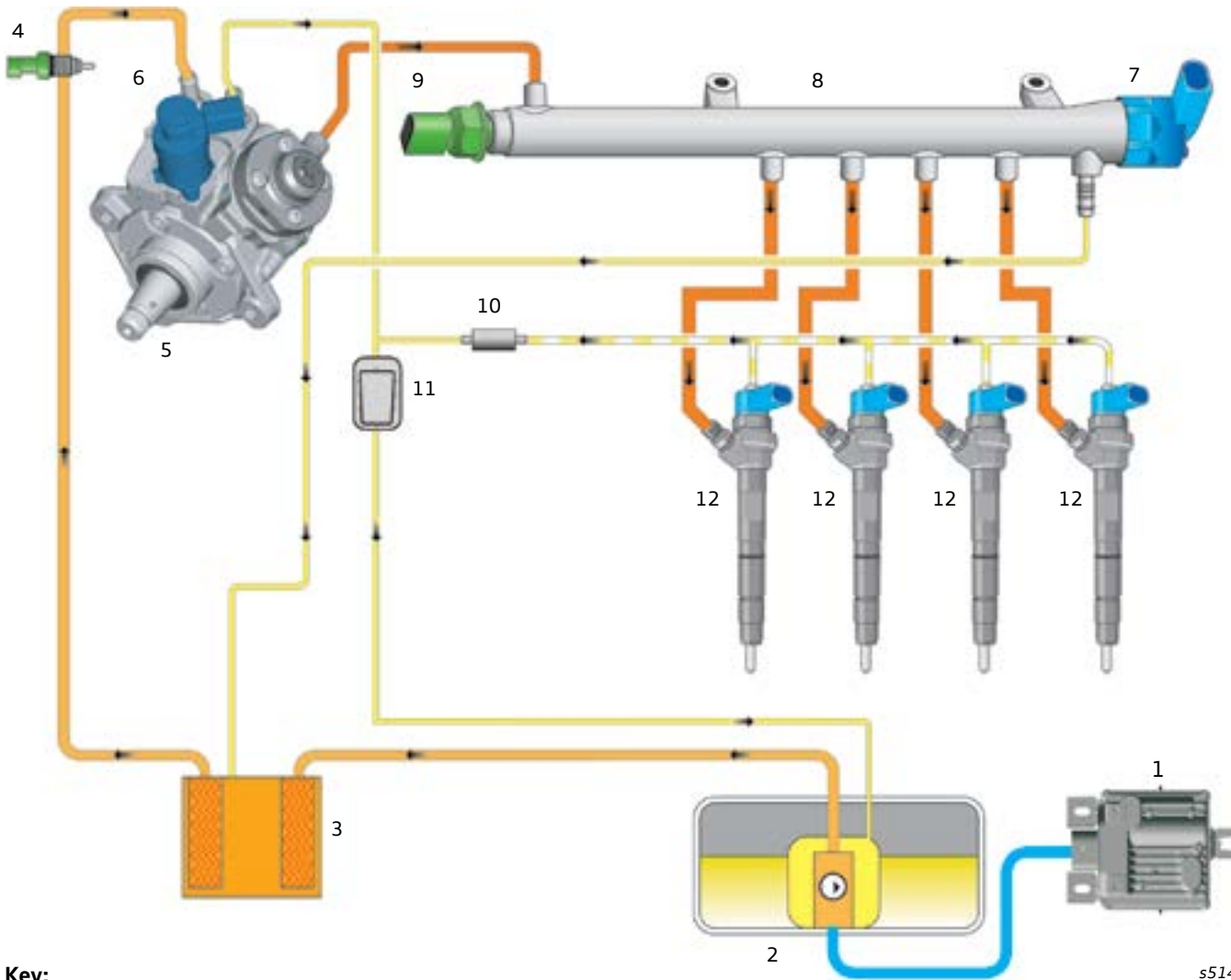
There is a silicate repository in the coolant expansion tank. The silicate is used to protect the aluminium components in the coolant circuit from corrosion. The silicates in the coolant G13 dissipate over time if the engine is subject to high thermal loads.

To compensate for the silicate consumption, silicate is taken from the repository and added to the coolant. The silicate repository is therefore used as additional protection against corrosion for aluminium components in the coolant circuit over the entire lifespan of the engine. The silicate repository is not a serviceable item and it is designed to last for the life of the vehicle.



s514\_079

# Fuel System



s514\_027

## Key:

- Fuel high pressure maximum 1800 bar
- Fuel return 0 - 1.0 bar

- Fuel supply pressure 3.5 - 5.0 bar as required
- Fuel return pressure from the injectors 0.4 - 1.0 bar

### 1 - Fuel Pump Control Module J538

J538 controls the pressure in the fuel supply and monitors the function of the fuel pump as required.

### 2 - Transfer Fuel Pump G6

G6 generates the fuel pressure in the fuel supply.

### 3 - Fuel Filter

The fuel filter keeps impurities in the diesel fuel from the components of the injection system. The high precision components, for example, the high-pressure pump and the injectors, can be damaged or their function impaired by even the most minute particles of dirt.

### 4 - Fuel Temperature Sensor G81

G81 measures the current fuel temperature.

### 5 - High-Pressure Pump

The high-pressure pump generates the high fuel pressure required for injection.

### 6 - Fuel Metering Valve N290

N290 regulates the quantity of fuel needed to generate the high pressure as required.

39

### 7 - Fuel Pressure Regulator Valve N276

N276 is used to adjust the fuel pressure in the high-pressure range.

### 8 - High-Pressure Accumulator (rail)

The high-pressure accumulator stores the fuel required for injection into all cylinders under high pressure.

### 9 - Fuel Pressure Sensor G247

G247 measures the current fuel pressure in the high-pressure area.

### 10 - Pressure Retention Valve

The pressure retention valve ensures a constant pressure of about 1 bar in the return of the injectors. This avoids variations in pressure and allows precise control of the injectors.

### 11 - Pulsation Damper

The pulsation damper has the task of reducing distracting noises caused by pulsating fuel in the fuel return line.

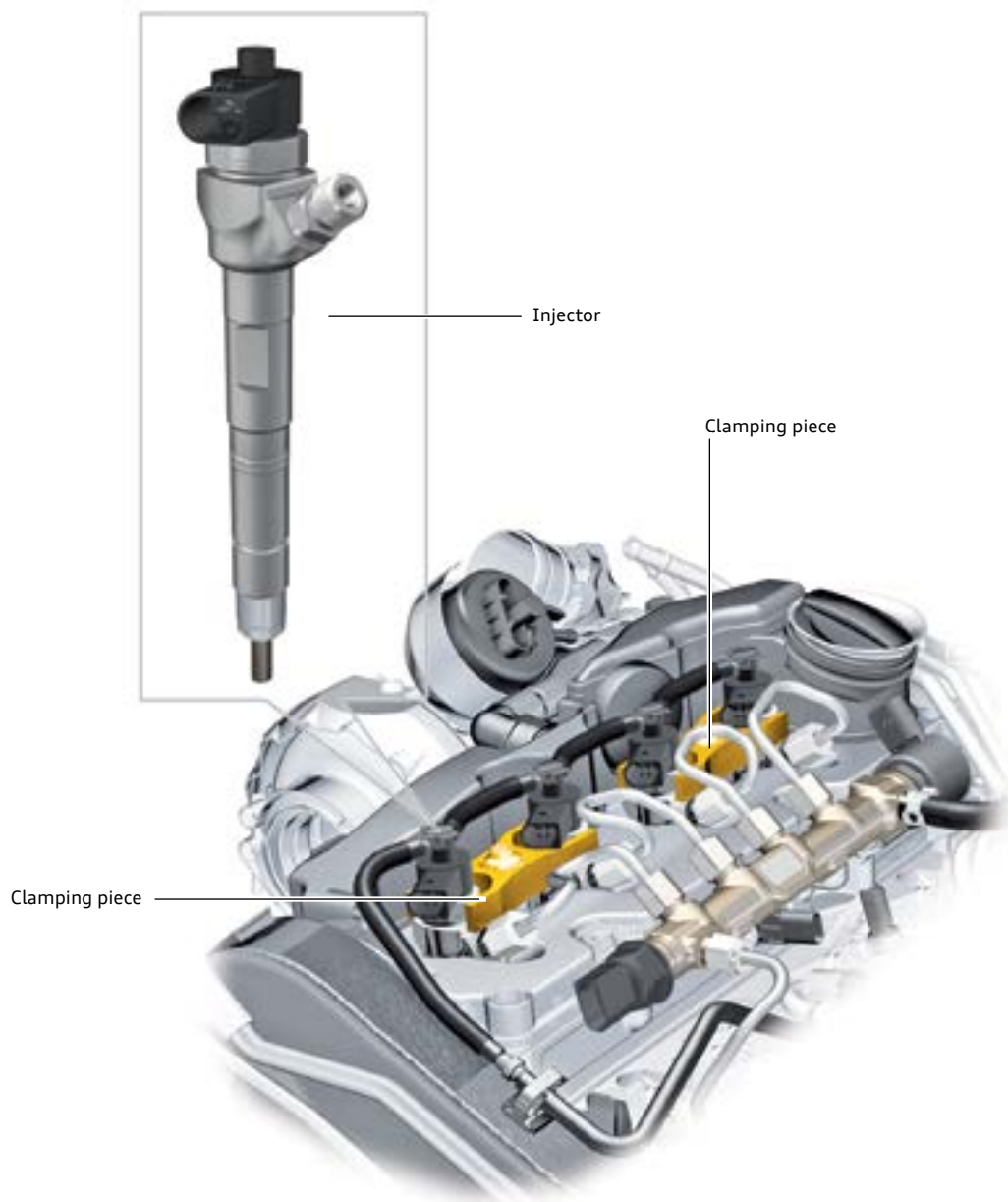
### 12 - Injectors N30, N31, N32, N33

The injectors inject the fuel into the combustion chambers.

## Fuel injectors

The fuel injectors are controlled by a solenoid valve actuator.

Bosch has developed an injector with solenoid valve technology that fulfils the requirements for high injection pressures and the ability to perform several injections per work cycle. Solenoid valve-controlled injectors have the advantage that they are simpler to manufacture than injectors with a piezo actuator.



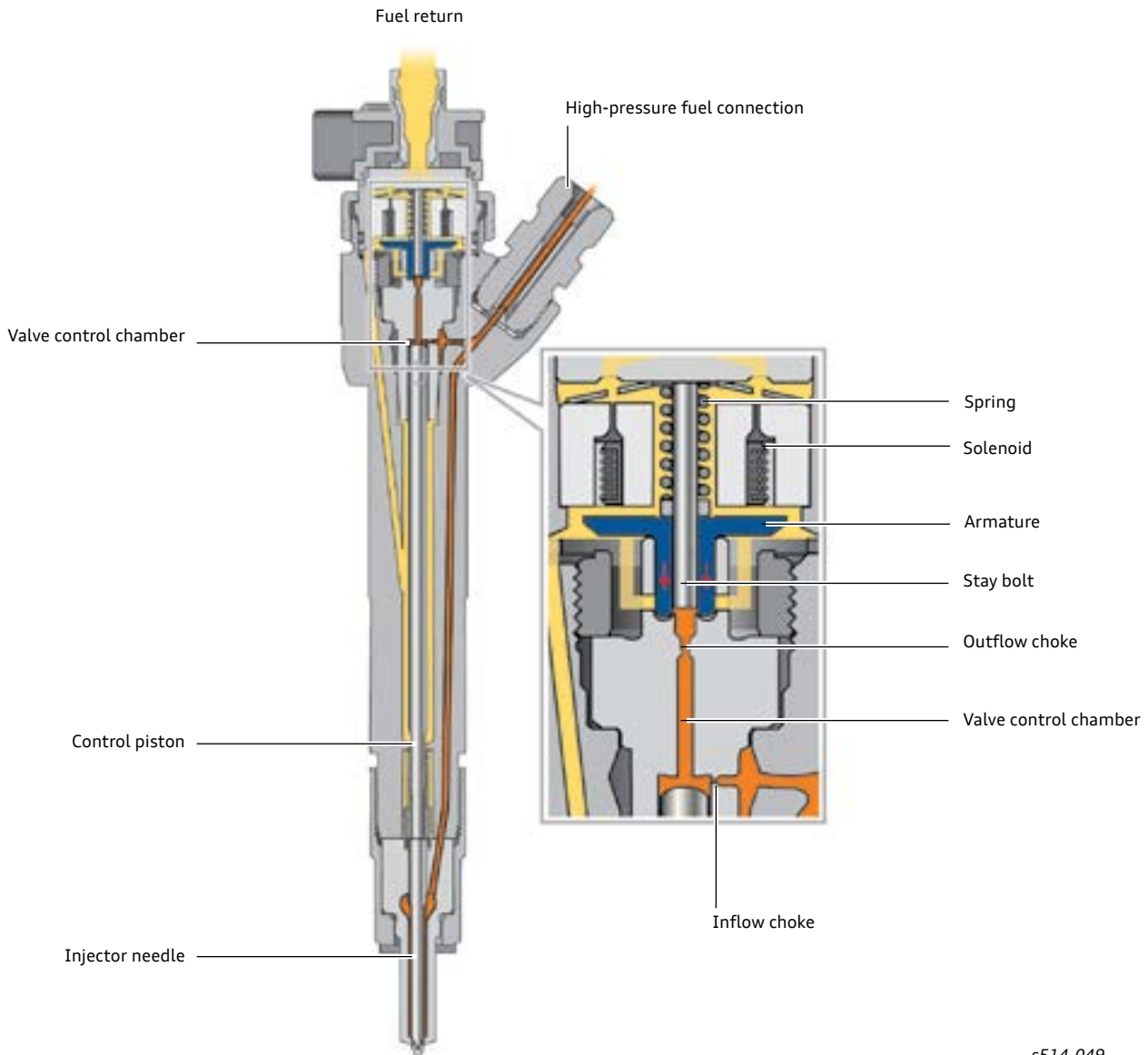
s514\_029

# Injector in rest position

## Design

In its rest position, the injector is closed. The solenoid is not actuated. The solenoid valve armature is pushed into its seat by the force of the solenoid valve spring and thus closes the path from the valve control chamber to the fuel return. The fuel is under high pressure in the valve control

chamber. Due to the larger pressure/surface ratio of the control piston surface to the injector needle, the injector needle is pushed into its seat and closes the injection nozzle.



s514\_049

### Key:

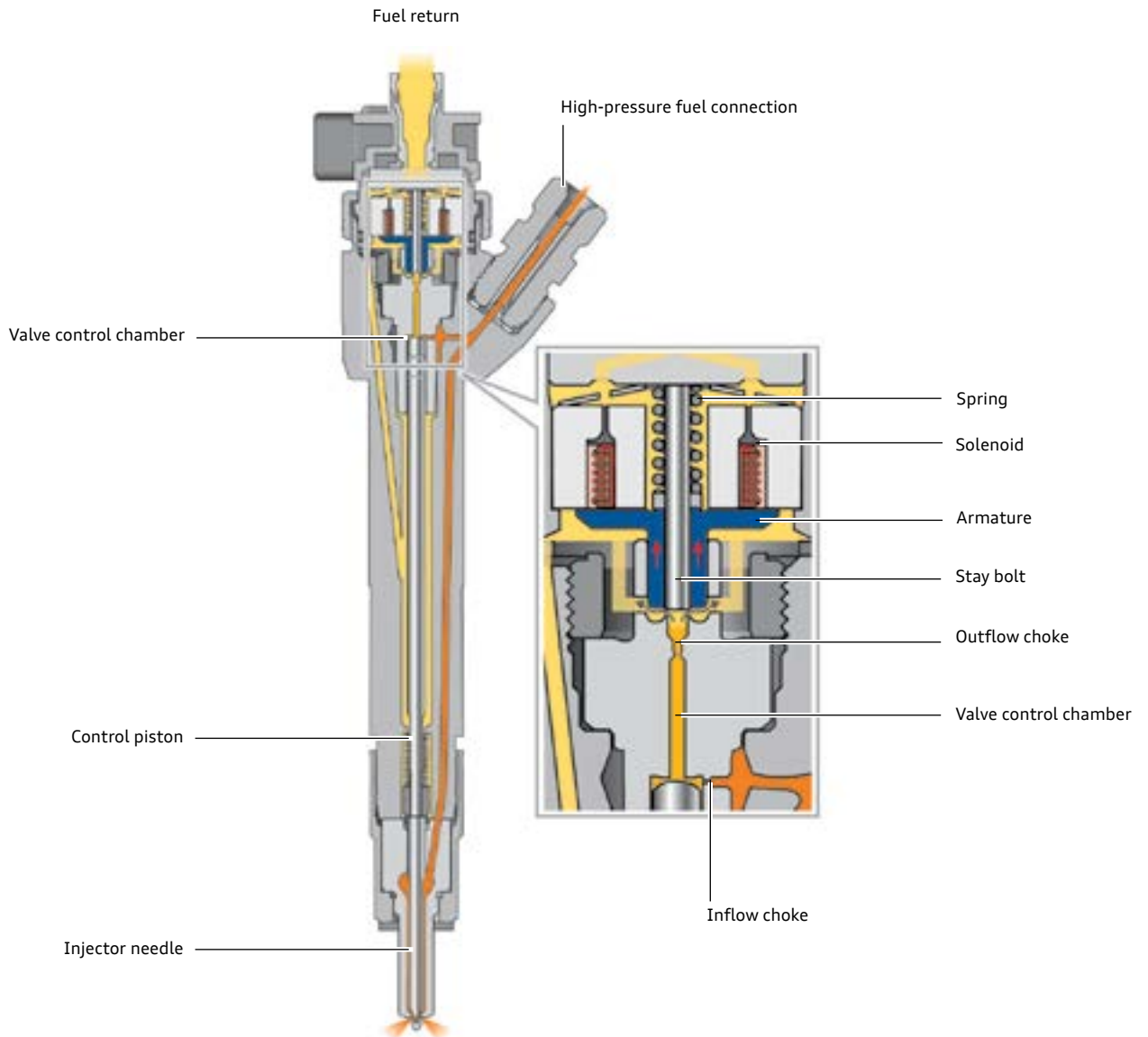
- High pressure
- Return pressure



## Start of injection



The solenoid is activated by the ECM to initiate the injection cycle. As soon as the magnetic force exceeds the closing force of the solenoid valve spring, the solenoid valve armature moves upwards, opening the outflow choke. The fuel in the valve control chamber flows via the opened outflow

choke into the fuel return line. The fuel pressure in the valve control chamber falls. The inflow choke prevents rapid pressure equalization between the fuel high-pressure section and the valve control chamber. The injector needle is raised by the high fuel pressure and injection begins



s514\_050

### Key:

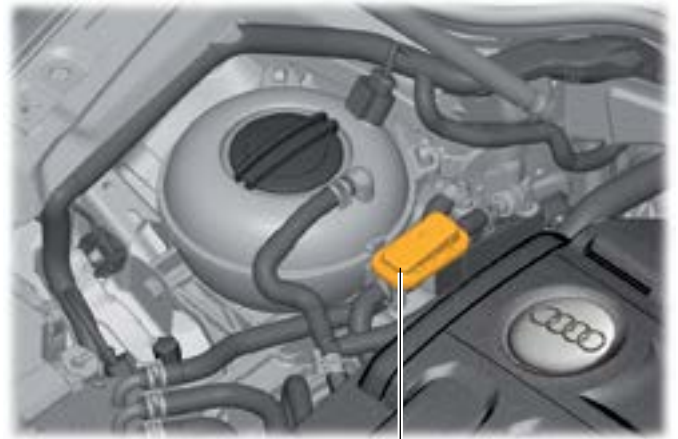
-  High pressure
-  Return pressure



## Pulsation damper

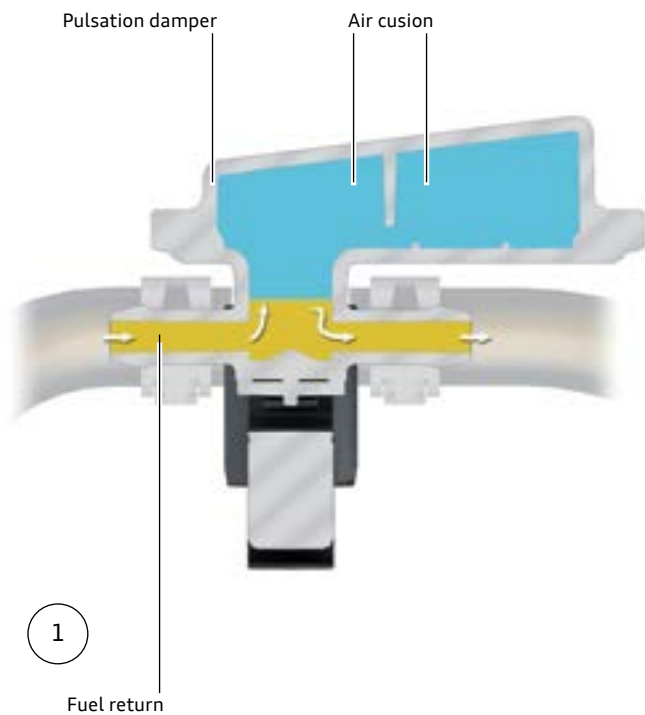
A pulsation damper is integrated near the plenum chamber bulkhead in the fuel return line. It has the task of reducing distracting noises caused by pulsating fuel in the fuel return line.

To reduce the pulsation in the fuel return line, a cushion of air builds up in the pulsation damper when the engine is running. The air cushion absorbs the pressure pulsations in the fuel return line and thereby reduces the vibrations.

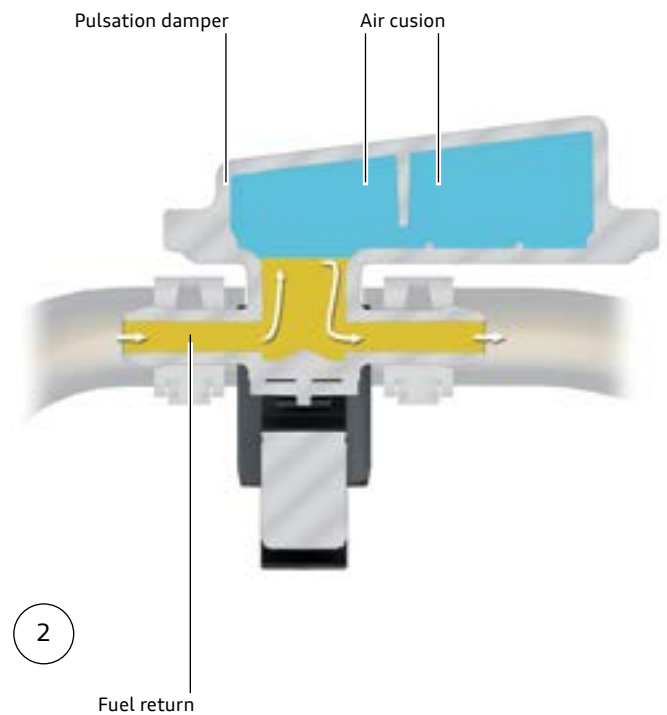


s514\_052a

Pulsation damper



s514\_057



s514\_058

# Engine management system

## System overview

### Sensors

Mass Airflow Sensor G70

Throttle Position Sensor G69

Engine Speed Sensor G28

Hall Sensor G40

Engine Coolant Temperature Sensor G62

Fuel Temperature Sensor G81

Engine Coolant Temperature Sensor on Radiator Outlet G83

Oil Level Thermal Sensor G266

Fuel Pressure Sensor G247

Accelerator Pedal Position Sensor G79 and  
Accelerator Pedal Position Sensor 2 G185

Exhaust Gas Recirculation Position Sensor 2 G466  
Charge Pressure Actuator Position Sensor G581

Brake Light Switch F  
Brake Pedal Switch F63

Combustion Chamber Pressure Sensors G677 - G680

Heated Oxygen Sensor G39

Charge Air Temperature Sensor in front of Charge Air Cooler G810

Charge Air Temperature Sensor after Charger Air Cooler G811

Charge Pressure Actuator Position Sensor G581

Oil Pressure Switch F22

Reduced Oil Pressure Switch F378

Exhaust Gas Temperature Sensor 3 G495

EGR Temperature Sensor G98

Exhaust gas Temperature Sender 1 G235

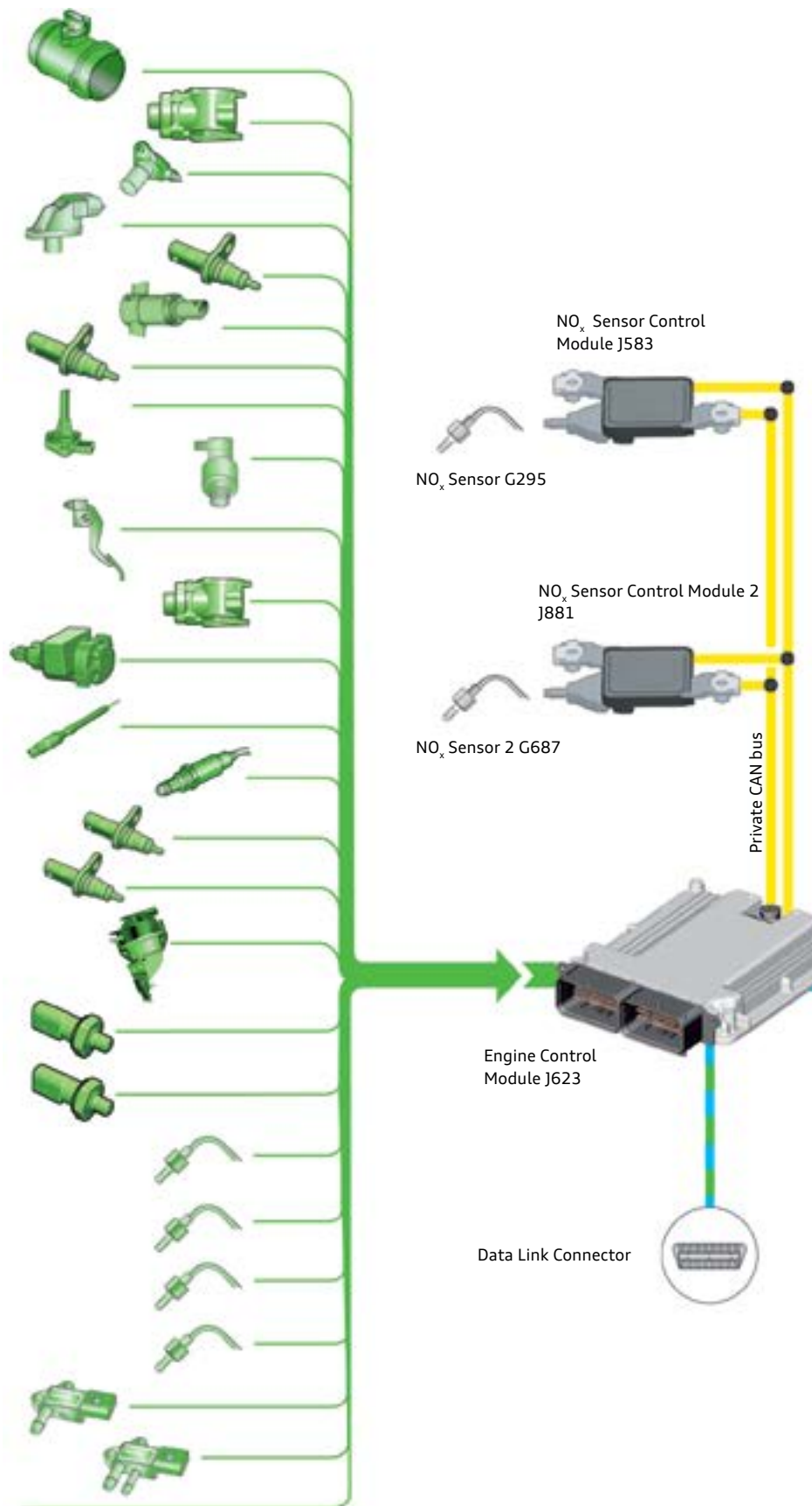
Exhaust Gas Temperature Sensor 4 G648

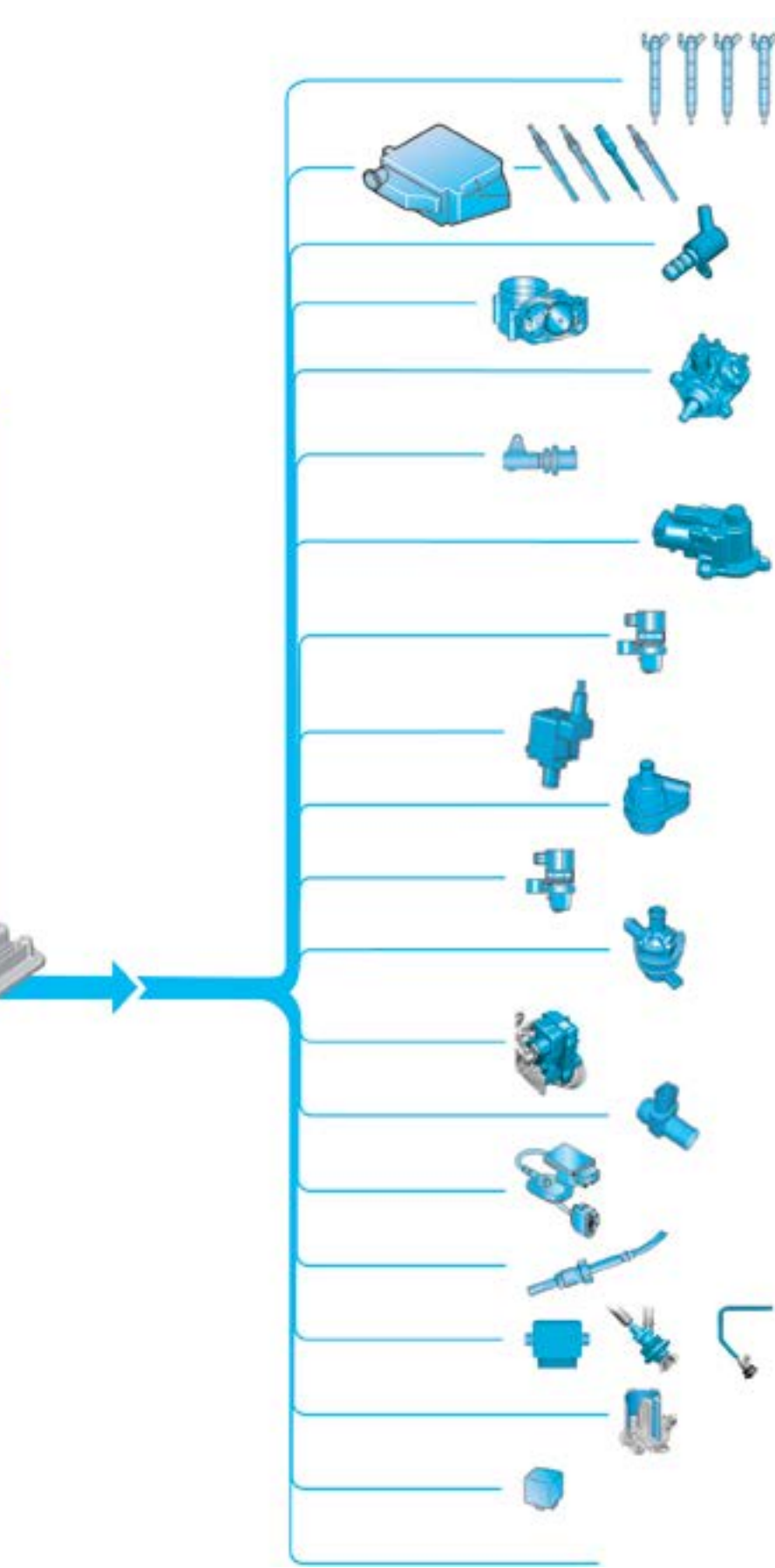
Charge Air Pressure Sensor G31

Differential Pressure Sensor G505

Auxiliary signals:

- Cruise control system
- Speed signal
- Start request to ECM (Kessy 1 + 2)
- Terminal 50
- Crash signal from Airbag Control Module





## Actuators

Injectors, cylinders 1 – 4  
N30, N31, N32, N33

Automatic Glow Time Control Module J179  
Glow plugs 1 – 4 Q10, Q11, Q12, Q13

Oil Pressure Regulation Valve N428

Throttle Valve Control Module J338

Fuel Metering Valve N290

Fuel Pressure Regulator Valve N276

EGR Motor V338  
(Low pressure exhaust gas recirculation)  
EGR Motor 2 V339  
(High pressure exhaust gas recirculation)

EGR Cooler Switch Over Valve N345  
(EU4)

Cylinder Head Coolant Valve N489

Charge Air Cooling Pump V188

Wastegate Bypass Regulator Valve N75

Heater Support Pump V488

Exhaust Door Control Unit J883

Positive Crankcase Ventilation Heating Element N79  
(cold-climate countries only)

Fuel Pump Control Module J538

Oxygen Sensor Heater Z19

Reducing Agent Metering System Control Module J880  
Reducing Agent Injector N474  
Reducing Agent Line Heater (heating circuit 2) Z104

Reducing Agent Pump V437  
Reducing Agent Tank Heater (heating circuit 1) Z102

Fuel Pump Relay J17  
Transfer Pump G6

Auxiliary signals:

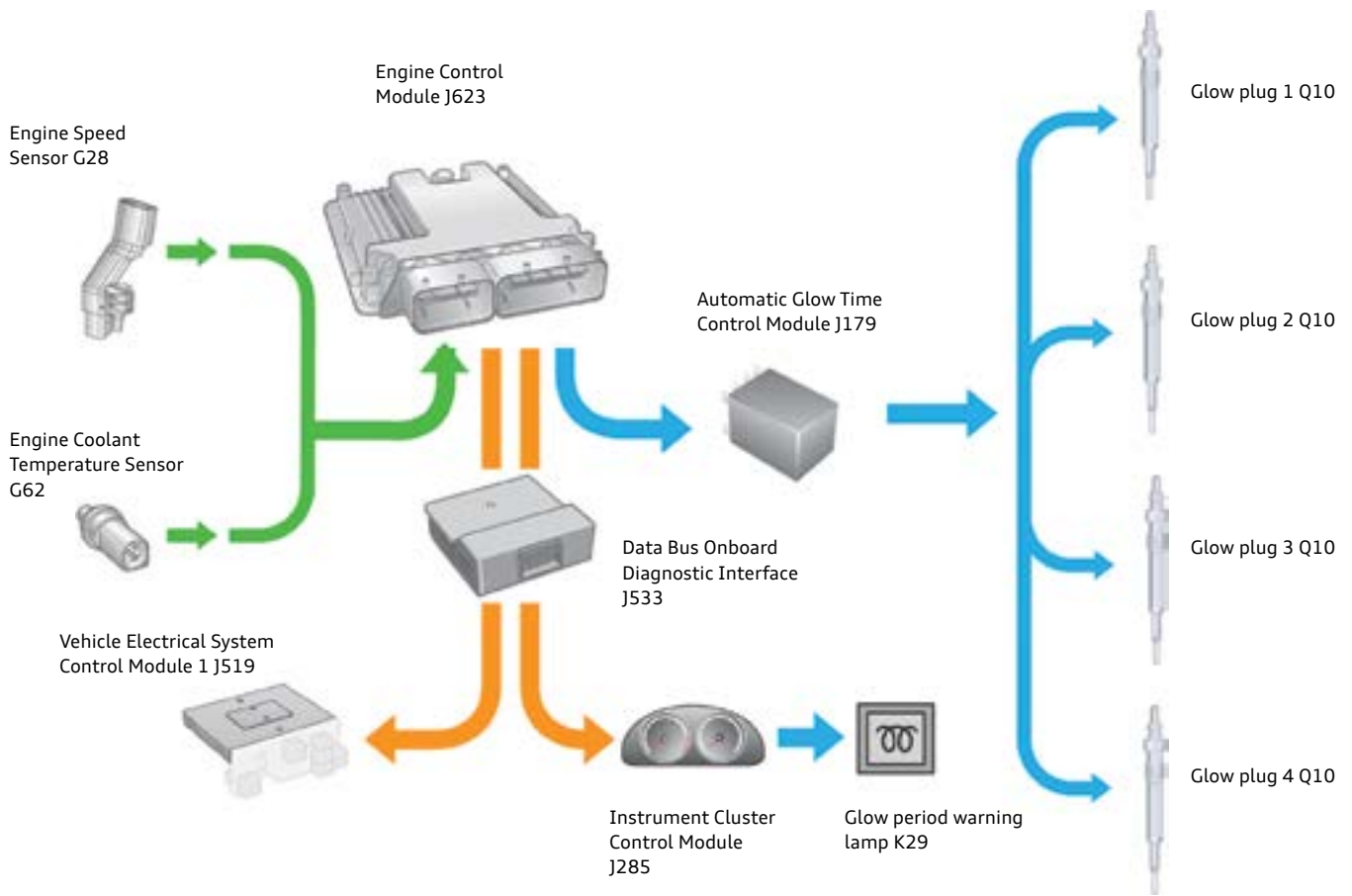
- A/C compressor
- Auxiliary coolant heater
- Fan setting 1 + 2
- Auxiliary air heater element Z35

# Glow plug system

The EA288 engine for the North American market uses a rapid start glow plug system. The advantages of this system are:


- ▶ Engine start comparable to a gasoline engines at temperatures down to -24 °C
- ▶ Extremely short heating time. Within 2 seconds, the glow plug temperatures reach up to 1000 °C
- ▶ Controllable temperatures for preglow and afterglow phases
- ▶ Self-diagnostic ability

## Overview of the system



s514\_081

eMedia

 VIDEO

Pressure Sensing Glow Plugs

## Function

### Pre-glowing

Engine Control Module J623 determines when to activate the steel glow plugs via Automatic Glow Time Control Module J179. J179 uses a PWM signal to activate the plugs. The voltage of the individual glow plug is adjusted via the duty cycle.

For rapid starting at an exterior temperature of less than 24 °C, there is a maximum of 11.5V. This ensures the glow plug is heated to over 1000 °C within a short period of time (approximately 2 seconds). This reduces the pre-glow time for starting.

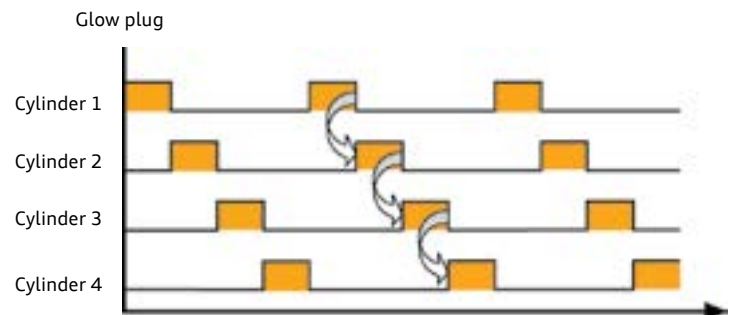
### Post-start glowing

For post-start glowing, the switch-on time of the supply voltage is adjusted in the PWM duty cycle to ensure that there is an effective voltage of 4.4 V. Post-start glowing is carried out for a maximum of 5 minutes after starting the engine up to a coolant temperature of 24 °C. Post-start glowing helps reduce hydrocarbon emissions and combustion noises during the warm-up phase.

On vehicles with a start/stop system, the post-start glowing process is not interrupted if the engine-stop function is active. This avoids frequent temperature changes and protects the material of the steel glow plug.

### Phase-shifted activation of the glow plugs

To relieve the load on the supply voltage during the glow phases, the glow plugs are actuated in a phase-shifted manner. The falling signal actuates the next glow plug.

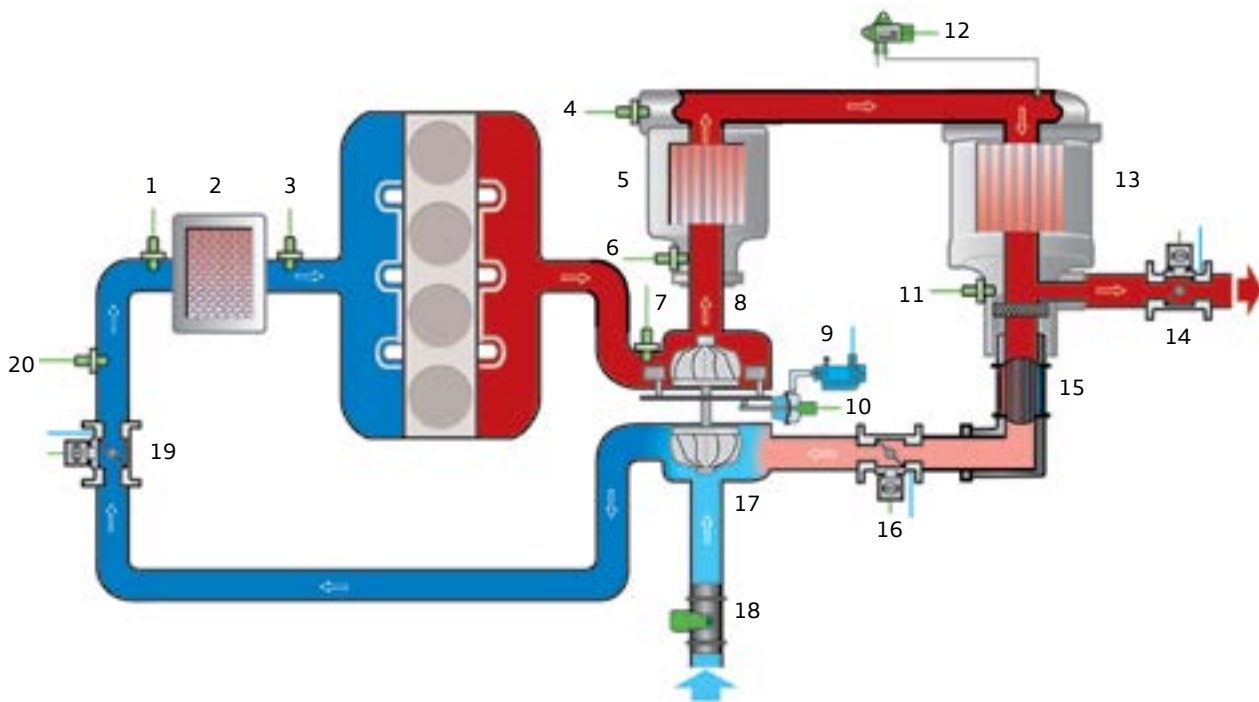


s514\_040

## Air regulation overview

The higher demands placed on exhaust gas after-treatment in the future require an enhanced control and regulation structure for both the air intake and exhaust of the engine. The air regulation system of the engine is based on a model that calculates conditions in all operational states of the engine.

All pressure figures, temperature values and mass flows on the intake air, charge air and exhaust lines of the engine are measured. These values are used to regulate the charge pressure, the cylinder filling and the exhaust gas recirculation rate. The advantage of this model is that the complex air regulation system of the engine manages with a limited number of sensors despite a large number of actuators.



s514\_035

### Key:

- |           |  |           |                                       |
|-----------|--|-----------|---------------------------------------|
| <b>1</b>  | Intake Air Temperature Sensor G42                          | <b>11</b> | Exhaust Gas Temperature Sensor 4 G648 |
| <b>2</b>  | Charge air cooler  | <b>12</b> | Differential Pressure Sensor G505     |
| <b>3</b>  | Charge Air Temperature Sensor after Charge Air Cooler G811 | <b>13</b> | Diesel particulate filter             |
| <b>4</b>  | Exhaust Gas Temperature Sensor 3 G495                      | <b>14</b> | Exhaust Door Control Unit J883        |
| <b>5</b>  | Oxidizing catalytic converter                              | <b>15</b> | Exhaust gas recirculation cooler      |
| <b>6</b>  | Heated Oxygen Sensor G39                                   | <b>16</b> | EGR Motor 2 V339                      |
| <b>7</b>  | Exhaust Gas Temperature Sensor 1 G235                      | <b>17</b> | Turbocharger compressor               |
| <b>8</b>  | Exhaust turbine with variable vanes                        | <b>18</b> | <b>Mass Airflow Sensor G70</b>        |
| <b>9</b>  | Wastegate By-pass Regulator Valve N75                      | <b>19</b> | Throttle Valve Control Module J338    |
| <b>10</b> | Charge Pressure Actuator Position Sensor G581              | <b>20</b> | Charge Air Pressure Sensor G31        |



## Turbocharger / exhaust manifold module

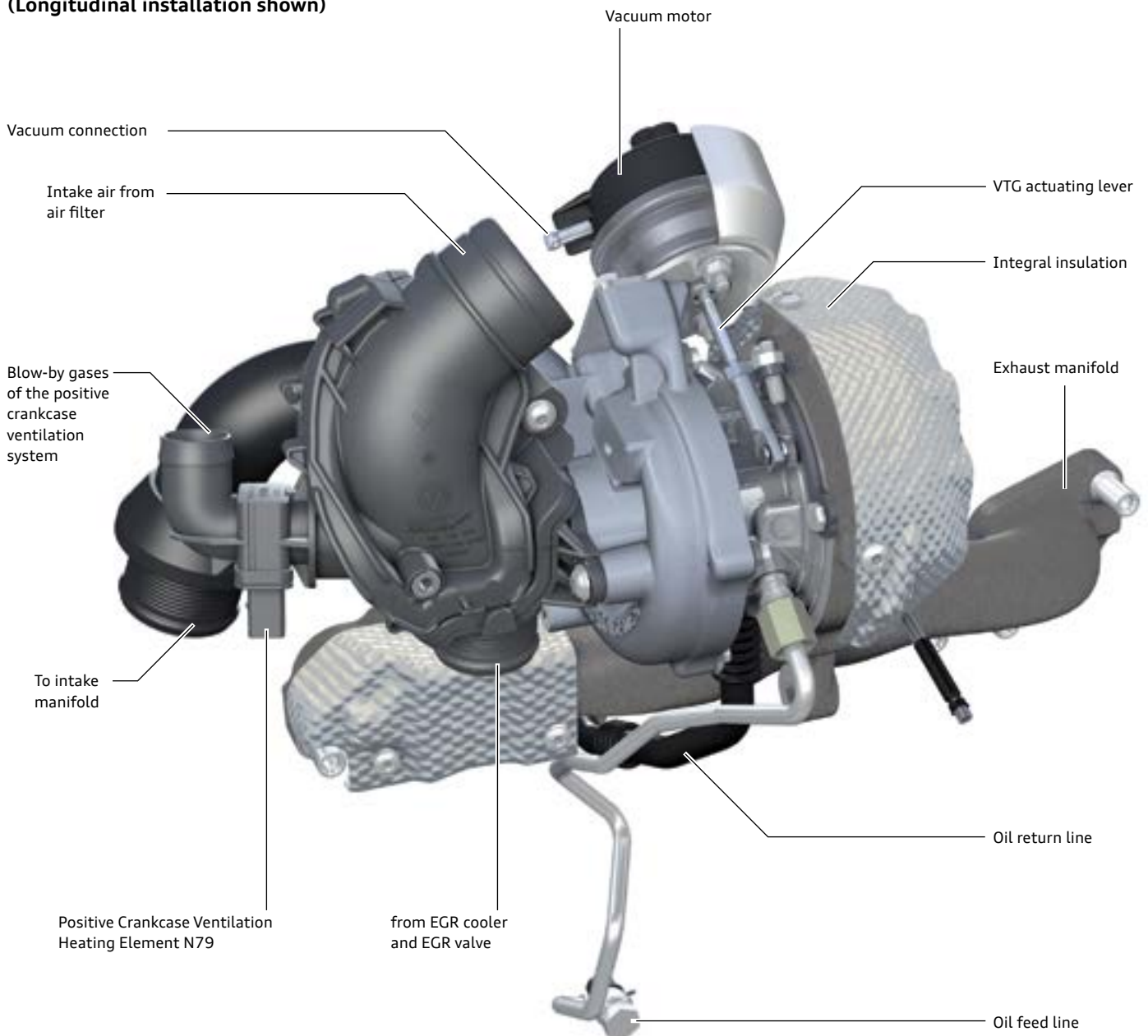
The turbocharger is integrated with the exhaust manifold to form a single module. The turbocharger is equipped with adjustable guide vanes (Variable Turbine Geometry) which allows the flow of exhaust gas into the turbine impeller to be regulated. The guide vanes are adjusted by an actuating link operated by a vacuum motor.

The recirculated exhaust gases are not extracted at the turbine housing, rather at the diesel particulate filter outlet. The full mass flow is always channeled through the turbocharger compressor by extracting the recirculated exhaust gases downstream of the diesel particulate filter outlet.

The turbocharger operates with greater efficiency. This allows higher charge pressures and higher volumetric efficiency to be achieved at part loads in particular. A benefit of this is the higher cooling capacity of the exhaust gas recirculation system, which helps to reduce the mixing temperature of the fresh air and recirculated exhaust gases.

The acoustic characteristics of the exhaust turbocharger were improved by using modified damping chambers in the baffled sound absorber.

(Longitudinal installation shown)



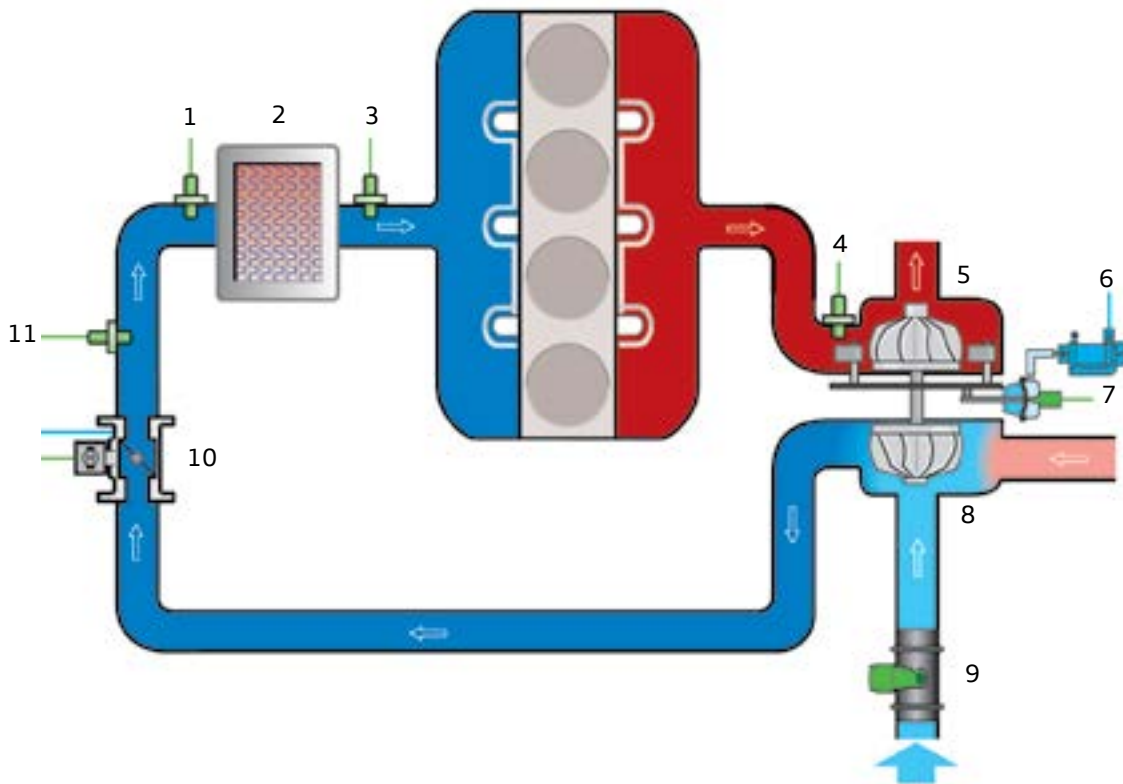
# Charge pressure control

## Wastegate By-pass Regulator Valve N75

N75 is actuated by the engine control module using a duty cycle (PWM). It switches the control pressure in the vacuum motor to move the variable vanes of the turbocharger.

### Effects of failure

The variable vanes of the turbocharger are moved to a steep working position which results in a low charge pressure when the engine speed is low. The engine has less power and active regeneration of the diesel particulate filter is not possible.



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### Key:

- |   |  |    |   |
|---|--|----|---|
| 1 | Intake Air Temperature Sensor G42                          | 7  | Charge Pressure Actuator Position Sensor G581 |
| 2 | Charge Air Cooler  | 8  | Turbocharger Compressor                       |
| 3 | Charge Air Temperature Sensor after Charge Air Cooler G811 | 9  | Mass Airflow Sensor G70                       |
| 4 | Exhaust Gas Temperature Sensor 1 G235                      | 10 | Throttle Valve Control Module J338            |
| 5 | Exhaust Turbine with variable vanes                        | 11 | Charge Air Pressure Sensor G31                |
| 6 | Wastegate By-pass Regulator Valve N75                      |    |   |

## Charge Air Pressure Sensor G31

### Signal use

The signal from G31 allows the ECM to determine the air pressure in the intake manifold and regulate charge pressure.

### Effects of failure

There is no substitute function in the event of signal failure. Charge air pressure regulation is shut off and there is a significant reduction in engine output. The particulate filter cannot be actively regenerated.

## Intake Air Temperature Sensor G42

### Signal use

The signal from G42 is used by the ECM to regulate charge pressure. Because temperature affects the density of the charge air, the ECM uses the signal as a correction value.

### Effects of failure

If G42 fails, the ECM uses a fixed substitute value for calculation purposes.

## Ambient Air Pressure Sensor

An ambient air pressure sensor is installed in the ECM. As the density of the intake air decreases as altitude increases, the air pressure is used as a correction value for charge pressure control.

## Charge Pressure Actuator Position Sensor G581

### Signal use

G581 provides the ECM with the position of the turbo-charger variable guide vanes. In conjunction with G31, the condition of the charge pressure regulation can be determined.

### Effects of failure

If G581 fails, the signal of the charge air pressure sensor and the engine speed sensor are used by the ECM to determine the position of the guide vanes.

## Throttle Valve Control Module J338

The throttle valve module is installed in the intake track before the charge air cooler. There is an electric motor in the throttle valve module that operates the throttle valve via gears. Adjustment of the throttle valve is infinite and can therefore be adapted to the respective engine operating situation. The position of the throttle valve is used to regulate the air pressure and the intake air quantity in the intake manifold. During regeneration of the diesel particulate filter, the throttle valve regulates the quantity of intake air and therefore the oxygen supply. The valve is closed when the engine is switched off. In this way, less air is drawn in and compressed, which results in the engine shutting down softly.

### Effects of failure

In the event of failure of the throttle valve module, correct regulation of the intake manifold pressure is no longer possible. There is no active regeneration of the diesel particulate filter.

## Throttle Position Sensor G69

G69 is integrated into the throttle valve module. The sensor elements detect the current position of the throttle valve.

### Signal use

The ECM uses the signal to identify the current position of the throttle valve in the intake manifold. This information is required for regulation of the intake manifold pressure and regeneration of the particulate filter.

### Effects of failure

If the sensor fails, the engine will be run in emergency mode with reduced power. No active regeneration of the diesel particulate filter takes place.

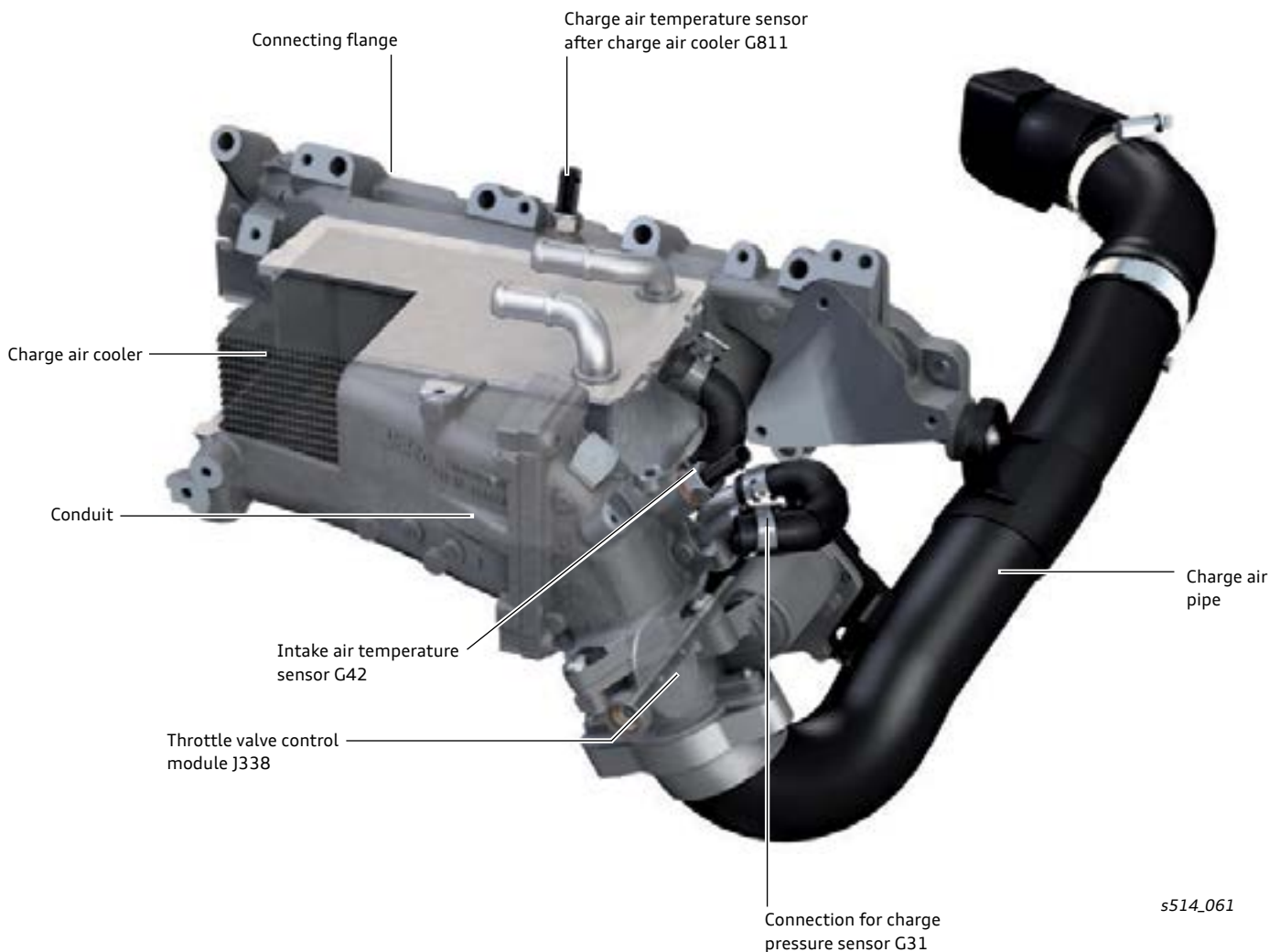
## Charge air cooler

A charge air cooler is integrated with the intake manifold.

This provides the following advantages:

- ▶ The intake manifold temperatures are adjustable within defined limits, the system can operate independently of the intake air temperature and the recirculated exhaust gas.
- ▶ A compact charge air circuit with reduced flow losses.
- ▶ Icing and condensation are avoided in the charge air cooler.

The charge air cooler operates according to the same principle as a heat exchanger.



## Intake manifold temperature regulation

To regulate the intake manifold temperature to a specific value, Charge Air Cooling Pump V188 is actuated by the ECM based on the requirements. The duty cycle to actuate the pump depends on the temperature measured by Charge Air Temperature Sensor after Charge Air Cooler G811 and a map in the ECM.

## Charge Air Temperature Sensor after Charge Air Cooler G81 1

### Signal use

The signal from G811 is required:

- ▶ to calculate the necessary duty cycle for actuating the charge air cooling pump and therefore for regulating the intake manifold temperature.
- ▶ to protect components. If the air temperature in the intake manifold exceeds a critical value, the engine power is reduced.

### Effects of failure

In the event of sensor failure, the engine control unit employs a fixed value for calculation purposes.

## Intake Air Temperature Sensor G42

### Signal use

G42 is used by the ECM to monitor the efficiency of the charge air cooler. The temperatures from before and after the cooler are compared by the ECM.

### Effects of failure

If G42 fails, the ECM uses a fixed value for calculation purposes.

## Charge Air Cooling Pump V188

### Usage

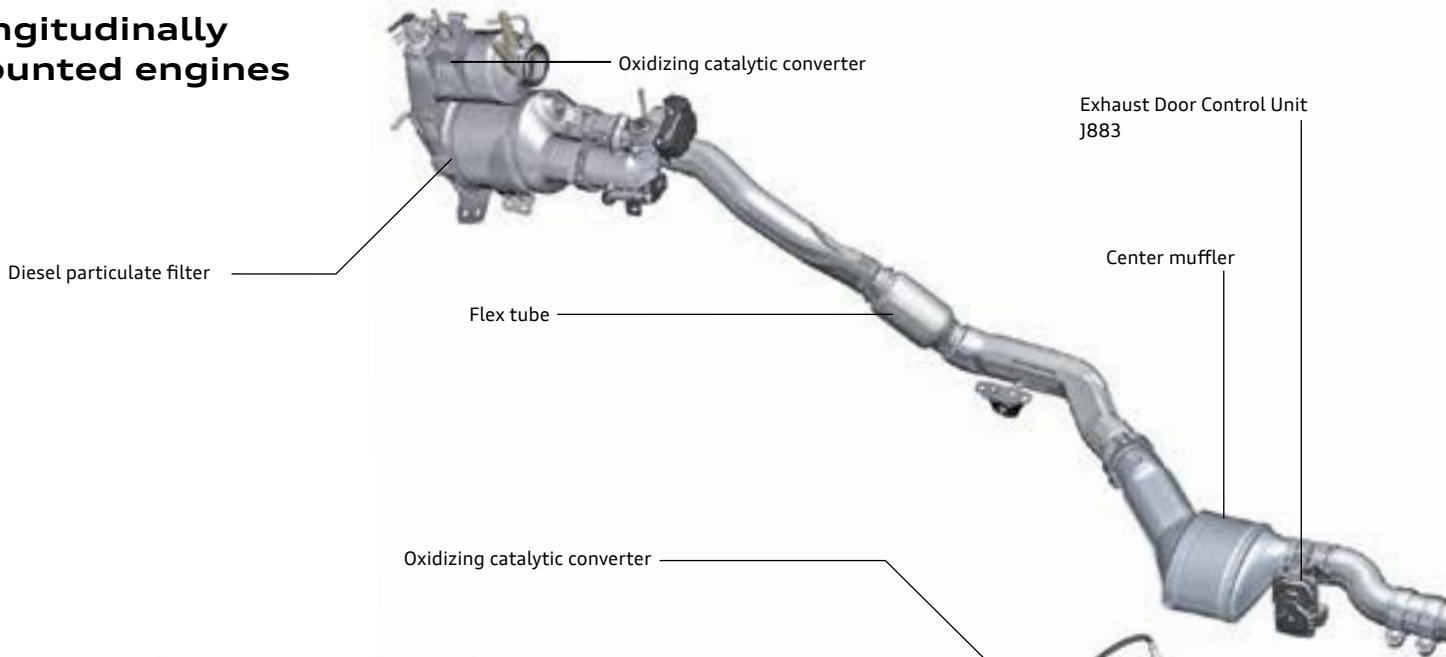
V188 is actuated by the ECM with a PWM signal based on engine requirements. It draws engine coolant from main engine radiator and pumps it to the charge air cooler.

### Effects of failure

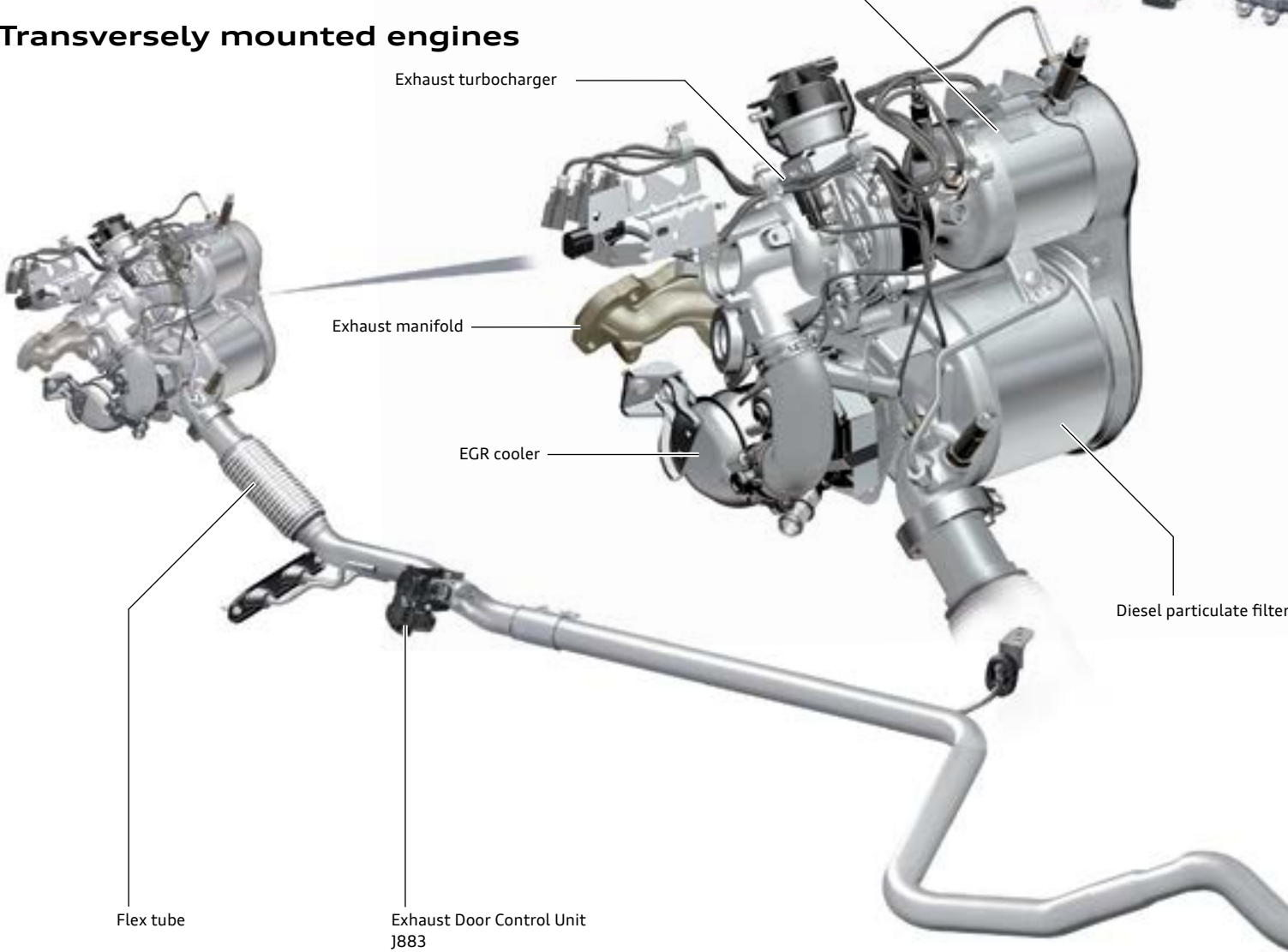
If V188 fails, a DTC is logged in the ECM fault memory and Malfunction Indicator Lamp K83 lights. If the intake manifold temperature exceeds a critical value, engine output is reduced to protect components.

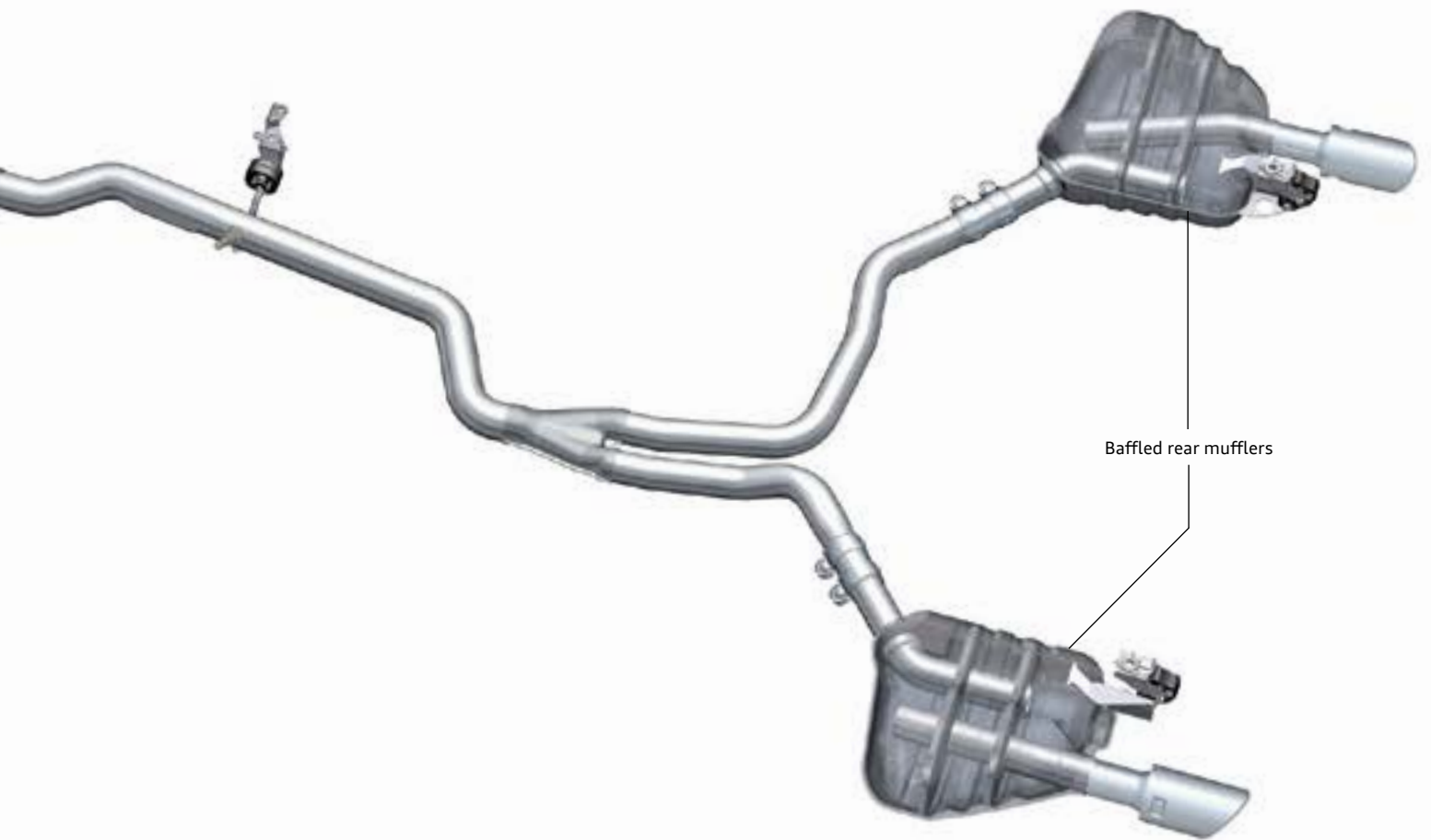
# Exhaust system

## Longitudinally mounted engines



## Transversely mounted engines





Baffled rear mufflers

608\_044



Baffled rear muffler

608\_050

# Exhaust gas treatment

## Exhaust emission standards

The chart on this page identifies the various emission standards that are met with the EA 288 TDI engines on a world-wide basis. In the United States the EA288 engines will comply with the BIN5\* Tier 2 standard.

Depending on the country applicable exhaust standard, there are differences between components, both in terms of type and how the exhaust gases enter the intake system.

In vehicles with BIN5 configurations, the Selective Catalytic Reduction (SCR) system with cylinder pressure sensors in the glow plugs is also installed. Also, in BIN 5 configuration Engine Coolant Temperature Sensor on Radiator Outlet G83 is installed.

Features	EU4	EU5	EU6	EU6 heavy duty	BIN5 <sup>1)</sup> /ULEV
High pressure exhaust recirculation	x		x	x	x
Low pressure exhaust recirculation		x	x	x	x
Cooled exhaust recirculation valve	x		x	x	x
Uncooled exhaust recirculation valve		x	x	x	x
SCR system (AdBlue)				x	x
EGR cooler	x	x	x	x	x
Additional temperature sensor at radiator outlet					x
4-way catalytic converter (modified coating on the monoliths)			x		
Cylinder pressure sensor			1	1	4

\*The term "BIN" stems from the word "bag". During exhaust emission tests, the exhaust gases are collected in bags and analyzed. Exhaust emission standards are ranked from BIN10 to BIN5.



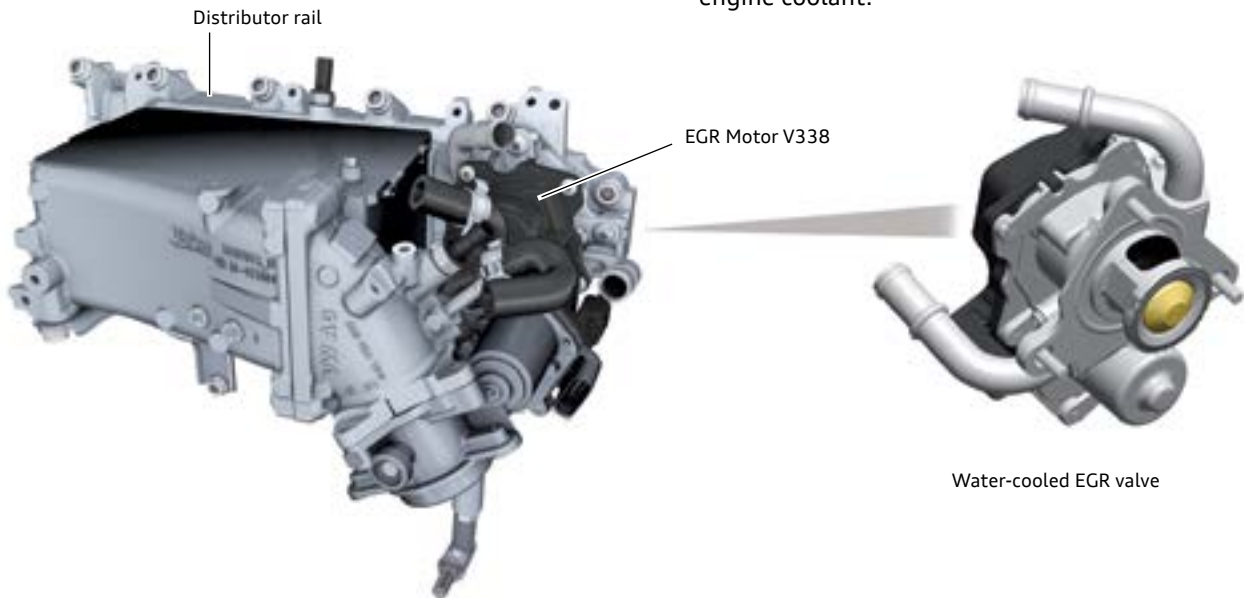
## Exhaust gas recirculation

The BIN5 Tier 2 configuration of the engine uses both high pressure and low pressure exhaust gas recirculation with a cooled EGR valve and an EGR cooler. The EGR cooler has a vacuum controlled by-pass flap actuated by the ECM depending on operating temperatures.

Upstream of the turbocharger, the recirculated exhaust gases flow through a port in the cylinder head and into a water cooled exhaust gas recirculation valve mounted on the distributor rail.

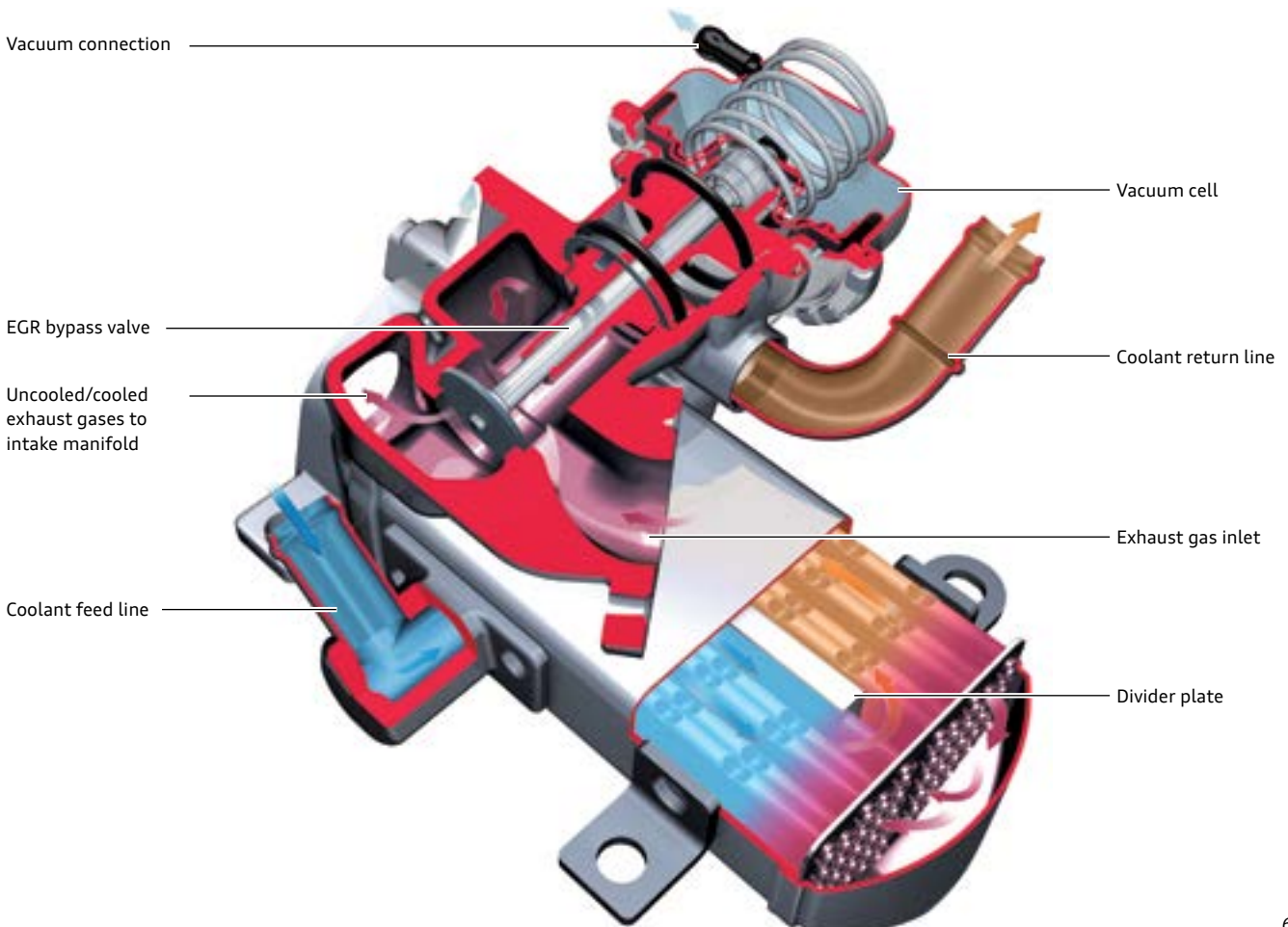
The recirculated exhaust gases are divided among the compressed air and the cooled charge air via the distributor rail. This air mixture is channeled to the cylinder head intake port.

The exhaust gas recirculation valve is powered by EGR Motor V338. It is actuated by the ECM. The quantity of recirculated exhaust gas is controlled by the stroke of the valve. To provide protection from the high temperature exhaust gas, the exhaust gas recirculation valve is cooled by engine coolant.



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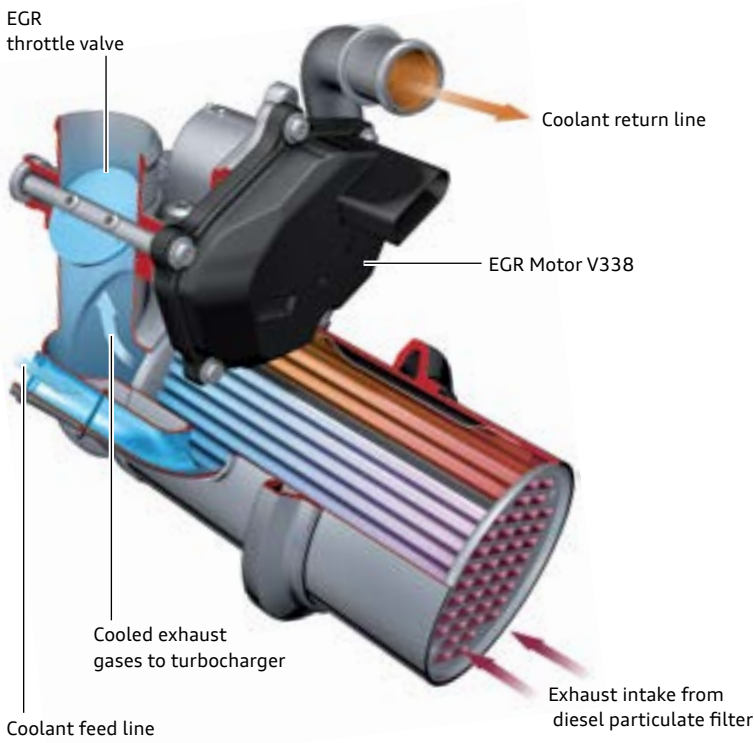
## Design of the exhaust gas recirculation (EGR) cooler



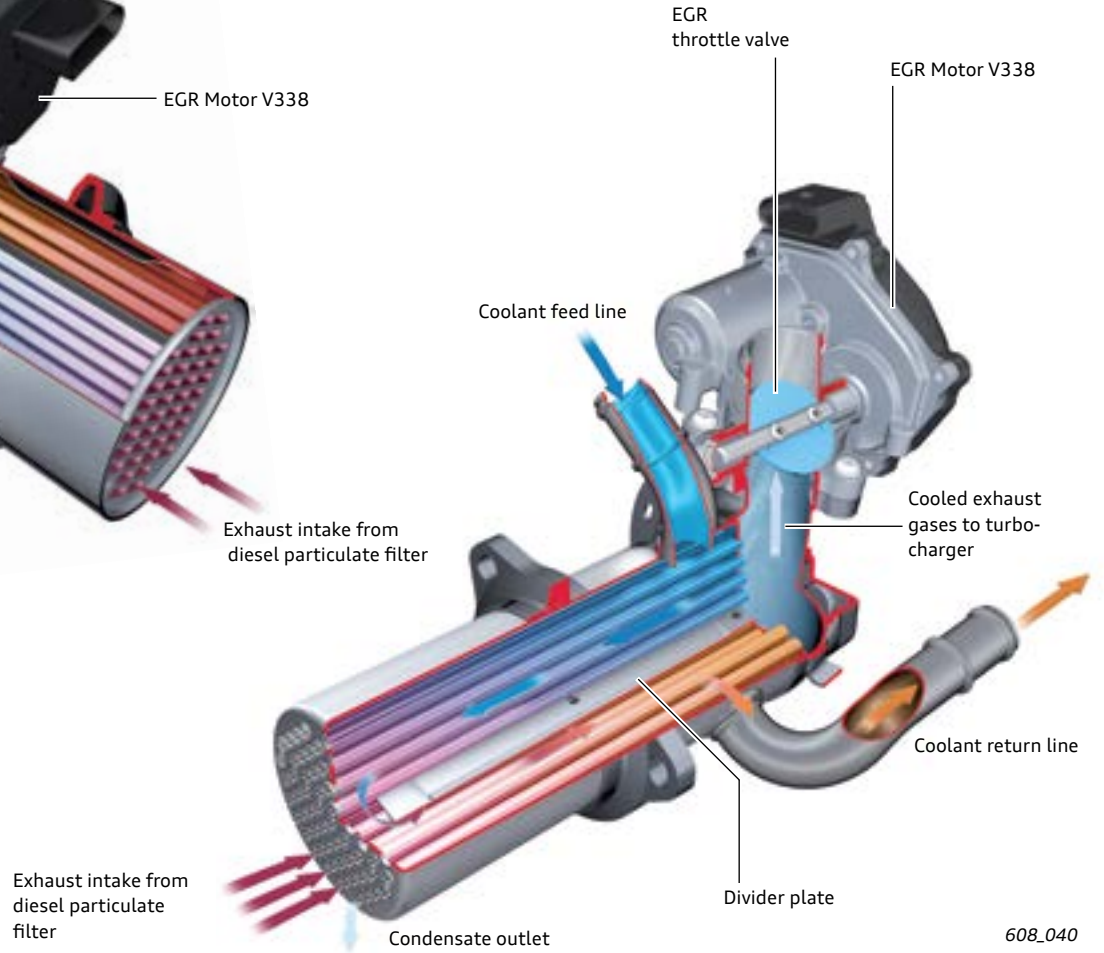
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# Design of the exhaust gas recirculation (EGR) cooler

## Transversely mounted engines



## Longitudinally mounted engines



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## Exhaust gas treatment module and SCR system

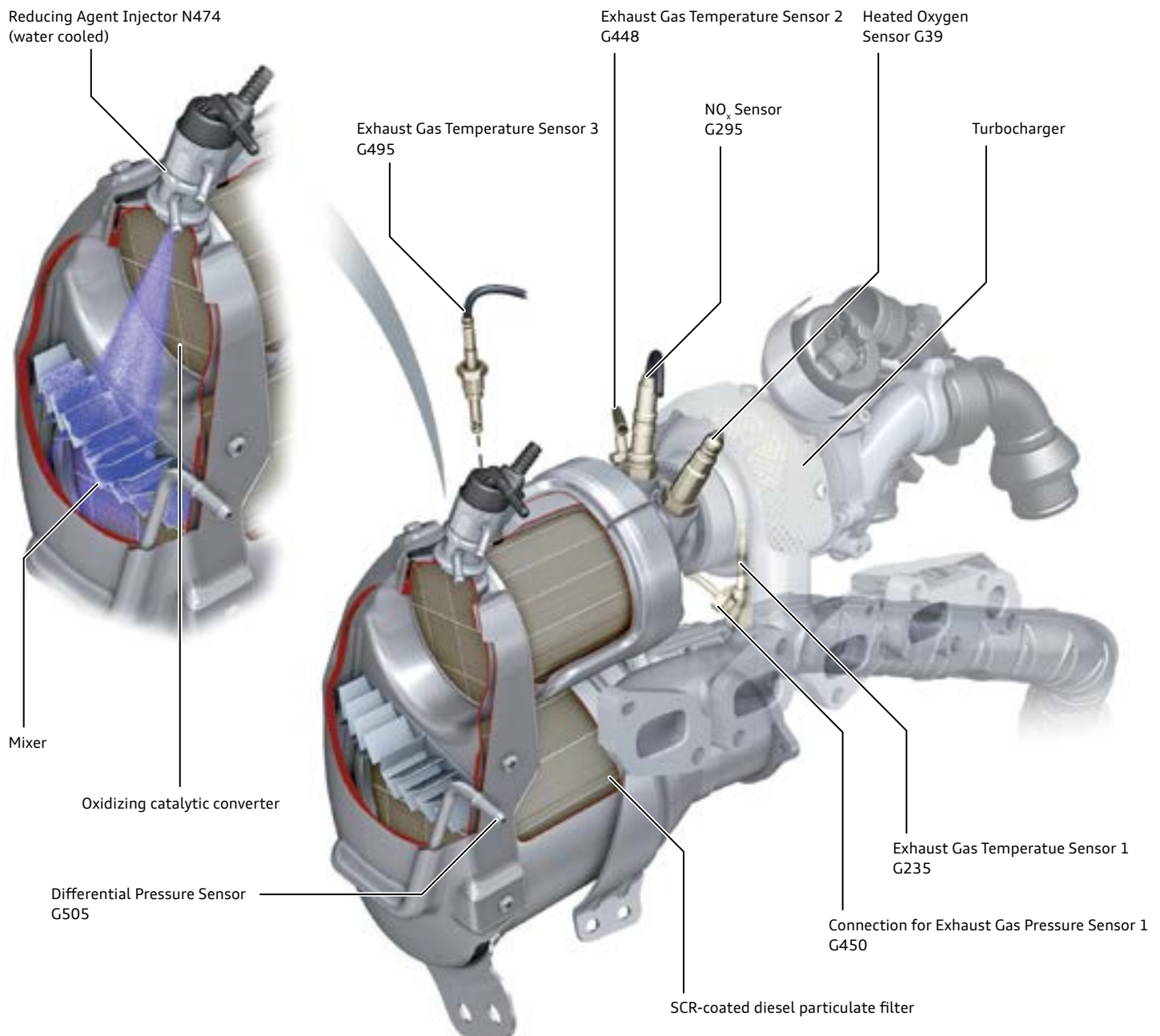
The substrate of the close-coupled exhaust gas treatment module is made of metal which allows it to reach its optimum operating temperature more quickly. The metal body is coated with a substrate of metal oxides including aluminum oxide with additional layers of platinum and palladium. These precious metals act as catalysts for hydrocarbons and carbon monoxide.

Integrating the SCR coating into the particulate filter using copper ziolite enables the system to be positioned close to the engine. After a cold start, the operating temperature of the SCR catalyst is reached more rapidly and maintained for a longer period during low-load vehicle operation.

Reducing Agent Injector N474 is mounted directly downstream of the oxidizing catalytic converter above a transition funnel to the diesel particulate filter. This allows the entire volume of the injector to be available for carburetion.

Because of its location, N474 cannot be sufficiently cooled by air alone. It has a cooling jacket and is integrated with the the low temperature circuit of the engine cooling system.

### Design

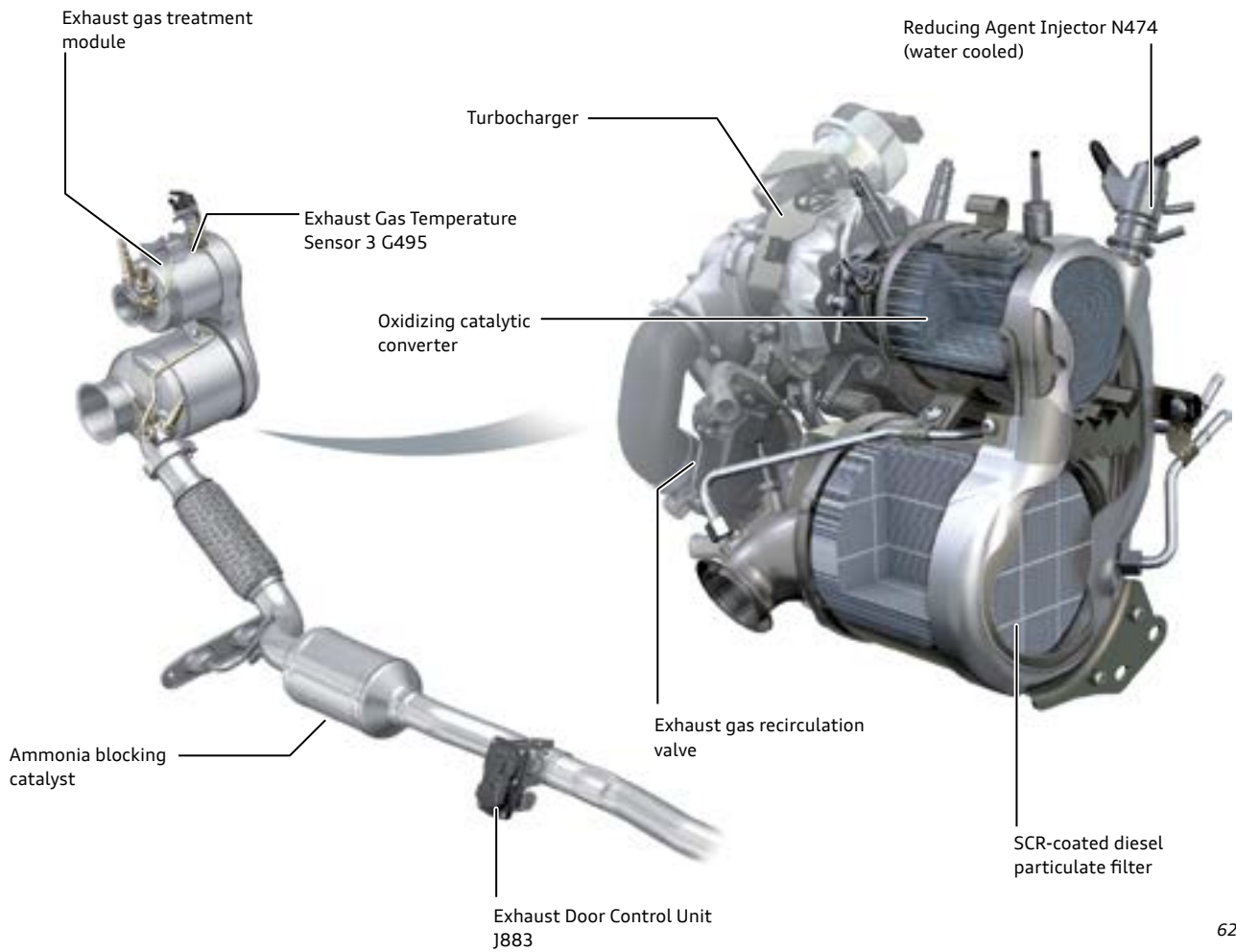


## Ammonia blocking catalyst

An ammonia blocking catalytic converter with a combined SCR and oxidizing catalyst coating is located downstream of the SCR-coated diesel particulate filter and performs two tasks:

Its first task is to oxidize the carbon monoxide (CO) produced during soot regeneration to carbon dioxide (CO<sub>2</sub>) through reaction with the precious metal-containing coating.

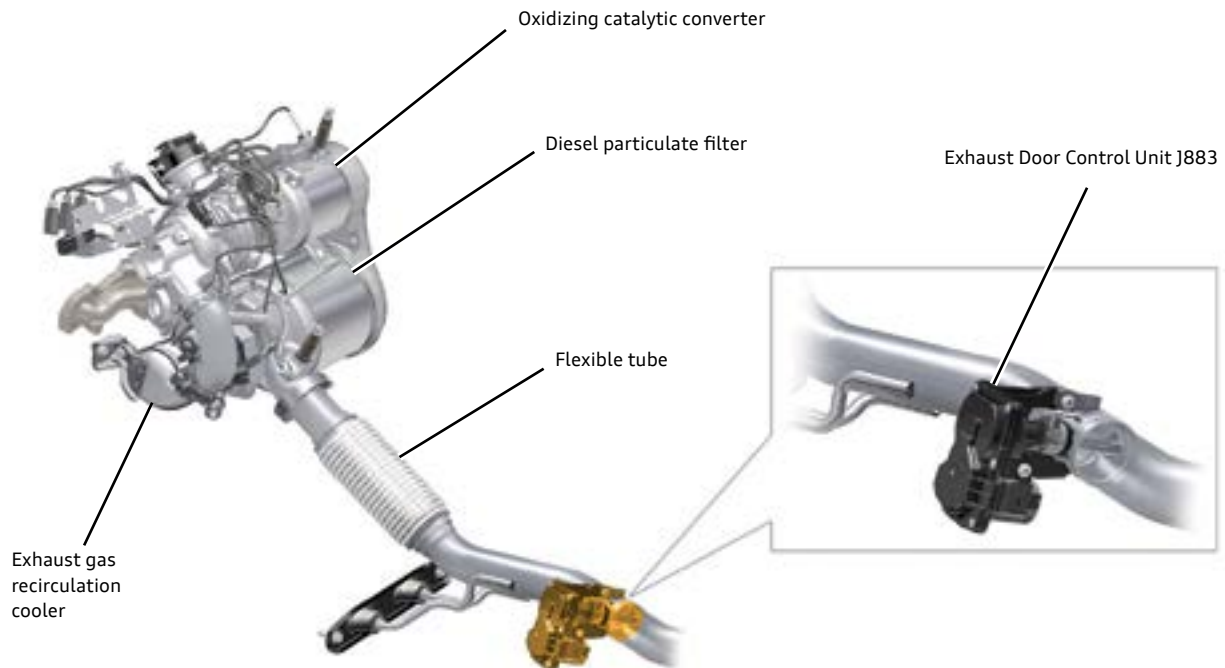
Its second task is to ensure that no NH<sub>3</sub> leaves the exhaust system. During this process, NH<sub>3</sub> is oxidized to N<sub>2</sub> and H<sub>2</sub>O.



625\_022

## Exhaust Door Control Unit J883

Exhaust Door Control Unit J883 is a throttle valve driven by an electric motor. It is mounted in the exhaust system in the direction of flow after the diesel particulate filter. J883 allows exhaust gas recirculation to be regulated. It is actuated by Engine Control Module J623 via a PWM signal.



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### Function

The task of this module is to generate a slight back pressure downstream of the diesel particulate filter. This produces an excess pressure of approximately 30 – 40 mbar downstream of the particulate filter relative to the exhaust pressure downstream of the exhaust flap.

This excess pressure results in a positive purging rate in the EGR cooler and in the downstream EGR valve. The flow of re-circulated exhaust gas is controlled (mapped) by the EGR valve. This back pressure is measured by Exhaust Gas Sensor 1 G450.

The 73° operating range of the exhaust flap door is defined by:

- ▶ the exhaust pressure downstream of the exhaust flap
- ▶ the nominal exhaust pressure upstream of the exhaust flap
- ▶ the mass flow through the exhaust flap

### Effects of failure

If Exhaust Door Control Unit J883 fails, the valve is moved to the open position by its return spring. Under these conditions, no exhaust gas recirculation takes place.

## Exhaust gas module mounting

The exhaust gas treatment module is attached to the engine block and cylinder head at four places. Compensation elements are used because of the normal production tolerances between different engine configurations. They ensure the module can be installed without subjecting it to stress.



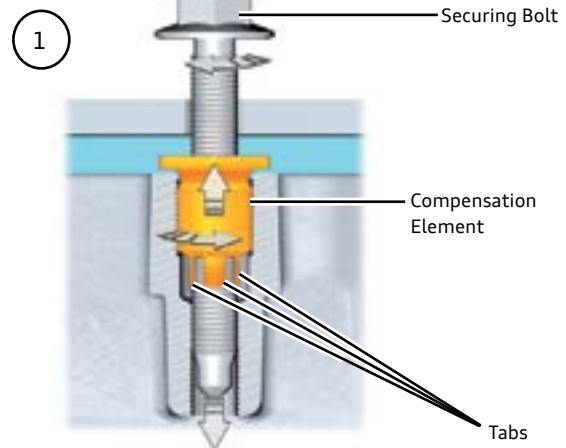
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### Function

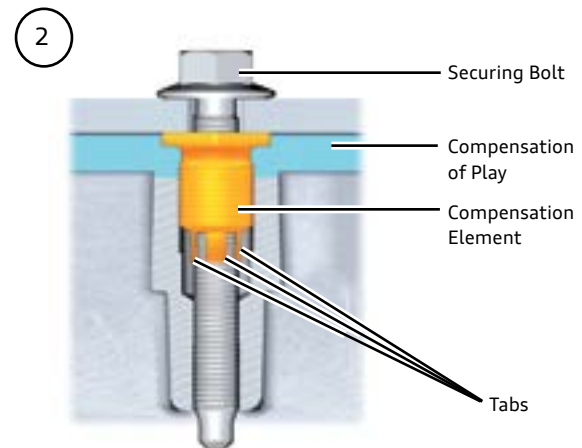
The external thread of the compensation element is a left hand thread. When the securing bolt is screwed into the respective attaching point, the bolt turns the compensation element with it as it turns due to the friction on the element tabs.

Because of the left hand thread, the compensation element turns in the opposite direction to the securing bolt when it is being inserted into the bracket.

The compensation element moves in the opposite direction to the bolt head and compensates the play between the exhaust gas treatment module and the engine.



s514\_055a



s514\_101



#### Reference

The exhaust gas treatment module must be removed and installed in a defined sequence. The compensation elements must be returned to their optimal position before re-installation and the securing bolts must always be replaced. Always refer to the latest repair information when performing these procedures.

# SCR-System

(2015 A3 model shown)

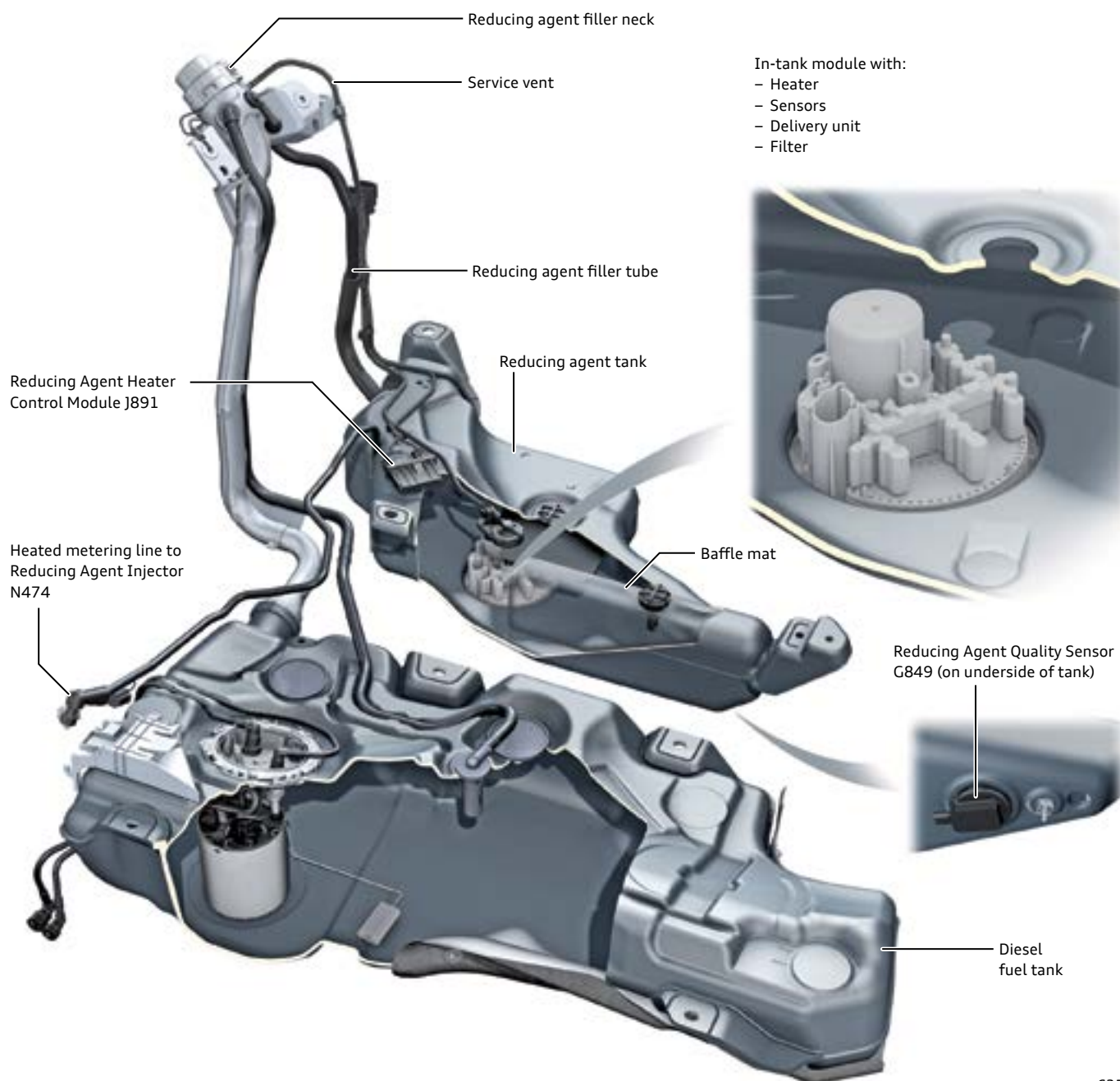
The SCR system has a special reducing agent tank with a capacity of approximately 17 liters. It is made from high grade plastic and adapted to the underbody contours of the particular vehicle.

The tank has its own filler neck and vented filler cap. The in-tank module of the system has a heater, various sensors,

a pump and a filter. A special anti-sloshing pan and baffle mat dampen the motion of the reducing agent that occurs under normal driving conditions.

The in-tank module is firmly attached to the tank. Only the pump can be replaced if servicing is necessary. All functions of the SCR system are controlled by the Engine Control Module.

## Overview



## Reducing Agent Quality Sensor G849

OBD regulations require the installation of a reducing agent quality sensor in SCR systems. The tank of this sensor is to detect insufficient reducing agent quality and manipulation.

The sensors are based on ultrasound technology which is used to measure urea concentration. This measurement also makes it possible to identify other fluids due to their different sound velocity characteristics.

625\_020

**In-tank module**

In-tank module houses the following components::

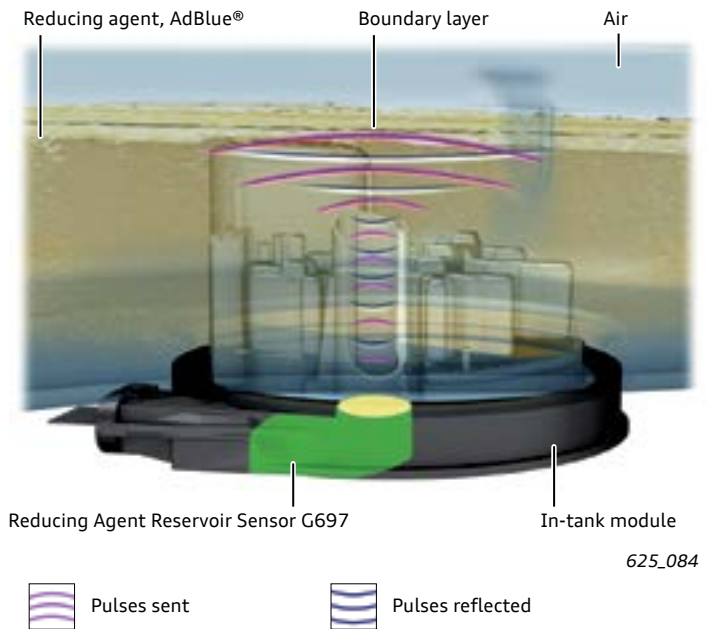
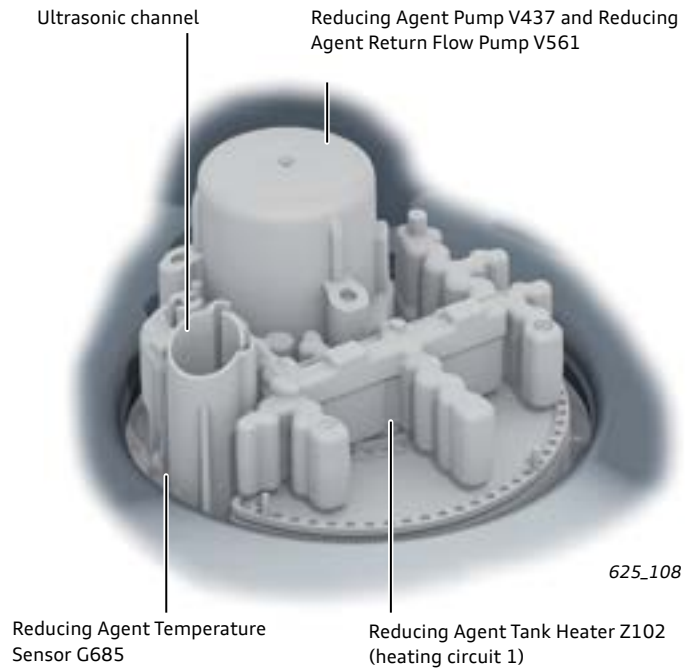
- ▶ Reducing Agent Tank Heater Z102
- ▶ Reducing Agent Reservoir Sensor G697
- ▶ Reducing Agent Pump V437
- ▶ Reducing Agent Return Flow Pump V561
- ▶ Reducing Agent Temperature Sensor G685

**Reducing Agent Tank Heater Z102**

Because the reducing agent (AdBlue) freezes at approximately 12 °F (-11 °C) the SCR system comes equipped with a PTC heater. Temperature settings are controlled by Reducing Agent Heater Control Module J891 in conjunction with Engine Control Unit J623. In addition, the line to the externally mounted Reducing Agent Injector N474 is heated.

**Reducing Agent Reservoir Sensor G697**

G697 is an ultrasound sensor. Ultrasonic waves are guided through the reducing agent by a special channel to prevent signal scatter and stray reflection. The waves are reflected by the boundary layer between the reducing agent and air. The level is determined by the time difference between the outgoing and incoming impulses taking into account the sonic velocity of the reducing agent level.

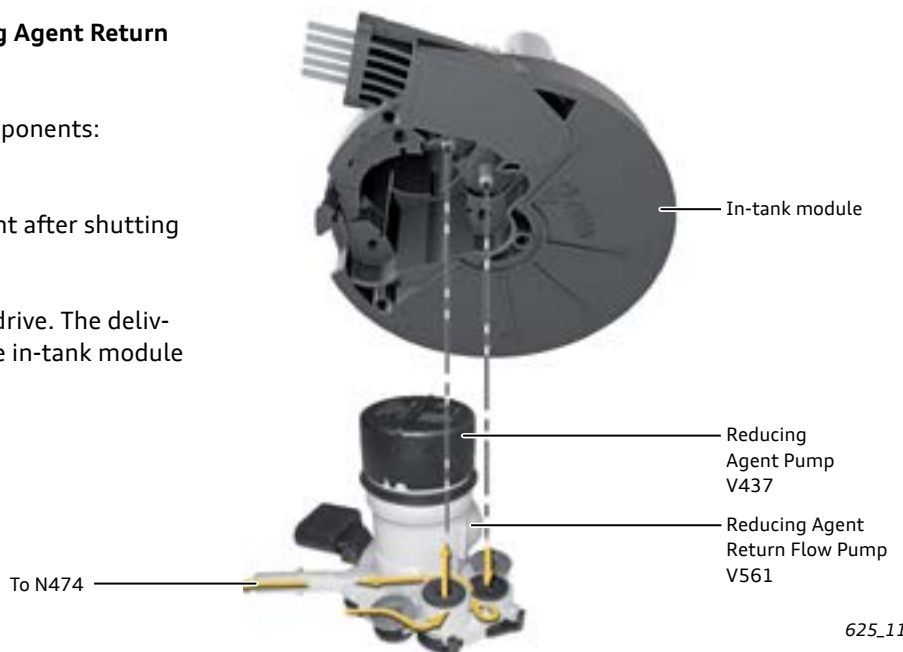


**Reducing Agent Pump V437 and Reducing Agent Return Flow Pump V561 (delivery module)**

The delivery module has the following components:

- ▶ Twin linear solenoid diaphragm pumps
- ▶ A reducing agent supply line to N474
- ▶ A line for recirculating the reducing agent after shutting off the engine

The linear solenoid serves here as a pump drive. The delivery module is mounted separately from the in-tank module and can be replaced.





## Solenoid diaphragm pump

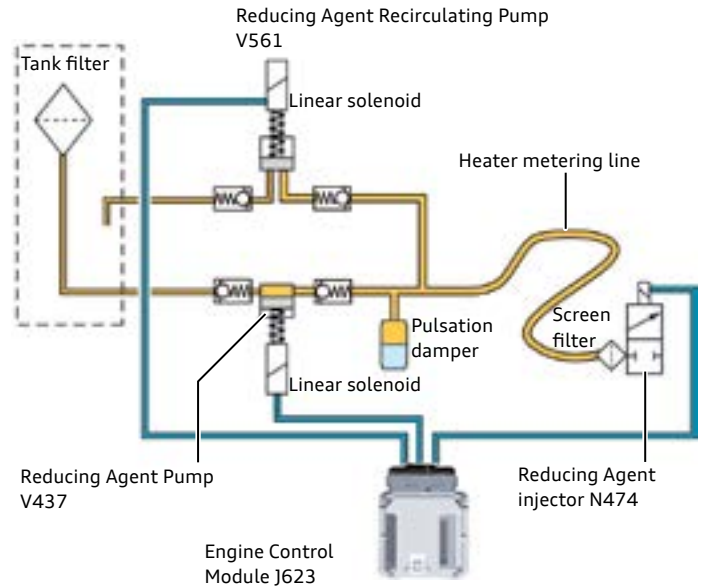
The SCR system on the A3 TDI uses a solenoid driven diaphragm pump to deliver the fluid to the injector instead of a motor driven pump as seen in the other TDI models. (Q7, A6, A7, A8, Q5).

The stroke volume is virtually constant and depends only to a minimal extent on the prevailing pressure. The urea solution is injected via the reducing agent injector on demand and depending on the nitrous oxides produced during the combustion cycle. The quantity of urea solution injected is then delivered by the reducing agent pump in a controlled manner. Due to the close tolerances of the reducing agent pump and reducing agent injector, pressure equilibrium occurs at approx. 6.5 bar ( $\pm 2$  bar). This process of constant volume delivery is also known as volumetric delivery. There is no need for a pressure sensor, including the required pressure sensor heater, pressure sensor housing and control system.

The pressure in the system can be determined by measuring the time when the pump is first energized to when the armature in the solenoid moves, as well as by measuring the amount of electrical current required to move the solenoid.

During delivery, V437 is energized by ECM J623 using pins 3 and 4. The recirculating pump V561 is energized by J623 using pins 1 & 2. Reducing Agent Recirculating Pump V561 is energized by the ECM using pins 1 and 2.

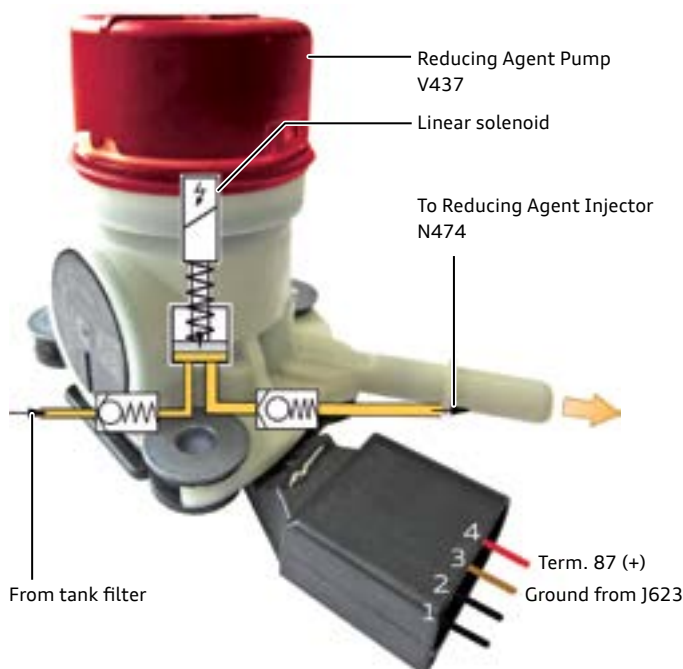
Large pressure deviations from the normal system pressure indicate faults in the system; for example, jamming of the pump, a defective pump diaphragm, a leak in the pressure line a clogged metering valve, or pump intake problems.



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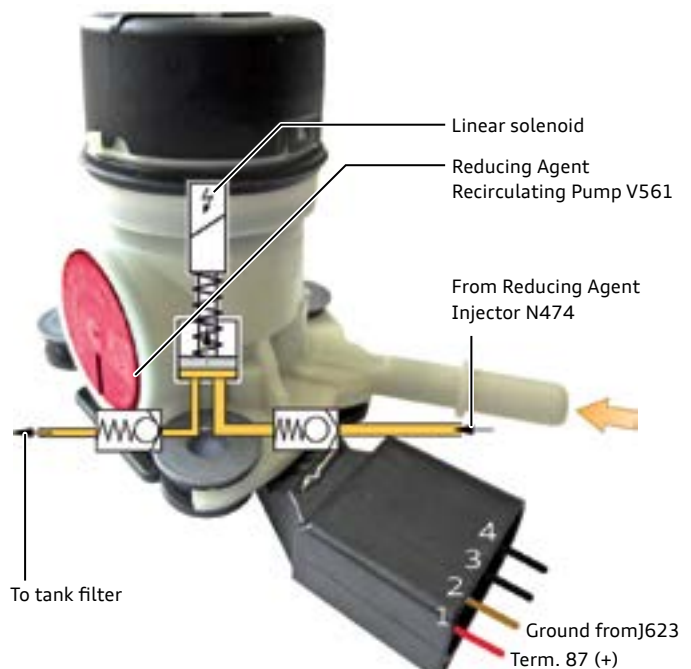
Immediately after shutting off the engine, N474 closes and some of the reducing agent is drawn back out of the metering line by the return flow pump. This is done with N474 closed so no hot exhaust gases are taken in. A short time later, N474 is opened and additional reducing agent is drawn back. This process prevents reducing agent from freezing and creating damage.

### Delivery



625\_138

### Return



625\_137

# Special tools and workshop equipment

## T10172 with T10172/11 Adapter

Adapter for the counter-holder of the camshaft sprocket.



608\_071

608\_072

## T10489 Puller

Puller to disassemble the hub of the high-pressure pump.



608\_064

## T10490 Crankshaft stop

Crankshaft stop for holding the crankshaft when adjusting the valve timing.



608\_066

## T10491 Socket SW22

Socket to remove and install the Oxygen sensor.



608\_068

## T10492 Locking pin

Locking pin to lock the pulley of the high-pressure pump.



608\_069

## T10493 Assembly tool

Tools for installing oil seals for the camshaft.



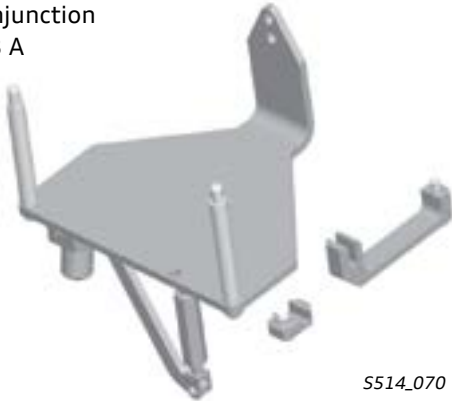
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## T10497 Engine bracket

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Engine bracket for removing and installing the engine in conjunction with V.A.G. 1383 A



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## T10501 Socket XZN 10

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Socket to remove and install the intake manifold.



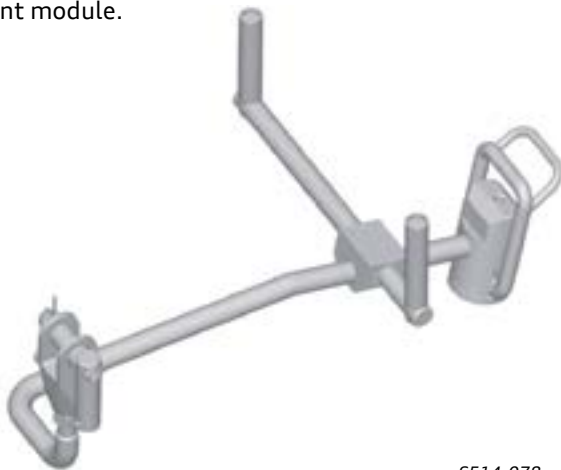
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## T10511 Assembly aid

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Assembly aid to remove and install the exhaust treatment module.



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## T10512 Calibration tool

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Calibration tool to adjust the compensation elements when installing the exhaust treatment module.



S514\_069

# Knowledge Assessment

An On-Line Knowledge Assessment (exam) is Available for this eSelf-Study Program.

The Knowledge Assessment is required for Certification.

You can find this Knowledge Assessment at:

[www.accessaudi.com](http://www.accessaudi.com)

From the [accessaudi.com](http://www.accessaudi.com) Homepage:

- ▶ Click on the “ACADEMY” tab
- ▶ Click on the “Academy site” link
- ▶ Click on the Course Catalog Search and select “920143 - The Audi 2.0L Third Generation TDI Engine”

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