



Modifications to the chain-driven 4-cylinder TFSI engine

Self-Study Programme 436

The 1.8-litre chain-driven 4V TFSI engine was the first engine of its kind when it was launched in 2006. This new 4-cylinder engine generation (EA888) is gradually replacing the timing belt-driven 4-cylinder engine generation, now being phased out. The engine first appeared on the Audi A3 as a transverse unit. This so-called "Stage 0" engine was developed with emphasis on the following development goals:

- Enhanced fuel economy
- Reduced exhaust emissions and compliance with future exhaust emission standards
- Extended performance range
- Longitudinal installation of the engine

For a detailed technical description of the "Stage 0" engine, please refer to Self-Study Programme 384, "Audi 1.8-litre chain-driven 4V TFSI engine". Stage 2 has now been implemented. A table summarising the various modifications is included in this Self-Study Programme. The modifications relevant to service centres are described below.

A key milestone for Audi was the launch of the engine on the North American market, where the world's most stringent exhaust emission standards (ULEV II and SULEV) apply. To meet these limits, further technical modifications were called for. You will also find a description of these modifications in this Self-Study Programme.



Illustrations on page 1

Large picture: longitudinal 1.8l TFSI engine

Small picture: longitudinal cylinder head of the 2.0l TFSI engine

Transverse 2.0l TFSI engine



436_001

The learning objectives of this Self-Study Programme:

In this Self-Study Programme, you will learn about the key modifications to the chain-driven 4-cylinder TFSI engine. Once you have worked your way through this Self-Study Programme, you will be able to answer the following questions:

- How do you differentiate between the various development stages of the longitudinal and transverse engines?
- What are the main technical modifications, and why were they introduced?
- Which modifications were made to the crankcase ventilation system?
- What are the points to observe when testing the oil pressure when a self-regulating oil pump is installed?
- What are the special features of the Audi valvelift system in the 4-cylinder TFSI engine compared to the system on the V6 FSI engine?
- What were the measures implemented to meet the ULEV II and SULEV exhaust emission standards, and how does this technology work?

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2.0l TFSI engine for SULEV

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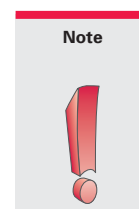
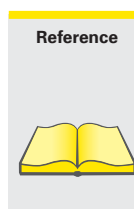
Terms shown in italics and marked by an asterisk (*) are explained in the glossary at the end of this Self-Study Programme.

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

The Self Study Programme is not a Repair Manual.

All values given are intended for reference purposes only and refer to the software version valid at the time of preparation of the SSP.

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



Overview of the development stages

Engine	Stage 0			
<p data-bbox="442 365 679 387">1.8l longitudinal engine</p> 				
<p data-bbox="442 730 672 752">1.8l transverse engine</p> 	EC: BYT	SOP: 01/2007	EOP: 06/2007	EU IV
<p data-bbox="442 1081 679 1104">2.0l longitudinal engine</p> 	<p data-bbox="798 779 1184 801">Initial rollout of the EA888 engine series</p>			
<p data-bbox="442 1592 672 1615">2.0l transverse engine</p> 				

You will find explanatory notes on the abbreviations used in this table on page 8.

Stage 1

Stage 2

EC: CABA	SOP: 02/2008	EOP: 09/2008	EU IV	EC: CDHA	SOP: 09/2008	EOP: - / -	EU V
EC: CABB	SOP: 07/2007	EOP: 05/2008	EU IV	EC: CDHB	SOP: 06/2008	EOP: - / -	EU V
EC: CABD	SOP: 10/2007	EOP: 11/2008	EU IV				
Modifications to Stage 0 (1.8l transverse engine): <ul style="list-style-type: none"> - Positive crankcase ventilation - Self-regulating oil pump 				Modifications to Stage 1: <ul style="list-style-type: none"> - Main bearing diameter reduced from 58 to 52 mm - Modified piston - Modified piston rings - Different honing process - Ixetic vacuum pump 			

EC: BZB	SOP: 06/2007	EOP: 06/2008	EU IV	EC: CDAA	SOP: 05/2008	EOP: - / -	EU V
Modification to Stage 0: <ul style="list-style-type: none"> - Positive crankcase ventilation 				Modifications to Stage 1: <ul style="list-style-type: none"> - Diameter of main bearing reduced from 58 to 52 mm - Modified piston - Modified piston rings - Different honing process - Self-regulating oil pump - Ixetic vacuum pump - Fuel supply line (routing) - Turbocharger control rod in accordance with EA113 			

EC: CDNA	SOP: 22/2009	EOP: - / -	EU II - V
EC: CDNB	SOP: 06/2008	EOP: - / -	EU V
EC: CDNC	SOP: 06/2008	EOP: - / -	EU V
EC: CAEA	SOP: 01/2009	EOP: - / -	ULEV II
EC: CAEB	SOP: 08/2008	EOP: - / -	ULEV II
Modifications to Stage 1 (1.8l longitudinal engine): <ul style="list-style-type: none"> - Audi Valvelift System (AVS) - Modified piston - Modified piston rings - Different honing process - Ixetic vacuum pump - Hitachi Generation III high-pressure fuel pump - New air mass meter 			

EC: CAWB	SOP: 11/2007	EOP: 05/2008	EU IV	EC: CCZA	SOP: 05/2008	EOP: - / -	EU V
EC: CBFA	SOP: 02/2008	EOP: 05/2009	PZEV, SULEV	EC: CCXA	SOP: 05/2009	EOP: - / -	BIN 5/ULEV II
EC: CCTA	SOP: 05/2009	EOP: 05/2009	BIN 5, ULEV II				
Modification to Stage 0 (1.8l transverse engine): <ul style="list-style-type: none"> - Positive crankcase ventilation 				Modifications to Stage 1: <ul style="list-style-type: none"> - Modified piston - Modified piston rings - Different honing process - Self-regulating oil pump - Ixetic vacuum pump - Hitachi Generation III high-pressure fuel pump - Fuel supply line (routing) - New air mass meter 			

Introduction

Technical features

Technical features of the 4-cylinder TFSI engines

Engine	1.8l TFSI	1.8l TFSI	1.8l TFSI
Engine codes	CDHA, CABA	BYT, BZB	CDAA, CABB, CDHB
Displacement in cm ³	1789	1789	1789
Max. power in kW at rpm	88 at 3650 – 6200	118 at 5000 – 6200	118 at 4500 – 6200
Max. torque in kW at rpm	230 at 1500 – 3650	250 at 1500 – 4200	250 at 1500 – 4500
Bore in mm	82.5	82.5	82.5
Stroke in mm	84.1	84.1	84.1
Compression ratio	9.6 : 1	9.6 : 1	9.6 : 1
Fuel in RON	95/91 ¹⁾	95/91 ¹⁾	95/91 ¹⁾
Injection/ignition system	FSI	FSI	FSI
Firing order	1–3–4–2	1–3–4–2	1–3–4–2
Knock control	yes	yes	yes
Charging	yes	yes	yes
Exhaust gas recirculation	no	no	no
Intake manifold change-over	no	no	no
Variable valve timing	yes	yes	yes
Secondary air system	no	no	no
Audi valvelift system (AVS)	no	no	no
Self-regulating oil pump	yes	no	yes
Intake manifold flaps	yes	yes	yes

¹⁾ Unleaded RON 91 petrol may also be used with a slight reduction in engine power

²⁾ The engine develops 130 kW, but all other parameters are identical

Abbreviations used in the table on pages 6/7:

EC Engine Code

SOP Start of Production

EOP End of Production

EA113 engine series 1.8l MPI

Exhaust emission standards:

EU IV, EU V, BIN 5, PZEV, SULEV, ULEV II

1.8l TFSI	2.0l TFSI	2.0l TFSI	2.0l TFSI	2.0l TFSI
CABD	CAEA, CDNB, (CDNA) ²⁾	CAWB, CBFA	CCTA, CCZA	CAEB, CDNC
1789	1984	1984	1984	1984
125 at 4800 – 6200	132 at 4000 – 6000	147 at 5100 – 6000	147 at 5100 – 6000	155 at 4300 – 6000
250 at 1500 – 4800	320 at 1500 – 3900	280 at 1700 – 5000	280 at 1700 – 5000	350 at 1500 – 4200
82.5	82.5	82.5	82.5	82.5
84.1	92.8	92.8	92.8	92.8
9.6 : 1	9.6 : 1	9.6 : 1	9.6 : 1	9.6 : 1
95/91 ¹⁾	min. 95	95/91 ¹⁾	95/91 ¹⁾	min. 95
FSI	FSI	FSI	FSI	FSI
1–3–4–2	1–3–4–2	1–3–4–2	1–3–4–2	1–3–4–2
yes	yes	yes	yes	yes
yes	yes	yes	yes	yes
no	no	no	no	no
no	no	no	no	no
yes	yes	yes	yes	yes
no	no	yes (CBFA only)	no	no
no	yes	no	no	yes
yes	yes	no	yes (CCZA only)	yes
yes	yes	yes	yes	yes

Reference



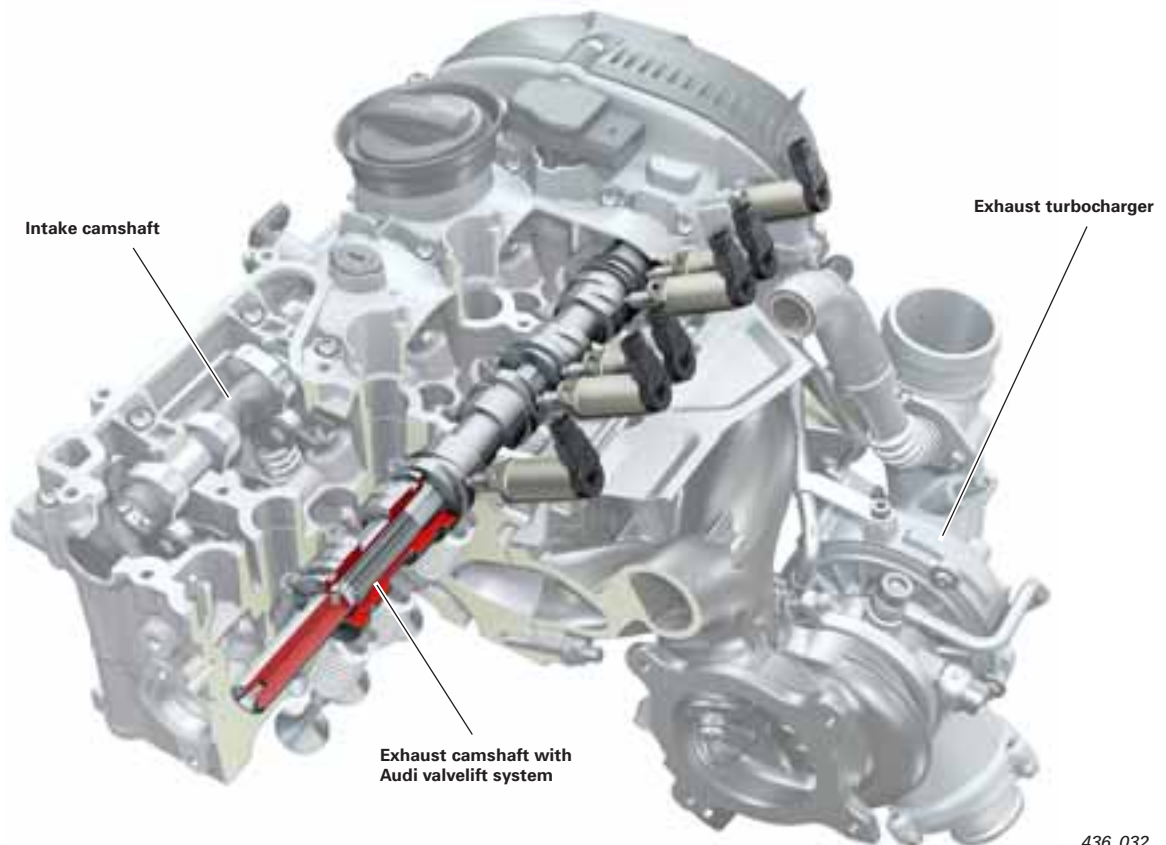
The engines compliant with the ULEV II and SULEV exhaust emission standards are not included in this table (engine code CCXA). You will find their technical specifications in the relevant sections of this Self-Study Programme (see page 32).

Audi valvelift system (AVS)

The Audi valvelift system was developed to optimise the charge cycle and launched on the 2.8l V6 FSI engine of the Audi A6 in late 2006.

In the case of the chain-driven 4-cylinder TFSI engines, the system is used on the longitudinal 2.0l TFSI (engine code: see table on page 6). Unlike the 6-cylinder naturally aspirated engines (2.8l and 3.2l), the system is not used on the intake side of the 2.0l TFSI engine, but on the exhaust side.

In this case, the firing order is separated, i.e. the exhaust turbocharger is pulse-charged. "Firing sequence separation" means that the gas pulses produced by the exhaust cycles in the individual cylinders do not affect the exhaust cycle in the previous cylinder due to "overlap". The result is what is known as "pulse charging".



Reference



The basic functions of the system are described in Self-Study Programme 411, "Audi 2.8l and 3.2l FSI engine with Audi valvelift system".

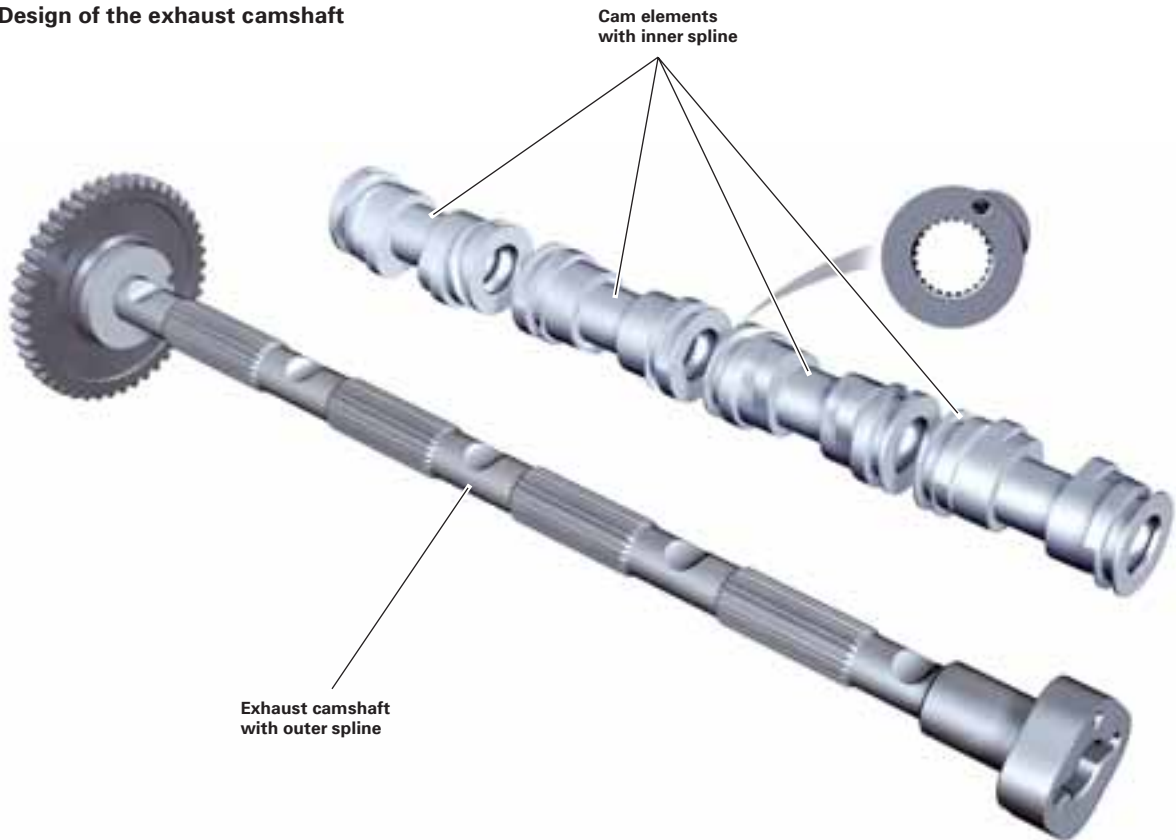
The mechanical design and function of the Audi valvelift systems on the 4-cylinder TFSI engine closely resemble those of the system on the 6-cylinder naturally aspirated engine. However, different thermodynamic effects are utilised.

At low engine speeds, a narrower cam lobe contour is used. At high engine speeds, the system changes over to the wide, basic cam lobe contour. The narrow cam lobe contour provides very late exhaust valve opening. This effectively prevents back-flow of exhaust gas during the valve overlap phase due to the pre-exhaust pulse (at the exhaust valve opening point) of the cylinder, which is offset at 180° crankshaft angle. Advance intake valve timings are therefore possible.

The positive pressure gradient allows the combustion chamber to be effectively purged. This considerably enhances carburetion, firstly, by reducing the residual gas content in the cylinder and, secondly, by facilitating advance intake valve timings (because less intake air is expelled after BDC).

These improvements, in turn, result in much better response and much higher torque at low rpm. Thus, charge pressure can be built up more quickly. The torque curve is steeper, and the driver hardly notices any turbo lag when accelerating.

Design of the exhaust camshaft



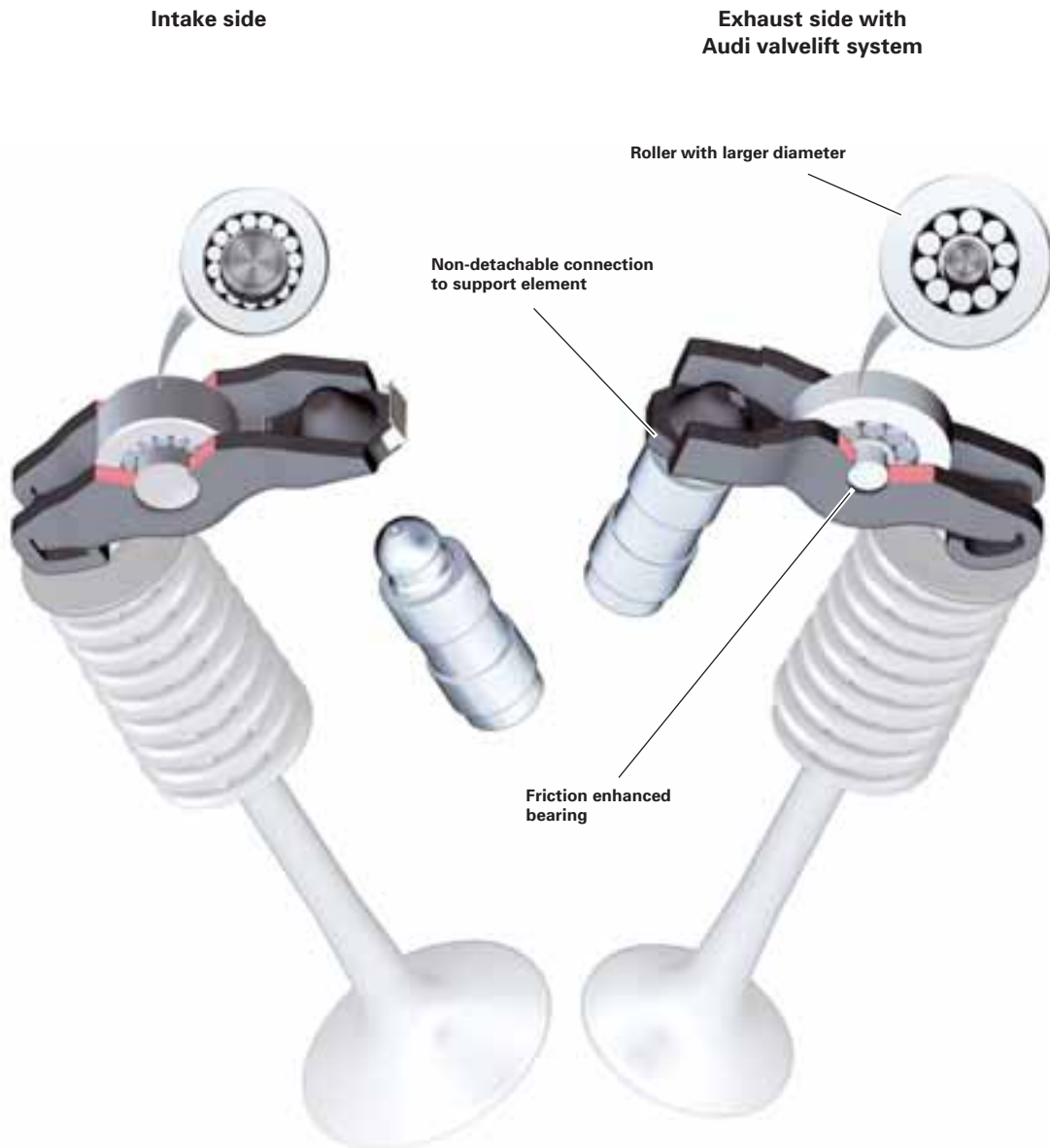
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Modifications to the roller cam followers

The roller cam followers for the exhaust camshaft have been modified to reach both valve lift cams on the cam elements. To achieve this, the roller is now larger in diameter and narrower in width.

At the same time, the roller cam followers have been optimised for low friction by using improved bearings. To prevent the roller cam followers from tilting downwards, it is connected non-detachably to the support element.

For this reason, a roller cam follower can only be replaced with a complete, pre-assembled module.



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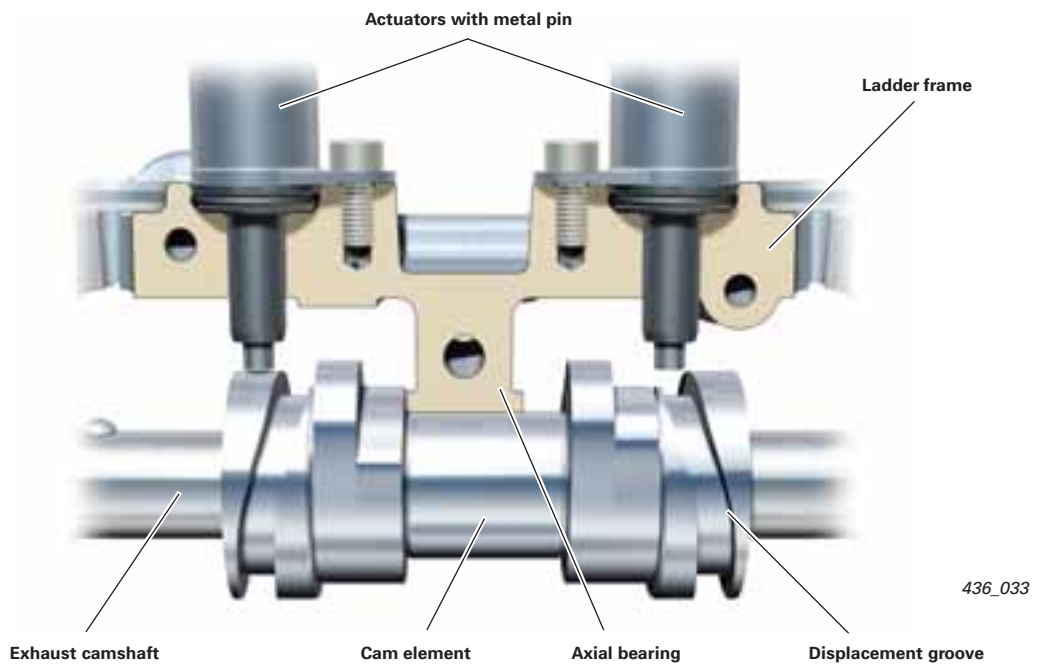
Function

Each cylinder has a movable cam element on the exhaust side. Two valve lift contours are therefore possible for each exhaust valve. Changing-over between the large and small cam lobe contours is achieved by the longitudinal displacement of the cam elements.

While one actuator switches from small valve lift to large valve lift, the other actuator switches from small valve lift to large valve lift.

The second actuator switches back from large valve lift to small valve lift. When an actuator is activated by the engine control unit, a metal pin is ejected and engages in the displacement groove of the cam element.

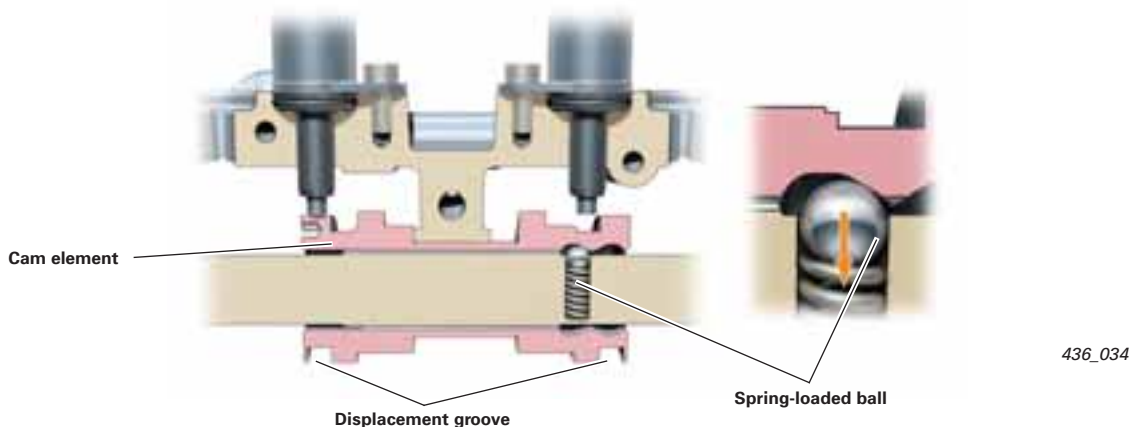
The cam element is designed to move automatically when the camshaft rotates, thereby changing over both exhaust valves to the other cam lobe contour. The displacement groove in the cam elements must, however, be shaped so that the metal actuator pin is pushed back again after the change-over is made. The metal pin cannot be actively changed back by the engine control unit.



Locking of the cam elements

To ensure that the cam elements are not displaced too far when they are adjusted, adjustment travel is limited by a stop. In this case, a camshaft bearing in the cylinder head cover acts as the stop.

It must also be ensured that the cam elements remain in position after they have been adjusted. For this purpose, the cam elements are located by a detent with a spring-loaded ball in the camshaft.



Engine mechanicals

Cam lobe contour

There are two cam lobe contours per valve on the cam elements. The cam timings are configured according to the required engine characteristic.

The small cam races (shown in green in the figure) implement a valve opening stroke of 6.35 mm. The length of opening is 180° crankshaft angle. The exhaust valve closes 2° after TDC.

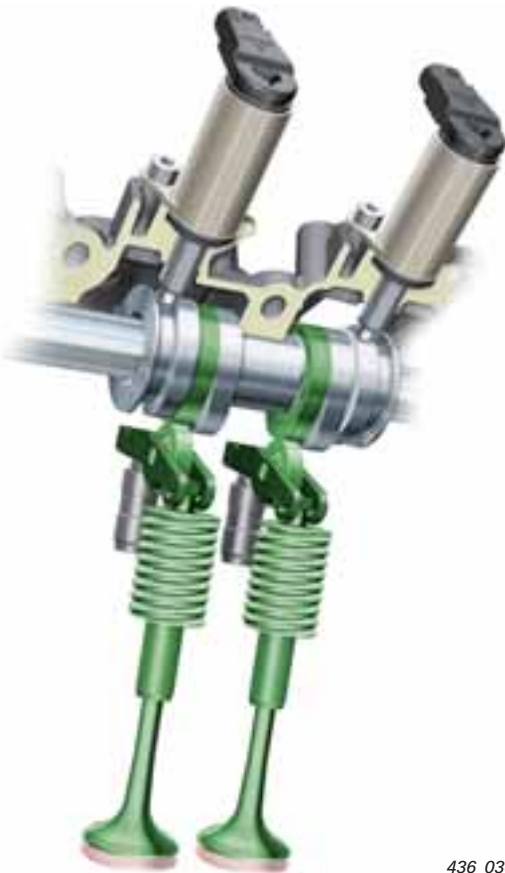
The full stroke provided by the large cam races (shown in red in the figure) is 10 mm with a length of opening of 215° crankshaft angle. The exhaust valve closes 8° before TDC.



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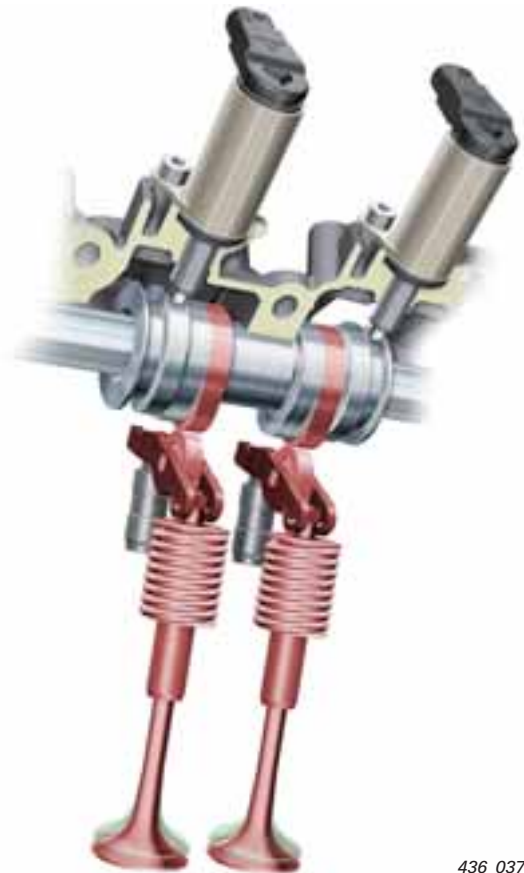
Method of operation

**Small cam races
(low engine speeds)**



436_036

**Large cam races
(high engine speeds)**



436_037

Cam adjustment actuators F366 – F373

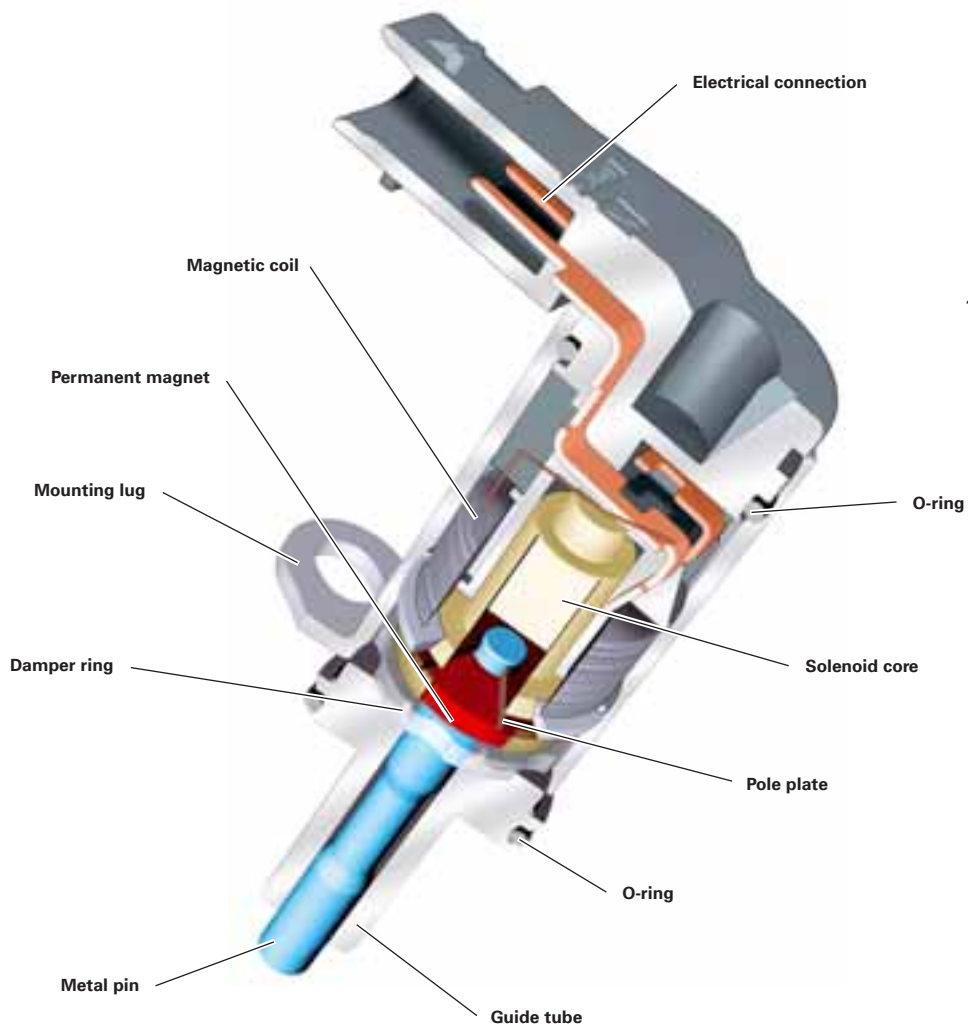
The cam adjustment actuators are electromagnetic actuators. Two actuators are used per cylinder. One actuator moves the cam element on the camshaft for large valve lift. The other actuator resets to the cam element for small valve lift.

Each actuator is attached externally to the cylinder head cover by a screw. An O-ring is used as a seal. When the actuator is activated by the engine control unit, a metal pin is ejected and engages in the displacement groove in the cam element, thereby switching to the other cam lobe contour.



Design

436_043



Engine mechanicals

Function

A solenoid is integrated in the actuator. When the solenoid is activated by the engine control unit, a metal pin is ejected. The solenoid is activated through brief application of battery voltage.

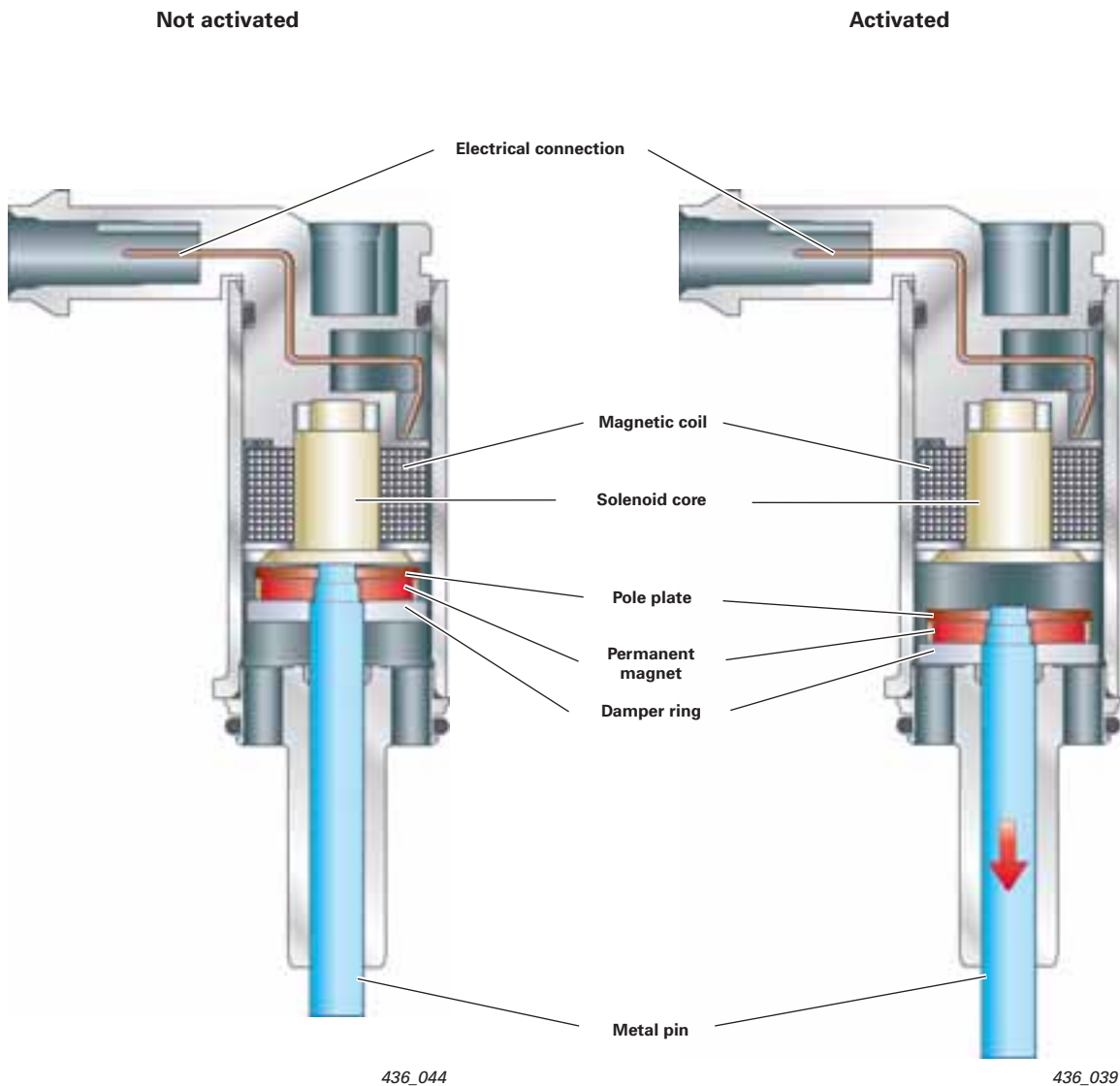
When the metal pin is ejected, it is held in position by means of a permanent magnet on the actuator housing.

Due to the quick extension time (18 – 22 ms), the metal pin undergoes very rapid acceleration. A damping ring near the permanent magnet ensures that the pin does not bounce back or become damaged.

The metal pin extending into the displacement groove now moves the cam element while the camshaft rotates.

The contour of the displacement groove is designed to push the metal pin of the actuator back after just under one revolution of the actuator. In this case, too, the permanent magnet ensures that the metal pin remains in this position. When the permanent magnet pushes the metal pin, a voltage is induced in the magnetic coil of the solenoid.

This signal is registered by the engine control unit (return signal). It can only be generated if the metal pin is pushed back by the displacement groove after the cam element has been moved. The engine control unit evaluates the signal input as a successful adjustment.



Activation of the cam adjustment actuators

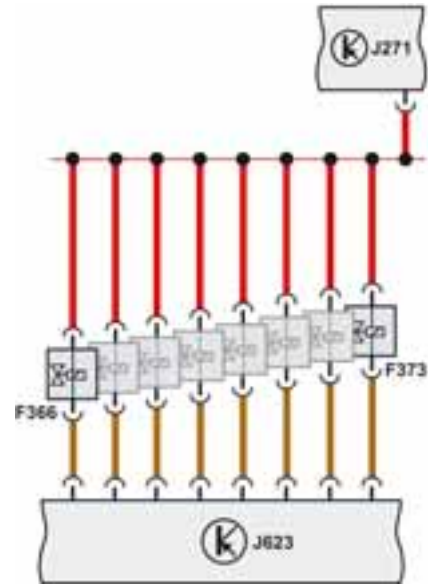
The cam adjustment actuators are activated by the engine control unit.

The engine control unit generates a ground signal for this purpose. Voltage is supplied via the Motronic power supply relay J271.

The system is ready for operation as of a coolant temperature of $-10\text{ }^{\circ}\text{C}$.

The engine is started using the basic cam, i.e. the cam with the large lobe contour. Immediately after that, the system changes over to the small cam lobe contour.

When the engine stops, the system changes back to the basic cam. Maximum power input per actuator is 3 amperes.

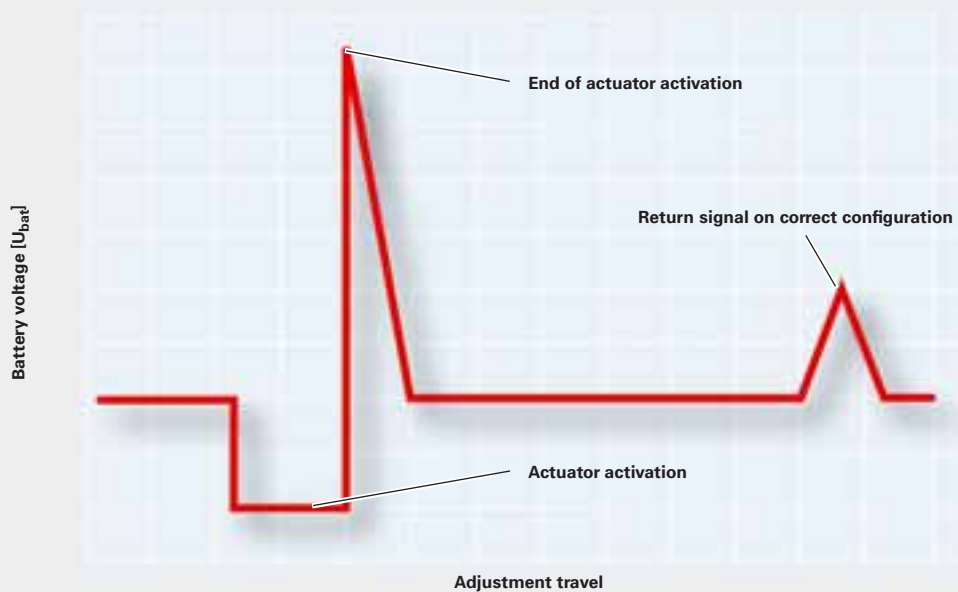


Legend:

- F366 – Cam adjustment actuators
- F373
- J271 Motronic current supply relay
- J623 Engine control unit

436_041

Activation of a cam adjustment actuator



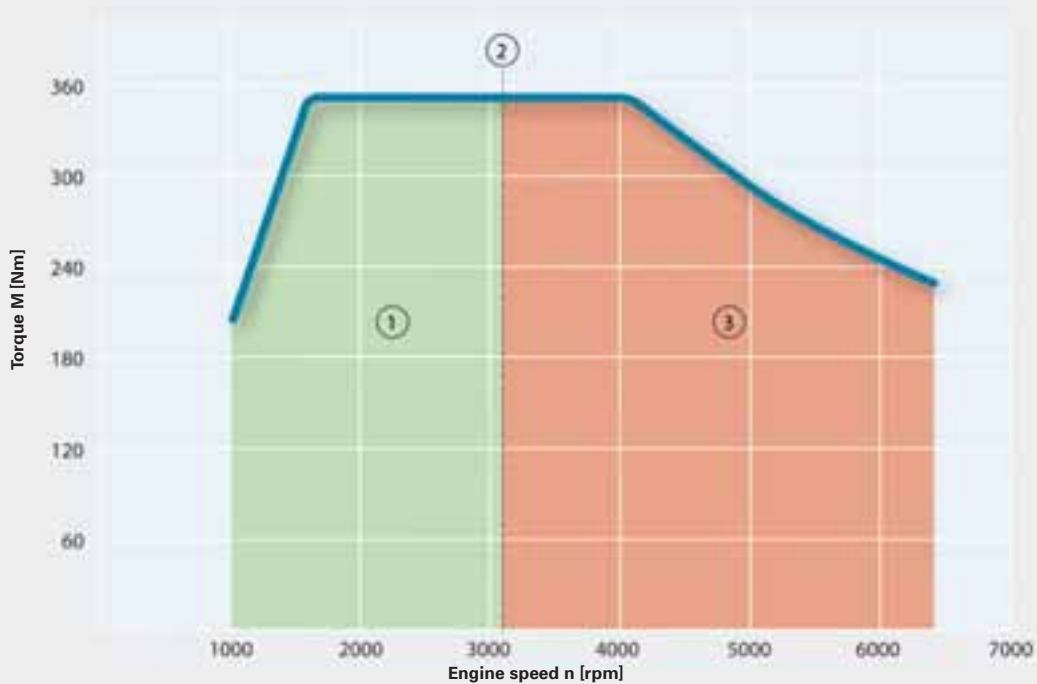
Engine mechanicals

Changing over between working ranges

This figure shows in schematic form the working range of the Audi valvelift system when the engine is at operating temperature. It clearly can be seen that the small valve lift is used up to medium engine speeds of approx. 3100 rpm.

In the engine speed range required for change-over to large valve lift, the intake manifold flaps are also opened wide.

Audi valvelift system in the operating ranges



- ① Small valve lift
- ② Operating point (at approx. 3100 rpm)
- ③ Large valve lift

Note



This figure uses an example to illustrate the torque curve and AVS operating point. Both are dependent on the current engine control unit software version, and can change in the course of ongoing model development.

Self-diagnostics

The self-diagnostics firstly check the mechanical function of the cam adjustment actuators (change-over to the other cam lobe contour) and, secondly, the system's electrical connections.

A system test is performed after the engine is started. The engine control unit activates each actuator for this purpose.

Both configurations are tested and evaluated. This system test is audible and is performed whenever the engine is started.

System failure will result corresponding fault memory entries.

Depending on the nature of the fault, a "perceptive" driver may notice a slight variation in engine idling speed or a different engine response under acceleration.

How the system responds to faults

If one or more actuators fails, the engine control unit will initially attempt (several times) to change over to the other cam. If no adjustment is made, the cam elements which cannot be adjusted remain in position.

All other cam elements are changed over to the large cam. They then remain in this position while the engine is running.

There is a special fault memory entry for faulty actuators.

The next time the engine is started, another attempt is made to adjust all cam elements.

Activation of the warning lamps

Exhaust emissions do not deteriorate due to system failure and virtually no adverse handling effects are to be expected, so neither the electronic power control fault lamp K132 nor the exhaust gas warning lamp K83 is activated. However, corresponding fault memory entries are generated.

Vehicle self-diagnostics		01 - Engine electronics	
004.01 - Interrogate fault memory		EV_ECM20AVS_X1	
1 Fault detected			
SAE code	Text	Status	
P11A100	Cam adjuster "A", cylinder 1 Electrical fault/open circuit	active/ static	
			Ambient conditions

436_065

Positive crankcase ventilation

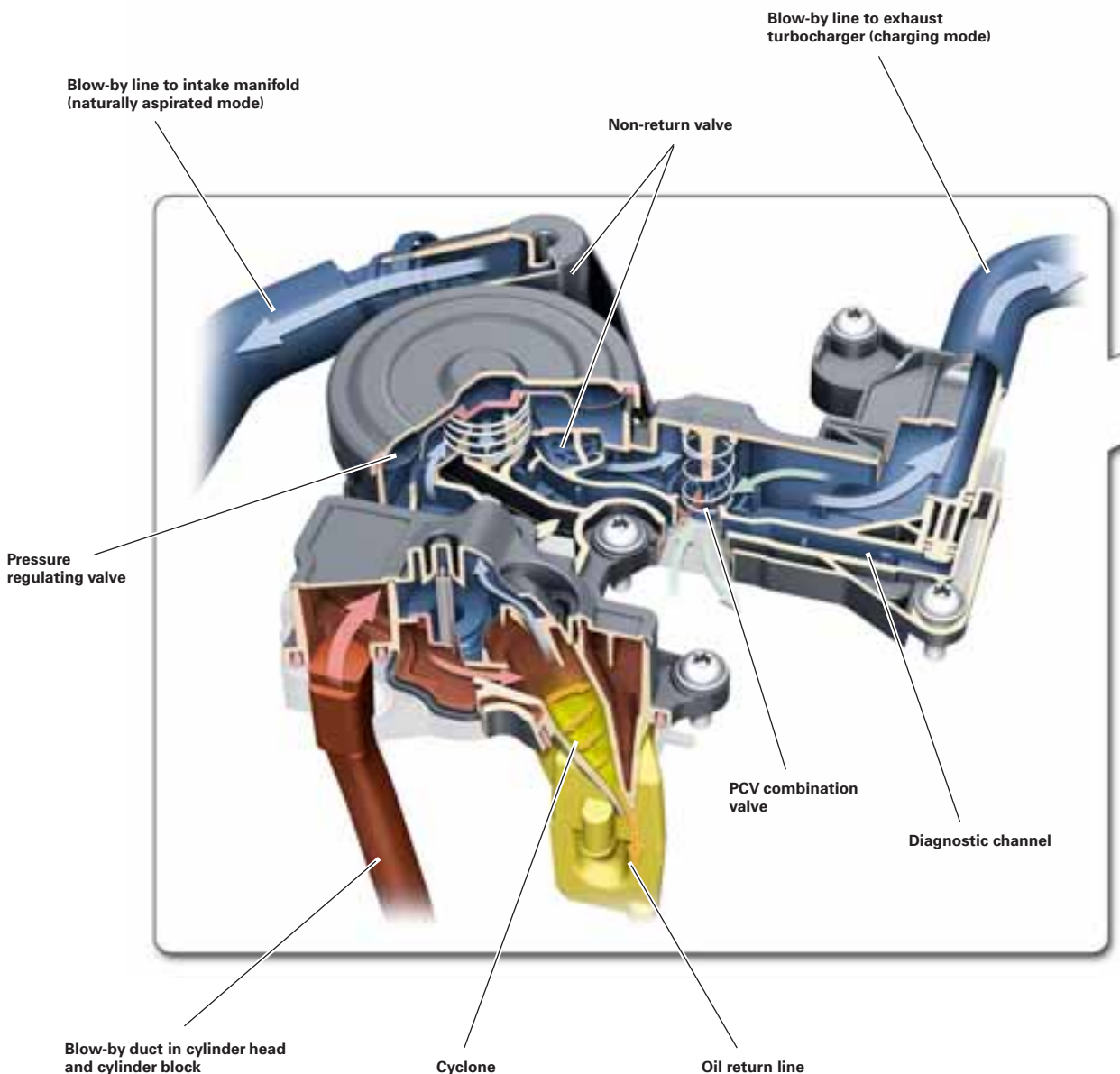
A key criterion for further development of the engine was to meet the more stringent requirements regarding pedestrian safety. Due to the more compact design of the components above the cylinder head cover, there is more clearance between the engine and engine hood. This means that the engine hood has a larger crumple zone.

Another advantage is that installation space is gained, thus making longitudinal installation possible.

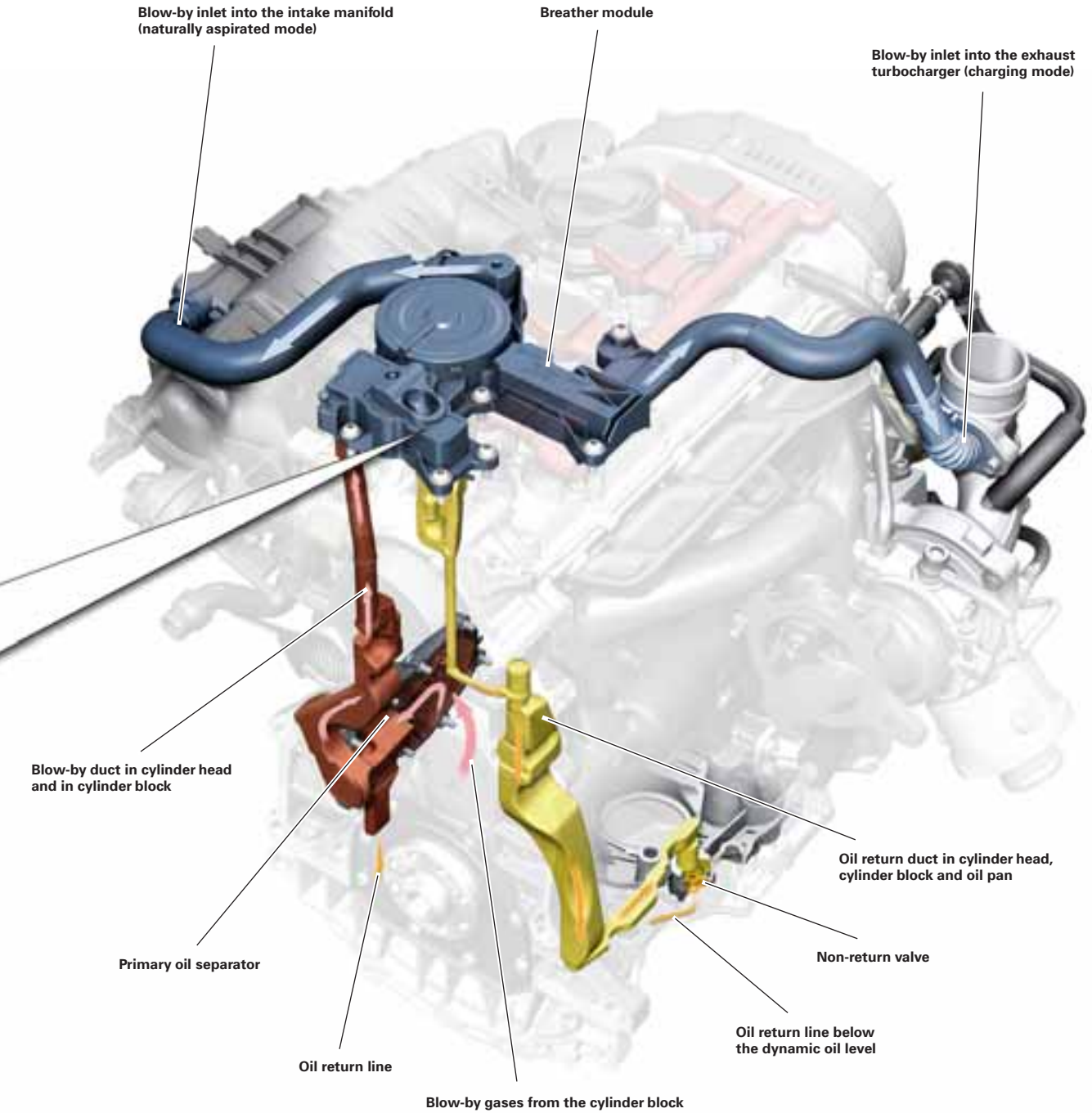
The following parts have been modified:

- *Blow-by gas** duct integrated in the cylinder crankcase
- Fine oil separator module with integrated pressure regulating valve, non-return valve and positive crankcase ventilation valve (*PCV valve**)

Valve unit



Overview



436_022

Reference



The components are positioned differently, but have retained the same functions as on the 1.8l TFSI engine (base engine). For further information, refer to Self-Study Programme 384 "Audi 1.8-litre chain-driven 4V TFSI engine".

Oil circulation system

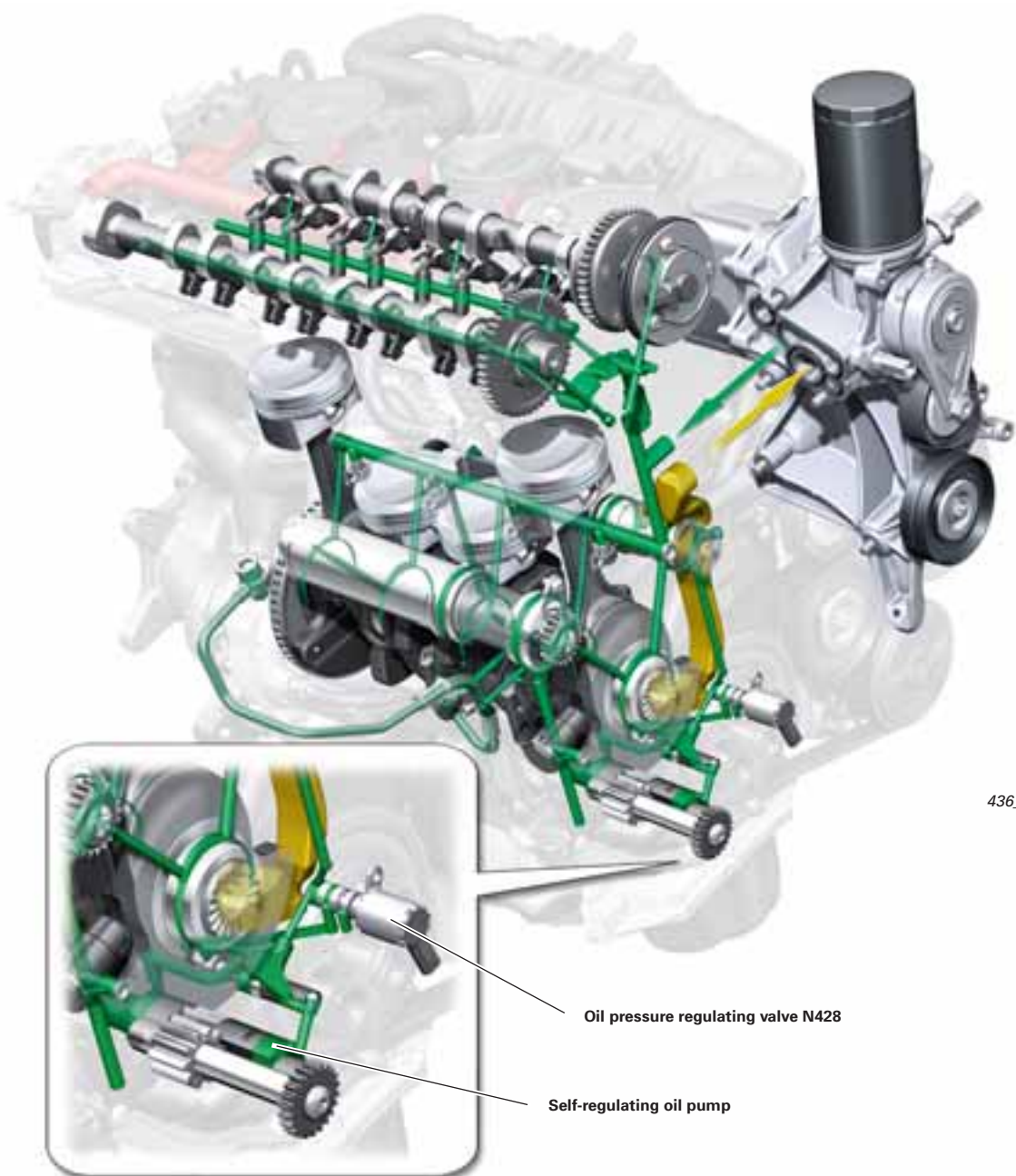
Overview

The oil circulation system design has basically been adopted unchanged from the 1.8l TFSI engine (basic engine).

For an exact description of the oil circulation system, refer to Self-Study Programme 384 "Audi 1.8-litre chain-driven 4V TFSI engine".

The modifications to the oil circulation system primarily refer to the use of the self-regulating oil pump.

For information on the engines in which this self-regulating oil pump is installed, please refer to "Overview of development stages" on page 6.

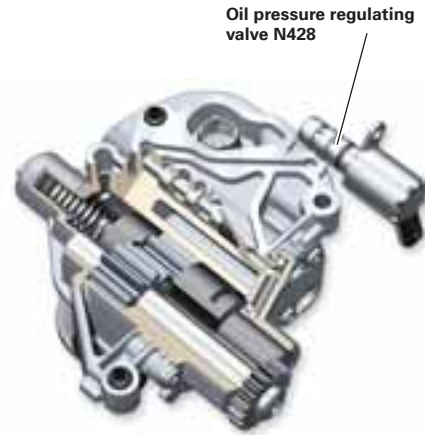


436_016

Self-regulating oil pump

A newly developed oil pump is used on the 1.8l and 2.0l TFSI engines. The principal aim of this development was to enhance the operating efficiency of the pump and to further improve fuel economy.

Compared to other self-regulating oil pumps, this design is characterised by an elaborate control concept that allows even more efficient operation.

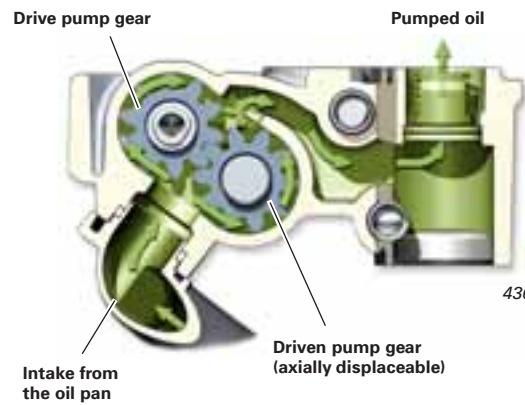


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Design

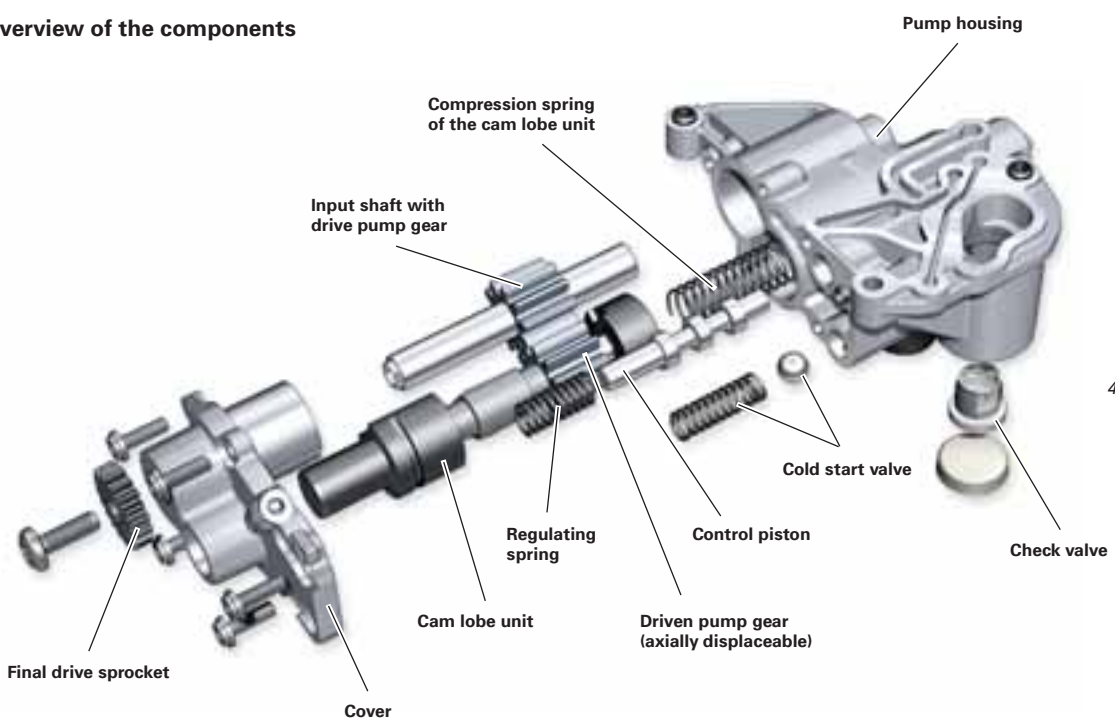
In design terms, the oil pump is an external gear pump.

A new feature of the pump is that a pump gear is axially displaceable (driven pump gear). By displacing the pump gear, the delivery rate and pressure in the oil circulation system can be influenced in a controlled manner.



436_013

Overview of the components



436_014

Oil circulation system

Function

Conventional method of control

The delivery rate of the oil pump increases as the engine turns faster. The oil consumers in the engine cannot process the excess oil being delivered, so the oil pressure increases. Previously, pressure limiting took place inside the pump. A mechanical valve opened for this purpose. However, since the pump pump is still operating at its maximum delivery rate, a portion of the input energy is converted to heat. The new pump control system is based on precisely this concept.

The concept of the new control system involves two different pressures. The low pressure setting is approx. 1.8 bar (relative). The system changes over to the high pressure setting at an engine speed of approx. 3500 rpm. The pressure is approx. 3.3 bar (relative).

The pressure is regulated by controlling the delivery rate of the pump gears. Oil delivery is controlled to produce exactly the required filtered oil pressure downstream of the oil cooler and oil filter.

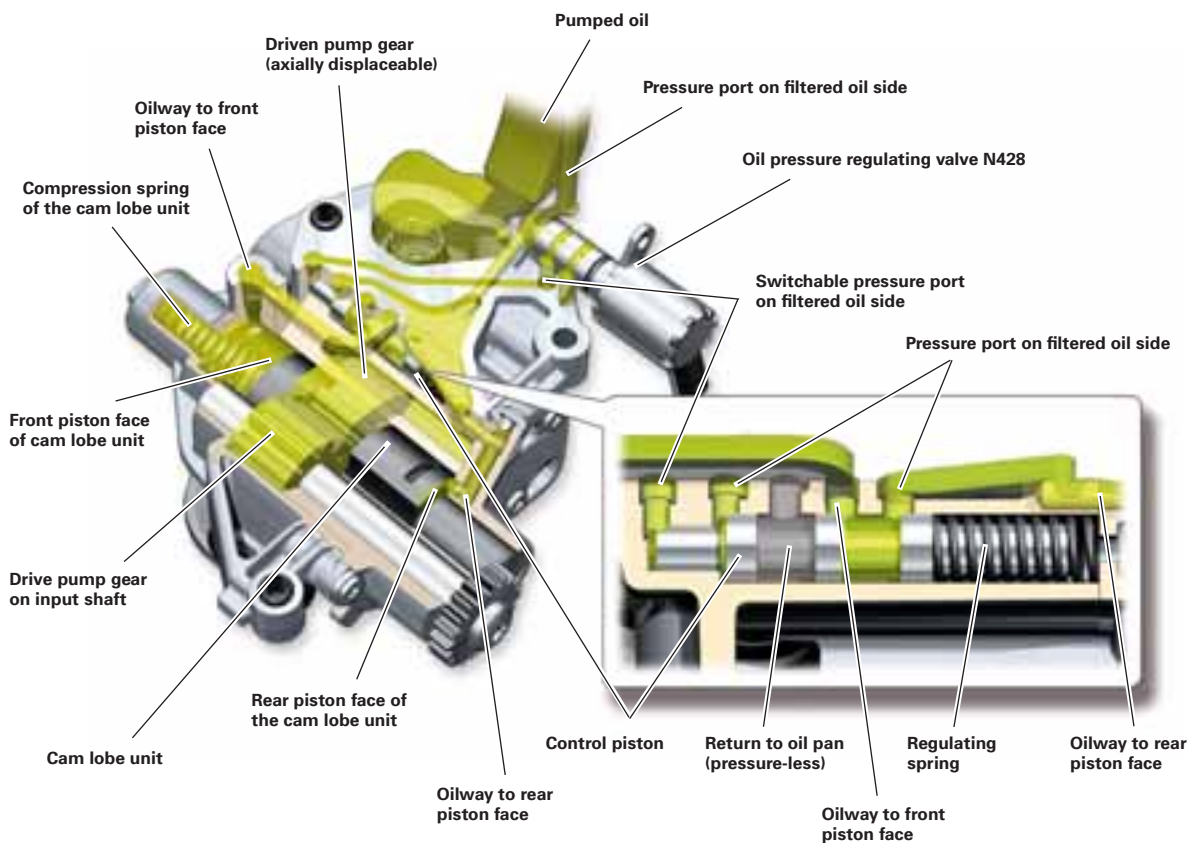
This is achieved by axial displacement of the cam lobe unit, i.e. by displacement of both pump gears relative to one another. The delivery rate is highest when both pump gears are aligned exactly opposite each other. The greater the axial displacement of the driven pump gear, the lower its delivery rate will be (only oil displaced between the pump gears is conveyed). The pump gear is displaced by the incoming filtered oil pressure acting on the front piston face of the cam lobe unit. A compression spring also acts upon the front piston face of the cam lobe unit.

Filtered oil pressure is permanently applied to the rear piston face of the cam lobe unit.

A control piston applies oil pressure (through the pressure port on the filtered oil side) to the front piston face of the cam lobe unit.

The engine oil pressure which has just been developed is used to counteract the force exerted by the regulating spring. The application of oil pressure is a continuous and dynamic process whereby the control piston moves continuously in alternating linear directions.

Overview



- Low oil pressure
- High oil pressure

436_015

Positions of the cam lobe unit



436_017



436_018

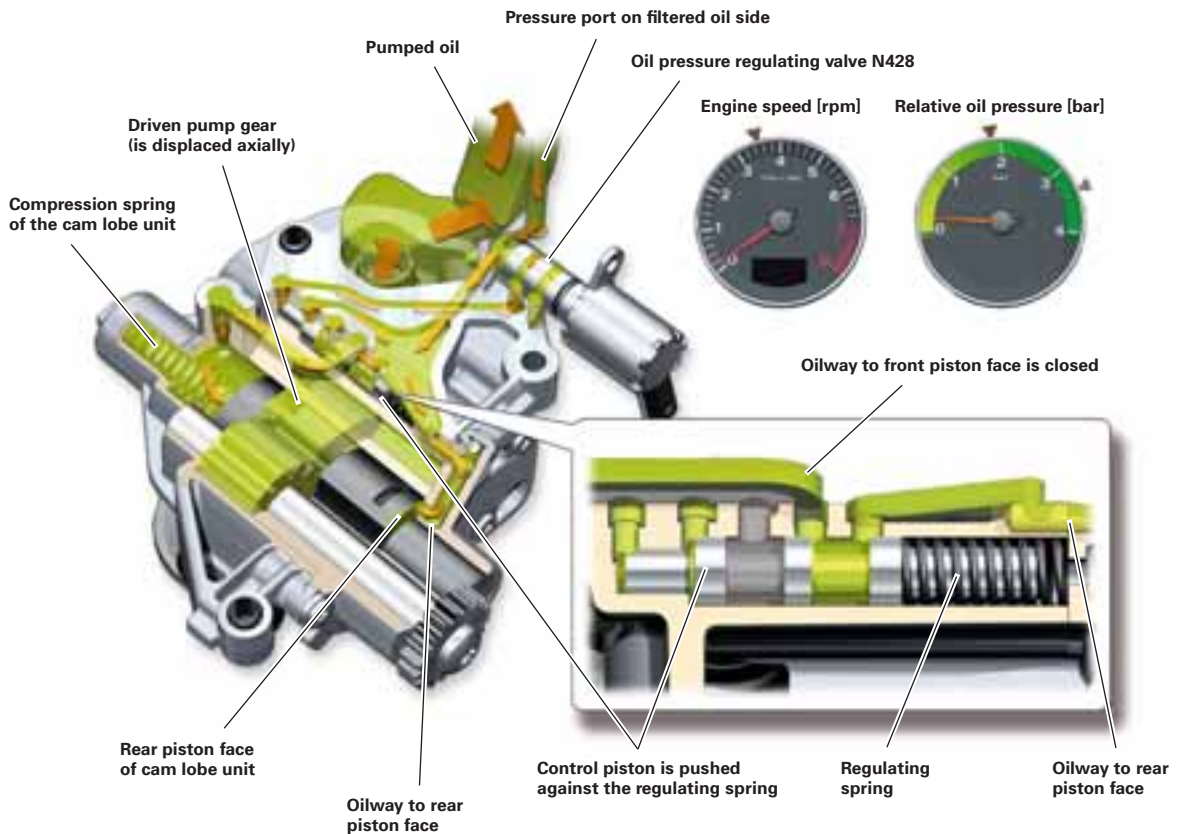
No axial displacement: maximum oil flow rate

Maximum axial displacement: low oil flow rate

Engine start-up

The figure below shows how oil pump behaves when the engine is started, i.e. it begins to deliver oil. Engine oil passes through the pressure port on the filtered oil side and impinges on all surfaces of the control piston while flowing to both sides of the cam lobe unit. The oil pressure control valve N428 is activated by the engine control unit and holds the switchable pressure port open so that oil pressure is applied to all surfaces of the control piston.

The cam lobe unit remains in this position. The pump operates at maximum output until the low pressure setting is reached (approx. 1.8 bar). A lower value is also possible when the engine is idling. However, an excessively low value would cause irreparable damage to the engine. Therefore, the oil pressure must be monitored. This task is performed by the oil pressure switch for reduced oil pressure F378.



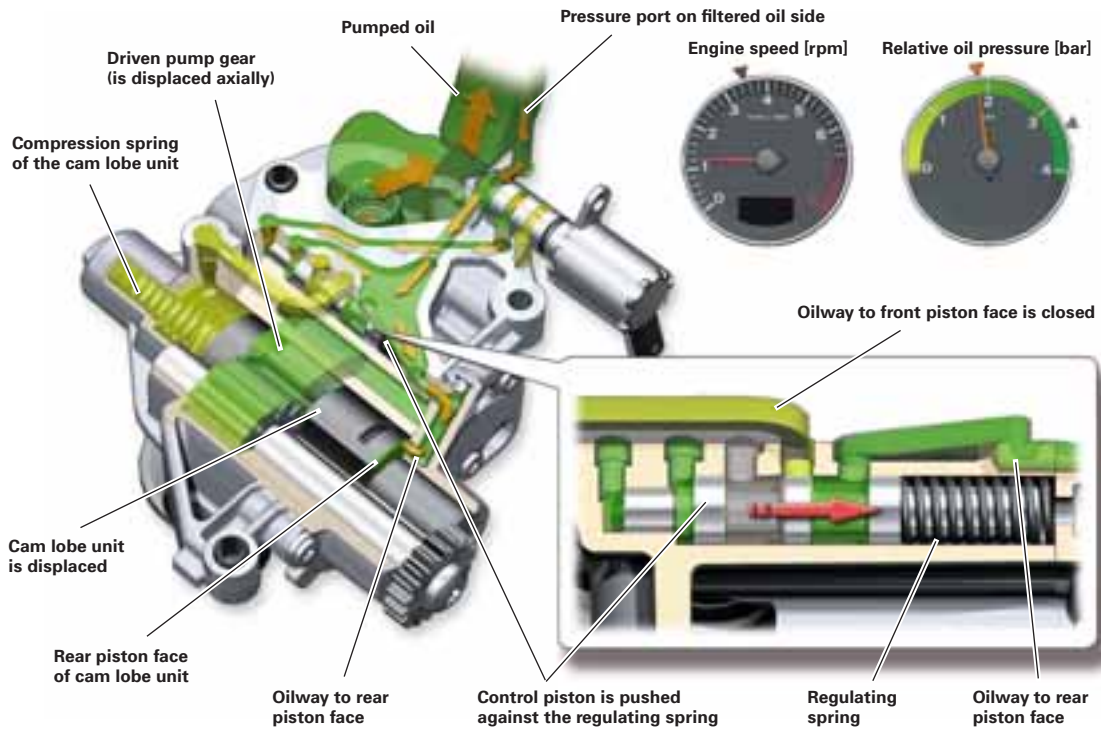
436_025

Oil circulation system

Low pressure setting reached

If engine speed increases, the oil pressure increases slightly and displaces the control piston against the force of the regulating spring. The pressure port to the front piston face of the cam lobe unit closes. At the same time, the connection to the pressureless return line leading into the oil pan opens. The hydraulic force exerted by the rear piston face of the cam lobe unit is now greater than the spring force.

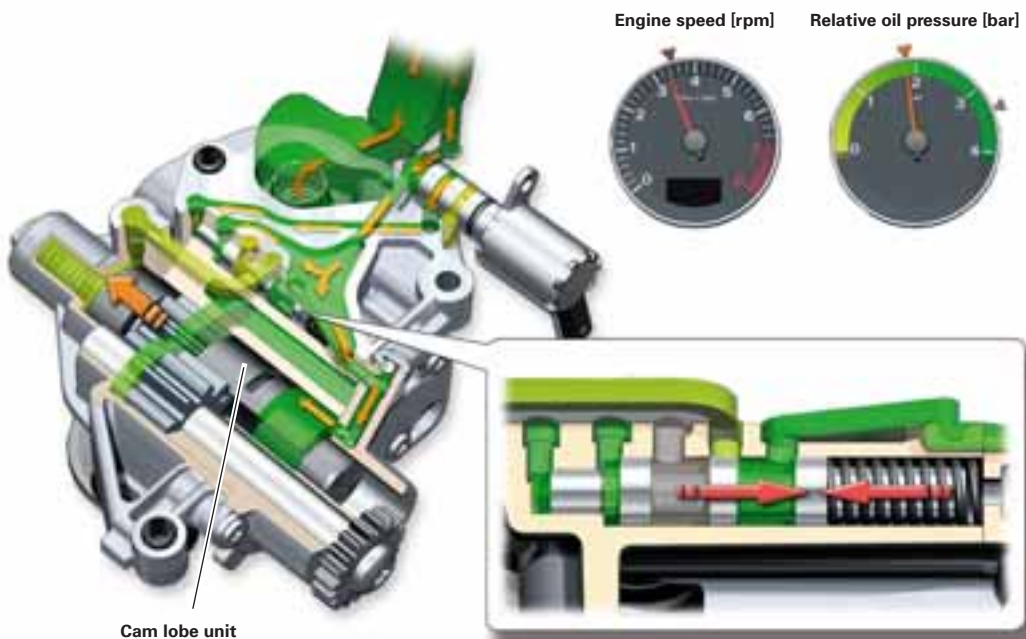
Therefore, the cam lobe unit moves against the force of the compression spring. The driven pump gear is displaced axially relative to the drive pump gear. The volumetric flow rate decreases and adjusts to the engine's oil consumption. By adjusting the volumetric flow rate, the oil pressure is kept at a relatively constant level.



436_019

Shortly before change-over to the high pressure setting

The cam lobe unit is fully extended.



436_026

Change-over point to high pressure setting

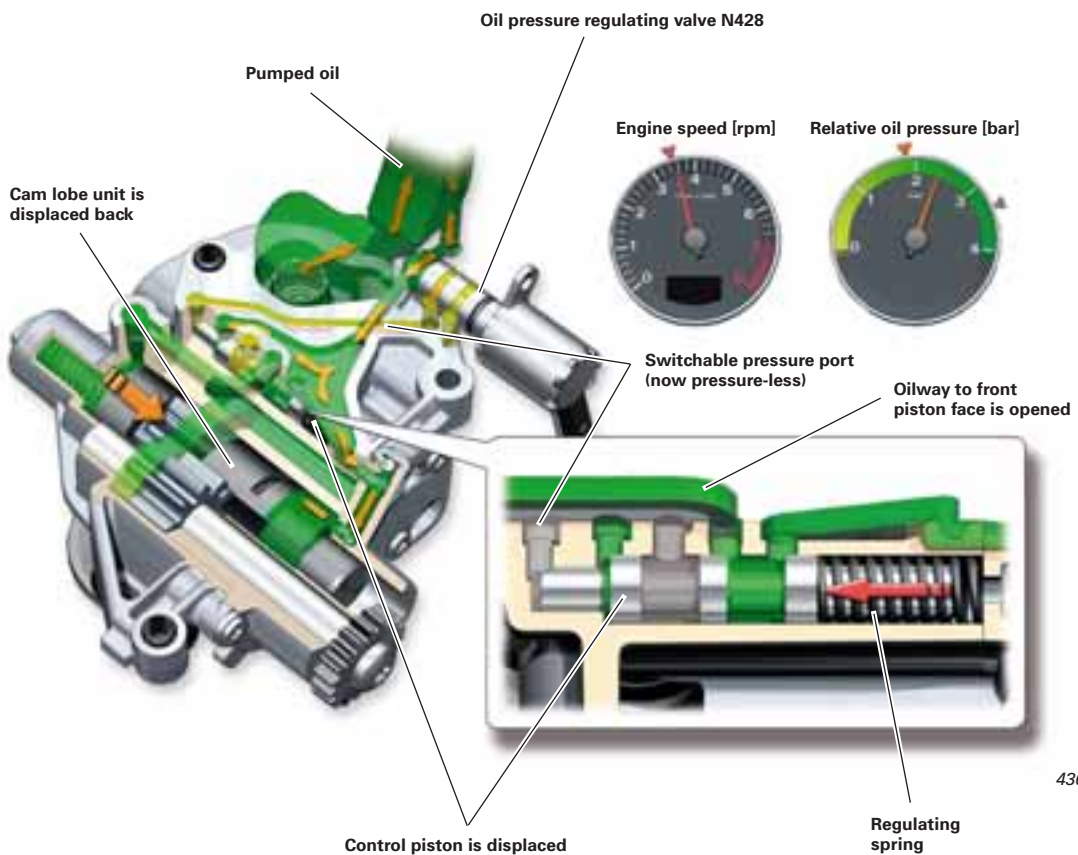
The system changes over to the high pressure setting at an engine speed of approx. 3500 rpm. The oil pressure regulating valve N428 is de-energised for this purpose.

This simultaneously causes the switchable pressure port and the port to the pressure-less chamber in the oil pan to close.

Since the surface of the control piston is no longer effective, the force of the regulating spring is now predominant.

The control piston moves far enough to open the port to the front piston face the cam lobe unit.

The oil pressure now acting upon the front piston face and the compression spring collectively push the cam lobe unit back again, so that both pump gears are again almost in parallel with one another and the pump is operating at its maximum delivery rate. The cam lobe unit remains in this position until an oil pressure of approx. 3.3 bar is reached.



Note



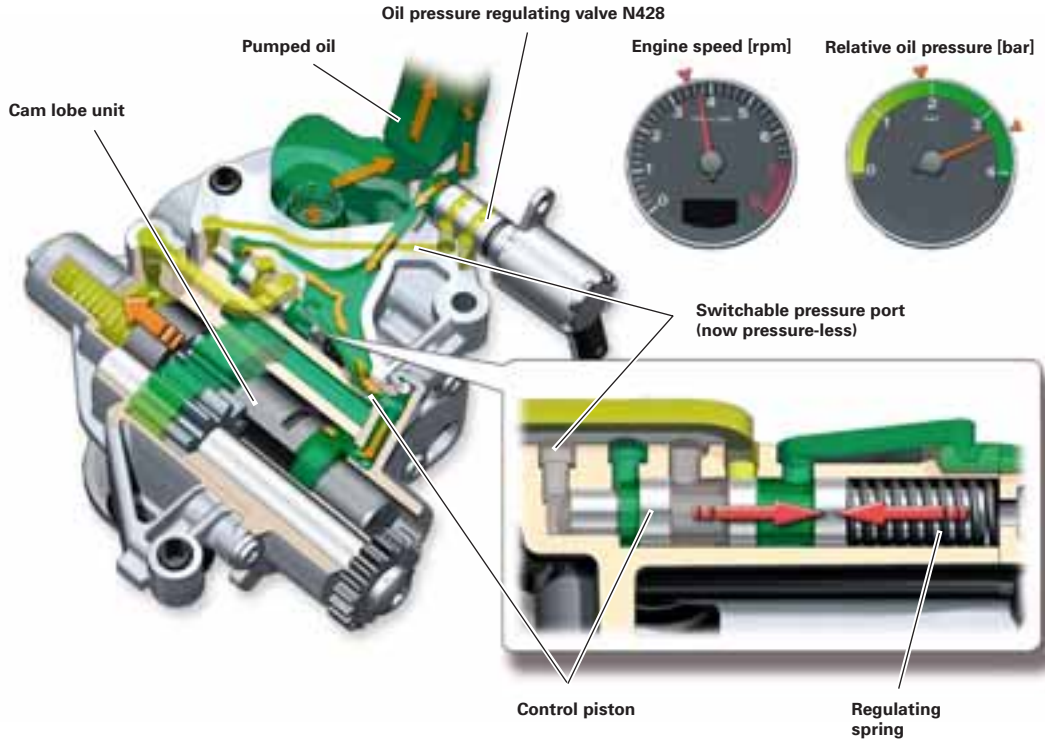
Please note that the self-regulating oil pump always operates in the high pressure setting during the first 1000 km. This is to allow for the higher thermal load on the components during run-in.

Oil circulation system

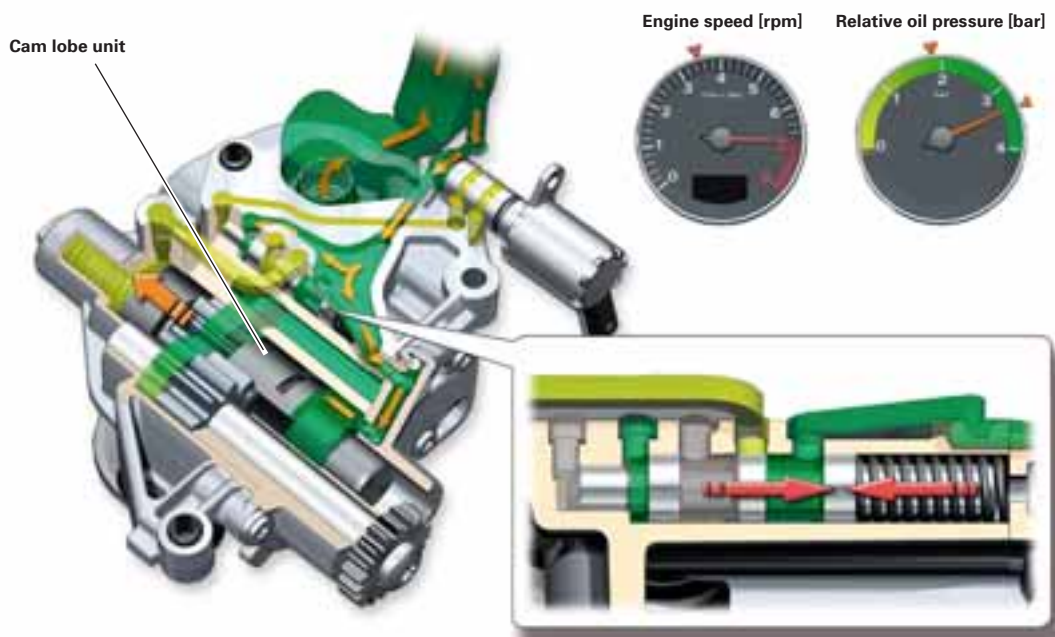
High pressure setting is reached

The oil pressure regulating valve N428 remains de-energised. The force equilibrium between the control piston and regulating spring is maintained by the higher oil pressure (the effective piston surface area is smaller).

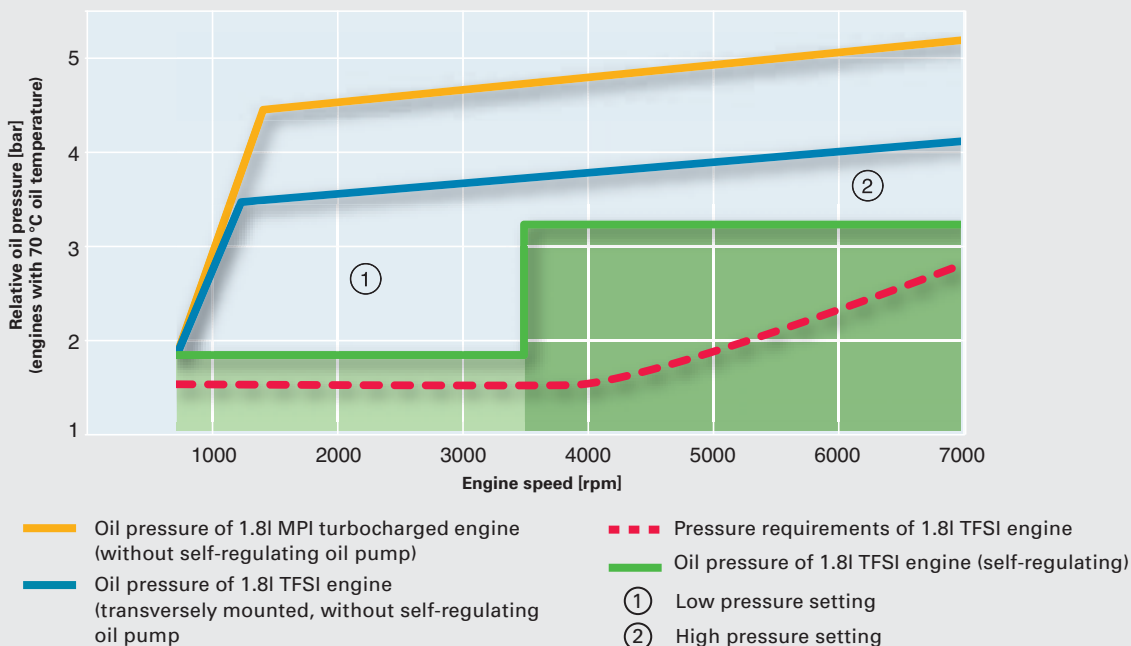
As the engine speed continues to increase, the cam lobe unit again begins to move (as in the low pressure setting). The change-over to the high pressure setting is registered by the oil pressure switch F22 (on the oil filter module). In the high pressure setting, the switchable oilway is kept closed by the oil pressure regulating valve N428.



Cam lobe unit at stop



Comparison of pressure characteristics



Oil pressure switch

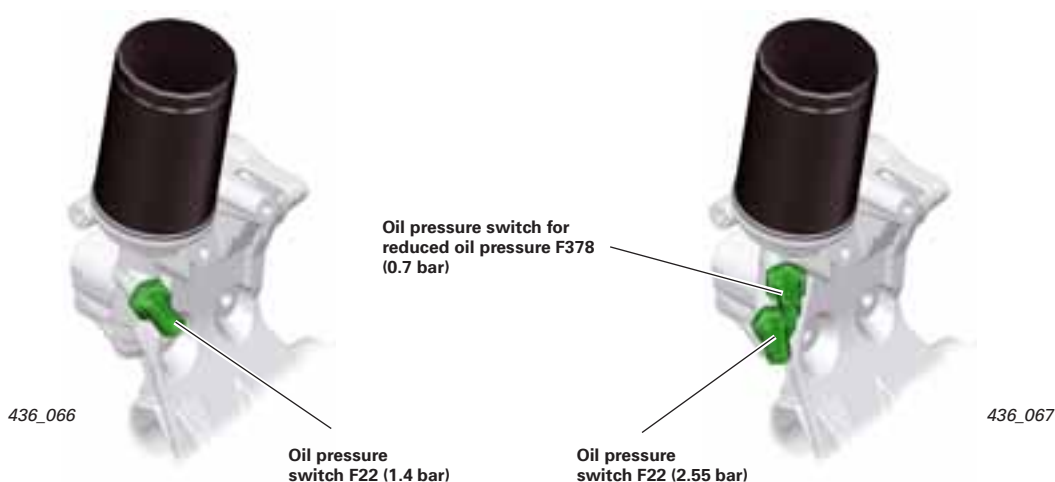
One or two oil pressure switches are used, depending upon whether the engine is equipped with a self-regulating oil pump. Oil pressure switches are generally mounted on the oil filter module.

Engine without self-regulating oil pump

Only the oil pressure switch F22 is used on engines which are not equipped with a self-regulating oil pump. However, this switch has a different part number (different oil pressures are measured).

Engine with self-regulating oil pump

In contrast to the version without self-regulating oil pump, the oil pressure switch for reduced oil pressure F378 is additionally used here. Switch F378 is located above the oil pressure switch F22.



Reference



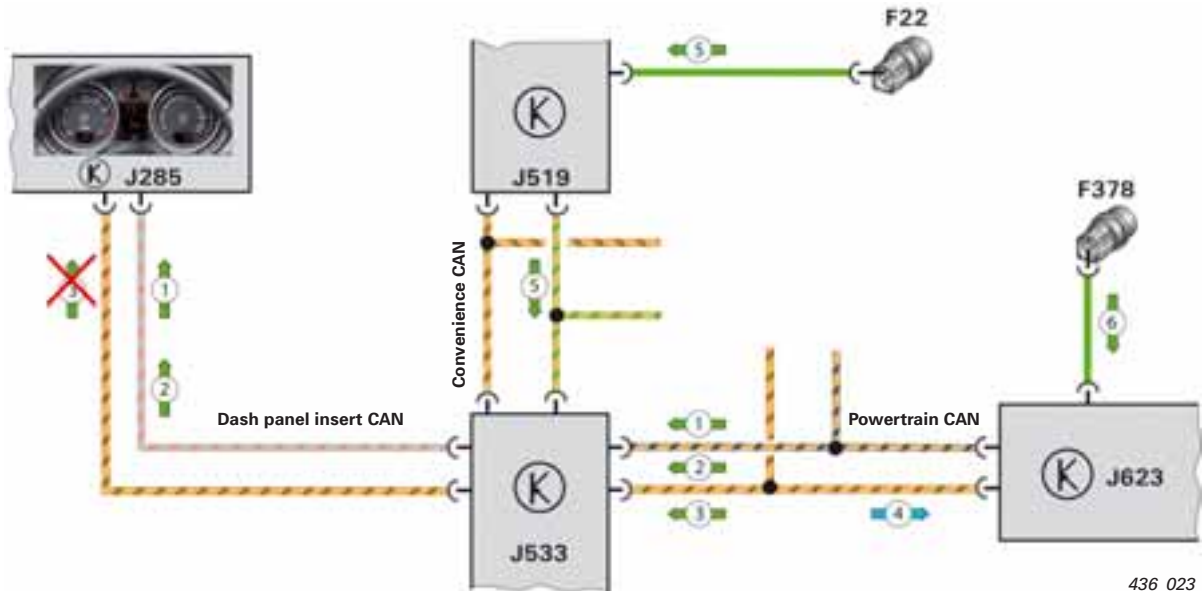
For information on the design of the oil filter module, please refer to Self-Study Programme 384, "Audi 1.8-litre chain-driven 4V TFSI engine".

Oil circulation system

Oil pressure monitoring

On engines with a self-regulating oil pump, the oil pressure is monitored by two oil pressure switches. This is necessary because two different oil pressures are used.

Signal flow (using the Audi A4 2008 as an example)



436_023

Legend:

- | | | | |
|---|---|------|--|
| ① | Warning bit "red oil can" | F22 | Oil pressure switch |
| ② | 2 text bits | F378 | Oil pressure switch for reduced oil pressure |
| ③ | Change-over bit = 1 | J285 | Control unit with display in dash panel insert |
| ④ | Switch bit | J519 | Onboard power supply control unit |
| ⑤ | Signal from oil pressure switch F22 | J533 | Data bus diagnostic interface |
| ⑥ | Signal from oil pressure switch for reduced oil pressure F378 | J623 | Engine control unit |

Functions and signals of the oil pressure switch

The two oil pressure switches serve to monitor the oil pressure. The oil pressure switch for reduced oil pressure F378 monitors for the presence of oil pressure.

The oil pressure switch F22 monitors the high-pressure level of the self-regulating oil pump, provided that it is operating in the high pressure setting.

Signals generated by the oil pressure switches

The oil pressure switch is evaluated by the engine control unit J623 (earlier concepts used a single-stage oil pump and the oil pressure switch was read in and evaluated by the control unit with display in dash panel insert J285). For this purpose, the oil pressure switch for reduced oil pressure F378 is connected directly to the engine control unit.

The oil pressure switch F22 in the Audi A4 2008 is read in by the onboard power supply control unit J519 and made available to the engine control unit J623 via the powertrain CAN data bus. The oil pressure switches are normally-open contacts; they connect to ground as soon as the required oil pressure is developed.

Oil pressure monitoring

In the engine control unit, the oil pressure switches are monitored at engine "on" and validated at engine "off".

Validation at engine "off"

No signal from a closed oil pressure switch may be present when the engine is turned off. Otherwise, it may be assumed that an electrical fault has occurred. At terminal 15 "on", a warning is indicated in the dash panel insert ("red oil can" together with the fault text "Shut off engine and check oil level").



436_070

Warning at engine "on"

The oil pressure switches are monitored upwards of a defined engine speed threshold, dependent on oil temperature.

The oil pressure switches are generally monitored when the engine is cold (up to 60 °C), i.e. they are also monitored when the engine is idling. When the engine is at operating temperature, the oil pressure switches are only monitored at high engine speeds. If the switch is not closed, the warning "red oil can" is indicated together with the fault text "Shut off engine and check oil level" in the dash panel insert.

The oil pressure switch F22 is monitored as soon as the self-regulating oil pump is operating in the high pressure setting and the engine speed exceeds a value computed from the characteristic map (dependent on oil temperature).

If the switch is identified as being "not closed", the engine electronics warning lamp K149 is activated. Engine speed is limited as well. Engine speed is indicated in the dash panel insert as a text and yellow engine speed symbol.

Fault analysis options

A diagnosis is made in the engine control unit by the oil pressure monitoring function.

The status of oil pressure switch F22 can be read out under the diagnostic address of onboard power supply control unit J519 (Diagnostic address 09 > Data block 28 > 2nd line).

Note



Text messages are only displayed for "Validation at engine "off"" and "Warning at engine "on"" in vehicles with a Highline dash panel insert.

2.0l TFSI engine for SULEV

Introduction

Audi brings to the US market an engine that combines direct injection and exhaust turbocharging: the 2.0l TFSI.

The challenge was to meet the world's most stringent exhaust emission limits.

The ULEV II regulations apply in the USA, but some federal states require the even more stringent exhaust emission limits for SULEV.

The measures undertaken to comply with the SULEV exhaust emission regulations will be explained in detail on the following pages.

The technical descriptions refer to the Audi A3.

To homologate a vehicle for the US market, the following conditions must be met:

- Compliance with statutory exhaust emission limits.
- No hydrocarbon emission from the fuel system.
- All exhaust-related systems and components must be monitored to OBDII requirements.
- Compliance with SULEV exhaust emission limits must be ensured over 150,000 miles (240,000 km) and 15 years.

2.0l TFSI engine for SULEV exhaust emission standard (rear view)



436_045

Modifications compared to engines for the European market

- Integral module including cast-steel exhaust turbocharger
- Exhaust gas measurement by three oxygen sensors:
 - A continuous-duty oxygen sensor (LSU4.9) in the turbine housing to ensure quick sensor availability
 - Two nonlinear lambda sensors (one before and one after the underbody catalytic converter)
- Secondary air system to reduce emissions during the heat-up phase of the catalytic converter
- Adaptation of the catalytic converters with regard to volume, cell density and load
- PremAir® system for the reduction of ozone to oxygen in the atmosphere
- Fuel-carrying lines and hoses of the crankcase ventilation system have sealing layers to prevent evaporation loss
- Optimisation of the application at engine start-up and during the warm-up phase
- Automatic starter control for the Audi A3
- All engines for the US market come with a fuel tank leakage diagnosis system.

Modifications to the lambda control system

To meet the more stringent US exhaust emission standards, it was necessary to modify the existing lambda control system to incorporate a broadband sensor upstream of the catalytic converter and a nonlinear sensor downstream of the catalytic converter.

To meet the SULEV exhaust emission standard, the system is equipped with an additional nonlinear sensor. The table below summarises the various lambda control systems.

Lambda control systems on Audi 1.8l and 2.0l TFSI engines

Stage 0	Stage 1	Stage 2 (except USA)
EU IV: Oxygen sensor G39 LSF*4.2 after primary catalytic converter	EU IV: corresponds to Stage 0	EU V: Oxygen sensor G39 LSU*4.9 before primary catalytic converter, Oxygen sensor G130 LSF*4.2 after primary catalytic converter
	ULEV II: Oxygen sensor G39 LSU*4.9 before primary catalytic converter, Oxygen sensor G130 LSF*4.2 after primary catalytic converter	ULEV II: corresponds to Stage 1
	SULEV: Oxygen sensor G39 LSU*4.9 before primary catalytic converter in integral module, Oxygen sensor G130 LSF*4.2 after primary catalytic converter, Oxygen sensor 3 after catalytic converter G287 LSF*4.2 after underbody catalytic converter	SULEV: corresponds to Stage 1

2.0l TFSI engine for SULEV

Secondary air system

To reduce hydrocarbon emissions at the earliest possible stage, fresh air is blown into the cylinder head exhaust ports during the start phase. The system is designed to rapidly develop pressure and achieve a high delivery rate on activation.

The figure shows the components of the secondary air system.

The following components are new to the system:

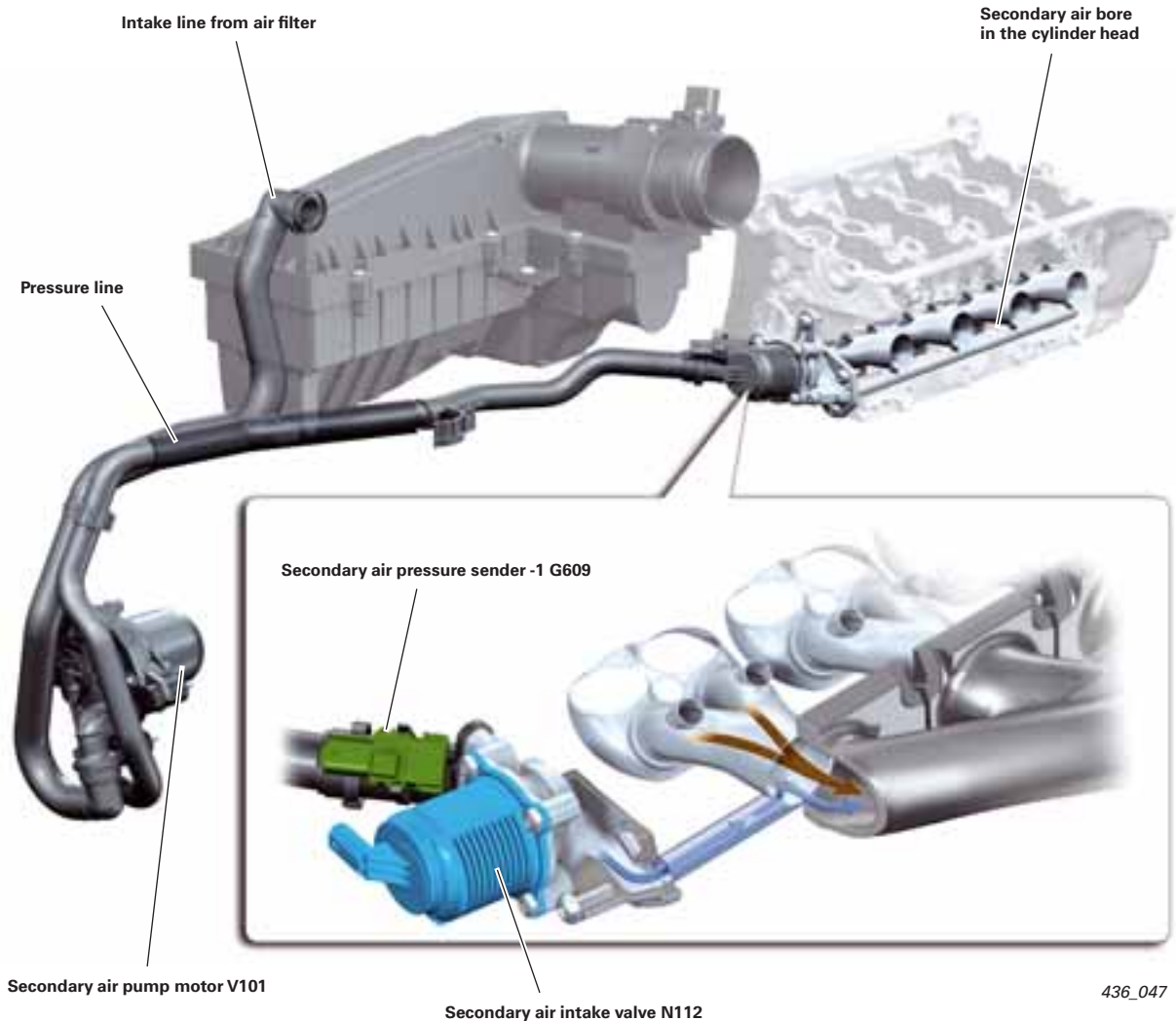
- Secondary air pressure sender -1 G609
- Secondary air intake valve N112

The secondary air pump is positioned above the lowest point of the hose system to prevent harmful condensate from collecting in the pump.

If the system is functional, an excess pressure of approx. 160 mbar will be achieved in the pressure line while the engine is idling after a cold start. The pressure acting on the sender increases with rising exhaust gas mass flow, depending on how the car is driven (high engine load). Pressure levels of greater than 200 mbar above ambient pressure can be achieved.

There is an elongated hole in the cylinder head below the exhaust ports. The secondary air which flows through the elongated hole is drawn directly into the exhaust ports. The proximity of the exhaust ports to the exhaust valves is advantageous. A secondary air reaction occurs immediately, thereby generating the thermal energy required to heat the catalytic converter.

Overview of the components

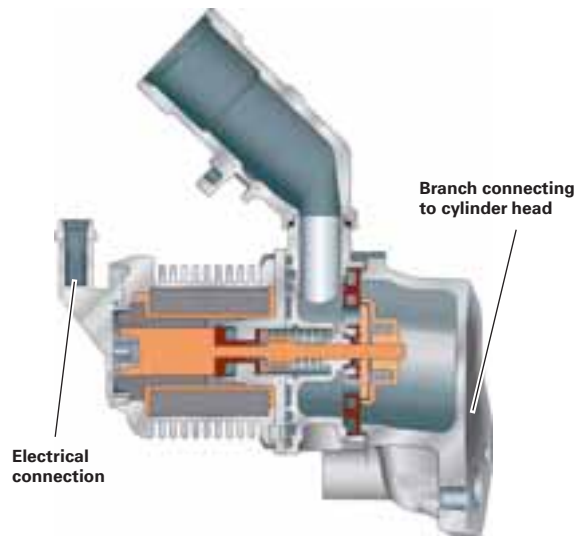


436_047

Secondary air intake valve N112

Unlike earlier valves, the newly developed secondary air intake valve N112 operates electrically. It is mounted directly to the cylinder head by screws. As compared to the pneumatic valves used previously, the secondary air intake valve is extremely rugged.

The valve also has a non-return function which prevents exhaust gases from flowing back into the secondary air system, even when the valve is open (see figure below).

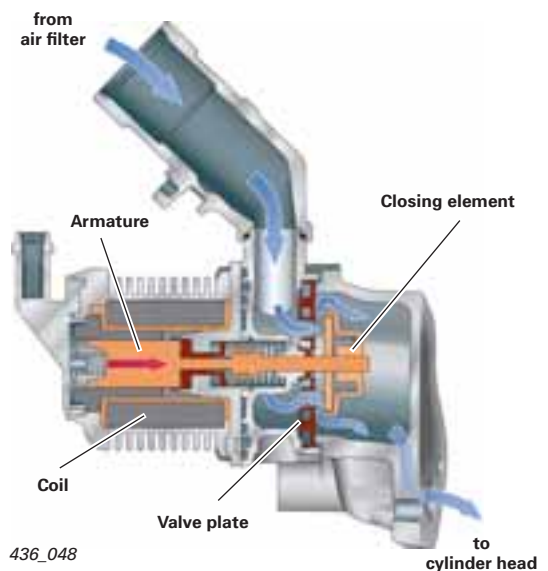


436_046

Valve activated

When the secondary air intake valve is activated by the engine control unit, secondary air flows through the valve to the cylinder head.

A solenoid lifts the closing element off the valve plate. The secondary air flows through the orifices in the valve plate.



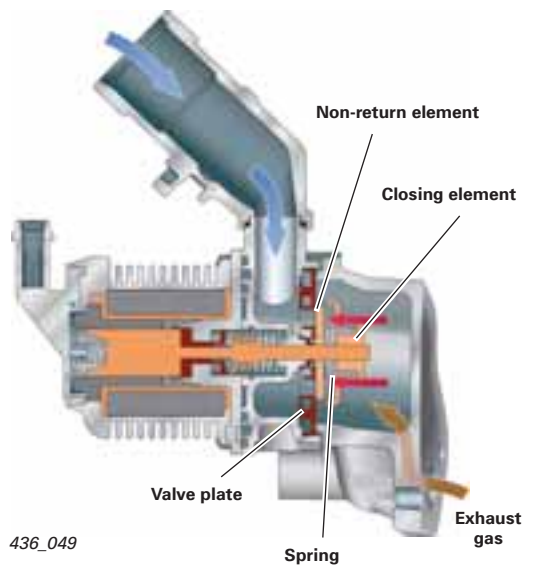
436_048

Non-return function

When the secondary air flows through the valve, the non-return element is pressed down and against a spring, thus holding the valve open. On the other hand, if exhaust gases flow back into the secondary air intake valve, the secondary air pressure will decrease.

As a result, the non-return element lifts off the closing element with spring assistance and seals the orifices in the valve plate.

The secondary air intake valve and the secondary air pump motor V101 are thus protected against possible damage by hot exhaust gases.



436_049

2.0l TFSI engine for SULEV

Secondary air pressure sender G609

The secondary air pressure sender -1 G609 connects to the pressure line coupling upstream of the electrical secondary air intake valve N112. It supplies the engine control unit with analogue output signal of between 0.5 and 4.5 V. Its measurement window is between 50 and 150 kPa.



436_051

Signal utilisation

The signal is used for diagnosing the secondary air system. As the system is relevant to exhaust emissions, legislation requires that it be monitored.

Effects of signal failure

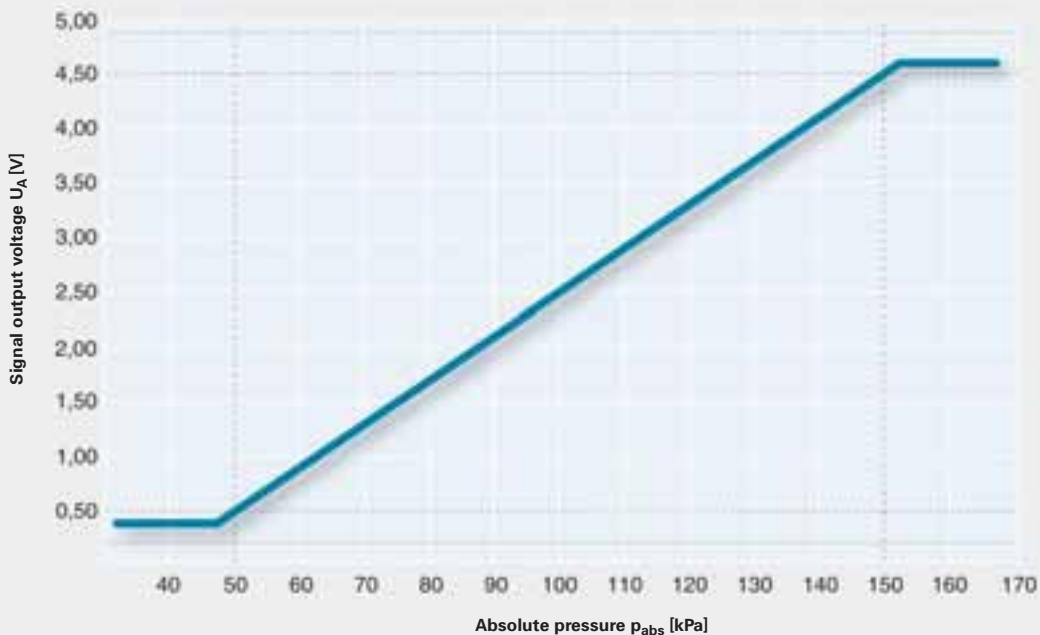
A diagnosis is made for the sender and used, firstly, to monitor the voltage (min-max threshold) and, secondly, to match the ambient pressure and the secondary air pressure sender (phase 0). If a fault occurs in a sensor, the system diagnosis result will not be evaluated because the sensor signal will be implausible. However, a diagnosis will still be made.

Diagnostics

If the electrically activated secondary air injection valve remains closed due to a malfunction, the resulting pressure will be too high. Conversely, the pressure will be too low if a leak occurs in the system upstream of the secondary air injection valve.

In both cases, the corresponding fault memory entries are saved to the engine control unit, and the exhaust gas warning lamp K83 (MIL) is activated.

Signal characteristic of the secondary air pressure sender



Testing the system

The California Air Resources Board (CARB) requires that the secondary air system be monitored during the heat-up phase of the catalytic converter.

Previously, the system was monitored using the oxygen sensor. However, this sensor does not become available quickly enough. For this reason, the system is monitored by pressure-based secondary air diagnosis. For this purpose, the signal is evaluated by the secondary air pressure sender G609.

Pressure-based secondary air diagnosis process

Phase 0

The control unit initialisation process commences at "ignition on". The signal from the secondary air pressure sender G609 is stored and compared to the signal received from the ambient pressure sensor .

Phase 1

When the secondary air mass is injected, the pressure within the secondary air system also rises to above atmospheric pressure. This pressure increase is determined by the secondary air pressure sender G609. The resultant analogue signal is evaluated by the engine control unit. If the signal exceeds the pre-defined limit, for example due to a blockage in the system or leakage, a fault entry will be generated. The engine electronics warning lamp K149 will also be activated. If the system is still in order, the diagnosis procedure will be continued.

Phase 2

During this phase, the secondary air injection valve N112 is closed and checked for leaks. The value determined by the secondary air pressure sender G609 is evaluated for this purpose.

Phase 3

The secondary air pump is shut off and the secondary air injection valve N112 closed. The difference between the actual measured pressure and the stored value generated in phase 0 is evaluated. A faulty secondary air pump (pump does not shut off) or a faulty secondary air pressure sender G609 can thus be detected.

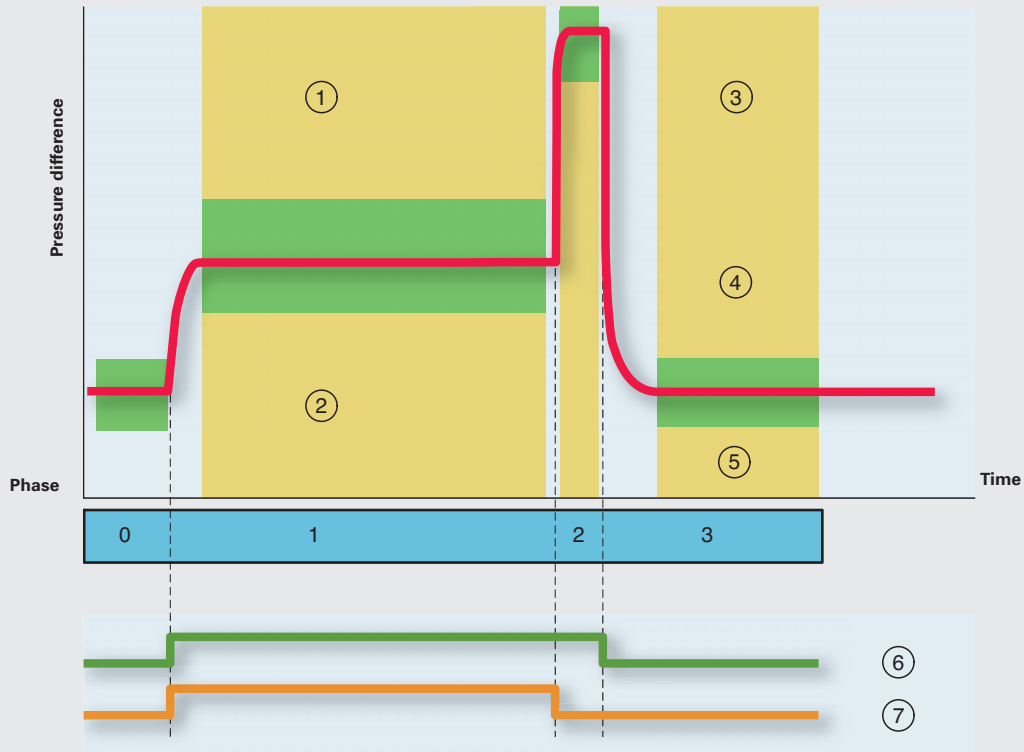
Reference



On the next page you will find a diagram showing the individual phases of the secondary air diagnosis process.

2.0l TFSI engine for SULEV

Phases of the secondary air diagnosis process



- | | |
|---|------------------------------|
| ① Blockage (restricted flow) | ④ Faulty pressure sensor |
| ② Reduced pumping capacity or a blockage upstream of secondary air pressure sender-1 G609 | ⑤ Faulty pressure sensor |
| ③ Secondary air pump running (does not shut off) | ⑥ Secondary air pump running |
| | ⑦ Combination valve 1 open |

Exhaust turbocharger

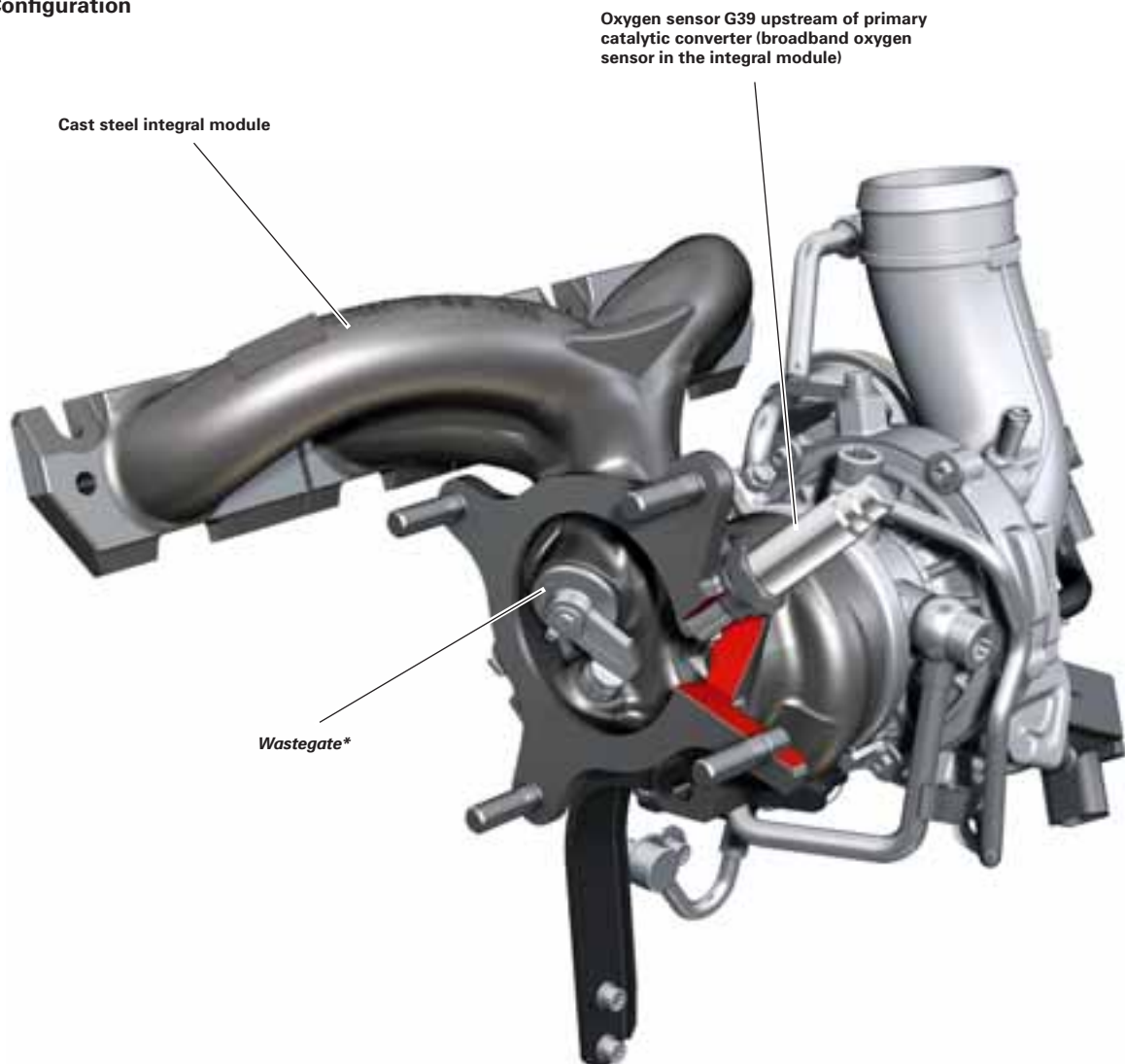
The exhaust turbocharger for the SULEV engine derives technically from the 147 kW 2.0l TFSI engine.

However, unlike the former, the new turbocharger is made of cast steel, and not cast iron. Cast steel provides excellent long-term stability. This is necessary to meet the new Californian exhaust emission regulations (SULEV). In addition, the components heat up more quickly after engine start-up, on account of the fact that they have thinner walls.

This material also allows the oxygen sensor to be positioned inside the turbine housing. This is necessary to ensure the rapid availability of the sensor.

Both air flow and catalytic converter inflow have been greatly improved, reducing the exhaust gas back-pressure upstream of the turbine. This means much more driving enjoyment for the customer, in conjunction with better fuel economy.

Configuration



436_053

2.0l TFSI engine for SULEV

Catalytic converter system

The exhaust system was developed with the following goals in mind:

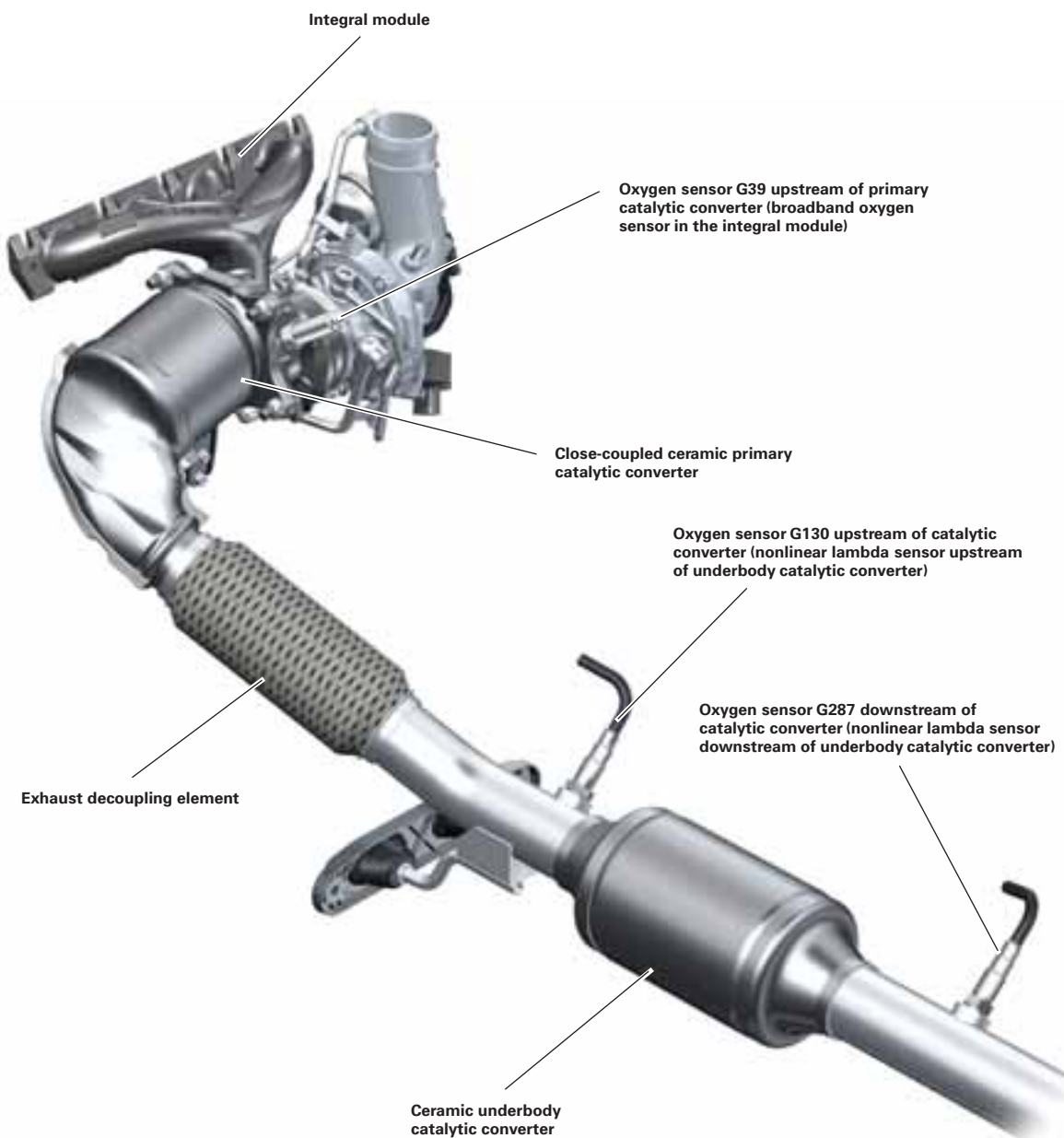
- Easy compliance with the SULEV exhaust emission limits
- High long-term stability over 150,000 miles (240,000 km) and 15 years
- Minimising the increase in exhaust backpressure in catalytic converters with a high cell density
- Reducing the *light-off time**

The primary catalytic converter is designed to comply with the statutory emission limits.

To achieve this, cell density has been increased and wall thickness reduced.

To minimise the light-off time of the primary catalytic converter, it is close coupled to the exhaust turbocharger turbine (directly in the integral module).

Overview of the components



436_052

Oxygen sensors

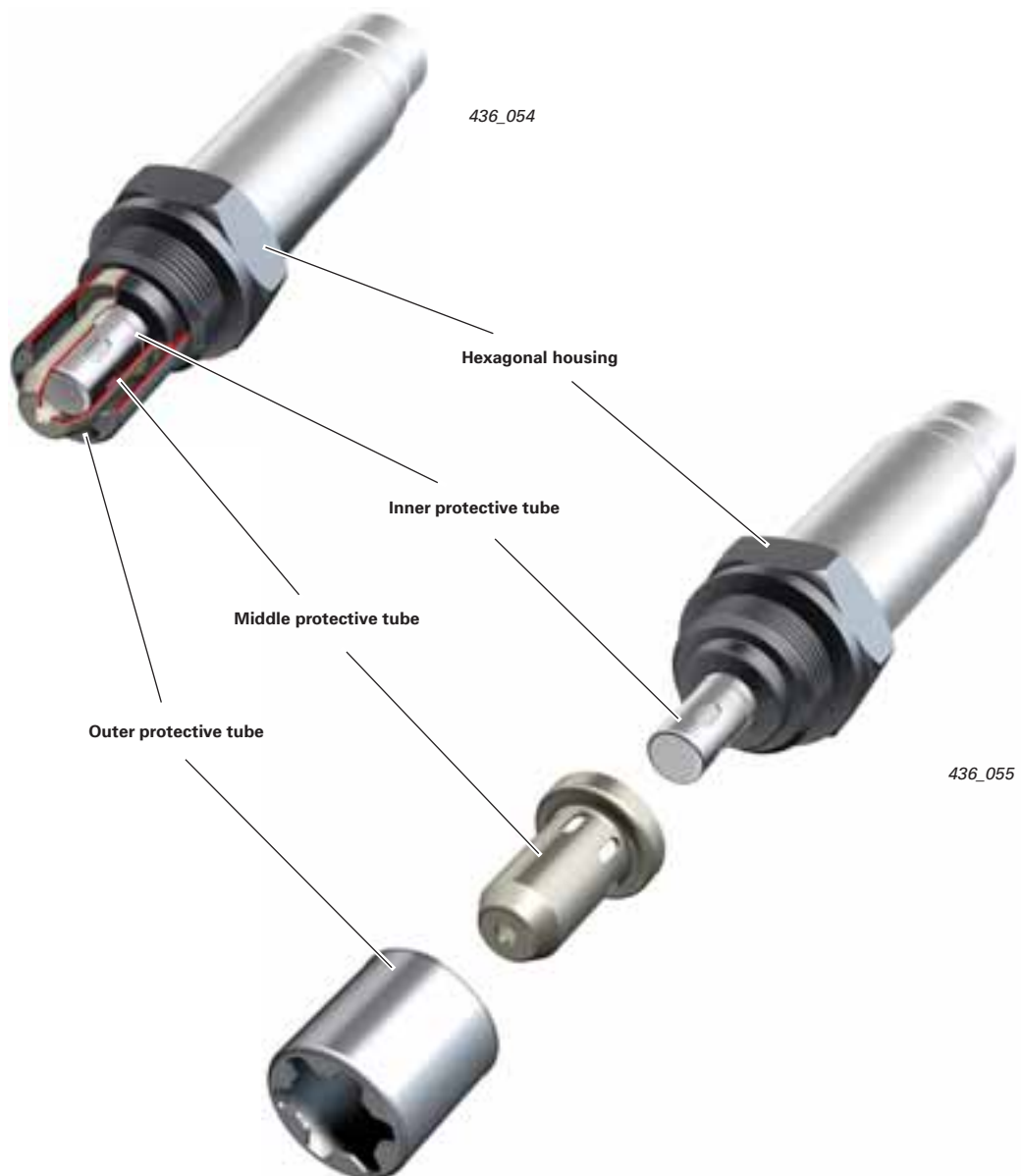
Here, the development goal was to minimise the time to readiness of the lambda control system.

By installing the broadband oxygen sensor in the turbine housing, lambda control can begin only 19 seconds after starting the engine. Due to the risk of water shock due to the rapid rate of heating of the broadband oxygen sensor, a special sensor is used here:

Oxygen sensor G39 (LSU4.9) upstream of the primary catalytic converter. This sensor has an additional triple-layer protective tube.

Two type LSF4.2 nonlinear oxygen sensors are used upstream and downstream of the underbody catalytic converter. They facilitate natural frequency-based lambda control, and allow the primary and underbody catalytic converters to be separately diagnosed with regard to ageing.

Design of oxygen sensor G39 (LSU4.9)



2.0l TFSI engine for SULEV

Natural frequency-based lambda control system

Task

The task of this system is to maximise utilisation of the primary catalytic converter during the conversion of pollutant gases.

Function

Oxygen sensor G130 LSF4.2 downstream of the primary catalytic converter supplies the engine control unit with a voltage signal (nonlinear) indicating "rich" or "lean".

Oxygen sensor G39 LSU4.9 determines a frequency from the flow rate and the condition of the catalytic converter. The engine control unit provides this frequency with an amplitude indicating whether the mixture is to be "rich" or "lean".

If the primary catalytic converter is supersaturated with oxygen (lean mixture), the oxygen sensor G130 will send the engine control unit a nonlinear signal indicating the lean mixture condition. The mixture is then enriched with fuel until the oxygen has been "displaced" from the catalytic converter. This condition, in turn, is registered by the oxygen sensor G130 as a nonlinear signal indicating the rich mixture condition.

The mixture is then leaned down again by the engine control unit. If the nonlinear signal is received again, the mixture will again be enriched. The frequency, i.e. period, during which the mixture is enriched or leaned down is variable, being dependent on the gas flow rate (engine load) at that moment. However, ageing of the catalytic converter (decrease in conversion rate) also reduces the frequency.

A large proportion of the exhaust gases is converted in the primary catalytic converter. The remaining exhaust gas constituents are then converted to non-toxic gases by the underbody catalytic converter.

Oxygen sensor 3 after catalytic converter G287 (LSF4.2 downstream of underbody catalytic converter) operates in much the same way as a conventional linear lambda control.

Its task is to control the fine adjustment of the oxygen sensor G39. For this purpose, the characteristic curve is corrected by the trimming control in the engine control unit. It also monitors the conversion process in the catalytic converters.

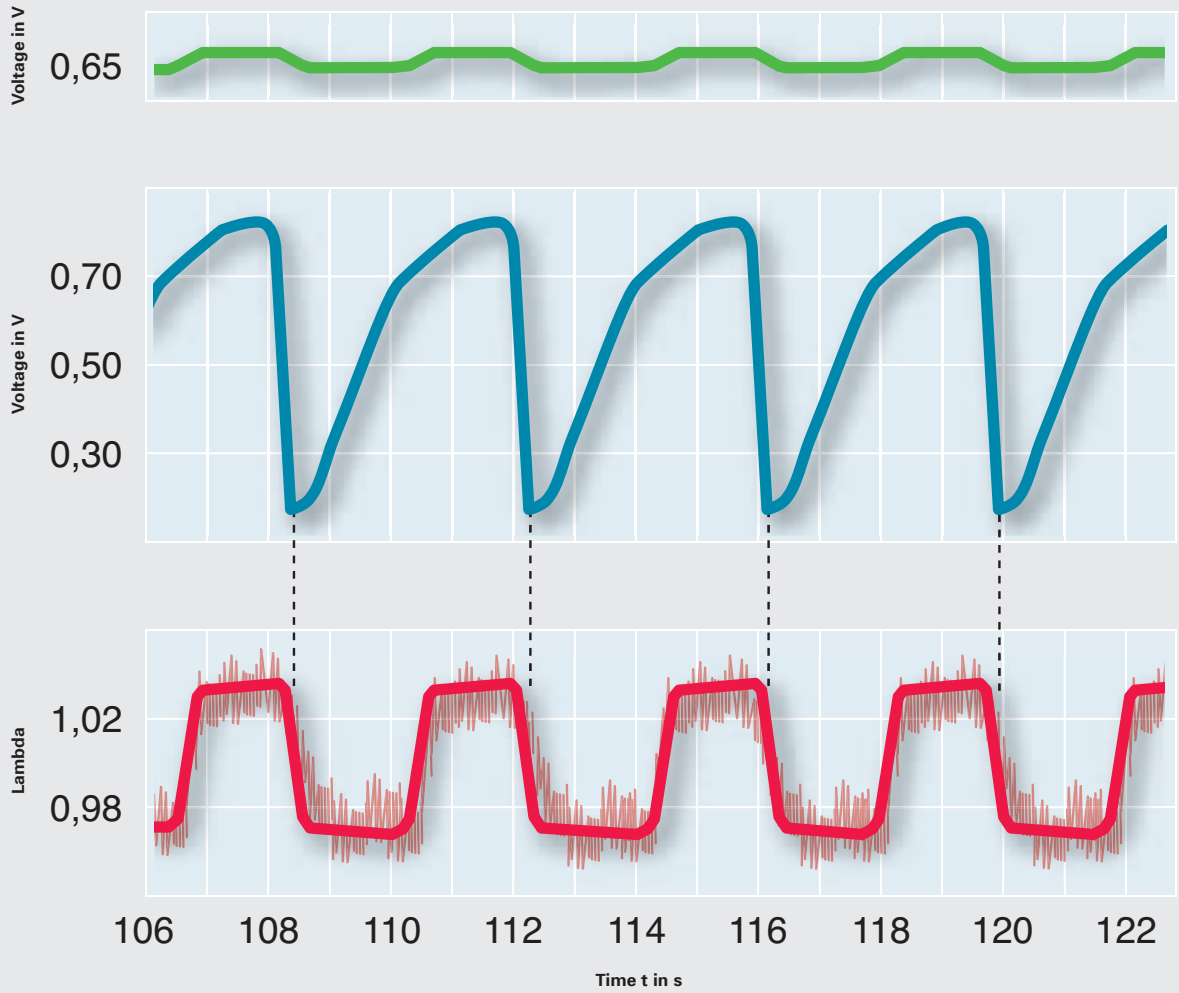
The pump flow rate cannot be measured using regular workshop equipment but is converted in the engine control unit to a lambda value that can be read in the corresponding data block.




Reference

For basic information on the oxygen sensor and the lambda control system, please refer to Self-Study Programme 231, "Euro On-Board Diagnostic System for Petrol Engines".



Signal characteristic of the oxygen sensors



-  Oxygen sensor after catalytic converter G287
-  Oxygen sensor after primary catalytic converter G130
-  Oxygen sensor before primary catalytic converter G39

2.0l TFSI engine for SULEV

Automatic starter control in the Audi A3

To ensure that the Audi A3 easily achieves the SULEV exhaust emission limits, an automatic starter control system is used.

This system is used so that the customer does not have to accept any compromises with regard to comfort, simply because starting takes a tenth of a second longer.

This slight delay in starting has the following background.

The engine control unit does not allow fuel to be injected into the combustion chamber until a pressure of at least 60 bar is measured in the fuel rail at start-up. This pressure is necessary to keep raw hydrocarbon emissions to an absolute minimum.

The complete starting cycle is performed automatically after briefly turning the ignition key to the start position.

Requirements for starting

The starter motor is only activated if the drive-line is securely open. On vehicles with manual transmission, this means that the clutch pedal must be fully depressed.

On vehicles with automatic transmission, the selector lever must be in position "P" or "N", in addition to a short press on the brake pedal.

If the engine does not start despite this, a check must be made to determine if the starter enable signal has been received from the travel sensor on the clutch master cylinder or by the gearbox control unit.

On vehicles with manual transmission, it could be the case that the clutch cannot be fully depressed due to a slipped floor mat.

Starting sequence

To activate the starter motor, both signal lines (1) and (2) are brought to ground by the engine control unit. After the starter motor has been activated, one of the two lines is brought to ground for approx. 3 seconds for diagnostic purposes. The other line is always diagnosed when the engine is started. On completion of the power-off diagnostics, both lines are diagnosed continuously by means of pulses with a short duration of only a few milliseconds. This results in a mean voltage level of approx. 3 to 9 volts.

When line (1) is brought to ground, battery voltage will again be present at the line (3), causing the voltage supply relay, terminal 50 J682 to close. Likewise for diagnostic purposes, the actual circuit status of the J682 load output is fed back across the diagnostic line (4) to the engine control unit and the onboard power supply control unit.

Since the starter has a high inductance, it takes up to approx. 3 seconds after the opening of the power supply relay until the ground level is restored on the diagnostic line (4).

Effects of failure

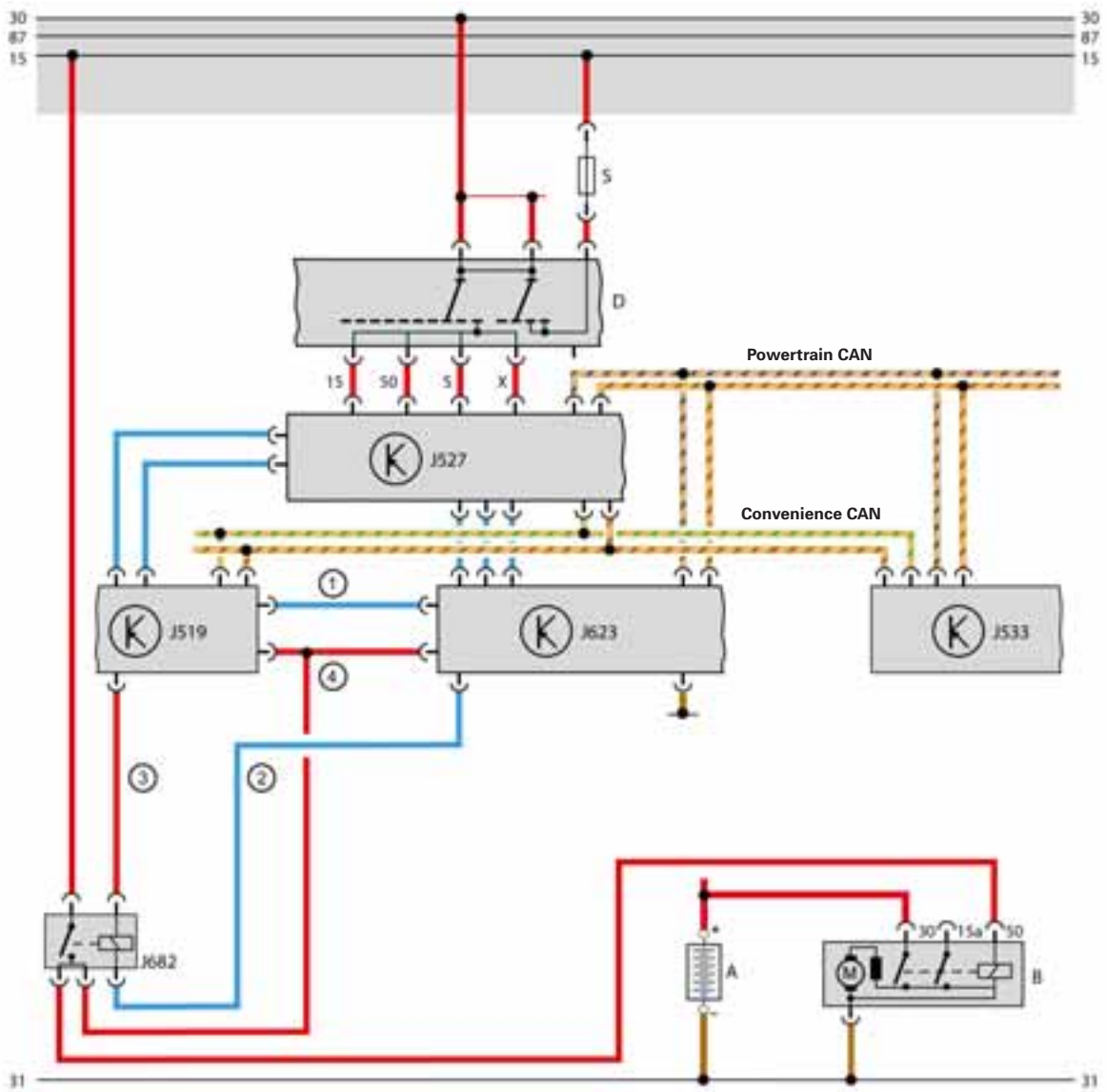
If a fault relevant to starting is entered in the memory, only one manual start will be performed as a substitute response, i.e. the starter will only be activated as long as the ignition key is turned to the start position and held there.

Reference

For information on the fuel system, please refer to Self-Study Programme 384, "Audi 1.8-litre chain-driven 4V TFSI engine".



Function diagram



436_071

Legend:

A Battery

B Starter

D Ignition starter lock

J519 Onboard power supply control unit

J527 Steering column electronics control unit

J533 Data bus diagnostic interface

J623 Engine control unit

J682 Voltage supply relay, terminal 50

S Fuse

① Start enable signal: is brought to ground by the engine control unit when a start request is received

② Ground connected signal from engine control unit

③ Connected terminal 30

④ diagnostic line

2.0l TFSI engine for SULEV

Operating modes

After cold-starting the engine, various operating modes and fuel injection strategies are implemented:

- Stratified start (high-pressure fuel injection)
- Catalyst heating by homogeneous split dual injection, in conjunction with secondary air injection
- Dual injection during the engine warm-up phase



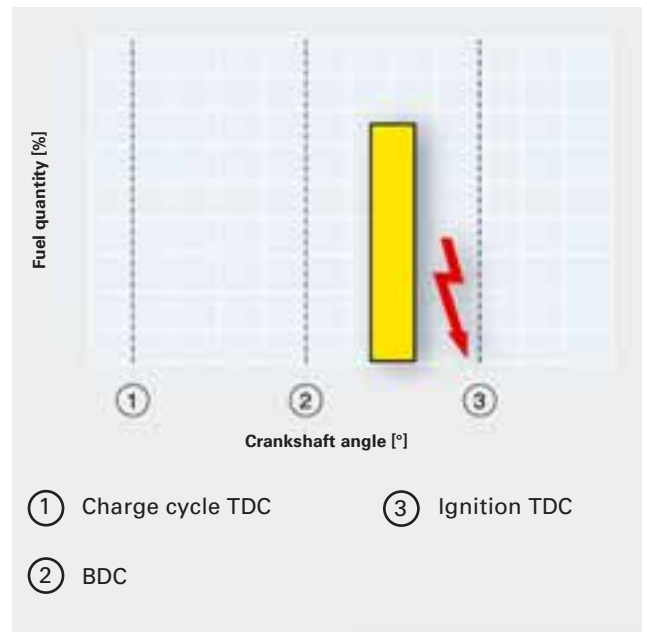
436_069

Stratified start (high-pressure fuel injection)

The full starting fuel charge is injected during the compression phase until 60° crankshaft angle before ignition TDC. The injection enable signal is issued by the engine control unit when the rail pressure exceeds 60 bar (absolute), thereby reducing the diameter of the fuel droplets.

At this stage in the process, both cylinder pressure and temperature are already considerably elevated, allowing the injected fuel to evaporate better. Thus, ingress of injected fuel into the combustion chamber is considerably reduced. The resulting, minimal fuel film on the cylinder walls is necessary to ensure extremely low raw hydrocarbon emissions at engine start-up.

A more rich mixture forms in proximity to the spark plug, thereby creating more stable ignition conditions.

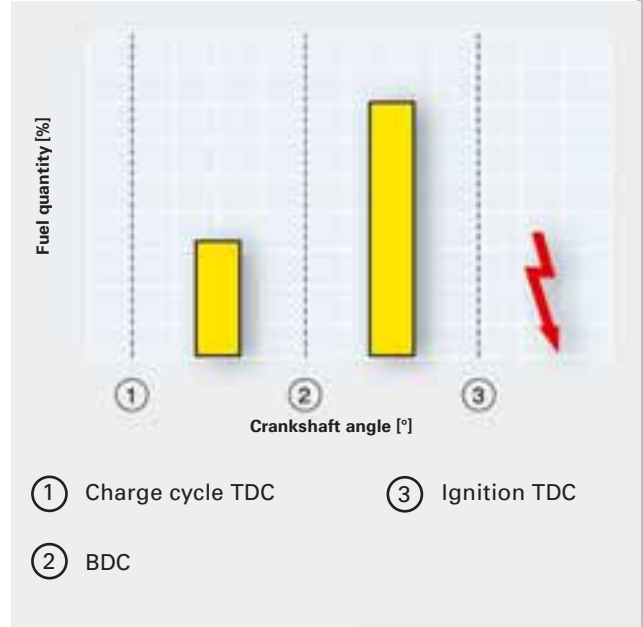


Catalyst heating with dual injection and secondary air injection

To achieve good idling quality, a special characteristic map has been selected. In this map the following parameters relevant to exhaust emissions have been adapted:

- Rail pressure
- Injection timing of the first injection during the intake phase
- Injection timing of the second injection during the compression phase
- Fuel split during first and second injections (approx. 70 % during first injection)
- Intake camshaft adjustment
- Position of the intake manifold flaps (open/closed)
- Ignition angle adjustment towards retard (up to 21° after TDC)
- Combustion chamber air ratio

By using the secondary air system, the exhaust gas temperature has been increased while reducing hydrocarbon emissions.



Dual injection during the engine warm-up phase

The catalytic converter heat-up phase is followed by the engine warm-up phase. During this phase, one dual injection is performed per working cycle. The main part of the fuel charge (approx. 80 %) is injected synchronous with the intake cycle, and the remainder (approx. 20 %) during the compression phase.

During the engine warm-up phase, dual injection is performed within the mapped range at engine speeds of less than 3000 rpm. At the same time, the intake manifold flaps are closed to increase flow intensity.

The advantage of this operating mode is that considerably less fuel is deposited on the cylinder walls due to the low penetration depth of the fuel during the second injection when the engine is still not fully warmed up.

Raw hydrocarbon emissions are lower, and entrainment of fuel into the engine oil is kept to a minimum.

2.0l TFSI engine for SULEV

Compliance with statutory limits (PremAir®)

When evaluating the environmental compatibility of a motor vehicle, US authorities award so-called "credits" for technical measures designed to improve air quality. These credits can for example be used to offset fleet emissions that are over the limit.

For this reason, a radiator with a special catalytic coating is used on the Audi A3. This *PremAir® technology** contributes to improving air quality. In exchange, the California Air Resources Board allows a higher *NMOG** limit.

Overview of the components



436_056

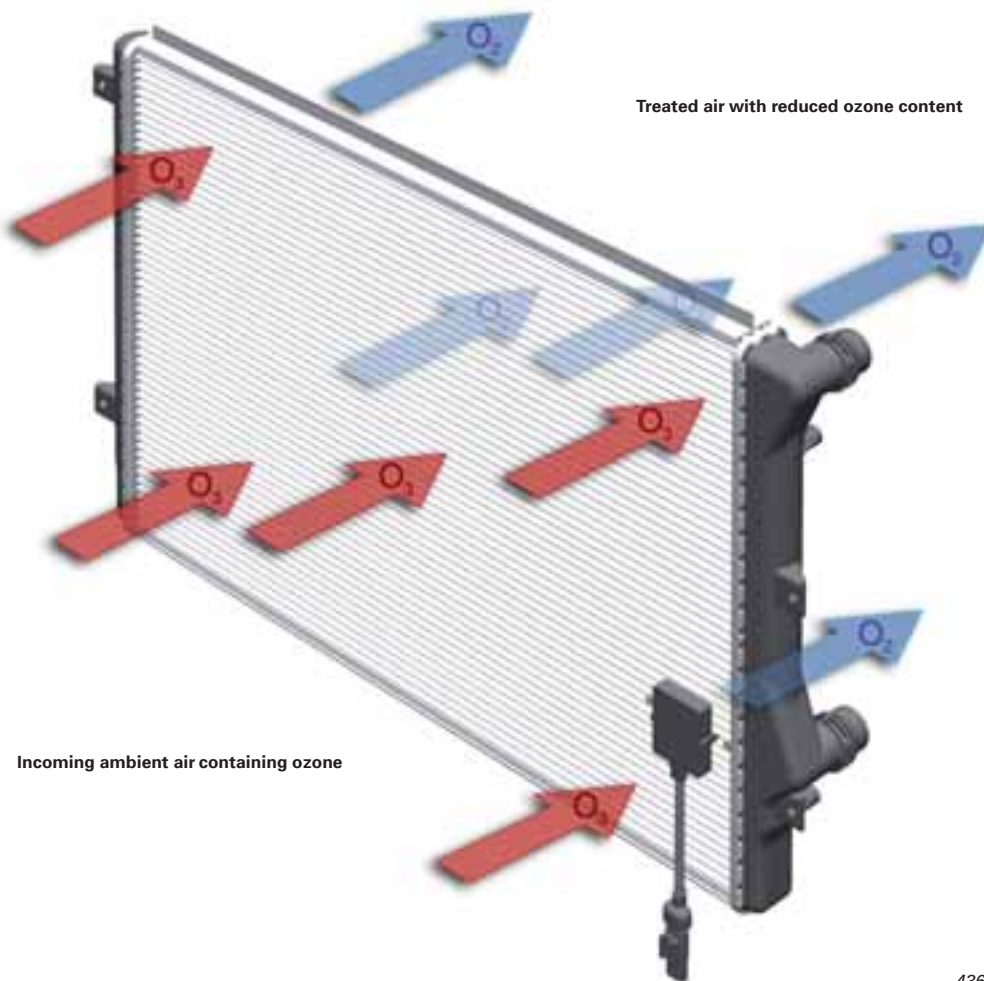
Function

The entire cooling surface of the car's radiator is coated with catalytic material. When air flows through this specially coated radiator, the *ozone** in the air is converted to oxygen (chemical symbol O_2). Ozone (chemical symbol O_3) is a gas which is harmful to health. Given that the air in a car radiator can flow at up to two kilograms per second, a car with a PremAir[®] radiator makes a significant contribution to reducing near-surface ozone levels. The efficacy of this technology is particularly high in strong sunlight and at high air pollution levels.

This ozone catalyst technology is for example used on aircraft, where it prevents stratospheric ozone from entering the cabin through the air conditioning system. The same technology is also used in printers and copiers.

To receive "credits" however, the Air Resources Board (ARB) demands not only that the PremAir[®] radiator actually be installed on the vehicle, but also that it functions reliably at all times.

The presence of the special radiator is, therefore, monitored by a sensor: the radiator identification sensor G611.



436_062

2.0l TFSI engine for SULEV

Radiator identification sensor G611

Requirements

The purpose of the radiator identification sensor G611 is to prevent

- a PremAir® radiator from being removed and replaced with a non-PremAir® radiator,
- radiator identification sensor G611 from being removed for the purpose of reproducing the electronics or software,
- radiator identification sensor G611 from being extensively cut out of the radiator and installed "elsewhere".

The requirements relating to the radiator identification sensor G611 are met as follows.

To check for the presence of the radiator, pre-determined distinguishing features (IDs) are stored in the engine control unit and in the radiator identification sensor G611, and exchanged.

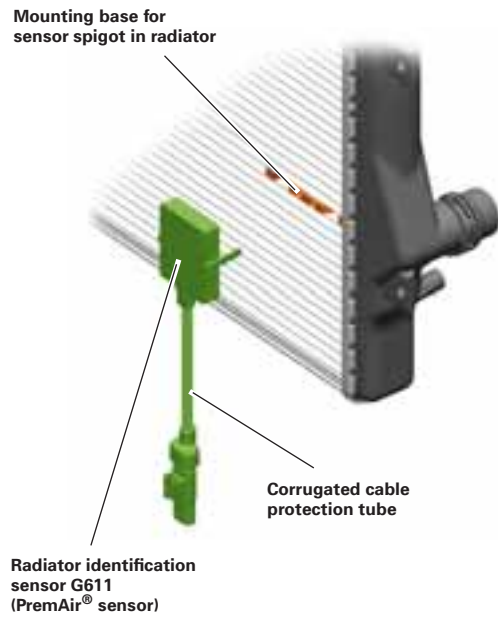
Information is exchanged via LIN bus according to the master-slave principle. This means that the radiator identification sensor G611 is interrogated by the engine control unit. The IDs are transmitted in an encrypted form after the engine is started. If the codes not longer match (e.g. due to manipulation), a fault will be indicated.

Integrated temperature sensor

A temperature sensor (NTC*, Negative Temperature Coefficient) measures the temperature at the point of installation. This temperature is compared with the temperature measured by the separate coolant temperature sender G62 in the engine control unit. The measured temperatures are transmitted to the engine control unit via LIN bus. In the engine control unit, the values are compared with a characteristic map and evaluated.

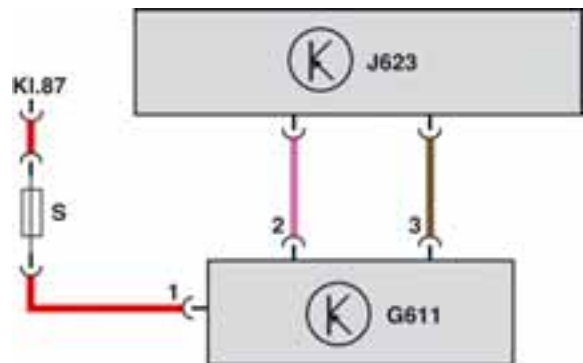
The temperature sensor is located in a specially shaped spigot on the sensor housing. During assembly, the sensor is bonded directly to a mounting base on the radiator.

The temperature sensor is made of cast polyurethane resin and is non-removable once attached. If, however, an attempt is made to remove the temperature sensor, the sensor spigot will break away from the housing causing it to become irreparably damaged, both electrically and mechanically. This is a safeguard to ensure that all attempts at manipulation will be detected. In the event of misuse, the exhaust gas warning lamp K83 (MIL) will be activated. In this case, both the radiator and the radiator identification sensor G611 must be replaced.



436_063

Circuit diagram



436_064

Legend:

- G611 Radiator identification sensor
- J623 Engine control unit
- Term. 87 Main relay, 12 volt power supply
- S Fuse
- Positive
- Ground
- LIN bus
- 1, 2, 3 pins on control unit

Temperature sensor diagnostics

The temperature sensor is diagnosed in the engine control unit only. To prevent manipulation, no tests can be performed using the VAS diagnostic unit. Furthermore, the temperature signal is not transmitted as a voltage value, but as a LIN message. Before the engine control unit can diagnose the temperature sensor, several enabling conditions must be met. The values are then checked in multiple measurement windows.

Enabling conditions of the diagnostics

- Engine temperature > 97.5 °C (so the thermostat is open).
- There is a 360-second time delay after the engine temperature exceeds 97.5 °C to ensure maximum flow through the radiator.

A measurement window is active if

- the engine has been idling for > 25 seconds,
- the engine is then accelerated to part throttle or wide-open throttle within 8 seconds,
- the measurement window then is active for 10 seconds in order to measure the temperature curves (gradients).

Three measurement windows are required to decide whether the system is in order, or not.

Additional conditions for diagnosis:

- Diagnostics are disabled for 45 seconds at radiator fan On/Off or Off/On
- Ambient temperature > 9 °C

The temperature sensor cannot be tested by reading out a measured value. If the engine control unit detects a fault, the following fault memory entries are possible:

- P2568 Implausible signal
- P2569 Short circuit to ground
- P2570 Short circuit to battery/open circuit
- U102E LIN message incorrect (implausible signal)
- U102F Timeout (no communication)
- U1030 LIN bus inactive



436_069



436_072

Note



The diagnostic strategy described in this SSP will be replaced by a new strategy in the course of ongoing development from model year 2011 onwards.

Special tools

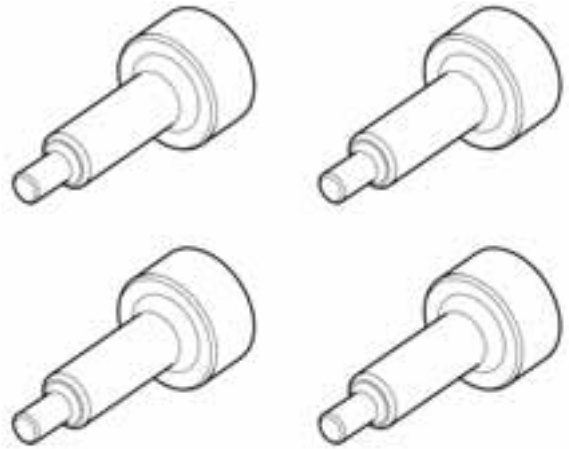


Here you can see the special tools for the 4-cylinder TFSI engines.



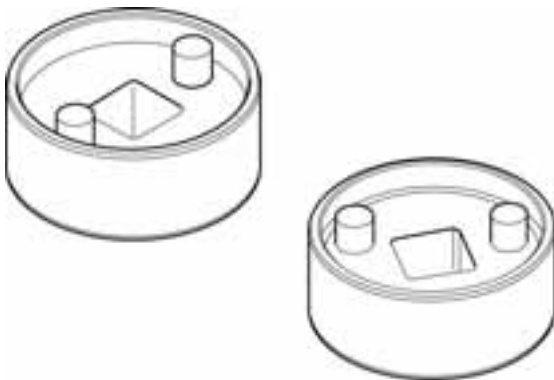
436_073

T40191/1 (narrow) and T40191/2 (wide) Spacers
For locating the AVS spline ends on the camshaft
(equipment group: A1)



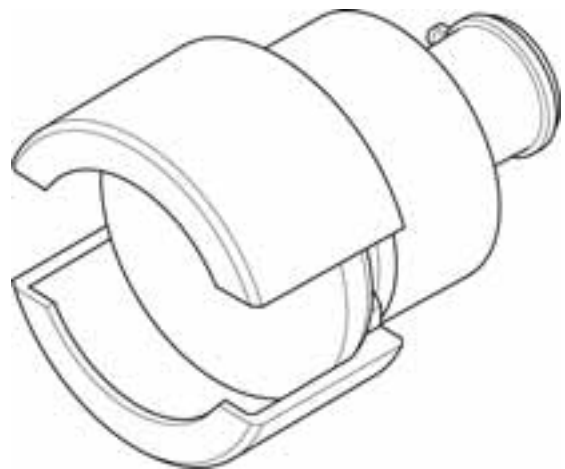
436_074

T40196 adaptor
For moving the AVS spline ends on the camshaft
(equipment group: A1)



436_091

T10352 assembly tool
For removing and installing the inlet camshaft timing adjustment valve
The "/1" tool has offset stud bolts.
It is used upwards of a defined engine version.
(equipment group: A1)



436_092

T10394 Puller
For removing the balancer shaft in conjunction with special tool T10133/3
(equipment group: A1)

Glossary

This glossary explains to you all terms written in italics or indicated by an asterisk (*) in this Self-Study Programme.

Blow-by gases

Blow-by gases are also known as "leakage gases". When the engine running, blow-by gases flow from the combustion chamber into the crankcase, and bypass the piston. This is caused by the high pressures inside the combustion chamber and by the absolutely normal leakage that occurs around the piston rings.

Blow-by gases are extracted from the crankcase by a PCV system and admitted into the combustion chamber.

Light-off time

The light-off time is the time calculated from engine start until the conversion rate of the catalytic converter is at least 50 %. It is of major relevance to future and US exhaust emission standards, as these standards require low pollutant emissions when the engine is cold.

LSF

This abbreviation stands for "solid electrolyte oxygen sensor" or "flat oxygen sensor". It is a planar two-point oxygen sensor, or what is also known as a nonlinear sensor due to its non-constant voltage curve.

LSU

This abbreviation stands for "universal oxygen sensor". The sensor in question is a linear broadband oxygen sensor. This oxygen sensor is used upstream of the catalytic converter and has a linear characteristic curve.

NMOG

This abbreviation stands for "Non Methane Organic Gases" and encompasses all hydrocarbon emissions except methane.

NTC

The abbreviation stands for "Negative Temperature Coefficient". Its resistance increases with rising temperature. These resistance values are commonly used for temperature measurement.

Ozone

Ozone is a toxic gas that can cause respiratory problems in some persons, as well as causing damage to vegetation, forests, crops and buildings.

PCV

This abbreviation stands for "Positive Crankcase Ventilation".

In this system, fresh air is mixed with the blow-by gases inside the crankshaft chamber. The fuel and water vapours contained in the blow-by gases are absorbed by the fresh air and discharged through the crankcase ventilation system.

PremAir®

This is a registered trademark of the Engelhard Corporation. Automobile manufacturer Volvo has had this technology patented. Volvo was the world's first automobile manufacturer to tackle the problem of near-surface ozone, and for this reason launched PremAir® in 1999.

Wastegate

To regulate the charge pressure on a turbocharger, a wastegate is installed in the exhaust gas stream. If the charge pressure is too high, an actuator opens the wastegate. The exhaust gas bypasses the turbine and is routed directly into the exhaust system, thus preventing a further increase in turbine speed.

Test yourself

Which of the following answers is correct? Sometimes only one answer can be chosen. At other times, more than one answer may be correct – or all of them!

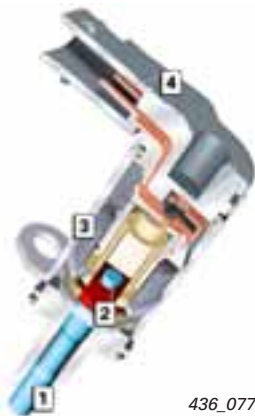
1. Which engine was the first of the engine series described in this Self-Study Programme?

- A 1.8l MPI engine (engine code AJQ)
- B 1.8l TFSI engine (engine code CABA)
- C 1.8l TFSI engine (engine code BYT)

2. What is the task of the PremAir® system?

- A Detoxification of the intake air for the occupant cell.
- B Highly effective treatment of the engine intake air.
- C Conversion of harmful ozone in the ambient air to oxygen by the radiator.

3. Please identify the component parts of an AVS actuator!



- 1
- 2
- 3
- 4

4. Which of the following statements applies to this illustration of the self-regulating oil pump?

- A The cam lobe unit has reached its maximum axial displacement.
- B The oil pump is operating at its maximum flow rate.
- C The oil pump is operating at a low oil flow rate.



5. What is the task of the oil pressure switch for reduced oil pressure F378?

- A It measures the minimal oil pressure present in the system.
- B It monitors oil pressure switch F22.
- C It monitors for the presence of oil pressure in an engine with self-regulating oil pump.

1. C;
 2. C;
 3. 1 = Metal pin, 2 = Permanent magnet,
 3 = Magnetic coil, 4 = Electrical connection
 4. A, C;
 5. C;

Solutions:

With the chain-driven 4-cylinder TFSI engine, Audi has developed a unit that can be found in a wide range of products.

The engine needed further development to meet the increasingly tough exhaust emission standards. The new US spec unit achieves emission levels that are even below the world's most stringent exhaust emission standards in California. This was achieved by a variety of improvements, as well as the use of new technology. One of the focal points of development was reducing the internal friction of the engine. To achieve this, the basic engine was friction-enhanced by a variety of measures. A newly developed self-regulating oil pump is also used.

Engine power output ranges from 88 to 155 kW. The 350 Nm torque level of the 2.0l TFSI engine allows sporty performance, combined with good fuel economy.

This has also been achieved by using the Audi valvelift system.

To keep fuel costs to a minimum, the engine is designed to run on 95 RON petrol. However, development of the engine is still work in progress. A Stage 3 engine is planned, and also the use of E85 fuel.

Self-Study Programmes

This Self-Study Programme summarises all key information on the 1.8l and 2.0l TFSI engines. For further information on the subsystems described in this document, please refer to the relevant Self-Study Programmes.



436_057



436_058



436_059



436_090

- SSP 231 Euro On-Board Diagnostic System
- SSP 384 Audi 1.8-litre Chain-driven 4V TFSI Engine
- SSP 401 Audi 1.8-litre Timing Chain Driven 118kW TFSI Engine
- SSP 411 Audi 2.8l and 3.2l FSI Engines with Audi Valvelift System

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