



The Audi 3.0L V6 TFSI Fourth Generation Engine

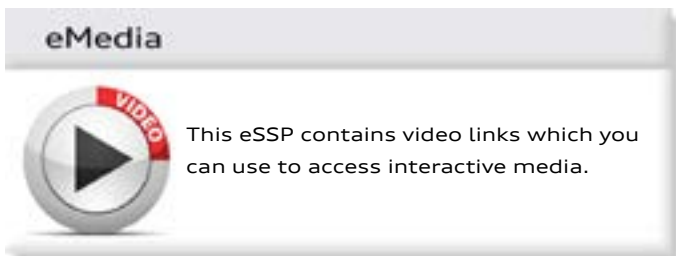
Audi of America, LLC
Service Training
Created in the U.S.A.
Created 10/2014
Course Number 920323

©2014 Audi of America, LLC

All rights reserved. Information contained in this manual is based on the latest information available at the time of printing and is subject to the copyright and other intellectual property rights of Audi of America, LLC., its affiliated companies and its licensors. All rights are reserved to make changes at any time without notice. No part of this document may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, nor may these materials be modified or re-posted to other sites without the prior expressed written permission of the publisher.

All requests for permission to copy and redistribute information should be referred to Audi of America, LLC.

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



This eSelf Study Program teaches 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



Reference

Contents

Introduction	5
Brief technical description	6
Engine mechanicals	8
Engine block and oil sump	8
Chain case cover (sealing flange) with oil filter and engine oil cooler	10
Crankshaft assembly	11
Positive crankcase ventilation	12
Vacuum supply system	13
Belt drives	14
Chain drive	15
Camshaft adjusters	16
Cylinder head	17
Oil supply.....	20
Introduction	20
Oil pump	21
Switchable oil cooler	22
Oil filter module	23
Air intake and turbocharger systems.....	24
Overview	24
Supercharger module	25
Compressor Magnetic Clutch N421	26
Turbocharger Speed Sensor 1 G688	29
Engine cooling system.....	30
Introduction	30
System overview	31
Switchable coolant pump	32
Thermostat	33
Engine oil cooler coolant shut-off valve	34
Electrical coolant pumps and coolant valve	35
Fuel system	37
Dual fuel injection system	37
System overview	39
Engine management system	43
System overview (2015 model Audi A8)	43
Secondary air system	45
Service	47
Tools	47
Maintenance operations	48
Knowledge Assessment	50

Introduction

Audi V6 gasoline engines

The first generation 3.2 liter V6 engine with direct fuel injection from Audi was introduced in 2004. This was followed in 2006 with a 3.2 liter V6 equipped with the Audi Valve Lift System. In 2008, a 3.0 liter V6 was rolled out. It was the first V6 engine from Audi that featured direct fuel injection and supercharging. It first appeared in the S4.

Now, a new generation 3.0 liter V6 – the fourth – has been launched. This new V6 is the fourth generation of the EA837 engine family and is sometimes referred to as the V6 “evo.”

It will have the same displacement, horsepower and torque as the previous generation engine however, it was extensively re-worked with the main goal of reducing emissions while maintaining excellent power output and fuel economy.

Many of the engine components may look similar to the previous generation but there are many changes; some of them very subtle.

The third-generation 3.0L V6 TFSI engine was revised with the aim of significantly improving fuel economy while retaining all the desirable characteristics of the previous engine. This was achieved by making the following modifications:

- ▶ Friction in the base engine was reduced by 9% by utilizing
 - ▶ an improved chain drive
 - ▶ an optimized piston ring assembly with reduced pre-load force, better volumetric efficiency and lower oil consumption
 - ▶ enhanced camshaft bearings (new finishing process)
- ▶ A "supercharging on demand" solution for the mechanical charging system, achieved by introducing a magnetic clutch
- ▶ A highly flexible fuel injection strategy combining high pressure injection and low pressure injection systems
- ▶ A radically improved combustion process
- ▶ Detailed enhancement of all components and systems relevant to fuel efficiency



624_069

Learning objectives of this eSelf-Study Program:

This eSelf-Study Program describes the design and function of the fourth-generation 3.0L V6 TFSI engine (evo). Once this is completed, you will be able to answer the following questions:

- ▶ Which modifications were made compared with the third-generation 3.0L V6 TFSI engine?
- ▶ How does the clutched supercharger drive system work?
- ▶ How is the fuel injection system designed?
- ▶ What are the differences in the oil supply and cooling systems?

Brief technical description

The description of the fourth-generation 3.0l V6 TFSI engine EA837 (evo) in this eSelf-Study Program is based on its introduction in the 2015 Audi A8.

The main new features at a glance:

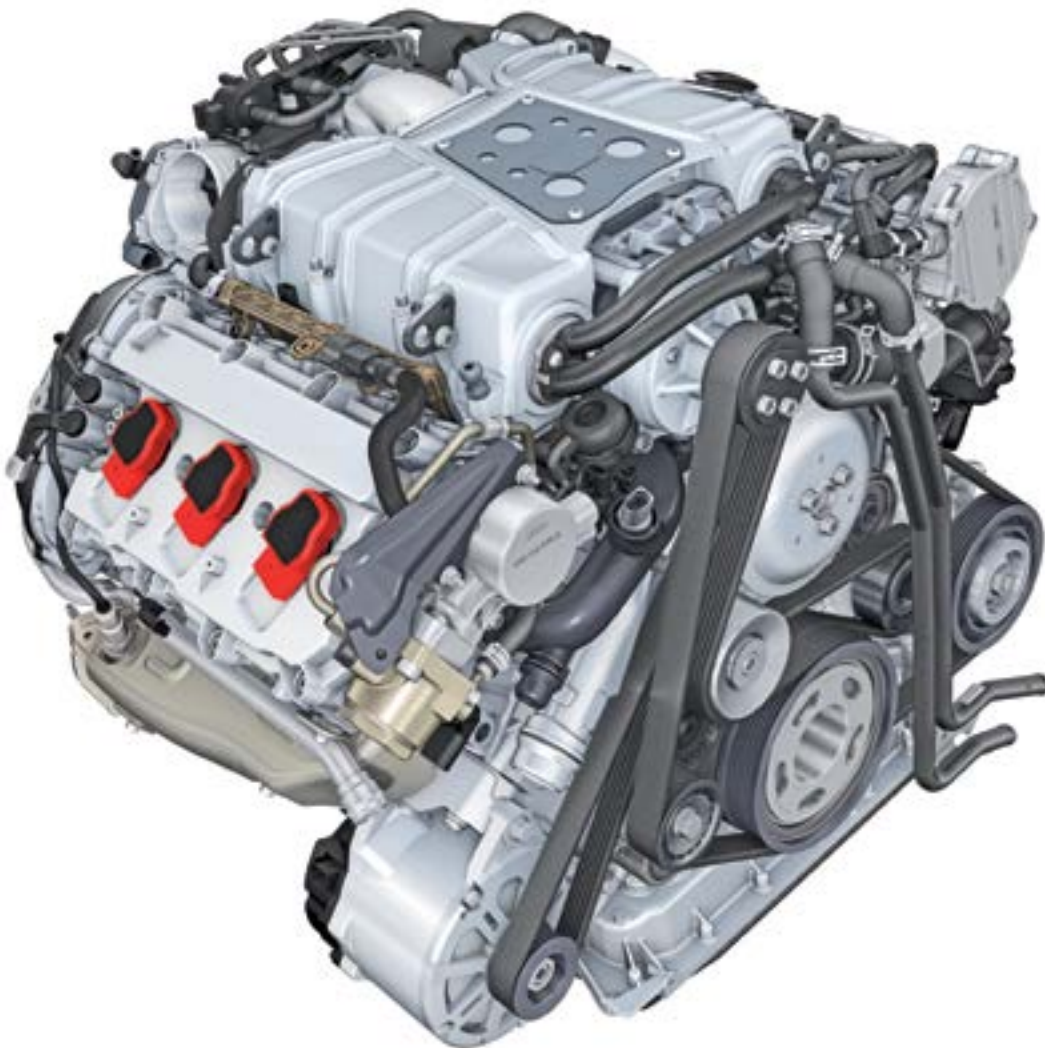
- ▶ 6-cylinder V-engine with mechanical supercharging by means of a belt-driven, clutched supercharger (Roots blower)
- ▶ Combined TFSI and MPI fuel injection
- ▶ Continuous camshaft adjustment on intake and exhaust side

Key modifications compared to the third-generation 3.0l V6 TFSI engine:

- ▶ Cast-iron cylinder liners
- ▶ Clutch driven (Roots blower)
- ▶ MPI fuel injection added
- ▶ Exhaust-side camshaft adjustment added
- ▶ Repositioning of the engine oil cooler (switchable) to the back of the engine
- ▶ Chain drive with different chain routing
- ▶ Positive crankcase ventilation on one cylinder bank only

The following adaptations were made:

- ▶ Piston shape
- ▶ Oil sump and chain case cover (sealing flange)
- ▶ Crankshaft with hollow-bored crank pin
- ▶ Coolant pump with modified pump impeller ("potted")
- ▶ Terophon coated timing chain covers
- ▶ Modifications to reduce friction and weight



624_004



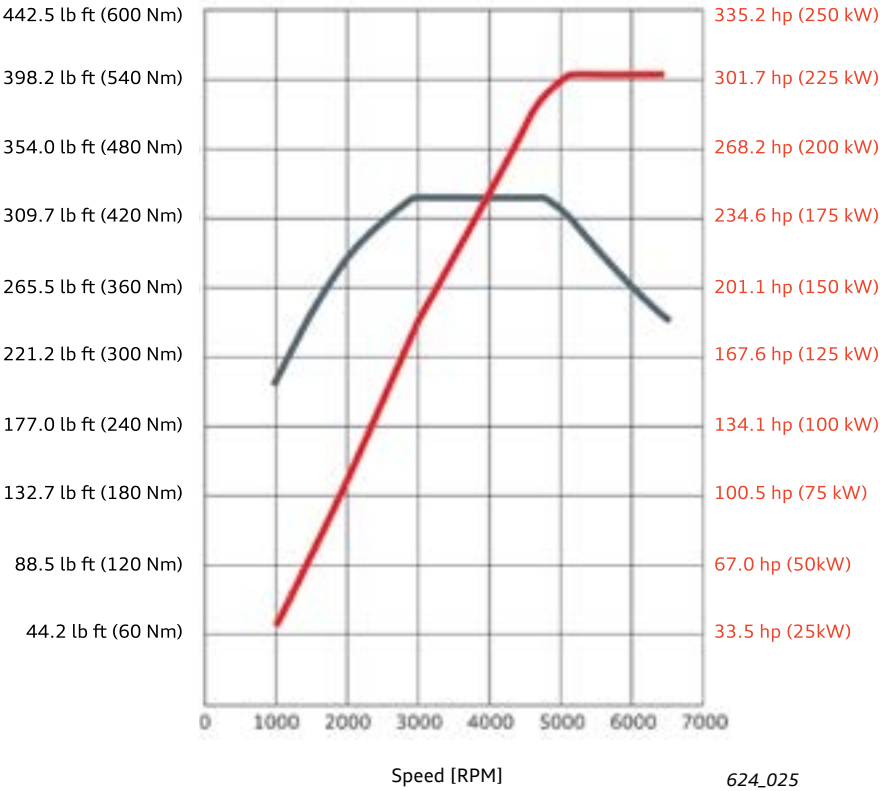
Reference

The design and function of the basic engine are described in eSelf-Study Program [924603](#), The 3.2 and 3.6 liter FSI Engine and [925803](#), Audi 3.0 V6 TFSI engine with Roots blower.

Specifications

Torque-power curve

- Power output
- Torque



Features	Specifications
Engine code	CREC
Type	V6 configuration
Displacement	182.7 cu in (2995 cm³)
Stroke	3.50 in (89 mm)
Bore	3.32 in (84.5 mm)
Number of valves per cylinder	4
Firing order	1-4-3-6-2-5
Compression ratio	10.8 : 1
Power output	305.7 hp (228 kW) @ 5200 - 6500 rpm
Torque	324.5 lb ft (440 Nm) @ 2900 - 4750 rpm
Fuel type	Premium unleaded 91 AKI
Turbocharging	Clutched supercharger (Roots blower)
Maximum charge pressure (absolute)	26.1 psi (1.8 bar)
Engine management system	Simos
Knock control	2 sensors
Oxygen sensor control	2 sensors upstream of catalytic converter and 2 sensors downstream of catalytic converter
Mixture formation	Combined TFSI and MPI
Emission standard	LEV II - ULEV/TIER 2 - BIN 5

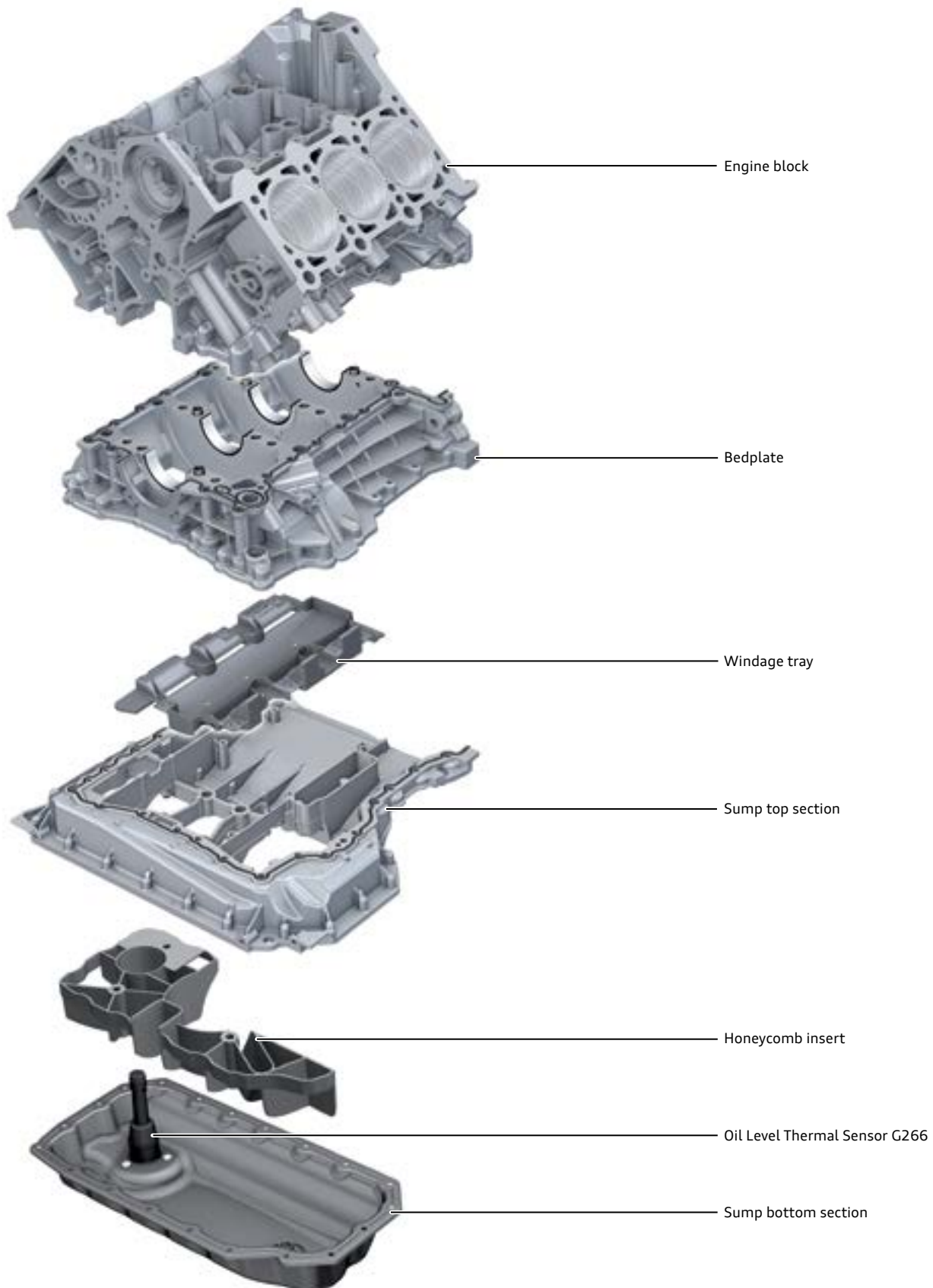
Engine mechanicals

Engine block and oil sump

Both the engine block and oil sump are new designs. They were re-designed mainly to allow installation space for an electromechanical power steering system.

Because of these modifications, some components of the oil supply system - the engine oil cooler in particular - and the engine cooling system were relocated.

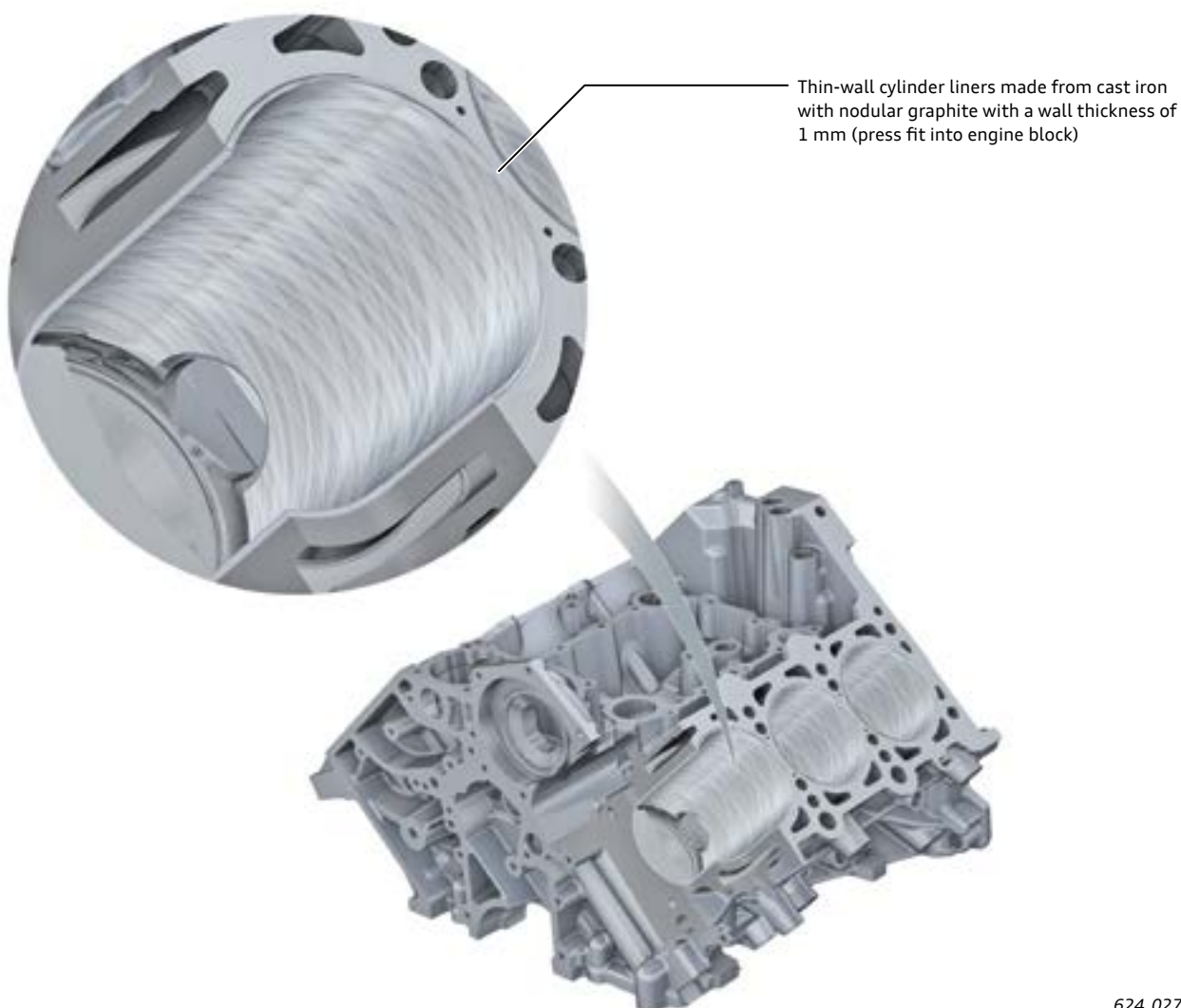
The honeycomb insert in the oil pan allows oil to be reliably drawn by the oil pump under high transverse acceleration.



Components and modifications at a glance

Component	Features and tasks
Engine block	<ul style="list-style-type: none"> ▶ Closed-deck construction ▶ Thin-wall cylinder liners made from cast iron with nodular graphite with a wall thickness of 1 mm ▶ Material: aluminium-silicon alloy
Bedplate	<ul style="list-style-type: none"> ▶ Accommodates the oil pump ▶ Material: aluminium-silicon alloy
Windage tray	<ul style="list-style-type: none"> ▶ Bolted into the oil pan top section ▶ Prevents frothing of the oil due to the crankshaft rotation ▶ Material: polyamide (PA) polymer
Oil sump top section	<ul style="list-style-type: none"> ▶ Geometrically adapted to facilitate the use of electro-mechanical power steering ▶ Increases engine block rigidity ▶ Houses the surge baffle ▶ Sealed to engine block with liquid sealant ▶ Material: aluminium-silicon alloy
Honeycomb insert	<ul style="list-style-type: none"> ▶ Ensures that oil pump can draw oil during sporty driving ▶ Bolted together with the oil pan top section ▶ Material: polyamide (PA) polymer
Oil sump bottom section	<ul style="list-style-type: none"> ▶ Extended measurement range of Oil Level Thermal Sensor G266 ▶ Uniform material thickness to optimize weight and reduce component warpage (leak tightness) ▶ Sealed with liquid sealing compound ▶ Material: sheet steel

Engine block with thin-wall cylinder liners



Chain case cover with oil filter and engine oil cooler

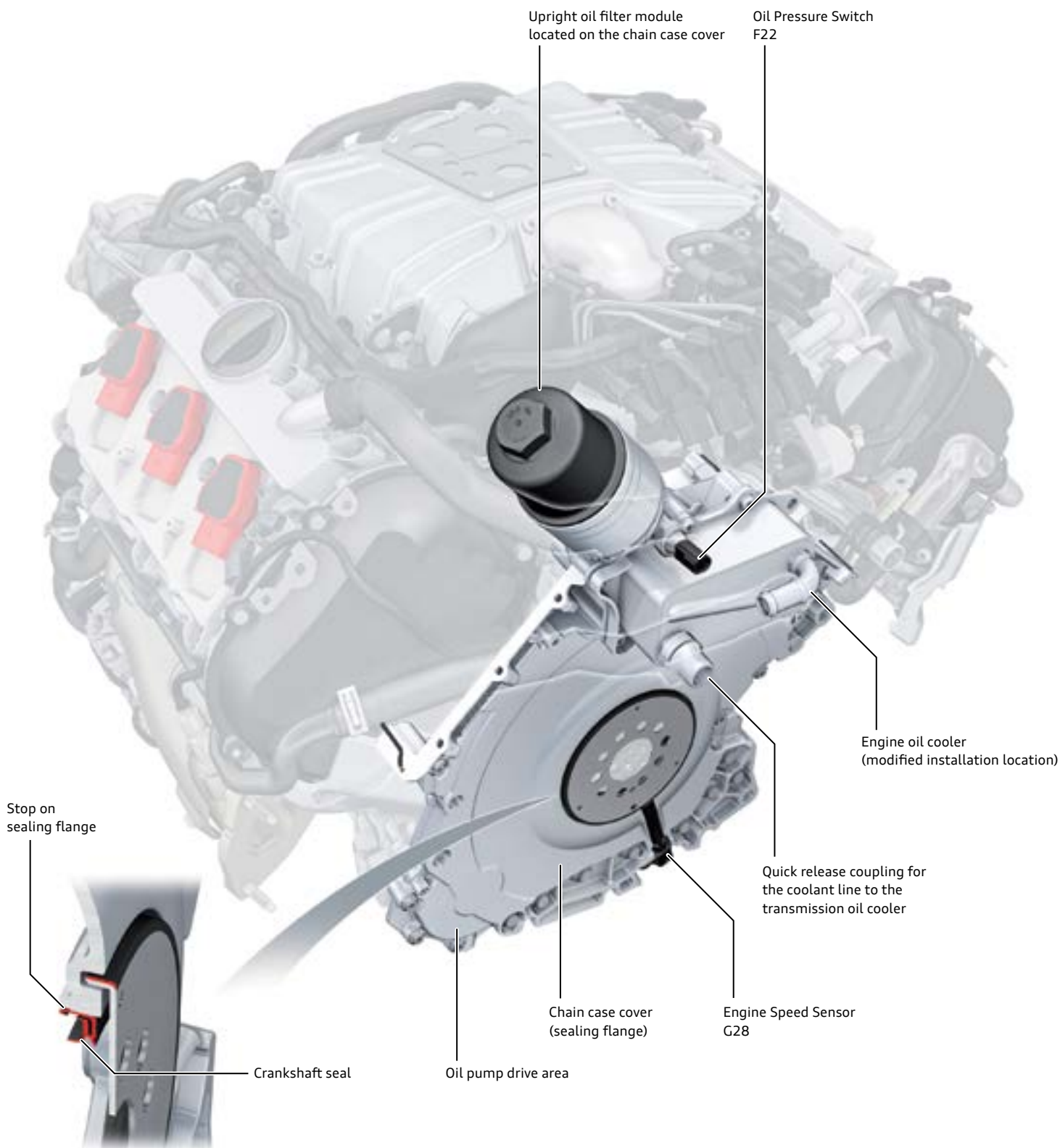
The die-cast aluminum chain case cover (also referred to as the sealing flange) was modified to allow space for an electromechanical power steering system in the engine compartment.

The chain case cover is mounted to the engine block and to the bedplate on the transmission side of the engine.

The upright oil filter module is a component of the chain case cover. The engine oil cooler was moved from the oil sump top section to the chain case cover next to the oil filter.

There is now a quick-release coupling for the coolant line running to the transmission cooler.

The pressure generated in the crankcase of this engine is slightly higher than that of the third generation engine and could potentially suck the crankshaft oil seal inward. To prevent this, a stop has been designed into the sealing flange.



Crankshaft assembly

The forged crankshaft was re-designed to reduce weight. This was achieved by reducing the size of the crank webs and by boring the crank pin. These modifications reduced the weight of the crankshaft by approximately 3.6 lb (1.67 kg).

Connecting rod

The connecting rods are cracked at the large end and have bronze bushings in the upper end.

Bearing specifications

Feature	Specifications
Bearing shells	<ul style="list-style-type: none">▶ Three-material bearing▶ Steel back with a bronze layer and an electro-plated bismuth layer▶ Main bearing: Two-material bearing (coated)
Diameter of main bearing	2.55 in (65 mm)
Diameter of connecting rod bearing	2.20 in (56 mm)



624_002

Piston

A new piston design helps define the new combustion chamber configuration. The objectives were to reduce weight which in turn reduces fuel consumption and exhaust emissions; especially particulate emissions.

The following modifications were made compared to the third generation engine:

- ▶ Reduction of piston weight through new piston ring design
- ▶ Reduction of squish zone (clearance between the piston crown and the cylinder head)
 - ▶ Compression ratio increased to 10.8 : 1
 - ▶ Reduction of tangential forces acting on the piston rings to reduce friction and CO₂ emissions
- ▶ New oil control ring design
 - ▶ Reduction in oil consumption
- ▶ Graphite skirt coating
 - ▶ Required for cast iron cylinder races
 - ▶ Reduction in friction



624_005

Positive crankcase ventilation

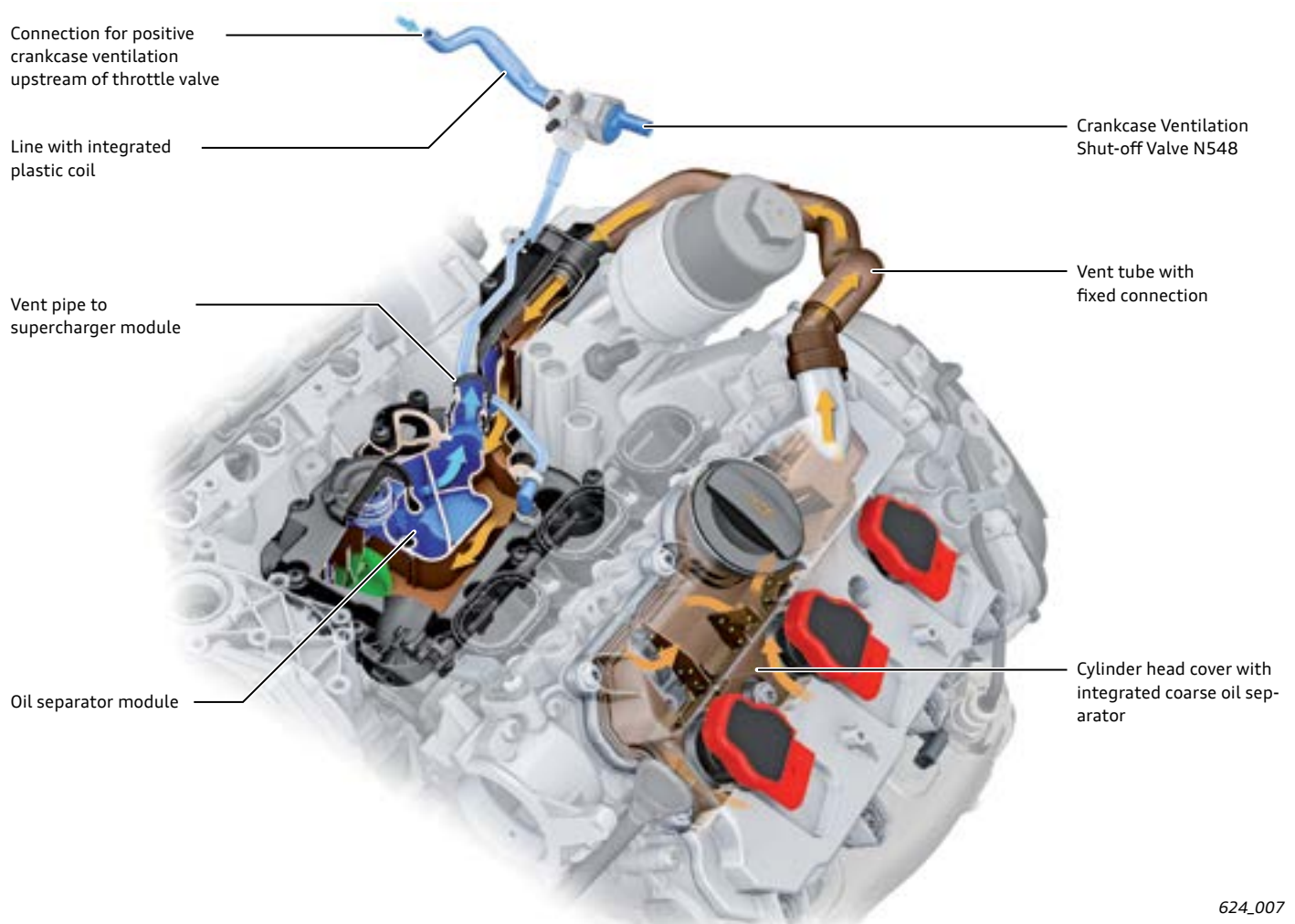
The positive crankcase ventilation system has been revised to optimize its separation behavior.

Other design objectives were to:

- ▶ Reduce noise
- ▶ Improve engine idling performance

Coarse oil separation takes place in a labyrinth of the cylinder head cover. The vent pipe between the coarse oil separator and the oil separator module is now insulated. This means that blow-by gases can't condense on the components.

The fine oil separator with its integrated pressure control valve is mounted in the inner 'V' of the engine. It was adopted from the third generation engine and is rated for a partial pressure of 2.17 psi (150 mbar).



To purge the crankcase, air is extracted from the clean air line downstream of the air filter. The clean air then flows into the crankcase through a connection on the fine oil separator. To reduce noise, a plastic coil was integrated in the line.

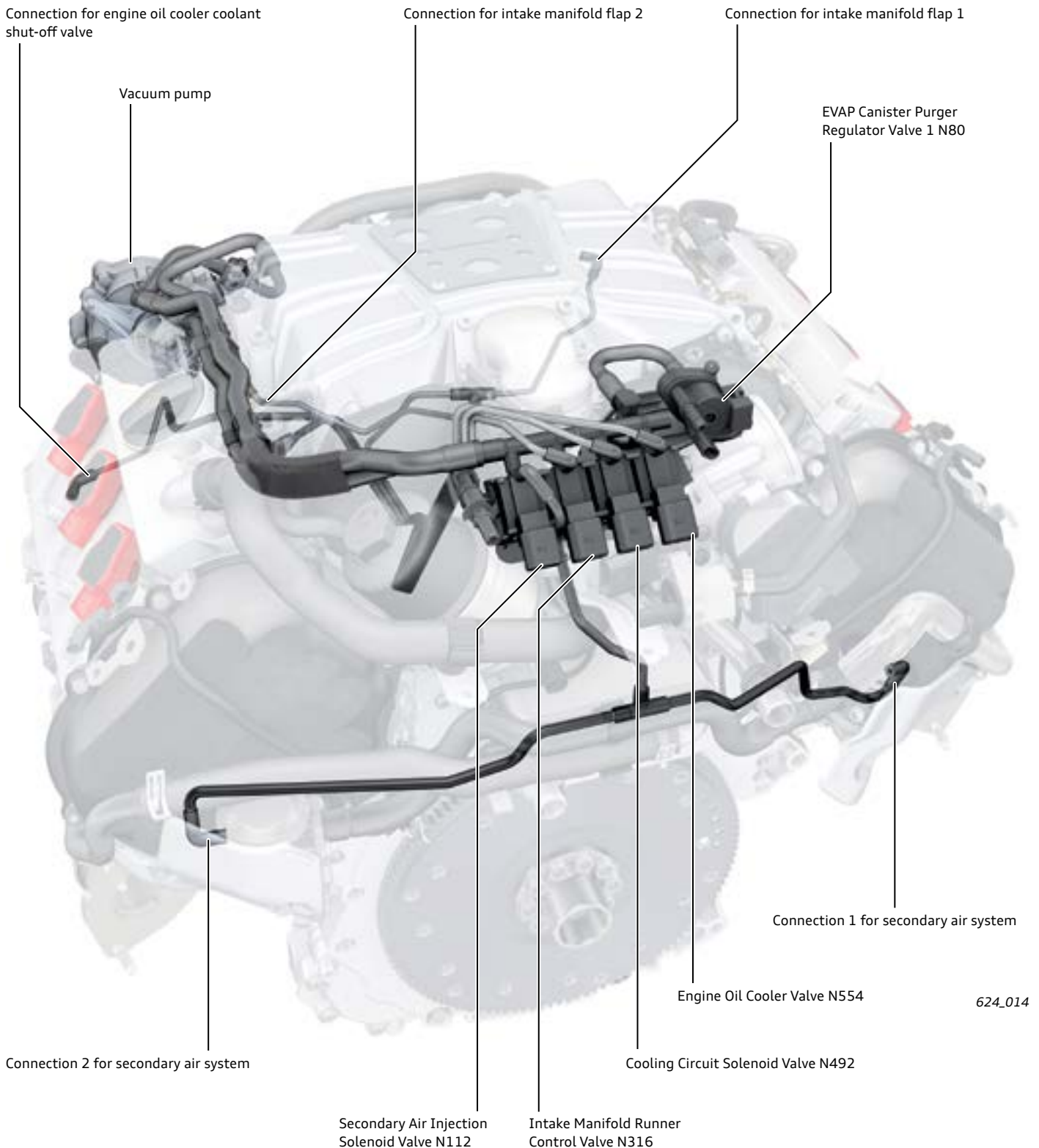
High hydrocarbon concentrations in the crankcase can impair the engine idling performance. To address this, Crankcase Ventilation Shut-Off Valve N548 closes the vent line when the engine is idling if the oxygen sensor detects an excessively high hydrocarbon concentration from the PCV system.

Vacuum supply system

A vacuum pump is located on the front of the engine. It is driven directly by the intake camshaft of the left cylinder bank. The solenoid valves for activating the vacuum consumers are located on the back of the engine.

The following systems are vacuum-activated:

- ▶ Secondary air system (2 combi valves)
- ▶ Intake manifold flaps
- ▶ Cooling system
 - ▶ Switchable engine oil cooler
 - ▶ Switchable coolant pump



624_014



Note

The vacuum lines and electrical connectors must always be correctly assigned and should not under any circumstances be interchanged.

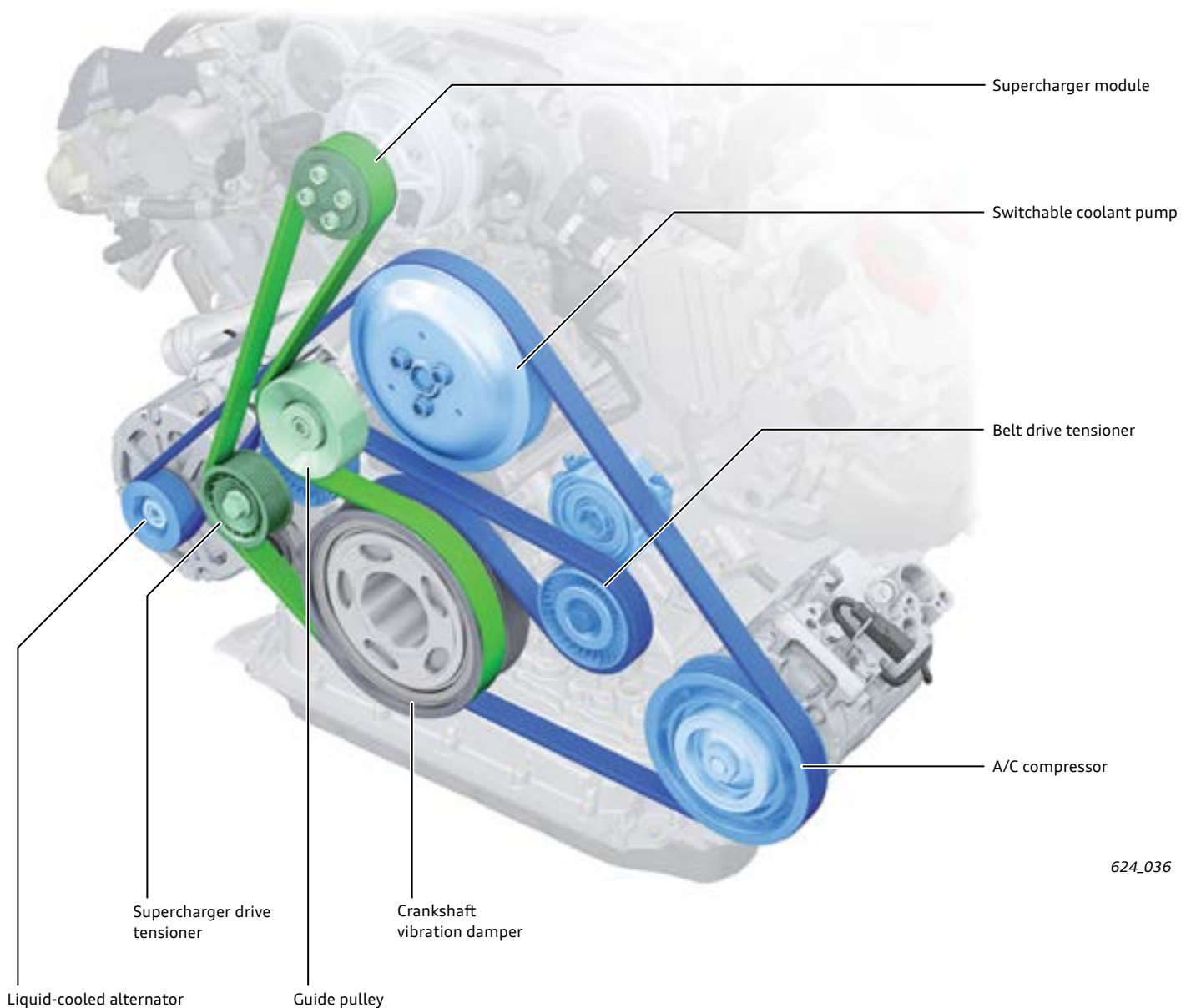
Belt drives

The engine has two separate belt drives. One belt drives the ancillary components consisting of the alternator, switchable engine coolant pump and A/C compressor. The supercharger is driven by a separate belt.

Key:

 Ancillary component drive

 Supercharger drive



624_036

Supercharger drive

Because a clutch is now used on the supercharger drive, a higher tensioning force must be applied to the Poly-V belt. The belt also requires a set change interval. Always refer to the current maintenance information.

Features:

- ▶ Tensile force 65.1 lbf (290 N)
- previously 49.2 lbf (219 N)
- ▶ Belt drive ratio $i = 2.5:1$

Supercharger drive
tensioner



624_067

Chain drive

The development objectives for the chain drive were to reduce friction, weight and cost.

Compared to the third-generation 3.0l V6 TFSI engine, the routings of chain drive A (also drives the balancer shaft) and chain drive D (drives the oil pump only) were modified. As a result, both chains have a fewer links, which in turn saves weight.

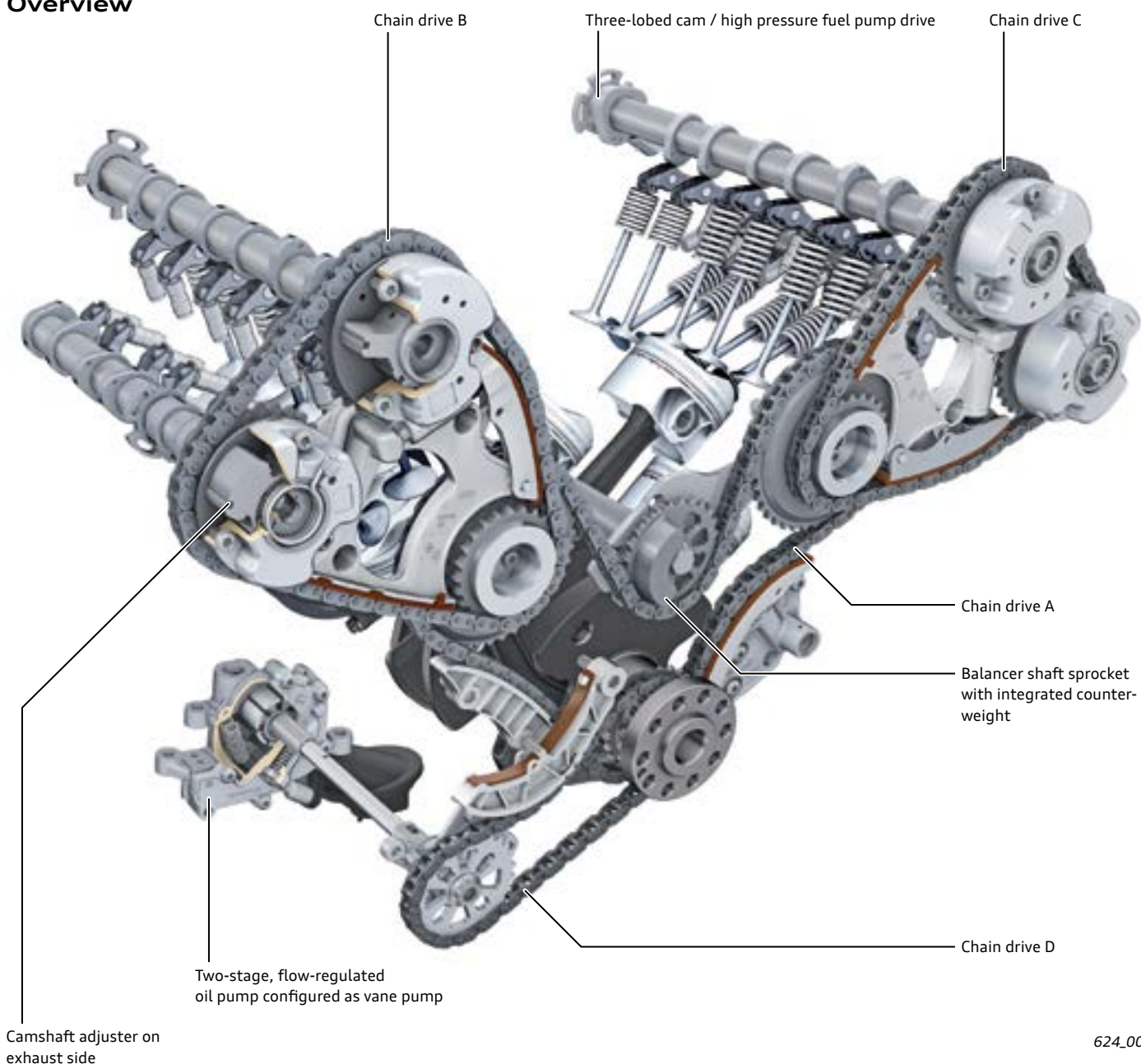
The chain tensioners of chain drives A, B and C are hydraulic-assisted mechanical chain tensioners – as used in the third-generation 3.0l V6 TFSI engine.

The chain tensioner housings for drives B and C are weight optimized. The short guide rails are integrated into the cylinder head cover.

The chain tensioner for drive D is a non-hydraulically assisted mechanical tensioner. It is a leaf spring assembly.

The engine also has a balancer shaft located in the inner 'V'. It features a sintered sprocket with an integrated counterweight. The shaft itself is "kneaded" (a special process during forging) and has no oil ring groove in either bearing.

Overview



624_006



Note

Due to the design modifications to the chain drive, it was also necessary to modify the assembly and repair operations. Please refer to ElsaPro for the most current details.

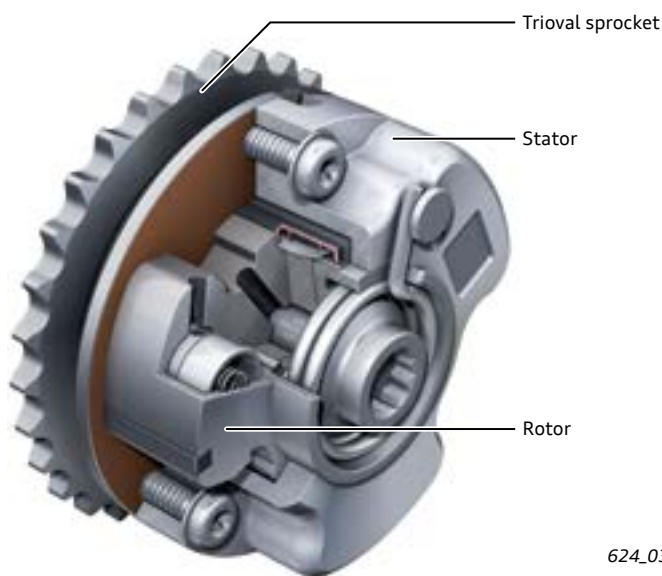
Camshaft adjusters

All the camshaft adjusters work in a similar manner as the previous generation. They are not pressurized and locked in place when the engine is not running. This minimizes knocking noises when the engine starts. Spring loaded locking pins are used to lock the camshaft adjuster's stator to the rotor.

During engine start-up, all camshaft adjustment valves are de-energized. The intake camshafts are in a retarded timing position while the exhaust camshafts are in an advanced position.

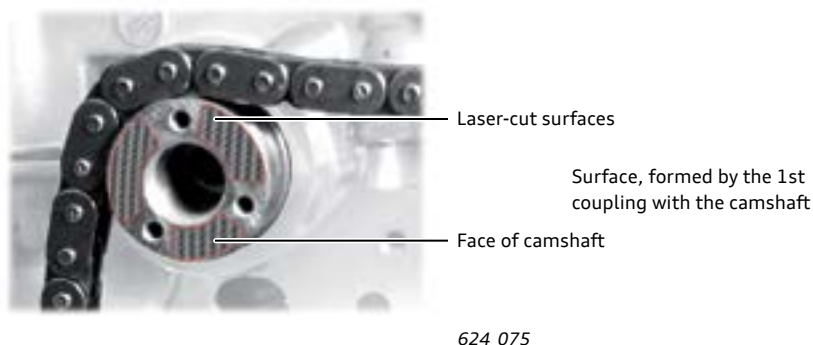
Design of camshaft adjusters

- ▶ Design carry-over from third-generation 3.0l V6 TFSI engine (reduced leakage, lightweight design)
- ▶ 50° intake crank angle adjustment range (3rd generation: 42°)
- ▶ 42° exhaust crank angle adjustment range (positioner is new)
- ▶ Trioval sprockets
- ▶ Camshaft adjustment valves with mesh inserts to prevent vibration breakage (carry-over from 4.0l V8 TFSI engine)



Laser-cut surfaces

To enhance torque transfer when coupling, the surface of the face of the camshafts is laser cut during manufacture. A corresponding pattern is formed during the first coupling with the aluminum camshaft adjuster. Special work procedures are required when replacing these components. Always refer to ElsaPro for the complete details.



Reference

The basic design and function of the camshaft adjuster is described in eSelf-Study Program [920113](#), The 6.3L W12 FSI Engine.

Cylinder head

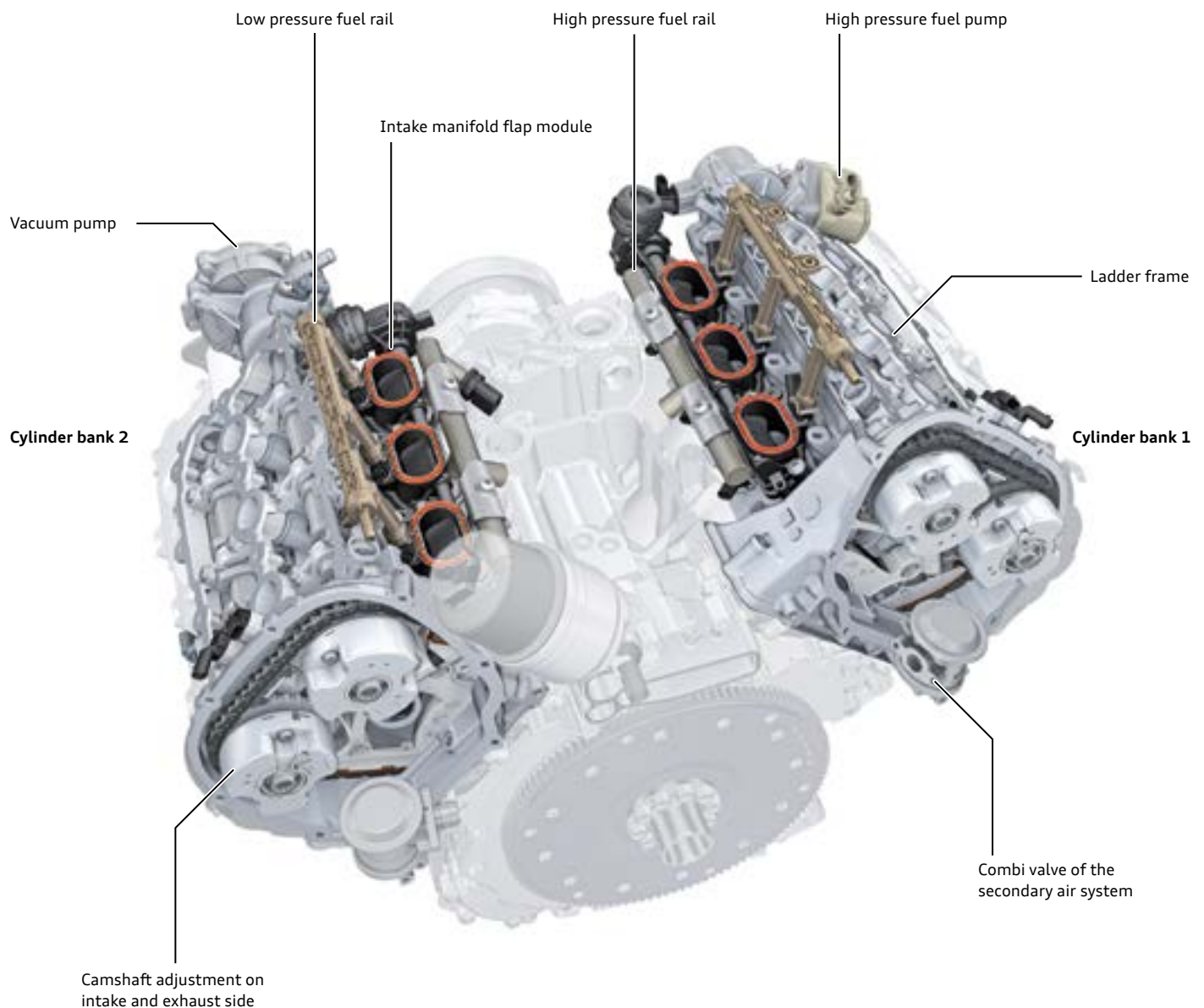
A number of design enhancements have been made to the cylinder heads. The key modifications are as follows:

- ▶ Adaptation to the new combustion chamber geometry
- ▶ Modified supercharger mounting
- ▶ Integration of the dual fuel injection system
 - ▶ Installation of additional low pressure injectors
 - ▶ Rerouting of the fuel lines
- ▶ Adapted cooling circuit (X bore)
- ▶ Adjusters on the exhaust camshafts
- ▶ More wear-resistant valve train components
- ▶ New intake valve seat ring
- ▶ Wear-resistant exhaust valve guides
- ▶ Ladder frame with mounting for camshaft adjustment valves 1+ 2
- ▶ New combi valves (secondary air system) with modified mounting

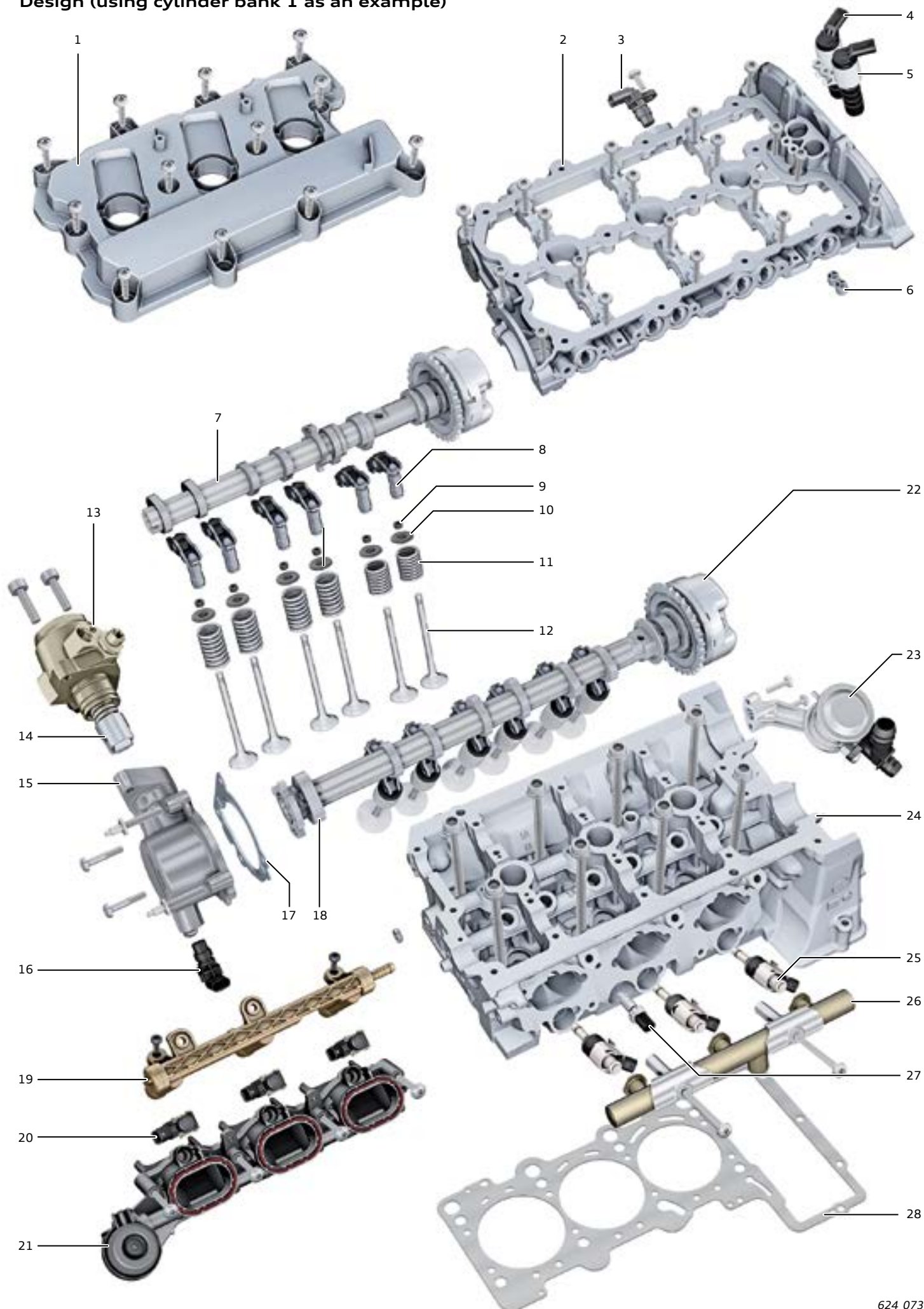
The weight of the cylinder heads was reduced by the re-design of the end piece of the camshaft adjuster connection.

The friction of the camshafts, especially at the beginning of the engine's service life, was reduced through a finishing a process which involves ultra-fine machining of the surfaces.

The intake and exhaust valves can be ground or replaced but the valves seat rings must never be re-worked.



Design (using cylinder bank 1 as an example)



Legend for illustration on previous page:

- | | | | |
|----|--|----|--|
| 1 | Cylinder head cover | 16 | Camshaft Position Sensor 2 G163 |
| 2 | Camshaft bearing frame (ladder frame) | 17 | Gasket |
| 3 | Camshaft Position Sensor G40 | 18 | Drive cam for high pressure fuel pump |
| 4 | Camshaft Adjustment Valve 1 N205 | 19 | Low pressure fuel rail |
| 5 | Exhaust Camshaft Adjustment Valve 1 | 20 | MPI injectors, cylinders 1 – 3 (low pressure)
N532 – N534 |
| 6 | Retention valves | 21 | Intake manifold flap module |
| 7 | Exhaust camshaft with camshaft adjuster | 22 | Intake camshaft with camshaft adjuster |
| 8 | Roller-lever cam follower with support | 23 | Combi valve of secondary air system |
| 9 | Valve keepers | 24 | Cylinder head |
| 10 | Valve spring retainer | 25 | TFSI injectors, cylinders 1 – 3 (high pressure)
N30 – N32 |
| 11 | Valve spring | 26 | High pressure fuel rail |
| 12 | Exhaust valve | 27 | Engine Temperature Control Sensor G694 |
| 13 | High pressure fuel pump | 28 | Cylinder head gasket |
| 14 | Roller cam follower for high pressure pump | | |
| 15 | High pressure fuel pump drive housing | | |

Timing chain covers

The sheet aluminum timing chain covers are bolted to the cylinder heads and sealed with a liquid sealant. Their wall thickness is 0.8 mm which results in a 400g weight reduction when compared to the previous generation engine. The shape of the covers was modified to accommodate the new secondary air system. Both covers are identical.

The covers are externally coated with a temperature-resistant soundproofing material called Terophon to reduce chain meshing noise. The spray-applied Terophon coating is approximately 3 mm thick.



Terophon coating

Oil supply

Introduction

Many design modifications were done to the oil supply system.

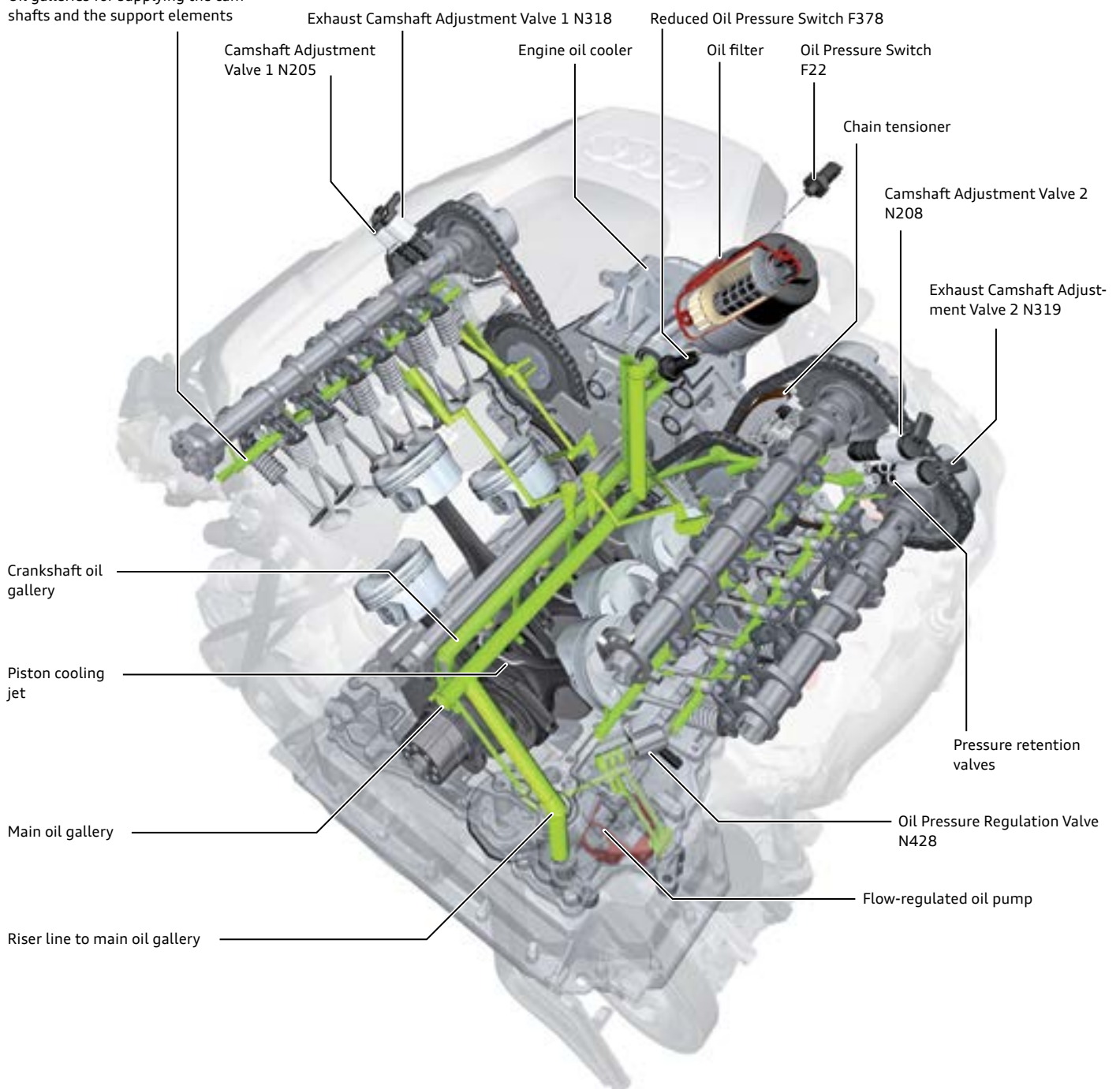
The engine oil cooler was moved to the timing chain cover (sealing flange) and is bolted in place. With the upright oil filter, this now forms a single unit.

The cylinder heads required modification to the oil galleries to accommodate the addition of exhaust camshaft adjusters.

Mechanically operated piston cooling jets are integrated in the cylinder block. They have an opening pressure of approximately 36.2 psi (2.5 bar) and a closing pressure of approximately 29.0 psi (2.0 bar).

Overview of the oil circuit

Oil galleries for supplying the camshafts and the support elements



Oil pump

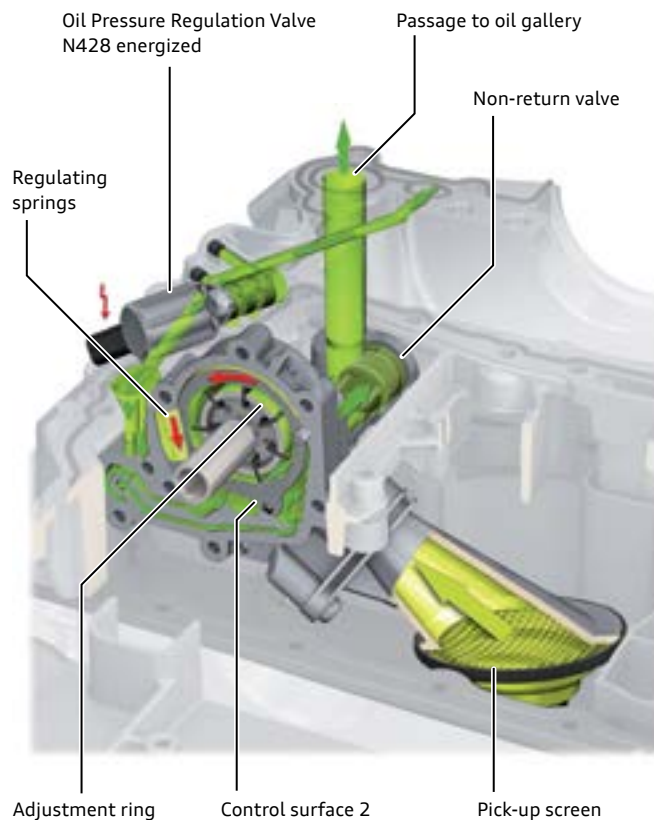
The new generation engine uses a two-stage flow-controlled engine oil pump.

Low pressure setting

Oil Pressure Regulation Valve N428 is activated by the ECM. When activated, N428 opens the duct to control surface 2. The oil pressure produced by the pump now acts upon both control surfaces and rotates the adjustment ring. The inner volume of the pump decreases which in turn reduces the oil flow rate. Consequently, the oil pressure drops. In this state the pump requires less drive power thereby increasing fuel economy.

At the low flow setting, oil pressure is approximately 21.7 psi (1.5 bar).

If N428 or the current supply to it fails, the oil pump operates continuously in the high pressure setting.



624_024

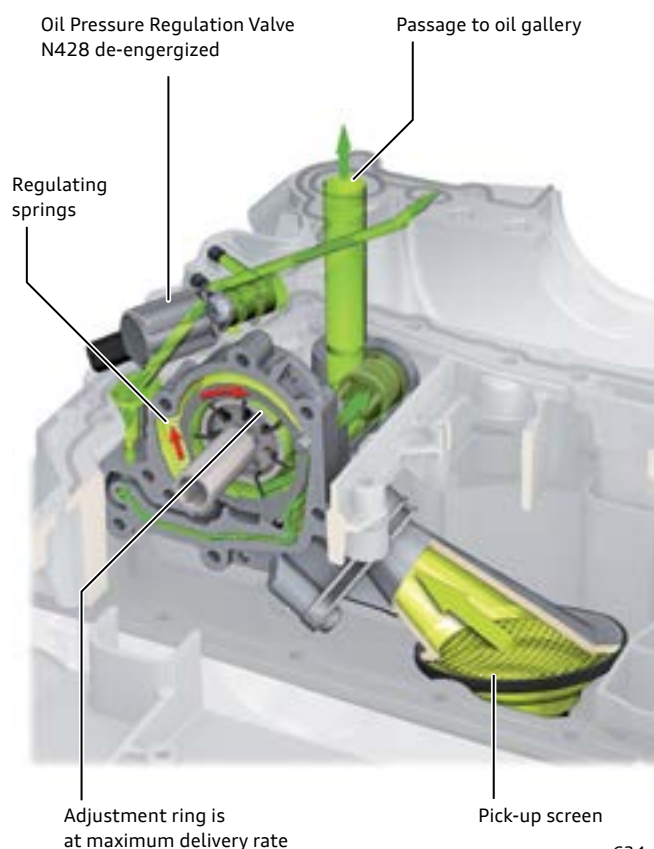
High pressure setting

The system switches to the high pressure setting at an engine speed of approximately 4600 rpm by de-energizing Oil Pressure Regulation Valve N428.

As a result, the oil flow to control surface 2 of the adjustment ring is interrupted. The regulating springs now push back the adjustment ring increasing the pump's inner volume. The delivery rate of the pump increases and the oil pressure rises to the high pressure setting. Oil pushed back from control surface 2 is diverted into the oil sump via N428. When the engine speed drops below 4300 rpm, the system reverts to the lower pressure setting after a five second delay.

Oil pressure at the high flow setting is approximately 47.8 psi (3.3 bar).

To protect the engine from excessively high oil pressure, caused for example by low viscosity oil with a low temperature, an over-pressure valve is integrated in the pump. This valve opens at approximately 159.5 psi (11.0 bar).



624_028

Reference

The flow-regulated oil pump is described in eSelf-Study Program [920223](#), The Audi 4.0L V8 TFSI Engine with Twin Turbochargers.



Oil pump drive gear

As in previous engines, the oil pump is bolted inside the upper oil sump. The oil pump is driven via the oil pump drive shaft, which in turn is driven by chain drive D from the crankshaft.

The drive ratio is $i = 1.08$. To remove the oil pump without having to dismantle the chain drive, the oil pump drive shaft can be displaced axially against the force of compression spring.



624_043

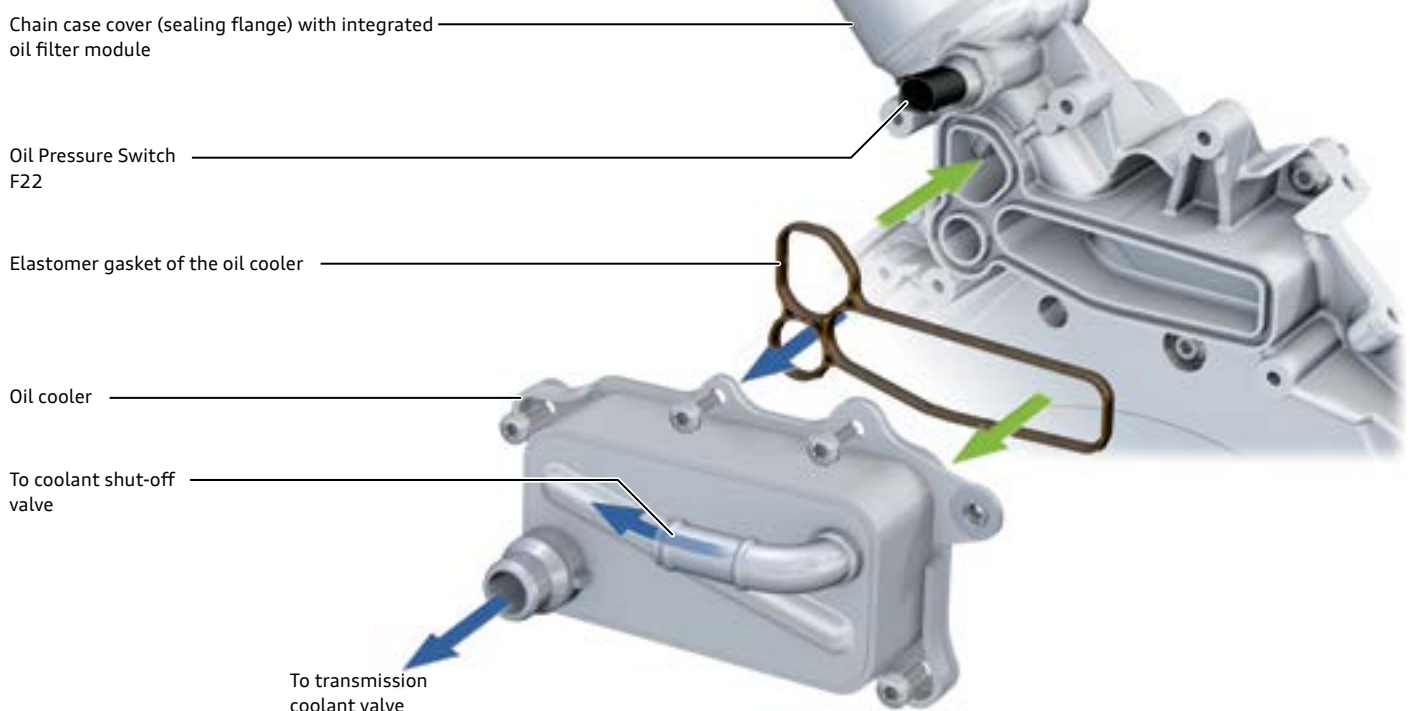
Switchable oil cooler

As noted earlier, the switchable oil cooler is now bolted in place on the chain case cover (sealing flange) and sealed with an elastomer gasket.

Coolant flow through the oil cooler is demand regulated by a vacuum activated actuator (refer to "Cooling system" page 30).

Key:

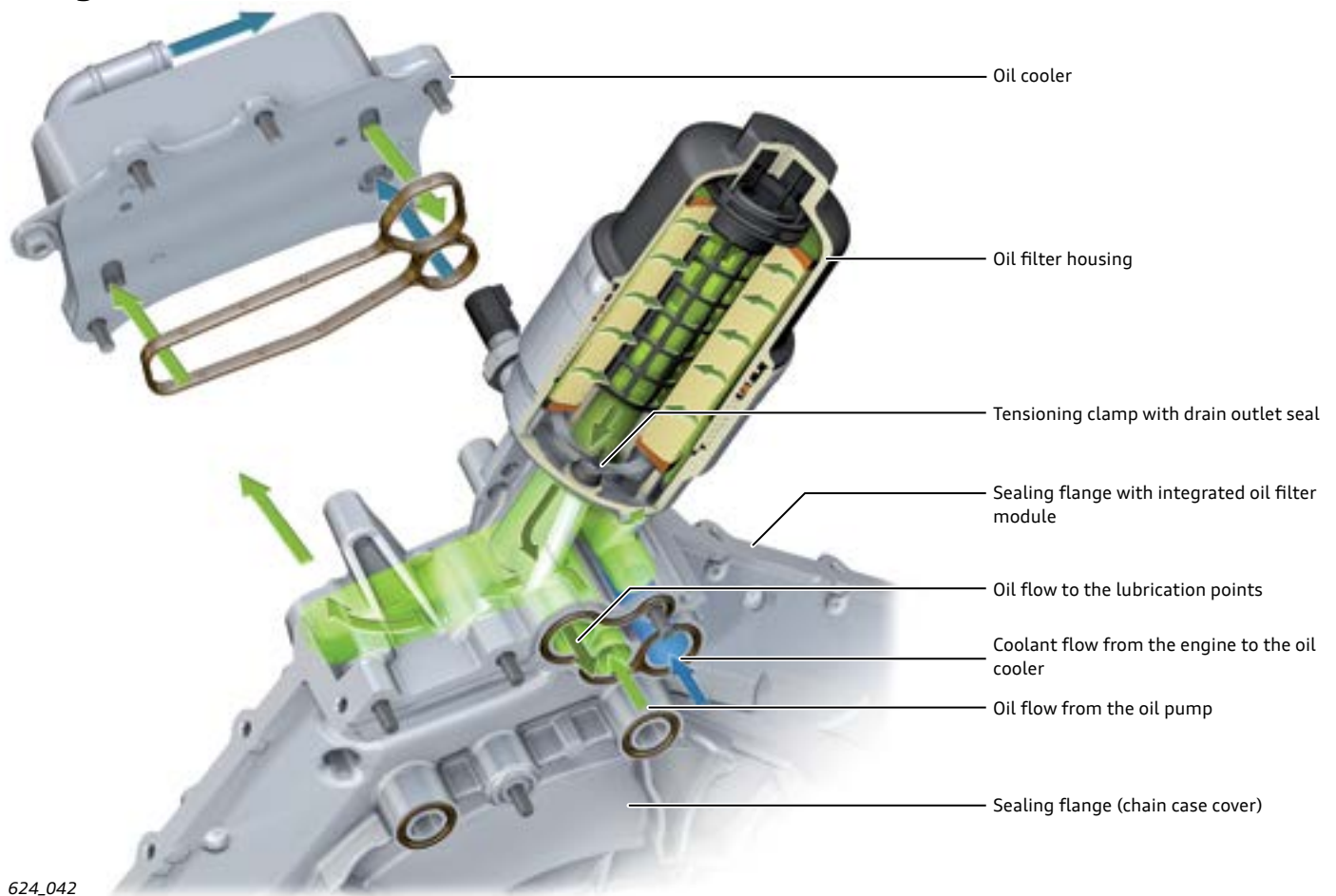
- Coolant
- Unfiltered engine oil
- Filtered engine oil



624_044

Oil filter module

Design

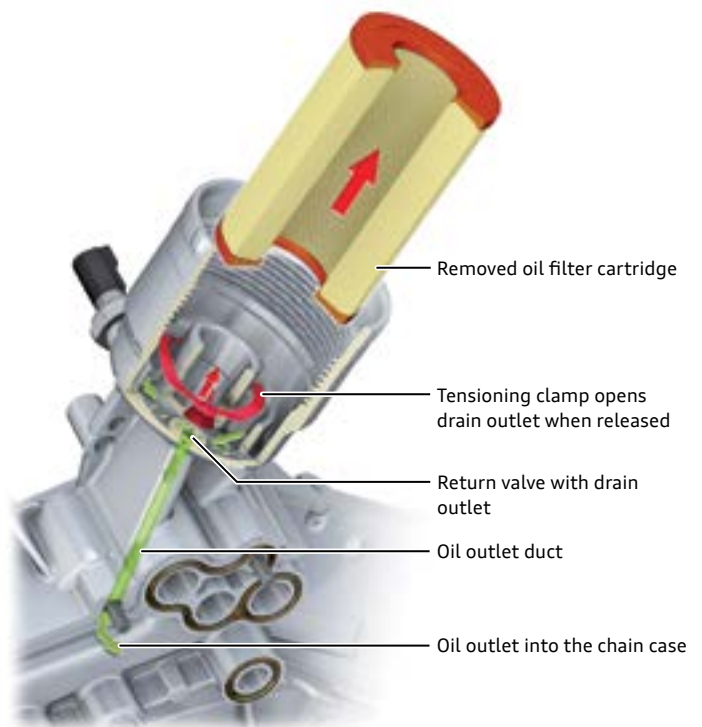


Oil filter replacement

A return valve in the housing is held shut by a spring-loaded tensioning clamp. The clamp is tensioned over the oil filter cartridge when the housing is securely bolted to the oil filter module.

After the oil filter housing has been loosened several turns during an oil change, a return valve opens to allow oil to flow out of the filter housing and into the oil sump.

Before installing a new oil filter cartridge, the tensioning clamp must be seated correctly. Engine oil pressure cannot build up unless the return valve is sealed by the tensioning clamp.

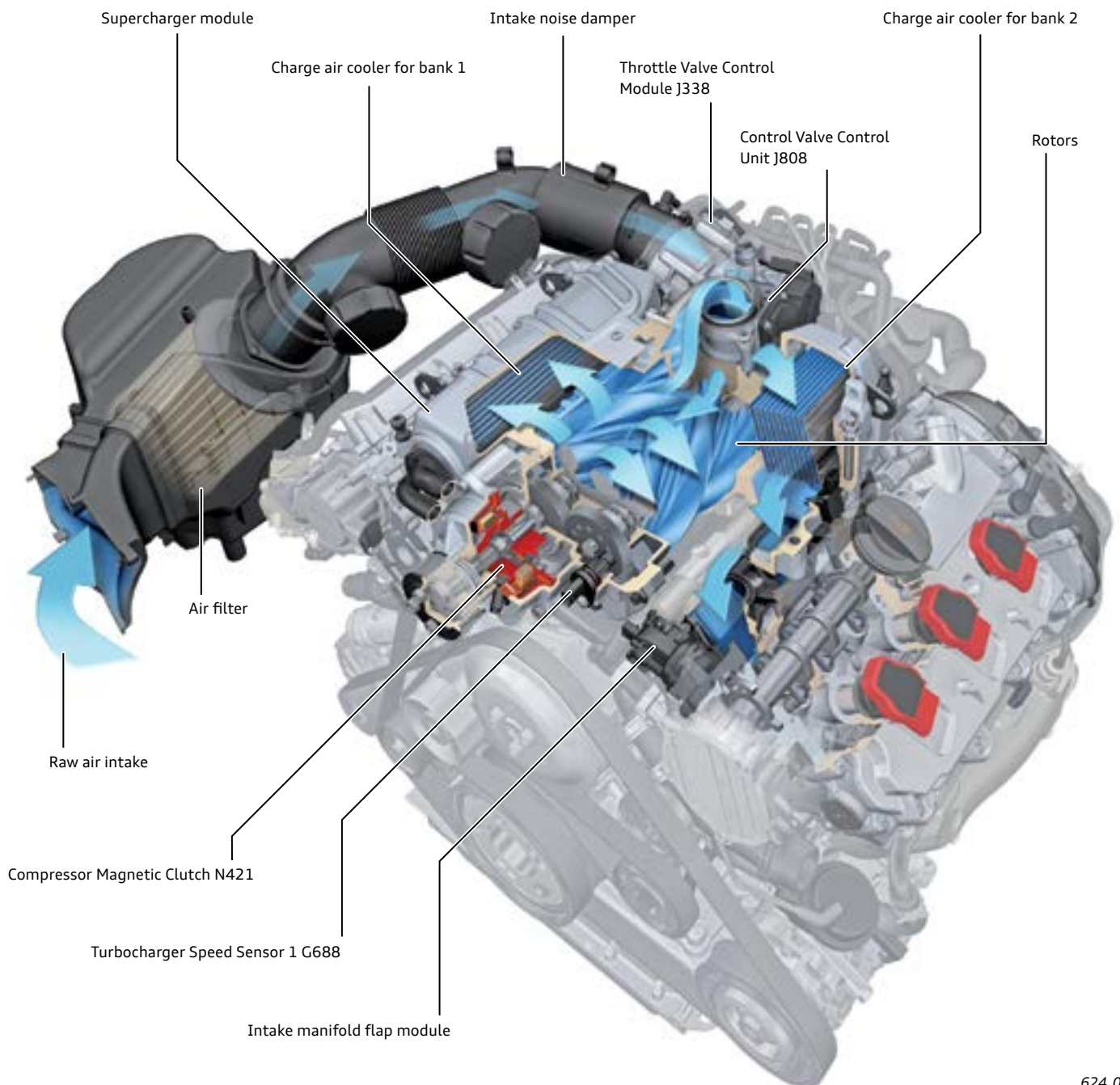


Air intake and turbocharger systems

Overview

The air supply and supercharging system of the new generation engine has been extensively revised. Previously, the supercharger was permanently driven and charge pressure was controlled only by the throttle and control flap regulation.

In the fourth generation engine, a magnetic clutch has been added to the supercharger drive system. This allows the power flow to the supercharger to be interrupted when no boost is required, improving fuel economy.



624_029

Supercharger module

In addition to the magnetic clutch for shutting off the supercharger, further changes were made to the supercharger module:

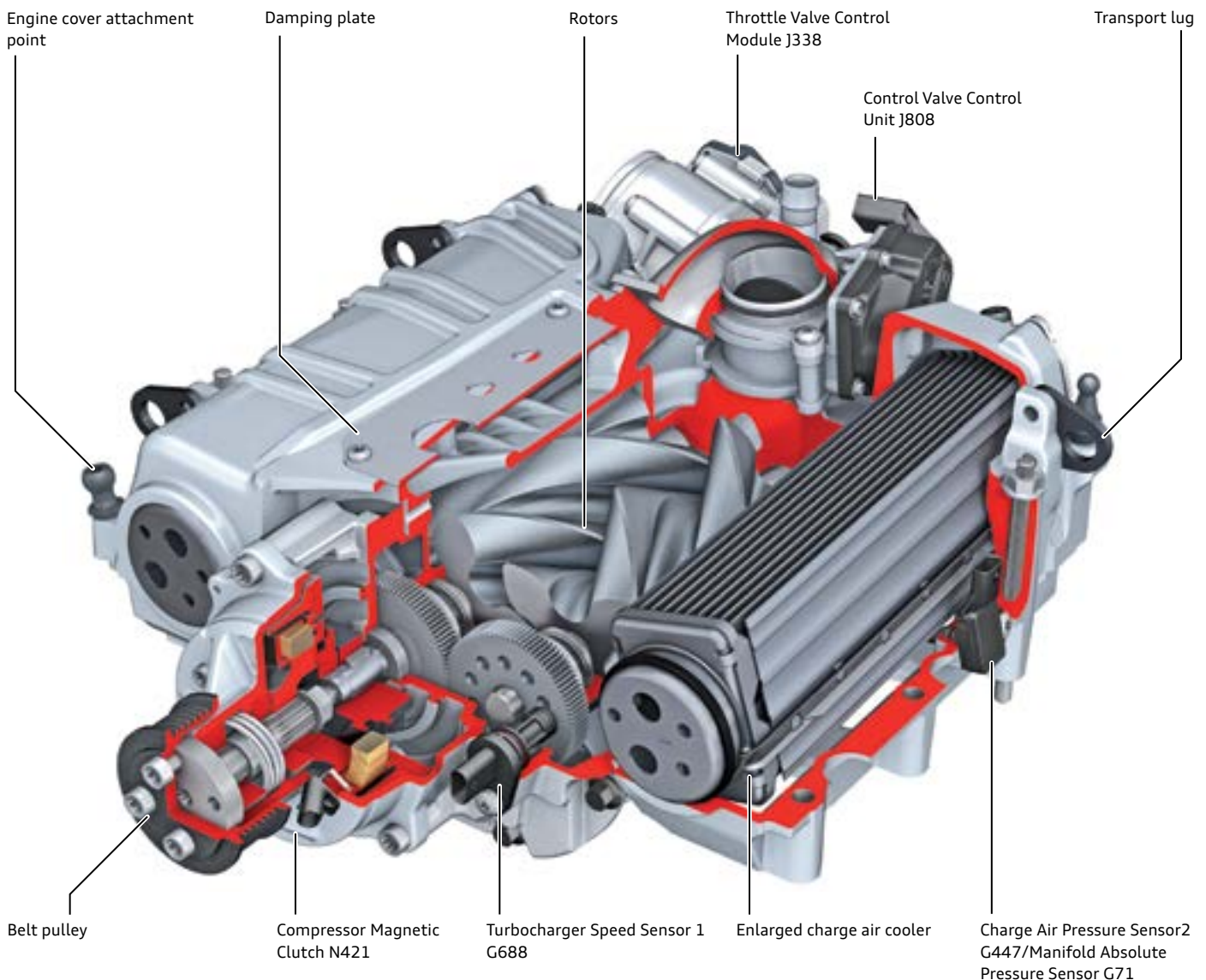
- ▶ Modified Charge Air Pressure Sensor 2 G447 and Manifold Absolute Pressure Sensor G71 (now digital sensors with SENT data protocol.)
- ▶ Additional attachment points for the plastic engine cover
- ▶ Enlarged and angled charge air cooler (higher overall efficiency)
- ▶ Enlarged transport lugs (for removal procedures)
- ▶ Improved flap bearings (throttle flap, air recirculation flap)

The use of a clutch drive on the supercharger puts more stress on the belt drive. For this reason, a stronger belt tensioner is used. There is also a fixed interval for supercharger belt replacement. Please refer to the maintenance information in ElsaPro for complete details.

Service operations

In comparison to the third-generation engine, additional components can be replaced during repair work on the supercharger module. The following assembly operations are possible:

- ▶ Removing and installing the magnetic clutch
- ▶ Removing and installing the supercharger belt pulley
- ▶ Removing and installing the rotor unit
- ▶ Replacing the drive shaft oil seal
- ▶ Replacing the needle bearings



624_001



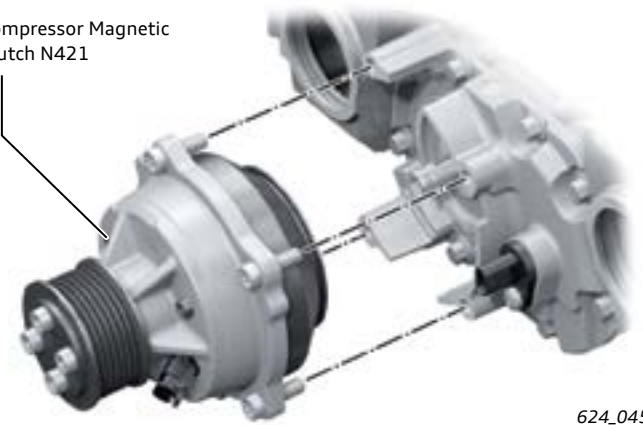
Reference

For more information about Roots blowers, charge pressure control and charge air cooling in the 3.0l V6 TFSI engine, please refer to eSelf-Study Program [925803](#), Audi 3.0 V6 TFSI engine with Roots blower.

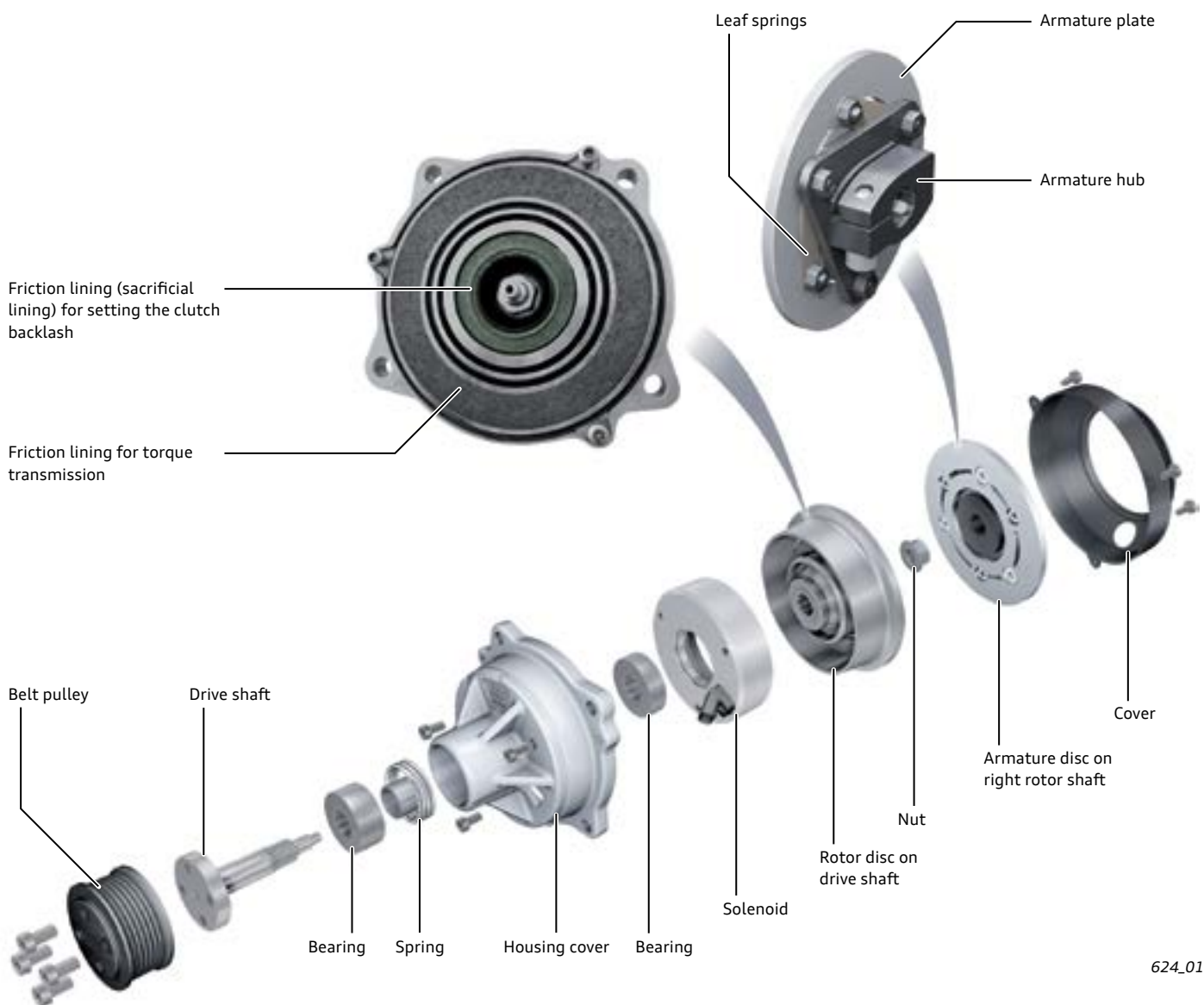
Compressor Magnetic Clutch N421

Compressor Magnetic Clutch N421 is a separate module bolted in front of the right rotor shaft. It is responsible for activating and deactivating the supercharger.

Compressor Magnetic Clutch N421



624_045



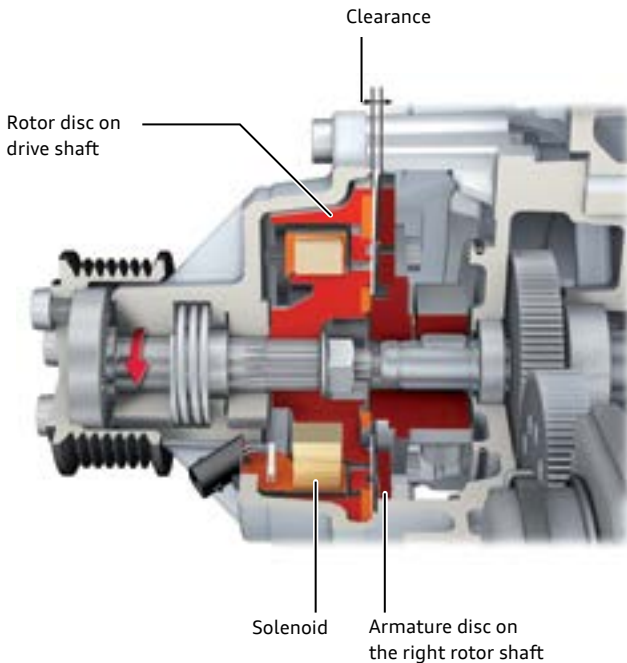
624_012

Function

Magnetic clutch open – supercharger deactivated

The compressor clutch is not activated at low or medium rpm nor at low engine load conditions. The supercharger is deactivated.

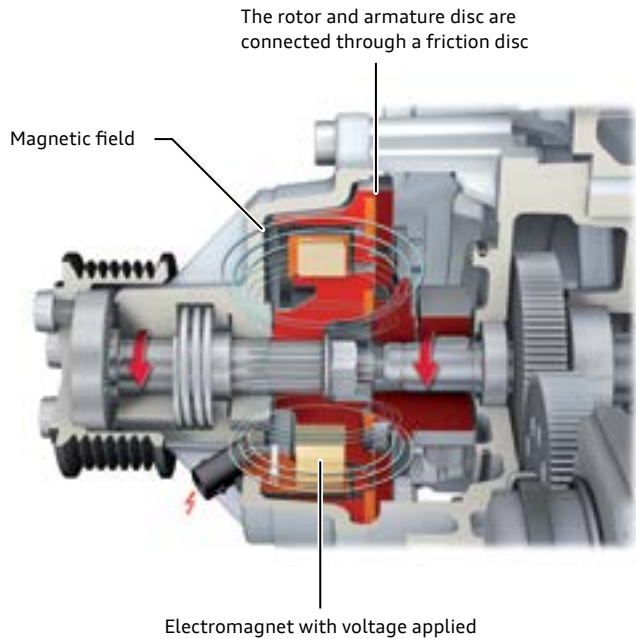
When no voltage is applied to the solenoid, there is a clearance between the rotor disc and armature disc. Power flow to the rotors is interrupted. In addition, the control flap is closed. The entire engine air throughput flows through the rotors allowing them to freely rotate at a low rpm.



624_020

Magnetic clutch closed – supercharger activated

The compressor clutch is activated by the ECM via a PWM signal. The magnetic force draws the armature disc onto the friction lining of the rotor disc against the force of the leaf springs. Traction is established and the supercharger rotors are driven.



624_021

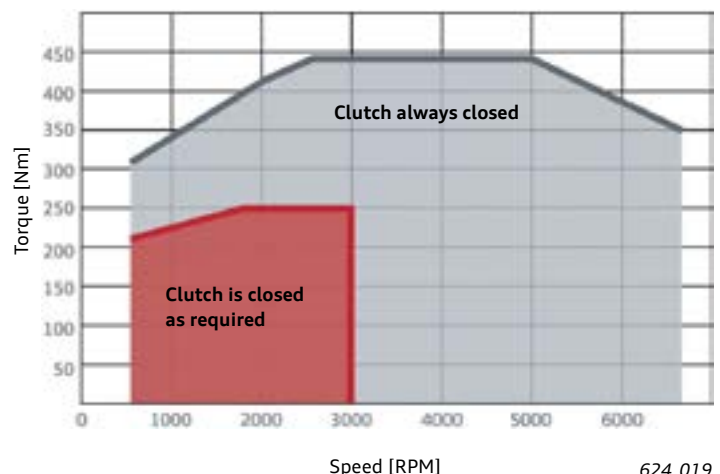
eMedia

[Link to find out more about how the magnetic clutch works.](#)

Supercharger activation/deactivation

Maximum activation/deactivation of the supercharger within the mapped engine speed/torque range is ensured by an elaborate ECM strategy. Disengagement at partial engine load results in better fuel economy.

In addition to other factors, the key parameters are engine speed and driver torque demand (based on accelerator pedal application).



624_019

Transition

One of the major challenges during development of the magnetic clutch drive system was to assure that the driver does not feel when the clutch is activated or deactivated.

Current regulation

Torque is reduced at the crankshaft whenever the supercharger is activated. This torque reduction can briefly result in up to 70 Nm of dynamic torque and would manifest itself to the driver as noticeable judder when the supercharger engages or disengages.

Function

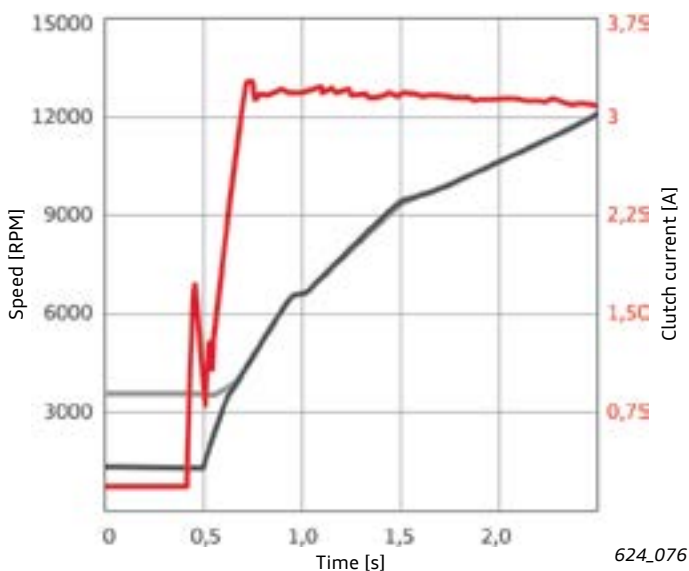
When the armature moves to within the magnetic field, a current drop occurs due to self-induction in the coil (see red line in diagram). This is detected by the current sensor in the engine control unit. The current control cycle begins when contact between the armature and rotor is detected. The current is controlled in dependence on nominal and actual supercharger RPM. The speed of the rotors is utilized as an input signal for this purpose and transmitted to the synchronous gear stage of the supercharger (Turbocharger Speed Sensor 1 G688) via a Hall-effect sensor.

To achieve this, two parameters are varied. First, the current to engage or disengage the clutch is closely controlled. Secondly, the airflow is directed over the supercharger rotors by selective activation of the throttle valve and air circulation in such a way that they always remain in motion.

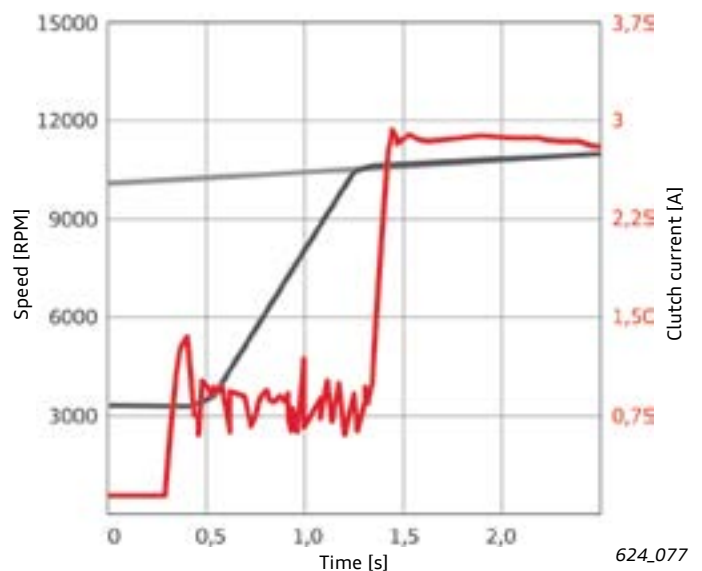
To ensure optimal ride comfort at all operating points, the engagement and disengagement of the clutch are PWM controlled. This allows clutch engagement/disengagement times to be adapted. The engagement/disengagement time is varied within the 100 – 1500 ms range depending on driver input. A shorter engagement/disengagement time is, therefore, required under dynamic acceleration.

A comfortable increase in engine torque is achieved during and after engagement/disengagement of the magnetic clutch through controlled activation of the throttle valve and the bypass valve and through an adapted increase in supercharger RPM based on vehicle operating mode (comfort = slow increase in speed, dynamic = rapid increase in speed).

Short transition (during kick-down)



Long transition (if max RPM is exceeded)



Key:

- Clutch input RPM
- Supercharger RPM
- Clutch current

Turbocharger Speed Sensor 1 G688

G688 is a Hall effect sensor. It is based technically on Engine Speed Sensor G28 of the third generation EA888 engine. The integrated sensor electronics were required because of the higher speed of the supercharger.

Signal use

The ECM uses the signal from G688 to determine the speed of the supercharger when the magnetic clutch engages. This signal is used for calculating the engagement/disengagement times of the clutch and for monitoring its operation.

Diagnostics

The sensor can be diagnosed for open circuit and short circuit faults. In addition, the following fault conditions can be identified:

- ▶ Plausibility of supercharger speed in comparison with crankshaft speed (ratio: $i = 2.5$) in the event of a MIL and EPC fault
- ▶ In the event of MIL signal loss

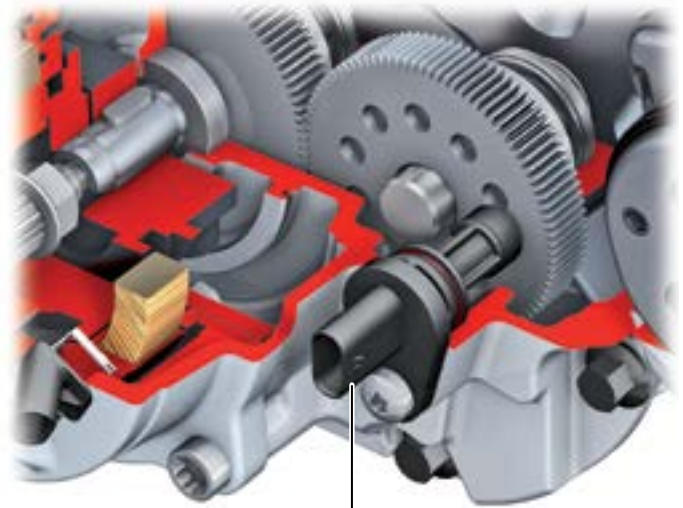
Failure of the sensor

In the event of a sensor failure, controlled activation and deactivation of the clutch is not possible. The clutch will activate and deactivate harshly and may be noticeable to the driver.

Clutch protection

Frequent engagement/disengagement of the clutch results in frictional heat build-up. Excessively high temperatures can destroy the component parts of the clutch. There is no sensor to monitor clutch temperature.

To protect the clutch, a model-based "stress factor" is calculated from the speed differential and the acceleration time in the ECM.



Turbocharger Speed Sensor 1 G688

624_046

This gives an indication of the temperature of components. If the stress factor exceeds a pre-defined threshold, the clutch will not be allowed to disengage for a set amount of time. The engaged components rotate and are not connected to the housing. This enables the clutch to dissipate the heat.

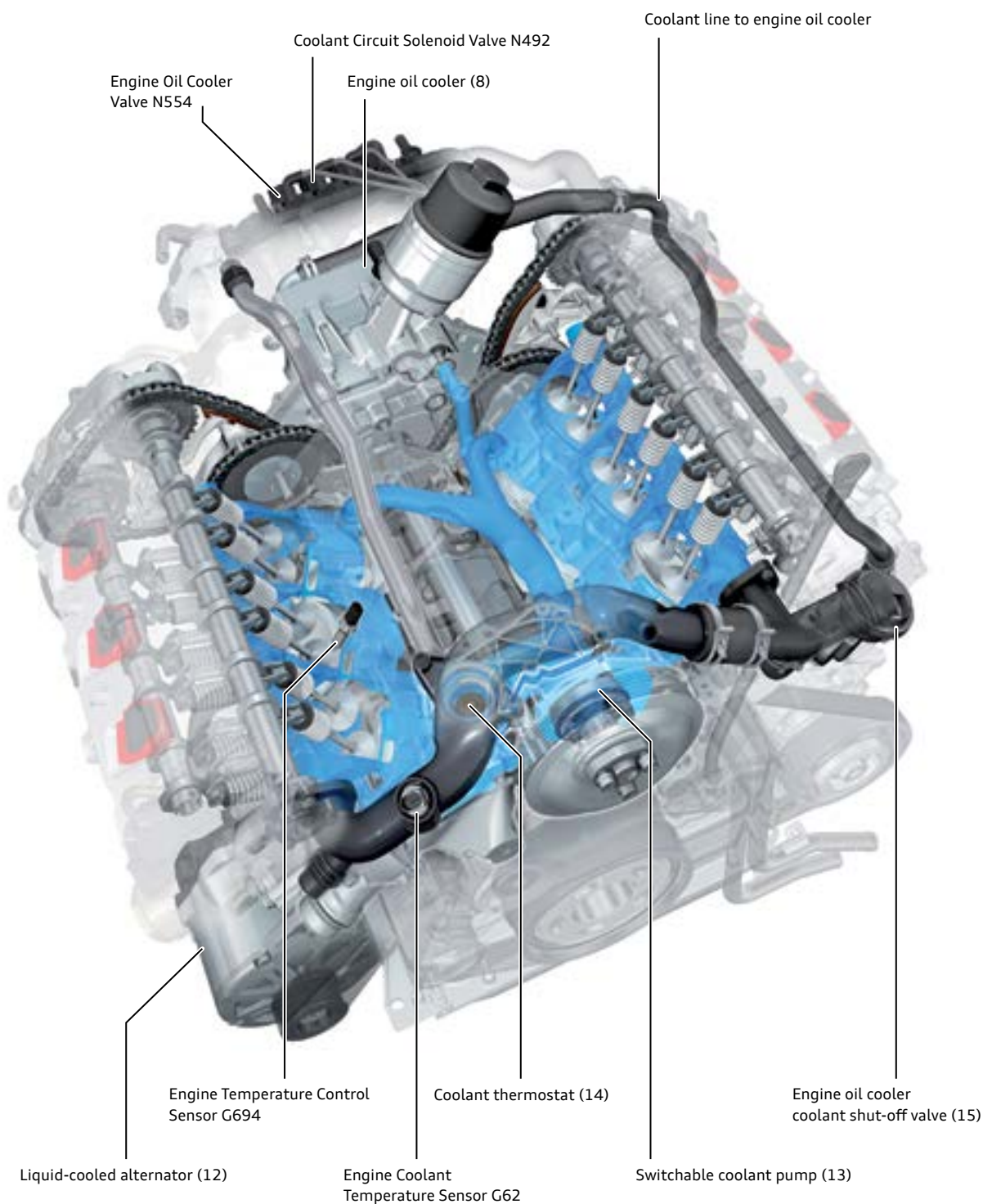
Engine cooling system

Introduction

The coolant circuit is a slightly modified version of the coolant circuit in the third-generation 3.0l V6 TFSI engine. This engine also had an a switchable coolant pump, which allows a non-circulating coolant phase as part of the Innovative Thermal Management system strategy.

Given that the oil cooler is on the back of the engine and its coolant flow can be shut off, additional lines and a shut-off valve were installed. The coolant shut off valve is vacuum actuated by Engine Oil Cooler Valve N554.

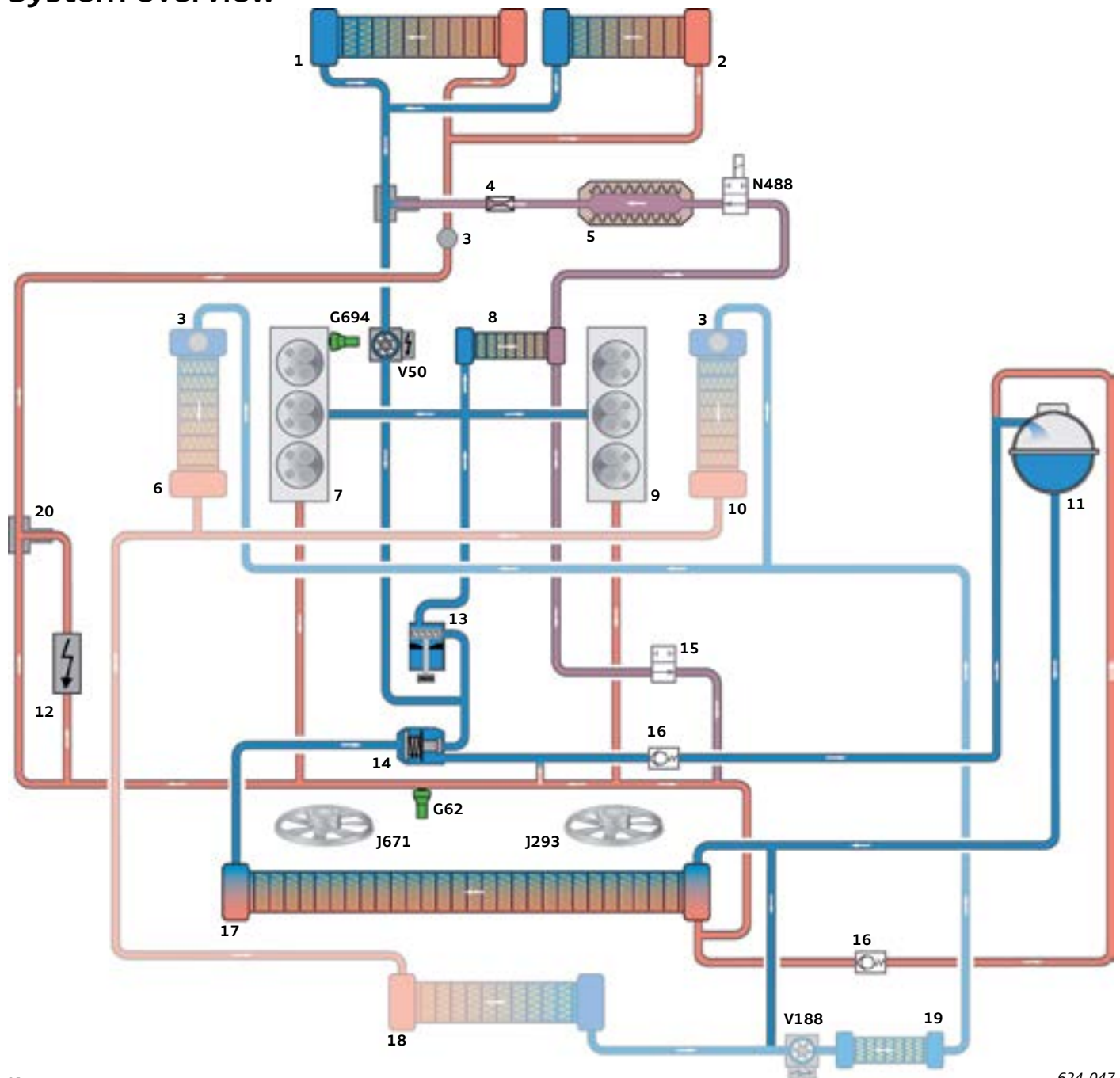
The coolant jacket in the engine block is shown blue in the figure below.



624_011

The numbers in brackets indicate the position of the component in the system overview on the next page.

System overview



Key:

- 1** Front heater heat exchanger
- 2** Rear heater heat exchanger
- 3** Vent
- 4** Flow restrictor
- 5** ATF cooler
- 6** Right charge air cooler
- 7** Cylinder head, bank 1
- 8** Engine oil cooler
- 9** Cylinder head, bank 2
- 10** Left charge air cooler
- 11** Coolant expansion tank
- 12** Liquid-cooled alternator
- 13** Switchable coolant pump
- 14** Coolant thermostat
- 15** Coolant shut-off valve
- 16** Non-return valve
- 17** Radiator
- 18** Front cooler for charge air cooling circuit
- 19** Left cooler for charge air cooling circuit
- 20** Suction jet pump

- G62** Engine Coolant Temperature Sensor
- G694** Engine Temperature Control Sensor
- J293** Coolant Fan Control Module
- J671** Coolant Fan Control Module 2
- N488** Gearbox coolant valve
- V50** Coolant Recirculation Pump
- V188** Charge Air Cooling Pump

- Cooled coolant
- Cooled coolant (charge air cooling)
- Hot coolant
- Hot coolant (charge air cooling)

624_047

Switchable coolant pump

The internal friction in an internal combustion engine is lowest at normal operating temperature. To reach this temperature as quickly as possible after engine startup, the thermal management system provides for "non-circulating coolant" during the warm-up phase. This is implemented by using a switchable coolant pump.

No coolant flow

This is achieved by pushing a shutter wheel over the pump impeller. The shutter wheel is displaced by means of a vacuum acting against the force of a spring. The springs pull the shutter wheel away from the impeller with the result that coolant flow is maintained even in the event of a system malfunction.

The condition for this operating state is a coolant temperature of less than 86 °F (30 °C).

Coolant is pumped

The vacuum supply is shut off to activate the coolant flow. The shutter wheel is retracted by spring pressure.

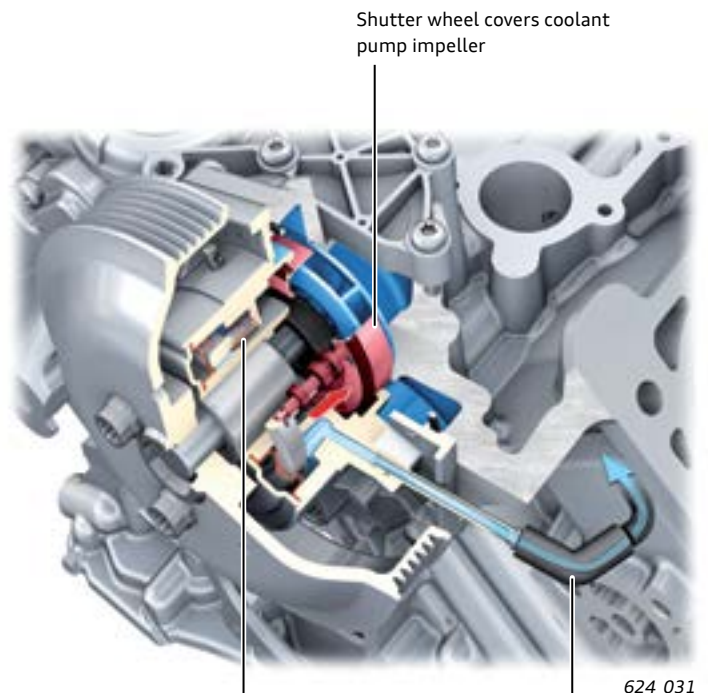
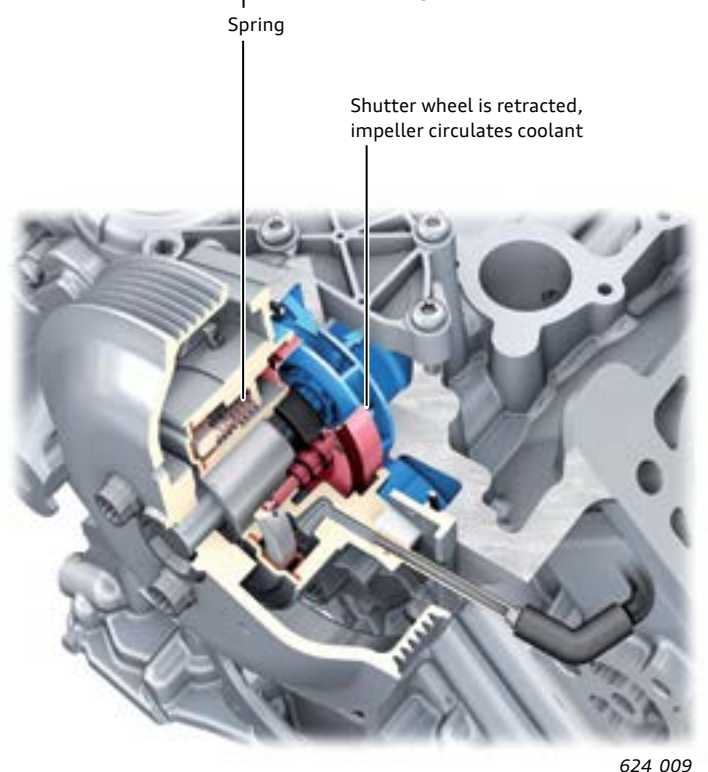
Special reactivating characteristics:

- ▶ Switches on and off for a duration of 1 second
- ▶ This cycle is repeated several times in succession
- ▶ The interval between cycles is approximately 7 seconds

The hot coolant from the engine mixes slowly with the cold coolant. When heating is required, the pump is switched on immediately.

Unlike the third generation 3.0l V6 TFSI engine that uses a vane type impeller, the new engine uses a "potted" impeller.

When the pump is activated, coolant stops circulating through the engine.

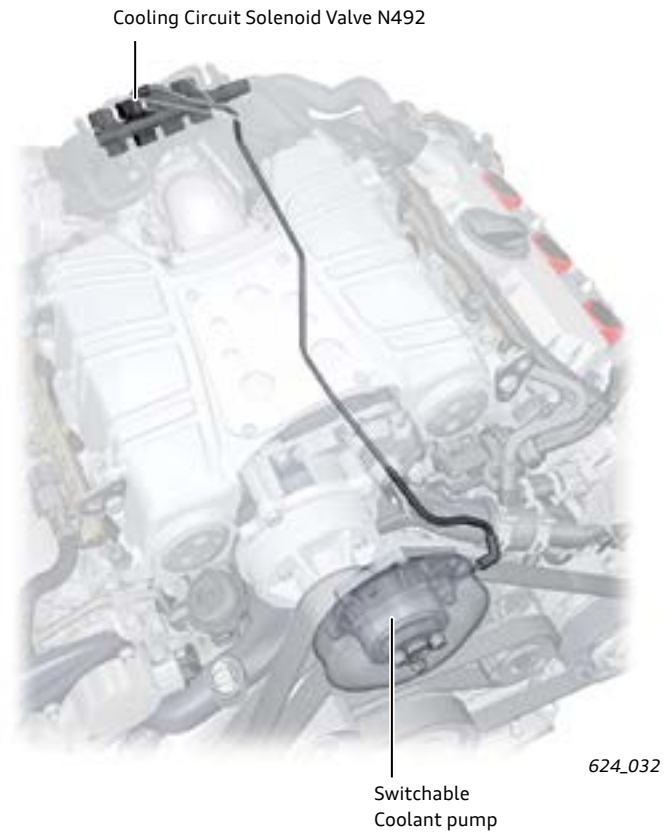


Vacuum activation

The vacuum for coolant pump operation is switched by Cooling Circuit Solenoid Valve N492. N492 is activated by a PWM signal from the ECM based on a programmed map. There is no intermediate position for the shutter wheel. It is only fully open or fully closed.

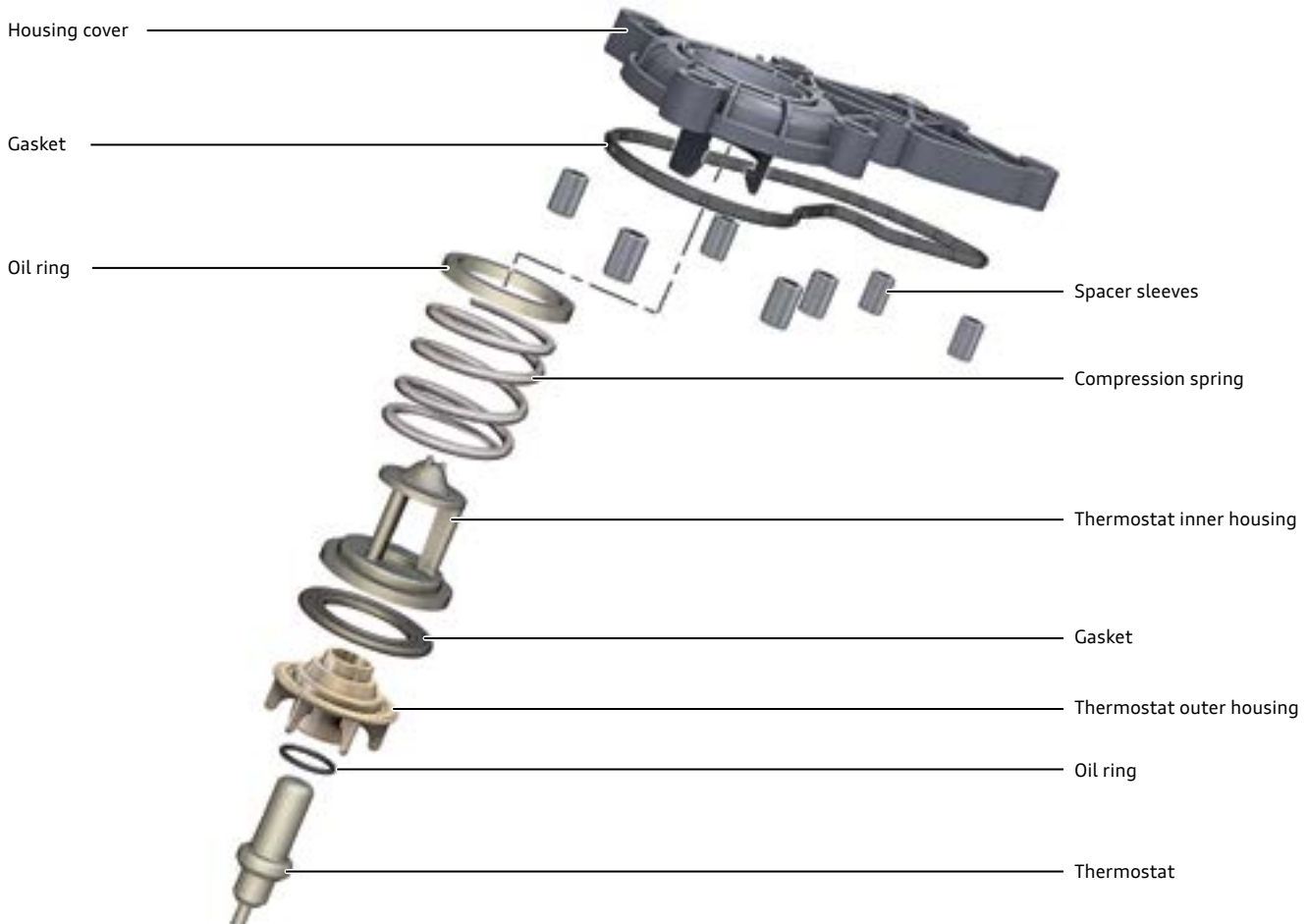
If N492 is de-energized or fails, coolant flow cannot be controlled. The shutter wheel is retracted by spring pressure. This means there is maximum coolant flow.

- ▶ **Failure when de-energized:** the engine reaches its operating temperature more slowly.
- ▶ **Failure when energized:** the coolant temperature rises to an unacceptably high level since the coolant pump is unable to circulate fresh coolant. The coolant temperature warning lamp and Malfunction Indicator Lamp K83 are both switched on.



Thermostat

The thermostat controls the engine coolant intake temperature by alternately opening the large and small cooling circuits.

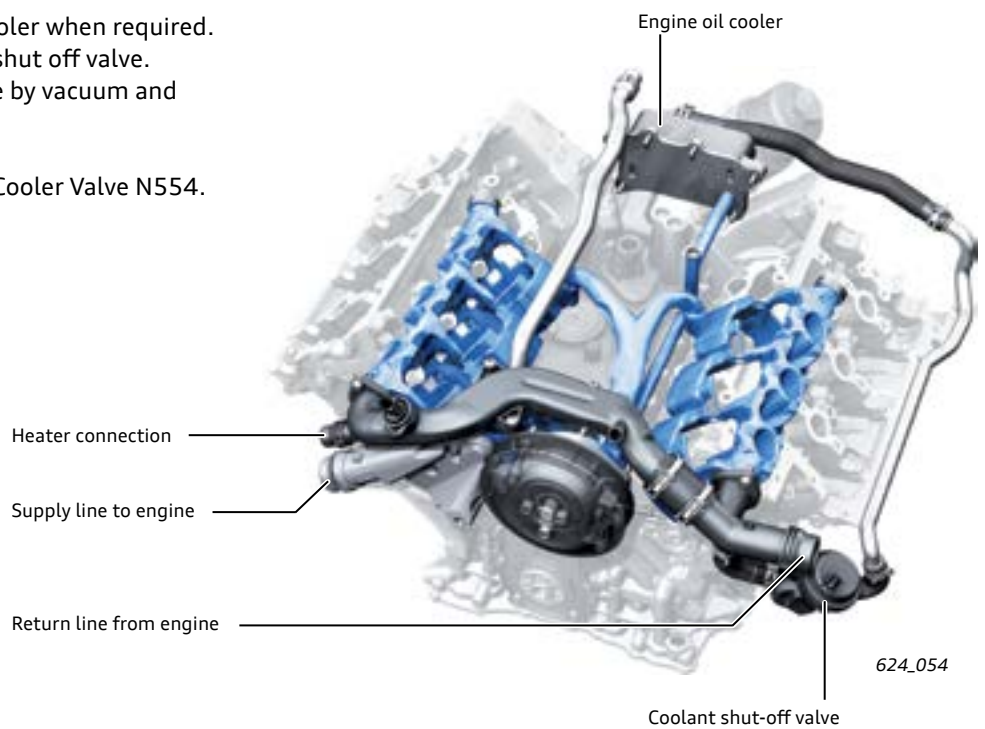


624_068

Engine oil cooler coolant shut-off valve

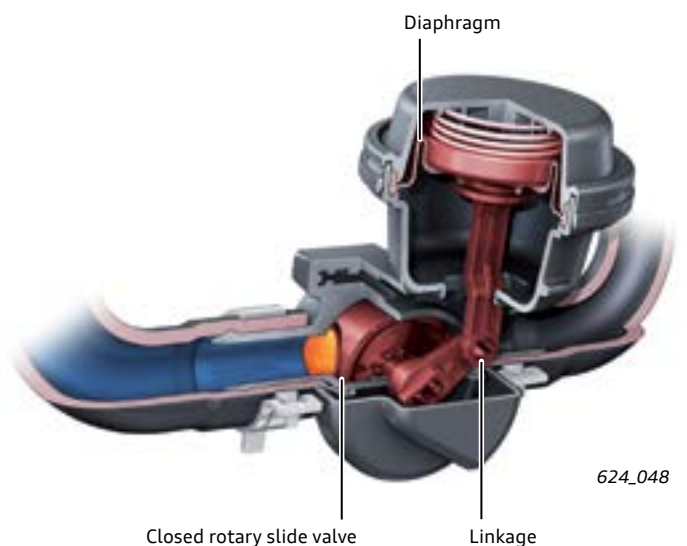
Coolant flows through the engine oil cooler when required. The supply is controlled by the coolant shut off valve. Opening and closing of the valve is done by vacuum and spring tension.

The vacuum is controlled by Engine Oil Cooler Valve N554.



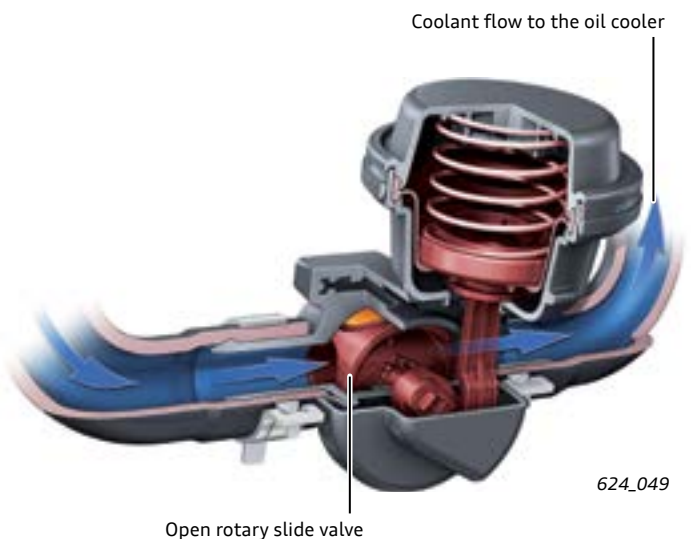
No coolant flow to the engine oil cooler

When N554 is energized, coolant flow to the engine oil cooler is interrupted. In this case, vacuum is applied to the coolant shut off valve diaphragm. The diaphragm linkage is pulled upwards against spring tension. The mechanism in the linkage closes the rotary valve and coolant flow stops.



Coolant flow to the engine oil cooler

When N554 is de-energized, the vacuum supply to the diaphragm is shut off. Spring tension opens the shut off valve and coolant flows to the engine oil cooler.



Electrical coolant pumps and coolant valve

Coolant Recirculation Pump V50

V50 is mounted to the vehicle transmission. It assists the engine coolant pump to ensure a sufficient flow of coolant through the passenger compartment heat exchanger(s). It is activated by a PWM signal and diagnosed through Climate Control Module J255.

Pump activation and the duration of pump operation are dependent on the previous driving condition and the thermal state of the engine. The pump is activated in such a way that the direction of flow of the coolant is reversed. This reverses the flow through the main radiator.

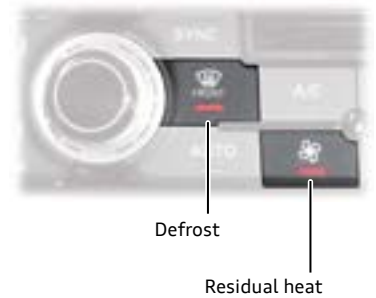
The pump is activated:

- ▶ When the ignition is switched ON, depending on coolant temperature and the setting of the climate control system.
- ▶ When the DEFROST function is selected.
- ▶ When the residual heat function is selected.
- ▶ To protect the engine. (In this case, V50 serves as a run-on pump when the engine is hot and switched OFF).

The pump is activated by J255 based on a characteristic map stored in the ECM.



624_053



624_082

Charge Air Cooling Pump V188

The delivery rate of V188 is controlled by a PWM signal from the ECM. When voltage is applied, the system performs a self-test and then waits for the PWM signal from the ECM. Once received, the system enters control mode.

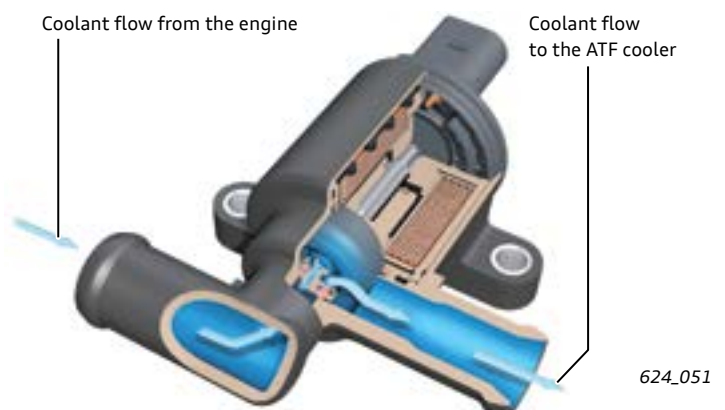
V188 is diagnosed through the ECM.



624_052

Transmission Coolant Valve N488

N488 controls the flow of warm coolant from the engine to the transmission oil cooler. It is demand activated by the ECM. It is held open by mechanical spring force when not energized.



624_051

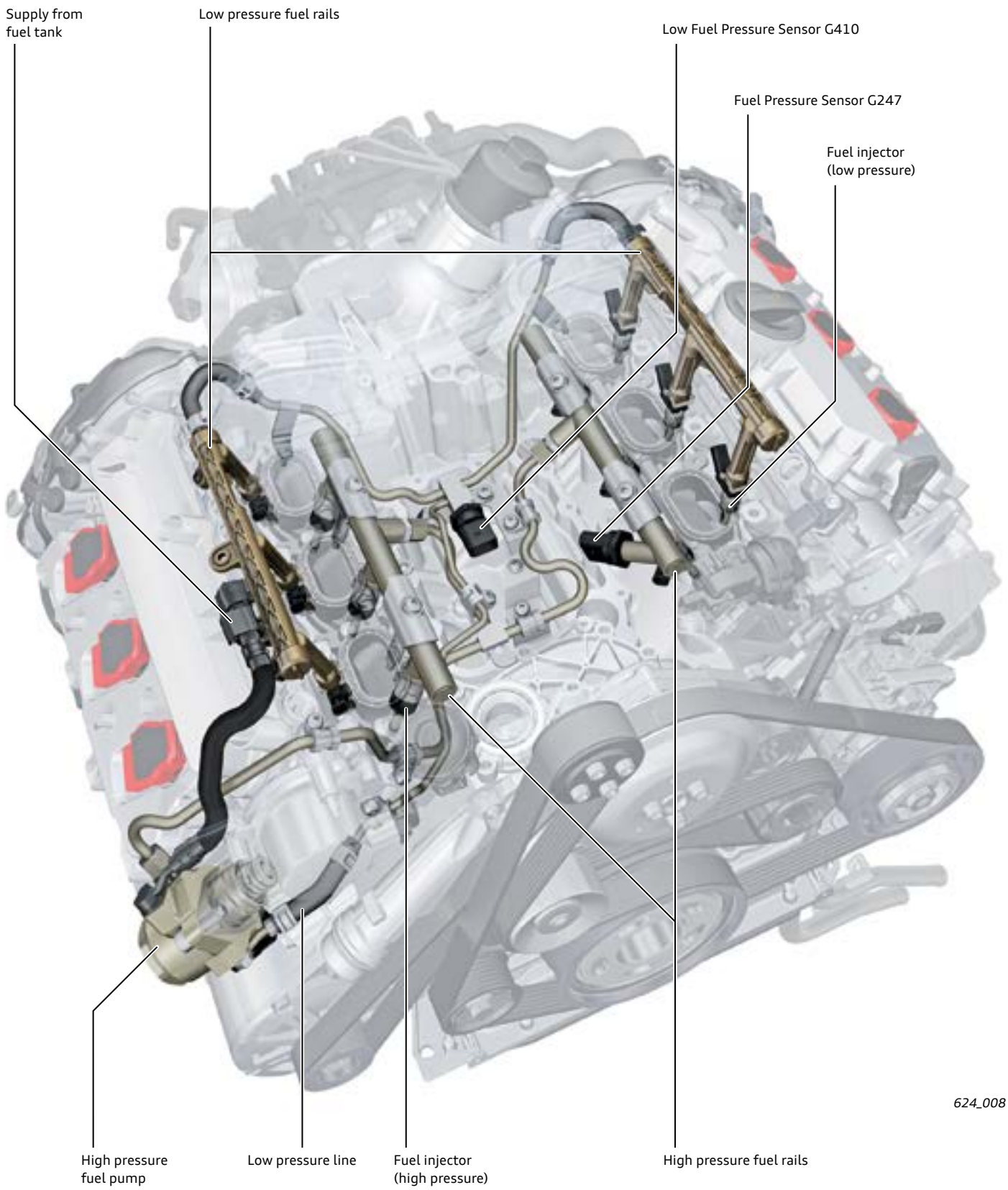


Reference

For more information on electrical coolant pumps and coolant valves, please refer to, eSelf-Study Program [920243](#), The Audi 1.8L and 2.0L Third Generation EA888 Engines.

Fuel system

Dual fuel injection system



624_008

Overview

To meet ever more demanding exhaust emission requirements worldwide, the fourth generation 3.0L V6 engine is equipped with both MPI and FSI fuel injections systems. Particulate emissions were substantially reduced through the selective use of the MPI system. By using a dual fuel system, it was not necessary to introduce a particulate filter.

MPI injection system

The fuel rails are arranged on the left and right of the supercharger module. They are made from polymer. Two lines leading to the MPI injectors branch off from the rails. The fuel injectors inject into the intake manifold flange behind the intake manifold flaps.

Fuel is supplied to the rails from a flushing connection on the high pressure fuel pump. This ensures that fuel flows through the pump in MPI mode thereby cooling the pump.

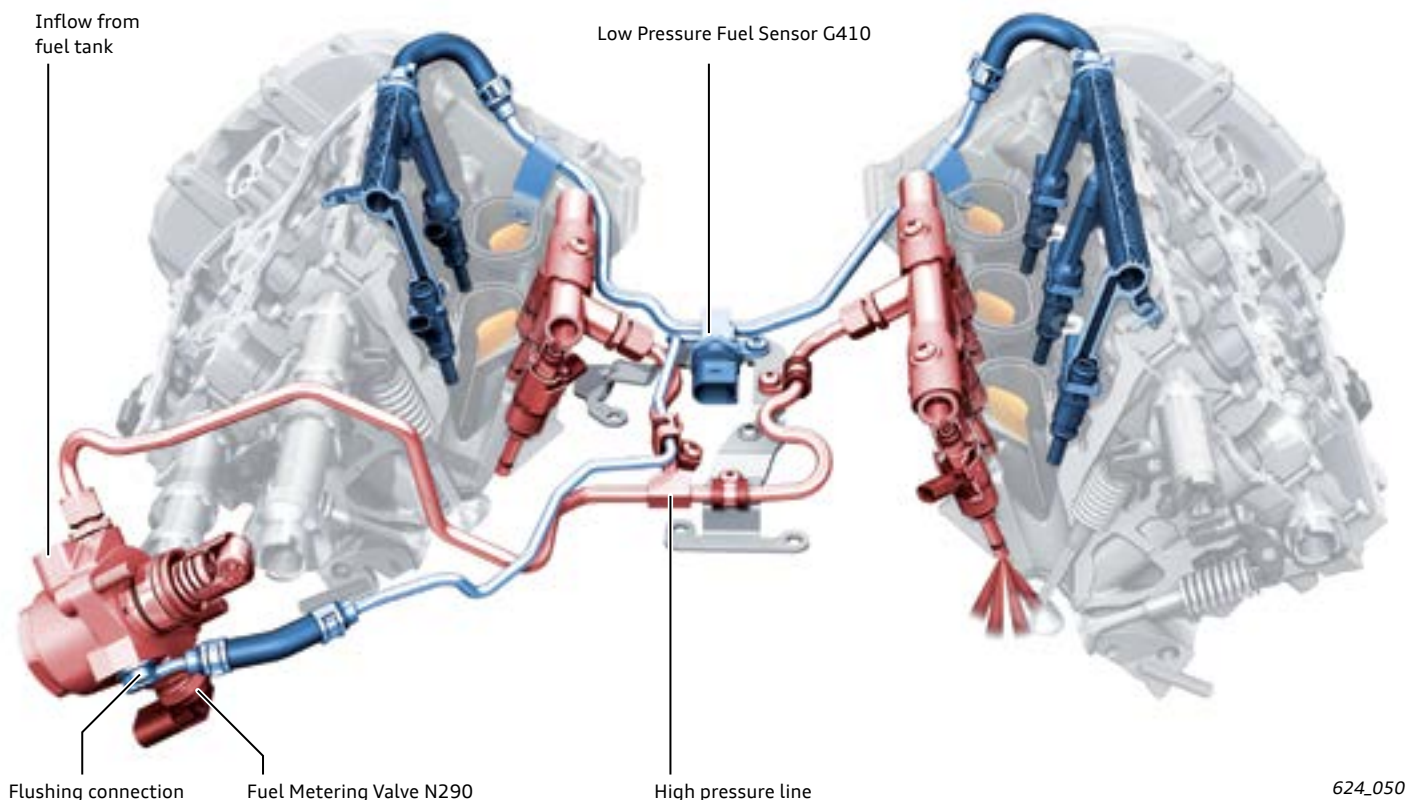
Another significant modification is the increase in fuel injection pressure within the FSI system from 2175.5 psi (150 bar) to 2900.7 psi (200 bar).

FSI injection system

The Hitachi high pressure fuel pump is driven by a three-lobed cam on the intake camshaft, cylinder bank 1 (refer to page 15). It produces a system pressure ranging from 1450.3 - 2900.7 psi (100 - 200 bar) depending on RPM and requirements (map).

The fuel rails were redesigned and adapted to suit the higher pressure conditions. In addition, the connection between the rail and intake system has been re-designed to reduce noise. For this purpose, the rails are bolted directly onto the cylinder head by means of 2 cast joints.

The high pressure injectors were also redesigned. They were adapted for flow behavior and interaction with the MPI system.



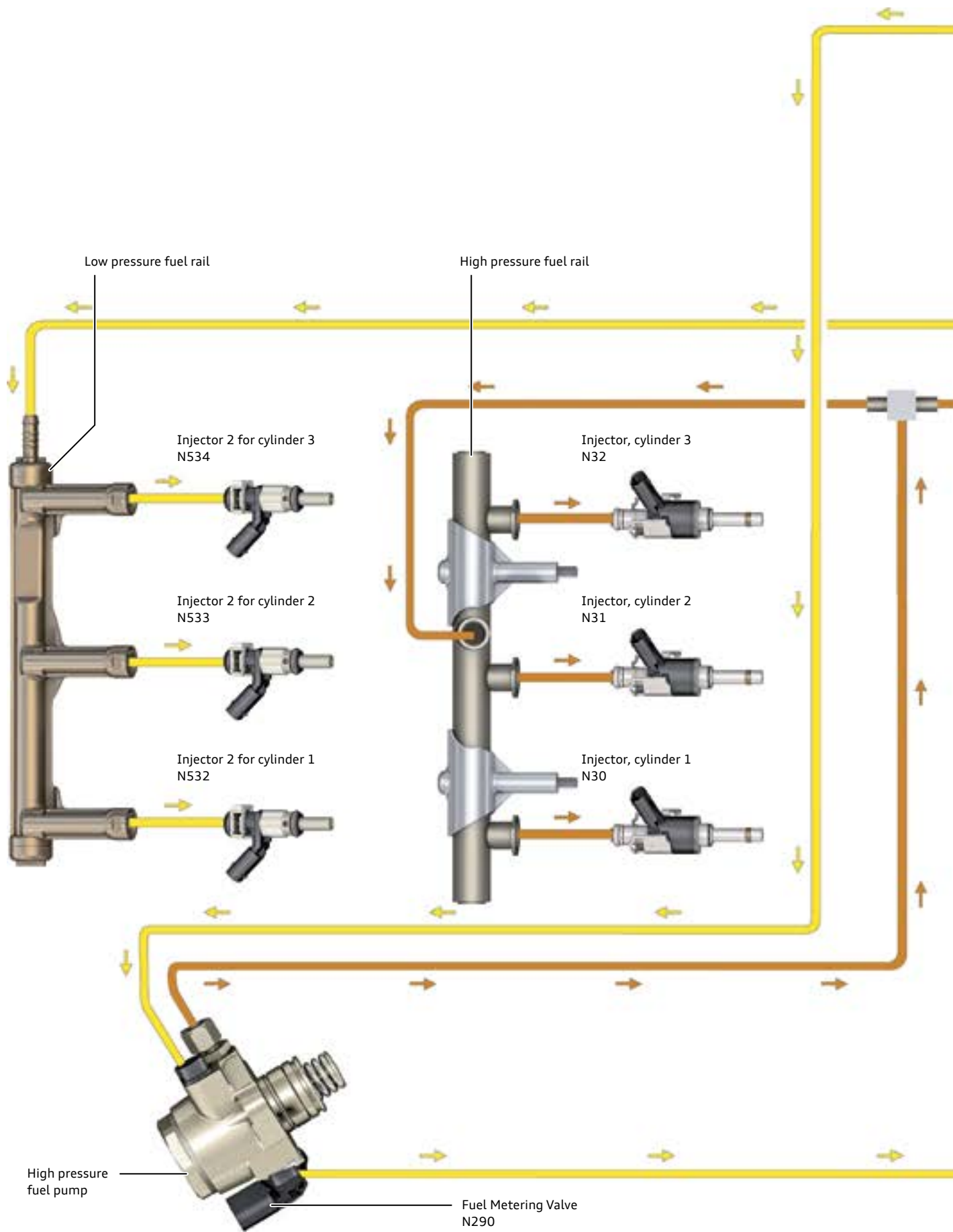
Key:

FSI injection system

MPI injection system

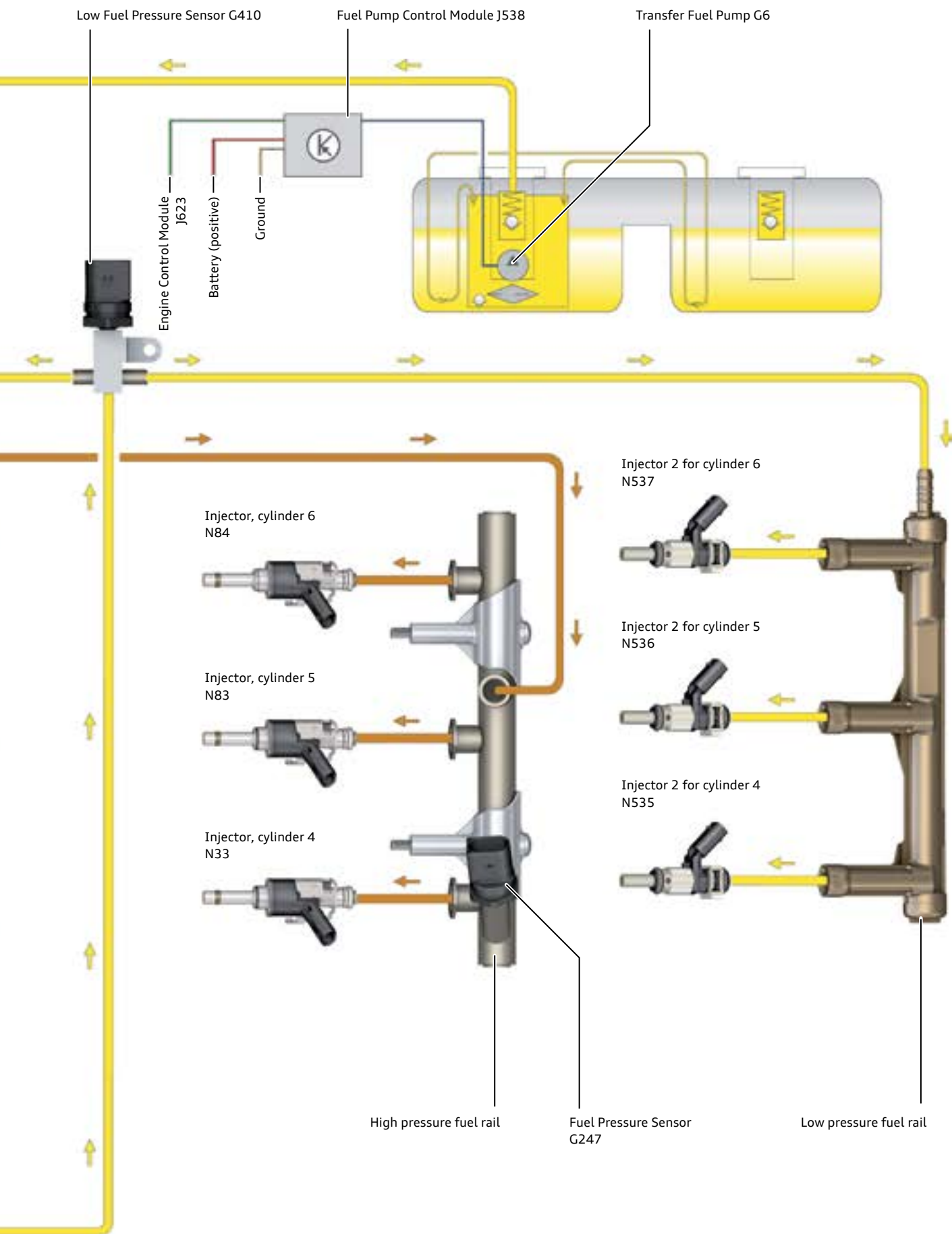
624_050

System overview



Key:

- MPI fuel pressure 58.0 - 72.5 psi (4 - 5 bar)
- FSI fuel pressure 1450.3 - 2900.7 psi (100 - 200 bar)



624_023

Combined injection

The MPI system integrated in addition to the direct injection system offers several advantages:

- ▶ More homogeneous mixture formation process reduces particulate emissions by a factor of approximately ten.
- ▶ The throttle flap can be opened further in the lower partial load range, resulting in better fuel economy.
- ▶ The low manifold wall fuel condensation during injection reduces the ingress of fuel into the engine oil.
- ▶ MPI fuel pressure is available earlier (no reliance on the high pressure pump build up) so fuel can be injected earlier allowing shorter cold starting times.
- ▶ MPI injection is used at idle and the MPI injectors are quieter in operation than those of the FSI system.

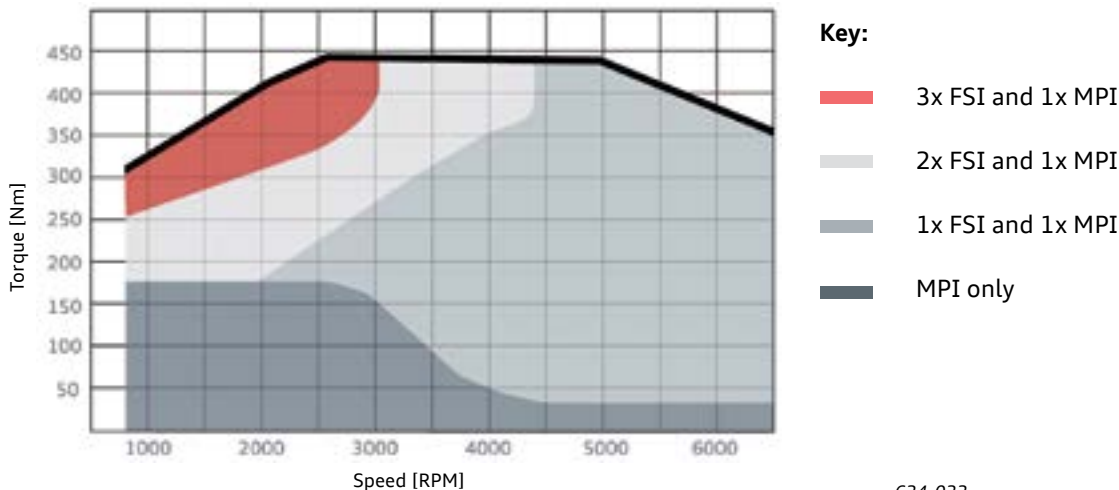
All ranges of the operating map (refer to illustration 624_022) can be individually optimized.

- ▶ To achieve better fuel economy at low RPM and high engine load, multi-pulse FSI injection is employed in combination with MPI injection.
- ▶ To reduce particulate emissions, the engine runs in MPI mode up to medium load.
- ▶ Approaching full throttle, the multi-point injection component is reduced resulting in more even basic homogenization of the air/fuel mixture and lower O_2 emissions. Due to the lower O_2 emissions in the exhaust gas there is less of an increase in the catalytic converter temperature. This makes it possible to reduce full throttle enrichment for the protection of the catalytic converter and improve fuel economy.

Operating map for fuel injection modes

A highly flexible fuel injection strategy is employed allowing a combination of high pressure fuel injection and low pressure fuel injection.

The distribution of individual quantities in the various fuel injection modes is fully variable. The transitions between the fuel injection modes are configured in the ECM in such a way that no sudden changes in the air/fuel ratio occur.



624_022

High pressure injectors

The Continental solenoid injector is a new development. Special emphasis was placed on meeting the stringent future exhaust emission standards.

Technical features:

- ▶ Suitable for fuel injection pressures of up to 2900.7 psi (200 bar)
- ▶ Fast opening and closing
- ▶ Very precise metering, particularly in the low volume range
- ▶ Option for multi-injection
- ▶ 65V activation voltage



624_078

Combustion process

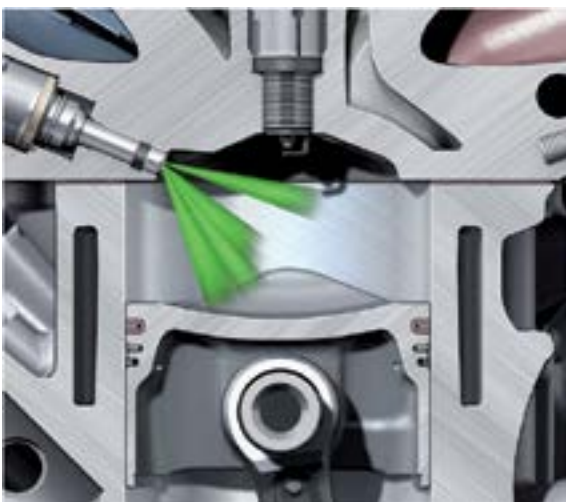
Compared with the third-generation 3.0l V6 TFSI engine, the following modifications were made:

- ▶ Increase in compression ratio from 10.3 to 10.8
- ▶ Intensification of charge motion inside the combustion chamber through modified piston shape
- ▶ Optimization of injector spray pattern
- ▶ The center of gravity of the fuel spray jet is angled further towards the spark plugs
- ▶ The injectors are positioned further to the rear in order to increase the clearance to the cylinder lining

Goals achieved:

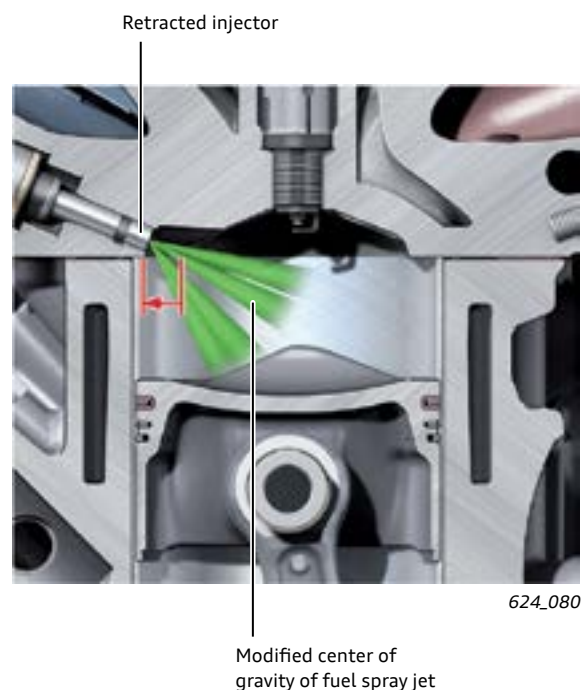
- ▶ Improved mixture formation
- ▶ Reduced exhaust emissions
- ▶ Improved combustion efficiency
- ▶ Reduced full throttle enrichment
- ▶ Better fuel economy

3.0l V6 TFSI, 3rd generation



624_079

3.0l V6 TFSI, 4th generation (evo)



624_080

Engine management system

System overview (2015 model Audi A8)

Sensors

Turbocharger Speed Sensor 1 G688

Charge Air Pressure Sensors 1 & 2, G31, G447

Brake Booster Pressure Sensor G294

Manifold Absolute Pressure Sensor G71

Intake Air Temperature Sensor G42

Engine Speed Sensor G28

Throttle Valve Control Module J338

EPC Throttle Drive Angle Sensors 1 & 2, G187, G188

Control Valve Control Unit J808

Control Valve Position Sensor G584

Camshaft Position Sensors G40, G163, G300, G301

Accelerator Pedal Position Sensor G79

Accelerator Pedal Position Sensor 2 G185

Brake Light Switch F

Oil Level Thermal Sensor G266

Fuel Pressure Sensor G247

Low Fuel Pressure Sensor G410

Knock Sensors 1 & 2 G61, G66

Fuel Level Sensor G

Fuel Level Sensors 2 & 3 G169, G237

Oil Pressure Switch F22

Engine Temperature Control Sensor G694

Reduced Oil Pressure Switch F378

Engine Coolant Temperature Sensor G62

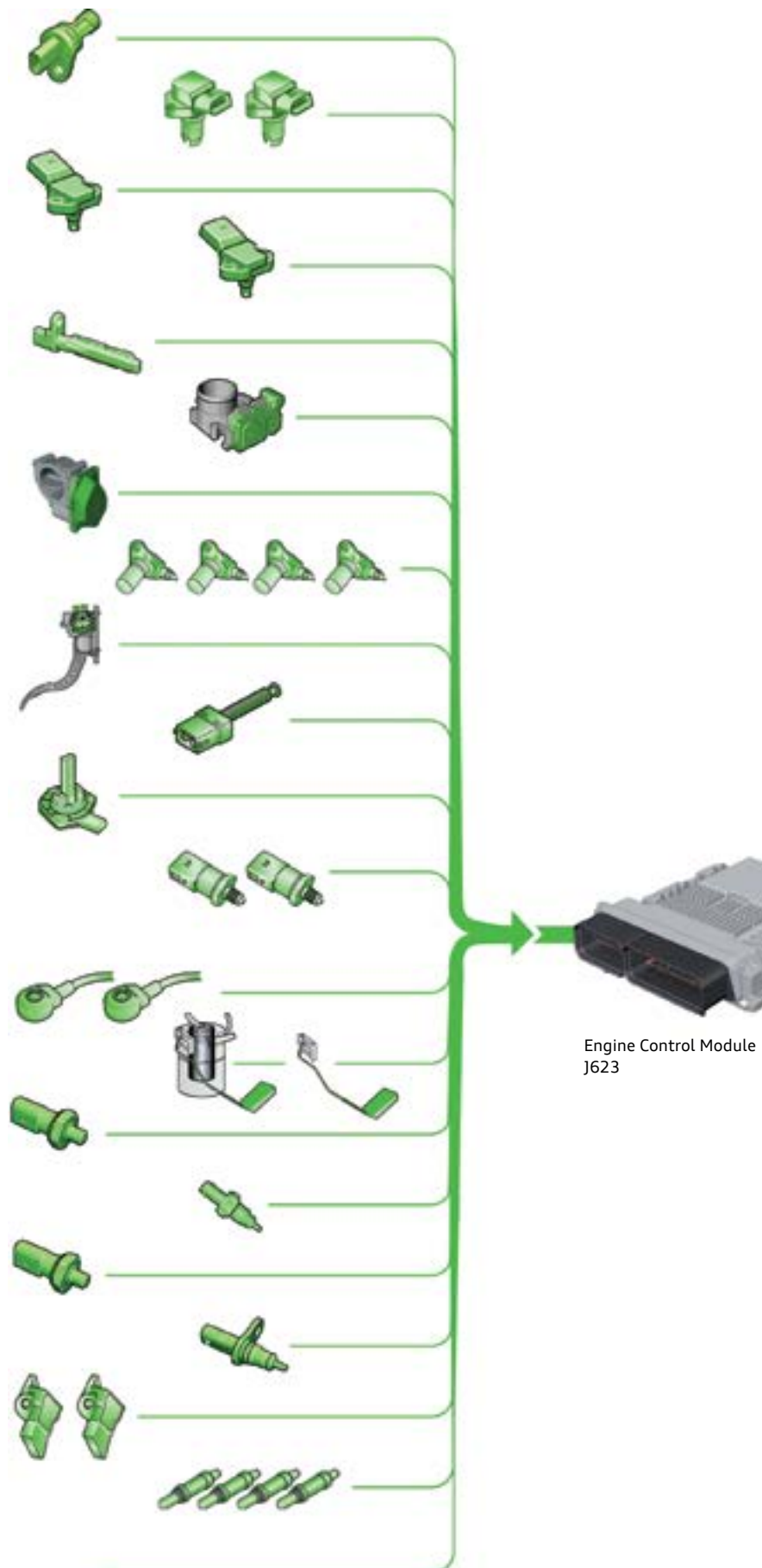
Intake Manifold Runner Position Sensors G336, G512

Heated Oxygen Sensors 1 & 2 G39, G108

Oxygen Sensors after Three-way Catalytic Converter G131, G132

Auxiliary signals:

- Comfort System Central Control Module
- Cruise control system
- Starter relays 1+2
- Access/Start Authorization Control Module



Actuators

Ignition Coils with Power Output Stages 1 – 6
N70, N127, N291, N292, N323, N324

Injector for cylinders 1 – 6
N30 – 33, N83, N84

Injectors 2, cylinders 1 – 6
N532 – N537

Throttle Valve Control Module J338
EPC Throttle Drive G186

Control Valve Control Unit J808
Control Door Adjustment Motor V380

Engine Component Power Supply Relay J757

Engine Control Module Power Supply Relay J271

Cooling Circuit Solenoid Valve N492

Oil Pressure Regulation Valve N428

Compressor Magnetic Clutch N421

Secondary Air Injection Solenoid Valve N112

Transmission Fluid Cooling Valve N509

Engine Oil Cooler Valve N290

Fuel Metering Valve N290

Camshaft Adjustment Valves 1&2 N205, N208
Exhaust Camshaft Adjustment Valves 1&2 N318, N319

Intake Manifold Runner Control Valve N316

Crankcase Ventilation Shut-off Valve N548

Charge Air Cooling Pump V188

Secondary Air Injection Pump Relay J299
Secondary Air Injection Pump Motor V101

Left Electro-hydraulic Engine Mount Solenoid Valve N144
Right Electro-hydraulic Engine Mount Solenoid Valve N145

Coolant Fan Control Module J293
Coolant Fans V7&V177

Oxygen Sensor Heaters 1&2 Z19, Z28
Heaters for Oxygen Sensors 1&2 After Catalytic Converter Z29, Z30

Fuel Pump Relay J17
Fuel Pump Control Module J538
Transfer Fuel Pump G6

EVAP Canister Purge Regulator Valve N80

Auxiliary signals:
Engine speed to TCM J217
(for vehicles with automatic gearbox 01) only)

Secondary air system

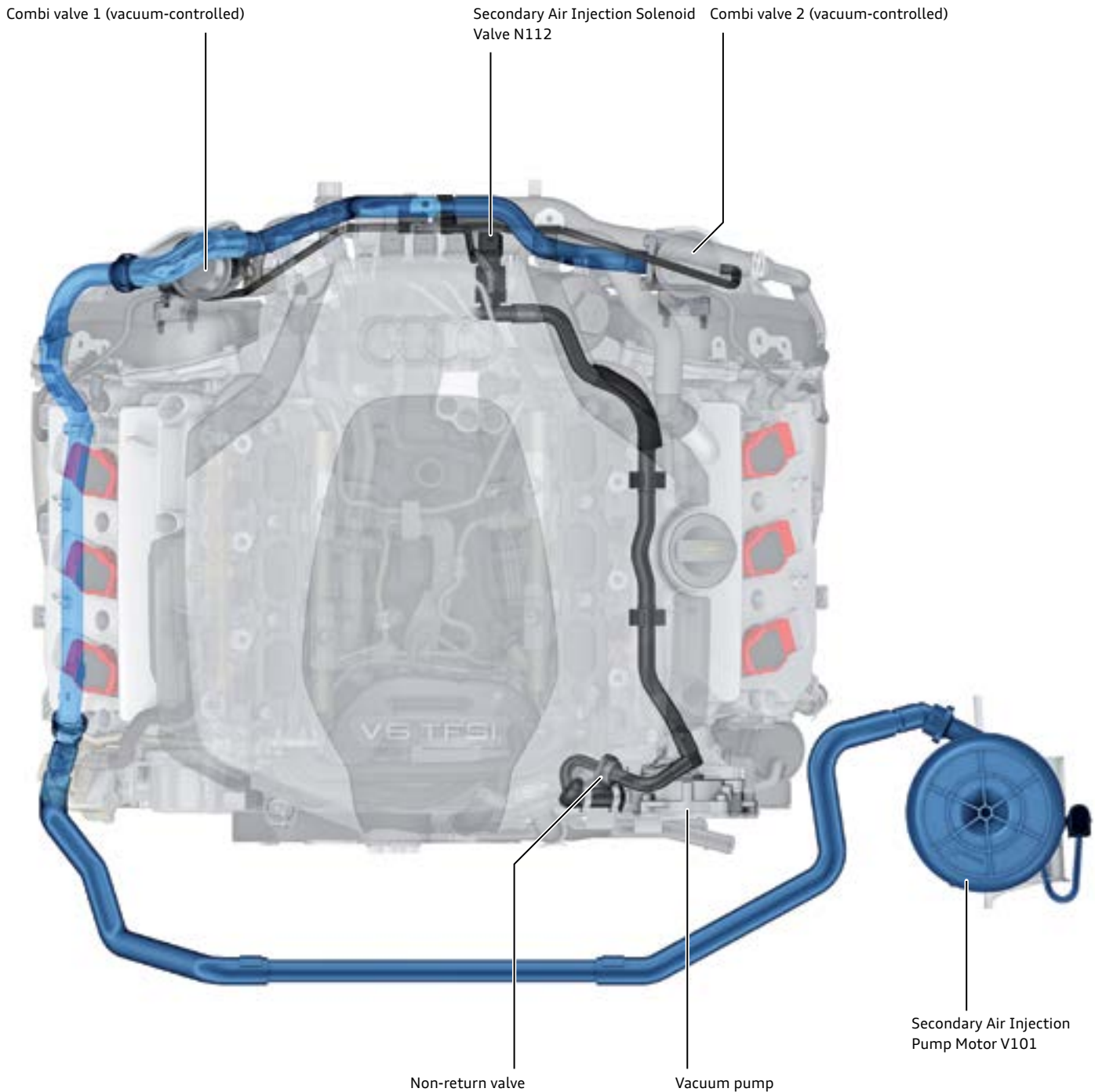
Compared with the third-generation 3.0l V6 TFSI engine, a number of modifications were made to the secondary air system.

Only one secondary air injection solenoid valve (N112) is used to activate the combi-valves. The intake of secondary air differs depending on vehicle model. On all vehicles with the fourth generation engine, except the A8 from model year 2015 forward, the secondary air is drawn from the air filter box.

On the Audi A8 from model year 2015 forward, secondary air is drawn through an air filter mounted on Secondary Air Injection Pump Motor V101.

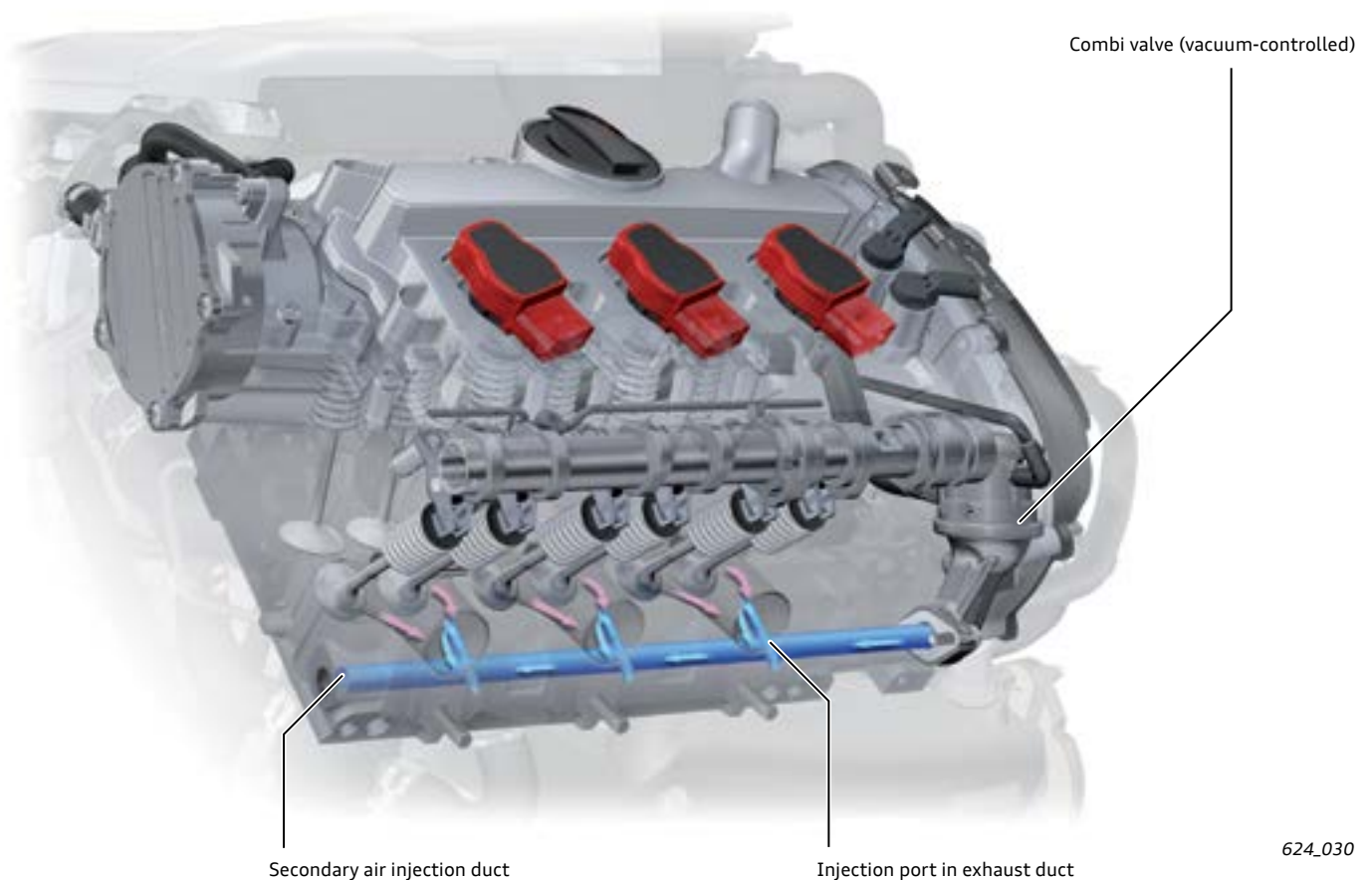
As a further result of the modifications to the third-generation 3.0l V6 TFSI engine, it was possible to reduce air throughput within the activated secondary air system. The engine therefore burns less fuel during the warm-up phase.

Overview



Secondary air ducts

Compared with the third-generation 3.0l V6 TFSI engine, the secondary air ducts were modified:



Diagnostics

Vehicles for the US and Canadian markets

A new oxygen sensor based diagnostic routine has been developed. The advantage over a pressure based diagnostic routine is reduced emission behavior. The new diagnostic routine is active while the secondary air pump is running in order to reduce exhaust emissions.

The O_2 value is measured by the oxygen sensors during secondary air injection and the secondary air mass is calculated from that value and the engine air mass value.

On completion of secondary air injection, the pump runs on for several seconds while the combi valves are closing, allowing the seal of the combi valves to be checked. If the O_2 value exceeds a lean threshold value, an event is registered indicating that a valve is leaky.

On completion of the valve leak test, the lambda value is re-measured and the result of the secondary air measurement corrected. In this way static deviations can be corrected, giving a more accurate result.

However, no measurement result or event memory entry is displayed until diagnosis of the oxygen sensors upstream of catalytic converter has been completed. This routine is performed at the same time the catalytic converter is diagnosed. To obtain a result after a cold start, therefore, the vehicle must be warmed up.

Service

Tools

Puller T40301



624_061

Removing clutch module from supercharger module

Centering device T40302



624_062

For centering the clutch module

Power supply unit clutch module VAS 6909



624_063

Pre-wiring for clutch module installation

Support T40304



624_064

Mounting supercharger module on support T40206 for assembly work and leak testing

Thrust piece T40303



624_065

Installing bearing to supercharger module

Inner extractor set VAS 501 001



624_081

Removing needle bearing from supercharger module

Maintenance operations

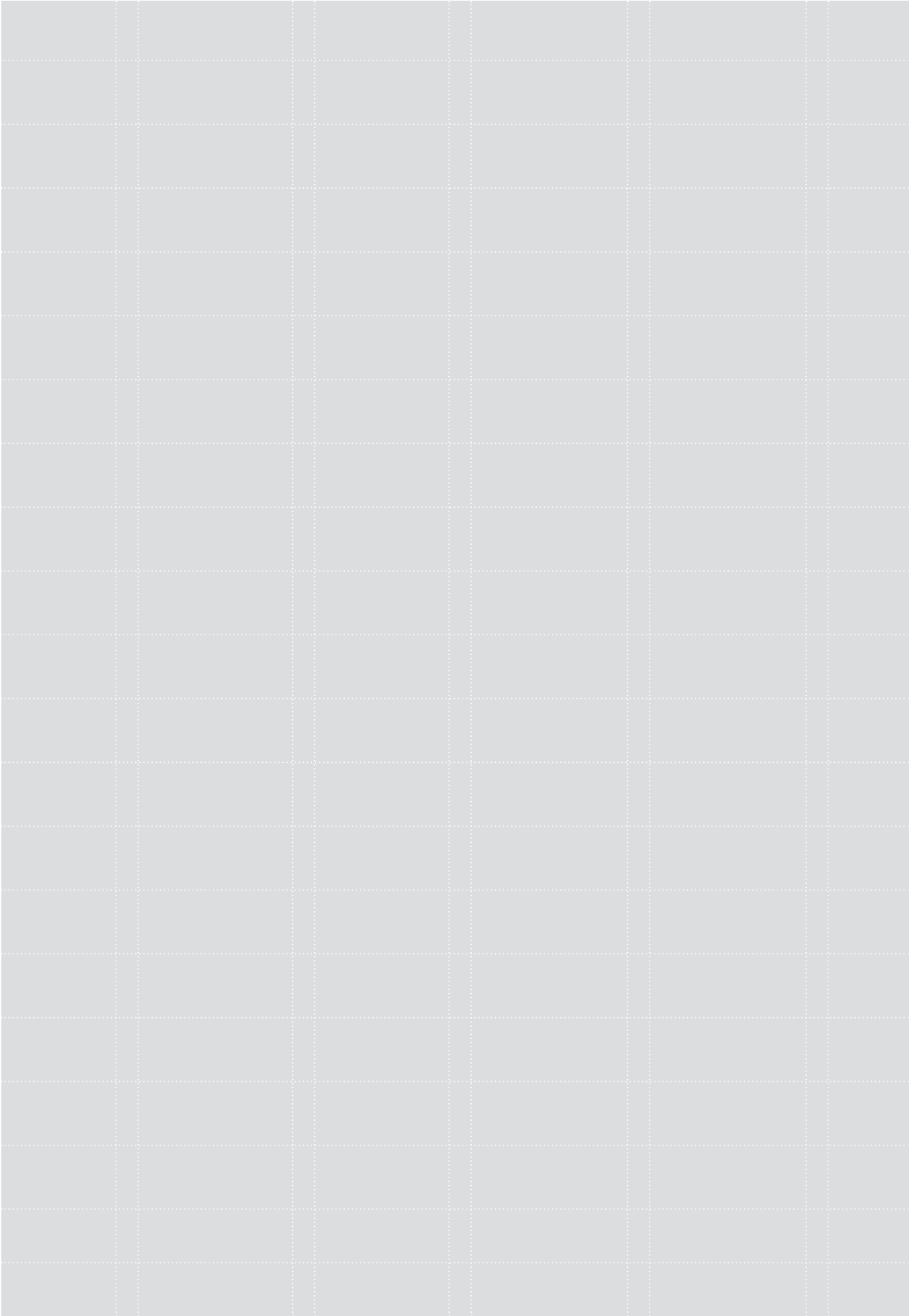
Description of maintenance operations	Interval or value
Quantity of engine oil including filter (change quantity)	7.1qt (6.8L)
Motor oil standard	VW 50400
Motor oil extraction permitted	yes
Electronic oil gauge tester (specifications for adjustment ring / specifications for min. oil to max. oil)	Upper scale value: 141 Lower scale value: 0 – 11
Service interval	The first scheduled service is due at 5,000 miles (8,000km) or 1 year after delivery, whichever occurs first. Thereafter, all remaining scheduled services are due every 10,000 miles or 1 year after previous service, whichever occurs first.
Air filter change interval	35,000 m (60,000 km)
Fuel filter change interval	Lifetime
Spark plug change interval	Replace at 55,000 miles (85,000 km) or 6 years, whichever occurs first. Thereafter, every 60,000 miles (90,000 km) or 6 years, whichever occurs first.
Transmission oil change interval	Lifetime
Poly V-belt change interval (supercharger)	55,000 m (90,000 km)
Timing drive / chain	Lifetime
Timing drive tensioning system	Lifetime



Note

Always check the current service literature for the latest information. This chart is listed as a reference.
When changing the oil, it is important to observe the applicable oil standard.

Notes



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

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 “920323b - The Audi 3.0L V6 TFSI Fourth Generation Engine”

Please submit any questions or inquiries via the Academy CRC Online Support Form which is located under the “Support” tab or the “Contact Us” tab of the Academy CRC.

Thank you for reading this eSelf-Study Program and taking the assessment.

All rights reserved.
Technical specifications are
subject to change without notice.

Audi of America, LLC
2200 Ferdinand Porsche Drive
Herndon, VA 20171