



The Audi 4.0L V8 TFSI Engine with Twin Turbochargers

Audi of America, LLC
Service Training
Created in the U.S.A.
Created 5/2012
Course Number 920223

©2012 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 reposted 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.

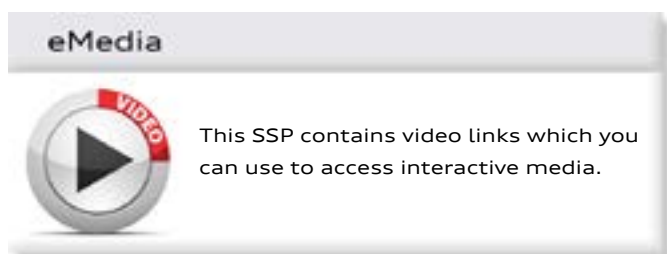
Always check Technical Bulletins and the latest electronic service repair literature for information that may supersede any information included in this booklet.

Contents

Introduction	1
Eight Cylinder Engines at Audi	2
Brief Technical Description.....	4
Variants.....	5
Audi S6 and S7 (C7 series)	6
Audi A8 and S8 (D4 series).....	8
Engine Mechanical	10
Cylinder Block.....	10
Bed Plate	11
Oil Module in the Inner V	12
Crankshaft Assembly	14
Overview	14
Connecting Rods	14
Pistons	14
Fine Oil Separation	18
Introduction of Cleaned Blow-By Gases	19
Crankcase Ventilation (PCV).....	20
Evaporative Emission System.....	21
Cylinder Heads	22
Chain Drive	24
Accessory Drive	25
Oil Supply	26
Overview	26
Oil Pump	28
Oil Pressure Regulation	30
Oil Cooling	31
Oil Filter	32
Oil Consumers.....	33
Oil Pressure Monitoring.....	34
Switchable Piston Cooling Jets	36
Cooling System.....	42
Overview	42
Engine Cooling Circuit and Cooling Module.....	46
Engine Coolant Pump (mechanical)	46
Map Controlled Engine Cooling Thermostat F265	47
Transmission Fluid Heating/Cooling	48
Turbocharger Cooling and Lubrication	50
Charge Air Cooling	51
Heater Circuit	52
Air Supply and Charging	54
Overview	54
Twin-Scroll Turbocharger	56
Twin-Scroll Design	57
Air Supply Schematic.....	58
Charge Pressure Regulation	59

Contents

Cylinder Deactivation (Cylinder on Demand)	60
Introduction	60
Allocation of Camshaft Adjustment Actuators (AVS).....	64
Active Engine Mounts	66
Purpose of the Engine Mount	67
Address word/diagnostic possibilities:	69
Active Noise Cancelation (ANC)	70
ANC Deactivation	73
ANC may be deactivated under the following conditions:.....	73
Fuel System	74
Overview	74
Exhaust System	76
Overview	76
Exhaust Flaps.....	78
Secondary Air System	80
Engine Management.....	82
System Overview	82
Engine Management MED 17.1.1.....	84
Engine Compartment Temperature Management	85
Special Tools and Fixtures	86
Knowledge Assessment	89



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

The eSelf-Study Program is not a Repair Manual!
All values given are intended as a guideline only.

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

Reference



Note



Introduction

The Audi family of V engines has been expanded. The new 4.0-liter V8 TFSI engine is the first 8-cylinder gasoline engine with twin turbocharging and FSI technology. Based on the 4.2L V8 FSI normally aspirated engine of the 2012 Audi A8, capacity was modified to further enhance fuel efficiency.

Additional fuel savings have been realized through cylinder deactivation. By deactivating four cylinders in various load and operating conditions, the engine uses less fuel.

Limited space in the engine compartment was overcome by mounting both turbochargers and the charge air cooler in the inner V of the engine. Referred to as an HSI (Hot Side In) arrangement, special monitoring ensures that under hood temperatures are kept within a safe and efficient range.

The broad performance spectrum of this engine is intended for use in other Audi models and other brands in the VW Group.

The 4.0L V8 TFSI engine uses Audi modular efficiency technologies, for example, in the design of the recuperation system and in friction reduction. High-end technologies, such as plate honing, are employed during manufacturing at the Audi factory in Győr, Hungary.



607_006

In this eSelf-Study Program you will become familiar with the technology of the 4.0L V8 TFSI. When completed, you will be able to answer the following questions:

- ▶ What are the basic design features of the engine?
- ▶ How do various engine systems operate, such as, air supply, oil supply, cooling?
- ▶ What is the effect of cylinder deactivation and how is it implemented?
- ▶ What are the special features of the second generation ITM system?
- ▶ What has changed in the engine management system when compared with the 4.2L V8 FSI engine?
- ▶ What are some of the special procedures that must be followed during service and repair work?

Eight Cylinder Engines at Audi

Powerful eight-cylinder engines have long been a part of Audi's product portfolio. They reflect the brand's premium status in the high performance and luxury sport sedan marketplace. V8 engines are optional equipment in Audi sports cars and SUVs as well.

1927 — First Eight-Cylinder Engine in Germany

The Horch 303, built in the Zwickau factory, offered an inline 8-cylinder engine in 1927. It was the first successful German production car with an 8-cylinder engine.

Designed by Paul Daimler, the son of Gottlieb Daimler, this 8-cylinder engine with two overhead camshafts was a significant entry in the premium field, despite being in a simpler open touring car. Noted for both its power and smooth running characteristics, 8,490 units were built by 1931.

It was said that the engine ran so quietly at idle that a coin placed on the cylinder head could be balanced on its edge without falling over.



607_103

The origins of eight-cylinder engines under the Four Rings logo go back to the Horch nameplate, an early brand within the Auto Union which would later become Audi AG.

1933 — First V8 Engine from Horch

At the Berlin Auto Show in 1933, Saxon Auto Union introduced a Type 830 Horch with a V8 engine. Named for its number of cylinders and 3-liter capacity, the engine of this "little" Horch produced 62 hp (46 kW) at 3200 rpm.

A type 830 BL debuted in 1935 on an extended chassis. The highest volume production vehicle manufactured at the Horch factory, 6,124 units were built, 50% of them Pullman limousines.



607_104

1988 — An Automotive Luxury Class Innovation

The first Audi V8 quattro sedan was introduced to the public at the Paris Salon in 1988. Built at the Neckarsulm factory, the permanent all-wheel drive coupled with a powerful V8 engine was a sensation in its premium class.

The Audi 3.6L V8 engine produced 250 hp (185 kW) at 5,800 rpm. A 4.2L V8 would follow, being used in the Audi V8 and its successor, the Audi A8.

The Audi V8 quattro sedan was Audi's first big splash in the automotive premium class field. Production of the V8 car ended after six years, in 1994. Audi won two German Touring Car Championships in the early 1990s with V8 engine equipped cars.



607_105

2006 — Direct Fuel Injection — FSI

In a technology breakthrough, the power output and fuel efficiency of the 4.2L V8 engine was greatly enhanced via the introduction of FSI direct injection in 2006. This engine was offered in two variants: a comfort-oriented base engine that was first used in the Audi Q7, and a sporty high-revving version for the 2006 Audi RS4 (415 hp [309 kW] at 7800 rpm).

For use in the Audi Q7, the V8 has been tuned differently. A fatter torque curve, impressive power, and quick response define this engine's characteristics. This is a high performing engine in every vehicle configuration.



607_106

2012 — Turbocharging/Cylinder Deactivation

The 4.0L V8 TFSI engine is the first 8-cylinder gasoline engine with twin-turbocharging and FSI technology from Audi. There are several power versions of this engine, used in different models of the C and D series of vehicles.

The main focus in development was on reducing fuel consumption. This was achieved by a number of innovations, including cylinder deactivation.



607_107

Brief Technical Description

- ▶ Eight-cylinder, 90° V engine
- ▶ Direct fuel injection (FSI)
- ▶ Cast aluminum cylinder block
- ▶ Twin-turbochargers mounted in the inner V
- ▶ Double air-gap insulated exhaust manifolds
- ▶ Indirect charge air intercooling
- ▶ Cylinder management/deactivation (ZAS)
- ▶ Second generation thermal management (ITM 2)
- ▶ Crossflow engine cooling system
- ▶ Bosch MED 17.1.1 engine management
- ▶ Start-stop system
- ▶ Energy recuperation during deceleration
- ▶ Active engine mounting with oscillating coil actuators





607_013

Variants

The 4.0L V8 TFSI engine is used in various Audi models. Depending on vehicle series and in which markets the vehicles are available, the engines have different features.

The table below contains information about variants and versions or adaptations. You can find additional technical data on the following pages.

Series	C7 ¹	D4 ²	
			
Vehicle use	Audi S6 Audi S7	Audi A8	Audi S8
Engine code	CEUC	CEUA	CGTA
Power	420 hp (309 kW)	420 hp (309 kW)	520 hp (382 kW)
Torque	406 lb ft (550 Nm)	443 lb ft (600 Nm)	479 lb ft (650 Nm)
Engine weight	483 lb (219 kg)	483 lb (219 kg)	494 lb (224 kg)
Transmission	DL511-7Q	AL551-8Q	AL551-8Q

¹ Illustration shows S6 engine

² Illustration shows S8 engine



Note

The technical descriptions in this eSelf-Study Program are based on engines available in the Audi S6 and Audi S7 (C7 series). Differences in other engine variants will be pointed out separately in the individual component group descriptions.

Audi S6 and S7 (C7 series)

Technical Data

The 4.0L V8 TFSI engine available in the C7 series has one power configuration.

The most distinguishing differences from the engines offered in the A8/S8 (D4 series) are:

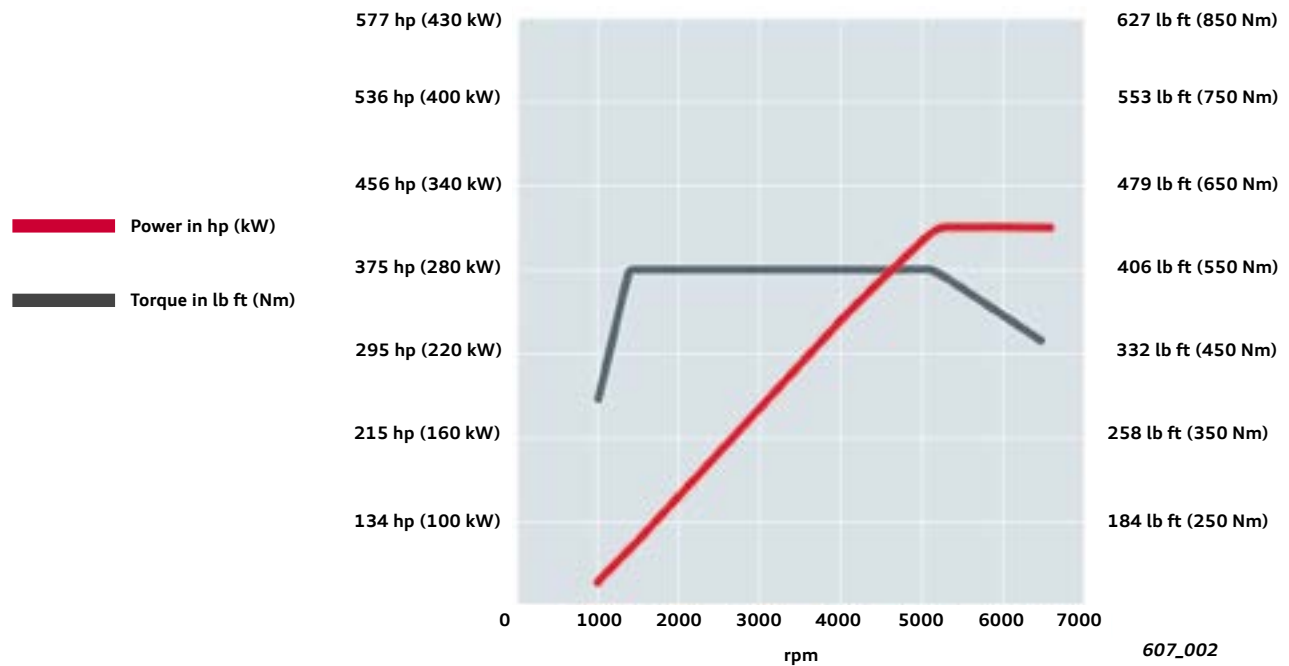
- ▶ Single air induction for both turbochargers
- ▶ No power steering pump
- ▶ Engine cover design



607_014

Specifications

4.0L V8 TFSI engine — CEUC



Engine Code	CEUC
Design	Eight cylinder, 90° V engine
Displacement	244 cu in (3993 cm ³)
Power	420 hp (309 kW) @ 5000–6400 rpm
Torque	405 lb ft (550 Nm) @ 1400–5200 rpm
Valves per cylinder	4
Firing order	1-5-4-8-6-3-7-2
Bore	3.32 in (84.5 mm)
Stroke	3.50 in (89.0 mm)
Compression ratio	10.1 : 1
Engine management	Bosch MED 17 1.1
Fuel requirement	Premium 91 AKI
Exhaust gas standards	EU 2 ddk, ULEV 2, Tier 2 BR, EU 5, EU 5 plus
CO ₂ emission	225g/km
Vehicle use	S6, S7

Audi A8 and S8 (D4 series)

Technical Data

The 4.0L V8 TFSI engine available in the D4 series comes in two power ratings.

The most distinguishing differences from the engines offered in the A6 and A7 (C7 series) are:

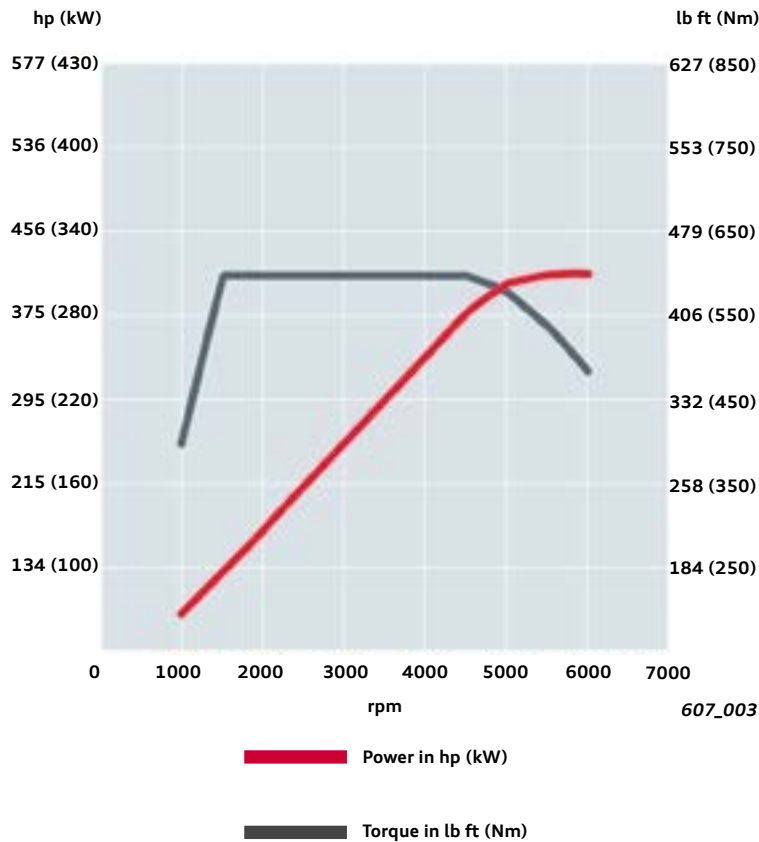
- ▶ Air induction for both cylinder banks (only in the Audi S8)
- ▶ Power steering pump
- ▶ Engine cover design
- ▶ Different installation location of the secondary air pump motor (right side of engine compartment)



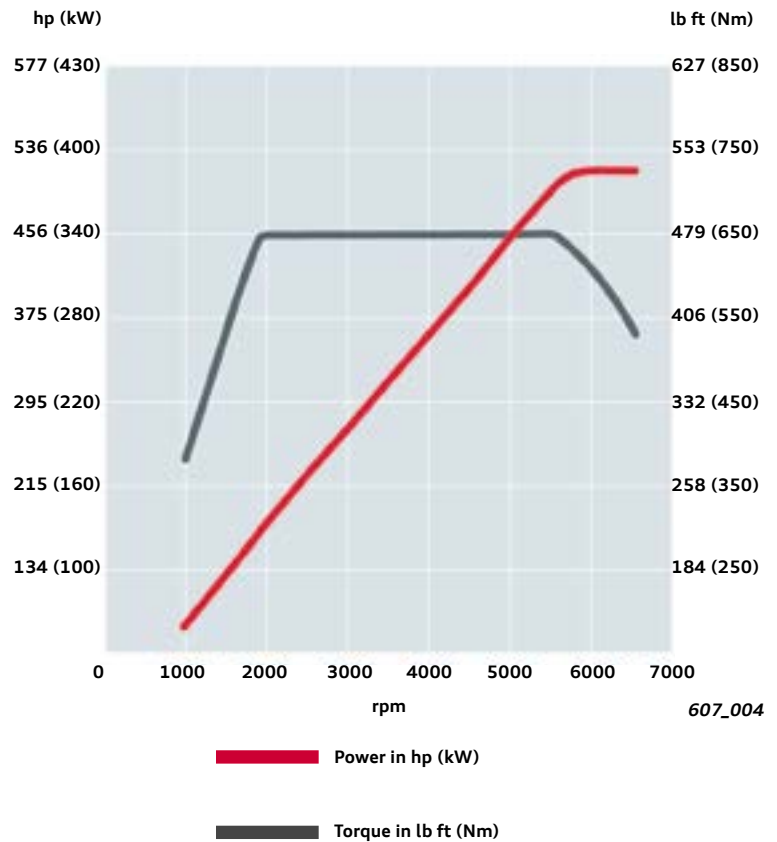
607_007

Specifications

4.0L V8 TFSI engine — CEUA



4.0L V8 TFSI engine — CGTA



Engine Code	CEUA	CGTA
Design	Eight cylinder, 90° V engine	Eight cylinder, 90° V engine
Displacement	244 cu in (3993 cm ³)	244 cu in (3993 cm ³)
Power	420 hp (309 kW) @ 5000–6000 rpm	520 hp (382 kW) @ 5800–6400 rpm
Torque	443 lb ft (600 Nm) @ 1500–4500 rpm	479 lb ft (650 Nm) @ 1700–5500 rpm
Valves per cylinder	4	4
Firing order	1-5-4-8-6-3-7-2	1-5-4-8-6-3-7-2
Bore	3.32 in (84.5 mm)	3.32 in (84.5 mm)
Stroke	3.50 in (89.0 mm)	3.50 in (89.0 mm)
Compression ratio	10.1 : 1	9.3 : 1
Engine management	Bosch MED 17 1.1	Bosch MED 17 1.1
Fuel	Premium 91 AKI	Super 93 AKI
Exhaust gas standards	EU 2 ddk, ULEV 2, Tier 2 BR, EU 5, EU 5 plus	ULEV 2, Tier 2 BR, EU 5 plus
CO ₂ emission	219g/km	235g/km
Vehicle use	A8	S8

Engine Mechanical

Cylinder Block

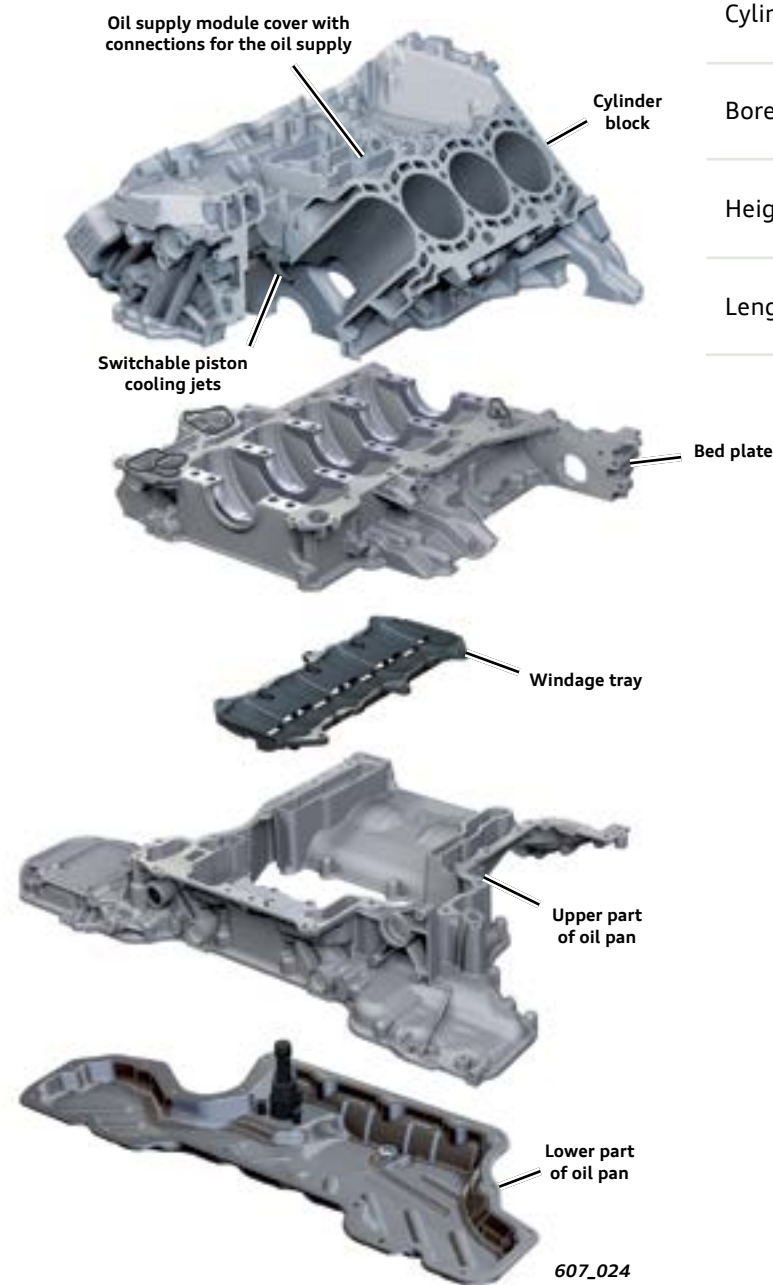
The crankcase is derived from the 4.2L V8 FSI engine of the 2012 Audi A8. It is a low pressure casting from a hypereutectic Alusil aluminum alloy. This alloy is very hard and corrosion resistant, while also being porous enough to hold oil.

The mechanical and thermal stresses of the 4.0L V8 TFSI engine surpass those of the 4.2L V8 FSI engine. To counter this additional stress, special heat treatment is used. This heat treatment differs depending on the engine variant.

The cylinder walls are honed after a plate has been installed. The cylinder walls are plate honed to maximize precision. This honing process uses a plate bolted onto the cylinder block to simulate the stresses of the installed cylinder head. A textured finish is applied during the final honing process.

Switchable piston cooling jets are mounted in the cylinder block to cool the pistons.

Cylinder Block Dimensions	
Distance between cylinders	3.54 in (90 mm)
Cylinder bank angle	90°
Bore	3.32 in (84.5 mm)
Height	8.97 in (228 mm)
Length	18.1 in (460 mm)



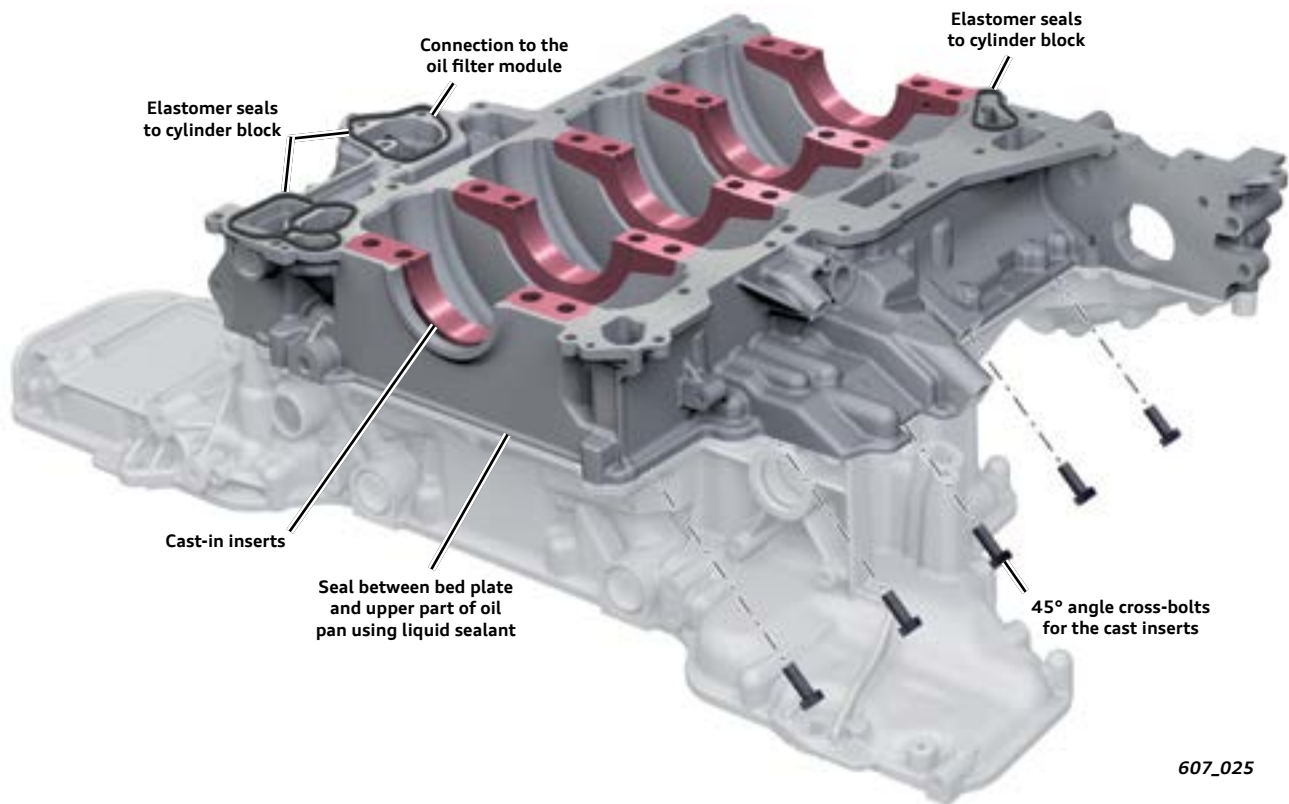
Bed Plate

The bed plate is produced in a pressure die-casting process from an aluminum alloy. The purpose of the bed plate is to provide a base for the crankcase and to absorb the loads exerted on the crankshaft bearings. It contributes substantially to the overall strength and acoustic characteristics of the engine.

Five cast-in-place inserts (crankshaft bearing caps) made of GGG 60 spheroidal cast iron are used to strengthen the bearing support. They are cross-bolted at a 45° angle to the bed plate.

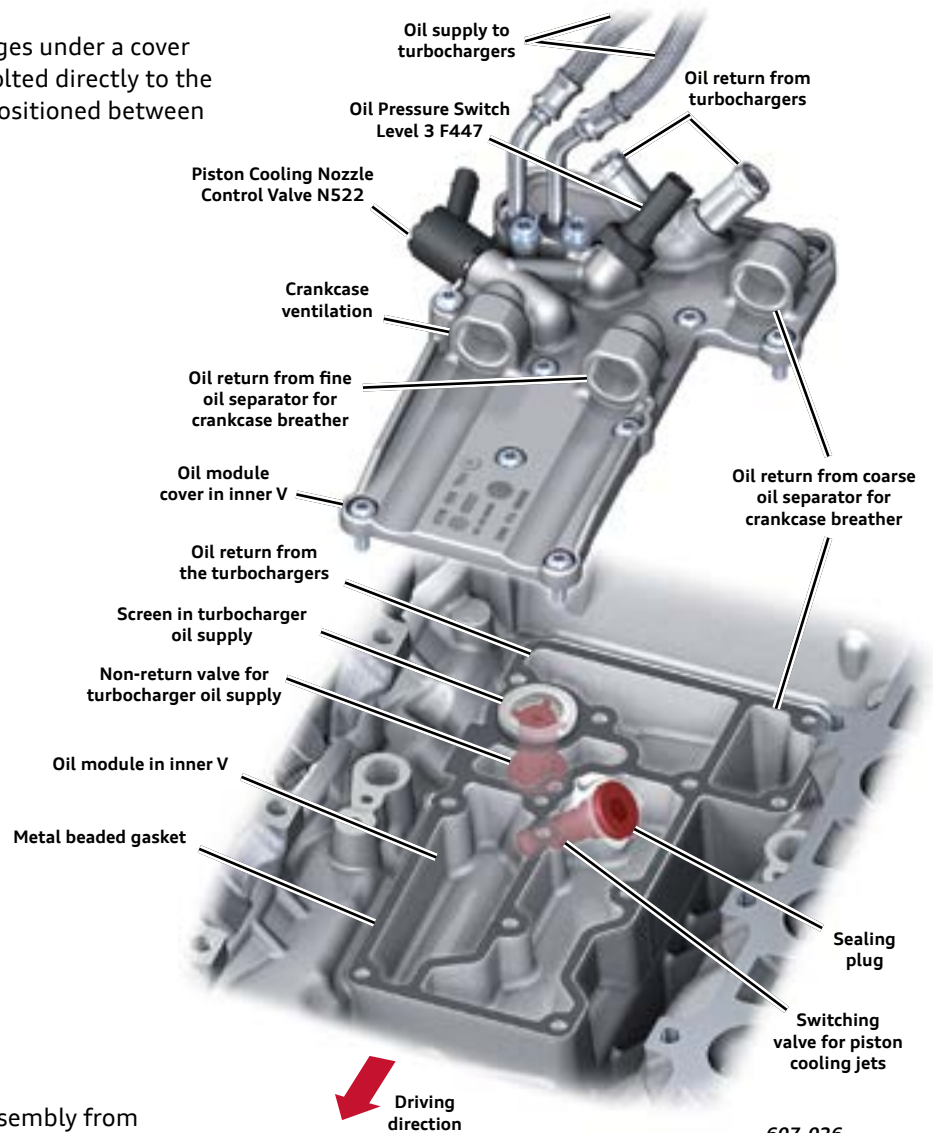
Engine coolant does not flow through the bed plate. However, it does contain oil passages and galleries to transport pressurized engine oil.

The bed plate is sealed to the cylinder block and oil pan by liquid sealant and formed elastomer seals. The oil filter module is integrated in the cylinder block.



Oil Module in the Inner V

There are numerous oil supply passages under a cover in the V of the engine. The cover is bolted directly to the cylinder block, with a metal gasket positioned between them.



607_026

Windage Tray

This tray separates the crankshaft assembly from the oil pan. As a result, the crankshaft webs are not immersed directly in the engine oil. This prevents foaming at high engine rpm. To reduce the weight of the engine, the windage tray is made of plastic.



607_027

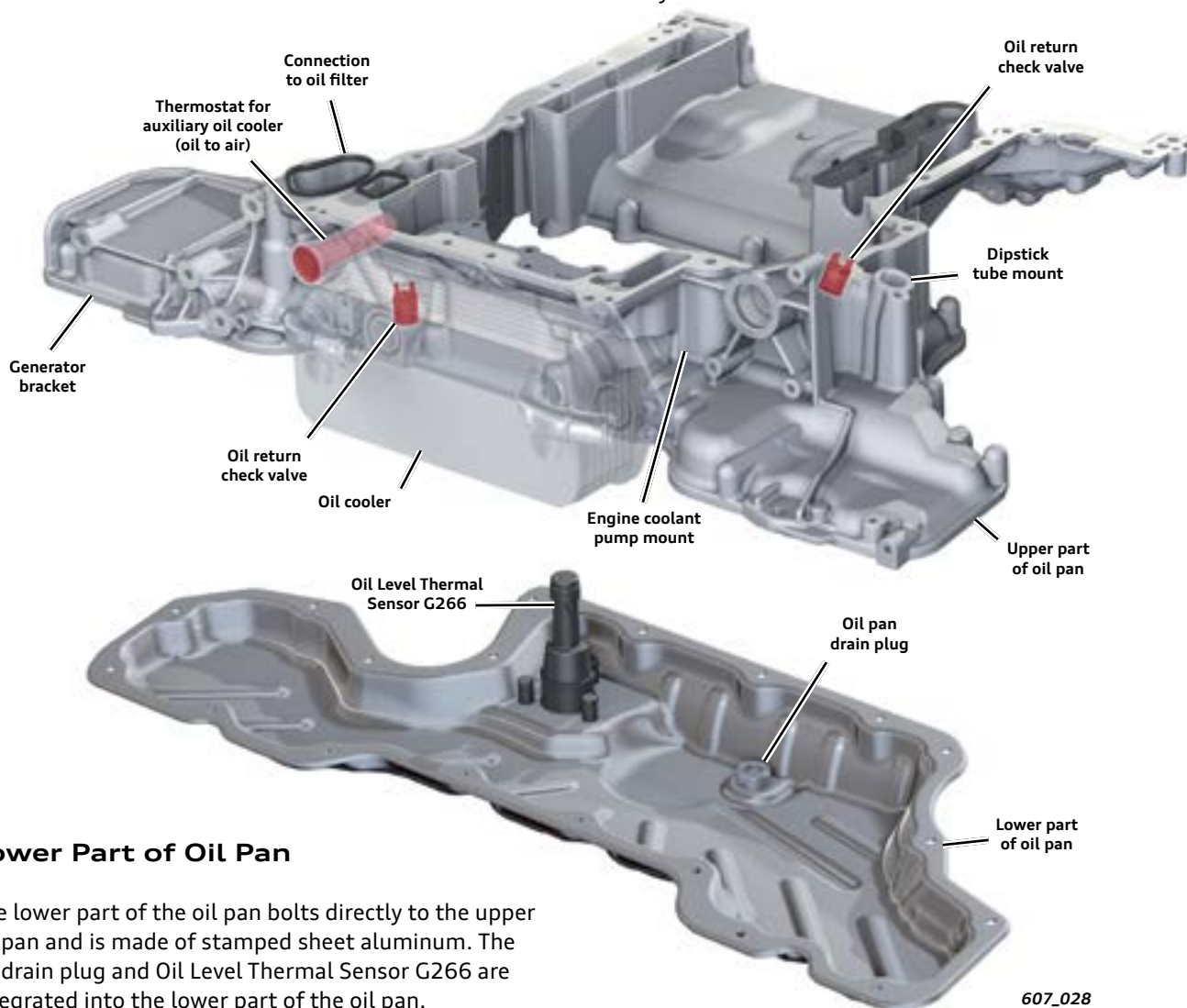
Upper Part of Oil Pan

The upper part of the oil pan contributes to the overall strength of the engine and transmission module assembly. The seals to the bed plate and the lower part of the oil pan are liquid sealant for the un-pressurized areas. Areas subject to pressure are sealed using elastomer gaskets.

All oil passages which transfer contaminated oil from the bed plate and clean oil to the bed plate, are an integral part of the upper oil pan section.

The following components are installed or integrated into the upper part of the oil pan:

- ▶ Bypass valve
- ▶ Oil cooler
- ▶ Poly V-belt tensioner
- ▶ Thermostat for auxiliary oil cooler (oil to air) (only on S8)
- ▶ Engine coolant pump mount
- ▶ Engine oil dipstick mount
- ▶ Generator bracket
- ▶ Oil returns from turbochargers and cylinder heads
- ▶ Oil return check valves for the crankcase ventilation system



Lower Part of Oil Pan

The lower part of the oil pan bolts directly to the upper oil pan and is made of stamped sheet aluminum. The oil drain plug and Oil Level Thermal Sensor G266 are integrated into the lower part of the oil pan.

607_028

Crankshaft Assembly

Overview



Connecting Rods

The connecting rods for all engine variants are specified as cracked connecting rods. The small end of the connecting rod has a trapezoidal angle of 13°. The piston pin has a diameter of 0.86 in (22 mm). The connecting rod bushing is bronze.

Pistons

Cast pistons with a cast-in ring carrier for the compression ring are used in all engine versions.

The principal difference in pistons for the engine variants is the shape of the piston crown. The piston pins have a fine diamond-like carbon coating, known as DLC. This coating reduces friction and wear considerably due to its extreme microhardness.

Engine with 420 hp (309 kW)



Engine versions above 520 hp (382 kW)



Crankshaft

The forged steel crankshaft is supported by five bearings. Different materials are used depending on the engine version. A different final finish machining process is also performed based on the power rating of the engine.

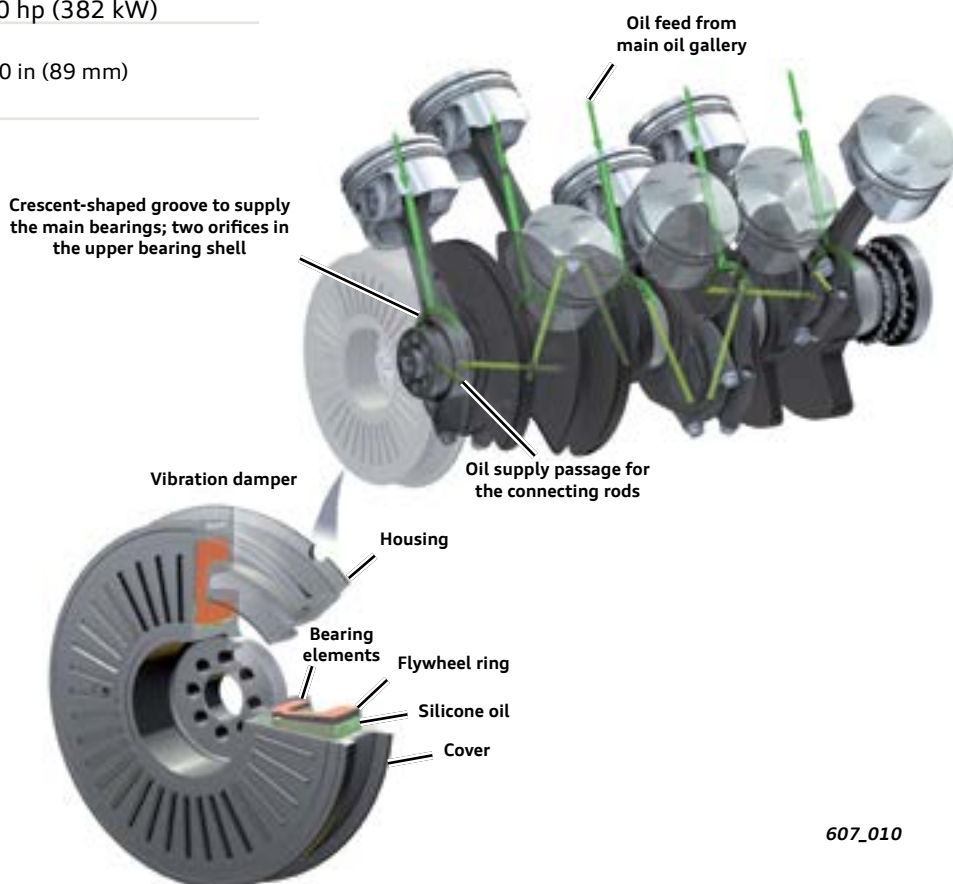
Crankshaft Dimensions

Crank pin diameter	3.54 in (90 mm)
Main bearing diameter	2.55 in (65 mm) Engine with 420 hp (309 kW) 2.63 in (67 mm) Engine versions above 520 hp (382 kW)
Stroke	3.50 in (89 mm)

Bearings and Oil Supply

The main bearings are a lead-free, three-material composite design. Oil supply is directed through two orifices per bearing via a crescent-shaped groove in the cylinder block. Different bearing materials are used for the upper and lower connecting rod bearing shells.

The lower connecting rod bearing shell, like the main bearing, is a lead-free, three-material composite bearing. A lead-free, two-material composite bearing is used for the upper connecting rod bearing shell.



607_010

Viscous Vibration Dampener

A viscous vibration damper reduces rotary vibrations created by internal combustion, and the rotating and oscillating masses. A rotary motion between the housing and the flywheel ring of the shear damper counters this vibration.

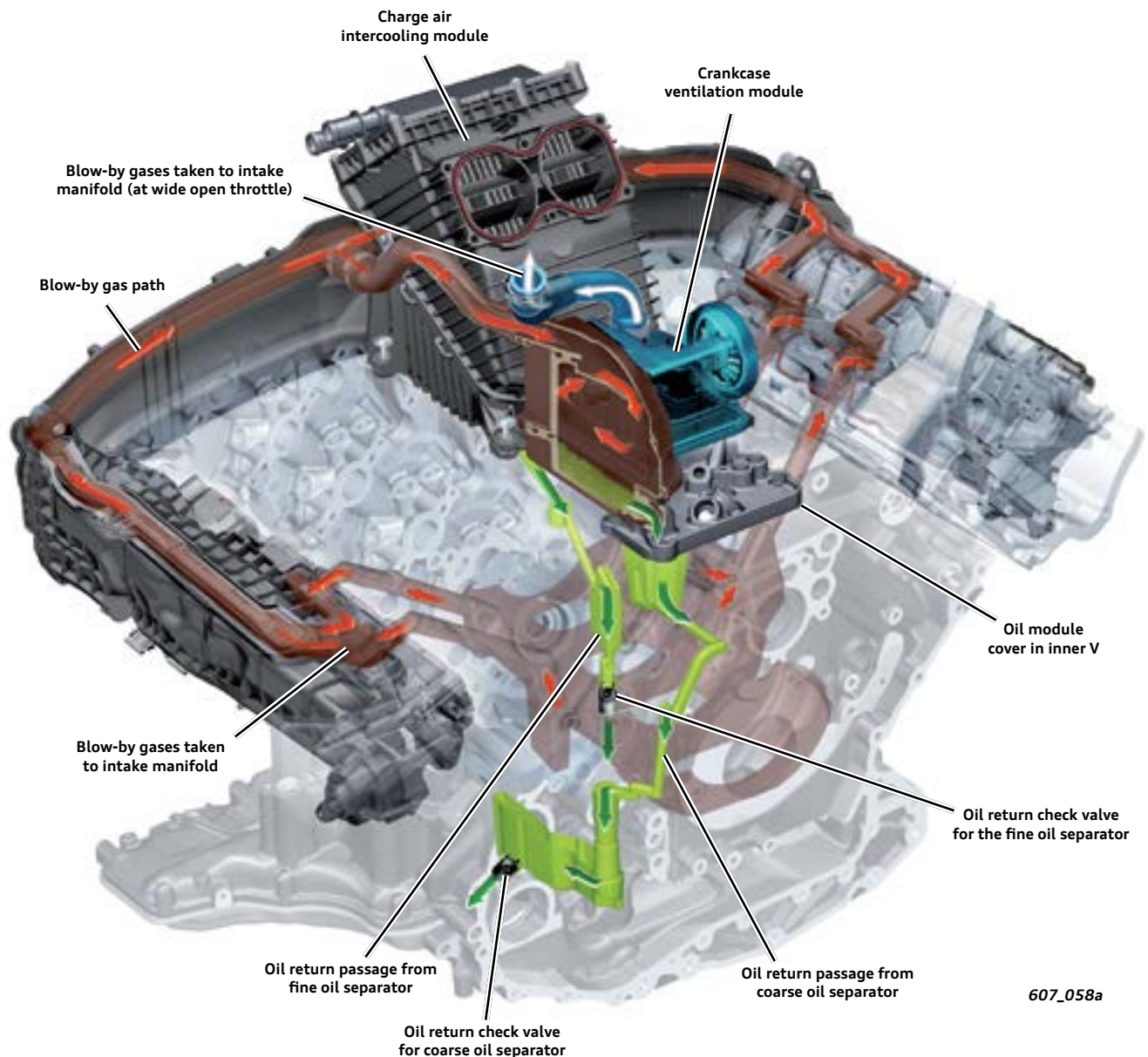
Silicone oil flows under the damper. Stress is distributed over the entire surface of the gap between the flywheel ring and the housing, creating the damping action.

Crankcase Breather and Ventilation

Crankcase ventilation takes place over both cylinder heads. The blow-by gases are taken into the crankcase breather module through separate ducts that lead into the intake manifolds and charge air module.

The crankcase breather module is placed in the inner V of the engine and performs several tasks:

- ▶ Coarse oil separation
- ▶ Fine oil separation
- ▶ Pressure regulation through the pressure control valve
- ▶ Positive crankcase ventilation (PCV)



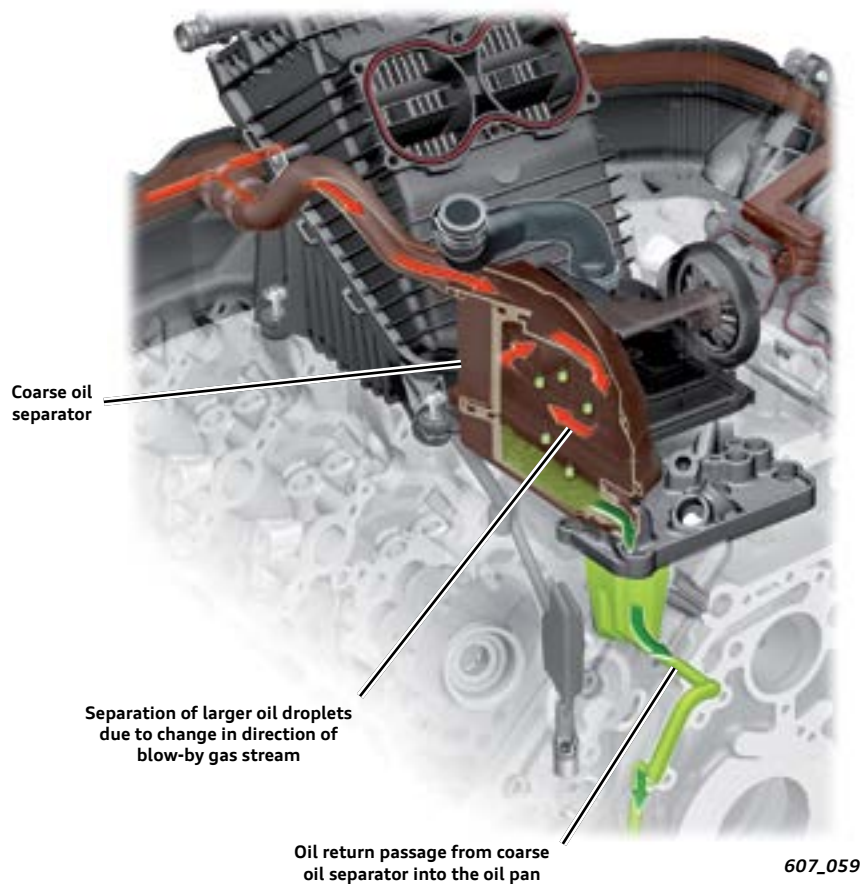
Note

Internal leaks in the oil return from the coarse oil separator can lead to increased engine oil consumption or blue smoke in the exhaust. The oil return check valves are integrated into the upper part of the oil pan. They cannot be replaced separately.

Coarse Oil Separation

The blow-by gas stream makes a 180° change of direction in the first, large-volume chamber. Because the larger drops of oil have greater inertia, they bounce off the chamber wall and run into the collector on the floor of the heavy oil separator. A drain opening is located there. It is attached to the cover of the oil module in the inner V.

The draining oil runs through a return passage below the oil level of the oil pan. An oil return check valve closes automatically when the engine is running, triggered by pressure differences in the crankcase and oil mist separator. This prevents untreated blow-by gases from flowing past the fine oil mist separator.



Oil Return Check Valves

Two oil return check valves are located inside the oil return passages. They prevent untreated blow-by gases from being sucked out of the crankcase. The valves are spring-loaded ball valves clipped into the upper part of the oil pan.



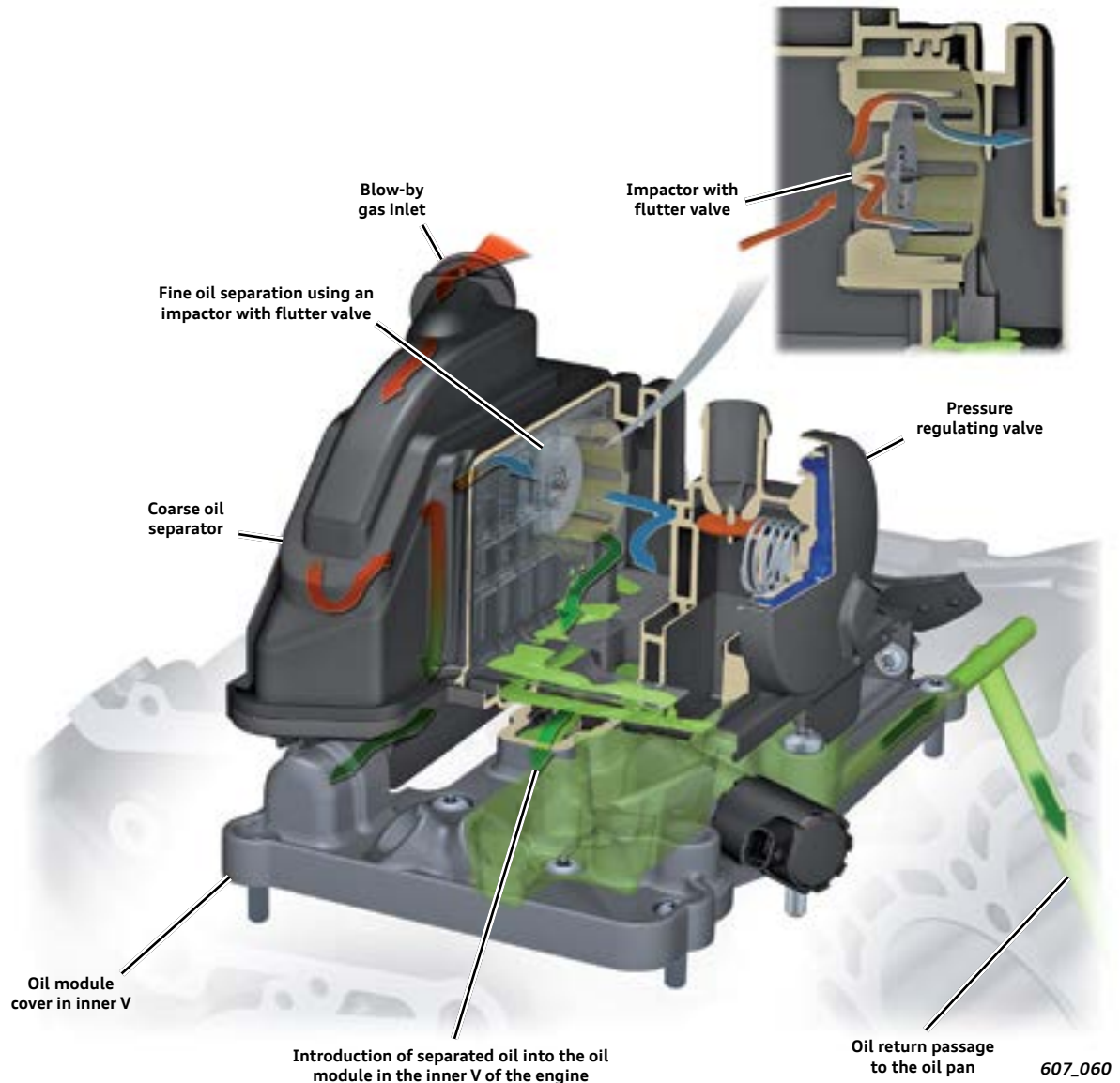
Fine Oil Separation

From the coarse oil separator, blow-by gases reach the second chamber through the fine oil separator. It contains the impactor, pressure regulator valve, blow-by valves, and the PCV valve.

The blow-by gases are cleaned first in the fine oil separator, which works on the principle of an impactor. It also works in conjunction with a pressure restriction valve that opens during increased blow-by volume flow. This limits pressure loss over the entire system.

The separated fine oil, like the coarse oil, is returned to the oil pan over a separate connection in the inner V of the engine. A non-return valve is also installed here.

Treated blow-by gases flow through the single-stage pressure regulator valve. Depending on the pressure ratio in the air supply, the blow-by gases are taken for combustion via the integrated blow-by valves in the charge air module or the crankcase ventilation module.



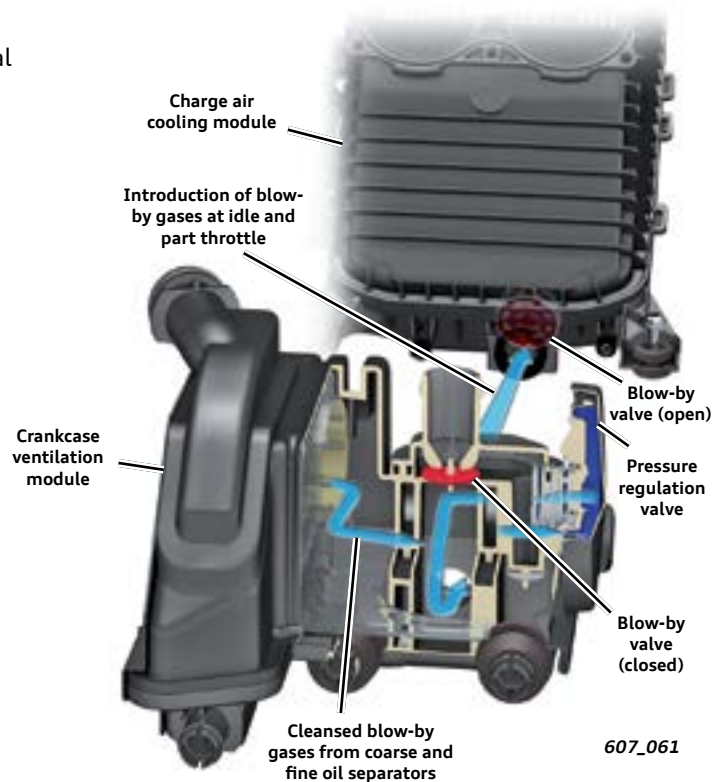
Reference

For further information about the construction and operation of an impactor, refer to eSelf-Study Program 920113, *The 6.3L W12 FSI Engine*.

Introduction of Cleaned Blow-By Gases

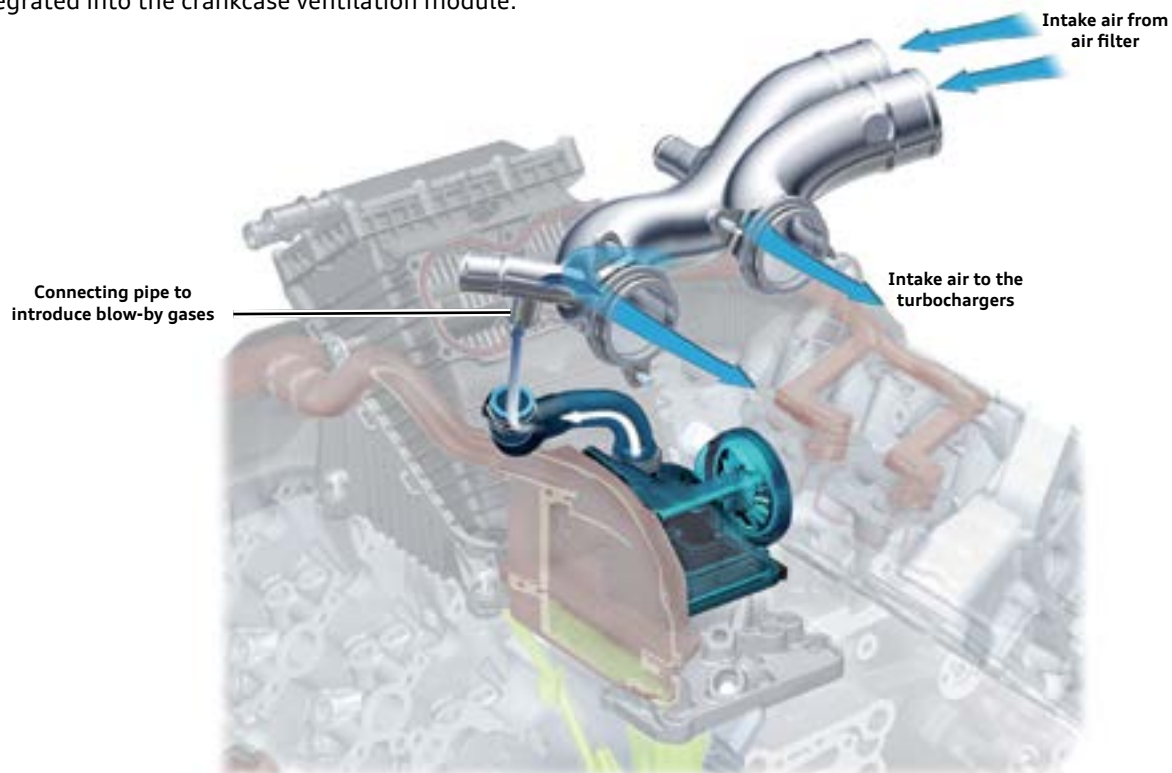
Idle and Part Throttle Operation

Vacuum is present in the air supply at idle and at partial load. The treated blow-by gases are admitted into the charge air cooling module. In the process, the blow-by valve for idle and partial load is opened by the suction effect.



Wide Open Throttle Operation

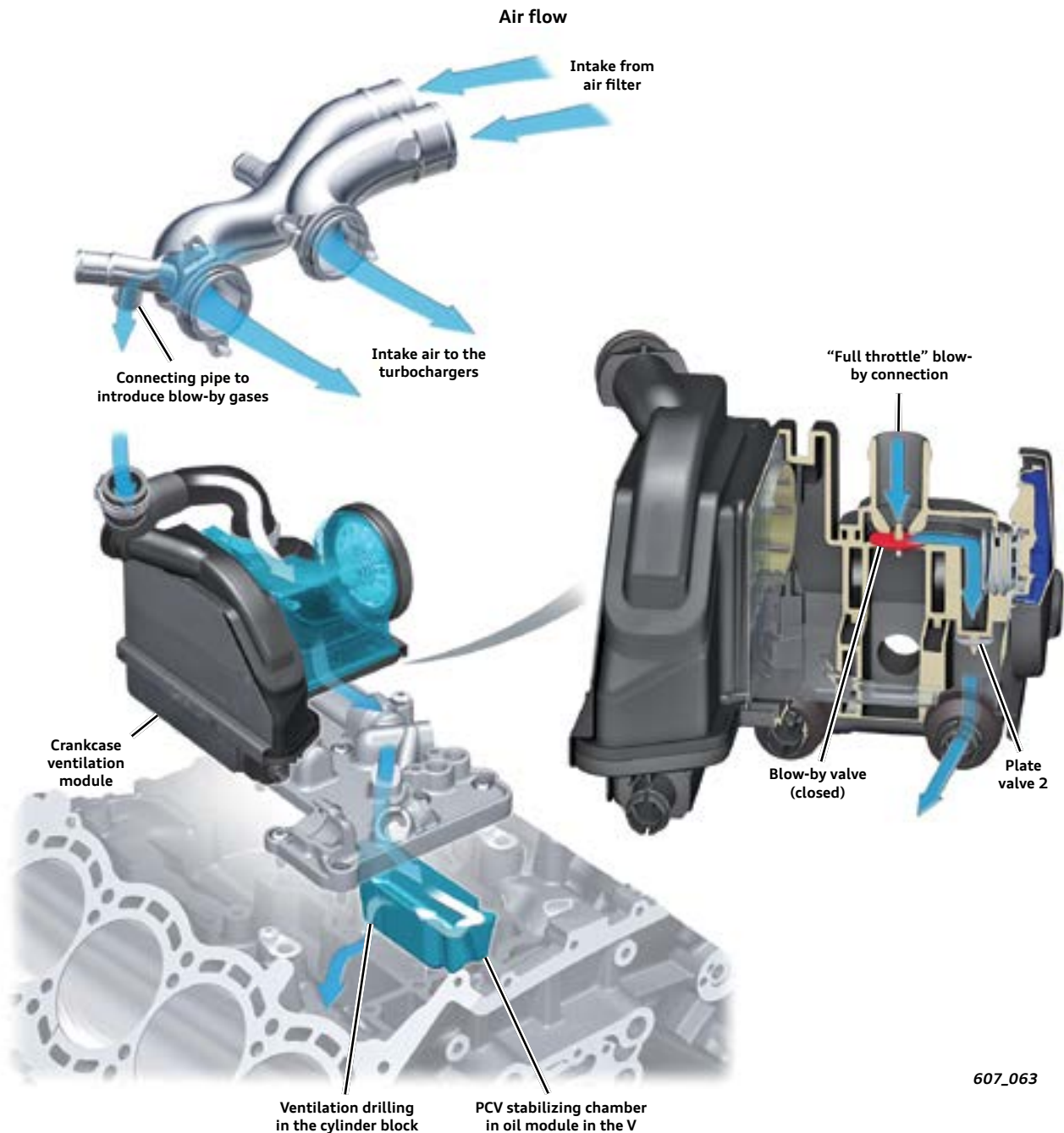
When there is positive pressure in the charge air module during turbocharged engine operation, the blow-by valve integrated into the charge air module closes. The cleansed blow-by gases are now introduced ahead of the turbochargers through the blow-by valve integrated into the crankcase ventilation module.



Crankcase Ventilation (PCV)

Fresh air is admitted into the crankcase via the positive crankcase ventilation module. The crankcase is ventilated at idle and at partial load only. The fresh air flows into the positive crankcase ventilation module through the “full throttle” blow-by connection.

A specified volume of fresh air is introduced over a plate valve and a drilling in the crankcase breather module through a connection in the cover of the inner V into the crankcase. If the engine is in turbocharged operation, the plate valve closes because of pressure differences.



607_063

Evaporative Emission System

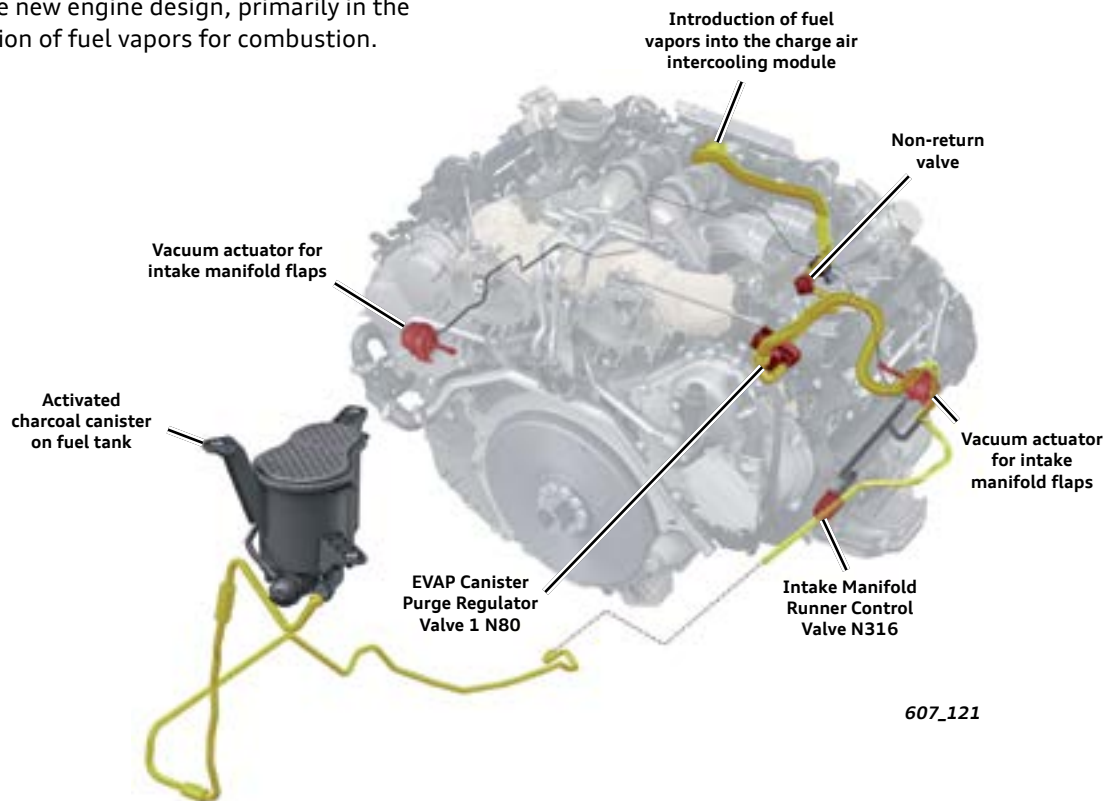
With earlier turbocharged gasoline engines, the fuel vapors were admitted at two points. First, at idle and at light part-throttle operation, fuel vapor admission was after the throttle valve because of the vacuum in the air intake.

Secondly, during turbocharger operation, charge pressure prevailed in the system and the fuel vapors were admitted ahead of the turbine. A mechanical valve system controlled the admission of fuel vapors.

This evaporative emissions system has been modified to suit the new engine design, primarily in the introduction of fuel vapors for combustion.

In the 4.0L V8 TFSI engine, engine management is designed so that in full-throttle range, the air supply is operated largely unthrottled. As a result, the pressure difference is too low to purge the EVAP canister.

To counter this, the EVAP system has been re-designed so that the admission of fuel vapors takes place only at idle and at light part-throttle. EVAP Canister Purge Regulator Valve 1 N80 is map-activated by the ECM to accomplish this task.



Intake Manifold Flap Control

Intake manifold flaps are integrated into the intake manifolds. They divide the lower air passage in the cylinder head when actuated. This creates the tumbling movement of air in the combustion chambers. The passages in the cylinder head are divided by the separating plates. All intake manifold flaps for one cylinder bank are mounted on a common shaft.

The shaft is driven by a spring-loaded vacuum actuator. Both vacuum actuators for the intake manifold flaps are switched together by Intake Manifold Runner Control Valve N316, which is located near cylinder number 4 on the intake manifold, next to Intake Manifold Runner Position Sensor G336.

To provide the vacuum actuator on cylinder bank 2 with vacuum from N316, a vacuum line is routed around the engine. The ECM receives feedback about the position of the intake manifold flaps from Intake Manifold Runner Position Sensors G336 and G512.

Two potentiometers are positioned opposite the vacuum actuator, to best monitor the functionality of the shafts.

Cylinder Heads

The cylinder heads for the 4.0L V8 TFSI engine have been redesigned. The design challenge was to remedy the higher mechanical and thermal requirements compared to the cylinder heads of the 4.2L V8 FSI engines.

The cylinder heads for all performance versions of the engine are laid out identically. The only difference consists in different valve timing (lift event lengths for the camshafts) in the engine variants with more than 420 hp (309 kW).

The most significant design change is the reversed arrangement of intake and exhaust sides, Hot Side In (HSI) of the cylinder head. This layout enables compact construction, improved thermodynamics, and short gas flow paths with minimal flow losses.

Technical Features

- ▶ Aluminum cylinder head with two camshafts
- ▶ Four-valve technology
- ▶ Cylinder head covers with a ladder frame
- ▶ Camshaft phasing on the intake and exhaust side
- ▶ Hall sensors monitor the position of each camshaft
- ▶ Crossflow cooling
- ▶ Coolant passage between intake and exhaust valves cooled
- ▶ Cylinder deactivation through AVS
- ▶ Triple-layer cylinder head gasket
- ▶ Sealing of cylinder head covers using liquid sealant

Valve Train

The valves are actuated by roller cam followers. They have a different geometry to allow for cylinder on demand. The roller cam followers with wide rollers are assigned to the cylinders without cylinder on demand. The roller cam followers with narrow rollers are assigned to the cylinders with cylinder on demand.

Additional features:

- ▶ Hydraulic valve lash compensation
- ▶ Exhaust valves with hardened seats, sodium filled for cooling
- ▶ Solid stem intake valves with hardened seats
- ▶ Sintered lead steel exhaust valve guides
- ▶ Bronze intake valve guides
- ▶ Single valve springs operating at relative low tension
- ▶ Valve lift: 11 mm

The 4.0L V8 TFSI engine responds crisply to throttle pedal inputs. Extensive insulation of hot components, particularly the exhaust manifolds, keeps thermal conditions in the inner V of the engine stable.

The fresh air intake system is placed on the outside of the cylinder banks.

Switchable flaps in the intake passages cause a rolling rotation of incoming air. The intensive tumbling action of the fuel-air mixture cools the combustion chambers, which allows a high compression ratio (even with turbocharging) with no tendency to knock.

- ▶ Intake passages with dividing plates
- ▶ Spark plugs centrally located (in the middle of the four inclined valves)
- ▶ Fuel injectors located to the side
- ▶ High pressure fuel pumps driven by the exhaust camshafts (triple lobes)
- ▶ Mechanical vacuum pump driven by the intake camshaft
- ▶ Non-return valves prevent engine oil from running back (running the pressure passages empty)
- ▶ Oil screen to protect against contamination

Camshaft Adjustment

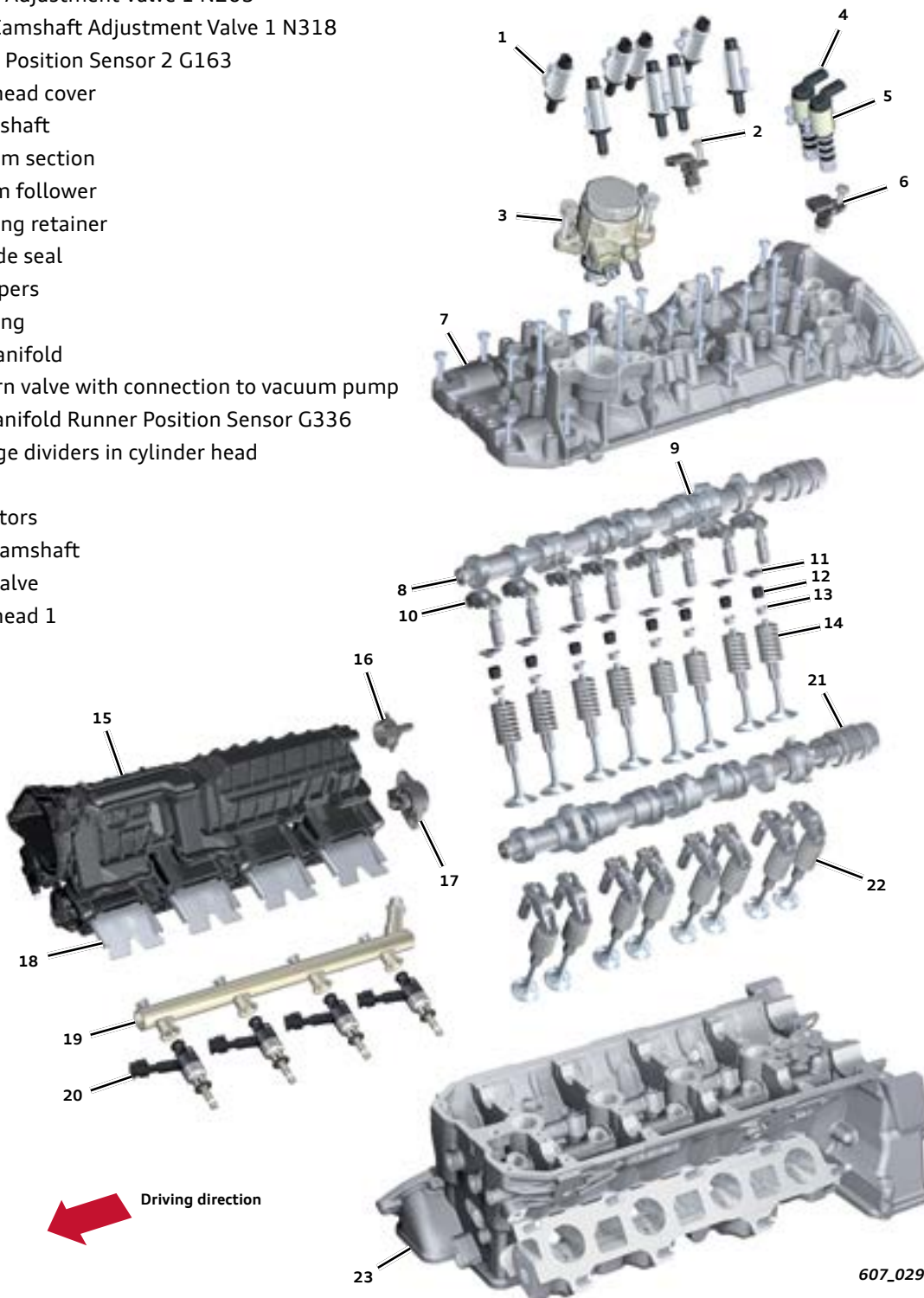
Both intake and exhaust camshafts are continuously adjustable. The range of adjustment is 42° of crankshaft angle for all. The position of each camshaft is monitored by a Hall sensor. After the engine is switched OFF, the oil pressure drops and the camshaft adjusters are locked by a spring actuated locking pin.

Internal exhaust gas recirculation is accomplished through camshaft timing adjustment (valve overlap). Exhaust gases are recirculated during 8-cylinder and 4-cylinder mode operations.

Construction

Legend:

- 1 Camshaft adjustment actuator
- 2 Camshaft Position Sensor G40
- 3 High pressure fuel pump
- 4 Camshaft Adjustment Valve 1 N205
- 5 Exhaust Camshaft Adjustment Valve 1 N318
- 6 Camshaft Position Sensor 2 G163
- 7 Cylinder head cover
- 8 Inlet camshaft
- 9 Sliding cam section
- 10 Roller cam follower
- 11 Valve spring retainer
- 12 Valve guide seal
- 13 Valve keepers
- 14 Valve spring
- 15 Intake manifold
- 16 Non-return valve with connection to vacuum pump
- 17 Intake Manifold Runner Position Sensor G336
- 18 Air passage dividers in cylinder head
- 19 Fuel rail
- 20 Fuel injectors
- 21 Exhaust camshaft
- 22 Exhaust valve
- 23 Cylinder head 1



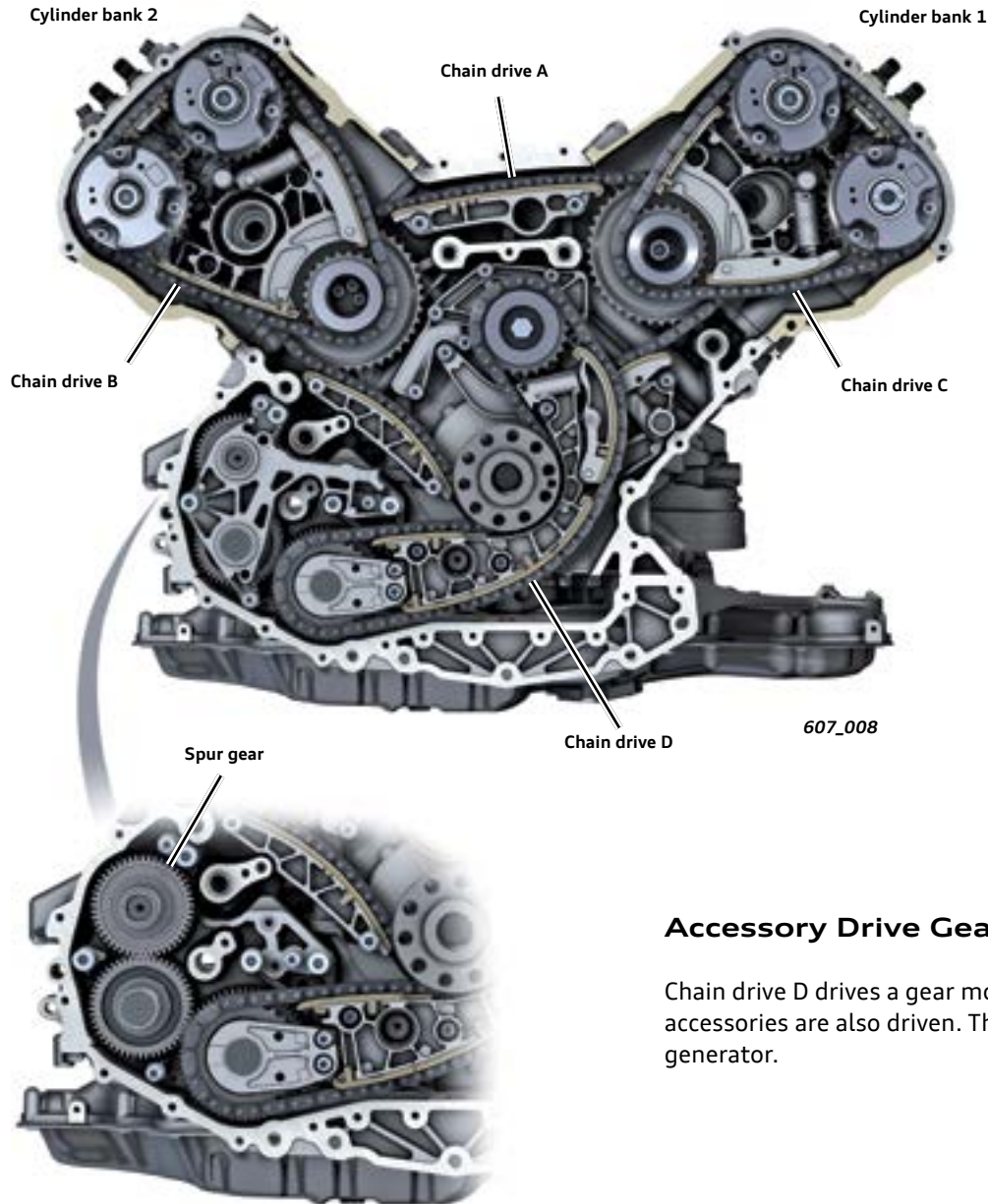
607_029

Chain Drive

Engine timing is by a chain drive arranged in two planes with four roller-type chains. The chain drive assembly is located on the power output side of the engine, and is hydraulically tensioned. Chain drive A acts as the distributor drive from the crankshaft to the intermediate gears.

Chain drives B and C are driven by intermediate gears and in turn drive the specific camshafts for each cylinder head. Chain drive D provides power to the accessories.

New special retaining tools T40264/1-3 are needed to check and adjust camshaft timing. Cylinder head covers do not need to be removed to locate the camshafts in correct position.



Accessory Drive Gear Module

Chain drive D drives a gear module from which all accessories are also driven. The only exception is the generator.



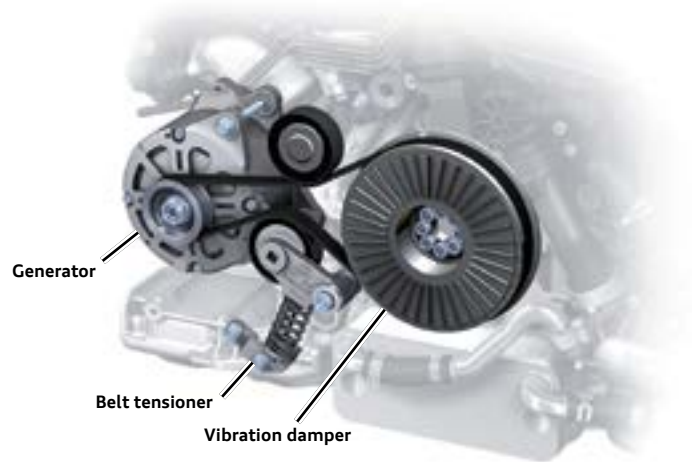
Note

The sprockets for the camshaft adjusters are tri-oval sprockets. Always refer to latest technical information during engine assembly.

Accessory Drive

Generator

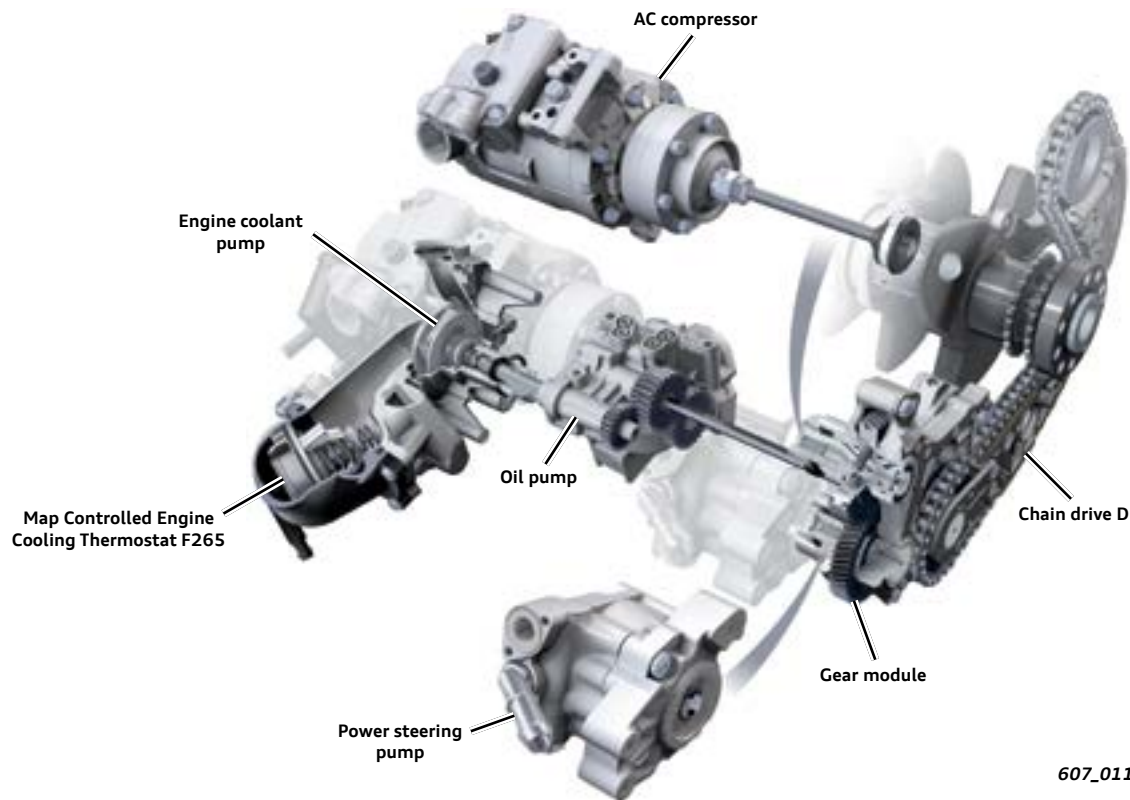
The generator is driven by a five-rib poly-V belt. A mechanical automatic belt tensioner with a damping function ensures correct tension.



607_009

Additional Accessories

Power is delivered from the crankshaft over chain drive D, a spur gear drive, a gear module, and drive shafts.



607_011

Power Steering Pump

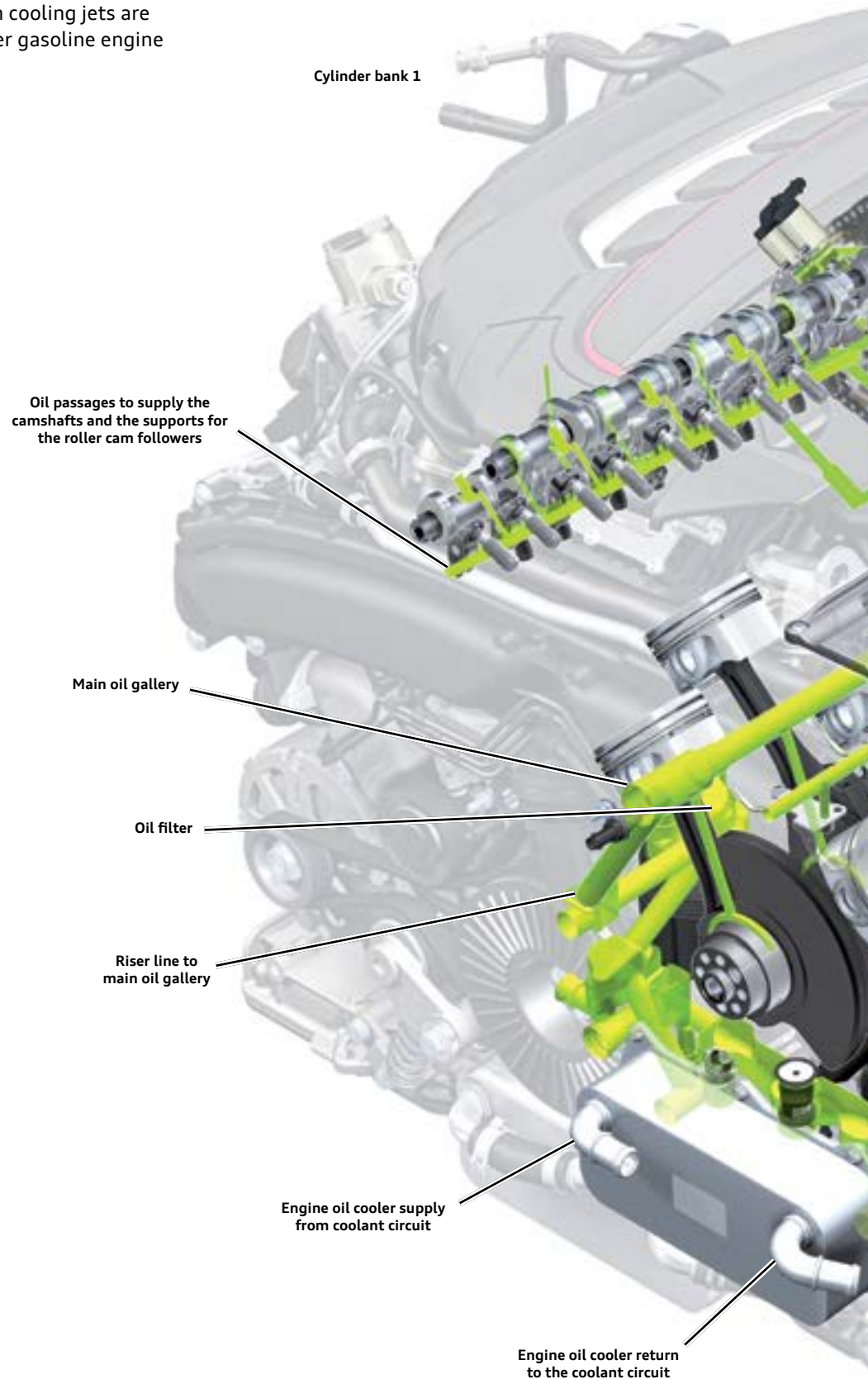
The power steering pump of the Audi A8 is driven by the engine. Drive is delivered from the crankshaft over chain drive D, a spur gear drive, and a gear module.

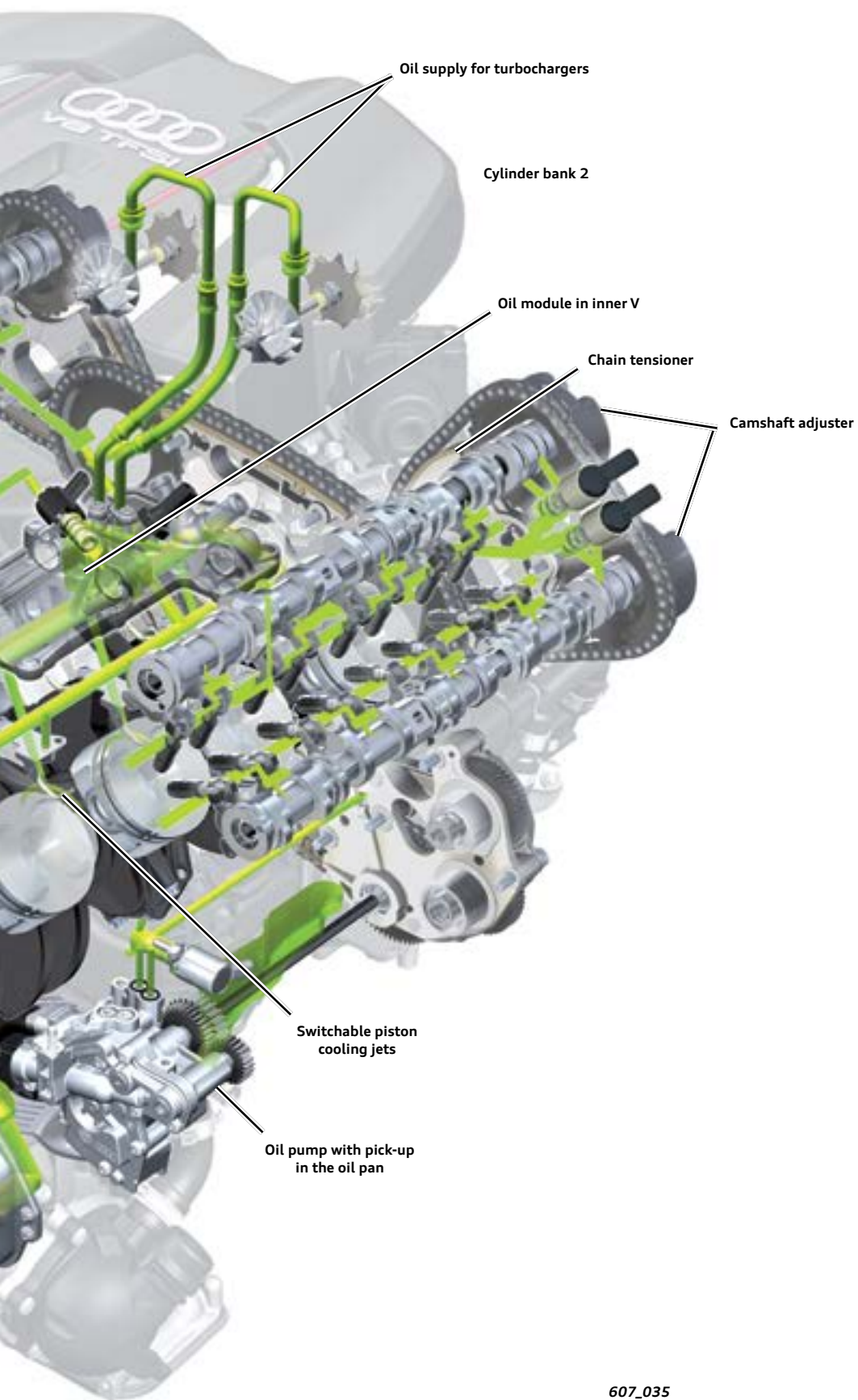
This drive arrangement for the power steering pump is not needed in C7 series vehicles because electro-mechanical steering is used.

Oil Supply

Overview

The 4.0L V8 TSFI engine uses a wet sump lubrication system. Electrically controlled piston cooling jets are used for the first time in an 8-cylinder gasoline engine from Audi.





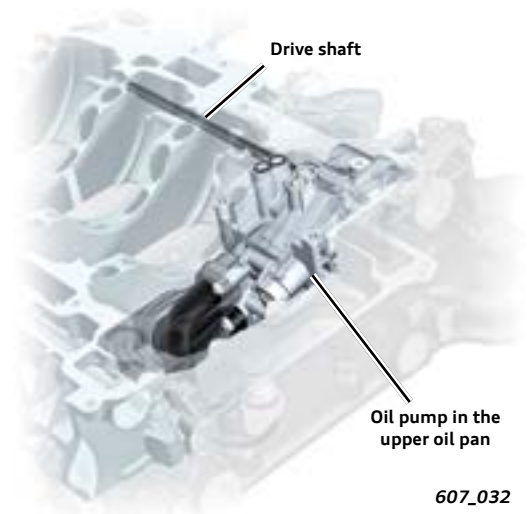
Oil Pump

The 4.0L V8 TFSI engine uses a flow-rate controlled oil pump. The pump operates in two pressure stages. In addition, the oil supply to the engine is constantly adjusted through volumetric flow control of the pump in both pressure stages.

By using this pump, it was possible to reduce fuel consumption. In lower rpm range, the pump is operated in a low pressure stage (reduced output capacity).

The low pressure level is at a relative pressure of approximately 29.0 psi (2 bar). The high pressure level is controlled to a value of approximately 65.3 psi (4.5 bar). The pressure relief valve in the pump opens at approximately 159.5 psi (11 bar).

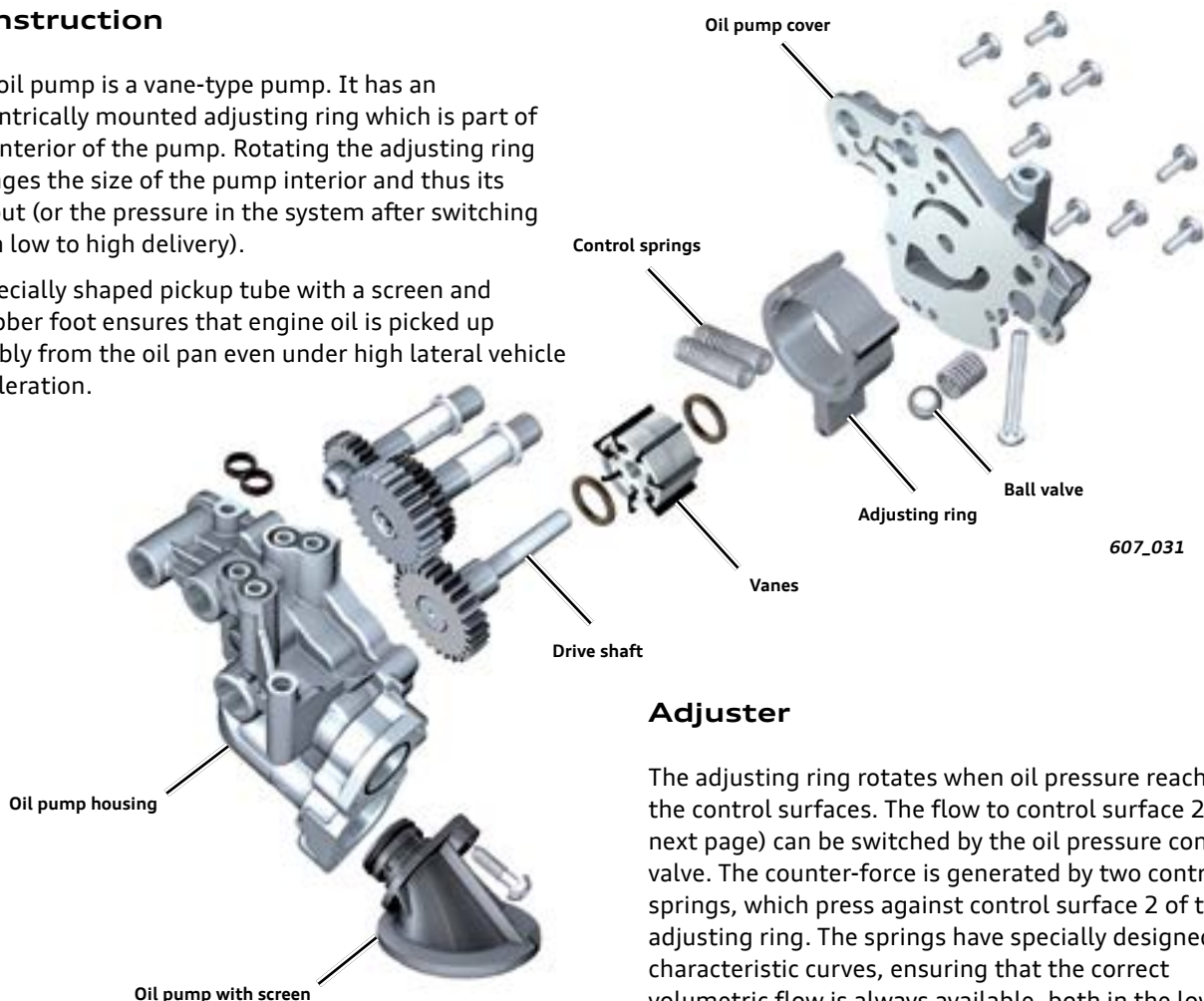
The oil pump is bolted to the bed plate. It is shaft-driven from the spur gear drive (chain drive D). In addition, the engine coolant pump is driven by the spur gear drive of the oil pump.



Construction

The oil pump is a vane-type pump. It has an eccentrically mounted adjusting ring which is part of the interior of the pump. Rotating the adjusting ring changes the size of the pump interior and thus its output (or the pressure in the system after switching from low to high delivery).

A specially shaped pickup tube with a screen and a rubber foot ensures that engine oil is picked up reliably from the oil pan even under high lateral vehicle acceleration.



Adjuster

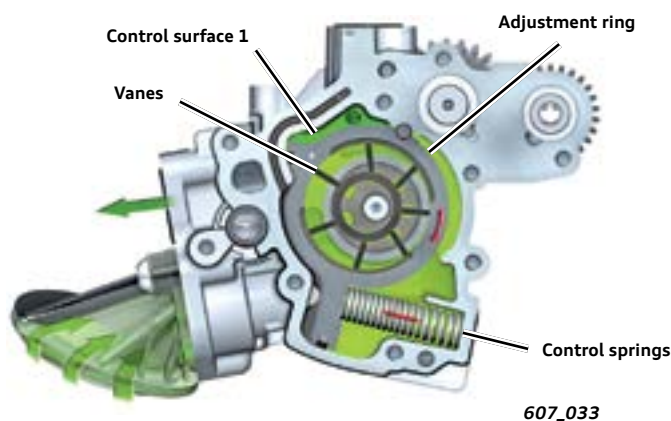
The adjusting ring rotates when oil pressure reaches the control surfaces. The flow to control surface 2 (see next page) can be switched by the oil pressure control valve. The counter-force is generated by two control springs, which press against control surface 2 of the adjusting ring. The springs have specially designed characteristic curves, ensuring that the correct volumetric flow is always available, both in the low and the high pressure stage.

Operation of Volumetric Flow Control

(identical for both pressure stages)

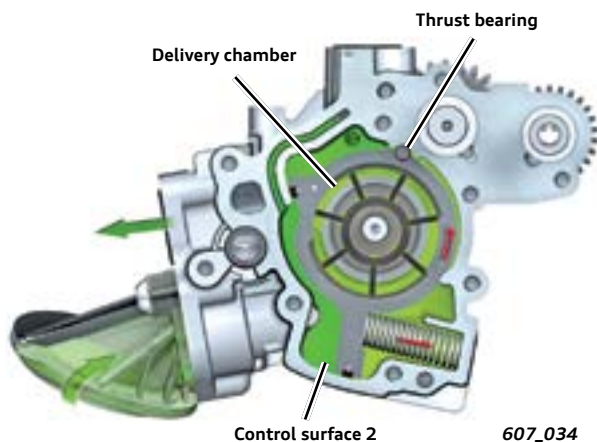
Increased Delivery Rate

With increased engine speed, there is a drop in oil pressure in the system. This is due to the increased requirements of the consumers. Control springs displace the adjusting ring, making the interior of the pump larger and increasing the pump delivery rate.

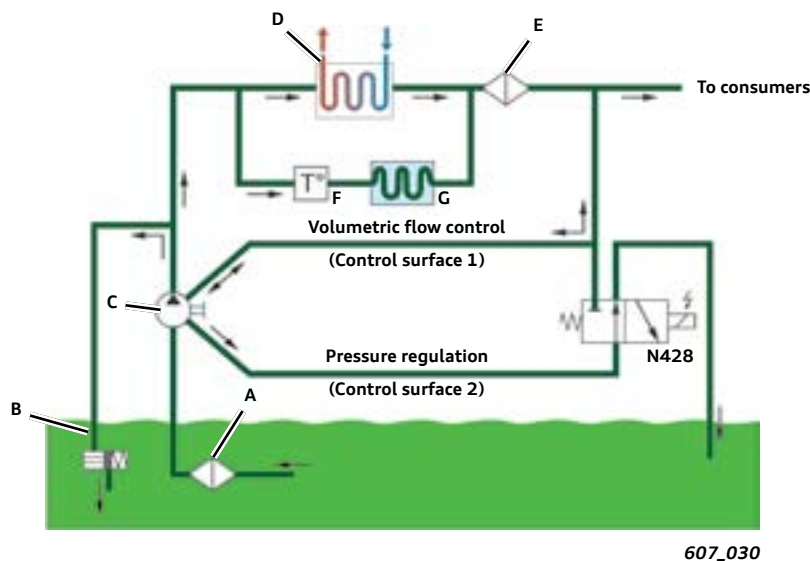


Reduced Delivery Rate

When engine speed drops along with the oil requirements of the engine, there is an increase in pressure. Higher pressure acts across the control surface(s) of the adjusting ring and displaces it so the interior of the pump is made smaller, decreasing the pump delivery rate.



Oil Pressure Regulation Schematic Overview



Legend:

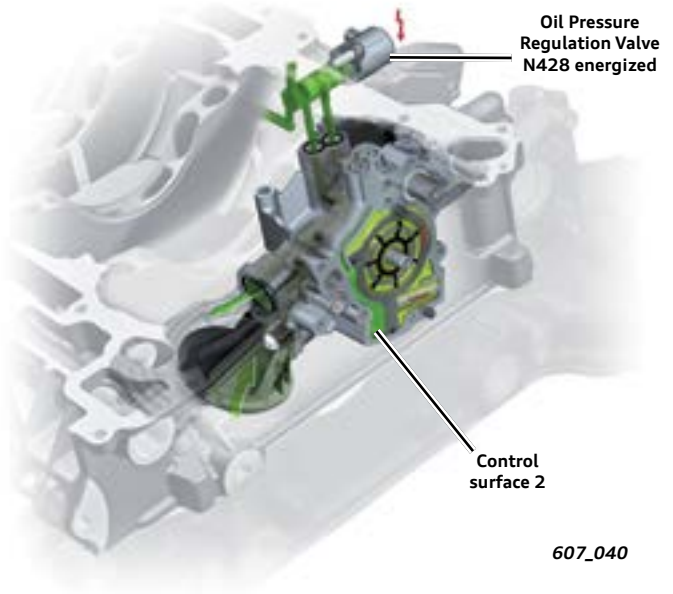
- | | |
|-----------------------|--------------------------------------|
| A Oil screen | E Oil filter |
| B Control valve | F Thermostat |
| C Oil pump | G Oil-to-air heat exchanger |
| D Water to oil cooler | H Oil Pressure Regulation Valve N428 |

Oil Pressure Regulation

Low Pressure Level

Oil Pressure Regulation Valve N428 is switched by the ECM. As a result, the passage to control surface 2 is opened. The oil pressure generated by the pump now acts on both control surfaces and rotates the adjusting ring more.

The pump area is therefore reduced, oil pressure drops and the oil pump operates at a reduced capacity. This results in less fuel consumption.



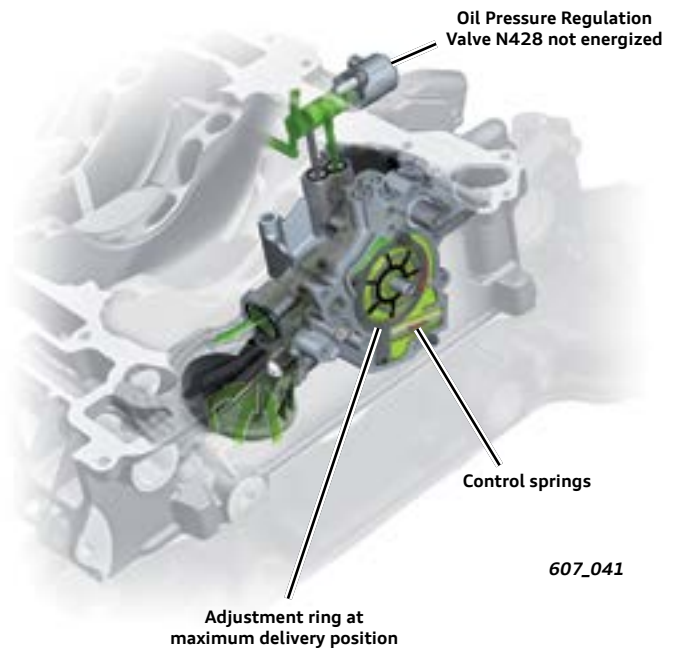
High Pressure Level

At an engine speed of 4000 rpm, a switch is made to the high pressure stage. To do this, Oil Pressure Regulation Valve N428 is switched OFF.

This interrupts oil flow to control surface 2 of the adjusting ring. Control springs now push the adjusting ring back, and the interior volume of the pump is enlarged.

The delivery rate of the pump rises and oil pressure is regulated to the high pressure level. The oil pushed back from control surface 2 is discharged by N428 into the oil pan.

The switch back to the lower pressure level takes place when engine speed falls below 3500 rpm.



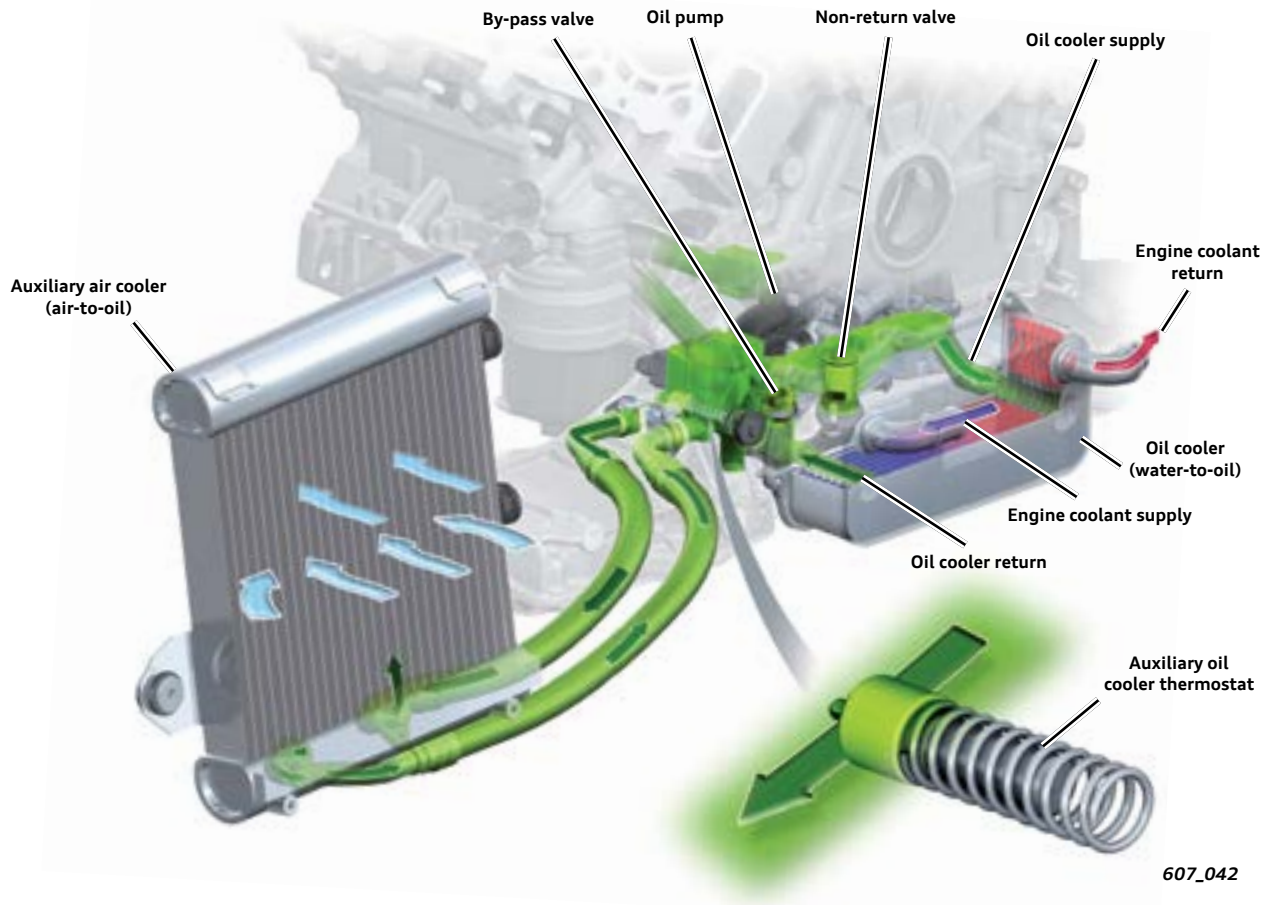
Oil Cooling

The oil delivered by the oil pump passes first into an oil passage system in the upper part of the oil pan. The oil passage has a non-return valve to ensure the oil circuit does not run empty.

The path also leads through an oil-to-water oil cooler.

The water-to-oil cooler is bolted below the vibration damper on the upper part of the oil pan. The oil from the oil cooler flows back again into the oil passages of the upper part of the oil pan and into the bed plate.

A by-pass valve is used to protect the oil cooler. It opens at a pressure of 36.2 psi (2.5 bar) and discharges into the oil cooler return.



Auxiliary Oil Cooler

An additional oil cooler is installed on the S8 version of the engine. It is an air-to-oil cooler mounted at the front of the vehicle. Oil does not flow through this cooler continuously. Flow through the additional oil cooler is regulated by a thermostat.

The thermostat is located in the oil passage of the upper part of the oil pan and opens at an oil temperature of 230 F (110°C). Ventilation of the auxiliary oil cooler takes place automatically. The auxiliary oil cooler does not drain when engine oil is changed.



Note

The thermostat for the auxiliary oil cooler cannot be replaced separately. If replacement is necessary, the upper part of the oil pan must also be replaced.

Oil Filter

The oil coming from the upper part of the oil pan (oil cooler) next reaches the cylinder block. The oil filter mount is located there. The oil filter is a polymer filter cartridge and is retained by a plastic cap.

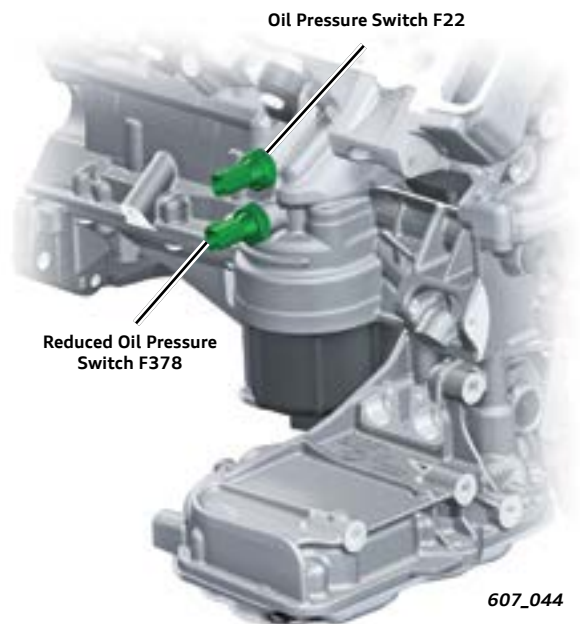
The inverted filter is placed at a service-friendly location on the engine. To make operations easier when changing the oil filter, there is a drain plug on the plastic cap.



Oil Pressure Switches F22 and F378

There are two oil pressure switches above the oil filter. They monitor the two pressure stages.

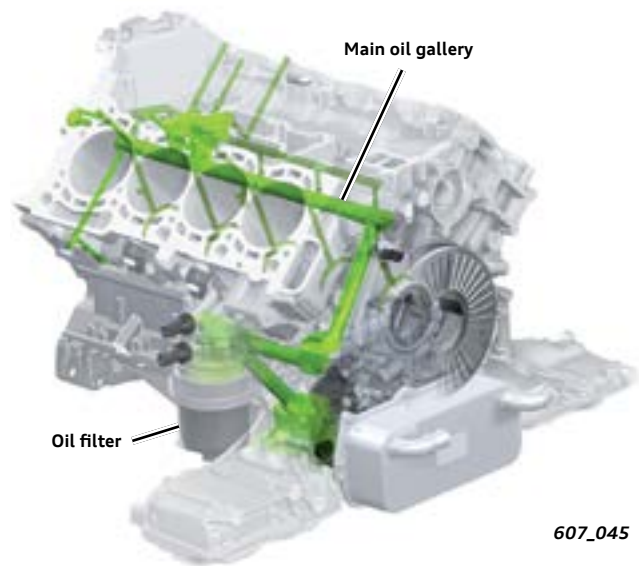
A third oil pressure switch is installed for monitoring the oil pressure of the piston cooling jets.



Oil Consumers

Clean oil reaches the main oil gallery from the oil filter. All oil consumers are supplied with engine oil from here:

- ▶ Crankshaft
- ▶ Piston cooling jets (switchable)
- ▶ Chain drives (chain tensioners)
- ▶ Cylinder heads (valve train, camshaft adjusting)
- ▶ Oil pump (oil pressure regulation)
- ▶ Exhaust turbocharger
- ▶ Vacuum pump



Additional Oil Temperature Measurement

Oil temperature is measured on its way to the main oil gallery by Oil Temperature Sensor 2 G664 (NTC).

If engine oil temperature exceeds a value of 257°F (125°C), engine power is reduced by the ECM. This protects the lead-free bearing shells in the crankshaft assembly.

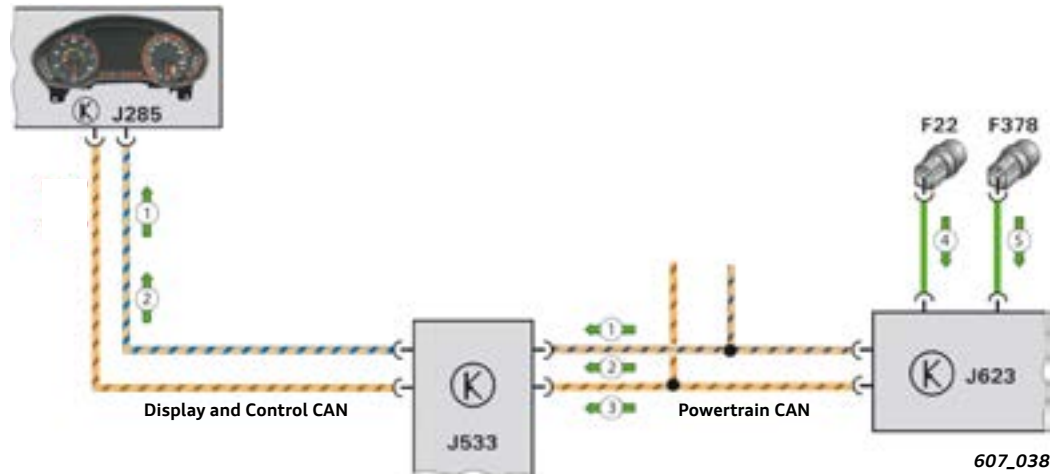
Power is also reduced if the ECM recognizes that the sensor is operating implausibly or no signal is present. An entry is made in the ECM DTC memory but a MIL is not activated.



Oil Pressure Monitoring

Oil pressure is monitored by two oil pressure switches. This is necessary because two oil pressures are implemented during engine operation.

Signal Flow



Legend:

- | | | | |
|---|--|----|---|
| 1 | Warning bit "Red Oil Can" | 6 | Oil Pressure Switch F22 |
| 2 | 2 Text-bits | 7 | Reduce Oil Pressure Switch F378 |
| 3 | Switch bit = 1 | 8 | Instrument Cluster Control Module J285 |
| 4 | Signal from Oil Pressure Switch F22 | 9 | Data Bus On Board Diagnostic Interface J533 |
| 5 | Signal from Reduced Oil Pressure Switch F378 | 10 | Engine Control Module J623 |

Oil Pressure Switch Signals/Operation

The two oil pressure switches monitor oil pressure. Reduced Oil Pressure Switch F378 monitors whether any oil pressure is present.

Oil Pressure Switch F22 monitors the high pressure level of the variable oil pump when the pump is running in the high pressure stage.

Oil Pressure Switch Signals

The ECM evaluates signals from the oil pressure switches. This was done by Instrument Cluster Control Module J285 on earlier versions of this system.

The oil pressure switches redirect electrically to ground as soon as a requisite oil pressure is reached. Both oil pressure switches are connected directly to the ECM.

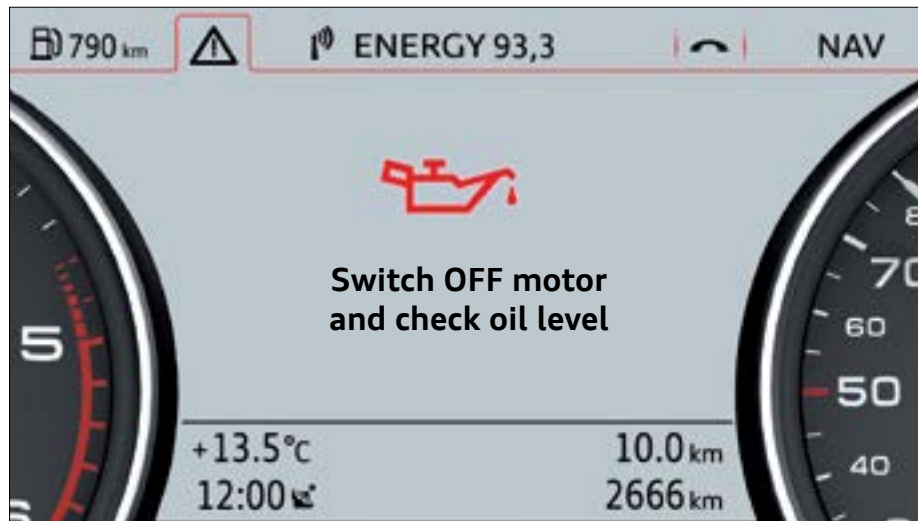
Oil Pressure Monitoring Sequence

The oil pressure switches are monitored for plausibility by the ECM with the engine both running and not running.

Plausibility with Engine Not Running

With the engine not running (ignition switched ON), there must be no signal from a closed oil pressure switch. Otherwise, it is assumed that there is an electrical fault.

With “terminal 15 ON,” a warning appears in the instrument cluster (“Red oil can” along with the error message “Switch off motor and check oil level”).



607_039

Warning with the Engine Running

With the engine running, the oil pressure switches are monitored above a specific rpm threshold depending on oil temperature.

Reduced Oil Pressure Switch F378 (low pressure stage)

With the engine not running (ignition switched ON), there must be no signal from a closed oil pressure switch. Otherwise, it is assumed that there is an electrical fault.

Possible Fault Analysis

Diagnosis for oil pressure monitoring is done by the ECM.

Oil Pressure Switch F22 (high pressure step)

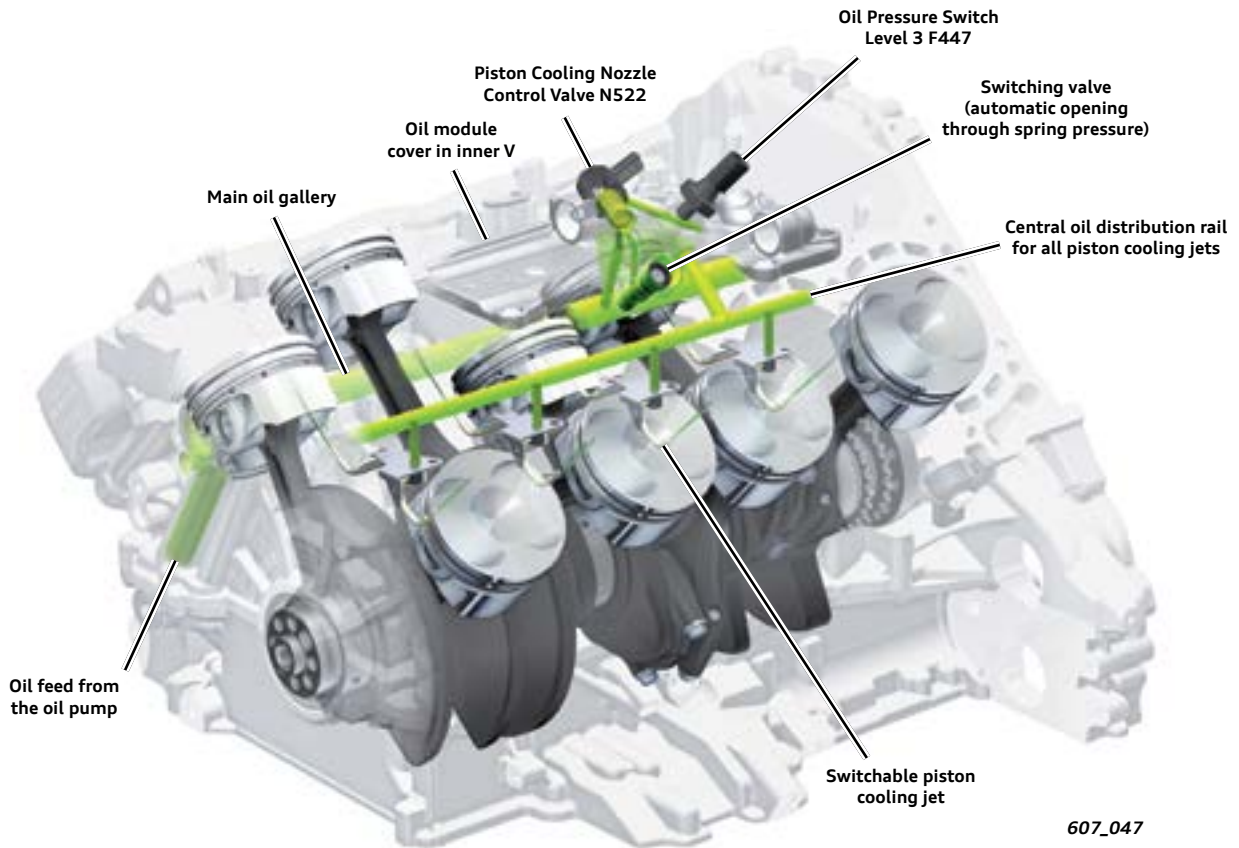
Oil pressure switch F22 is monitored as soon as the oil pump delivers in the high pressure stage and engine speed exceeds a value calculated by the ECM map, which is temperature dependent.

If the oil pressure switch is not recognized as closed, Engine Electronics Indicator Lamp K149 is activated and engine speed is restricted. The restriction of engine speed is displayed in the instrument cluster as a yellow rpm symbol and text message.

Switchable Piston Cooling Jets

It is not necessary to cool the piston crowns with oil spray during every engine operating condition. If the piston cooling jets are switched OFF, the oil pump delivers less oil (volumetric flow control), resulting in reduced fuel consumption.

The task of switching the piston cooling jets ON and OFF is done by Piston Cooling Nozzle Control Valve N522, which is located in the inner V of the cylinder block. N522 controls a hydraulic switching valve for this purpose.



eMedia



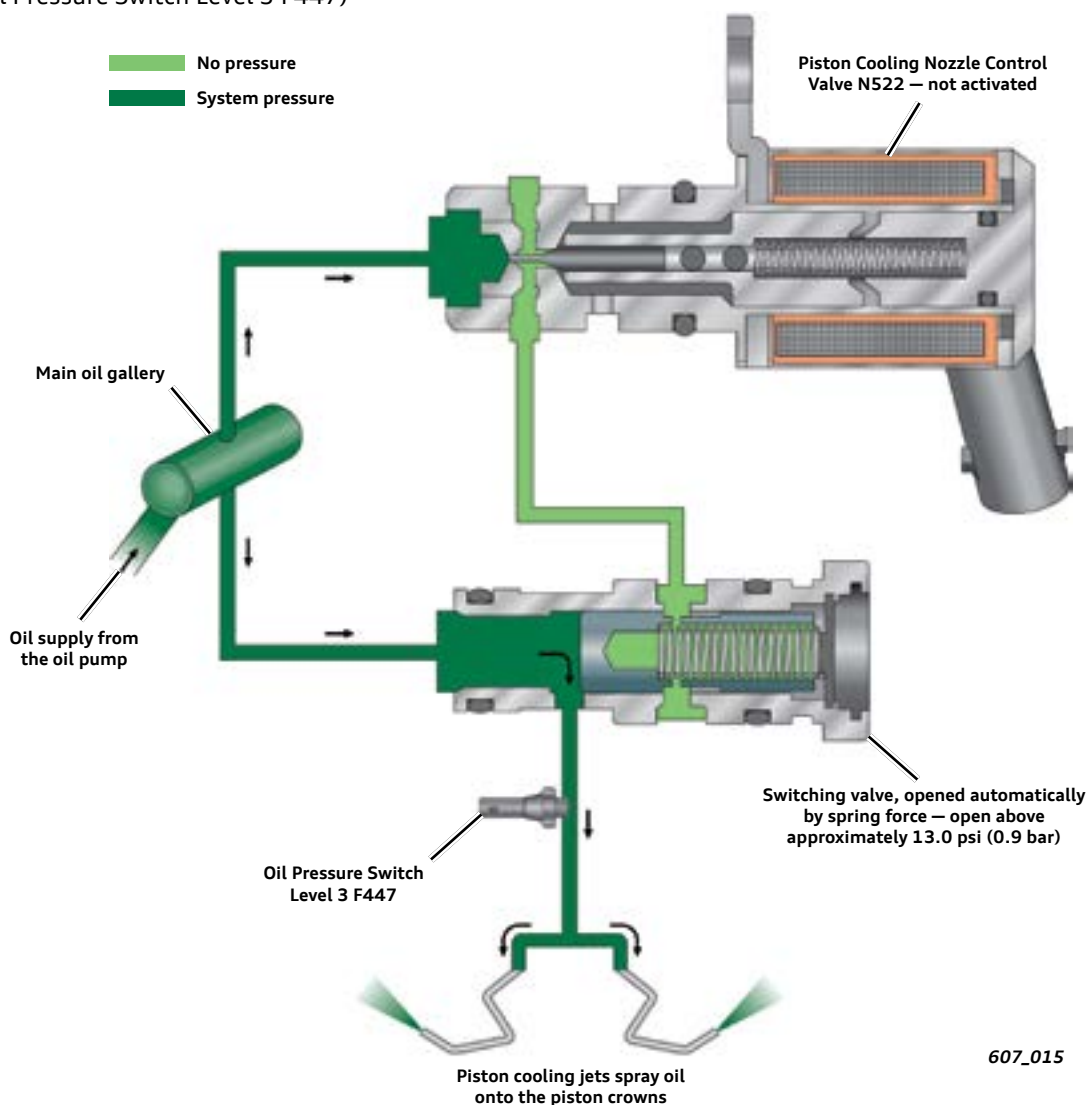
Click this link to view an animation describing piston oiling.

Operation

Piston Cooling Jets Switched ON

If N522 is not activated by the ECM, the passage to the piston cooling jets is open. Oil is sprayed onto the piston crowns. This ensures that the pistons are cooled should one of the following malfunctions occur:

- ▶ A wire is defective, a connector is loose, or the electric control valve sticks
- ▶ Sticking hydraulic switching valve
- ▶ Faulty activation
- ▶ Sticking control valve in piston cooling jets OFF position (can only be detected by the diagnosis of Oil Pressure Switch Level 3 F447)



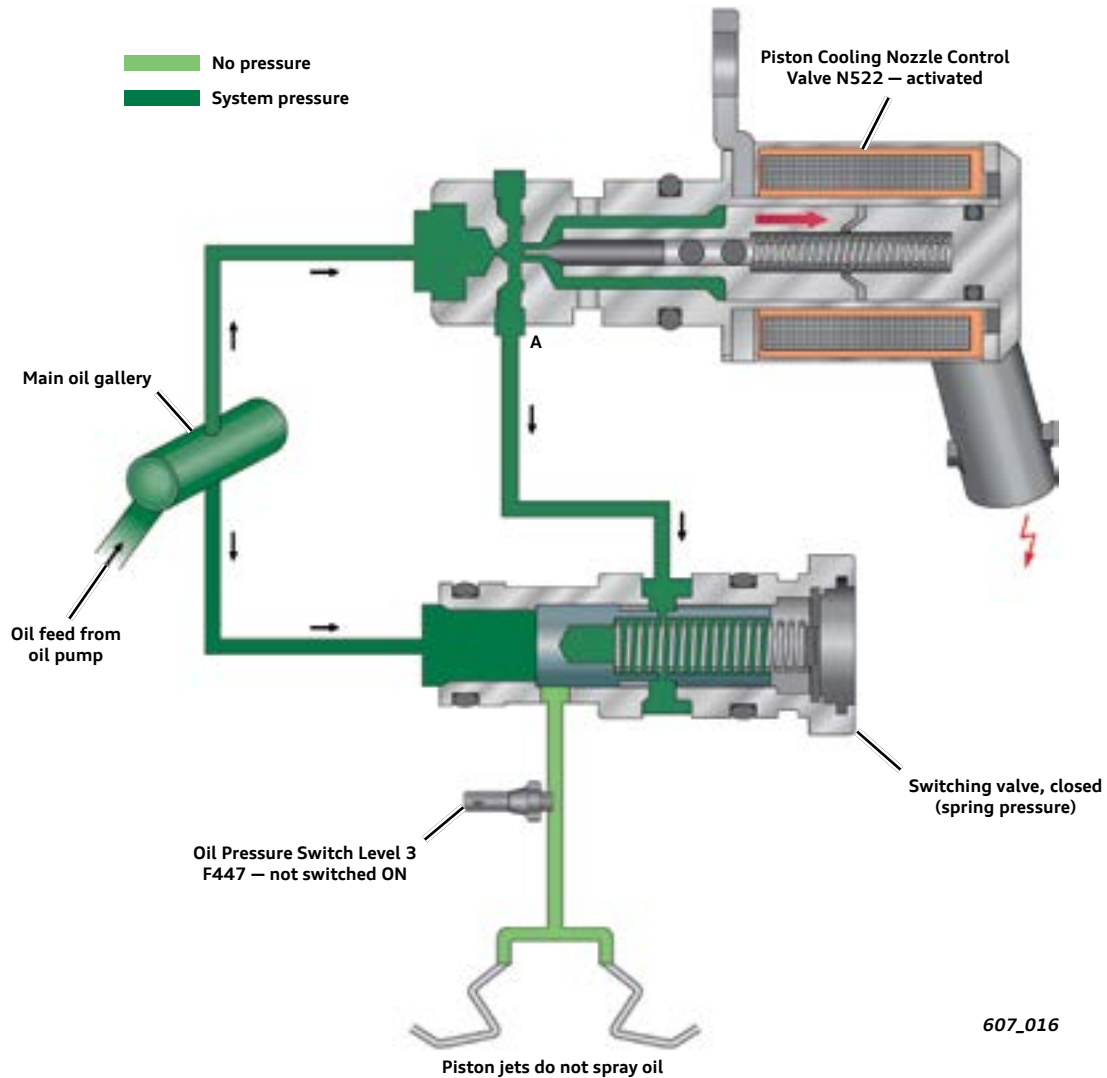
607_015

Piston Cooling Jets Switched OFF

The deactivation of the piston cooling jets is controlled. A characteristic map is stored in the ECM for this purpose. The piston cooling jets can only be switched OFF when current is present.

When N522 is activated, passage A is opened.

Oil flows out of the main oil gallery onto the control piston of the switching valve. Since oil pressure is now present on both sides of the piston, spring force predominates in the switching valve, closing access to the piston cooling jets.

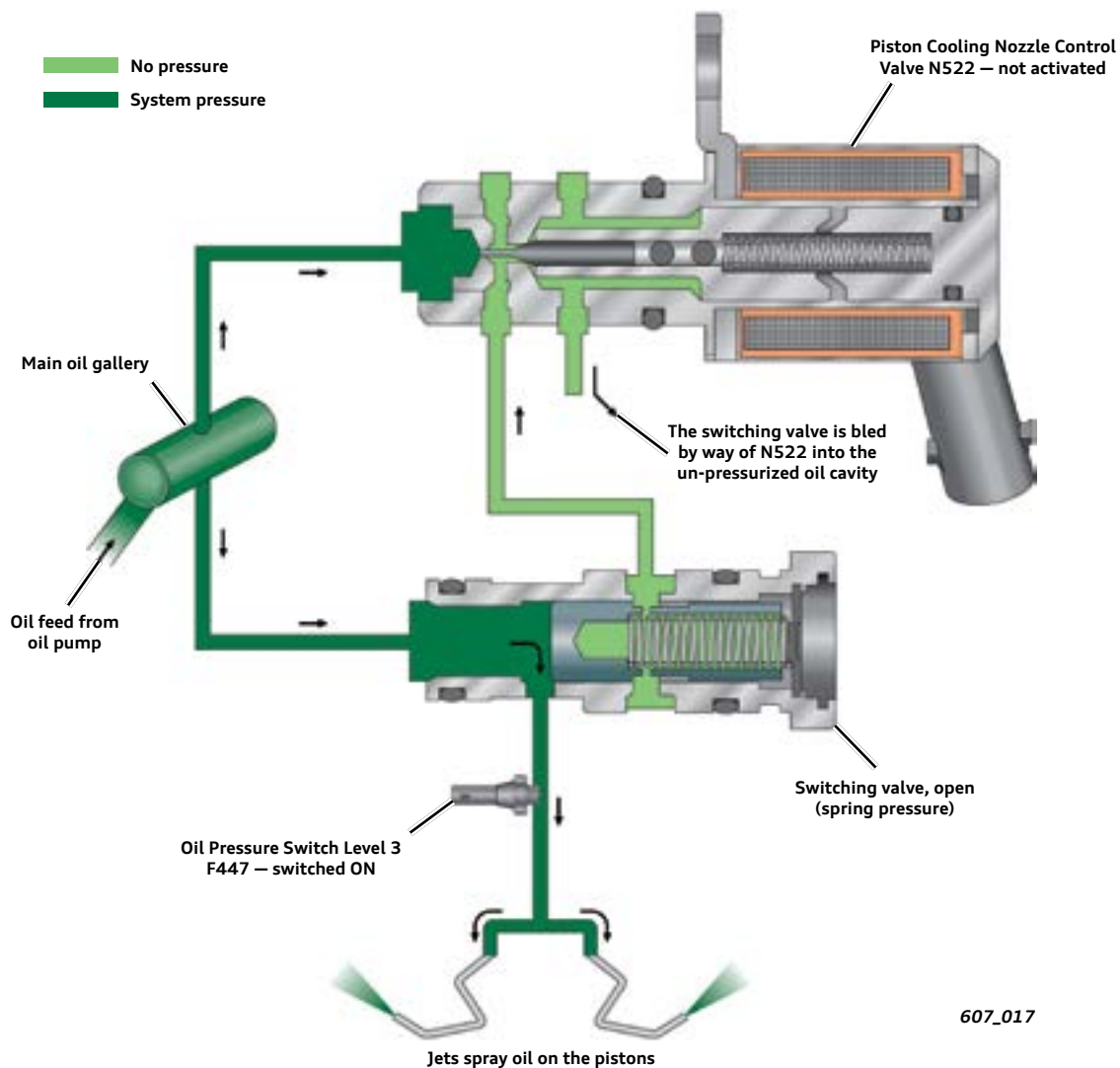


607_016

Bleed Function

Switching OFF N522 interrupts the flow to the second piston surface of the switching valve. At the same time a passage opens in the control valve for piston cooling jets.

The discharged oil from the second surface of the switching valve can run off through this passage, flowing into the oil return passage for the turbochargers.



Oil Pressure Switch Level 3 F447

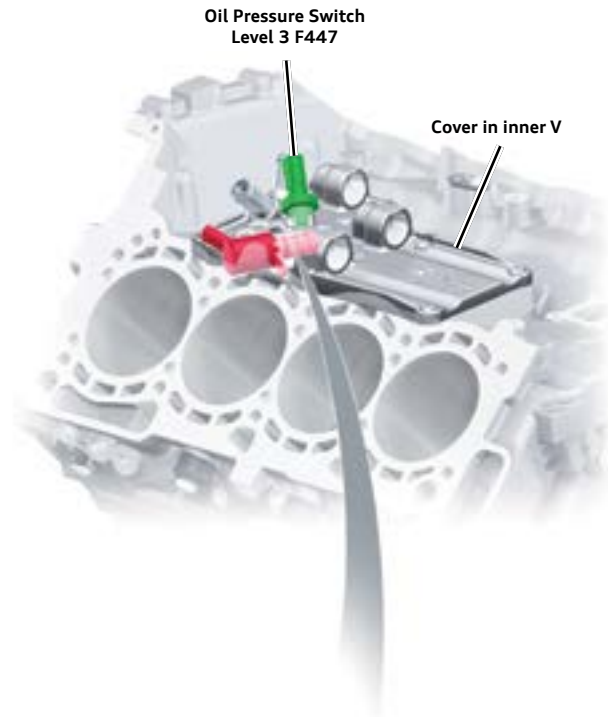
F447 is bolted to the cover in the inner V. It measures oil pressure between the switching valve and the piston cooling jets.

When the piston cooling jets are activated, F447 is closed. Its switching range is between 2.5 psi (0.3 bar) and 8.7 psi (0.6 bar).

If N522 is not activated by the ECM, the passage to the piston cooling jets is open (F447 closed).

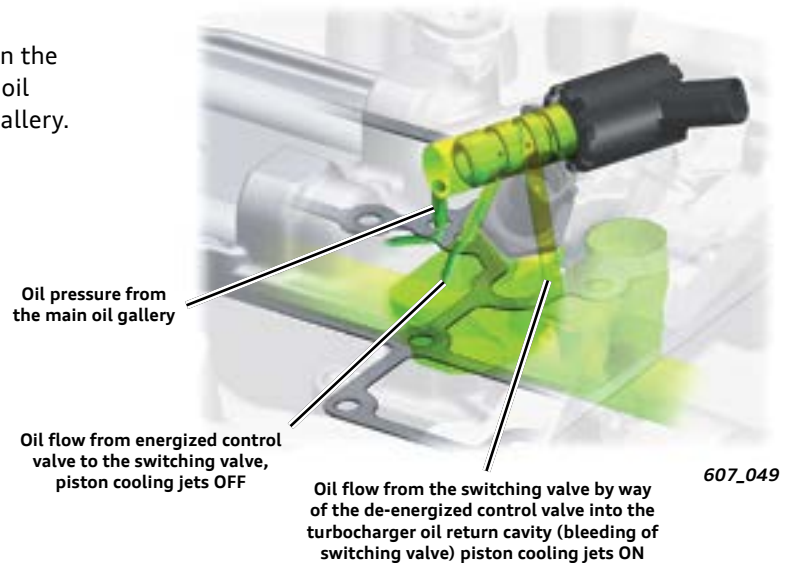
This ensures that in the event of a failure in activation, the piston crowns are cooled during every engine operating situation.

A sticking N522 ("piston cooling jets OFF position") can be detected through diagnosis. In this condition, engine power is reduced.



Piston Cooling Nozzle Control Valve N522

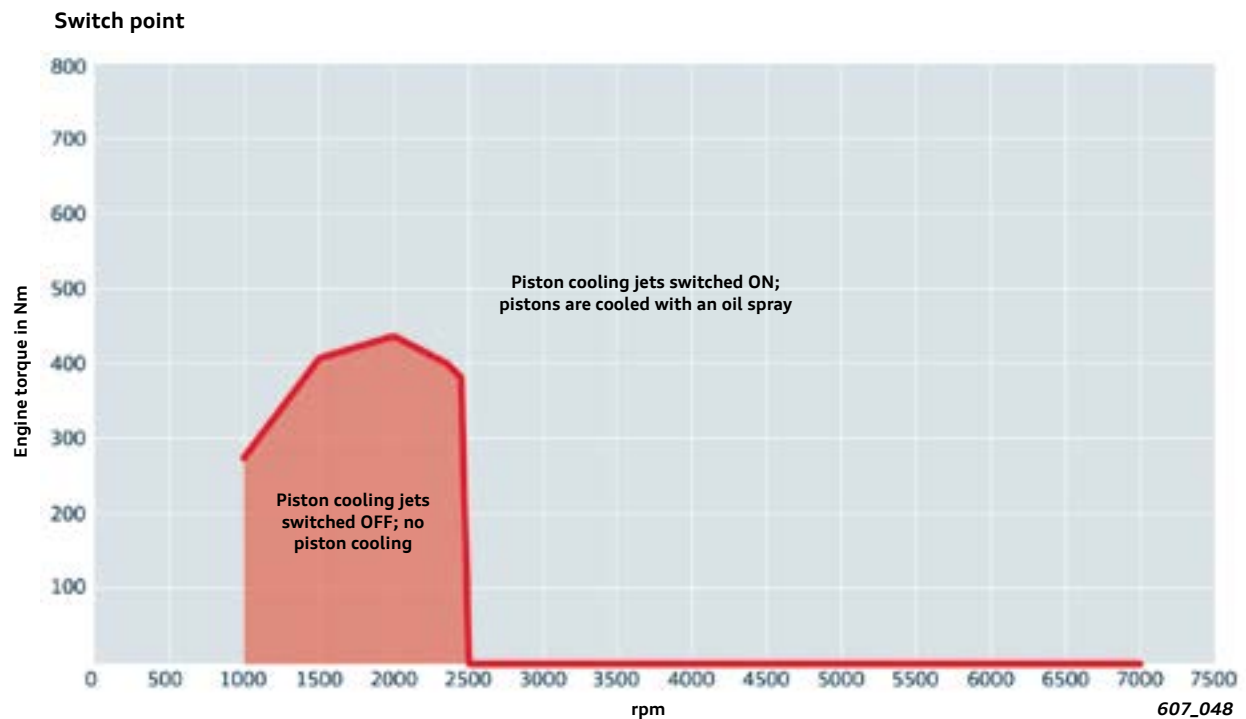
N522 is located on the cover of the oil module in the inner V of the cylinder block. It is supplied with oil pressure through a connection to the main oil gallery.



Piston Cooling Jet Operating Range

An ECM map determines the switch point and time period the piston cooling jets are switched ON. Engine torque and engine rpm are used as the variables for calculation. The area represented by red in the graph below shows when the piston cooling jets are switched OFF.

The piston cooling jets are operated initially when an engine speed of 2500 rpm is exceeded. They are then operated when a stored engine torque value is exceeded as a function of rpm.



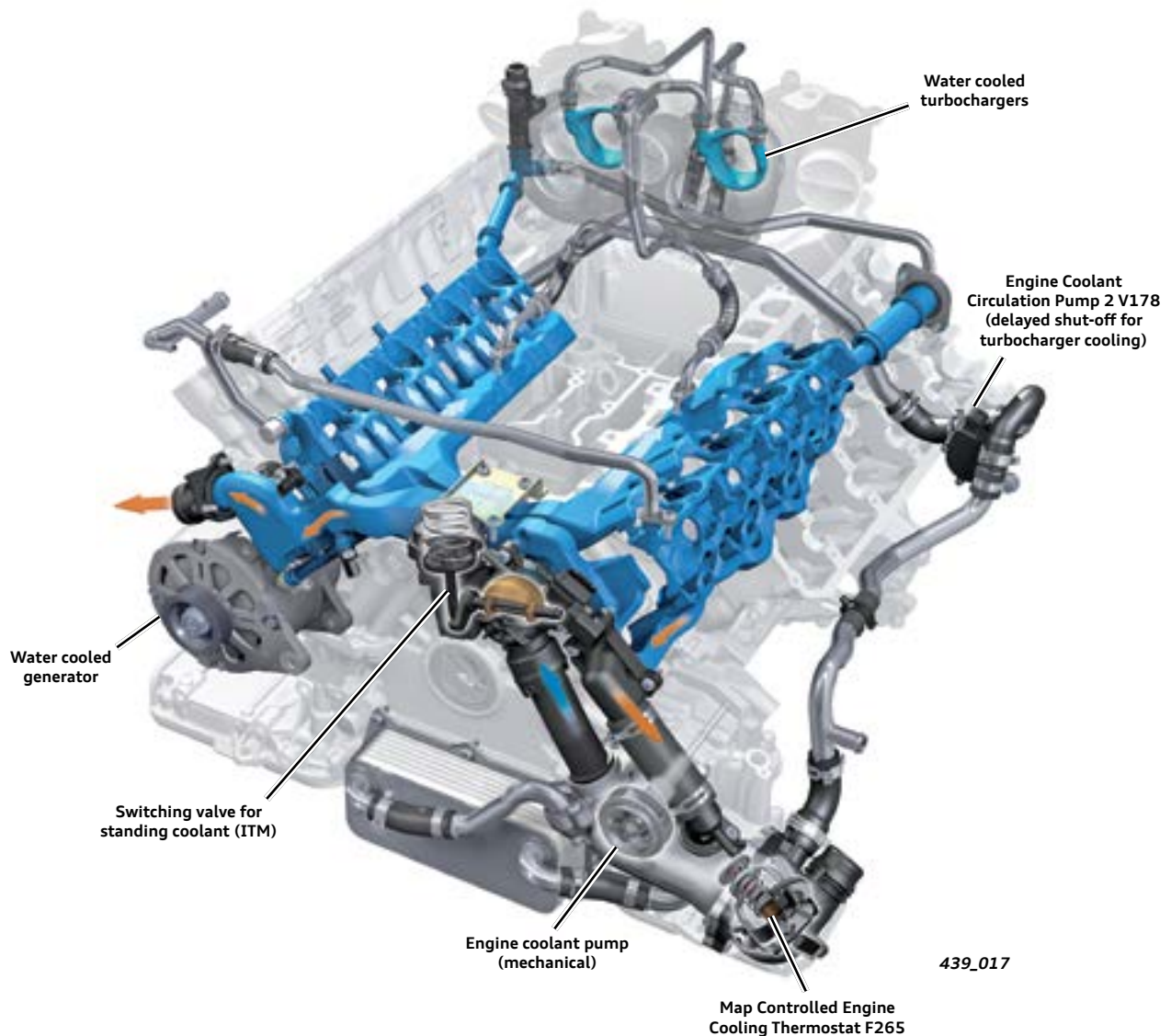
Cooling System

Overview

Different cooling systems are used depending on engine and vehicle version. The number of radiators differs, as well as their design.

The cooling systems for the A8 and S8 are identical with the exception of the ATF heating/cooling (refer to page 48 for more detailed information).

The version illustrated on page 45 shows the cooling system for the Audi A8.

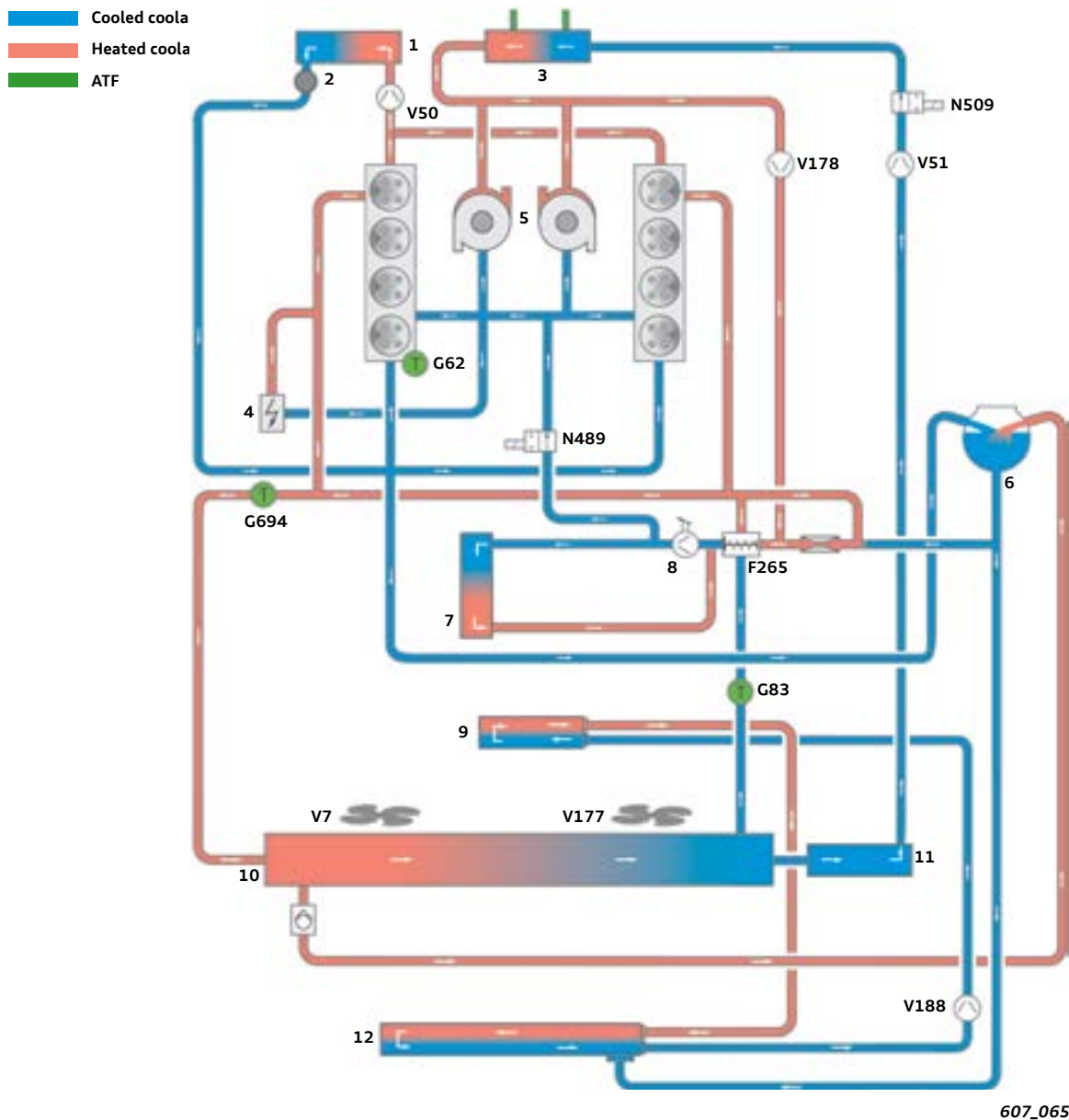


eMedia



Click this link to view an animation describing the cooling system.

Audi S6 and S7



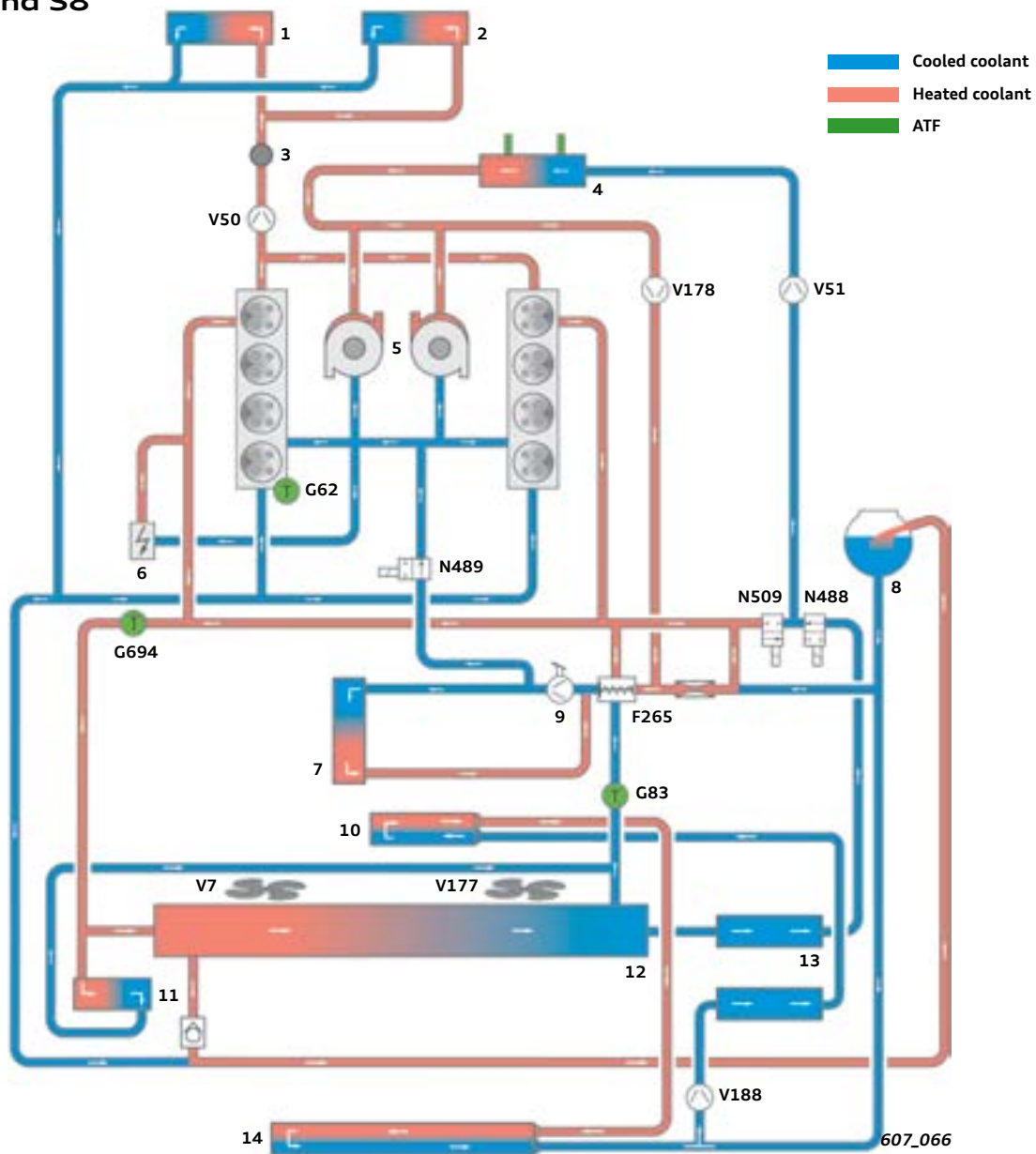
Legend for the following page:

F265	Map Controlled Engine Cooling Thermostat	1	Heat Exchanger (passenger heating)
G62	Engine Coolant Temperature Sensor	2	Bleeder Screw
G83	Engine Coolant Temperature Sensor on Radiator Outlet	3	ATF Heat Exchanger
G694	Engine Temperature Control Sensor	4	Generator
N279	Heater Coolant Shut-Off Valve	5	Turbochargers
N489	Cylinder Head Coolant Valve	6	Coolant Expansion Tank
N509	Transmission Fluid Cooling Valve	7	Engine Oil Cooler
V7	Coolant Fan	8	Coolant Pump
V50	Coolant Recirculation Pump	9	Charge Air Cooler
V51	After-Run Coolant Pump	10	Radiator
V55	Recirculation Pump	11	Auxiliary Coolant Radiator
V177	Coolant Fan 2	12	Cooler for Charge Air Intercooling Coolant
V178	Engine Coolant Circulation Pump 2		
V188	Charge Air Cooling Pump		

Notes



Audi A8 and S8



Legend:

F265	Map Controlled Engine Cooling Thermostat	1	Heat Exchanger (front passenger compartment)
G62	Engine Coolant Temperature Sensor	2	Heat Exchanger (rear passenger compartment)
G83	Engine Coolant Temperature Sensor on Radiator	3	Bleeder Screw
G694	Engine Temperature Control Sensor	4	ATF Heat Exchanger
N279	Heater Coolant Shut-Off Valve	5	Turbochargers
N488	Transmission Coolant Valve	6	Generator
N489	Cylinder Head Coolant Valve	7	Engine Oil Cooler
N509	Transmission Fluid Cooling Valve	8	Coolant Expansion Tank
V7	Coolant Fan	9	Coolant Pump
V50	Coolant Recirculation Pump	10	Charge Air Cooler
V51	After-Run Coolant Pump	11	Auxiliary Radiator (A8 '12 only)
V55	Recirculation Pump	12	Radiator
V177	Coolant Fan 2	13	Auxiliary Radiator 2
V178	Engine Coolant Circulation Pump 2	14	Radiator for Charge Air Cooling
V188	Charge Air Cooling Pump		

Engine Cooling Circuit and Cooling Module

Engine Coolant Pump (mechanical)

Engine coolant circulation is driven by the primary coolant pump, which provides necessary volumetric flow for:

- ▶ Cooling the engine and the turbochargers
- ▶ Flow through the engine oil cooler

The design is based on the coolant pump of the normally aspirated 4.2L V8 FSI engine.

The pump is driven by a shaft connected by a rigid reduction gear in the oil pump to the crankshaft. The thermostat is flanged to the coolant pump on the suction side.

Switching Valve for ITM

The Innovative Thermal Management (ITM) system uses a ball valve. When closed, it interrupts the flow of coolant. This allows the oil to reach its operating temperature quickly, with the period of increased frictional losses shortened. This reaction is implemented following each engine start when coolant temperatures are below 176°F (80°C).

The switching valve is mounted to the cylinder block between the vibration damper and air intake. Integrated into the pressure-side coolant pipe, between the coolant pump and the cylinder block, the valve is switched pneumatically through a vacuum actuator. Vacuum is provided by the vacuum pump and controlled by Cylinder Head Coolant Valve N489.

The switching valve, vacuum actuator, and electrical switch-over valve form one assembly unit. All circuit operating modes are determined by an ECM characteristic map.

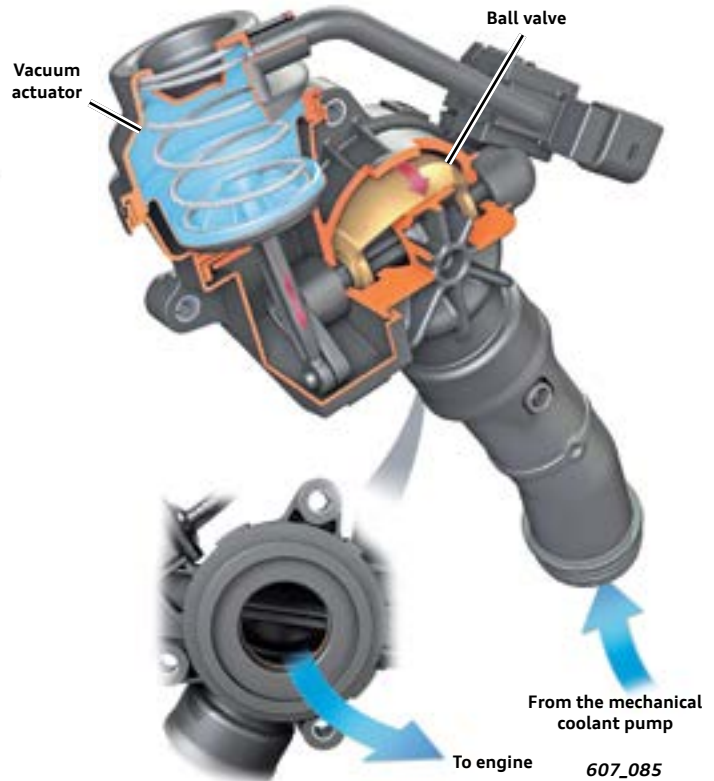
When the switch is closed, the ball valve is activated. No intermediate positions are used. When coolant flow is opened up again when the engine reaches operating temperature, it is done in stages. This prevents a drop in coolant temperature in the cylinder-engine block from the sudden onset of coolant flow.

The switching valve can be activated by the Scan Tool (DTM) for diagnostic purposes. A manual check or a check using a hand vacuum pump is also possible.

Switching valve closed



Switching valve open

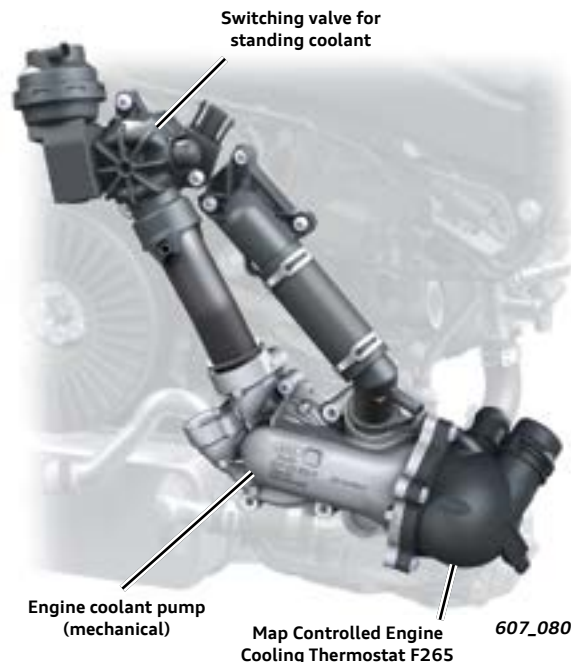


Map Controlled Engine Cooling Thermostat F265

The thermostat is positioned on the suction side of the coolant pump. The thermostat opening is temperature-activated by a wax element. The opening temperature can also be lowered using a heating element.

Heating element activation is managed through the ECM per a characteristic map. The ECM uses the input variables of air temperature, engine load, speed, and coolant temperature for its calculation. From these, it calculates the continuously adjustable electrical heating of the expansion element.

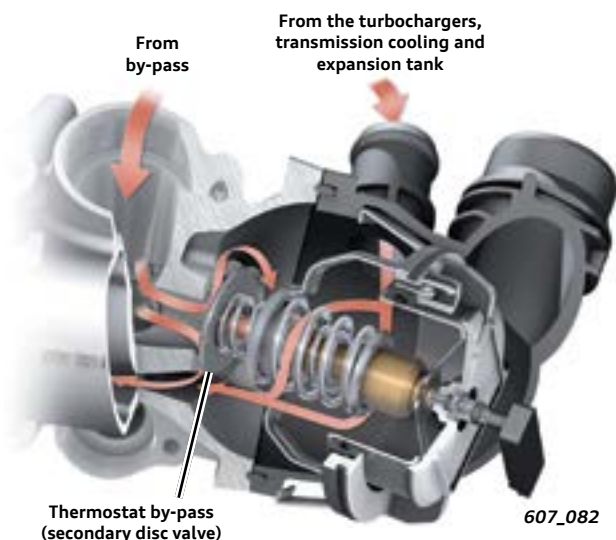
The mechanics of the thermostat are the same as those of an annular slide-valve thermostat. The latter is similar in construction and function to that of the 6.3L W12 engine.



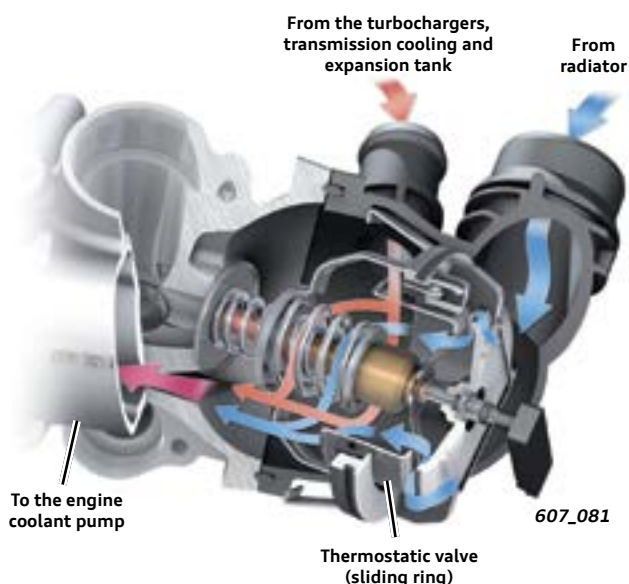
Operating temperatures

Operating range	-40 to +275°F (-40 to +135°C)
Thermostat opens at (de-energized)	206.6 ±1°F (97 ±2°C)
Thermostat opens at (energized)	Depending on current applied and outside temperature (ECM map controlled)

Thermostat closed (by-pass open)



Thermostat open (by-pass closed)



Reference

For further information about Mapped Controlled Engine Cooling Thermostat F265, refer to eSelf-Study Program 920113, *The 6.3L W12 FSI Engine*.

Transmission Fluid Heating/Cooling

An additional function of ITM is the cooling and heating of the transmission fluid (ATF). There are differences in the system, depending on the engine variant.

The two versions are:

- ▶ System 1: Audi S6, S7, and S8
- ▶ System 2: Audi A8 with 420 hp (309 kW) engine

System 1 in Audi S6, S7, and S8

Only the transmission cooling system is used. Transmission Fluid Cooling Valve N509 and After-Run Coolant Pump V51 are installed in the ATF cooling circuit. N509 and V51 are activated by the ECM.

V51 is switched on by the ECM when the ATF temperature is above 204.8°F (96°C). N509 is opened at temperatures greater than 197.6°F (92°C) and closed again at temperatures less than 176°F (80°C).

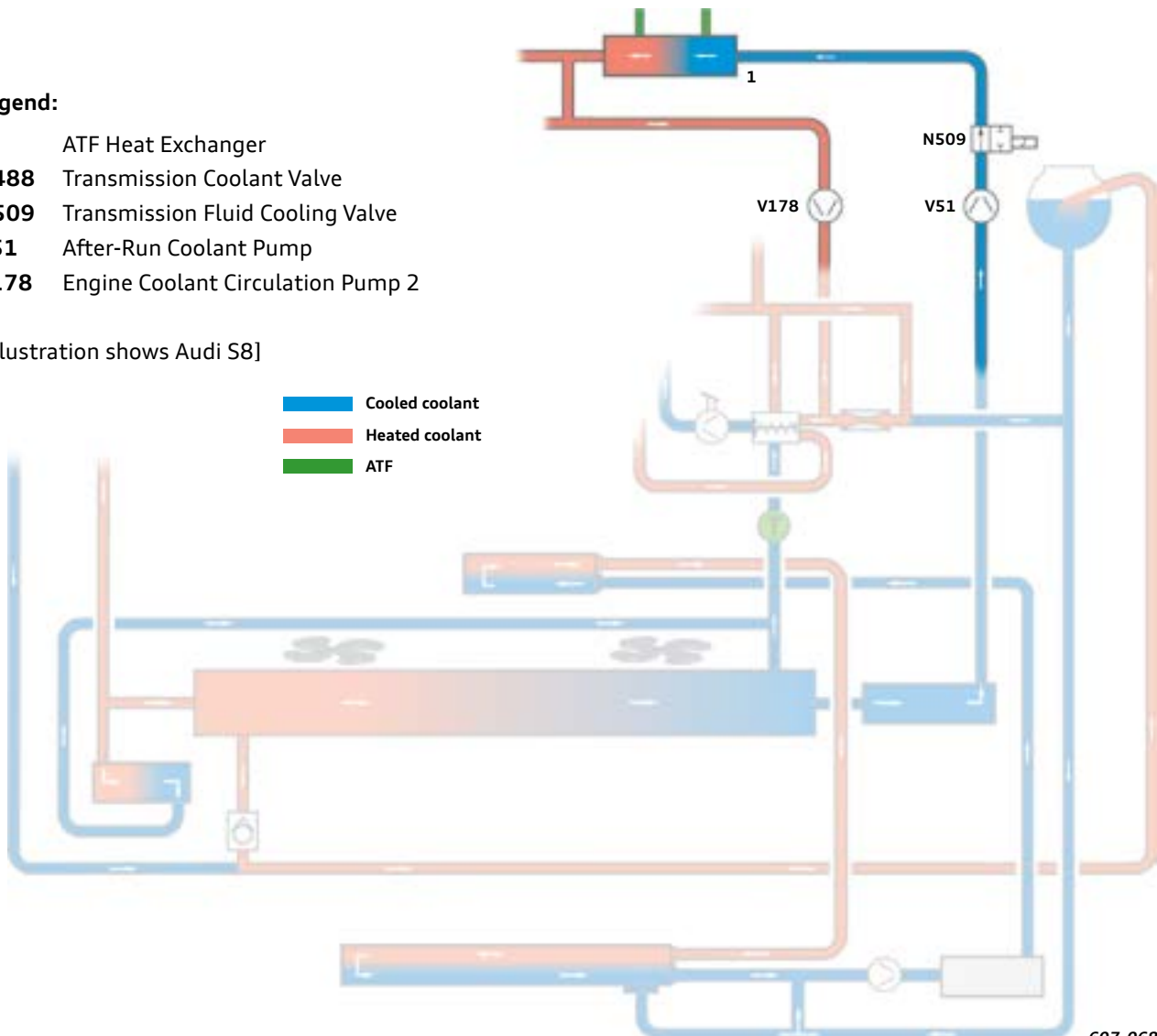


607_071

Legend:

- 1** ATF Heat Exchanger
- N488** Transmission Coolant Valve
- N509** Transmission Fluid Cooling Valve
- V51** After-Run Coolant Pump
- V178** Engine Coolant Circulation Pump 2

[Illustration shows Audi S8]



607_068

System 2 in Audi A8 (420 hp 309 kW version)

The Audi A8 with a 420 hp (309 kW) engine has a second solenoid that allows the heating of the ATF in addition to its cooling.

Operation

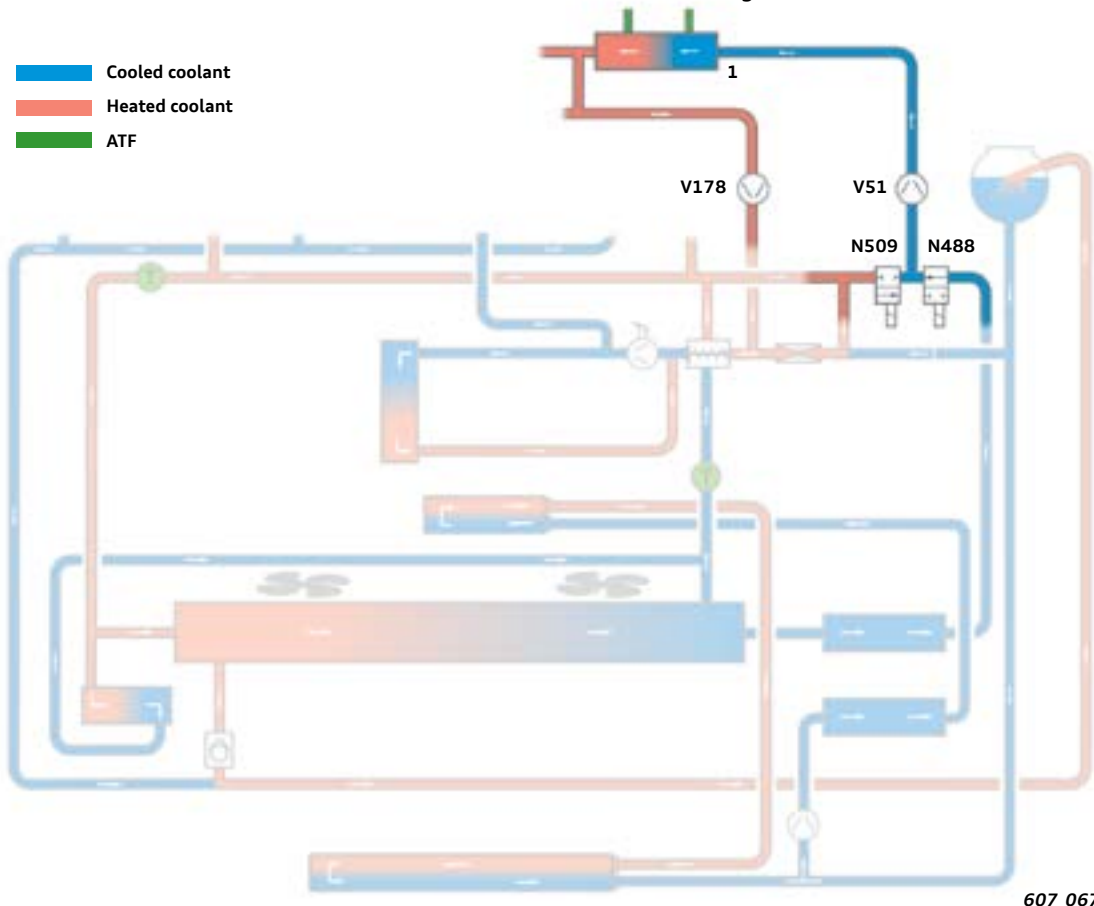
When the engine is cold and the ignition is switched ON, N488 is activated and closed by the transmission control module (TCM). Transmission Fluid Cooling Valve N509 is activated by the ECM and remains closed.

Rapid engine warm up is achieved during this “standing coolant” mode. Once the engine has reached operating temperature, the ITM software in the ECM issues the command: “Heat transmission fluid.” N509 is opened by the TCM. Hot coolant from the engine flows across the ATF cooler and heats the transmission fluid.

Transmission Coolant Valve N488 is integrated into the coolant flow between the auxiliary water radiator and the transmission fluid cooler. N488 is activated by the ECM. In its de-energized state (ignition OFF) N488 and the ATF cooling circuit are open.

V51 and V178 are not running at this point. Once an optimal temperature of 185°F (85°C) for the ATF has been reached, N509 is closed again (both valves are shut).

Above an ATF temperature of 197.6°F (92°C), N488 is opened, and the ATF is cooled. The pumps are still OFF. Pump V51 is switched ON above a transmission fluid temperature of 204.8°F (96°C) and OFF again at 197.6°F (92°C). If ATF temperatures reach a value of 248°F (120°C), pump V178 is switched ON. When the temperature falls below 230°F (110°C), V178 is switched OFF again.



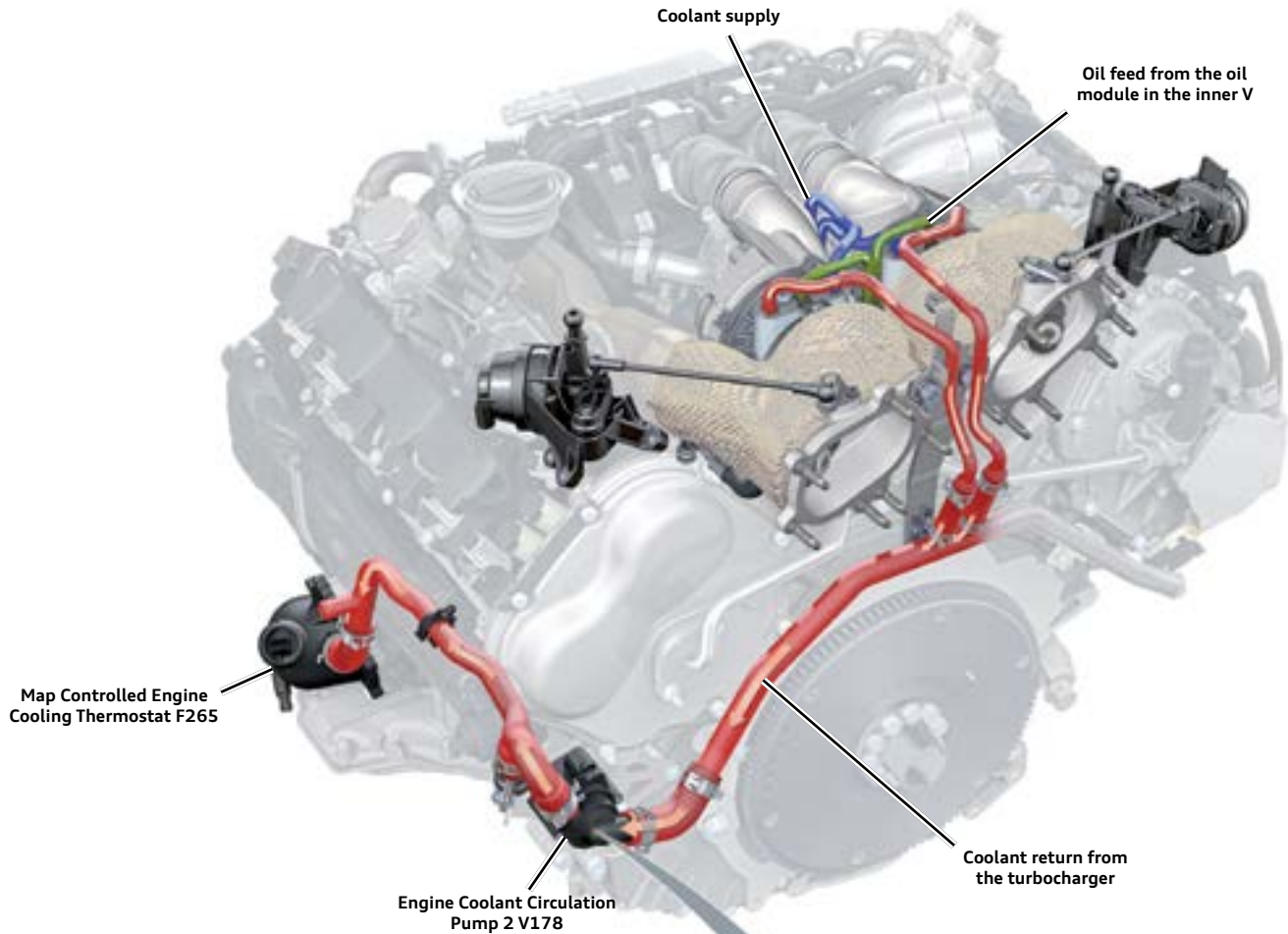
607_067

Cooling After Engine Shut-Off

If the vehicle is parked and the engine is hot, there may be an additional need for cooling to prevent damage to engine and transmission components.

To prevent possible damage, pumps V51 and V178 are switched ON for a maximum of 10 minutes. If the need arises, radiator fans are also switched ON. The after-run operation is initiated by the ECM according to a characteristic map.

Turbocharger Cooling and Lubrication



Engine Coolant Circulation Pump 2 V178

This pump (identical to V51) has two functions. The first is cooling the ATF. The second is providing additional turbocharger cooling at engine idle speed.

Turbocharger Cooling

Under certain operating conditions (maximum speed, mountain operation, and high outside temperatures) the engine may be subject to boil-off from residual heat after being shut OFF. This is prevented by the delayed shut-off function of Engine Coolant Recirculation Pump 2 V178.

After the engine is switched OFF, the pump starts up for a specific time as a function of a map stored in the ECM.

If ATF temperature exceeds 248°F (120°C), the electric radiator cooling fan runs. The radiator fan will also run when the engine is near idle speed to aid in cooling the ATF.

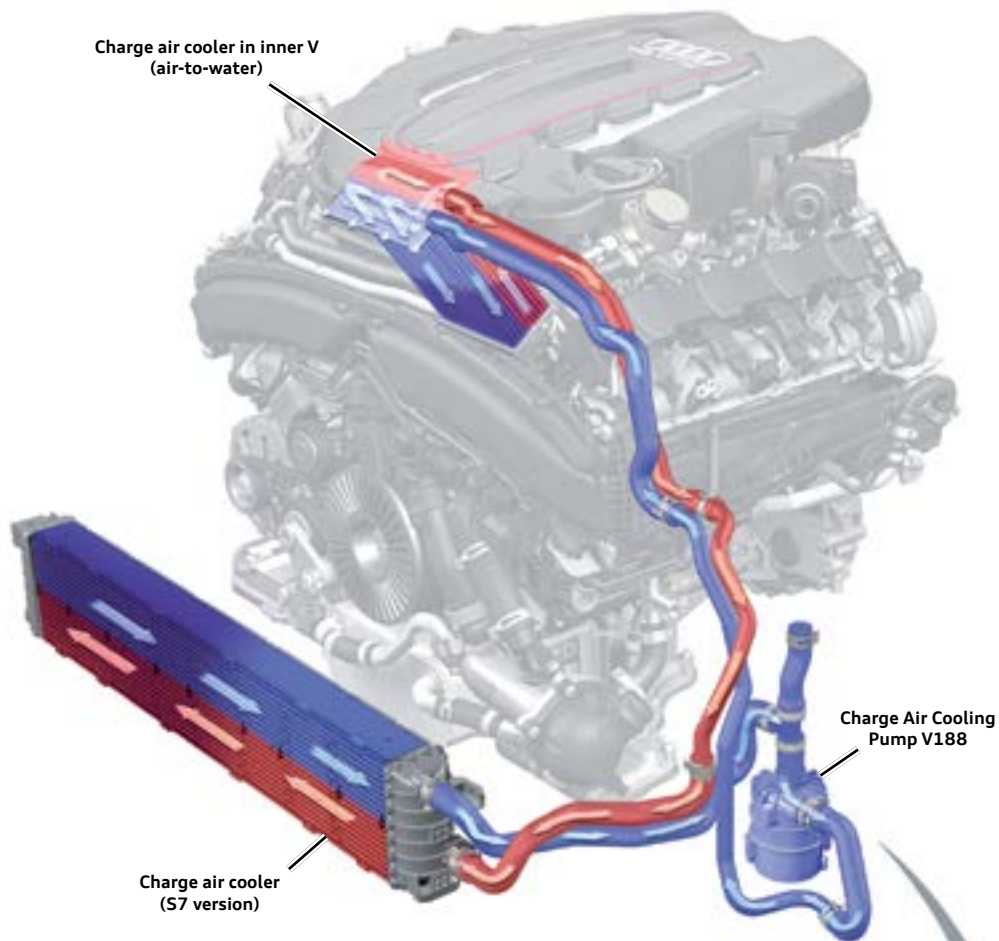


607_054

Charge Air Cooling

Charge air intercooling is done through an indirect air-to-water intercooler located in the air duct in the inner V. The charge air coolant circuit is a separate circuit from the primary cooling system. Both, however, are connected and jointly use the coolant expansion tank.

Generally, a lower temperature level prevails in the charge air cooling and primary engine cooling circuits. To monitor charge air intercooling, the ECM uses signals from sensors G763, G764 and G71. Activation of Charge Air Cooling Pump V188 then takes place according to an ECM stored characteristic map.



Charge Air Cooling Pump V188

This pump moves coolant from the charge air intercooler to the low temperature cooler. V188 is activated by the ECM as a function of various maps (load, engine speed, difference between ambient temperature, and intake air temperature). A detailed description of Charge Air Cooling Pump V188 can be found in eSelf-Study Program 925803, Audi 3.0 V6 TFSI Engine with Roots Blower.



607_055

Heater Circuit (passenger compartment)

The passenger compartment heating circuit is supplied from the cooling circuit of the cylinder heads. The latter is separate from the primary cooling circuit of the engine.

This ensures that with standing coolant in the engine block, hot coolant is available for heating. Coolant is circulated by Coolant Recirculation Pump V50.

Coolant Recirculation Pump V50

V50 is identical to After-run Coolant Pump V51. It is activated by Climatronic Control Module J255. Its activation is dependent on coolant temperature and the passenger compartment temperature setting.

It also runs when the “residual heat” function is activated or when maximum heating performance is demanded.

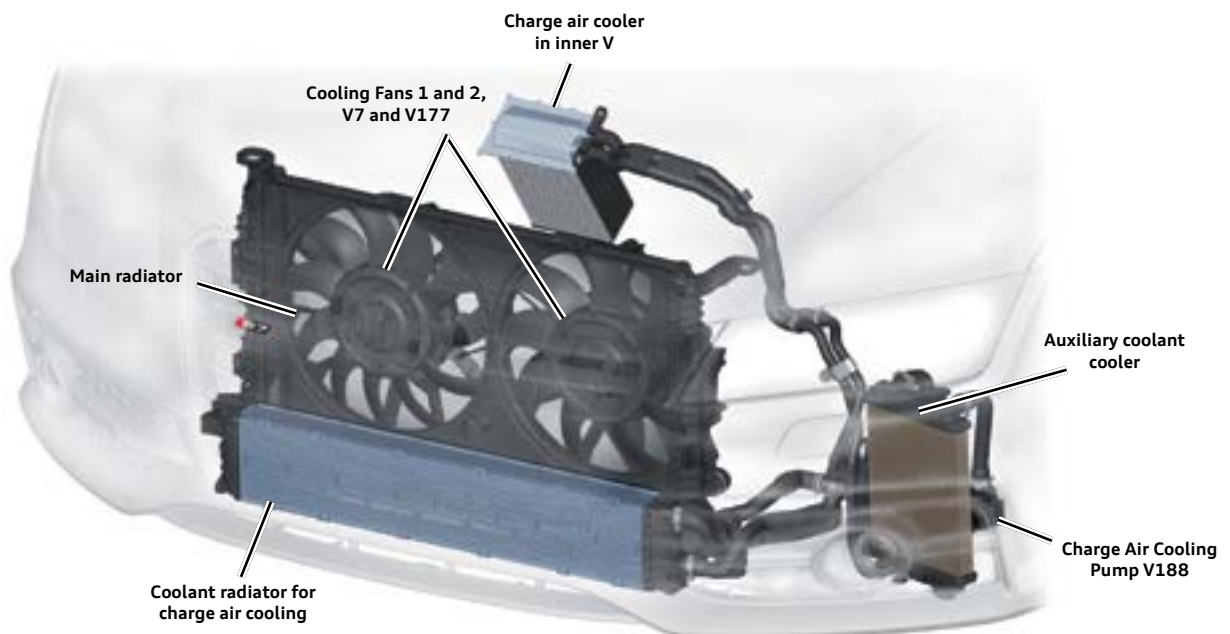
During the warm-up phase of the engine, there is “standing coolant” in the engine block. With a request for heating, the pump circulates coolant to the passenger compartment heat exchanger.

When using the “residual heat” function, the pump circulates hot water continuously in the heater circuit for approximately 30 minutes. It is switched OFF automatically. Activation takes place through a PWM signal so that the preselected temperature is reached and maintained. Pump activation is mapped by the ECM.



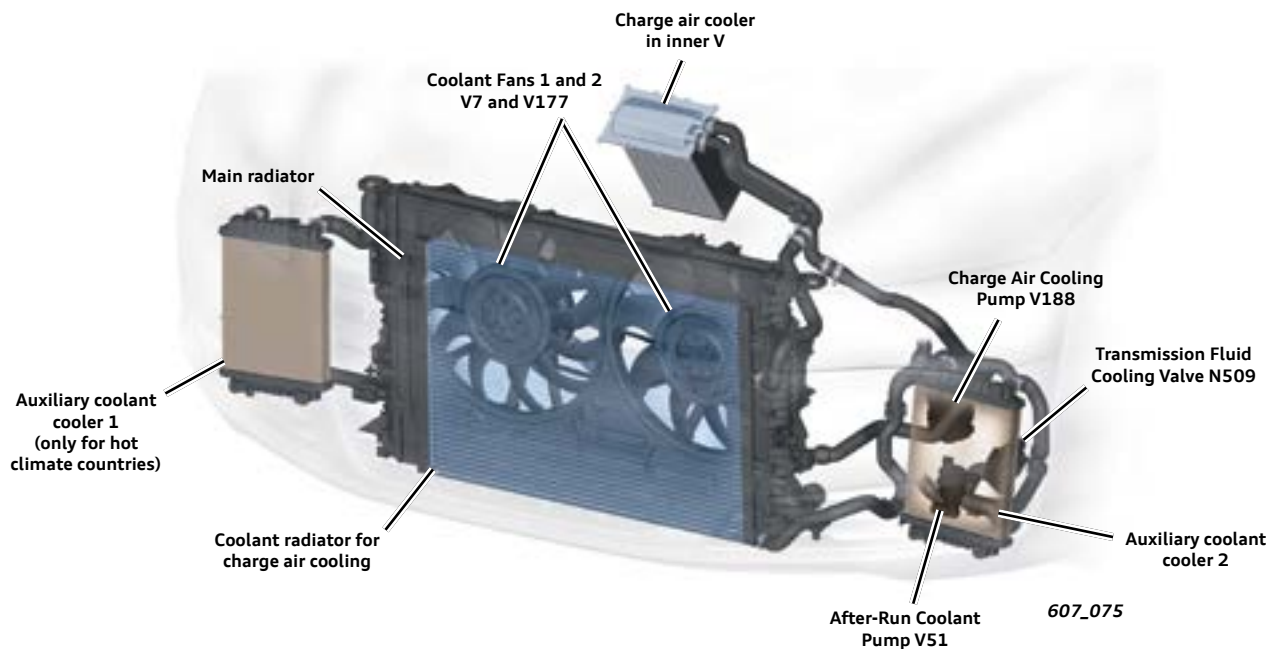
607_071

Radiator Arrangement S6 and S7

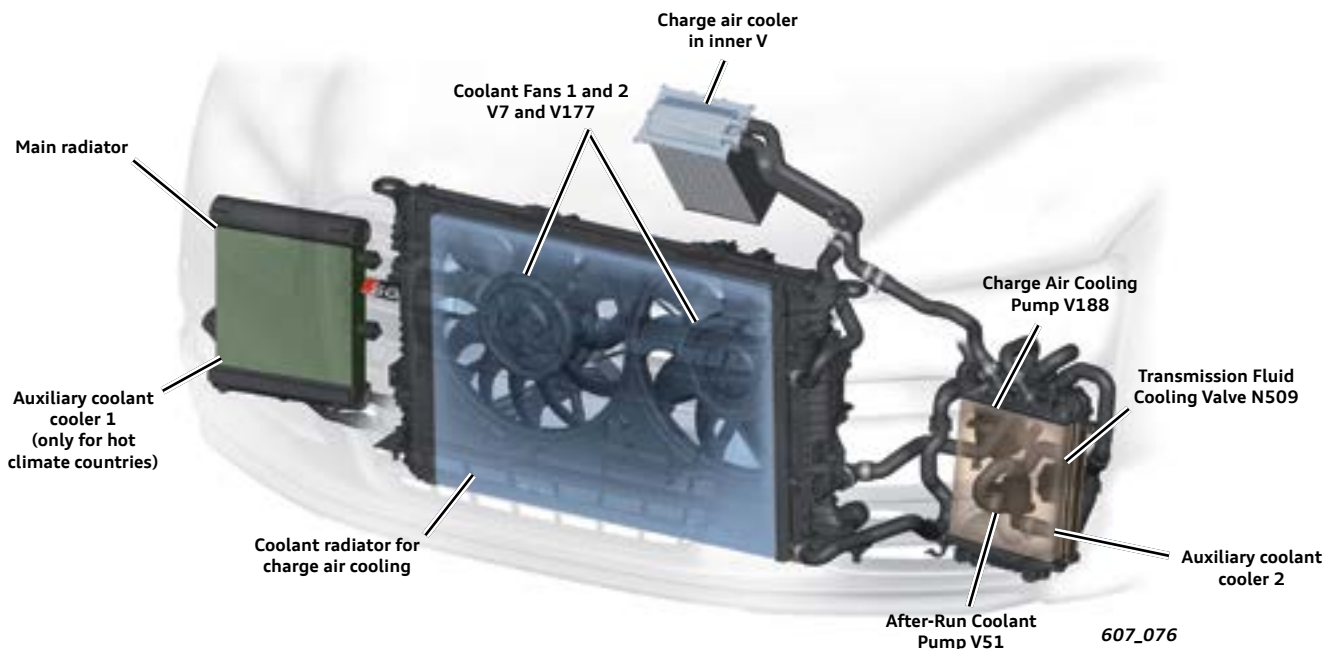


607_074

A8



S8



Note

After performing work on the cooling system, it is necessary to perform a bleeding procedure. Always consult the latest technical information for current procedures.

Air Supply and Charging

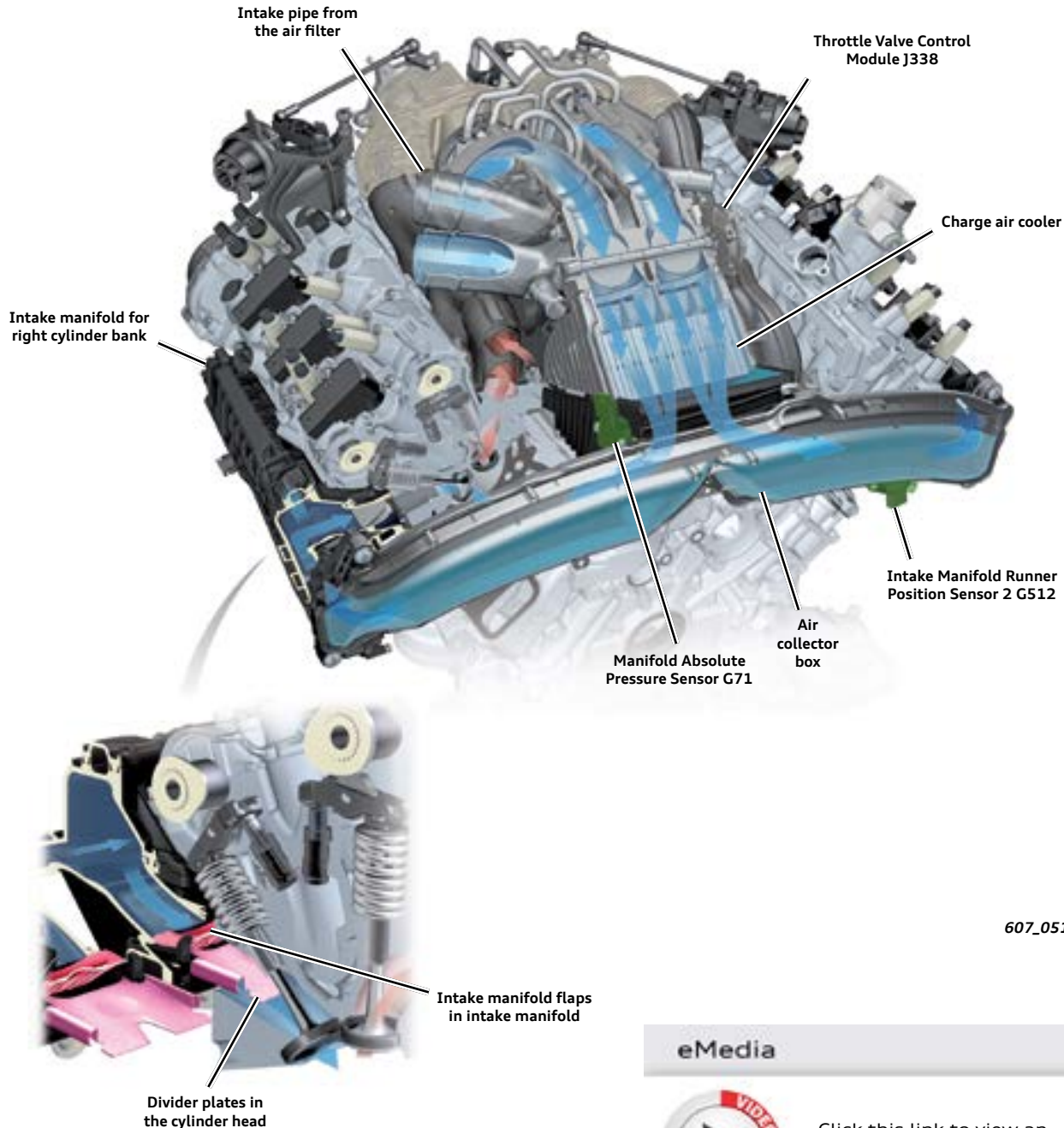
Overview

Moving the turbochargers to the inner V of the engine necessitated a change to their air supply path. All intake air is drawn in at the front of the engine and cleaned by the air filter before flowing to the turbochargers. Airflow is also engine variant dependent.

After the intake air has passed the turbochargers, it flows through the throttle valves to the air-to-water charge air intercooler placed centrally in the inner V of the engine.

Both throttle valves are mounted on a common shaft and are driven by Throttle Valve Control Module J338. The compressed intake air passes from the charge air intercooler through the air collector box to the intake manifolds on the outer side of the engine. The intake manifold flaps are located in the intake manifolds.

Tumbling air movement in the combustion chamber is accomplished by the shape of the intake runners, divider plates in the cylinder heads, and shape of the pistons.



607_051

eMedia



Click this link to view an animation describing air intake.

Airflow in the S6, S7, and A8

All engines in the C7 series and the A8 with the 420 hp (309 kW) engine variant have their air intake on one side. The intake air is taken through only one air filter module.

The air filter module is located on the right side of the vehicle. Clean air is routed from the air filter module through two separate passages to the two turbochargers.

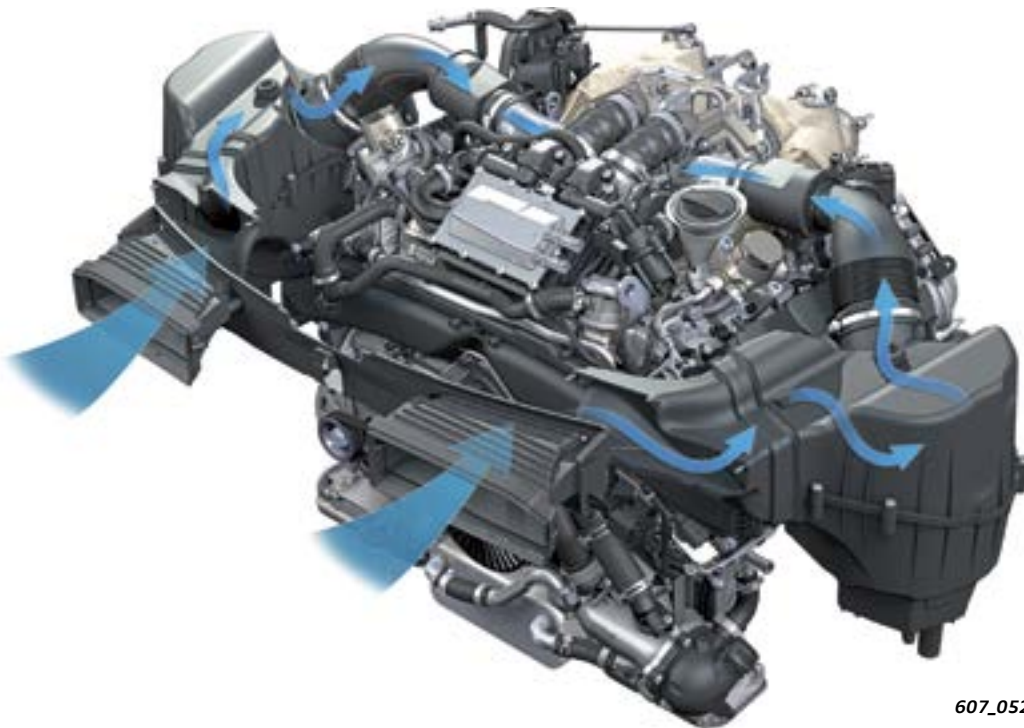


607_094

Airflow in the S8

The Audi S8 has a dual-branch air intake. Each cylinder bank has its own air filter module on the respective side of the vehicle.

Clean air is routed from the respective air filter module to the two turbochargers.



607_052

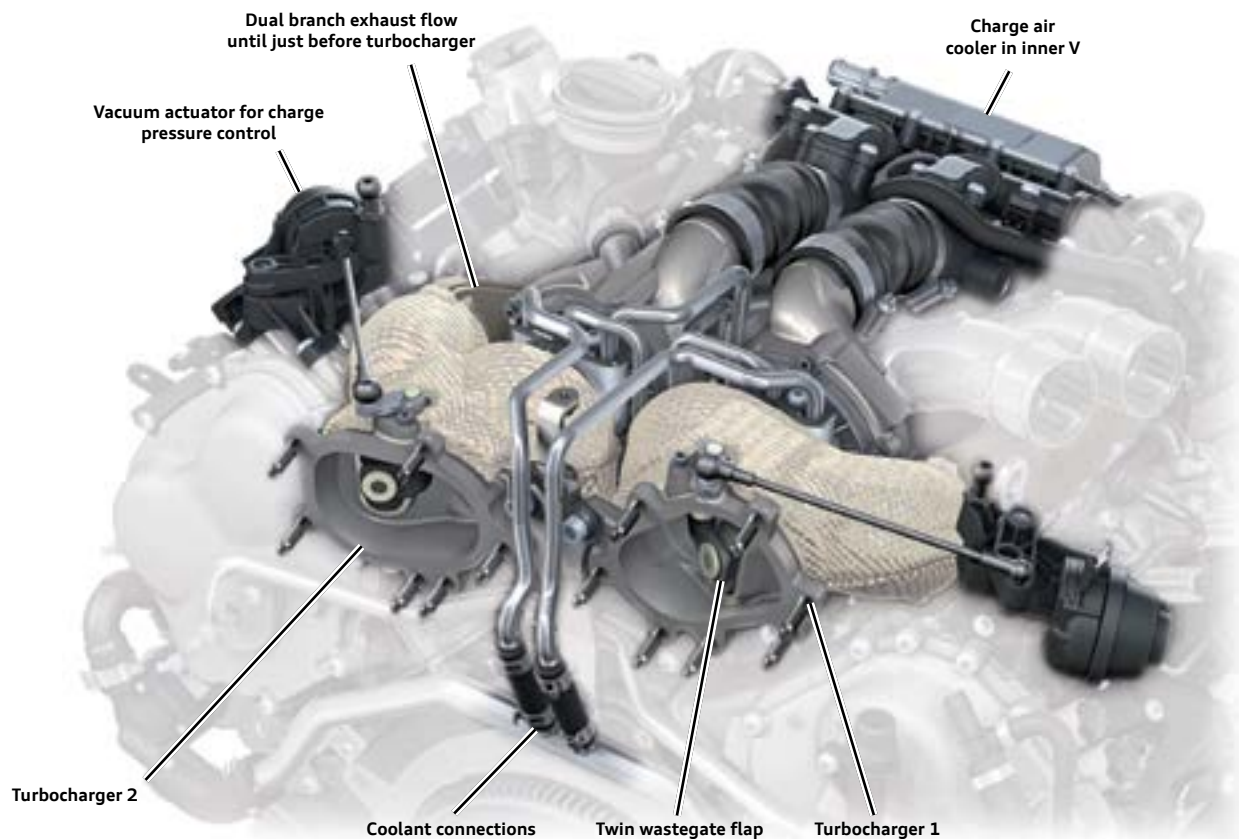
Twin-Scroll Turbocharger

Rationale

A twin-scroll turbocharging design was developed for the 4.0L V8 TFSI engine because more common designs and methods of turbocharging posed limitations for gasoline engines. For example, Variable Turbine Geometry (VTG), which is already standard in turbocharged diesel engines, proved unacceptable because of the higher exhaust temperatures found in gasoline engines.

Turbine housing design also presented limitations. In passenger cars with twin turbochargers, turbine housings are predominantly single-branch designs, where the intake cross-section into the turbine has no divider in the center. As a result, the impulse energy of one branch could interfere with the adjacent branch over this common entry area.

The new dual branch design of the 4.0L V8 enabled separation of the two exhaust manifold tracts until right before the turbine housing intake.



607_012

Differences for the Individual Engine Variants

No differences can be seen from its outside appearance. The exhaust manifold, the material of the turbocharger, and the turbine are the same on all performance versions. On engines with a power output of 520 hp (382 kW) the compressor wheels are larger, providing for the greater air requirements of the engine.

eMedia



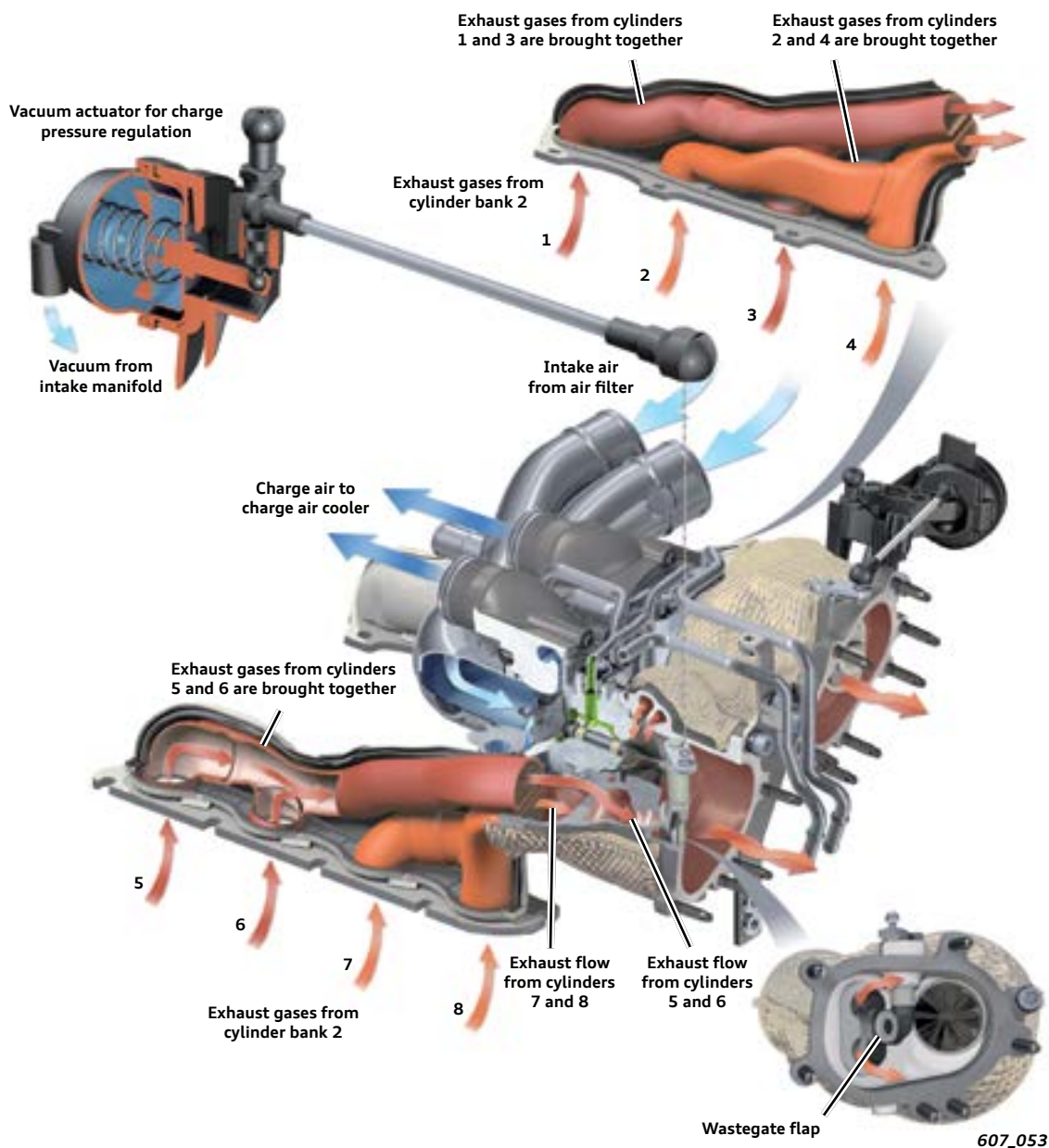
Click this link to view an animation describing turbos.

Twin-Scroll Design

Exhaust passages from two cylinders at a time run separately from each other in the exhaust manifold and turbocharger housing. They are joined just before the turbine, preventing reciprocal interference of exhaust flows. This guarantees a rapid buildup of torque and outstanding response.

Torque builds up quickly from idle speed. The 4.0L V8 TSFI engine develops approximately 295 lb ft (400 Nm) of torque as early as 1000 rpm.

The high output version of this engine makes its maximum 479.4 lb ft (650 Nm) of torque available full-time from 1750 to 5000 rpm.



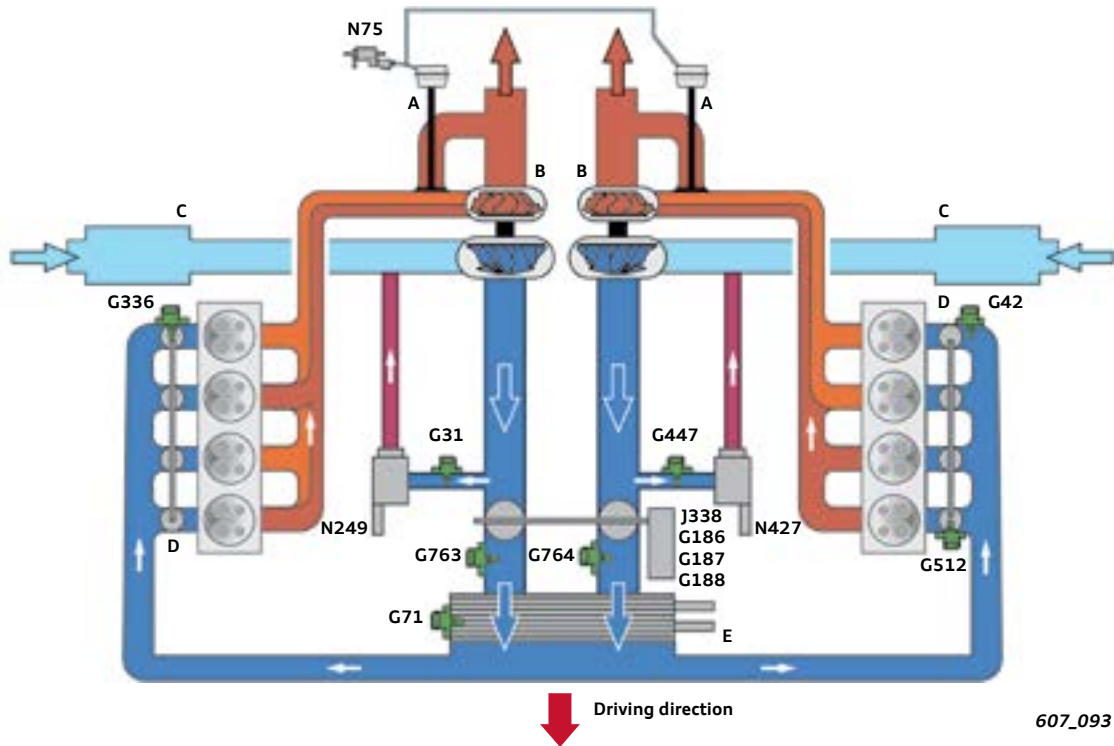
Exhaust Manifold

Both exhaust manifolds are designed as double-air-gap insulated manifolds. Because each cylinder has its own exhaust path to the turbine, the exhaust gas flows of specific cylinders are directed separately to the turbochargers.

Exhaust gas flows are brought together according to the firing order of the individual cylinders:

- ▶ Bank 1: Cylinders 1 and 3, 2, and 4
- ▶ Bank 2: Cylinders 5 and 6, 7, and 8

Air Supply Schematic



607_093

Legend:

- A** Wastegate
- B** Turbocharger
- C** Air filter
- D** Intake manifold flaps
- E** Charge air cooler in inner V
- Exhaust gases with separate flow
- Intake air (vacuum)
- Charge air pressure
- Recirculating air (charge air venting)

- G31** Charge Air Pressure Sensor
- G42** Intake Air Temperature Sensor
- G71** Manifold Absolute Pressure Sensor

- G186** EPC Throttle Drive
- G187** EPC Throttle Drive Angle Sensor 1
- G188** EPC Throttle Drive Angle Sensor 2
- G336** Intake Manifold Runner Position Sensor
- G447** Charge Air Pressure Sensor 2
- G512** Intake Manifold Runner Position Sensor 2
- G763** Charge Air Cooler Temperature Sensor 1
- G764** Charge Air Cooler Temperature Sensor 2
- J338** Throttle Valve Control Module
- N75** Wastegate Bypass Regulator Valve
- N249** Turbocharger Recirculation Valve
- N427** Bank 2 Turbocharger Recirculation Valve

Charge Pressure Regulation

A new strategy of charge air pressure regulation is being used. Previously, charge pressure was regulated by means of a pressure actuator. A wastegate was held closed by spring force and opened if charge pressure was too high. The pressure required was diverted from the charge pressure and introduced directly to the pressure actuator using a solenoid.

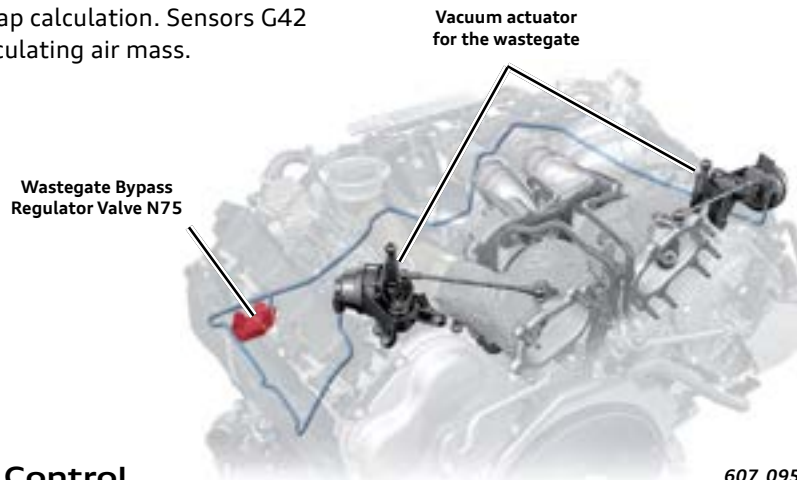
For the first time at Audi, vacuum is being used to regulate charge pressure. The wastegate is opened through mechanical spring force. If charge pressure is required, the flaps are closed using vacuum actuators activated simultaneously by Wastegate Bypass Regulator Valve N75.

The signals from sensors G31 and G447 are detected for charge pressure regulation. This charge pressure data is included in the map calculation. Sensors G42 and G71 are used for calculating air mass.

The advantages of this type of regulation are

- ▶ Less heat loss during the warm-up phase of the catalytic converters because the heat flow is in a direct path to the catalytic converters (not over the turbines) immediately after the engine starts
- ▶ At part throttle, there is reduced exhaust backpressure because of open wastegate valves
- ▶ During the transition to overrun phase, the wastegate is opened briefly in order in order to keep turbine speeds high

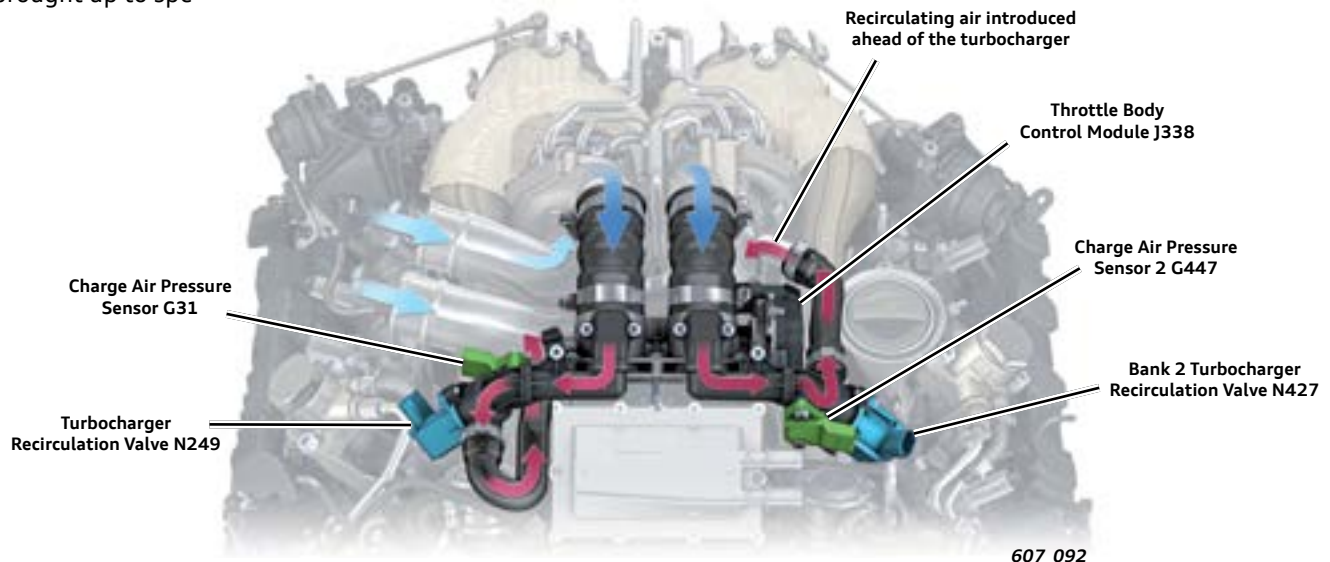
The primary control variable for charge pressure is the request for torque.



Recirculating Air Control

If the throttle valves are closed, back pressure is created in the compressor circuits because of continuing charge pressure. The compressor wheels of the turbocharger are severely slowed as a result. When the throttle valves are opened, the turbine has to be brought up to speed again.

The turbo lag that would otherwise result is reduced by recirculating air control. Turbocharger Recirculation Valve N249 and Bank 2 Turbocharger Recirculation Valve N427 operate electromagnetically and are activated by the ECM.



Cylinder Deactivation (Cylinder on Demand)

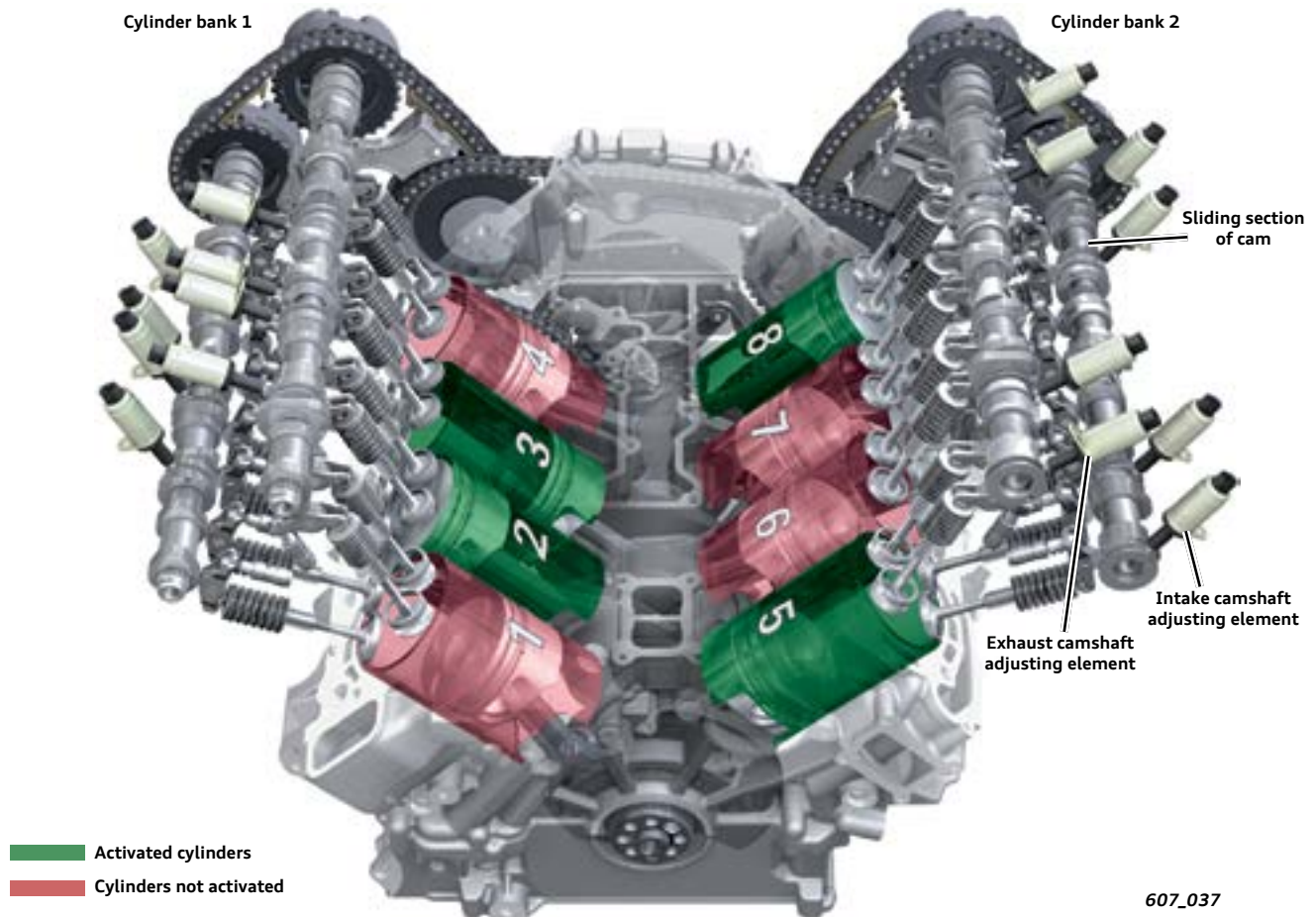
Introduction

Large-capacity spark-ignition engines are operated largely in the light-load range. Pumping losses are high because the throttle valve(s) are opened only a small amount. This results in reduced efficiency and poor specific fuel consumption.

A 4-cylinder engine under a higher load in relation to an 8-cylinder engine under a lesser load is more efficient. This is the rationale for using cylinder deactivation, also referred to as “cylinder on demand.”

The basic challenge for cylinder deactivation was keeping the valves in deactivated cylinders closed. Otherwise, too much air would reach the exhaust system and the engine would cool down too rapidly.

By deactivating four cylinders, the smoothness of the 8-cylinder engine could be reduced because of the altered spark plug firing frequency. The deactivation and activation of the cylinders had to take place as unobtrusively as possible to avoid load variations.



Development Objectives

- ▶ Reduced fuel consumption
 - ▶ Optimized emission reduction
 - ▶ About 10 to 12 grams of CO₂ per kilometer
 - ▶ Largest possible load range in 4-cylinder mode
 - ▶ 4-cylinder operation possible at a constant speed below 87 mph
 - ▶ No loss of comfort for passengers when in 4-cylinder mode

eMedia



Click this link to view an animation describing cylinder on demand.

Operation

Cylinder deactivation is achieved through AVS (Audi valvelift system) technology. The key to this design is the shape of the second cam. During 4-cylinder mode, the camshafts are shifted to a round lobe that does not create any valve lift, so the valves remain closed.

Corresponding to the firing order, it is always cylinders 2, 3, 5, and 8 that are deactivated. When the cylinders are deactivated, the valves remain closed.

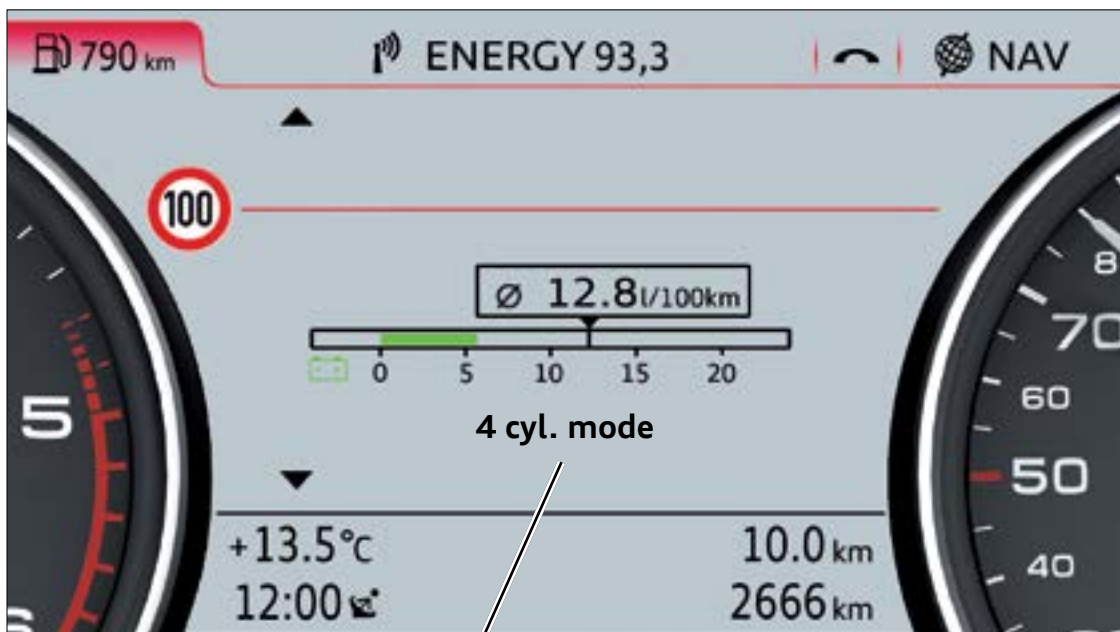
Fuel injection and ignition are switched OFF during this time. During deactivation of the cylinders, the exhaust valves remain closed following ignition and combustion. Exhaust gas is therefore “trapped.”

The deactivated cylinders operate as air springs, with temperatures remaining at a high level.

Any vibration of the engine that occurs is reduced as much as possible by newly developed active engine mounts during deactivation.

The newly developed Active Noise Control (ANC) system also comes into play to minimize any discomfort to the passengers.

Display in instrument cluster



607_036

Indication of cylinder deactivation
in instrument cluster

Operation in 4-Cylinder Mode

- ▶ Engine speed is above idle (for smoothness)
- ▶ Engine speed lies in the range of about 960–3500 rpm
- ▶ Oil temperature is at least 122°F (50°C)
- ▶ Coolant temperature is at least 84°F (30°C)
- ▶ Transmission shift position is at least 3rd gear
- ▶ The system is also operational in the S-mode of the automatic transmission and in the “dynamic” map of Audi drive select

Driver Profile Recognition

The cylinder deactivation system has control logic that monitors throttle and brake pedal position, and driver steering movements.

If it detects an irregular pattern from this data, it prevents cylinder deactivation because deactivation for only a few seconds duration would tend to increase rather than decrease fuel consumption.

Operation

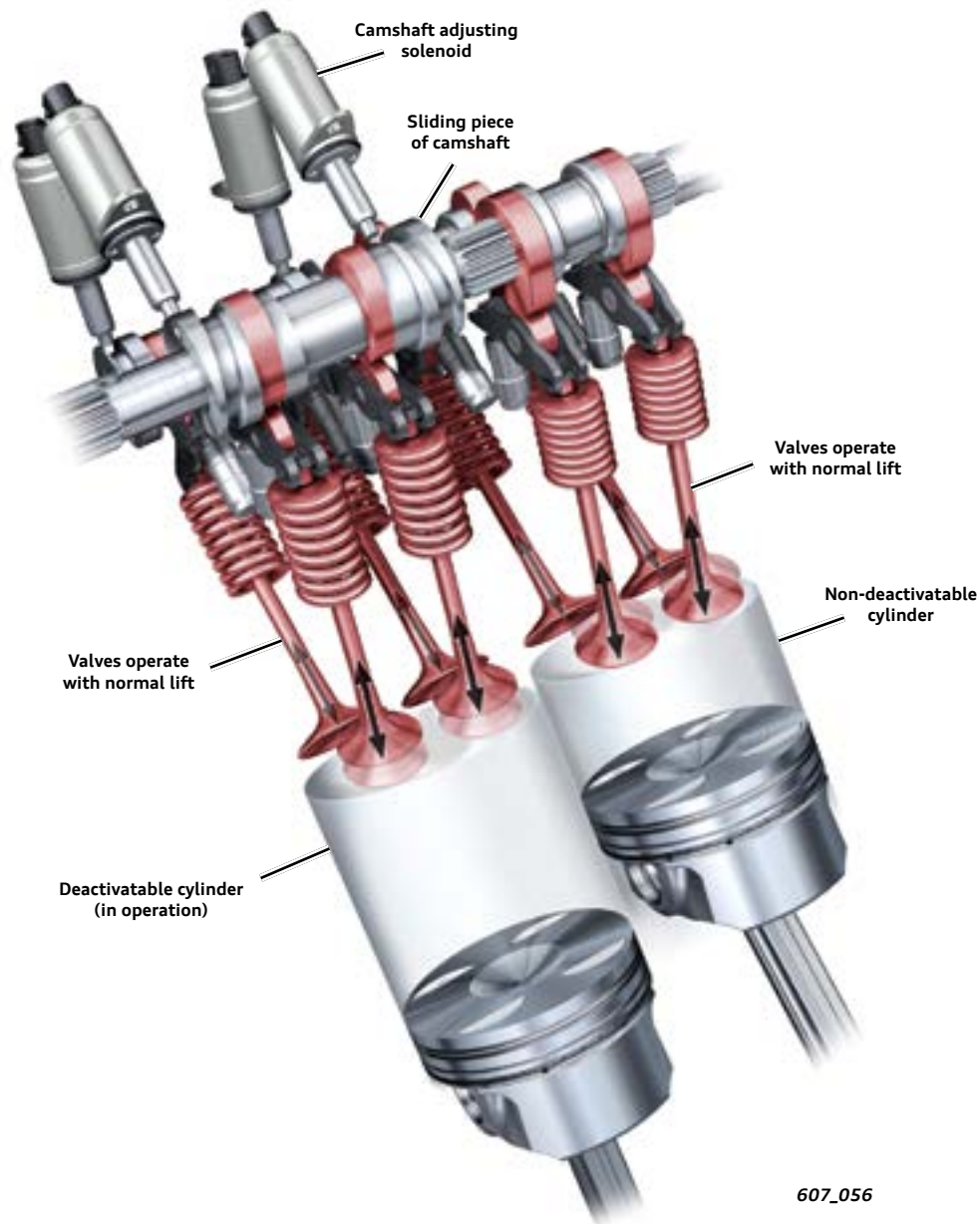
Cylinder deactivation is implemented with the help of AVS. However, AVS is used here to turn valve lift completely ON or OFF. AVS is not used in the 4.0L V8 TFSI engine for valve lift regulation.

When cylinder deactivation is active, it is always cylinders 2, 3, 5, and 8 that are deactivated. No other cylinders can be deactivated. It is always only four cylinders that are deactivated, never only one, two or, three cylinders.

Eight Cylinder Mode

Cylinder deactivation is inactive in this operating mode. The sliding cam sections of AVS are in the position in which the valves are actuated.

In eight-cylinder operation the firing order is:
1-5-4-8-6-3-7-2



607_056

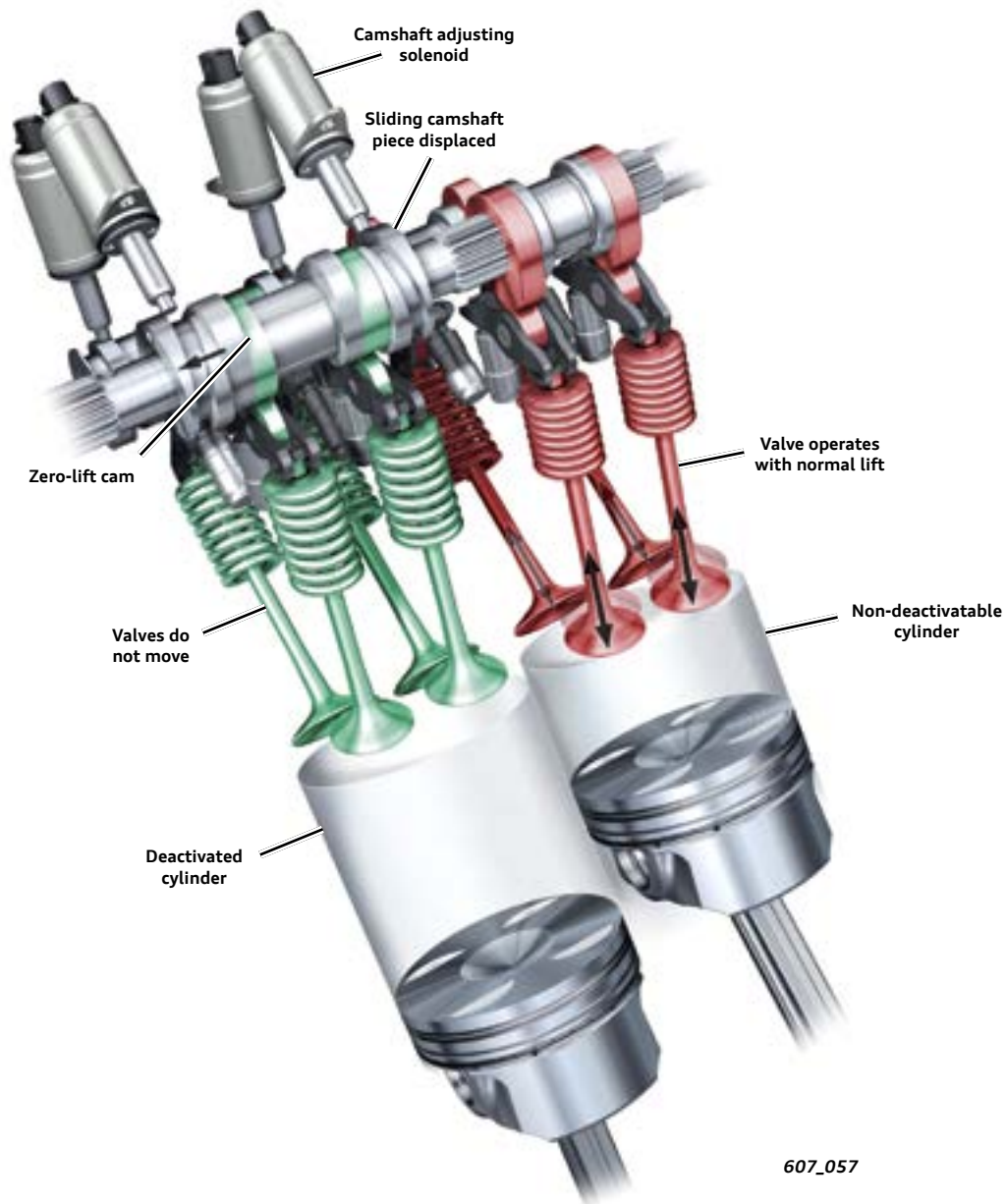
Four-Cylinder Mode

By switching a corresponding solenoid for cam adjustment, the metal pin engages the groove of the sliding cam section. The cam section is displaced so the roller cam follower runs over a “zero-lift cam.”

This cam has no profile, and as a result there is no longer any lift motion in the corresponding valve. No valves in the deactivated cylinders ever open. They remain closed.

Ignition and fuel injection are also switched OFF. The exhaust gas is “trapped.” The deactivated pistons operate as air springs.

In 4-cylinder operation the firing order is:
1-4-6-7



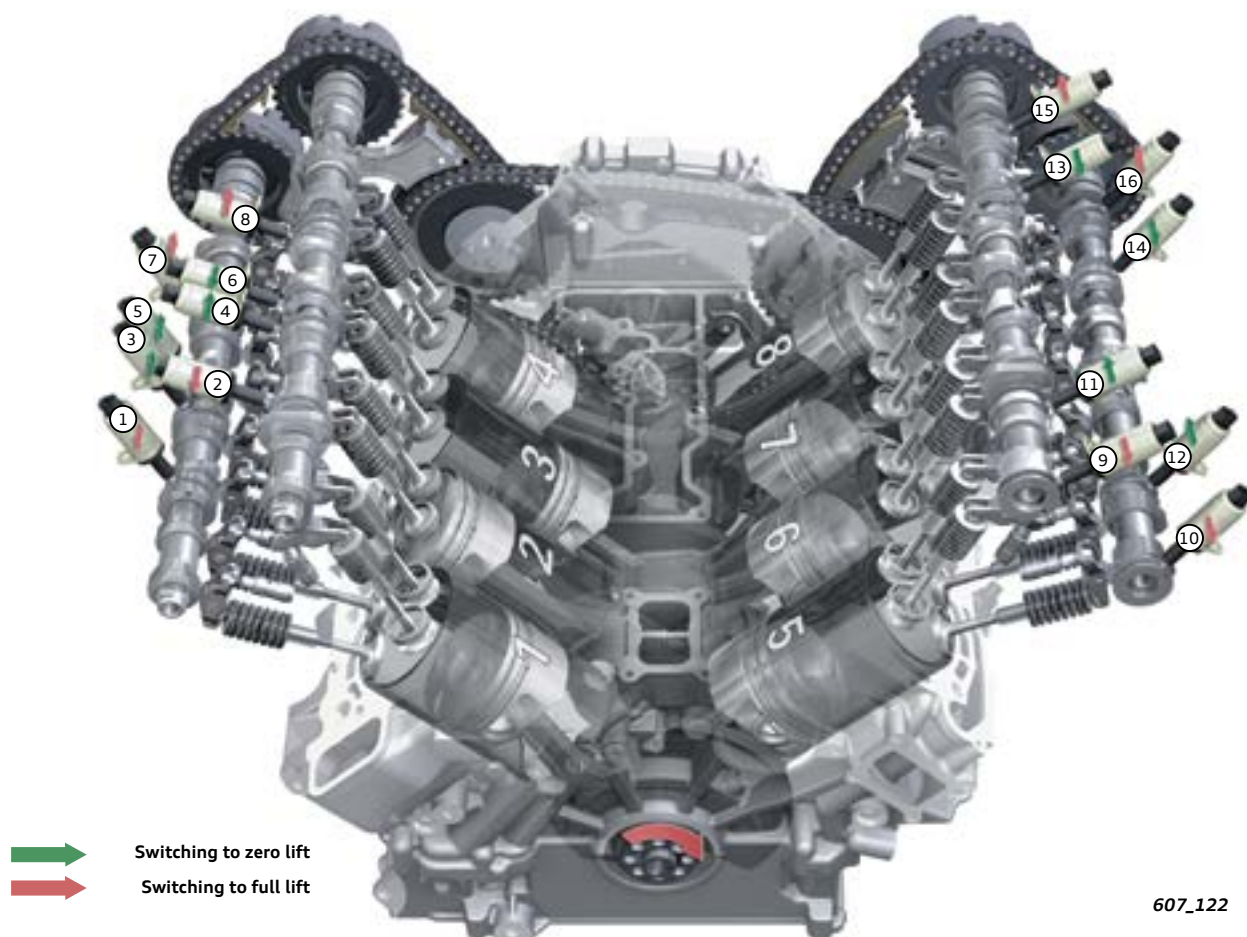
607_057



Reference

For further information about the Audi Valvelift System (AVS), refer to eSelf-Study Program 922903, *The 2.0L 4V TFSI Engine with AVS*.

Allocation of Camshaft Adjustment Actuators (AVS)



Legend:

- | | |
|--|--|
| ① Intake Camshaft Actuator 2, Cylinder 2 F453 | ⑩ Intake Camshaft Actuator 2, Cylinder 5 F465 |
| ② Exhaust Camshaft Actuator 2, Cylinder 2 F455 | ⑪ Exhaust Camshaft Actuator 1, Cylinder 5 F466 |
| ③ Intake Camshaft Actuator 1, Cylinder 2 F452 | ⑫ Intake Camshaft Actuator 1, Cylinder 5 F464 |
| ④ Exhaust Camshaft Actuator 1, Cylinder 2 F454 | ⑬ Exhaust Camshaft Actuator 1, Cylinder 8 F478 |
| ⑤ Intake Camshaft Actuator 1, Cylinder 3 F456 | ⑭ Intake Camshaft Actuator 1, Cylinder 8 F476 |
| ⑥ Exhaust Camshaft Actuator 1, Cylinder 3 F458 | ⑮ Exhaust Camshaft Actuator 2, Cylinder 8 F476 |
| ⑦ Intake Camshaft Actuator 2, Cylinder 3, F457 | ⑯ Intake Camshaft Actuator 2, Cylinder 8 F477 |
| ⑧ Exhaust Camshaft Actuator 2, Cylinder 3 F459 | |
| ⑨ Exhaust Camshaft Actuator 2, Cylinder 5 F467 | |

System Diagnosis

The first priority when a malfunction occurs is to prevent engine damage, while providing maximum utility for engine operation. If a malfunction occurs in one cylinder (valves cannot be activated), fuel injection is disabled and driving continues in 7-cylinder operation.

An emergency mode (limp home) is initiated and displayed to the customer through an illuminated Check Engine Light (MIL). If the valves can no longer be switched OFF, the customer will notice emergency mode through the absence of cylinder deactivation. Any valve lift changeover malfunction in cylinder deactivation is indicated by an illuminated MIL.

Internal Diagnosis in the ECM

The ECM determines whether a changeover procedure was concluded successfully by means of a feedback signal.

If valves should not remain closed or be opened according to ECM specification, the balance of the engine is changed. The resulting vibrations are detected by the ECM from Engine Speed Sensor G28. Intake manifold pressure is also constantly monitored. If irregularities start to occur here, they are also detected by the ECM.

Background:

When a cylinder is operating properly, for example, the intake and exhaust valves open/close at specified times, an equilibrium is established between intake air and exhaust air. If an unwanted valve event occurs in one cylinder, this equilibrium is disturbed and indicates a suspected malfunction.






607_123

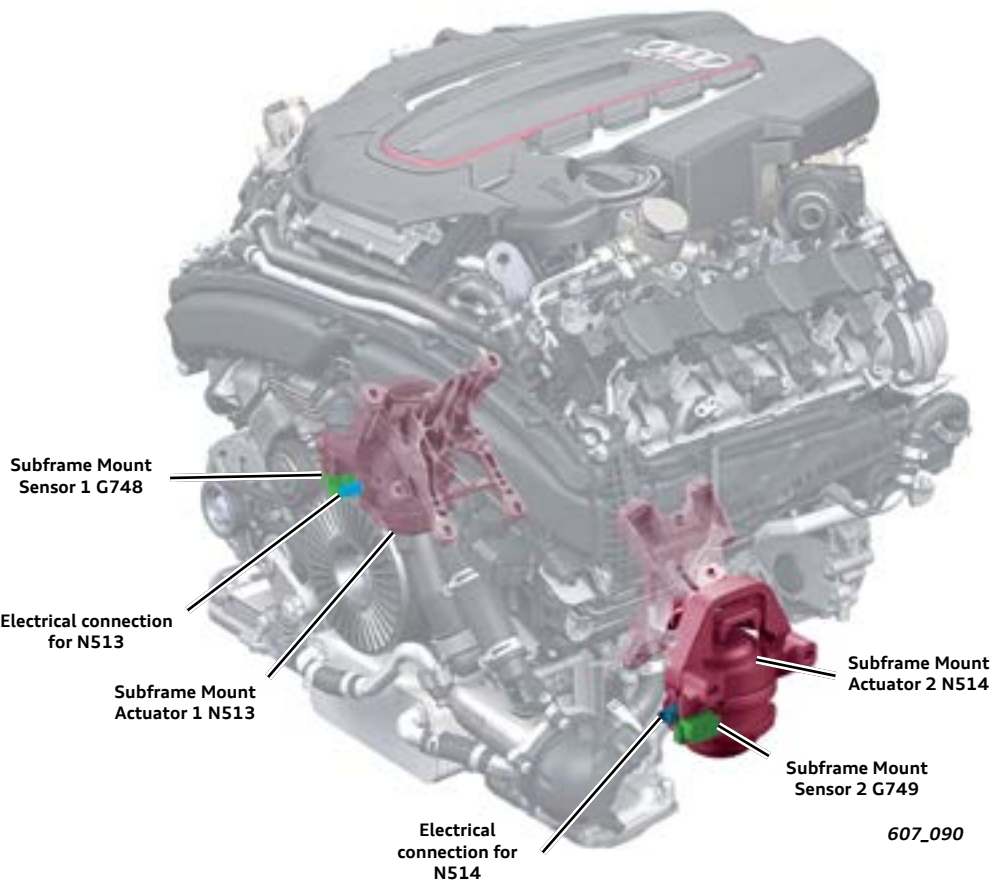
Service Diagnosis

- ▶ Read fault memory
- ▶ Read MVBs
 - ▶ Cylinder deactivation status (8- or 4-cylinder mode active)
 - ▶ Percentage share of 4-cylinder since last flash action
 - ▶ Number of 4-cylinder phases since last flash action
 - ▶ Duration of current 4-cylinder phase or, in 8-cylinder operation, of the last 4-cylinder phase
 - ▶ Status bars of the 4-cylinder releases through which any jamming parts can be identified
- ▶ End of line test/short trip
- ▶ As with the AVS system, a cycling from 4 to 8 to 4-cylinder operation can be initiated by the Scan Tool. The changeovers at low and high rpm can be checked for reliability in this way. A measured value for status indicates whether the system is OK or not OK or whether necessary releases are not being fulfilled or a malfunction exists in the system.
- ▶ Adaptation channels:
 - ▶ It is possible to block 4-cylinder or 8-cylinder mode through a protected adaptation channel for precisely one drive cycle (until the next ignition cycle). This provides the opportunity to investigate issues more thoroughly.
- ▶ Examples of required sustained 4-cylinder operation:
 - ▶ Inspection of active engine mounts checking "Active Noise Control" in 4-cylinder operation

Active Engine Mounts

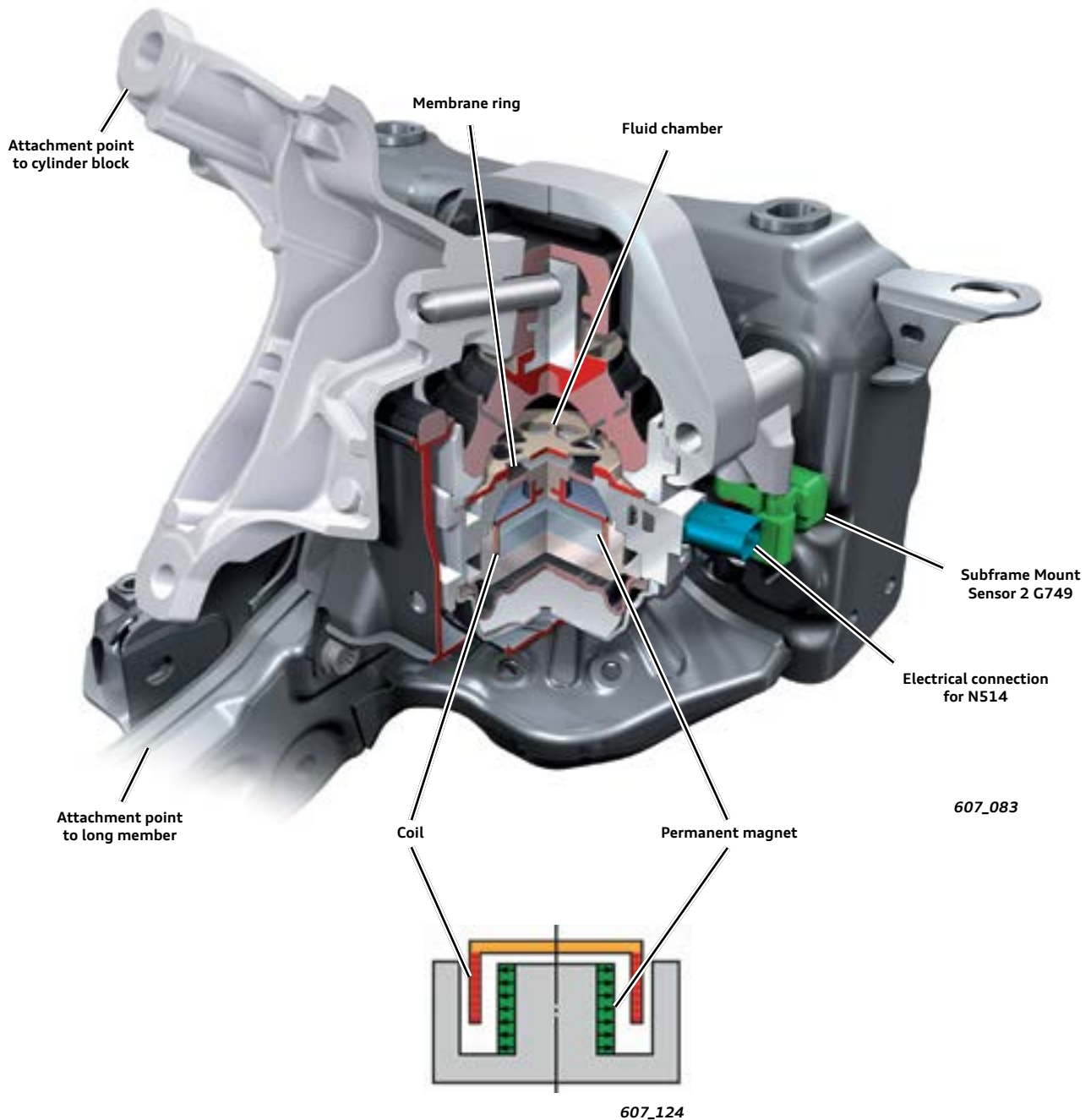
A new active engine mount system debuts with the 4.0L V8 TFSI engine. It is intended (like ANC) to provide a high degree of customer comfort by eliminating vibrations over a broad frequency spectrum.

Audi Engine Mounts			
First application	1977	1989	2011
Vehicle			
	Audi 100 (C2) <ul style="list-style-type: none"> 5-cylinder gasoline engine 	Audi 100 (C3) <ul style="list-style-type: none"> 5-cylinder TDI engine (not in USA) 	Audi S8 (D4) <ul style="list-style-type: none"> 4.L V8 TFSI engine
Construction	Hydraulic engine mount	Switchable hydraulic engine mounts	Active hydraulic engine mount
	<ul style="list-style-type: none"> Designed for a specific damping frequency 	<ul style="list-style-type: none"> Two conditions, hard and soft 	<ul style="list-style-type: none"> Vibration elimination over broad frequency range
Objective	Improved protection from vibration	Improved idle comfort	To accommodate cylinder deactivation



Purpose of the Engine Mount

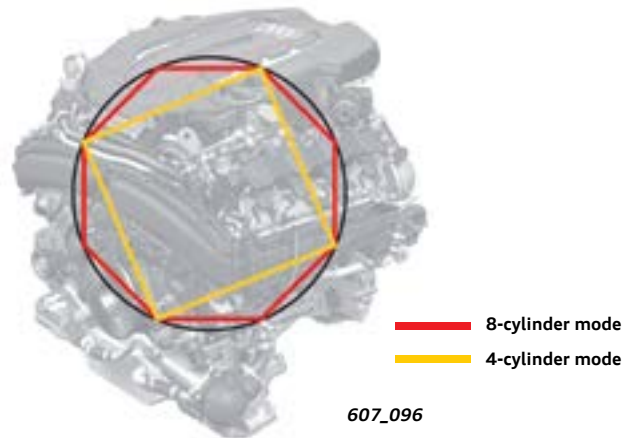
- Positions the engine in the vehicle
- Absorbs drive torque
- Isolates engine vibrations
- Dampens engine oscillations



Operating Principle

When the engine operates in 4-cylinder mode, more severe vibrations are transferred into the body because ignition pulses are halved. These vibrations are reduced by generating counter-oscillations.

The counter-oscillations are generated by active engine mounts. Their frequency range is between 20 and 250 Hz.



Operation

The oscillations transmitted from the engine are measured by the Subframe Mount Sensors 1 and 2 G748 and G749. They are installed on the body side of the engine mount.

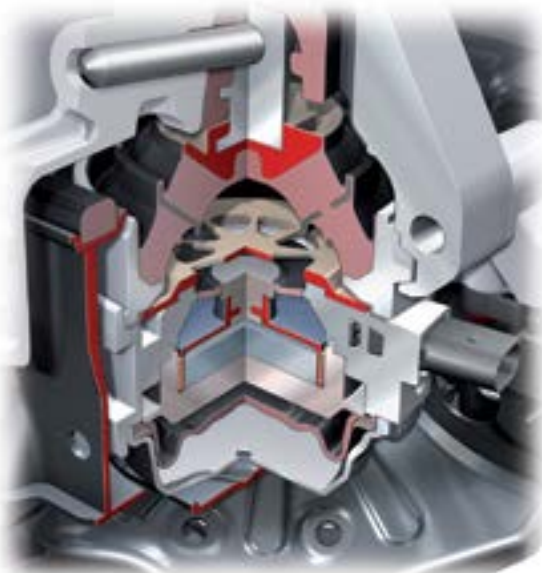
The measured values are converted in the sensor and sent as analog voltage signals (0.2–0.8 volts) to Subframe Mount Control Module J931, where they are used for map calculations. The crankshaft speed signal is sent discretely from the ECM to Subframe Mount Control Module J931, which in turn sends the calculated control signal (PWM) to the Subframe Mount Actuators N513, N514. Counter-oscillation is generated by the active engine mounts.

If oscillations encounter each other at the right time, the disturbing oscillations are eliminated.

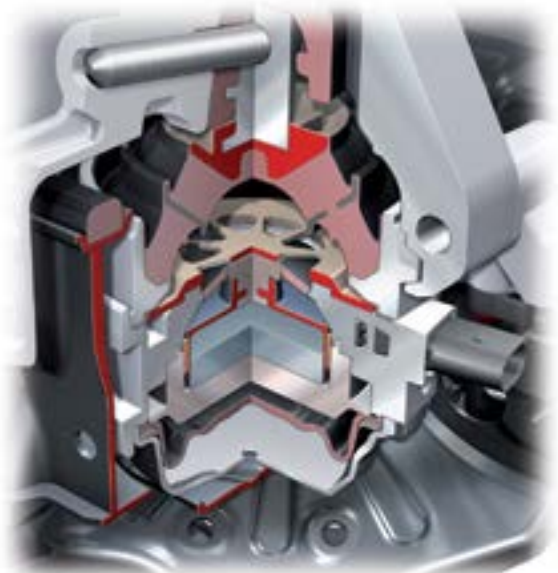
A counter-oscillation in the engine mount is generated by the specific up and down movement of the membrane ring. This movement is transferred to the hydraulic fluid (glycol) in the fluid chamber. The oscillation generated is transferred from there into the engine mount.

The membrane ring is solidly attached to the magnetic coil. The magnetic coil is activated by a sine-wave signal from J931. A change in the frequency or the amplitude of the signal results in the coil moving up and down quickly or slowly. This then generates the desired oscillation in the engine mount. Calculation of the activation signal takes place in real time in the control module.

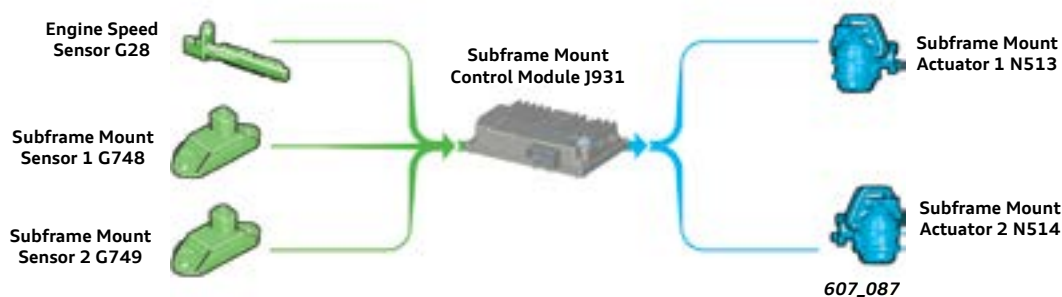
Lower position



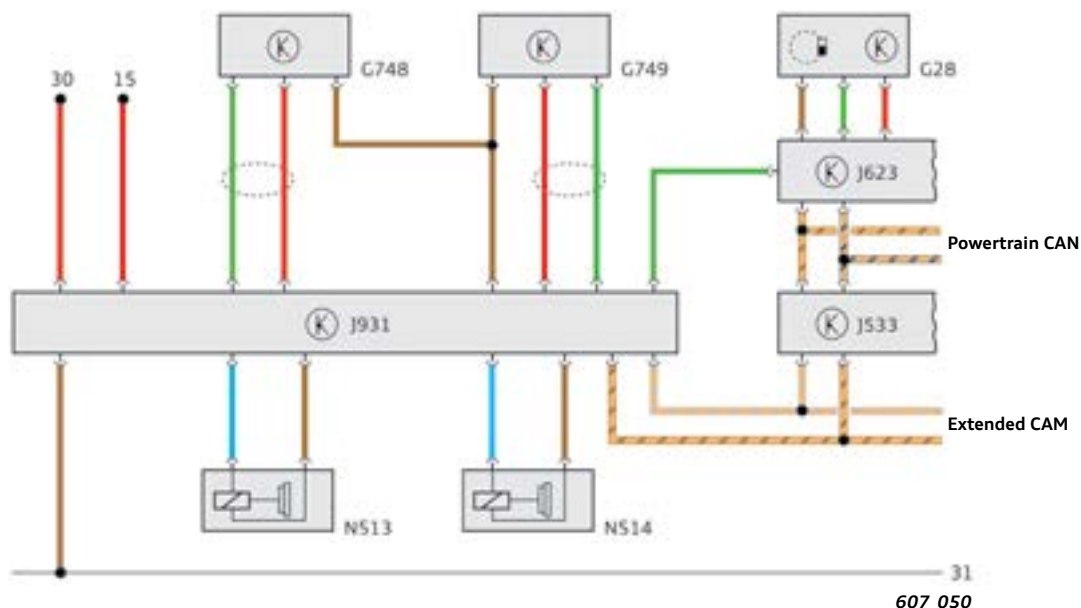
Upper position



System Overview



Functional Diagram



Legend:

G28 Engine Speed Sensor

G748 Subframe Mount Sensor 1

G749 Subframe Mount Sensor 2

J533 Data Bus On Board Diagnostic Interface

J623 Engine Control Module

J931 Subframe Mount Control Module

N513 Subframe Mount Actuator 1

N514 Subframe Mount Actuator 2

Diagnosis Possibilities

Control module:

- ▶ Subframe Mount Control Module J931
- ▶ Located behind left front wheelhouse liner
- ▶ Output power per mount maximum 60 W
- ▶ Diagnostic protocol UDS/ISO
- ▶ Input signals from the sensors

Address word/diagnostic possibilities:

- ▶ Acceleration correlation engine mount
- ▶ Read memory
- ▶ Output diagnostic test mode
- ▶ Basic settings
- ▶ Read MVBs



Note

The operation of the sensors for the engine mount is comparable to that of the sensors for body acceleration in the adaptive air suspension system.

Active Noise Cancelation (ANC)

From the customer's point of view, comfort and noise characteristics are just as important as the power of a premium class vehicle.

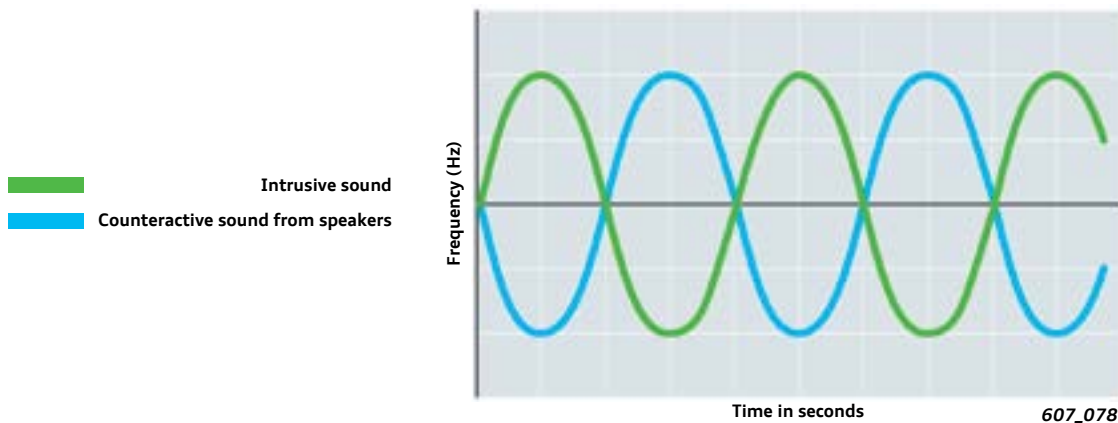
A fundamental change in acoustics during 4-cylinder mode operation may be unacceptable to customers.

Which Noises Does the System Offset?

Since the engine compartment is sound insulated so well, few intrusive engine noises reach the vehicle interior. The majority of intrusive noises are emitted by the exhaust system. These drumming noises are reduced by switchable exhaust flaps in the rear mufflers. An additional source of disturbance is the sport differential.

How are Intrusive Noises Counteracted?

ANC targets unwanted sounds using the counter-sound principle (destructive interference). To do this, the woofers in the sound system are activated in such a way that a sound is produced with the same frequency as the intrusive noise. The amplitudes must be timed exactly and phase-offset by 180° to the intrusive noise for them to cancel each other out.



The spread of sound waves in the vehicle interior depends on many factors. Also dependent on these factors, there must be multiple adjustment criteria so that the system can operate with maximum efficiency. This means there are many different maps that are precisely calibrated to the specific vehicle.

For this reason an active noise cancellation system was developed. The system compensates for intrusive noises.

The intrusive noises can exist up to 400 Hz and have a noise level of up to 106 decibels.

Noises caused by road surface, airflow around the vehicle, or other external sources cannot be eliminated.

Differentiating factors in this are, for example:

- ▶ Four different sound systems
- ▶ Different body shapes
- ▶ Different engine outputs
- ▶ Three roof shapes (sliding sunroof, panorama roof, full roof)

In spite of many disturbance possibilities, the ANC system can lower sound levels by 12 decibels, corresponding to a minimization of intrusive noise by approximately 75%.

System Components

ANC is an extension of the sound system. The ANC control module is integrated into Digital Sound System Control Module J525. The woofers integrated in the vehicle serve as actuators. Four microphones are installed in the vehicle headliner in precise locations.

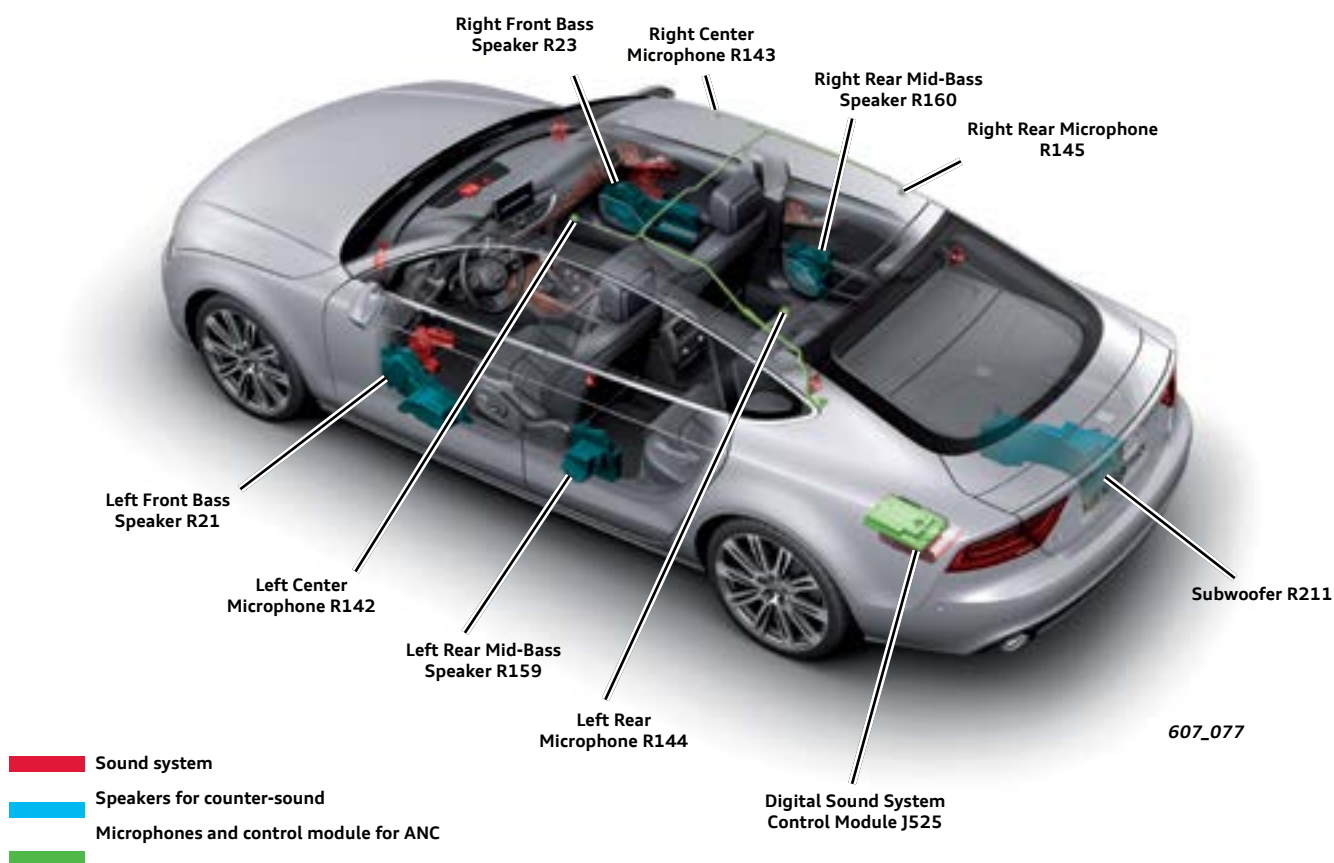
The ANC control module needs engine speed data and the current number of active cylinders to calculate output signals. The engine speed signal comes directly from the ECM over a discrete line. The engine speed signal from G28 is supplied to both the ECM and the ANC control module.

The ANC control module obtains the cylinder deactivation data from the CAN bus. It also takes information from the bus about the open/closed status of vehicle doors and the sunroof.

Operation

Based on input signals, the ANC control module calculates the phase, frequency, and amplitude needed for each of the four door woofers and subwoofer. The five calculated ANC woofer signals are combined in the amplifier with the woofer signals of the sound system and output to the speakers. Noises are picked up by four microphones and sent to the ANC control unit over discrete lines.

System Components (shown on S7)



Operation

The system is operational as soon as the ignition is switched ON.

Signals are output to the speakers even when the engine is operating with eight cylinders. This is necessary in order to create a transition that is imperceptible to the passengers when the engine changes to 4-cylinder mode.

The system has to react and operate very quickly. This applies particularly to special situations, for example, when the volume level in the sound system drops abruptly.

ANC is always active with the ignition switched ON, regardless of whether the sound system is switched OFF or is loud, quiet, or muted.

System Diagnosis

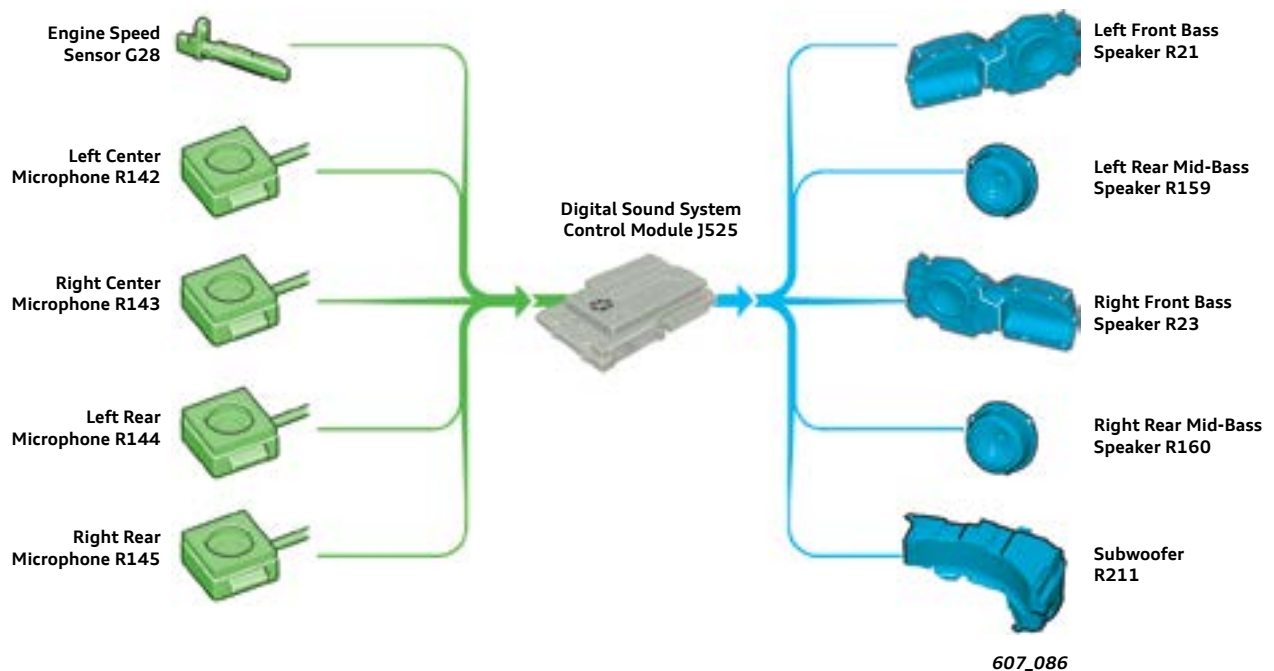
The system is fully diagnosable.

The control module is accessed through the Scan Tool using Address Word 47.

The following possibilities are available in diagnosis:

- ▶ Read DTC memory
- ▶ Coding
- ▶ Output check diagnostics (calibration of the microphones is performed only with Bang & Olufsen systems)
- ▶ Read MVBs
- ▶ GFF tests

System Overview



ANC Deactivation

ANC may be deactivated under the following conditions:

- ▶ On Bang & Olufsen system, window open*
- ▶ On Bang & Olufsen system, sunroof open*
- ▶ Doors and rear hatch open
- ▶ Wind turbulence at one microphone
 - ▶ Default operation to only three microphones
 - ▶ Deactivation if multiple microphones are in use
 - ▶ First 10–20 hours are for characteristics adaptation
- ▶ ECM reports that the MIL is ON
 - ▶ No switching between 4- and 8-cylinder modes
 - ▶ Hall signal is implausible
- ▶ Speed signal not present
- ▶ Microphones defective
- ▶ Variability of interior
- ▶ Rear seat folded down
- ▶ Ambient temperature conditions
- ▶ Mixed installation of speakers. For example, if a new speaker was installed. A new speaker may have a different characteristic than the ones remaining in the vehicle. It may also be possible that a new speaker comes from a different manufacturer

*Does not apply to BOSE Sound Systems

Service

When changes are made to the engine control module software (flashing) the ANC software must also be adapted. If modifications are made to the exhaust system, there may be functional interference in the ANC system. Only OEM replacement parts should be used.

If a customer states that the engine in their vehicle is suddenly louder, check the sound system for DTCs. The ANC system may be switched OFF.

Similarly, the system can switch OFF (although all the components are “electrically” free of defects) if a part was installed incorrectly. An Output Check Diagnosis can help determine the root cause of the issue.

Fuel System

Overview

The fuel system is divided into low pressure and high pressure zones, operating on demand. There is no fuel return to the fuel tank with this system.

Transfer Fuel Pump G6 in the fuel tank is activated by Fuel Pump Control Module J538. The maintenance free filter is installed in the fuel delivery unit in the tank. The fuel supply for the high pressure pump for cylinder bank 2 is managed by the high pressure pump for cylinder bank 1.

Low Pressure Range

The low pressure zone operates variably between 72.5–94.2 psi (5–6.5 bar) . The ECM always tries to keep the pressure as low as possible.

Fuel starts to boil above a certain temperature range, which can cause a supply problem for high pressure pumps. The engine will start to buck because of fuel starvation. Fuel temperature is dependent on a large number of ambient conditions, for example, outside temperature, temperature in the engine compartment, and vehicle speed.

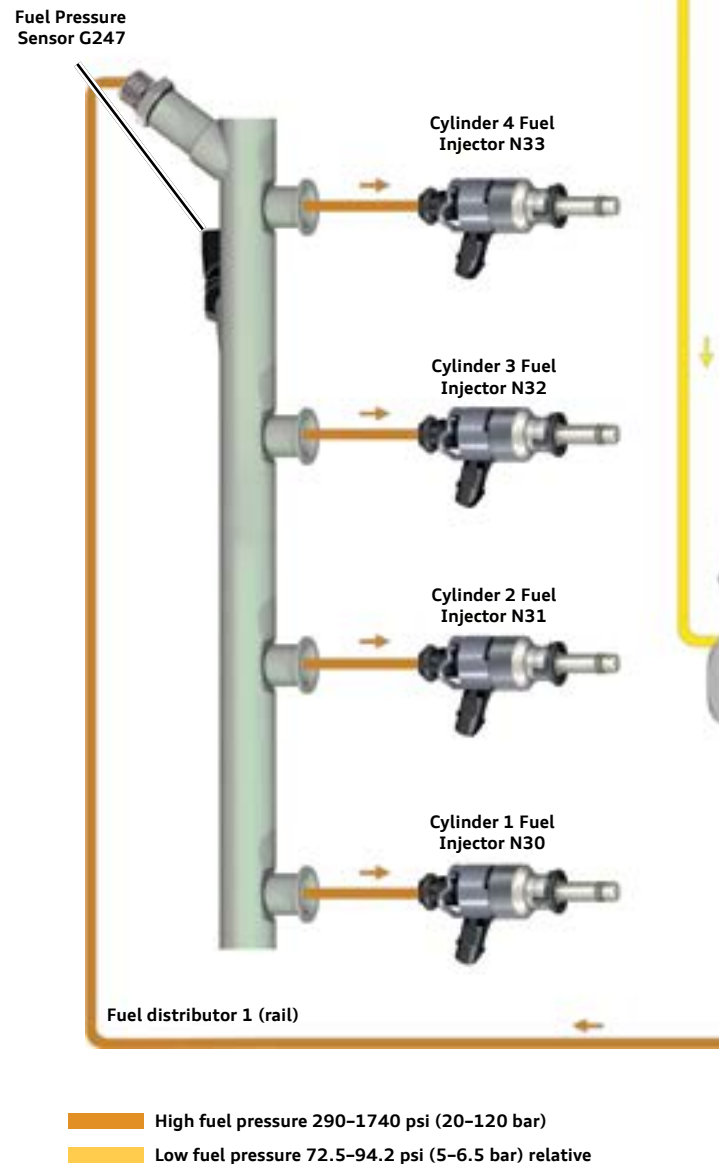
Determining the fuel temperature for an ECM map calculation is model-based. Another important variable in the calculation is engine load. Activation for the fuel pump in the tank is established by the ECM map and transmitted to Fuel Pump Control Module J538.

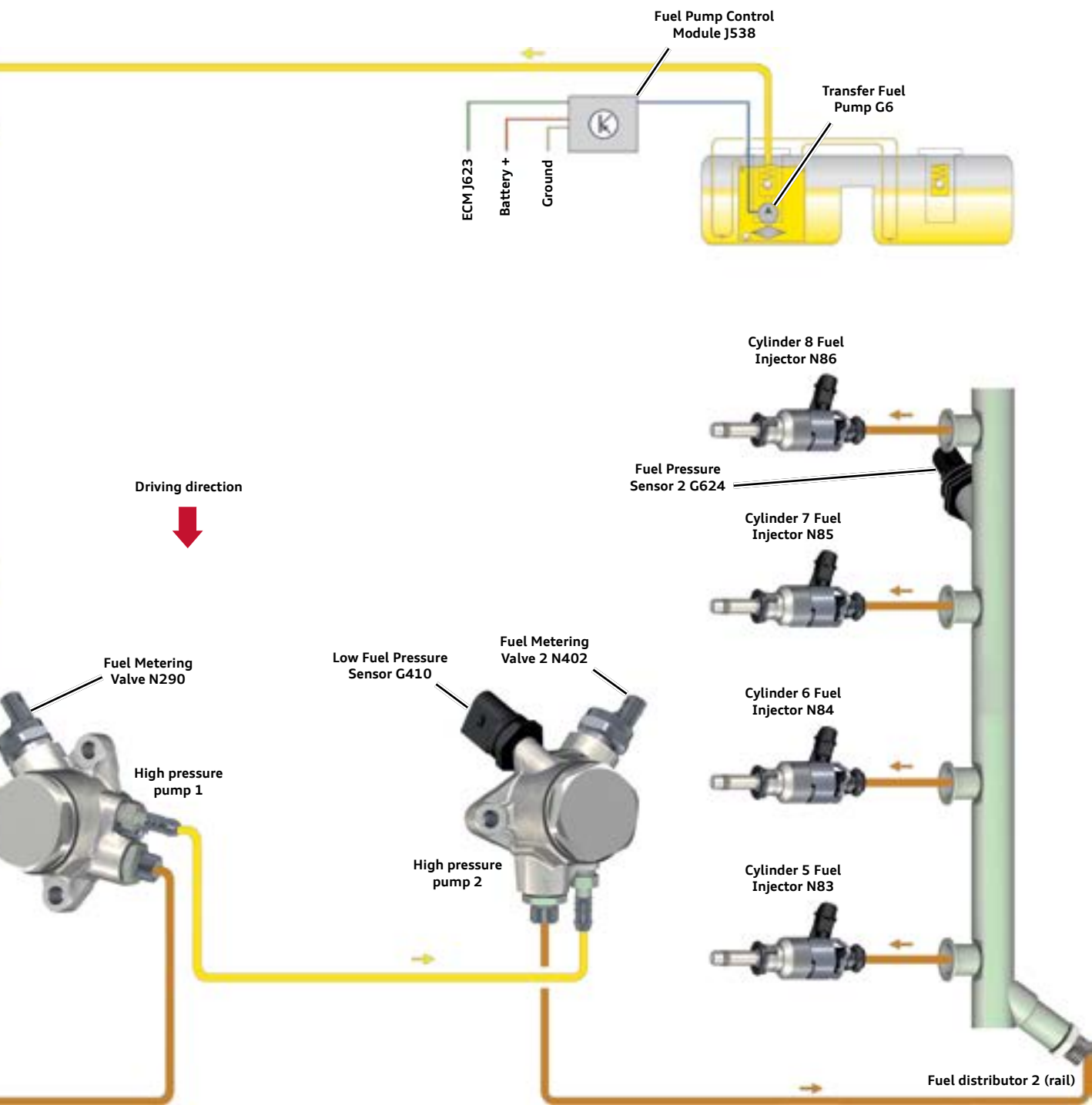
At high vehicle speeds, fuel pressure may be lower because the fuel-conducting components are cooled by the wind. Low Fuel Pressure Sensor G410 checks whether the target pressure specifications are being maintained and readjusted if necessary. It is located on the high pressure pump of cylinder bank 2.

High Pressure Range

The high pressure zone operates between 290–1740 psi (20–120 bar). A mechanical pressure relief valve opens at a pressure of 2103 psi (145 bar). Both cylinder banks have their own high pressure circuit. There is no connection between the high pressure lines of the individual cylinder banks. Because of this, the system needs two fuel pressure sensors for the high pressure zone.

The high pressure pump is manufactured by Hitachi. It is driven by a three-lobed cam on the exhaust camshaft of each cylinder bank.

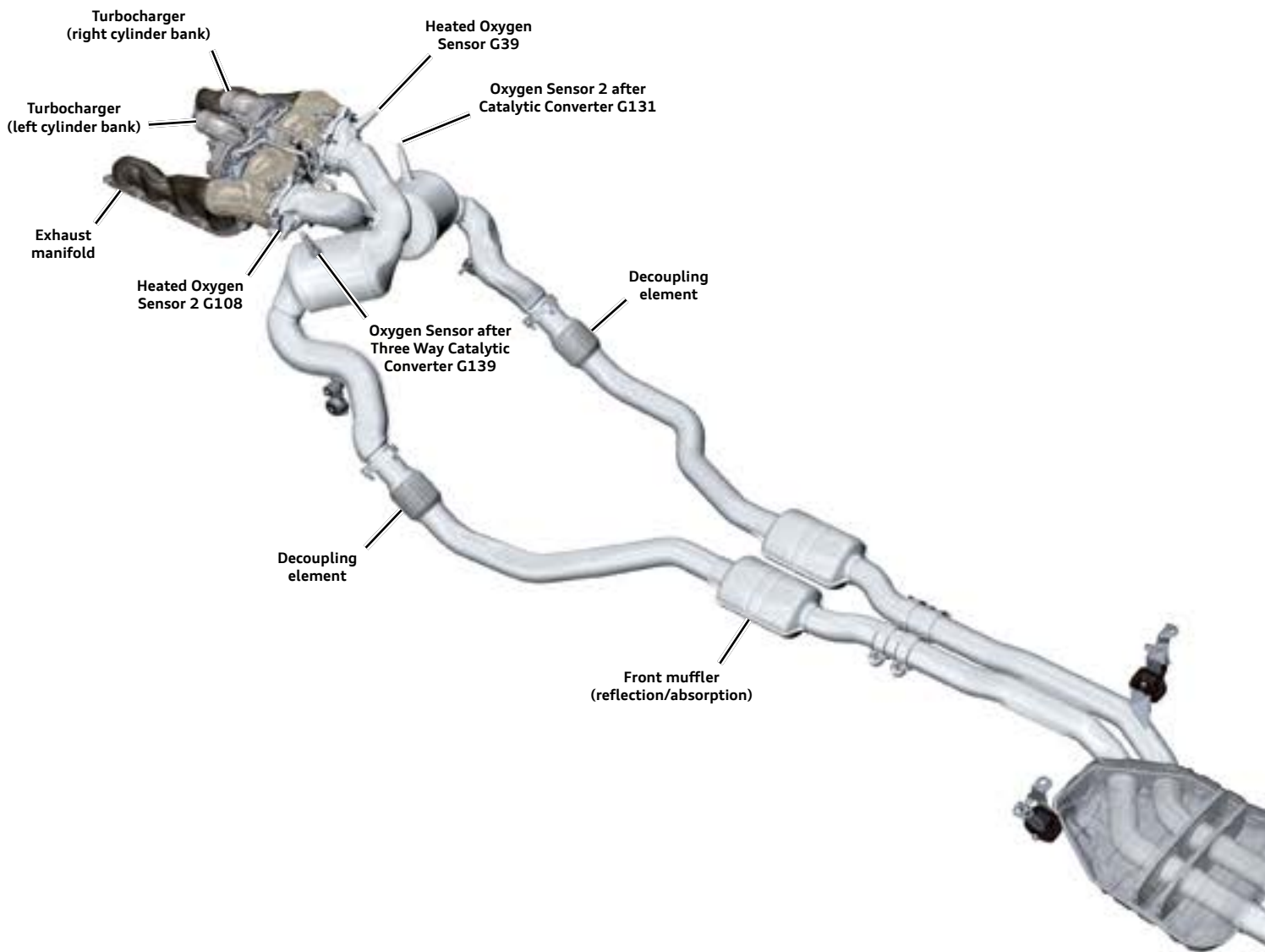




607_079

Exhaust System

Overview



Oxygen Sensors and Catalytic Converters

The oxygen sensor control design is largely the same as that of other TFSI engines from Audi. This includes:

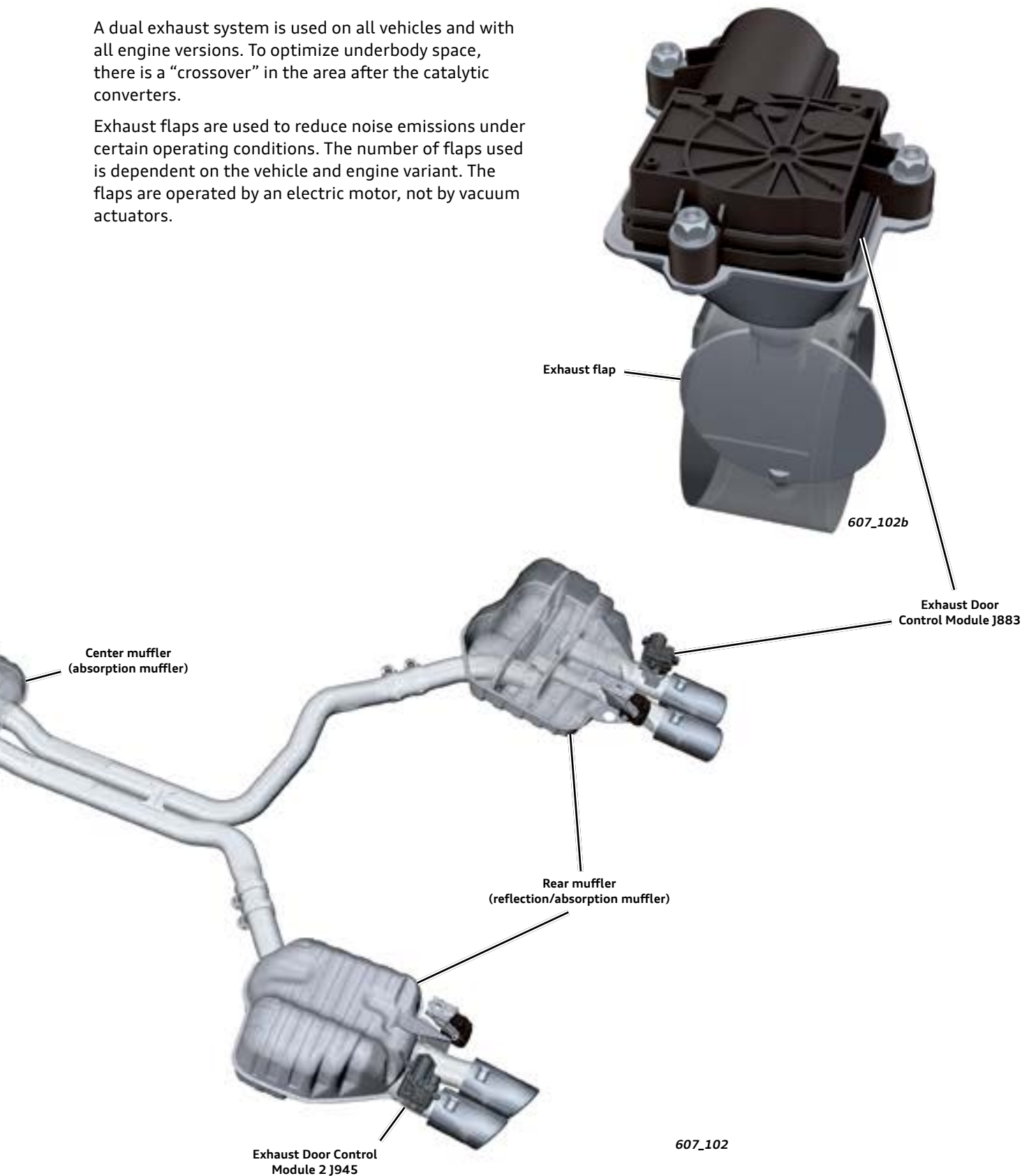
- ▶ Pre-catalytic converter oxygen sensors implemented as linear sensors. These are also known as wide-band planar style (Bosch LSU 4.9)
- ▶ Post-catalytic converter O2 sensors implemented as dynamic sensors. These are also known as jump sensors (Bosch LSF 4.2)

Both catalytic converters are ceramic.

Special Features

A dual exhaust system is used on all vehicles and with all engine versions. To optimize underbody space, there is a “crossover” in the area after the catalytic converters.

Exhaust flaps are used to reduce noise emissions under certain operating conditions. The number of flaps used is dependent on the vehicle and engine variant. The flaps are operated by an electric motor, not by vacuum actuators.



Exhaust Flaps

The exhaust flaps for the 4.0L V8 TFSI engine are operated by electric motors. This provides the capability for self-diagnosis.

All the requirements regarding noise emissions in both 4-cylinder mode and 8-cylinder mode must be addressed. Because the acoustic and back pressure/engine performance requirements are clearly different for each mode, the 4.0L V8 TFSI engine exhaust system must satisfy both versions. This is made possible by a switchable layout using exhaust flaps.

The exhaust flaps are closed in 4-cylinder mode. The exhaust system selectively reduces the low frequencies produced by 4-cylinder mode. Without this step, unwanted buzzing would be transferred into the interior that could not be eliminated by the ANC system alone.

In 8-cylinder mode, the exhaust flaps are open to the maximum. Flow noise and exhaust back pressure are reduced and the exhaust system sounds sporty.

The exhaust flaps are permanently integrated into the rear mufflers and therefore can only be replaced along with the mufflers. However, the possibility does exist of replacing the electric actuator motor or of separating it from the exhaust flap for diagnostic purposes.

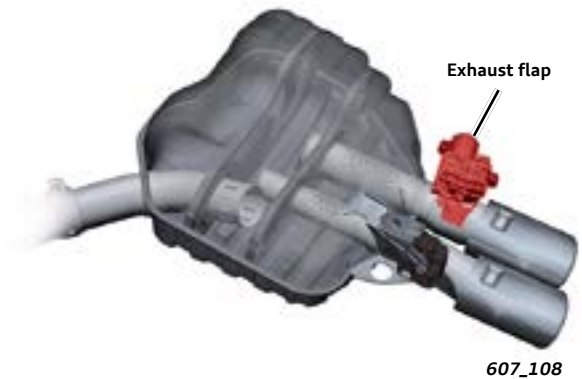
Ceramic bearings prevent the flaps from jamming in normal use.

Construction

There is a circuit board with power electronics in the housing for the electric actuator motor. The power of the electric motor is transmitted to the exhaust flaps by a worm drive.

The transmission of power from the worm drive to the exhaust flap is managed through a special torsion-compression spring. The actuator motor is insulated from the hot exhaust system by this spring.

In addition, this spring protects the worm drive from being damaged if the flap should jam because of a foreign body. The electronics can also switch the actuator motor OFF if it locks.



Function

Activation of the exhaust flaps is managed through the ECM. The commands “Open actuator” or “Close actuator” are issued using a PWM signal. Diagnosis of the electric actuator takes place over the same line, also using a PWM signal.

Exhaust flap switching is map dependent. The following factors are considered by the ECM when calculating the map:

- ▶ Engine load
- ▶ Engine speed
- ▶ Gear selected
- ▶ Vehicle speed

Functional Schematic

Legend:

J623	ECM
J883	Exhaust Door Control Unit
J945	Exhaust Door Control Unit 2
1	Terminal 87 (+)
2	Bi-directional line (PWM)
	▶ Signals from ECM to J883 and J945
	▶ Fault memory signal to the ECM
3	Ground

Diagnosis

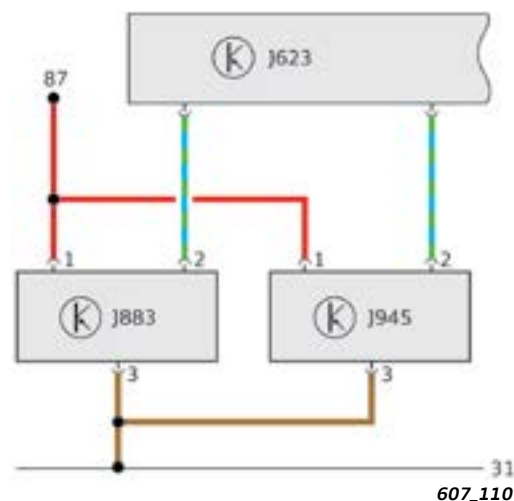
If an electrical malfunction occurs, the flap stops, regardless of its position. A DTC entry is made in the ECM and in the flap door control modules.

No further diagnostic possibilities are planned.

Service

The actuator motor can be replaced. It is attached by three self-locking nuts to the heat shield of the flap unit. The position of the worm drive does not need to be indexed for installation. The parts are constructed so that they form a positive locking connection during their first operation (initialization phase). Initialization begins when the electrical connector is connected and the ignition is switched ON.

The basic position of the exhaust flap at idle is different depending on the vehicle model. On the Audi S6, A7, and the A8, the flaps are open. On the Audi S8, they open or close depending on gear selector position.



Mechanical diagnosis is also possible. To do this, the electric actuator motor has to be detached from the exhaust flap. The components in the worm drive are made of plastic and could be damaged otherwise. Once the electric actuator motor is separated from the exhaust flap, a check can be made whether the exhaust flap operates easily.

During initialization, the motor drives the flap against both end stops and records the position. This allows the flaps to approach the end stops gently. This avoids switching noises from the exhaust flap. Initialization is performed:

- ▶ During PDI
- ▶ After a detected malfunction and a reset (connector detached)
- ▶ After 35 cycles and a reset



Note

DTCs for the exhaust flaps can only be cleared by the ECM after first disconnecting the actuator.

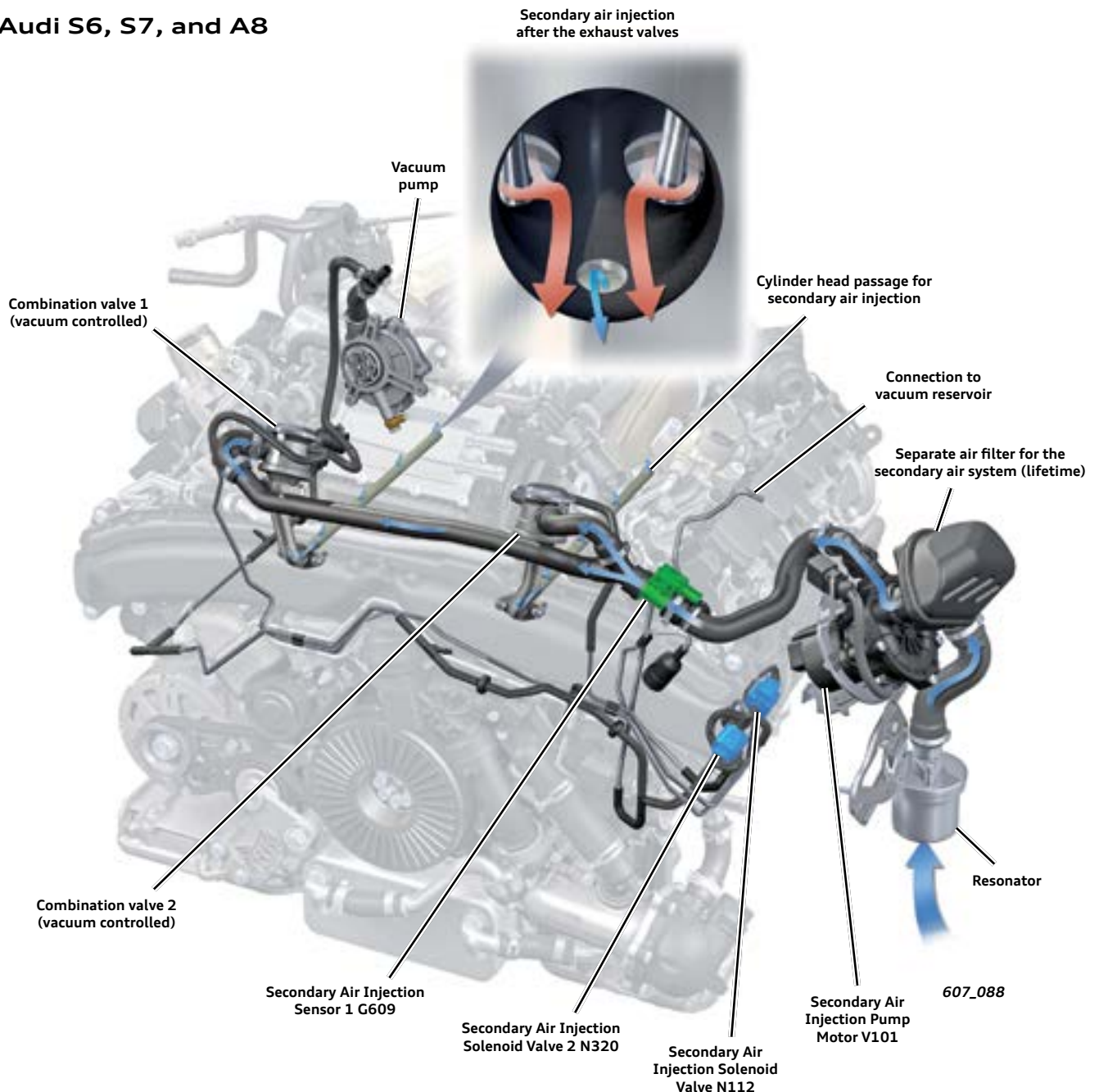
Secondary Air System

A secondary air injection system helps bring the catalytic converters up to operating temperature quickly following a cold start. Air is injected into the exhaust system for a specified period after a cold start by the secondary air system.

The unburned hydrocarbons and carbon monoxides contained in the exhaust gas or accumulated in the catalytic converter react with oxygen. The catalytic converters are heated up more rapidly by the heat that is released.

Some components used on the 4.0L V8 TFSI engine are located or designed differently depending on the engine version.

Audi S6, S7, and A8



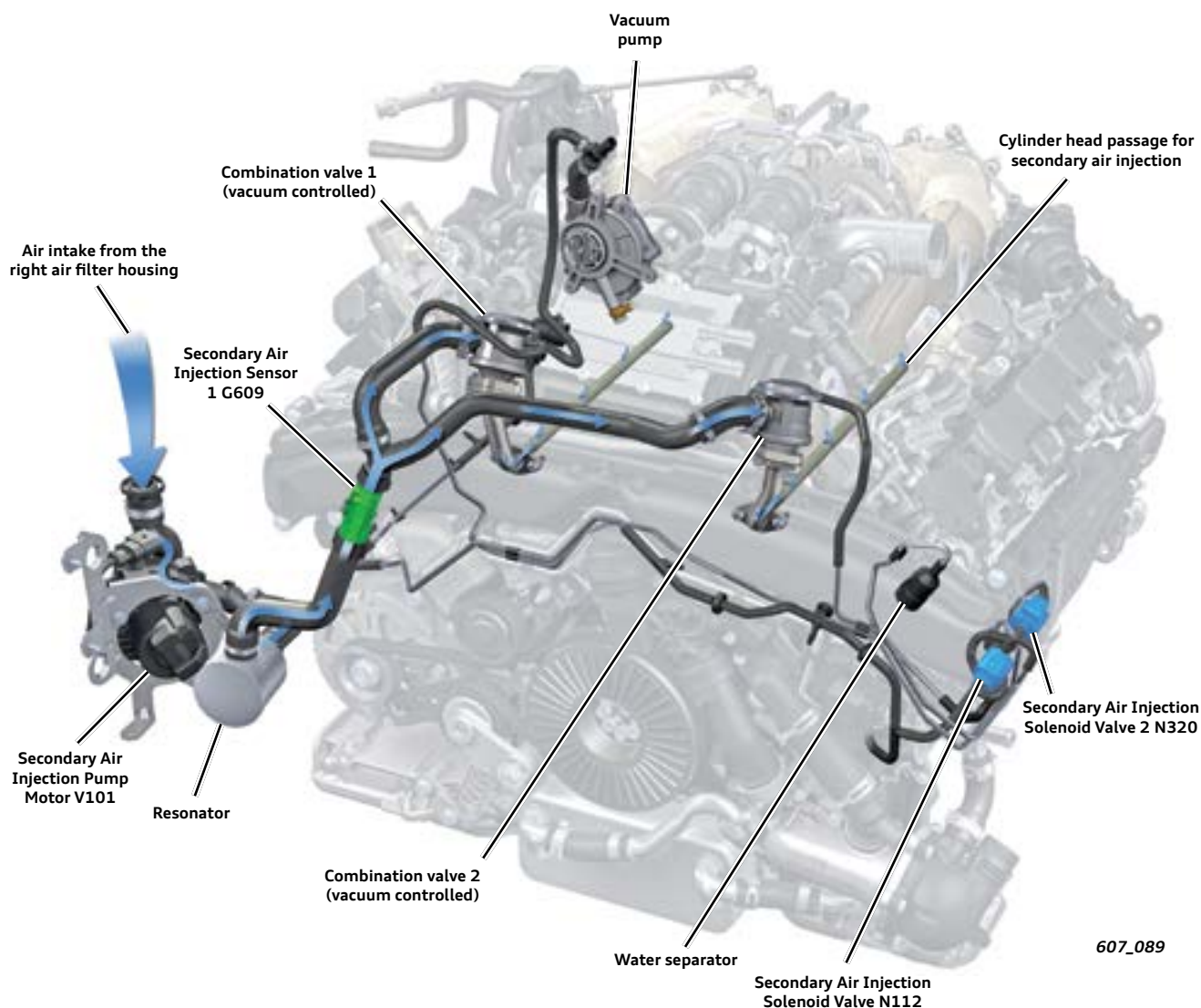
Secondary Air Injection Valves

Secondary Air Injection Solenoid Valves N112 and N320 are controlled by the ECM. They switch vacuum to the two combination valves and are located on bank 2 of the engine. The vacuum supply comes from a mechanically driven vacuum pump.

Water Separator

In extreme situations, for example, the vehicle is driving through puddles or dirty water, water spray can reach the valves N112, N320, and N75. Moisture could penetrate the interior of the vacuum system via the breather and ventilation opening. This moisture could damage the components in the system. To prevent damage, two filter elements are installed in the vacuum hoses.

Audi S8



Engine Management

System Overview

Sensors

Throttle Body Control Module J338
EPC Throttle Drive Angle Sensors G187/G188

Brake Light Switch F

Camshaft Position Sensors G40, G163, G300, G301

Accelerator Pedal Position Sensor G79
Accelerator Pedal Position Sensor 2 G185

Knock Sensors 1–4, G61, G66, G198, G199

Low Fuel Pressure Sensor G410

Secondary Air Injection Sensor 1 G609

Engine Coolant Temperature Sensor G62

Engine Coolant Temperature Sensor on Radiator Outlet G62

Oil Temperature Sensor 2 G664

Engine Temperature Control Sensor G694

Engine Speed Sensor G28

Oil Level Thermal Sensor G266

Intake Manifold Runner Position Sensor G336
Intake Manifold Runner Position Sensor 2 G512

Intake Air Temperature Sensor G42
Manifold Absolute Pressure Sensor G71

Fuel Pressure Sensor G247
Fuel Pressure Sensor 2 G624

Engine Cover Temperature Sensor G765

Charge Air Pressure Sensor G31
Charge Air Pressure Sensor 2 G447

Charge Air Cooler Temperature
Sensors 1 and 2 G763, G764

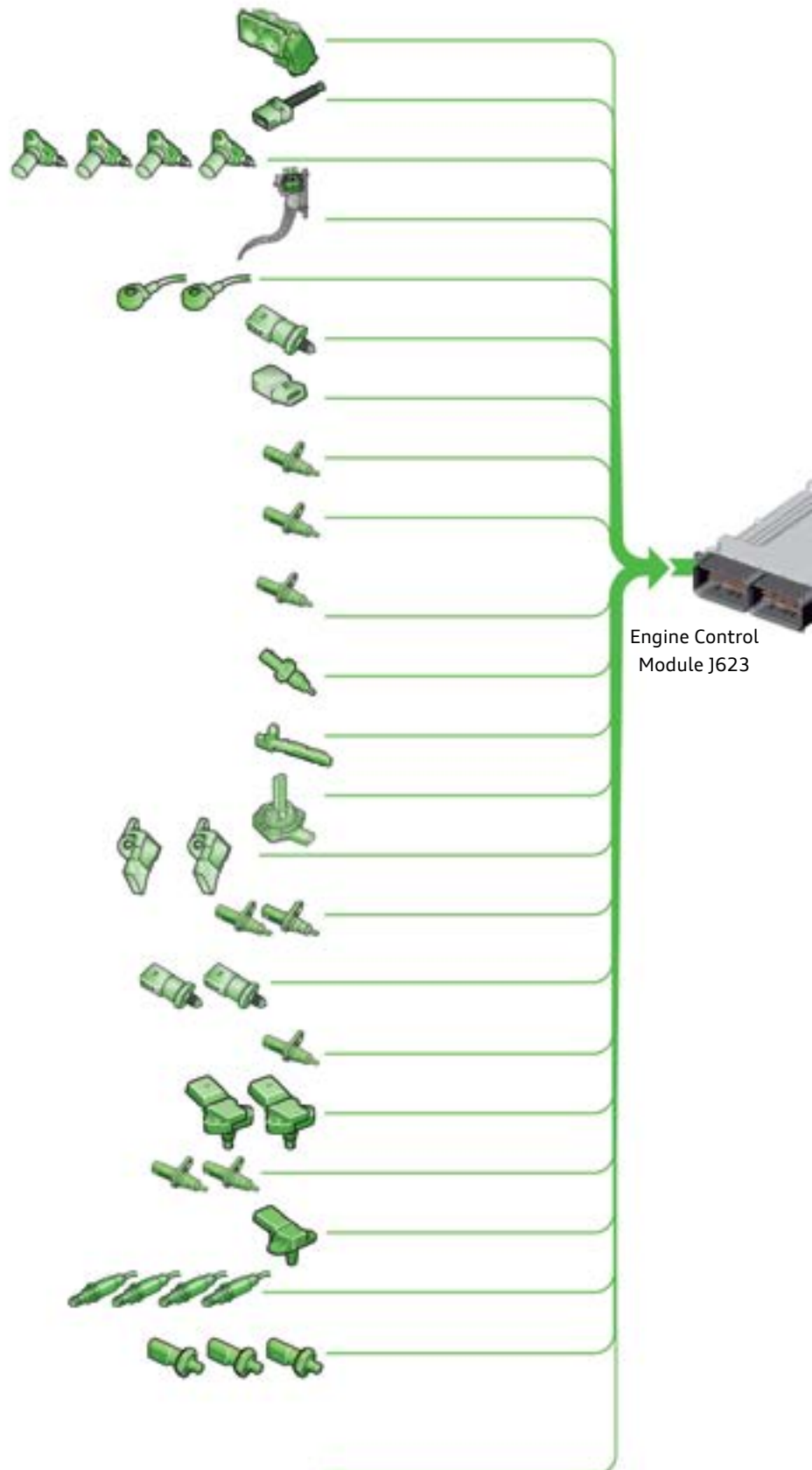
Brake Booster Pressure Sensor G294

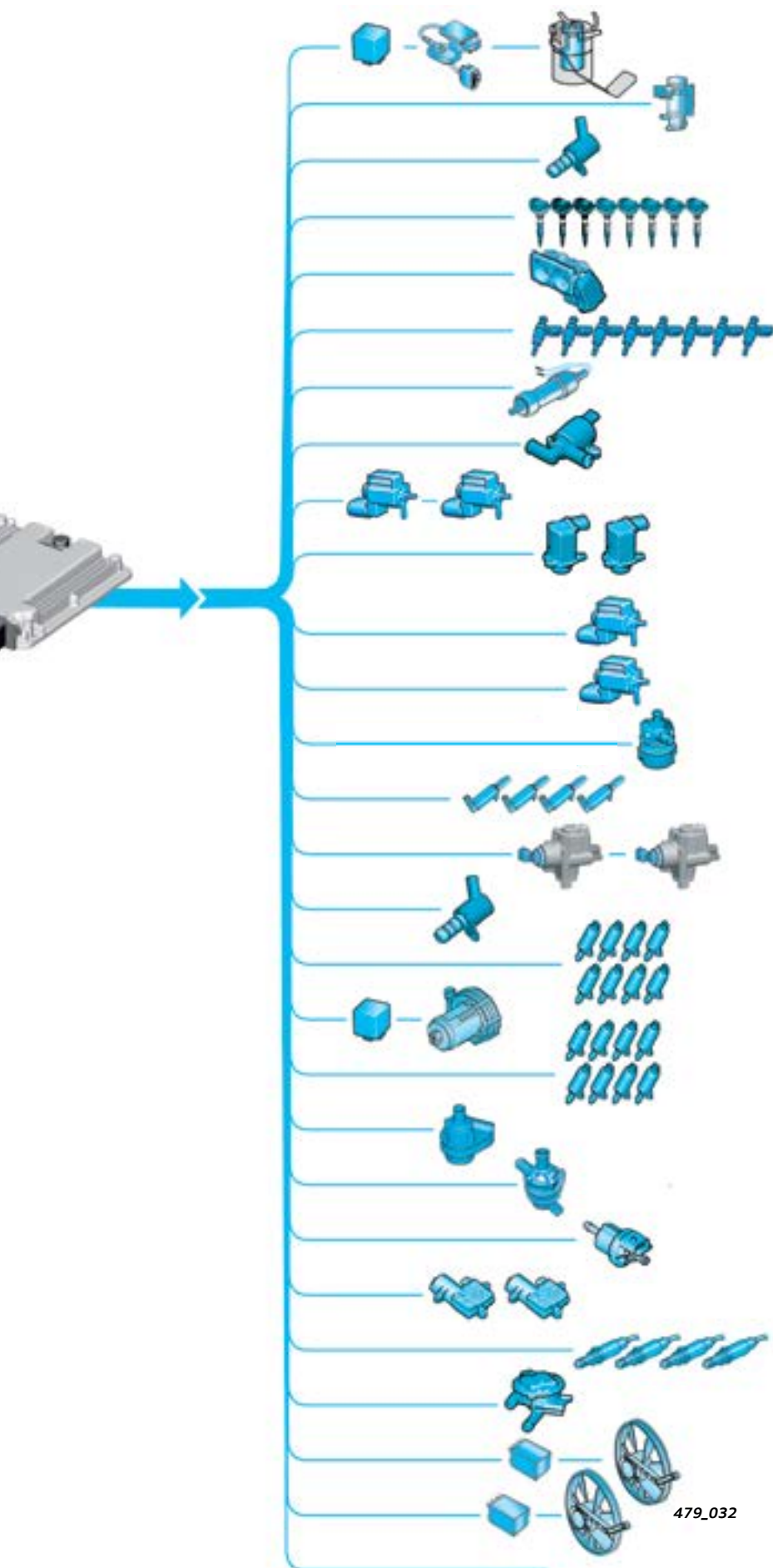
Heated Oxygen Sensors 1 and 2, G39 and G108
Oxygen Sensor after Three-Way Catalytic Converter G130
Oxygen Sensor 2 after Catalytic Converter G131

Oil Pressure Switch F22
Reduced Oil Pressure Switch F378
Oil Pressure Switch Level 3 F447

Additional signals:

- Cruise control
- Vehicle speed
- Start request to ECM (Keyless start 1 + 2)
- Terminal 50
- Crash signal from Airbag Control Module





Actuators

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

Wastegate Bypass Regulator Valve N75

Piston Cooling Nozzle Control Valve N522

Ignition coils 1-8, N70, N127, N291, N292, N323-N326

EPC Throttle Drive J186

Fuel Injectors for cylinders 1-8, N30-N33, N83-N85

Map Controlled Engine Cooling Thermostat F265

Transmission Fluid Cooling Valve N509

Secondary Air Injection Valve Solenoids 1+2,
N112+N320

Turbocharger Recirculation Valve N249
Bank 2 Turbocharger Recirculation Valve N427

Intake Manifold Runner Control Valve N316

Cylinder Head Coolant Valve N489

Charge Air Cooling Pump V188

Camshaft Adjustment Valves 1+2, N205+N208
Exhaust Camshaft Adjustment Valves 1+2, N318+N219

Fuel Metering Valves 1+2, N290+N402

Oil Pressure Regulation Valve N428

Intake Camshaft Adjusters 1+2 for Cylinder 2, F452+F453
Exhaust Camshaft Adjusters 1+2 for Cyl. 2, F454+F455
Intake Camshaft Adjusters 1+2 for Cylinder 3, F456+F457
Exhaust Camshaft Adjusters 1+2 for Cyl. 3, F458+F459

Secondary Air Injection Relay J299 and Motor V101

Intake Camshaft Adjusters 1+2 for Cylinder 5, F464+F465
Exhaust Camshaft Adjusters 1+2 for Cyl. 5, F466+F467
Intake Camshaft Adjusters 1+2 for Cylinder 8, F476+F477
Exhaust Camshaft Adjusters 1+2 for Cyl. 8, F478+F479

Engine Coolant Circulation Pump 2 V178

After-Run Coolant Pump V51

EVAP Canister Purge Regulator Valve 1 N80

Exhaust Door Control Modules 1+2, J883+J945

Oxygen Sensor Heaters 1+2, Z19+Z28
Oxygen Sensor Heaters 1+2 after Catalytic Converter
Z29+Z30

Fuel Tank Leak Detection Control Module J909

Coolant Fan Control Module J293

Coolant Fan V7

Coolant Fan Control Module 2 J671

Coolant Fan 2 V177

Additional signals:
- A/C compressor
- Subframe Mount Control Module J931
- Digital Sound System Control Module J525

Engine Management MED

17.1.1

The 4.0L V8 TFSI engine uses Bosch engine management system MED 17.1.1. Pressure and temperature sensor signals are the principal control variables used to register load.

Operating Modes

As with all FSI and TFSI engines, the 4.0L V8 TFSI engine operates in several modes. Fuel pressure and opening times of the fuel injectors are determined by characteristic maps.

The following descriptions refer to a cold start, to the point when the engine reaches operating temperature.

Injection During Compression Stroke

A cold engine is started in “high pressure stratified start mode” using one injection event per stroke. The injection is during the intake stroke.

Catalytic Converter Heating

Once the engine has started, the heating phase for the catalytic converters begins immediately. There are three injection events per stroke. The triple injection lasts for a maximum of one minute (map regulated). Catalytic converter heating is aided by secondary air injection.

Sound Actuator System

The sound actuator system consists of the Structure Borne Sound Control Module J869 and Structure Borne Sound Actuator R214. Various sound files are stored on J869 that are played as a function of vehicle and operating data (load, engine speed, vehicle speed) and forwarded to the actuator.

The actuator generates the structure-borne sound. The sound is then introduced via the body and the windshield to the vehicle interior. The actuator is installed using a special bracket on the left at the base of the windshield. The bracket is the “tuning fork” of the system.

Different vehicles and engines require different excitation for a balanced engine sound. Information about the engine installed and the body are communicated on the CAN bus and are evaluated. J869 recognizes independently in which vehicle it is installed. The driver can select different sound settings through the MMI.

There is also a sensor in the ECM to record ambient air pressure. Its signal can be collated in the corresponding measurement. The control module is a UDS device and communicates over the CAN bus.

Warm Up

Then warm up begins. In this phase there are two injection events until the coolant temperature has reached 158°F (70°C).

Homogeneous Operation

When coolant temperature exceeds 158°F (70°C), the engine switches to homogenous operation. There is one injection event on the intake stroke.



607_111

Engine Compartment Temperature Management

Engine Cover Temperature Sensor G765 is installed to monitor temperature in the engine compartment. An NTC sensor, G765 is installed under the engine cover close to the turbocharger for cylinder bank 1. Its working range is up to approximately 356°F (180°C). Its job is to record temperature in the area of the turbocharger.

In some situations, for example, when the vehicle has to stop suddenly at a red light while driving at highway speeds, heat buildup can arise due to high heat dissipation from the turbochargers and catalytic converters. As a result, surrounding components in the inner V and in the area of the vehicle bulkhead could be damaged.

If a specific temperature stored in the map is exceeded, the ECM switches on the cooling fans. This creates a forced airflow through the engine compartment. The accumulated heat buildup is drawn off via the vehicle underbody. The radiator fan may also activate after the vehicle has been parked. Delayed shut off of the fans can last up to 10 minutes, if required.

Effects of a Malfunction

In the event of a malfunction, an entry is made in the DTC memory. A substitute value of 356°F (180°C) is used for calculation and both fans are activated with an output of 100%. The sensor is checked (only for short circuits) by the ECM.



Engine Cover Temperature
Sensor G765

607_113a

If the sensor is defective, there is no error message in the instrument cluster nor is engine power reduced.

Special Tools and Fixtures

T40272



607_125

Rotation of the crankshaft in the Audi A8 and S8

T40269



607_126

Assembly operations on chain drive in the area of the camshaft phaser

T40048



607_127

Replacing crankshaft seal ring on the belt side

VAS 6095/1-13



607_129

In conjunction with VAS 6095 and VAS 609/1 engine-dependent holder for 4.0L V8 TFSI

T40264



Locking the camshafts

607_128

T40257



Turning the crankshaft of S6 and S7

607_0130



Note

For more information, refer to current technical information.

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 Homepage:

- ▶ Click on the “ACADEMY” tab
- ▶ Click on the “Academy Site” link
- ▶ Click on Course Catalog Search and select “920223B — The Audi 4.0L V8 TFSI Engine with Twin Turbochargers”

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.

