



## 6.0L W12 Engine in the Audi A8L



**SELF-STUDY PROGRAM  
COURSE NUMBER 921403**

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**The self-study program is not intended as a Workshop Manual. Values given are only intended to help explain the subject matter and relate to the software version applicable at the time of publication.**

The self-study program contains information on design features and functions.

Always use the latest technical publications when performing maintenance and repair work.

New



Attention Note



# Introduction

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The new top of the line models from the Volkswagen Group feature an innovative generation of W engines developed from the model used for the VR engine family.

To achieve this, mass produced components have been integrated into a completely new engine concept.

This process has yielded compact, multi-cylinder gasoline engines of a consistently high standard not previously achieved in passenger car series production.

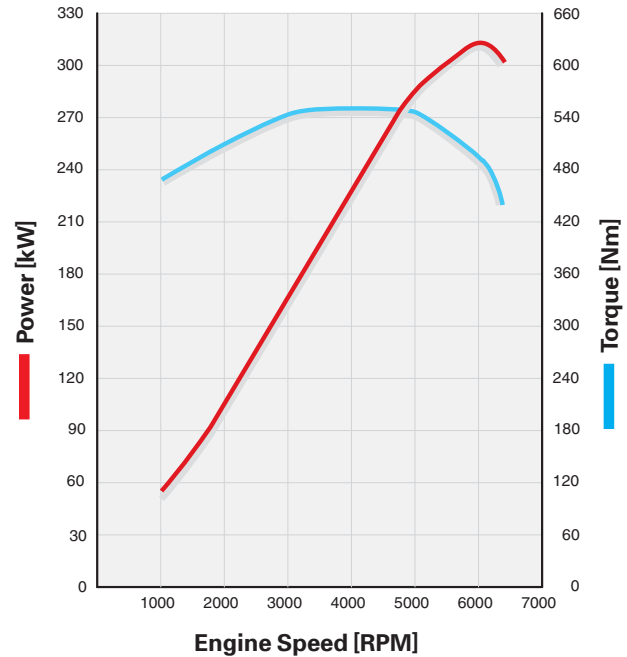
For example, the W12 6.0 L engine, featured for the first time in the Audi A8L, is currently the most powerful 12-cylinder engine available in this vehicle class, providing a combination of quality and optimum performance.



SSP267\_205

## Technical Data

Engine Code Letters:	BSB
Design:	W Engine with a V Angle of 15° and a Bank Angle of 72°
Capacity:	366 cu. in. (5998 cm <sup>3</sup> )
Maximum Power:	450 hp (335 kW) at 6200 RPM
Maximum Torque:	428 lb-ft (580 Nm) at 4000-4700 RPM*
Bore:	3.31 in. (84.0mm)
Stroke:	3.55 in. (90.27mm)
Compression Ratio:	11:1
Weight:	540 lb. (245 kg)
Fuel:	Premium Unleaded
Firing Order:	1-12-5-8-3-10-6-7-2-11-4-9
Ignition Interval:	60° Crankshaft
Engine Management:	Motronic ME 7.1.1
Emission Standard:	BIN 9 Federal LEV I California



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Engine Oil:	VW 50301 (OW 30)
Oil Change Quantity:	Approximately 13 qt. (12.5 L) with Filter
Idling Speed:	560 RPM

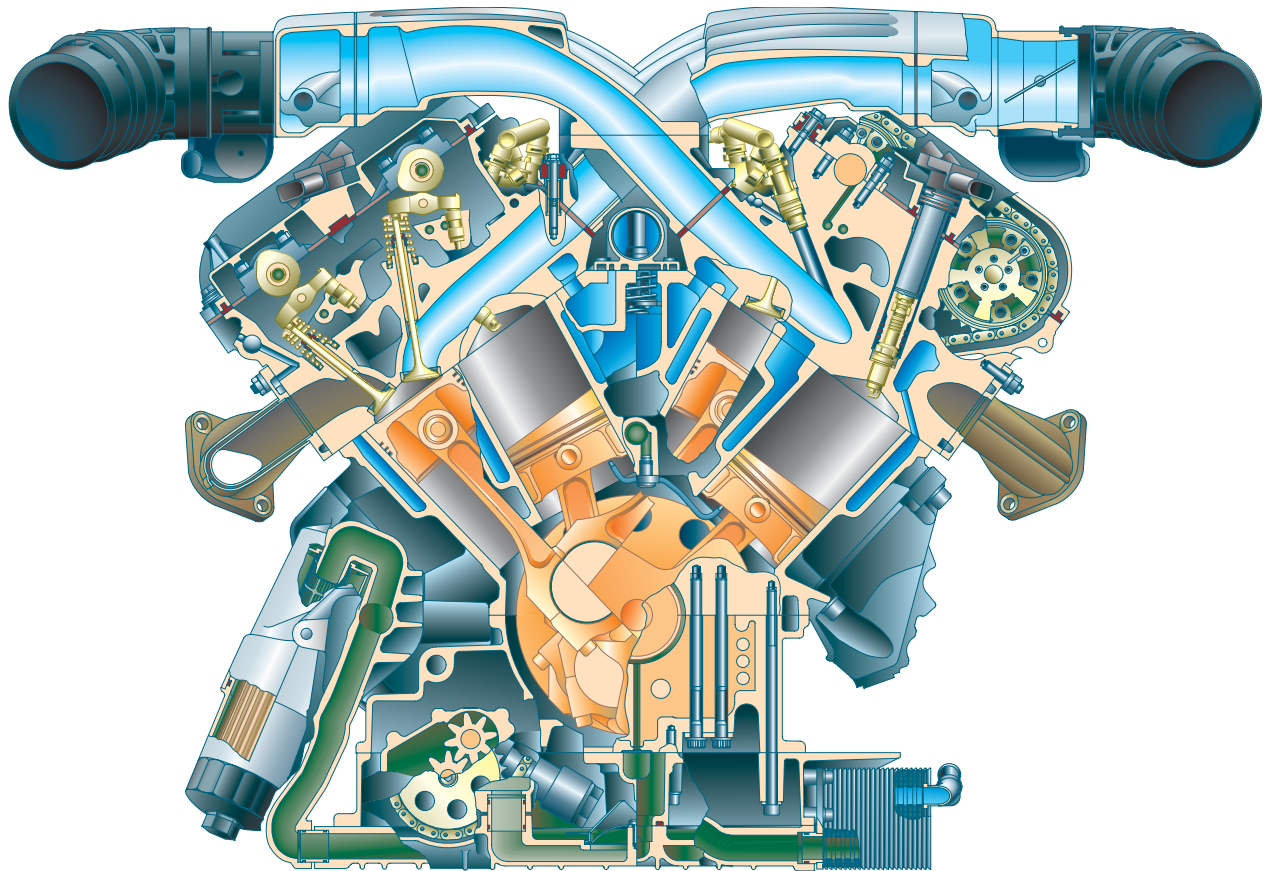


Premium unleaded 91 AK1/95 RON is recommended for maximum performance. Using regular unleaded results in reduced power.

\* More than 90 % of Maximum Torque is available at 1800 RPM.

# Introduction

## Cross Section

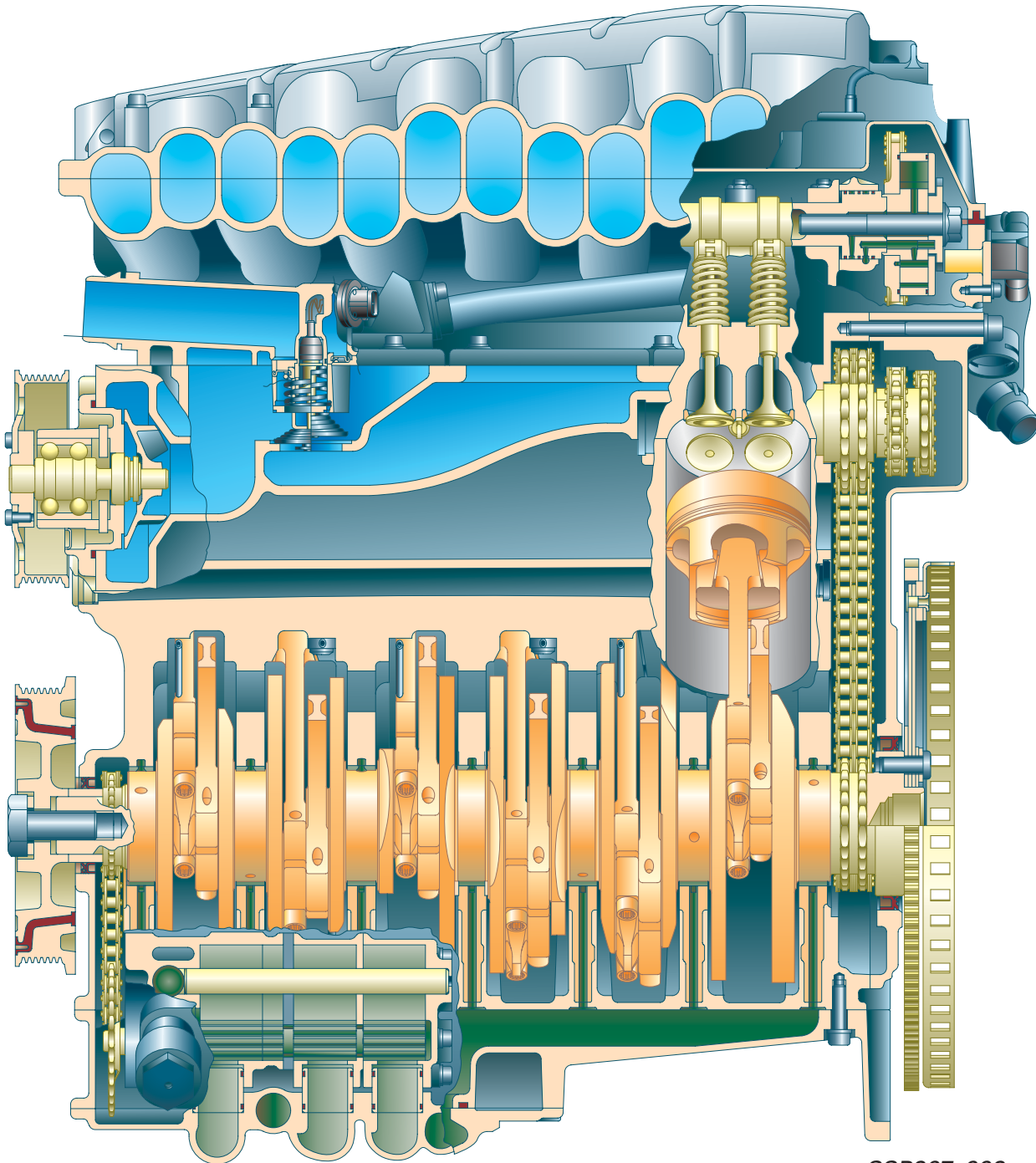


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### Special Features of the W12

- 12-Cylinder, W Design Gasoline Engine
- Aluminum Engine Block and Cylinder Heads
- Oil Supply with Wet Sump Lubrication
- Twin Overhead Camshafts with Four Valves Each per Cylinder
- Roller-Type Rocker Fingers Valve Operation
- Infinitely Variable Timing Control for Inlet and Exhaust Camshafts

## Longitudinal Section

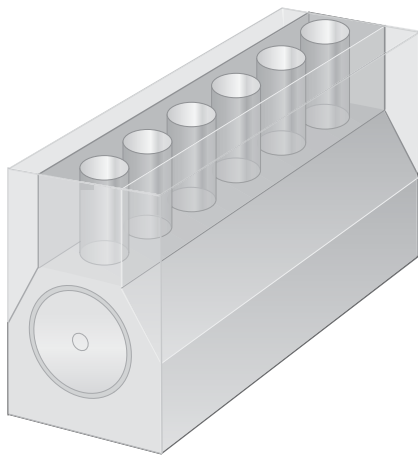


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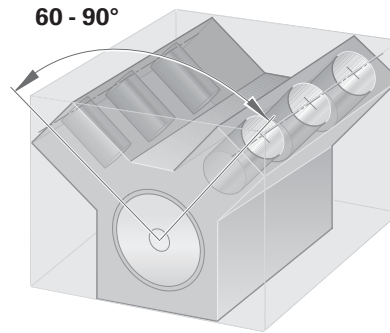
- Four Catalytic Converters for Emission Control
- Eight Oxygen Sensors for Mixture Formation Control and Emission Control Monitoring

# Introduction

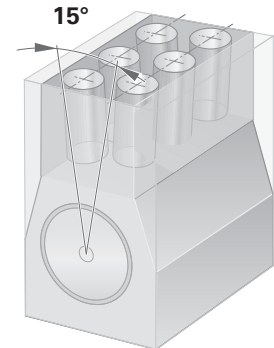
## W Design



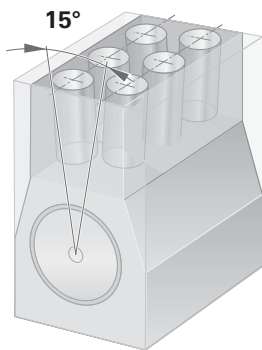
**In-line engine**



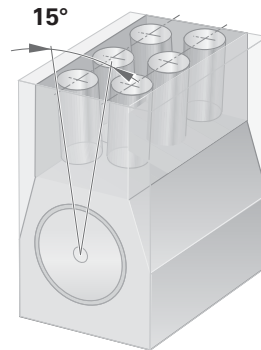
**V-engine**



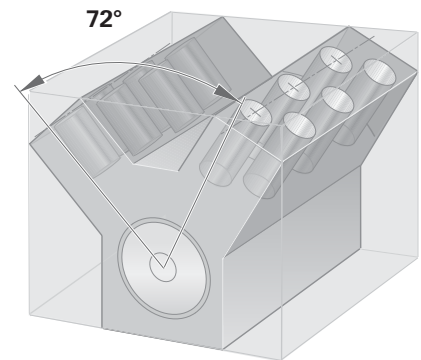
**VR-engine  
(V-engine with  
small V-angle)**



**VR-engine**



**VR-engine**



**W-engine**

*SSP267\_082*

The new generation of W engines was developed to achieve a more compact design in relation to the number of cylinders.

The W engines incorporate design features of the VR engine generation.

Combining two VR6 engines using a bank angle of 72° and a joint crankshaft creates a "V" V12 engine or a W12 engine.

V-engines with a small V angle are also called VR engines. They benefit from the design advantages of both the smooth running in-line engine, and the short design of the V-engine.

With a length of 20.2 in. (513mm) and a width of 28.0 in. (710mm), the W12 engine has the same space saving dimensions as the V8 5V engine.



# Cylinder Block

The cylinder block is cast from a hyper-eutectic aluminum silicon alloy (Alusil).

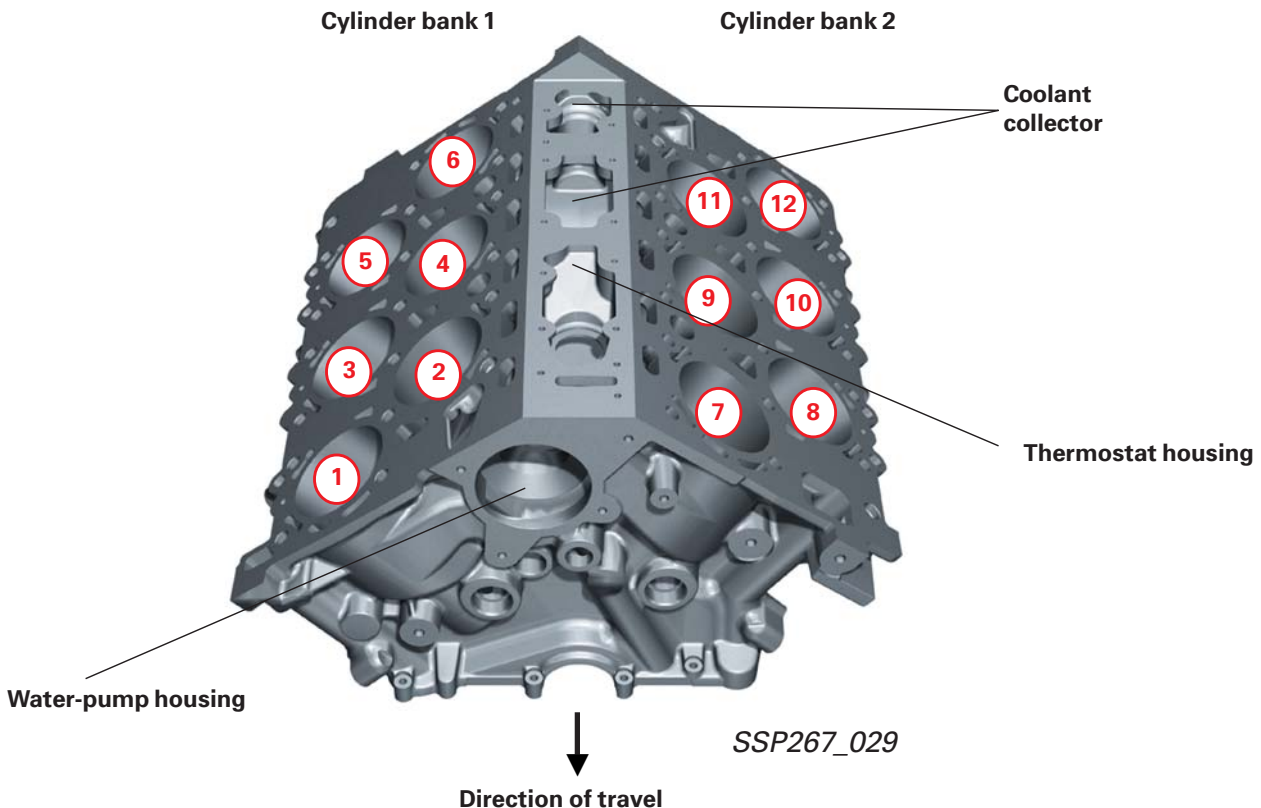
When this alloy solidifies, it produces pure silicon crystals and aluminum silicon mixed crystals.

A special cylinder honing process exposes the separated silicon crystals and the process creates wear resistant cylinder contact surfaces that eliminate the need for additional liners.

The coolant reservoir, water pump housing and thermostat housing are integrated into the vee of the cylinder banks and reduce the number of external coolant pipes.

## Major Advantages of this Monolithic Solid Aluminum Block:

- Optimum heat transfer from cylinder surface to heat-dissipating water jacket
- No thermal expansion problems compared to material combinations (e.g. inserted grey cast iron liners)
- Same thermal expansion characteristics allow minimal piston running clearance over the entire temperature range and results in smooth operation
- Considerable weight saving



# Cylinder Block

The “fan” arrangement of the cylinder bores with a V angle of  $15^\circ$ , and a bank angle of  $72^\circ$ , creates a compact and rigid cylinder block.

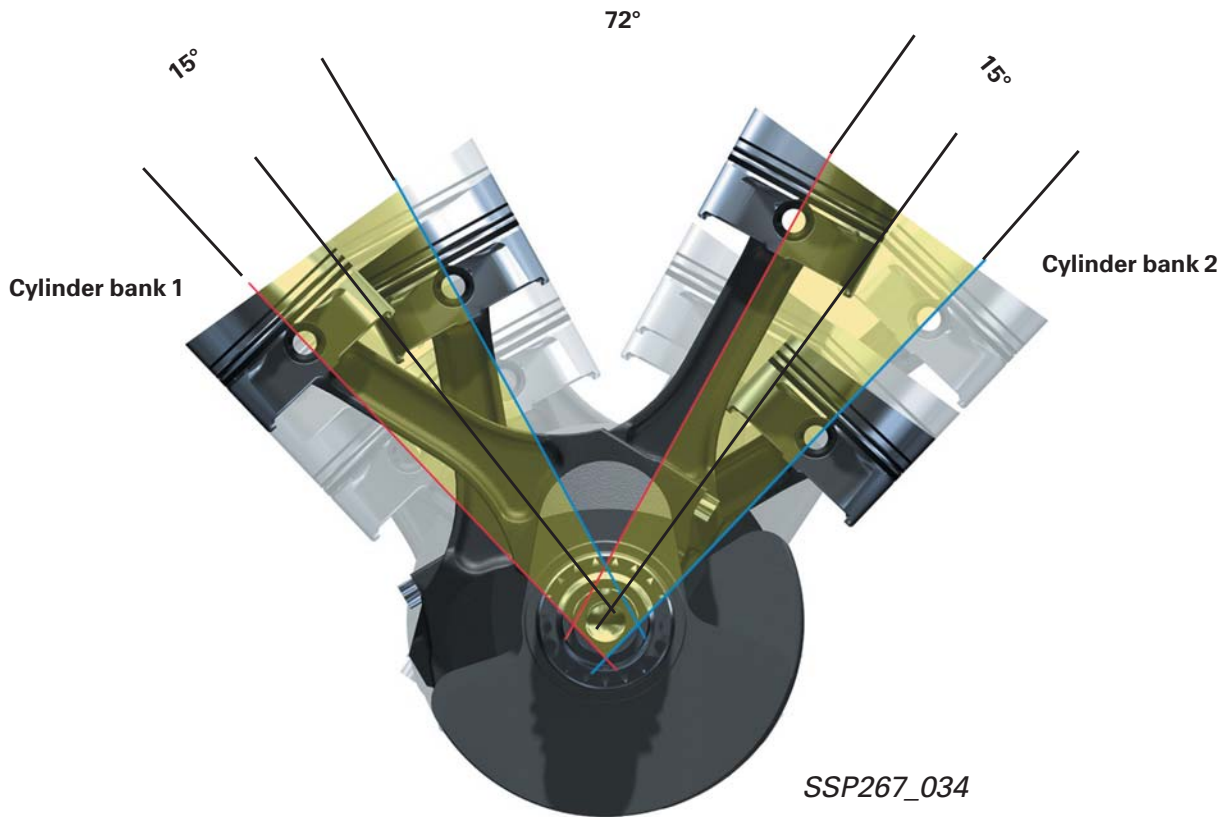
With a conventional layout, the very narrow V angle of  $15^\circ$  and the design of the cylinder block would affect the cylinder overlap in BDC position.

As a result, the cylinders are offset with respect to the axis of crankshaft rotation. The cylinder center axes do not coincide with the crankshaft axis, but are offset to the left or right.

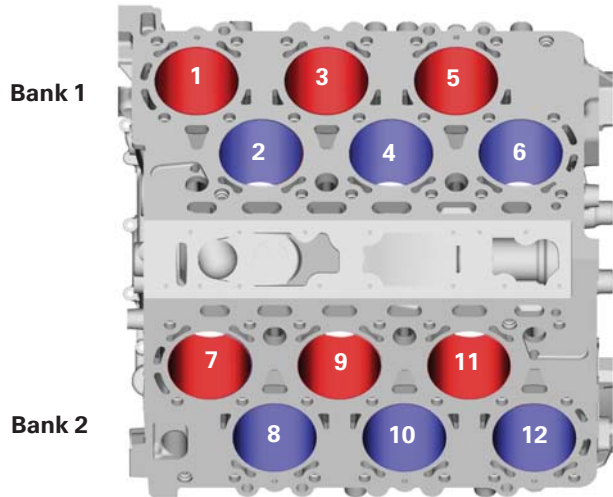
This arrangement is known as cylinder offset.

Together with an appropriate piston skirt design, the necessary clearance in BDC position is achieved. (Refer to Section on Pistons/Connecting Rods.)

The offset cylinder configuration requires corresponding design modifications affecting both crankshaft group and valve timing.



# Cylinder Block



The offset is as follows:

Odd-numbered cylinders - 0.5 in.  
12.5 mm (cyl. 1-3-5-7-9-11)

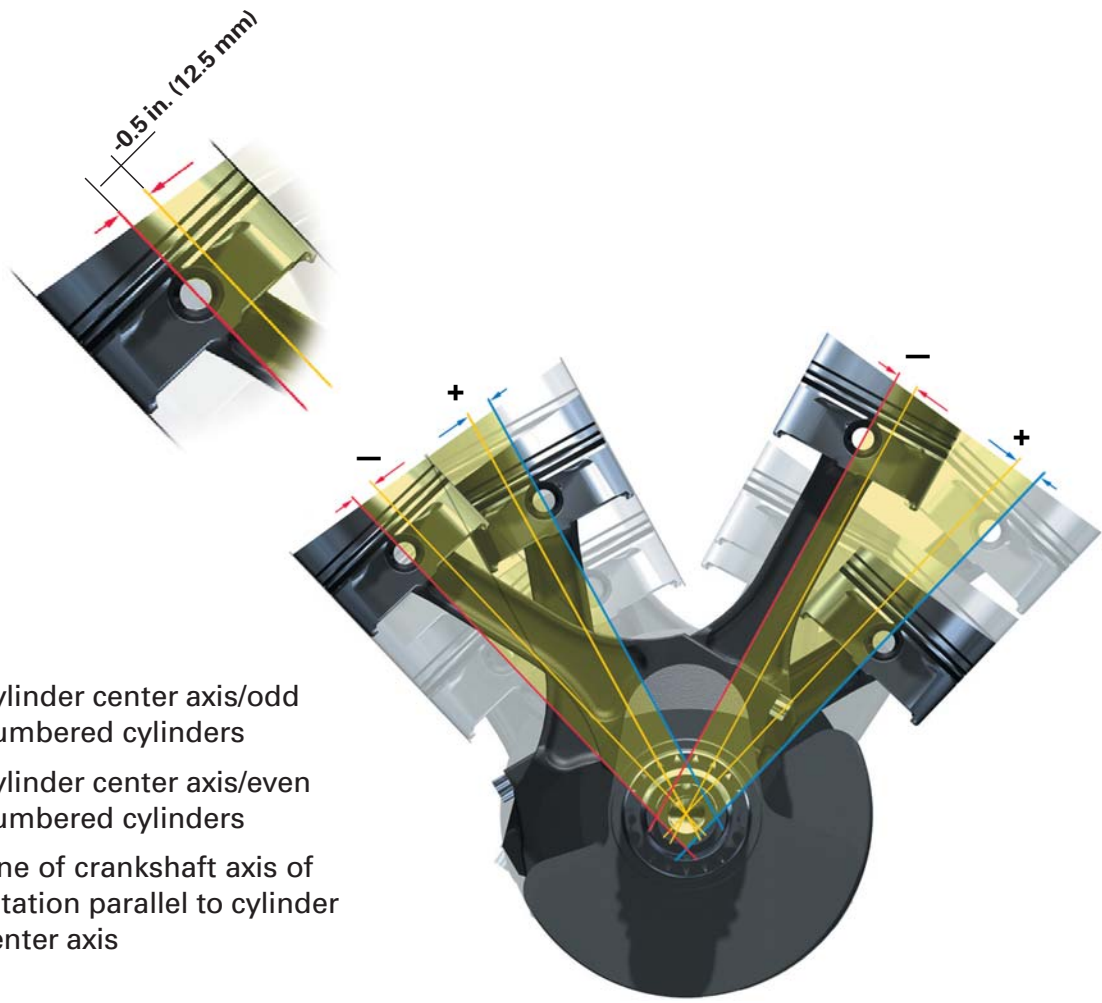


and

Even numbered cylinders + 0.5 in.  
+ 12.5 mm (cyl. 2-4-6-8-10-12)



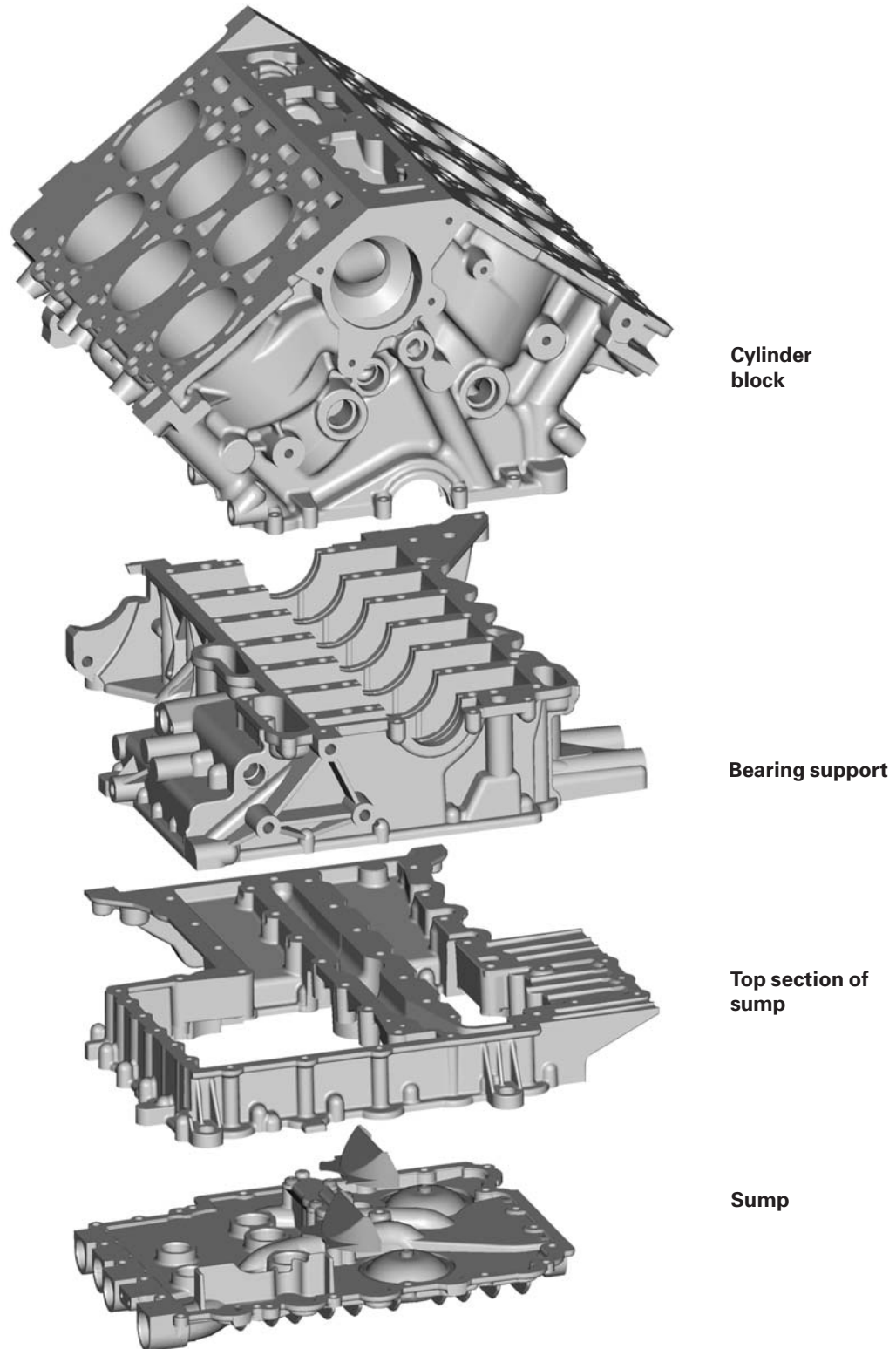
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- Cylinder center axis/odd numbered cylinders
- Cylinder center axis/even numbered cylinders
- Line of crankshaft axis of rotation parallel to cylinder center axis

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# Cylinder Block and Crankcase



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The crankcase is formed by the cylinder block and the bearing support.

# Cylinder Block and Crankcase

The main bearing clearance is as constant as possible to satisfy noise level requirements over the entire operating temperature range. This is accomplished by using a rigid bearing assembly.


The cast iron main bearing caps produce a form-fit in a rigid aluminum bearing support.

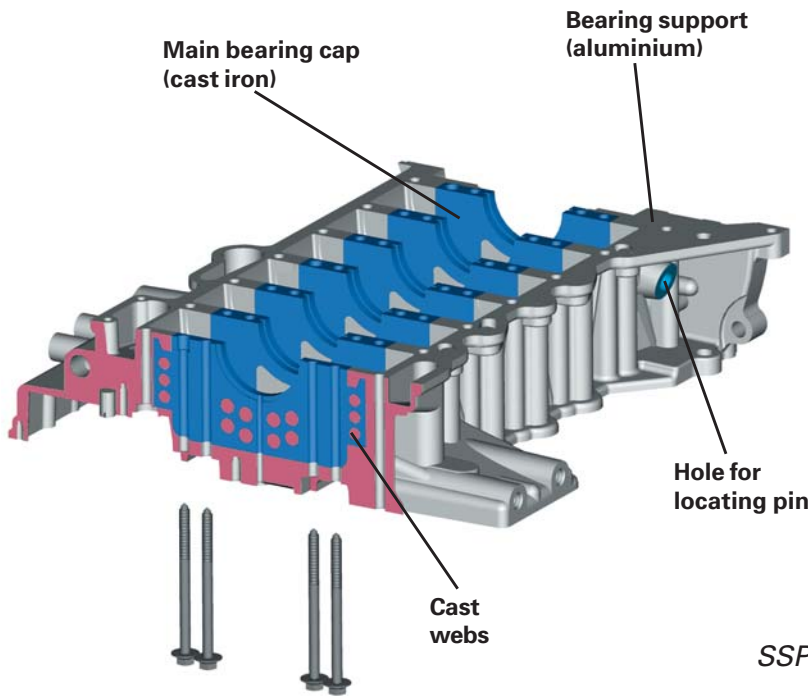
Each of the main bearings is only 0.59 in. (15mm) wide. Four permanently tightened M8 bolts secure the main bearings.

The bearing support bolts to the cylinder block, together with the top section of the sump and enhances the stability of the entire engine block.

A tapped crankshaft locating hole is provided at the rear left of the bearing support.

By using of the appropriate locating pin, the crankshaft is fixed in position at Number 1 Cylinder TDC. The locating Pin is engaged in the crank web of Number 12 Cylinder.

 Do not use the locating pin to provide support, for example when loosening and tightening the central bolt.



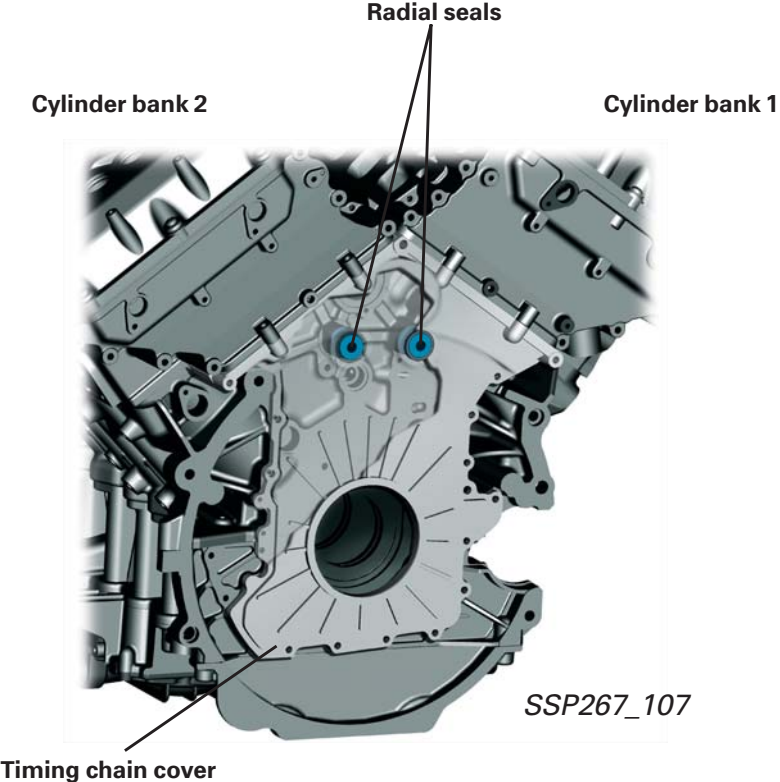
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# Cylinder Block and Crankcase

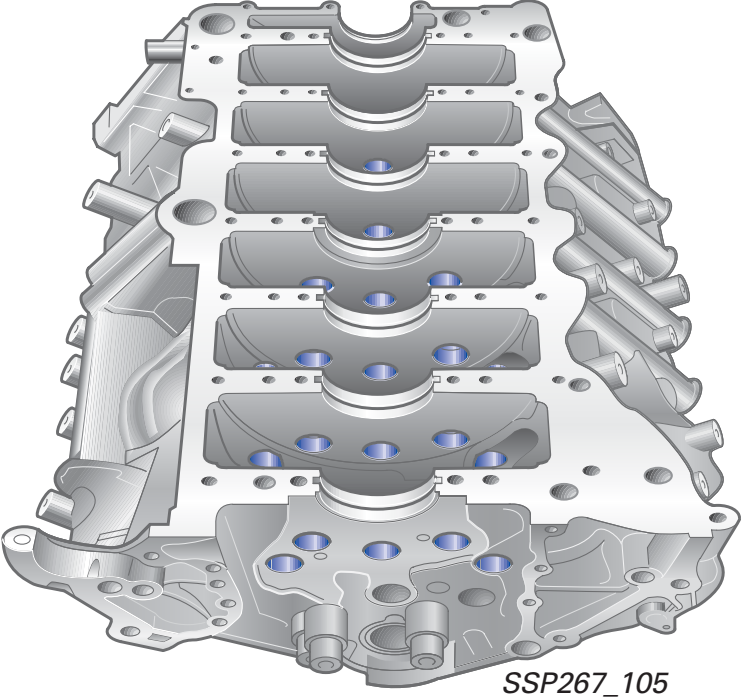
The method of attaching the engine block to the transmission is unique.

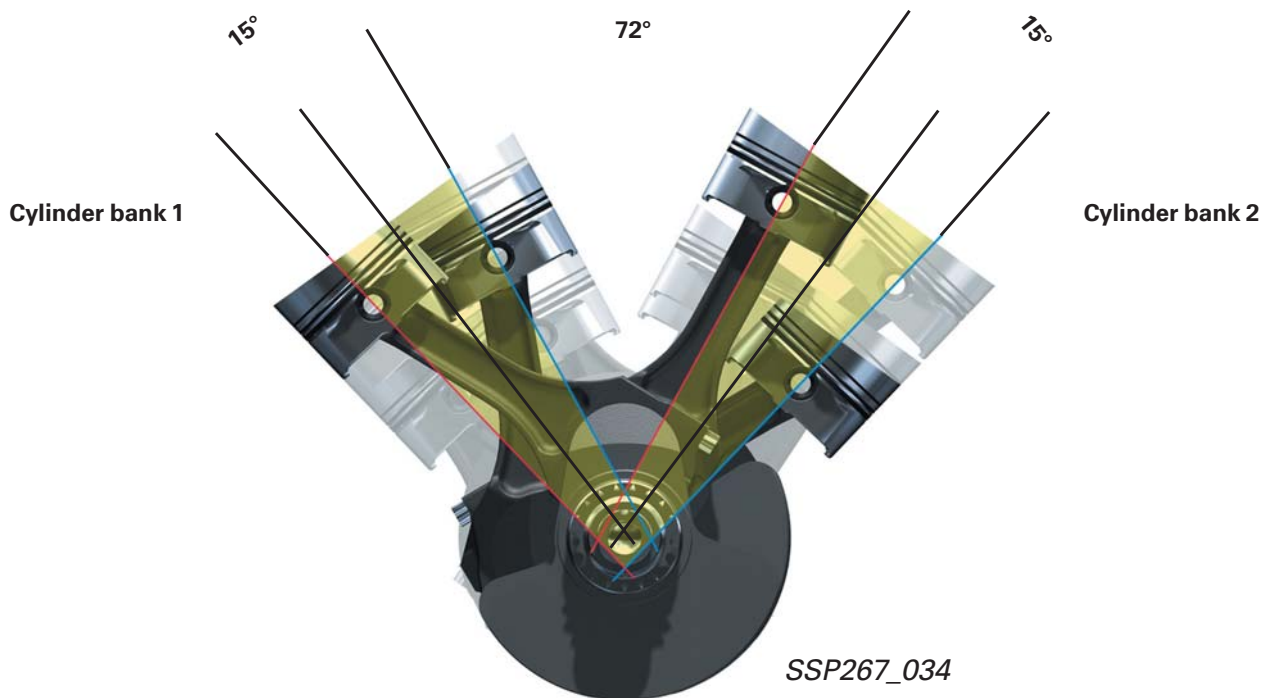
The two upper transmission attachment points protrude through the timing chain cover to provide a connection.

These connection pieces are fitted with radial seals.



Pulsation holes in the bearing blocks allow pressure equalization between the cylinder chambers.



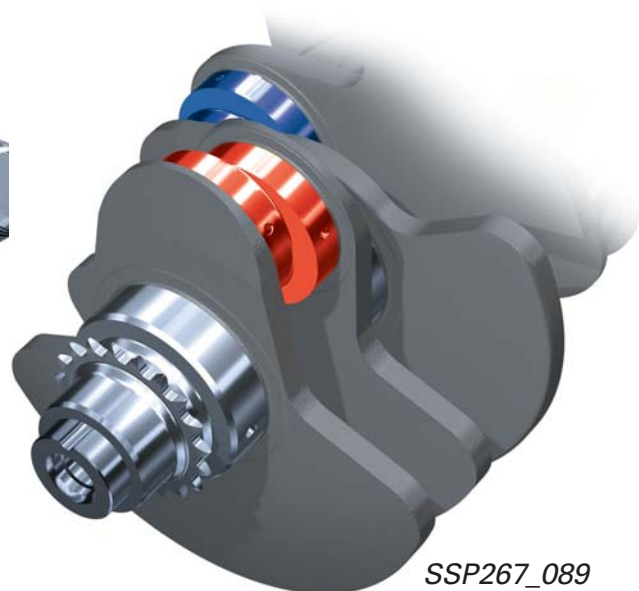


The seven bearing crankshaft is forged and made of heat-treated steel.

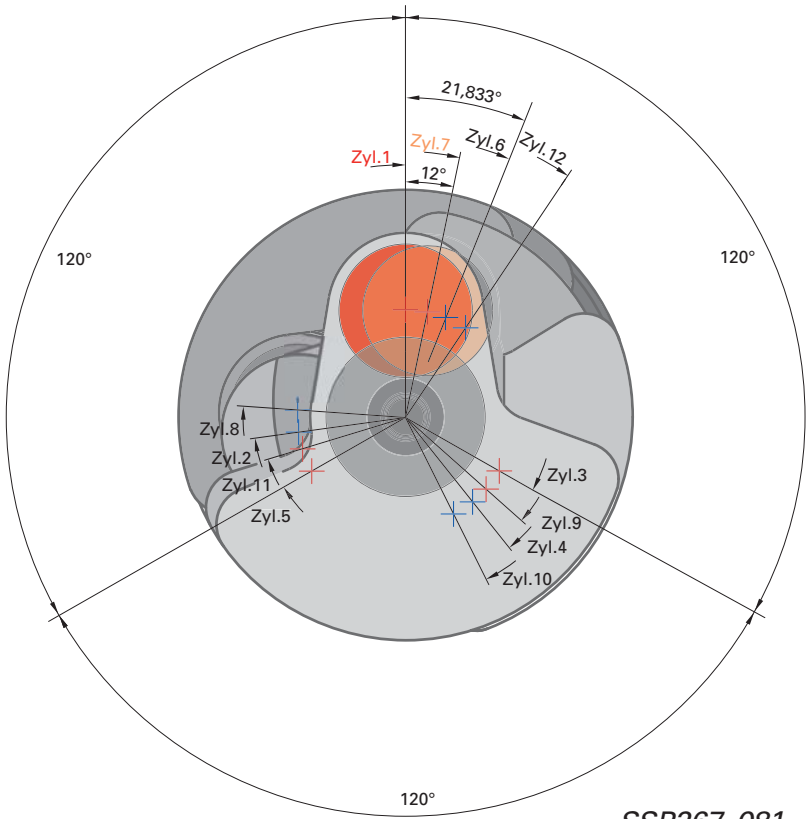
The creation of the uniform ignition interval of 60° (standard for 12 cylinder engines), requires modifications to the crankshaft.

As is the case with V-engines, two connecting rods are mounted on each crank pin.

Due to the bank angle of 72°, the six crank pins are offset 12° relative to the corresponding opposite cylinders. This is a "split pin" configuration.

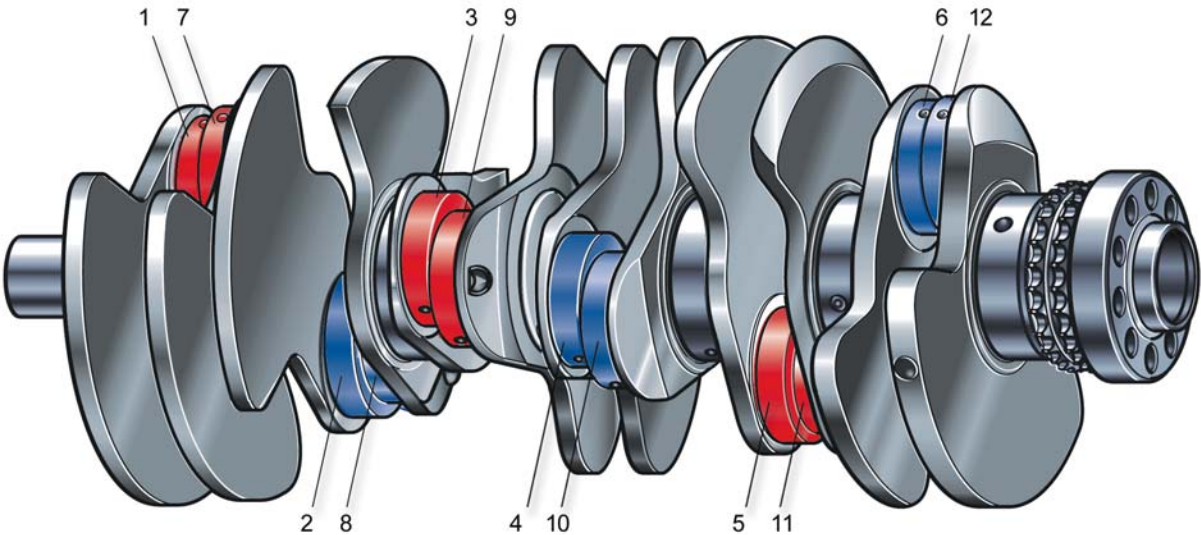


# Crankshaft



SSP267\_081

+/+ Center points of corresponding crank pins



SSP267\_080



# Crankshaft

On a conventional 12-cylinder engine, the crank pins are mutually offset by  $120^\circ$ .

With the W12 engine, the cylinder offset means that there is an interval of  $21.833^\circ$  between the two crank pins on each plane.

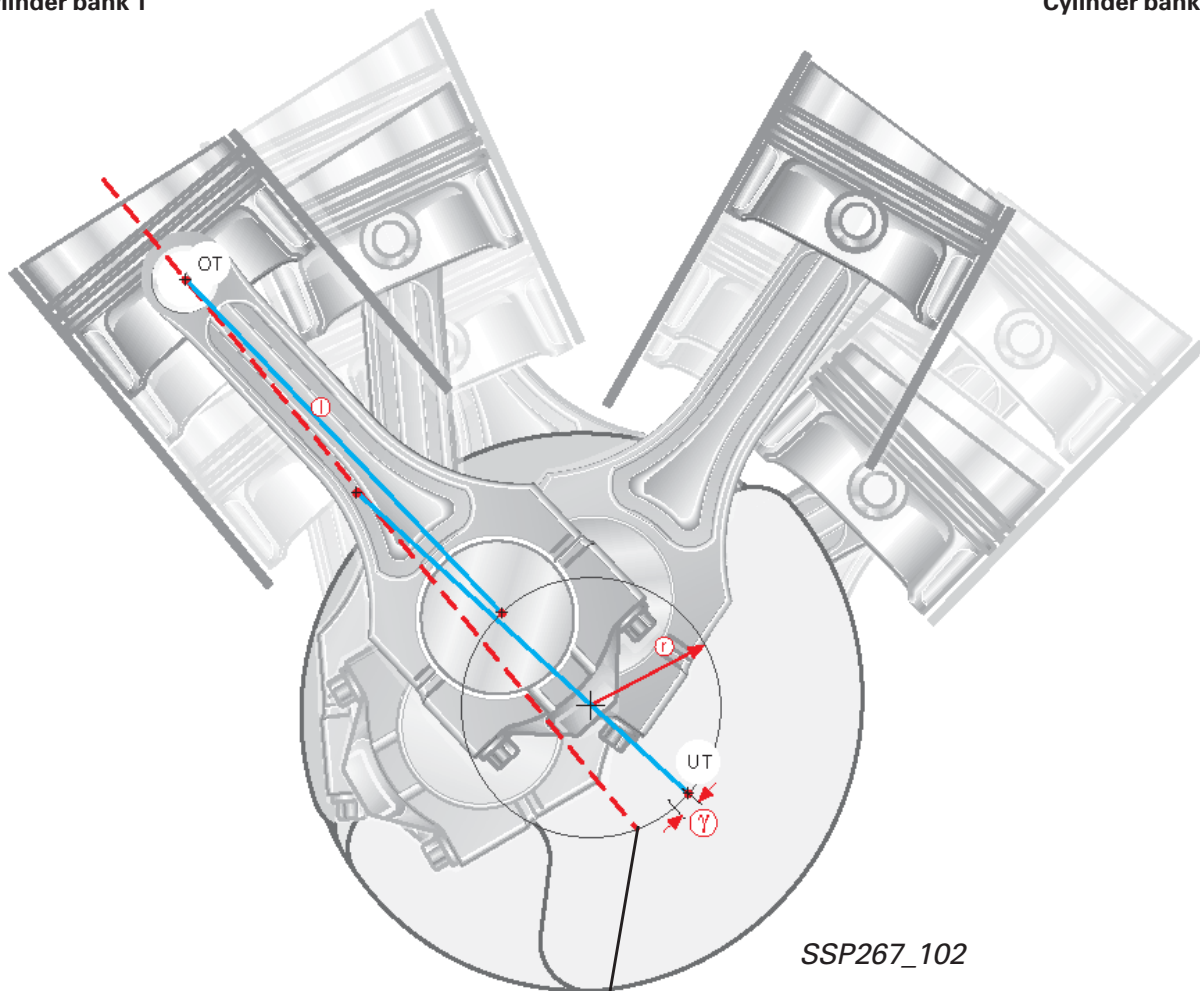
As a result, the crank pin travel (angle) differs along the circular path from TDC to BDC and from BDC to TDC.

The two facing rows of cylinders in one bank oppose those in the other bank.

This explains the need for both the unconventional crank pin offset and the differences in valve timing for the even numbered and odd numbered cylinders.

Cylinder bank 1

Cylinder bank 2



Cylinder axis

**l** - Conrod length  
**r** - Crank radius  
**y** - Offset at BDC

# Pistons/Connecting Rods

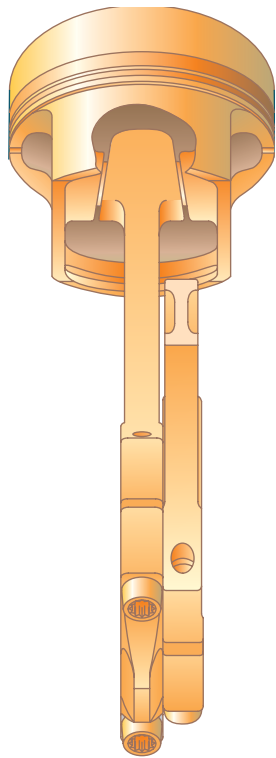
The pistons are made of a eutectic aluminum silicon alloy and are identical for both rows of cylinders in each bank.

The joint flat cylinder head surface of the two rows of cylinders in each bank results in an asymmetrical combustion chamber. The piston crown is angled to create a symmetrical combustion chamber.

The installation direction is guided by the piston crown angle.

The piston skirt is a shorter, stepped design to allow it to move between the bearing blocks.

Since the pistons move in aluminum cylinders, they have an electroplated iron coating (Ferrostan).



SSP267\_031

Oil spray jets cool the pistons and prevent thermal overloading.

The connecting rod upper end is a trapezoidal shape to reduce oscillating masses and distribute the combustion force more evenly.

Because of the compact design of cylinder block and crankshaft, the connecting rods are only 0.51 in. (13mm) wide at the large connecting rod eye.

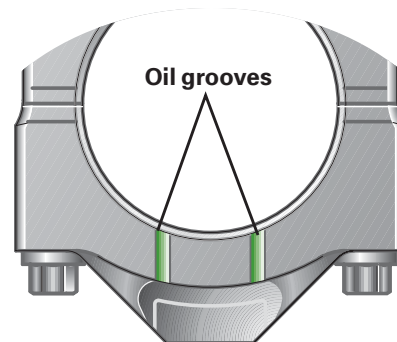
As a result, the contact surface between connecting rod cap and connecting rod is very small. The bolted joint is machined and fitted with anti-fatigue bolts.

Oil grooves in the connecting rod cap facilitate the exit of oil from the connecting rod bearing.

Compensation for the specific load acting on the connecting rod bearing is provided by a sputter bearing shell for the connecting rod and a three-material bearing shell in the connecting rod cap.

Sputtering is the application of bearing material using electrical energy.

Since the bearings have no lugs, a special tool must be used for connecting rod assembly.



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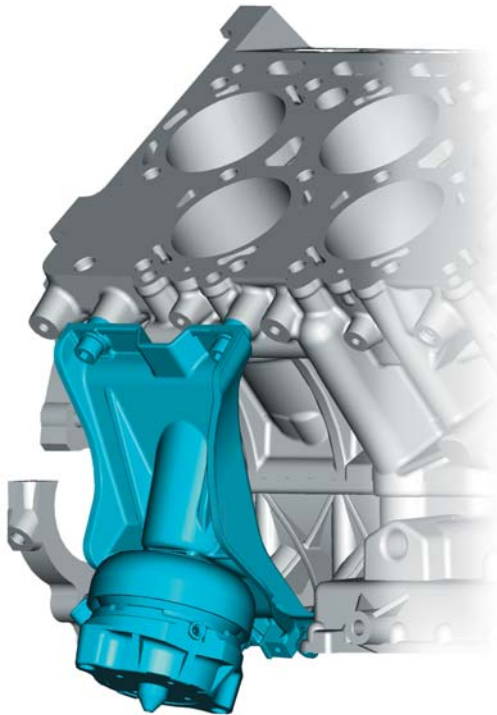
## Engine Mounting

Maximum ride comfort is achieved with the aid of two electrically-actuated engine mounts with hydraulic damping.

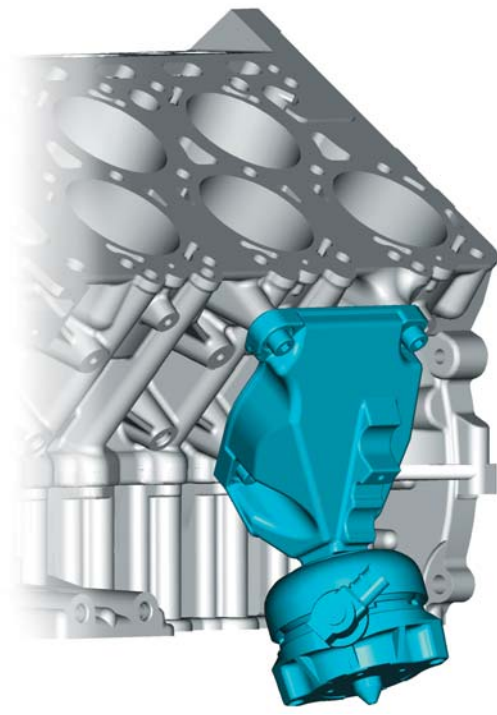
The solenoid valves are actuated by the ECMs as a function of engine and vehicle speed.

The left and right Electro-Hydraulic Engine Mounting Solenoid Valves (N145 and N144) are actuated by Engine Control Modules (ECUs) 1 and 2 (J623 and J624) respectively.

The switching point is approximately 1100 RPM when the vehicle is stationary, compared to less than 850 RPM at a speed of more than 4.5 mph (7 km/h).



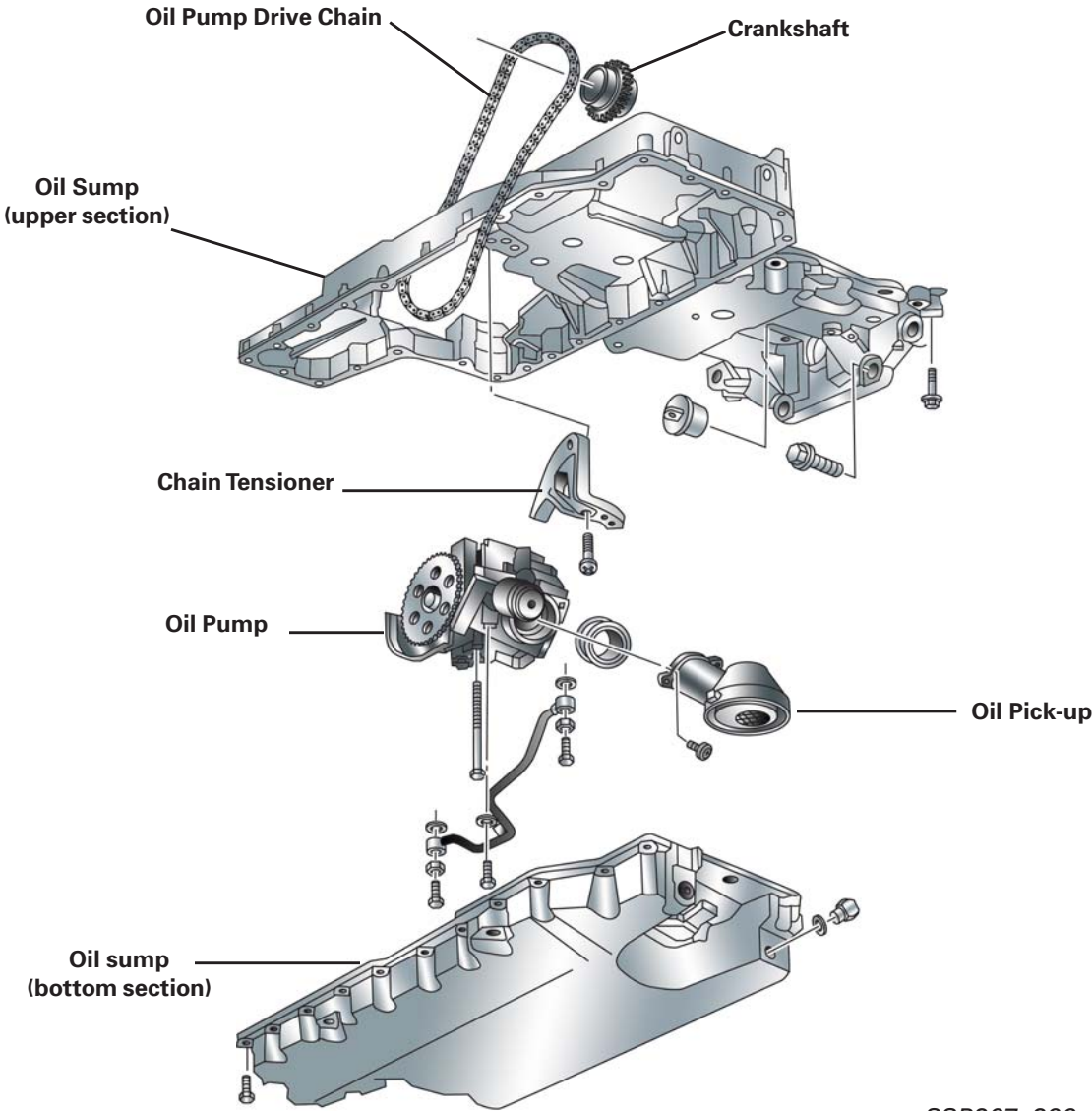
Engine Mount/Cylinder Bank 1 with the Right Electro-Hydraulic Engine Mount Solenoid Valve (N145)



*SSP267\_124*

Engine Mount/Cylinder Bank 2 with Left Electro-Hydraulic Engine Mount Solenoid Valve (N144)

# Engine Lubrication



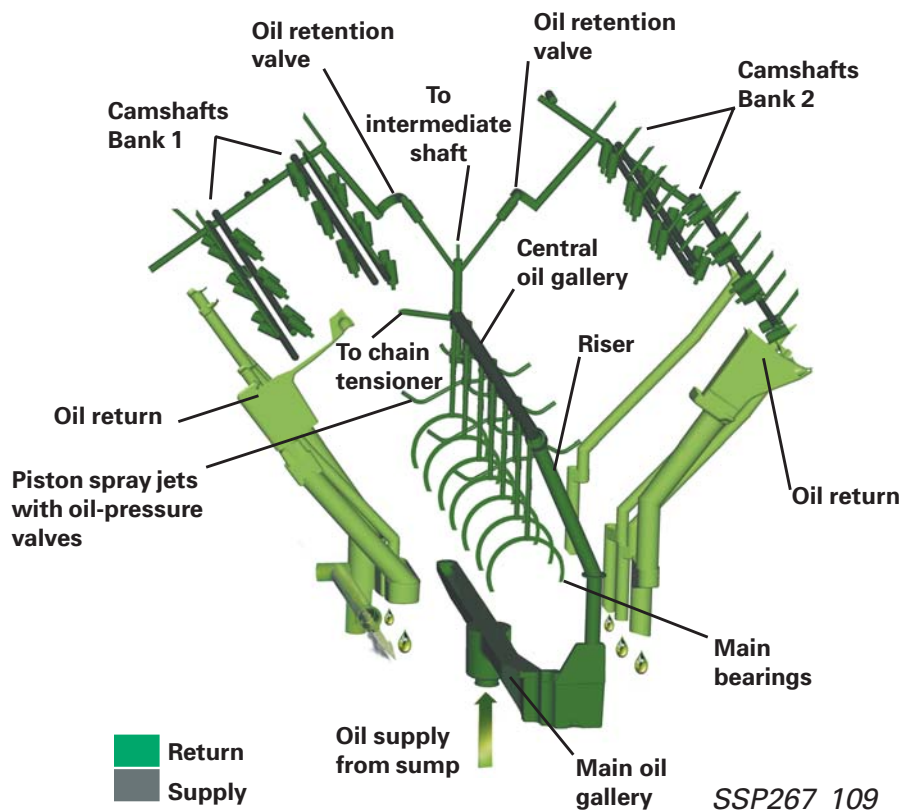
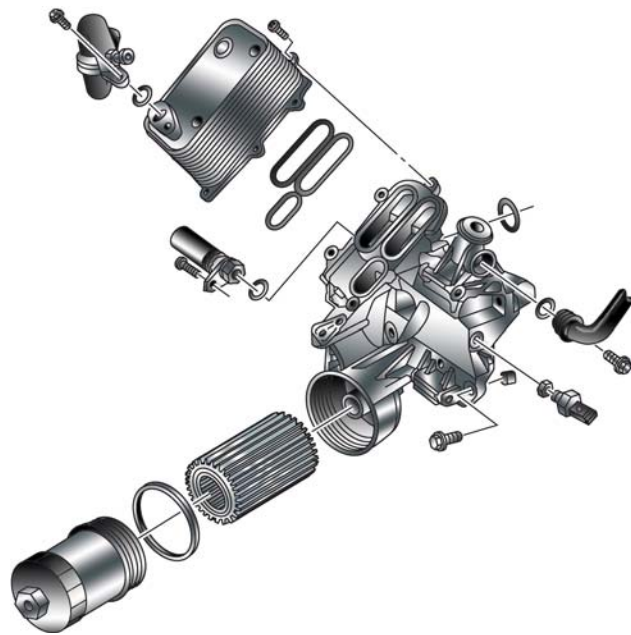
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The W12 engine lubrication system in the 2005 A8L is a wet sump system. Earlier W12 engines used a dry sump system.

The oil pump is mounted in the sump and is chain driven by the crankshaft.

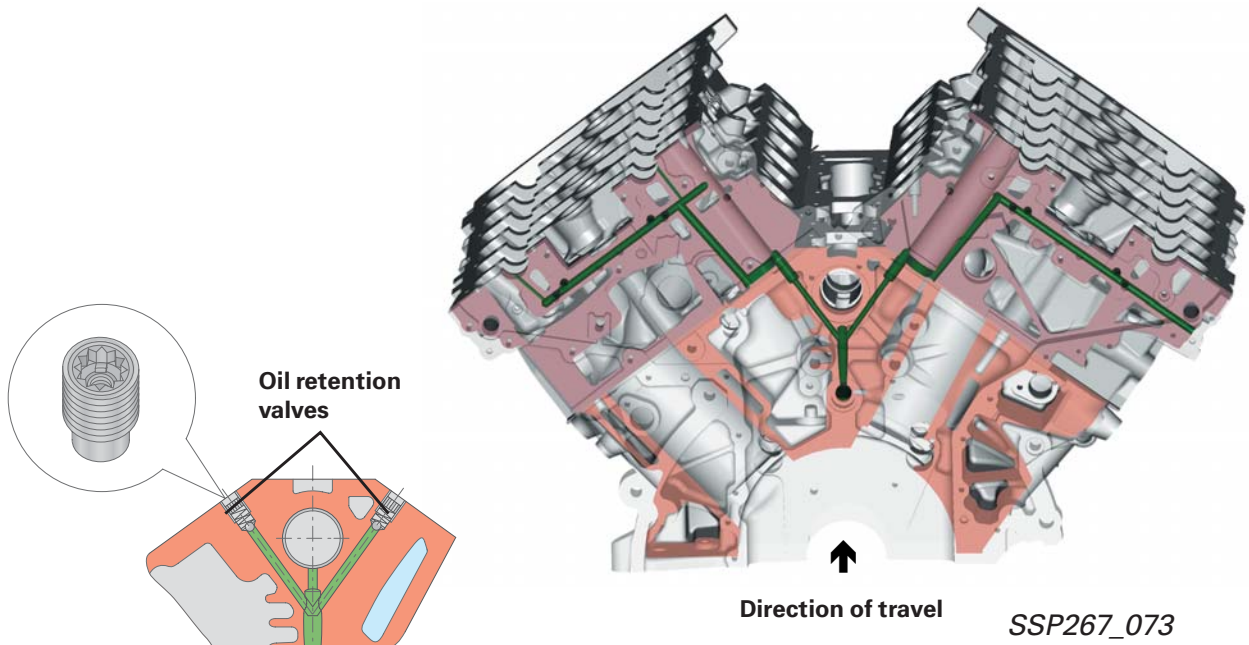
# Engine Lubrication

The oil filter housing and oil cooler module are mounted on the side of the engine that includes the water-cooled alternator module.



Another major difference with the lubrication system compared to the earlier W12 versions is that the main bearings receive oil from the top of the central oil gallery rather than from the bottom.

# Engine Lubrication

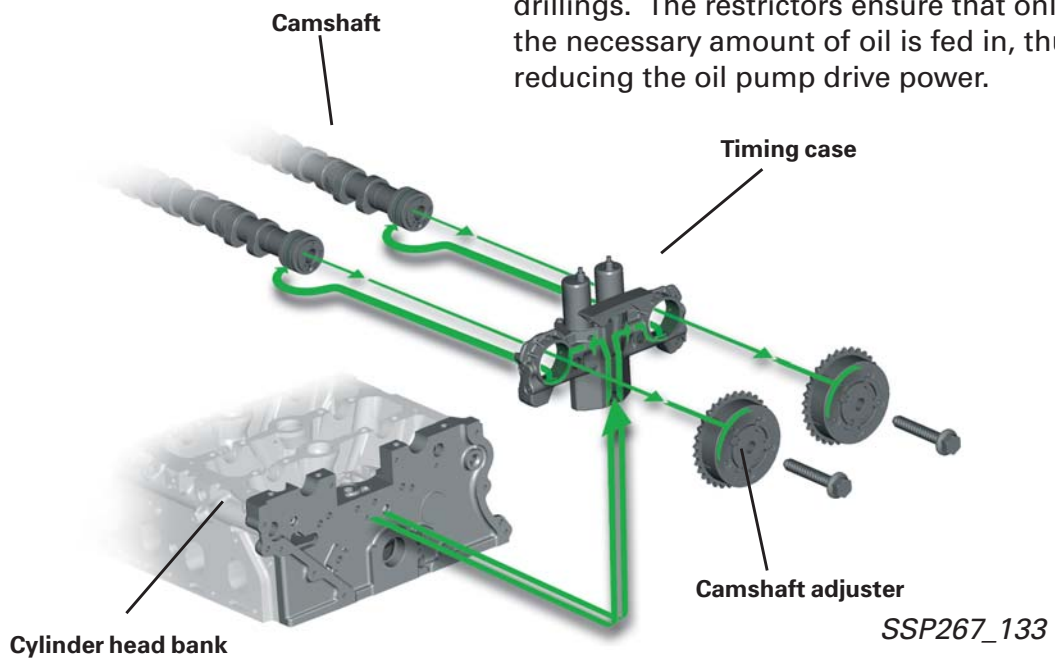


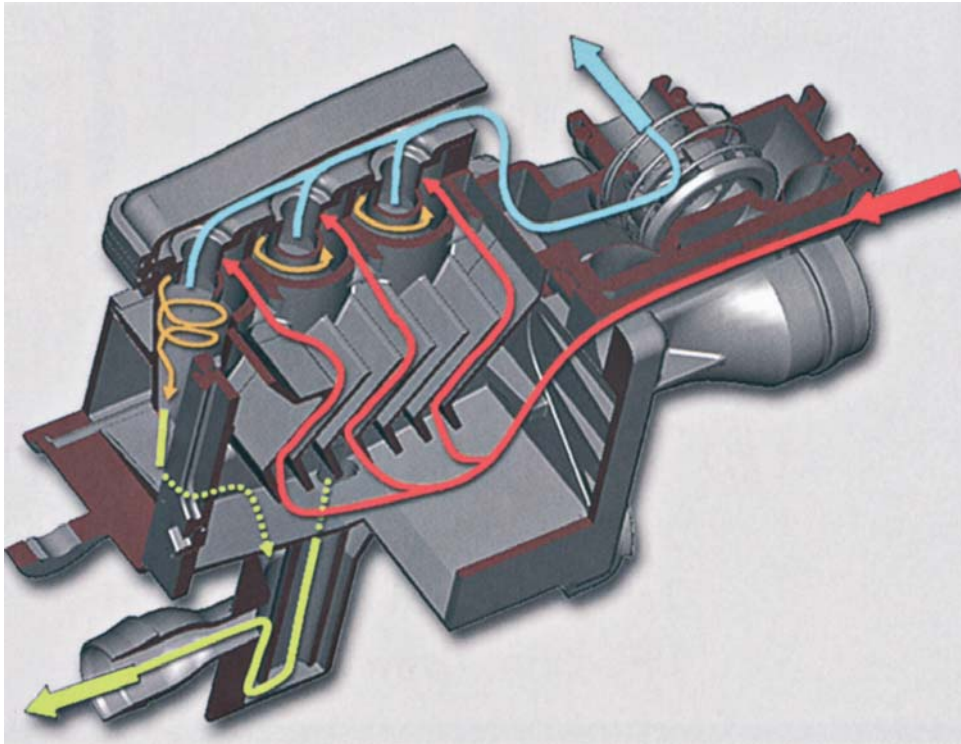
The oil retention valves are located in the risers leading to the cylinder heads.

The valves prevent oil flowing back into the sump from the cylinder heads when the engine is turned off. This helps ensure a rapid build up of oil pressure in the cylinder heads when the engine is restarted.

In the cylinder heads, the flow of oil is distributed to the camshaft adjusters. Restrictors supply oil to the longitudinal galleries, which supply the camshaft bearings and hydraulic elements.

At high engine speeds, the cylinder heads receive large amounts of oil that flows back into the sump through the oil return drillings. The restrictors ensure that only the necessary amount of oil is fed in, thus reducing the oil pump drive power.





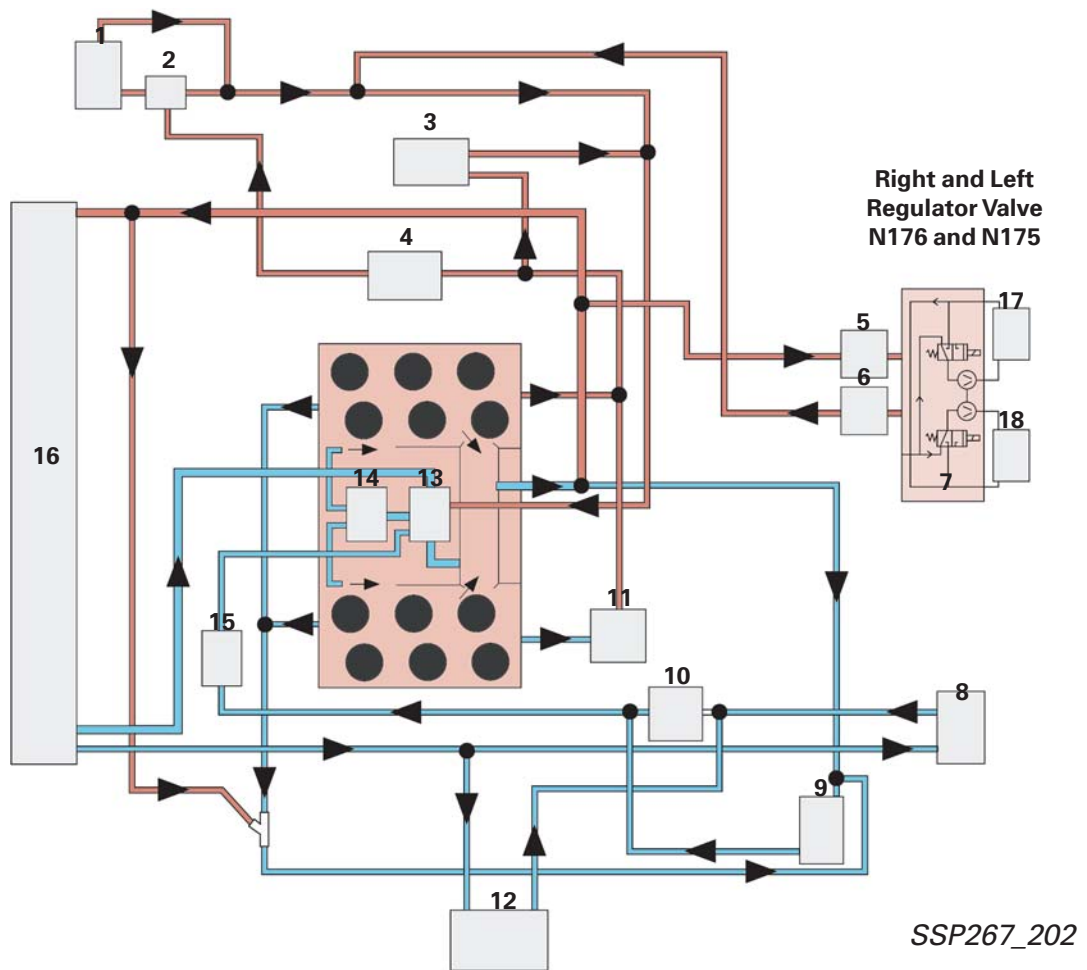
An oil separator for each cylinder bank is mounted under the intake manifold. The separators remove oil particles from the blow-by gases.

Blow-by gases are channeled to the oil separator first through coarse-particle separators integrated in the cylinder heads and lines.

A large portion of the oil is separated at the inlet to the oil separator by baffle plates. Three cyclone fine-separators operating in parallel separate the existing ultra-fine oil droplets and channel the blow-by gases through a pressure control valve into the cylinder bank intake manifolds.

The separated oil collects in the bottom part of the separator and returns directly to the cylinder heads.

# Cooling System



The cooling system of the W12 engine is made up of the following components:

- Water Pump in Cylinder Block/Crankcase Driven Mechanically by Poly V Belt
  - Map-Controlled Electrically Operated Continued Coolant Circulation Pump
  - After-Run Coolant Pump (V51) as back up for Mechanical Water Pump and for Continued Coolant Circulation
  - Electronically Controlled Cooling System (Map-Controlled Coolant Thermostat)
  - Dual electric cooling fans
  - Map-Controlled Continued Coolant Circulation
  - Water-Cooled Alternator
- 1 – Auxiliary Radiator
  - 2 – Thermostat for Auxiliary Radiator
  - 3 – Alternator
  - 4 – Engine Oil Cooler
  - 5 – Bleeder Screw
  - 6 – Bleeder Screw
  - 7 – Right and Left Regulating Valves
  - 8 – ATF Cooler
  - 9 – Expansion Tank
  - 10 – Map Controlled Engine Cooling Thermostat
  - 11 – Coolant Temperature Sensor
  - 12 – Oil Cooler
  - 13 – Thermostat
  - 14 – Coolant Pump
  - 15 – After-Run Coolant Pump
  - 16 – Radiator
  - 17 – Heat Exchanger
  - 18 – Heat Exchanger



The water pump distributes the coolant to each of the two cylinder banks. The flow of coolant is split before being routed longitudinally through the cylinder bank on the inlet and exhaust ends.

Guide vanes ensure an even flow around all cylinders.

From the back of the cylinder head, part of the coolant flow for each cylinder bank is withdrawn for alternator cooling and for the oil cooler.

Most of the coolant flows through calibrated holes on the exhaust end into the cylinder heads and passes transversely through them towards the inlet end.

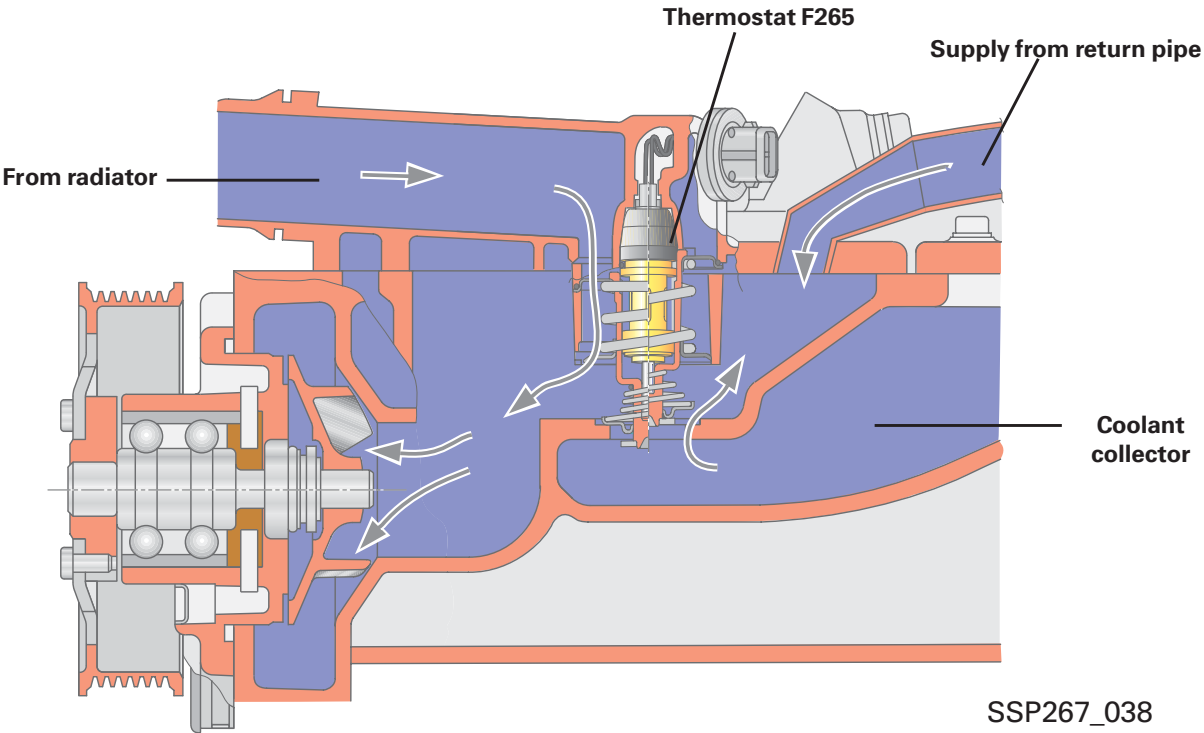
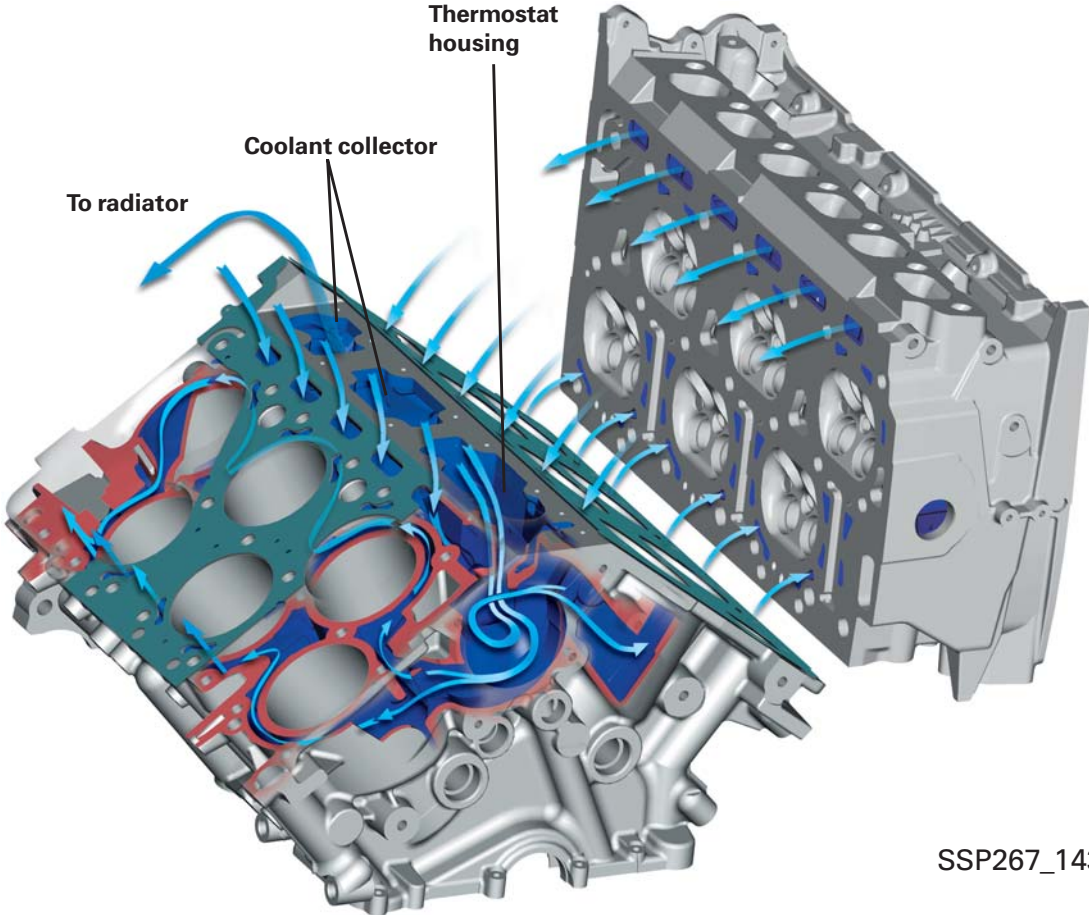
The remainder of the coolant flow is routed into the cylinder head on the inlet end.

The inner vee of the cylinder block has a coolant collector into which the coolant from both cylinder heads flows.

From there, the coolant flows through the large cooling circuit to the radiator, or through the small cooling circuit directly to the thermostat housing and back to the water pump.

Two heat exchangers, the alternator and oil cooler are integrated into the small cooling circuit. The joint return pipe provides a constant return flow to the water pump.

# Cooling System



The After Run Coolant Pump (V51) has two functions:

1. To provide back up for the mechanically driven coolant pump at low engine speeds and to ensure adequate coolant circulation.

The After Run Coolant Pump (V51) is actuated by the Coolant Pump Relay (J496) by ECU 1 (J623). Self-Diagnosis does not detect a blockage of the After Run Coolant Pump (V51).

Map control is used in the After-Run Coolant Pump (V51) as necessary. The parameters used are engine speed and coolant temperature supplied by the Engine Coolant Temperature Sensor (G62).

Switching levels:

Cut in: <840 RPM and >226°F (108°C)

Cut out: >3000 RPM or <223°F (106°C)

2. To circulate the coolant during continued coolant circulation.

## Other Cooling Circuit Components

A Non-Return Valve 1 stops the return of coolant to the radiator when the After-Run Coolant Pump V51 is operating.

A Non-Return Valve 2 in the inlet to the heating system heat exchangers prevents the flow of coolant through the heating system heat exchangers during continued coolant circulation.

To understand the need for Non Return Valve 2, it is helpful to imagine the following situation with no Non Return Valve 2 in the circuit:

If a warm engine is briefly turned off at high ambient temperatures, e.g. for re-fuelling after a long road trip, continued coolant circulation starts to operate. The After-Run Coolant Pump (V51) distributes the coolant through the open thermostat and the mechanical water pump into the engine cooling jacket.

The coolant then flows back to the radiator from the coolant collector. The coolant also passes through the permanently open return pipe and heating system return to the pump/valve unit of the air conditioner (compared to when the engine is running).

As the Left and Right Heat Regulation Valves (N175 and N176) of the pump/valve unit open, the flow would pass through the heating system heat exchangers and cause them to heat up if there were no non return valve fitted (because the **circuit to radiator would be closed off on heating system supply end**).

The combination of hot heating system heat exchangers next to a cold, damp evaporator would cause enormous humidification of the air in the air conditioner unit. Restarting (blower start up), would result in excessive misting of the (cold) windshield, **a situation which Non Return Valve 2 is designed to prevent**.

A Non Return Valve 2 is defective when an excessively high vent outlet temperature is present during a re-start after a brief stop (as described above).

# Cooling System

## Electronically Controlled Cooling System

To enhance efficiency, the coolant temperature of the W12 engine is controlled electronically based on a map.

The coolant temperature regulation function should be viewed as a system.

The specified coolant temperature is implemented with the aid of the electrically heated Engine Cooling Thermostat (F265) and the Electric Fans operating as a function of engine speed.

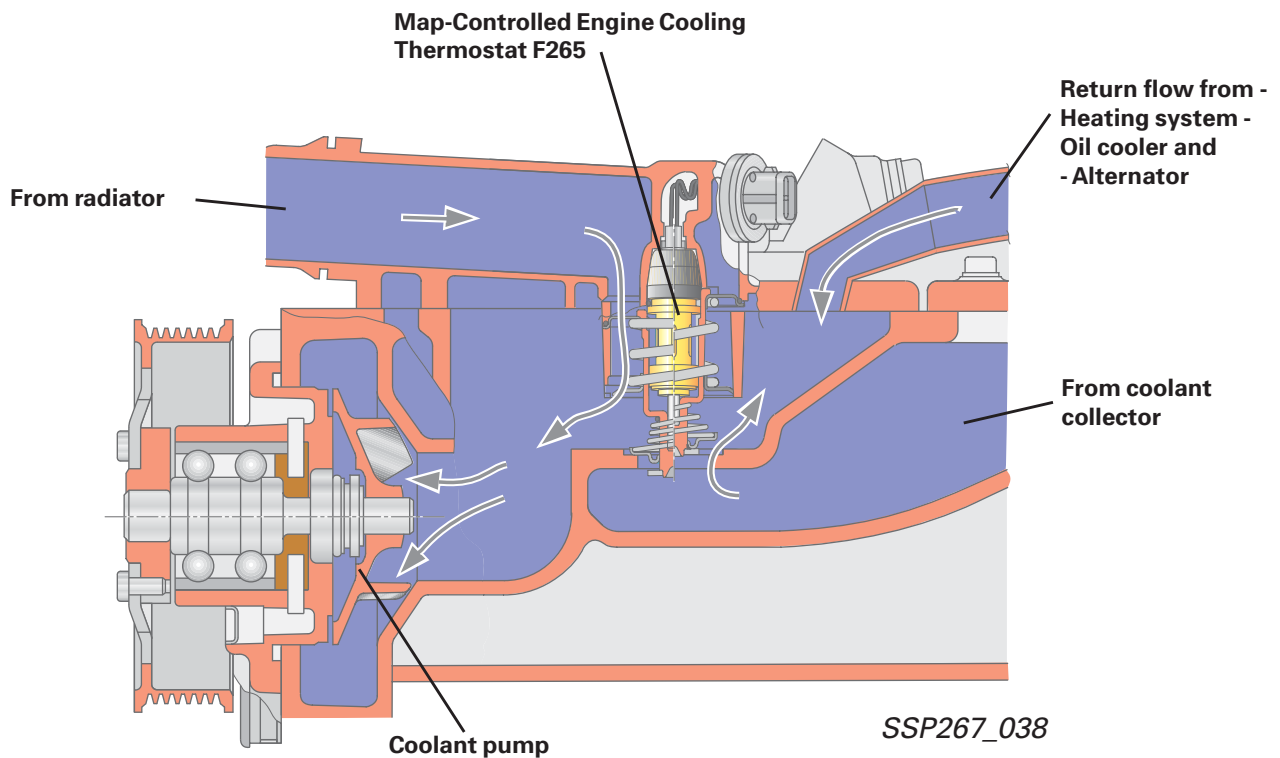
A particular feature of the W12 engine is that there is only one Engine Coolant Temperature Sensor (G62) for the control loop.

**Engine speed, engine load, ambient temperature** (obtained from Intake Air Temperature Sensor [G42] in air mass meter) and **engine oil temperature** (from Engine Oil Temperature Sensor [G8]) form the basis for calculating a **specified coolant temperature**.

The specified coolant temperature is also influenced by the knock control function, with the specified temperature being reduced if possible in the event of knocking combustion.

The specified coolant temperature varies between 221°F (105°C) in the lower part throttle range and 194°F (90°C) at high engine loads or vehicle speeds in excess of 112 mph (180 km/h).

The specified coolant temperature forms the reference input variable for closed loop control of the Map-Controlled Engine Coolant Thermostat (F265) and open loop control of the Coolant Fan Valve (N313).



## Map-Controlled Engine Cooling Thermostat (F265) Control Loop

The Map-Controlled Engine Cooling Thermostat (F265) is actuated on a pulse width modulated basis with a duty cycle of 0% to 100%.

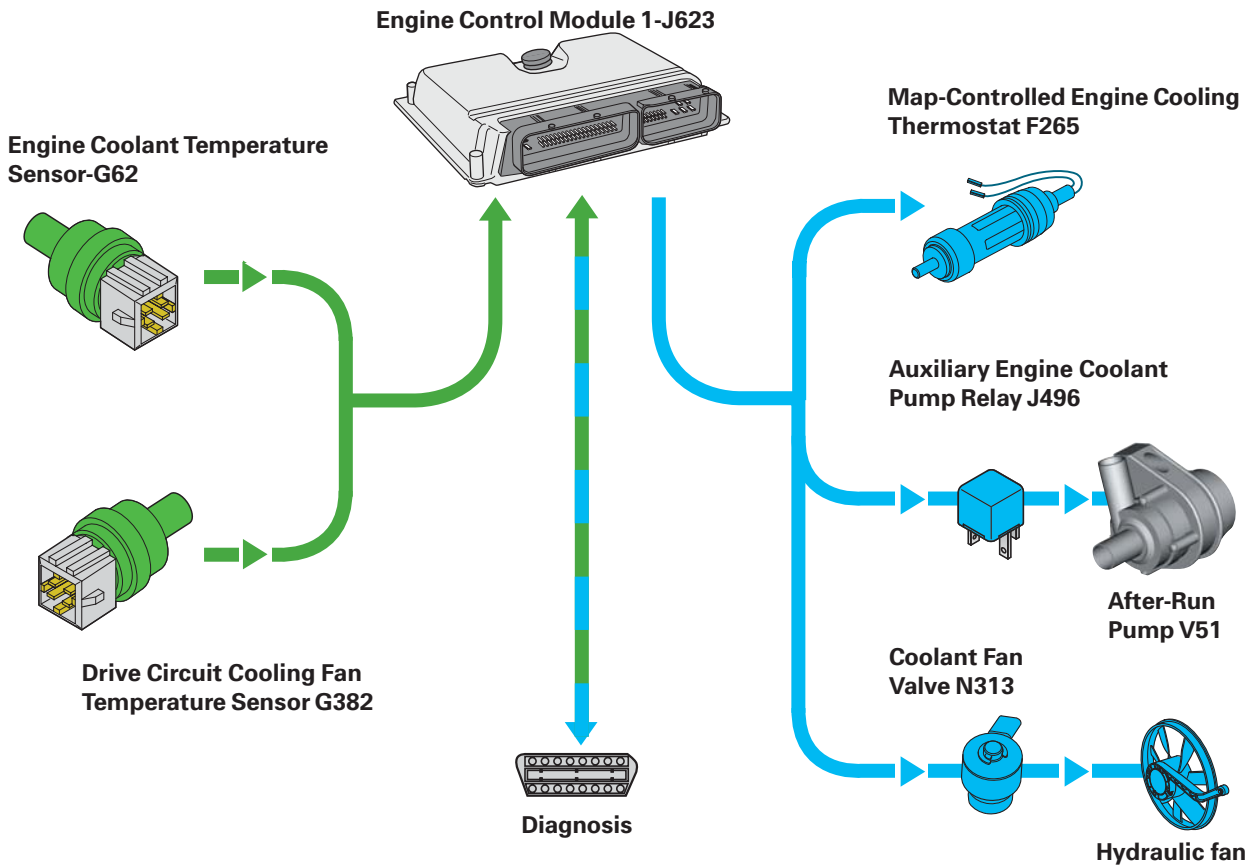
ECM 1 (J623) uses the **actual** and **specified** coolant temperature to calculate the Map-Controlled Engine Cooling Thermostat (F265) duty cycle and actuate it accordingly.

When de-energized (duty cycle 0%), the control characteristic of the Coolant Temperature Regulator is at 221°F (105°C) at the thermostat.

Given maximum (duty cycle 100%) of the Map-Controlled Engine Cooling Thermostat (F265), the control characteristic can be reduced to 194°F (90°C).

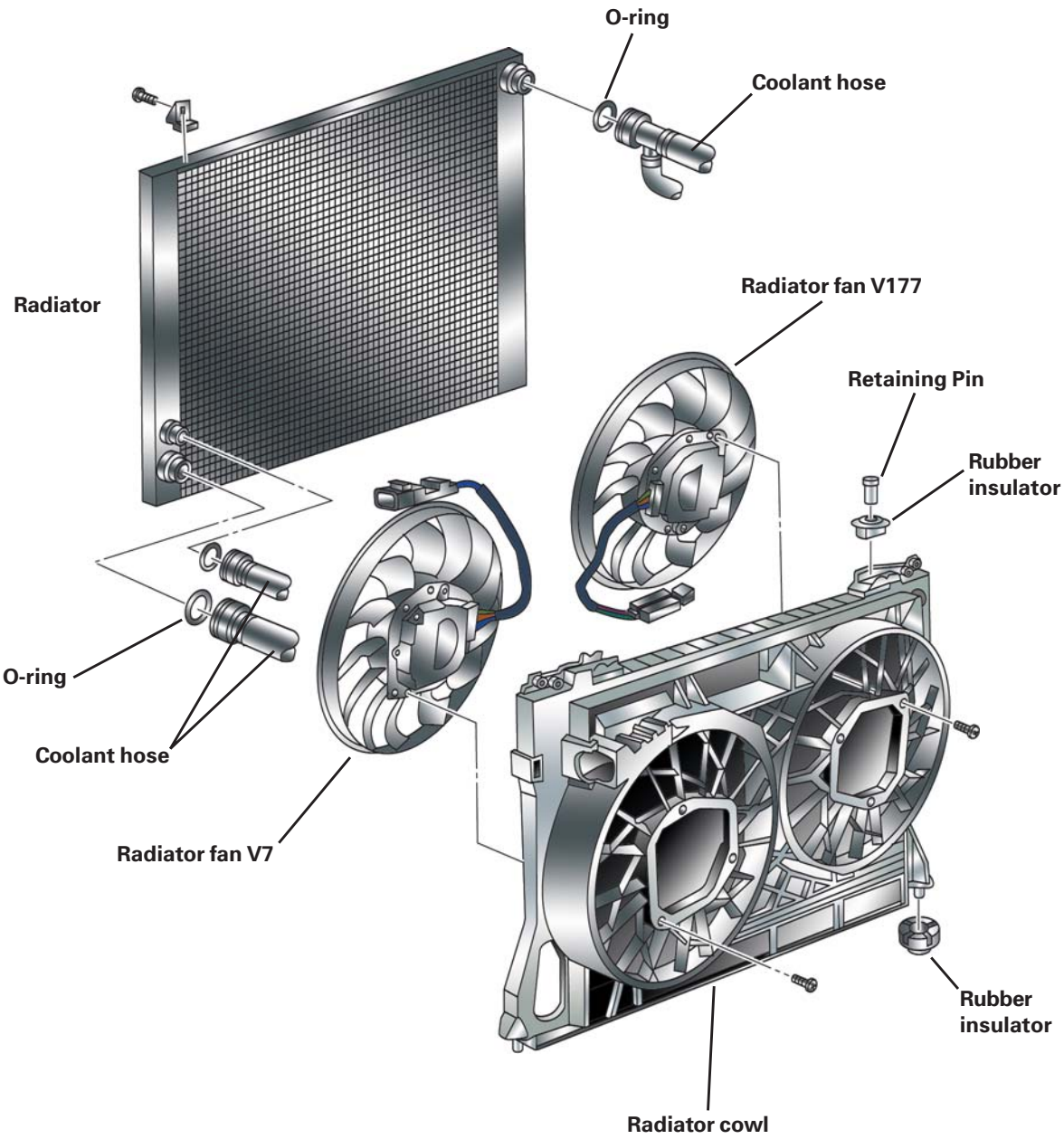
During continued coolant circulation, the duty cycle is 100%. As a result, the Map-Controlled Engine Cooling Thermostat (F265) opens at an appropriately low temperature, thus ensuring coolant circulation by the After-Run Coolant Pump (V51).

If the Map-Controlled Engine Cooling Thermostat (F265) (Heating Element) fails, a fault message is stored in the fault memory of ECM 1 (J623).



SSP267\_144

# Cooling System



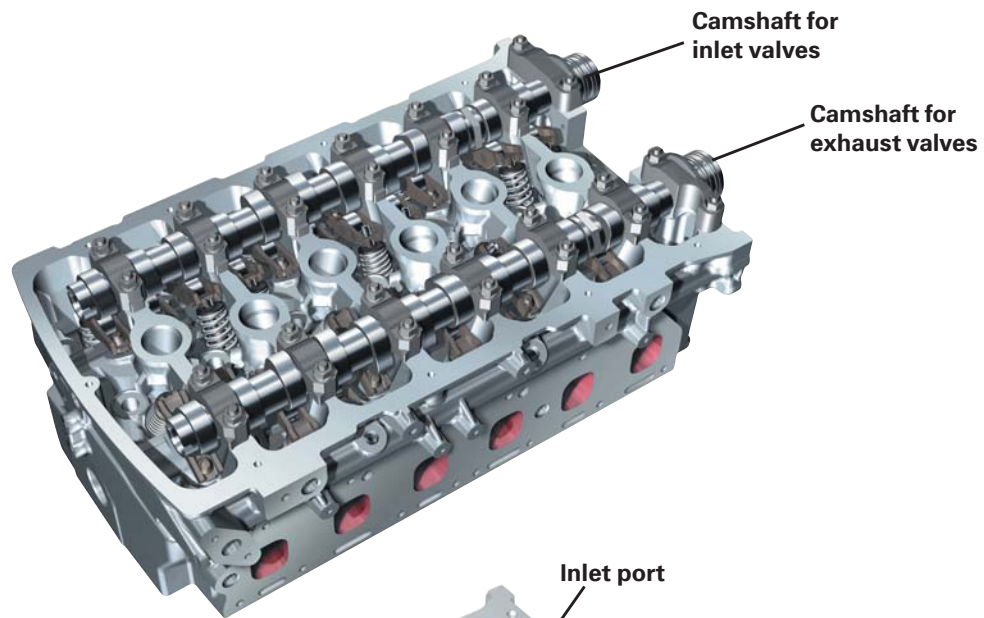


# Cylinder Head

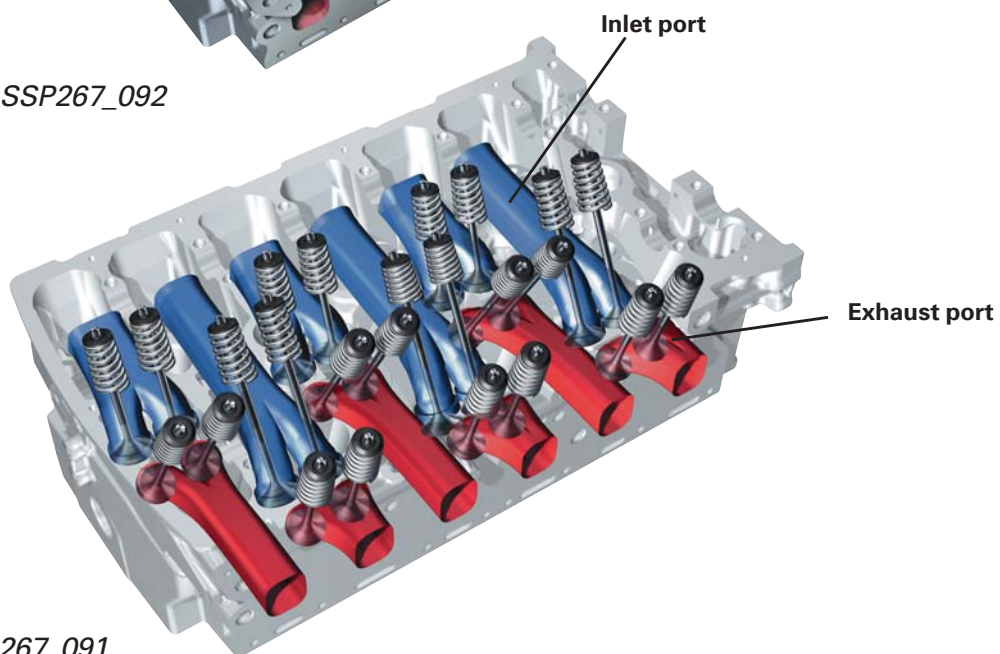
The two cylinder heads in the W12 engine are based on the new cylinder head of the VR6 engine. The cylinder heads are bank specific to permit camshaft drive from one side.

Main features:

- Cross flow cylinder head with four valves –two overhead camshafts for inlet and exhaust
- Valve operation by roller type rocker fingers
- Hydraulic valve lifters
- Infinitely variable timing control for inlet and exhaust camshaft

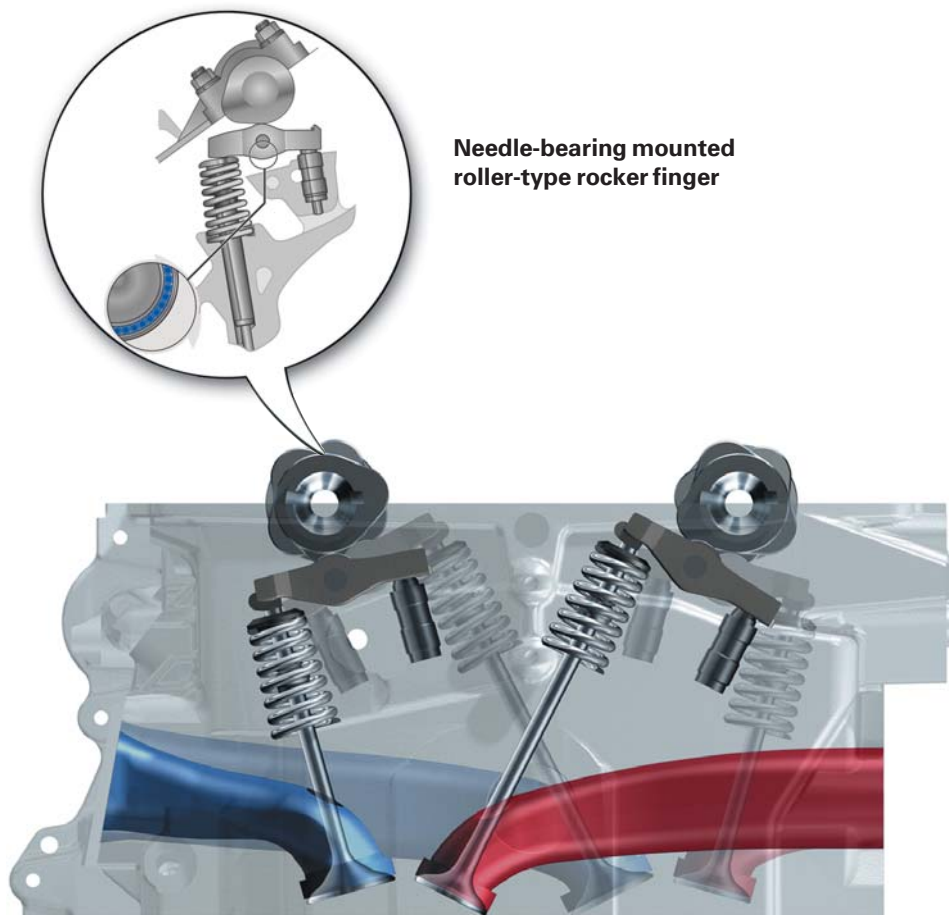


SSP267\_092



SSP267\_091





Needle-bearing mounted roller-type rocker finger

SSP267\_090

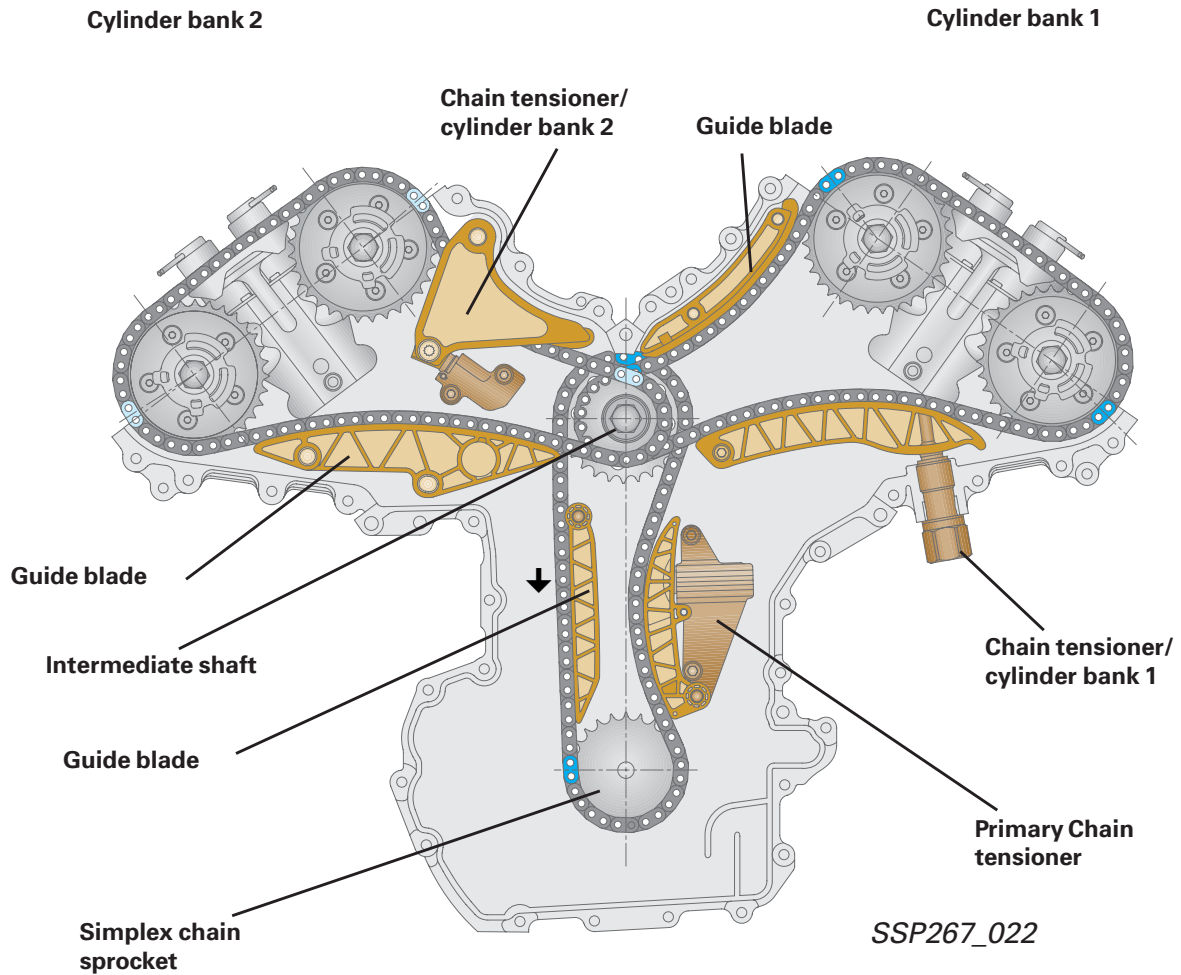
The cylinder heads used in the VR6 engine were modified as follows for the W12 engine:

- Additional oil return channels on exhaust end due to greater inclination of cylinder banks resulting from V angle of 72°.
- Adaptation of cylinder head water jacket to cross flow cooling concept.

The particular arrangement of the valves permits the use of an inlet and an exhaust camshaft and therefore separate camshaft adjustment.

The VR principle results in different inlet and exhaust port lengths in the cylinder head. This is offset by way of appropriate intake and exhaust system design, thus ensuring virtually identical charge cycles in all cylinders.

# Camshaft Drive



The timing mechanism is located on the engine output end.

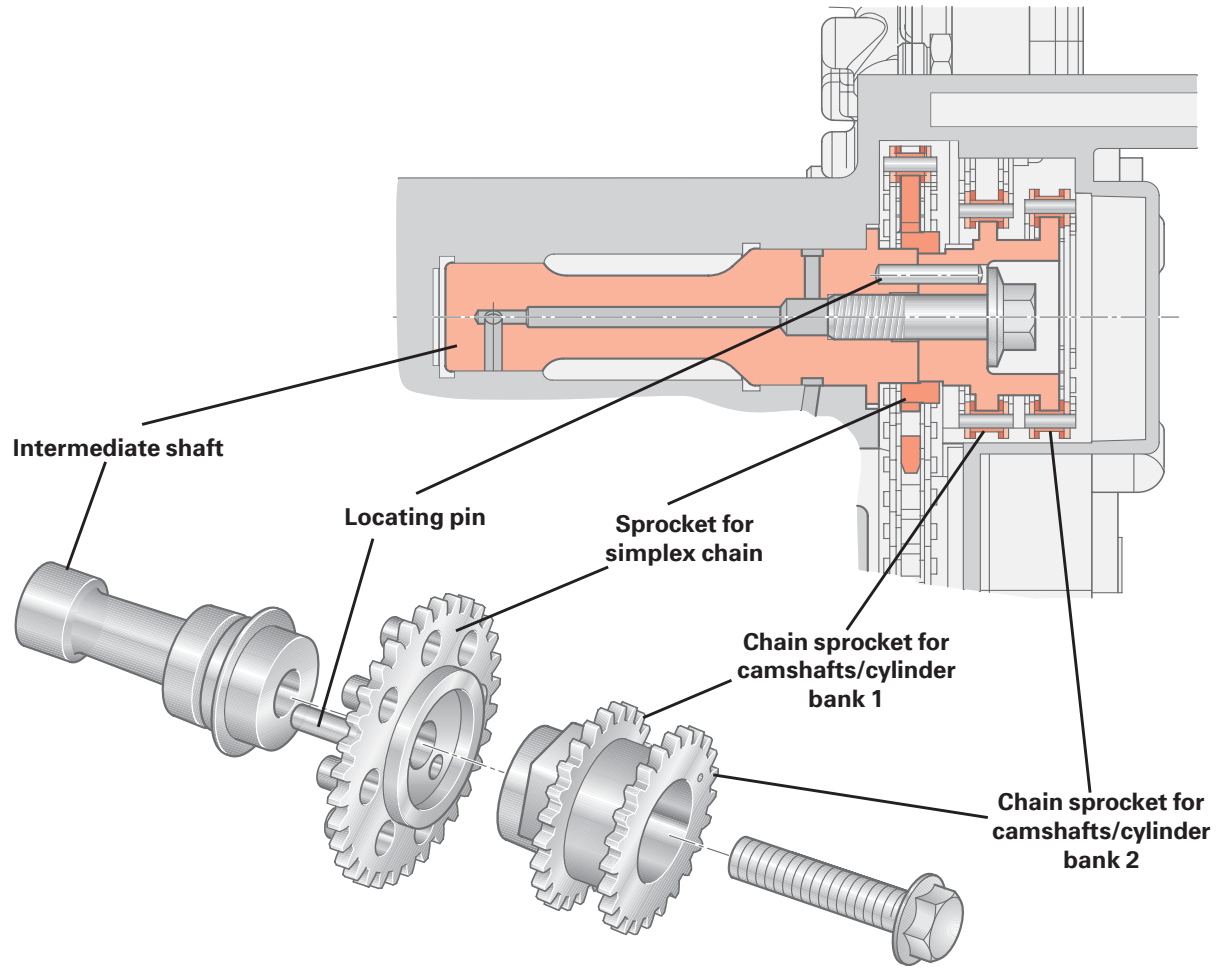
Timing mechanism drive is provided by a simplex chain running from the duplex chain sprocket mounted on the crankshaft, to the central intermediate shaft.

From there, one simplex chain each runs to the left and right cylinder head to drive the inlet and exhaust camshafts in each case.

# Camshaft Drive

Three spring-loaded hydraulic chain tensioners and the chain guides ensure the correct chain tension and smooth chain operation (no ratchet mechanism).

Oil spray jets in the chain tensioner runners provide the necessary chain lubrication and cooling.



SSP267\_020

# Camshaft Drive

## Sealing of Timing Mechanism

SIS sealing (as of start of production)

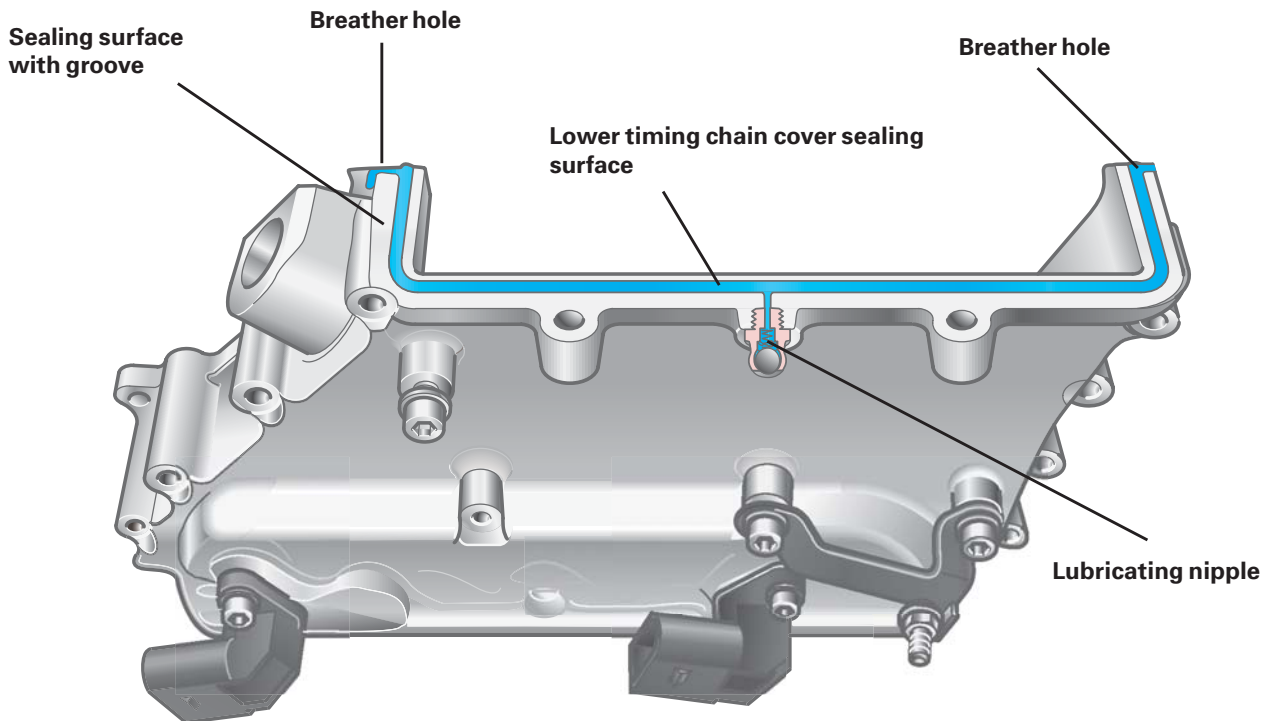
A new feature is the use of the Seal Injection System (SIS) for sealing the upper timing chain covers.

The upper timing chain cover to lower cover sealing surface has a groove, into which the sealing fluid is injected under pressure after the timing chain cover is installed.

The sealant is injected into the groove with a lubricating nipple.

Breather holes are provided at both ends of the groove to allow the escape of the air displaced by the sealant. Sealant is injected into the groove until it emerges without any bubbles at both breather holes.

For details, refer to the current Workshop Manual.



Upper timing chain cover of cylinder bank 1  
(Bottom view)

SSP267\_062

# Camshaft Drive

## Silicone liquid seal (new)

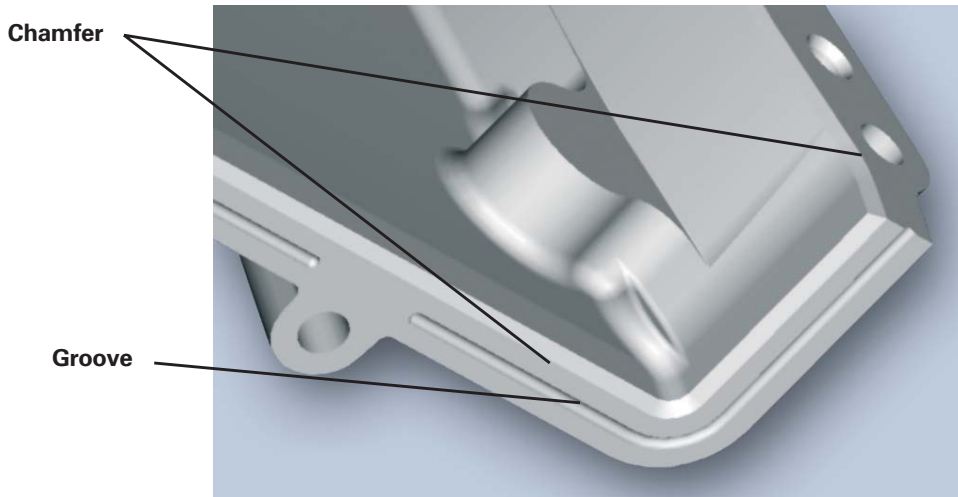
A modified method of sealing the timing chain covers is gradually being introduced.

Sealing is performed in the usual way by applying the sealant to the components before assembly.

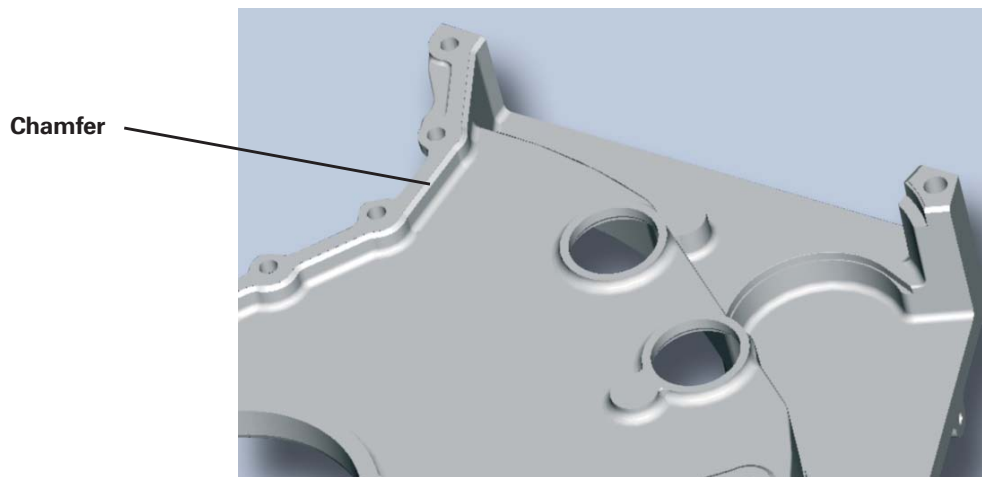
The production of the sealing surfaces with groove and chamfer is a new feature.

Both the groove and the chamfer improve adhesion and extend the service life of the seal.

For details, refer to the current Workshop Manual.



SSP267\_198



SSP267\_197

# Camshaft Drive

## Valve Timing/Camshaft Timing Control

The infinitely variable timing control for the inlet and exhaust camshafts on the W12 engine permits "internal exhaust gas recirculation." This is why exhaust gas recirculation is described here.

### Exhaust Gas Recirculation (EGR)

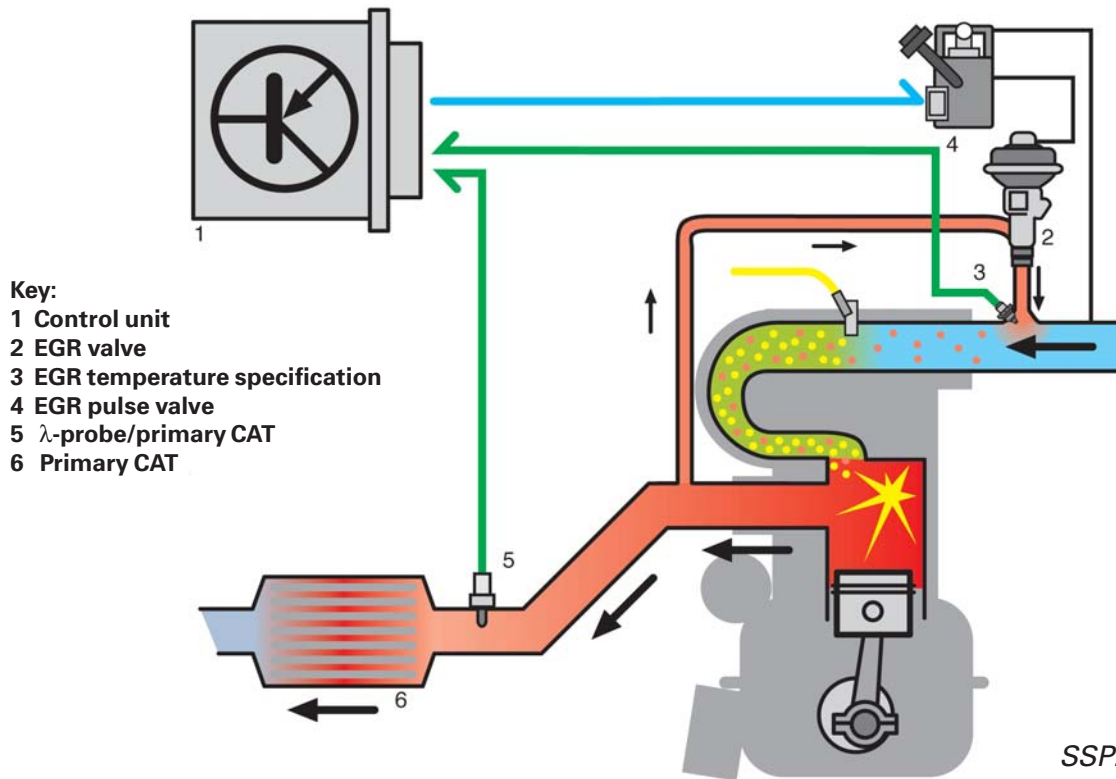
Ever more stringent demands are being made of internal combustion engines regarding power, torque, fuel economy and exhaust emission standards.

High combustion temperatures and pressures create unwanted NO<sub>x</sub> formation from the nitrogen contained in the intake air.

Recirculating the exhaust gases to the combustion chamber lowers the combustion temperature and pressure, and leads to reduced NO<sub>x</sub> formation.

A distinction is made between external and internal EGR.

With external EGR, the exhaust gas is routed through a piping system with EGR valve back into the intake port, where it is drawn in again.



External exhaust-gas recirculation

SSP267\_108

## Internal EGR

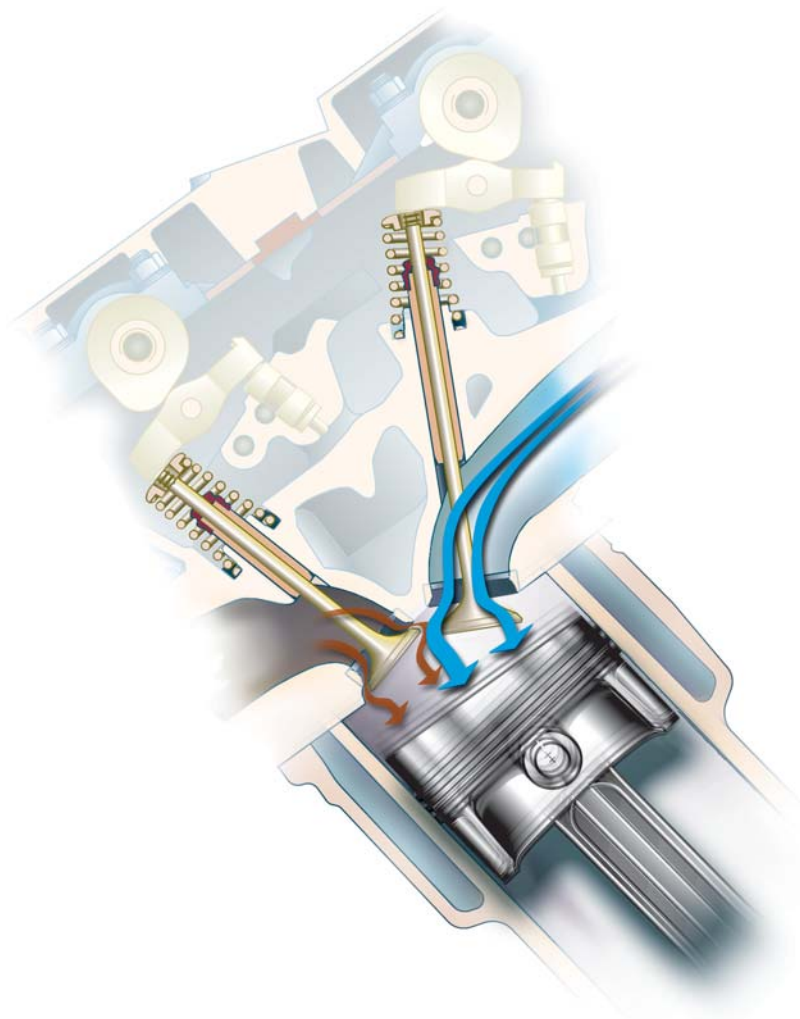
With the W12 engine, an internal EGR system is used to reduce the NO<sub>x</sub> level.

Internal EGR involves controlling the optimum setting of the residual gas component in the cylinders with an inlet and exhaust valve timing adjustment.

The volume of exhaust gas re-circulated depends on the amount of valve overlap.

Valve overlap is the angular range in which the inlet valve is already open before the exhaust valve closes.

The advantages of internal EGR include a rapid reaction time (short distances), high recirculation rate which can be achieved, good formation of the exhaust, fresh gas mixture, and fewer components.



Internal exhaust-gas recirculation

SSP267\_117

# Camshaft Drive

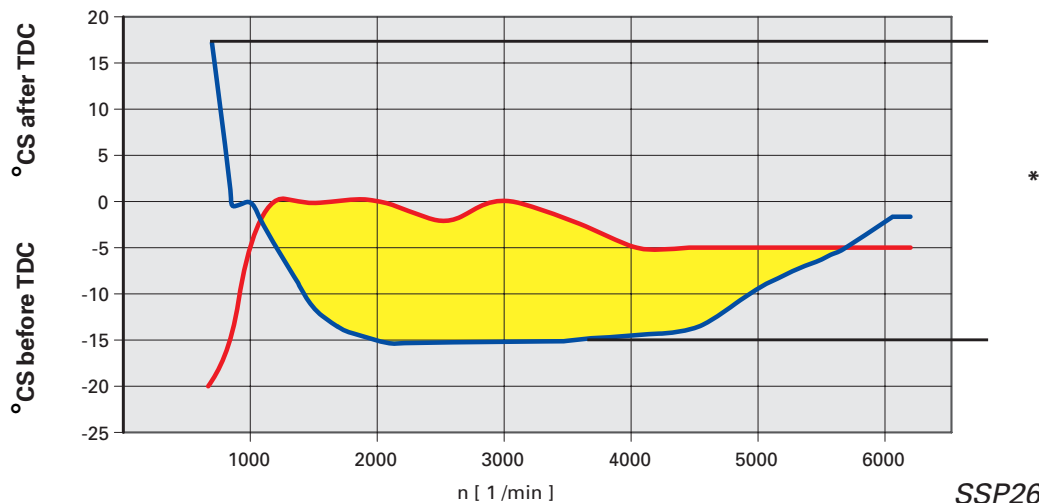
The graphs below illustrate the valve opening/closing times (maps) for different load statuses with a warm engine. There is no valve overlap at idle and in the near idle range.

There is no significant occurrence of NOx in this range, thus eliminating the need for EGR. The precisely controlled charge cycle produces a particularly smooth running engine.

An appropriate valve overlap is set in the part throttle range as a function of load and engine speed. This is the operating status in which the highest level of NOx is found. The EGR reduces the NOx level and also has a positive effect on fuel consumption.

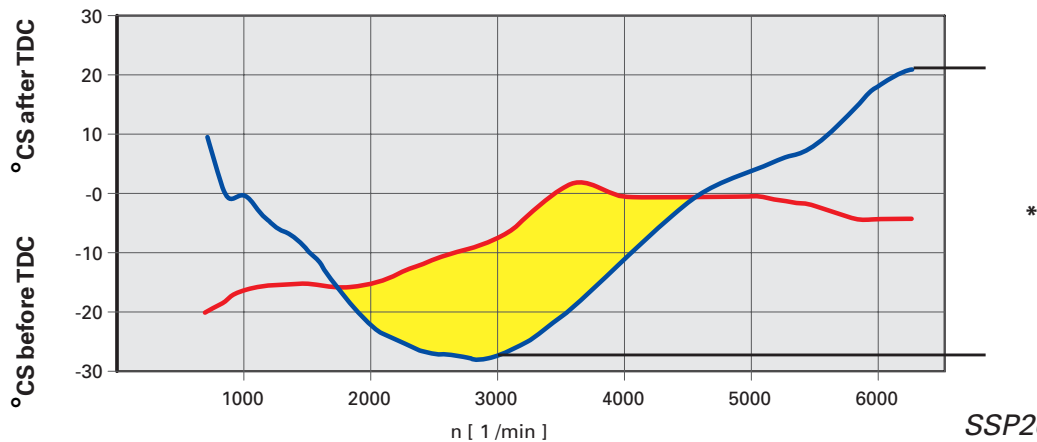
In the full throttle range, the camshafts are set for maximum cylinder charge in line with engine speed.

50 % load/operating temperature



— Inlet opening  
— Exhaust closing  
— Valve overlap

90 % load/operating temperature



\* max. possible adjustment range/  
exhaust camshaft

\* max. possible adjustment range/  
inlet camshaft



## Valve Timing/Adjustment Range

Infinitely variable adjustment of the inlet and exhaust camshafts is provided on the W12 engine to achieve optimum matching of valve timing to the wide range of engine operating points.

- The range of inlet camshaft adjustment is 52° crankshaft.
- The range of exhaust camshaft adjustment is 22° crankshaft.

Optimum adjustment of valve timing is ensured for the operating statuses...

- ...rapid catalytic converter warm up
- ...warm up phase
- ...operating temperature
- ...by way of separate maps.

The maps are referenced to engine speed, engine load and engine temperature (refer to Page 38).

### Valve Timing\*

Odd Numbered Cylinder Bank  
(Cylinders 1 - 3 - 5 - 7 - 9 - 11)

Io	Advance	27°	Before TDC
	Retard	25°	After TDC
Ic	Advance	183°	After TDC
	Retard	235°	After TDC
Eo	Advance	235°	Before TDC
	Retard	213°	Before TDC
Ec	Advance	20°	Before TDC
	Retard	2°	After TDC

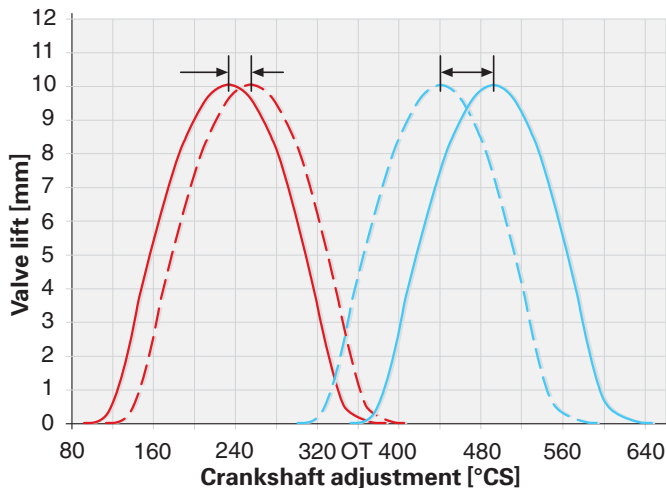
\*with 1mm valve lift and 0mm valve clearance

### Valve Timing\*

Even Numbered Cylinder Bank  
(Cylinders 2 - 4 - 6 - 8 - 10 - 12)

Io	Advance	27°	Before TDC
	Retard	25°	After TDC
Ic	Advance	188°	After TDC
	Retard	240°	After TDC
Eo	Advance	230°	Before TDC
	Retard	208°	Before TDC
Ec	Advance	20°	Before TDC
	Retard	2°	After TDC

Io = Inlet Opens  
Ic = Inlet Closes  
Eo = Exhaust Opens  
Ec = Exhaust Closes



Because of the offset crankshaft group, the valve timing (Ic and Eo) differs for the even and odd numbered cylinder banks.

SSP267\_173

# Camshaft Drive

## Control and Monitoring of Camshaft Position

A position sensor is located at each camshaft for control and monitoring of the camshaft adjusters.

For exact determination of the camshaft adjustment, the basic settings (retard position) of the four camshafts are learned by the control modules (adaptation).

During adaptation, the solenoid valves are de-energized. The camshafts are moved to retard position (basic setting) both by the setting of the solenoid valves and the direction of pull exerted by the chain.

The position of the camshaft position sensor signals relative to the engine speed sensor reference mark (actual values), is stored as basic position and compared to the specified values. This provides the basic values for camshaft timing control.

A distinction is made between basic and fine adaptation.

Basic adaptation is always implemented after the ECM is de-energized (no Terminal 30) or erasing of DTCs.

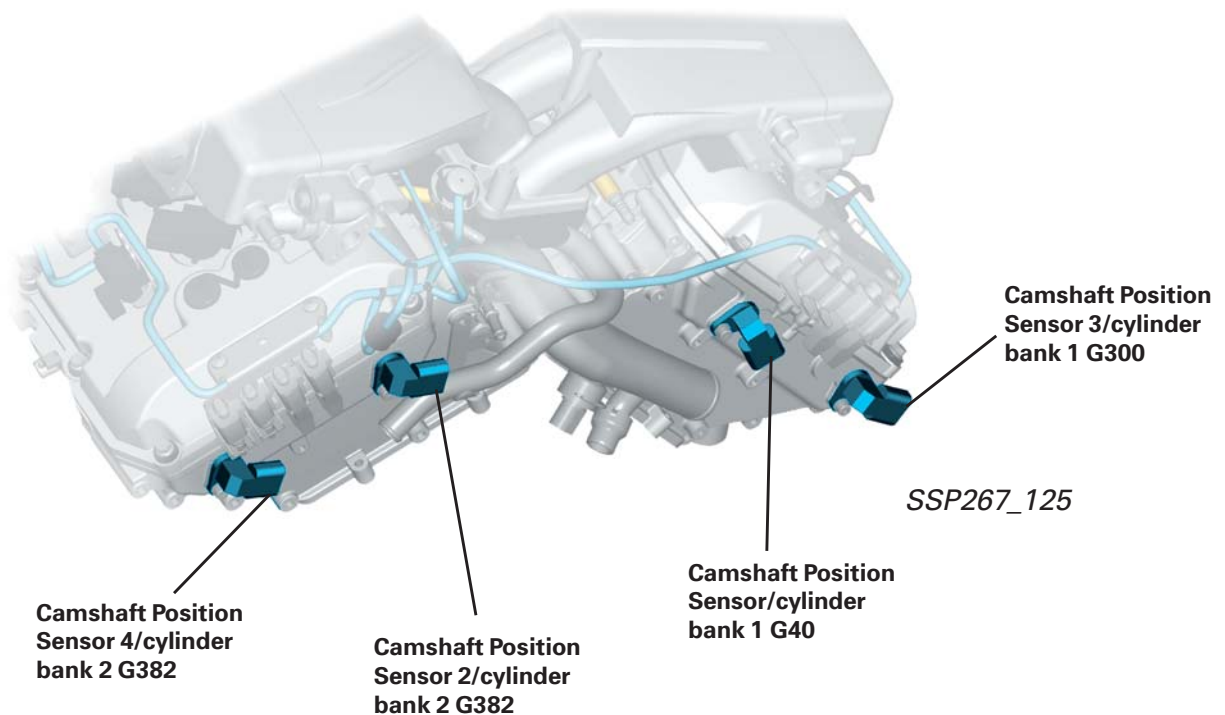
After starting the engine, the camshafts briefly remain in the basic position until the exact position of the camshafts with respect to the crankshaft has been established.

If the camshafts are already in basic position (valves de-energized) and the coolant temperature is greater than 185°F (85°C), and assuming basic adaptation has been implemented, fine adaptation is always performed briefly several times (for approximately one second) after starting the engine.

Adaptation of the inlet camshafts takes place at idle or in the near idle range.

Adaptation of the exhaust camshafts takes place in the engine speed range between 1200 and 2000 RPM and at low engine load.

The two ECMs implement independent adaptation of the camshaft positions. The camshaft timing control function is disabled if adaptation is not performed successfully.



## Camshaft Adjusters

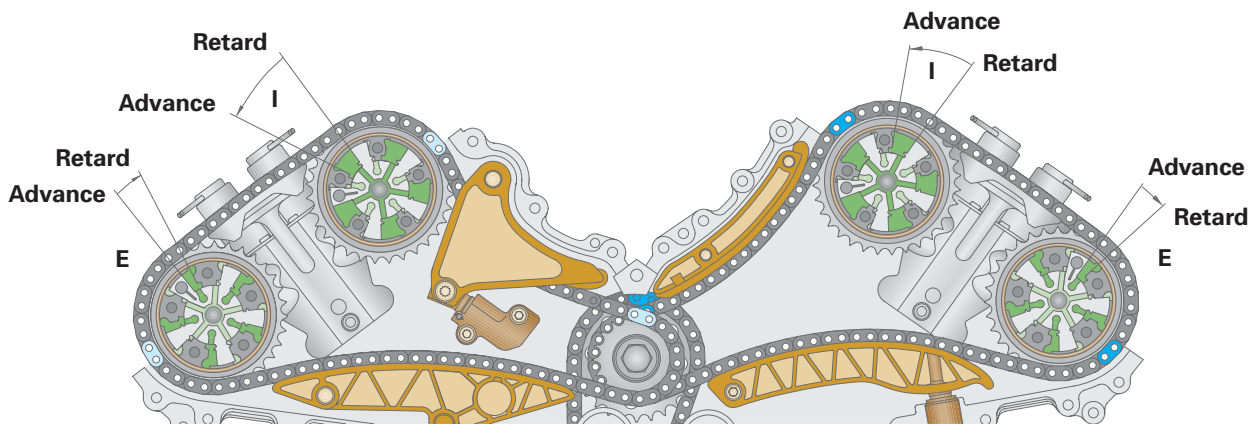
The mode of operation of the camshaft adjusters is based on a hydraulic vane-type rotary motor.

The illustration below shows the position of the camshafts with the engine idling at operating temperature.

The inlet camshaft is in retard position, whereas the exhaust camshaft is in advance position. When the engine is

started, the exhaust camshafts are initially “drawn” towards retard position due to the low oil pressure and direction of chain pull.

When the solenoid valves are de-energized, the inlet and exhaust camshafts also assume the retard position.



Cylinder bank 2

Cylinder bank 1

**E** - Exhaust adjustment range 11° (22° crankshaft)

**I** - Inlet adjustment range 26° (52° crankshaft)

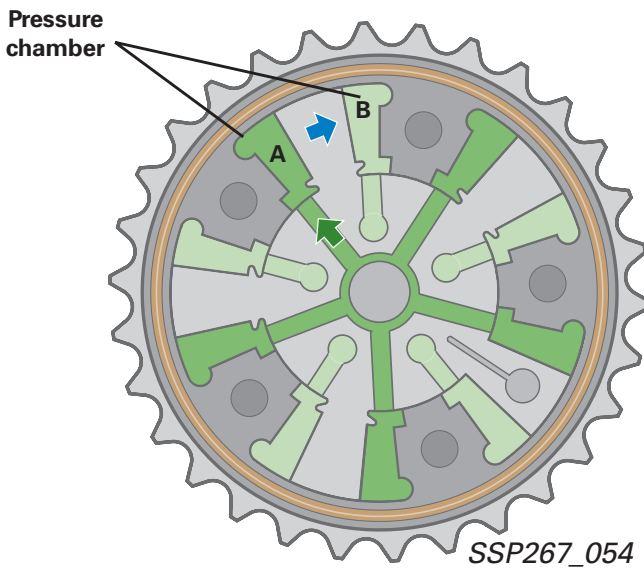
# Camshaft Drive

## Function of Camshaft Adjusters

The camshaft adjuster consists of the five-vane rotor (connected to the camshaft), the stator (connected to the chain sprocket) and the electro-hydraulic control unit.

The arrangement of the oil drillings in the rotor creates a pressure chamber on either side of each vane (pressure chambers A and B).

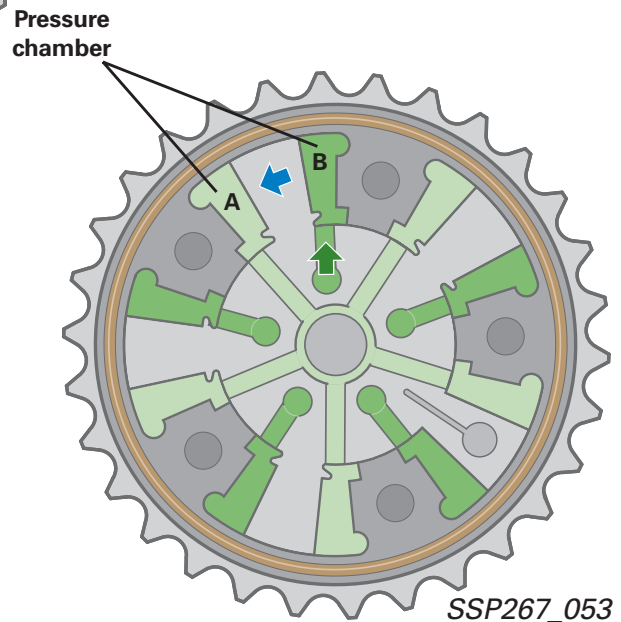
When oil pressure is applied to pressure chamber A, the rotor turns clockwise (in relation to the stator). In terms of the camshaft, this represents the "retard" position.



When oil pressure is applied to pressure chamber B, the rotor turns counter-clockwise (in relation to the stator). In terms of the camshaft, this represents the "advance" position.

**!** The term "stator" may seem misleading. The stator is driven by the timing chain which causes it to rotate and thus it is not actually "static" in itself. It does however always maintain the same angular position with respect to the crankshaft. The rotor turns relative to the crankshaft and thus to the stator.

Appropriate pressure control in the two pressure chambers (A and B) makes it possible to set any arbitrary position between the two stops, thus providing infinitely variable camshaft timing control.



## Electro-Hydraulic Control

Pressurized oil is conveyed without restrictions, to the control unit/solenoid valves through two separate holes. Non-return valves in the solenoid valve inlets boost the system function at low oil pressure. Depending on how they are actuated, the solenoid valves route the pressurized oil to pressure chambers A and B of the rotary motors.

The control unit also acts as the housing for the camshaft rotary bushes, forming the link between solenoid valve and rotary motor.

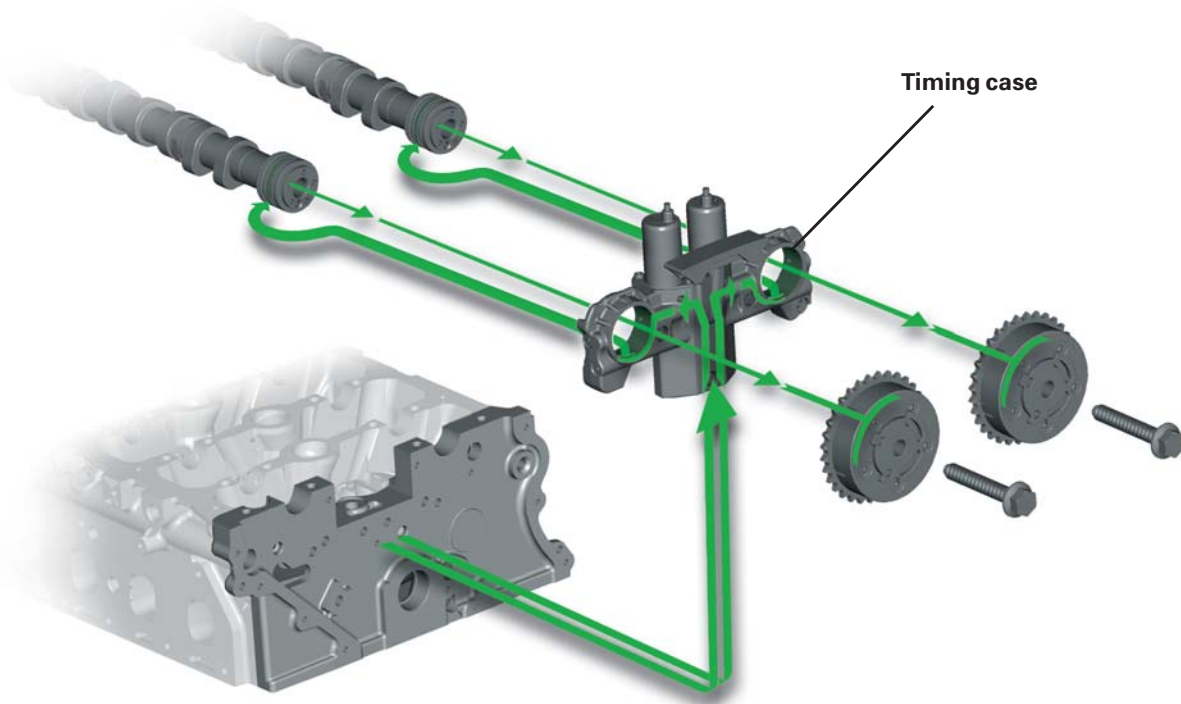
ECMs 1 and 2 (J623/J624) actuate Cylinder Bank 1 Valve 1 for Camshaft Adjustment (N205)/Valve 2 for EGR (N213), Camshaft Adjustment Valve 1 (N318) and Cylinder Bank 2 Solenoid Valve 2 for Camshaft Adjustment (N208)/Camshaft Adjustment Valve 1 (N318).

The solenoid valves are proportional valves. They are PWM actuated and convert the control current into a switch position depending on the pulse width. The valves are identical. The wiring harness connectors are different shapes and colors to make them easier to service.

The position to which the solenoid valves switch when de energized is the same for both the inlet and exhaust rotary motors.

The setting of the solenoid valves is defined (by spring force), so that the oil pressure is applied to Pressure Chamber A. The inlet and exhaust camshafts are therefore in the retard position.

If there is no or only marginal oil pressure, the camshafts are also set to the retard position because of the chain pull.

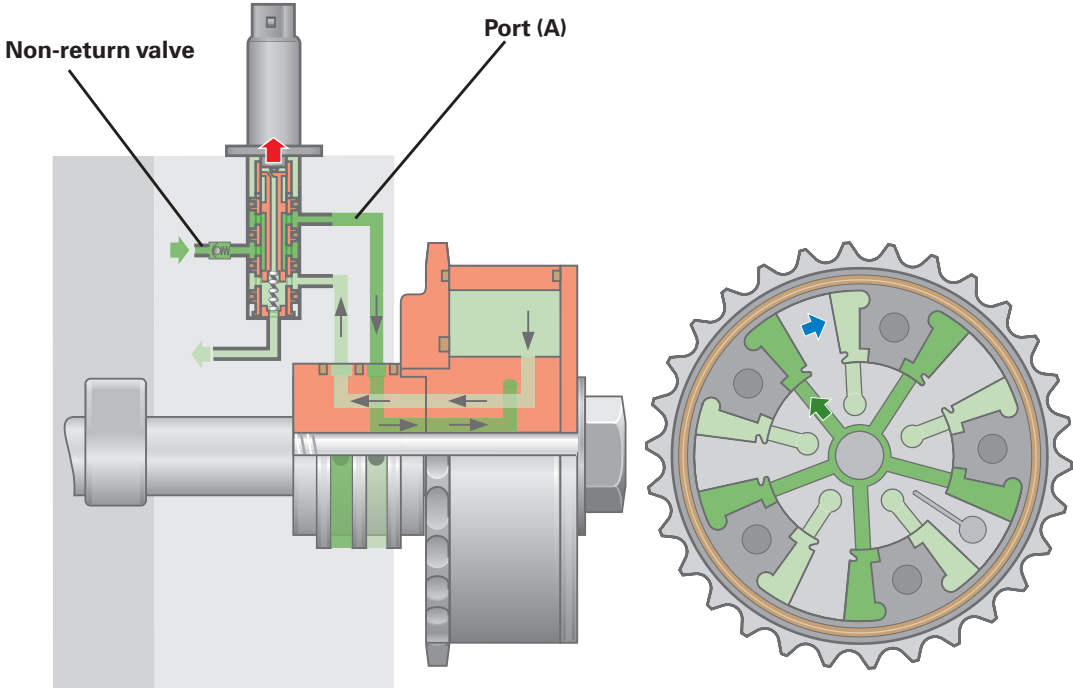


Hydraulic control unit

SSP267\_133

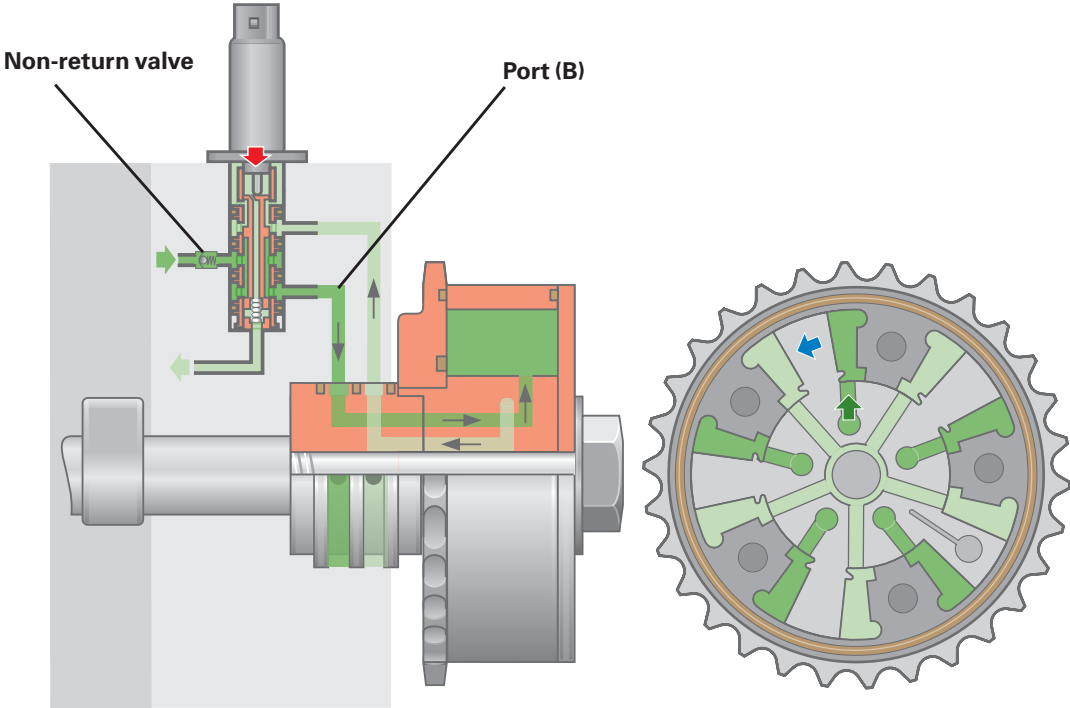
# Camshaft Drive

## Adjustment in Retard Direction



SSP267\_127

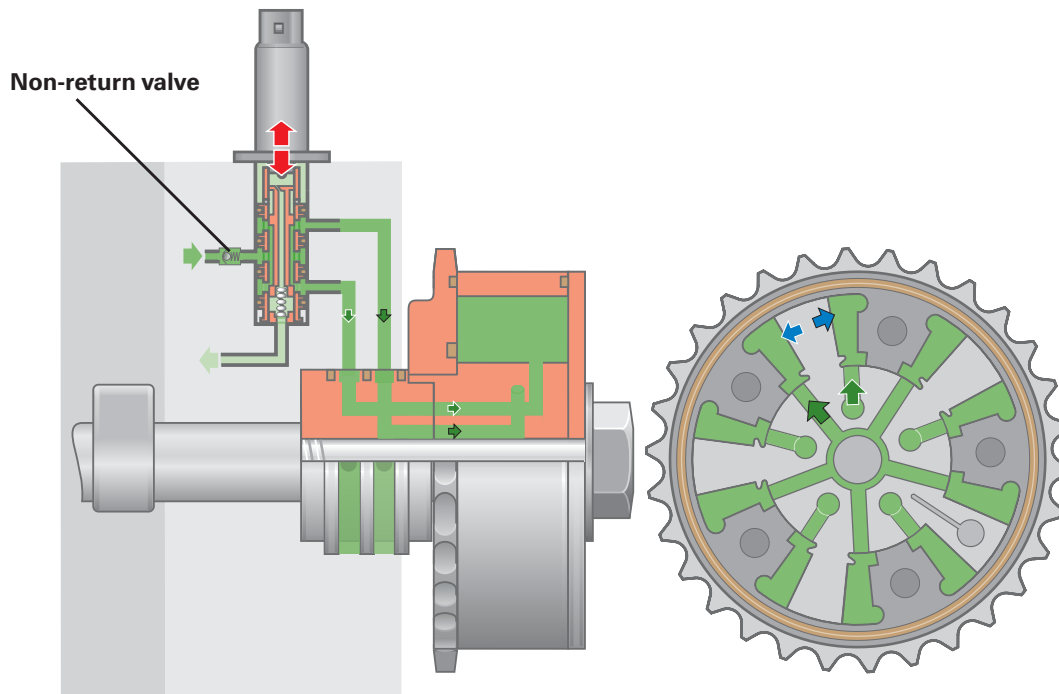
## Adjustment in Advance Direction



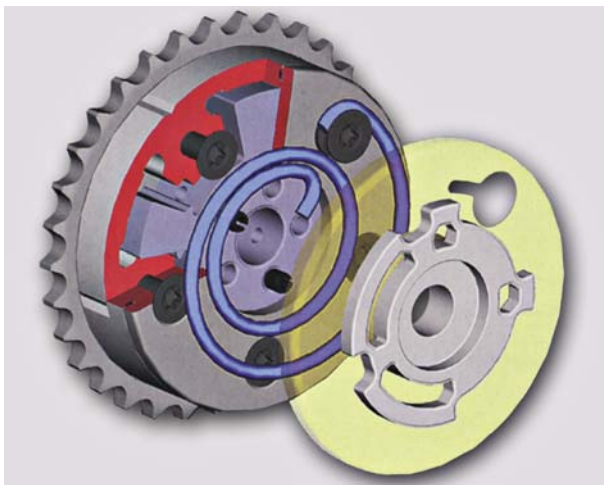
➡ Oil supply    ⬅ Oil drain

SSP267\_126

## Adjustment in Controlled Position



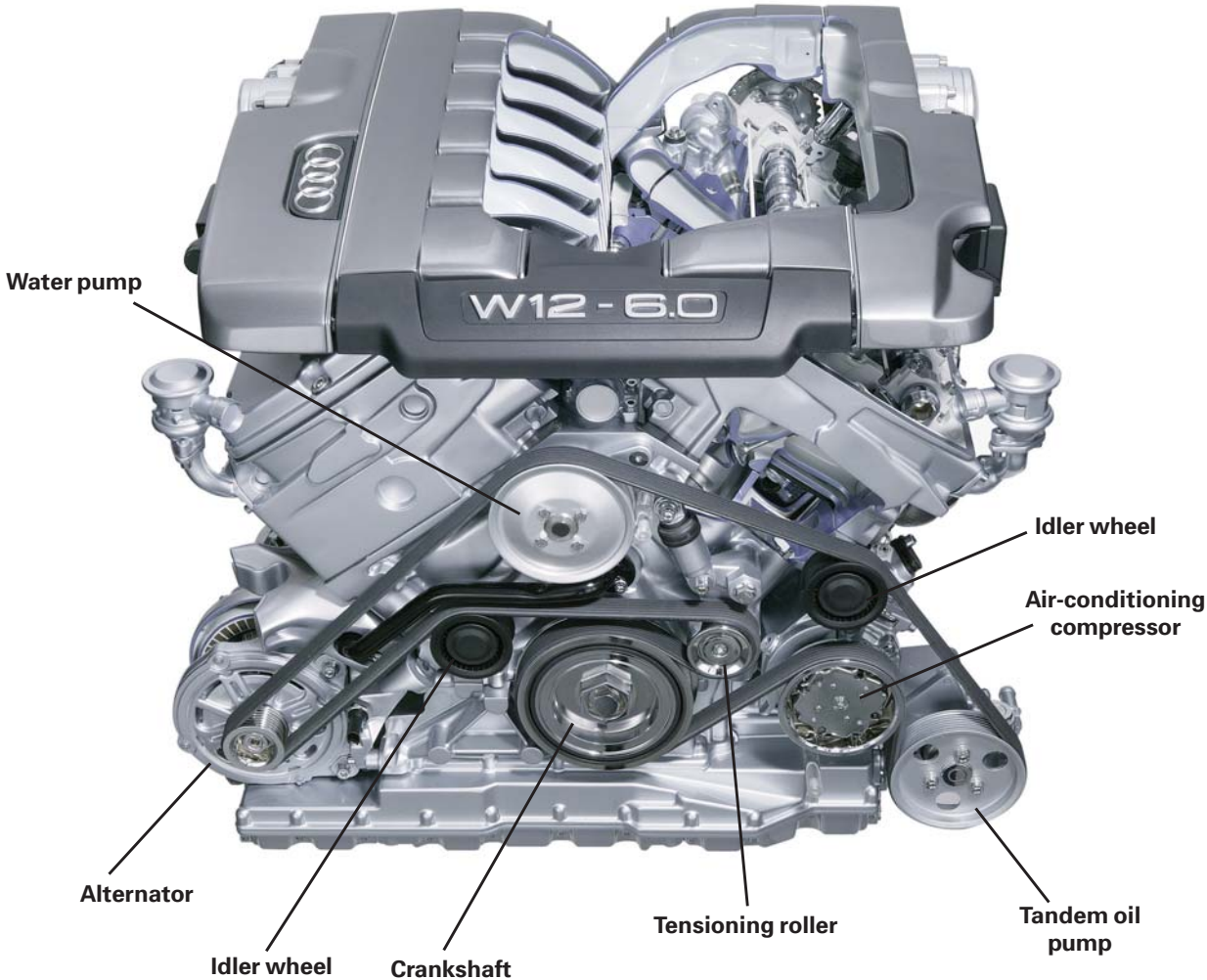
SSP267\_146



The camshaft adjusters are equipped with an auxiliary coil spring attached to the adjuster housing. This spring helps to turn the internal rotor of the adjuster in the "advance" direction.

# Belt Drive/Auxiliaries

## Belt Drive/Auxiliaries





## Water-Cooled Alternator

Alternators generate a high level of current even at low speeds. With air-cooled alternators, the cooling output is a function of speed, which results in extreme heating of the components during high power output combined with low speed. High ambient temperatures add to this situation.

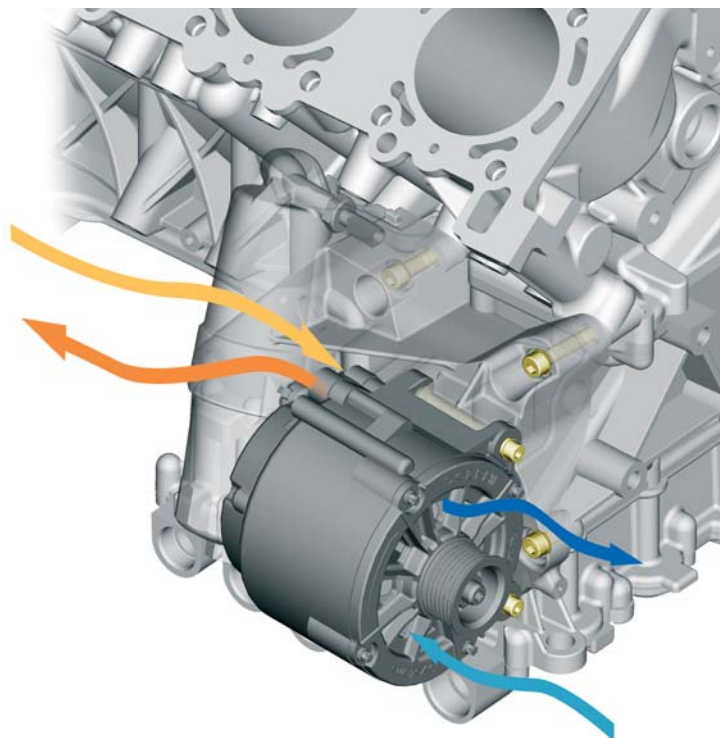
To alleviate this condition, a water-cooled 190 alternator with a power output of 2660W is used on the Audi A8L W12.

The water-cooled alternator has a water jacket that surrounds the stator winding and the surface of the rectifier diodes and regulator mounting plate.

The alternator water jacket is incorporated into the engine cooling circuit and provides cooling in all operating ranges, especially high power output at low speeds. The “open” design pulley provides an exchange of cooling air for the claw-pole rotor. Since the air vortex of the claw-pole rotor is enough, a fan impeller is not necessary.

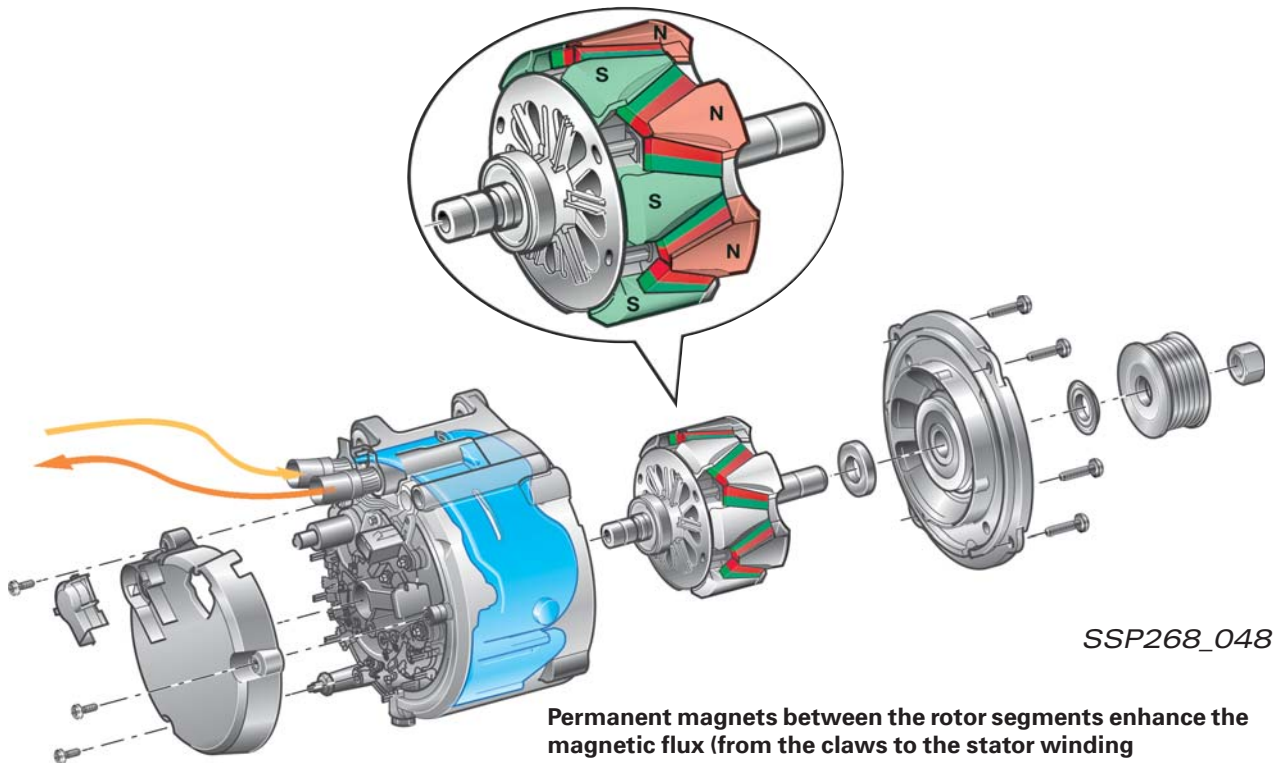
Permanent magnets between the rotor segments enhance the magnetic flux between the claw-pole rotor and stator winding and increase efficiency. The poles of the permanent magnets have the same polarization as the rotor segments.

The permanent magnets are relatively weak to minimize self-excitation and to allow regulation of the alternator voltage.



SSP268\_097

# Water-Cooled Alternator

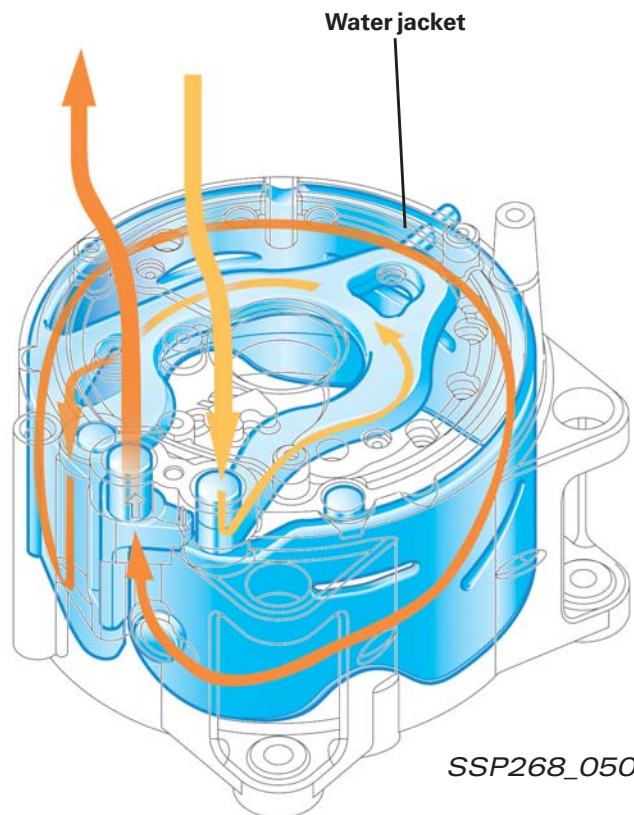


SSP268\_048

Permanent magnets between the rotor segments enhance the magnetic flux (from the claws to the stator winding and vice versa), thus preventing stray flux between the individual poles.

## More Advantages of Water-Cooled Alternators

- Quiet operation results from eliminating the fan impeller. There is no aerodynamic flow noise.
- Smooth running due to rigid, enclosed design of alternator housing.
- Eliminating the fan impeller results in a decrease in drive power required and yields up to 5% more efficiency (as a function of speed).
- Recovery of heat lost to engine cooling circuit during warm-up phase.
- High performance level due to constant cooling over entire speed range.
- Reduced susceptibility to high ambient temperatures.



SSP268\_050

# Induction System

Throttle Body Control Module J544

Throttle Body Control Module J338

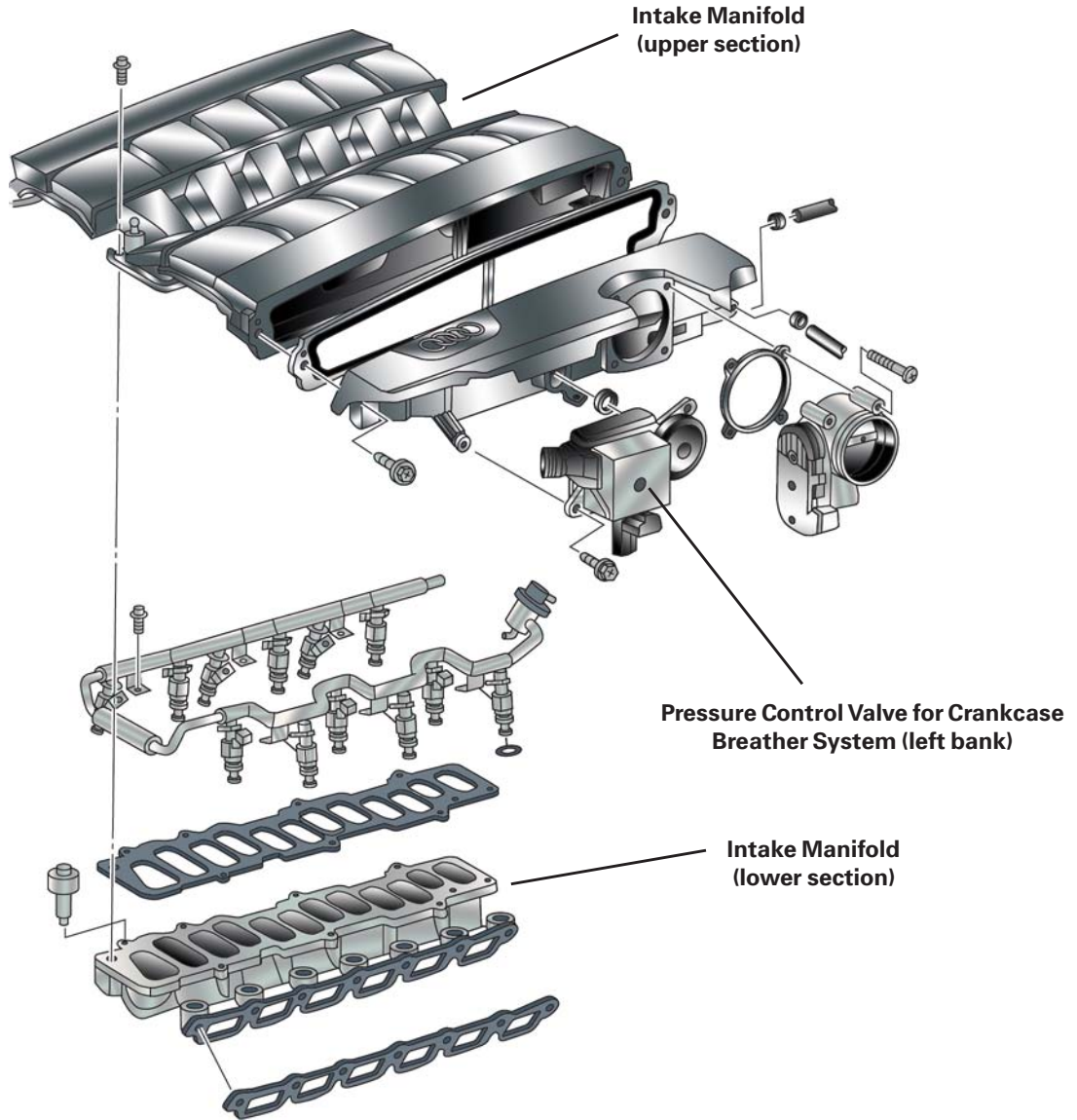



The intake system of the W12 features two Mass Airflow Sensors and two Throttle Body Control Modules. Each sensor and throttle body is fed fresh air from its own air box and filter.

The manifold itself is a split design comprised of an upper and lower half. The upper portion must be removed before servicing the ignition coils or fuel injectors is possible. The upper half can be further disassembled into three separate pieces.

Separate crankcase ventilation boxes are mounted under the upper half of the intake manifold.

# Induction System



 Always refer to the repair information when removing and installing the intake manifold.

Gaskets and seals must always be replaced. Special bolt tightening procedures must also be followed.

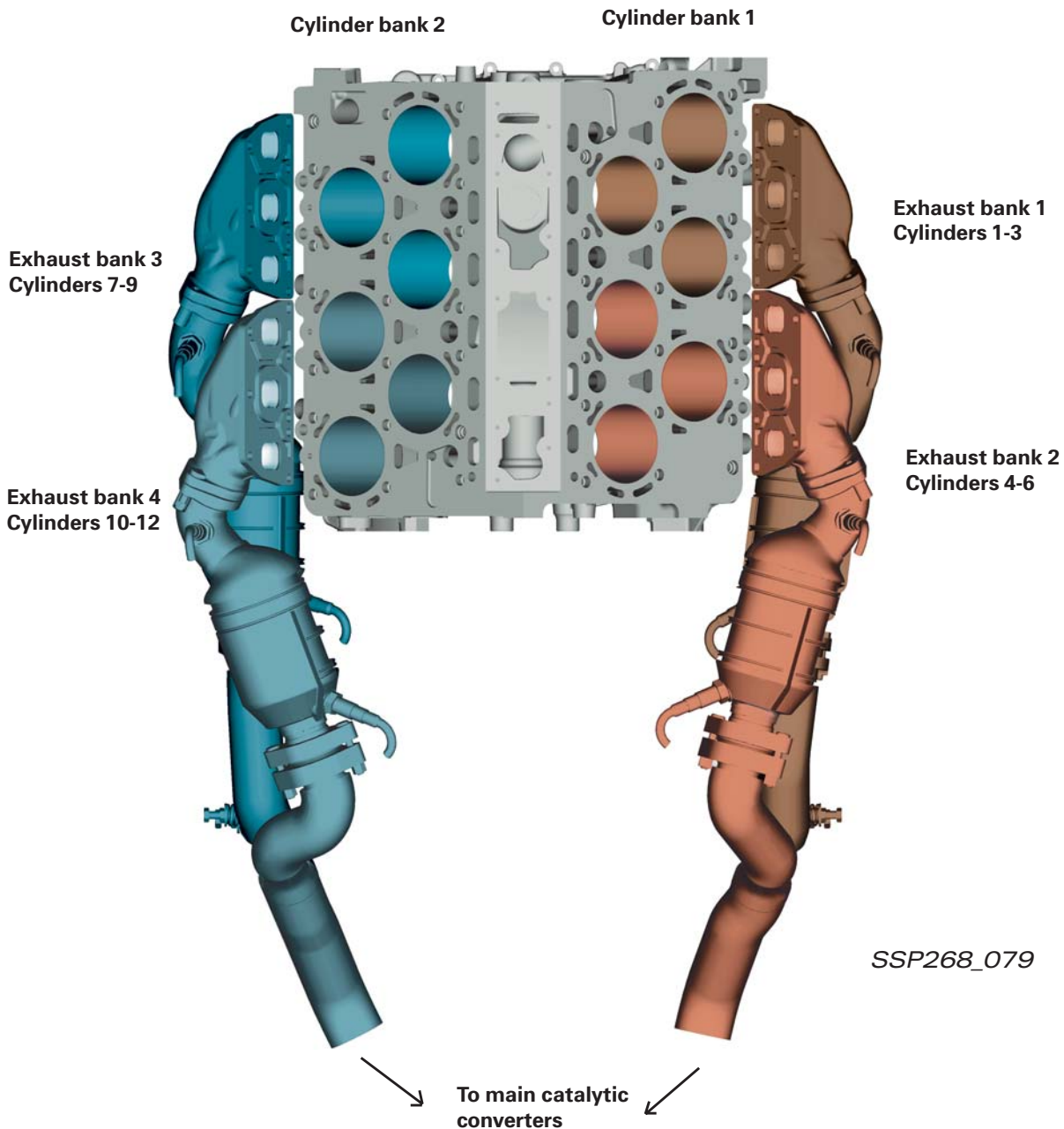
# Engine Sub-Systems

Advantages of metal substrate over ceramic substrate catalytic converters:

- The lower flow resistance results in a lower exhaust backpressure and enhanced power yield.
- The catalytic converter response temperature is reached faster because of the lower heat capacity of the metal substrate and reduces unwanted emissions.

Mixture composition and emission control are monitored by four independent control loops using eight heated oxygen sensors.

Each primary catalytic converter is assigned a wide band oxygen sensor as upstream probe and a step change probe as downstream sensor. Operation of the wide band oxygen sensor is described in SSP 247.



# Engine Sub-Systems

## Exhaust Flaps

The W12 engine has two exhaust flaps. As a function of engine load, engine speed and vehicle speed, the ECM 1 (J623) switches the exhaust flap on the right side and ECM 2 (J624) switches the exhaust flap on the left side.

The exhaust flaps are closed at idle, in the lower part throttle range and enhance silencer efficiency.

When parameters exceed defined values, the exhaust flaps open and reduce exhaust backpressure.

The comfort level is maintained in low load ranges without increasing exhaust backpressure in higher load ranges.

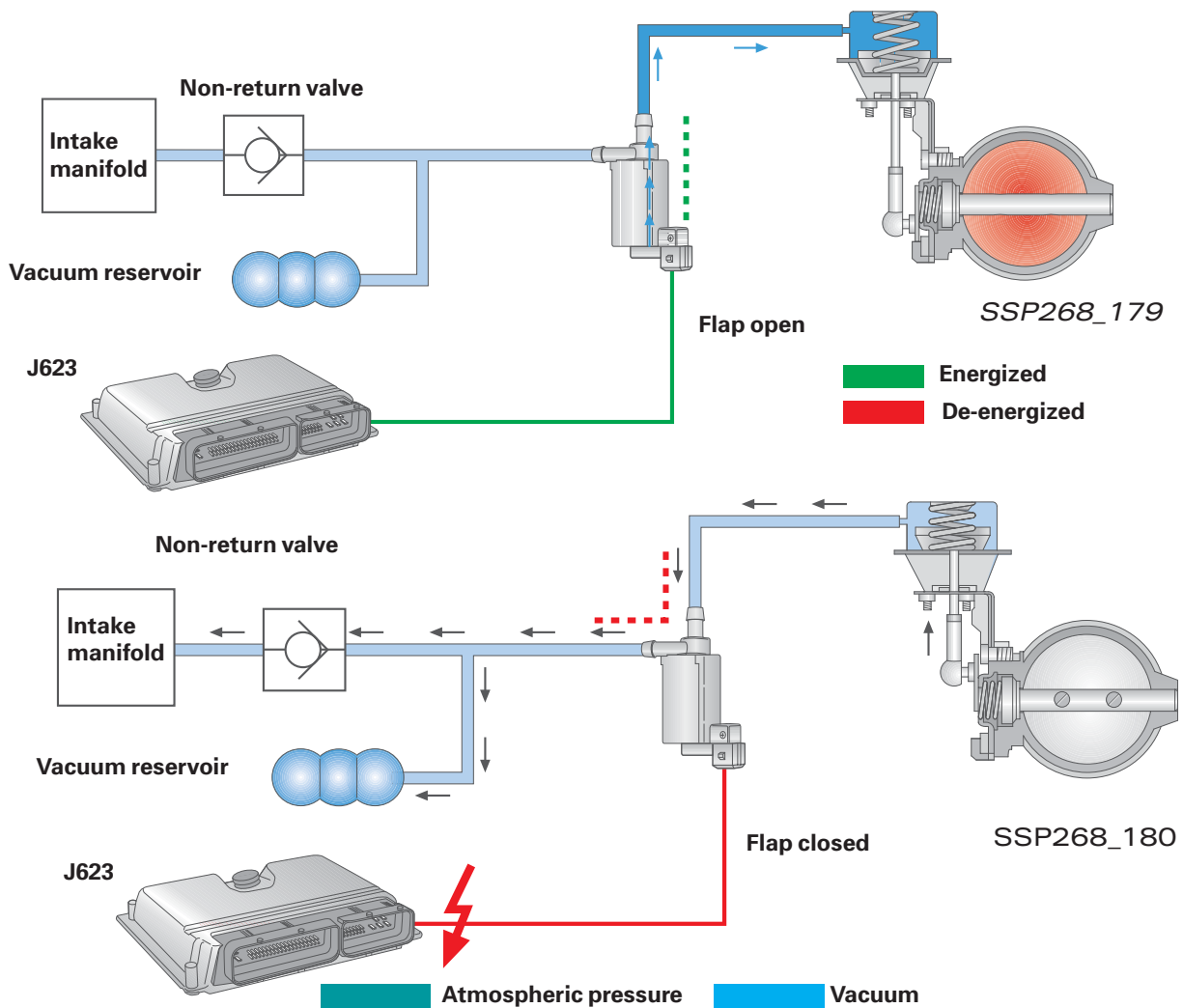
## Operation/Control of Exhaust Flap

Spring force keeps exhaust flaps open in de-energized and depressurized conditions.

This ensures the free discharge of exhaust gases if the system fails and prevents reduced performance and/or damage to the components.

Actuation of Exhaust Flap Valve (N321) or Exhaust Flap Valve 2 (N322) applies vacuum to the vacuum unit and closes the exhaust flap by overcoming the spring force. Switching conditions for opening of exhaust flaps is as follows:

- Vehicle Speed > 3 mph (5 km/h)
- Engine Load > 50%
- Engine Speed > 2500 RPM

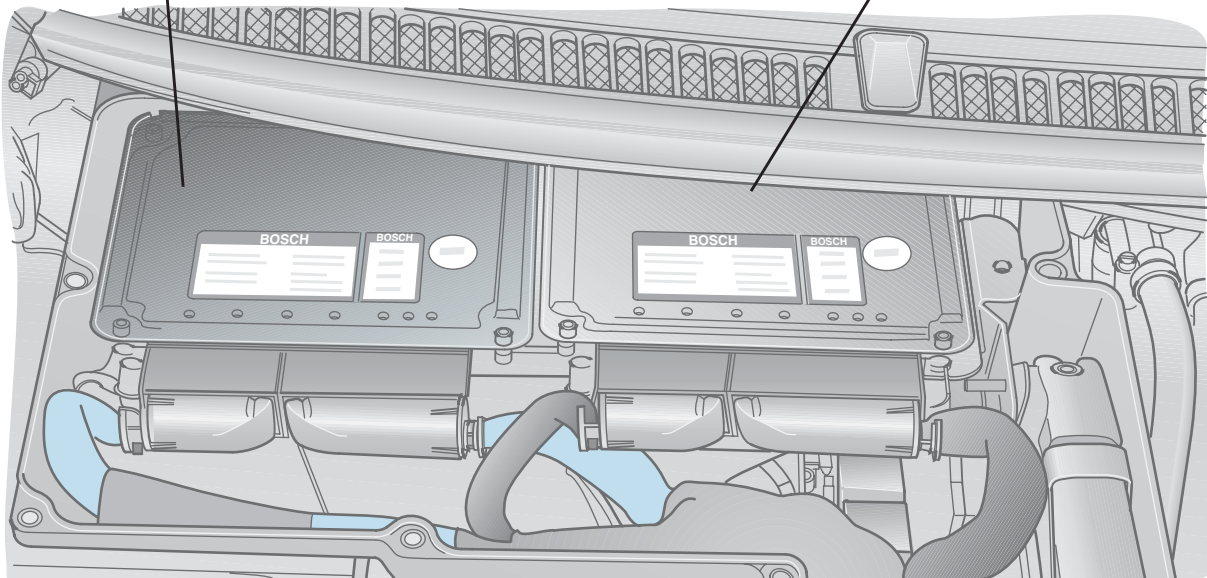




# Engine Management Concept

Engine control module 2 J624

Engine control module 1 J623



SSP268\_129

The Engine Management System for the W12 engine, Motronic ME7.1.1, is a two control module concept.

Two control units are identical and each is assigned to one cylinder bank. The two cylinder banks are considered separate engines.

However, certain sub-functions are common to ECM 1 (J623) for Cylinder Bank 1 and Engine Control Module 2 (ECM 2) (J624) for Cylinder Bank 2

Control unit/cylinder bank assignment identification is provided by pin encoding in the wiring harness. To provide a clear distinction, the wiring harness to each control unit is wrapped with different colored tape.

Pin encoding means that:

- Pin 49 of ECM 1 (J623) is connected to Terminal 15.
- Pin 49 of ECM 2 (J624) is connected to Terminal 31.

Because of the Twin Control Unit Concept, both control units must:

- have the same software version.
- be matched to the Cruise Control System (CCS).
- be matched to the Immobilizer.
- be viewed as separate entities for self-diagnosis.
- have the same encoding.



# Engine Management Concept

**Only ECM 1 (J623) performs the following functions.**

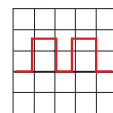
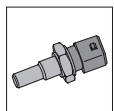
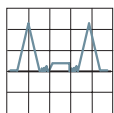
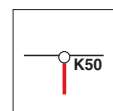
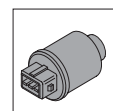
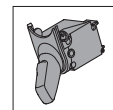
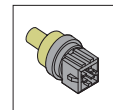
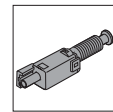
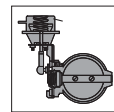
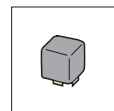
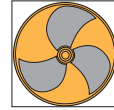
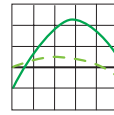
- Determination of specified speed values for idling speed control
- Coolant temperature regulation, continued coolant circulation, actuation of continued After-Run Coolant Pump (V51)
- Provision of CAN data for drive system CAN
- Actuation of Fuel Pump Relay (J17) and Motronic ECM Power Supply Relay (J271)
- Control of exhaust flap

**ECU 1 (J623) processes the following interfaces.**

- Brake Light Switch F/Brake Pedal Switch (F47)
- Engine Coolant Temperature Sensor (G62)
- Cruise Control Switch (E45)
- A/C High Pressure Signal from A/C Pressure Switch (F129)
- Terminal 50 Signal
- Engine Speed Signal

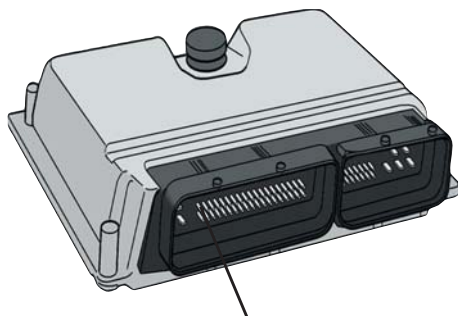
**Only ECM 2 J624 performs the following functions.**

- Misfire Detection
- Processing of Engine Oil Temperature Sensor (G8) signal



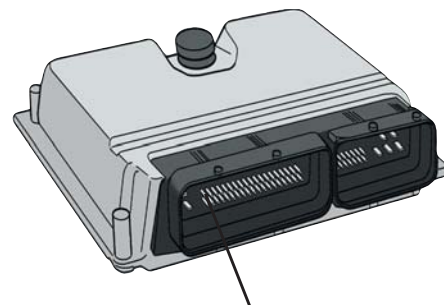
SSP268\_148

Engine control module 2 J624



Terminal 31

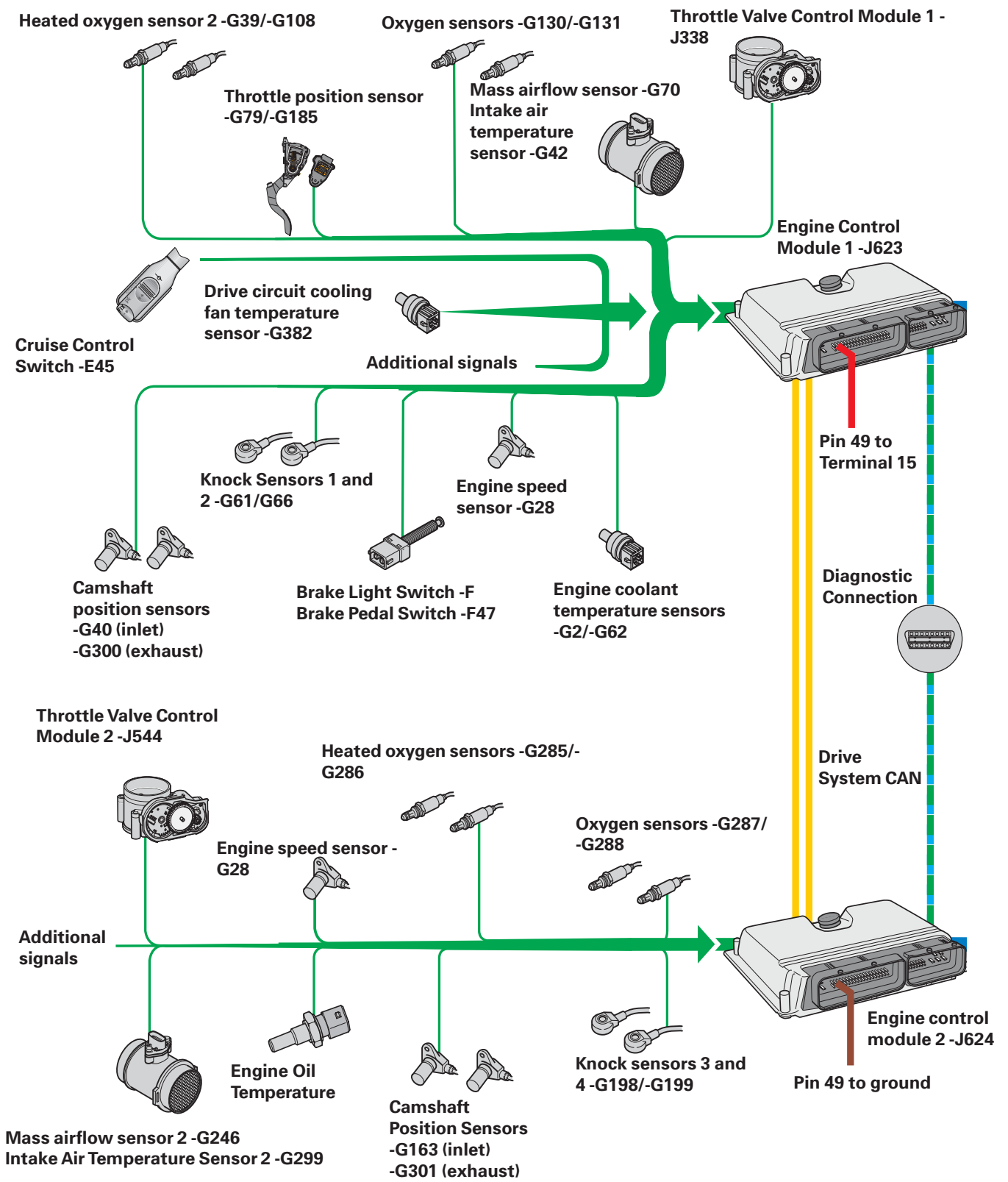
Engine control module 1 J623



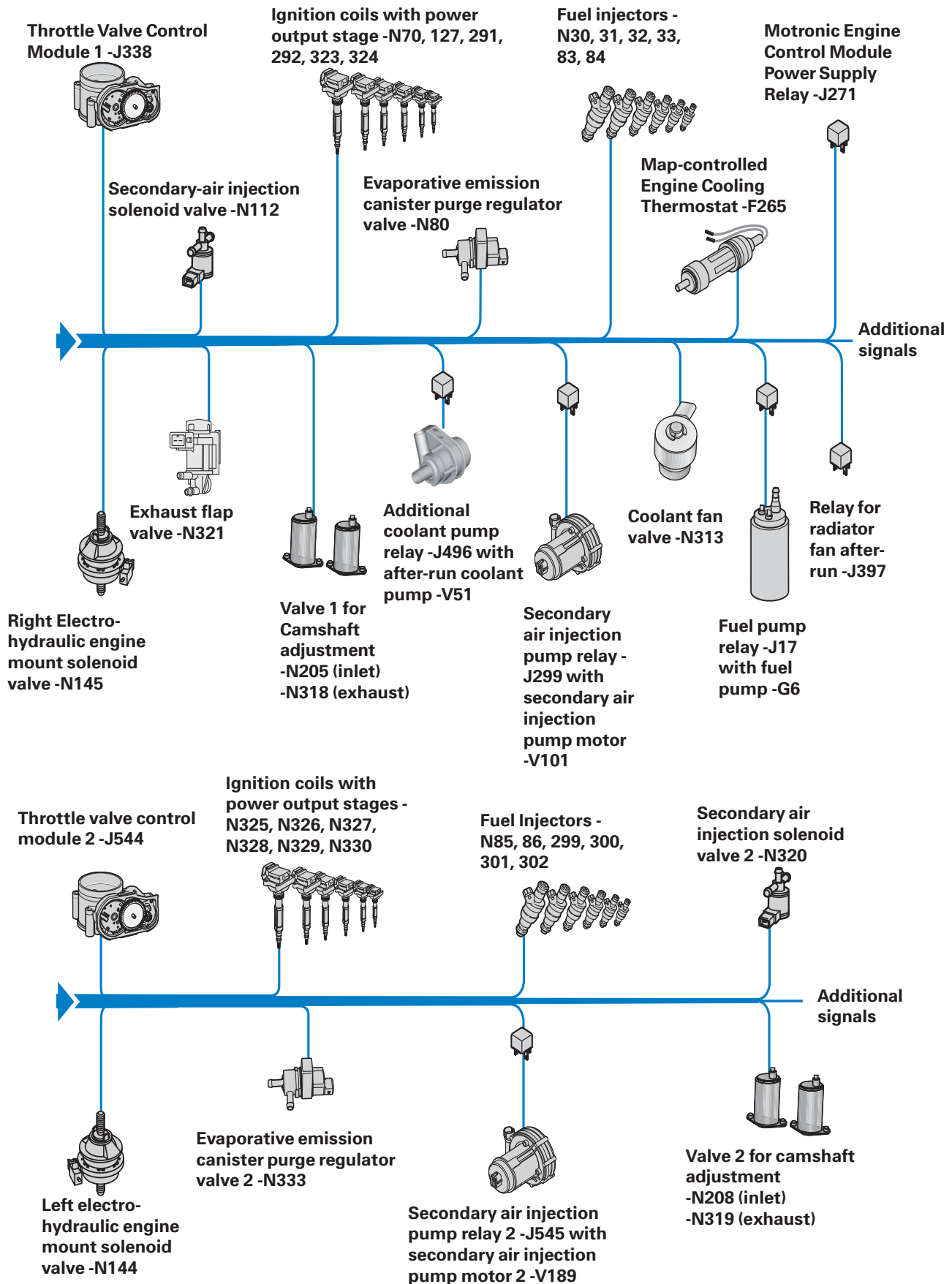
Terminal 15

# Engine Management Concept

## System Layout



# Engine Management Concept



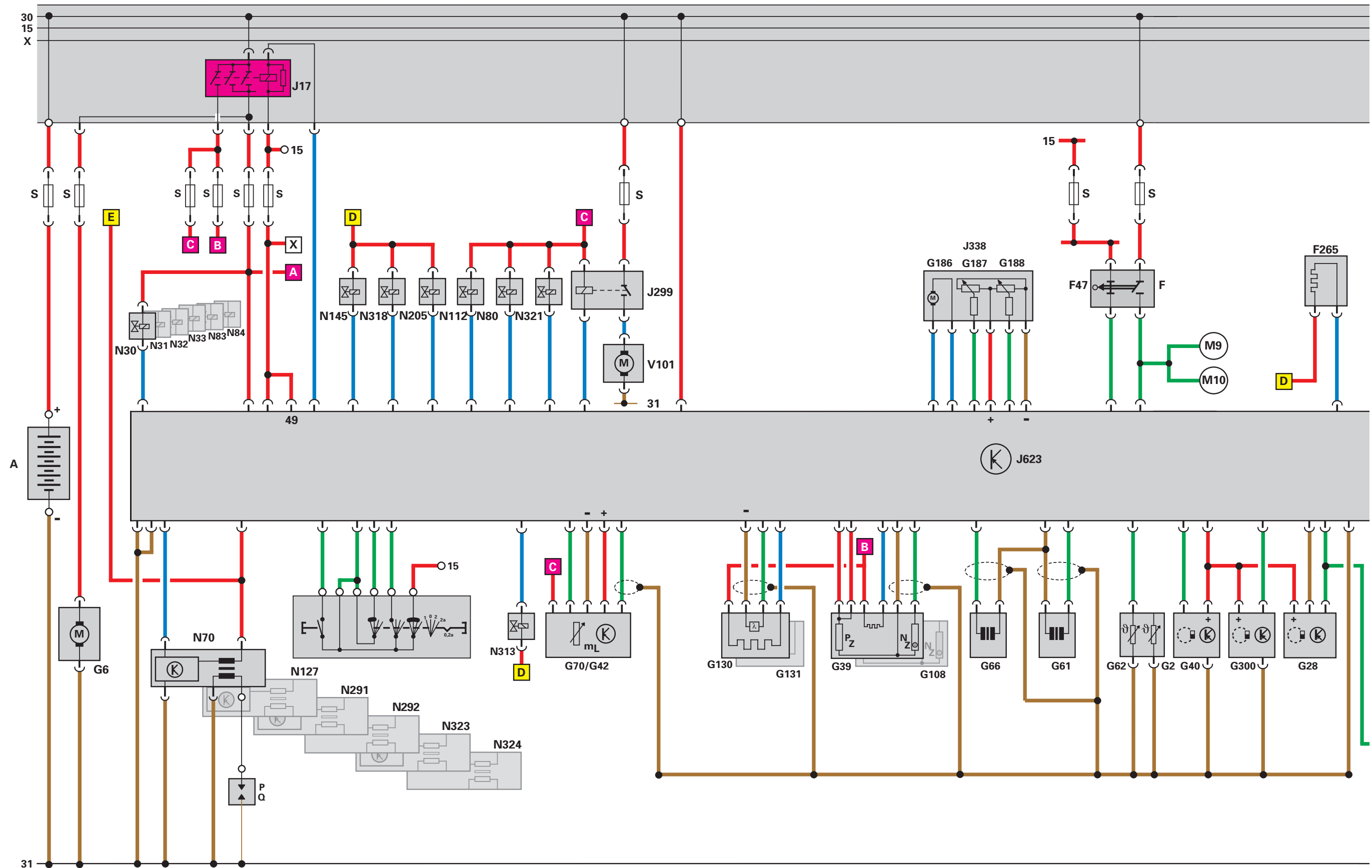
# Engine Management Concept

## Sensors/Actuators

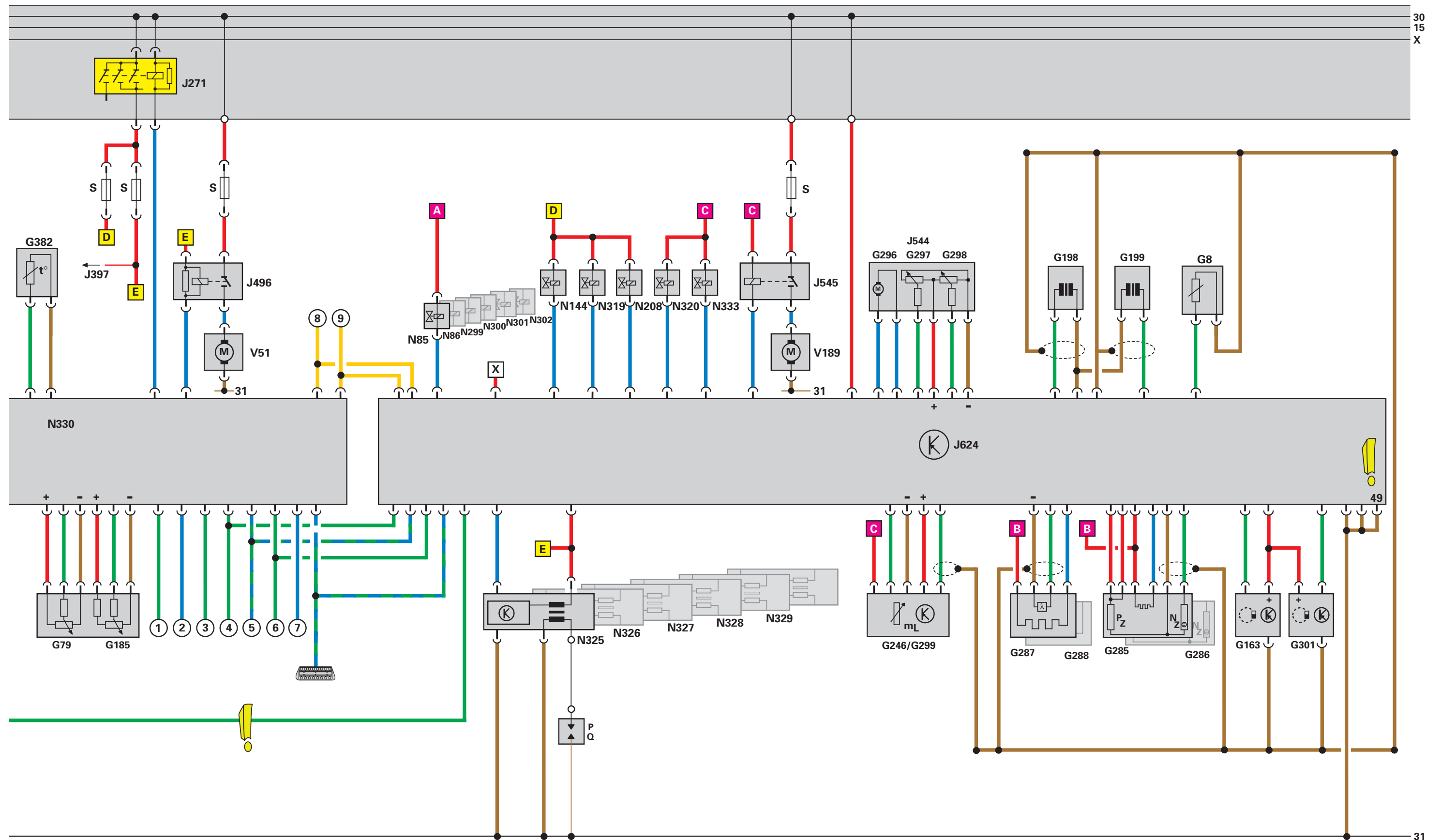
### Block Diagram Motronic ME7.1.1

A	Battery	G301	Camshaft Position Sensor 4
E45	Cruise Control Switch	G382	Drive Circuit Cooling Fan Temperature Sensor
F	Brake Light Switch	J17	Fuel Pump Relay
F47	Brake Pedal Switch	J271	Motronic ECU Power Supply Relay
F265	Map-Controlled Engine Cooling Thermostat	J299	Secondary Air Injection Pump Relay
G2	Coolant Temperature Sensor	J338	Throttle Valve Control Module
G6	Fuel Pump	J397	Relay for Radiator Fan After Run
G8	Oil Temperature Sensor	J496	Auxiliary Engine coolant Pump Relay
G28	Engine Speed Sensor	J544	Throttle Valve Control Module 2
G39	Heated Oxygen Sensor	J545	Secondary Air Injection Pump Relay 2
G40	Camshaft Position Sensor	J623	ECM 1
G42	Intake Air Temperature Sensor	J624	ECM 2
G61	Knock Sensor 1	M9	Left Brake Light Bulb
G62	Engine Coolant Temperature Sensor	M10	Right Brake Light Bulb
G66	Knock Sensor 2	N30	Cylinder 1 Fuel Injector
G70	Mass Air Flow Sensor	N31	Cylinder 2 Fuel Injector
G79	Throttle Position Sensor	N32	Cylinder 3 Fuel Injector
G108	Heated Oxygen Sensor 2	N33	Cylinder 4 Fuel Injector
G130	Oxygen Sensor	N70	Ignition Coil 1 with Power Output Stage
G131	Oxygen Sensor 2	N80	Evaporative Emission Canister Purge Regulator Valve
G163	Camshaft Position Sensor 2	N83	Cylinder 5 Fuel Injector
G185	Sensor 2 for Accelerator Pedal Position	N84	Cylinder 6 Fuel Injector
G186	Throttle Drive (Power Accelerator Actuation)	N85	Cylinder 7 Fuel Injector
G187	Angle Sensor 1 for Throttle Drive (Power Accelerator Actuation)	N86	Cylinder 8 Fuel Injector
G188	Angle Sensor 2 for Throttle Drive (Power Accelerator Actuation)	N112	Secondary Air Injection Solenoid Valve
G198	Knock Sensor 3	N127	Ignition Coil 2 with Power Output Stage
G199	Knock Sensor 4	N144	Left Electro Hydraulic Engine Mount Solenoid Valve
G246	Mass Airflow Sensor 2	N145	Right Electro Hydraulic Engine Mount Solenoid Valve
G285	Heated Oxygen Sensor 3	N205	Camshaft Adjustment Valve 1
G286	Heated Oxygen Sensor 4	N208	Camshaft Adjustment Valve 2
G287	Oxygen Sensor 3	N291	Ignition Coil 3 with Output Power Stage
G288	Oxygen Sensor 4	N292	Ignition Coil 4 with Output Power Stage
G296	Throttle Drive 2	N299	Cylinder 9 Fuel Injector
G297	Angle Sensor 1 on Throttle Valve Drive 2	N300	Cylinder 10 Fuel Injector
G298	Angle Sensor 2 for Throttle Valve Drive 2	N301	Cylinder 11 Fuel Injector
G299	Intake Air Temperature Sensor 2	N302	Cylinder 12 Fuel Injector
G300	Camshaft Position Sensor 3	N313	Coolant Fan Valve
		N318	Camshaft Adjustment Valve 1

# Engine Management Concept



# Engine Management Concept



30  
15  
X

31






# Engine Management Concept







- N319 Camshaft Adjustment Valve 2
- N320 Secondary Air Injection Solenoid Valve 2
- N321 Exhaust Flap 1 Valve
- N323 Ignition Coil 5 with Final Power Output Stage
- N324 Ignition Coil 6 with Final Power Output Stage
- N325 Ignition Coil 7 with Final Power Output Stage
- N326 Ignition Coil 8 with Final Power Output Stage
- N327 Ignition Coil 9 with Final Power Output Stage
- N328 Ignition Coil 10 with Final Power Output Stage
- N329 Ignition Coil 11 with Final Power Output Stage
- N330 Ignition Coil 12 with Final Power Output Stage
- N333 Evaporative Emission Canister Purge Regulator Valve
- V51 After-Run Coolant Pump
- V101 Secondary Air Injection Pump Motor
- V189 Secondary Air Injection Pump Motor 2

## Additional Signals

- ① Terminal 50
- ② To Relay for Radiator Fan After-Run (J397)
- ③ AC High Pressure Signal from A/C Pressure Switch (F129) (High Pressure Switch)
- ④ AC Requirement Signal (from A/C Control Head [E87])
- ⑤ Compressor "ON/OFF" Signal
- ⑥ Crash Signal
- ⑦ Engine Speed Signal
- ⑧ CAN Low/Drive
- ⑨ CAN High/Drive

## Color Code

-  = Input Signal
-  = Output Signal
-  = Positive Supply
-  = Ground
-  = CAN Bus

-  } Power Supply from Fuel Pump Relay (J17)
-  }
-  }
-  } Motronic ECM Power Supply Relay (J271)
-  }
-  Connections within Block Diagram

# Engine Management Concept

## Special Features of Motronic ME7.1.1

The Motronic ME7.1.1 is an advanced version of the Motronic ME7.1 and has these features:

- Larger computer capacity because of new computer-bound sub-functions
- Extension of control unit activities after turning off the ignition with the aid of main relay concept
- Infinitely variable adjustment of inlet and exhaust camshafts
- Designed to suit new broad band oxygen sensor upstream of catalytic converter
- Designed for coolant temperature regulation
- Enhanced evaluation of signals from Engine Coolant Temperature Sensor (G62)
- Management of additional and new CAN messages

### G62 Evaluation

Precision sensing of the coolant temperature over a broad temperature range is very important.

Precise determination of the coolant temperature in the lower operating temperature range is required for cold starting and subsequent warm up.

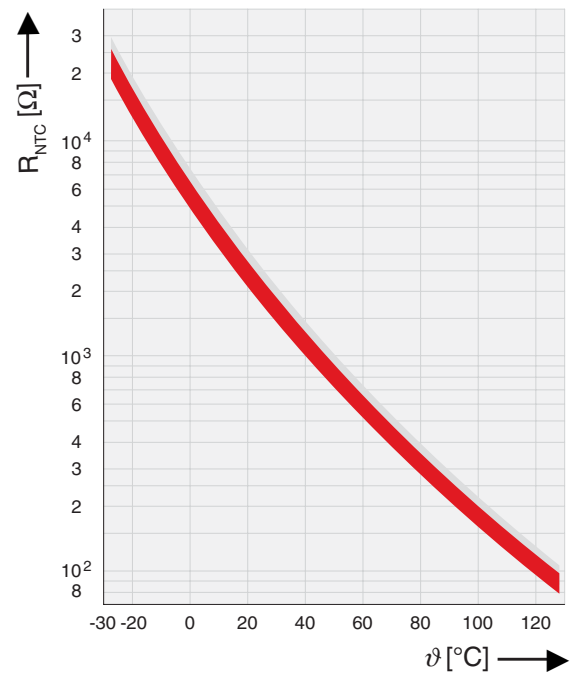
Coolant temperature regulation demands exact recognition of the coolant temperature in the upper operating temperature range.

The characteristic curve of the Engine Coolant Temperature Sensor (G62) (NTC Sender) is steep over the temperature range to be recorded – approximately 86°F (30°C) to 248°F (120°C).

At the same time, the coefficient of resistance ranges from approximately 25,000 Ohms to approximately 115 Ohms. The change in resistance per Kohm varies considerably at low and high temperatures.

To achieve the required level of accuracy for both temperature ranges, the ME7.1.1 has a separate evaluation circuit for each.

Changing to the evaluation circuit for the upper temperature range takes place at a coolant temperature of approximately 122°F (50°C).



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# Engine Management Concept

## Main Relay Concept

In earlier versions of the W12, the Fuel Pump Relay (J17) provided the power supply for the sensors and actuators.

Now this task is performed by the Motronic ECM Power Supply Relay (J271) (Main Relay).

As with the Fuel Pump Relay (J17), ECM 1 actuates the Motronic ECM Power Supply Relay (J271). Due to the Motronic ECM Power Supply Relay (J271), the ECMs can still execute certain functions after the engine ignition has been turned off.

The following sensors/actuators are supplied with power by the Motronic Current Supply Relay (J271):

- ECM 1
- ECM 2
- Cylinder Bank 1 Ignition Coils
- Cylinder Bank 2 Ignition Coils
- Camshaft Adjustment Valves
- Engine Mounting Solenoid Valves
- Coolant Fan Valve (N313)
- Auxiliary Engine Coolant Pump Relay (J496) (Continued After-Run Coolant Pump [V51])
- Relay for Radiator Fan After-Run (J397) (Coolant Fan [V7])
- Map-Controlled Engine Cooling Thermostat (F265)

After turning off the ignition, the ignition coils are still actuated until the engine stops to ensure ignition of the fuel already injected. This means that no unburned fuel/air mixture reaches the exhaust system, which reduces the level of exhaust emissions.

The camshaft adjustment valves also remain actuated until the engine stops when the ignition is turned off, to ensure that the camshafts are kept in the proper position until the engine has stopped.

The Engine Mounting Solenoid Valves provide smooth engine shutoff.

The Solenoid Valve for the hydraulic fan prevents brief fan speed increase.

Since ECM 1 is responsible for control of the continued coolant circulation process, it actuates: Auxiliary Engine Coolant Pump Relay (J496), Relay for Radiator Fan After-Run (J397) and Map-Controlled Engine Cooling Thermostat (F265).

# Engine Management Concept

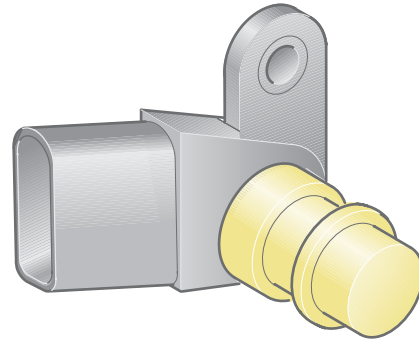
## Engine Speed Sensor G28

The Engine Speed Sensor G28, supplies the most important engine management input signal.

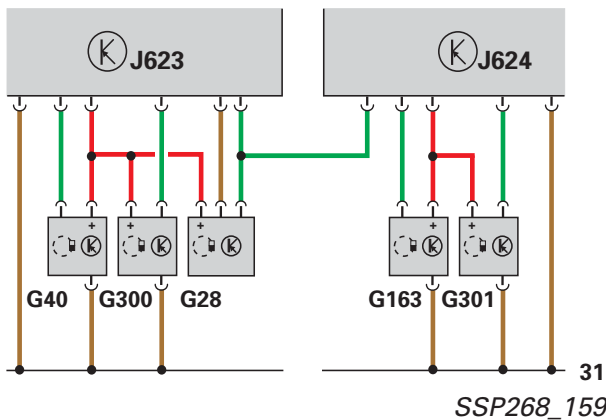
If the Engine Speed Sensor (G28) fails, the engine will not run.

The Engine Speed Sensor (G28) is directly connected to both ECMs. The sensor is a Differential Hall Sensor with integrated permanent magnet that scans ferromagnetic sensor wheels.

If the sensor signal is missing, it is recognized by the ECM self-diagnosis function.

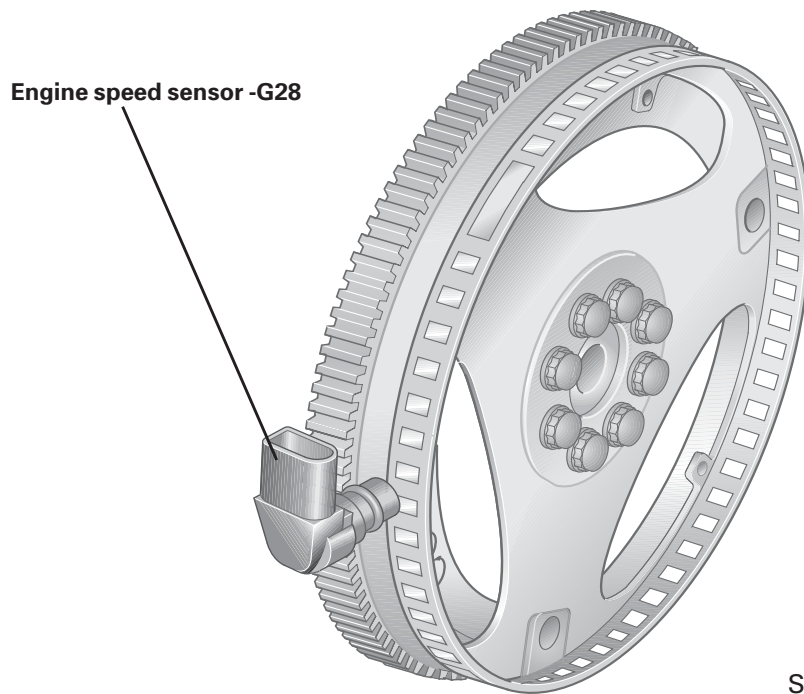


SSP268\_164

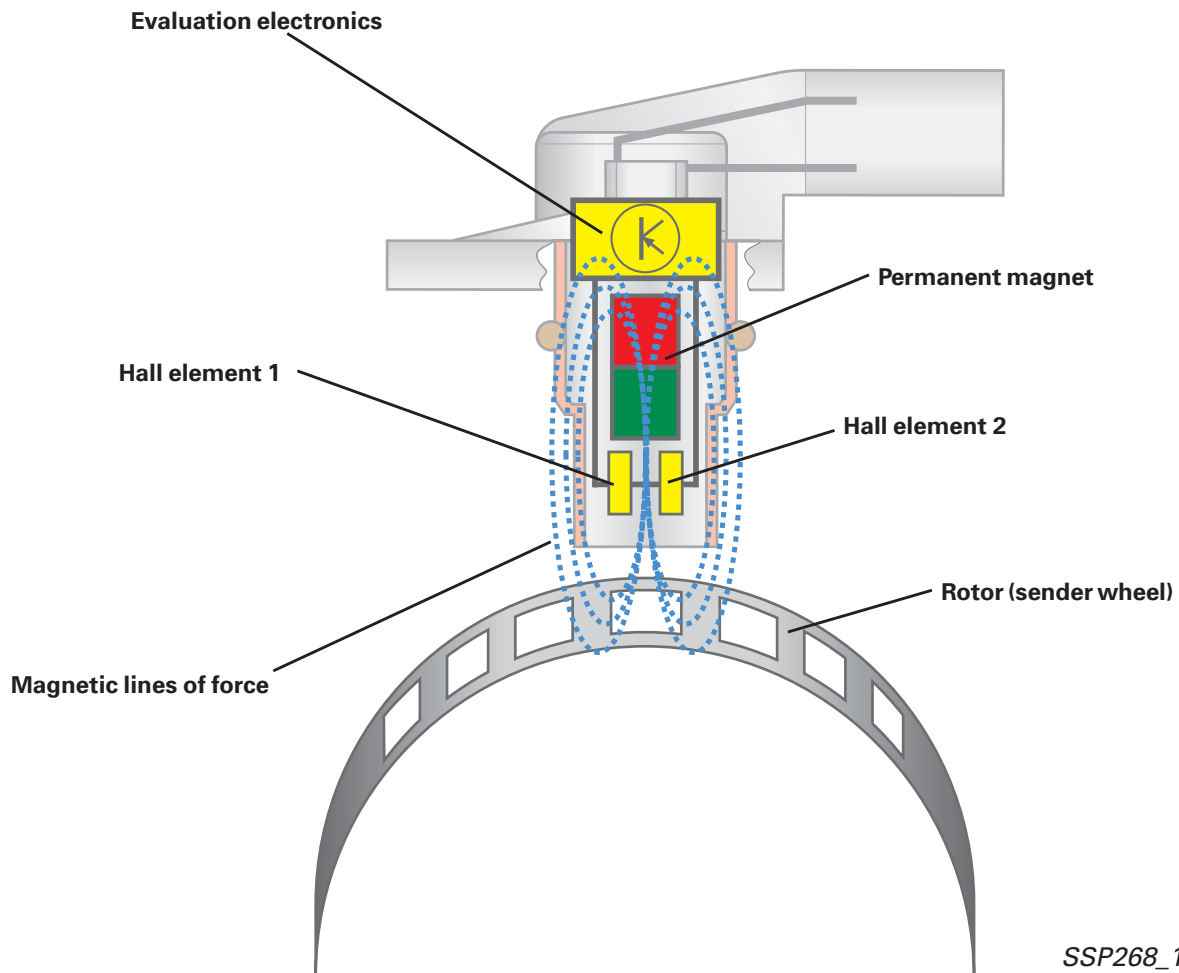


- G40 Camshaft Position Sensor/Cylinder Bank 1
- G163 Camshaft Position Sensor/Cylinder Bank 2
- G300 Camshaft Position Sensor/Cylinder Bank 1
- G301 Camshaft Position Sensor/Cylinder Bank 2

# Engine Management Concept



SSP268\_167



SSP268\_168

# Engine Management Concept

## Sensor Design

Signals are generated by two Hall elements arranged behind the sensor wheel.

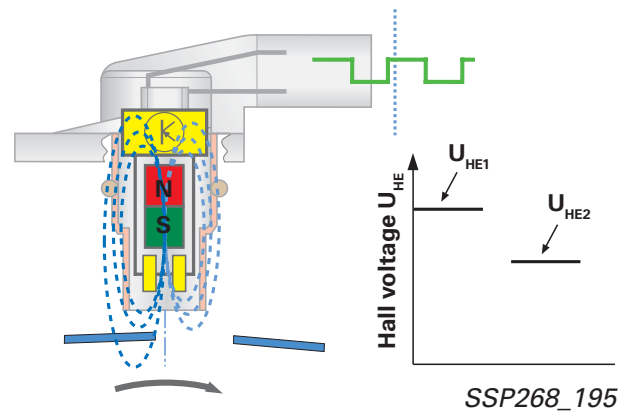
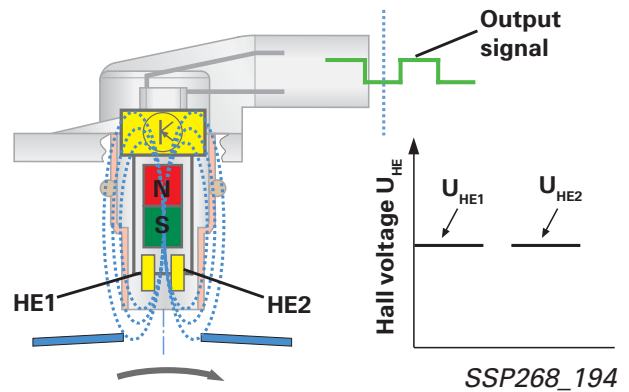
A permanent magnet is located above the two Hall elements and integrated into the sensor. The magnetic field acts on the Hall elements. The integrated evaluation electronics, also called Hall Integrated Circuit (IC) evaluate the Hall voltages of the two Hall elements and generate the sensor output signal.

Hall elements react to changes in the magnetic field. IC refers to an integrated semi-conductor circuit.

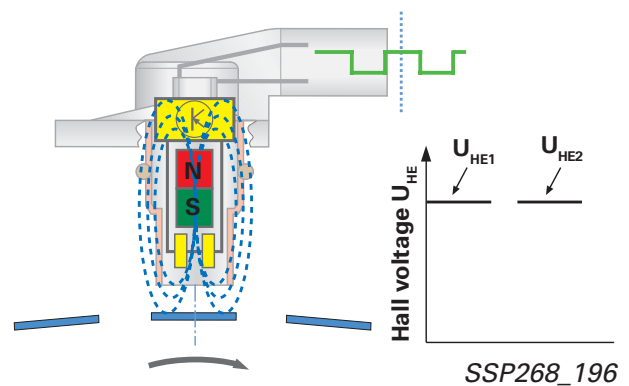
The sensor wheel is a rotor and influences both the field strength of the permanent magnet and the Hall voltages of the two Hall elements. If the ferrous metal rotor is located directly under the Hall elements, the ferrous metal intensifies the magnetic field in the area of the Hall elements. The Hall voltage of the two Hall elements increases with increasing magnetic field strength.

Since the two Hall elements are arranged behind one another, the Hall voltage levels at the Hall elements change during the transition from rotor to gap (or vice versa).

The difference between and the magnitude of the Hall voltages are used for evaluation and generation of the output signal.



IC means "Integrated Circuit" and refers to an integrated semi-conductor circuit.



# Engine Management Concept

## Camshaft Position Sensors

In addition to defining the camshaft position with respect to the position of the crankshaft, a camshaft position sensor is required for each inlet and exhaust camshaft adjustment.

Sensor signals are required for the following functions.

### — Engine Speed Sensor (G28) and Camshaft Position Sensor (G40)

— Synchronization of Bank 1 (with Cylinder 1/Cylinder 6) for knock control and sequential injection; G300 is responsible for synchronization if G40 fails.

### — Engine Speed Sensor (G28) and Camshaft Position Sensor (G163)

— Synchronization of Bank 2 (with Cylinder 12/Cylinder 7) for knock control and sequential injection; G301 is responsible for synchronization if G163 fails.

Bank 2 synchronization is offset by 60° with respect to Bank 1. The pin encoding ensures that allowance is made for this in the software.

### — Engine Speed Sensor (G28) and Camshaft Position Sensors (G40/300)

— Control and monitoring of camshaft adjustment for Cylinder Bank 1

### — G28 and G163/301

— Control and monitoring of camshaft adjustment for Cylinder Bank 2

— There is no camshaft timing control function if one of the camshaft position sensors is defective.

— If both the camshaft position sensors on one bank fail, engine starting is enabled by the engine run-out detection function.

Adaptation of Sensor Signals (G40/G300/G163 and G301) provides more accurate determination of the camshaft basic positions.

Cylinder bank 2



Camshaft position sensor 4 -G301

Camshaft position sensor 2 -G163

Cylinder bank 1



Camshaft position sensor 1 -G40

Camshaft position sensor 3 -G300

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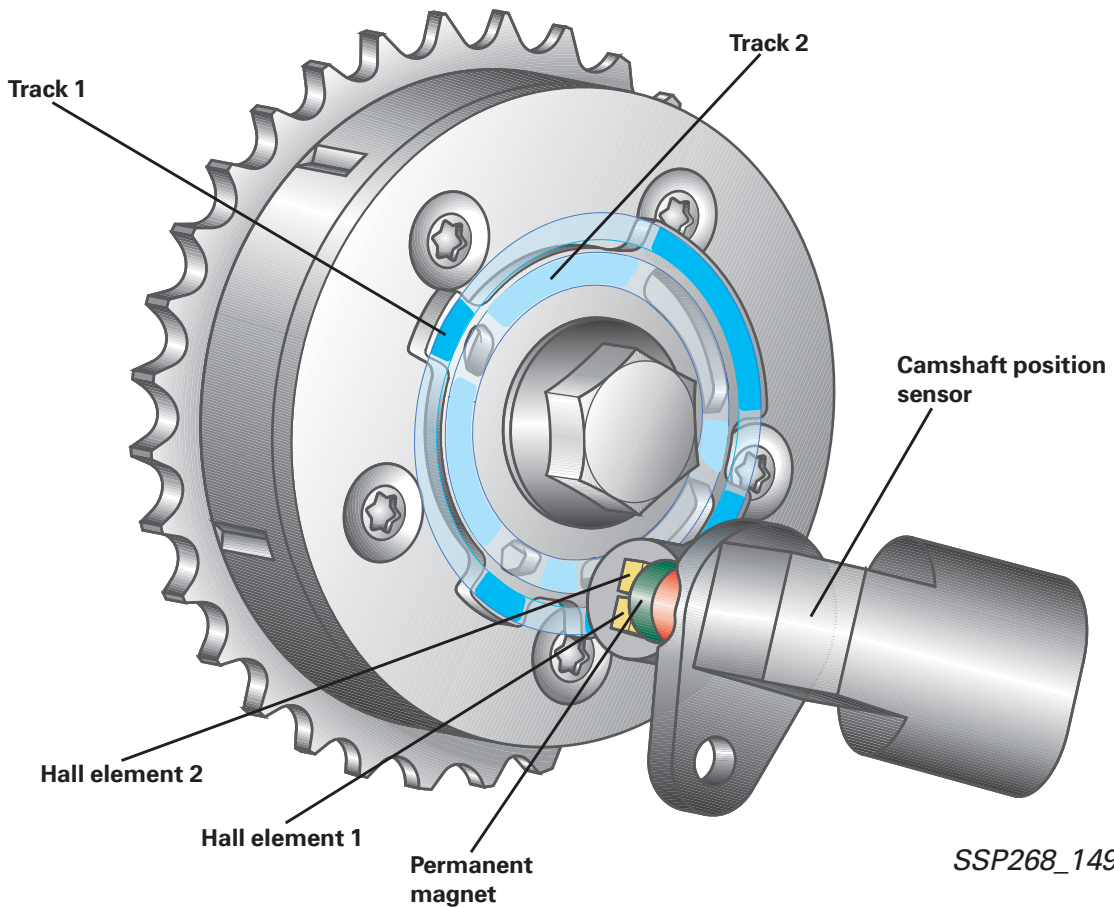
# Engine Management Concept

## Sensor Design

The camshaft position sensor is also called a "Differential Hall Sensor" that uses a two-track rapid start sensor wheel made of ferrous metal.

The sensor wheel has two broad and two narrow rotors/gaps.

This design has different rotor widths and enables the signal profiles of the Camshaft Position Sensors (G40/G163) and the Engine Speed Sensor (G28) to be used for faster determination of camshaft adjustment with respect to the crankshaft.



# Engine Management Concept

Another feature of the sensor wheel design is that two “tracks” are in adjacent, mutually inverted arrangement.

The two-track system ensures more precise generation of the sensor signal.

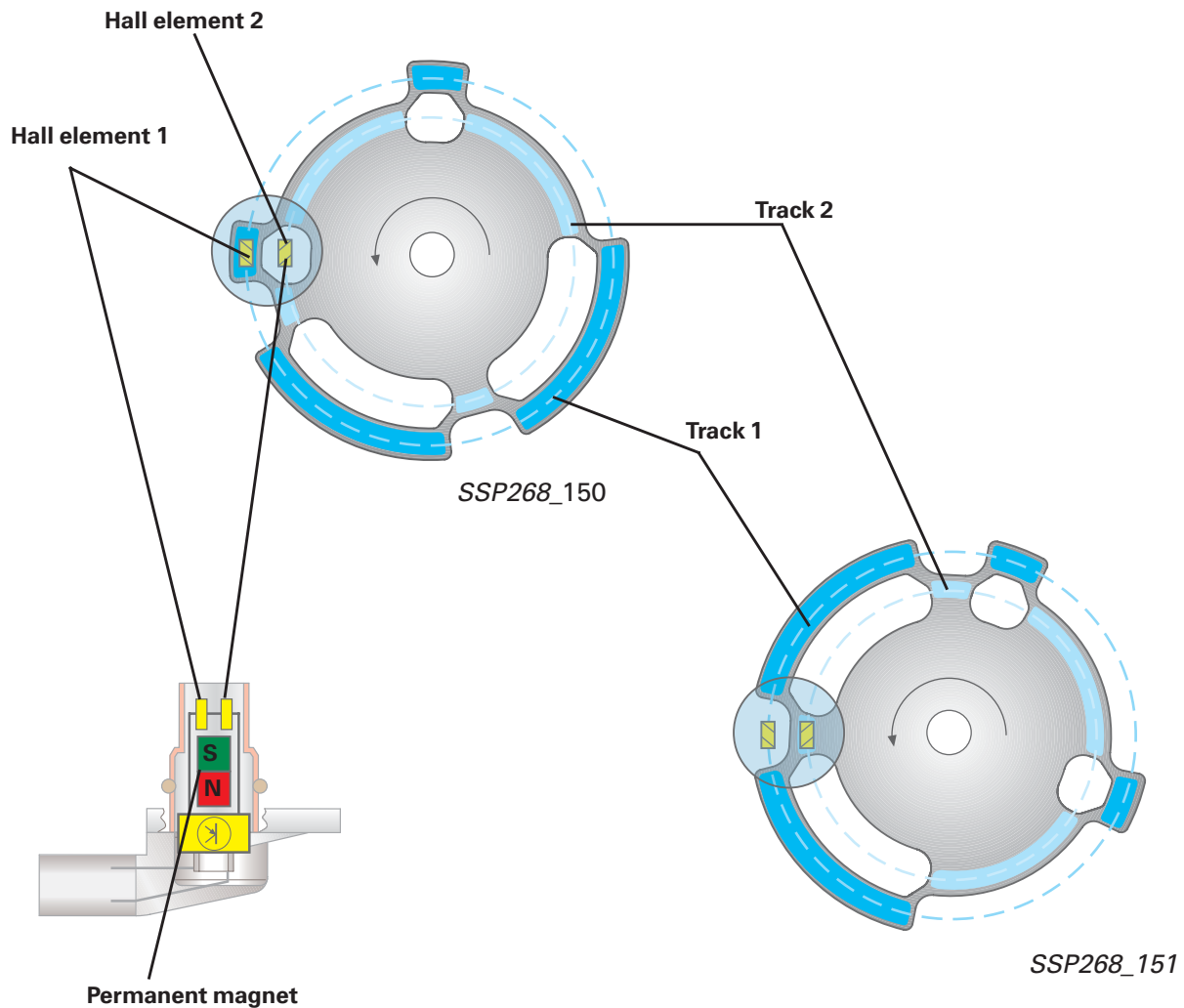
The signals are generated by two **Hall elements HE1** and **HE2** that are situated next to the sensor wheel. One track is assigned to each of the Hall elements.

A permanent magnet is situated above the two Hall elements and integrated into the sensor, the field of which acts on the Hall elements. The IC electronics evaluate the Hall voltages of the two Hall elements and generate the sensor output signal.

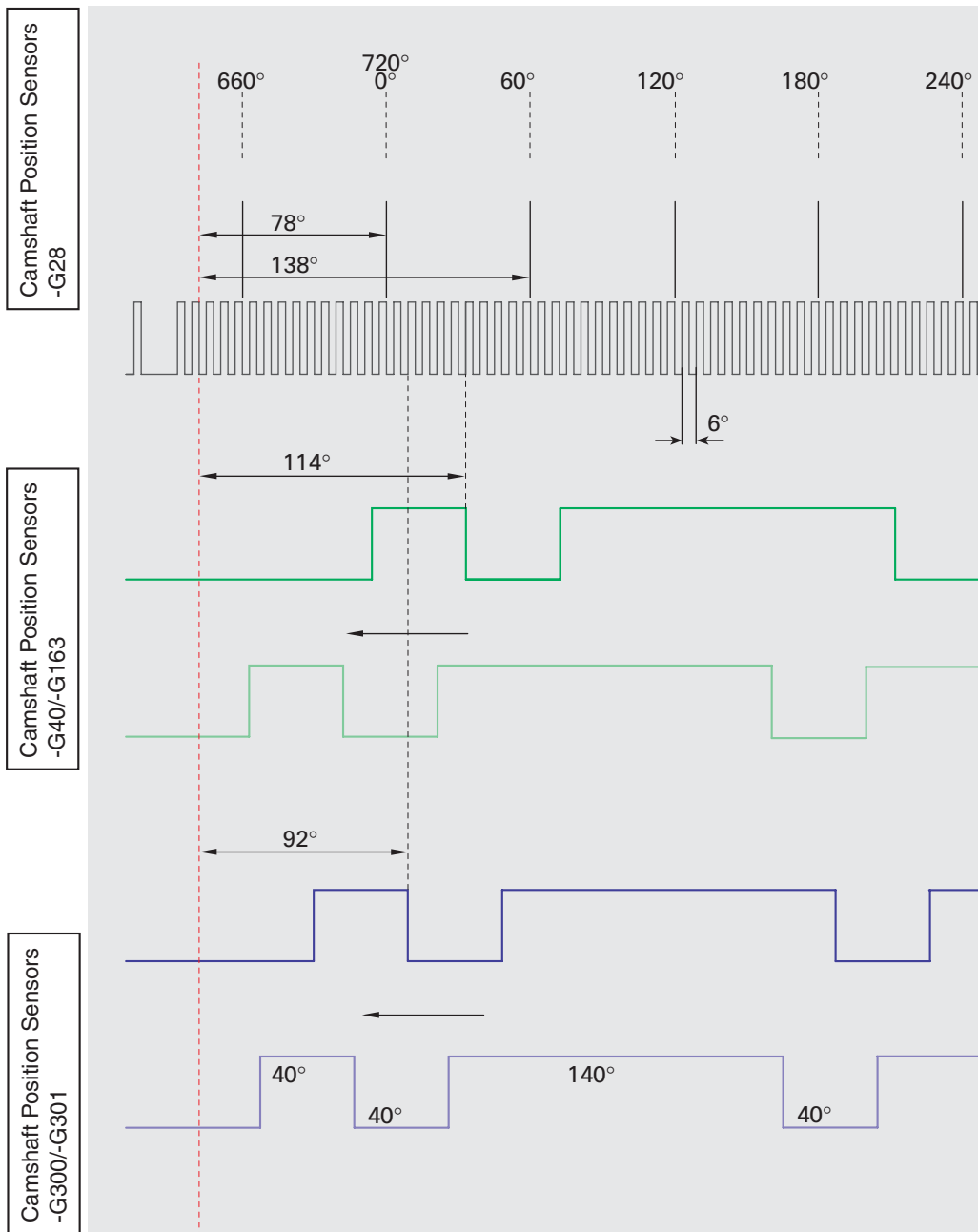
Hall elements react to changes in the magnetic field. The two-track sensor wheel influences the strength of the permanent magnet.

When the ferrous metal rotor of track 1 is located directly under HE1, there is a gap under HE2. The ferrous metal intensifies the magnetic field in the area of HE1 and the Hall voltage of HE1 increases with respect to HE2.

The difference between HE1 and HE2 and the magnitude of the two Hall voltages is used for evaluation and generation of the output signal.



# Engine Management Concept



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The signal profiles of the camshaft position sensors are identical for Cylinder Banks 1 and 2 intake and exhaust camshafts (same distance from software reference mark).

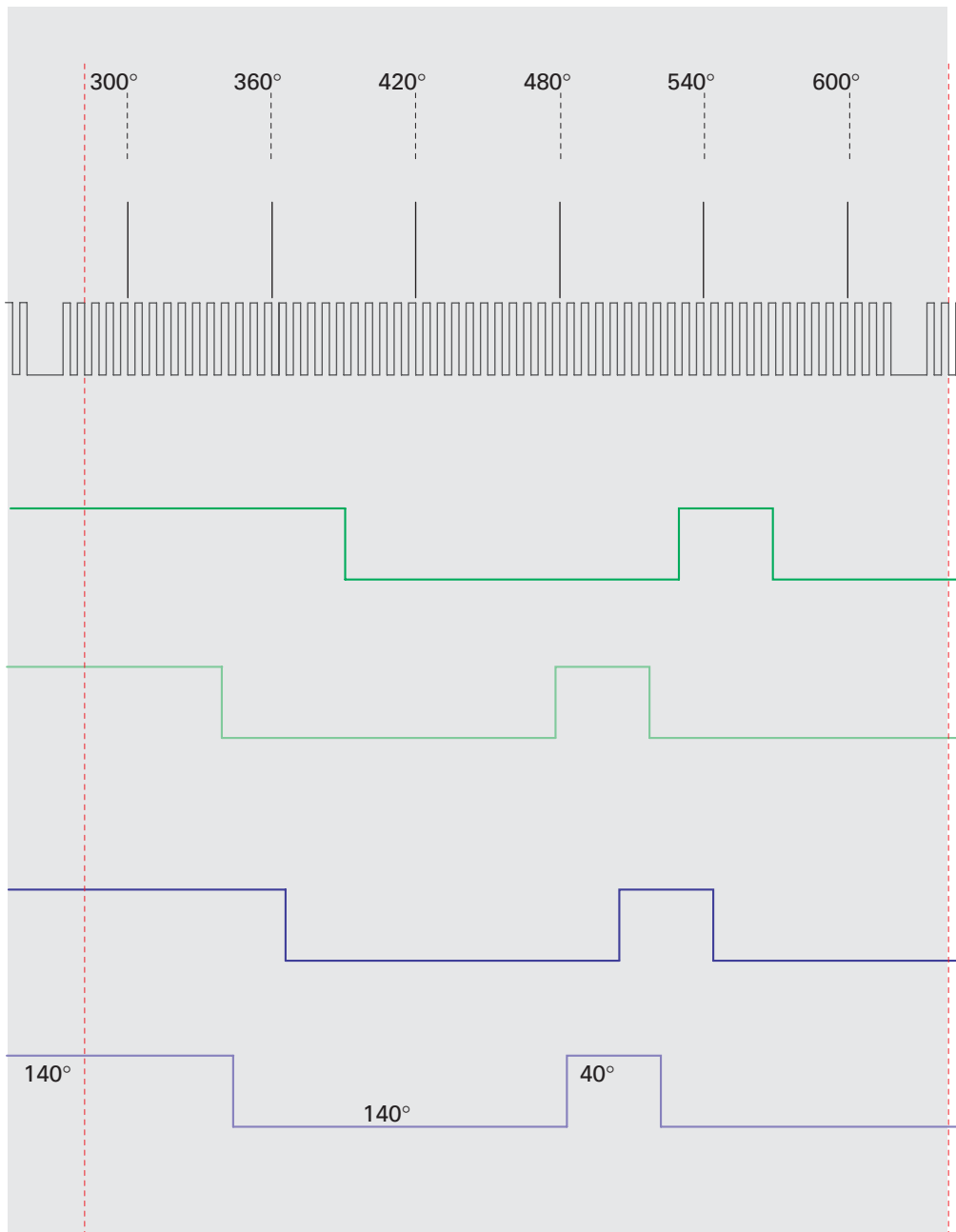
Basic synchronization of the first ignition TDC (ITDC) of Cylinder Bank 1 (Cylinder 1) is 78° after the software reference mark.


Because of the special features of the engine mechanical and management systems, basic synchronization of the first ignition TDC (ITDC) of Cylinder Bank 2 (Cylinder 12) is 138° after the software reference mark.

Allowance is made for this in the control unit and the pin encoding specifies it.



# Engine Management Concept



 The engine speed sensor is a Hall sensor. The software reference mark is the second trailing edge after the gap (60-2 system).

The camshafts are in “retard” position if the Camshaft Adjustment Valves are de-energized when the engine is running. If there is no or not enough oil pressure, the camshafts are set to retard position because of the chain pull.

# Engine Management Concept

## Engine Oil Temperature Sensor (G8)

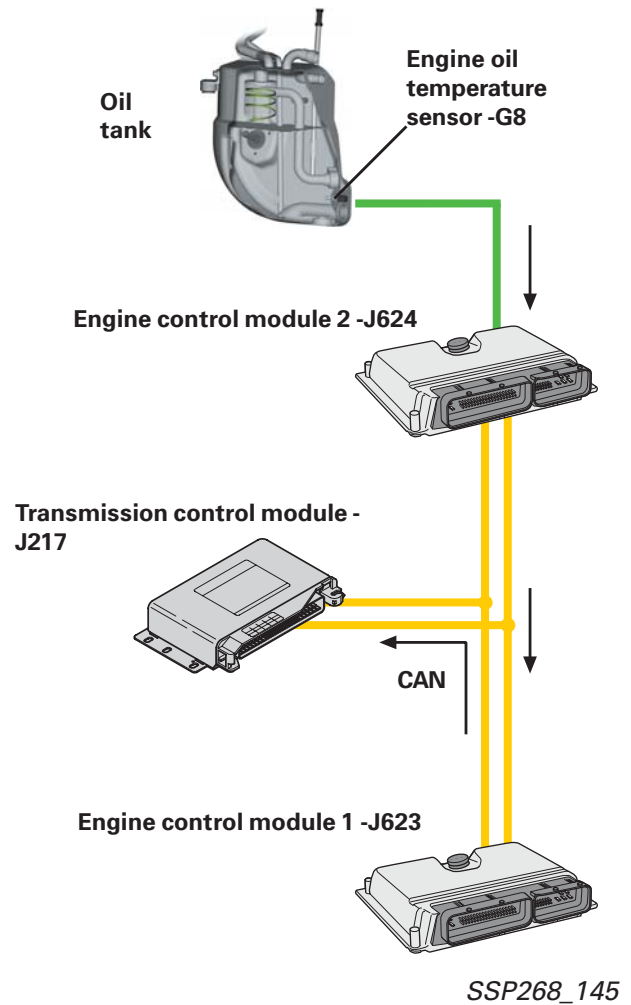
The signal of the Engine Oil Temperature Sensor (G8) is evaluated by ECM 2 (J624) and transmitted by the CAN Bus to ECM 1 (J623).

It is used for calculating the specified coolant temperature and the continued coolant circulation time.

To prevent overheating of the engine, mandatory change from 4th to 5th gear is implemented when the engine oil temperature is more than 266°F (135°C).

The decrease in engine speed counteracts a further increase in engine oil temperature.

The mandatory change described above also takes place when the coolant temperature is more than 248°F (120°C).






# Engine Management Concept



## CAN Data Exchange

The Twin Control Module Concept has resulted in the addition of new CAN messages, over which the two ECMs exchange data. ECM 1 transmits information to ECM 2 by "Master/Slave Messages."

Master/Slave Messages provide ECM 1 with data from ECM 2.

**Although these messages are transmitted by the general drive system CAN, they are only used for the exchange of data between the two ECMs.**

 ECM 2 can only transmit by way of Slave/Master Messages. Although ECM 2 can transmit data to ECM 1 and the Dash Panel Insert (Immobilizer), it is only designed to receive data.

-  Data transmitted by the ECMs
-  Data received and evaluated by the ECMs

<sup>1</sup> These data are additionally transmitted by way of Master Slave Messages

<sup>2</sup> These data are only transmitted by way of Master/Slave Messages

<sup>3</sup> These data are only transmitted by way of Slave/Master Messages



### ECM 1

(Master Control Module)

- Intake Air Temperature
- Brake Light Switch<sup>1</sup>
- Brake Pedal Switch
- Throttle Valve Angle
- Electronic Throttle Warning Lamp/Info
- Driver Input
- Torque
- Fault Status<sup>1</sup>
- Accelerator Pedal Position<sup>1</sup>
- CCS Switch Positions
- CCS Specified Speed
- Altitude Information
- Compressor Switch-Off
- Compressor ON/OFF (Feedback from Bi-Directional Interface)
- Fuel Consumption
- Coolant Temperature<sup>1</sup>
- Idling Speed Recognition
- Engine Shutoff Position<sup>2</sup>
- Engine Speed
- ACTUAL Engine Torques
- Emergency Running Programs (Self-Diagnosis Information)
- G8 Oil Temperature Warning
- $V_{Max}$  Limit Active<sup>2</sup>
- Immobilizer
- Crash Signal<sup>2</sup>



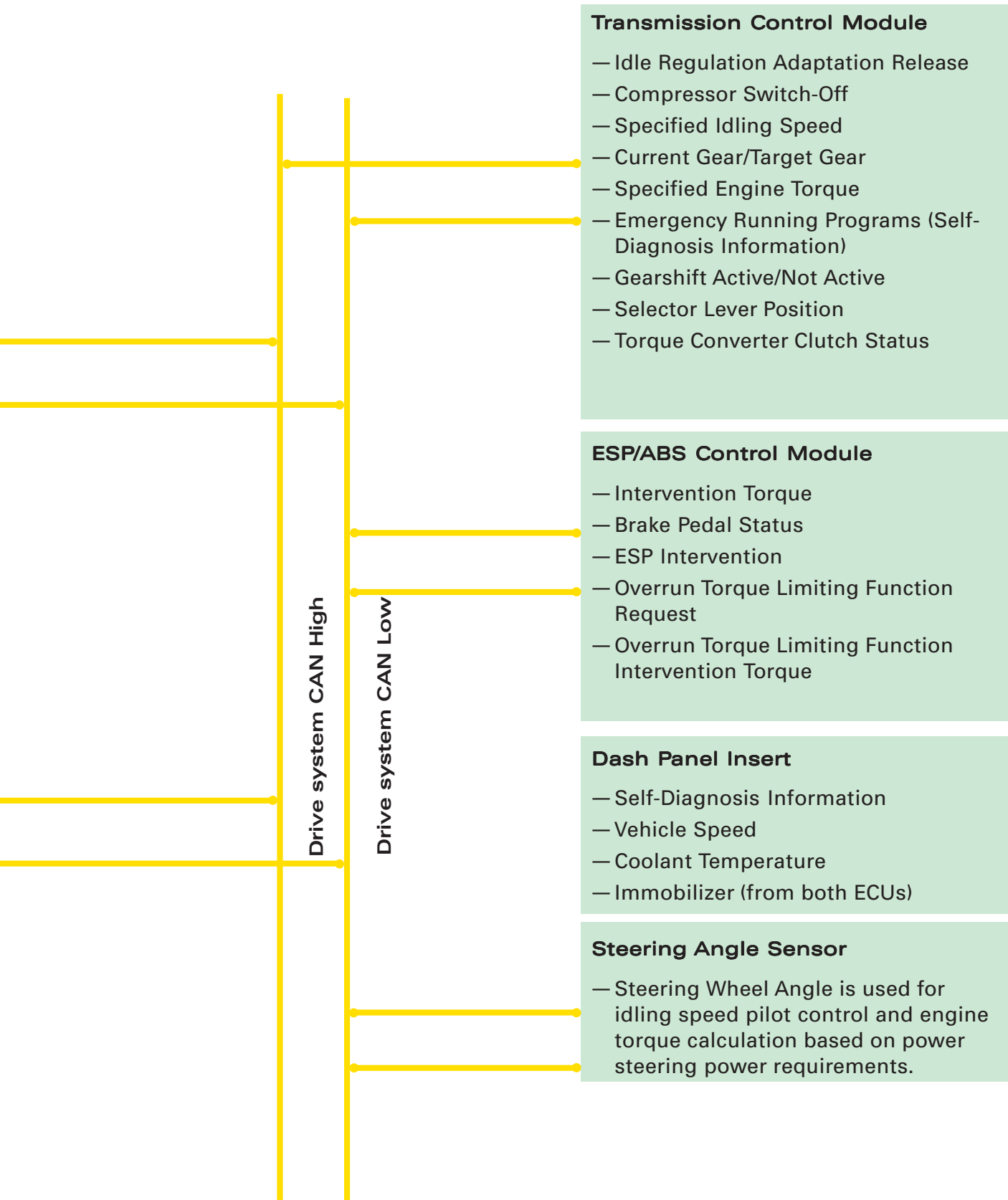
### ECM 2

(Slave Control Module)

- EPC fault Lamp Request<sup>3</sup>
- OBD Fault Lamp Request<sup>3</sup>
- Misfiring Detection<sup>3</sup>
- Fault Status<sup>3</sup>
- Engine Oil Temperature (From G8)<sup>3</sup>
- Immobilizer<sup>3</sup>



# Engine Management Concept




# Engine Management Concept

## Additional Signals/Interfaces

In addition to CAN BUS data exchange, the following signals are sent by separate interfaces.

Pin 42	Terminal 50	ECM* 1 Only
Pin 67	Crash Signal	ECM 1 and ECM 2
Pin 41	A/C Compressor Signal ON/OFF	ECM 1 and ECM 2
Pin 40	A/C Requirement Signal	ECM 1 and ECM 2
Pin 54	A/C High-Pressure Switch Signal	ECM 1 Only
Pin 37	Engine Speed Signal	ECM 1 Only
Pin 49	Pin Encoding of Control Units + to Pin 49 = ECU 1 - Pin 49 = ECU 2	
Pin 43	K-Wire/Diagnosis	ECM 1 and ECM 2
Pin XX	only interfaces Cruise ECM 1 Control System	

\* ECM = Engine Control Module

 Always check the wiring diagrams for the latest pin assignments.

### Terminal 50 Signal

The Engine Run-Out Detection Function can recognize “reversing” in the course of the engine shutoff process. Because reversing of the engine is ruled out on starting, the Terminal 50 information (starter operated) is used for checking the plausibility of and evaluating the reversing detection function.

### Air-Conditioner Compressor ON/OFF Signal

The compressor on signal is also used as a source of information for calculating the speed of the electric fan.

### Air-Conditioner High-Pressure Switch Signal

The signal from the A/C Pressure Switch (F129) (High Pressure) provides information for actuating the radiator cooling fans.

When the High Pressure Switch is closed (approximately 16 bar), maximum electric fan speed is set.

### Crash Signal

Although ECM 1 switches the fuel pump, the crash signal is also transmitted to ECM 2. In addition to powering the Fuel Pump, the Fuel Pump Relay is also responsible for supplying voltage to other actuators of both ECMs (refer to block diagram).

The crash signal in ECM 2 suppresses unwanted entries in the fault memory such as those caused by deactivation of the fuel pump.

To avoid unnecessary expense, no modifications have been made to the wiring harness (wiring to Pin 67 interface still exists).

## Notes on Maintenance

Because of the Twin Control Module Concept, there are several factors to remember when using diagnostic testers and the self-diagnosis function

Regarding self-diagnosis, the two control modules should be viewed as separate entities (this does not apply to misfire detection).

The self-diagnosis functions are implemented in the control module to which the components are connected (with the exception of combustion missing detection).

Separate address words are required for entry into self-diagnosis function:

Address word **01** ECM 1 (J623)  
Cylinder Bank 1  
(Exhaust Banks 1 and 2)

Address word **11** ECM 2 (J624)  
Cylinder Bank 2  
(Exhaust Banks 3 and 4)

If a fault has been stored in ECM 2, the fault "Please read out fault memory of ECM 2" is stored in ECM 1. This fault message can only be erased when there is no fault entry stored in ECM 2.

Both control modules must:

- have the same software version
- be matched to the Cruise Control System (CCS)
- be matched to the Immobilizer
- be viewed as separate entities for self-diagnosis
- have the same encoding

The readiness code must be set, read out and reset separately for each control module (e.g. by starting "short trip" test sequence with scan tool). Raising the fault memory automatically sets the readiness code in the appropriate control module.

The misfire detection function is only activated in ECM 2 (J624), which is thus responsible for both cylinder banks.

**Misfire detection affecting Cylinder Bank 1 can only be read out in ECM 2.**

# Service

## Workshop Equipment/Special Tools

These are the new items of workshop equipment and special tools designed for the W12 engine.

### **VAS 6100 Workshop Crane**

With a load bearing capacity of 2650 lb. (1200 kg), the workshop crane VAS 6100 can handle the new larger volume engines.

VAS 6101 Extension (load bearing capacity 660 lb. or 300 kg) is available as an option.

### **VAS 6095 Engine and Gearbox Assembly Mount**

In addition to a load bearing capacity of 1320 lb. (600 kg), the Engine and Gearbox Assembly Mount offers several new features.

Unit mounting with universally adjustable clamps and locating pins provides easy access to the back of the engine.

The height of the unit can be adjusted by approximately 7.9 in. (200 mm).

The tilt mechanism enables the unit to be moved into any angular position required.

The mechanism is self-locking so that there is no need for separate fixing.

Integrated storage facilities and sliding drip tray for collecting fluids is included.

Compatible with existing engine and gearbox supports.

### **Unit Assembly Trolley**

This special tool is a unit assembly trolley for all engine and gearbox preassembly work.

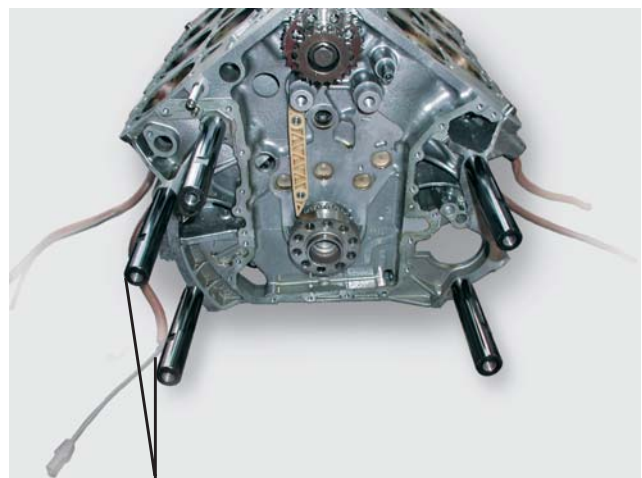
The worktable is in two sections to facilitate separation and joining of the engine and the gearbox.



SSP268\_186



SSP268\_184



Locating pins

SSP268\_182

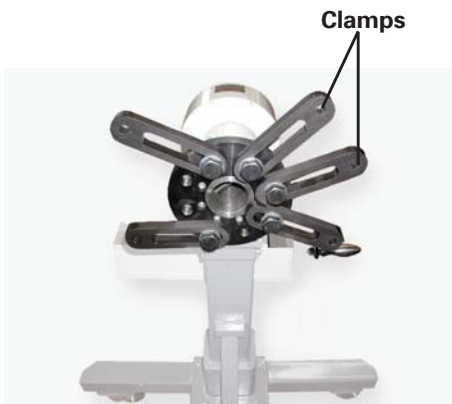


## VAS 6131 Scissor Lift Table

Used for removing engine and transmission assemblies from vehicles.

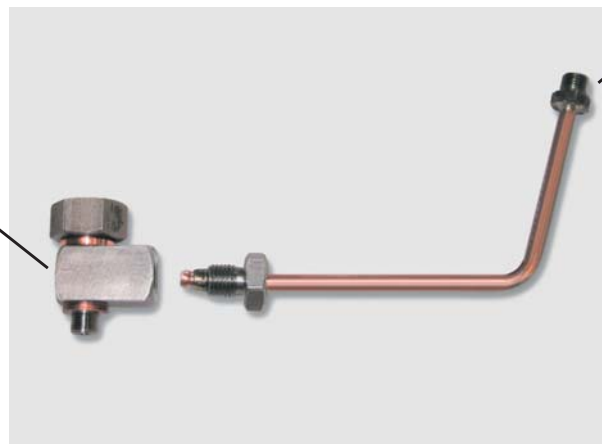


SSP268\_185



SSP268\_187

VAG 1342/15 Oil pressure test adapter



VAG 1342/16 Oil pressure test pipe section

SSP268\_181

# Service

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# Knowledge Assessment

An on-line Knowledge Assessment (exam) is available for this SSP.  
The Knowledge Assessment may or may not be required for Certification.

You can find this Knowledge Assessment at:

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

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

- Click on the "ACADEMY" Tab
- Click on the "Academy Site" Link
- Click on the "CRC Certification" Link

For assistance, please call:

**Audi Academy**  
**Learning Management Center Headquarters**  
**1-877-AUDI-LMC (283-4562)**  
**(8:00 a.m. to 8:00 p.m. EST)**

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