

1.5L TSI EA211 EVO2 Engine

Tablet Format Version 1.1



Volkswagen Group of America, LLC
Volkswagen Academy
Published in U.S.A.
10/2022

Course Number SSP 821223, Version 1.1

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Introduction

1.5L TSI EA211 EVO2 Engine

This engine is manufactured in the Silao Guanajuato México factory.



Introduction

1.5L TSI EA211 EVO2 Engine - Technical Data

Technical features:

- Cylinder head with four valves per cylinder and integrated exhaust manifold
- Friction optimization of all outward-acting shaft seals
- Low-friction camshaft toothed belt drive
- Valve drive using roller ball bearing rocker arms
- Deep groove roller bearings on the belt drive side of both camshafts
- Optimized vane-type oil pump with infinitely variable oil pressure control
- 0W-20 low-friction oil
- Miller combustion method
- Exhaust gas turbocharger with Variable Turbine Geometry (VTG)
- Thermal management
- Fuel system with injection pressure up to 350 bar (5,076 psi)
- Intake camshaft adjustment (70° of crankshaft angle)
- Exhaust camshaft adjustment (40° of crankshaft angle)
- Aluminum alloy engine block
- Liquid to air charge air cooler
- Electrically driven oil separator (Active Oil Separator)

VTG Exhaust Turbocharger



Crankcase Breather Valve Module



Thermal Management Module



Fuel System with Injection Pressure up to 350 bar (5,076 psi)



Timing Belt



Accessory Drive



Oil Pan with Variable Oil Pump and Vacuum Pump

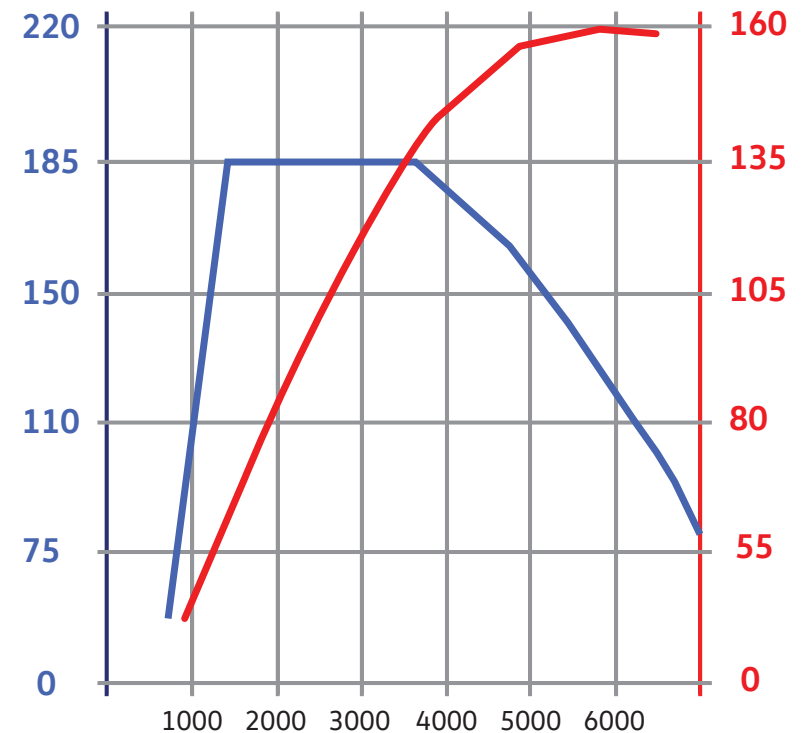


Charge Air Cooler Outside the Intake Manifold

Introduction

1.5L TSI EA211 EVO2 Engine - Technical Data

Type	4-cylinder inline engine
Capacity	1498 cm3
Bore	74.5 mm
Stroke	85.9 mm
Valves per cylinder	4
Compression ratio	11.5 : 1
Maximum output	158 hp (118 kW) from 5500-6000 rpm
Maximum torque	184 lb-ft (249 Nm) from 1750-4000 rpm
Engine management system	Bosch MG1
Fuel	Regular unleaded
Exhaust gas treatment	Main 3-way catalytic converter. Lambda control with a broadband lambda probe upstream and a binary lambda probe downstream to the main catalytic converter with secondary air system
Emission standard	LEV 3/Tier 3 20



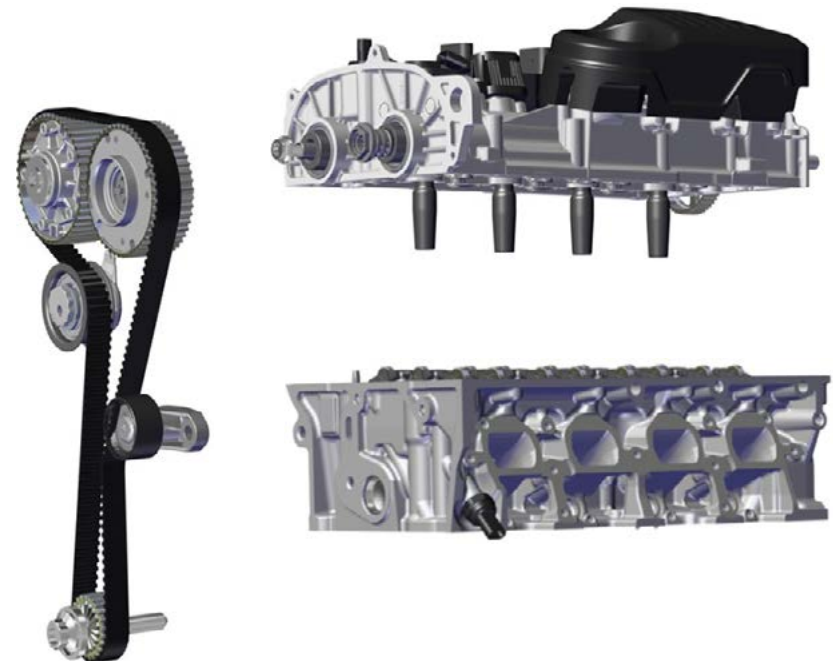
Engine Mechanics

Structure of the Cylinder Head, Camshaft Housing

Cylinder Head

The cylinder head has:

- Four valves per cylinder
- Cross-flow cooling design
- An integrated exhaust manifold that is optimized for heat dissipation and easy coolant flow
- Altered valve angles to allow for a more compact combustion chamber and better air flow
- Deep grooved roller bearings on the heavily-loaded timing belt drive side

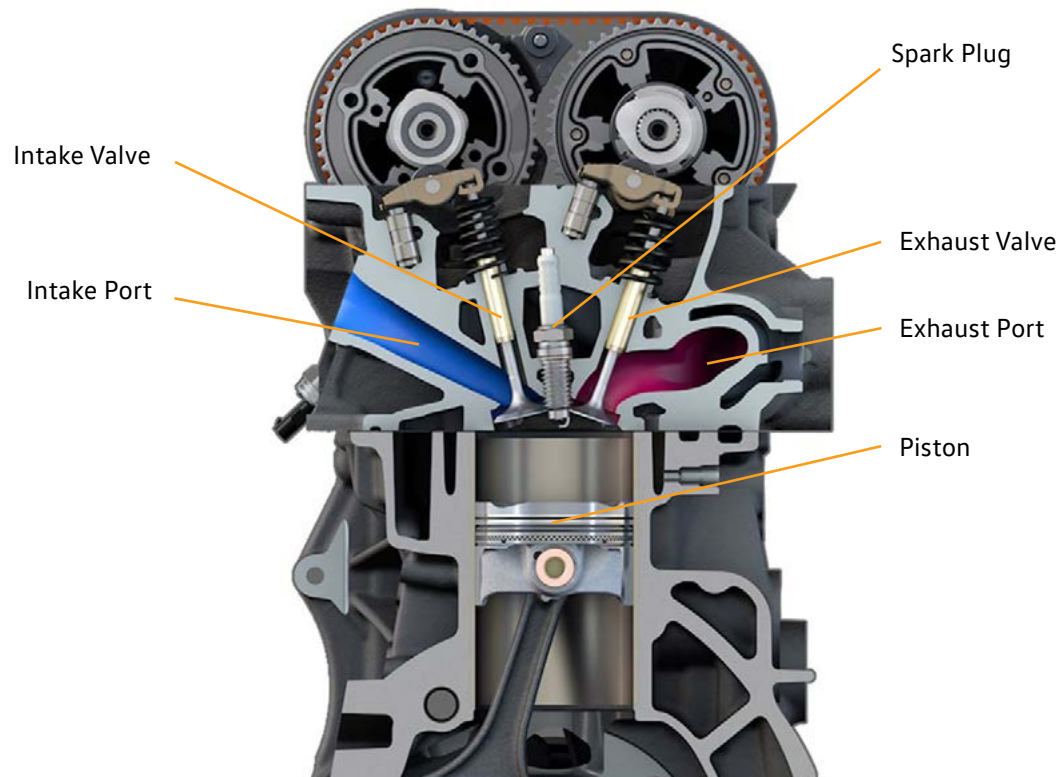


In case of failure, camshafts cannot be replaced separately. The entire component must be replaced.

Engine Mechanics

Cylinder head – Combustion Chamber, Piston, Valvetrain

- Sodium-filled exhaust valves due to high exhaust gas temperatures
- Exhaust valve angles reduced to 18.54° and intake valve angles to 13.0° for better flow
- Intake valves slightly retracted for optimal flow of fresh air into the combustion chamber
- Flat piston surface with a slight trough to support the charge movement and mixture formation
- Slightly off-center spark plug position for a more robust ignition that:
 - Ensures simultaneous flame reaching areas near the cylinder wall
 - Reduces knock cavities



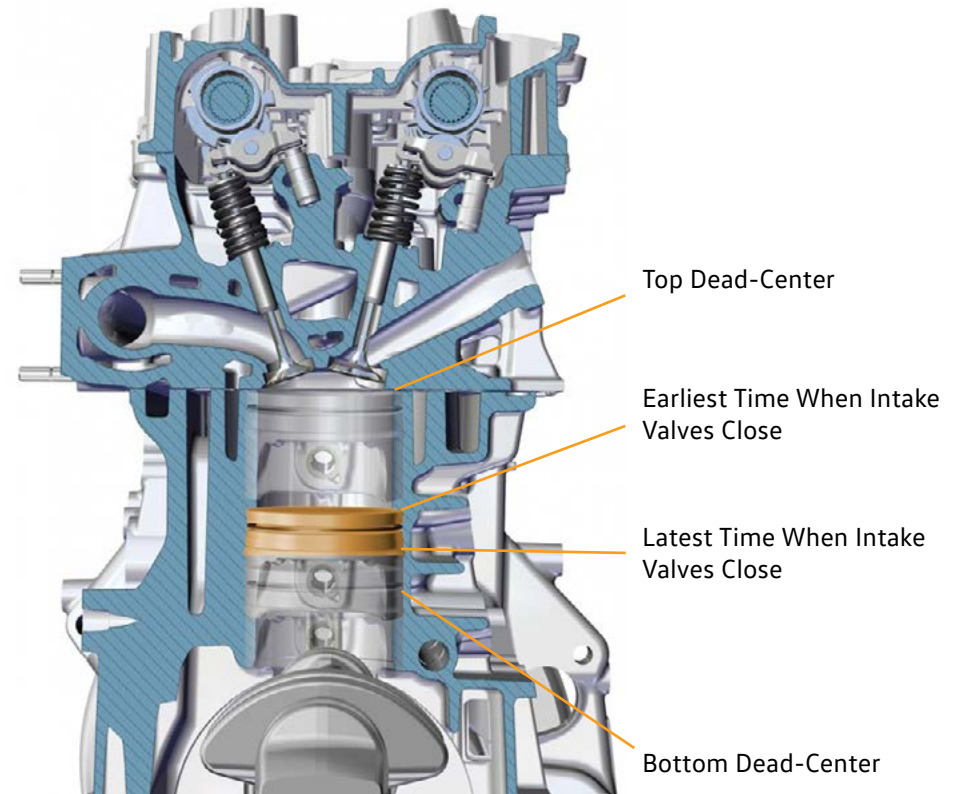
Engine Mechanics

The Miller Combustion Cycle

The Miller Cycle closes intake valves far before bottom dead-center. The trapped air/fuel mixture is pulled and expanded, causing a cooling effect. This results in a lower compression temperature and also allows for an increased compression ratio.

The advantages of the Miller Cycle compared to conventional combustion are:

- Due to the cooler mixture, the compression temperature drops along with the tendency to knock. The compression ratio can be increased to 11.5:1, which allows thermal efficiency increases and burns fuel more effectively
- The throttle valve is opened more in partial load and the charging can be reduced
- Less compression work due to increased displacement
- Due to the cooler mixture, knocking combustion is reduced at full load



Intake and Turbocharging

Equipment for the Miller Combustion Process

An efficient exhaust gas turbocharger and cooled intake gases are required for the Miller combustion process.

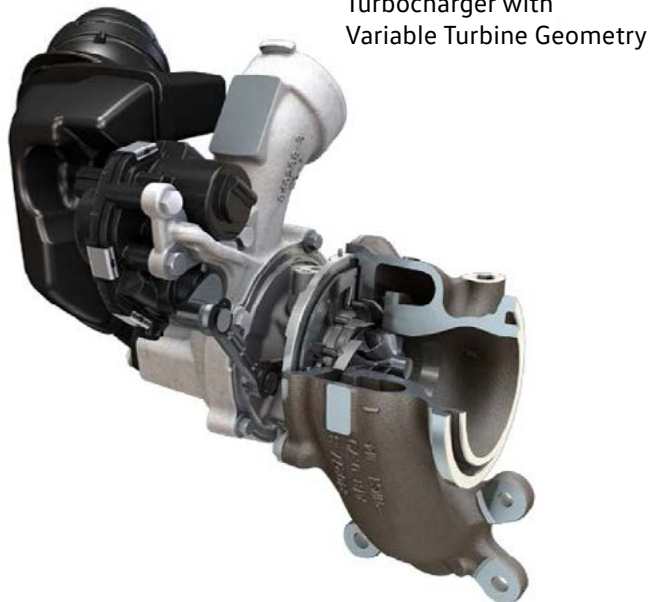
Turbocharger with Variable Turbine Geometry

This is the only design of exhaust gas turbocharger that can build high charge pressure even at low engine speeds. It has traditionally been used on diesel engines, but has been modified in the 1.5L engine for use with gasoline engines.

High charge pressure is required because the intake valves are closed up to 70° of crankshaft angle before bottom dead center. Despite the shortened time, there still must be enough fresh air introduced into the combustion chamber.

Charge Air Cooler with High Cooling Capacity

Due to heat generated when the turbocharger compresses the air, a charge air cooler is needed to cool the intake charge. This design can cool the charge air to approximately 59° F (15° C) compared to the ambient air.

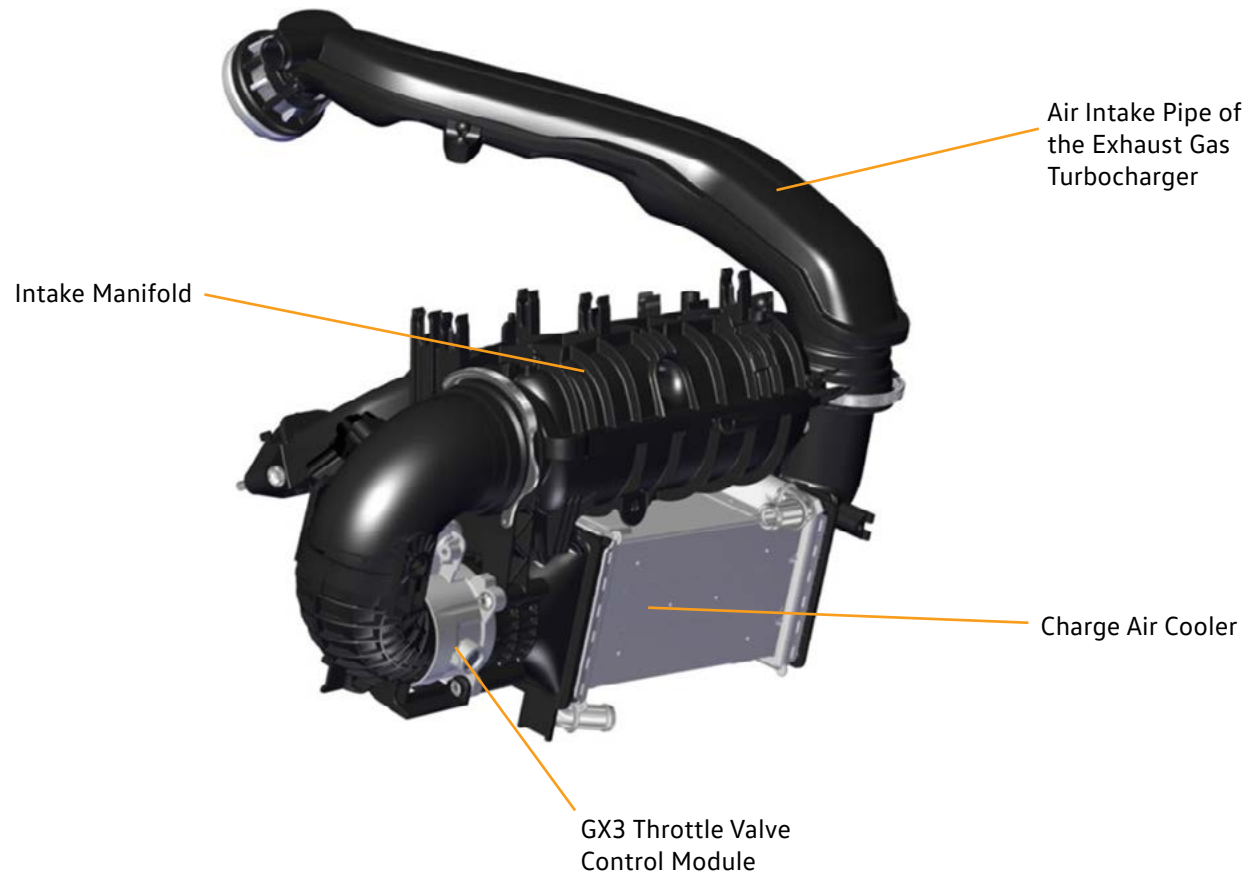


Intake and Turbocharging

Charge Air Cooler

The charge air cooler is now located between the pressure pipe and the throttle valve. This provides a large cooling capacity and:

- Provides a shorter path from the turbocharger to the throttle valve
- Provides charge air temperature that is lowered as much as 59° F (15° C), compared to the ambient air

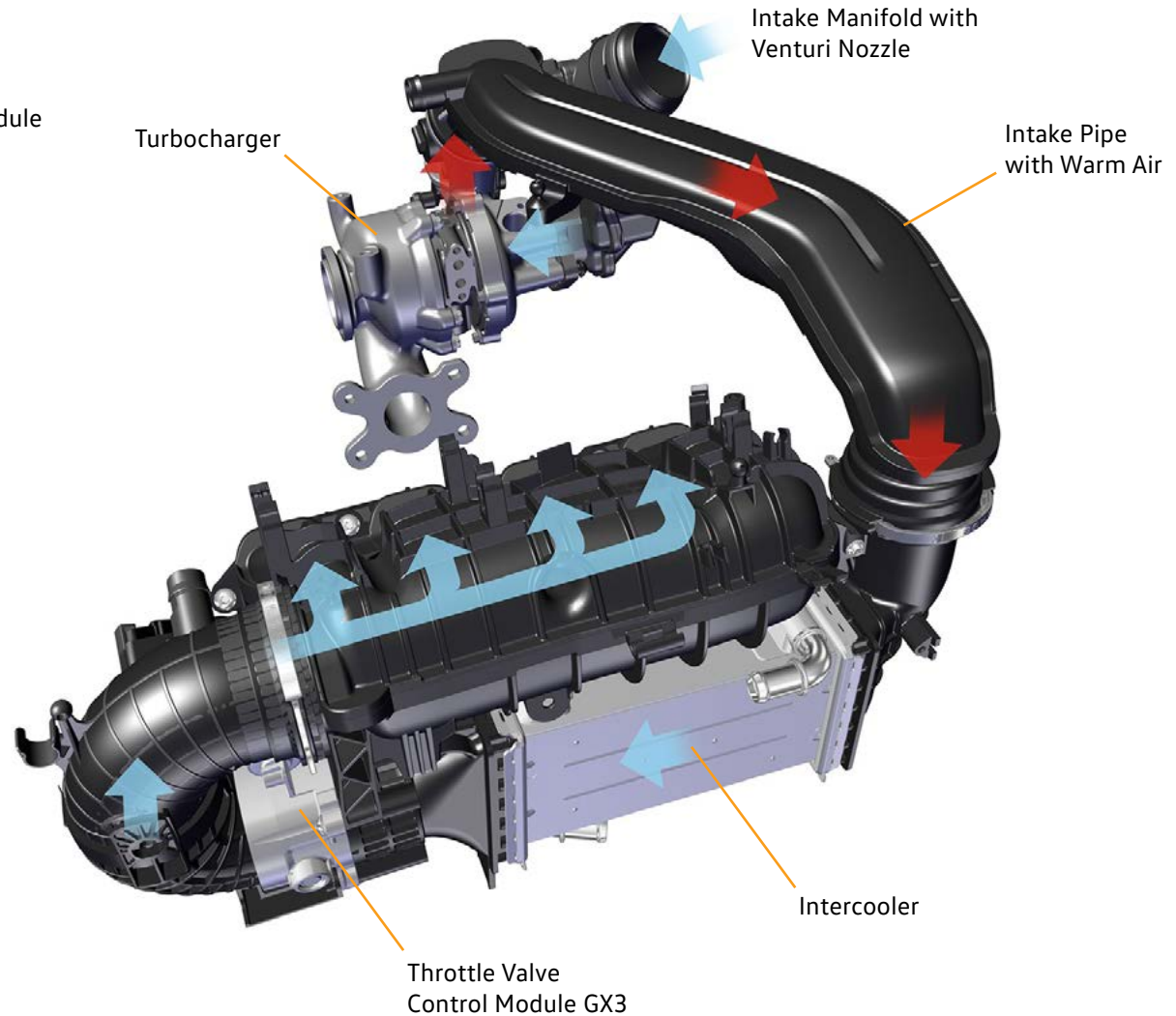


Intake and Turbocharging

Charge Air Cooling System Components

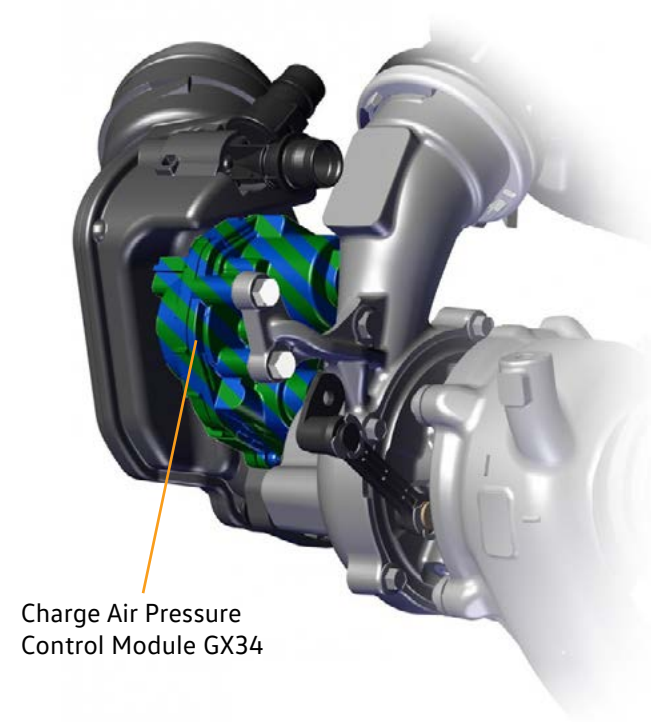
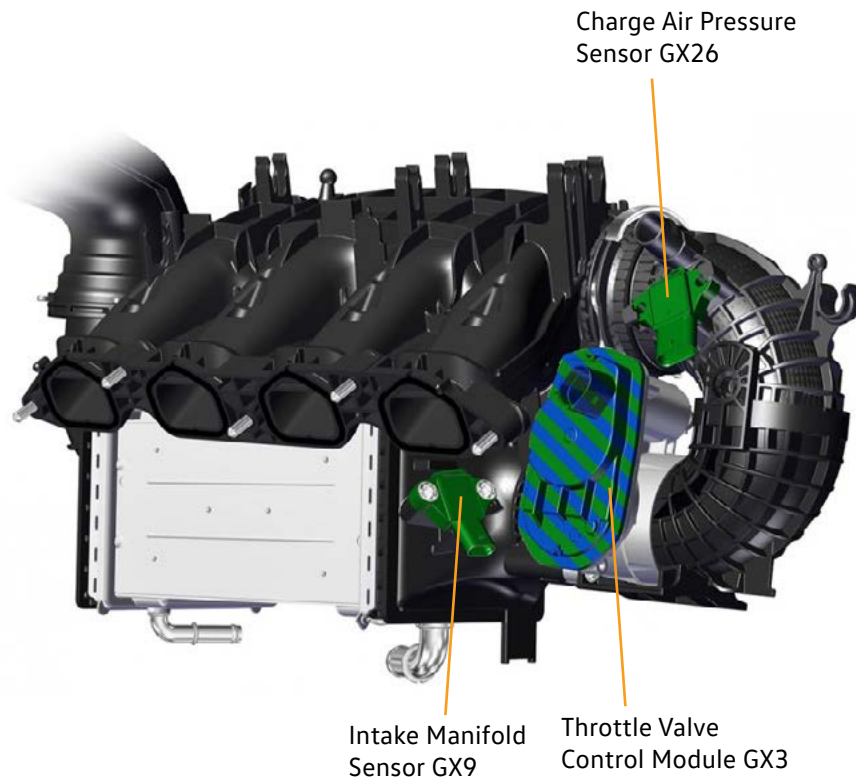
The charge air system consists of:

- The air filter
- The connecting pipes
- The turbocharger
- The intercooler
- The boost pressure sensor of the throttle valve control module
- The intake manifold
- The intake channels in the cylinder head



Intake and Turbocharging

Charge Air Cooling System Components

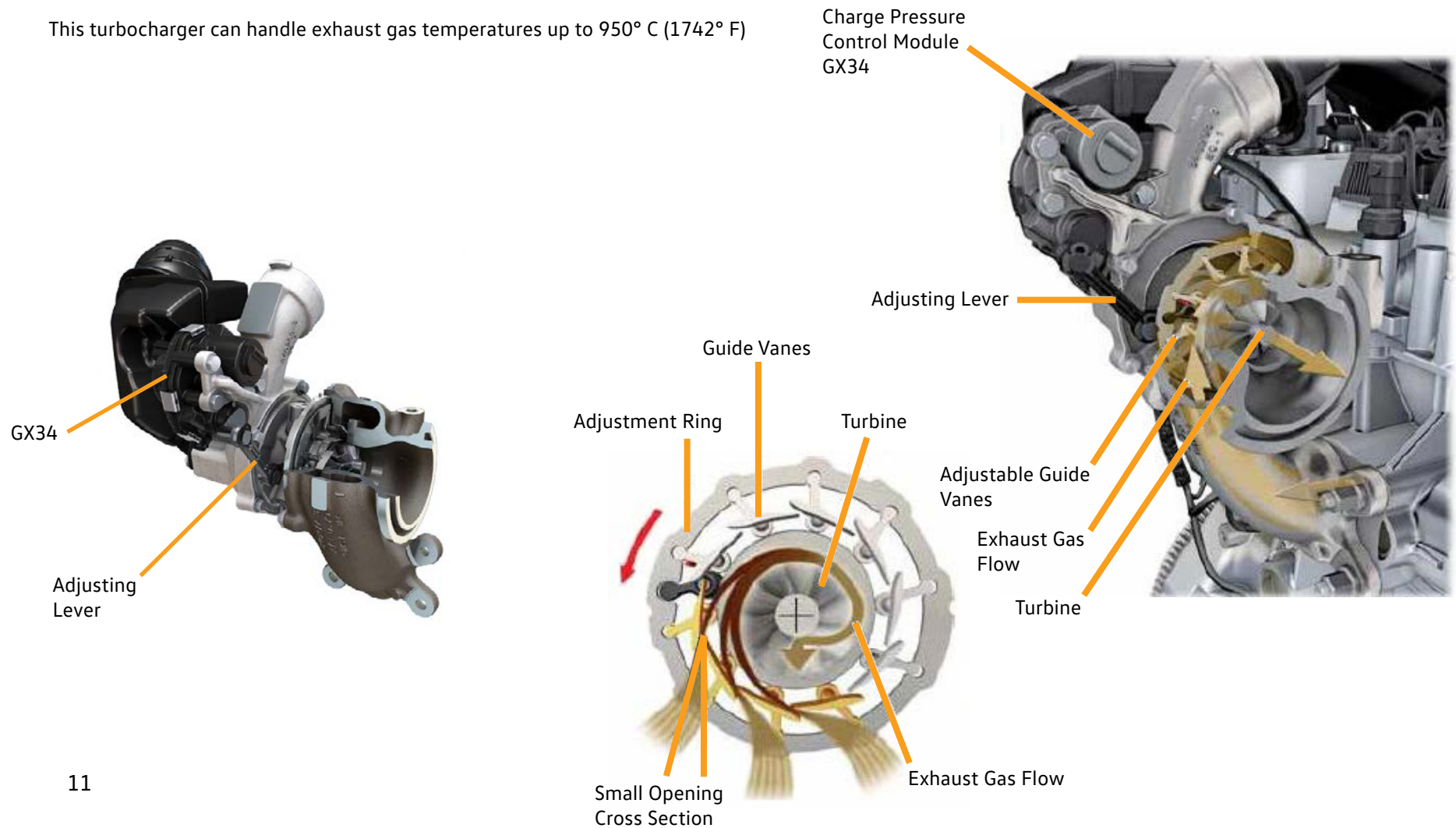


Intake and Turbocharging

Design of the Exhaust Gas Turbocharger with Variable Turbine Geometry VTG

The Miller combustion process shortens the time to get fresh air into the cylinders. To compensate for this, a variable turbine geometry turbocharger is used since the engine must be operated at a high charge pressure of up to 2.8 bar (absolute). This type of turbocharger uses moveable vanes to direct air flow across the turbocharger impeller. The guide vanes are adjusted using the GX34 Charge Air Pressure Control Module with V465 Charge Air Pressure Actuator and the G581 Charge Air Pressure Actuator Position Sensor.

This turbocharger can handle exhaust gas temperatures up to 950° C (1742° F)

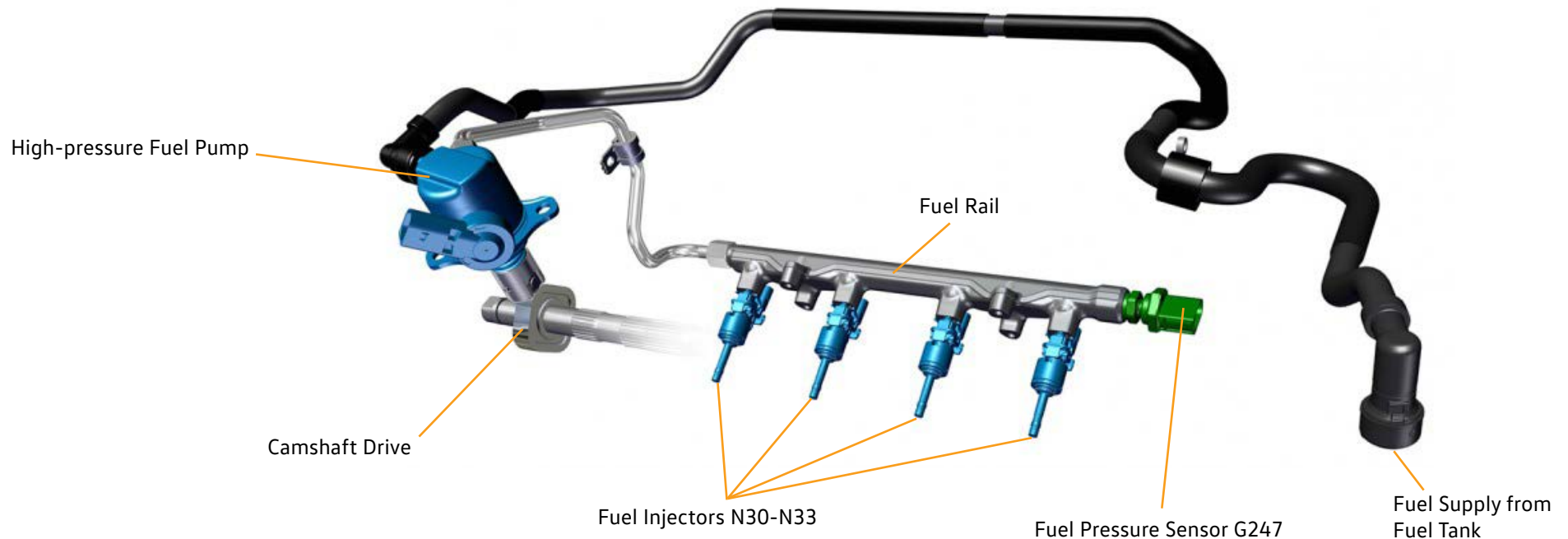


Fuel Injection

High-pressure Fuel System

The design of the fuel system is similar to the 1.4L TSI engine. However, some components have been modified to significantly improve mixture formation. The modifications are:

- Fuel injection pressure increased up to 350 bar. The pressure relief valve opens at 400 bar
- The fuel rail made of forged stainless steel
- Four cam lobes on the exhaust camshaft drive the high-pressure fuel pump
- Injectors with 5-holes and with 6mm tip diameter that can perform five injections per work cycle
- Due to the associated reduced fuel atomization the mixture formation improves, leading to a significant reduction in the hydrocarbon emissions



Oil Supply

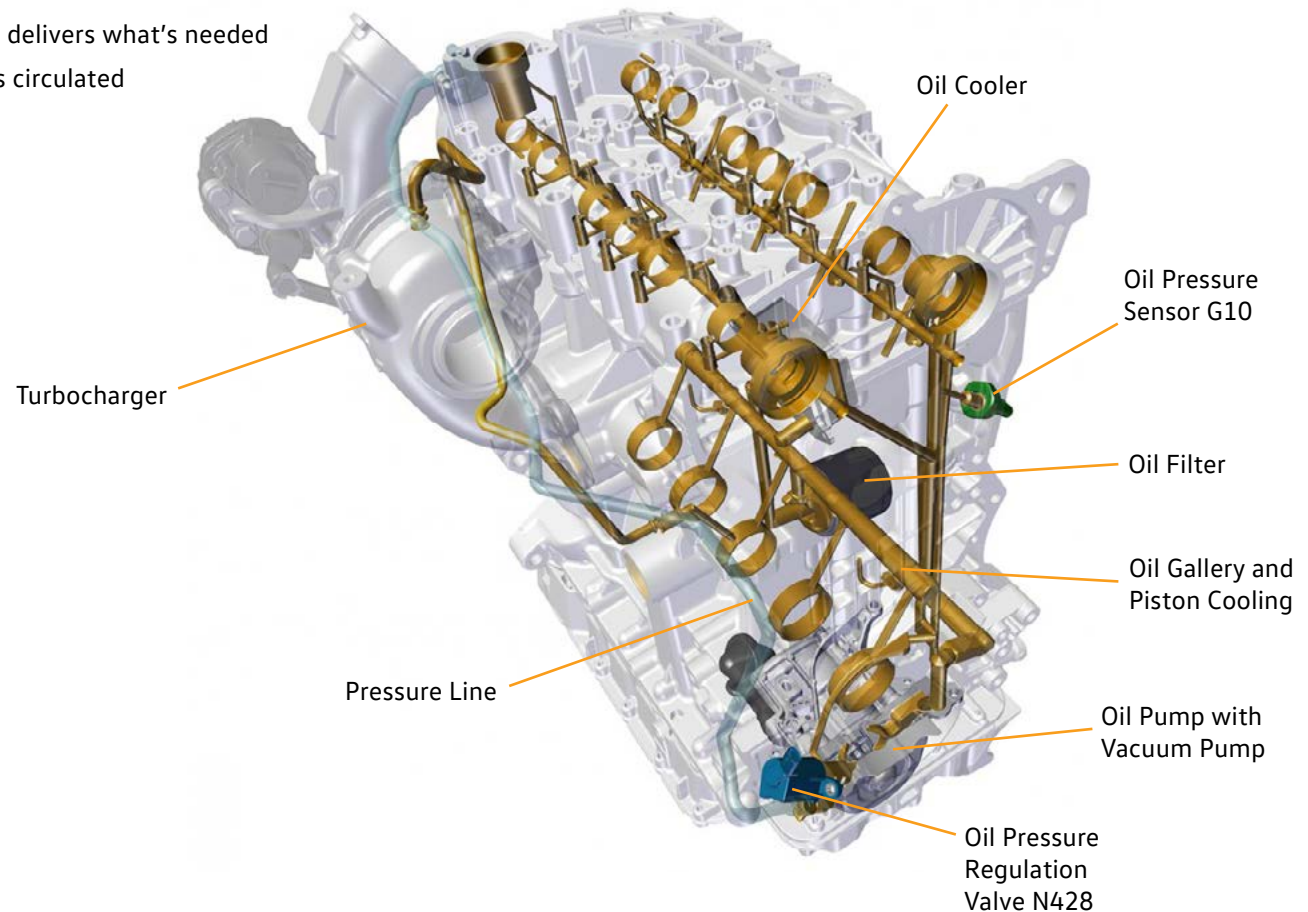
Oil Supply

The 1.5L engine has an infinitely variable oil pressure control that is based on engine load, speed and oil temperature. Oil pressures are varied between 1.4 to 3.3 bar.

A second oil gallery for piston cooling has been added to the cylinder block.

Advantages of infinitely variable oil pressure control:

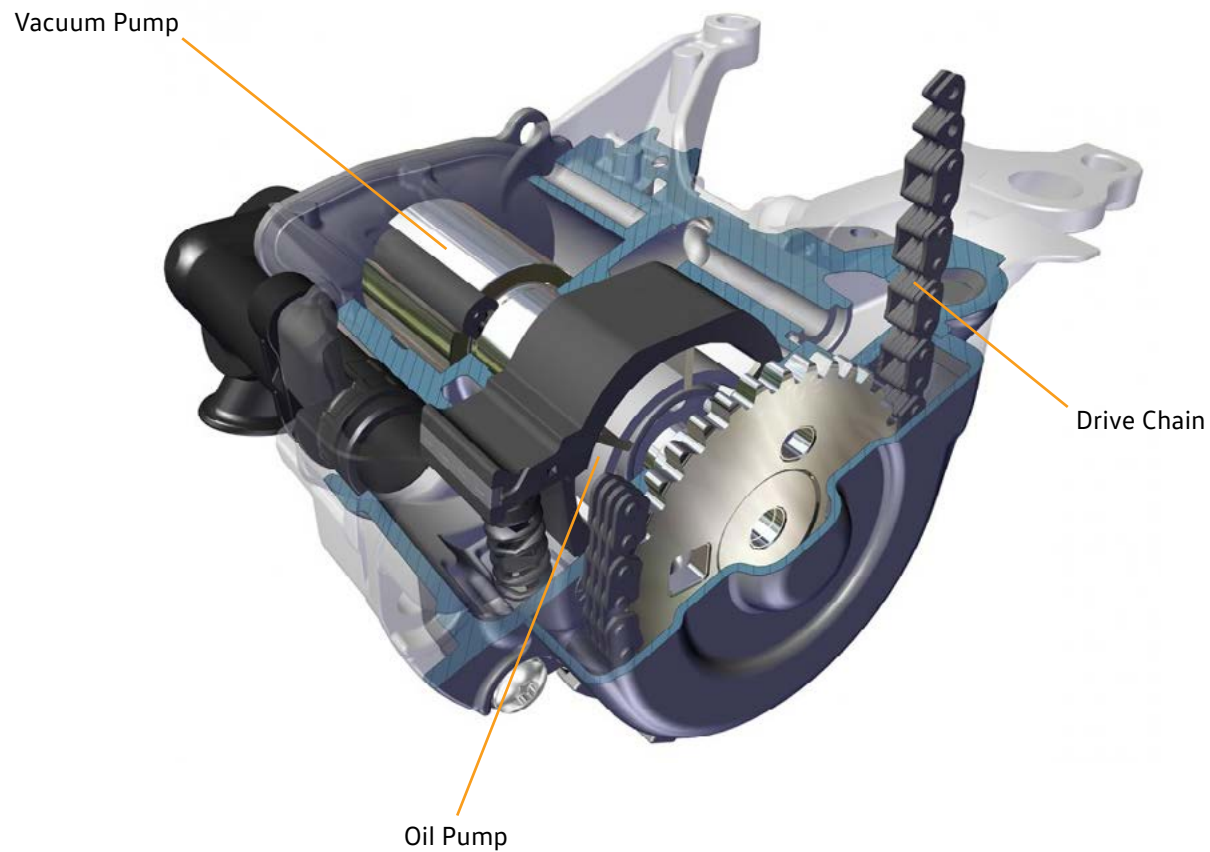
- Internal friction of the engine is reduced
- Low oil pump power consumption because it only delivers what's needed
- The wear in the oil circuit is low, because less oil is circulated



Oil Supply

Vane Oil Pump with Vacuum Pump

The vane oil pump is driven by a maintenance-free chain from the crankshaft and is in the oil sump area. The pump assembly includes both the vane-type oil pump and the vacuum pump.

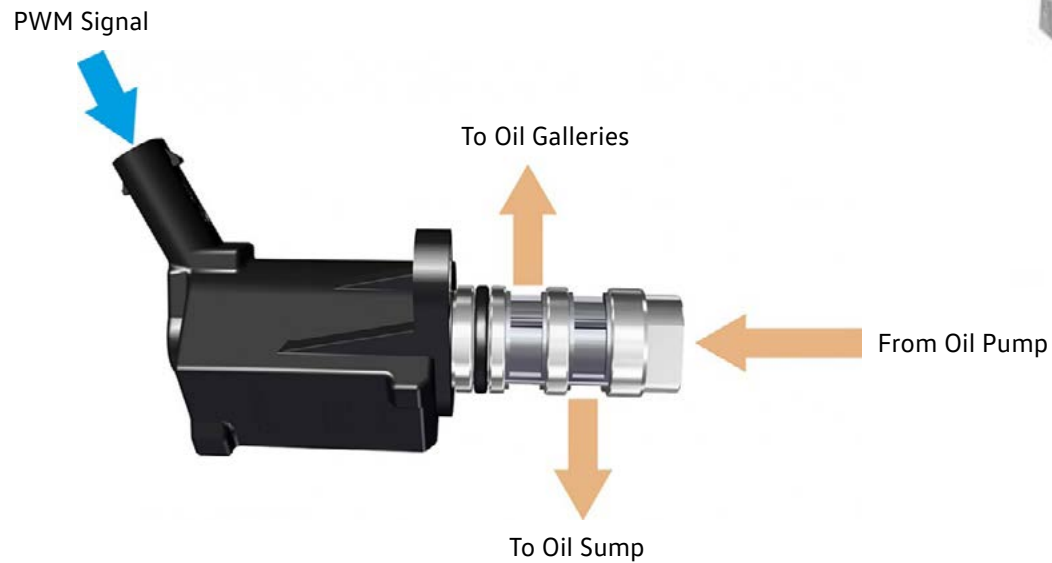


Oil Supply

Oil Pressure Regulation Valve N428

The oil pressure regulation valve is a hydraulic 3/2-way valve. It is controlled using a Pulse Width Modulated (PWM) signal.

For regulation, oil flow can be directed at a certain cross-section of the vane pump. This has a control surface that moves the adjustment ring that controls oil output.

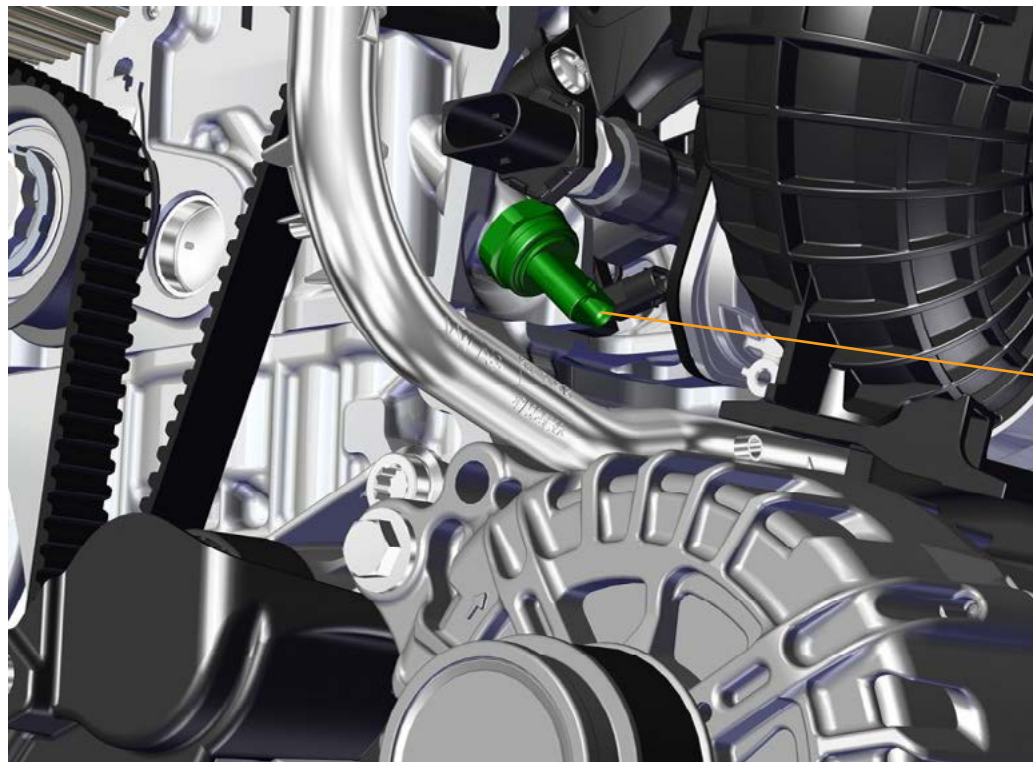


Oil Supply

Oil Pressure Sensor G10

The Oil Pressure Sensor G10 constantly monitors oil pressure and sends the current oil pressure to the ECM using a SENT data protocol.

Based on the information from G10, the ECM controls Oil Pressure Regulation Valve N428. This increases or decreases oil output.



Oil Pressure Sensor G10

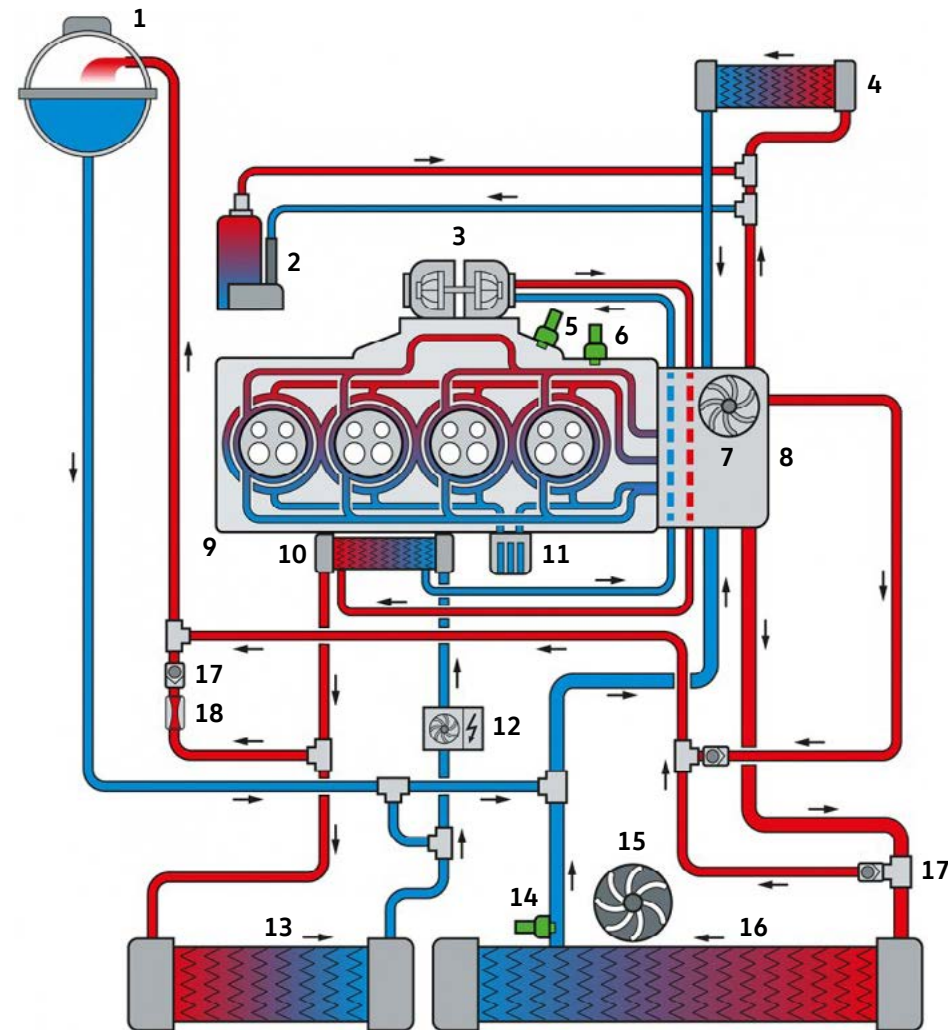
Cooling System

The thermal management of the cooling system enables targeted control of the coolant as it flows through different areas. This includes the engine, the heater core, the radiator and charge air cooler.

The mapped cooling module enables fast warm-up of the engine, a fast response of the interior heating and an optimal temperature range for the engine.

The charge air cooling system is used only for cooling the turbocharger and charge air.

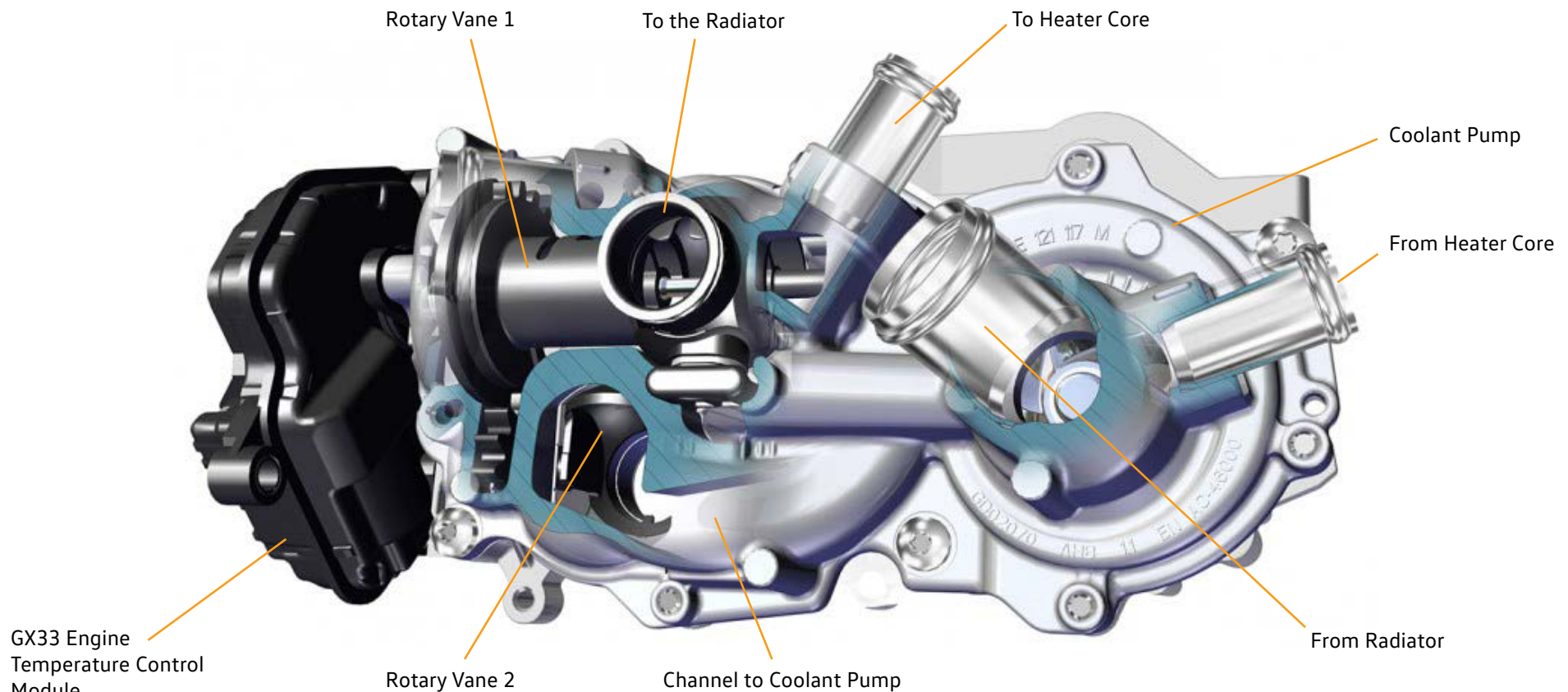
- 1 Reservoir
- 2 Heating
- 3 Turbocharger
- 4 Heater Core
- 5 Engine Coolant Temperature Sensor G62
- 6 Engine Coolant Temperature Sensor on Engine G82
- 7 Coolant Pump
- 8 Engine Temperature Control Module GX33
- 9 Cylinder Head/Cylinder Block
- 10 Intercooler
- 11 Engine Oil Cooler
- 12 Charge Air Cooling Pump V188
- 13 Cooler for Charge Air Cooling Circuit
- 14 Engine Coolant Temperature Sensor on Radiator Outlet G83
- 15 Radiator Fan VX57
- 16 Radiator
- 17 Check Valve
- 18 Restrictor



Cooling System

The Internal Structure of the Mapped Cooling Module

A completely new thermostat is used in the 1.5L engine. During the warm-up phase, coolant in the entire engine or in the cylinder block can be completely stationary. This allows the engine to heat faster, and improves the speed of heat to the vehicle interior. This also reduces engine friction in the warm-up phase, causing the oil to become less viscous. During higher loads, the coolant flow is increased to reduce the possibility of knock. At low load, a higher temperature level is used to reduce friction due to a less viscous engine oil.



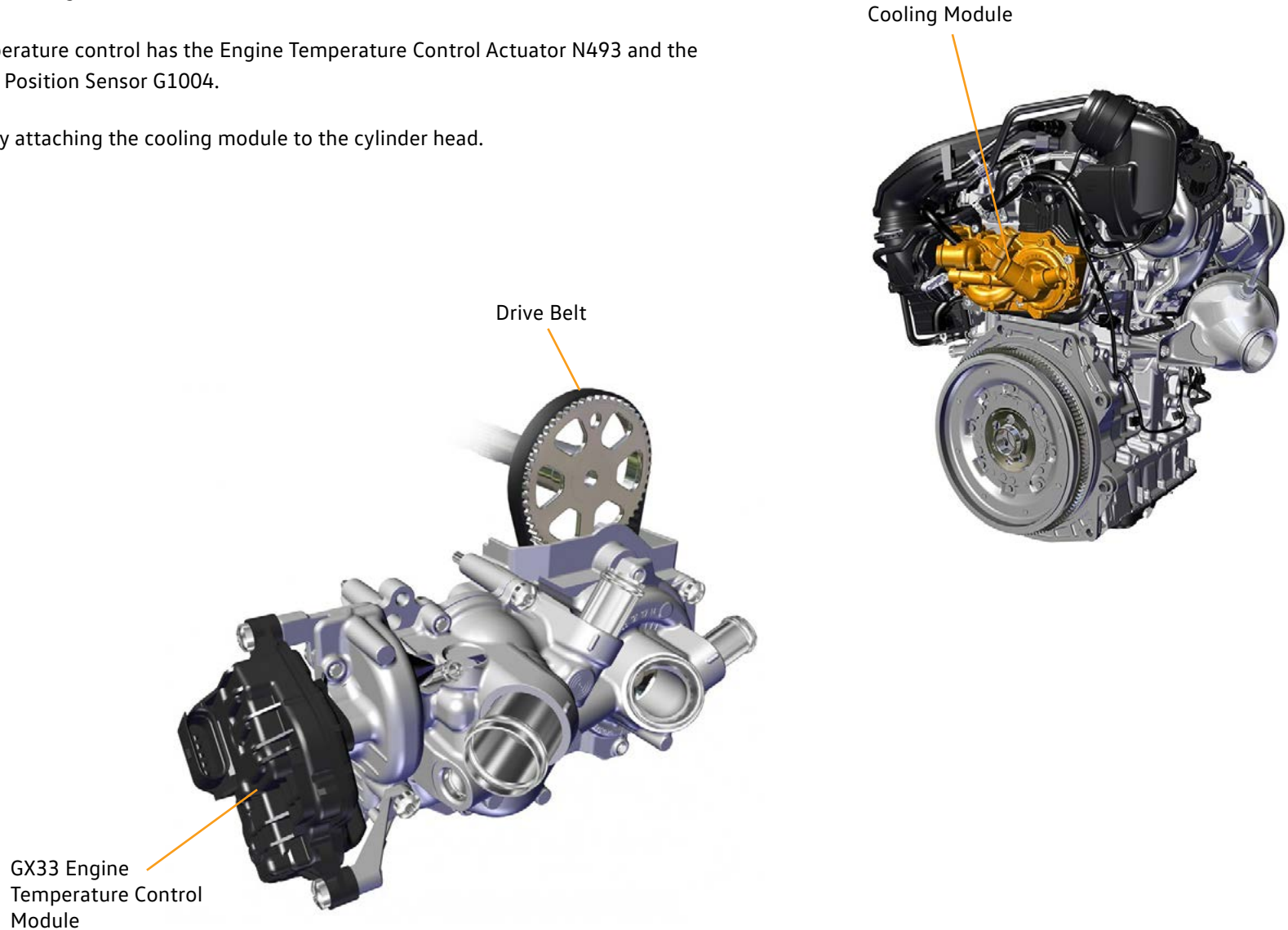
Cooling System

The Mapped Cooling Module

The map cooling module is located on the transmission side of the cylinder head. The coolant pump is driven by a maintenance-free timing belt connected to the exhaust camshaft.

The module for engine temperature control has the Engine Temperature Control Actuator N493 and the Engine Temperature Control Position Sensor G1004.

The drive belt is tensioned by attaching the cooling module to the cylinder head.



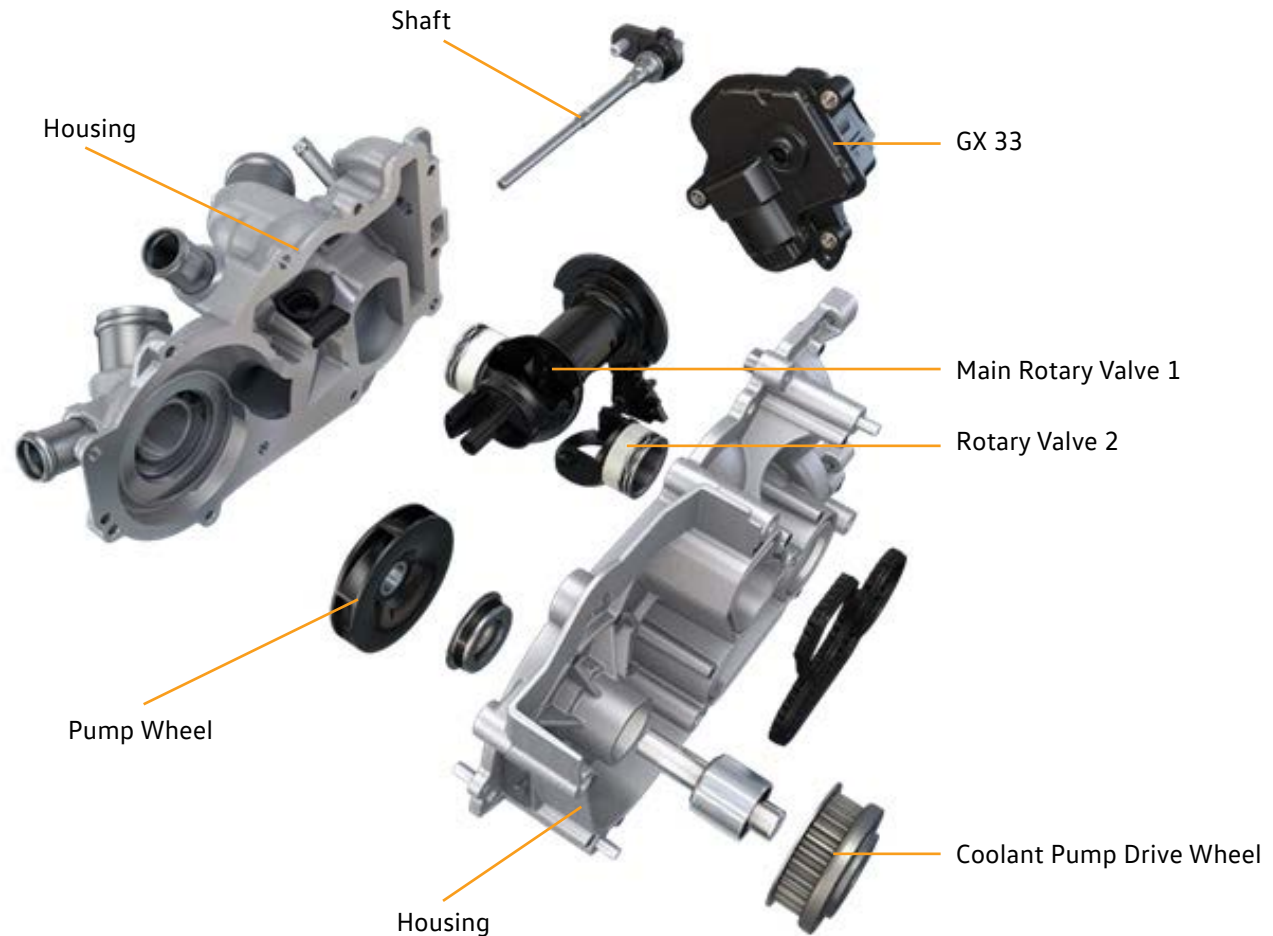
Cooling System

The rotary actuator is controlled by a fast and precise electrical actuator.

The Main Rotary Valve 1 controls flow through:

- The radiator
- Expansion tank for breathing
- The crankcase return
- The main coolant intake

The Rotary Valve 2 is responsible for stationary coolant during engine warm-up.

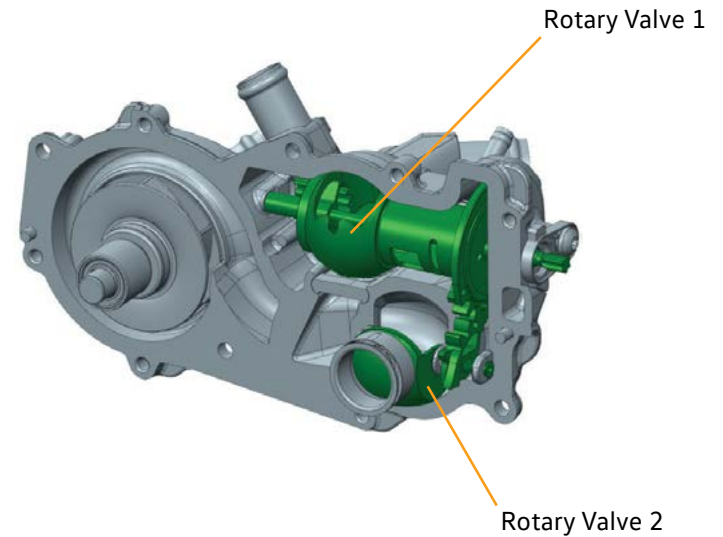


Cooling System

Cooling Module Modes

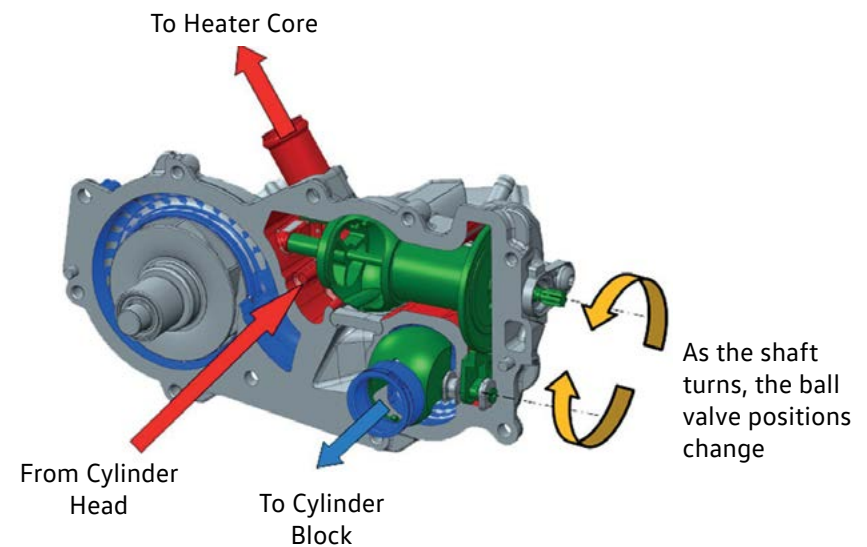
Mode 1 (cold engine)

Both rotary ball valves are closed and the coolant does not flow. This allows for faster coolant heating.



Mode 2 (90 °C)

Rotary Valve 1 is completely open, Rotary Valve 2 is in position 2. The coolant flows through the block to the cylinder head and then through the cylinder head outlet to the heating system where the same amount of heat is drawn off the coolant. The cylinder block outlet to the water pump is closed.



Cooling System

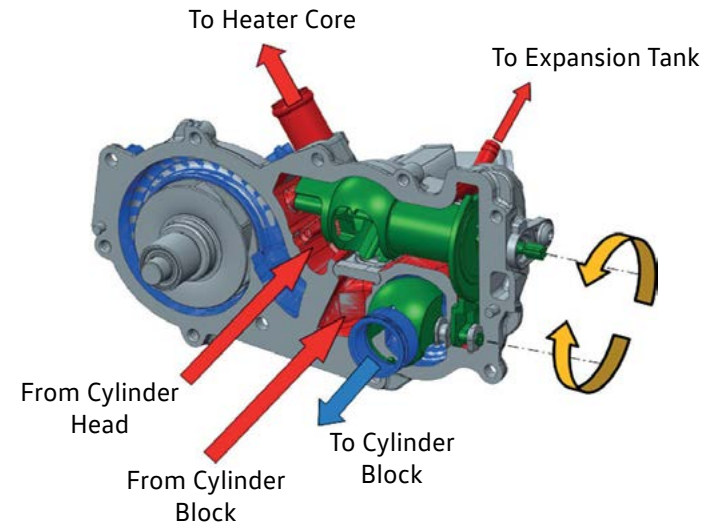
Cooling Module Modes continued...

Mode 3

Rotary Valve 1 is completely open, Rotary Valve 2 is in position 3. The coolant flows through the block to the cylinder head, then through the block and cylinder head outlets to the heating system.

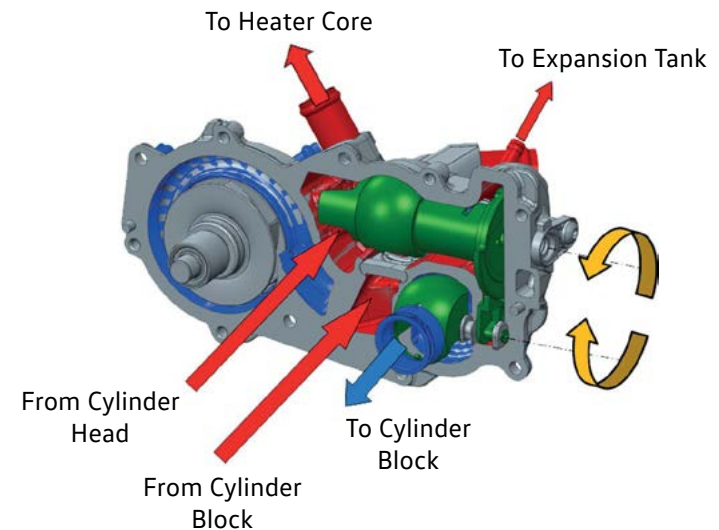
The cylinder block outlet to the water pump is open.

In Modes 3, 4 and 5, the cooling system is ventilated to the expansion tank.



Mode 4

Rotary Valve 1 is completely open, Rotary Valve 2 is in position 4. The coolant flows through the block to the cylinder head and then through the block and cylinder head outlets to the heating system and radiator.

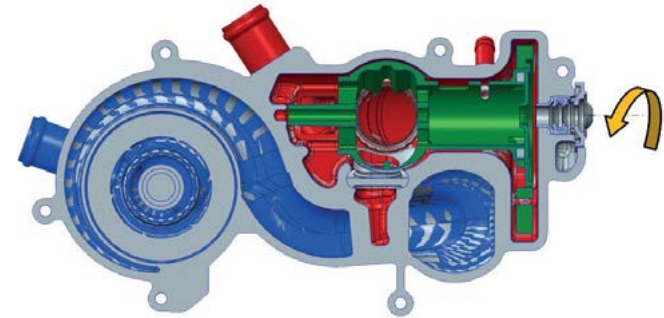


Cooling System

Cooling Module Modes continued...

Mode 5

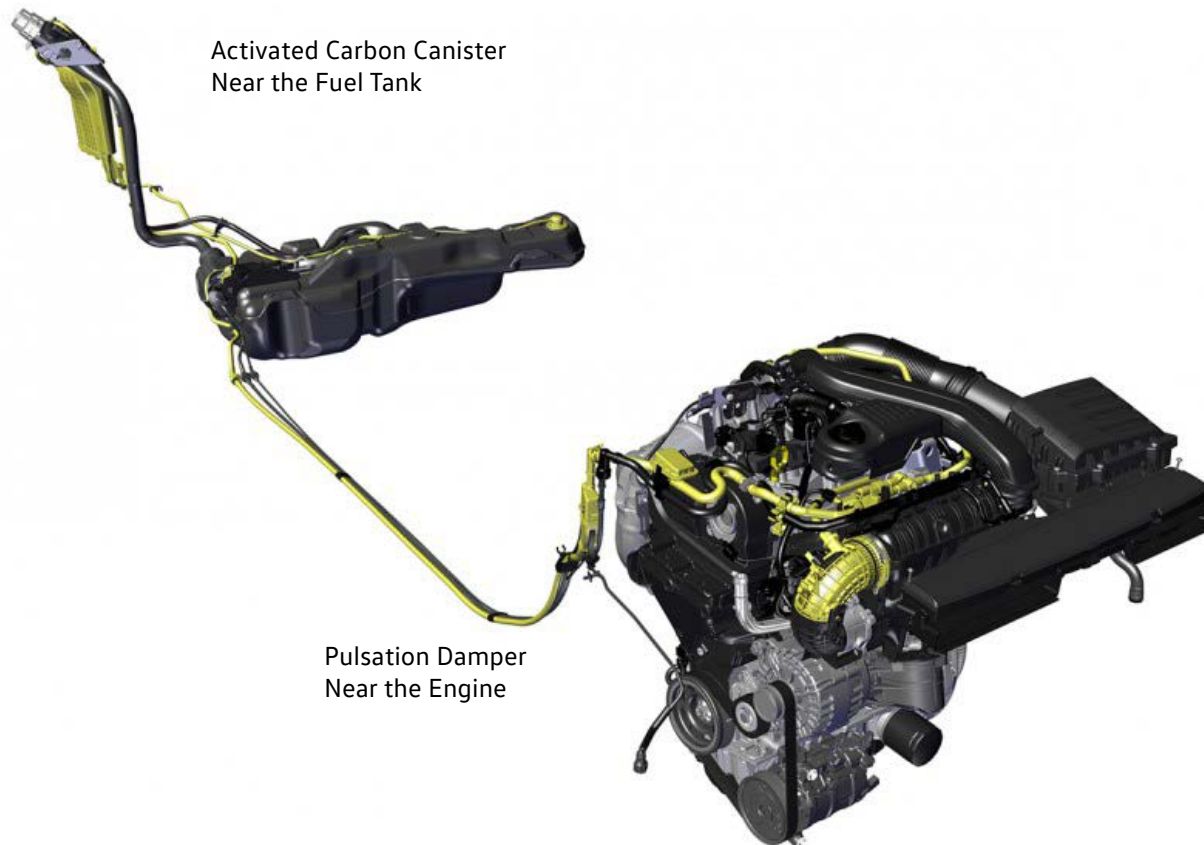
Both rotary valves are completely open – the water pump operates at its maximum cooling level.



Evaporative Emissions

Evaporative Emissions

The evaporative emissions system traps fuel tank vapors and introduces them into the engine intake system to be burned. This keeps them from entering the atmosphere as unburned hydrocarbons.

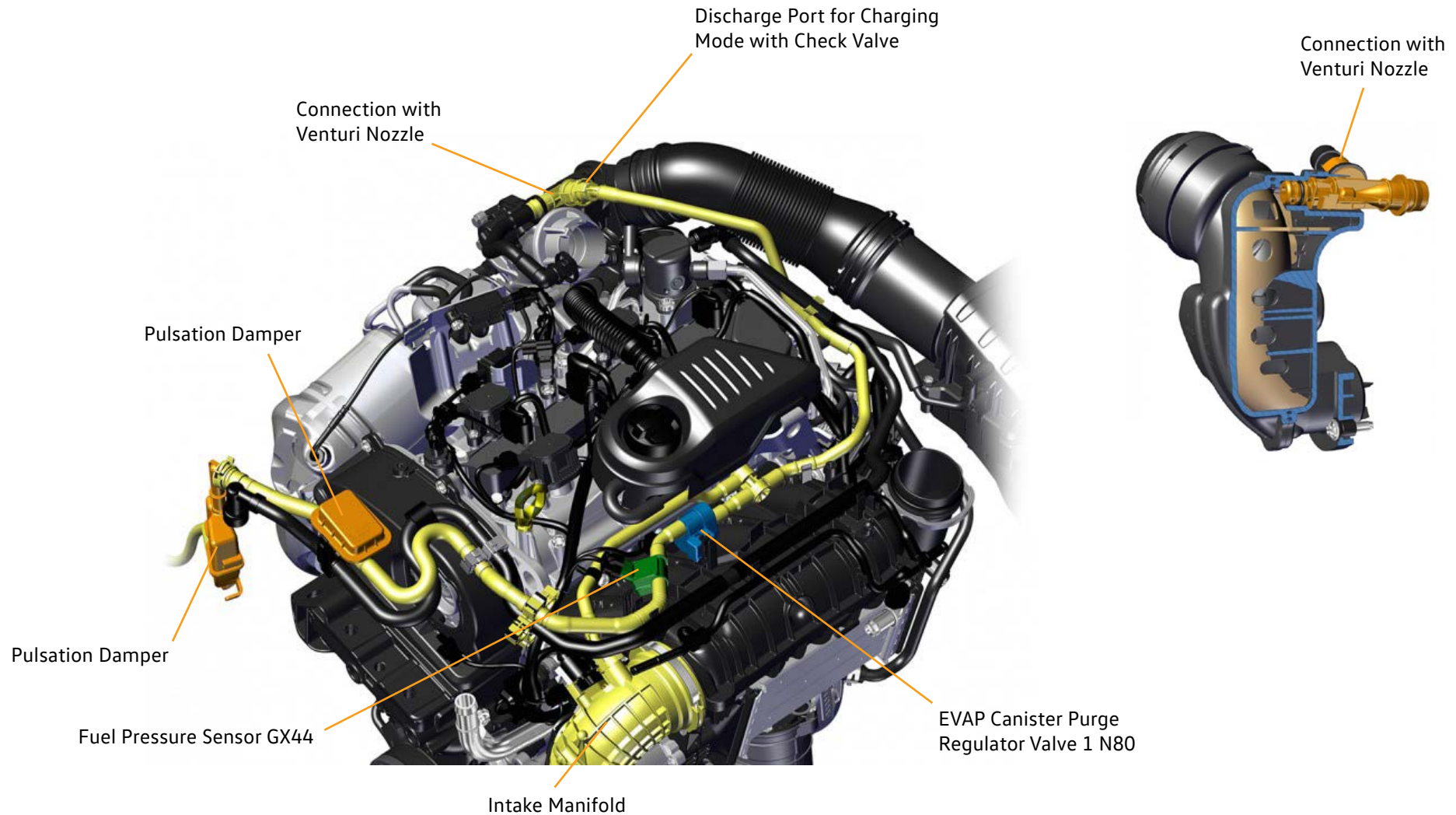


The fuel tank is semi-pressurized, similar to the system used on the 1.4L Jetta Hybrid. For more information, refer to SSP 890323, the Jetta Hybrid.

Evaporative Emissions

The Activated Carbon Canister System

With the solenoid valve open, the fuel vapors from the carbon canister are sucked in, depending on the pressure conditions at the intake manifold or in front of the turbocharger.

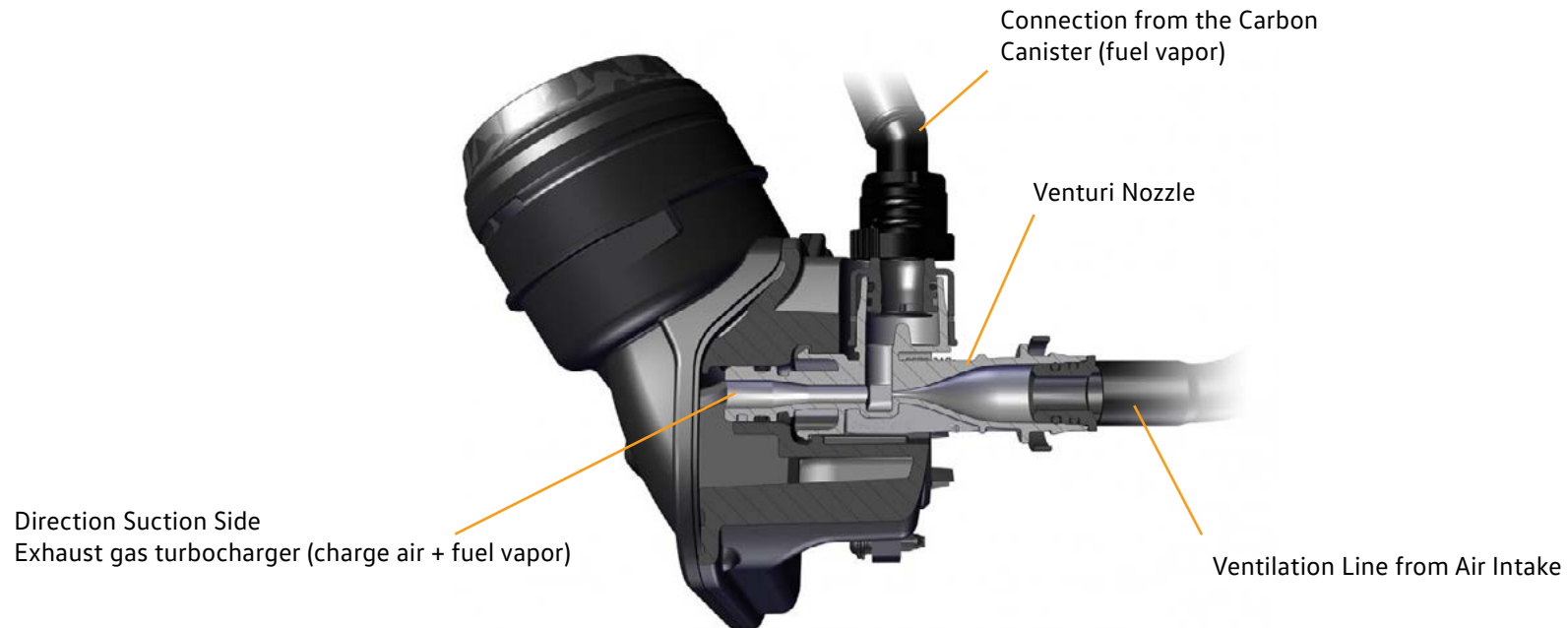


Evaporative Emissions

Intake Manifold with Venturi Nozzle

The Venturi nozzle allows for increased fuel vapor transfer. Using a ventilation line, a small part of the charge air is directed towards the Venturi nozzle. This increases flow by creating a negative pressure that sucks in fuel vapors.

The charge air and the fuel vapors flow together to the suction side of the exhaust gas turbocharger.



Active Oil Separator

The crankcase breather is almost exclusively inside the engine. It is protected from spray oil. Blow-by gases from the crankcase are collected and fed to the electric separator located on the cylinder block. The pre-purified gases are then routed to the fine oil separator located in the camshaft housing using a port in the cylinder block.

Charging Mode:

During charging mode, the blow-by gases are fed into the intake stream and then to the turbocharger.

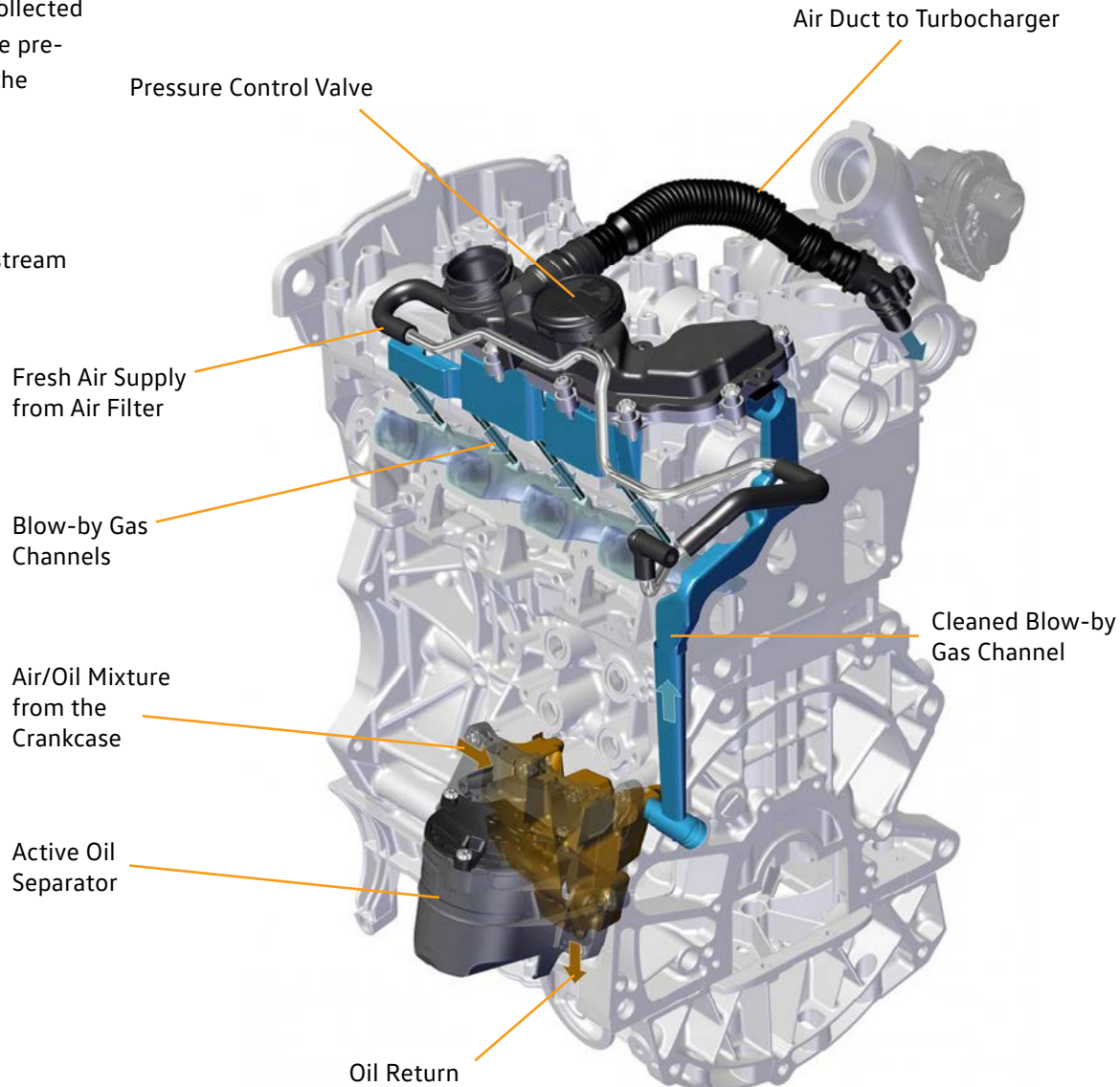
Intake Mode:

During intake mode, the blow-by gases reach the intake ports through holes in the cylinder head and are fed to the combustion chamber. Fresh air from the air filter is drawn through the engine by the negative pressure in the crankcase using a one-way valve in the fine oil separator. Condensate that escapes during engine heating is captured by the fresh air stream and routed to the combustion via the holes.

The crankcase breather ensures discharge of condensation from the engine oil even during frequent short trips.

Innovations to crankcase ventilation:

- An active oil separator performs the tasks of the previous coarse and fine oil separator
- A valve module is installed instead of the previous fine oil separator

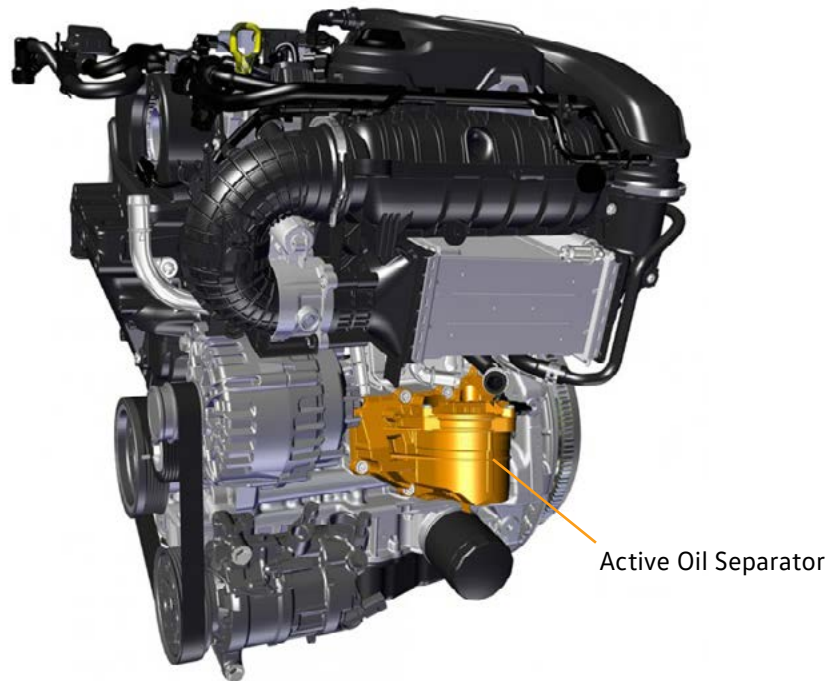


Active Oil Separator

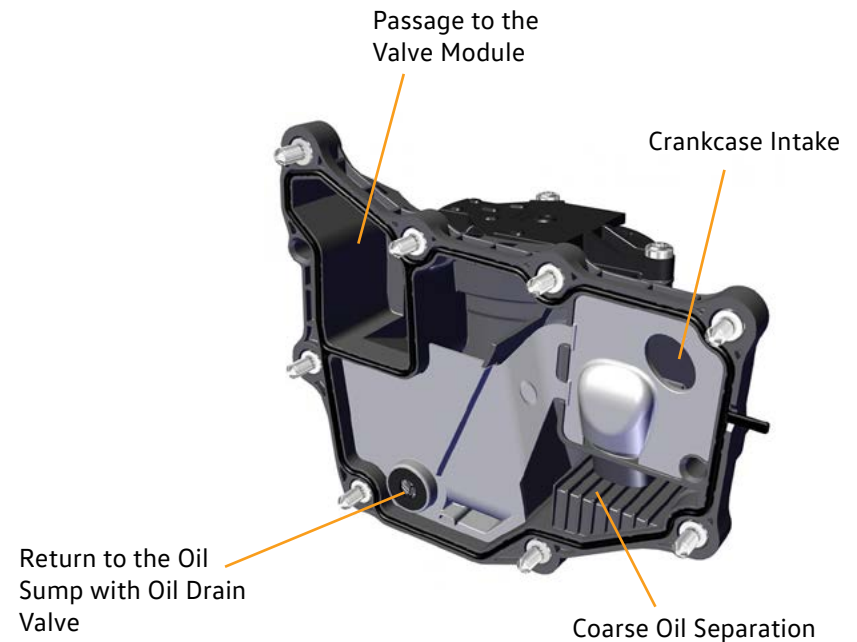
Active Oil Separator

The Active Oil Separator is located on the intake side of the engine block under the charge air cooler. It filters out even the smallest oil particles out of the blow-by gases, then returns this separated oil to the oil pan.

This results in fewer oil particles in the combustion chamber, decreasing oil consumption and resulting in cleaner combustion.



Control Module for
Active Oil Separation
J1240



Active Oil Separator

Active Oil Separator

The Control Module for Active Oil Separation J1240 is controlled by the ECM based on load and speed.

The electric motor (Active Oil Separation Motor V704) rotates the plate package between 0 - 12,000 rpm.

The fine separator (plate package) has 30 individual plates. Due to the centrifugal forces, even the smallest oil droplets are separated from the blow-by gases to the plates and removed.

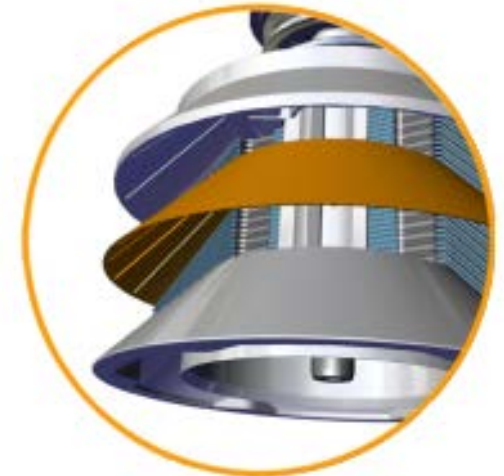
At the edges of the plate, the oil collects into larger drops, falls into the oil collection area and flows over a check valve back into the oil pan.



**Control Module for
Active Oil Separation
J1240**



**Active Oil Separation
Motor V704**



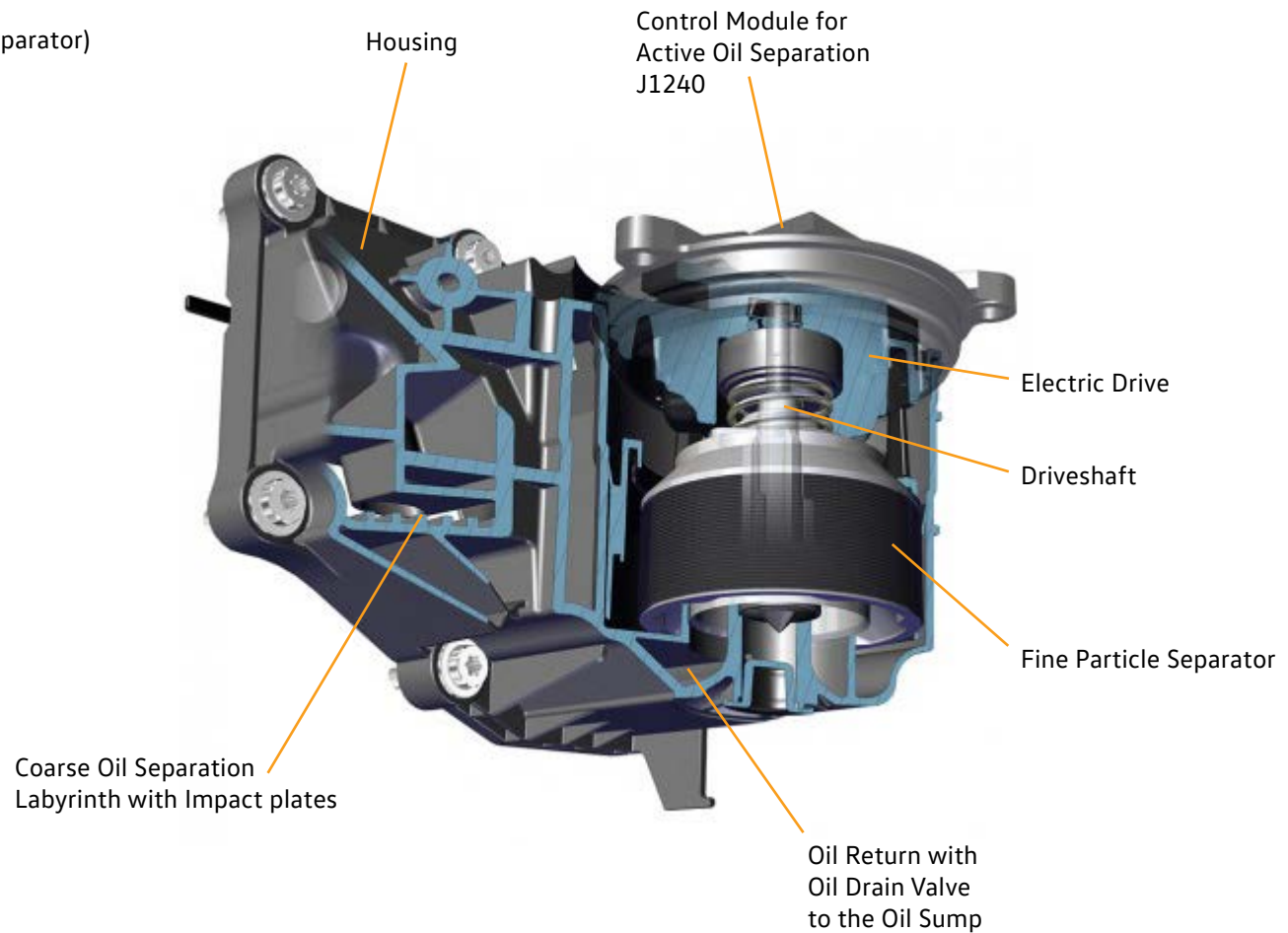
**Fine Oil Separator
Plates**

Active Oil Separator

Active Oil Separator

The Active Oil Separator consists of:

- The housing
- The control module
- The drive unit
- The fine screen separator (disc separator)



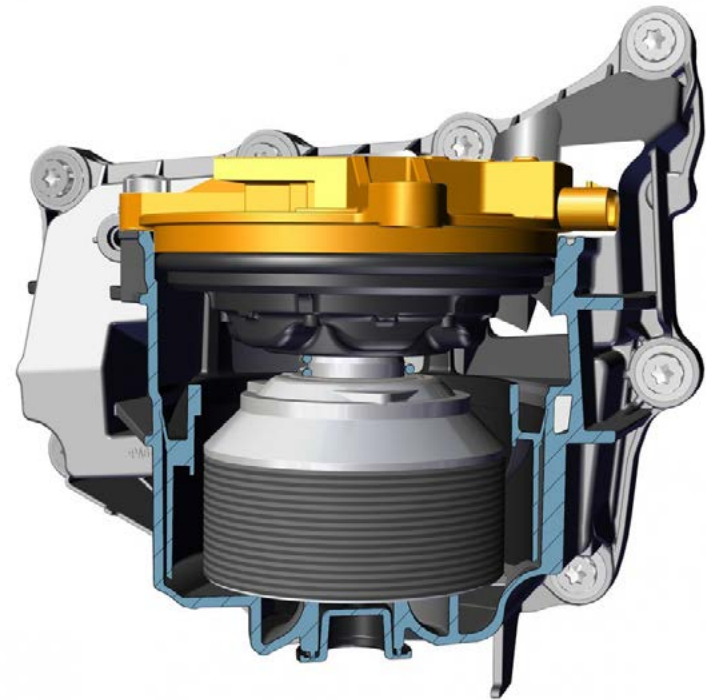
Active Oil Separator

Control Unit for Active Oil Separation J1240

The control unit for active oil separation is attached to the Active Oil Separator. It controls the active oil separation motor and communicates with the ECM using a LIN-bus signal.

Tasks:

- The control module receives data from the ECM via a LIN-bus signal. This data is based on a map for speeds of the fine stone separator
- The control unit controls the motor for active oil separation and adjusts the speed of the fine stone separator between 5 speed levels
- The control unit sends diagnostic information about the active oil separator to the ECM



Active Oil Separator

Control Unit for Active Oil Separation J1240

Diagnostic information (error messages)

- Electric drive blocked
- Electric drive overheated
- Speed deviation target/is greater than 3%
- Other malfunctions of electric drive

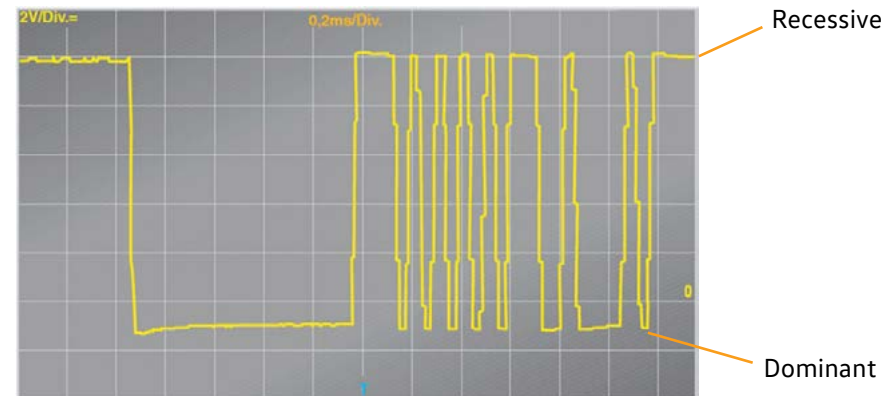
Effect of signal failure

If the control unit is defective or one of the three lines is disconnected, active oil separation stops. Oil separation takes place in the coarse oil separator and in the stationary fine oil separator.

Depending on the error, the error type is sent to the ECM. An entry is made in the event memory and the error lamp for Electronic Power Control Malfunction Indicator Lamp K132 and the Malfunction Indicator Lamp K83 are illuminated.

Electrical circuit

- Pin 1: Positive voltage supply (9-16 Volt operating voltage)
- Pin 2: LIN bus (bi-directional)
- Pin 3: Ground



Active Oil Separator

The Active Oil Separation Motor V704 is integrated with the Function Unit for Active Oil Separation GX47. It is controlled by the Control Unit for Active Oil Separation J1240.

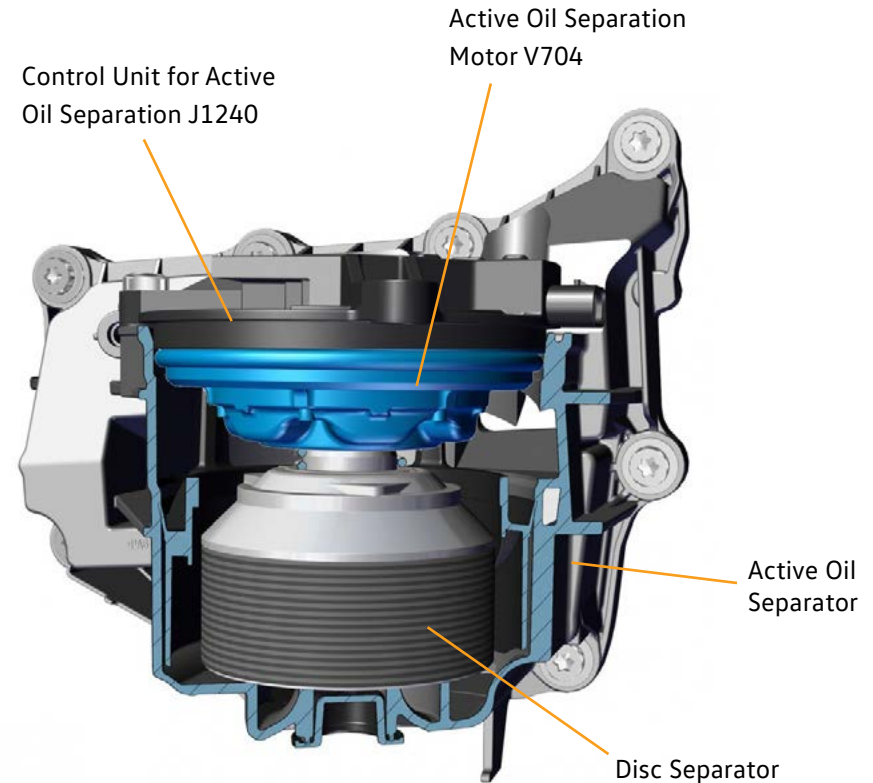
Depending on the control, the speed of the electric motor is load and speed-dependent between zero and 12,000 1/min. The load ranges according to the speed of the disc separator are:

1. Stop: 0 rpm
2. Idle: 2,000 rpm
3. Low load: 4,000 rpm
4. Mid load: 6,000 rpm
5. Full load: 12,000 rpm

Task

The motor is connected to the disc separator by a shaft. The rotation of the plates created by centrifugal forces and even the smallest oil particles are thrown from the plates to be gathered.

If the motor fails, active oil separation stops. Oil separation still happens using the coarse oil separator. Depending on the error, the error type is sent to the ECM. An entry is made in the event memory and the error lamp for Electronic Power Control Malfunction Indicator Lamp K132 and the Malfunction Indicator Lamp K83 are illuminated.



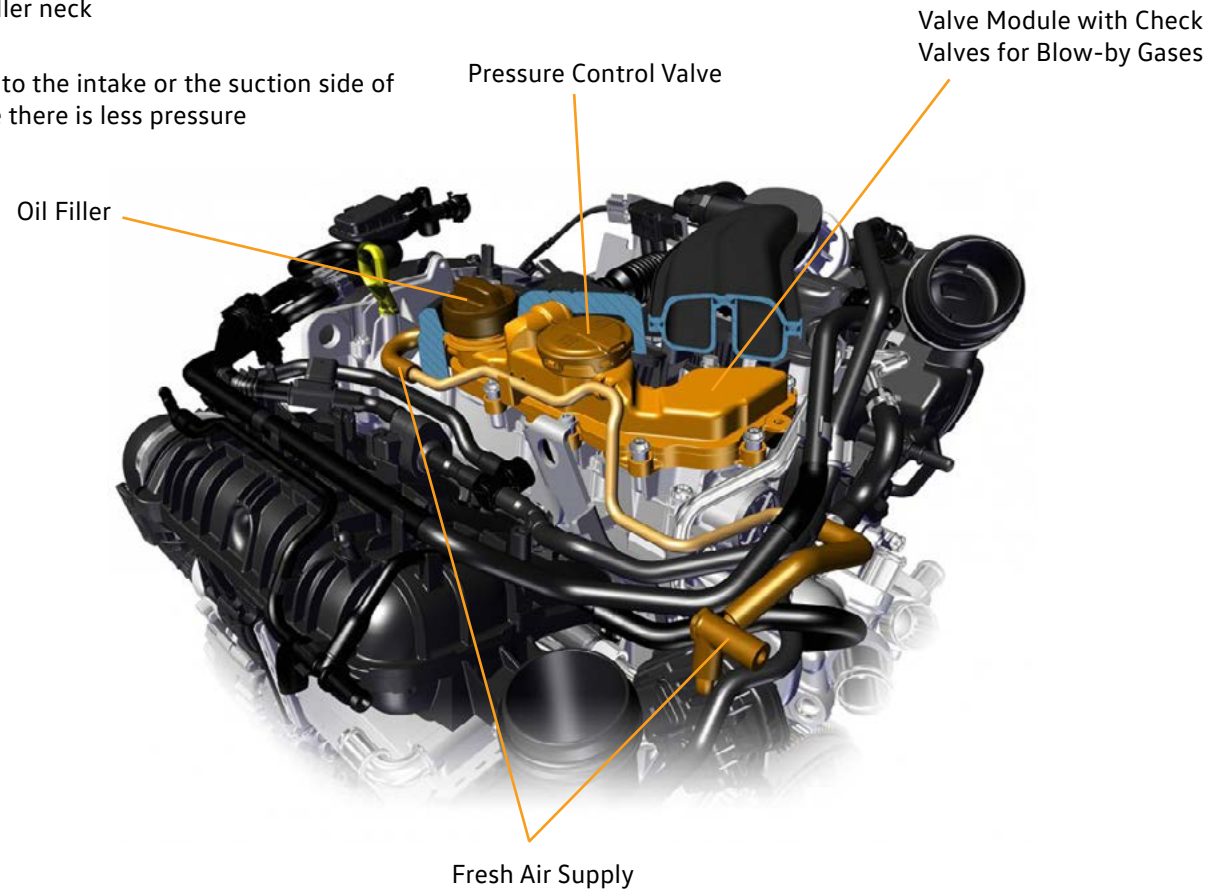
Active Oil Separator

The Crankcase Breather Valve Module

The valve module is attached to the camshaft housing. After the Active Oil Separator has removed the oil from the gases, they are directed through a channel in the cylinder block, cylinder head and camshaft housing to the valve module.

The valve module provides:

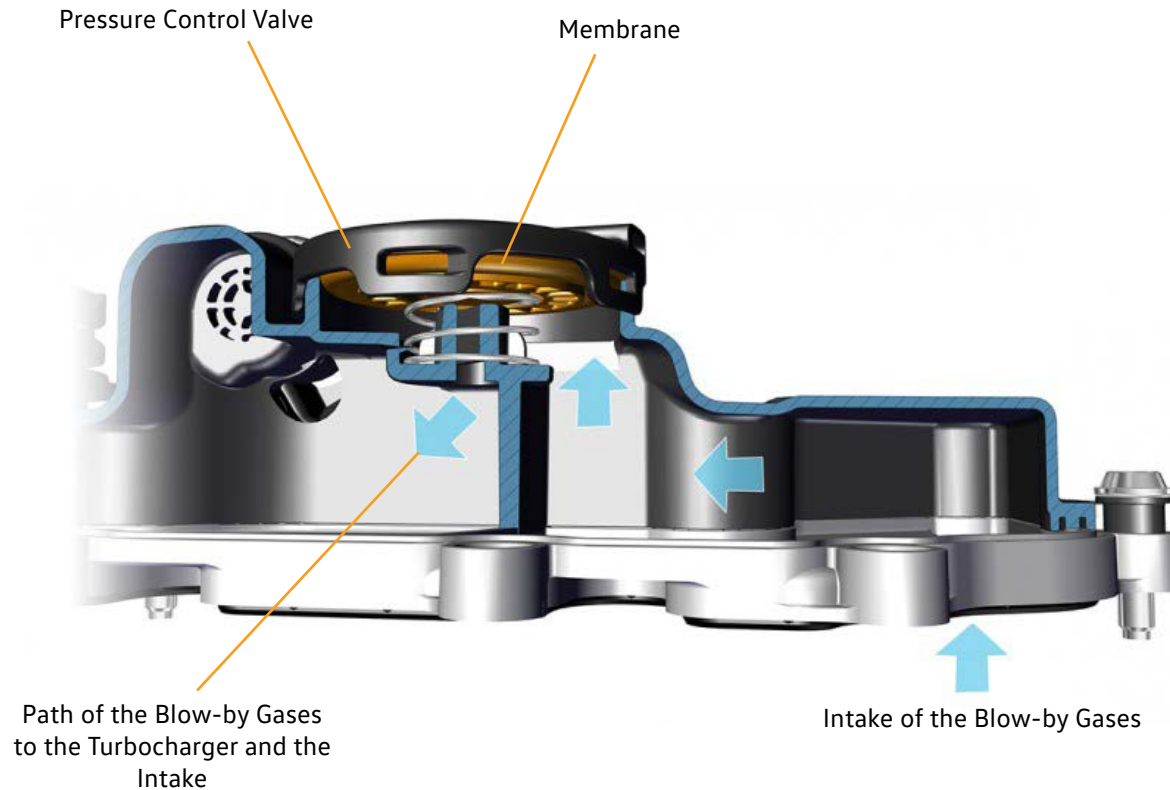
- Fresh air from the air filter to the oil filler neck
- Pressure control in the crankcase
- The introduction of the blow-by gases to the intake or the suction side of the turbocharger, depending on where there is less pressure



Active Oil Separator

The Vent Module in the Crankcase Breather Valve Module

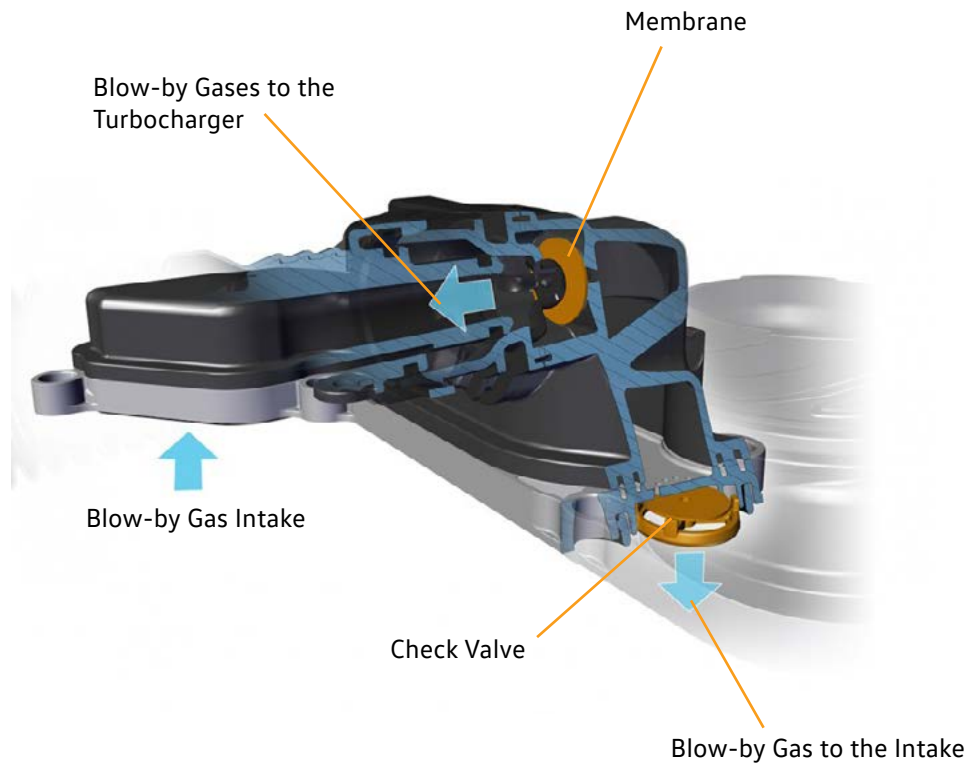
First, the blow-by gases flow into the valve module to the pressure control valve. This ensures a uniform pressure level within the system of about -90 mbar (relative).



Active Oil Separator

Check Valves for Blow-by Gases in the Crankcase Breather Valve Module

The two check valves make sure blow-by gases direct the pressure to the turbocharger or the intake. Gases are directed through the check valve with lower pressure.

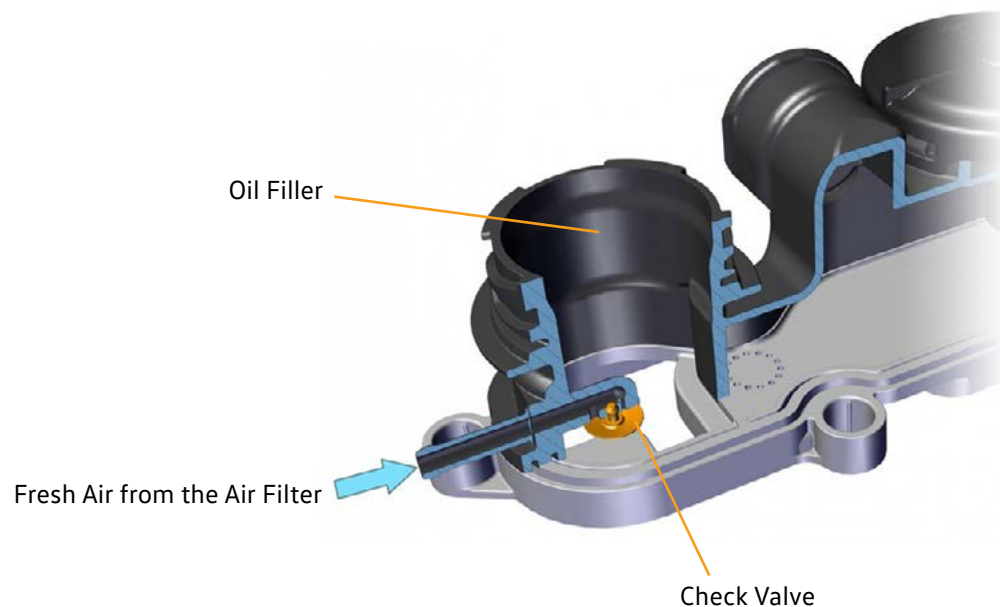


Active Oil Separator

Check Valve for Fresh Air Supply in the Crankcase Breather Valve Module

The fresh air comes in from the air filter and through a check valve.

- The check valve opens when the pressure in the crankcase is lower than in the air filter
- The fresh air passes from the air filter through the oil filler neck into the crankcase
- The check valve closes when the pressure is lower in the air filter than in the crankcase, preventing uncleaned crankcase gases from going in to the air filter

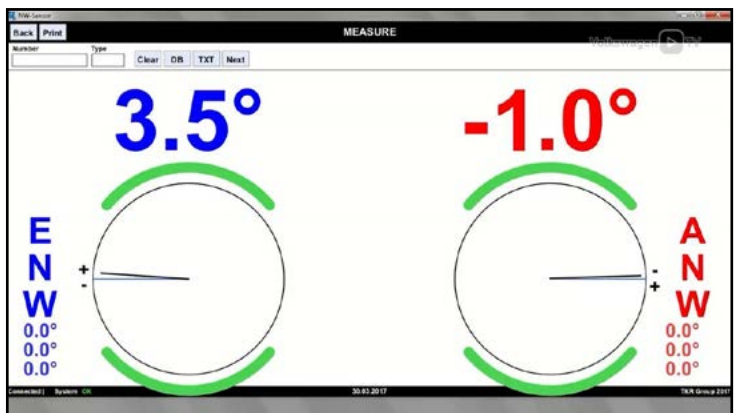


Camshaft Timing Checking and Setting

The VAS 611 007, an electronic measuring tool, must be used to precisely set camshaft timing checking and adjustment because traditional timing procedures are not accurate enough. The VAS 611 007 uses electronic angle sensors to determine camshaft position.

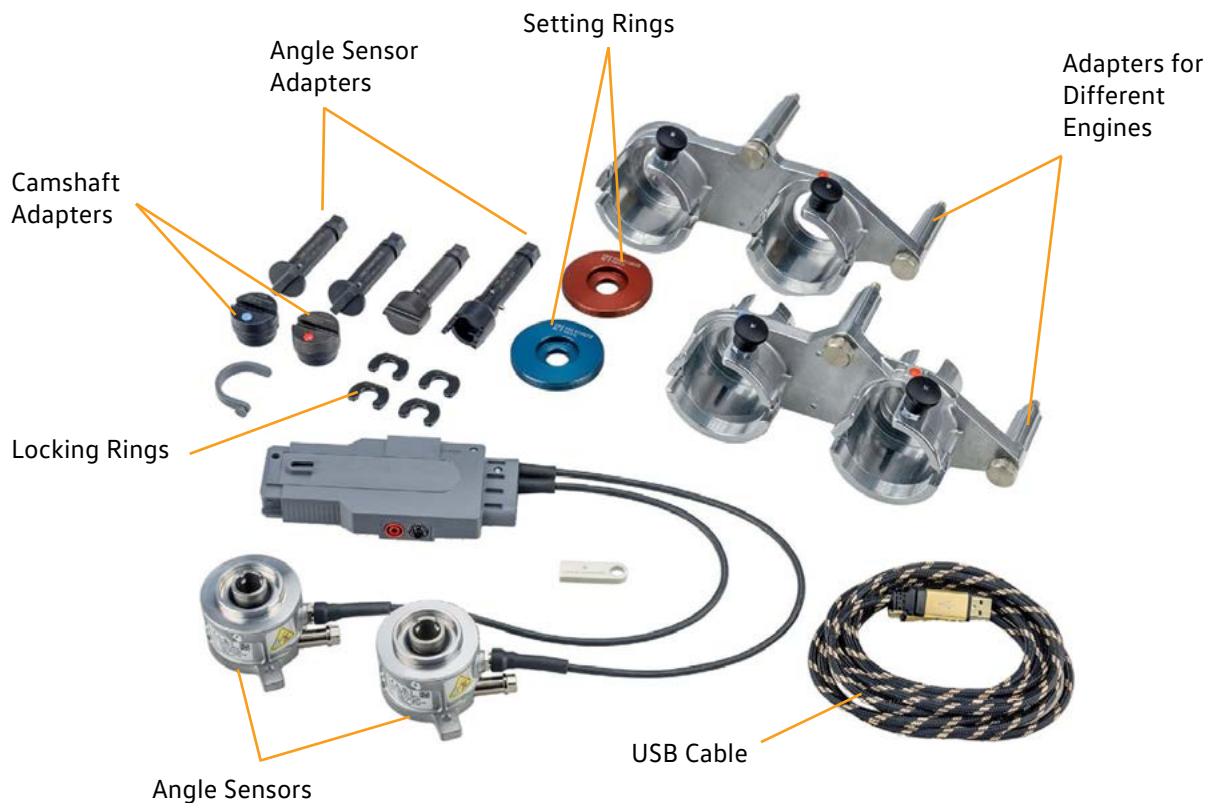
Before any measurement, the measurement device needs to be assembled and calibrated. The provided USB stick has the calibration program that has to be installed on the scan tool or other computer. This program can also be found on Servicenet under Workshop Equipment/Tool Information/Tool Software Updates. This is a stand-alone program that displays very precise camshaft rotation readings. It does not interact with ODIS Service. The Repair Manual has instructions for using the VAS 611 007 and performing the timing measurements/adjustments. It's recommended to print out the readings, then attach them to the Repair Order for documentation purposes.

Calibration Program Screen



Intake Camshaft

Exhaust Camshaft



Camshaft Timing Checking and Setting

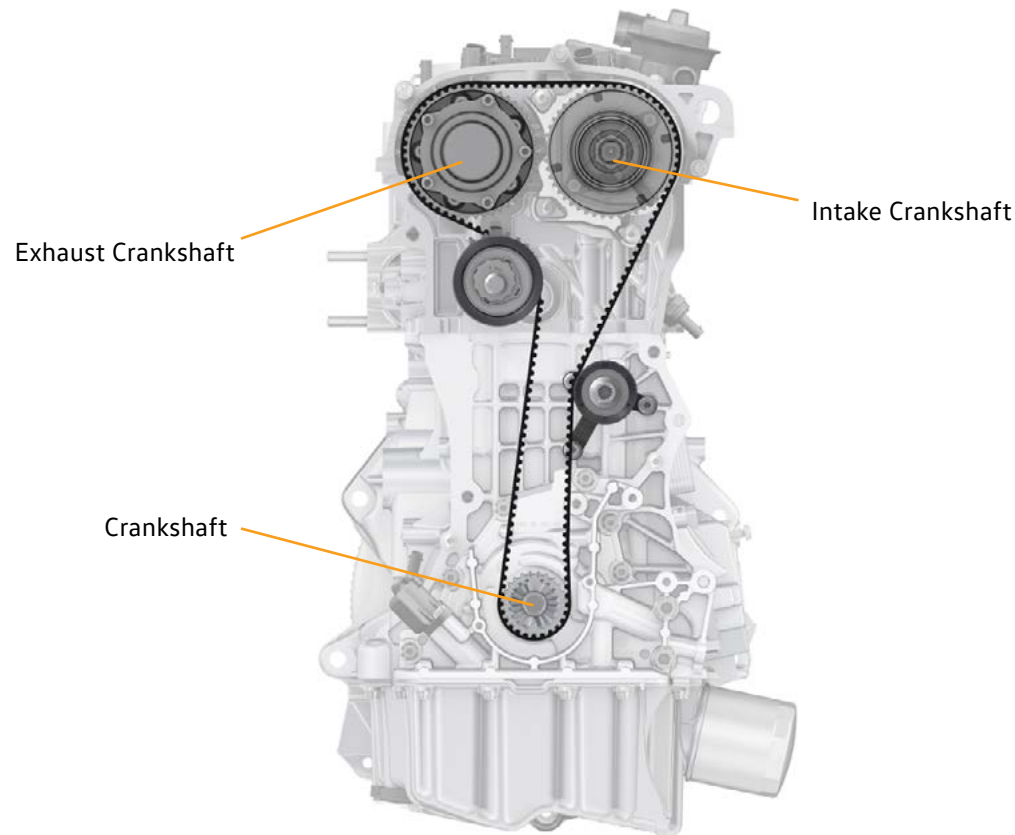
This is the general image for installation of the VAS 611 007 on the engine. There are some videos on how to use this tool to check and then set camshaft timing on VW Cup. Since this tool is used on different engines worldwide, the videos are not specific to the 1.5L engine. Information regarding installation and setup for each engine is found in the Repair Manual.

VAS 611 007



Tolerance Compensation in the Belt Drive

Even with tight production tolerances, angle deviations can happen in the camshaft housing and crankshaft drive. However, when calculating cylinder fill rates, precise valve control timing is needed, especially with the 1.5L engine that uses the Miller combustion process. The time that the intake valves close has a very large influence on the cylinder filling. The piston speed is still very high with early closing, while it is relatively "slow" with closing of the intake valves near bottom dead center. The valve control times are precisely measured during production and stored in the ECM.

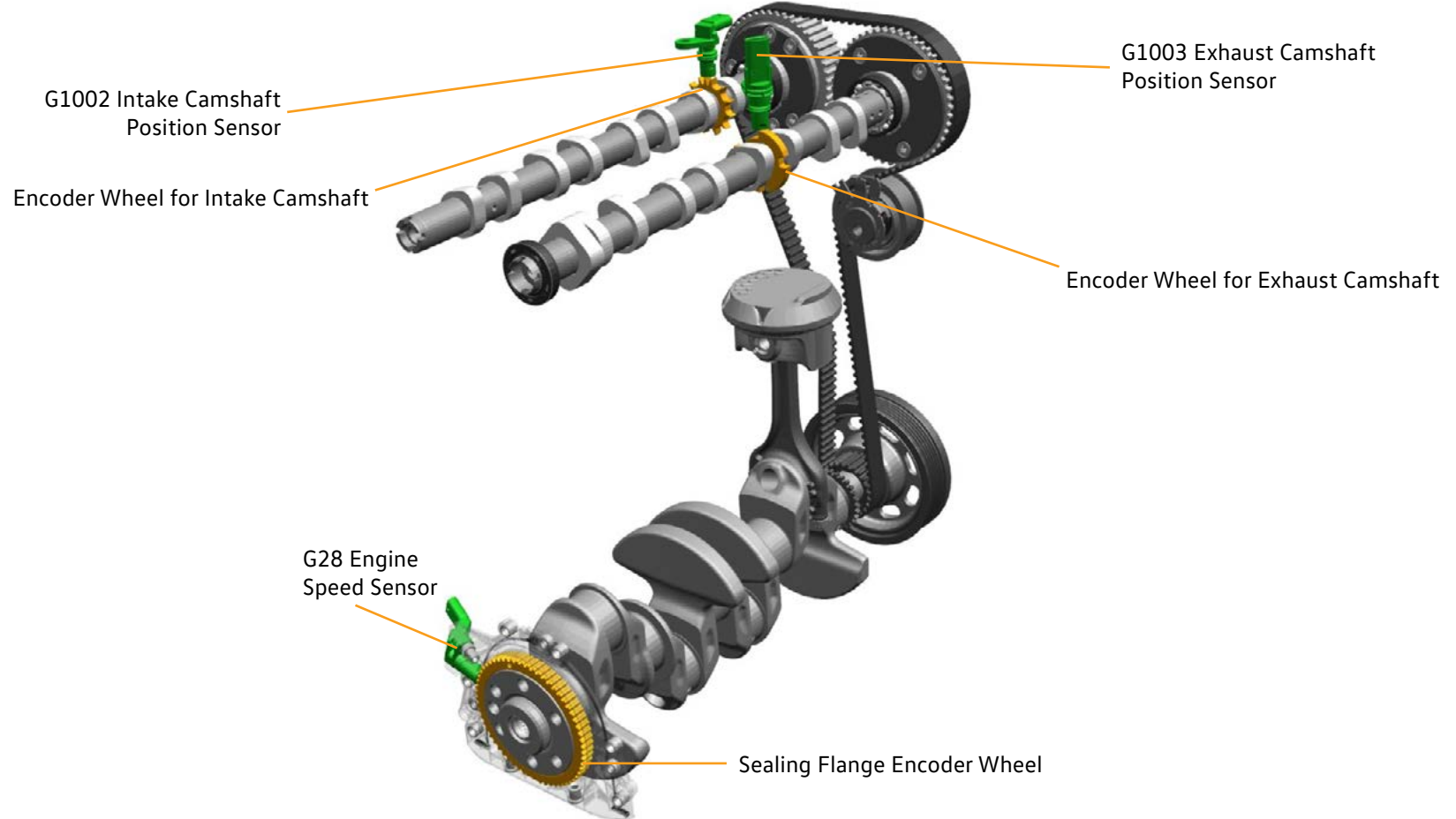


Tolerance Compensation in the Belt Drive

The production tolerances of the following components are measured during the production process:

- The valve stroke curves are recorded for each camshaft
- The electrical deviations of the intake and exhaust position sensors, the engine speed sensor, and the mechanical deviations of the three encoder wheels are recorded

These deviations are stored in the ECM and are used for precise cylinder filling. In addition, the deviations in the camshaft housing are laser-etched onto the camshaft housing as a Data Matrix Code (DMC) and as a character string. The deviations of the crankshaft are printed as a character string and located on the upper timing belt cover.



Camshaft Data Matrix Code Location and Explanation

- Tolerances are not adjustable using normal workshop procedures
- Sensors cannot be removed and "swapped" for known good sensors. Break away security bolts are used for cam and crank sensors
- There is a numeric sequence on the cylinder head and timing cover which indicates the tolerance of the camshaft sensors and the engine speed sensor/ tone wheel.



Camshaft Tolerance Location



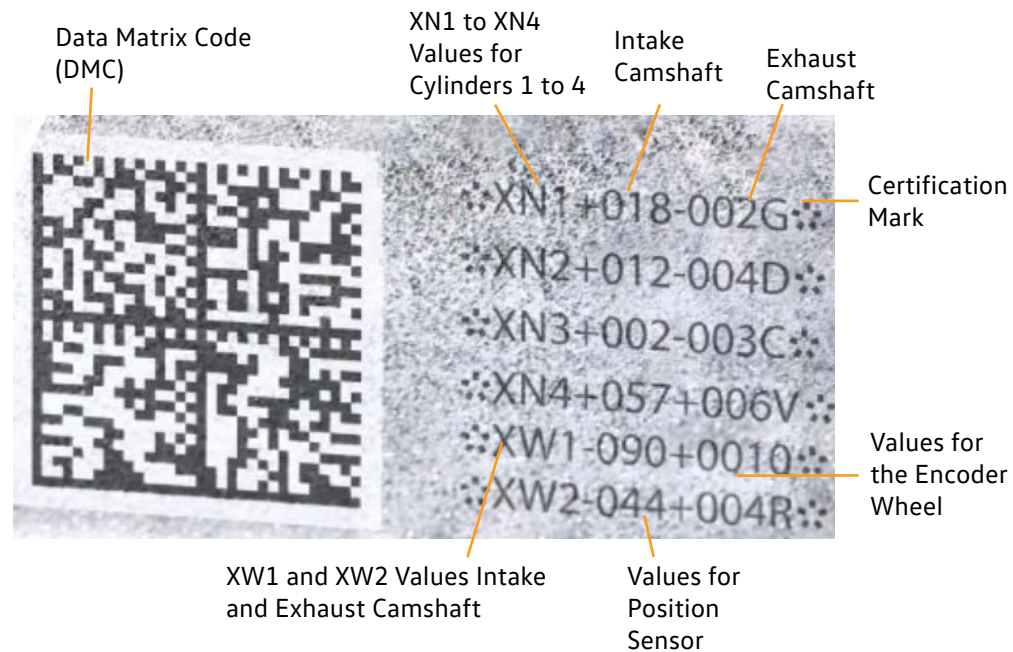
Crankshaft Tolerance Location



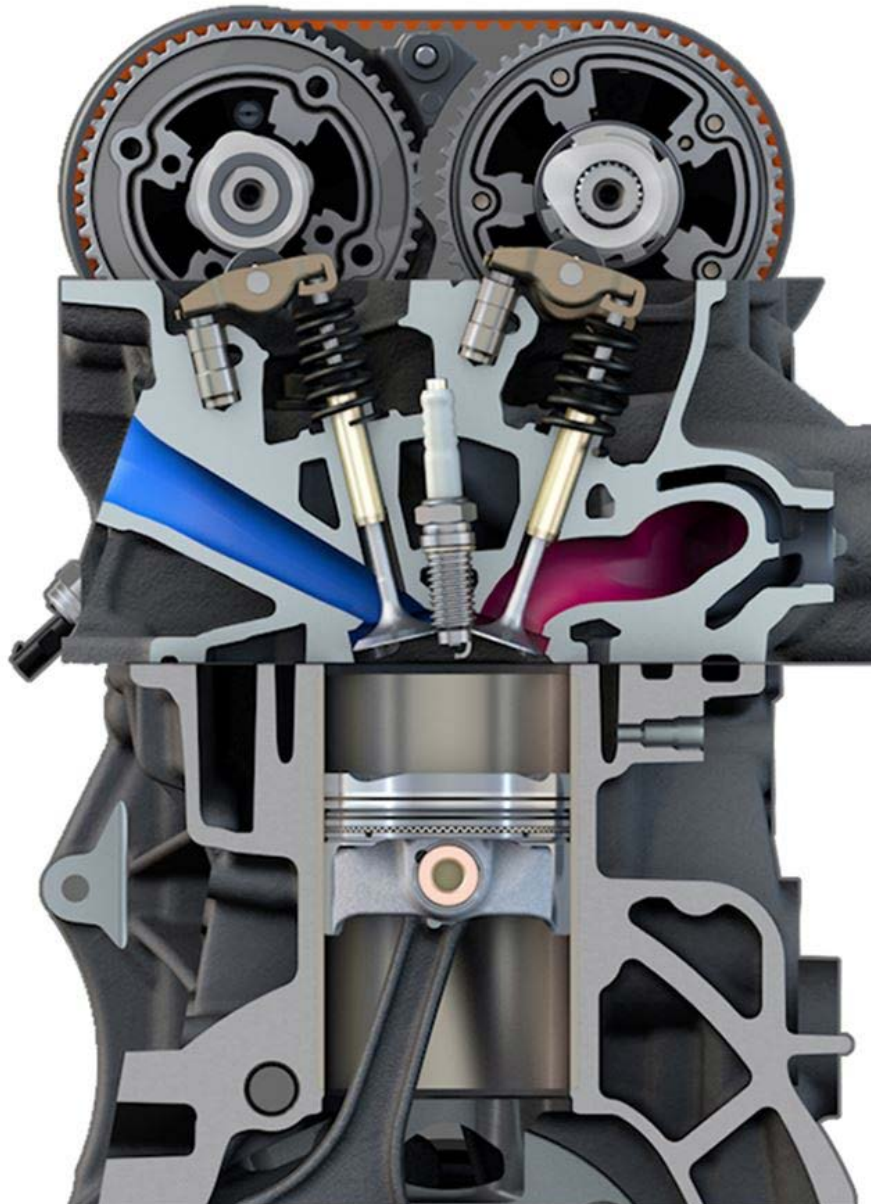
Security Bolt

Camshaft Data Matrix Code Explanation

These values will need to be entered into the scan tool when performing cylinder head timing procedures.



This image is only an example. Do not attempt to use these values! Only the values on the specific cylinder head should be used.



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October 2022

