General

Completely new engines have been developed for the Cayenne S and Cayenne Turbo for the 2008 model year.

The main development aims were:

- More power and torque, while at the same time,
- Improving fuel economy and,
- Reducing the weight of the engine compared to previous engines.

These development aims have essentially been achieved due to the following enhancements and new technologies:

- Larger displacement
- Direct fuel injection (DFI)
- Sport button as standard
- VarioCam Plus
- Demand controlled oil pump

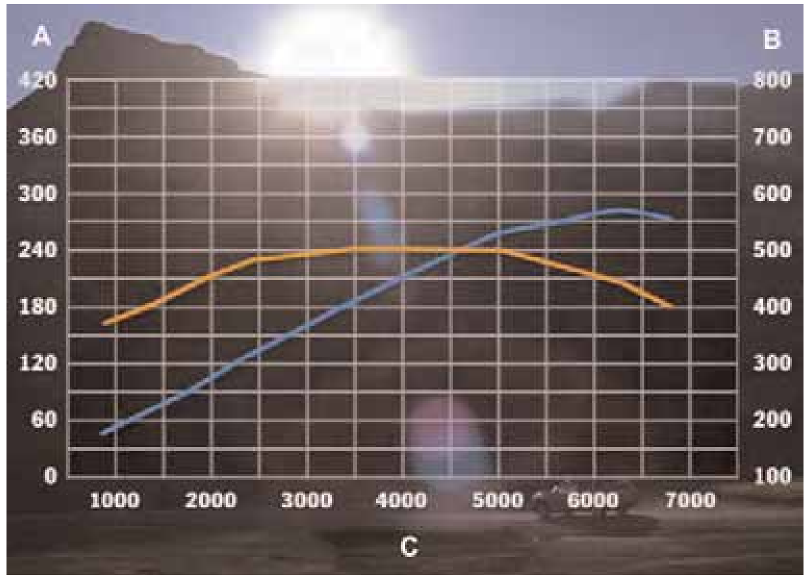
Contents

V8

Engine – Cayenne V8

A - Power rating in kW
B - Torque in Nm
C - Engine speed

Cayenne S Full Load Curve



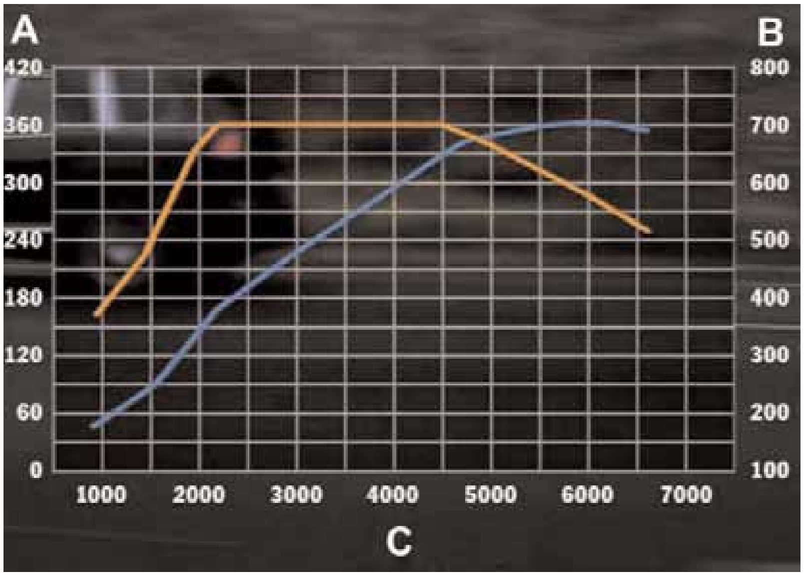
Engine Data – Second Generation Cayenne S

Engine type M48.01
No. of cylinders 8
Bore . . . . .96 mm
Stroke . . . . .83 mm
Displacement . . . . .4.8 Liter
V-angle 90
Compression ratio 12.5
Max. output . . . . .385 HP (283 kW)
At engine speed . . . . .6200 rpm
Max. torque . . . . .370 ftlb. (500Nm)
At engine speed . . . . .3500 rpm
Governed speed . . . . .6700 rpm
Engine weight (manual transmission) . . . . .503 lbs (228 kg)
Engine weight (Tiptronic transmission) . . . . .456 lbs (217 kg)
Firing order 1-3-7-2-6-5-4-8

Engine Data – Previous Cayenne S V8 for Comparison

Engine Type M48.00
Number of Cylinders 8
Bore . . . . .93 mm
Stroke . . . . .83 mm
Displacement . . . . .4.5 Liter
Compression Ratio 11.5
Max. Power . . . . .340 hp (250 kW)
at Engine Speed . . . . .6000 rpm
Max. Torque . . . . .310 ftlb. (420 Nm)
at Engine Speed . . . . .2500 – 5500 rpm
Governed Engine Speed Tiptronic .6500 rpm
Engine Weight . . . . .500 lbs (227 kg)
Firing Order 1-3-7-2-6-5-4-8

Cayenne Turbo Full Load Curve



A - Power rating in kW
B - Torque in Nm
C - Engine speed

Engine Data – Second Generation Cayenne Turbo

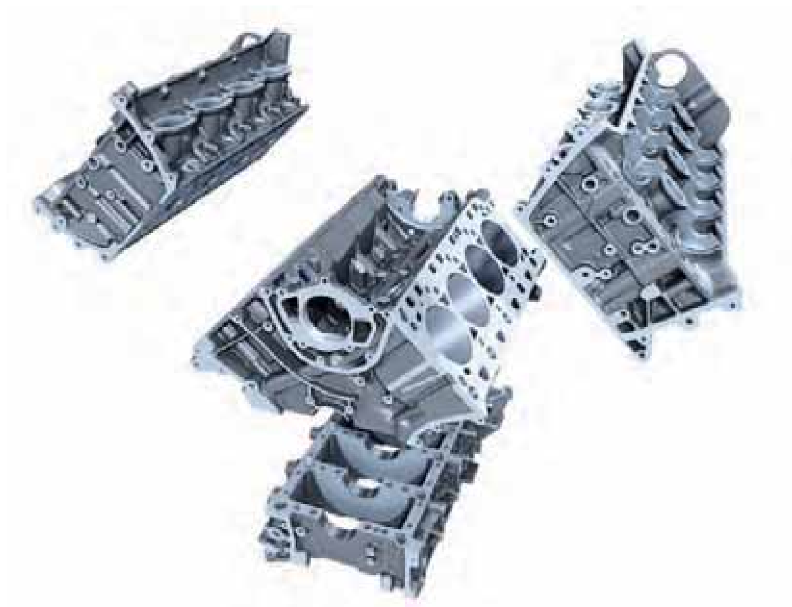
Engine type M48.51
No. of cylinders 8
Bore . . . . .96 mm
Stroke . . . . .83 mm
Displacement . . . . .4.8 Liter
V-angle 90
Compression ratio 10.5
Max. output . . . . .500 HP (358 kW)
At engine speed . . . . .6000 rpm
Max. torque . . . . .518 ftlb. (700Nm)
At engine speed . . . . .2250-4500 rpm
Governed speed . . . . .6700 rpm
Engine weight . . . . .520 lbs (236 kg)
Firing order 1-3-7-2-6-5-4-8

Engine Data – Previous Cayenne Turbo V8 for Comparison

Engine Type M48.50
Number of cylinders 8
Bore . . . . .93 mm
Stroke . . . . .83 mm
Displacement . . . . .4.5 Liter
Compression Ratio 9.5
Max. Power . . . . .450 hp (331 kW)
at Engine Speed . . . . .6000 rpm
Max. Torque . . . . .458 ftlb. (620 Nm)
at Engine Speed . . . . .2250 - 4750 rpm
Governed Engine Speed Tiptronic .6500 rpm
Engine Weight . . . . .558 lbs (253 kg)
Firing Order 1-3-7-2-6-5-4-8

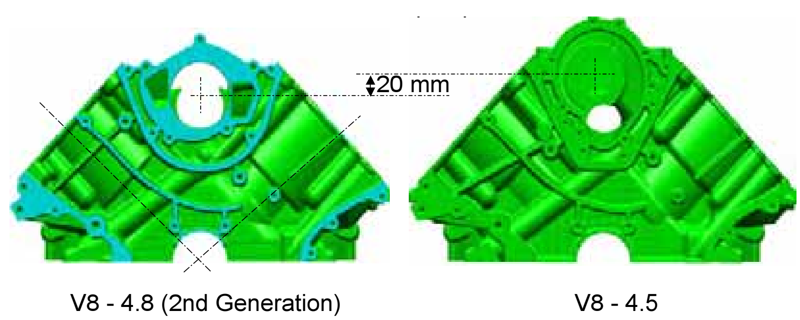
Crankcase

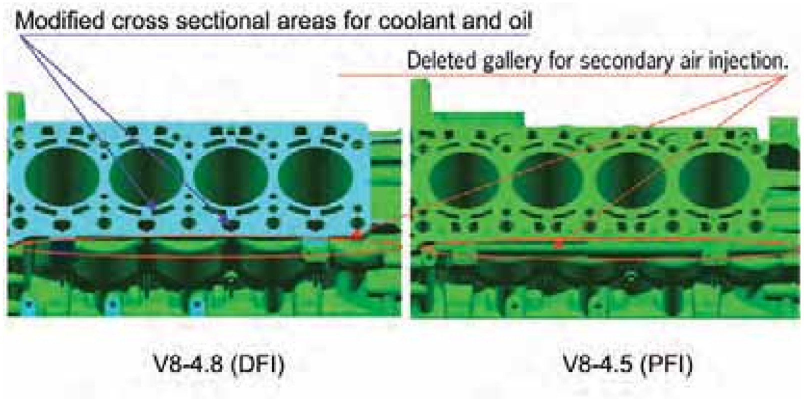
The crankcase in the Porsche Cayenne S and Cayenne Turbo is designed as a two-piece closed-deck component in a light metal alloy (AlSi17Cu4Mg). In the closed-deck design, the sealing surface of the crankcase is, for the most part, closed to the cylinder head, only the bores and channels for oil and coolant are exposed. The entire structure is additionally strengthened as a result of this design. This leads to less cylinder distortions and helps to reduce oil consumption.

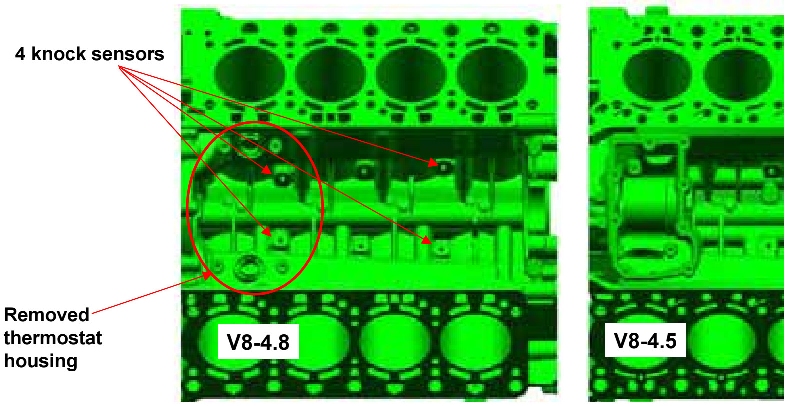


Modified water flow circuit.

The alloy used for the crankcase is known as a hypereutectic alloy in which silicon crystals form. These silicon crystals are exposed using several specialized honing processes in order to make the surface more durable. The crankcase has been lowered by 20 mm compared to the previous engine. As a result, the coolant pump and thermostat housing cover are also 20 mm lower and a modified water flow circuit was required.







The lower part of the crankcase is machined and paired together with the upper part. To keep the weight as low as possible, the spheroidal graphite iron inserts are no longer used and the wall thickness has been reduced.

A low-pressure chill-casting procedure is used to make the upper and lower part of the crankcase.

Crankshaft

The drop-forged crankshaft runs in five bearings and has eight counter-weights. Main bearing 3 is designed as a thrust bearing. Axial play is determined by two thrust washers, which are inserted into the bearing halves. The main bearings are two-component bearings and have a diameter of 64 mm. Since the lower part of the crankcase is made of an all aluminum alloy, the main bearings are stronger than those used previously and the retaining lugs have been changed to avoid confusion. The main bearings are also “lead-free.”

Torsional Vibration Balancer

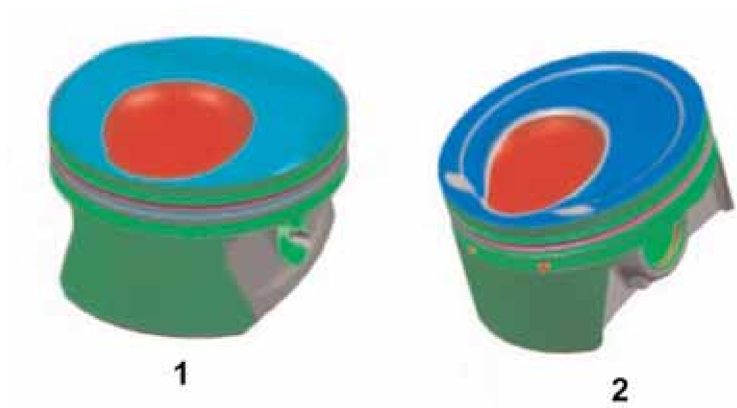
A torsional vibration balancer is used to reduce torsional vibrations on the crankshaft and to minimize component stress, e.g. on the belt drive. A shock absorber with the very best damping characteristics was selected because of the greater power impulses associated with direct fuel injection engines.

The viscous shock absorber has a floating flywheel in silicon oil in the housing. This allows the counter movement of the bearing mass to a not quite evenly rotating crankshaft.

Connecting Rods

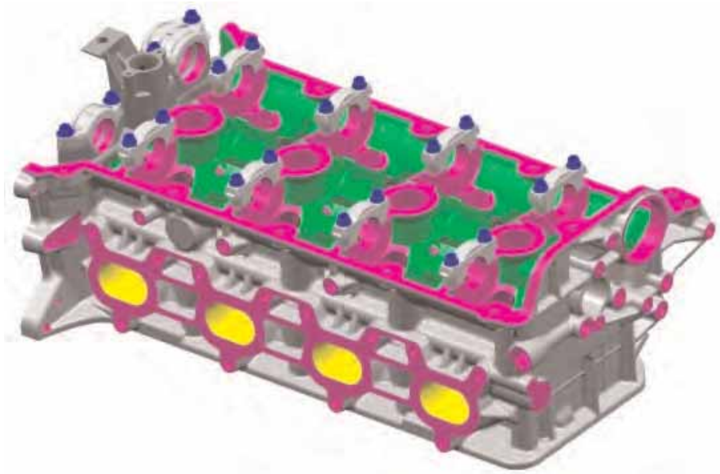
Compared to the 4.5 liter engine, the connecting rods are 2.4 mm longer. This reduces piston lateral runout and is more efficient. The connecting rod bearings are “lead-free” three-component bearings with a diameter of 54 mm. Oil is supplied to the connecting rod bearings via a Y-bore in the crankshaft.

Pistons



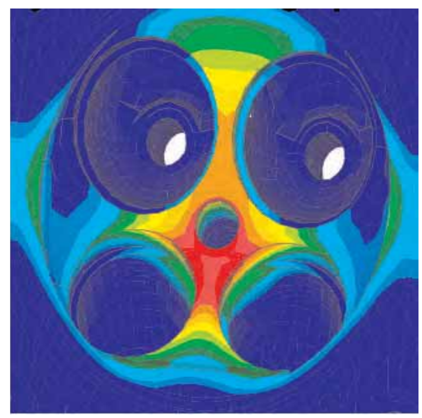
1 - Piston (naturally aspirated engine)
2 - Piston (turbo engine)

The pistons are designed as recessed pistons made of aluminum alloy. They have an iron coating (Ferrocout) at the sides to improve friction characteristics. The pistons are different on cylinder bank 1 and 2 both in the Cayenne S and Cayenne Turbo. Another difference between the pistons in the Cayenne S and Cayenne Turbo is that the combustion cavities have different depths because the compression ratios of both engines are different. The piston ring packages for the turbo and naturally aspirated engines are the same.



Cylinder head water jacket.

The cylinder head and camshaft mount is one joined component and is identical for the Cayenne S and Cayenne Turbo.

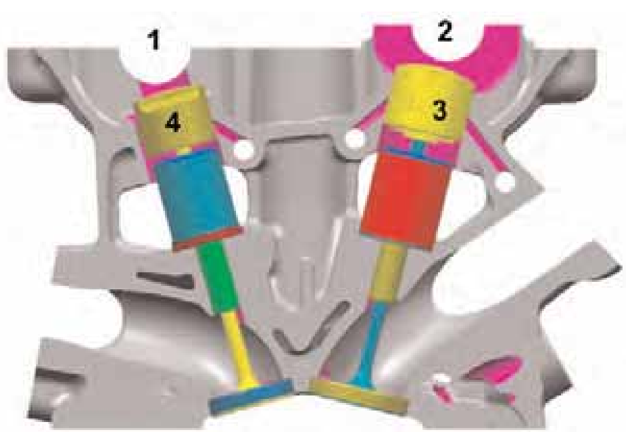


Combustion chamber stress area.

Technical Data, Valve Drive

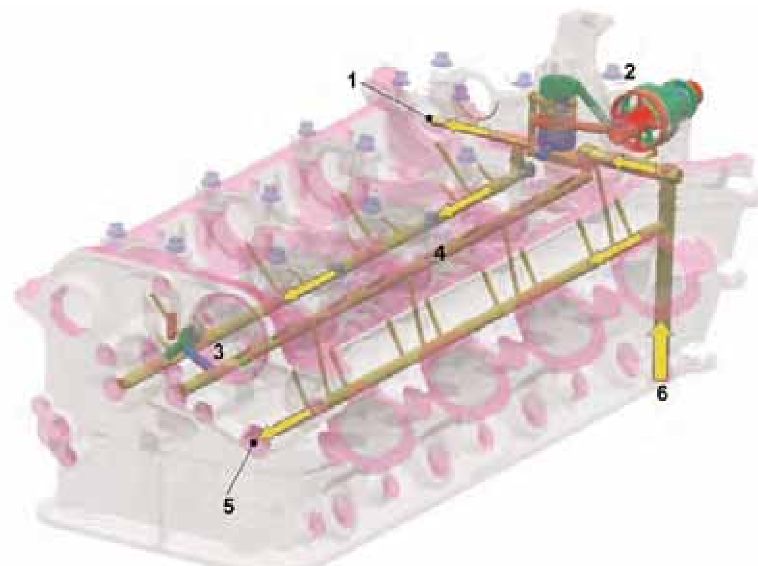
Intake valve diameter	38.3mm
Intake valve lift, large	11.0mm
Intake valve lift, small	3.6mm
Exhaust valve diameter	33.0mm
Exhaust valve lift, cyl. 3, 4, 5, 7	9.2mm
Exhaust valve lift, cyl. 1, 2, 6, 8	8.0mm
Intake valve angle	13.5°
Exhaust valve angle	15.4°
Fuel injector installation angle	29.0°
Camshaft bearing diameter	28.0mm

To ensure efficient gas exchange and valve lift control, the camshaft mount is 9 mm higher on the intake side compared to the outlet side. This arrangement meant that is was possible to optimize the intake port. The cooling system was designed in such a way that high temperature parts are optimally cooled. The cylinder head is made of AlSi7Mg.



1 - Exhaust side
2 - Intake side
3 - Operating plunger
4 - Outlet valve tappet

Oil Supply in the Cylinder Head



1 - Oil supply to the chain tensioner
2 - Camshaft control system
3 - Valve lift control system
4 - Oil supply for valve lift control
5 - Oil supply for turbocharger
6 - Oil intake

Camshaft Control With Valve Lift Control (VarioCam Plus)

The requirements imposed on engine design with regard to higher performance combined with improved driving comfort, compliance with emission regulations and reduced fuel consumption give rise to conflicting design criteria.

The development of the VarioCam Plus was therefore based on the idea of producing a variable engine, which can be optimized for maximum performance and also for regular driving in city traffic or on secondary roads. A control system for the intake camshaft to vary the opening and closing times in combination with a valve lift system is necessary.

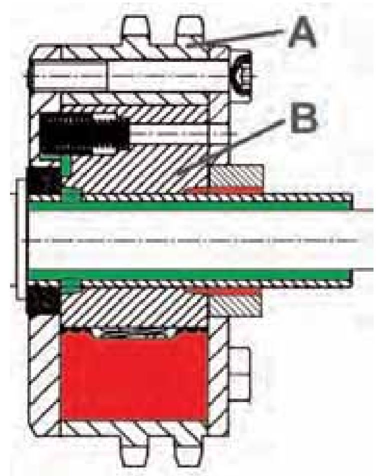
Camshaft Control

Camshaft control on the intake camshaft is based on the principle of a vane controller. The DME control unit determines the current position of the camshaft in relation to the crankshaft (actual angle) on the basis of the speed sensor signal and the Hall sensor signal. The position control in the control unit receives the desired nominal angle via the programmed map values (speed, load, engine temperature). A regulator in the DME control unit activates a solenoid hydraulic valve according to the desired adjustment when there is a difference between the target angle and actual angle. The adjustment angle is 50° in relation to the crankshaft (25° in relation to the camshaft).

Vane Controller

The vane controller consists essentially of the stator **(-A-)**, which is installed on the crankshaft via the sprocket, the rotor **(-B-)**, which is installed on the camshaft, the inserted vanes and two lids. The sprocket is mounted to the outer diameter of the stator. It is interlocked with the crankshaft via the chain drive. The rotor is screwed securely to the camshaft. Rotation is possible between the rotor and stator (inner mounting of the controller). The rotation is limited by the vanes inserted in the rotor and by the stops on the stator. The vanes also divide the recesses on the stator into two separate chambers.

These chambers can be filled with oil via oil bores and oil passages in the rotor. To guarantee secure sealing, small springs are installed between the vanes and rotor. The chambers are each sealed off at the sides with a lid fixed to the sprocket. The controller is locked at a stop (retarded). To do this, a spring-loaded pin in the retarding device of the controller moves into a bore in the lid. An interlocked connection between the stator and the rotor is created for the engine's starting process. This locking prevents noises during the period before oil pressure is produced.

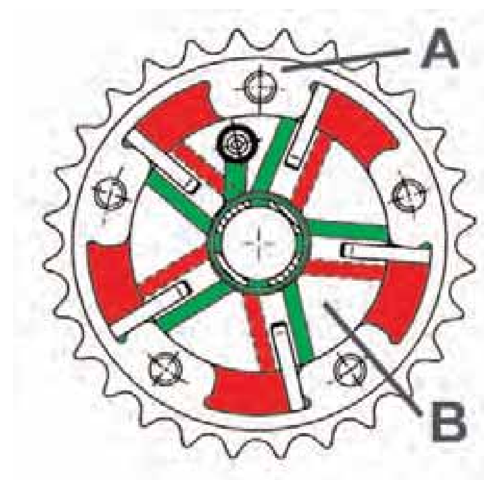


A - Stator
B - Rotor

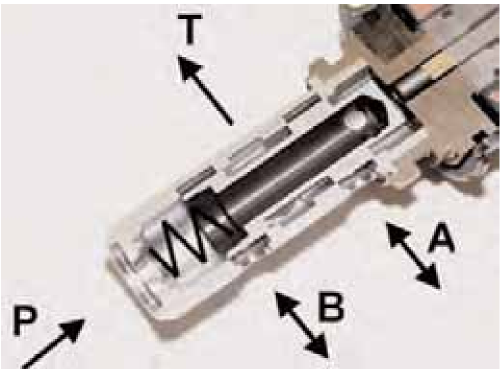
Function

Two chambers, which act in different directions of flow, are contained in the controller. Filling of one chamber turns the rotor with respect to the stator. The rotor and the camshaft can be turned back into the original position by filling the other chamber. The oil of the non-pressurize chamber flows back into the chamber via the solenoid hydraulic valve.

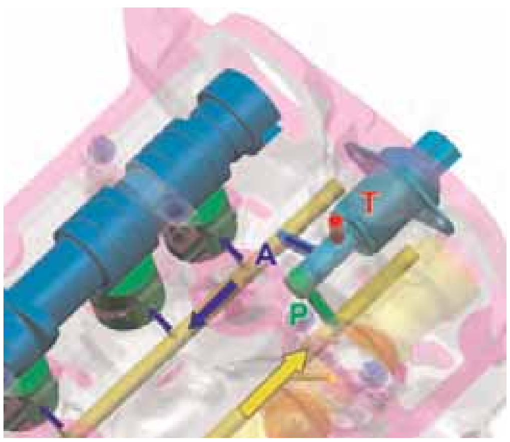
If the oil supply and the oil return are interrupted at the solenoid hydraulic valve (center position of the valve) during the filling of a chamber, the controller remains at the position just assumed. The chambers lose oil through leakage so that the controller leaves its position. The solenoid hydraulic valve is controlled correspondingly by the control unit, and the controller returns to the desired position.



A - Stator
B - Rotor



T - Solenoid hydraulic valve
P - Main oil pressure
A - Control pressure

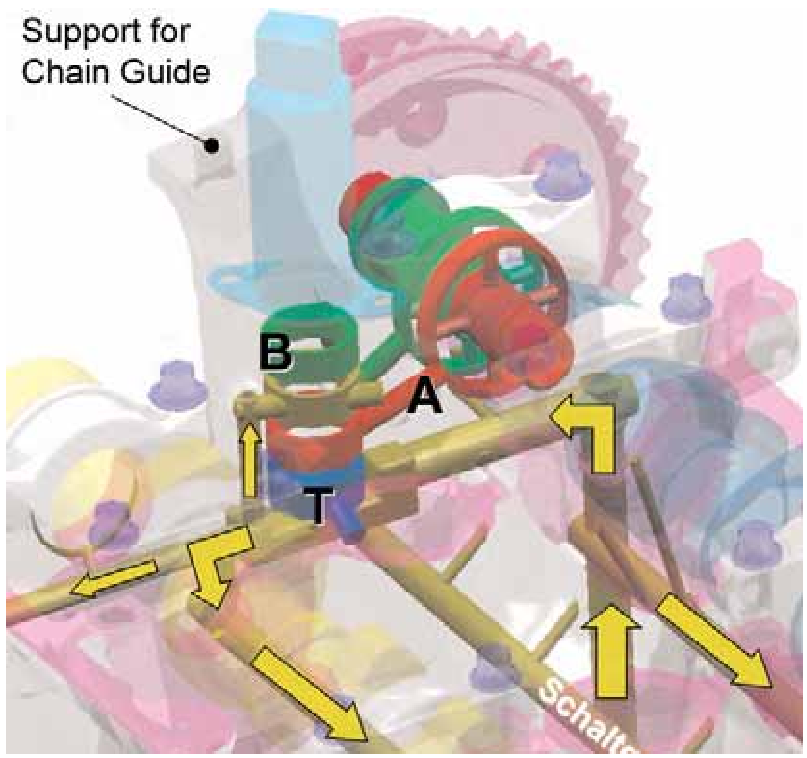


Solenoid Hydraulic Valve

The solenoid hydraulic valve is designed as a 4-way proportional valve, which connects one of the two control lines **(-A/B-)** to the oil pressure supply line **(-P-)** depending on the control unit specification and opens the other line so that the oil can flow into the crank chamber **(-T-line-)**.

If the **-A-** line is pressurized with oil, the controller will change direction to advance the valve timing. If the **-B-** line is pressurized with oil, the controller will change direction to retard the valve timing. Both control lines are closed in the center position. The camshaft is held in the desired position. In addition, any intermediate position between the three switch positions described above can be set via the control unit.

Therefore, it is possible not only to move the adjustment position very quickly but also to move it very slowly in the case of slight deviations of the valve from the central position. In this way, the solenoid hydraulic valve defines the adjustment direction and speed of the controller.



- Oil supply for cam phaser camshaft bearings and timing chain tensioner integrated in one bearing support.
- Screw connection of bearing support together with cam cap bolts.
- Oil Supply for first camshaft bearing (intake side) integrated in A-B oil supply for cam phaser (bleed > T).
- Advantage: no separate oil supply housing (V8 - 4.5) and no square section sealing rings necessary.

Tappet Evolution

Cayenne V8 engines use a "Ultra Leichtbau" lightweight 3CF bucket tappet.

Advantages are:

- Reduced mass
- Increased rigidity

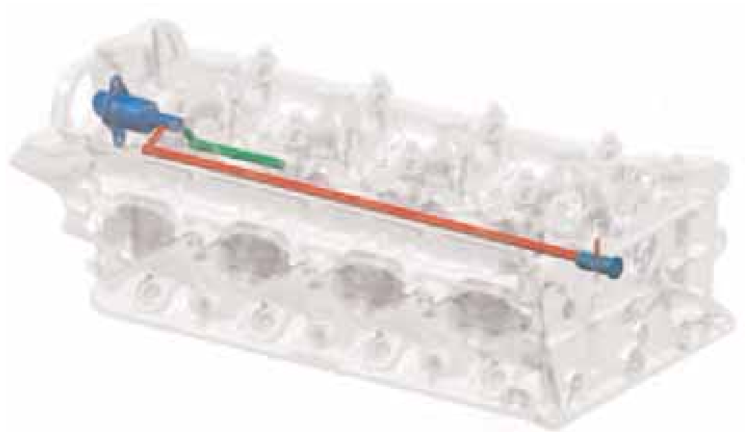
Cylinder Head Design

Previous Cylinder Head

Second Generation Cylinder Head

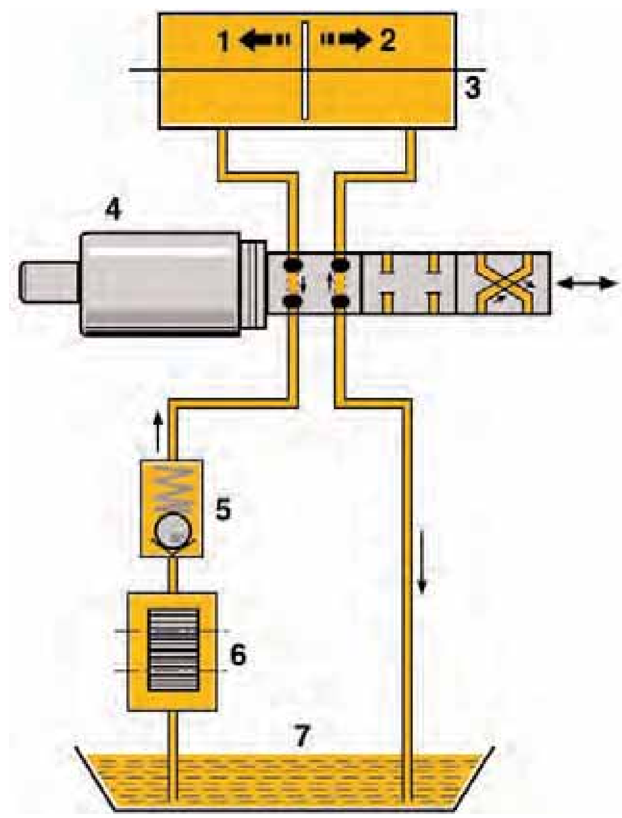
Additional weight savings were gained from the second generation V8 engine cylinder head design. On the left is the previous V8 4.5 liter cylinder head – fully machined, total weight including camshaft housing and bolts was 41 lbs (18.6 kg). On the right is the new second generation 4.8 liter head – fully machined, total weight including valve cover and DFI is 28 lbs (12.6 kg).

Scavenging Concept



A scavenging restrictor is installed on the end of the control pressure line to keep the switching time to a minimum during valve lift control. This scavenging restrictor is used to bleed the line and reduce switching time.

Check Valve



1 - Adjustment direction retarded
2 - Adjustment direction advanced
3 - Camshaft controller
4 - Solenoid hydraulic valve
5 - Check valve
6 - Oil pump
7 - Oil pan

The camshaft requires a high drive torque at times due to the valve actuation, but the camshaft continues rotating unaided at other times (alternating torques). If a check valve is inserted into the P-line and the solenoid hydraulic valve is energized, for example (adjustment in direction of advanced valve timing), the controller automatically intakes oil via the feed line, the solenoid hydraulic valve and the check valve for an advancing camshaft. If the camshaft then tries to lag due to the high drive torque, the check valve closes and the oil cannot escape. The camshaft is driven by the oil cushion of the sprocket during this time, as with a freewheel. The advancing and lagging phases of the camshafts repeat so that the camshaft automatically shifts to advanced valve timing in stages.

As the principle described above only functions with well sealed adjustment control systems and low-friction valve drives, oil pressure is required. To ensure that an extremely large oil pump is not required, the principle described above is taken advantage of when the engine is hot and at a low oil pressure through the use of the check valve. The check valve serves to increase the adjustment speed at low oil pressures.

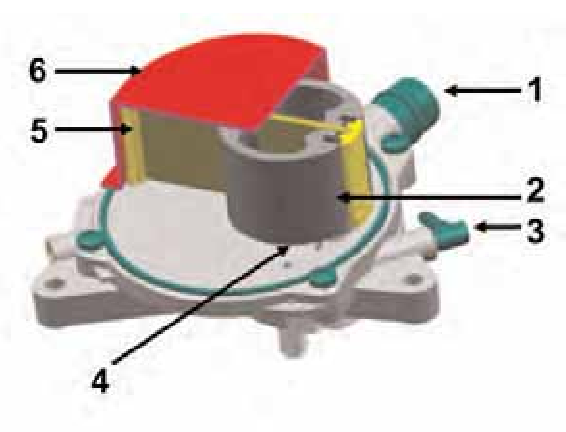
Valves, Valve Springs

The intake and exhaust valves on the Cayenne S and Cayenne Turbo have a shaft diameter of 6 mm. The intake and exhaust valves are bimetallic, i.e. the materials used for the valve plate and the lower part of the valve stem are different to those used for the upper part of the valve stem. In addition, the exhaust valves on the Cayenne Turbo are filled with sodium.

The intake valve springs on the Cayenne S and Cayenne Turbo are identical. They are designed as a conical double valve spring set. This gives a very compact design. The exhaust valve springs on the Cayenne S are conical single valve springs. The Cayenne Turbo features cylindrical double-valve spring sets to ensure that the exhaust valves close, even at higher pressures in the exhaust system.

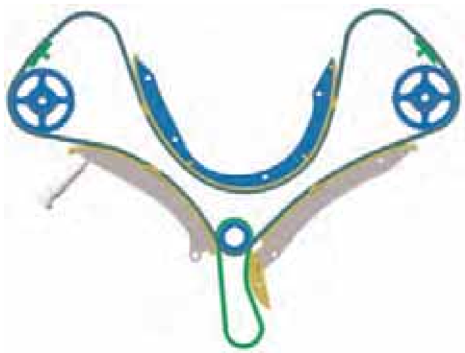
Vacuum Pump

Increased engine dethrottling means that the vacuum supply is no longer sufficient for unfavorable underlying conditions, e.g. low external air pressure at high altitudes and highly dynamic driving. A mechanical single-vane pump driven by the camshaft is used for this reason.



1 - Intake opening
2 - Rotor
3 - Secondary load connection
4 - Outlet valve in crank chamber
5 - Vane with guide shoes
6 - Housing

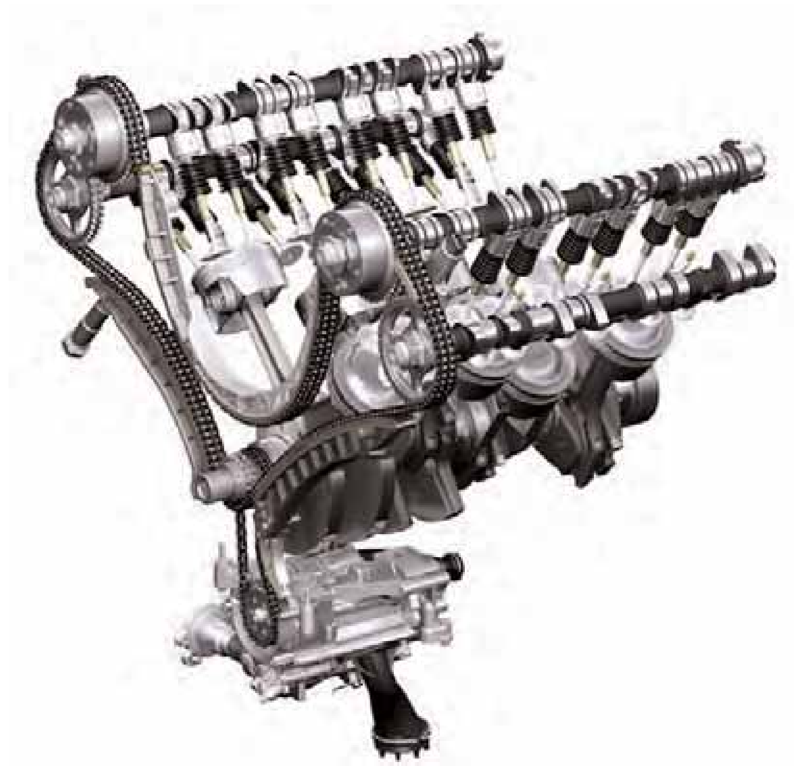
The pump delivery rate is 260cm/revolution.



The chain is guided by two specially coated guide rails. The lower guide rail on cylinder row 1 to 4 is also designed as a tensioning rail. The hydraulic chain tensioner is connected to the engine oil circuit and is totally maintenance free.

The chain drive consists of a 3/8" 8 mm wide duplex bush chain, which drives the two intake and exhaust camshafts.

Timing Drive Mechanism



Camshafts With Cylinder Specific Cam Contours

The intake and exhaust camshafts for both engines have a basic outer diameter of 38 mm. The intake valve lift is 3.6 mm and 11 mm. The exhaust valve lift on cylinders 1, 2, 6 and 8 is 8 mm, while the exhaust valve lift on cylinders 3, 4, 5 and 7 is 9.2 mm.

The engine design, with a V8 crankshaft and 90° throw, guarantees superb mass and torque balancing. In this engine design and a design with normal cam contours (same cam strokes), individual cylinders would be hindered during exhaust outflow into the exhaust manifold. The reason for this is that the surge of exhaust gas that emerges during the early (sooner than normal) exhaust valve opening for the respective cylinder (e.g. cylinder 2) goes into the overlap period of the next cylinder (cylinder 3). This would have a detrimental effect on the charging of the cylinders. Too many residual exhaust gases would also have a negative effect on the knock limit.

The firing order of the Cayenne (1-3-7-2-6-5-4-8) would put cylinders 3, 4, 5 and 7 at a disadvantage in terms of volumetric efficiency. These cylinders therefore have a larger cam stroke. This means that the cylinders are charged evenly, which results in an optimized torque curve in the entire rpm range.

Sprocket

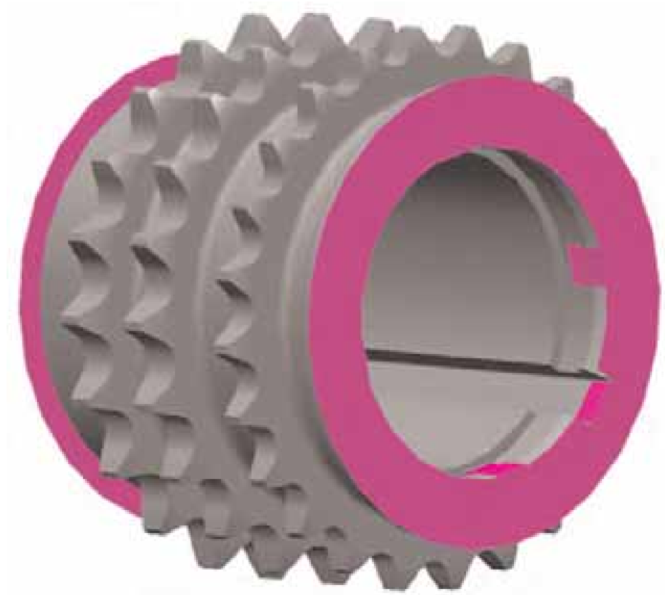


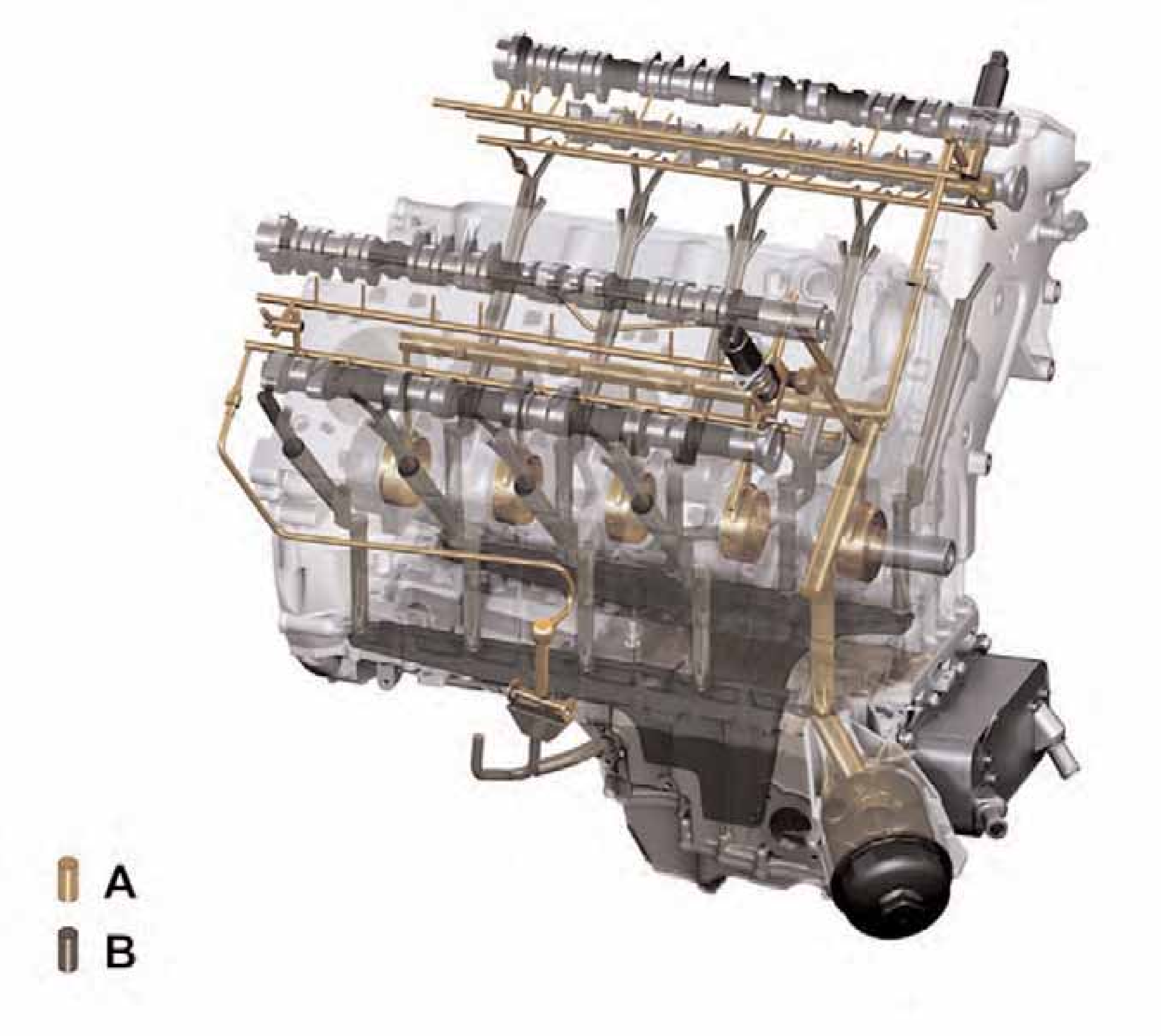
Illustration above shows the surface of the friction disk viewed under a microscope.

The lower sprocket, which drives the timing chain and the chain for the oil pump, has a friction disk on the front (facing the pulley) and rear (facing the crankshaft) for improved torque transmission.

Belt Drive

The secondary units, such as the generator, coolant pump, power-steering pump and air conditioning compressor, are driven from the torsional vibration balancer via a polyrib belt. A maintenance free belt tensioner ensures the correct belt tension in all operating states.

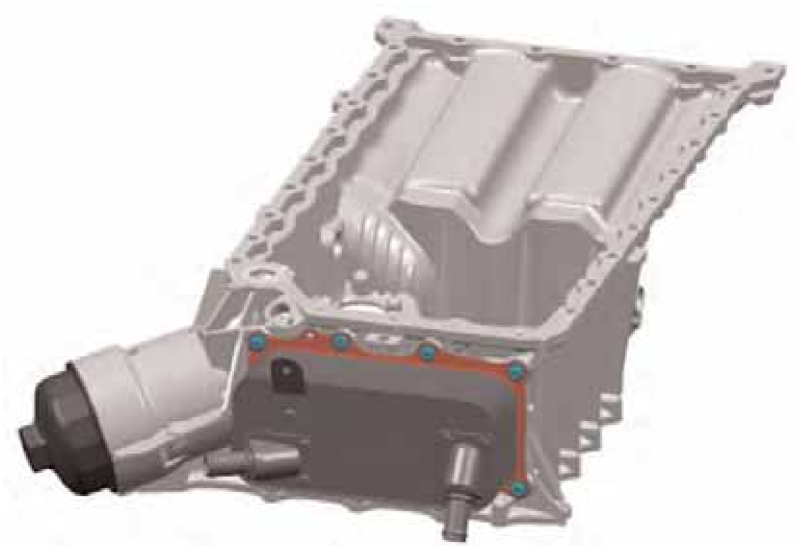
Lubricating Oil System



A - Pressure oil channels
B - Oil return channels

To guarantee a reliable oil supply in all driving situations, the V8 engines in the Cayenne S and Cayenne Turbo have an integrated dry-sump lubrication system.

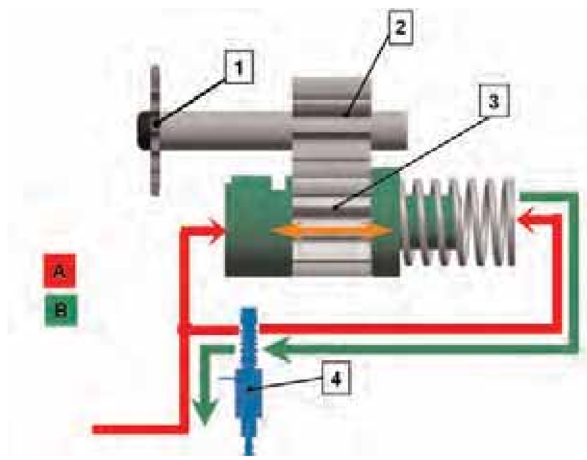
The oil pan is designed in two parts and has an upper and lower part. The oil-water heat exchanger and the oil filter are fitted directly on the upper part of the oil pan. To ensure a lightweight design, the windage tray, the oil return collection tank and the suction pipe are all together in a plastic housing fitted in the oil pan.



The oil pan wall is very thin so as to keep the weight as low as possible.

Oil Pump

The integration of VarioCam Plus, the mechanical vacuum pump and the fact that the lower part of the crankcase is fully aluminum means that oil throughput on the Cayenne S and Cayenne Turbo is very high. A relatively large and efficient pump must be used to guarantee the required oil supply. However, a lot of energy is required to drive such a pump and this energy requirement in turn increases fuel consumption. To counteract this, a variable oil pump is used for the first time in the Cayenne S and Cayenne Turbo.

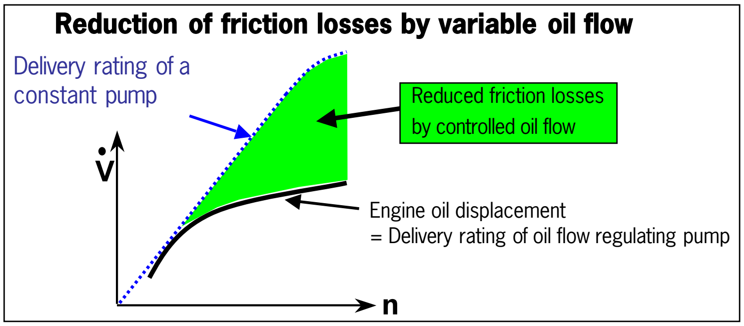


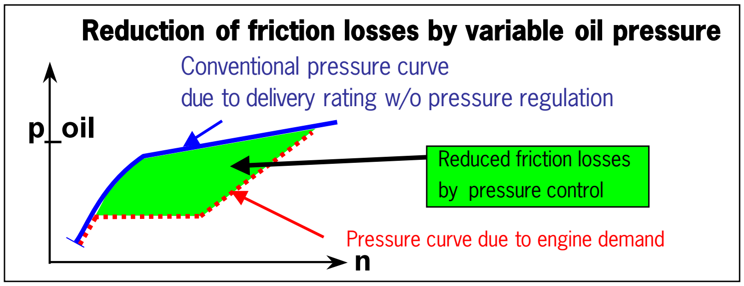
1 - Oil pump chain drive gear
2 - Oil pump driven gear
3 - Movable oil pump gear
4 - Oil pump control valve (lowers pressure on spring end of control piston)

Function

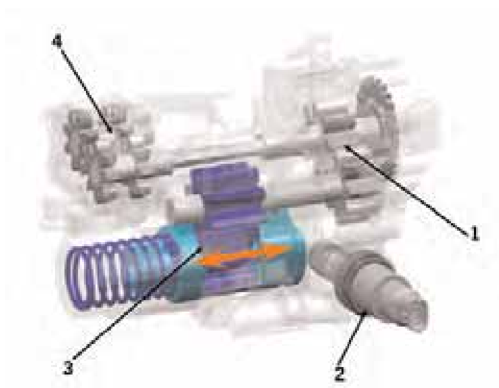
Depending on the input values for engine rpm, engine load, engine oil temperature and the expected change in engine rpm, a specific control valve position **(-4-)** is defined using a map in the DME control unit. The control valve position regulates the oil pressure for the spring piston on the gear wheel, which can move in axial direction. The oil pressure on the control piston is not regulated on the other side. The control valve is open fully in the non-energized state and as a result, the oil pressure is the same on both sides, which means that the gear wheel will not move.

In other words: the pressure difference between the spring piston and the control piston can be used to control every position. When the gear wheel moves, the teeth are still only partially engaged and as a result, performance and friction as well as energy requirements are reduced.



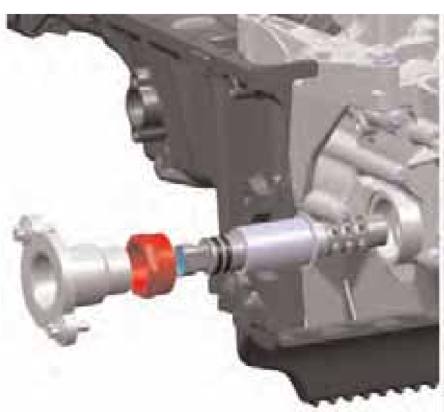


Cayenne Turbo Oil Pump



1 - Intake stage
2 - Control valve
3 - Variable pressure stage
4 - Turbocharger suction pump

The Cayenne Turbo has an additional pressure oil line for turbocharger lubrication. A turbocharger suction pump **(-4-)** is integrated in the main oil pump for suctioning off the lubricating oil.



The control valve is fitted on the oil pump in such a way that it can be accessed from the outside.

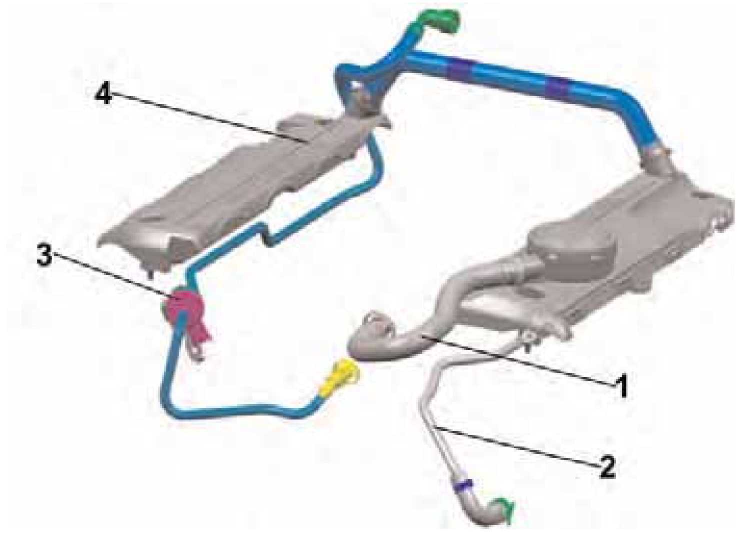
Oil Spray Jets

The temperature of the pistons in the Cayenne S and Cayenne Turbo engine is reduced by means of spray cooling. The spray jets are fitted on the upper part of the crankcase. The spray oil is also used for improved lubrication of the cylinder lining. To ensure the necessary engine oil pressure at low rpms and high engine oil temperatures, the spray jets have an opening pressure of approx. 1.8 bar.

Positive Crankcase Ventilation

During combustion, every engine blows some of the combustion gases past the piston towards the crankcase – these gases are called blow-by gases. If these gases are not drawn off, the pressure in the crankcase would increase considerably. A vent connection is installed in the crankcase for this reason. For environmental protection reasons, these gases are not released into the atmosphere, but are sent back to the engine for combustion via the intake system. Of course, these positive crankcase ventilation gases contain a high proportion of engine oil and other combustion residues as well as fuel residues in some cases. If these gases get into the intake duct, they will contaminate the intake air and can then impair running smoothness, exhaust emissions and reduce knock resistance. For these reasons effective oil separation is important for the engine.

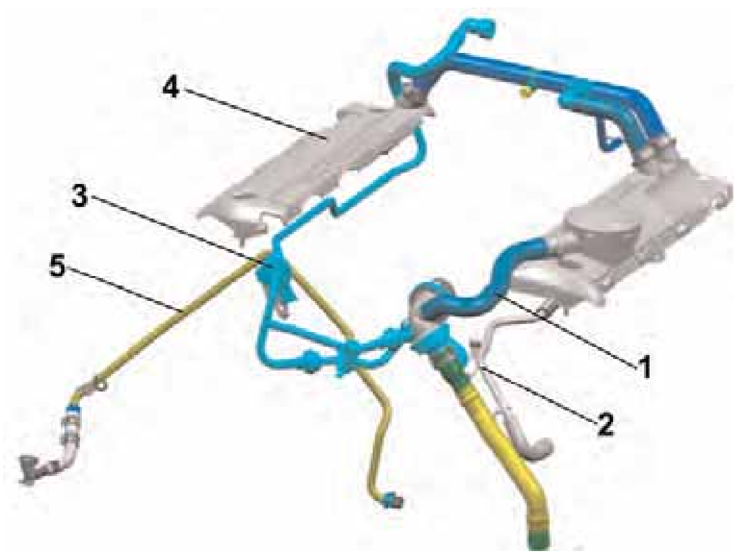
Positive Crankcase Ventilation – Naturally Aspirated Engine



1 - Return connection for blow-by gases
2 - Return line
3 - Tank vent
4 - Positive crankcase ventilation

Positive Crankcase Ventilation - Turbo Engine

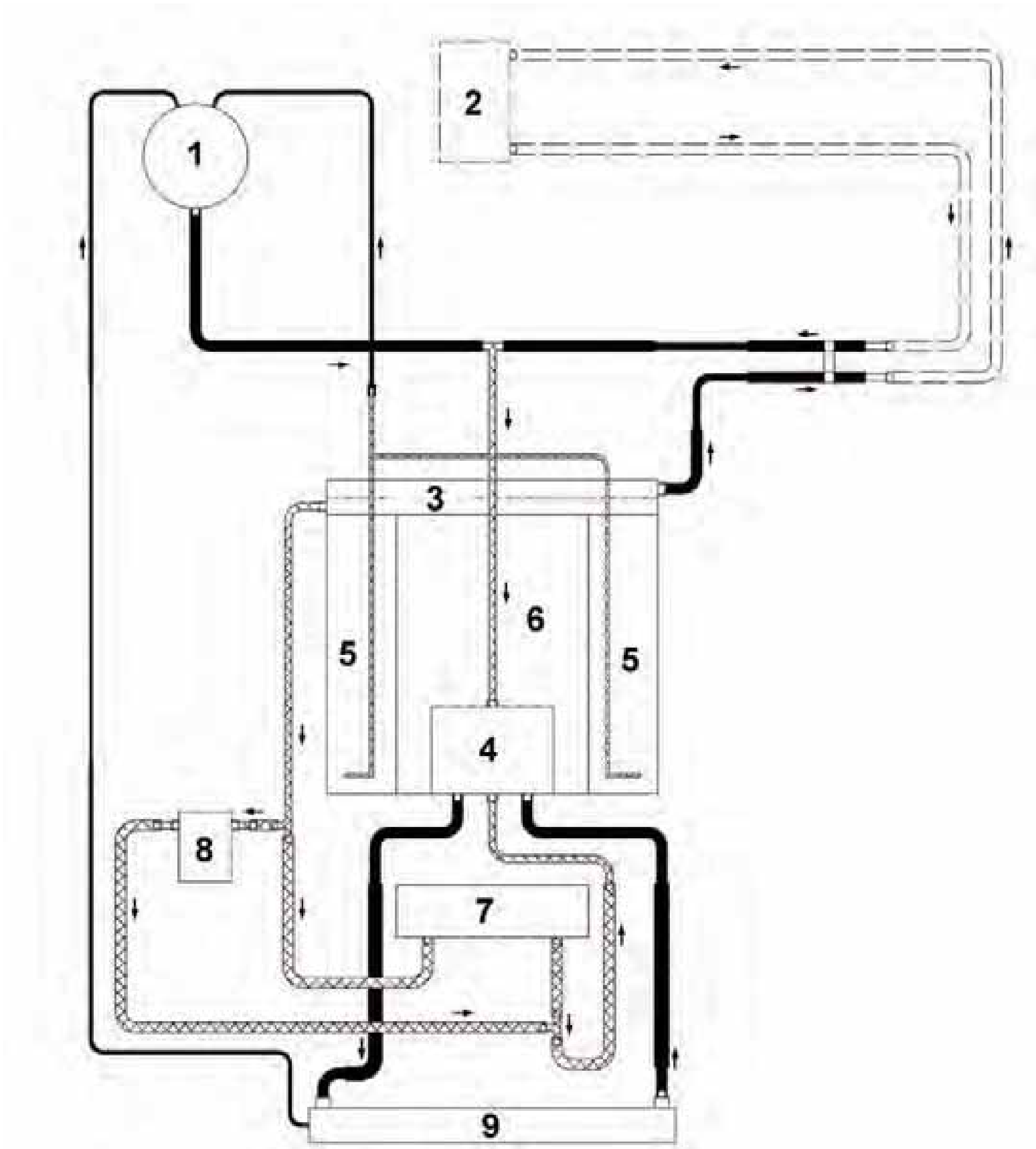
The positive crankcase ventilation system in the Cayenne Turbo can reduce the amount of fuel that goes into the engine oil during combustion. The aeration and ventilation system (Positive Crankcase Ventilation-PCV) ventilates the crankcase with a steady stream of fresh air, which accelerates the evaporation of fuel that is carried in.



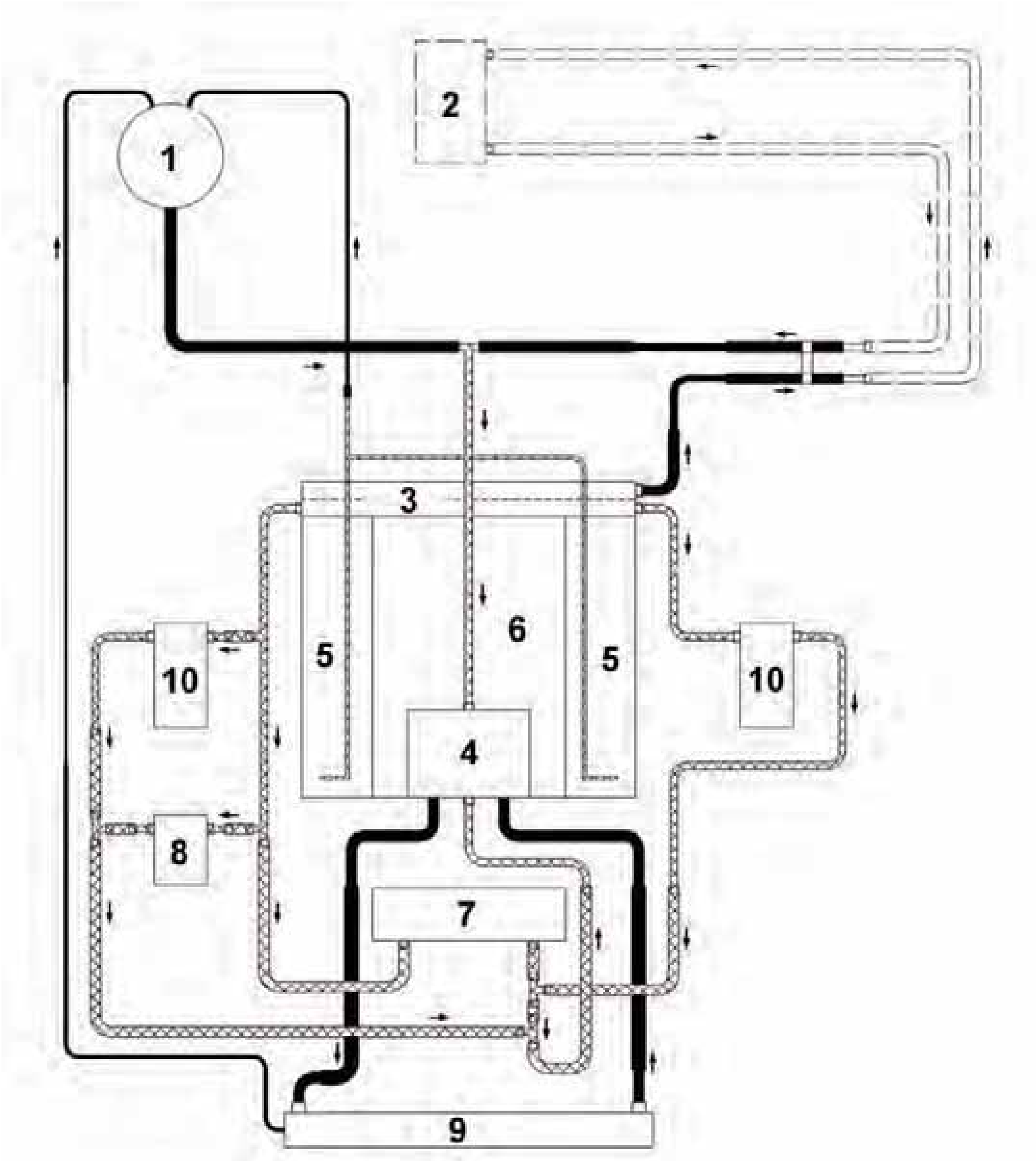
1 - Return connection for blow-by gases
2 - Return line
3 - Tank vent
4 - Positive crankcase ventilation
5 - PCV connection

For this purpose, fresh air is removed between the charge air cooler and throttle valve and is delivered to the crank chamber via a line. The pressure that exists at any time between the removal position and the crankcase causes a steady flow of fresh air through the crankcase. To ensure enough vacuum in the crankcase in all operating states, the vacuum in the intake manifold is used in the part-load ranges. A pressure regulating valve regulates this vacuum until the required value is reached. The vacuum from the compressor is used in the boost range (no vacuum present).

Cayenne S Cooling System



1 - Coolant reservoir
2 - Heat exchanger
3 - Coolant collection pipe
4 - Coolant pump/thermostat housing
5 - Cylinder head
6 - Crankcase
7 - Oil-water heat exchanger
8 - Generator
9 - Radiator



1 - Coolant reservoir

2 - Heat exchanger

3 - Coolant collection pipe

4 - Coolant pump/thermostat housing

5 - Cylinder head

6 - Crankcase

7 - Oil-water heat exchanger

8 - Generator

9 - Radiator

10 - Turbocharger