

1 Engine

Cayenne

General

The completely new developed V8 engines are a naturally aspirated engine for the Cayenne S and a turbocharged version for the Cayenne Turbo, each with a capacity of 4.5 liters.

They are 8-cylinder, 32-valve gasoline engines, with the cylinder banks arranged at 90 degrees and two camshafts per cylinder bank.

Particular attention was paid during the development of these new engines to achieving the maximum specific output while at the same obtaining outstanding emissions and fuel consumption characteristics.



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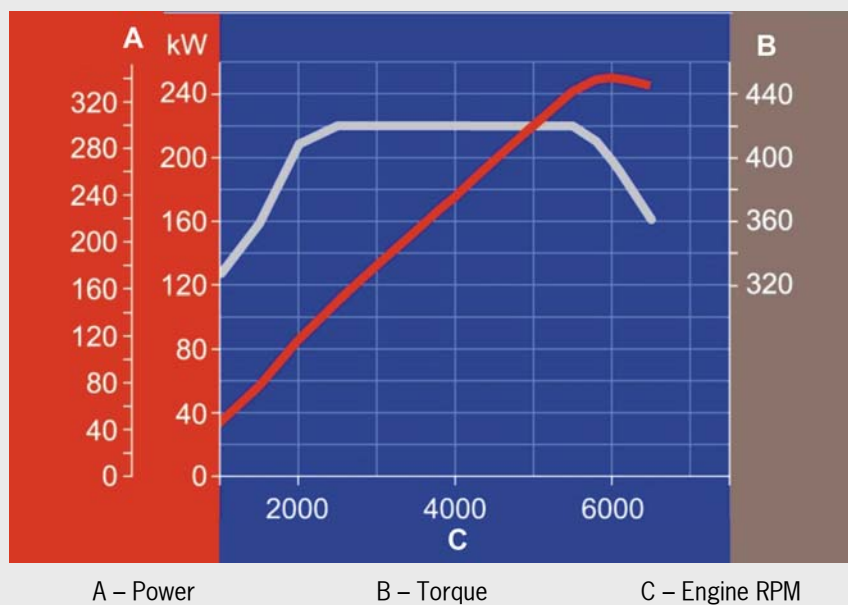
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Important Features

- Two-piece closed deck aluminum crankcase with integrated cast-iron bearing blocks
- Two-piece cylinder heads with separate camshaft housing
- Continuously variable camshaft adjustment on the intake side (VarioCam)
- Cylinder-selective exhaust cam contours
- Integral dry-sump lubrication
- Two-stage oil scavenging, additional turbocharger scavenge pump for V8 twin-turbo engine
- Spray cooling of pistons (V8 twin-turbo engine only)
- Oil-water heat exchanger
- Cross-flow cooling of cylinder heads, longitudinal flow through crankcase

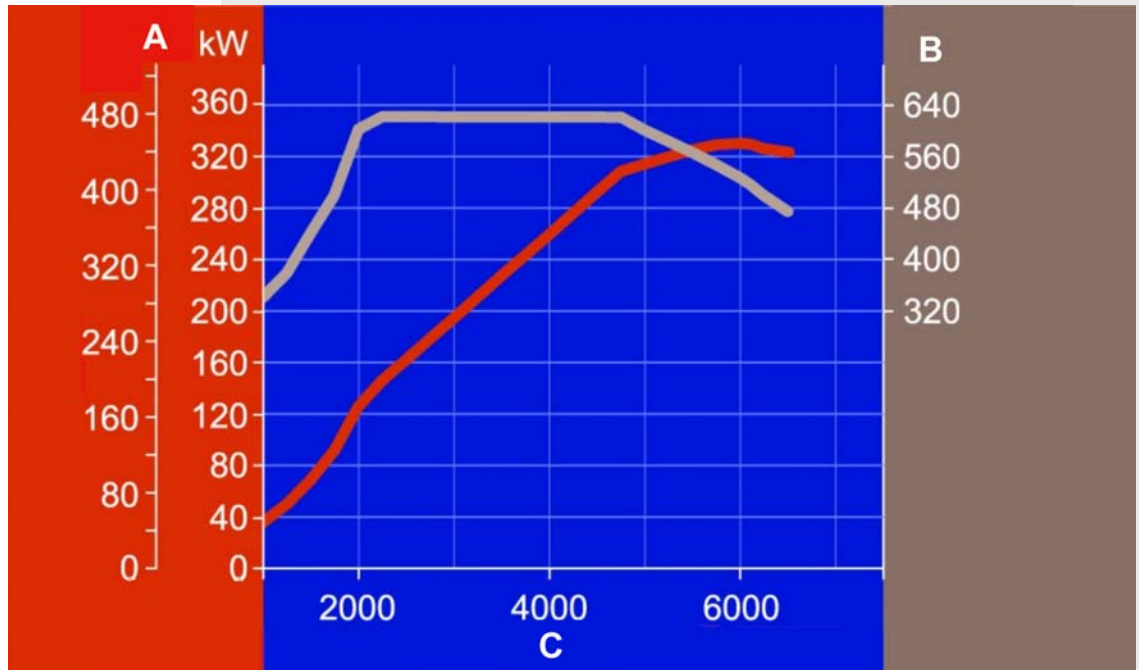
Full-Throttle Curve Cayenne S

Cayenne



Engine Data Cayenne S

Engine type	M48/00
Number of cylinders	8
Bore	93 mm
Stroke	83 mm
Capacity	4511 cc
Compression ratio	11,5
Max. power	250 kW (340 hp)
@	6000 rpm
Max. torque	420 Nm
@	2500 – 5500 rpm
Governed engine speed manual shift/Tiptronic	6700 / 6500 rpm
Engine weight	227 kg
Firing order	1 – 3 – 7 – 2 – 6 – 5 – 4 – 8



A – Power

B – Torque

C – Engine RPM

Engine Data Cayenne Turbo

Engine type	M48/50
Number of cylinders	8
Bore	93 mm
Stroke	83 mm
Capacity	4511 cc
Compression ratio	9,5
Max. power	330 kW (449 hp)
@	6600 rpm
Max. torque	620 Nm
@	2250 - 4750 rpm
Governed engine speed manual shift/Tiptronic	6500 rpm
Engine weight	253 kg
Firing order	1 – 3 – 7 – 2 – 6 – 5 – 4 – 8

Engine Mounts

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The engine mounts consist of two hydro mounts attached to an engine cross member and an elastomer mount in the center of the transmission. The hydro mounts uncouple low-frequency vibrations with their rubber bearing, but also suppress high-frequency vibrations with their damping section and thus ensure that no undesirable vibration and noise is conducted into the body. To limit loads on the rubber body, which occur particularly in hard off-road use, the engine mounts are furnished with stops.

For reasons of weight and rigidity, the engine cross-member is formed as a hollow profile.



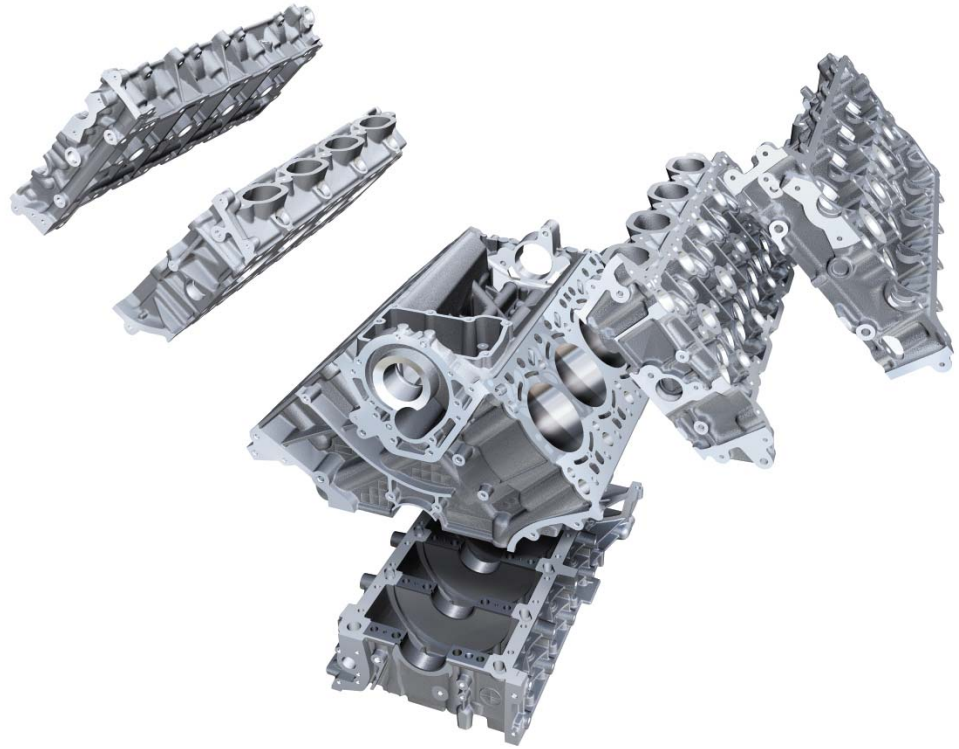
The high torque produced by the V8 engines is absorbed by an additional torque strut on the cylinder head.



Cayenne

Crankcase

The crankcase in the Porsche Cayenne is a two-piece “closed deck” design, made of a light-weight alloy (AlSi17Cu4Mg). In closed deck construction, the sealing surface of the crankcase to the cylinder head is largely closed, only the bores and passages for oil and coolant are present. The entire structure is additionally stiffened by means of this design. The result is reduced cylinder distortion and benefits in oil consumption.



The alloy for the crankcase housing is a so-called hypereutectic alloy, in which silicon crystals are formed. To create a wear-resistant surface on the cylinder walls, these silicon crystals are uncovered by multiple special honing procedures. To minimize thermal changes in bearing clearance and thus reduce mechanical noise, the lower section of the crankcase is furnished with cast-in cast iron bearing blocks. A further benefit is that when the engine is at operating temperature, oil flow at the main bearings does not increase substantially as a result of the constant bearing clearance (approximately the same coefficient of thermal expansion between steel/crankshaft and cast iron/bearing block).

Crankshaft

The drop-forged crankshaft runs in five bearings and has eight counterweights. Main bearing number 3 is designed as a thrust bearing. Axial play is determined by two thrust washers, which are set into the bearing housing halves. The main bearings are dual material bearings and are 64 mm in diameter. The connecting rod bearings are triple material bearings and are 54 mm in diameter.

Vibration Damper

A vibration damper is used to reduce torsional vibration at the crankshaft and additionally reduce component loads. In addition, core plugs are provided for various maintenance and repair operations.



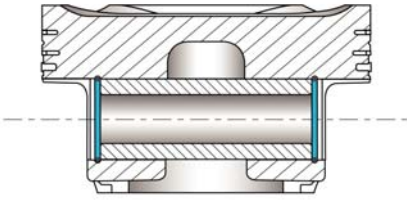
Connecting Rods

After machining, the forged connecting rods are broken apart at the rod bearing (cracked). The two parts are centered to one another by means of the resulting fracture pattern. To prevent incorrect assembly, the connecting rods are marked with additional matching pairs of numbers and the bores for the big-end bolts are offset.

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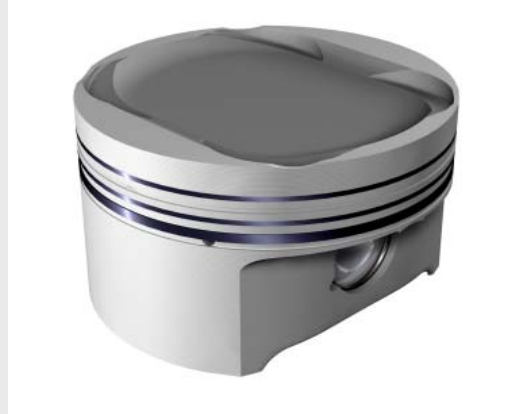


Cayenne



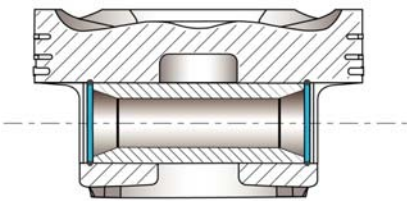
Cayenne S Pistons

The pistons for the naturally aspirated engines are cast.



Cayenne Turbo Pistons

The pistons for the turbocharged engines are stamped.



One feature distinguishing the pistons of the naturally aspirated engine from the turbocharged engine are the combustion bowls. The bowls in the pistons for the turbo engine are much deeper in order to reduce the compression ratio.

Cayenne S Cylinder Head

The cylinder head for the Cayenne S is designed in two pieces. It consists of the cylinder head proper and the camshaft housing with the lifter guides and the camshaft bearings. This multi-piece construction offers the best environment for the use of high-heat resistant aluminum alloys and thus maximum specific loads can be realized.

The exchange of gases is managed by 4 valves per cylinder, which are operated directly over hydraulic self-adjusting lifters. The two inlet and two exhaust valves are arranged in a V, with a valve angle of 29.6°.



Cayenne Turbo Cylinder Head

The cylinder head design of the Cayenne Turbo is identical in principle to that of the Cayenne S, but because of the higher loading a special high-heat resistant aluminum alloy is used.

The inlet ports in the cylinder head have been reworked with respect to different gas velocities compared to the naturally aspirated engine.

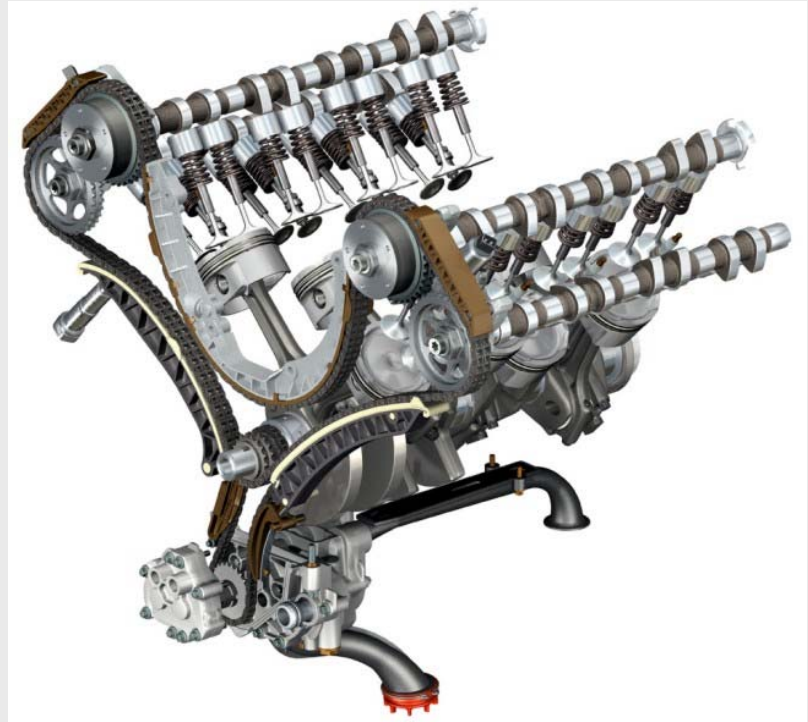
Valves, Valve Springs

The valve stem diameter for the intake and exhaust valves on the Cayenne S and the Cayenne Turbo is 6 mm. The intake and exhaust valves are bi-metallic, that is to say different materials are used for the valve head and the lower part of the stem than for the upper part of the valve stem. In addition, the exhaust valves for the Cayenne Turbo are sodium-filled.

The diameter of the intake valve heads is 37.1 mm and that of the exhaust valve heads is 32.5 mm for both engine versions.

The intake and exhaust valve springs on the Cayenne S and the intake valve spring on the Cayenne Turbo are single helical springs. To ensure proper closing of the exhaust valves even at higher pressures in the exhaust system, dual valve springs are installed on the exhaust side on the Cayenne Turbo.

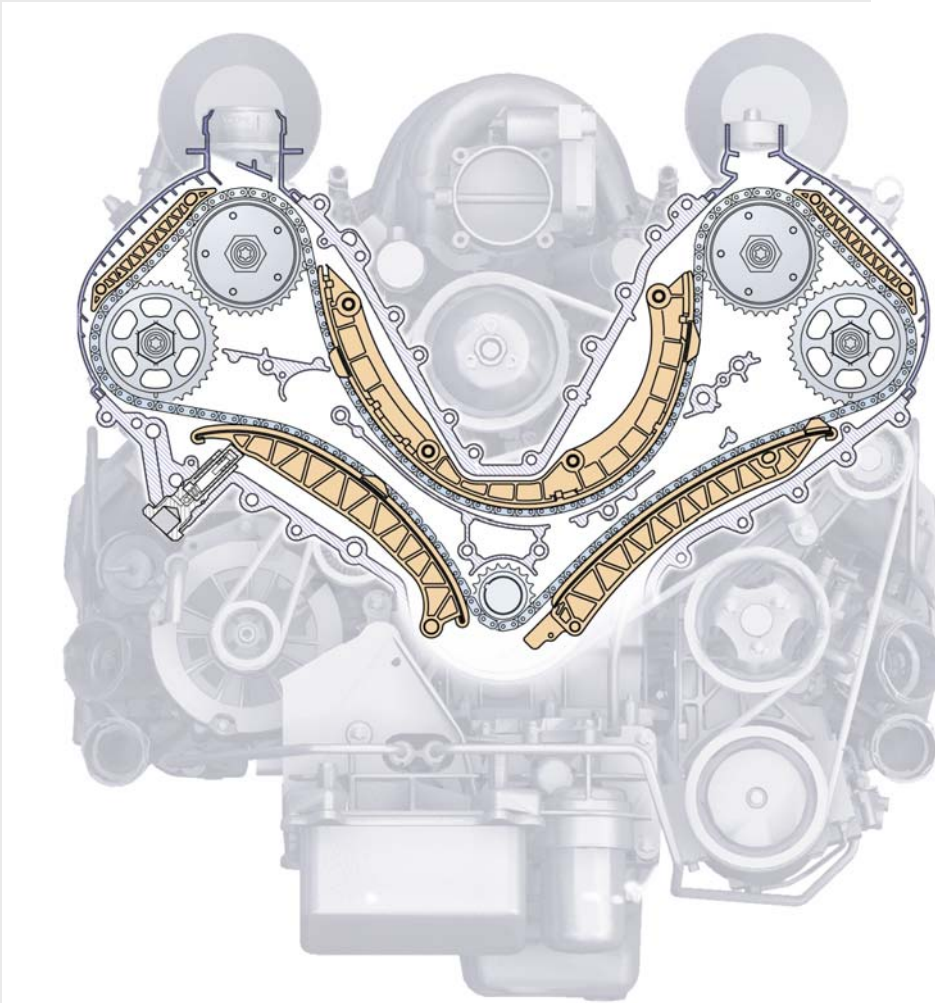
Camshafts with Cylinder-Specific Cam Contours



The intake and exhaust camshafts for both engine versions have a base diameter of 38 mm. Intake valve lift is 10 mm. Exhaust valve lift for cylinders 1, 2, 6 and 8 is 8 mm, for cylinders 3, 4, 5 and 7 exhaust valve lift is 9.85 mm.

The engine design with a V8 crankshaft and 90° throws ensures outstanding balancing of masses and forces. However, with this engine design and a layout with conventional cam contours (equal cam lift) individual cylinders would hamper each other as gas flows out into the exhaust header.

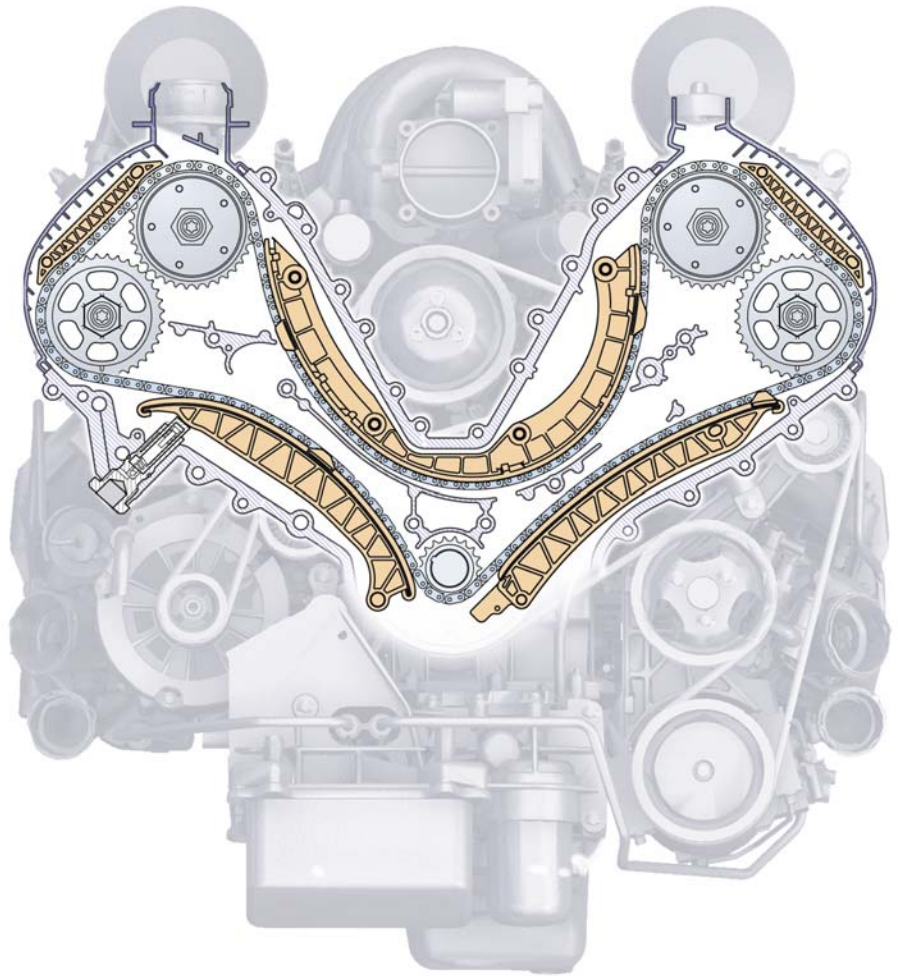
The reason is that the exhaust lead impulse of the particular cylinder on the exhaust stroke (e.g. cylinder number 2) gets into the crossover phase of the following cylinder (cylinder number 3). This would have a detrimental effect on cylinder filling. In addition, excess residual gases have a negative effect on the knock limit. Because of the Cayenne's firing order (1 – 3 – 7 – 2 – 6 – 5 – 4 – 8), cylinders 3 and 4 as well as 5 and 7 would be at a disadvantage in their charge. So these cylinders are given higher cam lift. This step achieves equal filling of the cylinders, which results in an optimized torque curve across the entire rpm range.



The chain drive consists of a duplex roller chain driving both intake and exhaust camshafts. The chain is guided by specially coated slippers. The lower slipper on cylinder bank 1 – 4 is designed to be a tensioner at the same time. The hydraulic chain tensioner is part of the engine oil circulation system and is maintenance-free.

Belt Drive

Accessories such as the alternator, coolant pump, power steering pump and air-conditioning compressor are driven over a PolyRip belt by the vibration damper. A maintenance-free, hydraulic belt tensioner ensures correct tension in all areas.



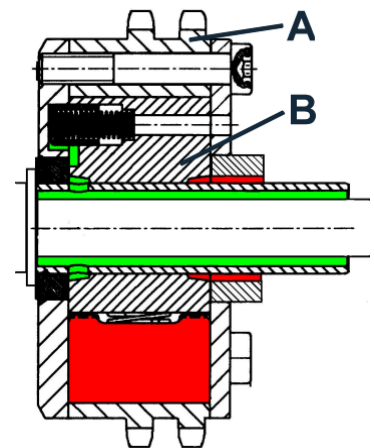
Camshaft adjustment at the intake camshaft is based on the principle of a vane-type adjuster. The DME control module determines the current position of the camshaft to the crankshaft (actual angle) from the engine speed sensor and Hall sensor signals. The position control in the control module receives the desired specified angle via the programmed map values (rpm, load, engine temperature). If there is a difference between the specified and actual angle, a regulator in the DME control module actuates a hydraulic solenoid valve according to the desired adjustment. Adjustment angle is 50° crankshaft angle (25° camshaft angle).

The vane-type adjuster consists of the stator (A) – attached to the crankshaft through a sprocket –, the rotor (B) – attached to the camshaft – the vanes and two covers. The sprocket is attached to the outer diameter of the stator. It is a positive fit to the crankshaft through the chain drive. The rotor is bolted to the camshaft. Rotation between rotor and stator is possible (inner mounting of the adjuster). This rotation is limited by the vanes mounted in the rotor and by the stops on the stator. The vanes also divide each of the recesses on the stator into two chambers.

These chambers can be filled with oil via oil orifices and oil lines in the rotor. To ensure secure sealing, small springs are installed between the vane and rotor. The chambers are sealed laterally by a cover attached to the sprocket. The adjuster is locked to a stop (retard). To do this, a spring-loaded pin in the retard position of the adjuster moves into a hole in the cover. A positive connection is created between stator and rotor for starting the engine. Noise during the period of no oil pressure is prevented by means of this locking action.

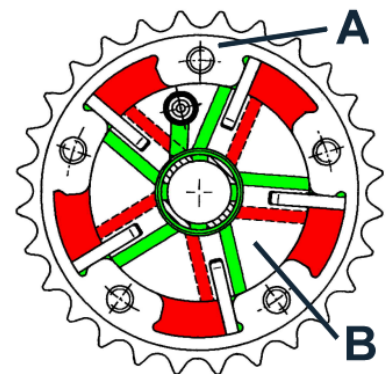
Operation

Two chambers acting in different directions are provided in the adjuster. Filling one chamber causes the rotor to rotate with respect to the stator. By filling the other chamber, the rotor and thus the camshaft can be rotated back to its initial position. The oil from the non-pressurized chamber flows via the hydraulic solenoid valve back into the crankcase. If the oil feed and the oil return at the hydraulic solenoid valve is interrupted while one chamber is being filled (middle position of the valve), the adjuster stops in the position it has just assumed. The chambers lose oil due to leakage so that the adjuster leaves its position. The hydraulic solenoid valve is actuated accordingly through the control module, and the adjuster returns to the desired position again.

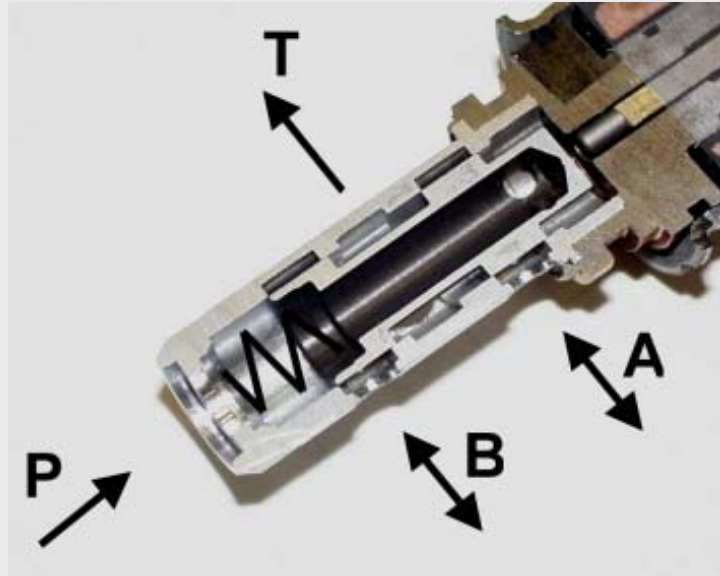


A – Stator

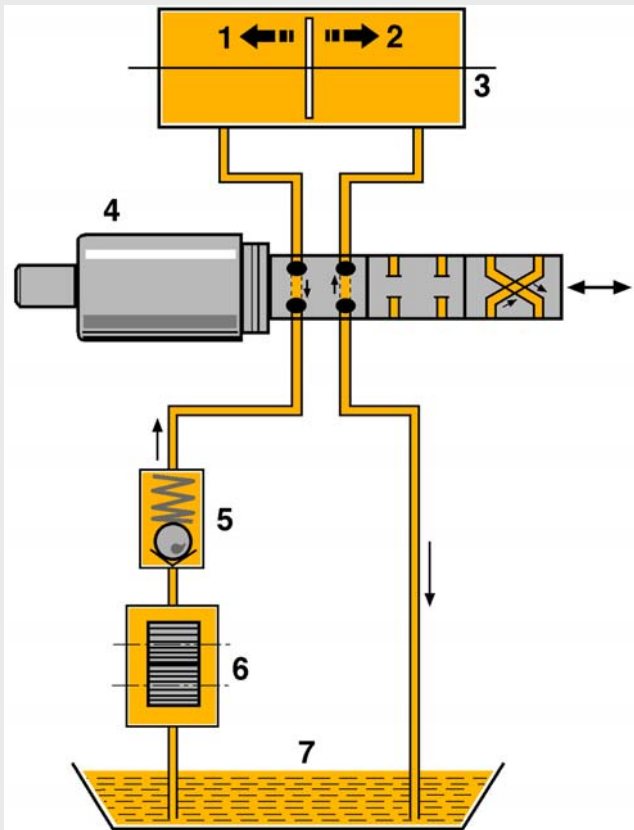
B – Rotor



Hydraulic Solenoid Valve

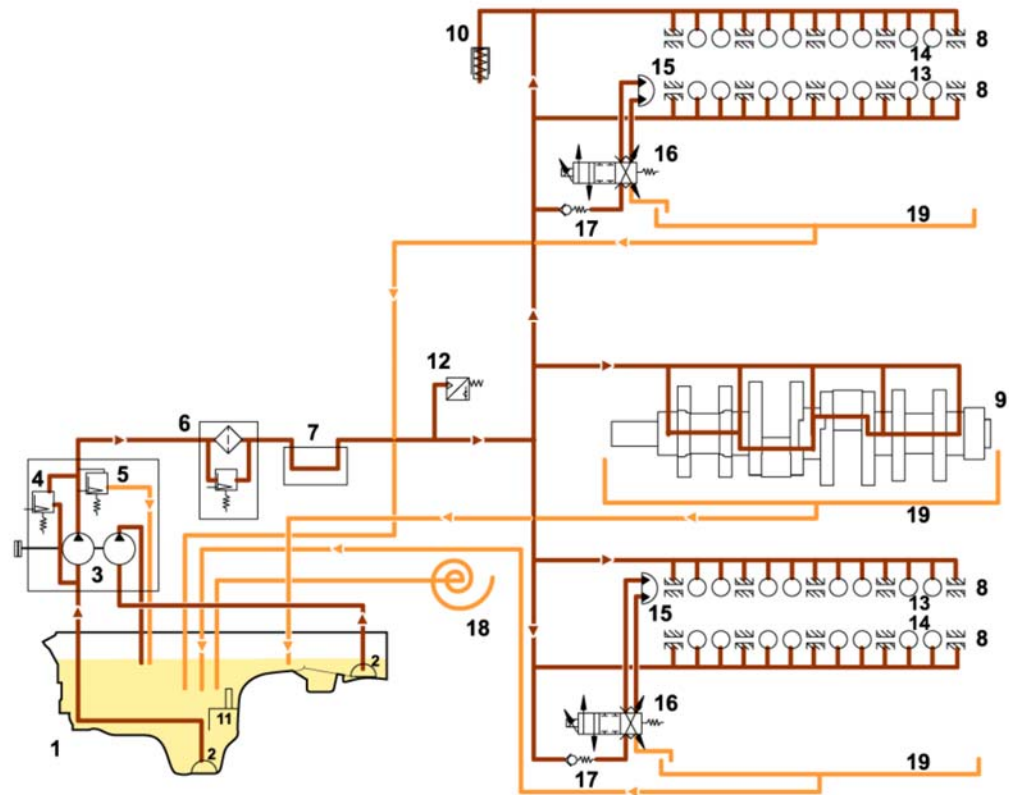


The hydraulic solenoid valve is designed as a four-way proportioning valve and, depending on the setting from the control module, connects one of the two control lines (A/B) to the oil pressure supply line (P) and opens the other line to allow the oil to flow out into the crankcase (T-line). If oil pressure is applied to the A-line, the adjuster is rotated in the direction of early. If oil pressure is applied to the B-line, the adjuster is rotated in the direction of later timing. In the middle position both control lines are closed. The camshaft is held in the desired position. Any interim position between the three positions described can be set through the control module. So it is not only possible to adjust the position very quickly, but also very slowly in the event of minor deviations of the valve from the middle position. The hydraulic solenoid valve sets the direction and the speed of adjustment of the adjuster.



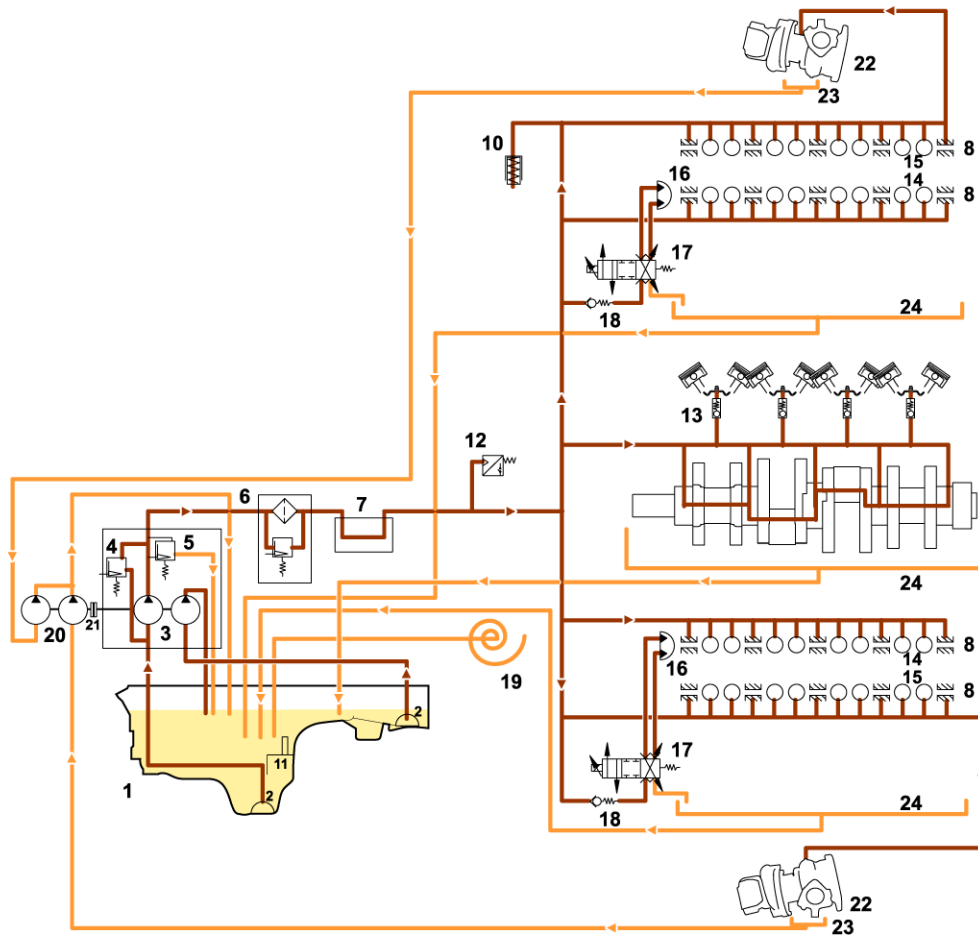
- 1 – Adjustment Direction Late
- 2 – Adjustment Direction Early
- 3 – Camshaft Adjuster
- 4 – Hydraulic Solenoid Valve
- 5 – Non-return Valve
- 6 – Oil Pump
- 7 – Oil Pan

Occasionally the camshaft requires high drive torque for valve operation, at other times the camshaft continues to run independently (alternating torque). If a non-return valve is placed in the P-line and current is applied to the hydraulic solenoid valve (adjustment toward early valve timing) with the camshaft advancing, the adjuster sucks oil by itself through the feed line, the hydraulic solenoid valve and the non-return valve. If the camshaft then wants to lag behind because of the high drive torque, the non-return valve closes and the oil cannot escape. During this time the camshaft is driven through the oil cushion by the sprocket, as happens when it is free-wheeling. The camshafts repeatedly advance and are then driven, so that the camshaft gradually runs at early valve timing by itself. Since the principle just described works only with very tightly sealed adjuster systems and low friction valve gear, oil pressure is required. To avoid the need for an extremely large oil pump, the principle described can be taken advantage of with a hot engine and low oil pressure by using the non-return valve. The non-return valve serves to increase adjustment speed under conditions of low oil pressure.



— Pressurized oil — Oil return

- | | |
|---|--|
| 1 – Oil pan | 10 – Chain tensioner |
| 2 – Suction tube with screen | 11 – Oil level detector and oil temperature sensor |
| 3 – Oil pump | 12 – Oil pressure sensor |
| 4 – Control valve (regulates oil pressure to about 5 bar) | 13 – Hydraulic lifters inlet |
| 5 – Safety valve (opens at 10 bar) | 14 – Hydraulic lifters outlet |
| 6 – Full-flow oil filter with pressure relief valve | 15 – Camshaft adjuster |
| 7 – Oil-water heat exchanger | 16 – Hydraulic solenoid valve |
| 8 – Camshaft | 17 – Non-return valve |
| 9 – Crankshaft | 18 – Oil mist separator |
| | 19 – Oil return passages |



— Pressurized oil

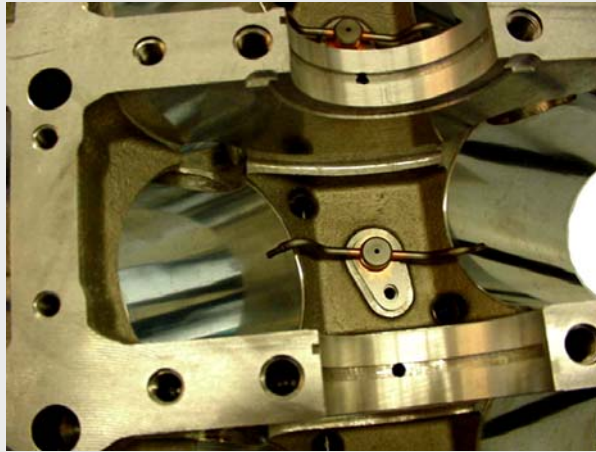
— Oil return

- 1 – Oil pan
- 2 – Suction tube with screen
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- 4 – Control valve (regulates oil pressure to about 5 bar)
- 5 – Safety valve (opens at 10 bar)
- 6 – Full-flow oil filter with pressure relief valve
- 7 – Oil-water heat exchanger
- 8 – Camshaft
- 9 – Crankshaft
- 10 – Chain tensioner
- 11 – Oil level detector and oil temperature sensor
- 12 – Oil pressure sensor

- 13 – Piston oil spray nozzle
(opening pressure 1.8 bar)
- 14 – Hydraulic lifter inlet
- 15 – Hydraulic lifter outlet
- 16 – Camshaft adjuster
- 17 – Hydraulic solenoid valve
- 18 – Non-return valve
- 19 – Oil mist separator
- 20 – Suction pump turbocharger
- 21 – Equalizer clutch
- 22 – Turbocharger
- 23 – Suspended oil container
- 24 – Oil return passages

Cayenne

Oil Spray Jets



To reduce piston temperatures the engine in the Cayenne Turbo has oil-cooled pistons. The spray nozzles are mounted on the crankcase.

To guarantee engine oil pressure at low engine rpm and high engine oil temperatures, opening pressure for the nozzles is set at 1.8 bar.

Oil Pump

To ensure a reliable supply of oil, even under extreme longitudinal and lateral acceleration, as well as in off-road operation on grades/descents and tilt angles up to 45°, integral dry sump lubrication is introduced on the Cayenne. In addition, a second suction point is provided in the forward area of the oil pan. A separate bulkhead guarantees an adequate volume of oil in the forward area of the oil pan. From there the engine oil is carried over the main pickup point through the oil pump into the oil filter and the oil-water heat exchanger bolted to the oil gallery housing and is finally made available to the lubrication circuit.

The oil pump is driven by a chain drive from the crankshaft.

Cayenne Turbo

The Cayenne Turbo receives additional lubrication and suction for the exhaust turbocharger. An additional oil suction pump is provided for this purpose.

Cayenne S Crankcase Ventilation

Crankcase ventilation takes place over the timing case into the valve covers.

Suitable cast contours are provided in the timing case cover, which partially scrape off the oil entrained by the timing chain.

This achieves a type of advance separation of the engine oil to reduce the load on the ventilation system.

In addition, the blow-by gases are carried by way of the crankcase and the cylinder heads into the valve covers. Here further advance separation of the engine oil takes place by means of an integral intermediate panel.

From there the oil vapors are taken through a spiral oil separator, freed from the very smallest oil particles and then taken over a pressure control valve behind the throttle valve to the induction system. To ensure the efficiency of the ventilation system in off-road operation, an additional connecting line was used between the valve covers.

Cayenne Turbo Crankcase Ventilation

To meet the turbo-specific requirements for the crankcase ventilation system, separate ventilation paths were provided for the intake and boost pressure areas. In the intake area ventilation takes place similar to the Cayenne S, so non-return valves are installed between the pressure control valve and the injection point in the induction system. When boost pressure builds up, the ventilation system switches over by way of the non-return valves, and the gases are injected ahead of the compressor stage of the turbocharger. In addition, the ventilation for the oil catch container is connected to the ventilation system.

1730 Oil Filter

A replaceable cartridge is used as the oil filter.

Oil capacity is 8.5 liters.

The engine oil change interval for the Cayenne S and the Cayenne Turbo is 30,000 km.

Cayenne



Cooling System

Coolant is circulated by the water pump (15) through a plastic pipe located in the internal V of the engine to the distribution pipe (12) on the transmission side of the engine. The coolant flow is separated in the distribution pipe, about 20% of the coolant is fed into the water jacket of the crankcase and passes through it in the longitudinal direction. About 80% of the coolant volume is fed into the cylinder heads on the cross-flow principle to achieve optimal temperature distribution and passes through them from the hotter (outlet) to the cooler side. Ahead of the thermostat housing (3) the coolant flows are brought together again and, with the thermostat closed (reduced circulation), taken directly to the water pump again.

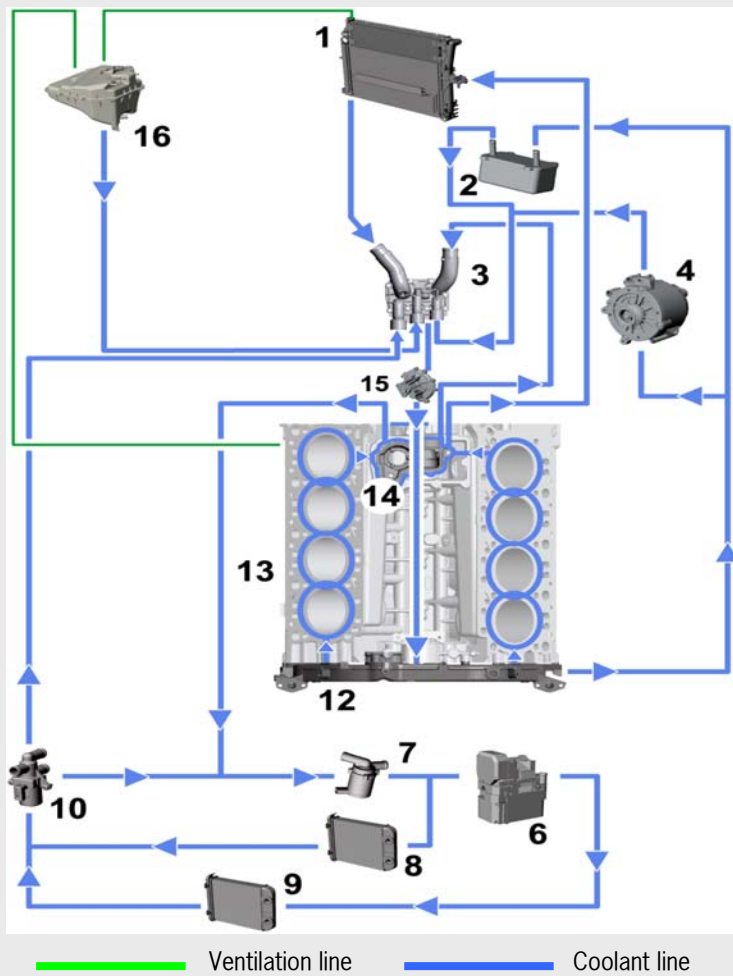
The thermostat starts to open at 83°C, lift is 9.8 mm at 98°C, and it reaches its maximum opening at 105°C. Coolant temperature is measured at the engine block inlet.

With the thermostat open (full circulation), the coolant is brought by way of the radiator at the front of the vehicle back to the intake side of the water pump.

Waste heat from the engine oil is given off (2) into the coolant by means of an oil-water heat exchanger. Partial volume flow for this and the liquid-cooled generator (4) are diverted at the distribution pipe. Volume flow for interior heating is taken off at the thermostat housing. The return for both volume flows is into the thermostat housing.

A supplementary electrical run-on pump provides circulation in the coolant circuit even after the engine has been switched off. Depending on coolant temperature and the last driving cycle (map derived from fuel consumption) this pump is actuated by the DME control module through a relay.

On the Cayenne Turbo the two turbochargers (5 and 11) additionally have coolant directed around them. This greatly reduces oil coking in the turbine bearing housing.

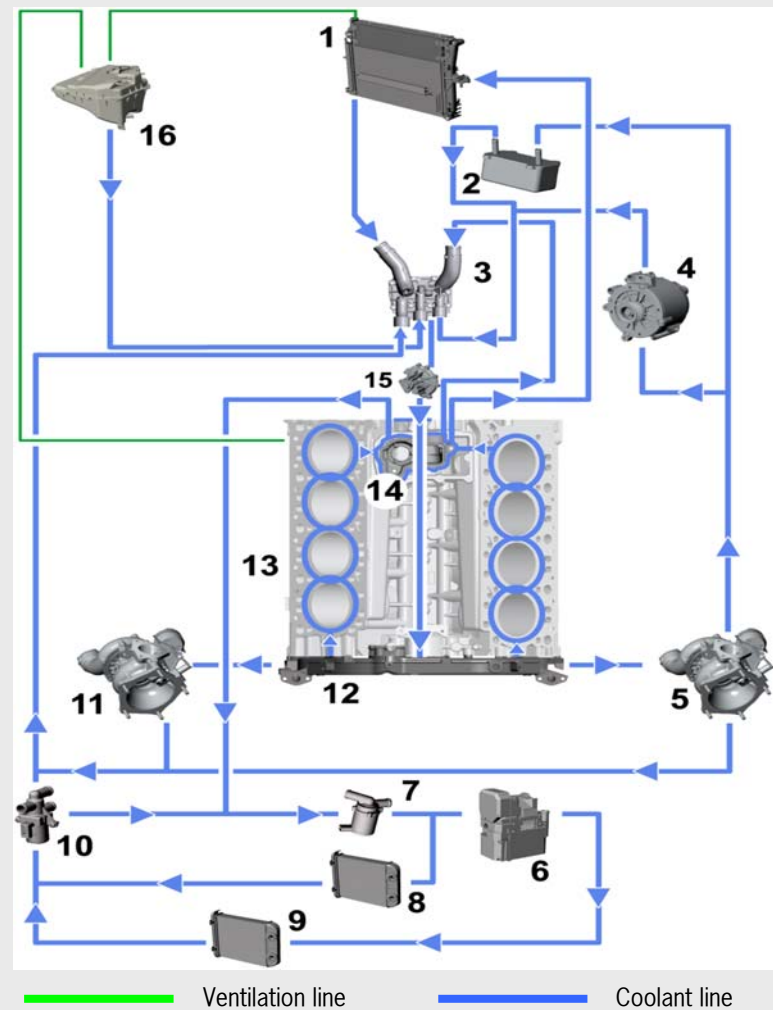


- 1 – Radiator
- 2 – Oil-water heat exchanger
- 3 – Thermostat housing
- 4 – Alternator
- 6 – Auxiliary heating
- 7 – Electrical run-on pump
- 8 – Heat exchanger for rear heater

- 9 – Heat exchanger for front heater
- 10 – 3/2-way valve
- 12 – Coolant distribution pipe
- 13 – Engine
- 14 – Coolant collection pipe
- 15 – Water pump
- 16 – Coolant overflow reservoir

Cayenne

Cayenne Turbo Coolant Circulation



- 1 – Radiator
- 2 – Oil-water heat exchanger
- 3 – Thermostat housing
- 4 – Alternator
- 5 – Exhaust turbocharger
- 6 – Auxiliary heating
- 7 – Electrical run-on pump
- 8 – Heat exchanger for rear heater

- 9 – Heat exchanger for front heater
- 10 – 3/2-way valve
- 11 – Exhaust turbocharger
- 12 – Coolant distribution pipe
- 13 – Engine
- 14 – Coolant collection pipe
- 15 – Water pump
- 16 – Coolant overflow reservoir