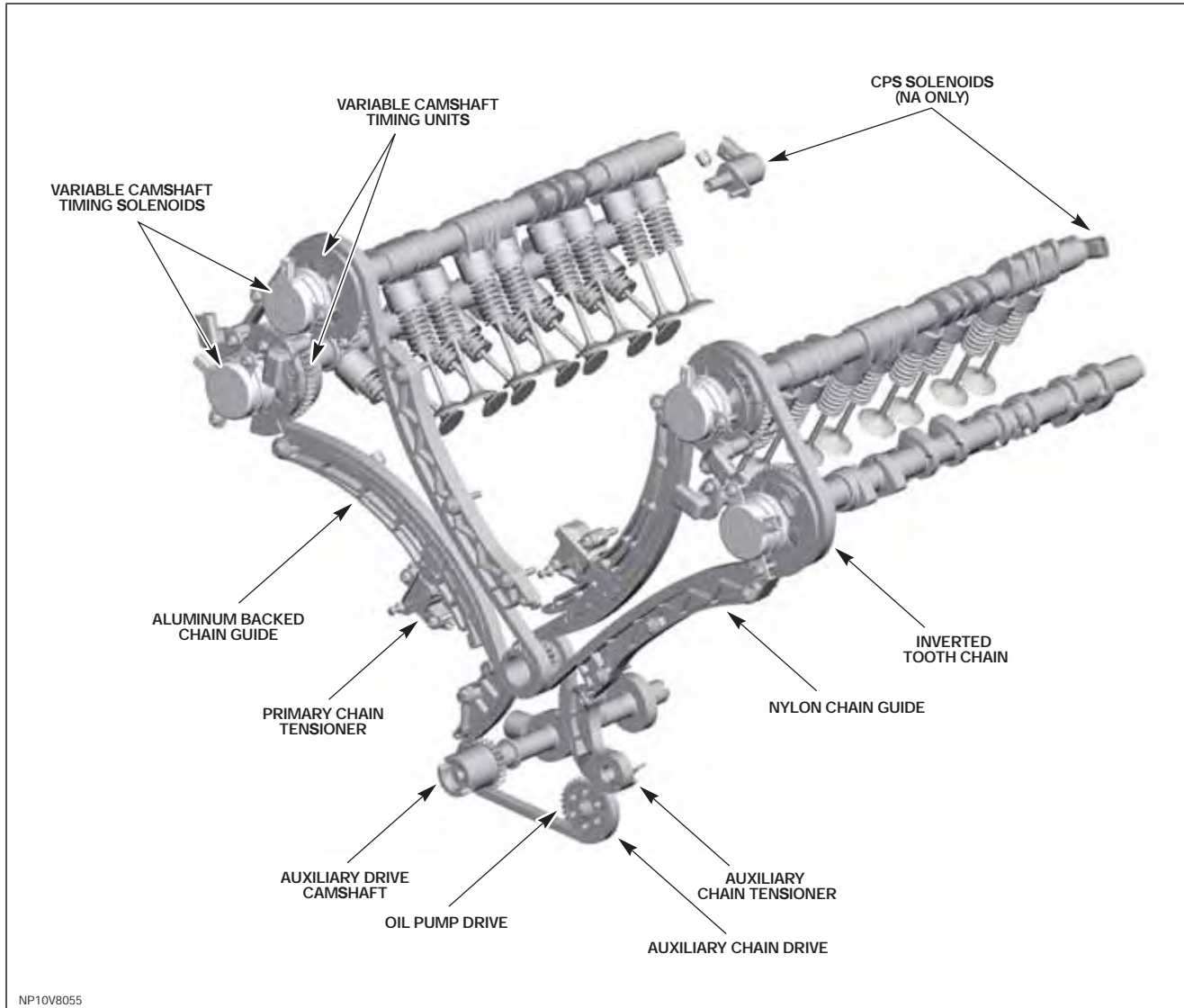


Valve Train

Twin overhead camshafts operate the engine's valves. A maintenance-free highly durable chain transfers drive from the crankshaft to the camshafts, via the variable camshaft timing (VCT) units. The oil pump is driven at 0.87 engine speed by a separate chain, also from the front of the crankshaft, for reduced friction.

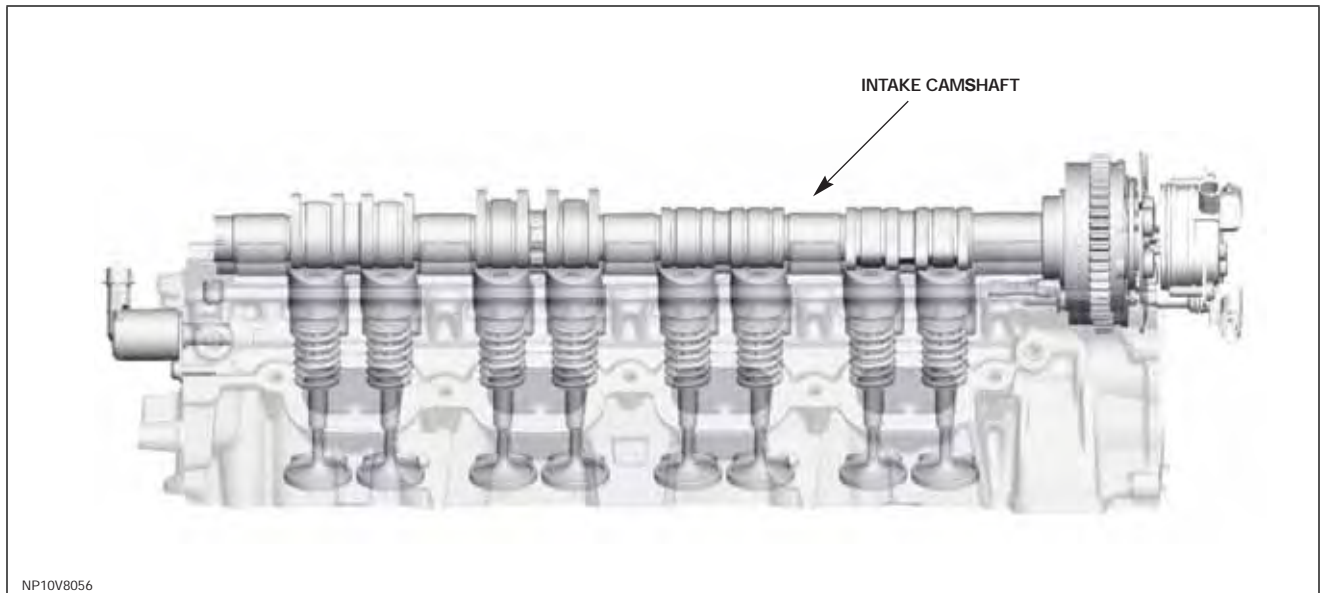


Each camshaft chain has a spring-assisted hydraulic tensioner operated by engine oil pressure. The chain tensioners also incorporate a ratchet mechanism to eliminate start-up noise. The chains are lubricated via oil squirt tubes located at the front of the engine block. Nylon chain guides control chain motion on the drive side.

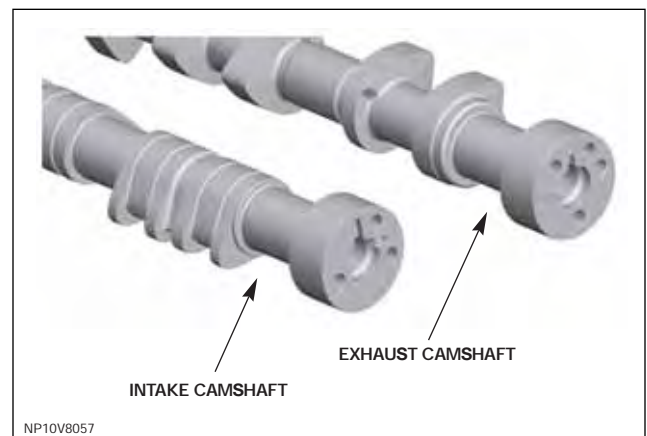
CAMSHAFT PROFILE SWITCHING

Overview

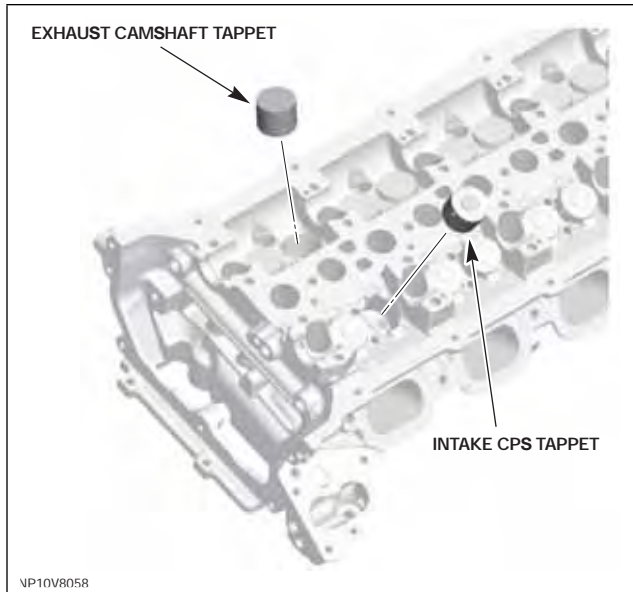
The Camshaft Profile Switching (CPS) system for the NA engine features two completely different intake camshaft profiles machined onto the same camshaft. The engine management system determines which camshaft profile to use, depending on the engine's running conditions and driver's torque demands. One profile is ideal for low-speed/low-load driving; the other, which gives higher valve lift, is better for higher speeds and loads. A two-piece hydraulic tappet arrangement alters the camshaft profiles.



The intake camshaft features three lobes per valve with two different profiles, one centrally located for low valve lifting height and two outer lobes for high valve lift. These are used by the CPS system to adjust the lift of the intake valves from 5.5mm to 10.53mm. Profile switching depends on the instantaneous engine running conditions and the driver's torque demands. The exhaust camshaft is a conventional design featuring a single lobe per valve, giving a set 9.36mm valve lifting height.

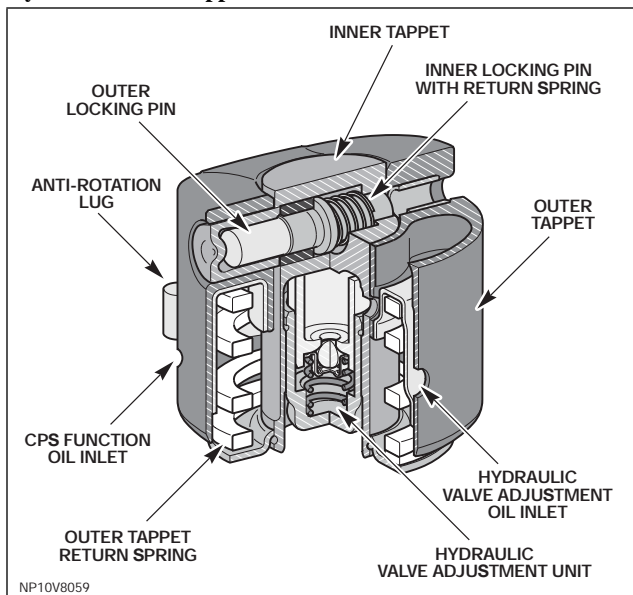


The tappets for the intake and exhaust camshafts differ from each other in their design and function. The exhaust tappets are mechanical with an adjustable valve clearance that is set using graded tappets. The intake camshaft tappets are hydraulic, which compensates for any wear – therefore the valve clearance is 0.



The intake tappets also feature a two-piece design which allows switching between the two intake valve lifting heights using an internal tappet locking mechanism.

Hydraulic Intake Tappet



CPS Operation

Varying the point at which the intake valve opens relative to the point at which the exhaust valve closes can yield a number of benefits. A high level of overlap (during which the exhaust and intake valves are both open simultaneously) encourages good cylinder charging at high engine loads as the incoming rush of air purges the cylinder of any residual exhaust gas.

While high overlap is good at high engine loads, the minimal cylinder charge and high intake vacuum at very low loads can lead to poor and unpredictable cylinder charging, as exhaust back-pressure means the cylinder will find it much easier to charge from the exhaust manifold than the intake system. This causes combustion instability, which manifests itself as uneven idle and hesitation under very light load conditions.

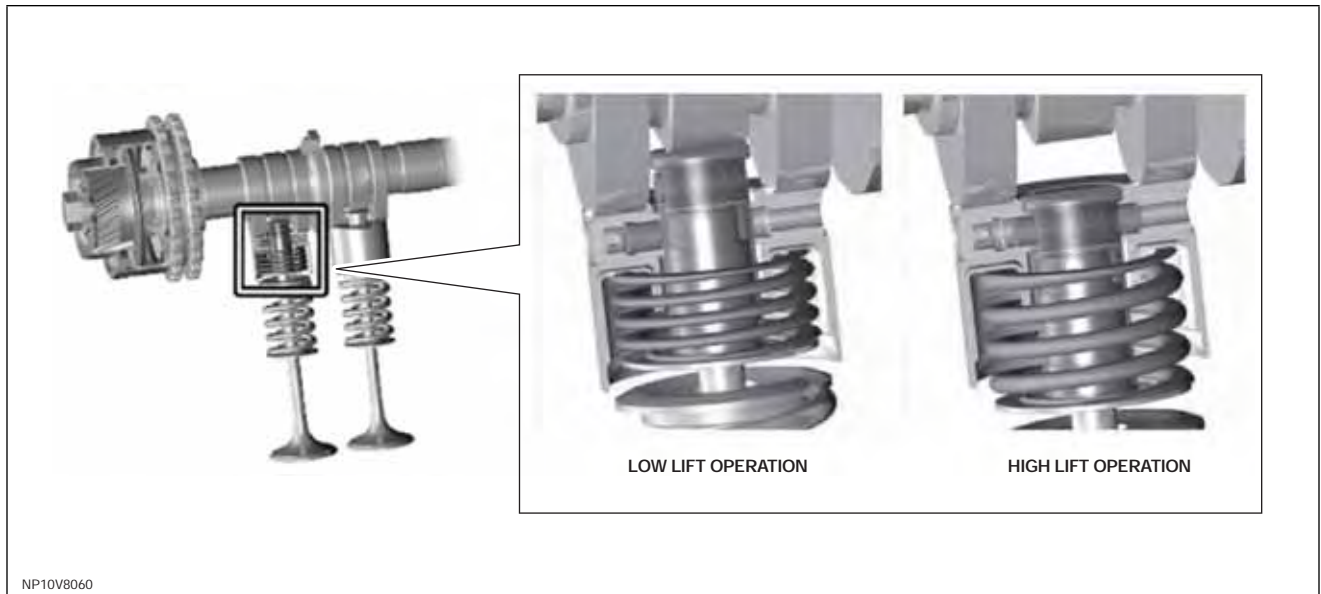
At moderate loads, overlap is beneficial, though for different reasons. Although the lower gas velocity eliminates any tendency for the incoming rush of charge air to purge the cylinder, the modest charge volumes and reduced manifold depression mean that a small volume of exhaust gas is drawn back into the cylinder. However, higher intake gas speeds ensure good mixing of this exhaust gas with the fresh charge, so combustion stability is not jeopardized.

This effect, known as internal exhaust gas recirculation (EGR), actually improves both the volumetric efficiency of the engine by reducing the work the engine has to do pumping a fresh air charge into the cylinder as well as its part-load emissions performance because the exhaust gas is inert, and does not interfere with the combustion process.

This conflict between low load stability and high power output means engines with fixed valve timing must operate compromised valve timing. This compromise attempts to balance the need for smooth and refined idle performance (demanding little or no overlap) with good high speed power and torque output (requiring significant overlap).

The new 5.0-liter V8 engine overcomes the need for compromise in two ways:

- The intake and exhaust camshafts are equipped with a continuous Variable Camshaft Timing (VCT) mechanism. The point at which the intake valve begins to open can be altered by up to 62° of crank rotation. The point at which the exhaust valve begins to open can be altered by up to 50° of crank rotation.
- Using the CPS system, the engine can choose between two completely different camshaft profiles that vary not only valve lift (between 5.5 and 10.53mm), but also the overall opening period of the intake valve over a range of approximately 175° to 310°. This capability provides exceptional control over intake valve operation and yields significant benefits in both engine response and fuel efficiency.



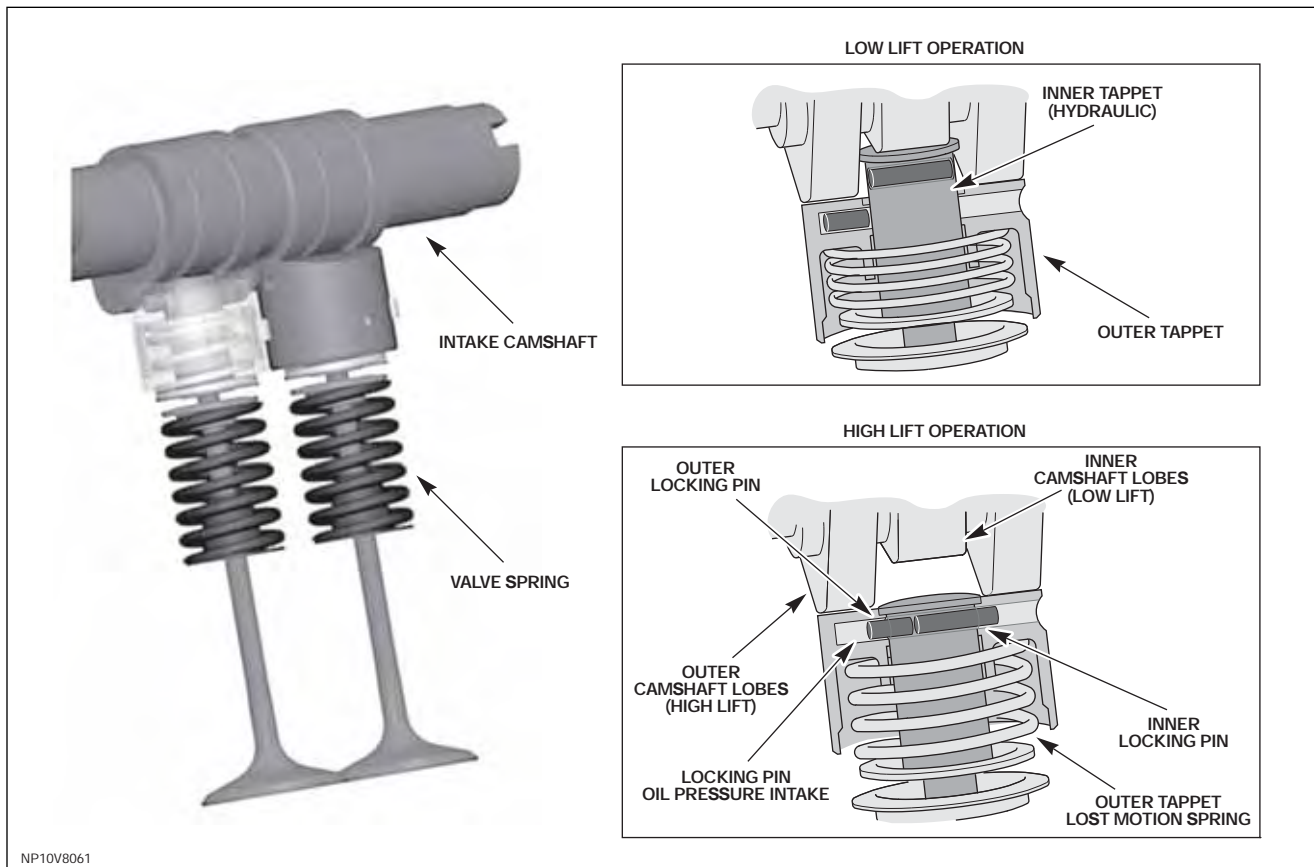
The CPS system controls the lifting height of the intake valves. At engine speeds from idle up to the range of 2,800 – 4,825 rpm (load dependent), the intake valves have a lifting height of 5.5mm. At speeds and loads outside of this range, the high lift cam (10.53mm) is used.

Lifting Height	Valve Opens	Valve Closes
Intake – 5.5 mm lifting height	27° BTDC to 35° ATDC	187° ATDC to 249° ATDC
Intake – 10.53 mm lifting height	37° BTDC to 25° ATDC	213° ATDC to 275° ATDC
Exhaust – 9.36 mm lifting height	244° BTDC or 194° BTDC	6° ATDC to 56° ATDC

NOTE: BTDC = Before Top Dead Center; ATDC = After Top Dead Center

When the CPS system is used in combination with the VCT function it is possible to control the cylinders' incoming air quantity in such a way as to optimize cylinder filling and apply the throttle as normal. The use of CPS and VCT allows larger than usual throttle openings during warm-up to gain heat from the exhaust and, hence, catalyst light-off.

At low engine speeds from idle up to the range of 2,800 – 4,825 rpm (load dependent), the center and outer sections of the tappet are not linked. Only the centrally located lobe on the camshaft acting on the center section of the tappet opens the valve. The outer camshaft lobes act on the outer section of the tappet, compressing the return spring ensuring the tappet is always in contact with the camshaft, but none of this movement is transferred to the valve, giving a valve lift height of only 5.5mm.



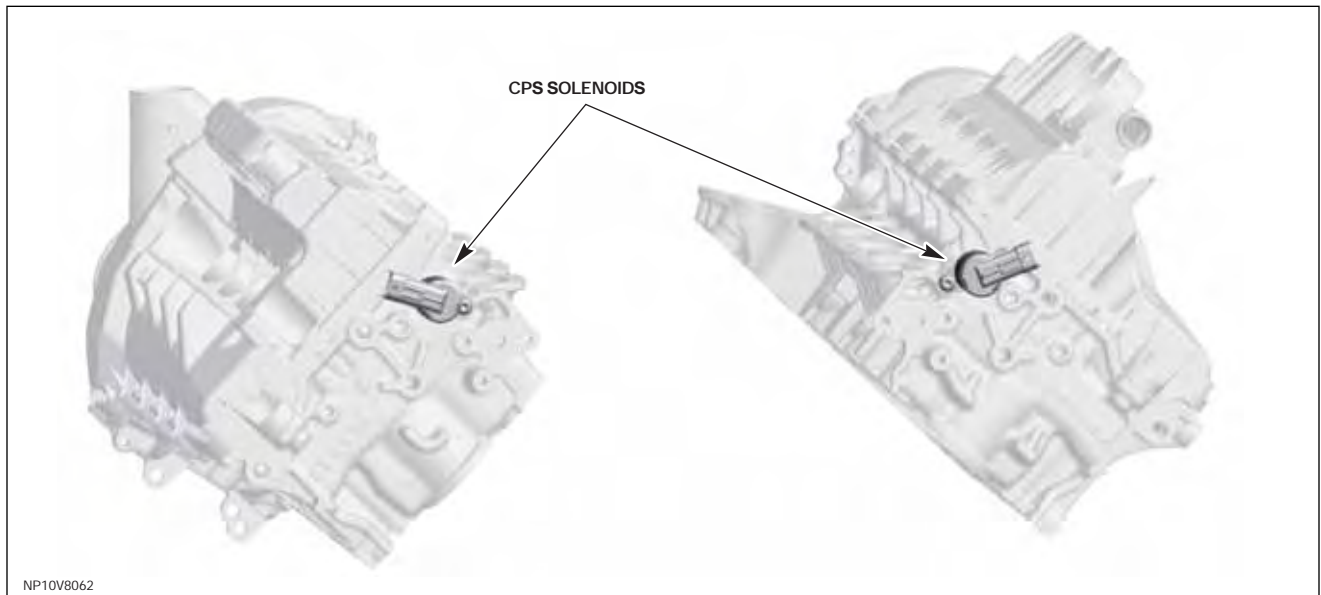
At engine speeds and loads outside of this range, the center and the outer sections of the tappet are joined by two hydraulically-controlled locking pins. The tappet has an anti-rotation lug to maintain alignment of the oil passages. The movement of the outer camshaft lobes is now transferred from the outer tappet section through the locking pins to the center tappet section, giving a valve lift of 10.53mm.

NOTE: Switching of all intake valves occurs within one complete camshaft revolution only when each tappet is in contact with the base circle of the camshaft lobes and the valves are closed.

To ensure that the switch from low lift (5.5 mm) to high lift (10.53 mm) is seamless, the switching speed is load-dependent to ensure that the volumetric efficiency of the engine is the same for low and high lift. Switching is only enabled at oil temperature above 20°C (calculated internally in the ECM). An engine speed limit of 5000 rpm is imposed in low lift (e.g., at oil temperatures below 20°C).

Camshaft Profile Switching Solenoids

The two CPS solenoids are located at each end of the cylinder head, adjacent to the intake camshaft.



The CPS solenoids control the supply of oil pressure to the hydraulic tappet locking pins, allowing the camshaft profile to be changed to adjust the intake valve lifting height from 5.5 mm to 10.53mm.

The CPS solenoids receive a fused battery supply from the main relay. The ECM provides a ground for the solenoid, which actuates a valve within the solenoid allowing oil pressure to adjust the camshaft profile.

The ECM can diagnose the operation of the CPS solenoids and store fault related codes.

NOTE: If the CPS solenoids fail, high valve lift is disabled.

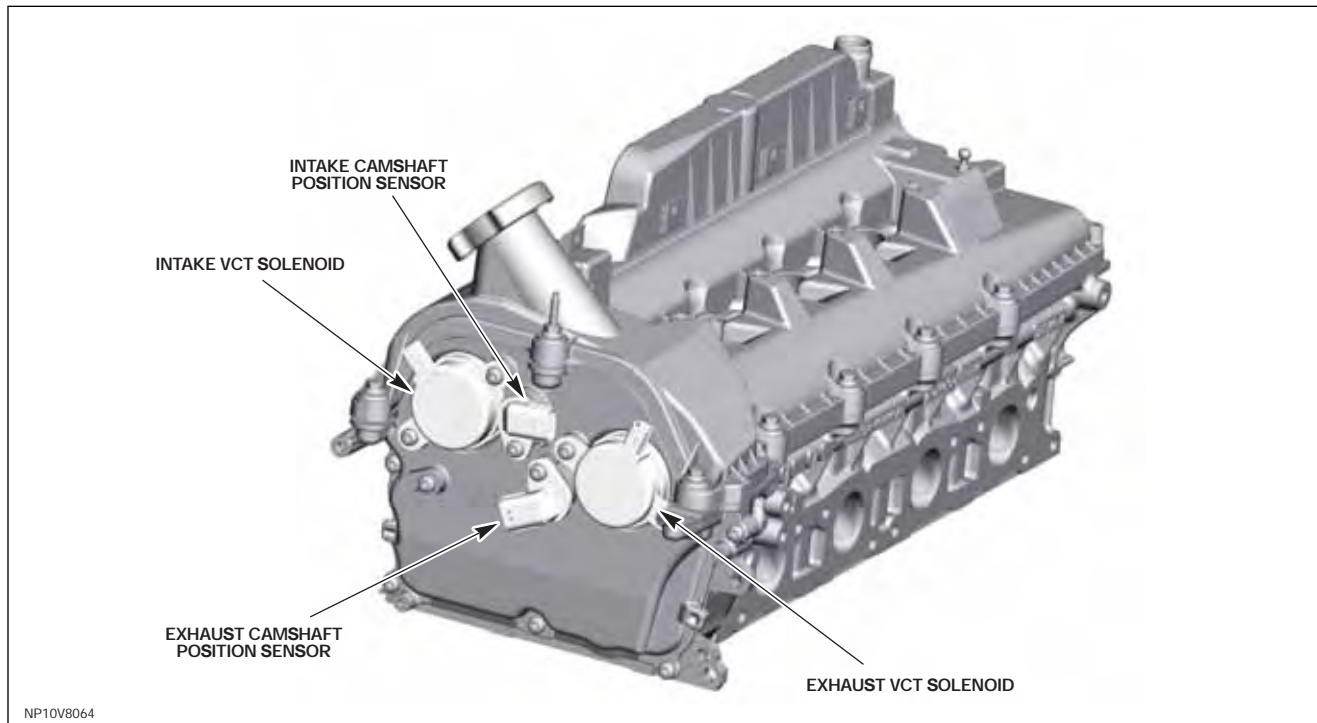


Specification	Function
Operating voltage	10.5 to 15V (normal: 13.5 ± 0.5V)
Supply current	0.8 to 1.85A
Functionality	On/Off
Resistance	8.5 ohms ± 0.5 ohms
Movement of magnetic valve	2mm

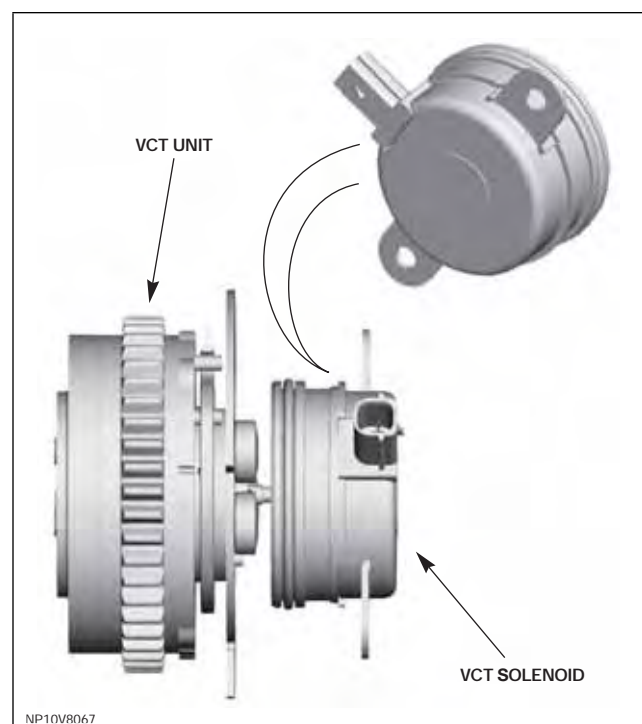
VARIABLE CAMSHAFT TIMING

Overview

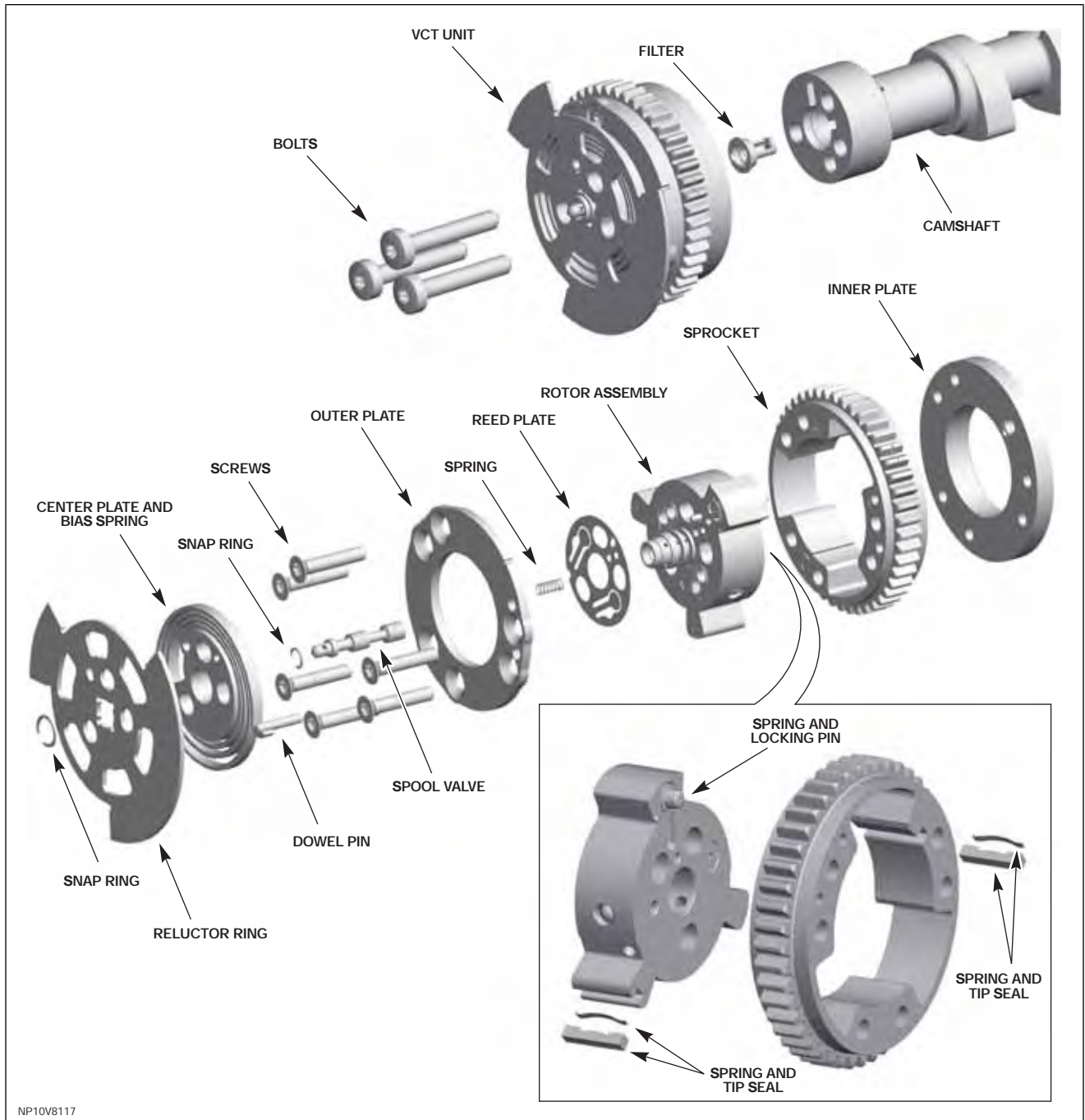
The camshaft torque-actuated, dual independent Variable Camshaft Timing (VCT) system constantly controls camshaft timing to deliver optimum power, efficiency, and emissions. With dual independent camshaft phasing, the intake and exhaust camshafts can be phased independently of each other.



The chain-driven camshaft timing units are mounted on the end of each camshaft, and advance or retard the camshaft timing to thereby alter the camshaft-to-crankshaft phasing. The control solenoids act on hydraulic control valves within each VCT unit to control angular position using camshaft torsional energy to alter the phase. This provides the most flexible method of camshaft phasing, allowing the overlap of exhaust valve closure and intake valve opening to be varied.



Variable Camshaft Timing Unit – Exploded View

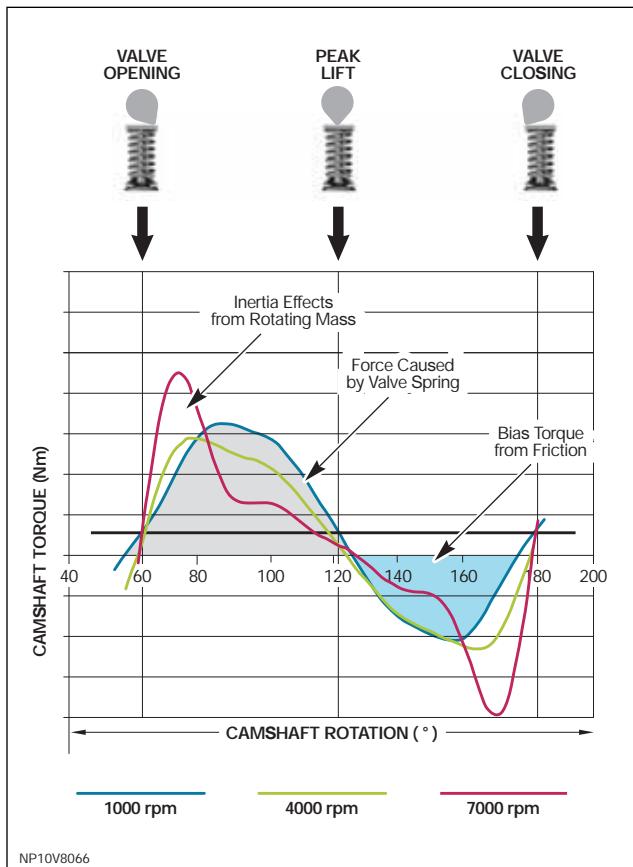


⚠ CAUTION: Do not reuse the VCT units if they have been subjected to an impact (such as being dropped on the floor).

Camshaft torque-actuated VCT technology uses camshaft torsional energy generated by the camshaft lobes acting against the valve springs and inertia of the valve train components to phase the camshafts, rather than using oil pressure generated by the oil pump. Angular phasing is achieved by the internal transfer of oil between the chambers of the phaser, via check valves, controlled by a hydraulic control valve – in essence a controlled hydraulic ratchet device. As a result, camshaft torque-actuated VCT technology has a much lower oil demand than that of oil-pressure actuated VCT units (approximately 15%). The reduction in oil demand allows the engine oil pump capacity to be reduced, resulting in fuel economy benefits.

As camshaft torque-actuated VCT technology is not reliant on engine oil pressure to phase the camshafts, response rates at low engine speeds and high temperatures – where engine oil pressure is typically low – is significantly improved. This translates to improved transient performance and response (performance feel).

Camshaft Torsional Energy (for a Single Valve Event)



VCT Operation

The required position of each camshaft is controlled in closed-loop from the ECM, by actuation of a variable force solenoid against the VCT hydraulic control valve at the front of each unit, with reference to signals from the four camshaft position (CMP) sensors and the crankshaft position (CKP) sensor.

The VCT solenoid force is controlled with a pulse width modulated (PWM) duty cycle at battery voltage. When the VCT solenoid is not energized, the phaser pintle is fully extracted (via spring force), locking the camshaft in the base timing position.

The intake camshafts will be in full retard and the exhaust camshafts will be in full advance. Under operation, the intake camshafts can advance 62° crankshaft angle; the exhaust camshafts can retard 50° crankshaft angle.

To hold the camshafts in any other position other than the base timing lock position, the ECM partially energizes the solenoids – holding them in the ‘null’ position. To retard the intake camshafts, the opposite is true, where the VCT solenoid is powered with a lower duty cycle and then returns to the null position once the target angle is reached.

The exhaust camshafts operate in the opposite manner to the intake camshafts, where the solenoid is energized to retard the exhaust camshafts and underpowered to advance the camshafts.

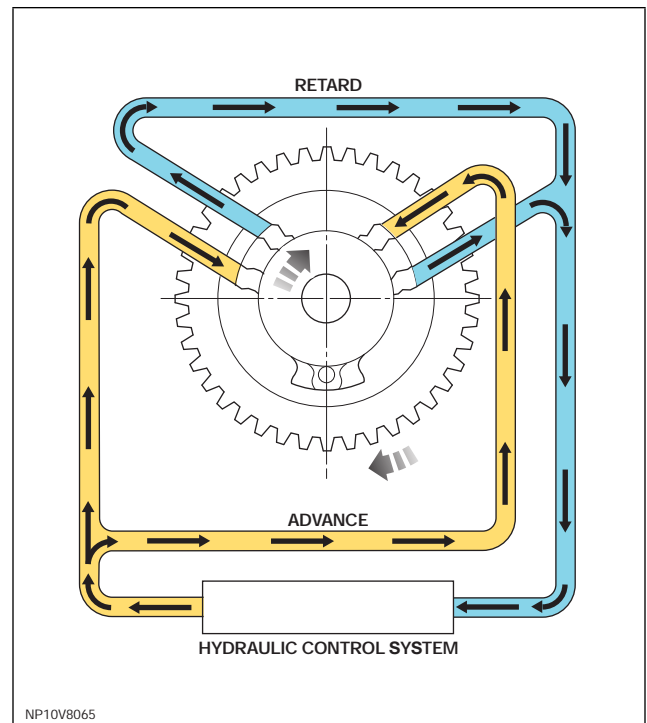
The control from the 'null' position is exponential, whereby the camshafts will advance or retard at a faster rate with a duty cycle displacing the pintle further from the 'null' position.

The major components within the system are:

- A single-source oil feed via a camshaft bearing through the camshaft to the VCT
- An inlet check valve to the VCT
- A common passage that always communicates with the center of the control valve and leads to the high-pressure check valves for the advance and retard hydraulic chambers
- A control valve that is used to control the direction and rate of oil flow from one hydraulic chamber to another and a mechanical spring loaded locking pin that is released on command by hydraulic oil pressure

The oil supplied to the VCT is necessary to fill the VCT initially and then supply a continuous amount of oil to replenish any oil that leaks back from the VCT.

Oil Recirculation



NOTE: By supplying source oil to both chambers via a common passage the force, due to oil pressure, is balanced on opposing sides of the vane. Therefore oil pressure does not cause the rotor to move relative to the housing.

After the initial filling the VCT is ready to actuate and control.

The first function of the control valve as it moves to the right is to selectively apply source oil pressure to the locking pin on command. In this control valve position, the locking pin has been commanded to release but the control valve has not reached the position where the VCT is being commanded to move yet. Therefore no force bias is applied to the VCT before releasing the locking pin.

Camshaft Advance

The camshaft torque-actuated VCT uses the camshaft torque energy to move while recirculating the oil within the VCT from one chamber to the other chamber. The control valve will continue to move to the right and open an exhaust port from the retard chamber to the common passage. During each valve-closing event, when negative camshaft torques are generated, the oil in the retard chamber is pressurized. By opening the exhaust port during valve closing events, oil is allowed to flow from the retard chamber, through the common passage past the advance chamber check valve, to the advance chamber via. The VCT advances an incremental amount with each valve-closing event. During valve-opening events, the advance chamber will be pressurized but no flow will occur because the advance chamber check valve is closed while the control valve has the advance chamber exhaust port blocked.

As a result, with each valve-closing event, oil from the retard chamber flows to the advance chamber, causing the VCT to advance. During the valve opening events when the camshaft torque is positive, the VCT holds position.

The control valve not only controls the direction of flow but also controls the rate of flow from one chamber to the other chamber by means of a variable size opening at the exhaust port.

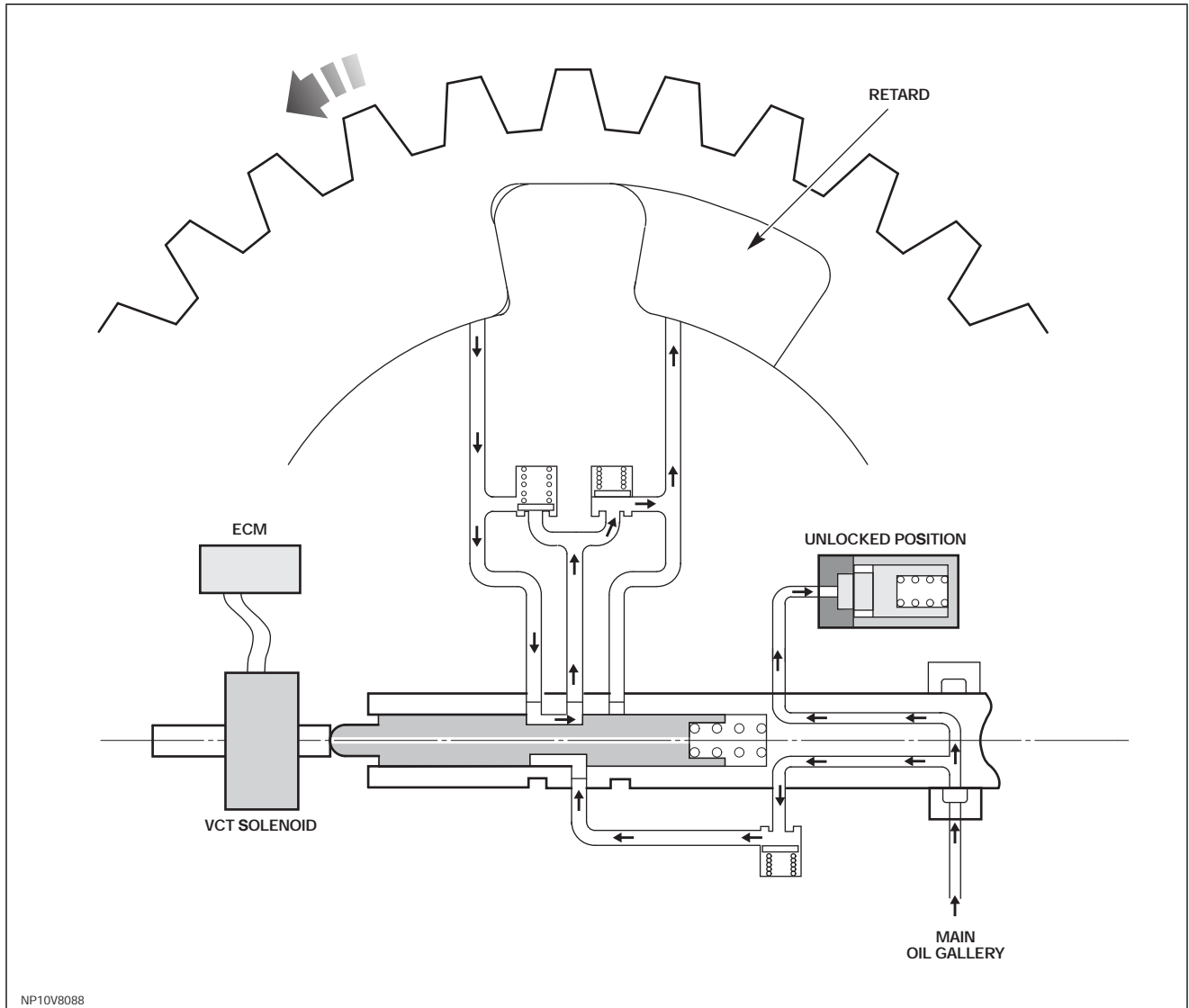
NOTE: When VCT reaches the advance stop, the control valve returns to the null or centered position.

Camshaft Retard

The VCT retards during valve-opening events by moving the control to the left and opening the exhaust port from the advance chamber. The VCT moves to retard with each valve-closing event and holds position during the valve-opening events. Since this VCT is operated under closed loop control motion, the VCT can be stopped at any moment and in any position by returning the control valve to the centered or null position. Even though there is pressure in both chambers from the positive and negative camshaft torque energy, the VCT is not moving because all exhaust ports from the hydraulic chambers are blocked by the high-pressure check valves and the centered control valve.

When the VCT is commanded to move to the fully retarded position, the control valve moves to the left. At the end of the VCT travel, the mechanical locking pin will align with its receiver and engage. The locking pin is allowed to engage because the control valve, when in the extreme left position, simultaneously blocks source oil pressure from reaching the locking pin and opens a vent to allow the oil in the locking pin passage to vent.

This is the default position for the VCT, which can occur by command, or can occur as a failsafe mode if power to the VCT control system is lost. This event can occur in less than 300ms from any phase position and at any engine speed.



NP10V8088

The VCT solenoid is powered directly from V battery (Pin 2) through the ECM controlled relay, with a low side driver in the ECM connected to Pin 1 on the VCT solenoid.

Safety Precautions

⚠ WARNING: The VCT solenoids are heat generators, and can reach high temperatures.

Failure Modes

- VCT Solenoid Stuck
- VCT Phaser Stuck

Failure Symptoms

- No VCT Control

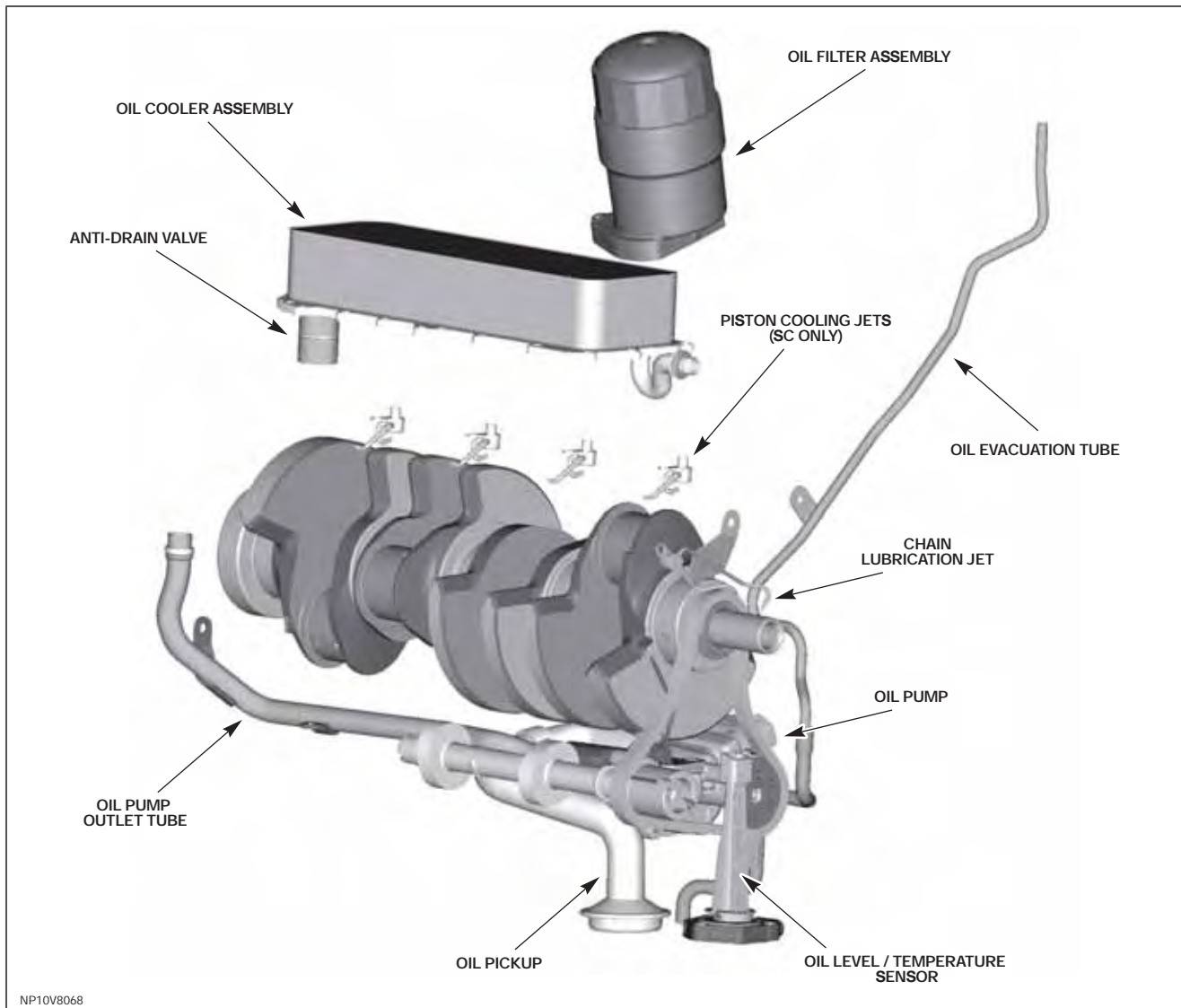
LUBRICATION SYSTEM

Overview

Castrol SLX A1 5W-20 is a dedicated engine oil that has been co-engineered with JLR. Its low viscosity and advanced additive package help to reduce engine friction and maintain engine cleanliness.

By running a cleaner, more efficient engine, the cost of ownership can be reduced and a saving on fuel can be made. With this improved efficiency the service intervals have moved to 15,000 miles / 12 months.

The oil pump is driven from the front of the crankshaft by the auxiliary chain. It draws oil from the aluminum sump via a centrally mounted pick-up. The oil pressure is regulated using gallery pressure feedback. Oil is then cooled by a plate-type oil-to-water cooler before being filtered by a replaceable element, accessible from the top of the engine.



The oil cooler is designed to ensure good control of engine oil temperature under all operating conditions. Cooled oil is distributed through a series of internal galleries to the engine's critical bearing surfaces before draining back into the sump.

Synthetic oil is specified; this is more resistant to temperature-related degradation than conventional mineral oil. It also has lower viscosity at low temperatures and improved lubrication performance at higher temperatures.

The specification of SLX Professional A1 5W-20 synthetic oil is an important part of new engine's oil change strategy as it permits longer oil-change intervals than conventional lubricants.

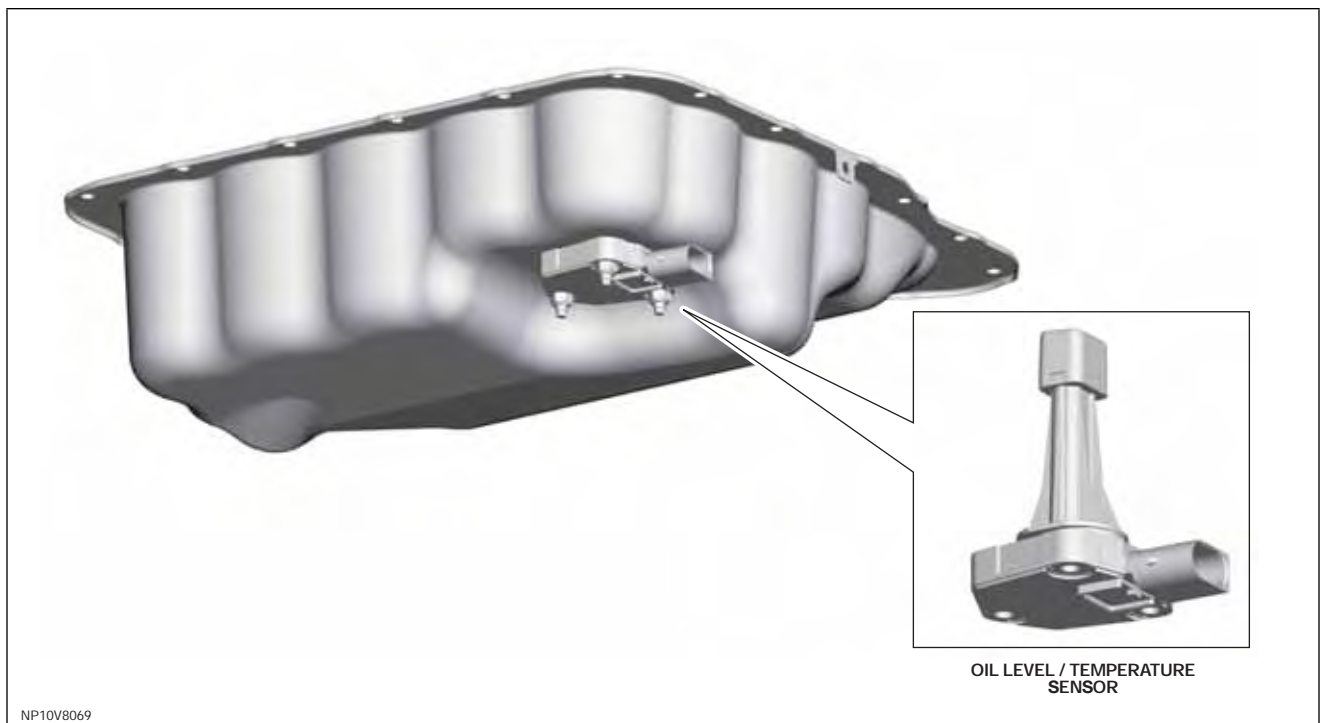
Oil Level / Temperature Sensor

The new ultrasonic sensor, a first for JLR, provides an electronic indication as to when the oil in the engines sump is low or high. This allows for the deletion of the mechanical dipstick.

The sensor maps the fill level of the oil continually during trips. An advantage in comparison with the static 'dipstick' method is that all marginal influences are compensated for by averaging. Marginal influences include the vehicle being on a slope, the oil flowing back at the end of a journey, lateral and longitudinal acceleration, or even dipstick tolerances.

The values determined can be used to signal that the minimum oil level has been reached or to display the current oil level if required.

NOTE: Jaguar Sump Shown



The continuous-mode sensor measures engine oil level and temperature. The oil level and oil temperature readings are taken and turned into a pulse-width modulated output signal.

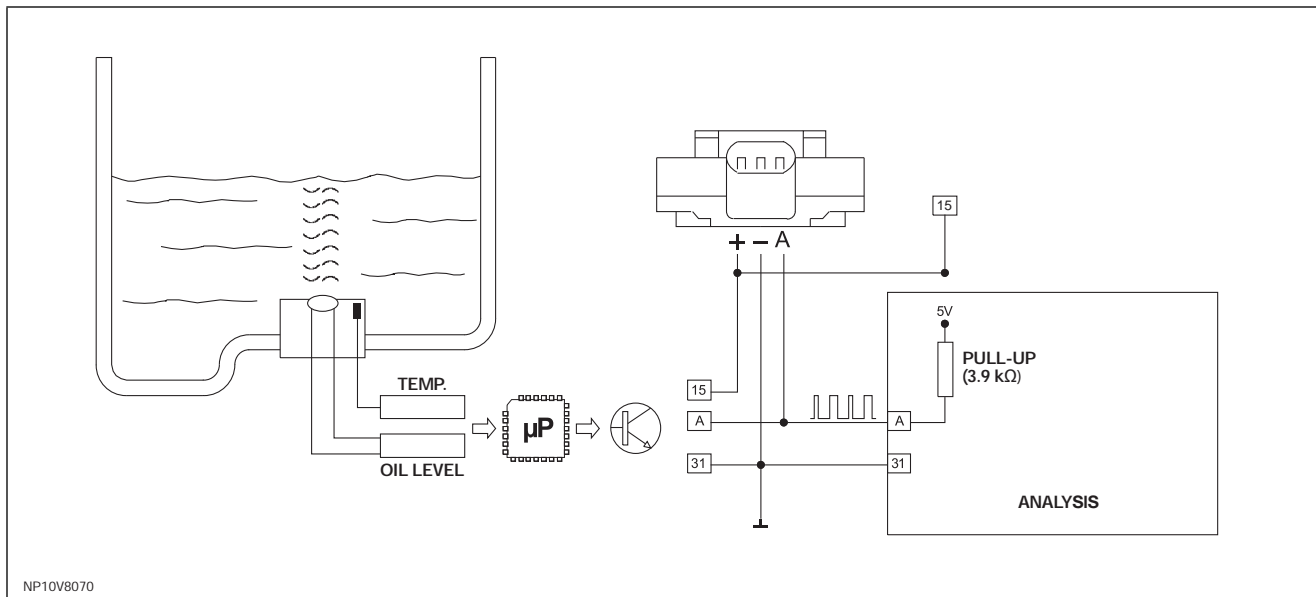
The measuring system consists of a flange, connector, electronic circuitry and the temperature and oil level sensor. Oil level metering is determined by the oil-to-air interface layer.

The oil level sensor has the following technical properties:

- Linear measuring range
- Continuous measuring under static and dynamic conditions
- Temperature signal and oil level signal 0.3s after switch-on
- Measuring frequency > 10 Hz
- Customer-specific output signal
- Installs at bottom of oil sump
- Temperature measuring

The sensor is mounted to the underside of the sump, from where it sends an ultrasonic pulse vertically upward (engine position). It then measures the time for the pulse to be reflected back from the top surface of the oil.

It compares this time period with a time period of a second pulse which travels within the sensor across a reference distance. With both time periods it can calculate the oil height from the sensor flange, negating the noise factors which affect the speed of the pulse through the oil.



NP10V8070

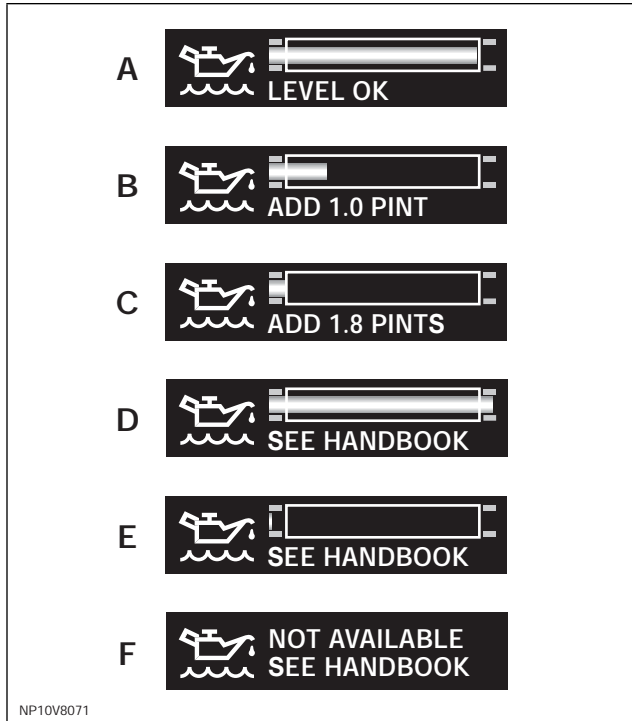
Specification	Function
Power source	Battery voltage
Level Accuracy	±2mm (±4mm < -30°C)
Temperature Accuracy	±2°C (35°F)
Operating Level Range	18mm – 116mm (Dynamic) 116mm – 147mm (Static)
Operating Temp. Range	-40°C – 160°C (-40°F – 320°F)
Pin 1	Power Supply
Pin 2	Ground
Pin 3	Output Signal

Oil Pressures

Engine Speed	Temperature	Pressure
Idle	20°C (68°F)	2 bar (29 psi)
1500 rpm	20°C (68°F)	6 bar (87 psi)
3000 rpm	40°C (104°F)	6.2 bar (90 psi)
3000 rpm	110°C (230°F)	5 bar (72.5 psi)
3000 rpm	130°C (266°F)	4 bar (58 psi)

Oil Level Check

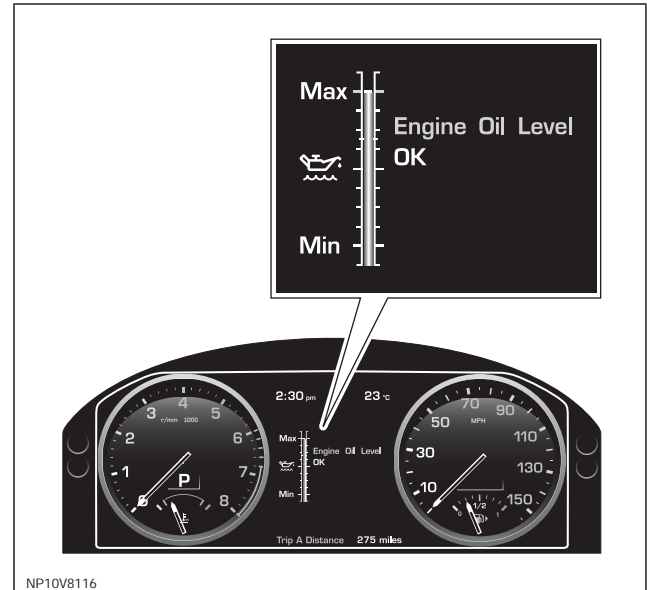
The engine oil level is automatically monitored and displayed in the trip computer area of the message center. The current oil level can be viewed by pressing the trip button with the ignition on, with the engine stopped and the transmission in park.



Key to illustration above:

- **A:** Oil level 50% to 100% of recommended level. No top-up required.
- **B:** Oil level 12.5% to 50% of recommended level. Add 0.5 liters of oil.
- **C:** Oil level 0% to 12.5% of recommended level. Add 1 liter of oil.
- **D:** Oil above maximum for safe operation. Do not drive vehicle. Seek qualified assistance.
- **E:** Oil level below minimum for safe operation. Add 1 liter of oil and re-check.
- **F1:** Oil drain in progress, oil level not available. Wait 5 minutes then re-check the oil level display.
- **F2:** If this display is accompanied by the warning message 'ENGINE OIL LEVEL MONITOR SYSTEM FAULT', a fault with the oil level monitor is indicated. Seek qualified assistance.

Land Rover LM Display



On the Land Rover LM display, messages to the right of the gauge advise of any action required.

- If the oil level is within the required operating range, the message 'Engine Oil Level OK' will be displayed. Do not add any additional oil to the engine.
- If the oil level is below the required operating range, a message will be displayed indicating the recommended quantity of oil to add (e.g. 'Add 0.5L'). Add the recommended quantity of oil then recheck the level.
- If the message 'Overfilled' is displayed, service may be required. Do not drive the vehicle as this will cause serious damage to the engine.