3.6L V-6 VVT (LY7)

2006 model year summary

- Engine remains unchanged for 2006.

Overview

The 3.6L V-6 VVT was launched in 2003. The global V-6 architecture was jointly developed by GM technical centers in Australia, Germany, North America and Sweden. The engine's design is based on the philosophy that a true family of global engines provides the best value and performance for the customer and the best return on investment for General Motors. The engines apply the most advanced automotive engine technology available, from state-of-the-art casting processes to full four-cam phasing to ultra-fast data processing and torque-based engine management. Each delivers a market-leading balance of good specific output, high torque over a broad rpm band, fuel economy, low emissions and first-rate noise, vibration and harshness control, with exclusive durability enhancing features and very low maintenance.

The 3.6L V-6 VVT (RPO LY7) was introduced in the 2004 Cadillac CTS and SRX, and was an option in the Buick Rendezvous Ultra. In 2005, this sophisticated 60-degree DOHC V-6 also became the standard powertrain for the Cadillac STS and the optional powertrain for the Buick LaCrosse.

The dual overhead camshafts over each bank of cylinders are driven by a chain that is powered by the engine’s crankshaft. The silent chain drive performs the same function as the previous-style chain, but does so with less noise. The silent chain design used an inverted tooth design that spreads out the period of engagement between the sprocket and chain. By lengthening the period of contact between the sprocket and chain, the force of the initial impact between the two is reduced because it is spread out longer. Therefore, the noise created by the initial sprocket/chain impact is significantly reduced. The result is much quieter and smoother sprocket-to-chain engagement, and that makes for a smoother and quieter engine.
The V-6 VVT employs four-cam phasing to change the timing of valve operation as operating conditions such as rpm and engine load vary. The result is linear delivery of torque, with near-peak levels over a broad rpm range, and high specific output (maximum horsepower per liter of displacement) without sacrificing overall engine response and driveability.

In a conventional, fixed-timing engine, the intake and exhaust valves operate in a mechanically fixed relationship. As the intake valves open, the exhaust valves are closing. The amount of overlap – periods when both intake and exhaust valves are partially open – is fixed by the shape of the cam lobes and can’t be varied, and the limitations lie in this fixed relationship. The smoothest, steadiest idle occurs when there is no valve overlap: In general, an engine operates more smoothly, and produces more torque, with little overlap at lower rpm. Yet when maximum horsepower is the objective, more valve overlap is beneficial. Cam phasing eliminates the fixed relationship between the intake and exhaust valves. Four-cam phasing allows the most possible variance in valve timing, and virtually eliminates the compromises required with fixed valve timing.

The V-6 VVT uses electro-hydraulic vane-type phasers to rotate the camshafts relative to the cam-drive sprockets. Managed by the engine control module (ECM), these vane phasers maximize control and minimize response time, turning the exhaust and intake cams (and cam lobes) in one direction or the other in infinitely variable combinations over a range of 50 degrees. Moreover, the cam phasing system was developed for maximum durability and outstanding noise, vibration and harshness control. It is virtually impervious to particles or contaminants in the engine oil and minimizes the chance that the phasers can stick, even in the most demanding operating conditions. At idle the V-6 VVT’s exhaust cams operate at the full advanced position for minimum valve overlap. At other engine speeds over the full range of operating conditions, the phasers adjust cam timing quickly and seamlessly for optimum performance, drivability, fuel economy and emissions control.

The result is smooth, even torque delivery without sacrificing high-rpm horsepower, and excellent specific fuel consumption. Cam phasing also pays big dividends in reducing exhaust emissions by optimizing exhaust valve overlap and eliminating the need for a separate exhaust gas recirculation (EGR) system. By closing the exhaust valves late at
appropriate times, the cam phasers force the desired amount of exhaust gas back into the combustion chamber for more complete burning in the next combustion cycle, greatly reducing oxides of nitrogen (NO\textsubscript{X}) emissions. As a result, the V-6 meets all emissions mandates without complex, weight-increasing emissions control systems such as EGR and air injection reaction (AIR).

Aluminum-intensive construction extends to the V-6 VVT’s pistons, which are manufactured of forged aluminum. These are lighter than conventional steel pistons. Less weight means less reciprocating mass in the engine, which in turn means less inertia and greater operating efficiency. Moreover, the V-6 VVT pistons are crafted with a number of features that enhance durability and reduce noise and harshness.

One such feature is the full floating wristpins. Conventional pistons typically use a fixed-pin assembly, in which the connecting rod is fixed to the piston’s wrist pin, and the pin rotates within the pin bore in the piston barrel. In the V-6 VVT, the wrist pins “float” inside the rod bushings and pin bores. Snap rings retain the wrist pin in the piston, while the rod moves laterally on a bushing around the pin. The floating-pin assembly allows tighter pin to pin-bore tolerances and reduces noise generated during engine operation. They also reduce friction, and are the standard for high-performance automobile engines.

Finally, the V-6 VVT engine family was developed with pressure-actuated oil squirters in all applications. Three jet assemblies in the block each hold a pair of oil-squirting jets that drench the underside of each piston and the surrounding cylinder wall with an extra layer of cooling, friction-reducing oil. The jets are activated when oil pressure reaches a prescribed level. They reduce piston temperature, which in turn allows the engine to produce more power without reducing long-term durability. Moreover, the extra layer of oil on the cylinder walls and piston wristpin further dampens noise emanating from the pistons, meaning quieter operation.

The V-6 VVT’s durability enhancing features included a polymer coating applied to the piston skirts. This high-tech coating was developed to withstand the heat and friction generated by piston movement in the cylinder, and it allows tighter piston-to-bore clearances without bore scuffing. The polymer coating extends the benefits of the floating-pin piston and rod assembly and further reduces noise generated by the piston’s
movement within the cylinder. The coating also helps limit bore scuffing, or abrasion of the cylinder wall over time from the piston’s up-down motion. The net result is a quieter, more durable engine.

The strength of a forged steel crankshaft ensures the durability required of high output variants of the V-6 VVT engine family, and it adds an extra level of robustness. The crank is forged from 1038V steel and is inherently stiffer than a conventional cast-iron crankshaft, which in turn reduces vibration from the engine’s core moving part and enhances the V-6’s credentials as one of the smoothest, quietest V-6 engines. Compared to cast iron, forged steel also reduces noise generated by the crankshaft. A dual-mass flywheel with an embedded torsional damper eliminates gear rattle and driveline shudder in vehicles equipped with a manual transmission. Finally, to help ensure lifetime leak-free performance, the V-6 VVT crank seals are manufactured of DuPont Teflon. Teflon is basically impervious to oil and gases generated in the crankcase, and the seals have been designed to eliminate the chance of misalignment during assembly.

The V-6 VVT’s connecting rods are manufactured of sinter-forged steel. Sinter-forging is one of the most advanced metallurgical techniques used in automotive engine applications, and it produces a part of superior performance and durability without an increase in piece cost.

Sinter-forged components start with a powder steel compact or preform that is heated just below the melting point of iron to fully bond the metal particles and increase strength. The compact is then hot-forged to finished size and shape in a closed die. Sinter-forging greatly reduces porosity in the metal and increases density, in turn improving mechanical properties, including ductility and tensile and impact strength. The result is not only improved durability, but an improvement in NVH control as well. The density of the sinter-forged connecting rod means less noise generated and less vibration transferred between the pistons and the crankshaft, reducing overall noise and harshness in the engine.

Sinter-forging is considerably more expensive than conventional casting or wrought forging. Yet because parts are manufactured with much greater precision, they require
Less machining, and both machine tooling costs and manufacturing time are reduced. Overall assembly efficiency – and quality – increases.

The oil pan provides another example of extensive efforts to minimize engine noise and vibration in the V-6 VVT. Cast aluminum dampens internal engine noise better than a conventional stamped steel pan; structurally, it is considerably stiffer. The design was optimized with math-based analysis and carefully crafted curves in the pan’s sides and bottom. These reduce broadcasting or “drumming” of noise created as oil flows through the crankcase, and they increase bending stiffness in the pan. Moreover, the oil pan bolts to the transmission bell housing as well as the engine block. This eliminates points of vibration and increases powertrain bending stiffness, which reduces booming sounds inside the vehicle.

Steel windage plates in the oil pan improve oil-flow dynamics and reduce friction at high engine speeds, while baffles ensure maximum lubrication in the most demanding operating conditions, including high lateral acceleration forces. The oil pump is driven from the crank with its own pressure relief valve. It’s designed to reduce operational noise and to ensure reliable priming and excellent lubrication during one of the engine’s highest-wear operating periods – during and immediately after startup.

The V-6 VVT variable intake manifold (VIM) uses a valve in the plenum, managed by the ECM, which opens and closes according to engine speed. At idle, the valve is open. From just past idle to mid rpm, the valve is closed, effectively creating two separate plenums, each feeding the intake runners and ports for half of the cylinders. This optimizes airflow at lower engine speeds to maximize low-end torque. At higher engine speeds, the plenum plate opens, creating a single higher-volume plenum feeding all cylinders for freer breathing and high-rev horsepower. The VIM allows optimal airflow for a given engine speed without the compromises of a fixed-volume plenum. In combination with cam phasing, it allows impressively linear torque delivery.

Moreover, the manifold’s intake runners are precisely equal in length to deliver consistent, symmetrical airflow to each cylinder bank. This maximizes flow to the combustion chambers without uneven intake noise sometimes associated with high-output, high-revving engines. The manifold is manufactured entirely of aluminum (sand
cast A319 alloy for the upper portion, A356-T6 for the lower). It is lighter than a conventional manifold, reducing overall engine mass, yet it dampens noise more effectively than a composite manifold and further reduces engine noise that might find its way to the vehicle cabin.

The V-6 VVT’s sequential fuel injection manages fuel pressure at the injectors and eliminates a fuel return line from the engine to the fuel tank. This “returnless” injection – also known as a demand system – improves performance and greatly reduces emissions. It is one of the most efficient fuel-delivery systems in production and, true to the V-6 VVT global development philosophy, provides the foundation for several fuel-injection variants that can be tailored to market demands or legislative mandates without extensive re-engineering.

All of the V-6 VVT’s fuel delivery components, from the fuel pump to the delivery line to the injectors, have been developed to minimize operational noise. The fuel rail is fitted with an internal fuel pressure damper, which virtually eliminates harsh pressure pulses.

Electronic “drive-by-wire” throttle eliminates a mechanical link between the accelerator pedal and throttle plate. The V-6 VVT has no throttle cable; instead, a potentiometer at the pedal measures pedal angle and sends a signal to the ECM; the ECM then directs an electric motor to open the throttle at the appropriate rate and angle. Electronic Throttle Control (ETC) is integrated with the ECM, which uses data from multiple sources, including the transmission’s shift patterns and traction at the drive wheels, in determining how far to open the throttle. With this data, the V-6 VVT effectively anticipates the driver’s demands, whether it’s a slow-speed parking maneuver or wide-open throttle operation on the open road, and responds appropriately. ETC delivers outstanding throttle response and greater reliability than a mechanical connection. Cruise control electronics are integrated in the throttle, reducing the amount of wiring required, further improving reliability and simplifying engine assembly.

The V-6 VVT’s coil-on-plug ignition delivers the highest energy spark and most precise timing available. The increased efficiency of coil-on-plug spark contributes to lower emissions. The system has no high-tension spark plug wires and fewer parts than
conventional ignitions, improving durability, allowing more efficient engine assembly and enhancing build quality.

Spark timing is managed with both a cam sensor that reads a reluctor wheel on the cam phaser and a sensor that reads a reluctor wheel pressed onto the crankshaft. This dual-measurement system ensures extremely accurate timing for the life of the engine. Moreover, it provides an effective back-up system in the event of a sensor failure.

The V-6 VVT’s nerve network is a new torque-based engine management system developed in cooperation with Robert Bosch Corp. to leverage GM Powertrain’s own expertise in engine controls and software. On the V-6 VVT, a single microprocessor manages the following functions and more: Cam phasing, which improves performance and efficiency and allows maximum valve overlap at appropriate times, in turn allowing sufficient exhaust gas recirculation without a separate EGR; electronic throttle control, with different throttle progressions based on operating conditions and driver demand; torque management for traction control and all-wheel drive; the returnless fuel injection system with injection and spark-timing adjustments for various grades of fuel; the ignition system and knock sensors, which push spark advance to the limit of detonation (hard engine knocking) without crossing over, maximizing fuel economy; fast-heating oxygen (02) sensors with pulse-width modulation, which varies electrical current like a rheostat rather than an on-off switch and allows lower cold-start emissions; and the variable intake manifold. The ECM provides a limp-home mode for ignition timing, in the event either the crank or cam sensor fails. It will continue to control timing based on data from the functioning sensor, and advise the driver with a warning light. It also provides coolant loss protection, which allows the V-6 VVT to operate safely at reduced power, even after there has been a total loss of engine coolant, so the driver can reach a secure location. Additionally, the ECM allows a number of other customer-friendly features, including GM’s industry-leading Oil Life System.

The center of the V-6 VVT nerve network is a state-of-the art 32-bit, 25 MHz Bosch Motronic ME9 microprocessor – the most powerful processor currently used in auto industry. The ECM communicates via a digital data bus with a separate vehicle control module, which manages anti-lock brakes, gauges and other chassis functions. Moreover, the ECM is not affected by the heat, high-speed vibration and electromagnetic
interference of its demanding operating environment. Its micro-hybrid design embeds all of the necessary electronic circuitry in a four-layer “sandwich” substrate that drastically reduces the size of the control unit and delivers new levels of durability. Engine mounting presents a number of advantages, including a reduction in wiring with fewer junctions. It also frees space in the vehicle’s engine bay, and reduces attachment complexity at assembly plants.

The V-6 VVT also uses a torque-based control strategy, which improves upon previous throttle-based management systems that rely exclusively on the throttle position sensor to govern throttle operation for the ETC. The torque-based strategy calculates optimal throttle position, the position of the intake plenum plate, cam phasing positions and other operational parameters and translates that data into an ideal throttle position and engine output, based on the driver’s positioning of the gas pedal.

The V-6 VVT exhaust manifolds are manufactured of cast nodular iron and protected with laminated heat shields to limit heat radiated in the engine bay. Cast iron was chosen for its durability, value and ability to limit radiated noise. The quantity and mix metals in the converters, including platinum, palladium, rhodium and other precious metals that create the chemical reaction to process exhaust gas, has been formulated for the best balance of efficiency and cost.

Perhaps most importantly, the V-6 VVT exhaust manifolds were designed so the catalytic converters can be mounted directly under the manifolds. The catalysts heat more quickly after start-up due to their proximity to the exhaust manifolds and achieve light-off – the temperature at which pollutants are most effectively oxidized – seconds sooner. This reduces emissions during cold starts, a period when engines operate at their highest emission level and a critical stage in government emissions tests. As a result, the V-6 VVT does not require the smaller supplemental converters used on many premium V-6 and V-8 engines since 2001. Moreover, the highly efficient converters, efficient combustion system and sophisticated controls systems such as cam phasing allow the V-6 VVT to meet all emissions mandates without devices such as a separate EGR system or AIR. Such systems add cost, assembly complexity, weight and sources for potential warranty claims.
All V-6 VVT engines employ positive crankcase ventilation, and even the PCV valve has been developed to virtually eliminate operational noise. The evaporative emission system performs to a leak detection standard of .020 inch (about the size of a pin prick).

The V-6 VVT’s cam covers are made of thermoset, glass-filled polyester composite. This material weighs less than the cast aluminum used on most premium engines and more effectively dampens noise. Required baffles are incorporated into the cover, which is manufactured as an assembly with seals and fasteners attached. Moreover, the V-6 VVT development team paid great attention to the design of the cam covers, which typically are sources of noise transmission. Surfaces were shaped to limit the broadcasting of undesirable noise, and the covers use isolating perimeter gaskets as well as isolating radial lips around the tubes that accommodate the spark plugs. These effectively decouple the covers from vibration generated in the block and engine during combustion.

The cam covers are only one example of the relentless quest to minimize noise, vibration and harshness in the V-6 VVT. The front cover also features damping plates to eliminate radiated noise. The plates of varied thickness are peened on the inner surface, provide damping and noise attenuation.

**Low maintenance**

The cam drive, cam phasing and valvetrain components require no scheduled maintenance; the sophisticated cam-chain tensioner, high-quality cam phasing components and hydraulic lash adjusters are designed to ensure optimal valvetrain performance for the life of the engine with no adjustment. Advanced control electronics and a wide range of sensors allow failsafe systems, including ignition operation in the event of timing sensor failures. The control software protects the V-6 VVT from permanent damage in the event of complete coolant loss, and allows the engine to operate at reduced power for a prescribed distance sufficient for the driver to find service.

Even perishable components provide extended useful life. The spark plugs have dual-platinum electrodes and a service life of 100,000 miles without a degradation in spark
density. The spark plugs are easy to remove because they are located in the center of the cam cover. When the ignition-coil cassettes are removed, the plugs can be reached with a short ratchet extension. Extended life coolant retains its cooling and corrosion-inhibiting properties for 100,000 miles in normal use. The two accessory-drive belts were specified primarily for their lapless construction and low-noise operation, yet they are manufactured of EPDM rather than neoprene and should last the same 100,000 miles before replacement is recommended.

A top-access, cartridge style oil filter requires only element replacement. The filter is easy to reach and designed to virtually eliminate spillage when the cartridge is removed. Moreover, with GM’s Oil Life System, those who own vehicles equipped with the V-6 VVT should never pay for an unnecessary oil change again, nor worry that the engine oil has degraded to the point where it has lost its lubricating properties. That, in turn, can significantly reduce the amount of motor oil used, and the amount of used motor oil that must be recycled. The six-quart sump capacity ensures maximum oil change intervals.

The industry-leading Oil Life System calculates oil life based on a number of variables, including engine speed, operating temperature, load or rpm variance and period of operation at any given load and temperature, and then recommends a change when it’s actually needed, rather than by some pre-determined mileage interval. In extreme operating conditions, such as short periods of operation in very cold temperatures, the Oil Life System might recommend a change in as few as 3,000-to-3,500 miles. When the engine runs at moderate loads for extended periods with little variance, the system might not recommend an oil change for 15,000 miles. The owner’s manual in vehicles equipped with the V-6 VVT recommends an oil change at least once a year, regardless of mileage.

The V-6 VVT development and production teams made assembly efficiency a priority. All global V-6 variants can be built with no significant casting changes to major components. Core engine components are designed to be common whenever possible. The basic V-6 block is used in all vehicle applications, with differences limited to machining. While different vehicles require different oil pans, the pan’s mating surfaces with the engine block and transmission are common in all circumstances, allowing considerable assembly efficiencies. The net result of the V-6 VVT’s design, development and
assembly objectives is streamlined procurement practices, fewer tool changes in the plant, shorter assembly time and improved quality for the customer.

Production facilities for the 3.6L V-6 VVT are located in St. Catharines, Canada and Port Melbourne, Australia.