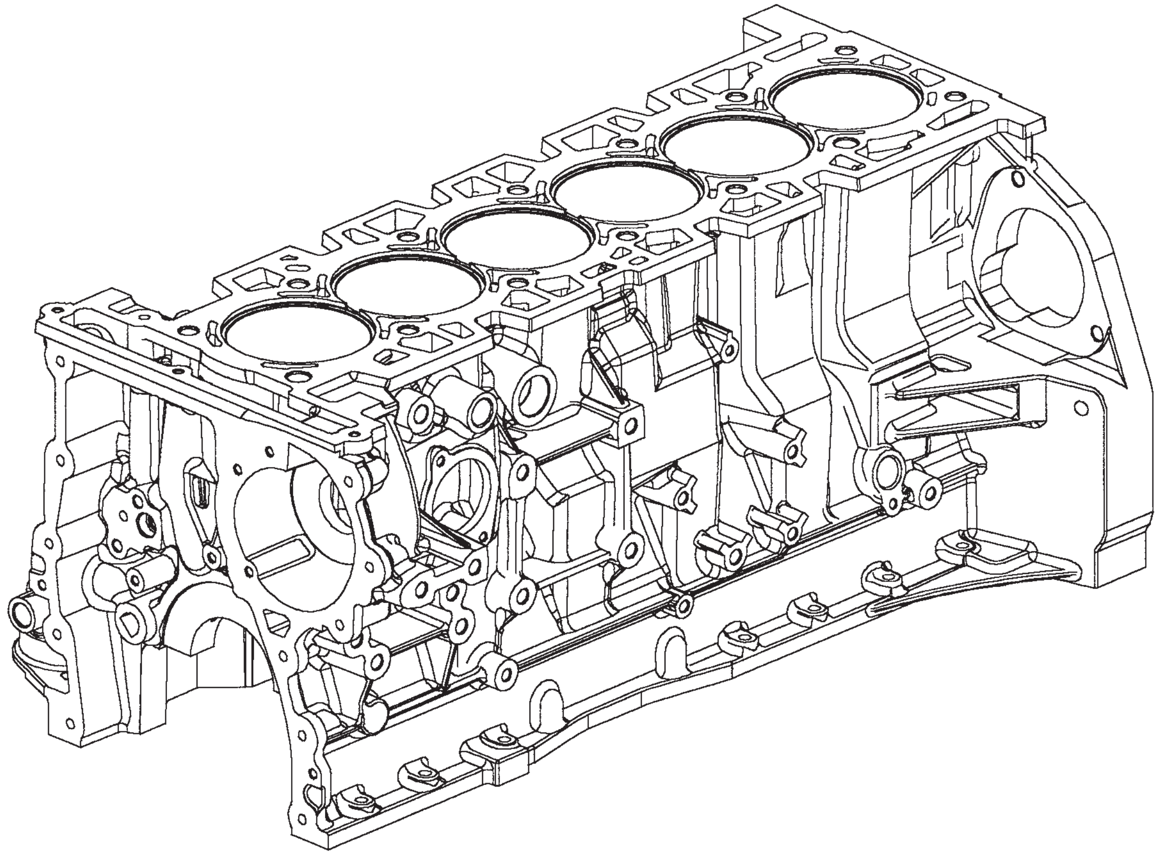
Cylinder Block / Lost Foam Casting Process



The all-aluminum cylinder block construction features a deep skirt design and is lighter than conventional cast iron truck engines. The premium A356 aluminum primary material is used with a T6 heat treatment to provide the strength requirements of a truck engine. This material is very similar to the aluminum used in wheels. The engine block and cylinder head are cast using General Motors' lost foam process. It offers a number of environmental benefits when compared to conventional casting.

GM pioneered lost foam cylinder block casting in 1982, and has continuously refined the process. The process begins with a styrofoam assembly that replicates the part being cast. Loose sand is poured around the assembly and shaken into its voids. Molten aluminum is then poured through a foam sprue into the sand where the hot metal melts the foam, displaces it and cools in the shape of the part.

Unlike conventional casting, the lost foam process allows passages and other features to be cast directly into the part. Oil galleries, ventilation and oil drain back passages (which keep oil away from the crank) are cast into the block. Coolant passages, which would otherwise require drilling or external plumbing (with a potential for leaks) are also cast into the block. This results in less machining and fewer opportunities for error.

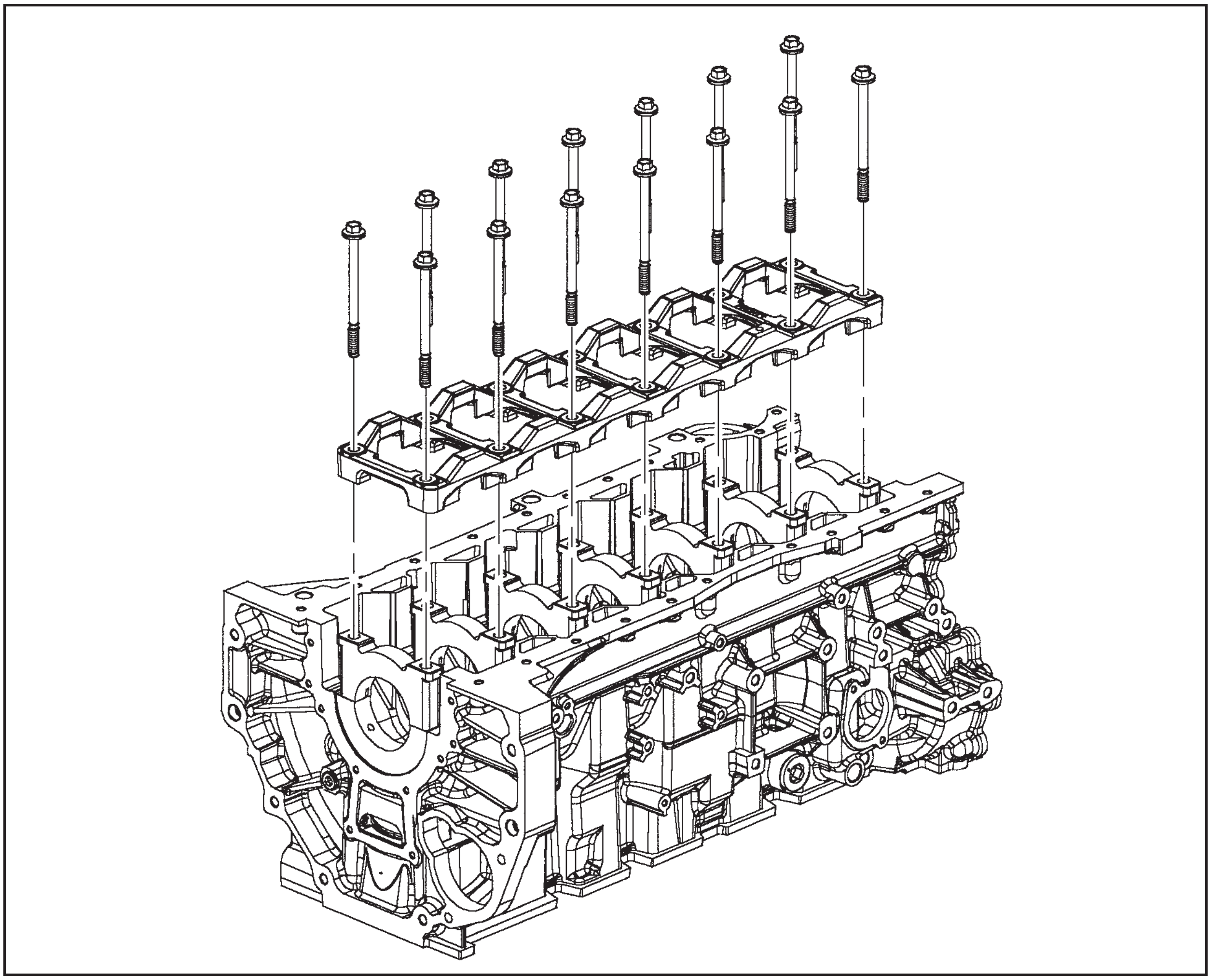
Another benefit of the lost foam process is that it allows narrow water jacket passages, which keep coolant velocities high. In addition, the lost foam process allows for a coolant jacket design that sweeps coolant in and out of the siamese region. The detailed design of the coolant jacket was optimized extensively using computational fluid dynamics. The result is a low volume coolant jacket that warms up quickly, yet provides cooling for 90 percent of the stroke, with even heat transfer.

This engine features pressed in cast iron liners. The installation process includes chilling the liner prior to placement and sophisticated precision force monitoring to insure proper installation.

The press-fit, ground outside diameter of the liner against the precision bored aluminum cylinder provides optimal heat transfer. After installation, the iron liner is bored to a mass saving 1.5 mm wall thickness.

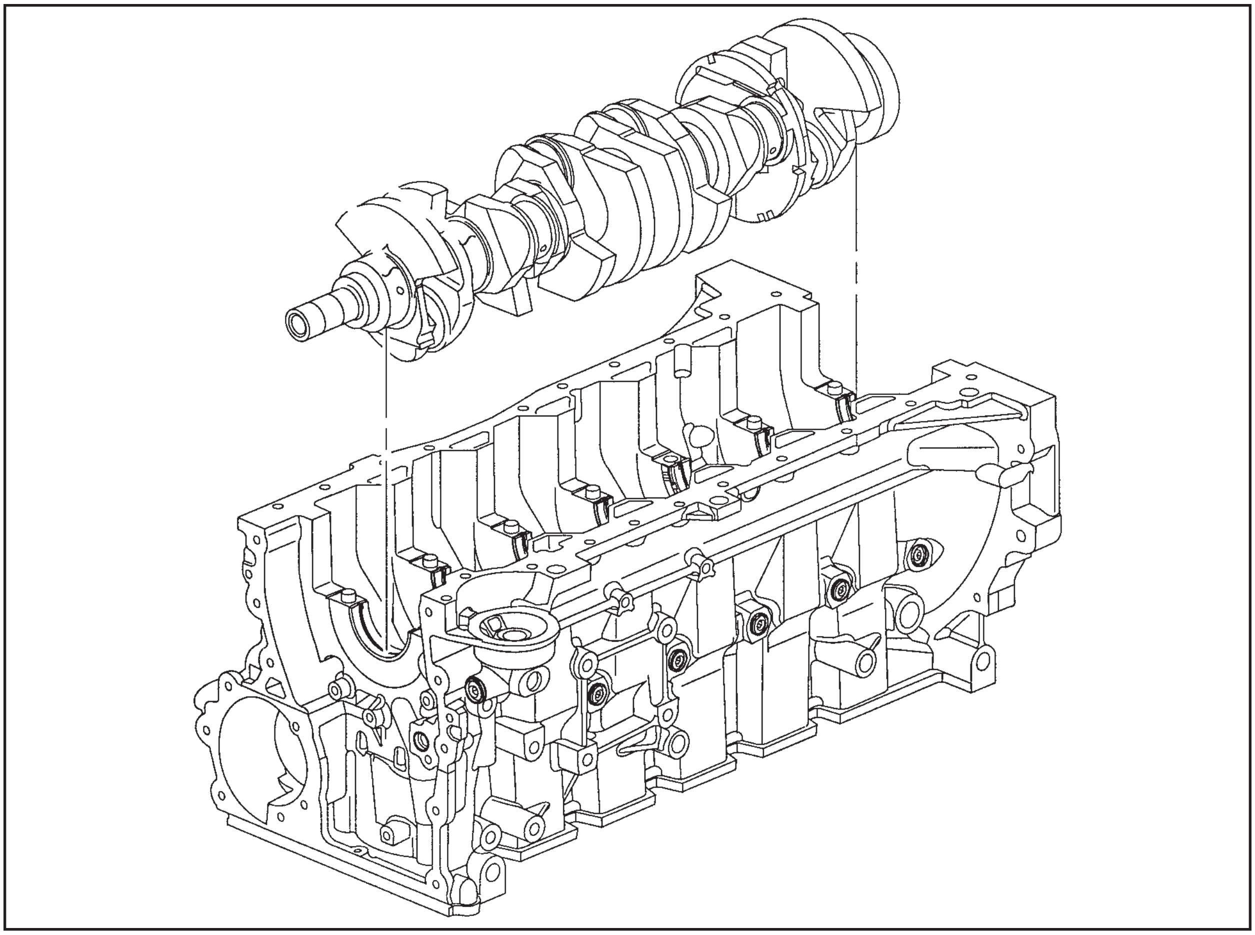
The sand used in conventional casting, typically seen heaped in large mounds outside of foundries, requires a binder and must be disposed of in landfills. The sand used in lost foam casting requires no binder and can be used again. Landfill waste is minimized. There is a substantial reduction in raw material disposed of and used.

Crank Bearing Structural Ladder



A bearing beam or "ladder" connects the seven main powder-metal bearing caps, stiffening the engine block's structure. The deep skirt cylinder block design contributes to the increase in structural stiffness, which reduces overall engine vibration and noise. The beam offers many advantages of a separate cast lower crankcase with less manufacturing complexity and less potential for oil leaks.

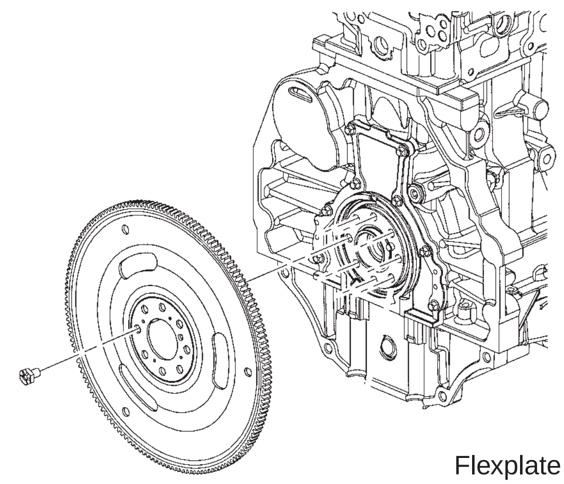
Crankshaft



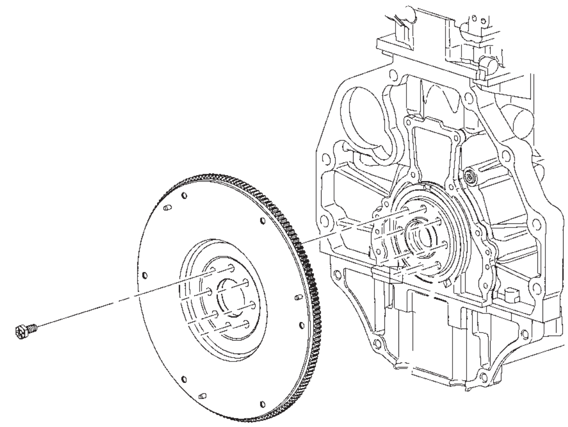
Designing the Vortec inline six-cylinder crankshaft was a challenging process because of its length and natural tendency to twist. Thorough engineering was required to ensure quiet operation, durability, and long-term reliability. Math-based computer tools were utilized to optimize the design and accelerate the pace of development. Durable nodular iron was selected as the crankshaft raw material, due to its superb material properties and manufacturability.

The crankshaft length and stroke can drive significant torsional vibration, a wave of flexing, from one end of the shaft to the other. The torsional vibration challenge was solved by using 70mm diameter main bearings, minimizing the crankshaft polar mass moment of inertia with an optimized counterweight design and adding a dual-frequency harmonic damper. The damper consists of a steel ring and a steel disk which are bonded to the hub, with injection molded premium rubber inserts of different thickness. It attaches directly to the front of the crank to counteract the inherent flex and greatly reduces the vibration. The damper is retained to the crankshaft with a hardened 16mm bolt and a press fit to the crankshaft.

Flexplate / Flywheel



Flexplate

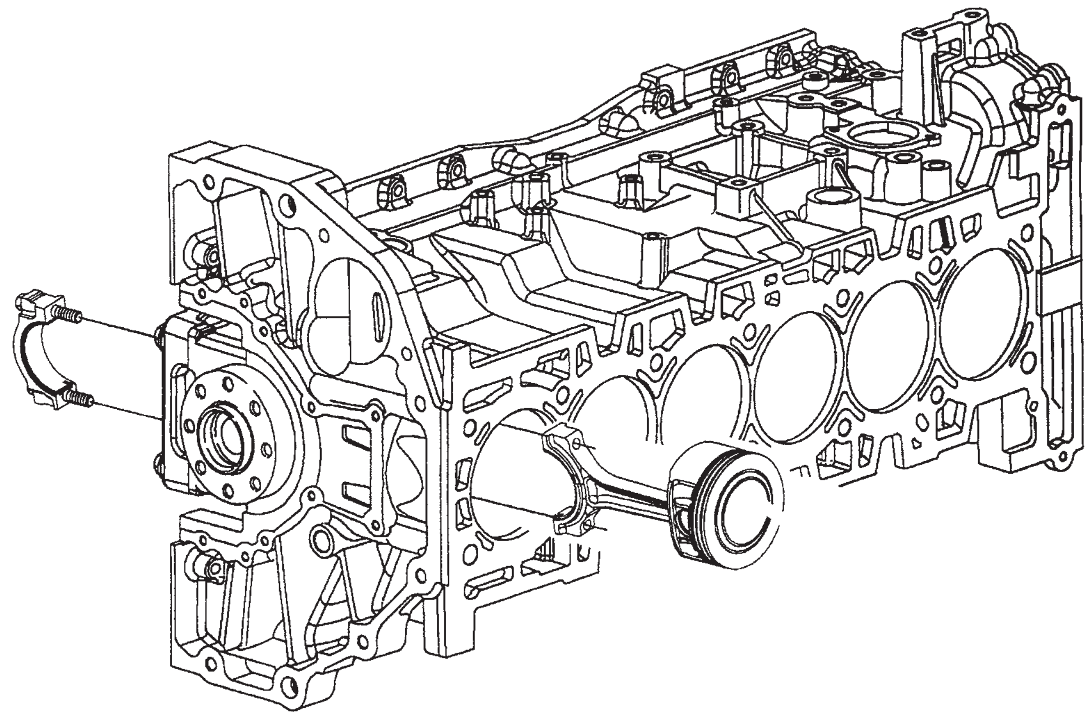


Flywheel

The flexplate is the link that transfers power from the engine to the automatic transmission. It is attached to the crankshaft with eight bolts. A hardened steel retainer plate, in the center of the flexplate, adds strength and maximizes robustness of the mounting surface. The single-piece flexplate material is roll-formed steel. Gear teeth are hobbed and flame hardened at the flexplate perimeter to allow the starter motor engagement to start the engine. By using blind threaded holes, the potential for oil leaks are eliminated at the crankshaft flange.

The manual flywheel is attached to the crankshaft with eight bolts. The flywheel material is durable nodular iron with a pressed-on steel flame hardened ring gear that engages with the starter motor to start the engine. Since the crankshaft is internally balanced, a symmetrical bolt pattern is used at the crankshaft flange and no external counter weighting is required with the flywheel.

Piston / Connecting Rods



The piston, found inside the cylinder bore of an engine block, transfers energy through the connecting rod to the crankshaft. Pistons are made of hyper-eutectic aluminum alloy. Surrounding the piston are piston rings. They seal the piston in the cylinder bore to control compression of air/fuel and flow of oil.

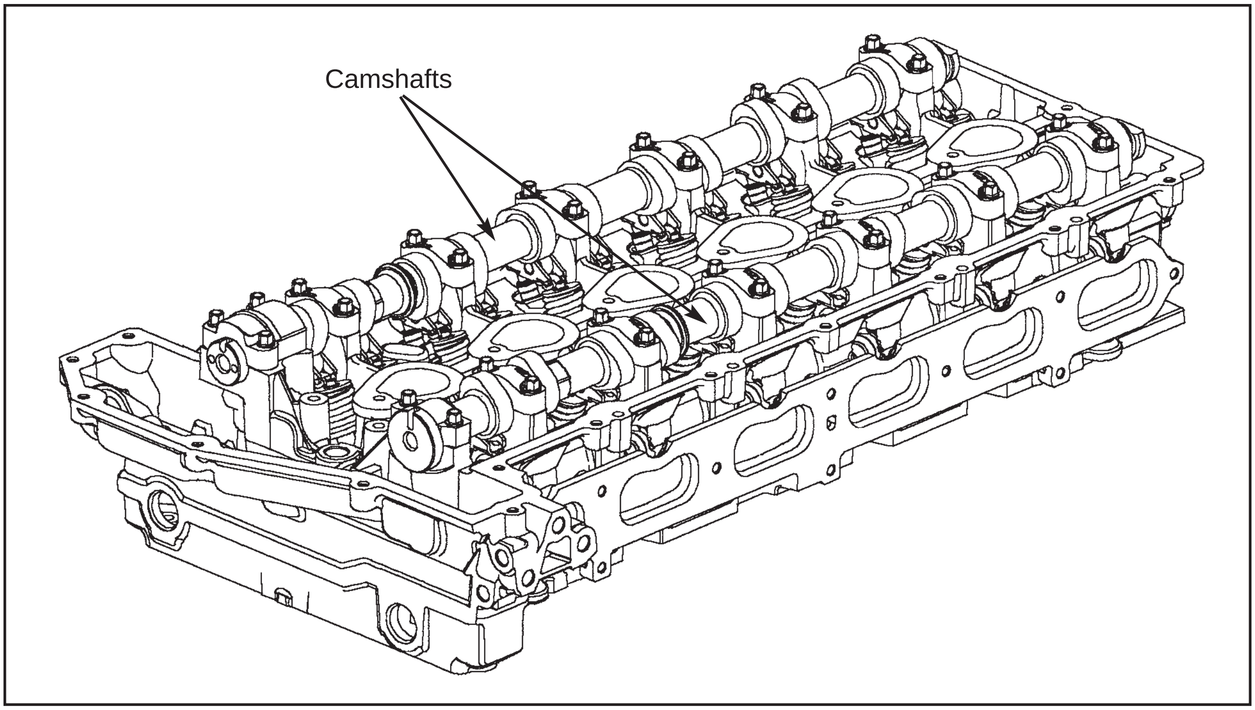
The piston features a short 3mm top ring land height, reducing the hydrocarbon crevice. The top ring is a moly filled, barrel faced steel ring, with a 1.2mm thick iron second ring. The engine features a full floating piston pin, riding in a bronze connecting rod bearing.

The distance a piston travels is called the stroke. From the bottom to the top of a stroke there is a change in volume; that change is referred to as the compression ratio (10:1).

The connecting rod connects the piston at one end, with a free floating wrist pin, to the crankshaft at the other end. The rod is steel, formed from powder metal, and hot forged. The rod is machined and then the cap is fractured from the rod portion. This fracture joint is used to accurately position the cap to the rod during engine assembly. Rod bearings are installed into the crankshaft end of the connecting rods. They provide a smooth surface for the connecting rods to rotate on the crankshaft. The bearings, sometimes called inserts, are made of steel with an aluminum alloy bearing surface, using a cladding process to the steel backing to provide the appropriate wear surface.

An arrow on top of the piston identifies how to install the piston for correct pin offset. The arrow always points toward the front of the engine.

Cylinder Head



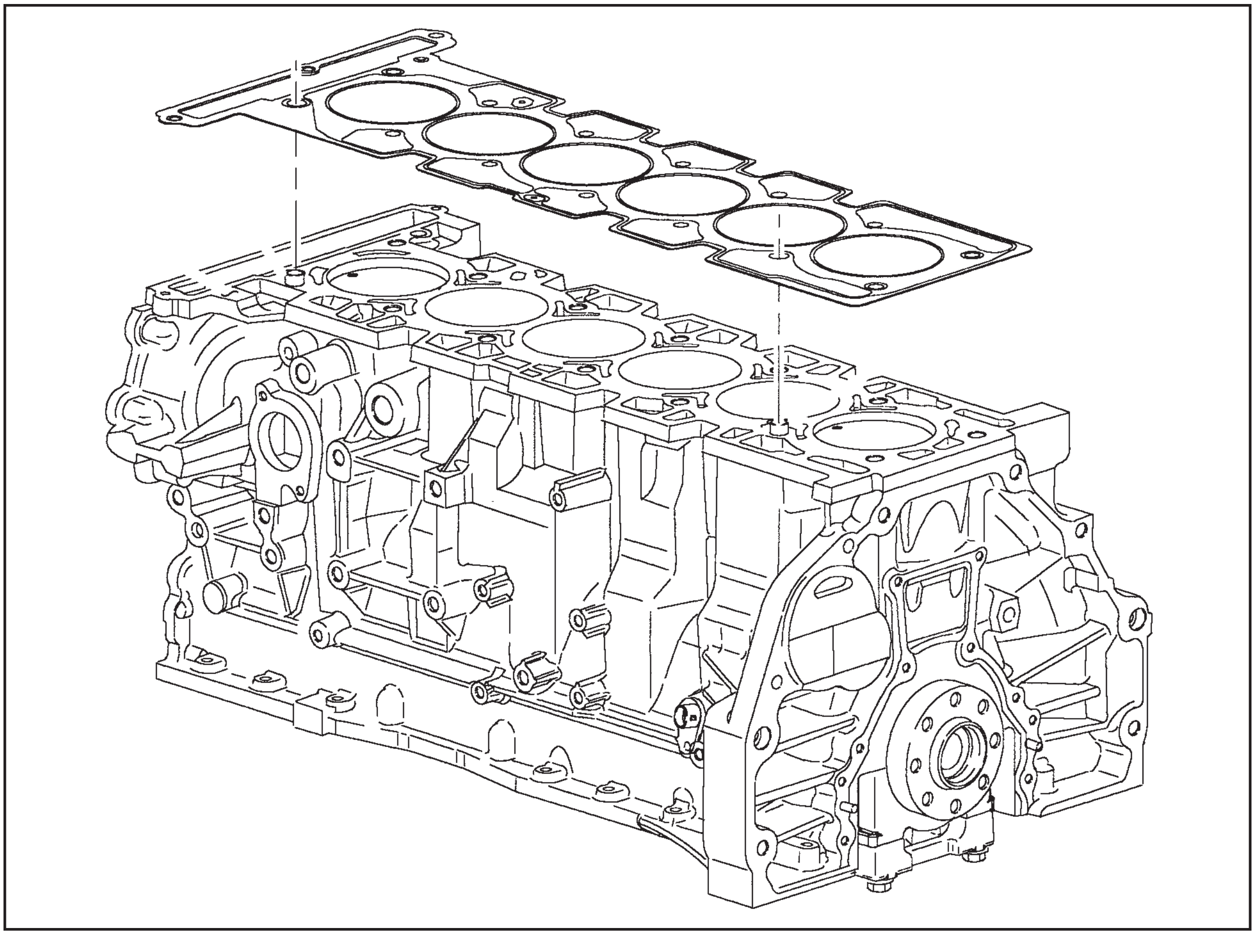
Dual overhead camshafts with four valves per cylinder and roller-follower valve actuation can be found on some premium passenger car engines, but are still rare in trucks. The cylinder head contributes to the engine's overall smoothness and high output. Overhead cams are one of the most direct, efficient means of operating the valves, while four valves per cylinder improves the flow of air in and out of the engine. Roller followers create less friction than conventional valve lifters. The lower friction improves fuel economy.

Compression ratio is important for both torque and horsepower output, as well as fuel economy. The combustion chamber and cooling system design used on this engine provides for a high (10:1) compression ratio. Typically, this high compression ratio would require high-octane gasoline to produce maximum power, or to avoid the hard knocking sound known as "detonation." However, this engine was designed to maximize fuel economy and it does – premium gasoline is not needed. Customers can use regular, unleaded fuel and benefit from the high horsepower this engine provides. The intake port and combustion chamber configuration provides exceptional air flow capability and provides appropriate mixture motion.

Valve sizes were kept to a minimum, giving generous exhaust valve bridge dimensions. These wide bridges allow for both good cooling and low thermal stress. In conjunction with the chambers, extensive coolant flow development occurred to provide high velocity coolant flow around the spark plug and exhaust valve seats. Testing confirms that cool spark plug and valve temperatures greatly enhance durability of the truck engine.

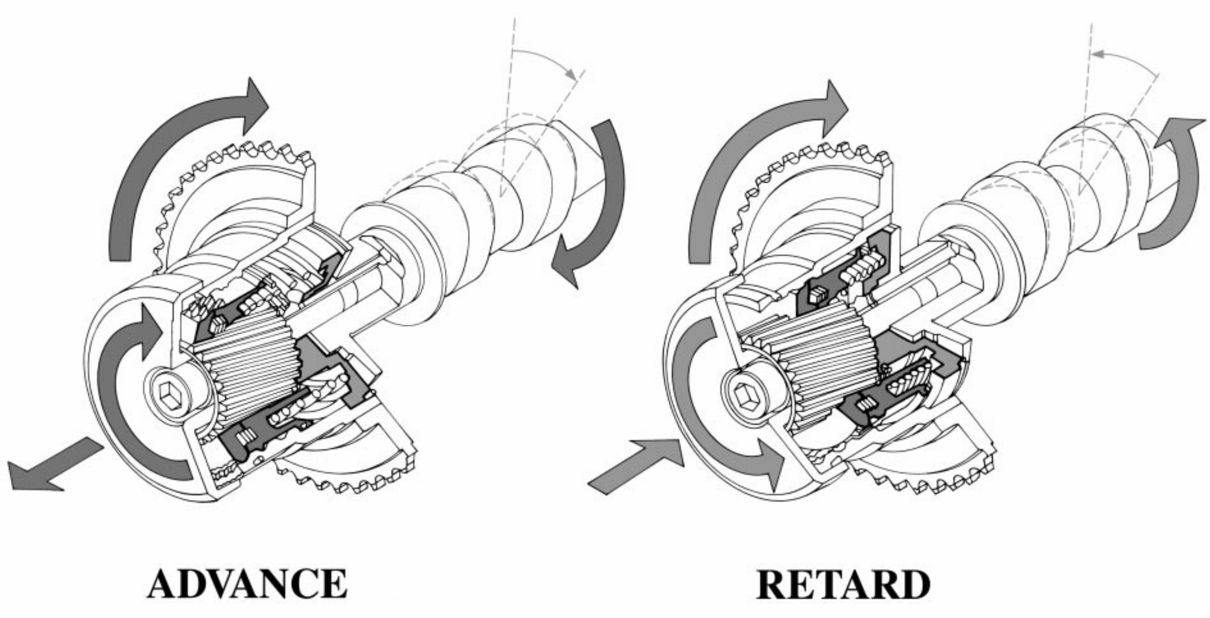
The cylinder head is also cast using the lost foam process, with the premium A356 aluminum with a T6 heat treatment for high fatigue strength and durability. Optimum cooling is achieved through high velocity coolant passages around the spark plug and exhaust port.

Cylinder Head Gasket



The cylinder head gasket seals the cylinder block to the cylinder head. The multi-layer gasket features three-layers of stainless steel. A folded-over center layer provides the additional load to seal the combustion chamber. A coating is used to help seal coolant and oil passages. The high pressure oil line that feeds the cam phaser has a Viton seal insert in the head gasket.

Variable Valve Timing

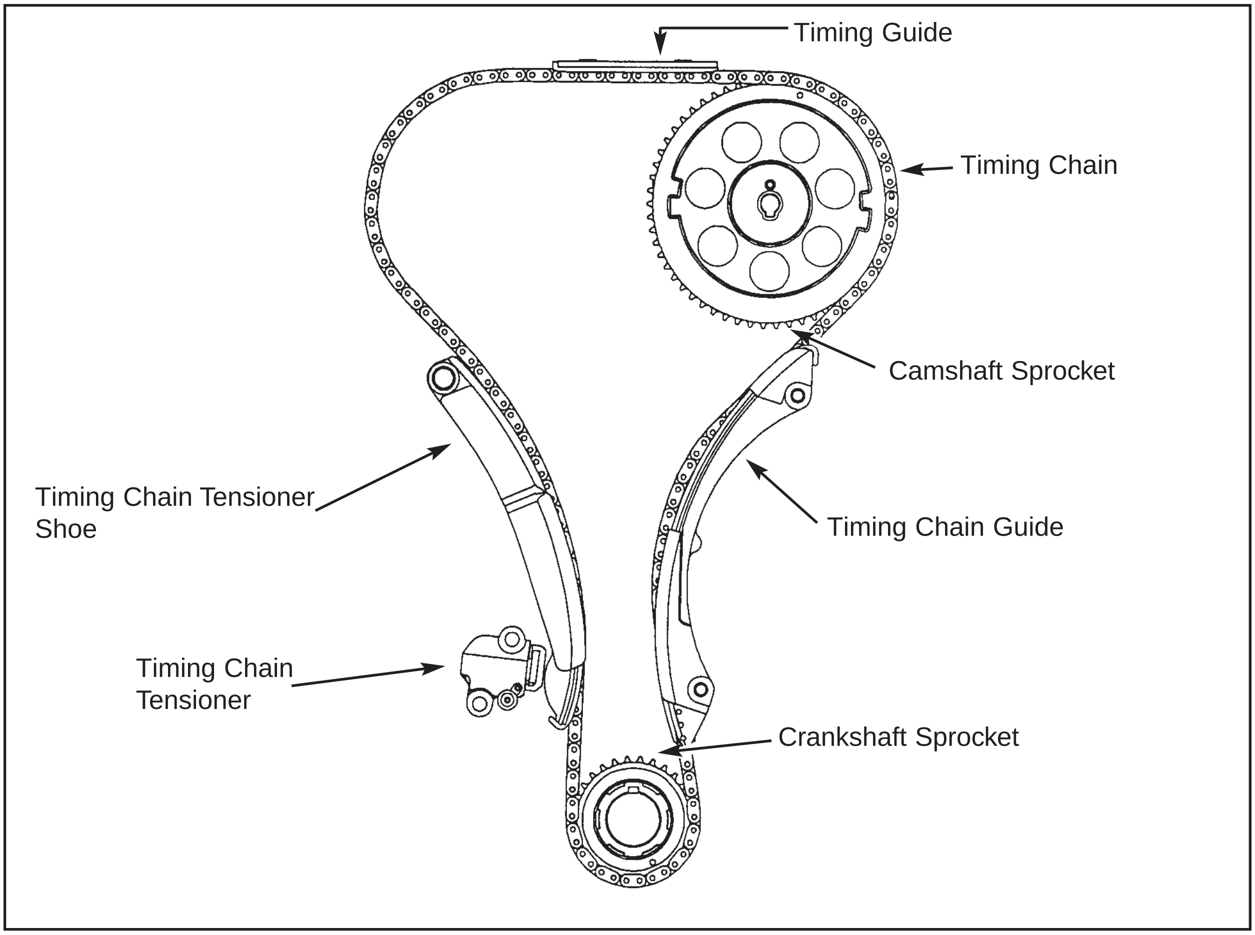


For the first time in a GM truck engine, variable valve timing (VVT) will be featured. The VVT on the Vortec I6 includes an exhaust cam phaser. Cam phasing changes exhaust-valve timing within a range of 25 degrees as engine rpm and operating conditions change. The result is linear delivery of torque, 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.

The cam phaser has an internal helical spline and piston mechanism that changes exhaust-cam lobe timing relative to the cam-drive sprocket. The helical spline/piston is controlled hydraulically. Engine oil is directed by a control valve to the appropriate passage in the phaser, turning the camshaft relative to the sprocket. At idle, the exhaust cam is at full advanced position for minimum intake valve overlap. This provides exceptionally smooth idling. Under other engine operating conditions, the phaser is controlled by the Powertrain Control Module (PCM) to deliver optimal exhaust valve timing for performance, driveability, and fuel economy.

VVT also contributes to a reduction in exhaust emissions. It optimizes exhaust valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system. Hydrocarbons are reduced by as much as 25 percent and NOx is reduced up to 40 percent over a conventional EGR system. Variation of cylinder to cylinder distribution of the internal residual exhaust is also improved significantly with cam phasing versus EGR.

Cam Drive

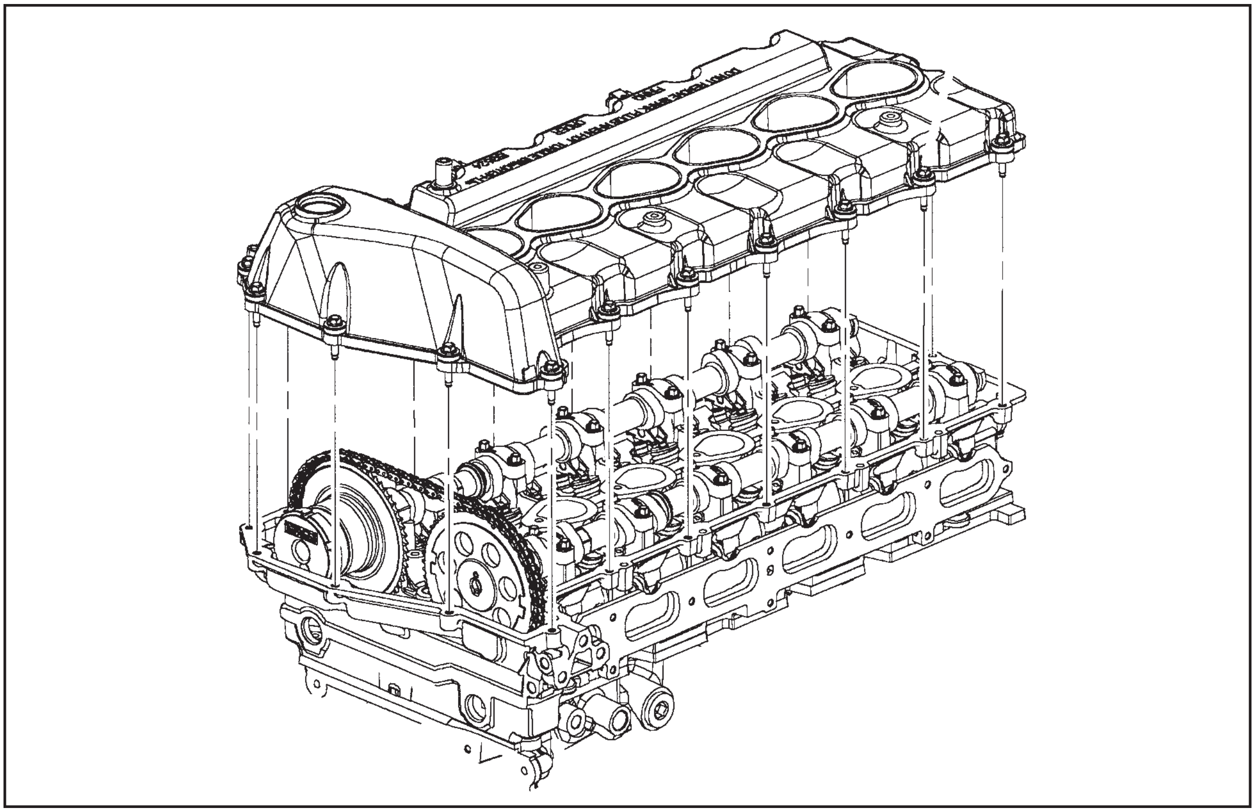


The cam drive assembly is a combination of chains and sprockets. These components drive the camshafts, which actuate the valves in the cylinder head. The cam drive also has a relationship to piston position for proper firing order and timing. A ratio of 2:1 is maintained — two rotations of the crankshaft to one rotation of the camshafts. A sprocket with 29 teeth is located on the crankshaft and provides the drive. The camshafts use 58 tooth sprockets. The crankshaft and camshaft sprockets are connected by a roller chain with an 8mm pitch.

Assembly of the camshaft timing drive system with proper cam timing is critical. During assembly, the crankshaft must be at top dead center (TDC) for the number one cylinder. The cams must be oriented with the timing slot pointing up. Cam orientation can be assured by laying a flat bar across the flats on the rear of the cams. The cam sprocket, crank sprocket and exhaust cam phaser can be assembled with the timing marks aligned to colored links on the chain. (Note: The exhaust cam phaser must be at the fully advanced position.)

Timing chain guides are used to guide the chain around the sprockets and dampen chain vibrations. A spring loaded hydraulic tensioner is used to tension the timing chain. The tensioner is installed in the retracted position. It is held in this position by a release pin. After assembly, the pin is removed and the chain is pre-tensioned. When the engine is running, oil pressure to the tensioner provides additional tension on the chain and dampens the drive system.

Camshaft Cover



The primary purpose of the camshaft cover is to prevent oil loss. Additional functions include noise suppression, mounting provisions, an oil fill port, positive crankcase ventilation (PCV), spark plug access wells and informative service notes.

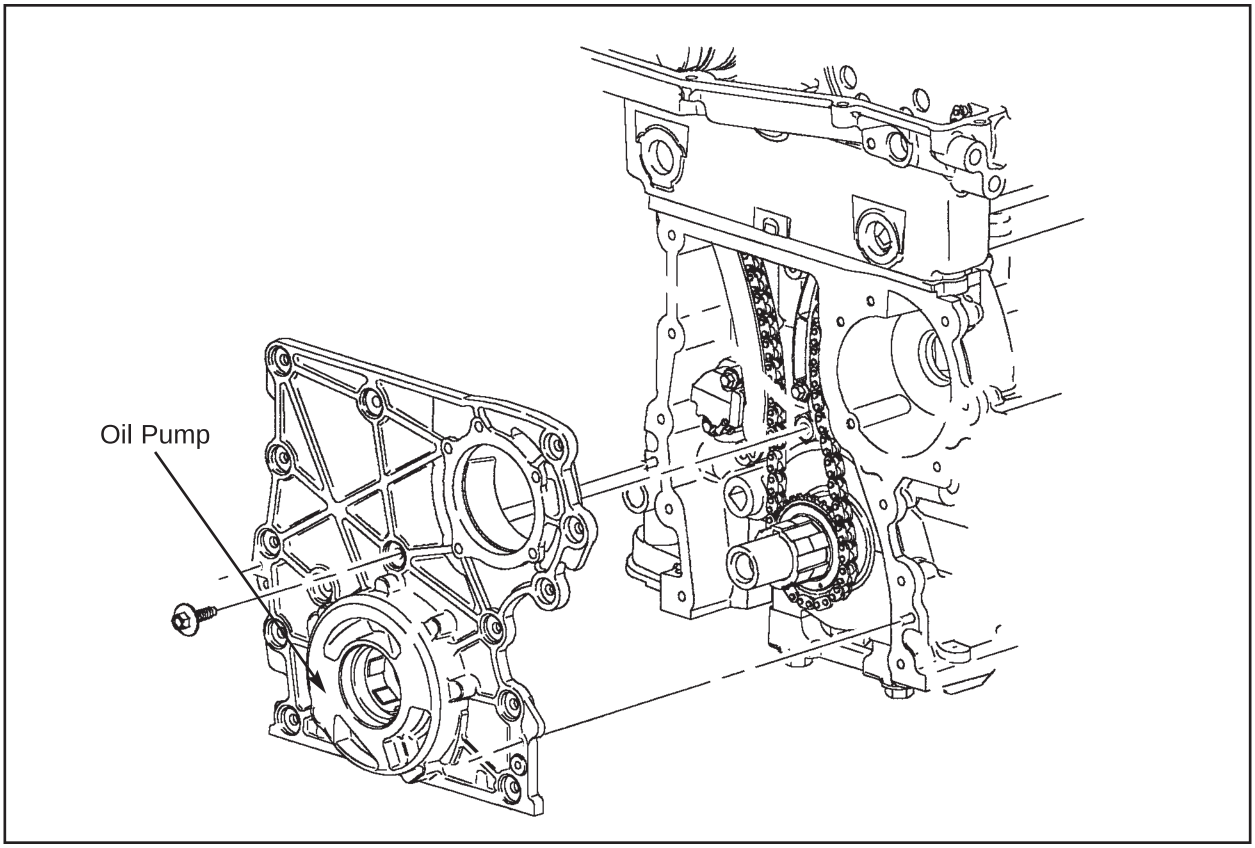
The cam cover suppresses noise through an isolation system comprised of 21 grommets and fasteners that work in conjunction with the silicone seals like a spring damping system. The isolation allows the cover to float on the cylinder head, while still providing enough sealing pressure to satisfy the cover's key function beyond 150,000 miles of service. It also eliminates much of the noise and vibration transfer that would occur with a typical rigidly mounted cover.

The fresh air portion of the PCV system in this engine utilizes fewer parts by incorporating molded separator baffles in the cover. Four fasteners were eliminated by employing a unique "star and post" attachment system for the baffle cover to the cam cover joint.

About three pounds were shaved from the cover by using sheet molding compound (SMC) vinyl ester material in place of aluminum. In addition to the mass benefit, SMC offers excellent strength and high temperature resistance.

The cam cover assembly is shipped complete with the PCV baffle, fasteners, clips and silicone gaskets. Prior to shipping, 100 percent of the covers are leak checked to ensure quality. At the engine plant, a second leak check is performed on every engine assembly, further ensuring a quality engine.

Front Cover / Oil Pump

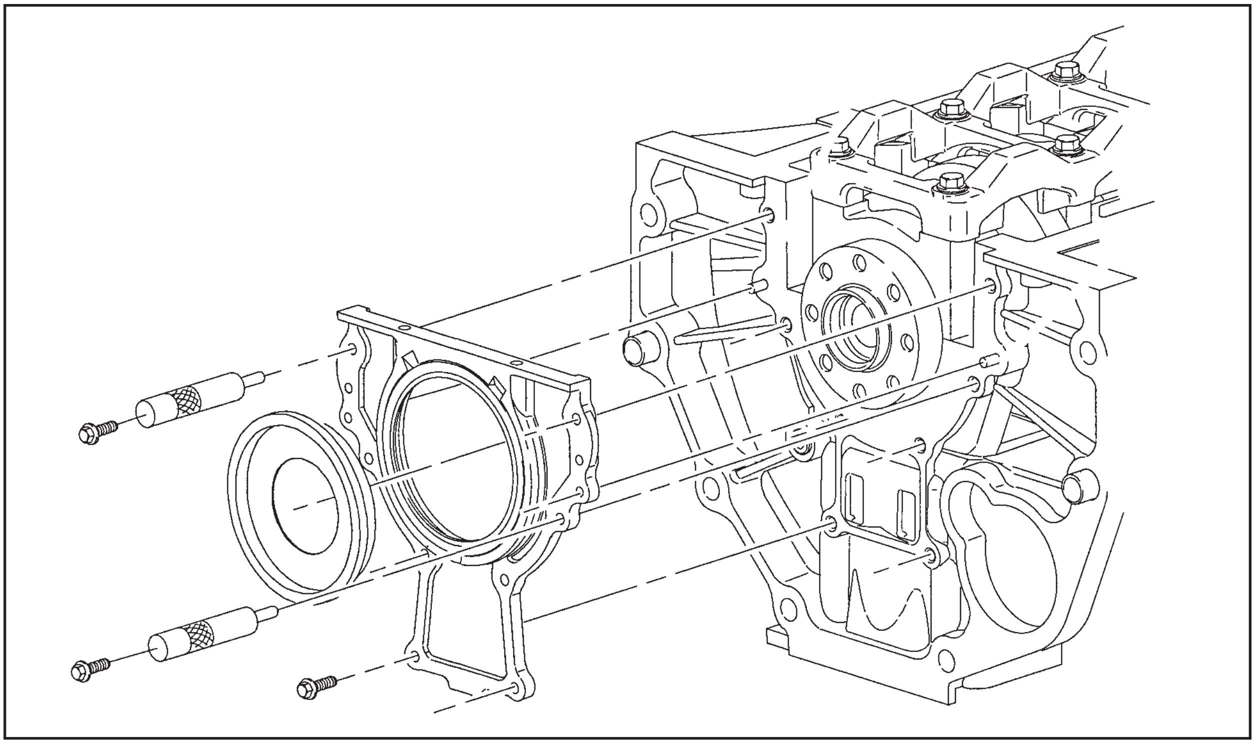


The aluminum front cover seals the front of the engine, preventing oil and coolant loss. Both the oil pump and coolant pump are housed in the front cover, which is sealed to the block with room temperature vulcanizing (RTV) silicone sealant. A PTFE (Teflon) radial lip seal, similar in design to the rear crankshaft seal, is pressed into the front cover and seals around the torsional damper's center hub to prevent oil leaks.

The oil pump pulls oil from the oil pan, through the oil pickup tube. It then forces oil through the oil filter and into the oil galleries. The oil pump's gerotor design uses eccentric lobes to move oil from the inlet to outlet ports. An inner ring with 10 lobes, driven by the front of the crankshaft, is surrounded by 11 lobes on an outer ring. As oil enters the pump, the eccentric design compresses the oil, then releases the oil at a regulated max pressure of 65 psi at 2,500 rpm, circulating 11 gallons per minute. The pump body is made of aluminum, and the gerotor gears are made of powder metal. The pressure regulator is a spring and piston design that is incorporated into the oil pump assembly.

A by-pass valve is also installed into the cylinder block in the main oil passage between the oil pump and the oil filter. This valve regulates the amount of oil pressure that is applied to the oil filter. During the filtering of oil, there is a restriction of oil flow through the filter, causing a build up of pressure (typically under cold oil conditions). When the pressure differential meets 18 psi the valve opens to by-pass a portion of oil around the filter to protect the filter element from collapsing.

Rear Cover / Main Seal



The rear crankshaft seal housing assembly prevents oil from escaping at four critical interfaces: housing to block, housing to oil pan, housing to the outer diameter of the radial seal element, and radial seal to crankshaft.

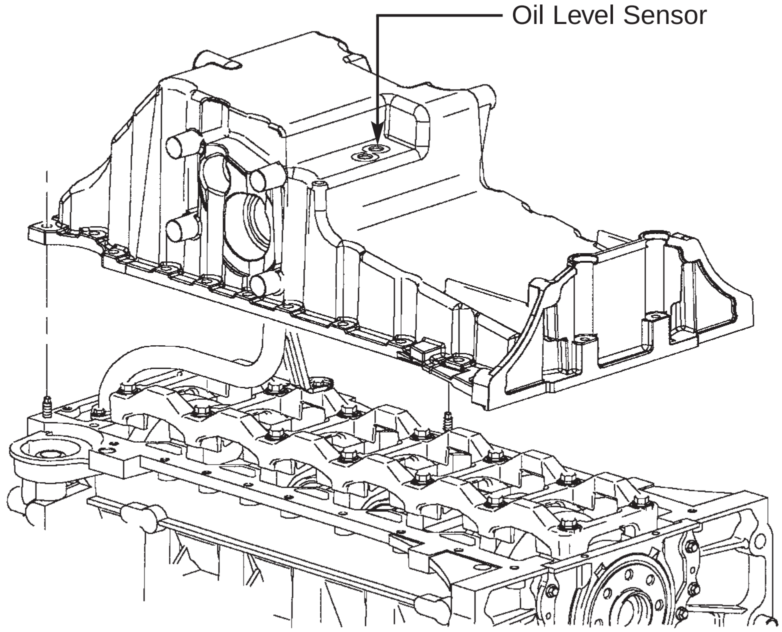
The seal assembly is made up of three materials: steel, polyacrylic rubber (ACM), and PTFE (Teflon). The steel backbone provides the form of the seal while the ACM coating seals the assembly to the aluminum housing through a press fit. The ACM also bonds the Teflon to the backbone forming yet another seal.

The key element of the housing assembly is the PTFE sealing lip. Traditional rubber seals contact the crankshaft at a narrow point creating a wear ring in the crankshaft that can lead to oil leakage and service issues. The low friction PTFE seal distributes load over a larger surface area and tends to polish the crankshaft. General Motors testing has shown this design may provide service beyond 150,000 miles.

The assembly is shipped with a recyclable plastic assembly tool which guides the PTFE seal lip over the crankshaft as the housing is aligned to two dowel pins. The dowel pins ensure proper alignment between the crankshaft and the radial seal, which is critical for sealing the crankshaft interface.

The housing to block joint is sealed with room temperature vulcanizing (RTV) silicone sealant. The front cover and oil pan to block joints are also sealed with RTV silicone. The RTV silicone sealant used on the Vortec 4200 I6 has successfully completed GM Powertrain’s most grueling sealing tests, which are equivalent to 10 years of service or 150,000 miles.

Oil Pan / Pan Axle



The oil pan provides another example of extensive efforts to minimize engine noise and vibration. The oil pan mounts to the transmission bell housing and the engine block, providing the necessary structure required to overcome powertrain bending inherent to a longitudinal engine package.

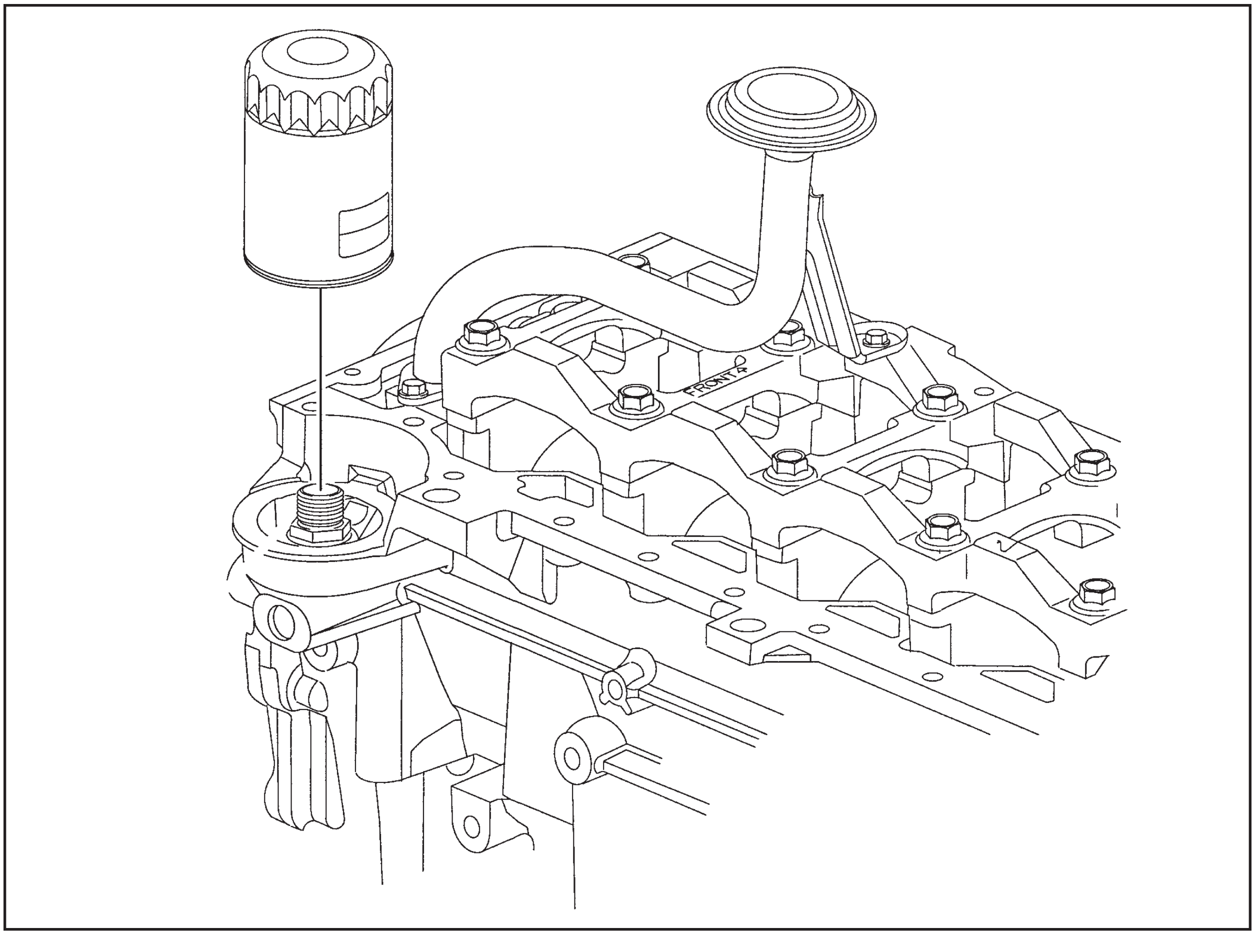
A passage cast through the width of the oil pan allows a drive axle to pass through it rather than under it. The engine can be placed lower in the vehicle, allowing a more compact package, improving the vehicle’s handling dynamics and giving designers greater styling flexibility. It also allows u-joint angles to be held closer to the ideal angle, so “growl” noise is minimized in four wheel drive.

The oil pan has a sensor installed that indicates the level of oil in the sump at vehicle start up. When the key is turned on before starting, the sensor measures the level of oil, adding engine protection. The sensor has a reed switch which is opened and closed by a float with a magnet installed.

The additional volume gained in the pan allows for a 7 quart oil fill, which prolongs the oil life and extends oil change intervals. Because it is a cool running engine, no oil cooler is required, even with heavy towing.

The four wheel drive differential and disconnect also bolt to the pan. All gear and drive noises are required to travel in a more difficult path as they are transmitted through the engine and dampened by the motor mounts. The pan is sealed to the block, front cover, and rear seal housing with room temperature vulcanizing (RTV) silicone sealant. The pan also provides mounting bosses for the pan baffles, the A/C compressor, the oil drain plug, the oil level sensor and wiring.

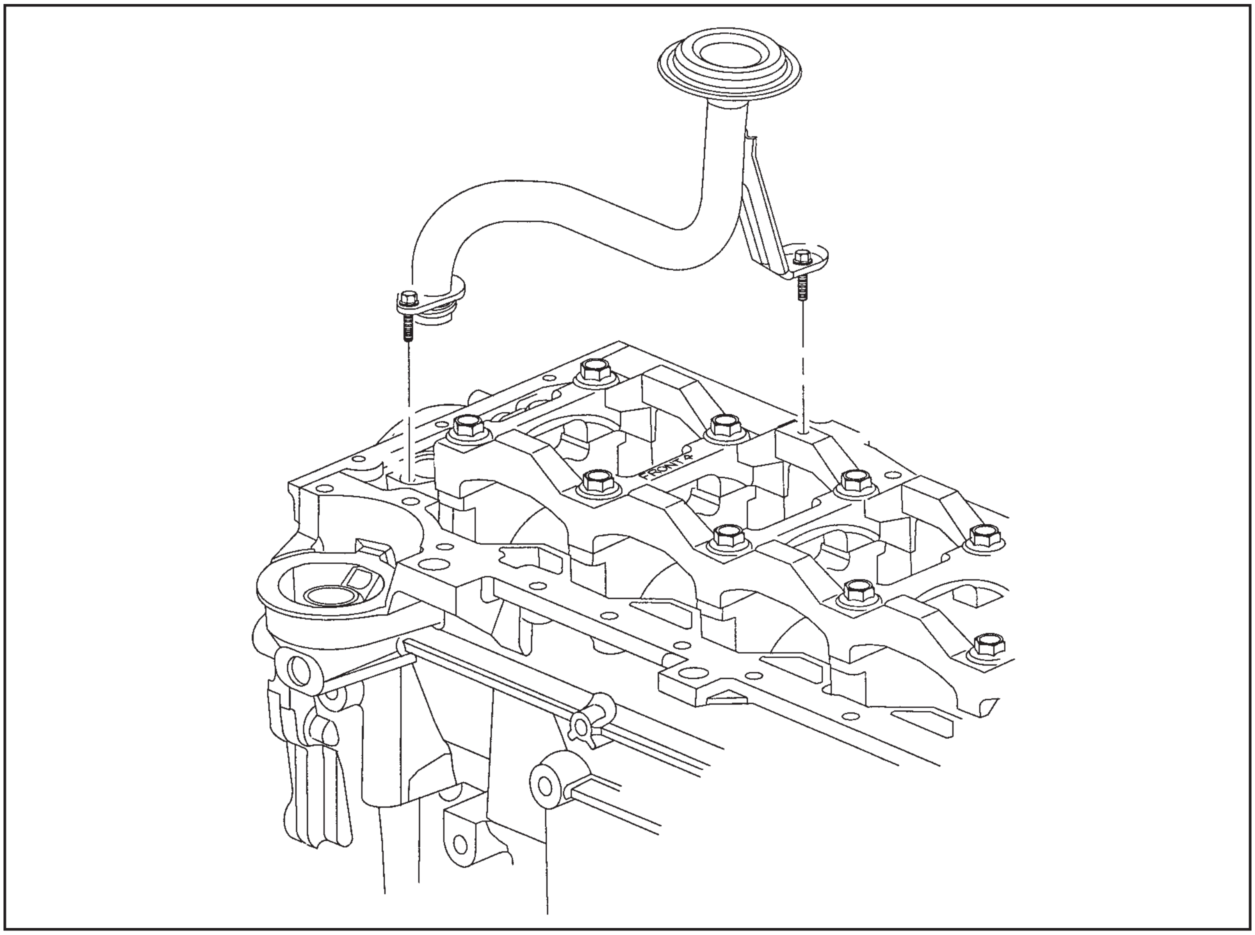
Oil Filter



The oil filter receives oil from the engine and traps debris to keep the engine oil clean. Clean oil will allow the engine to run cooler and extend durability by reducing friction. The outside shell is steel and inside there is a paper filter element that collects debris. A silicon rubber seal at the mounting surface also prevents oil leaks. When following recommended maintenance schedules, the oil filter should be replaced when the oil is changed.

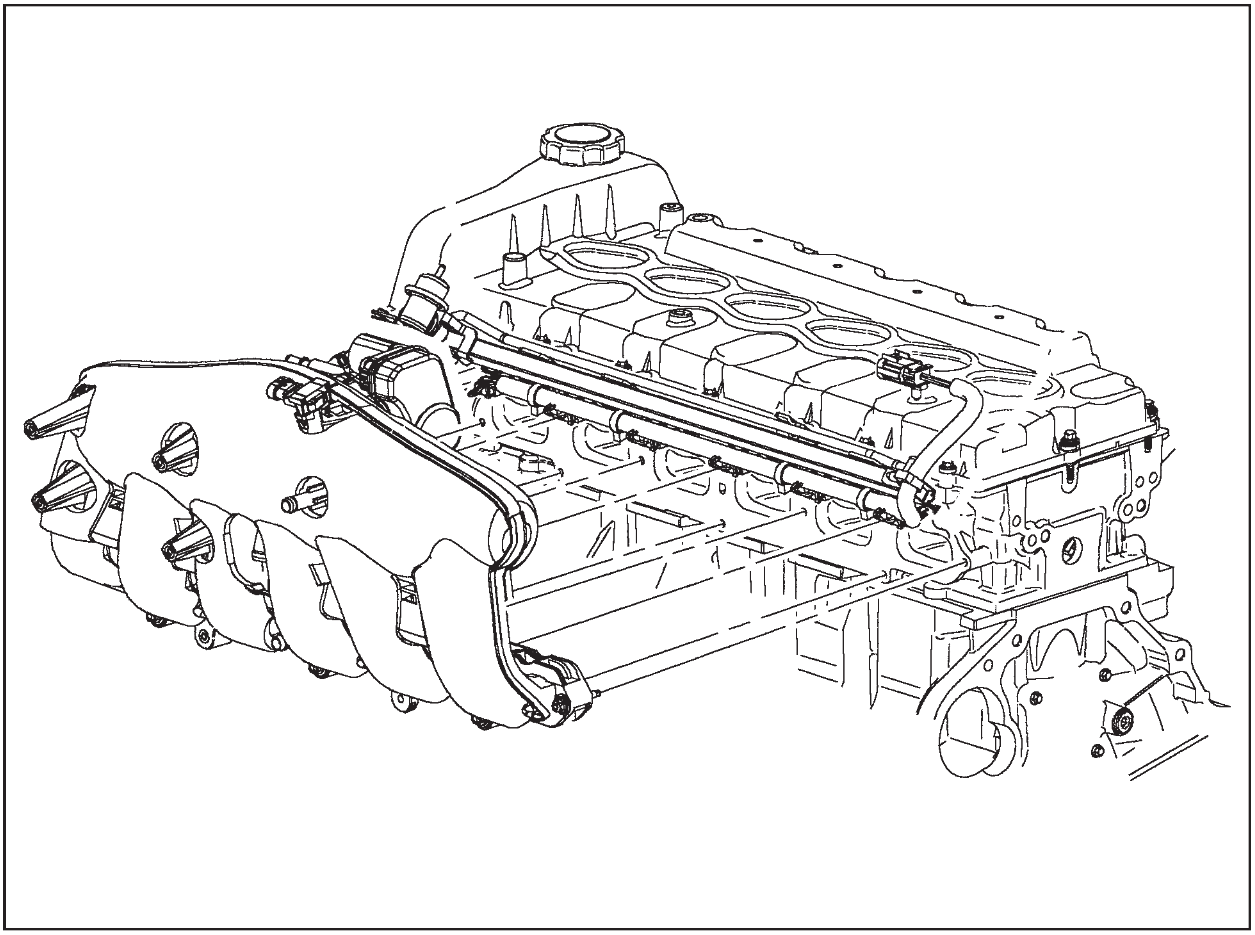
Installation begins by hand and then is rotated until the seal makes contact (one full turn). No lubrication is needed on the seal. A common filter wrench is used for removal. The filter has a rubber anti-drainback valve, which stops oil from draining out of the engine's oil circuit upon engine shutdown. This allows for faster oil pressure build-up upon start-up.

Oil Pickup Tube



The oil pickup tube routes oil from the sump (or oil pan) to the oil pump. It is made of steel tubing with a pickup screen, brazed to one end to strain out large debris particles. The pickup tube is fastened to the oil pump (front cover assembly) and to the bearing beam. The tube is sealed to the oil pickup with an o-ring.

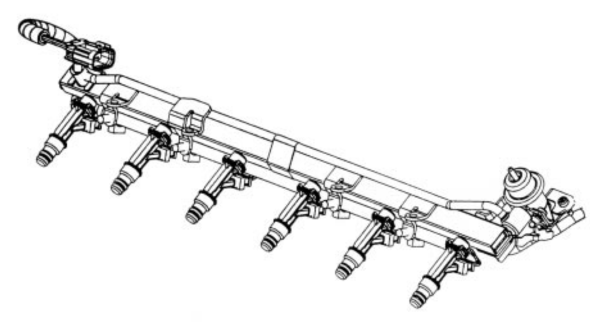
Intake Manifold



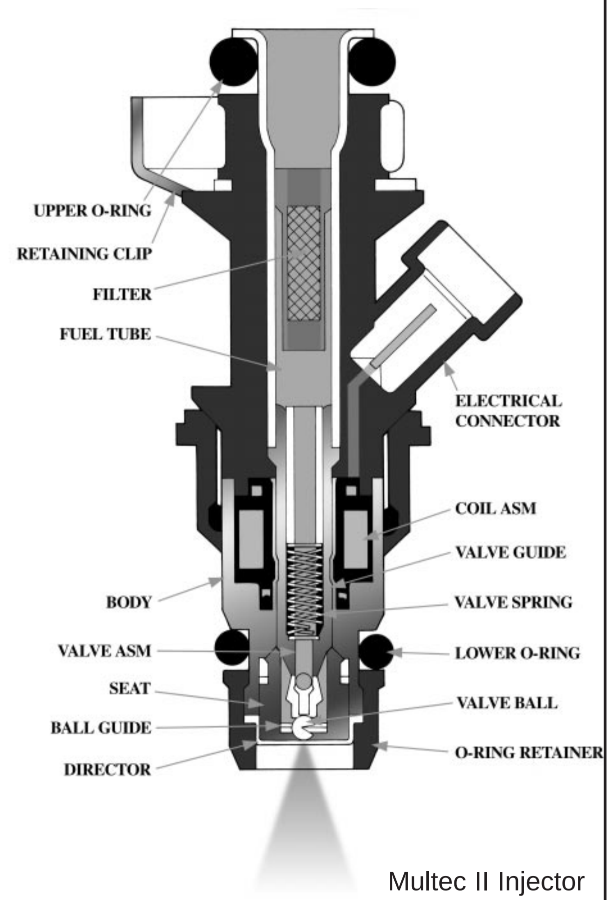
Compared to conventional metal designs, the glass-reinforced nylon composite intake manifold delivers several advantages including less weight and improved airflow. Radiated noise is dampened by a “form fitting” noise cover, which snaps around the intake manifold assembly.

The intake manifold is formed by injection molding when two separate shells are then vibration welded together. This is the first application of a vibration welded intake manifold for GM in North America. Extensive finite element analysis (FEA) modeling was used to develop a design that could withstand the rapid overpressurization that could occur in the event of an engine backfire. Because of this modeling, a pressure relief valve is not required, providing additional cost savings over competitive designs.

Fuel Rail / Injectors



Fuel Rail



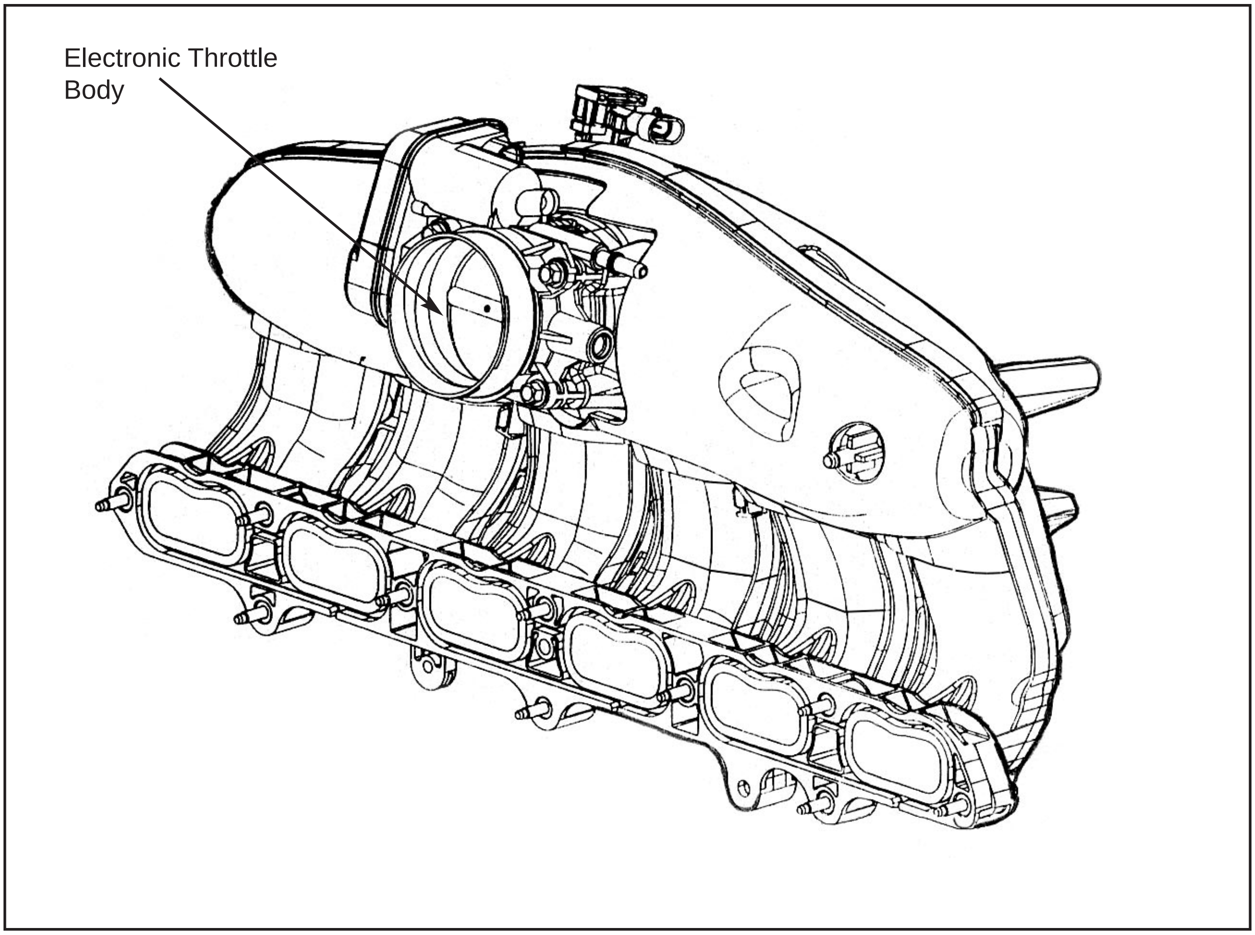
Multec II Injector

The fuel rail body is a fabricated, single rectangular tube with side rail walls capable of flexing. This effectively dampens fuel pressure pulsations and reduces audible vibration. This feature helps to eliminate fuel-line hammer while also improving fuel metering accuracy.

The fuel rail is comprised of a stainless steel fuel rail body, fuel pressure regulator, dual-spray injectors, and an injector wire harness. The fuel rail assembly mounts directly to the cylinder head for improved injector targeting and optimum emission performance.

The operating pressure of the fuel rail assembly is 350 kPa. The latest generation Multec II injectors deliver fuel more precisely and consistently than previous injectors, increasing efficiency and reducing emissions. These injectors are lighter than the previous generation and feature a stainless steel director plate. They reduce the potential for fuel leakage at the tip by up to 66 percent, maintain more consistent performance under hot-fuel conditions, and greatly reduce the potential of plugging due to contamination.

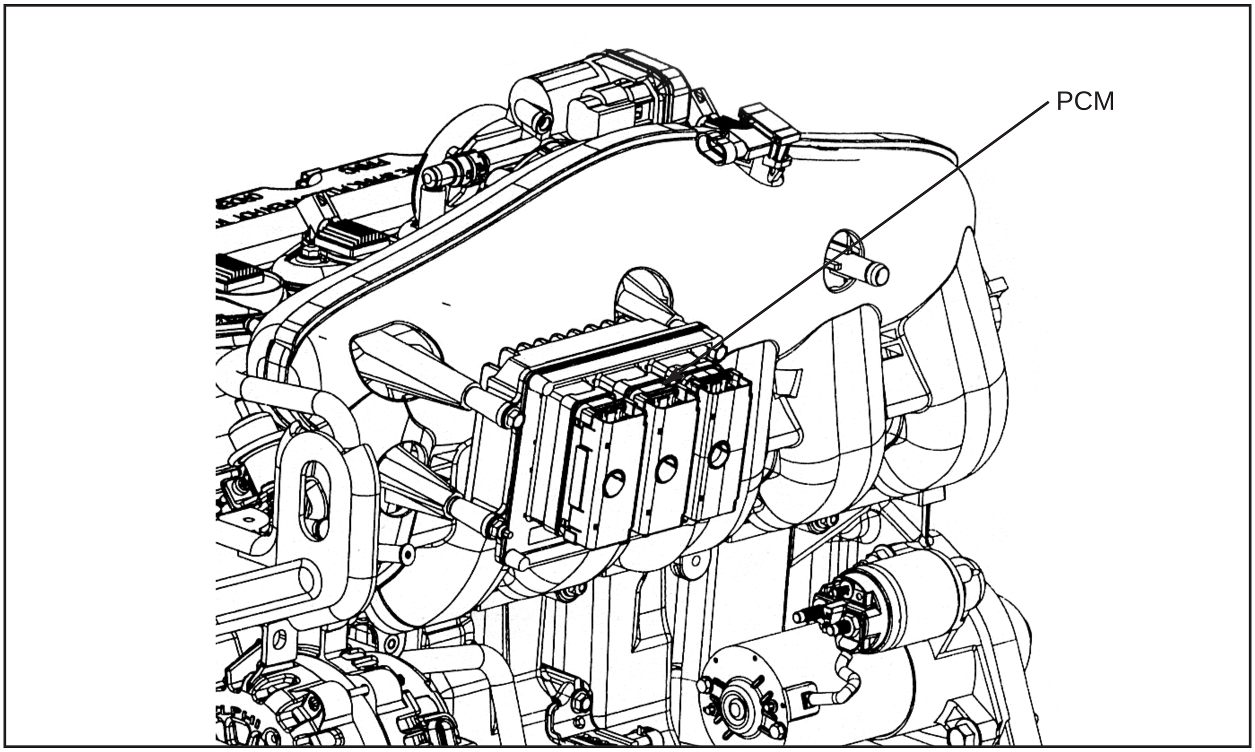
Electronic Throttle



Electronic "drive-by-wire" throttle is featured in premium V8 engines such as the LS1 V8 for Chevrolet Corvette, but is rare in truck engines. In the Vortec 4200 engine, there is no mechanical link between the accelerator pedal and the throttle. The throttle is controlled through an integrated controller within the Powertrain Control Module (PCM). The PCM directs an electric motor to open the throttle at the appropriate rate. Two independent throttle position sensors are utilized in the PCM in addition to other data such as transmission gear and traction at the wheels. In addition to excellent throttle response and control, the Electronic Throttle Control (ETC) provides other functions including idle air control, traction control and transmission shift torque management.

The ETC has a 77mm diameter, dual shaped progressive throttle bore. The dual progression improves idle stability at minimum airflow and ensures peak power is achieved during high airflow requirements. The die cast aluminum throttle body housing contains sealed needle bearings and a wrap-around DC brush motor. Due to the location of the throttle above the ignition coils, a wrap-around design was chosen to ensure the spark plugs could be serviced without removal of the throttle while maintaining adequate hood line clearance.

Advanced PCM

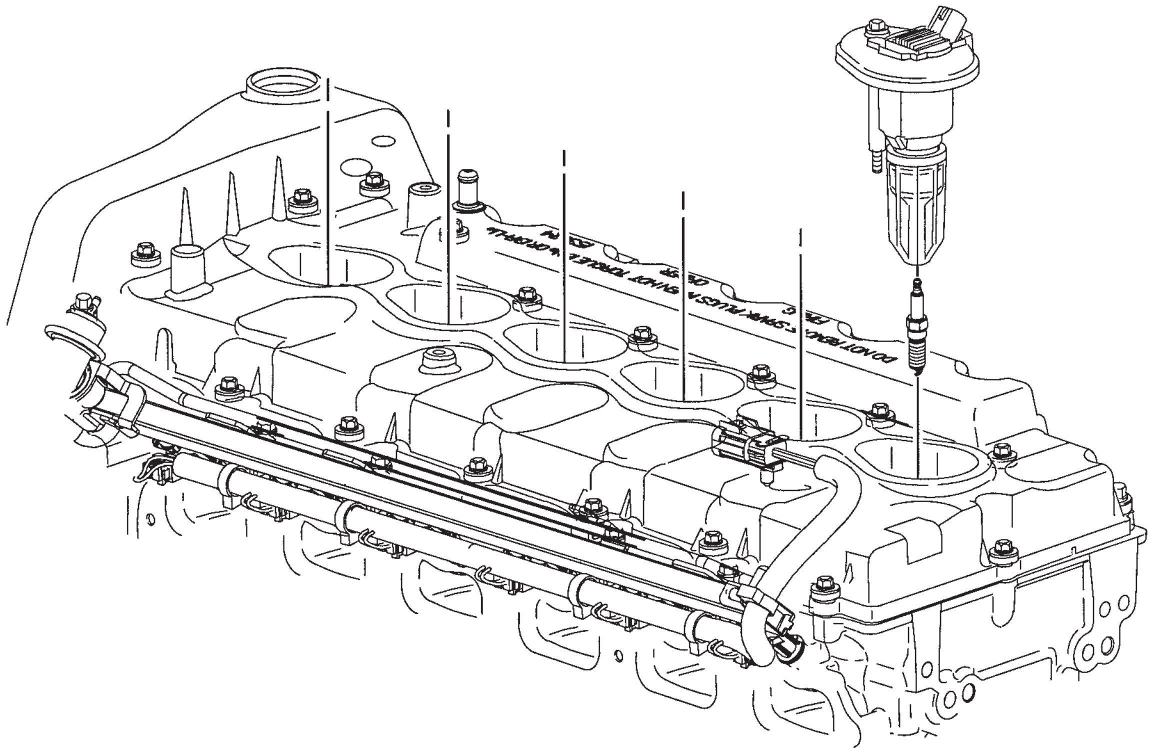


The advanced Powertrain Control Module (PCM) is housed in an aluminum box approximately 5 inches square and 2.5 inches deep and mounted on the intake manifold on the left side of the engine. Engine mounting minimizes the lengths and junctions in the engine wiring. The PCM has dual microprocessors. The main processor operates at 24 MHz with 1 MB of memory. The electronic throttle processor operates at 22 MHz with 48 KB of memory. The controller monitors 11 engine sensors including crank and cam timing sensors, manifold absolute pressure sensor, oxygen sensors, oil-level and coolant sensors, as well as transmission sensors. The PCM manages all engine and transmission functions, as well as communicates with other vehicle Electronic Control Modules.

Fueling is controlled by a speed density algorithm. This eliminates the requirement for a mass air flow meter. Additional key functions the PCM controls on the engine include the electronic throttle body, cam phaser adjustment, ignition system timing and starter engagement/disengagement.

The PCM manages the electronic throttle, considering data such as drive-wheel slip and transmission gear. It controls throttle progression for maximum driveability and ease of operation. In conjunction with the cam phaser, the PCM optimizes valve overlap and allows sufficient exhaust gas recirculation without a separate system. The PCM provides a limp-home mode for ignition timing in the event either the crank or cam sensor fails. It continues to control timing based on data from the functioning sensor and warns the driver with a warning light. Finally, the PCM will not allow the starter to be engaged when the engine is already running. This feature, called "Smart Start," was added after development testing revealed that several people attempted to re-start the engine when it was already running, because the engine is so smooth and quiet.

Ignition System



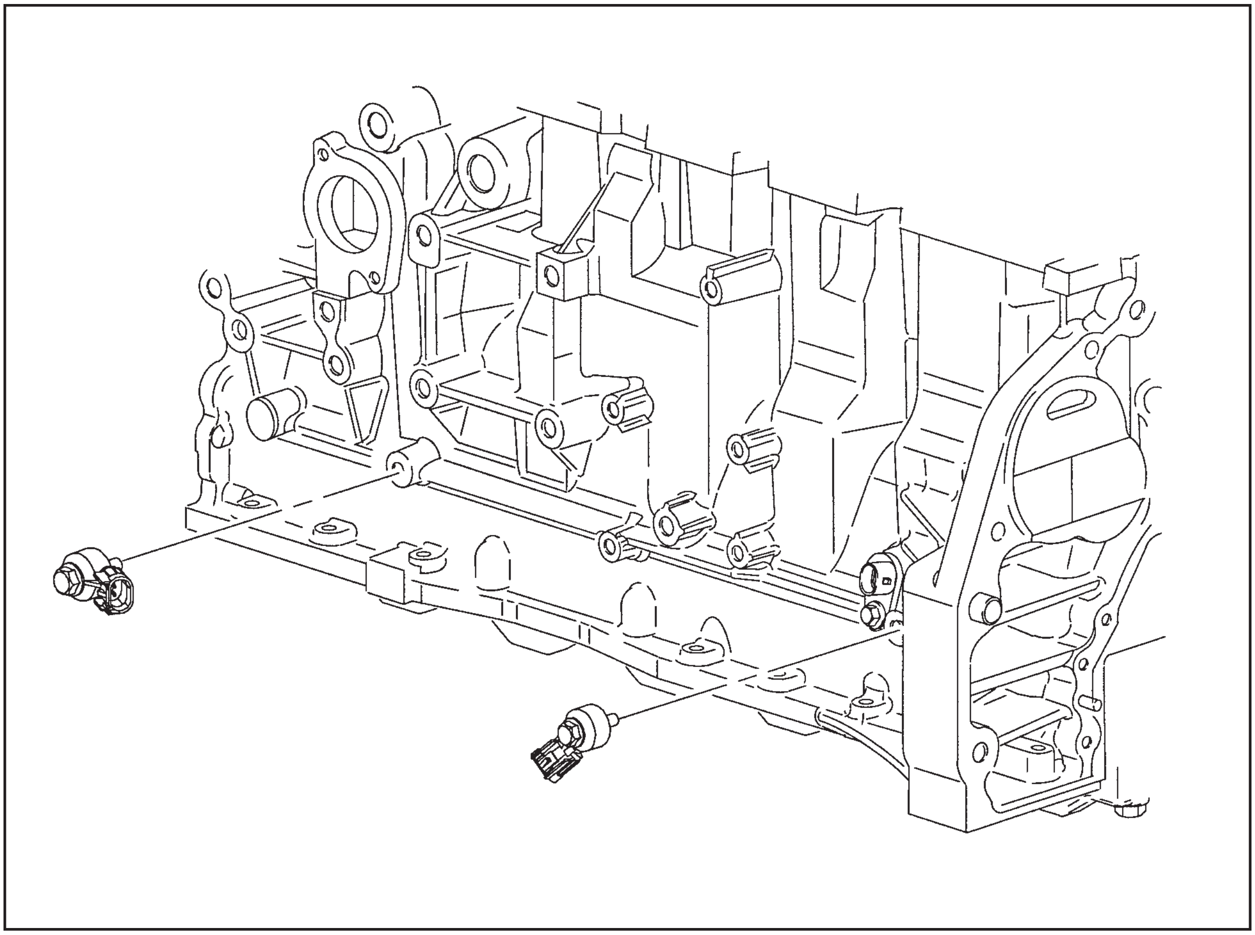
The ignition system features six individual ignition modules located directly above the spark plugs. The high energy coils deliver 25 milli joules to each spark plug for optimal combustion. The 100,000 mile spark plugs have dual platinum electrodes with a one-inch tapered seat and a plug gap of 1.07mm. Coolant flow around the plugs and the one-inch reach reduces plug operating temperature and improves durability.

The platinum tip spark plugs are easy to remove because they are located in the center of the cam cover. One fastener holds the ignition-coil cassette. When the cassette is removed, the plugs can be reached with a short ratchet extension.

Coil-on-plug ignition, which is not commonly found in truck engines, delivers the highest energy spark and most precise timing available. The increased efficiency of coil-on-plug spark also contributes to lower emissions. The system has no wires and fewer parts than conventional ignitions, providing for a greater ease of assembly.

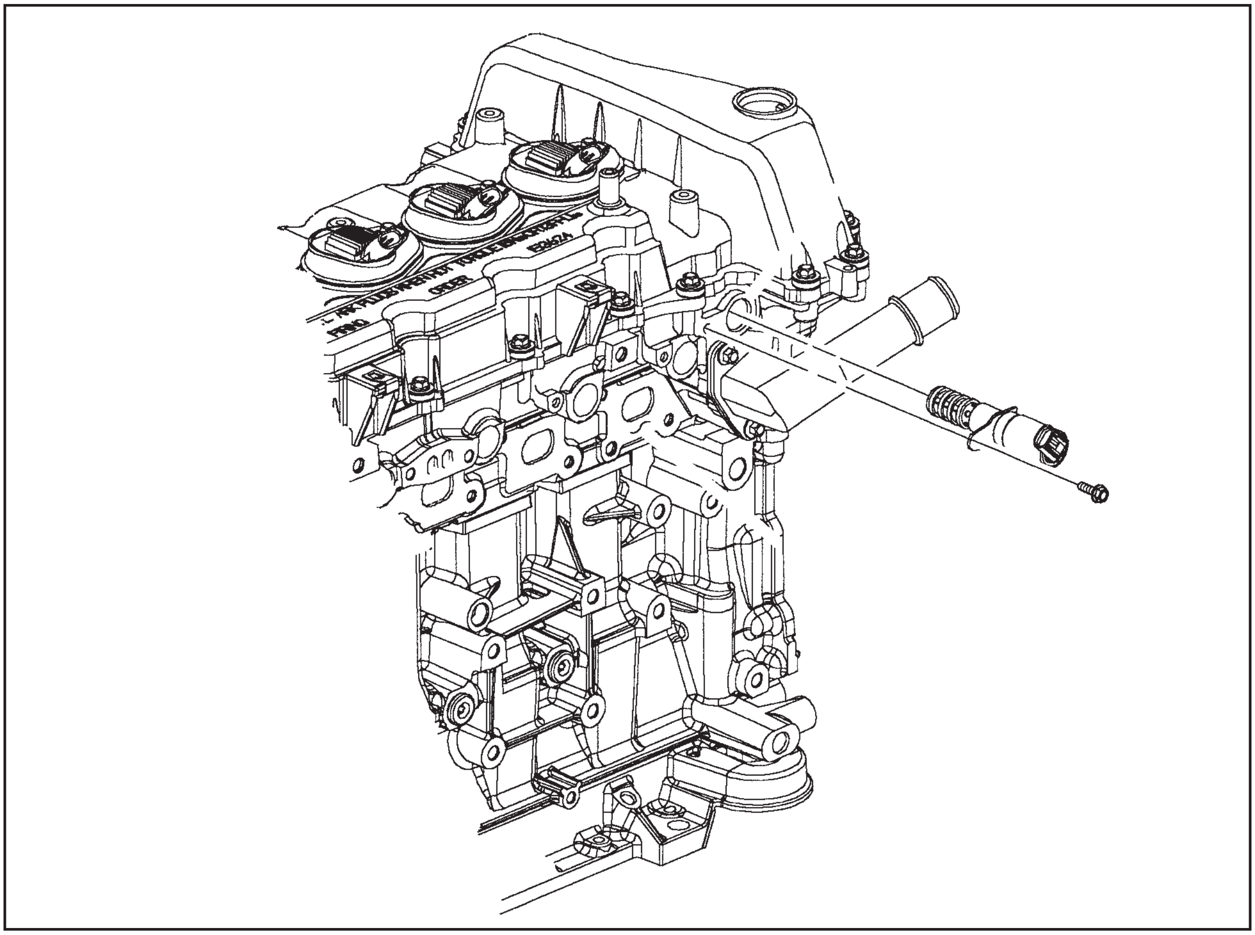
Spark timing is managed with both a cam sensor that monitors camshaft position and a sensor that reads crankshaft position. This dual-measurement system ensures extremely accurate timing throughout the life of the engine. It also provides an effective backup in the event one sensor fails.

Electronic Spark Control / Knock Sensor



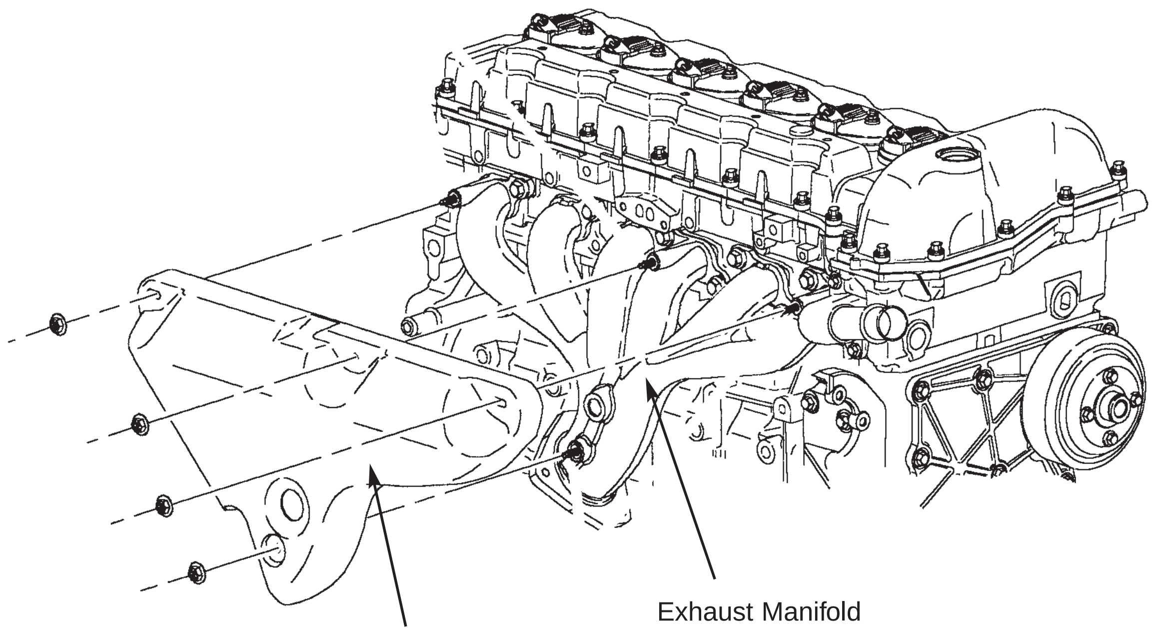
The purpose of the electronic spark control sensor is to retard ignition timing if spark knock were to occur. Two flat response knock sensors are utilized for spark knock control. Sensor locations were chosen to ensure all cylinders could be identified during a knock condition. Knock-induced vibrations excite the crystal in the sensor and produce a signal. The signal is interpreted by the powertrain control module (PCM) to determine when knock is present. The PCM will readjust engine ignition timing until the knock is gone. This allows the engine to run at top performance and efficiency without risking engine damage.

Cam Position Sensor



The cam position sensor identifies the position of the exhaust camshaft. A trigger wheel on the cam phaser aligns with the sensor's tip. As this target rotates, the cam position sensor reads the changing magnetic field and sends a digital signal to the controller. The sensor is installed in the front of the cylinder head. It has an o-ring to prevent oil leaks. The cam position sensor also provides a back-up to the crank sensor to allow engine operation in the event of a malfunction. A position sensor failure will not cause the engine to stop running.

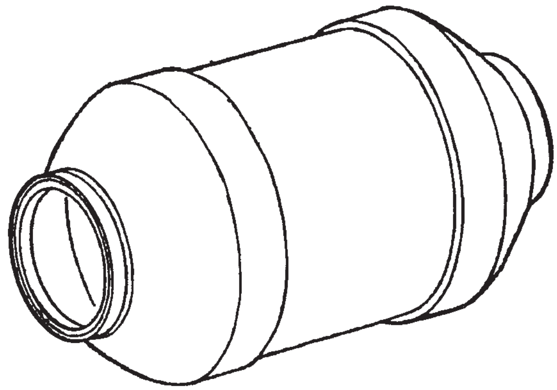
Exhaust Manifold / Heat Shield



To achieve desired flow, durability and noise requirements, a one piece 6-2-1 runner design casting is featured on the Vortec 4200 I6. Small outlet ports on the cylinder head were chosen to maximize the outlet velocity of the exhaust gas. The runners on the manifold are designed for low turbulent flow to minimize the heat transfer of the exhaust gas to the manifold runners. Also, an advantage of an inline six cylinder configuration is that a crossover exhaust pipe is not required, further reducing the exhaust gas heat loss and improving catalytic converter light-off for low emissions.

A three-layer stainless steel embossed gasket is used to seal the manifold to the cylinder head. The manifold is covered with a 1.35mm thick, three-layer (aluminized steel, synthetic fiber insulation and aluminum clad) exhaust shield.

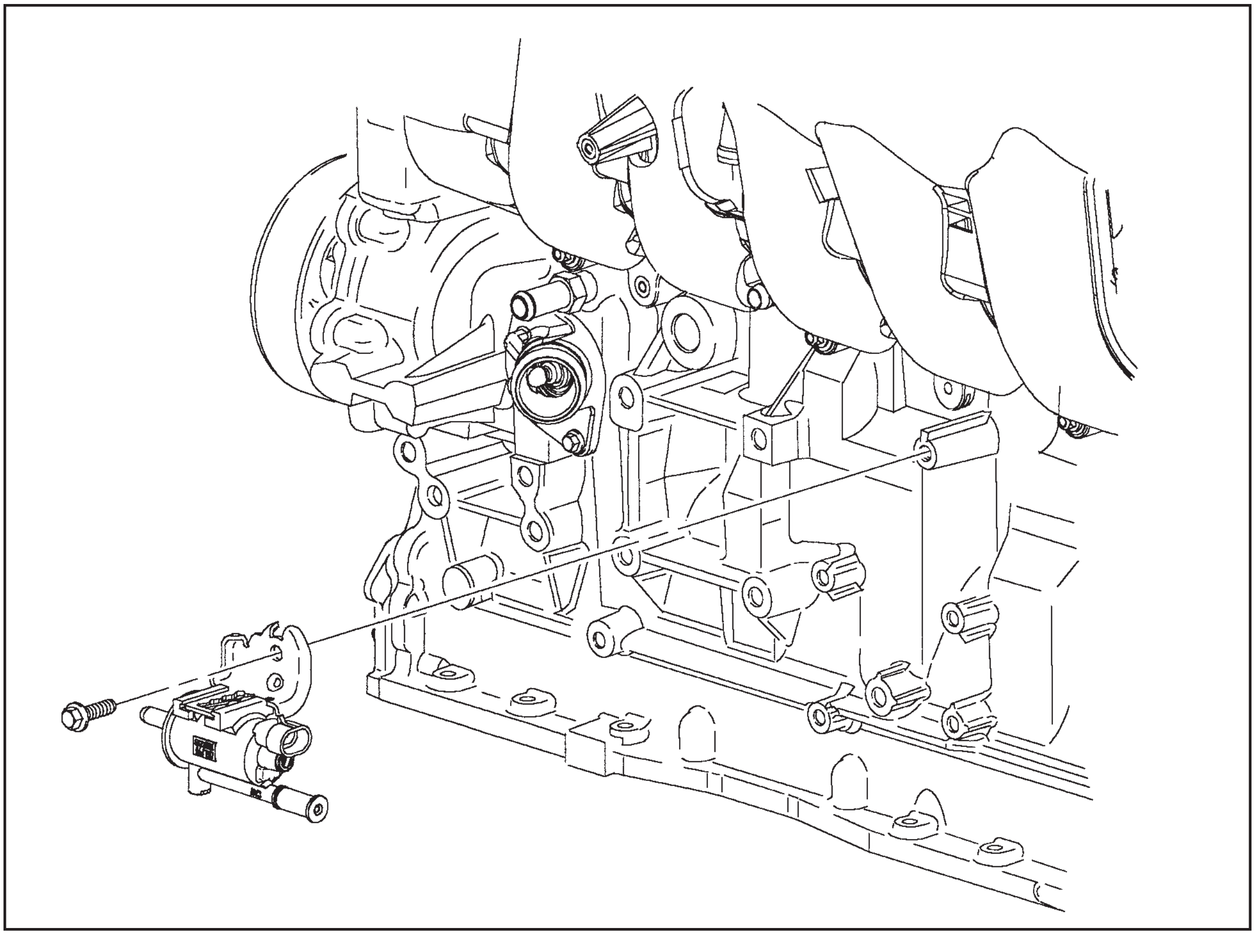
Catalytic Converters



The catalytic converter is mounted near the exhaust manifold, decreasing the time it takes the converter to reach emissions “light-off” temperature. The tri-metal three way catalyst has 1.7 liters of volume with a large, round cross section of 600 cells-per-inch ceramic substrate in a stainless steel shell.

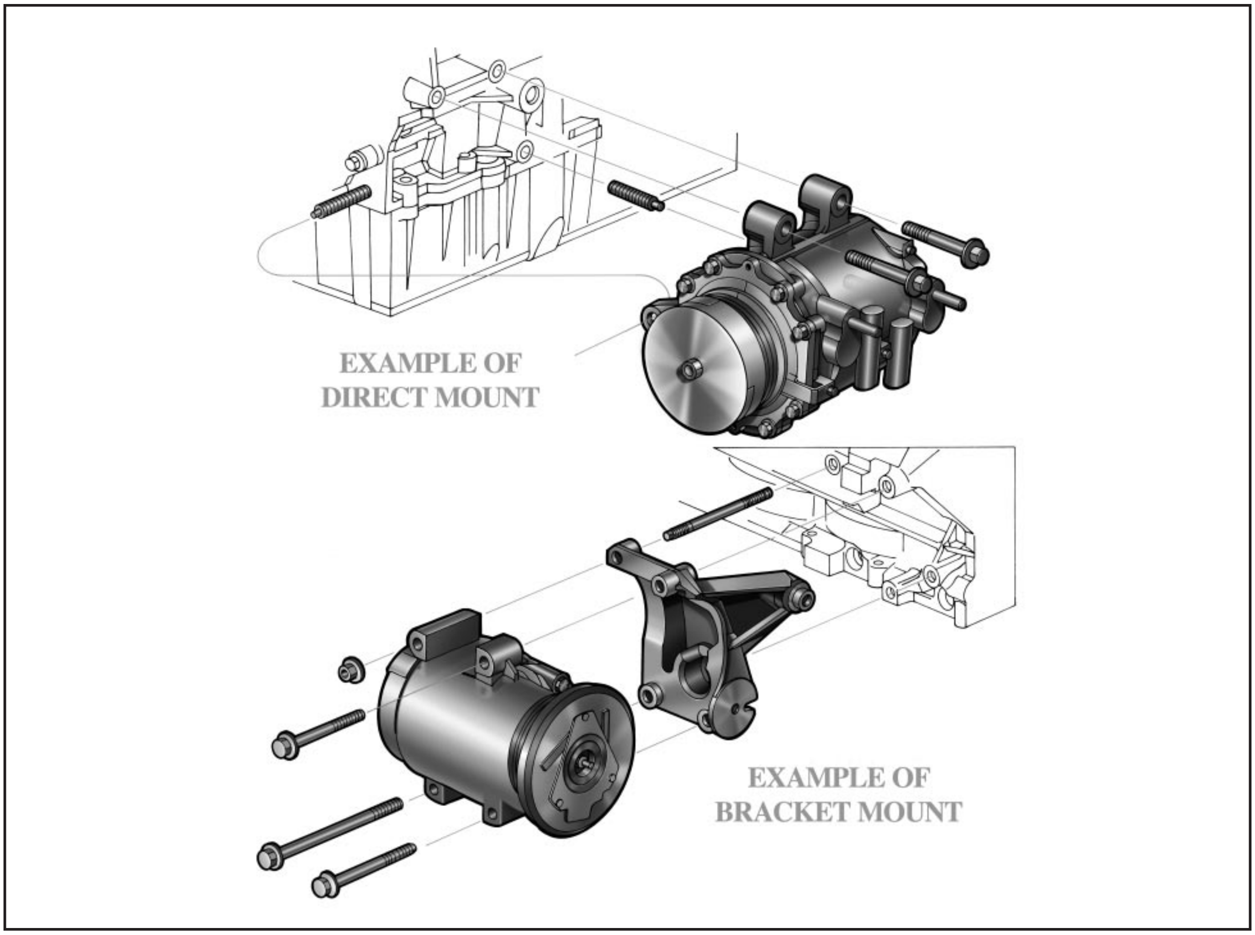
Combined with other efficiency enhancing features including coil-on-plug ignition, variable valve timing and optimal exhaust port design, the new catalyst allows the Vortec 4200 to perform 20 to 30 percent cleaner than the National Low Emissions Vehicle (NLEV) standards without an expensive air injection reaction (AIR) system. Key benefits from eliminating AIR include fewer parts and lower cost. This engine also meets emissions standards for export to Europe and Japan.

Evaporative Emissions Canister Purge Control Valve



The canister purge control valve is part of the vehicle's evaporative emission and on-board refueling vapor recovery systems. This "enhanced precision purge" valve allows for purge fuel vapor to be precisely metered for combustion during idle as well as high load conditions. The increased metering resolution is achieved through the design of the internal sonic flow orifice. This valve allows the vehicle to meet the enhanced evaporative emissions standard while achieving good driveability.

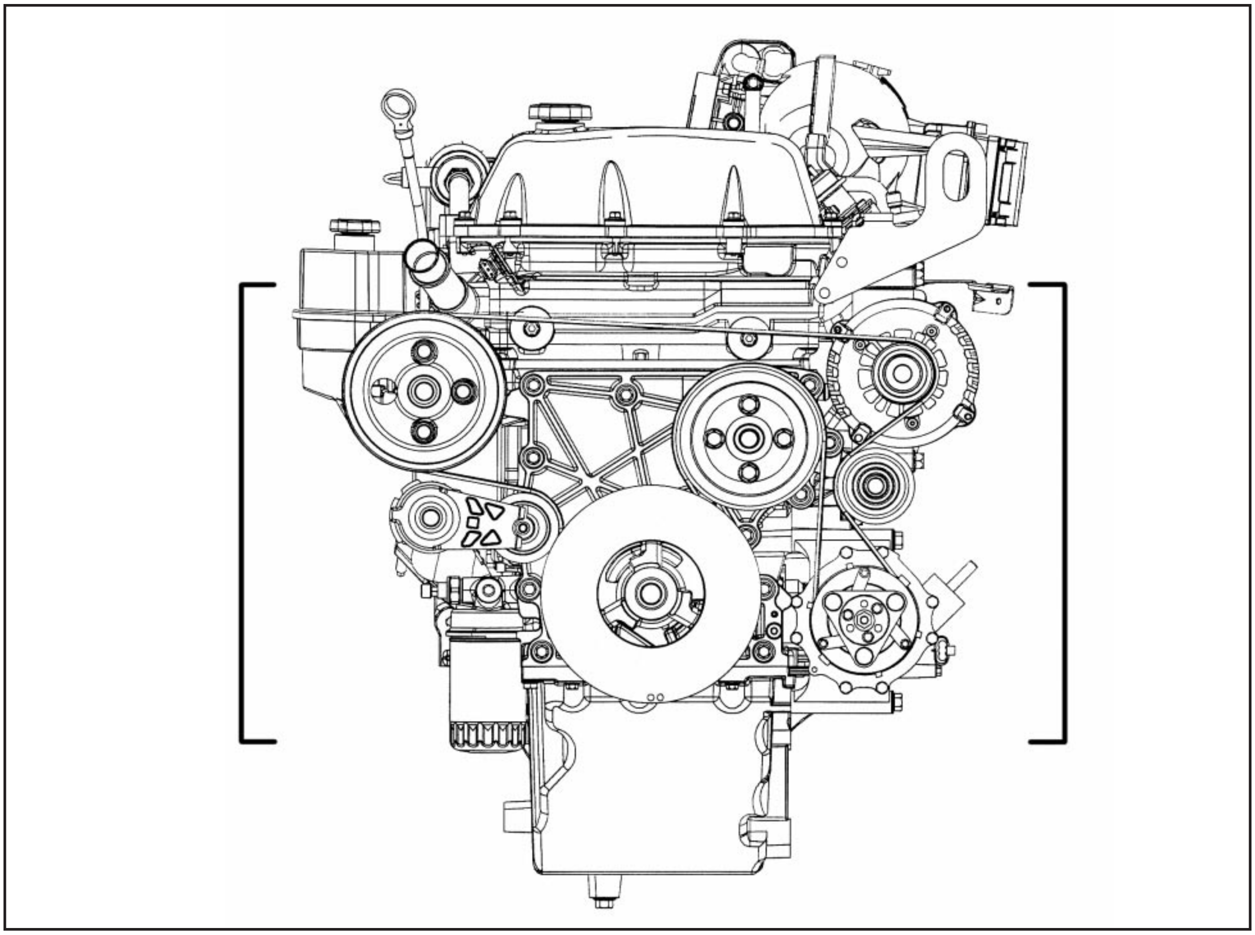
Direct Mount Accessories



With the exception of a single bracket for the power steering pump, all engine accessories are bolted directly to the engine. Direct mounting reduces assembly complexity and build tolerances, and it improves pulley alignment, which reduces belt noise. It also provides a more rigid accessory mounting, reducing overall powertrain vibration and radiated noise.

The Vortec 4200 also features a scroll-type air conditioning compressor. It uses a screw-like scroll to pump refrigerant. The scroll compressor is more efficient than conventional piston compressors and is much quieter in operation.

Accessory Drive Belt / Water Pump Pulley

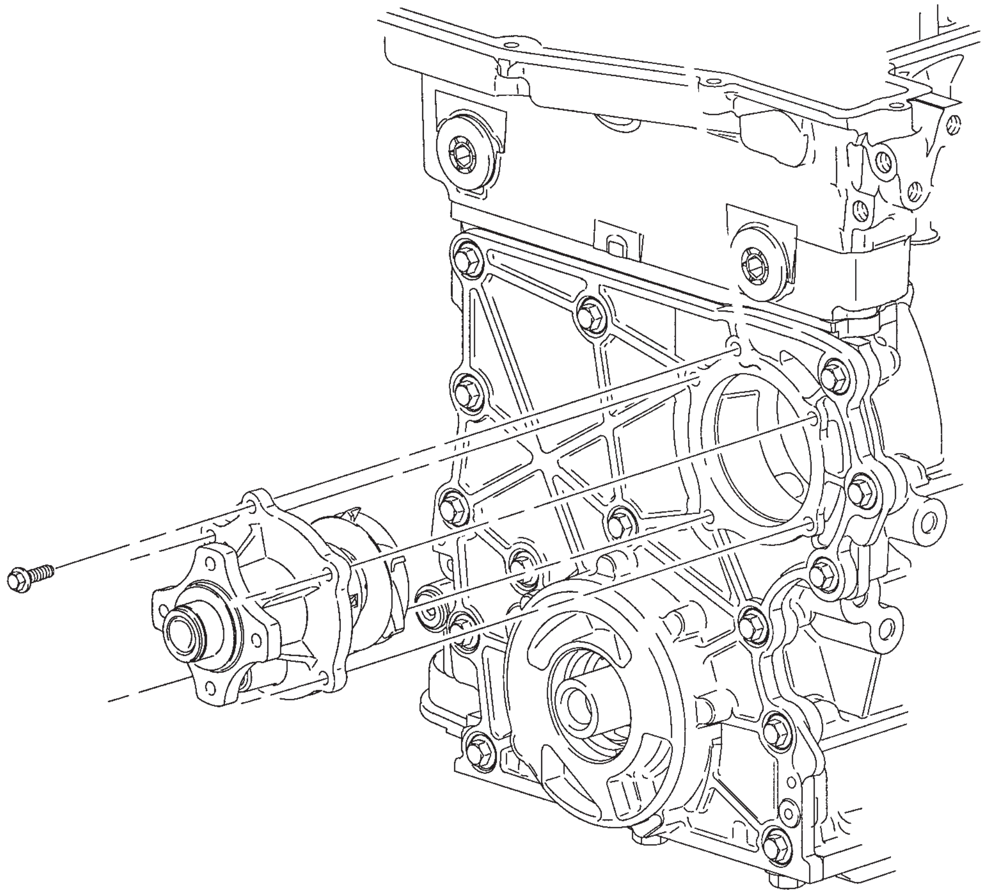


The accessory drive belt transfers the rotation of the crank to the water pump, A/C refrigerant pump, generator and power-steering pump. All pulleys are made of durable steel. The belt is EDPM (synthetic rubber) which has excellent wear characteristics. The robust accessory drive system (belt, tensioner, pulleys and bearings) is virtually maintenance free.

The accessory drive belt tensioner maintains 72 pounds of force against the belt, to prevent belt slipping at the pulleys. The tensioner has a steel pulley with a sealed bearing attached to an aluminum pivot arm. An internal steel coil spring attaches to the pivot arm and to the aluminum mounting. This entire assembly attaches to the power steering pump bracket on the right side of the engine with one bolt. A wear indicator is cast into the pivot arm and base bracket. The wear indicator identifies when the drive belt or serpentine belt is within acceptable length limits. A square hole is cast into the pivot arm to provide easy belt removal with a 3/8 ratchet/breaker bar.

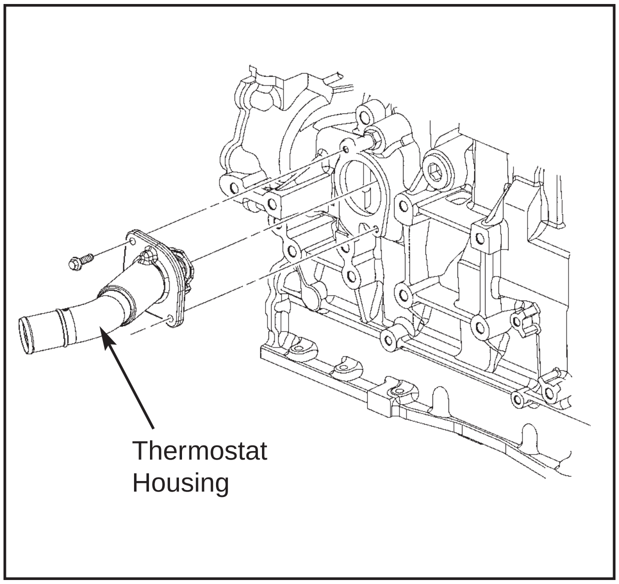
The steel water pump pulley provides drive to the water pump and the cooling fan through the accessory drive belt.

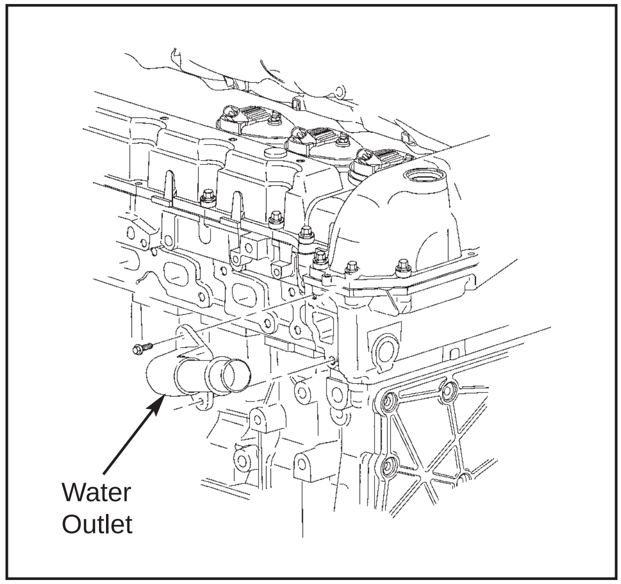
Water Pump



The water pump is a cartridge style unit with the inlet and outlet formed into the block and front cover assemblies. The flow is directed rearward through the block and forward through the head in a “U” pattern for optimum cylinder cooling. The pump has a double shrouded impeller for high flow efficiency, a long life face seal material and a rubber coated steel gasket for reliability.

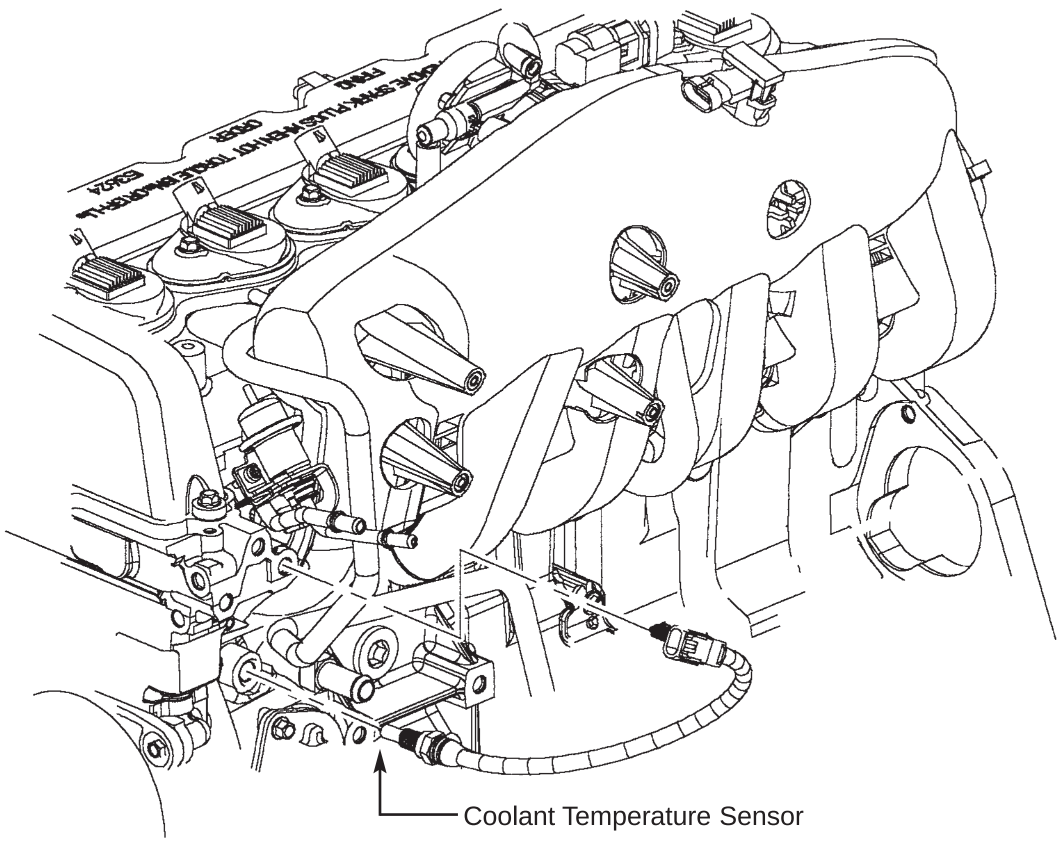
Thermostat Housing / Water Outlet





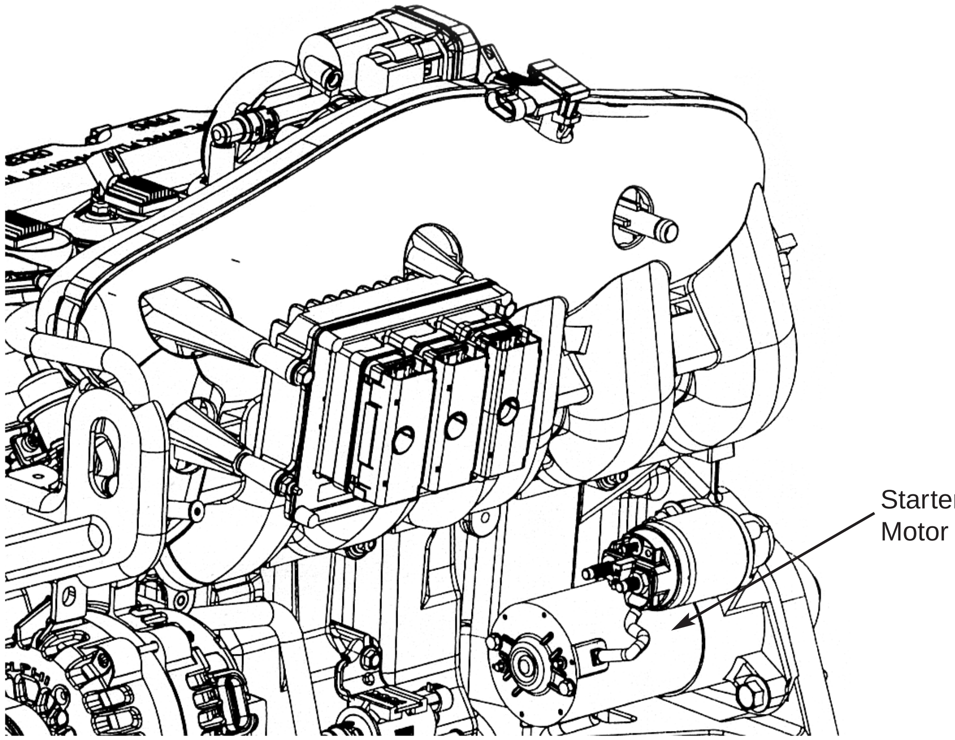
The thermostat has an opening set point of 88^{O}C (190^{O}F) and is positioned on the inlet side of the cooling circuit to maintain steady control temperatures. The thermostat regulates the by-pass flow of coolant to the heater and radiator. A rubber-coated valve is incorporated to eliminate radiator flow during warm up for best heater performance. Also, the thermostat internal components have been upgraded to meet more stringent long life requirements.

Coolant Temperature Sensor



The coolant temperature sensor is installed into a coolant passage on the left side of the cylinder block. It contains a negative temperature co-efficient thermistor, which changes resistance with temperatures. This change in resistance is used by the Powertrain Control Module to measure coolant temperature and to calculate the appropriate air/fuel, spark, and valve timing for the given driving condition.

Starter Motor

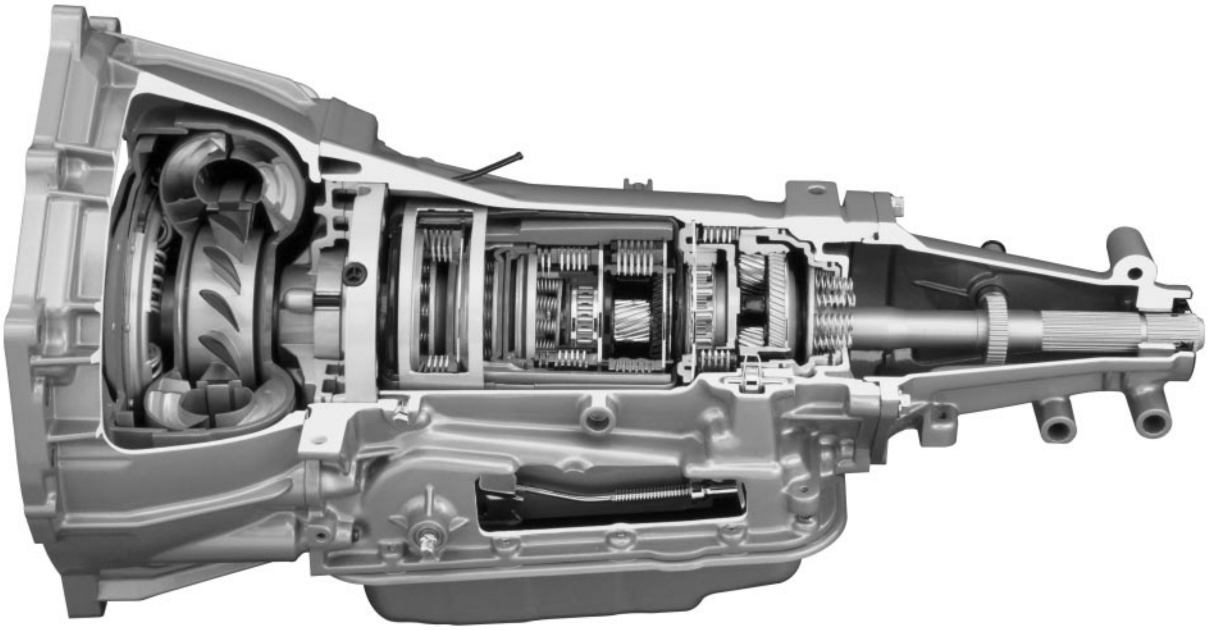


The purpose of the starter motor is to initiate rotation of the crankshaft so that the engine can begin the cycle of producing its own power. The starter motor torque is multiplied by the use of planetary gears at a 4.9:1 ratio. The planetary gear system increases torque with less electrical need, puts load on the battery, and provides more power to rotate the engine.

The permanent magnet gear reduction starter improves starter performance while reducing size and weight. Typically a much bigger and heavier starter would be necessary to overcome a 10:1 compression ratio. In this case the starter has been mounted high on the intake side of the engine. This protects it from direct road splash, heat and water exposure.

Engagement/disengagement is controlled by the Powertrain Control Module (PCM). The PCM will not allow the starter to engage after the engine is running.

Hydra-Matic 4L60-E Transmission



The 2002 Hydra-Matic 4L60-E 4-speed automatic transmission transfers torque from the Vortec 4200 I6 engine into vehicle speed. This transmission features a 280mm torque convertor and unique bell housing.

The 4L60-E has a two-piece case design with a 360-degree bell housing that completely encases the torque converter assembly. Traditional designs utilize three-piece construction with bell housings that only partially enclose the converter. The result is improved powertrain stiffness and reduced levels of noise and vibration.

The Powertrain Control Module (PCM) measures key vehicle factors including throttle position, vehicle speed, gear range, temperature and engine load to create a seamless interface between engine and transmission. Shift timing is controlled by an electronic signal sent to the valve body shift solenoids, which activate the shift valves for precise execution.

A common problem in climbing or descending hills is “shift business,” which is the tendency of transmission to hunt between gears. The PCM addresses this issue by sensing when the vehicle is operating on a grade and selecting and holding an appropriate gear, based on throttle position, engine speed and other factors.

The 4L60-E uses an electronic controlled capacity clutch (used instead of a mechanical lock-up clutch). This clutch uses sophisticated electronics to maintain very small amounts of slip between the pressure plate and the torque converter housing cover. The ability to precisely control continuously variable amounts of slip leads to reduced torque pulses and allows the clutch to be applied at lower vehicle speeds and with smoother engagement. As a result, driveability and fuel economy are improved.

When a vehicle is subjected to an abusive maneuver, such as moving quickly from drive to reverse while rocking the car to get out of a snow drift, abnormal wear can occur. The PCM helps to protect the powertrain by retarding spark to reduce engine output during such situations. Similarly, the PCM briefly cuts engine torque prior to each shift to reduce driveline lash, thus producing smoother shifts.

The second gear start option on the 4L60-E provides an extra measure of security and control in hazardous driving conditions. By moving the gear selector to the D2 position, the driver can reduce torque to the drive wheels, increasing control during initial acceleration on slippery roads.

The 4L60-E uses long-life DEXRON III transmission fluid, which has a 100,000-mile service interval under normal use (50,000-mile for severe use). Additionally, the PCM monitors operating conditions of the transmission and alerts the driver with a warning light if there is a deterioration that would cause a significant loss in vehicle performance, such as shift feel or drivability. The PCM also monitors for deteriorations that would allow the vehicle to exceed acceptable emissions levels, in compliance with OBD II regulations.